Dynamic daylight simulations for façade optimization (and some other applications)

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7th International RADIANCE workshop
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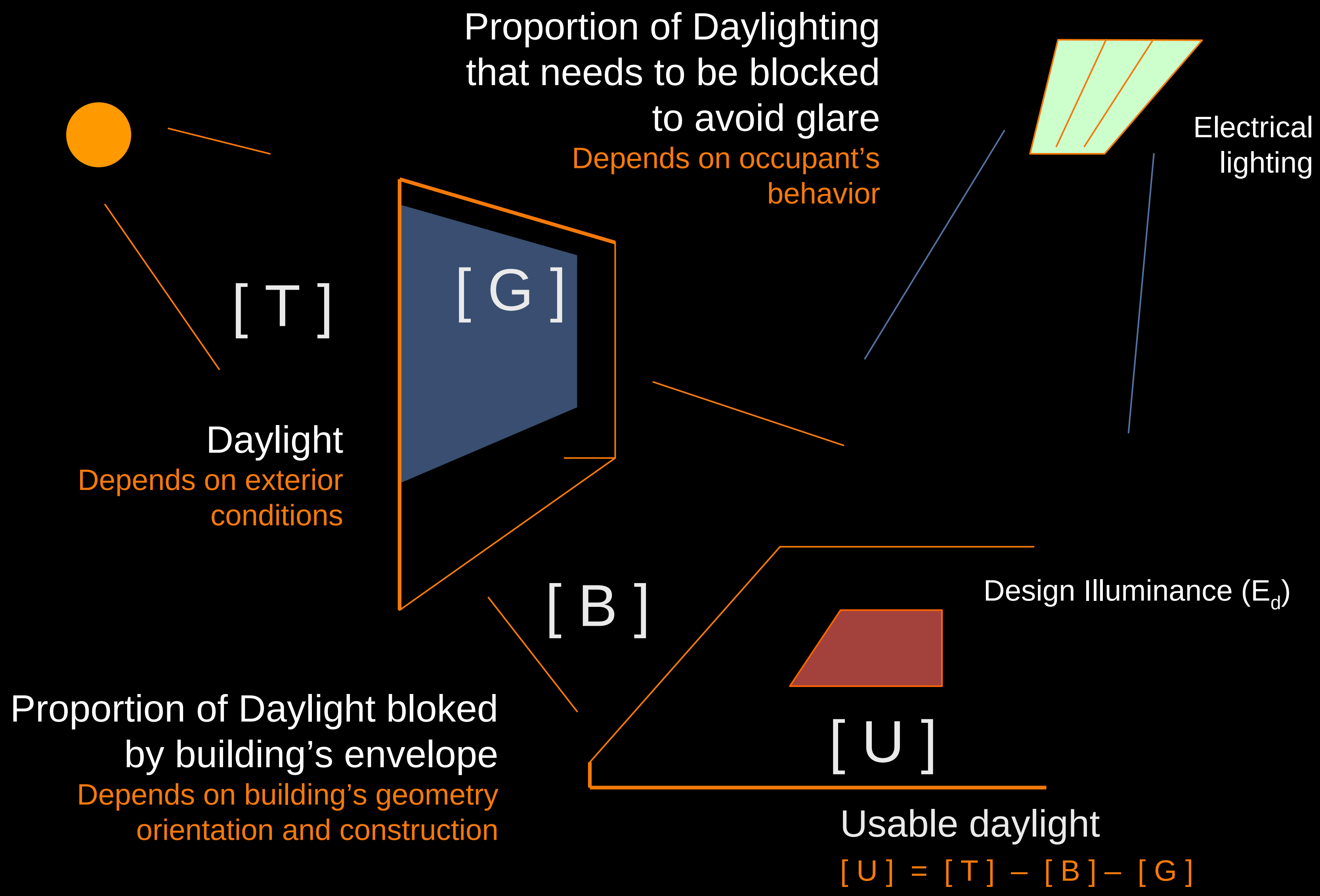
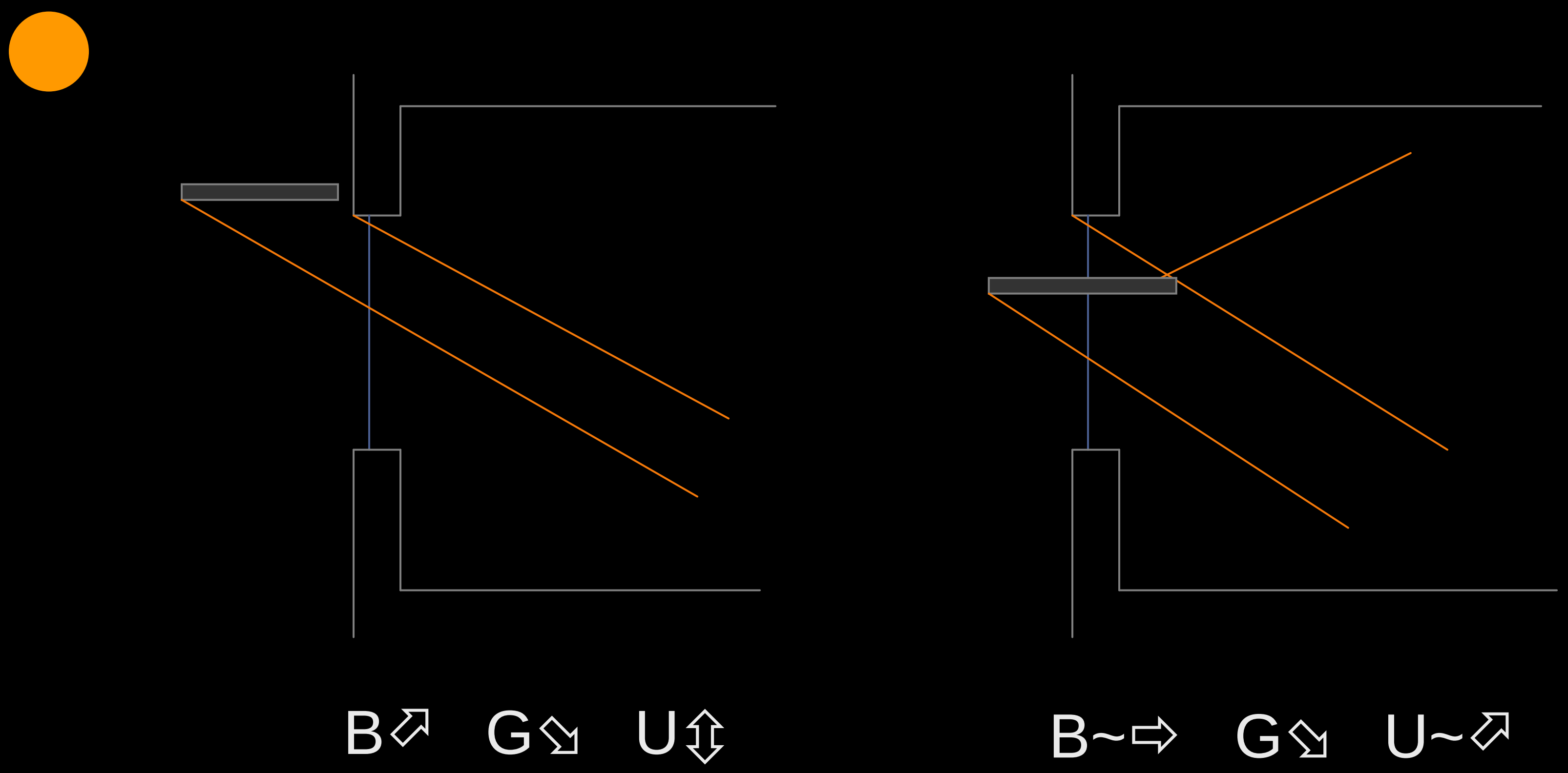
ARUP

