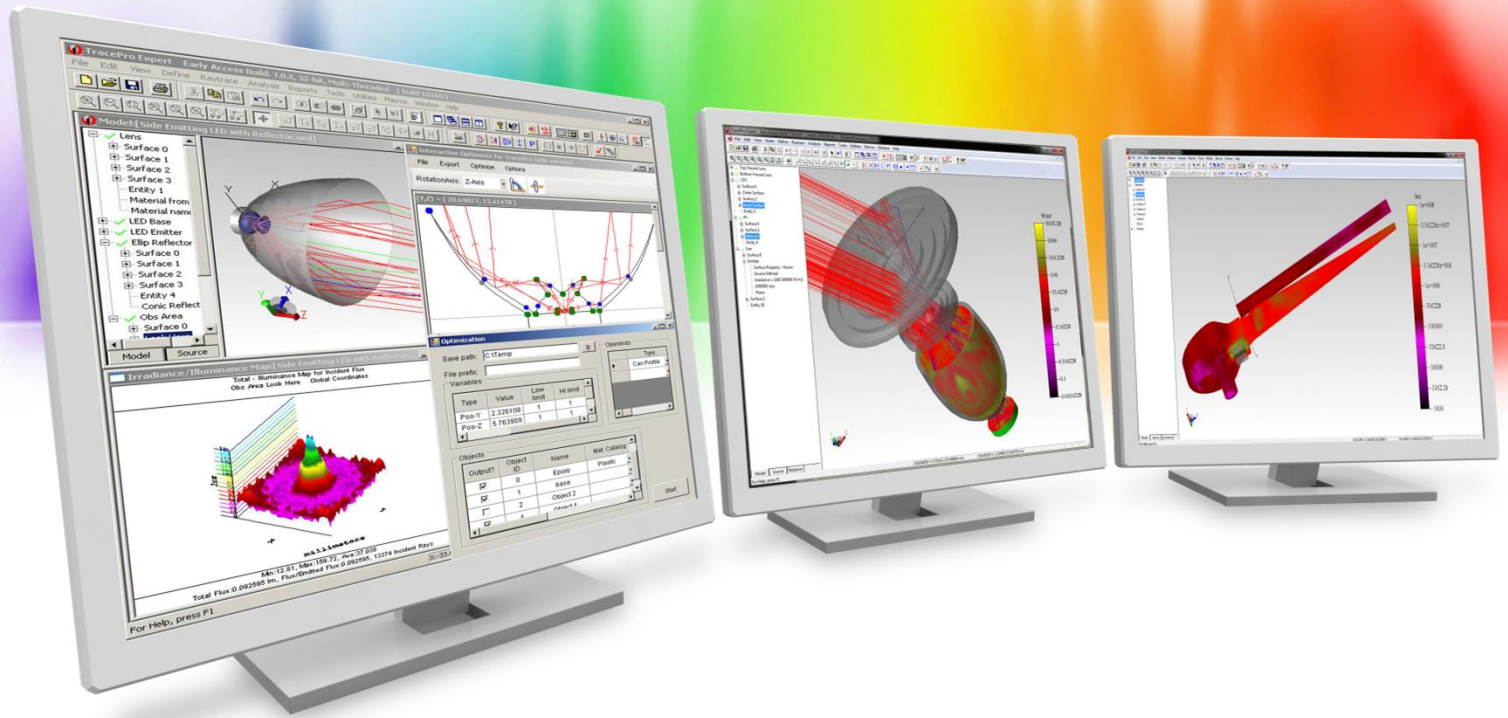
TracePro



Efficient Luminaire Design Using Virtual Prototyping

A Photonics Online and Lambda Research Corporation Webinar

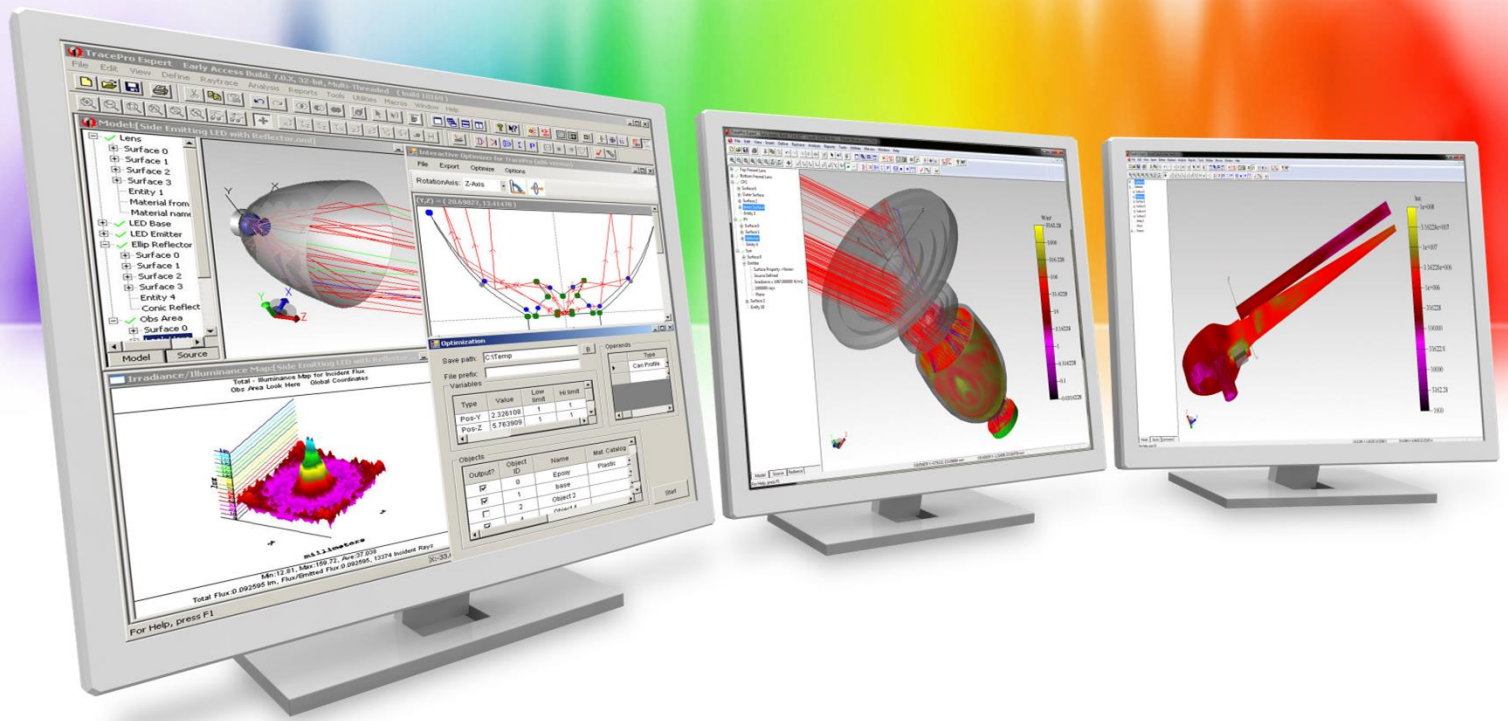
October 12, 2017

LAMBDA RESEARCH CORPORATION

Agenda

- Why use virtual prototyping?
- Workflow for designing luminaires in software
- Analysis tools for design verification
- Optimizing luminaires in software
- Examples
- Questions and Answers

TracePro

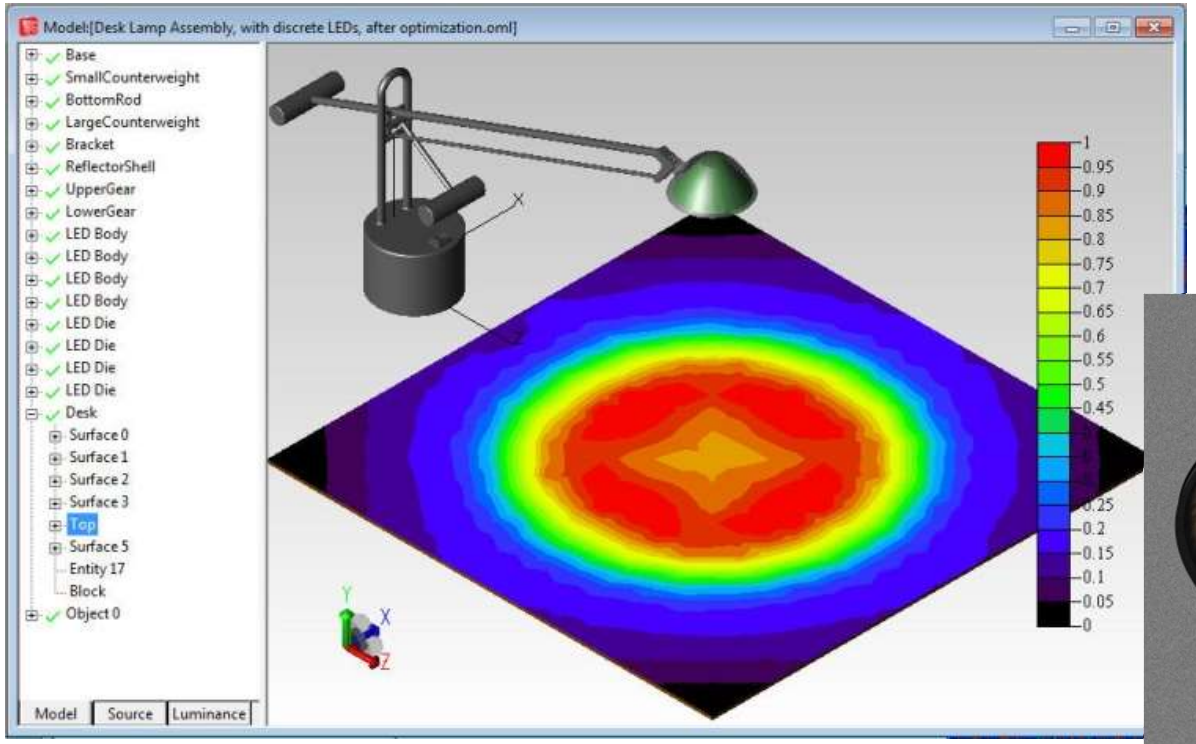


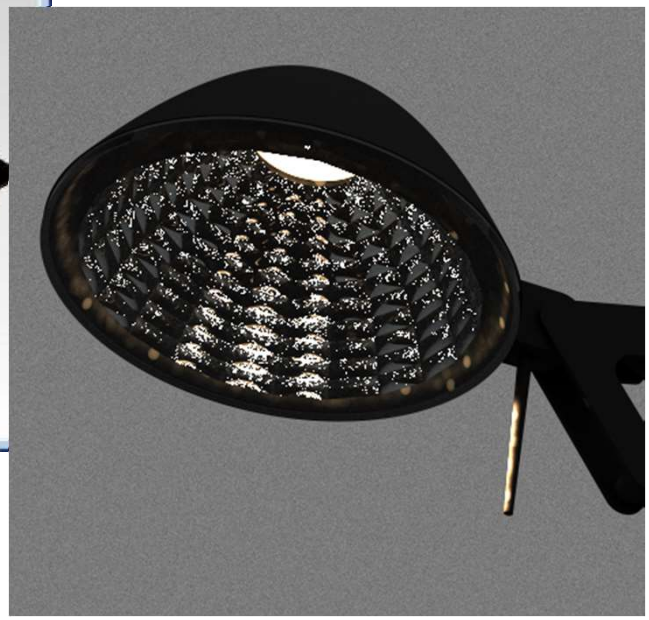
Why Use Virtual Prototyping?

