

# Using Radiance to Generate Lighting and Solar Surface Heat Gain Schedules for Energy Plus

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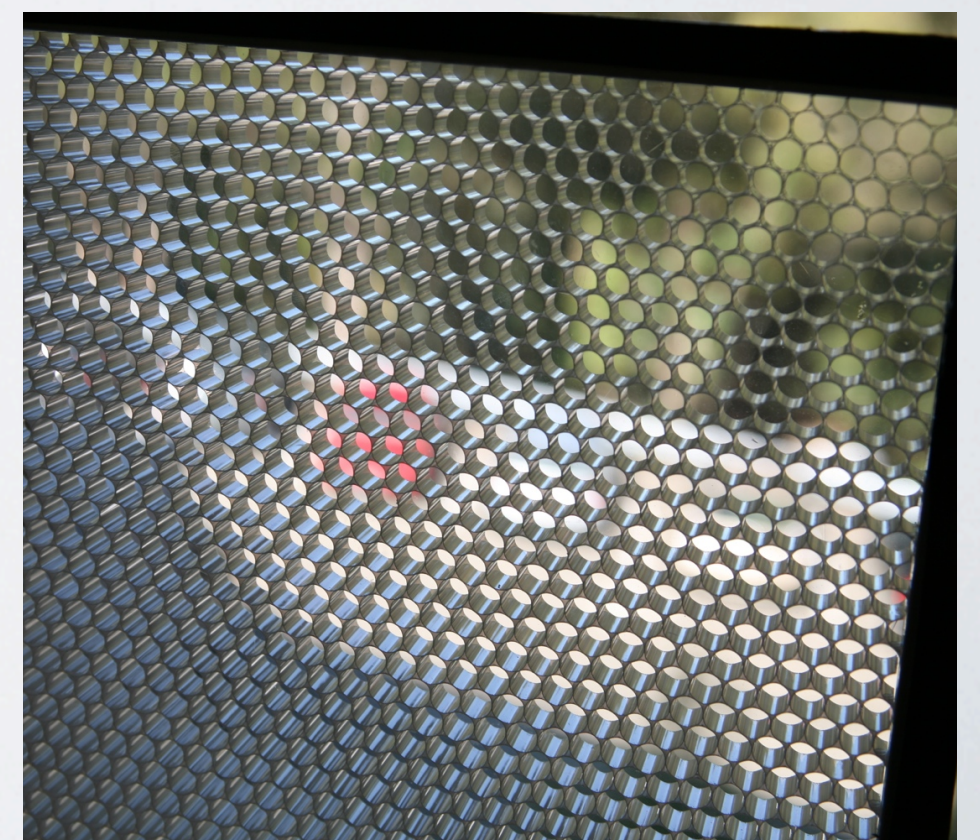
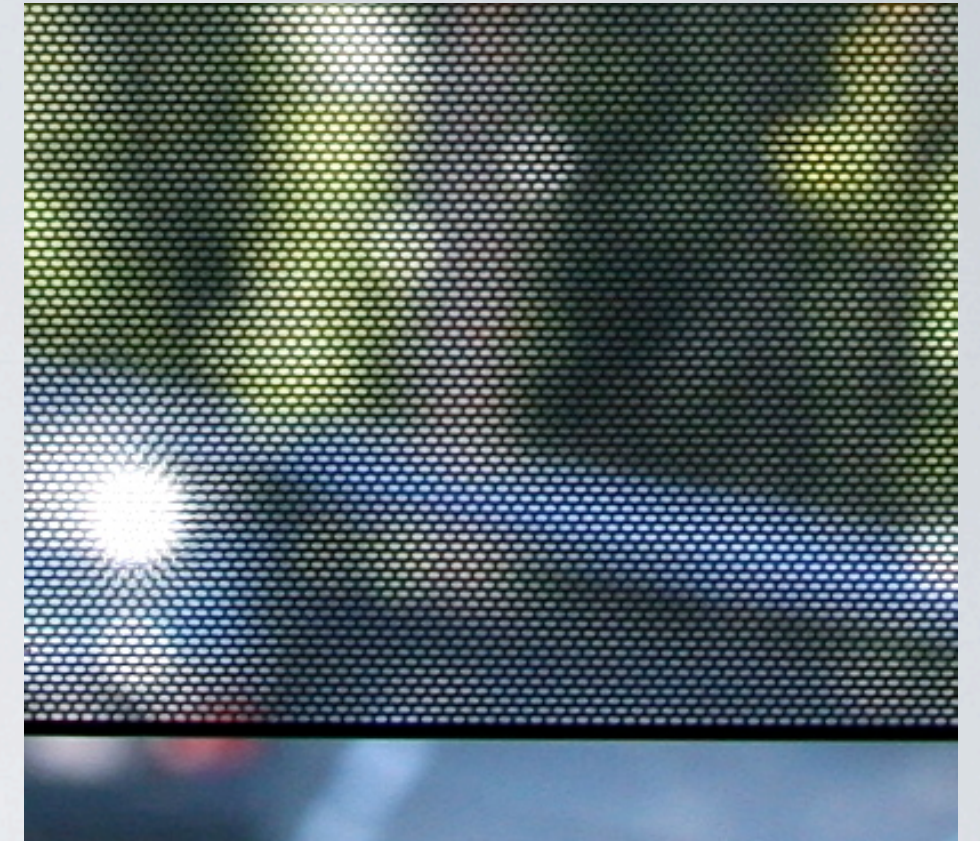
# Contents

- Objectives
- Process:
  - 1 - Make BSDFs (solar and visible wavelengths)
  - 2 - Generate lighting schedule (typical 3-phase)
  - 3 - Generate surface irradiance schedule (modified 3-phase)
  - 4 - Speed things up (dctimestep optimization)
  - 5 - Run energy plus



# Objectives

- Whole building energy simulation
- Complex Fenestration Systems (CFS)
- Run parametric simulations to simulate performance for:
  - WWR
  - LPD
  - Climate
  - Building Energy Performance
  - Glazing Type





# Objectives

- Why use Radiance to Replace E+ functionality?
  - Energy Plus doesn't support CFS (yet).
  - Split flux method isn't great



