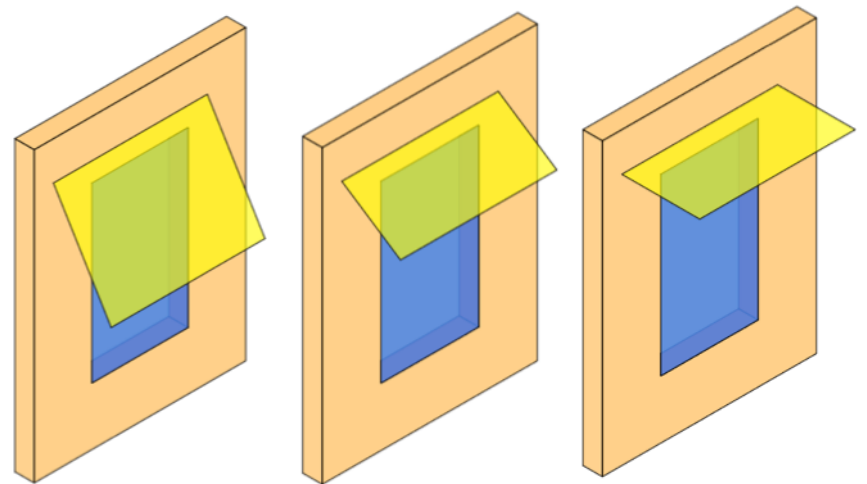


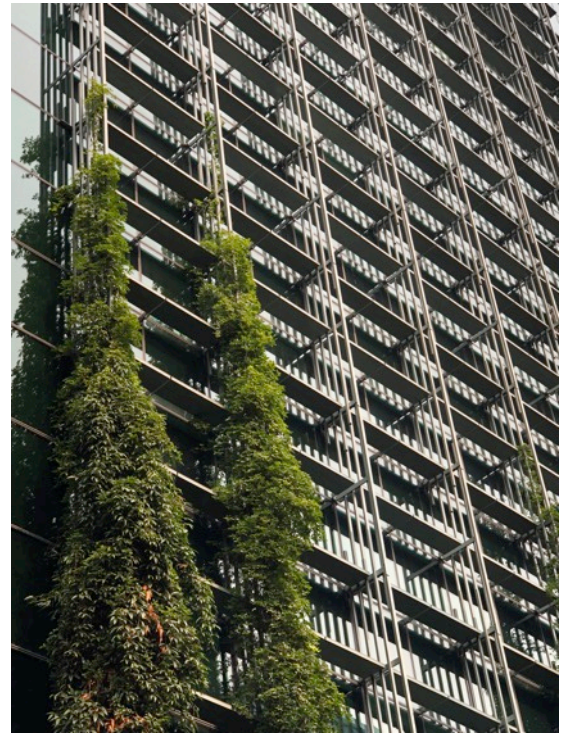
Enabling parametric analysis of non-coplanar shading system for daylight and energy performance

Taoning Wang, Greg Ward, Eleanor Lee
LBNL, Anywhere software

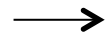




Non-coplanar
shading system
(NCP)



