

Virginia Tech - Basketball Practice Facility
Blacksburg, VA



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April 14, 2010
Professors Houser and Dannerth

Project Scope

1. Electrical Depth
 - 1.1 Feeder Cost Analysis
 - 1.2 SKM Analysis

2. Lighting Depth
 - 2.1 Outdoor Space – Façade
 - 2.2 Circulation Space – Lobby
 - 2.3 Large Work Space – Gymnasium
 - 2.3.1 M.A.E Daylighting Analysis
 - 2.3.2 Structural Breadth*
 - 2.3.3 Mechanical Breadth
 - 2.4 Special Purpose Space – Lounge and Locker Room*

*Not included in presentation

Presentation Outline

- 1. Introduction**
2. Feeder Cost Analysis
3. SKM Analysis
4. Lighting Overview
5. Façade
6. Lobby
7. Gymnasium
 - 7.1 Lighting
 - 7.2 Mechanical
8. Conclusion

Introduction

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Building Background

Location	Blacksburg, VA
Size	50,000 ft ²
Cost	\$21 million
Construction Dates	April 2008 – August 2009
Delivery Method	Design – Bid - Build
Architect	Cannon Design
Associate Architect	Ballou Justice Upton
General Contractor	Whiting Turner
Lighting Consultants	Atelier Ten USA LCC

Location



Coordinates: 37° 13' 48" N 80° 25' 4" W
Orientation: 31° West of True North

www.maps.google.com

Feeder Cost Analysis

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Overview

- Determine if substituting aluminum feeders for copper feeders will provide cost savings
- Consider increase conductor and conduit and conduit size
- Obtain cost data from RSMMeans *Buidling Construction Cost Data*

Sample Calculation

Example Feeder: 1LNH1 to 2LNH1
1 Set 3PH 1N 1G, 100'

	Copper	Aluminum	Cost Difference
Phase Conductor	4/0 AWG	350 KCMIL	
Cost	\$1,365	\$960	-\$293
Neutral Conductor	4/0 AWG	350 KCMIL	
Cost	\$455	\$320	-\$98
Ground Conductor	4 AWG	6AWG	
Cost	\$118	\$105	-\$38
Conduit	1-1/2"	1-1/2"	
Cost	\$1,035	\$1,595	+\$560
Total:			+\$7

Total Cost Analysis

Phase Conductors	\$60,723.74	\$39,699.92
Neutral Conductors	\$14,385.83	\$9,511.31
Ground Conductors	\$6,331.57	\$4,992.70
Conduit	\$48,304.63	\$82,569.91
Total:	\$129,745.77	\$136,773.84

Total Cost Increase = \$7,028.07

Switching to aluminum feeders does not provide and cost savings, therefore use copper.

SKM Systems Analysis

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Design Goals

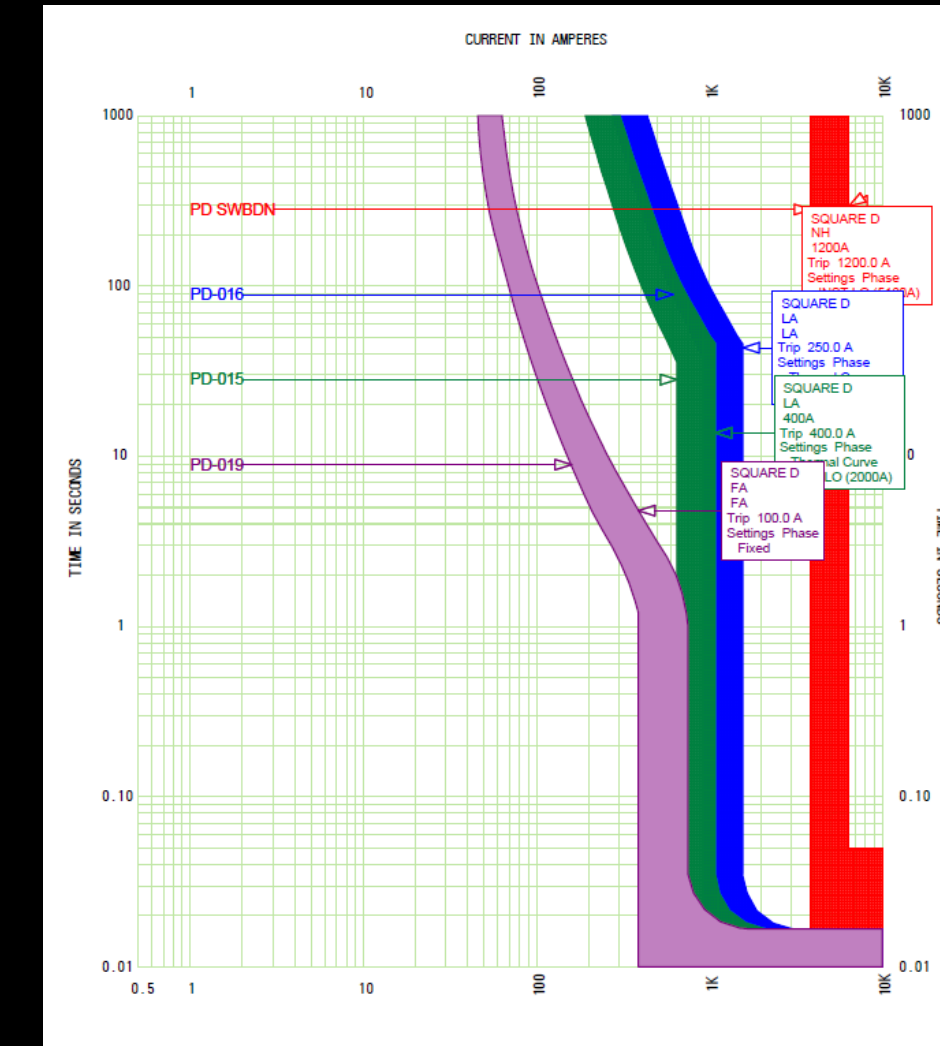
- Analyze electrical distribution system
- Comprehensive short circuit analysis, arc fault study, and protective device coordination

Arc Flash Analysis

Arc Flash Evaluation IEEE 1584 - 2002/2004a Edition Bus + Line Side Report (Include Line Side + Load Side Contributions) Project: VT BASKETBALL, Base Project

	Bus Name	Protective Device Name	Bus kV	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/Delay Time (sec.)	Breaker Opening Time (sec.)	Ground	Equip Type	Gap (mm)	Arc Flash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	Required Protective FR Clothing Category	Label #
1	B-SWBDN-1	PD SWBDN	0.480	19.15	11.43	17.18	10.25	0.05	0.000	Yes	PNL	25	24	18	1.9	Category 1	# 0002
2	B-SWBDN-1	PD-011	0.480	19.15	11.43	0.36	0.22	0.083	0.000	Yes	PNL	25	25	18	2.1	Category 1	
3	B-SWBDN-1	PD-012	0.480	19.15	11.43	1.61	0.96	0.083	0.000	Yes	PNL	25	25	18	2.1	Category 1	
4	B-SWBDN-1 (PD SWBDN LineSide)	PD SWBDN	0.480	19.15	11.43	1.98	1.18	0.083	0.000	Yes	PNL	25	33	18	3.2	Category 1 (*N2)	
5	B-SWBDN-1 (PD SWBDN LineSide)	MaxTripTime @2.0s	0.480	19.15	11.43	17.18	10.41	2	0.000	Yes	PNL	25	214	18	70	Dangerous! (*N2) (*N9)	# 0002

Protective Device Coordination Study



Lighting Overview

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Overview

- Highlight architectural elements of the building
- Complement the interior design
- Use energy efficient design solutions
- Create an environment comfortable for the athletes and that can be used as a recruiting tool for potential players

Façade

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Design Goals

- Draw visitors into the building
- Illuminate the surfaces within the lobby so that it glows from within
- Highlight building materials – bring out the texture of the “Hokie Stone”

Design Criteria

- LPD = 5 W/ft

Entrance Façade



Courtesy Canon Design

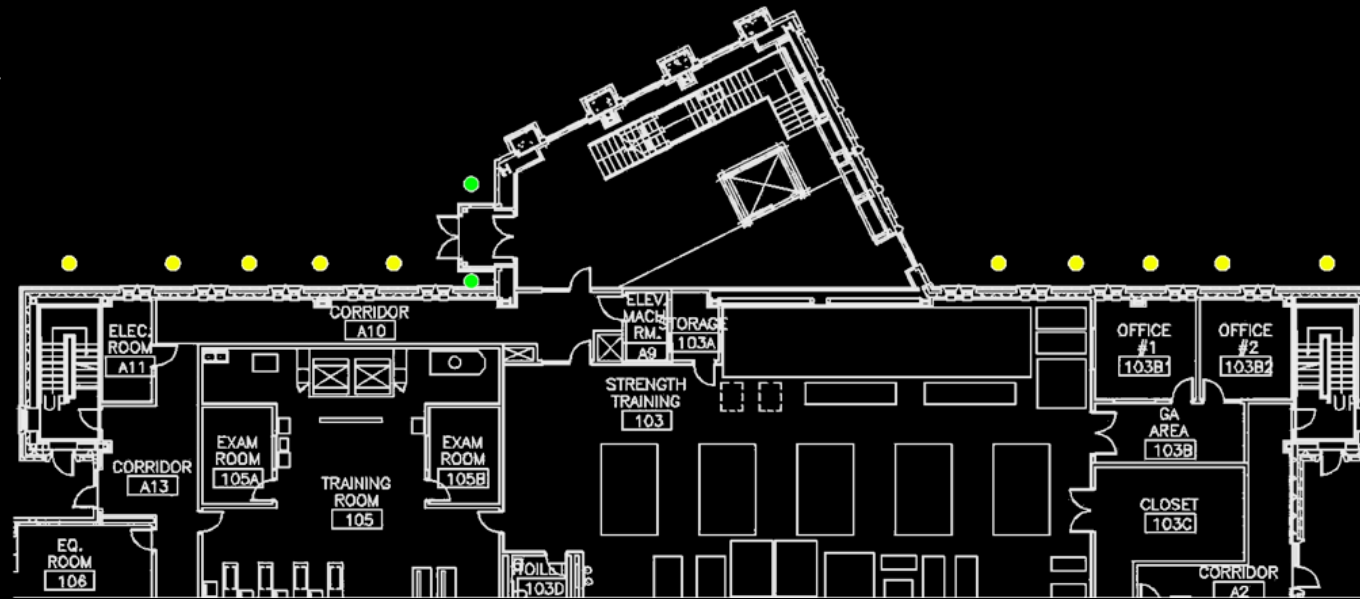
“Hokie Stone”



<http://www.viriniaplaces.org/>





Façade

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Lighting Power Density = 2.6 W/ft

Luminaires

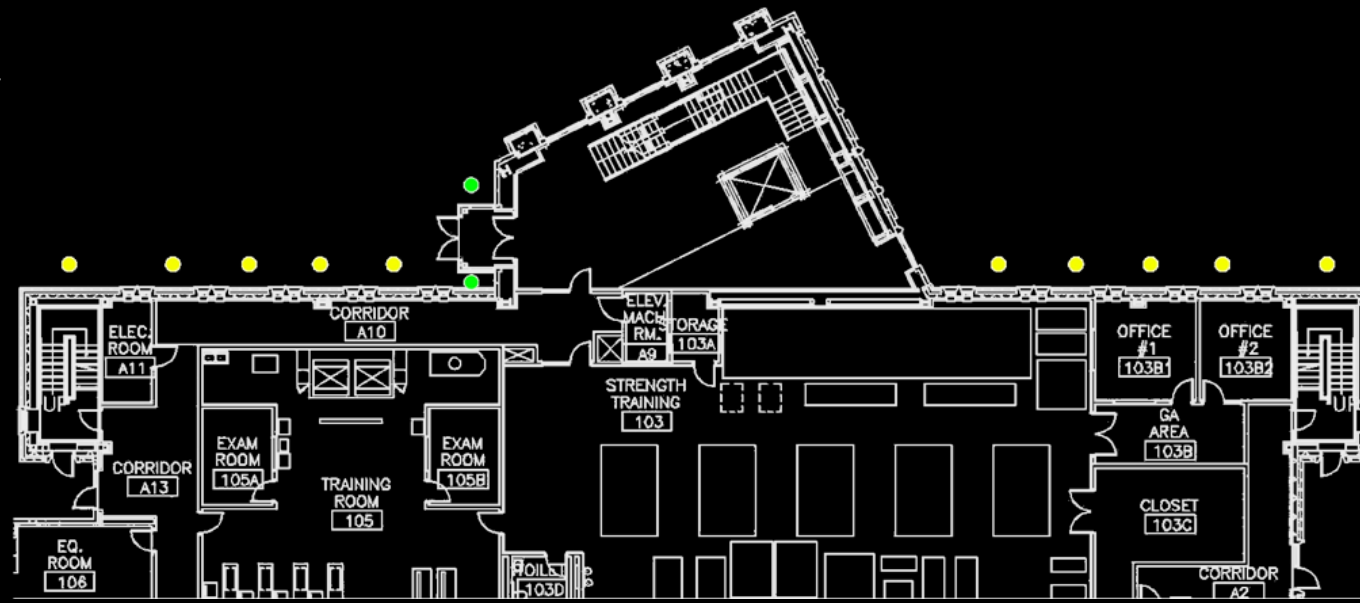
-   In-ground wall washer 20W/842 T4 Metal Halide Lamp
-   In-ground wall washer 35W/842 T4 Metal Halide Lamp

