21st International Radiance Workshop
August 28-31, 2023

# Validation of VELUX Daylight Visualizer CBDM Predictions Against *Radiance*

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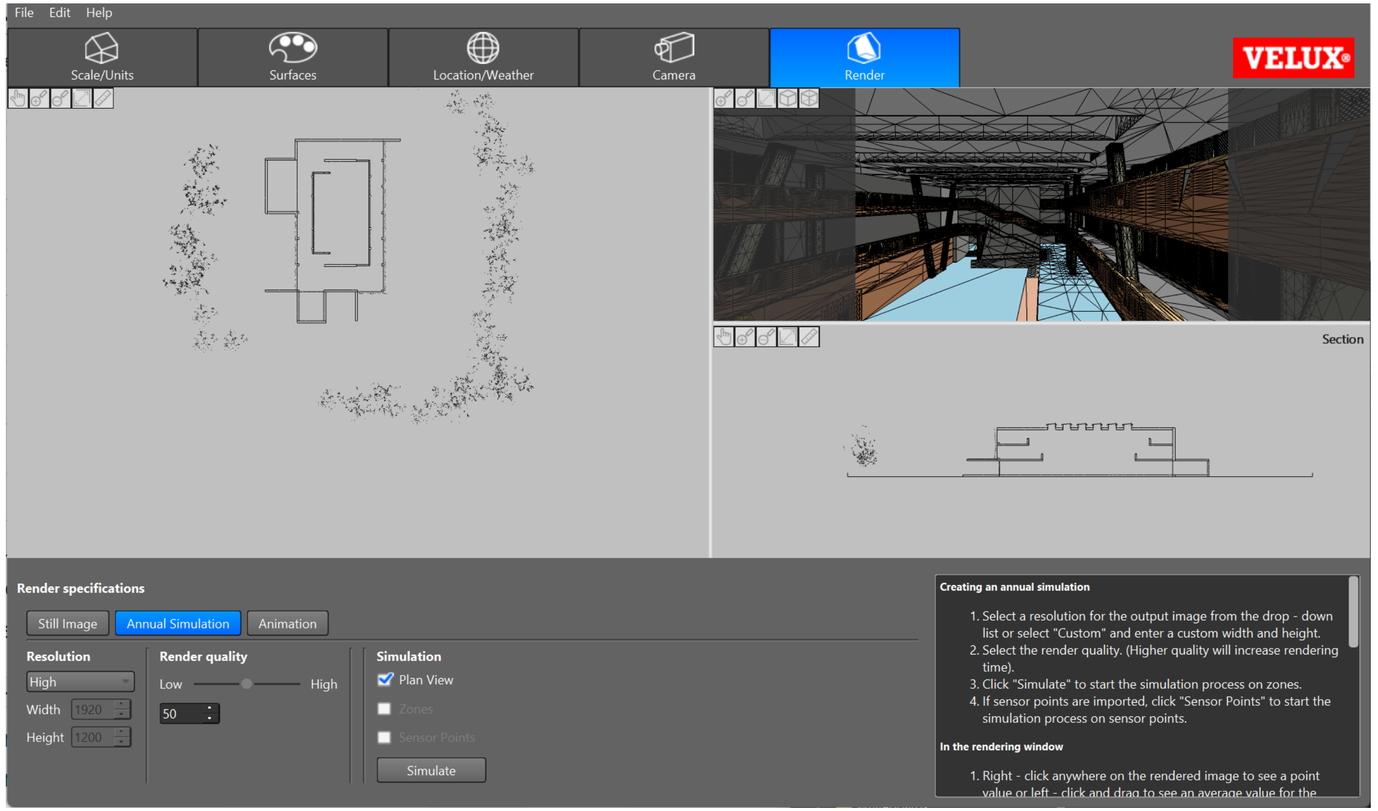
Expert Witness | Simulation | Measurement | Conservation

# Velux Daylight Visualizer

## by Velux and Luxion

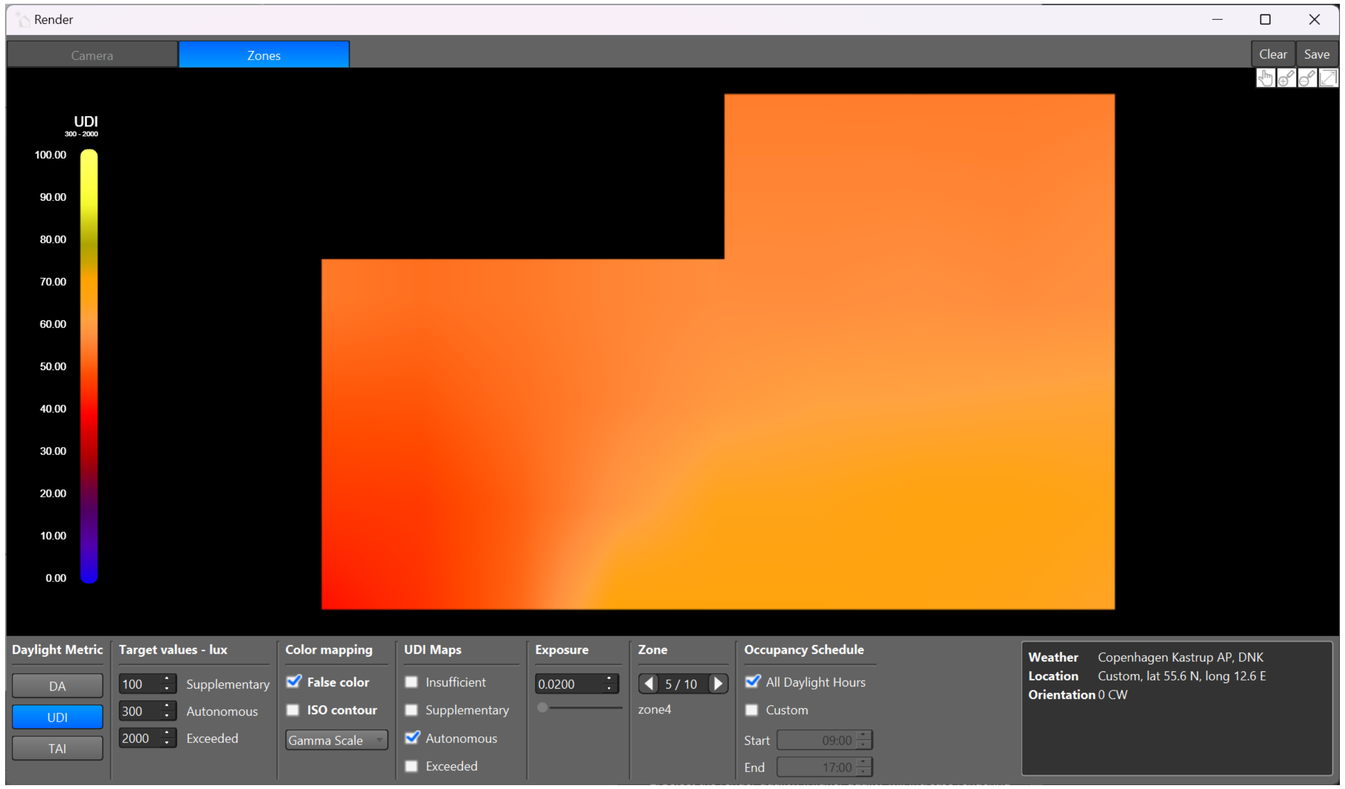
Free tool for daylight simulations

- Images, Animations and Sensor Points
- Luminance, Illuminance, DF
- Integrated modeller



# Annual Simulation

## CBDM in DViz




Consulted by John Mardaljevic and David Geisler-Moroder

Features

- SDA, UDI and TAI Output
- EN17037 and Active House

**EN17037**

| | | |
|---|---|---|
| $F_{plane,\%} \geq DA_{100,TM}$ | 100% | Pass (≥95%) |
| $F_{plane,\%} \geq DA_{300,T}$ | 100% | Pass (≥50%) |
| $F_{plane,\%} \geq DA_{500,T}$ | 98% | Pass (≥50%) |
| $F_{plane,\%} \geq DA_{750,T}$ | 32% | Fail (<50%) |

**Active House**

| | | |
|---|---|---|
| $F_{plane,\%} \geq DA_{300,T}$ | 100% | |
| C1 | Pass | (≥70) |
| C2 | Pass | (≥60) |
| C3 | Pass | (≥50) |
| C4 | Pass | (≥40) |

# Methodology

## 4 Component Method

### Daylight Coefficients

| | | | |
|---|---|---|---|
| **Direct Sky**<br>Shadow rays | **Direct Sun**<br>Shadow rays | **Indirect Sky**<br>Photon Mapping | **Indirect Sun**<br>Photon Mapping |

### Luminance

| | |
|---|---|
| **Sky Luminance**<br>gendaymtx | **Sun Normal Illuminance**<br>Perez LE [1] with 3h sma DPT |

[1] Perez, Richard, et al. "Modeling daylight availability and irradiance components from direct and global irradiance." *Solar energy* 44.5 (1990): 271-289.

# Light Transport

**Adaptive Progressive Photon Mapping**

combined with **Bidirectional Path Tracing** [2][3][4]

In-House Engine: Dali

[2] Hachisuka, Toshiya, and Henrik Wann Jensen. "Robust adaptive photon tracing using photon path visibility." *ACM Trans. Graph.* 30.5 (2011): 114-1.

[3] Jensen, Henrik Wann. *Realistic image synthesis using photon mapping*. Vol. 364. Natick: Ak Peters, 2001.

[4] Hachisuka, Toshiya, et al. "Multidimensional adaptive sampling and reconstruction for ray tracing." *ACM SIGGRAPH 2008 papers.* 2008. 1-10.

# Scene

## Geometry

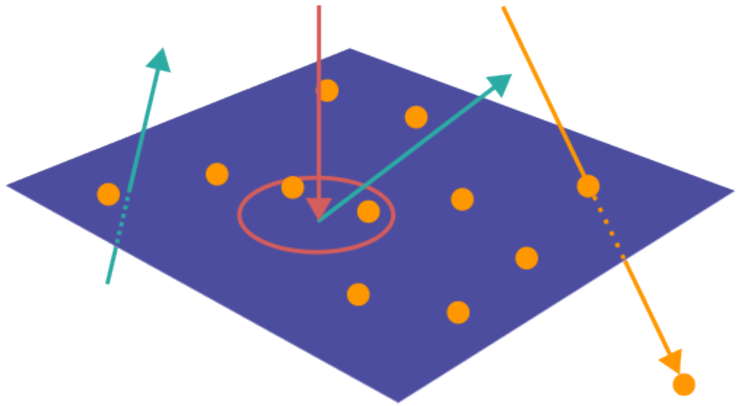
| Imported | Modelled in DViz |
|---|---|

## Light Sources

| **Sky**<br>Environment Light – 360x180 | **Sun**<br>“Directional” Light<br>0.5° or 11° opening angle |
|---|---|

## Sensor Point

- Plane 4x4 cm
- “Intercepts” photons
- Interacts with primary rays
- “Invisible” to other rays



# Overview: Three Stages

I. Preparatory — review of CBDM approaches (with Eleonora Brembilla).

II. Developmental testing of the ‘evolving’ DVIZ CBDM engine.

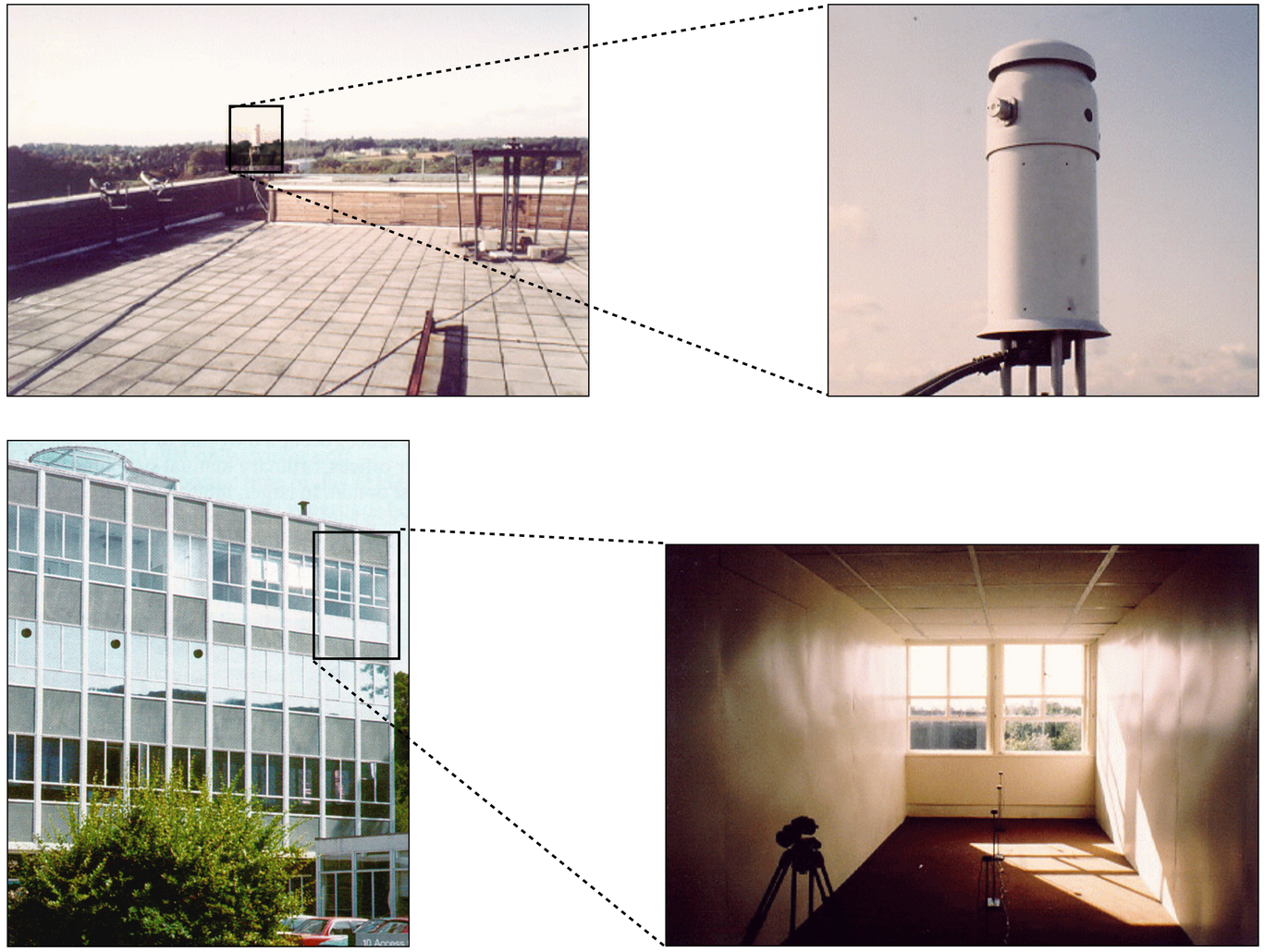
III. Validation against results from the 4 Component Method using two complex/realistic scenarios.

# CBDM 4 Component Method

- Use an unmodified version of *Radiance* (circa 1995).
- Maintain the efficiency advantage of using material type **`light`**.
- Maintain the efficiency advantage of employing ambient interpolation & overture calculation.
- Make (independent) use of multiple CPUs.
- Tested against the best possible validation dataset at the time: BRE-IDMP.
- Method determines direct and indirect components of sunlight and skylight.

