Experiences with Radiance in Daylighting Design, Part V

2011 Radiance Conference
Berkeley, California
August 24-26, 2011

Zack Rogers, P.E., IESNA, LEED AP BD+C

Daylighting Innovations, LLC

Presentation Outline

- Project Examples
    - Laboratory / Office Atrium Study
    - Raleigh-Durham Airport Study

- Overhead Projector Studies

- Skylight Validation Studies

- Parametric Modeler and Daylight Profiler

Lab/Office Atrium Study – Schott PV

- Lab / Office building with Zero Energy Goals

- Balance between PV production and daylight saturation

- Schott PV with small gaps between each small cell

- Low PV efficiency, glare / solar gain concerns for office
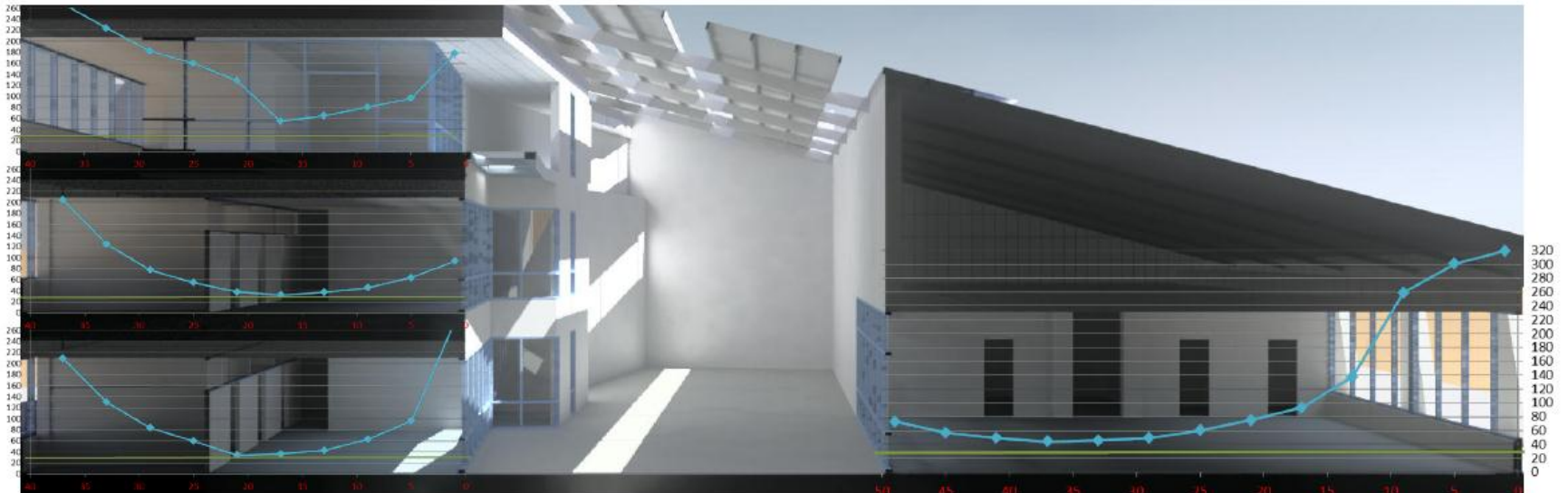
Lab/Office Atrium Study – PV

- High Efficiency PV with gaps between each panel

- Glare / solar gain concerns for office

Lab/Office Atrium Study – 3 Open Strips

- Nice sky view

- Direct glare and solar gain issues for offices

Lab/Office Atrium Study – 3 Translucent Strips

- No sky view

- No glare and solar gain issues for offices

- Nice diffusion, brightened walls

Lab/Office Atrium Study – 3 Baffled Skylights

- Nice sky view

- Limited glare and solar gain issues for offices

- Baffles help provide some diffusion and brighten walls

Lab/Office Atrium Study – Random Translucent Skylights

- Some sky view

- No glare and solar gain issues for offices

- Filtered light through tree canopy effect

Lab/Office Atrium Study – Stair Tower Highlight 1

- Some sky view

- Limited glare and solar gain issues for offices

- Highlighted stair tower walls

Lab/Office Atrium Study – Stair Tower Highlight 2

- Some sky view

- No glare and solar gain issues for offices

- Highlighted stair tower walls

Lab/Office Atrium Study – Combined Strips

- Some sky view

- No glare and solar gain issues for offices

Lab/Office Atrium Study – Sloped Ceiling

- Slight increase in the north zone of the lab
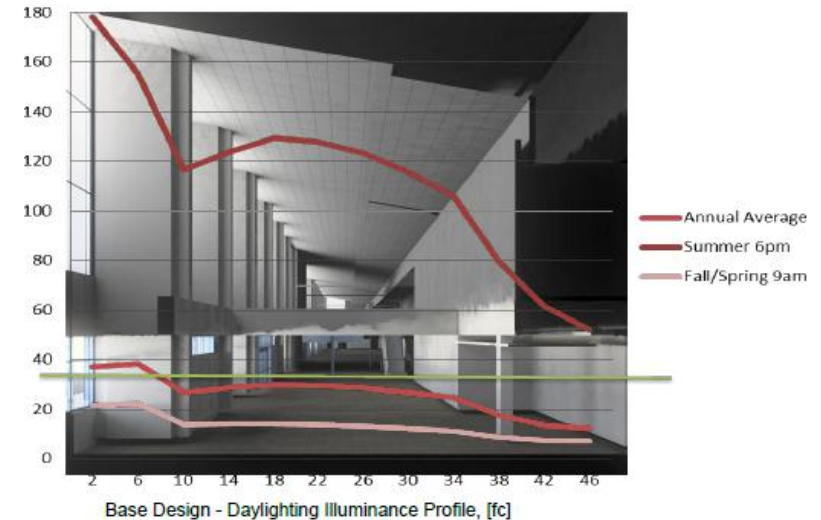
Raleigh-Durham Airport Terminal 1 Renovation

- Glare and thermal comfort issues on recently finished Terminal 2

- Expensive ($ and political) after the fact fix could have been avoided by inexpensive design effort

