# BIOENGINEERING BUILDING

Victoria Riedinger
Lighting & Electrical

# INTRODUCTION

## Building Overview

**Location:** Eastern USA

**Occupancy Type:** Research Facility

**Size:** 184,239 GSF

**Floors above grade:** 6

**Construction Dates:** July 2015 - March 2017

**Cost:** $120,000,000

# INTRODUCTION

## What is Bioengineering?

# INTRODUCTION

## What is Bioengineering?

living organisms

# INTRODUCTION

## What is Bioengineering?

living organisms

↓

materials & machines

# INTRODUCTION

## What is Bioengineering?

living organisms

↓

materials & machines

↓

improve human life

# DESIGN CONCEPT





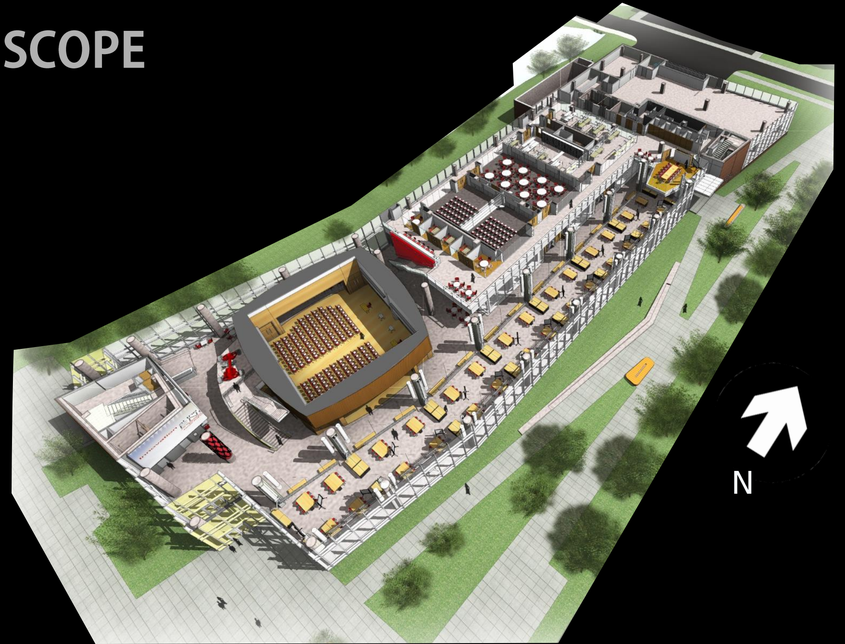
# DESIGN CONCEPT





# INTRODUCTION

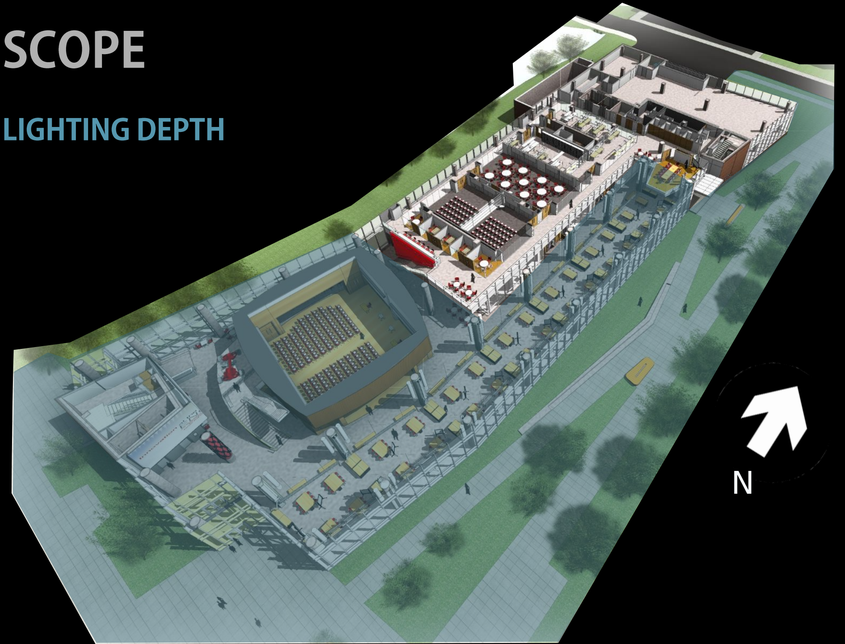
## SCOPE



# INTRODUCTION

## SCOPE

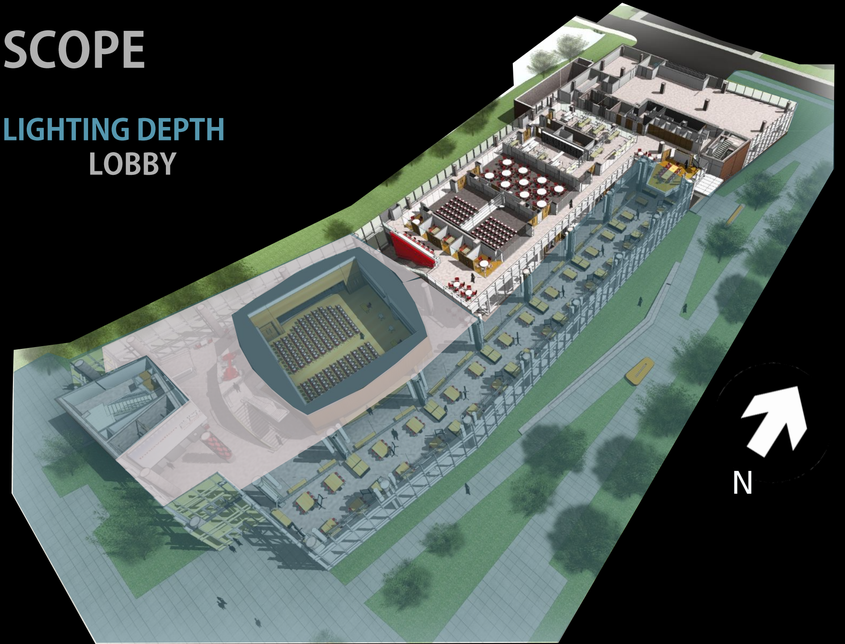
### LIGHTING DEPTH



# INTRODUCTION

## SCOPE

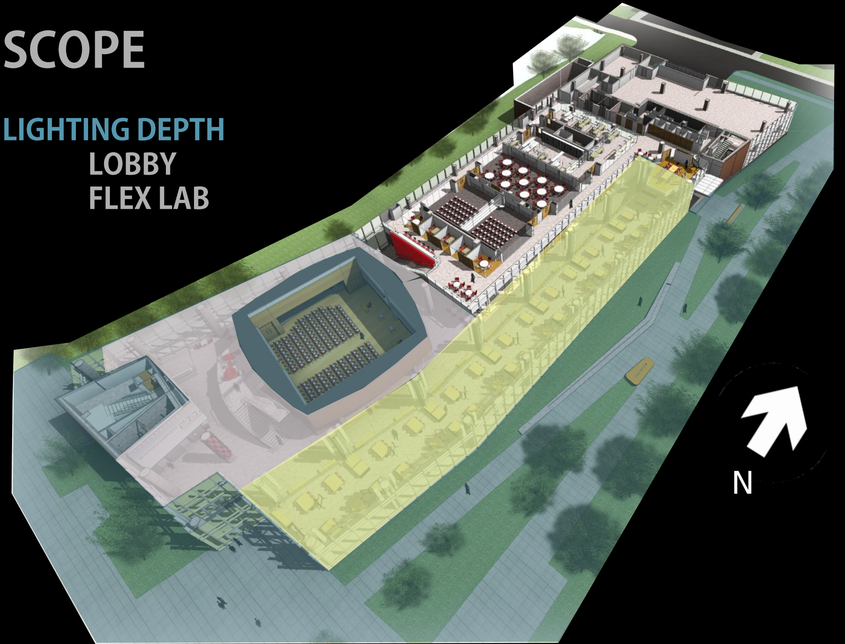
**LIGHTING DEPTH**
LOBBY



# INTRODUCTION

## SCOPE

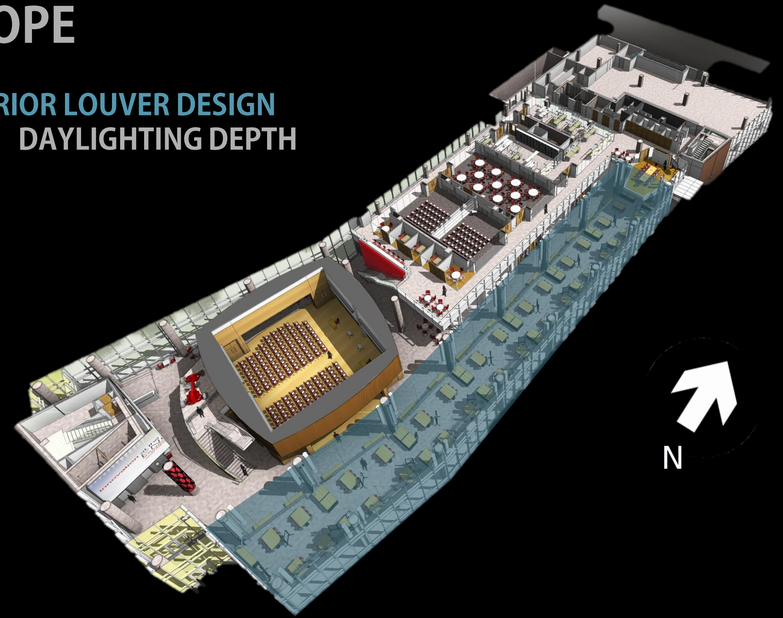
**LIGHTING DEPTH**
LOBBY
FLEX LAB



# INTRODUCTION

## SCOPE

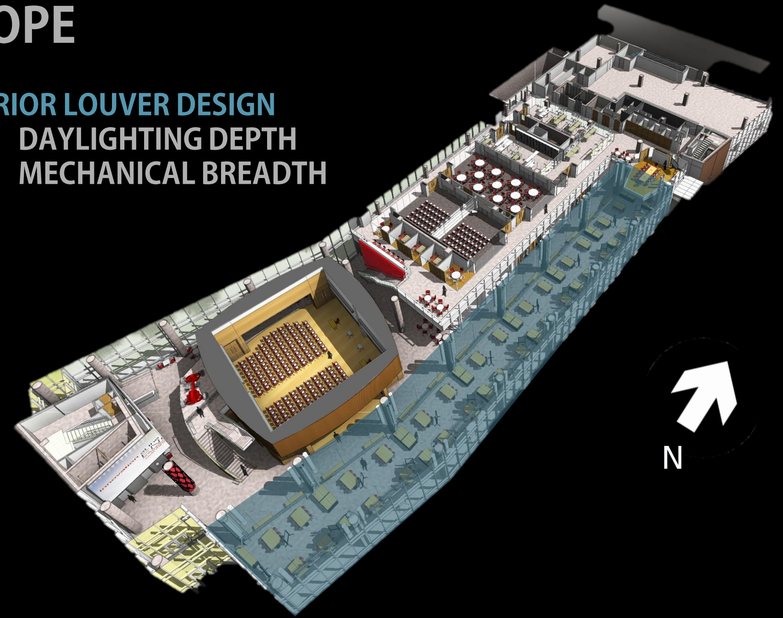
INTERIOR LOUVER DESIGN
DAYLIGHTING DEPTH



# INTRODUCTION

## SCOPE

**INTERIOR LOUVER DESIGN**
DAYLIGHTING DEPTH
