Karlsruhe Institute of Technology

Lighting Technology Lab
Simulation of Optical Systems

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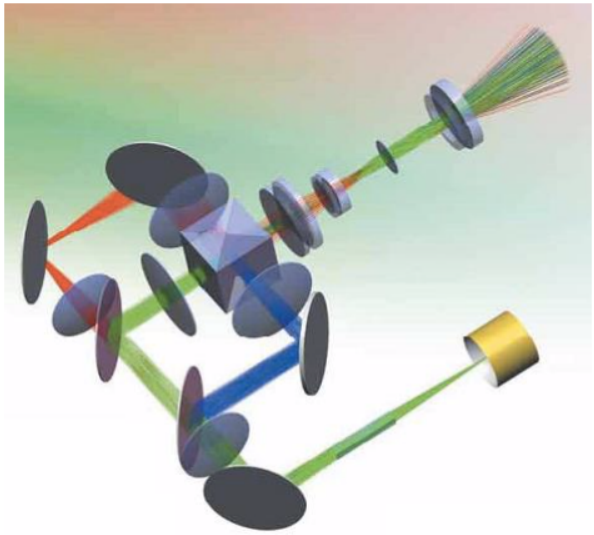
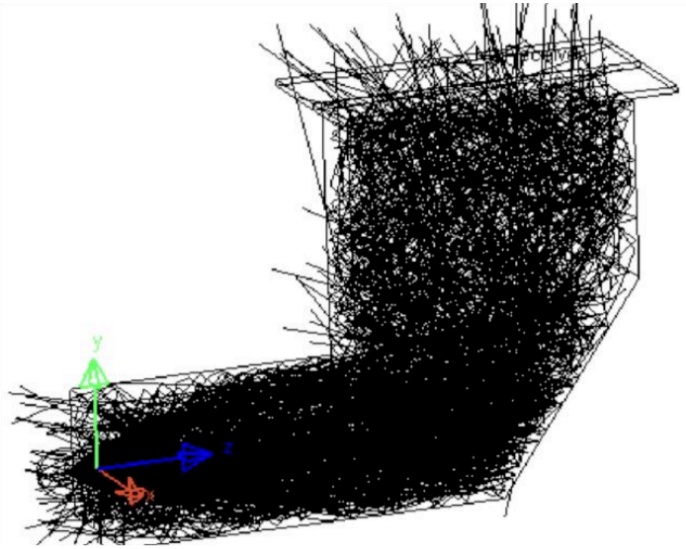
Motivation

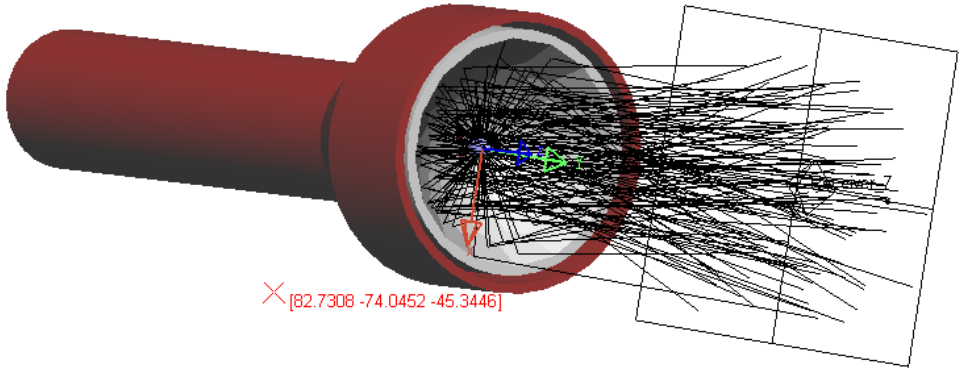
- Optical systems are used in more and more industries (e.g. optoelectronics, measurement technology)
- Computer simulation increases quality and decreases costs of design
- LightTools – Computer Aided Lighting Software



