Using RADIANCE to design a PRISMATIC LIGHT REDIRECTING FENESTRATION

Islam A. Mashaly, Sally I. El-Henawy, Mohamed W. N. Mohamed, Osama N. Mohamed, Ola Galal, Khaled Nassar, and Amr M. E. Safwat

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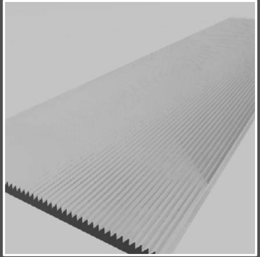
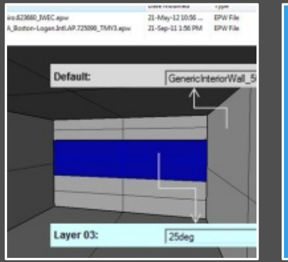
Outline



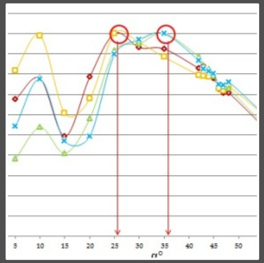
Introduction

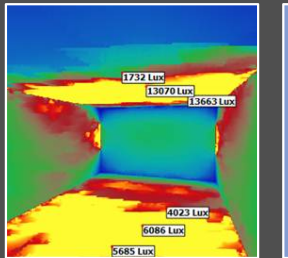
Workflow for BSDF



Simulation

Comparing w. Tracepro



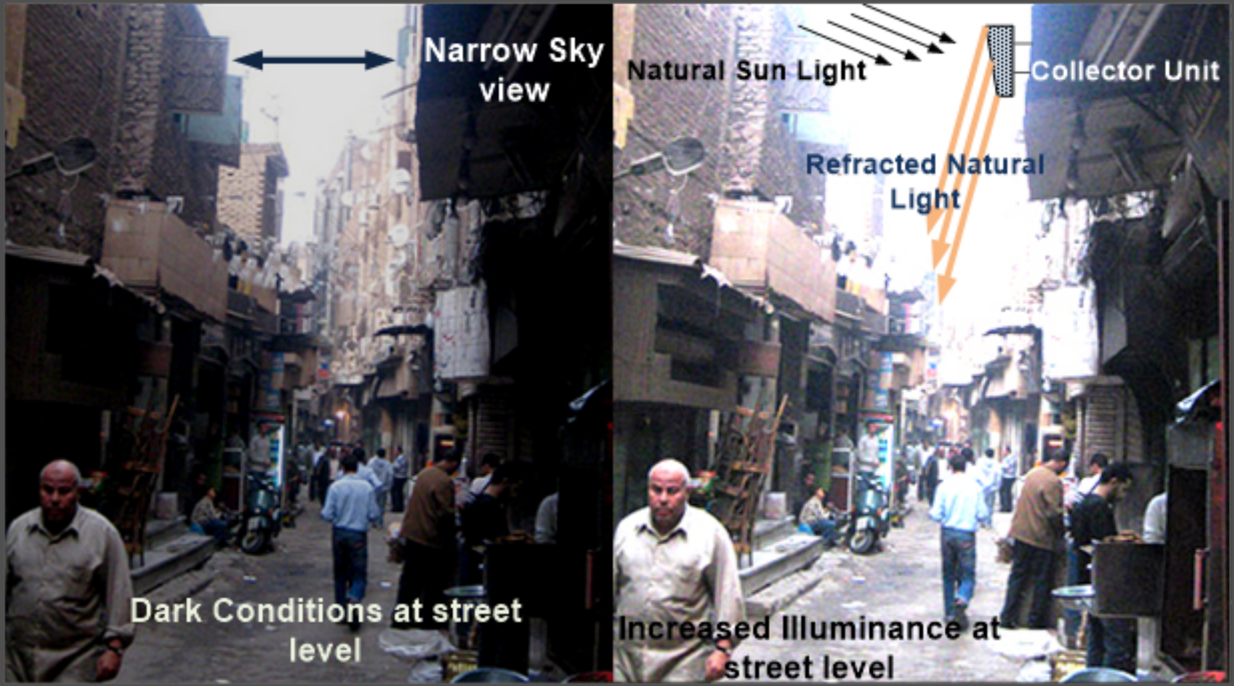


Conclusions & Recommendations

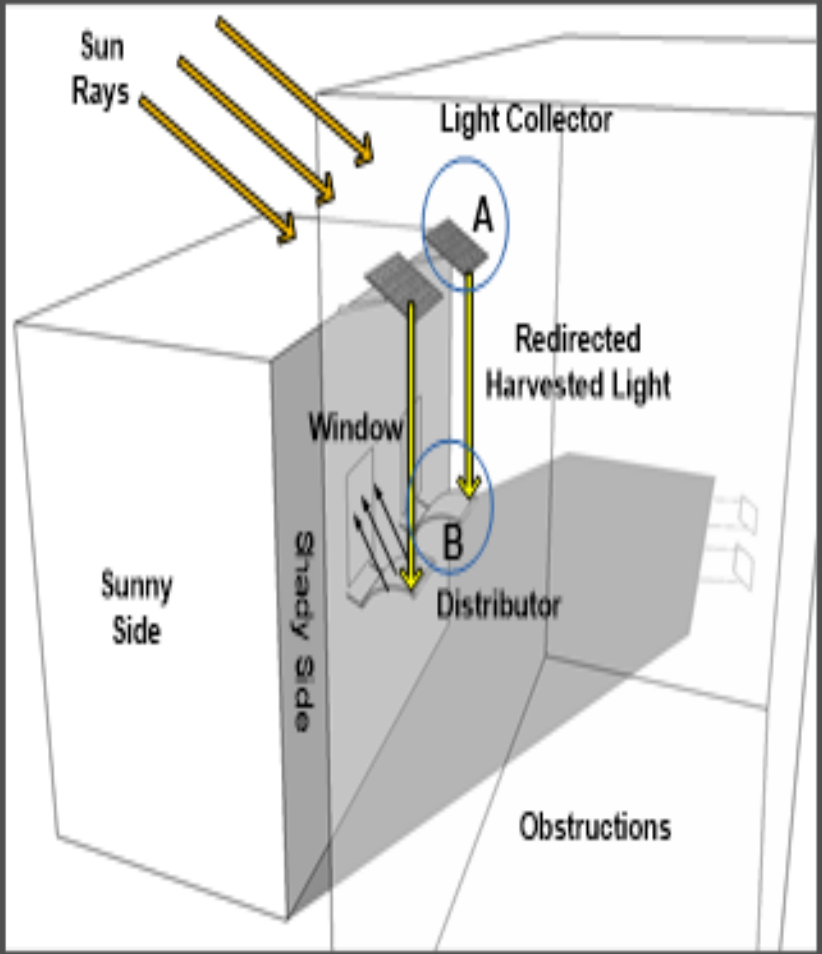
Introduction

Light Redirecting Systems

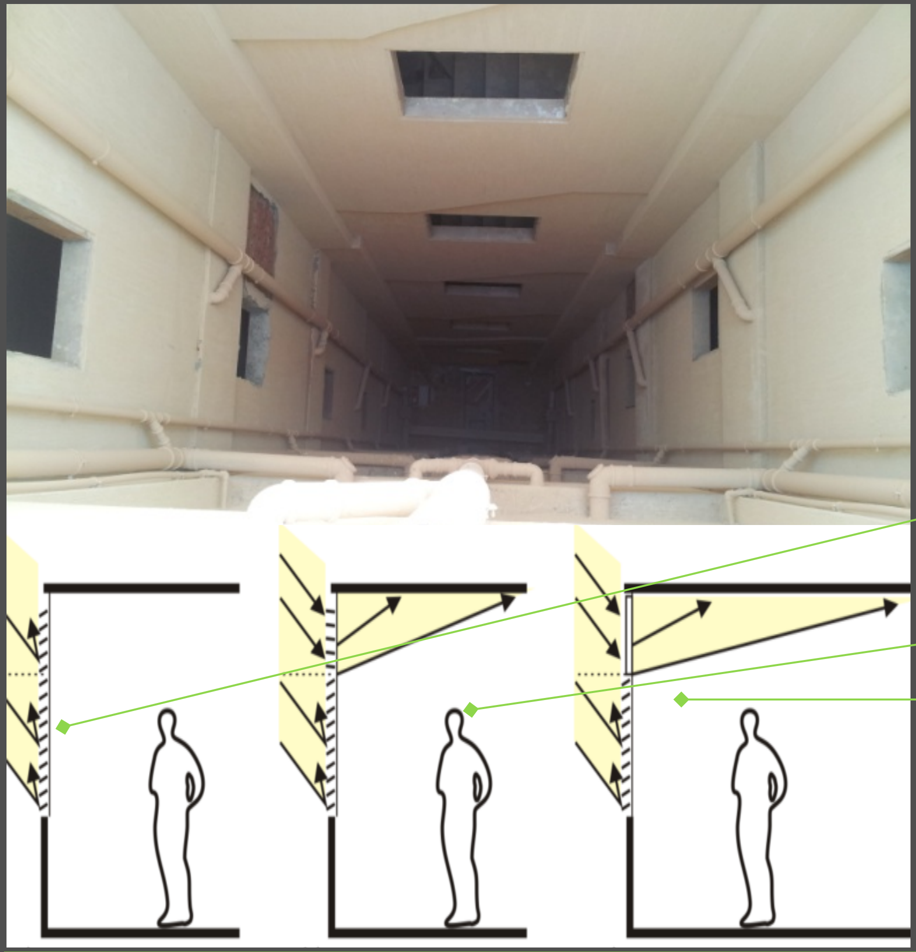
Proposed Application

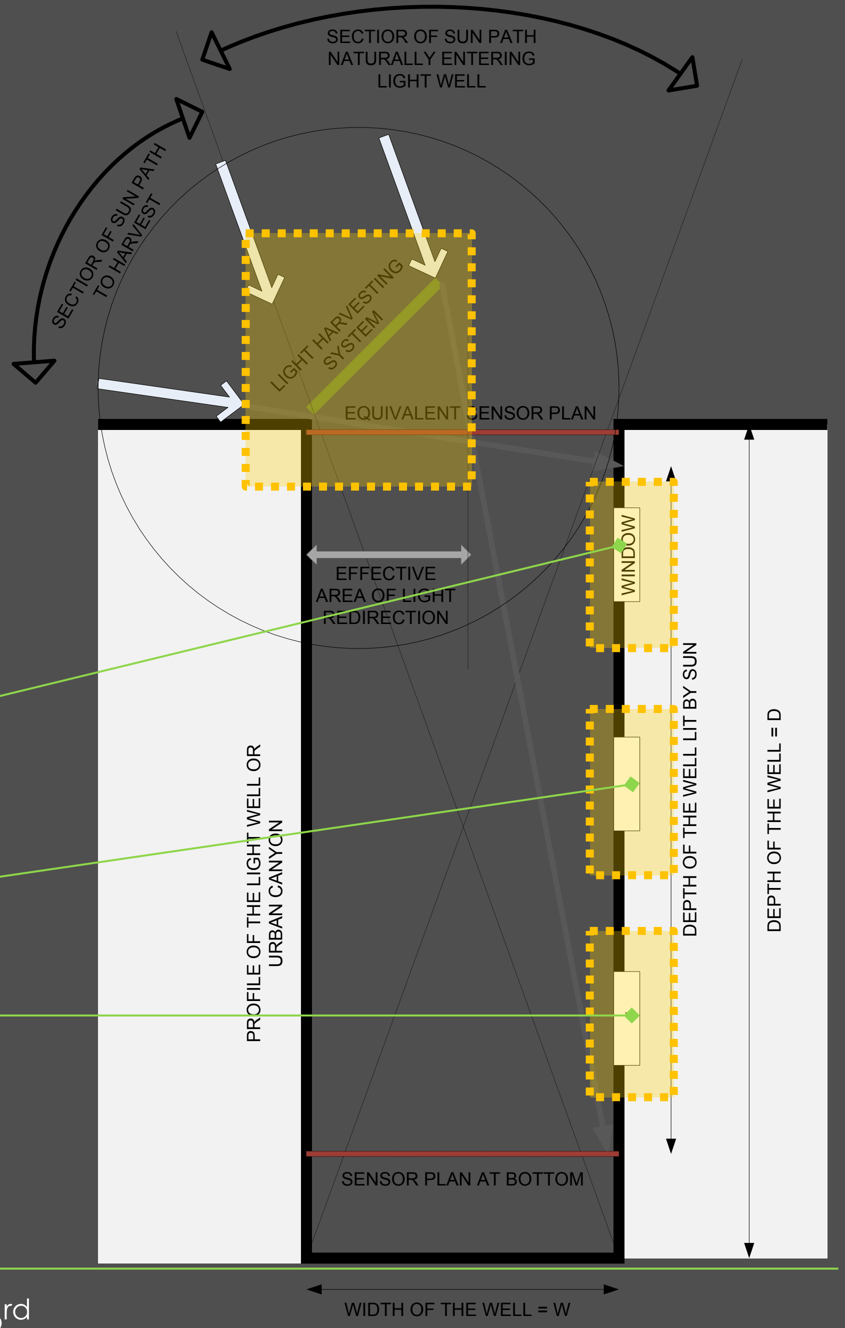


Light Redirecting Systems



Light Redirecting Systems

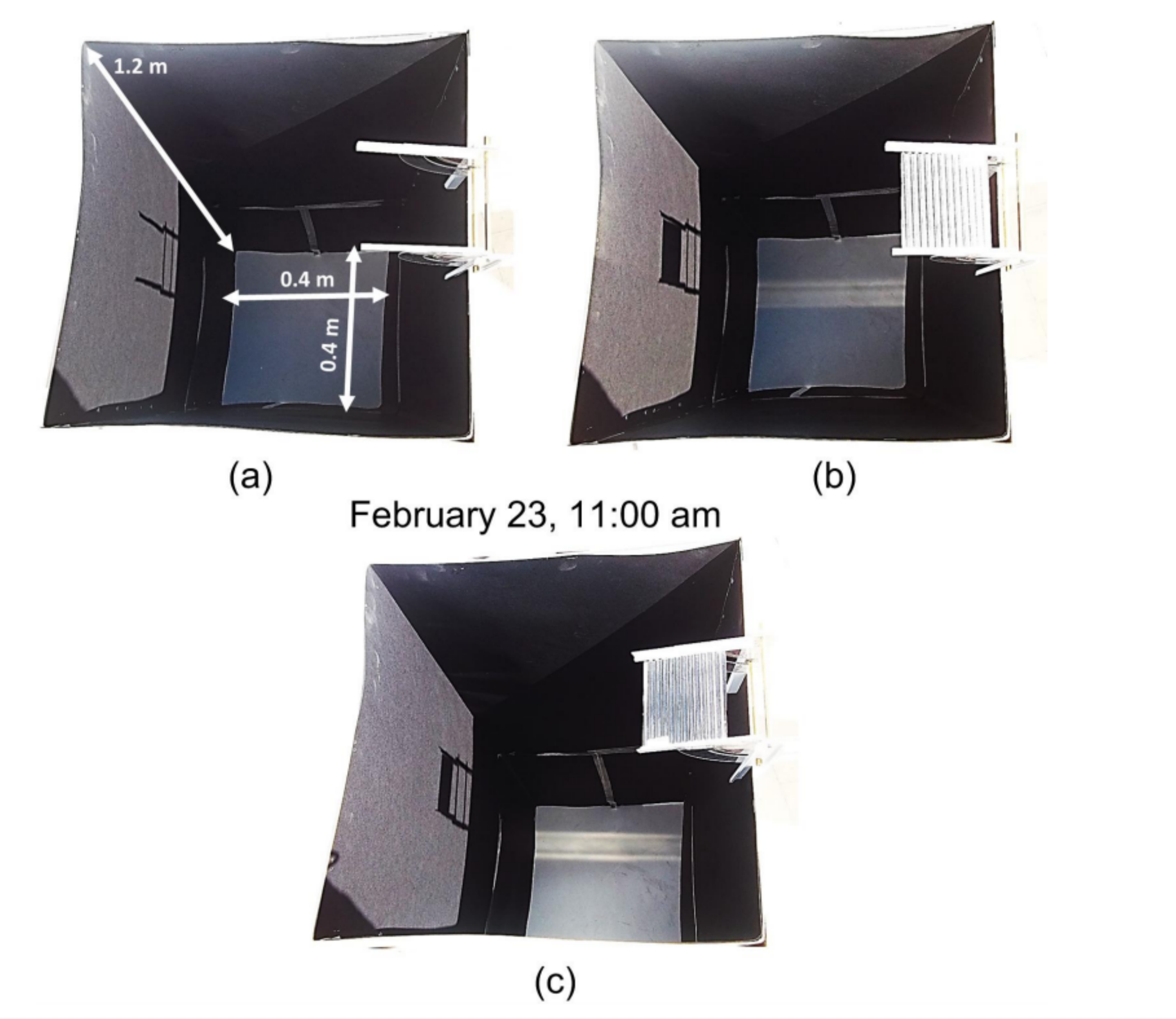




Light Redirecting Systems

Sally I. El-henawy, Mohamed W. N. Mohamed, Islam A. Mashaly, Osama N. Mohamed, Ola Galal, Iman Taha, Khaled Nassar, And Amr M. E. Safwat, ***Illumination Of Dense Urban Areas By Light Redirecting Panels***, Optics Express, Vol. 22, Issue S3, Pp. A895-a907 (2014)

http://dx.doi.org/10.1364/OE.22.00A895



Objectives

- Develop a step-by-step tutorial as a guide to use BSDF to simulate prismatic panel in a room.
- Design optimized light redirecting system for southern skies.

Workflow

Steps of workflow

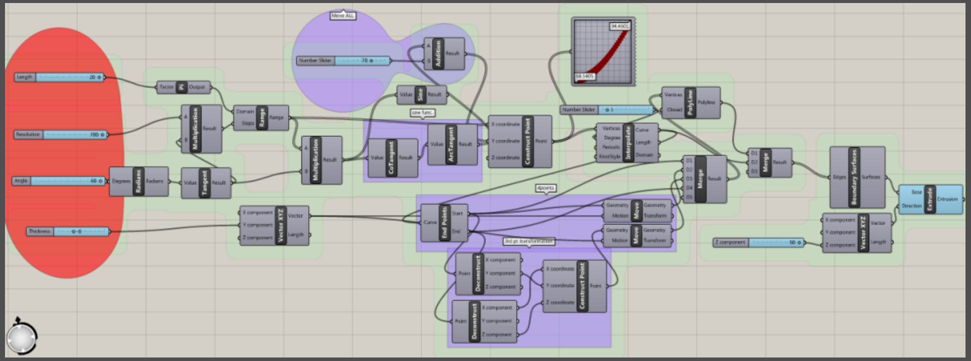
Drafting
- Modeling

Exporting Geometry
- DIVA
- RAD File

BSDF Generation
- genBSDF
- Radiance

Drafting Options

- Drafting the geometry with rhino.
- Other options including text input & grasshopper parametric modification.



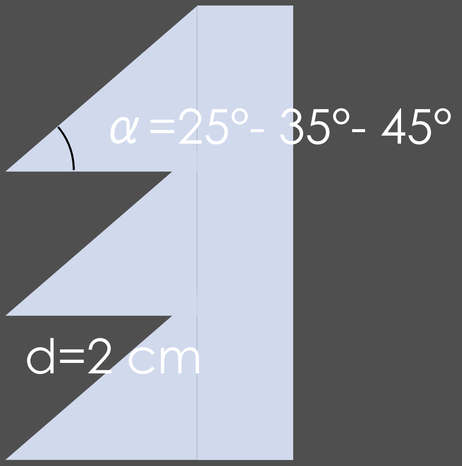
Grasshopper Parametric modification

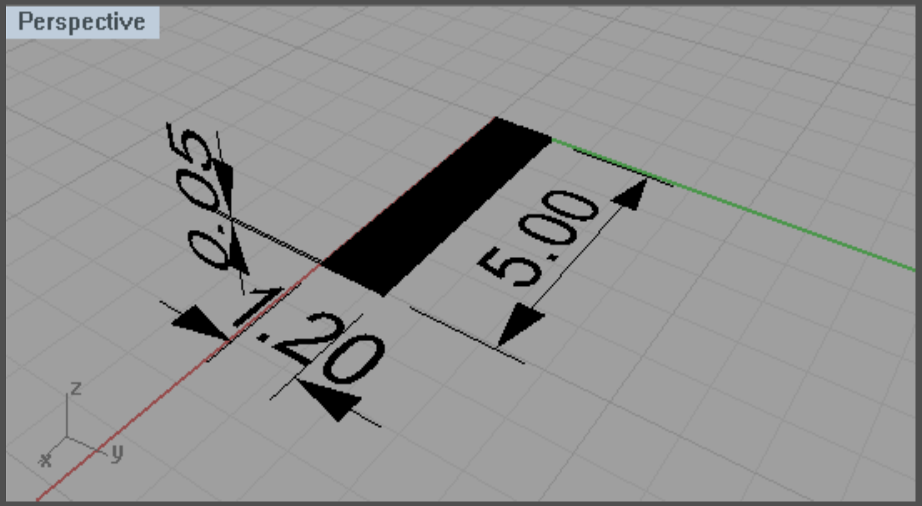
```
MonitorGlass polygon MonitorGlass.1
0
0
9
          0     0.0923076942563    -0.0472499988973
          0     0.0923076942563    -0.0405000001192
          0      0.184615388513    -0.0405000001192

MonitorGlass polygon MonitorGlass.2
0
0
9
          0      0.184615388513    -0.0337500013411
          0      0.184615388513    -0.0405000001192
          0     0.0923076942563    -0.0405000001192
```

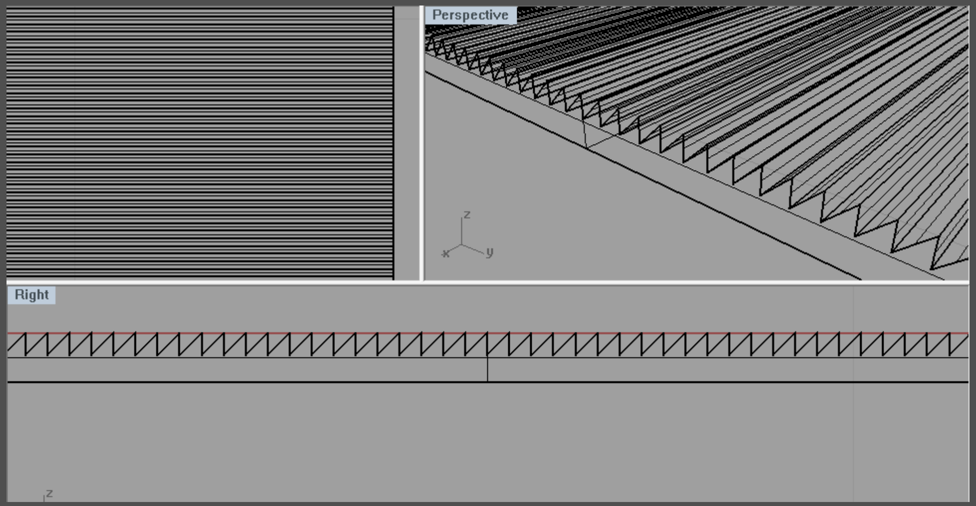
Text input using notepad

Workflow for BSDF to surface geometry

- Drafting the geometry with Rhino



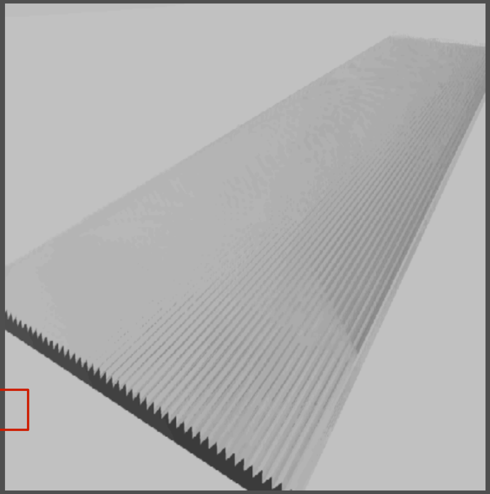




Workflow for BSDF to surface geometry

- Exporting the geometry using DIVA Rhino