MECHANICAL BREADTH



# LIGHTING DEPTH


## Design Goals

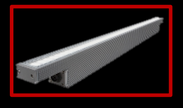
Create eye-catching space

Emphasize height of space

Facilitate circulation

Complement surrounding spaces

# LIGHTING DEPTH



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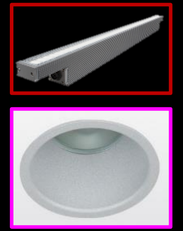



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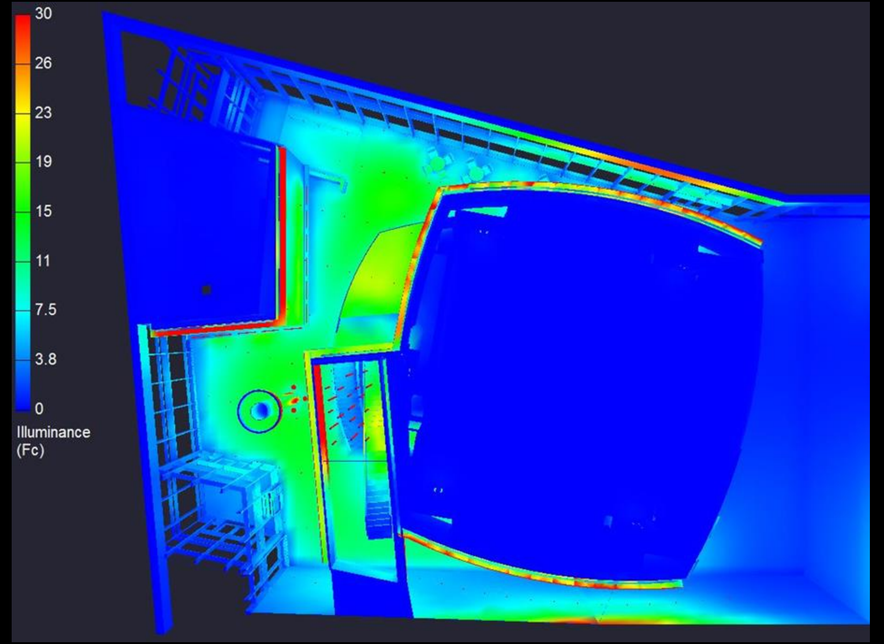


## Quantitative Criteria

| | |
|---|---|
| Illuminance during day @ grade | 10 fc |
| Uniformity (avg to min) | 3 : 1 |
| Lighting Power Density | 1.36 |

## Quantitative Performance

| | |
|---|---|
| Illuminance during day @ grade | 10.1 fc |
| Uniformity (avg to min) | 2.3 : 1 |
| Lighting Power Density | 1.33 |

# LIGHTING DEPTH

## Renderings

# LIGHTING DEPTH

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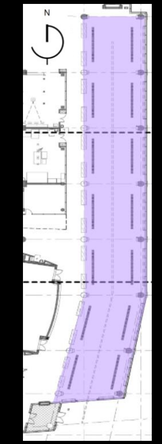
# LIGHTING DEPTH


## Design Goals

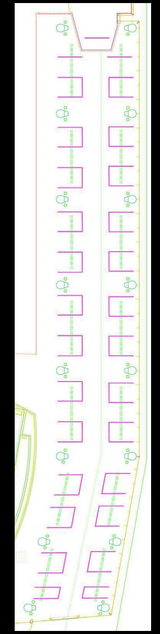
Create comfortable research environment

Provide individual task lighting

Control daylight to reduce glare



# LIGHTING DEPTH



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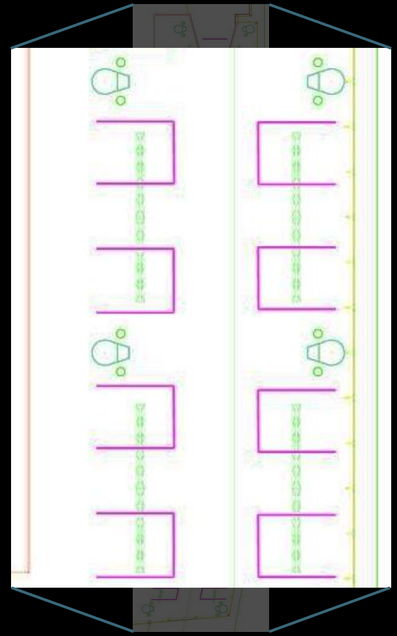
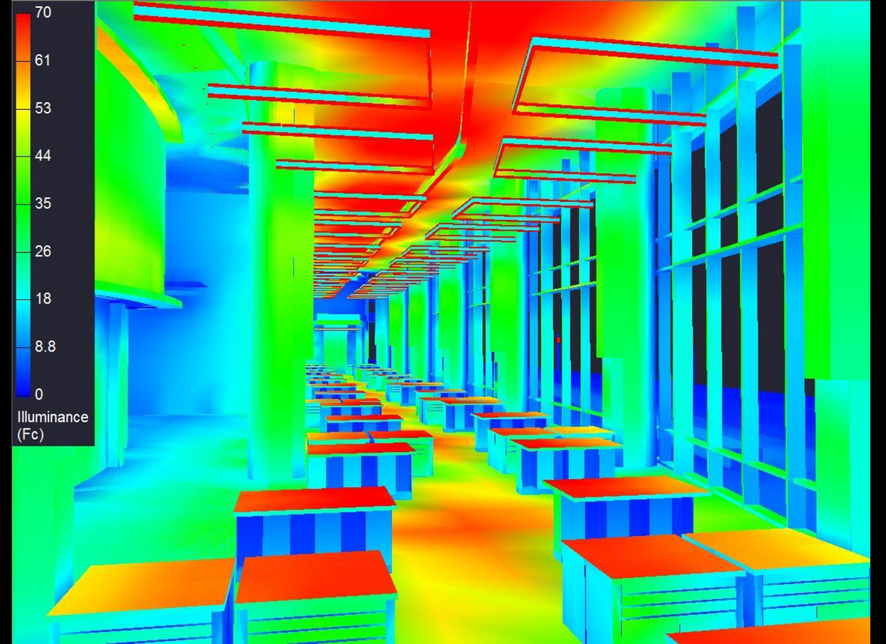


