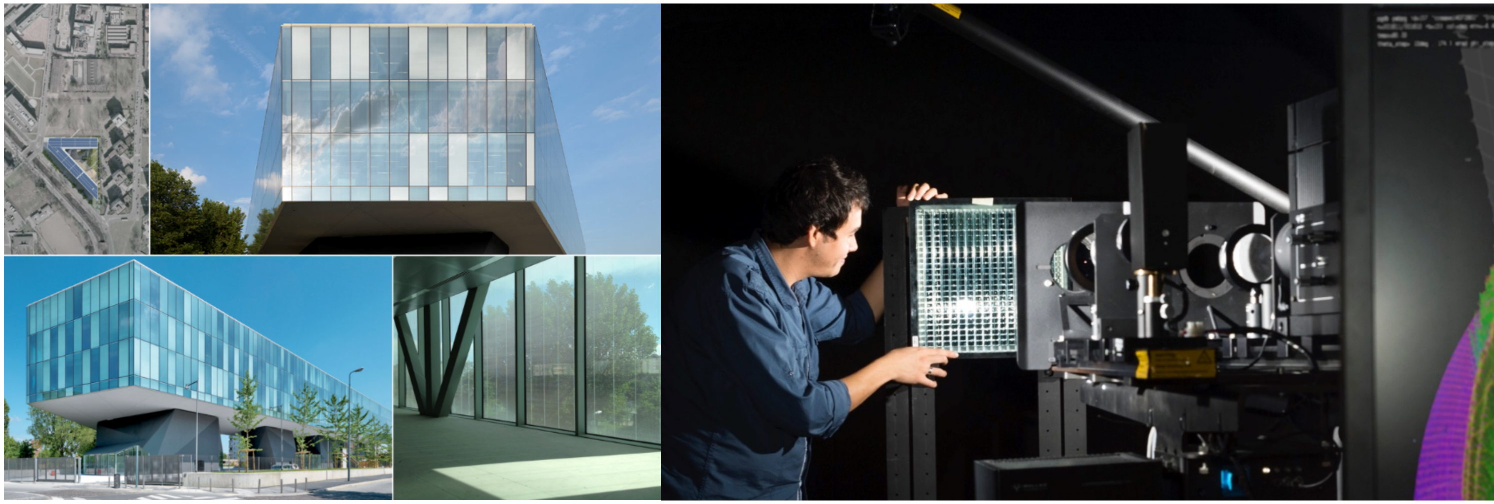

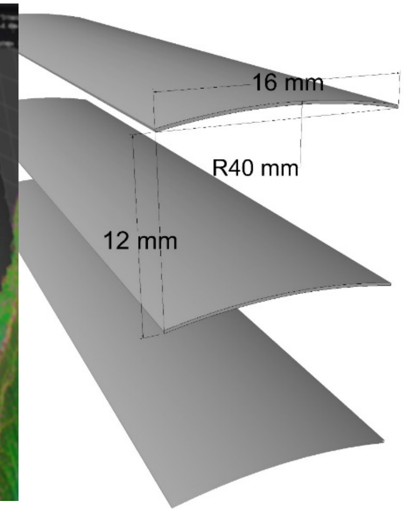

Modelling the reflective properties of coated blinds comprising an innovative CFS in Radiance

pellini industrie
PelliniNautica
Pellini
ScreenLine

Lucerne University of Applied Sciences and Arts
HOCHSCHULE LUZERN
Technik & Architektur

EURAC research

Padua, 31st August 2016

The speakers

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pelliniindustrie
PelliniNautica
Pellini TENDE E SISTEMI
ScreenLine

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HOCHSCHULE LUZERN
Technik & Architektur

Giuseppe De Michele

EURAC research
unibz

About Pellinindustrie

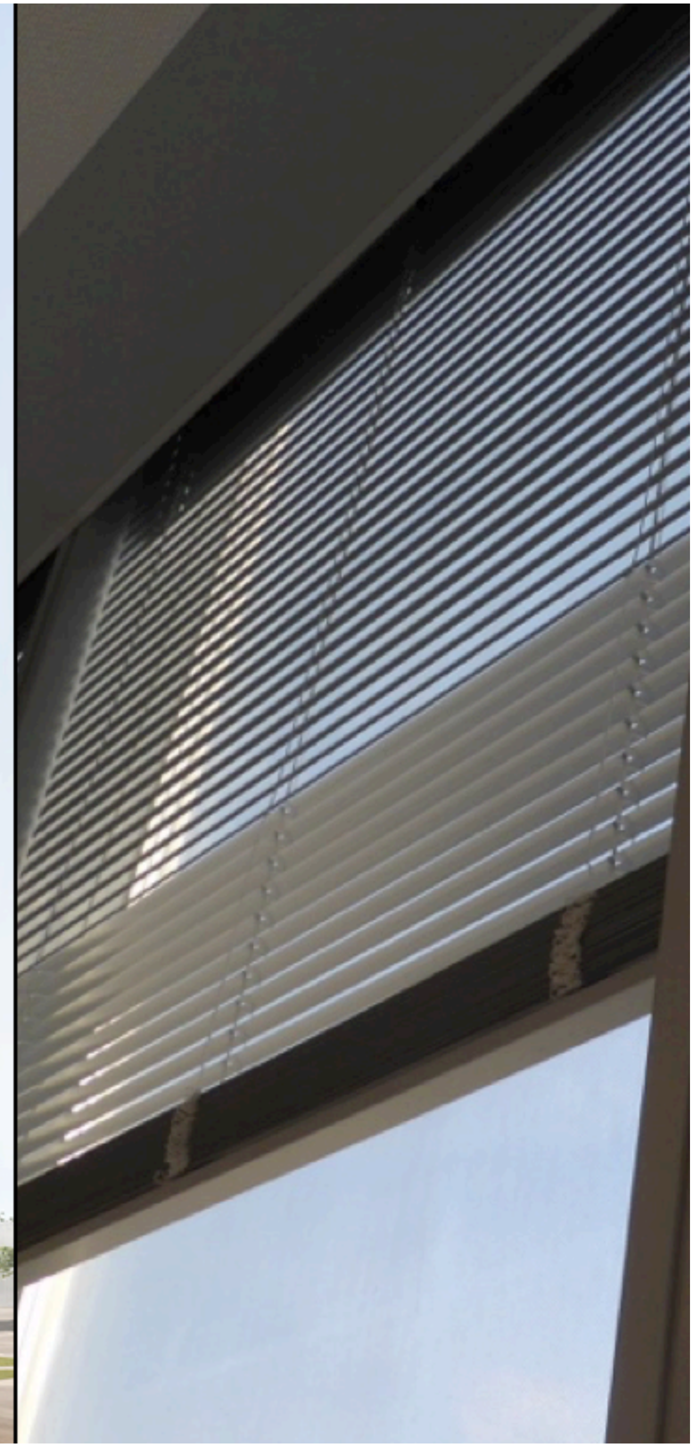
pellinindustrie

-inventor of ScreenLine integrated blind

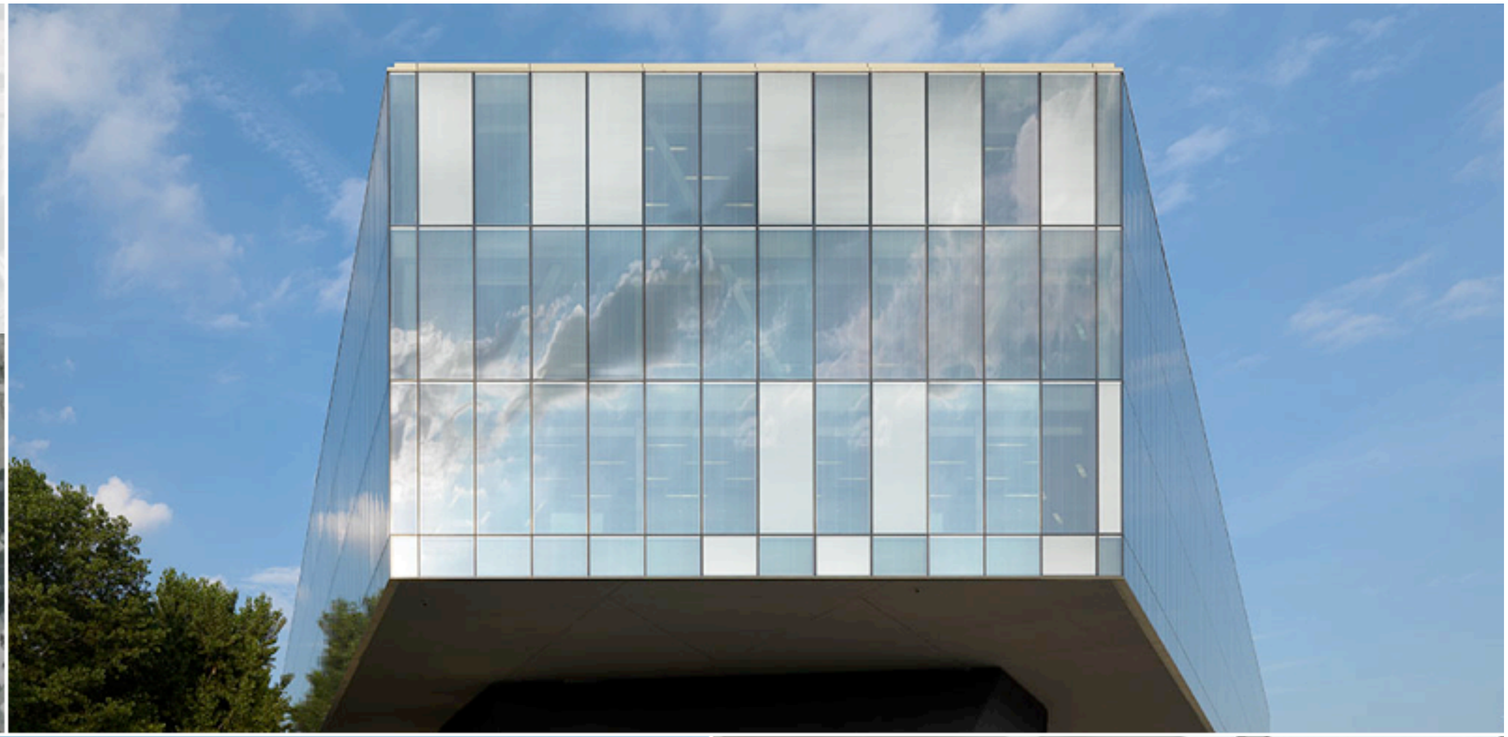
-world largest producer (8 production facilities worldwide)

-world oldest producer (more than 25 years)


