Modelling of a micro-structured, angle selective shading device in Radiance

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MicroShade™

Fraunhofer ISE

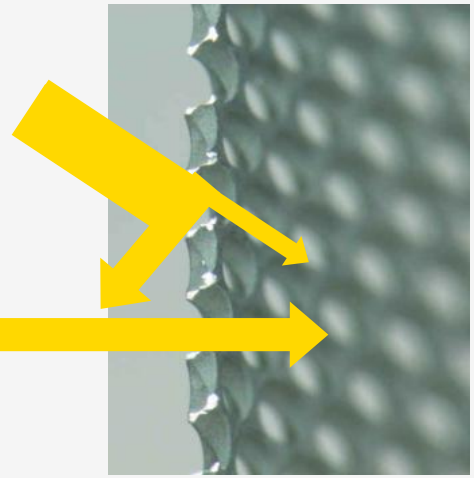
Agenda

- MicroShade™ - a complex solar shading system
- Modelling of MicroShade™
  - Geometric model
  - Functional model
- Validation of the model
- Calculation in DAYSIM
- Future work


MicroShade™: a transparent metal layer of fixed micro lamellas built into two- or three-layer glazing
Micro Shade™

MicroShade™ - a complex solar shading system

Patented micro lamella structure

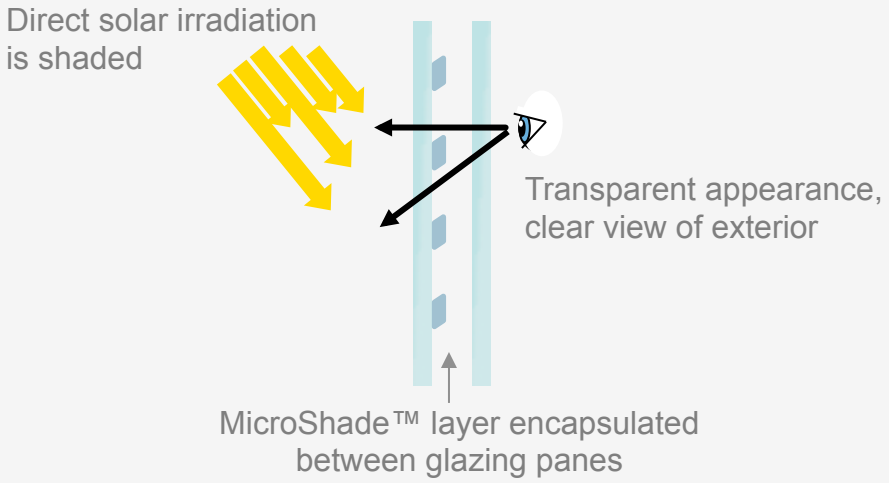


- The strip
  - is 140 mm wide with a maximum length of 2 m
  - is less than 0.2 mm thick steel
- The hole
  - diameter is less than 0.7 mm
  - sloping 16 degree downward
- Sunlight from low angles passes relatively unimpeded between the micro lamellas, while light from higher angles is blocked

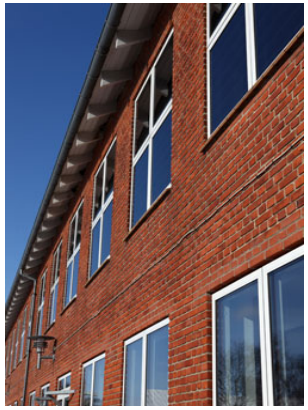

DAMEN

Modelling challenges

Challenges



- Due to the complexity of the system it cannot be dealt with in simple daylight tools
- Due to the very tiny micro-structure (compared to window size and room geometry) a geometrical model will not give reliable results

