Using annual daylight simulation to evaluate design alternates

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Arup

8th International Radiance Workshop, 2009

My first year at Arup someone said:

“Try something new on every project”

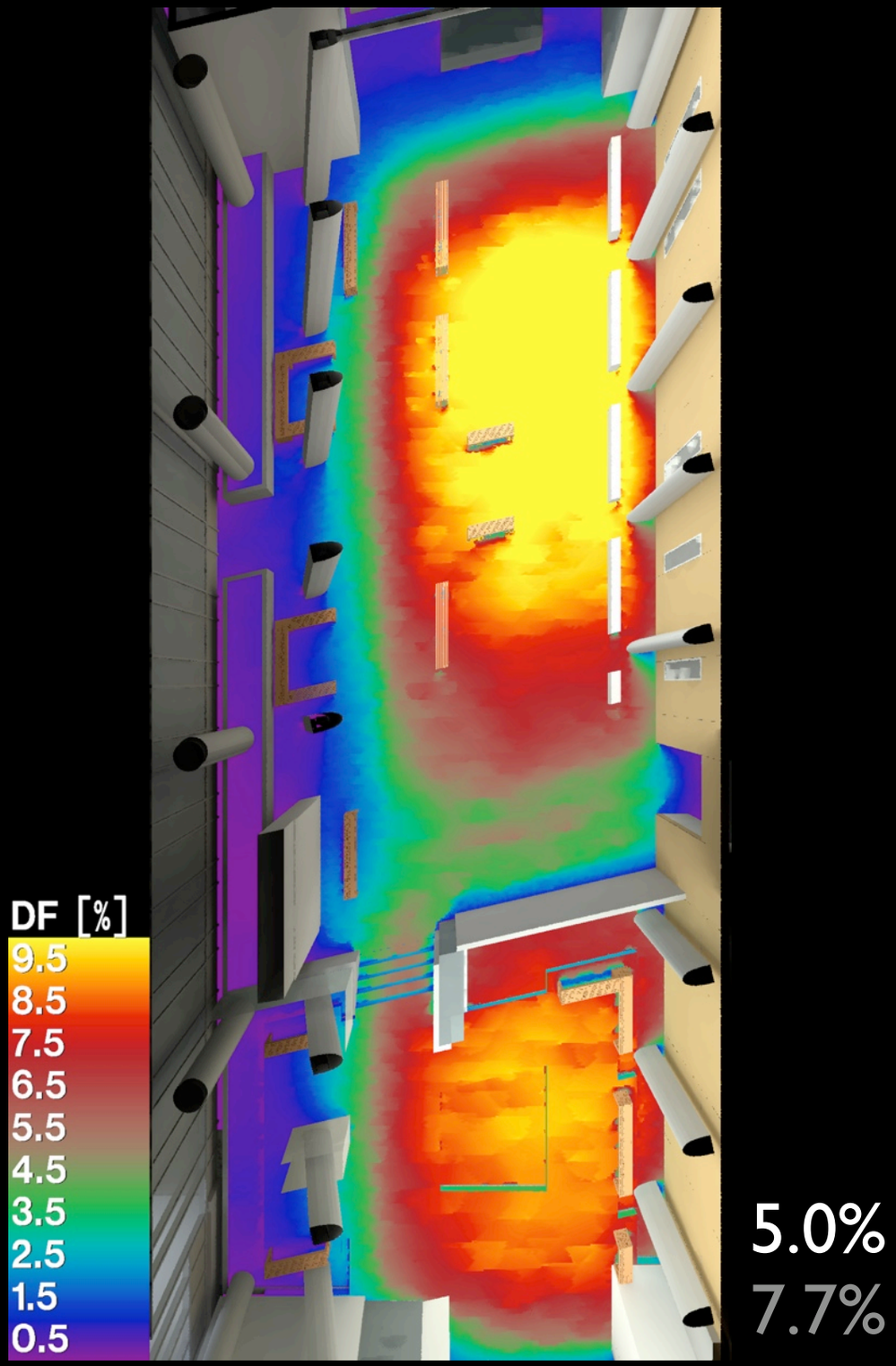
I don’t remember who.

Lobby Link (Solarium)


Moderate Reflectance
(afternoon sun)
Stone Flooring
(non specular)
Fritted Glass

Architect wanted glazing recommendations
(How much frit?)

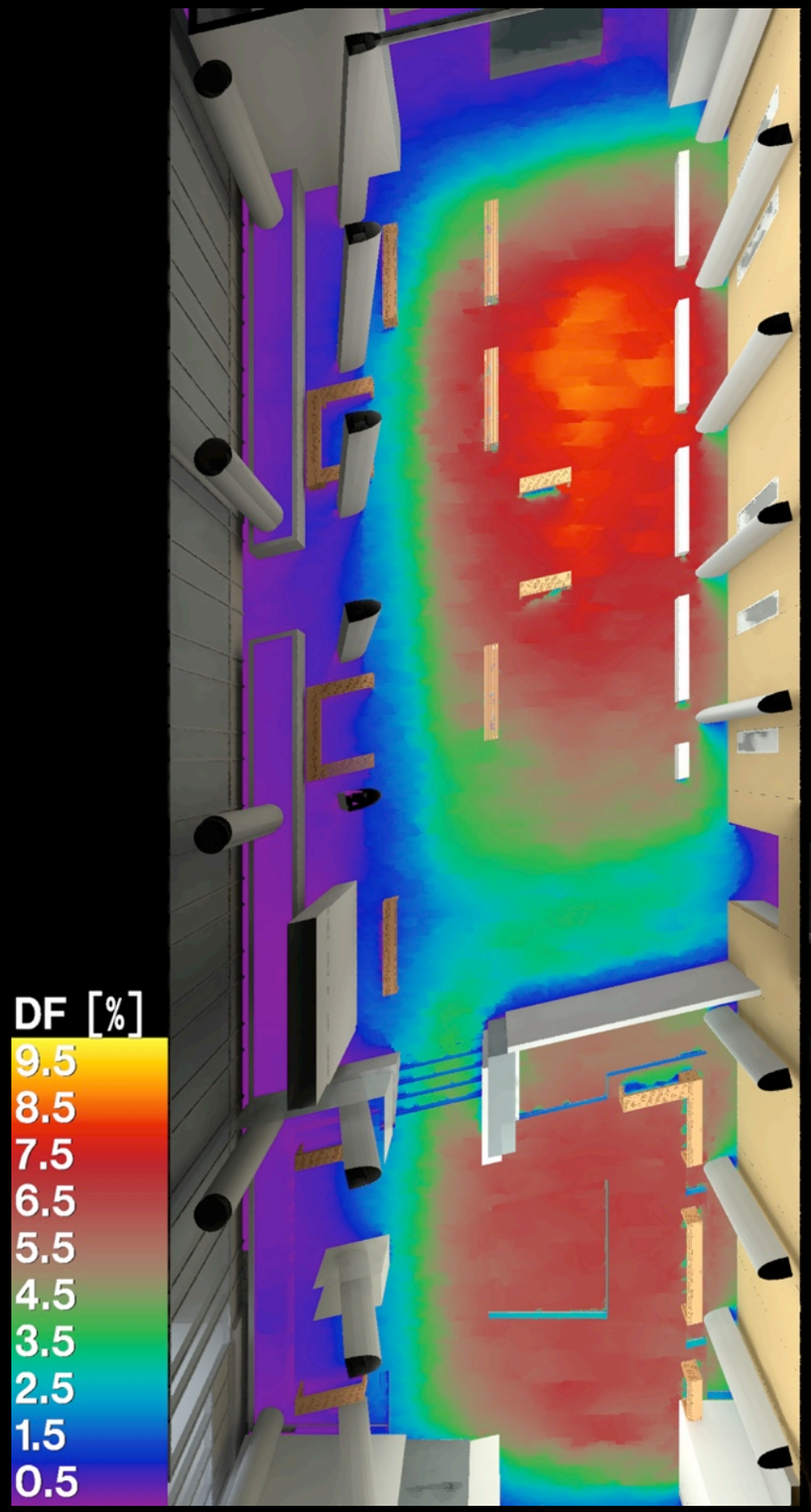
* I excluded trees from our analysis.
    - The trees will be small at first.
    - The trees had a relatively sparse canopy
    - Light passing through trees is difficult to simulate.



5.0%

7.7%

30% Gray Frit



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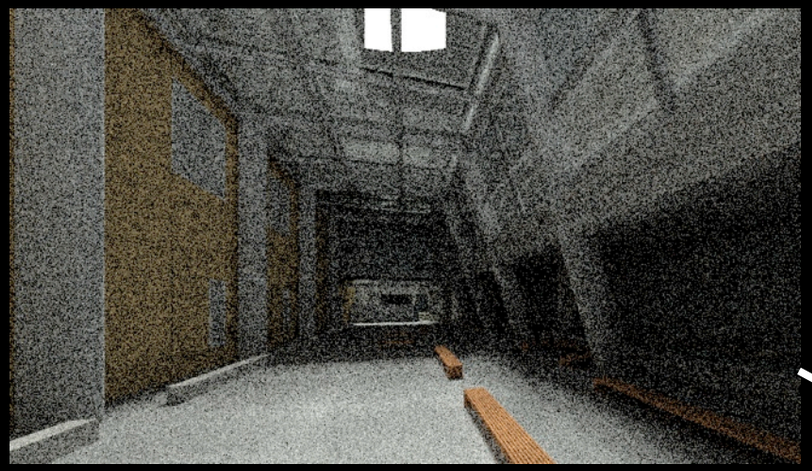
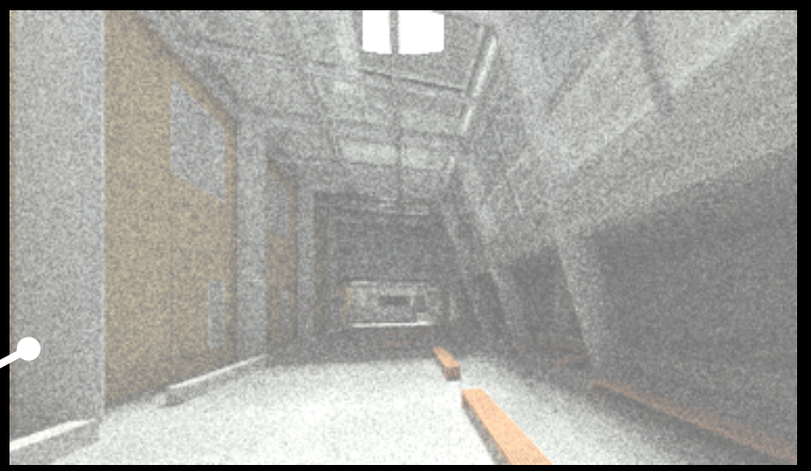
50% Gray Frit

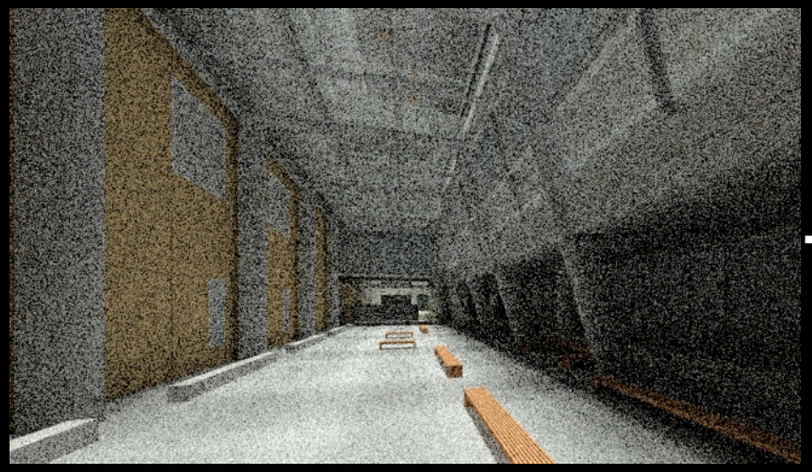
What about glare?

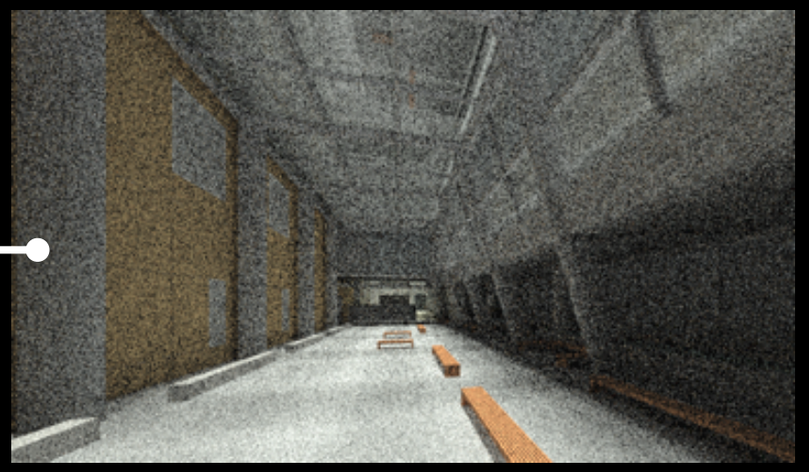
No fixed position occupants (ie. security desk, info desk, coffee cart, etc.)

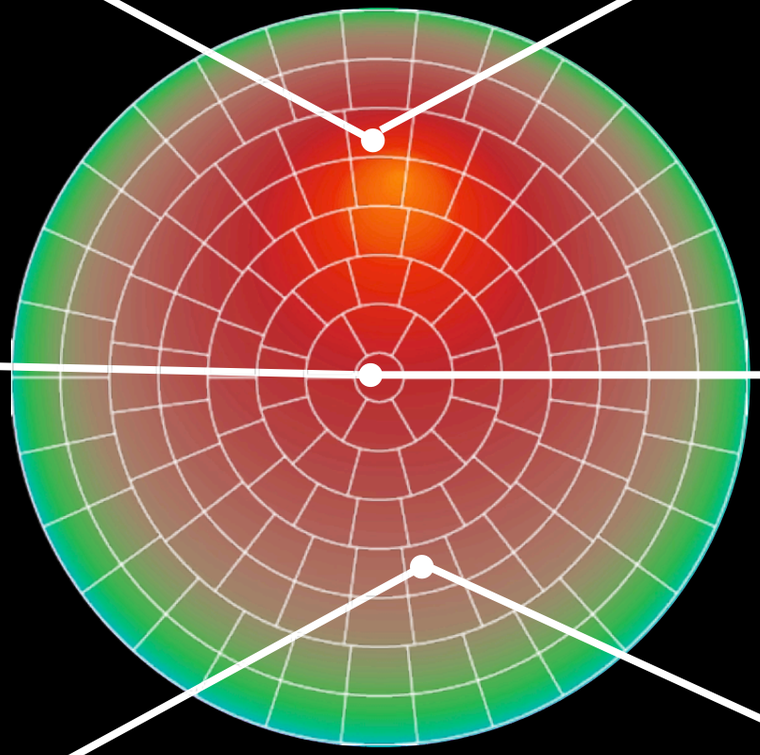
hmm...

