

THE PENNSYLVANIA STATE UNIVERSITY  
SCHREYER HONORS COLLEGE

DEPARTMENT OF ARCHITECTURAL ENGINEERING

THE INTRODUCTION OF DAYLIGHT IN BUILDINGS: A STUDY OF FAÇADE AND  
SHADING SYSTEMS

VICTORIA RIEDINGER  
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A thesis  
submitted in partial fulfillment  
of the requirements  
for a baccalaureate degree  
in Architectural Engineering  
with honors in Architectural Engineering

Reviewed and approved\* by the following:

Kevin Houser  
Professor of Architectural Engineering  
Thesis Supervisor

Richard Mistrick  
Associate Professor of Architectural Engineering  
Honors Adviser/Faculty Reader

\* Signatures are on file in the Schreyer Honors College.



# BIOENGINEERING BUILDING



All renderings created by Ballinger

## BUILDING INFORMATION

LOCATION - Eastern Region, USA

OCCUPANCY TYPE - Research Facility

SIZE - 183,000 gsf

FLOORS ABOVE GRADE - 6

CONSTRUCTION DATES - July 2015-March 2017

OTAL COST - \$120,000,000

PROJECT DELIVERY METHOD - Design-Bid-Build

## PROJECT TEAM

OWNER - Withheld by request

GENERAL CONTRACTOR - Withheld by request

ARCHITECT & ENGINEER - Ballinger

LIGHTING DESIGNER - The Lighting Practice

## ARCHITECTURE

The Bioengineering Building is a large multipurpose facility containing labs, classrooms, offices, and conference rooms. Curtain walls wrap around most of the building, while the remaining façade is a modular brick and cast stone veneer. The large amounts of glass provide daylighting capabilities and allow for a direct relationship to the outside, allowing the building to glow at night. LEED Silver certification was acquired through this design.



## STRUCTURAL

The structural system of the elevated floor of the building consists of a 13" thick, cast-in-place, two-way concrete slab with drop panels at the columns. A flat plate system was selected for its economy, ease of constructability, flexibility, and resistance to vibration. Floor slabs were thickened around the perimeter to support heavy or brittle exterior wall finishes and at the interior where added depth was needed to control deflection.

## LIGHTING/ELECTRICAL

All lighting in the building is designed with either LED or fluorescent fixtures. Most fixtures allow for dimming and most individual spaces are controlled by occupancy sensors or switches. Electrical service is provided from the existing site medium voltage distribution system. Service comes from 13.8 kV 3-phase, 3-wire loop feeders. The electrical service capacity is designed to server 20% additional load if needed.

## MECHANICAL

Three 400 ton electric oil-free centrifugal chillers supply chilled water to the air handling units. Three single cell cooling towers will be used for chiller heat rejection. The mechanical penthouse of the building contains three 100% outdoor variable volume air supply handlers which create a single supply air system. Six fans are mounted to the rooftop plenum which will handle building exhaust.



**BALLINGER**

VICTORIA RIEDINGER — LIGHTING/ELECTRICAL

Advisor: Dr. Kevin Houser

<http://vyr5033.wix.com/vriedingerthesis>



## **ABSTRACT**

The building studied in this thesis report is a Bioengineering Building located in the Eastern United States. It serves as a research facility that houses labs, classrooms, offices, and conference rooms. The entirety of this thesis focuses on the redesign of four spaces located on the first floor of the building. The redesign includes topics in lighting, electrical, mechanical, structural, and daylighting design.

The daylighting, structural, and mechanical portion of the thesis were designed based on the preliminary research conducted in Chapter 1 of this report. A new façade shading system was designed to maximize daylighting benefits and improve occupant comfort in the work space. The daylighting design was analyzed for illuminance and glare properties and found that they both improved greatly after the implementation of the new louver system. The structural study analyzed the loading of the new louvers on the façade to ensure that the concrete beams in the Flex Lab could support the addition. It was discovered that the structural properties of the existing column were more than capable of supporting the new louvers across the façade. The mechanical study discovered that the louver system raised the heating and cooling loads in the space. While both were raised slightly, the energy saved from utilizing daylight instead of electric light can compensate for the increase.

The lighting redesigned in the four spaces reflects the idea of a building functioning much like a human body. Each space has its own use, but because they're all connected, the design requires an integration of systems and aesthetics. The Exterior Plaza, Lobby, Flex Classroom, and Flex Lab space are all located on the first floor of the building and are open to each other. A detailed analysis of each space was conducted and reported in this thesis.

## TABLE OF CONTENTS

ABSTRACT .....	ii
LIST OF FIGURES .....	vii
LIST OF TABLES .....	xii
ACKNOWLEDGEMENTS .....	xiii
Chapter 1 Daylight in Buildings .....	15
1.1 Properties of Daylight .....	16
1.2 Daylight Application in Buildings .....	17
1.3 Effects of Daylight on Occupants in Work Environments .....	19
1.3.1 Positive Effects .....	20
1.3.2 Negative Effects .....	21
1.4 Types of Shading Systems .....	23
1.4.1 Shades .....	23
1.4.2 Louvers .....	25
1.4.3 Light Shelves .....	27
1.5 Types of Curtain Wall Façade Systems .....	29
1.5.1 Types of Glazing .....	29
1.5.2 Double Skin Façades .....	31
1.5 Conclusion .....	33
Chapter 2 Existing Building Construction .....	34
2.1 Building Statistics .....	34
2.2 Project Team .....	34
2.3 Architecture .....	35
2.3.1 Major Codes .....	35
2.4 Building Enclosure .....	36
2.4.1 Façade .....	36
2.4.2 Sun Shading System .....	39
2.4.3 Roof .....	39
2.4.4 Sustainability .....	40
2.5 Primary Engineering Systems .....	40
2.5.1 Construction .....	40
2.5.2 Electrical .....	41
2.5.3 Lighting .....	41
2.5.4 Mechanical .....	42
2.5.5 Structural .....	43
2.6 Additional Engineering Support Systems .....	44
2.6.1 Fire Protection .....	44
2.6.2 Transportation .....	44
2.6.3 Telecommunications .....	45



2.6.4 Special Systems .....	45
Chapter 3 MAE Daylighting Depth .....	47
3.1 Existing Space Study.....	49
3.2 Daylighting Study of Existing Curtain Wall.....	50
3.2.1 Summer Solstice: June 21 <sup>st</sup> - 9 am (Looking North) .....	51
3.2.2 Summer Solstice: June 21 <sup>st</sup> - 10 am (Looking North) .....	51
3.2.3 Winter Solstice: December 21 <sup>st</sup> - 9am (Looking North) .....	52
3.2.4 Winter Solstice: December 21 <sup>st</sup> – 10 am .....	52
3.2.5 Evaluation.....	53
3.2.6 Evalglare Analysis in Radiance.....	54
3.3 Interior Louver Design.....	56
3.4 Daylighting Study of Interior Louver System.....	61
3.4.1 Summer Solstice: June 21 <sup>st</sup> - 9 am (Looking North) .....	61
3.4.2 Winter Solstice: December 21 <sup>st</sup> - 10 am (Looking North) .....	62
3.4.3 Evalglare Analysis in Radiance.....	62
3.4.4 Evaluation.....	63
Chapter 4 Structural Breadth .....	65
4.1 Structural Analysis of Louver Addition .....	65
4.1.1 Floor Slab Load.....	65
4.1.2 Curtain Wall Load.....	68
4.1.3 Louver Load .....	69
4.1.4 Total Load on Column .....	70
4.1.5 Column Strength .....	71
4.1.6 Analysis & Conclusion.....	71
Chapter 5 Mechanical Breadth.....	72
5.1 Louver Modeling in COMFEN .....	73
5.2 Analysis of Shading in Summer .....	74
5.3 Analysis of Shading in Winter .....	76
5.4 Conclusion .....	78
Chapter 6 Electrical Depth.....	79
6.1 Analysis of Roof Sunlight Exposure .....	79
6.2 Equipment Selection .....	80
6.2.1 PV Panel Selection .....	80
6.2.2 Inverter Selection .....	81
6.3 System Design.....	81
6.4 Payback Period Calculation .....	85
6.5 Conclusion .....	85
Chapter 7 Lighting Depth .....	87
7.1 Background .....	87

7.2 Overall Lighting Concept.....	89
7.3 Exterior Plaza Design.....	90
7.3.1 Space Summary.....	90
7.3.2 Tasks & Design Considerations .....	92
7.3.3 Design Criteria .....	93
7.3.4 Overall Design Strategy .....	93
7.3.5 Proposed Lighting Design.....	95
7.3.6 Luminaire Schedule.....	95
7.3.7 Final Lighting Design.....	96
7.3.8 Lighting Power Density Calculations.....	97
7.3.9 Lighting Calculations .....	98
7.3.10 Renderings.....	101
7.3.11 Evaluation & Controls Discussion .....	104
7.4 Lobby Design.....	105
7.4.1 Space Summary .....	105
7.4.2 Tasks & Design Considerations .....	106
7.4.3 Design Criteria .....	107
7.4.4 Overall Design Strategy .....	108
7.4.5 Proposed Lighting Design.....	109
7.4.6 Luminaire Schedule.....	110
7.4.7 Final Lighting Design.....	111
7.4.8 Lighting Power Density Calculations.....	115
7.4.9 Lighting Calculations .....	116
7.4.10 Renderings.....	118
7.4.11 Evaluation & Controls Discussion .....	124
7.5 Flex Classroom Design .....	125
7.5.1 Space Summary.....	125
7.5.2 Tasks & Design Considerations .....	126
7.5.3 Design Criteria .....	127
7.5.4 Overall Design Strategy .....	128
7.5.5 Proposed Lighting Design.....	129
7.5.6 Luminaire Schedule.....	130
7.5.7 Final Lighting Design.....	130
7.5.8 Lighting Power Density Calculations.....	131
7.5.9 Lighting Calculations .....	131
7.5.10 Renderings.....	133
7.5.11 Evaluation & Controls Discussion .....	136
7.6 Flex Lab Design .....	137
7.6.1 Space Summary.....	137
7.6.2 Tasks & Design Considerations .....	138
7.6.4 Design Criteria .....	139
7.6.3 Overall Design Strategy .....	140
7.6.5 Proposed Lighting Design.....	141
7.6.6 Luminaire Schedule.....	141
7.6.7 Final Lighting Design.....	142
7.6.8 Lighting Power Density Calculations.....	142
7.6.9 Lighting Calculations .....	143
7.6.10 Renderings.....	145
7.6.11 Evaluation & Controls Discussion .....	148

Chapter 8 Conclusion.....	149
Appendix A Shading System Tables .....	150
Appendix B Structural Calculations .....	154
Appendix C Photovoltaic Panel Component Specifications.....	159
Appendix D Lighting Plans .....	164
Appendix E Lighting Cutsheets .....	169
BIBLIOGRAPHY .....	258
ACADEMIC VITA .....	262



## LIST OF FIGURES

Figure 1 Spectral Power Distribution of Daylight (Burnett 2015).....	16
Figure 2 Top-down and Bottom-up shading systems (Lawrence Berkeley National Laboratory) ..	25
Figure 3 Vertical louvers on building exterior & Horizontal louvers as building overhang....	26
Figure 4 “Fish” System: Curved louvers made to redirect daylight upward into building (IEA SHC TASK 21 2000) .....	27
Figure 5 Various effects of light shelves during the winter and summer (IEA SHC TASK 21 2000) .....	28
Figure 6 Sun-directing glass application (IEA SHC TASK 21 2000) .....	29
Figure 7 Insulating glass unit (IGU) (Lawrence Berkeley National Laboratory) .....	30
Figure 8 Types of double-skin facades (Memari 2013) .....	31
Figure 9 Double-skin facade of the The Tower at PNC Plaza (Paladino 2015) .....	32
Figure 10 Interior cavity of the façade (Ko & Tranel 2015) .....	32
Figure 11 Axonometric of interior section.....	35
Figure 12 Curtain wall system 1 axonometric .....	37
Figure 13 Curtain wall system 1 wall section .....	37
Figure 14 Curtain wall system 2 axonometric .....	38
Figure 15 Curtain wall system 2 wall section .....	38
Figure 16 Existing Sunshades .....	39
Figure 17 Perspective of existing sun shades.....	39
Figure 18 Existing roof detail .....	39
Figure 19 Sun path over top of Flex Lab floor plan generated by University of Oregon Solar Radiation Monitoring Laboratory .....	48
Figure 20 Floor plan of Flex Lab highlighted in purple.....	48
Figure 21 Elevation of Flex Lab curtain wall .....	49
Figure 22 Fritted glass type IG-2 .....	49
Figure 23 Pseudo color of June 9 am condition.....	51

Figure 24 Raytrace of June 9 am condition .....	51
Figure 25 Pseudo color of June 10 am condition.....	51
Figure 26 Raytrace of June 10 am condition .....	51
Figure 27 Pseudo color of December 9 am condition.....	52
Figure 28 Raytrace of December 9 am condition .....	52
Figure 29 Pseudo color of December 10am condition.....	52
Figure 30 Raytrace of December 10 am condition .....	52
Figure 31 Radiance daylight rendering on December 21st, 10 am .....	54
Figure 32 Radiance daylight rendering on June 21st, 9 am .....	54
Figure 33 Kawneer vertical louver system (Kawneer) .....	57
Figure 34 Mounting and adjustment of vertical louvers (Kawneer) .....	57
Figure 35 Plan view of new louver .....	58
Figure 36 Elevation of new louver system concept with louvers represented as the red lines	58
Figure 37 Sun angle study and louver angle orientation for December 21st at 9 am & 10 am	59
Figure 38 Sun angle study and louver angle orientation for June 21 <sup>st</sup> at 9 am & 10 am .....	60
Figure 39 Plan of June 21st louver orientation .....	60
Figure 40 Plan of December 21st louver orientation .....	61
Figure 41 Raytrace of June 9 am condition .....	61
Figure 42 Pseudo color of June 9 am condition.....	61
Figure 43 Raytrace of December 10 am condition .....	62
Figure 44 Pseudo color of December 10 am condition.....	62
Figure 45 Radiance daylight rendering on June 21st, 9 am .....	63
Figure 46 Radiance daylight rendering on December 21st, 10 am .....	63
Figure 47 Wall section of east facade .....	65
Figure 48 Section of Flex Lab structural plan.....	66

Figure 49 Perspective of curtain wall design .....	68
Figure 50 Elevation view of curtain wall system modeled in COMFEN .....	72
Figure 51 Comparison of Louver design and COMFEN shading model.....	73
Figure 52 Energy use of original design compared to June 21st shading system.....	74
Figure 53 Monthly heat gain of original design compared to June 21 <sup>st</sup> shading system .....	75
Figure 54 Comfort level of occupants in the summer at 9am compared to the comfort with the shading system .....	75
Figure 55 Energy use of the original design compared to the December 21st design .....	76
Figure 56 Monthly heat gain of original design compared to December 21st shading system.....	77
Figure 57 Comfort level of occupants in the winter at 10am compared to the comfort with the shading system .....	77
Figure 58 Pseudo color rendering of daylight exposure of roof (with highest roof plane outlined in white) .....	79
Figure 59 PV panel dimensions from SunPower specifications .....	80
Figure 60 PV panel spacing calculation.....	82
Figure 61 PV panel layout plan produced in AutoCAD .....	82
Figure 62 PVWatts calculator inputs from online program.....	83
Figure 63 Results of PVWatts calculation .....	84
Figure 64 Pseudo color rendering of PV panel array on building rooftop.....	85
Figure 65 Axonometric view of four designed spaces located on the first floor (highlighted in blue) .....	87
Figure 66 Axonometric view of foot traffic through designed spaces (indicated with red lines) .....	88
Figure 67 Lighting concept sketch.....	89
Figure 68 Site plan of Exterior Plaza showing main building entrances .....	90
Figure 69 Exterior Plaza planting plan .....	91
Figure 70 Social Table elevation .....	91
Figure 71 Perspective view rendering of Exterior Plaza, courtesy of Ballinger .....	92



Figure 72 Exterior Plaza concept sketch.....	94
Figure 73 Initial proposed Exterior Plaza lighting design .....	95
Figure 74 Detail of flexible LED bench lighting installation .....	96
Figure 75 Exterior Plaza plan view pseudo color calculation (AGi32) .....	98
Figure 76 Typical walkway illuminance distribution (blue: >1, red: >2) (AGi32) .....	99
Figure 77 Main entrance illuminance calculation (AGi32) .....	100
Figure 78 Final design pseudo color rendering without interior lighting (AGi32).....	101
Figure 79 Final design pseudo color rendering with interior lighting (AGi32) .....	102
Figure 80 Final design raytrace rendering with interior lighting (AGi32).....	102
Figure 81 Exterior Plaza perspective view raytrace rendering (AGi32).....	103
Figure 82 Exterior Plaza raytrace rendering main entrance (AGi32) .....	103
Figure 83 Lobby floor plan highlighted in purple.....	105
Figure 84 Lobby concept sketch .....	108
Figure 85 Initial proposed Lobby lighting design.....	109
Figure 86 Plan of cove detail around Flex Classroom core (AutoCAD) .....	111
Figure 87 Perspective view of double cove around Flex Classroom core (AutoCAD) .....	112
Figure 88 Perspective view into coves around Flex Classroom (AGi32).....	113
Figure 89 Perspective view into coves above elevator (AGi32).....	113
Figure 90 Plan view of elevator core cove (AutoCAD).....	114
Figure 91 Lobby plan view pseudo color calculation (AGi).....	116
Figure 92 Typical corridor calculation values (AGi32).....	116
Figure 93 Main Entry calculation values (AGi32).....	117
Figure 94 Lobby interior pseudo color rendering from main entrance - view 1 (AGi32) .....	118
Figure 95 Lobby interior raytrace rendering from main entrance – view 1 (AGi32) .....	119
Figure 96 View 1 direction for Figure 89 & 90 .....	119

Figure 97 Lobby interior pseudo color rendering from Cafe entrance – view 2 (AGi32) .....	120
Figure 98 Lobby interior raytrace rendering from Cafe entrance - view 2 (AGi32).....	120
Figure 99 View 2 direction for figure 92 & 93 .....	121
Figure 100 Lobby interior pseudo rendering facing main entrance - view 3 (AGi32) .....	121
Figure 101 Lobby interior raytrace rendering facing main entrance - view 3 (AGi32).....	122
Figure 102 View 3 direction for figure 95 & 96 .....	122
Figure 103 Interior Lobby pseudo color rendering from top of stairs - view 4 (AGi32).....	123
Figure 104 Interior Lobby raytrace rendering from top of stairs - view 4 (AGi32) .....	123
Figure 105 View 4 direction for figure 98 & 99 .....	124
Figure 106 Flex Classroom floor plan highlighted in purple .....	125
Figure 107 Flex Classroom concept sketch .....	128
Figure 108 Initial proposed Flex Classroom lighting design, entire space design.....	129
Figure 109 Flex Classroom plan view pseudo color calculation (AGi32).....	131
Figure 110 Flex Classroom illuminance levels with all fixtures on for classroom setting, typical for each half of the space (AGi32) .....	132
Figure 111 Plan view raytrace rendering (AGi32).....	133
Figure 112 Interior Flex Classroom pseudo color rendering (AGi32).....	134
Figure 113 Interior Flex Classroom raytrace rendering with all lights on (AGi32) .....	134
Figure 114 Full classroom pseudo rendering (AGi32) .....	135
Figure 115 Full classroom raytrace rendering (AGi32).....	135
Figure 116 Flex Lab floor plan highlighted in purple.....	137
Figure 117 Flex Lab concept sketch .....	140
Figure 118 Initial proposed Flex Lab lighting design.....	141
Figure 119 Flex Lab typical work space illuminance values .....	143
Figure 120 Interior Flex Lab pseudo rendering facing North (AGi32).....	145
Figure 121 Interior Flex Lab raytrace rendering facing North (AGi32) .....	145

Figure 122 Interior Flex Lab pseudo rendering facing South (AGi32).....	146
Figure 123 Interior Flex Lab raytrace rendering facing South (AGi32) .....	146
Figure 124 Interior Flex Lab pseudo color rendering facing into Lobby (AGi32) .....	147
Figure 125 Interior Flex Lab raytrace rendering facing into Lobby (AGi32).....	147



## LIST OF TABLES

Table 1 Curtain wall glass properties.....	50
Table 2 Daylight illuminance values of existing curtain wall.....	53
Table 3 DGP values .....	54
Table 4 DGI values .....	55
Table 5 DGP values .....	62
Table 6 DGI values .....	62
Table 7 Daylight illuminations levels with interior louver system .....	64
Table 8 Exterior Plaza luminaire schedule .....	95
Table 9 LPD calculation for plaza walkways .....	97
Table 10 LPD calculation for main building entrance at southeastern corner of building .....	97
Table 11 LPD calculation for cafe entryway at southwestern corner of building.....	97
Table 12 LPD calculation for eastern building entryway .....	98
Table 13 Exterior Plaza Illuminance Levels .....	101
Table 14 Materials in Lobby .....	106
Table 15 Lobby luminaire schedule.....	110
Table 16 Lobby calculation results (AGi32).....	118
Table 17 Materials in Flex Classroom .....	126
Table 18 Flex Classroom luminaire schedule .....	130
Table 19 Flex Classroom calculation results (AGi32).....	133
Table 20 Materials in Flex Lab .....	138
Table 21 Flex Lab luminaire schedule .....	141
Table 22 LPD calculation for Flex Lab .....	142
Table 23 Flex Lab calculation results (AGi32).....	143

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## Chapter 1 Daylight in Buildings

Before electric lighting existed, humans survived mainly under the influence of daylight. During this time, architects strived to design buildings that created large open spaces allowing for the filtration of daylight [Ruck and others 2000]. Since the introduction of artificial lighting, people now spend over 90% of their day indoors [Burnett 2015]. The use of electric lighting has supplemented the need for daylighting with its ability to reach the majority of indoor lighting requirements. The introduction of this technology shifted architects design priorities away from daylight integration. Recently, with the increasing environmental concerns, daylighting has once again become a primary lighting system in building design. Because it's a free natural resource, daylight design helps lower building energy consumption [Edwards and Torcellini 2002].

Daylight also has the potential to influence the health of building occupants [Aries and others 2015]. It's been credited with improving people's mood, relieving skin conditions, reducing eyestrain, improving vision, and lowering fatigue, along with other health benefits [Edwards and Torcellini 2002; Aries and others 2015]. Although statistically significant results have accredited daylight to improving human health, there is still a limited amount of research available. Even within the existing data, there's a large amount of uncertainty in the contribution of pure daylight to occupant's health [Aries and others 2015].

Although researchers are still in the process of determining the exact health benefits, studies suggest a definite preference among occupants for daylighting in indoor environments [IEA SHC Task 21 2000; Boyce 2014; Edwards and Torcellini 2002]. Work environments are one of the most studied spaces in terms of daylighting preference. The IEA SHC Task 21 [2000] Report credits the preference of daylight to the occupant's access to environmental stimulation as well as their ability to see the space and



the tasks. This report examines the importance of daylighting to the indoor environment and its effect on the comfort and performance of the occupants.

## 1.1 Properties of Daylight

Daylight travels to the Earth's surface from the sun through either direct or indirect light, traveling as distinct rays or scattered light from the atmosphere. Those two quantities can be described as sunlight and skylight respectively. One of the major characteristics of sunlight is its variability. It differs in scale, spectral quality, and distribution depending on weather, location on earth, day, and time of year [Boyce 2014].

The sun emits light as electromagnetic radiation which is a mixture of visible light, infrared (IR) radiation, and ultraviolet (UV) light. The visible spectral distribution of daylight is made up of the various wavelengths between approximately 380 nm and 780 nm and can be seen in Figure 1 below.

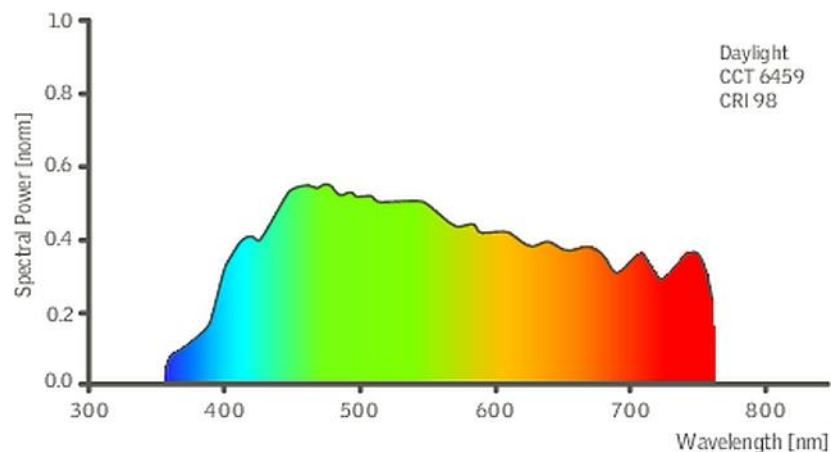


Figure 1 Spectral Power Distribution of Daylight (Burnett 2015)

As shown in Figure 1, the spectral power distribution of daylight is relatively even over the various wavelengths, with a higher peak between 400 and 500 nm. Although this graph gives a good representation of the wavelength distribution of daylight, the actual wavelengths of daylight change throughout the day with various weather patterns. This variability is what separates daylight from electric

lighting sources [Boyce 2014]. Edwards and Torcellini [2002] claim that the “majority of humans prefer a daylight environment because sunlight consists of a balanced spectrum of color.” It also allows for excellent color rendering and color discrimination and provides a higher illuminance which supports better vision [IEA SHC Task 21 2000]. The illuminance and correlated color temperature of daylight are affected by time and location on the Earth. The illuminances can range from approximately 1,000 lux on a very overcast winter day to approximately 100,000 lux on a sunny summer day. The correlated color temperature (specifies the color appearance of light) can range from 4,000 on an overcast day to 40,000 K on a clear day [Boyce 2014].

Human interaction with daylight also depends on location relative to buildings at the time of exposure. While outdoors, people experience the full daylight exposure, meaning they are introduced to all ranges of solar radiation with both its positive and negative effects. Because people spend most of their time inside, they are typically exposed to limited ranges of the daylight spectrum. This includes visible light and some infrared radiation [Aries and others 2015]. These daylighting properties influence the indoor environment, specifically occupant comfort and the ability to perform necessary tasks. The human preference for window accessible workstations stresses the importance of daylight integration in architecture.

## **1.2 Daylight Application in Buildings**

With the increasing need for energy reductions in building design, daylighting has once again become an integral part of architecture [Kroelinger 2005]. When designing buildings for daylighting, a number of design considerations need to be made. The type of architecture can determine the need for daylight in a building. Churches are known to be designed for the integration of a significant amount of daylight, making it a design consideration from the beginning. Daylighting becomes more of an overall architectural strategy the more that it's a generating design factor [IEA SHC Task 21 2000].

As mentioned in the previous section, daylight is a variable light source that provides different qualities and quantities of light depending on time of year, location, and weather conditions. These properties and the availability of daylight determine the nature of architectural design. Building orientation, façade design, and window design are among the many architectural design strategies that consider the amount of daylight present at the site. The latitude determines the amount of daylight present in the environment, or the luminance. Higher latitudes experience distinct seasonal conditions throughout the year. During the summer months, the sun is higher in the sky and produces longer days. The winter months experience shorter days where the sun is lower in the sky. This variation challenges designers to create architecture that can integrate daylight throughout the seasons, letting in more daylight in the winter months and blocking more during the summer. Locations with lower latitudes experience less variation in season and have a relatively steady high level of daylight throughout the year. Because daylight also has a thermal influence on a building, architects strive to limit the amount of daylight during the summer months, where it could contribute significantly to the mechanical load. [IEA SHC Task 21 2000]

By analyzing the specific characteristics of a buildings site, designers can decide how they need to approach daylighting design. Climate and daylight availability help to determine the building envelope requirements and the specific façade design that will optimize daylighting benefits and minimize unwanted qualities [IEA SHC Task 21 2000]. Along with the façade design, the interior floor plan can significantly determine the needs of daylight in a building. Because people prefer working under the influence of daylight, the access to windows and openings is important to a wide range of building types [Aries and others 2015]. Unfortunately, most existing architecture doesn't provide this for occupants.

While there is an increasing desire for daylight in architecture, there is a clear distinction between wanted and unwanted daylight. Although the preference for daylight cannot be explicitly explained, it's thought that the connection to outside views, the presence of the continuous wavelength spectrum, and the variable quantity of daylight could be potential reasons [Aries and others 2015]. With this influx of

natural light, architects have to be careful to design spaces that minimize the visual discomfort that can occur from sunlight. Both glare and thermal gain can make a space uncomfortable for occupants and overpower the positive qualities of daylight [Jakubiec 2014]. Ultimately the effect daylight has on occupants is determined by how it's delivered into buildings [IEA SHC Task 21 2000]. The desire to minimize discomfort has increased as the amount of glazing and reflective surfaces has increased in architectural design [Jakubiec 2014]. Various daylighting delivery systems will be discussed in the later sections of this report.

### **1.3 Effects of Daylight on Occupants in Work Environments**

Daylight is a natural form of illumination that the majority of humans experience for some period of time during the day. Depending on whether people are outside or inside, they experience different properties of daylight. Indoors, people are only influenced by the visual and infrared radiation from the sun [Aries and others 2015]. The visual aspect of daylight is the light that people perceive through their eyes. As mentioned previously, the visual aspect of daylight varies throughout the day, year, and weather conditions [IEA SHC Task 21 2000]. High and low illuminance levels can enter into buildings, influencing the amount of light available to use. The infrared radiation is what causes the thermal influence inside buildings, bring in heat at different times of the day and year. This variable nature can be beneficial and problematic to building occupants, depending on their accessibility to daylight. 'Usable daylight' is a term that describes the preferred form of daylight. This term can be described as "higher illuminance levels typically at greater depths from daylight openings..., greater uniformity of light distribution, and reduction of glare and cooling loads by controlling direct sun without compromising daylight admission" [IEA SHC Task 21 2000]. Architects strive to maximize the amount of usable daylight in a building. As previously mentioned, people typically prefer being near windows when they're working inside. This exposes them to both the positive and negative effects that can be experienced from

daylight. The degree to which one or the other is experienced depends on the success of the architectural daylighting design.

### **1.3.1 Positive Effects**

Although the exact reason people prefer to sit near windows isn't known, it's clear that those that do have experienced 'usable daylight' the majority of the time [Aries and others 2015]. Along with the preference, daylight has been linked to increasing the general well being of occupants in work environments [Edwards and Torcellini 2002]. Studies have found that access to usable daylight can decrease the occurrence of eyestrain, seasonal affective disorder, and headaches, while also decreasing absenteeism at work [Franta and Anstead 1994]. The degree at which people experience the positive effects of daylight can depend on their proximity to windows. A study done by Veitch and her colleagues [2005] found that occupants were less satisfied with the interior lighting the further they were from a window.

Another important consideration is the view people have outside the window. This is thought to play a role in the satisfaction of an indoor environment and can contribute to the overall health benefits [Aries and others 2010]. A number of studies found that natural views were preferred over urban views, providing an opportunity for relieving mental fatigue [Chang & Chen 2005; Hartig and others 2003; Tennessen & Cimprich 1995]. A study done by Aries and her colleagues [2010] found that view type in an office had an influence on psychological and physical discomfort. A better view quality was found to lower occupant's discomfort.

Aries and her colleagues [2010] found that being close to windows reduced people's discomfort. Comfort in a work environment has been linked to overall job satisfaction, but it's difficult to differentiate between job satisfaction and office environmental satisfaction [Newsham and others 2009]. Newsham and



others [2009] concluded in their study that access to windows had a significant effect on the satisfaction with the indoor lighting, with people closer to windows rating the lighting conditions better.

Lighting has also been found to have non-visual effects on humans, which can determine sleep patterns, alertness, and cognitive performance. This can be directly related to the exposure to bright polychromatic light during the day, which is indicative of daylight. A study done by Borisuit and colleagues [2014] found daylight availability gave some indication of people's satisfaction with work. The results claim that visual acceptance and perception of light levels were somewhat related to non-visual responses such as alertness and mood.

While daylight can affect the immediate comfort of people in a space, it has also been found to affect life outside of work. A study done by Boubekri and his colleagues [2014] examined subjects' response to environments with and without windows. They found that the subjects working in a windowless room had worse overall sleep quality and more sleep disturbances than the people did with access to windows. The workers exposed to windows also tended to be more physically active and sleep longer. Although it's difficult to definitely link daylight exposure to health and comfort levels in a work environment, existing research shows that there are some correlations between them. With this data, researchers suggest that architectural design of offices should incorporate more appropriate daylight to enhance the health and comfort of workers [Boubekri and others 2014].

### **1.3.2 Negative Effects**

While the research suggests a heavy emphasis on sufficient daylight exposure, the quality of daylight needs to be considered [Boubekri and others 2014]. Along with its positive influence, daylight can also produce very high levels of illuminance and unwanted glare. Both result in an interference with the occupant's vision and their ability to complete tasks [IEA SHC TASK 21 2000].

Intense reflections or strong contrasts within people's field of view can create visual discomfort.

This means that solving the discomfort issue requires more than knowing the level of light reaching the eye. The negative visual impact of daylight can be classified by two terms. Discomfort glare is merely a level of light which is uncomfortable to view, while disability glare can impair vision. The obscured field of vision caused by glare is typically due the scattering of light in the eye which reduces contrast in the image on the retina [IEA SHC TASK 21 2000].

The number one health problems in offices is eyestrain, which can be described as fatigue and pain in the eyes. [Franta and Anstead 1994; Aries and others 2013] Research has found that people reported having less eyestrain when they had larger portions of natural light at their work stations [Aries and others 2013]. Eyestrain can also be triggered when there's a large amount of daylight coming in at a certain angle. This causes glare and can create pain in the eyes. Headaches can also be an adverse effect of eyestrain [Aries and others 2013]. The line between discomfort and disability glare can be blurred if people are exposed to interesting views. This increases their tolerance of glare, and can make it seem less detrimental [Tuaycharoen & Tregenza 2007; Aries and others 2013]. Although a view can alleviate the negative impacts of daylight, research has found that people who sat closer to windows and thought the lighting was a lower quality experienced higher thermal and glare problems [Aries and her colleagues 2010].

Daylighting can also affect the thermal gain in a building at both ends of the temperature spectrum. In the winter, a cold window can cause more thermal discomfort, creating a "radiative exchange between the window and occupant," and bringing in unwanted cold air [IEA SHC TASK 21 2000]. This can also occur in the summer time, instead bringing an excess of heat into the space. These unwanted thermal gains combined with glare and improper distribution of daylight can make a work environment uncomfortable, adversely affecting productivity, mood, alertness, and work attendance [Edwards & Torcellini 2002].

## **1.4 Types of Shading Systems**

As daylighting becomes a greater priority in architectural design, strategies of daylight integration need to be developed to satisfy various design needs. Daylight can enter buildings in a number of ways including: through windows, skylights, light ducts, and light shafts. The most common of these applications is the window [Boyce 2014]. One strategy of daylight design is to use a shading system at the windows. These types of systems are designed for daylighting and solar shading, helping to maximize the amount of diffuse skylight let into a room and minimize direct solar gain [IEA SHC TASK 21 2000]. Shading systems can be located on the interior or exterior of a building and can be automatic or directly controlled by occupants. The desire for sunlight can also be overpowered by the influx of unwanted daylight causing glare and thermal discomfort. When studying office environments, researchers found that the complaints regarding visual and thermal discomfort were stronger depending on the types of control systems available in the space [Boyce 2014].

### **1.4.1 Shades**

The simplest form of solar shading is pull-down shades that are directly controlled by occupants and reduce or block the amount of daylight coming through windows. This is common in residential spaces where people tend to have more control over their internal environment [IEA SHC TASK 21 2000]. Exterior shades can also be attached to a building, which assist with both light and thermal control. These systems are typically more efficient at minimizing solar gain than interior shades. Interior shades are less effective at blocking thermal gain because they allow the thermal radiation to enter windows before controlling it. They also have the ability to completely block direct sunlight, reducing glare. But this also contributes to blocking occupant's view to the exterior [Lawrence Berkeley National Laboratory].

The function of a shading system depends on the orientation of the building and the physical design of the system. In current design practices, computational programs are used to calculate light and energy levels, which help to drive energy efficient designs. A study done by Gonzalez and Fiorito [2006] used an energy related function in the DIVA tool (Design, Iterate, Validate, and Adapt) to analyze the uniformity of daylight distribution across an office. Their external shading optimization study tested a variety of shade orientations for daylighting efficiency. They found that this computational design is an effective strategy for producing daylighting control solutions.

With the variety of shade orientations, a top-down or bottom-up shade system can also alter the daylighting influence. As shown in the Figure 2 on the next page, shades can be pulled down from above windows or up from below. A bottom-up shading system can help preserve a view for occupants while blocking direct sunlight. A study done by Kapsis and colleagues [2010] looked at the performance of bottom-up shading. They found that it resulted in a higher daylight performance and provided more daylight to areas further away from the window. As with the study done by Gonzalez and Fiorito [2006], the efficiency of shading systems depends on the orientation of the building and the relation they have to the existing windows. Refer to tables in Appendix A for more examples of shading devices.

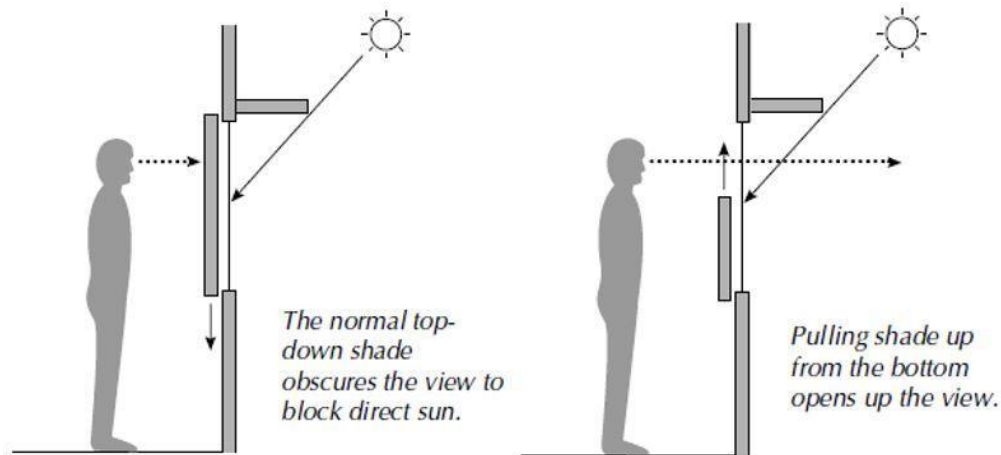


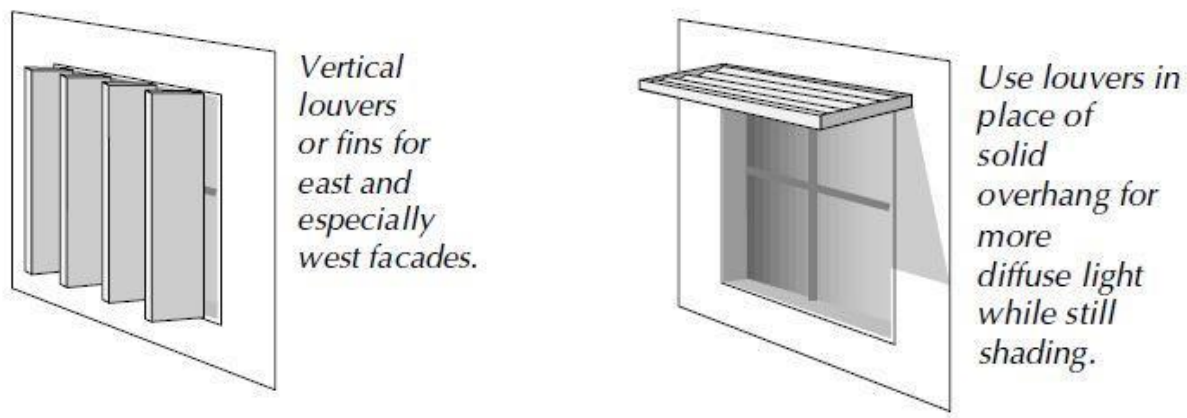
Figure 2 Top-down and Bottom-up shading systems (Lawrence Berkeley National Laboratory)

### 1.4.2 Louvers

Another type of shading tool used in buildings is louvers. Louvers can be made of vertical, horizontal, or sloped slats that help redirect daylight. They can be placed on the interior or exterior of windows as well as between the glass window panes [IEA SHC TASK 21 2000]. Because the sun is a variable source, different orientations receive different amounts of daylight throughout the day. Rising in the east and setting in the west, the sun travels throughout the sky during the day. Midday the sun is at its highest which occurs in the south direction. This exposes south facing façades to the most daylight throughout the day. Louvers can replace the use of overhangs on building exteriors to allow more diffuse light to enter through the window [Lawrence Berkeley National Laboratory].

When using louvers in a design, it's important to consider the orientation and location of the building. The best practice for this type of design relies on the location of the sun and the angle at which daylight is entering into a space. For south facing windows, it's best to use horizontal louvers. Because the sun is highest in the sky when in the south, horizontal louvers help to block the higher angle of light. Vertical louvers are most effective on the east and west facing windows because they can block the lower

angles of light, particularly at high azimuth angles [IEA SHC TASK 21 2000, Lawrence Berkeley National Laboratory]. South and west façades should be the priority in design because heat gain is more significant in the middle and later part of the day [Lawrence Berkeley National Laboratory].



**Figure 3 Vertical louvers on building exterior & Horizontal louvers as building overhang**  
(Lawrence Berkeley National Laboratory)

Louvers can also be either fixed or operable. Fixed systems are typically only designed to assist with daylight shading because they cannot adjust to the varying sun position throughout the day. They also can't adjust to varying weather conditions. On overcast days, fixed louvers can block diffuse daylight that would otherwise be desirable for occupants. Operable louvers can help to control glare, redirect daylight, and control thermal influence with the varying solar positions throughout the day. There are some positives and negatives to automatic louvers. Their dynamic nature can help reduce energy use in the building by decreasing the thermal gains. While energy savings can occur, occupants can also feel less comfortable in these spaces because they don't have control of their environment. [IEA SHC TASK 21 2000]

While louvers can be used to block direct light, they can also help redirect daylight to various places in a building. Highly specular materials can be used as reflectors on louvers and can allow relatively accurate control of light distribution [Boyce 2014]. The shape of the louver can also determine

how light is redirected. One type of louver design, shown in Figure 4 below, has a curved design which bounces light up into a room [IEA SHC TASK 21 2000]. This type of louver is known as the “Fish” system, and is typically located between the panes of glass in a window. The horizontal pieces are fixed and are designed to transfer light from the upper quarter of the sky to the upper quarter of the room. This system limits glare and bounces diffuse daylight into a space and redirects it toward the ceiling [IEA SHC TASK 21 2000]. Refer to the tables in Appendix A for more examples of louver systems.

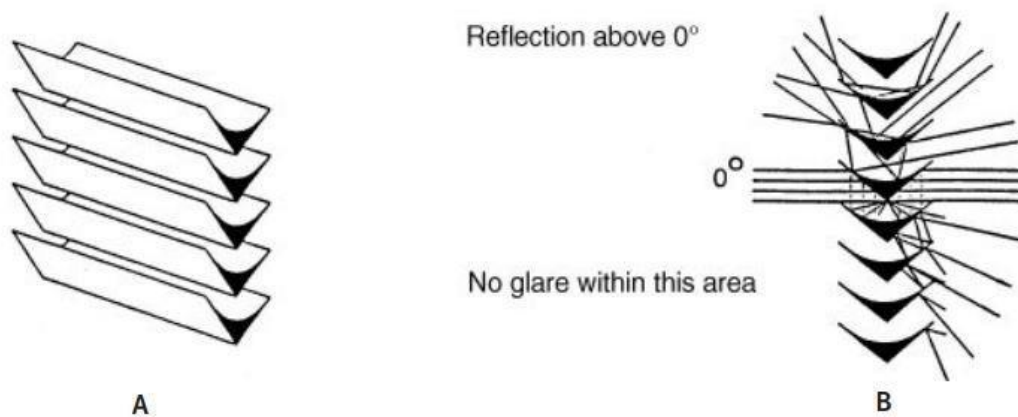


Figure 4 “Fish” System: Curved louvers made to redirect daylight upward into building (IEA SHC TASK 21 2000)

### 1.4.3 Light Shelves

Another form of daylight shading and redirection is light shelves. They are typically horizontal forms that can be located within the building façades or on the exterior or interior of the building. Unlike standard shades which can be used to fit conventional windows, light shelves have to be designed specifically for the architecture in which they’re placed [IEA SHC TASK 21 2000, Kroelinger M 2005]. When placed toward the middle of a window, they provide shading and when placed in a higher position they help re-direct sunlight into the building. Light shelves are most effective when located on the southern façade of a building because they are able to redirect the higher sun angle [Kroelinger M 2005].

The main purpose of light shelves is to minimize glare while preserving the view out the window.

Architects need to consider the use of light shelves at the beginning of design. Ceiling height of a space can determine how effective light shelves are in daylighting design as well as the orientation of the building. They tend to be less effective on eastern and western facing façades as well as in locations that have mostly overcast skies [IEA SHC TASK 21 2000]. Figure 5 below shows the varying position of internal/external light shelves and how they redirect light at different times of the year. During the winter months, glare cannot simply be controlled by a horizontal shelf, and in the summer time, the majority of direct sunlight is controlled with a flat shelf. The figure also shows how a tilted light shelf can help redirect light higher in the sky toward the ceiling. Refer to the tables in Appendix A for more examples of louver systems.

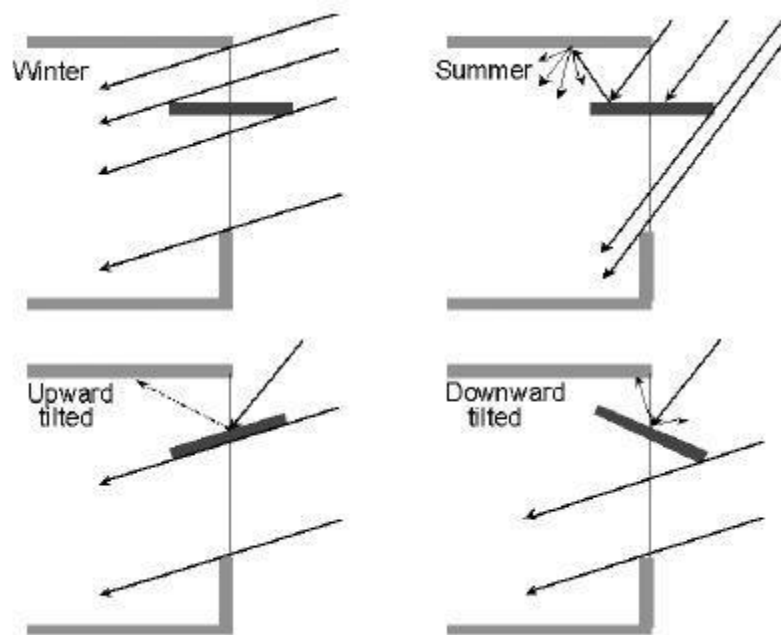


Figure 5 Various effects of light shelves during the winter and summer (IEA SHC TASK 21 2000)



## 1.5 Types of Curtain Wall Façade Systems

Another strategy of daylighting design is through various all glass façade systems. Unlike conventional shading, façades can integrate various shading systems along with solar redirecting techniques which have the ability to redirect daylight to various locations inside a space [IEA SHC TASK 21 2000]. The higher performance buildings being built today demand curtain wall systems that provide high quality glazing that protects against glare and environmental influences [Memari 2013]. This can be achieved through the use of specially designed glazing and integration of shading systems.

### 1.5.1 Types of Glazing

The specific glass used within various façade systems can aid in solar redirection. Sun-directing glass contains light-guiding acrylic pieces on the inside of the window. Like louvers, they are placed on top of each other in a pattern that redirects light toward the ceiling. This type of glass is typically placed above the height of occupant's eyes so that it doesn't block the view out the window. Typically this type of glass should take up about 10% of the height of the wall. Figure 6 below shows the placement of this specific glass type on the façade. In order to control as much daylight as possible, the remaining glass below should utilize shading techniques [IEA SHC TASK 21 2000].

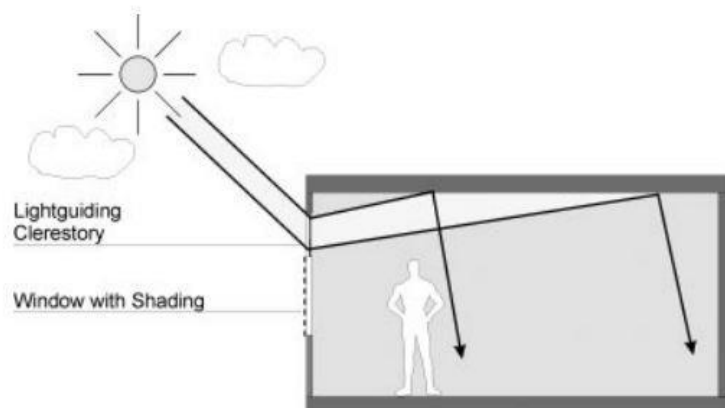


Figure 6 Sun-directing glass application (IEA SHC TASK 21 2000)

Glass can also be treated with a low-e coating on the surface, which can control the parts of the solar spectrum that can pass through the glass. This application strives to admit desirable daylight, consisting of the visible part of the electromagnetic spectrum. It also aims to block the infrared radiation from the sun, which can cause thermal discomfort for occupants [Memari 2013]. However, architects should be careful when planning to use dark glazing. Although they reduce the intensity of direct sunlight, treated glass may not be the most effective shading and glare control unless it has a low transmittance value [Lawrence Berkeley National Laboratory].

Insulating glass units (IGU) can also be used in curtain walls and are glass systems that contain multiple panels of glass with various properties. Figure 7 below shows an IGU. Low-e coatings can be placed on one of the panels, typically the interior side of the exterior panel, which will reduce heat transfer [Memari 2013]. The cavity of the IGU can contain a variety of glass products with coatings or films to reduce heat and light influence. Fritted glass can also be used to control light. This type of glass contains a diffusing pattern that's fused to the surface of the glass, helping to control some direct sunlight [Lawrence Berkeley National Laboratory].

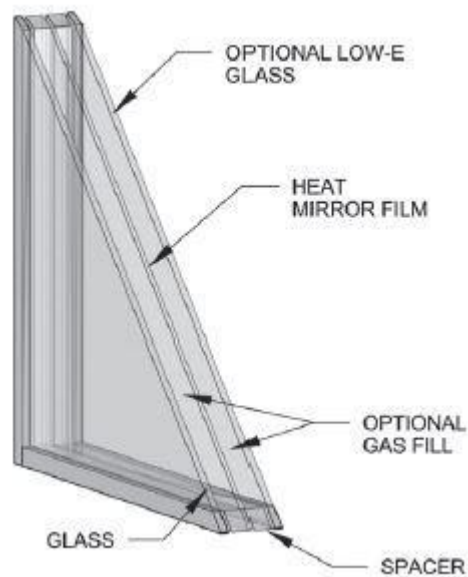


Figure 7 Insulating glass unit (IGU) (Lawrence Berkeley National Laboratory)

### 1.5.2 Double Skin Façades

Double-skin façades are curtain wall systems that utilize two layers of façade with an air space between them. The separation between the interior and exterior glazing can help control wind, sound, and thermal gain [Memari 2013]. The main goal of a double-skin façade design is to use natural air ventilation, shading, and daylighting through spectrally selective glass to increase occupant comfort and energy savings [Boake 2003]. Mignat [2007] claims that, with a double skin façade, “the requirement for artificial light can be reduced by 60 to 70 percent. With improved utilization of solar radiation and solar heat, the heating requirement decreases by 40 to 60 percent, and the cooling loads and air-exchange rate can be reduced by 70 to 80 percent.” The systems located in the double-façade cavity can help with exhaust in the summer time and solar collectors in the winter [IEA SHC TASK 21 2000]. Figure 8 below shows a variety of double-skin façade designs which differ in ventilation.

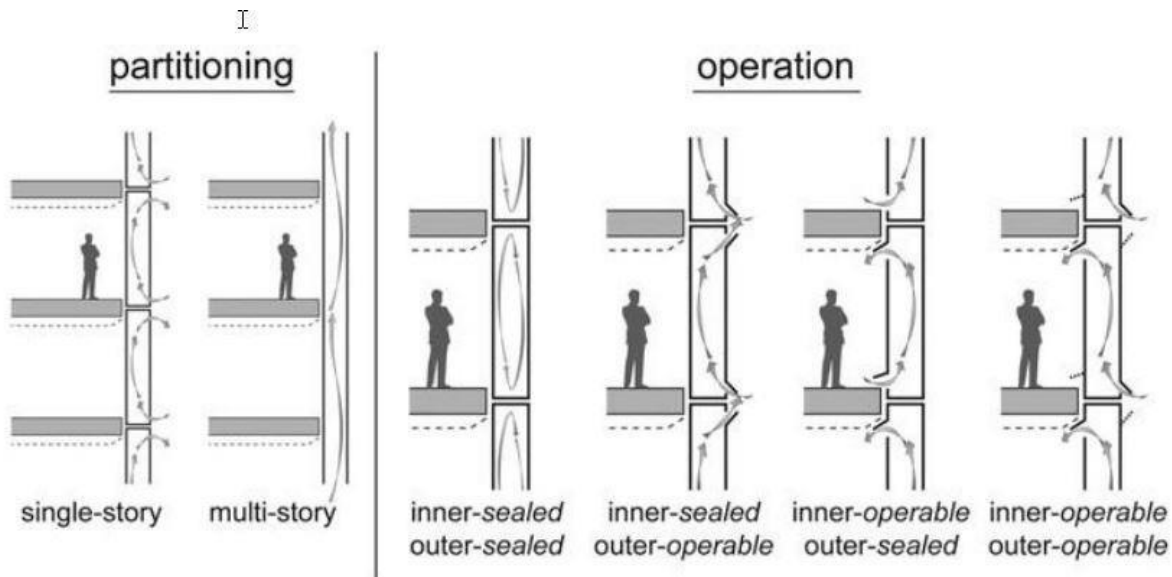


Figure 8 Types of double-skin facades (Memari 2013)

It's possible to install shading devices within double-skin façades such as louvers, operable blinds, and other shading devices. An example of this double-skin façade construction can be seen in the Tower at PNC Plaza located in Pittsburgh, PA. This façade design is considered the most innovative part of the building's green design and is the "country's only fully-automated double-skin façade that is part of a solar-assisted natural ventilation system" [Paladino 2015]. The system integrates automated blinds that help regulate indoor temperatures and help minimize glare. Figure 9 below shows the façade system. The notches on the curtain wall open outward in optimal weather conditions, letting fresh air into the office floors. Figure 10 below shows the double-skin façade from the inside. The interior portion of the façade gives occupants control over their environment with large sliding doors opening to the porch-like interior of the façade [Ko & Tranel 2015]. This façade type is only one example of the possible designs and serves as an example of the effect double-skin façades can have on the indoor environment.

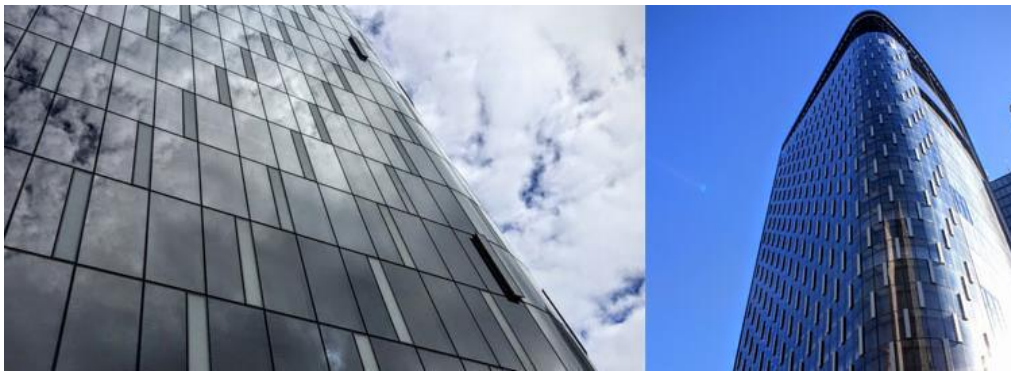


Figure 9 Double-skin facade of the The Tower at PNC Plaza (Paladino 2015)



Figure 10 Interior cavity of the façade (Ko & Tranel 2015)

## 1.5 Conclusion

The overall trend toward curtain wall design requires a more careful innovation of façade systems that integrate shading and thermal control techniques. Daylighting can provide desirable influence in work environments that helps increase occupant comfort and performance. With useful daylight comes unwanted elements as well, such as glare and thermal gains, overpowering the benefits that daylight may have. The influence daylight has on a building depends on the orientation, height, and materials, which are all under the architect's control. Effective daylighting studies can help architects plan for daylighting integration before the design even begins.

In order to maximize the good daylight and minimize harmful daylight, shading systems can be placed on the interior or exterior of the façade. They can help block or redirect sunlight and help minimize the amount of glare affecting occupants. The façade itself can also be tailored to daylighting design. Innovative systems and progressing technology make this element an ever-changing feature that can implement a variety of shading techniques. Using the existing shading methods available, architects and engineers have the ability to innovate and create new systems that can improve daylighting design and satisfy the trend toward energy efficient architecture.

## Chapter 2 Existing Building Construction

### 2.1 Building Statistics

**BUILDING NAME** – Cannot be published

**BUILDING LOCATION** – Cannot be published

**BUILDING OCCUPANT NAME** – Cannot be published

**OCCUPANCY TYPE** – Research Facility

**SIZE** – 184,239 GSF

**FLOORS ABOVE GRADE** – 6

**CONSTRUCTION DATES** – July 2015-March 2017

**TOTAL COST** – \$120,000,000

**PROJECT DELIVERY METHOD** – Design-Bid-Build

### 2.2 Project Team

**OWNER** – Cannot be published

**GENERAL CONTRACTOR** – Cannot be published

**ARCHITECT** – Ballinger (<http://www.ballinger-ae.com/>)

**MECHANICAL ENGINEER** – Ballinger

**PLUMBING ENGINEER** – Ballinger

**ELECTRICAL ENGINEER** – Ballinger

**LIGHTING DESIGNER** – The Lighting Practice (<http://thelightingpractice.com/>)

## 2.3 Architecture

The Bioengineering Building is a 6-story research and educational facility that houses classrooms, labs, offices, and multipurpose spaces. The ground level contains a variety of spaces that are for both research and large events. The second, third, and fourth floor are identical in plan and contain offices and research labs. A mechanical penthouse occupies the sixth floor of the building.

Because the building and site are oriented to have long east and west facades, special consideration was needed to control solar and heat gain. High performance glazing systems and mechanical systems are used to improve energy efficiency.



Figure 11 Axonometric of interior section

### 2.3.1 Major Codes

INTERNATIONAL BUILDING CODE (IBC) - 2012

INTERNATIONAL MECHANICAL CODE (IMC) - 2012

NATIONAL ELECTRIC CODE (NEC) - 2008

INTERNATIONAL ENERGY CONSERVATION CODE (IECC) - 2012

ASME A17.1, SAFETY CODE FOR ELEVATIONS AND ESCALATORS - 2007

NFPA 1, FIRE CODE – 2012

## **2.4 Building Enclosure**

### **2.4.1 Façade**

A majority of the building façade consists of glass curtain walls, while the rest is a modular brick and cast stone veneer wall assembly. Modular brick will be typical over the façade using the standard 3-5/8" x 2-1/4" x 7-5/8" with an even mix of three brick colors. The curtain wall system is composed of thermally broken extruded aluminum framing and Low-E 1" insulating glass units. A prefinished extruded aluminum sun shading system covers the curtain wall system from the second floor to the sixth floor.

The façade is broken up into six systems, each showing a typical design that exists along the building. One of the systems is shown in Figure 12 and Figure 13 on the next page, which show the aluminum sun shading system, curtain wall, and brick cavity wall.



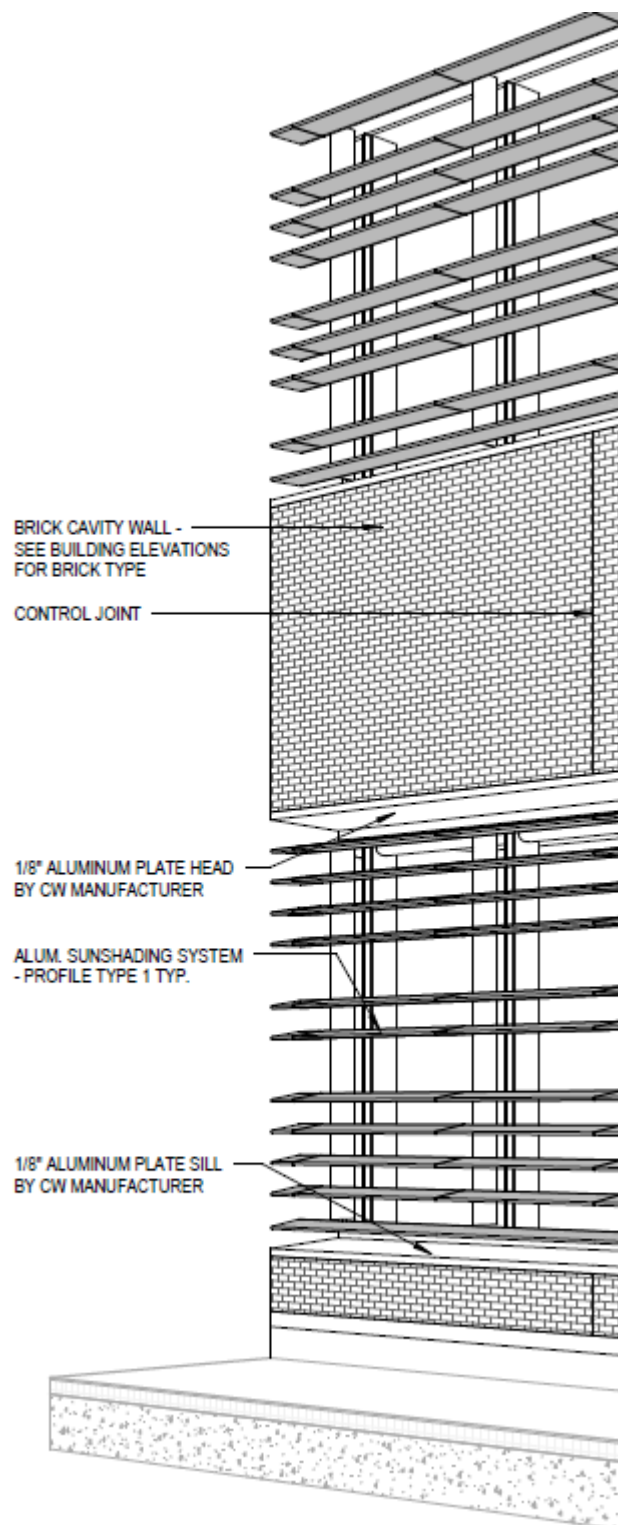


Figure 12 Curtain wall system 1 axonometric

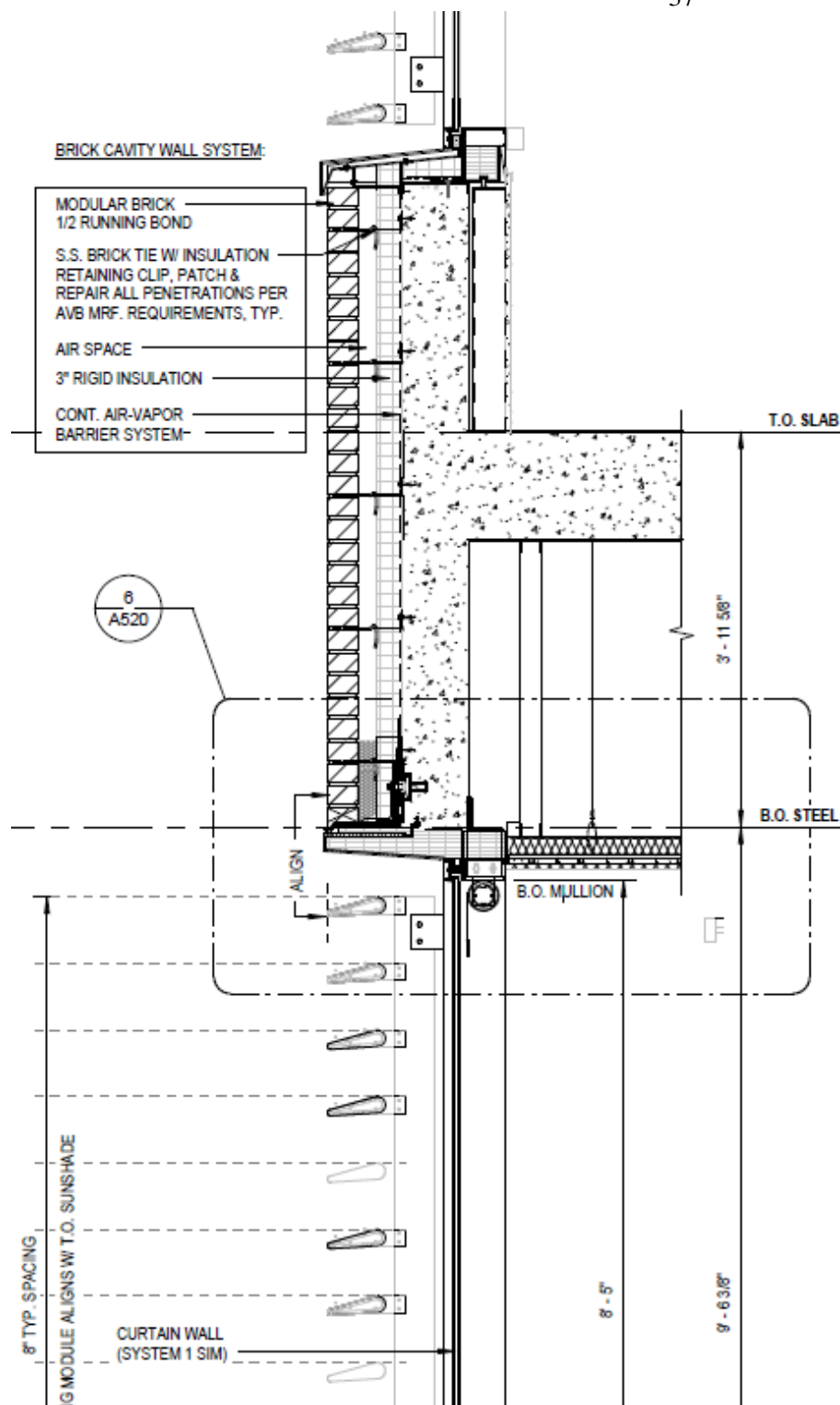


Figure 13 Curtain wall system 1 wall section

The curtain wall system at the ground level of the building is different from the floors above.

Only a glass curtain wall serves as the façade. Figure 14 and 15 below show the first floor curtain wall system without the sun shading system.

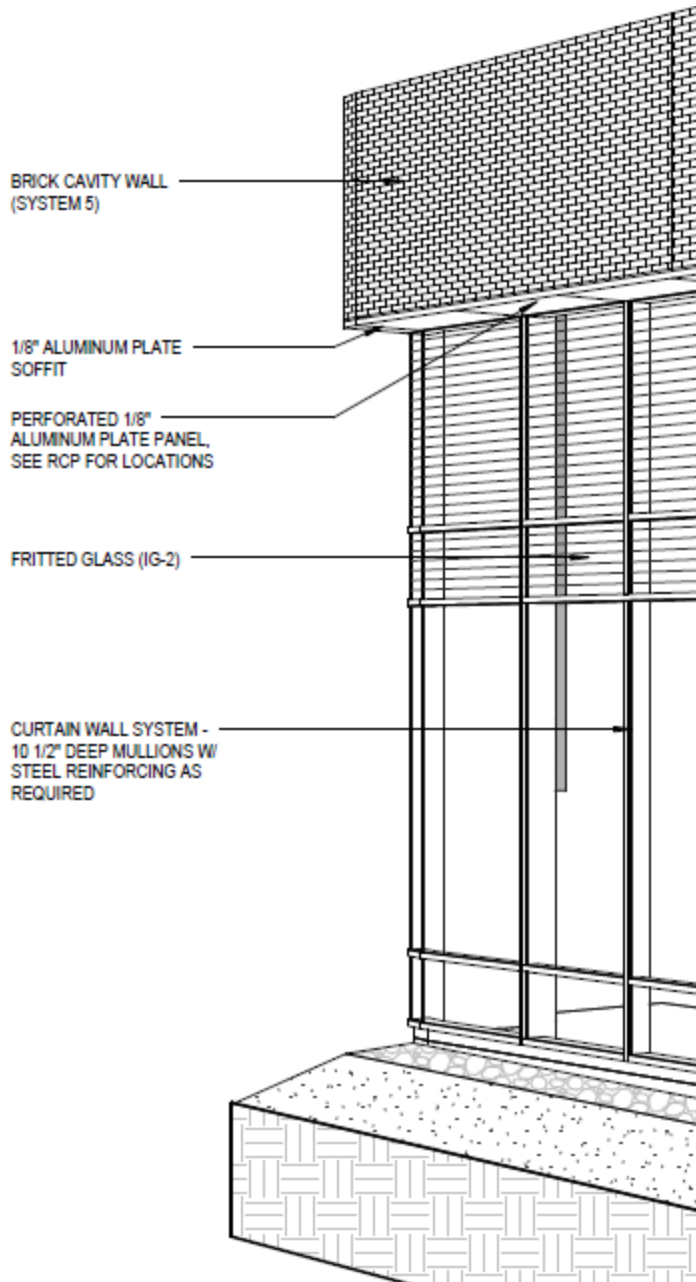


Figure 14 Curtain wall system 2 axonometric

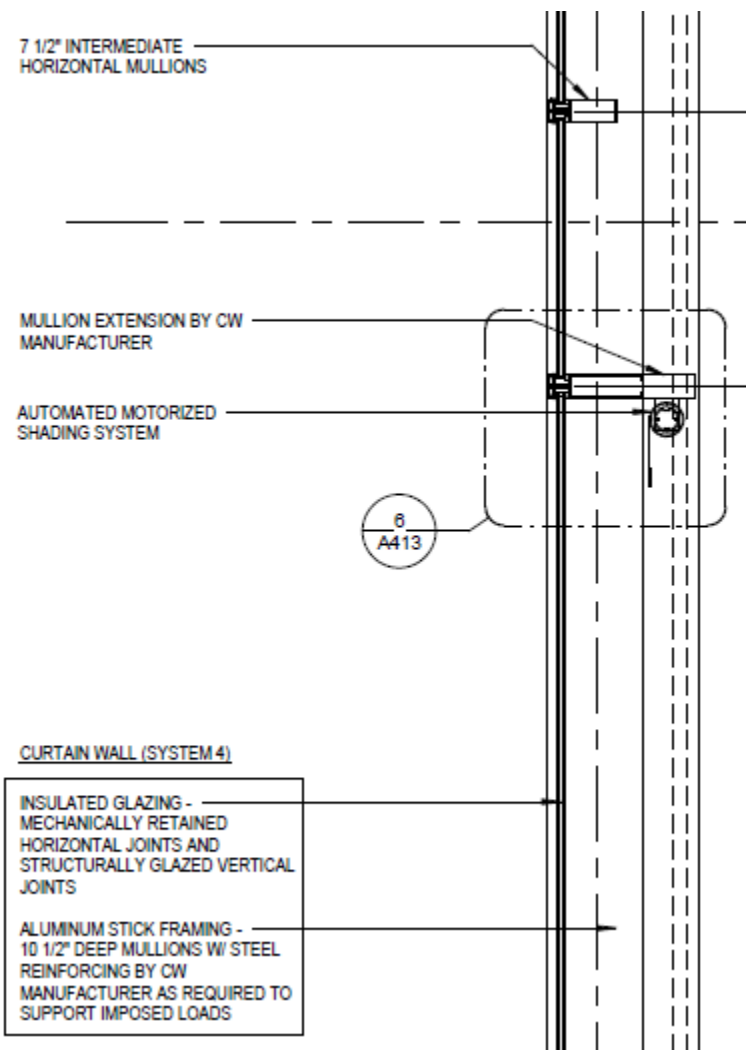


Figure 15 Curtain wall system 2 wall section

### 2.4.2 Sun Shading System

Two types of sun shading pieces are used on the façade (floors 2 to 6) and are used intermittently along the curtain wall system. Figure 17 shows a perspective of the varied shapes.

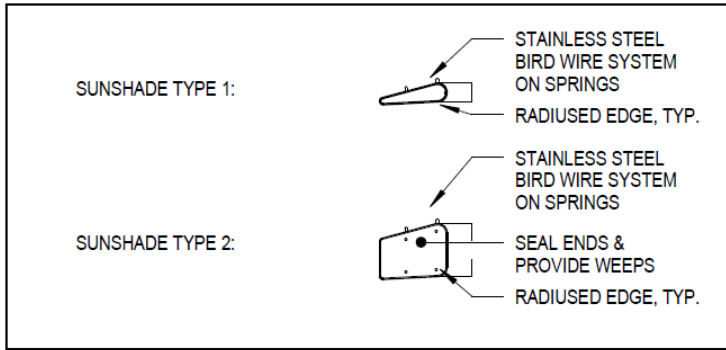


Figure 16 Existing Sunshades

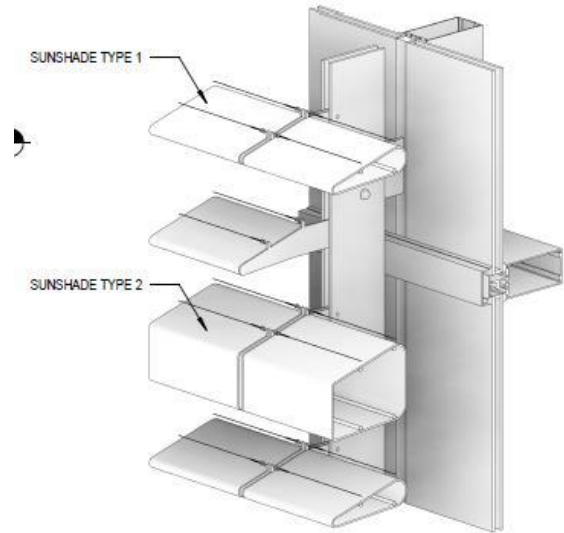


Figure 17 Perspective of existing sun shades

### 2.4.3 Roof

The building utilizes a Polyvinyl-Chloride (PVC) Roofing System. Figure 18 below shows the roof detail.

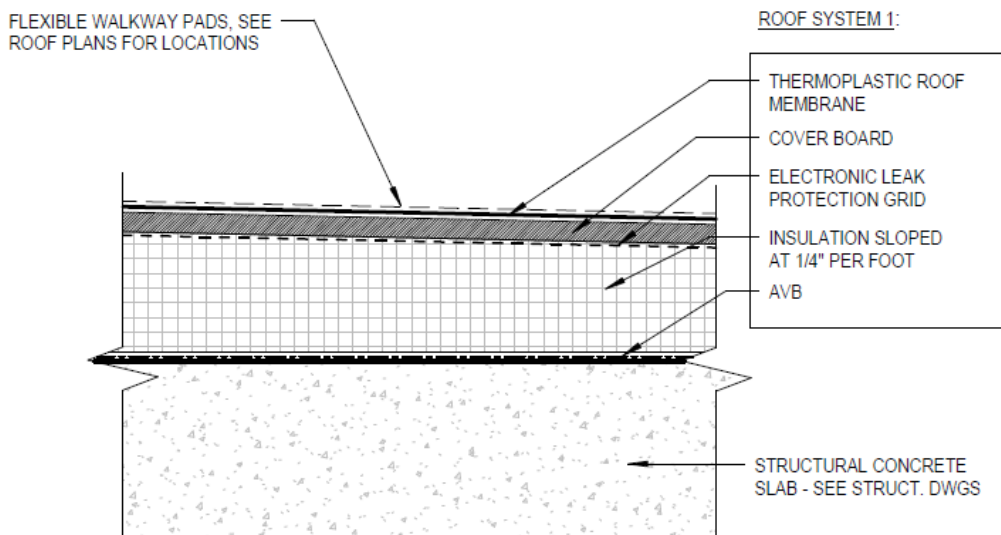


Figure 18 Existing roof detail

#### **2.4.4 Sustainability**

The project was designed to meet all prerequisites and earn at least 50 points to acquire a Silver level rating according to US Green Building Council's LEED 2009 for New Construction and Major Renovations Rating System. In order to achieve that rating, the design focused on water conservation, sustainable sites, indoor environment, material and resource conservation, and energy conservation.

The design utilized the following in order to gain certification:

- Recycled materials
- A minimum of 20% of materials used from within a 500 mile radius of project
- Low-emitting products
- ‘Green’ User Education
- Conservation Waste Management Plan
- Using submeters to measure energy consumption

### **2.5 Primary Engineering Systems**

#### **2.5.1 Construction**

The Bioengineering Building is classified as a Group B occupancy building which includes offices, assembly areas of fewer than 50 persons, and research and testing laboratories. It's constructed under a Design-Bid-Build delivery method. The site is located on an existing parking lot which will be removed for construction and is also partially in a floodplain.

One of the important features of the building is the consideration of future change in the design. Adaptability of laboratory spaces has been given significant consideration during design in order to allow for flexibility in the architectural design and future expansion.

### **2.5.2 Electrical**

Electrical service shall be provided from the existing medium voltage distribution system on the site. The service comes from 13.8 kV, 3-phase, 3-wire loop feeders: Feeders #5, #6, and #7 each consist of (3) 500 kcmil MV cables and (1) #2/0 grounding conductor. The feeders are accessible in existing manholes located at the northeast and northwest of the project site.

The low voltage switchgear is a 4000A, 480Y/277V 3-phase 4-wire double ended 30-cycle power circuit breaker switchgear. Switchgear feeders distribute power within in the building via switchboards, distribution panels, and busways located in electrical equipment rooms and electrical closets. The low voltage switchgear is in a main-tie-main arrangement, with each side of the tie served from a separate pad mounted transformer via the low voltage switchboards on the first floor. The tie circuit breaker in the switchgear is electrically operated. Programmable logic controllers allow the switchgear to automatically transfer between sources through the switchgear's electrically operated tie breaker and the electrically operated main circuit breakers in the switchboards on the first floor.

The switchgear and switchboards shall be capable of closed transition automatic transfer between sources. Control power shall be derived at each switchboard and shall be arranged so that automatic transfer is available from either of the available source. The electrical service capacity shall be designed to serve the calculated diversified load of the facility plus an additional 20% for future loads.

### **2.5.3 Lighting**

All lighting in the building is designed with either LED or fluorescent fixtures. Most fixtures allow for dimming and occupancy sensors or switches control most individual spaces. Site standard lighting poles will provide exterior lighting; recessed downlighting at canopies and entries, wall mounted asymmetric lighting at exits and back of house spaces, and steplights/wall mounted lighting at terraces.

Exterior lighting will be controlled by an astronomical time clock and rooftop photocell connected to the building management system.

Interior lighting is designed using all high quality LED and fluorescent sources, providing the building with the best long-term value lighting. Lighting controls in The Bioengineering Building consist of a Microprocessor Based Lighting Control system, Occupancy Sensors, Switches, and Dimming. Dimming controls consist of multi-scene, multi-zone programmable lighting controls, capable of various interfaces, including AV and partition sensors. The system is similar to the Lutron Grafik Eye QS. Wall-box dimmer switches provide local and multi-location full range lighting controls and are similar to the Lutron Diva series.

#### **2.5.4 Mechanical**

High-pressure steam (100 psig) is supplied by the existing site system to the building and is provided with isolation valves on the steam supply and condensate return piping, together with a steam flow meter. The estimated, peak building steam demand is approximately 21,000 pounds per hour (13,500 pounds per hour for heating and 7,500 pounds per hour for domestic hot water heating).

The heating hot water system will consist of two shell-and-tube low pressure steam-to-hot water heat exchangers to heat hot water from 150° F to 180° F to serve radiation and miscellaneous heating loads. Each heat exchanger is sized for 100% of full design flow. Two primary system pumps are provided, each with variable-frequency drives (VFD), one pump being a dedicated standby. VFDs will decelerate to maintain the differential (supply/return) pressure set point in the system.

Three 400-ton electric oil-free centrifugal chillers supply chilled water to the air handling units. A primary/secondary chilled water pumping system is provided to supply 42 degrees F chilled water to the building. Three single-cell cooling towers are used for chiller heat rejection. The mechanical penthouse of

the building contains three 100% outdoor variable volume supply air handlers, which create a single supply air system. Six fans are mounted to the rooftop plenum, which will handle building exhaust.

The ceiling mounted, or suspended, chilled beam terminal units will provide room sensible cooling through their chilled water coil. Coil condensation will be prevented by using higher temperature chilled water. The de-humidified supply air from the air handlers will maintain humidity control. This air-water system will achieve significant reductions in the amount of outdoor air/supply air to be handled for cooling purposes, which will result in substantial energy savings.

The exhaust air system will consist of (6) fans mounted on a common rooftop plenum. They'll draw exhaust air through air-to-air energy recovery wheels before being discharged to the outside.