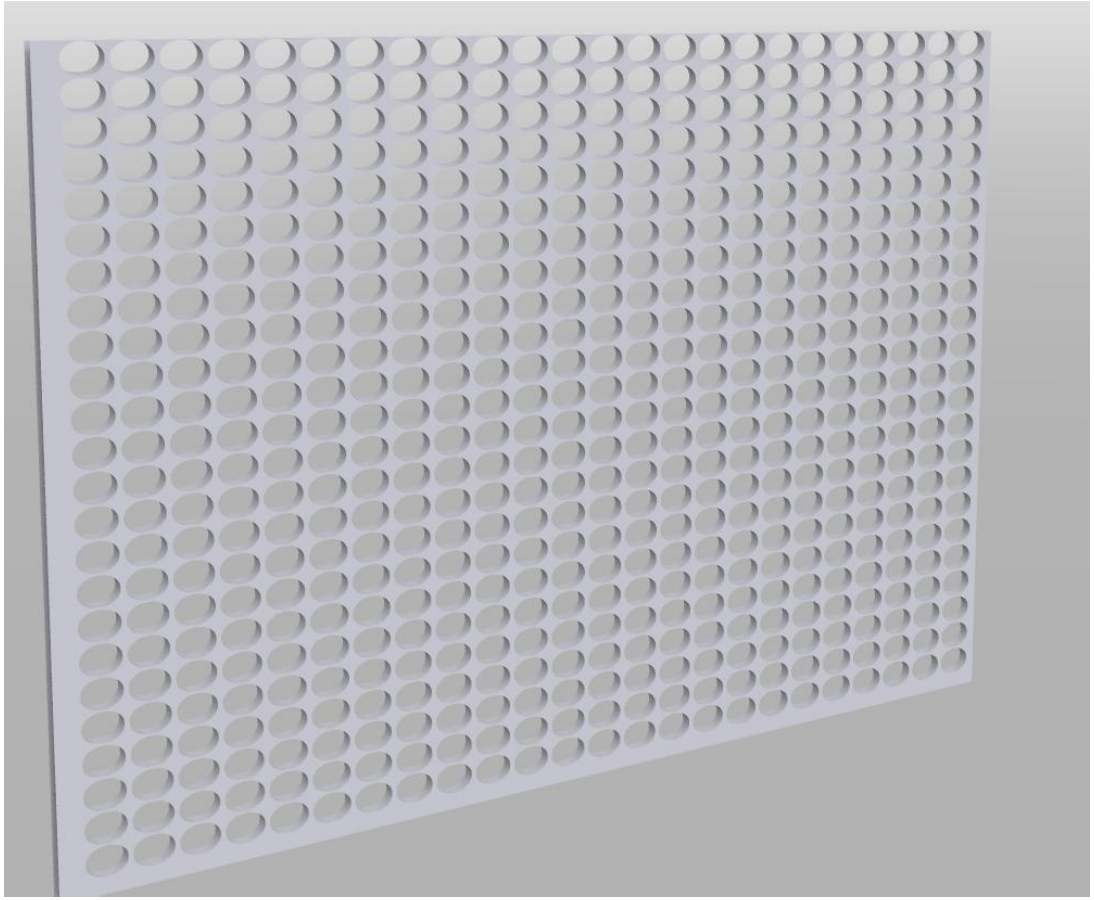


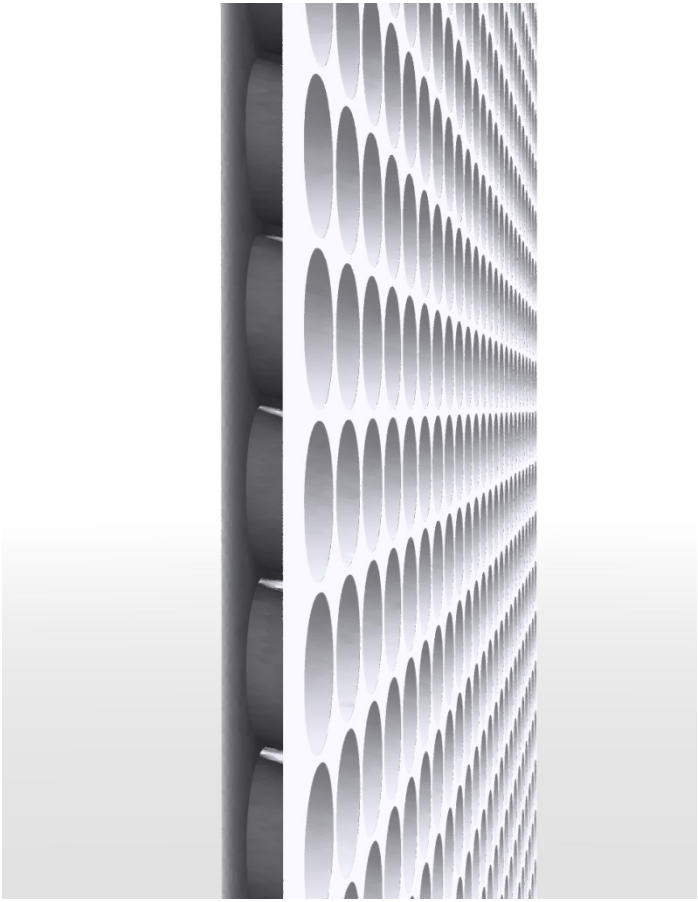
Four steps to get a usable model

1. Set up a small geometric model
2. Derive angle dependent transmission data
3. Fit a function to the data
4. Derive functional model