  - Assign a unique name e.g. “MonitorGlass” to the designed geometry within Diva, so all polygons have the same material name
  - Run Visual Simulation to generate the files.
  - Add the material description in the material file (full.rad) with a refractive index similar to the pmma material (n=1.4893)

EGY_Cairo.623660_IWEC.epw	21-May-12 10:56 ...	EPW File	1,532 KB
full.map	16-Jul-14 2:02 PM	MAP File	2 KB
full.obj	16-Jul-14 2:00 PM	OBJ File	123 KB
full.oct	16-Jul-14 2:00 PM	OCT File	545 KB
full	16-Jul-14 2:00 PM	RAD File	190 KB
full_sky	16-Jul-14 2:00 PM	RAD File	1 KB
fullfull_Perspective	01-Jul-14 2:22 PM	Windows Batch File	1 KB
fullfull_Perspective_1	16-Jul-14 2:00 PM	Windows Batch File	1 KB
fullimg	16-Jul-14 2:00 PM	Windows Batch File	1 KB
fullmaterial	30-Jun-14 12:41 PM	RAD File	6 KB
fullobj	16-Jul-14 2:00 PM	Windows Batch File	1 KB



void dielectric
MonitorGlass
0
0
5 0.5 0.5 0.5 ***1.4893*** *0*

Workflow for BSDF to surface geometry

- *.rad file: A text file containing the polygons co-ordinates in 3D space

X-coordinates Y-coordinates Z-coordinates

```
MonitorGlass polygon MonitorGlass.1
0
0
9
        0   0.0923076942563   -0.0472499988973
        0   0.0923076942563   -0.0405000001192
        0    0.184615388513   -0.0405000001192

MonitorGlass polygon MonitorGlass.2
0
0
9
        0    0.184615388513   -0.0337500013411
        0    0.184615388513   -0.0405000001192
        0   0.0923076942563   -0.0405000001192
```

X-coordinates
Y-coordinates
Z-coordinates

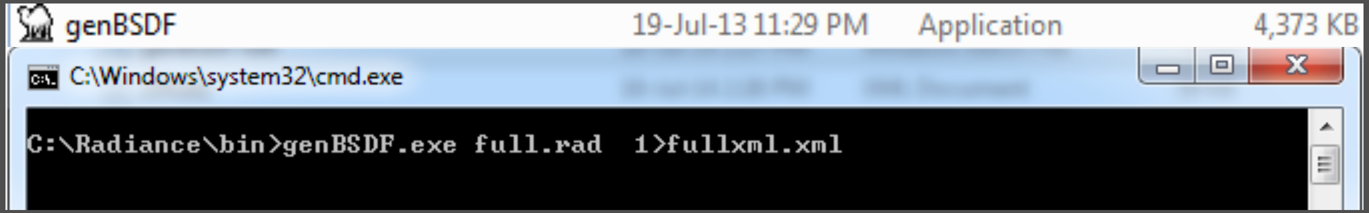
full - Notepad

File Edit Format View Help

```
# obj2rad -m full.map full.obj
# Rhino

MonitorGlass polygon MonitorGlass.1
0
0
9
        0    0.184615388513   -0.0405000001192
        0    0.184615388513   -0.0472499988973
        0   0.0923076942563   -0.0472499988973

MonitorGlass polygon MonitorGlass.1
0
0
9
        0   0.0923076942563   -0.0472499988973
        0   0.0923076942563   -0.0405000001192
        0    0.184615388513   -0.0405000001192

MonitorGlass polygon MonitorGlass.2
0
0
9
        0    0.184615388513   -0.0337500013411
        0    0.184615388513   -0.0405000001192
        0   0.0923076942563   -0.0405000001192

MonitorGlass polygon MonitorGlass.2
0
0
9
        0   0.0923076942563   -0.0405000001192
        0   0.0923076942563   -0.0337500013411
        0    0.184615388513   -0.0337500013411

MonitorGlass polygon MonitorGlass.3
0
0
9
        0    0.184615388513   -0.0270000007004
        0    0.184615388513   -0.0337500013411
        0   0.0923076942563   -0.0337500013411
```