Background


Proportion of Daylighting
that needs to be blocked
to avoid glare
Depends on occupant's
behavior
Electrical
lighting
[T]
[G]
Daylight
Depends on exterior
conditions
[B]
Design Illuminance (E_d)
[U]
Proportion of Daylight bloked
by building's envelope
Depends on building's geometry
orientation and construction
Usable daylight
[U] = [T] – [B]– [G]

Background



Relevant factors

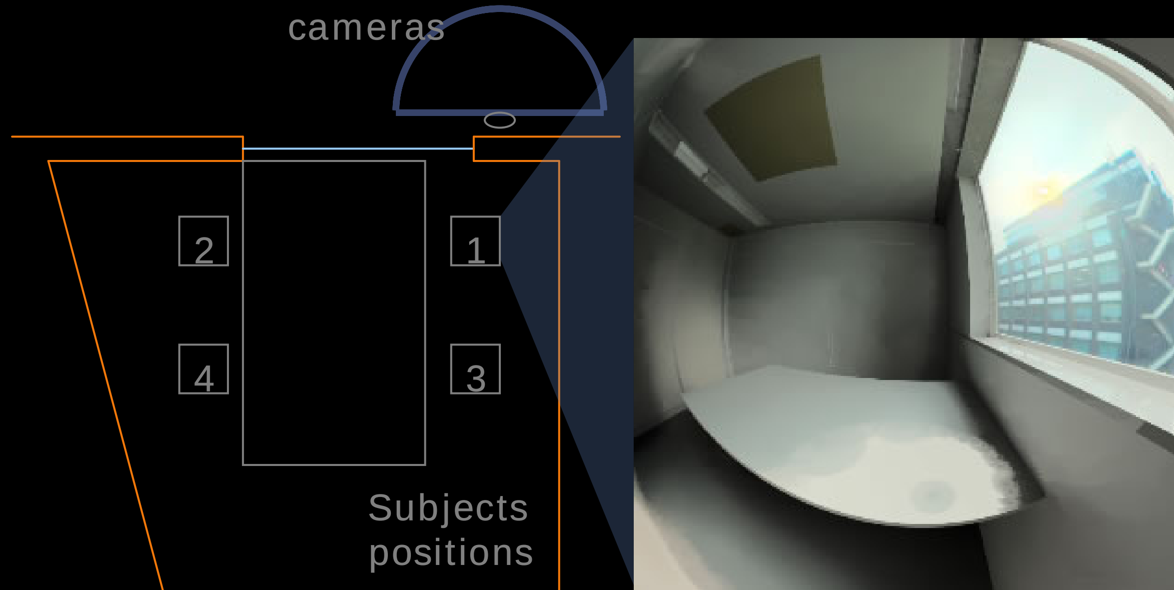
Considered

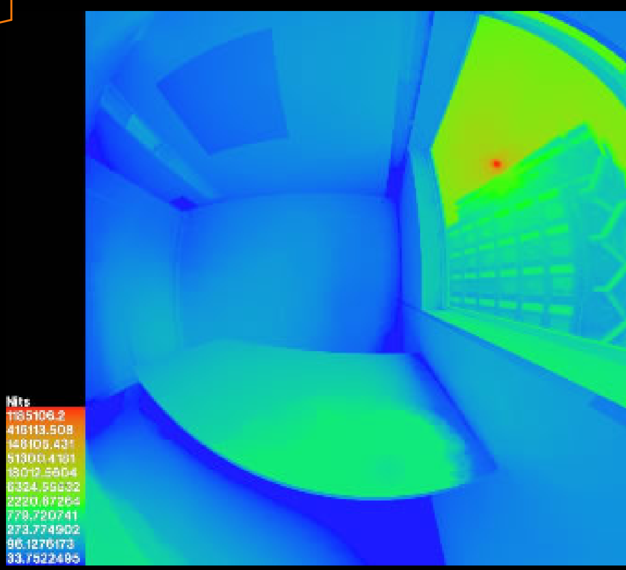
- Climate
- Facade geometry
- Occupant’s response to glare
- Resulting illuminance on work plane

Not considered

- Furniture location
- Lighting control strategies
- Sensor placement
- Type of luminaire / type of blinds
- Diffusing window panes
- … etc.

