Irradiance Modelling Using LightTools
A Ray Tracing Technique

TRAINING SCHOOL III SIMULATION TOOLS AND MODELS FOR THE ANALYSIS OF PV SYSTEM PERFORMANCE
BRASOV, ROMANIA, 07/07/2021

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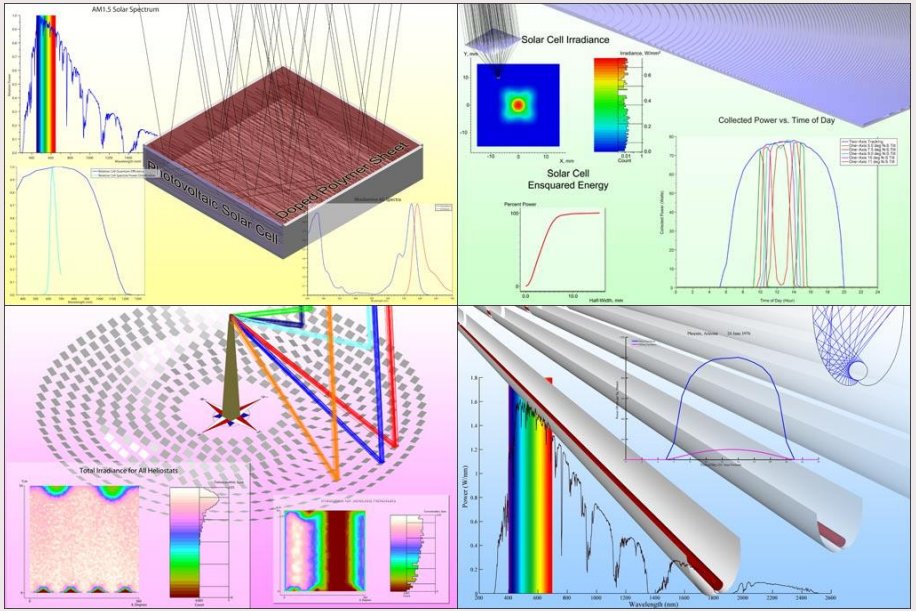
Outline

- Why use LT
- How LT work
- Solar simulation in LT
  - Basic solar panel model
  - One day scan
  - Yearly calculation
- Example and exercise

Why use LightTools

LightTools is a complete optical design and analysis software, Through Monte Carlo ray tracing, LightTools can simulate the optical performance of photovoltaic systems, especially when irradiances need to penetrate the cover layer or transmission in the light guide material (such as LSC). Moreover, with the Solar Tracker tool, LightTools can also perform one-day or full-year simulation calculations on the photovoltaic system based on the illumination data.



https://www.synopsys.com/optical-solutions/lighttools/application-gallery.html#solar