Modelling of MicroShade™

First Step: Set up geometric model

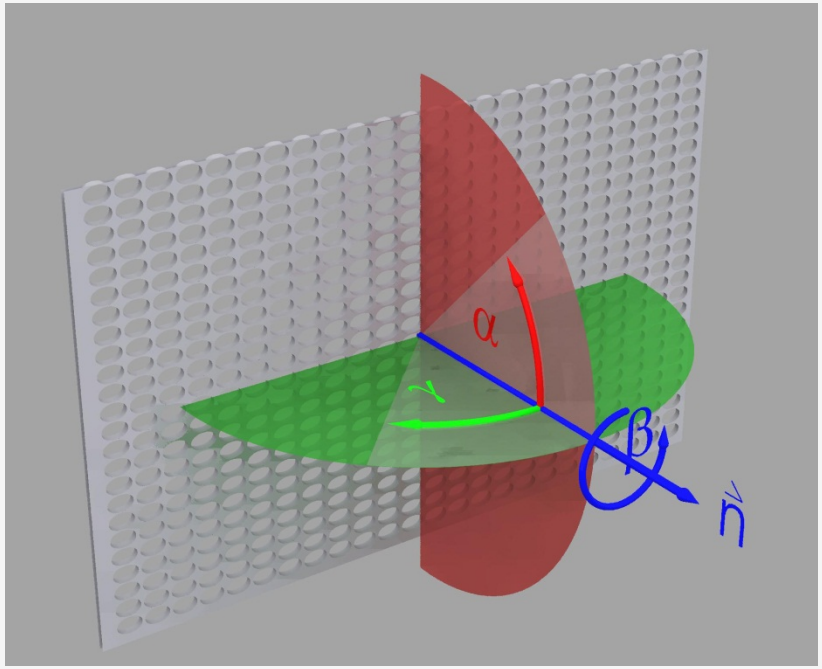




Modelling of MicroShade™

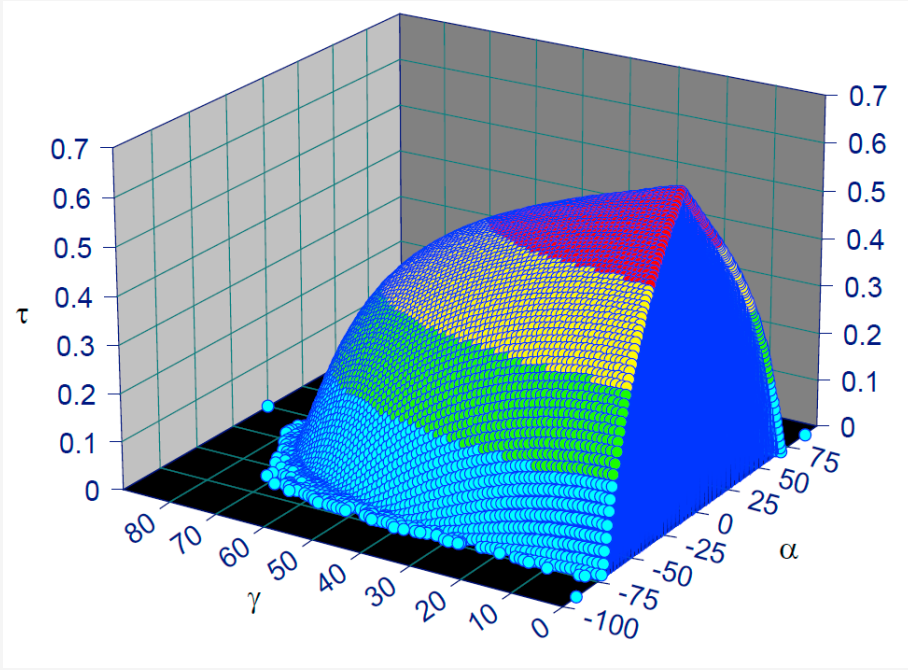
Second Step: Characterisation of the angular transmission