Agenda

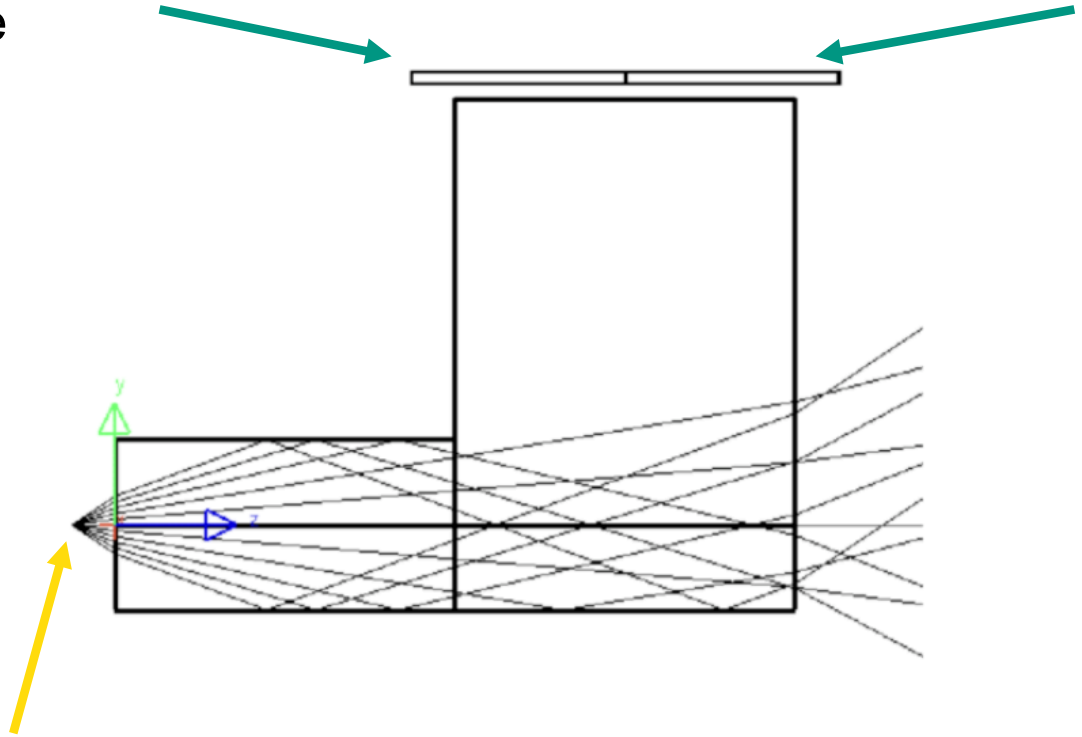
- Analysis of a light pipe
- Construction and simulation of flashlight
- Upgradation of flashlight: construction and analysis of the measured RGB LED



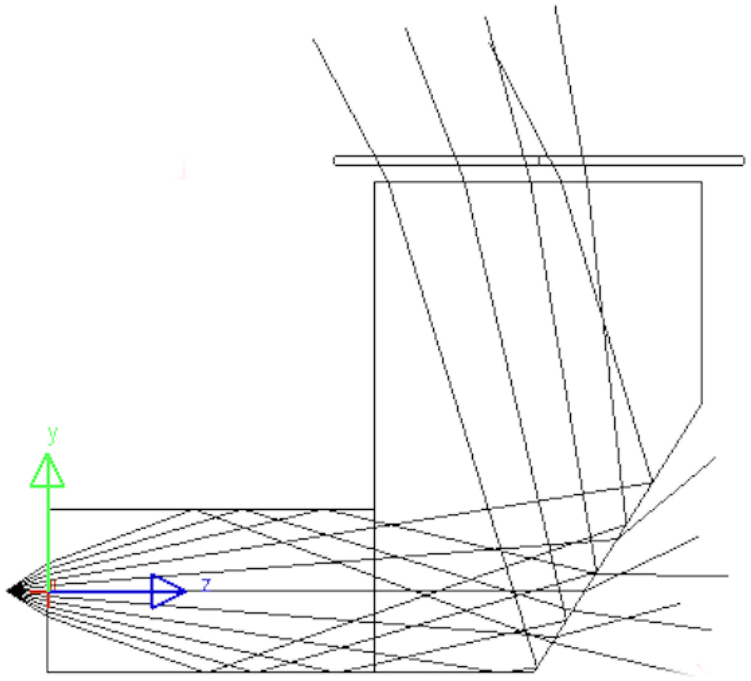


Analysis of a light pipe

- Plastic light pipe with simple light source and a receiver
- Ray tracing
- Desired output surface not reached

