Approaches to Calculating Annual Sunlight Exposure in LightStanza

Will Whiteneck

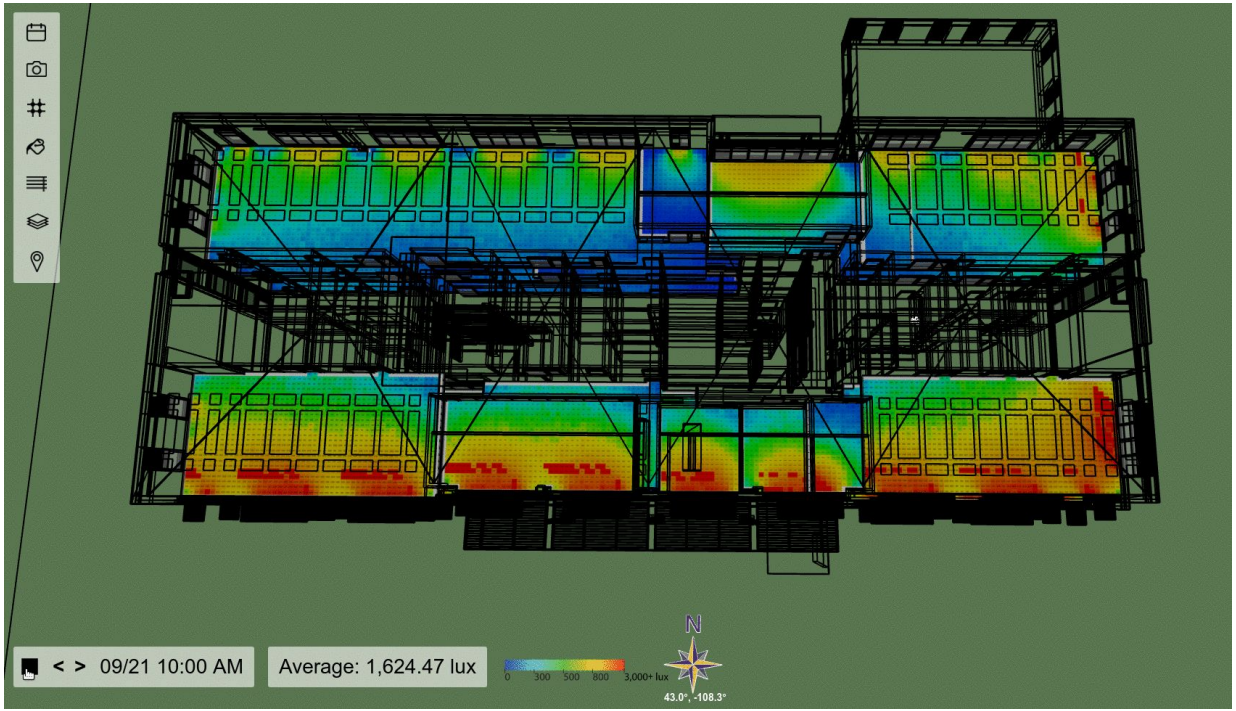
Director of Technology, LightStanza

Daniel Glaser, PhD

Founding Principal, LightStanza

Radiance Workshop, Portland, Oregon
August 23, 2017

What is LightStanza?

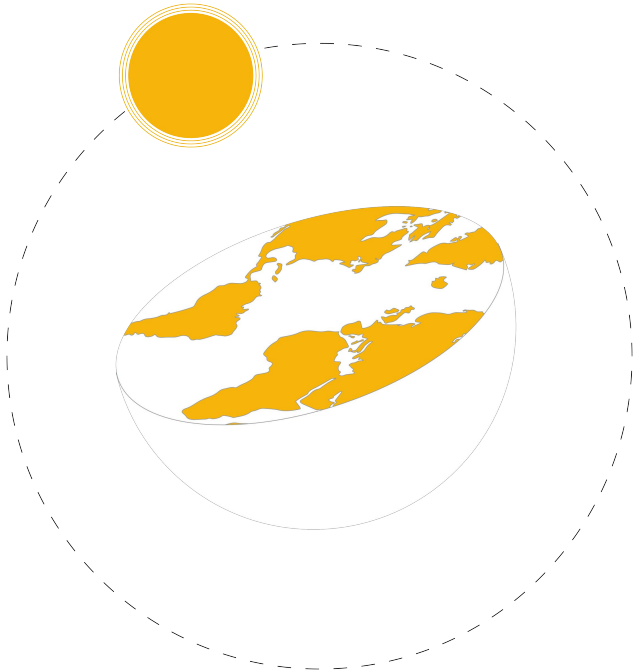


An App that is powered by optimized Radiance servers

Who is LightStanza?

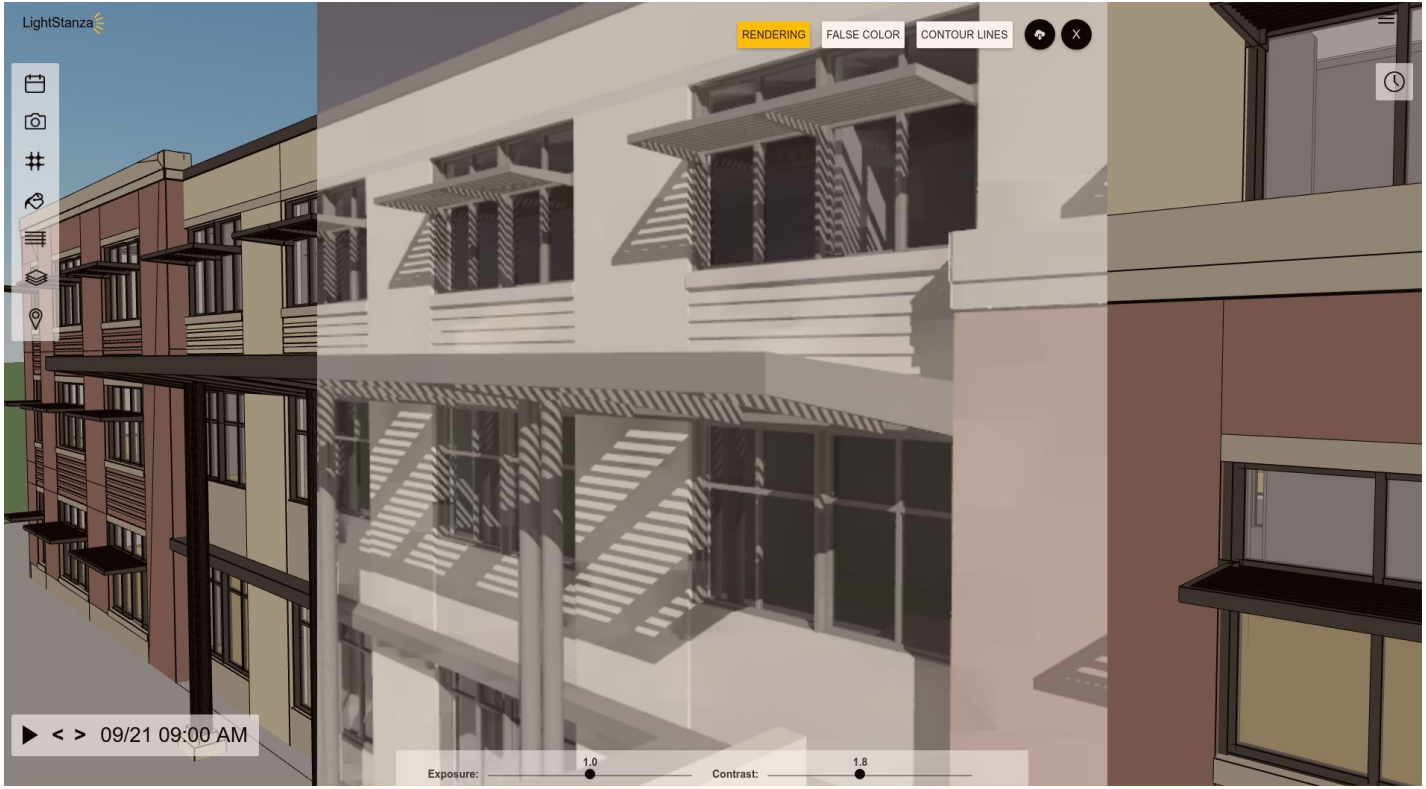
Dan, Will, Sydney, Josh

Outline



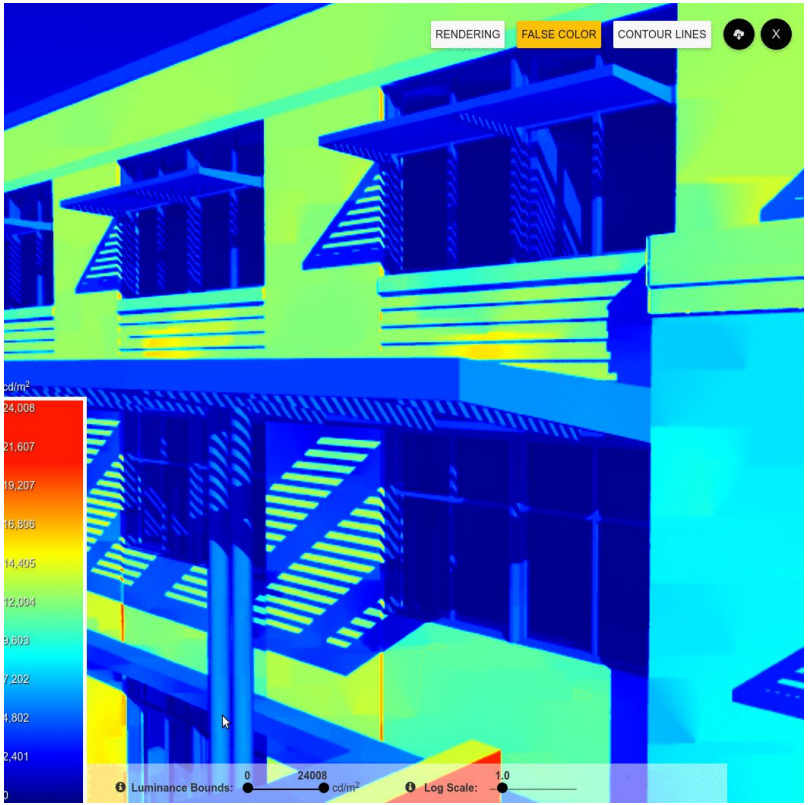
1. What is LightStanza?
2. Annual Sunlight Exposure Discussion
3. Demo