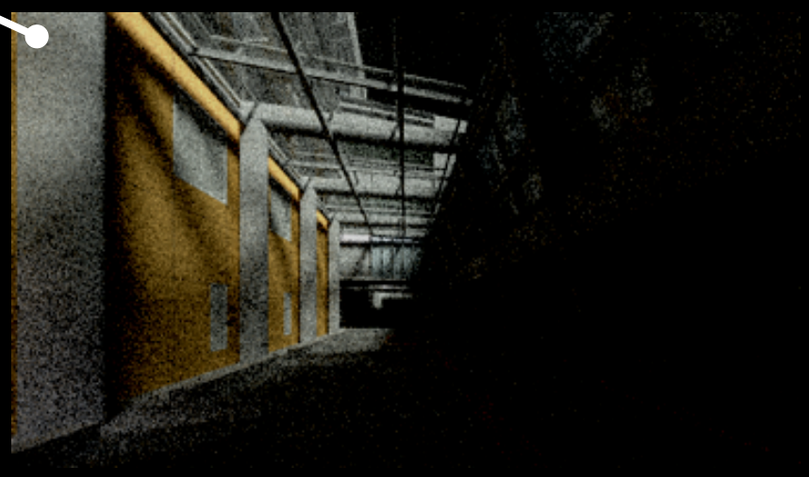


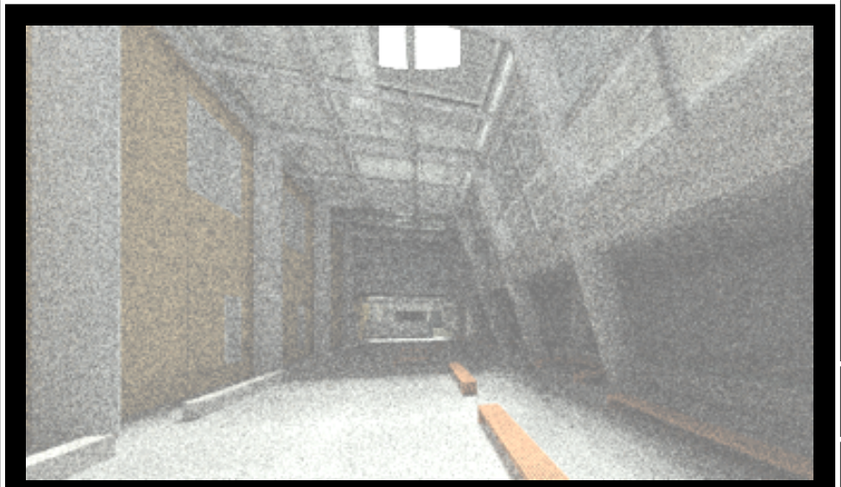


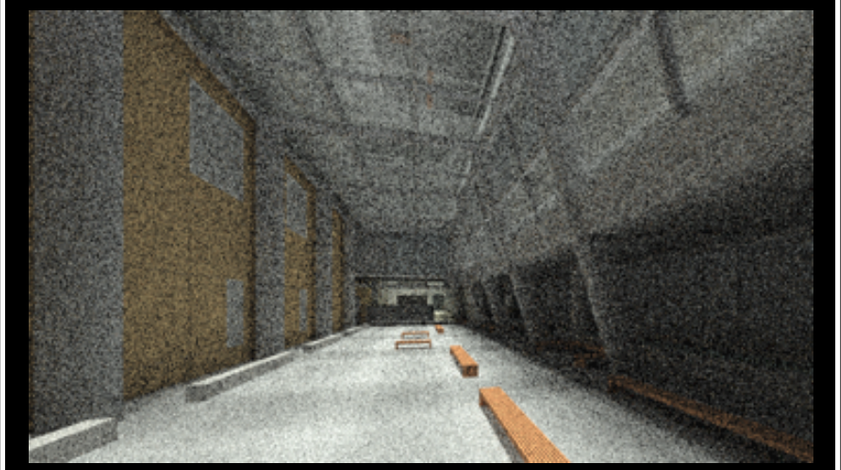


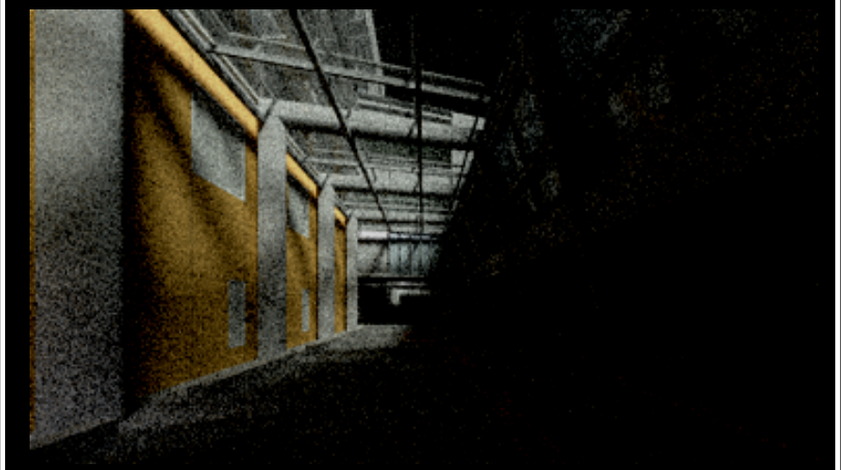


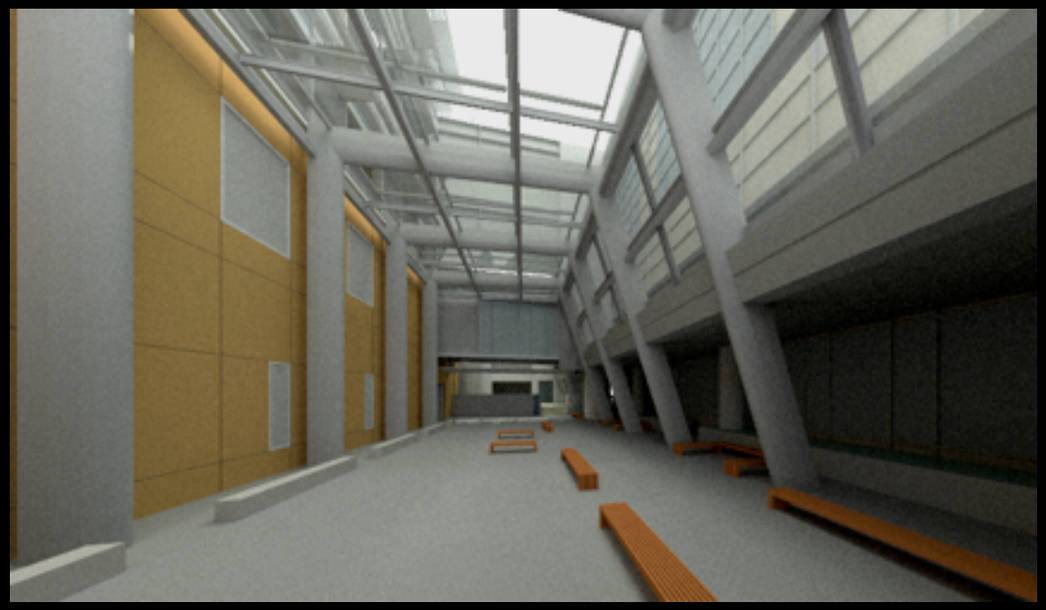


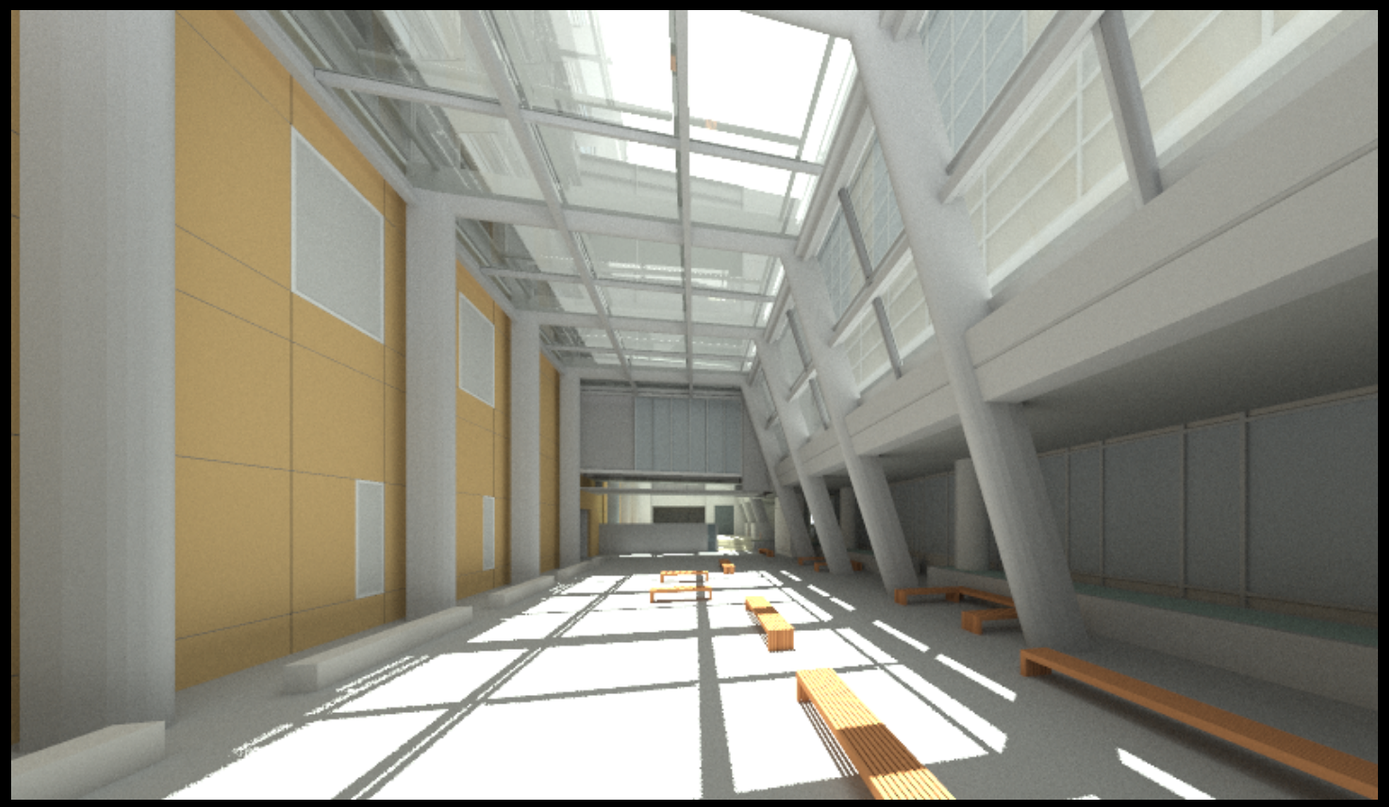


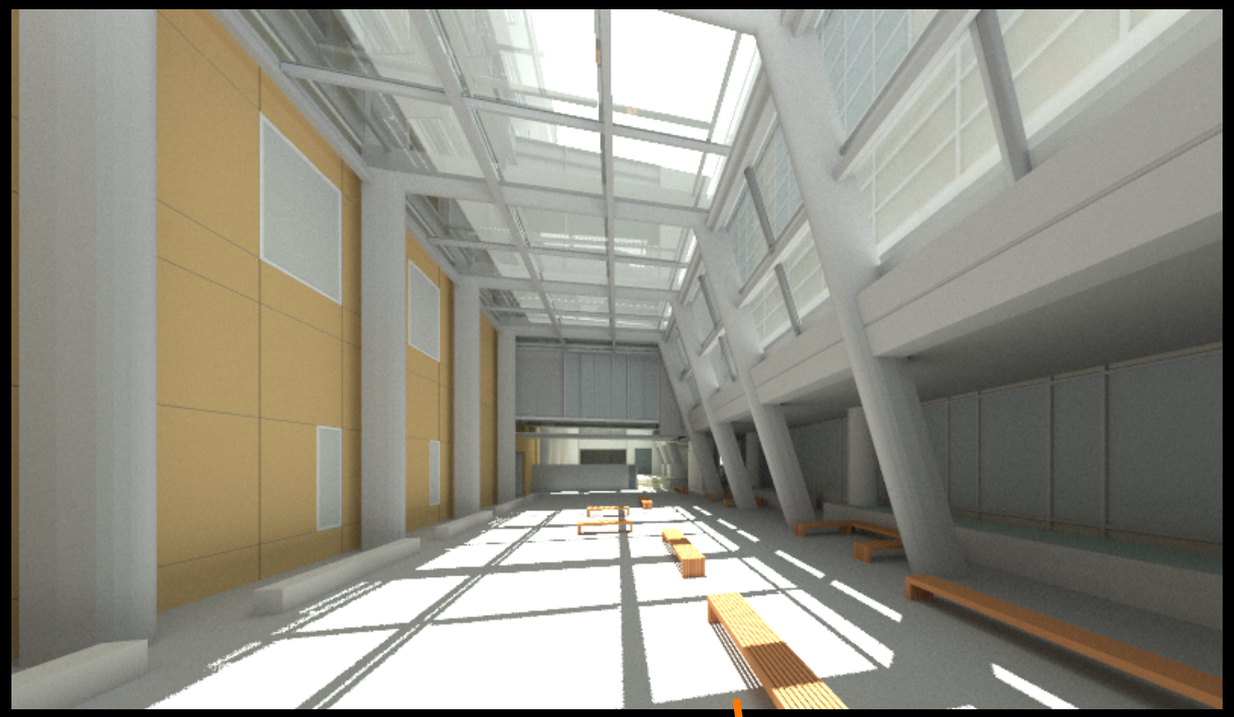


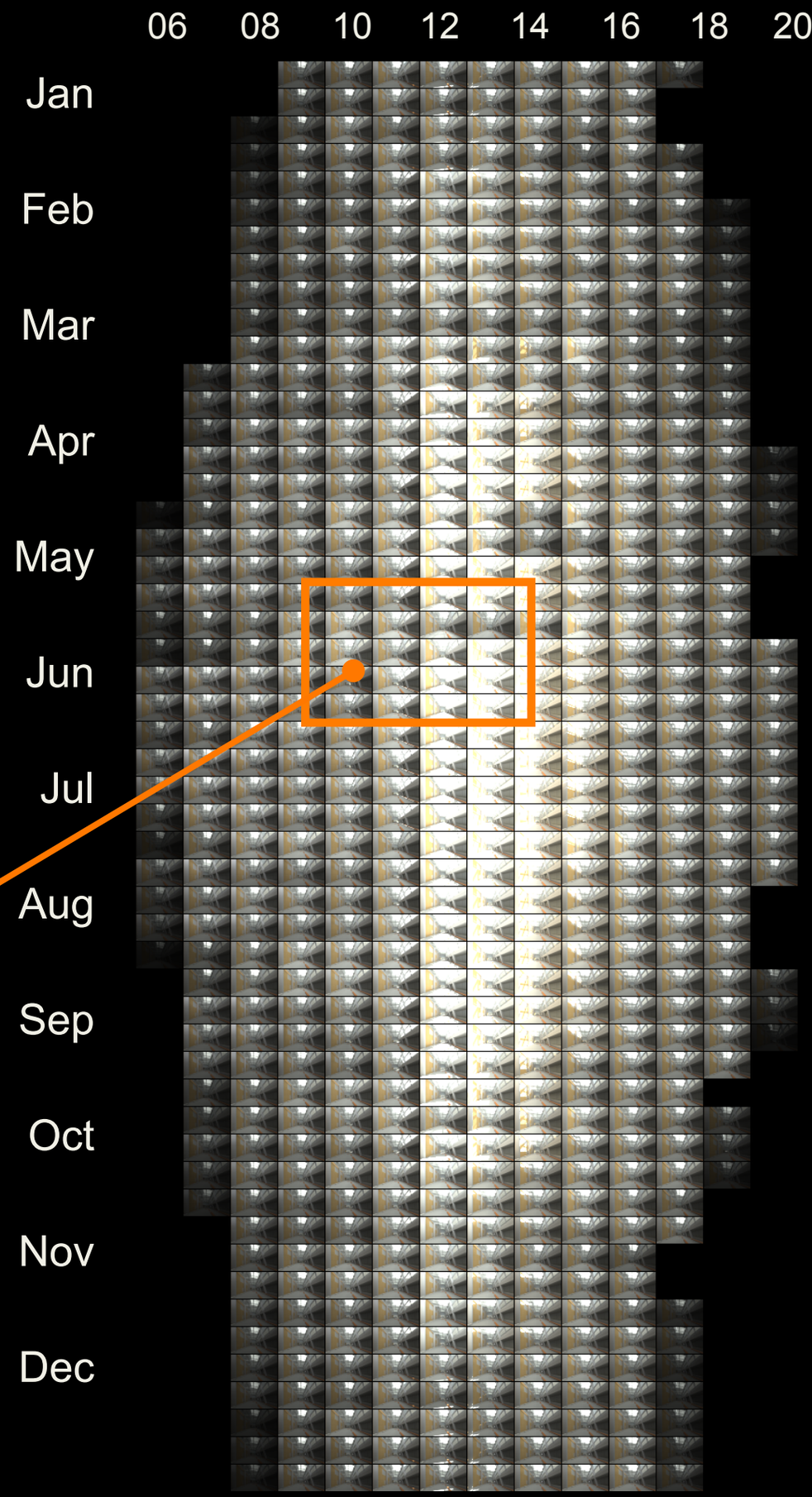








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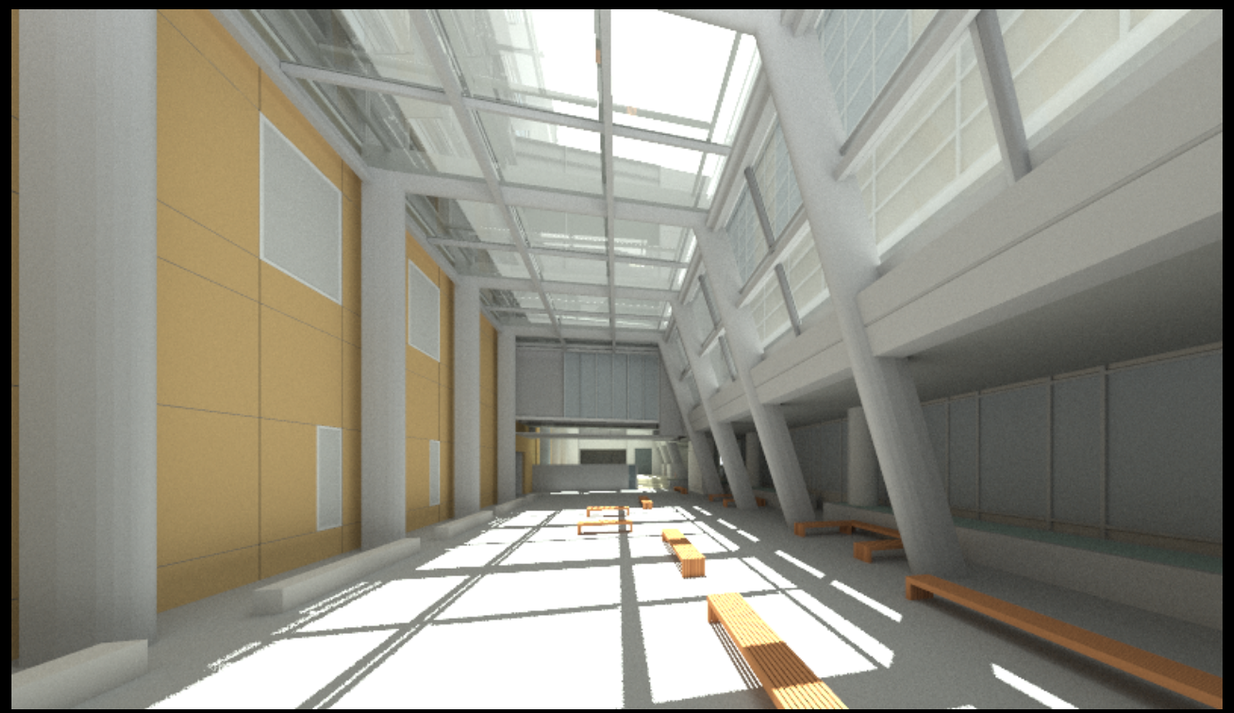

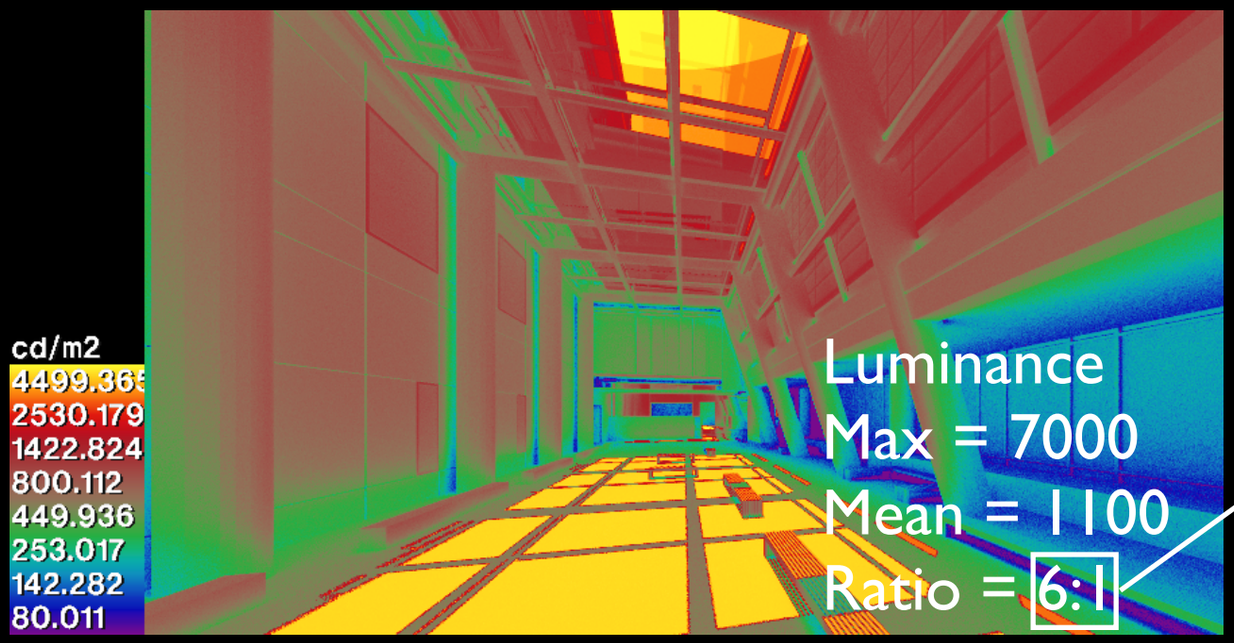
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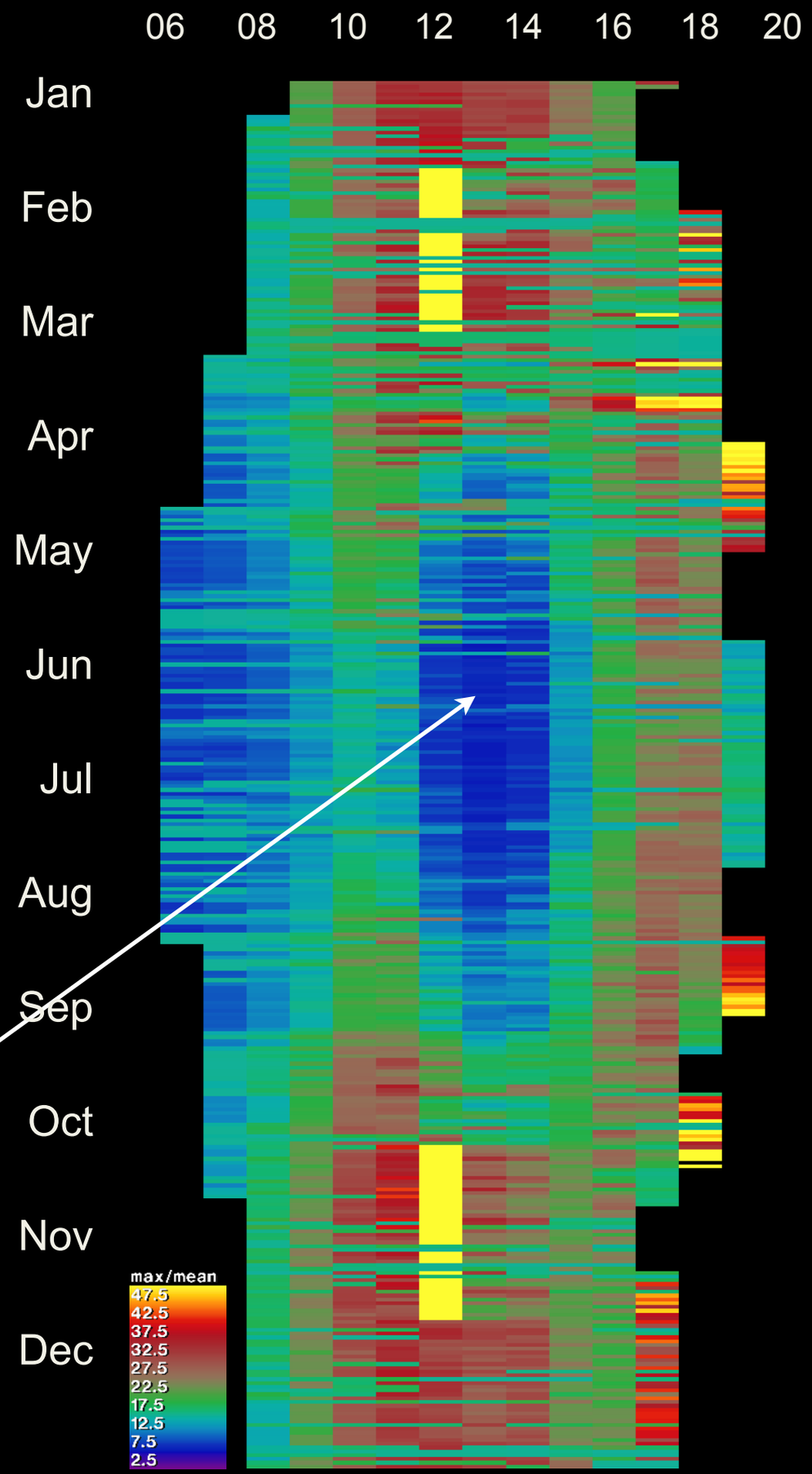
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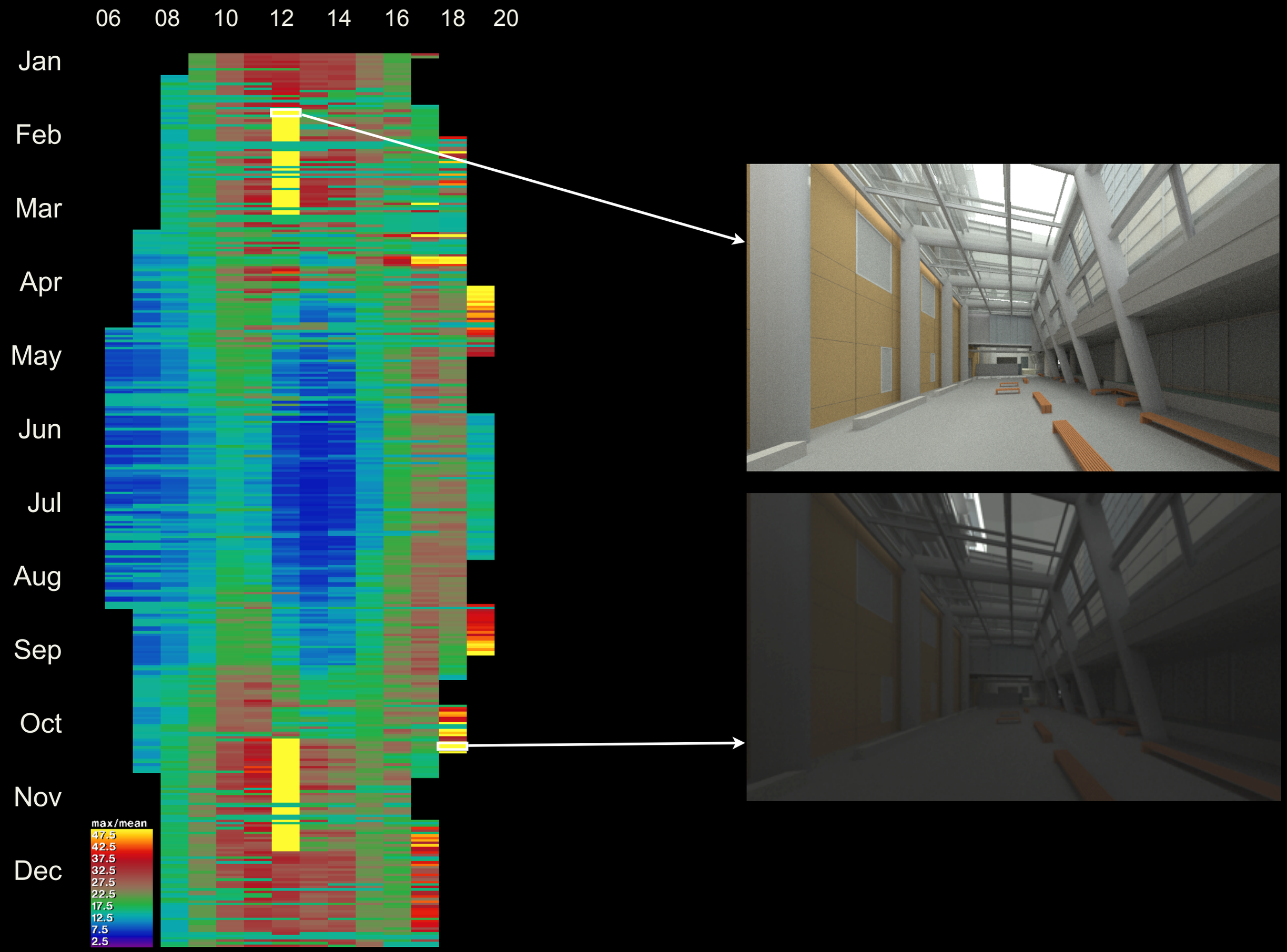
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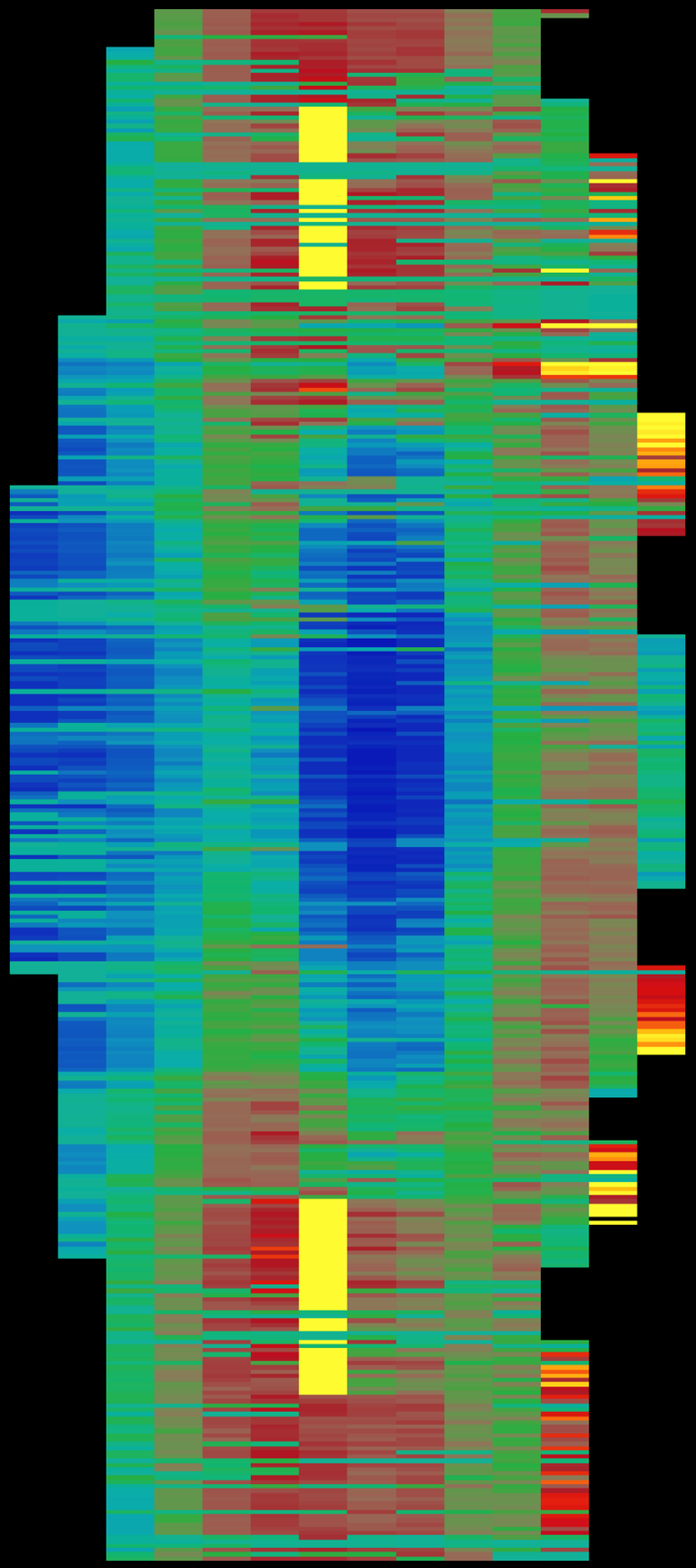
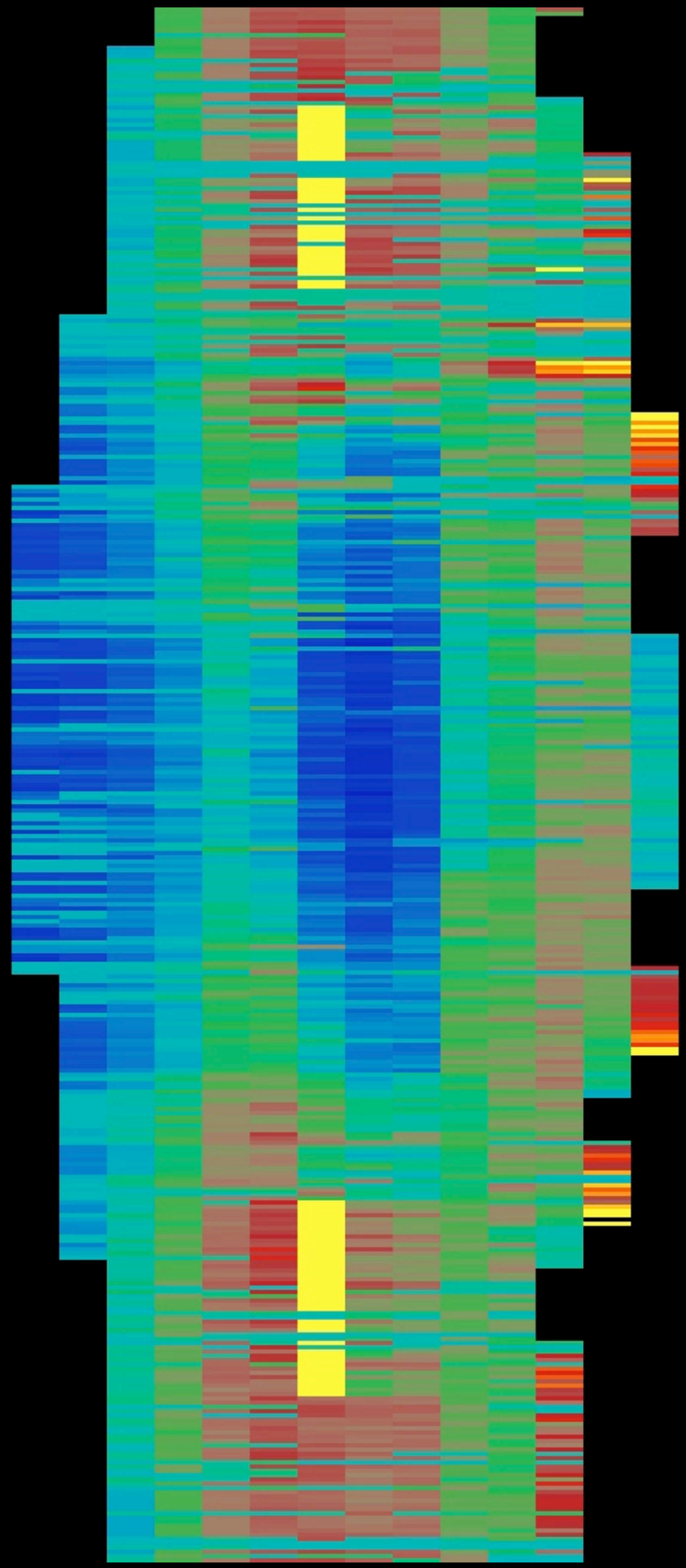
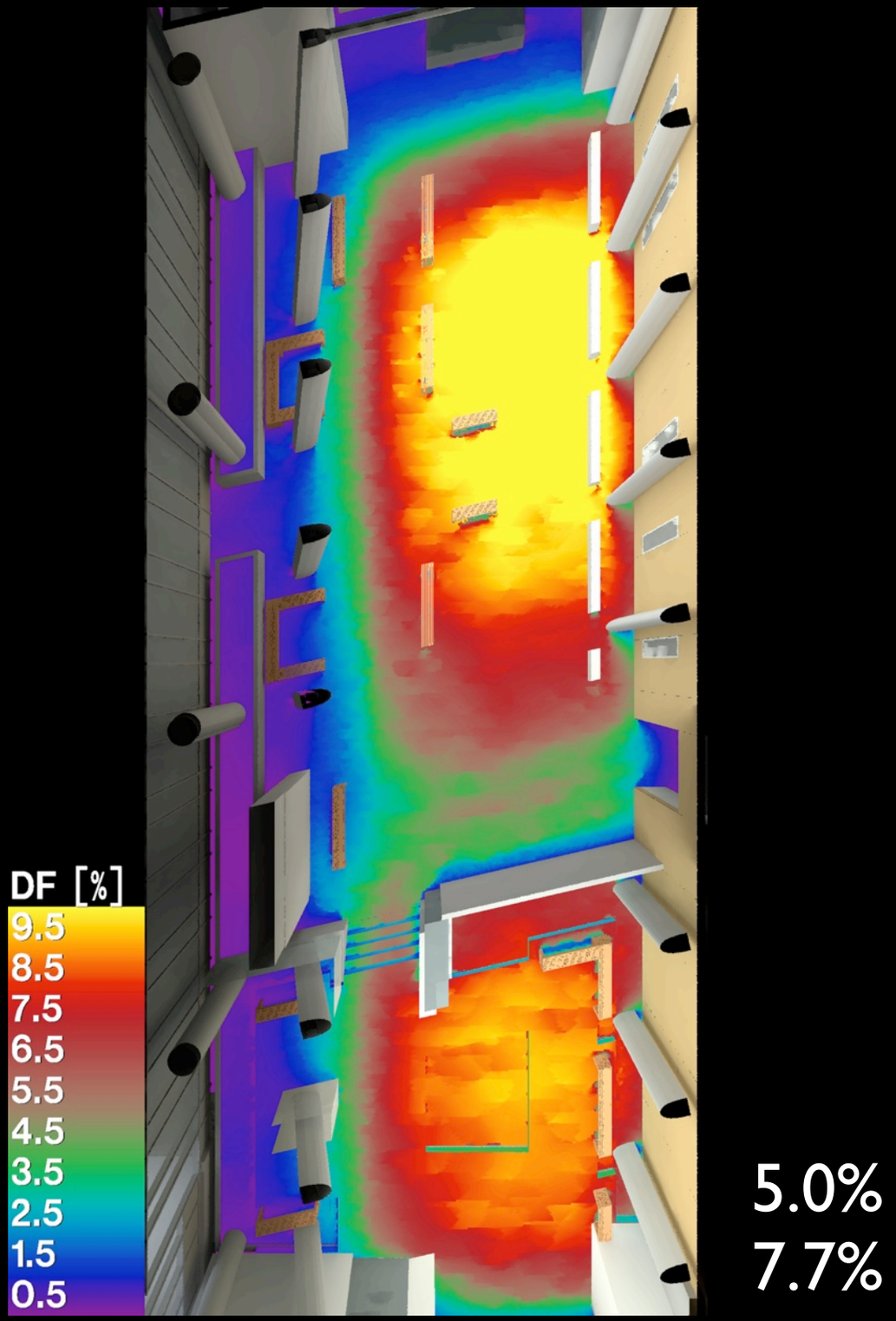