# BRE IDMP Validation Dataset

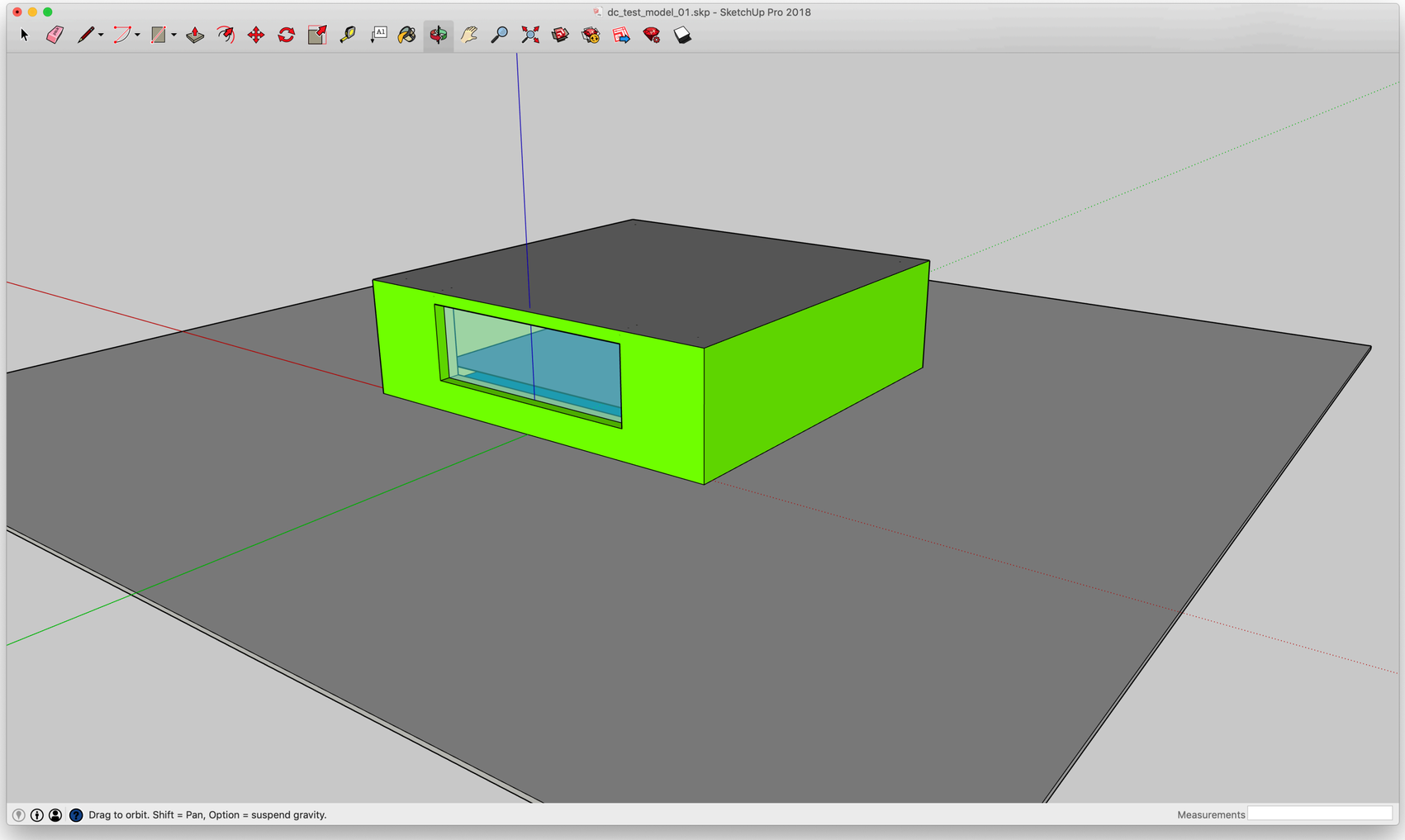
Building 9, BRE,
Garston, UK



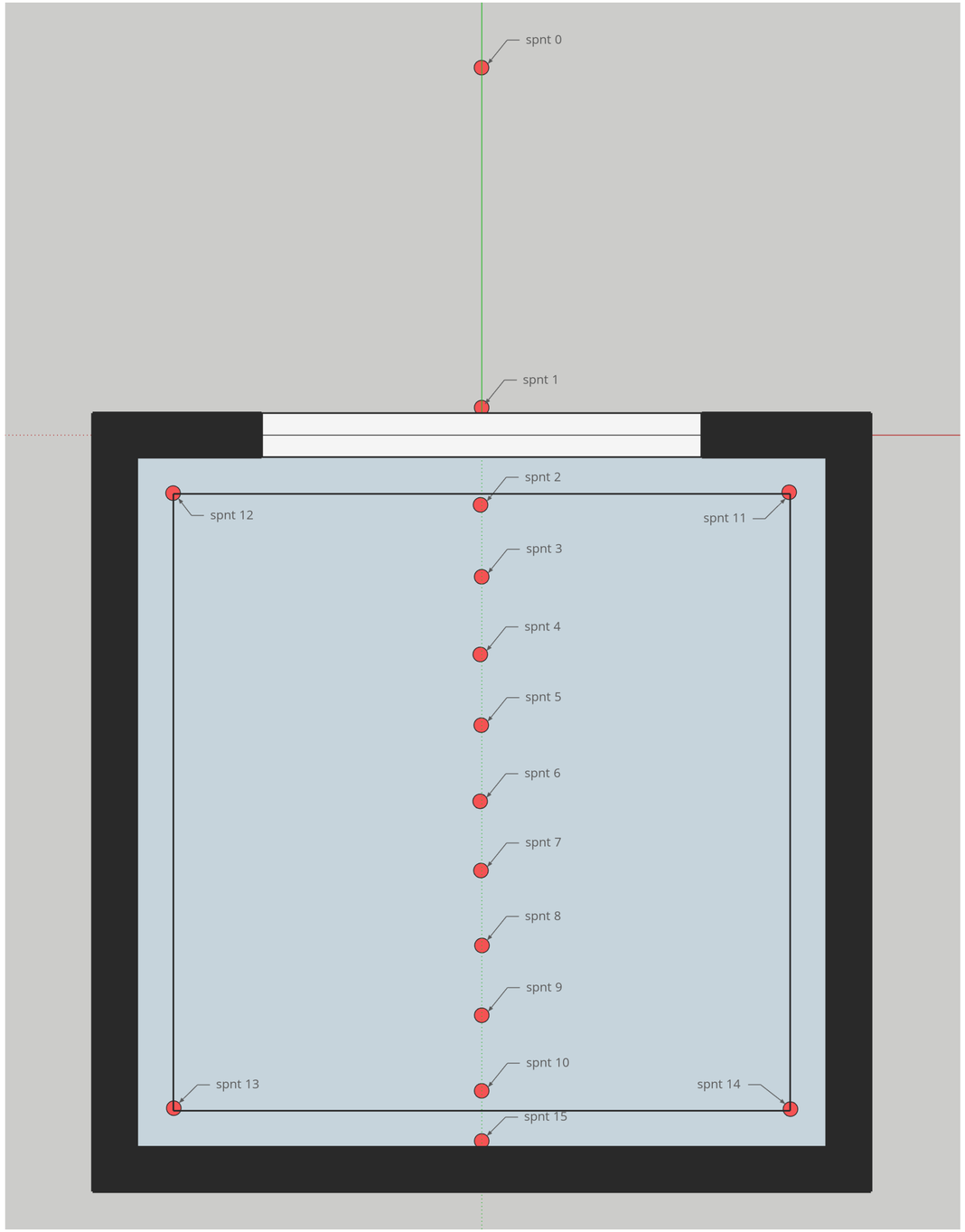
Krochmann
sky scanner

Standard *Radiance* and 4CM (CBDM) predictions
within ±10% measurements

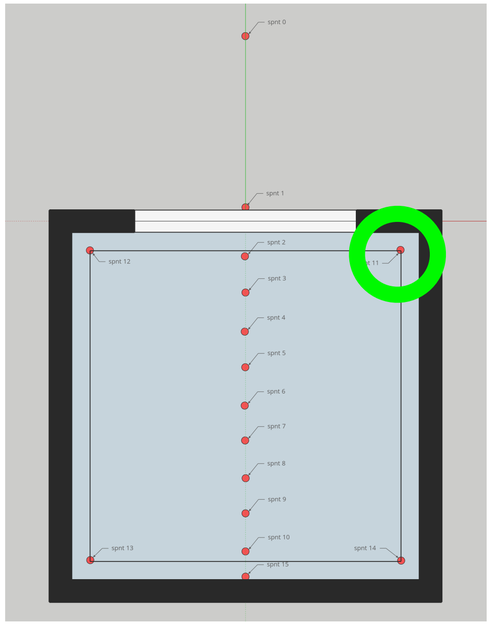
# The ‘development’ shoebox model



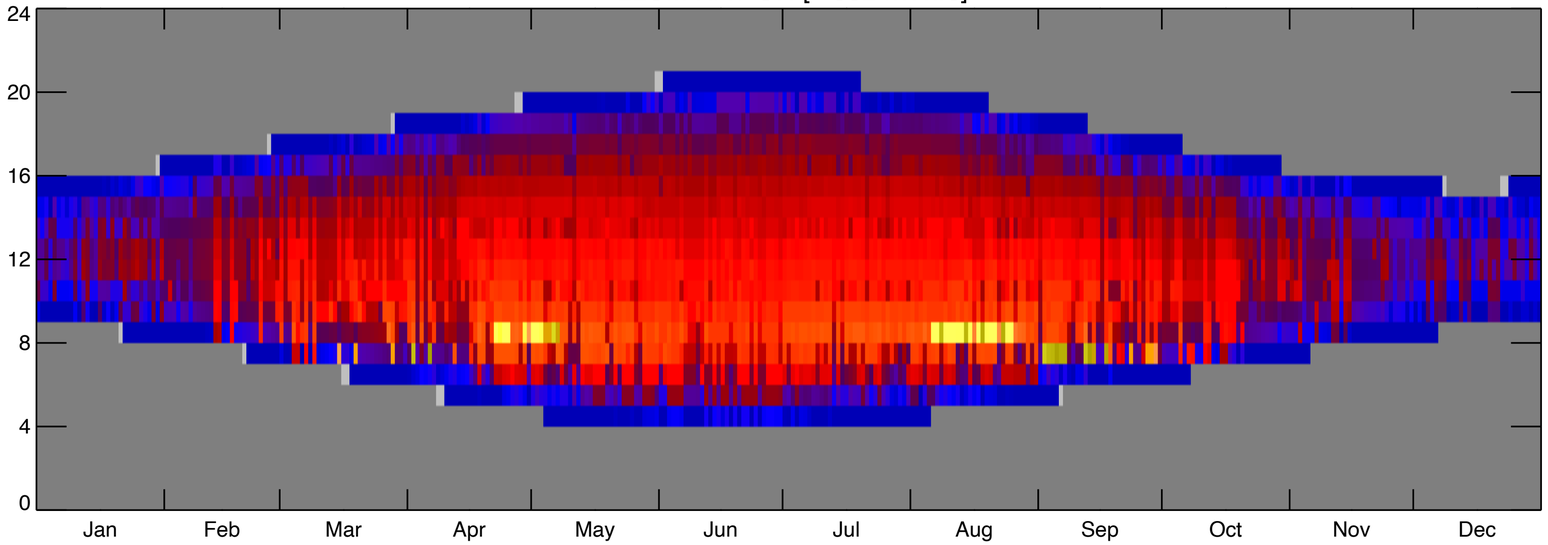

Used to define/refine the DVIZ CBDM workflow

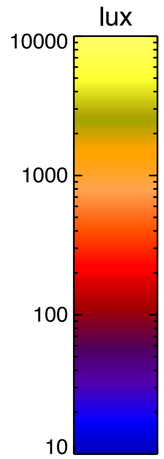

spnt 0
spnt 1
spnt 2
spnt 12
spnt 11
spnt 3
spnt 4
spnt 5
spnt 6
spnt 7
spnt 8
spnt 9
spnt 10
spnt 13
spnt 14
spnt 15

Sensor 011 [ 4.20 -0.80 0.80 ] [ 0 0 1 ]

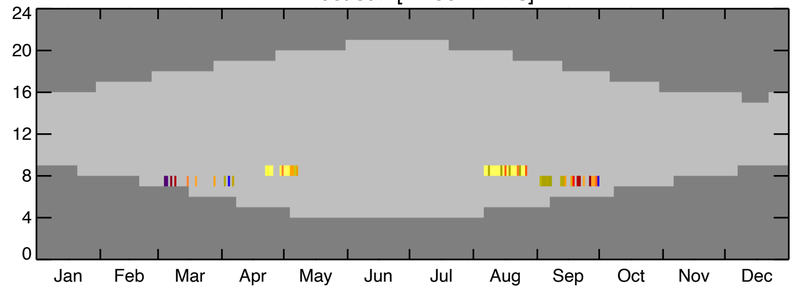



ILLUMINATION [ 882 klx hrs]

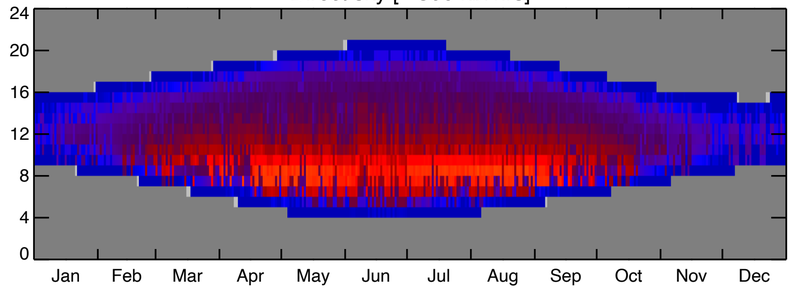


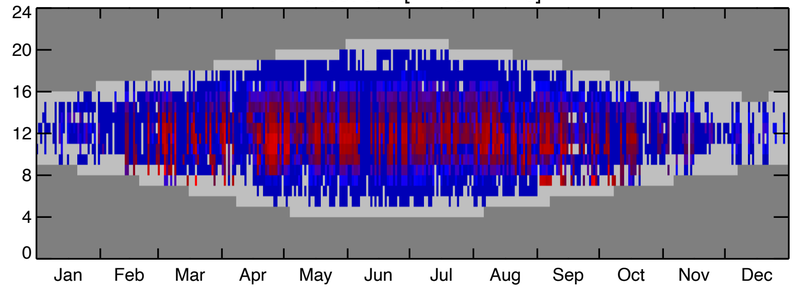

Direct sun [ 299 klx hrs]



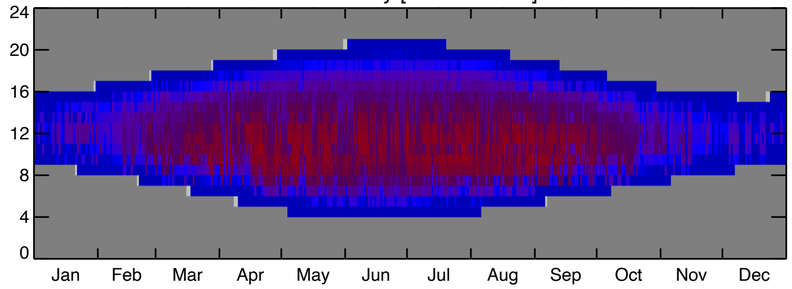

Direct sky [ 306 klx hrs]




Indirect sun [ 105 klx hrs]




Indirect sky [ 170 klx hrs]




ModGlazRhoP20 SENS-011

DNK_HS_Copenhagen-Kastrup.AP.061800_TMYx

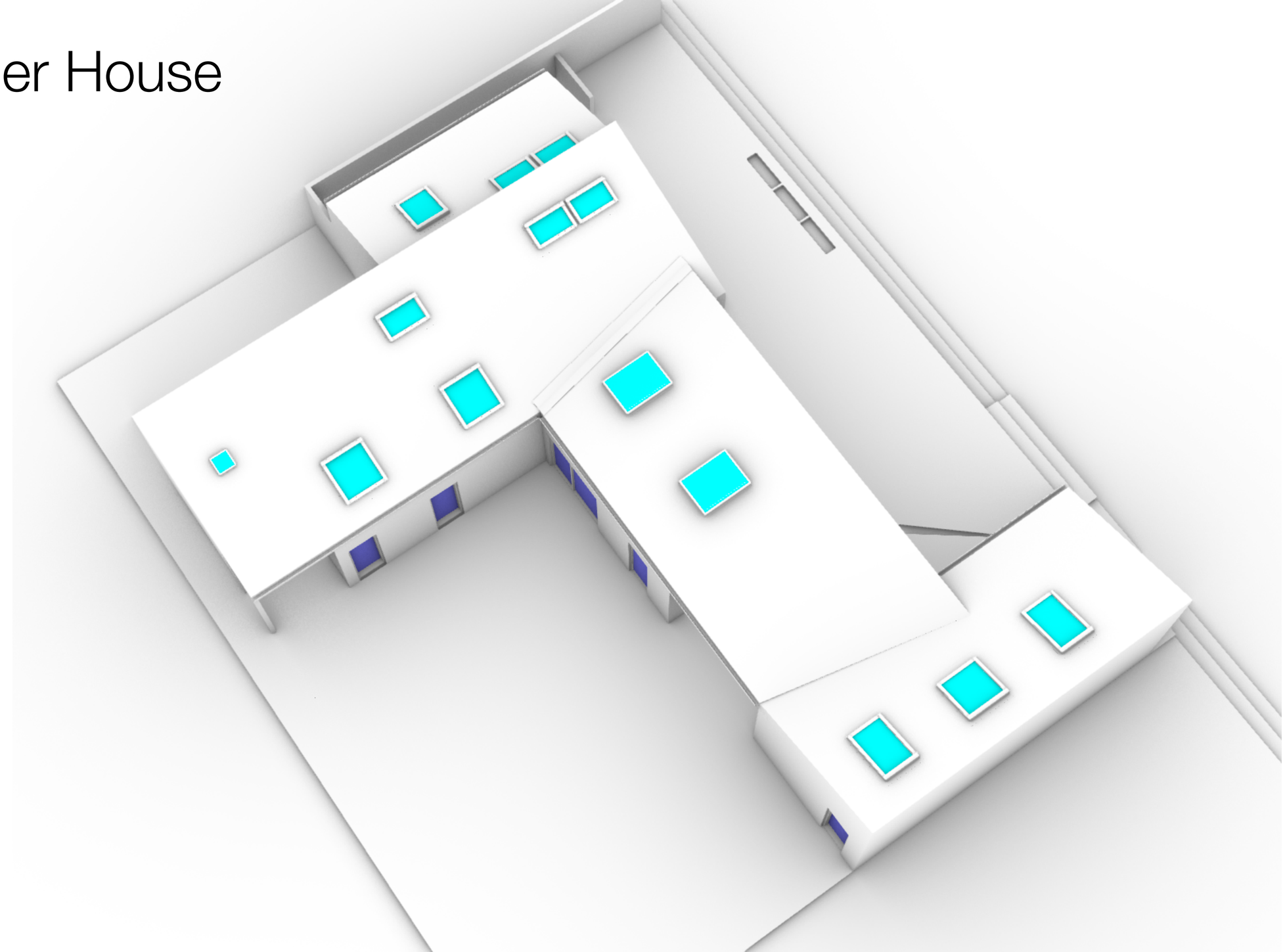
# The validation scenarios

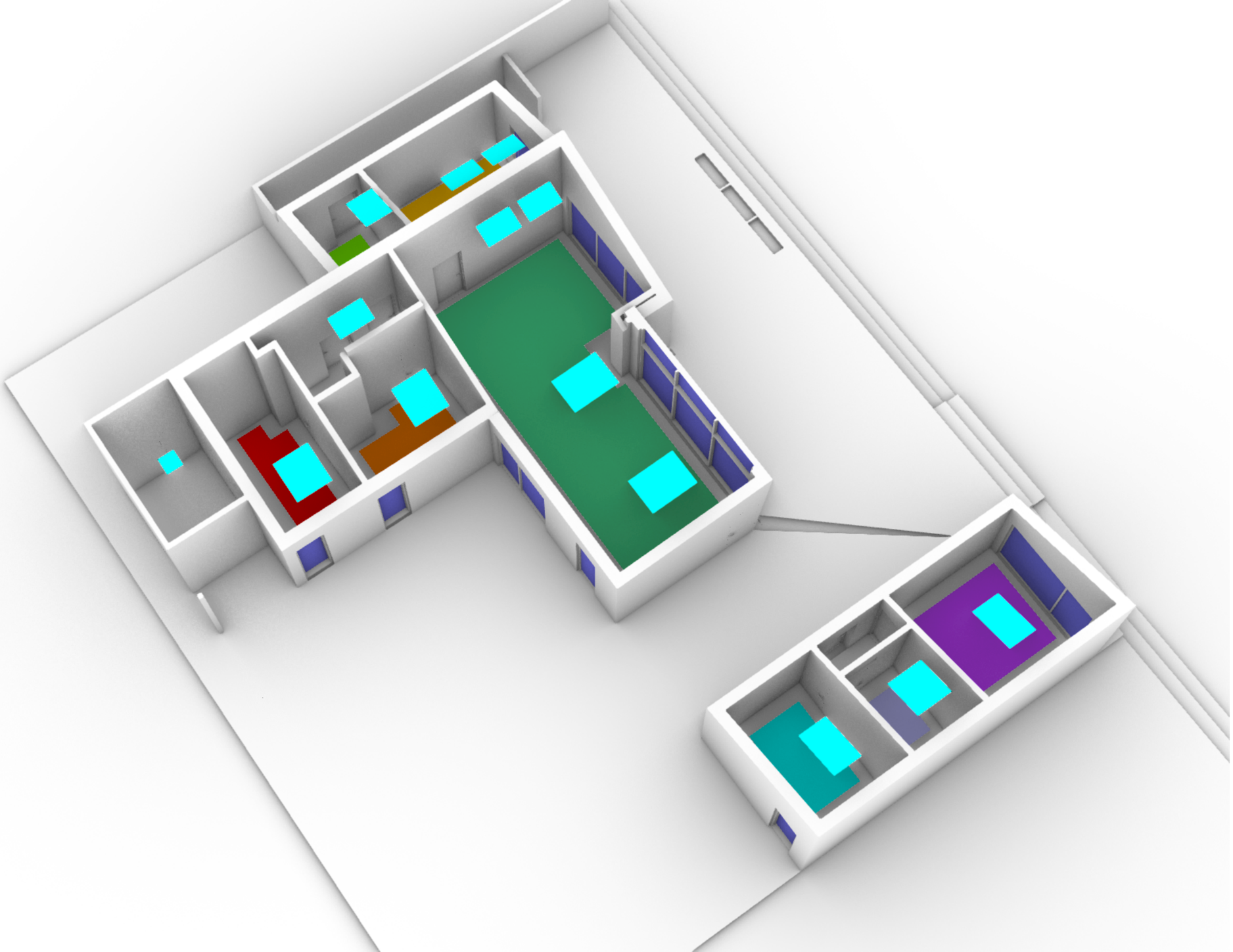
- Summer House — 8 zones, 3D model comprised 51,291 polygons.
- IT Factory — 5 zones, 3D model comprised 2,368,382 polygons.
- 3 weather files —