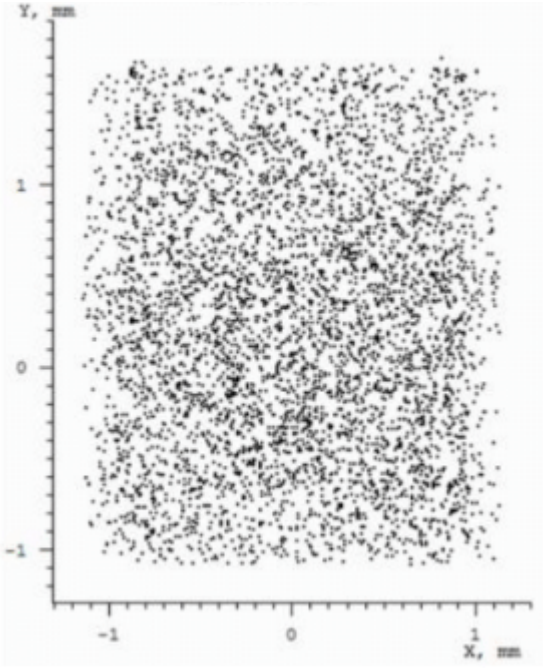


Modification of the light pipe

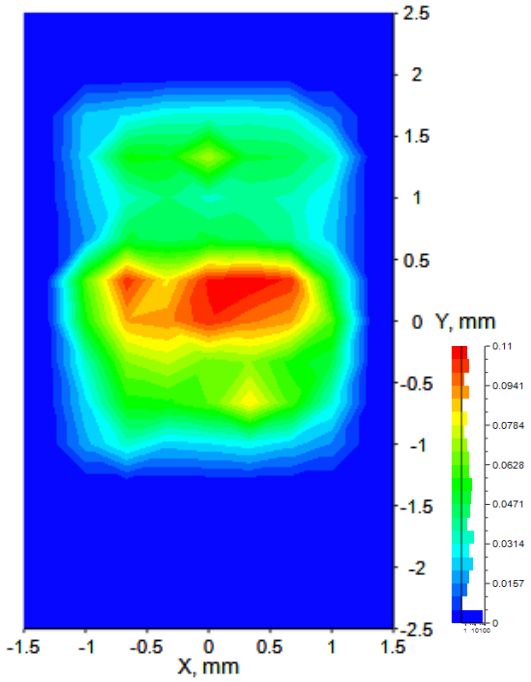


- Introduction of a trimmed surface
- Total internal reflection
- Position and the angle of the trimmed surface