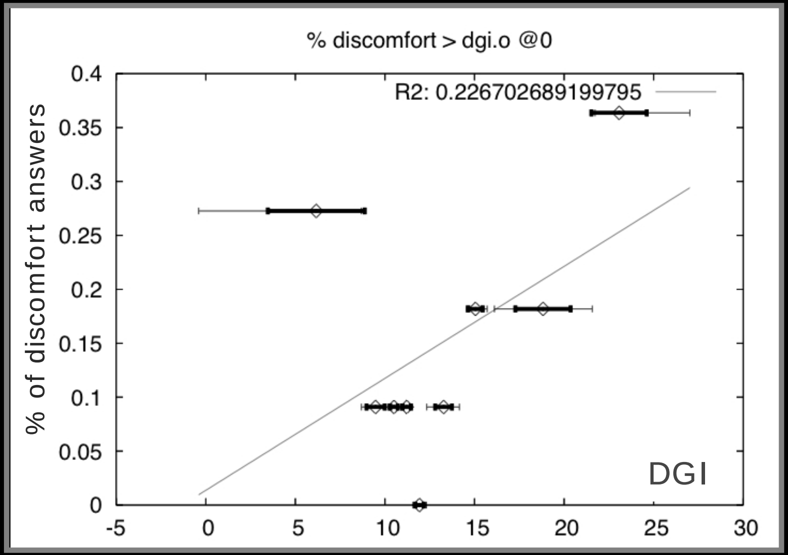
Assessment of glare conditions

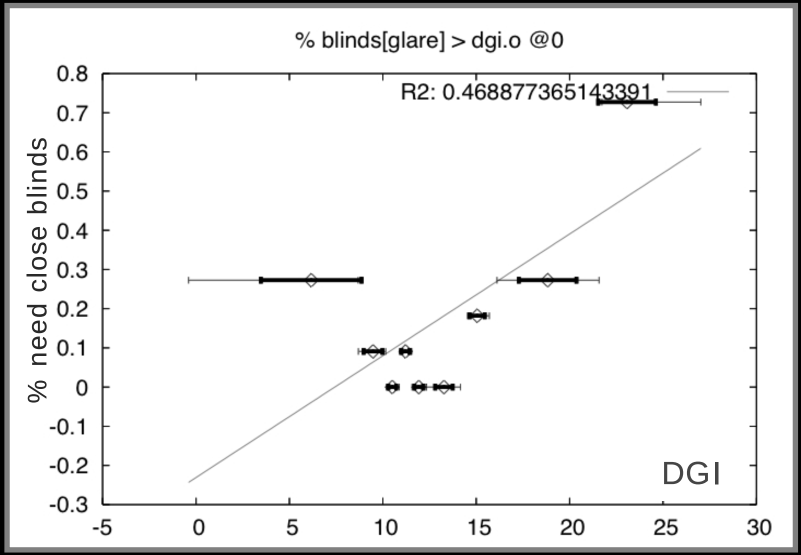


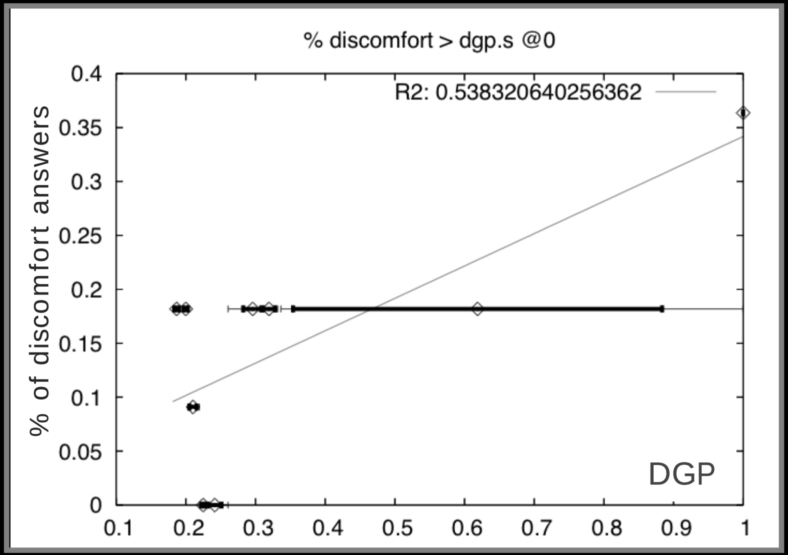


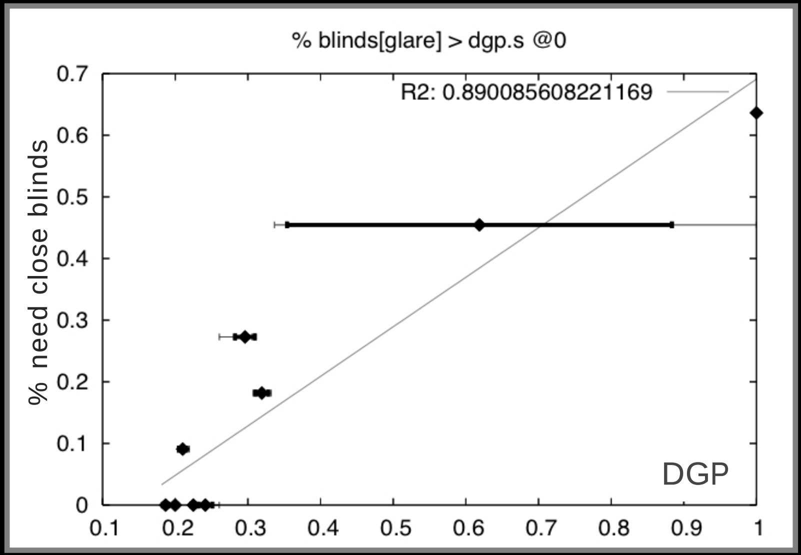
Assessment of glare conditions

Survey answers compared to calculated glare (% dissatisfied vs. glare index)









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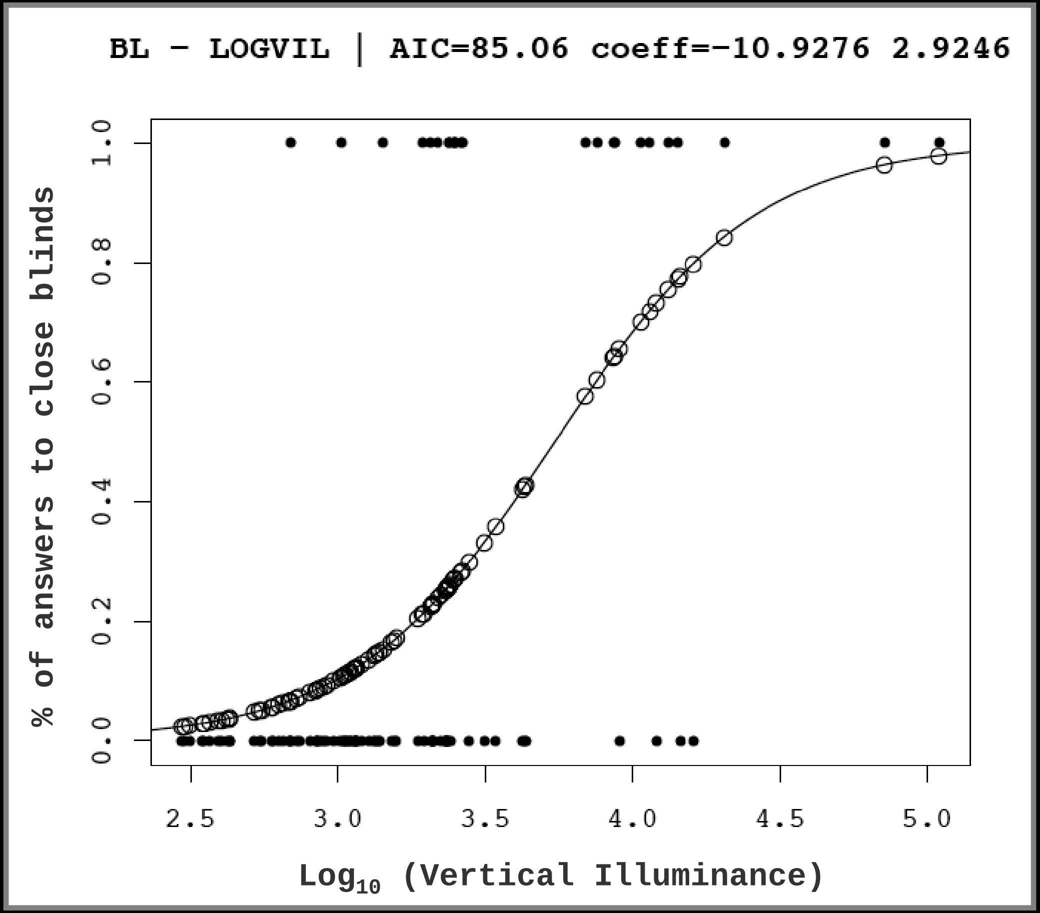
Survey answers compared to calculated glare (% of answers for closing blinds)



Optimization by a **simple** genetic algorithm

Obtain a new generation
(10 individuals)

↓

Produce new individuals
by mutation, crossover, etc.

