

Daylight Simulation Analysis of an Innovative Daylighting System: **Optical Vertical Louver (OVL) System**

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Outline

- To introduce the OVL system
- To generate the BSDF data.
- To quantify the efficiency of OVL system in comparison with state of the art daylighting systems.
- To provide the future studies of the OVL system

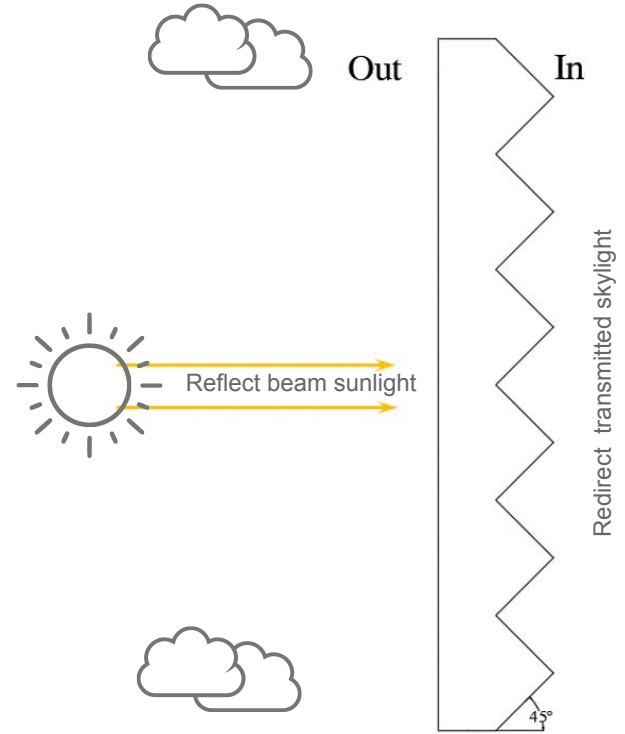


INTRODUCTION

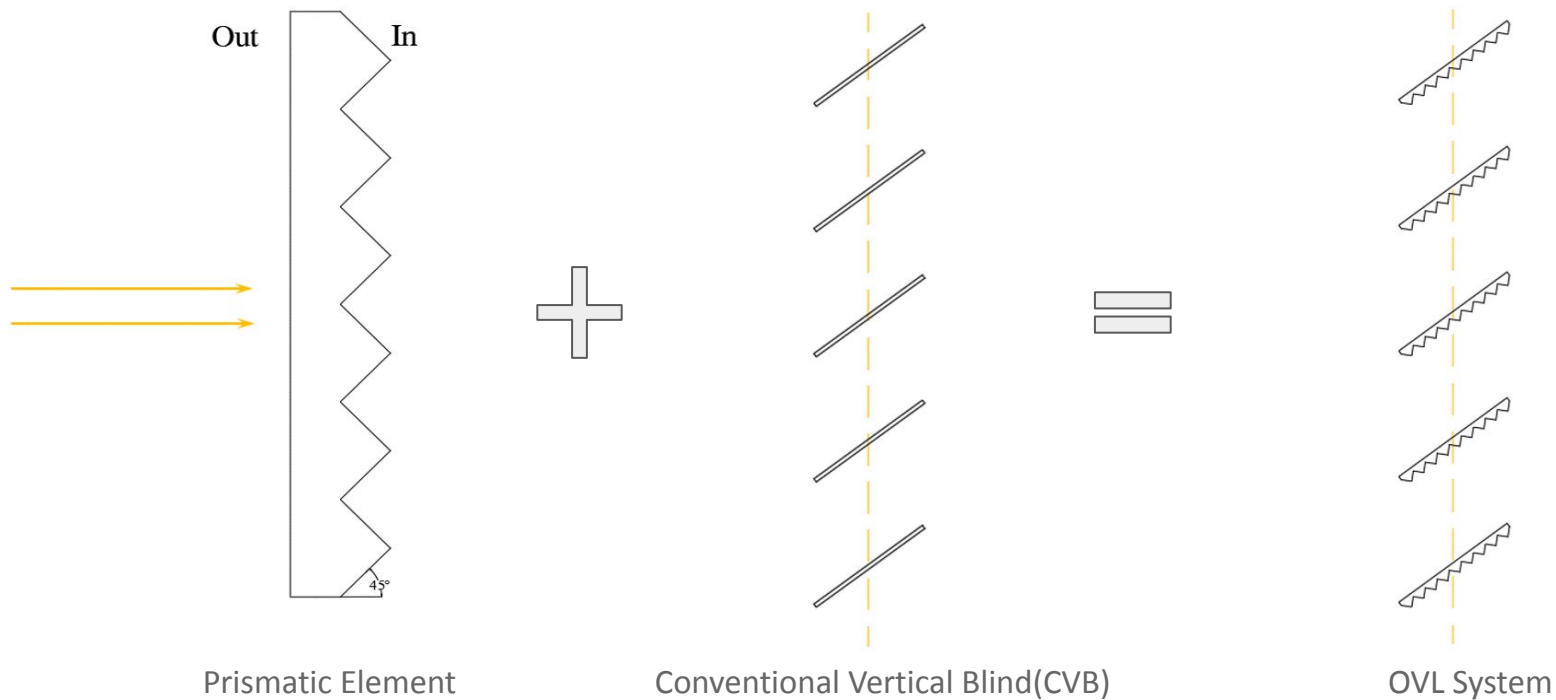


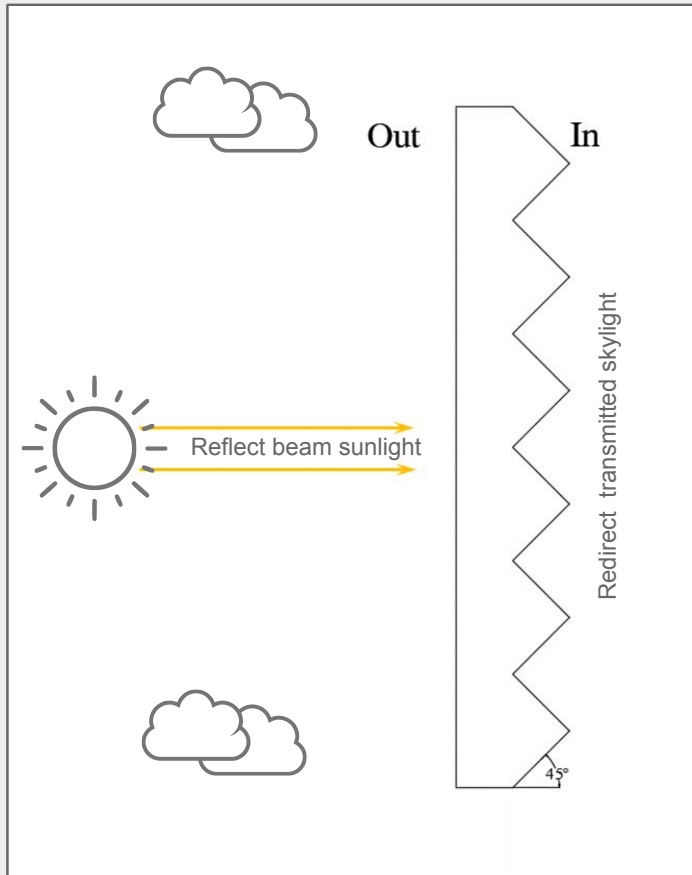
Prismatic Panel

- Blocks beam sunlight while transmits diffuse skylight
- Light perpendicular to the prismatic panel is completely reflected away (around 99%).
- Light not perpendicular to the prismatic panel is partially transmitted (around 45-50%).



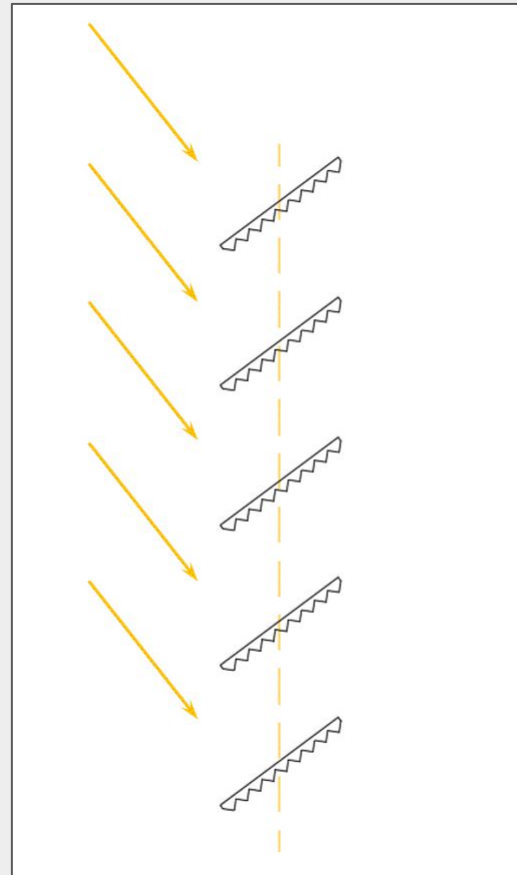
Optical Vertical Louver (OVL)