$$E = VTD$$



$$E = VTFD$$

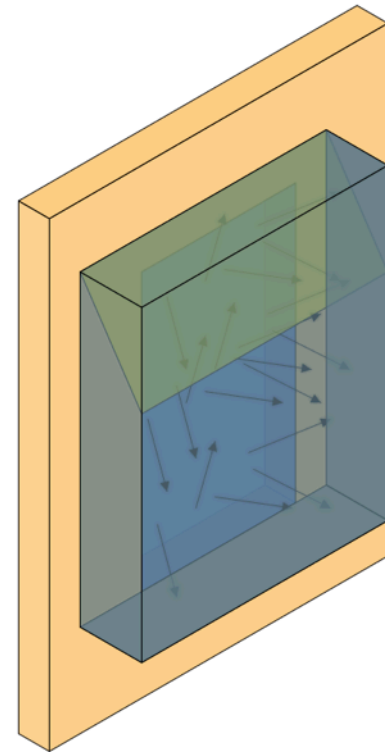
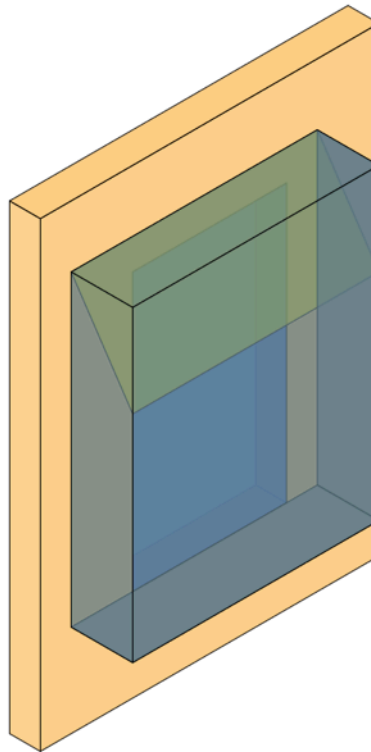
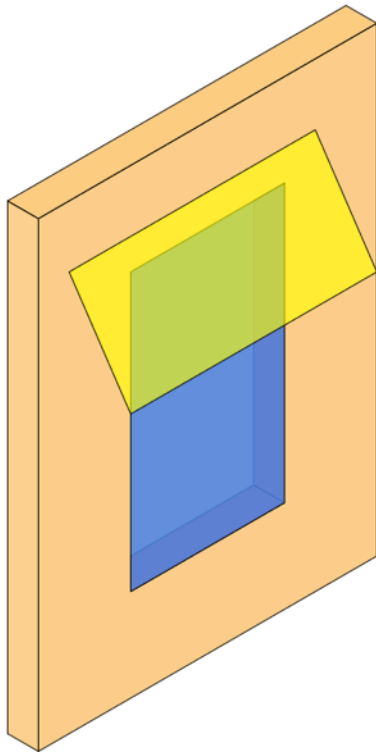
E: Illuminance or luminance;

V: view matrix;

T: Transmission matrix;

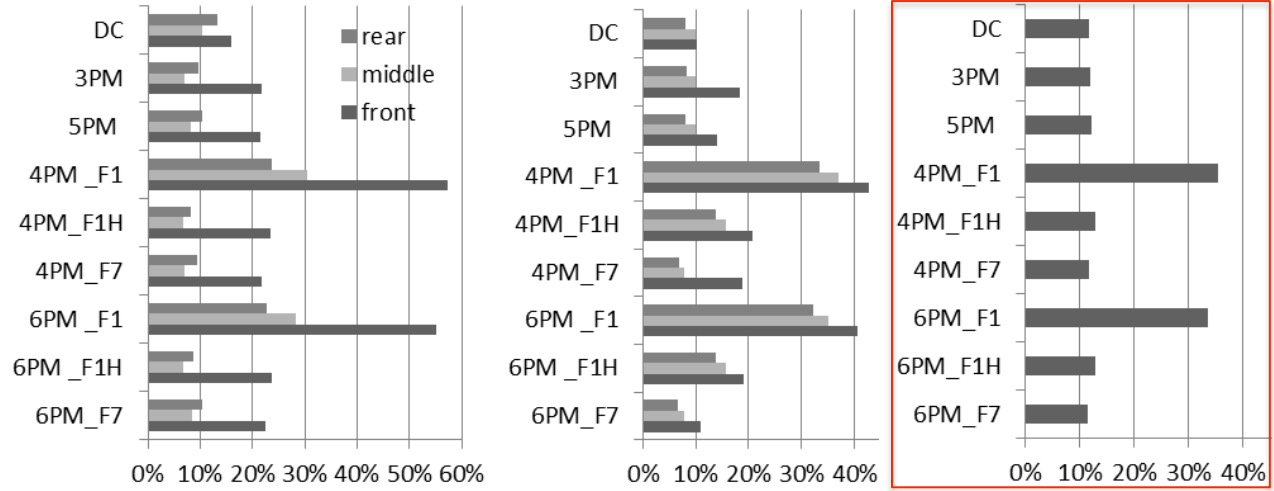
F: Façade matrix;