↓

Generate Radiance
geometry ← Character encoding

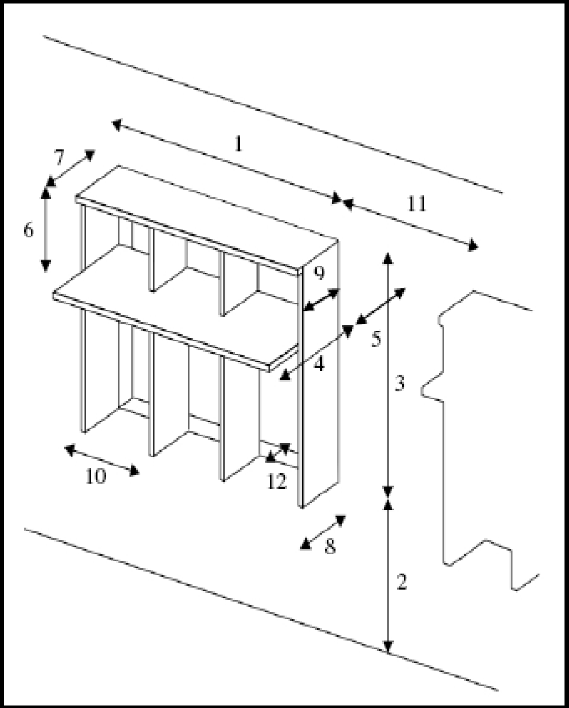
↓

Calculate the Fitness
of each ← Dynamic simulation

↓

Select best 10

Model definition



1-window width
2-sill height
3-window height
4-ext lightshelf depth
5-int lightshelf depth
6-lightshelf height
7-overhang depth
8-low sunshade depth
9-high sunshade depth
10-Nr. Shades / window
11-Nr. Windows
12-window sill depth
13-wall reflectance
14-ext lightshelf reflec.
15-int lightshelf reflec.
16-window sill reflec.
17-sunshade reflectance
18-window size factor
19-shading size factor
20-window transmission
21-reflective Lightshelf (Y/N)

1 Determine sky conditions from weather data

2 Calculate discomfort of users from glare probability index

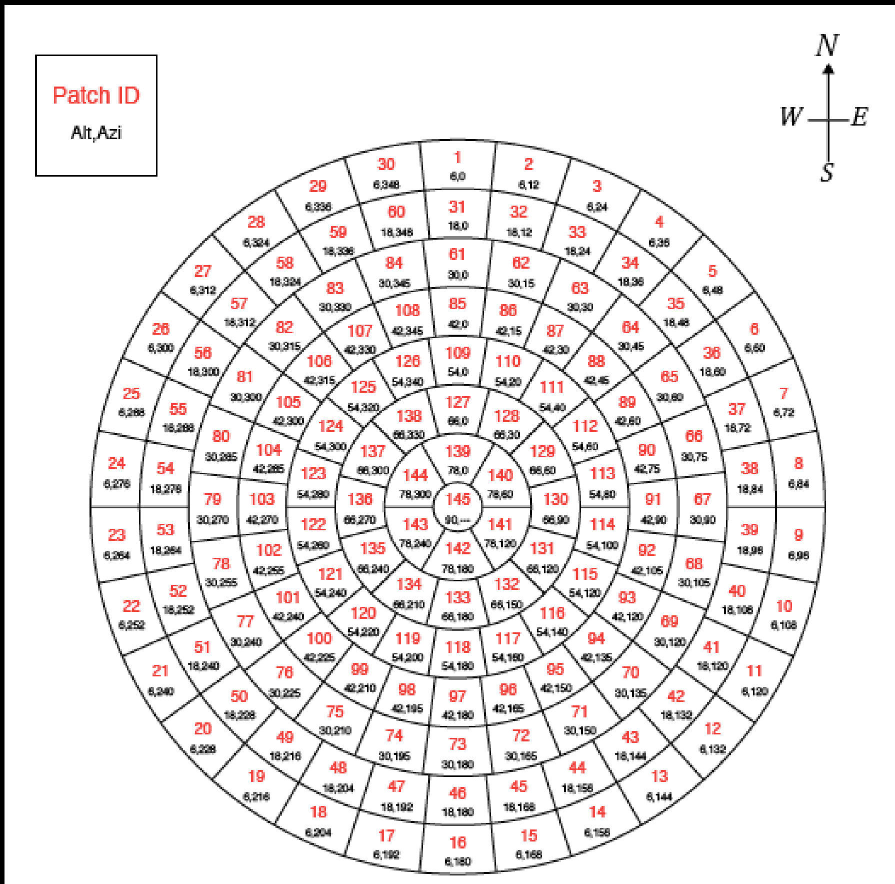
3 Determine the position of blinds
(open - closed) proportionally to discomfort

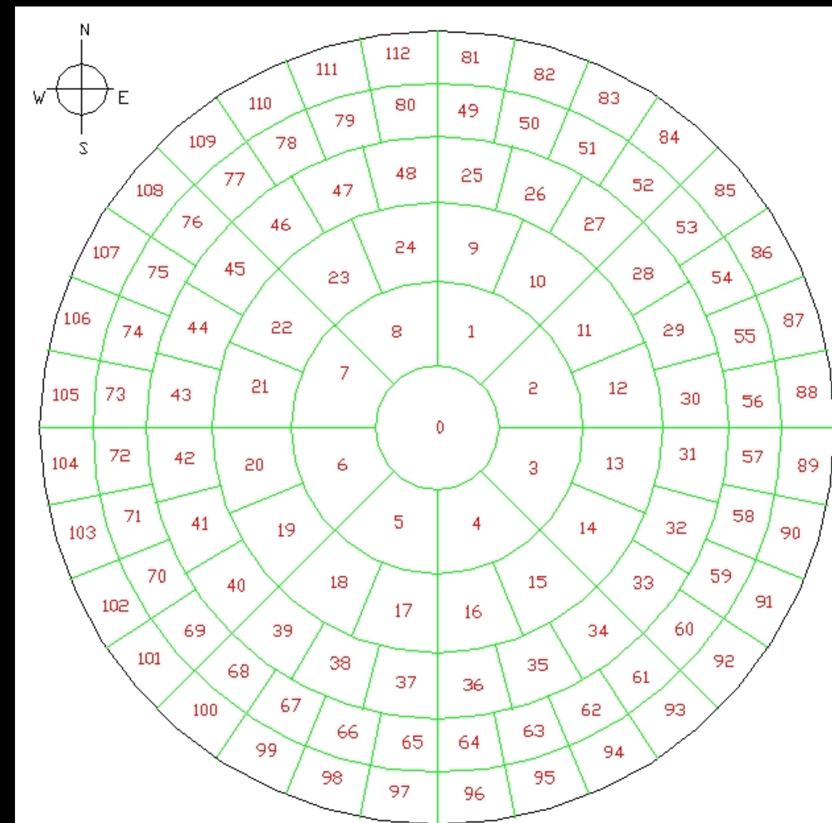
4 Calculate daylight illuminance on work plane considering the position of blinds ($0 \leq U_{ho} \leq E_d$)