Workflow for BSDF to surface geometry

- Use radiance's genBSDF command to convert the surface geometry into a BSDF function through an *.xml file



Output file:

Workflow for BSDF to surface geometry

- The generated xml file contains data about the geometry.


```
<?xml version="1.0" encoding="UTF-8" ?>
- <WindowElement xmlns="http://windows.lbl.gov" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://windows.lbl.gov/BSDF-v1.4.xsd">
  <!--  File produced by: genBSDF New.rad   -->
  <WindowElementType>System</WindowElementType>
- <Optical>
  - <Layer>
    - <Material>
        <Name>Name</Name>
        <Manufacturer>Manufacturer</Manufacturer>
        <Thickness unit="Meter">0.054000</Thickness>
        <Width unit="Meter">5.000000</Width>
        <Height unit="Meter">1.200000</Height>
        <DeviceType>Other</DeviceType>
      </Material>
    - <Geometry format="MGF" unit="Meter">
        <MGFblock unit="Meter">xf -t -2.500000 -0.600000 0 # The following was converted from RADIANCE scene input o Untitled # Begin conversion from:
          C:\Users\SONY\AppData\Local\Temp\genBSDF.d9jRqS\device.rad # xform -e # obj2rad -m full.map full.obj # Rhino m MonitorGlass = ir 1.489000 0 sides 1 c
          rs 0.0386 0 c cxy 0.3333 0.3333 ts 0.9609 0 o o MonitorGlass v v0 = p 0 0.184615388513 -0.0405000001192 v v1 = p 0 0.184615388513 -0.0472499988973 v v2
      </Geometry>
  - <DataDefinition>
      <IncidentDataStructure>Columns</IncidentDataStructure>
    - <AngleBasis>
        <AngleBasisName>LBNL/Klems Full</AngleBasisName>
      - <AngleBasisBlock>
          <Theta>0</Theta>
          <nPhis>1</nPhis>
        - <ThetaBounds>
            <LowerTheta>0</LowerTheta>
            <UpperTheta>5</UpperTheta>
     - <ThetaBounds>
          <LowerTheta>75</LowerTheta>
          <UpperTheta>90</UpperTheta>
        </ThetaBounds>
      </AngleBasisBlock>
    </AngleBasis>
  </DataDefinition>
- <WavelengthData>
    <LayerNumber>System</LayerNumber>
    <Wavelength unit="Integral">Visible</Wavelength>
    <SourceSpectrum>CIE Illuminant D65 1nm.ssp</SourceSpectrum>
    <DetectorSpectrum>ASTM E308 1931 Y.dsp</DetectorSpectrum>
  - <WavelengthDataBlock>
      <WavelengthDataDirection>Transmission Back</WavelengthDataDirection>
      <ColumnAngleBasis>LBNL/Klems Full</ColumnAngleBasis>
      <RowAngleBasis>LBNL/Klems Full</RowAngleBasis>
      <ScatteringDataType>BTDF</ScatteringDataType>
      <ScatteringData>1.84544825, 0, 0.0272355272, 0.155386546, 0.0225397952, 4.7997216e-006, 0.00535121091, 0.0430501674, 0.00579432325, 0, 0, 0,
        0.000203233326, 0.215134637, 0.00159476778, 0, 0, 0, 0, 0, 0.0290100592, 0.62753799, 0.0105542819, 0, 0, 0, 0, 0, 0, 0.0222971612, 0.303029857,
     </WavelengthDataBlock>
   </WavelengthData>
 - <WavelengthData>
     <LayerNumber>System</LayerNumber>
     <Wavelength unit="Integral">Visible</Wavelength>
     <SourceSpectrum>CIE Illuminant D65 1nm.ssp</SourceSpectrum>
     <DetectorSpectrum>ASTM E308 1931 Y.dsp</DetectorSpectrum>
   - <WavelengthDataBlock>
       <WavelengthDataDirection>Reflection Back</WavelengthDataDirection>
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         0.00509370089, 0.000176922776, 0, 0, 0, 0, 0, 0, 0.00909929079, 0.0988927397, 0.00517322679, 0, 0, 0, 0, 0, 0, 0, 0.000109727881, 0.0213593273,
```
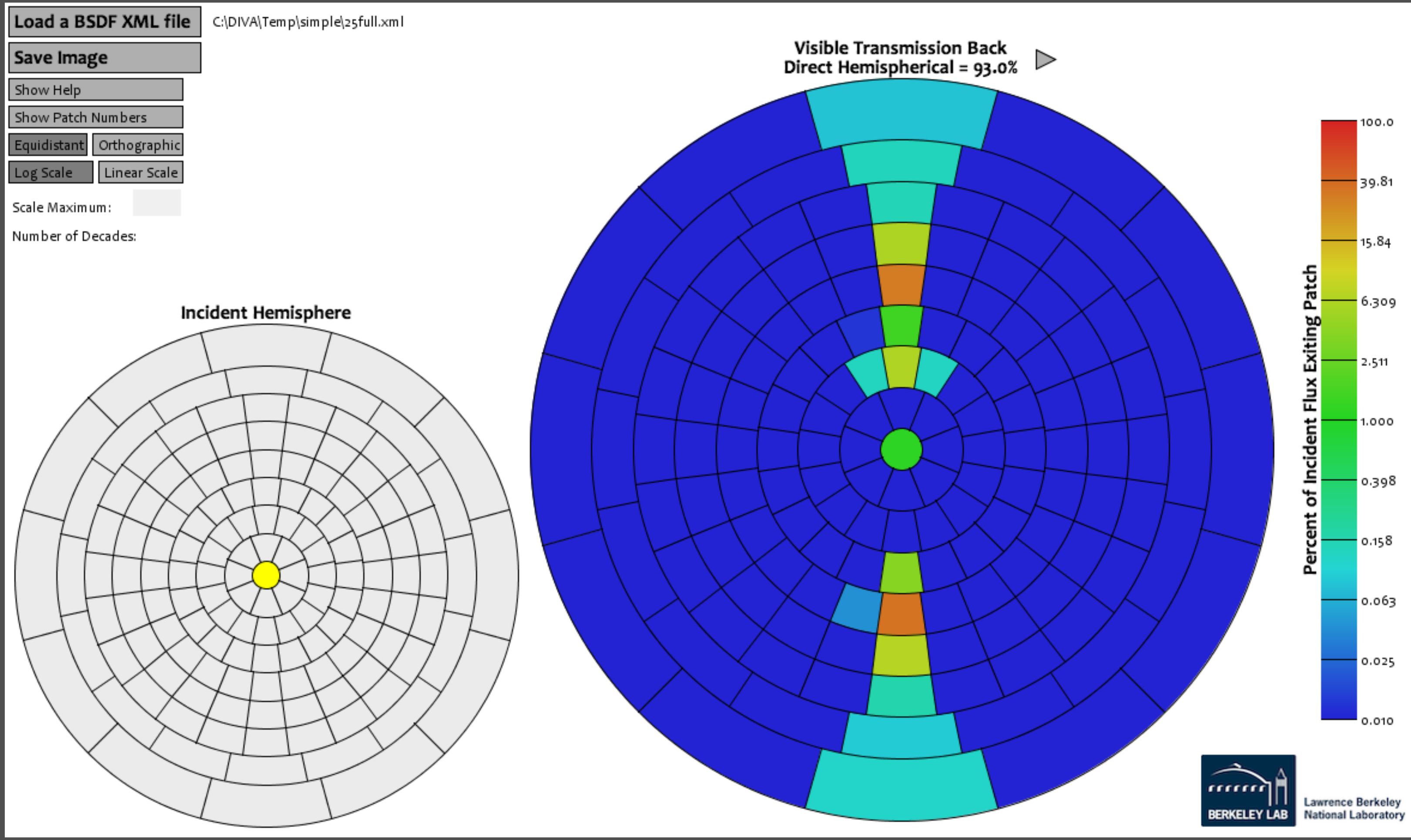


Geometry

Scattering Data (Transmission)

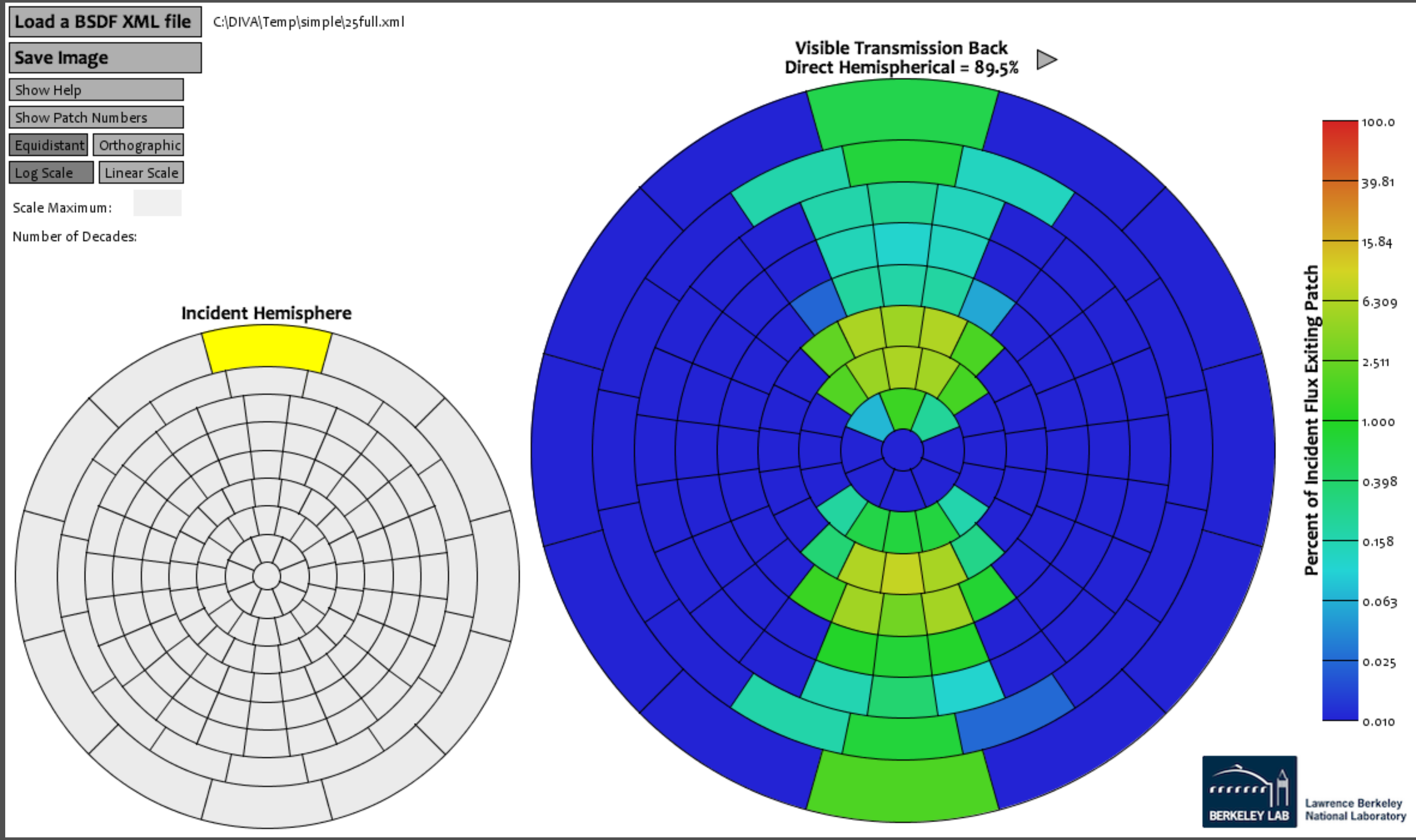
Scattering Data (Reflection)