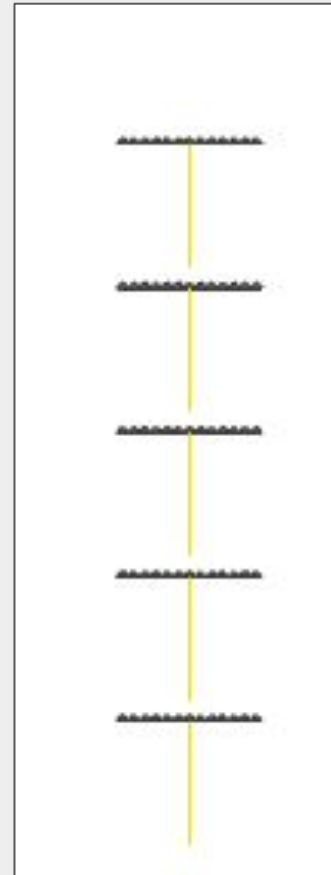


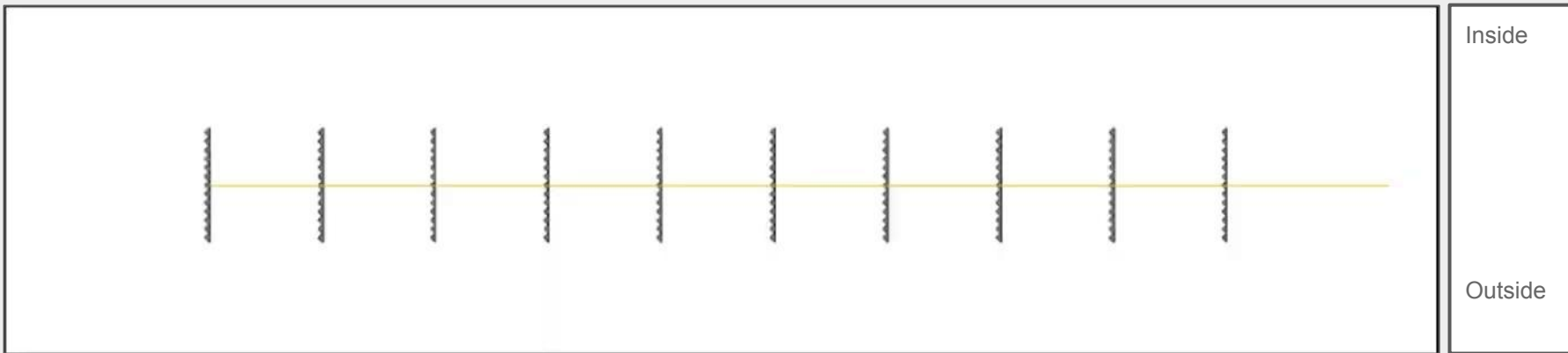
Prismatic Element

as a



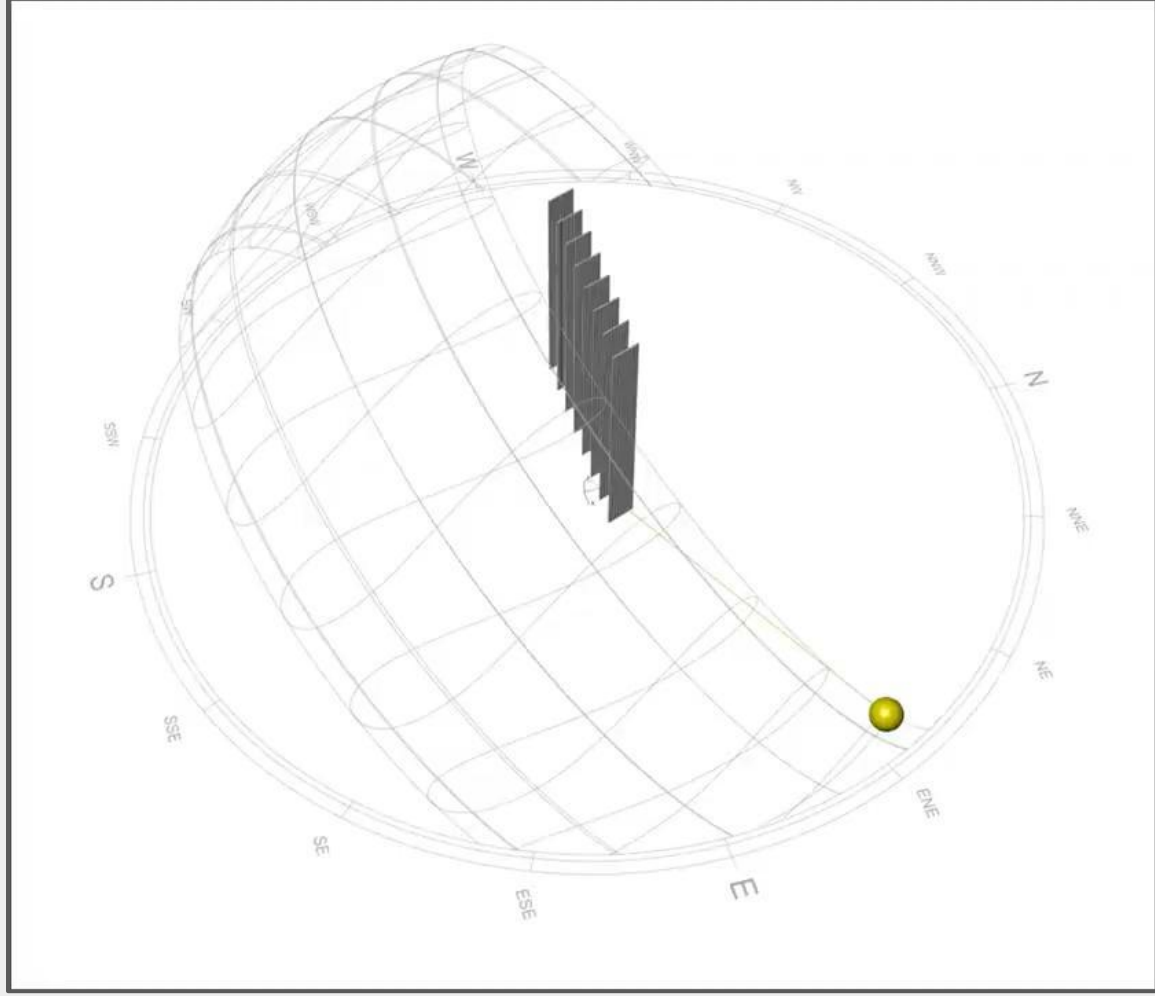
Solar Shading System



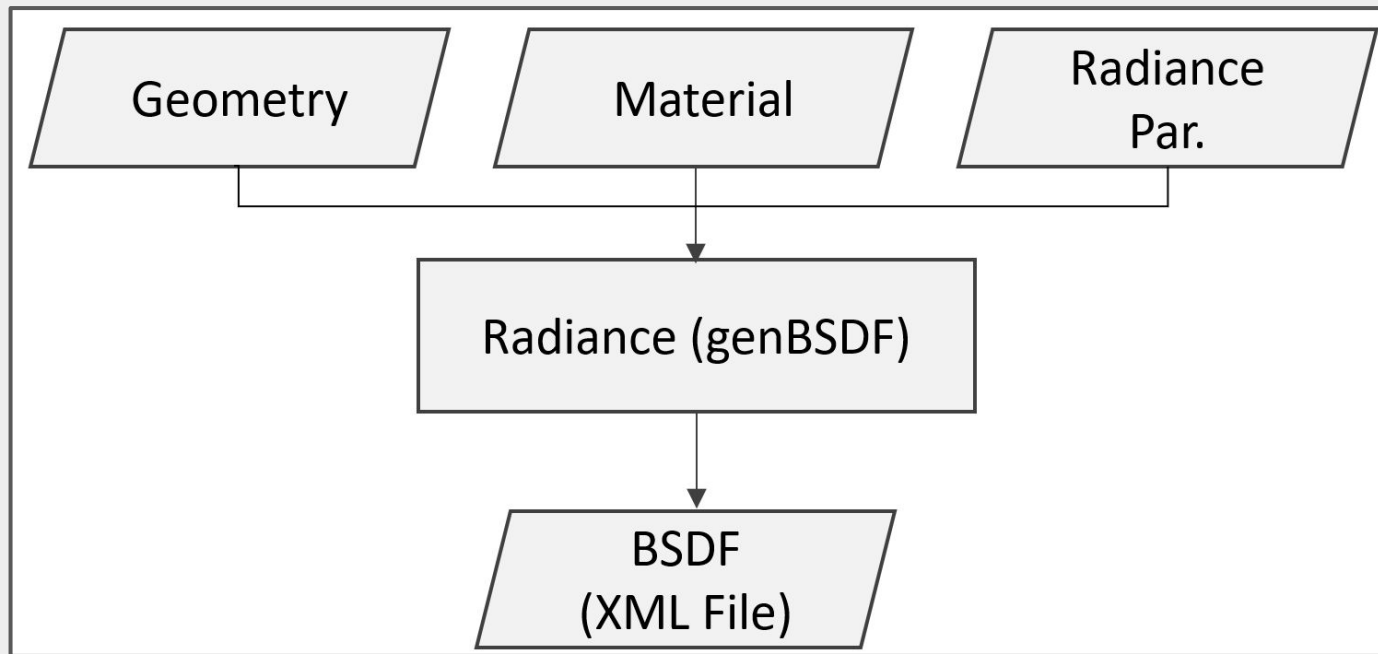


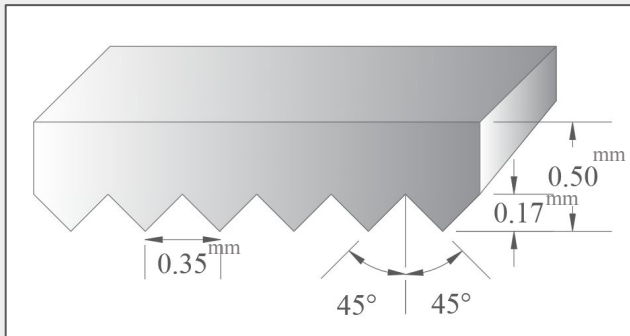
*Yellow lines show the sun azimuth angle which are perpendicular to the slat surfaces