ScreenLine®

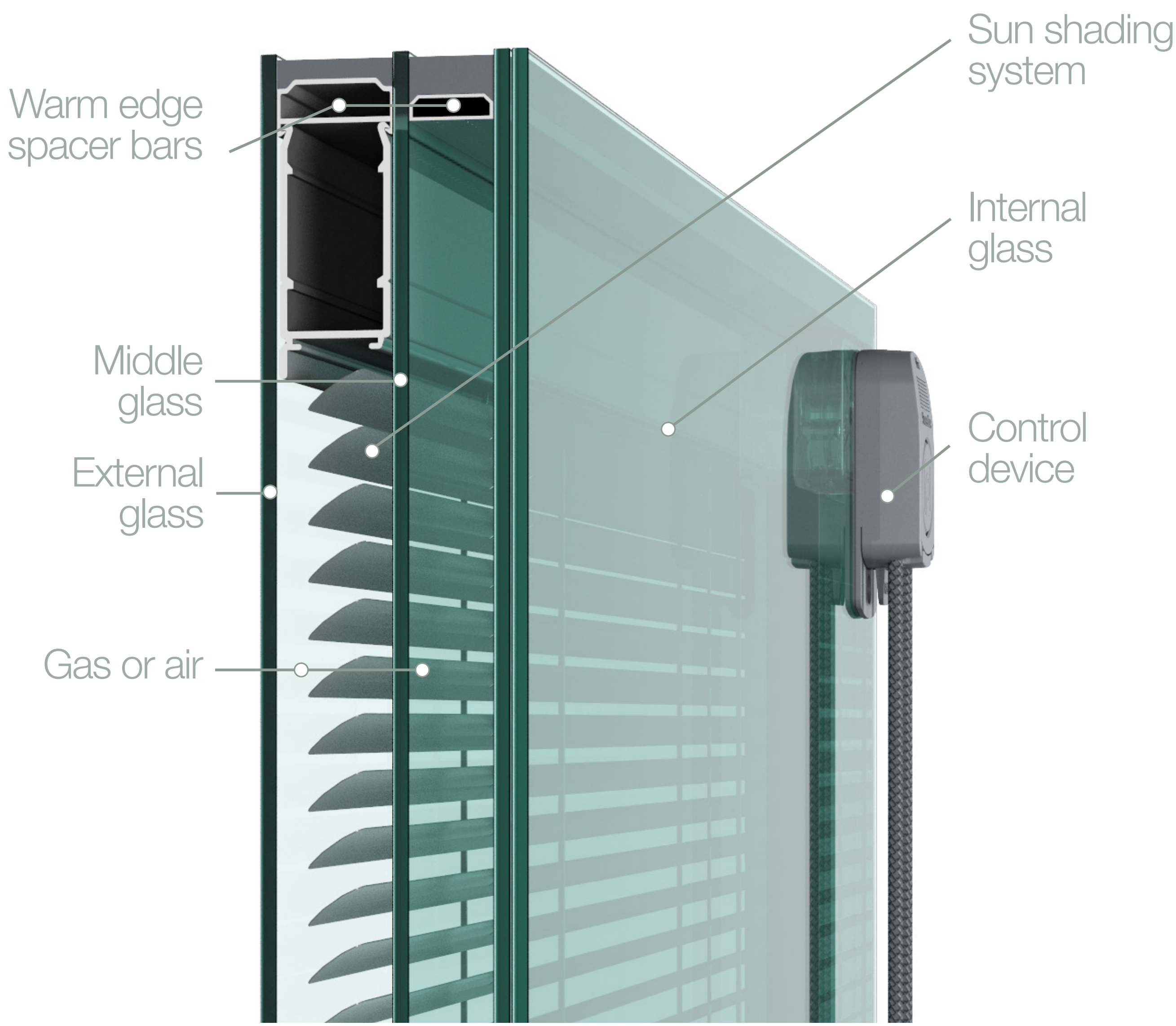


ScreenLine®



ScreenLine®

ScreenLine integrated blinds

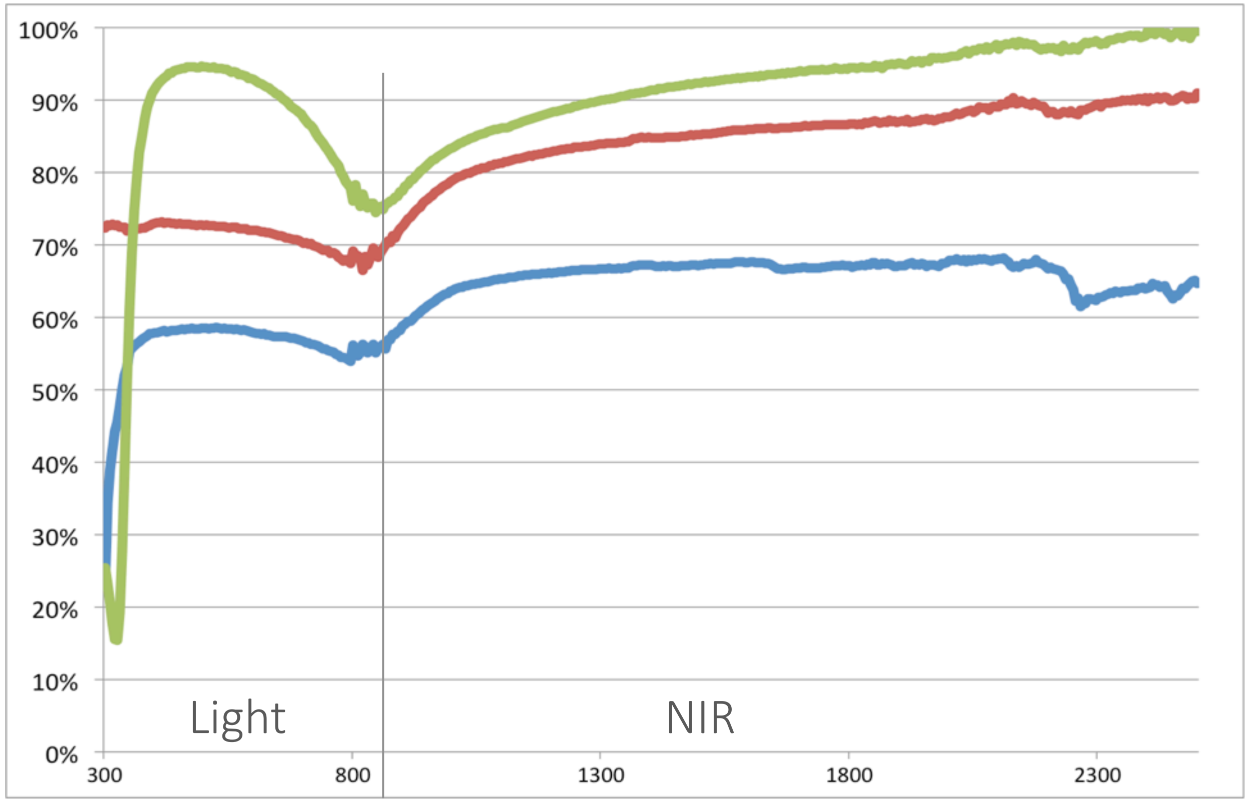


Improve spectral reflectance

ScreenLine

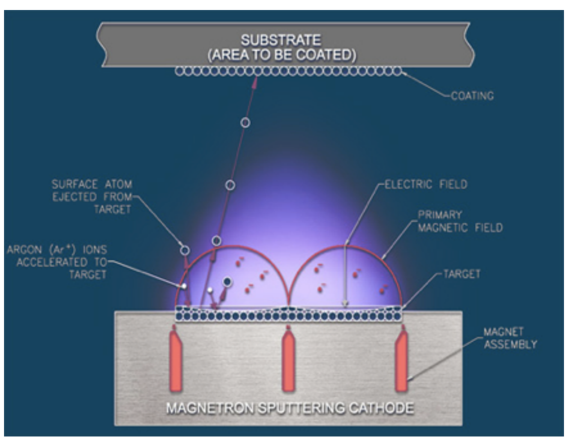
A high reflective coating

An Interference filter deposited through a process of Physical Vapour Deposition (PVD) makes the slat more reflecting and with low emission to long wave infrared.

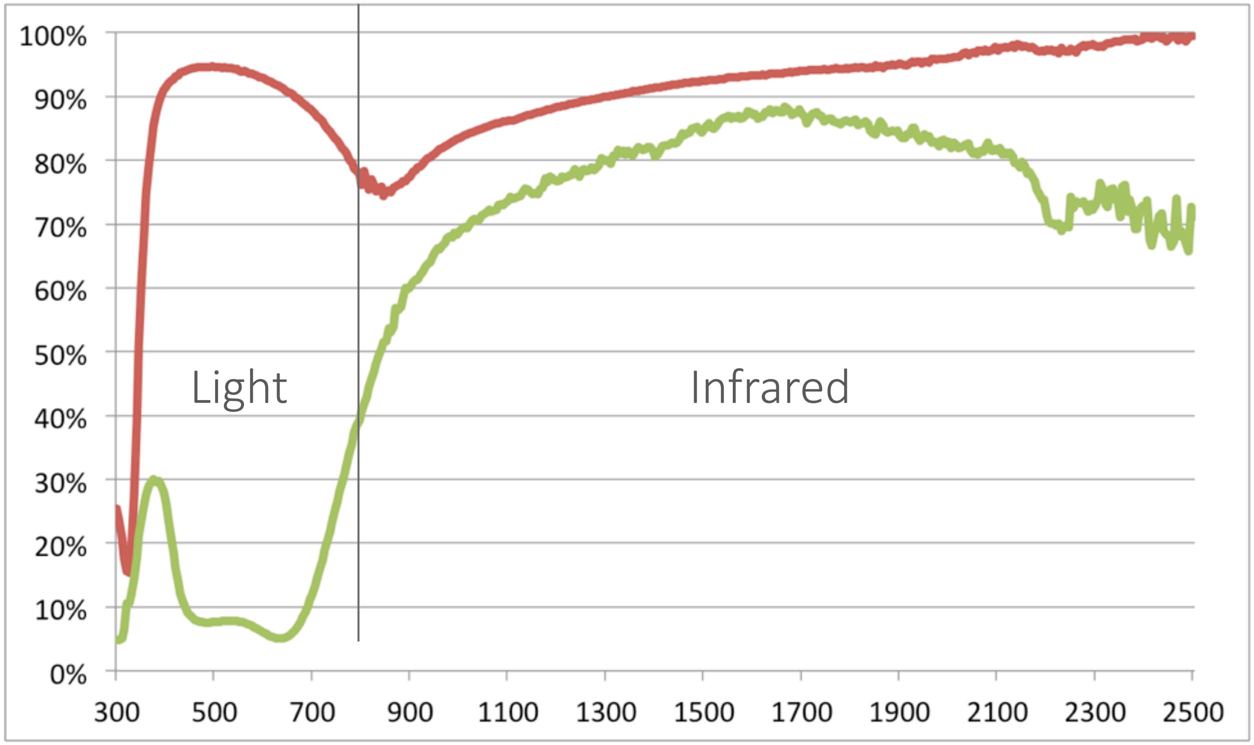


Reflection spectra:

- Coated V95 Slat
- Raw Aluminum
- Painted Slat



The new coating



Reflection spectra:

Coated V95 Slat

Selective glazing

The reflection of the coated slat is calibrated to compensate the low reflection (hence high transmission) of the solar control selective glazing. The two solutions spectra are complementary.

Having a high reflection slat has its pros and cons

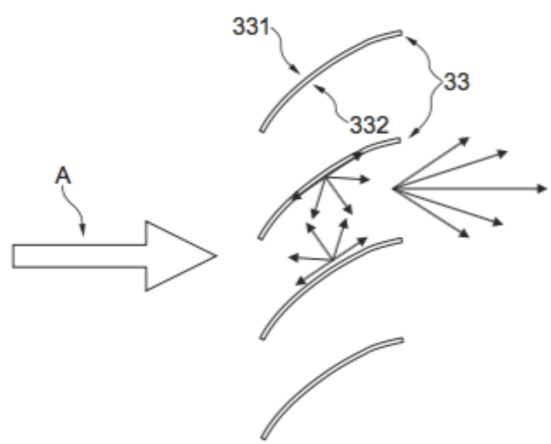
Very low g-value

Very good light shelf

But if blinds are not controlled precisely

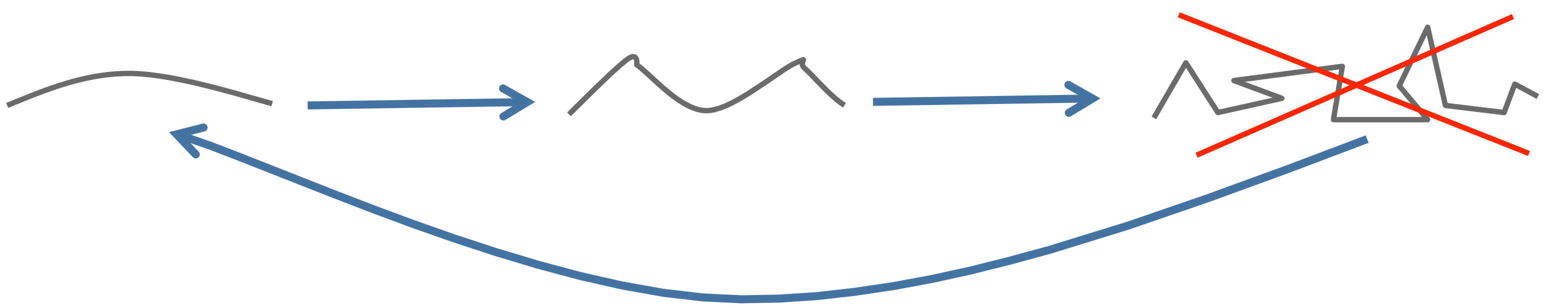
Blinds too closed

Higher solar gain and possible glare



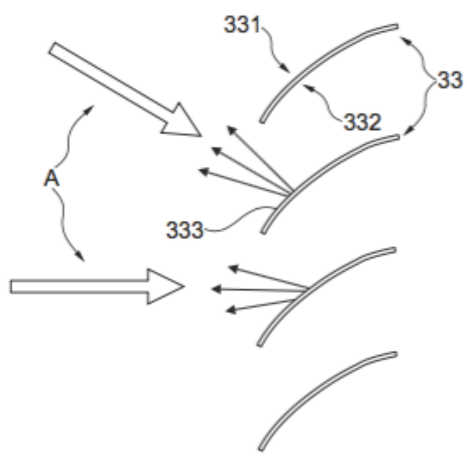
How to improve light/energetic performance

Improve slat reflectance “geometry”



New concept of retro-reflection slats

<u>Retro-refletive microstructure</u> on standard shaped slats



- Low g-value even with open slats (visual contact)
- Glare reduction

The forming of the research group

Patent and Product Engineering phase for retro-reflective micro-structure on slats