What is LightStanza: Renderings



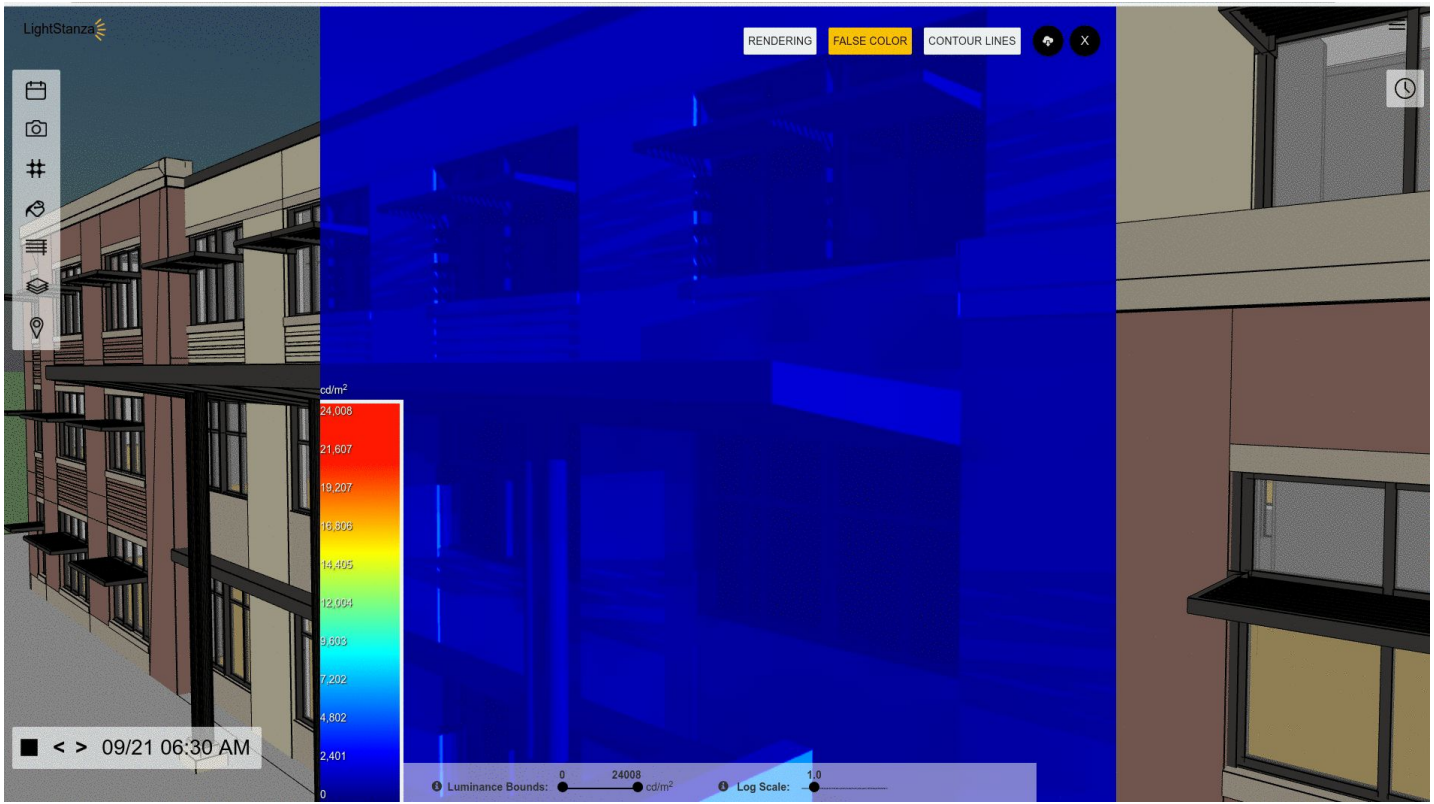
Fort Collins Utilities Administration Building Design by RNL Design, Denver, CO (Achieved LEED v4 Platinum)

Renderings



Fort Collins Utilities Administration Building Design by RNL Design, Denver, CO (Achieved LEED v4 Platinum)

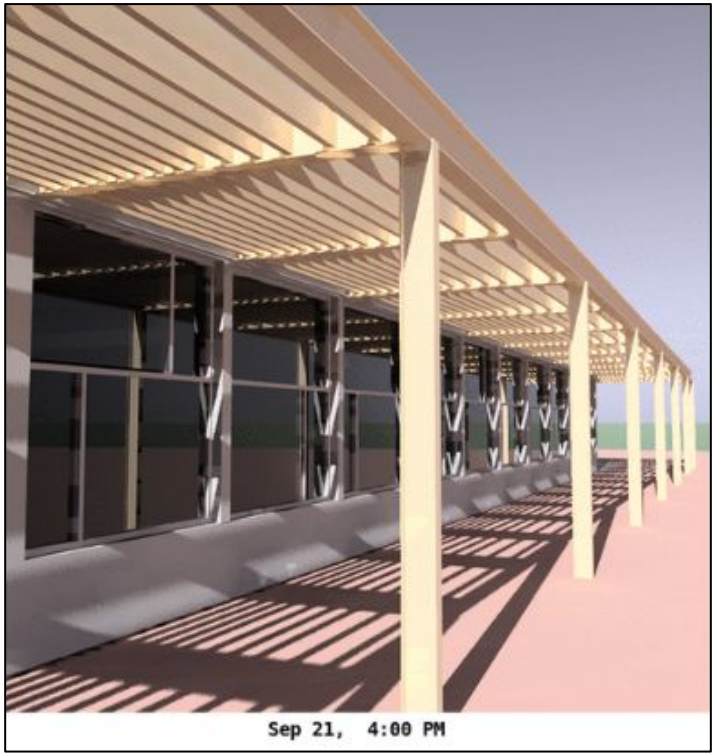
Renderings



Fort Collins Utilities Administration Building Design by RNL Design, Denver, CO (Achieved LEED v4 Platinum)

Analysis → Design

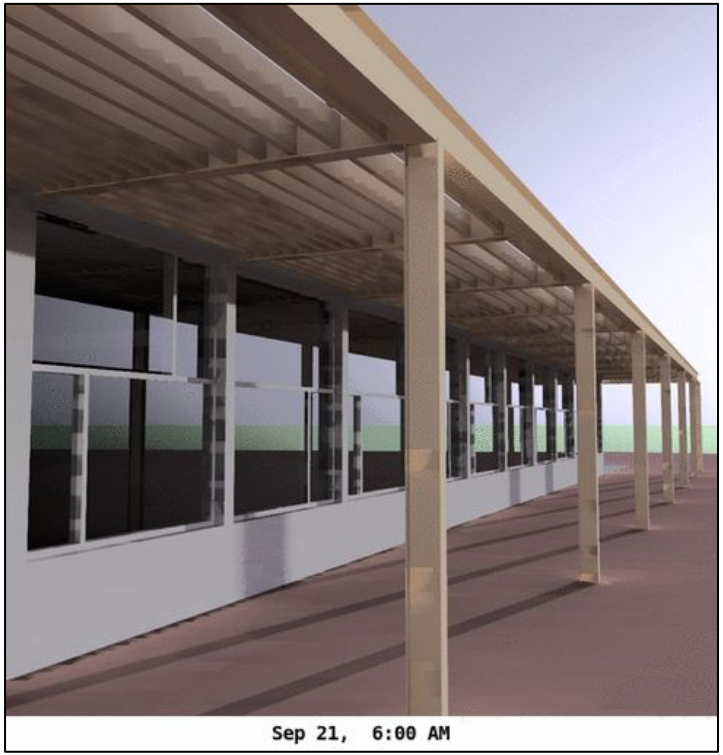
Trellis



Aspen Community School, Cuningham Group

Analysis → Design

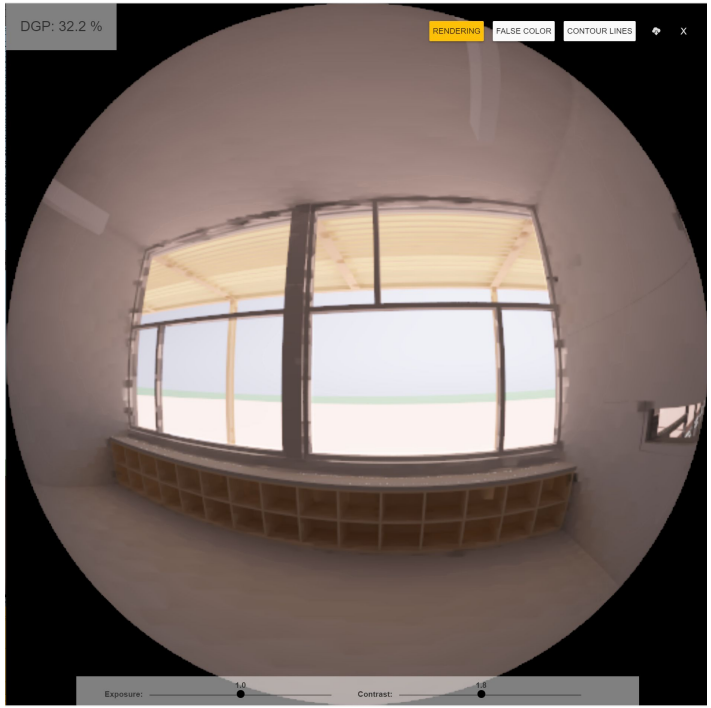
Trellis



Aspen Community School, Cuningham Group

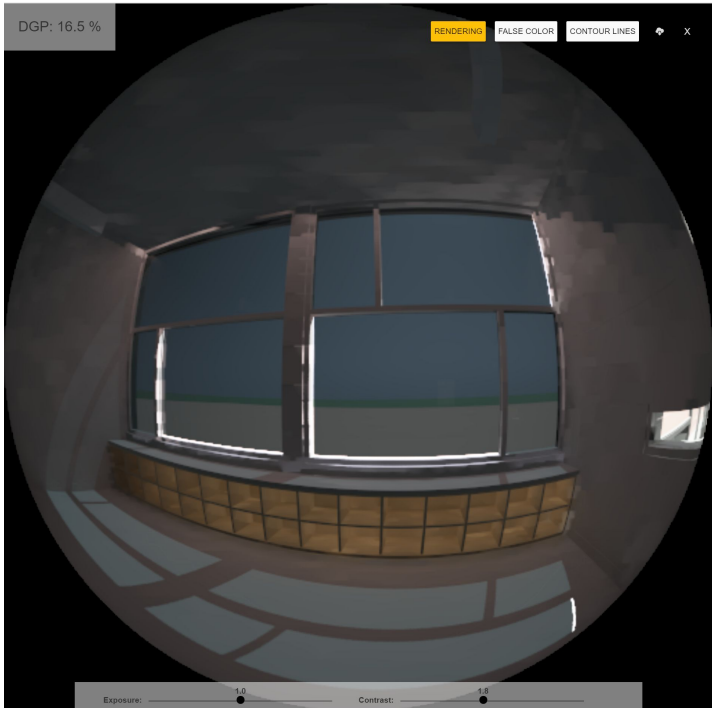
Easy Access to High Quality Information to Evaluate Tradeoffs