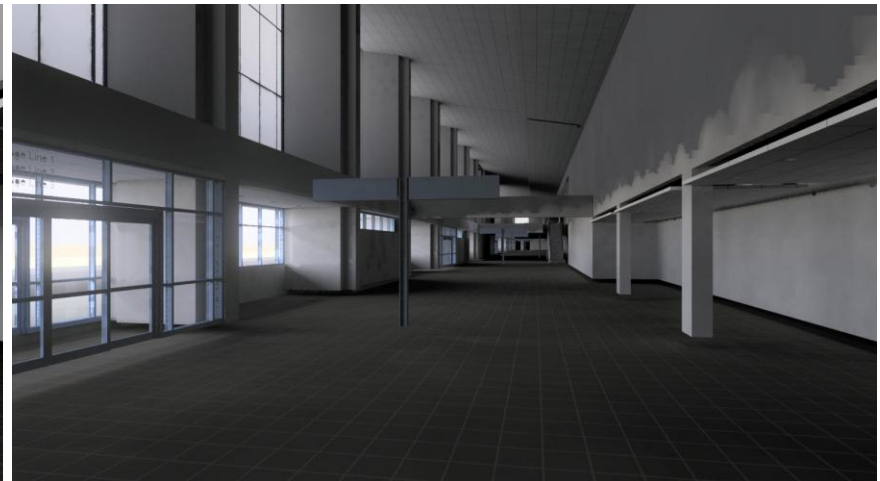- Interesting mix of mainly public, transient spaces with critical task locations
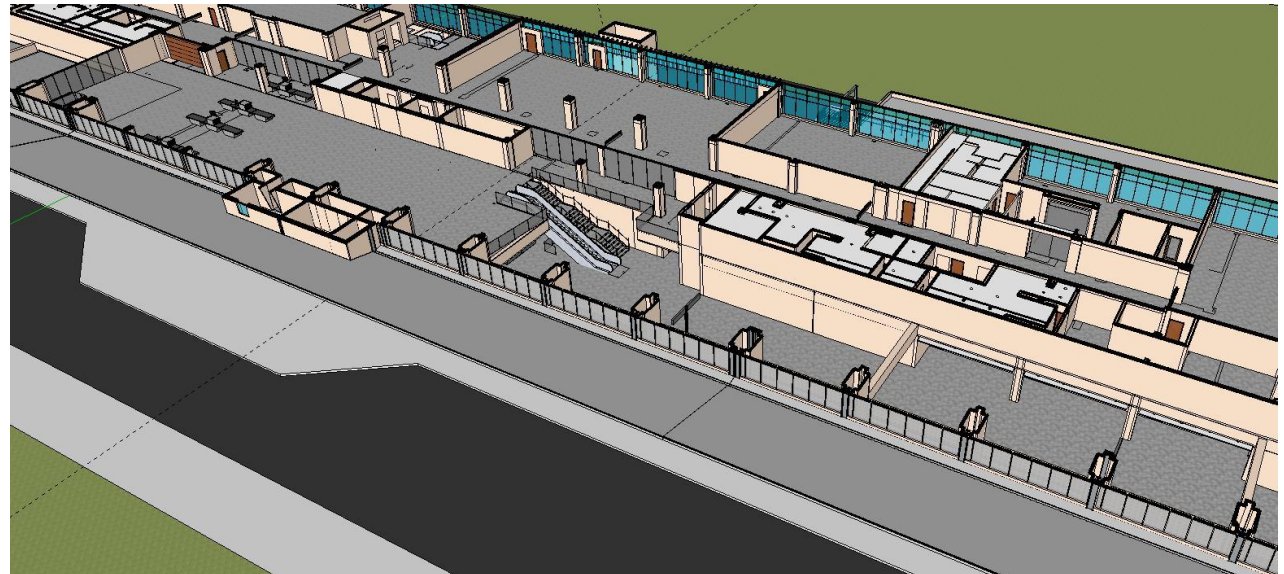
RDU Terminal 1 Ticketing Hall – 8% Kalwall

- Ticket counters are critical view
- 15 min of glaring sunlight when a passenger has just missed a plane is intolerable
- Large variance between morning (no sun) and afternoon (sun) conditions
- Lack of clerestory contribution apparent in splotchy shadow line

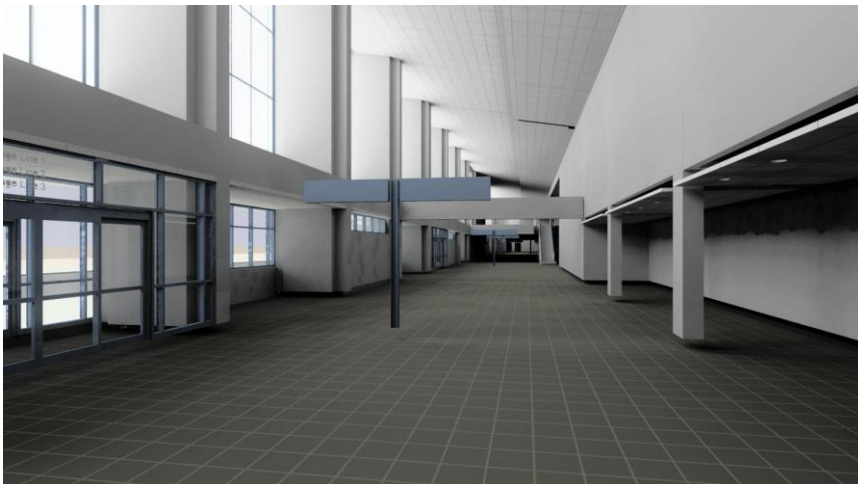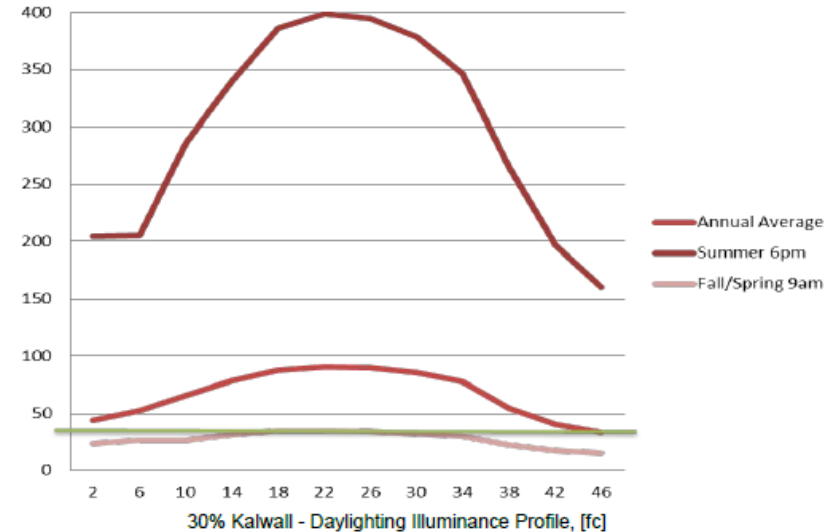Base Design - Daylighting Illuminance Profile, [fc]

Legend:
— Annual Average
— Summer 6pm
— Fall/Spring 9am
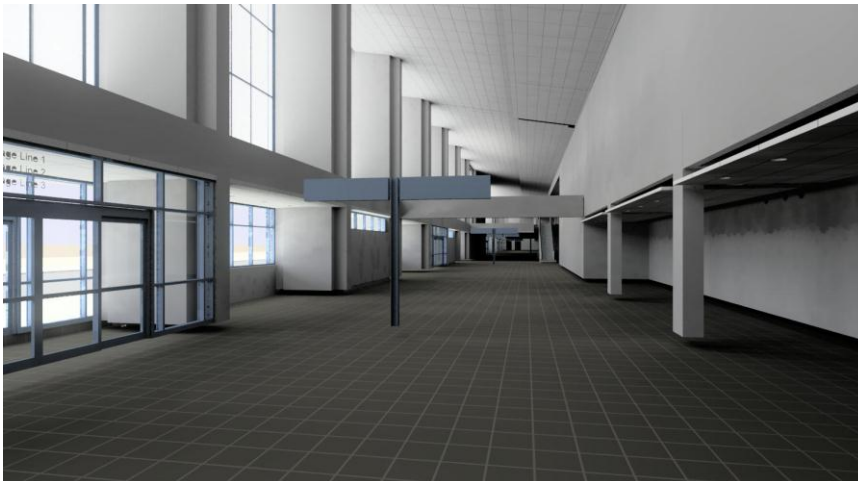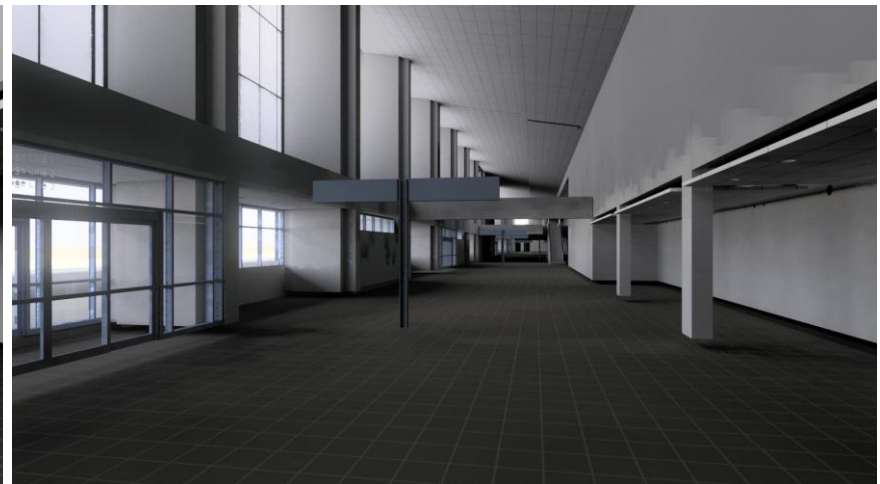