### **2.5.5 Structural**

The typical center-to-center column spacing is 32'-0" in the N-S direction and approximately 30'-0" in the E-W direction. The selected column bay is both structurally efficient, and large enough to accommodate flexible/modular laboratory space, a core feature of the proposed program. The typical floor-to-floor height is approximately 16'-0" with larger heights required in certain areas. Two-story lab space is proposed for large portions of the ground floor and the penthouse requires an approximate roof height of 25'-0". The structural system proposed for the elevated floors consists of a 13" thick, cast-in-place, two-way concrete slab with 10'-8"x10'-8"x5½" deep drop panels at the columns. A flat plate system was selected for its economy, ease of constructability, flexibility, and inherent resistance to vibration. Floor slabs were thickened around the perimeter to support heavy or brittle exterior wall finishes and at the interior where added depth was needed to control deflection.

## **2.6 Additional Engineering Support Systems**

### **2.6.1 Fire Protection**

Elevator, stair, and utility shaftways are constructed with 2 hr. rated gypsum. Three types of Fire Rated Drywall Partitions are used throughout the building: one hour rated partitions, two hour rated partitions, and three hour rated partitions. Fire rated partitions will be fully sealed and stopped at penetrations and abutting construction.

A combination automatic class I standpipe/automatic wet pipe sprinkler system will be used to protect The Bioengineering Building. The automatic sprinkler systems will be monitored by the building fire alarm system. The municipal water supply will be boosted by a new electric driven fire pump taking suction from a new, dedicated fire service connected to the public water supply main.

The building is to be fully sprinklered. The system will be predominantly wet-pipe. A combination automatic class I standpipe will be placed in both mandatory exit stairwells. Sprinkler mains will be interconnected between the standpipes. The building will be protected with a combination of pendant, concealed pendant, sealed concealed pendant and upright sprinklers.

### **2.6.2 Transportation**

Transportation throughout the building happens through three types of elevators. Passenger Elevators (South Core, 2 total) make 5 stops and travel 80'-0". Their rated capacity and speed respectively are 3500 lb and 350 feet per minute. The Service/Ambulatory Elevator (North Core, 1 total) is a gearless traction elevator with machine room-less application. It makes 6 stops and travels 80'-0". The rated capacity and speed respectively are 4500 lbs and 350 feet per minute. The Freight Elevator (North Core, 1 total) makes 7 stops and travels 96'-0". It's rated capacity and speed respectively are 7500 lbs and 350 feet per minute.



### **2.6.3 Telecommunications**

A communications ductbank connects the building to the existing site. New 4-inch conduits are connected to an existing manhole and enter the facility underground, terminating in the new Main Telecommunications Room/Equipment Room. A new Main Telecommunications Room (MTR)/Main Distribution Frame (MDF) that is approximately 200 square feet is designed on the ground floor of the building. This accommodates cabling for this floor. This is the connection to the site network, so outside conduits terminate in this room. This means it's not necessary to locate the Telecommunications Rooms on every floor. Cable distances are typically not longer than 250 feet per the site standards. All Telecommunication Rooms will have appropriate ceiling lighting and HVAC. The HVAC will maintain the rooms at a constant temperature of approximately 72 degrees F with a complete air change approximately every hour.

Main and secondary entrance doors as well as all telecom, electrical and mechanical room doors are equipped with access control devices. Video cameras are provided on the interior of the building to cover main and secondary entrances, areas where occupants congregate, and entrances to any "security zones". The building utilizes an interior alerting system called Alertus which uses a small LCD display to provide informational messages and alerts. Typically, one is installed in each classroom as well as other areas.

### **2.6.4 Special Systems**

The building is connected to the site Central Control & Monitoring System (CCMS). The CCMS is utilized to override local building controls but doesn't replace them. It's a microprocessor based, Environmental Management and Control System (EMCS) which uses a distributed processing architecture to achieve a high degree of system efficiency and reliability. The CCMS manages energy systems and monitors energy usage. Connection to the site CCMS is achieved via modem and phone

lines. A local, standalone and complete Building Automation System (BAS) will be provided for the Bioengineering Building. The new BAS will be integrated with the site CCMS. It will communicate over the Owner's site Ethernet network and will continuously monitor/alarm the positions of all fire dampers, smoke dampers and combination fire/smoke dampers.

## Chapter 3 MAE Daylighting Depth

The Bioengineering Building's façade is mostly a curtain wall system, meaning solar influence is an important consideration for the interior spaces of the building. Because many of the spaces are laboratories, occupants need comfortable, glare free work areas to complete research and use precise machinery and tools. For the purpose of this thesis, one space was studied in particular for its daylighting exposure and the effects of an integrated shading system.

Because about a third of the area of the first floor is 30 feet tall and clad in a curtain wall, a significant amount of daylight can reach into the spaces. The Flex Lab located on the eastern wall of the first floor is a particularly sensitive space. It requires higher illuminance levels than many of the other spaces on the first floor but has a stricter uniformity across the lab desks. The 24 ft tall curtain wall runs along the entire eastern side of the lab giving occupants access to daylight and views of the outside.

Figure 19 on the next page shows the floor plan of the Flex Lab (shaded in grey) with the path of the sun throughout the year over top. The sun path shows direct daylight coming into the space during the morning hours in both the summer and winter months. In June, sunlight comes in until about 10am and in December until about 10:30 am. These times of direct daylight will bring high levels of illuminance into the space, which could cause glare conditions unsuitable for research work.

The results of the research conducted in Chapter 1 shows that control of daylight on the eastern façade is more successful with vertically oriented shading systems. In order to help control the daylight entering into the Flex Lab in the morning hours, the design of an interior vertical louver system was explored. The study done in this chapter analyzes the existing curtain wall performance in the space and compares it to the performance of the new shading system during both the summer and winter months.

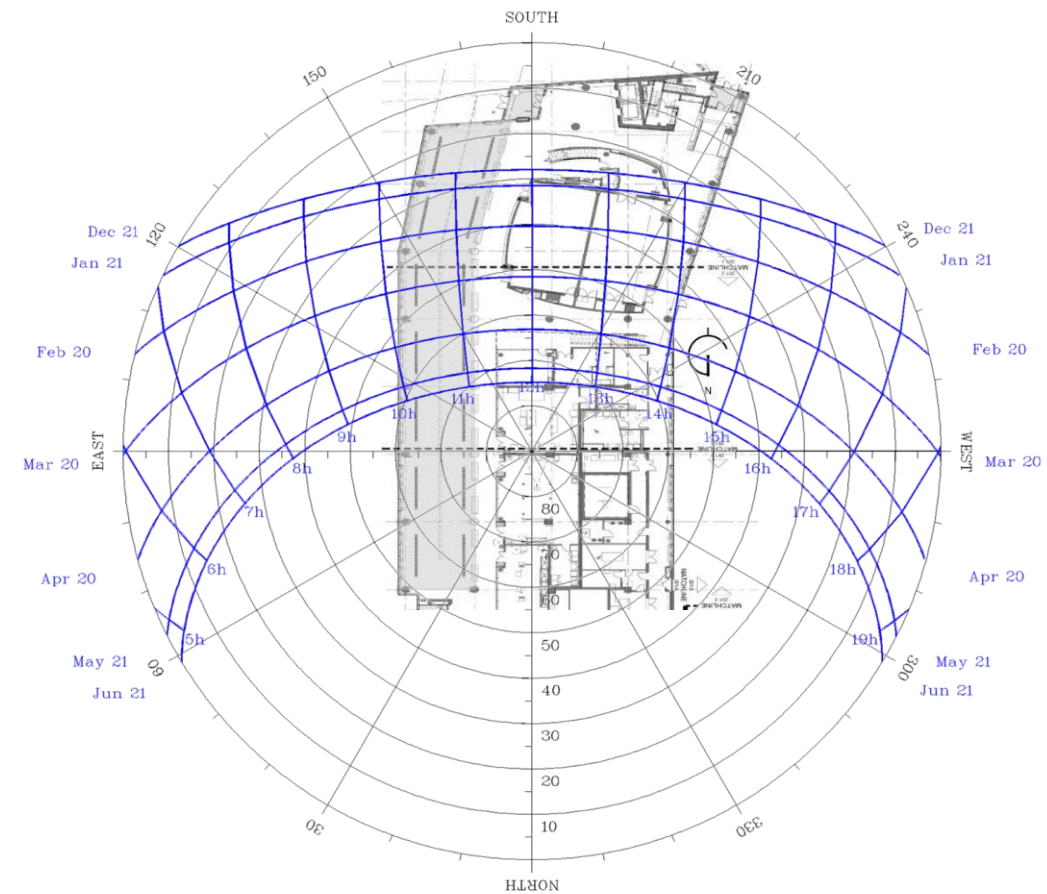


Figure 19 Sun path over top of Flex Lab floor plan generated by University of Oregon Solar Radiation Monitoring Laboratory

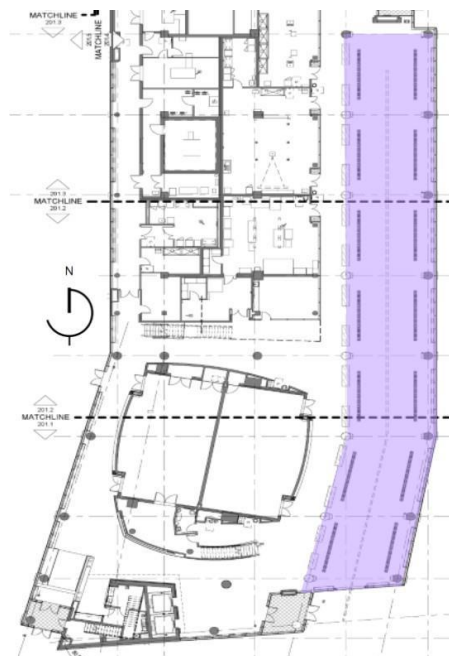


Figure 20 Floor plan of Flex Lab highlighted in purple

### 3.1 Existing Space Study

The Flex Lab space is approximately 6,900 ft<sup>2</sup> with a façade length of approximately 230 ft and height of 30 ft. The space is completely open to the rest of the first floor so the western side of the space doesn't have a wall. The lab has a sealed concrete floor and acoustic ceiling panels. Some metal panels sit on the large columns to protect the mechanical equipment.

Figure 21 below shows an elevation of the curtain wall system. The curtain wall itself is 24 ft tall and is composed of two different types of glass. The first type of glass (IG-1) is located on the lower part of the wall and takes up 14.5 ft of the height of the wall. The second type (IG-2) is located on the top part of the wall and takes up 9.25 ft of the wall. IG-1 is Low-e, clear insulating glass, while IG-2 is a Low-e fritted insulated glass. Table 1 on the next page gives a detailed description of the two types of glass. The frit pattern of glass type IG-2 can be seen in Figure 22 below. The frit pattern covers 50% of the area with 1/8" lines.

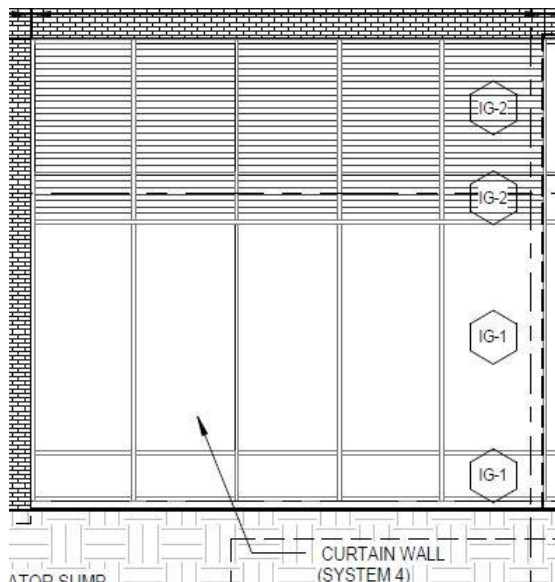
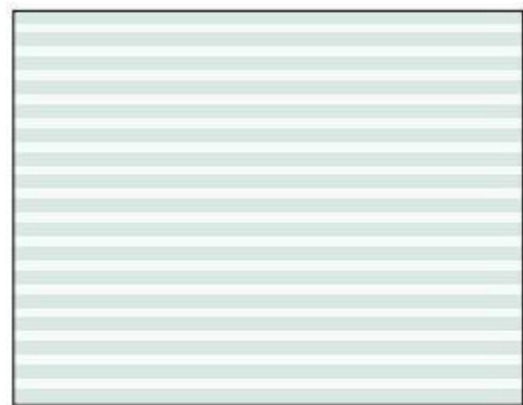


Figure 21 Elevation of Flex Lab curtain wall



**Lines**—50% coverage;  
1/8" lines on 1/4" centers

Figure 22 Fritted glass type IG-2

**Table 1 Curtain wall glass properties**

<i>Glass Type</i>	<i>Description</i>	<i>Manufacturer</i>	<i>Color</i>	<i>Visible Transmittance</i>	<i>Interspace Content</i>	<i>U-Factor</i>	<i>SHGC</i>
IG-1	1” thick, Low-e coated, clear insulating glass	Guardian Industries Corp.	clear	61%	Argon	Summer- 0.29 Winter- 0.30	0.40
IG-2	1” thick, fritted insulating, clear glass, with 50% standard 1/8” line coverage fritting	Guardian Industries Corp.	clear	49%	Argon	Summer- 0.49 Winter- 0.47	0.45

### 3.2 Daylighting Study of Existing Curtain Wall

To accurately quantify the amount of sunlight influence on the Flex Lab space, a study was completed in AGi32. The original curtain wall design contains some fritted glass as well some pull down shades. The pull down shades provide relief from direct sunlight but they also block 100% of the view when down. For the purpose of this study, the use of the shades was ignored and the curtain wall was tested with the two different types of glass. An existing Revit model of the Bioengineering Building was exported into AutoCAD as a 3D model and then imported into AGi32. The same model was used for the lighting design of the Flex Lab, which is discussed in Chapter 7.6. The reflectance of the various materials were assigned according to the material properties, which are located in Table 18.

Because the façade faces directly east, the morning sun will be the focus in the study. For that reason, four initial studies were done during the morning hours with clear sky conditions. Two were done for the summer solstice (June 21<sup>st</sup>): one at 9am and another at 10am. The two studies were repeated at the same times for the winter solstice (December 21<sup>st</sup>). Those were chosen based on the occupied times of the building. Because it’s a research and educational facility, the majority of the occupancy typically starts around 9am. The results of those AGi32 studies is shown in the next section. All views are looking into the Flex Lab in the North direction.

### 3.2.1 Summer Solstice: June 21<sup>st</sup> - 9 am (Looking North)

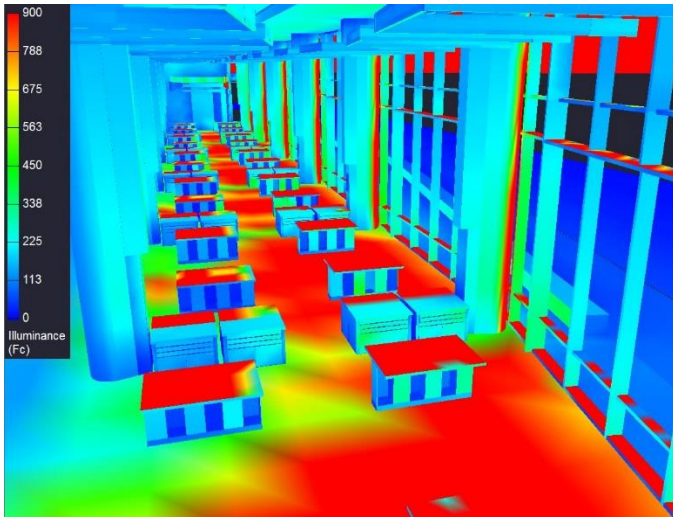


Figure 23 Pseudo color of June 9 am condition

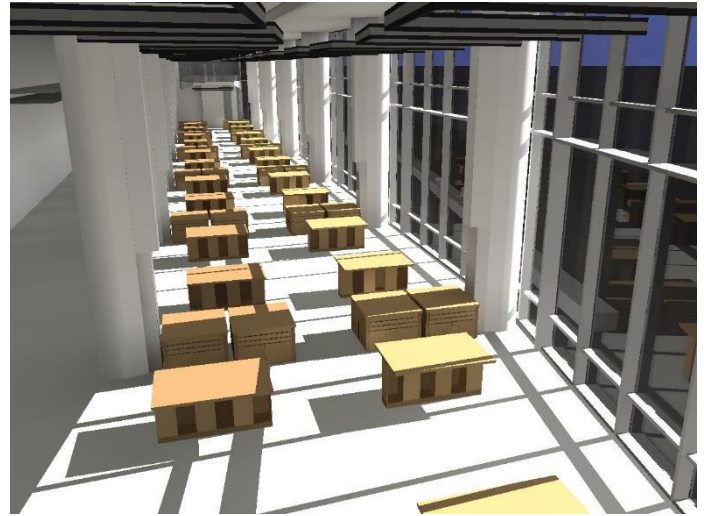


Figure 24 Raytrace of June 9 am condition

### 3.2.2 Summer Solstice: June 21<sup>st</sup> - 10 am (Looking North)

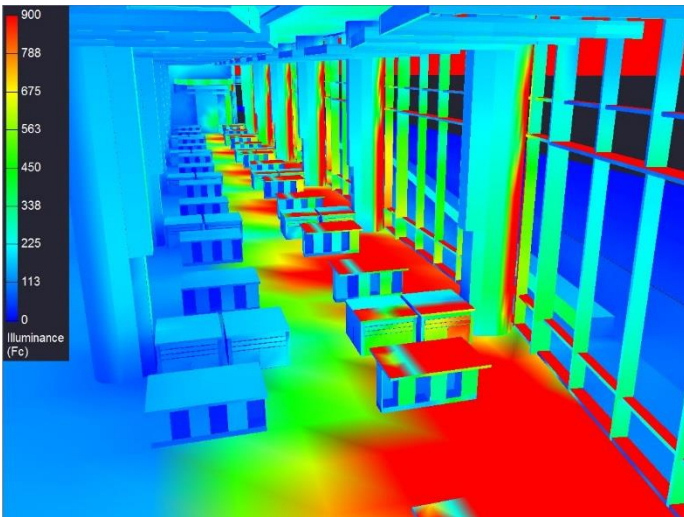


Figure 25 Pseudo color of June 10 am condition



Figure 26 Raytrace of June 10 am condition



### 3.2.3 Winter Solstice: December 21<sup>st</sup> - 9am (Looking North)

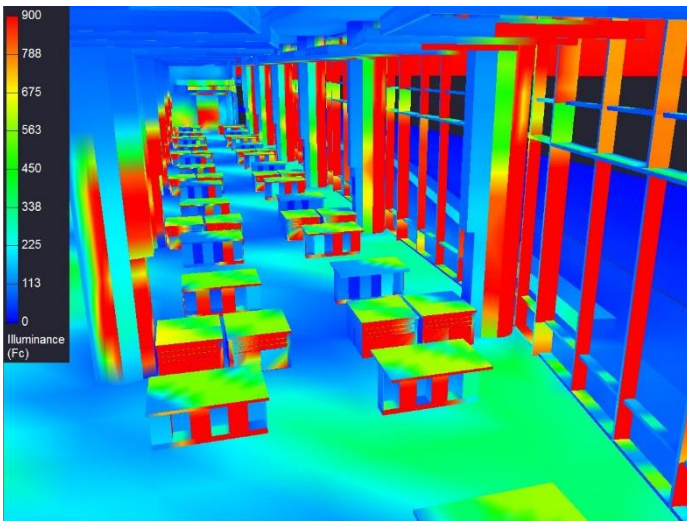


Figure 27 Pseudo color of December 9 am condition



Figure 28 Raytrace of December 9 am condition

### 3.2.4 Winter Solstice: December 21<sup>st</sup> – 10 am

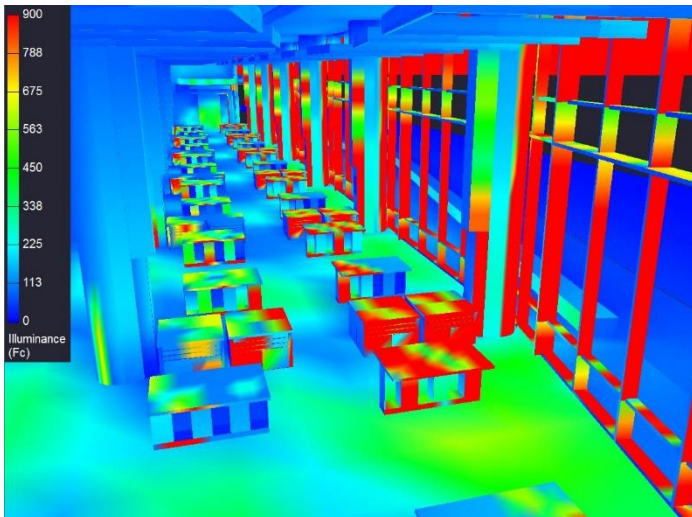


Figure 29 Pseudo color of December 10am condition

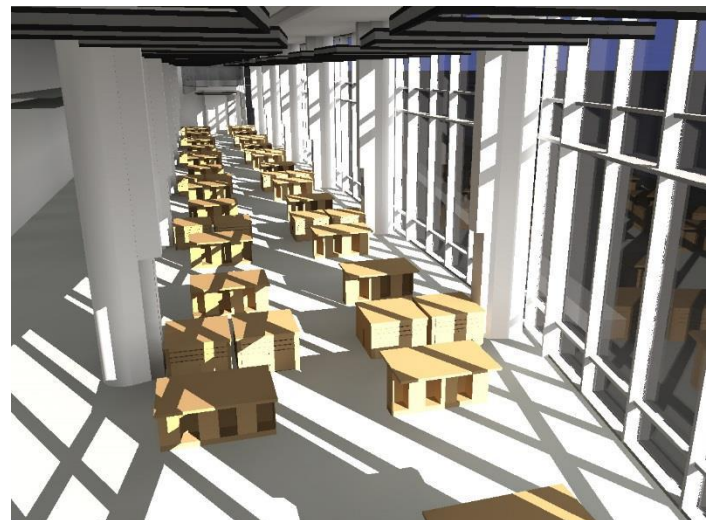


Figure 30 Raytrace of December 10 am condition



### 3.2.5 Evaluation

As shown in the AGi32 pseudo color and raytraced rendering, plenty of direct sunlight comes into the Flex Lab during the morning hours. The illuminance on the lab benches is the most crucial part of the study because of the technical tasks and the use of small and large machinery. In the daylighting studies, the illuminance was measured at one of the lab benches along the window side of the space. This was done to document the worst-case scenario for the task planes. The illuminance values for the various settings are shown in Table 2 below.

**Table 2 Daylight illuminance values of existing curtain wall**

<i>Date &amp; Time</i>	<i>June 21<sup>st</sup> 9 am</i>	<i>June 21<sup>st</sup> 10 am</i>	<i>December 21<sup>st</sup> 9 am</i>	<i>December 21<sup>st</sup> 10 am</i>
<i>Illuminance on Lab bench max. (fc)</i>	1695	2252	471	824
<i>Illuminance on Lab bench min. (fc)</i>	1694	87	50.3	47.2
<i>Illuminance on Lab Bench avg. (fc)</i>	1695	1760	156.37	211.28
<i>Illuminance across space max. (fc)</i>	1834	2361	1563	2870
<i>Illuminance across space min. (fc)</i>	62	61.9	48.4	36
<i>Illuminance across space avg. (fc)</i>	1021	915	349.31	395

The two settings that were chosen for study for the louver design study are highlighted in yellow in Table 2. The June 21st 9 am setting was chosen because the average illuminance was higher across the entire space. Even though the values were a little lower than the 10 am condition, the sunlight reached further into the space, affecting more of the occupants. The December 21st 10 am setting was chosen because the average illuminance was also higher across the entire space. Even though the direct sunlight doesn't reach as far into the space, the light comes in at a higher angle, making the values harsher on the lab benches. All four settings show the large amount of direct sunlight that washes the lab benches, causing uncomfortable light levels for a lab workspace.

### 3.2.6 Evalglare Analysis in Radiance

In order to quantify the amount of glare that actually comes into the space, the same AutoCAD model that was used for the AGi32 study was converted into Radiance. The model was run with a material file and a sky file that satisfied the existing properties of the location and space. After rendering an image of the space, the Evalglare command was used to measure the glare metrics in the space. Two separate studies were done in Radiance for the existing conditions: June 21<sup>st</sup> at 9am and December 21<sup>st</sup> at 10am. The renderings and the glare values of the two studies are shown in the figures below.

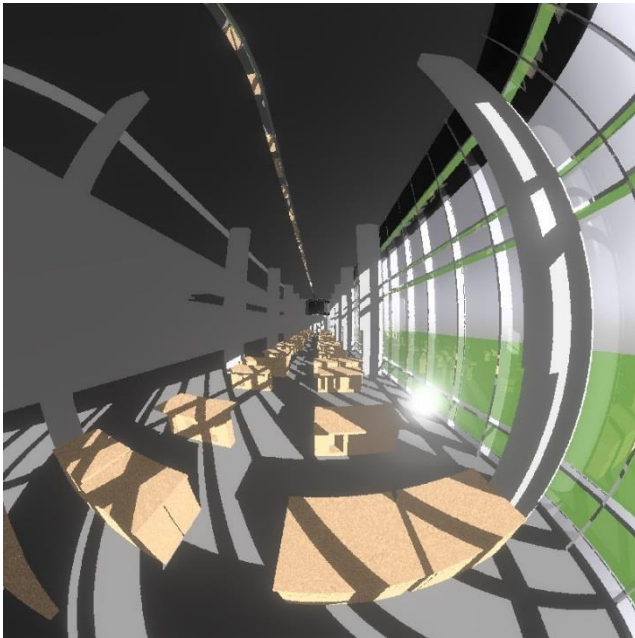


Figure 31 Radiance daylight rendering on December 21st, 10 am

*Daylight Glare Index (DGI): 38.02*  
*Daylight Glare Probability (DGP): 73%*

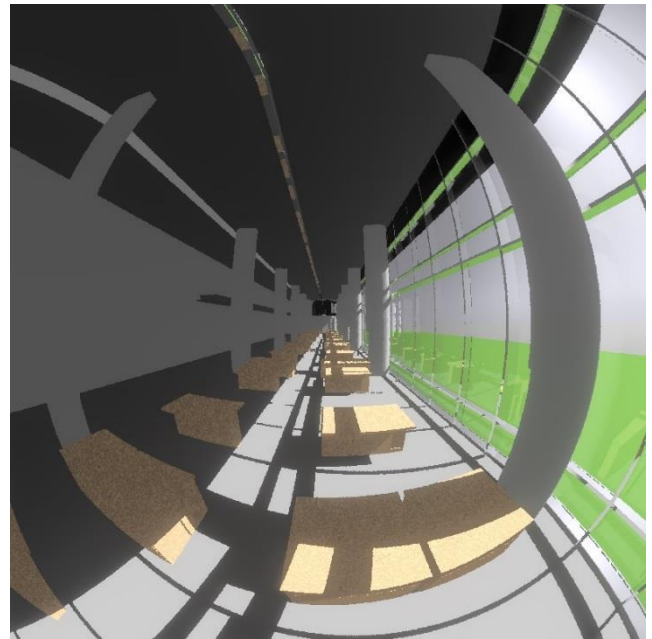


Figure 32 Radiance daylight rendering on June 21st, 9 am

*Daylight Glare Index (DGI): 23.91*  
*Daylight Glare Probability (DGP): 27 %*

Table 3 DGP values

	<i>Daylight Glare Probability (DGP)</i>
Imperceptible Glare	< 35%
Perceptible Glare	35-40%
Disturbing Glare	40-45%
Intolerable Glare	>45%

Table 4 DGI values

	<i>Daylight Glare Index (DGI)</i>
Imperceptible Glare	0-10
Perceptible Glare	10-16
Acceptable Glare	16-22
Uncomfortable Glare	22-28
Intolerable Glare	>28

The values of the glare study were taken at one of the lab benches in order to closely represent the occupant experience in the space. The results of both conditions reveal an unacceptable amount of glare coming into the Flex Lab. The Daylight Glare Index (DGI) value represents the main quantification of discomfort glare in spaces with non-uniform light sources, such as sunlight. The Daylight Glare Probability (DGP) represents the percentage of people who are uncomfortable in the space due to the vertical illuminance at eye level [Bellia and others 2007]. During the December condition, both the DGI and DGP values lie in the red highlighted areas of the chart, requiring some sort of control to make the space more comfortable. The DGI of the June 21<sup>st</sup> condition reveals that there is uncomfortable glare in the space, but the DGP was an acceptable value. Because glare is “position and view direction-dependent within a space” the variation in values is not uncommon [Jakubiec 2011]. The specific view in the study faces away from the direct source of sunlight making the actual brightness of the window lower. The sun is reflected more on the façade in the December view, which made that study compute a higher DGP value. Because the DGP metric is less sensitive to contrast, the study didn’t recognize the vertical eye illuminance versus the task plane illuminance as having uncomfortable glare [Jakubiec 2011]. DGI on the other hand considers the possibility of large glare sources, but is focused more on diffuse light through a window and the influence due to the size of the window. In this case, DGI evaluated the large illuminated window versus the illuminance in the room to calculate the appearance of glare in the space. Because of

the specific view chosen to complete the glare studies, DGI would be the more relevant metric. It considers the window as a diffuse source of light and assumes that the viewer can't see the direct source of light in the space. This value would be accurate for about half of the occupants in the space so it would still be an accurate metric to evaluate glare in the Flex Lab. The occupants within the Flex Lab need to have access to a glare-free research environment in order to complete the necessary tasks of the space safely and comfortably.

### **3.3 Interior Louver Design**

Although the existing curtain wall provides almost uninterrupted views, the 80% window to wall ratio allows for the variation of solar influence through the seasons. As per owner request, the exact location can't be disclosed, but is assumed to be situated in the Northeastern United States for the purpose of this report. This location experiences seasonal changes throughout the year with lower solar altitudes in the winter and higher altitudes in the summer. The research conducted in Chapter 1 of the report reveals that eastern facing façades are harder to shade because of the variability of the sun position in a small amount of time.

After studying the results of the initial daylighting study, it was determined that the strong direct sunlight will need to be blocked or diffused. The amount of glare on the lab benches should be reduced to provide a comfortable work environment. Ideally the occupants would also be able to adjust the shading system to their preference. In order to achieve those goals, a vertical shading system was determined to be the best solution for the façade because it would accommodate the changing solar altitude. Because of the importance of glare control, adjustable vertical louvers have been designed to attach to the interior of the curtain wall. This gives occupants the ability to control their sun exposure and comfort level in the space.

The movable louvers will perform perfectly at blocking direct sunlight throughout the year depending on the occupant education. As long as the people in the space understand their ability to control their visual comfort, the shading system will be very effective.

The framing of the existing curtain wall was studied in order to integrate the new shading system successfully. The manufacturer of the existing curtain wall (Kawneer) designs louver systems capable of attaching directly to the framing. These products were referenced for relative widths and depths. Figure 33 and 34 below show the Kawneer vertical louver system and its ability to be mounted directly to the curtain wall framing [Kawneer 2016]. This same construction was used in the design of the new curtain wall system. This ensures the successful integration of the two systems. The louvers will also have the same finish and reflectance as the curtain wall framing (0.439).



Figure 33 Kawneer vertical louver system (Kawneer)

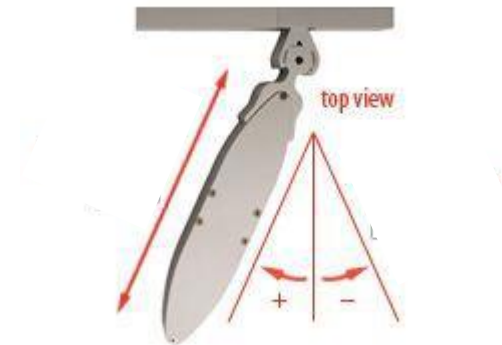


Figure 34 Mounting and adjustment of vertical louvers (Kawneer)

The new louvers utilize the same general shape as the Kawneer pieces, but are slightly different in size. In order to preserve the access to views a greater spacing was designed between louvers. The individual pieces are 3 ft deep and 6" wide and are spaced 32" apart in order to be evenly distributed across the curtain wall. Figure 36 on the next page shows an elevation of the existing curtain wall with the conceptual addition of the vertical louvers. The spacing matches up perfectly with the vertical mullions and places an additional louver directly in the middle. The central louver will attach to the horizontal mullions for support. The louver system stretches up the entire length of the curtain wall (24') blocking any direct sunlight that may come in. Figure 35 below shows a plan view of the new louvers.

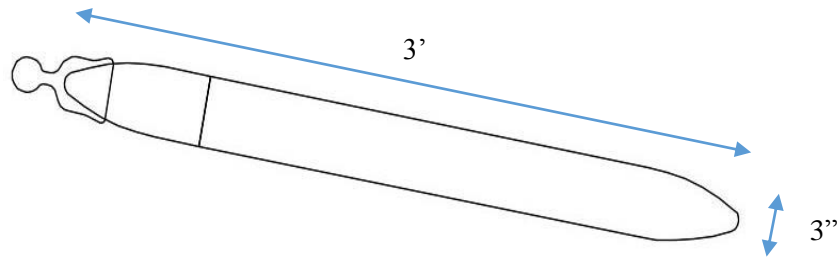


Figure 35 Plan view of new louver

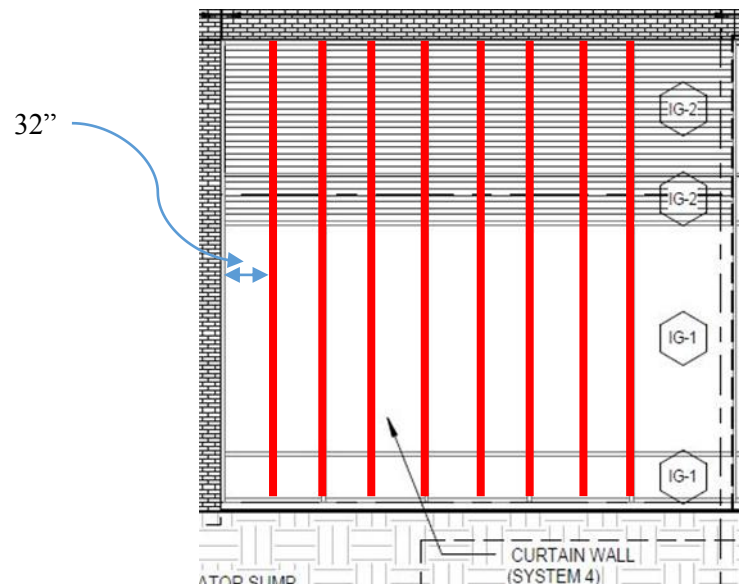


Figure 36 Elevation of new louver system concept with louvers represented as the red lines

After determining the dimensions and spacing of the louvers, a solar angle study was completed for the June 21<sup>st</sup> and the December 21<sup>st</sup> 9 am and 10 am settings. This was done to determine the angles that the louvers would need to be angled to block the direct sun angles. This winter angle study is shown in Figure 37 below and the summer angle study is shown in Figure 38 on the next page.

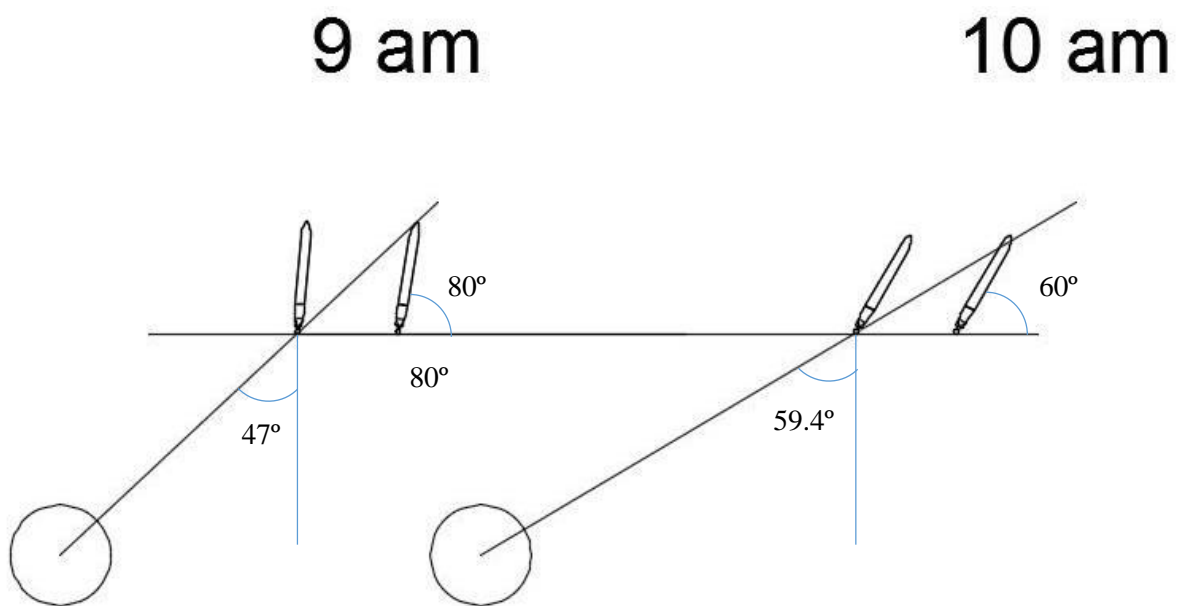


Figure 37 Sun angle study and louver angle orientation for December 21st at 9 am & 10 am

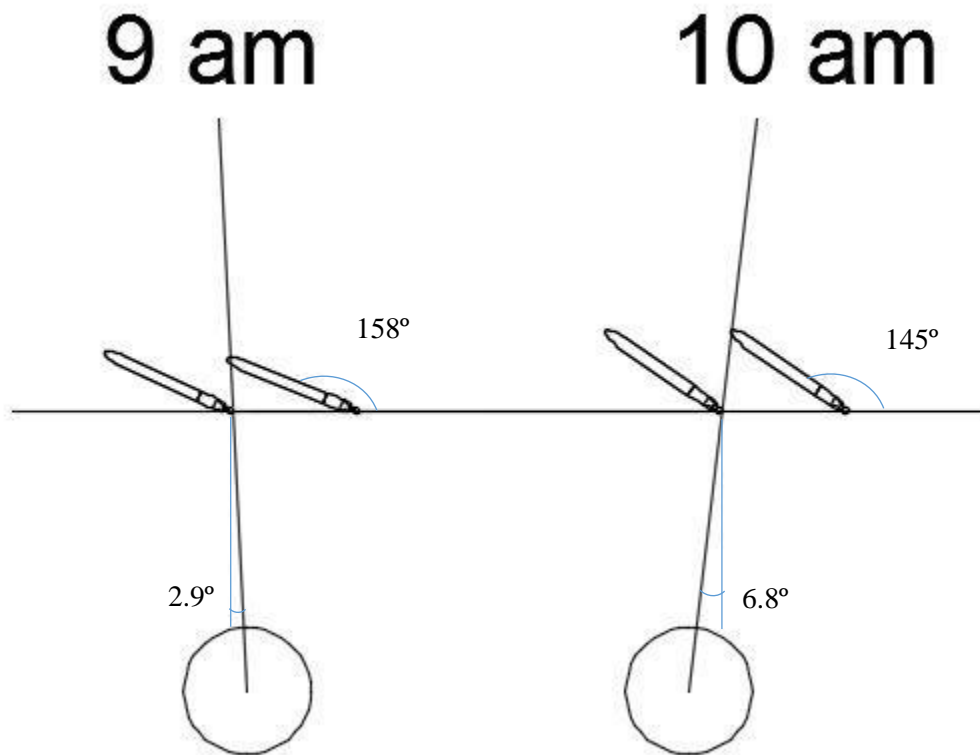


Figure 38 Sun angle study and louver angle orientation for June 21<sup>st</sup> at 9 am & 10 am

After the louver angles were determined, an AutoCAD model was made of the louvers on the curtain wall at the June 21<sup>st</sup> 9am and December 21<sup>st</sup> 10 am settings. A section of the plan is shown for each of the settings in Figure 39 and 40. The plans show the orientation of the louvers between the columns over the Flex Lab curtain wall, which repeat throughout the space.

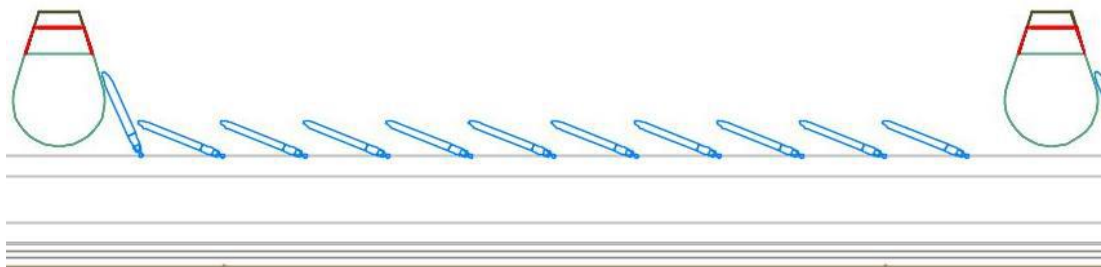


Figure 39 Plan of June 21<sup>st</sup> louver orientation



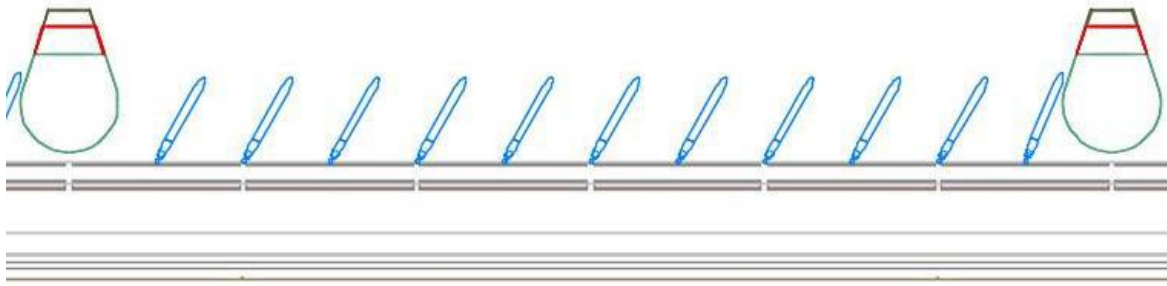


Figure 40 Plan of December 21st louver orientation

### 3.4 Daylighting Study of Interior Louver System

A final daylighting study was completed in AGI32 for the new louver system at the two chosen settings. The June 21<sup>st</sup> and December 21<sup>st</sup> settings were tested under the same sky conditions as the initial daylighting study. The only addition to the study was the new interior louver systems.

#### 3.4.1 Summer Solstice: June 21<sup>st</sup> - 9 am (Looking North)

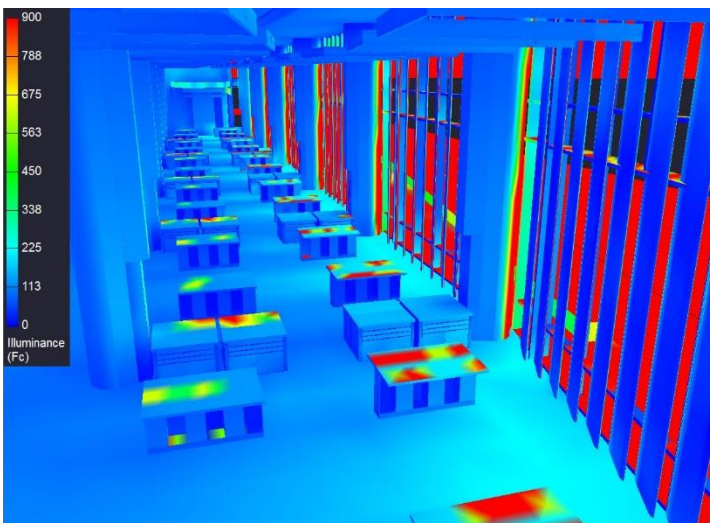


Figure 42 Pseudo color of June 9 am condition



Figure 41 Raytrace of June 9 am condition

### 3.4.2 Winter Solstice: December 21<sup>st</sup> - 10 am (Looking North)

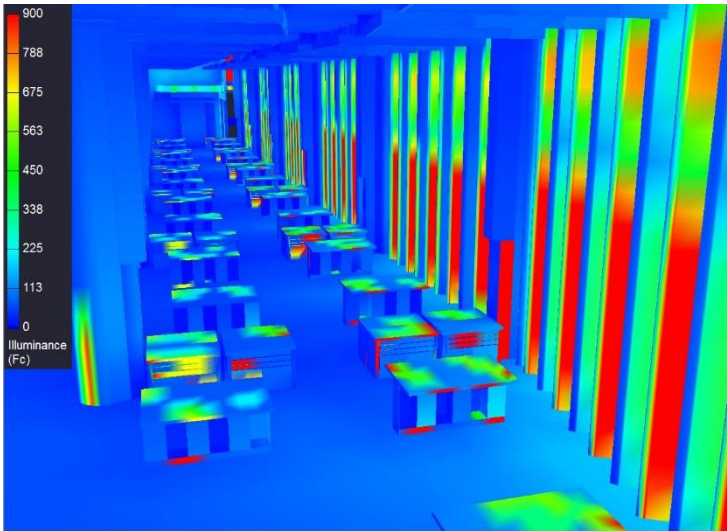


Figure 44 Pseudo color of December 10 am condition



Figure 43 Raytrace of December 10 am condition

### 3.4.3 Evalglare Analysis in Radiance

In order to evaluate the glare control performance of the shading system, the Radiance commands were repeated for the new conditions. The Evalglare command measured the glare metrics at the two separate conditions: June 21<sup>st</sup> at 9 am and December 21<sup>st</sup> at 10 am. The final renderings and glare values of the two studies are shown in the figures on the next page.

Table 5 DGP values

	<i>Daylight Glare Probability (DGP)</i>
Imperceptible Glare	< 35%
Perceptible Glare	35-40%
Disturbing Glare	40-45%
Intolerable Glare	>45%

Table 6 DGI values

	<i>Daylight Glare Index (DGI)</i>
Imperceptible Glare	0-10
Perceptible Glare	10-16
Acceptable Glare	16-22
Uncomfortable Glare	22-28
Intolerable Glare	>28

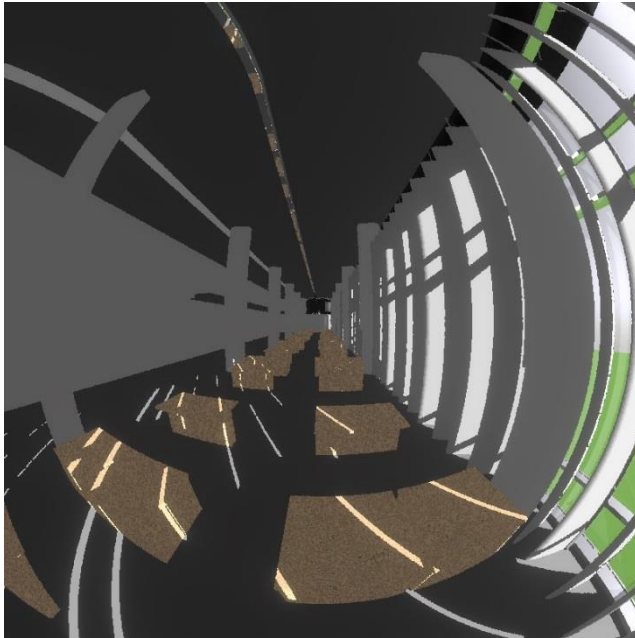


Figure 46 Radiance daylight rendering on December 21st, 10 am

*Daylight Glare Index (DGI): 17.6*  
*Daylight Glare Probability (DGP): 20.8%*

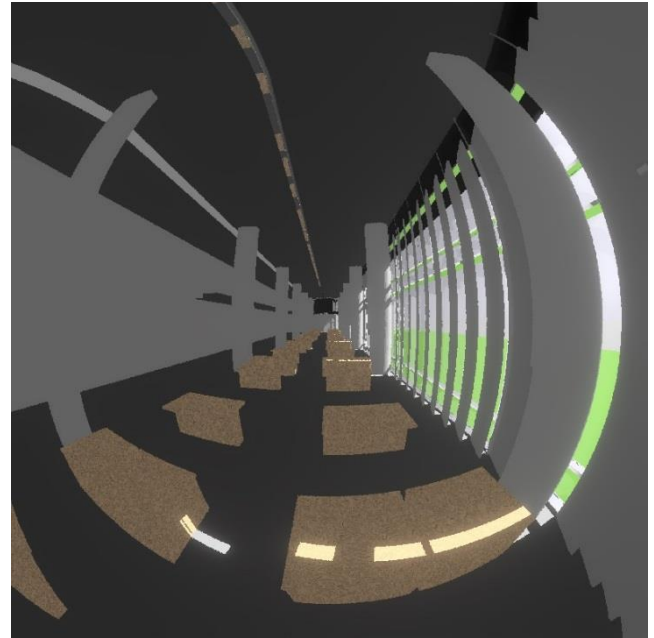


Figure 45 Radiance daylight rendering on June 21st, 9 am

*Daylight Glare Index (DGI): 18.9*  
*Daylight Glare Probability (DGP): 22.3 %*

The results of the secondary study show the louver systems successfully reducing glare at both times. The DGI and DGP values of both conditions lie within the imperceptible glare and acceptable glare categories.

### 3.4.4 Evaluation

As shown in the new June 21<sup>st</sup> 9 am and December 21<sup>st</sup> 10 am studies, the interior louver system provides a significant reduction in direct sunlight shining on the lab benches. There are slight leaks of light where the columns are in the June condition, which is due to limitations in louver mounting on the curtain wall. There's also some leaks through the southeastern corner of the Flex Lab, where the façade started to angle slightly. This could be solved simply by adjusting the angle of the louvers on that end of the façade to block the direct sunlight.

Overall the design is successful in reducing the direct sunlight coming into the Flex Lab. The illuminance and glare levels were lowered significantly through the space, making the visual environment more comfortable for research. The shading system still filters in a significant amount of light that is spread through the space diffusely. During the winter months, light levels on the lab benches meets the illuminance criteria set by the IES Handbook (see 7.6.4 for more details), meaning that the daylight integration could provide significant savings in lighting loads. The illuminance is almost met during the summer months as well. Table 7 below shows the quantitative results of the second daylighting study. The illuminance levels across the space will allow dimming to be utilized on the lighting fixtures, providing energy savings for the space and the building as a whole.

**Table 7 Daylight illuminations levels with interior louver system**

<i>Date &amp; Time</i>	<i>June 21<sup>st</sup> 9 am</i>	<i>December 21<sup>st</sup> 10 am</i>
<i>Illuminance on Lab bench max. (fc)</i>	48.3	66.5
<i>Illuminance on Lab bench min. (fc)</i>	41.5	46.9
<i>Illuminance on Lab Bench avg. (fc)</i>	44.3	55
<i>Illuminance across space max. (fc)</i>	2135	2870
<i>Illuminance across space min. (fc)</i>	36.8	13.5
<i>Illuminance across space avg. (fc)</i>	111.01	163.8

## Chapter 4 Structural Breadth

### 4.1 Structural Analysis of Louver Addition

The new vertical louvers designed to shade the first floor Flex Lab will attach directly to the framing of the curtain wall system (see louver design details on page 58 of the previous section). In order to determine if the existing columns on the first floor could support this addition, a structural analysis was performed to account for the new 24' louvers. The result of the study determined whether the columns would need to be resized to hold the higher load. Three components were calculated for their dead and live loads including: the floor slab, the curtain wall, and the louvers. The existing first floor column strength was compared to the total load from the three components to determine the need for redesign.

#### 4.1.1 Floor Slab Load

As shown in Figure 47, the curtain wall design of the first floor is different from the floors above. The Flex Lab space (located between the first floor and third floor) also utilizes equipment (such as the Lab Cranes) that adds an additional load, which isn't repeated to the same magnitude in the spaces above. For the purpose of this calculation, it was assumed that the loads of all floors were the same. This is justifiable because my calculations are over estimating the load from the floors, which is safer than underestimating.

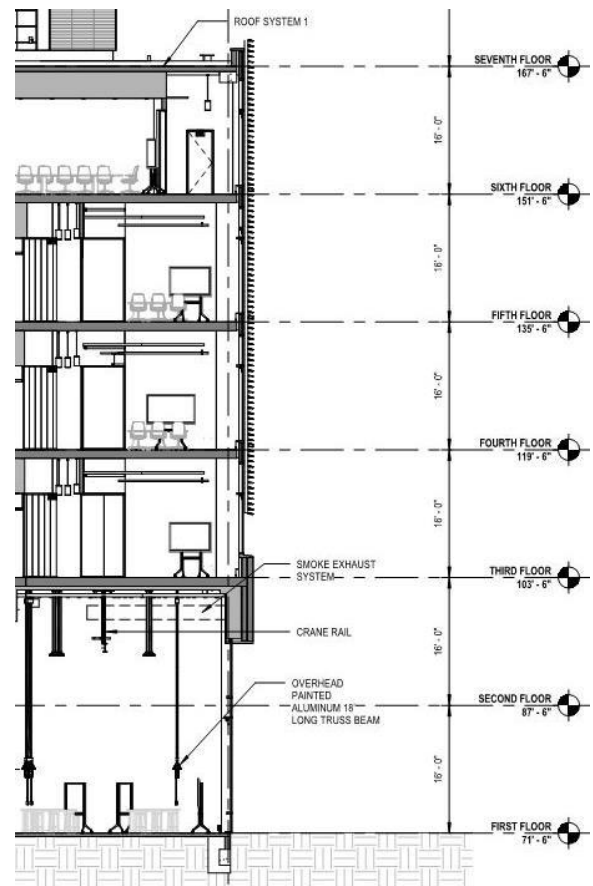


Figure 47 Wall section of east facade

Figure 48 shows a section of the Flex Lab structural plan (refer to Figure 100 in 7.6 for a complete floor plan), showing a few of the columns in the space. The area highlighted in blue represents the tributary area of the column, which is assumed to be the same throughout the whole space. The columns are spaced 32' apart along the façade and 26.75' into the building. There is also a 2.75' overhang on the east façade that is accounted for in the loading on the column. The specifications and calculations of the load of the floor slab are shown below.

**Materials:**

Concrete: 13" thick, normal weight concrete  
@ 5000 psi strength

Rebar: #5 @ 12" o.c. each way bottom mat  
#4 @ 12" o.c. each way top mat

**Tributary Area:** 32 ft x 16.125 ft = 516 ft<sup>2</sup>

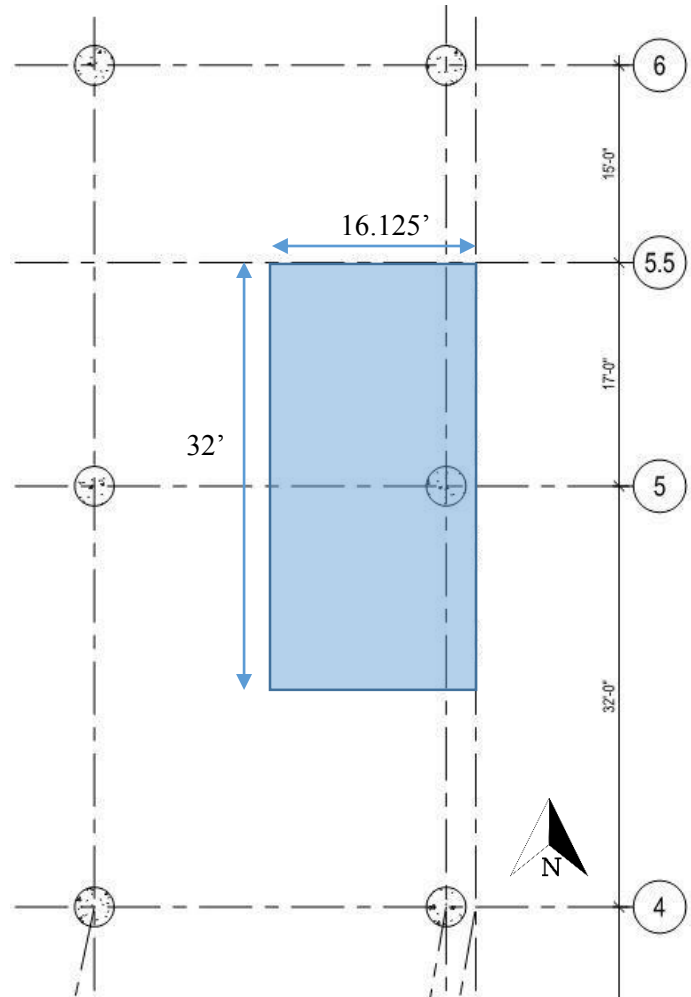


Figure 48 Section of Flex Lab structural plan

**Calculation:**

(\*load values taken from project specifications)

**Dead Load:**

Concrete Slab	-	163 psf
Sprinklers	-	3 psf
Mechanical & Electrical System	-	5 psf
Floor Finish	-	2 psf
Lab Crane (*see below for specifics)	-	19.38 psf
Superimposed Dead Load	-	10 psf

***Total Dead Load                      202.38 psf***

\*Lab Crane (1 per column): 10,000 lbs per crane

$$10,000 \text{ lbs} / 516 \text{ ft}^2 = 19.38 \text{ psf}$$

**Live Load:**

100 psf (unreducible as per owner requirements)

+ 10% (from Lab Crane)

***Total Live Load                      110 psf***

**Total Floor Load:**  $1.2D + 1.6L = 1.2 (202.38 \text{ psf}) + 1.6 (110 \text{ psf}) = \mathbf{420 \text{ psf}}$

$$W_u = 420 \text{ psf} \times 516 \text{ ft}^2 = \mathbf{216.7 \text{ kips}}$$



### 4.1.2 Curtain Wall Load

For the purpose of this calculation, it was assumed that the load of the curtain wall is the same along the entire height of the building. Because the first floor contains a brick veneer and a concrete foundation, the load of the curtain wall system will be larger than the walls on the rest of the floors. This will result in an over estimation of the load of the curtain wall on the column, which will be acceptable for the purpose of this calculation. The curtain wall type used in this calculation is shown in Figure 49 below.

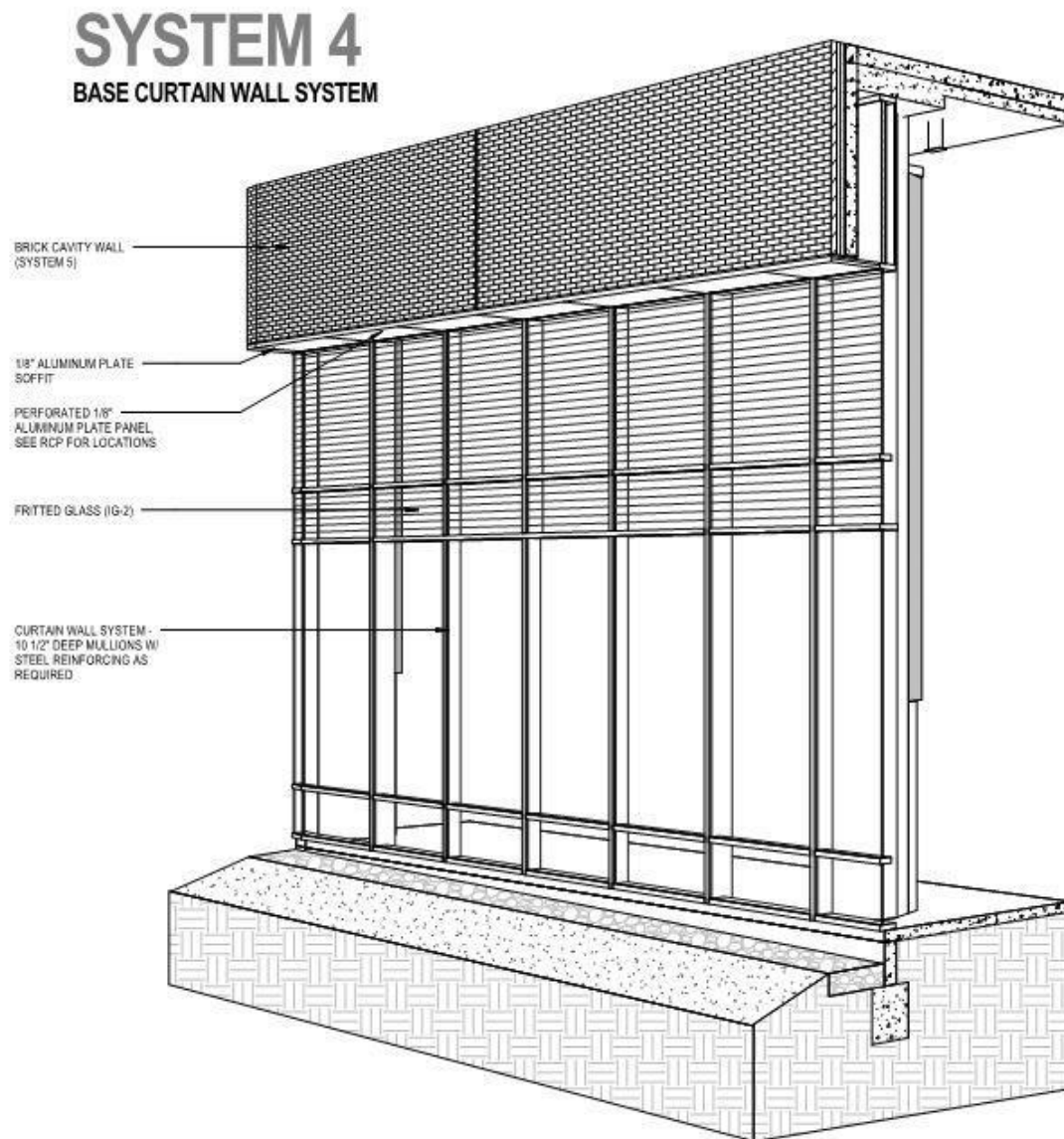


Figure 49 Perspective of curtain wall design



**Calculation:** (3 parts: Curtain Wall (*CW*), Brick Veneer (*BV*), & Concrete Foundation Wall (*FW*))

(\*load values taken from project specifications)

Dead Load:

$$CW: \quad 15 \text{ psf} \times 24 \text{ ft} = 360 \text{ plf}$$

$$FW: \quad 150 \text{ pcf} \times 0.67 \text{ ft} \times 4 \text{ ft} = 402 \text{ plf}$$

$$BV: \quad 40 \text{ psf} \times 4 \text{ ft} = 160 \text{ plf}$$

$$\textbf{\textit{Total Dead Load}} \quad \quad \quad \textbf{922 plf}$$

#### 4.1.3 Louver Load

The addition of the louvers to the curtain wall results in an additional load applied to façade, which is supported by the building's structural system. For a detailed description of the louvers and their dimensions refer to Chapter 3 of the report. Because the louvers are only being applied to the first floor façade, including them in the overall load will result in an overestimation. The curtain wall on the floors above does contain horizontal shading devices, which will be accounted for in this repetition of load. As shown in the louver layout plan in Chapter 3, there are 11 louvers supported by each column. Each 24 ft x 3 ft louver will have a load of about 1.454 psf, which was estimated using the weight of the aluminum.

**Calculation:**

$$2 \text{ psf} \times 72 \text{ ft}^2 = 144 \text{ lbs per louver} \quad \times \quad 11 \text{ louvers} = 1,584 \text{ lbs}$$

$$1,584 \text{ lbs} / 32 \text{ ft} = \textbf{49.5 plf}$$

#### 4.1.4 Total Load on Column

The curtain wall and louver loads were combined to find the total dead loads of the components. The floor height of the first floor is 32 ft while the rest of the floors are 16 ft tall. Because the load of the curtain wall and louvers is for the entire height of the first floor (32 ft), the actual load applied to each floor is half of this value.

Load of curtain wall & louvers per floor:

$$922 \text{ plf} + 49.5 \text{ plf} = 971.5 \text{ plf} = 0.9715 \text{ klf}$$

$$0.97 \text{ klf} \times 32 \text{ ft} = 31 \text{ kips} / 2 = \mathbf{15.5 \text{ kips}}$$
 (for 16 ft floor height)

Total load per floor:

$$P_u = 216.7 \text{ kips} + 1.2(15.5 \text{ kips}) = \mathbf{235 \text{ kips}}$$

Because a column holds half its load from the floor above and half from the floor below, the load on the column at the top of the structure will be half of the total load per floor. See Appendix B for a detailed drawing of the loading on the structural frame.

Total load on column:

$$\mathbf{P_u = 1528 \text{ kips}}$$

#### 4.1.5 Column Strength

For the purpose of this study, only one column was studied in the space because of the repetition of design. The tributary area outlined in section 4.1.1 contains the load applied to each column in the space and is repeated for each floor. In order to determine the strength of the existing column, the CRSI Manual was referenced for existing column strengths. Because the manual didn't contain the exact column specified, the strength was calculated by hand using Equation 10.2 in ACI Chapter 10. Refer to Appendix C for a detailed calculation of the column strength.

$$\phi P_{n, max} = 2544 \text{ kips}$$

#### 4.1.6 Analysis & Conclusion

The result of the load calculations were compared to the result of the column strength calculation to determine whether the existing structure can support the addition of the louvers on the Flex Lab façade.

$$\phi P_{n, max} \geq P_u$$

$$2544 \text{ kips} \geq 1528 \text{ kips} \quad \text{YES!}$$

The total load on the column is much lower than the designed column strength. Even with the overestimation of the loads of the curtain wall and the louver system, the column will still be able to support the design of the shading system. In conclusion, the structural system can remain as designed and doesn't require and alterations to the column design.

## Chapter 5 Mechanical Breadth

After designing the new louver shading system on the east façade of the Bioengineering Building, the Flex Lab experienced a decrease in daylight influence. While the façade system remained the same, vertical louvers attached to the interior of the curtain wall provide shading from daylight throughout the year. Chapter 3 of this report provides a detailed breakdown of the louver design and the effect it has on the daylight levels in the Flex Lab. With the addition of the louvers, there's a potential for a heating and cooling load reduction in the space. In order to analyze the mechanical loads, a study was conducted in COMFEN of the original curtain wall design as well as the addition of the interior vertical louvers at the critical summer and winter times. The three scenarios were compared for their energy usage, heat gain, and thermal comfort. The results of the study were used to determine whether the mechanical equipment could be resized to account for the change in load.

As discussed in Chapter 3, the Flex Lab stretches along the eastern façade of the Bioengineering Building. The entire east and south wall are made up of a curtain wall, which stretches to a height of 24 ft tall. The large amount of glass exposure in a laboratory space has the potential to cause glare and thermally uncomfortable conditions. The curtain wall was modeled in COMFEN for the eastern wall of the Flex Lab. Figure 50 below shows the model of the façade. The glass in the curtain wall was modeled as Double High Performance Tint (Argon), which closely matched the solar heat gain coefficient (SHGC), visual transmittance, and U-factor specified for the project. A detailed description of the existing curtain wall can be found in Chapter 3.

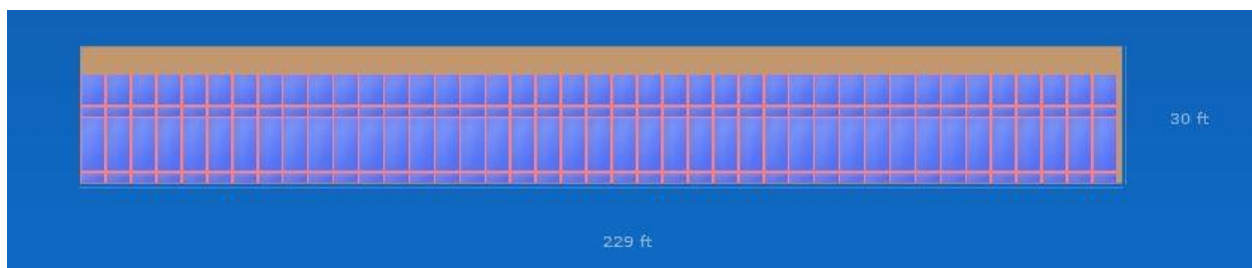


Figure 50 Elevation view of curtain wall system modeled in COMFEN

## 5.1 Louver Modeling in COMFEN

Due to constraints in COMFEN, interior vertical louvers cannot be designed. In order to compensate for this, interior vertical venetian blinds were modeled. To accurately represent the design of the new louver system, the dimensions of the vertical blinds were created as a ratio of the system designed in Chapter 3. This design technique created a window to shading ratio equal to the one modeled for daylighting design, allowing the COMFEN results to represent the design relatively accurately. Figure 51 below shows the comparison between the interior louver design and the design of the interior shading in the COMFEN model.

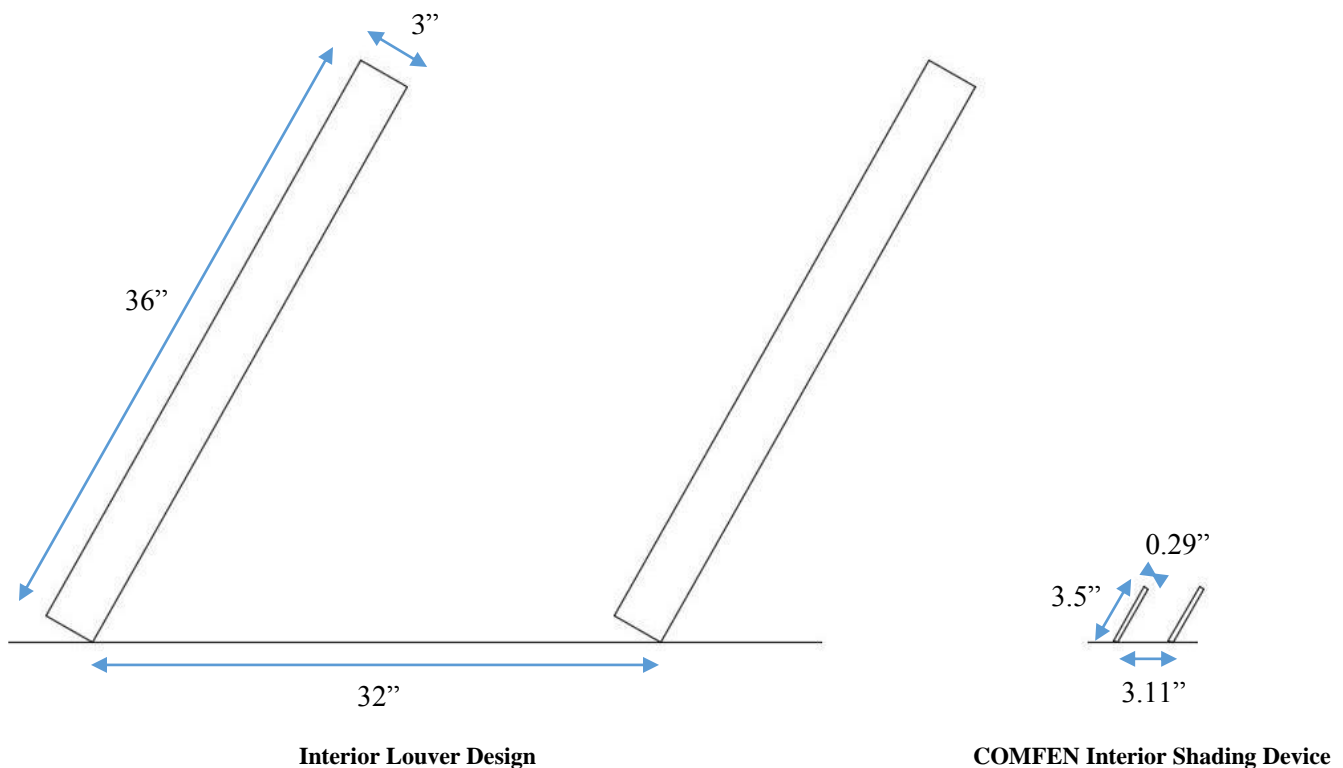


Figure 51 Comparison of Louver design and COMFEN shading model

## 5.2 Analysis of Shading in Summer

One of the conditions designed for in the daylighting study was a louver orientation that would shade the sun on the summer solstice (June 21) at the peak daylighting load hour of 9 am. This shading system was designed in COMFEN to have the same angle orientation as in the daylighting study. Figure 52 below shows the calculated energy usage of the Flex Lab with the shading system condition (the bar on the right) compared to the lab's existing condition (the bar on the left). Because the shading system was designed for June, the energy use values during the month of June were the only ones evaluated and are highlighted in the red box. The chart generated shows that the energy use actually increased with the new shading system from the original load of 11.6 kBtu/ft<sup>2</sup> to a load of 11.73 kBtu/ft<sup>2</sup>. While the cooling load decreased slightly, the fan load increased, meaning that the space required additional air for cooling the space. The reasoning behind this increase could be due to the redistribution of solar energy in the space by the shading system that causes the heating and cooling loads to increase. The addition of the interior shading system could also be trapping the hot air inside which increases the fan load in the space.

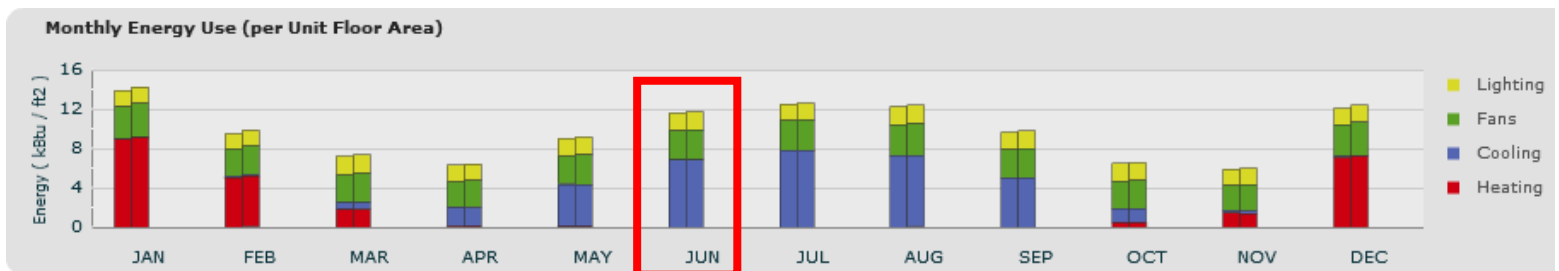


Figure 52 Energy use of original design compared to June 21st shading system

The heat gain on the curtain wall was also analyzed for the existing curtain wall as well as the June shading system. Figure 53 on the next page shows the existing systems value in red and the new shading systems value in orange. The heat gain on the windows did decrease in June with the addition of the shading system, which can be seen highlighted with the red box.

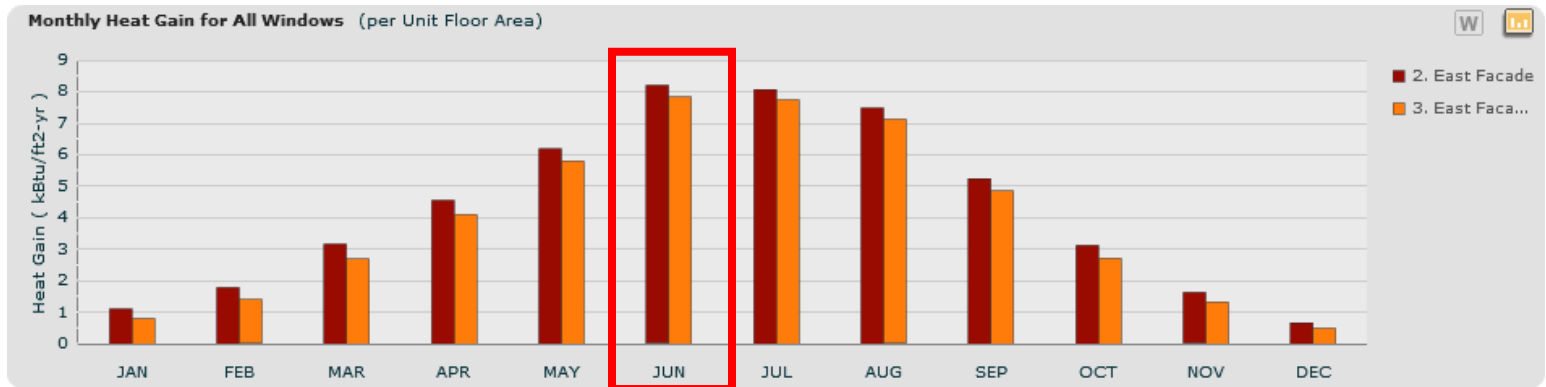


Figure 53 Monthly heat gain of original design compared to June 21<sup>st</sup> shading system

Lastly, the comfort levels in the space were analyzed. Figure 54 below shows the existing curtain wall condition in the dark purple and the new shading system condition in the light purple. Because the shading system was designed for June 21<sup>st</sup> at 9am, the 9am piece was the only part considered in the analysis of the summer months (highlighted in red). The chart shows an increase in occupant comfort at the 9am time, meaning that the shading system succeeds at satisfying more people in the space.

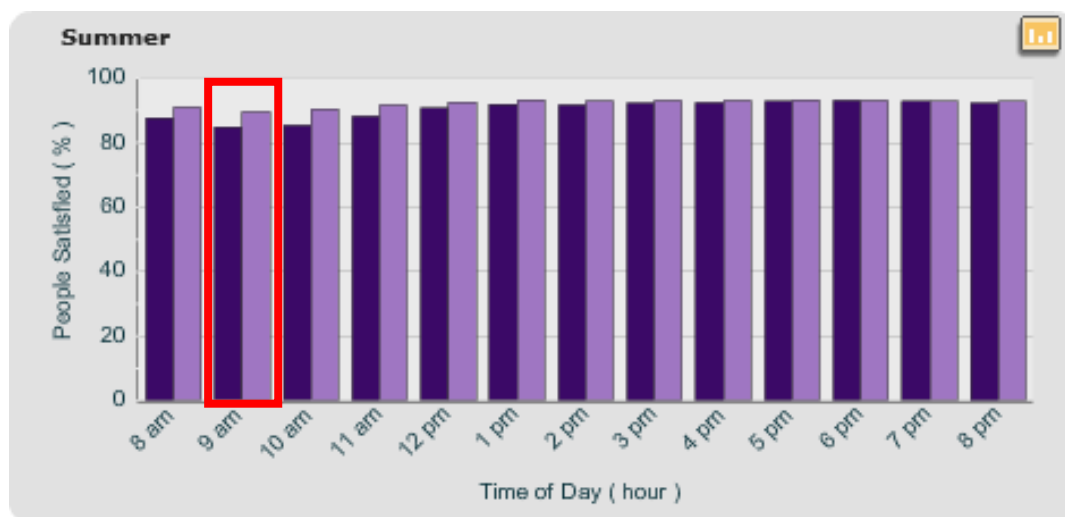


Figure 54 Comfort level of occupants in the summer at 9am compared to the comfort with the shading system

### 5.3 Analysis of Shading in Winter

The other condition designed for in the daylighting study was a louver orientation that would shade the sun during the winter solstice (December 21) at the peak daylighting load hour of 10 am. This shading system was designed in COMFEN to have the same angle orientation as in the daylighting study. Figure 55 below shows the calculated energy usage of the Flex Lab with the shading system condition (the bar on the right) compared to the lab's existing condition (the bar on the left). Because the shading system was designed for December, the energy use values during the month of December were the only ones evaluated and are highlighted in the red box. The chart generated shows that the energy use increased with the new shading system from the original load of 12.09 kBtu/ft<sup>2</sup> to a load of 12.30 kBtu/ft<sup>2</sup>. While the fan load decreased slightly, the heating load increased, meaning that the space required additional energy to keep the space warm enough in the winter months. Due to the decreased solar influence, the space isn't getting as much heat gain from the sun as in the existing curtain wall condition. The heating load increased in order to make up for the lower solar heating influence in the space.

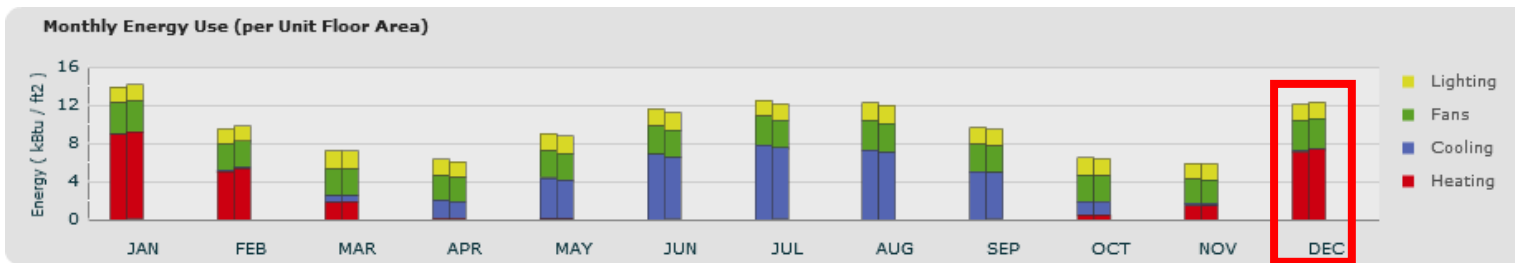


Figure 55 Energy use of the original design compared to the December 21st design

The heat gain on the curtain wall was also analyzed for the existing curtain wall as well as the December shading system. Figure 56 on the next page shows the existing systems value in red and the new shading systems value in orange. Like in the June shading system, the heat gain on the windows



decreased in December with the addition of the shading system, which can be seen highlighted with the red box.