Trellis



11:45AM

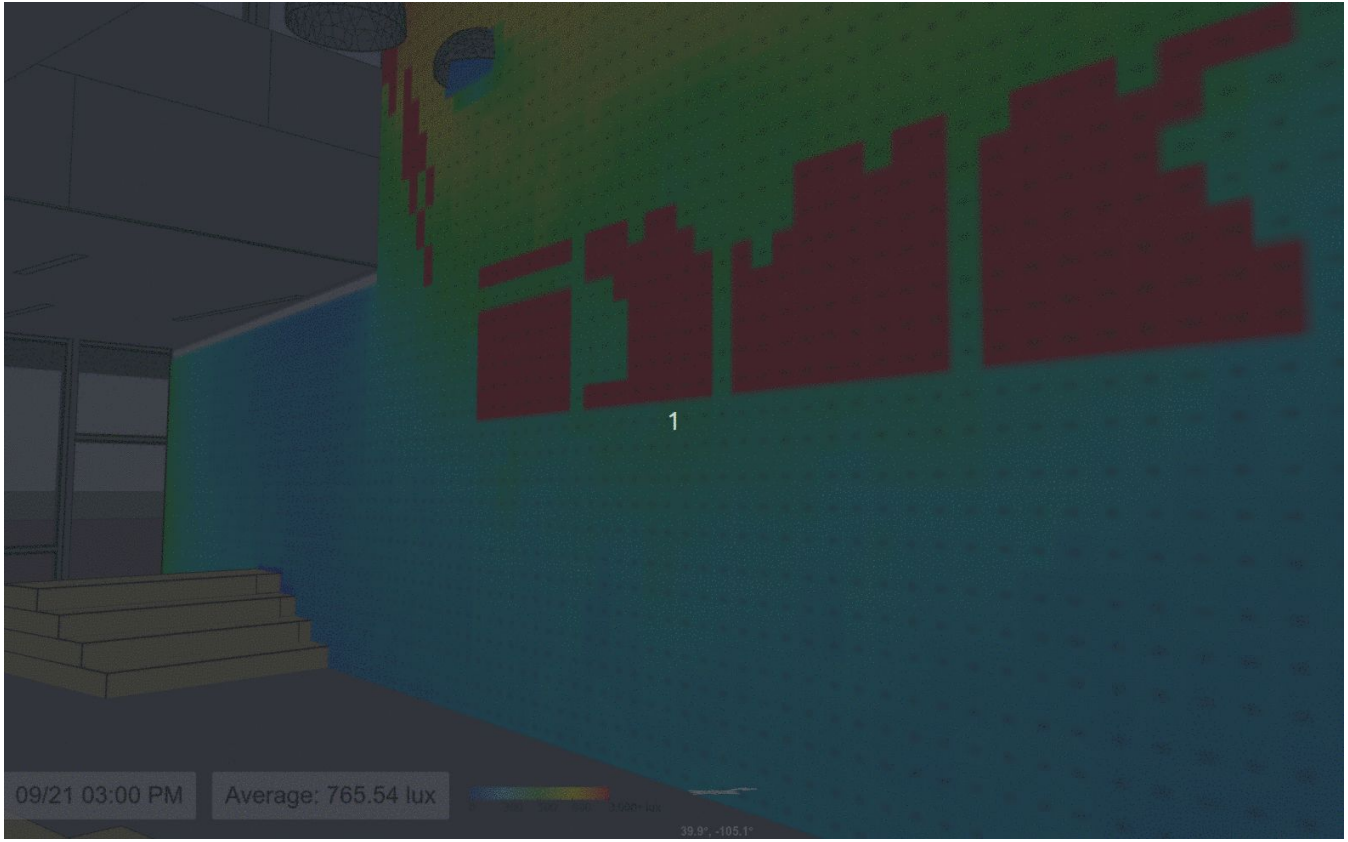
Dynamic Glass



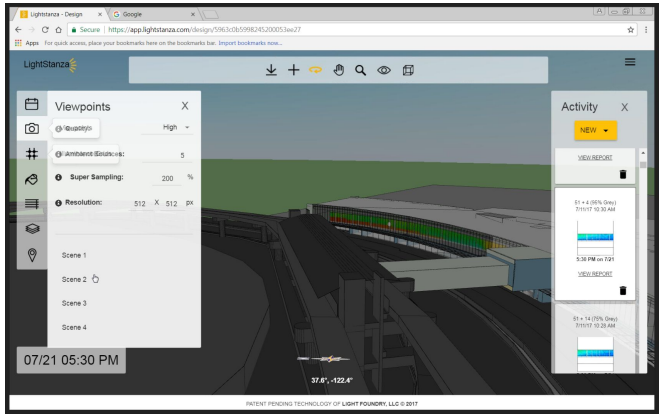
11:45AM

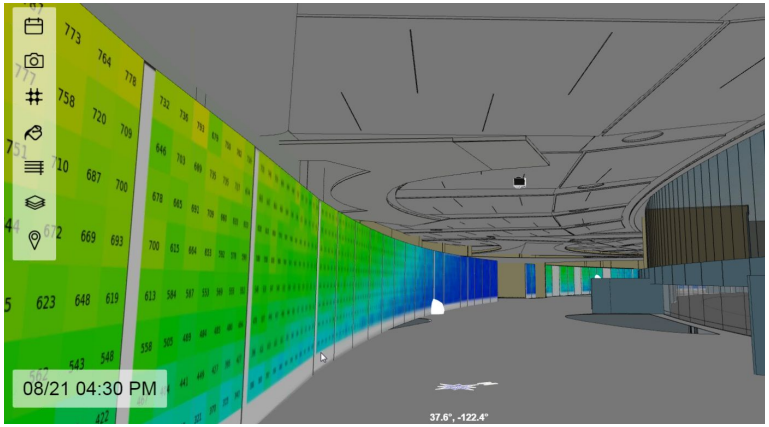
Aspen Community School, Cuningham Group

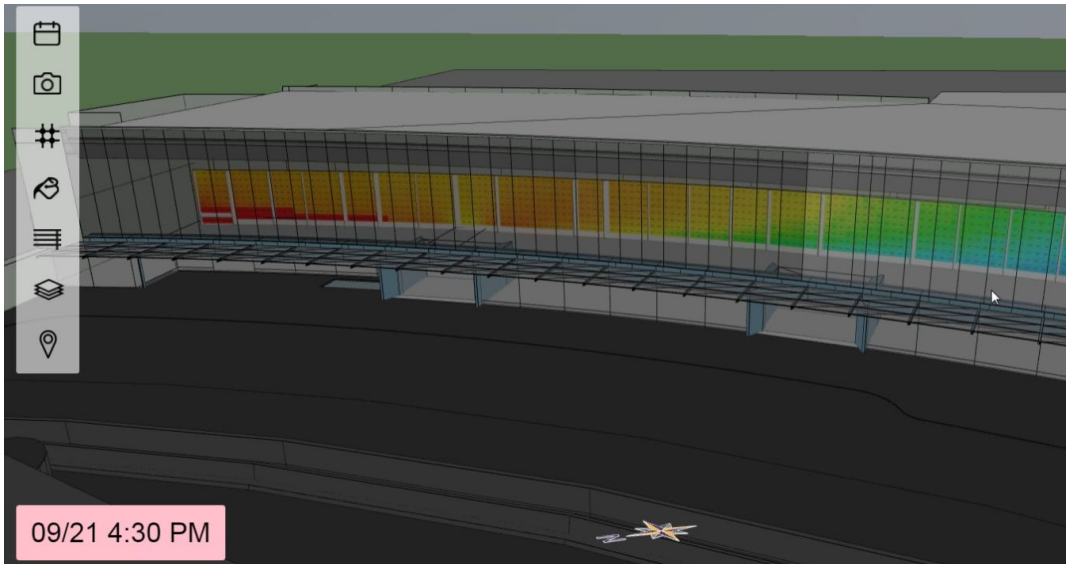
Illuminance Grids

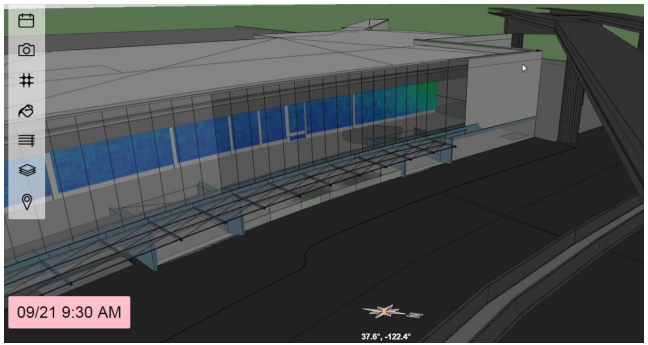


Gensler









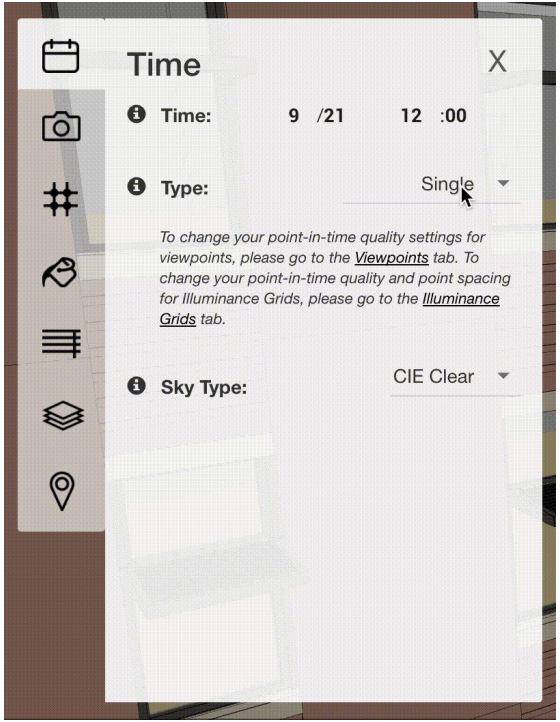
Tuning the Façade w/ Electrochromic Glazing and LightStanza