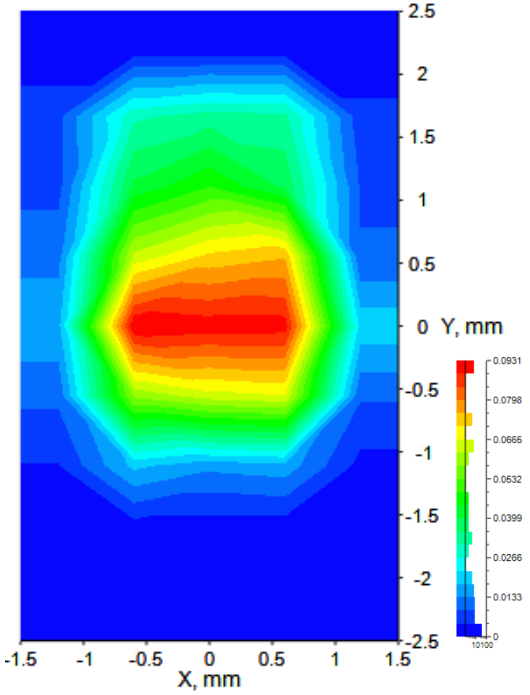
Light pipe – Illumination analysis



- 10k rays
- Scatter chart

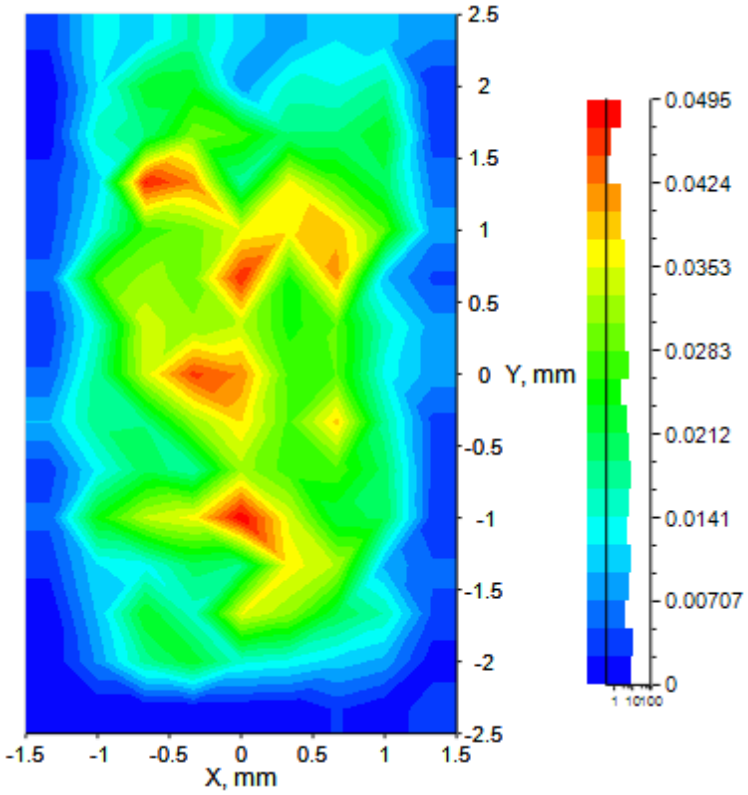


- 10k rays
- Mesh: 9 x 15 bins
- Power: 0.35 W
- Error estimate at peak: 12.72 %

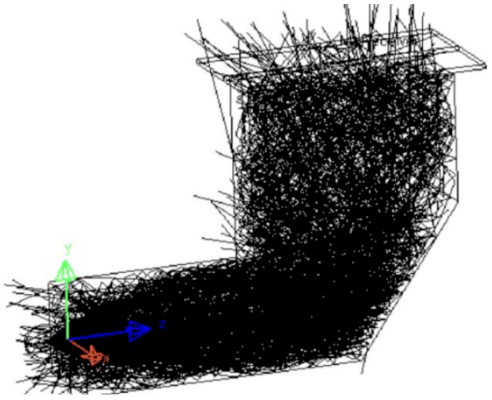


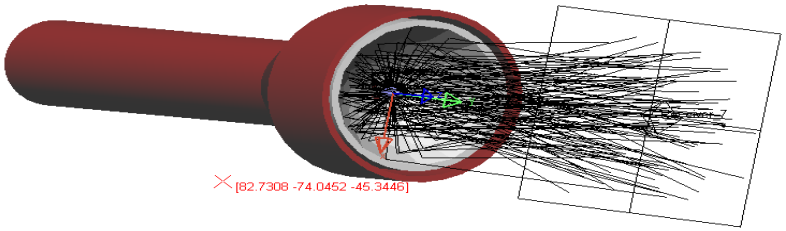
- 10k rays
- Mesh: 5 x 9 bins
- Power: 0.35 W
- Error estimate at peak: 8.18 %

Light pipe – modification of the trimmed surface



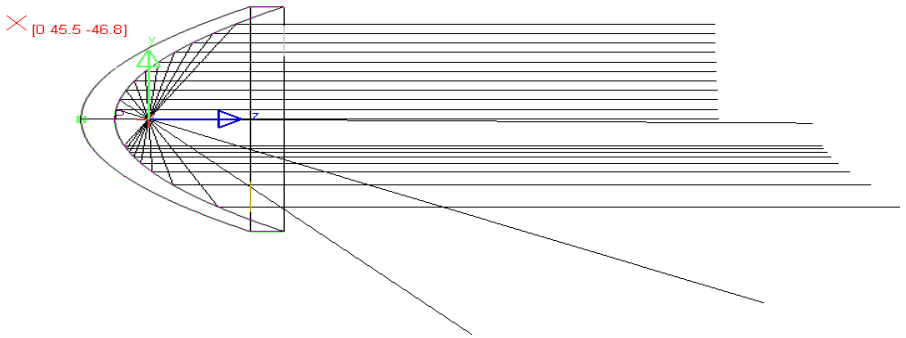
- Lambertian scattering
- Reflectance: 92 %
- Mesh: 9 x 15 bins
- Power: 0.27 W
- Error estimate at peak: 19.74 %
- Improved uniformity