Support for product modeling and coating optimization during engineering phase

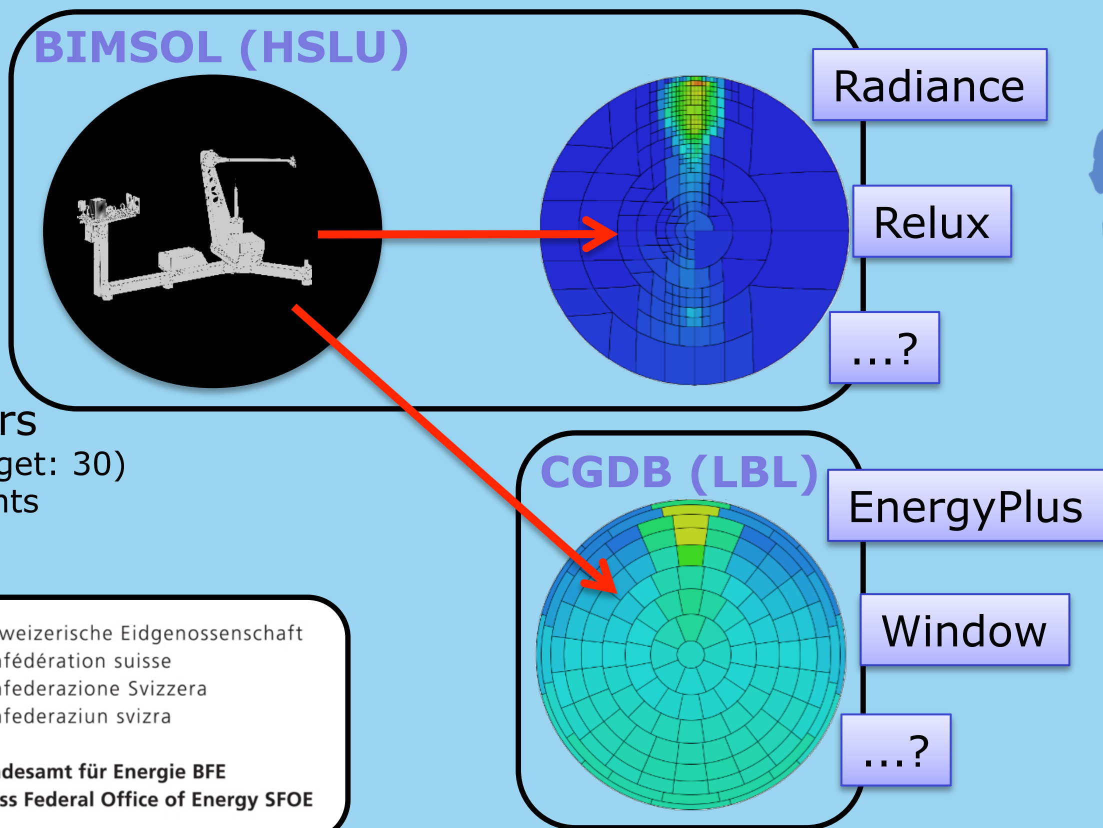
Support from HSLU: coating modeling and goniophotometric measurement for Luzern's "High Resolution Complex Glazing Library" project.

Research context at HSLU: The High Resolution Complex Glazing Library (BIMSOL)

- Project started at Lucerne University of Applied Sciences and Arts right now
- Two year duration, supported by the Swiss Federal Office of Energy SFOE
- Public availability of high-resolution models to experts on time
- Provide derived models to Complex Glazing Database CGDB
- Industry partners
  - Siteco Beleuchtungstechnik GmbH, Hella Storen AG, Pellini SpA, ...
- Research partners
  - Lawrence Berkeley National Lab, EURAC Institute for Renewable Energy
- Partners from consultancy, planning, software development
  - Transsolar Energietechnik GmbH, HZDS AG, Reflexion AG, Preluce AG, Relux AG, Bartenbach, ...

BIMSOL: Contributors

Industry partners
Provide samples (target: 30)
Funding measurements



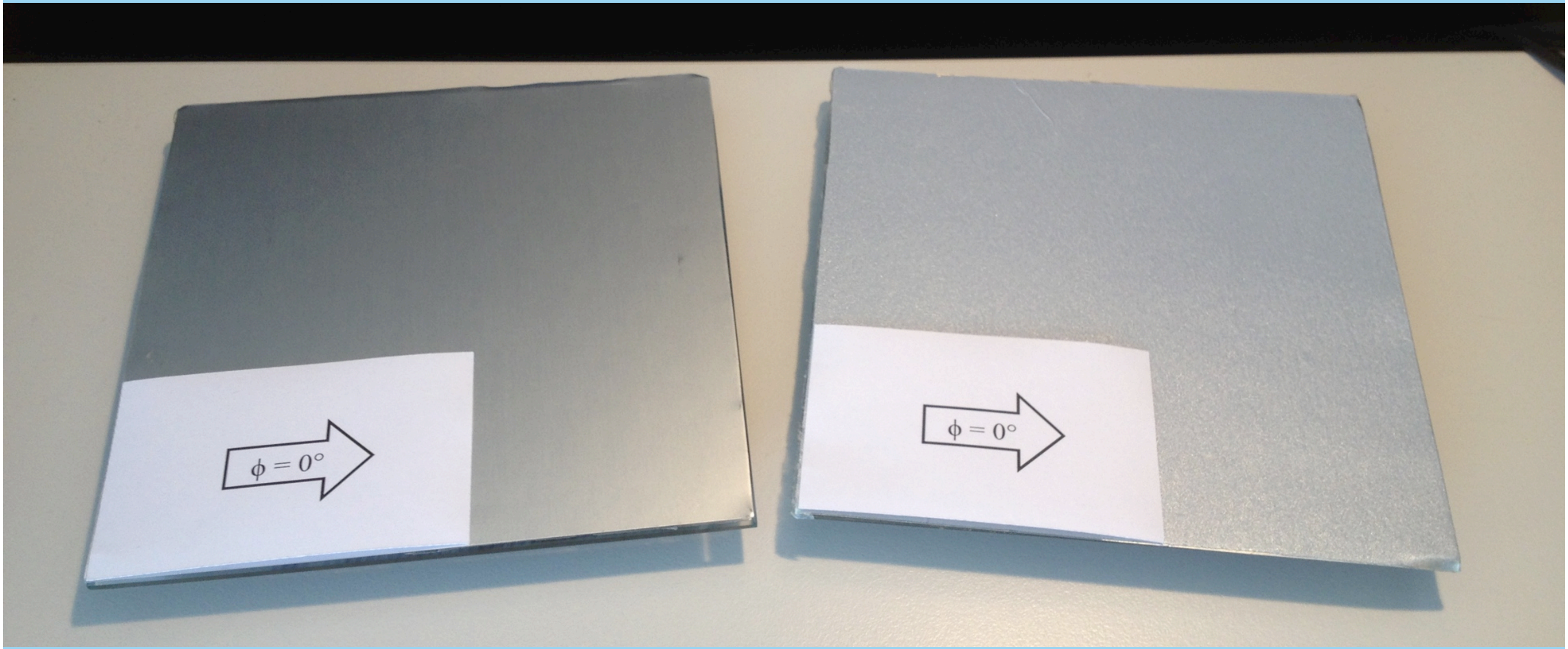
Consultants, Planners, ...
Testing
Demonstration

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Bundesamt für Energie BFE
Swiss Federal Office of Energy SFOE

Swiss Federal Office of Energy
Funding of measurement infrastructure
Model development

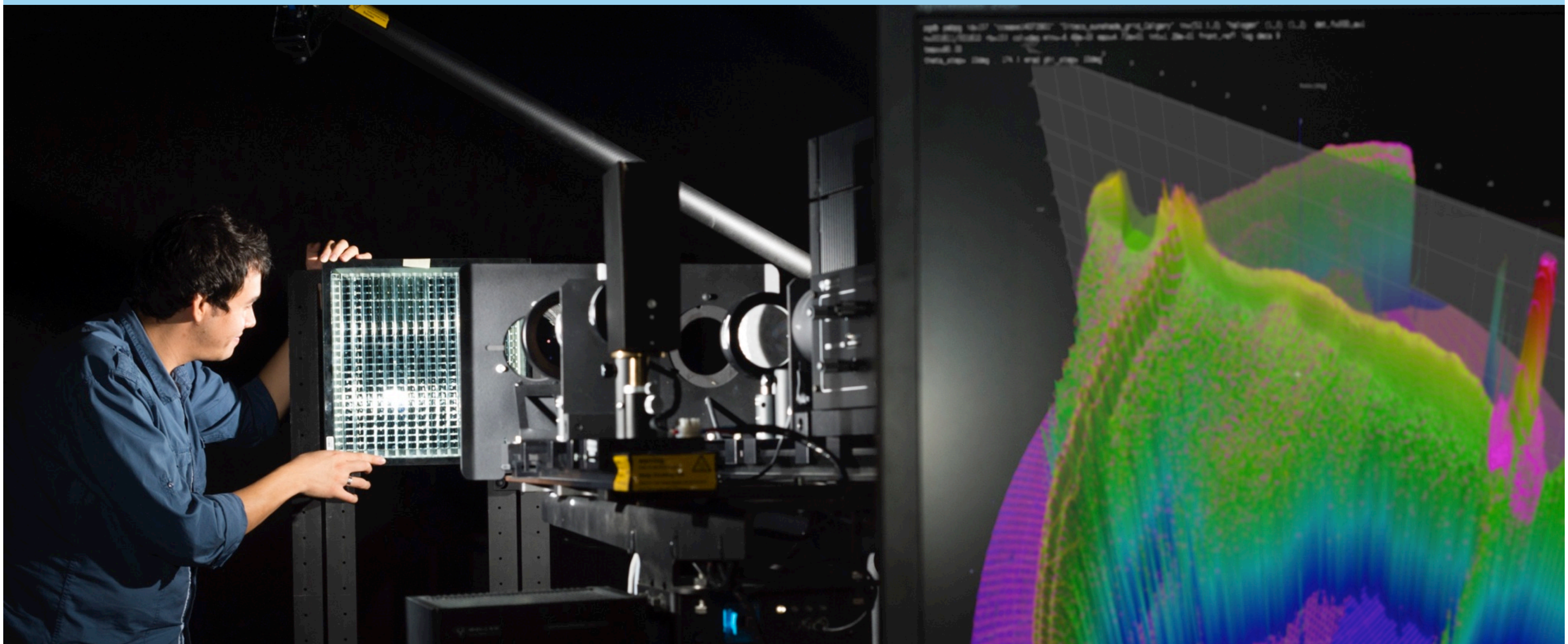
Two innovative coatings for CFS: The samples



Sample A: Highly reflective coating on metal substrate.

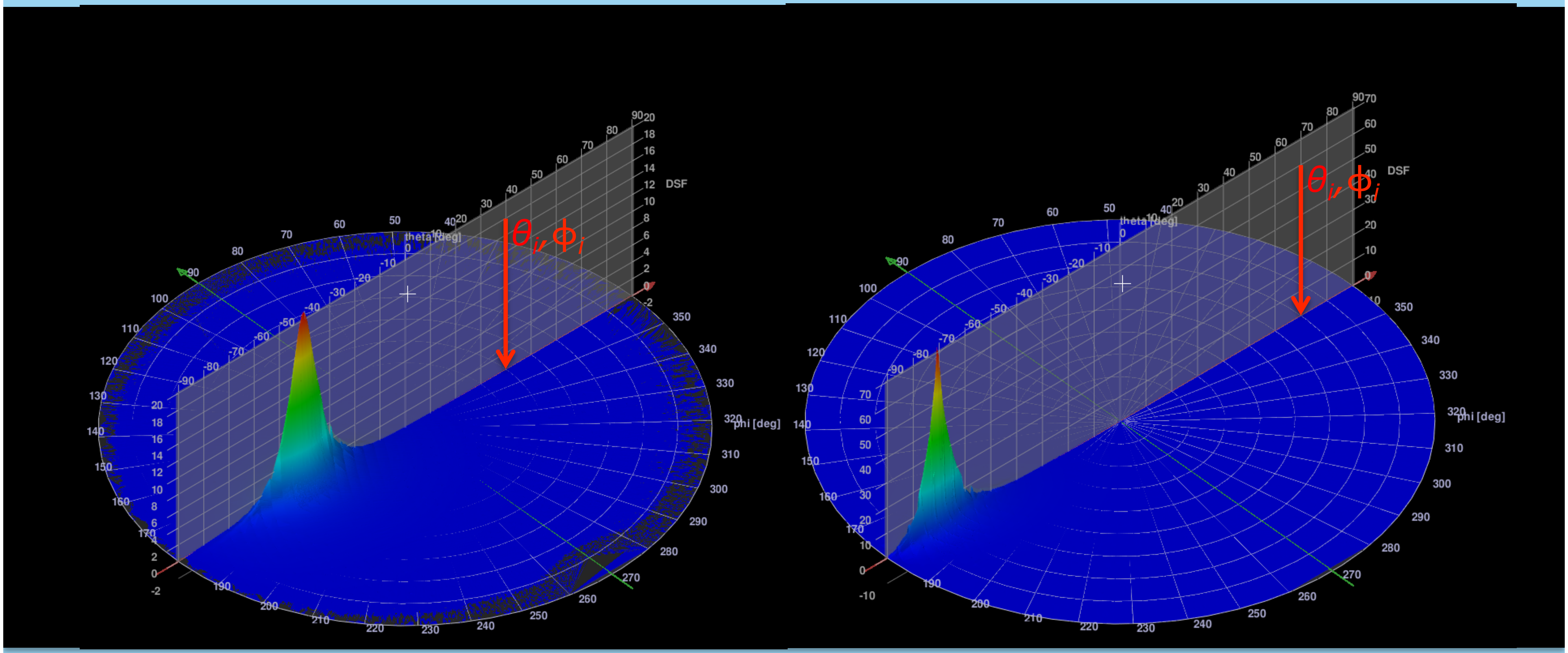
Sample B: Retro-reflective coating on metal substrate.