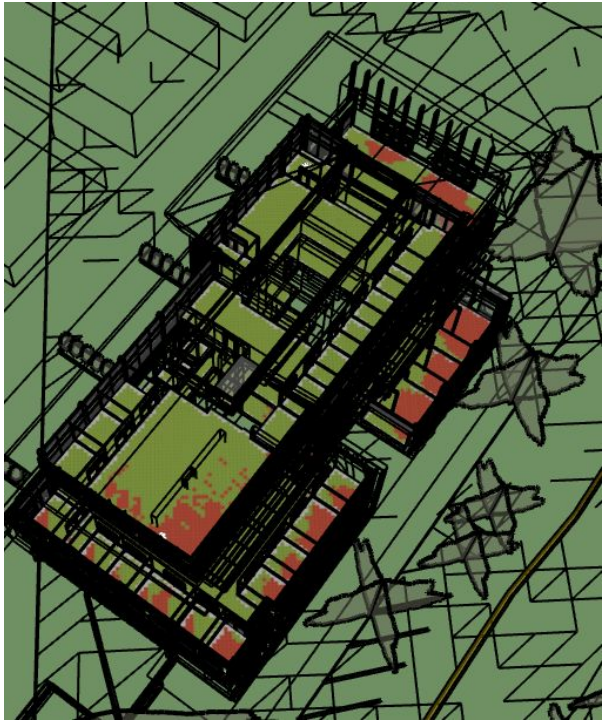
Advanced Fenestration

Dynamic Glass

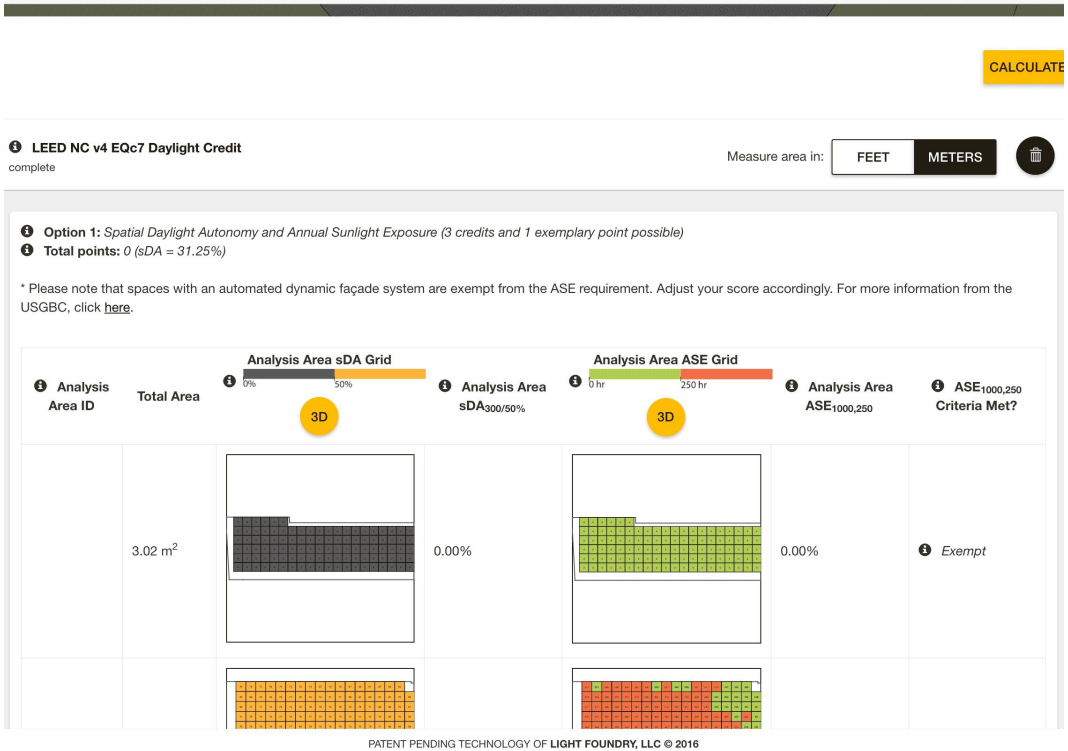
Blinds

Annuals

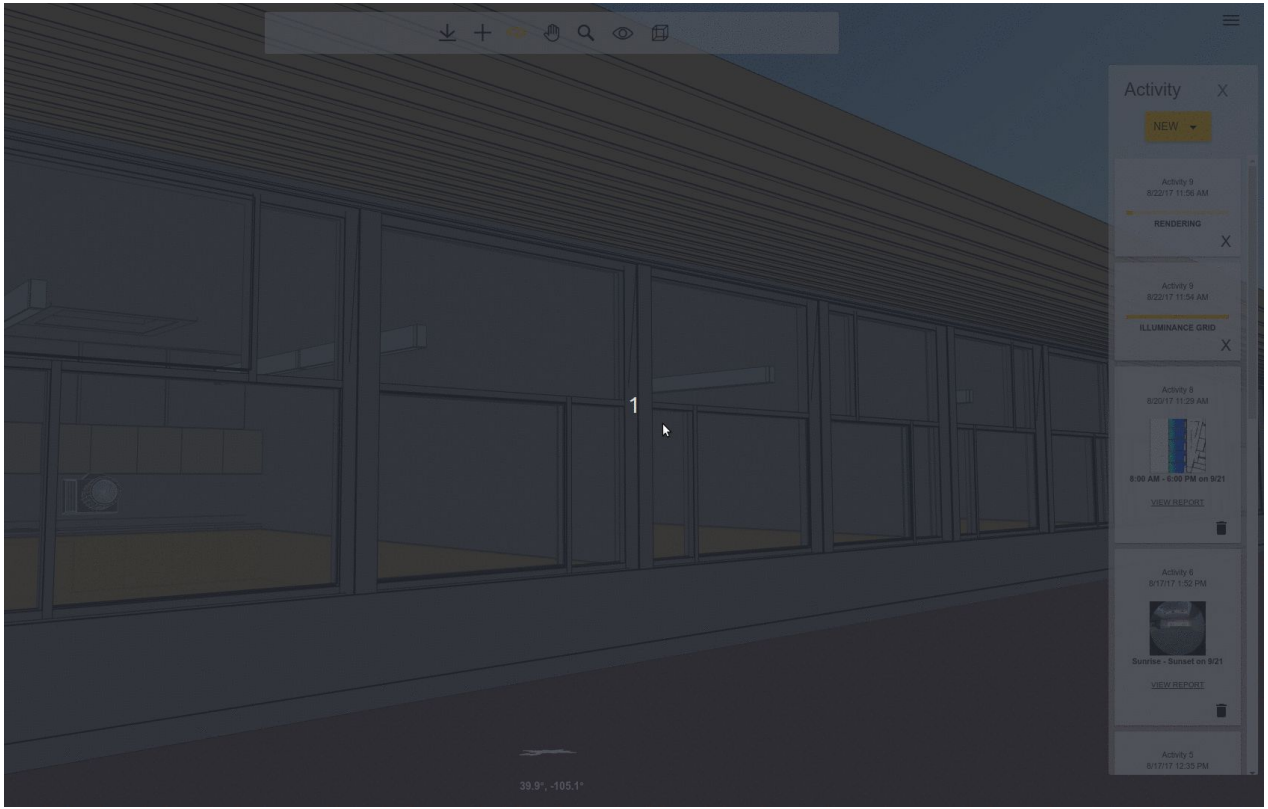




Green Building Industry Certification



Parallelizable Simulations



Annual Sunlight Exposure

“A metric that describes the potential for visual discomfort in interior work environments.”

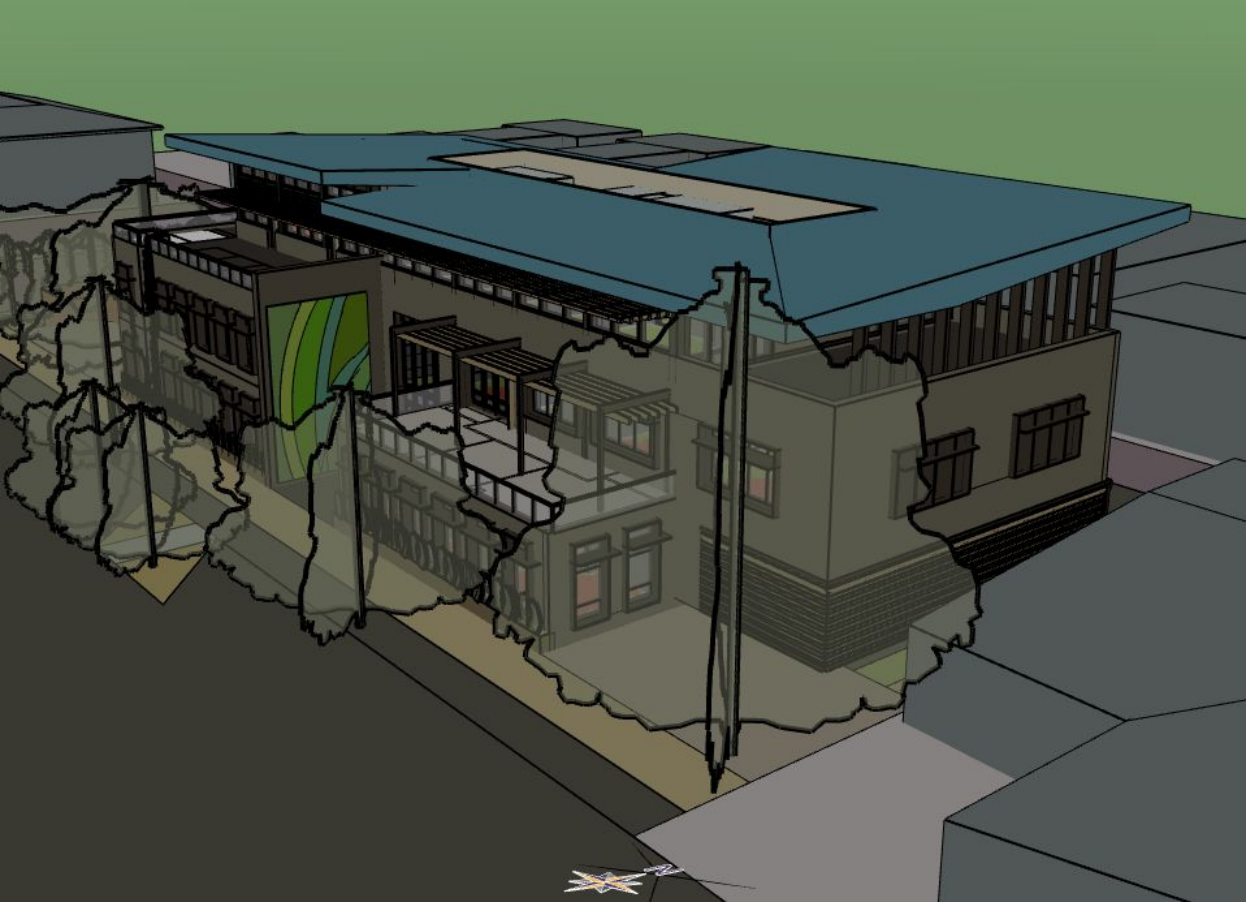
- IES LM-83-12 p. 10

Definitions

The Bedford Building, Winnipeg

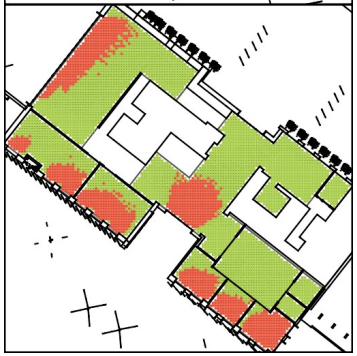
ASE Score: The percent of the analysis area that exceeds a 1000 lx from *direct sunlight* for more than 250 hours per year.

Direct sunlight: “The light directly from the orb of the sun, after filtering by atmospheric conditions and transmission losses through fenestration. It ***does not account for surface inter-reflections***.” -IES LM-83-12 p. 11



Floor 3

Floor 2



Floor 1

ASE scores on Alma Station by Point Energy Innovations, San Francisco, CA*

****model not final***

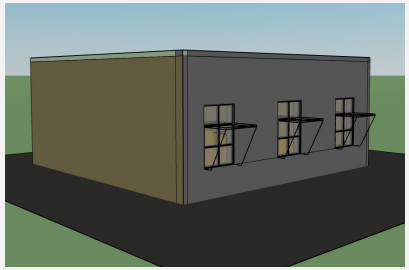
ASE scores on City of Fort Collins Utilities Administration Building by RNL Design, Denver, CO*

*****model not final***

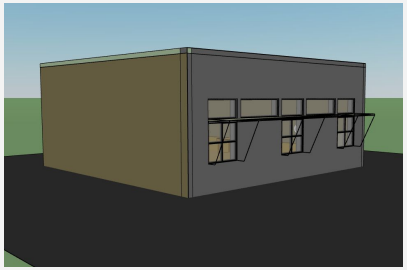
Four Methods to Calculate ASE

1. rtrace
2. 3-Phase method
3. 5-Phase method
4. Geometric

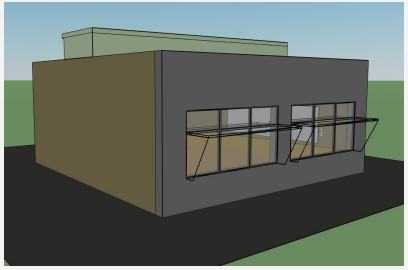
Test Models



Classroom A



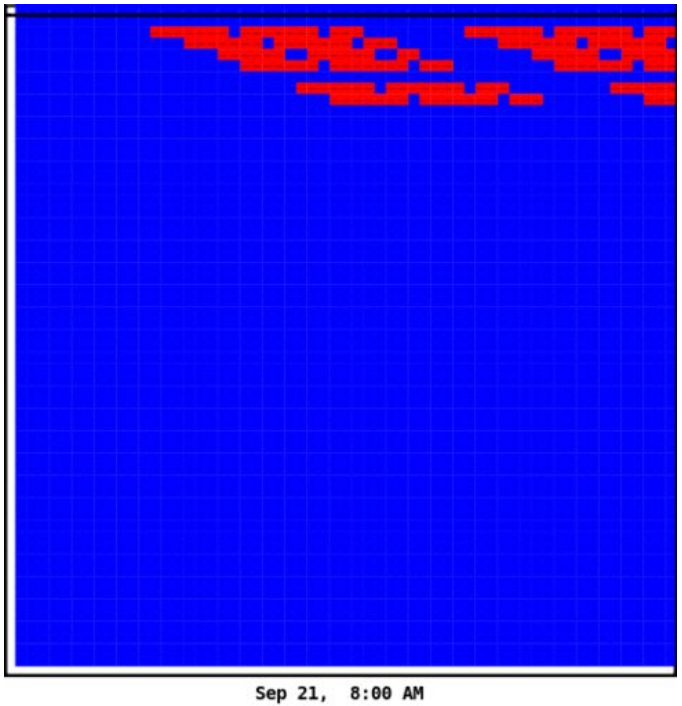
Classroom B

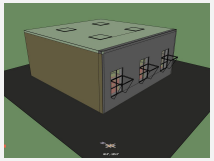


Classroom C

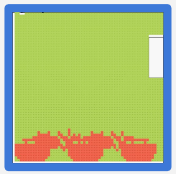
Method 1: rtrace

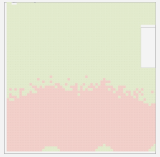
- Most accurate of the four methods.
- Calculate the direct illuminance at each time-step independently, this is the slowest method of the four.
- Glass will transmit rays with “-ab 0”
- For BSDF fenestration, “-ab 1” is needed for off angle transmissions.