# LIGHTING DEPTH




## Quantitative Criteria

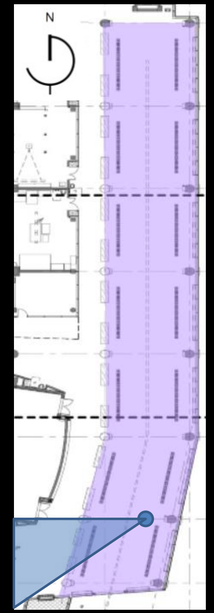
| | |
|---|---|
| Lab Illuminance @ 3′ | 50-60 fc |
| Uniformity across task (avg to min) | 1.5 : 1 |
| Uniformity across space (max to min) | 3 : 1 |
| Lighting Power Density | 1.81 |

## Quantitative Performance

| | |
|---|---|
| Lab Illuminance @ 3′ | 55 fc |
| Uniformity across task (avg to min) | 1.1 : 1 |
| Uniformity across space (max to min) | 3 : 1 |
| Lighting Power Density | 1.94 |

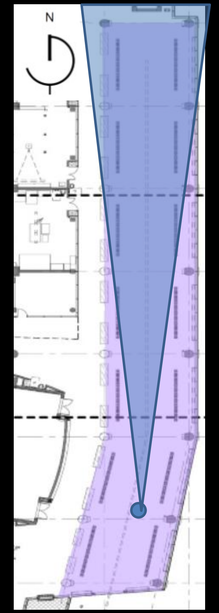
# LIGHTING DEPTH

## Renderings



# LIGHTING DEPTH

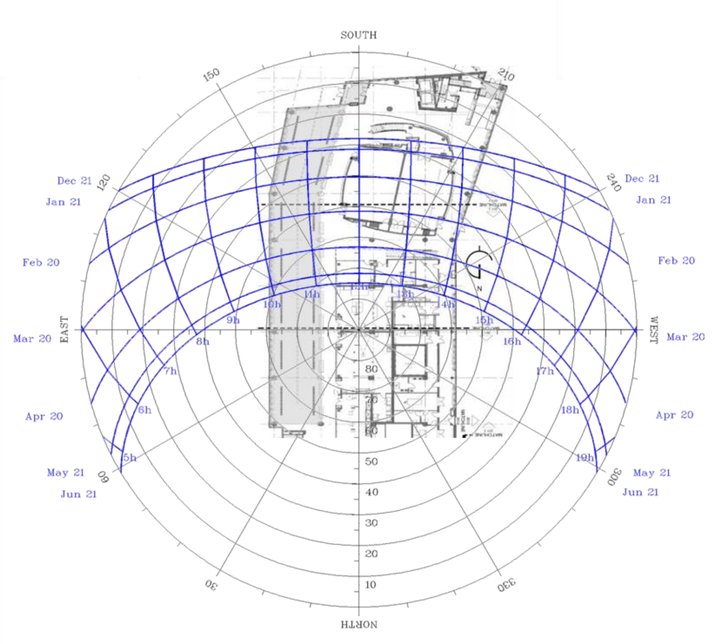
## Renderings



# LIGHTING DEPTH

## Renderings

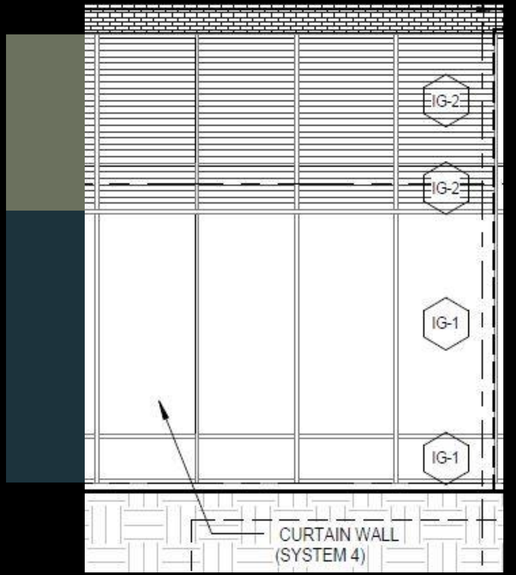
# LOUVER DESIGN



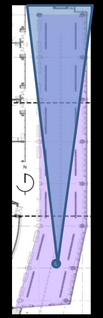
# LOUVER DESIGN

1″ fritted, clear
50% coverage
VT: 49%

1″ Low-e, clear
VT: 61 %

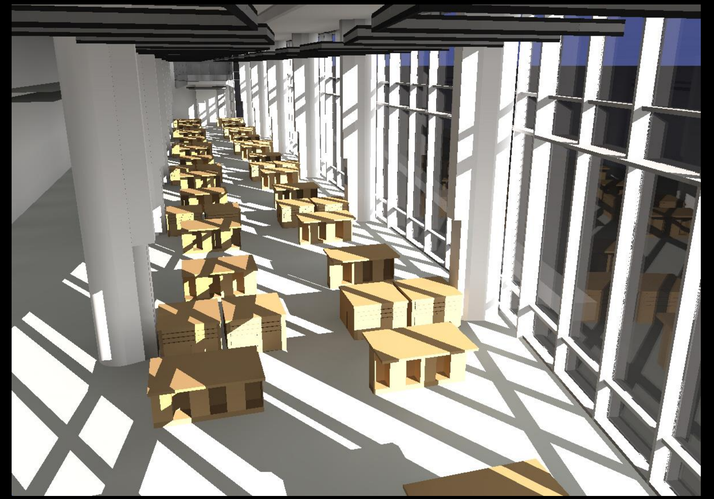


# LOUVER DESIGN



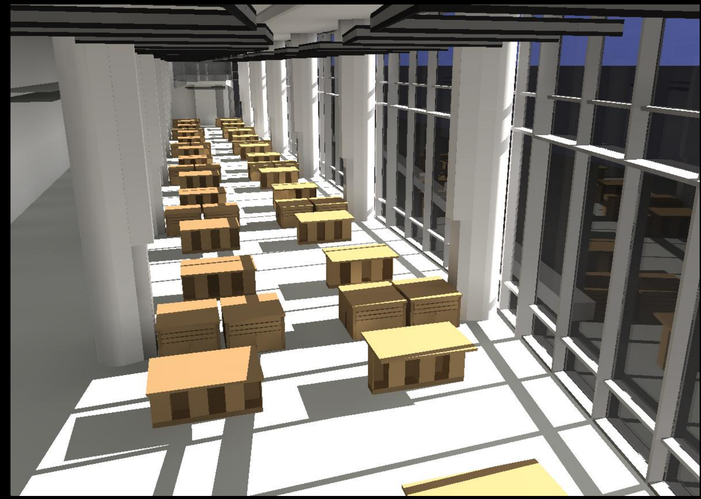
## December 10 am

Avg. Illuminance across lab benches: 212 fc



## June 9 am

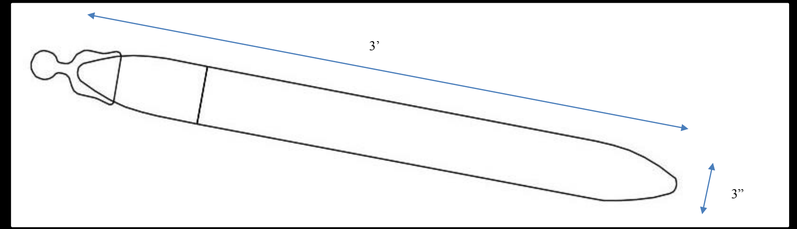
Avg. Illuminance across lab benches: 1695 fc