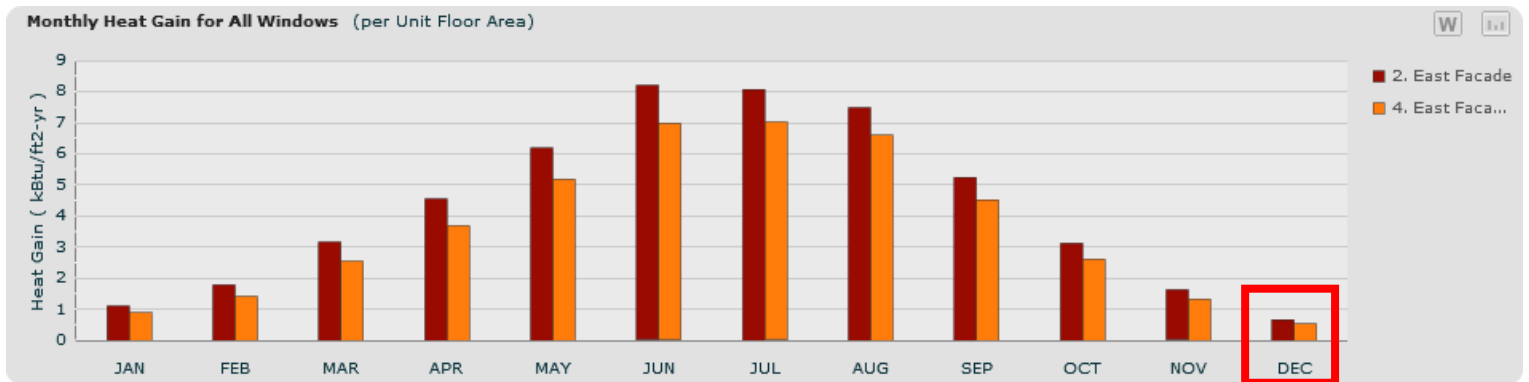


Figure 56 Monthly heat gain of original design compared to December 21st shading system

Lastly, the comfort levels in the space were analyzed. Figure 57 below shows the existing curtain wall condition in the dark purple and the new shading system condition in the light purple. Because the shading system was designed for December 21<sup>st</sup> at 10am, the 10am piece was the only part considered in the analysis of the summer months (highlighted in red). The chart shows an increase in occupant comfort at the 10am time, meaning that the shading system succeeds at satisfying more people in the space.

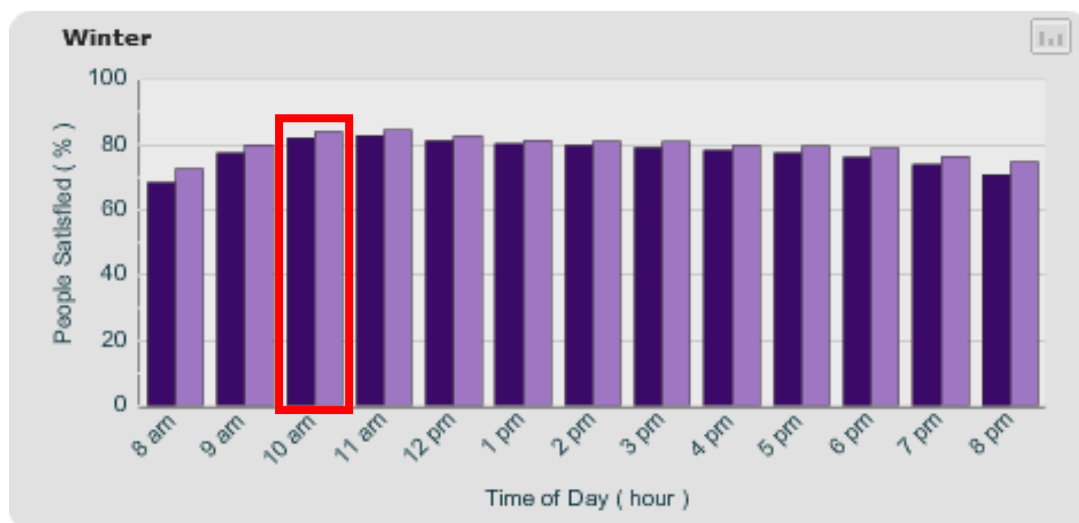


Figure 57 Comfort level of occupants in the winter at 10am compared to the comfort with the shading system

## 5.4 Conclusion

The results of the mechanical study of the two shading systems revealed that there wouldn't be any savings in heating and cooling load of the new louver design. Instead, the design would use slightly more energy than the original curtain wall. Because of this result, there wouldn't be any need to resize the mechanical equipment in the space. The current system would still be able to support the heating and cooling load needed for the adjustable shading system. The reason for the slight increase in load is most likely because of the solar loads being trapped more by the shading system.

The existing curtain wall has a window to wall ratio of about 80%, meaning that the majority of the wall is made up of glass. This allows a huge amount of solar gain into the Flex Lab, causing glare conditions for the occupants working in the space. The large surface area of the curtain wall also allows energy to escape from the space, adding to the mechanical loads in the space. Although the shading system doesn't help to reduce the heating and cooling loads, it significantly reduces the illuminance levels and glare in the space, making the work area more comfortable and functional for the occupants. Using the louvers controls the daylight allowed into the space, providing light levels that almost reach the target illuminance for the space. This integration of good daylight into the space will help lower the load from electric lighting, offsetting the slight increase in mechanical load needed in the space. For this reason, the interior louver system has been deemed practical from a mechanical standpoint.

## Chapter 6 Electrical Depth

A photovoltaic panel (PV) array design was explored in order to determine the possible load offset that could be achieved in the building. The mechanical penthouse located on the top of the building provides a significant amount of area for the installation of the PV panels. Because the Bioengineering Building is the tallest building in the vicinity, the tallest part of the roof doesn't experience any shading from surrounding buildings. This will allow for the maximum possible output from the PV panels at all time for the weather conditions.

### 6.1 Analysis of Roof Sunlight Exposure

In order to justify the study of a PV array, an initial study was done of the roof to determine that high solar illuminance levels reach the roof plane. A daylighting study was conducted for the location of the Bioengineering Building in AGi32 of the roof at noon on the Summer Solstice (June 21<sup>st</sup>). Figure 58 below shows a pseudo color rendering of the calculation.

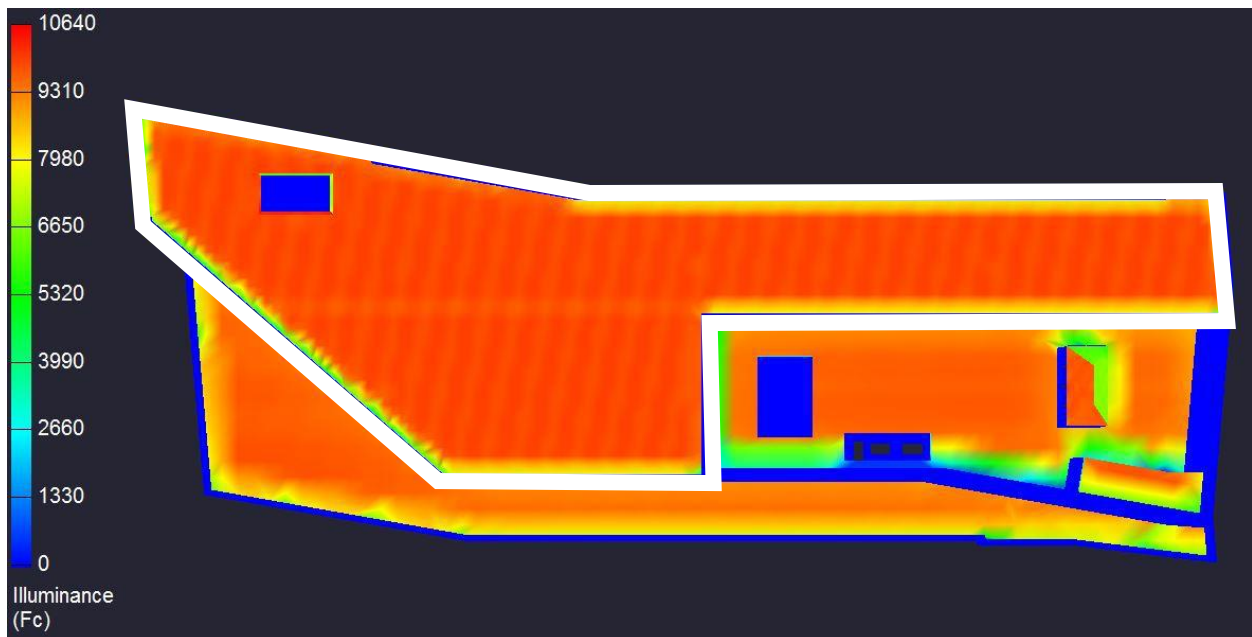


Figure 58 Pseudo color rendering of daylight exposure of roof (with highest roof plane outlined in white)

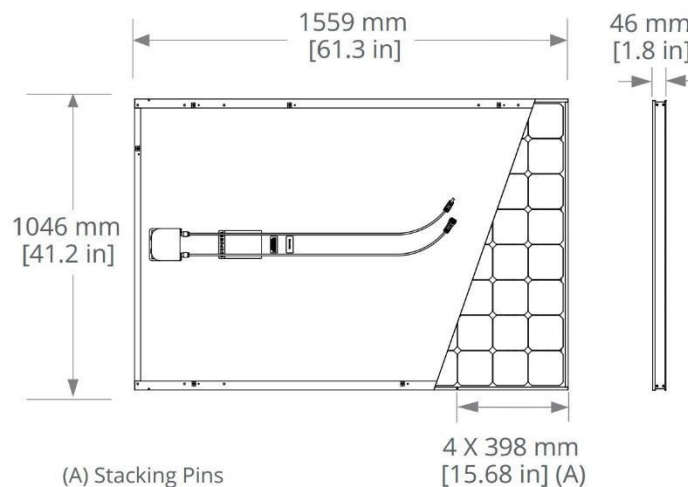
As shown in the pseudo color, the maximum illuminance level on the roof is about 10,000 footcandles (fc). The average illuminance over the highest part of the roof (which is outlined in white) was calculated to be 9,686 fc. Because the entire roof plane receives a relatively uniform amount of light, it was determined that a PV panel study would be beneficial for the project.

## 6.2 Equipment Selection

Within a PV panel design there are a couple critical components that come together to create the array. The first is the PV panel, which harvests the solar power. Next is the PV inverter, which converts the DC current from the PV panel into AC current, which is then used as electric power in the building.

### 6.2.1 PV Panel Selection

Before determining the layout or power generation of the PV array, specific panels were chosen in order to determine the space that each would take up on the roof. The SunPower X-Series Commercial Solar Panels (SPR-X21-345-COM) were chosen from SunPower's website. A dimensioned plan is shown in Figure 59 below. The panels run at 345 W with an efficiency of 21.5%. The complete specification sheet for the PV panel can be found in Appendix C.



**Figure 59 PV panel dimensions from SunPower specifications**

### 6.2.2 Inverter Selection

The inverter that was chosen for the PV panel array was manufactured by SMA America and found on their website. Because the PV panels run on a 1000 V system, the inverter had to be able to support that. The Sunny Tripower 30000TL-US model was chosen because it holds the highest wattage (30800W) on a 1000V system and has a 98.6% efficiency. The complete specification sheet for the inverter can be found in Appendix C.

## 6.3 System Design

In order to design the layout on the roof, the panel tilt had to be determined in order to find how much space the PV array would take up. The National Renewable Energy Laboratory (NREL) provides a PV panel array calculator online (PVWatts) that can be used to estimate panel system designs [NREL 2016]. This online calculator was used to perform the PV modeling. The program incorporates the location and basic energy usage information of a building with the PV system specifications in order to predict the energy output. Based on the area of the roof, an estimated DC system size (kW) was produced. After inserting the inverter efficiency, building electric system information, and a few other inputs, a few different tilt angles were tested. It was determined that 35 degrees was the optimal tilt angle for the PV panels.

Using the calculated tilt angle, the spacing of the panels on the roof was determined. In order to design for the maximum amount of sunlight harvested, the sun angle at the winter solstice was found (December 21<sup>st</sup> at noon). This angle represents the lowest that the sun will be shining on the panels during the peak noon hour. Designing the spacing around this angle means that the panels rarely shade one another during the year and should face directly south. Figure 60 on the next page shows the study of the panel dimensions, sun angle, and tilt used to determine the panel spacing.

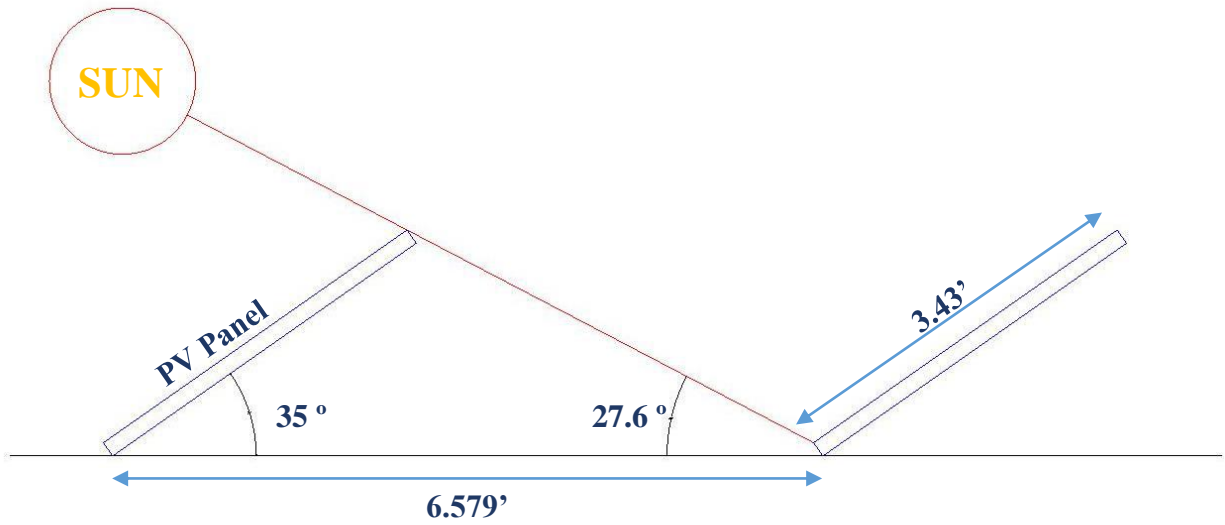


Figure 60 PV panel spacing calculation

After calculating the panel spacing, a layout was created in AutoCAD with the exact dimensions of the roof plan and the roof area that each panel would cover. Figure 61 below shows the layout of the panels that face directly south. The orientation and layout resulted in a configuration of 337 panels on the roof.

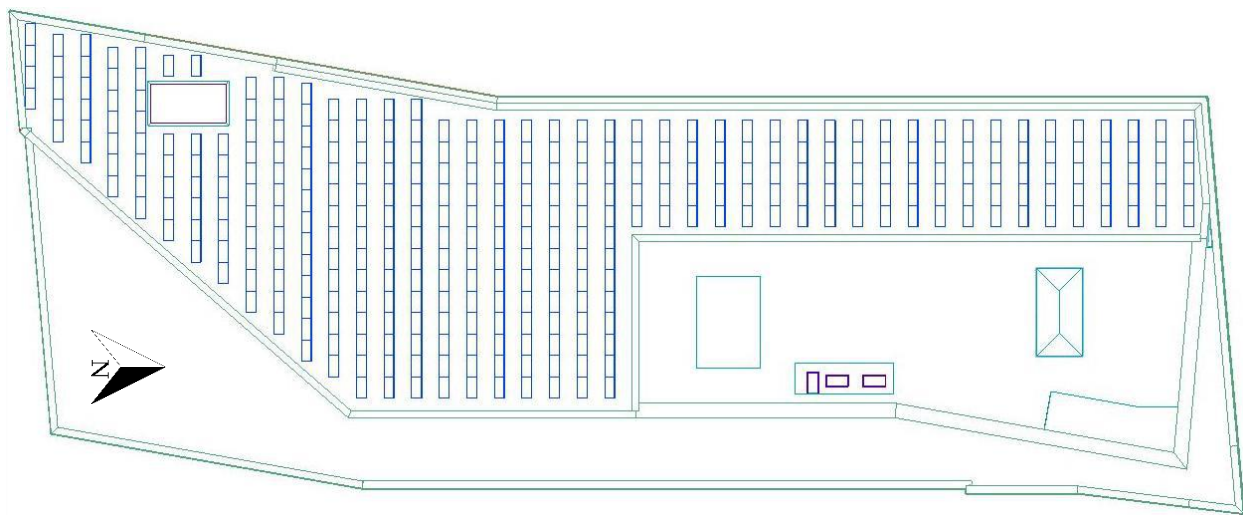


Figure 61 PV panel layout plan produced in AutoCAD

After determining the amount of panels that fit on the roof plane, the PVWatts calculator was used to determine the output of the system. The DC system size of the 337 panels came out to be 116.265 kW (337 panels x 345 Watts). Because of the high efficiency of the SunPower panels, the module type was selected as 'Premium,' which estimates the panels to be 19% efficient. This value was slightly lower than the actual efficiency, which means that the result of the study is slightly lower than the actual power production. The system losses were automatically generated within the program, but were slightly lowered to eliminate any calculated loss of shading from buildings or from other panels. The system information inputs are shown in Figure 62 below.

### SYSTEM INFO

Modify the inputs below to run the simulation.

DC System Size (kW):	116.265	<a href="#">i</a>
Module Type:	Premium	<a href="#">i</a>
Array Type:	Fixed (roof mount)	<a href="#">i</a>
System Losses (%):	8.68	<a href="#">i</a> <a href="#">Loss Calculator</a>
Tilt (deg):	35	<a href="#">i</a>
Azimuth (deg):	180	<a href="#">i</a>

Advanced Parameters

DC to AC Size Ratio:	1.1	<a href="#">i</a>
Inverter Efficiency (%):	98.6	<a href="#">i</a>
Ground Coverage Ratio:	0.426	<a href="#">i</a>

Figure 62 PVWatts calculator inputs from online program

In order to generate a rough estimate of the cost of energy produced by the PV array, the system type was classified as commercial. The average cost of electricity purchased from the utility company was estimated from the Bureau of Labor Statistics. Their website provides average energy prices for each month of the year going back to 2006. The average price of electricity for the Bioengineering Building was determined to be \$0.13, which was taken from the year 2015 [Bureau of Labor Statistics 2016]. The results of the calculation done in the PVWatts calculator is shown in Figure 63 below.

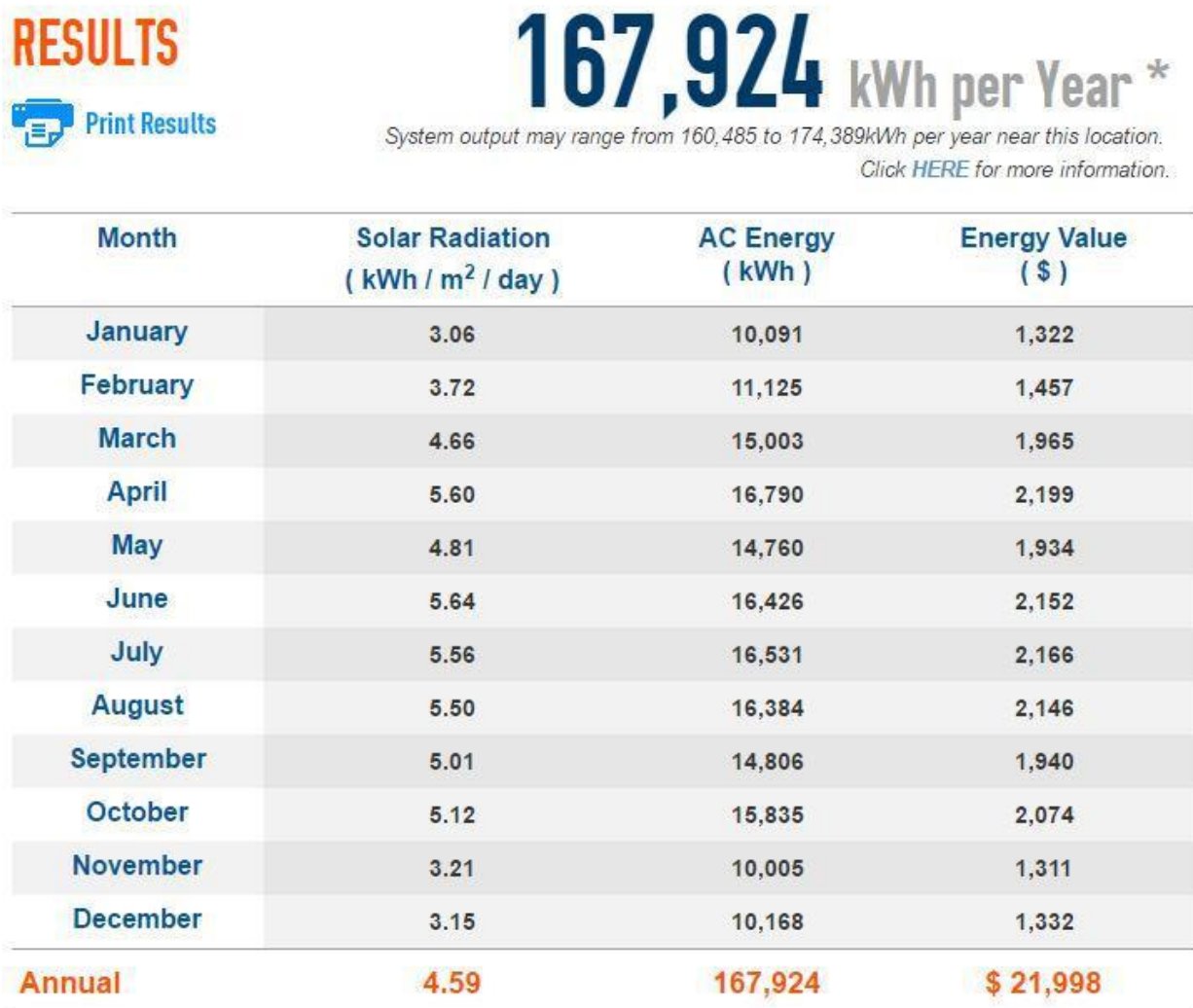


Figure 63 Results of PVWatts calculation



## 6.4 Payback Period Calculation

The PVWatts program also provides an estimate for the initial cost of installing the PV panel array based on the type of building that the array is designed for. This predicted value includes the PV panels, the inverter, extra hardware, and labor costs. The cost generated by PVWatts was **2.60 \$/W<sub>dc</sub>**, which means that the cost is in dollars per watt of dc power. The calculation of the payback period for the PV array on the Bioengineering Building is shown below.

### Calculation:

Initial Cost for 337 panels:  $\$2.60 / \text{W} \times 116.265 \text{ kW} \times 1,000 \text{ W/kW} = \$302,289$

Payback Period:  $\$302,289 / \$21,998 \text{ per year} = \mathbf{13.74 \text{ years}}$

## 6.5 Conclusion

A final pseudo color rendering of the PV panel array is shown in Figure 64 below. The panels are shown receiving the maximum amount of sunlight, which is distributed evenly across the roof plane.

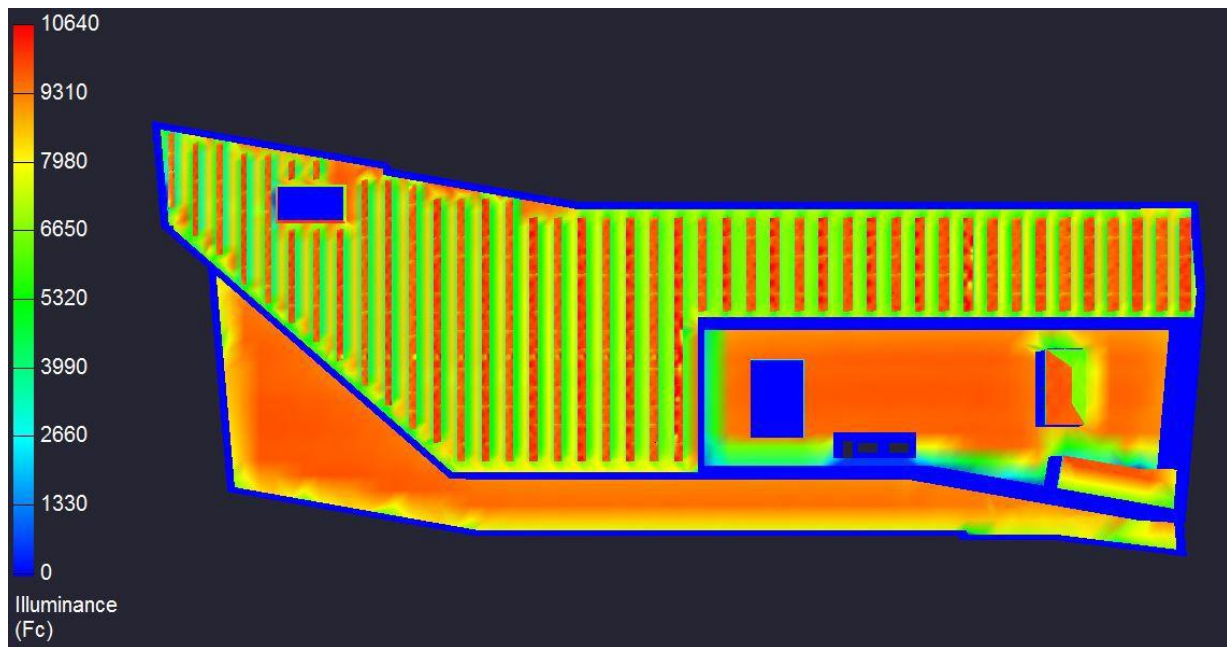


Figure 64 Pseudo color rendering of PV panel array on building rooftop

After analyzing the calculated payback period of the PV panel array, it was decided that it would be beneficial for the design to utilize this proposed system. Although a payback of 13.74 years is still a little steep, the PV manufacturer (SunPower) guarantees a 25 year warranty on the system. This would ensure at least 11 years of a fully functioning system that would be generating energy the building could use. PV panel systems typically last more than 30 years, which would provide a long energy-generating lifetime for the system [Solar Energy 2016].

## Chapter 7 Lighting Depth

As part of the study of the Bioengineering Building, the lighting was redesigned for four spaces. The Exterior Plaza, the Lobby, the Flex Classroom, and the Flex Lab were studied for their existing properties such as material design, occupant use, and design goals. Using this information, design criteria was established and used to create a concept oriented lighting design. The lighting designs have been documented in the following sections and include lighting plans, calculations, lighting fixture schedules, and design renderings.

### 7.1 Background

The four spaces designed for the purpose of this report are located on the first floor of the Bioengineering Building and can be seen highlighted in blue in the axonometric view in Figure 65 below. This figure shows a birds eye view looking down into the first floor, including the Exterior plaza that wraps around the eastern and southern sides of the building.

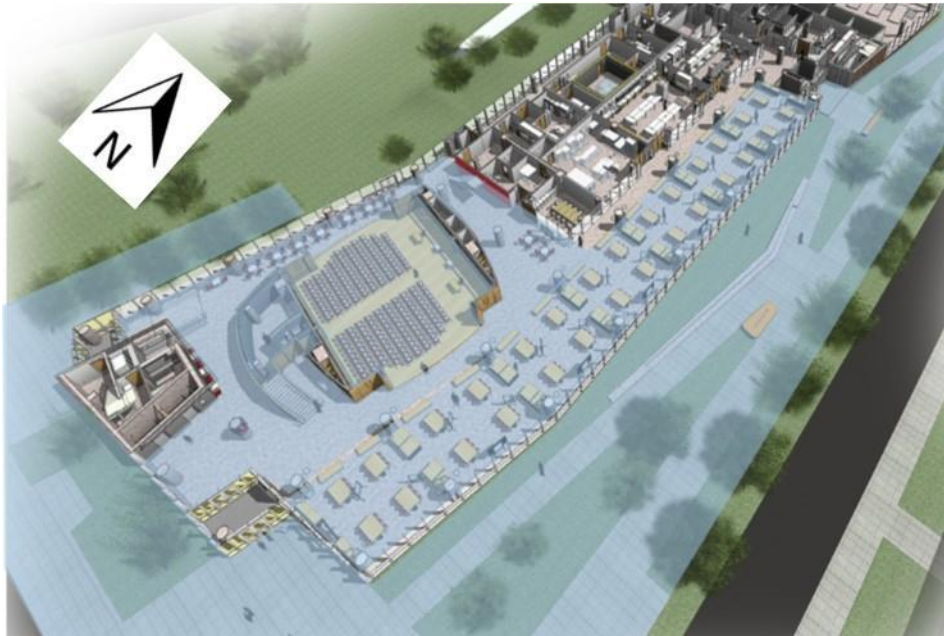


Figure 65 Axonometric view of four designed spaces located on the first floor (highlighted in blue)

The flow through the building was an important consideration within the design because of the connectivity of the four designed spaces. The goal of the design was to relate to the buildings located in the surrounding campus and facilitate movement through the site and into the building. The pathways that run along the length of the building are shown in red in Figure 66 below. As people move into the building, their main point of entry is the entrance in the southeastern corner. From there they can filter through the four designed spaces freely.

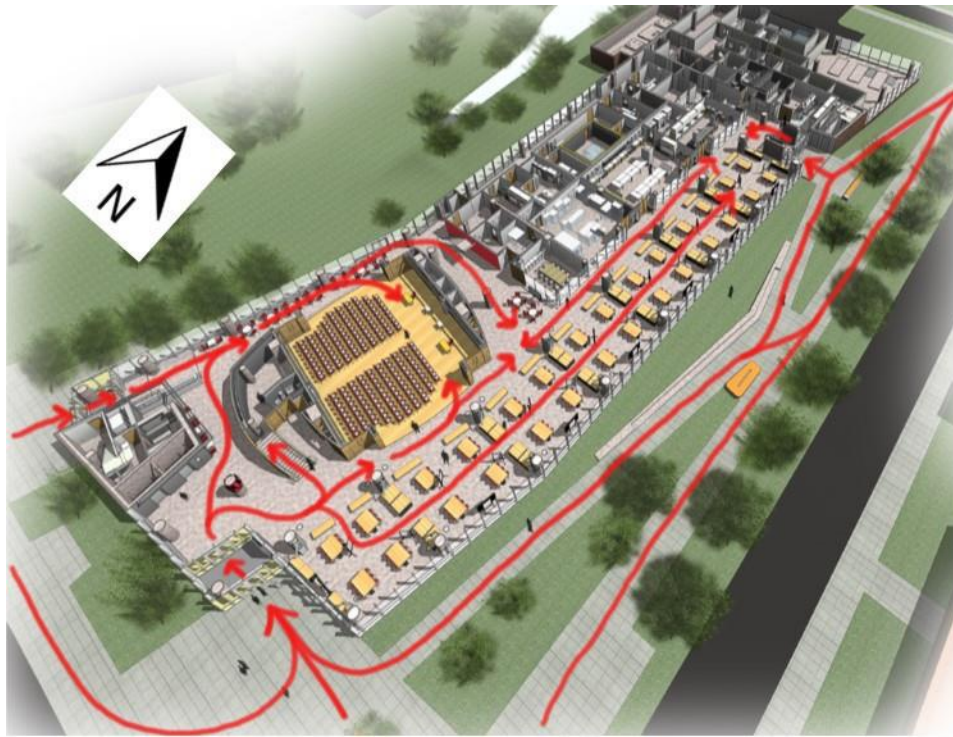


Figure 66 Axonometric view of foot traffic through designed spaces (indicated with red lines)

## 7.2 Overall Lighting Concept

The main principal of bioengineering is to find ways that the structures and functions of living organisms can be used as models for the design and engineering of materials and machines. The specific research done in this building combines the principles of biology and the tools of engineering to create usable and practical devices that improve the function of the human body, therefore enhancing the quality of life. With the research done in the building, there's a clear emphasis on the human body and the study of maintaining a consistent flow and function of its various systems. A building functions very similarly to a human body, requiring a connection and flow between its various interacting parts, which rely on each other to stay 'healthy'. Because each of the studied spaces are directly connected to each other, that flow is very important to the design, and like the body, each space must complement one another to create one cohesive design that represents the purpose of the building.



Figure 67 Lighting concept sketch

### 7.3 Exterior Plaza Design

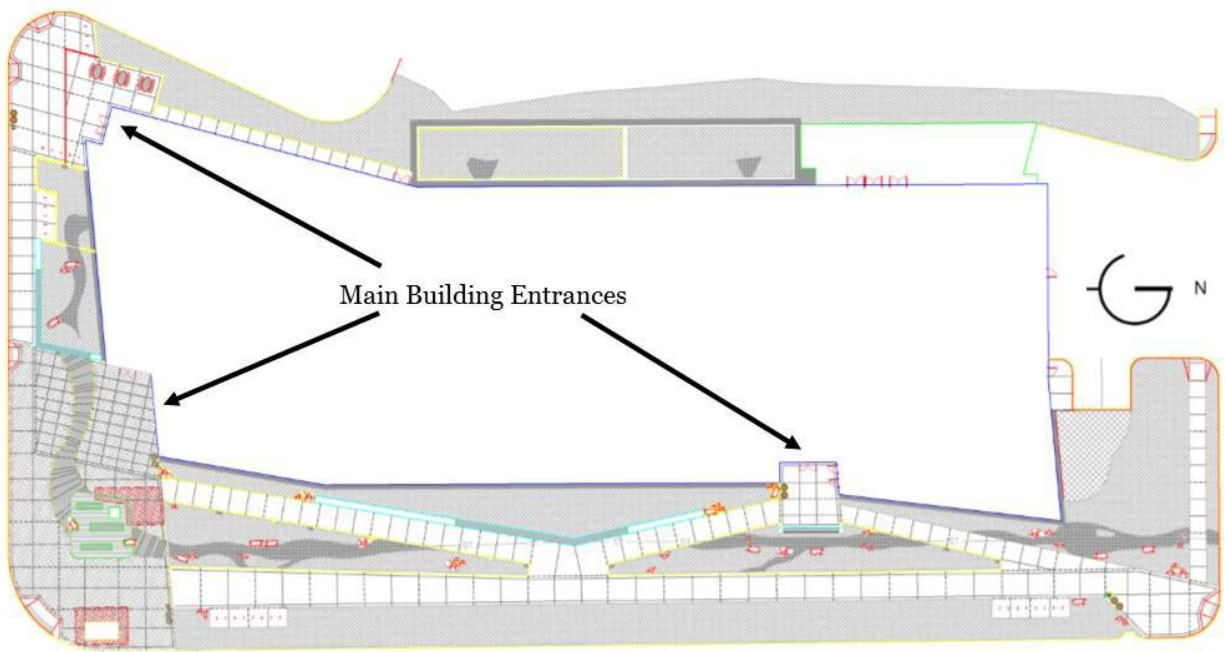


Figure 68 Site plan of Exterior Plaza showing main building entrances

#### 7.3.1 Space Summary

The Exterior Plaza wraps around the eastern and southern side of the Bioengineering Building and contains paths leading to all three of the main building entrances. Various paving materials mix with grasses and trees to create a landscaping fit for transition and gathering. One of the important design considerations for this space is the foot traffic from building to building. The proximity to the surrounding buildings requires a space that people can transition through simply and pleasantly. Benches along the paths make it easy for people to sit and enjoy the shade of the trees or meet up with others. A site plan can be seen in Figure 68 above.

**Dimensions:** approximately 48,000 ft<sup>2</sup>

**Amenities:** Benches, outdoor café seating, social table, pathways, bike racks



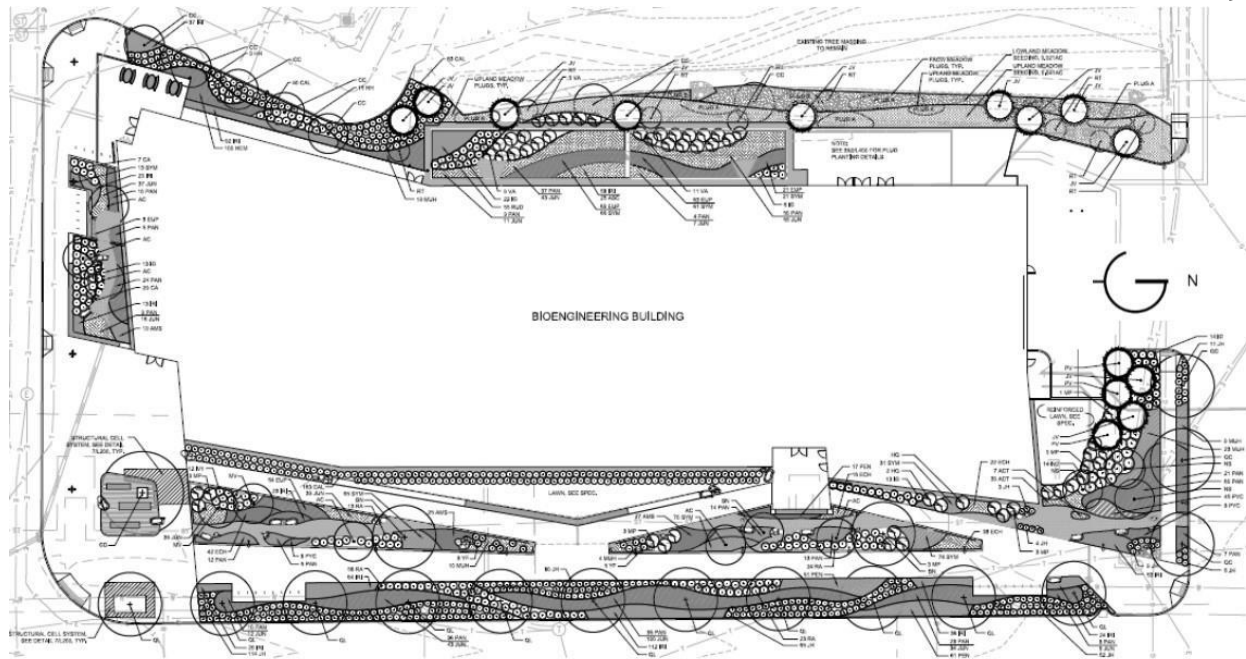


Figure 69 Exterior Plaza planting plan

The Exterior Plaza contains a mixture of paving and plantings that weave around the building, creating directional paths for people to travel. The landscaping contains shade trees, ornamental trees, Evergreen trees, shrubs, groundcover, ornamental grasses, and seed mixes. The paving in the plaza is built mainly with concrete and concrete pavers with some beach pebble splash. The site contains boulders, benches, bike racks, dining tables and chairs, recycling receptacles.

The plaza also has a 'social table,' which sits close to the main entrance to the building. This is a built up gathering spot containing benches for people to sit and relax. A section of this feature can be seen in Figure 70 below.

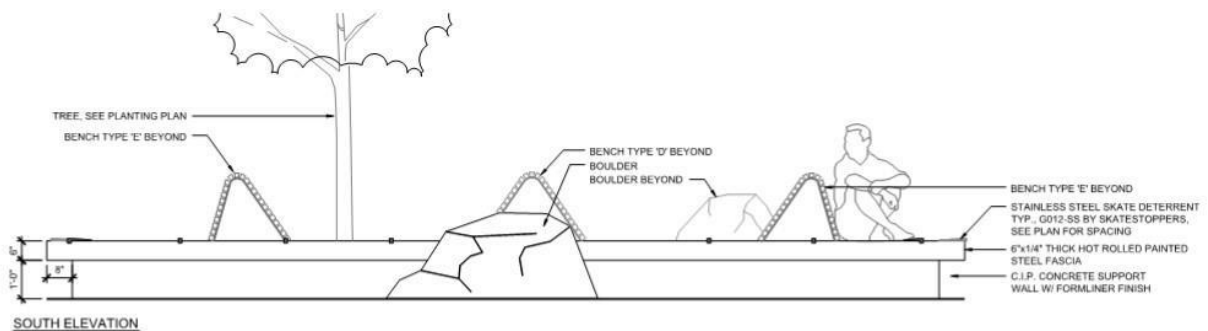


Figure 70 Social Table elevation



Figure 71 Perspective view rendering of Exterior Plaza, courtesy of Ballinger

### 7.3.2 Tasks & Design Considerations

The main purpose of the Exterior Plaza is to facilitate movement through the space while inviting visitors to sit and relax. People will be transitioning between the surrounding buildings and will typically be using the space for a few tasks. *These consist of:*

Transition, Safety, Wayfinding, Relaxation, Gathering

#### *Design Considerations:*

- Consider the connection to surrounding buildings
- Transition through the space
- Areas for relaxation and gathering
- Safety concern for occupants
- Light spill from the building interior
- Create an eye catching space



### 7.3.3 Design Criteria

The following illuminance and uniformity criteria was compiled using the IES Lighting Handbook, 10th edition as well as the campus standards for the building's location. The lighting power density allowance was found in ASHRAE/IESNA Standard 90.1-2010.

#### ***Illuminance:***

Walkways (horizontal ambient @ grade ): 0.5 fc

Entries (horizontal ambient @ grade ): 4 fc

#### ***Lighting Power Density:***

Walkway allowance (W/ft<sup>2</sup>): 0.2 or 1 W/ft of walkway

Entry allowance (W/ft<sup>2</sup>): 0.4

### 7.3.4 Overall Design Strategy

Much like people, the exterior of a building expresses the idea of its purpose and design. The landscape doesn't define the building, but it's the first impression that visitors have. Because of this quality, the plaza symbolizes a person's hair. It acts as an identity for the building but doesn't represent everything that goes on within.

Because the Exterior plaza is an outdoor space, transition and safety are main concerns for occupants, while wayfinding and social gathering will be important for the space as well. The goal of the design of this was to compliment the architecture of the building without throwing too much light on the façade. Because the façade is mostly curtain wall, light will spill out into the plaza. While over lighting is a concern, applying light to the transition areas and entryways is necessary for the safety of passerby.

Architectural light columns standing about 11ft tall line the pathways to direct people through the space. They provide general illumination as well as provide linearity along the façade of the building, helping to direct people down the paths to the surrounding buildings. The benches on the site are lined with tapelight, drawing people to those areas where they can gather. At the social table near the main entrance, linear lensed fixtures are integrated into the wood paneled benches, illuminating the platform with light. This encourages gathering in that space as well and creates a point of interest near the main entry to the building. Downlights are installed in the canopies to provide illumination at the building entries. Circular ingrade led lighting creates a sparkle that leads people to the entrances of the building, getting more concentrated as you get closer to the doors. This also mimics the point at which hair joins the body (exterior plaza joins the building) and where the transition through the rest of the body (building) can begin.



Figure 72 Exterior Plaza concept sketch

### 7.3.5 Proposed Lighting Design

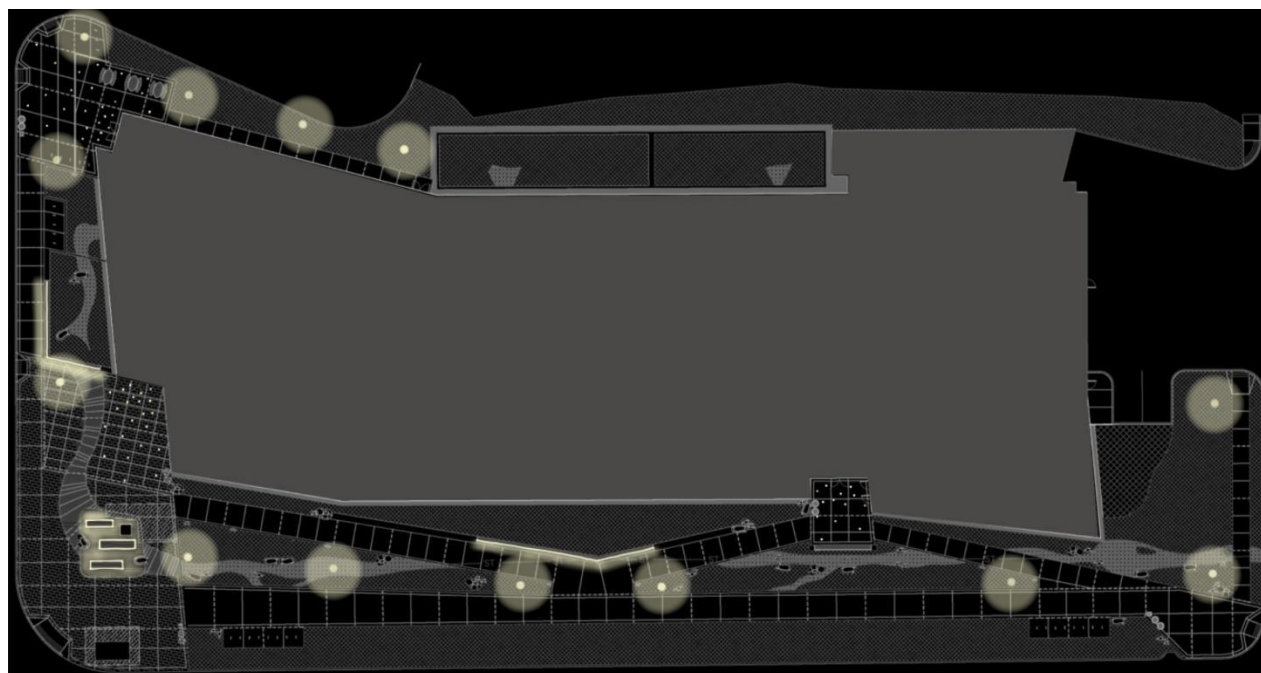






Figure 73 Initial proposed Exterior Plaza lighting design

### 7.3.6 Luminaire Schedule

Table 8 Exterior Plaza luminaire schedule

Type	Tag	Description	Manufacturer	Catalog Number	Wattage	Voltage
	EL1	LED Pedestrian Light Column, 6" diameter, 3790 lumens, 4000K CCT	Forms & Surfaces	LPLCO-612-LED-NS	32 W	277
	EL2	Flexible LED tube, 171 lumens per foot, 4000K CCT, >80 CRI	Acclaim Lighting	FTU-124-(length)AEN	3.3 W per foot	24VDC
	EL3	LED Downlight, 1.75" diameter, 2000 lumens, 4000K CCT, 95 CRI	Lumenpulse	LACN-A-277-L20-40K-CR95-M-RD-WH-DALI2-NC-WET-NA	24.8 W	277
	EL4	Ingrade LED uplight, Medium optics (35°), 136 lumens, 4000K CCT, >70 CRI	Philips Hadco	IL9-D-C-A	1.7 W	12 V

### 7.3.7 Final Lighting Design

The final design solution includes architectural light columns that line the walkways in the plaza, throwing light on the pedestrian paths. This aids in safety as well as wayfinding through the space without putting a high amount of light on the building façade. Flexible LED fixtures were used to line the benches as well as the social table, creating points of interest in the plaza for visitors to gather and relax. Figure 74 below shows a detail of the bench lighting. A channel will be cut into the concrete base of the benches, allowing the linear fixture to sit inside and shine out onto the site. Recessed downlights were installed above the doorways to light up the building entries, directing people inside. Ingrade LED uplights were also installed near the entries to create some sparkle in the space and draw people into the Bioengineering Building. In order to provide maximum legibility, the lighting plan for the Exterior Plaza has been placed in Appendix D.

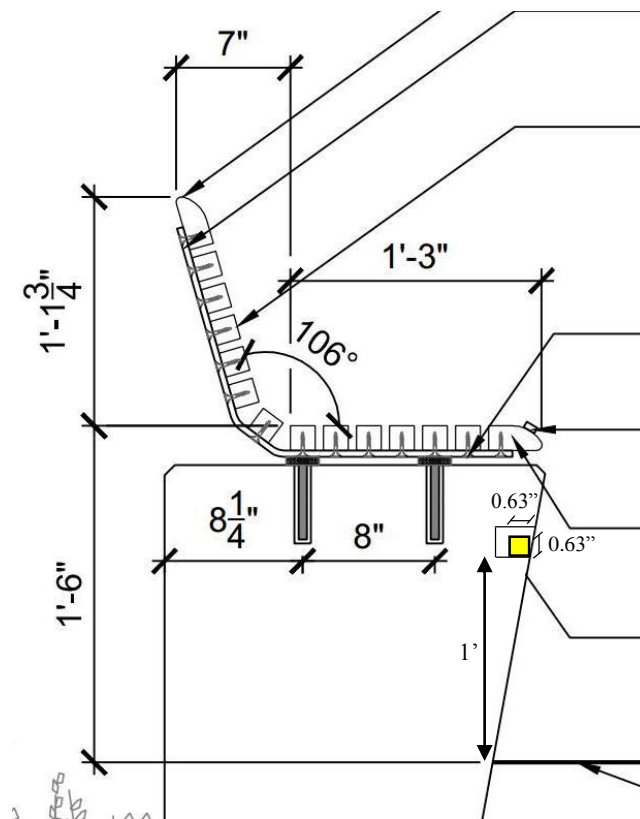


Figure 74 Detail of flexible LED bench lighting installation

### 7.3.8 Lighting Power Density Calculations

#### Walkways:

Table 9 LPD calculation for plaza walkways

<i>Fixture Type</i>	<i>Number of Fixtures</i>	<i>Watts/fixture</i>	<i>Total Watts (W)</i>
EL1	29	32	928
EL2	250'	3.3W/ft	825
EL4	30	1.7	51
Total Space Wattage (W)			1804
Space Area (ft <sup>2</sup> )			20,336.14
Watts/ft <sup>2</sup>			0.089 √
Allowed Watts/ft <sup>2</sup>			0.2

#### Main Entry:

Table 10 LPD calculation for main building entrance at southeastern corner of building

<i>Fixture Type</i>	<i>Number of Fixtures</i>	<i>Watts/fixture</i>	<i>Total Watts (W)</i>
EL3	2	24.8	49.6
EL4	13	1.7	22.1
Total Space Wattage (W)			71.7
Space Area (ft <sup>2</sup> )			512
Watts/ft <sup>2</sup>			0.14 √
Allowed Watts/ft <sup>2</sup>			0.4

#### Café Entry:

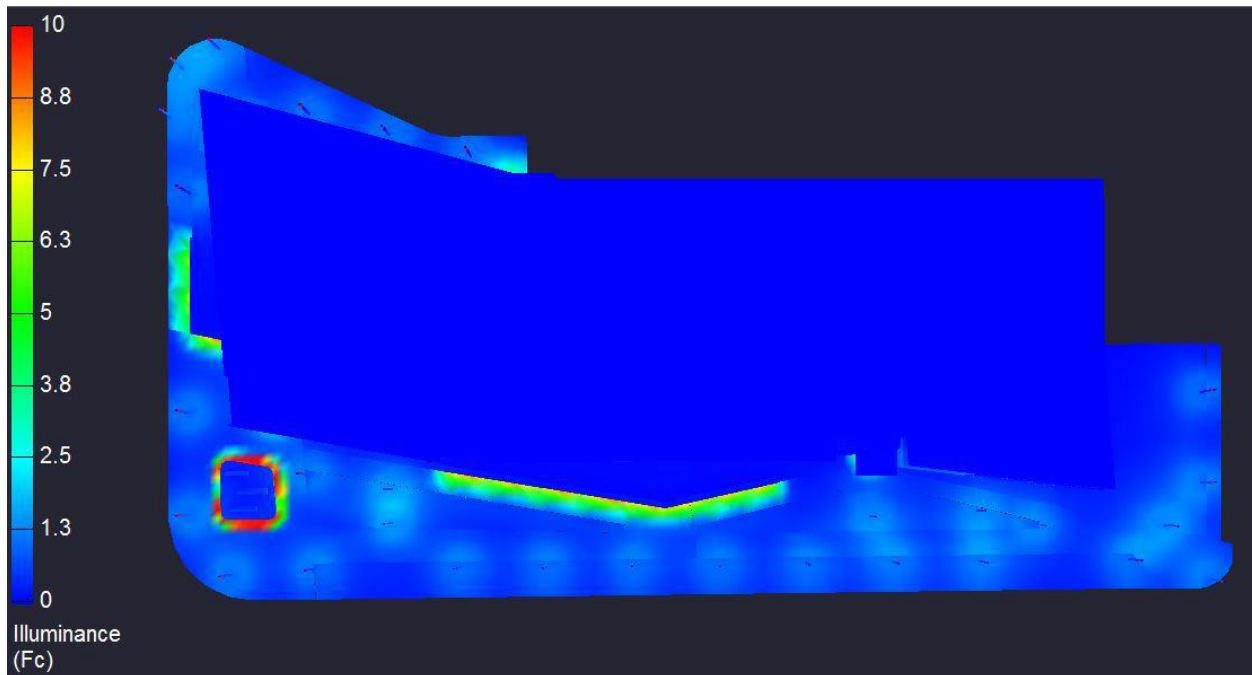
Table 11 LPD calculation for cafe entryway at southwestern corner of building

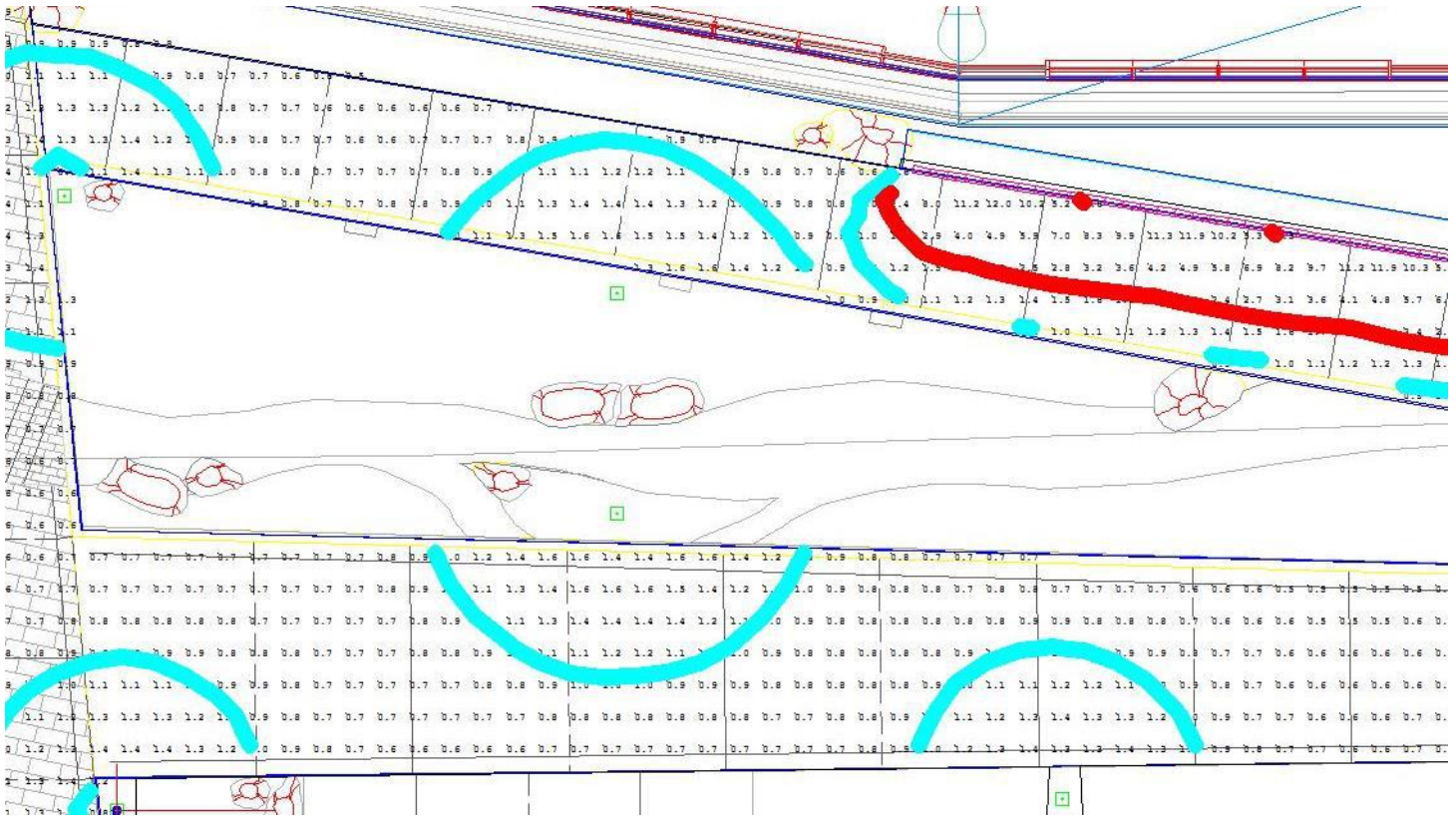
<i>Fixture Type</i>	<i>Number of Fixtures</i>	<i>Watts/fixture</i>	<i>Total Watts (W)</i>
EL3	1	24.8	24.8
EL4	2	1.7	3.4
Total Space Wattage (W)			28.2
Space Area (ft <sup>2</sup> )			129.5
Watts/ft <sup>2</sup>			0.218 √
Allowed Watts/ft <sup>2</sup>			0.4

***Eastern Entry:*****Table 12 LPD calculation for eastern building entryway**

<i>Fixture Type</i>	<i>Number of Fixtures</i>	<i>Watts/fixture</i>	<i>Total Watts (W)</i>
EL3	1	24.8	24.8
EL4	6	1.7	10.2
Total Space Wattage (W)			35
Space Area (ft <sup>2</sup> )			269.13
Watts/ft <sup>2</sup>			0.13 $\checkmark$
Allowed Watts/ft <sup>2</sup>			0.4

Each of the areas in the Exterior Plaza satisfy the lighting power density requirements set by ASHRAE/IESNA Standard 90.1-2010.

**7.3.9 Lighting Calculations****Figure 75 Exterior Plaza plan view pseudo color calculation (AGi32)**





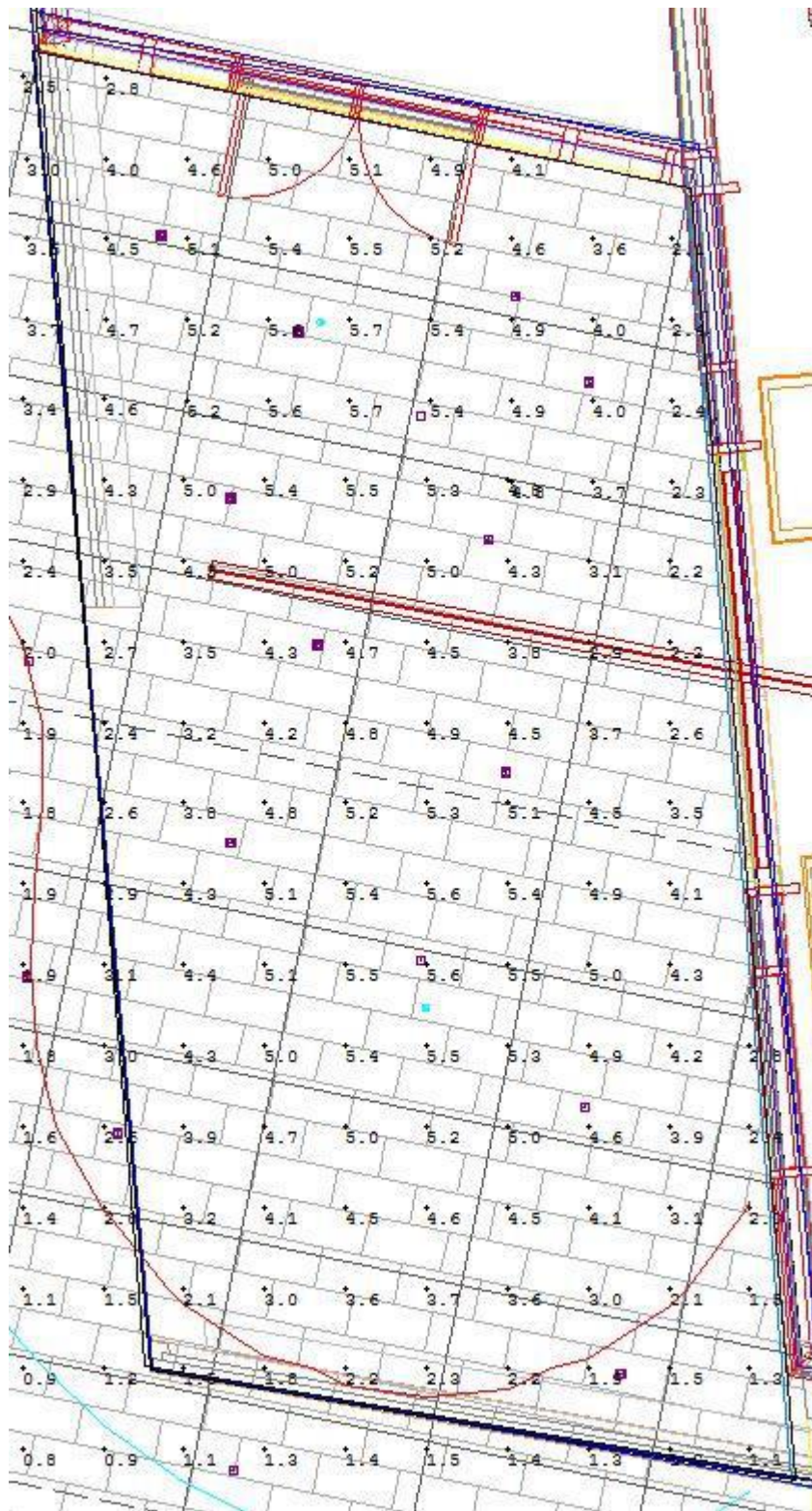


Figure 77 Main entrance illuminance calculation (AGi32)

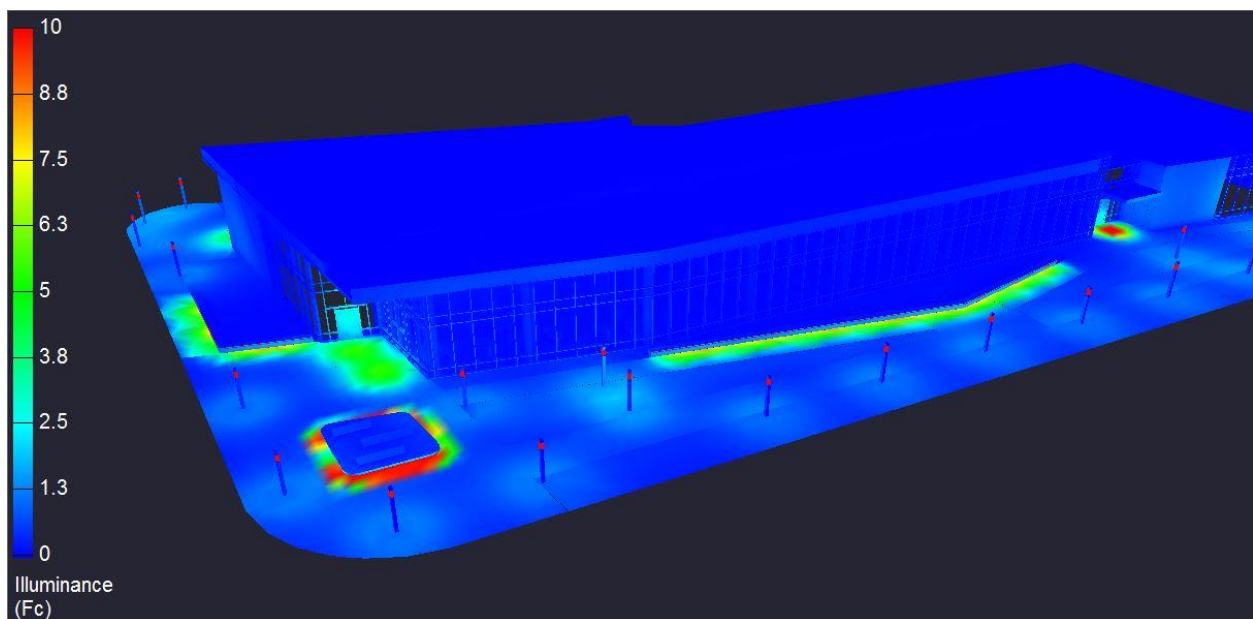


Calculation points were placed at the ground level and were compared to the target values listed in the Design Criteria section. Figure 76 and 77 on the previous pages show the results of the illuminance calculation across the Exterior Plaza. The Light Loss Factor was assumed to be 0.70, as is typical with LED fixtures in industry practice.

**Table 13 Exterior Plaza Illuminance Levels**

<i>Calculation Area</i>	<i>Average Illuminance (fc)</i>
Main Entry	4.39 √
South Entry	5.05 √
Café Entry	5.59 √
Walkways	1.59 √

### 7.3.10 Renderings



**Figure 78 Final design pseudo color rendering without interior lighting (AGi32)**

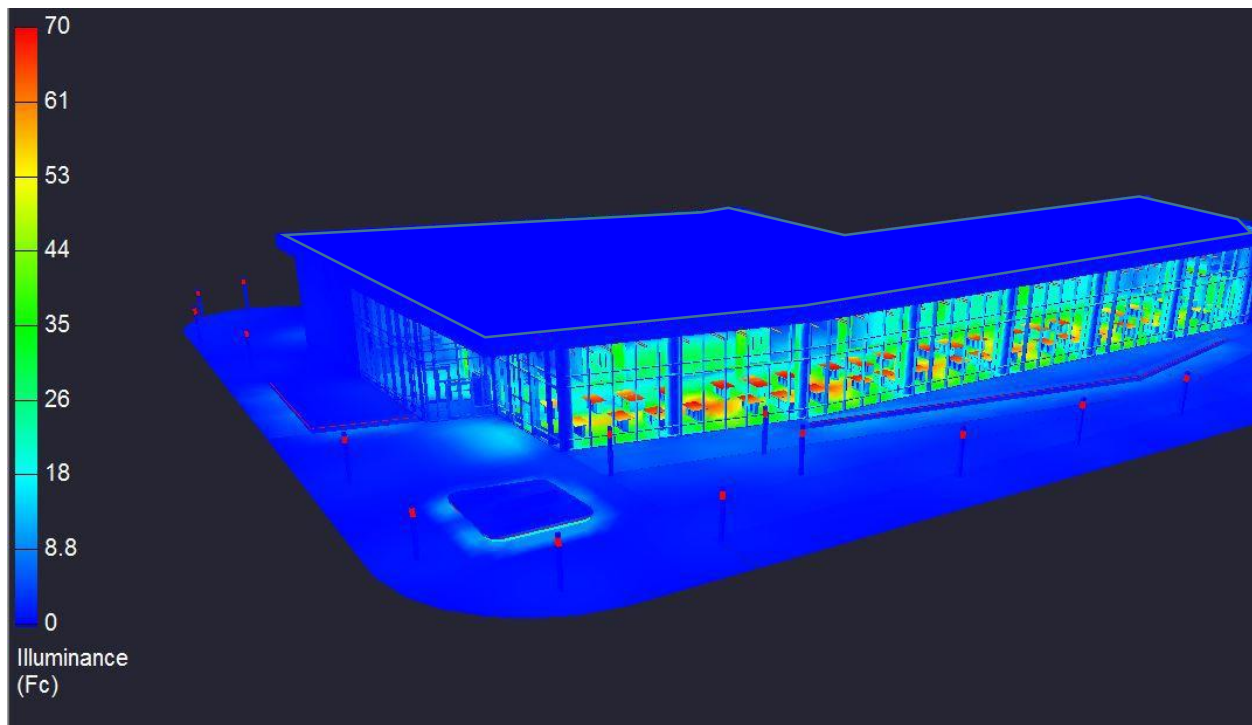


Figure 79 Final design pseudo color rendering with interior lighting (AGi32)



Figure 80 Final design raytrace rendering with interior lighting (AGi32)

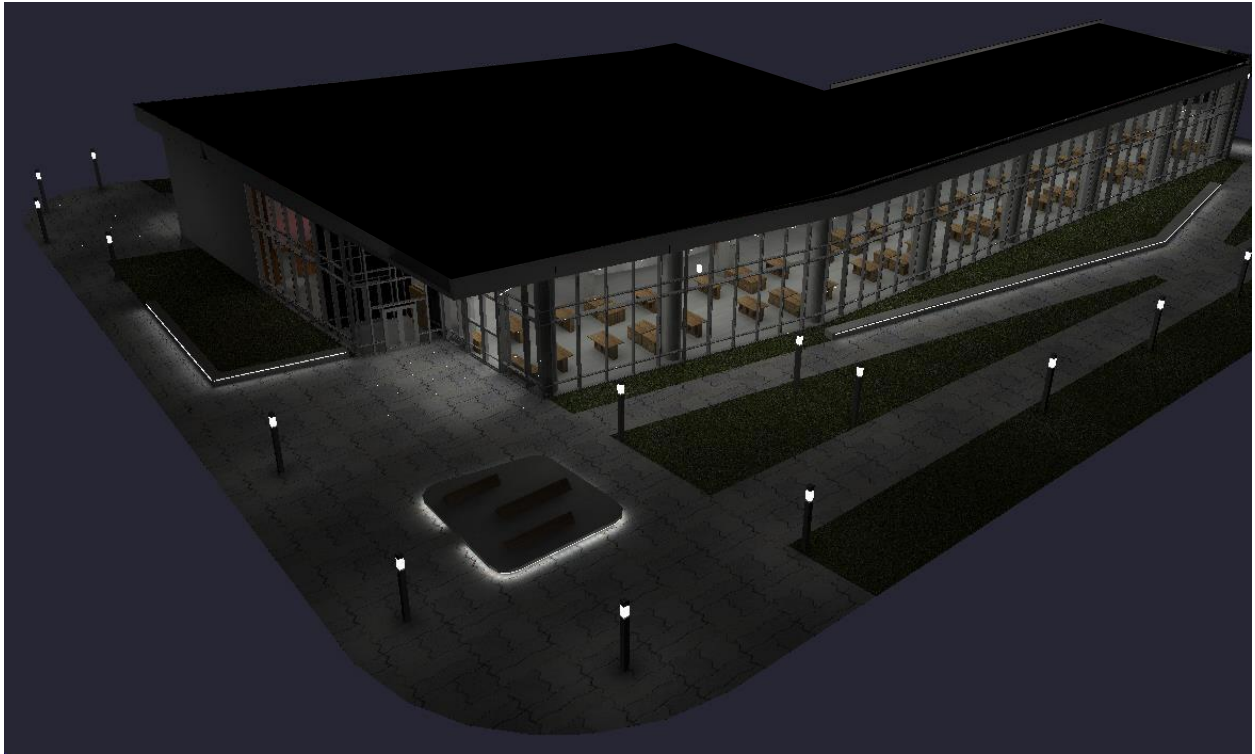


Figure 81 Exterior Plaza perspective view raytrace rendering (AGi32)



Figure 82 Exterior Plaza raytrace rendering main entrance (AGi32)

### **7.3.11 Evaluation & Controls Discussion**

The Exterior Plaza design uses a lot less wattage than the required amount. The lighting facilitates movement throughout the space, guiding people into the Bioengineering Building and to the surrounding buildings. The illuminated benches and Social Table provide areas for visitors to sit and relax. The architectural light columns provide enough light over the plaza for safety and help provide a directional line of light to guide people. They are positioned far enough away from the building façade so that the exterior lighting doesn't leak into the building. The entryways are appropriately illuminated and highlighted with a bit of sparkle from the ingrade fixtures. Overall the design integrates well with the Flex Lab and Lobby space that looks out into the Plaza. The design doesn't overwhelm the façade with light, allowing the interior to stand out as a glowing box.

The lighting in the Exterior plaza will be controlled by the Building Automation System that exists on the site, which will have an automatic timer to control the times the lighting switches on and off. To satisfy the requirements of ASHRAE 90.1, the plaza lighting will automatically turn off when there is sufficient daylight on the site. The light columns, linear bench lighting, and downlights have the ability to dim through integral DALI and DMX drivers, while the ingrade uplights can be adjusted through four present lighting levels. The governing campus will have the ability to monitor the lighting systems and determine the output that they would like to run the fixtures throughout the day.

## 7.4 Lobby Design



Figure 83 Lobby floor plan highlighted in purple

### 7.4.1 Space Summary

The two-story lobby serves as the main entry to the building and centers around the grand staircase. Occupants will mainly filter in through the southeastern entrance and transition through the rest of the building. Curtain walls surround the space on the southern and western side, while the eastern side is open directly to the Flex Lab. A café is located by the elevator core at the southwestern end of the lobby. This provides a point of gathering for occupants that choose to stay and relax in the space. A floor plan for the lobby can be seen in Figure 83 above.

***Dimensions:*** 4,767 ft<sup>2</sup>

***Height:*** 26' 3"

**Materials:****Table 14 Materials in Lobby**

<i>Location</i>	<i>Material</i>	<i>Product</i>	<i>Manufacturer</i>	<i>Color</i>	<i>Reflectance</i>
Floor	Sealed Concrete				.5
Wall	Wood Panel	Maple Wood on MDF			.4
	Acoustical Wall Panels	Maple Wood			.3
	Metal Wall Panel (2)				.7
	Metal Wall Panel (1)				.7
	Gypsum Wall Board 2				.85
	Stone Panels				.24
	Paint	Scuffmaster	Wolf Gordon	GOH 09796259	.74
	Paint	Harmony Series	Sherwin Williams	SW7018 Dovetail	.8
Base	Wood Base, Maple Stained				.4
	Rubber Base	Pinnacel Type TS	Roppe	178 Pewter	.1
	Metal Base				.7
Ceiling	Gypsum Wallboard 1				.85
	Gypsum Wallboard 2				.85
	Acoustical Ceiling Panel	Fiberglass		White	.3

**7.4.2 Tasks & Design Considerations**

The main purpose of the Lobby is to serve as an eye-catching space, drawing occupants into the building. This requires a design that is visually appealing while facilitating the tasks completed in the space. *These consist of:*

Circulation, Wayfinding, Group gathering, Café seating, Events, Transition into connecting spaces

***Design Considerations:***

- Consider the height of space
- Emphasize grandeur of the space
- Main entry to the building
- Openness and connection to surrounding spaces
- Daylighting influence
- Controls

**7.4.3 Design Criteria**

The following illuminance and uniformity criteria was compiled using the IES Lighting Handbook, 10th edition as well as the campus standards for the building's location. The lighting power density allowance was found in ASHRAE/IESNA Standard 90.1-2010.

***Illuminance:***

Horizontal ambient during day @ grade:	10 fc
Horizontal ambient at night @ grade:	5 fc
Vertical during day @ 5':	5 fc
Vertical during at night @ 5':	2 fc

***Uniformity:***

Across space (avg to min):	3 : 1
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***Lighting Power Density:***

Allowance (W/ft <sup>2</sup> ):	1.36
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### 7.4.4 Overall Design Strategy

The large lobby is the main entry and the first thing most people will see when they enter the Bioengineering Building. Because it's double story, occupants should feel like they're walking into a grand and welcoming entry. It serves as a transition space as well as the main gathering area for visitors, encouraging occupants to branch off to various destinations in the building. For this reason, the lobby acts as **the heart**, facilitating the movement of occupants. Like veins and arteries, pathways branch from "the heart" to the rest of "the body."



Figure 84 Lobby concept sketch

Because circulation is the main task, the main goal for the design was to create an eye-catching space that also facilitates movement through the building. The grand stairway and connected hallways are important points of interest for transition through the space that require specific lighting to emphasize them. One of the main considerations for this space is the relationship to the surrounding rooms. From the exterior, the lobby is extremely visible and opens directly to the Flex Lab, which is a showpiece for the building. The design creates minimal spill light leaving the lobby and utilizes fixtures that compliment the style and performance of the ones used in the lab. Surface mounted cylindrical LED pendants mimic arteries connected to the heart and are clustered above the staircase to create a centralized artistic chandelier-like piece. These glowing tubes drop from the ceiling at varied lengths. Linear LED grazers wrap around the flex classroom in a cove, grazing the wood wall upward bringing some texture into the space. A cove is also built at the ceiling, tracing the stairway core and the flex classroom. Linear LED cove lighting washes the ceiling with light heightening the space and creating the grand feeling that the lobby should embody. Downlights are installed in the ceiling bringing ambient light to the floor and helping to create a uniform illumination over the lobby that easily relates to the surrounding spaces.



Ingrade uplights are also installed at the base of the column to graze upward, illuminating the large piece in the entryway. A color-changing LED cove fixture is installed around the elevator core, grazing the wall with various colors depending on the owner's preference.








#### 7.4.5 Proposed Lighting Design



Figure 85 Initial proposed Lobby lighting design

### 7.4.6 Luminaire Schedule

Table 15 Lobby luminaire schedule

Type	Tag	Description	Manufacturer	Catalog Number	Wattage	Voltage
	LL2	LED RGBW cove, 10 ° x60° distribution, 2,041 lumens for 4ft	Lumenpulse	LOG-277-48-RGBW-10x60-UMAS-SI-DMX/RDM	17.25 W/ft	277
	LL3	Linear Asymmetric LED cove, 1757 lumens, 4000K CCT, >85 CRI	Lumenpulse	LOGRO-277-48-40K-WWLF-UMAS-SI-ES	8.5 W/ft	277
	PL2	LED Cylindrical Tube, 3.5” diameter, 8 ft long, 2706 lumens, 4000K CCT, >70 CRI	Buck	25721110-NW2/840-LED-8ft-2706-63W	63 W	277
	PL3	LED Cylindrical Tube, 3.5” diameter, 6 ft long, 2706 lumens, 4000K CCT, >70 CRI	Buck	25721110-NW2/840-LED-6ft-2706-63W	63 W	277
	PL4	LED Cylindrical Tube, 3.5” diameter, 4 ft long, 2706 lumens, 4000K CCT, >70 CRI	Buck	25721110-NW2/840-LED-4ft-2706-63W	63 W	277
	DL2	Recessed LED Downlight, 3” diameter, 700 lumens, 4000K CCT, 95+ CRI	Lumenpulse	LADN-A-277-L07-40K-CR95-M-RD-GRY-DALI2-CL	7 W	277
	UL1	Ingrade LED uplights, 13” diameter, 3041 lumens, 4000K CCT	Kim Lighting	LTV81SS-SP-36L-4K-UV	44W	277

### 7.4.7 Final Lighting Design

The final design solution includes multiple layers of light, highlighting various area of the large lobby. Small downlights are oriented throughout the space to provide general illumination without creating large bright spots on the ceiling. Cove fixtures graze the Flex Classroom core, creating linearity in the space that draws visitors down the corridors and highlights the wood textured walls. Cove fixtures near the ceiling graze the ceiling of the lobby with light, making the space feel grand. Figure 86 below shows a plan of the cove installed around the Flex Classroom core. The cove wraps around the entire core (not shown on right side because it's out of scope of Lobby design) and sits about 26' high. The cove itself protrudes 1.5' away from the wall with a 6" tall lip to hide the fixture.

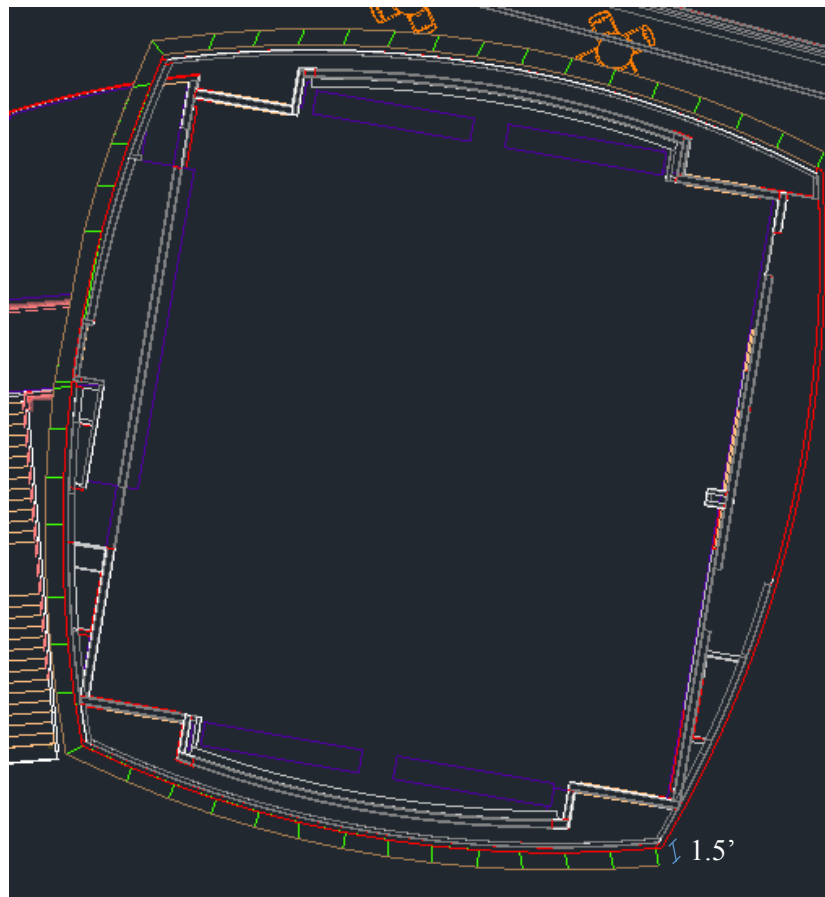


Figure 86 Plan of cove detail around Flex Classroom core (AutoCAD)

Figure 87 below shows the cove grazing the wall as well as the ceiling. Both coves are the same dimensions but sit at different heights. The bottom cove sits 12' above the ground while the top sits about 26' above the ground.