LAMBDA RESEARCH CORPORATION

Why use virtual prototyping?

- In luminaire design applications virtual prototyping is done using optical design and analysis software.





TracePro

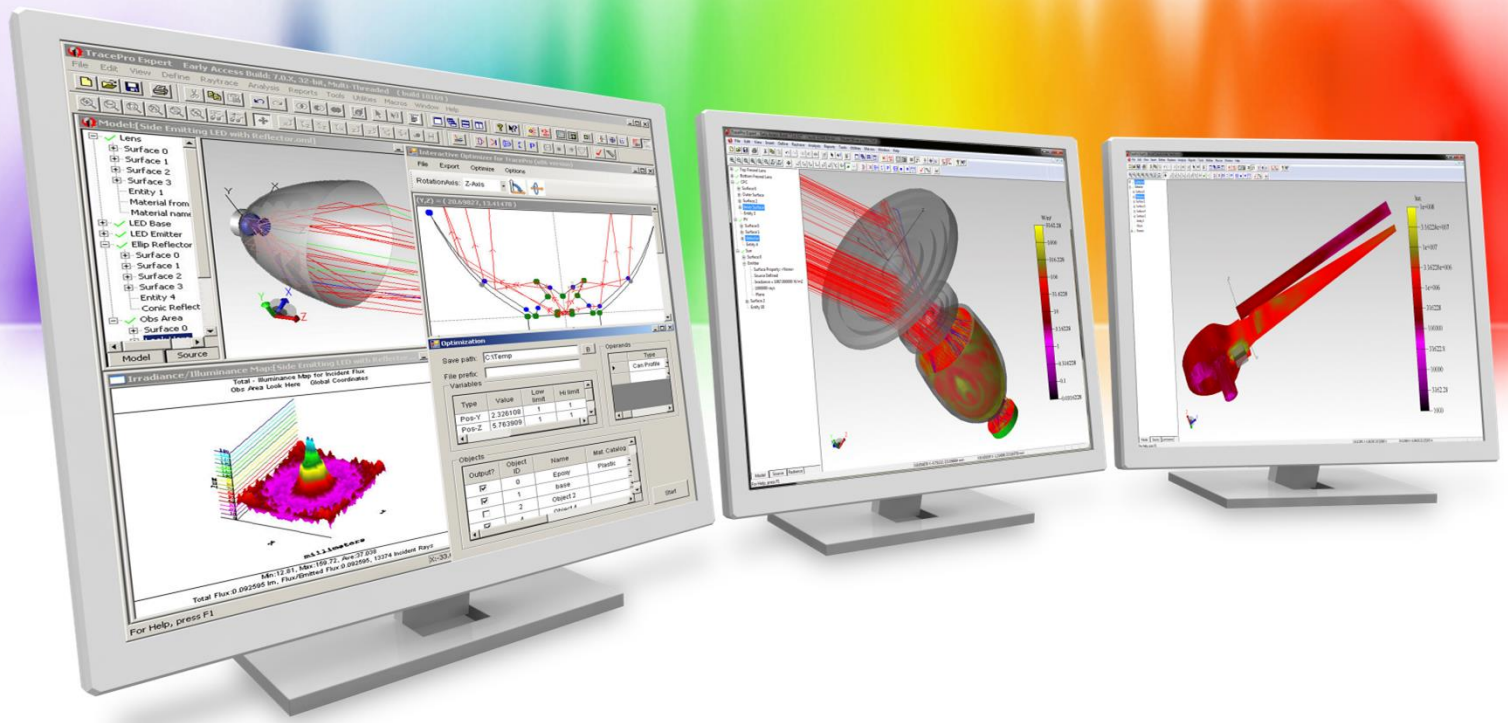
Advantages of virtual prototyping

- Easier to make multiple designs in software compared to physical prototypes
- Luminaire performance can be checked quickly and easily in software
- Multiple designs can be compared quickly and easily in software
- Faster to make multiple designs in software compared to physical prototypes
- Better to make mistakes in software instead of with physical prototypes
- Less expensive to make mistakes in software compared to physical prototypes

Disadvantages of virtual prototyping

- Initial cost of software
- Ongoing cost of software – maintenance and support
- Learning curve – training and learning how to use the software
- Initial correlation of model vs. actual results
- Need to have accurate property data
- Possible cost of having materials measured for accurate property data