Façade

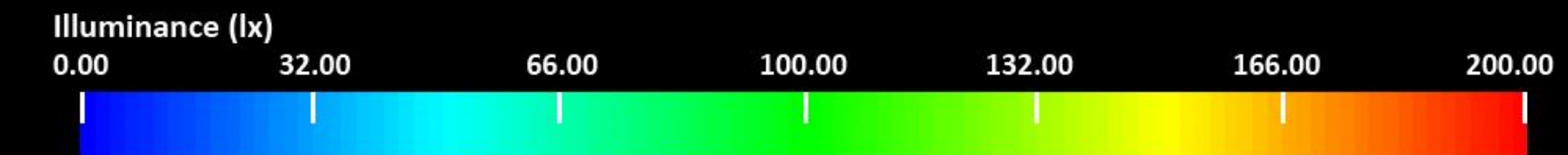
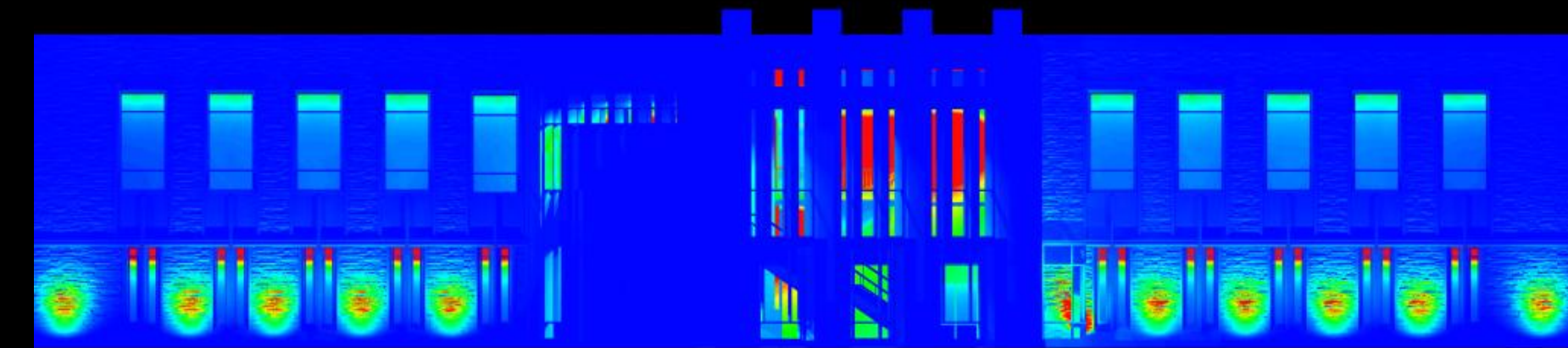
Entrance Rendering

Façade False Color - Illuminance

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Lighting Power Density = 2.6 W/ft

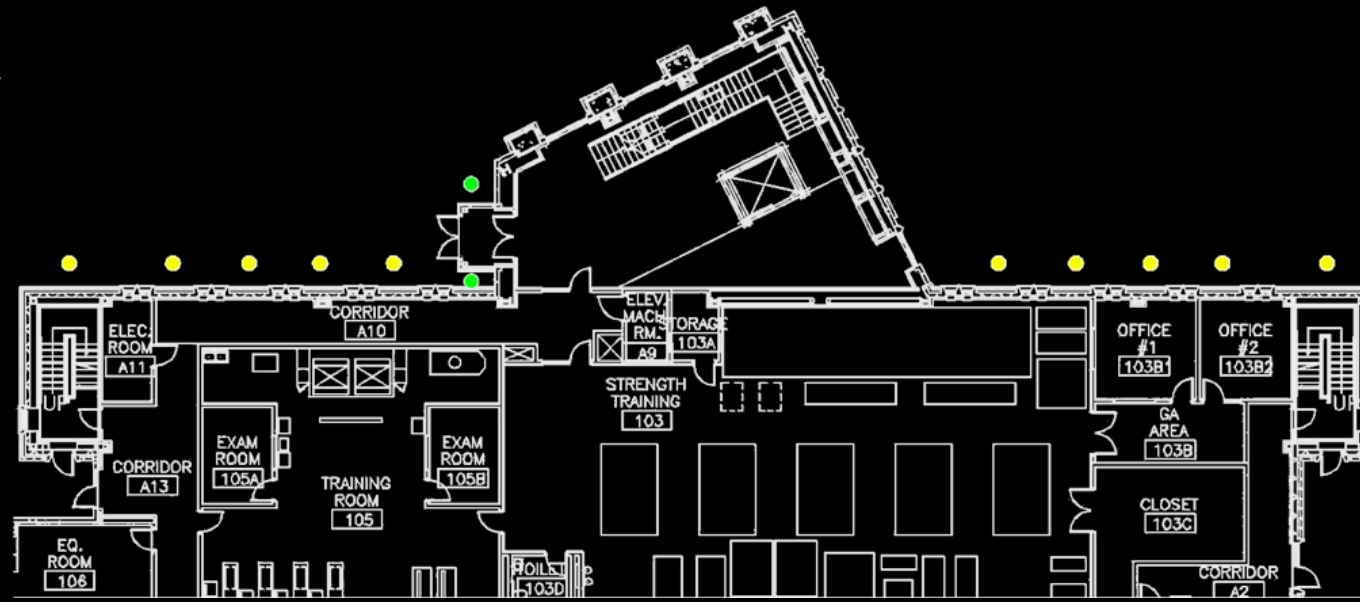


Façade

Entrance Rendering

Entrance Rendering

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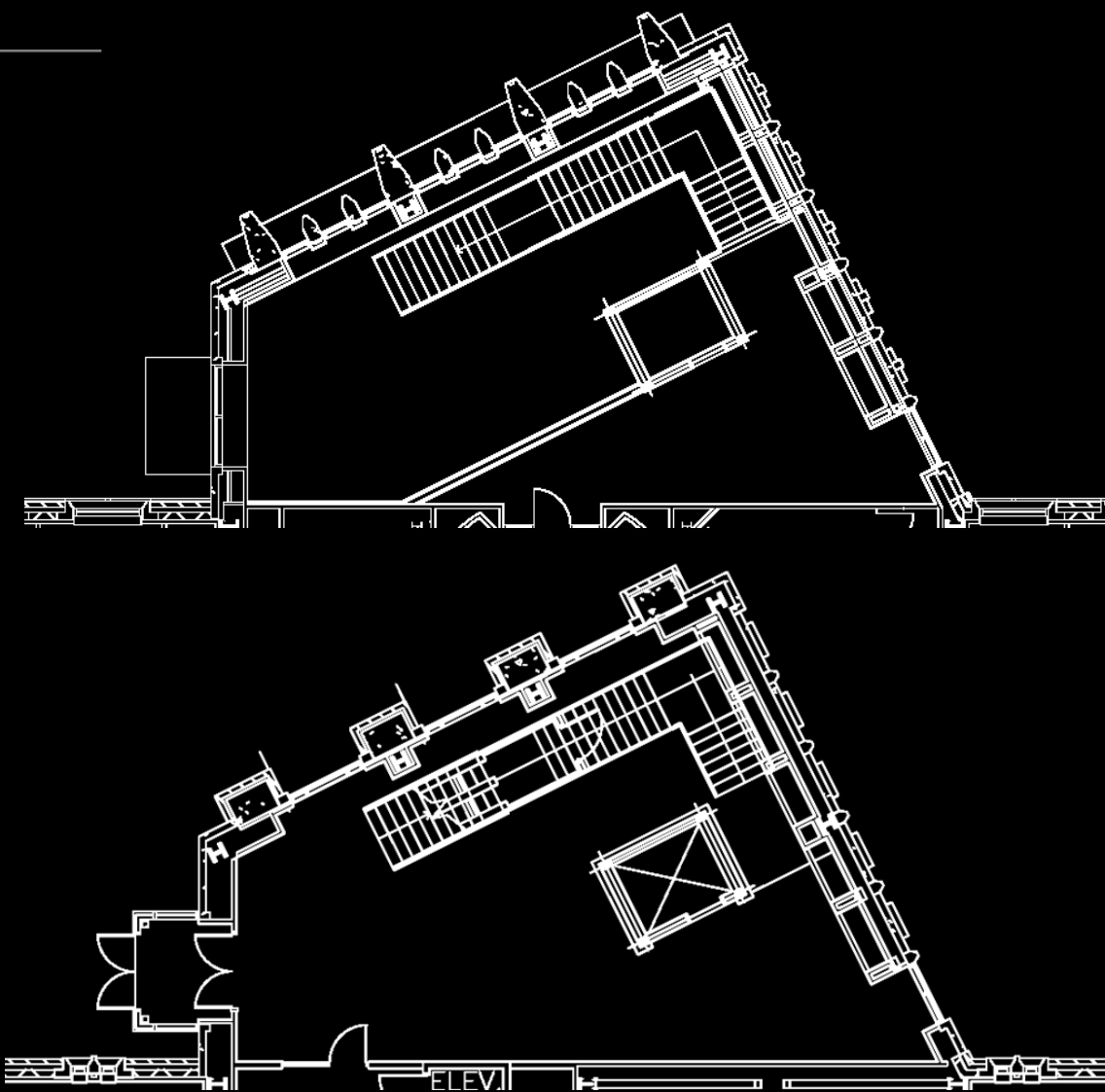


Lighting Power Density = 2.6 W/ft

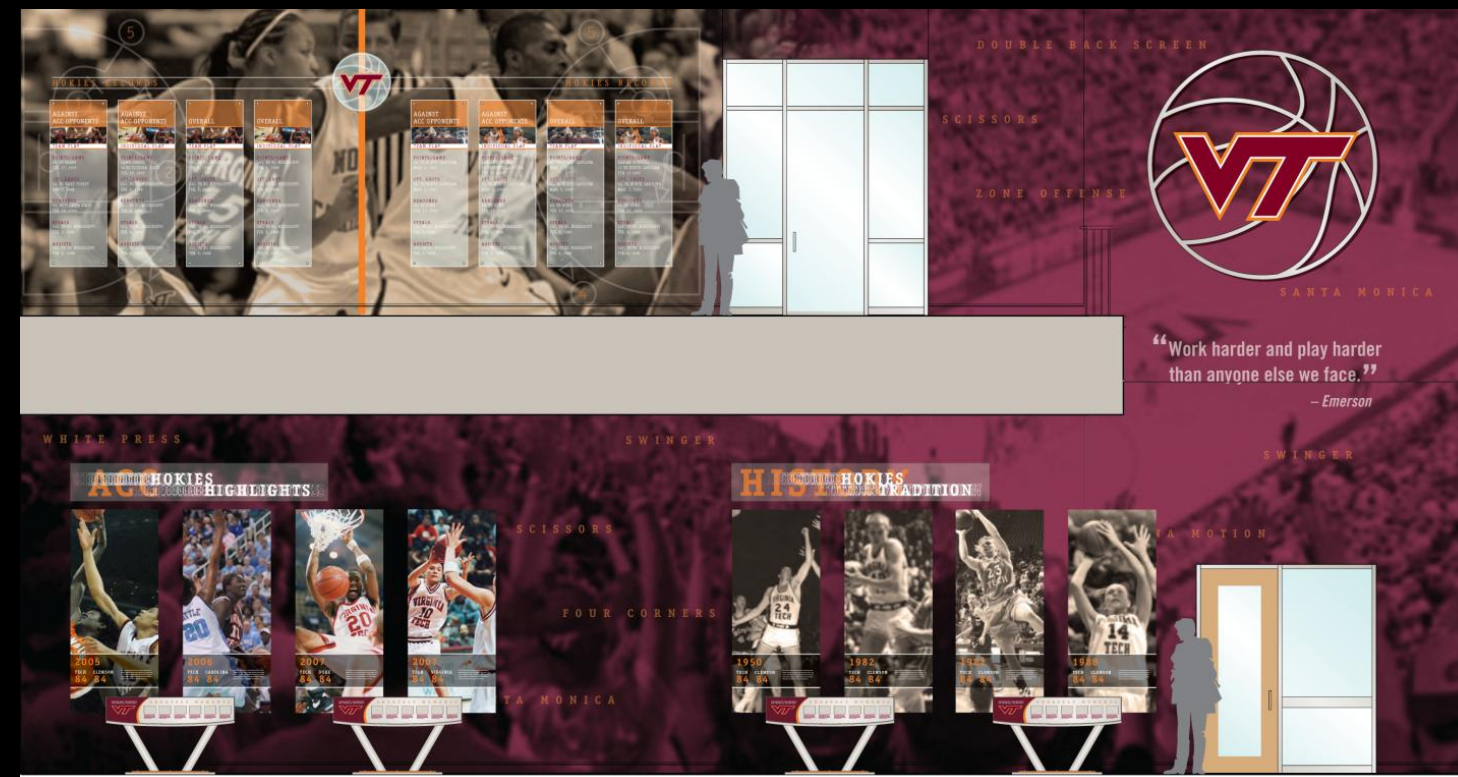


Lobby

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Lobby Graphics – South Wall



Lobby Graphics – East Wall



Lobby

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Design Goals

- Highlight the graphics in the space to celebrate the tradition of Virginia Tech Basketball
- Orient visitors to circulation of the building
- Illuminate wall surfaces to create glow from within