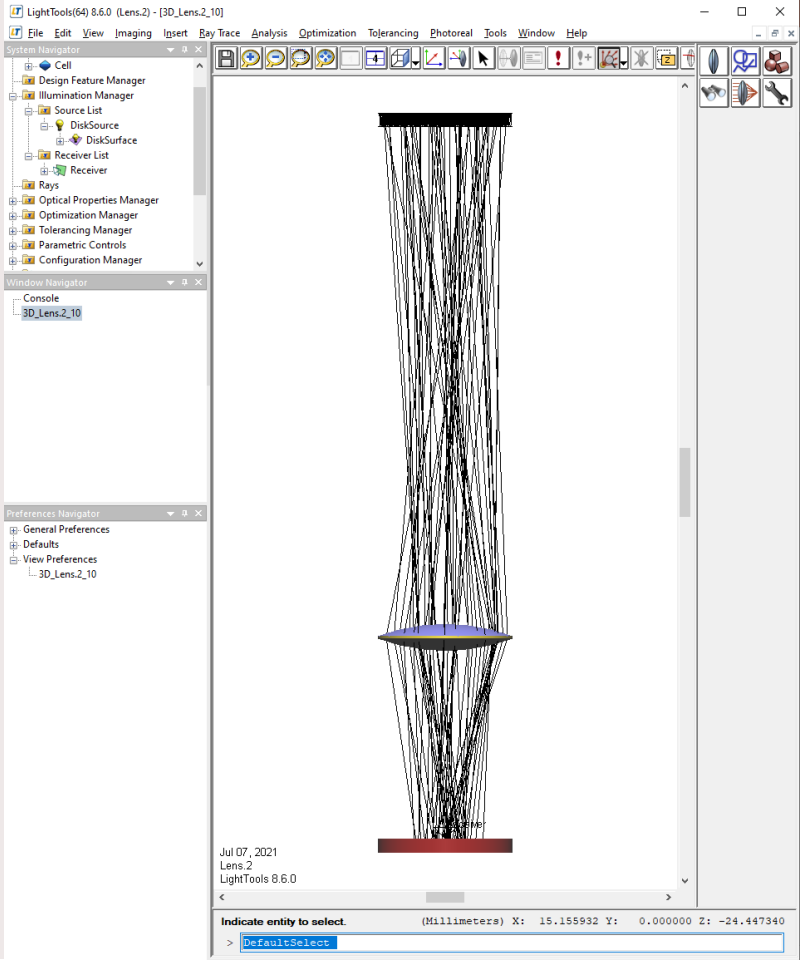
How LightTools work

- Monte Carlo ray-tracing
  - Light source

    Direction, wavelength, illuminance…
  - Optical system

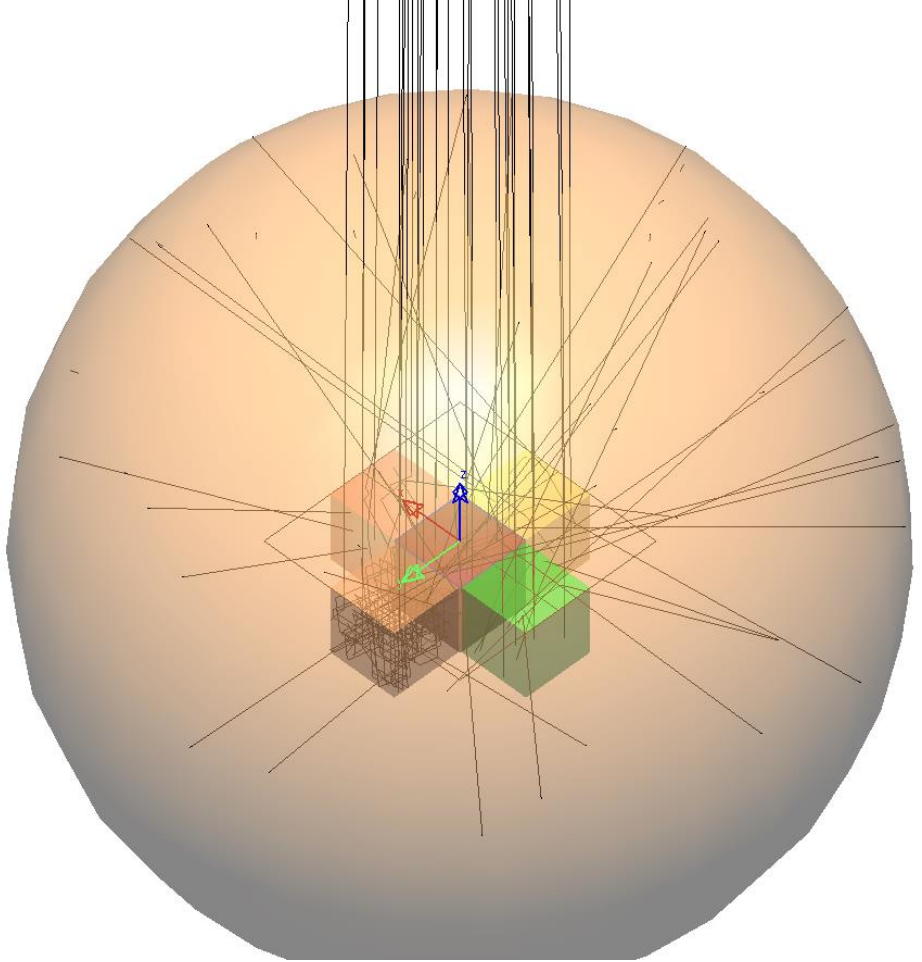
    Reflection, refraction, absorption…
  - Receivers

    Collect data for analysis



Solar system model in LightTools

- Light source
  - Solar source
  - Artificial light source
- Optical syetem
  - Solar cells
  - Light guide
  - Block (cover, shadow, et, al.)
- Receivers
  - Illuminance
  - Spectral distribution