Definition of angles



- α: altitude angle
- γ: azimuth angle
- β: rotation angle of the system
- n: normal vector

Angular transmission data – virtual measurements



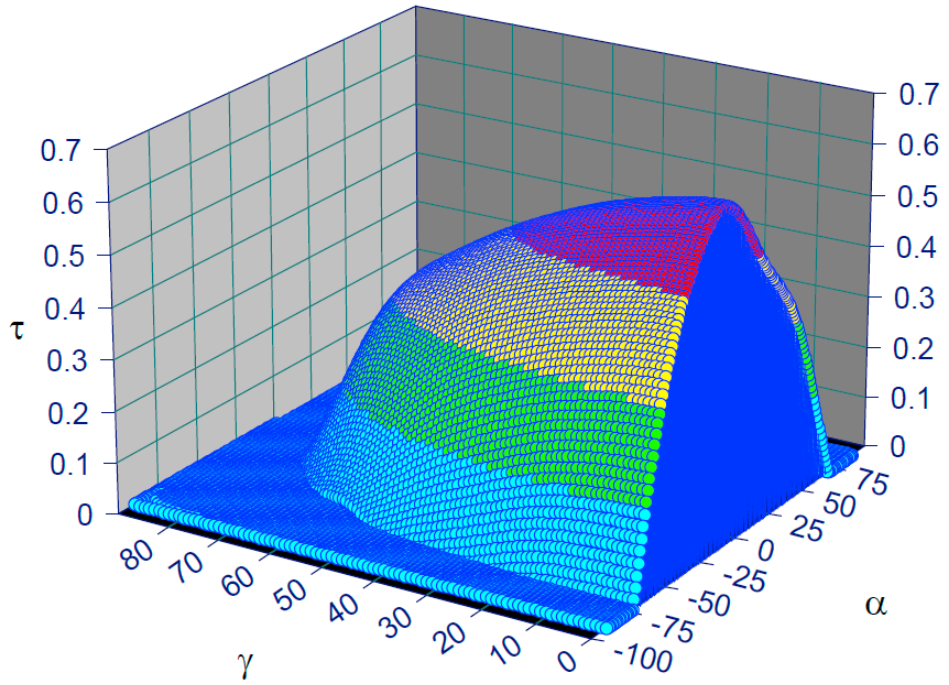
- Small geometrical model (18 x 20 holes) was generated in Radiance
- Virtual sensors are placed within the simulations
- Angular transmission are calculated in 1 degree step for α ± 90 and γ ± 90

Modelling of MicroShade™

Third Step: Derive fit-function for the transmission

Fit function	
Transmission function	$\tau = f(\alpha, \gamma)$
Tablecurve 3D	The calculated transmission data are plugged into the fitting software “Tablecurve 3D”
8 order cos bivariate	$\tau = a + b \cdot \cos(\alpha) + c \cdot \cos(\gamma) + d \cdot \cos(2\alpha) + e \cdot \cos(\alpha) \cdot \cos(\gamma) + f \cdot \cos(2\gamma) + \cdots$
Incident angles above 80 degree	The transmission of resulting incident angles larger than 80 degree are set to zero

