

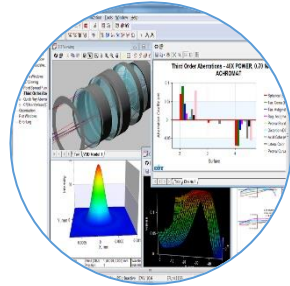
# Optical Simulation software for Horticulture Lighting

*EPIC meeting, 10th July 2020  
by Yan Cornil, CEO*



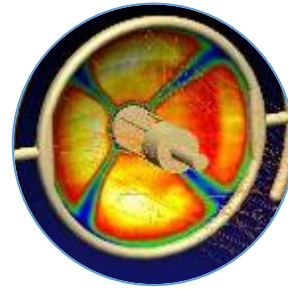
# LIGHT TEC ACTIVITIES

## Synopsys Optical Simulation Software



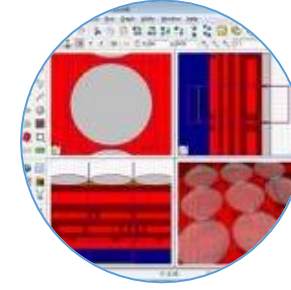
**C**ODE V

Imaging optical design



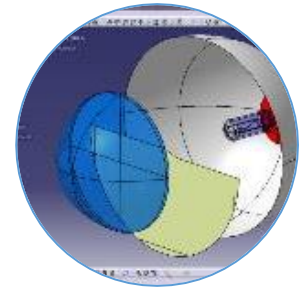
**L**ightTools

Illumination design



**R**Soft

Micro & nano optics



**L**ucidShape

Automotive Illumination

## Optical Scattering Measurement Instruments Services



**M**easurement Service

Scattering measurement



**M**easurement Instruments

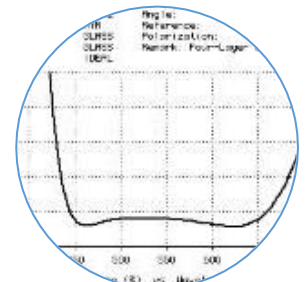
Mini-Diff V2 / Mini-Diff VPro

Reflet 180 S



**E**ngineering & **T**raining

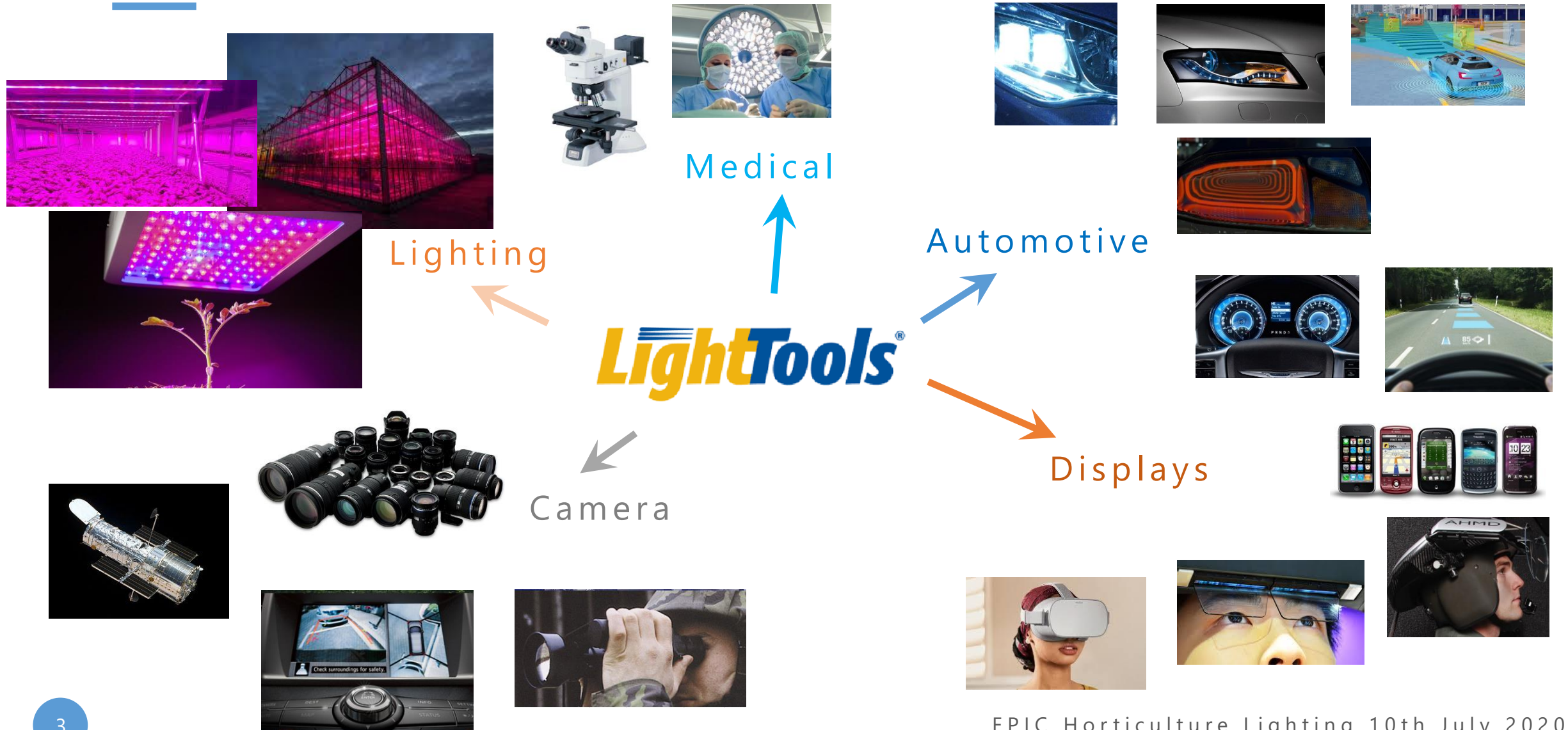
Illumination design &  
Imaging optical design