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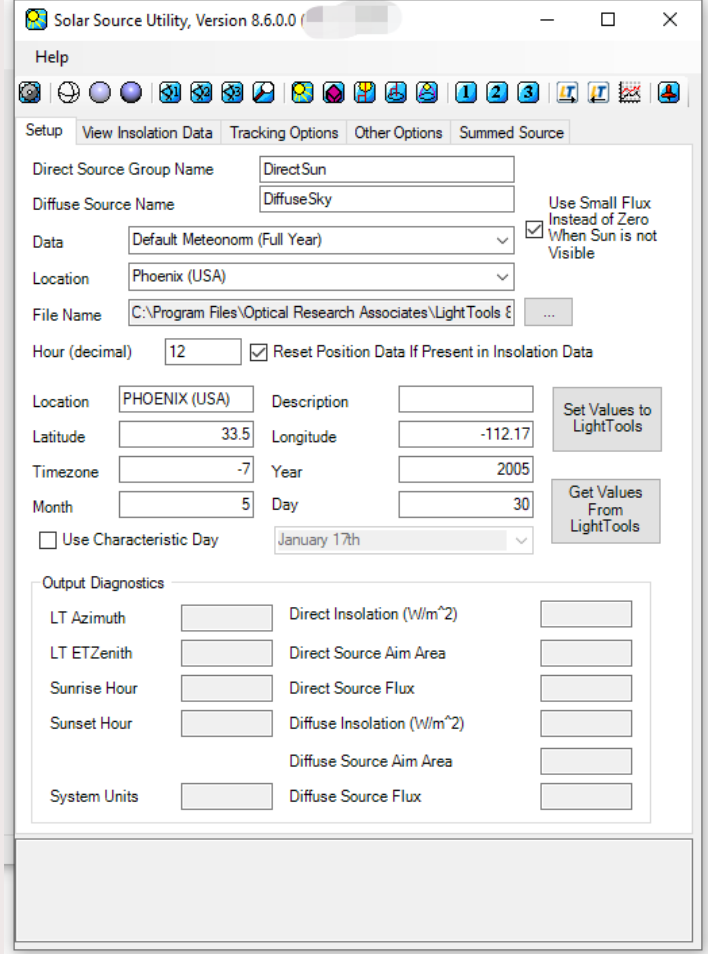
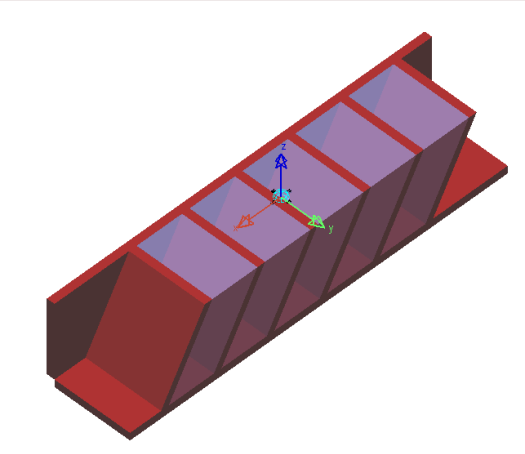
Light source