Design Criteria

- Horizontal Illuminance = 100 lux
- LPD = 1.1W/ft²

Lobby Graphics – South Wall

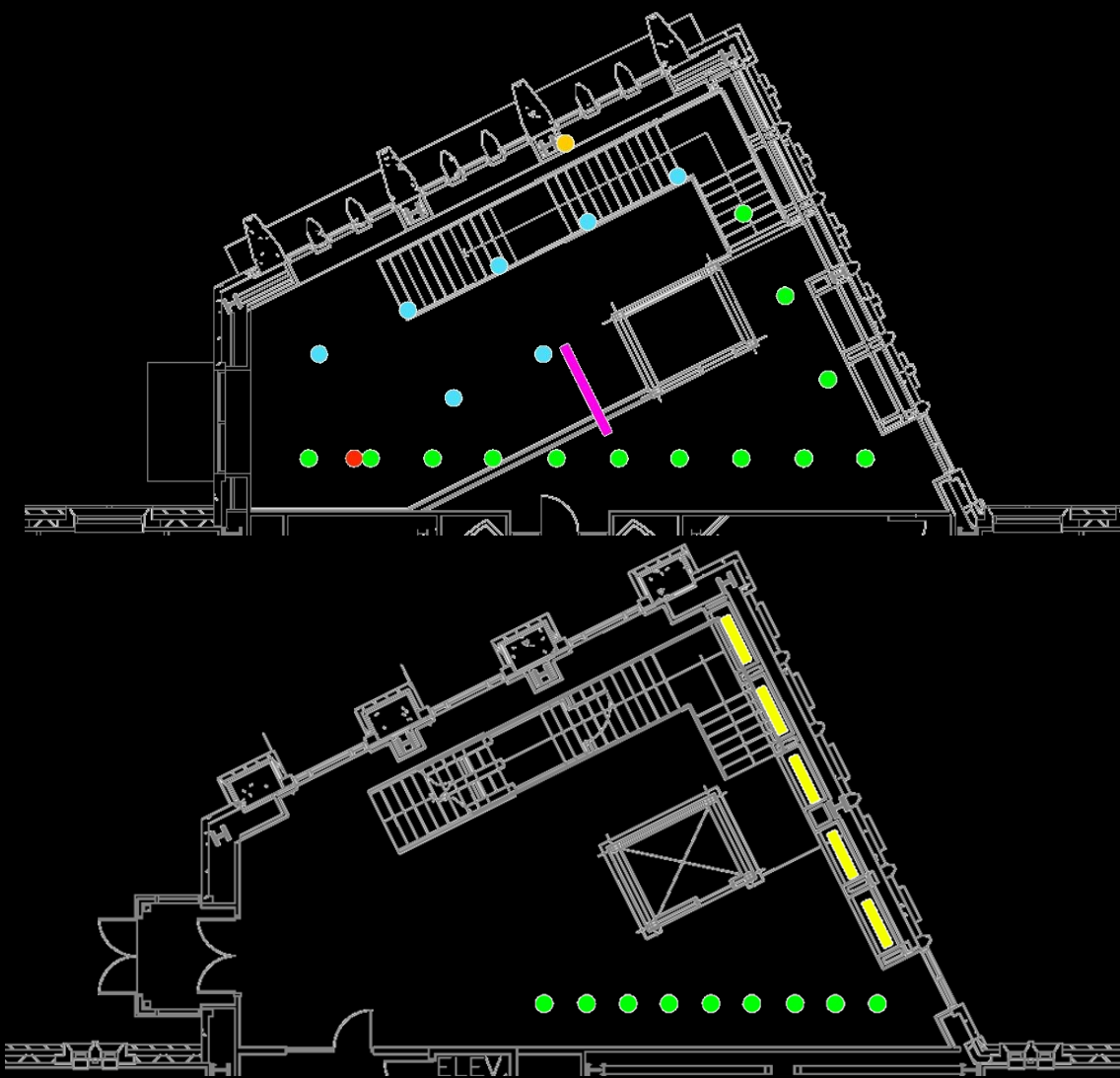


Lobby Graphics – East Wall



Lobby

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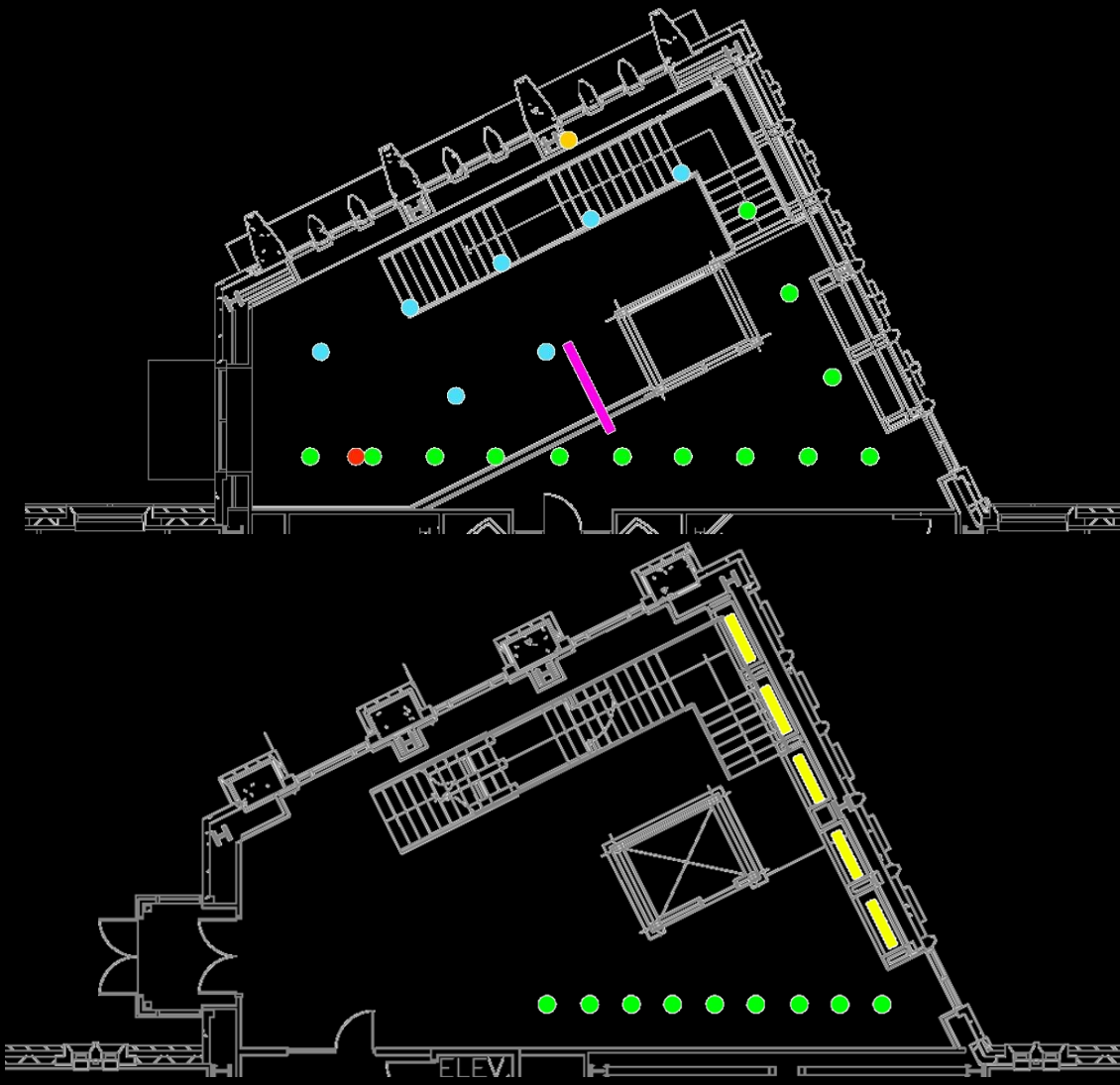
Lighting Power Density = 1.09 W/ft²

Luminaires

		Wall Slot	FO32/841 Linear Fluorescent
		Recessed Wall Washer	(2) CF32DT 841
		Recessed Downlight	35W/842 T4 Metal Halide
		Surface Mounted Spot Light	35W/842 T4 Metal Halide
		Recessed Spot Light	35W/842 T4 Metal Halide
		Recessed Wall Washer	FP28/841 Linear Fluorescent

Lobby

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Lighting Power Density = 1.09 W/ft²

Lobby Rendering

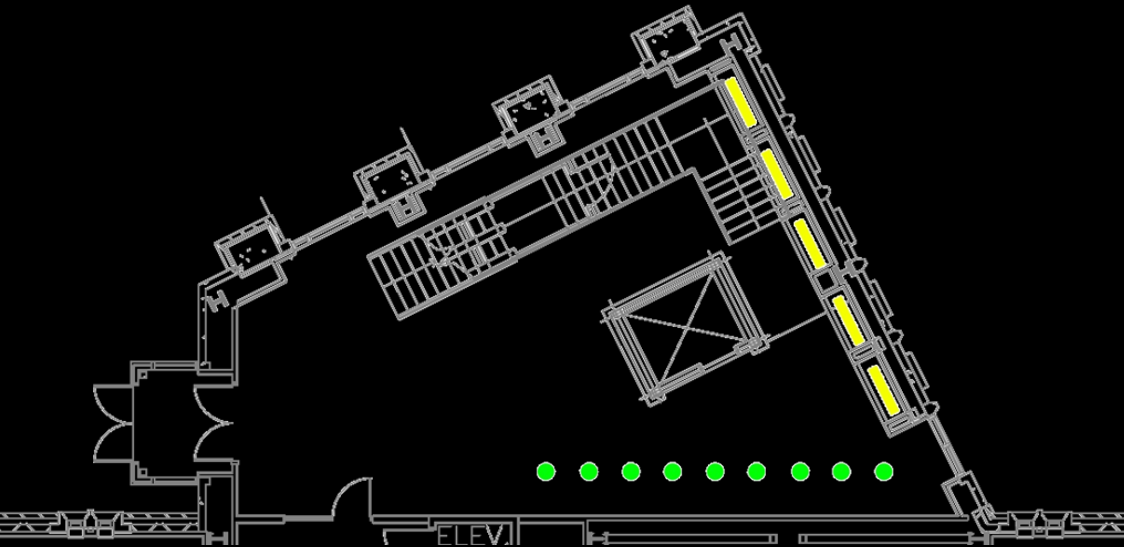
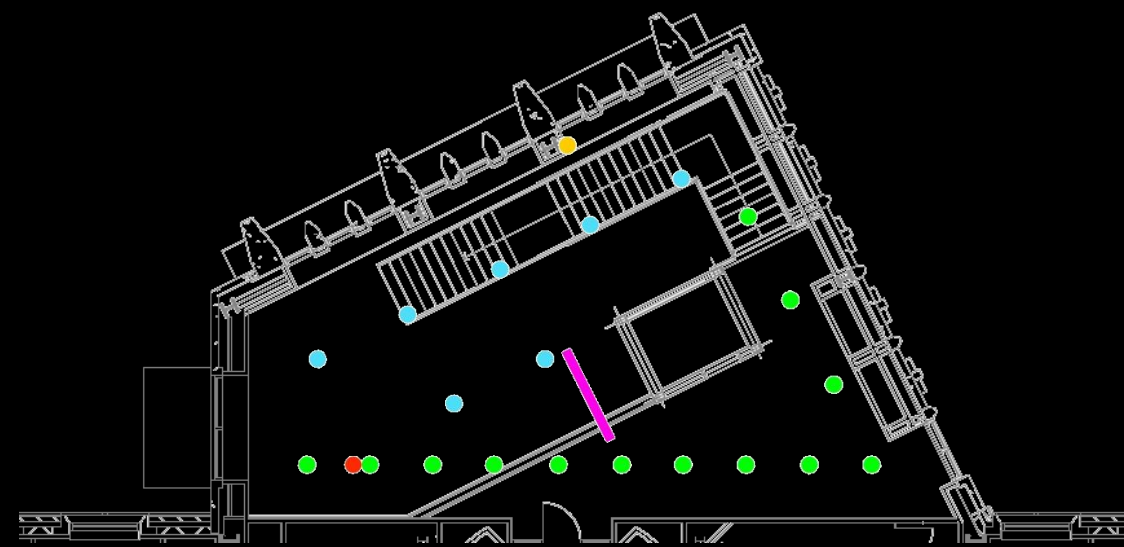