5 Calculate Fitness
with data from all hours

$$F = \frac{U_a}{500lx} = \frac{\sum_h^H \sum_o^O U_{ho}}{H \cdot O \cdot 500lx}$$

Sky contribution (Tregenza model)





rtcontrib with sky subdivisions adapted for vertical openings

"Real" time step calculation

0 Determine contributions with blinds open and closed
(vertical at eye level and horizontal on work plane for each observer)

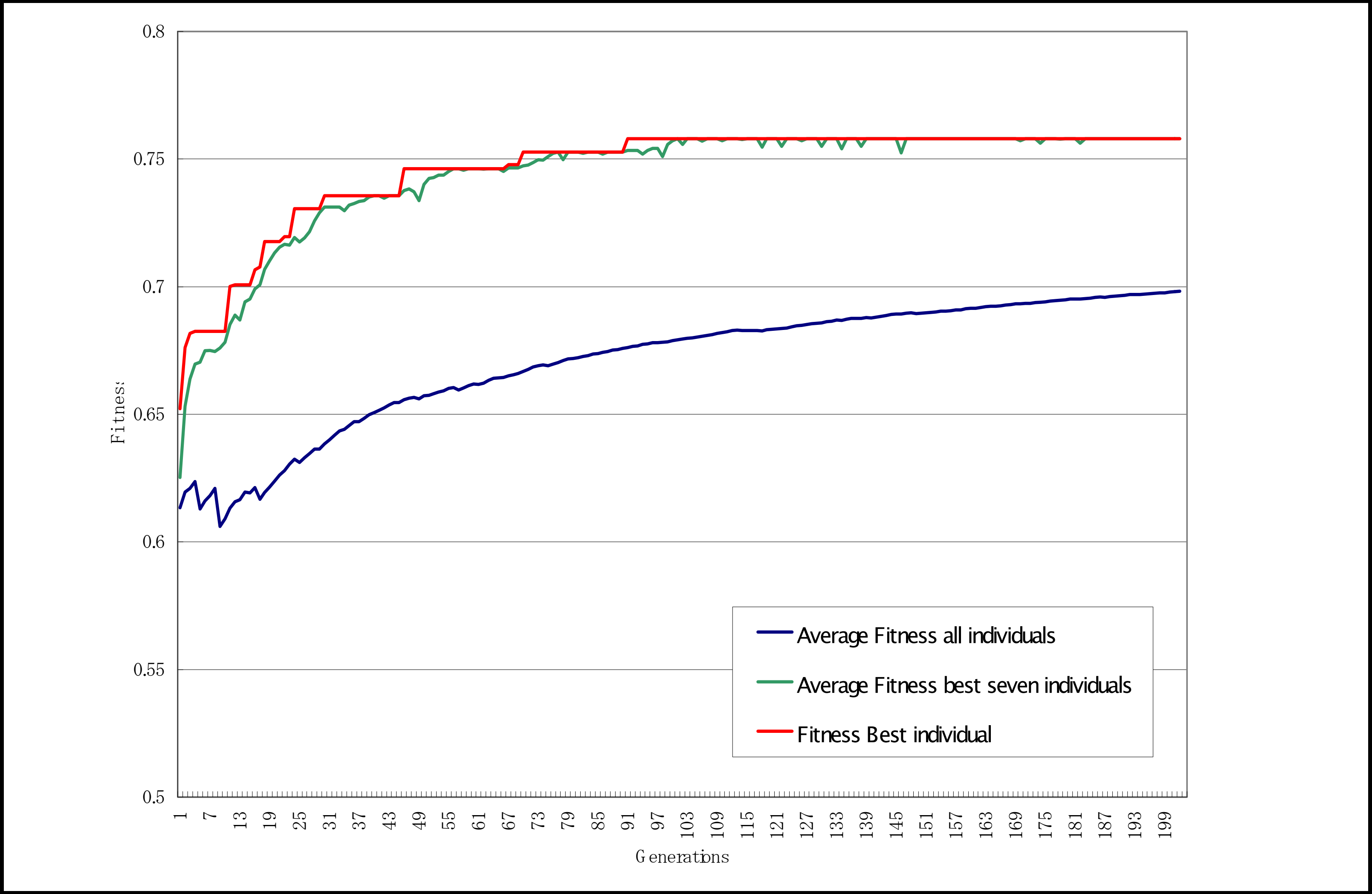
1 Calculate vertical illuminance at eye level for each observer
=> calculate discomfort glare and closing probability

2 Determine which set of contributions to use for illuminance calculations => calculate average illuminance on work plane

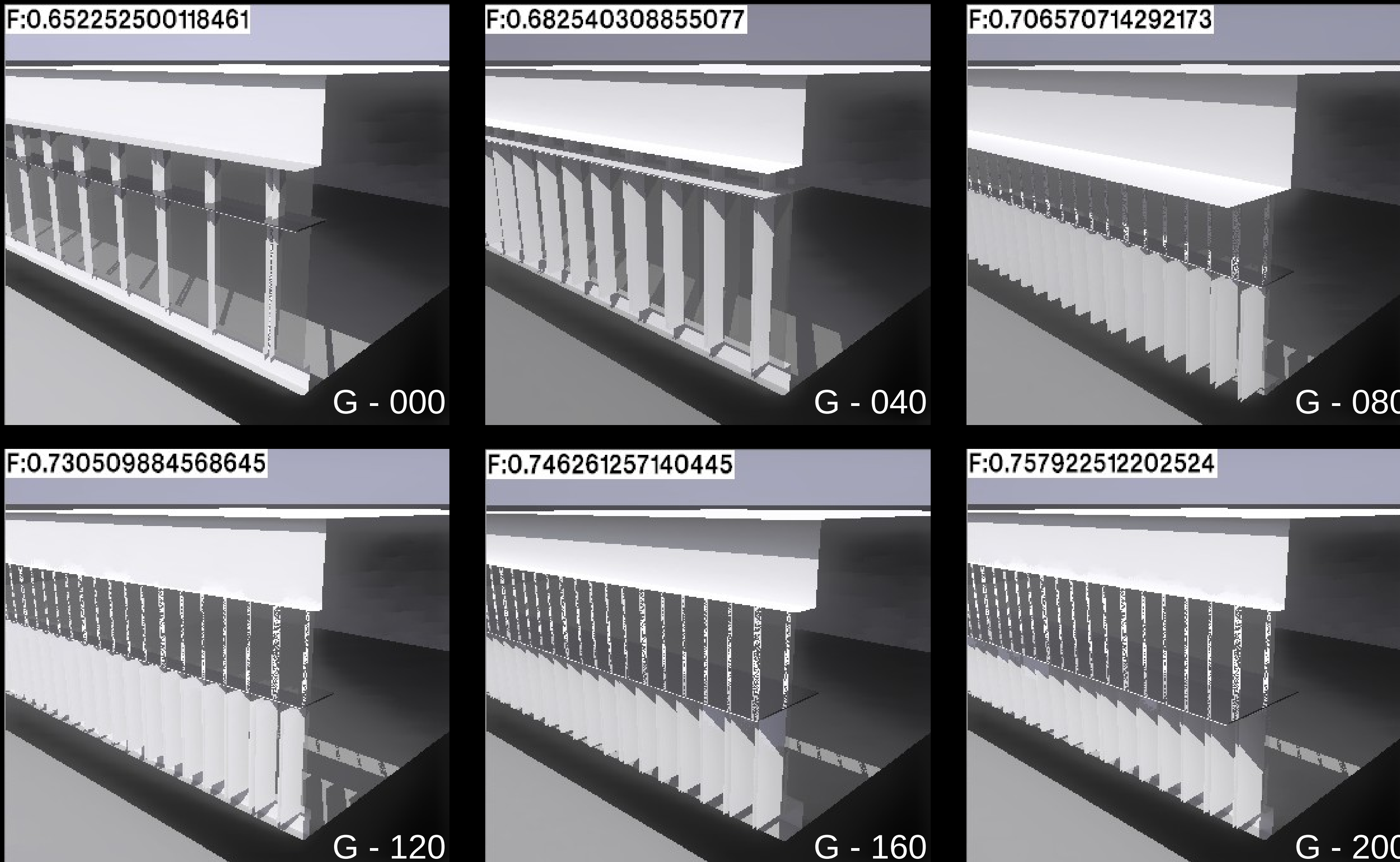
3 Add average illuminance to annual total