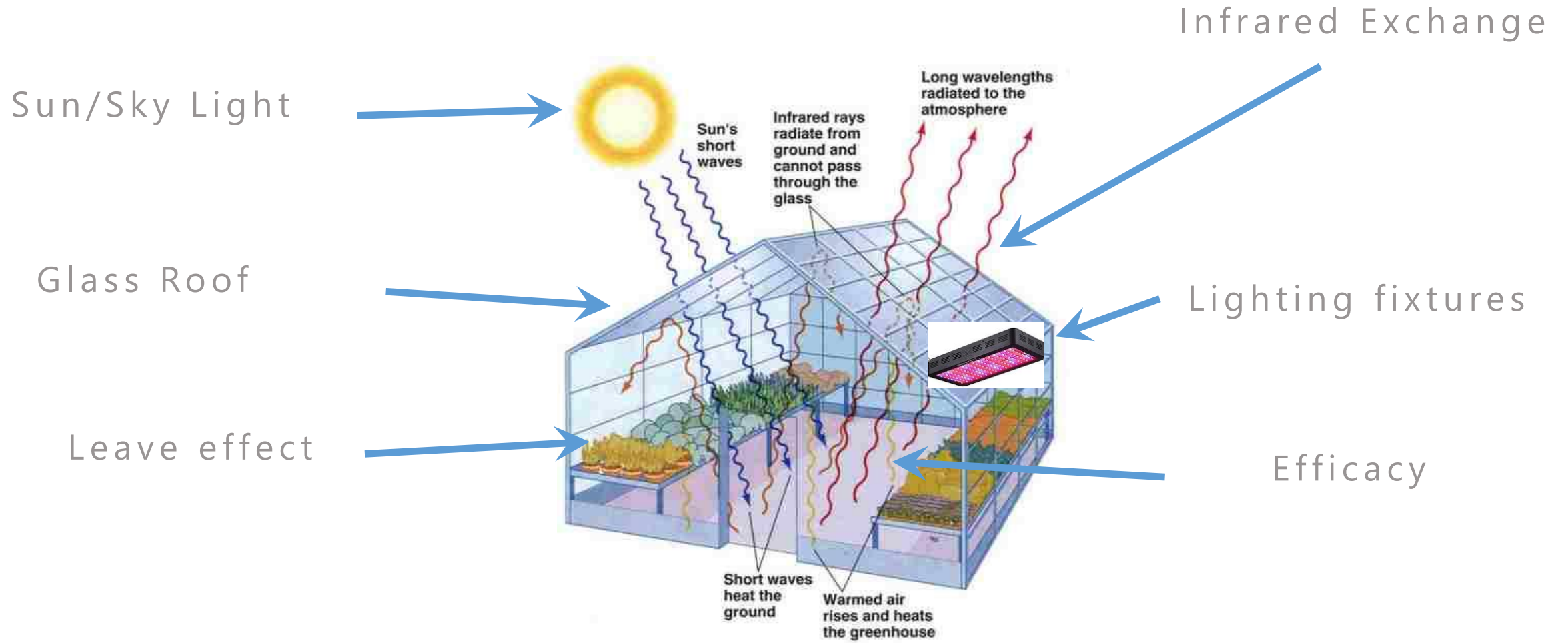
**TF** calc

Thin films, analysis,  
optimization

# Illumination Design Software: Applications



# Type of optical simulation possible





# The dedicated Units

are available

- PAR = Photosynthetically Active Radiation
- Photon Flux - PF is used for the units displayed in the user interface to reduce visual clutter and is calculated in  $\mu\text{mol/s}$
- Photon Intensity – PI is used for the units displayed and is calculated in  $\mu\text{mol/s/sr}$
- Photon Flux Density – PFD is used for the units displayed and is calculated in  $\mu\text{mol/s/m}^2$ , regardless of the default system units
- *Example ,full sunlight is:*

$2000 \mu\text{mol m}^{-2} \text{s}^{-1} \leftrightarrow 108,000 \text{ Lux}$



The screenshot shows the LightTools software interface. The main window displays a 3D model of a lighting fixture with a color-coded mesh representing light distribution. The interface includes a toolbar, a 'Receiver\_6 - Properties' panel, and two 'Illuminance Mesh - Mesh Results' panels. The 'Receiver\_6 - Properties' panel shows 'Photon Flux' selected as the unit. The 'Illuminance Mesh - Mesh Results' panels show error estimates, number of samples, total power, incident and absorbed power, and statistics based on smoothed mesh data.

**Receiver\_6 - Properties**

Properties

Units

Radiometric Power

Photometric Flux

Photon Flux

**Illuminance Mesh - Mesh Results**

Mesh Results

Error Estimate

At Peak 20.82 % Average 40.37

Number of Samples 4 718

Total Power (Unsmoothed)

Incident 0.87326 PF Clipped by Apert

Absorbed 0.00000 PF 0.00000

Statistics Based on Smoothed Mesh Data

Photon Irradiance

Min 4483.5 PFD Contrast Ratio

Max 39918. PFD Standard Deviation

Average 19568. PFD Average Deviation

**Illuminance Mesh - Mesh Results**

Error Estimate

At Peak 10.97 % Average 29.14

Number of Samples 4 718

Total Power (Unsmoothed)

Incident 0.87326 PF Clipped by Aperture

Absorbed 0.00000 PF 0.00000 PF

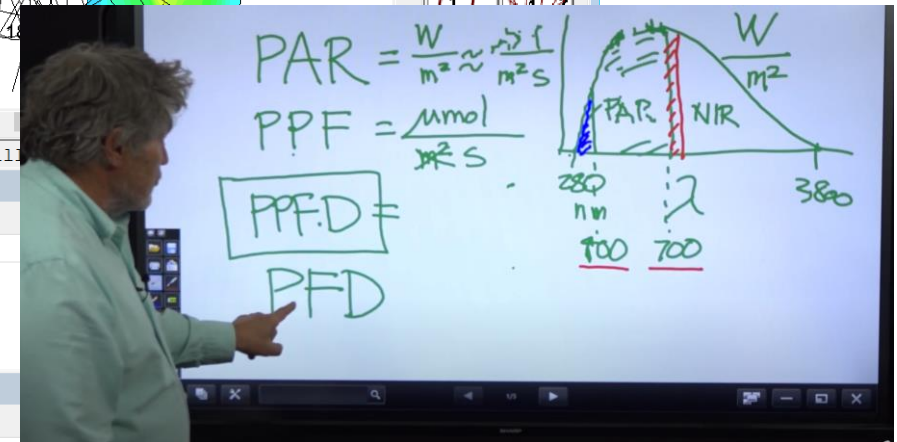
Statistics Based on Smoothed Mesh Data

Photon Intensity

Min 0.00000 PI Contrast Ratio

Max 3.9878e+05 PI Standard Deviation 1.

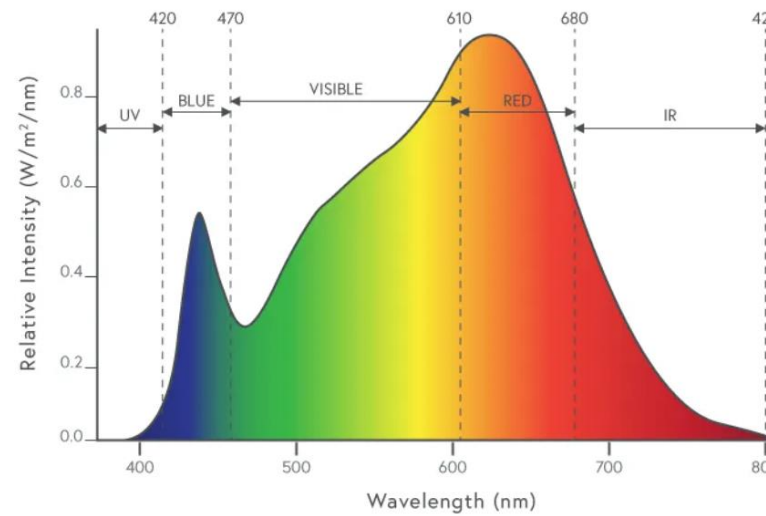
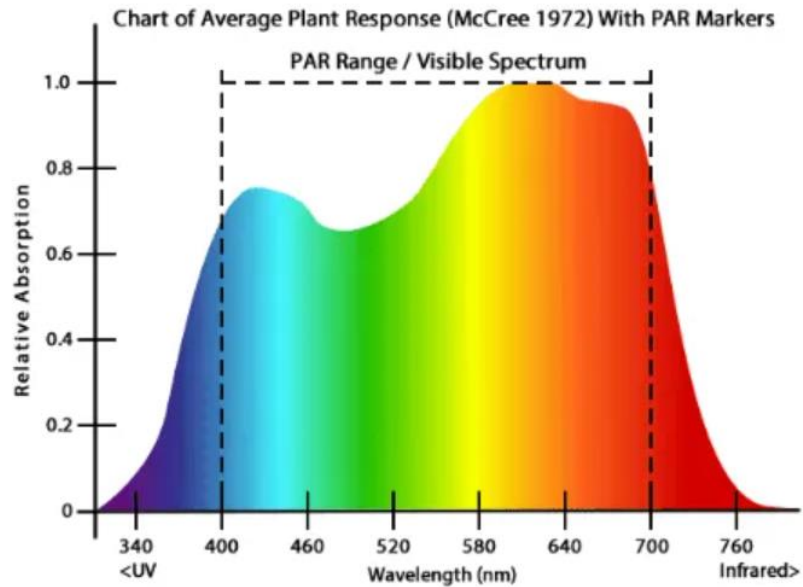
Average 69067. PI Average Deviation



# Special needs



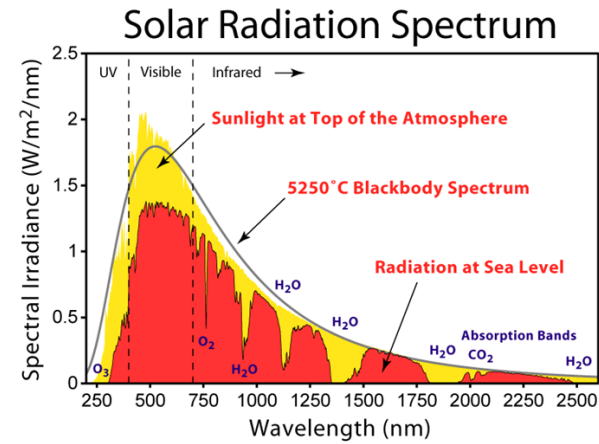
PAR = Photosynthetically Active Radiation (PAR)