30% Gray Frit



50% Gray Frit



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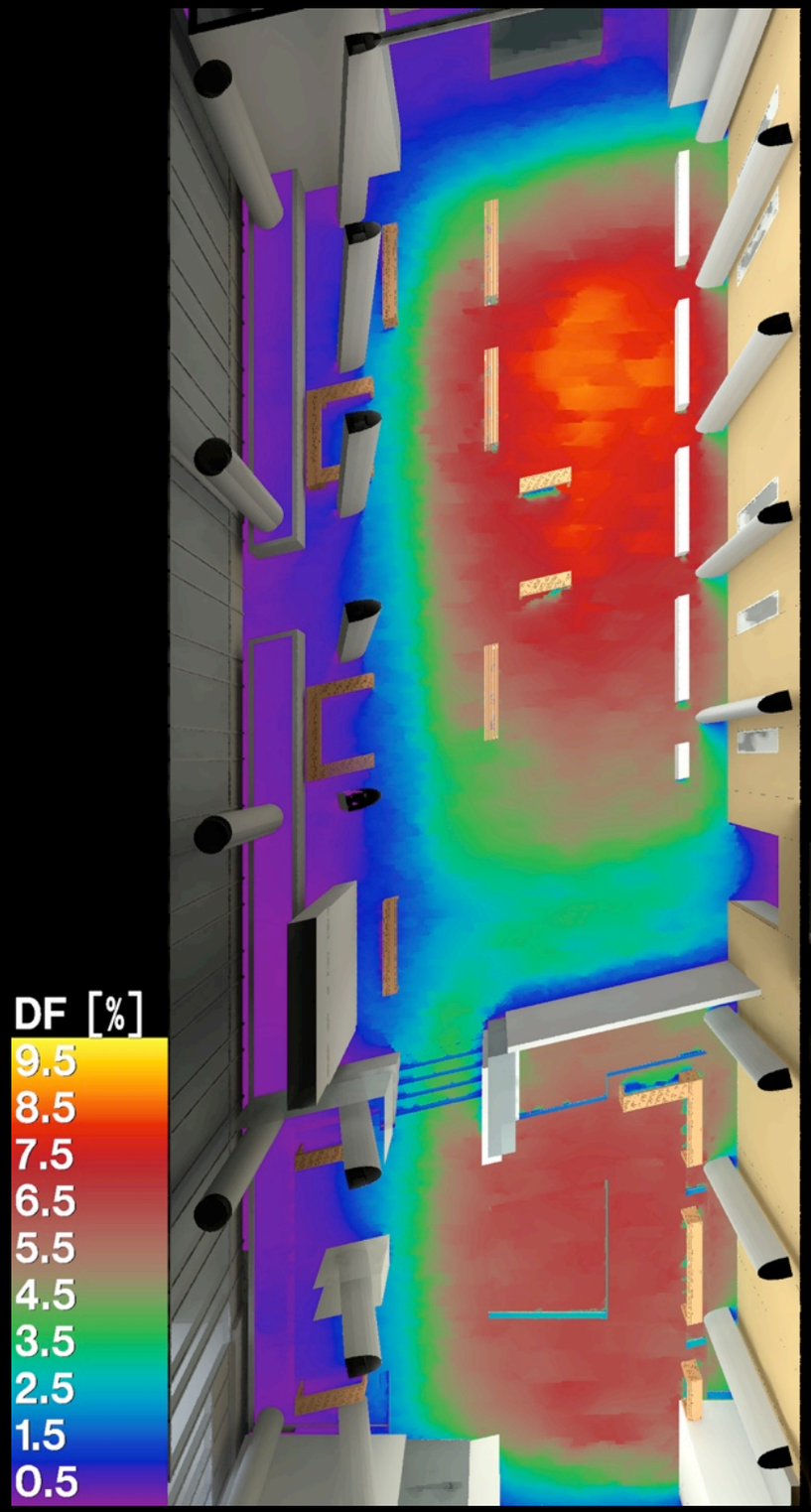
7.7%

30% Gray Frit



3.8%
5.0%

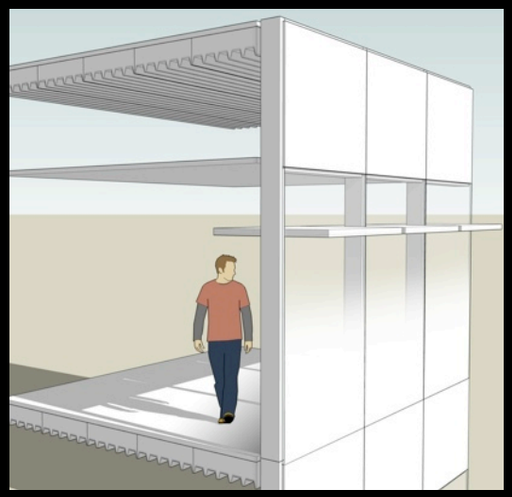
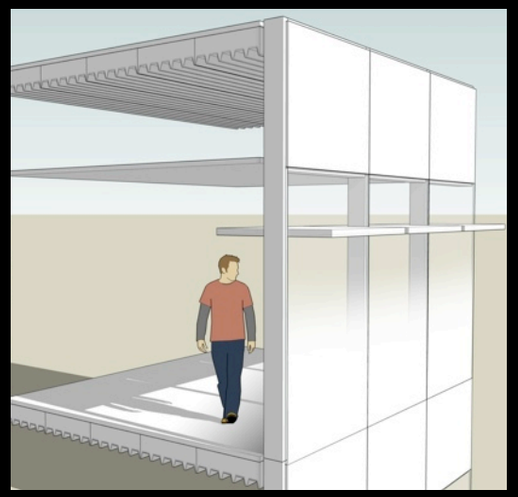
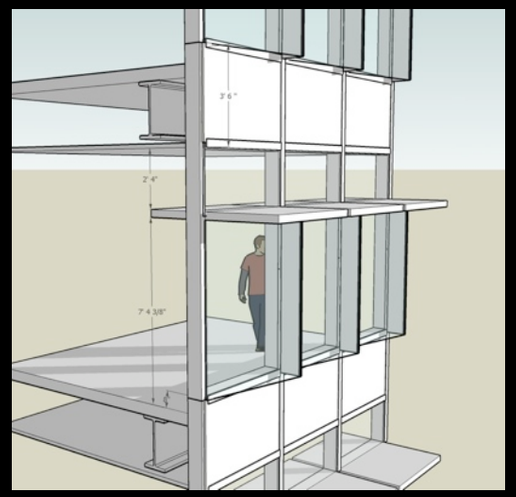
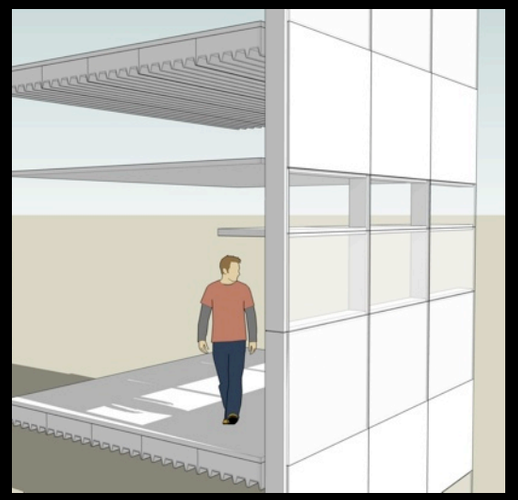
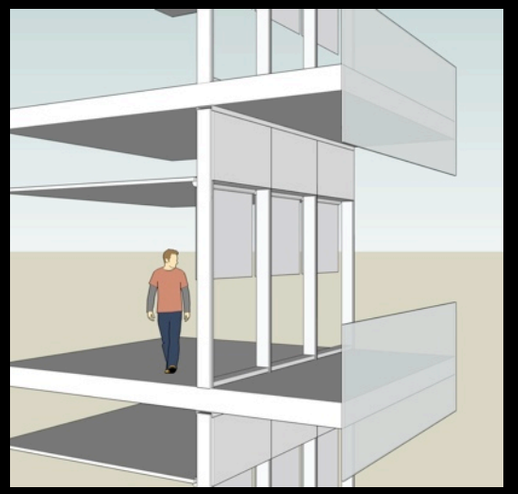
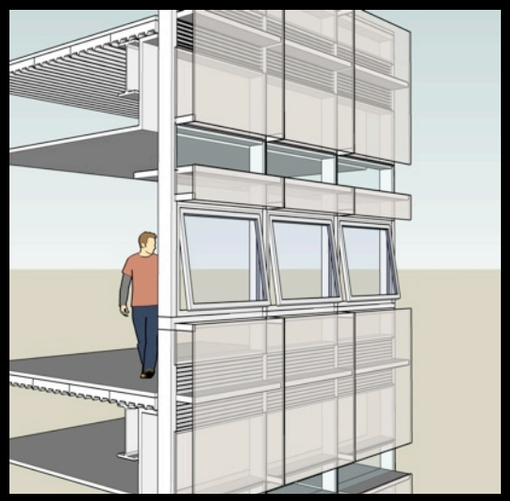
50% Gray Frit

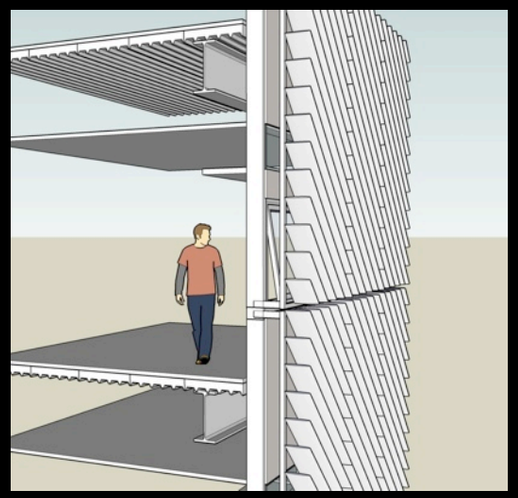
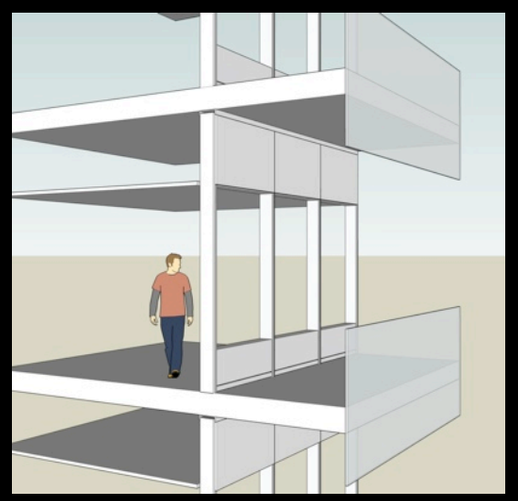
Recommended least amount of frit thermally permissible.

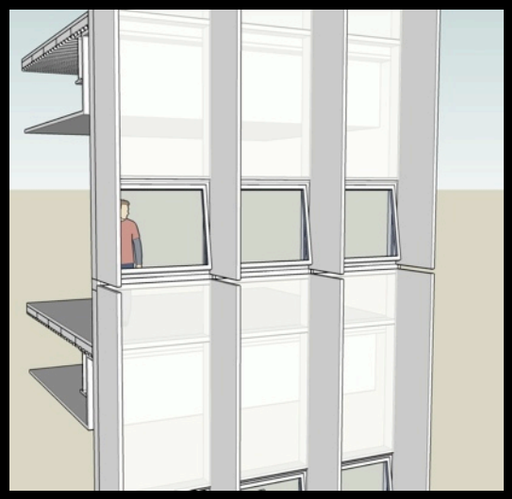
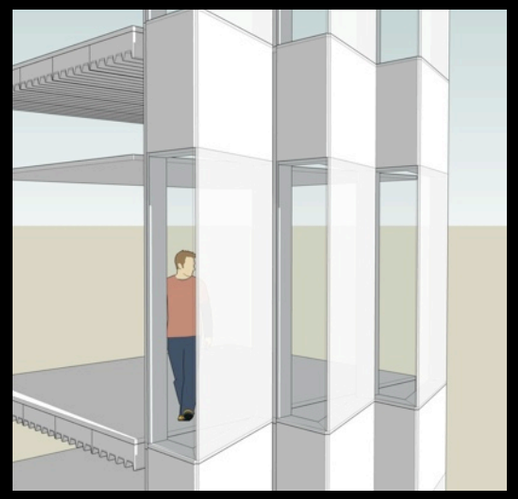
Thermally, 0% frit permissible.

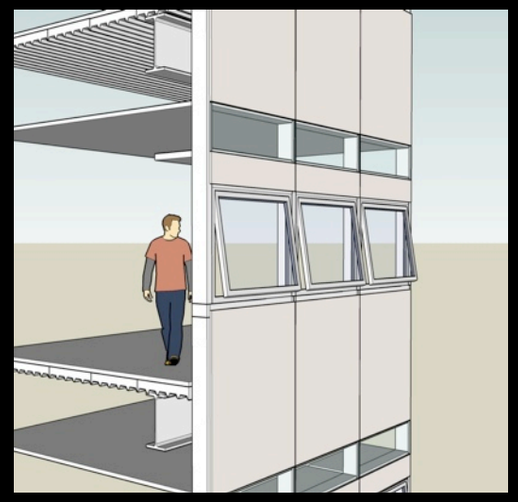
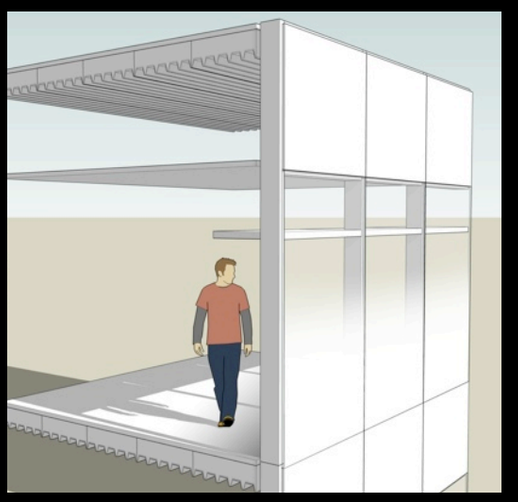
No Frit!?! - First time ever.