INTRODUCTION



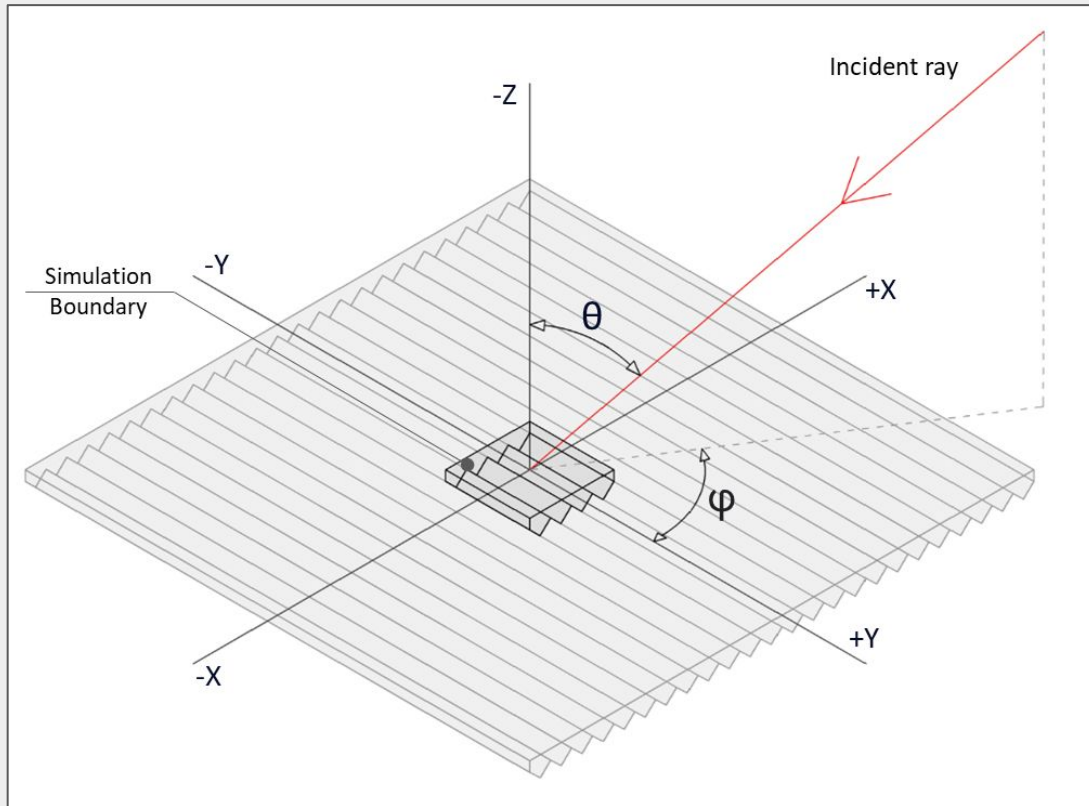
OPTICAL CHARACTERIZATION



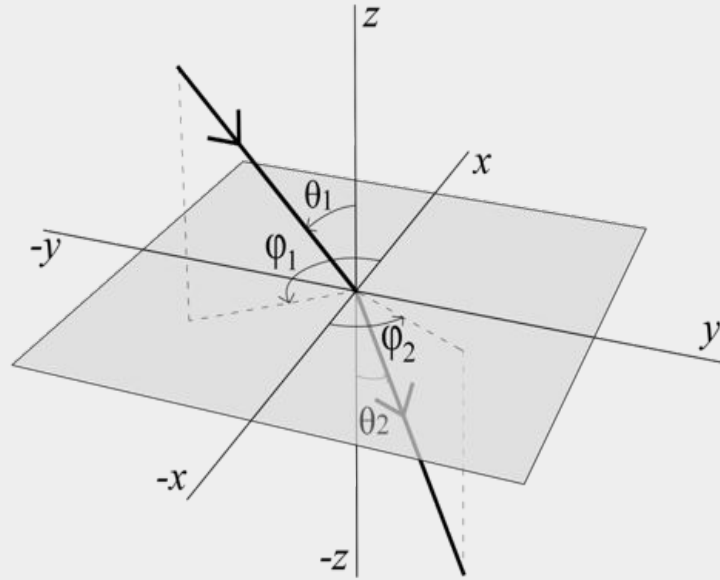


Refractive index: 1.59

```
genBSDF -n 4 -c 12288 -r "-" -ab 15 -ad
100 -lw 0.001" -t4 6 +f +b -geom
millimeter -dim -2.56472 3.43528
2.28433 7.71567 -1.09901 -0.09901
mat.rad 9112020.rad >BSDF.xml
```

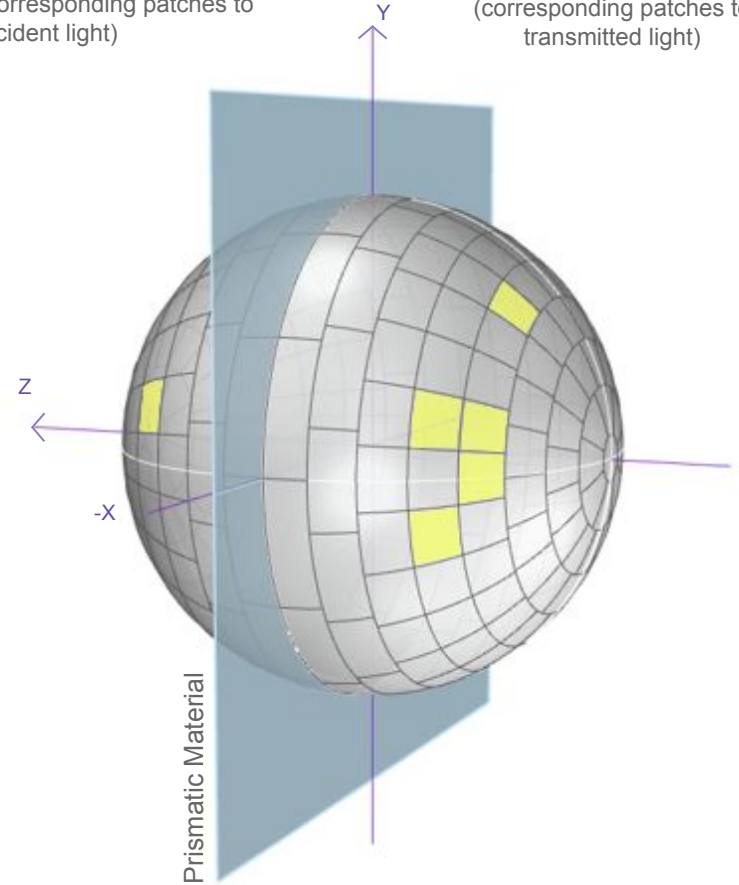


Transmission of Prismatic Element

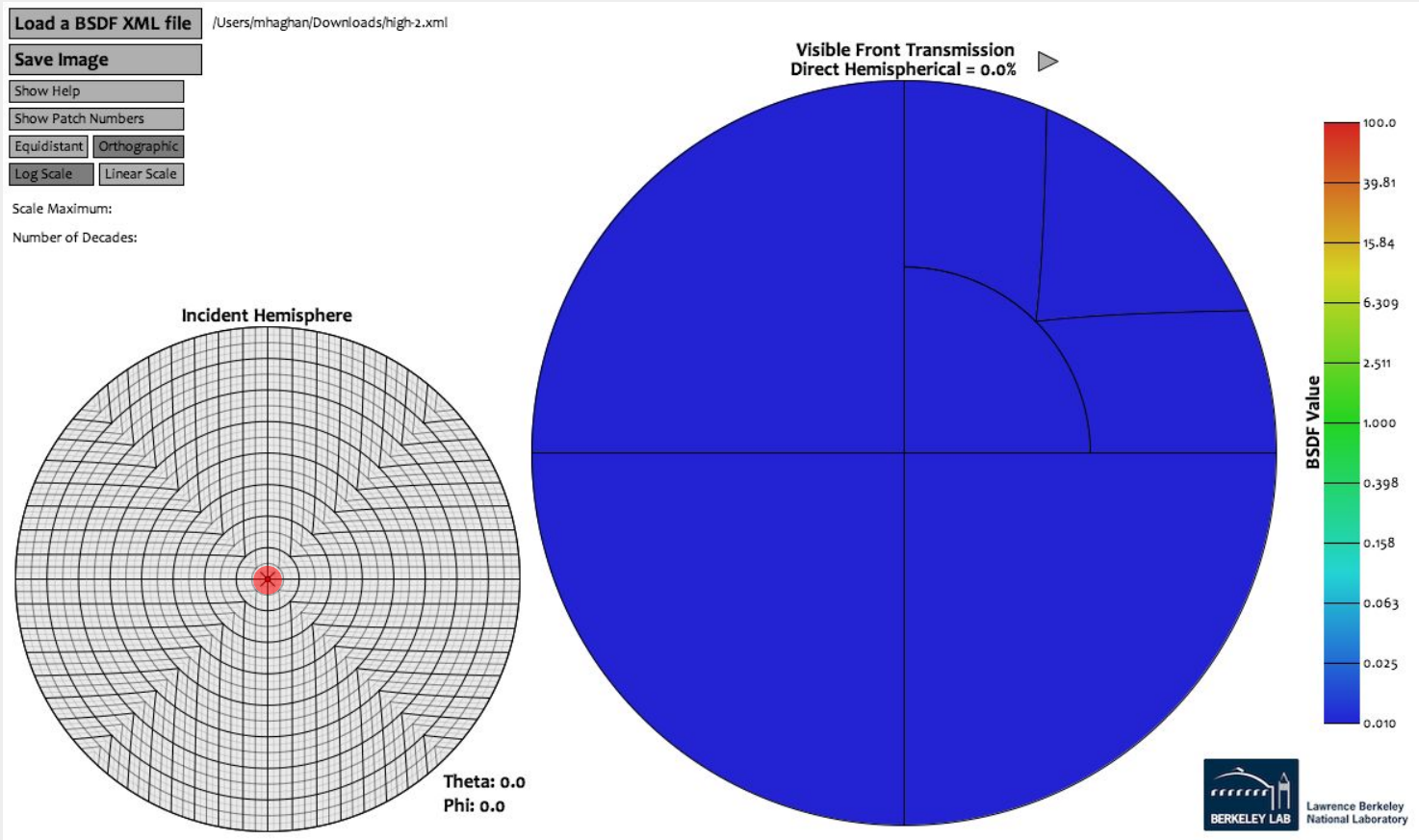


Incident Hemisphere
(corresponding patches to incident light)

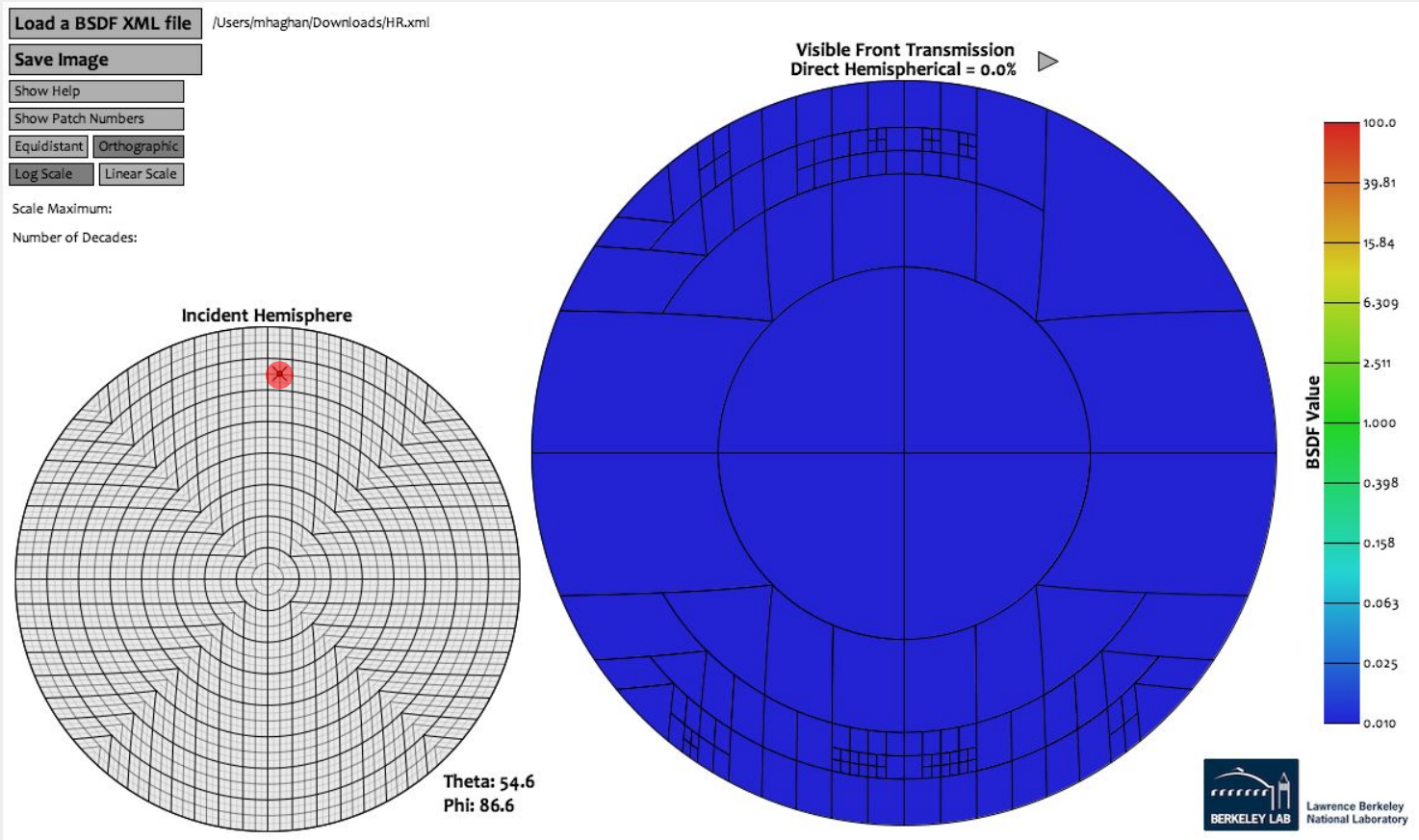
Transmission Hemisphere
(corresponding patches to transmitted light)