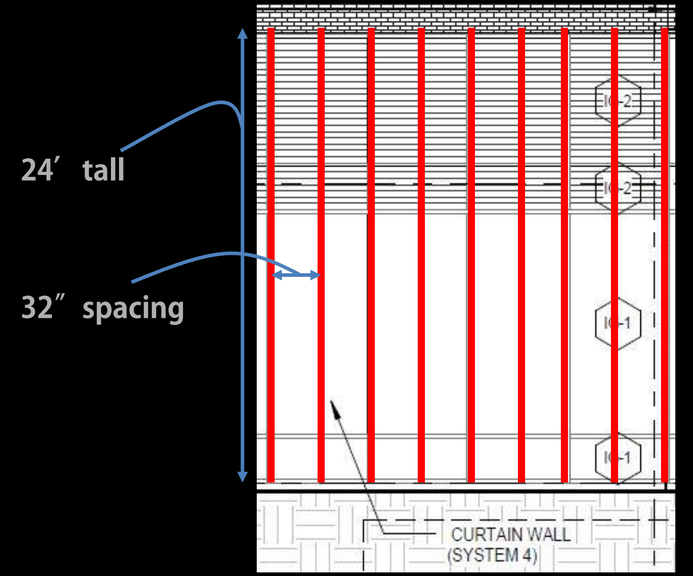


# Interior Vertical Louvers

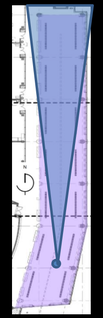


## LOUVER DESIGN



# LOUVER DESIGN

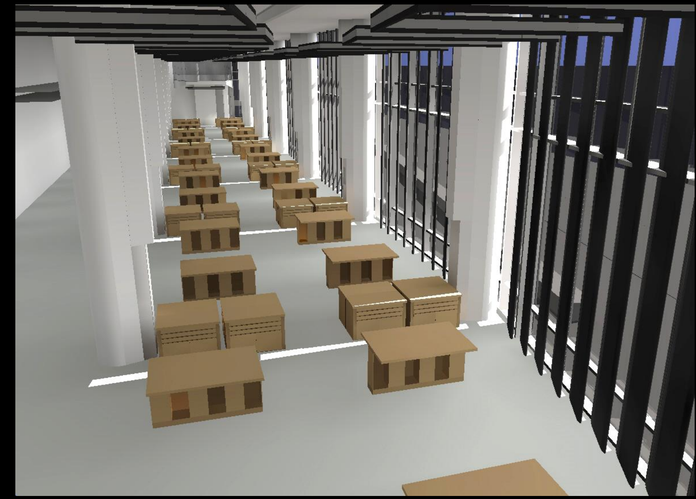


## December 10 am

Avg. Illuminance across lab benches: **55 fc**

## June 9 am

Avg. Illuminance across lab benches: **44.3 fc**

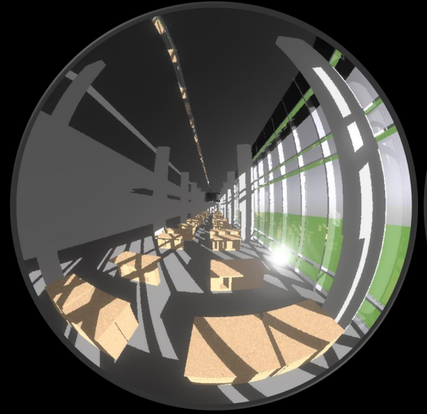


# LOUVER DESIGN

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

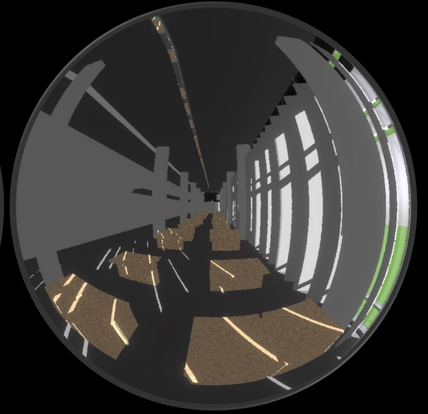
## December 10 am

BEFORE



DGI : 38.02

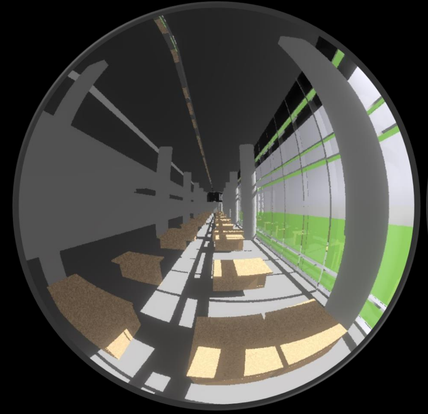
AFTER



DGI : 17.6

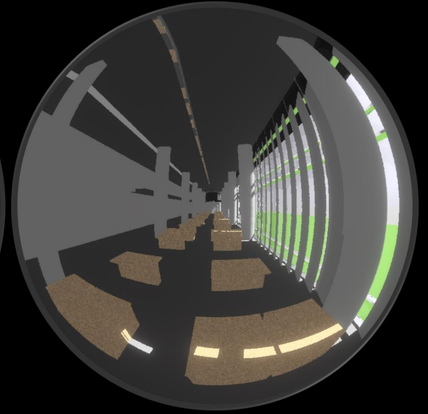
## June 9 am

BEFORE



DGI : 23.91

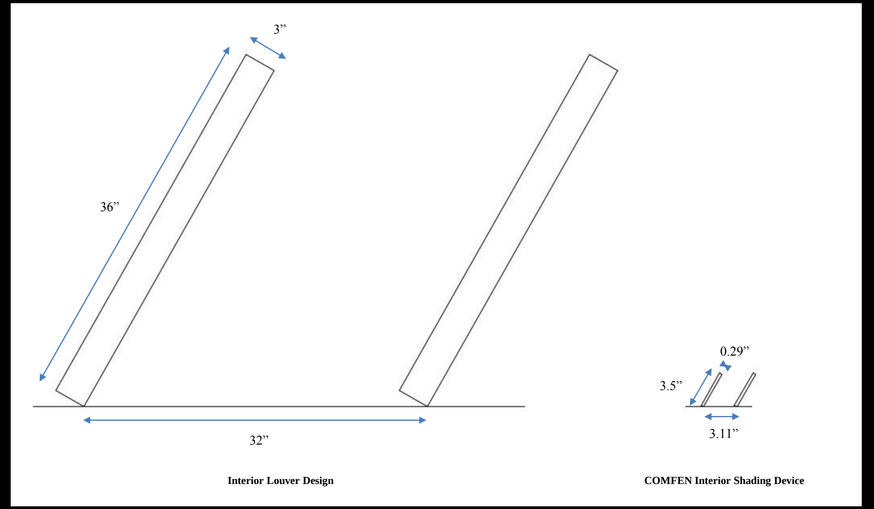
AFTER



DGI : 18.9

# LOUVER DESIGN

## COMFEN Shading Model

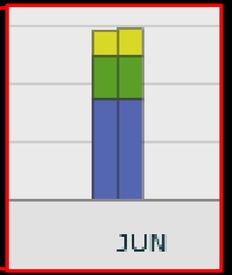



Interior Louver Design

COMFEN Interior Shading Device

# LOUVER DESIGN

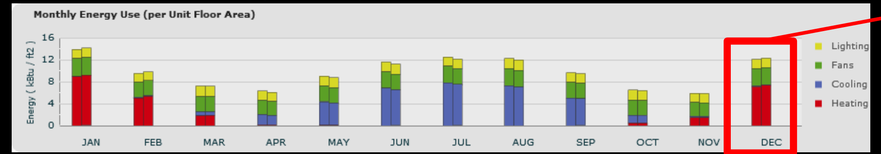
## Summer Energy Analysis (June)

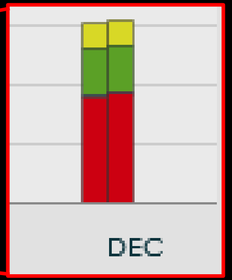




11.6 kBtu/ft$^2$

11.73 kBtu/ft$^2$

## Winter Energy Analysis (December)



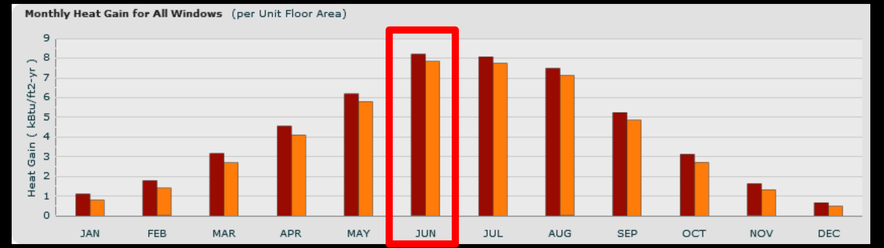




12.09 kBtu/ft$^2$

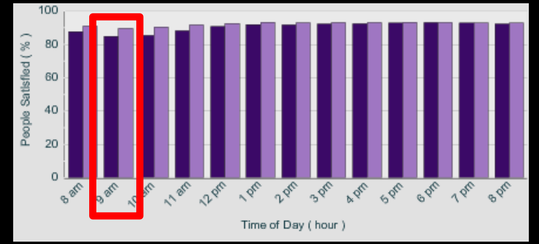
12.3 kBtu/ft$^2$

# LOUVER DESIGN

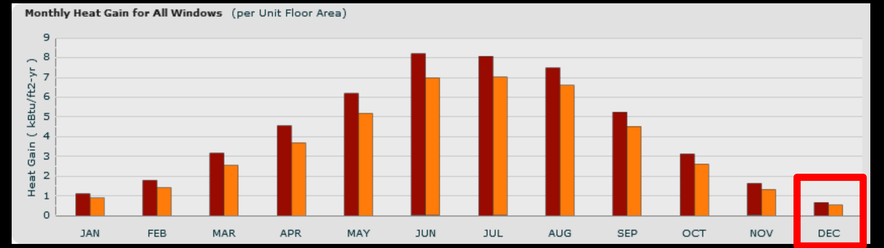
## Summer Heat Gain (June)