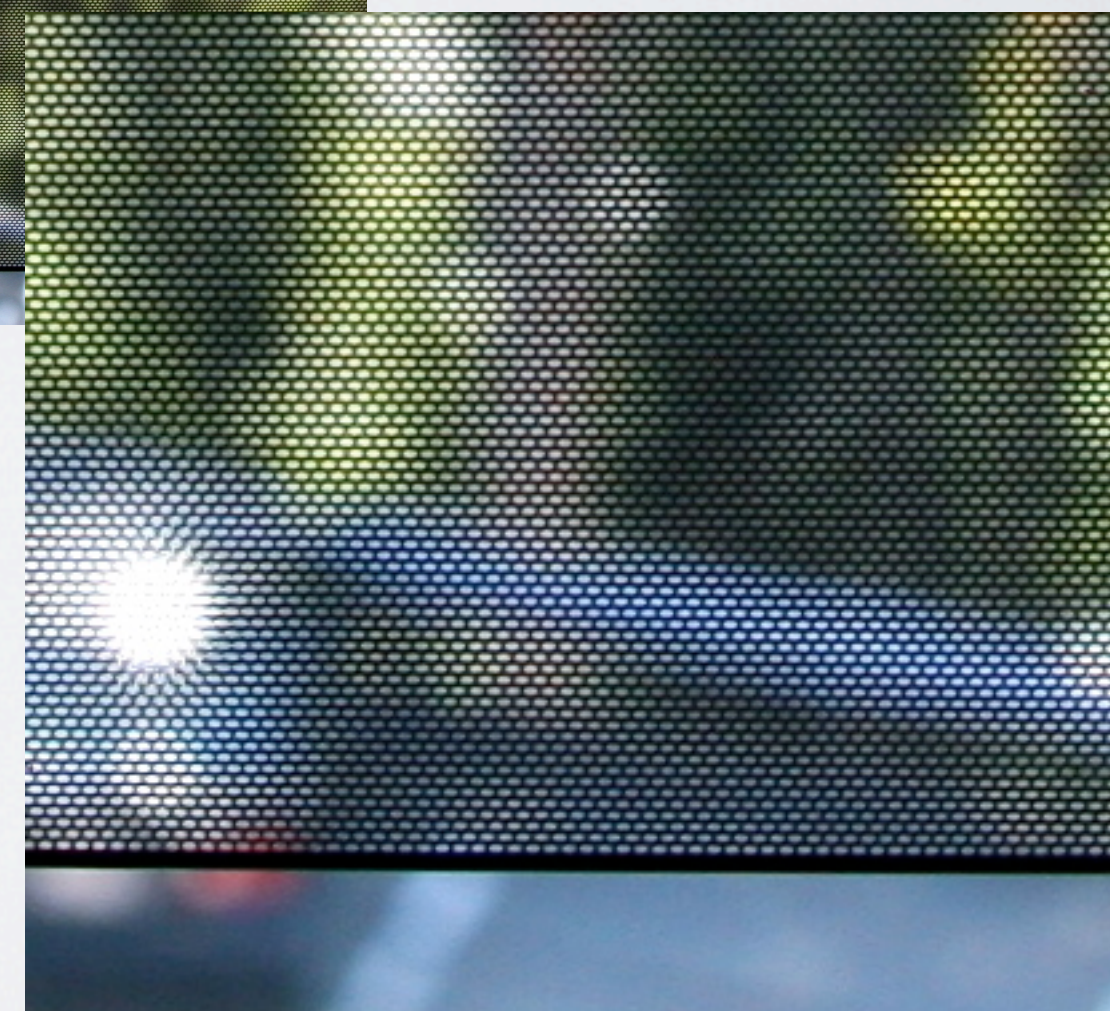
# Make BSDFs for CFS

- Three systems:
  - Micro-perforated metal screen
  - Expanded metal mesh
  - Columnar structure
- Need BSDF for solar and visible spectrum
  - Run genBSDF using solar reflectance properties
  - change wavelength tag from “visible” to “NIR”