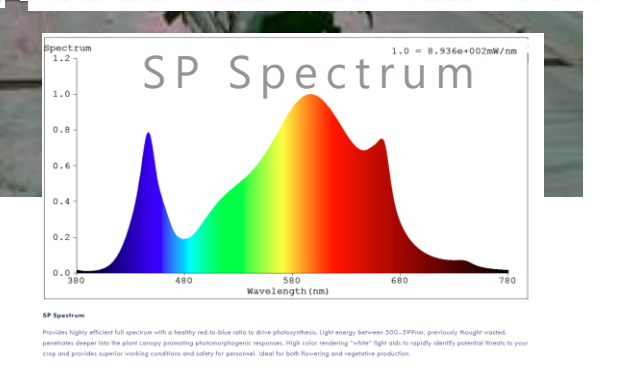
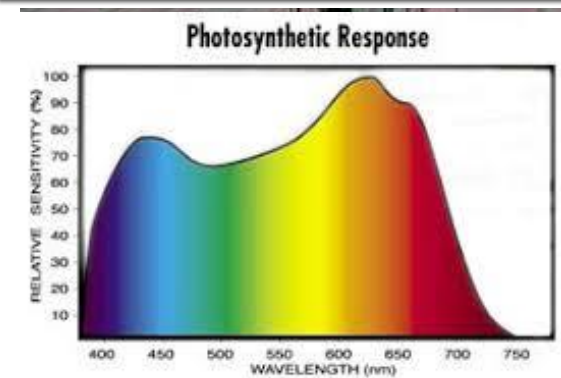
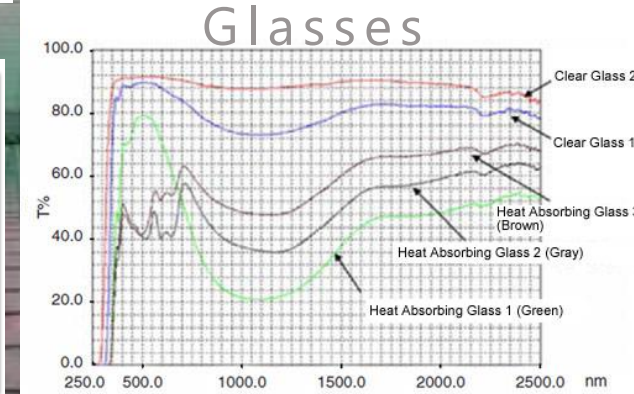
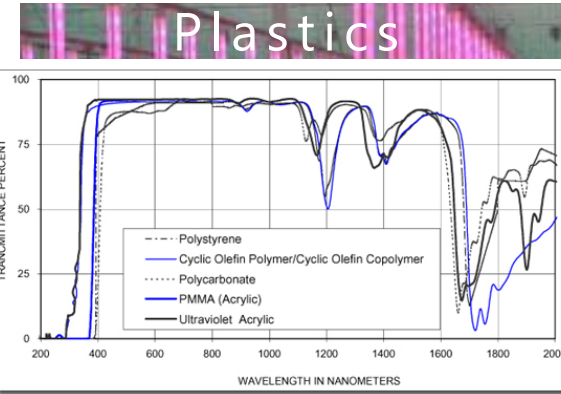
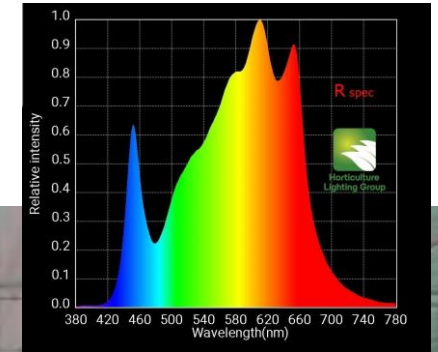
- Blue Light**  
 Plant Leaf Growth.  
 Promoting the synthesis of chlorophyll, carotenoids, chlorophyll A&B, boosting photosynthesis.
- Red Light**  
 Plant Blooming & Fruiting.  
 Promoting the synthesis of chlorophyll A&B. Resulting in fruit and blooming.
- Ultraviolet Light**  
 Disinfect the Virus.  
 Good for germination and sterilization. Prevents plants from being infected.
- Infra-red Light**  
 Promoting Cell Division.  
 Have a certain impact on promotion cell division and good for plant blooming.

# Defining each spectrum

- Sun Light
  - User Defined
  - Spectrum Libraries
  - Importing data (Meteonorm, etc)
- Led/Lamp
  - User Defined
  - Spectrum Libraries
- Glass/Plastic transmission
  - User Defined
  - Spectrum Libraries
- Plant absorption
  - User Defined

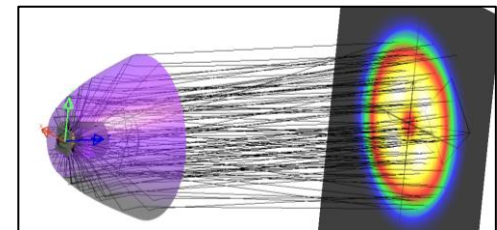
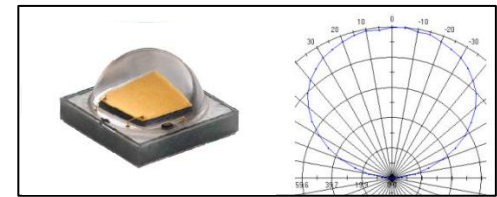
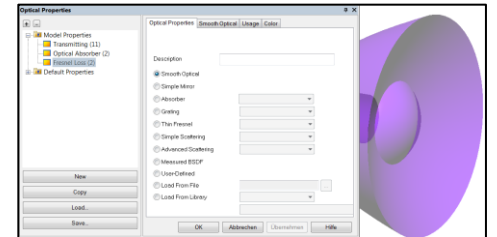
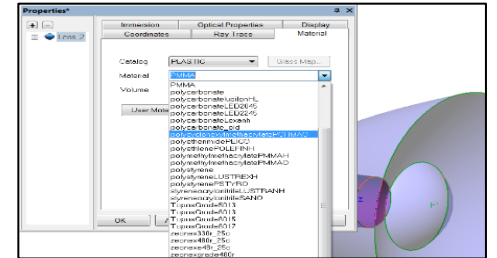
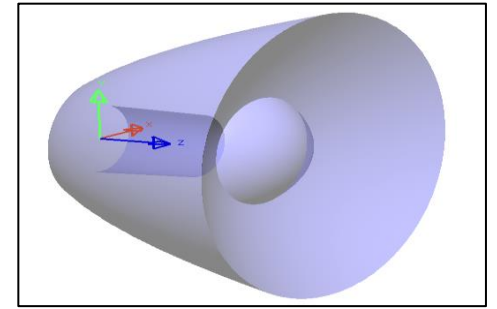


## LED sources



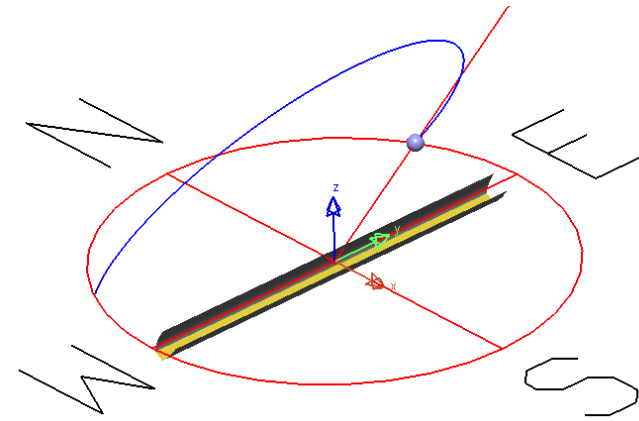
# Analysis work flow

- **Create** the model geometry – native or imported from a CAD package (or combination)
- **Define** the materials
- **Define** the optical properties of the model surfaces
- **Define** the source spectrum, power and apodization
- **Define** the receivers for analysis





# Day Light Simulation



**SolarTools rev 2.0**

User Default Values For Macro  
Save User Defaults | Restore User Defaults | User defaults are stored in C:\User\ directory | 5804 | LightTools PID

Step 1: Solar Source Creation | Step 2: Insolation Data/Test Position | **Step 3: Solar Day Scan**

### Description of Tab Functions

This tab scans the direct sun and calibrates it and the diffuse sun using the insolation data on the previous tab. A simple scale factor or a merit function can be used to determine the electrical power generated from solar cells in the system. The incident solar power and electrical power are plotted. Additionally, peak values are recorded and the summed energy is calculated.