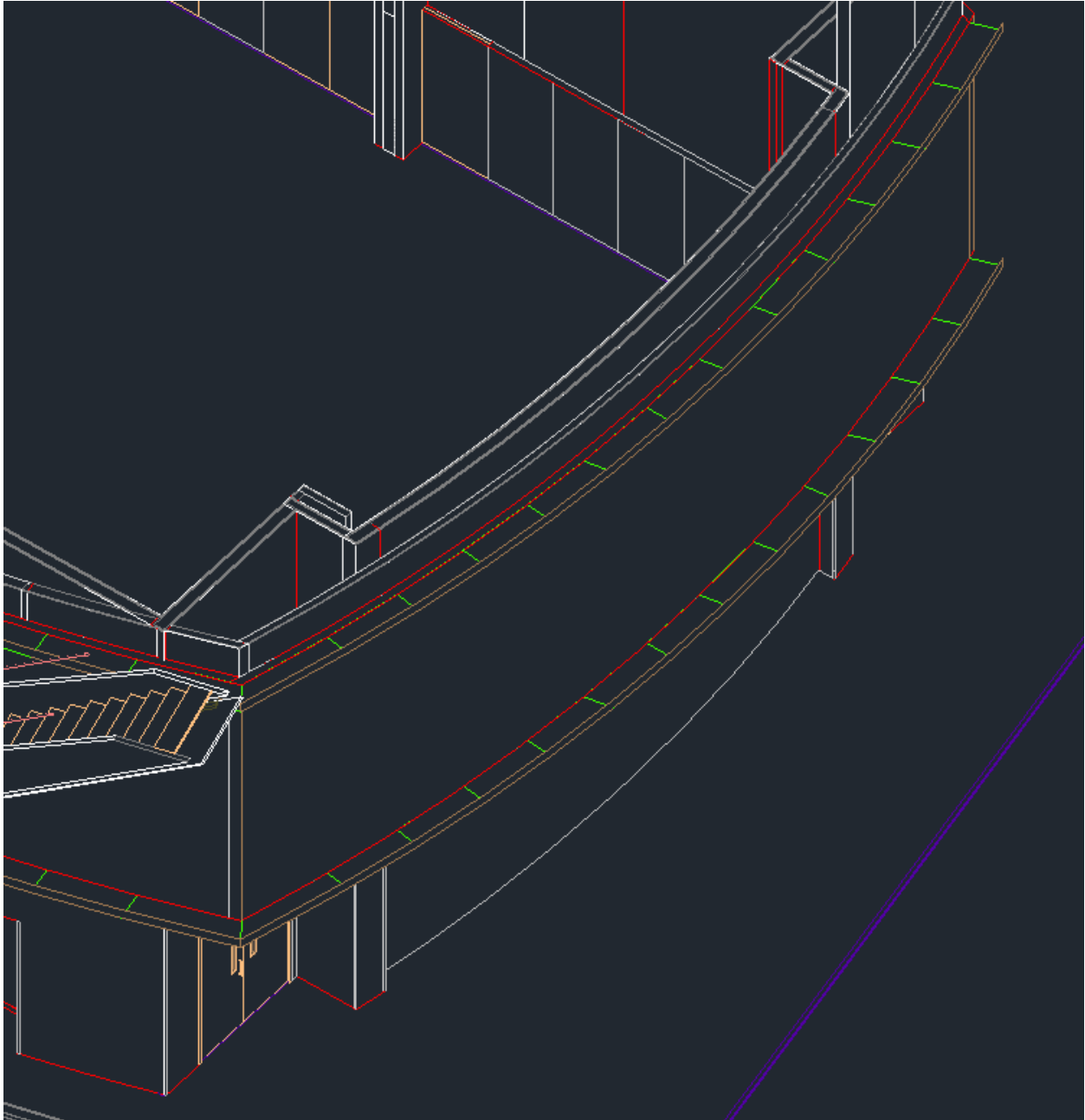


Figure 87 Perspective view of double cove around Flex Classroom core (AutoCAD)



Figure 88 Perspective view into coves around Flex Classroom (AGi32)



Figure 89 Perspective view into coves above elevator (AGi32)

Color changing wall grazers sit in a cove around the elevator core, providing a pop of color to the space. Figure 90 below shows a plan view of the cove lined in green. The cove stretches 1' from the wall and 8' off the ground.



Figure 90 Plan view of elevator core cove (AutoCAD)

Ingrade uplights surround the large column near the main entry, grazing the column with light.

Cylindrical glowing tubes hang from the ceiling above the large staircase. This creates a point of interest in the space, drawing people's eyes upward right when they enter the space. In order to provide maximum legibility, the lighting plan for the Lobby has been placed in Appendix D.

#### 7.4.8 Lighting Power Density Calculations

<i>Fixture Type</i>	<i>Number of Fixtures</i>	<i>Watts/fixture</i>	<i>Total Watts (W)</i>
LL2	44'	17.25 W/ft	759
LL3	424'	8.5 W/ft	3,604
DL2	85	7 W	595
PL2	6	63 W	378
PL3	5	63 W	315
PL4	8	63 W	504
UL1	4	44 W	176
Total Space Wattage (W)			6,331
Space Area (ft <sup>2</sup> )			4,767
Watts/ft <sup>2</sup>			1.33√
Allowed Watts/ft <sup>2</sup>			1.36



### 7.4.9 Lighting Calculations

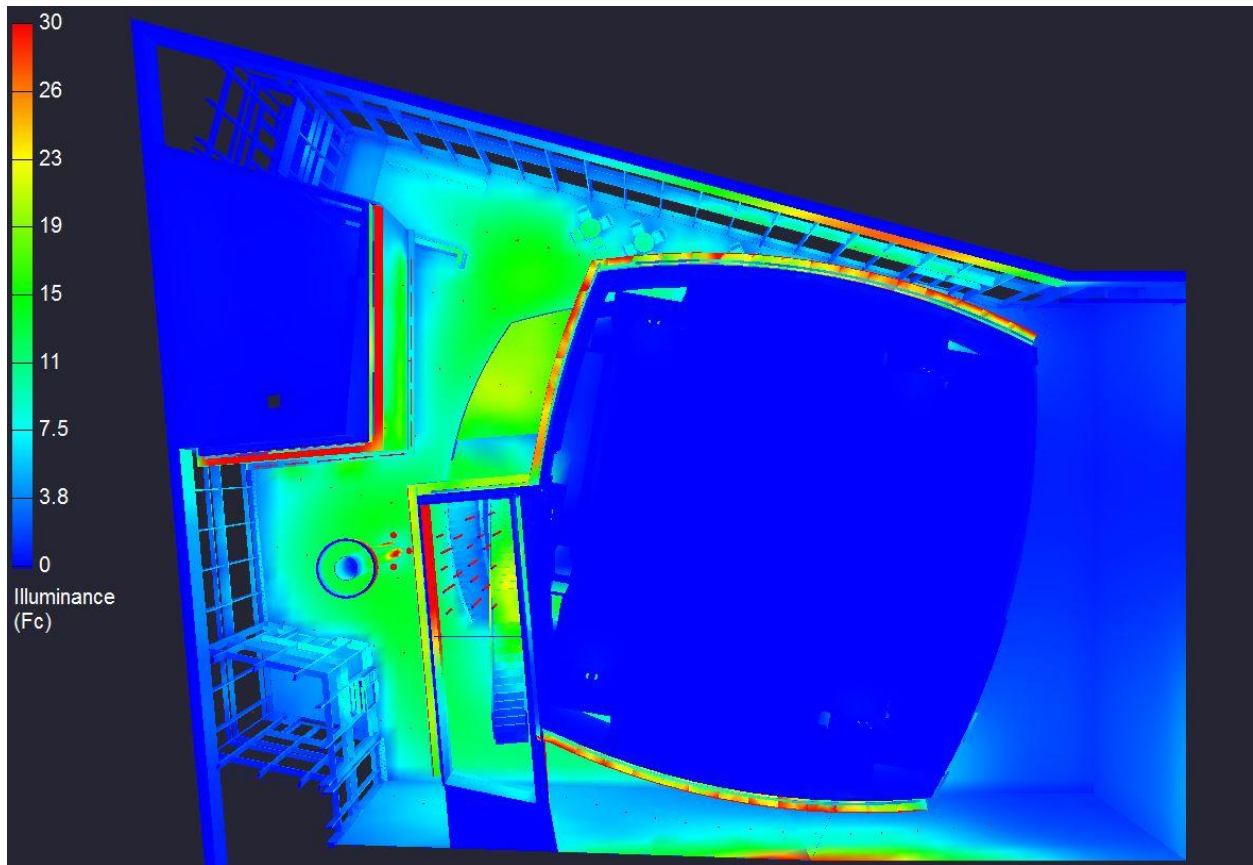


Figure 91 Lobby plan view pseudo color calculation (AGi)

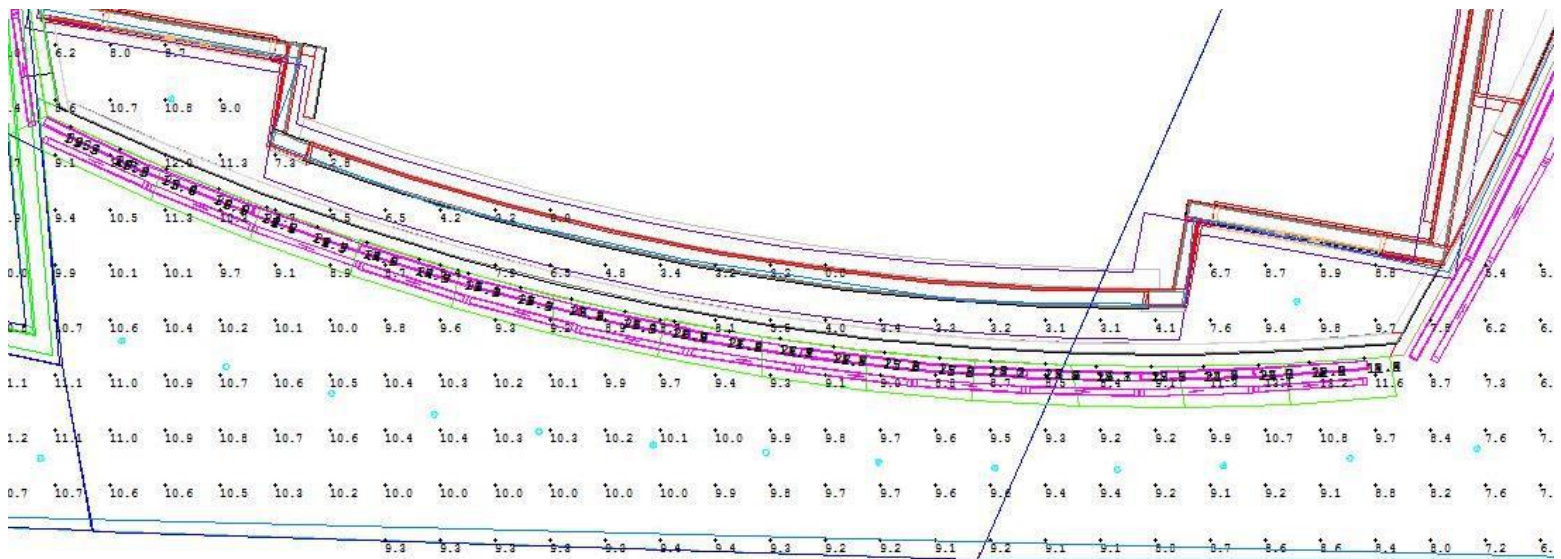


Figure 92 Typical corridor calculation values (AGi32)



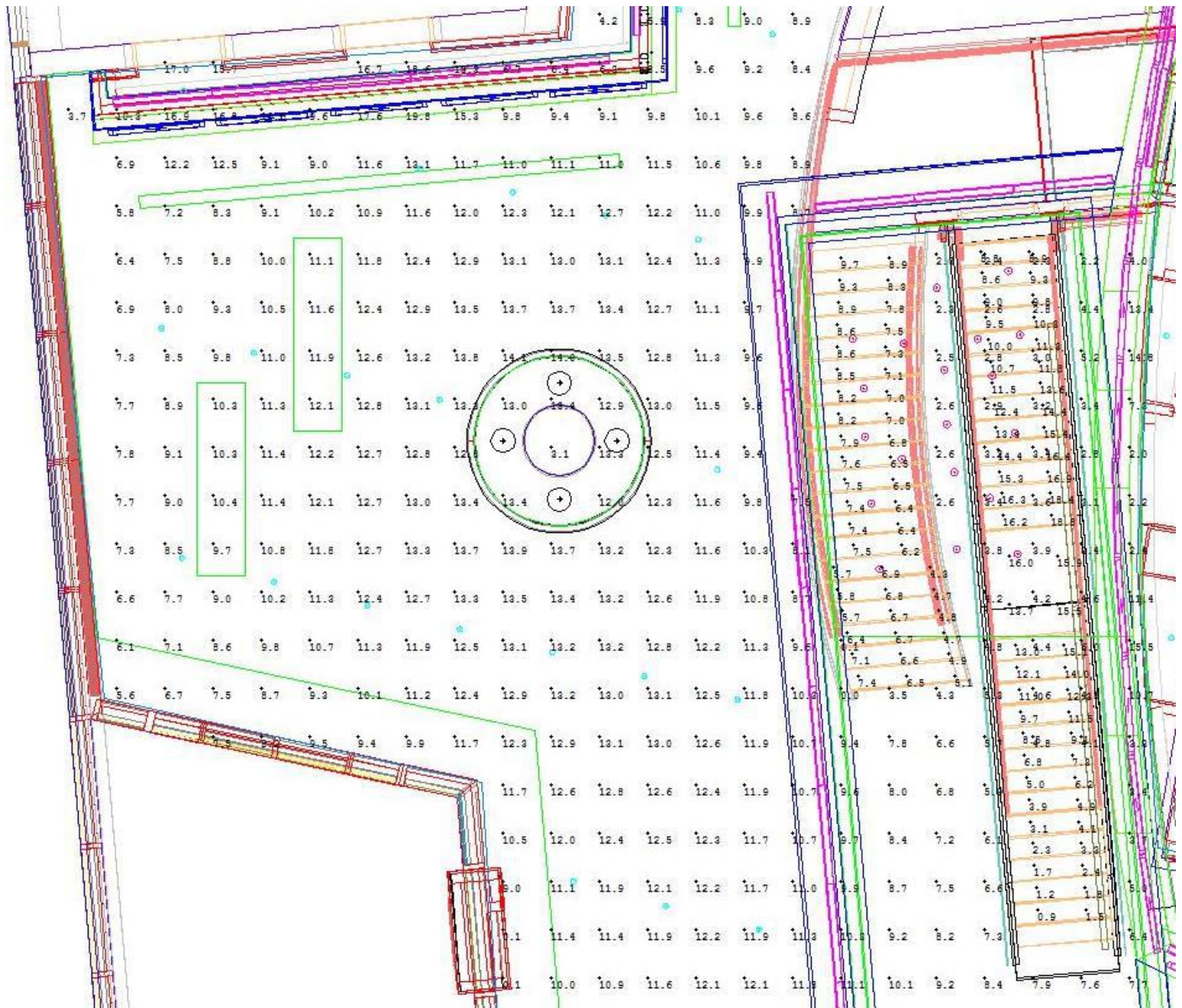


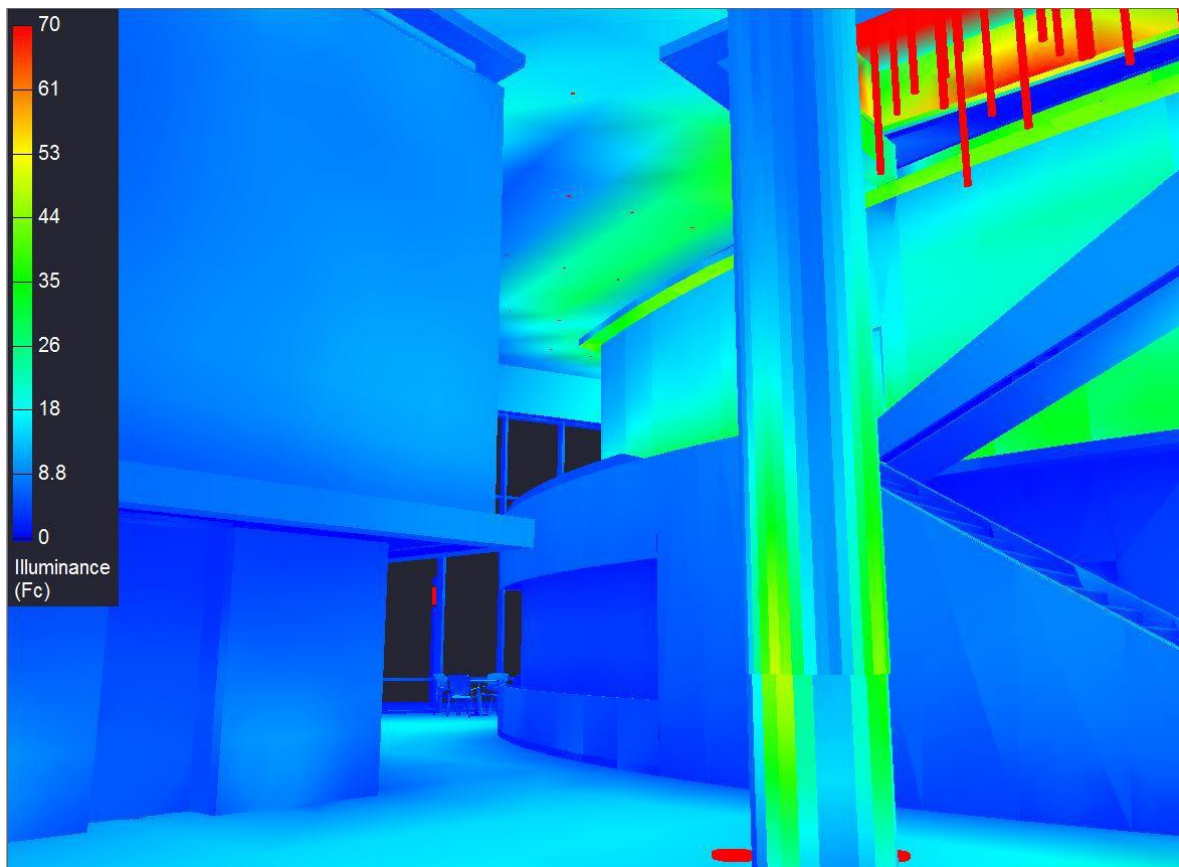
Figure 93 Main Entry calculation values (AGi32)

Calculation points were placed at the ground level and were compared to the target values listed in the Design Criteria section. Figure 92 and 93 on the previous pages show the results of the illuminance calculation across the Lobby. The Light Loss Factor was assumed to be 0.70, as is typical with LED fixtures in industry practice.

**Table 16 Lobby calculation results (AGi32)**

<i>Calculation Area</i>	<i>Values (fc or uniformity)</i>
Floor	10.1 $\sqrt$
Floor Uniformity	2.31:1 $\sqrt$

#### 7.4.10 Renderings



**Figure 94 Lobby interior pseudo color rendering from main entrance - view 1 (AGi32)**



Figure 95 Lobby interior raytrace rendering from main entrance – view 1 (AGi32)



Figure 96 View 1 direction for Figure 89 & 90



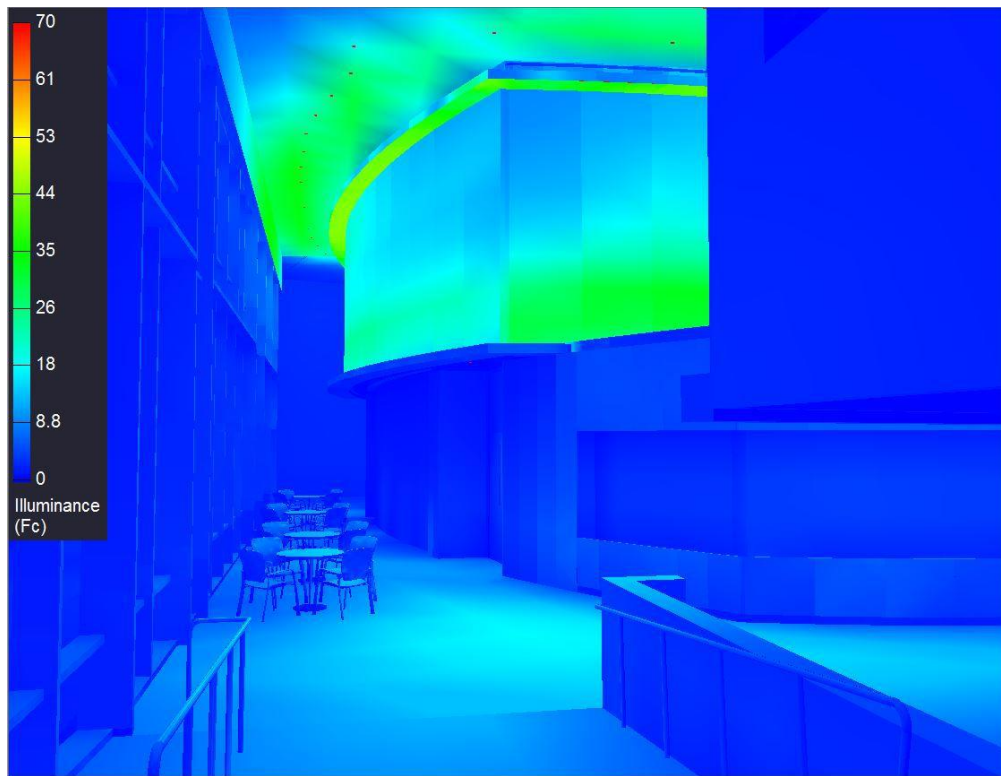


Figure 97 Lobby interior pseudo color rendering from Cafe entrance – view 2 (AGi32)



Figure 98 Lobby interior raytrace rendering from Cafe entrance - view 2 (AGi32)



Figure 99 View 2 direction for figure 92 & 93

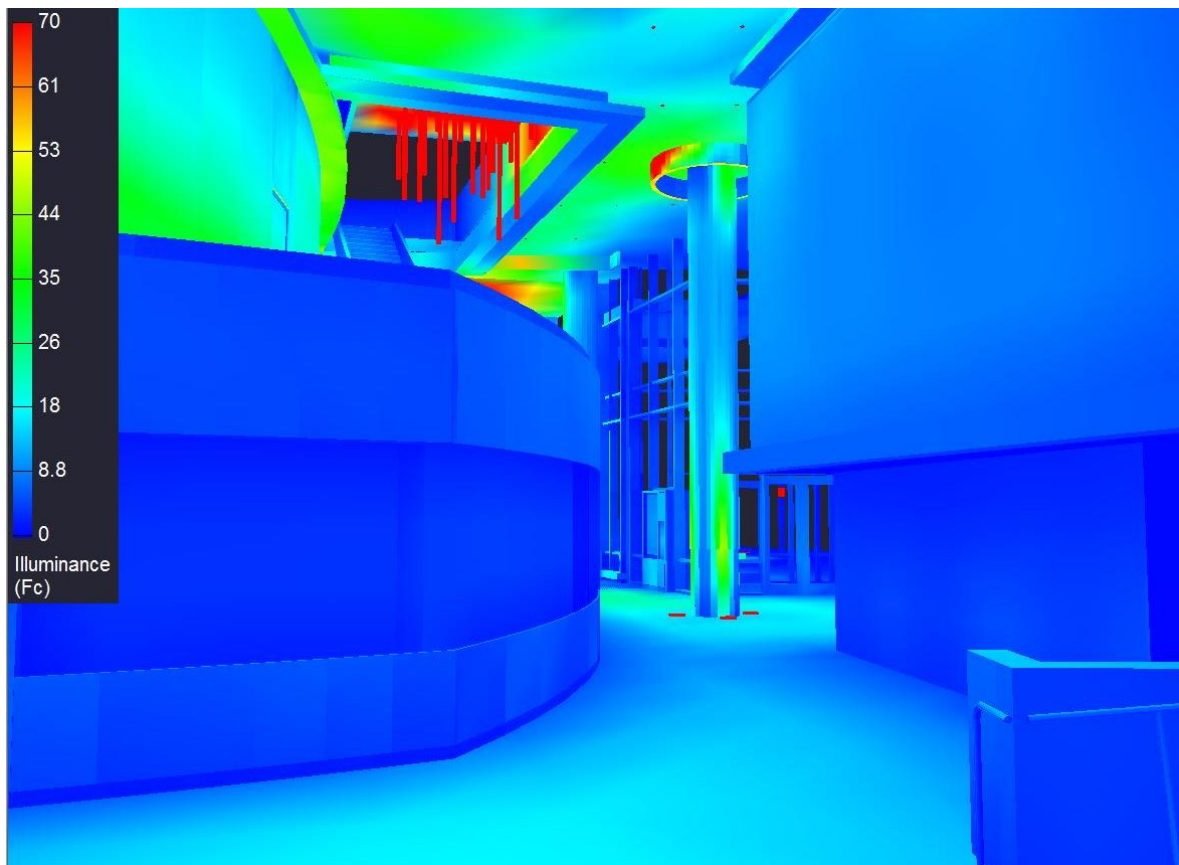


Figure 100 Lobby interior pseudo rendering facing main entrance - view 3 (AGi32)



Figure 101 Lobby interior raytrace rendering facing main entrance - view 3 (AGi32)



Figure 102 View 3 direction for figure 95 & 96

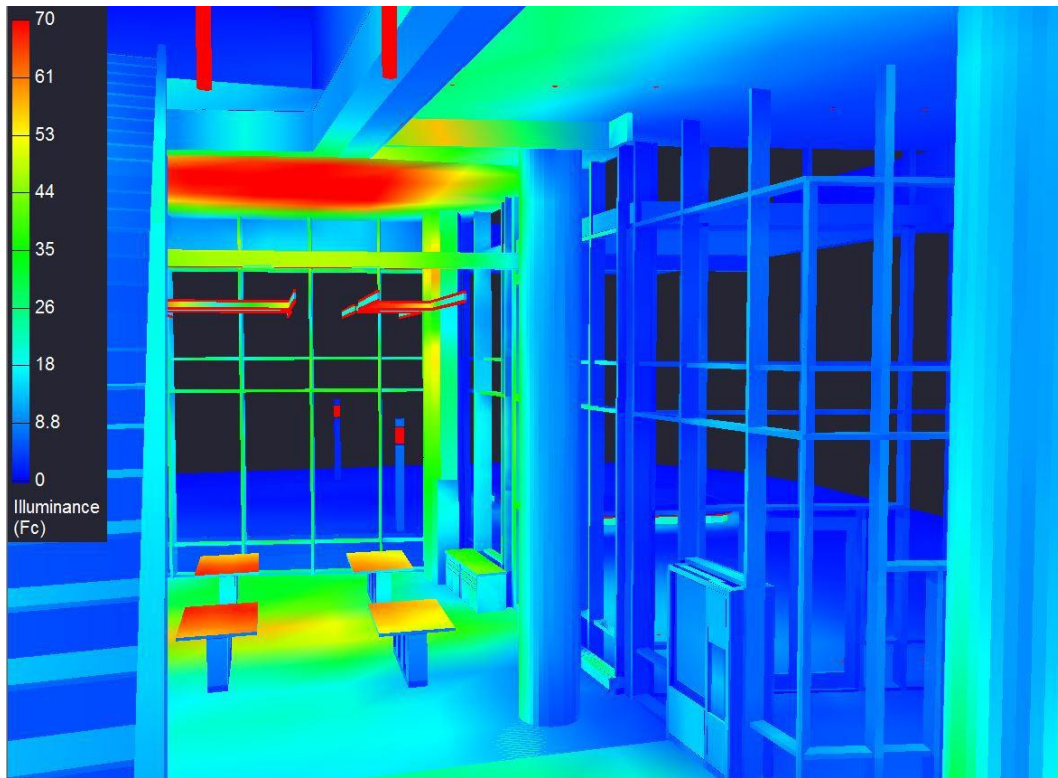


Figure 103 Interior Lobby pseudo color rendering from top of stairs - view 4 (AGi32)

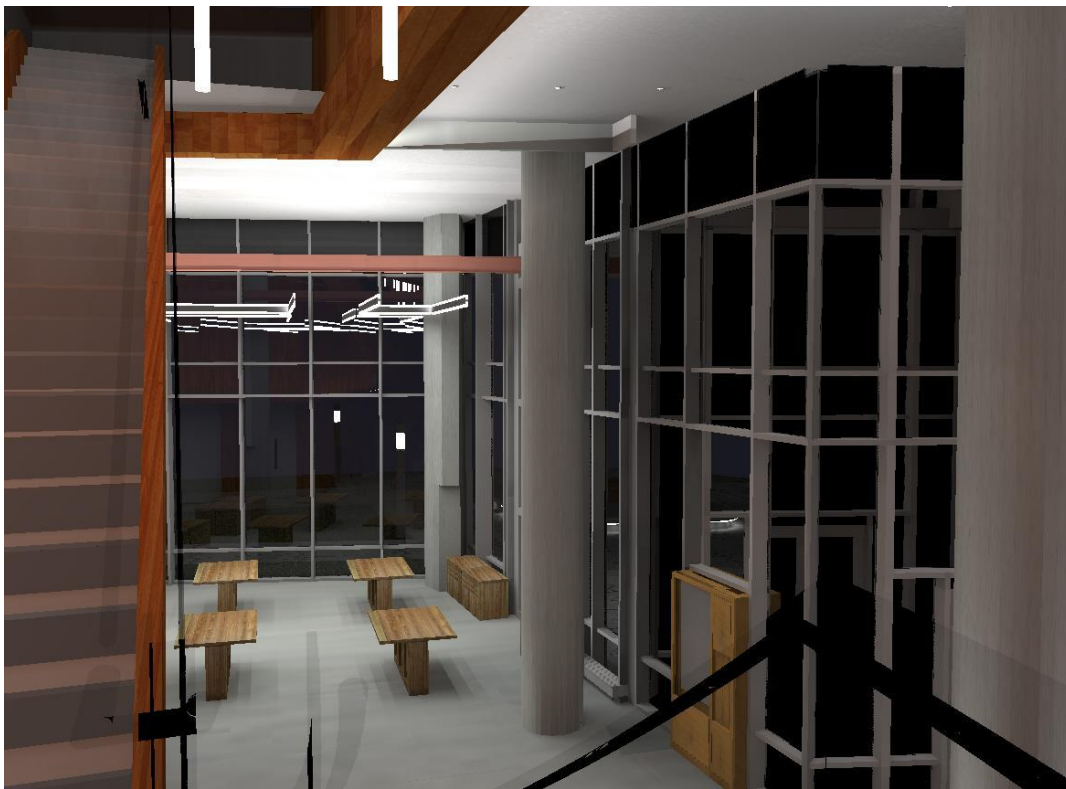


Figure 104 Interior Lobby raytrace rendering from top of stairs - view 4 (AGi32)





Figure 105 View 4 direction for figure 98 & 99

#### 7.4.11 Evaluation & Controls Discussion

The lighting design in the Lobby creates an eye-catching space that draws people into the building. The cluster of glowing pendants above the stairs draw visitors into the space and emphasizes the grandeur of the space. The cove fixtures graze the texture of the wood wall, creating a pleasing warmth in the space. It's assumed that the fixtures in the lobby will be on 24 hours a day, 7 days a week. The lobby space is an exception to the requirements of ASHRAE 90.1, and can operate without occupancy sensors or automatic control devices. Although the fixtures will be on all the time, they will have the capability of dimming during off hours of operation at night as well as during the day when daylight is sufficient. Because the lobby is surrounded mostly by a curtain wall, a sufficient amount of daylight will filter into the space. During the day, the fixtures will be able to be dimmed or shut off completely using photocontrol sensors. This will help save some energy by lowering the fixture outputs. The downlights will be controlled with a logarithmic DALI dimming system. The linear cove fixtures will be controlled with a Lutron EcoSystem Enabled Dimming system. These controls have been specified with the lighting fixture schedule and on the lighting cutsheets. The color changing LED grazer above the elevators can also be controlled for various color settings based on owner preference.



## 7.5 Flex Classroom Design



Figure 106 Flex Classroom floor plan highlighted in purple

### 7.5.1 Space Summary

The Flex Classroom is a multipurpose space located in the central part of the building and surrounded by the lobby. It can be used for lectures, large speaking events, classroom instruction, as well as formal events and banquets. It can also be split into one, two, or four spaces according to need. The east and west walls of the room can also be opened up into the lobby space, making it fit for large events. Because the space has so many functions it's layout is flexible. Whiteboards and projection screens are located throughout the room, fit to be used in any of the configurations.

***Dimensions:*** 2,930 ft<sup>2</sup>

***Height:*** 20' 9"

Table 17 Materials in Flex Classroom

<i>Location</i>	<i>Material</i>	<i>Product</i>	<i>Manufacturer</i>	<i>Color</i>	<i>Reflectance</i>
Floor	Wood Floor	Rift & Quartered White Oak	Nydree	Natural	0.4
Wall	Wall Protection	Rigid Vinyl Sheet	C/S Acrovyn	#265 fog, suede texture	.7
	Paint	Scuffmaster	Wolf Gordon	GOH 09796259	0.74
	Gypsum w/ Projection Screen Paint	Screen Goo	Goo Systems Global		.9
	Wood Panel	Maple Wood on MDF			.4
	Acoustical Wall Panels	Maple Wood			.3
	White Board				.9
	Acoustical Fabric	Ecoustic Felt	Unika Vaev	Light Grey	.3
	Fabric Wall Panel	Ecoustic Felt	Unika Vaev	Light Grey	.3
Base	Wood Base, Maple Stained				.4
	Wood Base, Painted				.7
Ceiling	Gypsum Wallboard 1				.85
	Gypsum Wallboard 2				.85
	Acoustical Ceiling Panels	Fiberglass		White	.3

### 7.5.2 Tasks & Design Considerations

The main purpose of the Flex Classroom is to educate students and visitors. This requires adequate light at the tables and desks to complete the various tasks done in the space. *These consist of:*

Class instruction, Lectures, Large events, Meetings, Group gatherings

***Design Considerations:***

- Consider the height of space
- Flexibility
- Variety of spaces (1, 2, or 4 configurations)
- Connection and openness to Lobby
- Controls

**7.5.3 Design Criteria**

The following illuminance and uniformity criteria was compiled using the IES Lighting Handbook, 10th edition as well as the campus standards for the building's location. The lighting power density allowance was found in ASHRAE/IESNA Standard 90.1-2010.

***Illuminance:***

Lecture w/ AV and notes (horizontal ambient @ 2' ):	5 fc
Lecture w/ AV and notes (vertical @ 4' ):	1.5 fc
Classroom (horizontal ambient @ 2.5' ):	40 fc
Classroom (vertical @ 4' ):	1.5 fc

***Uniformity:***

Across entire space (avg to min):	2 : 1
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***Lighting Power Density:***

Allowance (W/ft <sup>2</sup> ):	1.24
---------------------------------	------

### 7.5.4 Overall Design Strategy

What separates the Flex Classroom from the other three spaces in the study is its extreme versatility. The classroom itself has three orientations that satisfy the different uses of the space. The space can be used for lectures, smaller classroom instruction, or large events. Whiteboards, projection screens, presenters and classroom writing/reading tasks will be completed within the space, requiring a variety of visual scenes. The flex classroom is a very flexible space, much like our lungs. As humans breath, the lungs are



Figure 107 Flex Classroom concept sketch

continuously expanding and contracting to let air in and out. Within the lungs, air is filtered through smaller and smaller branches, eventually passing oxygen into the bloodstream. This breakdown mimics the way the flex classroom can be separated into various spaces. Beginning with one large space, it can then be broken into two or four separate rooms.

Because of the flexibility of the space, the lighting needed to fit into every orientation of the space, providing various light settings. Like the Flex Lab, the Flex Classroom also has the ability to open directly to the lobby through the large openings on the east and west sides of the room. When those large doors are open, the first floor becomes one large space used for public events. Linear recessed LED fixtures run the length of the room, providing general ambient light over the desk seating areas. LED downlights are placed sparsely throughout the room to fill in the light levels where needed. Adjustable accent fixtures light the walls of the classrooms, providing light for both lectures and whiteboard use. A linear LED cove fixture sits at the edge of the drop acoustic ceiling, washing the ceiling with light and making the 21' tall space feel large and grand for events.

When all the partition walls are down, four separate classrooms need to be lit. When only the middle partition wall is down, two larger classrooms are formed which need similar illuminance levels for

the tasks. One of the most important criteria of this space is the flexibility of the systems being designed. The fixtures in the space need to be positioned to accommodate the various room orientations, as well as provide varying light levels for the different scenes. Controls will be integrated into the space so that various scenes can be set for the different uses. Fixtures will have the ability to dim and switch on and off when needed for lectures, classes, and public gatherings.






### 7.5.5 Proposed Lighting Design



Figure 108 Initial proposed Flex Classroom lighting design, entire space design

### 7.5.6 Luminaire Schedule

Table 18 Flex Classroom luminaire schedule

Type	Tag	Description	Manufacturer	Catalog Number	Wattage	Voltage
	LL1	Recessed linear LED, 2” wide, 3615 lumens, 4000K CCT, >80 CRI	Lumenpulse	LLI2P-277-C_-dHO35K-ES-FGL-WH	12 W/ft	277
	DL1	LED Downlight, 2.5” diameter, 1196 lumens, 3500K CCT, >80 CRI	Focal Point	FLS2-RF-LL3-277-L3D-T-LS2-RD-35K-DN-NFL-CD-WH	19.2 W	277
	CL1	Linear LED Cove, 3/4” wide adjustable mounting, 118 lumens/ft, 3500K CCT, 95 CRI	Luminii Kendo	KM-48-D-35K-SO-H-A-SA	3.2 W/ft	24VDC
	CL2	Linear LED Cove, 3/4” wide adjustable mounting, 189 lumens/ft, 3500K CCT, 95 CRI	Luminii Kendo	KM-48-D-35K-MO-H-A-SA	4.8 W/ft	24VDC
	AL1	Adjustable LED Downlight, 2.5” diameter. 1121 lumens, 3500K CCT, >80 CRI	Focal Point	FLS2-RF-LL3-277-L3D-T-LS2-RD-35K-AA-WFL-CD-WH	19 W	277

### 7.5.7 Final Lighting Design

The final design solution includes multiple layers of light, helping to create various scenes in the space for the various uses. Linear recessed LED luminaires are integrated into the dropped acoustical ceiling to provide illumination on the task planes. LED downlights run on either side of the linear fixtures to provide the higher illumination needed for the classroom setting. LED cove fixtures sit in the already existing coves and wash the ceiling with light. This setting heightens the space making the room feel grand, which is suitable for public events. Adjustable LED downlights provide vertical illuminance on the

perimeter walls for the use of whiteboards. In order to provide maximum legibility, the lighting plan for the Flex Classroom has been placed in Appendix D.

### 7.5.8 Lighting Power Density Calculations

<i>Fixture Type</i>	<i>Number of Fixtures</i>	<i>Watts/fixture</i>	<i>Total Watts (W)</i>
LL1	160'	12 W/ft	1920
DL1	32	19.2	614.4
CL1	88'	3.2 W/ft	281.6
CL2	264'	4.8 W/ft	1267.2
AL1	24	19	456
Total Space Wattage (W)			4539.2
Space Area (ft <sup>2</sup> )			2,930
Watts/ft <sup>2</sup>			1.55
Allowed Watts/ft <sup>2</sup>			1.24

### 7.5.9 Lighting Calculations

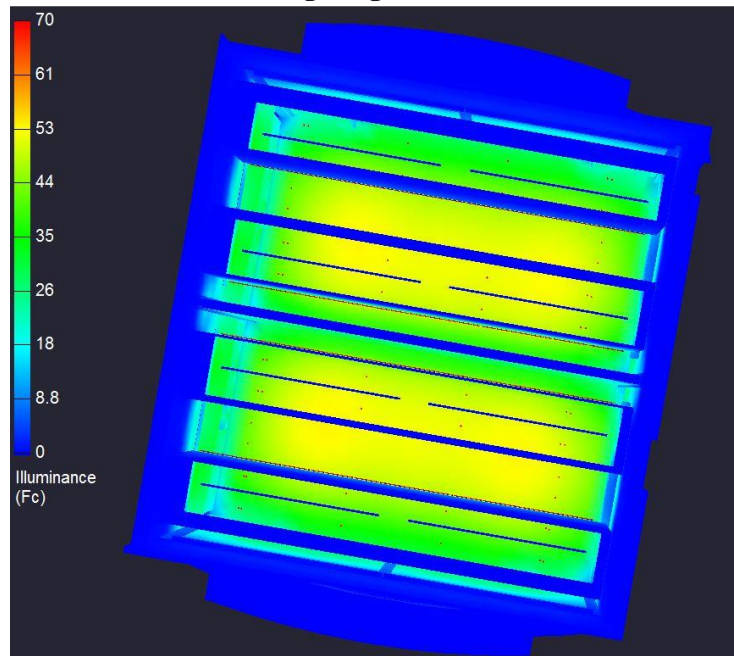


Figure 109 Flex Classroom plan view pseudo color calculation (AGi32)



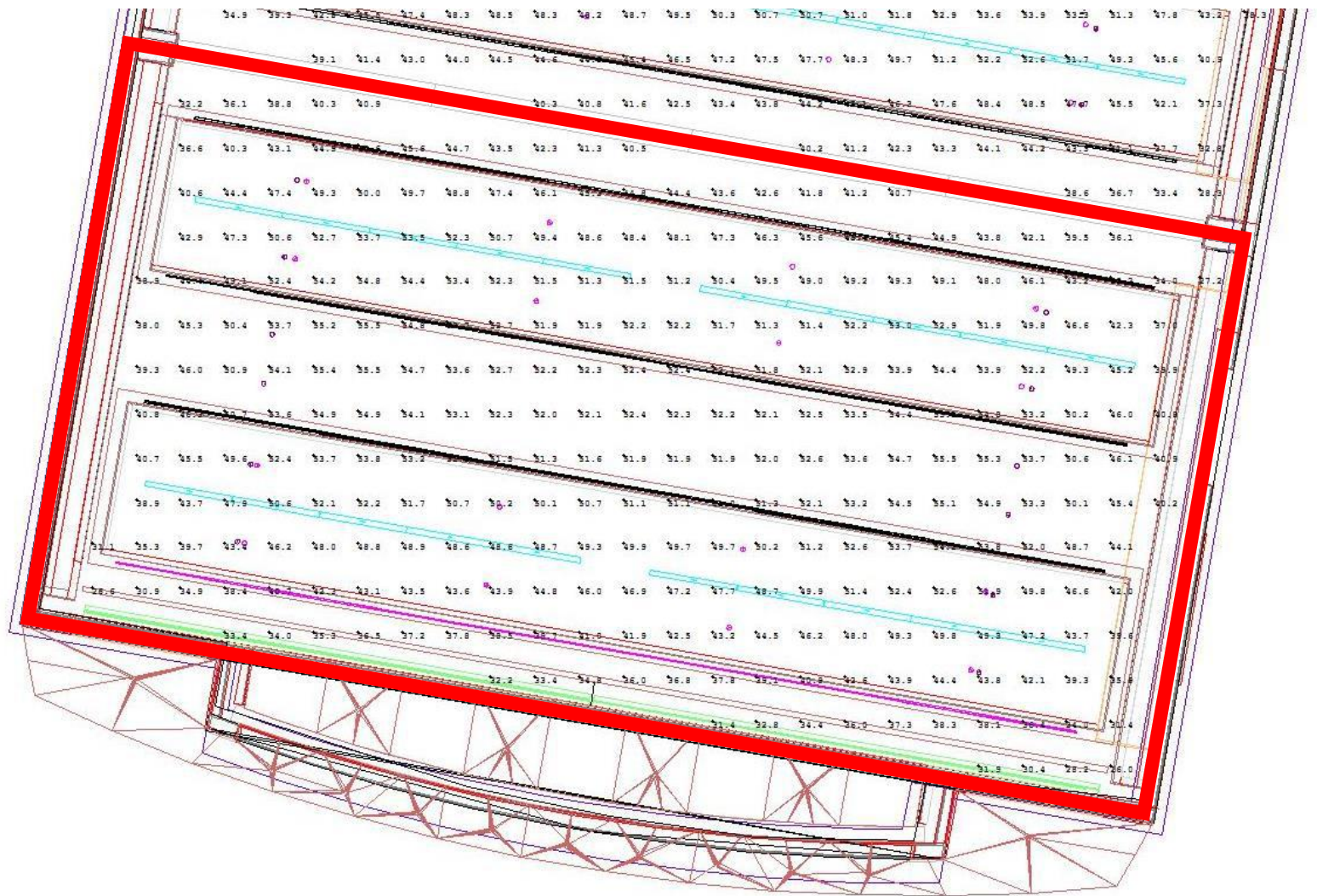


Figure 110 Flex Classroom illuminance levels with all fixtures on for classroom setting, typical for each half of the space (AGi32)

Calculation points were placed at the task plane at 2.5' and were compared to the target values listed in the Design Criteria section. Figure 110 above shows the results of the illuminance calculation across half of the Flex Classroom, which is repeated on the other side of the space. The Light Loss Factor was assumed to be 0.70, as is typical with LED fixtures in industry practice.



Table 19 Flex Classroom calculation results (AGi32)

<i>Calculation Area</i>	<i>Values (fc or uniformity)</i>
Floor	52.62 $\checkmark$
Floor Uniformity	1.83 :1 $\checkmark$
Vertical near presenter	16.4 $\checkmark$

### 7.5.10 Renderings



Figure 111 Plan view raytrace rendering (AGi32)

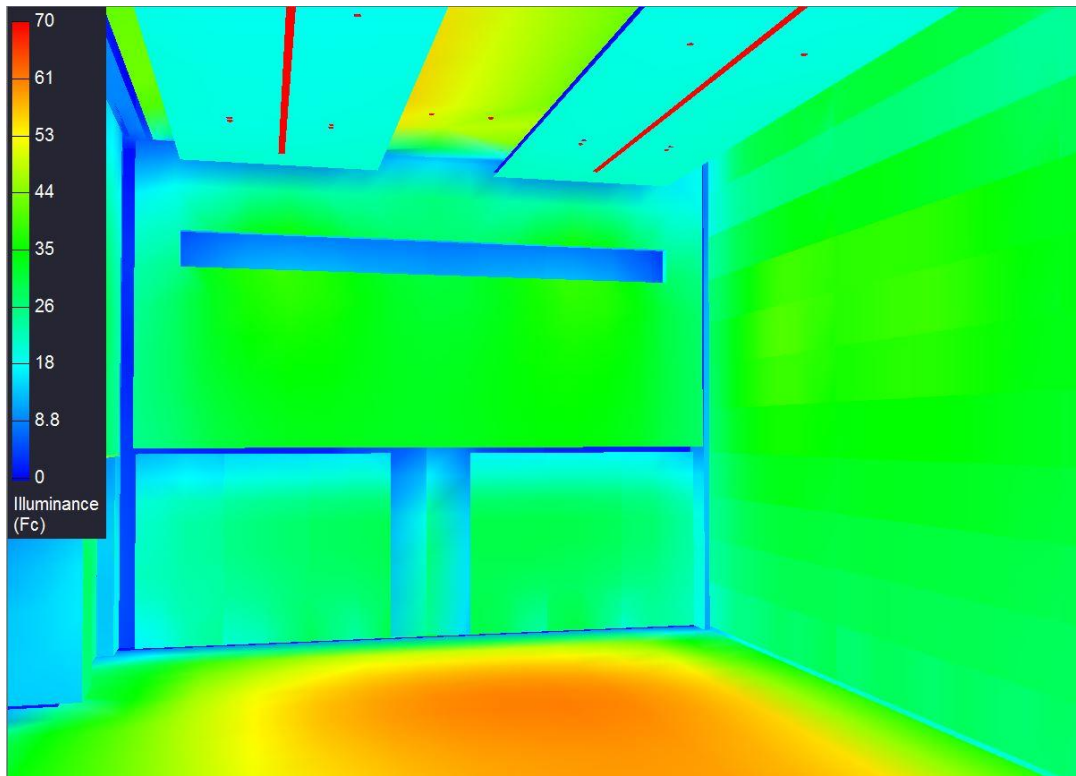


Figure 112 Interior Flex Classroom pseudo color rendering (AGi32)

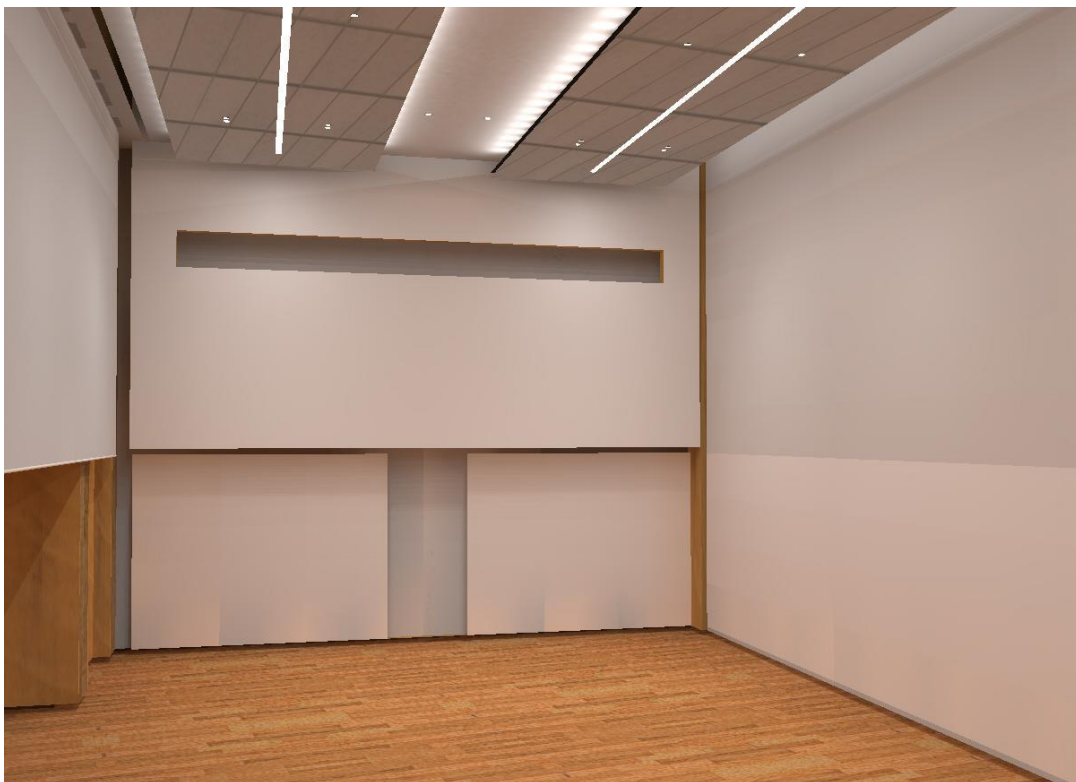


Figure 113 Interior Flex Classroom raytrace rendering with all lights on (AGi32)

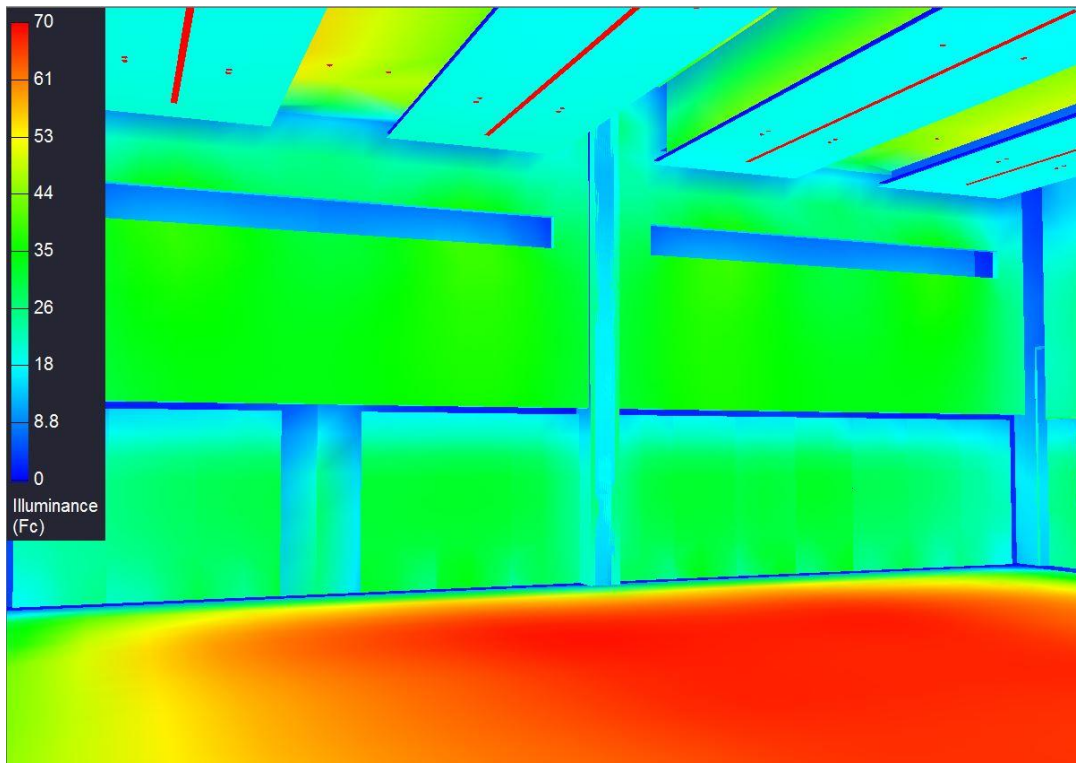


Figure 114 Full classroom pseudo rendering (AGi32)



Figure 115 Full classroom raytrace rendering (AGi32)

### **7.5.11 Evaluation & Controls Discussion**

Although the final design for the Flex Classroom exceeds the LPD requirements, the design provides a variety of scene settings for the multiple uses of the space. This means that not all the fixtures will be on at all times, reducing some of the wattage actually being used in the space. The design provides an even distribution of light throughout the whole space to facilitate a comfortable classroom environment. When the classroom is used for public events, fixtures can be dimmed or shut off for a specific ambiance in the space. The Flex Classroom has the ability to be both a public and private space, providing low intimate light levels, as well as higher even light levels throughout the entire room.

A controls system will be implemented in the Flex Classroom which will function for the space as a whole as well as the various space orientations. This will give user control of the lighting settings in the space so that the four spaces can have unique settings if need be. The classroom will utilize occupancy sensors as required by ASHRAE 90.1 that shut off the lights after 30 minutes of inactivity. As required by code, each of the four spaces will have individual control devices that can personalize the spaces based on individual need. Each device will be programmed with various scenes for lecture settings, event settings, and classroom settings including both AV usage and reading and writing tasks. All fixtures will be dimmable using a Lutron EcoSystem dimming driver. The Flex Classroom will be broken into four zones, based on the four partitions in the space. The individual scene controls will also be able to be combined to act as one or two when the space is split into those configurations.

## 7.6 Flex Lab Design

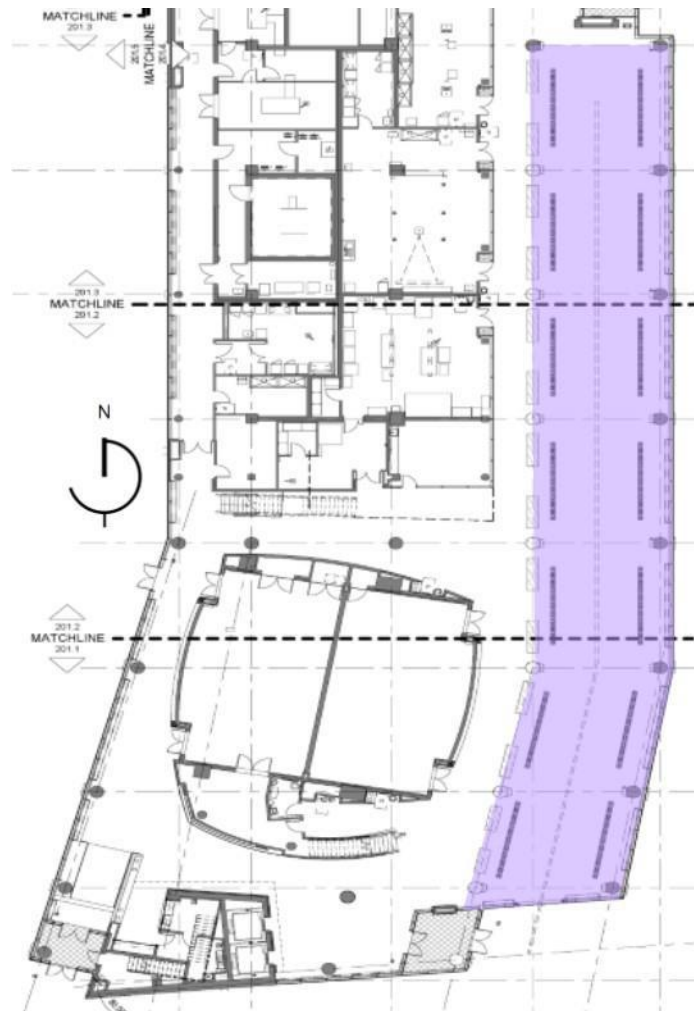


Figure 116 Flex Lab floor plan highlighted in purple

### 7.6.1 Space Summary

Located on the eastern side of the first floor, the Flex Lab serves as the showpiece of the building. There are no walls on the western side of the room, which makes the lab completely open to the lobby. The eastern wall is made entirely of a curtain wall, which enhances the open feeling in the space and allows a lot of natural light to filter in. Because it's a lab, this space has some interesting mechanical and structural systems in it. A beam runs through the entire room and out the main entrance for moving

large machinery that may be needed or built in the lab. Fume hoods and ventilation systems are also in the space for any work that may be done. A floor plan of the space can be seen in Figure 116 above.

***Dimensions:*** 6,908 ft<sup>2</sup>

***Height:*** 30' 6"

***Furnishings:*** Lab Benches, Stools, Demonstration Tables, and moveable Whiteboards

**Table 20 Materials in Flex Lab**

<i>Location</i>	<i>Material</i>	<i>Product</i>	<i>Manufacturer</i>	<i>Color</i>	<i>Reflectance</i>
Floor	Sealed Concrete				.5
Wall	Paint	Scuffmaster	Wolf Gordon	GOH 09796259	.74
	Metal Wall Panel				.7
Base	Rubber Base	Pinnacl Type TS	Roppe	178 Pewter	.1
Ceiling	Acoustical Ceiling Panel	Textured surface fiberglass back		White	.3
	Ceiling edge trim	Extruded aluminum		White	.7

### **7.6.2 Tasks & Design Considerations**

The main purpose of the Flex Lab is to conduct research and use the hands on experience as an educational and demonstration tool. This requires higher amounts of light at the work benches for the more technical tasks and the use of small and large tools and machinery. *These consist of:*

Class instruction, Use of machinery and technical equipment, and Research

***Design Considerations:***

- Consider the height of space
- Openness to surrounding spaces
- Placement around mechanical and lab equipment
- Daylighting influence
- Controls
- Individual task lighting

**7.6.4 Design Criteria**

The following illuminance and uniformity criteria was compiled using the IES Lighting Handbook, 10th edition as well as the campus standards for the building's location. The lighting power density allowance was found in ASHRAE/IESNA Standard 90.1-2010.

***Illuminance:***

Laboratories (horizontal ambient @ 3' ):	50-60 fc
Laboratories (vertical ambient @ 4' ):	30 fc
Laboratories (with task lights):	75-100 fc

***Uniformity:***

Across task plane (avg to min):	1.5 : 1
Across entire space (max to min):	3 : 1

***Lighting Power Density:***

Allowance (W/ft <sup>2</sup> ):	1.81
---------------------------------	------



### 7.6.3 Overall Design Strategy

The Flex Lab serves as the eloquent showpiece of the Bioengineering Building, informing visitors of the purpose and identity of the building and the people that work and learn within. Because of its openness and accessibility, it has the ability to convey any message to the public that the building's users want it to. It acts like the building's mouth, communicating information about the work that students and researchers are doing. Visitors are able to observe the space easily from both the Exterior Plaza as well as the Lobby and the corridor through the open western wall.



Figure 117 Flex Lab concept sketch

The goal for the design in this space was to facilitate productivity and research by providing enough quality light to the occupants. Linear direct/indirect pendants will hang from the 30' ceiling, providing light on the lab benches and the ceiling. This will make the space feel grand and open, while illuminating the mechanical equipment around the room. This exposed equipment is an important part of the function of the space and should be celebrated. Individual lighting control is important as well, giving the occupants working in the space a comfortable place to research. Adjustable pop up task lighting in the lab benches will allow the occupants to personalize their area and have access to the amount of light that they desire in their work space. It will also allow them to keep the fixtures out of their way when they have adequate amounts of light, giving them more space at their tables to work.

Flexibility is also necessary for the lab because of the movement in the space. At times, large equipment may be moved through the space, so lighting needs to be out of the way or movable. The lighting also needs to integrate with the mechanical equipment needed in the space so that the locations don't overlap. The linear fixtures hanging from the ceiling are oriented parallel to the large beam that runs through the center of the room. This allows enough space for machinery to run along that track.



### 7.6.5 Proposed Lighting Design



Figure 118 Initial proposed Flex Lab lighting design

### 7.6.6 Luminaire Schedule

Table 21 Flex Lab luminaire schedule

Type	Tag	Description	Manufacturer	Catalog Number	Wattage	Voltage
	PL1	Linear LED direct/indirect 4' or 2' pendant mounted at 20'. 1,374 lumens per foot, 4000K CCT, >80 CRI	Selux	L36DI-1A35-1A35-40-LW-LW-C-40-SV-277-DCE	17.6 W/ft	277
	TL1	Flexible LED task light, 88.59 lumens per watt, 3500K CCT, 80 CRI	Mockett	Levity PCS55-17S Satin Nickel	12 W	120

### 7.6.7 Final Lighting Design

The final design solution includes a direct/indirect pendant mounted fixture configured in a square U-shape. The pendants are mounted at 20' from the floor and throw light down toward the task plane and up toward the ceiling. They're mirrored across the structural beam that runs through the space allowing room for mechanical equipment and any machinery that needs to be transported through the room. The task lights are integrated into the lab benches and are easily accessible by all occupants. In order to provide maximum legibility, the lighting plan for the Flex Lab has been placed in Appendix D.

### 7.6.8 Lighting Power Density Calculations

\*The task light fixture doesn't contribute to the overall LPD of the space

**Table 22 LPD calculation for Flex Lab**

<i>Fixture Type</i>	<i>Number of Fixtures</i>	<i>Watts/fixture</i>	<i>Total Watts (W)</i>
PL1 (4')	163	70.4	11475.2
PL1 (3')	1	52.8	52.8
PL1 (2')	54	35.2	1900.8
Total Space Wattage (W)			13,428.8
Space Area (ft <sup>2</sup> )			6,908
Watts/ft <sup>2</sup>			1.94
Allowed Watts/ft <sup>2</sup>			1.81

**Figure 119 Flex Lab typical work space illuminance values**

Calculation points were placed at the task plane of 3' and were compared to the target values listed in the Design Criteria section. Figure 119 above show the results of the illuminance calculation across the lab benches. The Light Loss Factor was assumed to be 0.70, as is typical with LED fixtures in industry practice.

### Table 23 Flex Lab calculation results (AGi32)

<i>Calculation Area</i>	<i>Values (fc or uniformity)</i>
Entire Space	50 $\sqrt$
Entire Space Uniformity	3 : 1
Lab Benches	55 $\sqrt$
Benches Uniformity	1.1 : 1 $\sqrt$

**Results:**

\*Across entire space

*Average (fc): 49.18*

*Maximum (fc): 66.0*

*Minimum (fc): 21.0*

*Max/Min: 3 : 1*

\*Across lab benches

*Average (fc): 54.89*

*Maximum (fc): 59.1*

*Minimum (fc): 50*

*Avg/Min: 1.1 : 1*

The overall average illuminance satisfies the 50 fc average requirements with a value of 49.18 fc. The lower values in this calculation are around the perimeter of the space, which is either open or a glass curtain wall where high illuminance is unwanted. The overall space also satisfies the 3:1 uniformity requirements with a value of 3.1. The individual task planes also satisfy the illuminance requirements with an average of 54.89 fc and all values higher than 50 fc. The uniformity also satisfies the 1.5:1 requirement with a value of 1.10.

### 7.6.10 Renderings

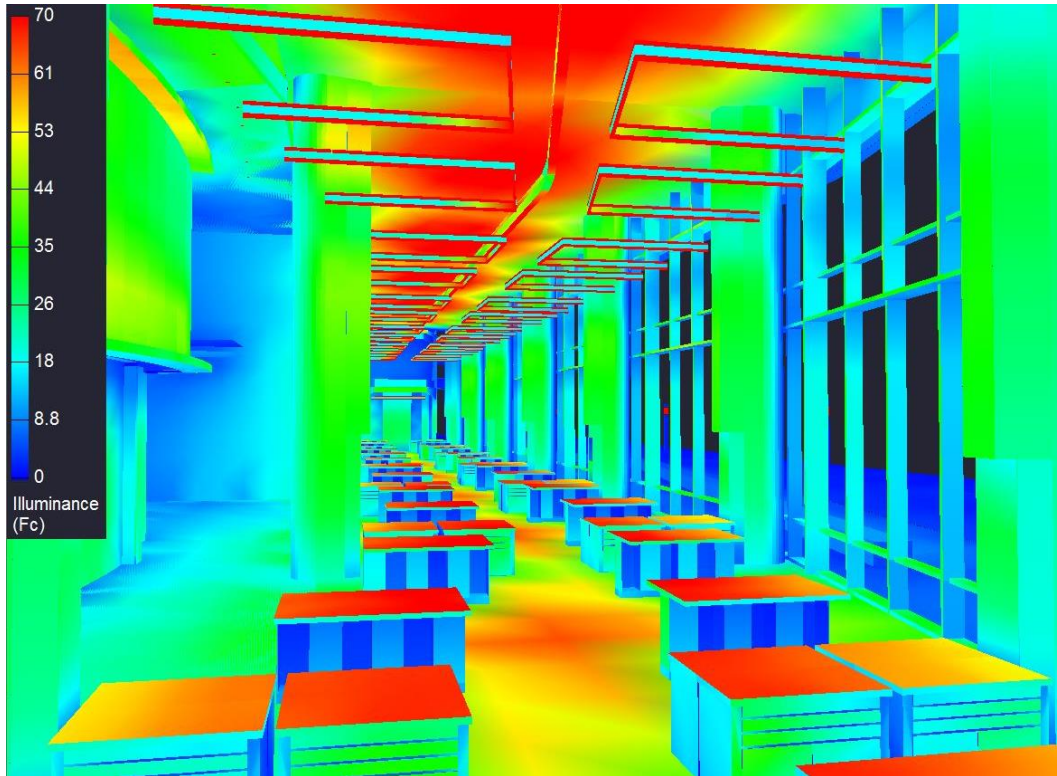


Figure 120 Interior Flex Lab pseudo rendering facing North (AGi32)



Figure 121 Interior Flex Lab raytrace rendering facing North (AGi32)



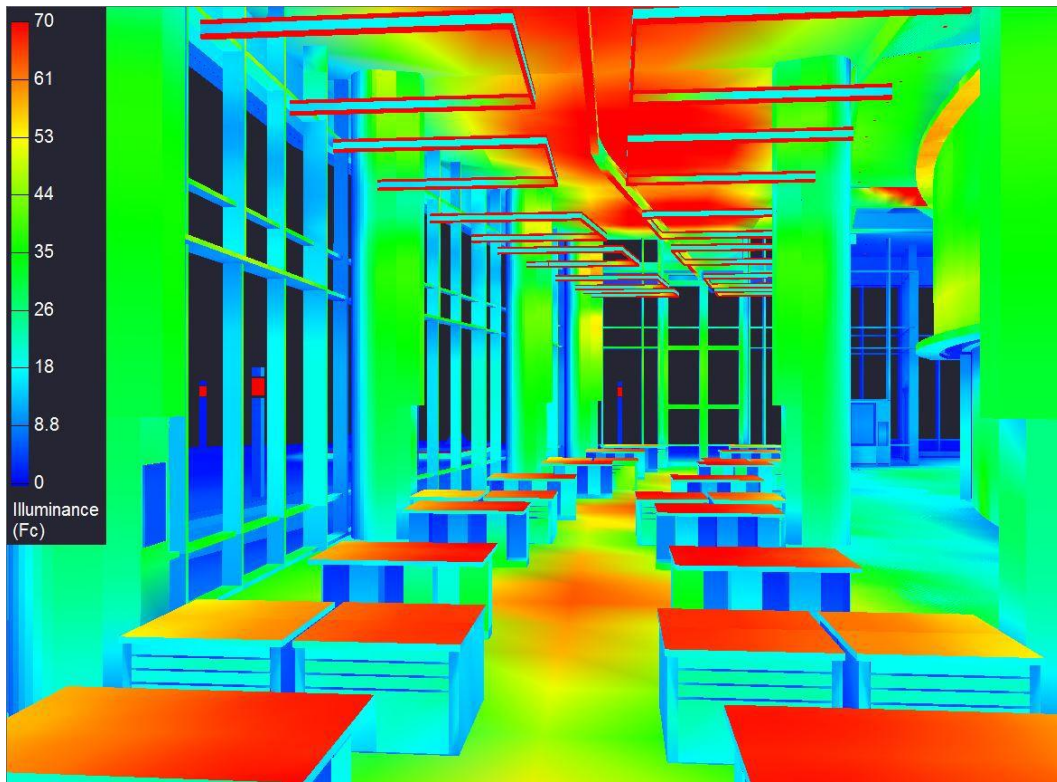


Figure 122 Interior Flex Lab pseudo rendering facing South (AGi32)



Figure 123 Interior Flex Lab raytrace rendering facing South (AGi32)



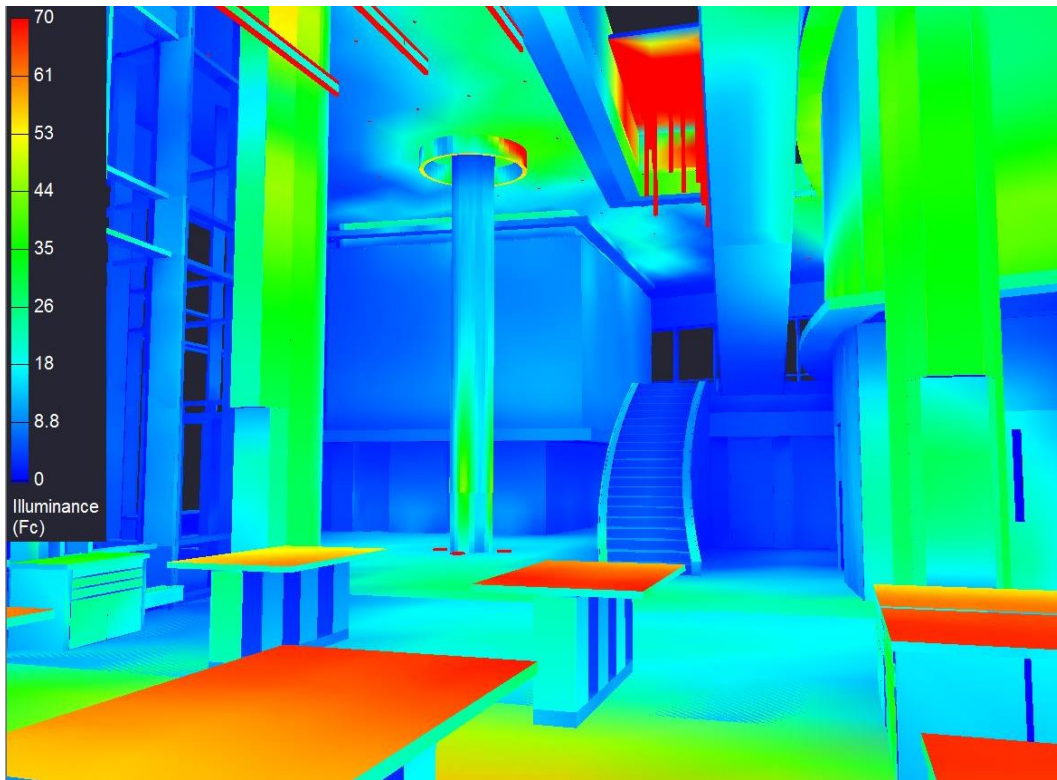


Figure 124 Interior Flex Lab pseudo color rendering facing into Lobby (AGi32)



Figure 125 Interior Flex Lab raytrace rendering facing into Lobby (AGi32)

### 7.6.11 Evaluation & Controls Discussion

Overall, the Flex Lab design satisfies the illuminance criteria for a laboratory and research space. The fixture configuration fits into the space successfully, allowing for movement of machinery along the central beam. The direct/indirect fixtures throw light up onto the ceiling, which heightens the space, making it feel open and grand. They also provide high levels of light for the occupants to conduct their research comfortably with access to natural light and pleasing views.

Because of the significant amount of daylight allowed into the space from a sidelighted source, the pendants will utilize photosensors to control the dimming of the fixtures throughout the day to satisfy the ASHRAE 90.1 requirement. After the integration of the vertical louvers, glare free daylight comes into the Flex Lab diffusely, providing adequate light levels during the morning hours. Dimming the fixtures allows for energy savings in the space. The pendants in the space will be controlled using a Lutron EcoSystem dimming system as specified in the luminaire schedule and lighting cutsheet. The Flex Lab will not utilize occupancy sensors because it's an exception to the ASHRAE 90.1 requirement for automatic lighting shutoff controls. The large space is completely open on it's west side and wouldn't benefit from the use of occupancy sensors.

## Chapter 8 Conclusion







This report culminates five years of Architectural Engineering study. The Bioengineering Building was analyzed for its existing systems including, but not limited to: lighting, electrical, mechanical, structural, and architectural. Much like a human body, the Bioengineering Building was designed to work as one coherent system, supporting the occupants and the research done within. The analysis of the existing architecture inspired the new designs in the various areas of study.

The lighting depth focused on four spaces located on the first floor of the building, and revolved around the concept of *the body*. Together each space can function as one, while also exuding an individual use and personality. Within the electrical depth, a new PV panel array was designed to sit on the expansive roof of the building. This generates excess electricity for the building that will be used to cover some of the building load.

The daylighting depth focused on the Flex Lab façade and the influence of sunlight in the space. To preface the daylighting study, an in depth research study was done of the influence of daylighting on people and the various ways to control its integration into buildings. In order to control the glare and high illuminance levels, an adjustable interior louver system was designed to give occupants control of their interior environment. Both the mechanical and the structural breadths branched from the daylighting design to study the influence the louvers had on the column support of the façade as well as the mechanical loads in the Flex Lab.

Combining the focus of the various breadths and depths, one coherent space was created on the first floor that complements the overall building. The systems studied in each space influenced one another and were combined to create the designs and analyses detailed within this thesis.







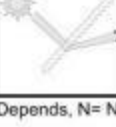
## Appendix A Shading System Tables

1. Shading Systems										
Category	Type/name	Sketch	Climate	Location	Criteria for the choice of elements					
					Glare protection	View outside	Light guiding into depth of room	Homogeneous illumination	Saving potential (artificial lighting)	Need for tracking
<b>1A</b> Primary using diffuse skylight	Prismatic panels (→ 4.5)		All climates	Vertical windows, skylights	D	N	D	D	D	D
	Prisms and venetian blinds		Temperate climates	Vertical windows	Y	D	Y	Y	Y	Y
	Sun protecting mirror elements		Temperate climates	Skylights, glazed roofs	D	N	N	Y	N	N
	Anidolic zenithal opening (→ 4.12, 4.13)		Temperate climates	Skylights	Y	N	N	Y	Y	N
	Directional selective shading system with concentrating Holographic Optical Element (HOE) (→ 4.11)		All climates	Vertical windows, skylights, glazed roofs	D	Y	N	D	Y	Y
	Transparent shading system with HOE based on total reflection (→ 4.11)		Temperate climates	Vertical windows, skylights, glazed roofs	D	Y	N	Y	Y	Y


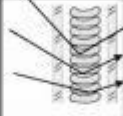
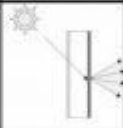




Y= Yes, D= Depends, N= No, A= Available, T= Testing phase, "→ n" = See section number n

1. Shading Systems											
Category	Type/name		Climate	Location	Criteria for the choice of elements						
					Glare protection	View outside	Light guiding into depth of room	Homogeneous illumination	Saving of energy for artificial lighting	Need for tracking	Availability
<b>1B</b> Primary using direct sunlight	Light guiding shade (→ 4.7)		Hot climates, sunny skies	Vertical windows above eye height	Y	Y	D	D	D	N	T
	Louvres and blinds (→ 4.4)		All climates	Vertical windows	Y	D	Y	Y	Y	Y	A
	Light shelf for redirection of sunlight (→ 4.3)		All climates	Vertical windows	D	Y	Y	Y	Y	N	A
	Glazing with reflecting profiles (Okasolar)		Temperate climates	Vertical windows, skylights	D	D	D	D	D	N	A
	Skylight with Laser Cut Panels (LCPs) (→ 4.7)		Hot climates, sunny skies, low latitudes	Skylights	D		Y	Y	Y	N	T
	Turnable lamellas		Temperate climates	Vertical windows, skylights	Y/D	D	D	D	D	Y	A
	Anidolic solar blinds (→ 4.13)		All climates	Vertical Windows	Y	D	Y	Y	D	N	T


Y= Yes , D= Depends, N= No, A= Available, T= Testing phase, "→ n" = See section number n

2. Daylighting systems without shading included										
Category	Type/name	Sketch	Climate	Location	Criteria for the choice of elements					
					Glare protection	View outside	Light guiding into depth of room	Homogeneous illumination	Saving of energy for artificial lighting	Need for tracking
<b>2A</b> Diffuse light guiding systems	Light shelf (→ 4.3)		Temperate climates, cloudy skies	Vertical windows	D	Y	D	D	D	N
	Anidolic Integrated System (→ 4.12)		Temperate climates	Vertical windows	N	Y	Y	Y	Y	N
	Anidolic ceiling (→ 4.12)		Temperate climates, cloudy skies	Vertical facade above viewing window		Y	Y	Y	Y	N
	Fish System		Temperate climates	Vertical windows	Y	D	Y	Y	Y	N
	Zenith light guiding elements with HOEs (→ 4.10)		Temperate climates, cloudy skies	Vertical windows (especially in court-yards), skylights		Y	Y	Y	Y	N
<b>2B</b> Direct light guiding Systems	Laser Cut Panel (→ 4.6)		All climates	Vertical windows, skylights	N	Y	Y	Y	Y	N
	Prismatic panels (→ 4.5)		All climates	Vertical windows, skylights	D	D	D	D	D	Y/N

Y= Yes , D= Depends, N= No, A= Available, T= Testing phase, "→ n" = See section number n

2. Daylighting systems without shading included											
Category	Type/name	Sketch	Climate	Location	Criteria for the choice of elements						
					Glare protection	View outside	Light guiding into depth of room	Homogeneous illumination	Saving of energy for artificial lighting	Need for tracking	Availability
<b>2B</b> Direct light guiding Systems	HOEs in the skylight		All climates	Skylights	D	Y	Y	Y	Y	N	A
	Sun-directing glass (→ 4.9)		All climates	Vertical windows, skylights	D	N	Y	Y	Y	N	A
<b>2C</b> Scattering systems			All climates	Vertical Windows, skylights	N	N	Y	Y	D	N	A
<b>2D</b> Light transport	Helio-stat		All climates, sunny skies				Y		Y	Y	A
	Light Pipe		All climates, sunny skies				Y	Y	Y	N	A
	Solar Tube		All climates, sunny skies	Roof			Y	D	Y	N	A
	Fibres		All climates, sunny skies				Y		Y	Y	A

Y= Yes , D= Depends, N= No, A= Available, T= Testing phase, "→ n" = See section number n

2. Daylighting systems without shading included											
Category	Type/name	Sketch	Climate	Location	Criteria for the choice of elements						
					Glare protection	View outside	Light guiding into depth of room	Homogeneous illumination	Saving of energy for artificial lighting	Need for tracking	Availability
<b>2D</b> Light transport	Light-guiding ceiling		Temperate climates, sunny skies				Y	Y	Y	N	T

Y= Yes , D= Depends, N= No, A= Available, T= Testing phase, "→ n" = See section number n



## **Appendix B Structural Calculations**

REINFORCEMENT:

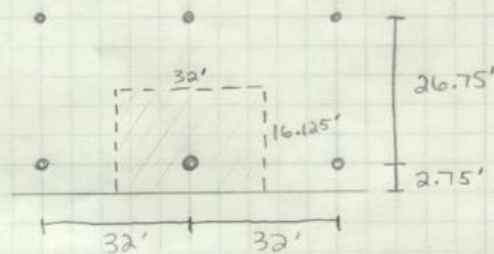
8 - #10  
#4 @ 12"

NOTE:

\* FOR THE PURPOSE  
OF THIS BREADTH  
STUDY, I'VE ASSUMED  
ALL FLOORS ARE  
EQUAL IN DESIGN

TRIBUTARY  
AREA =

$$32' \times 16.125' \\ = \underline{516 \text{ ft}^2}$$

FLOOR SLAB:

13" THICK NORMAL WEIGHT CONCRETE @ 5000 psi

REINFORCED w/ #5 @ 12" O.C EACH WAY BOTTOM MAT

#4 @ 12" O.C EACH WAY TOP MAT

DEAD LOAD:  
\* FROM BASIS OF DESIGN

CONCRETE SLAB	-	163	psf
SPRINKLERS	-	3	psf
MECH + ELEC SYST.	-	5	psf
(SEE DRAW) LAB CRANE	-	19.38	psf
FLOOR FINISH	-	2	psf
SUPERIMPOSED DEAD	-	10	psf

\* 202.38 psf

LAB CRANE TROLLEY  
DEAD LOAD: (1 PER COLUMN)

5 TONS  $\rightarrow$  10,000 lbs

$$10,000 \text{ lbs} / 516 \text{ ft}^2 = \underline{19.38 \text{ psf}}$$

VICTORIA RIEDINGER

PAGE 2

THESIS STRUCTURAL

FLOOR SLAB:

$$\begin{aligned} \text{LIVE LOAD: } & 100 \text{ psf (UNREDUCIBLE} \rightarrow \text{AS PER OWNER)} \\ & + 10\% \text{ (FROM LAB CRANE)} \\ & \underline{110 \text{ psf}} \end{aligned}$$

$$\begin{aligned} \text{TOTAL FLOOR LOAD: } & 1.2D + 1.6L = 1.2(202.38 \text{ psf}) + 1.6(110 \text{ psf}) \\ & = 242.856 \text{ psf} + 176 \text{ psf} \\ & = 418.856 \text{ psf} \\ & \downarrow \\ & 420 \text{ psf} \end{aligned}$$

$$W_u = 420 \text{ psf} \times 516 \text{ ft}^2 = \boxed{216.7 \text{ kips}}^*$$

CURTAIN WALL: (3 PARTS: <sup>(CW)</sup> CURTAIN WALL, <sup>(BV)</sup> BRICK VENEER, + CONCRETE FOUNDATION WALL <sup>(FW)</sup>)  
 $\downarrow$   
 HEIGHT = 24'

DEAD LOADS: (LOAD VALUES FROM PROJECT BASIS OF DESIGN)

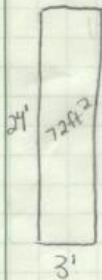
$$\text{CW: } 15 \text{ psf (24')} = 360 \text{ plf}$$

$$\text{FW: } 150 \text{ psf} (.67') (4') = 402 \text{ plf}$$

$$\text{BV: } 40 \text{ psf (4')} = 160 \text{ plf}$$

$$\text{DEAD LOAD} = \boxed{922 \text{ plf}}^*$$

LOUVERS: 11 LOUVERS PER COLUMN @ 2 psf (\*FROM MANUFAC. WEBSITE)



$$2 \text{ lb/ft}^2 \times 72 \text{ ft}^2 = 144 \text{ lbs PER LOUVER} \times 11 \text{ LOUVERS} = 1,584 \text{ lbs}$$

$$1,584 \text{ lbs} / 32 \text{ ft} \text{ (RIB WIDTH)} = \boxed{49.5 \text{ plf}}^*$$

VICTORIA RIEDINGER

PAGE 3

THESIS STRUCTURAL

CURTAIN WALL  
+  
LOUVER  
DEAD LOAD

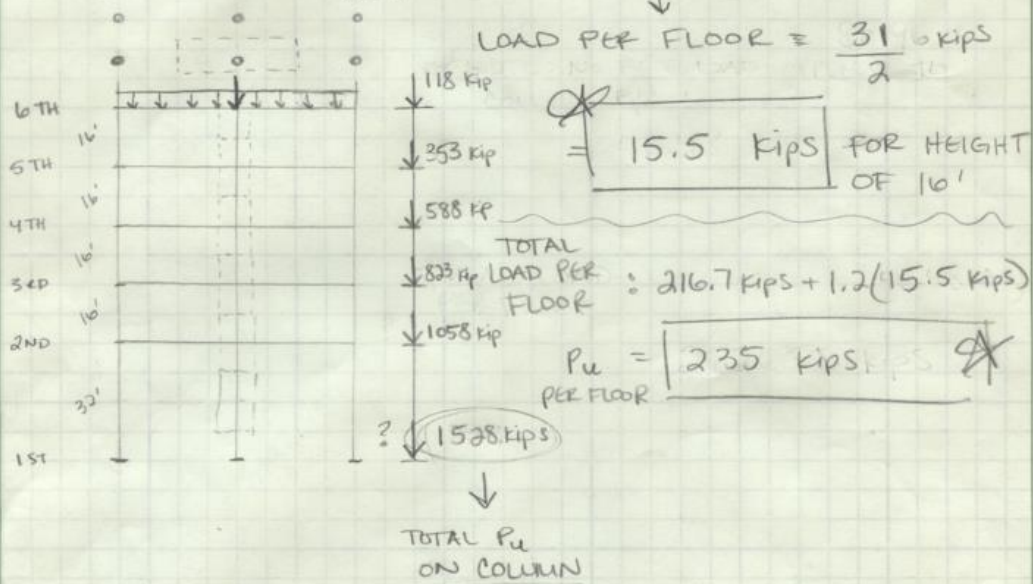
$$922 \text{ plf} + 49.5 \text{ plf} = 971.5 \text{ plf}$$

$$= 0.972 \text{ kif}$$

$$0.972 \text{ kif} (32 \text{ ft}) = 31 \text{ kips}$$

TRIB  
WIDTH

$$\text{LOAD PER FLOOR} = \frac{31 \text{ kips}}{2}$$



$$\text{TOTAL LOAD ON COLUMN } P_u = 1528 \text{ kips}$$



VICTORIA RIEDINGER

PAGE 4

THESIS STRUCTURAL

COLUMN STRENGTH : REFERENCED ACI CH. 10  
(COMPARED TO CRSI MANUAL)

ACI

CH. 10

EQ. 10-2

$$\begin{aligned}\phi P_{n,\max} &= 0.80 \phi [0.85 f'_c (A_g - A_{st}) + f_y A_{st}] \\ &= (0.80)(0.65) [(0.85)(5000 \text{ psi})(1018 \text{ in}^2 - 10.16 \text{ in}^2) + (60,000 \text{ psi})(10.16 \text{ in}^2)] \\ &= (0.52) [4,283,320 \text{ lb} + 609,600 \text{ lb}] \\ &= (0.52) (4,892,920 \text{ lb}) \\ &= 2,544,318.4 \text{ lb} \rightarrow \boxed{2544 \text{ kips}} \star\end{aligned}$$

 $\phi = 0.65$  $f'_c = 5000 \text{ psi}$ 

$$\begin{aligned}36" \text{ diam. } A_g &= \pi (18 \text{ in})^2 \\ &= 1018 \text{ in}^2\end{aligned}$$

$$\begin{aligned}8 \#10s \rightarrow A_{st} &= 8(1.27) \\ &\quad \text{AREA OF} \\ &\quad \#10s \\ &= 10.16 \text{ in}^2\end{aligned}$$

 $f_y = 60,000 \text{ psi}$ 

CAN MY COLUMN SUPPORT THE NEW LOUVERS?

$$\phi P_n \geq P_u$$

$$\phi P_n = 2544 \text{ kips}$$

$$\phi P_u = 1528 \text{ kips}$$

$$\begin{array}{ccc} 2544 & \checkmark & 1528 \\ \text{kips} & \geq & \text{kips} \end{array}$$

YES!