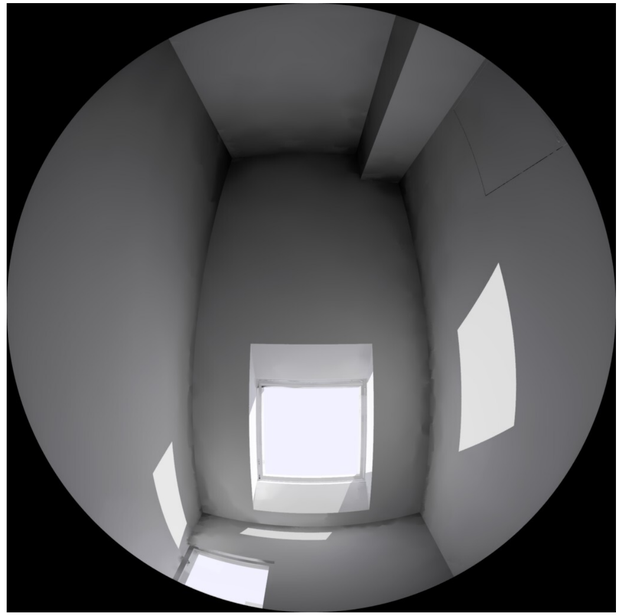
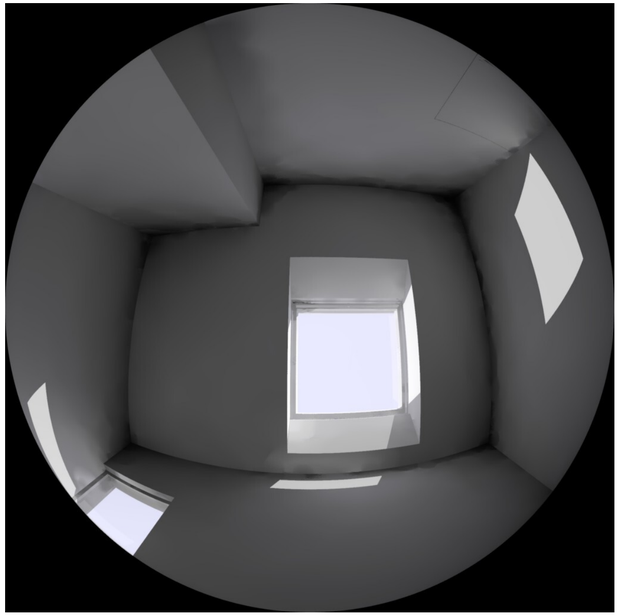
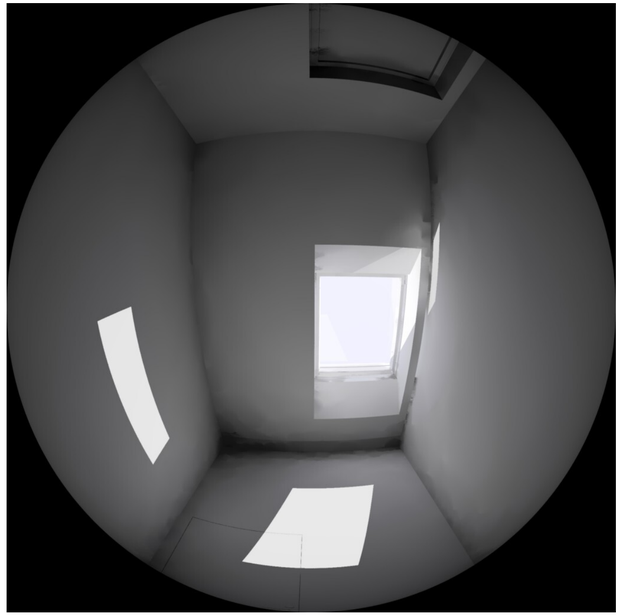
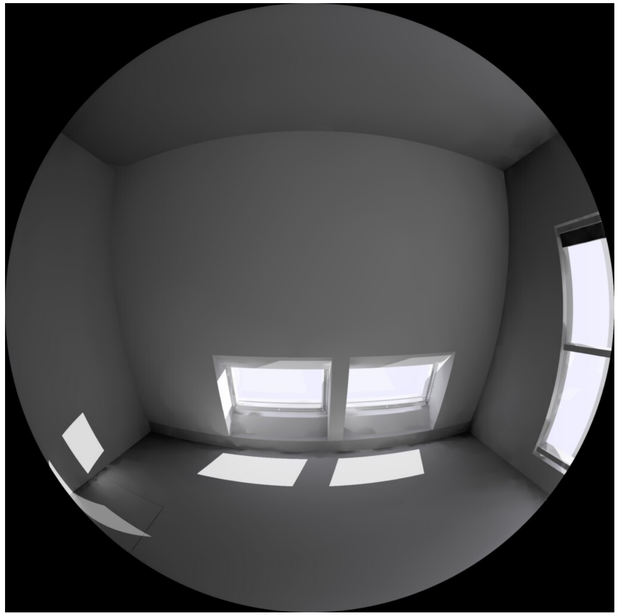
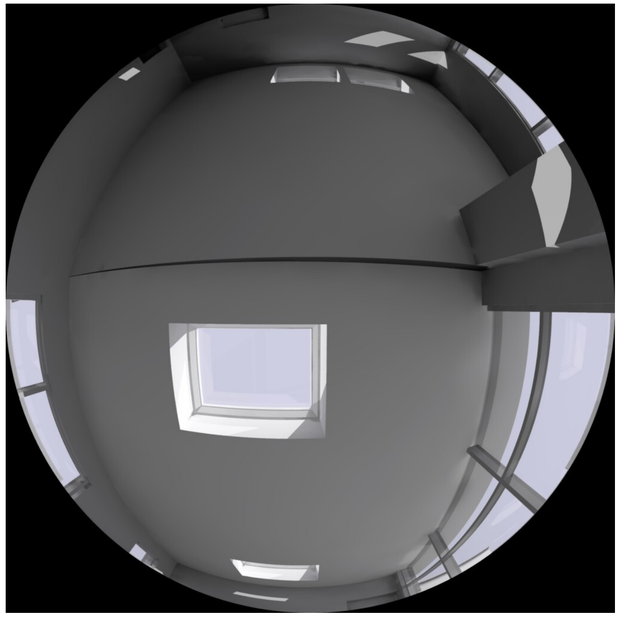
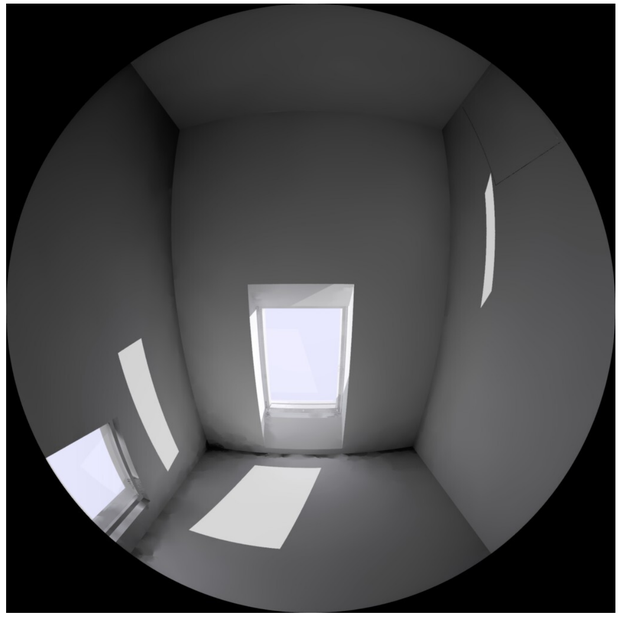
  DNK_Copenhagen.061800_IWEC
  FRA_Paris.Orly.071490_IWEC
  ITA_Rome.162420_IWEC

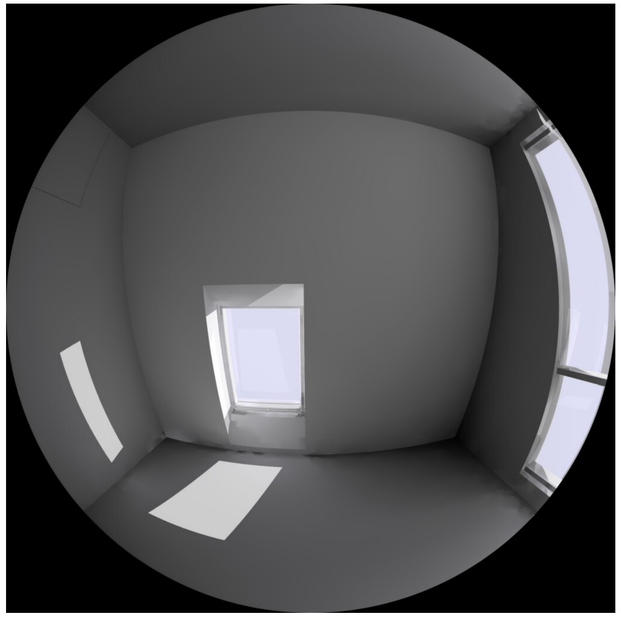
- 4 cardinal orientations

# Summer House

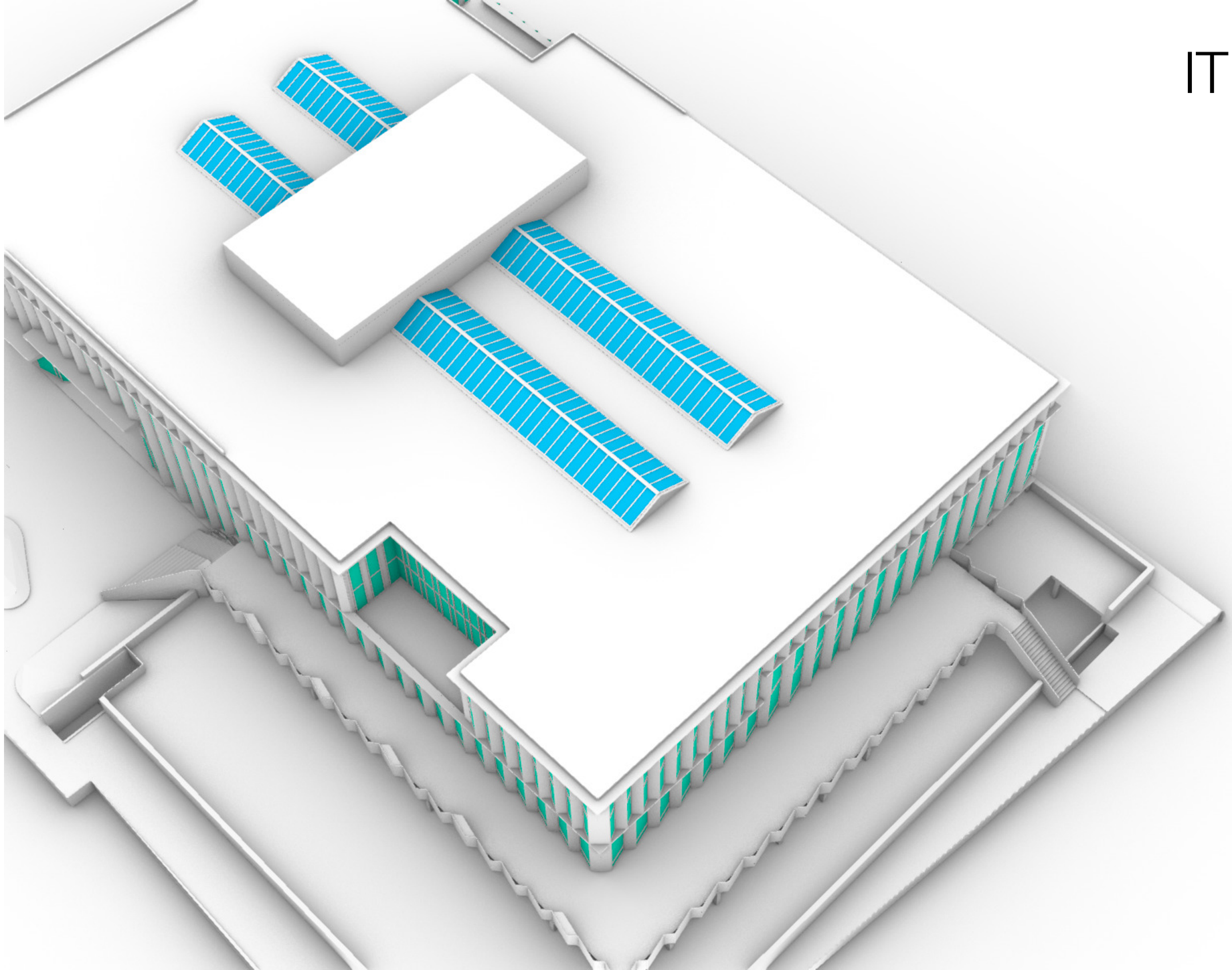


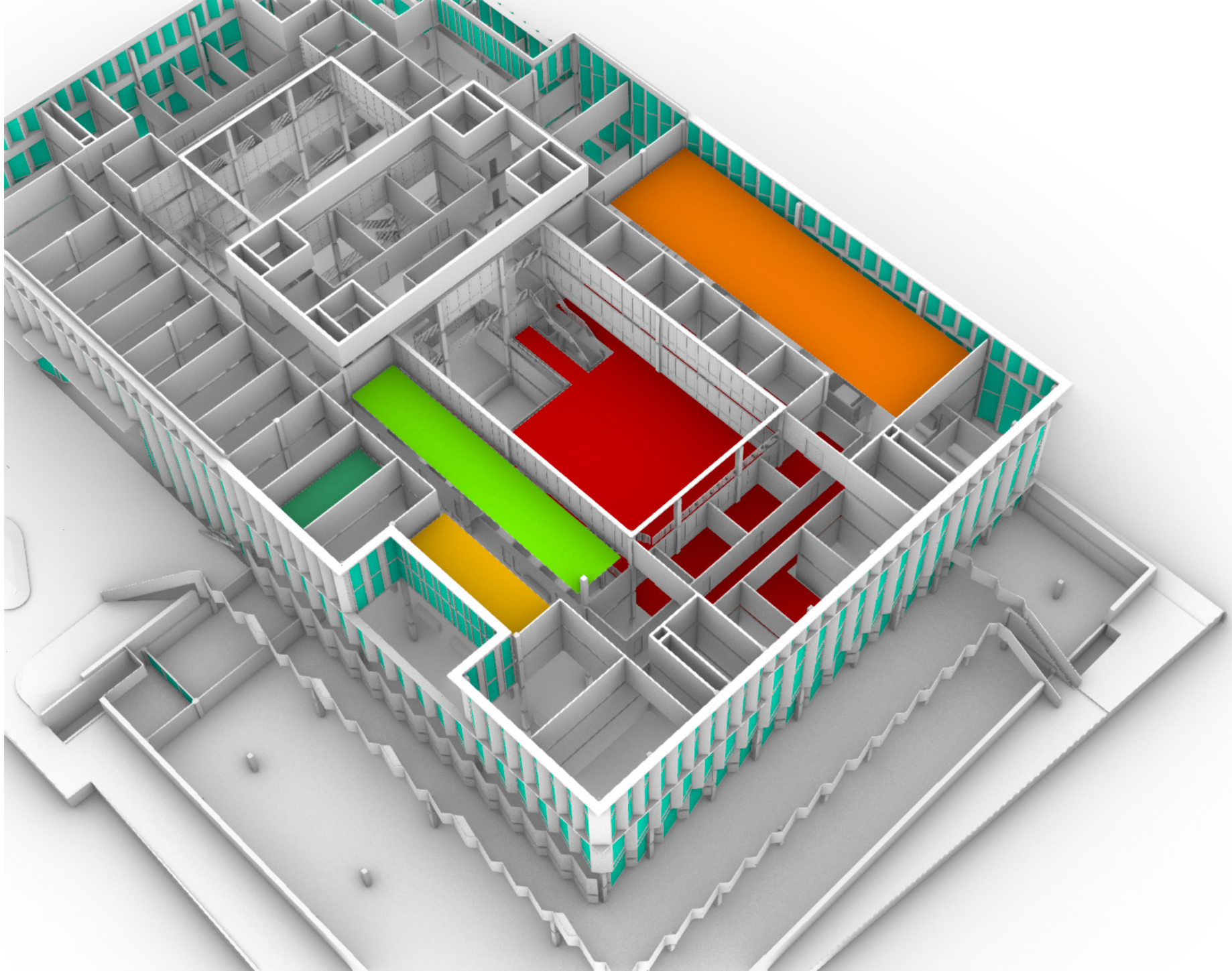


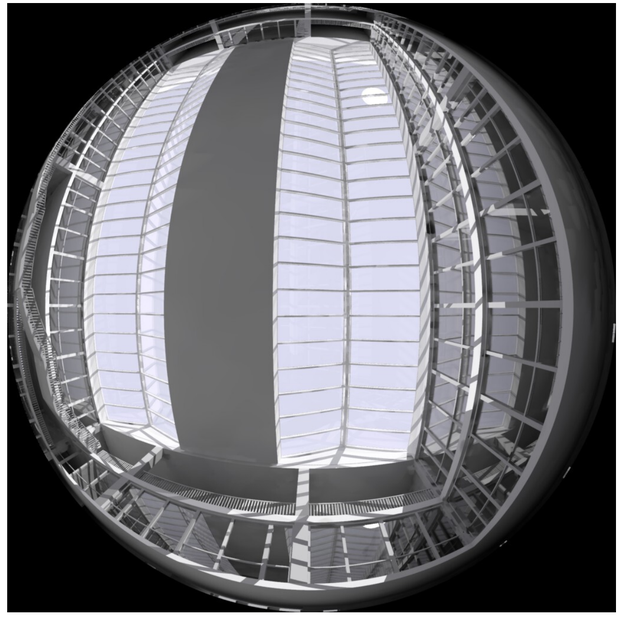
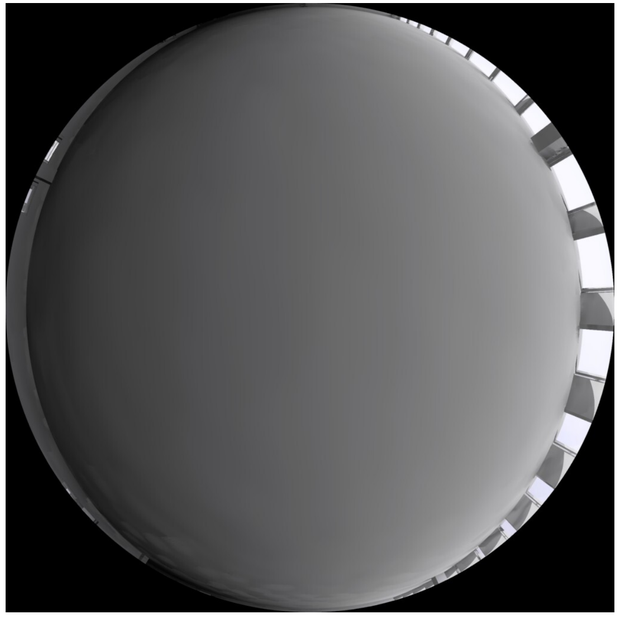
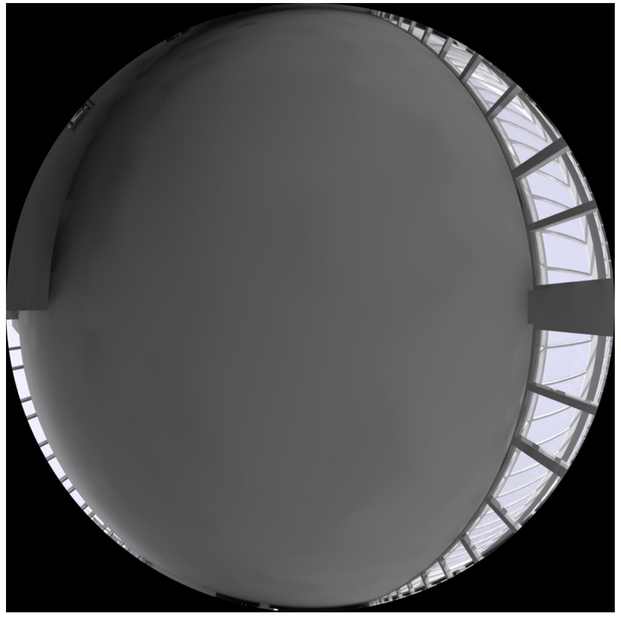
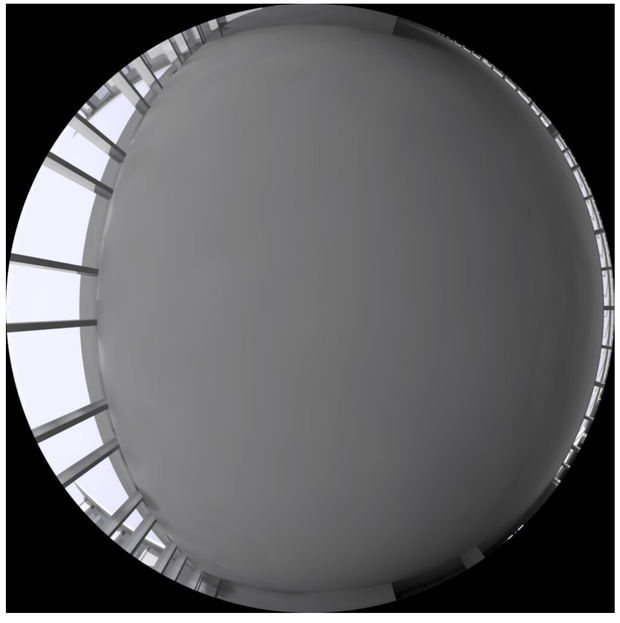
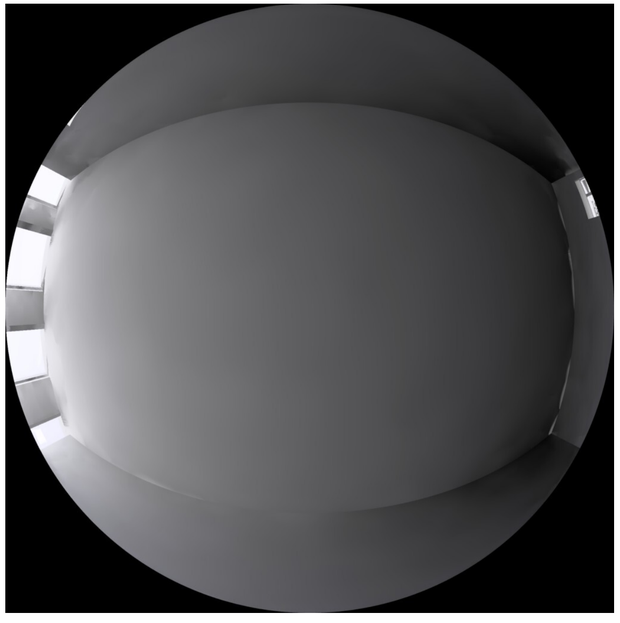