Measurement: Instrumentation



Scanning gonio-photometer at Lucerne University of Applied Sciences and Arts.

Measurement: Sample A / highly reflective coating



DSF incident elevation θ_i=40° *DSF incident elevation θ_i=70°*

Modelling: Compiling data-driven BSDF model from measured DSF

- Generate interpolants (front reflection)

nCPU

front toward light source

```
pabopto2bsdf -n 8 -p *.dat > rff.sir
```

DSF for 56 incident directions

interpolants front reflection

- Compile adaptive resolution tensor tree from interpolants:

tensor resolution $2^{7+7} * 2^{7+7}$

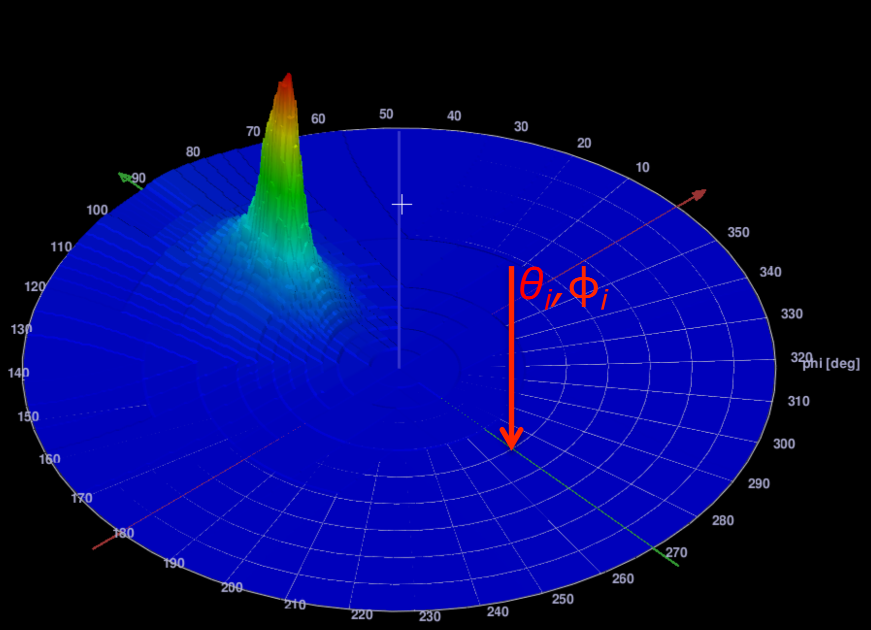
```
bsdf2ttree -g 7 -t 98 rff.sir > highrefl_g7t98.xml
```

data reduction by 98%

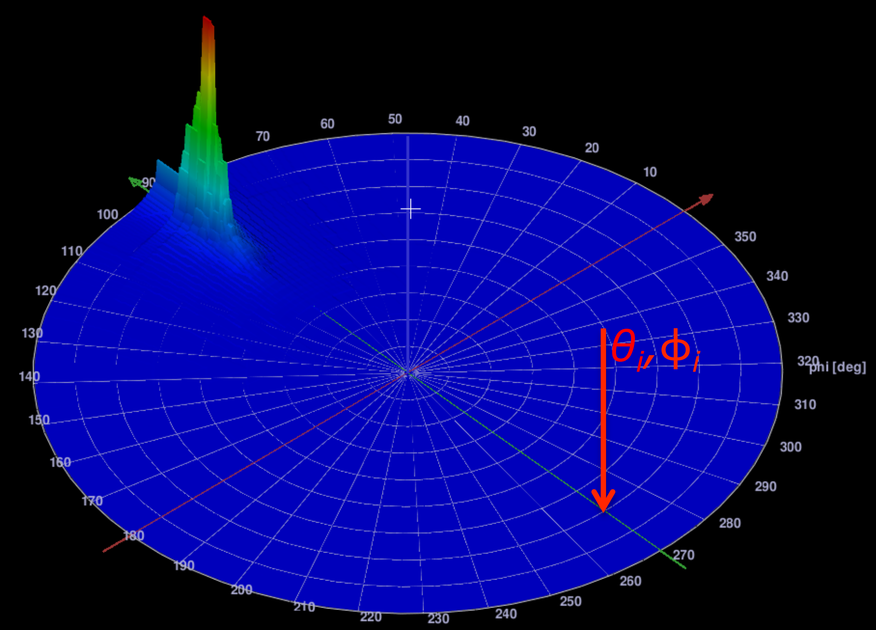
data-driven model

Hochschule Luzern
Technik & Architektur

Modelling: Tensor tree model from measurement

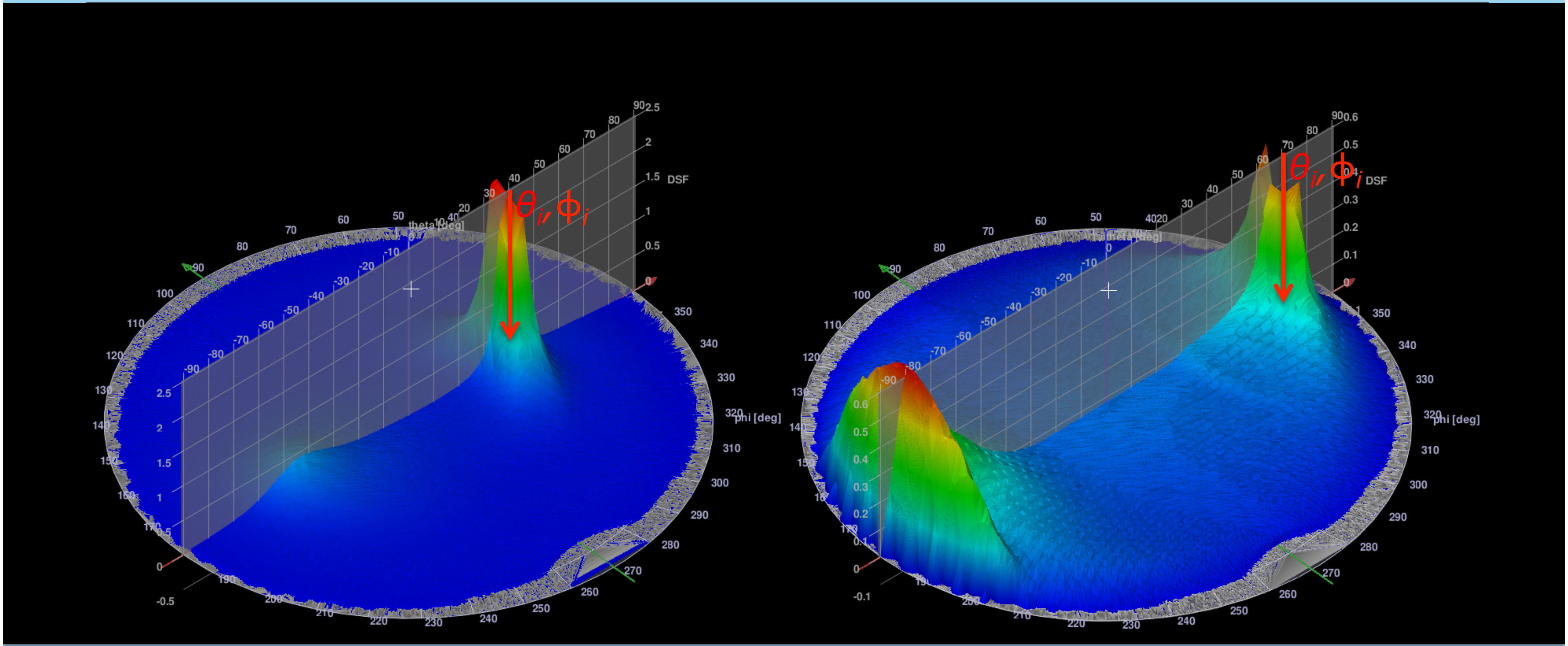


DSF incident elevation θ_i=40°



DSF incident elevation θ_i=70°

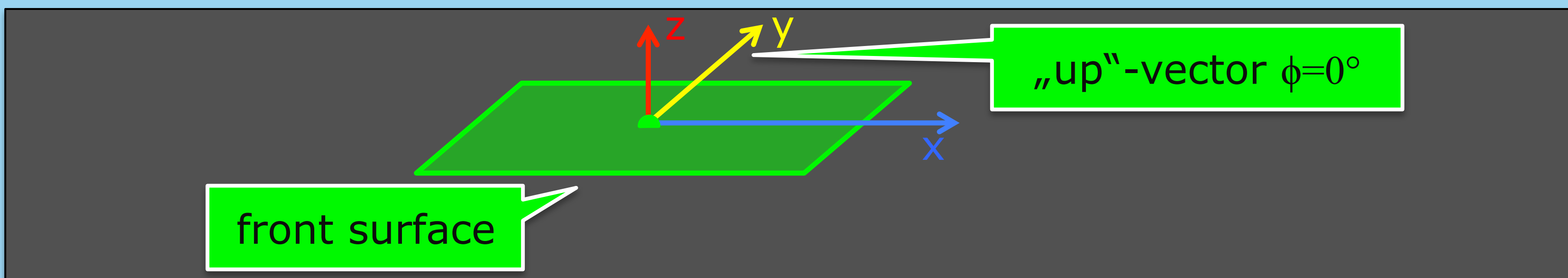
Measurement: Sample B / retro-reflective coating