## **Appendix C Photovoltaic Panel Component Specifications**



## SunPower® X-Series Commercial Solar Panels | X21-345-COM

### More than 21% Efficiency

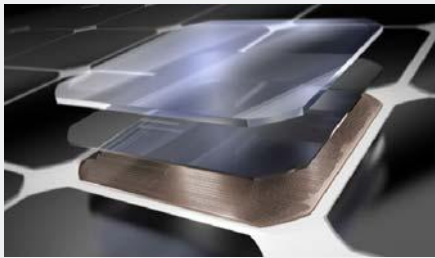
Captures more sunlight and generates more power than conventional panels.

### Maximum Performance

Designed to perform in demanding real-world conditions of high temperatures, partial shade from overhead wires, and low light.<sup>1,2,4</sup>

### Commercial Grade

Intended for commercial sites where maximum energy production is critical.



Maxeon® Solar Cells: Fundamentally better

Engineered for performance, designed for reliability.

### Engineered for Peace of Mind

Designed to deliver consistent, trouble-free energy over a very long lifetime.<sup>3,4</sup>

### Designed for Reliability

The SunPower Maxeon Solar Cell is the only cell built on a solid copper foundation. Virtually impervious to the corrosion and cracking that degrade conventional panels.<sup>3</sup>

Same excellent durability as E-Series panels.

#1 Rank in Fraunhofer durability test.<sup>9</sup>

100% power maintained in Atlas 25+

comprehensive durability test.<sup>10</sup>

### High Performance & Excellent Reliability



SPR-X21-345-COM

### Highest Efficiency<sup>5</sup>

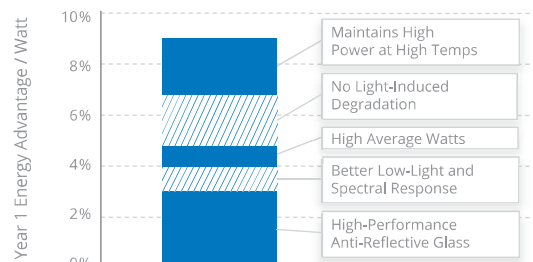
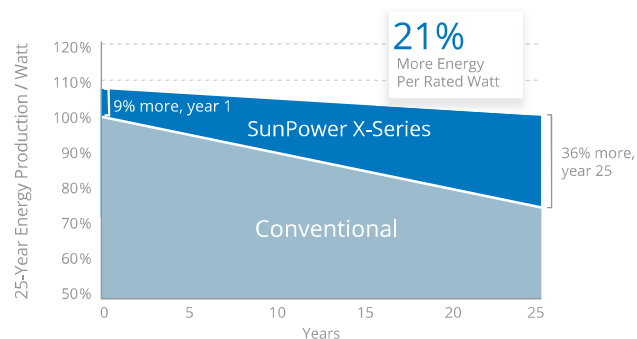
#### Generate more energy per square foot

X-Series commercial panels convert more sunlight to electricity by producing 38% more power per panel<sup>1</sup> and 70% more energy per square foot over 25 years.<sup>1,2,3</sup>

### Highest Energy Production<sup>6</sup>

#### Produce more energy per rated watt

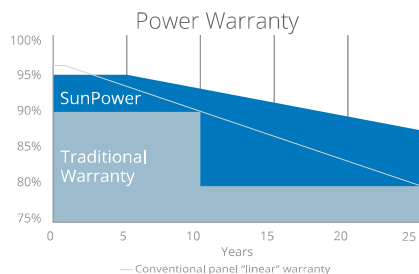
More energy to power your operations. High year-one performance delivers 8–10% more energy per rated watt.<sup>2</sup> This advantage increases over time, producing 21% more energy over the first 25 years to meet your needs.<sup>3</sup>



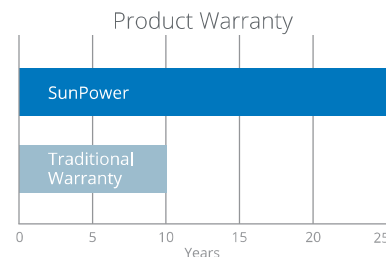


# SunPower® X-Series Commercial Solar Panels | X21-345-COM

## SunPower Offers The Best Combined Power And Product Warranty



More guaranteed power: 95% for first 5 years,  
-0.4%/yr. to year 25<sup>7</sup>



Combined Power and Product defect 25-year coverage  
that includes panel replacement costs<sup>8</sup>

### Electrical Data

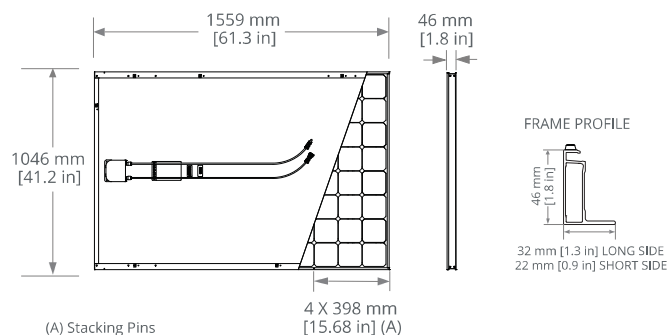
	SPR-X21-345-COM	SPR-X20-327-COM
Nominal Power (P <sub>nom</sub> ) <sup>11</sup>	345 W	327 W
Power Tolerance	+5/-3%	+5/-3%
Avg. Panel Efficiency <sup>12</sup>	21.5%	20.3%
Rated Voltage (V <sub>mpp</sub> )	57.3 V	57.3 V
Rated Current (I <sub>mpp</sub> )	6.02 A	5.71 A
Open-Circuit Voltage (V <sub>oc</sub> )	68.2 V	67.6 V
Short-Circuit Current (I <sub>sc</sub> )	6.39 A	6.07 A
Max. System Voltage	1000 V UL & 1000 V IEC	
Maximum Series Fuse	15 A	
Power Temp Coef.	-0.30% / °C	
Voltage Temp Coef.	-167.4 mV / °C	
Current Temp Coef.	3.5 mA / °C	

### Tests And Certifications

Standard Tests <sup>13</sup>	UL1703 (Type 2 Fire Rating), IEC 61215, IEC 61730
Quality Certs	ISO 9001:2008, ISO 14001:2004
EHS Compliance	RoHS, OHSAS 18001:2007, lead free, REACH SVHC-163, PV Cycle
Sustainability	Cradle to Cradle (eligible for LEED points) <sup>14</sup>
Ammonia Test	IEC 62716
Desert Test	10.1109/PVSC.2013.6744437
Salt Spray Test	IEC 61701 (maximum severity)
PID Test	Potential-Induced Degradation free: 1000 V <sup>9</sup>
Available Listings	UL, TUV, JET, CSA, CEC

### Operating Condition And Mechanical Data

Temperature	-40° F to +185° F (-40° C to +85° C)
Impact Resistance	1 inch (25 mm) diameter hail at 52 mph (23 m/s)
Appearance	Class B
Solar Cells	96 Monocrystalline Maxeon Gen III
Tempered Glass	High-transmission tempered anti-reflective
Junction Box	IP-65, MC4 compatible
Weight	41 lbs (18.6 kg)
Max. Load	Wind: 50 psf, 2400 Pa, 244 kg/m² front & back Snow: 112 psf, 5400 Pa, 550 kg/m² front
Frame	Class 2 silver anodized; stacking pins



Please read the safety and installation guide.

#### REFERENCES:

- 1 All comparisons are SPR-X21-345 vs. a representative conventional panel: 250 W, approx. 1.6 m², 15.3% efficiency.
- 2 Typically 8–10% more energy per watt, BEW/DNV Engineering "SunPower Yield Report," Jan 2013.
- 3 SunPower 0.25%/yr degradation vs. 1.0%/yr conv. panel. Campeau, Z. et al. "SunPower Module Degradation Rate," SunPower white paper, Feb 2013; Jordan, Dirk "SunPower Test Report," NREL, Q1-2015.
- 4 "SunPower Module 40-Year Useful Life" SunPower white paper, May 2015. Useful life is 99 out of 100 panels operating at more than 70% of rated power.
- 5 Highest of over 3,200 silicon solar panels, Photon Module Survey, Feb 2014.
- 6 1% more energy than E-Series panels, 8% more energy than the average of the top 10 panel companies tested in 2012 (151 panels, 102 companies), Photon International, Feb 2013.
- 7 Compared with the top 15 manufacturers, SunPower Warranty Review, May 2015.
- 8 Some restrictions and exclusions may apply. See warranty for details.
- 9 X-Series same as E-Series, 5 of top 8 panel manufacturers tested in 2013 report, 3 additional panels in 2014. Ferrara, C., et al. "Fraunhofer PV Durability Initiative for Solar Modules: Part 2". Photovoltaics International, 2014.
- 10 Compared with the non-stress-tested control panel. X-Series same as E-Series, tested in Atlas 25+ Durability test report, Feb 2013.
- 11 Standard Test Conditions (1000 W/m² irradiance, AM 1.5, 25° C). NREL calibration Standard: SOMS current, LACCS FF and Voltage.
- 12 Based on average of measured power values during production.
- 13 Type 2 fire rating per UL1703:2013, Class C fire rating per UL1703:2002.
- 14 See salesperson for details.

See [www.sunpower.com/facts](http://www.sunpower.com/facts) for more reference information.  
For more details, see extended datasheet: [www.sunpower.com/datasheets](http://www.sunpower.com/datasheets).

Document # 505700 Rev E /LTR\_US

# SUNNY TRIPOWER 12000TL-US / 15000TL-US / 20000TL-US / 24000TL-US / 30000TL-US



STP 12000TL-US-10 / STP 15000TL-US-10 / STP 20000TL-US-10 / STP 24000TL-US-10 / STP 30000TL-US-10



RATED FOR  
1000 V DC & 600 V DC  
SYSTEMS



## Design flexibility

- 1000 V DC or 600 V DC
- Two independent DC inputs
- 15° to 90° mounting angle range
- Detachable DC Connection Unit

## System efficiency

- 98.0% CEC, 98.6% Peak
- 1000 V DC increases system efficiency
- OptiTrac Global Peak MPPT

## Enhanced safety

- Integrated DC AFCI
- Floating system with all-pole sensitive ground fault protection
- Reverse polarity indicator in combination with Connection Unit

## Future-proof

- Complete grid management feature set
- Integrated Speedwire, WebConnect, ModBus interface
- Bi-directional Ethernet communications
- Utility-interactive controls for active and reactive power

## SUNNY TRIPOWER 12000TL-US / 15000TL-US / 20000TL-US / 24000TL-US / 30000TL-US

The ultimate solution for decentralized PV plants, now up to 30 kilowatts

The world's best-selling three-phase PV inverter, the SMA Sunny Tripower TL-US, is raising the bar for decentralized commercial PV systems. This three-phase, transformerless inverter is UL listed for up to 1000 V DC maximum system voltage and has a peak efficiency above 98 percent, while OptiTrac Global Peak minimizes the effects of shade for maximum energy production. The Sunny Tripower delivers a future-proof solution with full grid management functionality, cutting edge communications and advanced monitoring. The Sunny Tripower is also equipped with all-pole ground fault protection and integrated AFCI for a safe, reliable solution. It offers unmatched flexibility with a wide input voltage range and two independent MPP trackers. Suitable for both 600 V DC and 1,000 V DC applications, the Sunny Tripower allows for flexible design and a lower levelized cost of energy.

[www.SMA-America.com](http://www.SMA-America.com)



Technical data	Sunny Tripower 12000TL-US	Sunny Tripower 15000TL-US	Sunny Tripower 20000TL-US	Sunny Tripower 24000TL-US	Sunny Tripower 30000TL-US
Input (DC)					
Max. usable DC power (@ cos φ = 1)	12250 W	15300 W	20400 W	24500 W	30800 W
Max. DC voltage	*1000 V	*1000 V	*1000 V	*1000 V	1000 V
Rated MPPT voltage range	300 V...800 V	300 V...800 V	380 V...800 V	450 V...800 V	500 V...800 V
MPPT operating voltage range	150 V...1000 V	150 V...1000 V	150 V...1000 V	150 V...1000 V	150 V...1000 V
Min. DC voltage / start voltage	150 V / 188 V	150 V / 188 V	150 V / 188 V	150 V / 188 V	150 V / 188 V
Number of MPP tracker inputs	2	2	2	2	2
Max. input current / per MPP tracker input	66 A / 33 A	66 A / 33 A	66 A / 33 A	66 A / 33 A	66 A / 33 A
Output (AC)					
AC nominal power	12000 W	15000 W	20000 W	24000 W	30000 W
Max. AC apparent power	12000 VA	15000 VA	20000 VA	24000 VA	30000 VA
Output phases / line connections	3 / 3-N-PE				3 / 3-N-PE, 3-PE
Nominal AC voltage	480 / 277 V WYE				480 / 277 V WYE, 480 V Delta
AC voltage range	244 V...305 V				
Rated AC grid frequency	60 Hz				
AC grid frequency / range	50 Hz, 60 Hz / -6 Hz...+5 Hz				
Max. output current	14.4 A	18 A	24 A	29 A	36.2 A
Power factor at rated power / adjustable displacement	1 / 0.0 leading...0.0 lagging				
Harmonics	< 3%				
Efficiency					
Max. efficiency / CEC efficiency	98.2% / 97.5%	98.2% / 97.5%	98.5% / 97.5%	98.5% / 98.0%	98.6% / 98.0%
Protection devices					
DC reverse polarity protection	●	●	●	●	●
Ground fault monitoring / grid monitoring	●	●	●	●	●
All-pole sensitive residual current monitoring unit	●	●	●	●	●
DC AFCI compliant to UL 1699B	●	●	●	●	●
AC short circuit protection	●	●	●	●	●
Protection class / overvoltage category	I / IV	I / IV	I / IV	I / IV	I / IV
General data					
Dimensions (W / H / D) in mm (in)	665 / 650 / 265 (26.2 / 25.6 / 10.4)				
Packing dimensions (W / H / D) in mm (in)	780 / 790 / 380 (30.7 / 31.1 / 15.0)				
Weight	55 kg (121 lbs)				
Packing weight	61 kg (134.5 lbs)				
Operating temperature range	-25°C...+60°C				
Noise emission (typical) / internal consumption at night	51 dB(A) / 1 W				
Topology	Transformerless				
Cooling concept / electronics protection rating	OptiCool / NEMA 3R				
Features					
Display / LED indicators (Status / Fault / Communication)	— / ●				
Interface: RS485 / Speedwire, WebConnect	○ / ●				
Data interface: SMA Modbus / SunSpec ModBus	● / ●				
Mounting angle range	15°...90°				
Warranty: 10 / 15 / 20 years	● / ○ / ○				
Certifications and approvals	UL 1741, UL 1998, UL 1699B, IEEE 1547, FCC Part 15 (Class A & B), CAN/CSA C22.2 107.1-1				
NOTE: US inverters ship with gray lids.      Data at nominal conditions.      *Suitable for 600 V DC max. systems					
● Standard features    ○ Optional features    — Not available					
Type designation	STP 12000TL-US-10	STP 15000TL-US-10	STP 20000TL-US-10	STP 24000TL-US-10	STP 30000TL-US-10

#### Accessories



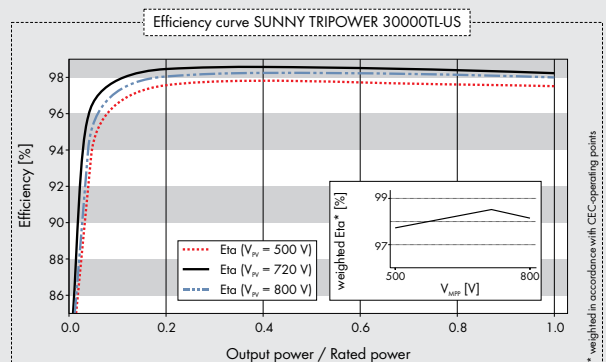
RS485 interface  
DM-485CB-US-10



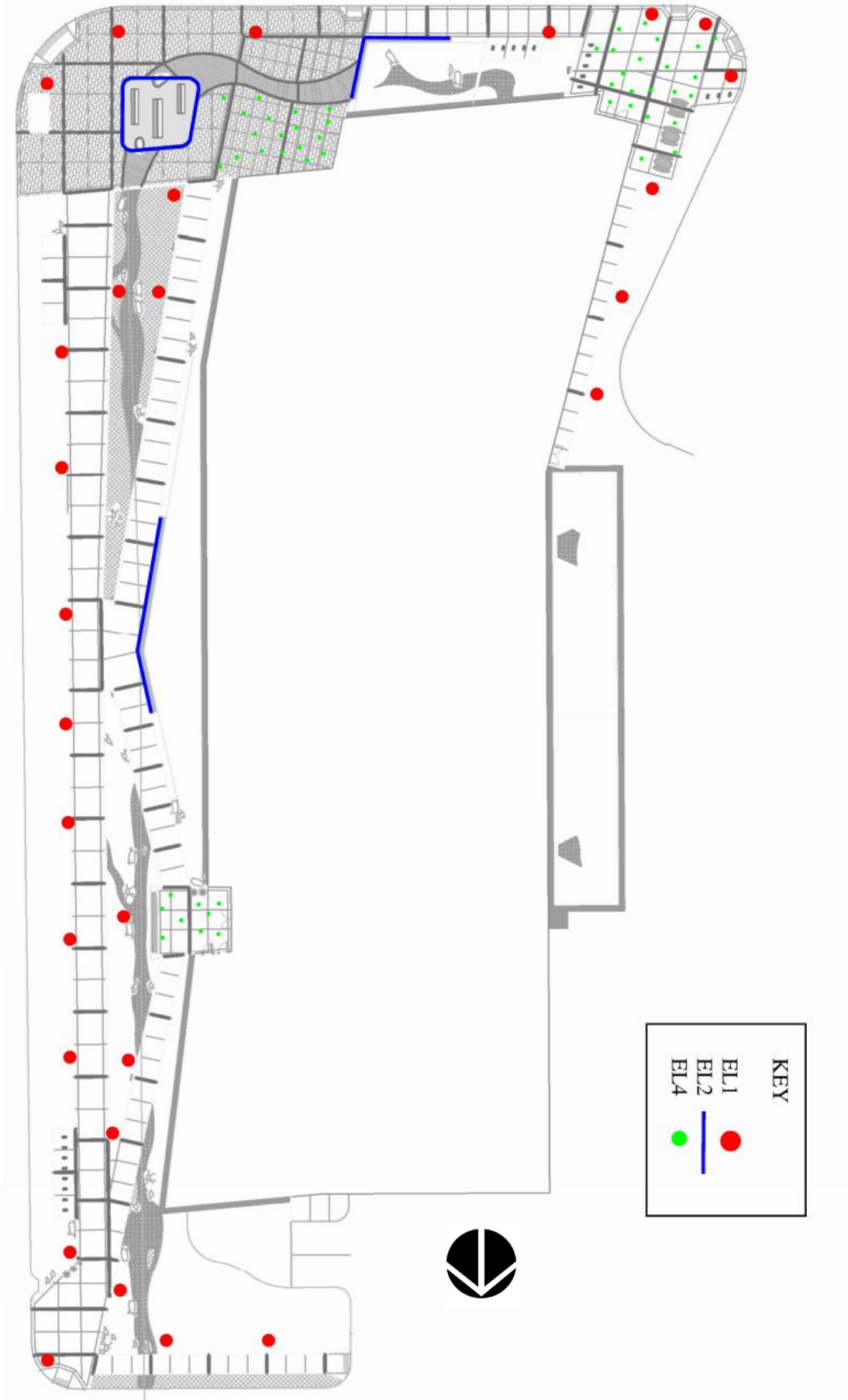
Connection Unit  
CU 1000-US-10



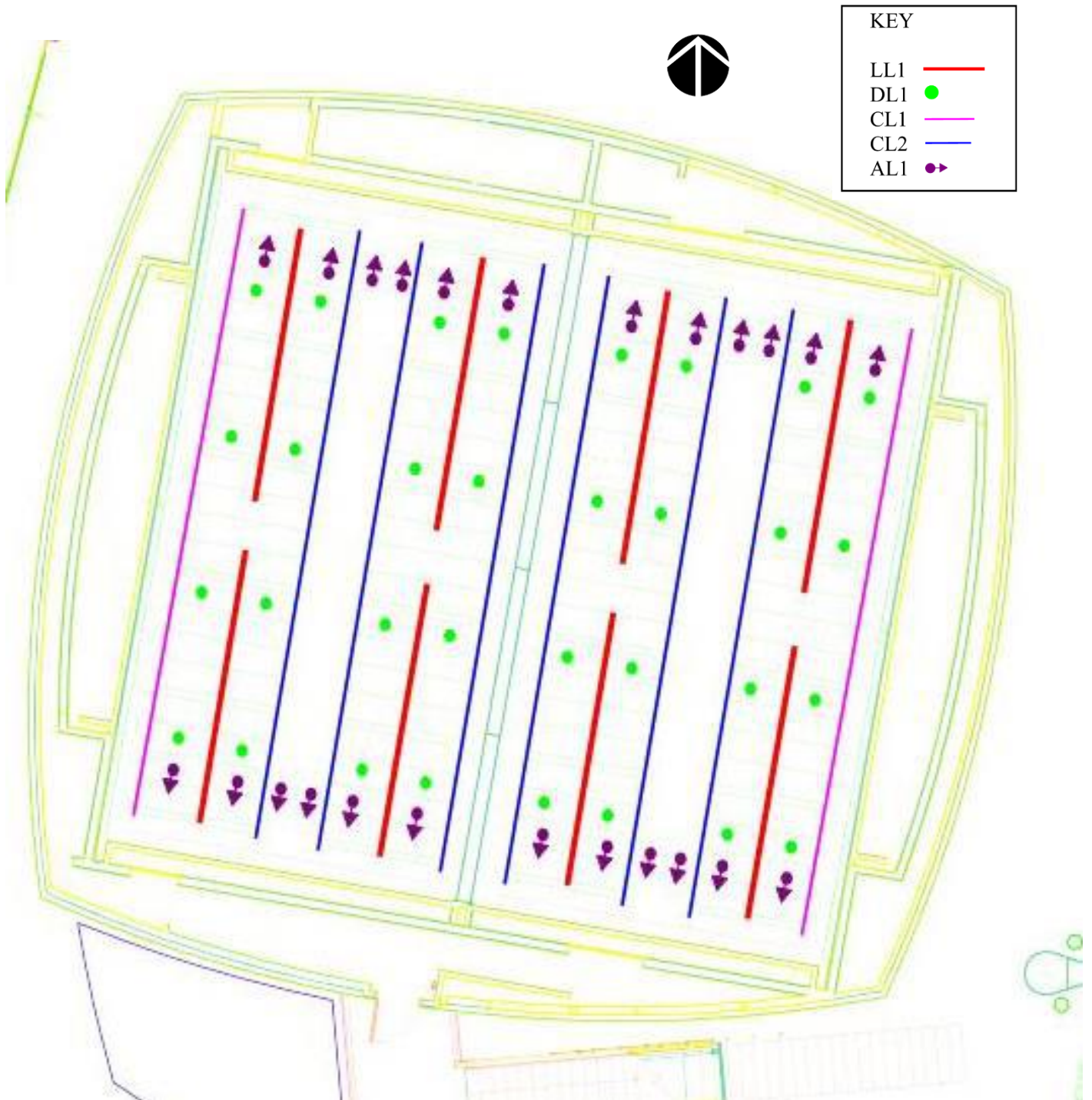
SMA Cluster Controller  
CLCON-10



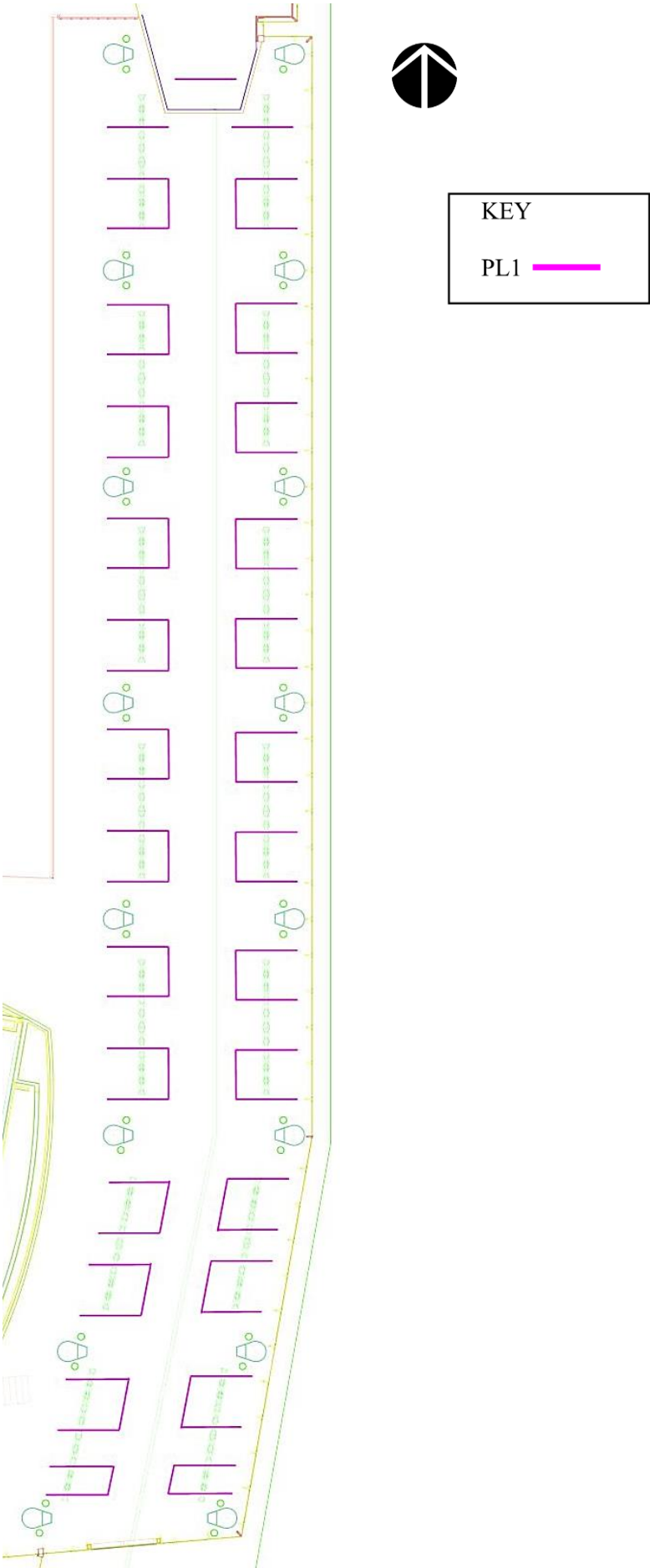
## **Appendix D** Lighting Plans














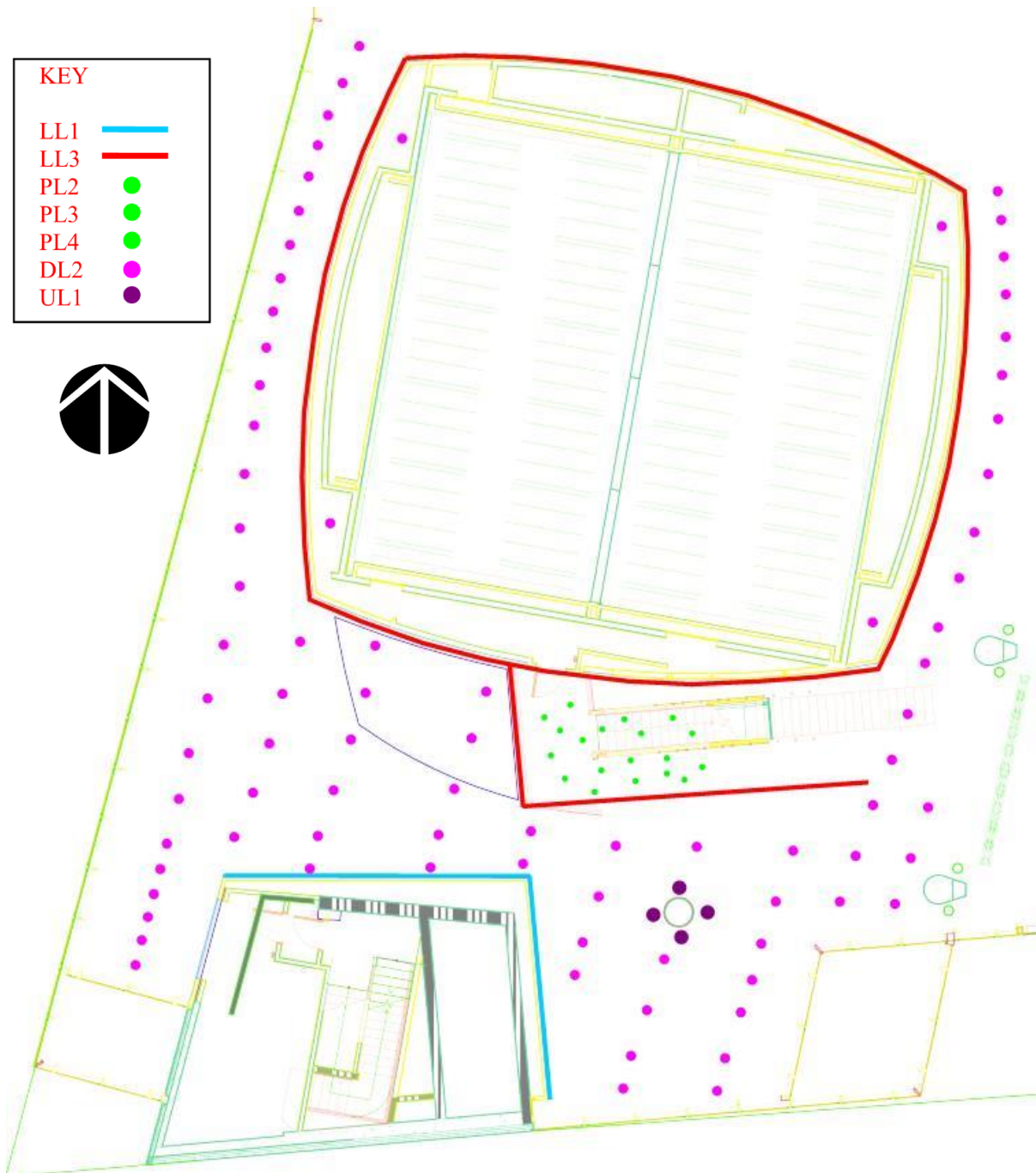
Flex Lab





## Lobby

KEY	
LL1	
LL3	
PL2	
PL3	
PL4	
DL2	
UL1	



## **Appendix E Lighting Cutsheets**

## LIGHT COLUMN PEDESTRIAN

QUOTE/ORDER FORM

PROJECT NAME: \_\_\_\_\_

DATE: \_\_\_\_\_

JOB LOCATION: \_\_\_\_\_

COMPANY: \_\_\_\_\_

PLEASE USE ADOBE READER OR ADOBE ACROBAT TO FILL OUT AND SAVE FORM. USING OTHER PROGRAMS COULD RESULT IN UNSAVED DATA.

## MODEL

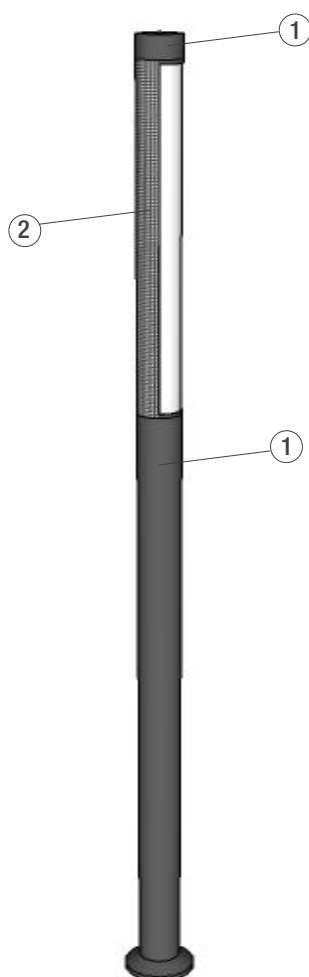
## QUANTITY

## MODEL

_____	LPLCO-512	Light Column Pedestrian, Series 500 - 5" diameter column
_____	LPLCO-612	Light Column Pedestrian, Series 600 - 6" diameter column

## OPTIONS

**FIG. 1: LIGHT COLUMN PEDESTRIAN**  
(180° perforated shield shown)



①

## Finish Options

Please select **one** option below.

## Standard Stainless Steel Finish

☐ Satin

**Standard Texture/Gloss from Forms+Surfaces Powdercoat Chart**  
(Please call for pricing information)

- |  |   |
|--|---|
| <input type="checkbox"/> Aluminum Texture    | <input type="checkbox"/> Evergreen Texture  |
| <input type="checkbox"/> Argento Texture     | <input type="checkbox"/> Fog Gloss          |
| <input type="checkbox"/> Black Gloss         | <input type="checkbox"/> Silver Texture     |
| <input type="checkbox"/> Black Texture       | <input type="checkbox"/> Slate Gloss        |
| <input type="checkbox"/> Bright Silver Gloss | <input type="checkbox"/> Slate Texture      |
| <input type="checkbox"/> Cobalt Texture      | <input type="checkbox"/> Taupe Grey Texture |
| <input type="checkbox"/> Cream Texture       | <input type="checkbox"/> White Texture      |
| <input type="checkbox"/> Evergreen Gloss     |   |

**Premium Texture from Forms+Surfaces Powdercoat Chart**  
(Please call for pricing information)

- |  |   |
|--|---|
| <input type="checkbox"/> Azure Texture | <input type="checkbox"/> Seafoam Texture        |
| <input type="checkbox"/> Lime Texture  | <input type="checkbox"/> Weathered Iron Texture |
| <input type="checkbox"/> Rust Texture  |   |

**Custom RAL Powdercoat Color**  
(Please call for pricing information)

☐ RAL Color: \_\_\_\_\_

2

Shield Options

Please select **one** option below. Please call for pricing information.

- |   |   |  |
|---|---|--|
| <input type="checkbox"/> No shield                    | <input type="checkbox"/> 180° shield with Bubbles     | <input type="checkbox"/> 360° shield with Bubbles  |
| <input type="checkbox"/> 180° shield with Kente*      | <input type="checkbox"/> 180° custom shield           | <input type="checkbox"/> 360° shield with Ribbon** |
| <input type="checkbox"/> 180° shield with Perforation | <input type="checkbox"/> 360° shield with Perforation | <input type="checkbox"/> 360° shield with Argyle** |
| <input type="checkbox"/> 180° shield with Scape       | <input type="checkbox"/> 360° shield with Scape       | <input type="checkbox"/> 360° custom shield        |

\*Kente shield is only available in Series 600, 180° configuration.

\*\* Argyle and Ribbon shields are only available in 360° configuration.

Lamp Options

Please select **one** option below. Please call for pricing information.

- ☐ 32W LED (32W custom LED light engine)  
Please select **one** color temperature below.
- ☐ 3000K      ☐ 4000K
- ☐ F32T8 (32W T8 linear fluorescent)
- ☐ F48T8/HO (48W T8HO linear fluorescent)

GFCI Outlet (for Series 600)

Please select **one** option below. Please call for pricing information.

- ☐ Yes      ☐ No

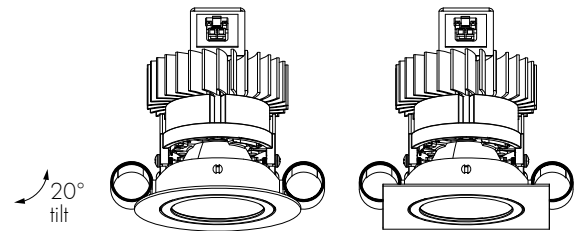
Client \_\_\_\_\_ Project name \_\_\_\_\_

Order# \_\_\_\_\_ Type \_\_\_\_\_ Qty \_\_\_\_\_

## FEATURES AND BENEFITS

### Physical

- Housing material: aluminum housing
- Reflector material: metallized polycarbonate
- Lens material for wet option: glass
- Trim finish: white, black or nickel satin
- Adjustability: +/- 20° tilt (not available for WET option)
- Damp location rating (interior applications only)
- Option: WET (IP54 rating suitable for wet locations, under covered ceiling)



### Performance

- Nominal lumen outputs: 700, 1000, 1300 and 2000 lumens
- Optics: 40° or 70°
- CRI values: 80+, 95+, Radiant 80+ or Radiant 95+
- Lumen maintenance: L70 @ 90,000 hrs [25°C]
- Operating temperatures: -20° C to 40° C (-4F to 104F)



### Performance summary

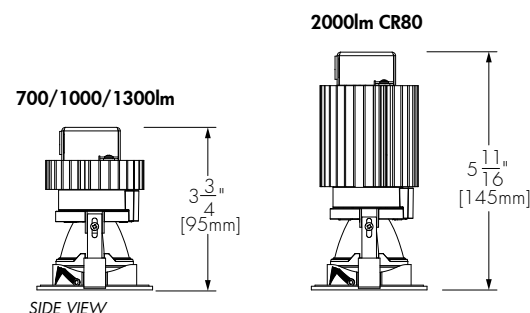
Based on Medium (40°), 4000K, CRI 80+  
insulated ceiling non-insulated ceiling

Nominal output [lm]	Delivered output [lm]	Power [W]	Efficacy [lm/W]	Power [W]	Efficacy [lm/W]
<b>700*</b>	728	7	104	9	80
<b>1000</b>	1040	10	104	12	86
<b>1300</b>	1352	14	96	16	84
<b>2000</b>	2080	N/A	N/A	25	83

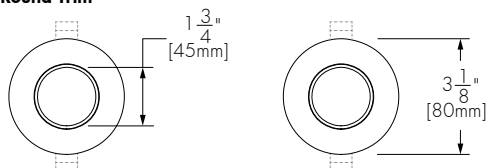
\*Photometric performance is measured in compliance with IESNA LM-79-08.

### Electrical

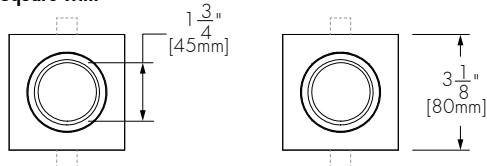
- Input voltage: 120 or 277V, consult factory for 347V
- Control options: non-dimming, 0-10 volt or DALI dimming



### Round Trim

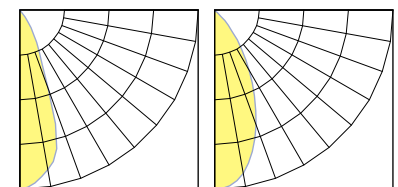


### Square Trim



BOTTOM VIEW

Cutout: Ø 2 7/8 " [73mm]  
Maximum ceiling thickness: 1 1/2" [38mm]

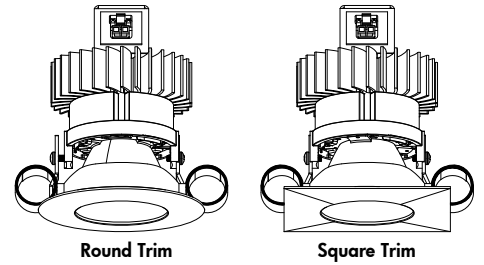
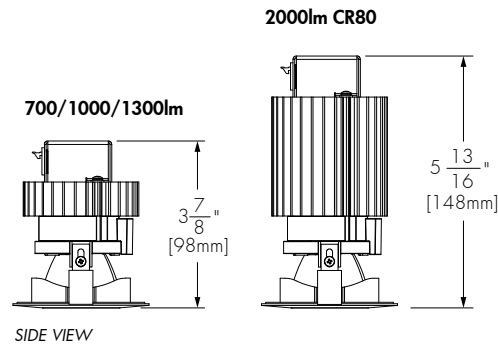


Medium (40°)

Wide (70°)

## WET OPTION

IP54 rating suitable for wet location.  
Suitable for covered ceiling-mounted recessed only.

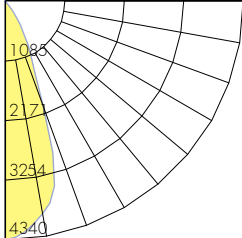
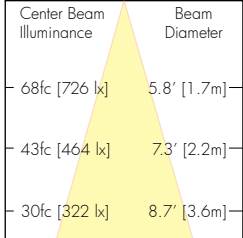


## PHOTOMETRIC INFORMATION

### Medium (40°), all color temperatures

Non-insulated ceiling installation types (RM and NC)<sup>1</sup>

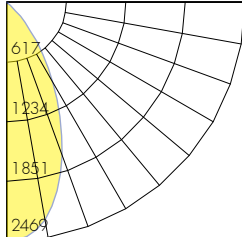
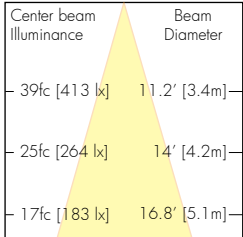
Nominal output [lm]	Power [W] <sup>†</sup>	Delivered output [lm] <sup>†</sup>	Candlepower distribution	Illuminance cone
	<b>CR80</b>	<b>CR95</b>		
<b>700*</b>	9	11	728	
<b>1000</b>	12	15	1040	
<b>1300</b>	16	20	1352	
<b>2000</b>	25	N/A	2080	

### Wide (70°), all color temperatures

Non-insulated ceiling installation types (RM and NC)<sup>1</sup>

Nominal output [lm]	Power [W] <sup>†</sup>	Delivered output [lm] <sup>†</sup>	Candlepower distribution	Illuminance cone
	<b>CR80</b>	<b>CR95</b>		
<b>700*</b>	9	11	696	
<b>1000</b>	12	15	994	
<b>1300</b>	16	20	1293	
<b>2000</b>	25	N/A	1989	

<sup>1</sup>Remove 2 watts per fixture when specifying new construction insulated ceiling installation types (IC and CP).

\*Photometric performance is measured in compliance with IESNA LM-79-08.

<sup>†</sup>Delivered wattage and delivered output: +/- 10% tolerance.



## PHOTOMETRIC INFORMATION - continued

### Color Rendering options comparison, 3000K

Color sample	Ra	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15
CRI 80+	81	80	85	89	81	78	80	86	66	16	64	79	58	81	93	75
CRI 95+	98	98	99	98	98	98	97	98	98	96	99	98	88	98	98	98
Radiant CRI 80+	81	81	86	89	81	80	80	85	68	16	66	80	62	82	93	77
Radiant CRI 95+	95	99	98	97	96	98	96	95	94	90	97	95	97	98	98	98

## CONTROL OPTIONS

### Dimming down to 1%

0-10V dimming

**DA1** - 0-10V dimming, 1% linear

**DA2** - 0-10V dimming, 1% logarithmic

### Dimming down to 0.1%

DALI dimming

**DALI1** - DALI dimming, 0.1% linear

**DALI2** - DALI dimming, 0.1% logarithmic

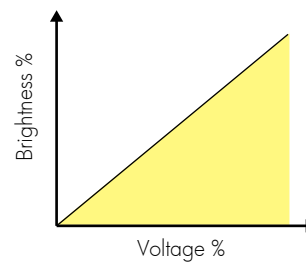
### Professional dimming down to 0.1%

0-10V dimming

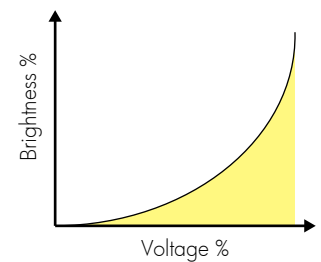
**PDA1** - Professional 0-10V dimming, 0.1% linear

**PDA2** - Professional 0-10V dimming, 0.1% logarithmic

Linear Curve

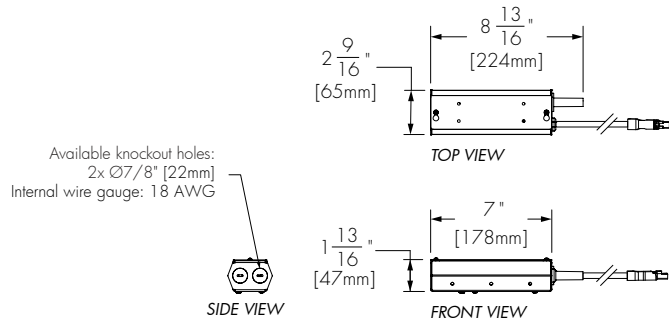


Logarithmic curve

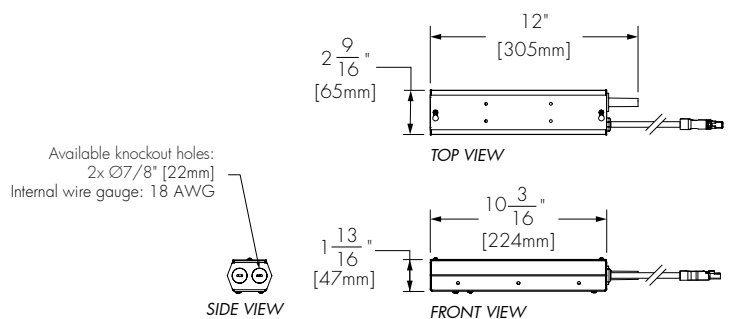


## INSTALLATION TYPES

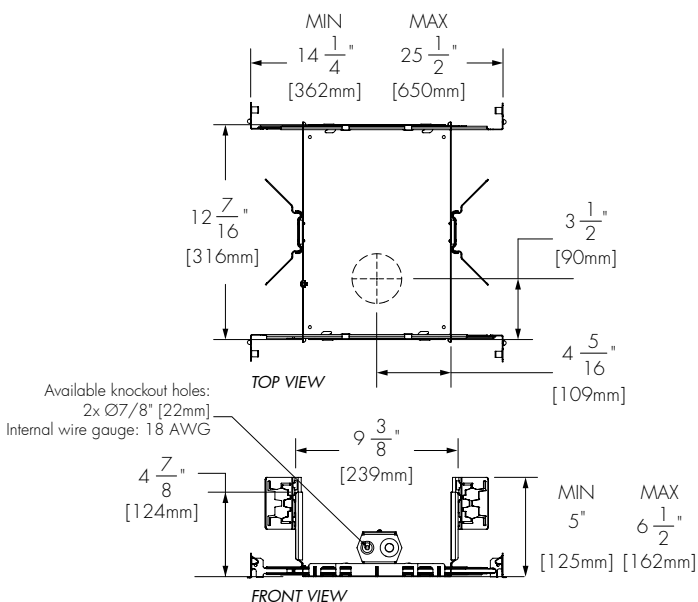
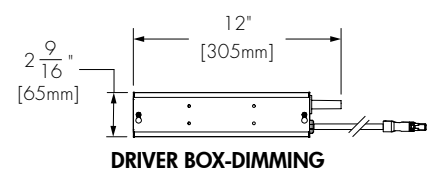
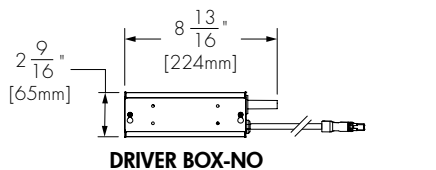
Minimum Ceiling Height Requirements				
	Up to 1000lm (CRI 80)	1300lm (CRI 80) 1000lm (CRI 95)	2000lm	3000lm
<b>Remodel (RM)</b>	On/Off = 8" Dimming = 10"	On/Off = 8" Dimming = 10"	On/Off = 8" Dimming = 10"	N/A
<b>New Construction (NC)</b>	On/Off = 8" Dimming = 10"	On/Off = 8" Dimming = 10"	On/Off = 8" Dimming = 10"	N/A
<b>Insulation Contact (IC/CP)</b>	7"	9"	N/A	N/A

**LACN-MTG-A-VOLTAGE-OUTPUT-COLOR RENDERING-NO-RM**

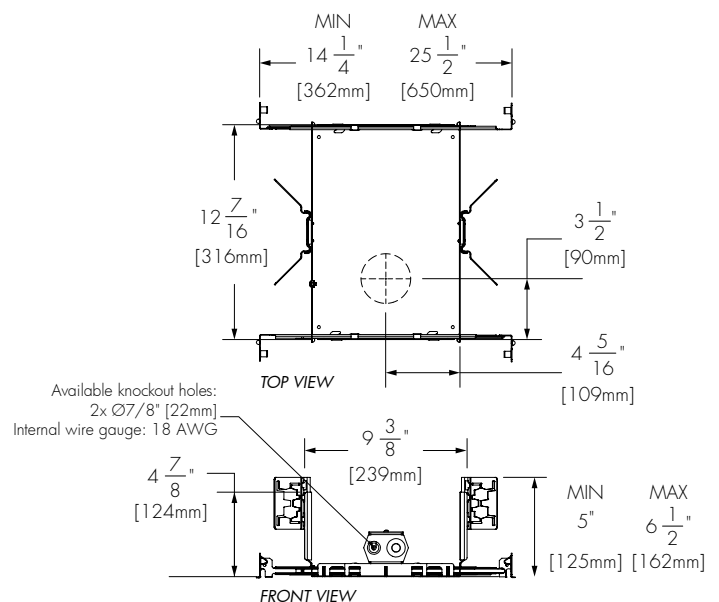
Remodel non-insulated ceiling - On/Off control

**LACN-MTG-A-VOLTAGE-OUTPUT-COLOR RENDERING-DIMMING-RM**

Remodel non-insulated ceiling - Dimming

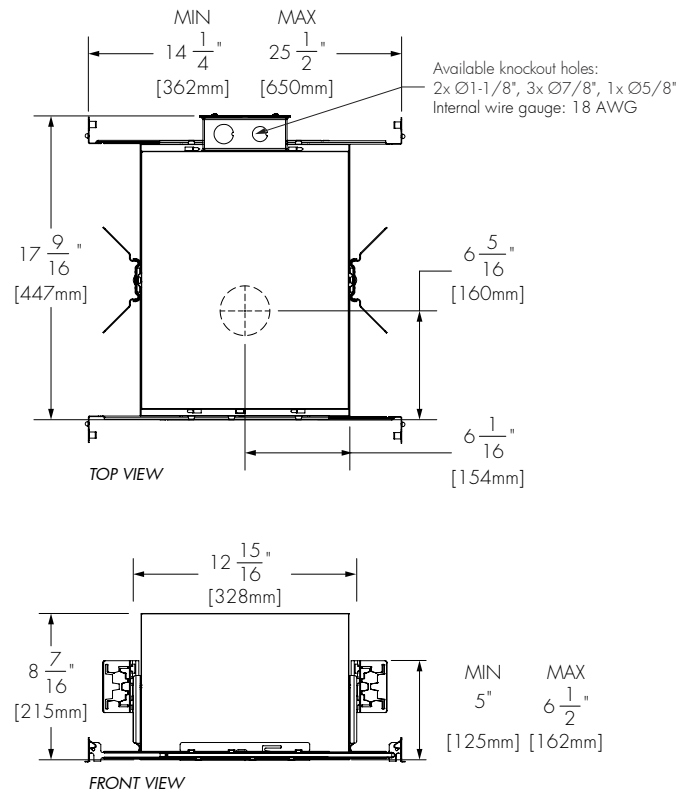
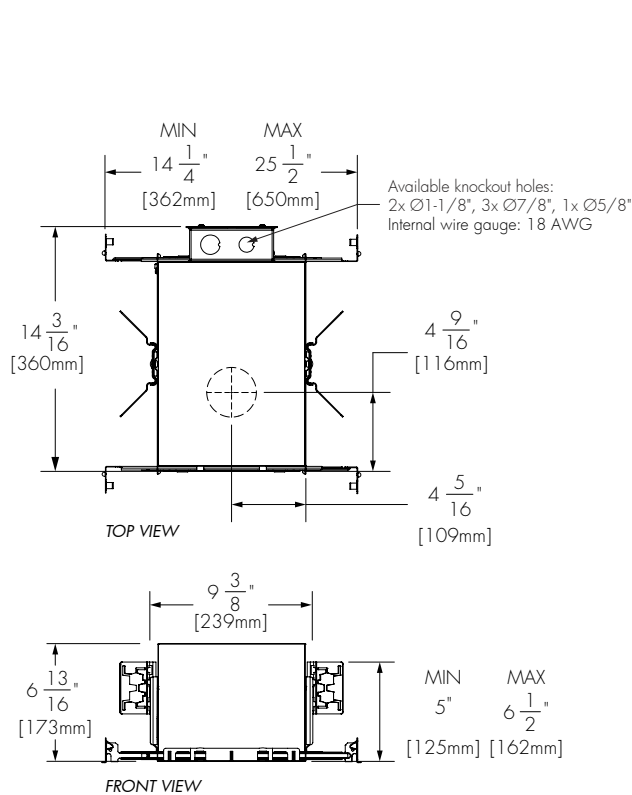
**LACN-MTG-A-VOLTAGE-OUTPUT-COLOR RENDERING-NO-NC**

New construction non-insulated ceiling - On/Off control

**LACN-MTG-A-VOLTAGE-OUTPUT-COLOR RENDERING-DIMMING-NC**

New construction non-insulated ceiling - Dimming

## INSTALLATION TYPES - continued



### LACN-MTG-A-VOLTAGE-OUTPUT-COLOR RENDERING-CONTROL-IC/CP\*

New construction insulated ceiling

New construction insulated ceiling, Chicago plenum rated option, airtight

\*Available for the following output and color rendering combinations:

Nominal output [lm]	Color rendering			
	CR80	CR95	RCR80	RCR95
<b>L07</b>	YES	YES	YES	YES
<b>L10</b>	YES	N/A	YES	N/A

### LACN-MTG-A-VOLTAGE-OUTPUT-COLOR RENDERING-CONTROL-IC/CP\*

New construction insulated ceiling

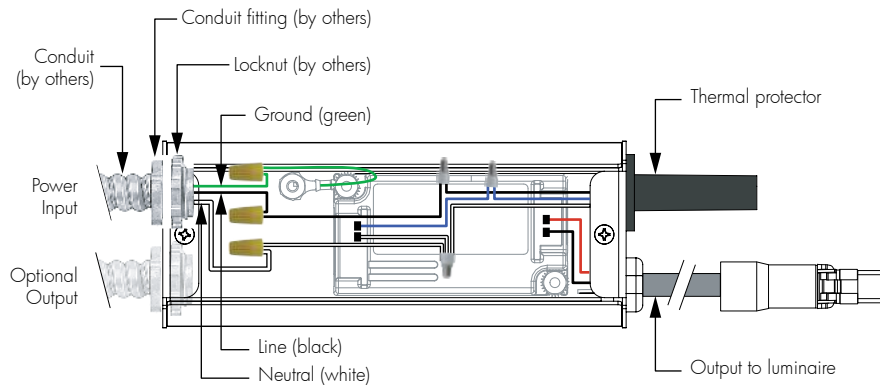
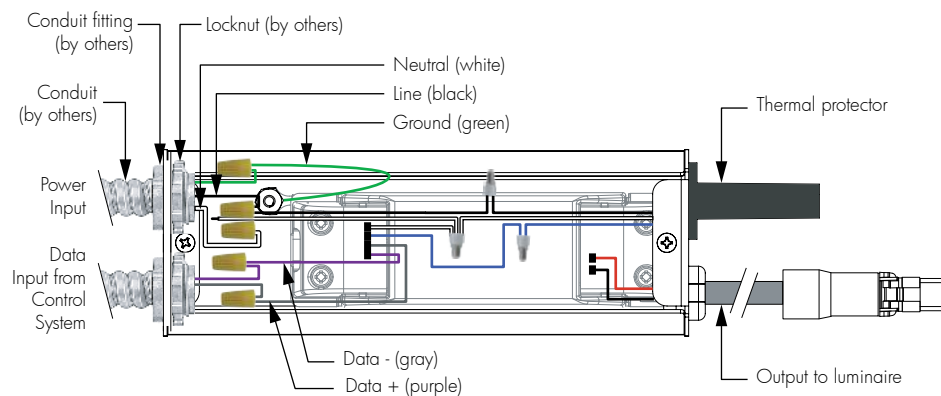
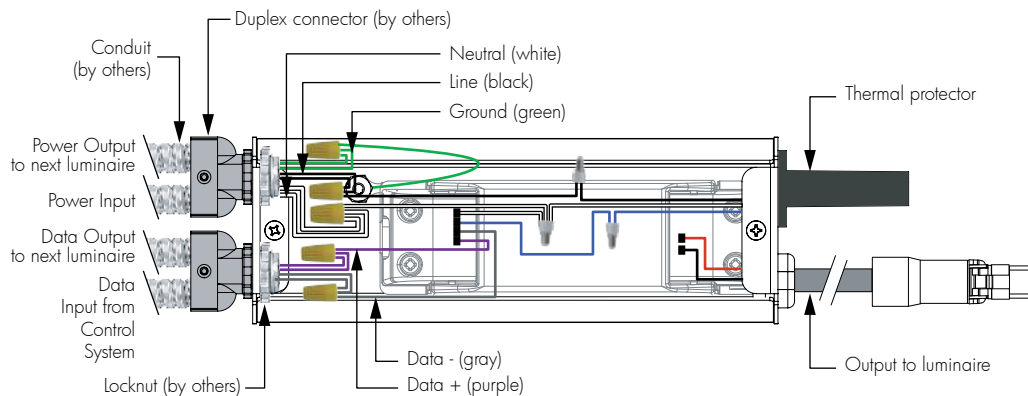
New construction insulated ceiling, Chicago plenum rated option, airtight

\*Available for the following output and color rendering combinations:

Nominal output [lm]	Color rendering			
	CR80	CR95	RCR80	RCR95
<b>L10</b>	N/A	YES	N/A	YES
<b>L13</b>	YES	N/A	YES	N/A

**WIRING DETAILS**

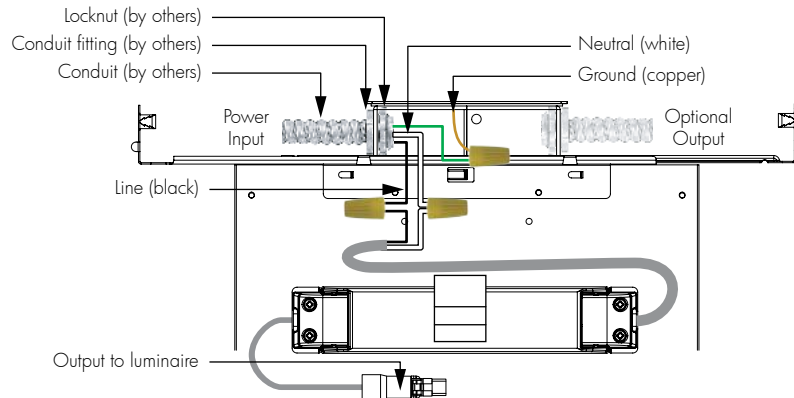
RM: remodel non-insulated ceiling and NC: new construction non-insulated ceiling

**No Control****Control****(DA1, DA2, PDA1, PDA2, DALI1, DALI2)****Control (Daisy Chain Layout)****(DA1, DA2, PDA1, PDA2, DALI1, DALI2)**

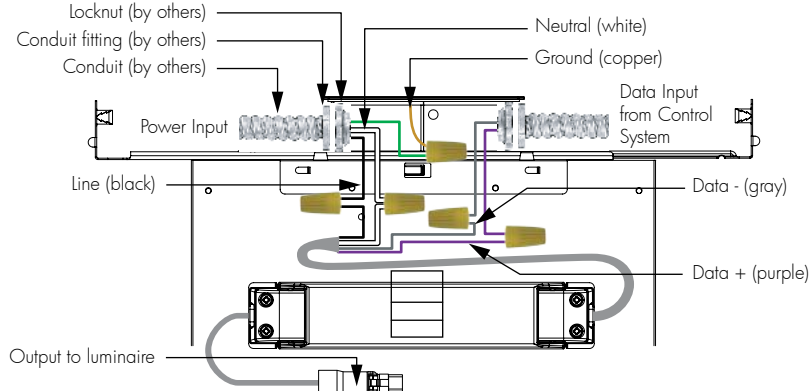
**WIRING DETAILS** - continued

IC/CP: new construction insulated ceiling

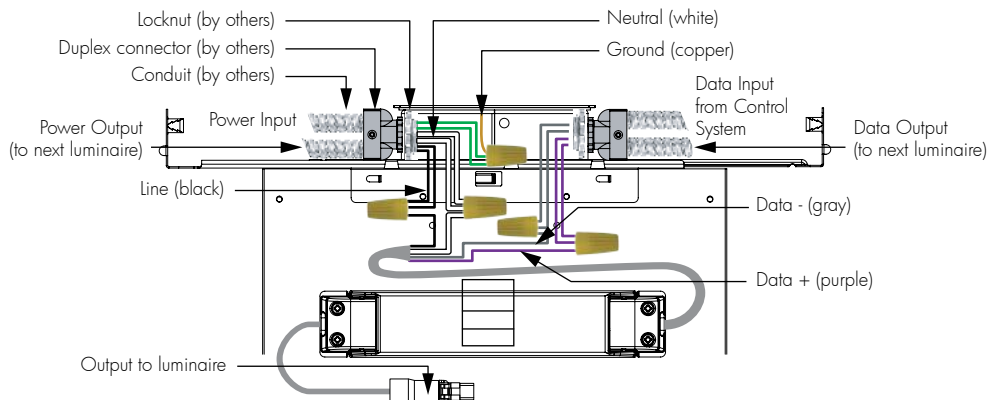
Insulated ceiling up to 1300 lumens (CR80 or RC80), 1000 lumens (CR95 or RCR95)

**No Control****Control**

(DA1, DA2, PDA1, PDA2, DALI1, DALI2)

**Control (Daisy Chain Layout)**

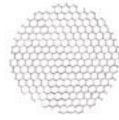
(DA1, DA2, PDA1, PDA2, DALI1, DALI2)



## OPTICAL ACCESSORIES

Maximum two accessories for standard construction.

**HL** - Honeycomb louver



**SL** - Softening glass lens



**RS** - Linear spread glass lens



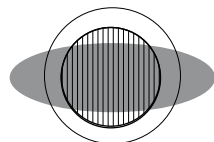
**CL** - Clear glass lens\*



\*Automatically included when selecting WET option, do not specify.  
Maximum one additional accessory with WET option.

## RS - LINEAR SPREAD GLASS LENS ORIENTATION

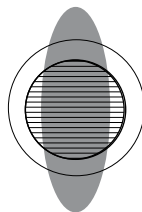
Factory installed, round trim shape shown



BOTTOM VIEW

**RS**

Horizontal Beam Distribution  
Not adjustable onsite



BOTTOM VIEW

**RS**

Vertical Beam Distribution  
Not adjustable onsite

Install fixture onsite according to desired beam pattern direction.

## HOW TO ORDER

LACN	A											
	1	2	3	4	5	6	7	8	9	10	11	12

## 1 | Region:

A - Americas

## 2 | Voltage:

120 - 120 volts

277 - 277 volts

Consult factory for 347 volts.

## 3 | Output (nominal lumens):

L07 - 700 lumens

L10 - 1000 lumens

L13 - 1300 lumens

L20 - 2000 lumens

## 4 | Color Temperature:

27K - 2700K

30K - 3000K

35K - 3500K

40K - 4000K

## 5 | Color Rendering:

CR80 - CRI 80+

CR95 - CRI 95+, up to 1300 lumen output

RCR80 - Radiant CRI 80+\*

RCR95 - Radiant CRI 95+, up to 1300 lumen output\*

\*Radiant CRI options available for 3000K only.

## 6 | Optics:

M - Medium distribution 40°

W - Wide distribution 70°

## 7 | Trim Shape:

RD - Round shape

SQ - Square shape

## 8 | Trim Finish:

WH - White trim

BK - Black trim

NS - Nickel satin trim

## 9 | Control:

NO - On/Off control

DA1 - 0-10V dimming, 1% linear

DA2 - 0-10V dimming, 1% logarithmic

PDA1 - Pro 0-10V dimming, 0.1% linear

PDA2 - Pro 0-10V dimming, 0.1% logarithmic

DALI1 - DALI dimming, 0.1% linear

DALI2 - DALI dimming, 0.1% logarithmic

## 10 | Installation Type:

RM - Remodel non-insulated ceiling

NC - New construction non-insulated ceiling

IC - New construction insulated ceiling\*

CP - New construction insulated ceiling, Chicago plenum rated option, airtight\*

\*Insulated ceiling up to 1300 lumens (CR80 or RCR80),  
1000 lumens (CR95 or RCR95).

## 11 | Option:

WET - IP54 rating suitable for wet location

Suitable for covered ceiling-mounted recessed applications only, clear glass lens included. No tilt adjustment.

## 12 | Accessories (factory installed):

NA - No accessory

HL - Honeycomb louver

SL - Softening glass lens

RS - Linear spread glass lens\*

CL - Clear glass lens\*\*

\*Refer to page 9 for orientation guidelines.

\*\*Automatically included when selecting WET option, do not specify.

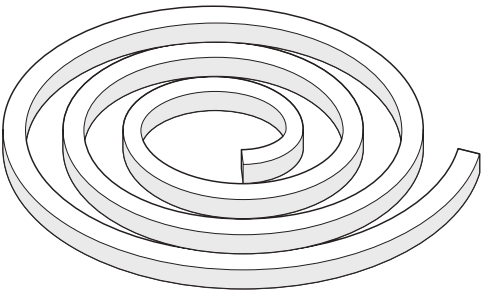
Maximum one additional accessory with WET option.

Maximum two accessories per fixture for standard construction.



# Flex Tube SE SC™ EL2

**ACCLAIM**  
LIGHTING



Client:

Project:

Type:

Order Code:

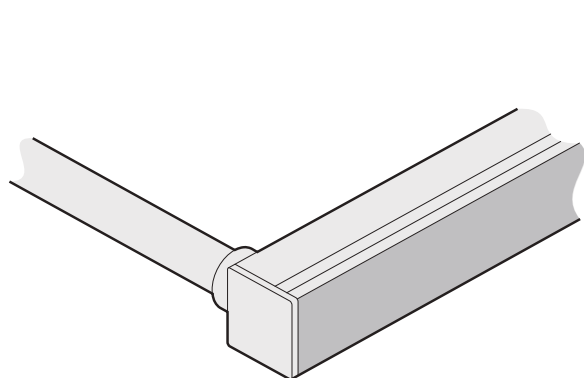
Quantity:

**Flex Tube SE SC** is a side emitting, outdoor rated flexible LED tube. It is available in multiple color temperatures of white, as well as single red, green, and blue versions. It features an IP68 rating, cut points every 3.25", and a maximum bend radius of 12". Sold in spools of 32' (10m), it is impact, UV, and saltwater resistant.

## Specifications

Color Temperature	2700K, 3000K, 3500K, 4000K, Red, Green, Blue
Spool Length + Cut Points	32' (10m), Cut points every 3.25" (82mm)
Beam Angle	160°
Max Fixture Runs	32' (10m) - 1 spool maximum
Photometrics	171 Lumens per foot, 54 center beam candlepower (3500K), >80 CRI
Dimming Protocol	via DMX-512, 1 channel per spool / section
Mounting	via Self lock mounting channel
Power Consumption	106W @ 32' (1 Spool), minimum 3.3W per foot
Operating Voltage	24VDC
Lumen Maintenance	L70 @ 50,000 Hours (25° C)
Housing & Finish	White UV coated, flexible silicone jacket
Installation Temperature	32°F to 113°F (-0°C to 45°C)
Operating Temperature	-40°F to 131°F (-40°C to 55°C)
IP / IK Rating	IP68 - Wet Location / Submersible, IK 08 - Up 5 Joule Impact Energy Protection
Fixture Connectors	10' (3m) Attached injection molded feed cable - rear or side mount options
Warranty	3 Years standard, 5 Years optional (additional charge)
Weight	8 lbs (3.62 kg)
Dimensions	W 0.63" x H 0.63" x L 32' (16mm x 16mm x 10m)
Certifications	 

\* Indicates Special Order

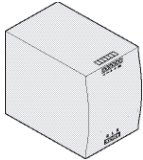


A diagram showing a vertical rod passing through a horizontal plate. The rod has a wider base (flange) that fits into a corresponding hole in the plate. The plate is shown in a perspective view, with the rod passing through its center.

**Specification Sheet 2.0.0**  
www.acclaimlighting.com

## Related Components

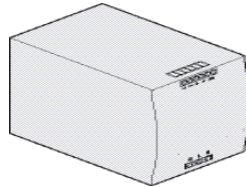
### Power Supplies (Non-dim or DMX)



#### **APS-240-24**

*Two Spools Maximum*

240W, 24VDC, Dry location, DIN Rail Mount  
115-230VAC (47-63Hz) Input

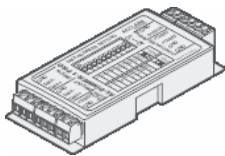


#### **APS-480-24**

*4 Spools Maximum*

480W, 24VDC, Dry location, DIN Rail Mount  
115-230VAC (47-63Hz) Input

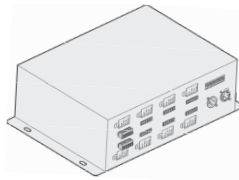
### DMX Drivers



#### **DPW-311-JBAT**

*AL Dimmer 1 Pro*

Single channel DMX driver, 1 spool max.  
Use in conjunction with APS Series

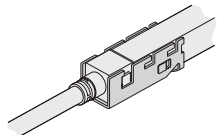


#### **DPW-111-FA**

*AL Driver 8 RGBW 24V*

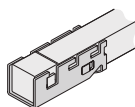
150W 12V power supply + DMX driver, 1 spool max.  
8 output ports, 120VAC or 240VAC input

### Wiring Accessories



#### **FTUFC**

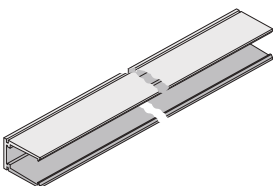
*Flex Tube SE feed cable kit*  
10' (3M)



#### **FTSEEC**

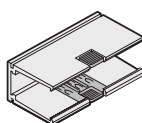
*Flex Tube SE end cap*

### Self Lock Mounting Channels



#### **FTSELC1M**

*Flex Tube SE self lock mounting channel*  
3.28' (1m)



#### **FTSELC5CM**

*Flex Tube SE self lock mounting channel*  
2" (5cm)

## Photometrics

For additional color data and IES files, please visit [acclaimlighting.com](http://acclaimlighting.com)

### 3000K

Total Lumens

149.9

Center Beam Candlepower

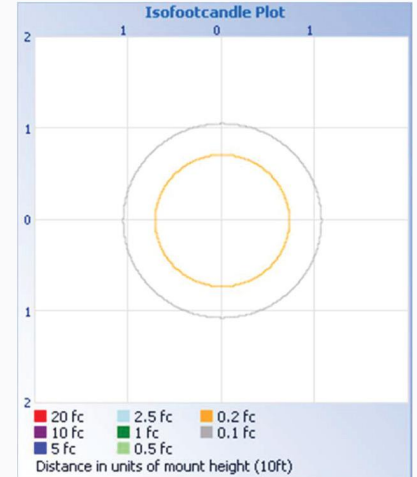
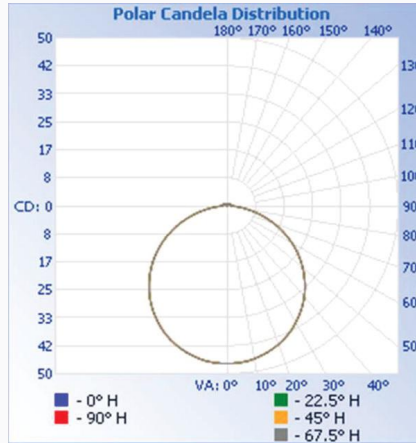
47

CRI

Ra: 79.9

R9: 10.6

Illuminance at a Distance		
Center Beam fc	Beam Width	
2.0ft	11.74 fc	6.3 ft
4.0ft	2.93 fc	12.7 ft
6.0ft	1.30 fc	19.0 ft
8.0ft	0.73 fc	25.4 ft
10.0ft	0.47 fc	31.7 ft



### 3500K

Total Lumens

171.1

Center Beam Candlepower

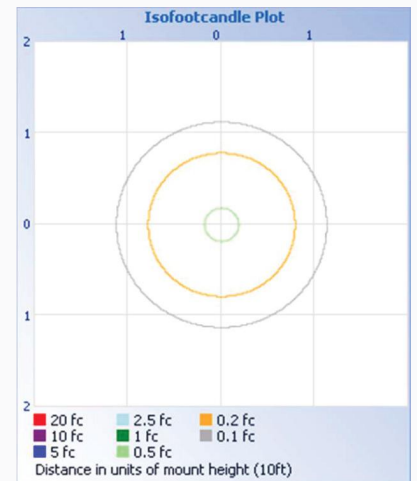
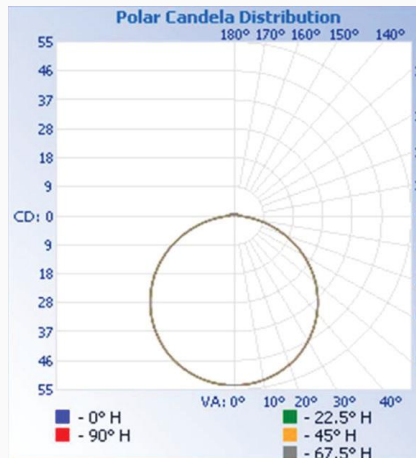
54

CRI

Ra: 80.8

R9: -0.7

Illuminance at a Distance		
Center Beam fc	Beam Width	
2.0ft	13.39 fc	6.4 ft
4.0ft	3.35 fc	12.7 ft
6.0ft	1.49 fc	19.1 ft
8.0ft	0.84 fc	25.4 ft
10.0ft	0.54 fc	31.8 ft



### 4000K

Total Lumens

133.9

Center Beam Candlepower

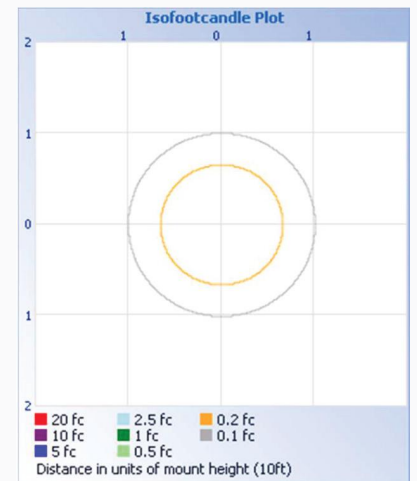
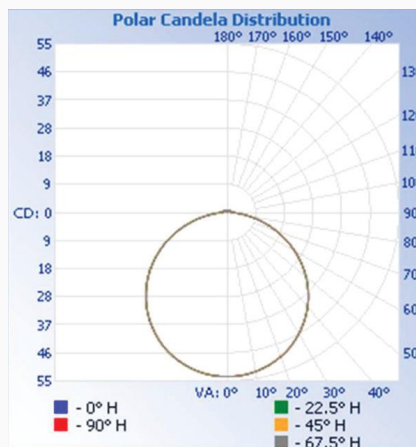
42

CRI

Ra: 83.4

R9: 13.6

Illuminance at a Distance		
Center Beam fc	Beam Width	
2.0ft	10.54 fc	6.3 ft
4.0ft	2.64 fc	12.5 ft
6.0ft	1.17 fc	18.8 ft
8.0ft	0.66 fc	25.0 ft
10.0ft	0.42 fc	31.3 ft

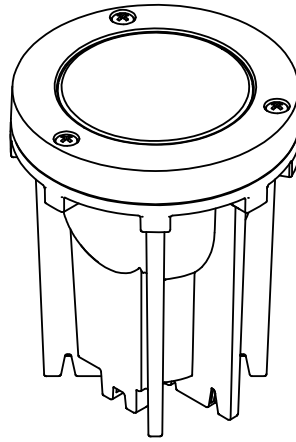


**PHILIPS**  
**HADCO**

Landscape

IL9  
FlexScape LED

Inground Bullet Luminaire



Project: \_\_\_\_\_  
Location: \_\_\_\_\_  
Cat.No: \_\_\_\_\_  
Type: \_\_\_\_\_  
Lamps: \_\_\_\_\_ Qty: \_\_\_\_\_  
Notes: \_\_\_\_\_

Breaking new ground with optimal versatility, the FlexScape BL9 has zoomable optics (15° to 35°) & 60° by switching optic element. This adjustable luminaire also has the ability to switch light output in 4 steps.