D: Daylight matrix



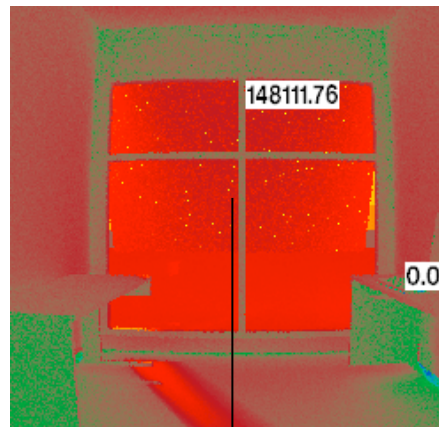
Illuminance

Overall illuminance error for awning angles (summer & winter) and for all periods

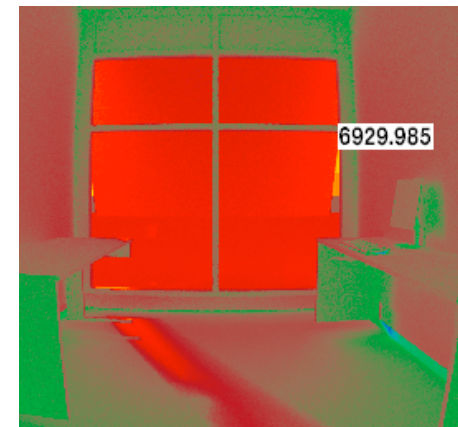


Glare

| Matrix method | Overall error |
|---------------|---------------|
| DC | 6.5% |
| 3PM | 6.8% |
| 5PM | 8.2% |
| 4PM_F1 | 12.9% |
| 4PM_F1H | 7.9% |
| 4PM_F7 | 6.4% |
| 6PM_F1 | 15.2% |
| 6PM_F1H | 8.6% |
| 6PM_F7 | 8.0% |



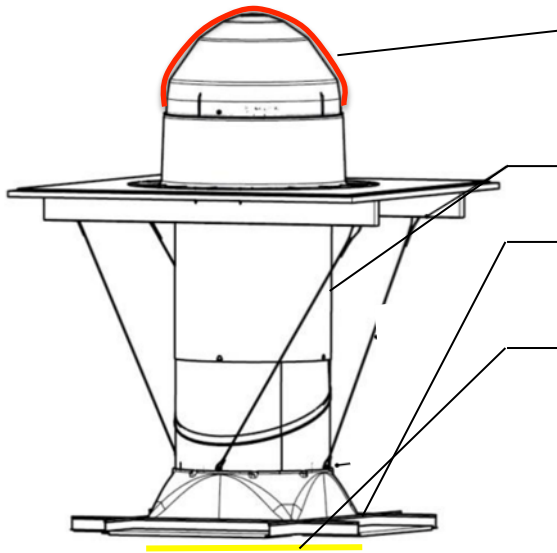
DC method with in scene Klems BSDF



Increase specular sampling (-ss) from 1 to 8000

Validation of simulating Tubular Daylighting Device (TDD), with *rfluxmtx*

Setup



Receiver surface: duplicate the acrylic dome surface and move up a little so that it sit just outside the dome

Tube: 99% reflectance from spectrophotometer measurement

Diffuser: Anisotropic tensor tree BSDF derived from scanning-goniophotometer measurement