Summer 5pm

Equinox 9am

RDU Terminal 1 Ticketing Hall – 30% Kalwall

- Higher Tvis improves annual contribution
- Still large variance from morning to afternoon
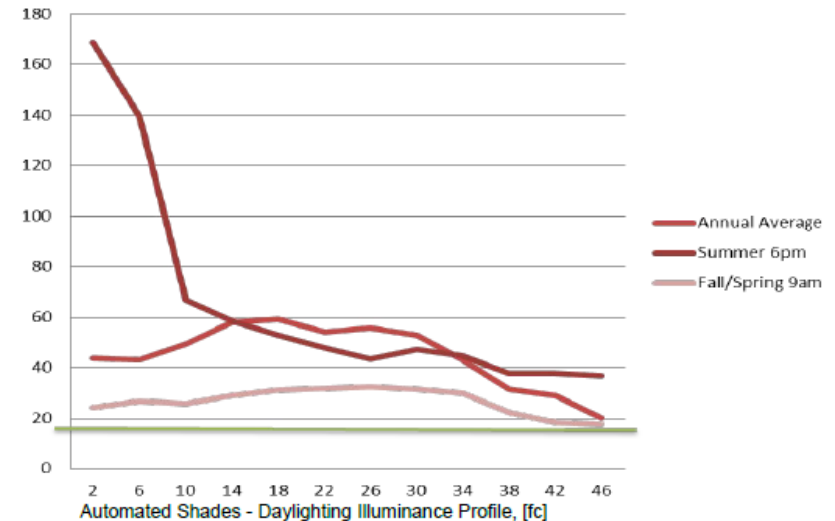- Increases potential for glare under direct sun
- Shadow line diminished

30% Kalwall - Daylighting Illuminance Profile, [fc]

Legend:
- Annual Average
- Summer 6pm
- Fall/Spring 9am

Summer 5pm

Equinox 9am

RDU Terminal 1 Ticketing Hall – 1% Automated Shades

- Variable window treatment provides good contribution annually
- Balances the morning to afternoon condition
- Maintains acceptable glare conditions in the afternoon
- Shadow line gone

Automated Shades - Daylighting Illuminance Profile, [fc]

Legend:
— Annual Average
— Summer 6pm
— Fall/Spring 9am

Summer 5pm

Equinox 9am

RDU Terminal 1 Security Checkpoint – Critical Views

- Security checkpoint most critical task in airport

- View of X-ray displays defined as most critical views

Security X-Ray Machine - Critical Views

View 4

View 1
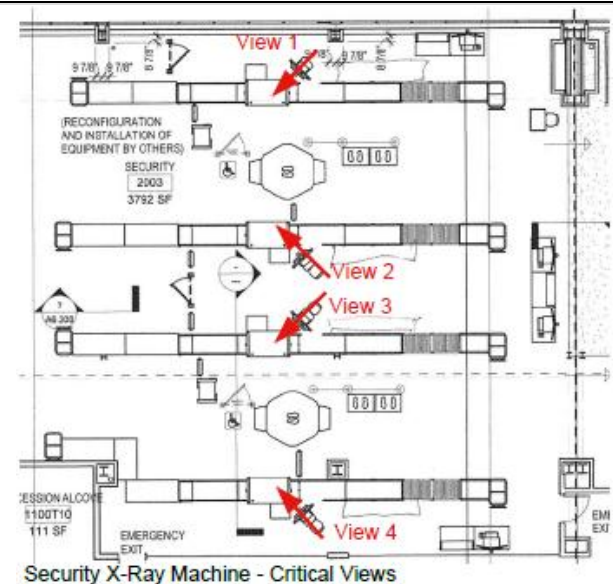
# RDU Terminal 1 Security Checkpoint – Glare Analysis

- Evalglare used to calculate Daylight Glare Probability for each scenario

- Task defined as 0.3 radian cone centered on display monitor

- Used cautiously – not as much absolute, more relative glare improvement

- Imperceptible: <33% critical, fixed location
- Perceptible: <38% critical, flexible location
- Disturbing: <42% no critical, "sparkle" desired
- Intolerable: <53%
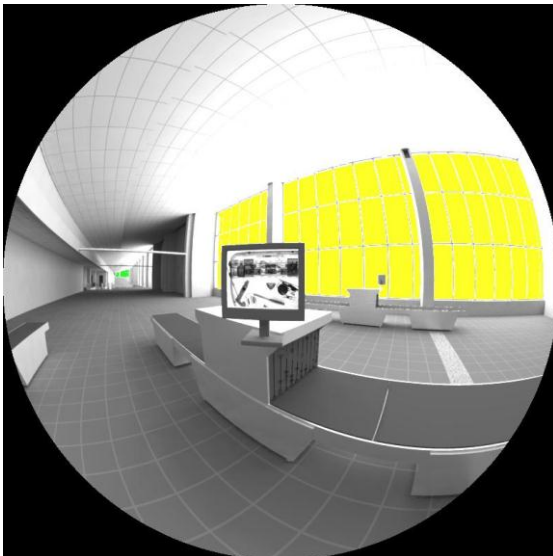
View 2 – 8% Kalwall: DGP 23%
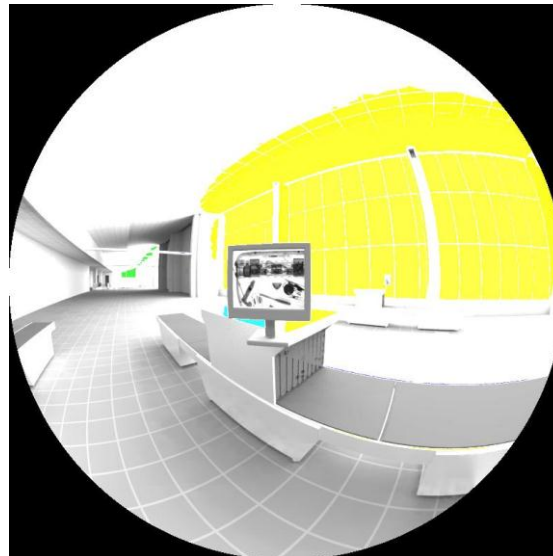
View 2 – 30% Kalwall: DGP 38%
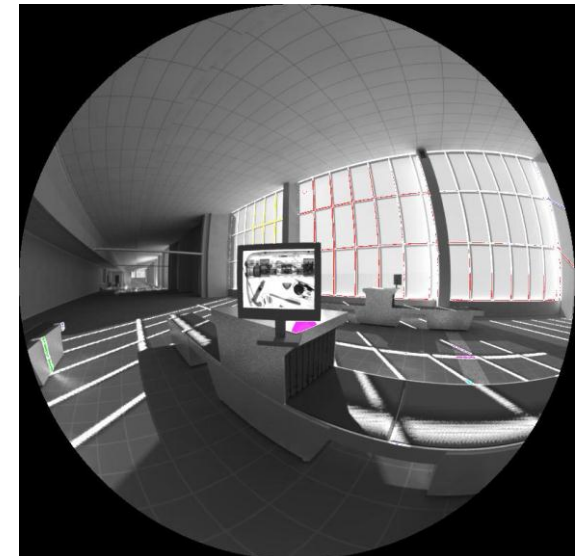
View 2 – 2% Fabric Shade: DGP 43%
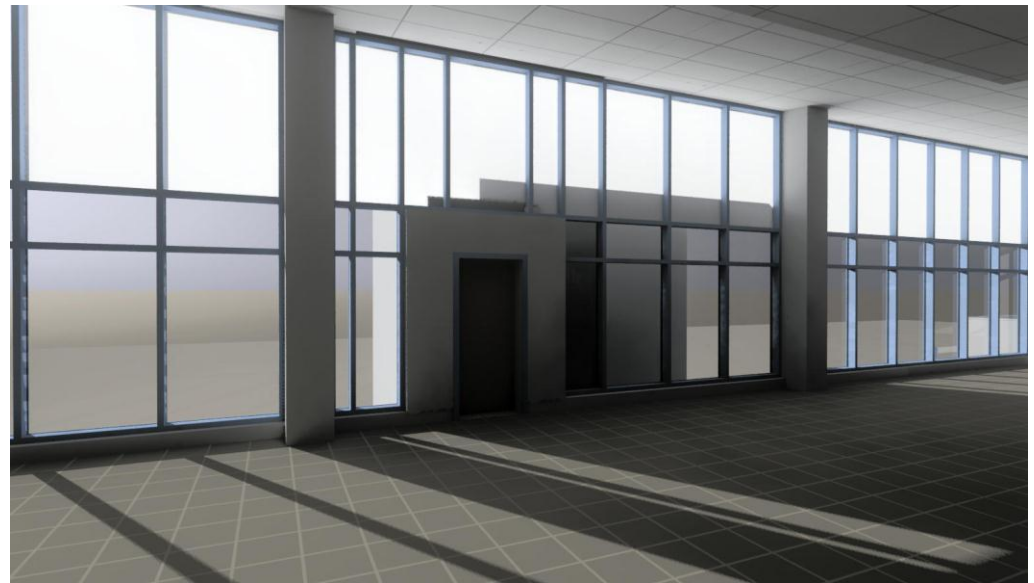
RDU Terminal 1 Holding Rooms – Base Design