# IT Factory





# CBDM Metrics

- Total annual illuminance (TAI) — including the four individual components of daylight

- Spatial daylight autonomy (SDA): 300, 500 and 750 lux

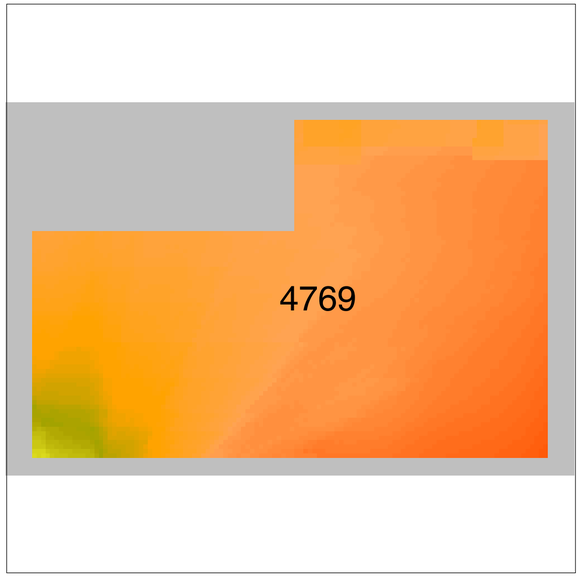
- Summer House:
  8 zones x 3 locations x 4 orientations x 3 DVIZ quality settings
  = 288 cases

- IT Factory:
  5 zones x 3 locations x 4 orientations x 3 DVIZ quality settings
  = 180 cases

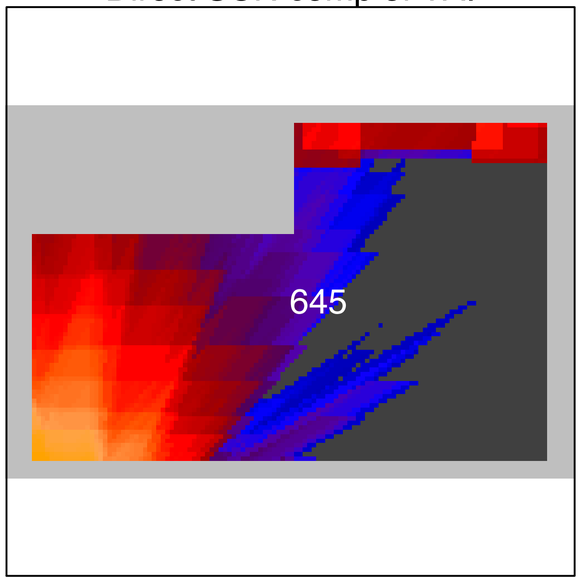
**Semantics:**

Relative Error / Relative Difference

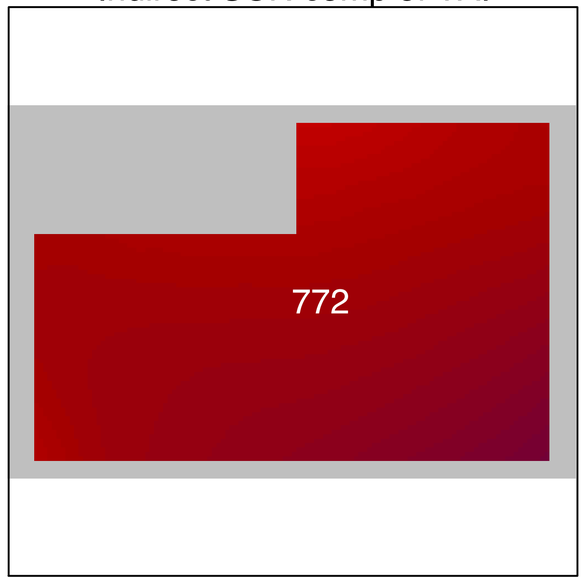
Total annual ILLUMINATION

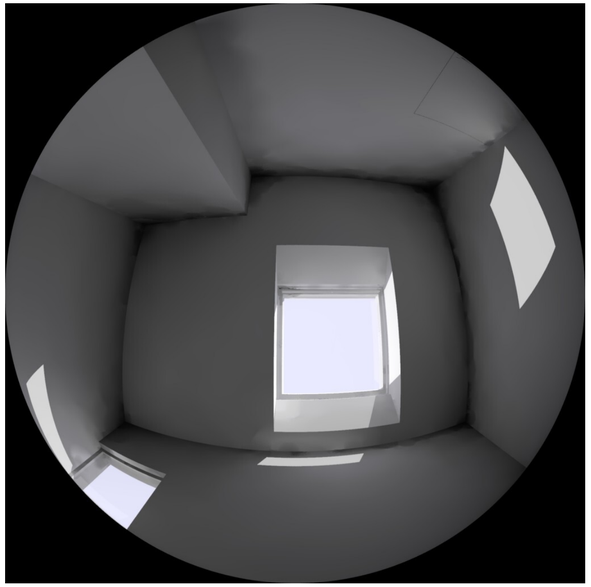


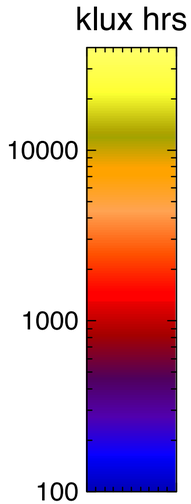

Direct SUN comp of TAI



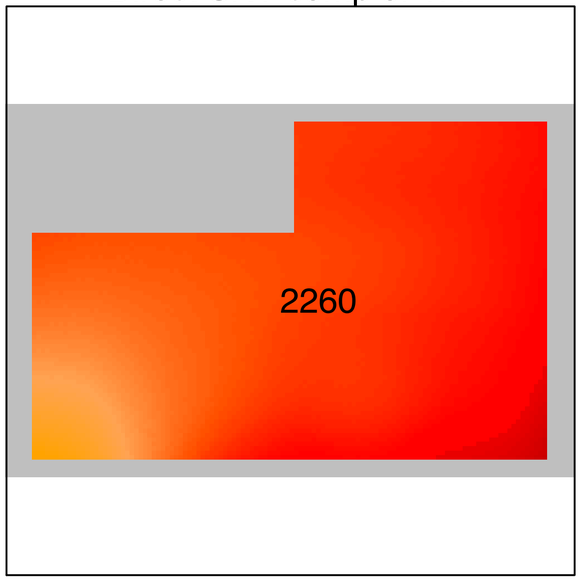

Indirect SUN comp of TAI






Direct SKY comp of TAI

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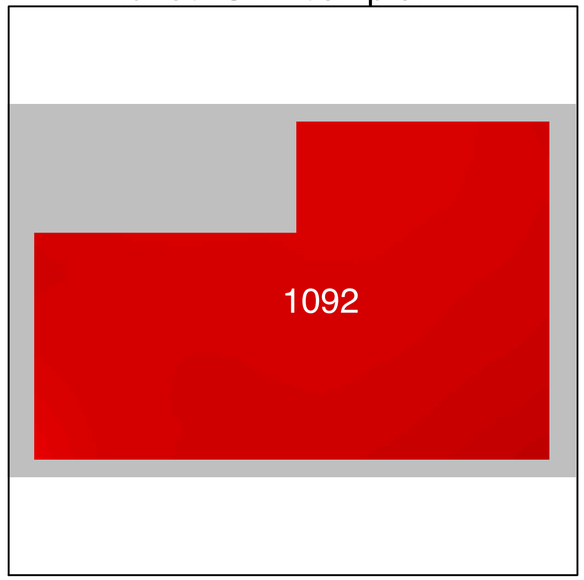
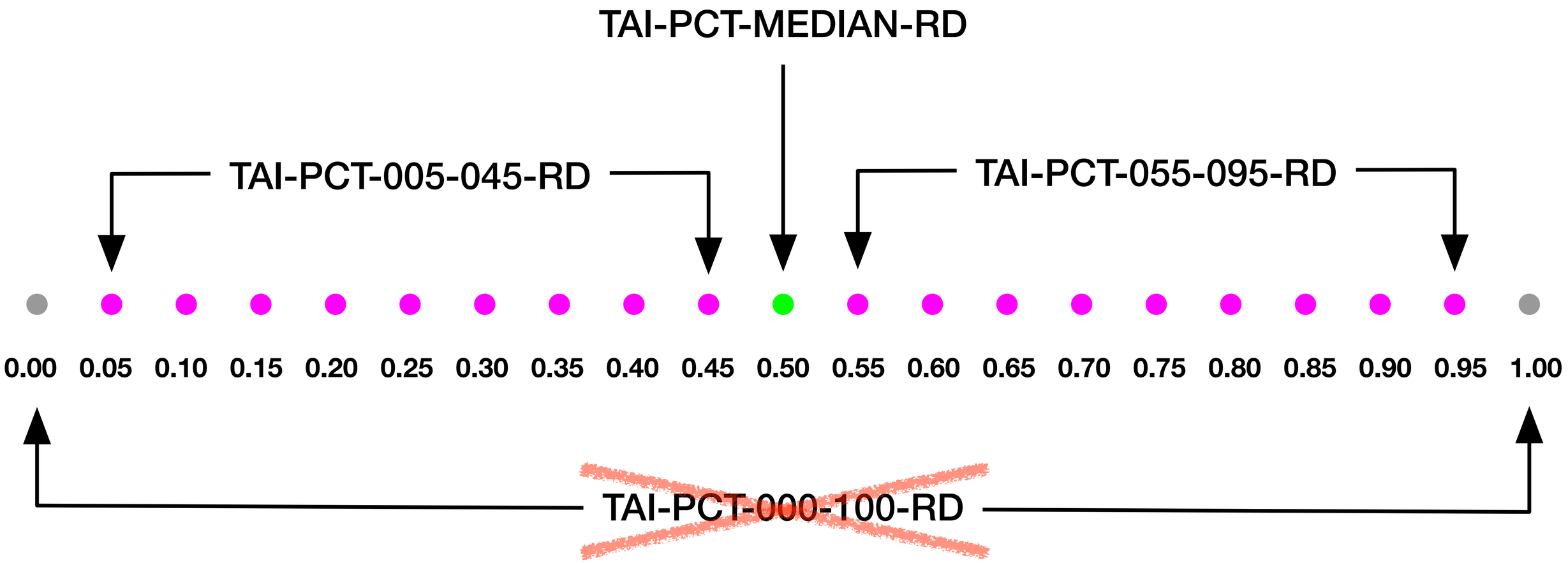



summer-house/zone04

DNK_Copenhagen.061800_IWEC

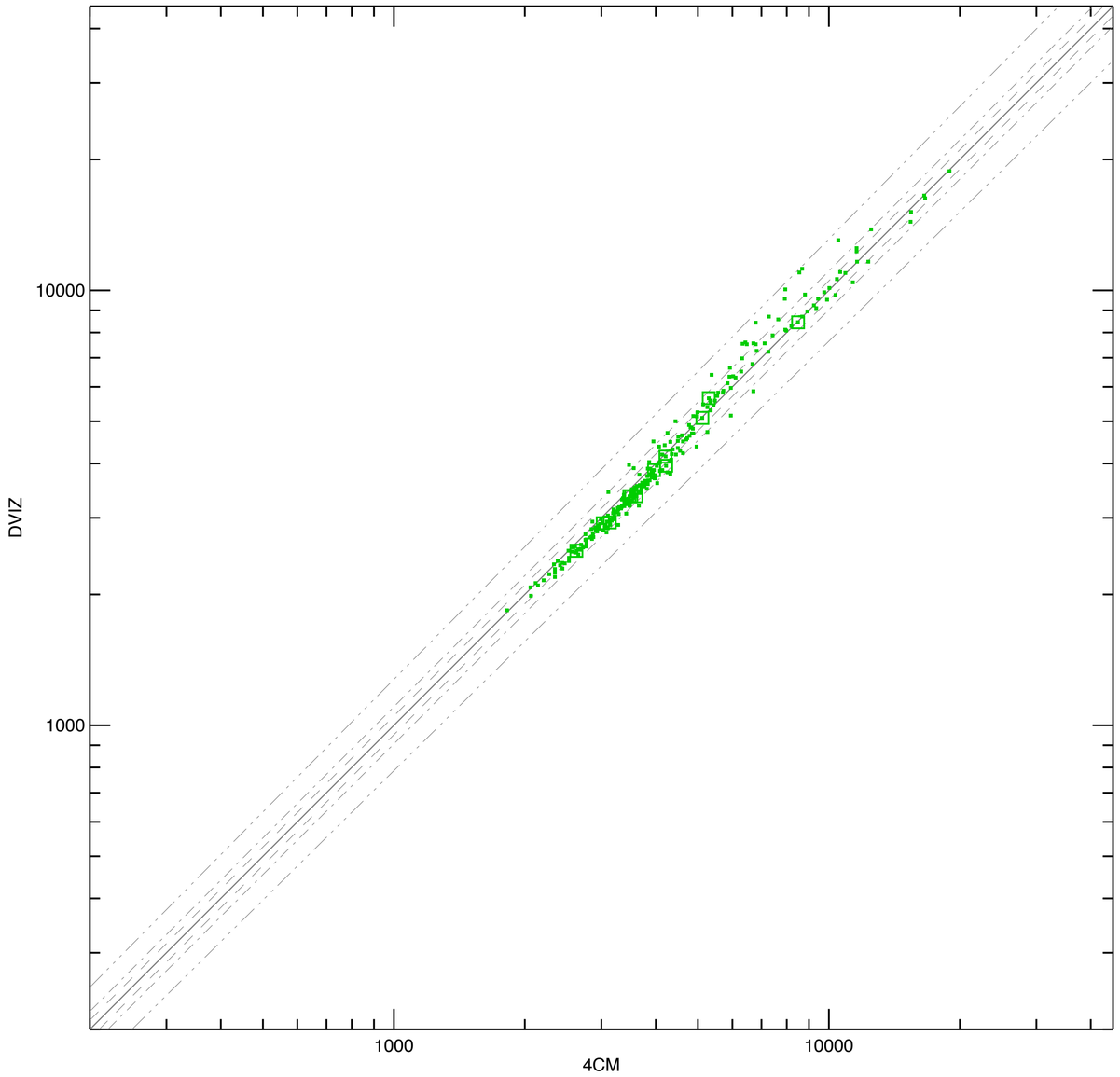

TAI-PCT-MEDIAN-RD
TAI-PCT-005-045-RD
TAI-PCT-055-095-RD
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70 0.75 0.80 0.85 0.90 0.95 1.00
TAI-PCT-000-100-RD