Transmission of the fit-function



Modelling of MicroShade™

Forth Step: Radiance model of MicroShade™

MicroShade™ model

- Transmission is modelled by a function and not geometry
- Material uses the mixfunc, mixing air and metal
- Only the MicroShade™ layer,
- When modelling a window with MicroShade™ the glazing should be modelled as well

Radiance code

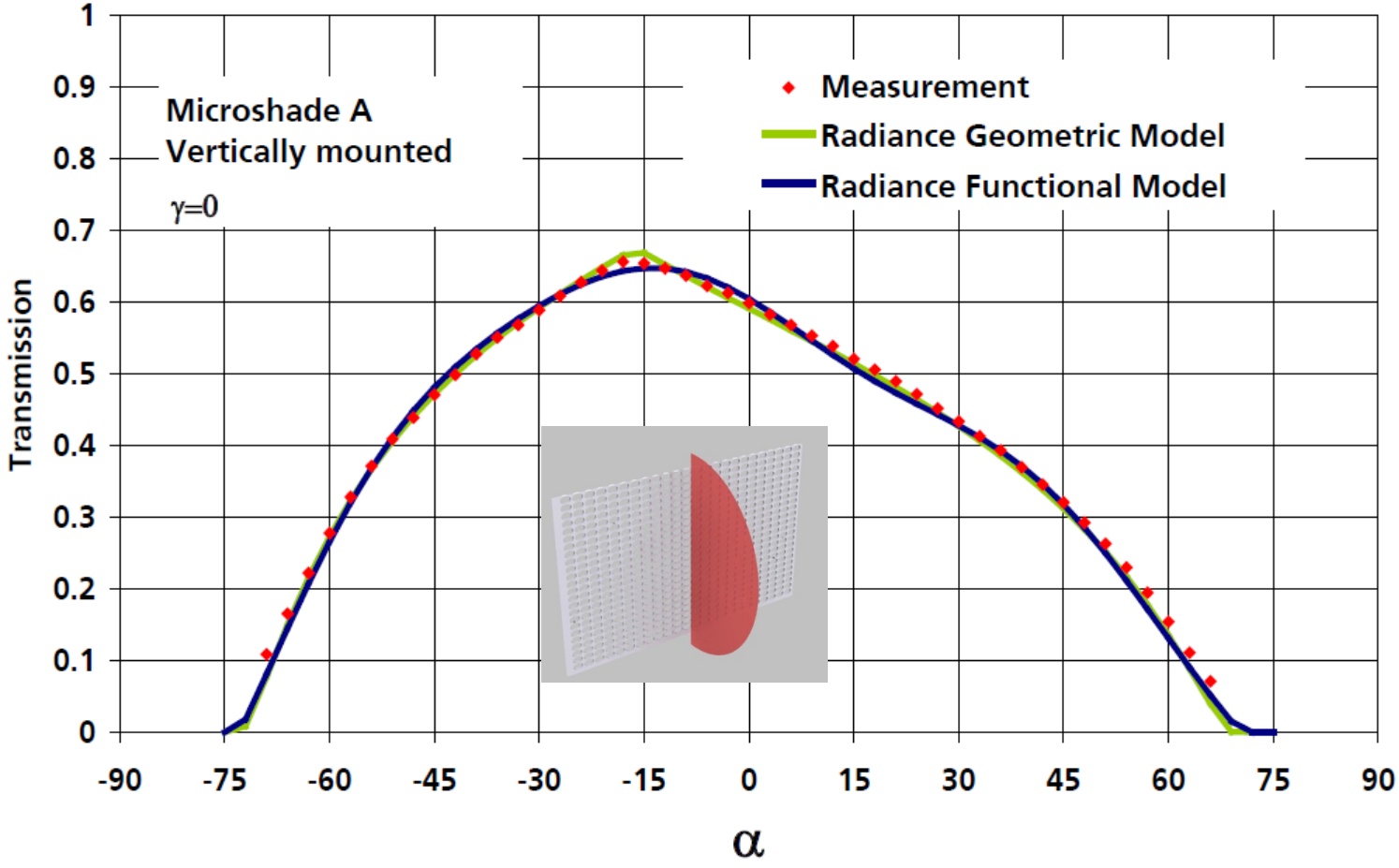
```
void glass microshade_air
0
0
4 1 1 1 1

void plastic microshade_metal
0
0
5 0.1 0.1 0.1 0.017 0.005

void mixfunc microshade_a_mat
4  microshade_air microshade_metal trans microshade_a.cal
0
1 0
```