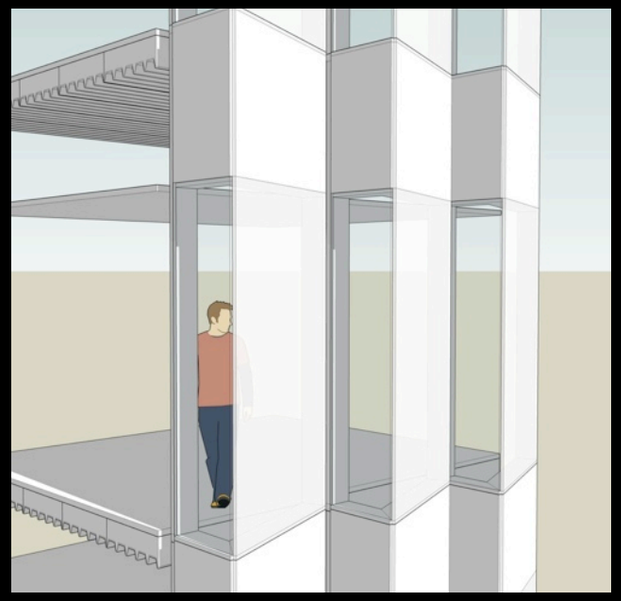
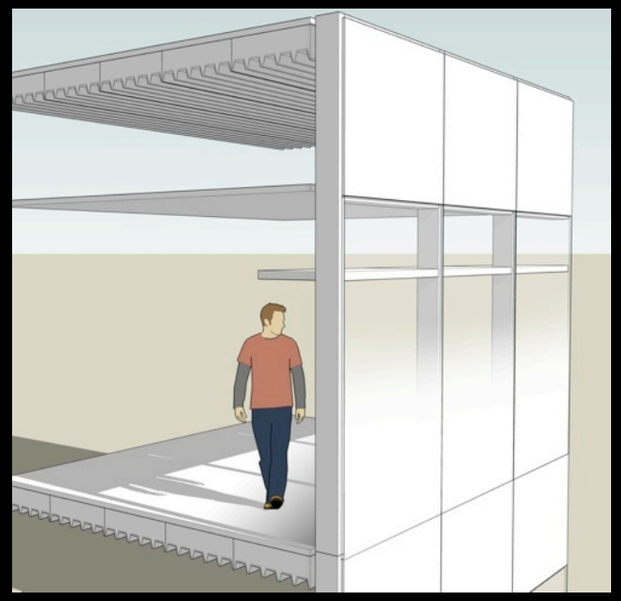
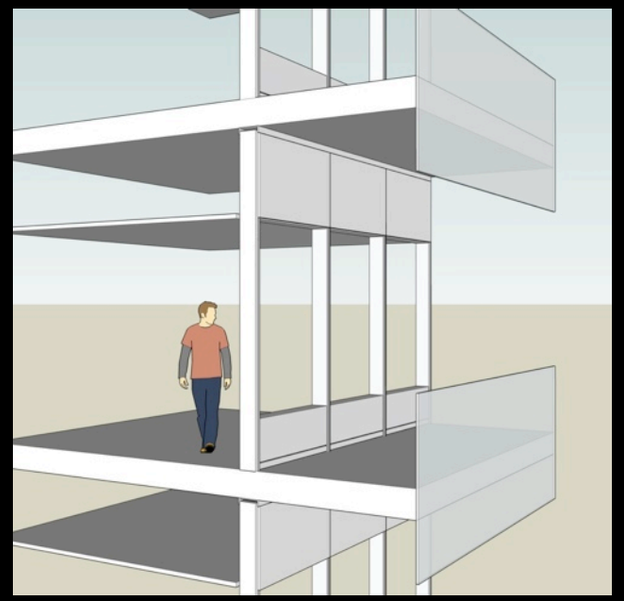
Office Building West Facing Facade




3' 6"
2' 4"
7' 4 3/8"




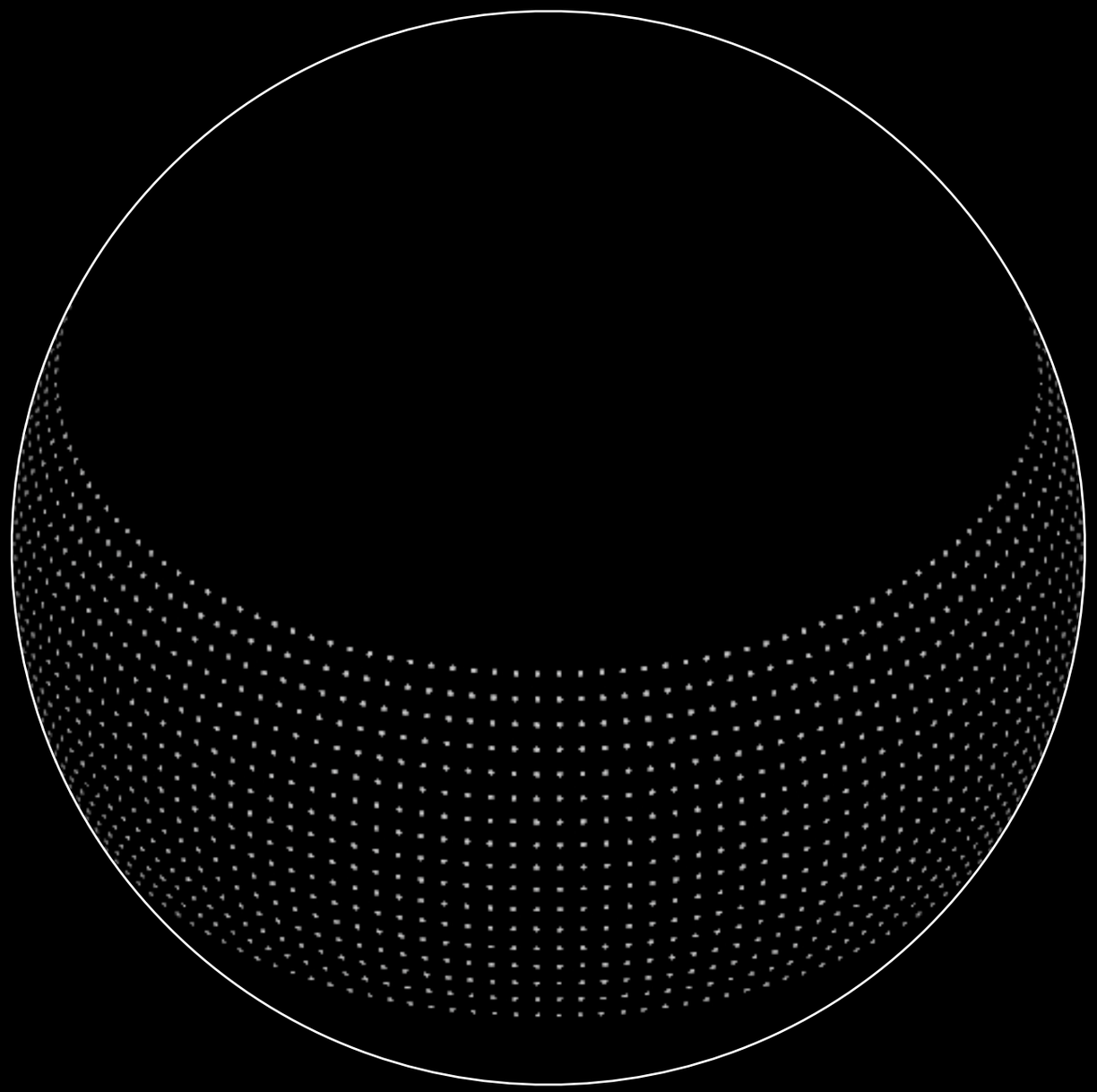



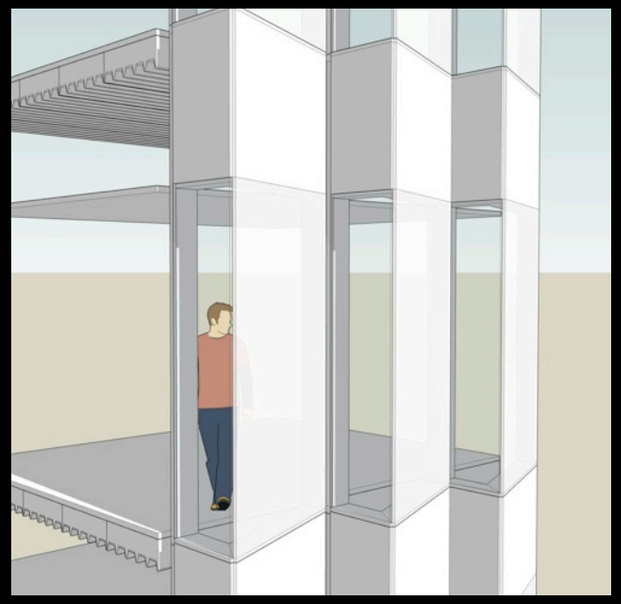



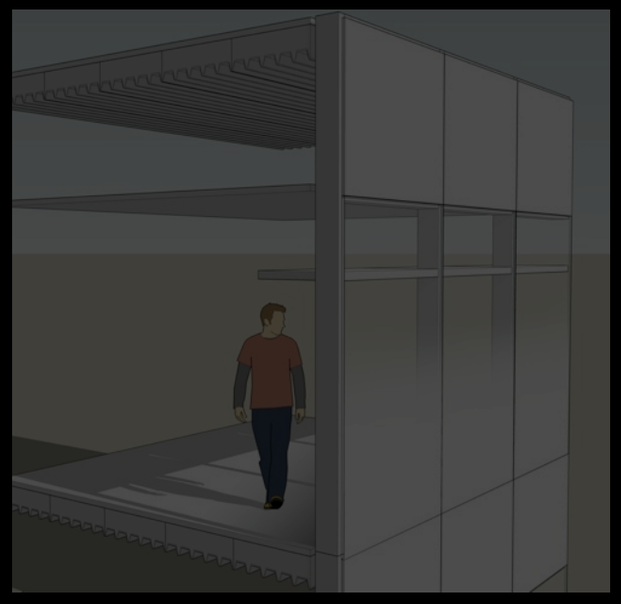



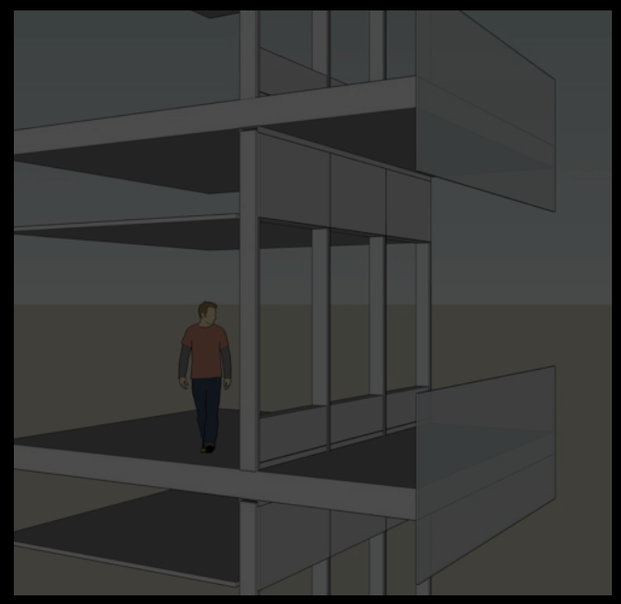




- Models parameterized to find optimal cases.
- Annual daylight analysis 5 minute timesteps & ~1200 sun positions



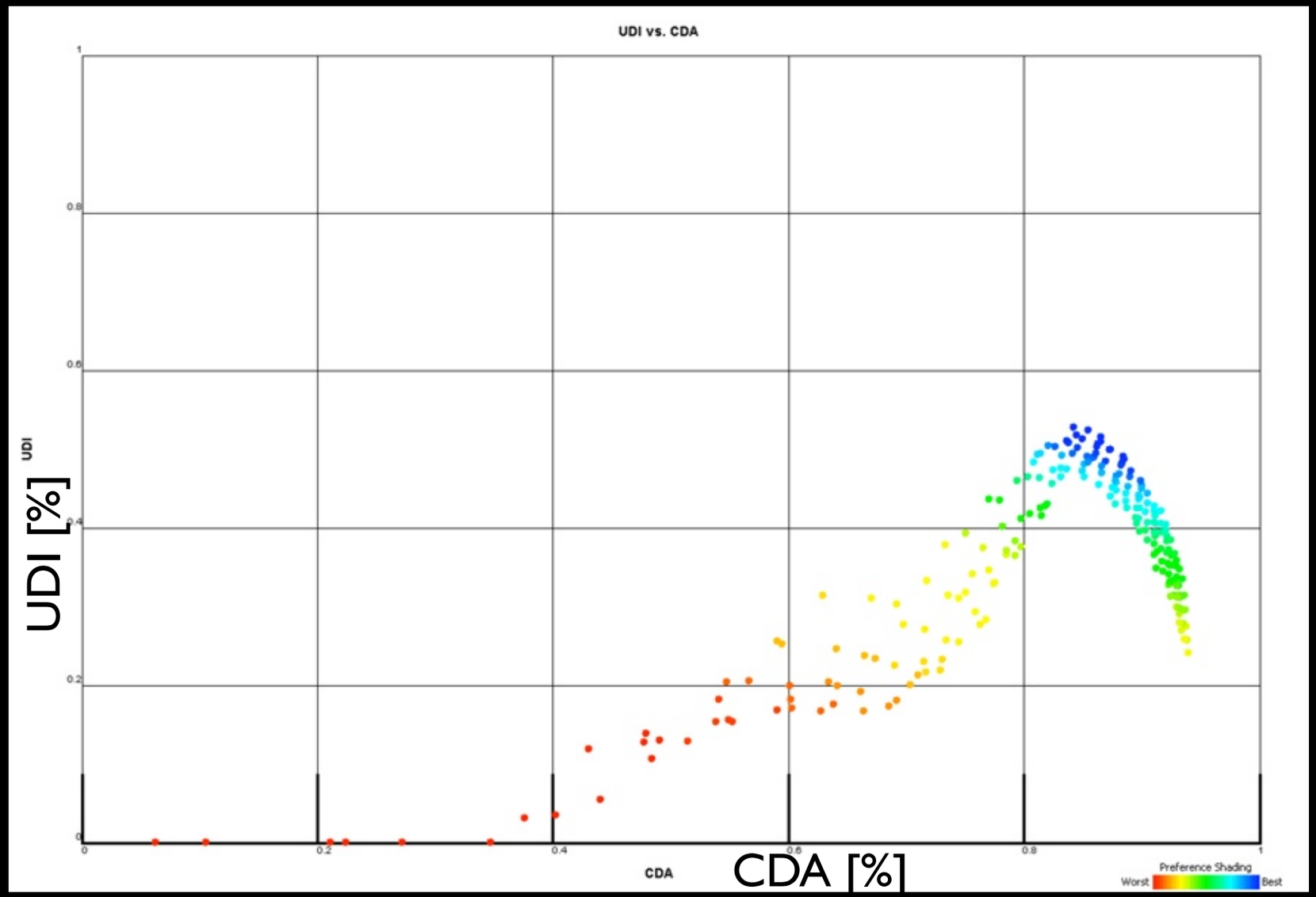


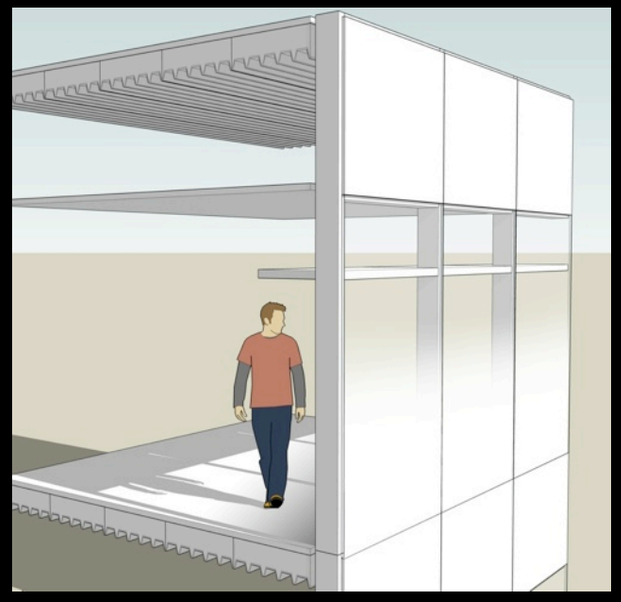


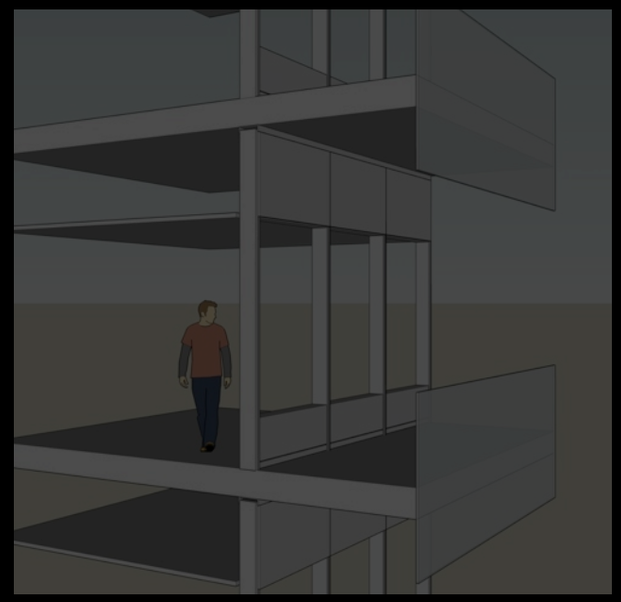


Parameters:

- Width of north facing glass
- Opacity of southwest facing glass

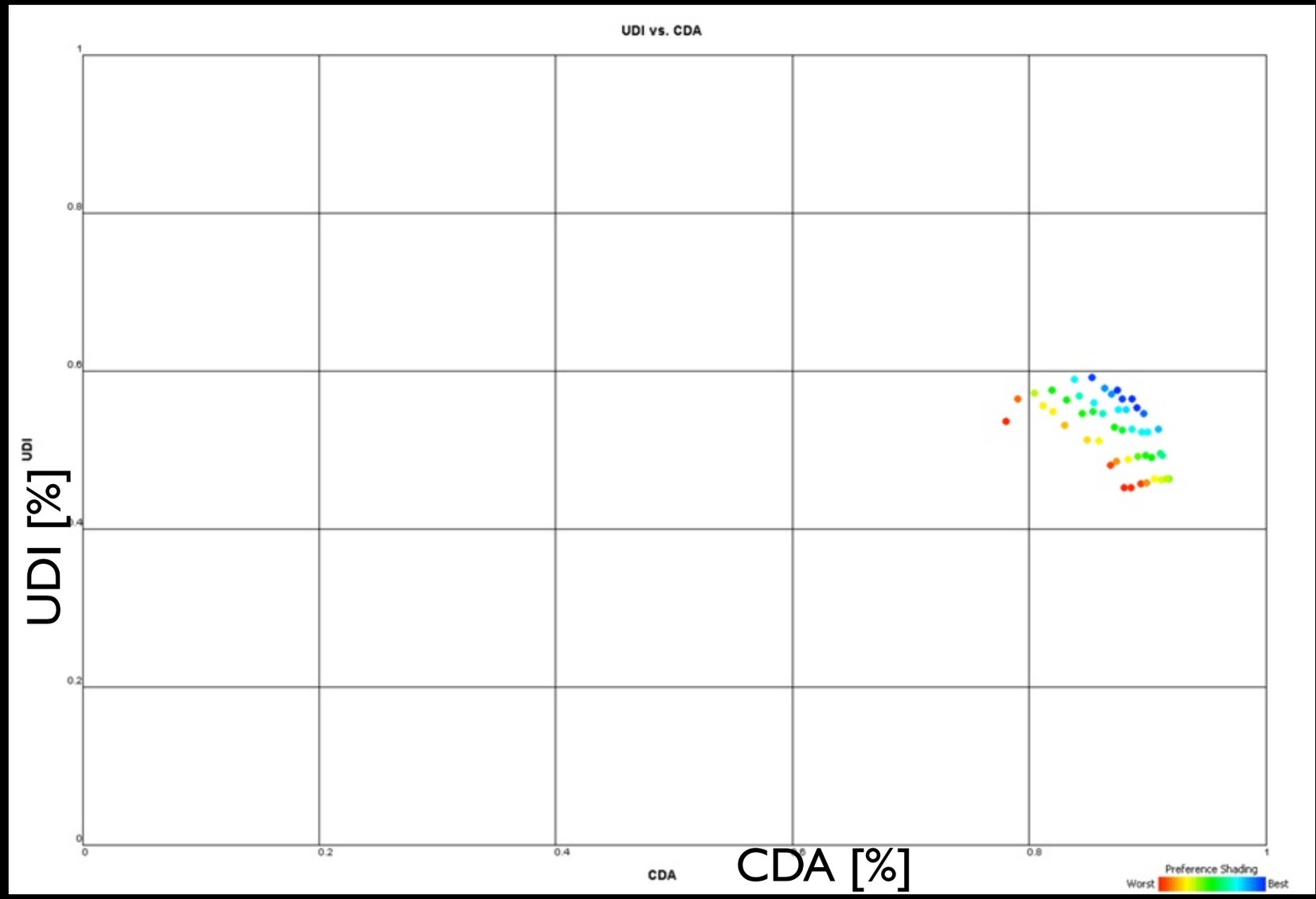


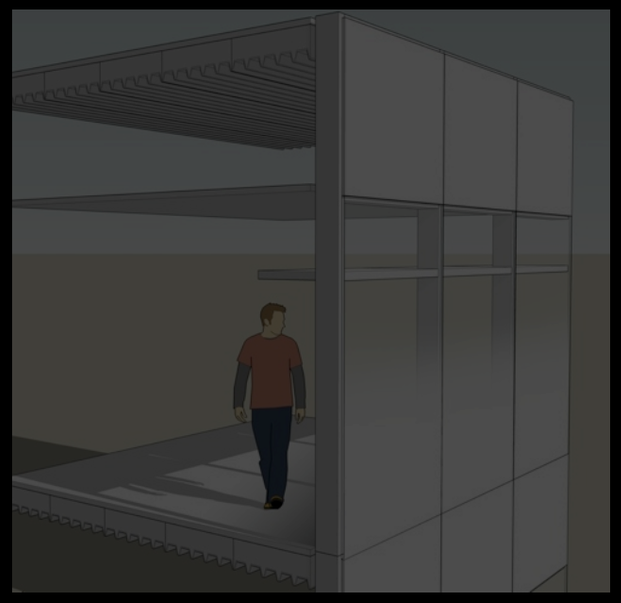


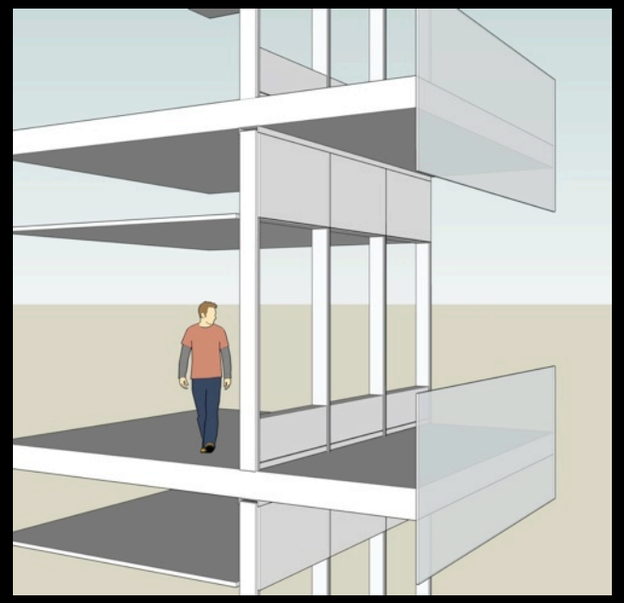


Parameters:

- Depth of light shelf.
- Percentage of frit coverage.