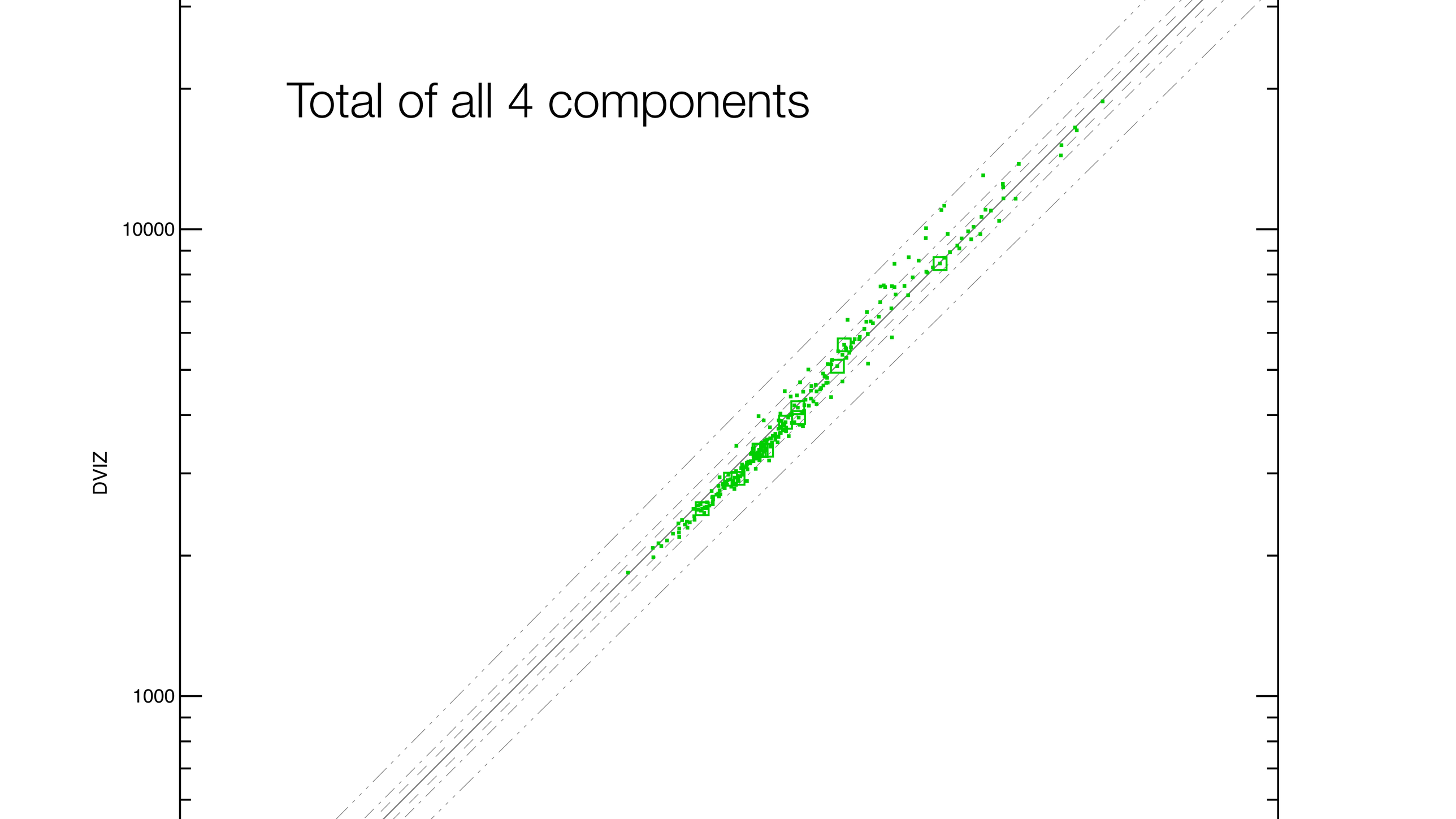
# summer-house

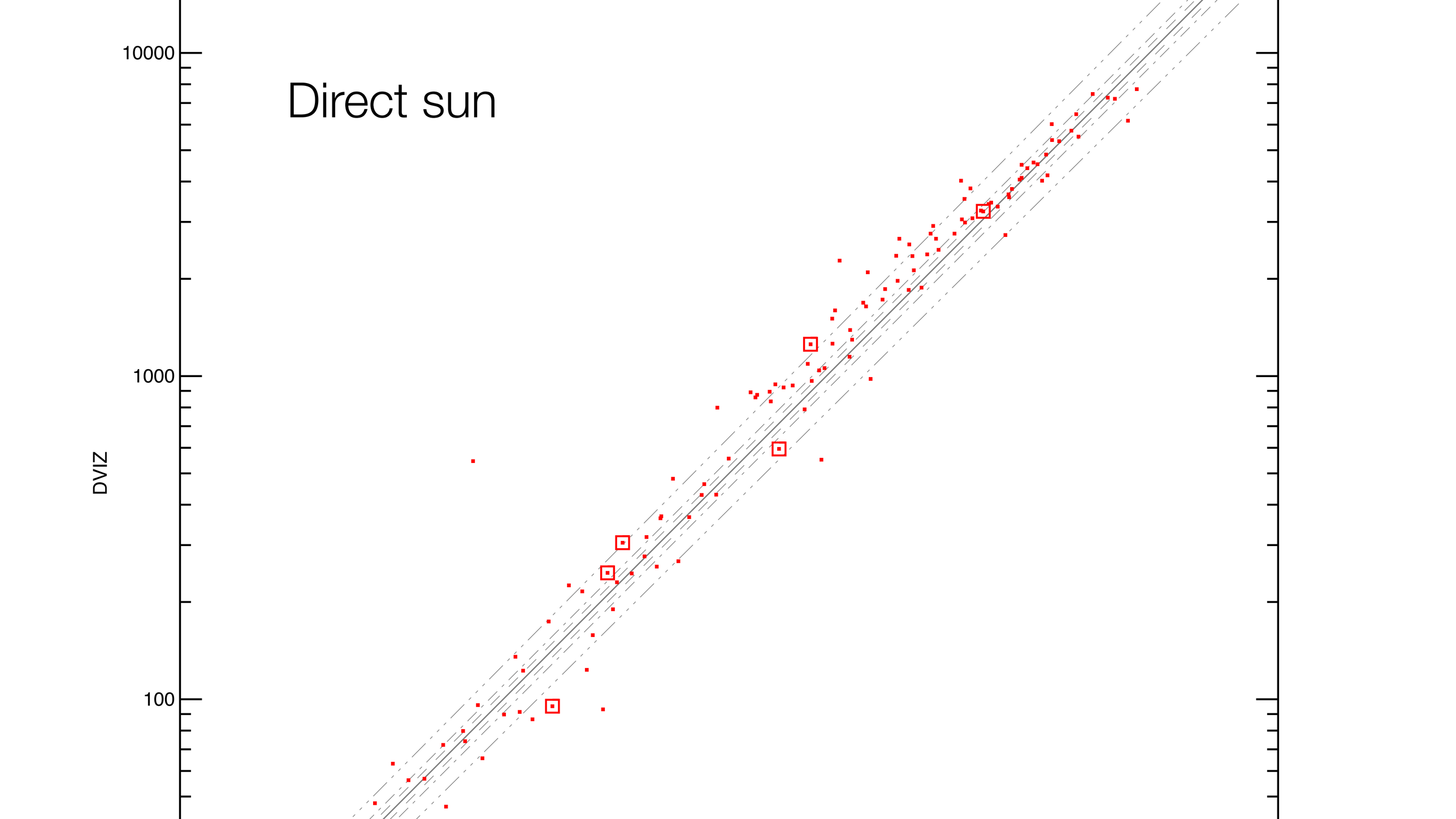
zone04

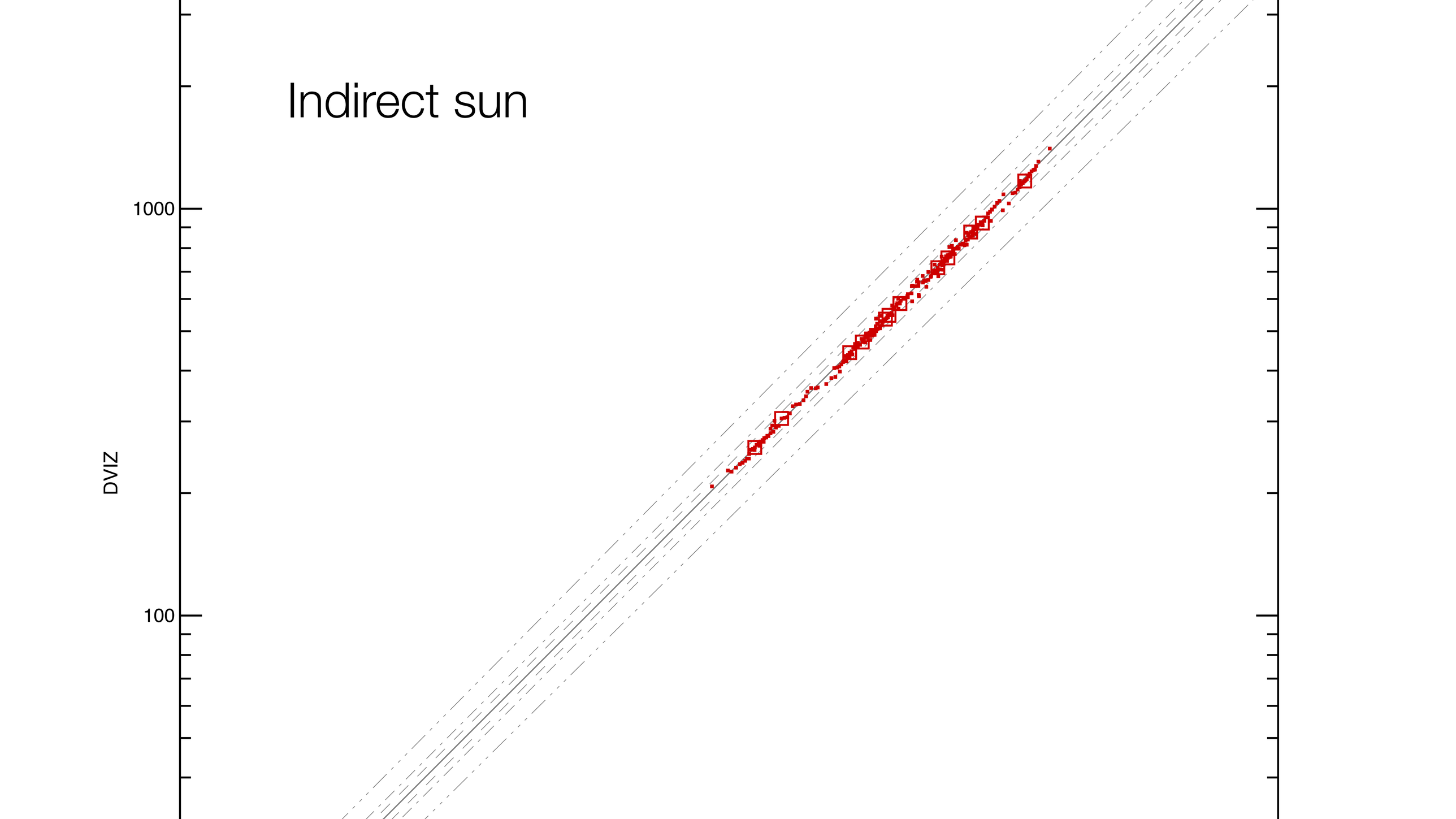
Q000

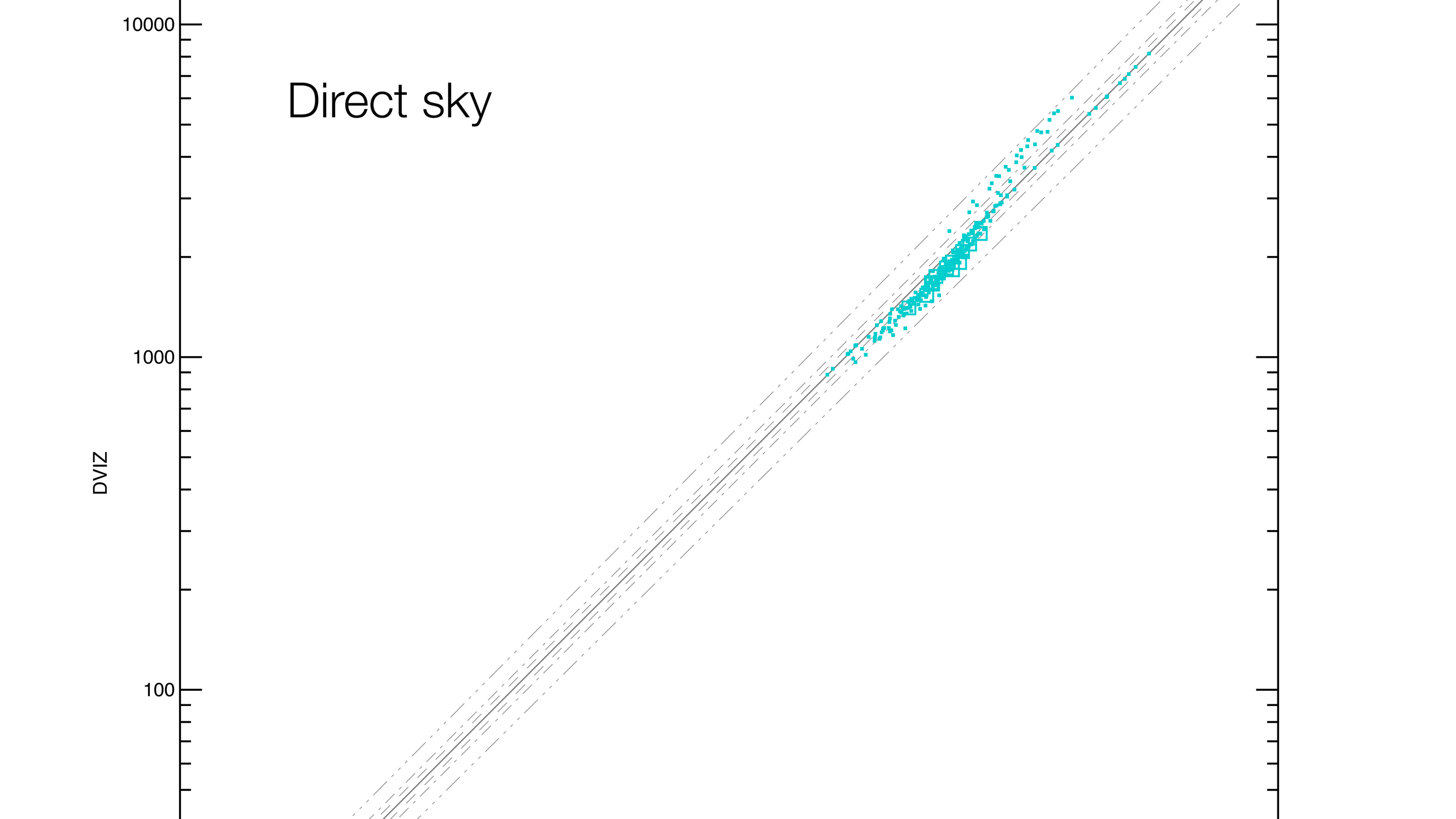
TOTAL All 4 Components

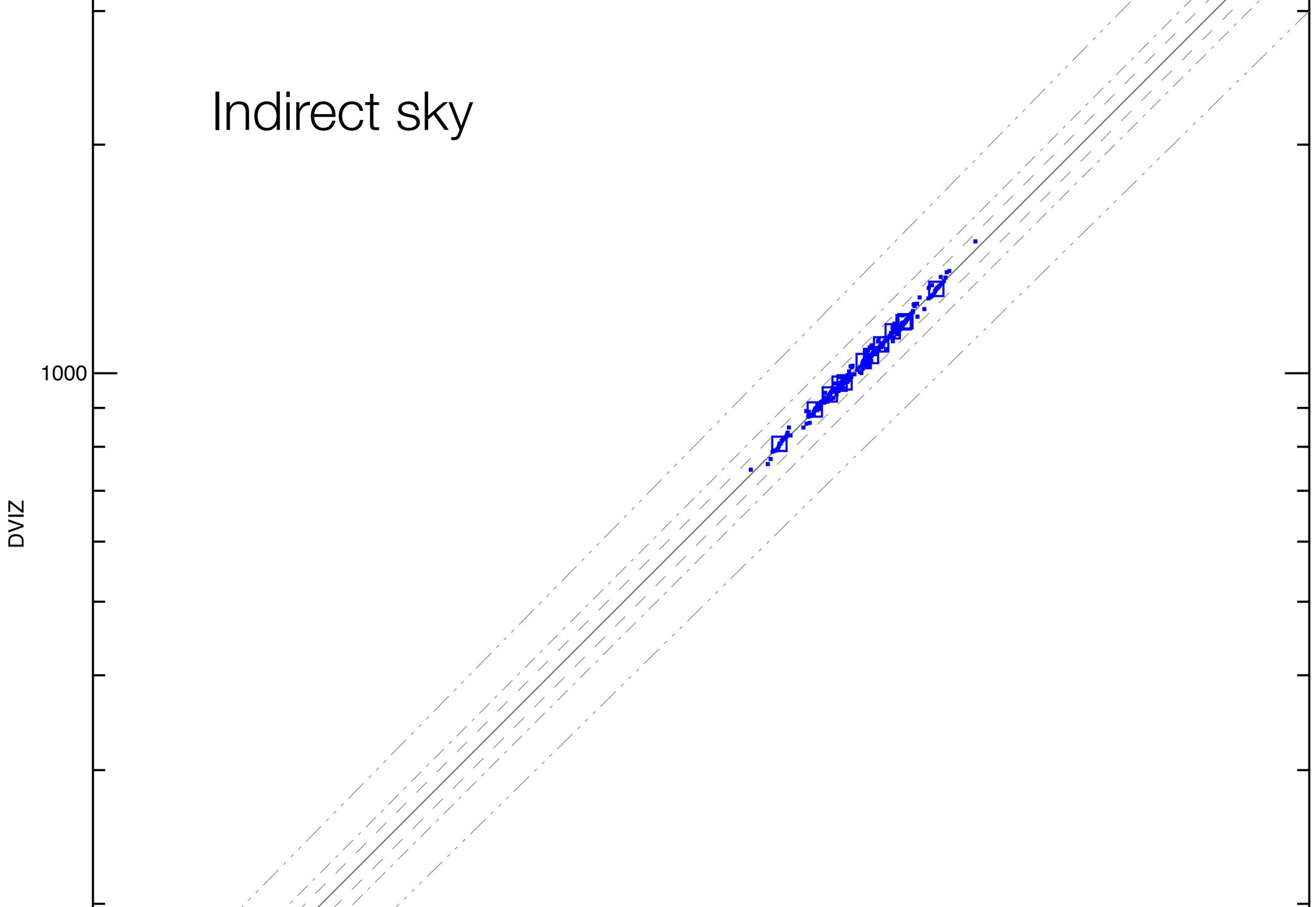



Total of all 4 components
10000
1000
DVIZ


Direct sun
10000
1000
100
DVIZ

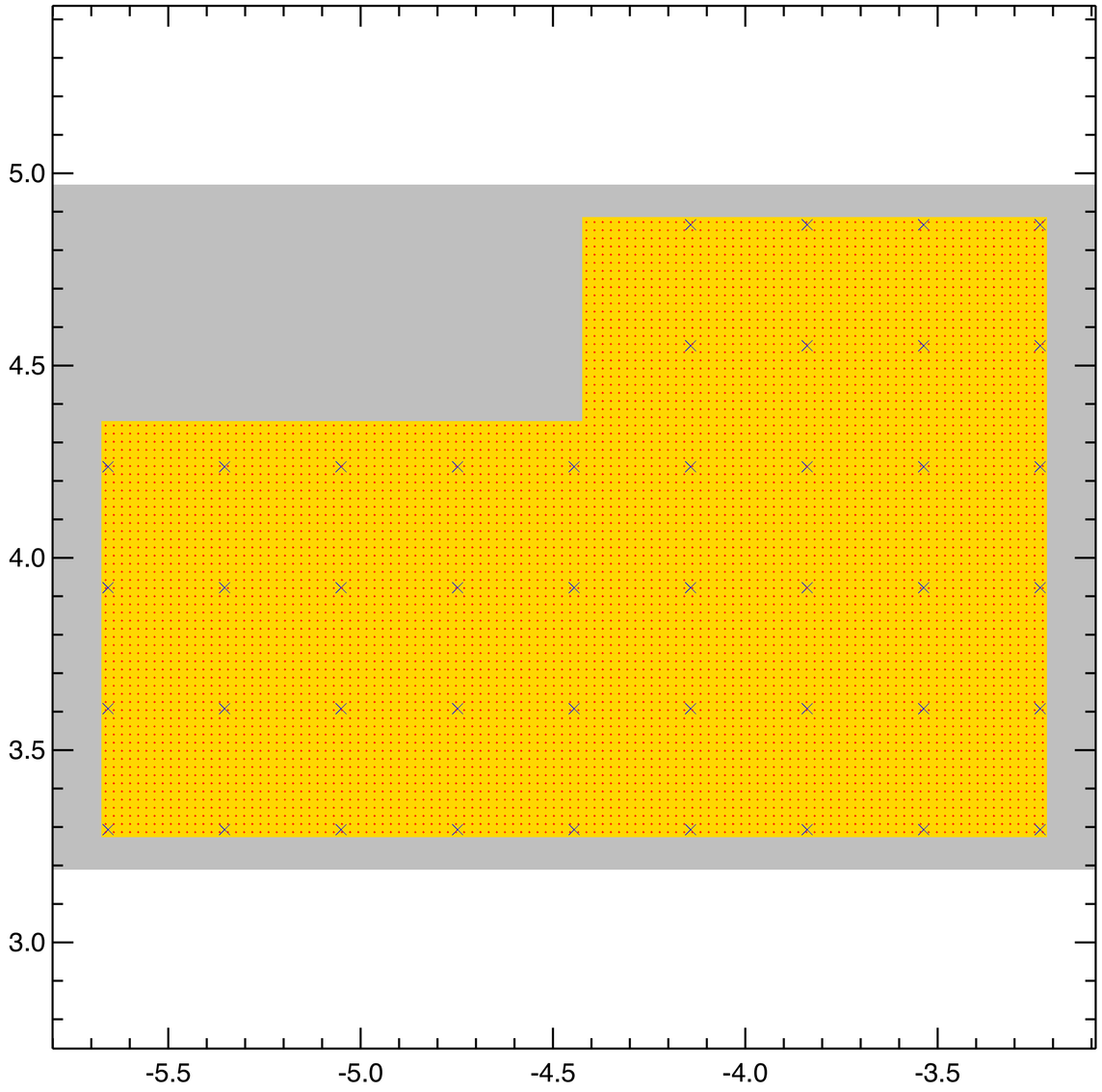

Indirect sun
1000
100
DVIZ


Direct sky
10000
1000
100
DVIZ


Indirect sky
1000
DVIZ

Summer-House-zone04-000-inside

Total sensor area = 3.32 $m^2$ / 7341 4CM pnts / 44 DVIZ pnts



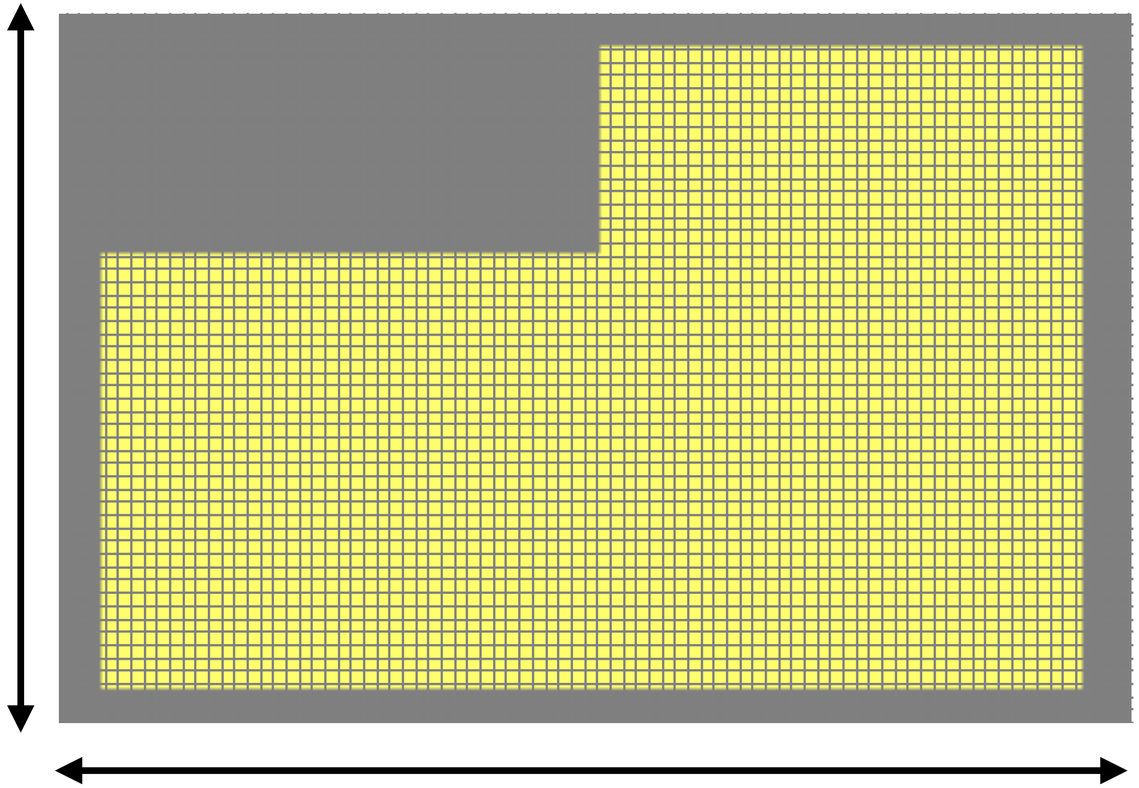

Effective sensor spacing = 0.021 m

Effective sensor area = 4.480E-04 $m^2$

$Z_{4CM}$ = 0.850

$Z_{DVIZ}$ = 0.850

# 4CM stencil method

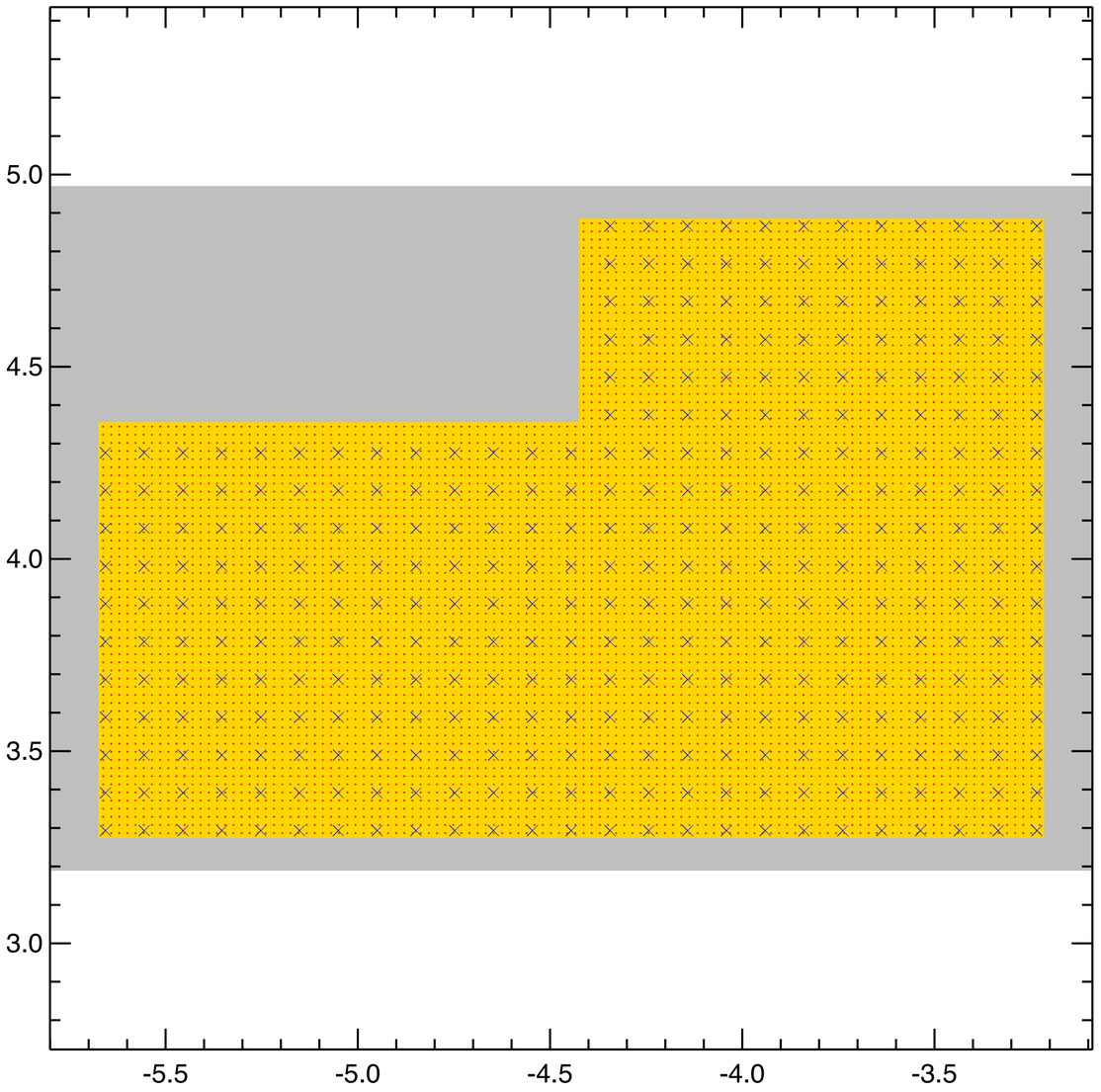


128 x 84 pixels

`-pj 0`

Summer-House-zone04-100-inside

Total sensor area = 3.32 $m^2$ / 7341 4CM pnts / 347 DVIZ pnts



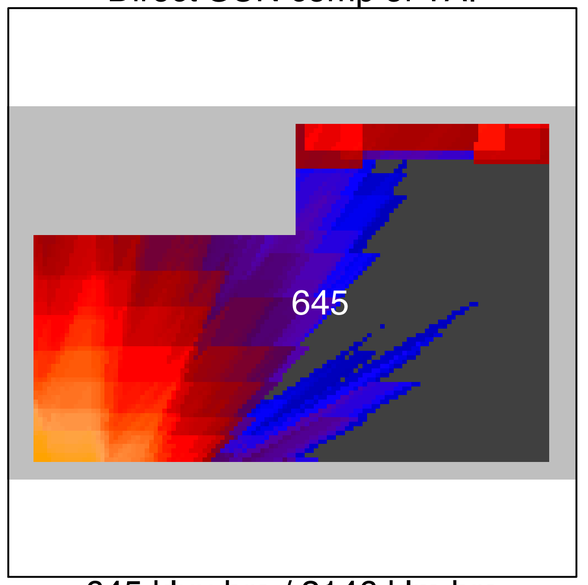

Effective sensor spacing = 0.021 m

Effective sensor area = 4.480E-04 $m^2$

$Z_{4CM}$ = 0.850

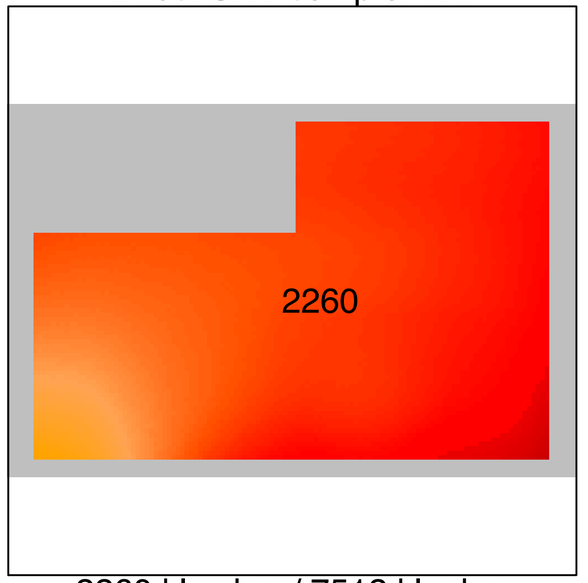
$Z_{DVIZ}$ = 0.850

Direct SUN comp of TAI



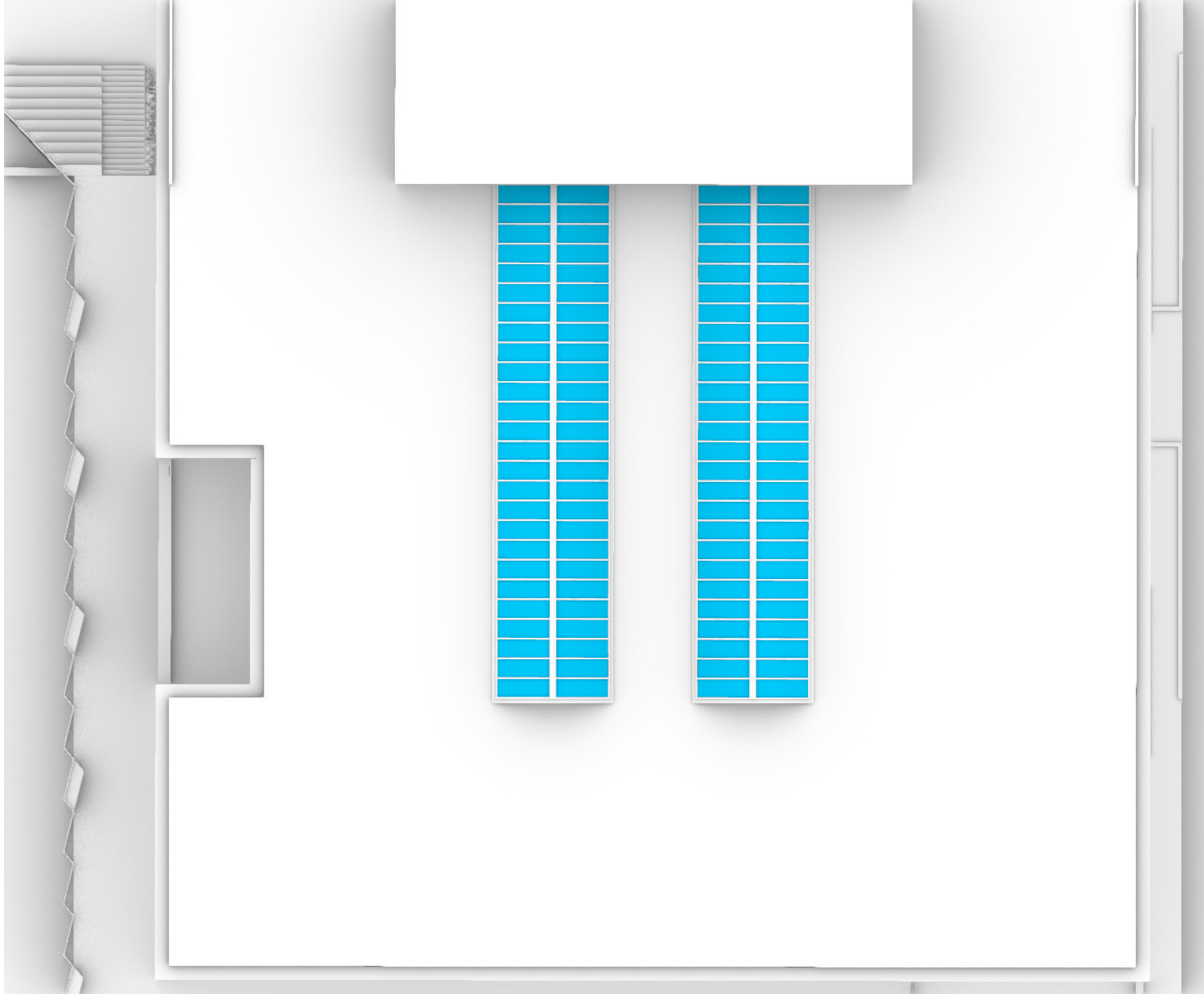

645 klux hrs / 2146 klm hrs

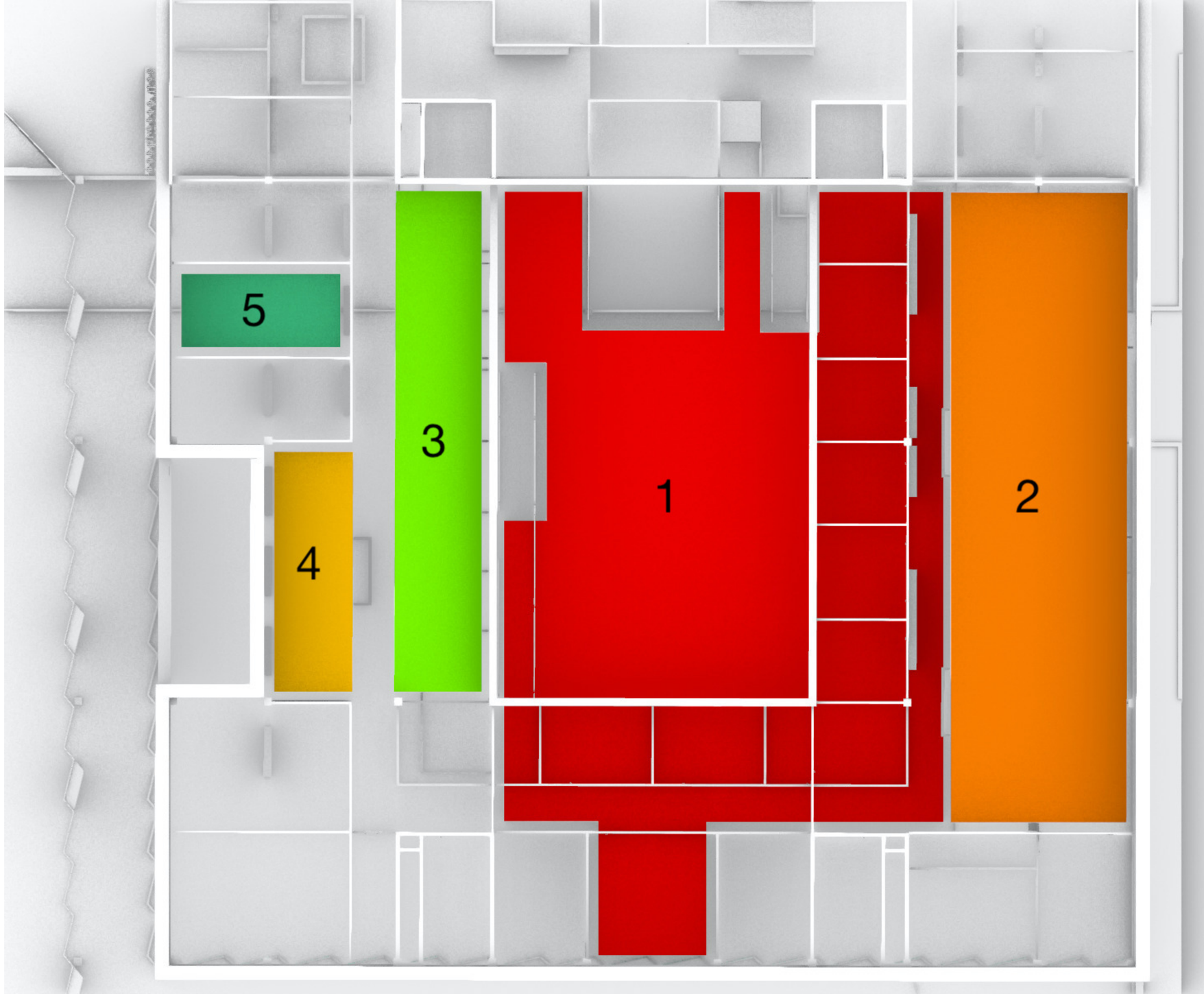
Direct SKY comp of TAI




2260 klux hrs / 7512 klm hrs

| Summer House | | TOTAL All 4 Components | | | | | |
|---|---|---|---|---|---|---|---|
| | | MBD [%] | | | RMSD [%] | | |