$\alpha = 25°$



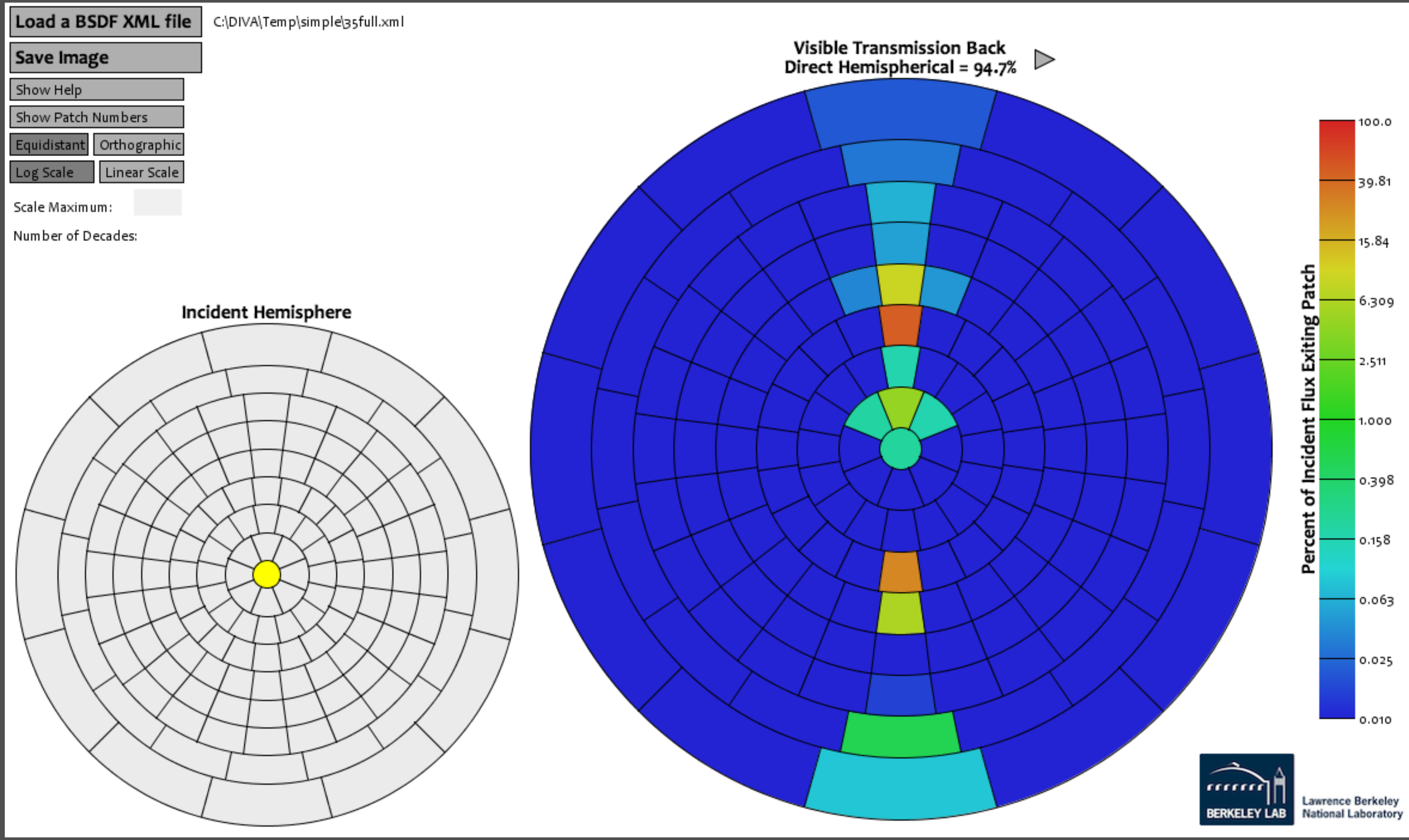
Klem Patches using BSDF viewer

$\alpha = 25°$



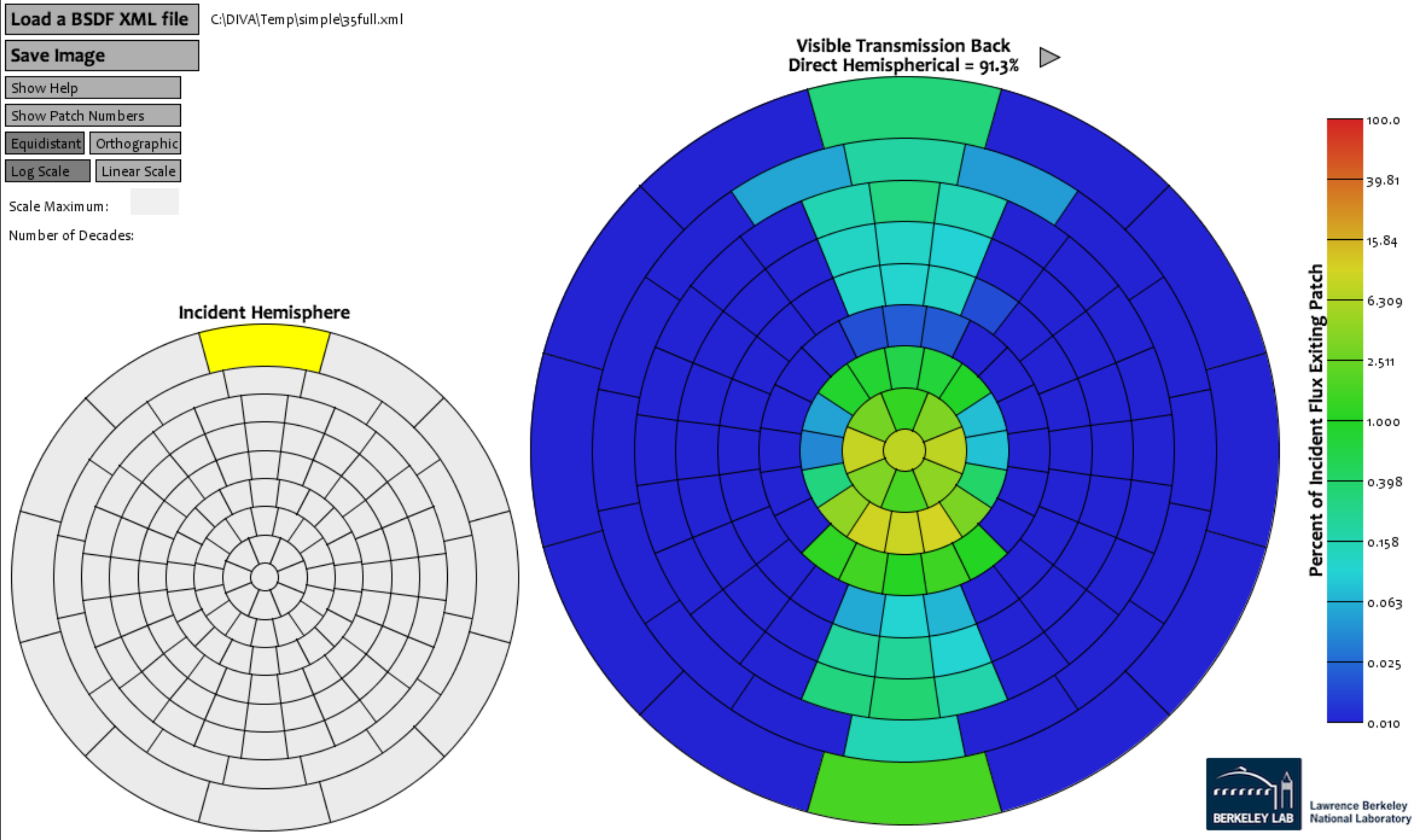
Klem Patches using BSDF viewer

$\alpha = 35°$



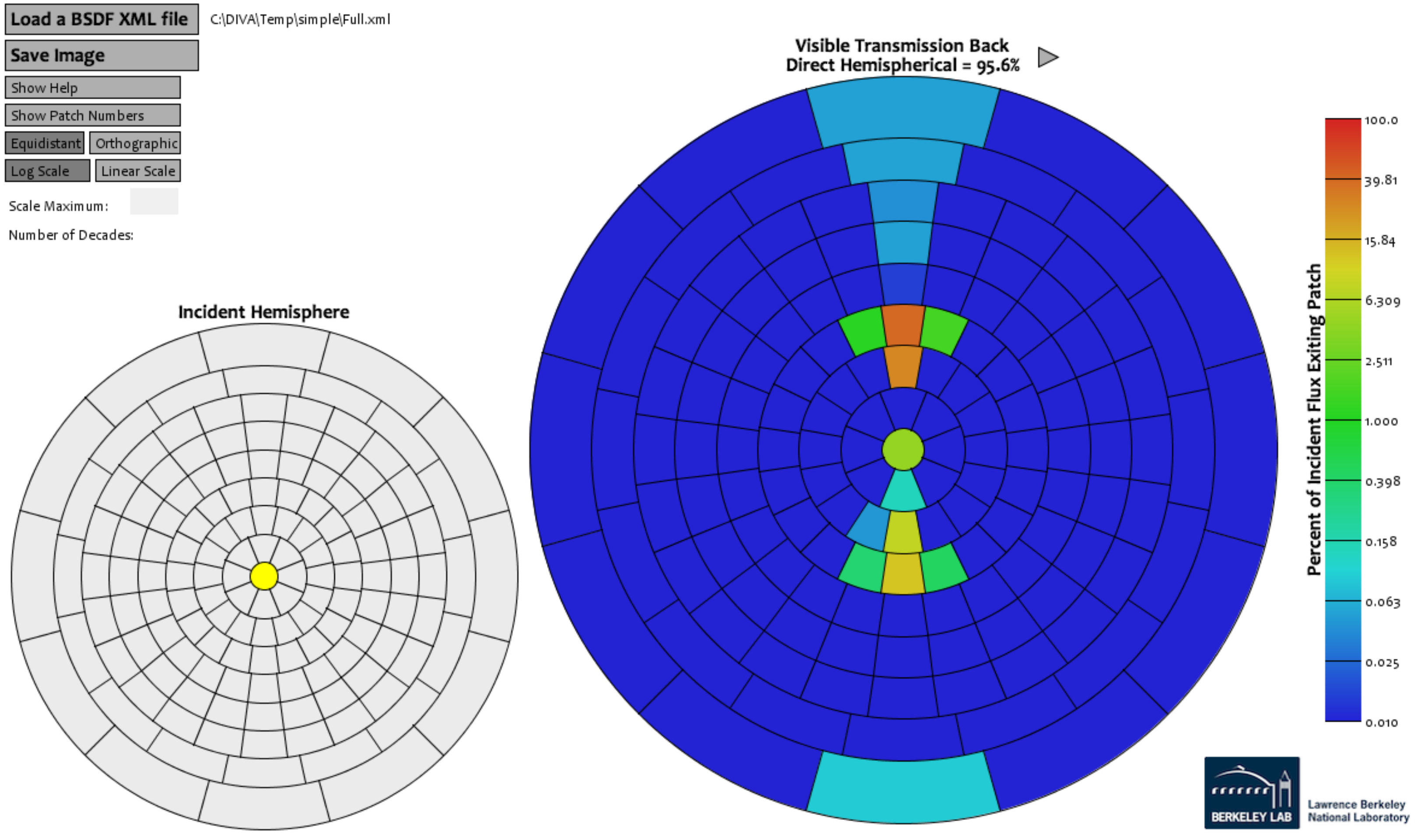
Klem Patches using BSDF viewer

$\alpha = 35°$



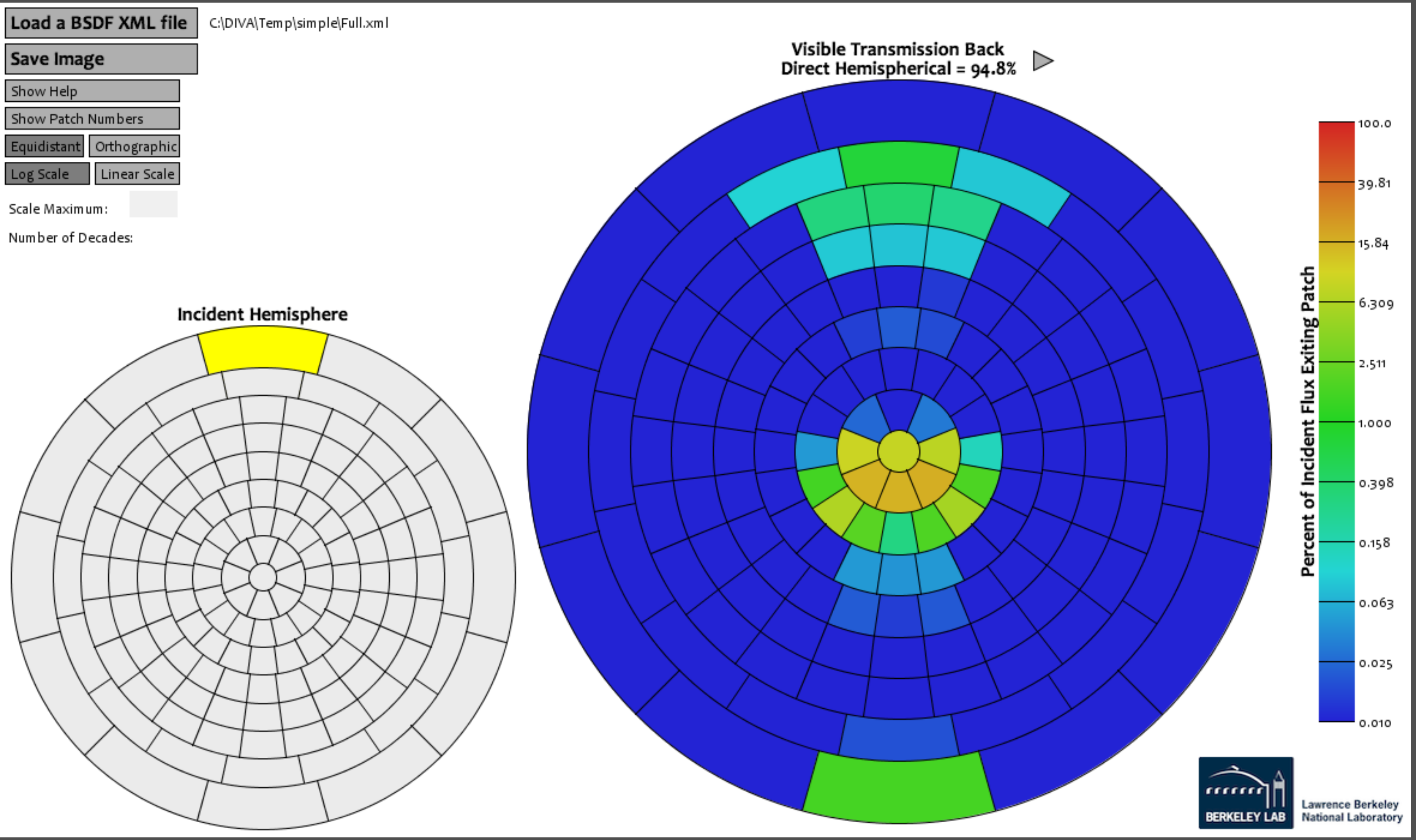
Klem Patches using BSDF viewer

$\alpha = 45°$



Klem Patches using BSDF viewer

$\alpha = 45°$



Klem Patches using BSDF viewer

Preparing for Simulation

- Need to consider more than one klem patch, therefore simulation
- Add the BSDF function xml file into the DIVA material file.