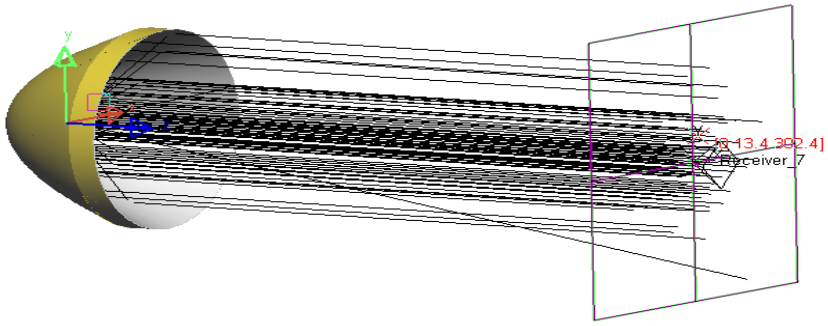




BUILD A VIRTUAL FLASHLIGHT

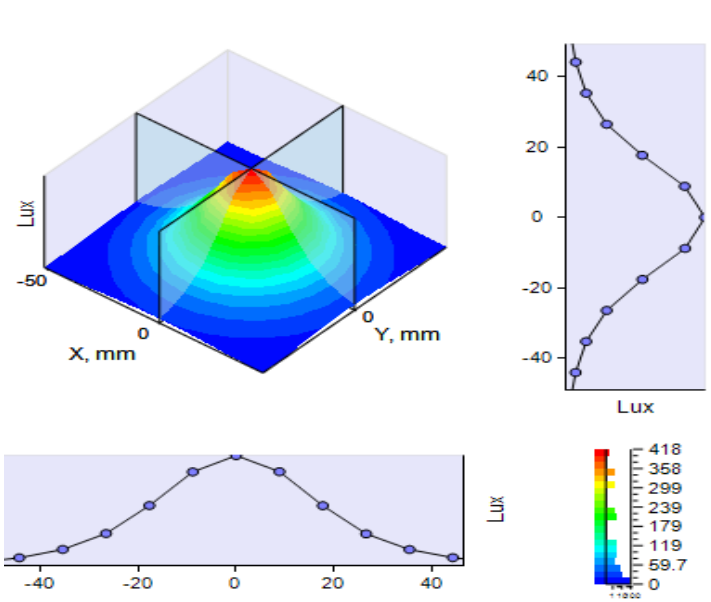
Point Source and Receiver

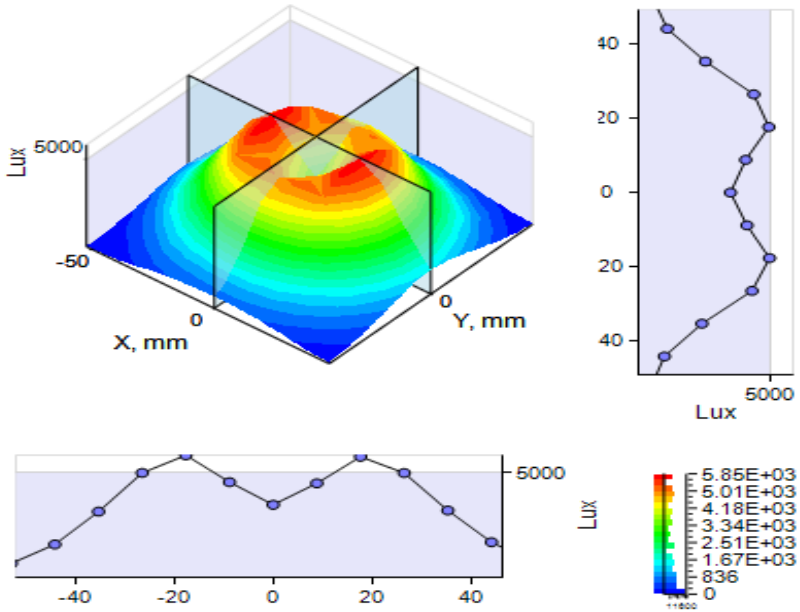




- Parabolic Reflector
- Receiver: 150mm width and height, 300mm far from the source
- Simulation with point source
- Re-run the simulation with incandescent lamp

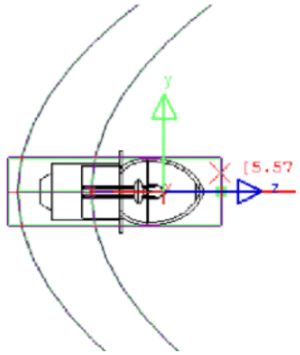
Comparison of luminaires with point light source and incandescent lamp





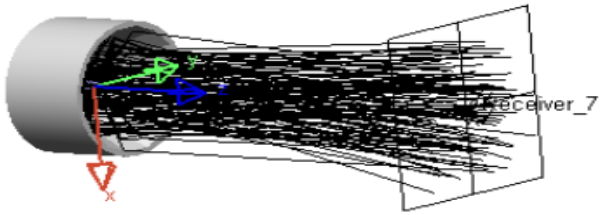
- Point light source
- 10000 rays

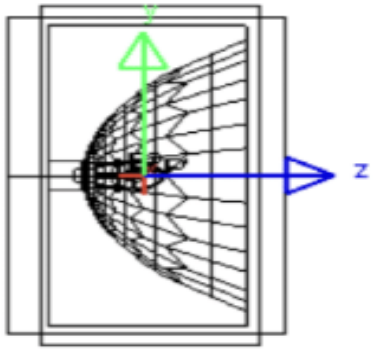
- Incandescent lamp
- 20000 rays



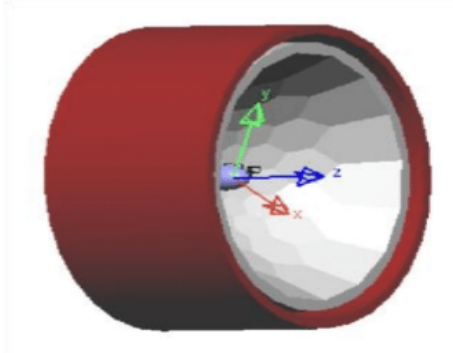
Faceted Reflector

One solution to the problem of uniformity is to use a faceted reflector.