4 Calculate Fitness with data from all hours

Typical evolution



Typical evolution



Advantages:

- Can consider the simultaneous variation of several parameters
- Increase the relevance of the cases studied
- Complements parametric studies

Disadvantages:

- Requires large number of simulations
- Different cases may require different optimization methods

Possible improvements:

- Larger population size
- Statistical analysis of climate data to improve the significance of the days that are simulated
- Selective fitness:
  - define separate fitness for different times of the year (e.g. summer / winter) and increase the probability of breeding between complementary individuals
- Extend the model to include other factors (e.g. thermal performance)

Translucent materials in a museum environment - Background

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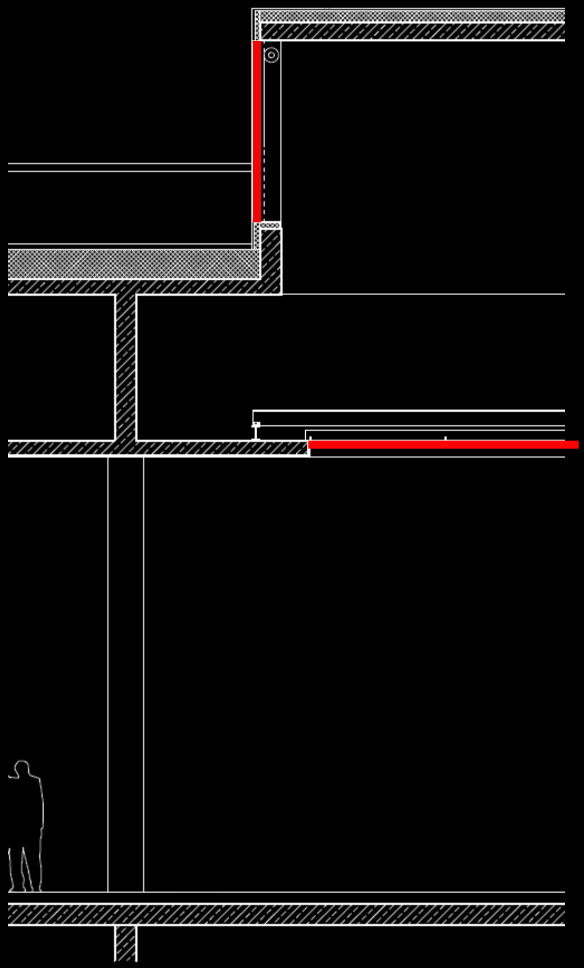
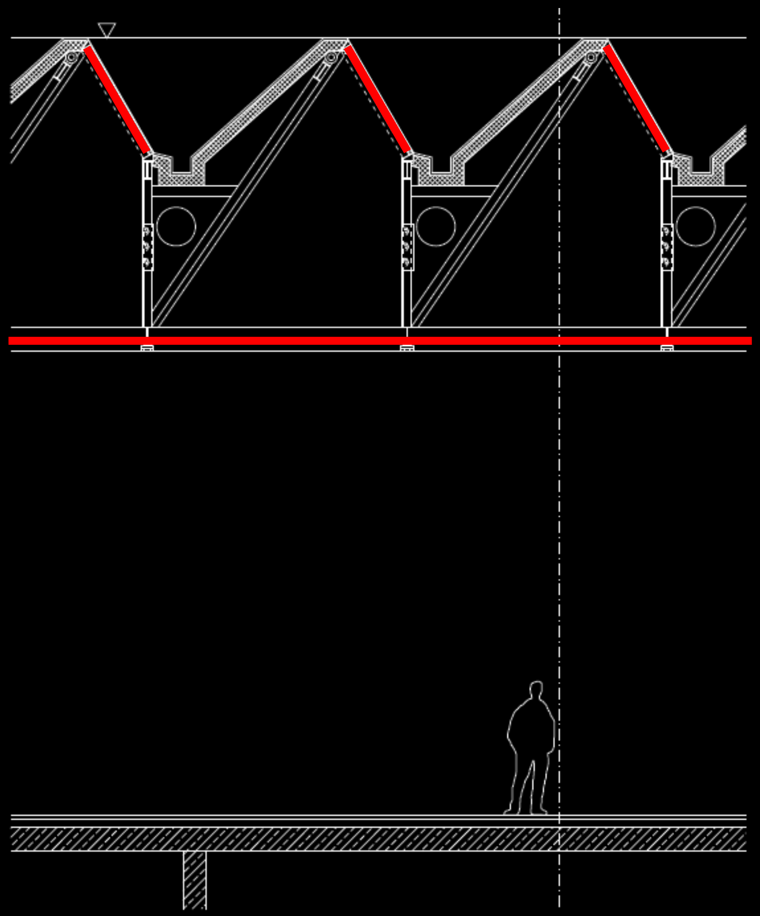
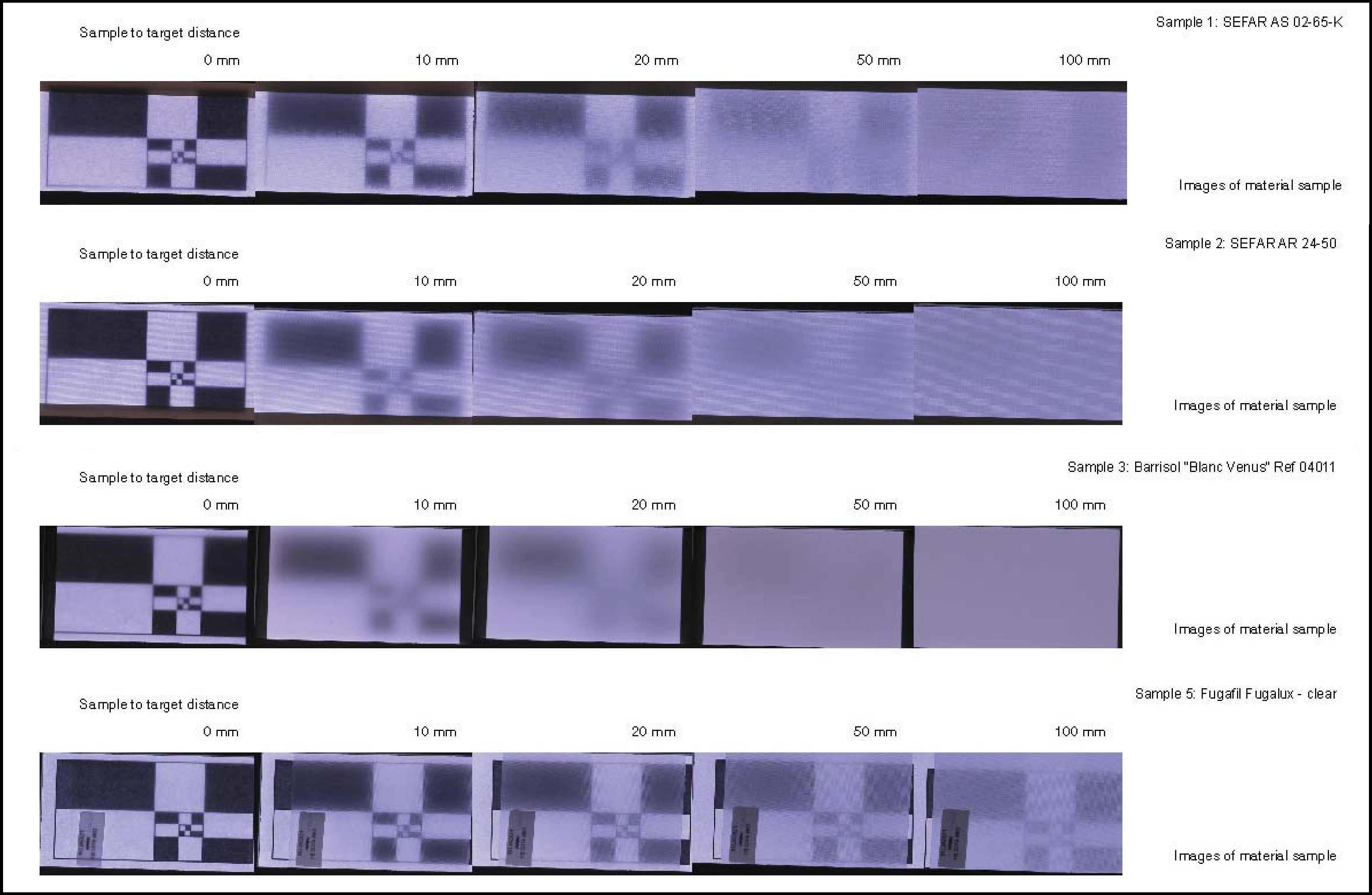
Translucent materials in a museum environment