DSF incident elevation θ_i=40° *DSF incident elevation θ_i=70°*

Modelling: Sample B / Computation of retro-reflection BSDF

- Prepare model of surface structure



- Call genBSDF

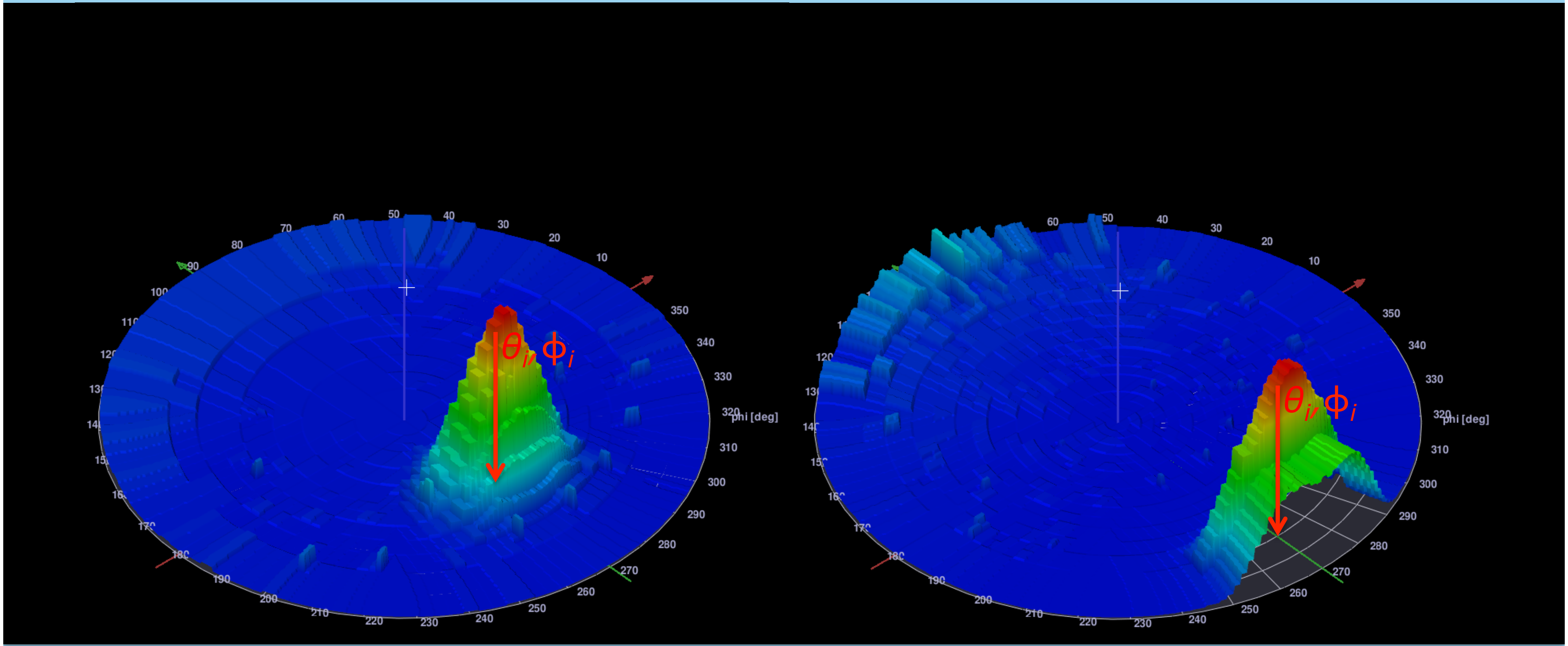
nCPU

nSamples

data-driven model

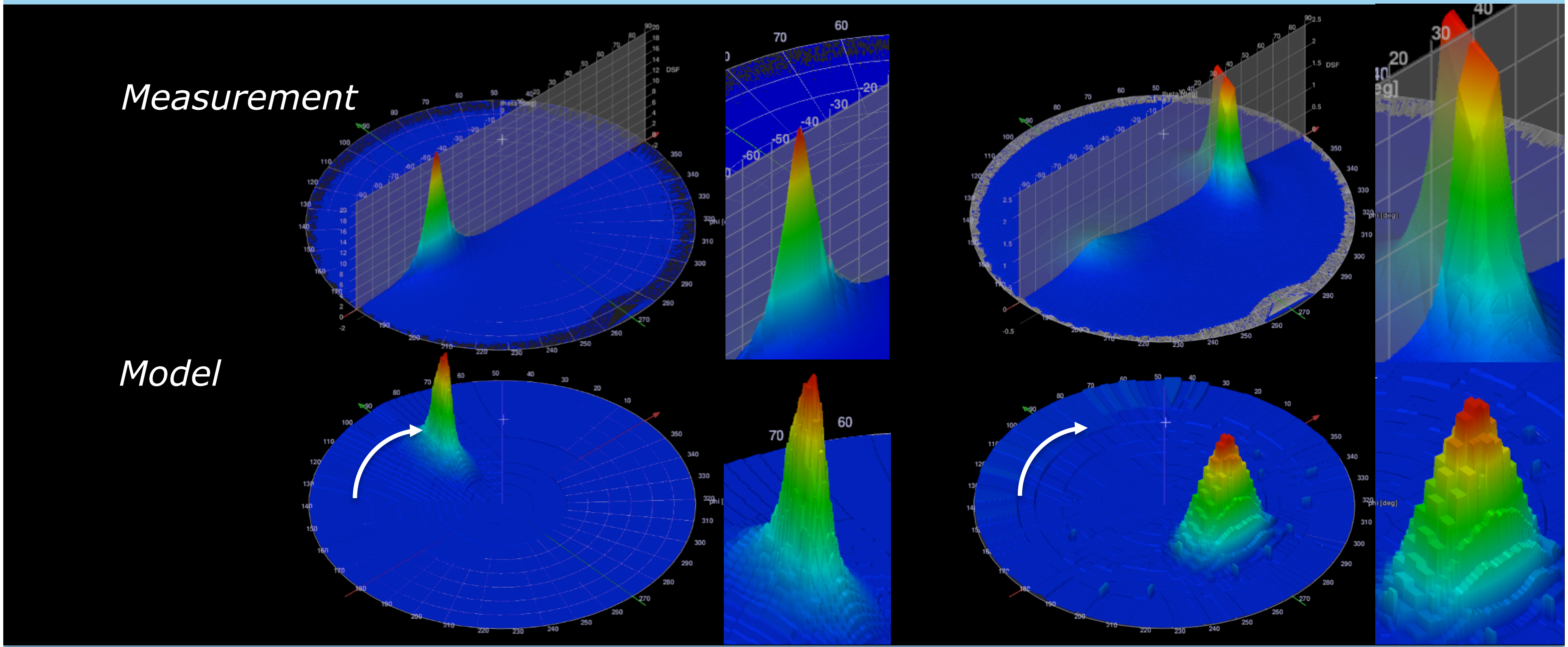
```
genBSDF -n 20 -t4 6 -c 16384 +b +f -r '-ab 5' \
-geom millimeter sampleB.rad > retrorefl_t45c16384.xml
```

Modelling: Tensor tree model computed with genBSDF



DSF incident elevation θ_i=40° *DSF incident elevation θ_i=70°*

Modelling: Comparing measurements with models



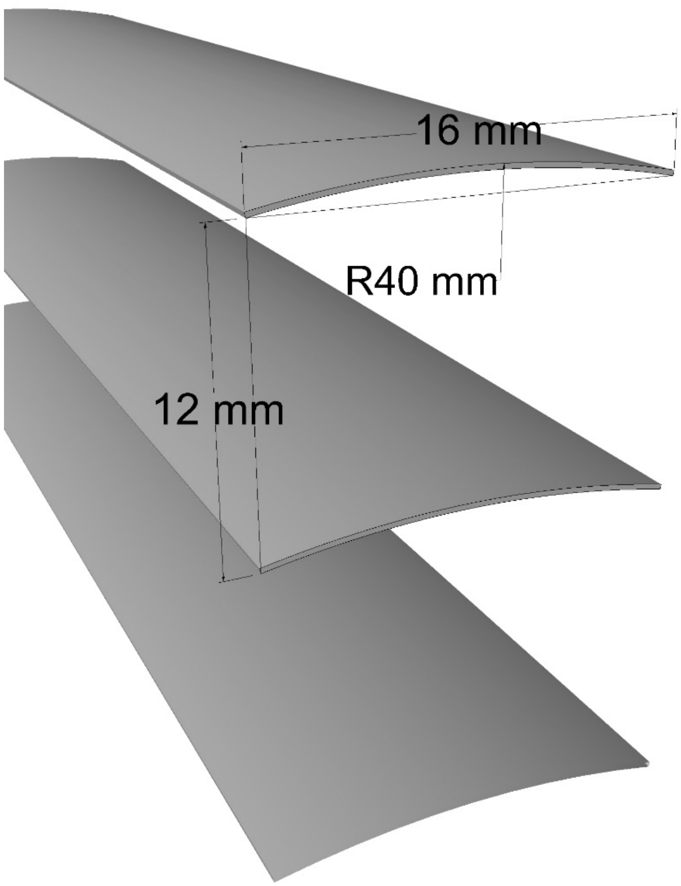
DSF Sample A, θ_i=40°

DSF Sample B, θ_i=40°

Simulation-based assessment of the blinds with Radiance

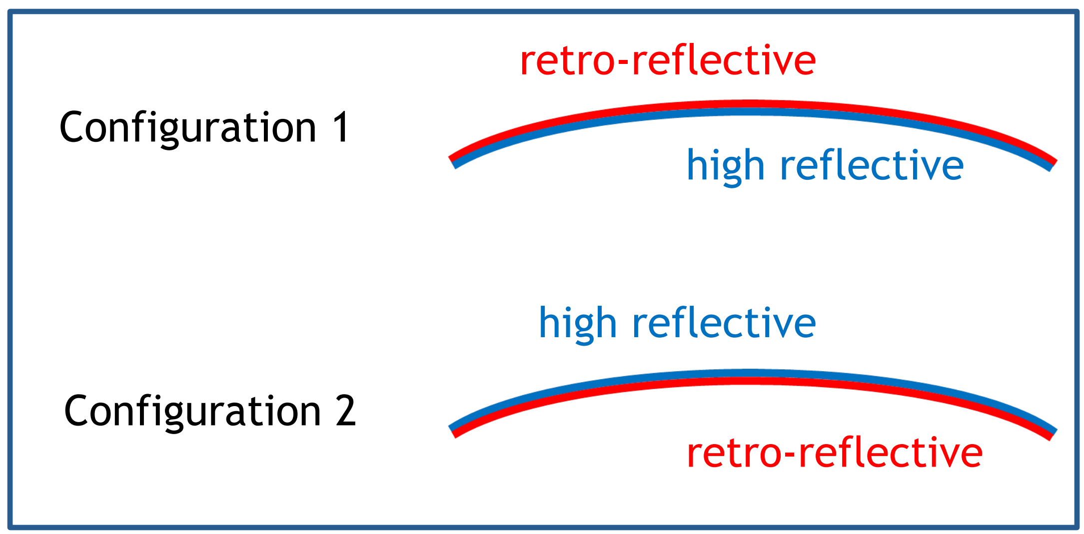
- Comparison: standard vs innovative system
- mkillum approach
- Glare and daylight availability

Shading system and configurations

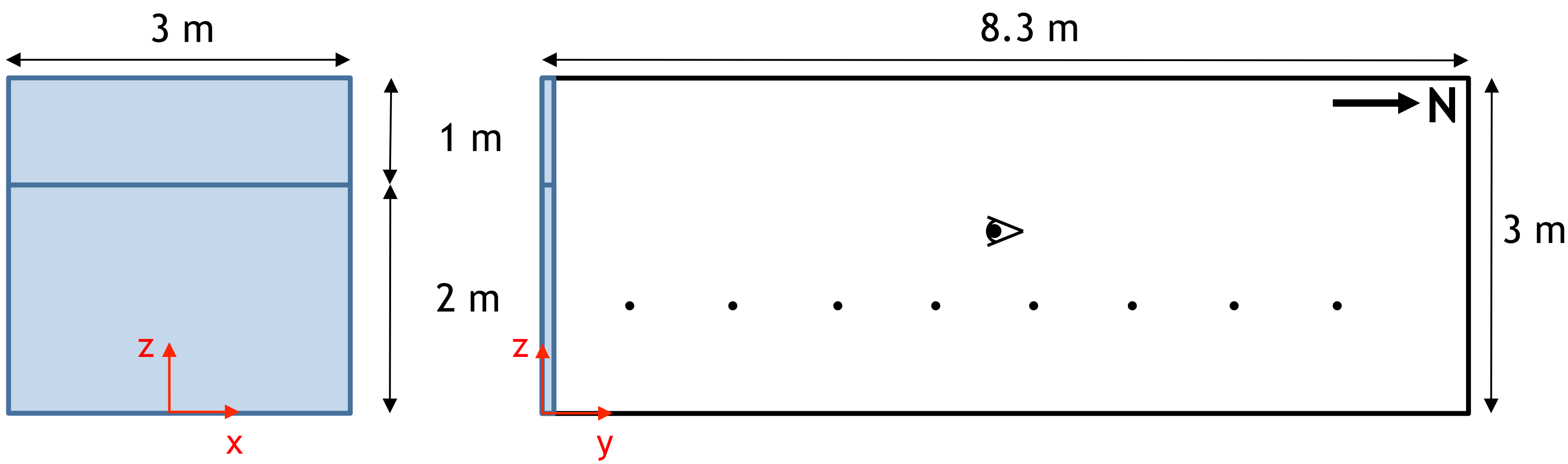


ScreenLine SL27 Pellinindustrie

VS



Test room

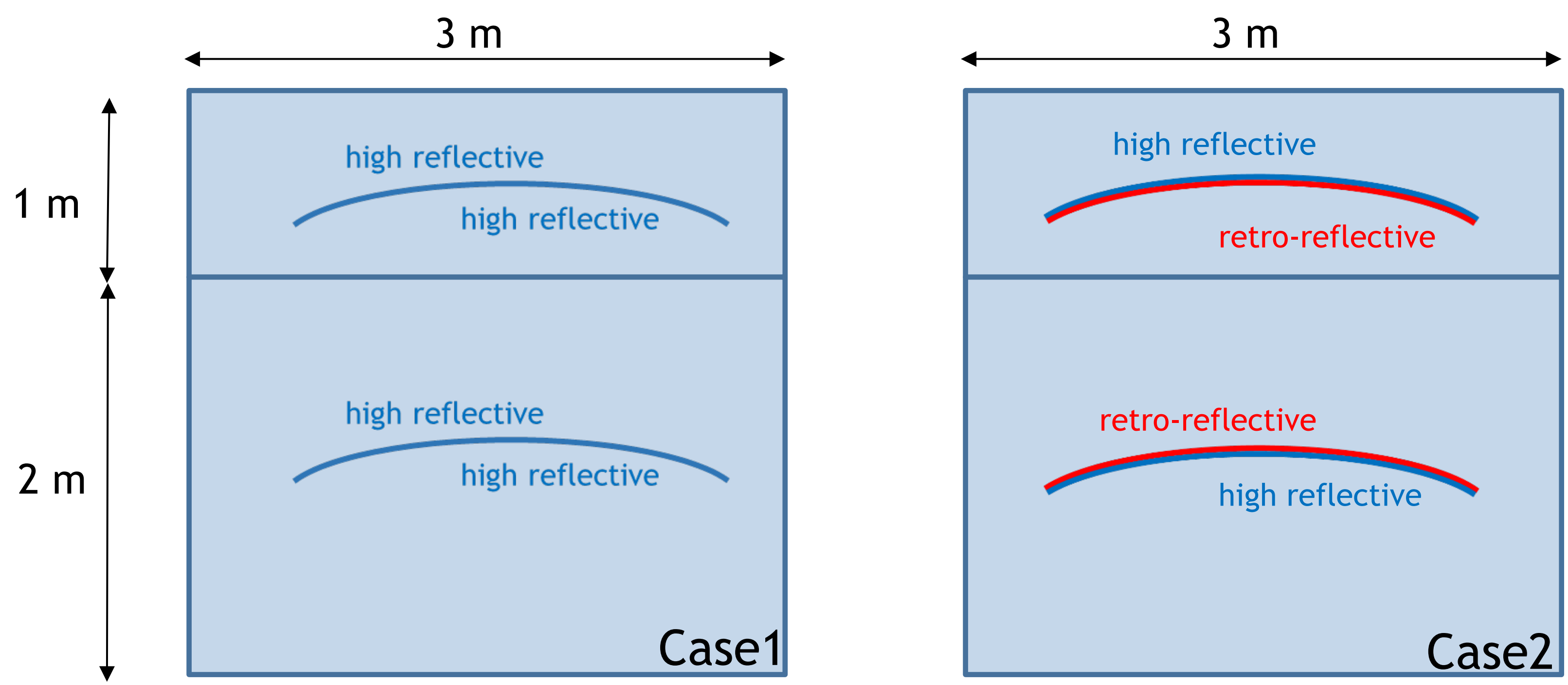


Reflections
Wall 0.6
Ceiling 0.8
Floor 0.2

View position -vp 0 4 1.6 -vd 0 -1 0 -vu 0 0 1

Sensor points 0 n0.5 0.85 0 0 1 (16 points)