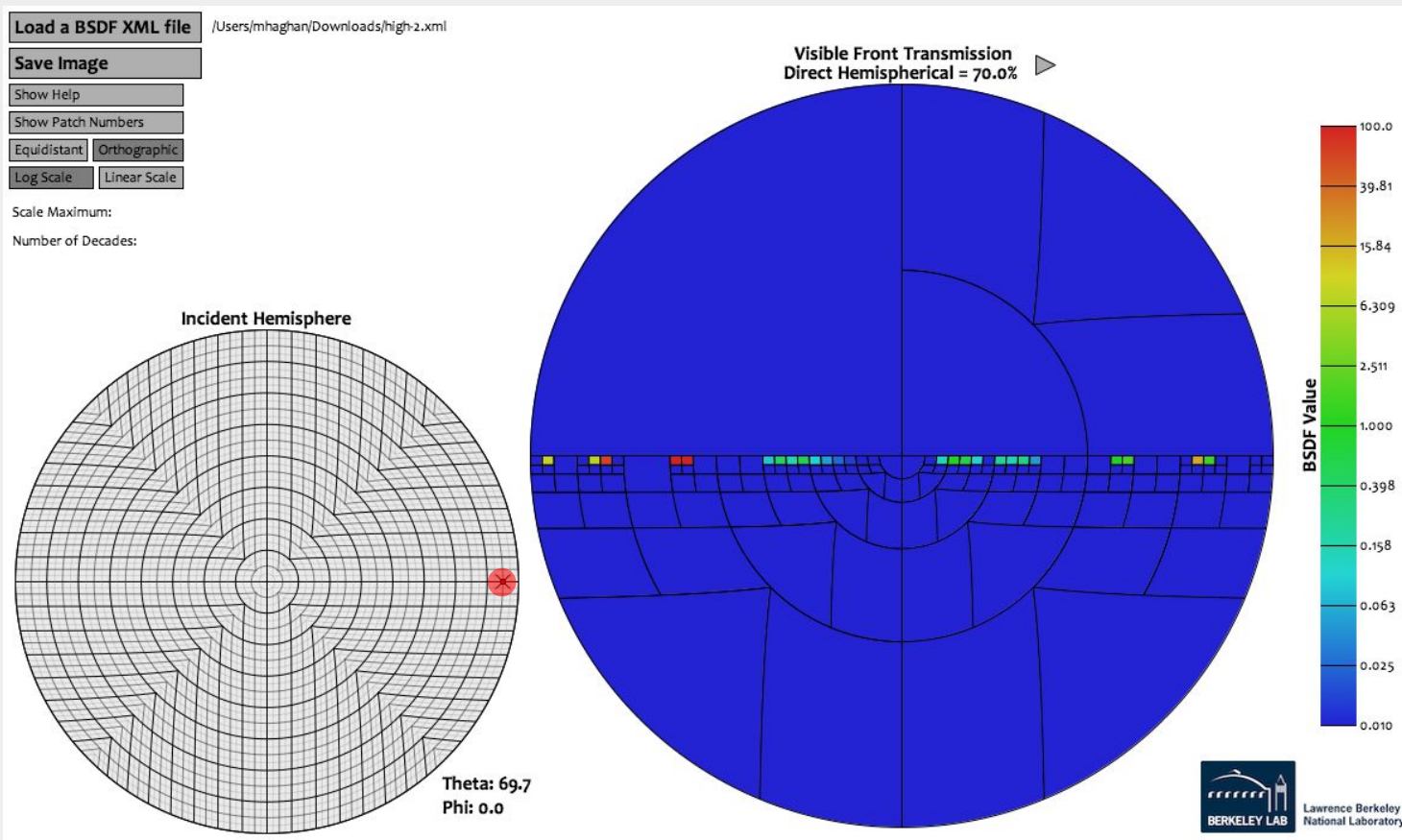
Transmission of prismatic element in different angles (genBSDF)



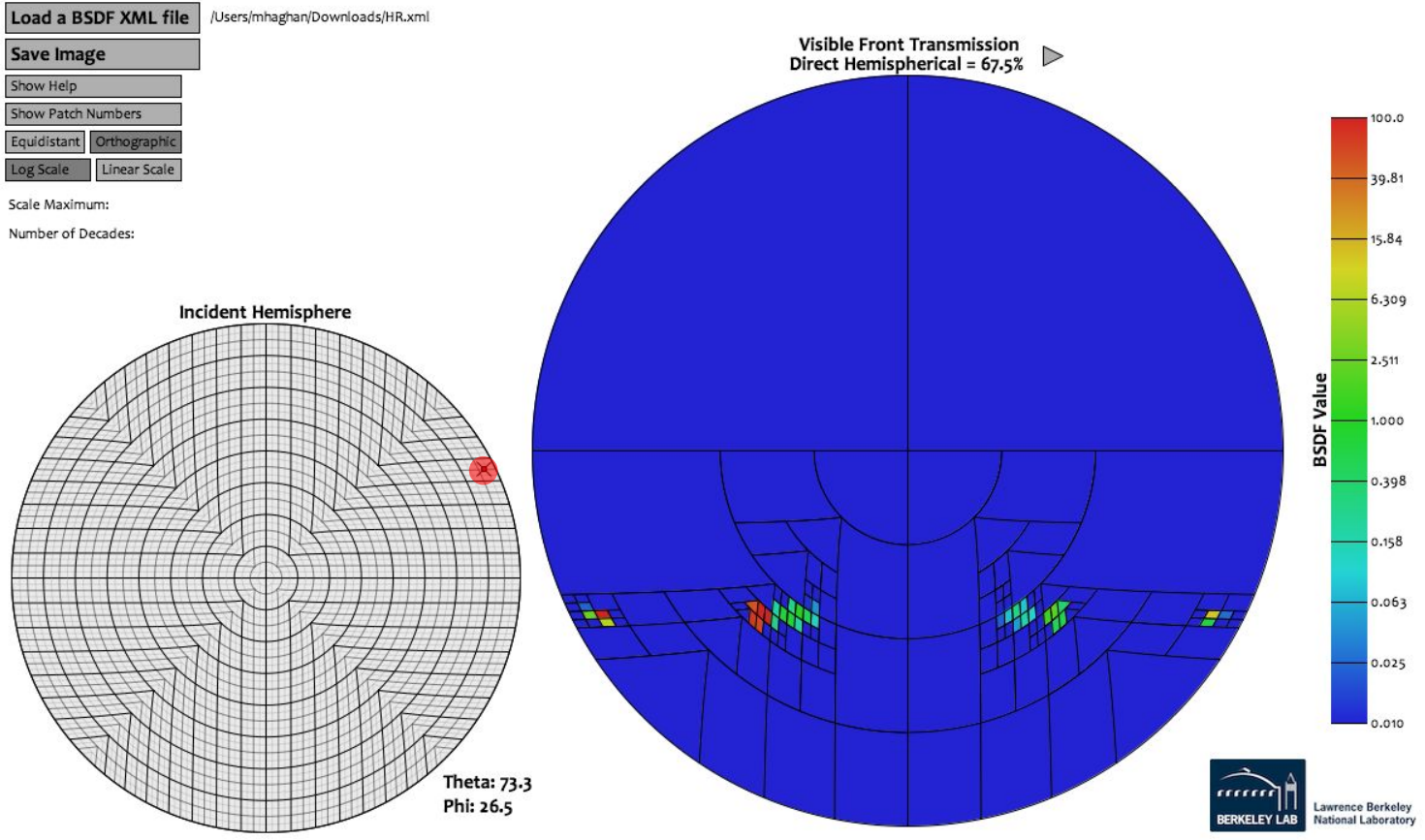
Transmission of prismatic element in different angles (genBSDF)



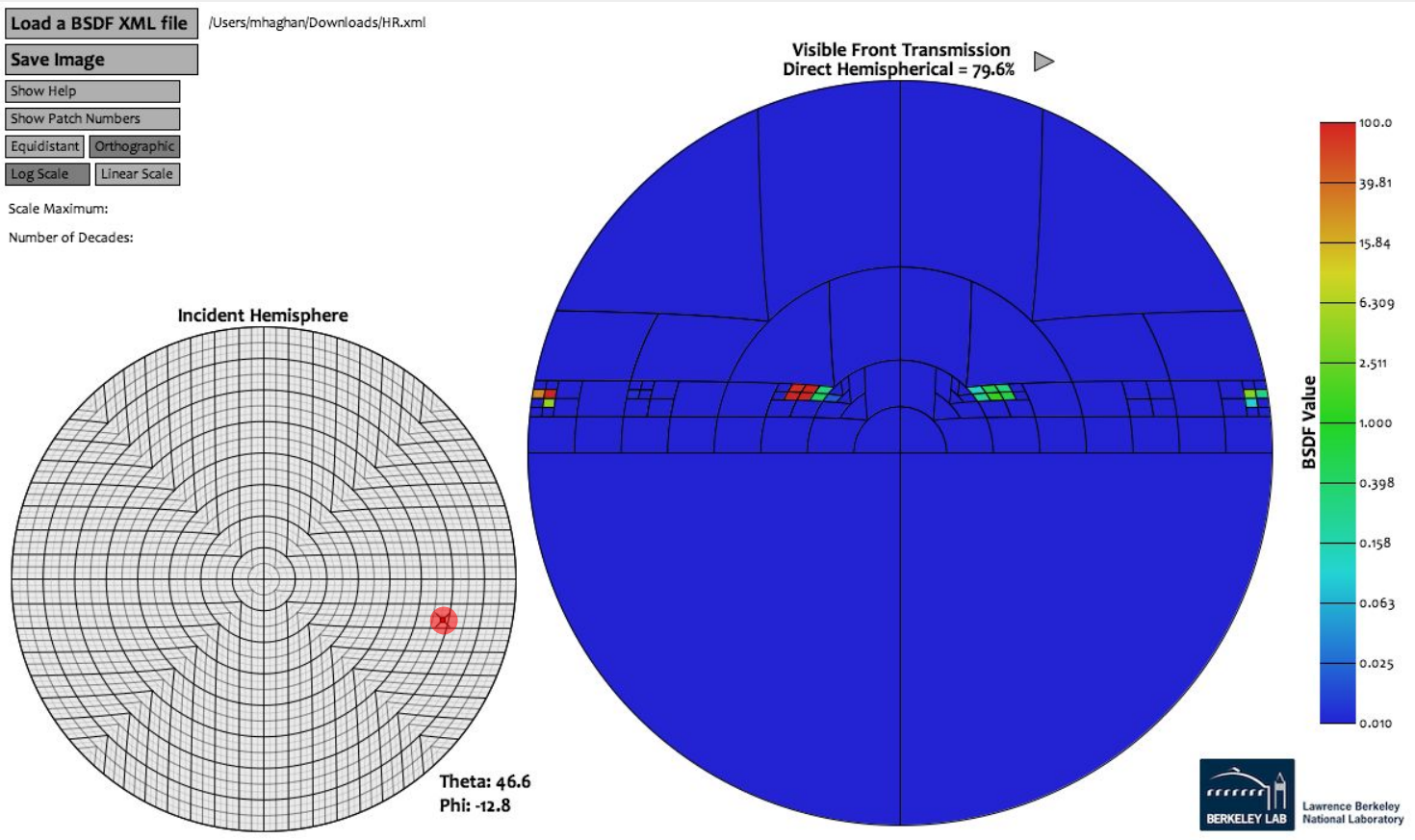
Transmission of prismatic element in different angles (genBSDF)