- Solar source
  - Direct light
  - Diffuse sky
- Artificial light source

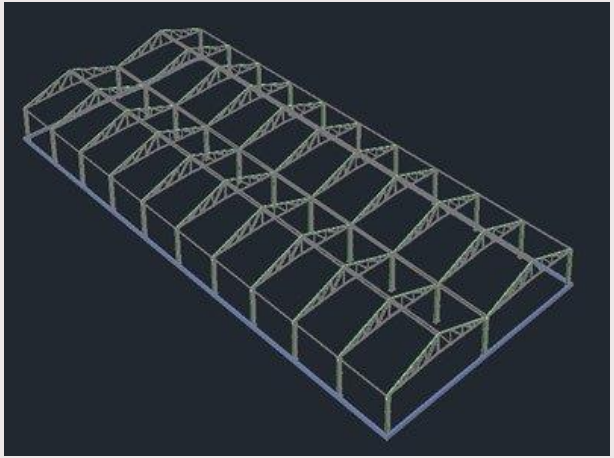


Optical system

- Drawing in LightTools
- Import CAD model



- Material
- Optical properties

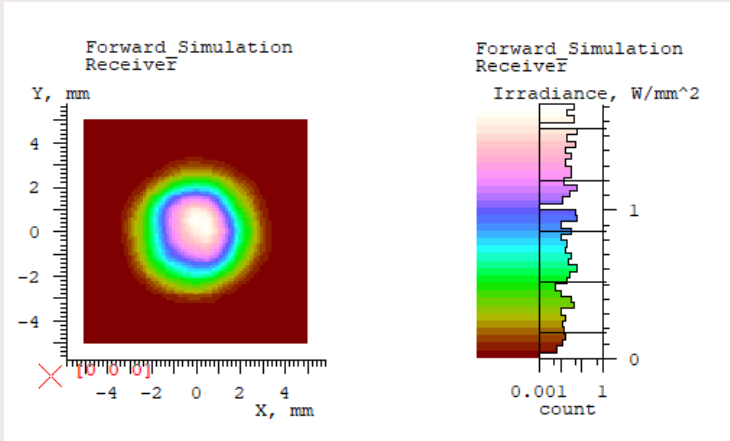


https://designscad.com/downloads/greenhouse-workshop-20x50-3d-dwg-model-autocad/

Receiver

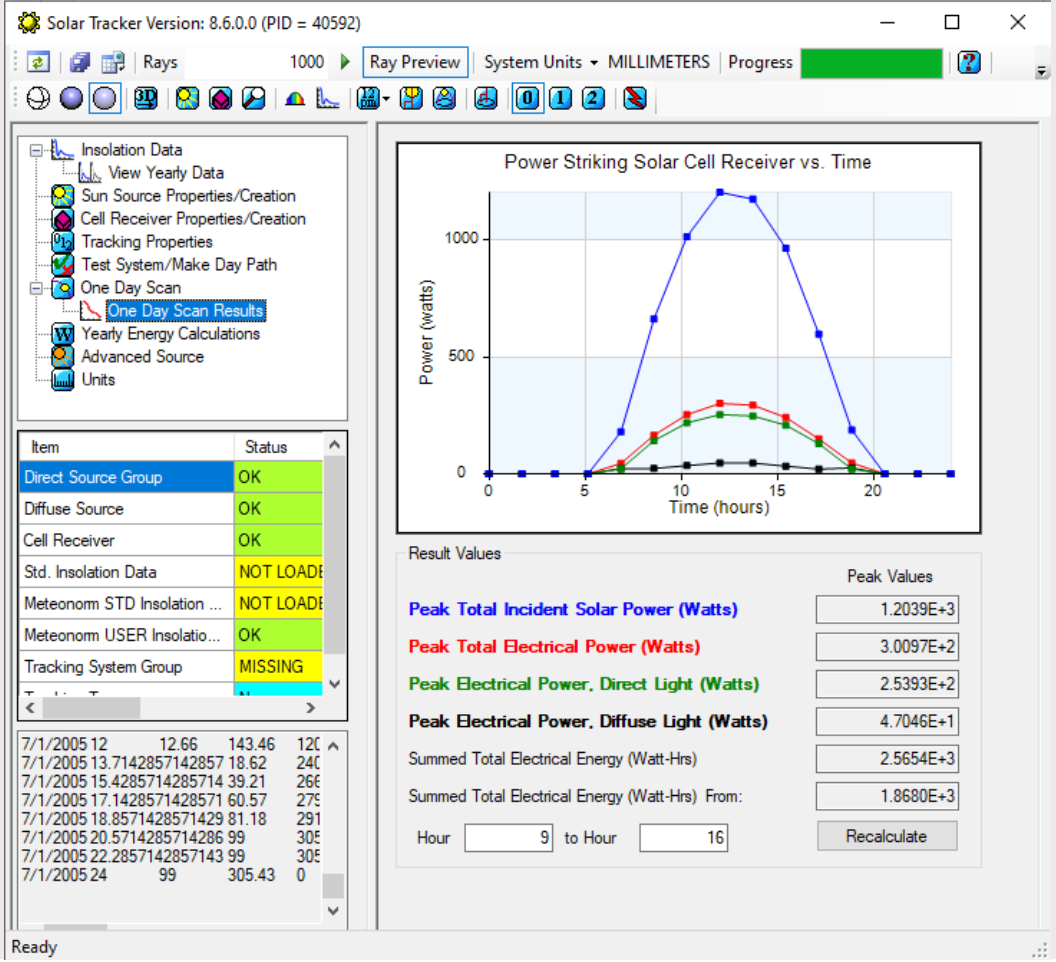
- Illuminance
  - Mesh Dimensions
  illuminance display (lens, solar concentrator)
  - Mesh Result
  Received power
  (Optical efficiency, Power conversion efficiency)

- Spectral distribution
  - Accurate received spectrum
  - Calculation with QE (Quantum Efficiency)