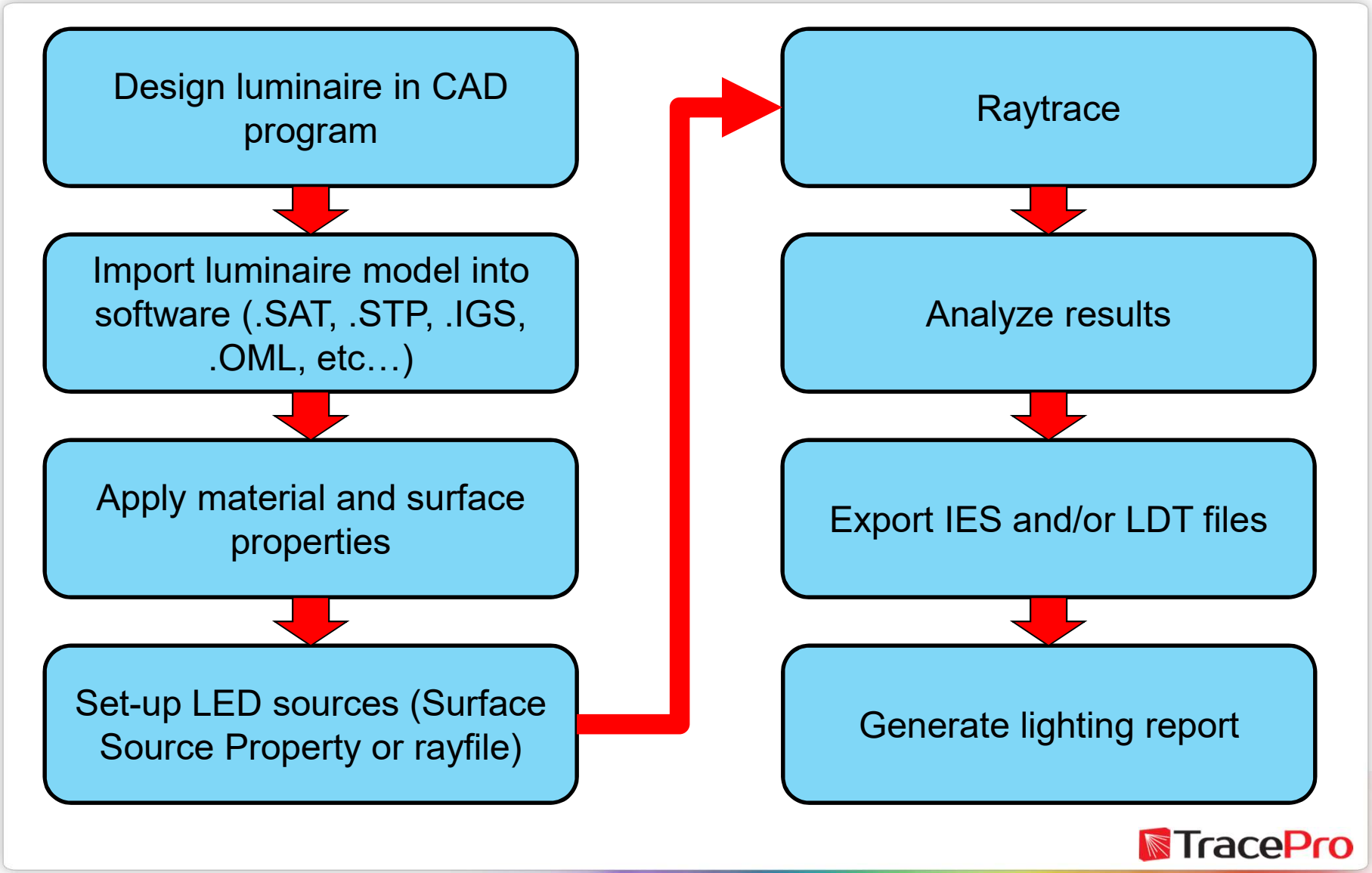
TracePro



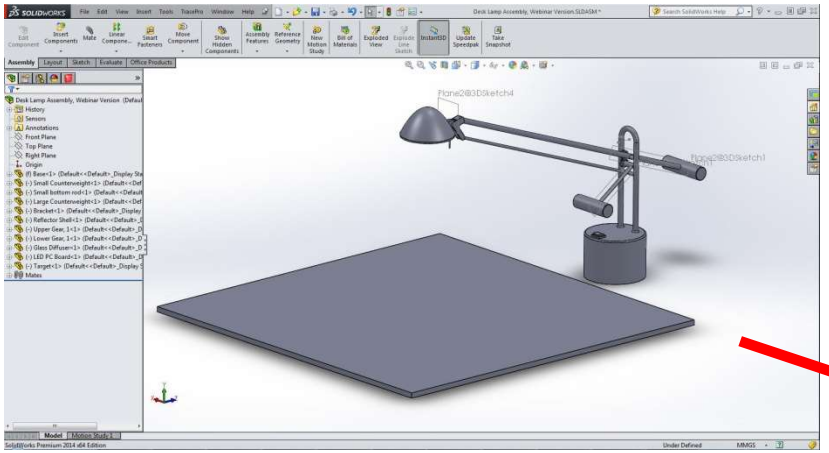
Workflow

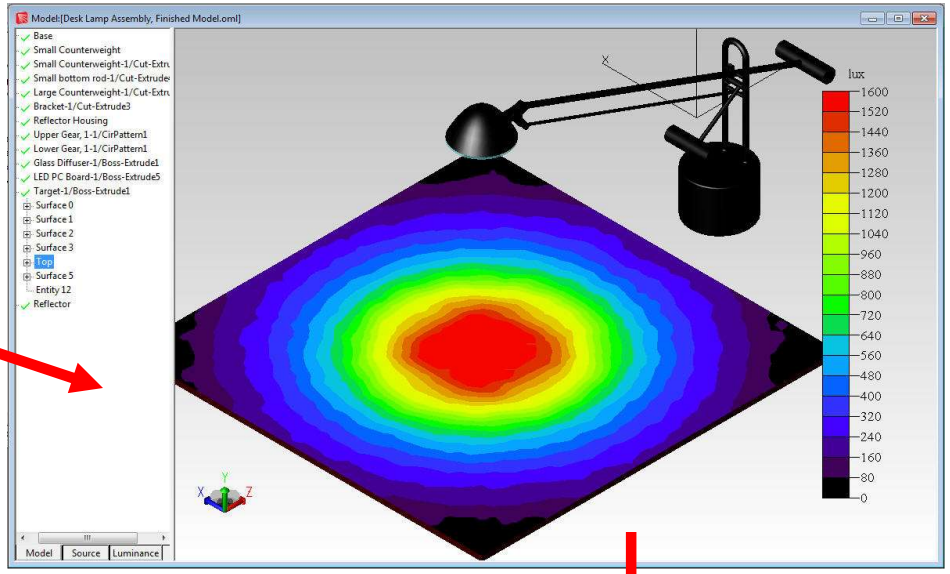
LAMBDA RESEARCH CORPORATION

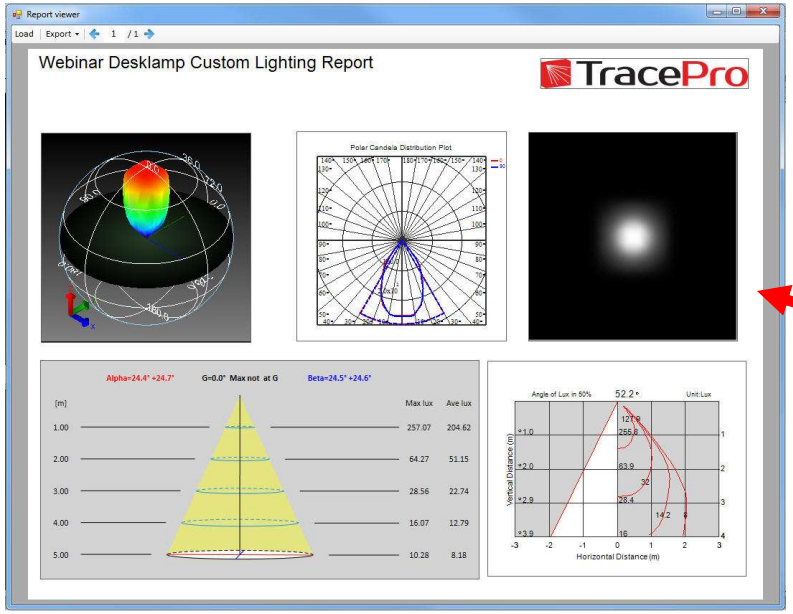
Simplified workflow

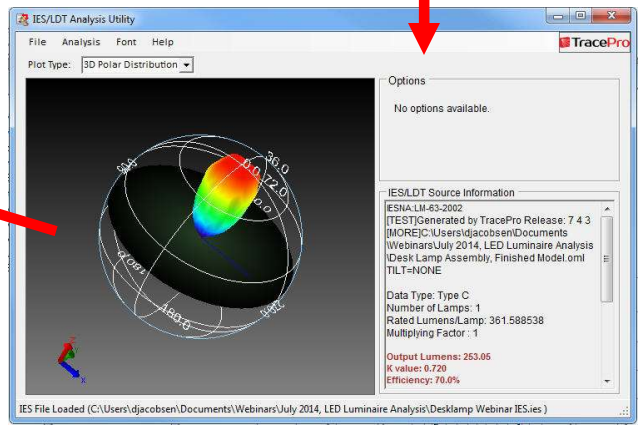


Simplified workflow



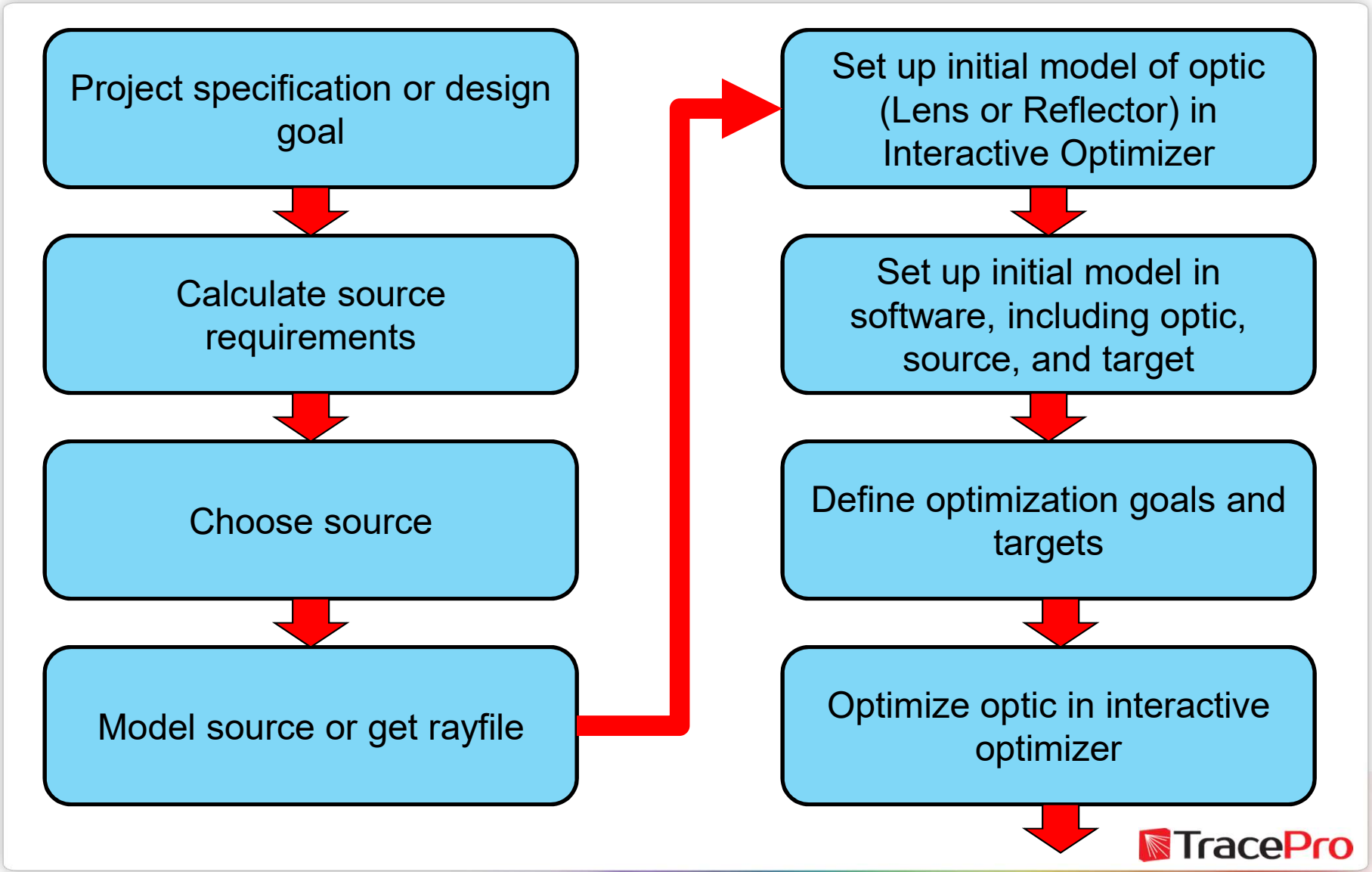




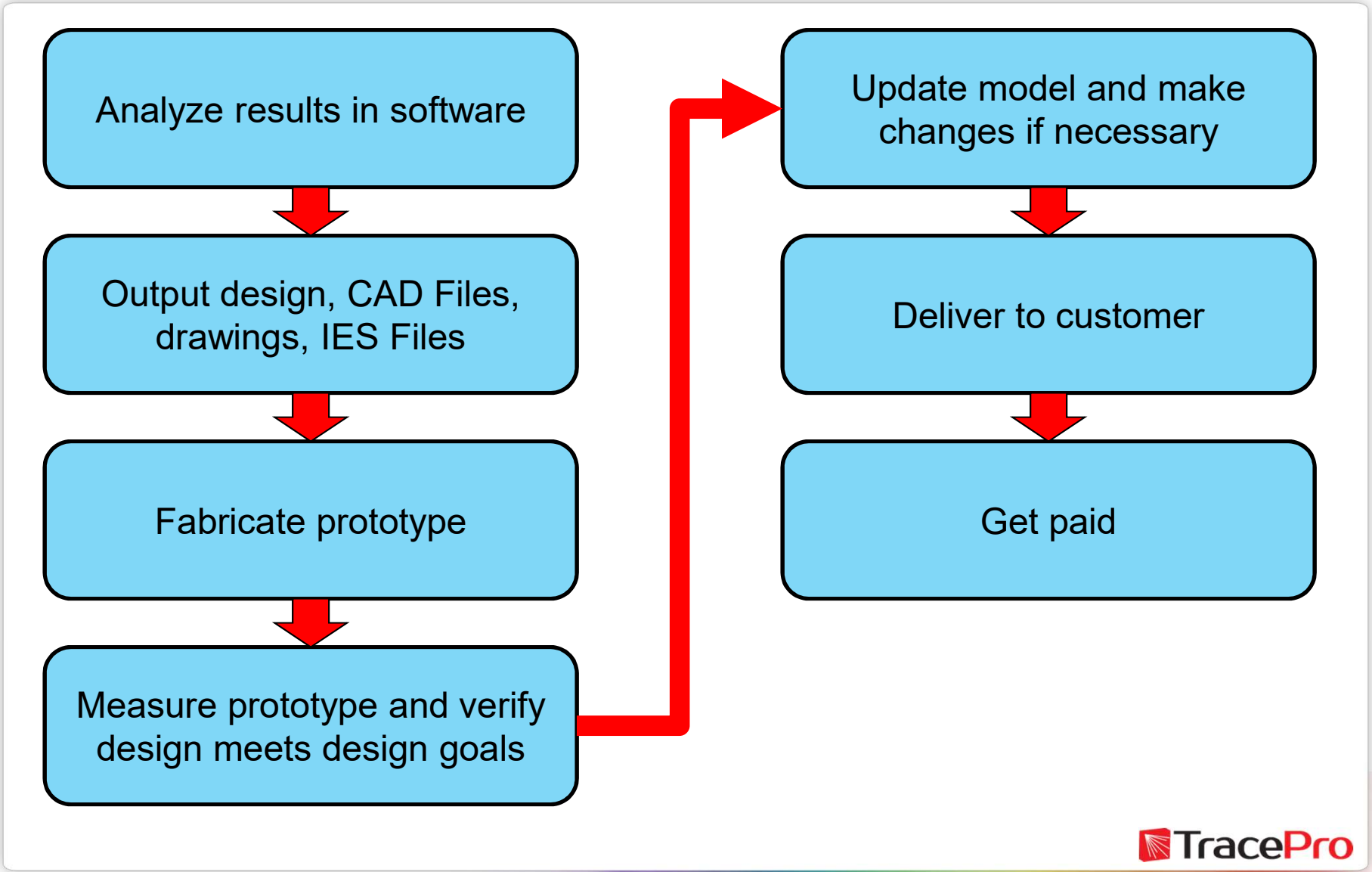


TracePro

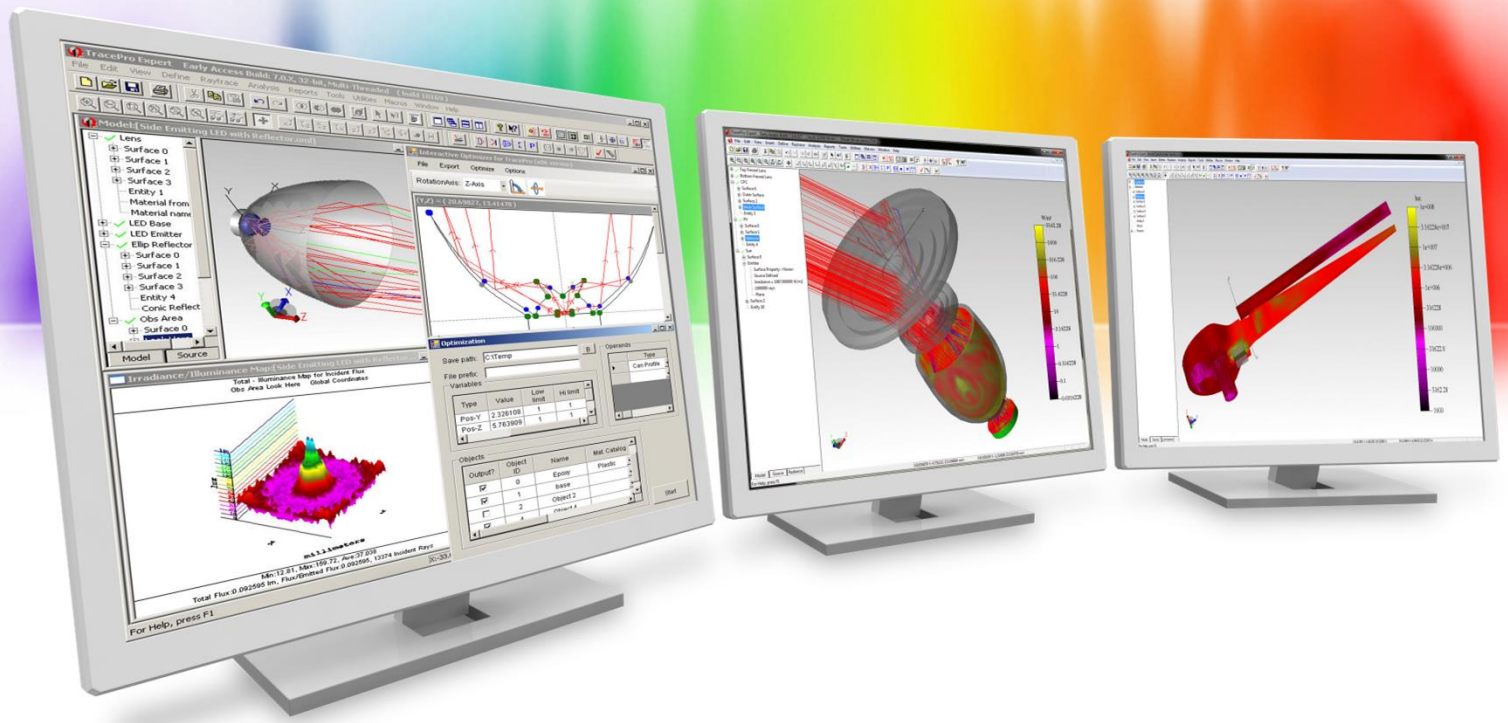
Typical workflow



Typical workflow



TracePro



Analysis Tools for Design Verification

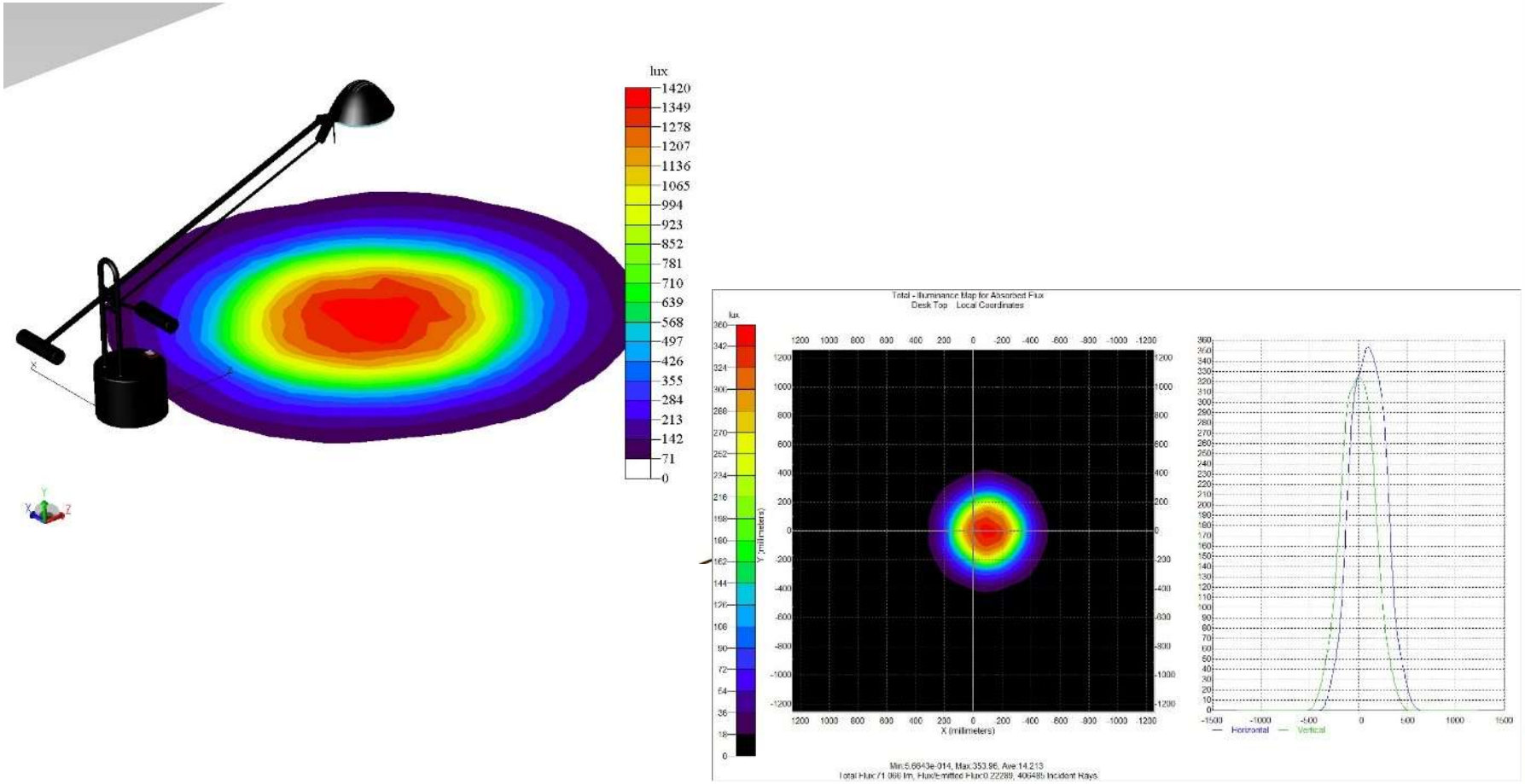
LAMBDA RESEARCH CORPORATION

Analysis Tools

- The analysis tools in optical design and analysis programs allow the users to test their designs in a virtual environment
- This can be accomplished much faster than setting up a prototype for measurement in an optical laboratory.
- Multiple types of measurements can be easily made
  - Illuminance, intensity (candela), luminance, total flux, efficiency, uniformity, colorimetry, photorealistic rendering
- Results can be saved as IES and LDT files
- Lighting reports can be generated using the data from the analysis
- Photometric and radiometric measurement units can be used