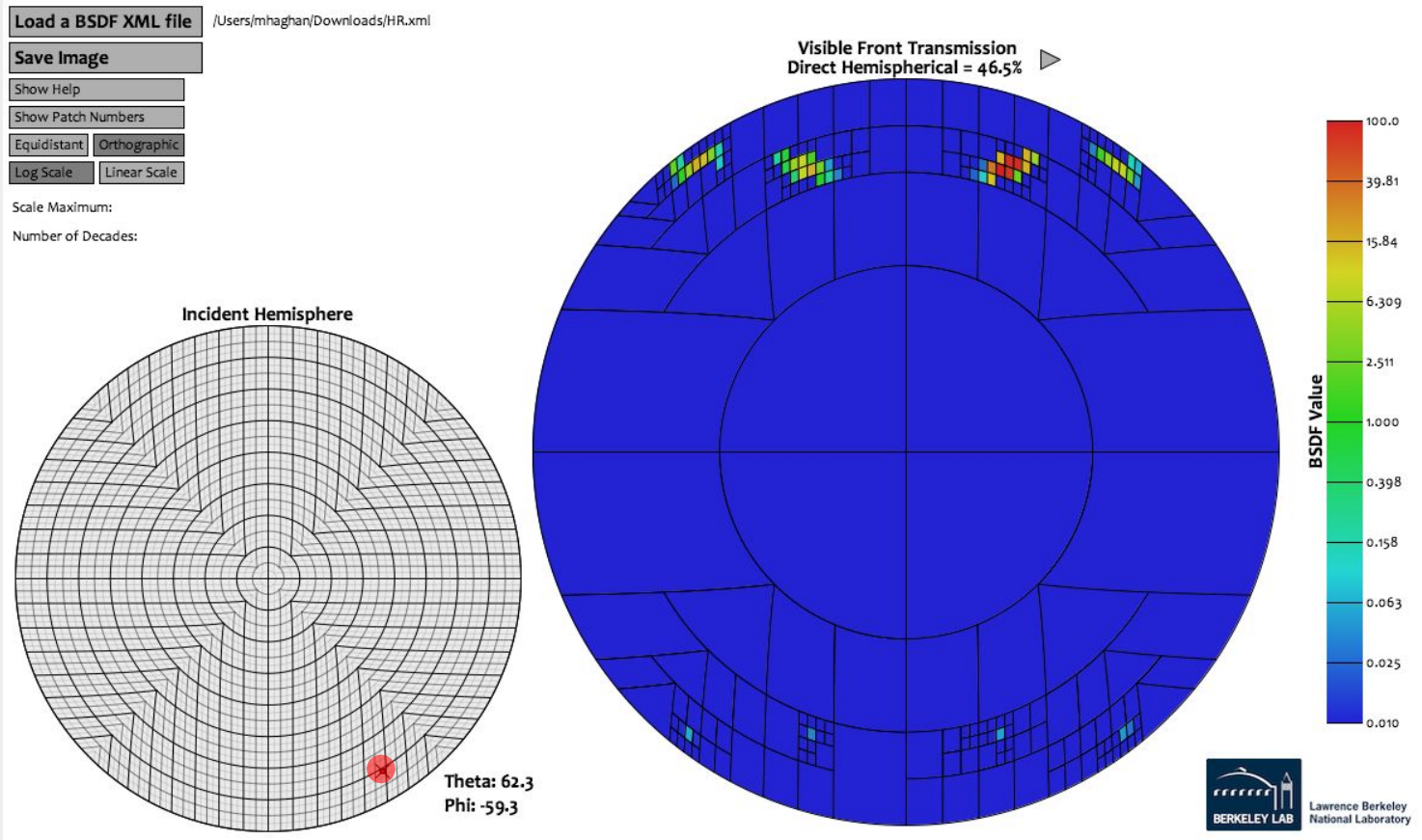
Transmission of prismatic element in different angles (genBSDF)



Transmission of prismatic element in different angles (genBSDF)



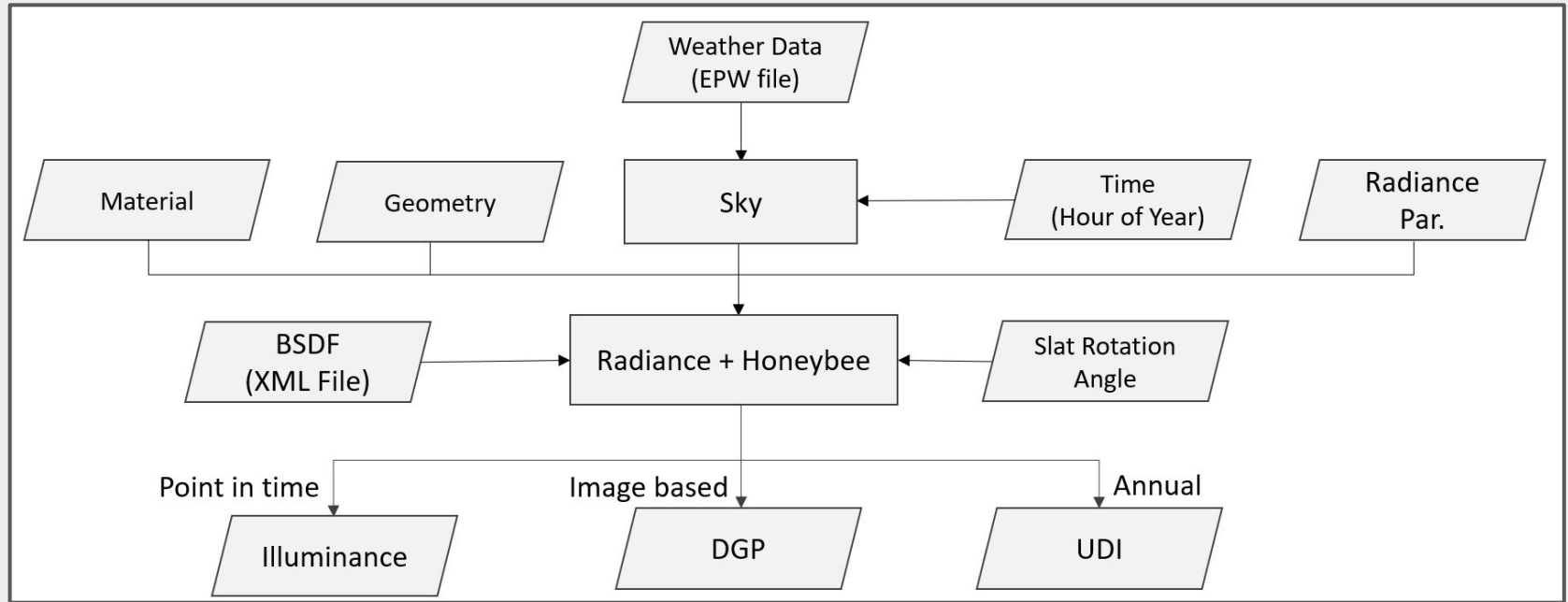
Transmission of prismatic element in different angles (genBSDF)