- Holding rooms contain small gate counter critical tasks

- Mostly leisure passenger space

- Thermal comfort major concern for crowded and delayed holding room

- Southwest facing 16' wall of glass!

- Too much direct sun – some control is needed

- Lower "view" glass treated separately
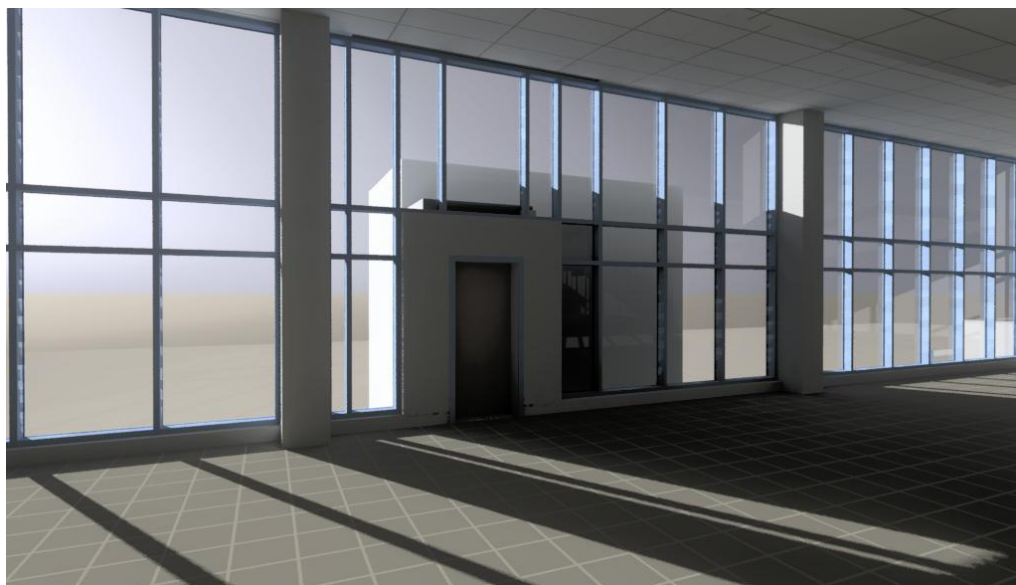
RDU Terminal 1 Holding Rooms – 30% Kalwall

- Diffusing glass provides thermal comfort

- Reduces direct sunlight glare, introduces potential glare from glass brightness

- Eliminates clerestory view to sky, does this matter?

- Fabric shade or additional translucent glass still likely needed mid and low panes

- Highly variable from morning to afternoon

RDU Terminal 1 Holding Rooms – 2% Fabric Shade

- Fabric shade provides visual relief and thermal comfort

- Provides balance between morning and afternoon

- Maintains some view through clerestory windows

- Airport authority scared of automated / motorized systems

RDU Terminal 1 Holding Rooms – Pivoting Ext. Louvers

- Static and pivotable exterior louver option explored

- Static option, given tough angles at 45deg south-east, deemed unacceptable

- Pivoting option allows for solar control while maintain views when possible – sun from north, view to the south

- Horizontal solutions undesirable – bird roosting, cleaning concerns

RDU Terminal 1 Holding Rooms – Pivoting Ext. Louvers

- Explored maintaining gaps between louvers at fully closed position

- Is a 21" shade patch between a 4" sun patch adequate for glare/thermal comfort control

- Are 4" gaps adequate to maintain view, is too much contrast introduced

- Gaps would only exist 30min when sun is near perpendicular

RDU Terminal 1 Holding Rooms – LightLouver Combo

- Combination LightLouver solution with diffusing glass

- Ceiling configuration not optimal, exploring reconfiguration

- LightLouver IES files created via TracePro

- Script automatically sizes LightLouver "light" definitions

- New BSDF material is awesome!!!

Projector Studies

- Will a projection wall be visible in a highly glazed common room?
- Projector model built in Radiance
    - Explored directly mapping image to screen using "light" material – ambient light did not show up on surface
    - Explored mapping directly to a "spotlight" definition
    - With my limited Radiance skill, created a spotlight source, aimed through a "trans" film with image mapped, shielded to create square projection
- Globe map used to explore varying levels of contrast – black text on white least concern – dark and intricate images greatest concern

6,000 mid-range projector

Projector Studies

- Explored varied fabric shade openness in 3 different zones

- Explored different projector lumen output options – increased lumens typically increased $

- Claims of 5,000:1 contrast?
    - Projector provides a max of 22fc for our globe scene
    - Ambient lighting would have to be less than 0.004fc?