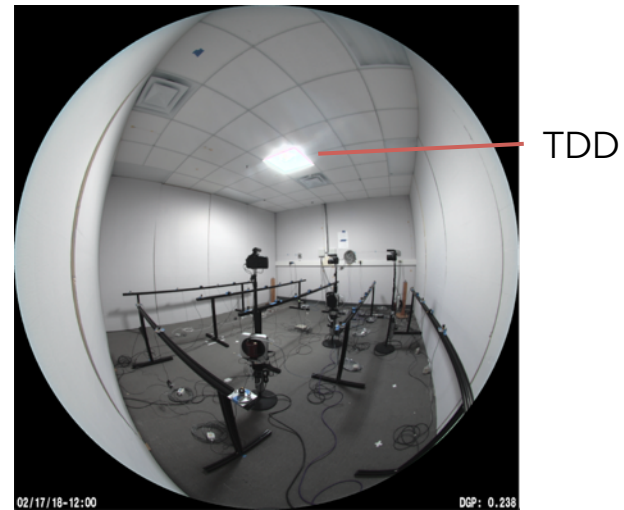
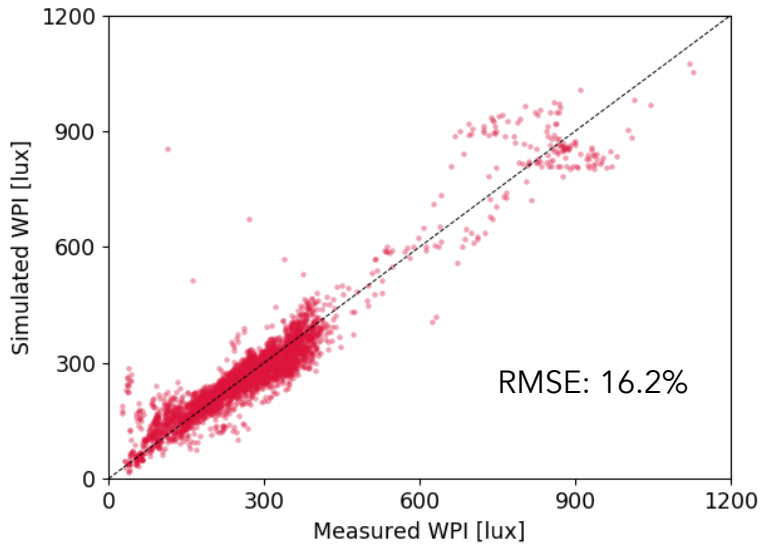
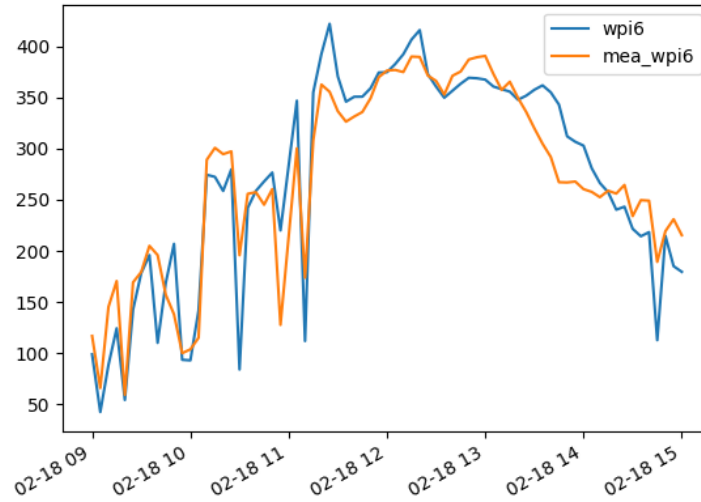
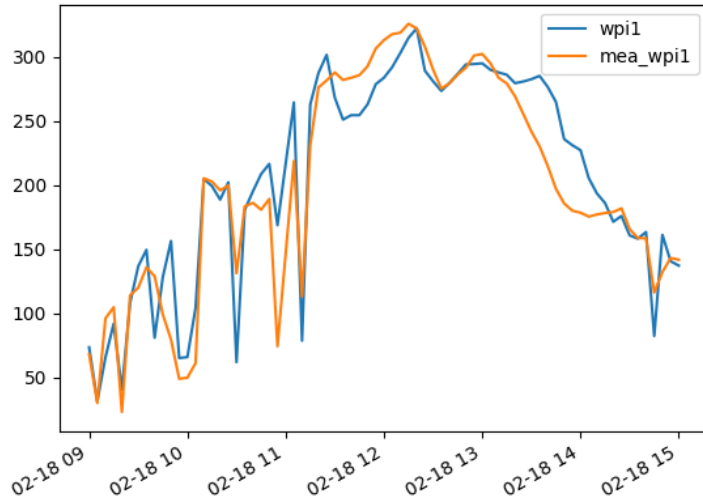
Sender surface : duplicate the diffuser surface and move down a little so that it's underneath the diffuser

```
rfluxmtx -ab 10 -c  
10000 sender  
receiver tdd.rad -o  
tdd.mtx
```