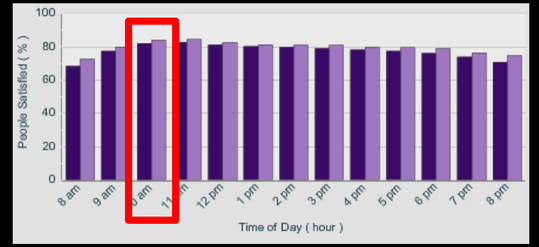

## Summer Comfort (June)




## Winter Heat Gain (December)



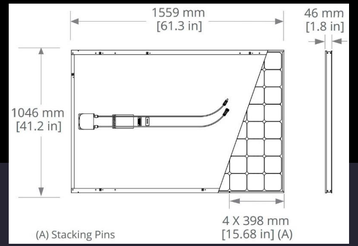

## Winter Comfort (December)

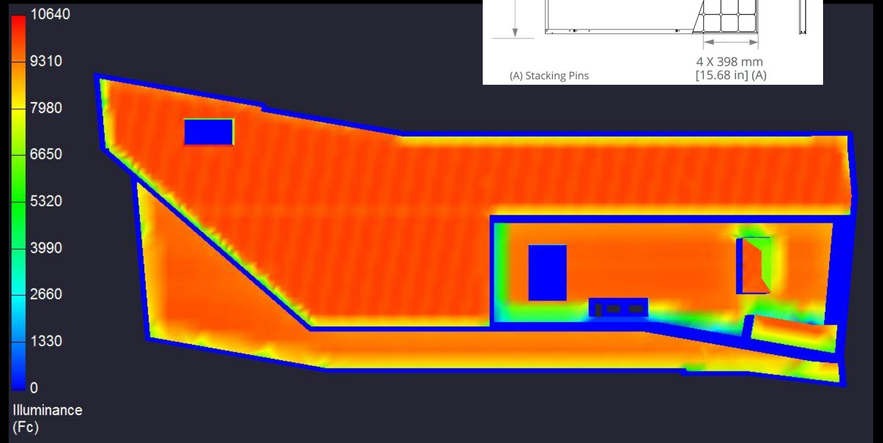


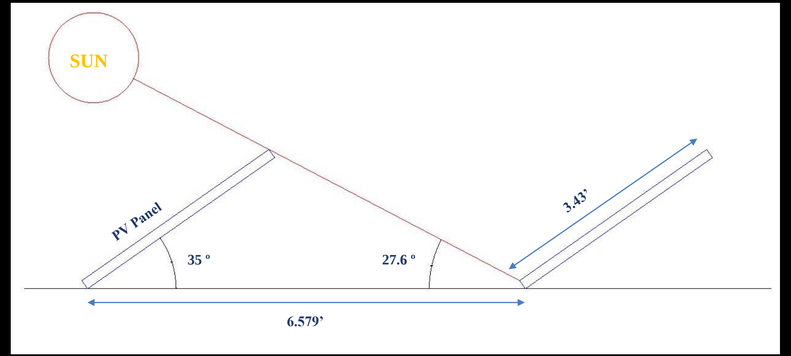
# ELECTRICAL

**Panels:** 345W, 21.5% efficiency

**Inverter:** 98.6 % efficiency

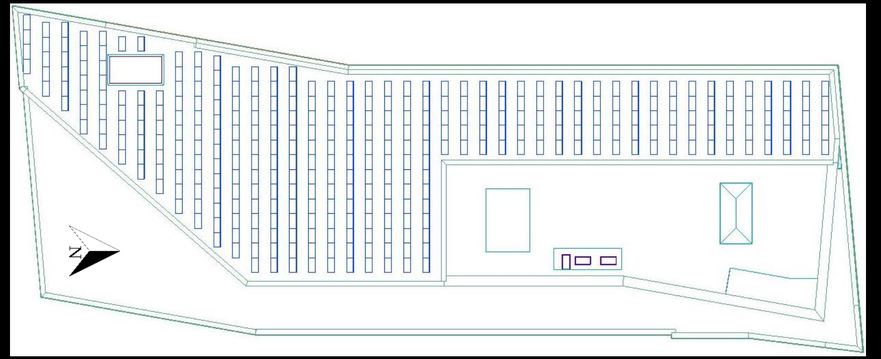


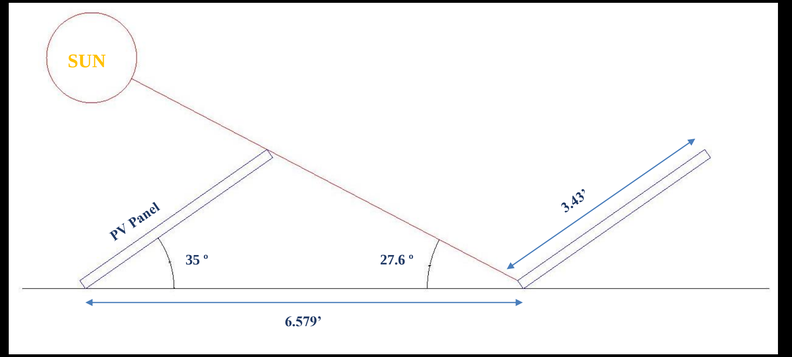



# ELECTRICAL

## 337 Panels



# ELECTRICAL

## 167,924 kWh per year

| Month | Solar Radiation ( kWh / $m^2$ / day ) | AC Energy ( kWh ) | Energy Value ( $ ) |
|---|---|---|---|
| January | 3.06 | 10,091 | 1,322 |
| February | 3.72 | 11,125 | 1,457 |
| March | 4.66 | 15,003 | 1,965 |
| April | 5.60 | 16,790 | 2,199 |
| May | 4.81 | 14,760 | 1,934 |
| June | 5.64 | 16,426 | 2,152 |
| July | 5.56 | 16,531 | 2,166 |
| August | 5.50 | 16,384 | 2,146 |
| September | 5.01 | 14,806 | 1,940 |
| October | 5.12 | 15,835 | 2,074 |
| November | 3.21 | 10,005 | 1,311 |
| December | 3.15 | 10,168 | 1,332 |
| Annual | 4.59 | 167,924 | $ 21,998 |

**Initial Cost for 337 panels:**

$2.60 /W x 116.265 kW x 1,000 W/kW = **$302,289**

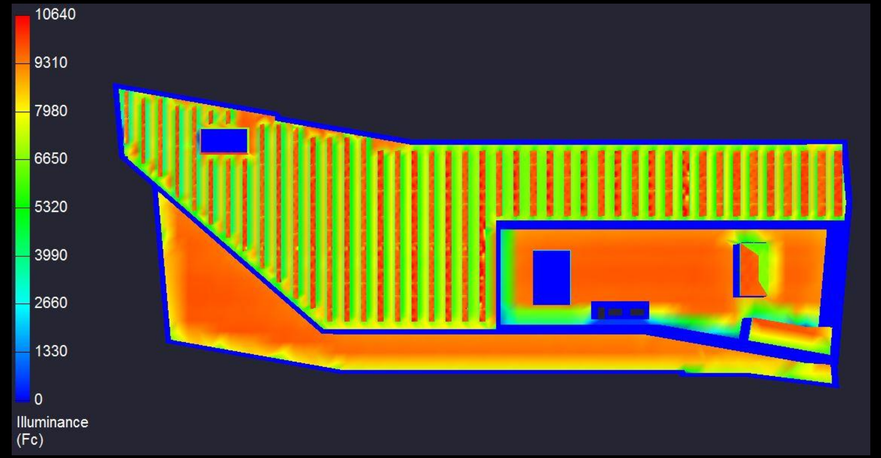
**Payback Period:**

$302,289 / $21,998 per year = ***13.74 years***

**PVWatts:** National Renewable Energy Laboratory (NREL)

# ELECTRICAL

## 167,924 kWh per year

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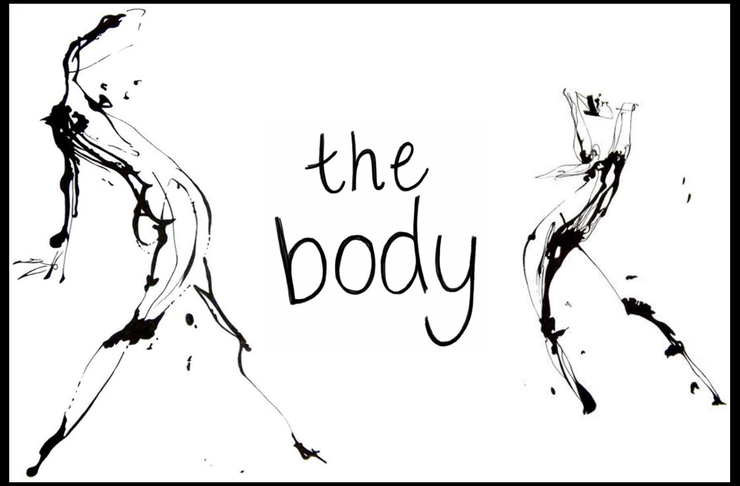
# CONCLUSION



THANK YOU

QUESTIONS?