Approximation of parameters for “trans” material



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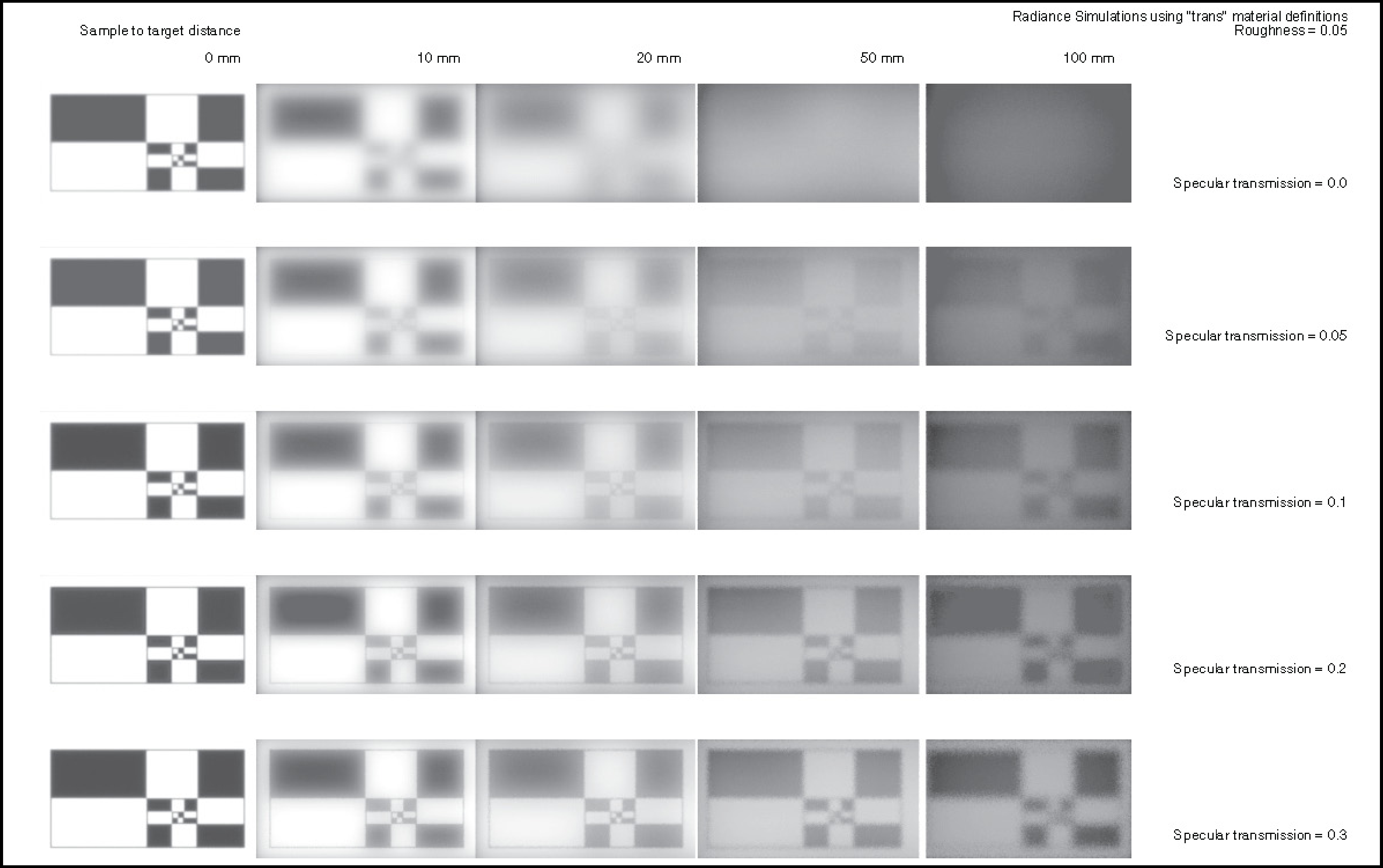
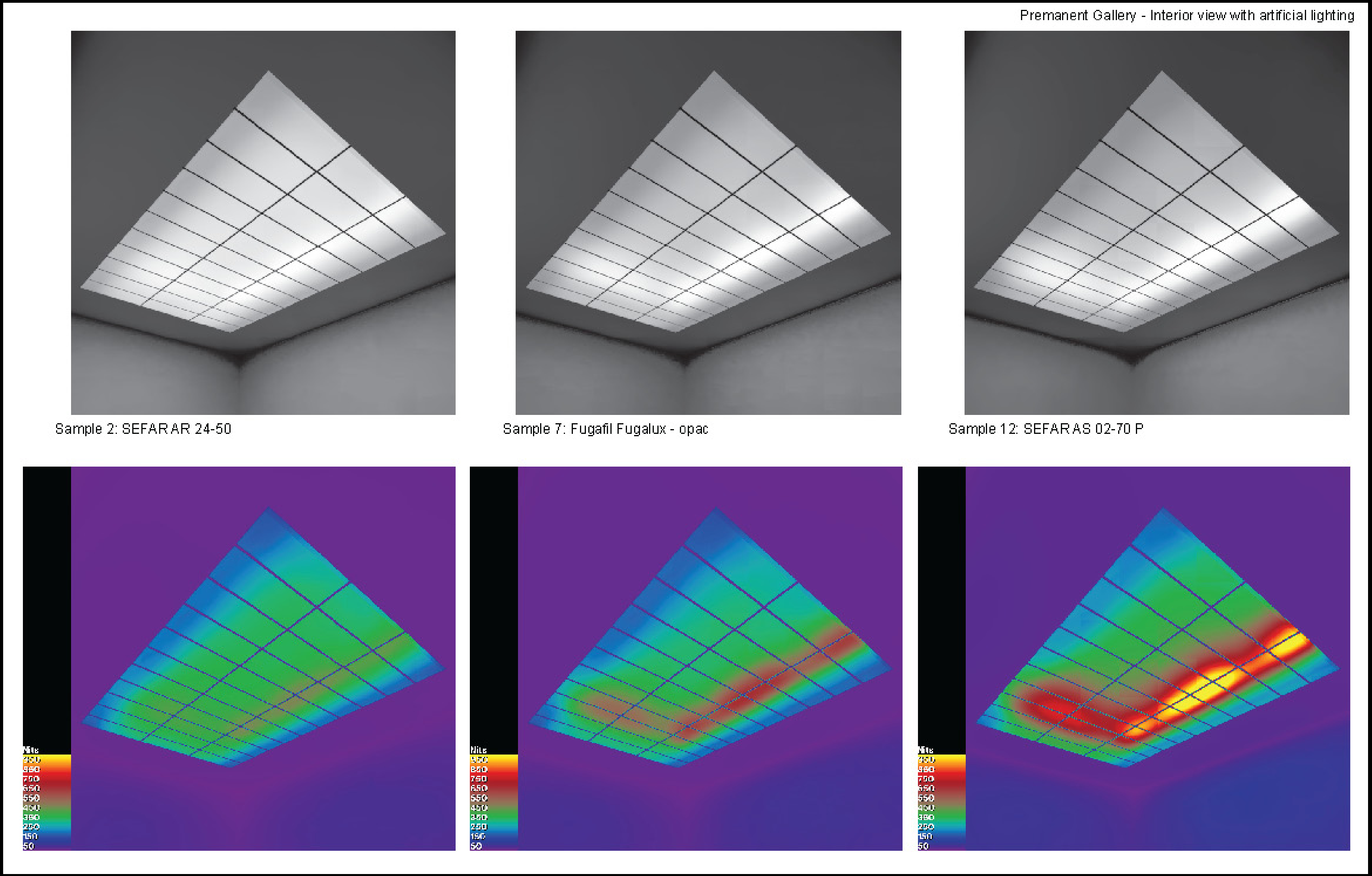


Translucent materials in a museum environment

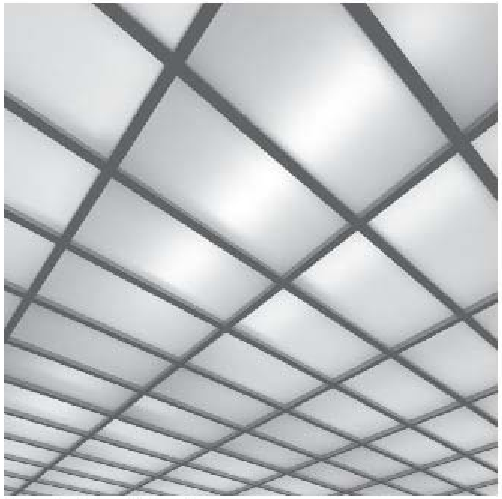


Translucent materials in a museum environment