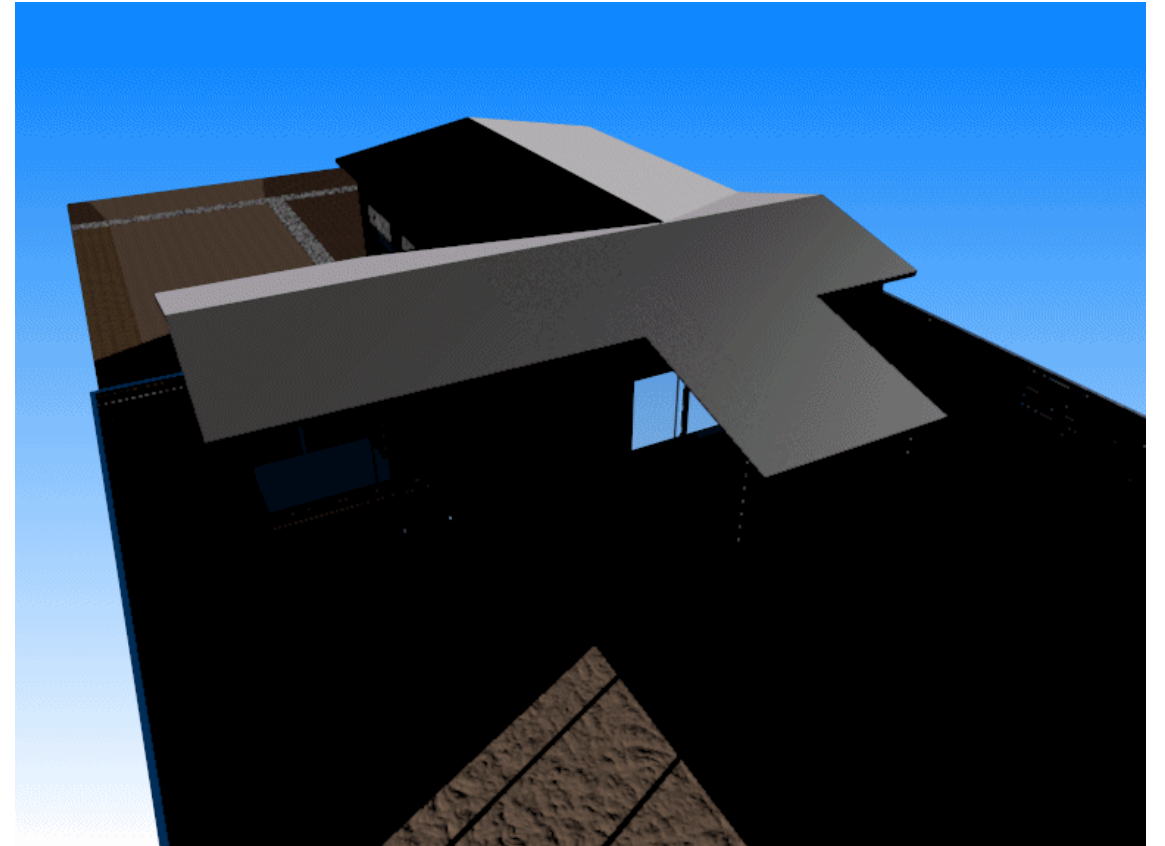
**Start Day Scan**

Scan Parameters

Start Hour (24hr format): 5.4 | Stop Hour (24hr format): 19.62  
 Calculate and Use Sunrise/Sunset Hours for Start/Stop  
 Number of Scan Steps: 15 |  Save 3D View At Each Step  
 Rays Per Source: 10000 |  Ray Preview  
 DirectSun: Direct Source Group Name  
 DiffuseSky: Diffuse Source Name  
 SolarCellReceiver: Input Receiver Name: 1.00001 | Input Receiver Area  
 Electrical Power Calculation:  
 Use Simple Conversion Factor: 0.25  
 Use Merit Function: SolarCalculations | Merit Function Name: | Merit Function Item: 1  
 Saved Scan Data File: C:\LTUser\ScanData.1.txt | Browse  
 Area Used in Calculations |  Use Receiver Area

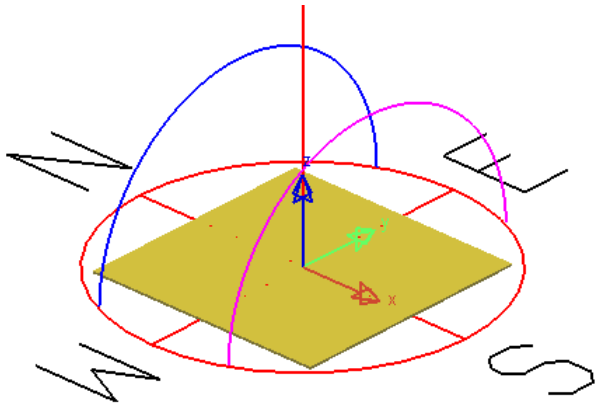
### Power Data (Watts)

<b>Total Incident Solar Power</b>	1112.22
<b>Electrical Power (Direct Light)</b>	Peak Values: 246.58
<b>Electrical Power (Diffuse Light)</b>	Peak Values: 34.29
<b>Total Electrical Power</b>	278.05
<b>Summed Total Electrical Energy (Watt-Hrs)</b>	2270.18
<b>Summed Total Electrical Energy From:</b>	1703.49
Hour: 9   to Hour: 16	<b>Recalculate</b>