Rotation angle β, 0= no rotation, 90=90˚ rotation anticlockwise, 180 (upside down)= 180˚, 270= 270˚ rotation anticlockwise seen from the exterior

Validation by transmission measurements



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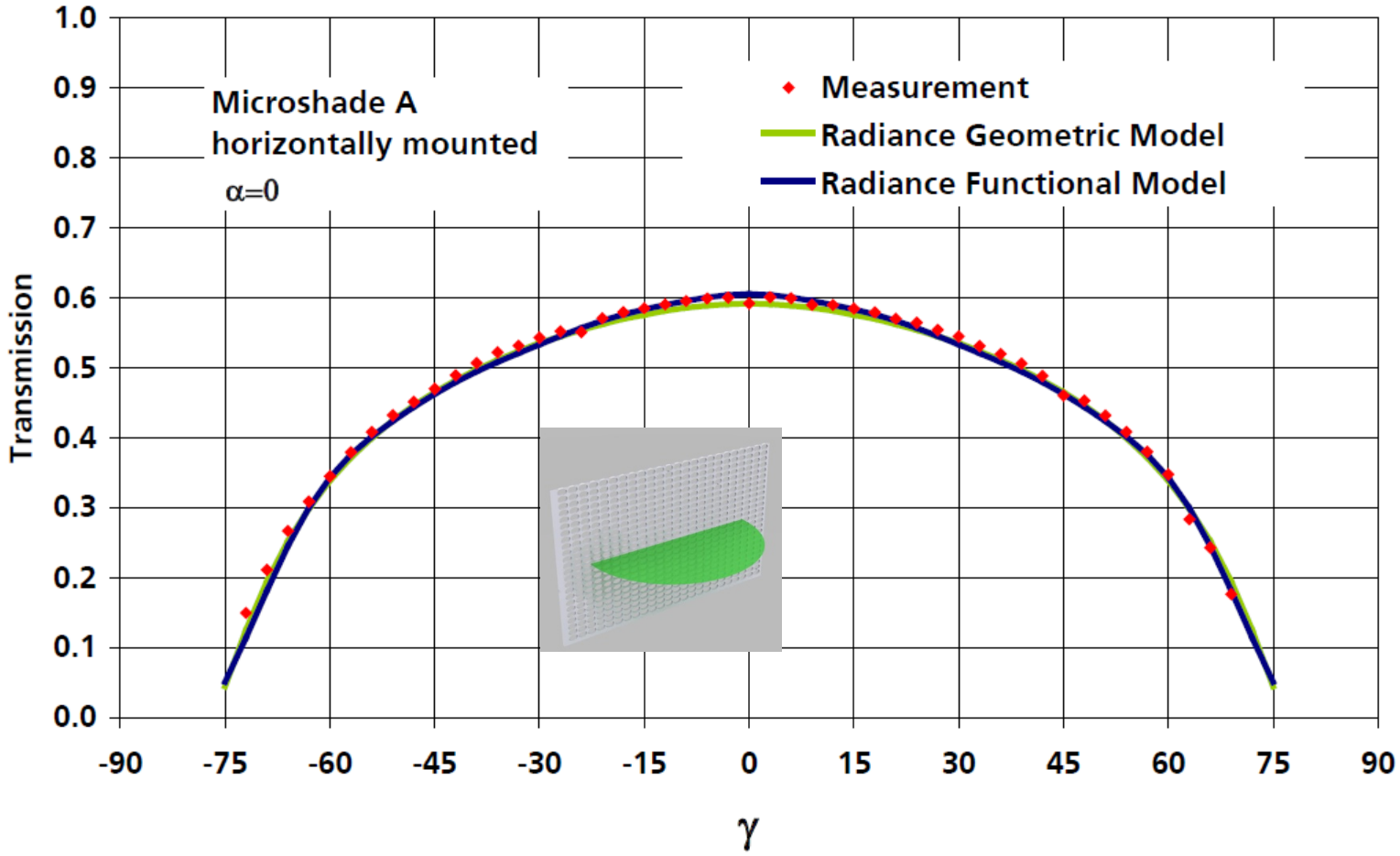
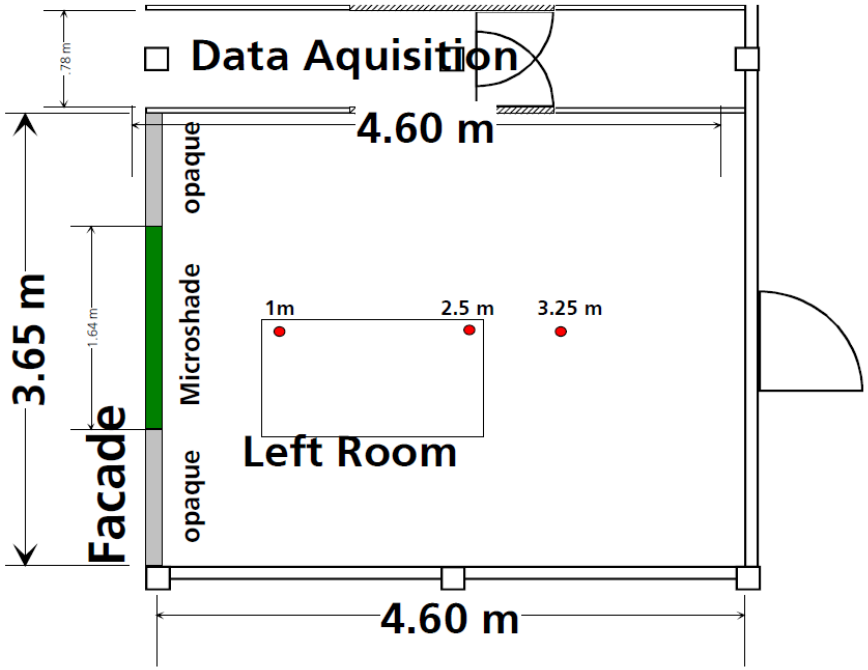