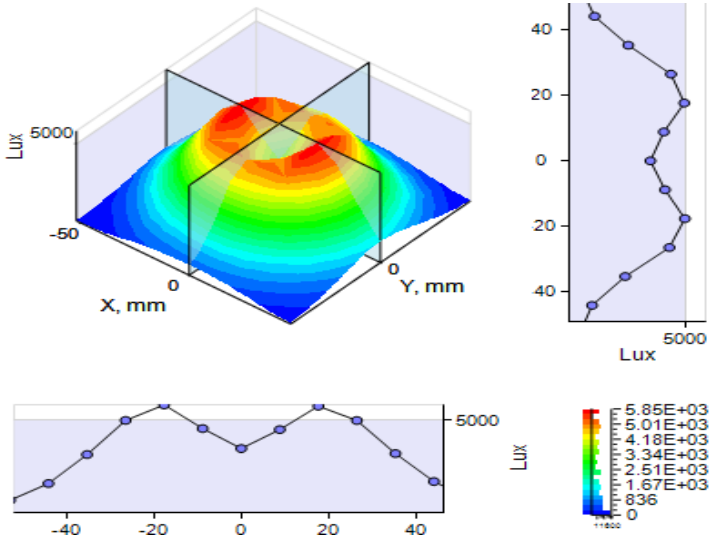


To create reflector separate program that communicate with LightTools is needed.

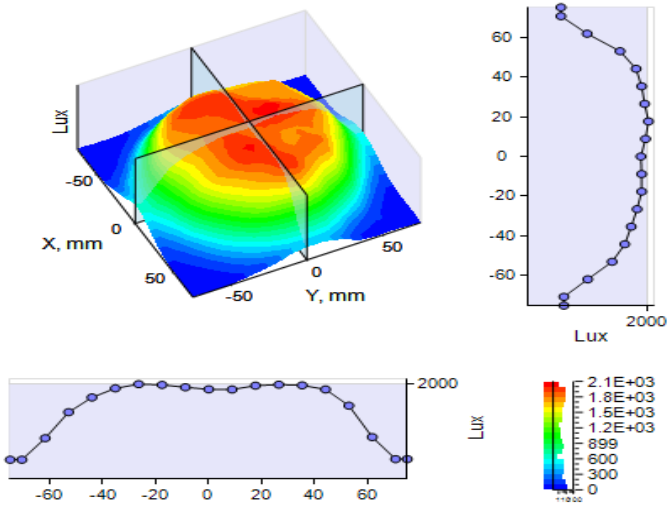


This program has many options for the type of reflector, facet geometry, etc.
In this case 100mm diameter disk at a distance 300mm was needed.