- Vertical illuminance must be below 20fc to even maintain 2:1 contrast

Shade Zone 1

Shade Zone 2

Shade Zone 3

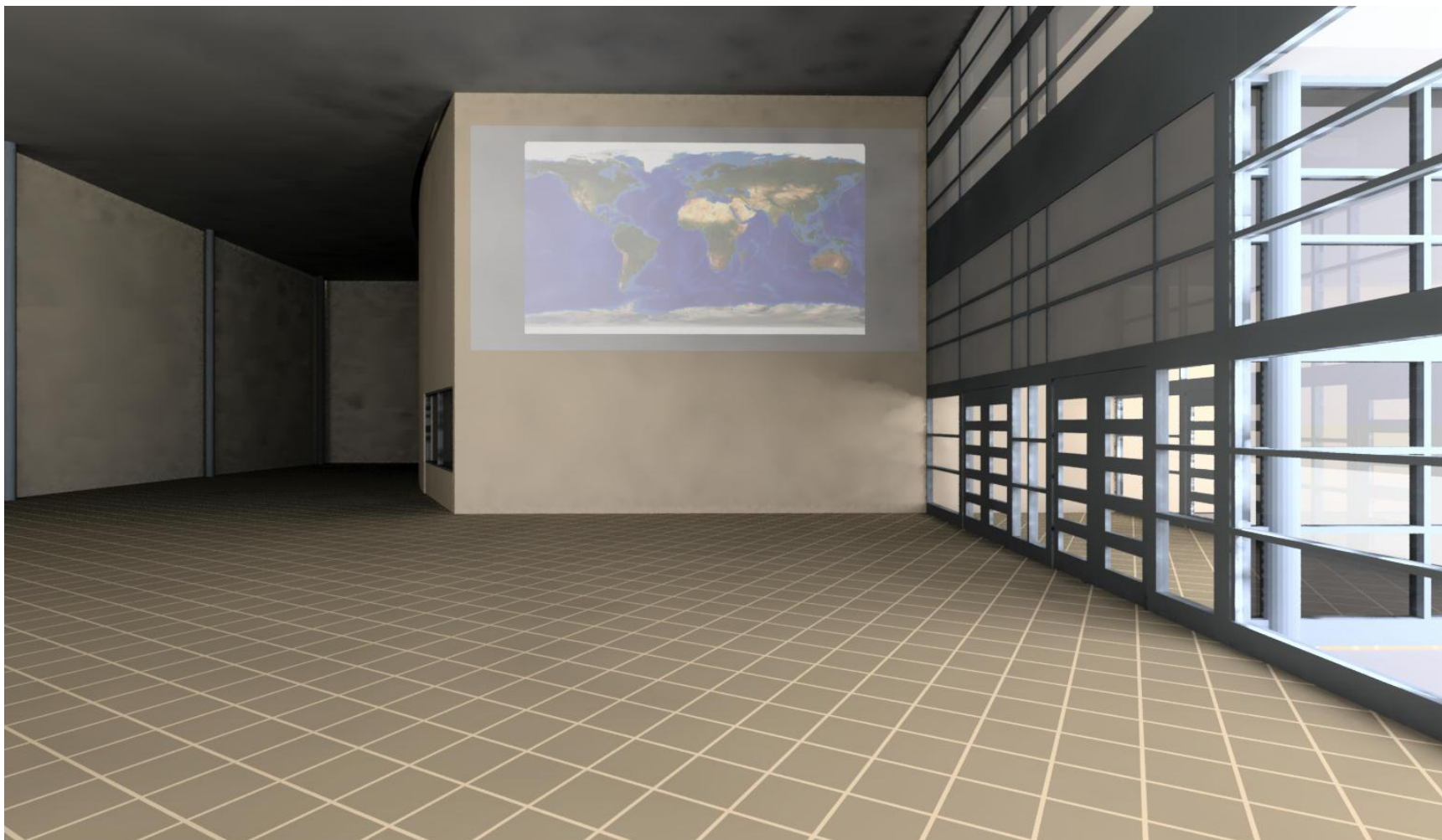Ceiling Mounted Projector, 37' from screen.
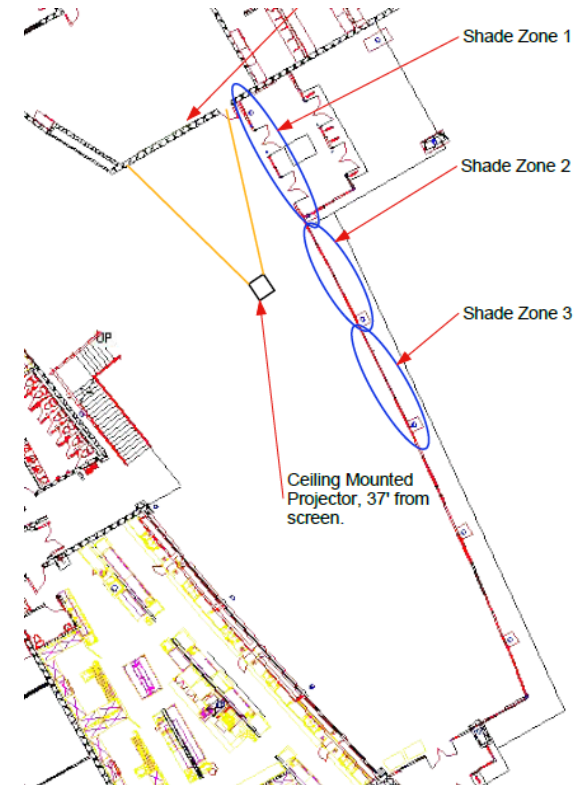
Projector Studies – Top 3% Shades, 6,000 Lumen projector
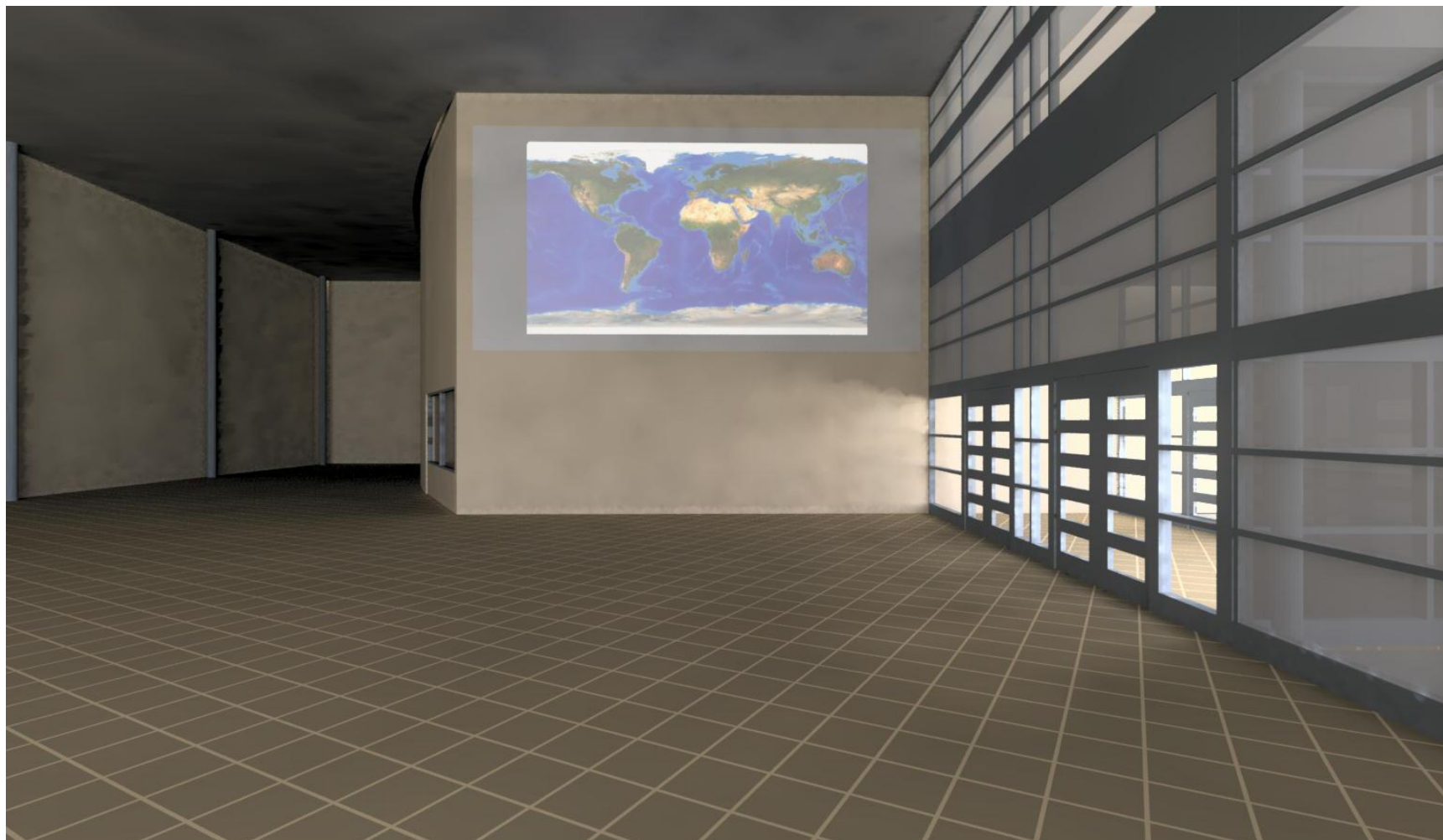
Projector Studies – Zone 1 Shades