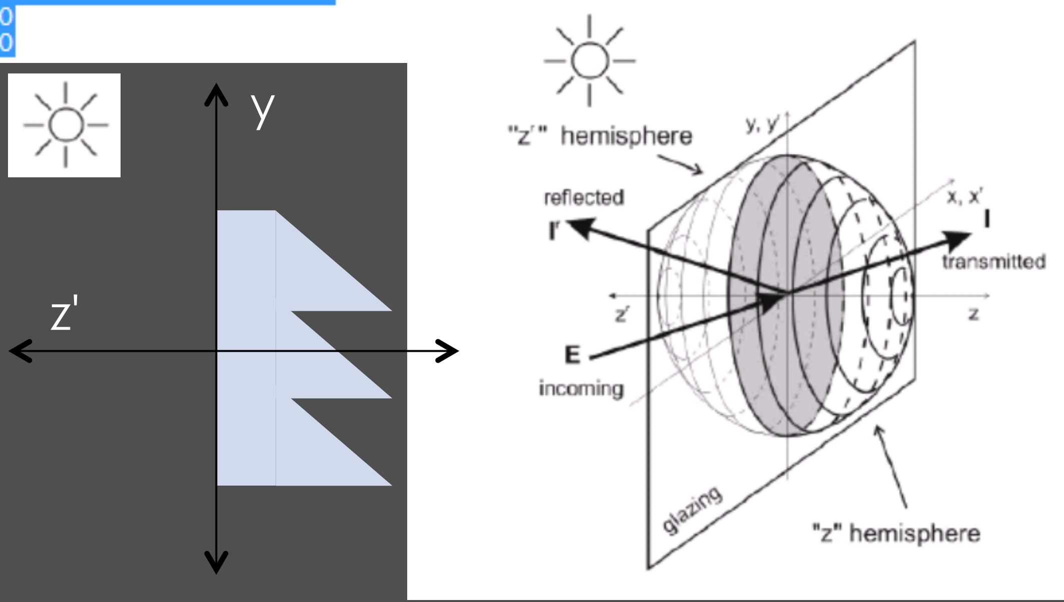
```
#++++++++++++++++++++++++++
# Radiance Material Library
#++++++++++++++++++++++++++

# This file contains a list of Radiance material descriptions and i
# material dialogue box. Users can automatically assign Radiance ma
# Rhino model. If you add a material to this file, it will appear i
# Please note that it is up to you to make sure that the Radiance m
# is going to crash otherwise. You are encouraged to make a backup

# material name: BSDF_Material
# material type: BSDF
# comment:<Comment>
# author: <Name>

void BSDF BSDF_Material
6 0 full.xml 0 0 -1 .
0
0
```

void BSDF BSDF_Material

6 0 full.xml ***0 0 -1****.*

0

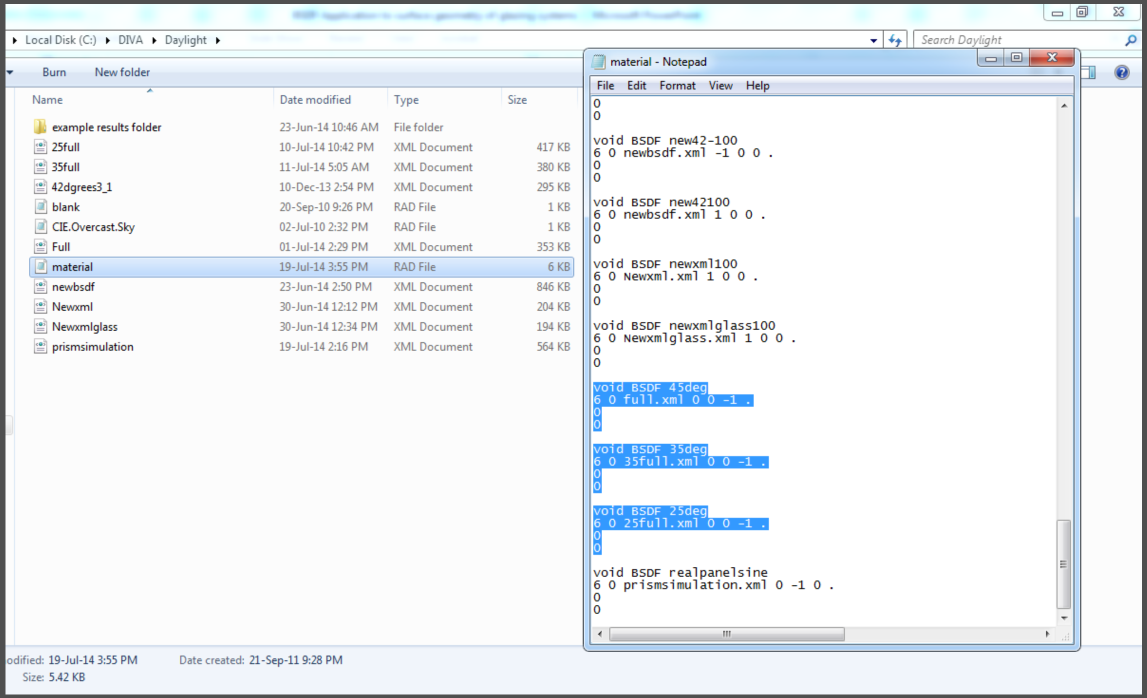
0

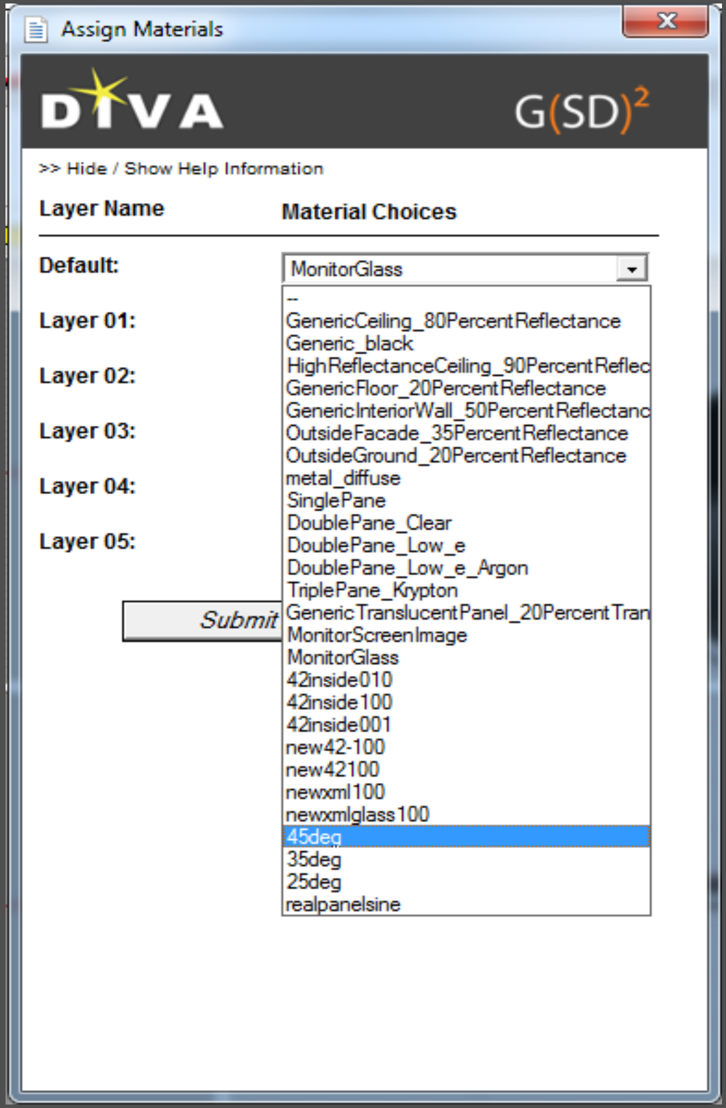


Schematic Diagram representing reflected and transmitted sides of a ***BSDF***

Diva Material

- Saved as a text file in C:\Diva\Daylight

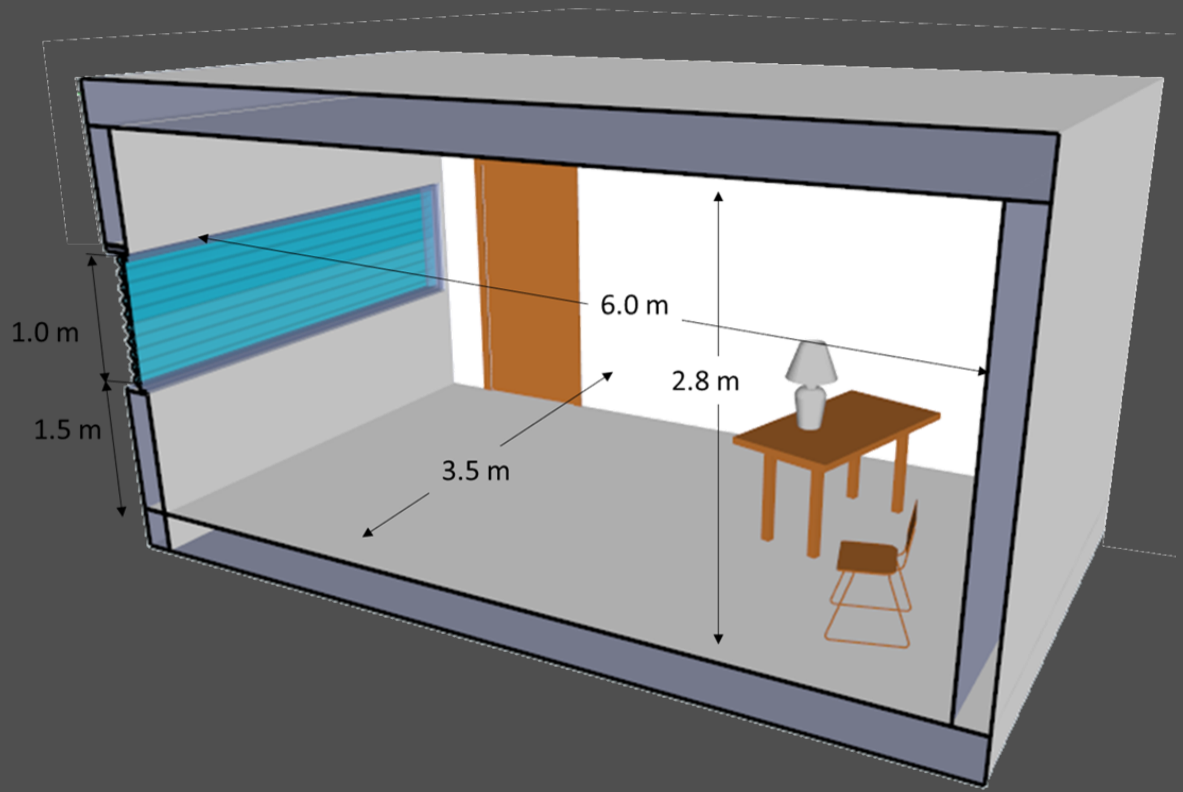




Simulations

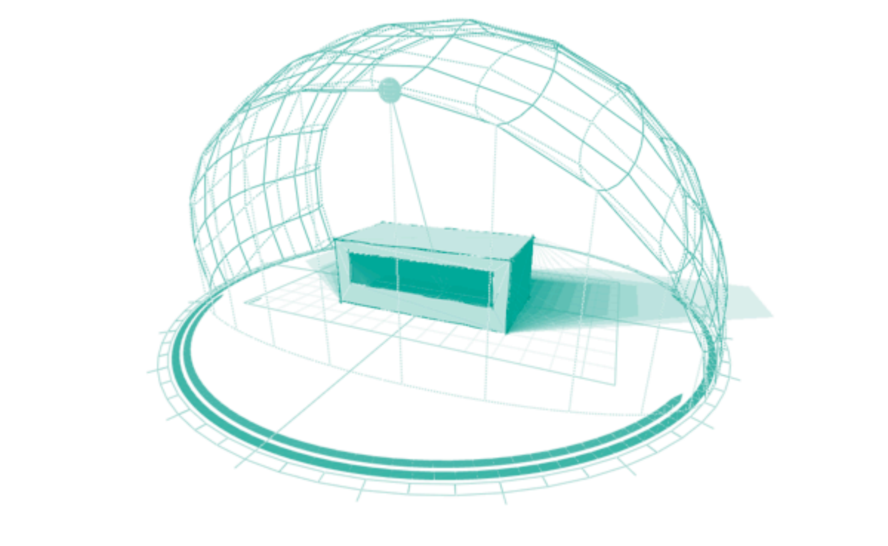
Room Dimensions

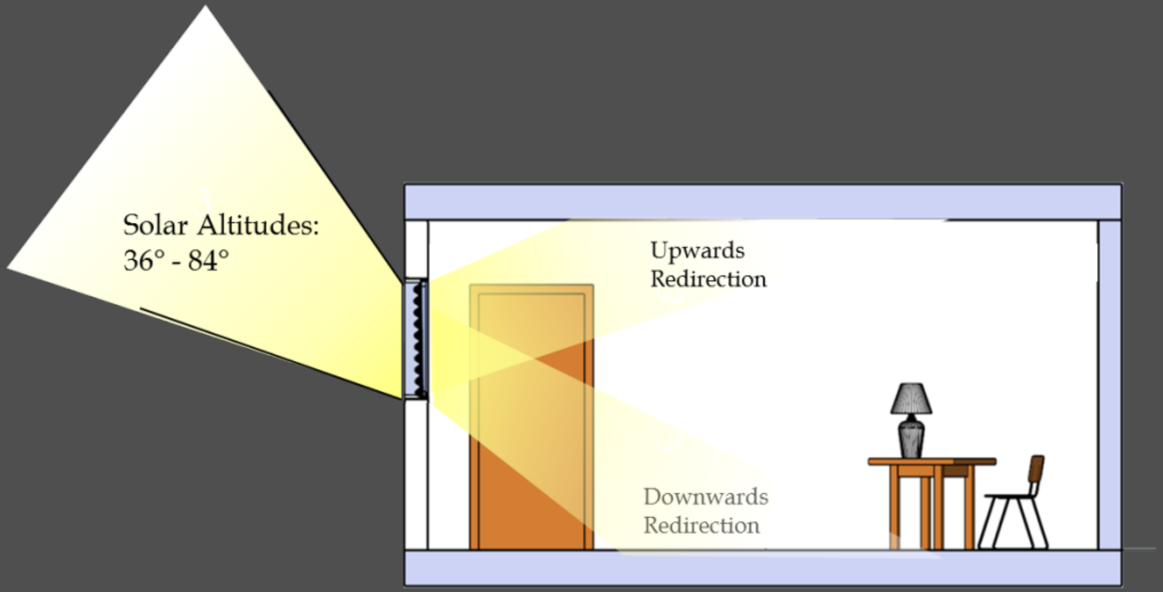
- The selected room is of dimensions 3.5 x 6.0 x 2.8 meters with a wide window of 1.0 meters high

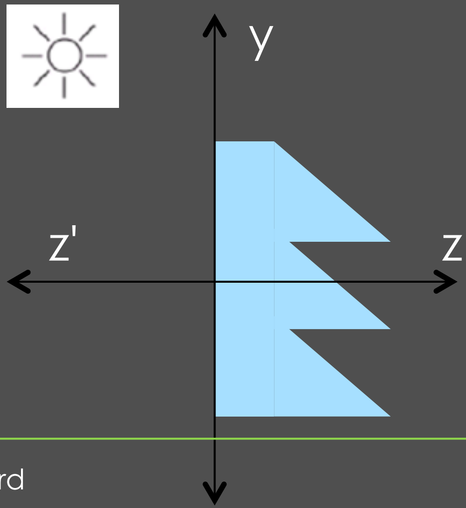


Simulations

- The idea of the simulations is to observe the improvement in light redirected upwards.