Illuminance Map

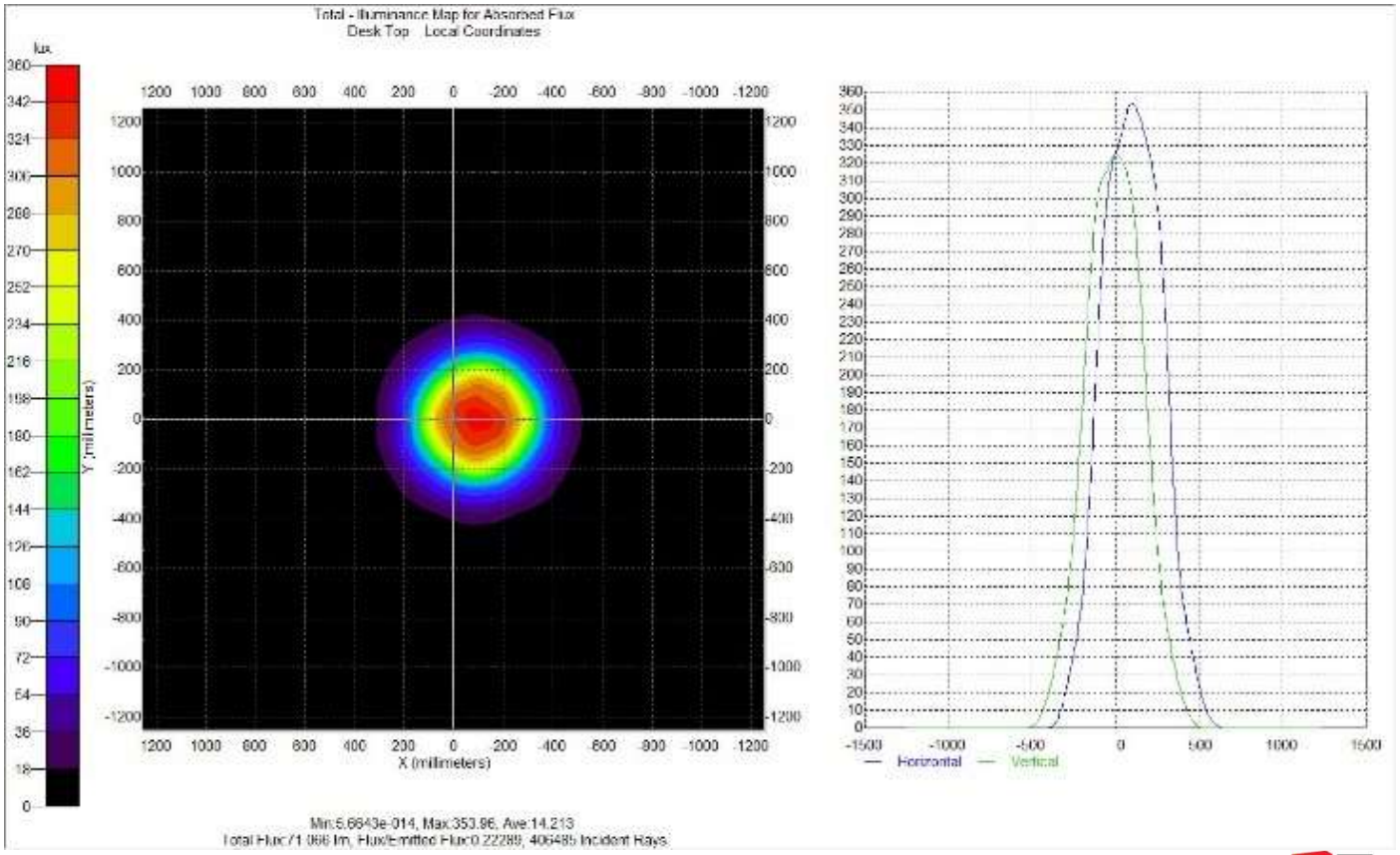
- The Illuminance Map displays the spatial distribution of the light on a selected surface or surfaces.



TracePro

Illuminance Map

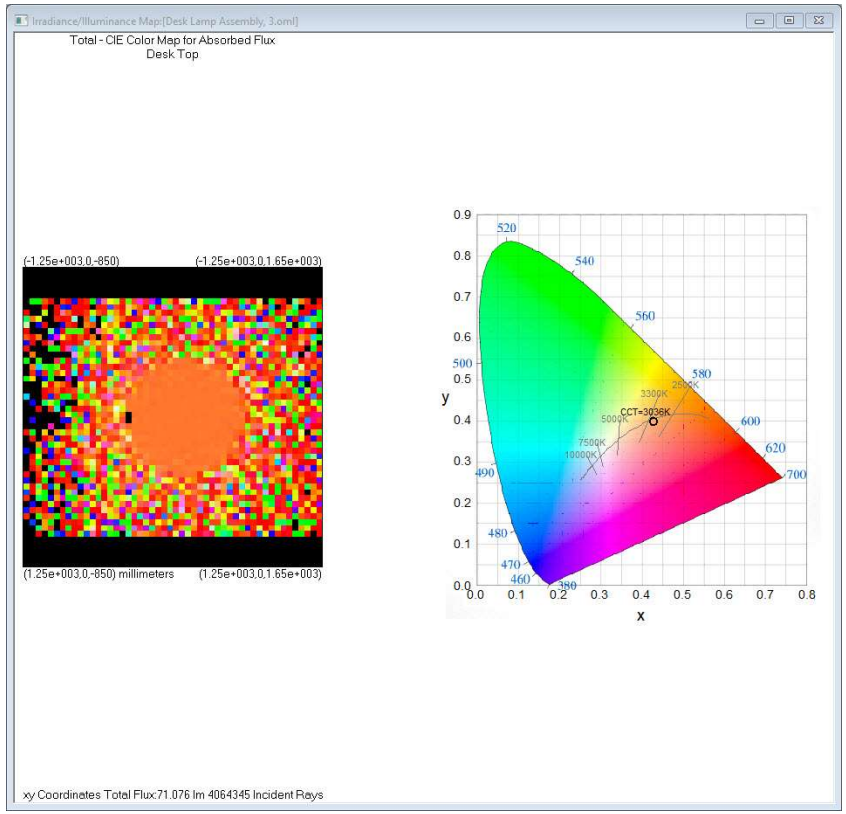
- The Illuminance Map also displays total flux, minimum, maximum, and average illuminance values, flux received vs flux emitted (efficiency), and profile plots.



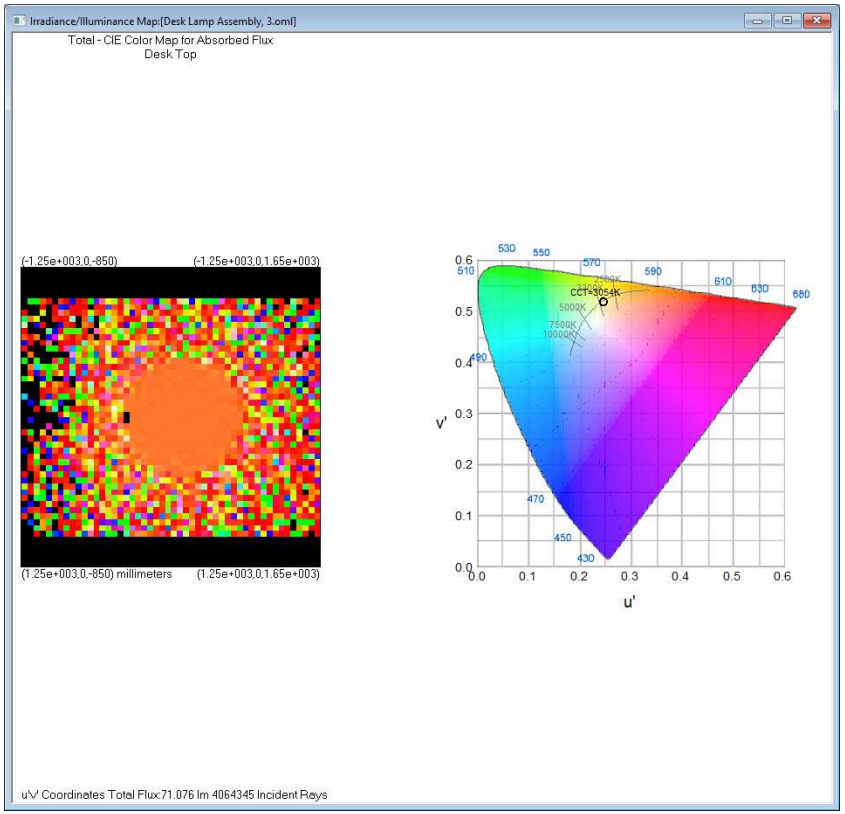
TracePro

Illuminance Map

- The Illuminance Map can also display the CCT, correlated color temperature, and CIE color coordinates, CIE xy and CIE u'v', of the light hitting a selected surface.