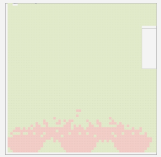


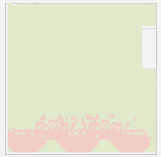


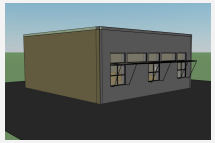
Classroom A


rtrace
13.0%

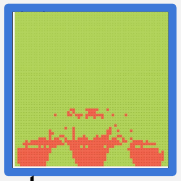

3-phase
41.6%

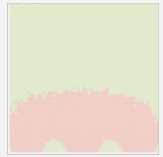

5-phase
14.1%

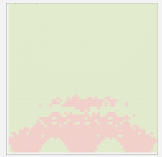

geometric
14.9%

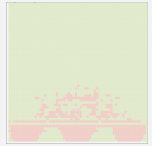


Classroom B

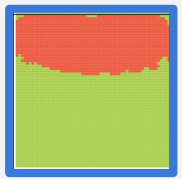

rtrace
12.8%

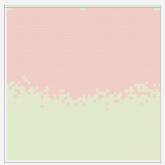

3-phase
35.0%

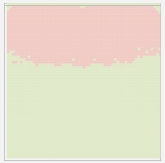

5-phase
19.7%

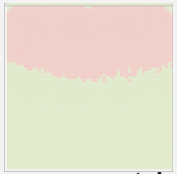

geometric
15.1%

Classroom C


rtrace
34.7%

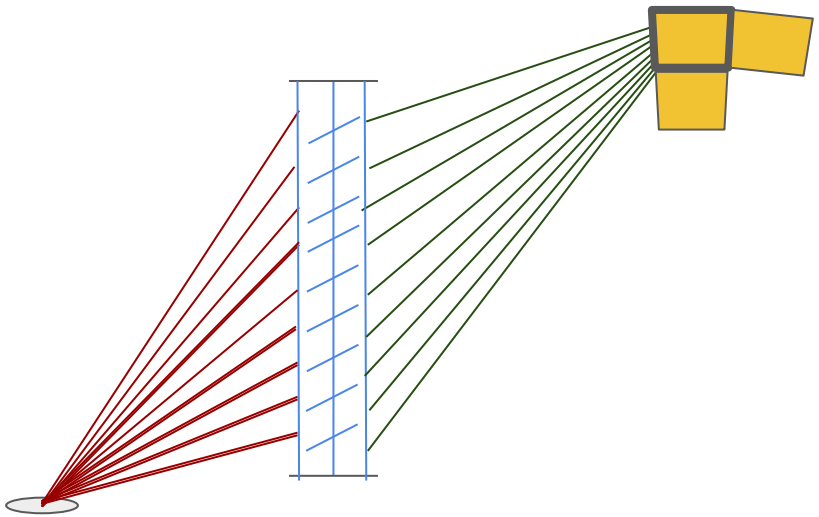

3-phase
54.8%


5-phase
35.6%


geometric
40.5%

Method 2: Direct 3-Phase

The Direct 3-Phase is the least accurate of the three methods at calculating ASE.

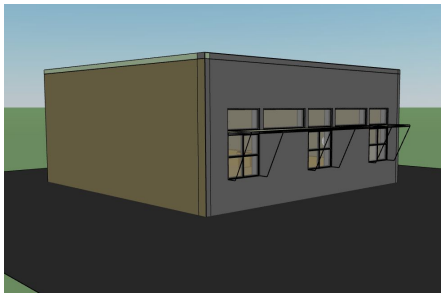


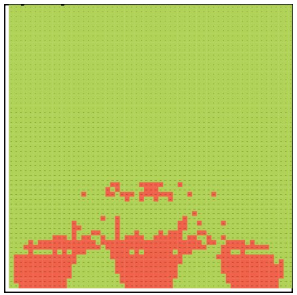
$$I_{d3pm} = V_d \; T \; D_s \; S_d$$

V_d T D_d S_d

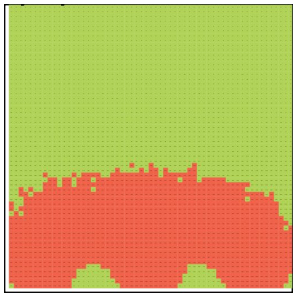
The Problem with Direct 3-Phase Method

- Disperses energy at the window transmission causing a “smearing” effect.
- Not recommended for calculations sensitive to the direct component!





rtrace
12.8%

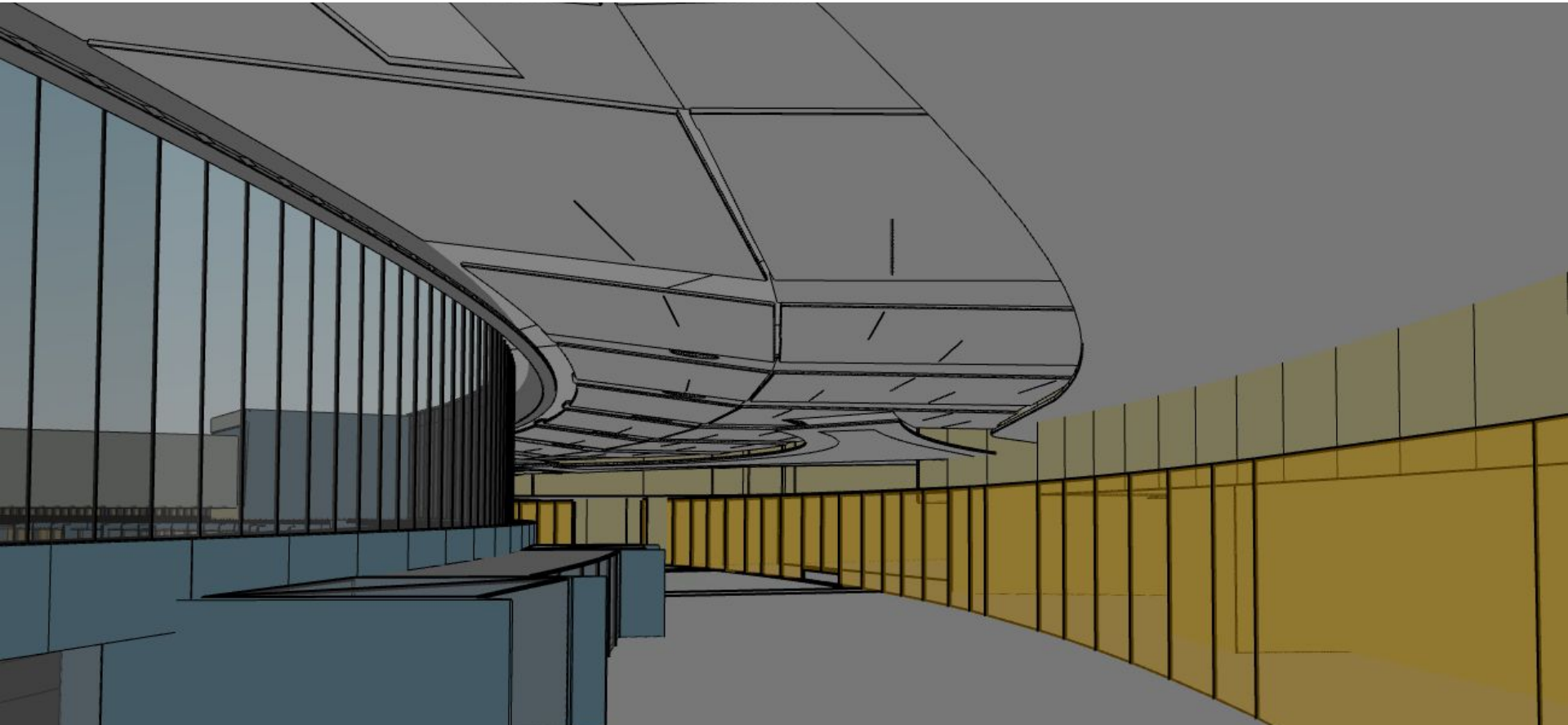


3-phase
35.0%

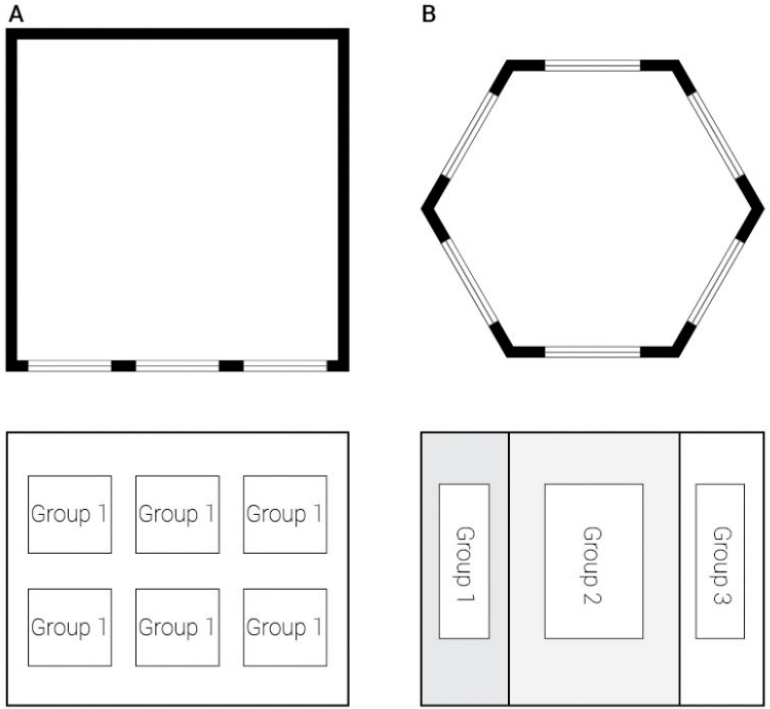
The Direct 3-Phase is a Component in the 5-phase