# THANK YOU

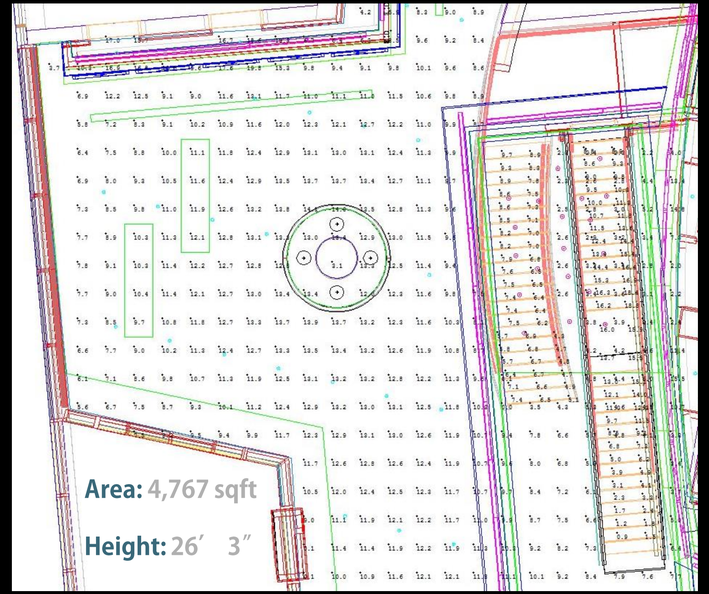
The Lighting Practice
Ballinger

AE Department & Staff
Dr. Kevin Houser
Dr. Richard Mistrick
Gary Golaszewski

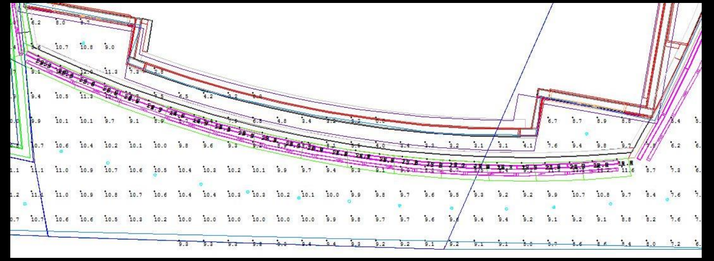
My loving parents & friends

The ladies of 623

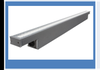
## LOBBY



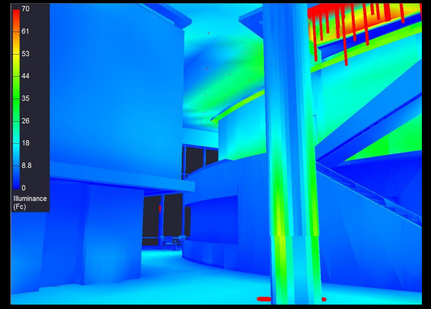

## LPD

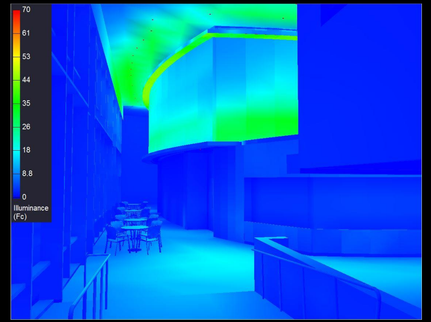


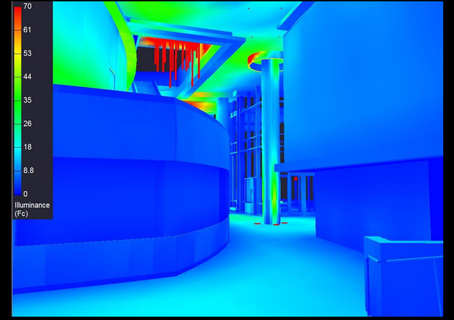
| Fixture Type | Number of Fixtures | Watts/fixture | Total Watts (W) |
|---|---|---|---|
| LL2 | 44′ | 17.25 W/ft | 759 |
| LL3 | 424′ | 8.5 W/ft | 3,604 |
| DL2 | 85 | 7 W | 595 |
| PL2 | 6 | 63 W | 378 |
| PL3 | 5 | 63 W | 315 |
| PL4 | 8 | 63 W | 504 |
| UL1 | 4 | 44 W | 176 |
| Total Space Wattage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

| 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 |

## LOBBY


70
61
53
44
35
26
18
8.8
0
Illuminance
(Fc)


70
61
53
44
35
26
18
8.8
0
Illuminance
(Fc)


70
61
53
44
35
26
18
8.8
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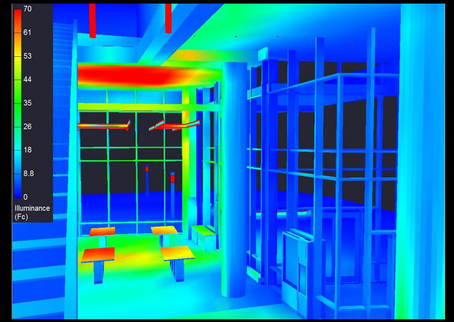
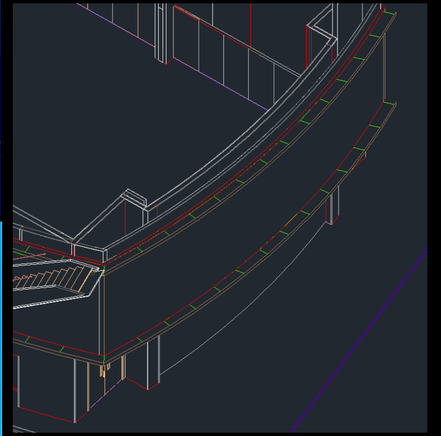
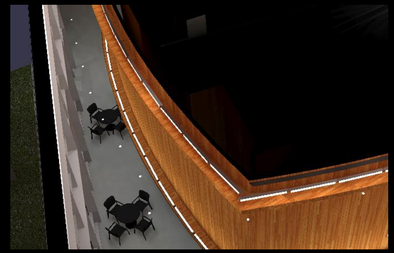
Illuminance
(Fc)


70
61
53
44
35
26
18
8.8
0
Illuminance
(Fc)



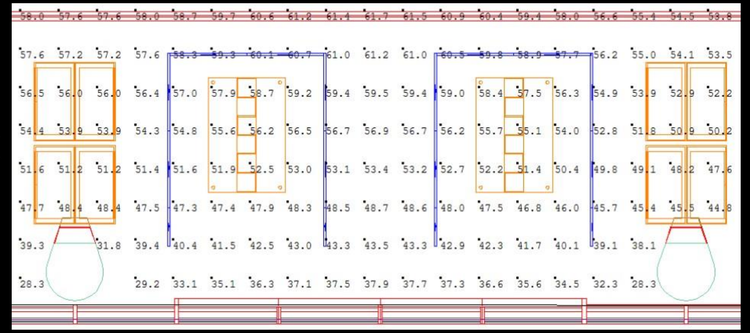



1.5'

FLEX LAB

**Area:** 6,908 sqft

**Height:** 30′ 6″



## Illuminance Values

*Across entire space

Average (fc): 49.18
Maximum (fc): 66.0
Minimum (fc): 21.0
Max/Min: 3 : 1

*Across lab benches

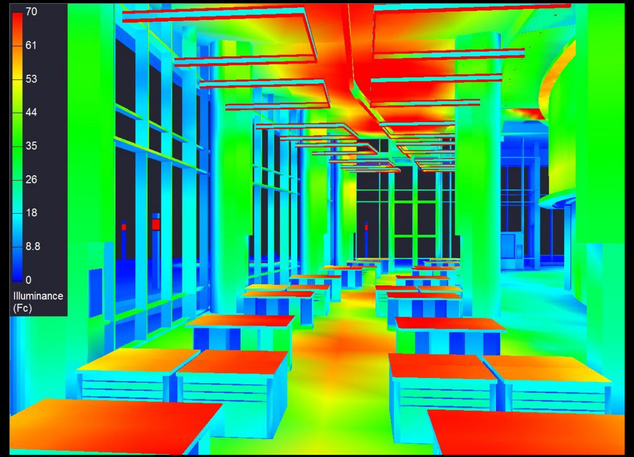
*Average (fc):* 54.89
*Maximum (fc):* 59.1
*Minimum (fc):* 50
*Avg/Min:* 1.1 : 1