## Ordering guide

Example: IL9DC-A

Series	Lamping	CCT	Finish
<b>IL9</b>	<b>D</b>	<b>-</b>	
<b>IL9</b> Low Voltage 9W Inground Lighting	<b>D</b> LED	<b>W</b> Warm (3000K) <b>C</b> Cool (4000K)	<b>A</b> Black

## Features

- Housing/Construction:** Black Injection molded, glass filled polyester, molded-in fins for thermal performance as well as to discourage heaving and twisting after installation. Molded-in brass inserts for repeatable opening / closing. Lens ring secured with three (3) screws that clamp lens and gasket into place, flush for ADA compliance and repeatable sealing.
- Electrical:** 10W (on high setting) Input voltage range (VAC): 10 -14. Pre-wired with a 3-ft. pigtail for easy hookup to the low voltage supply cable. Driver housed in injected molded case with electronics encapsulated. 12V class 2 driver with integral switch for 4 preset light levels.
- LED Board and Array:** Single Luxeon M LED.
- Controls:** 12 Volt Class 2 driver with integral switch provides simple customer access to the adjustment between 4 present light levels.
- Optical Systems:** Low iron-tempered clear glass, molded gasket slips onto lens without tools or RTV. Zoomable optic / Injection molded acrylic (PMMA) clear, highly polished molded with select surfaces textured. Inter-changeable lens provides Narrow 15° to Medium 35° beam pattern depending on the position, Inter-changeable lens provides Wide 60° flood output. Limited Aiming: Heatsink doubles as an aiming apparatus, providing a range of 30° (15° from center both ways). Aiming can be adjusted after easy removal of three screws on lens ring.

## Finish

Composite is textured, pressure formed, black molded-in-color.

## Lamps

Integral LED module

## Power Supply

Fixtures can be used with the HADCO Low Voltage Transformers series TC152, TSS, TC. Power supplies are available in 150W / 300W / 600W and 900W. Ask your Philips representative for a full list of options.

Watts Consumed / Needed to Drive	2.0 W	4.5 W	8.6 W	10.7 W
mA	230	600	1100	1500
3K 15°	111	235	419	554
3K 35°	129	273	485	642
3K 60°	115	245	436	571
4K 15°	118	262	465	587
4K 35°	137	303	539	681
4K 60°	122	272	484	606

## IP68 Rating

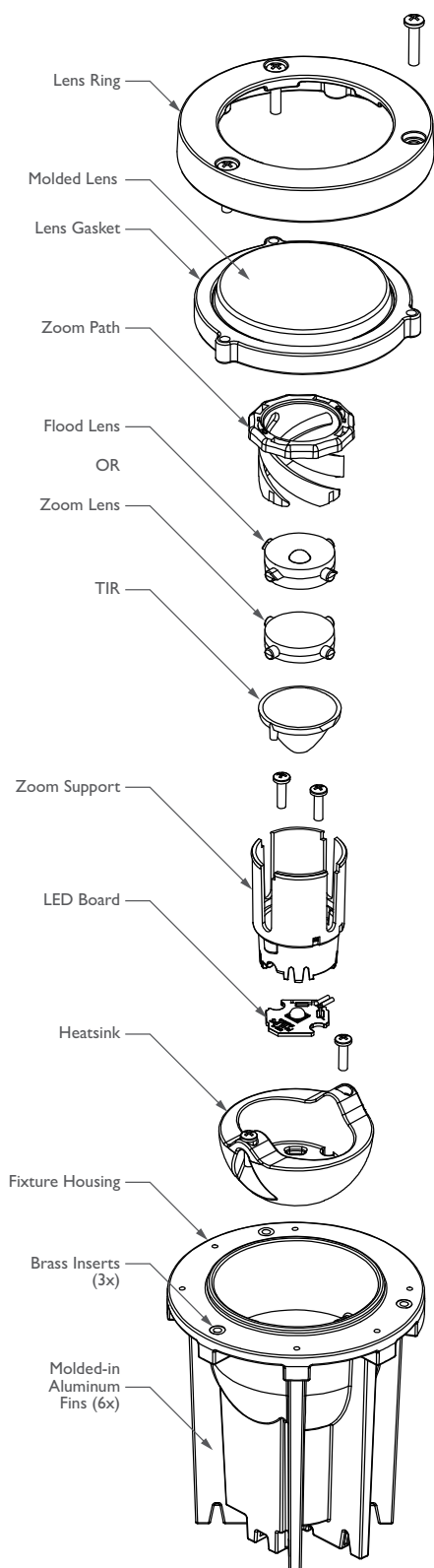
Dust-tight and sealed against direct jets of water and against continuous immersion up to a depth of 1 meter (3.28 feet).

## Labels

ETL Listed to U.S. safety standards for wet locations. cETL listed to Canadian safety standards for wet locations. Manufactured to ISO 9001:2008 Standards. 5-year limited warranty.

# IL9 FlexScape LED

## Landscape Inground Bullet Luminaire



Component	Material	Finish	Feature/Function
1. Lens Ring	Injection molded, glass filled polyester	Black, texture on top surface only	Lens ring secures with three (3) Phillips-head screws. Clamps lens and gasket into place, flush for ADA compliance.
2. Molded Lens	Molded, low-iron, tempered	Clear (glass)	Environmental barrier, sealing, flush for ADA compliance, slight curvature to shed water and debris.
3. Lens Gasket	100% molded-silicone	Black	Molded gasket slips onto lens without tools or RTV.
4. Zoom Path	Injection-molded, UV-resistance polycarbonate	White <sup>1</sup>	Tool-lessly adjustable/removable path for Zoom Lens and Flood Lens, high brightness white for maximum light output.
5. Flood Lens <sup>3</sup>	Injection-molded acrylic (PMMA)	Clear <sup>2</sup>	Interchangeable lens provides 60° flood output.
6. Zoom Lens <sup>3</sup>	Injection-molded acrylic (PMMA)	Clear <sup>2</sup>	Interchangeable lens provides 15° to 35° beam depending on position.
7. TIR	Injection-molded acrylic (PMMA)	Clear <sup>2</sup>	Snap-in optic shapes beam for zoom and flood lenses.
8. Zoom Support	Injection-molded, UV-resistance polycarbonate	White <sup>1</sup>	Support for TIR and Zoom Path, locates optics precisely relative to LED, high brightness white for maximum light output.
9. LED Board	Philips Lumileds Luxeon M	White solder mask, silk screen printing	Custom PCB with Philips Lumileds Luxeon M, 3000K/4000K.
10. Heatsink	Injection molded zinc	As cast	Spherical shape enables aiming while transferring heat to exterior housing for better thermal performance.
11. Fixture Housing	Injection molded, glass-filled polyester, molded-in aluminum fins, molded-in brass inserts	Black	Housing includes molded-in metal fins for thermal performance, molded-in brass inserts for repeatable opening/closing. External fins aid thermal management and discourage "heaving" and twisting after installation. Incoming wires factory sealed including anti-wicking feature.

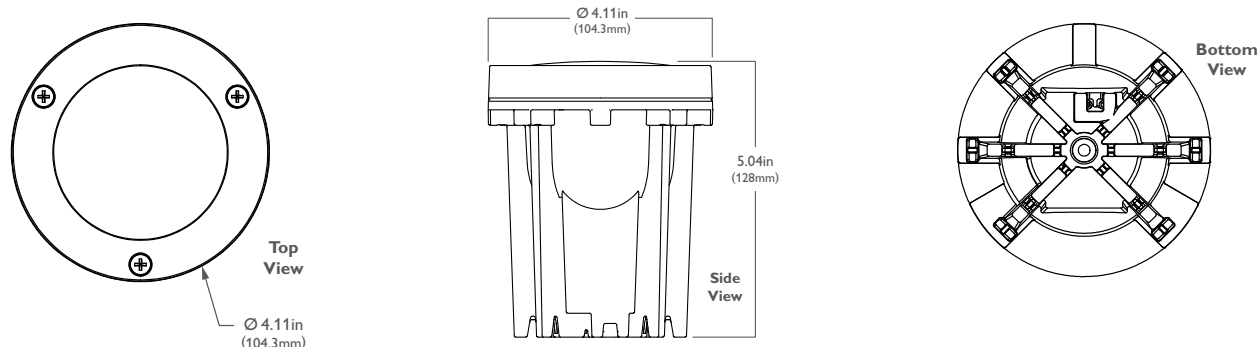
1. Highly polished molded.

2. Highly polished molded, select surfaces textured.

3. Select from either a Zoom or Flood lens optics for customized lighting effects.

## IL9 FlexScape LED

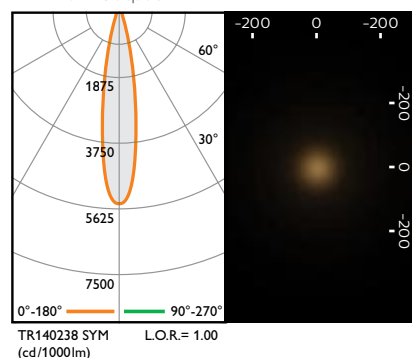
## Landscape Inground Bullet Luminaire



### IL9 Warm 3000 K

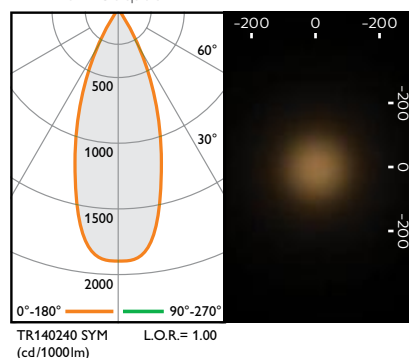
Spot

minimum output



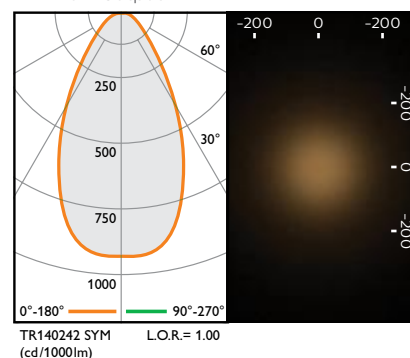
### Narrow Flood

minimum output



## Flood

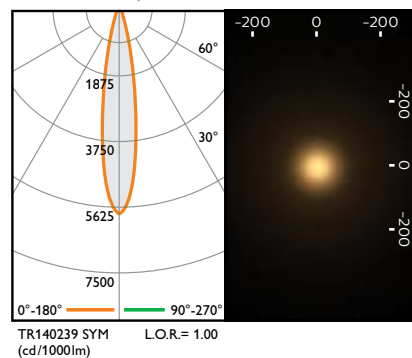
minimum output



IL9 Cool 4000 K

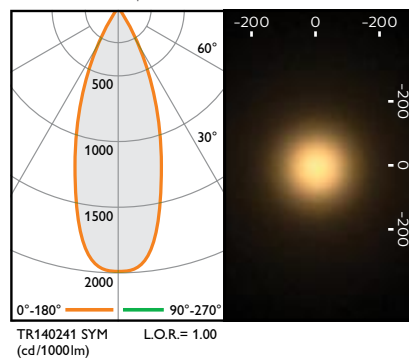
Spot

maximum output



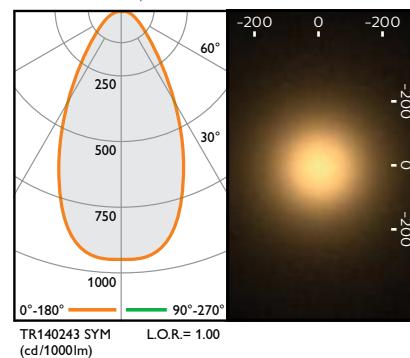
### Narrow Flood

maximum output



## Flood

maximum output



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Philips Lighting, North America Corporation  
200 Franklin Square Drive, Somerset, NJ 08873  
Tel. 855-486-2216

Philips Lighting Canada Ltd.  
281 Hillmount Rd, Markham, ON, Canada L6C 2S3  
Tel. 800-668-9008



JOB \_\_\_\_\_ TYPE \_\_\_\_\_

NOTES \_\_\_\_\_ APPROVALS \_\_\_\_\_

**FEATURES**

- Sealed IP68 LED light engine
- Bluetooth connectivity for remote control aiming and dimming
- Free Mobile App for Android and iOS
- Easy to install and pair devices
- Advanced thermal management provides long life in excess of 100,000+ hours
- Runs cool to the touch - less than 40°C

**Certifications**

**SPECIFICATIONS**

Pour Box rough-in housing ships separately and as a quick-ship if requested.


**LTV82SS**

**LTV81SS**

**LTV83SS**

**DEBRIS SHIELDS**

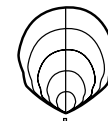
**LTV81**

**LTV82**

**LTV83**
**LIGHT DISTRIBUTIONS:**

LTV81SS, LTV82SS, LTV83SS


**Spot (SP)**

**Narrow Flood (NF)**

**Wall Wash (WW)**
**ORDERING CODE**

Fixture Size	Distribution*	Source
<b>LTV81SS</b> 13" Dia.	<b>SP, NF, WW</b>	<b>36L 36 LEDs</b>
<b>LTV82SS</b> 10-3/8" Dia.	<b>SP, NF</b>	<b>18L 18 LEDs</b>
<b>LTV82SS</b> 10-3/8" Dia.	<b>WW</b>	<b>16L 16 LEDs</b>
<b>LTV83SS</b> 7-15/16" Dia.	<b>SP, NF, WW</b>	<b>12L 12 LEDs</b>

\* SP = Spot, NF = Narrow Flood, WW = Wall Wash

Electrical Module
Color Temperature
<b>3K 3000K</b>
<b>4K 4000K</b>
5K 5000K
Voltages
<b>UV 120-277V</b>

Lens Options¹
<b>SR</b> Slip-Resistant Lens
<b>PL</b> Prismatic Lens

¹ All lens options are integral parts of component module and must be installed at factory.

Rebar Cage Anchor
<b>RCA81</b> for LTV81
<b>RCA82</b> for LTV82
<b>RCA83</b> for LTV83

Kim Lighting reserves the right to change specifications without notice.

**LTV81SS**

Optical Module	Source	Color Temperature	Absolute Lumens	Center Beam Candle Power*	Voltage	Total System Watts	Max. Amps	Beam Angle (50%) H x V	Field Angle (10%) H x V	NEMA Type
SP	36L	3K	2426	29469	UV	44W	.367 for 120V .212 for 208V .183 for 240V .159 for 277V	12.9 x 12.9	27.3 x 27.3	2H X 2V
		4K	3041	36773						
		5K	3324	41827						
NF	36L	3K	2171	2422	UV	44W	.367 for 120V .212 for 208V .183 for 240V .159 for 277V	46.1 x 54.7	79.9 x 83.7	5H X 5V
		4K	2726	3022						
		5K	2745	3071						
WW	36L	3K	2574	4188	UV	44W	.367 for 120V .212 for 208V .183 for 240V .159 for 277V	53.1 x 28.2	102.5 x 61.1	6H X 4V
		4K	3209	5220						
		5K	3526	5736						

**LTV82SS**

Optical Module	Source	Color Temperature	Absolute Lumens	Center Beam Candle Power*	Voltage	Total System Watts	Max. Amps	Beam Angle (50%) H x V	Field Angle (10%) H x V	NEMA Type
SP	18L	3K	1285	16787	UV	23W	.192 for 120V .111 for 208V .096 for 240V .083 for 277V	13.4 x 13.4	26.9 x 26.9	2H X 2V
		4K	1633	20282						
		5K	1705	22899						
NF	18L	3K	1049	1272	UV	23W	.192 for 120V .111 for 208V .096 for 240V .083 for 277V	43.9 x 52.8	76.4 x 81.3	5H X 5V
		4K	1410	1687						
		5K	1470	1758						
WW	16L	3K	1083	2336	UV	20W	.167 for 120V .091 for 208V .079 for 240V .069 for 277V	58.9x21.3	93.3 x 53.9	5H X 4V
		4K	1389	2992						
		5K	1549	3336						

**LTV83SS**

Optical Module	Source	Color Temperature	Absolute Lumens	Center Beam Candle Power*	Voltage	Total System Watts	Max. Amps	Beam Angle (50%) H x V	Field Angle (10%) H x V	NEMA Type
SP	12L	3K	825	10750	UV	14W	.117 for 120V .067 for 208V .058 for 240V .051 for 277V	12.7 x 12.7	26.3 x 26.3	2H X 2V
		4K	998	13008						
		5K	1085	14144						
NF	12L	3K	709	863	UV	14W	.117 for 120V .067 for 208V .058 for 240V .051 for 277V	50.3 x 50.3	81.2 x 81.2	5H X 5V
		4K	888	1082						
		5K	932	1136						
WW	12L	3K	806	1724	UV	14W	.117 for 120V .067 for 208V .058 for 240V .051 for 277V	52.3 x 20.8	93 x 53.6	5H X 4V
		4K	1034	2210						
		5K	1152	2463						

**KEY:** SS = Flat Frame, SP = Spot, NF = Narrow Flood, WW = Wall Wash (PicoPrism™), 36L = 36 LEDs, 18L = 18 LEDs, 16L = 16 LEDs, 12L = 12 LEDs, 3K = 2800K to 3175K, 4K = 3800K to 4600K, 5K = 4600K to 5600K, UV = Universal Voltage shall range from 120V-277V with a ±10% tolerance.

\* The SP and NF are based on Candela exiting unit straight up. The WW is for highest candela angle.

**Spectroradiometric**

	3K	4K	5K
Correlated Color Temp. CCT (K)	2800K to 3175K	3800K to 4600K	4600K to 5600K
Color Rendering Index (CRI)	≤80	≤80	≤70
Power Factor	>.90	>.90	>.90

**L70 Data**

	Calculated	Reported*
350 mA	100,000	60,000

\*Based on test duration.

Kim Lighting reserves the right to change specifications without notice.

## SPECIFICATIONS

### Housing:

- Pour Box rough-in housing for installation below grade.
- High temperature UV resistant thermal plastic, 1/2" minimum wall, black.
- Includes a splice box with molded plastic splice cover and silicone gasket.
- Three 1" NPT in bottom for through wiring on LTV81 and LTV82.
- Two 1" NPT in bottom for through wiring on LTV83. 107 cu. in. splice area for LTV81.
- 52 cu. in. splice area for LTV82. 24 cu. in. splice area for LTV83.
- Supplied with protective aluminum debris shield mask with orientation label for proper installation alignment for clean and easy installation in concrete pad or soil. Ships separately and as a quick-ship if requested.

### Component Module:

- One-piece impregnated cast bronze, fully sealed component module secured to the face trims from the underside.
- A high temperature, anti-siphon, IP67 sealed cable extends from the component module to the splice box inside the housing.
- The fully assembled component module is secured to the housing with (4) 1/4-20 tamper-resistant high grade stainless steel fasteners.

### Face Trim:

- 1/16" 304 stainless steel plate with M33 brushed finish shall cover the cast bronze Lens Frame and provide a flat surface.

### Optical Modules:

- Spot (SP), Narrow Flood (NF), and Wall Wash (WW) optical modules are adjustable up to 15° utilizing a Bluetooth enabled motor assembly.

### Bluetooth:

- Integral Bluetooth module used to adjust optics and dim fixture to desired setting when paired with KIM LTV8 Remote App via cellular/tablet device.
- Fully qualified Bluetooth 1.1, 1.2, 2.0, 2.1. Bluetooth v2.0+EDR compatible with Android devices running Android Gingerbread API level 9 forward. Bluetooth 4.0 LE compatible with iOS devices - iPhone 4S and later, 5th generation iPod touch, the iPad Mini and the 3rd generation and later of the full size iPad with iOS 5 or later.
- Bluetooth Apps are available for Apple iOS and Google Android mobile devices and are downloadable via the internet at Apple App Store or Google Play.

### Lens:

- Clear 5/16" thick tempered glass lens and silicone gasket is retained securely within the component module.

### Options:

- Slip Resistant Lens (SR), Prismatic Lens (PL), Rebar Cage Anchor (RCA8x).

### Electrical Equipment:

- All electronic components are UL and CSA recognized and mounted directly to the component module for maximum heat dissipation and modularity. Driver is IP67 with -30°C minimum temperature rating.

### Drive-Over Durability:

- When installed in concrete, fixture will withstand drive-over by vehicles weighing up to 4,500 lbs.

### Certification:

- (UL1598, UL8750). 25°C ambient operation.
- SASO Certified for LTV82/83.

### Warranty:

- For full warranty see <http://www.hubbellighting.com/resources/warranty>
- Opening of Component Module on site will void warranty.



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Client \_\_\_\_\_ Project name \_\_\_\_\_

Order# \_\_\_\_\_ Type \_\_\_\_\_ Qty \_\_\_\_\_

## FEATURES AND BENEFITS

### Physical

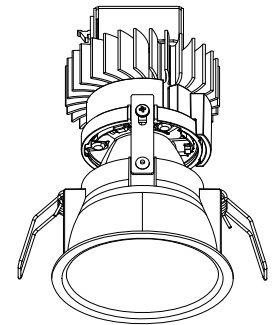
- Housing material: aluminum housing
- Reflector material: metallized polycarbonate
- Trim finish: white, black, gray or custom RAL color
- Option: TILT (fixed tilt, 30°)
- Damp location rating (interior applications only)

### Performance

- Nominal lumen outputs: 700, 1000 and 1300 lumens
- Optics: 40° or 60°
- CRI values: 80+, 95+, Radiant 80+ or Radiant 95+
- Lumen maintenance: L70 @ 90,000 hrs [25°C]
- Operating temperatures: -20° C to 40° C (-4F to 104F)

### Electrical

- Input voltage: 120 or 277V, consult factory for 347V
- Control options: non-dimming, 0-10 volt or DALI dimming

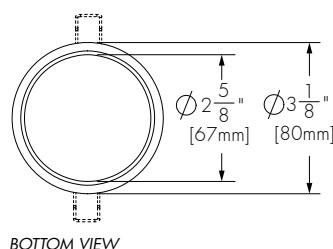
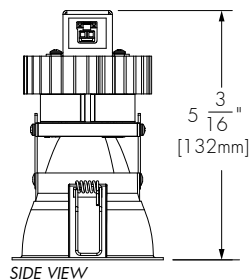


### Performance summary

Based on Medium (40°), 4000K, CRI 80+  
insulated ceiling    non-insulated ceiling

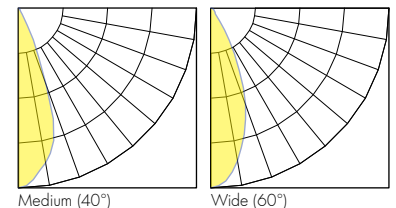
Nominal output [lm]	Delivered output [lm]	Power [W]	Efficacy [lm/W]	Power [W]	Efficacy [lm/W]
<b>700*</b>	611	7	87	9	67
<b>1000</b>	873	10	87	12	72
<b>1300</b>	1135	14	81	16	70

\*Photometric performance is measured in compliance with IESNA LM-79-08.

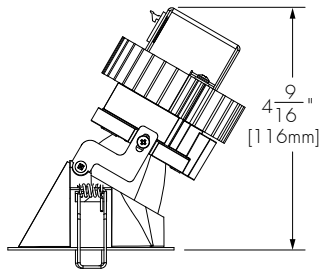


Cutout: Ø 2 15/16" [75mm]

Maximum ceiling thickness: 1" [25mm]

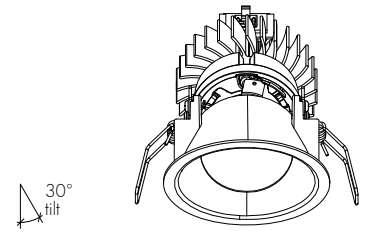


**TILT OPTION (FIXED TILT)\***



SIDE VIEW

**Cutout: Ø 2 15/16" [75mm]**  
**Maximum ceiling thickness: 1" [25mm]**

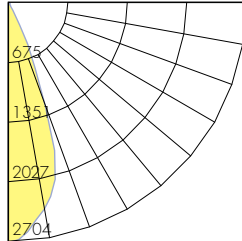


\* Fixed tilt construction is factory set and cannot be adjusted in the field.

## PHOTOMETRIC INFORMATION

**Medium (40°), all color temperatures**Non-insulated ceiling installation types (RM and NC)<sup>1</sup>

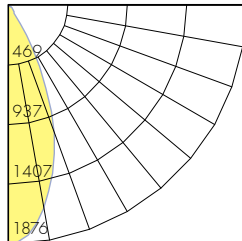
Nominal output [lm]	Power [W] <sup>†</sup>	Delivered output [lm] <sup>†</sup>	Candlepower distribution	Illuminance cone
	<b>CR80</b>	<b>CR95</b>		
<b>700*</b>	9	11	611	
<b>1000</b>	12	15	873	
<b>1300</b>	16	20	1135	



Center Beam Illuminance	Beam Diameter	Height
42fc [452 lx]	5.8' [1.7m]	8' [2.5m]
27fc [289 lx]	7.3' [2.2m]	10' [3m]
19fc [201 lx]	8.7' [3.6m]	12' [4m]

**Wide (60°), all color temperatures**Non-insulated ceiling installation types (RM and NC)<sup>1</sup>

Nominal output [lm]	Power [W] <sup>†</sup>	Delivered output [lm] <sup>†</sup>	Candlepower distribution	Illuminance cone
	<b>CR80</b>	<b>CR95</b>		
<b>700*</b>	9	11	608	
<b>1000</b>	12	15	869	
<b>1300</b>	16	20	1129	



Center beam Illuminance	Beam Diameter	Height
29fc [314 lx]	9.2' [2.8m]	8' [2.5m]
19fc [201 lx]	11.5' [3.5m]	10' [3m]
13fc [139 lx]	13.9' [4.2m]	12' [4m]

<sup>1</sup>Remove 2 watts per fixture when specifying new construction insulated ceiling installation types (IC and CP).

\*Photometric performance is measured in compliance with IESNA LM-79-08.

<sup>†</sup>Delivered wattage and delivered output: +/- 10% tolerance.

## PHOTOMETRIC INFORMATION - continued

### Color Rendering options comparison, 3000K

Color sample	Ra	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15
CRI 80+	81	80	85	89	81	78	80	86	66	16	64	79	58	81	93	75
CRI 95+	98	98	99	98	98	98	97	98	98	96	99	98	88	98	98	98
Radiant CRI 80+	81	81	86	89	81	80	80	85	68	16	66	80	62	82	93	77
Radiant CRI 95+	95	99	98	97	96	98	96	95	94	90	97	95	97	98	98	98

## CONTROL OPTIONS

### Dimming down to 1%

0-10V dimming

**DA1** - 0-10V dimming, 1% linear

**DA2** - 0-10V dimming, 1% logarithmic

### Dimming down to 0.1%

DALI dimming

**DALI1** - DALI dimming, 0.1% linear

**DALI2** - DALI dimming, 0.1% logarithmic

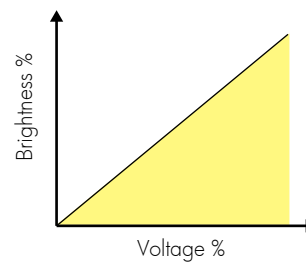
### Professional dimming down to 0.1%

0-10V dimming

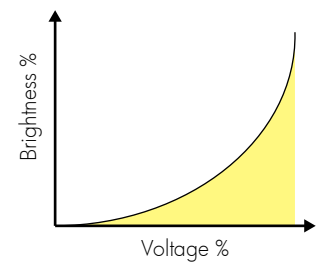
**PDA1** - Professional 0-10V dimming, 0.1% linear

**PDA2** - Professional 0-10V dimming, 0.1% logarithmic

Linear Curve



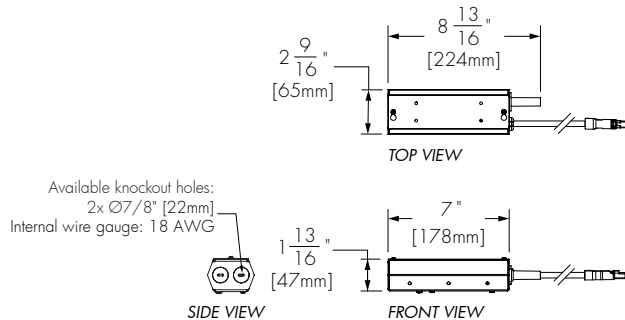
Logarithmic curve





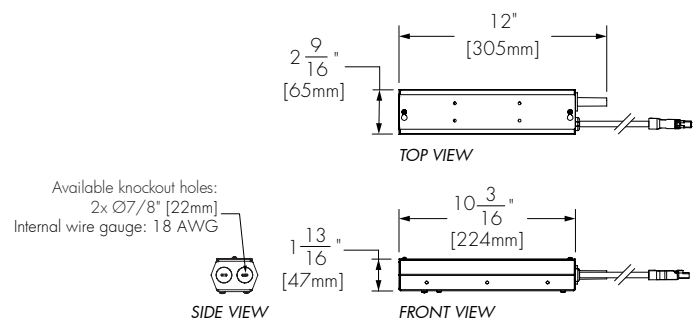
## INSTALLATION TYPES

Minimum Ceiling Height Requirements				
	Up to 1000lm (CRI 80)	1300lm (CRI 80) 1000lm (CRI 95)	2000lm	3000lm
<b>Remodel (RM)</b>	On/Off = 8" Dimming = 10"	On/Off = 8" Dimming = 10"	N/A	N/A
<b>New Construction (NC)</b>	On/Off = 8" Dimming = 10"	On/Off = 8" Dimming = 10"	N/A	N/A
<b>Insulation Contact (IC/CP)</b>	7"	9"	N/A	N/A



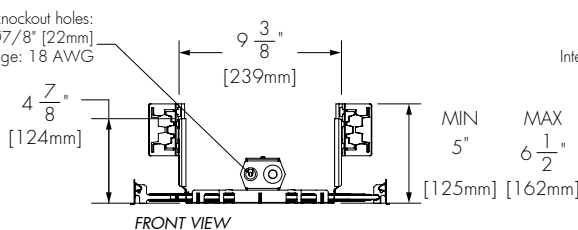
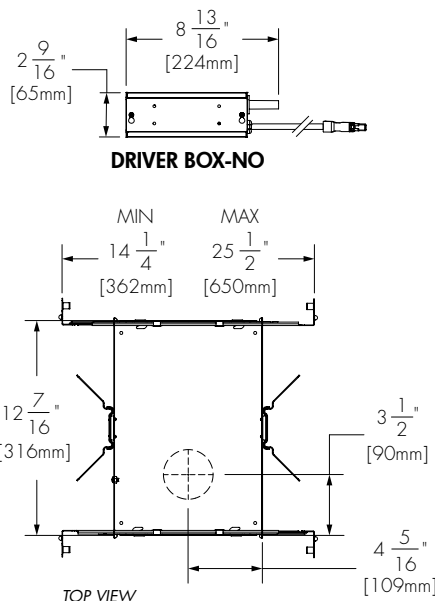
### LADN-MTG-A-VOLTAGE-OUTPUT-COLOR RENDERING-NO-RM

Remodel non-insulated ceiling - On/Off control



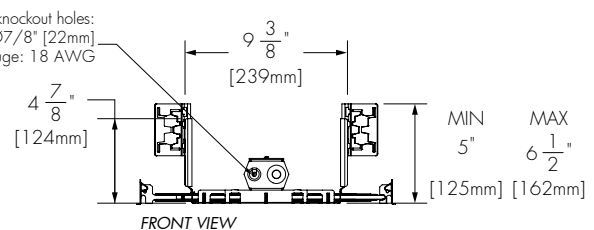
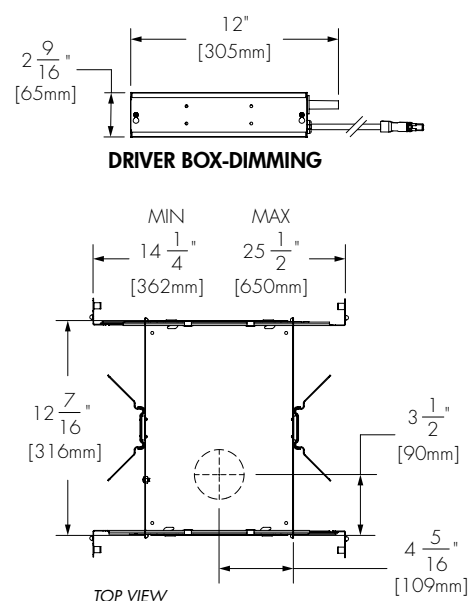
### LADN-MTG-A-VOLTAGE-OUTPUT-COLOR RENDERING-DIMMING-RM

Remodel non-insulated ceiling - Dimming



### LADN-MTG-A-VOLTAGE-OUTPUT-COLOR RENDERING-NO-NC

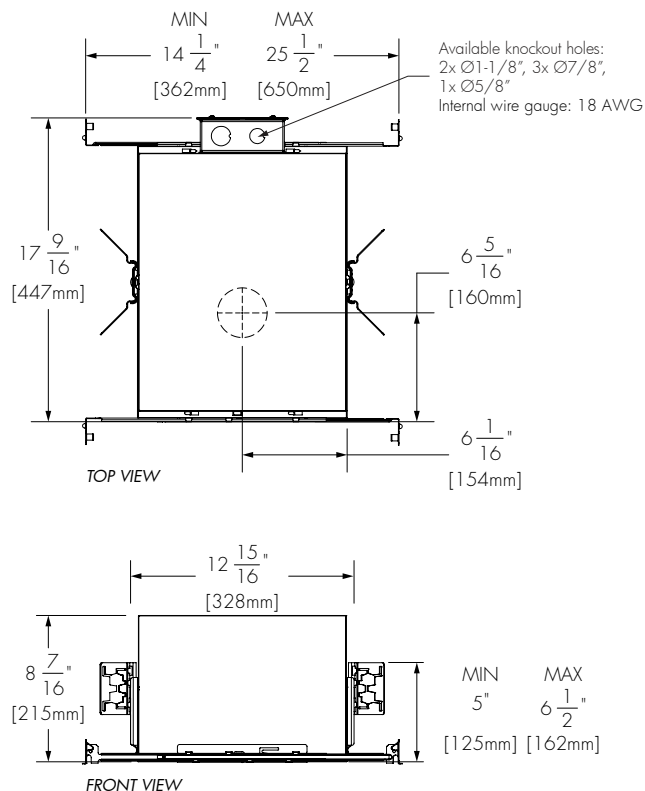
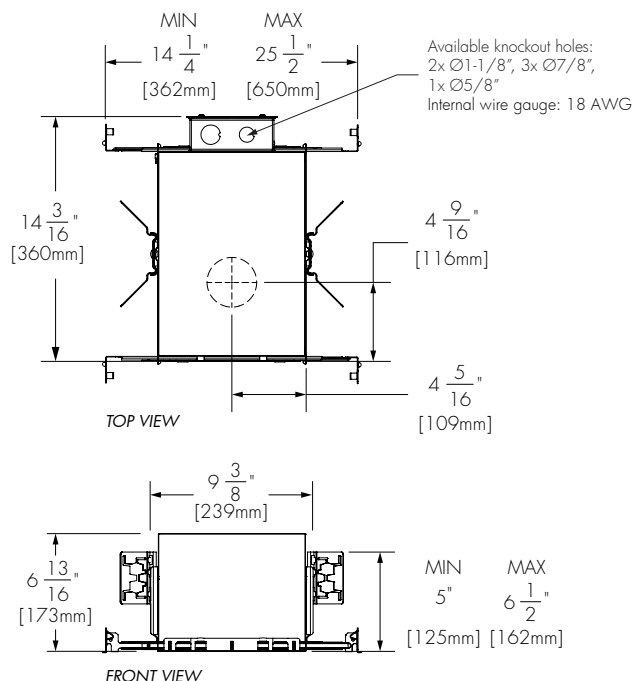
New construction non-insulated ceiling - On/Off control



### LADN-MTG-A-VOLTAGE-OUTPUT-COLOR RENDERING-DIMMING-NC

New construction non-insulated ceiling - Dimming

## INSTALLATION TYPES - continued



### LADN-MTG-A-VOLTAGE-OUTPUT-COLOR RENDERING-CONTROL-IC/CP\*

New construction insulated ceiling

New construction insulated ceiling, Chicago plenum rated option, airtight

\* Available for the following output and color rendering combinations:

Nominal output [lm]	Color rendering			
	CR80	CR95	RCR80	RCR95
<b>L07</b>	YES	YES	YES	YES
<b>L10</b>	YES	N/A	YES	N/A

### LADN-MTG-A-VOLTAGE-OUTPUT-COLOR RENDERING-CONTROL-IC/CP\*

New construction insulated ceiling

New construction insulated ceiling, Chicago plenum rated option, airtight

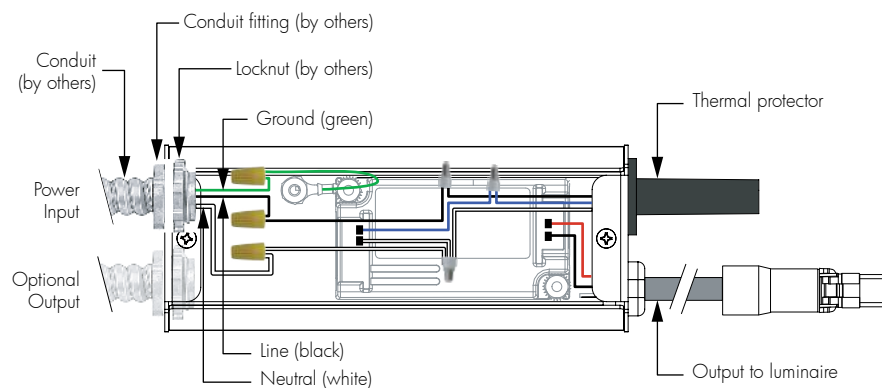
\* Available for the following output and color rendering combinations:

Nominal output [lm]	Color rendering			
	CR80	CR95	RCR80	RCR95
<b>L10</b>	N/A	YES	N/A	YES
<b>L13</b>	YES	N/A	YES	N/A

## WIRING DETAILS

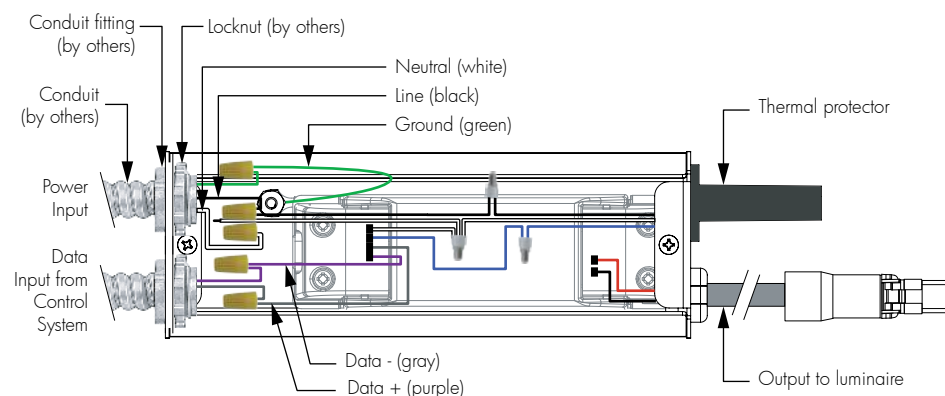
RM: remodel non-insulated ceiling and NC: new construction non-insulated ceiling

### No Control



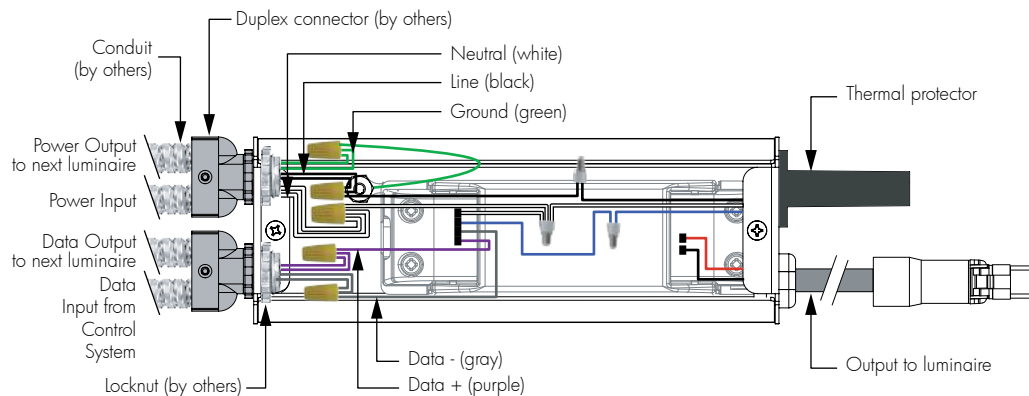
### Control

(DA1, DA2, PDA1, PDA2, DALI1, DALI2)



### Control (Daisy Chain Layout)

(DA1, DA2, PDA1, PDA2, DALI1, DALI2)

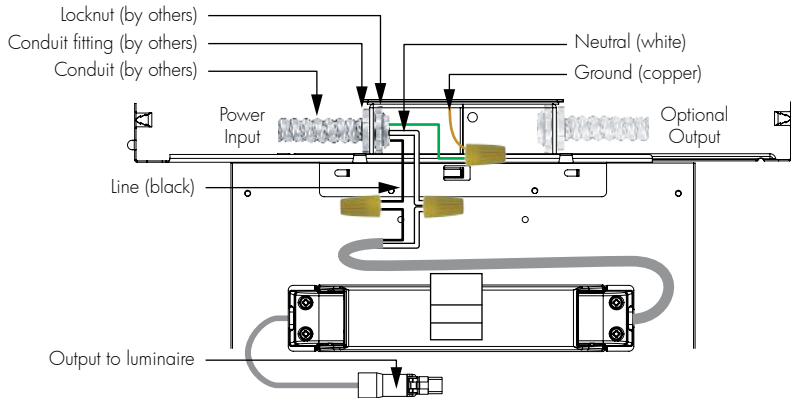


## WIRING DETAILS - continued

IC/CP: new construction insulated ceiling

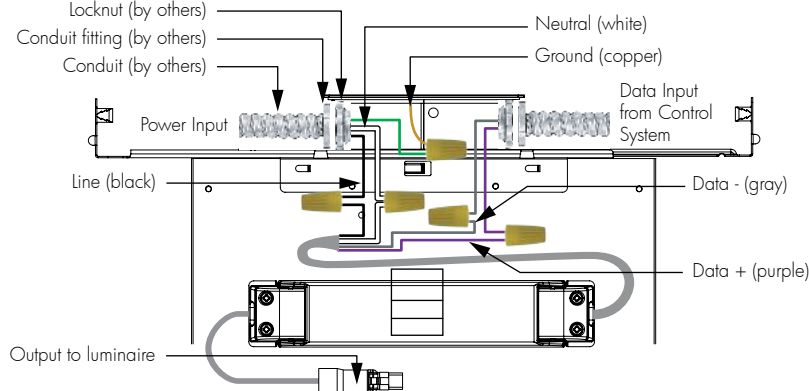
Insulated ceiling up to 1300 lumens (CR80 or RC80), 1000 lumens (CR95 or RCR95)

### No Control



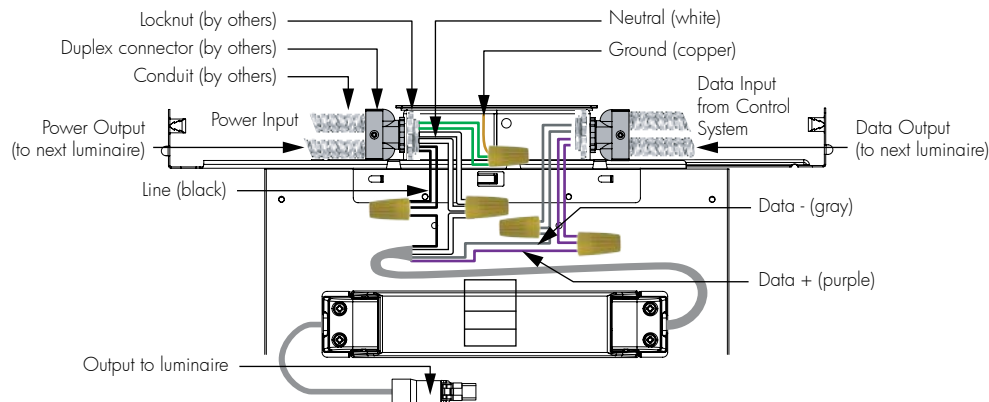
### Control

(DA1, DA2, PDA1, PDA2, DALI1, DALI2)



### Control (Daisy Chain Layout)

(DA1, DA2, PDA1, PDA2, DALI1, DALI2)



## OPTICAL ACCESSORIES

Maximum one accessory per fixture.

The softening glass lens will be replaced by any other specified accessory.

**HL** - Honeycomb louver



**RS** - Linear spread glass lens

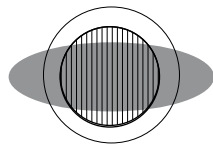


**CL** - Clear glass lens



## RS - LINEAR SPREAD GLASS LENS ORIENTATION

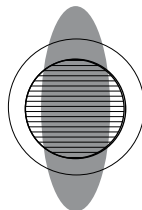
Factory installed



BOTTOM VIEW

**RS**

Horizontal Beam Distribution  
Not adjustable onsite



BOTTOM VIEW

**RS**

Vertical Beam Distribution  
Not adjustable onsite

Install fixture onsite according to desired beam pattern direction.

## HOW TO ORDER

<b>LADN</b>	<b>A</b>						<b>RD</b>					
	1	2	3	4	5	6	7	8	9	10	11	12

### 1 | **Region:**

**A** - Americas

### 2 | **Voltage:**

**120** - 120 volts

**277** - 277 volts

Consult factory for 347 volts.

### 3 | **Output (nominal lumens):**

**L07** - 700 lumens

**L10** - 1000 lumens

**L13** - 1300 lumens

### 4 | **Color Temperature:**

**27K** - 2700K

**30K** - 3000K

**35K** - 3500K

**40K** - 4000K

### 5 | **Color Rendering:**

**CR80** - CRI 80+

**CR95** - CRI 95+

**RCR80** - Radiant CRI 80+\*

**RCR95** - Radiant CRI 95+\*

\*Radiant CRI options available for 3000K only.

### 6 | **Optics:**

**M** - Medium distribution 40°

**W** - Wide distribution 60°

### 7 | **Trim Shape:**

**RD** - Round shape

### 8 | **Trim Finish:**

**WH** - White trim

**BK** - Black trim

**GRY** - Gray trim

**CC** - Custom (please specify RAL color)

### 9 | **Control:**

**NO** - On/Off control

**DA1** - 0-10V dimming, 1% linear

**DA2** - 0-10V dimming, 1% logarithmic

**PDA1** - Pro 0-10V dimming, 0.1% linear

**PDA2** - Pro 0-10V dimming, 0.1% logarithmic

**DALI1** - DALI dimming, 0.1% linear

**DALI2** - DALI dimming, 0.1% logarithmic

### 10 | **Installation Type:**

**RM** - Remodel non-insulated ceiling

**NC** - New construction non-insulated ceiling

**IC** - New construction insulated ceiling\*

**CP** - New construction insulated ceiling, Chicago plenum rated option, airtight\*

\*Insulated ceiling up to 1300 lumens (CR80 or RCR80), 1000 lumens (CR95 or RCR95).

### 11 | **Option:**

**TILT** - Fixed tilt (30°)\*

\*Fixed tilt construction is factory set and cannot be adjusted in the field.

### 12 | **Accessories (factory installed):**

**NA** - No accessory (softening glass lens by default)

**HL** - Honeycomb louver\*

**RS** - Linear spread glass lens\*\*

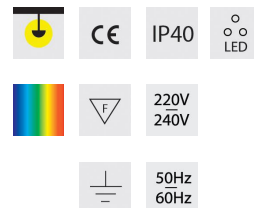
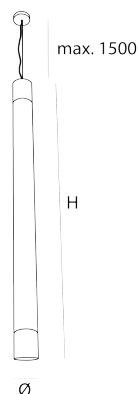
**CL** - Clear glass lens\*

\*Maximum one accessory per fixture. The softening glass lens will be replaced by any other specified accessory.

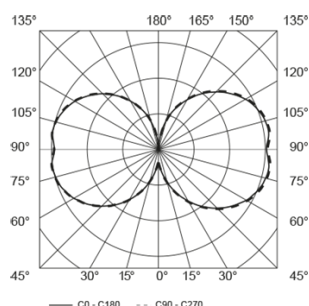
\*\*Refer to page 9 for orientation guidelines. Maximum one accessory per fixture. The softening glass lens will be replaced by any other specified accessory.

# BUCK PL2, PL3, PL4

## TUBE DOWN



OC ECG	Lamp	Socket	Ø/H[mm]	ø/h[mm]	Weight [kg]	Flux [lm]*	∠	Total power [W]
25751110	NW2 /840	LED	90/2000	-	3	3888	-	63



CCT [K]
4000 K
CRI
>70
LED Service life
-

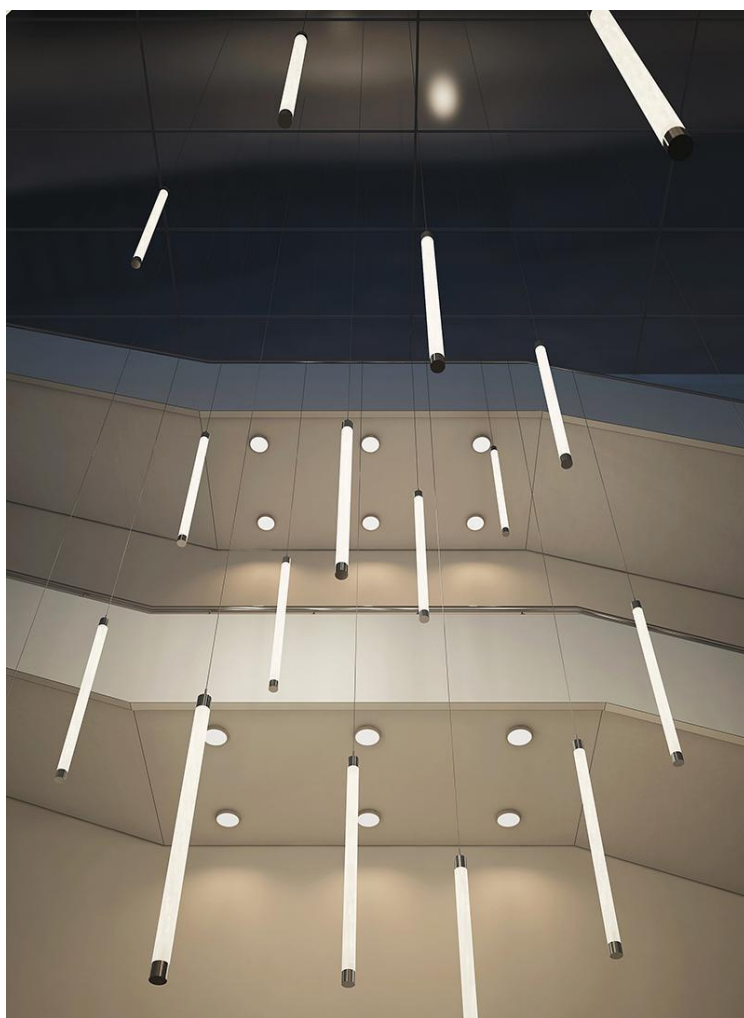
GENERAL Suspension luminaire for general illumination of high spaces.

HOUSING/ OPTICS Luminaire of opal PMMA with polished stainless steel holders.

APPLICATION Appropriate for different multiplication models.

EQUIPMENT Supplied with suspension kit.

ADDITIONAL Other light colour temperatures available upon request.



\* Luminaire luminous flux



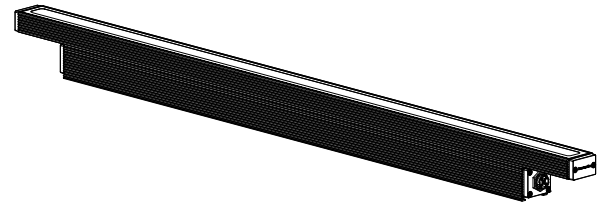
Client \_\_\_\_\_ Project name \_\_\_\_\_

Order# \_\_\_\_\_ Type \_\_\_\_\_ Qty \_\_\_\_\_

## FEATURES AND BENEFITS

### Physical :

- Low copper content extruded aluminum housing
- Available in 1', 2', 3' or 4' sections
- Electro-statically applied polyester powder coat finish
- Machined aluminum end caps and silicone gaskets
- Stainless steel hardware
- Clear tempered glass
- Asymmetric wallwash, 10° x 10°, 10° x 60°, 30° x 60° or 60° x 60° optics
- IP66
- IK07 rated (asymmetric wallwash lens is IK06 rated)
- Corrosion-resistant coating for hostile environments\*\*
- Meets 3G ANSI C136.31 Vibration standard for bridge applications



### Performance :

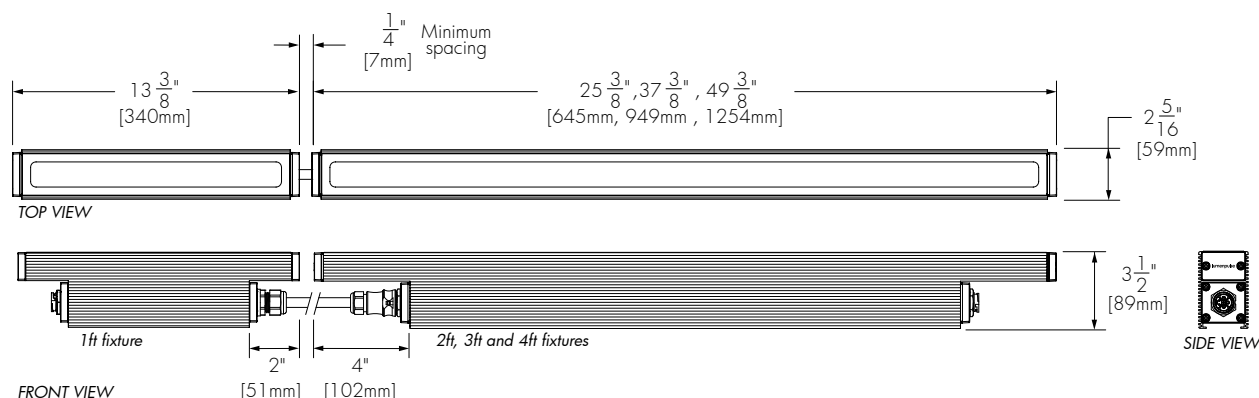
- CRI values: 85+ (2700K), 80+ (3000K), 78+ (4000K)
- Lumen maintenance 120,000 hrs [L70 @ 25°C]
- Lumen measurements comply with LM - 79 - 08 standard
- Resolution per foot or per fixture (configured with LumenID V3 software & RDM)
- Operating temperatures: -25° C to 50° C [-13F to 122F]

4ft HO 4000K	Delivered Output [lm]	Intensity [peak cd]
10°x10°	-	-
10°x60°	3,692	19,654
30°x60°*	3,584	4,750
60°x60°*	3,676	3,137
WW	3,592	5,159

Estimated. Consult lumenpulse website for the latest files.

### Electrical :

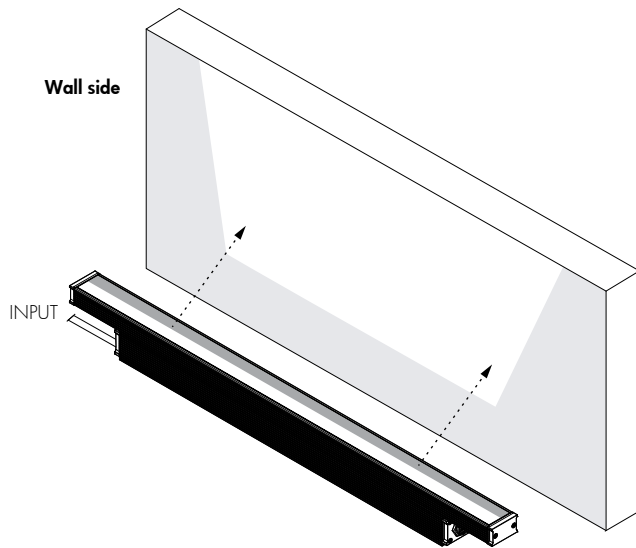
- Line voltage luminaire for 100 to 277V
- Power and data in 1 cable (#16-5)
- Up to 88 feet with a single 120V power feed, HO version
- 5W/ft version meets ASHRAE standards for linear lighting on building facades
- 8.5W/ft Regular Output version
- 15.25W/ft High Output version
- Dimming options: 0-10 volt, DMX/RDM enabled, DALI, Lumentalk or Lutron® EcoSystem® enabled



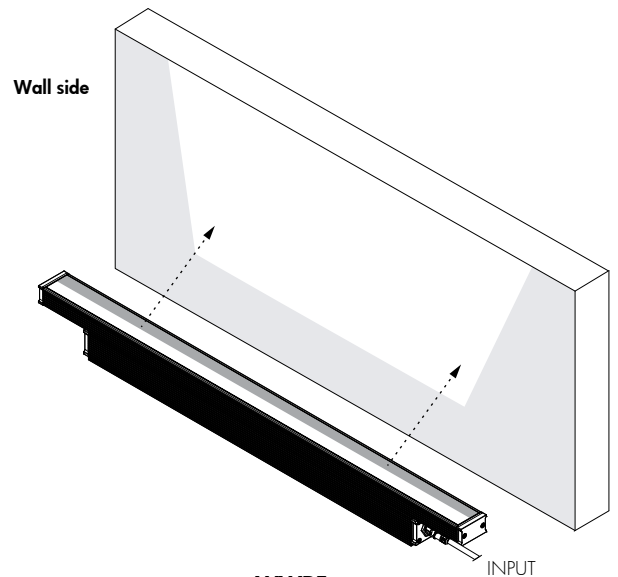
\*Asymmetric wallwash lens is IK06 rated.

\*\* Use only when exposed to salt spray and harsh chemicals. This option is not required for normal outdoor exposure!

**ASYMMETRIC WALLWASH OPTIC FEEDING SIDE DETAIL**



**WWLF**  
Asymmetric Wallwash Optic, Left Feed

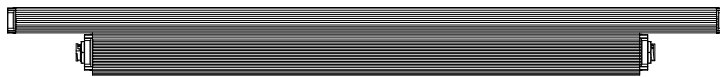


**WWRF**  
Asymmetric Wallwash Optic, Right Feed

**Always position frosted side toward the wall**



TOP VIEW



FRONT VIEW



RIGHT SIDE VIEW  
(Fixture pointing upwards)

\*Fixture's feeding side is based on uplight installations. Feeding sides are reversed when fixture is used in a downlight application.

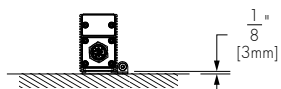
Recommended setback from wall is 1/10 of the wall height.

Example: 2ft setback for a 20ft wall.

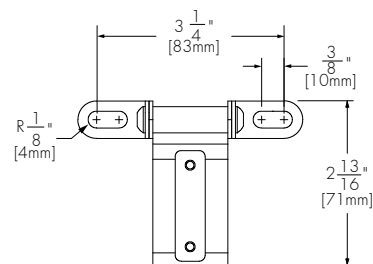
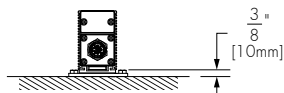
## MOUNTING OPTIONS

### Surface Mount

**SAM**  
Slim Adjustable Mounting



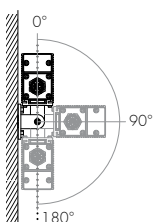
**UMP**  
Fixed Mounting



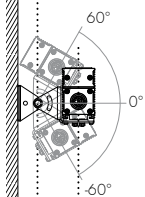
**SAM**  
Mounting Hole Pattern

### Wall Mount

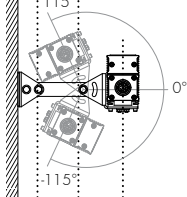
**UMAS**  
Universal Adjustable Mounting



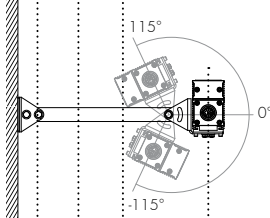
**WAM2**  
Adjustable Wall Mounting 2"



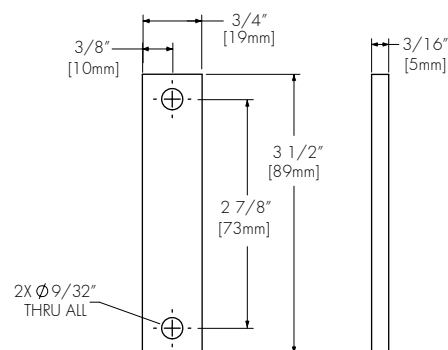
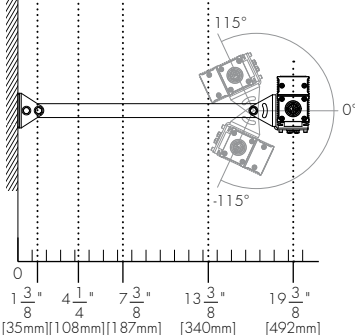
**WAM6**  
Adjustable Extended Arm Mounting 6"



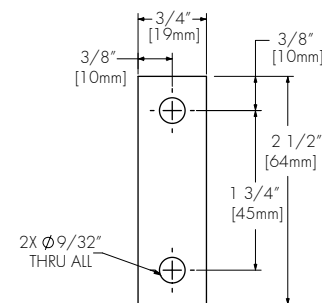
**WAM12**  
Adjustable Extended Arm Mounting 12"



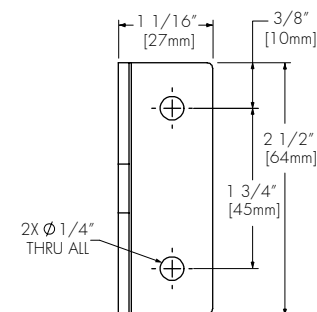
**WAM18**  
Adjustable Extended Arm Mounting 18"



**UMP**  
Mounting Hole Pattern



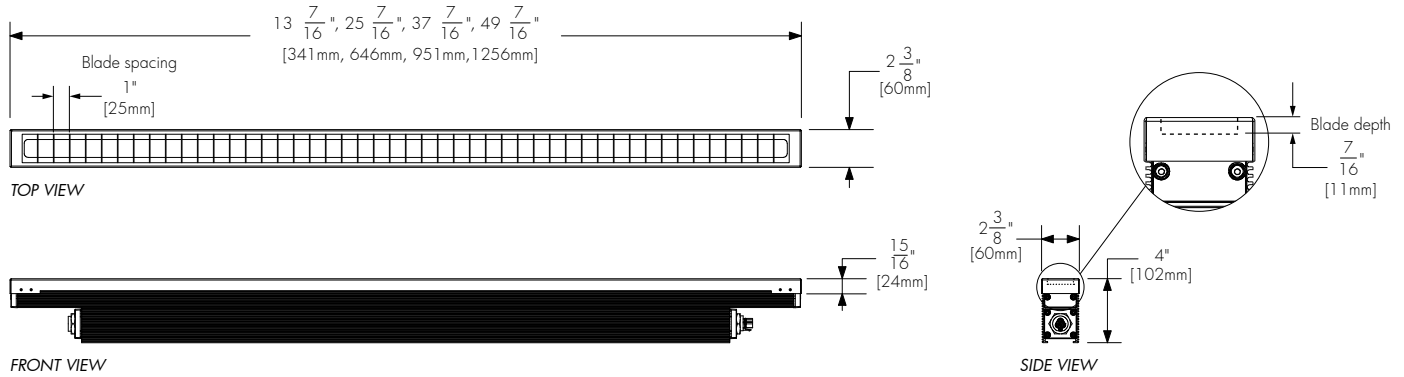
**UMAS**  
Mounting Hole Pattern



**WAM**  
Mounting Hole Pattern

## LOUVER ACCESSORY INSTALLATION DETAIL

Not suitable for asymmetric wallwash optic

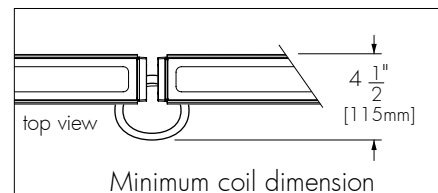
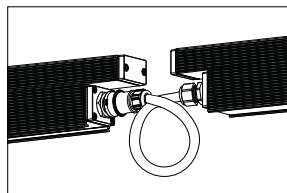


### LOGRD

Radial Louver for Lumenfacade  
 (See page 5 for ordering code)

## OPTION

**ETE** - End-to-end configuration,  
 no jumper cable needed.  
 16" cable included at input.



## ACCESSORIES

Order separately

### Control Systems:

- LTO2** Lumentouch is a wall mount DMX 512 controller keypad.
- LCU** Lumencue is a USB / mini SD DMX 512 controller.
- LID** LumenID is a diagnostic and addressing DMX 512 controller.  
It must be specified on all DMX applications.  
Refer to LID specification sheet for details.
- LTN** Lumentone is a simple pre-programmed DMX 512 controller with a push button rotary dial and live feedback.

### Control Boxes:

- CBX** DMX/RDM control box.  
Up to six power and data outputs to fixtures or fixture runs.  
Ethernet enabled option.  
Refer to CBX specification sheet for details.

### Leader Cable :

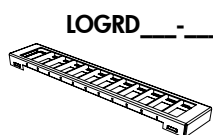
- LOGLCD\_\_** Leader Cable for Lumenfacade.  
Please add desired cable length : 10', 25' or 50' [3m, 7.6m or 15.2m] standard lengths  
Sealing endcap is mandatory for any unused connector.  
(1) included with every leader cable
- LOGLCD\_\_-ETE** Leader Cable for Lumenfacade, ETE option.  
Please add desired cable length : 10', 25' or 50' [3m, 7.6m or 15.2m] standard lengths  
Sealing endcap is mandatory for any unused connector.  
(1) included with every leader cable

### Jumper Cable :

- LOGJCD\_\_** Jumper Cable for Lumenfacade.  
Please add desired cable length : 2' or 4' [0.6m, 1.2m] standard lengths
- LOGJCD\_\_-ETE** Jumper Cable for Lumenfacade, ETE option.  
Please add desired cable length : 2' or 4' [0.6m, 1.2m] standard lengths

### Radial Louver :

Not suitable for asymmetric wallwash optic



- LOGRD\_\_-\_\_** Radial louver for Lumenfacade.  
Louver blade depth: 7/16" [11mm]; louver blade spacing: 1" [25mm]
  1. Please specify desired nominal length: 1', 2', 3' or 4'.
  2. Please specify finish as SI - Silver SandText, BK - Black SandText or WH - White  
(Custom color available on request, please specify as CC together with RAL color : \_\_\_\_\_)

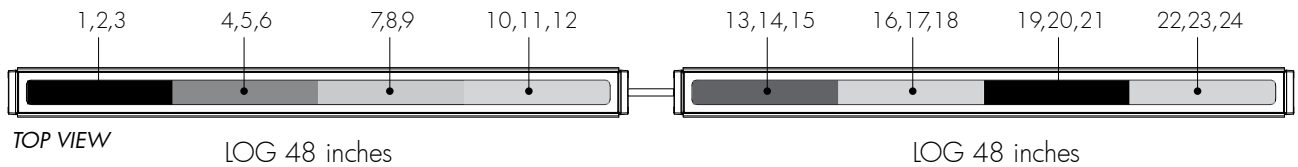
## RESOLUTION DETAILS

Applicable for DMX/RDM control option only.

Fixture resolution can be configured on-site within the LumenID V3 software. A DMX/RDM enabled CBX is required.

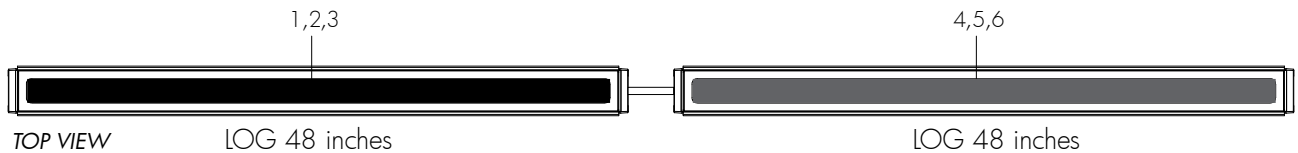
Resolution per foot: each foot is addressed independently

DMX ADDRESSES:



Resolution per fixture: each fixture is addressed independently

DMX ADDRESSES:

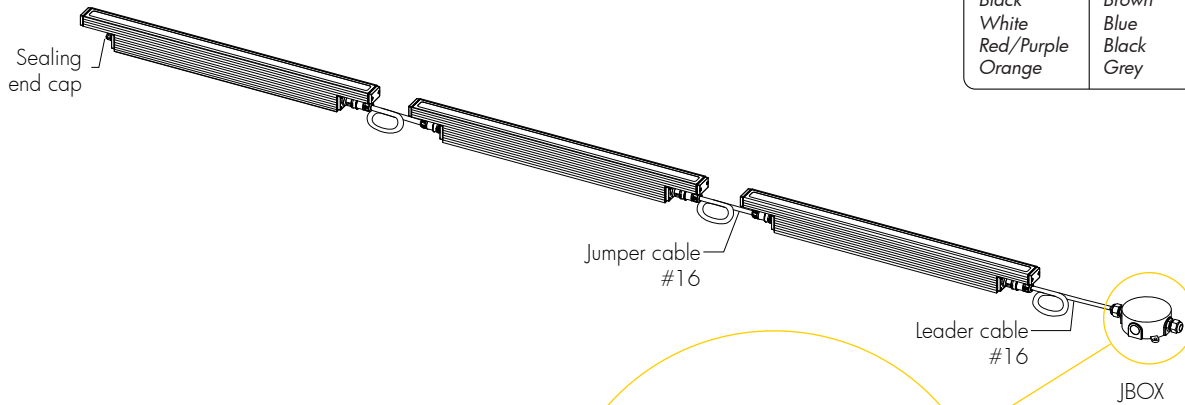


**TYPICAL WIRING DIAGRAMS**

**Non-Dimming or Lumentalk Dimming Version**

1% minimum dimming value with Lumentalk dimming

American Color Code	CE Color Code	USE
Green	Yellow/Green	Ground
Black	Brown	Live 100-277V
White	Blue	Neutral
Red/Purple	Black	0-10V / Data +
Orange	Grey	0-10V / Data -

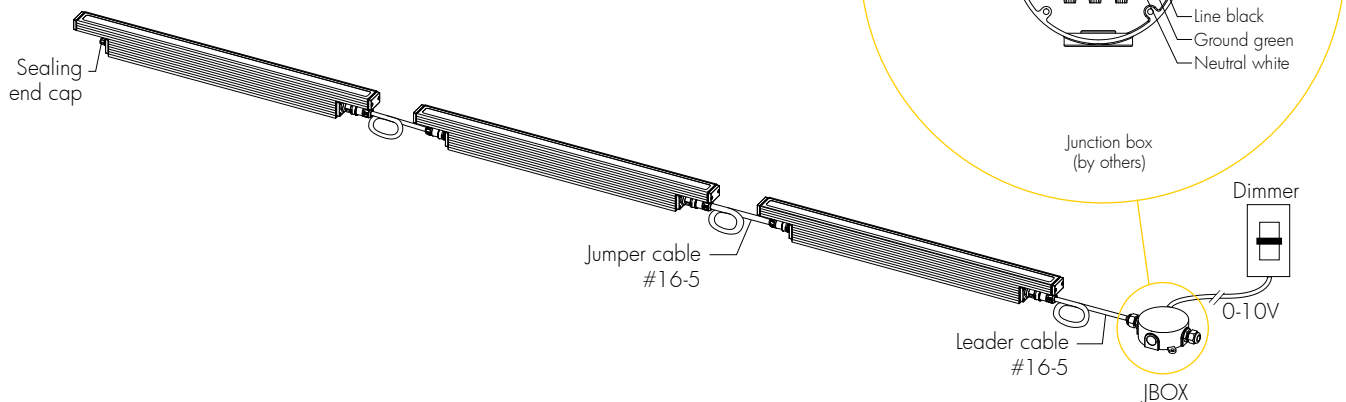


Maximum run length by 15A circuit - Lumenfacade™ HO			
Cable length/Voltage	120V	240V	277V
10ft leader cable	88ft	100ft	112ft
50ft leader cable	68ft	76ft	84ft
Maximum run length by 15A circuit - Lumenfacade™ RO			
10ft leader cable	148ft	168ft	184ft
50ft leader cable	120ft	132ft	148ft
ASHRAE Code Compliant - Lumenfacade™ 5W/ft Maximum run length by 15A circuit			
10ft leader cable	180ft	250ft	300ft
50ft leader cable	168ft	230ft	280ft

\*Maximum run length calculations are typically based on 4ft fixtures.

**Dimming Version (0-10V)**

10% minimum dimming value

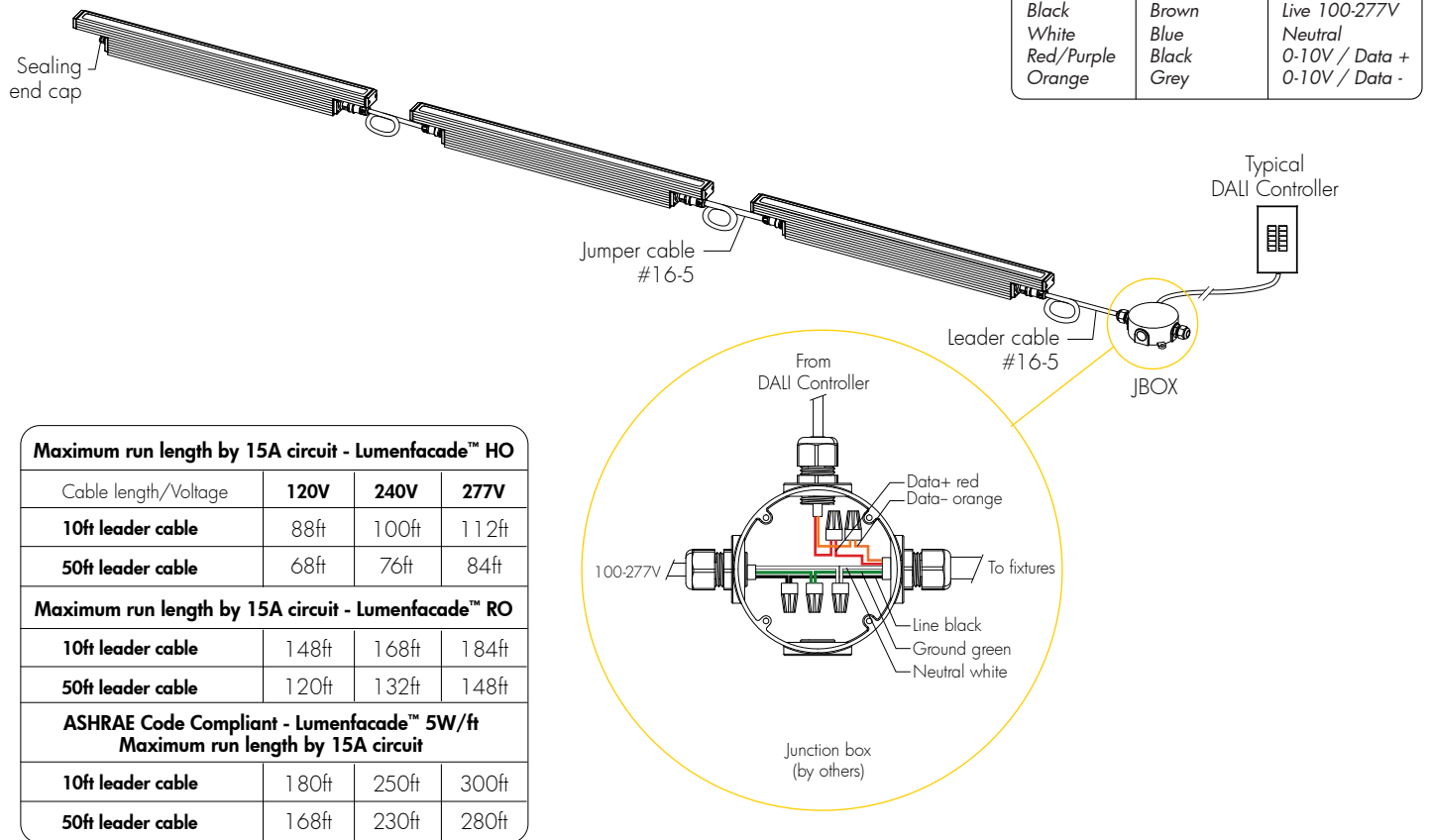




**TYPICAL WIRING DIAGRAMS - continued**

**Dimming Version (DALI)**

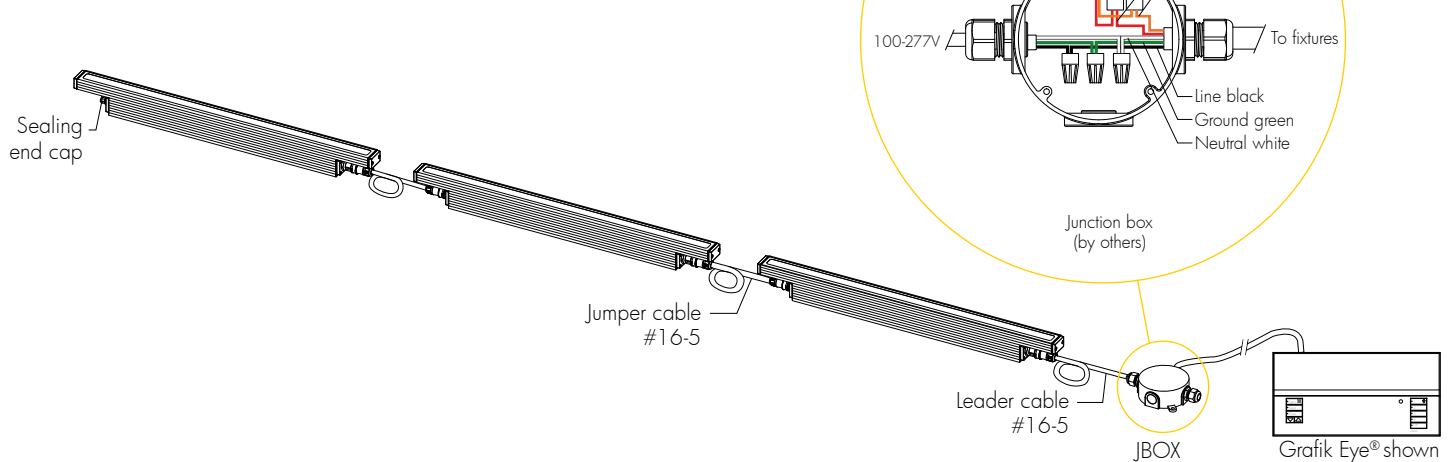
1% minimum dimming value



\*Maximum run length calculations are typically based on 4ft fixtures.

**Dimming Version (EcoSystem®)\***

1% minimum dimming value



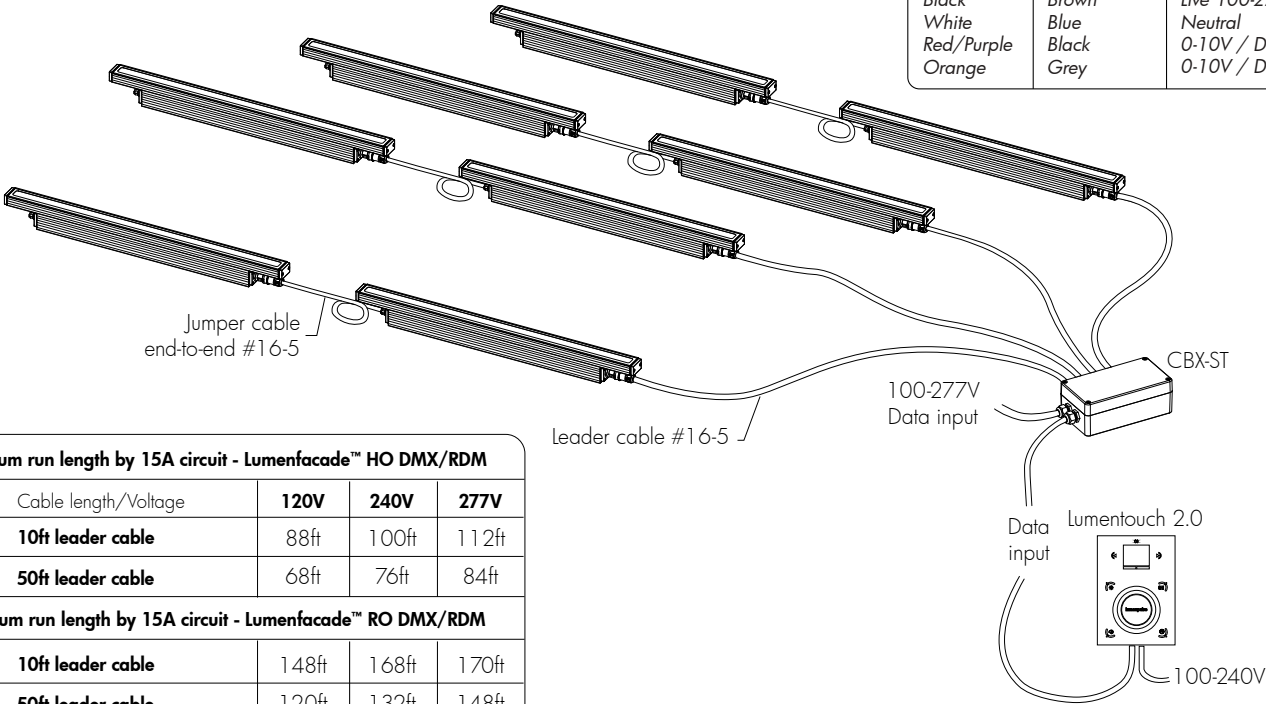
\*Each Lutron® EcoSystem® enabled fixture has its own address; for the example shown above, there are a total of 3 EcoSystem® addresses.