Validation of simulating Tubular Daylighting Device, with *rfluxmtx*

Result: compare again three days of workplane illuminance measurements



Flexlab, LBNL

To automate the process of generating façade matrices ...

```
GENFMTX(1)
```

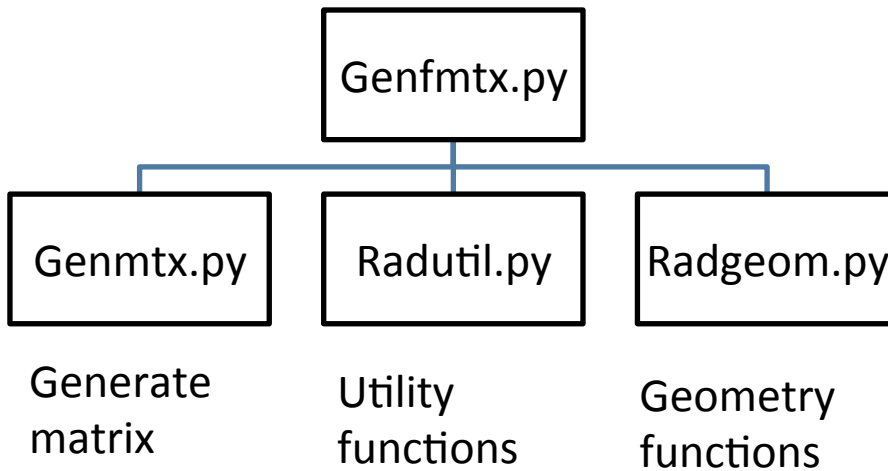
```
GENFMTX(1)
```

```
NAME
```

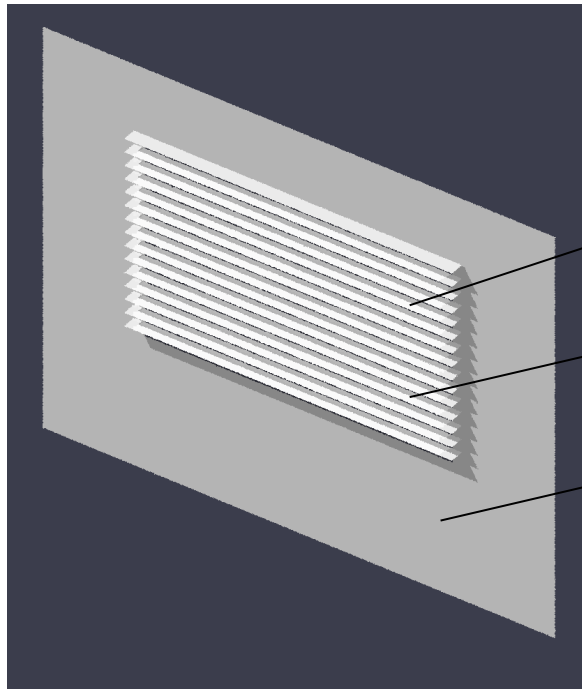
```
genfmtx - generate facade matrix / BSDF description from Radiance
```

```
SYNOPSIS
```

```
genfmtx [ -wf win_path ][ -sf ncs_path ][ -ss Sender basis ][ -rs Receiver  
basis ][ -o Output path ][ -wrap wrap to .XML ][ -env Environment ][ -opt  
rcontrib options... ][ -back 'backwards' ][ -refl reflection ][ -FN using  
FN method ][ -depth system depth ][ -scale scale port ]
```



Example: venetian blind (comparing with genBSDF)



window.rad

venetian_blind.rad

ext_wall.rad

or

overhang.rad

vertical_fin.rad

awning.rad

```
genfmtx.py -wf window.rad -sf venetian_blind.rad  
-rs kf -ss kf -opt '-ab 5 -ad 700 -lw 3e-6 -c  
500' -o venetian_blind.mtx -wrap -env  
material.rad venetian_blind.rad ext_wall.rad
```

klems

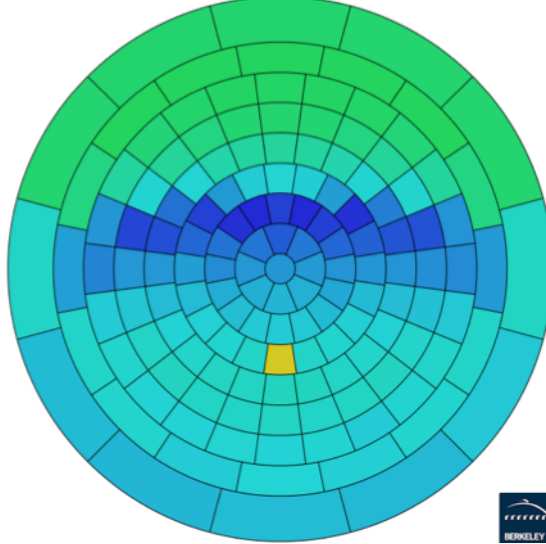
```
genfmtx.py -wf window.rad -sf venetian_blind.rad  
-rs sc64 -ss sc64 -opt '-ab 5 -ad 700 -lw 3e-6 -  
c 500' -o venetian_blind.mtx -wrap -env  
material.rad venetian_blind.rad ext_wall.rad
```