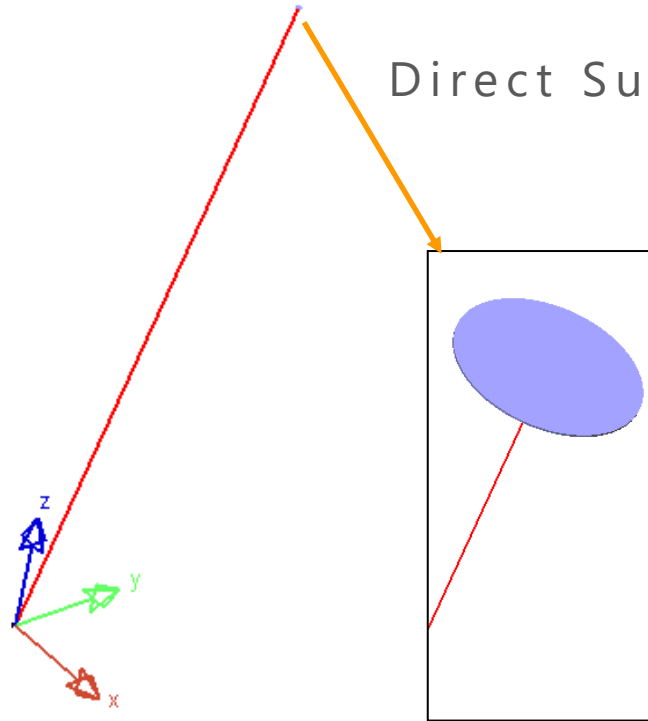


# Direct Sun and Diffused Sky

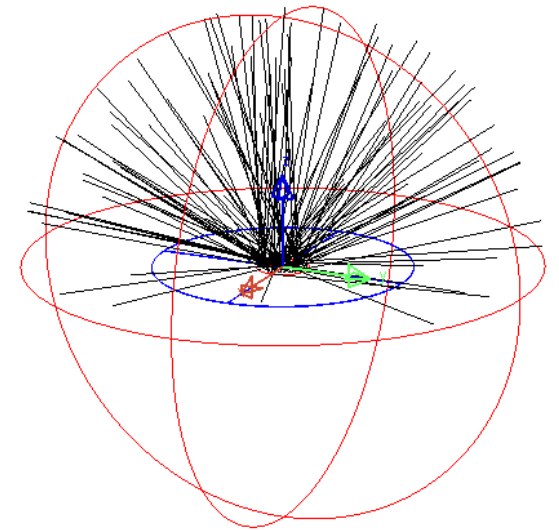
Green House Area



Direct Sun

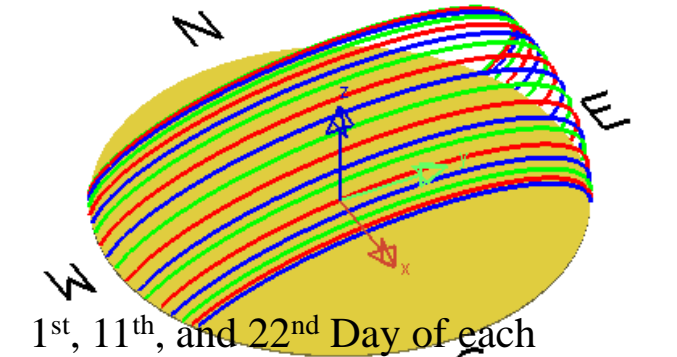
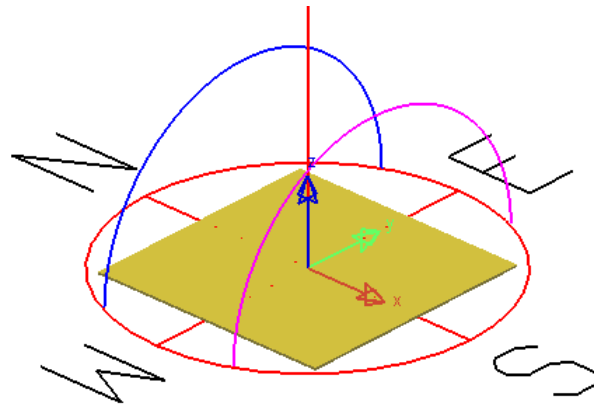
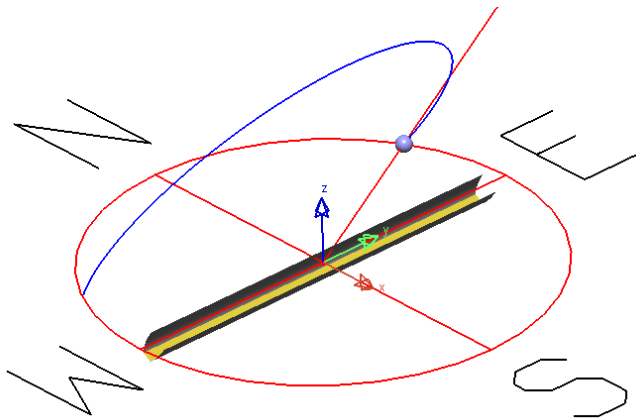


Diffused Sky



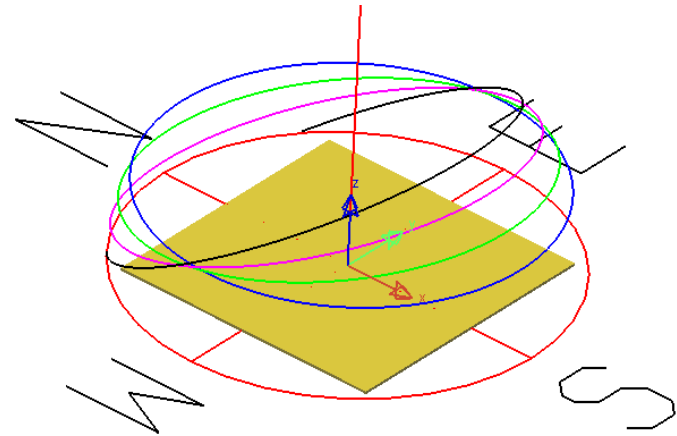
# Solar Day path

Scanning for a position on earth,  
one day of the year , for each hour



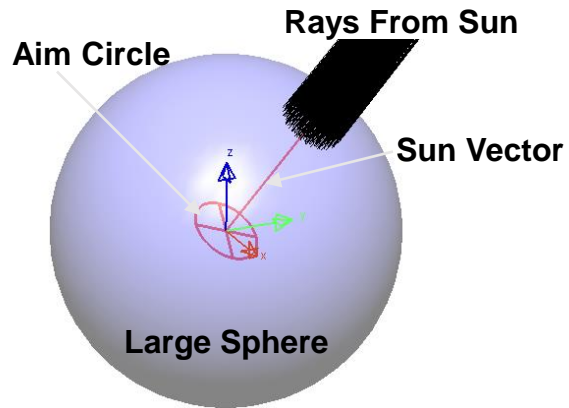
1<sup>st</sup>, 11<sup>th</sup>, and 22<sup>nd</sup> Day of each  
month from January through  
June, with alternating colors

(Phoenix, AZ, latitude: 33.4°)

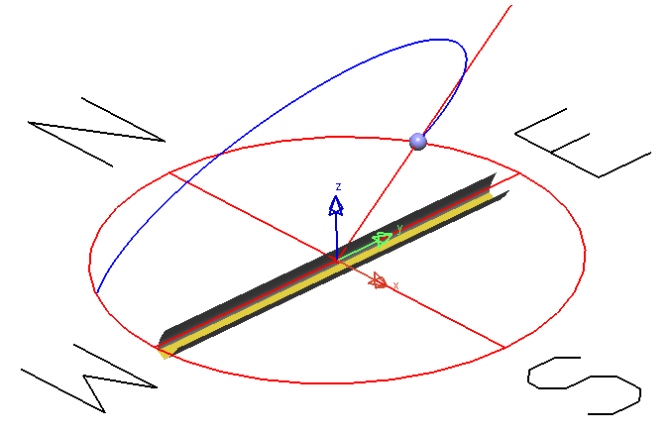
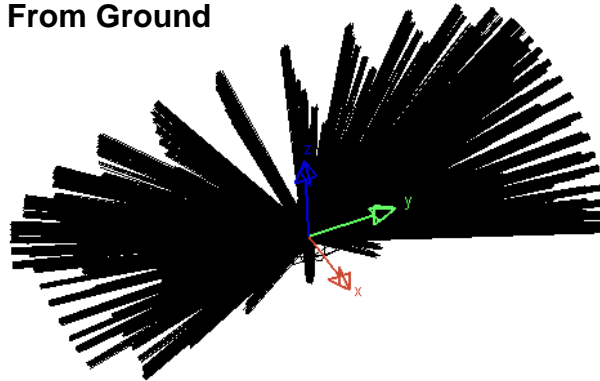


# Collection with scan

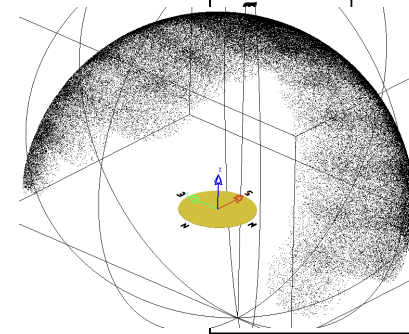
Possibility to create an « annual source » representing one source for all year/ date/hour



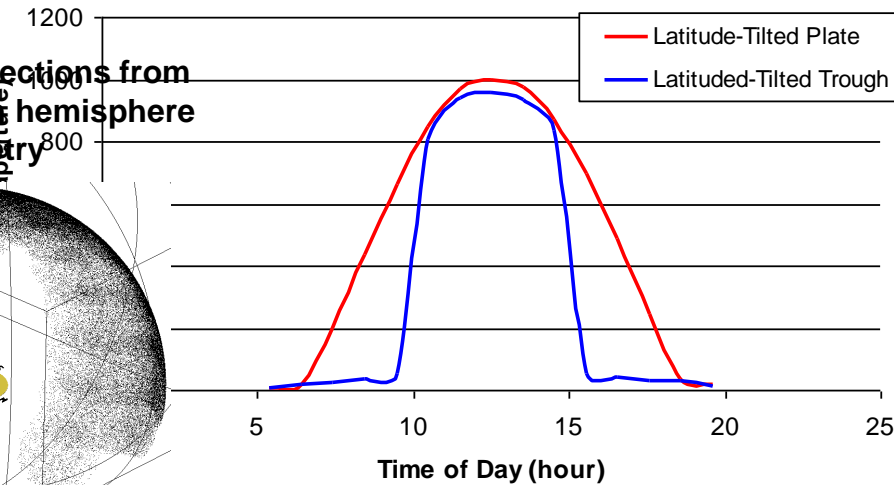
Hourly Ray Bundles From Each Sun Position in Time Band Far From Ground