TYPICAL WIRING DIAGRAMS - continued

Star Layout (DMX/RDM)

1% minimum dimming value

American Color Code	CE Color Code	USE
Green	Yellow/Green	Ground
Black	Brown	Live 100-277V
White	Blue	Neutral
Red/Purple	Black	0-10V / Data +
Orange	Grey	0-10V / Data -

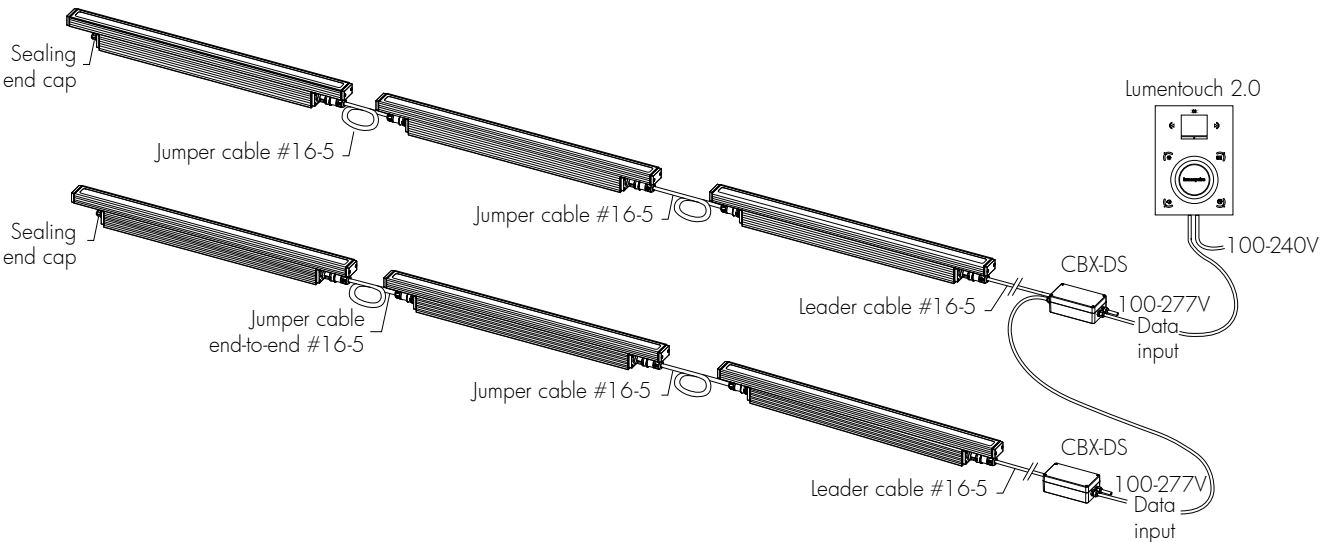


Maximum run length by 15A circuit - Lumenfacade™ HO DMX/RDM			
Cable length/Voltage	120V	240V	277V
10ft leader cable	88ft	100ft	112ft
50ft leader cable	68ft	76ft	84ft
Maximum run length by 15A circuit - Lumenfacade™ RO DMX/RDM			
10ft leader cable	148ft	168ft	170ft
50ft leader cable	120ft	132ft	148ft
ASHRAE Code Compliant - Lumenfacade™ 5W/ft DMX/RDM Maximum run length by 15A circuit			
10ft leader cable	170ft	170ft	170ft
50ft leader cable	168ft	170ft	170ft

\*Up to 170 individually addressable 1 foot sections per DMX/RDM run.  
\*Maximum run length calculations are typically based on 4ft fixtures.  
Consult factory for specific applications.

Daisy Chain Layout (DMX/RDM)

1% minimum dimming value



## HOW TO ORDER

### LOG

1 2 3 4 5 6 7 8 9

1

### Housing:

**LOG ASHRAE** - lumenfacade™, 5W/ft ASHRAE compliant

**LOG RO** - lumenfacade™ Regular Output, 8.5W/ft

**LOG HO** - lumenfacade™ High Output, 15.25W/ft

2

### Voltage:

**100** - 100 volts

**120** - 120 volts

**208** - 208 volts

**220** - 220 volts

**240** - 240 volts

**277** - 277 volts

3

### Length:

**12** - 13 3/8 inches (340mm) (2 kg/4.5 lbs)

**24** - 25 3/8 inches (645mm) (3.17 kg/7 lbs)

**36** - 37 3/8 inches (949mm) (4.75 kg/10.5 lbs)

**48** - 49 3/8 inches (1254mm) (6.35 kg/14 lbs)

4

### Colors and Color temperatures:

**27K** - 2700K

**30K** - 3000K

**35K** - 3500K

**40K** - 4000K

**RD** - Red

**GR** - Green

**BL** - Blue

5

### Optics:

**WWLF** - Asymmetric Wallwash optic, left feed\*

**WWRF** - Asymmetric Wallwash optic, right feed\*

**10x10** - 10° x 10°\*\*

**10x60** - 10° x 60°

**30x60** - 30° x 60°

**60x60** - 60° x 60°

\*Available September 2015. Right feeding side is standard unless otherwise specified.

\*\*For best results use with HO fixtures at a 6-inch (15cm) setback from surface. Contact factory for application support.

6

### Mounting Option:

**SAM** - Slim Adjustable Mounting

**UMP** - Fixed Mounting

(Suitable to use when **3GV** option is specified)

**UMAS** - Universal Adjustable Mounting

(Suitable to use when **3GV** option is specified)

**WAM2** - Adjustable Wall Mounting 2"

**WAM6** - Adjustable Extended Arm Mounting 6"

**WAM12** - Adjustable Extended Arm Mounting 12"

**WAM18** - Adjustable Extended Arm Mounting 18"

7

### Finish:

**SI** - Silver SandText

**BK** - Black SandText

**WH** - White

**CC** - Custom (please specify RAL color)

8

### Control:

**NO** - No Dimming

**LT** - Lumentalk Dimming<sup>1</sup>

**DIM** - 0-10V Dimming option<sup>2</sup>

**DMX/RDM** - DMX/RDM enabled<sup>3</sup>

**DALI** - DALI Dimming option<sup>4</sup>

**ES** - Lutron® EcoSystem® Enabled Dimming<sup>5</sup>

9

### Option:

**ETE** - End - to - end configuration, no jumper cable needed

**CRC** - Corrosion-resistant coating for hostile environments

**3GV** - 3G ANSI C136.31 Vibration Rating

N.B. Available with UMP and UMAS mounting options only.

### Notes:

<sup>1</sup> Available for 2' RO, 3' and 4' lengths only. 1% minimum dimming value.

<sup>2</sup> 10% minimum dimming value.

<sup>3</sup> 1% minimum dimming value. Fixtures come pre-addressed by fixture (3 DMX channels per fixture).

<sup>4</sup> 1% minimum dimming value.

<sup>5</sup> Available for 2' RO, 3' and 4' lengths only. One EcoSystem® address per fixture length. 1% minimum dimming value.

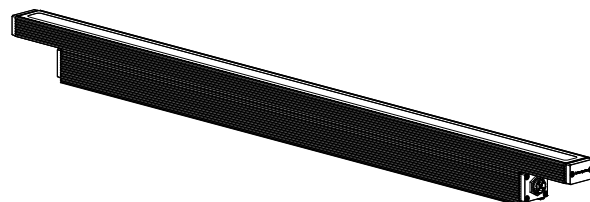
Client \_\_\_\_\_ Project name \_\_\_\_\_

Order# \_\_\_\_\_ Type \_\_\_\_\_ Qty \_\_\_\_\_

## FEATURES AND BENEFITS

### Physical :

- Low copper content extruded aluminum housing
- Available in 1', 2', 3' or 4' sections
- Electro-statically applied polyester powder coat finish
- Machined aluminum end caps and silicone gaskets
- Stainless steel hardware
- Clear tempered glass
- Asymmetric wallwash, 10° x 10°, 10° x 60°, 30° x 60° or 60° x 60° optics
- IP66
- IK07 rated (asymmetric wallwash lens is IK06 rated)
- Corrosion-resistant coating for hostile environments\*\*
- Meets 3G ANSI C136.31 Vibration standard for bridge applications

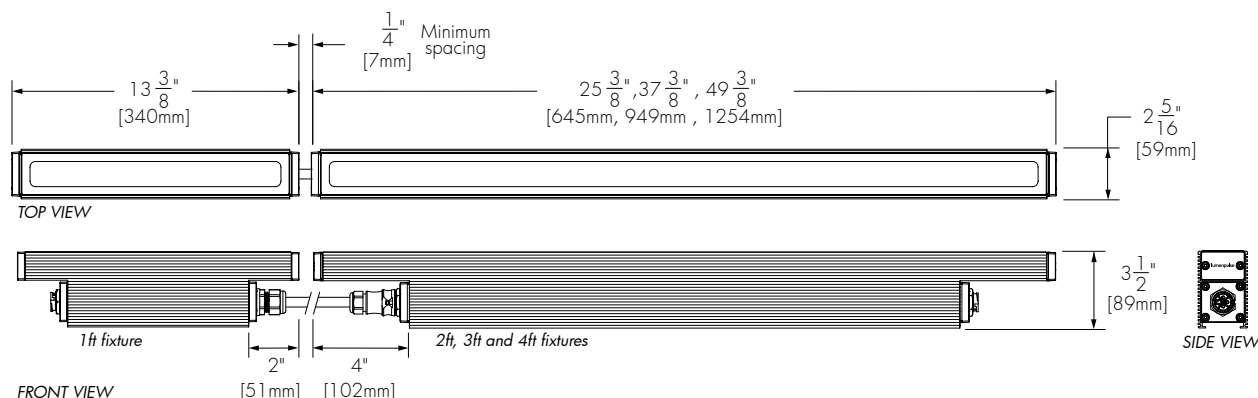


### Performance :

- Minimum 1fc (10.7 lux) @ 102 feet (31.1m) distance (RGB full white, 4' unit, 10° x 60° optic)
- 2,041 delivered lumens and 10,415 candelas at nadir (RGB full white, 4' unit, 10° x 60° optic)
- Color mixing options: RGB (3 channels) or RGBW (4 channels)
- Lumen maintenance L70 @ 25°C - 120,000 hrs
- Lumen measurements comply with LM - 79 - 08 standard
- Resolution per foot or per fixture (configured with LumenID V3 software & RDM)
- Operating temperatures: -25° C to 50° C [-13F to 122F]

### Electrical :

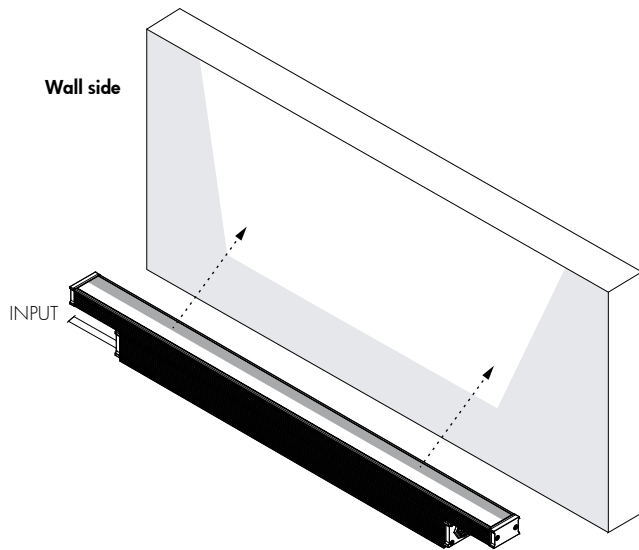
- Line voltage luminaire for 100 to 277V
- Power and data in 1 cable (#16-5)
- Up to 112 feet with 1 power & data feed (277V)
- 17.25W/ft
- DMX/RDM enabled



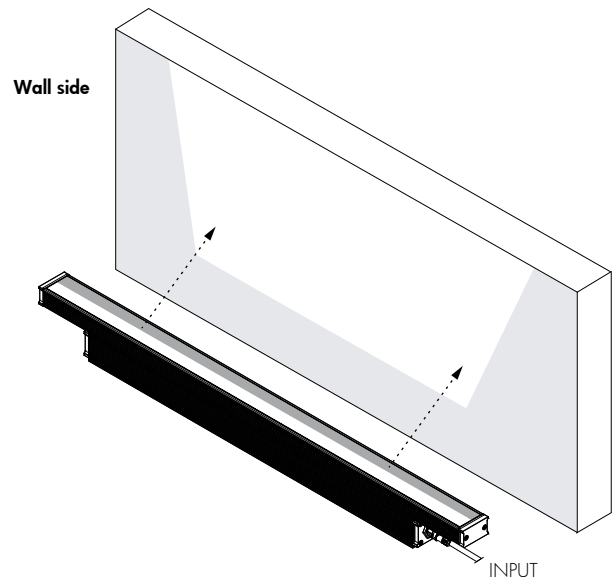
\* Asymmetric wallwash lens is IK06 rated.

\*\* Use only when exposed to salt spray and harsh chemicals. This option is not required for normal outdoor exposure!

**ASYMMETRIC WALLWASH OPTIC FEEDING SIDE DETAIL**

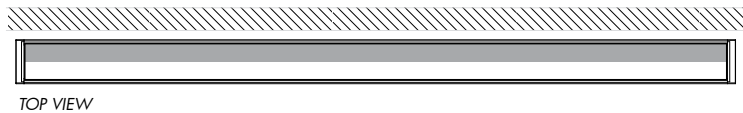


**WWLF**  
Asymmetric Wallwash Optic, Left Feed

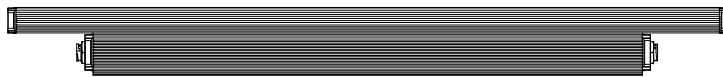


**WWRF**  
Asymmetric Wallwash Optic, Right Feed

**Always position frosted side toward the wall**



TOP VIEW



FRONT VIEW



RIGHT SIDE VIEW  
(Fixture pointing upwards)

\*Fixture's feeding side is based on uplight installations. Feeding sides are reversed when fixture is used in a downlight application.

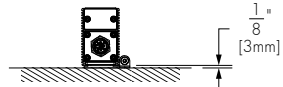
Recommended setback from wall is 1/10 of the wall height.

Example: 2ft setback for a 20ft wall.

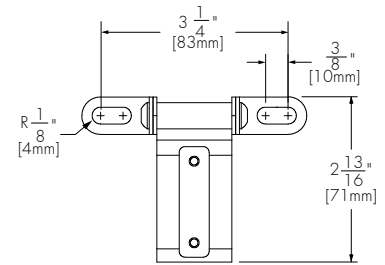
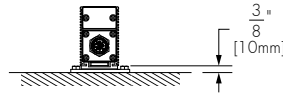
## MOUNTING OPTIONS

### Surface Mount

**SAM**  
Slim Adjustable Mounting



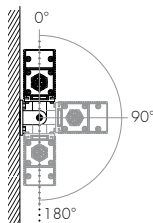
**UMP**  
Fixed Mounting



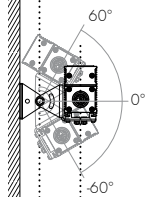
**SAM**  
Mounting Hole Pattern

### Wall Mount

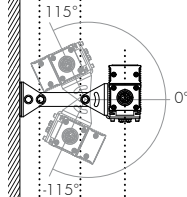
**UMAS**  
Universal Adjustable Mounting



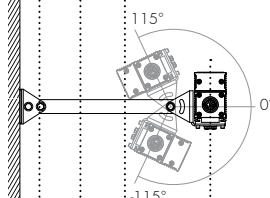
**WAM2**  
Adjustable Wall Mounting 2"



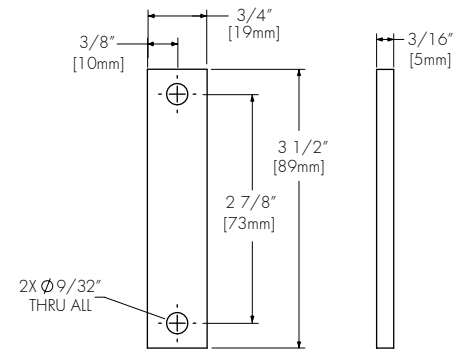
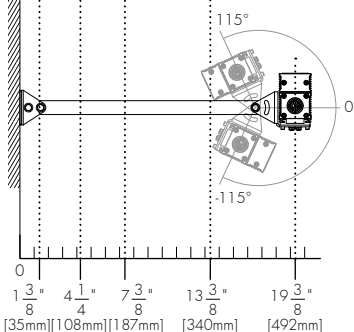
**WAM6**  
Adjustable Extended Arm Mounting 6"



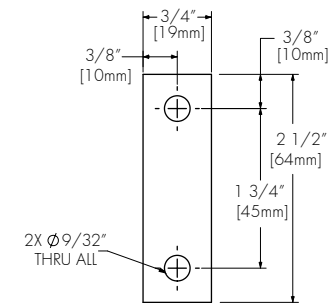
**WAM12**  
Adjustable Extended Arm Mounting 12"



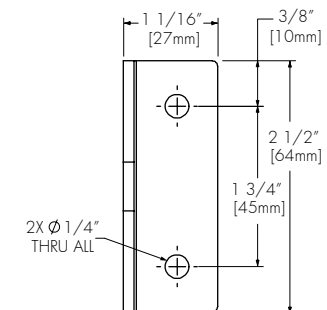
**WAM18**  
Adjustable Extended Arm Mounting 18"



**UMP**  
Mounting Hole Pattern



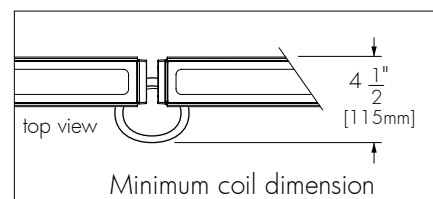
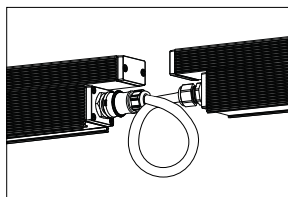
**UMAS**  
Mounting Hole Pattern



**WAM**  
Mounting Hole Pattern

## OPTION

**ETE** - End-to-end configuration,  
no jumper cable needed.  
16" cable included at input.



## ACCESSORIES

Order separately

### Control Systems:

- LTO2** Lumentouch is a wall mount DMX 512 controller keypad.
- LCU** Lumencue is a USB / mini SD DMX 512 controller.
- LID** LumenID is a diagnostic and addressing DMX 512 controller.  
It must be specified on all DMX applications.  
Refer to LID specification sheet for details.
- LTN** Lumentone is a simple pre-programmed DMX 512 controller  
with a push button rotary dial and live feedback.

### Control Boxes:

- CBX** DMX/RDM control box.  
Up to six power and data outputs to fixtures or fixture runs.  
Ethernet enabled option.  
Refer to CBX specification sheet for details.

### Leader Cable :

- LOGLCD\_\_\_** Leader Cable for Lumenfacade.  
Please add desired cable length : 10', 25' or 50' [3m, 7.6m or 15.2m] standard lengths  
Sealing endcap is mandatory for any unused connector.  
(1) included with every leader cable
- LOGLCD\_\_\_-ETE** Leader Cable for Lumenfacade, ETE option.  
Please add desired cable length : 10', 25' or 50' [3m, 7.6m or 15.2m] standard lengths  
Sealing endcap is mandatory for any unused connector.  
(1) included with every leader cable

### Jumper Cable :

- LOGJCD\_\_\_** Jumper Cable for Lumenfacade.  
Please add desired cable length : 2' or 4' [0.6m, 1.2m] standard lengths
- LOGJCD\_\_\_-ETE** Jumper Cable for Lumenfacade, ETE option.  
Please add desired cable length : 2' or 4' [0.6m, 1.2m] standard lengths

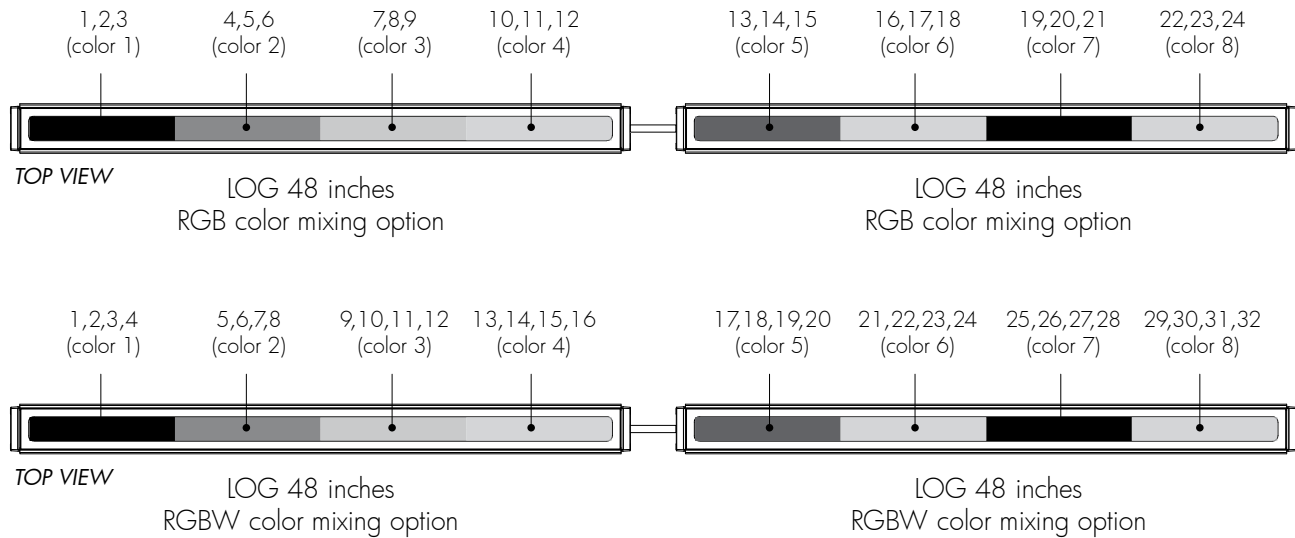


## RESOLUTION DETAILS

Fixture resolution can be configured on-site within the LumenID V3 software. A DMX/RDM enabled CBX is required.

Resolution per foot: each foot is addressed independently

DMX ADDRESSES:



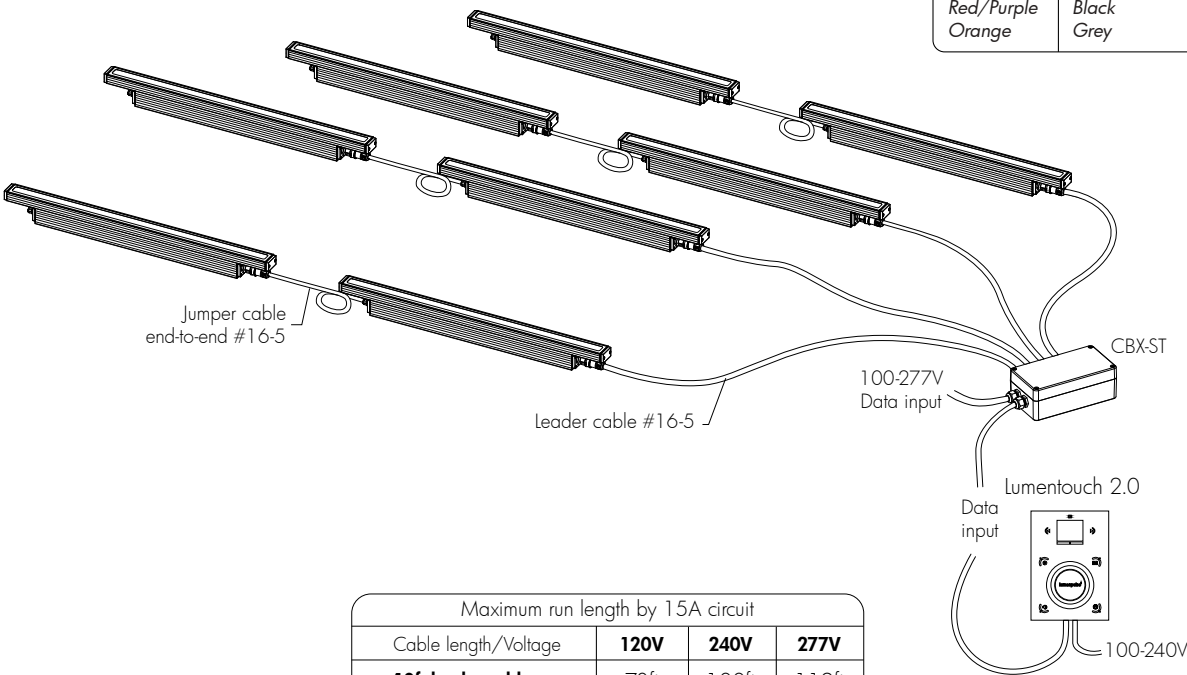
Resolution per fixture: each fixture is addressed independently

DMX ADDRESSES:



TYPICAL WIRING DIAGRAMS

Star Layout (DMX/RDM)

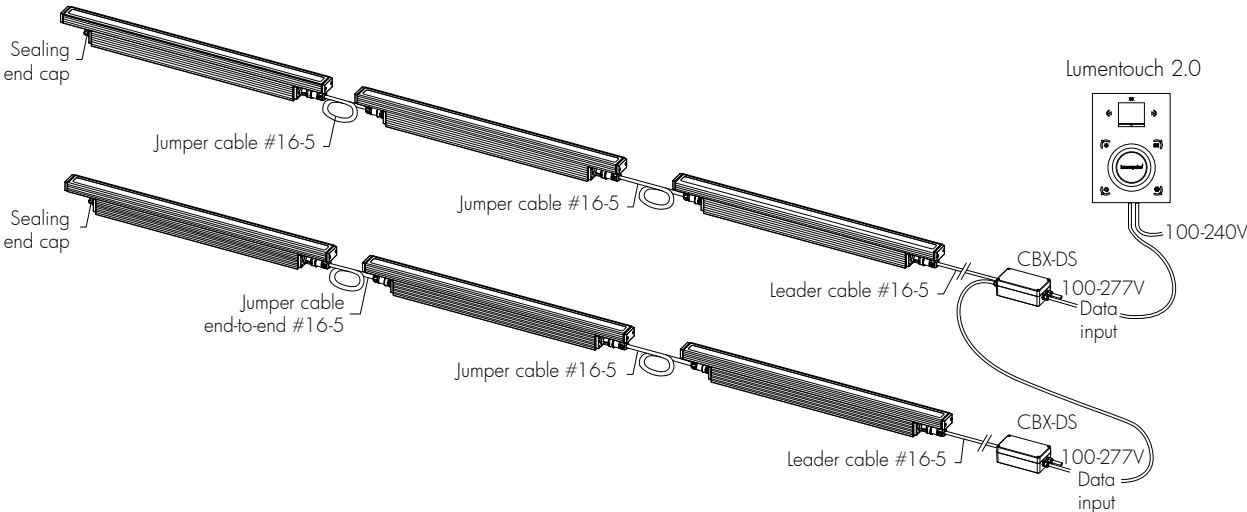


American Color Code	CE Color Code	USE
Green	Yellow/Green	Ground
Black	Brown	Live 100-277V
White	Blue	Neutral
Red/Purple	Black	0-10V / Data +
Orange	Grey	0-10V / Data -

Maximum run length by 15A circuit			
Cable length/Voltage	120V	240V	277V
10ft leader cable	78ft	100ft	112ft
50ft leader cable	68ft	80ft	88ft

\*Up to 170 individually addressable 1 foot sections per RGB DMX/RDM run.  
\*Up to 128 individually addressable 1 foot sections per RGBW DMX/RDM run.  
\*Maximum run length calculations are typically based on 4ft fixtures.  
Consult factory for specific installation requirements.

Daisy Chain Layout (DMX/RDM)



## HOW TO ORDER

LOG							DMX/RDM	
1	2	3	4	5	6	7	8	9

1

### Housing:

**LOG** - Lumenfacade™

2

### Voltage:

**100** - 100 volts      **220** - 220 volts  
**120** - 120 volts      **240** - 240 volts  
**208** - 208 volts      **277** - 277 volts

3

### Length:

**12** - 13 3/8 inches (340mm) (2 kg/4.5 lbs)  
**24** - 25 3/8 inches (645mm) (3.17 kg/7 lbs)  
**36** - 37 3/8 inches (949mm) (4.75 kg/10.5 lbs)  
**48** - 49 3/8 inches (1254mm) (6.35 kg/14 lbs)

4

### Colors and Color temperatures:

**RGB** - Additive red, green and blue  
**RGBW** - Additive red, green, blue and white 4000K

5

### Optics:

**WWLF** - Asymmetric Wallwash optic, left feed\*  
**WWRF** - Asymmetric Wallwash optic, right feed\*  
**10x10** - 10° x 10°\*\*  
**10x60** - 10° x 60°  
**30x60** - 30° x 60°  
**60x60** - 60° x 60°

\*Available September 2015. Right feeding side is standard unless otherwise specified.

\*\*For best results, we recommend a 6-inch (15cm) setback from surface. Contact factory for application support.

6

### Mounting Option:

**SAM** - Slim Adjustable Mounting  
**UMP** - Fixed Mounting  
 (Suitable to use when **3GV** option is specified)  
**UMAS** - Universal Adjustable Mounting  
 (Suitable to use when **3GV** option is specified)  
**WAM2** - Adjustable Wall Mounting 2"  
**WAM6** - Adjustable Extended Arm Mounting 6"  
**WAM12** - Adjustable Extended Arm Mounting 12"  
**WAM18** - Adjustable Extended Arm Mounting 18"

7

### Finish:

**SI** - Silver SandText  
**BK** - Black SandText  
**WH** - White  
**CC** - Custom (please specify RAL color)

8

### Control:

**DMX/RDM** - DMX/RDM enabled  
 Fixtures come pre-addressed by fixture (consult Resolution Details page for the number of DMX addresses per color mixing option).

9

### Option:

**ETE** - End - to - end configuration, no jumper cable needed  
**CRC** - Corrosion-resistant coating for hostile environments  
**3GV** - 3G ANSI C136.31 Vibration Rating  
 N.B. Available with UMP and UMAS mounting options only.

Date: \_\_\_\_\_ Customer: \_\_\_\_\_

Project: \_\_\_\_\_

Type: \_\_\_\_\_ Qty: \_\_\_\_\_

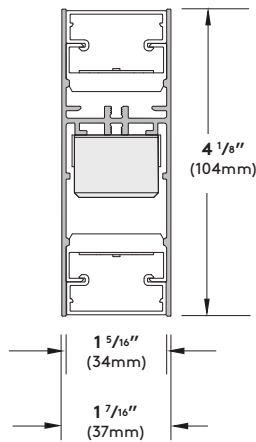
**selux**  
**PL1**

## M36 LED Direct/Indirect



Order Code: L36DI - - - - -

L36DI	Series	L36DI											
		M36 LED Direct/Indirect											
	Direct Light Engine	1A35 <sup>1,2</sup> 704lm/8.8W per foot		1A30 <sup>1,2</sup> 620lm/7.6W per foot		1A25 <sup>1,2</sup> 521lm/6.3W per foot		1A20 <sup>1,2</sup> 422lm/5.1W per foot		¹Values calculated from a 4' fixture @4000°K using LW Shielding and standard driver. For additional information please see page 2.			
	Indirect Light Engine	1A35 <sup>1,2</sup> 670lm/8.8W per foot		1A30 <sup>1,2</sup> 590lm/7.6W per foot		1A25 <sup>1,2</sup> 496lm/6.3W per foot		1A20 <sup>1,2</sup> 402lm/5.1W per foot		²Mixed output available 4' and up, see page 7 for details			
	CCT	27 2700K		30 3000K		35 3500K		40 4000K					
	Direct Shielding	LW LED Optimized white lens		MI Clear Lens w/micropism		NB LMO Symmetric		A2 LMO Asymmetric 20° Wall Washer		A5 LMO Asymmetric 5° Wall Grazer		BW LMO Batwing	
	Indirect Shielding	LW LED Optimized white lens		MI Clear Lens w/micropism		NB LMO Symmetric		A2 LMO Asymmetric 20° Wall Washer		A5 LMO Asymmetric 5° Wall Grazer		BW LMO Batwing	
	Mounting	C Cable		S Swivel Stem		RS Rigid Stem		W Wall Mount					
	Nominal Fixture Length	02 2 ft.	03 3 ft.	04 4 ft.	05 5 ft.	06 6 ft.	07 7 ft.	08 8 ft.	09 9 ft.	10 10 ft.	11 11 ft.	12 12 ft.	XX Runs (over 12') are available in 1' nominal increments, round up to the nearest foot and replace the "xx" with the # (i.e. 13=13' nominal)
		Individual fixtures, Runs and Configurations are supplied in nominal lengths to ensure full, even, illumination. See pages 2 thru 5 for additional details.											
	Finish	WH White		BK Black		SV Silver		SP Specify Premium Color		Custom colors are available, Please consult factory			
	Voltage	120 120 Volt		277 277 Volt		UNV 120 thru 277 50/60hz capable							
	Fixture Options	DL <sup>3</sup> Damp Location Rated		FS <sup>3</sup> In-Line Fuse		SS <sup>3</sup> Separate Switching		*See page 7 for full details and restrictions					
	Dimming Options	DML <sup>4</sup> eldoLED 0-10V (Logarithmic)		DMD <sup>4</sup> eldoLED DALI (Logarithmic)		DC2 <sup>4,5</sup> Lutron 2-Wire		DC3 <sup>4</sup> Lutron 3-Wire		DCE <sup>4</sup> Lutron Eco-System		*See page 6 for full details ¹120V only	
	Emergency Options	EC <sup>6</sup> Emergency Circuit Wiring		*See page 7 for full details and restrictions									
	Configuration Options	IL90 <sup>7</sup> Lit Horizontal 90° Corner		IT90 <sup>7</sup> Lit "T" section		IX90 <sup>7</sup> Lit "X" section		*See page 8 for full details and restrictions					



### Construction:

**Housing** - Continuous, low copper 6063-T6 extruded aluminum profile with aluminum endcaps, available as Individual fixtures (up to 12') or Runs.

**Geartray** - Low copper 6063-T6 extruded aluminum profile.

**Shielding** - Extruded, impact resistant acrylic lens:

- LED optimized white lens (LW)
- Clear lens with microprism inlay (MI)
- "LMO" Symmetric lens (NB)
- "LMO" Asymmetric 5° wall grazer (A5)
- "LMO" Asymmetric 20° wall washer (A2)
- "LMO" Batwing (BW)

**Mounting(s)** - 1/16" Aircraft Cable, Ø1/2" Swivel or Rigid Steel Stem, Wall Bracket, (see pages 3 thru 5 for details).

\*\* Cable, Stem and Wall mountings may not be symmetrical for Runs and Configurations due to the use of modular housing lengths. If symmetrical suspensions are required please consult the factory.

**Standard Luminaire lengths** - All standard luminaires are supplied in nominal lengths to ensure full, even, illumination. Runs and Configurations are available in approximately 12' increments starting at the nominal 12' fixture length.

\*\* Individual luminaires are not joinable in the field.

**Exact length luminaires** - Individual luminaires, runs, and configuration are available in exact lengths to meet your project needs. Please consult factory with you requirements.  
\*\* Lens luminance may soften at the very ends of the straight sections for exact length luminaires.

**M36 Joiner(s)** - Runs and configurations are supplied in multiple housing that are joined together in the field using the supplied M36 Joining System. This allows ease of installation and ensures a uniform appearance (see page 7 for detail).

### Electrical/Performance:

**LED Light Engine** - Brand-name mid-power LEDs create a high efficiency LED light engine able to provide a lumen maintenance of 96% at 25,000 hours and 93% at 60,000 hours per TM-21 report.

**LED Life** - Calculated L70 greater than 366,000 hours and Reported L70 Greater than 60,000 hours @ 25°C per TM-21

**Delivered Lumens** - Due to LED manufacturer's tolerances the listed output has a ±5% tolerance. For outputs based on different shielding or CCT please see photometry section at the end.

**CCT** - Available in 2700K, 3000K, 3500K and 4000K, tolerance within a 3-step MacAdam ellipse.

**CRI** - Min. 80

**All Drivers** - High efficiency, constant current, soft start, Electronic Class 2 with a PFC>0.90. For more detailed information on the available drivers please see page 6.

### Thermal Performance:

**Ambient Operating Temperature** - Luminaires suitable for Max. ambient temperature of 35° C (95° F) for all drivers, standard and optional.

Min. ambient temperature of:  
-20°C (-4°F) for the Standard driver and optional DML and DMD drivers.  
0°C (32°F) for the optional DC2, DC3 and DCE drivers.

### Luminaire Finish:

**Powder Coat** - All Selux luminaires are finished in high quality polyester powder coating in our Tiger Drylac certified facility and are tested in accordance with test specifications for coatings from ASTM and PCI.

All products undergo a five stage intensive pretreatment process where product is thoroughly cleaned, phosphated, and sealed. Selux powder coated products provide excellent salt and humidity resistance as well as ultra violet resistance for color retention.

Standard interior colors are White (WH), Black (BK), and Silver (SV). Selux premium colors (SP) are available, please specify from your Selux color selection guide.

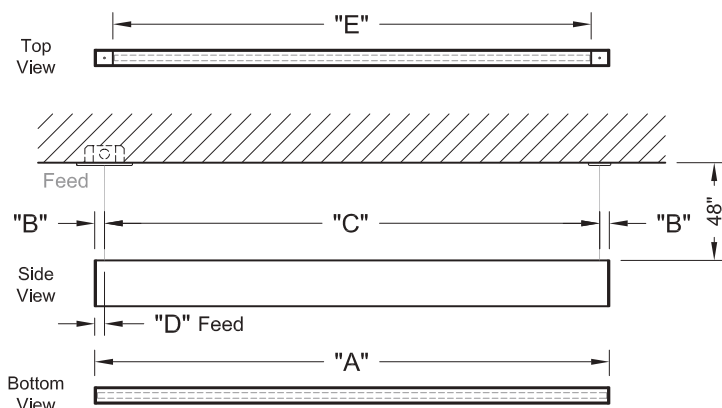
### Warranty:

**5 Year Limited LED Luminaire Warranty** - Selux offers a 5 Year Limited Warranty to the original purchaser that the M36 series LED luminaire shall be free from defects in material and workmanship for up to five (5) years from date of shipment. This limited warranty covers the LED driver and LED light engine when installed according to Selux instructions and operated within the Ambient Temperature. For additional details and exclusions, see "Selux Terms and Condition of Sale".

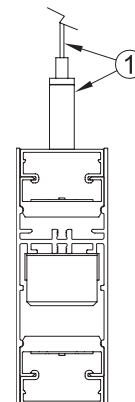
### Certifications and Compliance:

NRTL - For Dry and Damp location  
(I.E. cULus; cCSAus)  
ADA Compliant  
ARRA Compliant  
RoHS Compliant

## Cable Mounting (C)



## Cable Mounting (C)

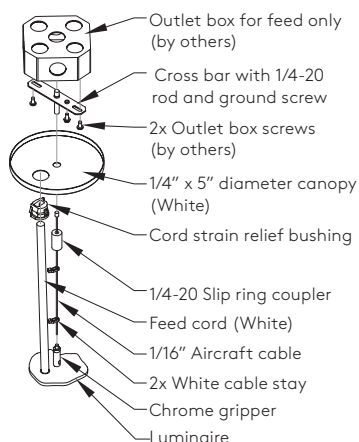


1. Ø 1/16" Aircraft Cable with chrome gripper for easy adjustment (48" max. from ceiling to luminaire).

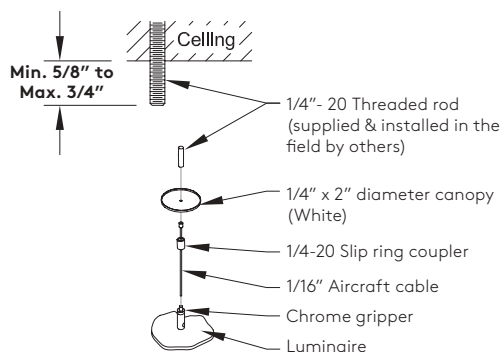
Cable Mounting (C) - Dimensions										
Nominal Length	"A" Housing Length		* "B" (Ref.) End Suspensions		"C" Mid. Suspension		"D" Feed Location		"E" Illuminated Length	
	Feet/Inch	MM	Feet/Inch	MM	Feet/Inch	MM	Feet/Inch	MM	Feet/Inch	MM
02 (2 ft.)	2' - 1/4"	616	0' - 7/8"	22	1' - 10 1/2"	572	0' - 3/8"	9	1' - 9"	534
03 (3 ft.)	3' - 5/16"	923	0' - 7/8"	22	2' - 10 5/8"	879	0' - 3/8"	9	2' - 9 1/8"	841
04 (4 ft.)	4' - 1/4"	1225	0' - 7/8"	22	3' - 10 1/2"	1181	0' - 3/8"	9	3' - 9"	1143
05 (5 ft.)	4' - 10 11/16"	1491	0' - 7/8"	22	4' - 8 15/16"	1446	0' - 3/8"	9	4' - 7 1/2"	1409
06 (6 ft.)	5' - 10 5/8"	1794	0' - 7/8"	22	5' - 8 7/8"	1750	0' - 3/8"	9	5' - 7 3/8"	1712
07 (7 ft.)	7' - 1/4"	2140	0' - 7/8"	22	6' - 10 1/2"	2095	0' - 3/8"	9	6' - 9"	2058
08 (8 ft.)	8' - 1/4"	2444	0' - 7/8"	22	7' - 10 1/2"	2400	0' - 3/8"	9	7' - 9"	2362
09 (9 ft.)	8' - 10 5/8"	2709	0' - 7/8"	22	8' - 8 15/16"	2665	0' - 3/8"	9	8' - 7 7/16"	2627
10 (10 ft.)	9' - 10 5/8"	3013	0' - 7/8"	22	9' - 8 7/8"	2968	0' - 3/8"	9	9' - 7 3/8"	2931
11 (11 ft.)	11' - 3/16"	3358	0' - 7/8"	22	10' - 10 1/2"	3314	0' - 3/8"	9	10' - 9"	3276
12 (12 ft.)	12' - 3/16"	3662	0' - 7/8"	22	11' - 10 3/8"	3617	0' - 3/8"	9	11' - 8 15/16"	3580

\*Dimension(s) rounded to the nearest 1/16" with a ± 1/16 (1mm) tolerance.

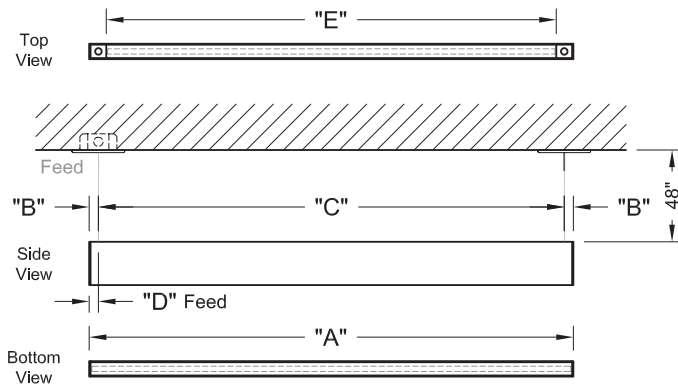
### L36DI Cable (C) Suspension Detail (Feed location(s) only)



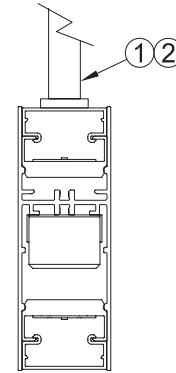
### L36DI Cable (C) Suspension Detail (Non-Feed location(s) only)



## Stem Mounting (S & RS)



## Stem Mounting (S & RS)



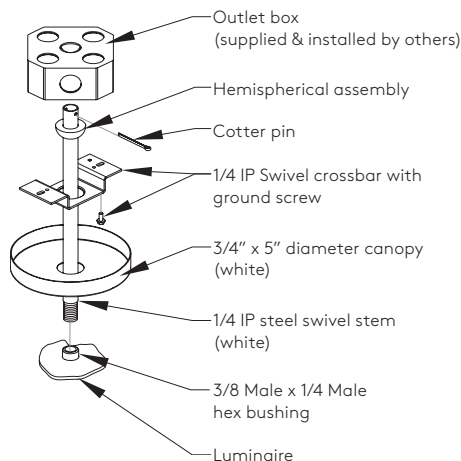
1.  $\varnothing 1/2"$  Swivel Stem provides 45° swivel and **can be cut in field** (48" max. from ceiling to luminaire).
2.  $\varnothing 1/2"$  Rigid Stem is fixed and is **not able to be cut/adjusted in field** (48" max. from ceiling to luminaire).

Swivel (S) & Rigid Stem (RS) Mountings - Dimensions

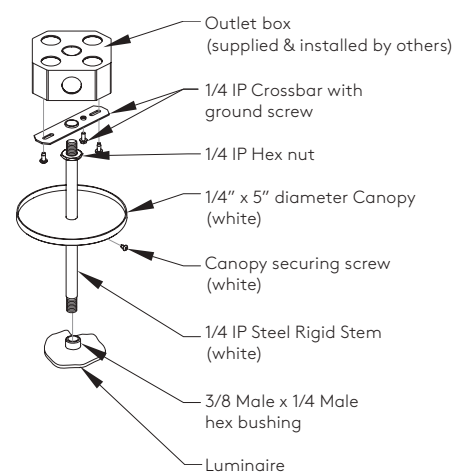
Nominal Length	"A" Housing Length		* "B" (Ref.) End Suspensions		"C" Mid. Suspension		"D" Feed Location		"E" Illuminated Length	
	Feet/Inch	MM	Feet/Inch	MM	Feet/Inch	MM	Feet/Inch	MM	Feet/Inch	MM
02 (2 ft.)	2' - 1/4"	616	0' - 7/8"	22	1' - 10 1/2"	572	0' - 7/8"	22	1' - 9"	534
03 (3 ft.)	3' - 5/16"	923	0' - 7/8"	22	2' - 10 5/8"	879	0' - 7/8"	22	2' - 9 1/8"	841
04 (4 ft.)	4' - 1/4"	1225	0' - 7/8"	22	3' - 10 1/2"	1181	0' - 7/8"	22	3' - 9"	1143
05 (5 ft.)	4' - 10 11/16"	1491	0' - 7/8"	22	4' - 8 15/16"	1446	0' - 7/8"	22	4' - 7 1/2"	1409
06 (6 ft.)	5' - 10 5/8"	1794	0' - 7/8"	22	5' - 8 7/8"	1750	0' - 7/8"	22	5' - 7 3/8"	1712
07 (7 ft.)	7' - 1/4"	2140	0' - 7/8"	22	6' - 10 1/2"	2095	0' - 7/8"	22	6' - 9"	2058
08 (8 ft.)	8' - 1/4"	2444	0' - 7/8"	22	7' - 10 1/2"	2400	0' - 7/8"	22	7' - 9"	2362
09 (9 ft.)	8' - 10 5/8"	2709	0' - 7/8"	22	8' - 8 15/16"	2665	0' - 7/8"	22	8' - 7 7/16"	2627
10 (10 ft.)	9' - 10 5/8"	3013	0' - 7/8"	22	9' - 8 7/8"	2968	0' - 7/8"	22	9' - 7 3/8"	2931
11 (11 ft.)	11' - 3/16"	3358	0' - 7/8"	22	10' - 10 1/2"	3314	0' - 7/8"	22	10' - 9"	3276
12 (12 ft.)	12' - 3/16"	3662	0' - 7/8"	22	11' - 10 3/8"	3617	0' - 7/8"	22	11' - 8 15/16"	3580

\*Dimension(s) rounded to the nearest 1/16" with a  $\pm 1/16$  (1mm) tolerance.

L36DI Swivel Stem (S) Suspension Detail  
(feed wires through stem supplied by Selux)

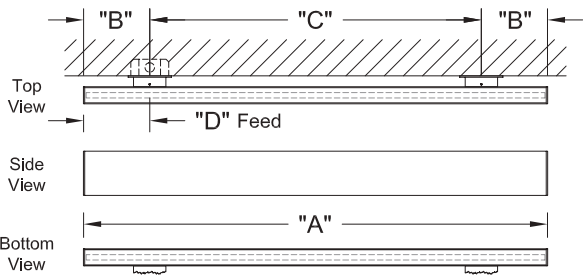


L36DI Rigid Stem (RS) Suspension Detail  
(feed wires through stem supplied by Selux)





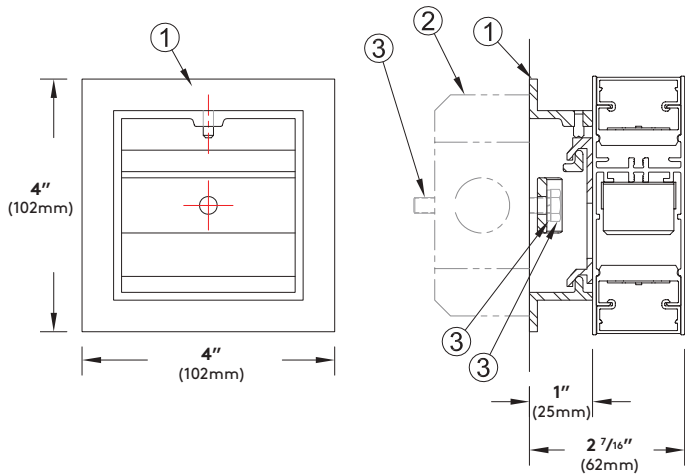
Wall Mounting (W)



Wall (W) Mount - Dimensions								
Nominal Length	"A" Housing Length		* "B" (Ref.) End Suspensions		"C" Mid. Suspension		"D" Feed Location	
	Feet/Inch	MM	Feet/Inch	MM	Feet/Inch	MM	Feet/Inch	MM
02 (2 ft.)	2' - 1/4"	616	0' - 3 1/8"	79	1' - 6 1/16"	458	0' - 3 1/8"	79
03 (3 ft.)	3' - 5/16"	923	0' - 6 1/8"	156	2' - 1/8"	612	0' - 6 1/8"	156
04 (4 ft.)	4' - 1/4"	1225	0' - 6 1/8"	156	3' - 0"	914	0' - 6 1/8"	156
05 (5 ft.)	4' - 10 11/16"	1491	0' - 6 1/8"	156	3' - 10 7/16"	1180	0' - 6 1/8"	156
06 (6 ft.)	5' - 10 5/8"	1794	0' - 6 1/8"	156	4' - 10 7/16"	1484	0' - 6 1/8"	156
07 (7 ft.)	7' - 1/4"	2140	0' - 6 1/8"	156	6'	1829	0' - 6 1/8"	156
08 (8 ft.)	8' - 1/4"	2444	0' - 6 1/8"	156	7'	2133	0' - 6 1/8"	156
09 (9 ft.)	8' - 10 5/8"	2709	0' - 6 1/8"	156	7' - 10 7/16"	2398	0' - 6 1/8"	156
10 (10 ft.)	9' - 10 5/8"	3013	0' - 6 1/8"	156	8' - 10 3/8"	2702	0' - 6 1/8"	156
11 (11 ft.)	11' - 3/16"	3358	0' - 6 1/8"	156	9' - 11 15/16"	3047	0' - 6 1/8"	156
12 (12 ft.)	12' - 3/16"	3662	0' - 6 1/8"	156	10' - 11 15/16"	3351	0' - 6 1/8"	156

\*Dimension(s) rounded to the nearest 1/16" with a ± 1/16 (1mm) tolerance.

Wall Mount (W)  
(Covers a 4x4 or 2x4 J-Box)



1. Aluminum wall bracket (by Selux)
2. 4" x 4" or 2" x 4" J-Box at feed location (supplied and installed by others).
3. 1/4-20 Threaded rod, 1/4-20 lock washer and 1/4-20 nut required to anchor the wall bracket. Mounting hardware supplied and installed to code by others.

Standard eldoLED Drivers for 2’ fixtures and longer:

eldoLED 0-10V linear dimming

Fixtures supplied with SOLOdrive drivers offering the capability of either normal switched operation or 0-10V dimming for linear dimming curve. Fixtures ship with the dimming leads capped, for dimming operation uncap the wires. Minimum dimming level preset at factory to 1%. For “dim to dark” (down to 0.1%), please consult factory. Max. inrush current per driver 30mA’s & 0-10V control current Max. 2mA per driver.

Optional eldoLED Dimming Drivers:

eldoLED 0-10V logarithmic dimming (DML)

Luminaires supplied with SOLOdrive 0-10V dimming driver for logarithmic dimming curve. Minimum dimming level preset at factory to 1%. For “dim to dark” (down to 0.1%), please consult factory. Max. inrush current per driver 30mA’s & 0-10V control current Max. 2mA per driver.

eldoLED DALI dimming (DMD)

Luminaires supplied with SOLOdrive DALI dimming driver for logarithmic dimming curve. Minimum dimming level preset at factory to 1%. For “dim to dark” (down to 0.1%), please consult factory. Max. inrush current per driver 30mA’s.

\*For control recommendation for eldoLED drivers, please contact eldoLED.

Optional LUTRON Dimming Drivers:

LUTRON 2-wire dimming (DC2)

Luminaires supplied with A-series 2-wire dimming driver programmed for Constant Current Reduction (CCR). For Pulse Width Modulation (PWM) dimming, please consult factory. Minimum dimming level down to 1%. Inrush current per driver < 2A.

LUTRON 3-wire dimming (DC3)

Luminaires supplied with A-series 3-wire dimming driver programmed for Constant Current Reduction (CCR). For Pulse Width Modulation (PWM) dimming, please consult factory. Minimum dimming level down to 1%. Inrush current per driver < 2A.

LUTRON EcoSystem dimming (DCE)

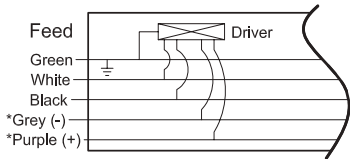
Luminaires supplied with A-series EcoSystem (4 wire, digital link) dimming driver programmed for Constant Current Reduction (CCR). For Pulse Width Modulation (PWM) dimming, please consult factory. Minimum dimming level down to 1%. Inrush current per driver < 2A.

\*\*For control recommendation and system layout for LUTRON drivers, please contact LUTRON.

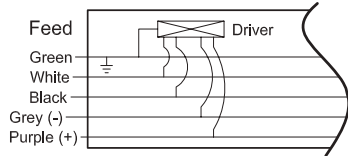
Driver Quantity (consult factory for SS option driver quantity)												
	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft.	10 ft.	11 ft.	12 ft.	RUN
Standard Driver and Optional DML & DMD drivers	1	1	2	2	2	3	4	4	4	5	6	Approximately 2 drivers per 4 ft.
Optional DC2, DC3, & DCE drivers	1	2	2	3	4	4	4	5	6	6	6	Consult Factory

Wiring Diagrams

Standard - 0-10V (Linear) dimming capable

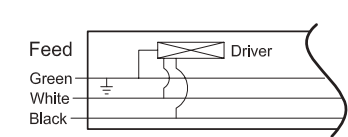


Optional Dimming - 0-10V Logarithmic (DML)  
Dali Logarithmic (DMD)

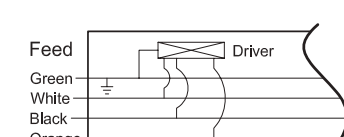


Standard Wiring supplied for all drivers.	Green = Ground White = Neutral Black = Hot
-The following wire(s) are in addition to the std. above-	
0-10V Dimming for Standard driver	*Grey = (-) 0-10V Dimming control *Purple = (+) 0-10V Dimming control  *Grey and Purple feed wires are capped at the factory for non-dimming operation. For 0-10v dimming operation remove the caps on the Grey and Purple wires.
DML & DMD	Grey = (-) Dali or 0-10V Dimming control Purple = (+) Dali or 0-10V Dimming control
DC2	No additional wires
DC3	Orange = 3-Wire Dimming control
DCE	Violet = "E1" Digital Link Dimming control Violet / White = "E2" Digital Link Dimming control

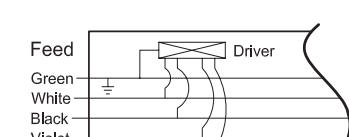
Optional Dimming - Lutron 2-Wire (DC2)



Optional Dimming - Lutron 3-wire (DC3)



Optional Dimming - Lutron EcoSystem (DCE)



**Fuse (FS)** - Fusing, luminaires supplied with a in-line fuse located on the hot wire for each feed (supplied with an 8A slow burn fuse).

**Damp Location (DL)** -Luminaires are suitable for use in damp location(s). Examples of such locations include protected areas under canopies, marquees, roofed porches, and similar locations where the fixture(s) are protected from direct contact with rain, snow, or excessive moisture (such as ocean spray). Interior locations include areas subject to moderate degrees of moisture, such as basements and certain barns and cold storage buildings. All solder points on LED boards are conformal coated. The phosphor layer of the LEDs is free of coating to avoid hazing.

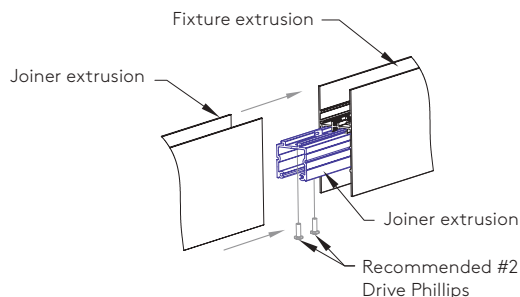
**Mixed Output** - Luminaires have ability to offer mixed light engines (i.e. 1A35 direct and 1A25 indirect) starting at 4' and then in 2' steps (i.e. 6', 8', 10', 12'...).

**Separate Switching (SS)** - Luminaire available with the Direct side switched separately from the Indirect side starting at the 4' nominal length and then in 2' nominal steps, i.e. 6', 8', 10', 12', etc... Luminaire is intended to be wired to the same panel/breaker (not intended for Emergency use).

\* If the project requires different separate switching than outlined above please consult the factory.

**Emergency Circuit (EC)** - Available starting at 4' nominal length and then in 2' steps (i.e. 6', 8', 10', 12'...). Luminaires to have the first 4' nominal length operated on separate EM circuit by default to meet the required "Life Safety Code" (NFPA 101). If a different configuration is needed please consult the factory. Luminaires with EC option compliant to UL 924. EC luminaires are intended to be wired to separate panels/breakers for emergency use.

#### **Joiner System -** Standard for Runs & Configurations



### Standard Direct/Indirect shapes/configurations:

Listed below are the minimum lengths and details for standard shapes. These standard shapes can be combined with each other and/or the standard luminaire lengths, ensuring full even illumination. If you have any questions, please consult the factory.

The minimum standard lengths for "L" shapes:

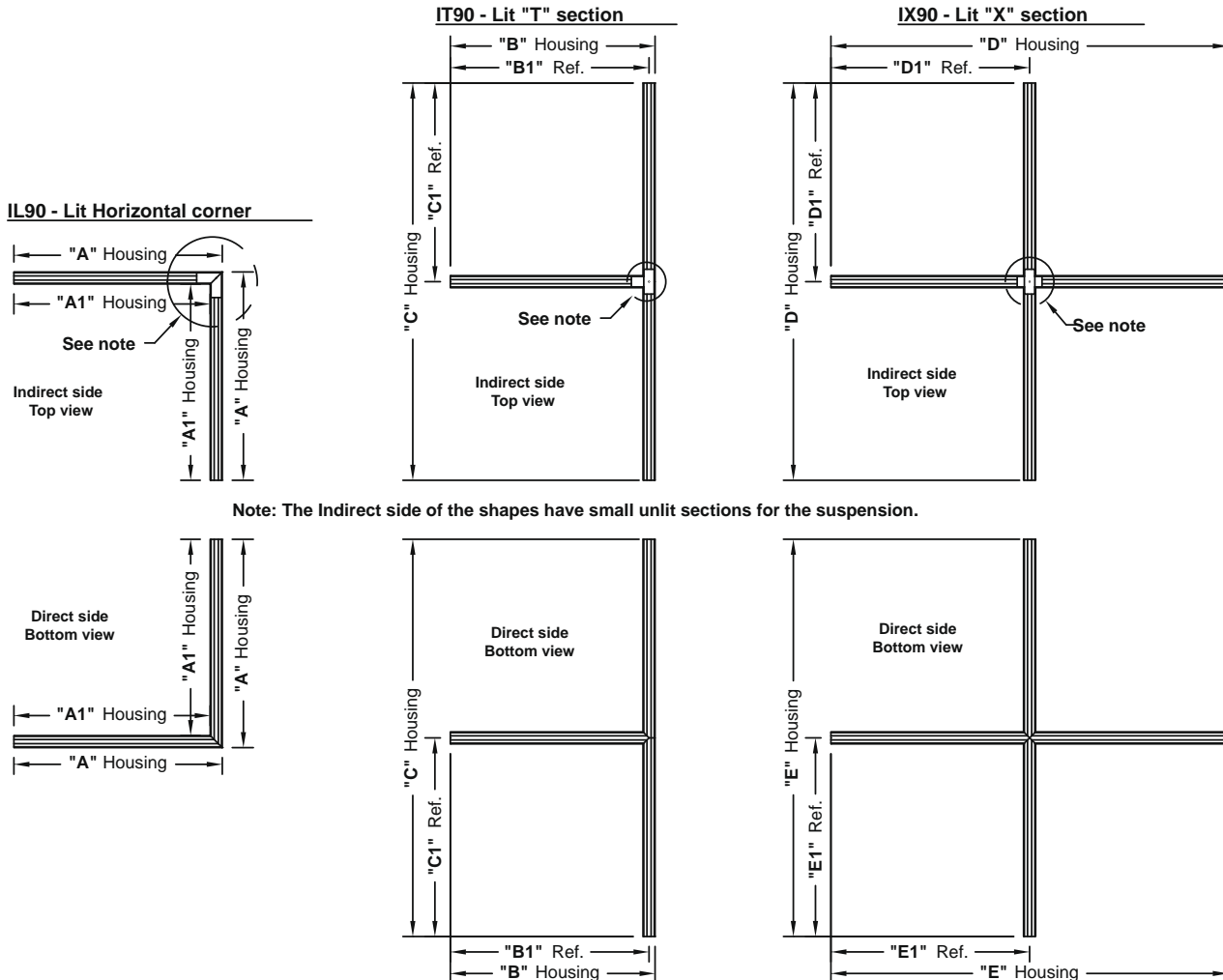
- IL90 or V90 open shapes is 4' x 4' nominal (example: leg, 90, leg)
  - IL90 or V90 closed shapes is 6' x 6' nominal (example: 90, leg, 90)
- (Exception is that the IL90 & V90's can be joined directly to provide a 4' x 4' nominal shape)

The minimum standard lengths for "T" & "X" shapes:

- IT90 = 4' nominal on the short leg and 8' nominal on the long side
- IX90 = 8' nominal for either direction

### Project Specific Direct/Indirect shapes/configurations:

Selux is capable of supplying a wide range of project solutions including different shapes, angles, and sizes to meet the project requirements. Due to the complex nature of these project specific layout(s) we ask that you please consult the factory with the project requirements for review.

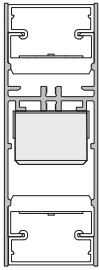


Direct/Indirect Lit Corner and Section - Dimensions						
	IL90		IT90		IX90	
	Feet/Inch	MM	Feet/Inch	MM	Feet/Inch	MM
"A" Housing (Outside)	2' - 13/16"	631				
"A1" Housing (Inside)	1' - 11 3/8"	594				
"C" Housing			2' - 13/16"	631		
* "C1" Ref.			2' - 1/8"	612		
"D" Housing			4' - 3/16"	1224		
* "D1" Ref.			2' - 1/8"	612		
"E" Housing					4' - 3/16"	1224
* "E1" Ref.					2' - 1/8"	612

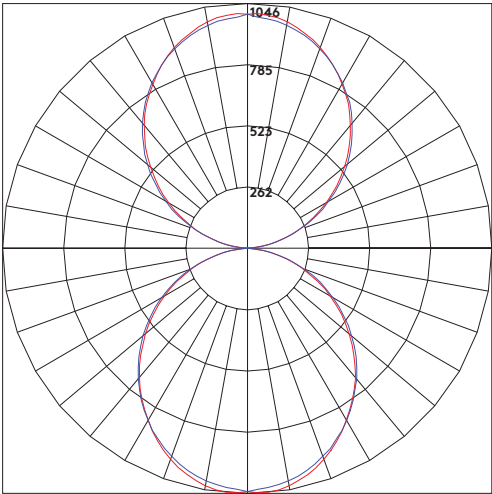
\*Dimension(s) rounded to the nearest 1/16" with a ± 1/16 (1mm) tolerance.

Photometry

LW Optics / 71W LED / 4000K CCT



[Link to photometry \(IES & PDF files\)](#)



Maximum Candela = 1046.239 Located At Horizontal Angle = 90, Vertical Angle = 5  
# 1 - Vertical Plane Through Horizontal Angles (90 - 270)  
# 2 - Vertical Plane Through Horizontal Angles (0 - 180)

Catalog #: L36DI-1A35-1A35-40-LW-LW-04-120  
Report #: 798393-1  
Delivered Lumens: 5499  
Input Watts: 71W  
Efficacy: 78  
Power Factor: 0.990  
Total Harmonic Distortion: 4.63  
CCT: 3982K  
CRI: 83.9  
Max Candela: 1046 @ 5° from Vertical  
Spacing Criterion (0-180): N/A  
Spacing Criterion (90-270): N/A  
Spacing Criterion (Diagonal): N/A

CCT Multiplier	
4000K	1.000
3500K	0.937
3000K	0.940
2700K	0.923

CCT multipliers apply to the photometry, IES files, and per foot values listed on page one (light engine).

Lens Multiplier	
LW	1.00
MI	1.01
NB	1.20
A2	1.23
A5	1.22
BW	1.16

Light Engine Multiplier		
Engine	Lumens	Watts
1A35	1.00	1.00
1A30	0.88	0.86
1A25	0.74	0.71
1A20	0.60	0.58

Lens and light engine multiplier supplied for per foot values listed on page one (light engine).

LED

lighting facts®  
A Program of the U.S. DOE

Selux Corporation

Light Output (Lumens)	2803
Watts	35.95
Lumens per Watt (Efficacy)	77.8

Color Accuracy

Color Rendering Index (CRI)

83

Light Color

Correlated Color Temperature (CCT)

3982 (Bright White)

Warm White

Bright White

Daylight

2700K

3000K

4500K

6500K

Warranty\*\*

Yes

All results, except LED Lumen Maintenance, are according to IESNA LM-79-2008: Approved Method for the Electrical and Photometric Testing of Solid-State Lighting. The U.S. Department of Energy (DOE) verifies product test data and results.

\*\* See [www.lightingfacts.com/products](http://www.lightingfacts.com/products) for details.

Registration Number: WVZA-7B2GK1 (4/29/2015)  
Model Number: L36-1A35-40-LW-X-04-XX-120  
Type: Luminaire - Linear

TL1



# Levity<sup>TM</sup>

SHINING A NEW LIGHT ON INNOVATION

**MOCKETT**  
DOUG MOCKETT & COMPANY, INC  
[www.mockett.com](http://www.mockett.com)



TL1



## Levity™ Delivers

- 6 LEDs per Levity
- Efficacy: 88.59 lumens/watt
- Rated Life: 35,000 hours of use
- Output: Up to 660 lumens (approx. 110 lumens/LED)
- Color Temperature: 3,500 Kelvin



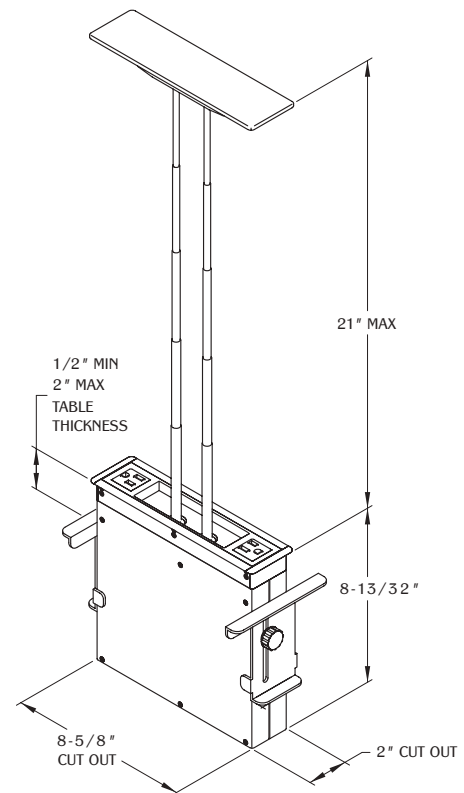
9" height for focused light on specific task need.



Lift up, opens to 4 1/2", lights come on.



Push down to close – closed it is just 8 29/32" long by 2 7/16" wide by 1/2" projection.



### Power Supply: Phillips Advance Xitanium LED-120A-0350C-33-F

- Voltage Output: 2.8 - 33.0 V
- Current Output: 0.350 A
- Rated Power Output: 12.0 Watts
- Voltage Input: 115-120 Volts
- Current Input: 0.13 A
- Power Consumption: 15.0 W



TL1



## Spill-Proof Technology

The Levity features a newly engineered and patented spill-proof outlet – a design that delivers a groundbreaking, ETL-listed solution parallel to any work surface.



A whole new 21<sup>st</sup> Century approach to task lighting, combining flexible, directed lighting with power options.

A slim, low line, fully modern design at just 8 <sup>29</sup>/<sub>32</sub> " long by 2 <sup>7</sup>/<sub>16</sub> " wide, Levity retracts almost completely flush into your table, desk or work surface. Simply pull cap and it then rises automatically to 4 <sup>1</sup>/<sub>2</sub> " and turns on its LED lights. Levity can then be adjusted to its full height of 21 " or positioned anywhere in between – wherever light is needed. Move Levity to wherever you need the light – right, left, front, back,

45° over there or 45° over here. Wherever you need focused, directed light, Levity can go with 360° of control.

Simply push down to stow lamp; LED lights automatically go off.

Using modern LED technology, Levity consumes far less electricity while having an equally bright output. Also, with a rated life of 35,000 hours of use per LED, that translates to roughly 17 years of usage. A unique design for the ages.

TL1



## Levity™ is –

- **Convenient:** The only task lamp that retracts into workspace.
- **Flexible:** Great for use in desks, tables, and smaller work surfaces.
- **Adjustable:** Supplies light and power where needed.
- **Safe:** ETL listed and incorporates power outlets with patented spill-proof technology.



ETL listed and tested to meet UL153.

# MOCKETT

DOUG MOCKETT & COMPANY, INC

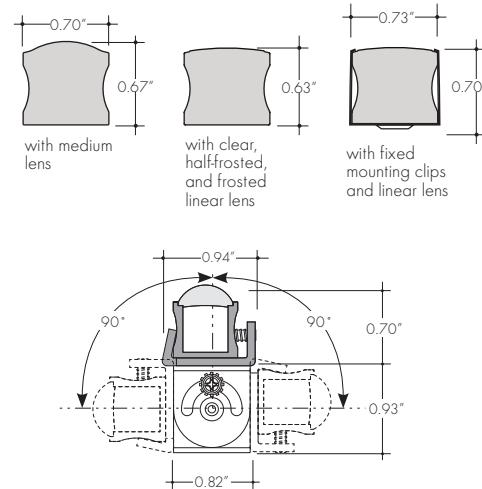
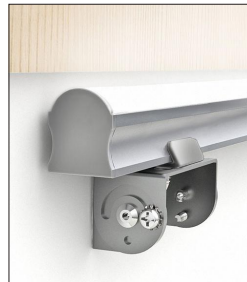
Doug Mockett & Company, Inc., the industry leader in distribution of the highest quality and most advanced design components for office and computer furniture.

[www.mockett.com](http://www.mockett.com) • 800.523.1269 • 310.318.2491

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Levity is covered under the following US Patents, with others applied for: 5,351,173, 7,244,128B2, 6,028,267.  
Levity is a proud collaboration among Peter Stathis, Byrne Electrical Specialists and Doug Mockett & Company, Inc.

Extruded aluminum linear illumination system, Kendo M features specifically designed LED engine that provides constant illumination levels from the beginning to the end of the runs. Kendo M is suitable for cove lighting, architectural accents, under or above cabinets, display cases and many other applications. Available in sections up to 116" long with the option to extend up to 240" long with Kendo M Seamless runs in high output only (view last page). Class 2 listed for damp location installations. Approved for closet/storage space installation per NEC 410.16(A)(3) and 410.16(C)(5).



Adjustable mounting bracket allows 90° tilt in both directions.



**TYPE IC**



**dimable**

## Finish options



Black powder coated



Bronze powder coated



Silver anodized



White powder coated

## Technical information

Output type	Output Options			
	SO (LL36)	MO (LLX18)	HO (LLX22)	VHO (LL72)
Lumens at 3000K (Clear lens)	118 lum/ft	189 lum/ft	311 lum/ft	349 lum/ft
Average power consumption at 4'	3.2 W/ft	4.8 W/ft	5.4 W/ft	6.5 W/ft
Maximum system length	35'	25'	23'	18'
Operating Voltage	24VDC	24VDC	24VDC	24VDC

### CCT/LUMEN MULTIPLIER

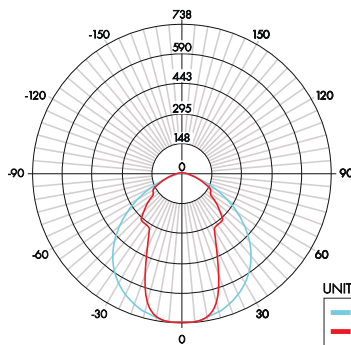
Color temperature	Multiplier (Multiple Light Output of 3000K HO)	CRI
2200 K	0.83	70+
2700 K	0.81	98
2900 K	0.86	97
3000 K	1.00	91
3500 K	0.98	95
4100 K	1.06	93

## Ordering code

MODEL	LENGTH	CCT	OUTPUT	LENS	MOUNTING	FINISH	POWER FEED
KM	12	22K	SO	C	A	SA	F1
Kendo M	12"-116" 4" increments	22K - 2200 K 27K - 2700 K 29K - 2900 K 30K - 3000 K 35K - 3500 K 41K - 4100 K	SO - Standard MO - Medium HO - High VHO - VeryHigh	C - Clear HF - Half Frosted F - Frosted M - Medium SI - Satin Ice	A - Adjustable F - Fixed	SA - Silver BK - Black BZ - Bronze WH - White (BK,BZ,WH finishes will have an upcharge and require longer lead times)	F1 - 72" wire leads F2 - 72" wire leads at one end and quick connect at other F3 - Single quick connect F4 - Dual quick connect

Photometry

KM-48-30K-VHO-H-C-XX



Zonal Lumen Summary 3000K

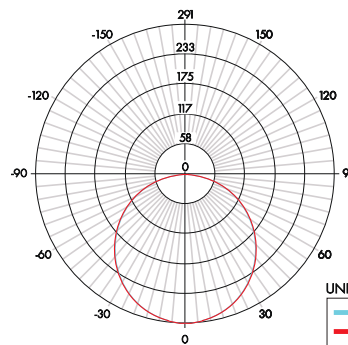
Zone	Lumen	% Fixture
0-30	496	36%
0-40	737	53%
0-60	1147	82%
0-90	1374	98%
0-180	1396	100%

Total

UNIT: CD

— C0/180  
— C90/270

KM-48-30K-VHO-H-F-XX



Zonal Lumen Summary 3000K

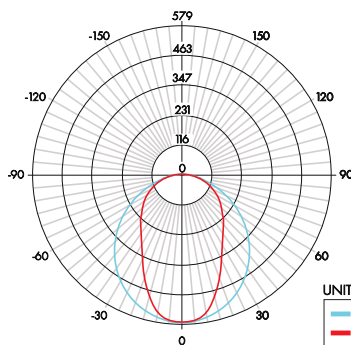
Zone	Lumen	% Fixture
0-30	226	26%
0-40	371	43%
0-60	657	78%
0-90	844	99%
0-180	856	100%

Total

UNIT: CD

— C0/180  
— C90/270

KM-48-30K-VHO-H-HF-XX



Zonal Lumen Summary 3000K

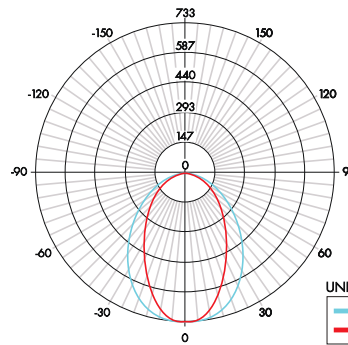
Zone	Lumen	% Fixture
0-30	402	33%
0-40	614	50%
0-60	988	80%
0-90	1211	98%
0-180	1232	100%

Total

UNIT: CD

— C0/180  
— C90/270

KM-48-30K-VHO-H-M-XX



Zonal Lumen Summary 3000K

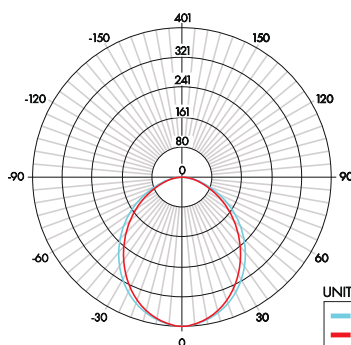
Zone	Lumen	% Fixture
0-30	484	36%
0-40	726	54%
0-60	1107	82%
0-90	1319	98%
0-180	1352	100%

Total

UNIT: CD

— C0/180  
— C90/270

KM-48-30K-VHO-H-SI-XX



Zonal Lumen Summary 3000K

Zone	Lumen	% Fixture
0-30	296	29%
0-40	470	47%
0-60	789	78%
0-90	991	98%
0-180	1007	100%

Total

UNIT: CD

— C0/180  
— C90/270

CCT/LUMEN MULTIPLIER

Color temperature	Multiplier (Multiple Light Output of 3000K )	CRI
2200 K	0.83	70+
2700 K	0.81	98
2900 K	0.86	97
3000 K	1.00	91
3500 K	0.98	95
4100 K	1.06	93

## Power consumption per fixture length

Based on operation with PSD series of power supplies.

		SO		MO		HO		VHO			
Nominal length	Actual length	W/ft	Total wattage	W/ft	Total wattage	Actual length	W/ft	Total wattage	Actual length	W/ft	Total wattage
12"	13-2/16"	3.25	3.25	5.00	5.00	13-4/16"	5.60	5.60	12-15/16"	6.75	6.75
16"	17"	3.25	4.00	5.00	7.00	17-2/16"	5.60	7.50	16-15/16"	6.75	9.00
20"	20-14/16"	3.25	5.25	4.95	8.50	20-13/16"	5.60	9.30	20-13/16"	6.75	11.25
24"	24-14/16"	3.25	6.50	4.95	9.90	24-2/16"	5.55	11.10	24-12/16"	6.75	13.50
28"	28-12/16"	3.25	7.75	4.95	11.00	28-8/16"	5.55	13.50	28-11/16"	6.75	16.75
32"	32-11/16"	3.25	8.50	4.90	13.25	32-14/16"	5.55	15.00	32-10/16"	6.75	19.00
36"	36-10/16"	3.25	9.75	4.90	14.70	36-3/16"	5.50	16.50	36-10/16"	6.65	19.95
40"	40-9/16"	3.25	10.25	4.90	16.00	40-8/16"	5.50	18.00	40-8/16"	6.65	22.20
44"	44-8/16"	3.20	11.75	4.85	17.50	44-14/16"	5.50	19.80	44-7/16"	6.65	24.40
48"	48-7/16"	3.20	12.80	4.85	19.40	48-3/16"	5.45	21.80	48-6/16"	6.55	26.20
52"	52-6/16"	3.20	13.30	4.85	21.00	52-9/16"	5.45	23.00	52-5/16"	6.55	28.50
56"	56-5/16"	3.20	14.80	4.80	22.50	56-3/16"	5.45	25.50	56-4/16"	6.55	30.50
60"	60-4/16"	3.20	16.00	4.80	24.00	60-3/16"	5.40	27.00	61-3/16"	6.45	32.25
64"	64-3/16"	3.20	17.00	4.80	25.50	64-9/16"	5.40	28.50	64-7/16"	6.45	34.40
68"	68-2/16"	3.15	18.00	4.75	27.00	68-15/16"	5.40	30.00	68-1/16"	6.45	36.55
72"	72-1/16"	3.15	18.90	4.75	28.50	72-4/16"	5.35	32.10	73"	6.40	38.40
76"	76"	3.15	19.00	4.75	30.00	76-10/16"	5.35	33.90	76-15/16"	6.40	40.50
80"	79-15/16"	3.15	21.50	4.70	31.50	80-15/16"	5.35	35.00	80-13/16"	6.40	43.00
84"	83-14/16"	3.15	22.05	4.70	32.90	84-4/16"	5.25	36.70	84-12/16"	6.25	43.75
88"	87-13/16"	3.15	23.00	4.70	34.00	88-10/16"	5.25	38.20	88-11/16"	6.25	46.00
92"	91-12/16"	3.10	24.00	4.65	35.50	92-15/16"	5.25	39.60	92-10/16"	6.25	48.00
96"	95-12/16"	3.10	24.80	4.65	37.20	96-4/16"	5.20	41.60	96-10/16"	6.15	49.20
100"	99-10/16"	3.10	26.30	4.65	39.00	100-9/16"	5.20	43.20	100-9/16"	6.15	51.25
104"	103-8/16"	3.05	27.10	4.60	40.20	104-15/16"	5.20	44.00	103-8/16"	6.15	53.00
108"	107-7/16"	3.05	28.00	4.60	41.40	108-4/16"	5.10	45.90	108-7/16"	6.00	54.00
112"	111-7/16"	3.05	28.50	4.60	43.00	112-10/16"	5.10	47.00	112-6/16"	6.00	56.00
116"	115-6/16"	3.05	30.00	4.55	44.20	116-11/16"	5.10	48.50	116-5/16"	6.00	58.00

actual length of assembled fixture

## Power supply

See fixture and power supply instructions &amp; spec sheet for wiring information. Dimming possible in select models - view luminii website for list of compatible dimmers.