tensor
tree g6

Full Klems

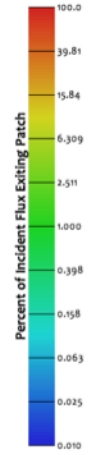
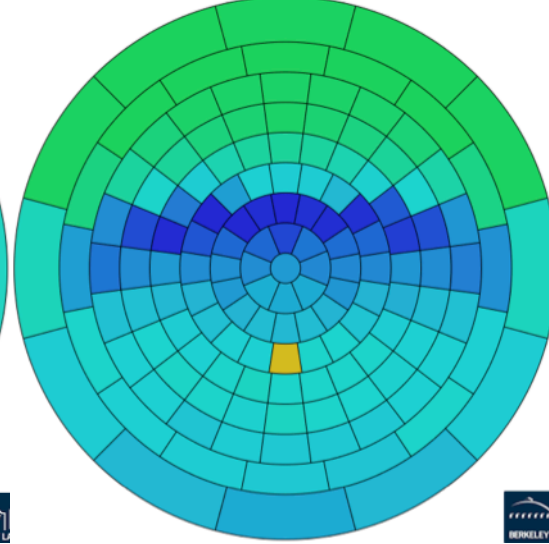
genBSDF

Visible Transmission Front
Direct Hemispherical = 31.0%



genfmtx

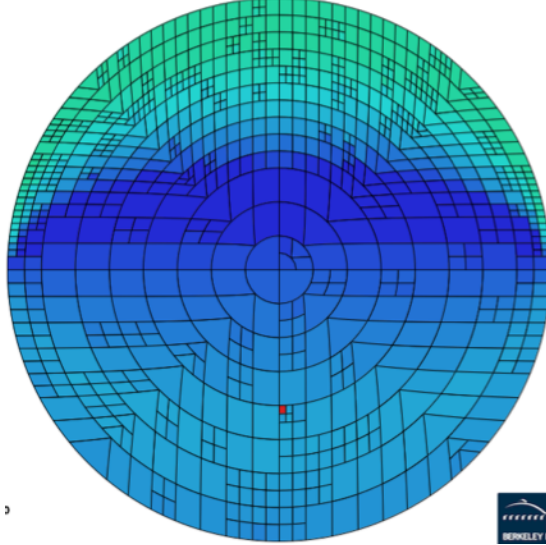
Visible Transmission Front
Direct Hemispherical = 32.8%



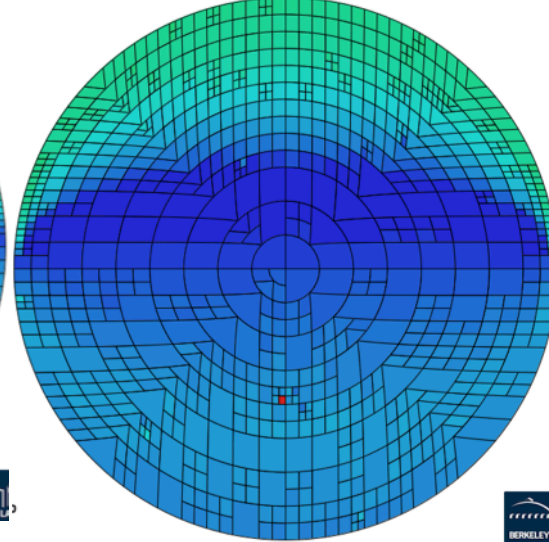
Lawrence Berkeley
National Laboratory

Tensor tree t4 g6

Visible Front Transmission
Direct Hemispherical = 26.6%



Visible Front Transmission
Direct Hemispherical = 30.5%



Lawrence Berkeley
National Laboratory

Validating matrix based method against EnergyPlus native NCP object

The screenshot shows the 'Glazing System Library' software interface. The main window displays configuration for a glazing system named 'sage_01'. The configuration includes:

- ID #: 1, Name: sage_01
- # Layers: 2, Tilt: 90 °, IG Height: 1000.00 mm, IG Width: 1000.00 mm
- Environmental Conditions: NFRC 100-2010
- Overall thickness: 28.705 mm, Mode: #, Model Deflection:

A table below the configuration shows the layer details:

| | ID | Name | Mode | Thick | Flip | Tsol | Rsol1 | Rsol2 | Tvis |
|---------|------|-------------------------|------|-------|--------------------------|-------|-------|-------|------|
| Glass 1 | 8905 | SageGlass_7_SR2_60c | # | 7.0 | <input type="checkbox"/> | 0.409 | 0.138 | 0.145 | 0.67 |
| Gap 1 | 9 | Air (10%) / Argon (90%) | | 16.0 | | | | | |
| Glass 2 | 103 | CLEAR_6_DAT | # | 5.7 | <input type="checkbox"/> | 0.771 | 0.070 | 0.070 | 0.88 |

A 'Report' dialog box is open, showing the 'Report type' set to 'Energy Plus BSRDF IDF File'. The 'Generate report for:' section has 'Selected record(s)' selected. The 'Text file options' section has 'Use default column widths' and 'Wrap columns' checked, and 'Preview' unchecked. The 'OK' and 'Cancel' buttons are visible at the bottom of the dialog.

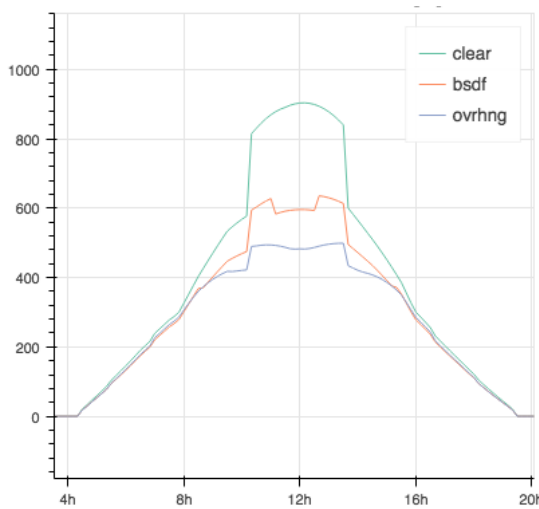
At the bottom of the window, there is a status bar with the text 'For Help, press F1' and 'Mode: NFRC SI NUM'.

Validating matrix based method against EnergyPlus native NCP object

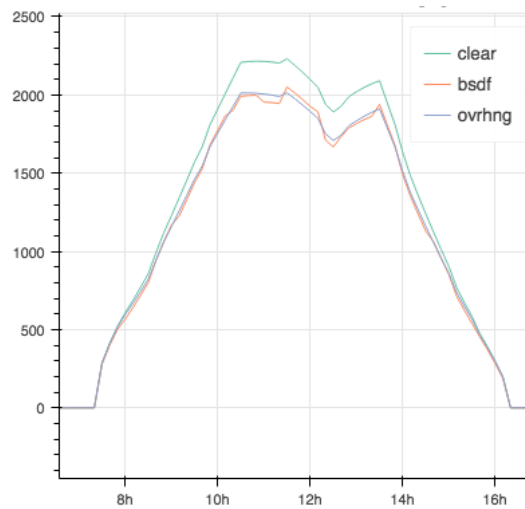
| | NCP shading object | Description |
|----------|--------------------------------------|---|
| 'clear' | None | Single zone slide lit office with glazing unit represented as a CFS - BSDF object |
| 'ovrhng' | E+ <i>shading zone detail object</i> | |
| 'bsdf' | Radiance modeled F matrix | |