| Zone | Qual | 005-045 | 055-095 | –050– | 005-045 | 055-095 | –050– |
| zone02 | Q000 | 0.0 | 1.3 | 0.1 | 4.1 | 4.9 | 2.5 |
| zone02 | Q050 | 0.1 | -0.0 | 1.2 | 2.9 | 4.0 | 3.1 |
| zone02 | Q100 | -0.4 | -0.9 | -0.6 | 2.4 | 4.1 | 3.3 |
| zone04 | Q000 | -4.9 | 3.6 | -2.8 | 6.7 | 11.8 | 4.2 |
| zone04 | Q050 | -4.5 | 0.3 | -3.8 | 5.4 | 4.8 | 4.3 |
| zone04 | Q100 | -4.2 | -1.1 | -4.2 | 5.2 | 3.2 | 4.2 |
| zone05 | Q000 | -4.8 | -3.9 | -4.8 | 5.4 | 10.6 | 5.2 |
| zone05 | Q050 | -4.9 | -4.7 | -5.7 | 5.4 | 9.0 | 6.4 |
| zone05 | Q100 | -4.6 | -5.7 | -6.2 | 5.3 | 8.4 | 6.7 |
| zone06 | Q000 | -3.2 | 1.2 | -2.9 | 4.8 | 7.7 | 5.7 |
| zone06 | Q050 | -3.3 | 0.6 | -2.4 | 4.6 | 5.2 | 3.6 |
| zone06 | Q100 | -2.1 | -0.4 | -1.9 | 2.9 | 2.5 | 2.7 |
| zone07 | Q000 | -3.1 | -1.4 | -2.5 | 3.8 | 2.1 | 2.7 |
| zone07 | Q050 | -1.7 | 0.5 | -0.8 | 2.0 | 2.7 | 1.2 |
| zone07 | Q100 | -1.4 | -0.7 | -1.5 | 1.6 | 1.1 | 1.8 |
| zone08 | Q000 | -4.1 | 0.2 | -2.4 | 5.9 | 8.9 | 2.9 |
| zone08 | Q050 | -4.0 | -2.6 | -3.0 | 4.9 | 4.4 | 3.6 |
| zone08 | Q100 | -3.5 | -3.1 | -3.4 | 4.1 | 4.4 | 4.0 |
| zone09 | Q000 | -6.0 | -7.1 | -7.4 | 6.5 | 9.2 | 7.7 |
| zone09 | Q050 | -6.6 | -7.5 | -8.1 | 7.0 | 9.4 | 8.3 |
| zone09 | Q100 | -7.0 | -7.8 | -8.4 | 7.3 | 9.7 | 8.7 |
| zone10 | Q000 | -3.9 | 3.8 | -1.6 | 4.5 | 9.5 | 2.4 |
| zone10 | Q050 | -3.8 | 1.8 | -2.5 | 4.1 | 4.7 | 2.5 |
| zone10 | Q100 | -3.3 | 0.1 | -2.3 | 3.5 | 1.9 | 2.2 |