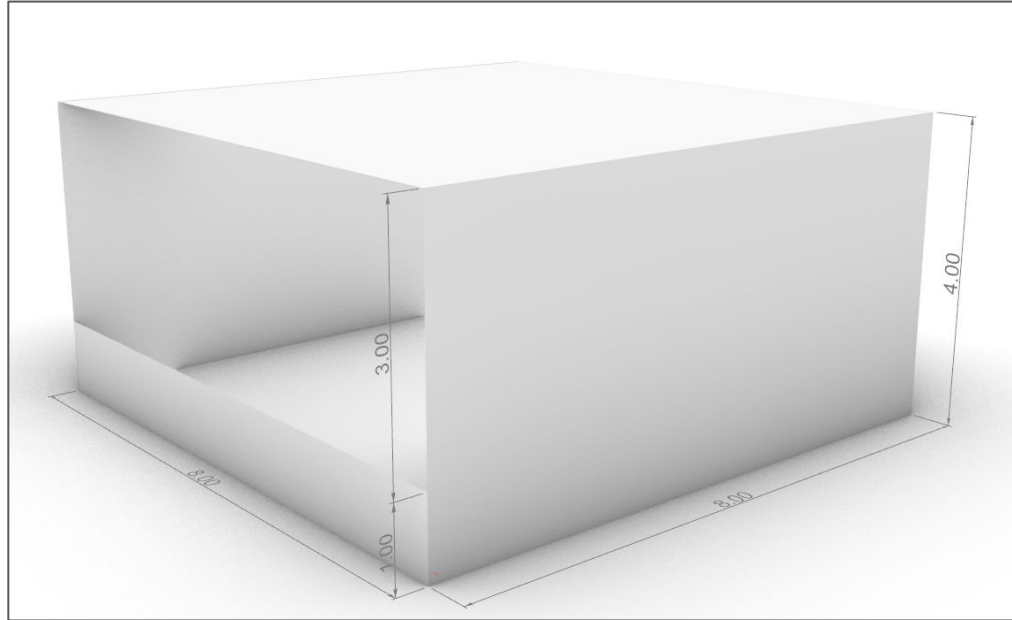




SIMULATION

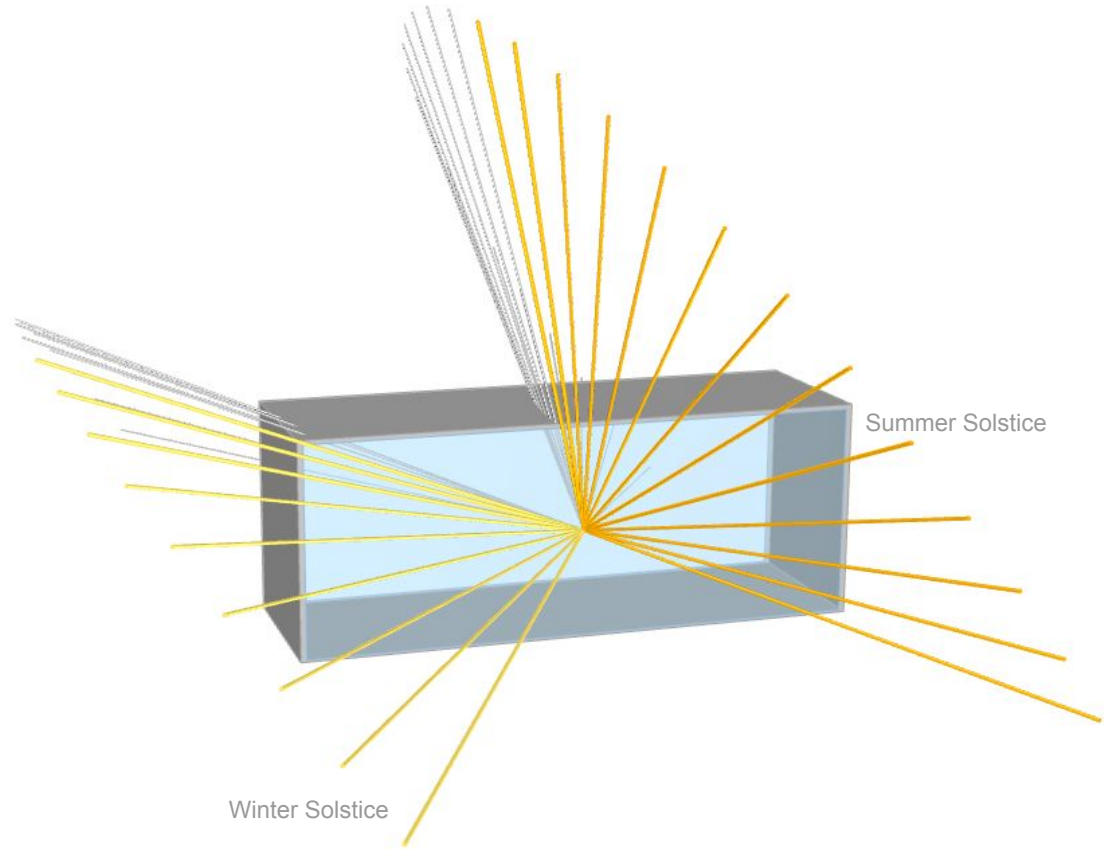
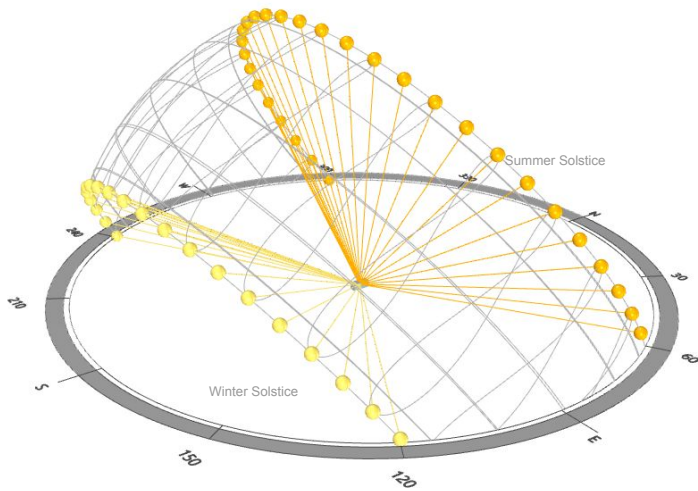


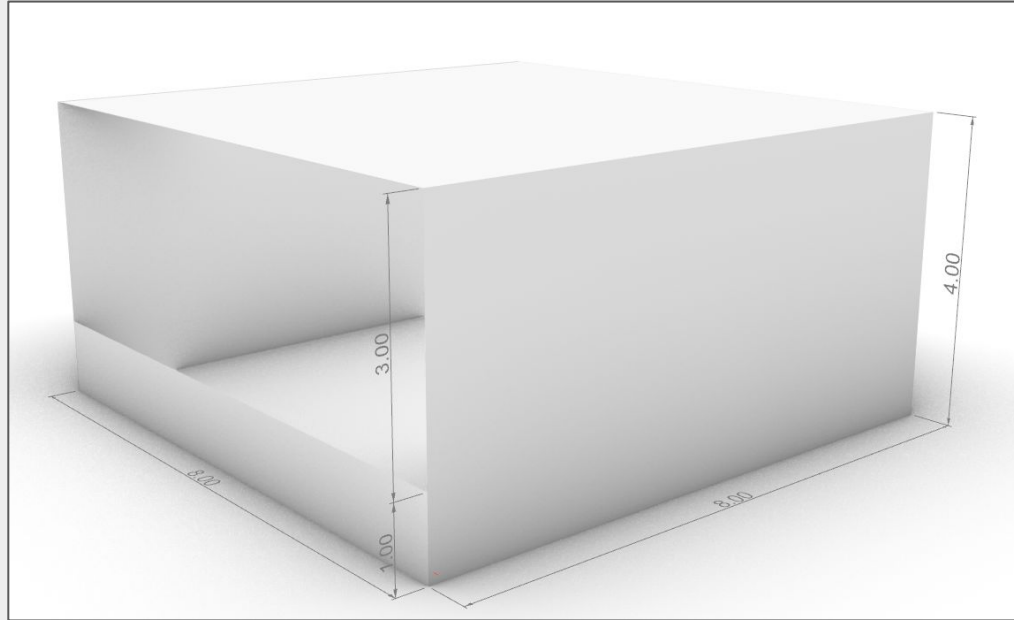




Width to depth ratio = 1:1
Width to height ratio = 2:1
Window to wall ratio = 75%