CIE xy

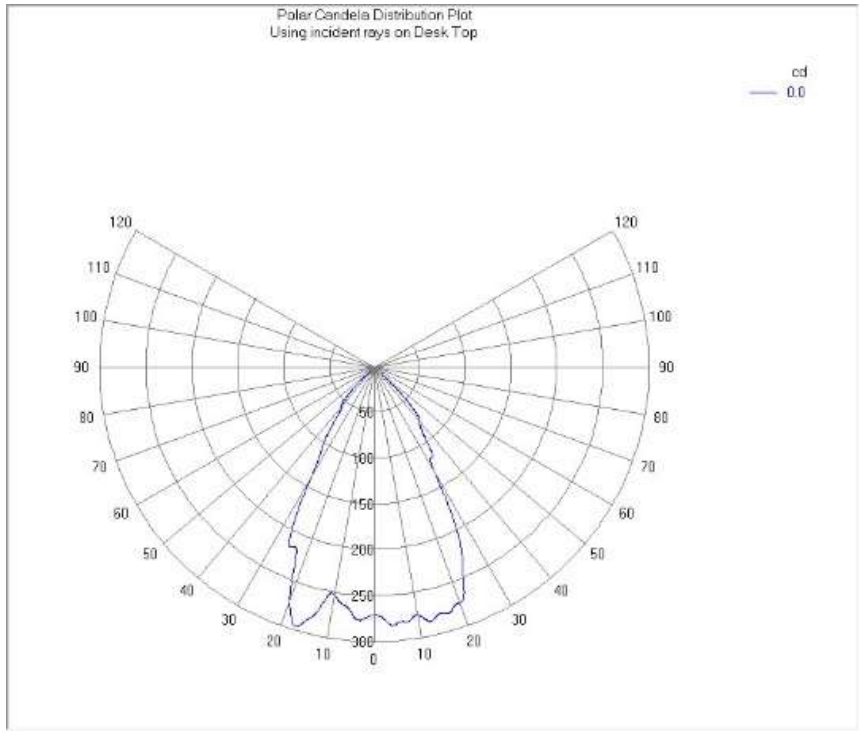


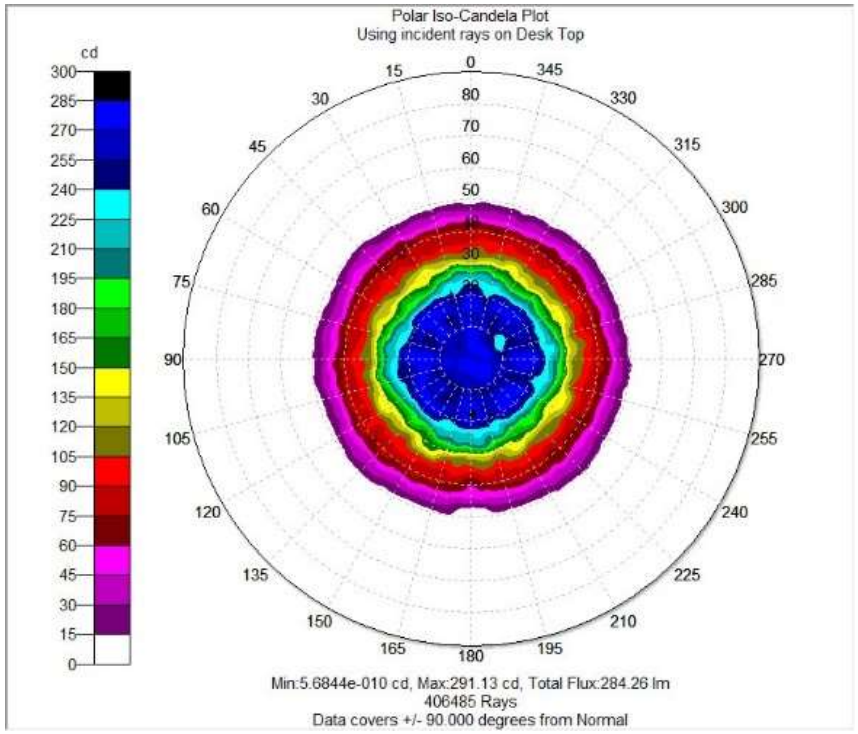
CIE u'v'

TracePro

Illuminance Map

- The Candela or Intensity plots show the intensity of the light as a function of angle. IES and LDT files can be generated from Candela Plots.

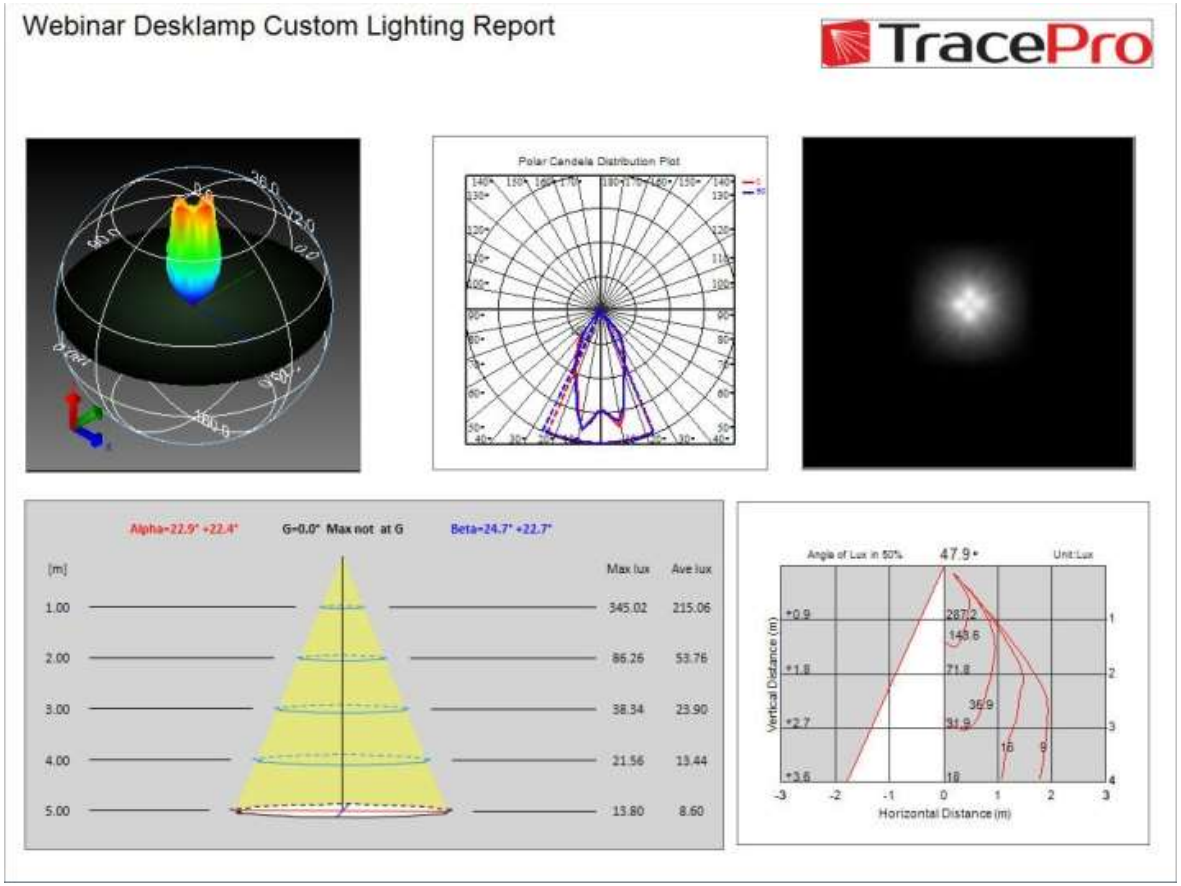




TracePro

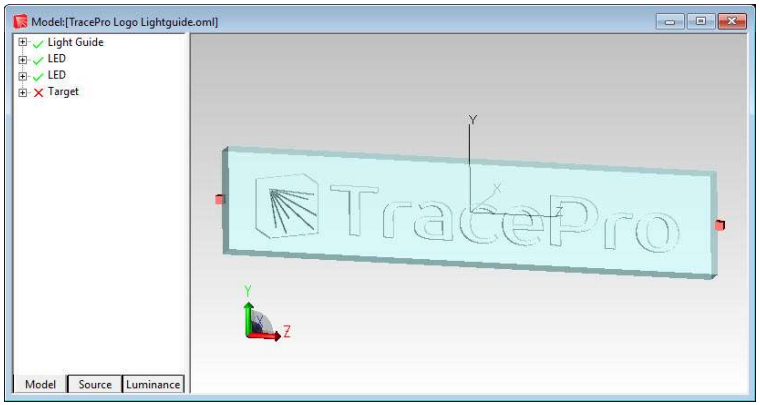
Illuminance Map

- The IES and LDT files can be used to generate custom light reports or export the photometric data to architectural lighting design software



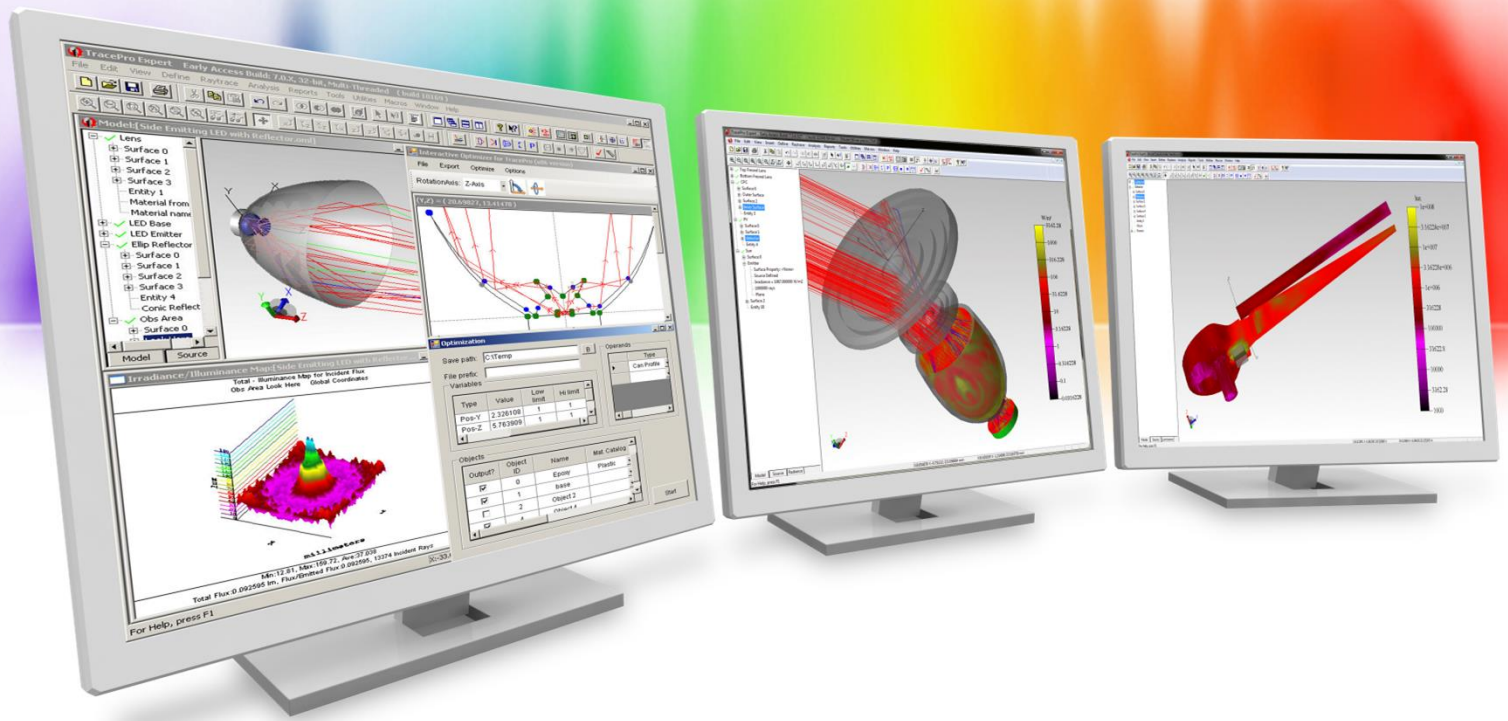
Illuminance Map

- Luminance Maps and Photorealistic Rendering show the luminance of the luminaire or light source and a lit appearance display of how it looks to a viewer.