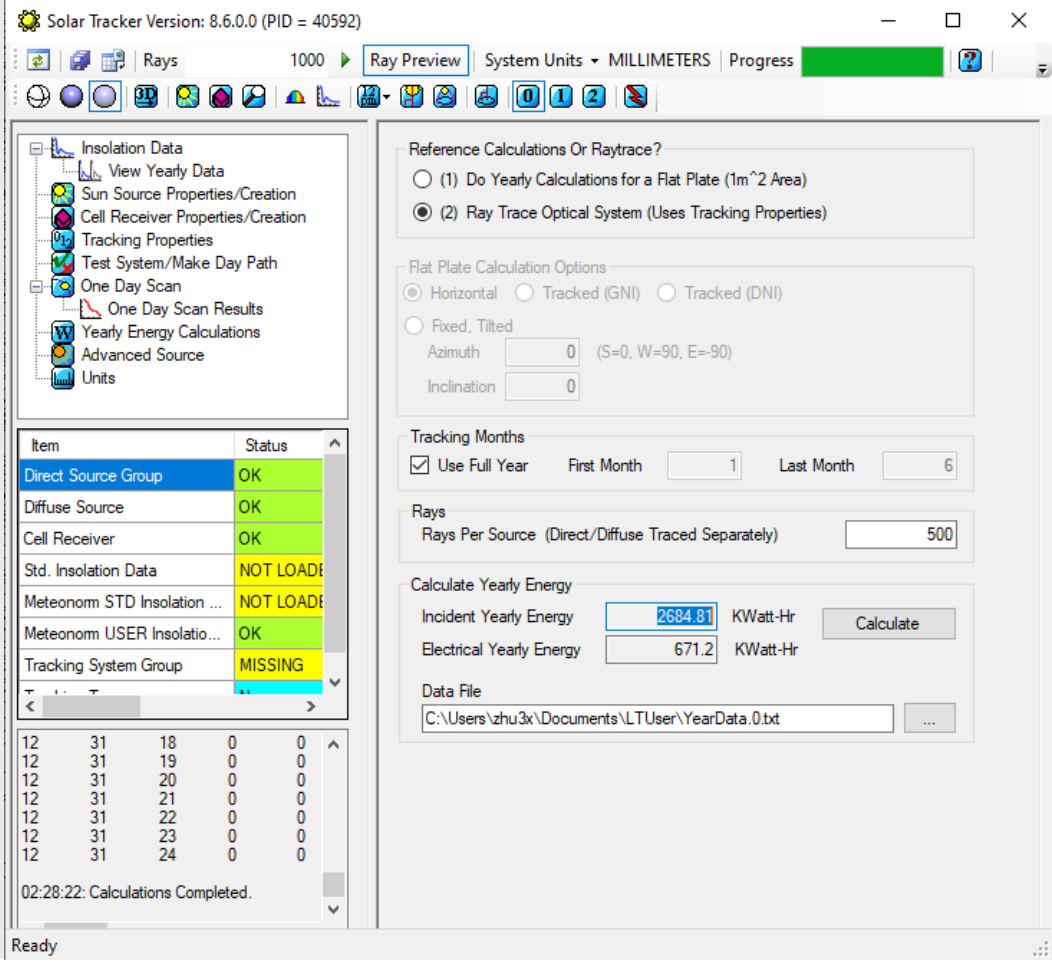
Solar tracker

- One day scan
  - Solar source data
    - 10 different locations
    - 2005 whole year data
  - Including direct light and diffuse light
  - Customized cell efficiency



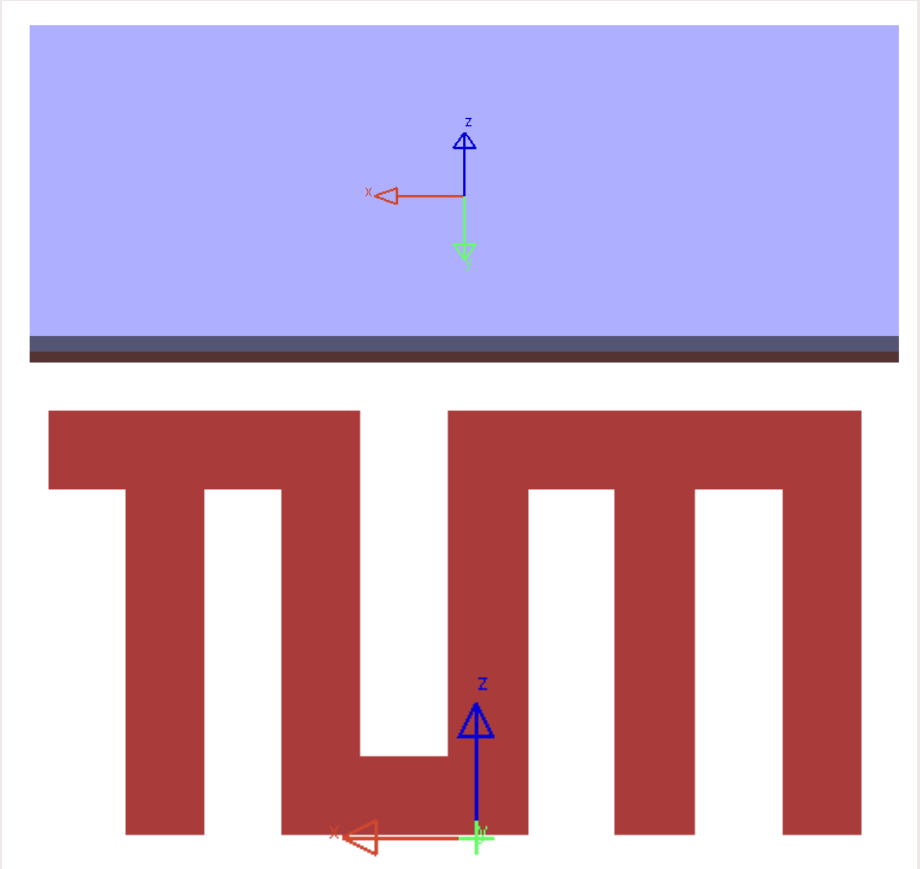
Solar tracker

- Yearly energy calculation
  Using whole year solar data to simulate the performance of the solar system.