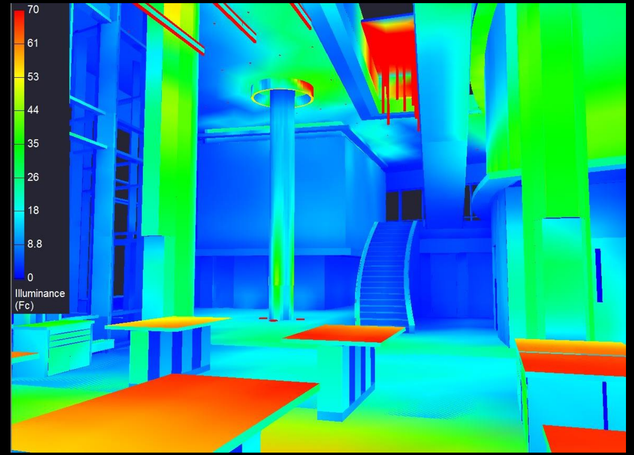
LPD

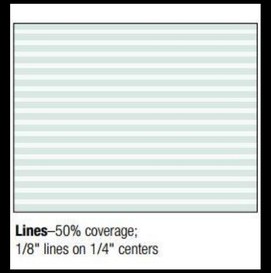
| Fixture Type | Number of Fixtures | Watts/fixture | Total Watts (W) |
|---|---|---|---|
| PL1 (4′ ) | 163 | 70.4 | 11475.2 |
| PL1 (3′ ) | 1 | 52.8 | 52.8 |
| PL1 (2′ ) | 54 | 35.2 | 1900.8 |
| Total Space Wattage (W) | | | 13,428.8 |
| Space Area (ft²) | | | 6,908 |
| Watts/ft² | | | 1.94 |
| Allowed Watts/ft² | | | 1.81 |

| 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 |

## FLEX LAB


70
61
53
44
35
26
18
8.8
0
Illuminance
(Fc)


70
61
53
44
35
26
18
8.8
0
Illuminance
(Fc)

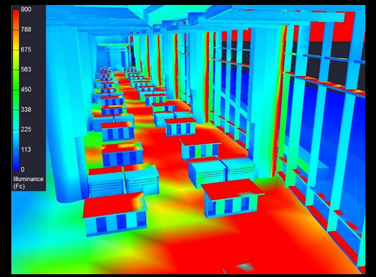



Fritted Glass

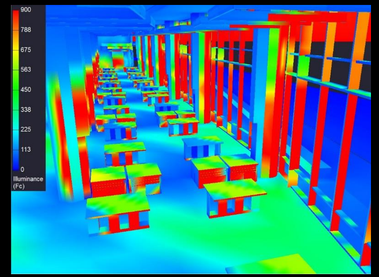
# DAYLIGHTING STUDY

| Glass Type | Description | Manufacturer | Color | Visible Transmittance | Interspace Content | U-Factor | SHGC |
|---|---|---|---|---|---|---|---|
| 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 |

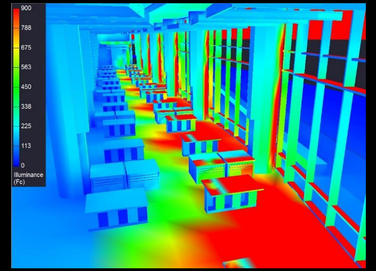
June 21st 9am



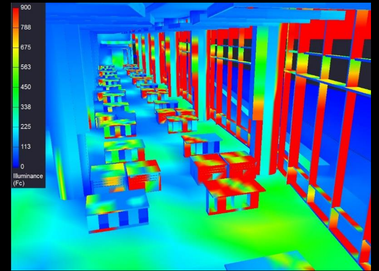

December 21st 9am

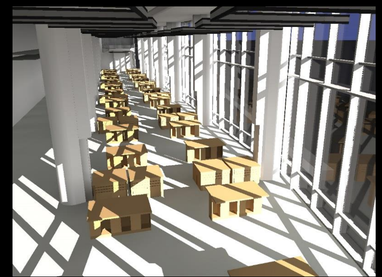



June 21st 10am




December 21st 10am



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

# DAYLIGHTING STUDY

## DGP Values

**BEFORE:**
December 21st 10am: 73%
June 21st 9am: 27%

**AFTER:**
December 21st 10am: 20.8%
June 21st 9 am: 22.3%

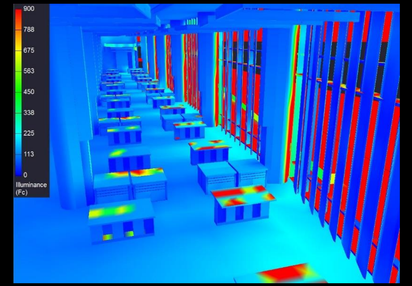
## Existing Daylight Illuminance Values

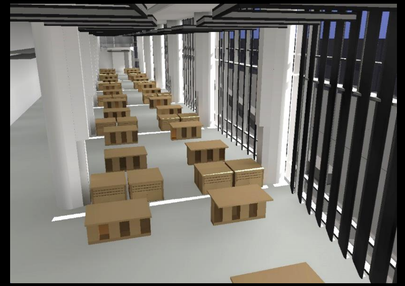
| Date &Time | June 21st 9 am | June 21st 10 am | December 21st 9 am | December 21st 10 am |
|---|---|---|---|---|
| Illuminance on Lab bench max. (fc) | 1695 | 2252 | 471 | 824 |
| Illuminance on Lab bench min. (fc) | 1694 | 87 | 50.3 | 47.2 |
| Illuminance on Lab Bench avg. (fc) | 1695 | 1760 | 156.37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

## Daylight Illuminance Values with Louvers

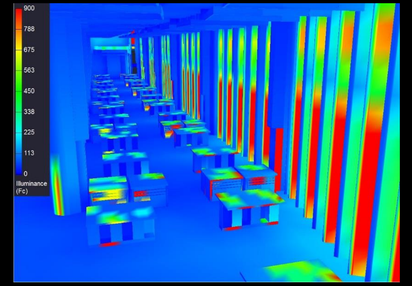
| Date &Time | June 21st 9 am | December 21st 10 am |
|---|---|---|
| Illuminance on Lab bench max. (fc) | 48.3 | 66.5 |
| Illuminance on Lab bench min. (fc) | 41.5 | 46.9 |
| Illuminance on Lab Bench avg. (fc) | 44.3 | 55 |
| Illuminance across space max. (fc) | 2135 | 2870 |
| Illuminance across space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