Comparison of luminaires with parabolic and faceted reflector

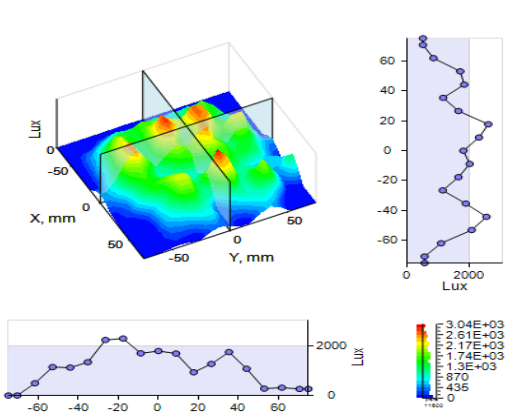


- Parabolic reflector

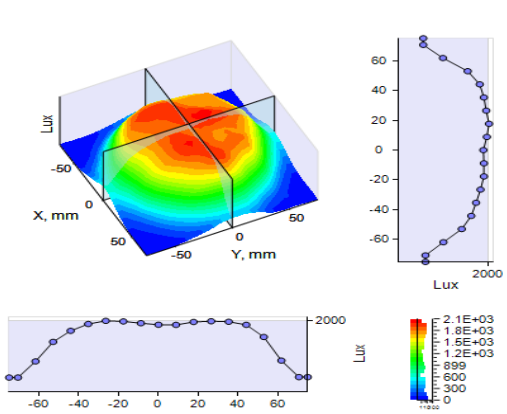


- Faceted reflector

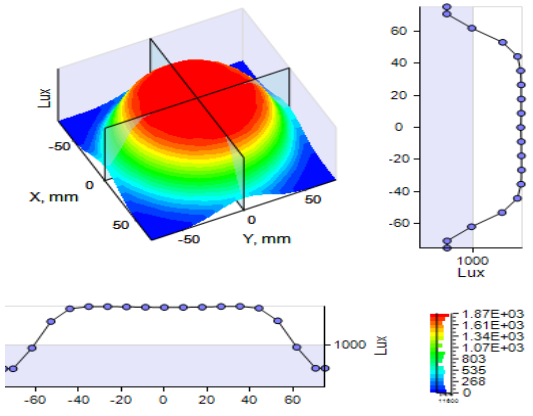
Number of Rays



- 200 rays



- 20000 rays



- 100000 rays

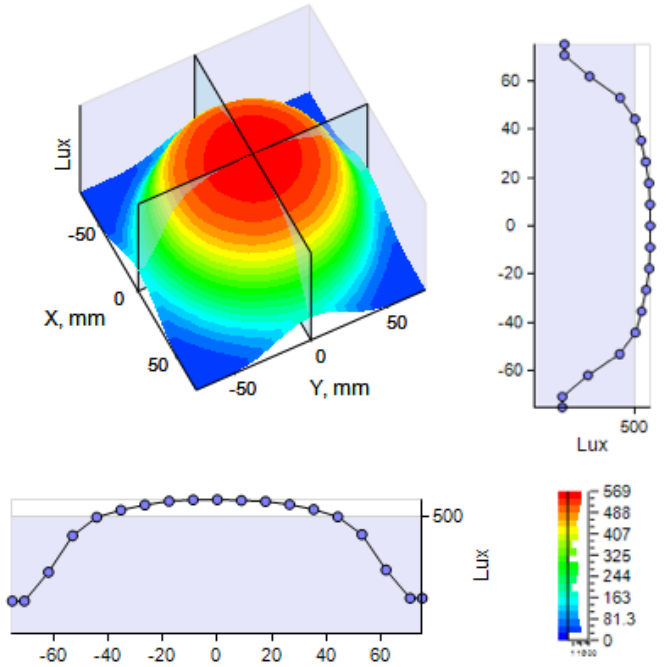
Spatial Resolution

0.5s — Time of simulation — 300s

Replace incandescent lamp with point light sources

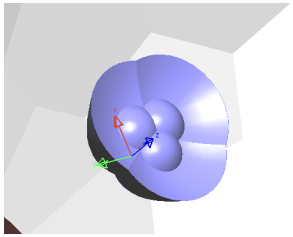
- Simulating with three equal point light sources
- Positions according to results of nearfield goniometer of a real RGB LED
- Spot size becomes bigger

→ To receive a smaller spot size the optics has to be improved

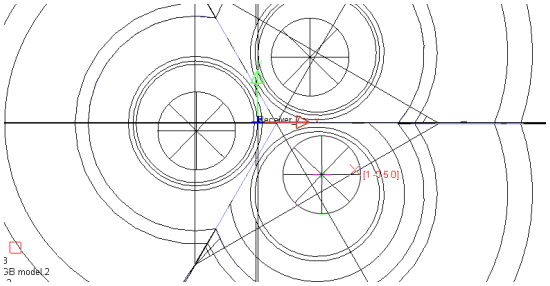


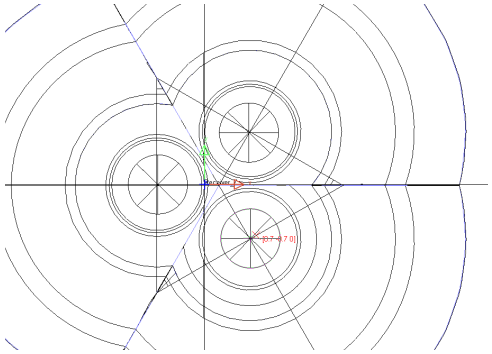
Colours	X-postion	Y-position	Z-position
Red	0.66	-0.54	0.11
Green	-0.63	-0.09	0.11
Blue	0.54	0.67	0.07

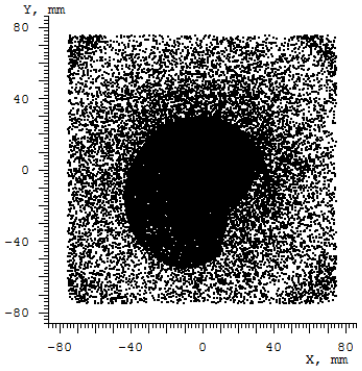
Using a TIR-optics



- Additional optics for the luminaire
- Optic optimized to the light source
- Improves the focusing power of the luminaire

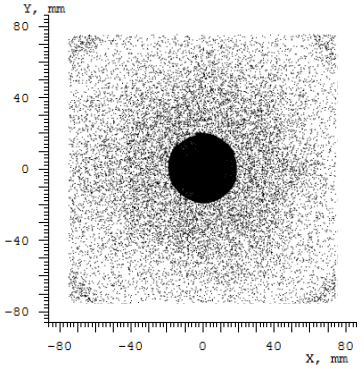






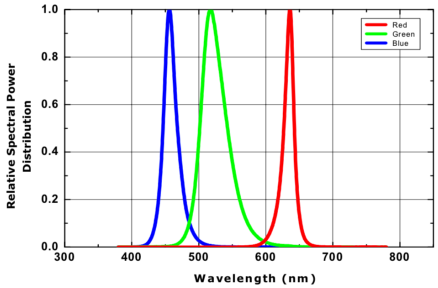
Each light source (colour chip) positioned to the optimum of TIR-optics

Colours	X-position	Y-position	Z-position
Red	0.62	-0.73	0
Green	-0.63	0	0
Blue	0.6	0.7	0