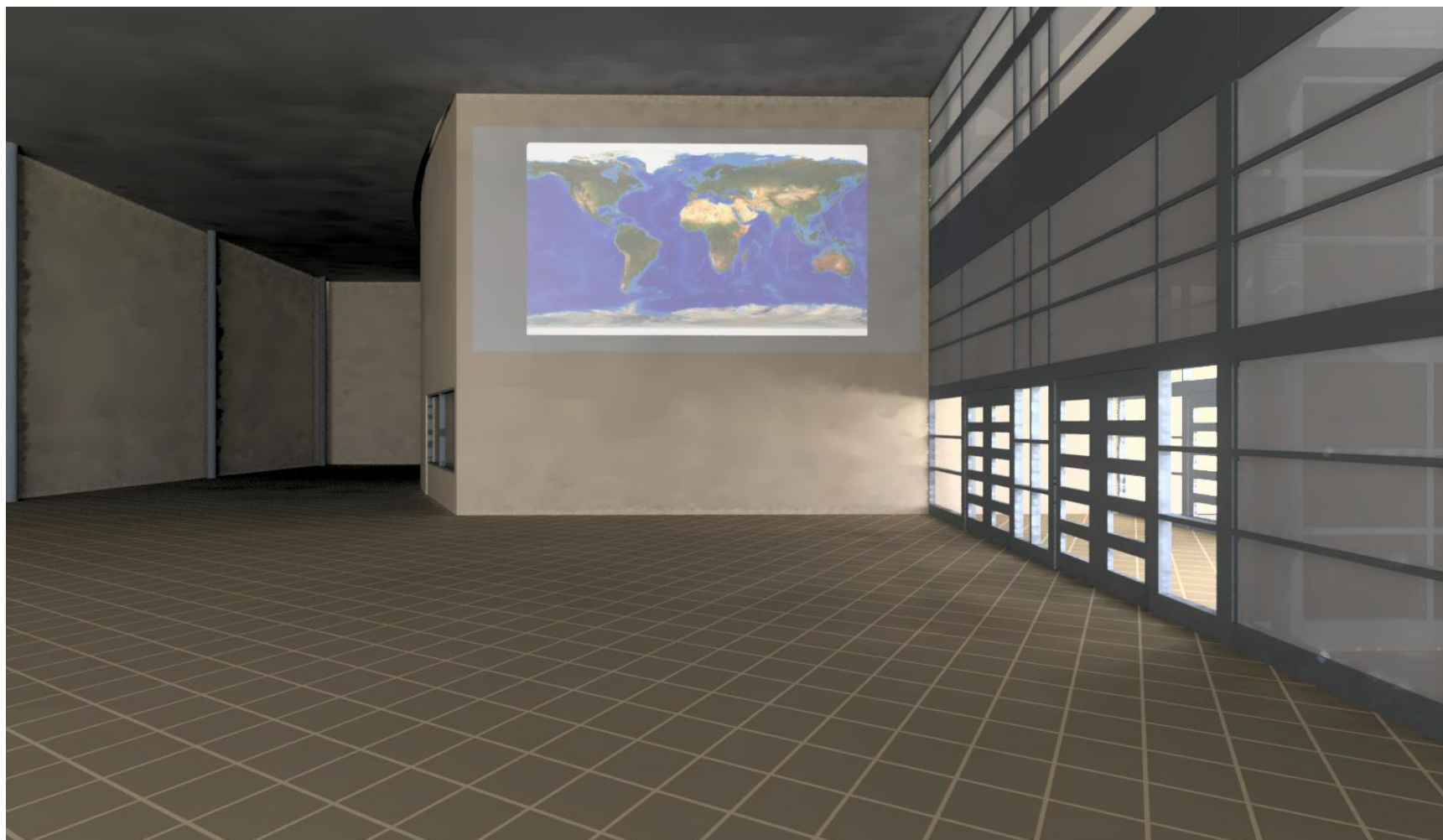# Projector Studies – Zone 1 & 2 Shades

Projector Studies – Zone 1 – 3 Shades

Projector Studies – 1% Shade

Projector Studies – 1% Shade, 12,000 lumen projector

Optical Skylight Validation – Team and Facility

- Effort to capture HDR skies and interior photometrics for optical skylights

- Thanks to Luis Fernandez and Anothai Thanachareonkit for developing measurement equipment and methodology

- Thanks to Bruce Mosher for providing facility

Optical Skylight Validation – Equipment / Installation

- Initially aimed at validating TracePro and Photopia methods for generating daylighting system photometrics

- Interest in validating photon-mapping and maybe genBSDF for larger optical systems?

- Testing done during July in Greenwood, South Carolina

- 90deg, 90% humidity = challenge: how to keep your butt from burning and your notes dry

- Chose summer to capture low and high sun angles

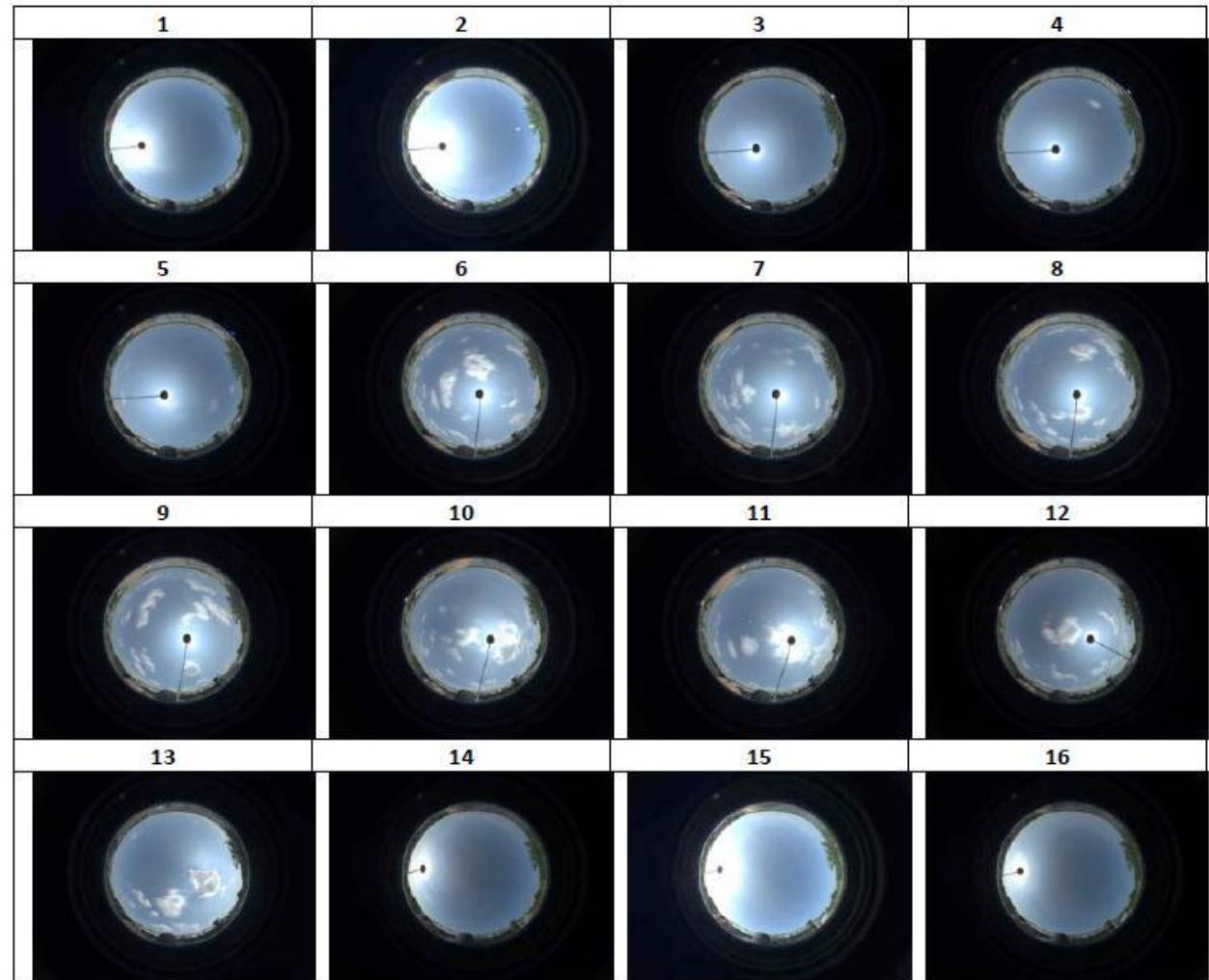# Optical Skylight Validation – Skylight Systems