} equivalent

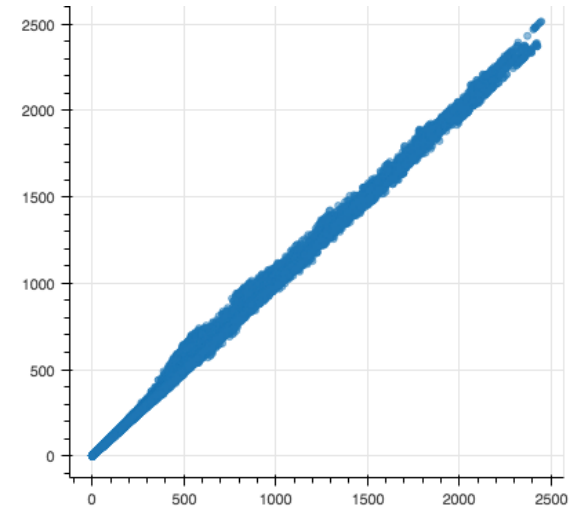
Transmitted solar [W]



Summer

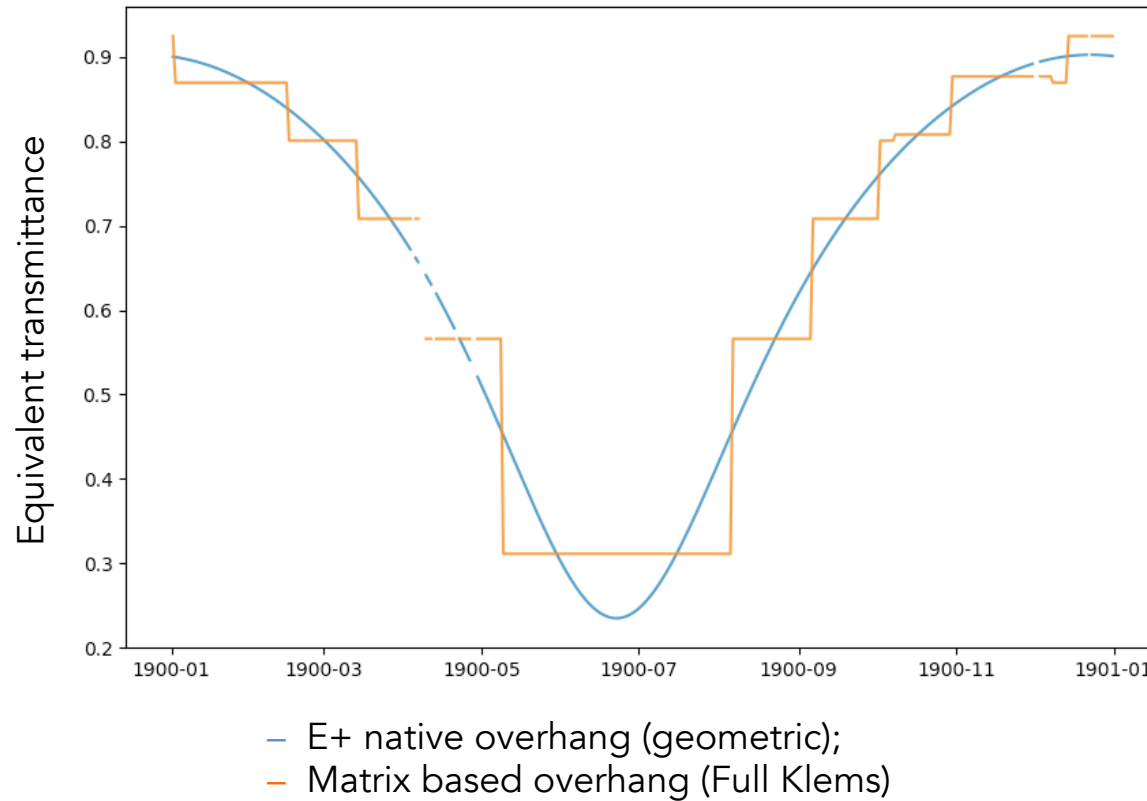


Winter



RMSE: 3.14W/m² (9.5%)
Chicago TMY

Equivalent transmittance (percentage of shaded window area) of overhang at 12pm



Acknowledgments

Dustin Davis, California Energy Commission

Amir Roth, U.S. Department of Energy

GlenRaven

Sunbrella

Solatube

Chris Humann and Andrew McNeil, Terrestrial Light

Christoph Gehbauer, Jacob Johnson, Anothai Thanachareonkit, Darryl
Dickerhoff, Daniel Fuller, Stephen Selkowitz, LBNL

<https://facades.lbl.gov>