Validation of the model

Validation by test room measurements at ISE

- MicroShade mounted in the central window. Other windows was shaded
- 3 Sensors at a height of 0.85 m
- Façade perpendicular to the sun during measurements



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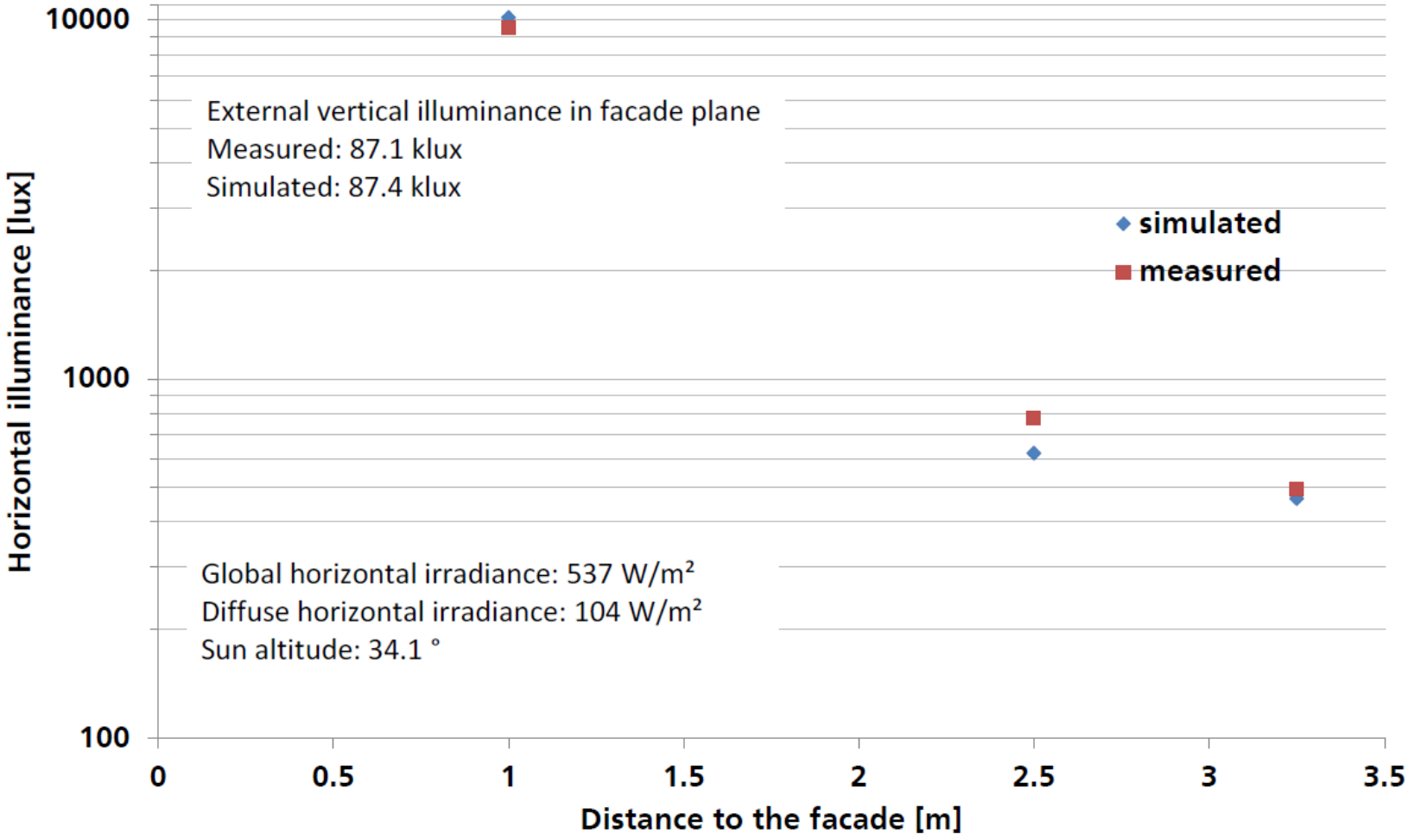

Calculation with the model

Bringing the model to a broader audience

Guideline

- Guideline to daylight simulations in DAYSIM (using Sketchup) is on our webpage www.photosolar.dk under download

Other possibilities

- BSDF file of MicroShade™ by David Applefeld DTU/LBNL
- BSDF is included in the CFS database for WINDOW 6

Guideline to daylight simulations in DAYSIM

This is a guideline to daylight simulations with MicroShade™ in DAYSIM. DAYSIM is a daylighting analysis software that calculates the annual daylight availability in buildings based on the Radiance backway raytracer. DAYSIM has been developed at Harvard University, the National Research Council Canada and Fraunhofer Institute for Solar Energy Systems.

Daylight metrics

DAYSIM calculates a series of climate-based daylight metrics including daylight autonomy (DA) and useful daylight illuminance (UDI). Furthermore DAYSIM can calculate the daylight glare probability (DGP) for glare assessments. DAYSIM can also calculate the simpler daylight factor (DF).

MicroShade™ model

Together with Fraunhofer Institute for Solar Energy System a Radiance model of MicroShade™ MS-A has been developed. The model has been validated against angle dependent transmittance measurements.

Future work

Next step

Other standard types of MicroShade™

- Measurements for each type
- Similar Radiance models for each type

Name	Description	Tilt of lamellas
MS-A	Standard facade product	16˚
MS-D	Facade product with more shading effect	23˚
MS-RS (roof skylight)	Roof product with limited view through	0˚
MS-RW (roof window)	Roof product with full view through	40˚

Architectural types of MicroShade™

- More complicated
- Mix of patterns of existing hole structures