$$I_{5\text{-phase}} = VTDS - \mathbf{V_d\, TD_s S_d} + C_{ds} S_{sun}$$

Automating the 3-Phase

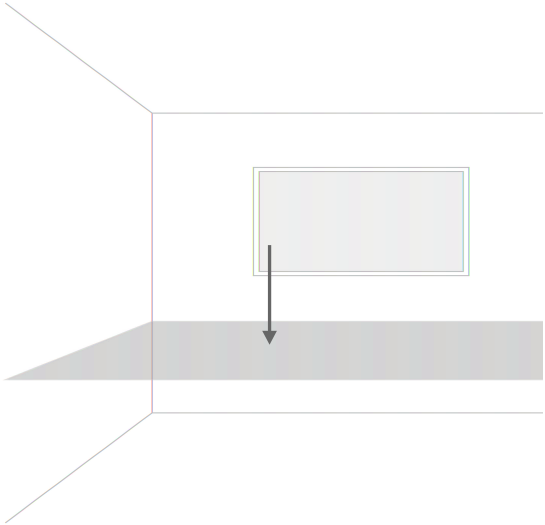


Challenge 1: Window Group Determination

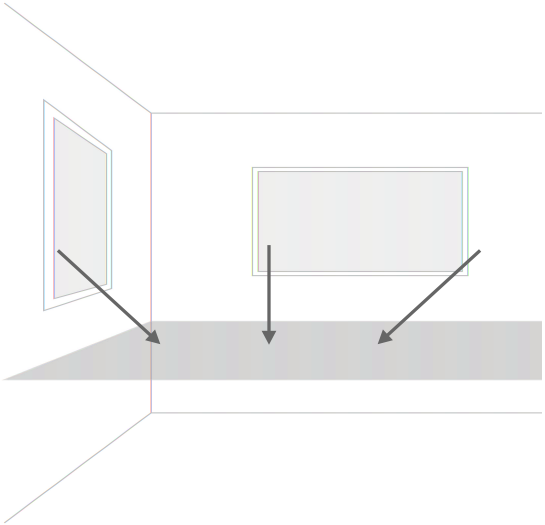


Challenge 2: Grid-to-Window Pairing

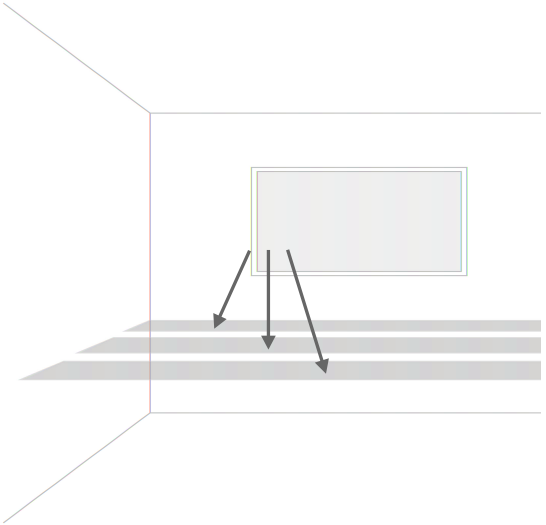
1 Window, 1 Grid



Many Windows, 1 Grid

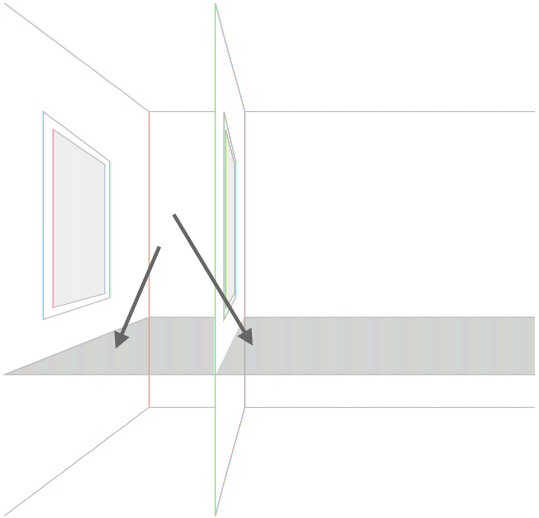


1 Window, Many Grids

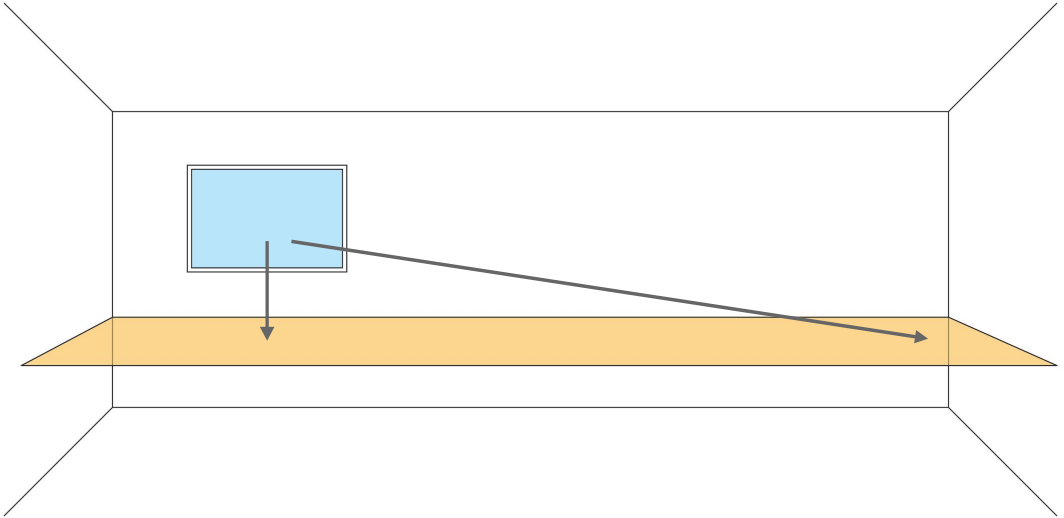


Challenge 2: Grid-to-Window Pairing (Continued)

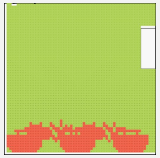
Interior Window, 1 Grid



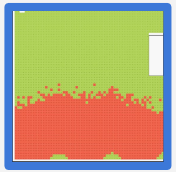
Small Window, Large Grid



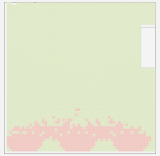
Classroom A



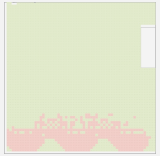
rtrace
13.0%



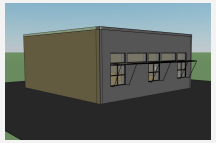
3-phase
41.6%



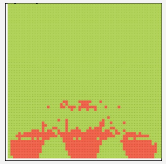
5-phase
14.1%



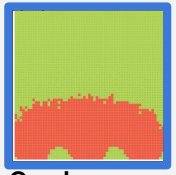
geometric
14.9%



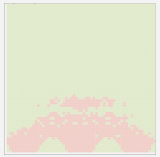
Classroom B



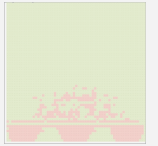
rtrace
12.8%



3-phase
35.0%

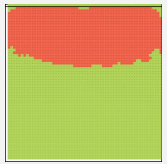


5-phase
19.7%

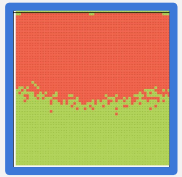


geometric
15.1%

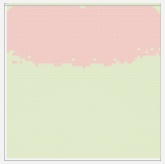
Classroom C



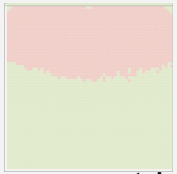
rtrace
34.7%



3-phase
54.8%



5-phase
35.6%

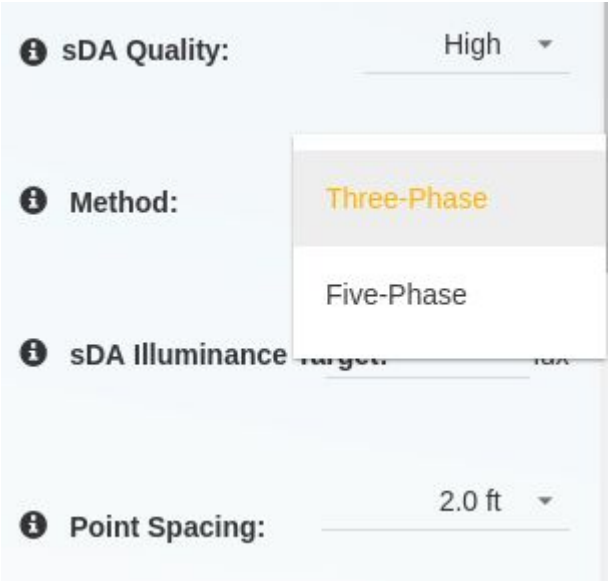


geometric
40.5%

Method 3: 5-phase

$$I_{5\text{-phase}} = VTDS - V_d TD_s S_d + \mathbf{C_{ds} S_{sun}}$$

- The *direct suns component* of the 5-phase is a fast and accurate way of calculating the annual direct sunlight.



5-phase is ready to use inside of LightStanza!

Different ASE Computations on Larger Models

ASE scores on City of Fort Collins Utilities Administration Building by RNL Design, Denver, CO

3-phase

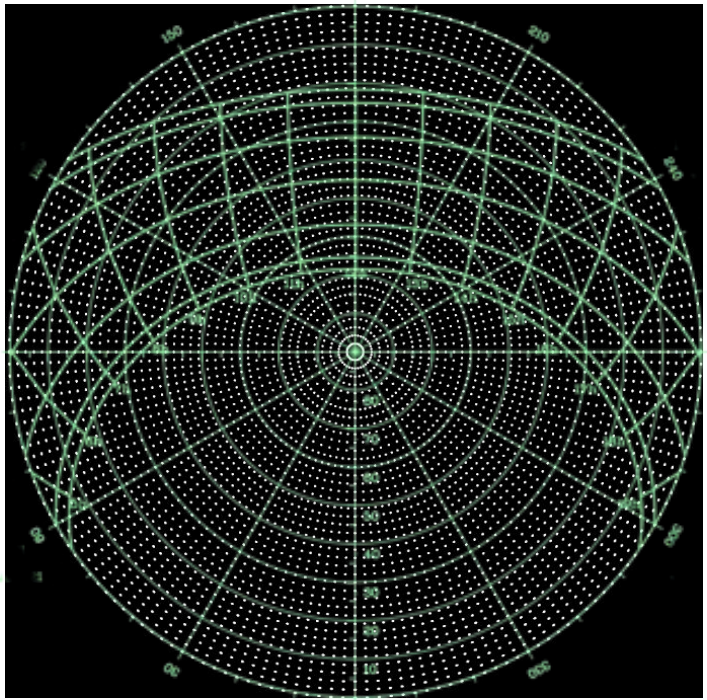
5-phase

ASE scores on Alma Station by Point Energy Innovations, San Francisco, CA

3-phase

5-phase

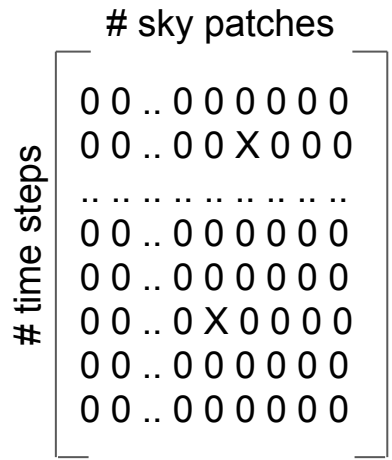
Can it be Faster?



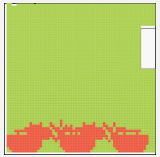
Many of the sample suns are outside of the sun path.

Can it be Faster? (Continued)

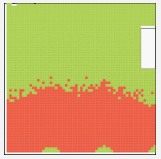
Gendaymtx “-d” produces a sparse matrix which increases processing time.