- Tested range of optical complexity

  - Simple: single layer of optics, diffuse light box

  - Medium: two layers of optics, simple mirror light box

  - Complex: two layers of optics, complex interreflection in between

- Imperfections in physical systems inevitable – how close can a computer simulation come

- Suggest adding computer simulation path for testing daylighting products in IESNA LM-81-10
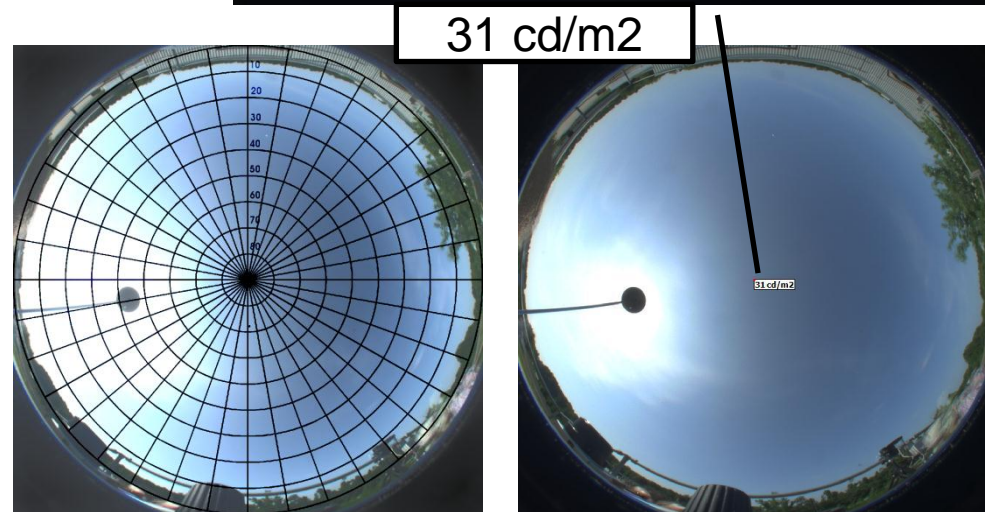
Optical Skylight Validation – HDR Sky Images

- Captured 31 skies, roughly 10 for each skylight system

- Used a 10° disc to shield sun

- Only got 1 partly cloudy sky with the solar disc obscured

- Need to figure out a way to fill in the disc

Optical Skylight Validation – HDR Sky Cropping

- First cropped sky capture to a perfect hemisphere

- Cropped image lost absolute luminance information
  - Zenith luminance appears to drop in cropped image
  - Thanks to Greg / Radiance online for method of maintain header information

- Concern with actual angular hemispherical mapping of Nikon FCE9 Fisheye Converter Lens system, any experience?
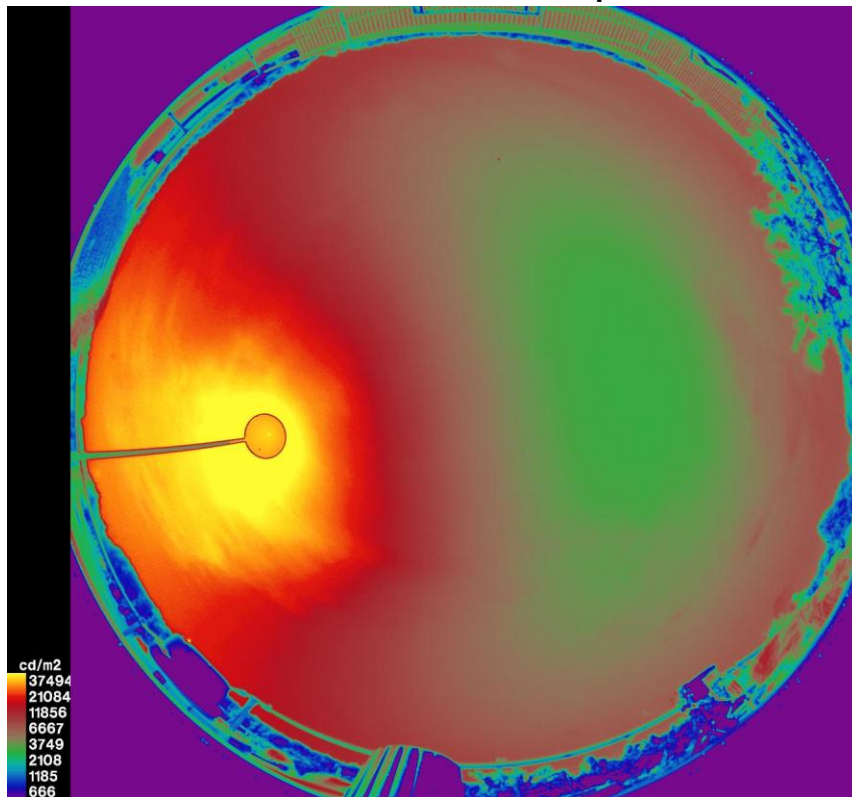