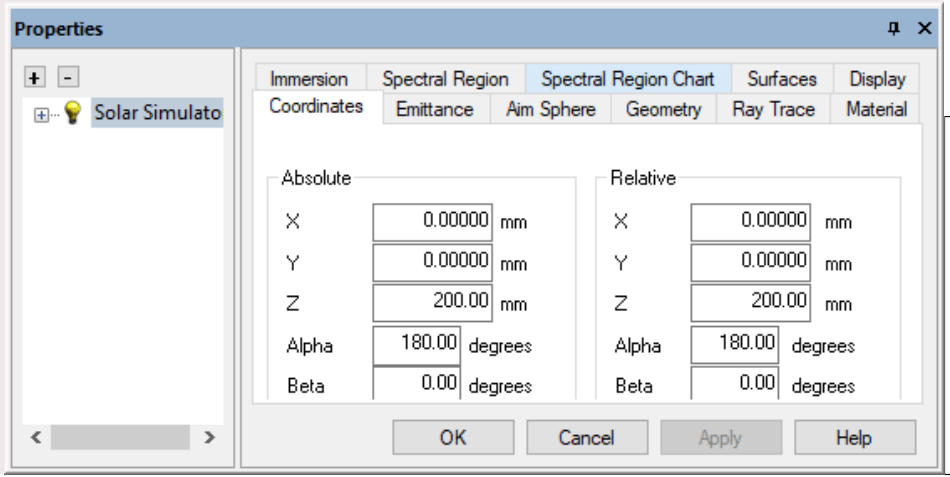
Example

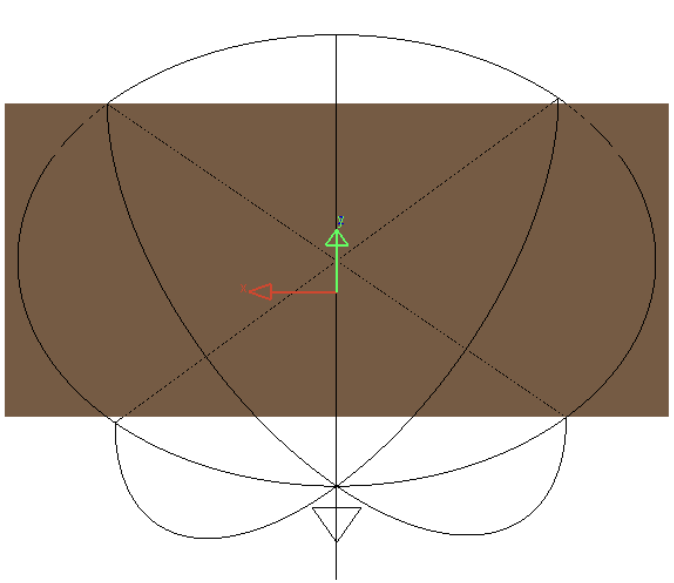
- PMMA covered silicon cell
- One day scan of a TUM logo solar panel in a sunny day (Show in LightTools)
- Yearly energy calculation of different angle solar panel in Seville (in exercise)

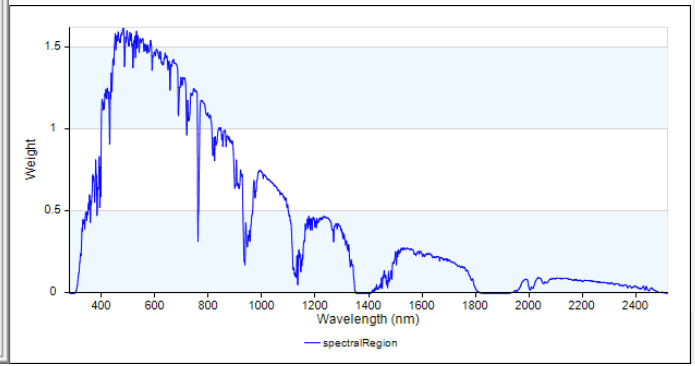


PMMA covered silicon cell

- Light source (Solar simulator)
  Ray Tracing > Surface Sources > RectSource
  Position, Size (geometry), Emittance,
  Spectral Region (Import)

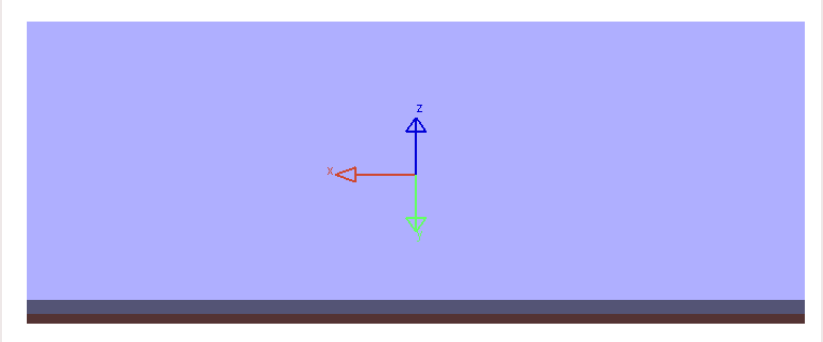


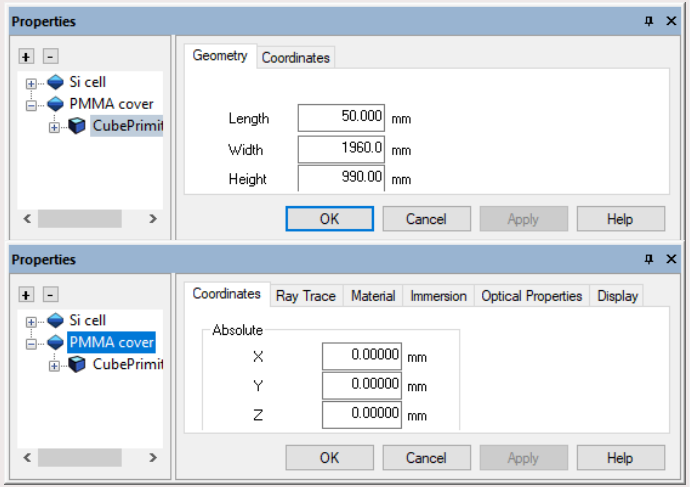


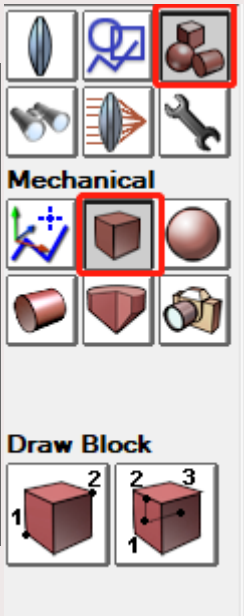


PMMA covered silicon cell

- Optical system
  - Silicon cell & PMMA cover
    Mechanical > Draw Block
    Size (geometry 1960*990*35),
    Position, Material
  - Optical properties
    PMMA: 95% Transmittance + 5%
    Reflectance
    Silicon cell: Mechanical Absorber