Hourly Sun Angle in East Aperture



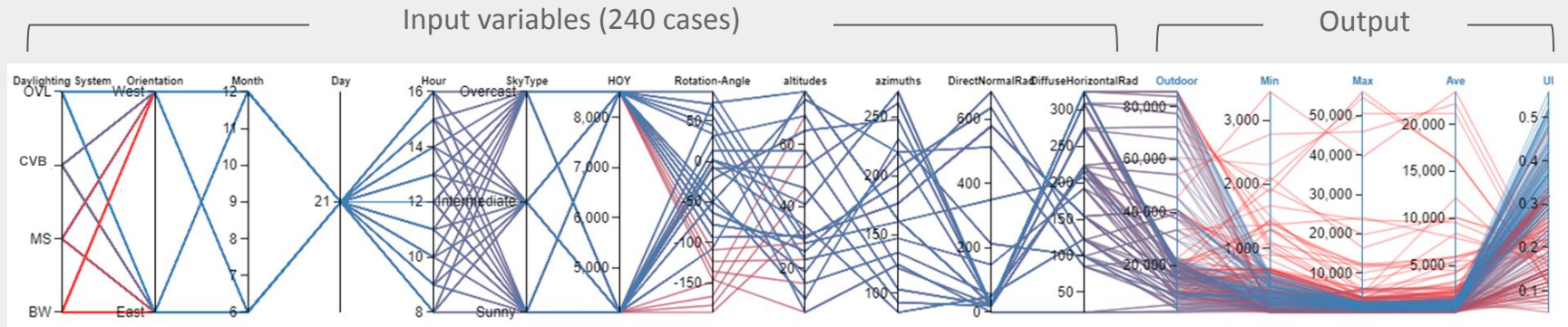


Bare
Window

Mesh
Shading

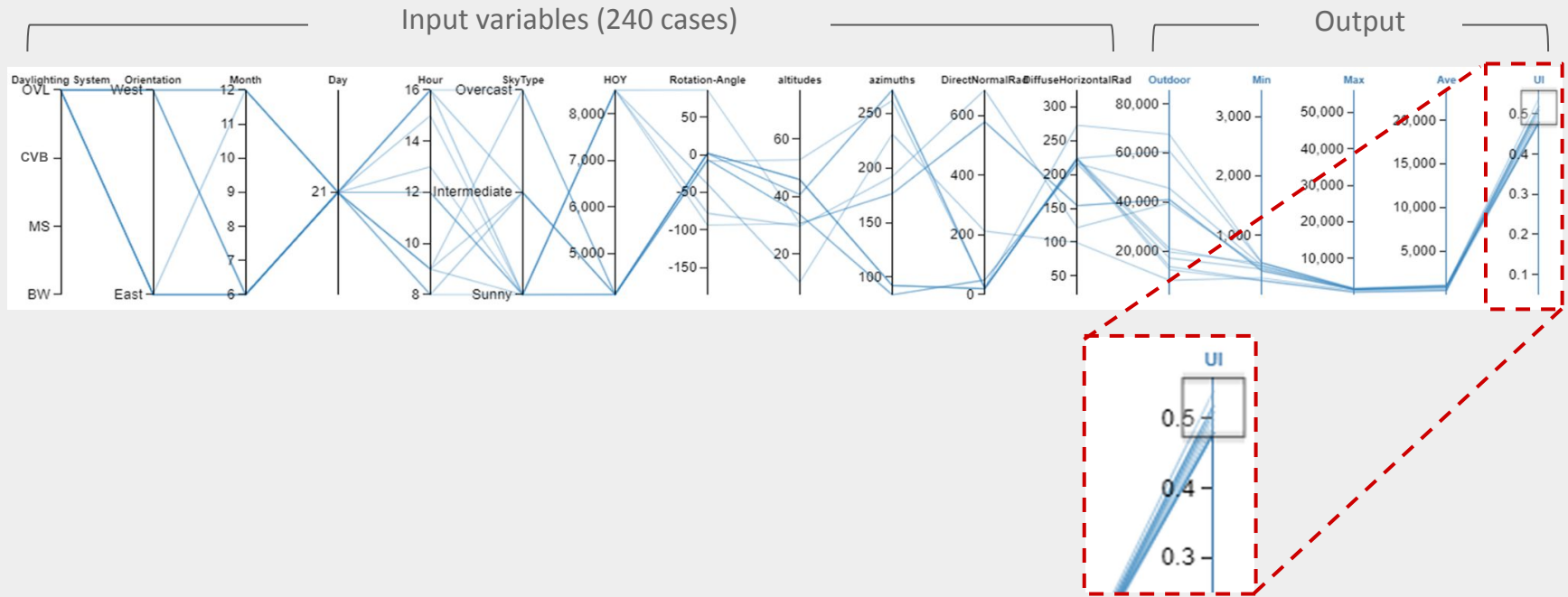
CVB




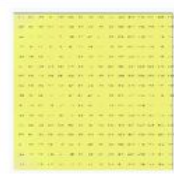

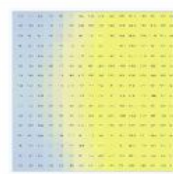

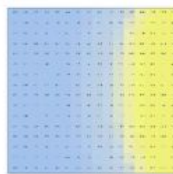

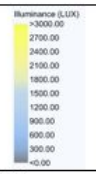

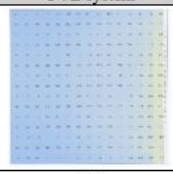

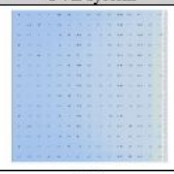

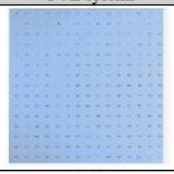
OVL

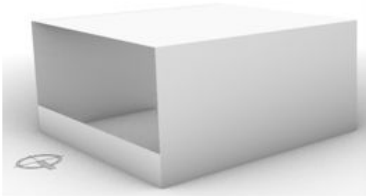




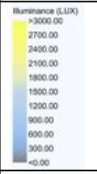


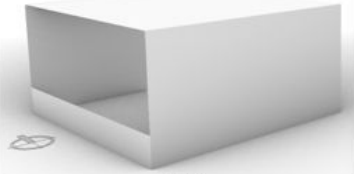

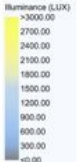


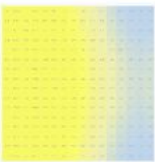



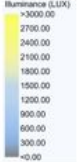






$$\text{Uniformity Index (UI)}^* = \frac{\text{Min Illuminance}}{\text{Average Illuminance}}$$

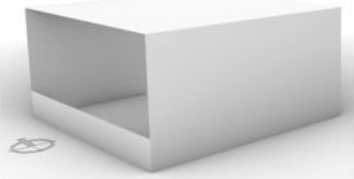

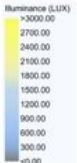

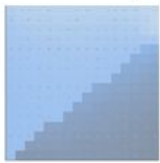
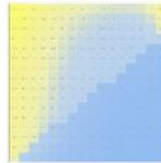



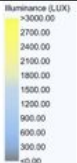
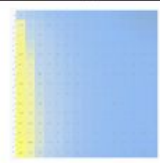





* Wagiman, K.R.; Abdullah, M.N.; Hassan, M.Y.; Radzi, N.H.M. A new metric for optimal visual comfort and energy efficiency of building lighting system considering daylight using multi-objective particle swarm optimization. J. Build. Eng., 2021, 43, 102525



East Aperture	
Geometry	
Altitude	45.94
Azimuth	92.36
Slat Rotation	-92.36°
Sky Type	Sunny Intermediate Overcast
Sky Pattern	
Outdoor Illuminance	60706 Lux 20949 Lux 13599 Lux
	Bare Window Mesh Shading Bare Window Mesh Shading Bare Window Mesh Shading
	     
Min	2302 166 1286 52 485 11
Average	21163.96 2429 5832.25 531 1559.07 80
UI	0.11 0.07 0.22 0.10 0.31 0.14
	CVB system OVL system CVB system OVL system CVB system OVL system
	     
Min	26 594 7 538 2 274
Average	83.04 1114.02 149 1016.52 74 521.65
UI	0.31 0.53 0.21 0.53 0.15 0.53

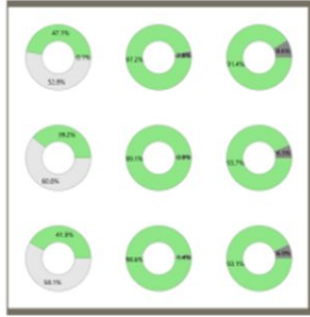
		East Aperture					
Geometry							
Altitude	15.2						
Azimuth	134.76						
Slat Rotation	-134.76°						
Sky Type	Sunny		Intermediate		Overcast		
Sky Pattern							
Outdoor illuminance	60670 Lux		20975 Lux		13622 Lux		
	Bare Window	Mesh Shading	Bare Window	Mesh Shading	Bare Window	Mesh Shading	
Illuminance (LUX)							
Min	2108	177	621	37	192	3	
Average	10024.5	1092	2342.5	214	605.23	30	
UI	0.21	0.16	0.27	0.17	0.32	0.10	
	CVB system	OVL system	CVB system	OVL system	CVB system	OVL system	
Illuminance (LUX)							
Min	562	371	171	202	50	96	
Average	1506.4	759.07	544.25	503.35	237.1	294.16	
UI	0.37	0.49	0.31	0.40	0.21	0.33	

West Aperture							
Geometry							
Altitude	40.68						
Azimuth	271.48						
Slat Rotation	-91.48°						
Sky Type	Sunny Intermediate Overcast						
Sky Pattern							
Outdoor illuminance	54316 Lux 19587 Lux 12324 Lux						
	Bare Window Mesh Shading Bare Window Mesh Shading Bare Window Mesh Shading						
Illuminance (LUX)							
Min	2777 222 1385 50 456 10						
Average	22198.1 2704 5972.45 578 1437.22 73						
UI	0.13 0.08 0.23 0.09 0.32 0.14						
	CVL OVL CVL OVL CVL OVL						
Illuminance (LUX)							
Min	14 619 4 530 1 235						
Average	43.86 1100.82 16.42 979.45 5.68 450.06						
UI	0.32 0.56 0.24 0.54 0.18 0.52						

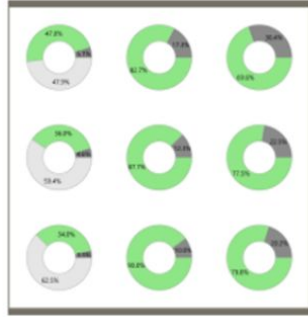
West Aperture	
Geometry	
Altitude	10.22
Azimuth	231.11
Slat Rotation	-51.11°
Sky Type	Sunny Intermediate Overcast
Sky Pattern	
Outdoor illuminance	8072 Lux 4139 Lux 3465 Lux
	Bare Window Mesh Shading Bare Window Mesh Shading Bare Window Mesh Shading
	     
Min	1445 126 399 22 127 3
Average	5417.56 611 1307.66 122 402.34 20
UI	0.27 0.21 0.31 0.18 0.32 0.15
	CVB system OVL system CVB system OVL system CVB system OVL system
	     
Min	309 282 83 125 30 66
Average	862.54 581.81 292.93 301.37 139.59 182.42
UI	0.36 0.48 0.28 0.41 0.21 0.36

West

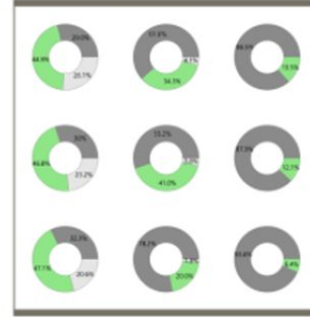
OVL system



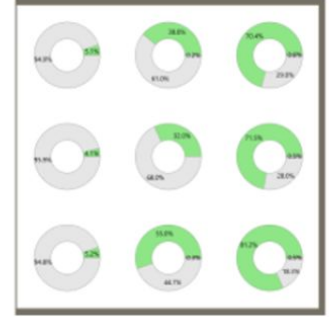
CVB system



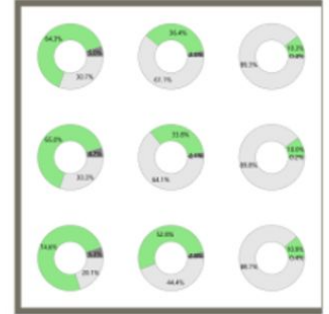
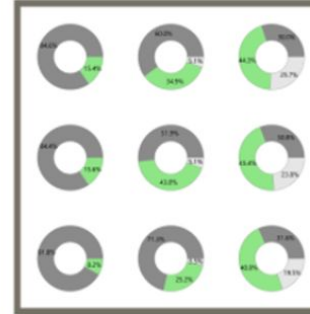
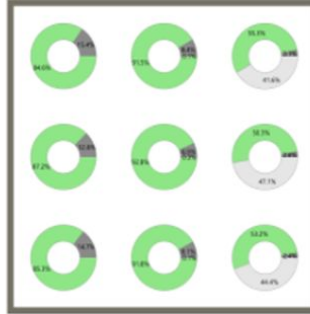
Mesh Shading