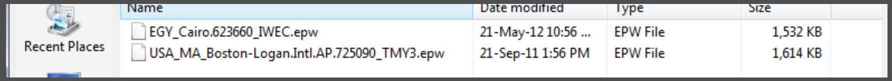


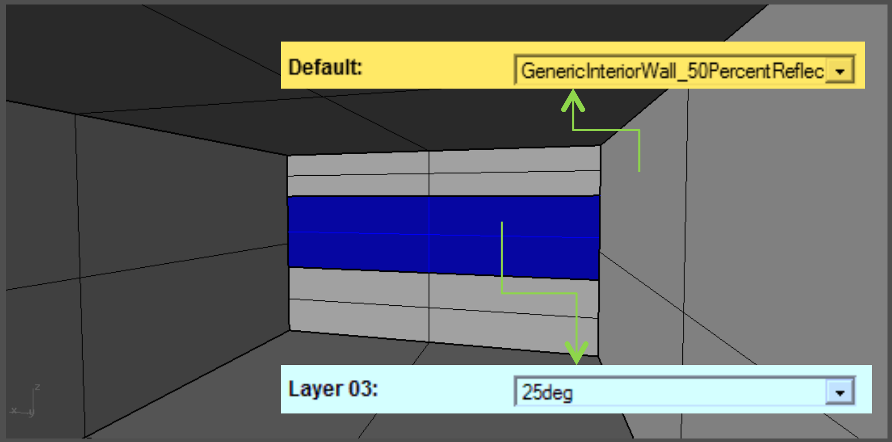


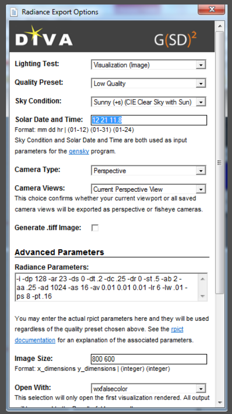


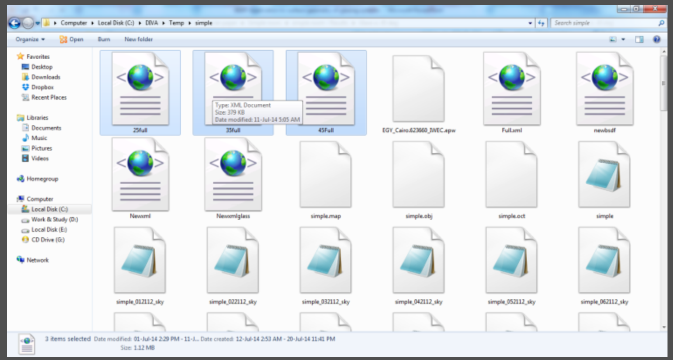
Simulations

- Add the BSDF material for the glass part.
- Make sure you add the .xml file in the folder of the model file too.

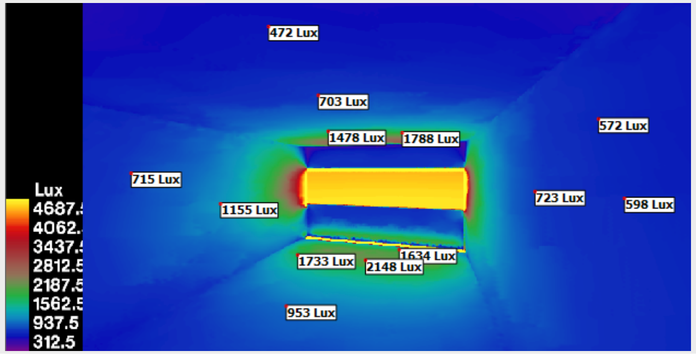
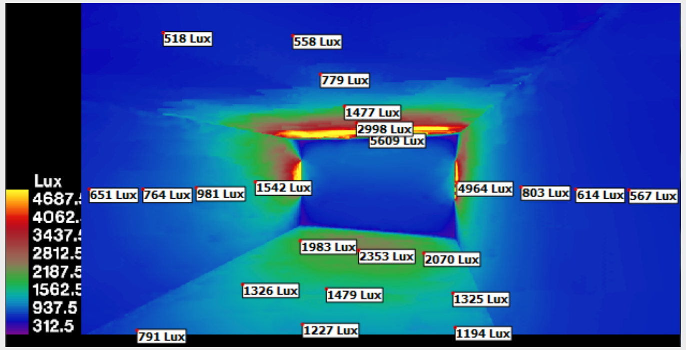
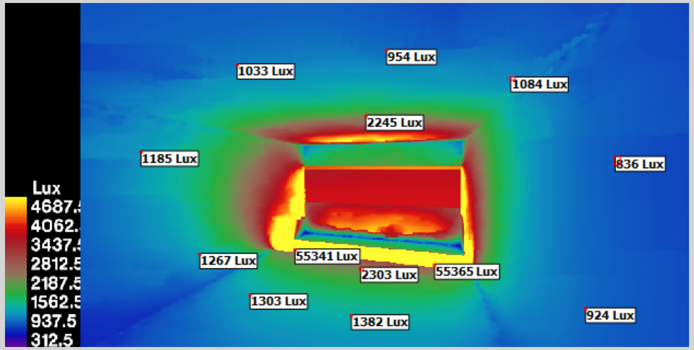
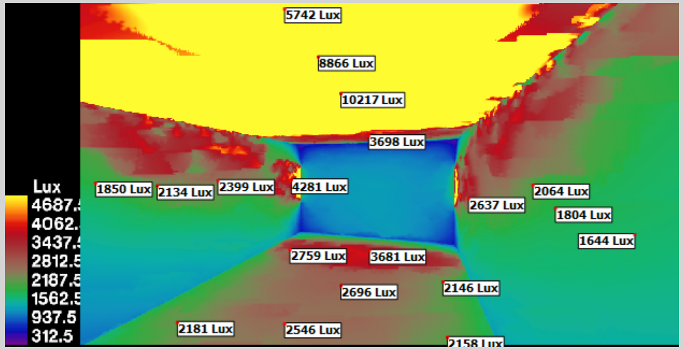
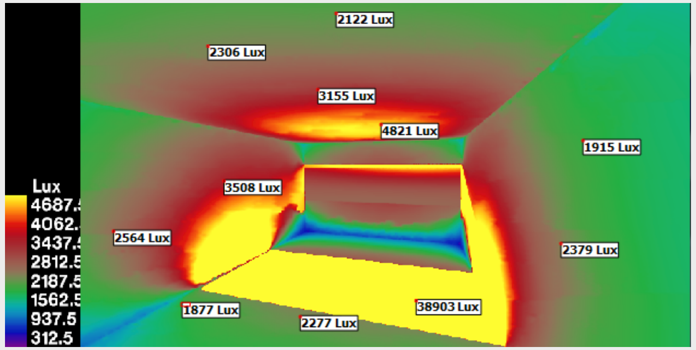
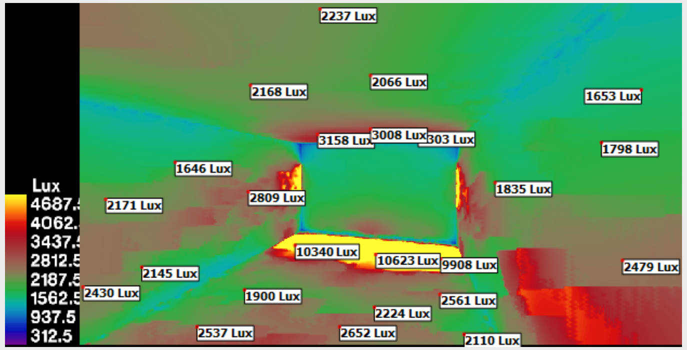








Prism $\alpha = 25°$

Date	Before	After
June 12:00 PM		
September 12:00 PM		
December 12:00 PM		

Prism α = 35°

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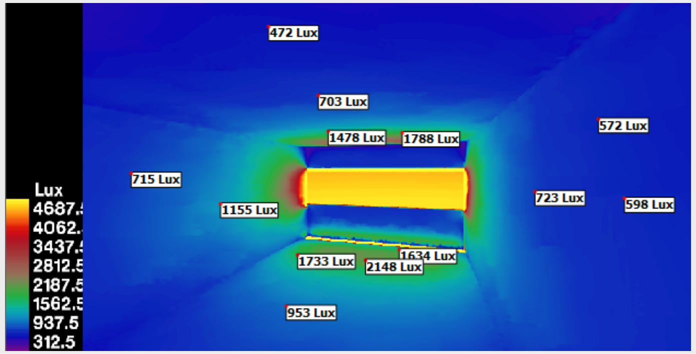
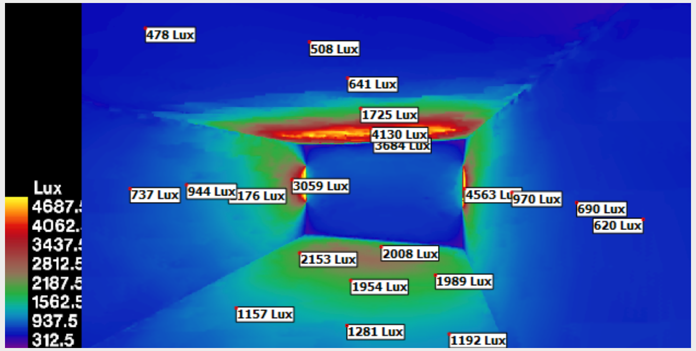
<tr><td>June 12:00 PM</td><td>
</td><td>
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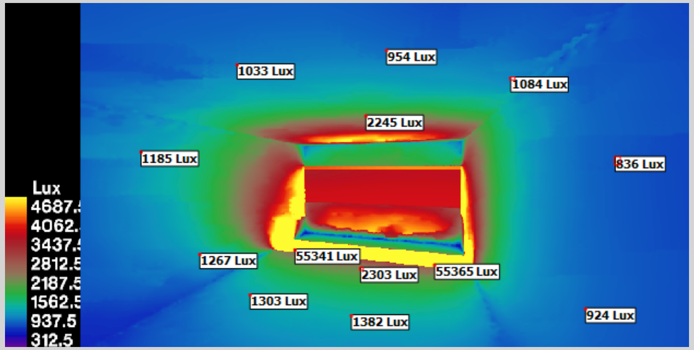
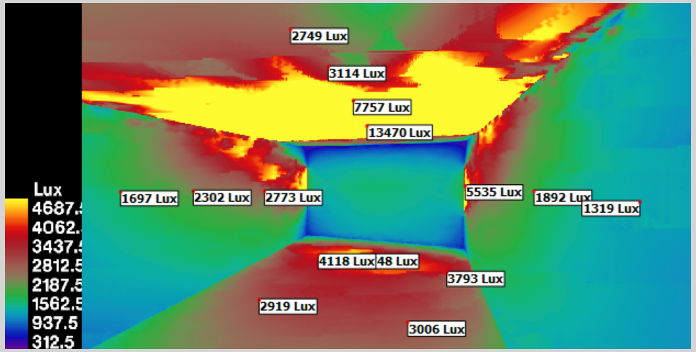
<tr><td>September 12:00 PM</td><td>
</td><td>
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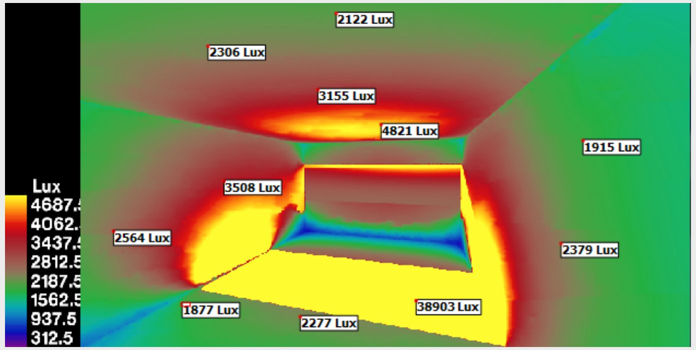
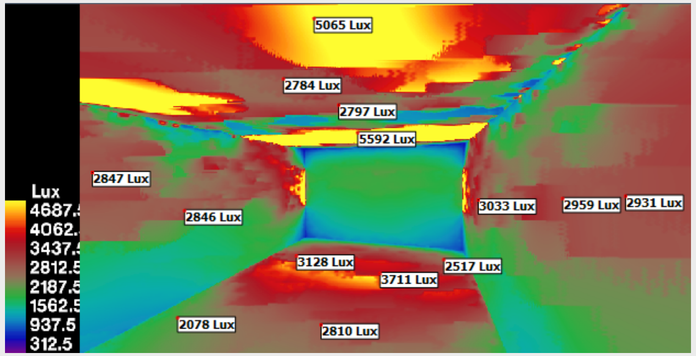
<tr><td>December 12:00 PM</td><td>
</td><td>
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Prism α = 45°