  - combine with visible in one BSDF



# Micro Perf Mesh

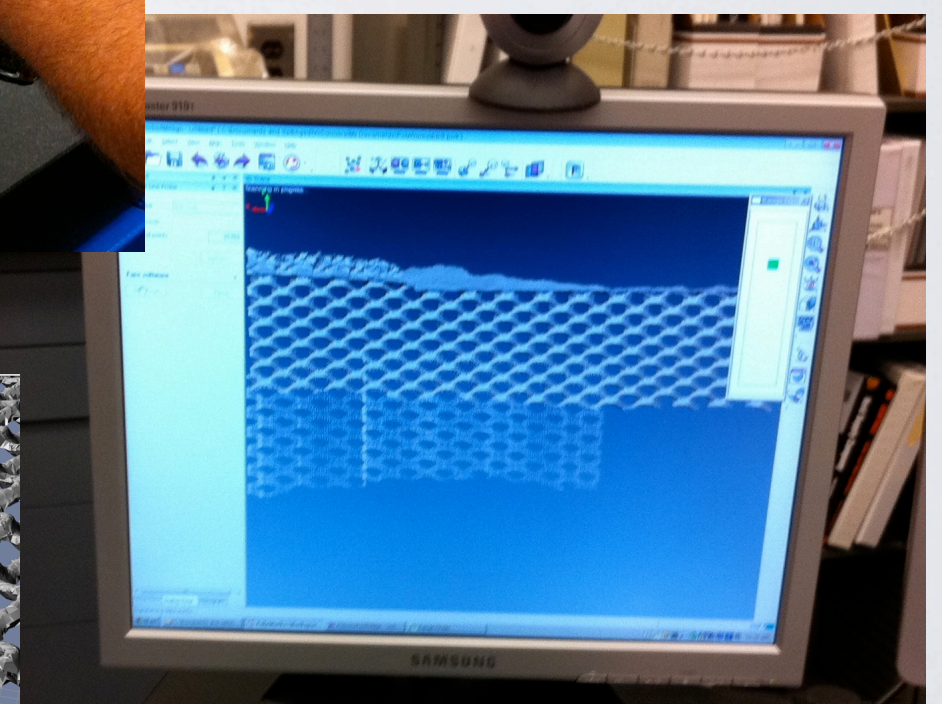
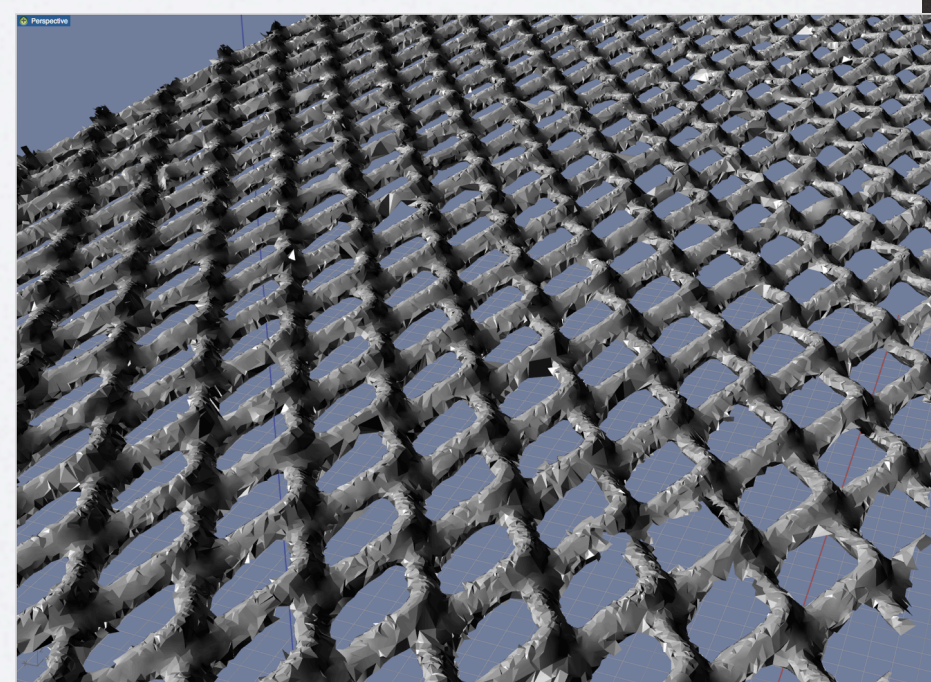
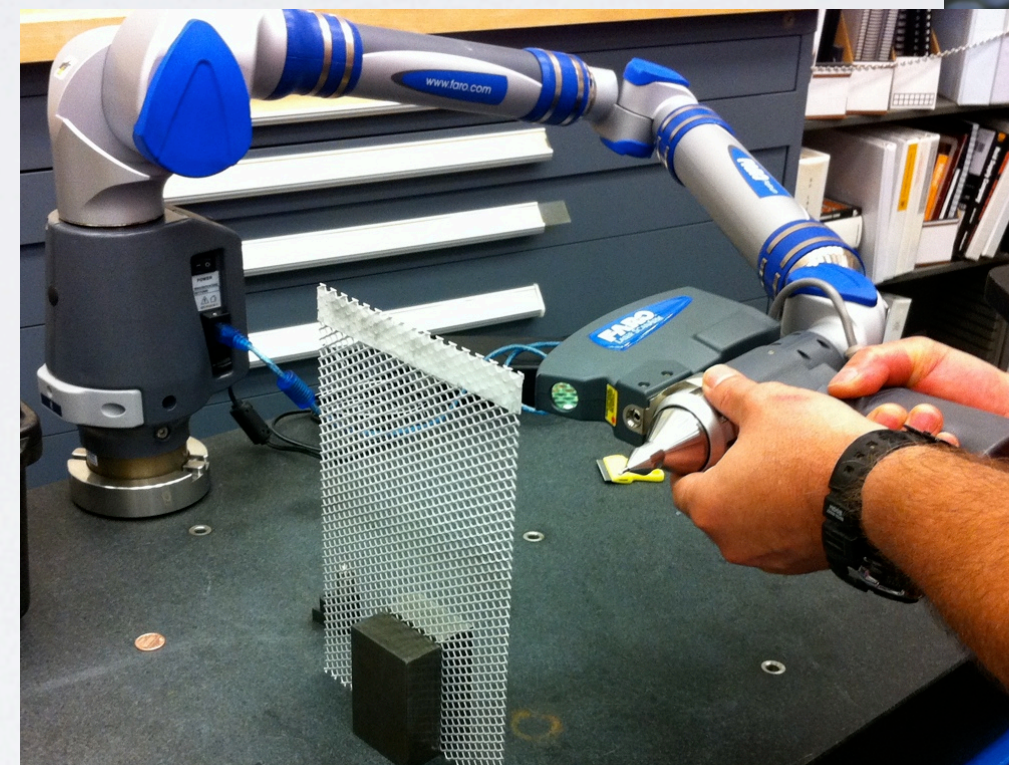
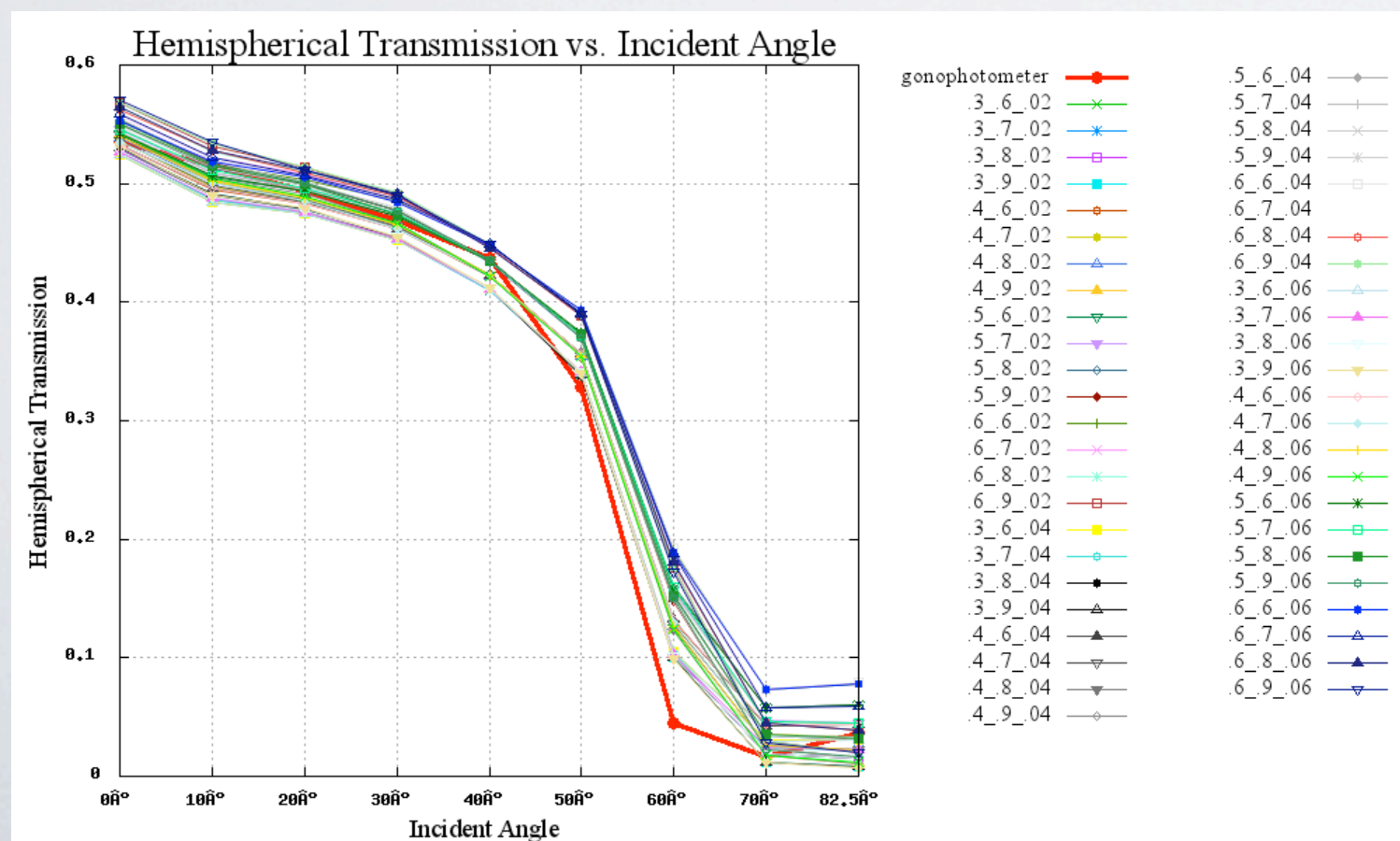
- Geometry from manufacturer
- Un-punched sample to get surface reflectance properties
- (David discussed yesterday)