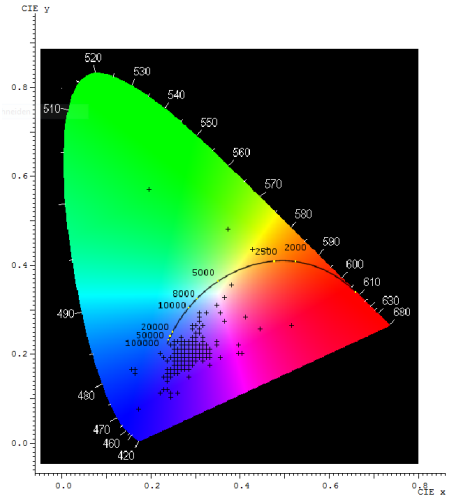
Colour analysis

- Set spectrum for each light source
- Colour information of light rays are preserved during simulation
- Adequate number of coloured rays are needed for reliable simulation



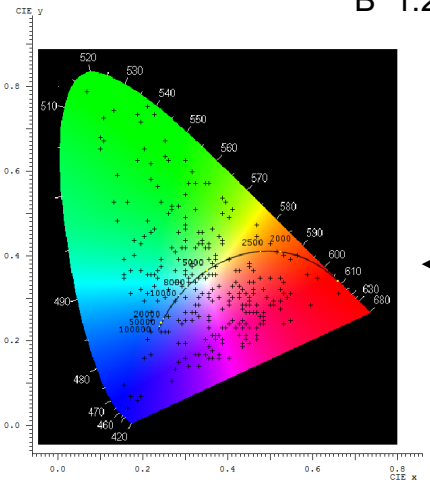
Colour	Central λ [nm]	λ_{min} [nm]	λ_{max} [nm]	Full with at half max [nm]
Red	625	585	670	20
Green	525	450	630	40
Blue	460	390	530	25

R 7.96 lm
G 12.63 lm
B 3.73 lm

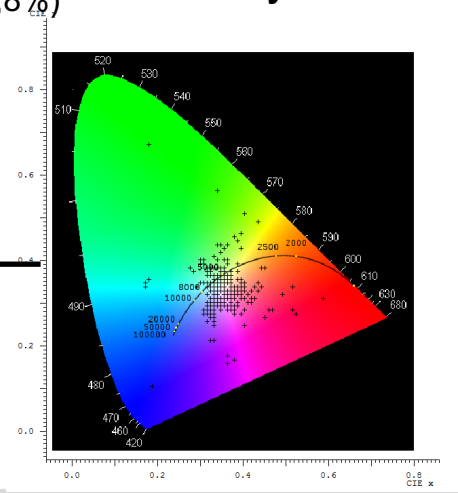


R 8.5 lm (+6,7%)
G 20 lm (+58,3%)
B 1.2 lm (-67,8%)

100k Rays

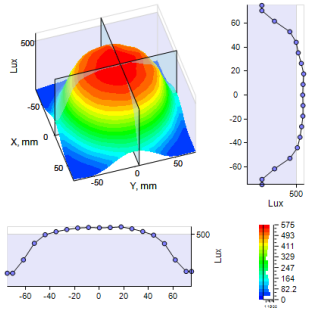


1/10 Rays

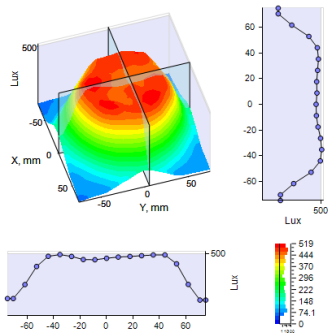


Using rayfile instead of point light source

Point light sources



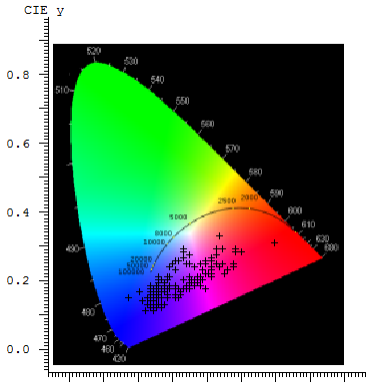
Rayfile

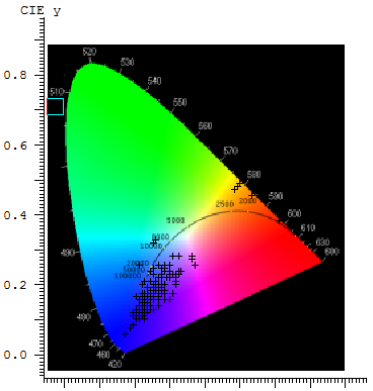


Simulating optical systems with inappropriate light sources lead to wrong conclusions!

→ Intensity distribution of rayfile less homogeneous

→ Colour distribution differs





Thank you for your attention