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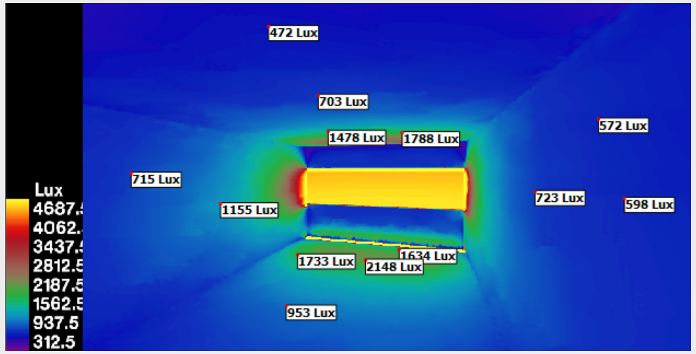
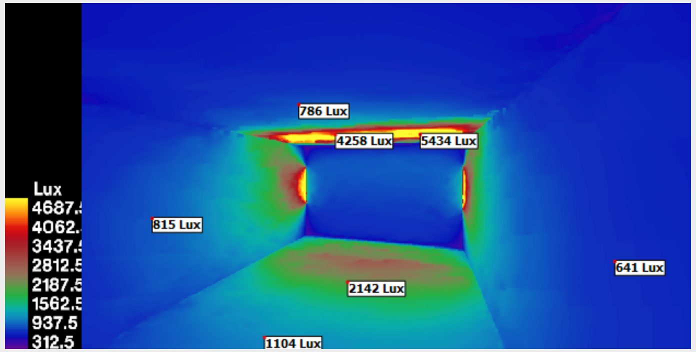
12:00 PM</td><td></td><td></td></tr>
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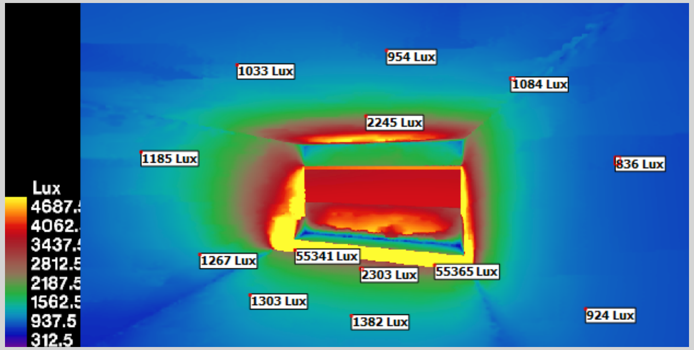
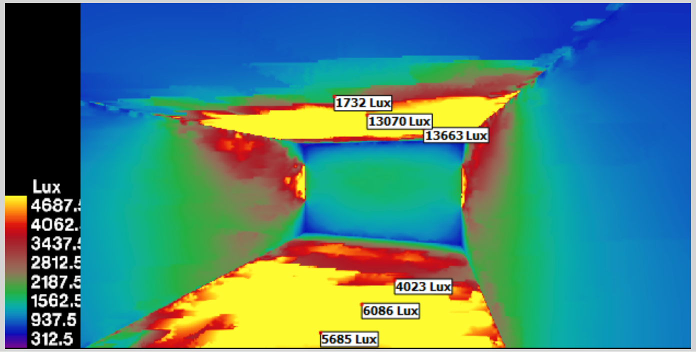
12:00 PM</td><td></td><td></td></tr>
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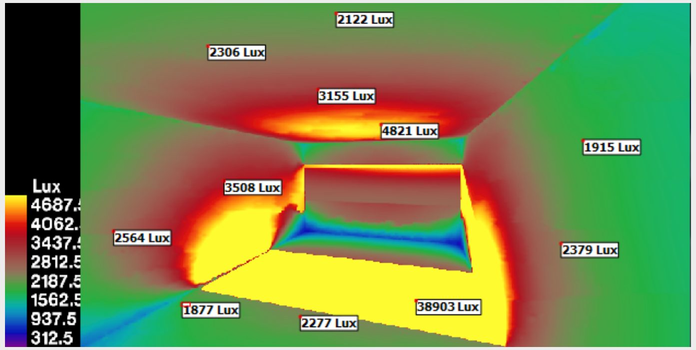
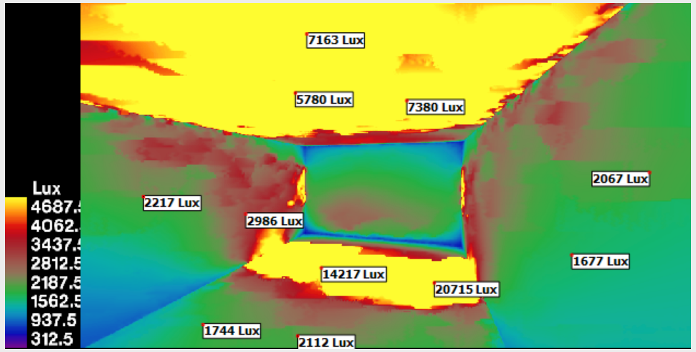
12:00 PM</td><td></td><td></td></tr>
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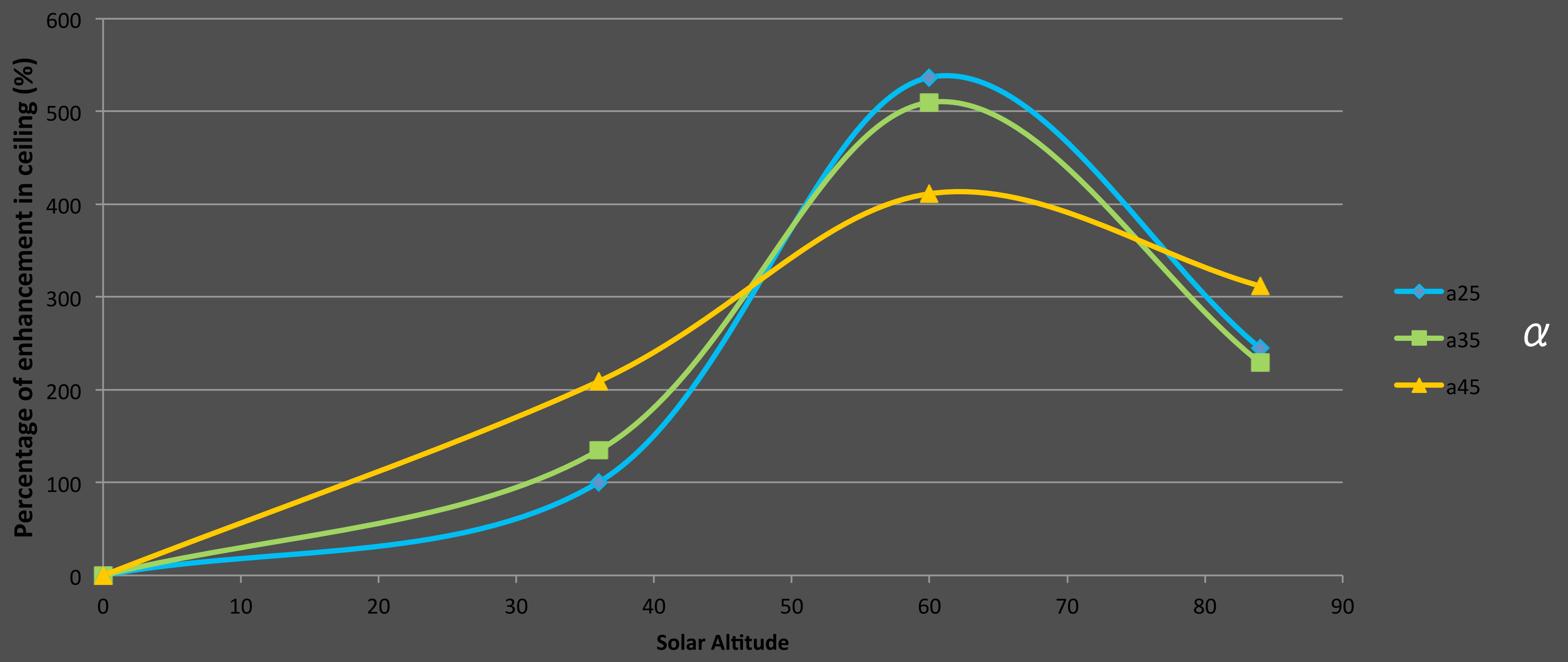
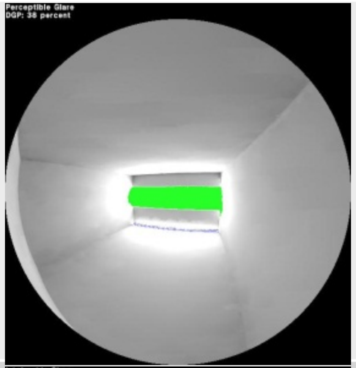
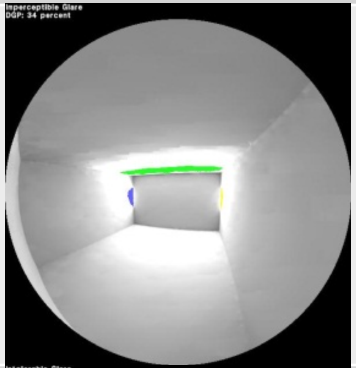
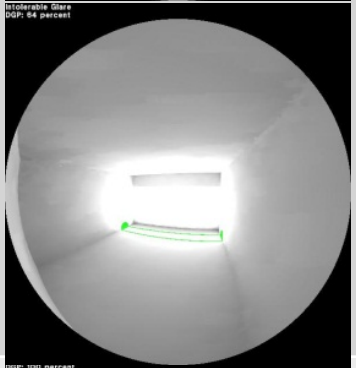
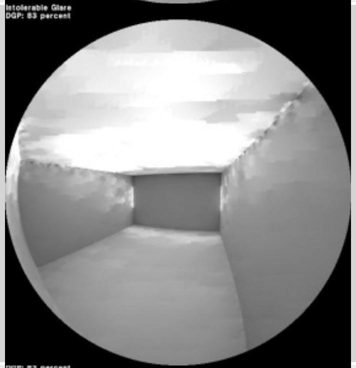
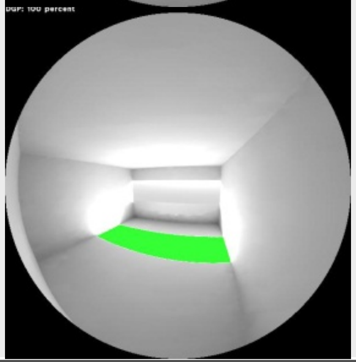
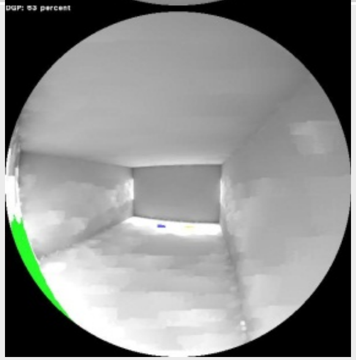
Simulation Results

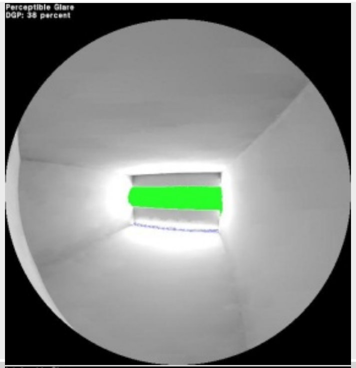
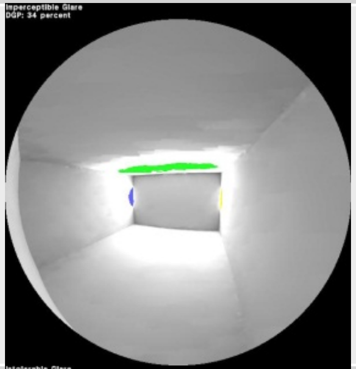
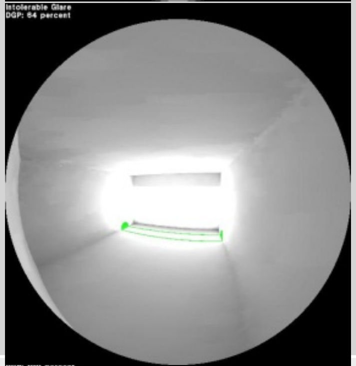
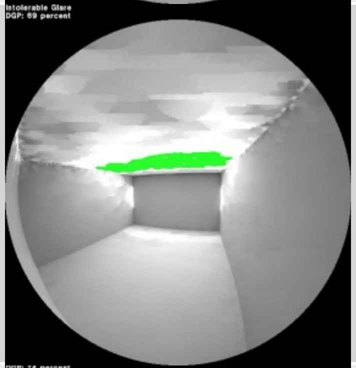
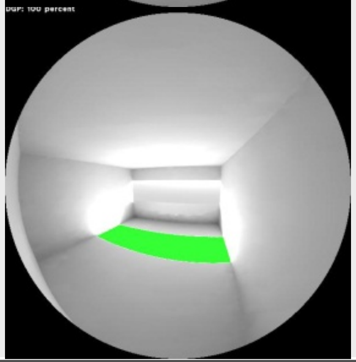
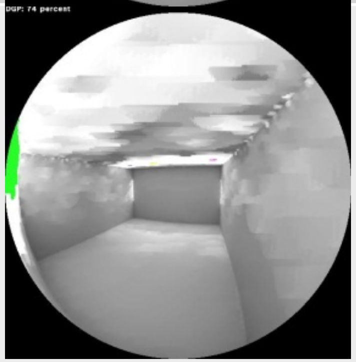


Graph showing the percent enhancement on the ceiling illumination (using average of sensor points on the ceiling)

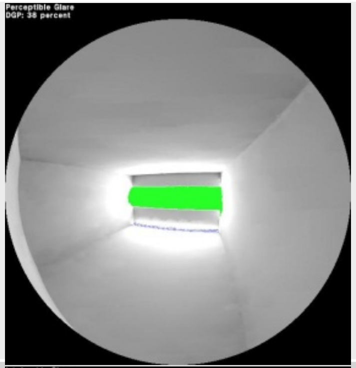
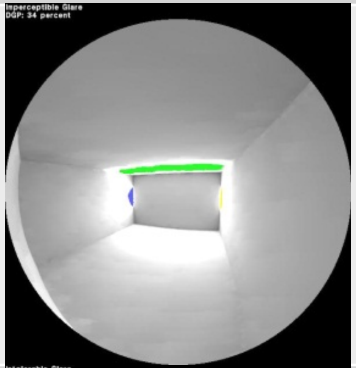
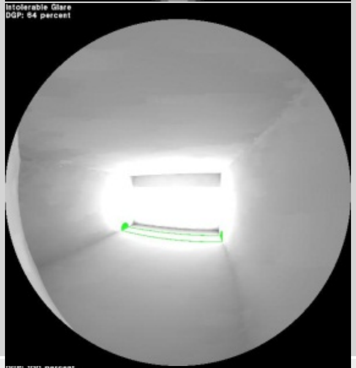
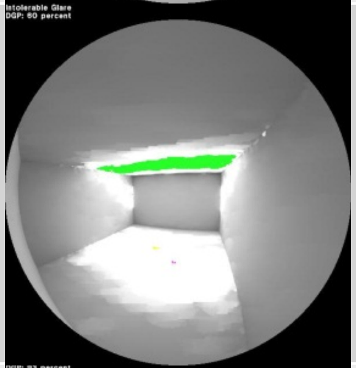
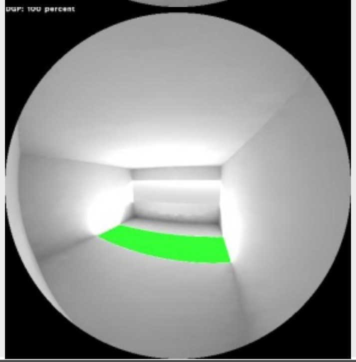
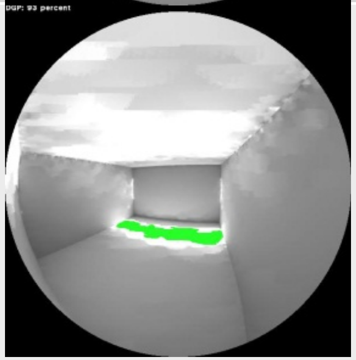
Prism α = 25°