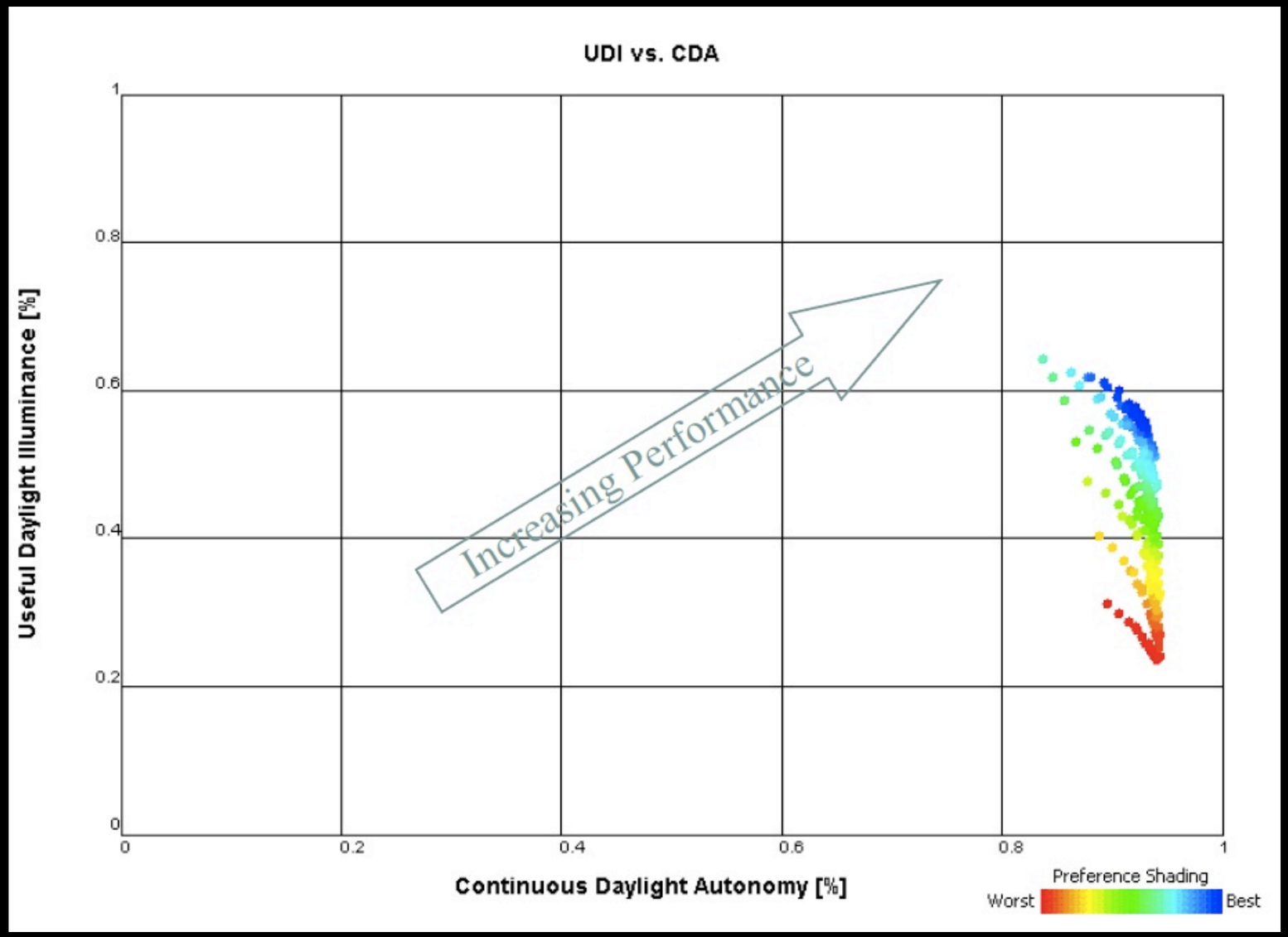


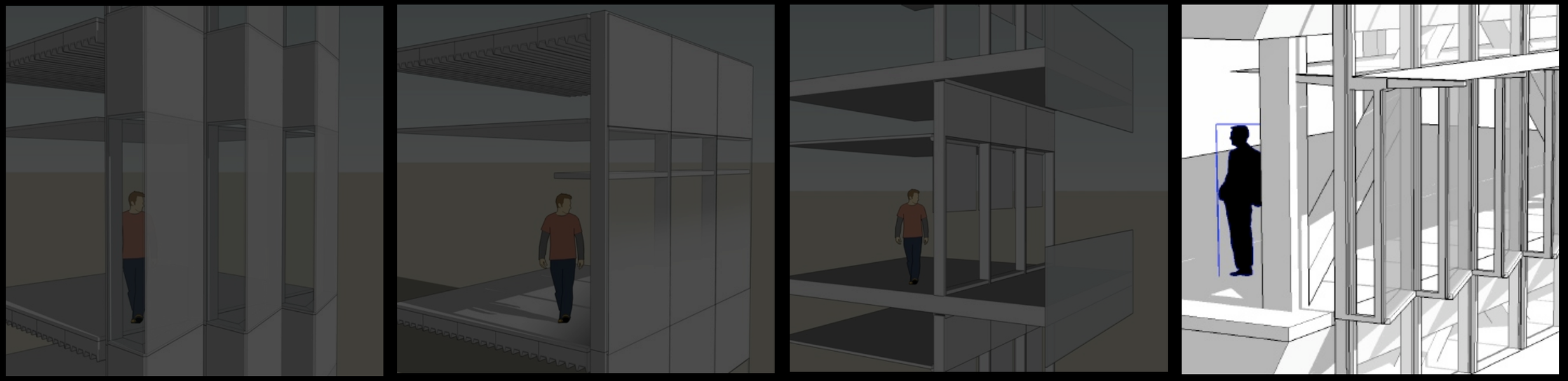




Parameters:

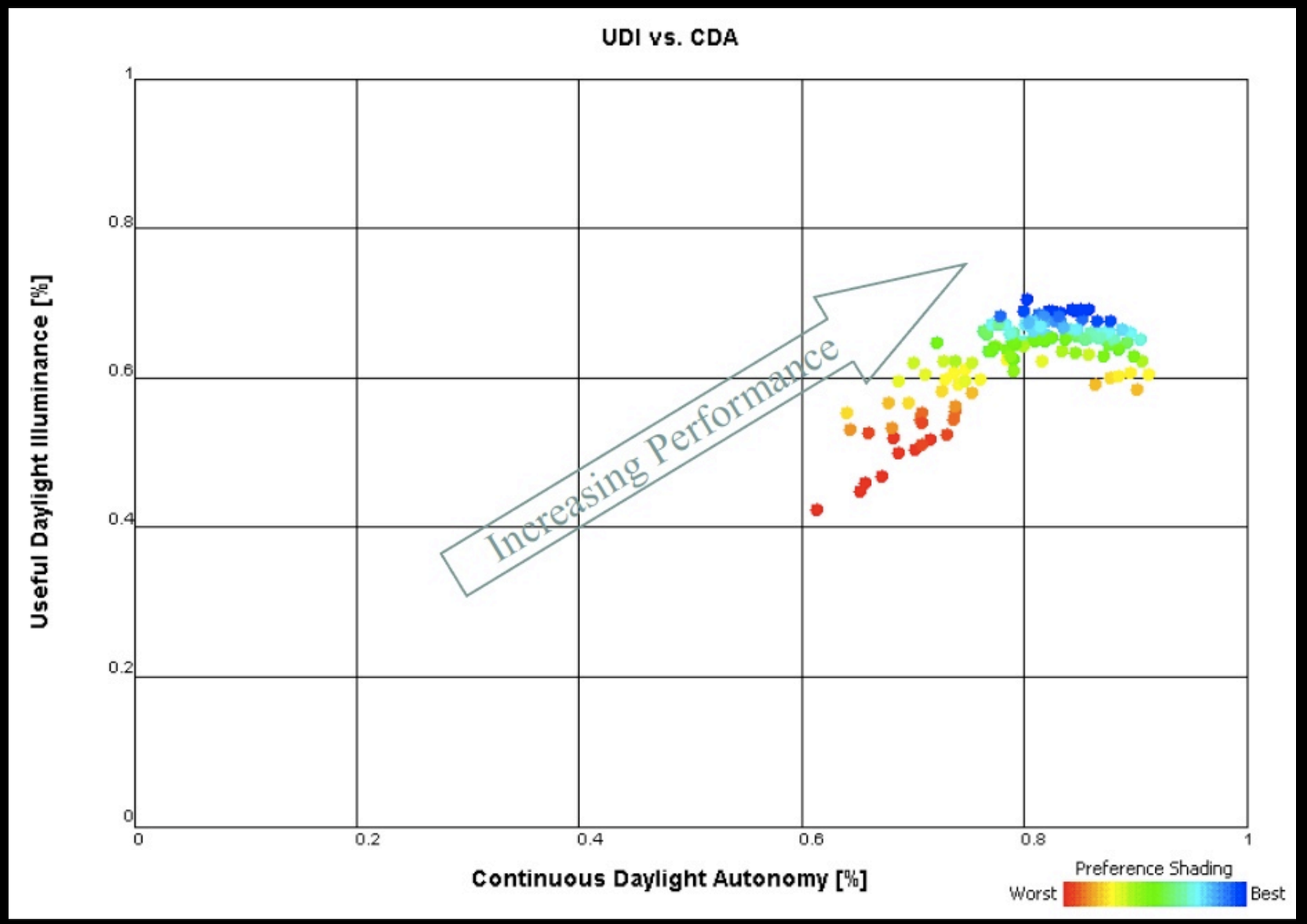
- Depth of external walk
- Transparency of glazing
- Size of scrim opening

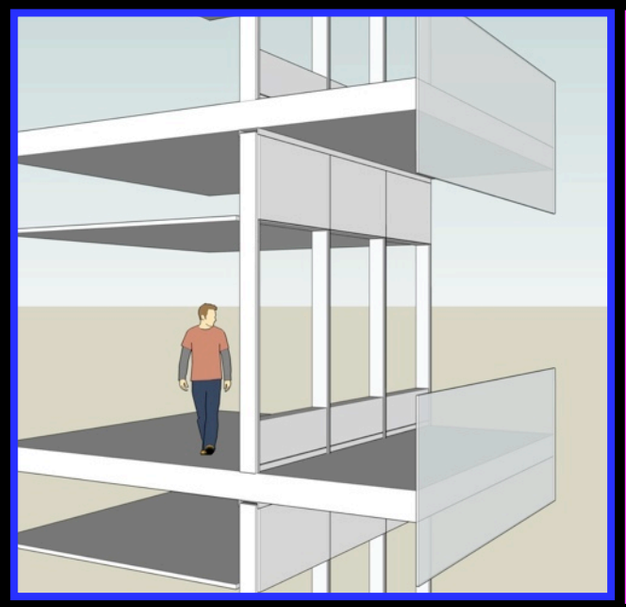


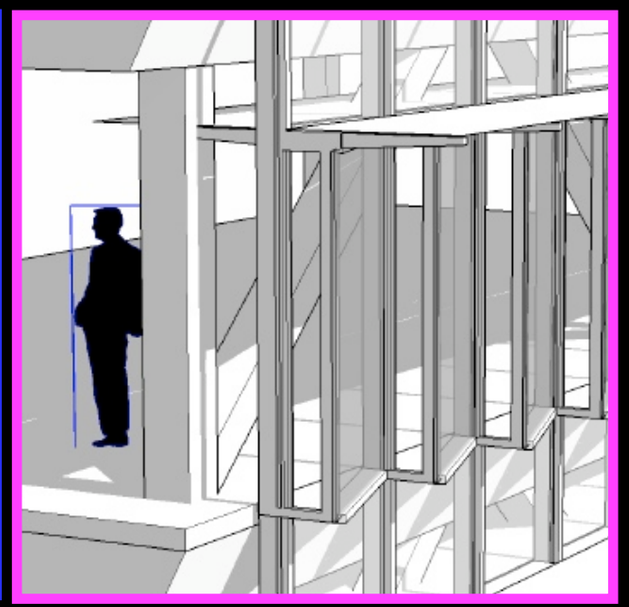


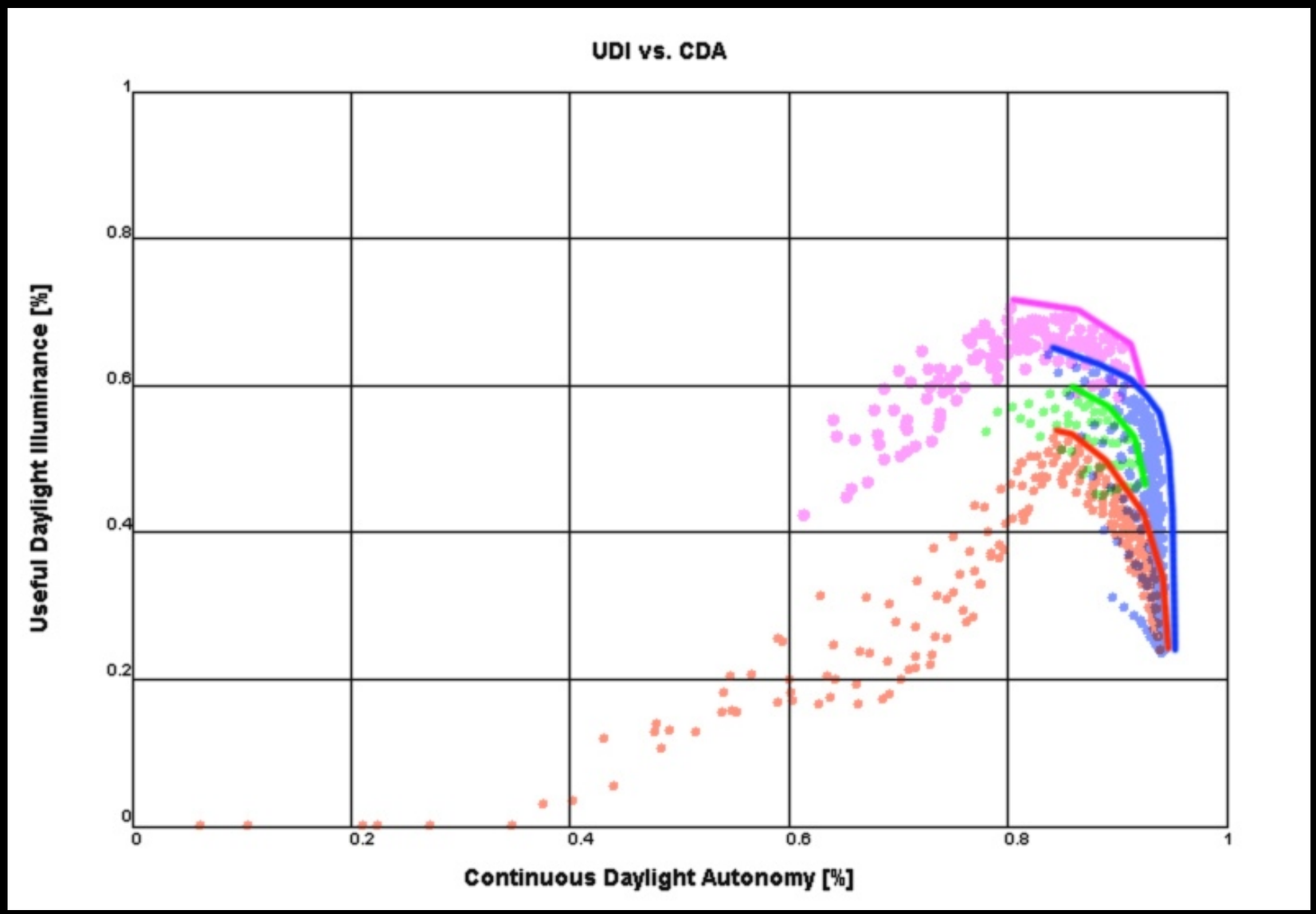
Parameters:

- Depth of light shelf
- Depth of overhang
- Opacity of southeast facing glazing.








UDI vs. CDA
Useful Daylight Illuminance [%]
Continuous Daylight Autonomy [%]
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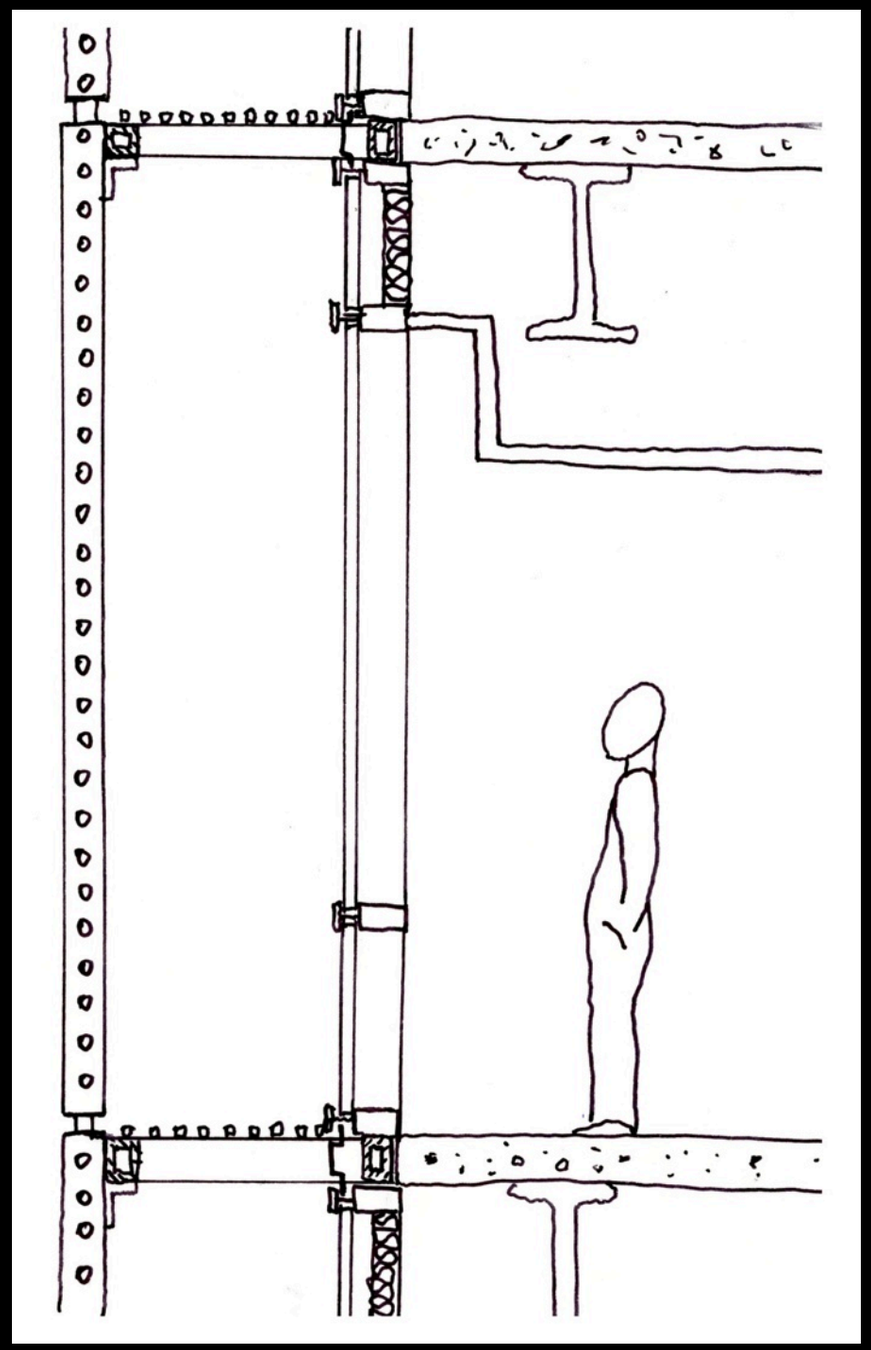
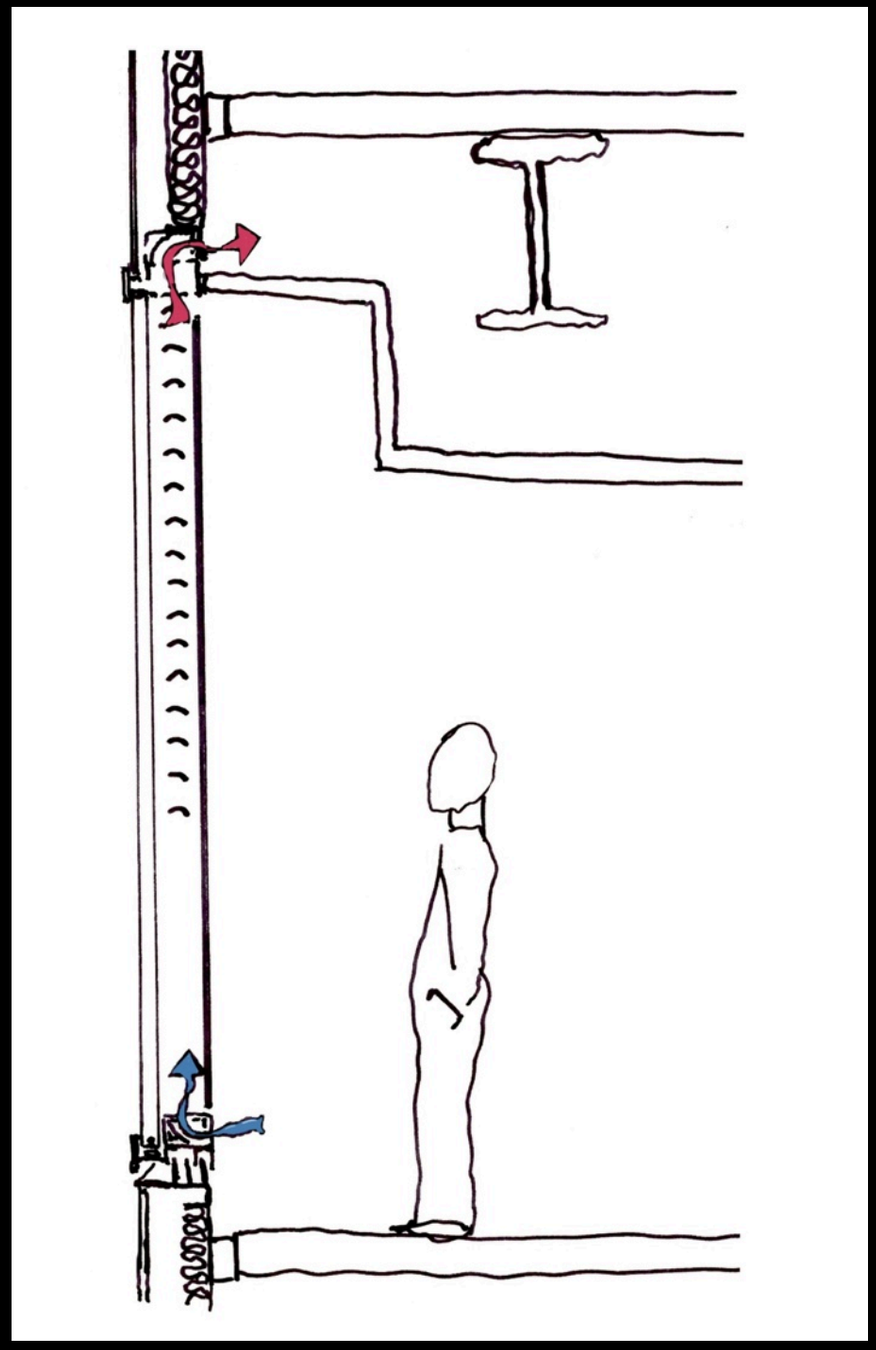
0.4
0.6
0.8
1

So which one did we choose?