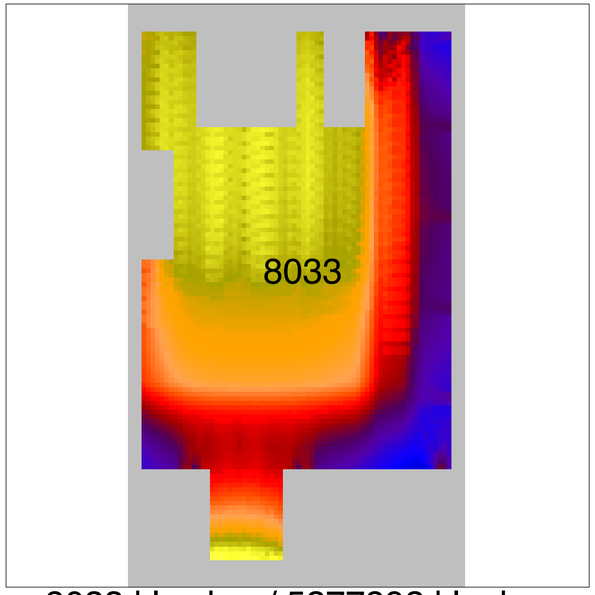

5
3
1
2
4

klux hrs

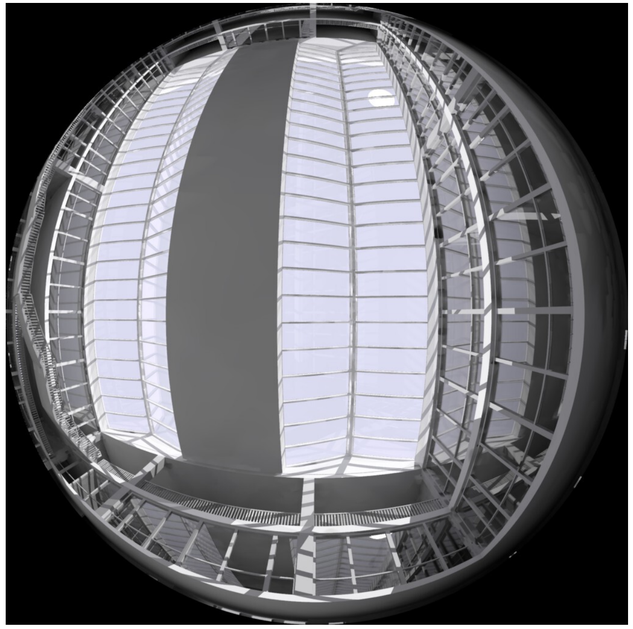
10000

1000

Total annual ILLUMINATION

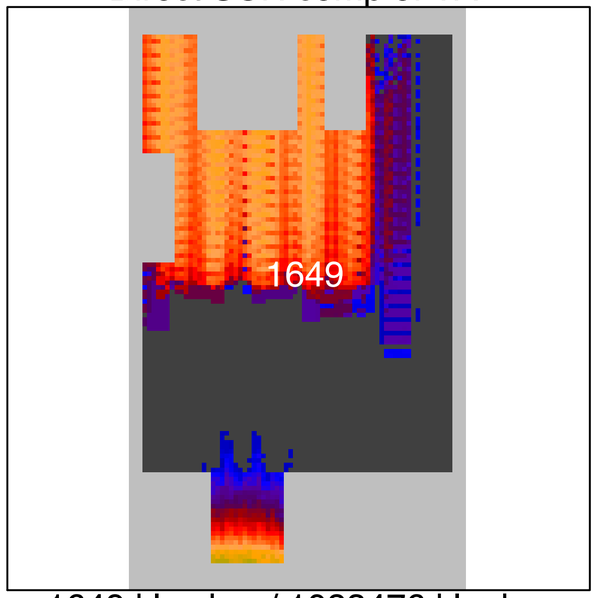



8033 klux hrs / 5277892 klm hrs



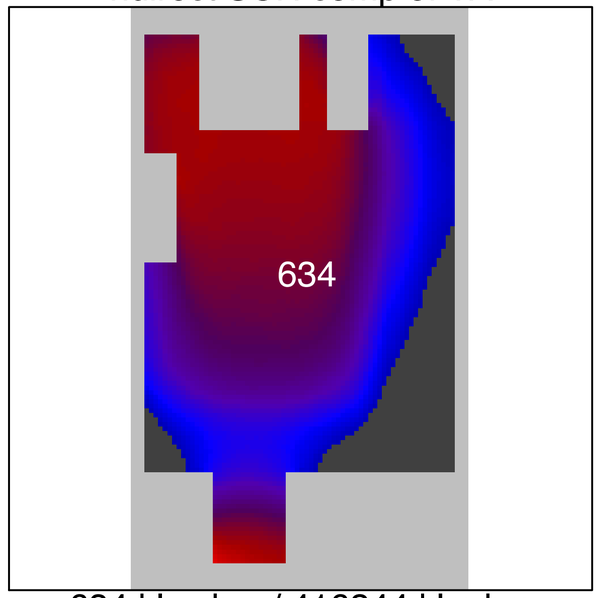
IT_Factory/w_zone1

Direct SUN comp of TAI



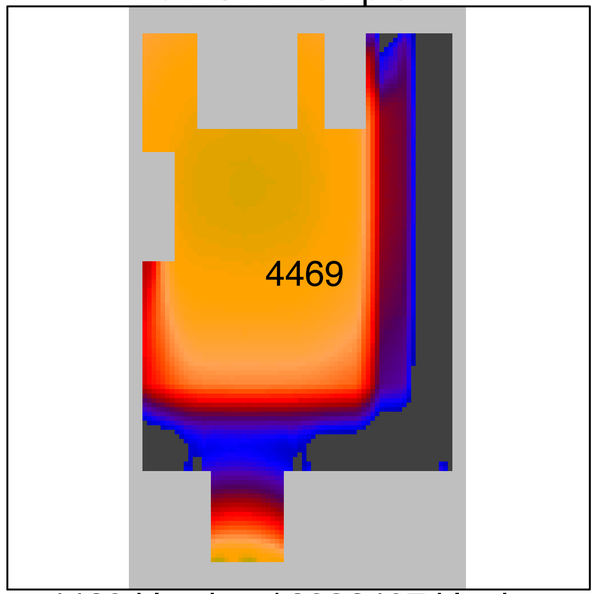

1649 klux hrs / 1083476 klm hrs

Indirect SUN comp of TAI



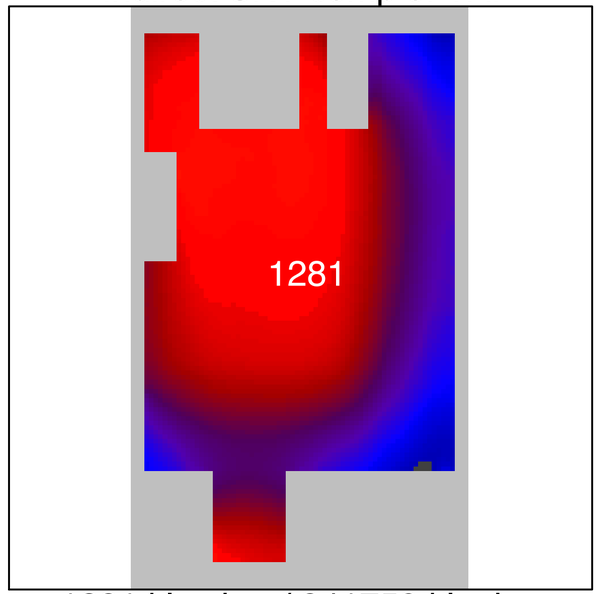

634 klux hrs / 416244 klm hrs

Direct SKY comp of TAI




4469 klux hrs / 2936407 klm hrs

Indirect SKY comp of TAI




1281 klux hrs / 841759 klm hrs

DNK_Copenhagen.061800_IWEC

| IT Factory | | TOTAL All 4 Components | | | | | |
|---|---|---|---|---|---|---|---|
| | | MBD [%] | | | RMSD [%] | | |
| Zone | Qual | 005-045 | 055-095 | –050– | 005-045 | 055-095 | –050– |
| w_zone1 | Q000 | 8.5 | 1.6 | 2.0 | 7.0 | 1.7 | 2.5 |
| w_zone1 | Q050 | 8.1 | 1.7 | 2.8 | 6.7 | 1.8 | 3.2 |
| w_zone1 | Q100 | 9.7 | 2.8 | 4.9 | 9.2 | 2.7 | 5.2 |
| w_zone2 | Q000 | 0.5 | 0.2 | -0.1 | 1.1 | 1.7 | 0.9 |
| w_zone2 | Q050 | 0.7 | 0.7 | 0.1 | 1.1 | 1.6 | 0.9 |
| w_zone2 | Q100 | 1.4 | 1.4 | 1.3 | 1.7 | 2.3 | 1.4 |
| w_zone3 | Q000 | 5.9 | 6.3 | 5.5 | 5.6 | 7.1 | 5.7 |
| w_zone3 | Q050 | 5.0 | 4.9 | 5.0 | 4.8 | 5.1 | 5.0 |
| w_zone3 | Q100 | 3.9 | 3.6 | 3.8 | 3.7 | 3.4 | 3.6 |
| w_zone4 | Q000 | 1.9 | 3.3 | 1.8 | 2.3 | 4.4 | 2.0 |
| w_zone4 | Q050 | 1.4 | 2.4 | 1.8 | 1.6 | 3.2 | 2.2 |
| w_zone4 | Q100 | 1.7 | 1.6 | 1.4 | 1.7 | 1.8 | 1.5 |
| w_zone5 | Q000 | -2.5 | 2.9 | 0.2 | 2.6 | 5.7 | 1.3 |
| w_zone5 | Q050 | -3.6 | 1.6 | -0.6 | 3.3 | 3.4 | 0.8 |
| w_zone5 | Q100 | -3.7 | 0.9 | -0.8 | 3.3 | 1.9 | 1.0 |

| IT Factory | | Direct SUN component | | | | | |
|---|---|---|---|---|---|---|---|
| | | MBD [%] | | | RMSD [%] | | |
| Zone | Qual | 005-045 | 055-095 | –050– | 005-045 | 055-095 | –050– |
| w_zone1 | Q000 | 1.6 | -1.0 | 1.5 | 11.3 | 2.4 | 2.7 |
| w_zone1 | Q050 | 0.8 | -1.0 | 1.1 | 12.6 | 2.3 | 3.3 |
| w_zone1 | Q100 | 3.7 | -0.2 | 4.5 | 10.2 | 2.1 | 10.9 |
| w_zone2 | Q000 | -7.4 | -2.0 | -12.2 | 10.2 | 5.4 | 6.4 |
| w_zone2 | Q050 | 1.2 | -0.4 | -11.9 | 8.2 | 4.6 | 7.2 |
| w_zone2 | Q100 | 2.5 | 0.5 | -10.3 | 6.2 | 5.4 | 3.2 |
| w_zone3 | Q000 | 6.4 | 7.3 | 2.7 | 5.8 | 11.0 | 6.4 |
| w_zone3 | Q050 | 4.1 | 4.1 | 3.0 | 5.4 | 6.7 | 5.4 |
| w_zone3 | Q100 | 2.6 | 2.2 | 0.5 | 2.2 | 3.2 | 1.9 |
| w_zone4 | Q000 | -1.2 | 2.1 | 0.2 | 3.2 | 6.9 | 5.0 |
| w_zone4 | Q050 | -3.9 | 1.0 | -0.7 | 3.1 | 5.1 | 3.3 |
| w_zone4 | Q100 | -1.3 | 0.3 | -0.9 | 1.4 | 1.9 | 1.2 |
| w_zone5 | Q000 | -1.7 | 1.1 | -3.8 | 8.2 | 8.1 | 5.4 |
| w_zone5 | Q050 | -1.7 | 0.5 | -0.8 | 6.1 | 4.0 | 2.0 |
| w_zone5 | Q100 | -0.7 | 0.1 | -0.9 | 3.8 | 2.1 | 1.5 |

| IT Factory | | Indirect SUN component | | | | | |
|---|---|---|---|---|---|---|---|
| | | MBD [%] | | | RMSD [%] | | |
| Zone | Qual | 005-045 | 055-095 | –050– | 005-045 | 055-095 | –050– |
| w_zone1 | Q000 | 14.4 | 14.2 | 14.1 | 14.3 | 14.2 | 14.1 |
| w_zone1 | Q050 | 13.2 | 14.7 | 13.9 | 13.4 | 14.8 | 13.9 |
| w_zone1 | Q100 | 14.3 | 18.7 | 16.0 | 14.9 | 19.4 | 16.1 |
| w_zone2 | Q000 | 0.3 | 0.9 | 1.2 | 1.8 | 2.1 | 2.0 |
| w_zone2 | Q050 | -0.3 | 0.6 | 0.9 | 1.9 | 1.8 | 1.7 |
| w_zone2 | Q100 | 0.1 | 1.1 | 1.4 | 2.3 | 2.3 | 1.9 |
| w_zone3 | Q000 | 7.2 | 7.0 | 7.3 | 7.5 | 7.0 | 7.4 |
| w_zone3 | Q050 | 6.1 | 6.3 | 6.6 | 6.5 | 6.3 | 6.7 |
| w_zone3 | Q100 | 5.5 | 6.2 | 6.2 | 6.0 | 6.1 | 6.3 |
| w_zone4 | Q000 | 1.1 | 2.0 | 1.6 | 2.7 | 2.7 | 2.7 |
| w_zone4 | Q050 | 1.0 | 1.7 | 1.4 | 2.3 | 2.3 | 2.3 |
| w_zone4 | Q100 | 1.1 | 1.9 | 1.6 | 2.4 | 2.5 | 2.5 |
| w_zone5 | Q000 | -7.5 | 4.6 | -0.4 | 6.9 | 8.0 | 1.3 |
| w_zone5 | Q050 | -11.1 | 1.4 | -3.6 | 9.9 | 4.6 | 3.0 |
| w_zone5 | Q100 | -12.1 | 0.3 | -4.8 | 10.7 | 3.6 | 3.9 |

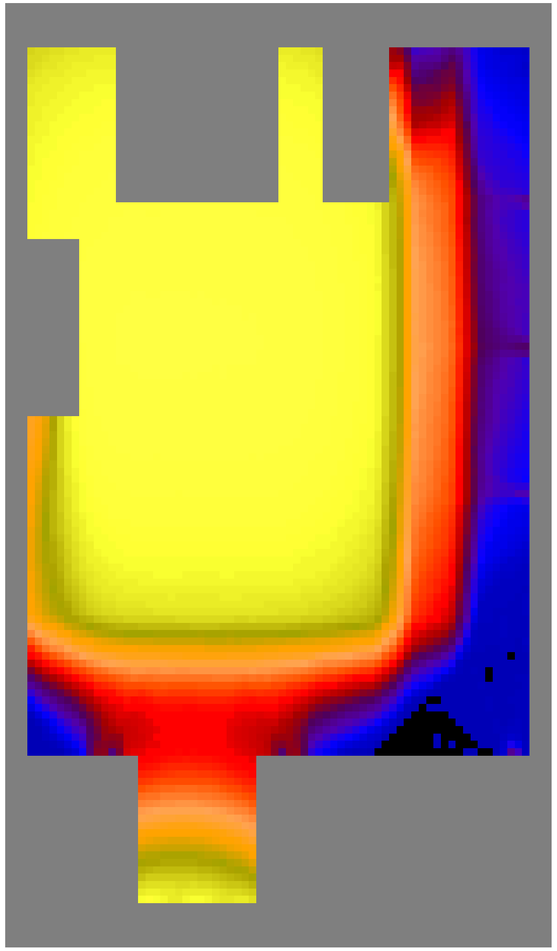
| IT Factory | | Direct SKY component | | | | | |
|---|---|---|---|---|---|---|---|
| | | MBD [%] | | | RMSD [%] | | |
| Zone | Qual | 005-045 | 055-095 | –050– | 005-045 | 055-095 | –050– |
| w_zone1 | Q000 | 0.1 | -2.1 | -1.2 | 4.2 | 2.1 | 2.3 |
| w_zone1 | Q050 | 2.8 | -2.0 | -0.8 | 3.6 | 1.9 | 1.7 |
| w_zone1 | Q100 | 5.0 | -1.7 | 1.6 | 5.5 | 1.8 | 2.5 |
| w_zone2 | Q000 | -4.0 | -1.4 | -3.7 | 4.1 | 2.3 | 3.8 |
| w_zone2 | Q050 | -2.9 | -0.3 | -2.9 | 2.9 | 1.4 | 2.9 |
| w_zone2 | Q100 | -1.8 | 0.5 | -1.5 | 1.8 | 1.6 | 1.5 |
| w_zone3 | Q000 | 4.4 | 4.9 | 3.2 | 4.1 | 5.6 | 3.6 |
| w_zone3 | Q050 | 3.0 | 3.1 | 2.1 | 2.8 | 3.5 | 2.3 |
| w_zone3 | Q100 | 1.8 | 1.4 | 1.3 | 1.7 | 1.6 | 1.4 |
| w_zone4 | Q000 | 0.5 | 3.1 | 1.0 | 1.2 | 3.8 | 1.2 |
| w_zone4 | Q050 | 0.5 | 2.0 | 1.2 | 0.8 | 2.5 | 1.3 |
| w_zone4 | Q100 | 0.5 | 1.1 | 0.6 | 0.7 | 1.3 | 0.7 |
| w_zone5 | Q000 | -2.6 | 1.7 | -0.8 | 2.9 | 3.7 | 1.9 |
| w_zone5 | Q050 | -1.2 | 1.1 | -0.3 | 1.4 | 2.4 | 1.0 |
| w_zone5 | Q100 | -0.4 | 0.6 | -0.4 | 0.7 | 1.1 | 0.6 |

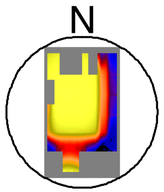
| IT Factory | | Indirect SKY component | | | | | |
|---|---|---|---|---|---|---|---|
| | | MBD [%] | | | RMSD [%] | | |
| Zone | Qual | 005-045 | 055-095 | –050– | 005-045 | 055-095 | –050– |
| w_zone1 | Q000 | 13.6 | 16.5 | 14.5 | 14.4 | 16.7 | 14.6 |
| w_zone1 | Q050 | 12.4 | 17.1 | 14.4 | 13.4 | 17.2 | 14.5 |
| w_zone1 | Q100 | 13.5 | 20.6 | 17.0 | 14.9 | 20.8 | 17.0 |
| w_zone2 | Q000 | 6.0 | 3.7 | 5.2 | 6.4 | 3.7 | 5.3 |
| w_zone2 | Q050 | 5.6 | 3.4 | 4.9 | 6.0 | 3.5 | 5.0 |
| w_zone2 | Q100 | 6.0 | 3.8 | 5.2 | 6.4 | 3.9 | 5.3 |
| w_zone3 | Q000 | 9.0 | 9.9 | 9.4 | 9.3 | 10.1 | 9.5 |
| w_zone3 | Q050 | 7.8 | 9.2 | 8.6 | 8.2 | 9.4 | 8.7 |
| w_zone3 | Q100 | 7.4 | 9.2 | 8.6 | 7.9 | 9.4 | 8.7 |
| w_zone4 | Q000 | 4.7 | 3.8 | 4.1 | 4.8 | 3.9 | 4.2 |
| w_zone4 | Q050 | 4.4 | 3.5 | 3.9 | 4.5 | 3.6 | 4.0 |
| w_zone4 | Q100 | 4.6 | 3.7 | 4.2 | 4.7 | 3.8 | 4.3 |
| w_zone5 | Q000 | -0.3 | 6.3 | 3.3 | 1.8 | 7.3 | 3.4 |
| w_zone5 | Q050 | -2.7 | 3.7 | 0.6 | 2.9 | 4.7 | 1.0 |
| w_zone5 | Q100 | -3.5 | 2.8 | -0.0 | 3.5 | 3.7 | 0.8 |