Lobby Rendering



Lobby

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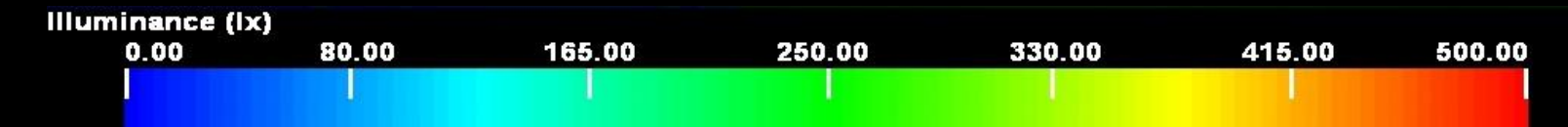
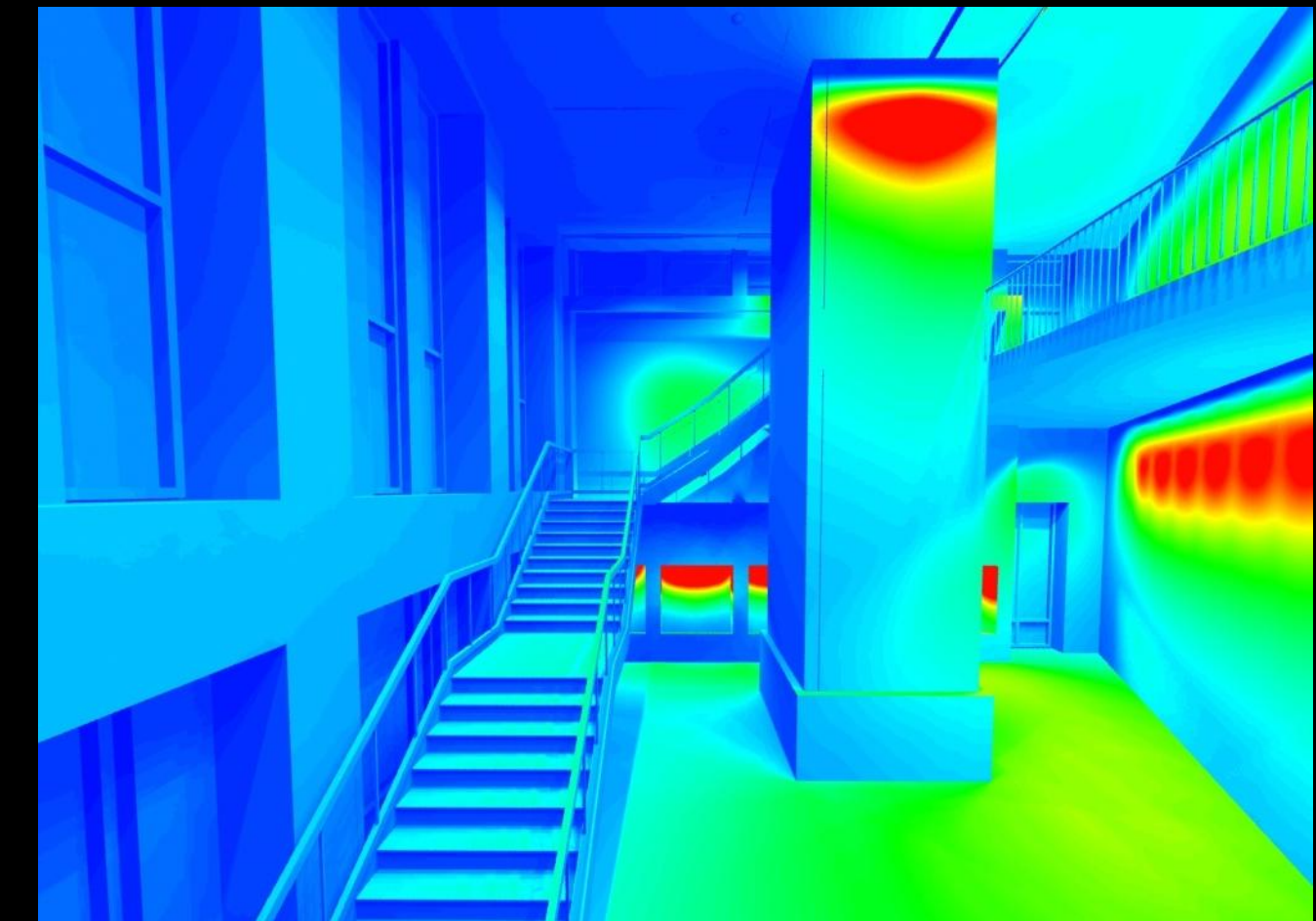


Lighting Power Density = 1.09 W/ft²

Lobby Rendering

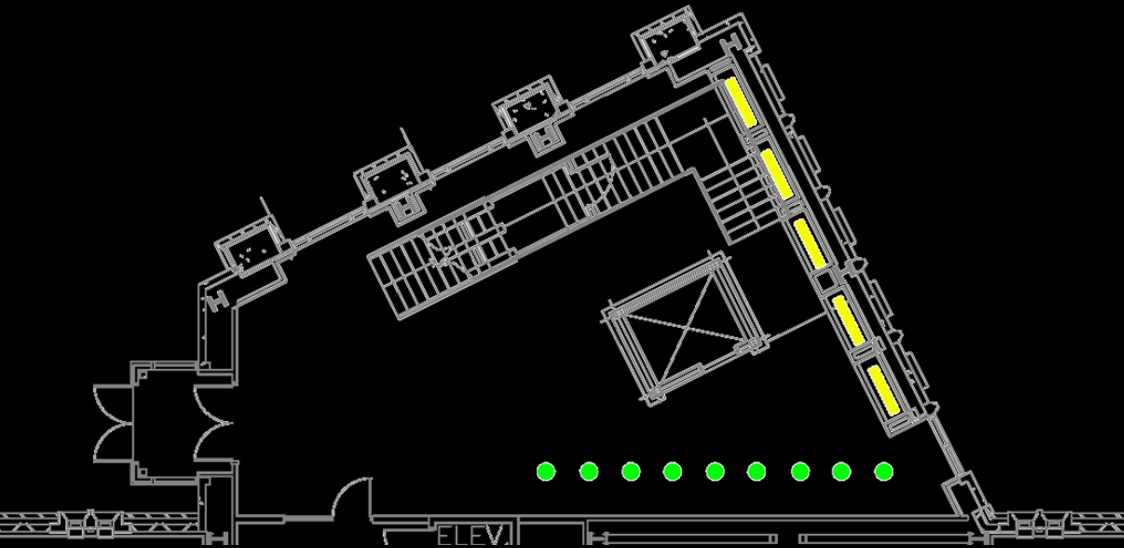
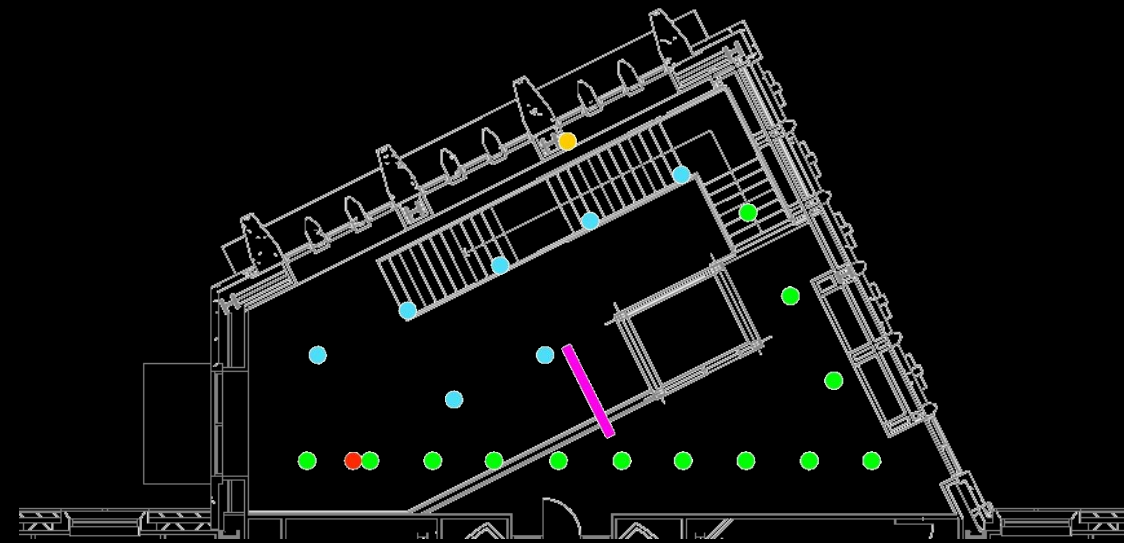


Entrance False Color - Illuminance



Lobby

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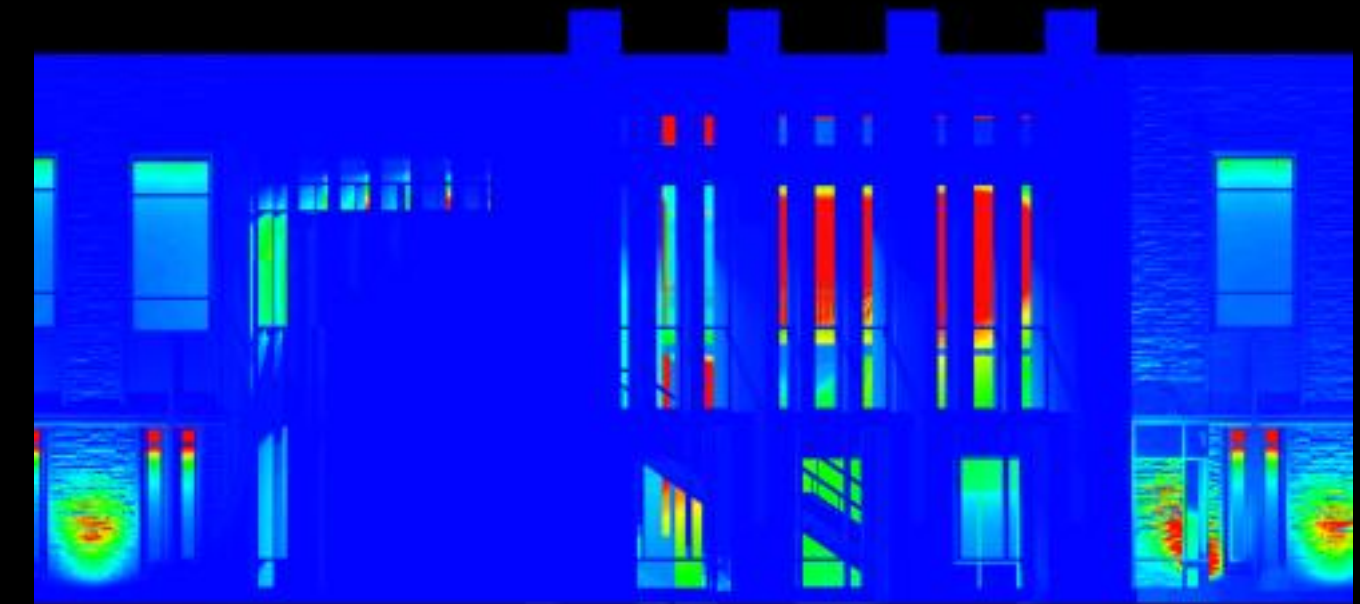