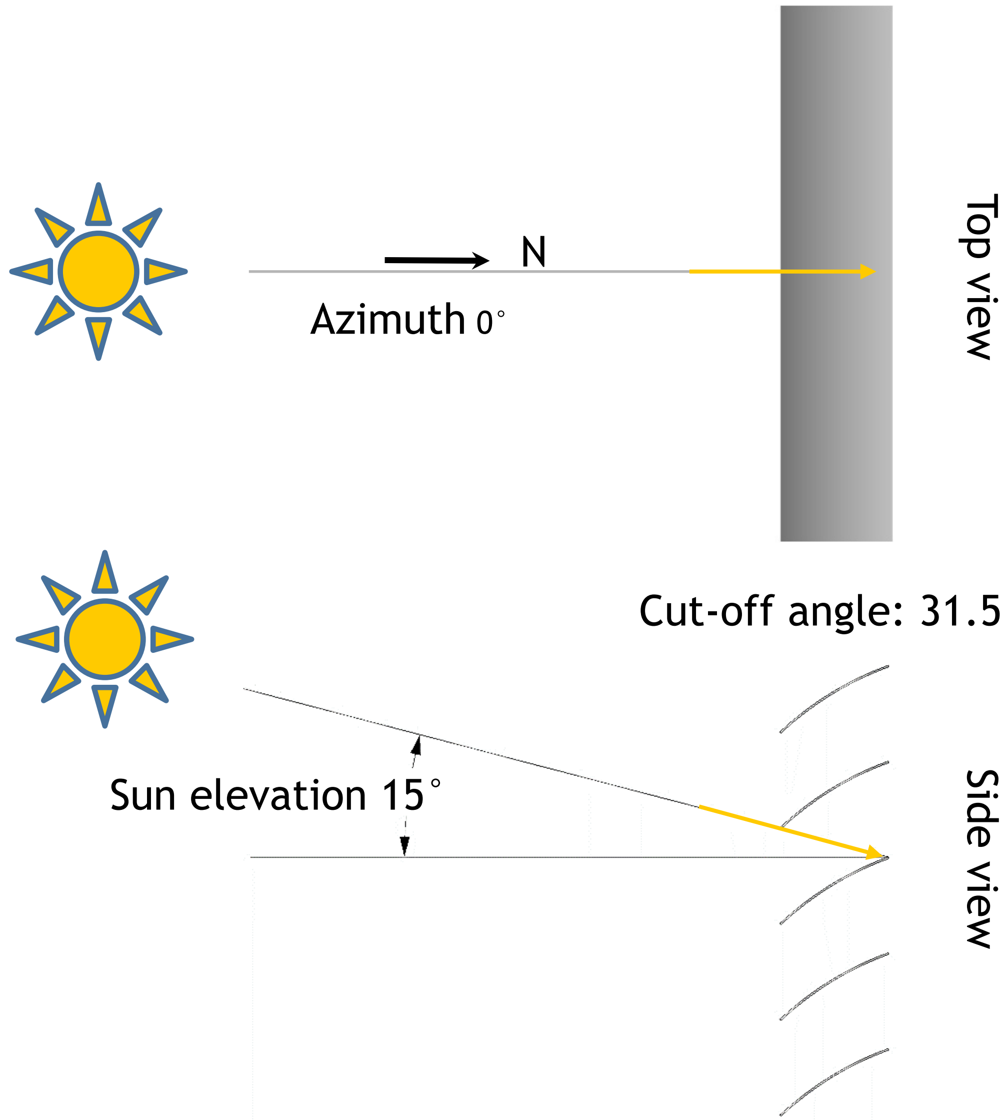
Combination over the façade



- Improve glare protection
- Daylight redirecting effect

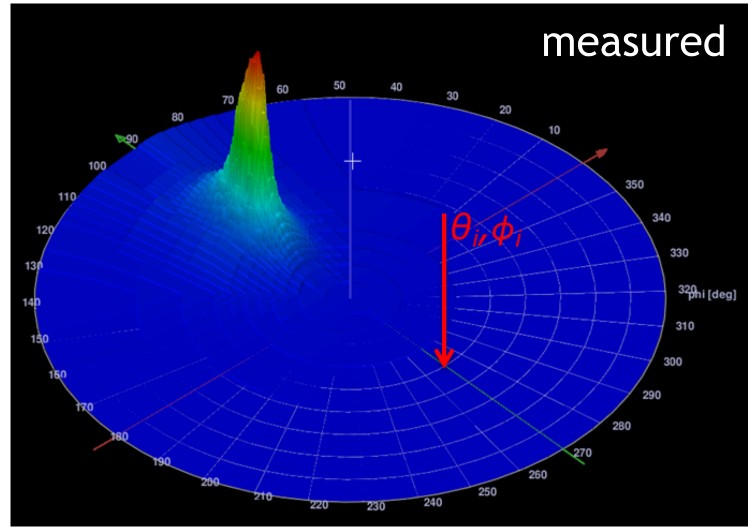
Sky condition

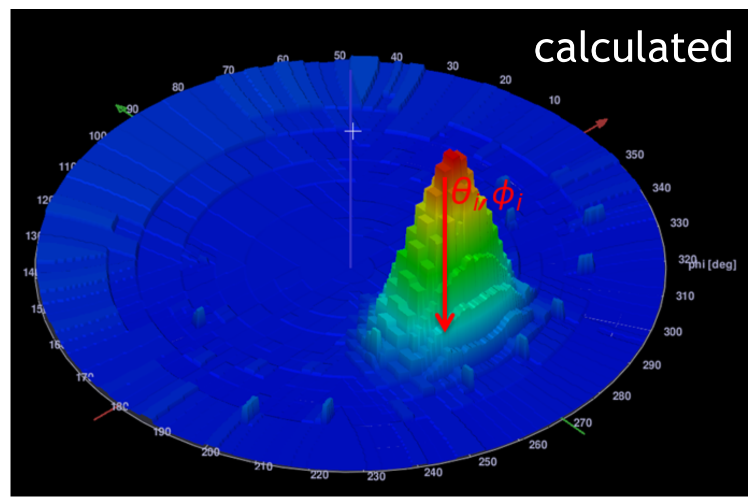
```
# sky description

!gensky -ang 15 0

skyfunc glow sky_glow
0
0
4 1 1 1 0
sky_glow source sky
0
0
4 0 0 1 180
skyfunc glow ground_glow
0
0
4 1 1 1 0
ground_glow source ground
0
0
4 0 0 -1 180
```



BSDF lamella surface material – coating.mat

```
# BSDF material

void BSDF blindsMat.Spec
6 0 ../HCCGL001-Pellini_g7t99.xml 0 1 0 .
0
0



void BSDF blindsMat.Retro
6 0 ../HCCGL002-Pellini_t4_6.xml 0 1 0 .
0
0
```





sceneCase2.rad

configuration1 - bottom window

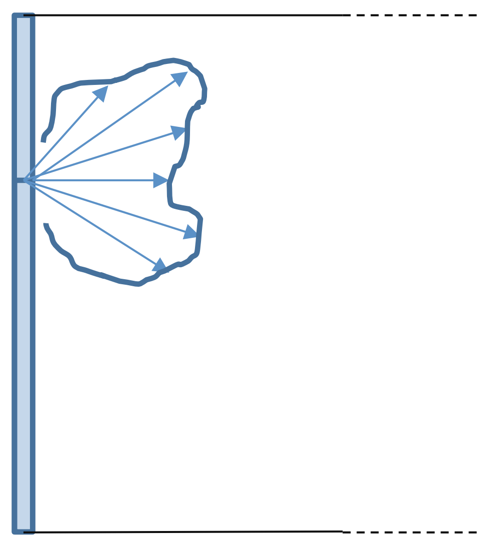
Configiuration2 - top window

```
# scene file Case2

# configuration 1 for the bottom window
!genblinds blindsMat.Retro blindsObj.LowerFront .016 3 2 166 -31.5 +r .040 | xform -rz -90 -t -1.5 0 0
!genblinds blindsMat.Spec blindsObj.LowerBack .016 3 2 166 -31.5 +r .040 | xform -I -rz -90 -t -1.5 0 -.0005

# configuration 2 for the top window
!genblinds blindsMat.Spec blindsObj.UpperFront .016 3 1 83 -31.5 +r 0.040 | xform -rz -90 -t -1.5 0 2
!genblinds blindsMat.Retro blindsObj.UpperBack .016 3 1 83 -31.5 +r 0.040 | xform -I -rz -90 -t -1.5 0 1.9995

+…
Sky condition
Material+Geometry
```

illum input file – sceneIllum.rad

```
#@mkillum d=64 s=24
void glass glassMat
0
0
3          .7          .7          .7

glassMat polygon windowObj.Bottom
0
0
12
         1.5          0          2
         1.5          0          0
        -1.5          0          0
        -1.5          0          2
glassMat polygon windowObj.Top
0
0
12
         1.5          0          2.994
         1.5          0          2
        -1.5          0          2
        -1.5          0          2.994
```

file with surfaces to be converted into illuminance sources



rad input file - sceneCase2.rif -> image-based simulation

```
# rad input file
OCTREE= oct/sceneCase2.oct
ZONE= I -1.5 1.5 0 8.3 0 3
RESOLUTION= 1024
QUALITY= M
PENUMBRAS= TRUE
VARIABILITY= H
INDIRECT= 2
REPORT= 10

PICTURE= hdr/sceneCase2
RAWFILE= unf/sceneCase2.unf
AMBFILE= amb/sceneCase2.amb
scene= rad/SceneCase2.rad
materials= rad/coating.mat
illum= rad/SceneIllum.rad
view= inside -vf vf/inside.vf
mkillum= -ad 512 -lw .0015 -aa .15
render= -ad 768 -aa .15 -lw .0008
```

…going to the terminal

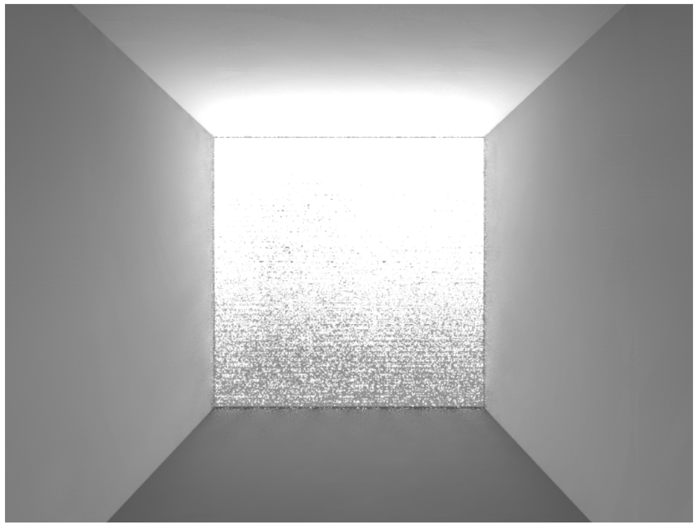
```
$ rad sceneCase2.rif
```

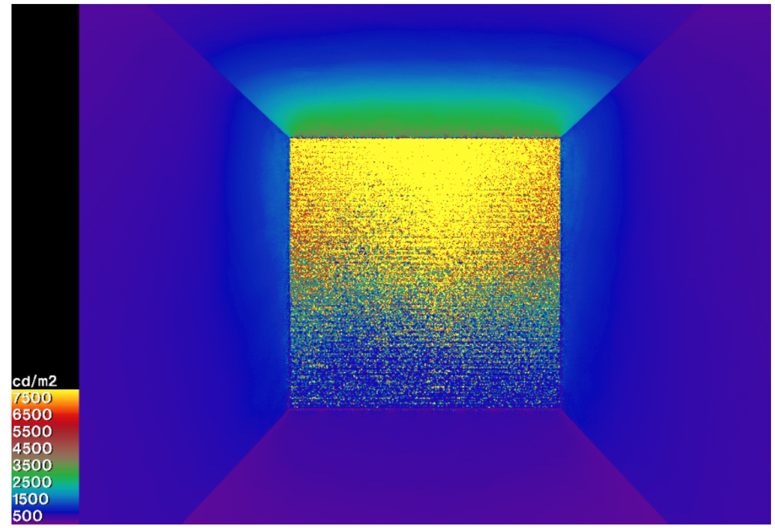
```
oconv rad/coating.mat rad/testScene.rad > oct/sceneCase1.oct
oconv -i oct/sceneCase1.oct rad/testSceneIllum.rad  \
> oct/sceneCase10.oct
mkillum oct/sceneCase10.oct "<" rad/testSceneIllum.rad > ilMjcjRf

oconv -f -i oct/sceneCase1.oct ilMjcjRf > oct/sceneCase11.oct

rpict -t 600 -vf vf/inside.vf -dp 512 -ar 55 -ms 0.12 -ds .2 -dj .9
-dt .1 -dc .5 -dr 1 -ss 1 -st .1 -ab 2 –af amb/sceneCase2.amb -aa .1
-ad 1536 -as 392 -av 0.01 0.01 0.01 -lr 8 -lw 1e-4 -x 64 -y 64 -ps 1
oct/sceneCase2.oct
```