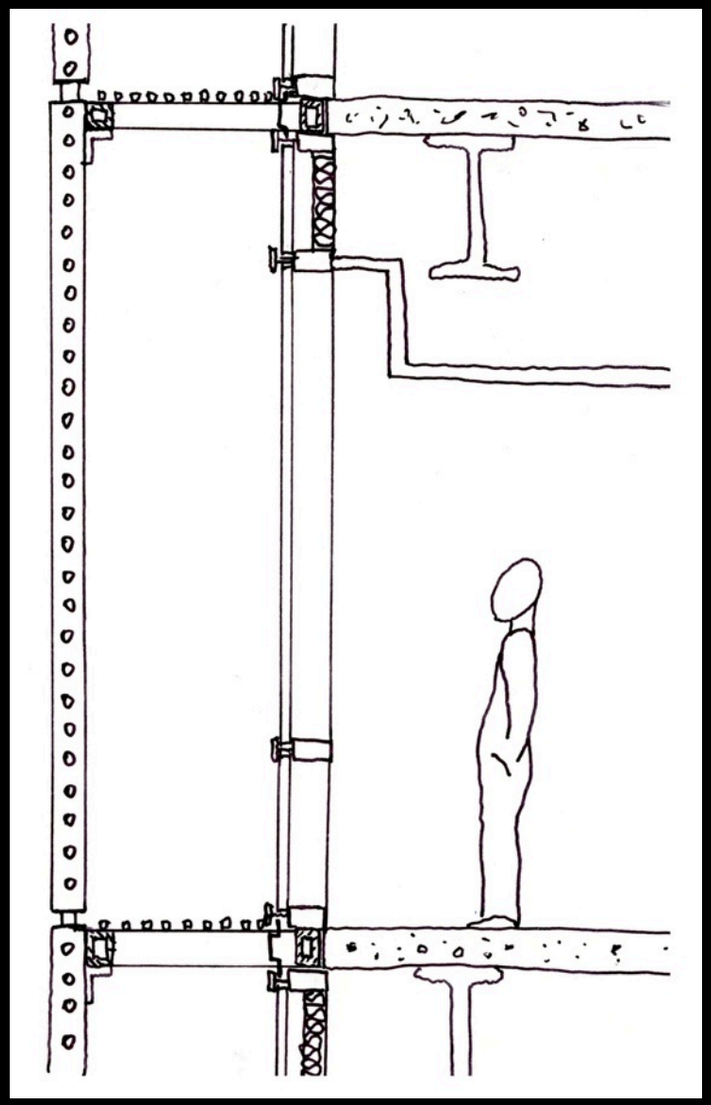
None - Two new options explored based on automated blinds.

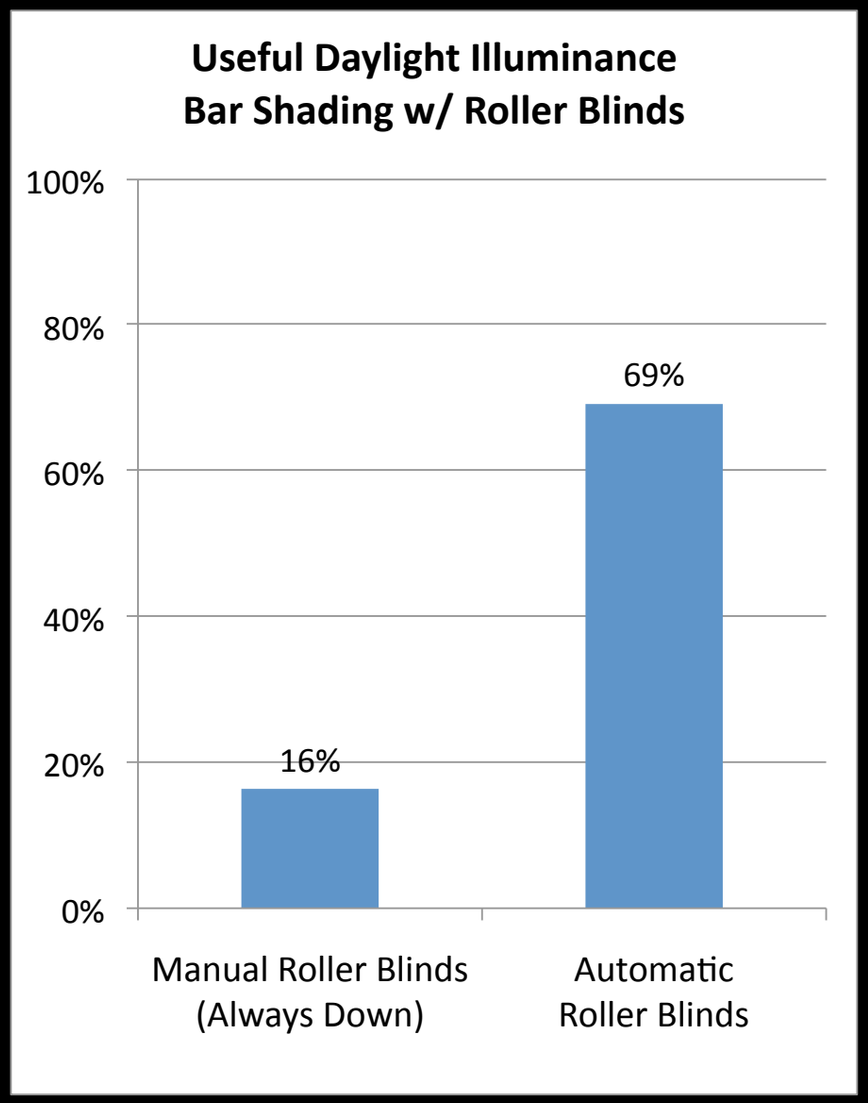


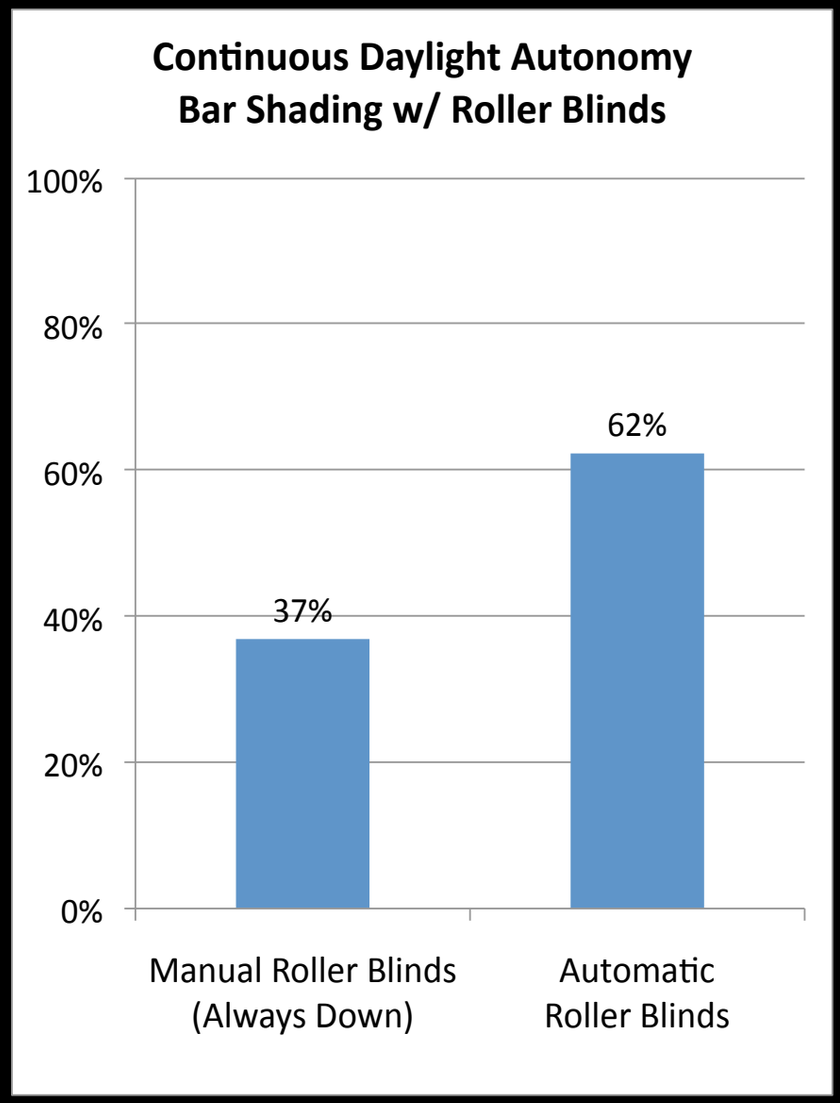
- External Rods
- Automated roller blind (internal)

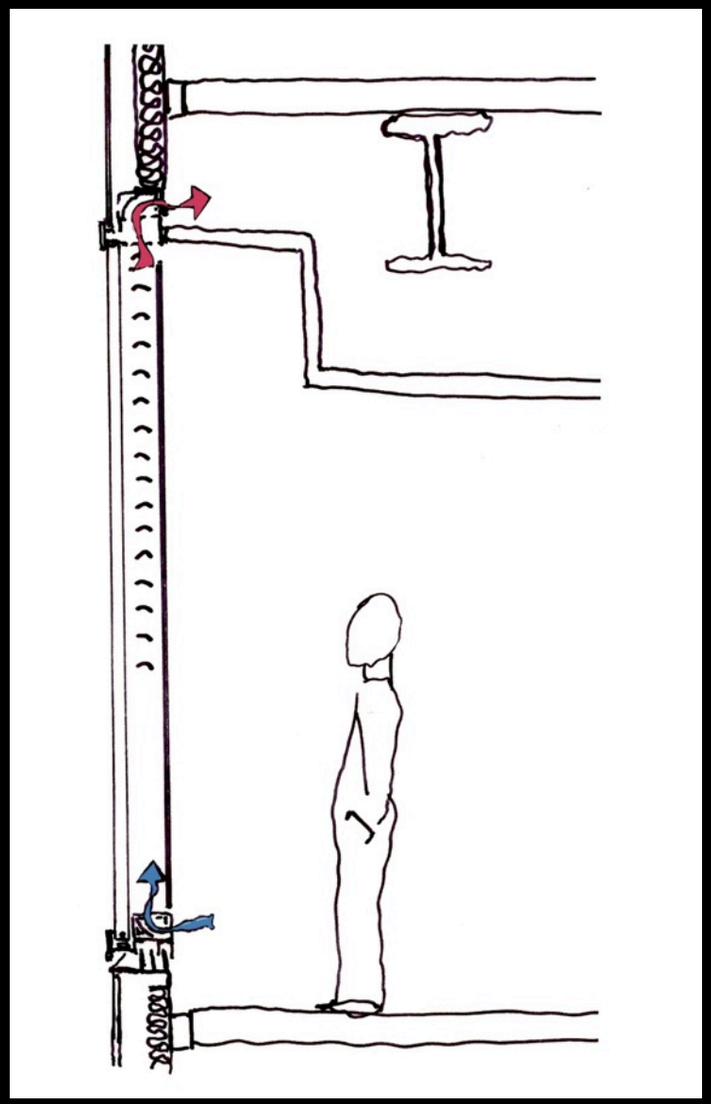


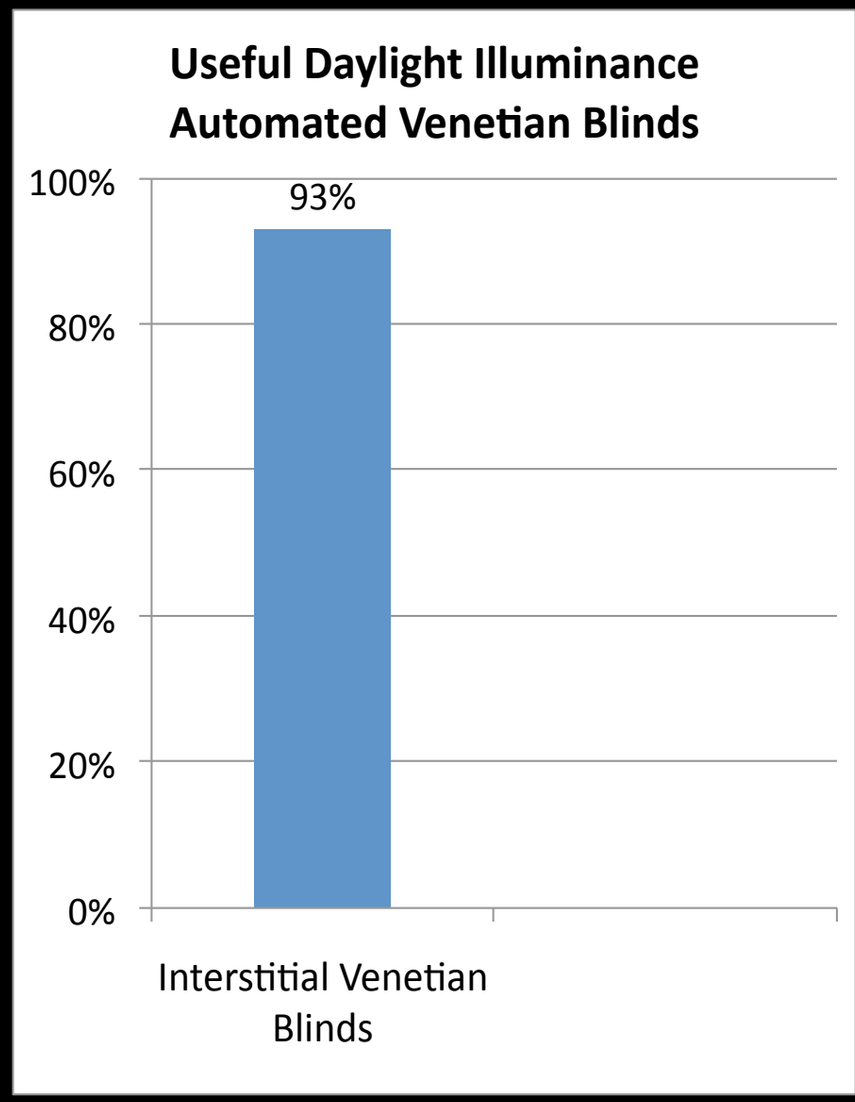
- Interstitial Venetian Blinds

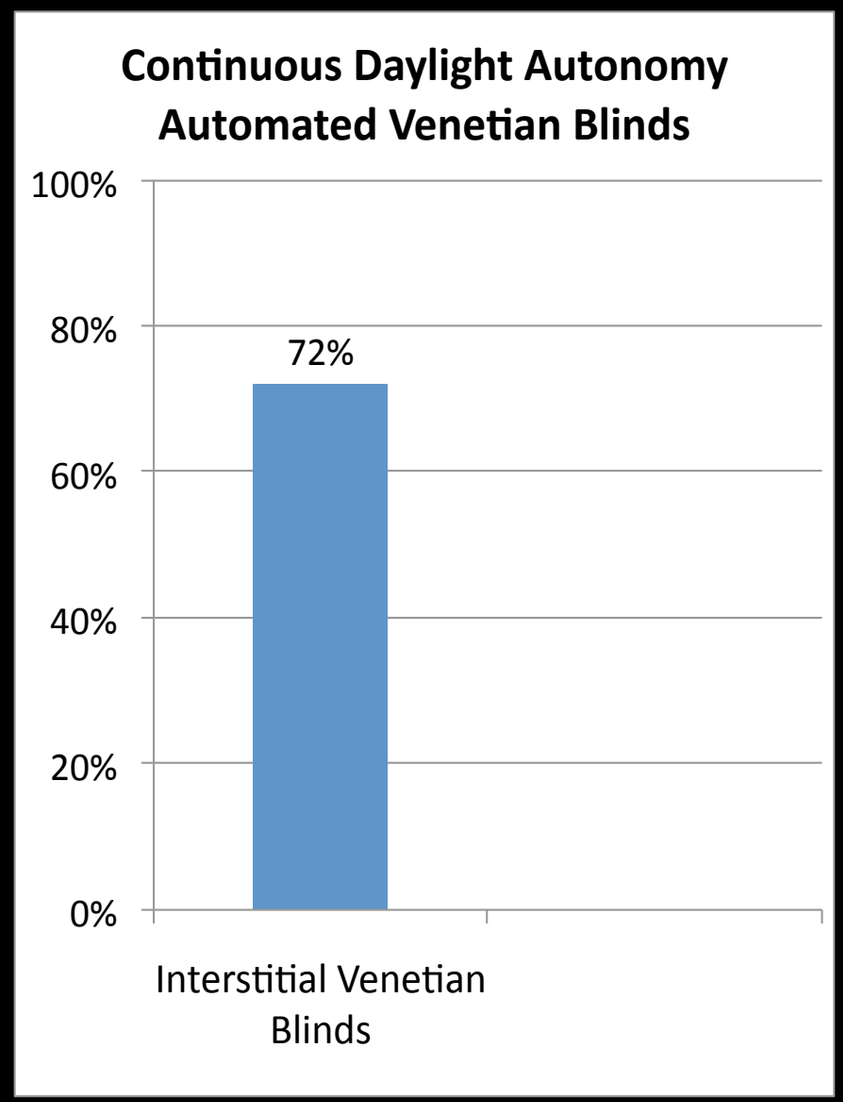


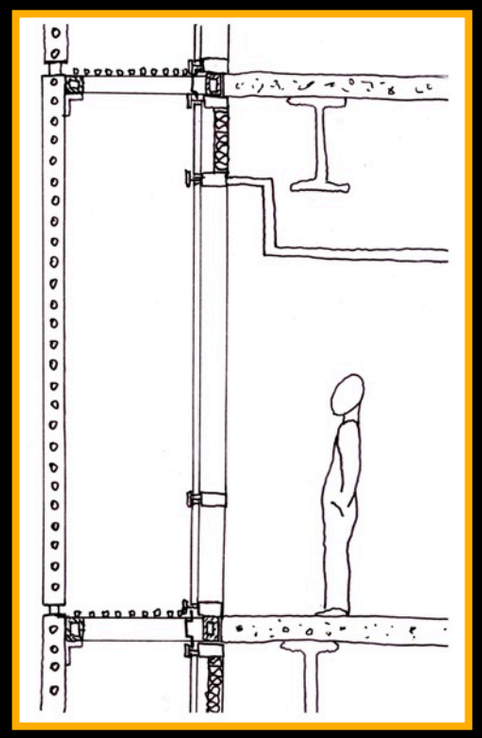

Useful Daylight Illuminance
Bar Shading w/ Roller Blinds
100%
80%
60%
40%
20%
0%
16%
69%
Manual Roller Blinds
(Always Down)
Automatic
Roller Blinds

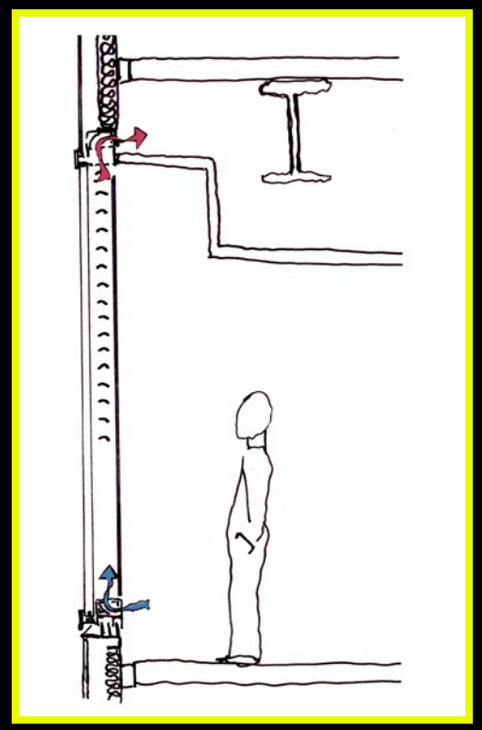

Continuous Daylight Autonomy
Bar Shading w/ Roller Blinds
100%
80%
60%
40%
20%
0%
37%
62%
Manual Roller Blinds
(Always Down)
Automatic
Roller Blinds

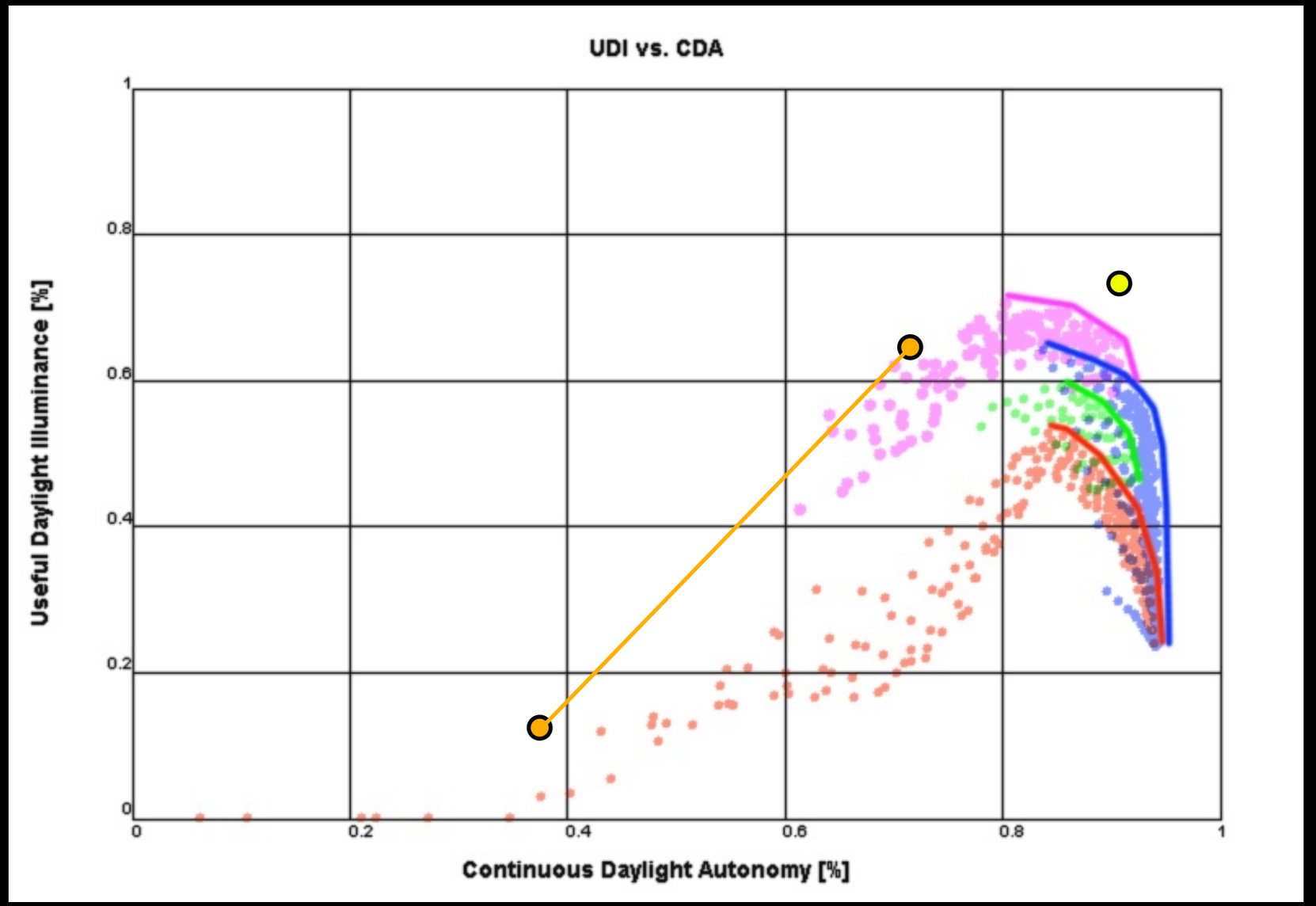



Useful Daylight Illuminance
Automated Venetian Blinds
100%
80%
60%
40%
20%
0%
93%
Interstitial Venetian Blinds


Continuous Daylight Autonomy
Automated Venetian Blinds
100%
80%
60%
40%
20%
0%
72%
Interstitial Venetian Blinds