Lighting Power Density = 1.09 W/ft²

Lobby Rendering

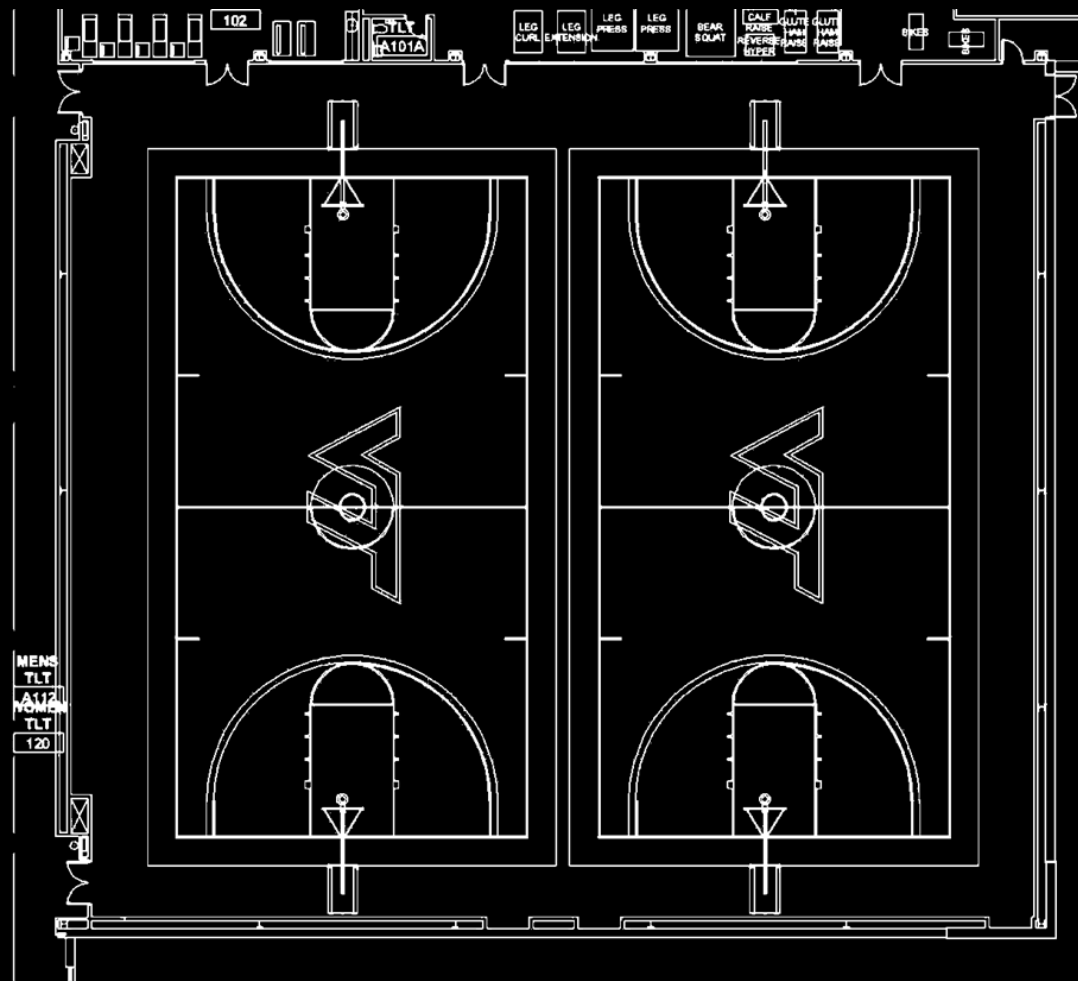


View From Exterior – False Color



Gymnasium

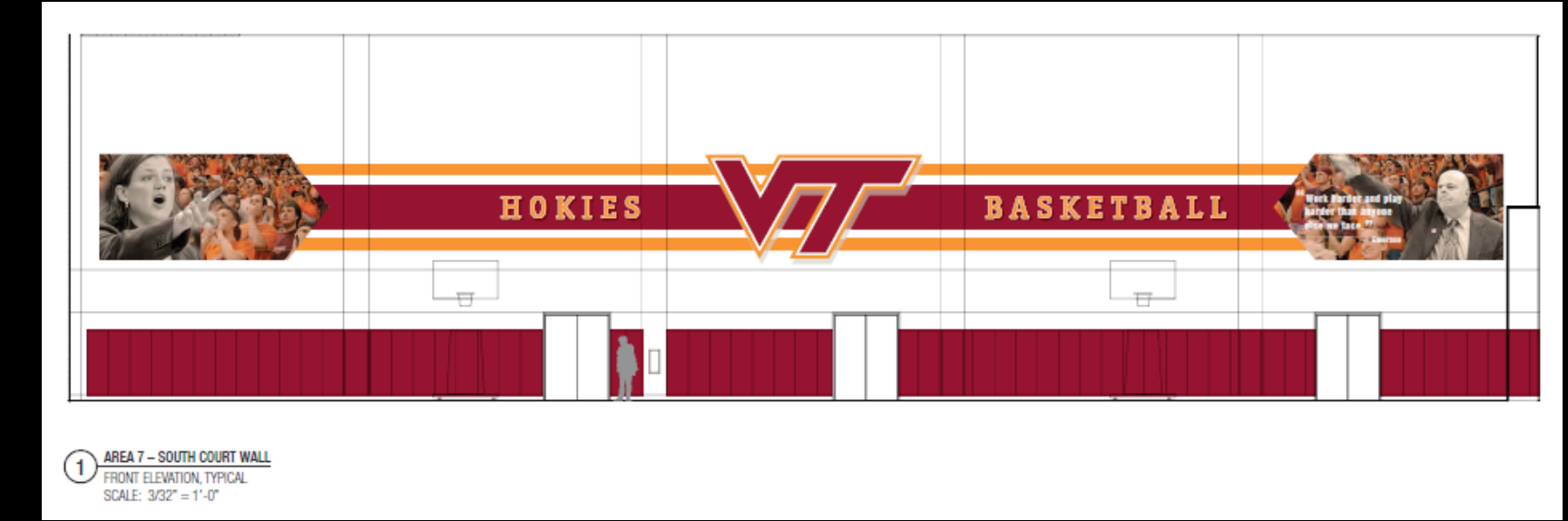
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Gymnasium Graphics – East Wall



Gymnasium Graphics – South Wall



Gymnasium - Lighting

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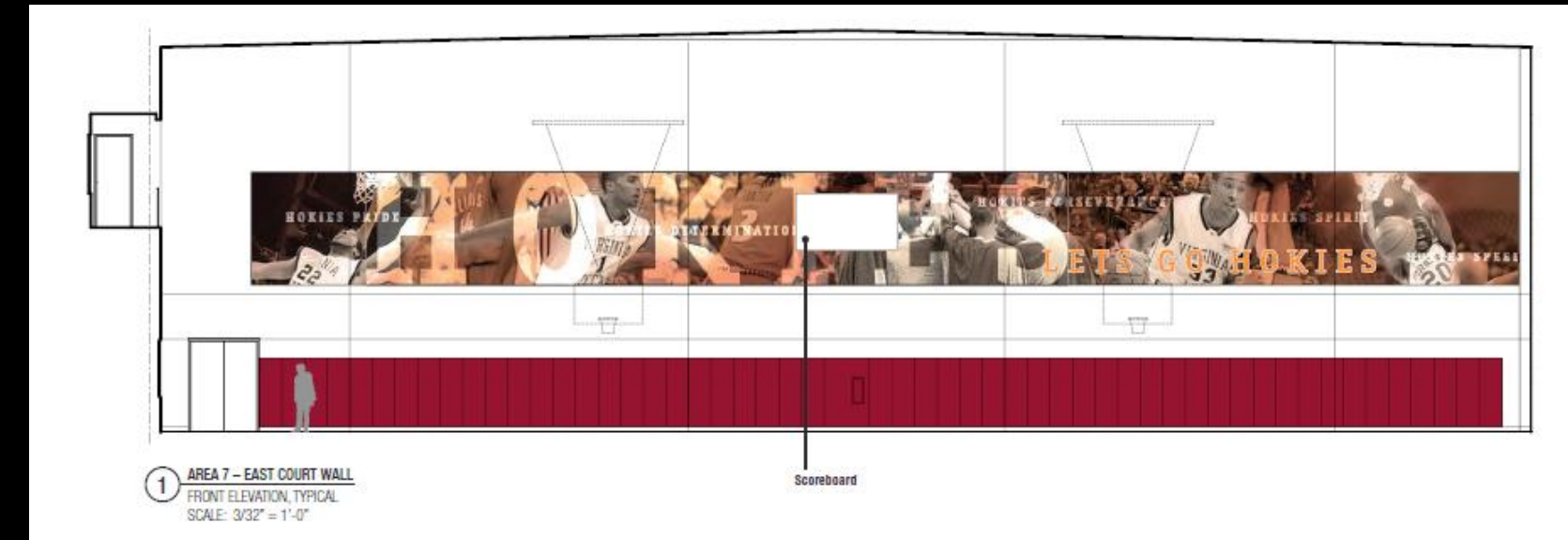
Design Goals

- Bring daylight into the space to reduce energy use while maintaining appropriate light levels for basketball playing

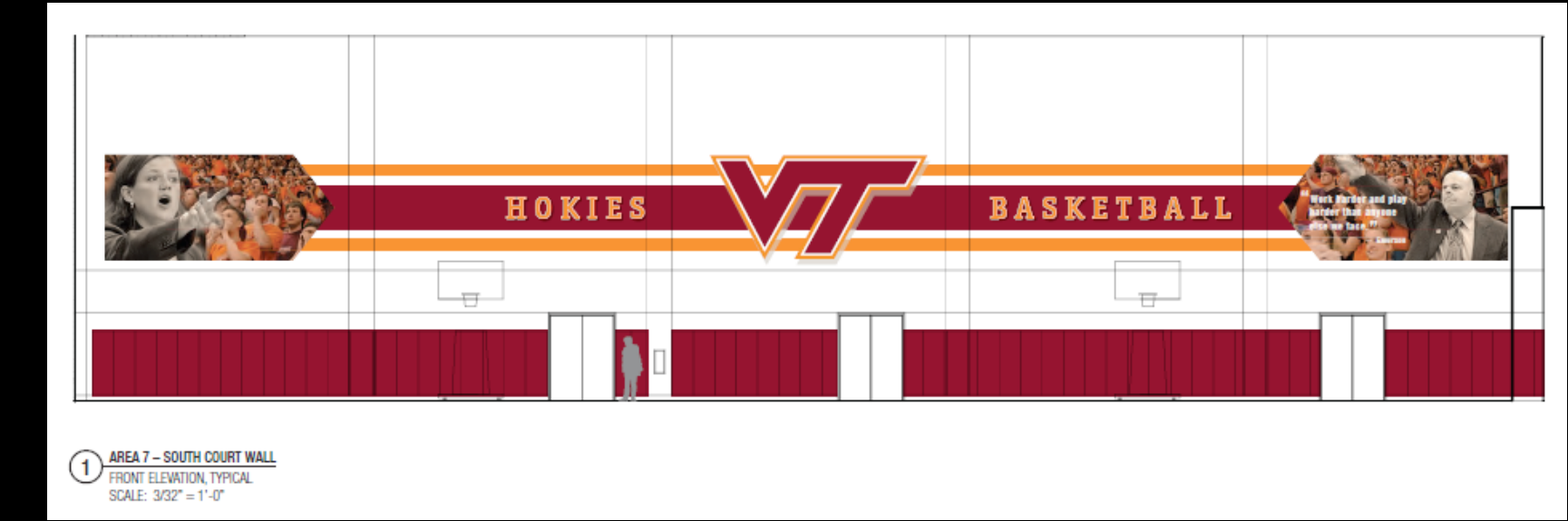
Design Criteria

- Horizontal Illuminance = 800 lux
- Illuminance Uniformity
 - CV= 0.21
 - E_{max}/E_{min} =2.5:1 or less
- LPD =2.3 W/ft²

Gymnasium Graphics – East Wall



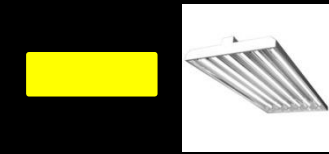
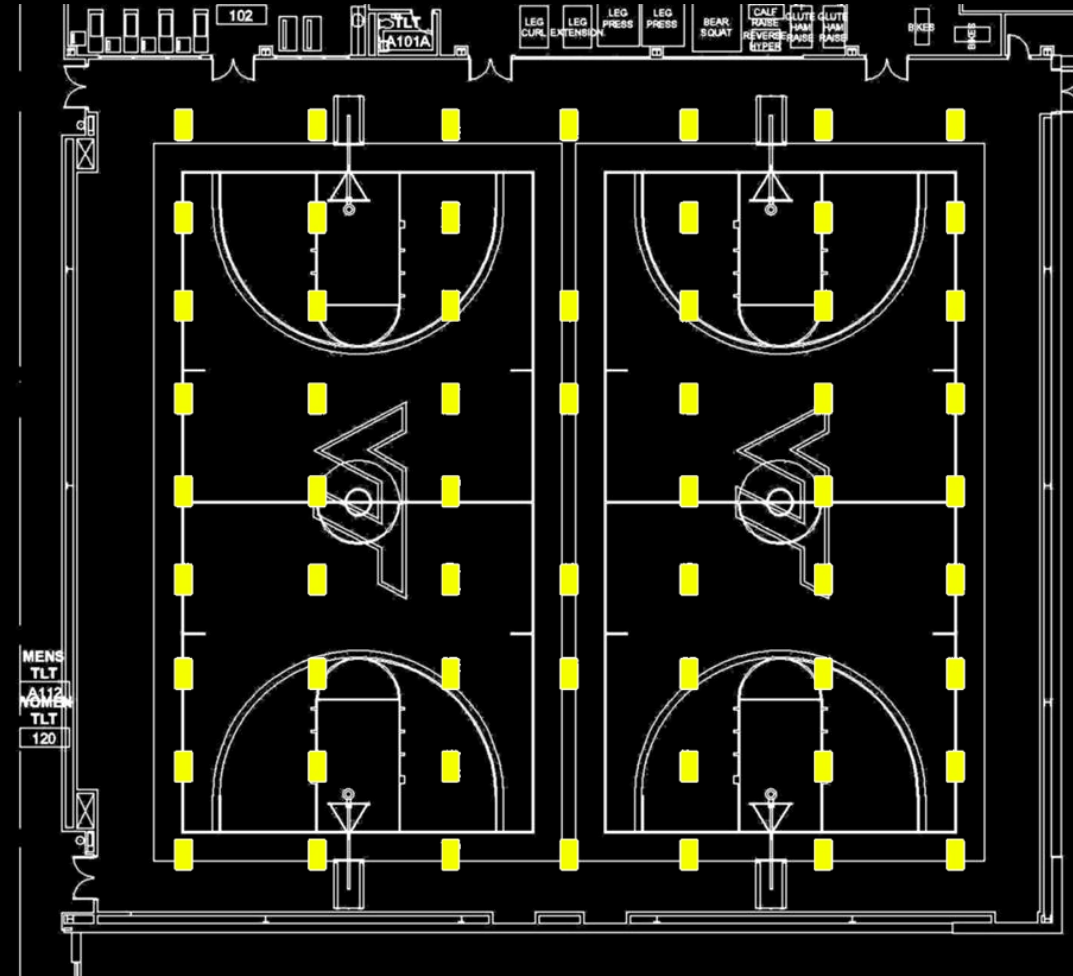
Gymnasium Graphics – South Wall