# Expanded metal mesh

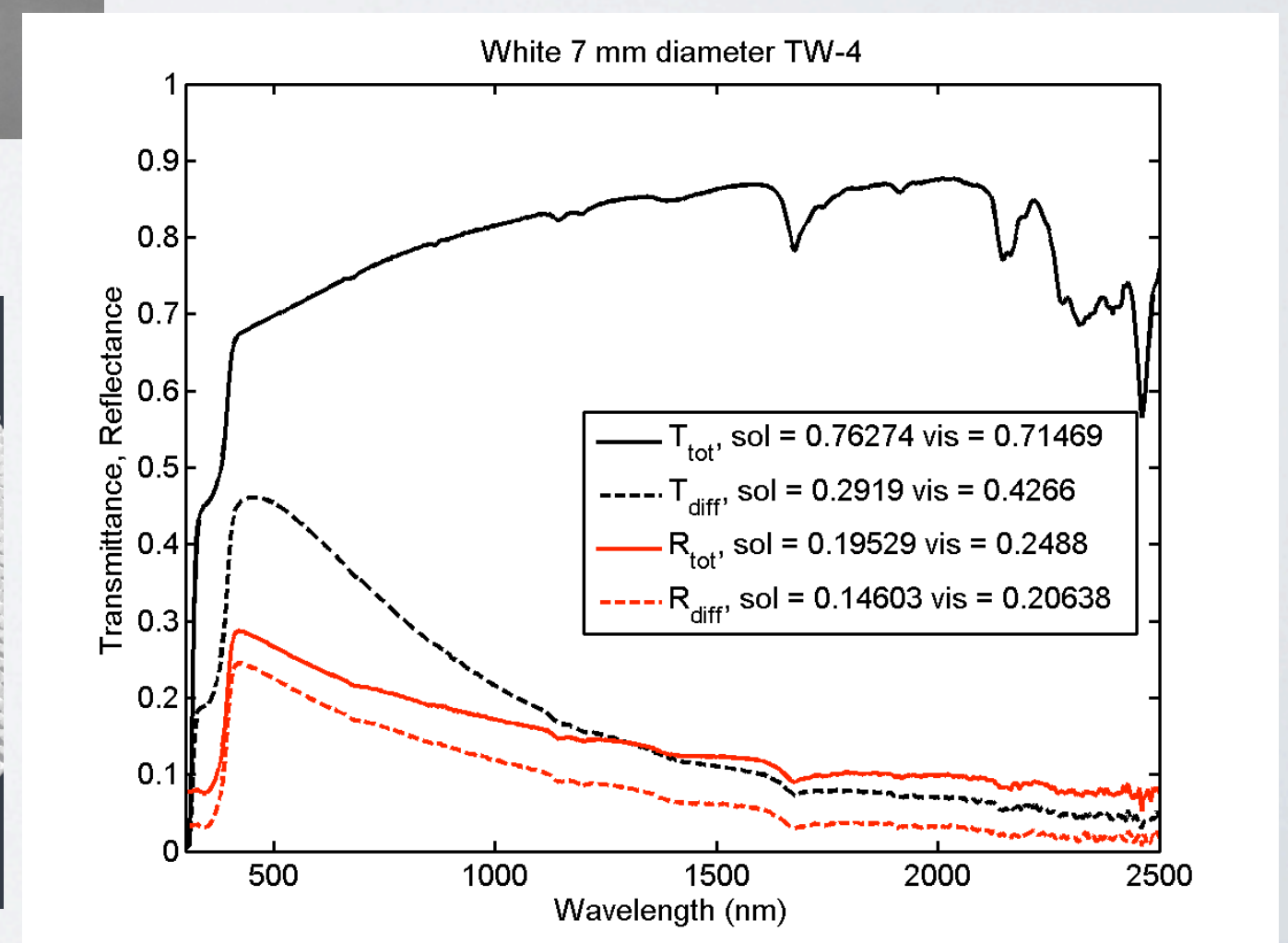
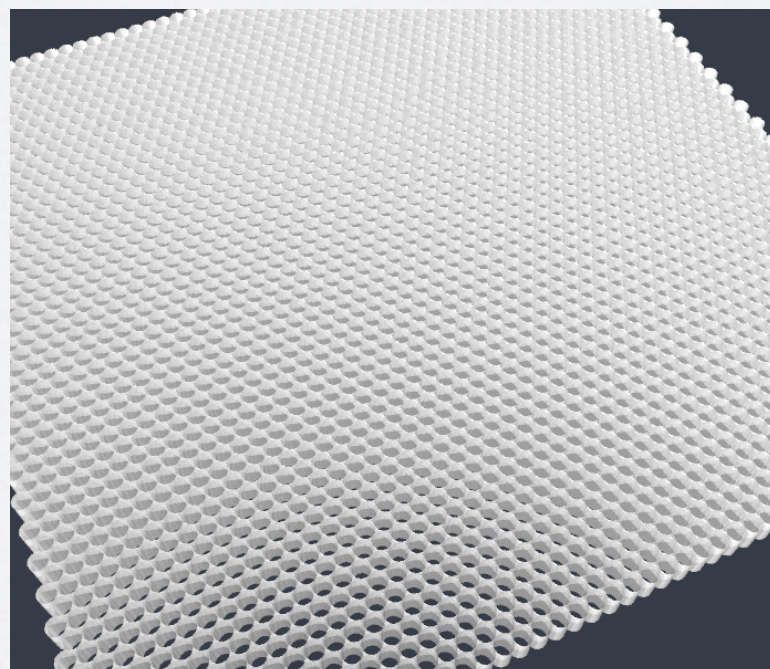
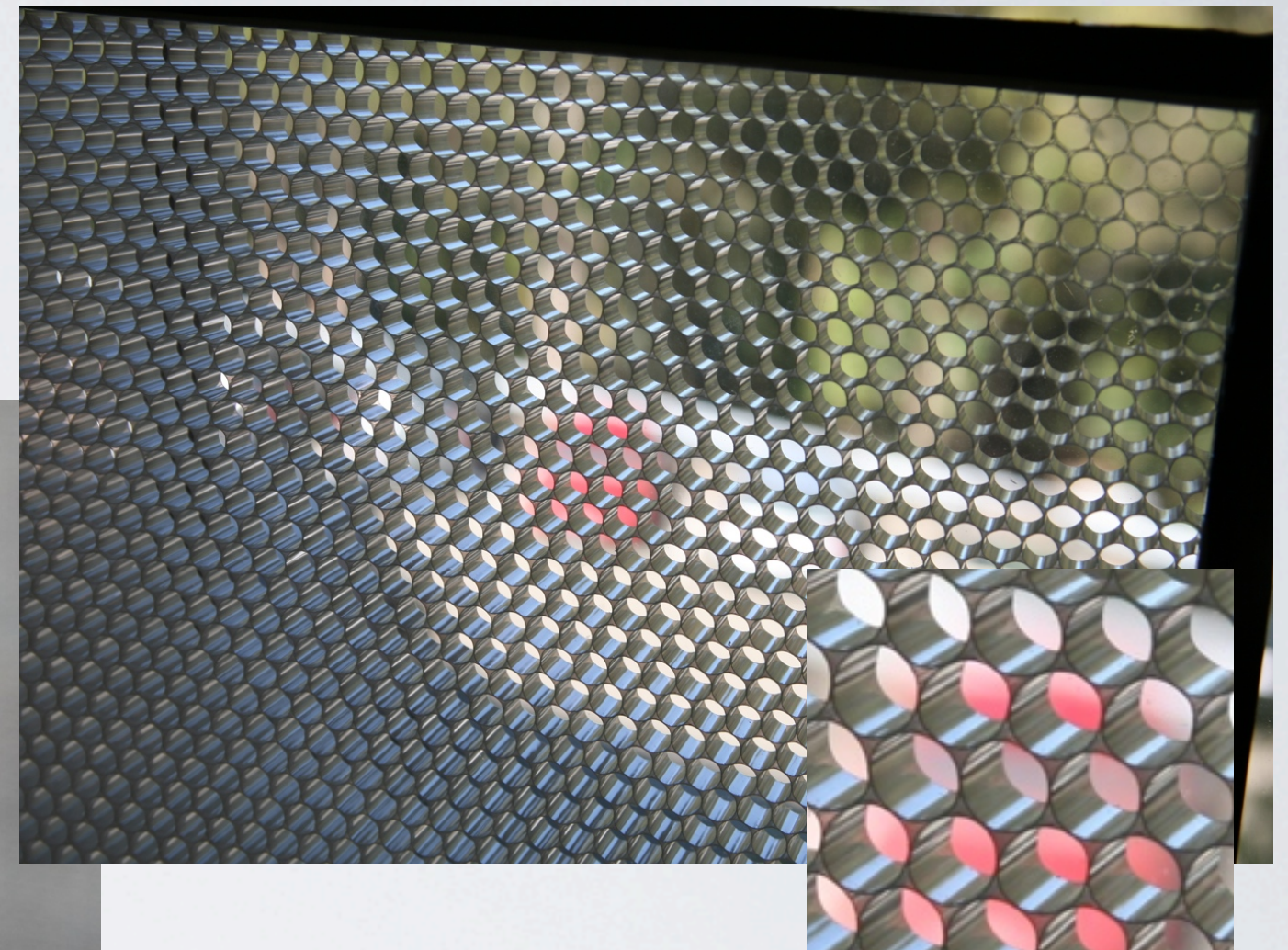
- Laser Scan to get geometry
- Parametric trial to fit gonio-photometer mesh measurement