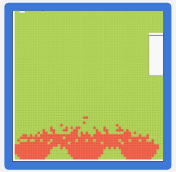
Classroom A



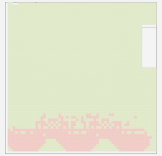
rtrace
13.0%



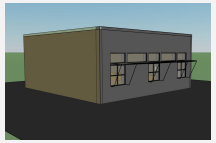
3-phase
41.6%



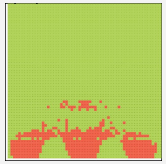
5-phase
14.1%



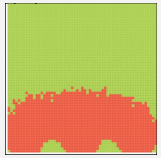
geometric
14.9%



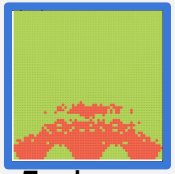
Classroom B



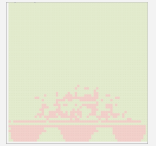
rtrace
12.8%



3-phase
35.0%

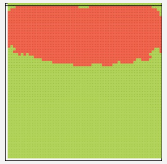


5-phase
19.7%

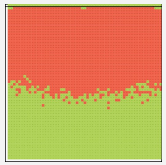


geometric
15.1%

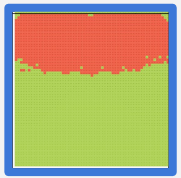
Classroom C



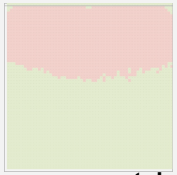
rtrace
34.7%



3-phase
54.8%

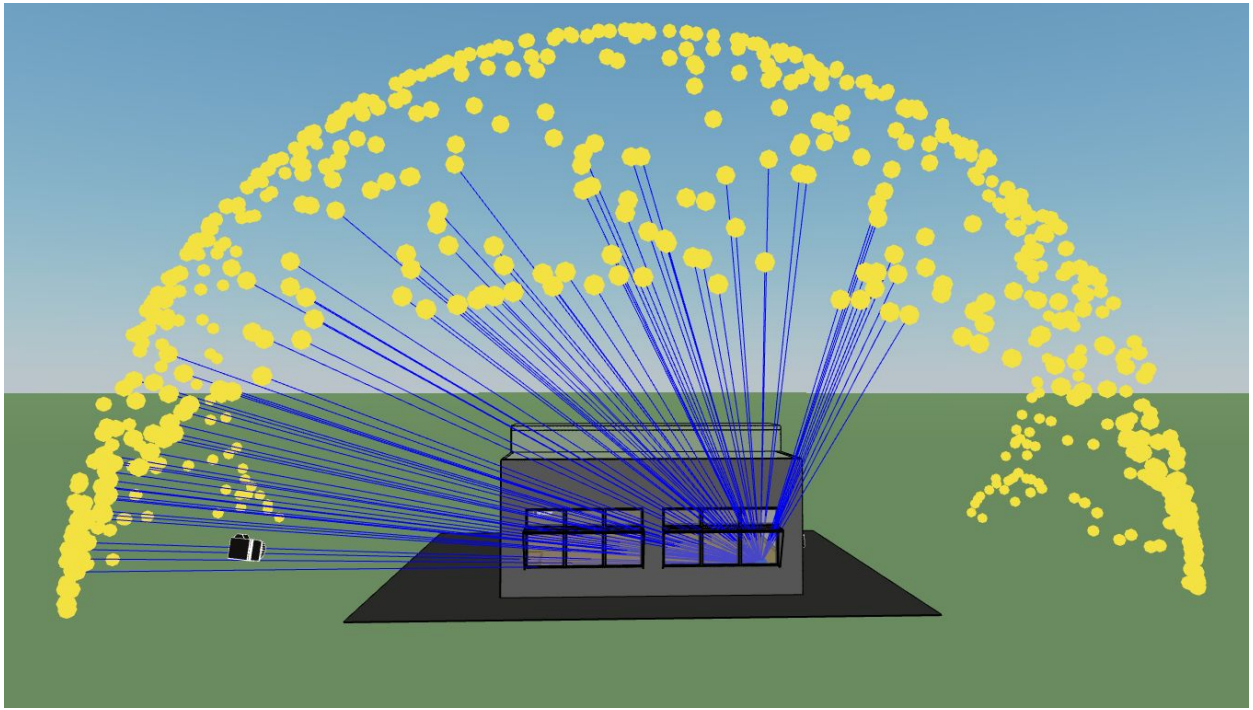


5-phase
35.6%



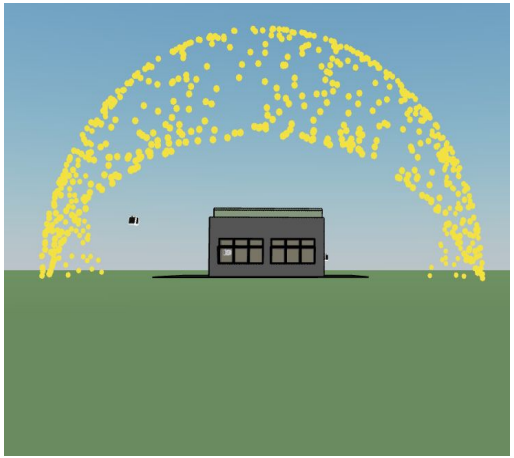
geometric
40.5%

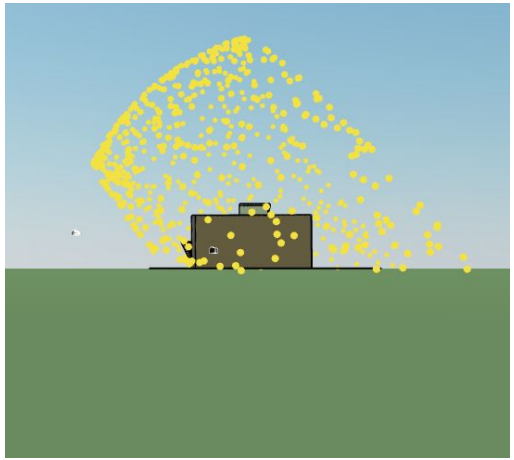
Method 4: Geometric

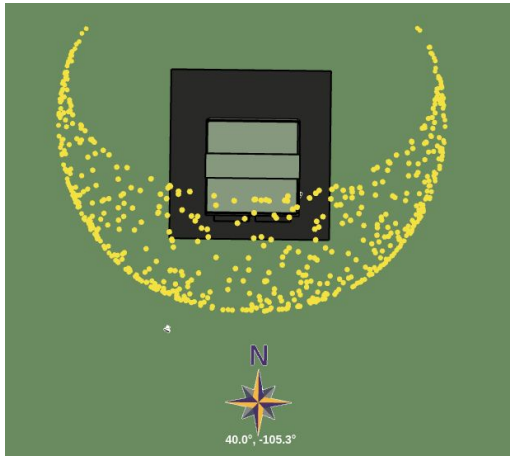


Get Sun Samples Inside Sun Path

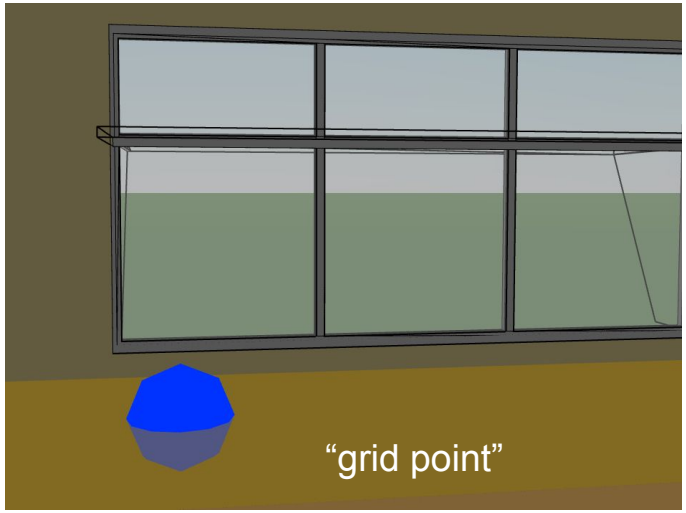
- Used random samples to account for *sub-hourly* annual analysis.
- Randomness reduces systematic error.
- Sun sample density inside solar envelope is on the order of a full sky with “-m 4” Reinhart patch subdivision (2305 sky patches).

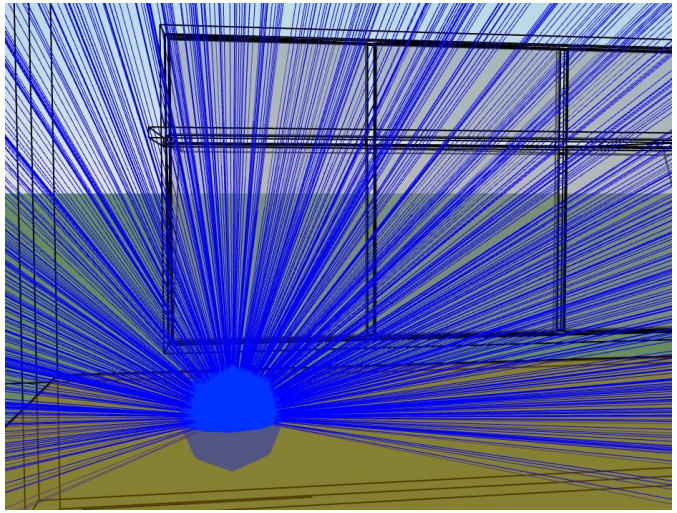




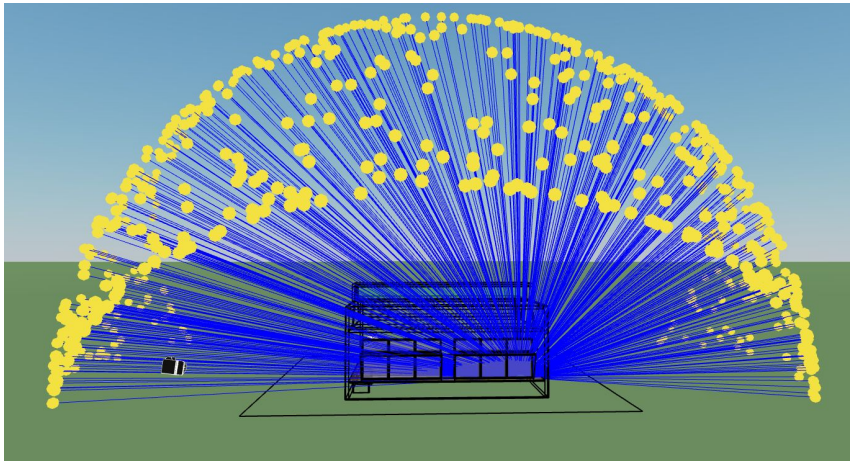


For Each Grid Point in the Model, Cast a Ray to Each Solar Sample.

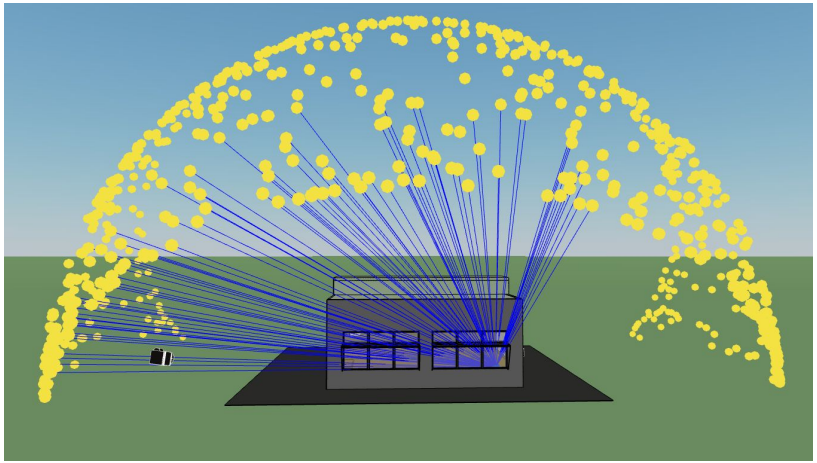




Identify Sun Rays

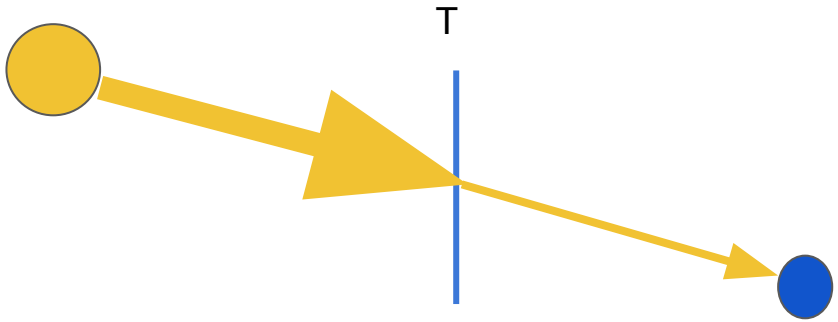


All Sun rays visible



Sun rays culled by geometry.