Gymnasium – Electric Lighting

Luminaires

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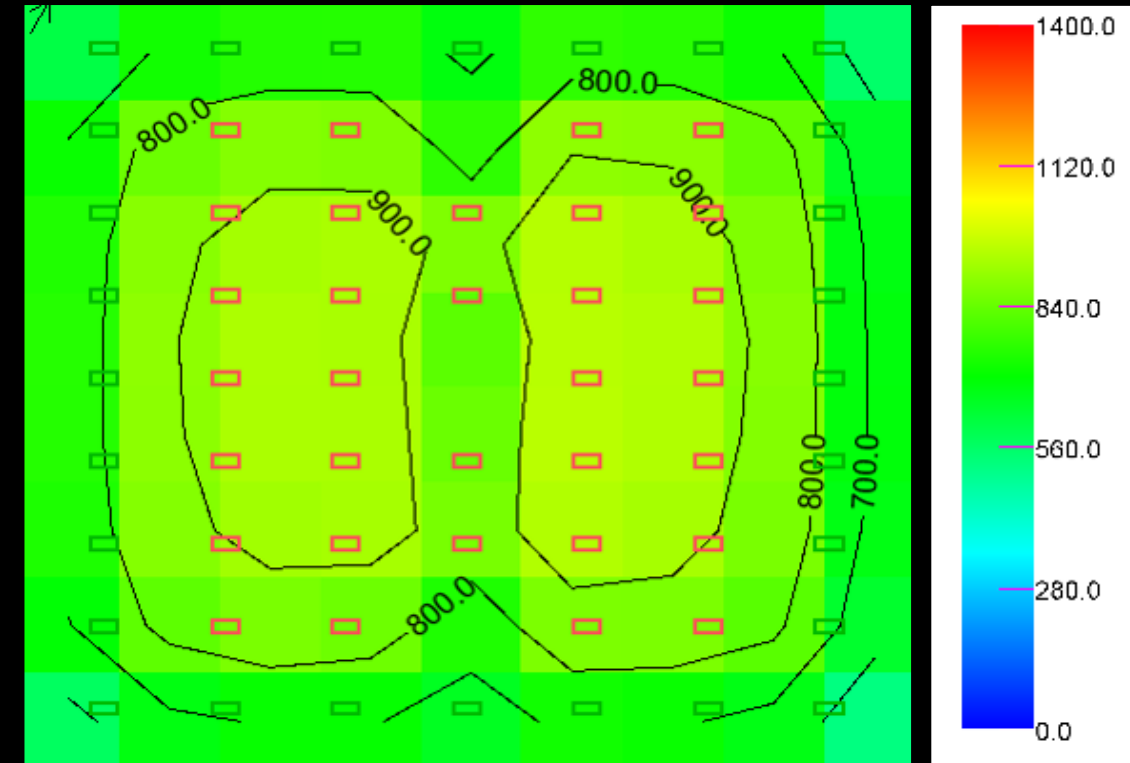
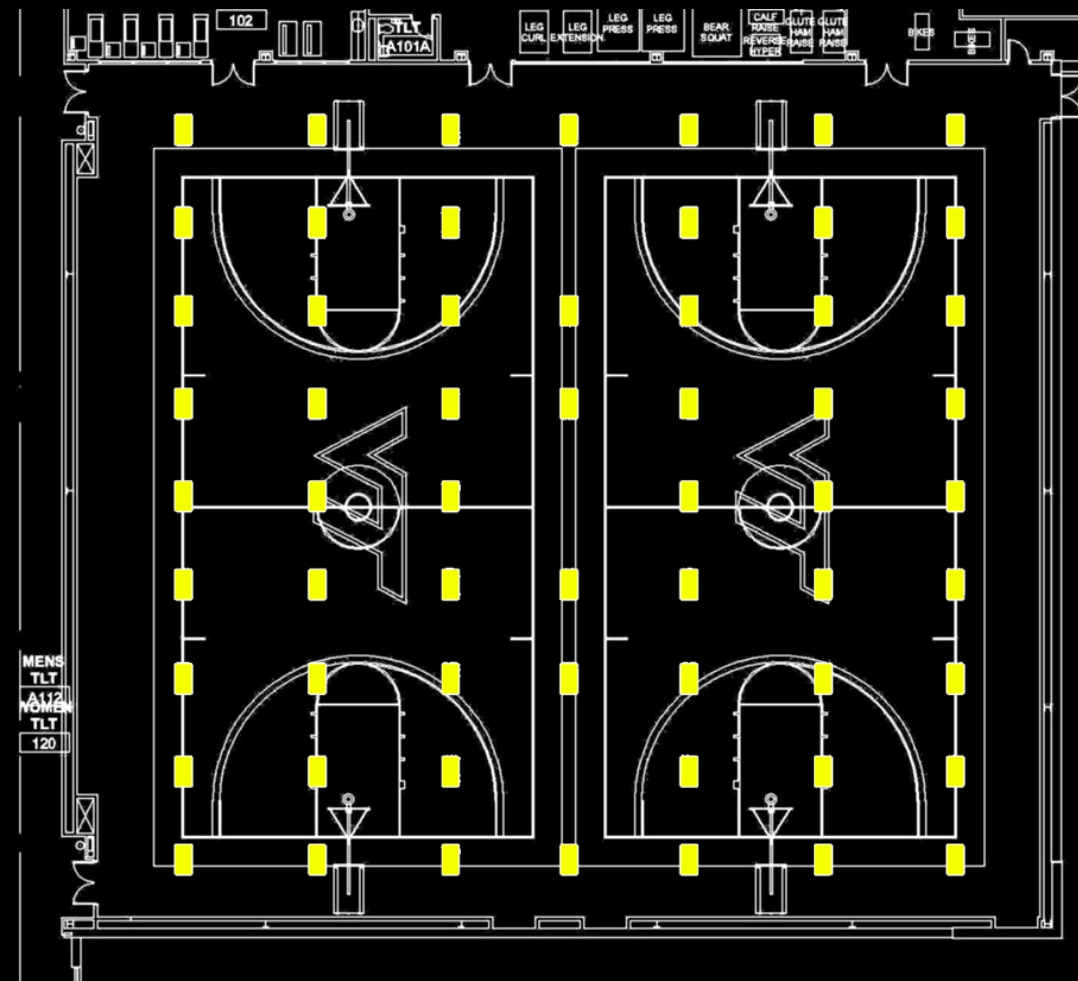


High Bay With Protective Cage (6) FP 54T5HO 841

Gymnasium – Electric Lighting

Electric Light Levels (lux)

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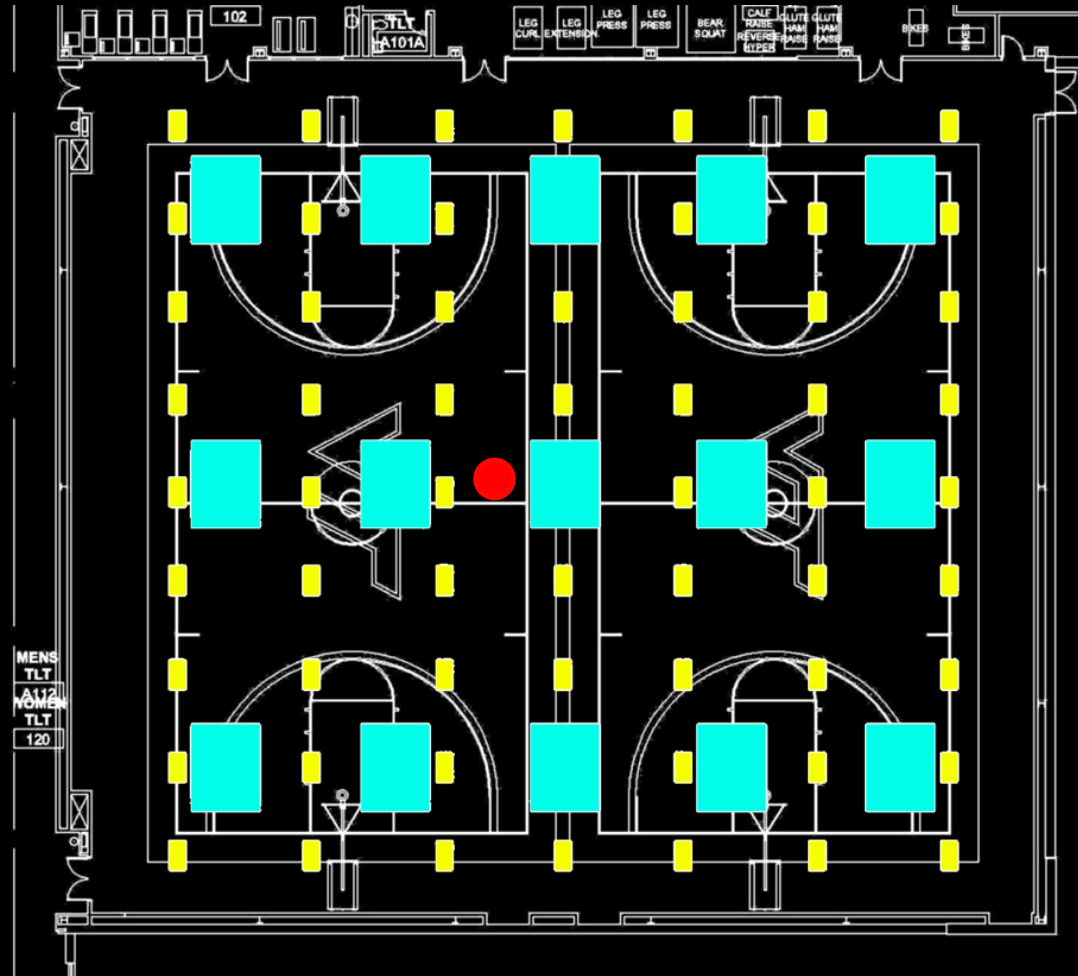
$E_{Average}$	877 lux
E_{max}/E_{min}	1.52
C.V.	0.09
LPD	1.35 W/ft ²