Sample of ray Intersections from time band source on hemisphere closer to test geometry



Received Optical Power/m<sup>2</sup> vs. Time



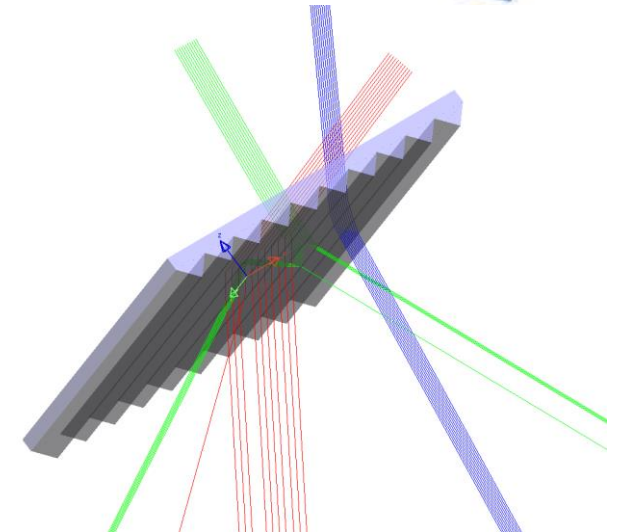
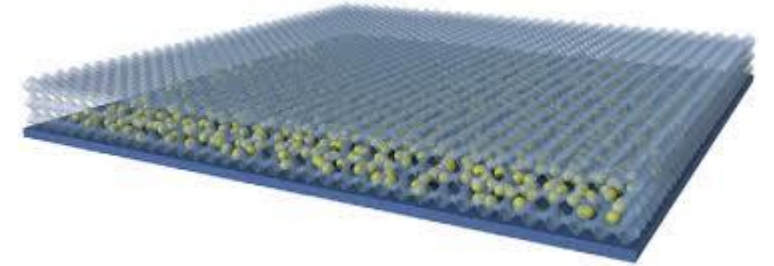


# Designing the roof windows

Possibility to set up

- any textures shapes,
- And any layout

Optimisation possible

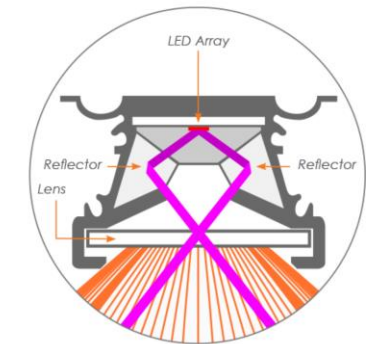
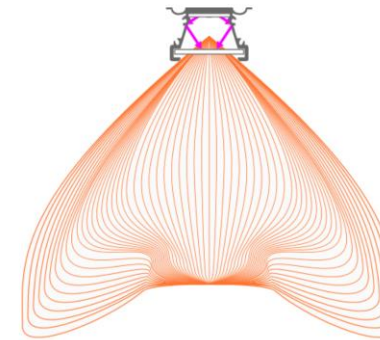
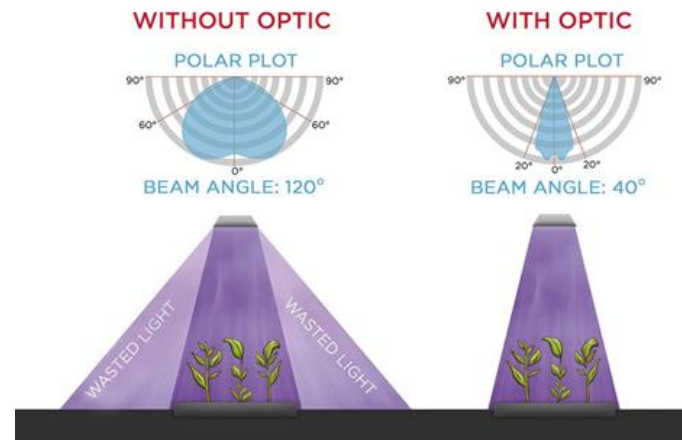


Jul 10, 2020  
texture 1  
LightTools 9.0.0

# Designing lighting fixtures

Several solutions

- Leds module directly from vendors
- Reflectors
- Lenses

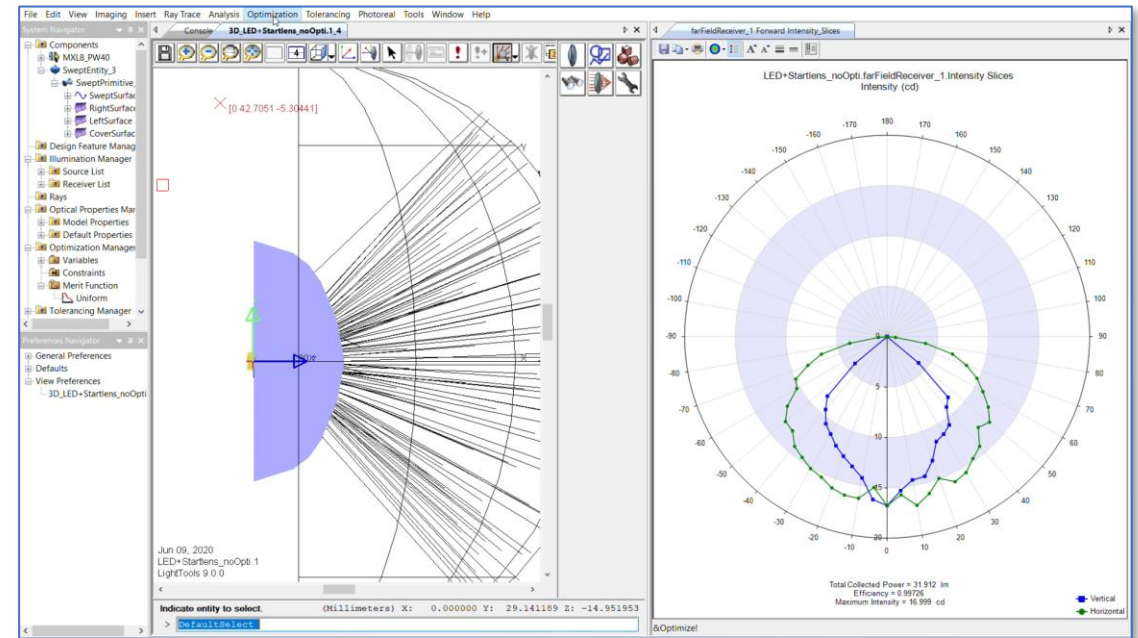
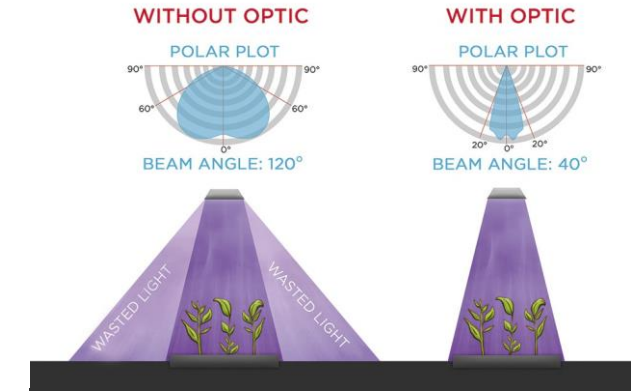


# Optimisation of the lighting system with lenses

Optimisation of the lens shape:

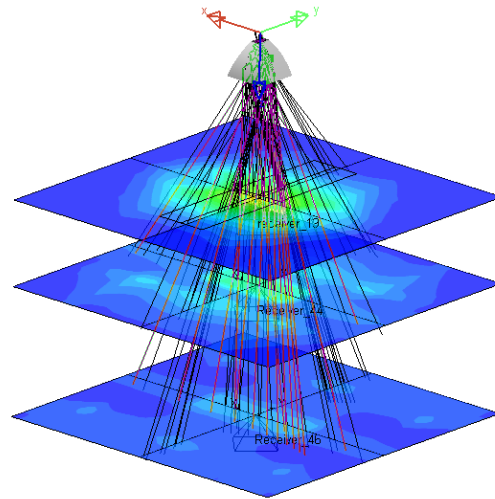
Optimisation targets :

- Photon Flux
- Photon Flux Density
- Efficacy



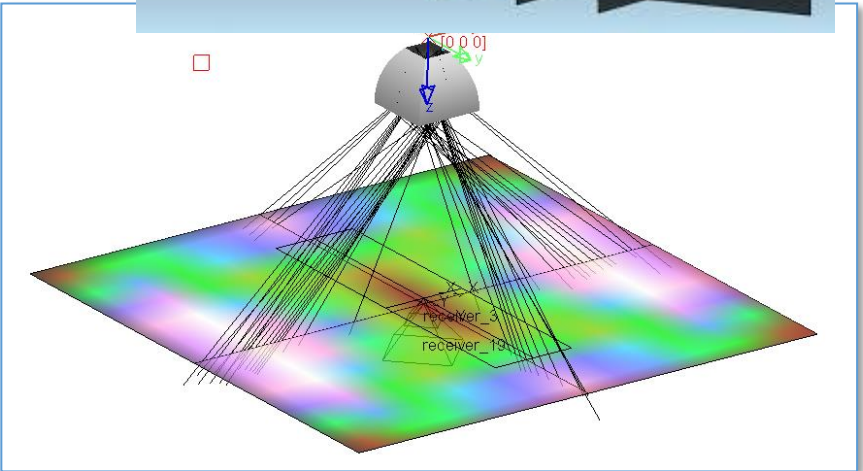
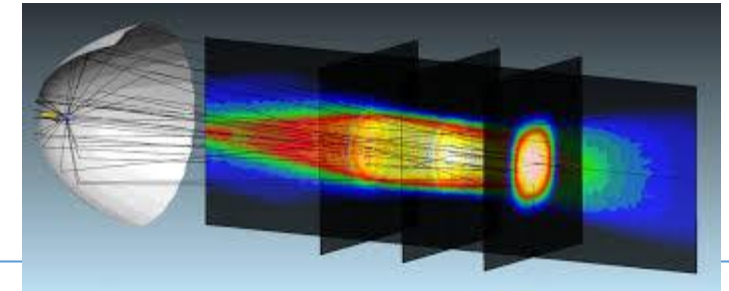
# Optimisation of the lighting system with reflector

With Light Distribution in one plane or one volume

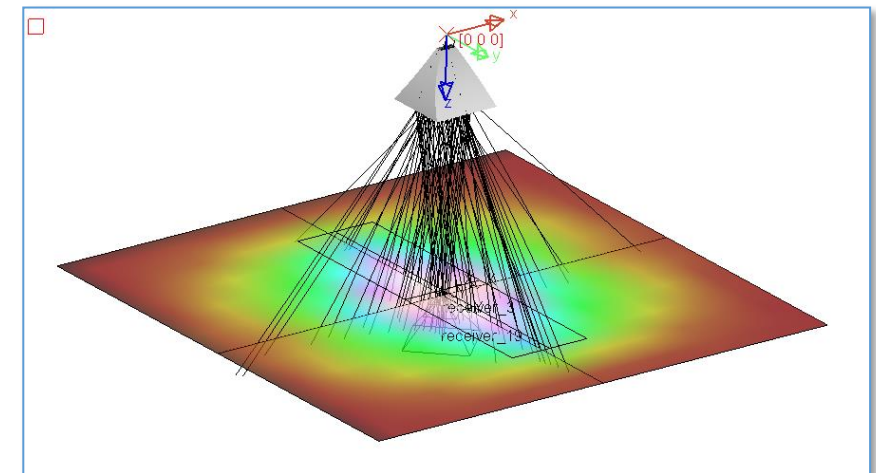


Jul 08, 2020  
RectangularBeziers\_Start horticulture.1  
LightTools 9.0.0

Before Optimization



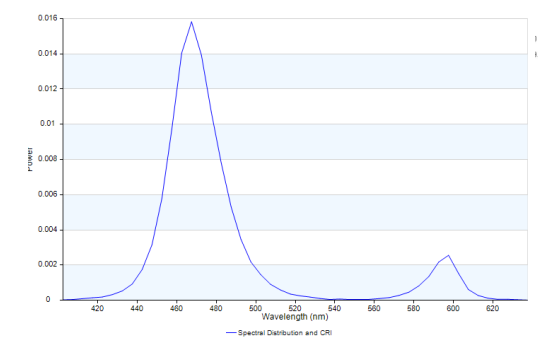
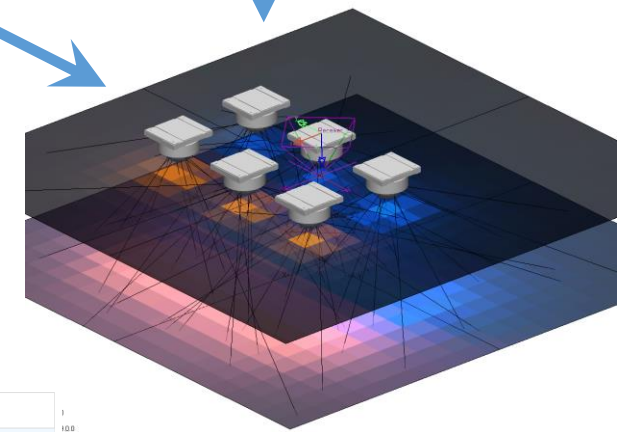
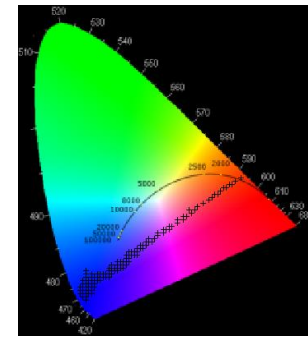
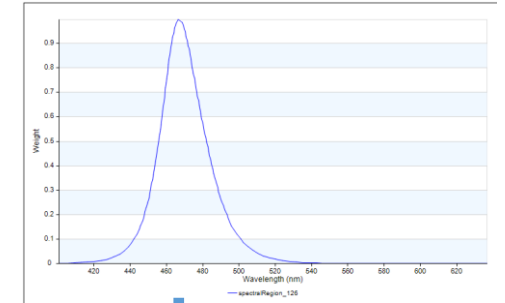
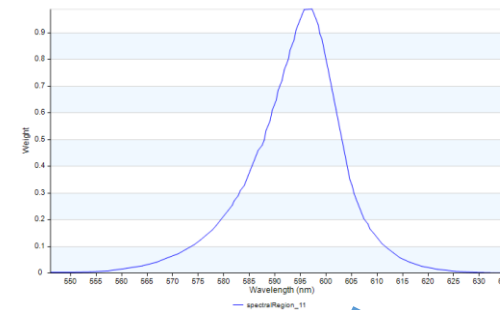
After Optimization





# Wavelength Analysis

Spectral consideration:  
 Source  
 Material (transmissive, reflective)  
 Spectral distribution in any plane