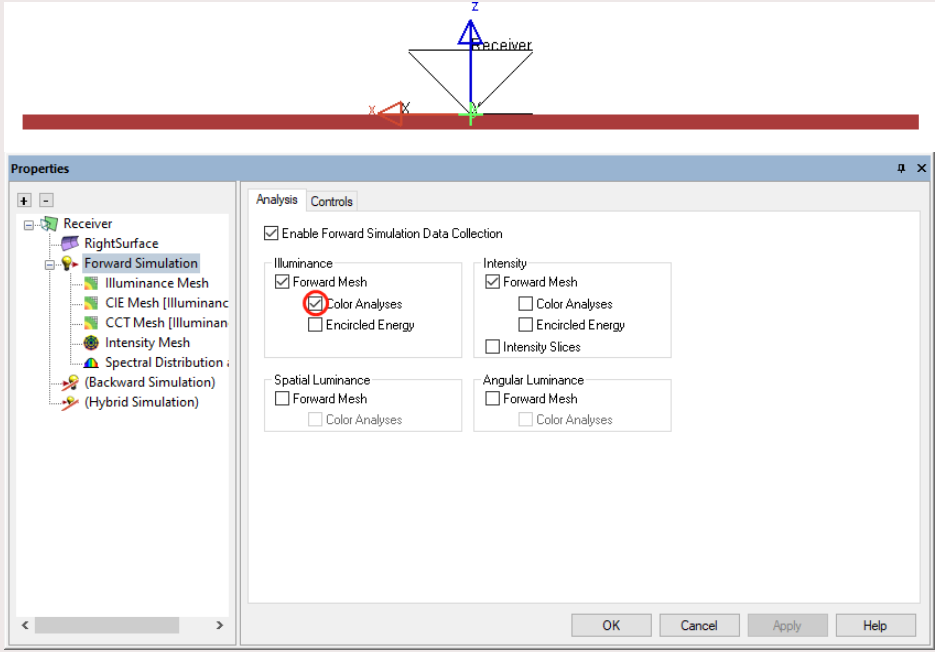






PMMA covered silicon cell

- Receiver
  Right click > Add Surface Receiver
  Properties > Forward Simulation > Color Analyses (spectral distribution)
  - Illuminance
  - Spectral distribution

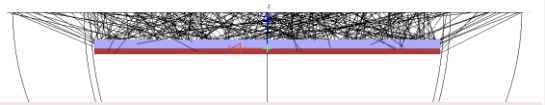


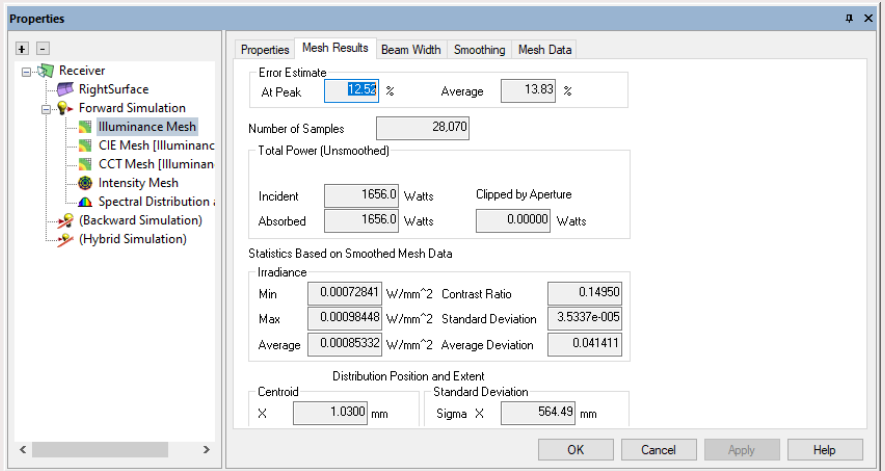
PMMA covered silicon cell

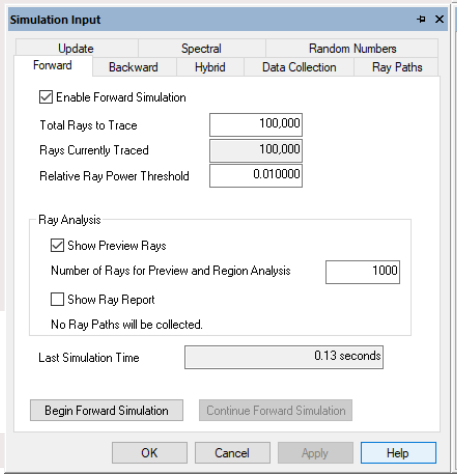
- Result
  - Running the simulation
    Ray Trace > Simulation Input
    Begin Forward Simulation
  - Illuminance
  - Optical efficiency:

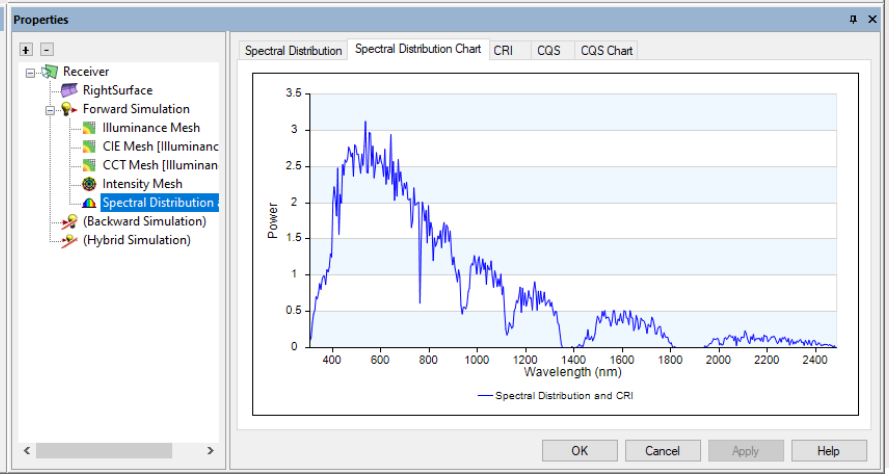
$$\frac{1656\ w}{1.9404 m^2 \times 1000\ w/m^2} = 85.34\%$$

  - Spectral distribution



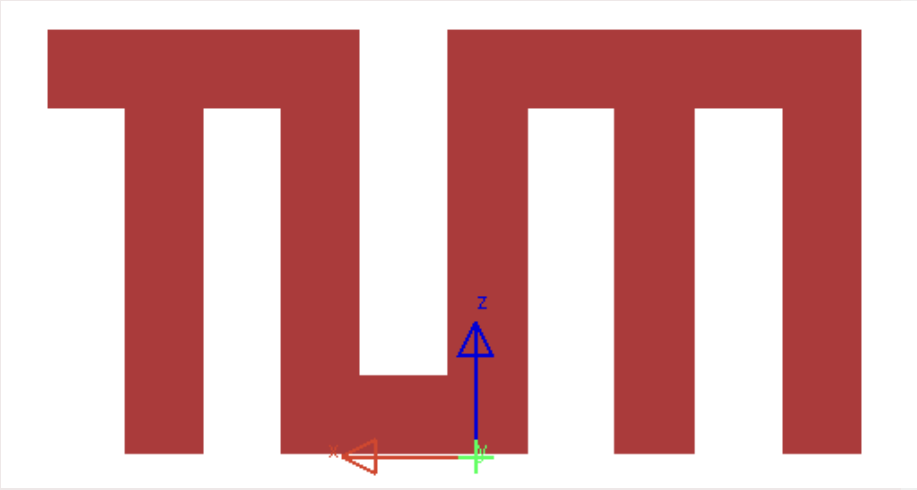


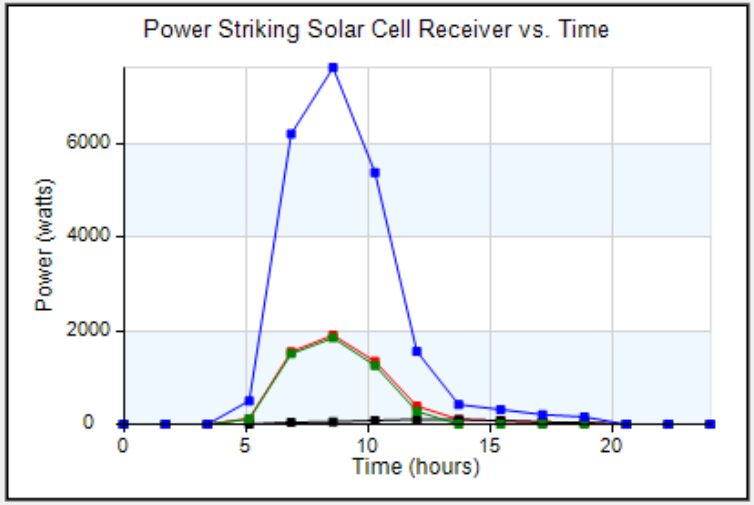




TUM logo solar panel

- 3.06m x 5.88m
- Show in LightTools





Result Values

	Peak Values
Peak Total Incident Solar Power (Watts)	7.6387E+3
Peak Total Electrical Power (Watts)	1.9097E+3
Peak Electrical Power, Direct Light (Watts)	1.8517E+3
Peak Electrical Power, Diffuse Light (Watts)	1.0894E+2
Summed Total Electrical Energy (Watt-Hrs)	9.6110E+3
Summed Total Electrical Energy (Watt-Hrs) From:	3.2972E+3

Hour 9 to Hour 16 Recalculate

Thanks

Want to try LightTools?
More example and exercise?

We can provide a trial account
Please contact me x.zhu@tue.nl