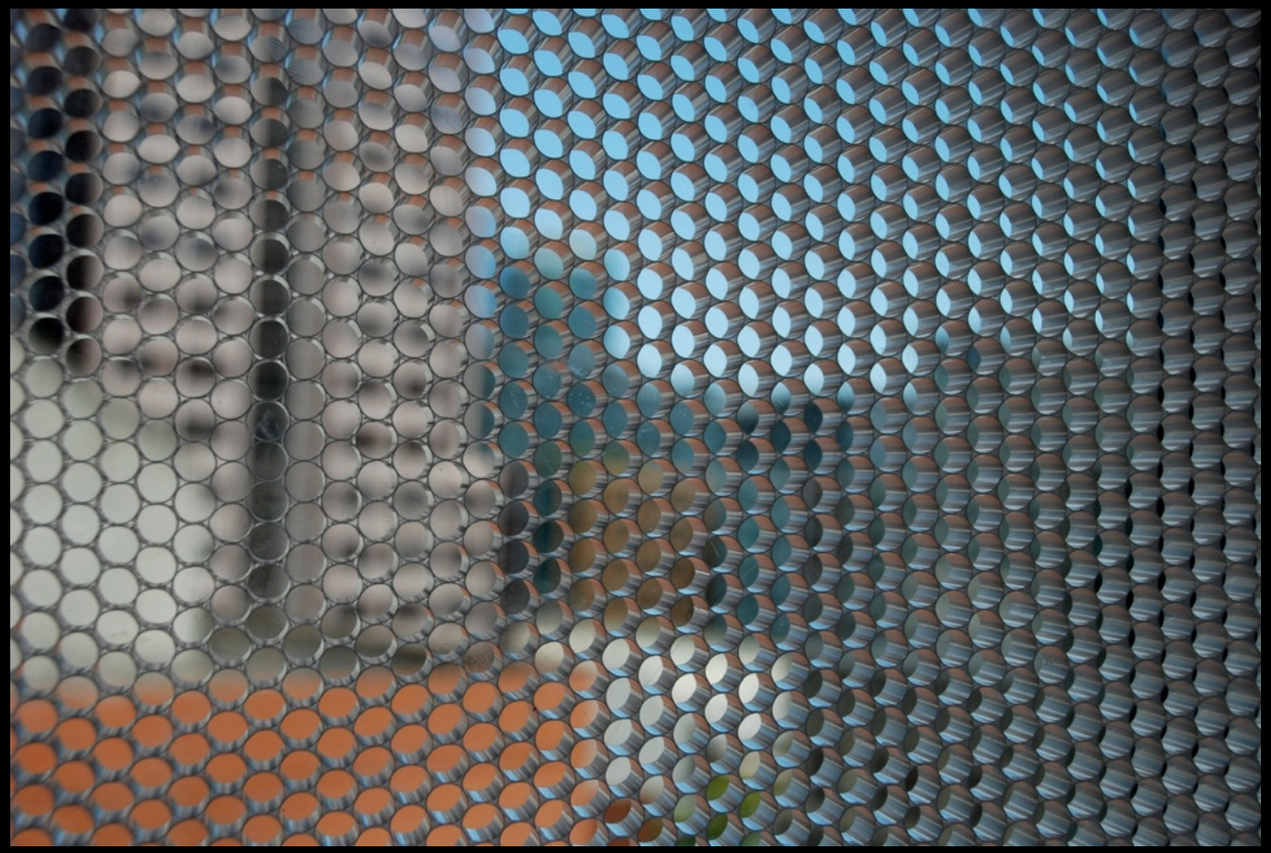


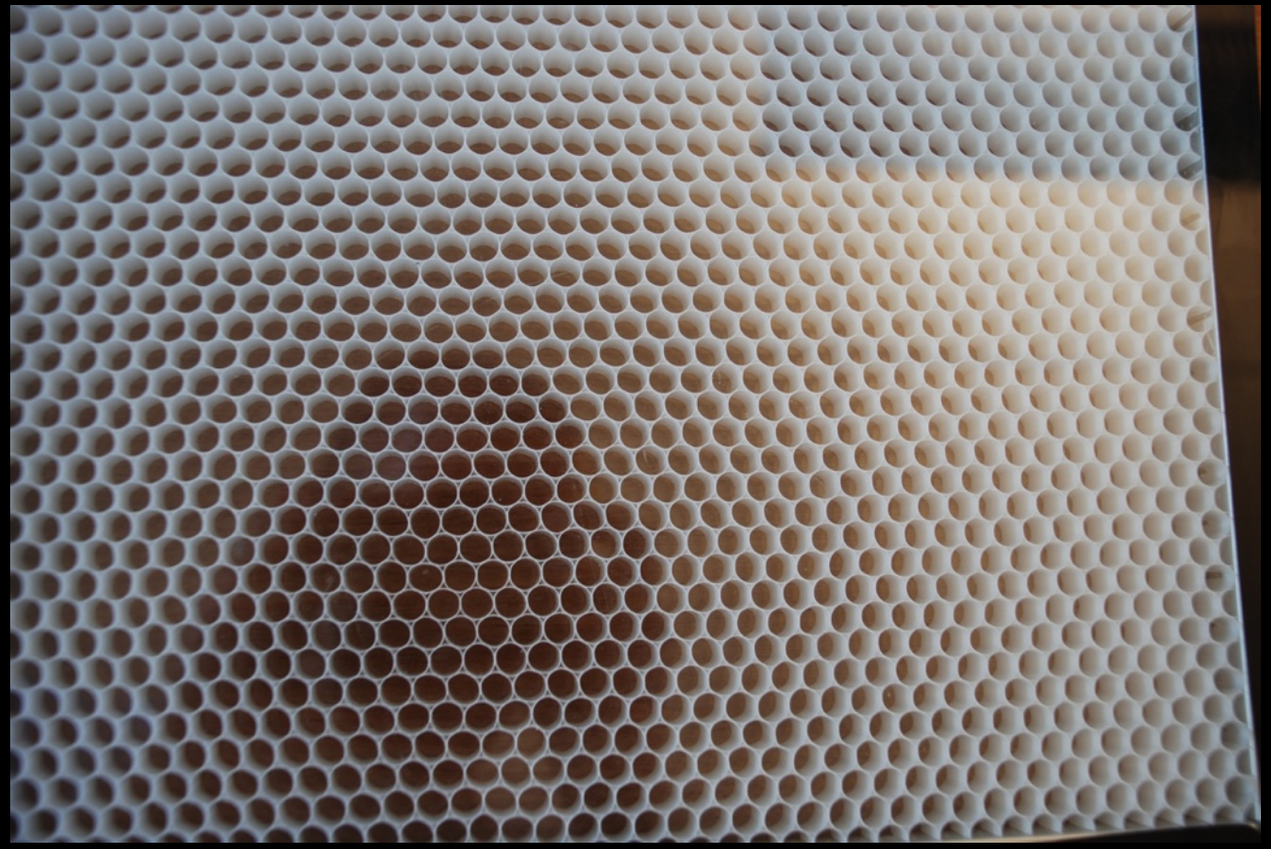


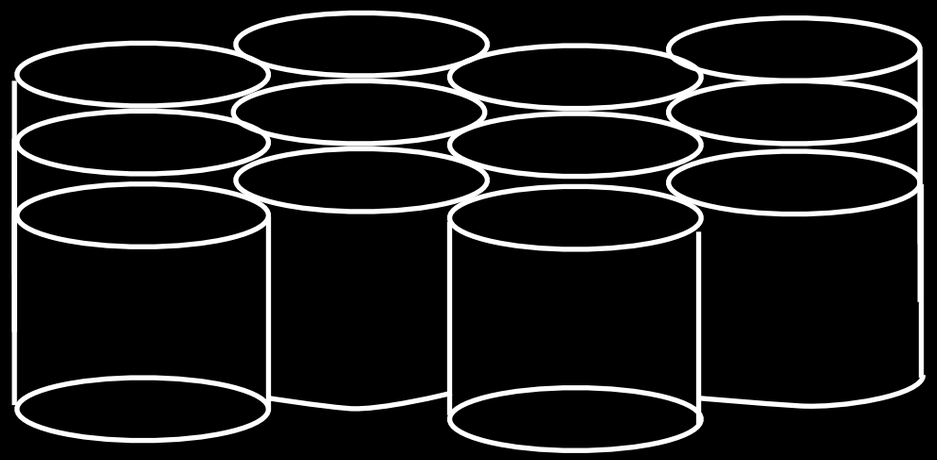

UDI vs. CDA
Useful Daylight Illuminance [%]
Continuous Daylight Autonomy [%]
0
0.2
0.4
0.6
0.8
1

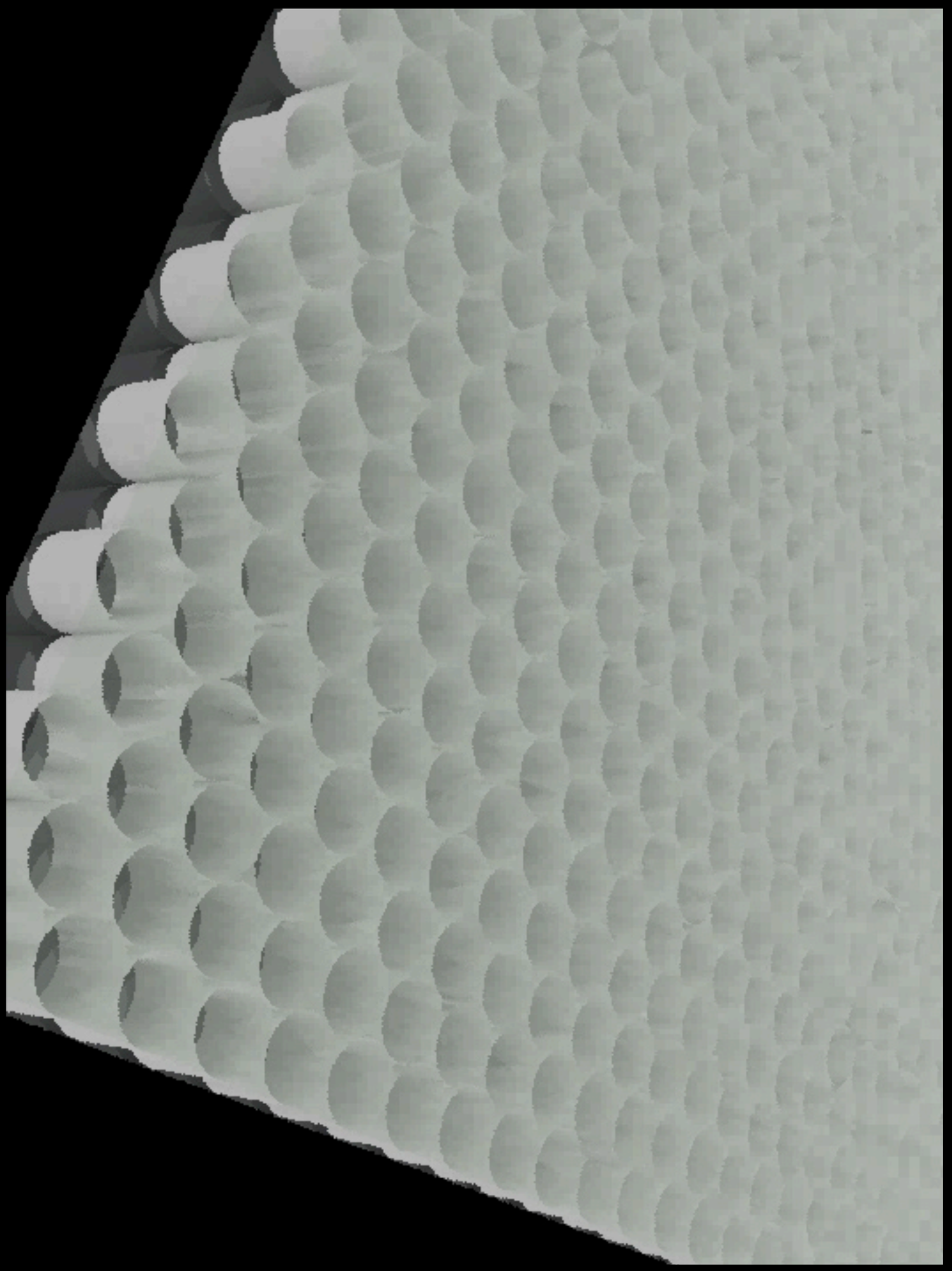
rtcontrib goniophotometer

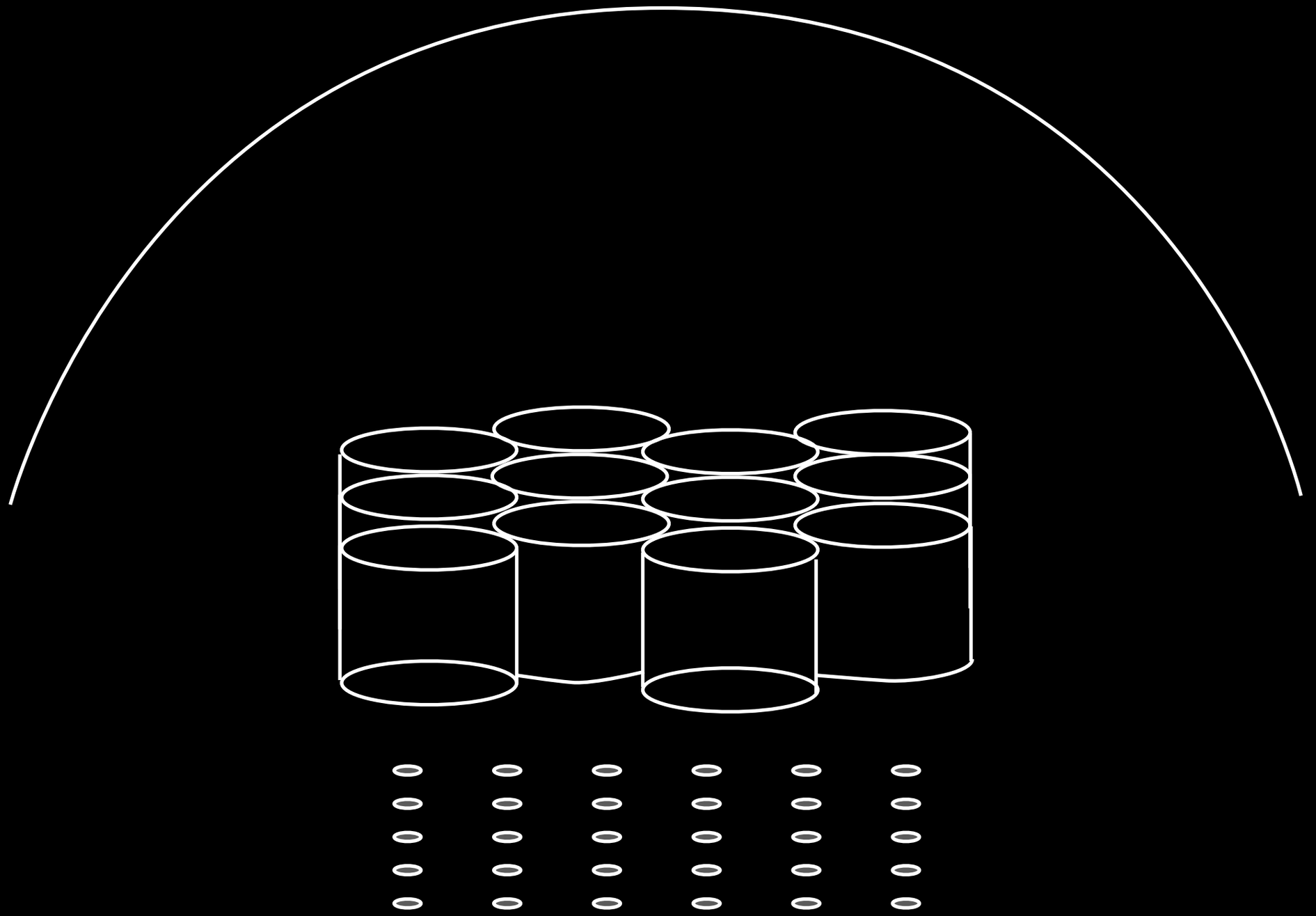
(leaping before looking)