# Columnar Structure

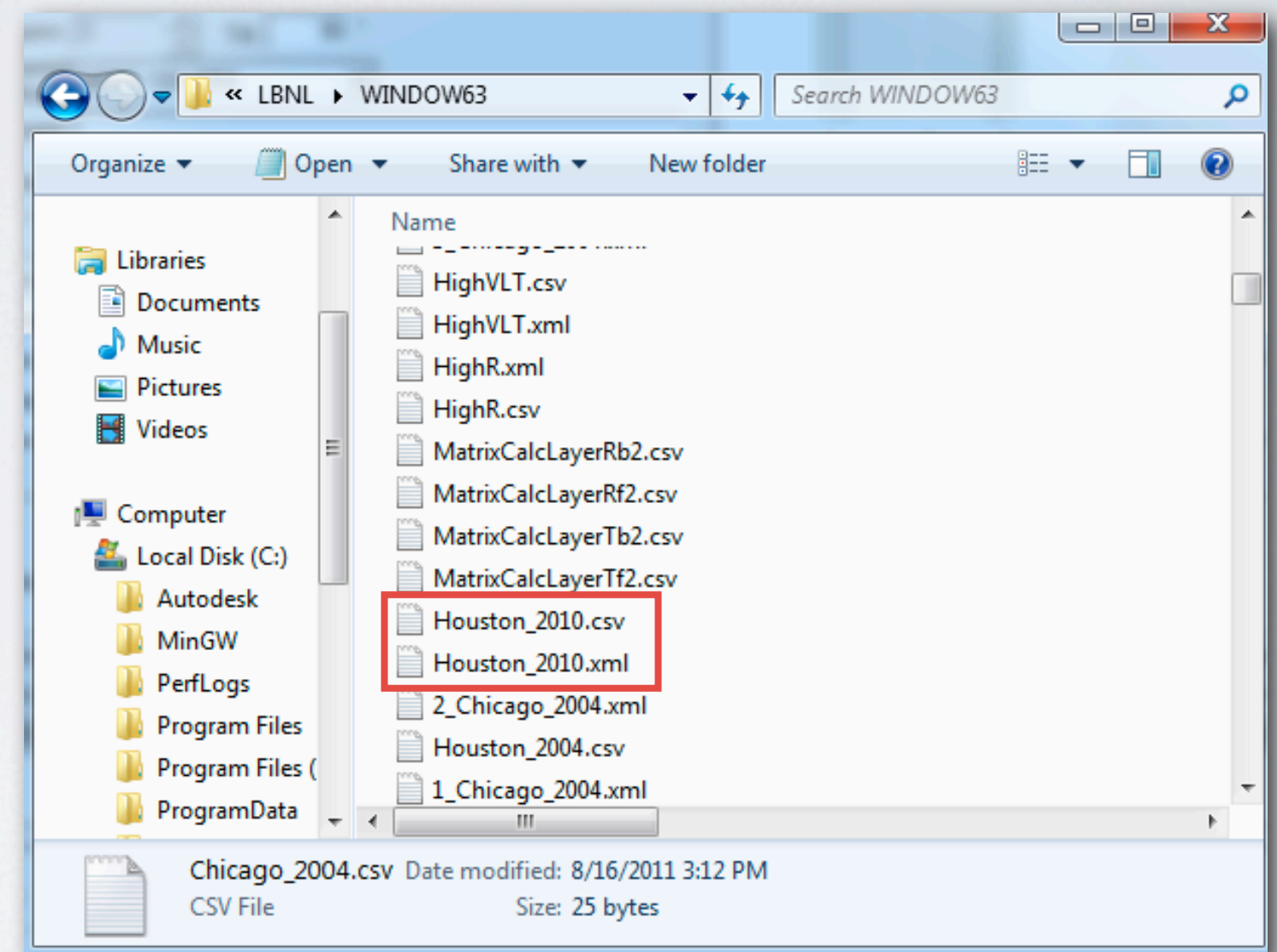
- Geometry from manufacturer
- Sample of plastic to measure transmission/reflection properties
- genBSDF to generate BSDF of layer