Bare Window

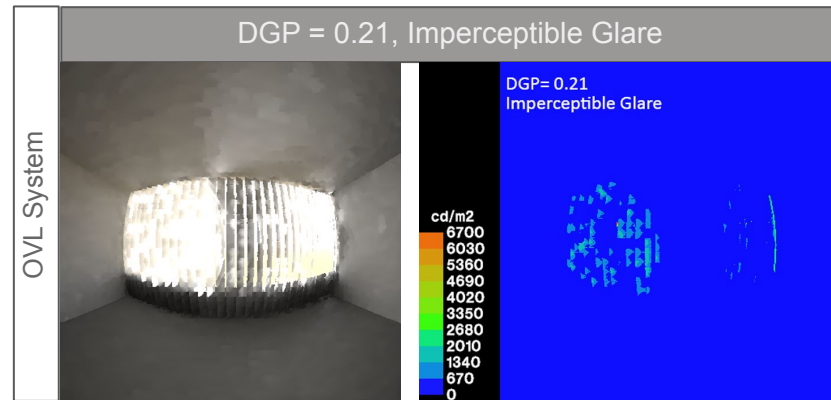
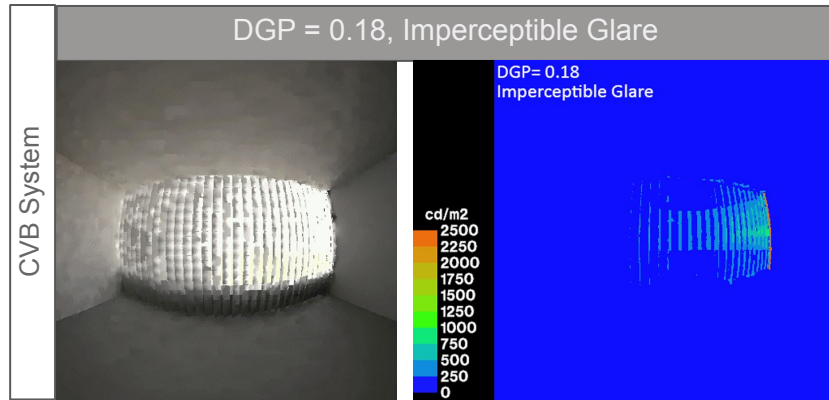
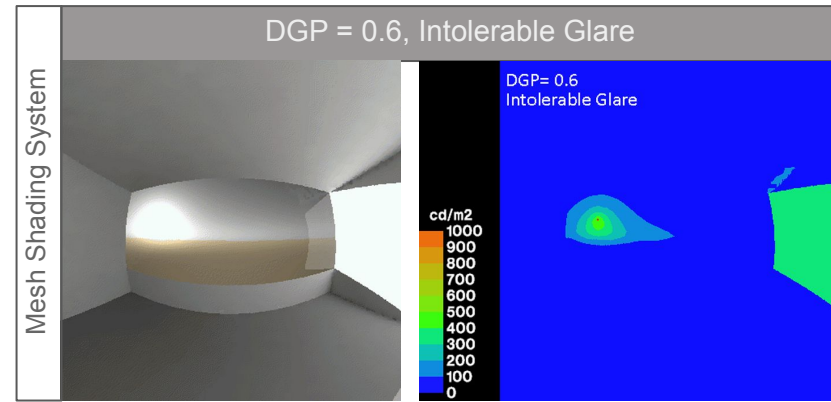
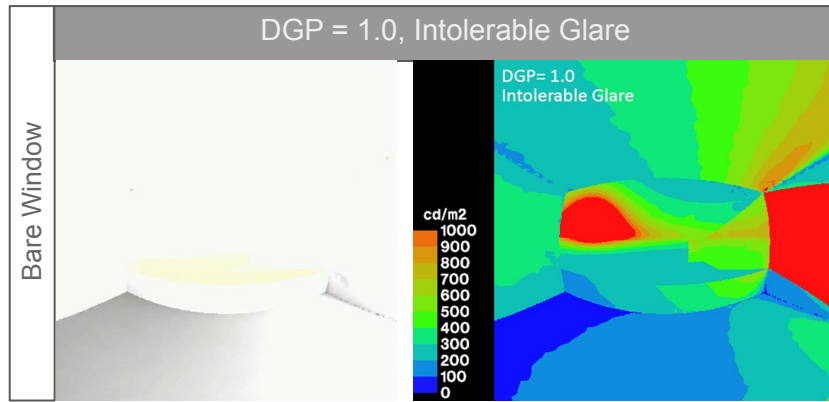


East



Useful Daylight Illuminance
(UDI) Analysis





Daylight Glare Probability (DGP) analysis;

December 21, 4 PM

○ DGP < 0.35, Imperceptible Glare

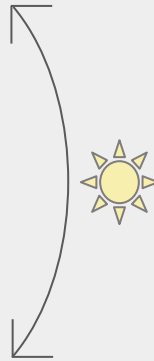
○ 0.35 < DGP < 0.40, Perceptible Glare

○ 0.4 < DGP < 0.45, Disturbing Glare

○ DGP > 0.45, Intolerable Glare

Optical Vertical Louver (OVL)

- Improve indoor daylight availability
- Improve visual comfort and connection to the outside environment



Initial Mockup of the Vertical-Slat Version of the Optical Elements.

Area of the wall bounded by yellow lines has been protected from beam sunlight by the blocking action of the optical elements.

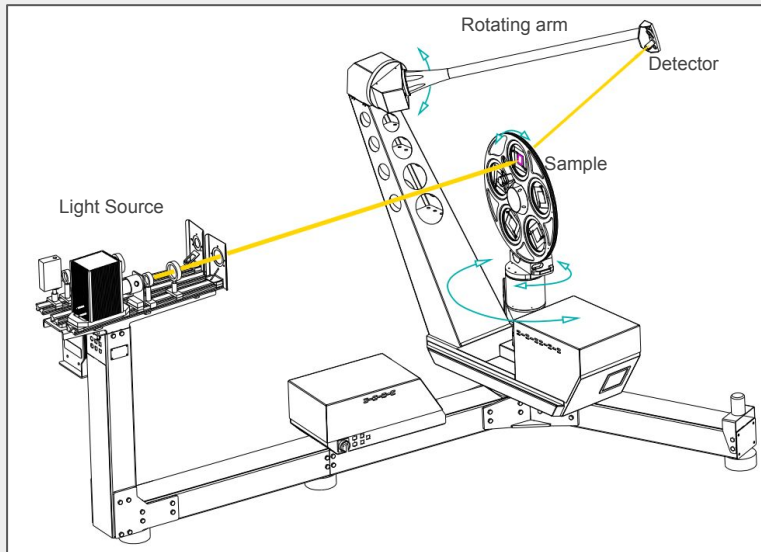




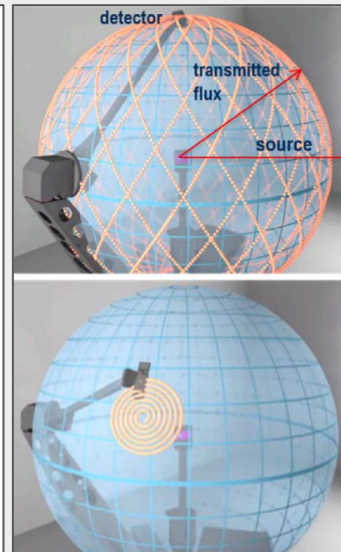
FURTHER STUDIES



- To conduct the annual glare probability analysis for different systems
- To validate the simulation result of BSDF data with Goniophotometer analysis
- To validate the daylight simulation result with experimental evaluation in a built environment
- To evaluate human visual experience in three different environments outfitted with different daylighting systems

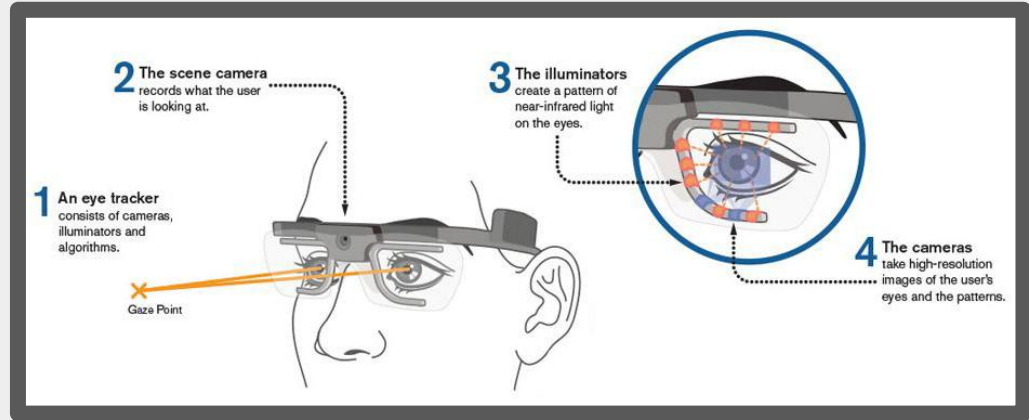


Path of the full hemispherical scan



detailed spiral or square scan of a peak region

24 Participants



To ask participants for their response of different questions regarding their visual comfort, and perception in terms of interior daylight.

Pre-test

Test

Post-test

Getting used to environment

Test Explanation

Photometric measurement

Calibration

Consent form

Demographic questionnaire

First, second, or third environment

Reading/Writing test

Reading/Writing questionnaire

Visual performance test

VP questionnaire

In random order

Debriefing

Overall questionnaire

Interview

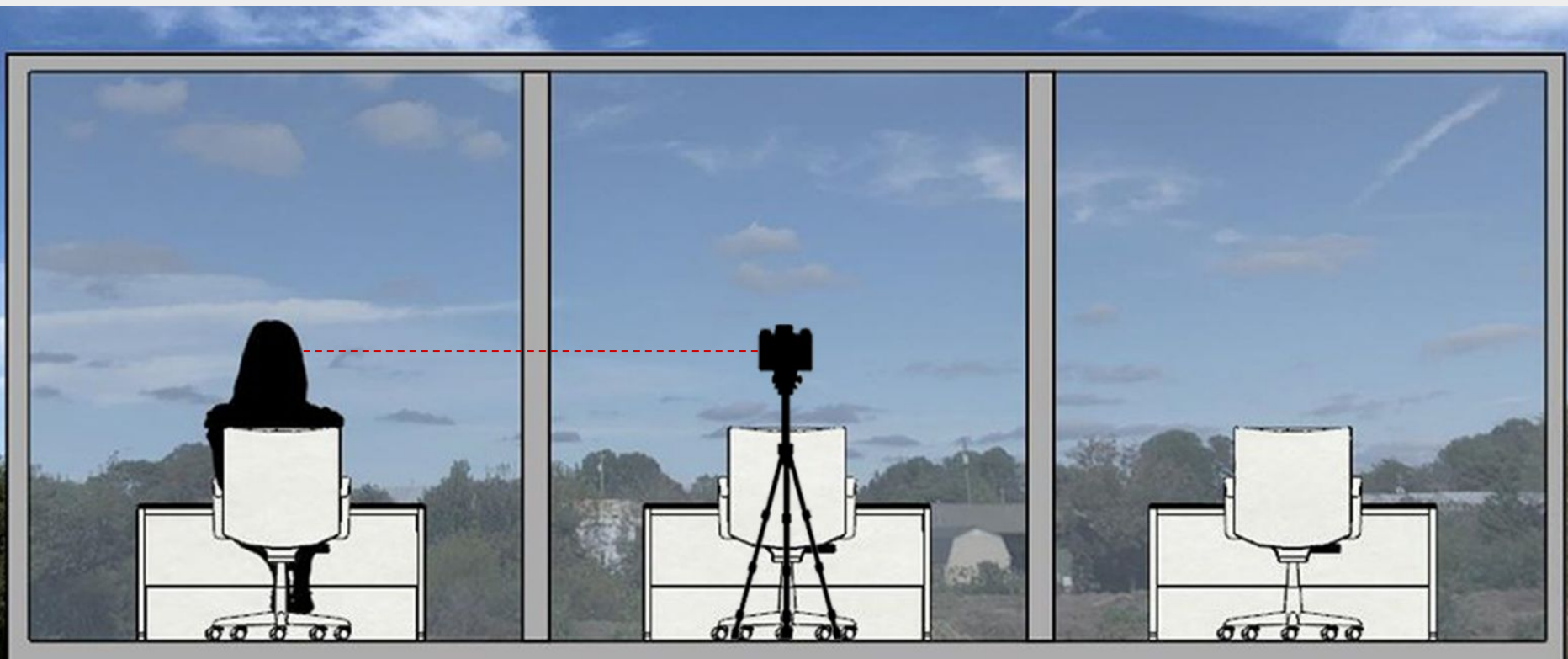
Photometric measurement

15 minutes

45-60 minutes

30 minutes

90-105 minutes in total



OVL outfitted

CVB outfitted

Mesh Shading outfitted

Questions/Comments!

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Thank YOU!