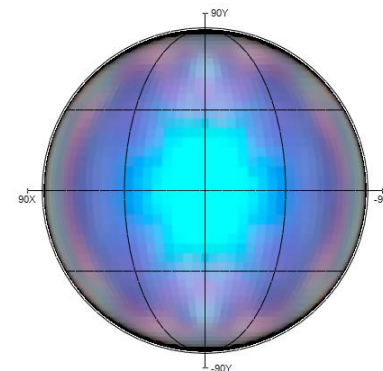
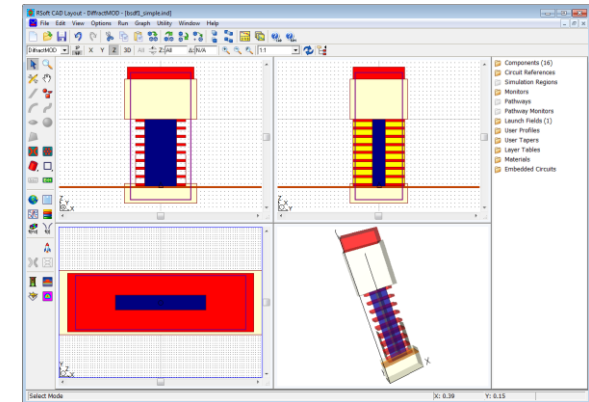
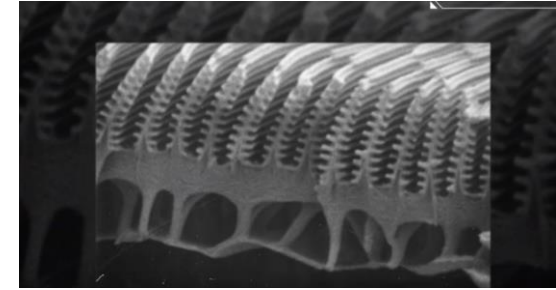
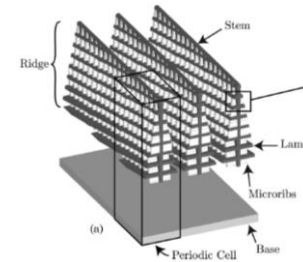


# Microstructure RSOFT

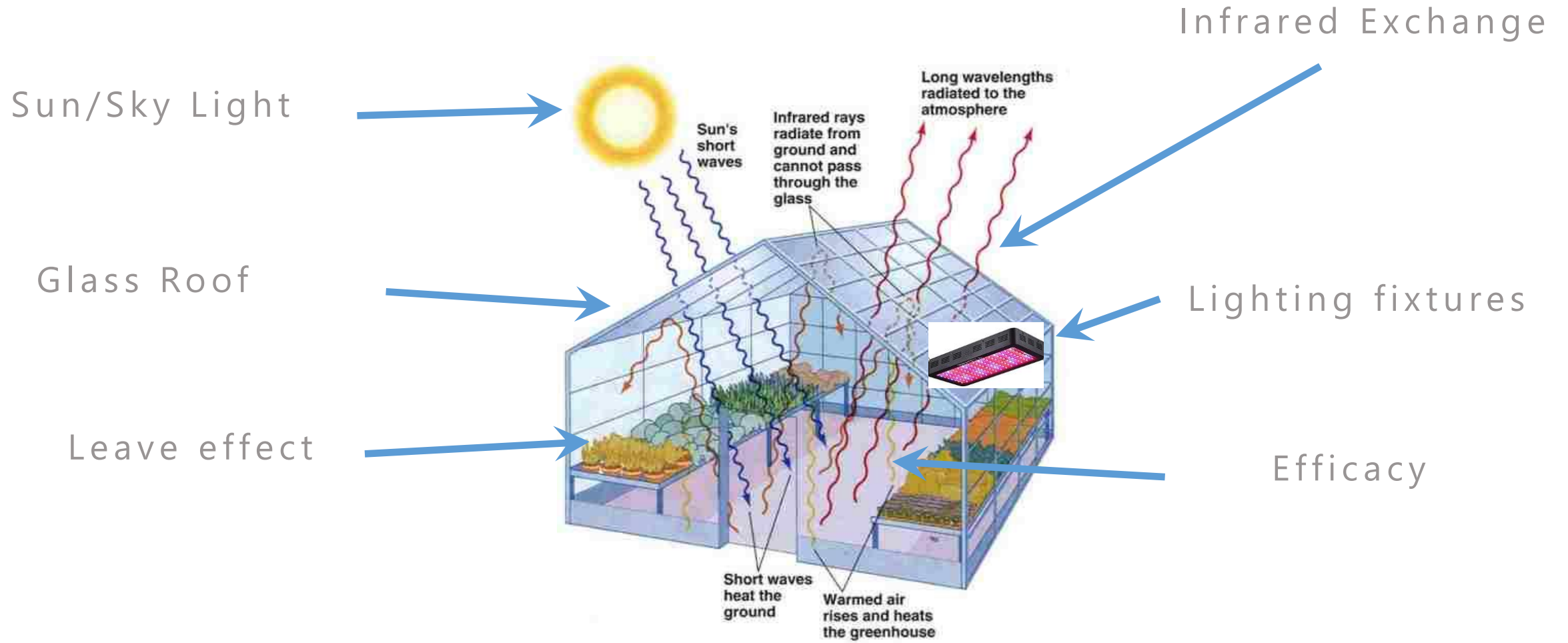
## Interaction between light and plants

The iridescent color of the Morpho butterfly is not due to pigments or dye.

It is the result of a complicated nano-patterned photonic structure on the butterfly wing. Rigorous photonic design tools were needed to accurately model the structure

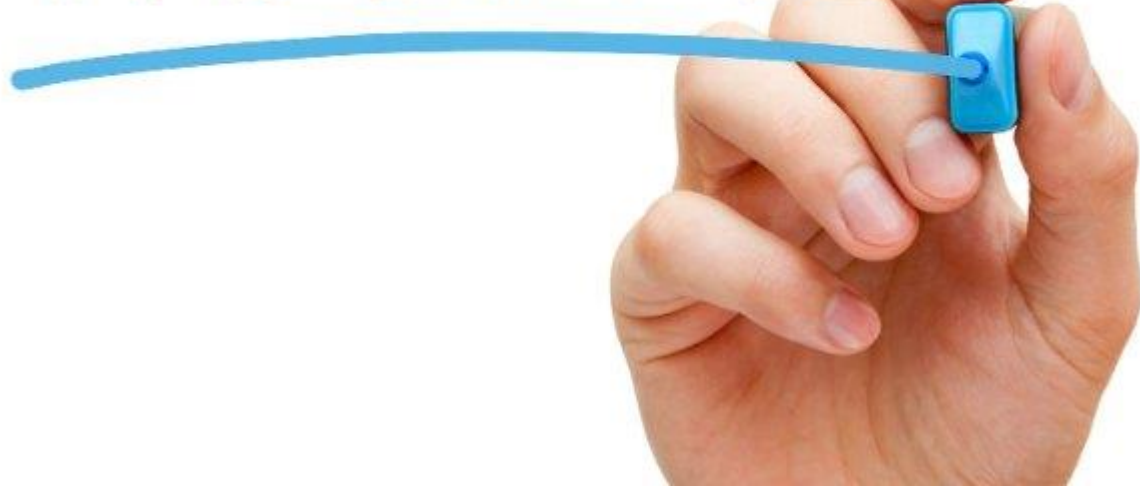


# Conclusion: we can do the job !





THANK YOU





---

# What we are looking for

- **More customers for our software !**
- **Partnership with material vendor**
  - Plastic
  - Glasses
- **Partnership with research laboratories**
  - Interaction light/plants
- **We can offer optical engineering tasks if needed**

---

# More information

There is a popular misconception that plants utilize only the blue and red wavelengths. As seen in the above figure outlining [the McCree curve](#), **the type of light that plants use also includes green and yellow radiation.**

**The most abundant plant pigment involved in photosynthesis, chlorophyll, is most efficient at absorbing blue and red light.** Therefore, most of the green light is not absorbed and is reflected by plants, giving leaves their characteristic green-colour. However, plants have other pigments called accessory pigments that include carotenes and xanthophylls. These **accessory pigments are able to absorb green light.**

Also, plants have physical responses to different types of light. **[Photomorphogenesis](#) are structural changes that take place in response to changes in the environment, such as variations in light exposure.** Below are some examples of the changes that can be induced by modulating the type of light that plants receive:

400 nm – 520 nm Blue Light can inhibit development if not combined with other types of light and can promote leaf thickness. Also chlorophyll absorbs wavelengths in this range.

500 nm – 600 nm Green Light penetrates deep and is absorbed more deeply into lower parts of the canopy.

630 nm – 660 nm Red Light influences germination, seed formation and plant flowering.

720 nm – 740 nm Infrared Light can promote early flowering, also enters more deeply into lower parts of the canopy.