# Combine BSDF with glazing

- Import into Window 6
- Add to IGU
- Calc
- Resulting XML only contains visible, use \*.csv to get solar
- keep visible and solar BSDFs separate (use visible wavelength tag for both)

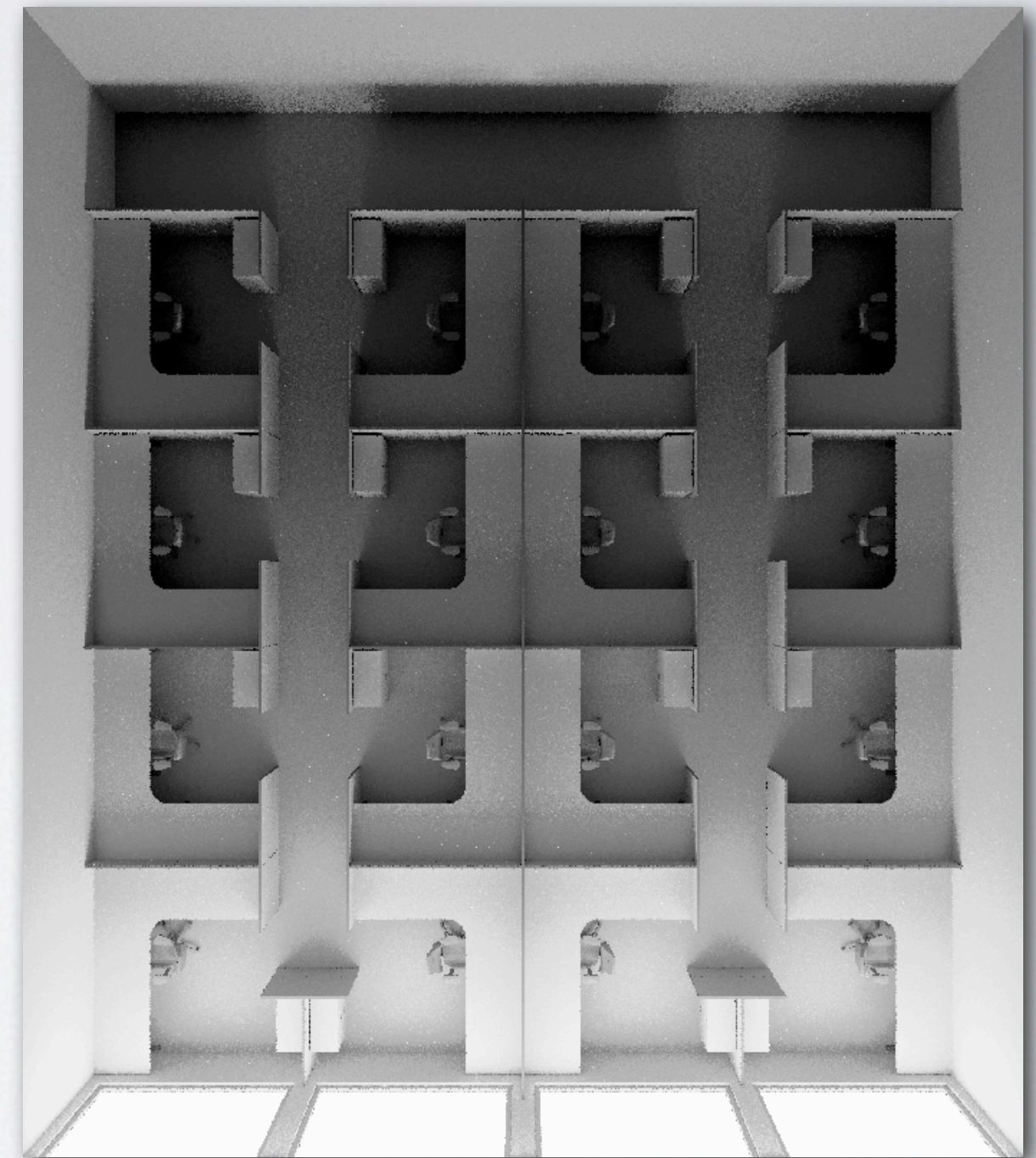
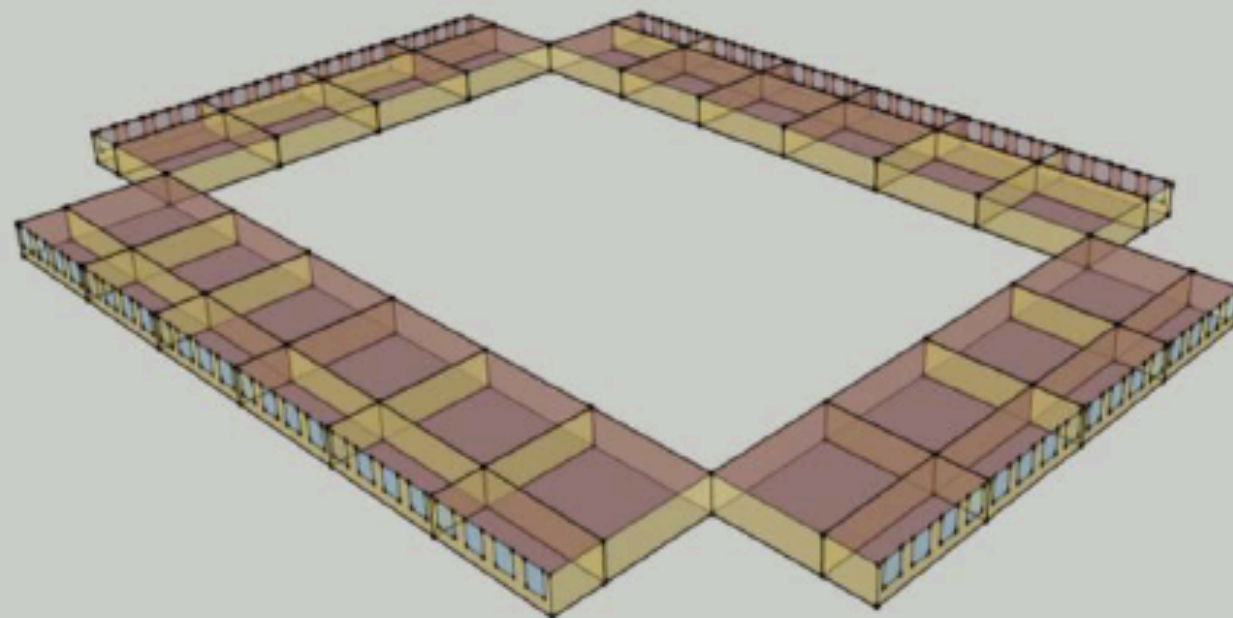
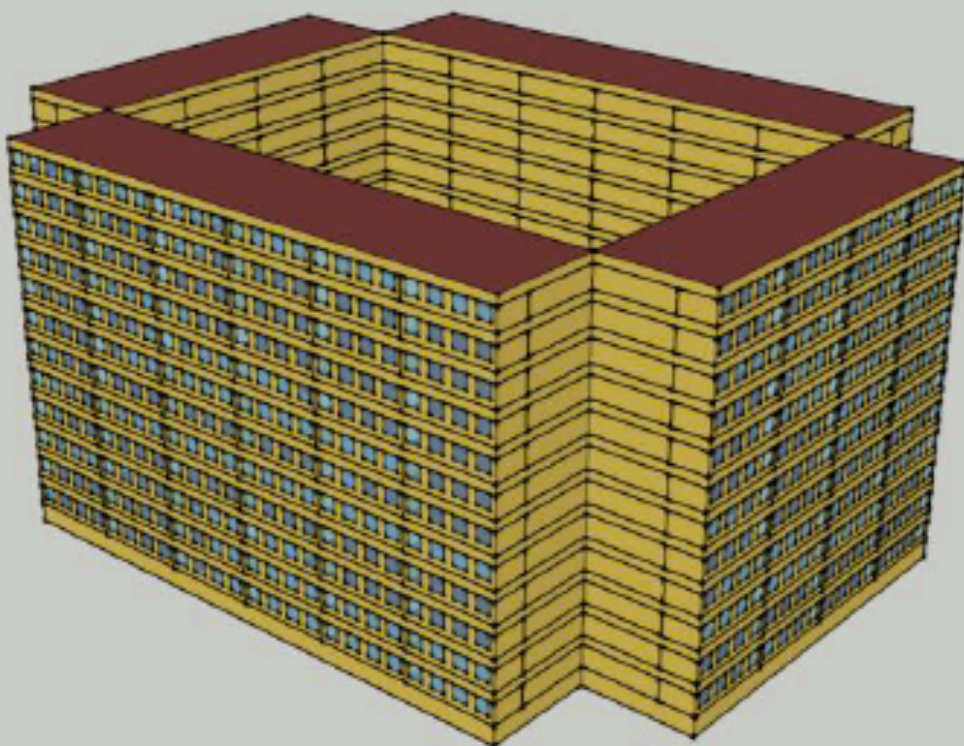
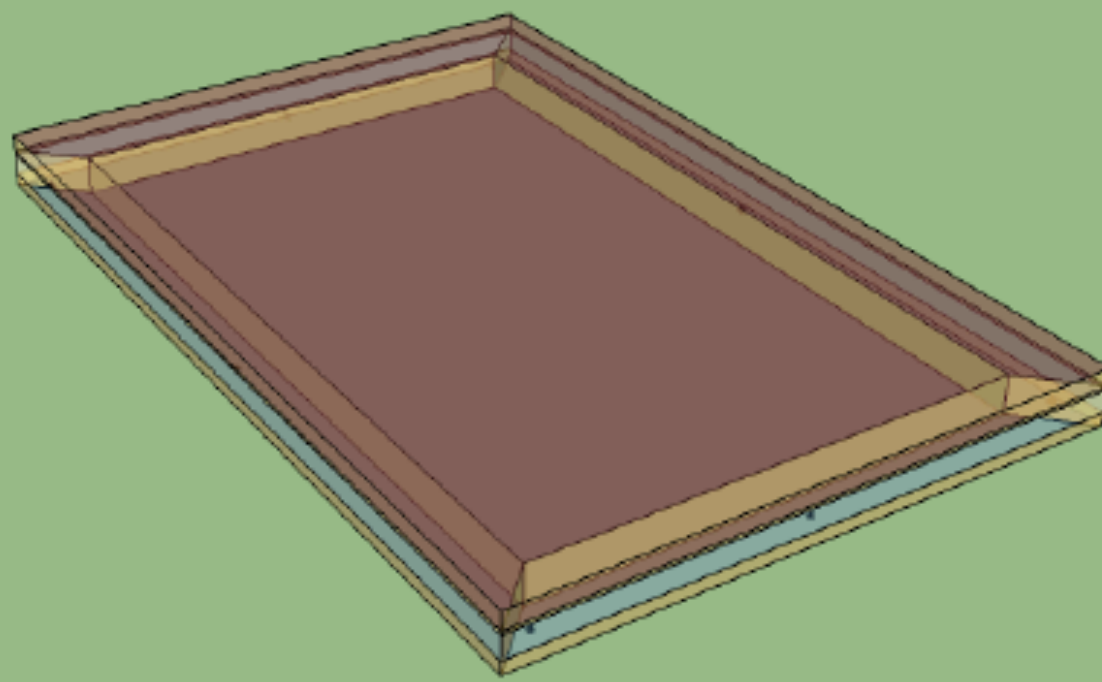
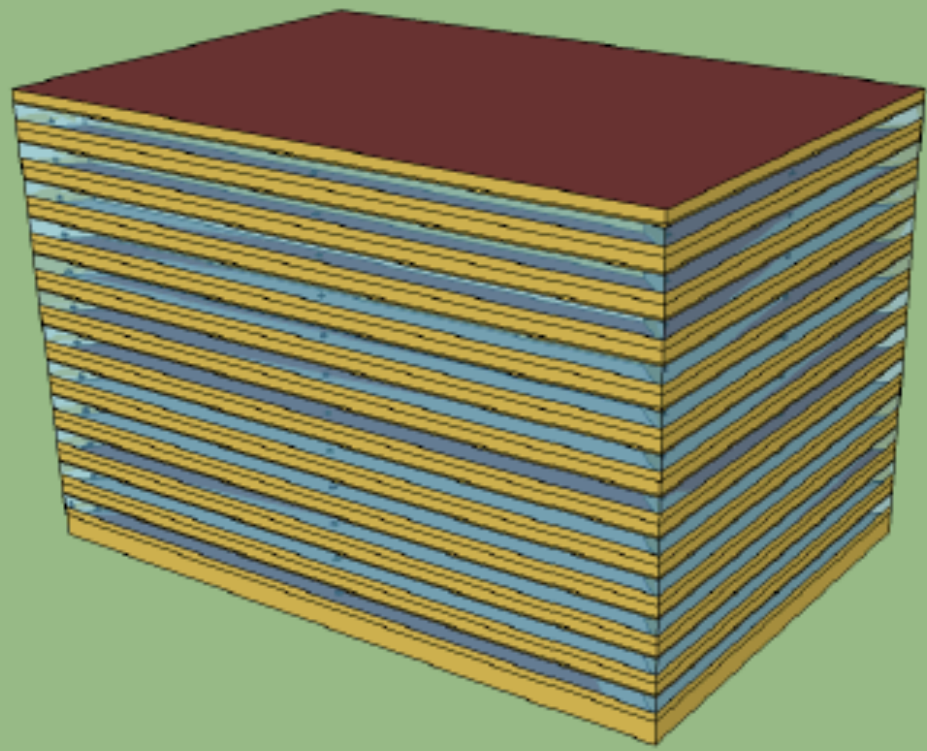