TracePro

TracePro



Optimization

LAMBDA RESEARCH CORPORATION

What is optimization?

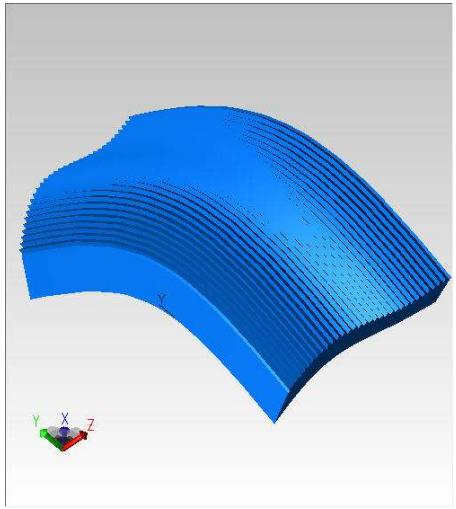
- An act, process, or methodology of making something (as a design, system, or decision) as fully perfect, functional, or effective as possible. *(Source: Merriam-Webster online dictionary)*

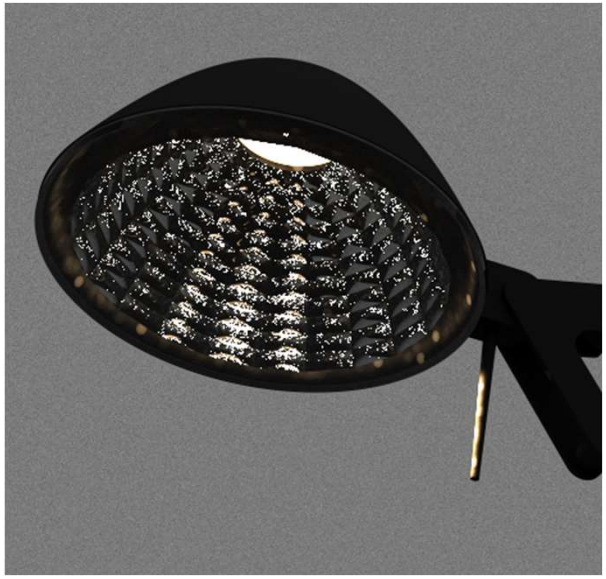
TracePro

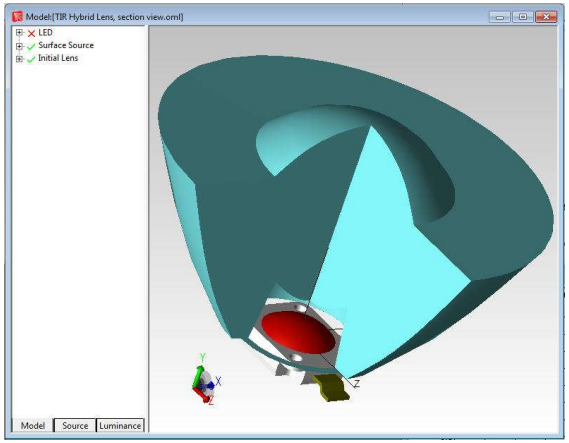
What is optimization?

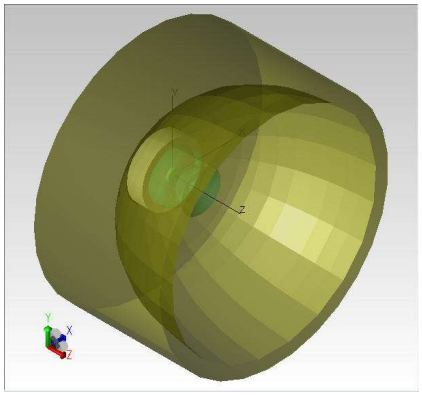
- What are some of the parameters that can optimized?

- Geometry
- Curvature
- Facets
- Position
- Angle
- Spacing
- Thickness
- Properties









TracePro

What is optimization?

- What many people would like to see…

TracePro

What is optimization?

- Or….

TracePro

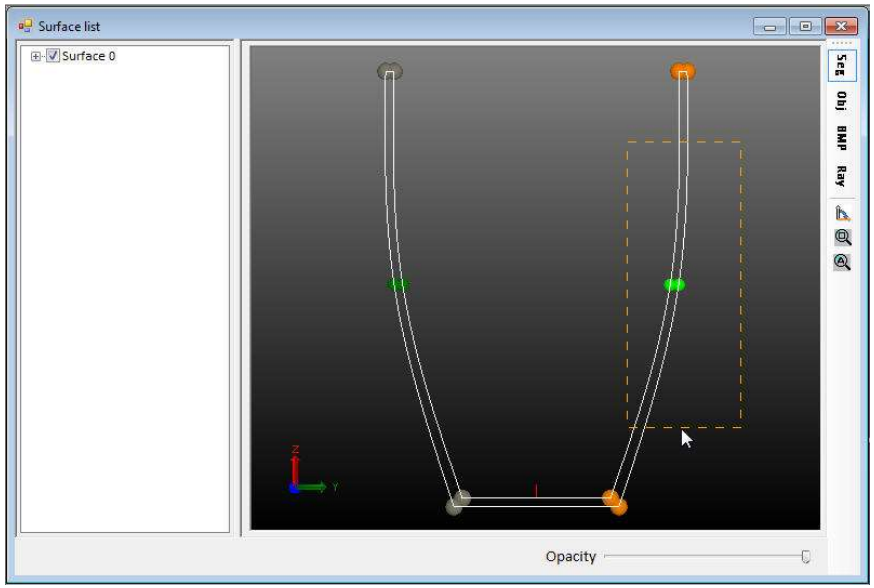
What is optimization?

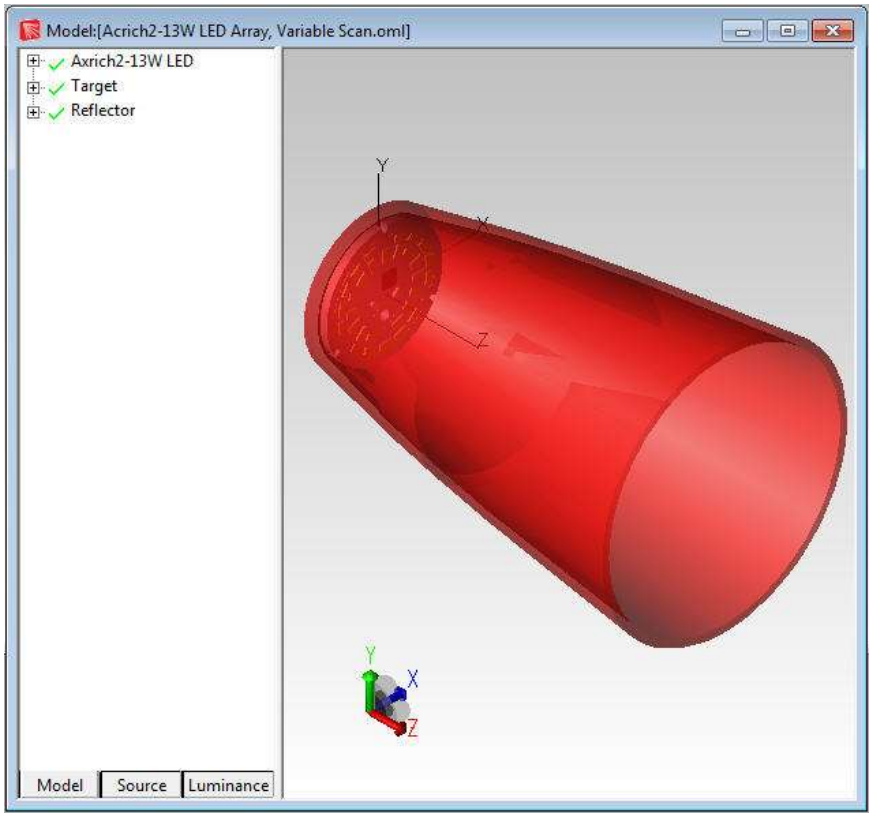
- What we can try to do with optimization….

TracePro

Why do we need optimization?

- Brute force vs. Optimization algorithm – The goal is to optimize the reflector shown below

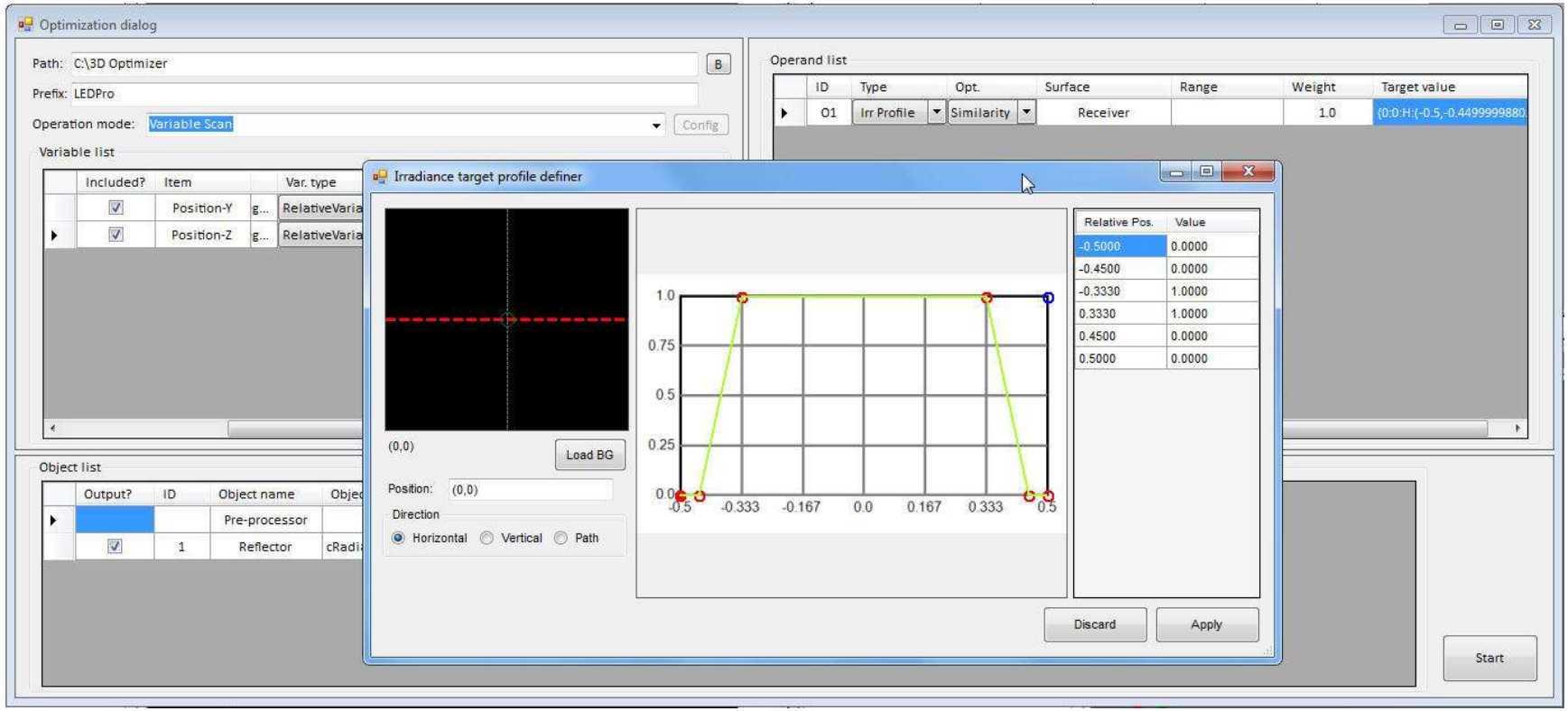




TracePro

Why do we need optimization? The brute force approach.