MODEL	POWER	OUTPUT	DIMMING	LOCATION
<b>PSV</b>	<b>40</b>	<b>24V</b>	<b>U2DIM</b>	<b>D</b>
PSV - PSV Series	40 - 40 W 60 - 60 W 96 - 96 W	24 - 24 VDC	U2DIM - Dimming 1-10V U2ND - Non Dimming	D - Dry Location IP65 - Wet Location

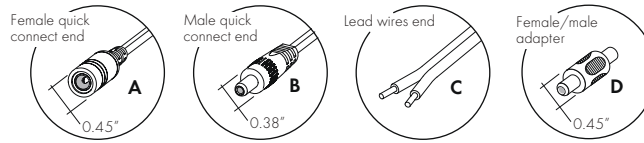
MODEL	POWER	OUTPUT	INPUT
<b>PSD</b>	<b>48</b>	<b>24</b>	
PSD - PSD Series	48 - 48 W 96 - 96 W 288 - 288 W (3x 96W)	24 - 24 VDC	Blank - 120 V 240 - 240 V 277 - 277 V

MODEL
<b>LTEA4U1UKL-CV240</b>
Lutron - Hi-lume™ 1% 2-wire LED driver (120V forward phase only)

MODEL
<b>L3DA4U1UKL-CV240</b>
Hi-lume™ 1% EcoSystem Voltage LED Driver

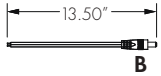
MODEL
<b>L3D0-96W24V-U</b>
Hi-lume™ 0.1% EcoSystem Voltage LED Driver with Soft-On, Fade-to-Black™

## Connectors

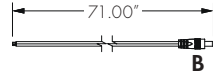


### Linking and extension cable options

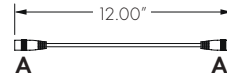
Male quick-connect  
Part # LMC



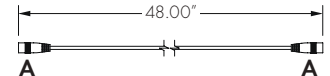
Male quick-connect long  
Part # LMC-70



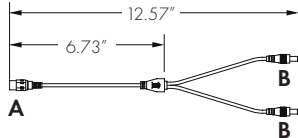
12" extension cable  
Part # EC-12



48" extension cable  
Part # EC-48



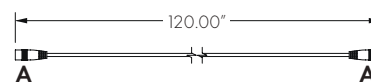
Y-splitter  
Part # LYC



Female/male adaptor  
Part # FMA

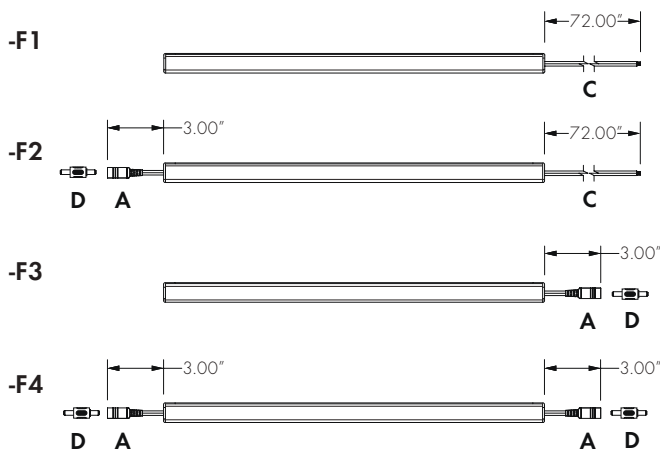


120" extension cable  
Part # EC-120



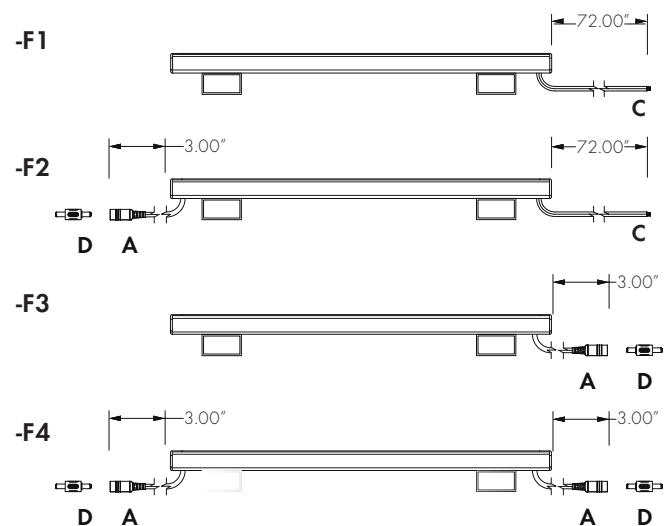
### Powerfeed options

#### Powerfeed options with fixed bracket

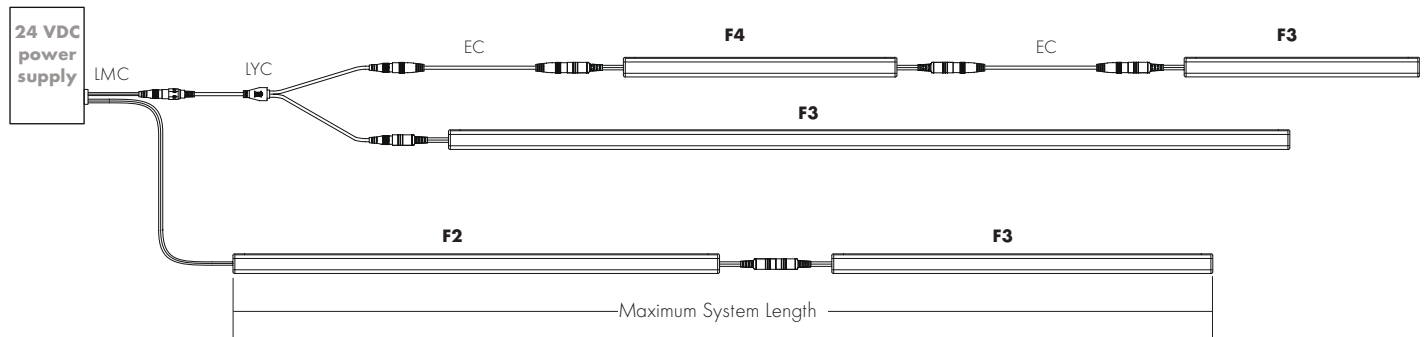


-F3 and -F4 powerfeed options require #LMC to connect to PSD series of power supplies.

#### Powerfeed options with adjustable bracket



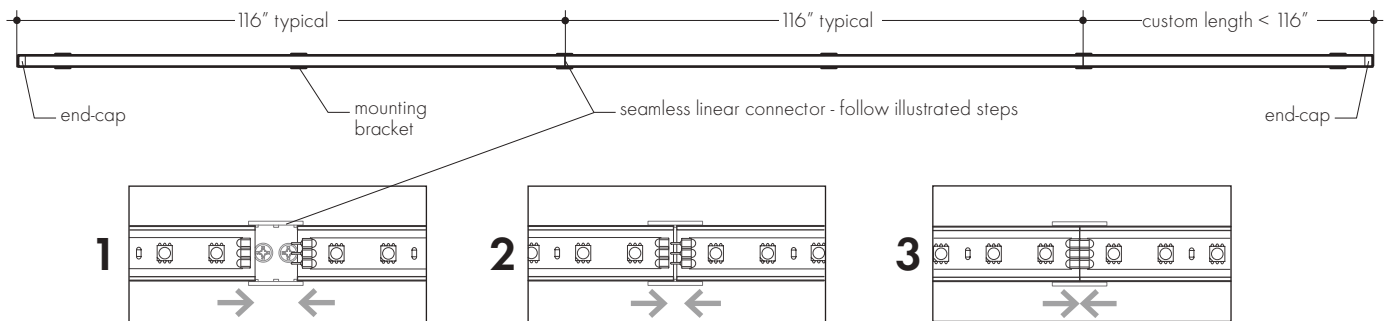
### Sample layout of powerfeed connections





## Kendo M Seamless runs

Available only for high output (HO) fixtures.



## Kendo M seamless run power consumption

Length		HO	
Nominal	Actual	W/ft	Total wattage
116"	116-11/16"	5.10	48.50
120"	120-4/16"	5.00	50.00
124"	124-10/16"	5.00	51.50
128"	128-12/16"	5.00	53.60
132"	132-10/16"	4.95	54.45
136"	136-5/16"	4.95	56.00
140"	139-10/16"	4.95	57.50
144"	144"	4.85	58.20
148"	148-6/16"	4.85	60.00
152"	151-11/16"	4.85	61.10
156"	156"	4.80	62.40
160"	160-6/16"	4.80	63.20
164"	163-11/16"	4.80	64.40
168"	168-1/16"	4.70	65.80
172"	171-11/16"	4.70	67.00
176"	175-11/16"	4.70	68.00

Length		HO	
Nominal	Actual	W/ft	Total wattage
180"	180-1/16"	4.60	69.00
184"	184-7/16"	4.60	70.00
188"	187-12/16"	4.60	71.00
192"	192-2/16"	4.50	72.00
196"	196-7/16"	4.50	73.20
200"	199-12/16"	4.50	74.40
204"	204-2/16"	4.45	75.65
208"	208-7/16"	4.45	77.00
212"	211-12/16"	4.45	78.10
216"	216-1/16"	4.40	79.20
220"	220-7/16"	4.40	80.50
224"	223-12/16"	4.40	81.60
228"	228-2/16"	4.35	82.65
232"	232-3/16"	4.35	84.00
236"	235-12/16"	4.35	85.00
240"	240-12/16"	4.30	86.00

## Ordering code

MODEL	LENGTH	CCT	OUTPUT	OPTIC	MOUNTING	FINISH	POWER FEED
KMS	120	22	HO	C	A	SA	F1
KMS - Kendo M Seamless	120"-240" 4" increments	22K - 2200 K 27K - 2700 K 29K - 2900 K 30K - 3000 K 35K - 3500 K 41K - 4100 K	HO - High	C - Clear F - Frosted M - Medium	A - Adjustable F - Fixed	SA - Silver BK - Black BZ - Bronze WH - White <small>(BK,BZ,WH finishes will have an upcharge and require longer lead times)</small>	F1 - 72" wire leads F3 - Single quick connect



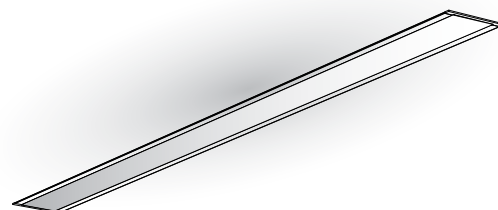
Client \_\_\_\_\_ Project name \_\_\_\_\_

Order# \_\_\_\_\_ Type \_\_\_\_\_ Qty \_\_\_\_\_

## FEATURES AND BENEFITS

### Physical :

- Aluminum extrusion housing, 2" wide
- Available in 1', 2', 3', 4', 5', 6', 7' or 8' sections
- Continuous runs available in 1' increments
- Durable polyester powder coat finish for trim
- Flange, flangeless and spackle flange trim options available
- Easy installation
- Extruded acrylic lens
- Illuminated corners available for custom configurations, consult factory for availability and orders
- Tool-less system for reflector assembly and control gear access
- Suitable for use with drywall ceiling and metal pan ceilings (millwork ceilings)
- Compatible with motion sensors
- CCEA option available
- Dry location only



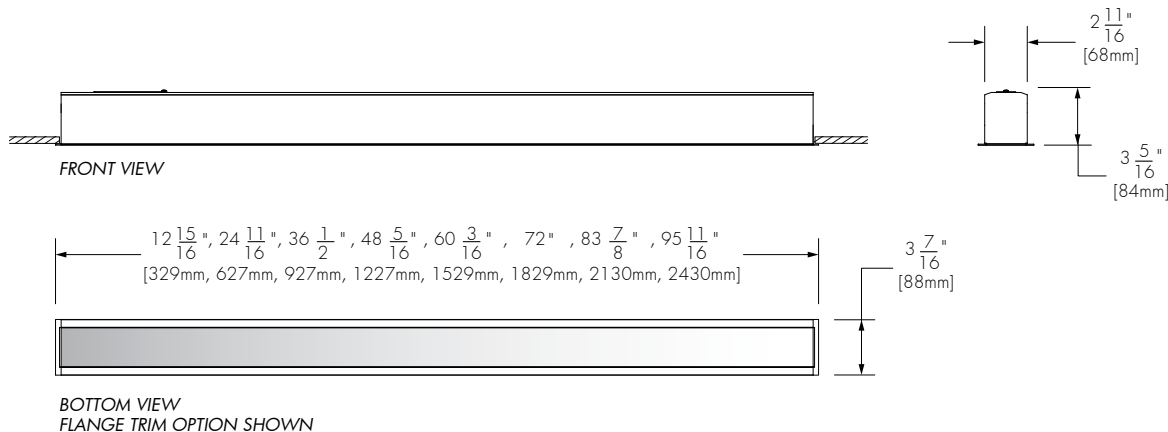
### Performance :

- Available in 2700K, 3000K, 3500K, 4000K or RGB color mixing
- 87 lumens per watt (delivered, RO 4000K)
- CRI value: 80+
- Binning within a 3 step MacAdam ellipse
- Lumen maintenance: 100,000 hrs [L70 @ 25° C]
- Lumen measurements comply with LM - 79 - 08 standard
- Resolution per foot or per fixture (configured with LumenID V3 software & RDM)
- Operating temperatures: -25° C to 50° C [-13F to 122F]

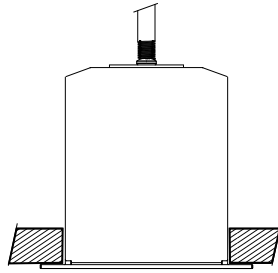
Lumens / 4ft	RO	HO
<b>2700K</b>	1831	3466
<b>3000K</b>	1871	3541
<b>3500K</b>	1910	3615
<b>4000K</b>	1969	3727
<b>RGB</b>	407	N/A

### Electrical :

- Line voltage luminaire for 100 to 277V
- 6W/ft Regular Output version
- 12W/ft High Output version
- Dimming options for white light: 0-10 volt, DMX/RDM enabled, DALI, Lumentalk or Lutron® EcoSystem® enabled
- 6W/ft optional RGB source, DMX/RDM enabled
- Quick connectors for continuous runs

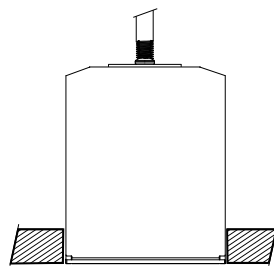


## TRIM OPTION



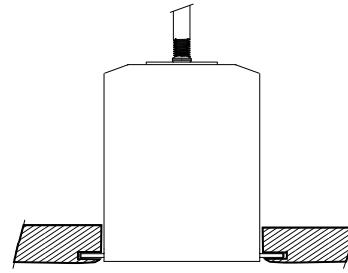
**FG**

Flange trim option



**FGL**

Flangeless trim option

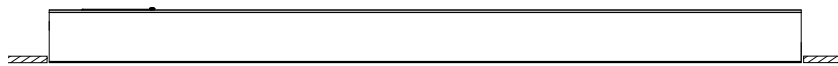


**SFG**

Spackle Flange trim option

## TRIM OPTION DIMENSIONS

Flangeless and Spackle flange trim options



FRONT VIEW

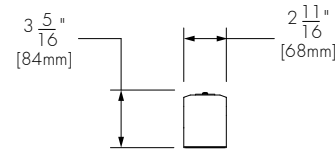
12  $\frac{1}{16}$ " , 23  $\frac{13}{16}$ " , 35  $\frac{5}{8}$ " , 47  $\frac{7}{16}$ " , 59  $\frac{5}{16}$ " , 71  $\frac{1}{8}$ " , 83" , 94  $\frac{13}{16}$ "  
[306mm, 605mm, 905mm, 1205mm, 1507mm, 1807mm, 2108mm, 2408mm]



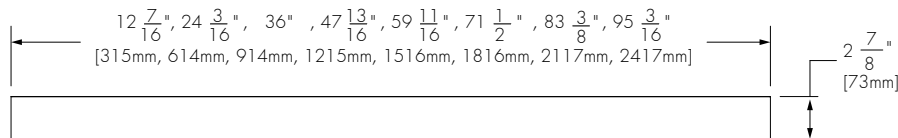
BOTTOM VIEW

FLANGELESS TRIM OPTION SHOWN

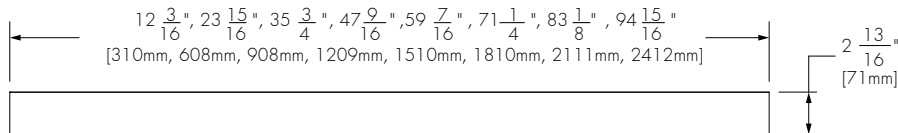
(USE SAME DIMENSIONS FOR SPACKLE FLANGE HOUSING)



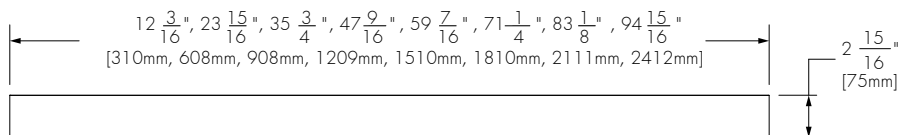
## CEILING OR WALL CUTOUT DIMENSIONS



FLANGE CEILING OR WALL CUTOUT DIMENSIONS

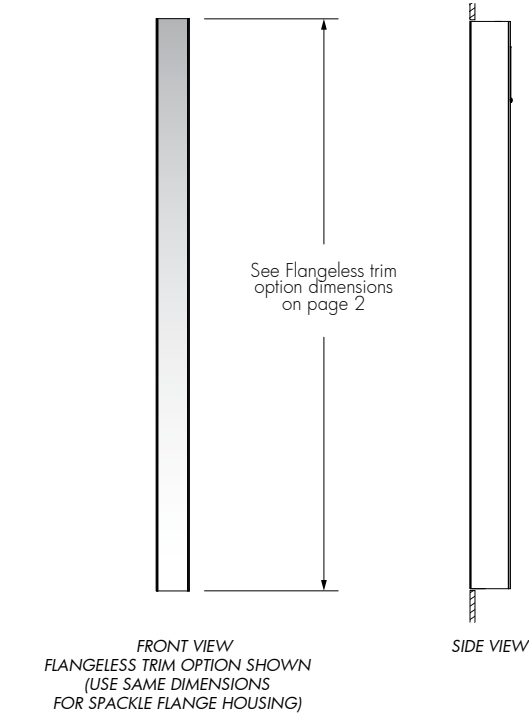
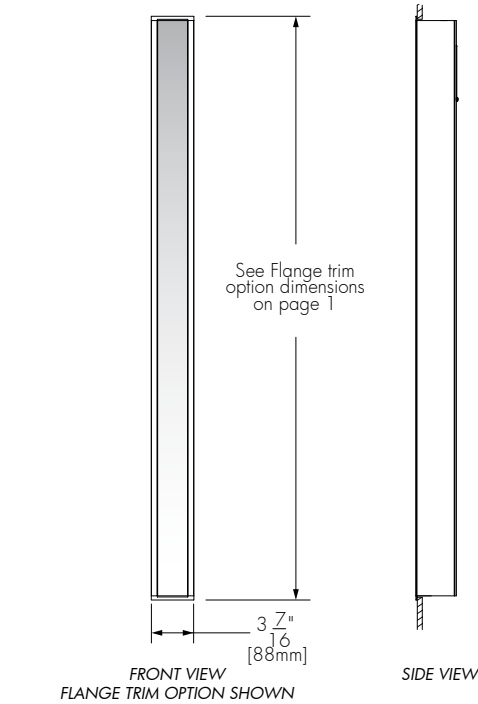


FLANGELESS CEILING OR WALL CUTOUT DIMENSIONS



SPACKLE FLANGE CEILING OR WALL CUTOUT DIMENSIONS

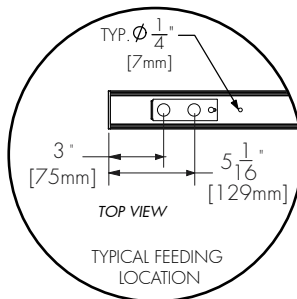
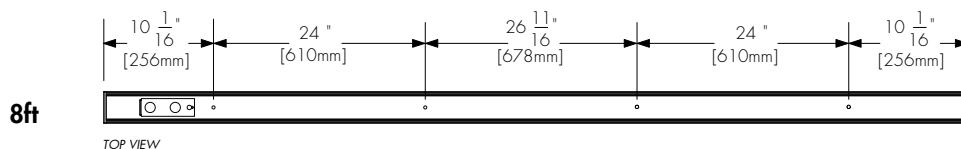
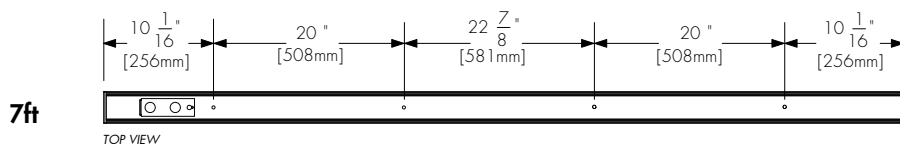
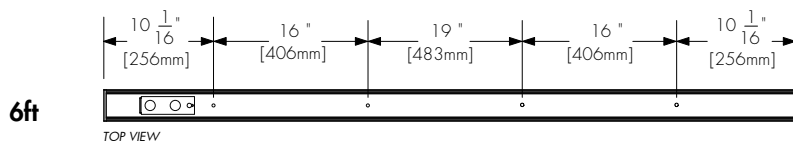
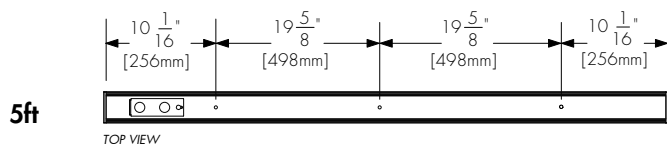
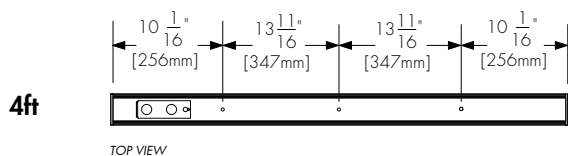
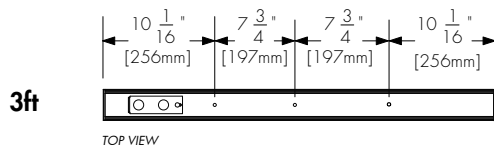
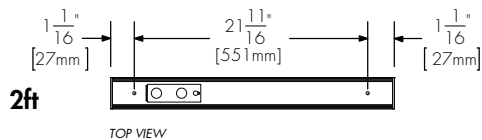
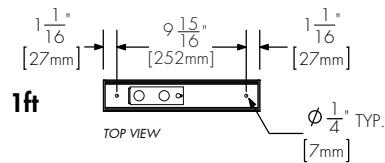
## VERTICAL RECESSED MOUNTING OPTION



# Specification Sheet

## THREADED ROD MOUNTING HOLE PATTERN

Flangeless trim option shown

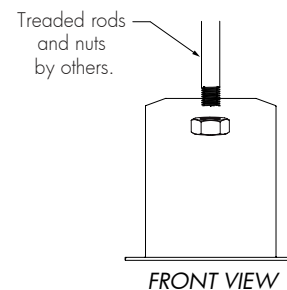
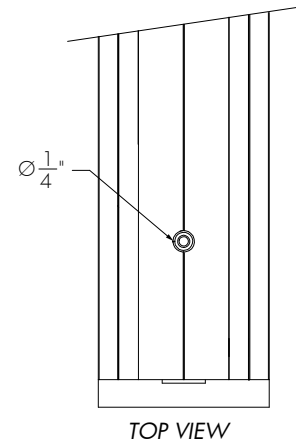


**lumenline™ 2**  
**LL1**

RECESSED  
SINGLE UNITS  
CONTINUOUS RUNS  
SHAPES

## THREADED ROD MOUNTING DETAIL

Flangeless, spackle flange and flangeless trim options

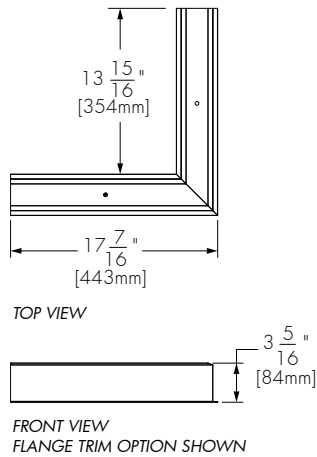


## LIT JOINER TYPES AND DIMENSIONS

Refer to the SHAPE ordering page

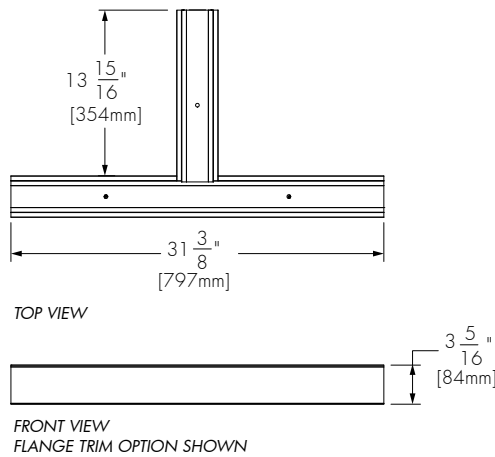
### HCNR

Horizontal 90°  
Used to build square,  
rectangle and "L" shapes  
(Equivalent of a 4' fixture)



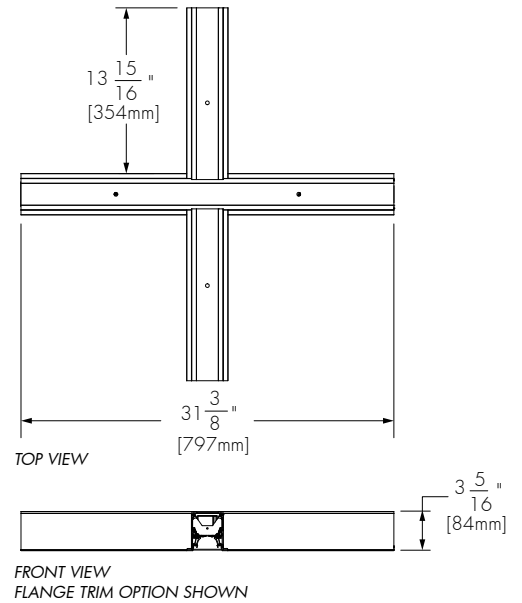
### TCNR

Tee 90°  
(Equivalent of a 6' fixture)



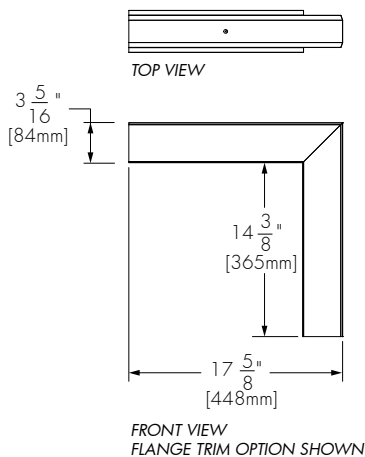
### CCNR

Cross 90°  
(Equivalent of an 8' fixture)



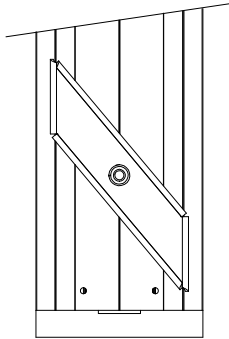
### ICNR

Inside 90°  
For Ceiling to Wall  
Configurations  
(Equivalent of a 4' fixture)

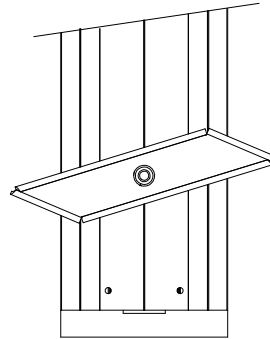


## ROTATING CROSSBAR MOUNTING OPTION

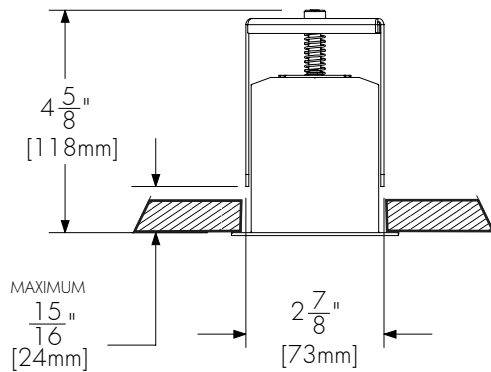
Available with Flange trim option only



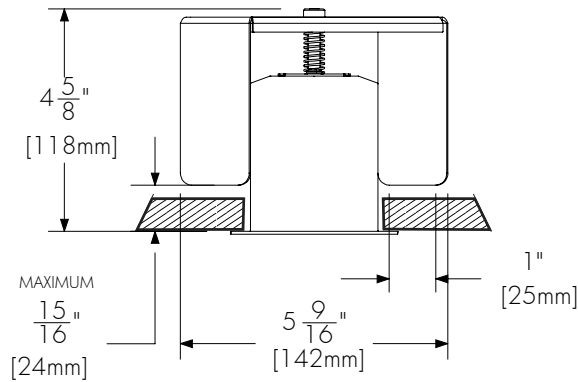
TOP VIEW  
ROTATING CROSSBAR CLOSED



TOP VIEW  
ROTATING CROSSBAR OPENED



SIDE VIEW  
ROTATING CROSSBAR CLOSED



SIDE VIEW  
ROTATING CROSSBAR OPENED

## ACCESSORIES

Order separately

### Control Systems:

- LTO2** Lumentouch is a wall mount DMX 512 controller keypad.
- LCU** Lumencue is a USB / mini SD DMX 512 controller.
- LID** LumenID is a diagnostic and addressing DMX 512 controller.  
It must be specified on all DMX applications.  
Refer to LID specification sheet for details.
- LTN** Lumentone is a simple pre-programmed DMX 512 controller  
with a push button rotary dial and live feedback.

### Control Boxes:

- CBX** DMX/RDM control box.  
Up to six power and data outputs to fixtures or fixture runs.  
Ethernet enabled option.  
Refer to CBX specification sheet for details.



## RESOLUTION DETAILS

Applicable for DMX/RDM control option only.

Fixture resolution can be configured on-site within the LumenID V3 software.

A DMX/RDM enabled CBX is required.

Resolution per foot: each foot is addressed independently

Total number of DMX addresses required per fixture	Single units								
		1ft	2ft	3ft	4ft	5ft	6ft	7ft	8ft
	WH	1	2	3	4	5	6	7	8
	RGB	3	6	9	12	15	18	21	24

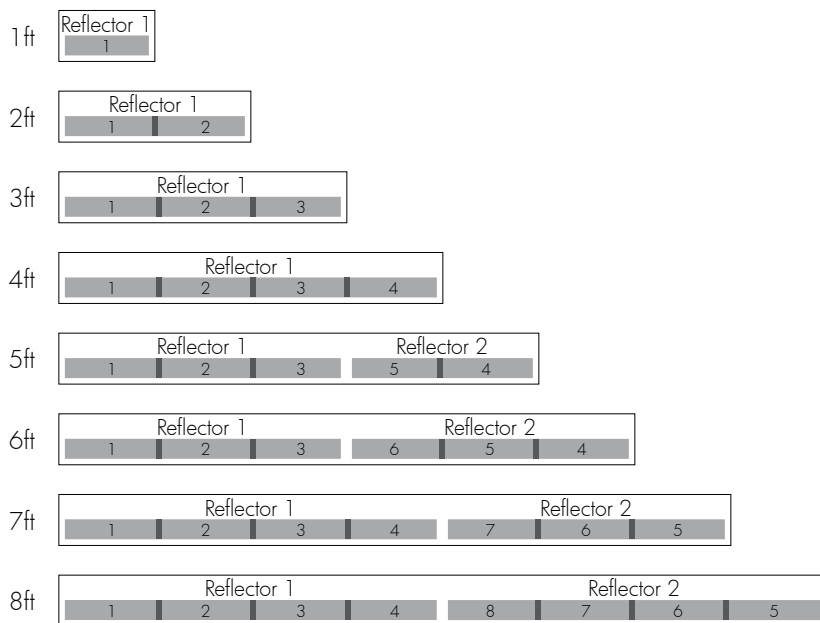
Lit joiners			
HCNR	TCNR	CCNR	ICNR
4	6	8	4
12	18	24	12

Resolution per fixture: each reflector is addressed independently

Total number of DMX addresses required per fixture	Single units		Lit joiners				
		1ft to 4ft	5ft to 8ft	HCNR	TCNR	CCNR	ICNR
	WH	1	2	1	2	2	1
	RGB	3	6	3	3	3	3

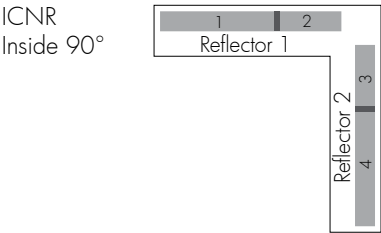
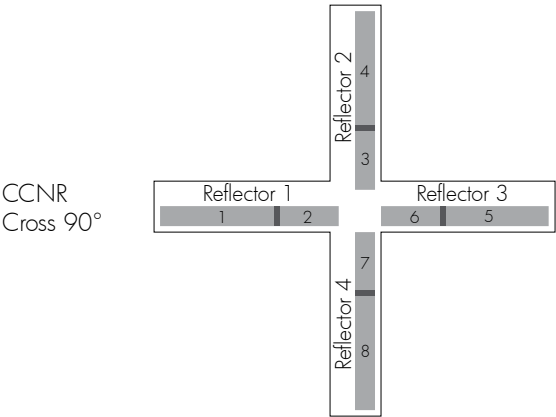
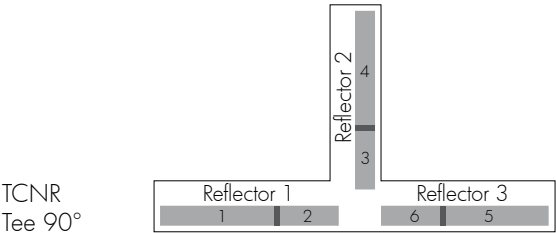
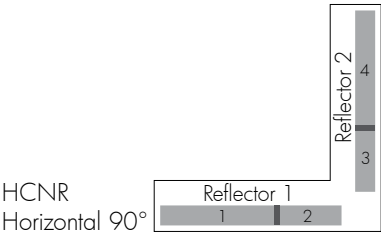
Board and reflector layout per fixture length

### SINGLE UNITS

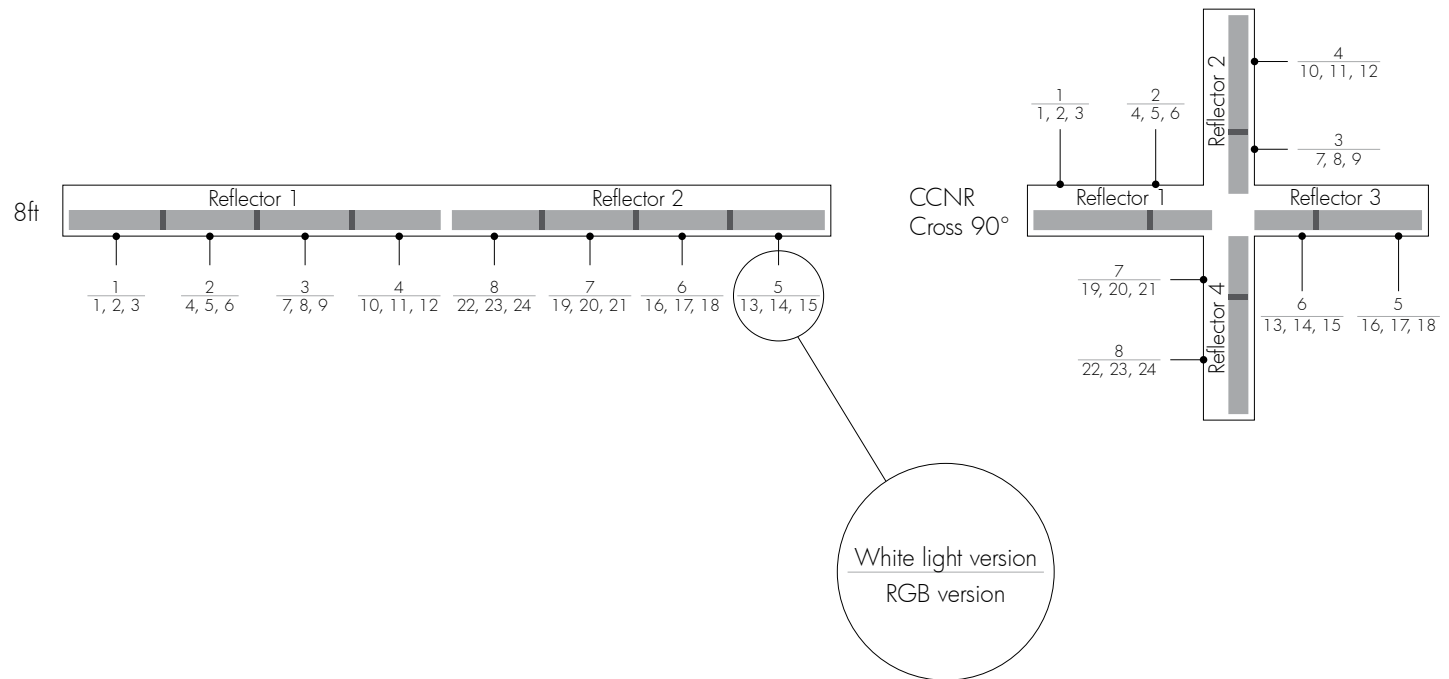


RESOLUTION DETAILS - continued

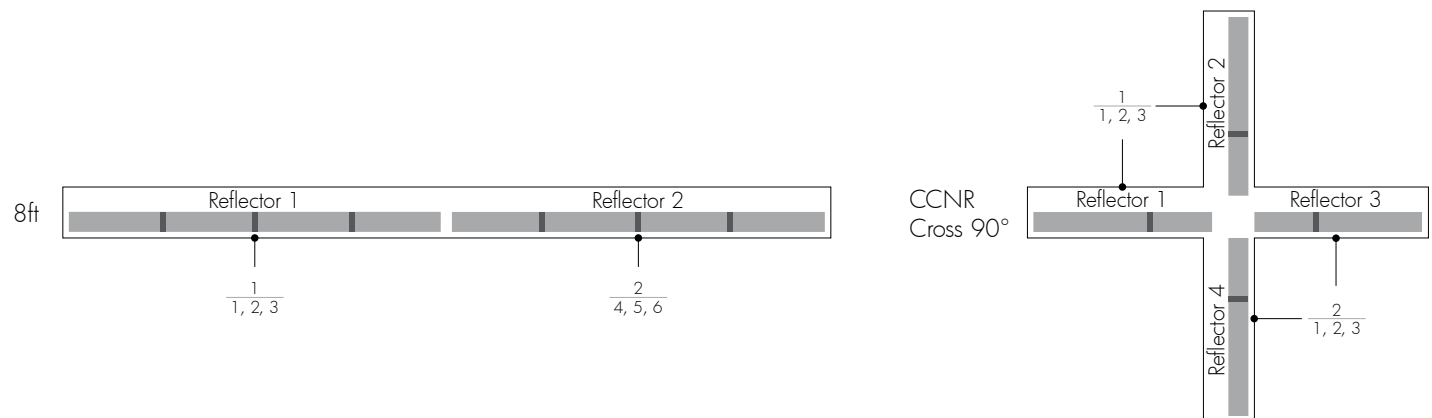
LIT JOINERS IN SHAPES



Example: DMX addresses, resolution per foot, 8ft fixture and CCNR lit joiner



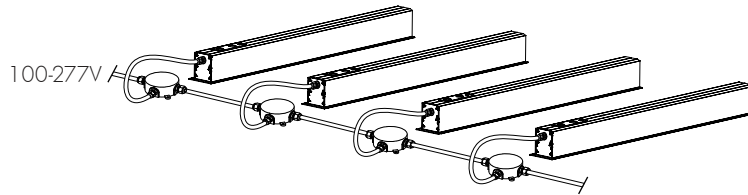
Example: DMX addresses, resolution per fixture, 8ft fixture and CCNR lit joiner



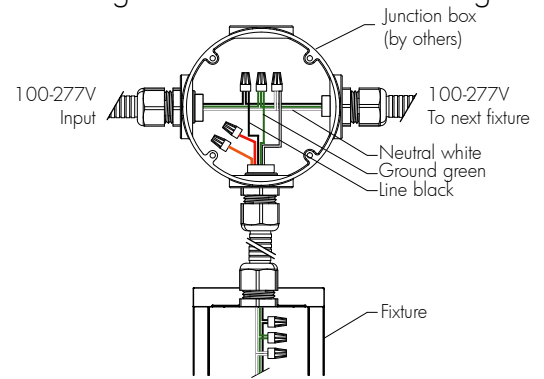
## TYPICAL WIRING DIAGRAMS

### Non-dimming or Lumentalk control options

Single units, daisy chain configuration  
Flange option shown

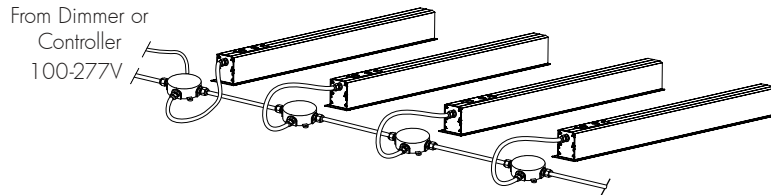


### Non-dimming or Lumentalk control wiring detail



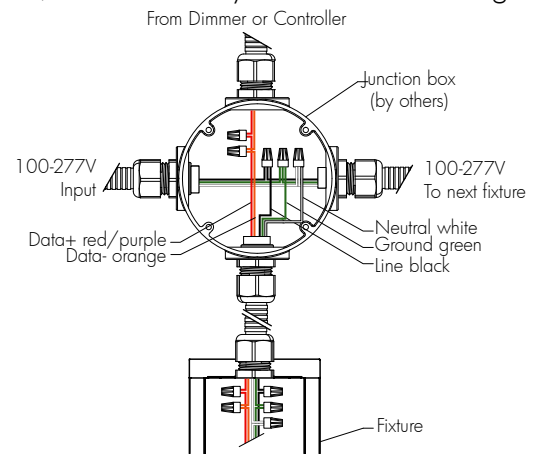
### 0-10V, DALI or EcoSystem® control options

Single units, daisy chain configuration  
Flange option shown



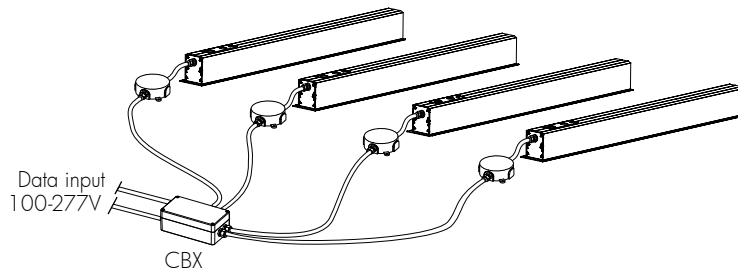
Each Lutron® EcoSystem® enabled fixture has its own address; for the example shown above, there are a total of 4 EcoSystem® addresses.

### 0/10V, DALI or EcoSystem® control wiring detail



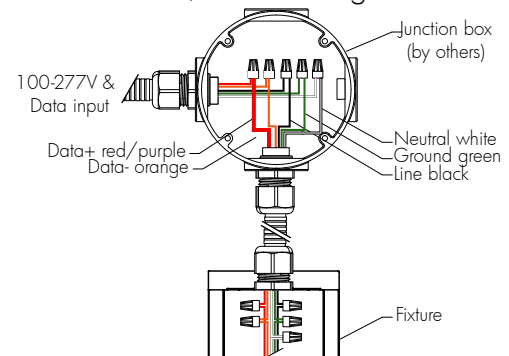
### DMX/RDM control option

Single units, star layout chain configuration  
Flange option shown



For stable DMX/RDM data signal, do not split data wires after CBX.

### DMX/RDM wiring detail



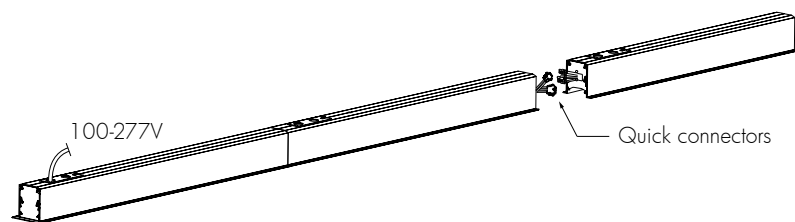
Maximum run lengths 7A maximum with 10ft fixture cord						
Configuration/Voltage	100V	120V	208V	220V	240V	277V
<b>RO: Regular Output</b>	93ft	116ft	126ft	126ft	126ft	126ft
<b>HO: High Output</b>	46ft	56ft	98ft	104ft	116ft	126ft

\*Maximum run length calculations are typically based on 4ft fixtures.  
Consult factory for specific applications.

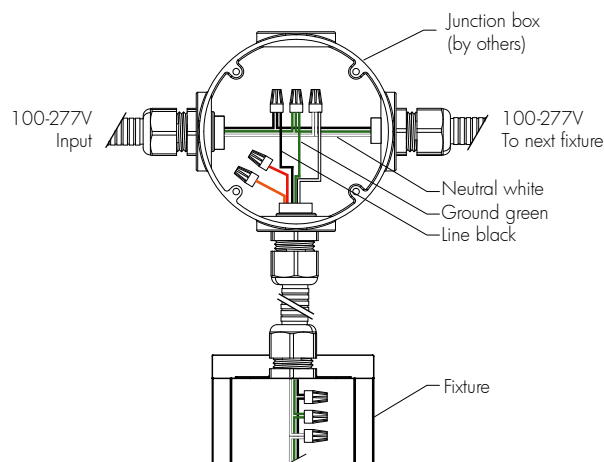
### Wiring detail

WIRE COLOR / USE	
GREEN	GROUND
WHITE	NEUTRAL
BLACK	LINE 100-277V
RED/ PURPLE	DATA +
ORANGE	DATA -

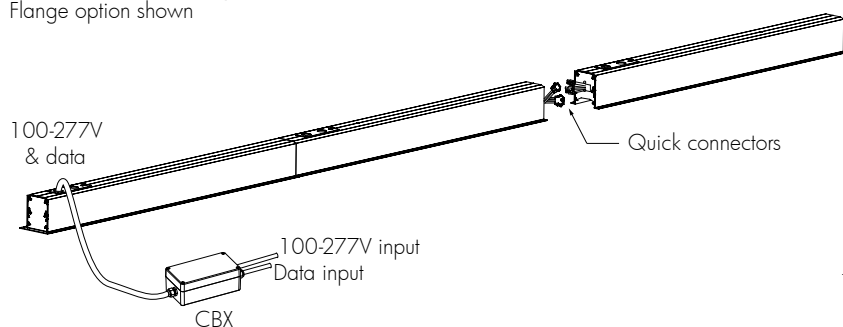
### Non-dimming or Lumentalk control options Continuous run, single feed Flange option shown



### Non-dimming or Lumentalk control wiring detail

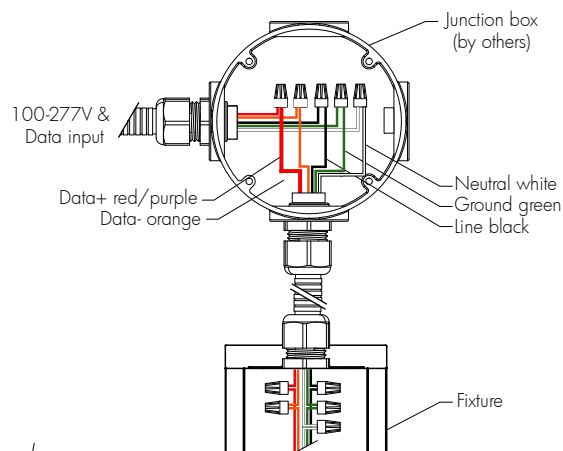


### DMX/RDM control option Continuous run, single feed Flange option shown

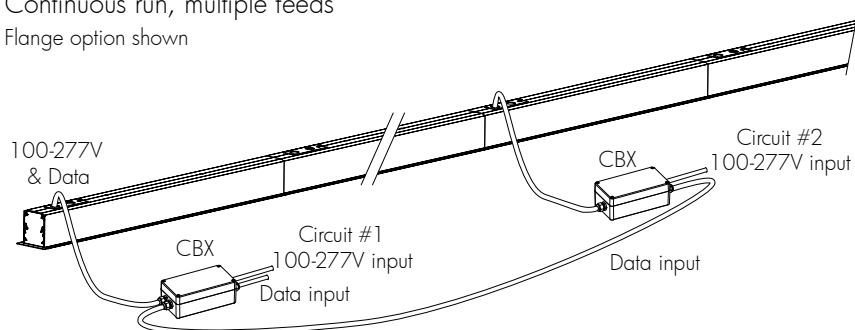


For stable DMX/RDM data signal, do not split data wires after CBX.

### DMX/RDM wiring detail

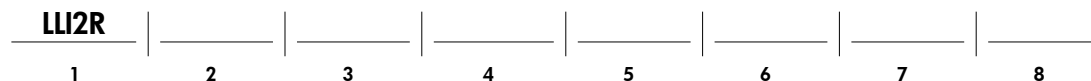


### DMX/RDM control option Continuous run, multiple feeds Flange option shown



For stable DMX/RDM data signal, do not split data wires after CBX.

## HOW TO ORDER - SINGLE UNITS AND CONTINUOUS RUNS



### 1 | Housing:

**LLI2R** - Lumenline™ Recessed, 2" wide

### 2 | Voltage:

**100** - 100 volts      **220** - 220 volts  
**120** - 120 volts      **240** - 240 volts  
**208** - 208 volts      **277** - 277 volts

### 3 | Length:

**Dimension shown are for flangeless**  
**SU1** - Single Unit 12 1/16" (306mm)  
**SU2** - Single Unit 23 13/16" (605mm)  
**SU3** - Single Unit 35 5/8" (905mm)  
**SU4** - Single Unit 47 7/16" (1205mm)  
**SU5** - Single Unit 59 5/16" (1507mm)  
**SU6** - Single Unit 71 1/8" (1807mm)  
**SU7** - Single Unit 83" (2108mm)  
**SU8** - Single Unit 94 13/16" (2408mm)  
**C\_\_** - Continuous run, specify in 1' increments

### 4 | Output & Color temperature:

**dRO 27K** - 2700K regular output 6W/ft  
**dRO 30K** - 3000K regular output 6W/ft  
**dRO 35K** - 3500K regular output 6W/ft  
**dRO 40K** - 4000K regular output 6W/ft  
**dHO 27K** - 2700K high output 12W/ft  
**dHO 30K** - 3000K high output 12W/ft  
**dHO 35K** - 3500K high output 12W/ft  
**dHO 40K** - 4000K high output 12W/ft  
**dRO RGB** - Tri-color red, green and blue direct lighting 6W/ft<sup>1</sup>

### 5 | Control:

**NO** - On/Off control  
**LT** - Lumentalk<sup>2</sup>  
**DIM** - 0-10V Dimming option<sup>3</sup>  
**DMX/RDM** - DMX/RDM enabled<sup>4</sup>  
**DALI** - DALI Dimming option<sup>5</sup>  
**ES** - Lutron® EcoSystem® Enabled Dimming<sup>6</sup>

### 6 | Trim Option:

**FG** - Flange  
**FGL** - Flangeless  
**SFG** - Spackle Flange

### 7 | Trim Finish:

**WH** - White  
**SI** - Silver  
**CC** - Custom (please specify RAL color)

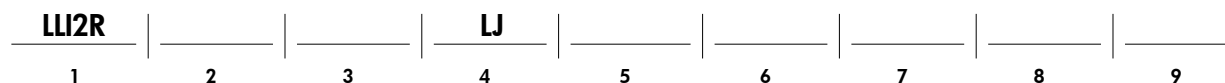
### 8 | Option:

**CCEA** - Chicago plenum rated option  
**RCB** - Rotating Crossbar mounting, available for flange trim option only<sup>7</sup>  
**VS** - Vertical recessed mounting

### Notes:

- <sup>1</sup> RGB option requires DMX/RDM control to be specified in Control section.
- <sup>2</sup> Available with white light only, not available for 1' lengths. 1% minimum dimming value.
- <sup>3</sup> 10% minimum dimming value.
- <sup>4</sup> 1% minimum dimming value. Fixtures come pre-addressed by fixture (consult the Resolution Details pages for the number of DMX addresses per fixture length and type).
- <sup>5</sup> 1% minimum dimming value.
- <sup>6</sup> Available with white light only, not available for 1' lengths. One EcoSystem® address per fixture length. 1% minimum dimming value.
- <sup>7</sup> 1 rotating crossbar included for 1' lengths,  
 2 rotating crossbars included for 2' to 5' lengths,  
 3 rotating crossbars included for 6' to 8' lengths.

## HOW TO ORDER - SHAPES



### 1 | Housing:

**LLI2R** - Lumenline™ Recessed, 2" wide

### 2 | Voltage:

<b>100</b> - 100 volts	<b>220</b> - 220 volts
<b>120</b> - 120 volts	<b>240</b> - 240 volts
<b>208</b> - 208 volts	<b>277</b> - 277 volts

### 3 | Length:

**IMPORTANT: Side length up to 20' as a standard. Consult factory for any other shape requirements.**

**S**\_\_ - Square shape: specify side length (equal sides)  
**R\_x**\_\_ - Rectangular shape: specify longer side x shorter side  
**L**\_\_ - "L" shape: specify side length (equal sides)  
**T**\_\_ - "T" shape: specify side length (equal sides)  
**X**\_\_ - Cross shape: specify side length (equal sides)  
**CW**\_ - Ceiling to wall: specify side length (equal sides)

### 4 | Joiner Type:

**LJ** - Lit joiner, 17 inches nominal side length module

### 5 | Output & Color temperature:

**dRO 27K** - 2700K regular output 6W/ft  
**dRO 30K** - 3000K regular output 6W/ft  
**dRO 35K** - 3500K regular output 6W/ft  
**dRO 40K** - 4000K regular output 6W/ft  
**dHO 27K** - 2700K high output 12W/ft  
**dHO 30K** - 3000K high output 12W/ft  
**dHO 35K** - 3500K high output 12W/ft  
**dHO 40K** - 4000K high output 12W/ft  
**dRO RGB** - Tri-color red, green and blue direct lighting 6W/ft<sup>1</sup>

### 6 | Control:

**NO** - On/Off control  
**LT** - Lumentalk<sup>2</sup>  
**DIM** - 0-10V Dimming option<sup>3</sup>  
**DMX/RDM** - DMX/RDM enabled<sup>4</sup>  
**DALI** - DALI Dimming option<sup>5</sup>  
**ES** - Lutron® EcoSystem® Enabled Dimming<sup>6</sup>

### 7 | Trim Option:

**FG** - Flange  
**FGL** - Flangeless  
**SFG** - Spackle Flange

### 8 | Trim Finish:

**WH** - White  
**SI** - Silver  
**CC** - Custom (please specify RAL color)

### 9 | Option:

**CCEA** - Chicago plenum rated option  
**RCB** - Rotating Crossbar mounting, available for flange trim option only<sup>7</sup>

### Notes:

- <sup>1</sup> RGB option requires DMX/RDM control to be specified in Control section.
- <sup>2</sup> Available with white light only, not available for 1' lengths. 1% minimum dimming value.
- <sup>3</sup> 10% minimum dimming value.
- <sup>4</sup> 1% minimum dimming value. Fixtures come pre-addressed by fixture (consult the Resolution Details pages for the number of DMX addresses per fixture length and type).
- <sup>5</sup> 1% minimum dimming value.
- <sup>6</sup> Available with white light only, not available for 1' lengths. One EcoSystem® address per fixture length. 1% minimum dimming value.
- <sup>7</sup> 1 rotating crossbar included for 1' lengths,  
 2 rotating crossbars included for 2' to 5' lengths,  
 3 rotating crossbars included for 6' to 8' lengths.



# id+ 2.5"

LED ADJUSTABLE ACCENT, DOWNLIGHT & WALL WASH

## DL1, AL1



clear diffuse  
reflector



matte black  
reflector



warm diffuse  
reflector



white trim



titanium silver trim

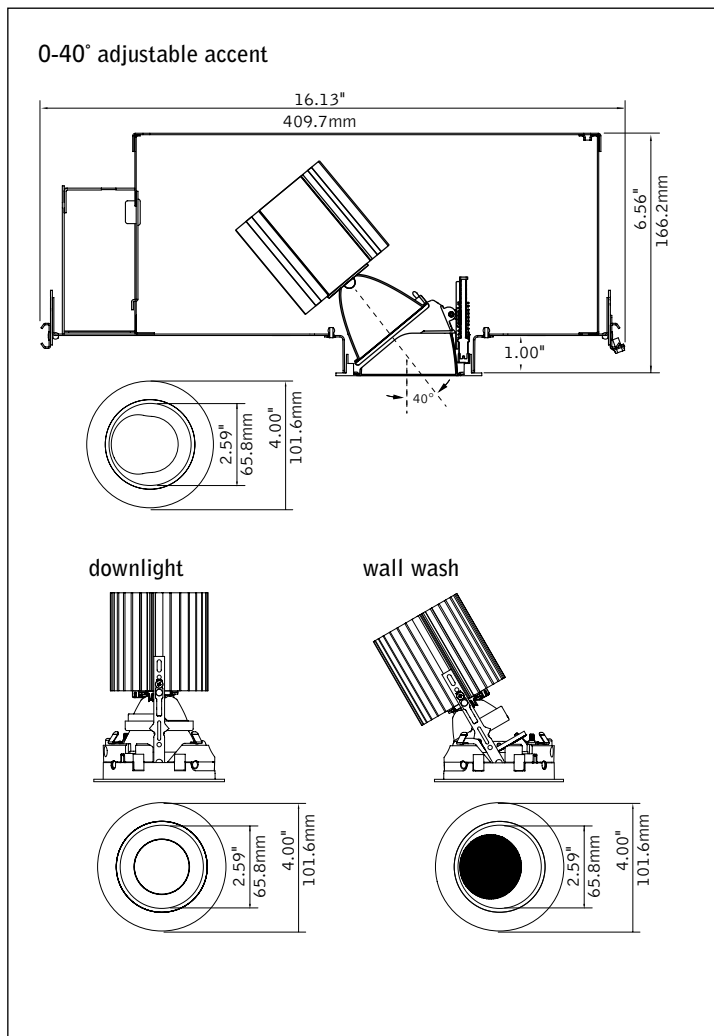


bronze trim



black trim

### DIMENSIONAL DATA



### FEATURES

Small aperture LED adjustable accent family.

15° beam is ideal for art and object accenting, additional beamreads up to 60° complement any application.

Adjustable accent allows for hot aiming with locking 40° vertical tilt and 362° rotation.

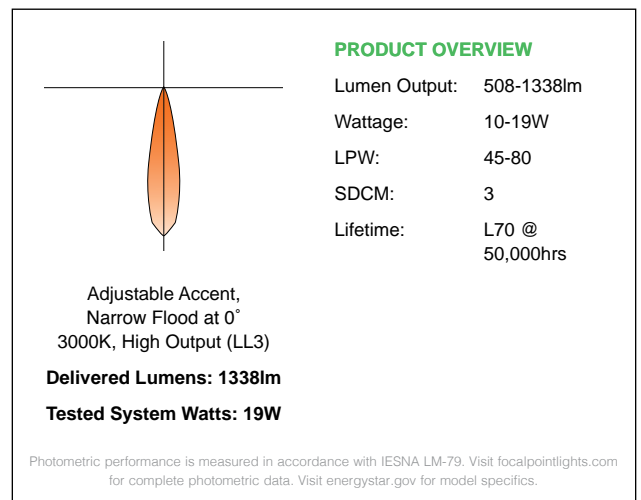
Center Beam Optic allows maximum light output at all tilt angles.

Fixed downlight and wall washer also available.

Selection of dimming drivers available.

Selection of trim styles and finishes to complement any design.

### PERFORMANCE

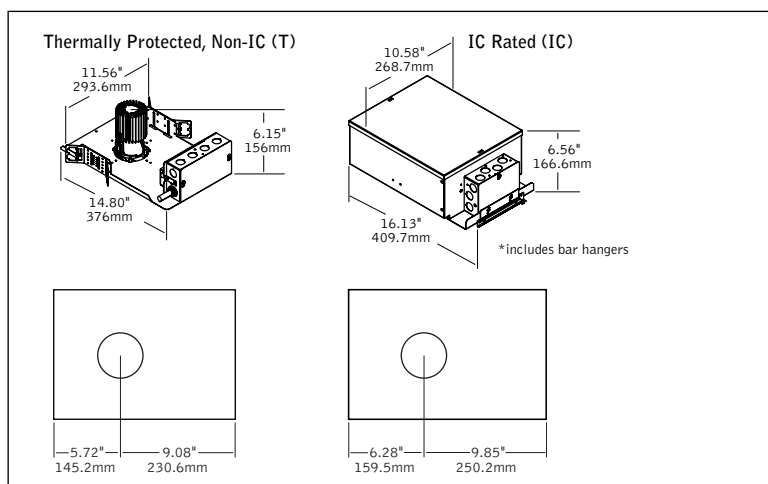


fixture:

project:

# DL1, AL1

## HOUSING DETAILS



## HOUSING SPECIFICATIONS

### Construction

Die-formed housing and integral junction box with (7) 1/2" pry outs. Accommodates ceiling thicknesses up to 1". For thicker ceiling consult factory. Die-cast aluminum heat sink designed for maximum thermal dissipation. Fixture will not exceed 5 lb.

(T) Thermally protected housing for new construction. Insulation to be kept 3" away from housing. Butterfly brackets allow mounting to 1/2" emt. Order bar hangers as an accessory.

(IC) Insulated ceiling housing for new construction drywall/hard ceiling applications with direct insulation contact. Bar hangers included. Overlap and flush wall wash housing complies with ASTM E-283, air-tight energy codes.

### Electrical

Choice of constant current dimming drivers. Power factor >.9 typical, 50/60 Hz., 350-2080mA.

### Emergency battery

Bodine BSL17C-C2. Emergency output—7 watts for 90 minutes.

### Labels

UL and cUL listed. Suitable for Dry or Damp Locations, indoor use only.

### Lumen Maintenance

L70 at 50,000 hours

### Warranty

LED System rated for operation in ambient environments up to 25°C. 5 year limited warranty.

## TRIM SPECIFICATIONS

### LED System

Proprietary LED module with one Cree MT-G2 LED. LED features EasyWhite technology for maximum efficacy, color consistency and optical control. Color accuracy within 2 SDCM.

### Adjustment

Manual locking 40° vertical tilt (AA) or 30° fixed vertical tilt (WW) and 362° rotation.

### Aesthetics

Parabolic reflector cone ensures glare free optics. Field-paintable flange. Trim clips pull trim tight to the ceiling.

### Optics

Beamspreads achieved with optical filters. Order accessory kits to easily change distribution in field.

## PERFORMANCE CHART

See Page 3

## HOUSING ORDERING

Housing Series	FLS2
ID* 2.5" Round Housing	FLS2
<b>Trim Type</b>	
Round Flush	RF
Round Overlap	RO
<b>Output</b>	
Low Output	LL1
Standard Output	LL2
High Output	LL3
<b>Voltage</b>	
120V	120
277V	277
<b>Driver</b>	
0-10V - 1% Dimming	L11
0-10V - 10% Dimming	LD1
Forward Phase	LFP
Lutron A-Series	L3D
1% EcoSystem Digital	
(Consult factory for 3-wire control)	
Lutron A-Series - Forward Phase	LTE
(120 only)	

<b>Housing Type</b>	
Thermally Protected, Non-IC	T
IC Rated	IC
(LL1 & LL2 )	
<b>Factory Options</b>	
Bar Hangers	BH
(T housing only)	
Chicago Plenum / National Plenum	CP
(IC housing only)	
Emergency Battery Pack*	EMR
(Remote test switch, above ceiling access, T housing & RF trim only)	

## TRIM & LED MODULE

<b>Aperture</b>	<b>LS2</b>
2.5" Round Aperture	LS2
<b>Trim Type</b>	<b>RD</b>
Round	RD
(Compatible with RO & RF housings)	
<b>Color Temperature</b>	
2700K, 90+ CRI	927K
3000K, 90+ CRI	930K
3000K, 80+ CRI	30K
3500K, 80+ CRI	35K
<b>Optic</b>	
Adjustable Accent	AA
Downlight	DN
Wall Wash	WW
<b>Distribution</b>	
15° Spot	SP
(Not compatible with WW)	
20° Narrow Flood	NFL
40° Flood	FL
(Recommended with WW)	
60° Wide Flood	WFL
Linear Spread Lens	LS
<b>Reflector Color</b>	
Clear Diffuse	CD
Matte Black	BK
Warm Diffuse	WD
<b>Flange Finish</b>	
White	WH
Black	BK
Titanium Silver	TS
Bronze	BR

## ACCESSORIES

(One kit included per order as indicated in Distribution above. Order additional kits to change distribution in the field as needed.)

15° Spot Kit	LS2-SPK
20° Narrow Flood Kit	LS2-NFLK
40° Flood Kit	LS2-FLK
60° Wide Flood Kit	LS2-WFLK
Linear Spread Kit	LS2-LSK

# DL1, AL1

## PERFORMANCE CHART

Optic	Output	Distribution	System Watts	Delivered Lumens	Beamspread	Center Beam Candlepower (CBCP)
Adjustable Accent	LL1	SP	10	630	11.75	6643
		NFL	10	738	19.8	4732
		FL	10	628	37.75	916
		WFL	10	620	52	705
	LL2	SP	14.6	940	11.75	9911
		NFL	14.6	1101	19.8	7061
		FL	14.6	938	37.75	1367
		WFL	14.6	924	52	1051
	LL3	SP	19	1140	11.75	12020
		NFL	19	1335	19.8	8563
		FL	19	1137	37.75	1658
		WFL	19	1121	52	1275
Downlight	LL1	SP	10	692	15.8	6207
		NFL	10	802	20.9	5055
		FL	10	655	38	1401
		WFL	10	717	58.9	848
	LL2	SP	14.6	973	15.8	8730
		NFL	14.6	1128	20.9	7110
		FL	14.6	921	38	1970
		WFL	14.6	1008	58.9	1193
	LL3	SP	19.4	1154	15.8	10071
		NFL	19.4	1338	21.9	8202
		FL	19.2	1093	38	2273
		WFL	19.2	1196	58.9	1376
Wall Wash	LL1	FL	10	508		
	LL2	FL	14.6	715		
	LL3	FL	19	848		

\*Tested with 3000K Clear Diffuse Reflector. \*\*Lumen output may vary +/- 5%. 0.963 Matte Black Reflector (BK) lumen multiplier. 0.777 90 CRI lumen multiplier. (values in grey are estimated based on a relative comparison to the tested data)

# DL1, AL1

## id+ 2.5"

LED ADJUSTABLE ACCENT - SPOT

FLS2-RO-LL3-120-LD1-T / LS2-RD-35K-AA-SP-CD-WH

Filename: FLS2AALL3L30SP .IES

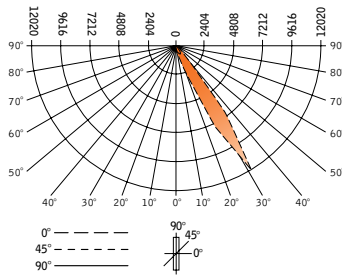
Lumens: 1140lm

Test #: 17613.0

System Watts: 19W

LPW: 60

### CANDLEPOWER DISTRIBUTION



Vertical Angle	0°	45°	90°	135°	180°
0°	294	294	294	294	294
5°	501	465	279	118	95
15°	1262	638	175	159	161
25°	7458	797	234	324	346
35°	661	289	104	131	151
45°	217	27	14	17	15
55°	25	5	1	3	4
65°	4	0	0	0	0
75°	0	0	0	0	0
85°	0	0	0	0	0
90°	0	0	0	0	0

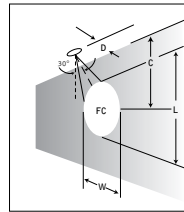
### LUMEN SUMMARY

Zone	Lumens	% Fixture
0-30°	663	58.1
0-40°	1089	95.6
0-60°	1139	99.9
0-90°	1140	100.0
Total Luminaire	1140	100.0

### FOOTCANDLE VALUES

30° aiming angle - vertical surface

D	C	FC	L	W
18"	2.7'	387	1.3'	1.1'
24"	3.2'	293	1.6'	1.2'
30"	4.3'	204	1.9'	1.3'
36"	4.8'	150	2.3'	1.4'



Footcandle results based on AGI32; Reflectances=0/0/0; LLF=1

Go to [www.focalpointlights.com](http://www.focalpointlights.com) for additional photometric data.

## id+ 2.5"

LED ADJUSTABLE ACCENT - NARROW FLOOD

FLS2-RO-LL3-120-LD1-T / LS2-RD-35K-AA-NFL-CD-WH

Filename: FLS2AALL3L30NFL .IES

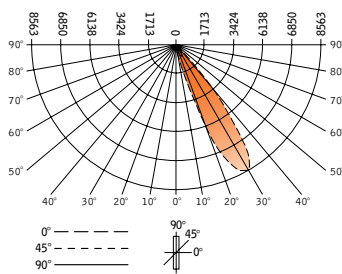
Lumens: 1335lm

Test #: 17610.0

System Watts: 19W

LPW: 70

### CANDLEPOWER DISTRIBUTION



Vertical Angle	0°	45°	90°	135°	180°
0°	213	213	213	213	213
5°	355	288	210	162	140
15°	2279	590	173	103	116
25°	7724	697	120	120	150
35°	6785	253	43	48	51
45°	750	49	6	5	9
55°	20	0	0	0	0
65°	0	0	0	0	0
75°	0	0	0	0	0
85°	0	0	0	0	0
90°	0	0	0	0	0

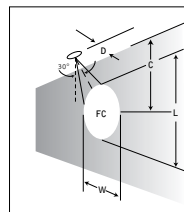
### LUMEN SUMMARY

Zone	Lumens	% Fixture
0-30°	730	54.7
0-40°	1233	92.3
0-60°	1335	100.0
0-90°	1335	100.0
Total Luminaire	1335	100.0

### FOOTCANDLE VALUES

30° aiming angle - vertical surface

D	C	FC	L	W
18"	2.3'	461	1.5'	1.2'
24"	3.2'	273	2.0'	1.4'
30"	3.8'	186	2.5'	1.8'
36"	4.7'	130	3.0'	2.1'



Footcandle results based on AGI32; Reflectances=0/0/0; LLF=1

Go to [www.focalpointlights.com](http://www.focalpointlights.com) for additional photometric data.

## id+ 2.5"

LED DOWNLIGHT - SPOT

## FLS2-RO-LL3-120-LD1-T / LS2-RD-35K-DN-SP-CD-WH

Filename: FLS2DNLL3L30SP.IES

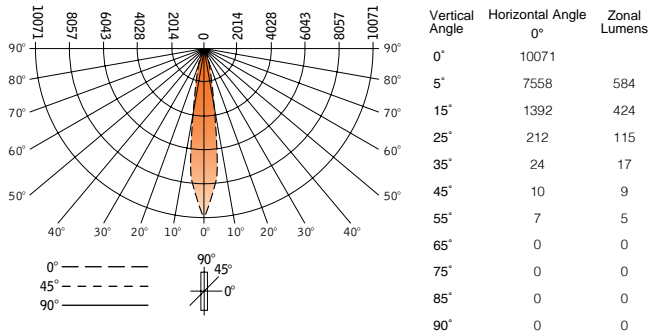
Lumens: 1154lm

Test #: 17396.0

System Watts: 19W

LPW: 59

## CANDLEPOWER DISTRIBUTION



## LUMEN SUMMARY

Zone	Lumens	% Fixture
0-30°	1123	76.0
0-40°	1140	89.0
0-60°	1154	100.0
0-90°	1154	100.0
<b>Total Luminaire</b>	<b>0-90°</b>	<b>1154</b>

## FOOTCANDLE VALUES

0° aiming angle - horizontal surface

Distance from source	Beam Diameter	Center Beam (FC)
2'	0.6'	2517.8
4'	1.1'	629.4
6'	1.7'	279.8
8'	2.2'	157.4
10'	2.8'	100.7
12'	3.3'	69.9

Footcandle results based on AGI32; Reflectances=0/0/0; LLF=1

Go to [www.focalpointlights.com](http://www.focalpointlights.com) for additional photometric data.

## id+ 2.5"

LED DOWNLIGHT - NARROW FLOOD

## FLS2-RO-LL2-120-LD1-T / LS2-RD-35K-DN-NFL-CD-WH

Filename: FLS2DNLL2L30NFL.IES

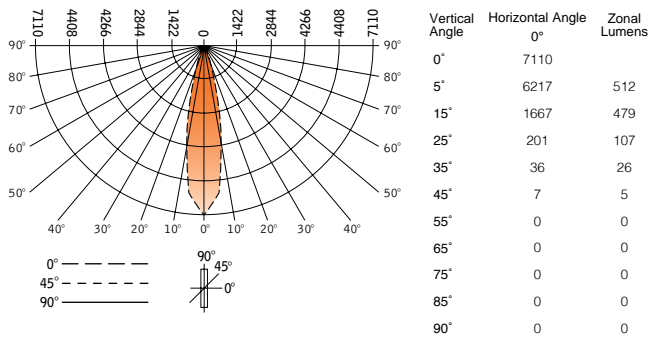
Lumens: 1128lm

Test #: 17617.0

System Watts: 14.6W

LPW: 77

## CANDLEPOWER DISTRIBUTION



## LUMEN SUMMARY

Zone	Lumens	% Fixture
0-30°	1098	97.3
0-40°	1124	99.6
0-60°	1128	100.0
0-90°	1128	100.0
<b>Total Luminaire</b>	<b>0-90°</b>	<b>1128</b>

## FOOTCANDLE VALUES

0° aiming angle - horizontal surface

Distance from source	Beam Diameter	Center Beam (FC)
4'	1.5'	444
6'	2.2'	198
8'	2.9'	111
10'	3.7'	71
12'	4.4'	50

Footcandle results based on AGI32; Reflectances=0/0/0; LLF=1

Go to [www.focalpointlights.com](http://www.focalpointlights.com) for additional photometric data.

# DL1, AL1

## id+ 2.5"

LED DOWNLIGHT - NARROW FLOOD

FLS2-RO-LL3-120-LD1-T / LS2-RD-35K-DN-NFL-CD-WH

Filename: FLS2DNLL3L30NFL.IES

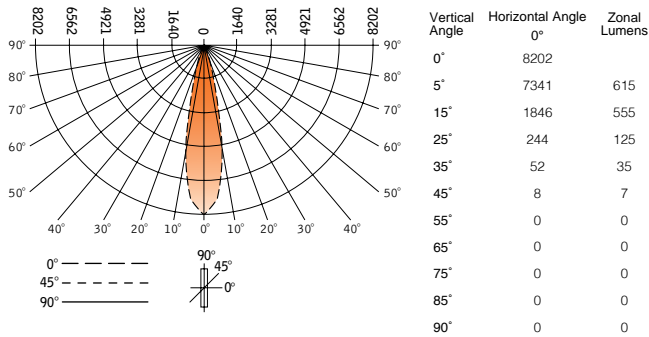
Lumens: 1338lm

Test #: 17399.0

System Watts: 19W

LPW: 70

### CANDLEPOWER DISTRIBUTION



### LUMEN SUMMARY

Zone	Lumens	% Fixture
0-30°	1296	96.8
0-40°	1331	99.4
0-60°	1338	100.0
0-90°	1338	100.0
<b>Total Luminaire</b>	<b>0-90°</b>	<b>1338</b>

### FOOTCANDLE VALUES

0° aiming angle - horizontal surface

Distance from source	Beam Diameter	Center Beam (FC)
2'	0.8'	2050.5
4'	1.5'	512.6
6'	2.3'	227.8
8'	3.1'	128.
10'	3.9'	82.0
12'	4.6'	57.0

Footcandle results based on AGI32; Reflectances=0/0/0; LLF=1

Go to [www.focalpointlights.com](http://www.focalpointlights.com) for additional photometric data.

## id+ 2.5"

LED DOWNLIGHT - FLOOD

FLS2-RO-LL3-120-LD1-T / LS2-RD-35K-DN-FL-CD-WH

Filename: FLS2DNLL3L30FL.IES

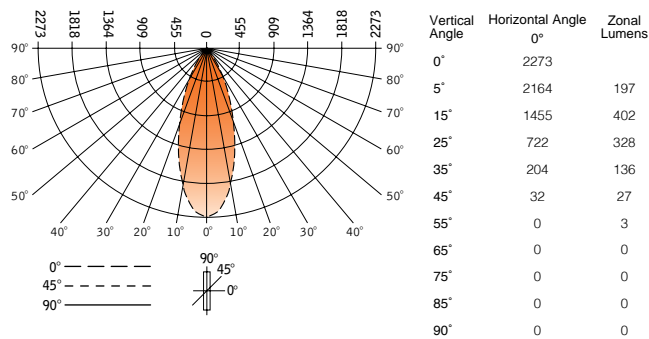
Lumens: 1093lm

Test #: 17397.0

System Watts: 19W

LPW: 57

### CANDLEPOWER DISTRIBUTION



### LUMEN SUMMARY

Zone	Lumens	% Fixture
0-30°	926	84.7
0-40°	1062	97.2
0-60°	1092	99.9
0-90°	1093	100.0
<b>Total Luminaire</b>	<b>0-90°</b>	<b>1093</b>

### FOOTCANDLE VALUES

0° aiming angle - horizontal surface

Distance from source	Beam Diameter	Center Beam (FC)
2'	1.4'	568.3
4'	2.8'	142.1
6'	4.1'	63.1
8'	5.5'	35.5
10'	6.9'	22.7
12'	8.3'	15.8

Footcandle results based on AGI32; Reflectances=0/0/0; LLF=1

Go to [www.focalpointlights.com](http://www.focalpointlights.com) for additional photometric data.

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# ACADEMIC VITA

**Victoria Riedinger**      vyr5033@psu.edu

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**Education:**      **BAE/MAE- Master's & Bachelor's of Architectural Engineering**  
ABET Accredited- Five Year Professional Degree  
The Pennsylvania State University, University Park, PA      August 2011-May 2016

- Schreyer Honors College

**Penn State Summer Study Abroad Program**      May-June 2014  
The Pantheon Institute, Rome, Italy

- 12 credit, 7 week program that completed an Architectural Studies Minor

**Work Experience:**      **The Lighting Practice, Philadelphia, PA**      May-August 2015  
Lighting Designer

- Participated in design collaborations in the initial stages of the design process
- Assisted with mock-ups and traveled on site to obtain hands-on project experience

**CannonDesign, Boston, MA**      July-August 2014  
Lighting Design Intern

- Used AGi32, to create models and conduct lighting calculations for multiple projects
- Used Revit to edit lighting plans and place luminaires in multiple projects
- Communicated with many professionals in the field and learned about new lighting products in the market

**Cruise and Travel Partners, LLC, West Chester, PA**      May 2012-January 2014  
Administrative Assistant

- Designed flyers and brochures, which were distributed to clients via the internet
- Communicated with clients, cruise lines, and travel companies by phone and email

**Honors/Awards:**

- John Flynn Memorial Scholarship – 2015 to 2016
- Schreyer Honors College Academic Excellence Scholarship - 2011 to present
- Michael J. and Virginia A. Youchak Scholarship - 2014 to 2015
- NHE Endowment and Industry Scholarship - 2014
- Solutionwerks International Scholarship - 2014
- Philip H. and Judith O. Sieg Trustee Scholarship - 2011

**Activities:**

- Illumination Engineering Society (IES) - 2013 to present
- National Association of Home Builders(NAHB), Secretary (2014-2015) - 2012 to present
- NAHB Residential Construction Management Competition (1<sup>st</sup> Place-2015) (7<sup>th</sup> Place-2014) (6<sup>th</sup> Place-2013) - 2012 to present
- Student Society of Architectural Engineers(SSAE), Mentoring Member, THON Chair (2013-2014) - 2012 to present
- Penn State IM Sports (Soccer & Volleyball) - 2011 to present
- Schreyer Honors College Orientation Mentor - 2012, 2013

**Computer Skills:**  
AGi32, Revit, AutoCAD, Illustrator, Photoshop, COMcheck, Microsoft Office, SketchUp