Calculate transmission coefficients

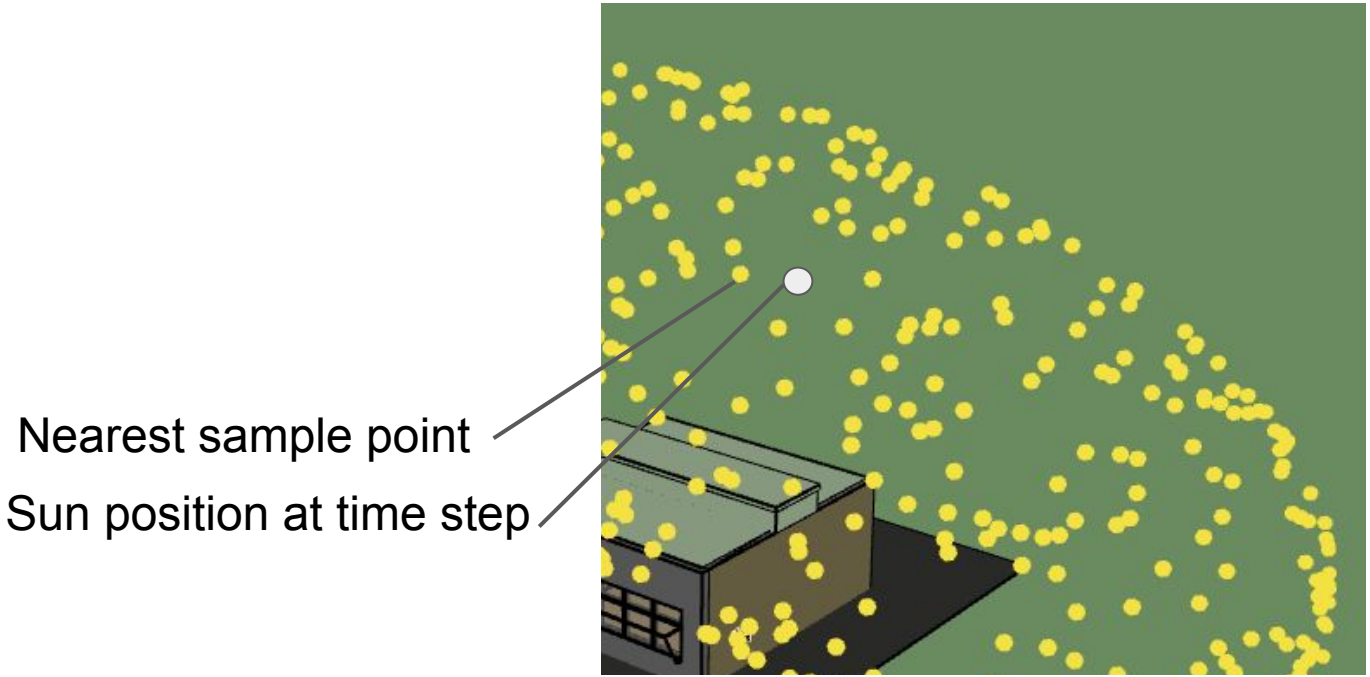


# of sun samples

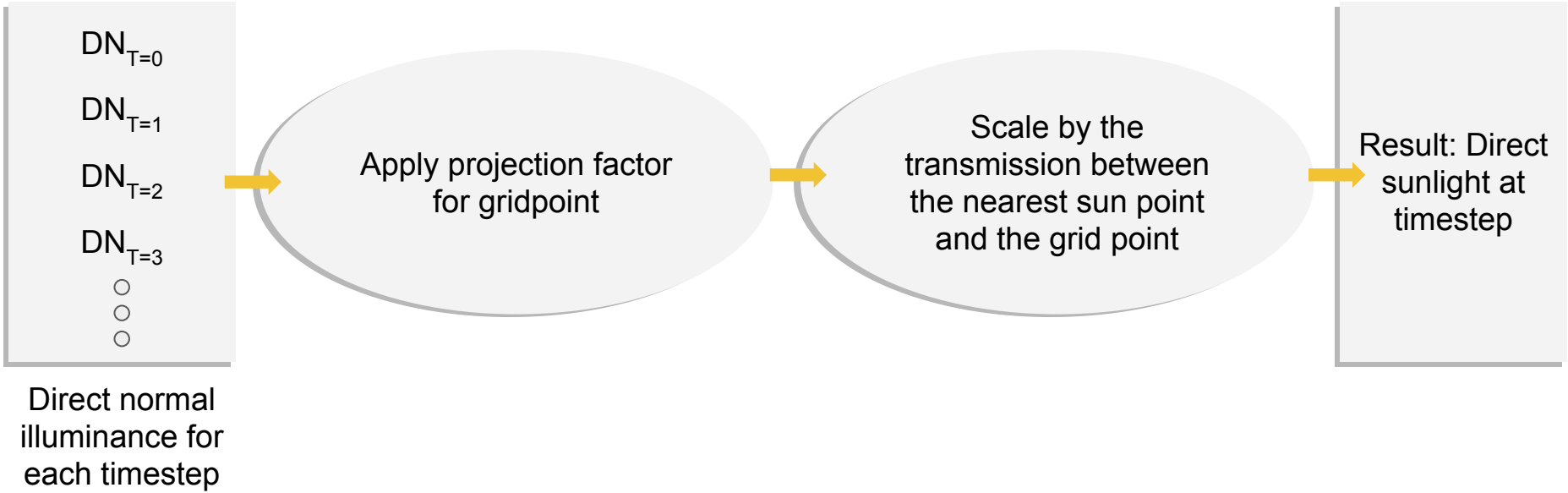
grid points

Transmission coefficient matrix

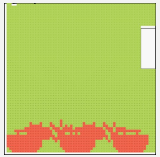
At each Timestep, Calculate the Sun Position and Get the Nearest Sample Point



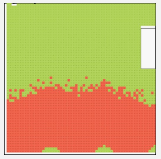
Putting it All Together



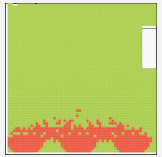
Classroom A



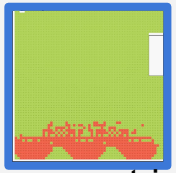
rtrace
13.0%



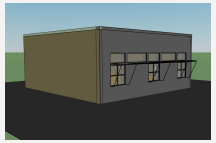
3-phase
41.6%



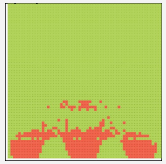
5-phase
14.1%



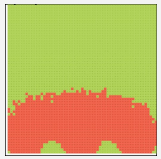
geometric
14.9%



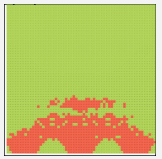
Classroom B



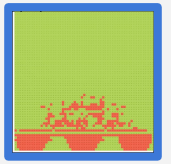
rtrace
12.8%



3-phase
35.0%

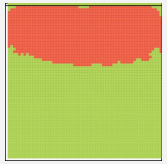


5-phase
19.7%

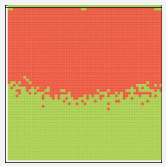


geometric
15.1%

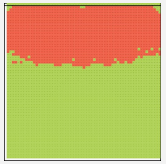
Classroom C



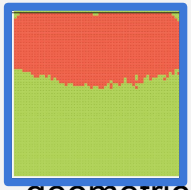
rtrace
34.7%



3-phase
54.8%



5-phase
35.6%

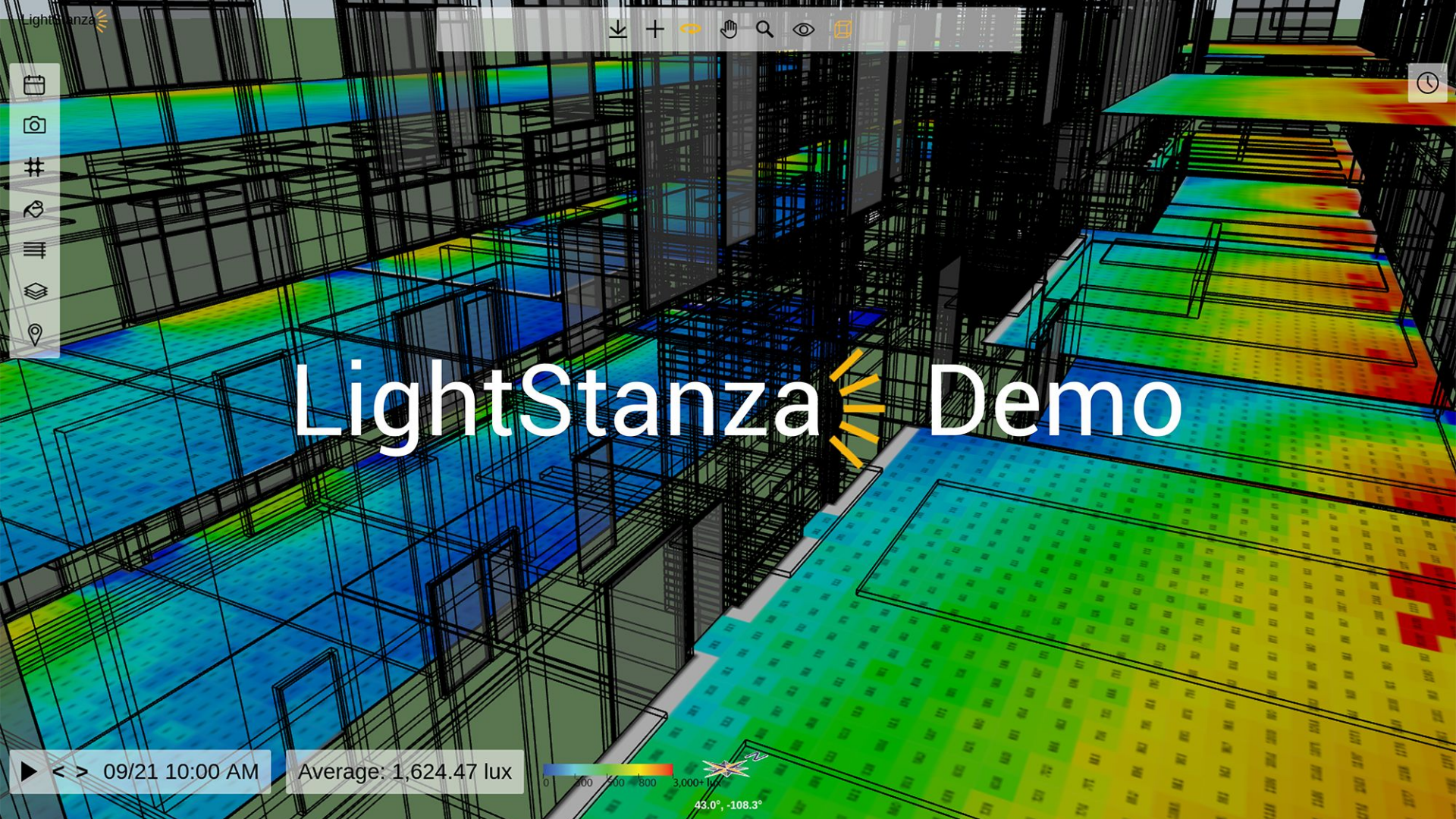


geometric
40.5%

Summary

- LightStanza's Web User-Interface Allows for more fluid, informative, and less-error prone experience

- LightStanza's cloud servers use automated analysis that provide fast, accurate, and robust results.


LightStanza
LightStanza Demo
09/21 10:00 AM
Average: 1,624.47 lux
0
300
500
800
3,000+ lux
43.0°, -108.3°


Questions?