\*.CSV

```
52, "dc1earvR5167_R18tw", 3, 0, " "
"solar Tf"
22.765039, 0.006813, 0.006654, 0.006728, 0.00654
09909, 0.009698, 0.009977, 0.009774, 0.009615, 0
0.002301, 4.552282, 0.293580, 1.165825, 1.486438
9632, 0.020972, 0.022267, 0.022842, 0.022298, 0
0.002313, 0.450400, 5.043482, 0.375927, 1.184917
5706, 0.016299, 0.017761, 0.019400, 0.021251, 0
0.002259, 1.259736, 0.438785, 5.030717, 0.367060
6713, 0.016356, 0.016073, 0.016159, 0.016587, 0
0.002339, 1.583684, 1.187915, 0.399651, 5.029981
7257, 0.017018, 0.016380, 0.016266, 0.015920, 0
0.002326, 1.596653, 1.599724, 1.088510, 0.428960
6398, 0.016911, 0.017314, 0.017622, 0.017407, 0
0.002279, 1.571510, 1.611276, 1.357301, 1.171660
5880, 0.016005, 0.015780, 0.016226, 0.016560, 0
```



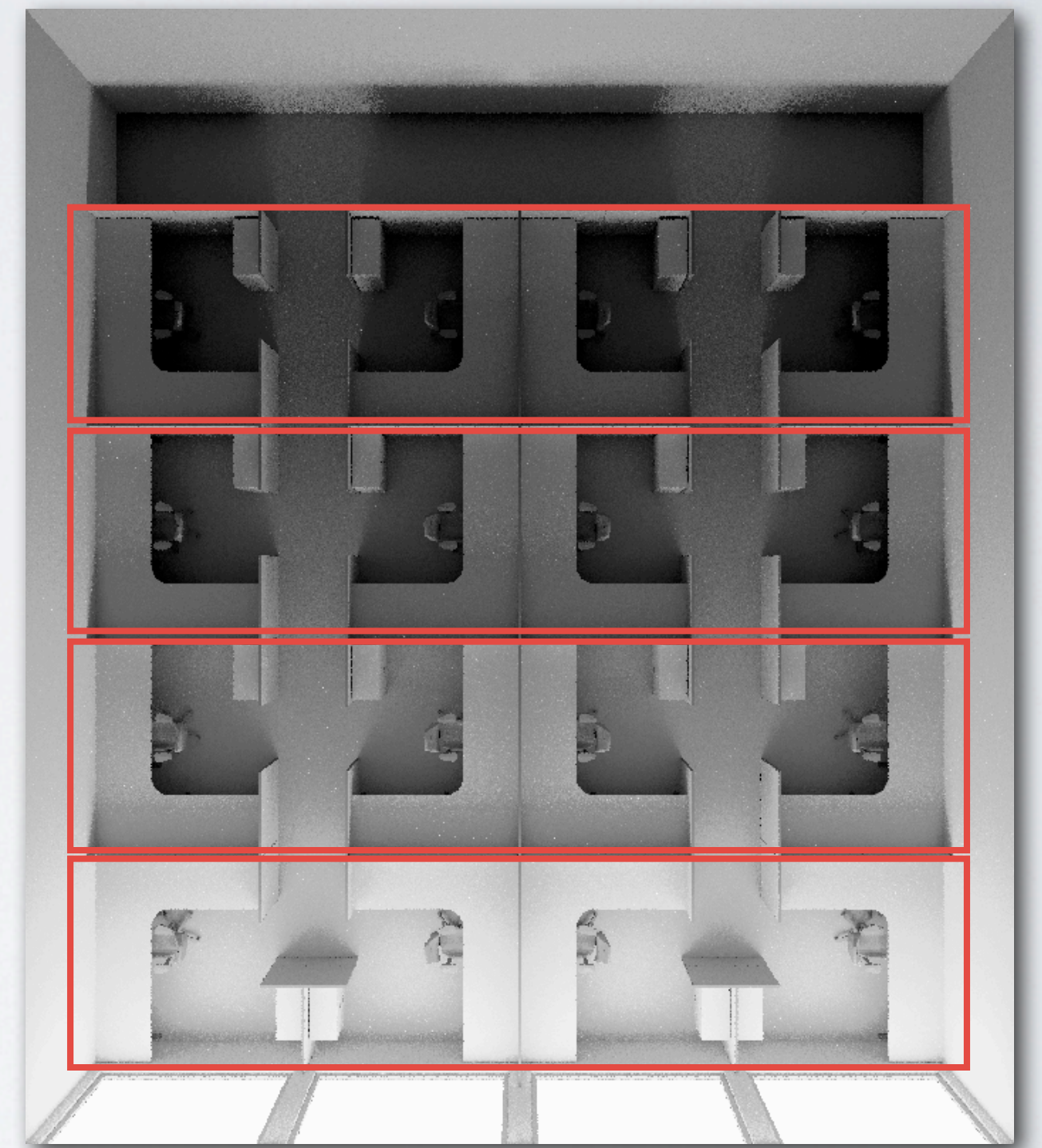
# Model





# Creating Lighting Schedule

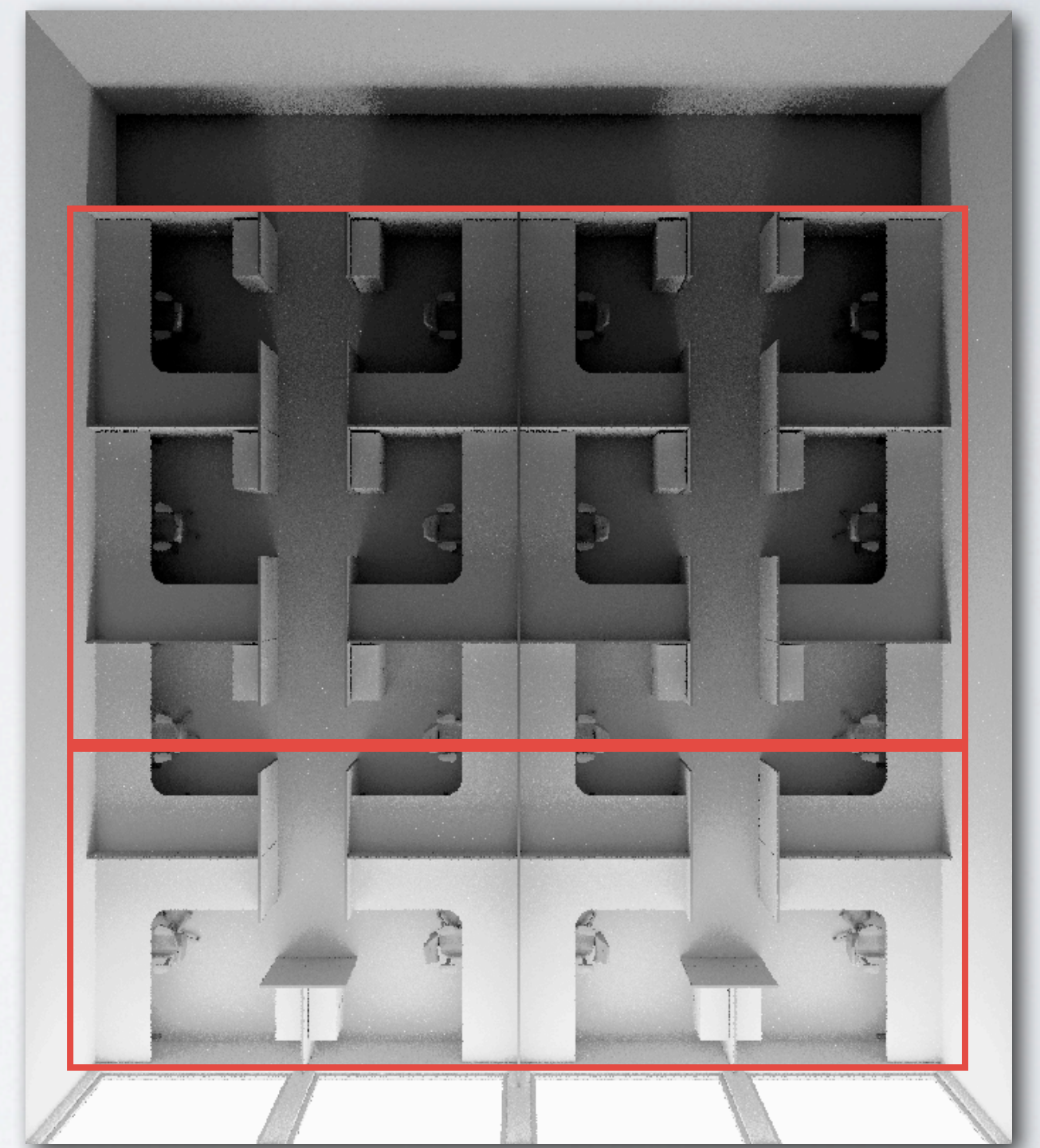
- Four 10' zones
- Calculate daylight in each zone using 3-phase method
- Minimum illuminance in each zone is used to determine electric lighting power per zone.





# Creating Surface Heat Gain Schedule

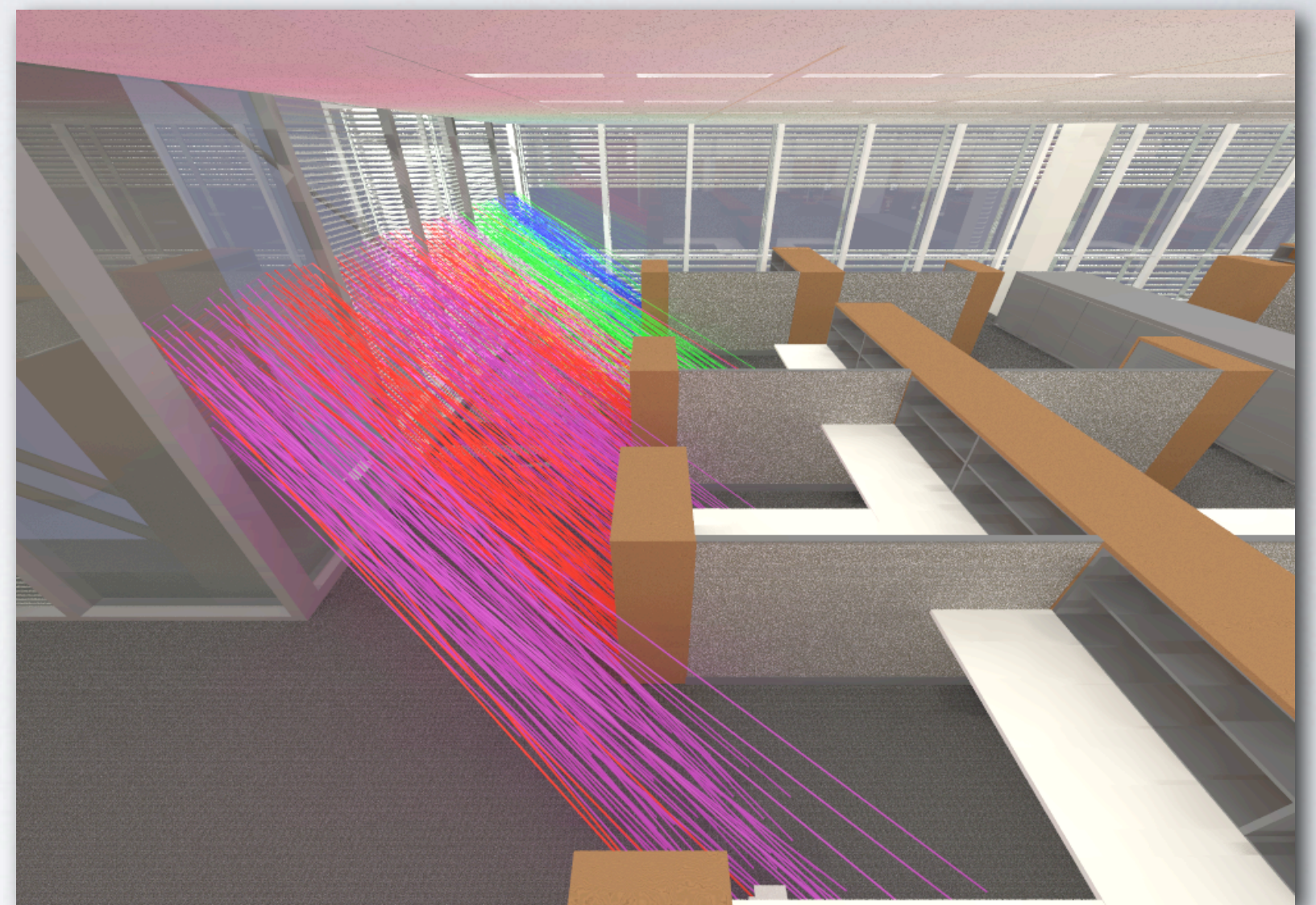
- 15' perimeter, 25' core zones
- Calculate heat gain on surfaces (ceiling, wall, floor furniture) in each zone





# Modified View Matrix

- genklemsamp used to generate interior sample rays (with coordinate mods)
- trace rays (rtrace) returning intersection point.
- intersection points are parsed to determine zone and surface
- ray fractions accumulated, multiplied by  $\cos(\theta)/\text{solid angle}$  of the outgoing patch.