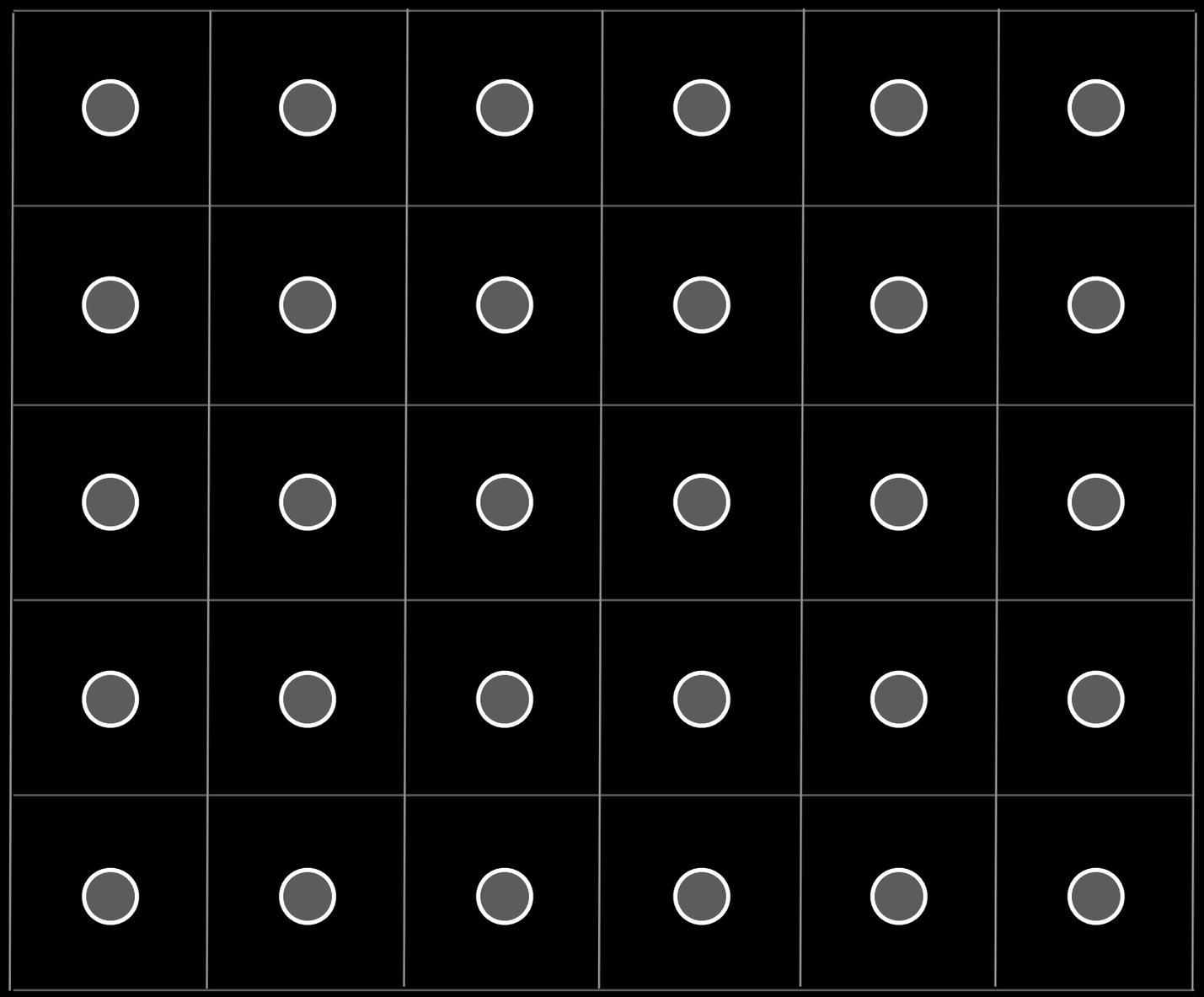


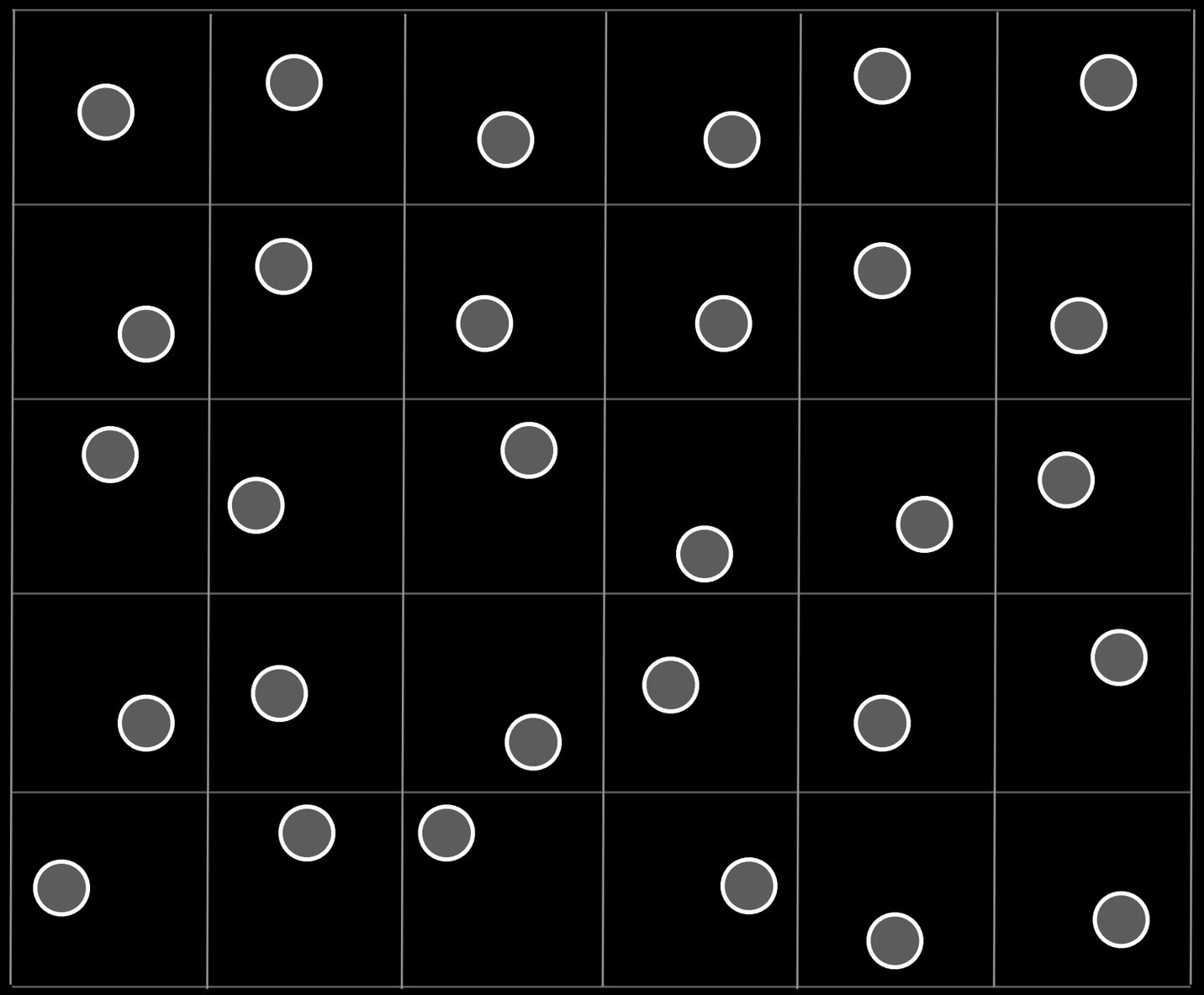


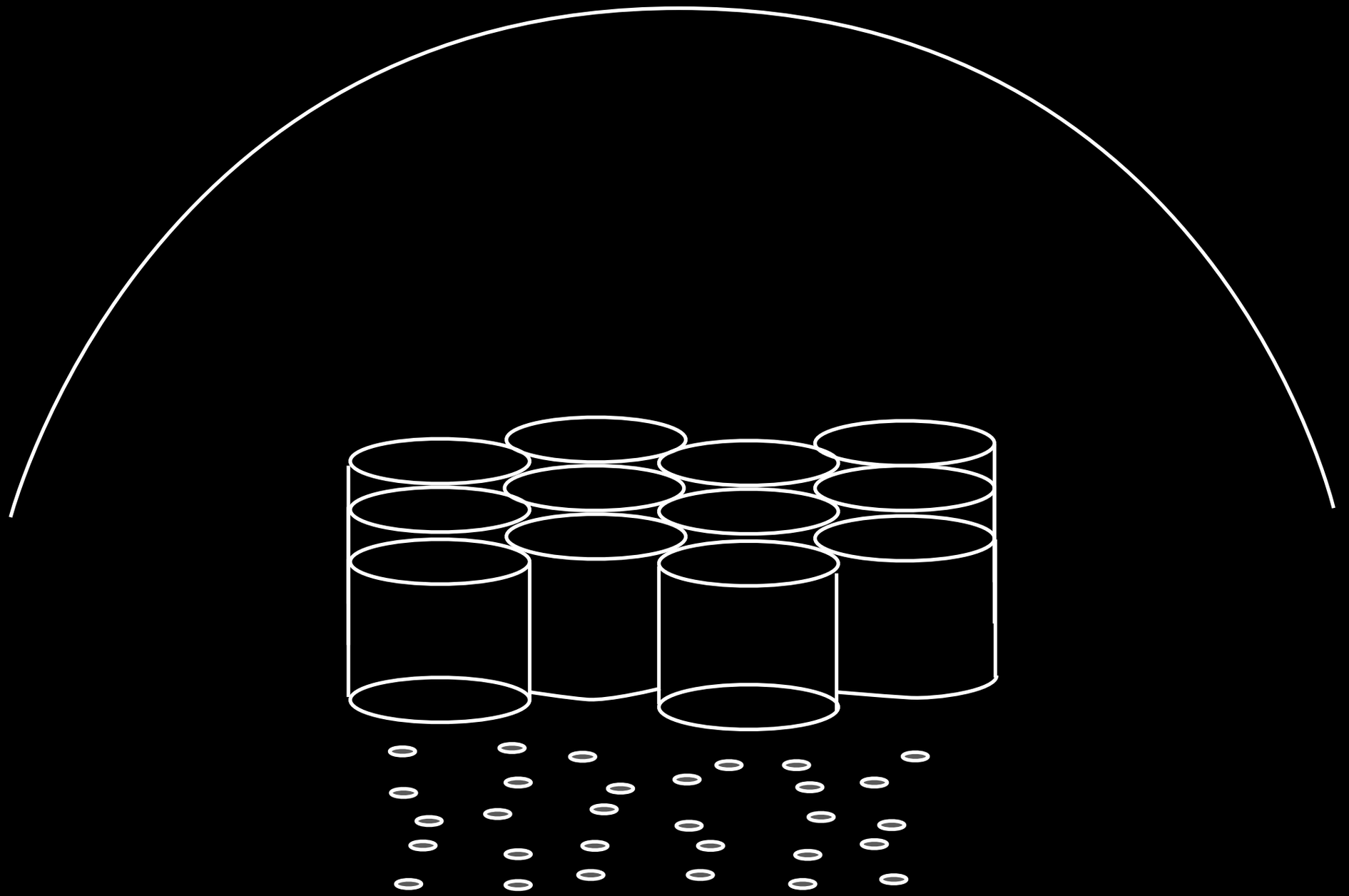


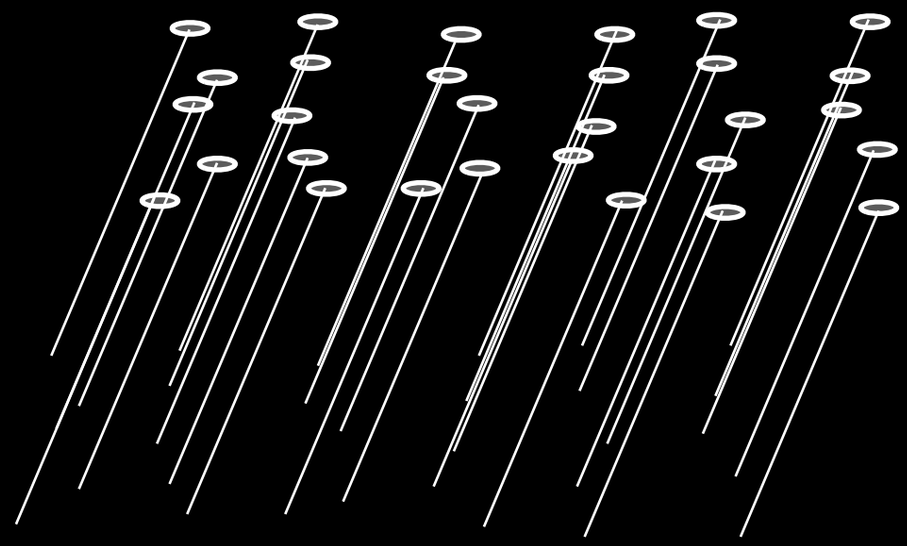


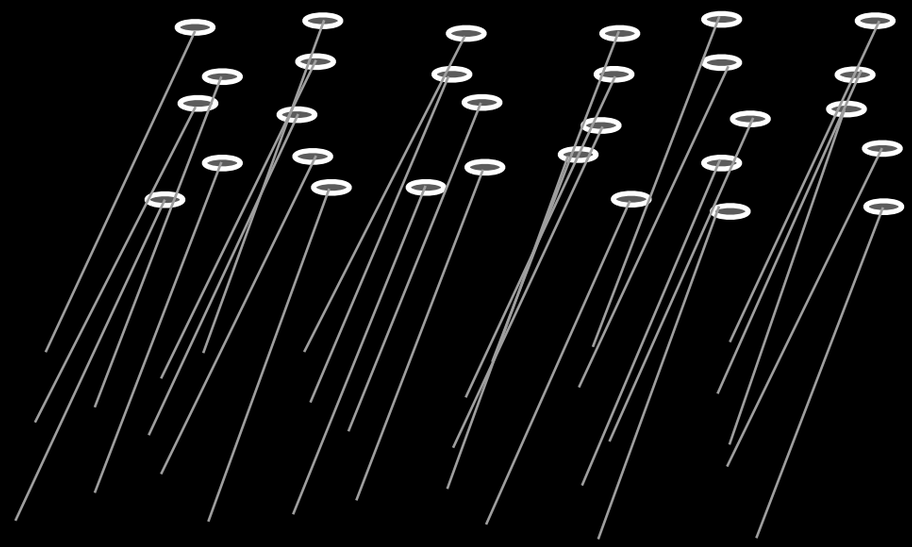


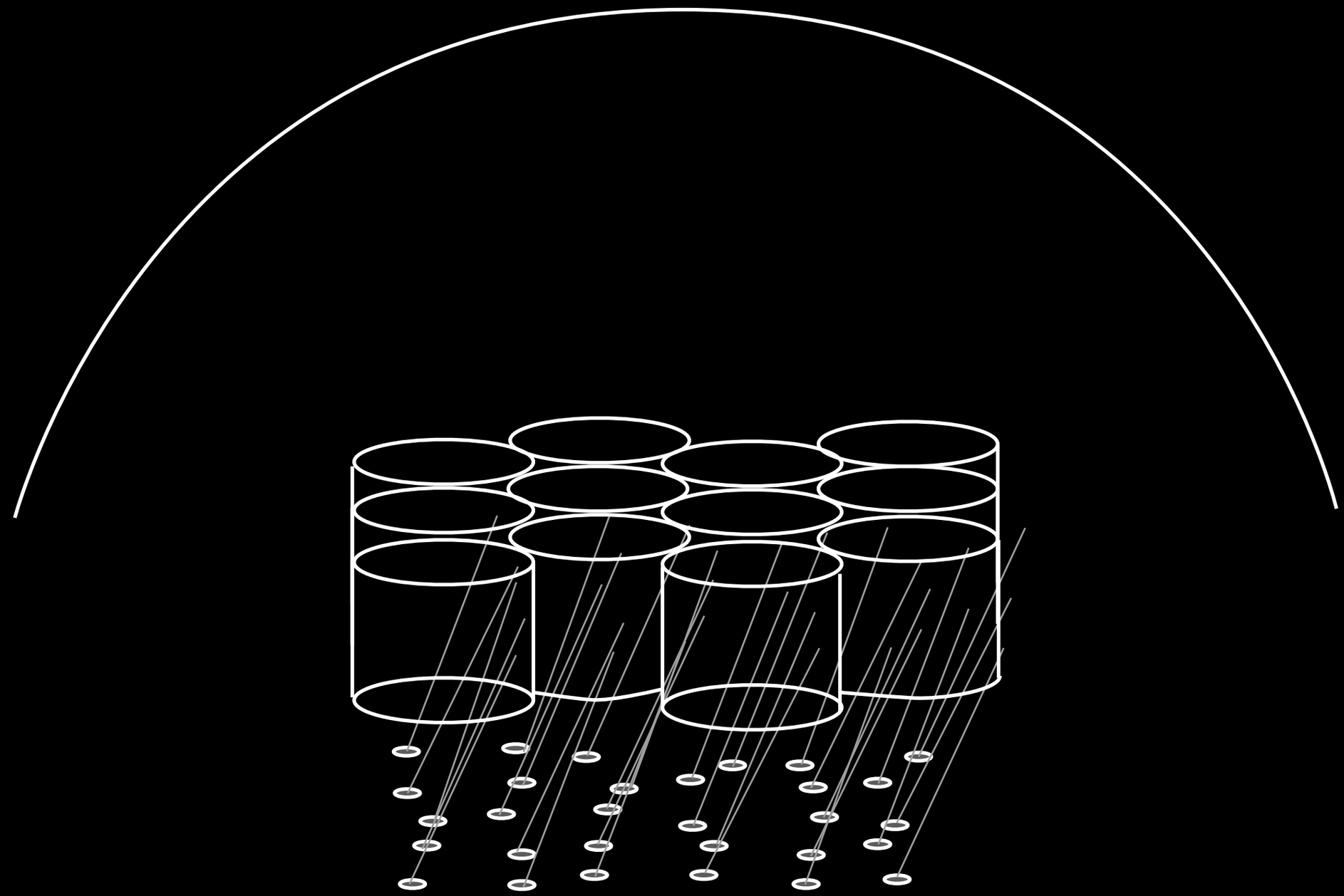








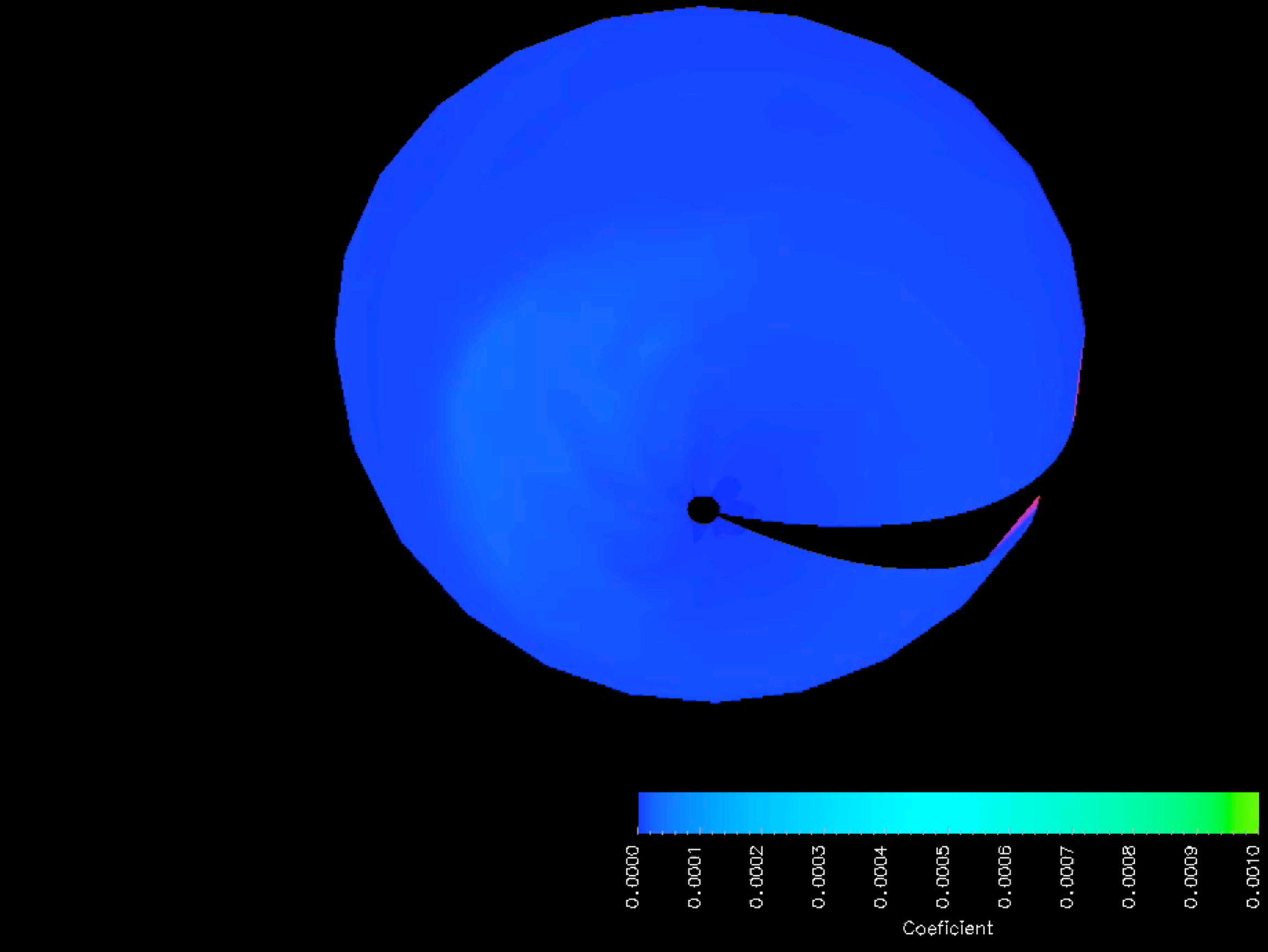




```
rtcontrib -h- -w -faa -n 2 -ab 5 -ad 3000 -as 0 -st .01 -lw .0000005 \
        -b tbin -bn 432 -m skyglow -f phitheta.cal < test.dat testmodel.oct \
        | total -m | rgb2lum -m 1 >> output.dat
```

24 phi angles (15 degrees apart)

18 theta angles (5 degrees apart)


0.0000
0.0001
0.0002
0.0003
0.0004
0.0005
0.0006
0.0007
0.0008
0.0009
0.0010
Coeficient

Converting to Window XML

"Make sure you understand the actual theta-phi data for the 3 Basis that we have defined – Standard Basis, Half Basis, or Quarter Basis"

- Robin, LBNL

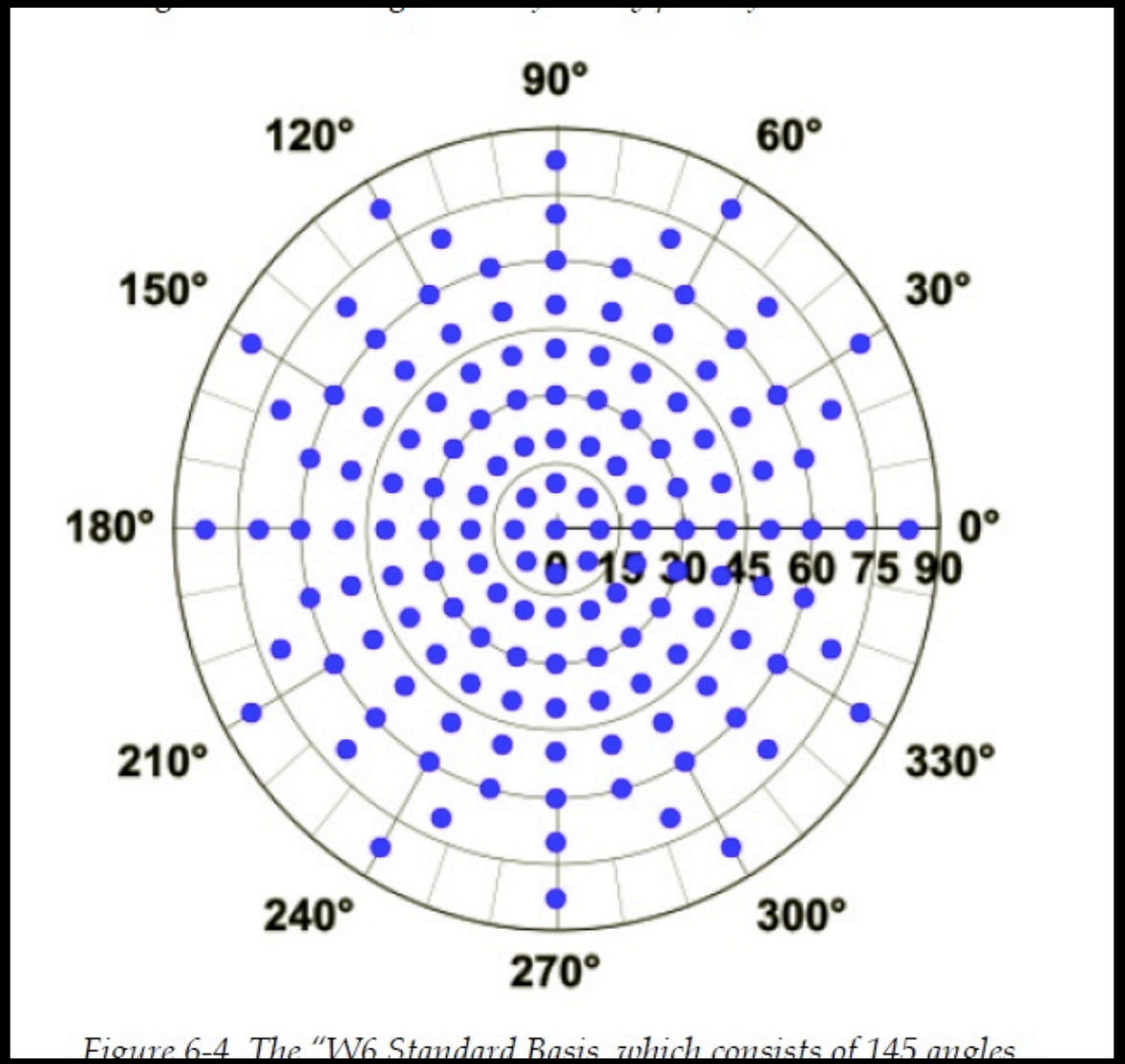


Figure 6-4. The "W6 Standard Basis, which consists of 145 angles

<AngleBasisName>LBNL/Klems Full</AngleBasisName>
<AngleBasisBlock>
<Theta>0</Theta>
<nPhis>1</nPhis>
<ThetaBounds>
<LowerTheta>0.000000</LowerTheta>
<UpperTheta>5.000000</UpperTheta>
</ThetaBounds>
</AngleBasisBlock>
<AngleBasisBlock>
<Theta>1</Theta>
<nPhis>8</nPhis>
<ThetaBounds>
<LowerTheta>5.000000</LowerTheta>
<UpperTheta>15.000000</UpperTheta>
</ThetaBounds>
</AngleBasisBlock>

bsdf.c:

/* XXX need to add routines for loading in foreign bases */

bsdf.c:

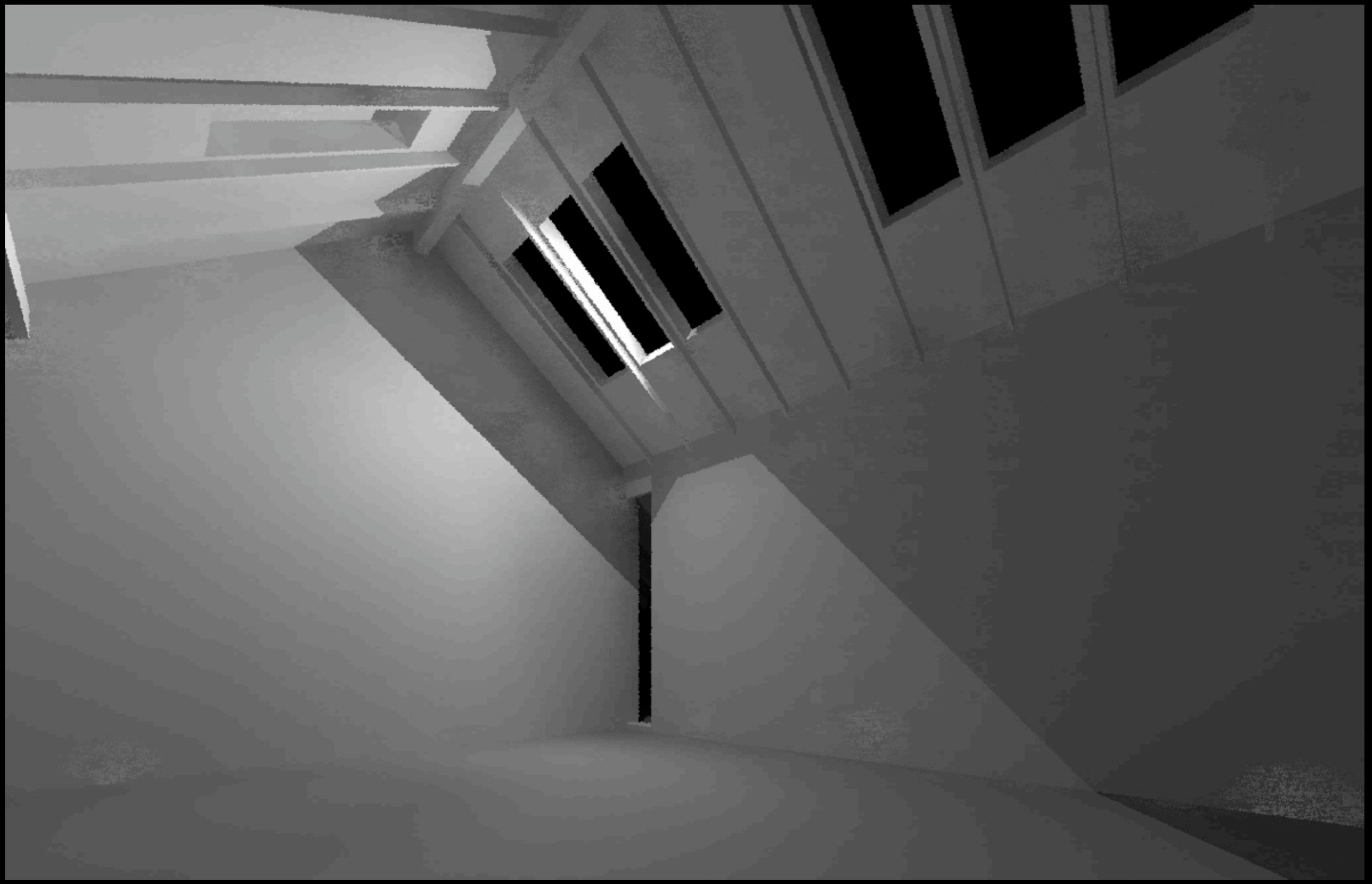
```
  static int  nabases = 3; /* current number of defined bases */

  static ANGLE_BASIS   abase_list[MAXABASES] = {
      {
          "LBNL/Klems Full", 145,
          { {-5., 1},
          {5., 8},
          {15., 16},
          {25., 20},
          {35., 24},
          {45., 24},
          {55., 24},
          {65., 16},
          {75., 12},
          {90., 0} }
  }, {
```

bsdf.c:

```
static int  nabases = 4; /* current number of defined bases */

static ANGLE_BASIS   abase_list[MAXABASES] = {
      }, {
            "Andy432", 432,
            { {0., 24},
            {5., 24},
            {10., 24},
            {15., 24},
            {20., 24},
            {25., 24},
            {30., 24},
            {35., 24},
  ...
  }}};
```



Aside from a 90 degree rotation in light transport (whoops) it works!

Thank you