Gymnasium – M.A.E - Daylighting

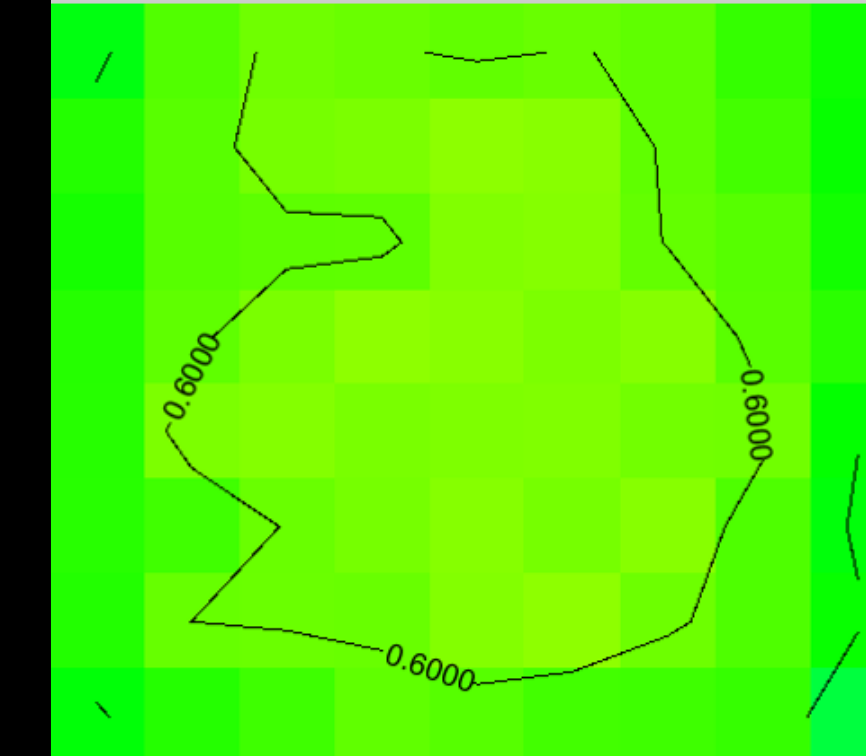
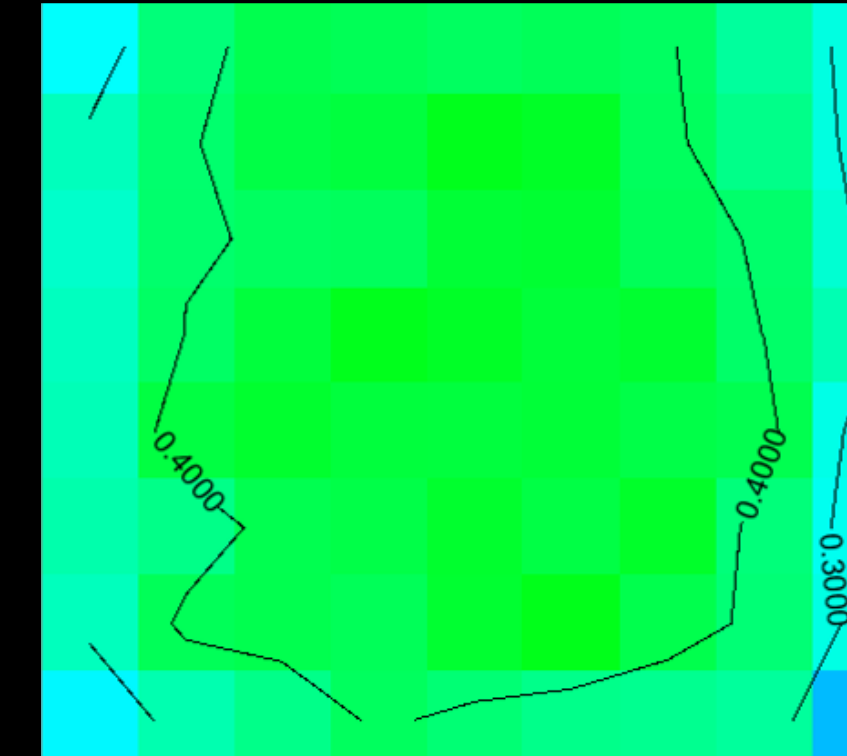
Skylight Design Data

Daylight Autonomy DA Continuous

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Dimensions	10' x 12'
Skylight/Floor Area	11.1%
τ	0.30
ρ	0.80
U	0.23 Btu/hr-sq ft °F
SHGC	0.26

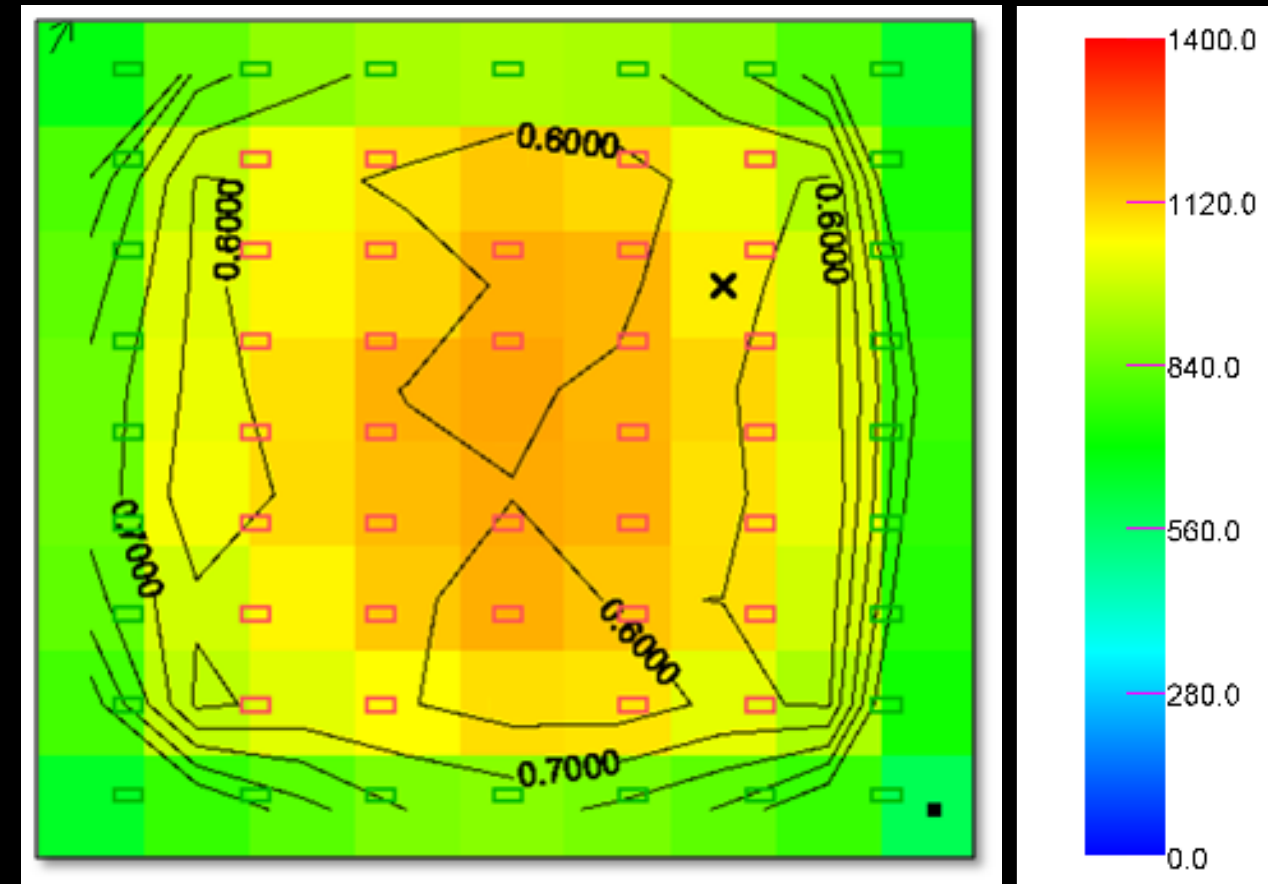
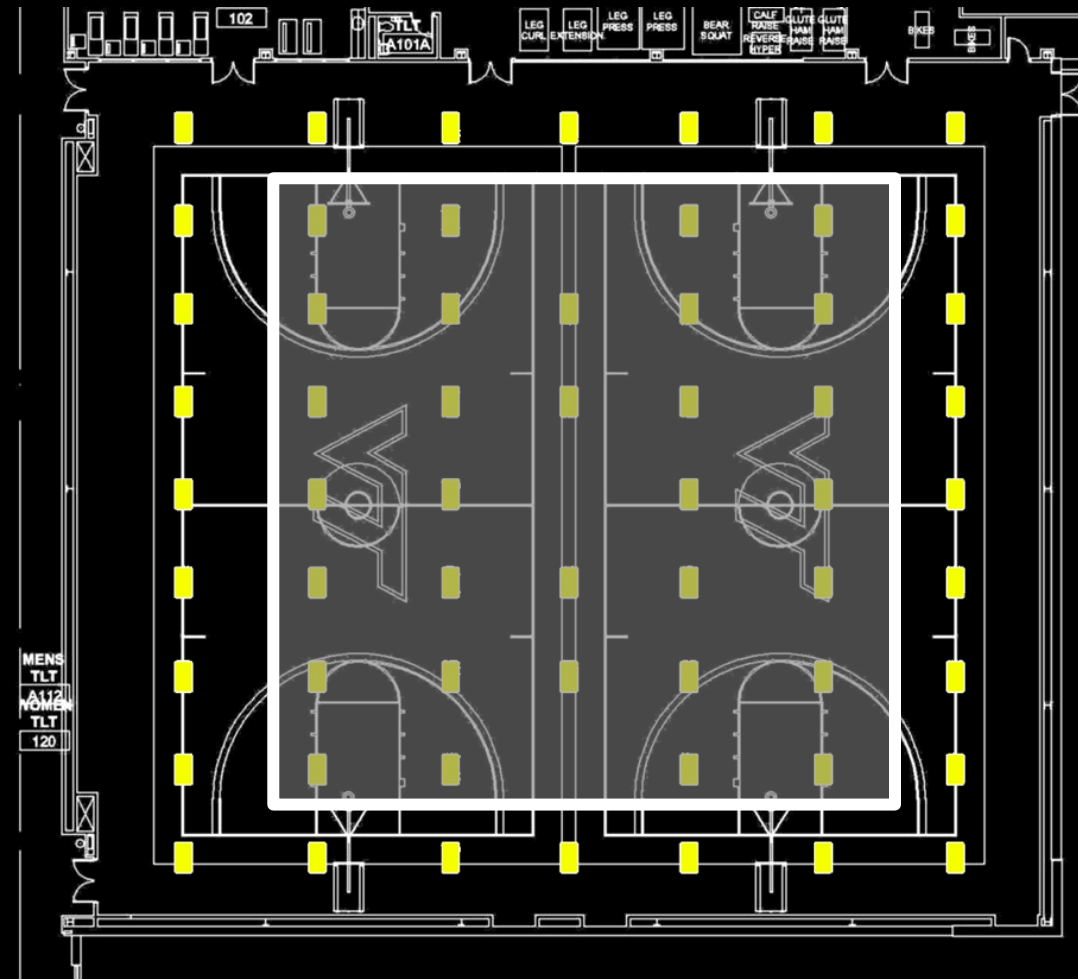