## June 21st 9am with Louvers



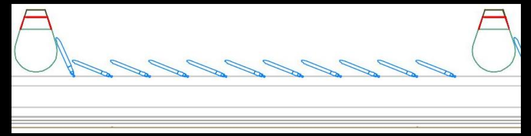



## December 21st 10am with Louvers

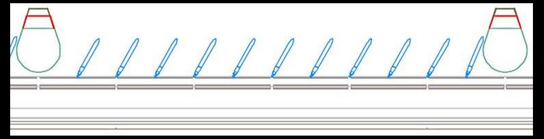



## LOUVER DESIGN

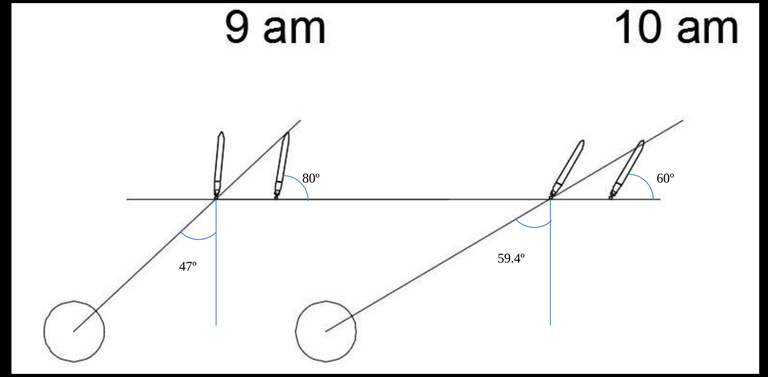
### June 21st louver plan



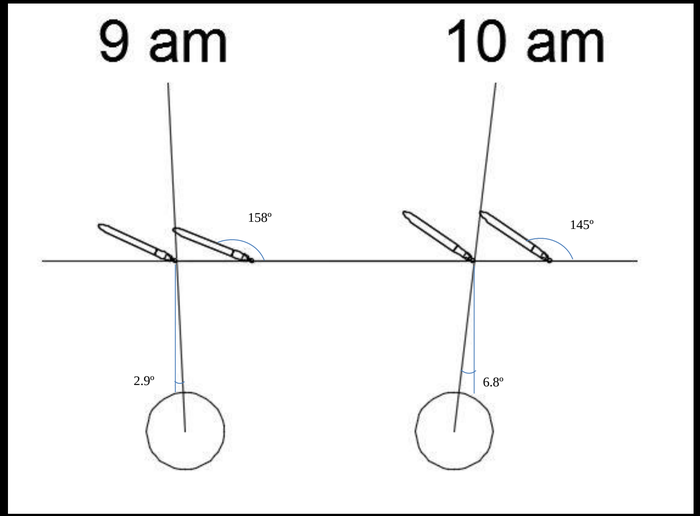
### December 21st louver plan



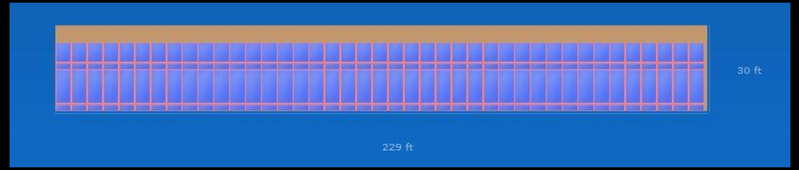
### December 21st angle studies




### June 21st angle studies



# MECHANICAL



## ELECTRICAL

**Panels:** SunPower X-Series Commercial Solar Panels (SPR-X21-345-COM)

Runs on 1000 V system

**Inverter:** Sunny Tripower 30000TL-US

Holds 30800 W on a 1000 V system

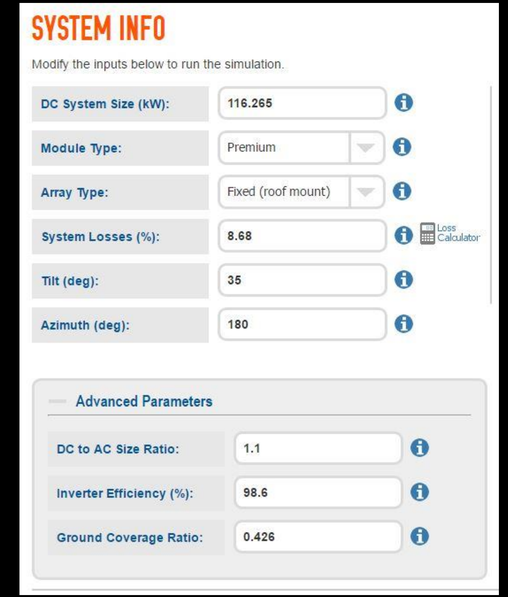
(Need 4 total inverters for panel array)

**Electricity Cost:** Based on the Bureau of Labor Statistics 2016 monthly electricity prices for 2015

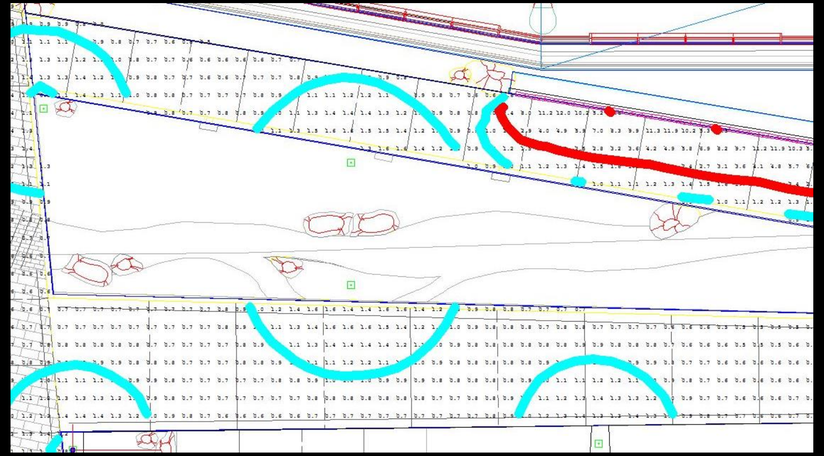
**$0.13**

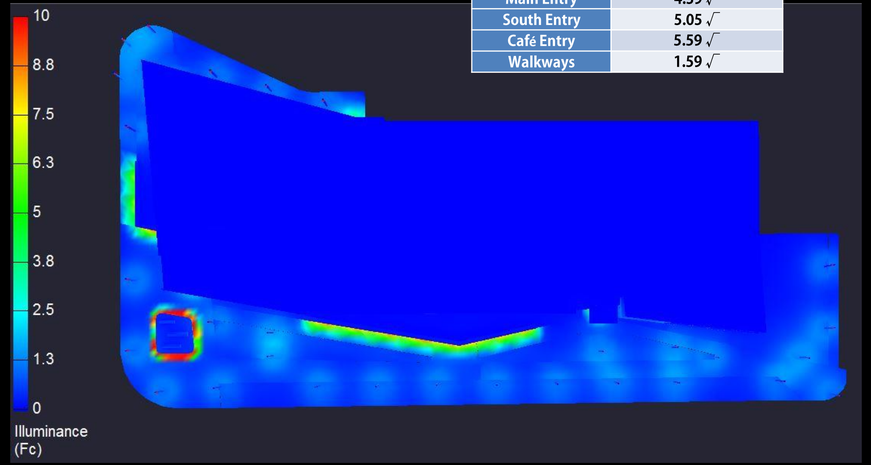
**Warranty:** SunPower guarantees 25 year warranty

**PVWatts:** National Renewable Energy Laboratory (NREL)

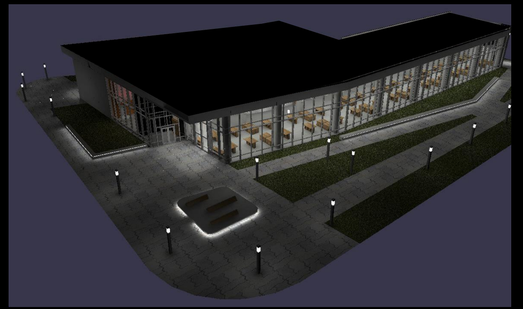


# EXTERIOR
# PLAZA

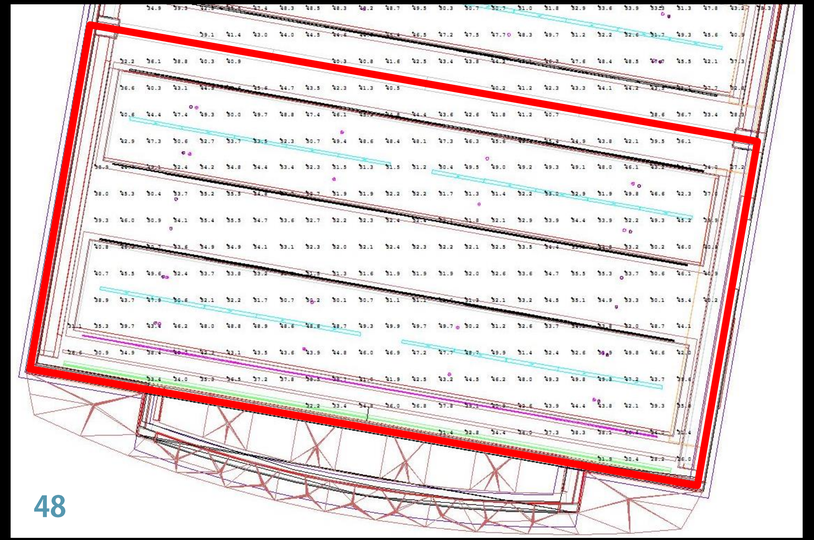


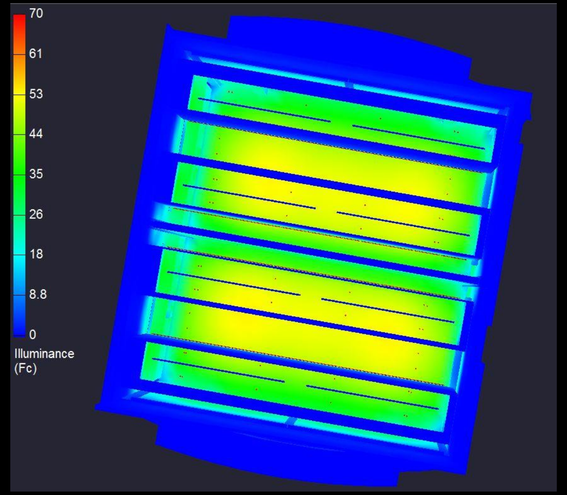



| Calculation Area | Average Illuminance (fc) |
|---|---|
| Main Entry | 4.39 √ |
| South Entry | 5.05 √ |
| Café Entry | 5.59 √ |
| Walkways | 1.59 √ |



# FLEX CLASSROOM






| Calculation Area | Values (fc or uniformity) |
|---|---|
| Floor | 52.62 √ |
| Floor Uniformity | 1.83 :1 √ |
| Vertical near presenter | 16.4 √ |