4732 cd/m2

31 cd/m2

Optical Skylight Validation – Masking
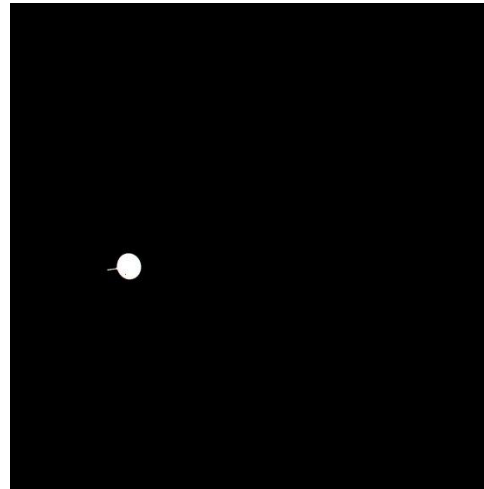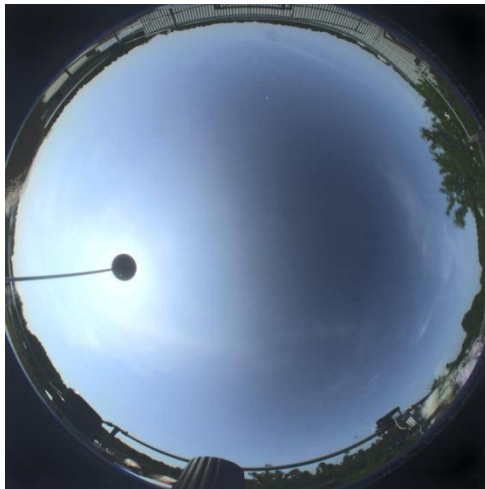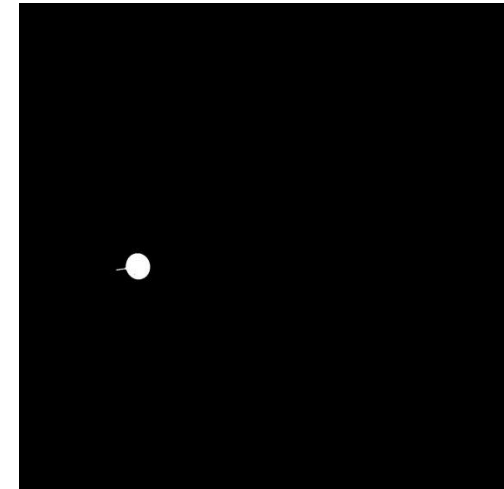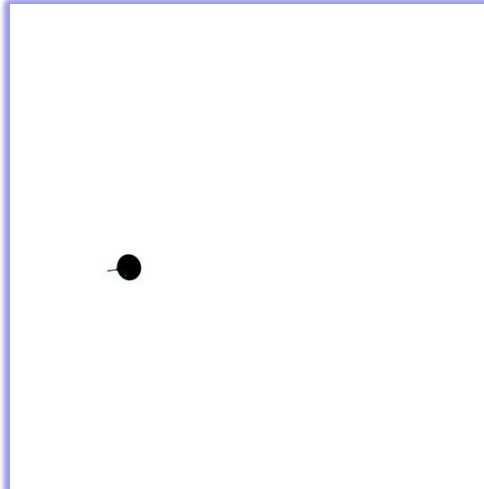
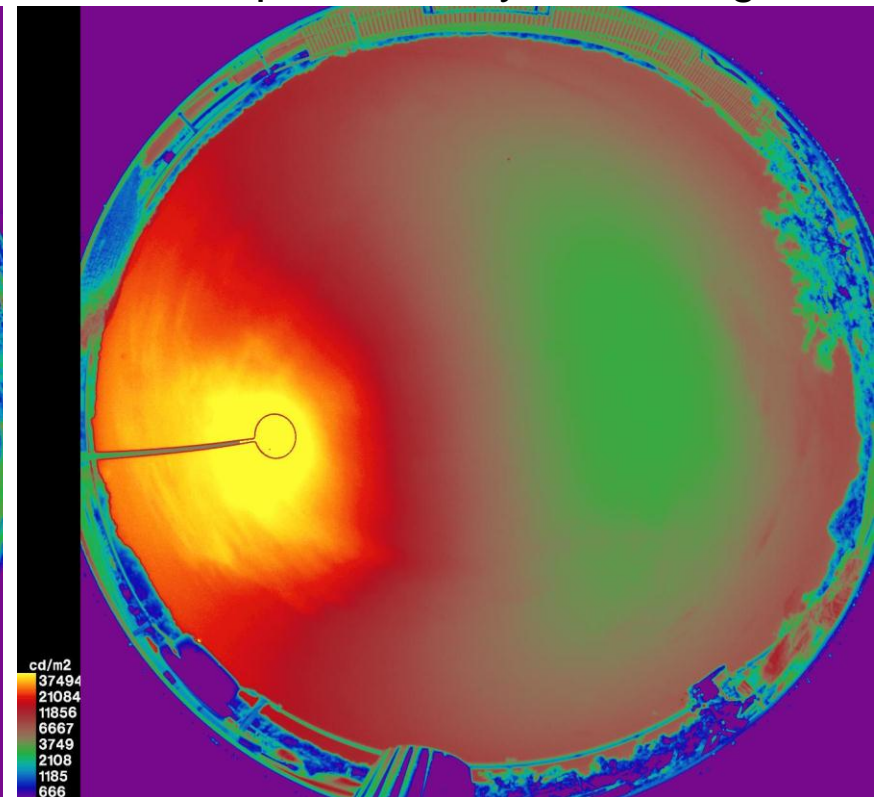# Optical Skylight Validation – Combined Sky

- Calibrate masked sky image to diffuse sky illuminance measurement
- Calibrate patch filler by matching luminance in circumsolar region
- Calibrate solar intensity to direct illuminance
- Create TracePro / Photopia source files via lookup to final sky HDR image


Sky filler calibrated to zenith luminance

Sky filler calibrated to circumsolar region

Parametric Modeling and Daylight Profiling – stay tuned

- Parametric modeler that creates Radiance and Energy Plus models via IFC files

- Challenge: how to efficiently automate daylight simulation for an entire building
    - Method to autogenerate illuminance grids for any shape of daylit space
    - Method to identify similar spaces to reduce overall calculation time
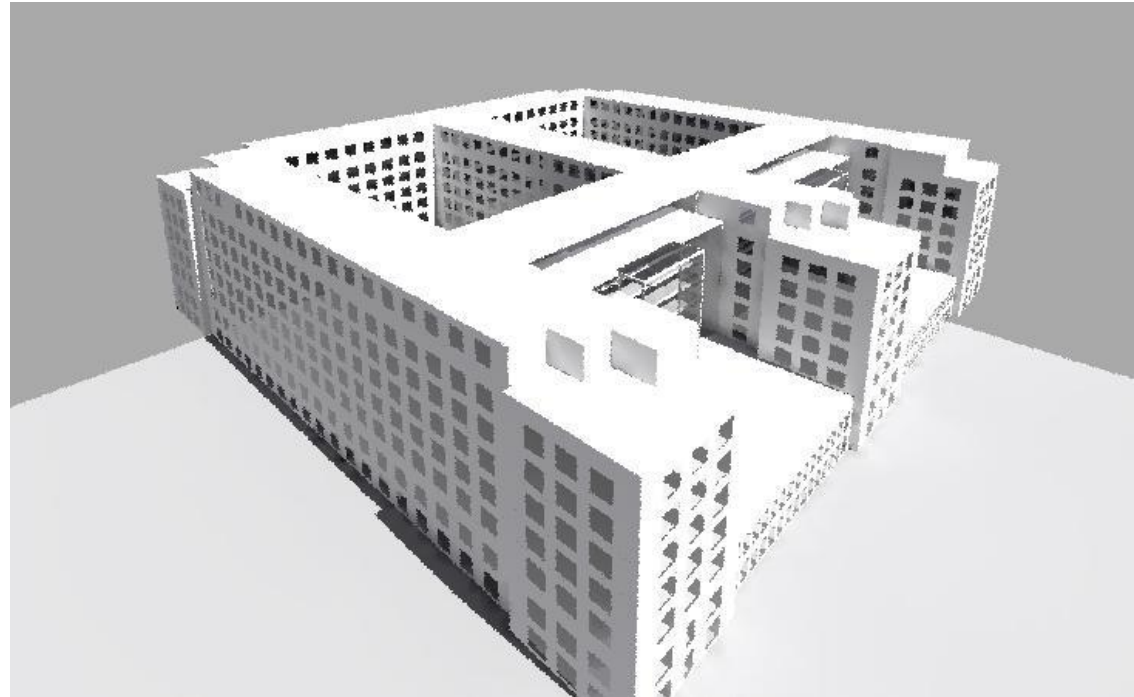
SPOT v4.2 Released

- Upgraded to work with newer Windows OS (Windows XP, Vista, 7; 32bit, 64bit)

- Upgraded to work with new versions of Office 2007 and 2010. Best under Excel 2010

- Variety of bugs fixed (some introduced?)
  - Compiled python scripts (eases installation)
  - Eliminated path related issues

- Added new annual daylight metrics
  - Daylight Saturation (aka Continuous Daylight Autonomy)
  - UDI

- Available for download: www.archenergy.com/SPOT

- New SPOT user list on google groups

Questions?

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