Results

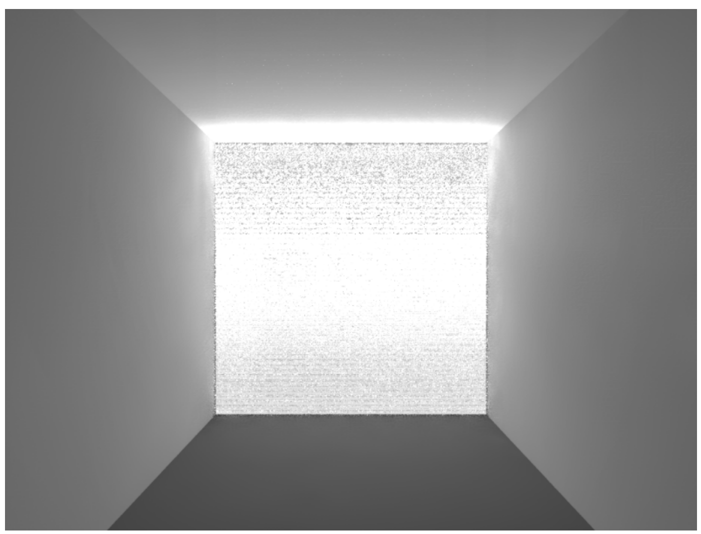
Prospective view

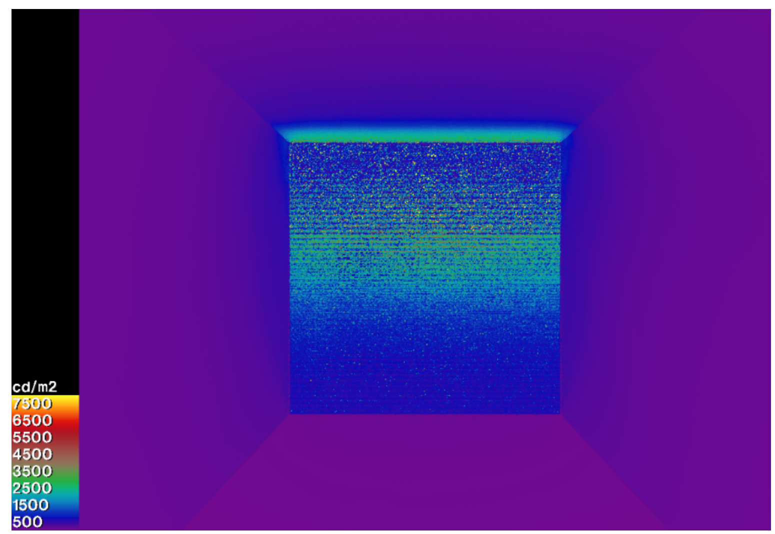
Case1





Case2

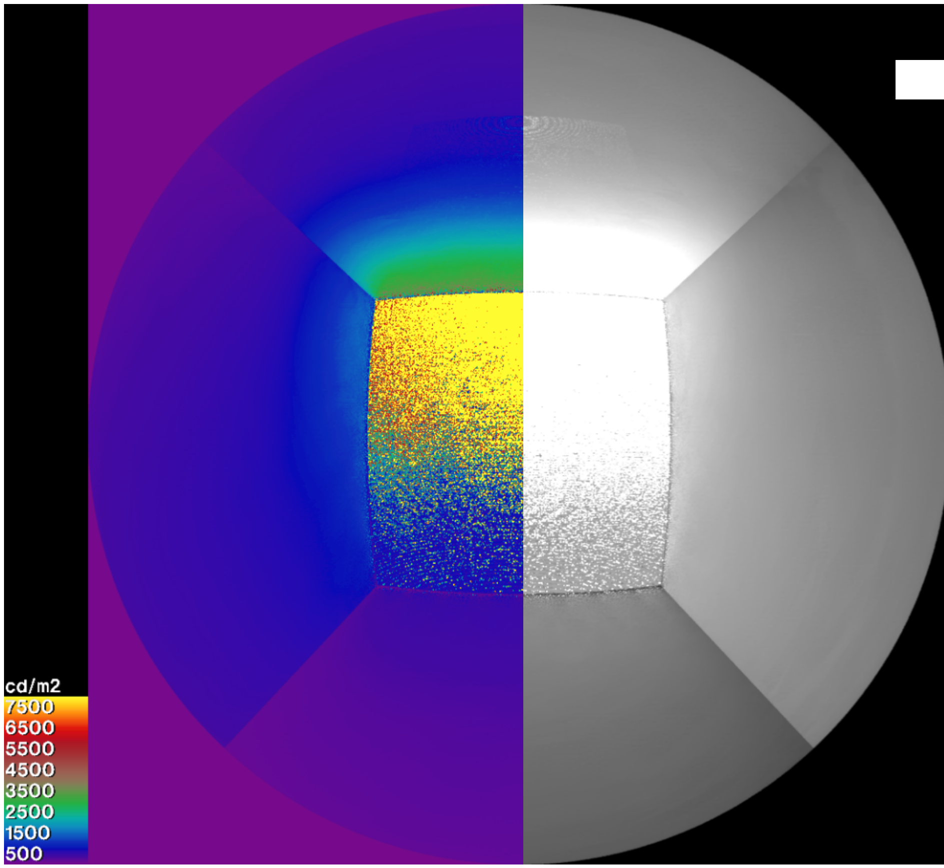


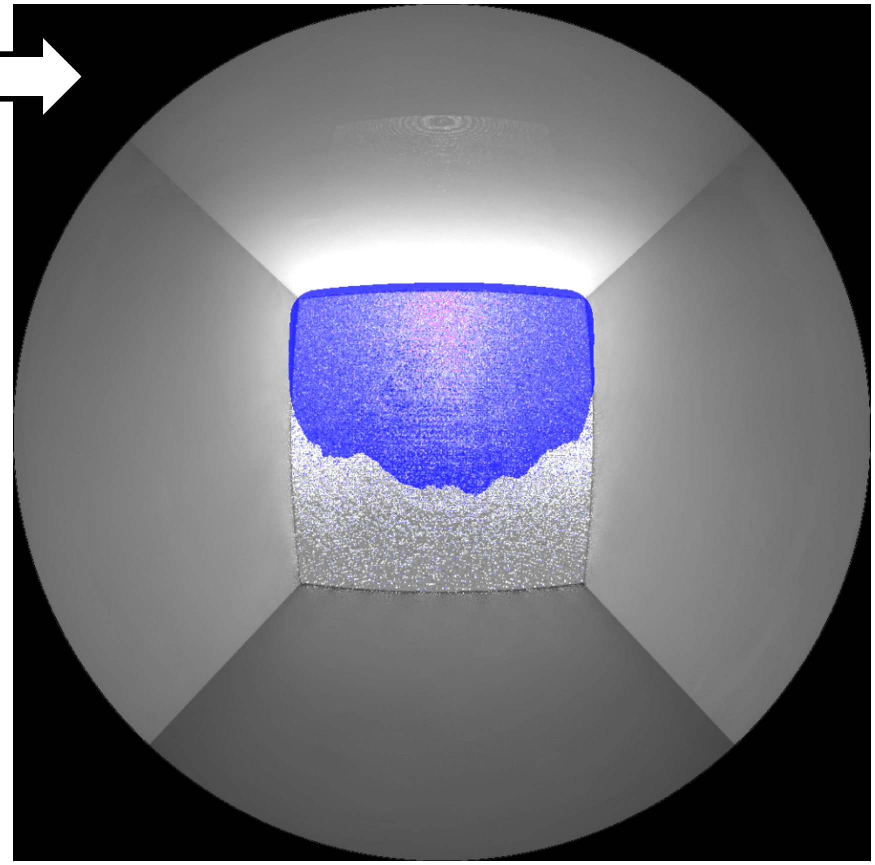


EURAC research unibz

Results

DGP calculation Case1



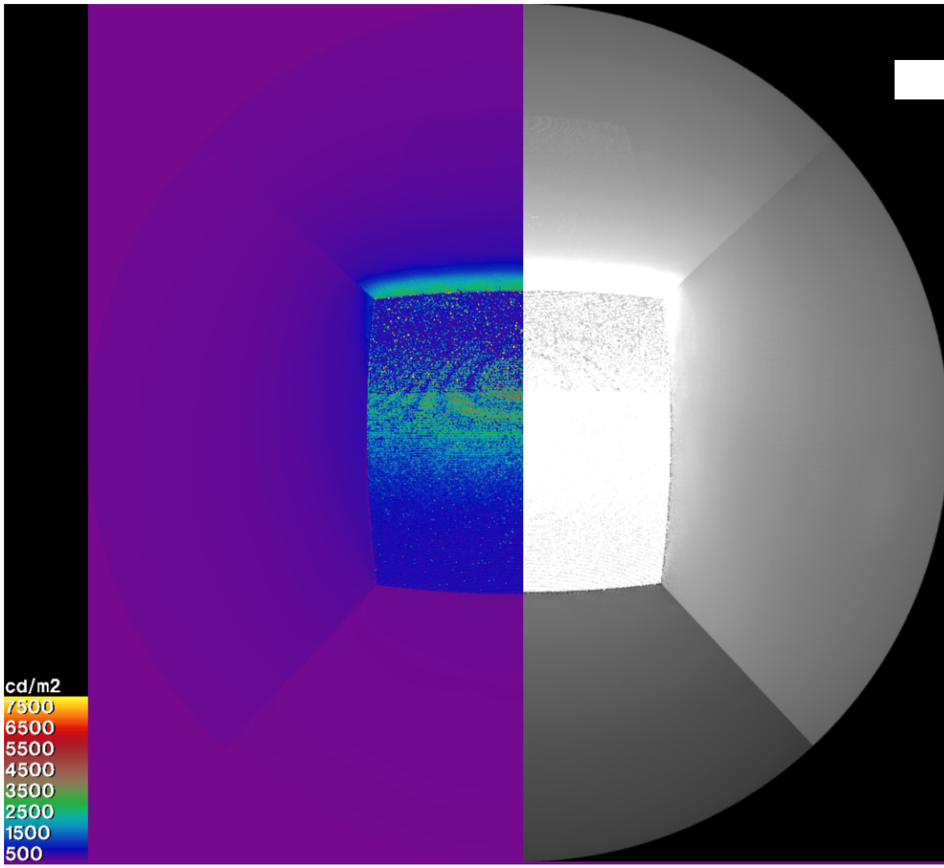


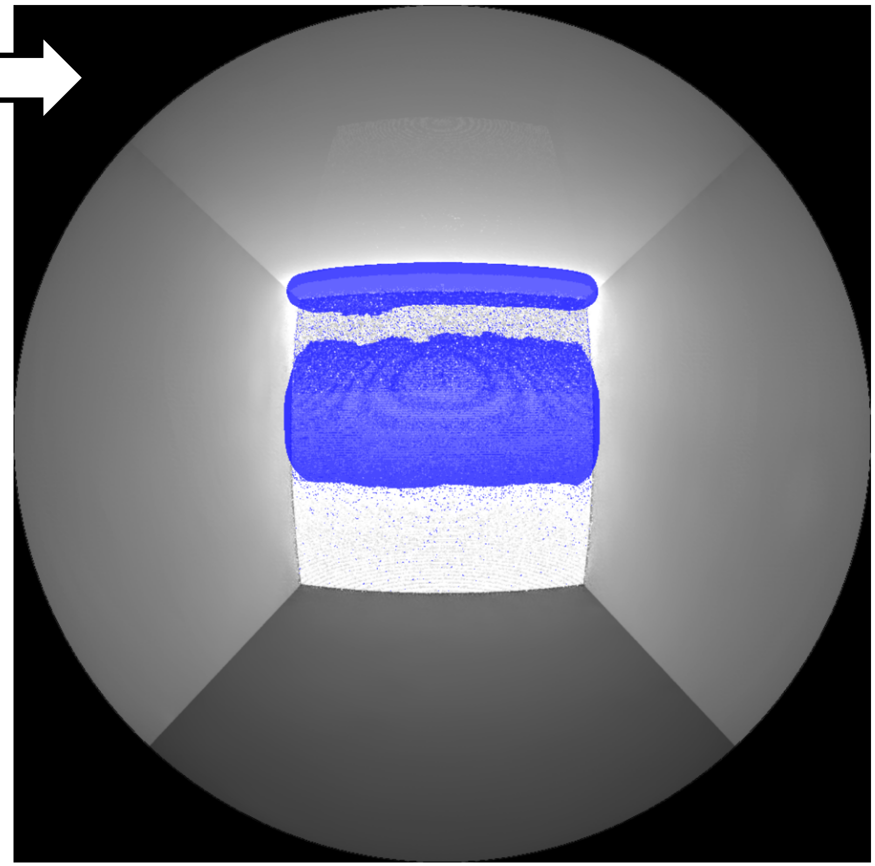
```
$ pcomb -o sceneCase1_fe.hdr | evalglare -vth
-vp 0 4 1.6 -vd 0 -1 0 -vu 0 0 1 -vh 180 -vv 180
-c sceneCase1_fe_check.hdr
```

```
dgp,dgi,ugr,vcp,cgi,Lveil: 0.567620
28.619001 34.613251 0.000000 40.963387
2974.534668
```