(Visualization from a different but similar project)

Ray color indicates zone & surface:

- Purple = floor, zone 2
- Red = furniture, zone 2
- Green = floor, zone 1
- Blue = floor, zone 1



# Creating Surface Heat Gain Schedule

- gendaylit -O | (gensky if gendaylit fails)
- calculate vertical irradiance at facade
- genskyvec | dctimestep (using solar data)
- multiply by window area.



# Window Layer Absorption

- Absorbed fractions per klems patch from Window 6
- Create view matrix for absorption
- gendaylit | dctimestep | rcalc like previous

Glazing System Library


ID #: 54 Name: DClearPpgSG500\_P28tw

# Layers: 3 Tilt: 90 ° IG Height: 39 inches

Environmental Conditions: NFRC 100-2004 IG Width: 39 inches

Comment:

Overall thickness: 0.775 inches Mode: #



	ID	Name	Mode	Thick	Flip	Tsol	Rsol1	Rsol2	Tvis	Rvis1	Rvis2	Ti
▼ Glass 1 ►►	102	CLEAR_3.DAT	#	0.120	<input type="checkbox"/>	0.834	0.075	0.075	0.899	0.083	0.083	0.00
Gap 1 ►►	1	Air		0.000	<input type="checkbox"/>							
▼ Shade 2 ►►	51	Panelite 1/4" True White		0.500	<input type="checkbox"/>							0.00
Gap 2 ►►	1	Air		0.000	<input type="checkbox"/>							
▼ Glass 3 ►►	5244	S500CL_4.PPG	#	0.154	<input type="checkbox"/>	0.692	0.125	0.106	0.830	0.113	0.108	0.00



# Accelerating dctimestep

- This takes several hours:

```
for hour in 8760
```

```
    gendaylight | genskyvec | dctimestep
```

```
done
```

- When running parametric analysis we need it to be faster.



# Accelerating dctimestep

- Problem 1: We are recalculating the same sky vectors for multiple runs in a climate
- Solution: store and zip sky vectors. Allows quick retrieval for subsequent runs using same climate
- Reduces time from >2 hours to 7 minutes.



# Accelerating dctimestep

- Problem 2: We load matrices into memory and perform the same multiplication several times ( $V * T * D$  - only  $s$  changes).
- Wangda Zuo created an version of dctimestep optimized for annual runs (ibpsa 2011 conference).

Usage:

dctimestepcpu **V T D S**

(sky matrix instead of vector)



# Accelerating dctimestep

- One call for the entire year (matrices loaded once, multiplied once).
- RGB channels parallelized
- Runtime 30 seconds
- Energy Plus is now the slow part of the simulation!  
(if you ignore days of matrix pre-calculation :-)



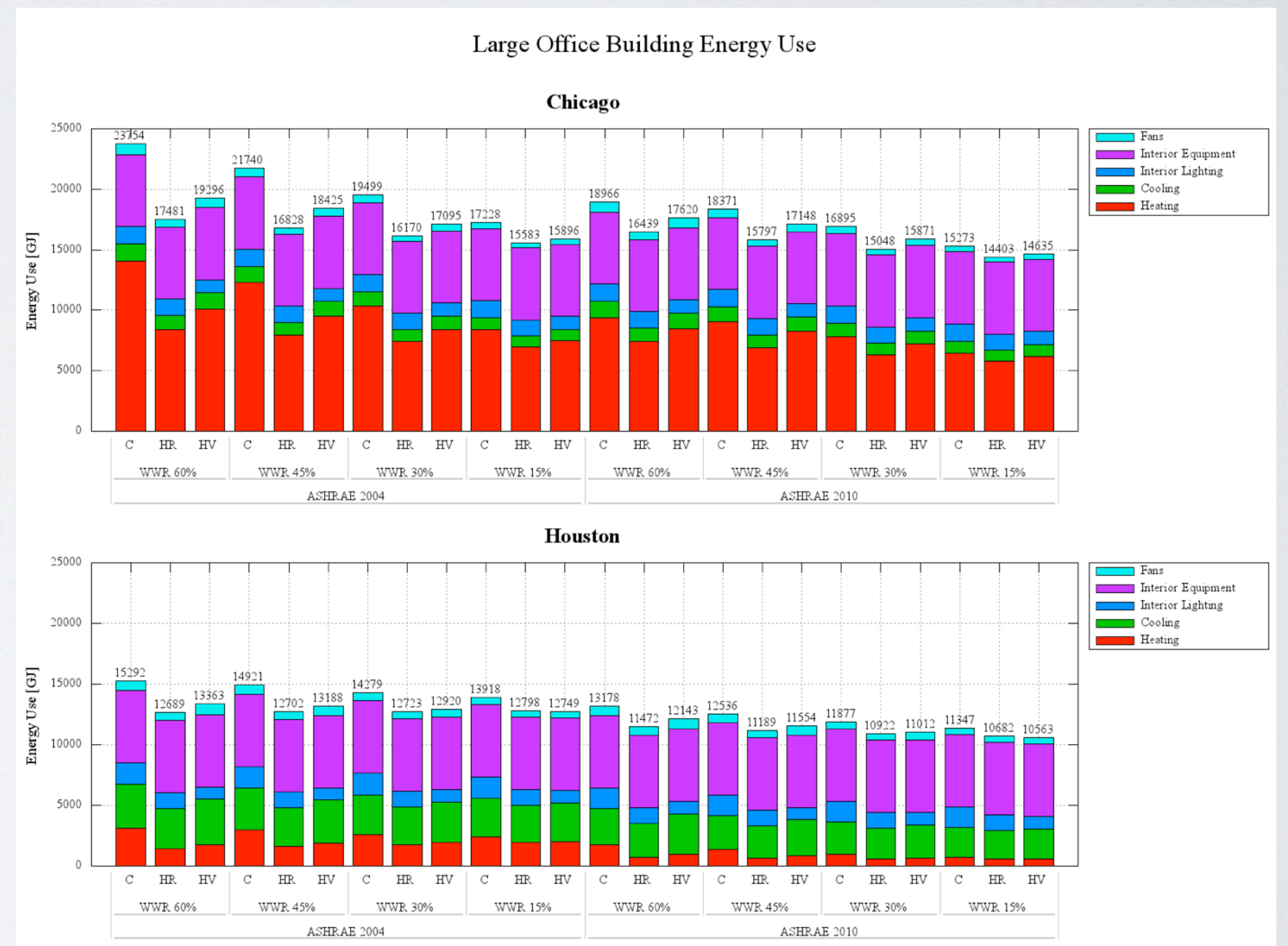
# Using Schedules in Energy Plus

- Lighting schedule capability exists.
- Energy Plus code modified to allow scheduling of surface heat gains and window layer absorption schedules
  - modification and validation (in progress) by Thierry Nouidui and Brian Coffey



# runenergyplus !

- No real results yet, still running simulations.





# Acknowledgements

- Jacob Jonsson & David Appelfeld - BSDF generation
- Christian Kohler - Window layer absorbed fraction (and other W6 stuff)
- Robert Hart - Window glazing makeup
- Wangda Zuo - dctimestep optimization
- Thierry Noudui and Brian Coffey - Energy Plus modifications
- Xiufeng Pang - Energy Plus model
- Luis Fernandes - Comfen model
- Eleanor Lee - Principal Investigator
- CEC Pier & DOE - Funding
- Me!