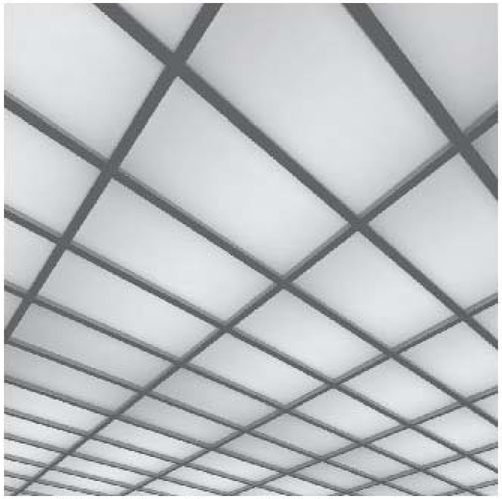
Sample 2: SEFAR AR 24-50

Sample 3: Barrisol "Blanc Venus" Ref 04011

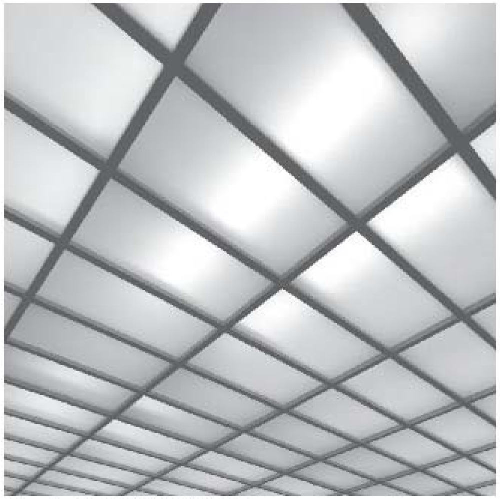
Sample 4: Cilextra Luxell 6596a



Sample 7: Fugafil Fugalux - opac



Sample 8: Fugafil Fugalite opac 790 multi



Sample 12: SEFAR AS 02-70 P