# SDA Metrics

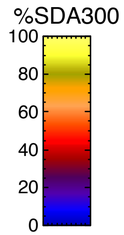
# SDA300

4380
Occ: 00h00-24h00






| | |
|---|---|
| AVG $DA_{300}$ | 64.6 |
| MED $DA_{300}$ | 81.6 |
| MIN $DA_{300}$ | 0.0 |
| MAX $DA_{300}$ | 92.2 |
| 05% $DA_{300}$ | 1.8 |
| 95% $DA_{300}$ | 92.0 |
| $F_{plane > 5\%T}DA_{300}$ | 0.94 |
| $F_{plane > 10\%T}DA_{300}$ | 0.91 |
| $F_{plane > 15\%T}DA_{300}$ | 0.88 |
| $F_{plane > 20\%T}DA_{300}$ | 0.85 |
| $F_{plane > 25\%T}DA_{300}$ | 0.82 |
| $F_{plane > 30\%T}DA_{300}$ | 0.81 |
| $F_{plane > 35\%T}DA_{300}$ | 0.79 |
| $F_{plane > 40\%T}DA_{300}$ | 0.77 |
| $F_{plane > 45\%T}DA_{300}$ | 0.73 |
| $F_{plane > 50\%T}DA_{300}$ | 0.70 |
| $F_{plane > 55\%T}DA_{300}$ | 0.67 |
| $F_{plane > 60\%T}DA_{300}$ | 0.63 |
| $F_{plane > 65\%T}DA_{300}$ | 0.60 |
| $F_{plane > 70\%T}DA_{300}$ | 0.57 |
| $F_{plane > 75\%T}DA_{300}$ | 0.55 |
| $F_{plane > 80\%T}DA_{300}$ | 0.51 |
| $F_{plane > 85\%T}DA_{300}$ | 0.47 |
| $F_{plane > 90\%T}DA_{300}$ | 0.30 |
| $F_{plane > 95\%T}DA_{300}$ | 0.00 |




| | |
|---|---|
| AVG $DA_{300}$ | 64.6 |
| MED $DA_{300}$ | 81.6 |
| MIN $DA_{300}$ | 0.0 |
| MAX $DA_{300}$ | 92.2 |
| 05% $DA_{300}$ | 1.8 |
| 95% $DA_{300}$ | 92.0 |

4380 daylight hours

IT_Factory/w_zone1

000

DNK_Copenhagen.061800_IWEC

| Summer House | | 300 lux Spatial Daylight Autonomy metrics | | | | | |
|---|---|---|---|---|---|---|---|
| | | MBD [%] | | | RMSD [%] | | |
| Zone | Qual | 000-100 | 005-095 | AVG-050 | 000-100 | 005-095 | AVG-050 |
| zone02 | Q000 | -0.7 | -1.8 | -0.7 | 1.9 | 2.0 | 0.8 |
| zone02 | Q050 | -0.7 | -1.4 | -0.8 | 1.5 | 1.8 | 0.9 |
| zone02 | Q100 | -1.0 | -1.6 | -0.9 | 1.6 | 1.9 | 0.9 |
| zone04 | Q000 | -1.0 | -1.6 | -1.3 | 1.6 | 1.9 | 1.5 |
| zone04 | Q050 | -1.1 | -1.7 | -1.3 | 1.5 | 1.9 | 1.4 |
| zone04 | Q100 | -1.1 | -1.6 | -1.4 | 1.5 | 1.8 | 1.5 |
| zone05 | Q000 | -3.2 | -3.3 | -2.3 | 4.5 | 3.8 | 2.3 |
| zone05 | Q050 | -3.5 | -3.5 | -2.6 | 4.7 | 4.0 | 2.6 |
| zone05 | Q100 | -3.4 | -3.4 | -2.7 | 4.7 | 4.0 | 2.7 |
| zone06 | Q000 | -0.2 | -0.7 | -0.5 | 0.9 | 0.8 | 0.5 |
| zone06 | Q050 | -0.5 | -0.9 | -0.5 | 0.9 | 1.1 | 0.5 |
| zone06 | Q100 | -0.6 | -0.8 | -0.4 | 1.0 | 1.2 | 0.4 |
| zone07 | Q000 | 0.1 | -0.2 | 0.1 | 0.5 | 0.4 | 0.1 |
| zone07 | Q050 | 0.1 | -0.1 | 0.1 | 0.3 | 0.3 | 0.1 |
| zone07 | Q100 | -0.1 | -0.2 | -0.0 | 0.4 | 0.4 | 0.0 |
| zone08 | Q000 | -0.7 | -1.1 | -1.0 | 0.9 | 1.1 | 1.1 |
| zone08 | Q050 | -1.4 | -2.1 | -1.4 | 1.9 | 2.4 | 1.4 |
| zone08 | Q100 | -1.4 | -1.9 | -1.4 | 1.8 | 2.2 | 1.4 |
| zone09 | Q000 | -2.5 | -2.7 | -2.6 | 3.5 | 3.2 | 2.6 |
| zone09 | Q050 | -3.0 | -3.2 | -3.1 | 3.9 | 3.6 | 3.1 |
| zone09 | Q100 | -3.2 | -3.4 | -3.3 | 4.0 | 3.8 | 3.3 |
| zone10 | Q000 | -0.5 | -0.7 | -0.4 | 0.7 | 0.8 | 0.4 |
| zone10 | Q050 | -0.5 | -0.7 | -0.5 | 0.6 | 0.7 | 0.5 |
| zone10 | Q100 | -0.5 | -0.7 | -0.5 | 0.6 | 0.8 | 0.5 |

| Summer House | | 500 lux Spatial Daylight Autonomy metrics | | | | | |
|---|---|---|---|---|---|---|---|
| | | MBD [%] | | | RMSD [%] | | |
| Zone | Qual | 000-100 | 005-095 | AVG-050 | 000-100 | 005-095 | AVG-050 |
| zone02 | Q000 | -1.2 | -3.7 | -1.1 | 3.1 | 3.5 | 1.3 |
| zone02 | Q050 | -1.4 | -2.7 | -1.4 | 3.0 | 3.6 | 1.4 |
| zone02 | Q100 | -2.0 | -3.2 | -1.4 | 3.2 | 3.9 | 1.4 |
| zone04 | Q000 | -1.9 | -3.0 | -2.3 | 3.0 | 3.7 | 2.4 |
| zone04 | Q050 | -1.9 | -2.9 | -2.2 | 2.8 | 3.5 | 2.3 |
| zone04 | Q100 | -1.9 | -2.8 | -2.3 | 2.8 | 3.5 | 2.4 |
| zone05 | Q000 | -6.0 | -6.2 | -4.9 | 7.6 | 6.8 | 4.8 |
| zone05 | Q050 | -6.1 | -6.2 | -5.0 | 7.8 | 6.8 | 5.0 |
| zone05 | Q100 | -6.1 | -6.1 | -5.3 | 7.9 | 6.9 | 5.2 |
| zone06 | Q000 | -0.3 | -1.1 | -0.6 | 1.4 | 1.5 | 0.8 |
| zone06 | Q050 | -0.8 | -1.4 | -0.5 | 1.5 | 1.8 | 0.6 |
| zone06 | Q100 | -1.0 | -1.3 | -0.4 | 1.8 | 2.1 | 0.5 |
| zone07 | Q000 | 0.2 | -0.3 | 0.1 | 0.9 | 0.5 | 0.1 |
| zone07 | Q050 | 0.2 | -0.1 | 0.2 | 0.5 | 0.3 | 0.2 |
| zone07 | Q100 | -0.0 | -0.2 | -0.0 | 0.5 | 0.5 | 0.1 |
| zone08 | Q000 | -1.4 | -2.1 | -1.6 | 1.6 | 1.9 | 1.7 |
| zone08 | Q050 | -2.6 | -3.6 | -2.3 | 3.5 | 4.2 | 2.4 |
| zone08 | Q100 | -2.7 | -3.4 | -2.3 | 3.3 | 4.0 | 2.3 |
| zone09 | Q000 | -4.6 | -5.2 | -4.9 | 6.1 | 5.9 | 4.9 |
| zone09 | Q050 | -5.3 | -5.7 | -5.4 | 6.7 | 6.2 | 5.3 |
| zone09 | Q100 | -5.5 | -5.9 | -5.6 | 6.8 | 6.4 | 5.6 |
| zone10 | Q000 | -0.6 | -1.0 | -0.6 | 0.9 | 1.1 | 0.6 |
| zone10 | Q050 | -0.7 | -0.9 | -0.7 | 0.8 | 1.0 | 0.8 |
| zone10 | Q100 | -0.7 | -0.9 | -0.6 | 0.9 | 1.0 | 0.7 |

| Summer House | | 750 lux Spatial Daylight Autonomy metrics | | | | | |
|---|---|---|---|---|---|---|---|
| | | MBD [%] | | | RMSD [%] | | |
| Zone | Qual | 000-100 | 005-095 | AVG-050 | 000-100 | 005-095 | AVG-050 |
| zone02 | Q000 | Inf | -7.8 | -1.7 | 4.1 | 5.1 | 2.0 |
| zone02 | Q050 | -3.9 | -5.7 | -2.2 | 5.2 | 6.5 | 2.2 |
| zone02 | Q100 | -4.6 | -6.4 | -2.4 | 5.5 | 6.8 | 2.3 |
| zone04 | Q000 | -3.0 | -4.8 | -3.5 | 4.6 | 5.8 | 3.7 |
| zone04 | Q050 | -3.0 | -4.4 | -3.2 | 4.3 | 5.4 | 3.3 |
| zone04 | Q100 | -2.9 | -4.2 | -3.2 | 4.4 | 5.5 | 3.3 |
| zone05 | Q000 | -12.2 | -13.1 | -8.7 | 14.0 | 12.9 | 8.5 |
| zone05 | Q050 | -12.4 | -13.1 | -9.2 | 14.4 | 13.0 | 9.0 |
| zone05 | Q100 | -12.1 | -11.9 | -9.3 | 14.2 | 12.5 | 9.1 |
| zone06 | Q000 | -1.3 | -2.0 | -0.9 | 2.1 | 2.6 | 1.2 |
| zone06 | Q050 | -2.0 | -2.5 | -0.9 | 2.7 | 3.2 | 1.0 |
| zone06 | Q100 | -2.2 | -2.1 | -0.6 | 3.2 | 3.8 | 0.7 |
| zone07 | Q000 | 0.5 | -0.7 | 0.2 | 1.4 | 0.9 | 0.3 |
| zone07 | Q050 | 0.3 | -0.2 | 0.3 | 0.8 | 0.6 | 0.4 |
| zone07 | Q100 | 0.0 | -0.4 | -0.0 | 0.8 | 0.8 | 0.1 |
| zone08 | Q000 | -4.1 | -4.0 | -2.8 | 2.7 | 3.1 | 2.8 |
| zone08 | Q050 | -5.4 | -6.6 | -3.8 | 6.3 | 7.7 | 3.7 |
| zone08 | Q100 | -5.7 | -6.3 | -3.8 | 5.9 | 7.2 | 3.7 |
| zone09 | Q000 | -7.6 | -8.5 | -8.4 | 9.6 | 9.2 | 8.2 |
| zone09 | Q050 | -8.4 | -9.0 | -8.8 | 10.0 | 9.5 | 8.5 |
| zone09 | Q100 | -8.7 | -9.3 | -9.2 | 10.3 | 9.8 | 9.0 |
| zone10 | Q000 | -1.2 | -1.6 | -0.9 | 1.4 | 1.7 | 0.9 |
| zone10 | Q050 | -1.3 | -1.6 | -1.1 | 1.4 | 1.6 | 1.2 |
| zone10 | Q100 | -1.3 | -1.5 | -1.0 | 1.4 | 1.6 | 1.1 |

| IT Factory | | 300 lux Spatial Daylight Autonomy metrics | | | | | |
|---|---|---|---|---|---|---|---|
| | | MBD [%] | | | RMSD [%] | | |
| Zone | Qual | 000-100 | 005-095 | AVG-050 | 000-100 | 005-095 | AVG-050 |
| w_zone1 | Q000 | 27.2 | 46.5 | 1.5 | 2.6 | 2.9 | 1.6 |
| w_zone1 | Q050 | 20.7 | 36.9 | 1.4 | 2.5 | 2.6 | 1.6 |
| w_zone1 | Q100 | 23.8 | 41.0 | 1.7 | 2.7 | 3.0 | 1.8 |
| w_zone2 | Q000 | -7.5 | 0.1 | 0.8 | 6.4 | 0.9 | 0.8 |
| w_zone2 | Q050 | -8.2 | -0.2 | 0.8 | 6.9 | 1.1 | 0.8 |
| w_zone2 | Q100 | -8.2 | -0.1 | 0.8 | 7.1 | 1.1 | 0.8 |
| w_zone3 | Q000 | 0.3 | 0.4 | 0.8 | 0.9 | 0.8 | 0.8 |
| w_zone3 | Q050 | -0.4 | 0.4 | 0.7 | 1.3 | 0.9 | 0.7 |
| w_zone3 | Q100 | -0.5 | 0.6 | 0.8 | 1.6 | 1.1 | 0.8 |
| w_zone4 | Q000 | -0.0 | -0.1 | 0.1 | 0.3 | 0.3 | 0.1 |
| w_zone4 | Q050 | -0.0 | -0.1 | 0.2 | 0.4 | 0.4 | 0.2 |
| w_zone4 | Q100 | -0.0 | -0.0 | 0.2 | 0.4 | 0.5 | 0.2 |
| w_zone5 | Q000 | -10.3 | -8.2 | -0.7 | 2.2 | 2.3 | 1.2 |
| w_zone5 | Q050 | -11.5 | -9.5 | -1.6 | 2.9 | 3.1 | 2.0 |
| w_zone5 | Q100 | -12.1 | -9.9 | -1.8 | 3.3 | 3.4 | 2.2 |

| IT Factory | | 500 lux Spatial Daylight Autonomy metrics | | | | | |
|---|---|---|---|---|---|---|---|
| | | MBD [%] | | | RMSD [%] | | |
| Zone | Qual | 000-100 | 005-095 | AVG-050 | 000-100 | 005-095 | AVG-050 |
| w_zone1 | Q000 | Inf | Inf | 1.8 | 1.4 | 1.5 | 1.8 |
| w_zone1 | Q050 | Inf | Inf | 1.7 | 1.3 | 1.4 | 1.7 |
| w_zone1 | Q100 | Inf | Inf | 2.2 | 1.6 | 1.8 | 2.1 |
| w_zone2 | Q000 | -4.1 | -1.3 | 2.0 | 2.8 | 2.0 | 2.0 |
| w_zone2 | Q050 | -4.8 | -1.6 | 1.8 | 3.0 | 2.2 | 1.8 |
| w_zone2 | Q100 | -4.9 | -1.4 | 1.9 | 3.2 | 2.3 | 1.8 |
| w_zone3 | Q000 | -0.6 | 1.6 | 1.6 | 2.5 | 2.0 | 1.6 |
| w_zone3 | Q050 | -4.8 | 1.4 | 1.6 | 3.1 | 1.9 | 1.6 |
| w_zone3 | Q100 | -4.8 | 1.9 | 1.7 | 3.5 | 2.4 | 1.7 |
| w_zone4 | Q000 | 0.0 | -0.1 | 0.2 | 0.4 | 0.5 | 0.2 |
| w_zone4 | Q050 | 0.1 | 0.0 | 0.3 | 0.5 | 0.5 | 0.3 |
| w_zone4 | Q100 | 0.2 | 0.1 | 0.3 | 0.6 | 0.7 | 0.4 |
| w_zone5 | Q000 | 0.3 | -1.1 | 1.6 | 2.2 | 2.7 | 1.9 |
| w_zone5 | Q050 | -2.1 | -3.4 | -2.0 | 2.8 | 3.5 | 2.3 |
| w_zone5 | Q100 | -2.8 | -3.7 | -2.6 | 3.0 | 3.7 | 2.4 |

| IT Factory | | 750 lux Spatial Daylight Autonomy metrics | | | | | |
|---|---|---|---|---|---|---|---|
| | | MBD [%] | | | RMSD [%] | | |
| Zone | Qual | 000-100 | 005-095 | AVG-050 | 000-100 | 005-095 | AVG-050 |
| w_zone1 | Q000 | -2.8 | -4.3 | 2.4 | 1.8 | 2.0 | 2.4 |
| w_zone1 | Q050 | -2.6 | -4.0 | 2.3 | 1.7 | 1.9 | 2.3 |
| w_zone1 | Q100 | -0.8 | -1.3 | 2.9 | 2.1 | 2.4 | 2.9 |
| w_zone2 | Q000 | -6.1 | 1.1 | 4.5 | 4.0 | 3.5 | 3.7 |
| w_zone2 | Q050 | -6.6 | 0.8 | 3.9 | 4.2 | 3.9 | 3.3 |
| w_zone2 | Q100 | -6.4 | 1.3 | 4.4 | 4.5 | 4.2 | 3.7 |
| w_zone3 | Q000 | -0.6 | 2.6 | 3.2 | 3.1 | 2.9 | 3.2 |
| w_zone3 | Q050 | -2.2 | 1.0 | 3.0 | 3.3 | 2.8 | 3.1 |
| w_zone3 | Q100 | -1.0 | 2.8 | 3.1 | 3.5 | 3.0 | 3.2 |
| w_zone4 | Q000 | 0.1 | 0.0 | 0.5 | 0.7 | 0.7 | 0.5 |
| w_zone4 | Q050 | 0.2 | 0.1 | 0.5 | 0.8 | 0.8 | 0.5 |
| w_zone4 | Q100 | 0.3 | 0.3 | 0.6 | 1.0 | 1.1 | 0.7 |
| w_zone5 | Q000 | -0.2 | -4.0 | 2.0 | 3.6 | 4.9 | 2.7 |
| w_zone5 | Q050 | -1.7 | -4.9 | 0.8 | 4.5 | 6.1 | 1.0 |
| w_zone5 | Q100 | -2.1 | -4.1 | 0.5 | 4.8 | 6.5 | 0.9 |

# Take-home messages

- Overall, very good agreement between DVIZ and 4CM for nearly all cases and metrics (±10% often better).
- TAI appears to be the most reliable metric for comparison.
- Small differences between DVIZ and 4CM predictions for indirect sun & sky for certain cases (TAI).
- Use of SDA metrics metrics for comparison needs some thought/care/caution.

# Acknowledgements


- Nicolas Roy, VELUX.
- The VELUX® corporation.
- Eleonora Brembilla, TU Delft, NL.
- Members of the (volunteer) CIBSE panel to formulate benchmarks for daylighting software accreditation.



DVIZ  CBDM video:
https://www.youtube.com/watch?v=ShfG_rggt_Q