Gymnasium – M.A.E - Daylighting

Critical Point Location

Daylighting Controls

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8 Circuit Dimming Panel



Low Voltage Control Interface



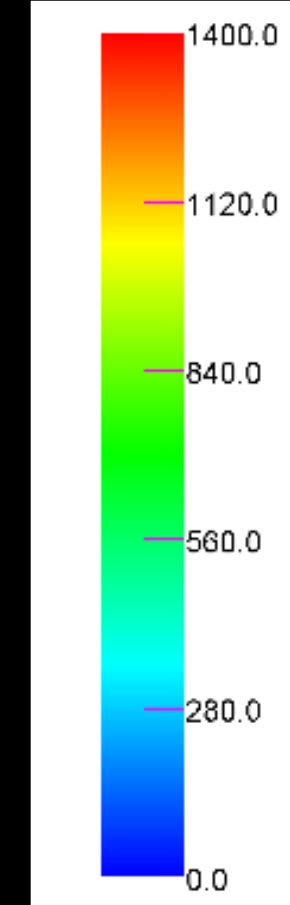
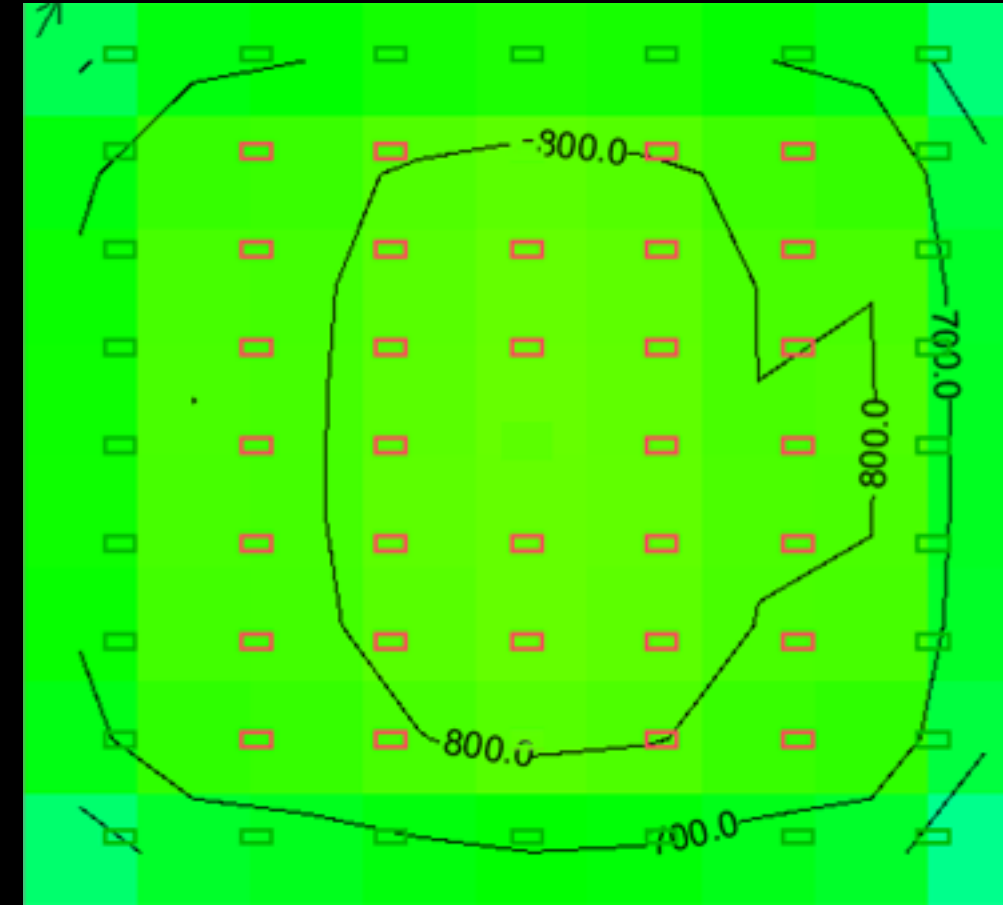
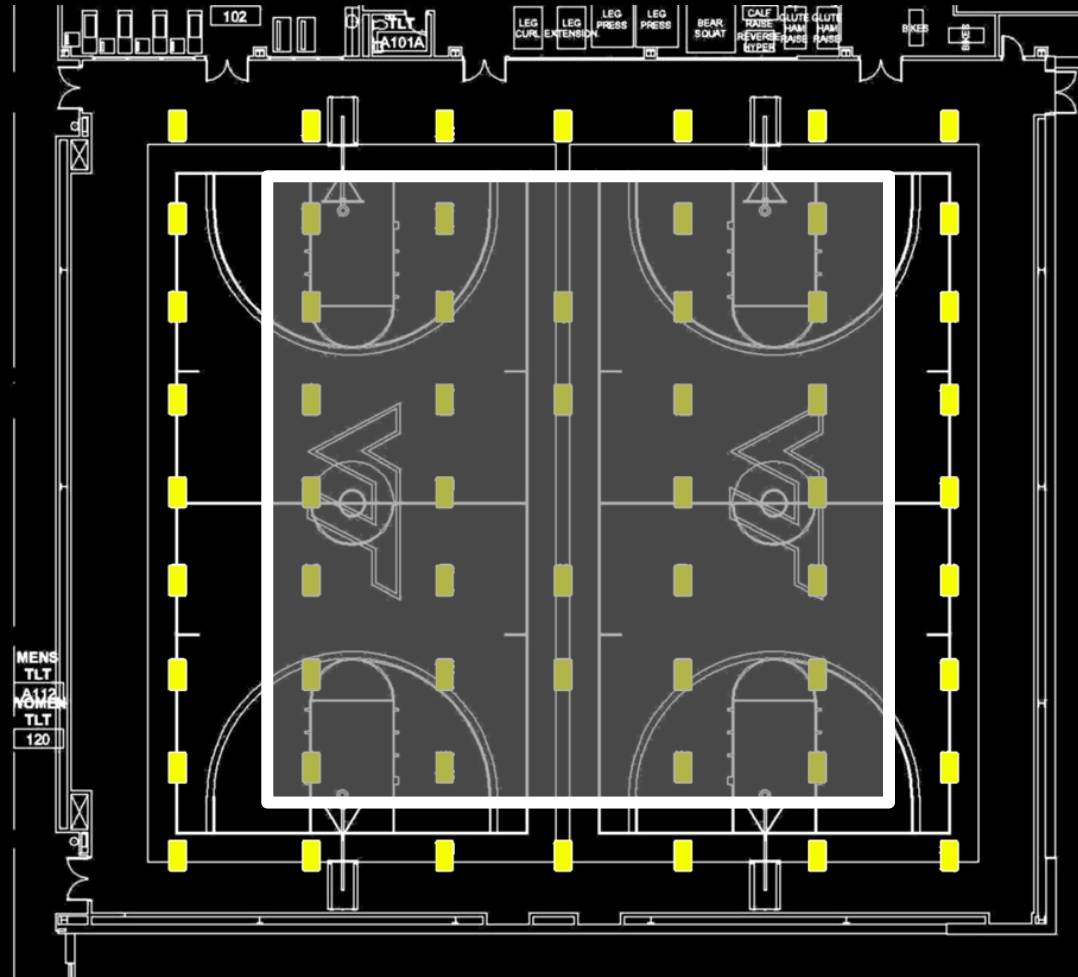
Micro PS Photocell – Closed Loop Proportional Set Point Algorithm

Gymnasium – M.A.E - Daylighting

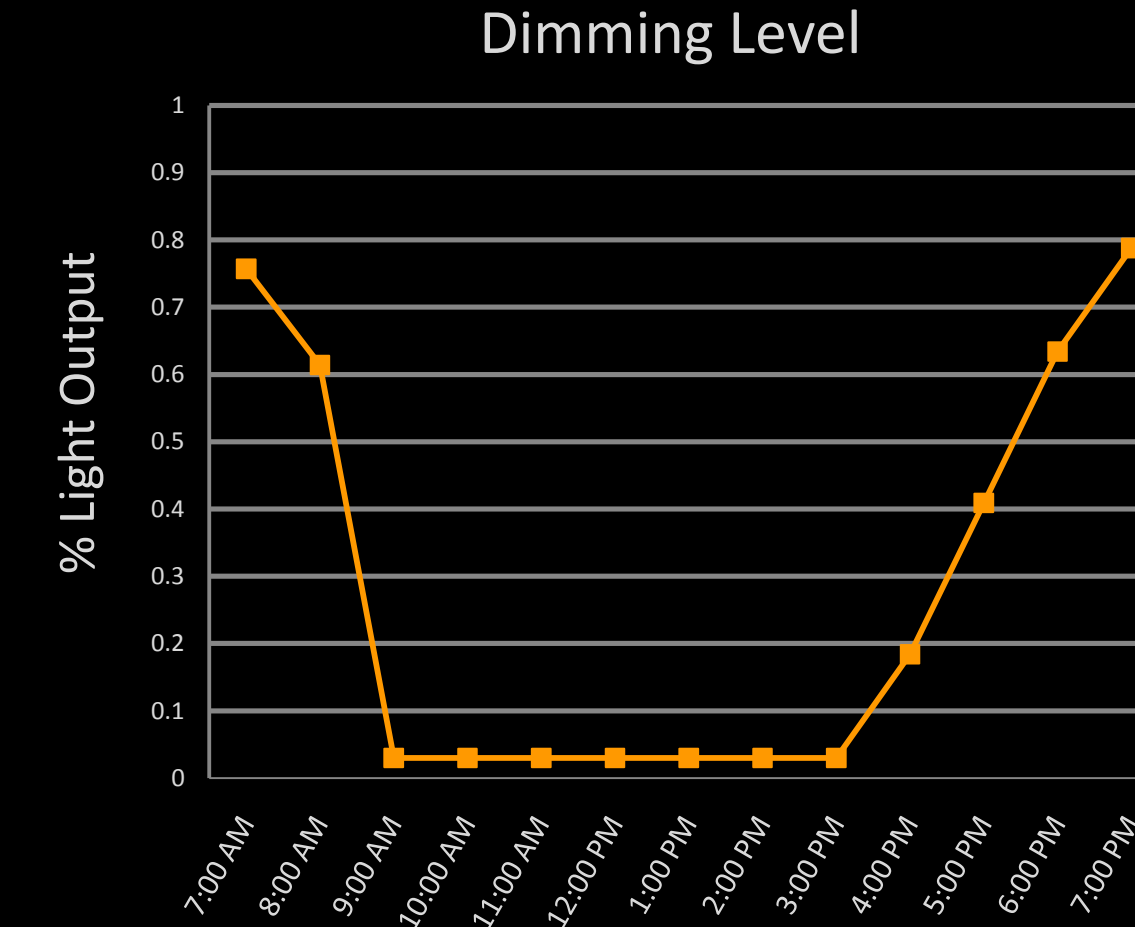
Daylight Tracking

Percent Light Output

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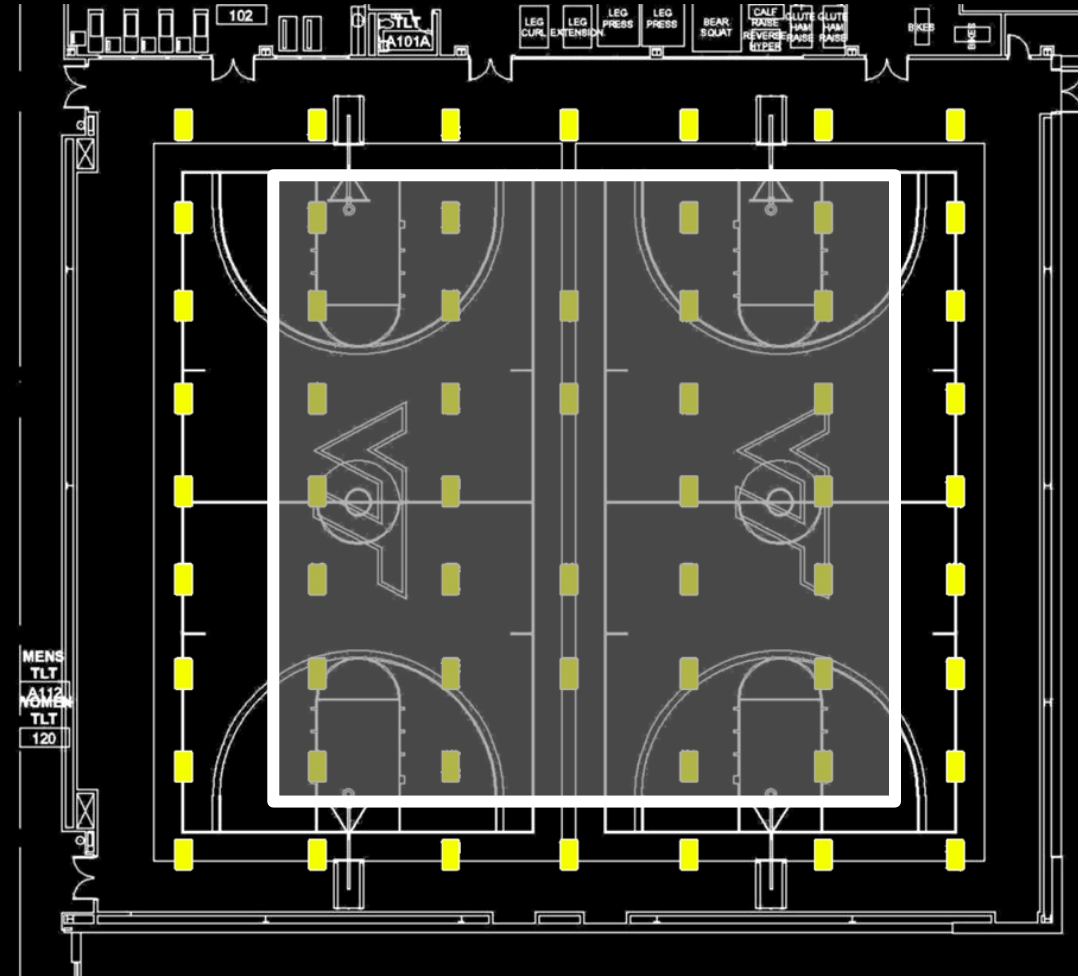
March 21: 7:00 am – 7:00 pm



Gymnasium – M.A.E - Daylighting

Energy Savings

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Annual Energy Consumption

All Lighting – Base	116,242 kWh
Dimmed Zone – Base	64,579 kWh
Dimmed Zone – Algorithm	21,028 kWh
Savings	43,550 kWh
Dimmed Zone	67.4%
Total	37.5%
SkyCalc Predicted Total Savings	28,311 kWh

Gymnasium – Mechanical

Existing System

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Overview

- Analyze the of the gymnasium skylighting design on the cooling system
- Use build an energy modeling to determine increase in loading

Cooling Data

Equipment	Scroll Air Cooled Chiller
Capacity	141.5 ton
Peak Cooling Load	155.1 ton

Gymnasium – Mechanical

Energy Model

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Roof U Value	0.0440 BTU/hr ft ² °F
Exterior Wall U Value	0.0544 BTU/hr ft ² °F
Interior Wall U Value	0.0616 BTU/hr ft ² °F
Floor	0.0440 BTU/hr ft ² °F
Cooling Setpoint	74°
Internal Gains	
Lighting	1.4 W/ft ²
People	
Sensible Gain	710.0 BTU/hr person
Latent Gain	1090.0 BTU/hr person
Occupancy Density	50 people
Increase in Peak Load	11.9 ton

Gymnasium – Mechanical

Chiller Redesign

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Overview

- Analyze the of the gymnasium skylighting design on the cooling system
- Use build an energy modeling to determine increase in loading

Cooling Data

Equipment	Scroll Air Cooled Chiller
Peak Cooling Load	167 ton
New Chiller Size	172.2 ton

Conclusion

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Acknowledgements

Thank you to the following for support throughout the year:

- AE Faculty and Staff
 - Professors Houser, Mistrick, and Dannerth
- Cannon Design
 - Kevin Ledoux and all the engineers in the Boston Office
- Fellow AE Lighting/Electrical Students
- All Family and Friends

Questions/Comments?