Date	Before		After	
	DGP		DGP	
June 12:00 PM	38%		34%	
September 12:00 PM	64%		83%	
December 12:00 PM	100%		63%	

Prism α = 35°

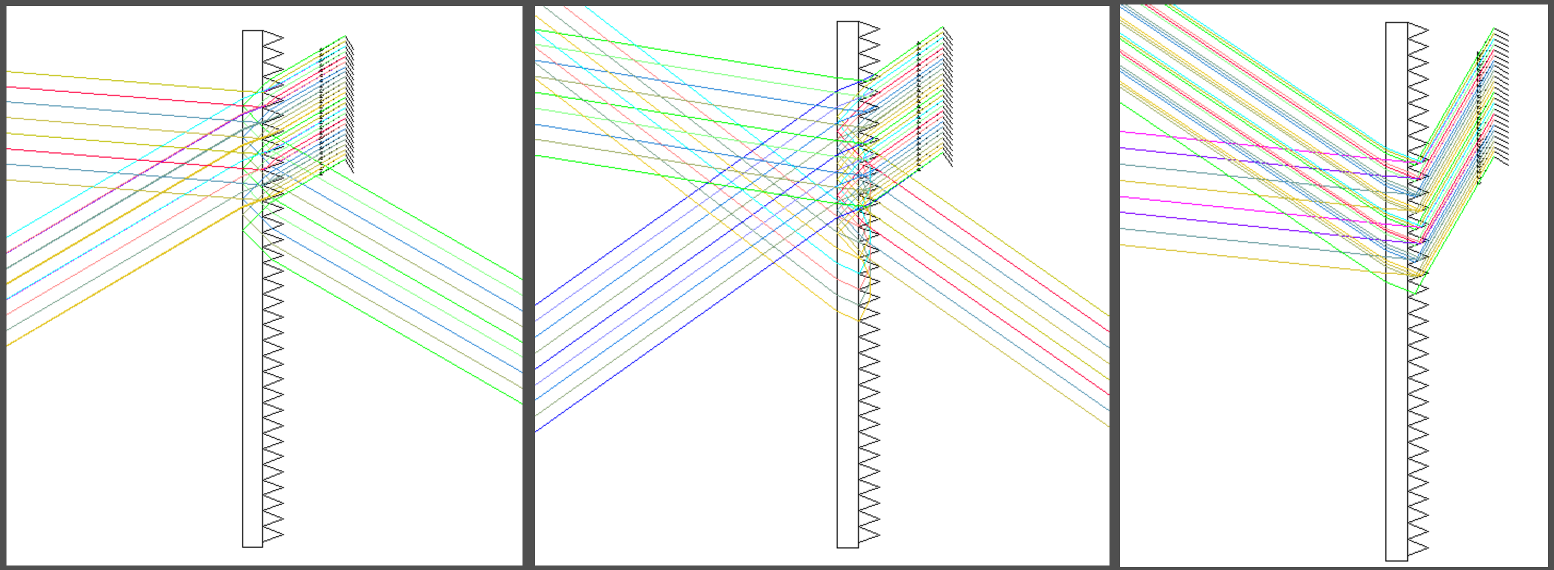
Date	Before DGP		After DGP	
June 12:00 PM	38%		34%	
September 12:00 PM	64%		69%	
December 12:00 PM	100%		74%	

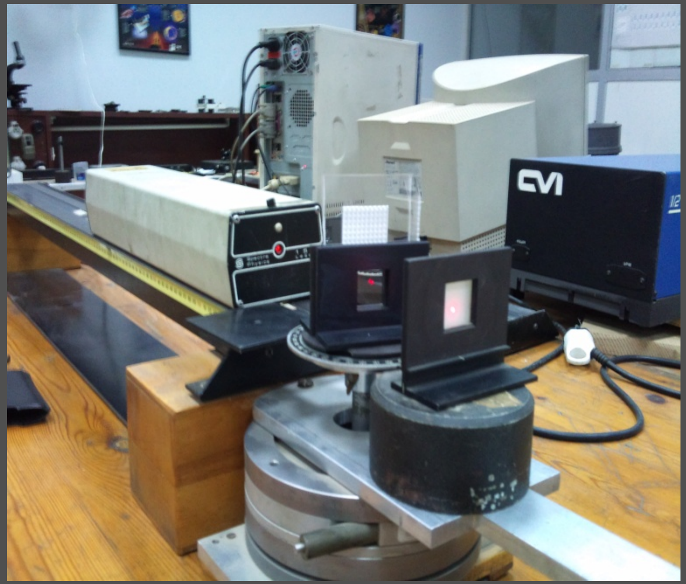
Prism α = 45°

Date	Before		After	
	DGP		DGP	
June 12:00 PM	38%		34%	
September 12:00 PM	64%		60%	
December 12:00 PM	100%		93%	

Compare with Tracepro

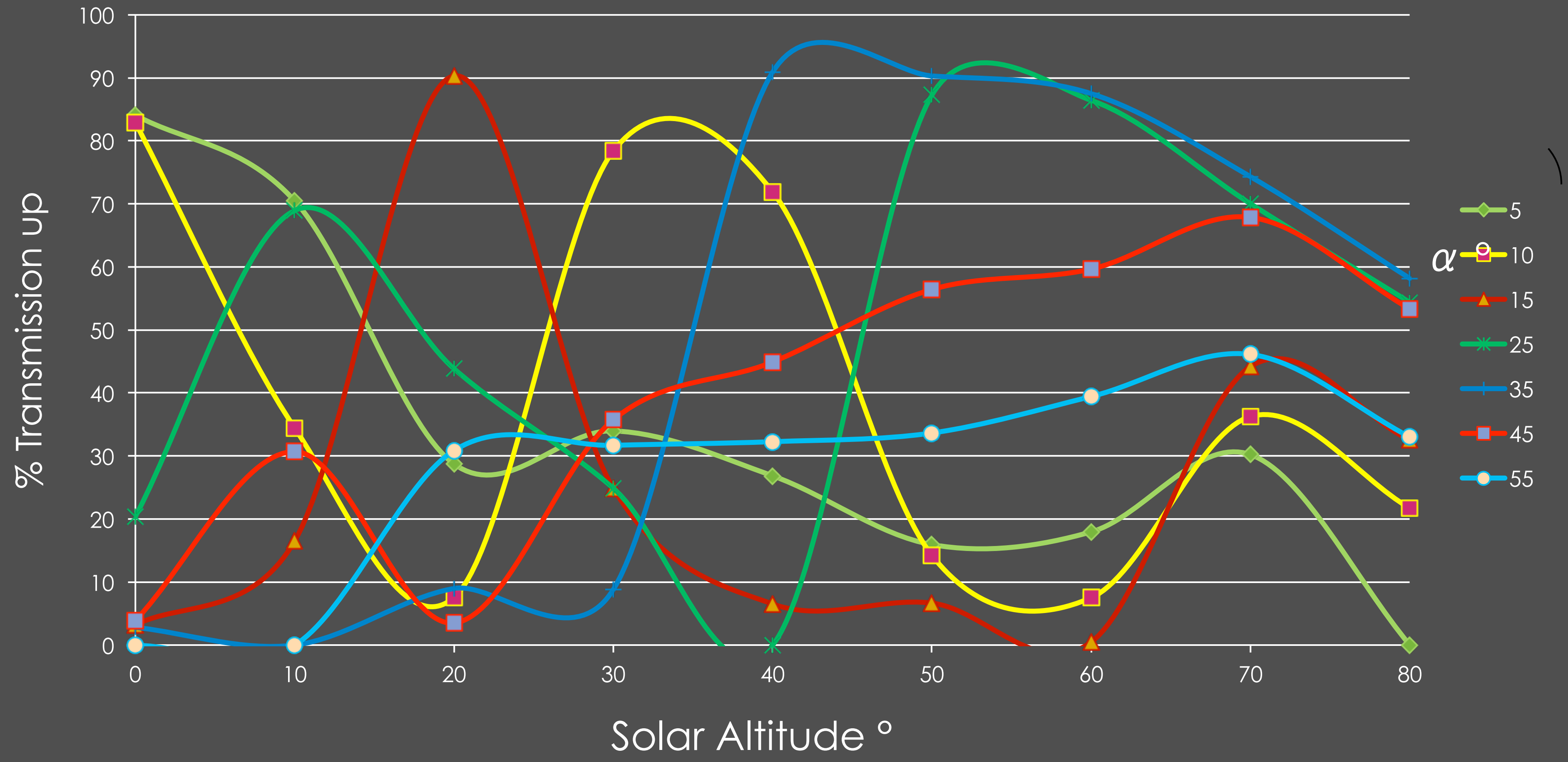
Light Redirecting Systems

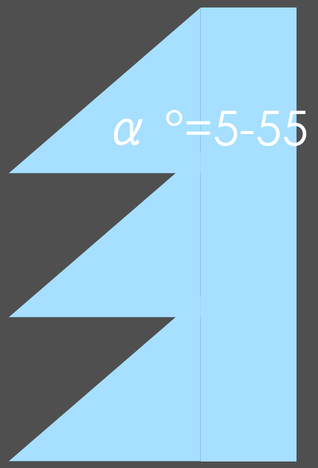




Compared genBSDF results with TracePro and small make shift setup

TracePro Results

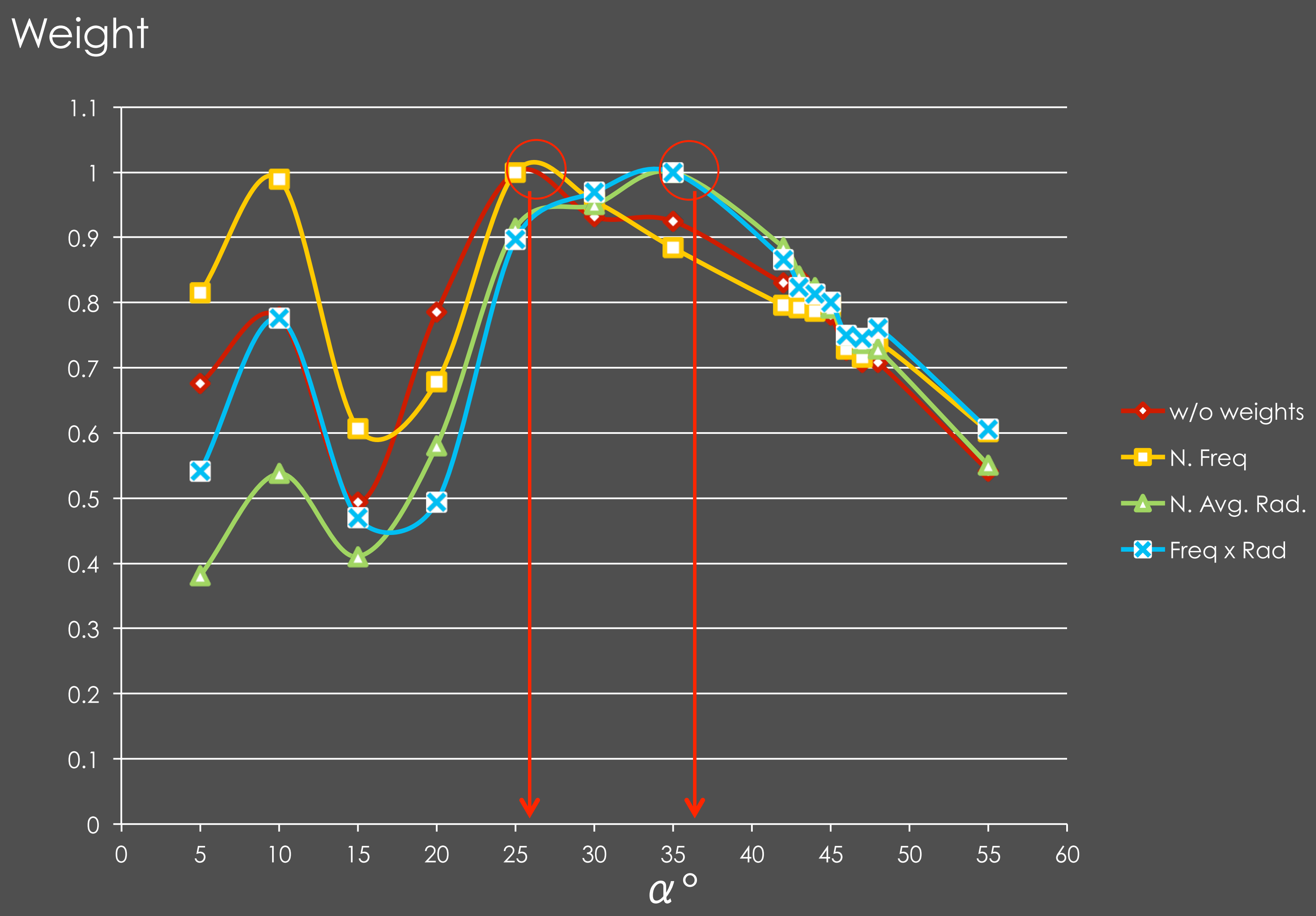




Graphs Show varying solar altitude with % Transmission

TracePro Results

Graphs Show the normalized frequency & average radiation through the year with respect to solar altitude



Graph Shows the weight of each combination and the optimum α

Conclusion

- In conclusion
  - The Prism α = 35° showed the optimum design in most solar altitudes -especially high ones- in Egypt.
  - A Prism with a different angle can be selected for the redirecting example
  - Need validation with the 3-phase method and perhaps the 5-phase

Questions??