Results

DGP calculation Case2





$ pcomb -o sceneCase2_fe.hdr | evalglare -vth -vp 0 4 1.6 -vd 0 -1 0 -vu 0 0 1 -vh 180 -vv 180 -c sceneCase2_fe_check.hdr

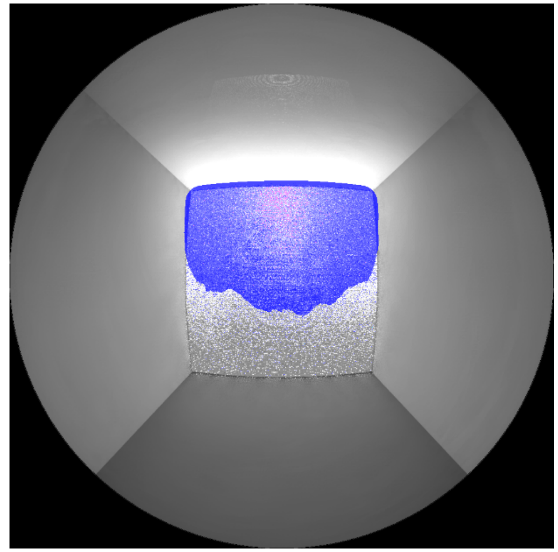
dgp,dgi,ugr,vcp,cgi,Lveil: 0.254569 20.078901 23.994635 4.022694 26.819836 399.066040

DGP comparison

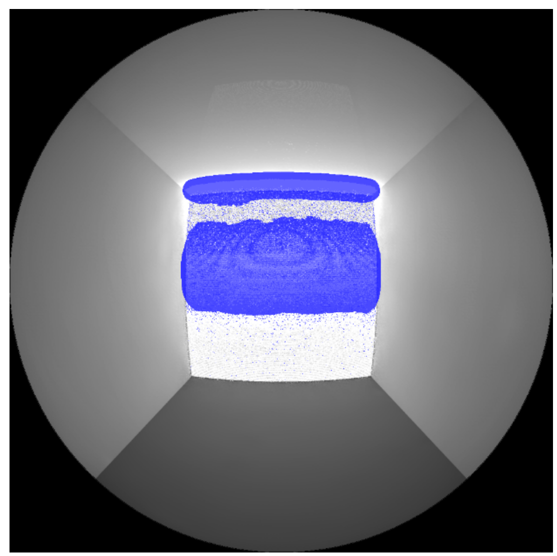
Daylight glare comfort classes

	A best class 95% of office-time glare weaker than ´imperceptible´	B good class 95% of office-time glare weaker than ´perceptible ´	C reasonable class 95% of office-time glare weaker than `disturbing`
DGP limit	≤ 0.35	≤ 0.40	≤ 0.45
Average DGP limit within 5% band	0.38	0.42	0.53

Source: Wienold 2009, DYNAMIC DAYLIGHT GLARE EVALUATION.



Case1
Ev = 5903 lux
DGP = 0.56
Category C



Case2
Ev = 1070 lux
DGP = 0.25
Category A

grid based simulatin - rtrace

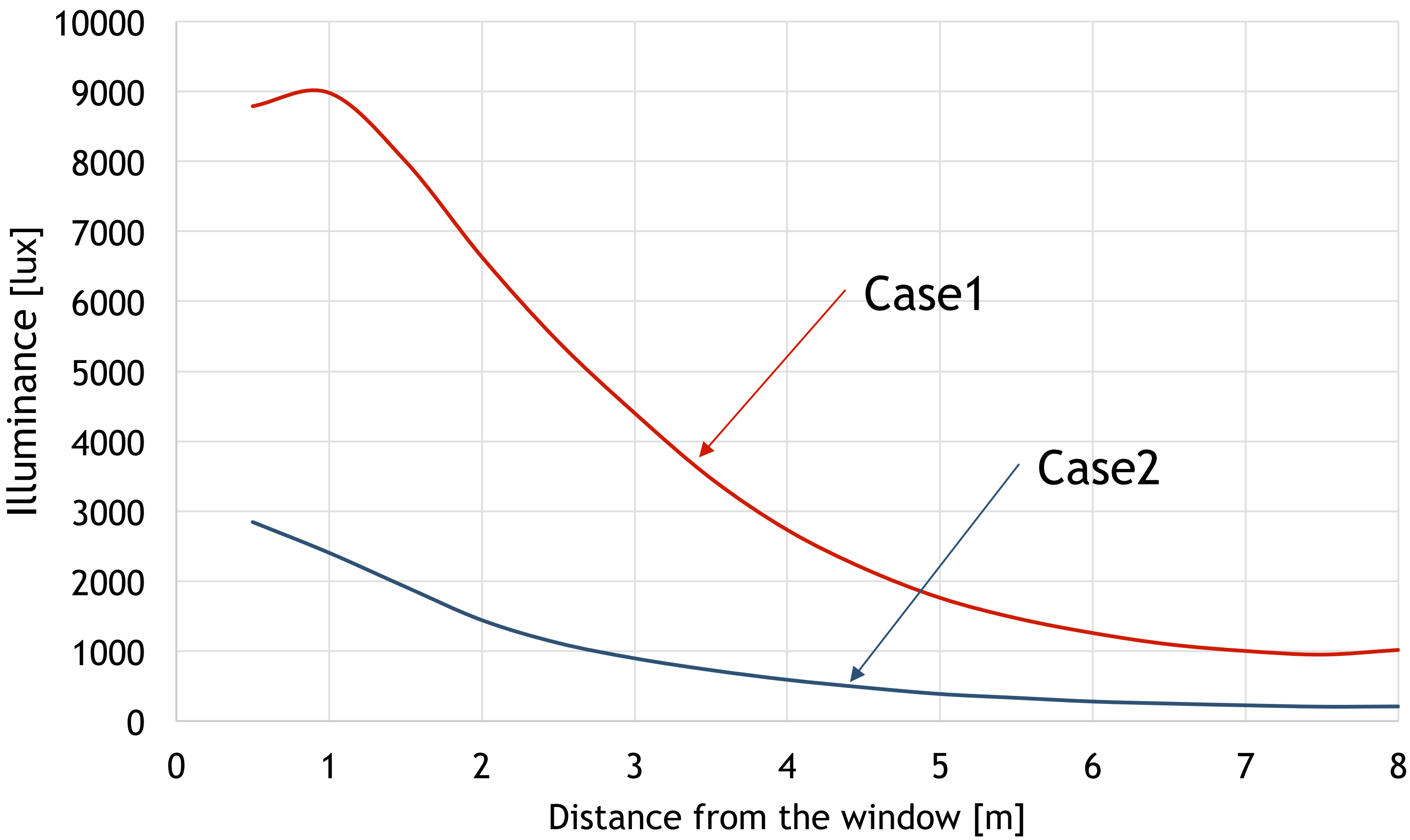
```
# sensors.pts
# x y z vx vy vz
 0   0.5  0.85   0    0    1
 0    1   0.85   0    0    1
 0   1.5  0.85   0    0    1
 0    2   0.85   0    0    1
 0   2.5  0.85   0    0    1
 0    3   0.85   0    0    1
 0   3.5  0.85   0    0    1
 0    4   0.85   0    0    1
 0   4.5  0.85   0    0    1
 0    5   0.85   0    0    1
 0   5.5  0.85   0    0    1
 0    6   0.85   0    0    1
 0   6.5  0.85   0    0    1
 0    7   0.85   0    0    1
 0   7.5  0.85   0    0    1
 0    8   0.85   0    0    1
```

take the octree file from the imaged-based simulation -> oct/**sceneCase12.oct**

```
$ cat illum/sensors.pts | rtrace -I+ -ab 5 \ oct/
sceneCase12.oct | rcalc \
 -e '$1=47.4*$1+120*$2+11.6*$3' > illum/sceneCase1.ill
```

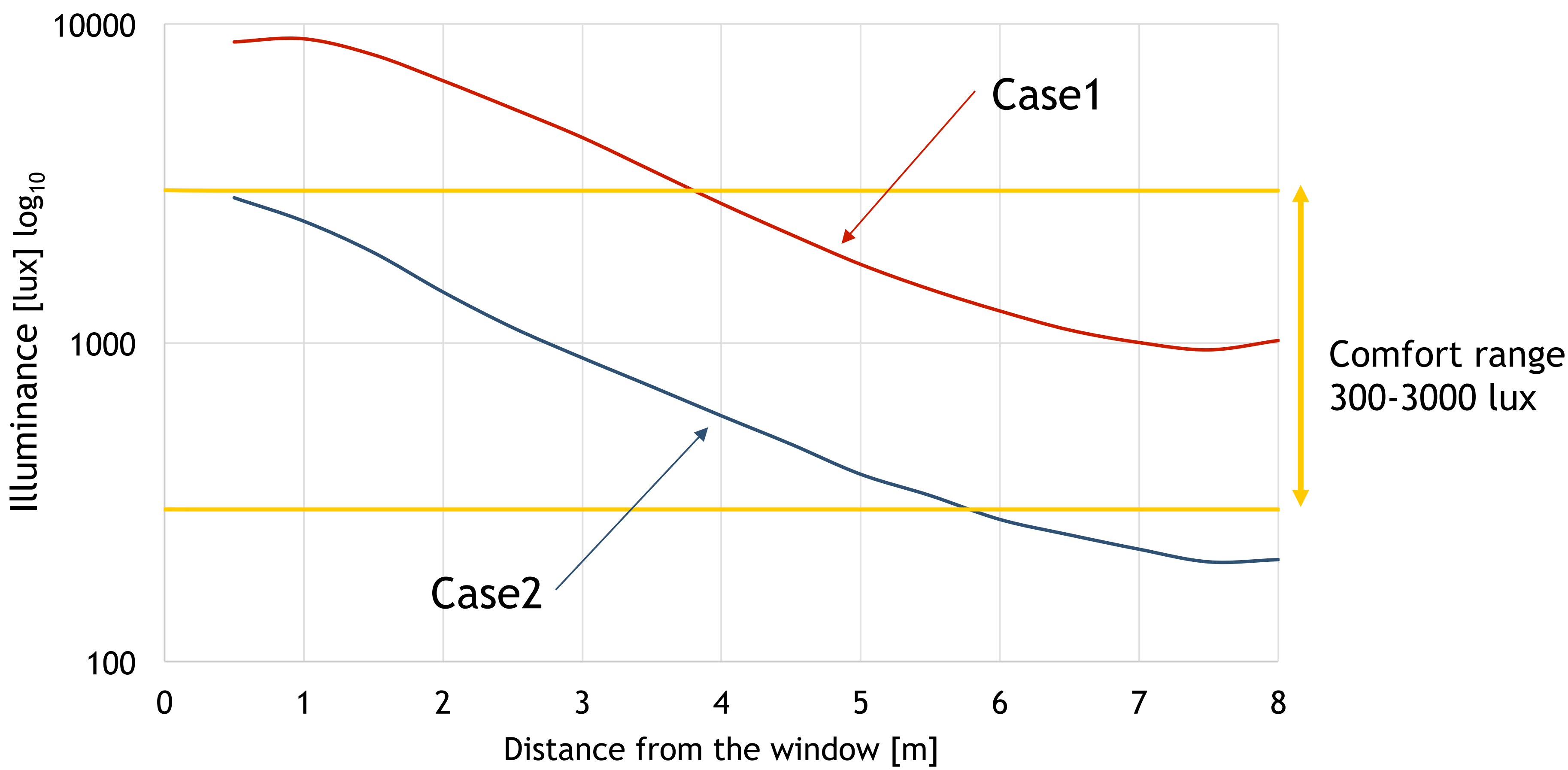
Results

Daylight availability



Results

Daylight availability



Conclusion

- Glare reduction
- Better regulation of the daylight inside the space

Outlook

- Improving daylight redirecting
- Optimization of the system

For any further information:

pellinindustrie

ScreenLine®

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Technik & Architektur

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Sole responsibility for content and conclusions by the author.

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
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Bundesamt für Energie BFE
Swiss Federal Office of Energy SFOE

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