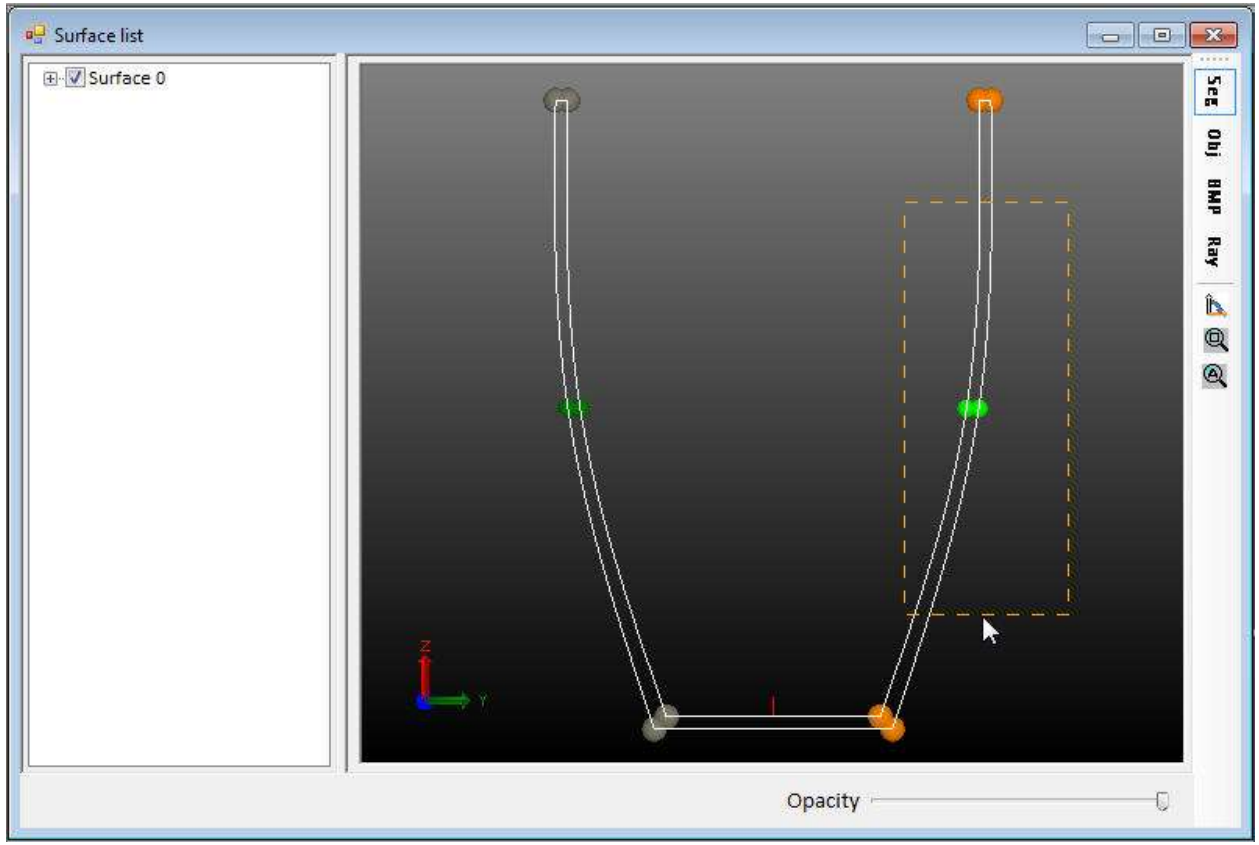
- Optimization goal – even illumination in the central 2/3 of the target



TracePro

Why do we need optimization? The brute force approach.

- Control Point variable range - 40mm in Y-axis and 100mm in Z-axis



TracePro

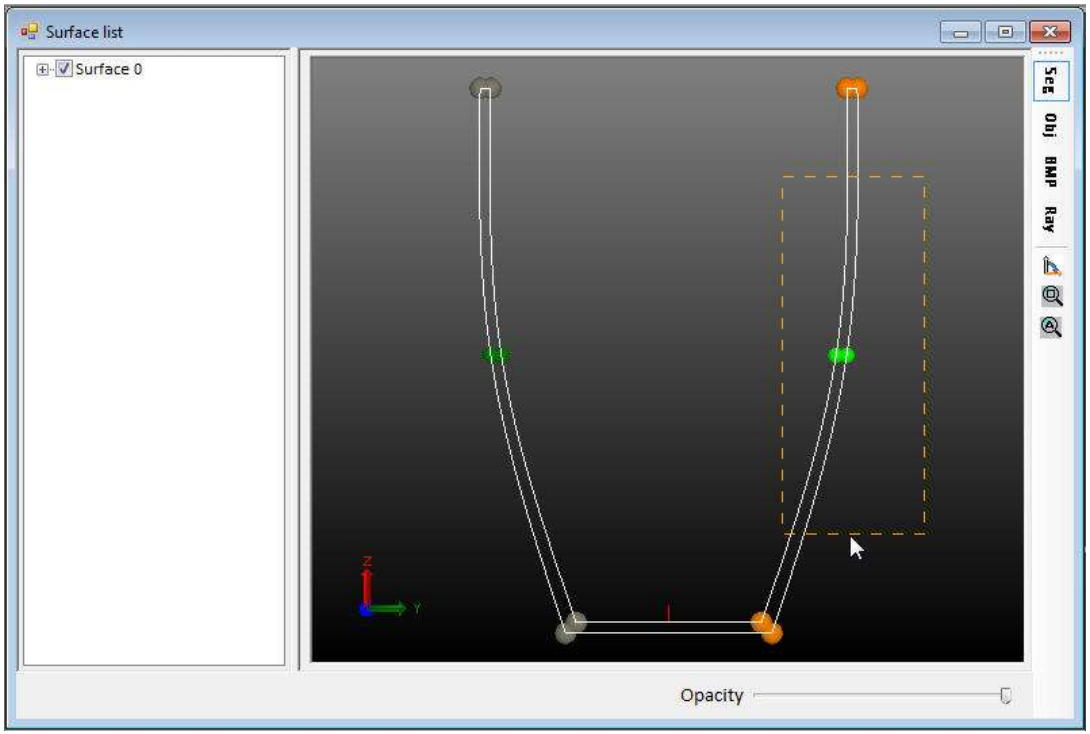
Why do we need optimization? The brute force approach.

- Control Point variable range - 40mm in Y-axis and 100mm in Z-axis

Scanning the entire variable range in 1mm increments would take 41 x 101 = 4141 increments.

If the raytrace time is 1-minute per iteration, this would take around 70-hours to complete.

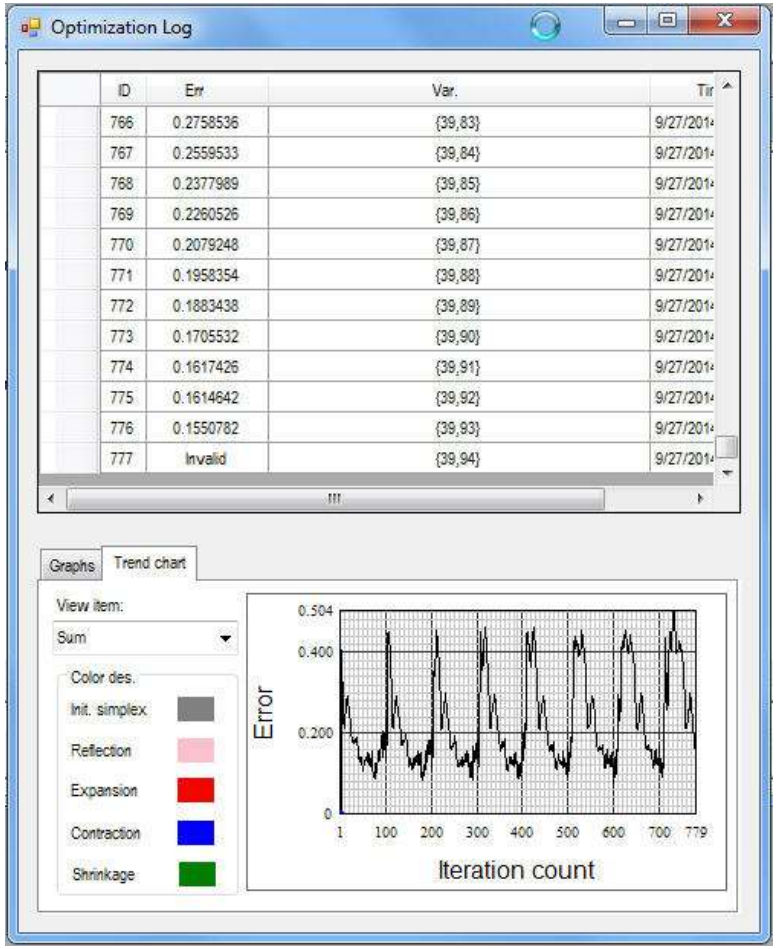
Scanning in 0.1mm increments would take around 6690 hours, or 279 days



TracePro

Why do we need optimization?

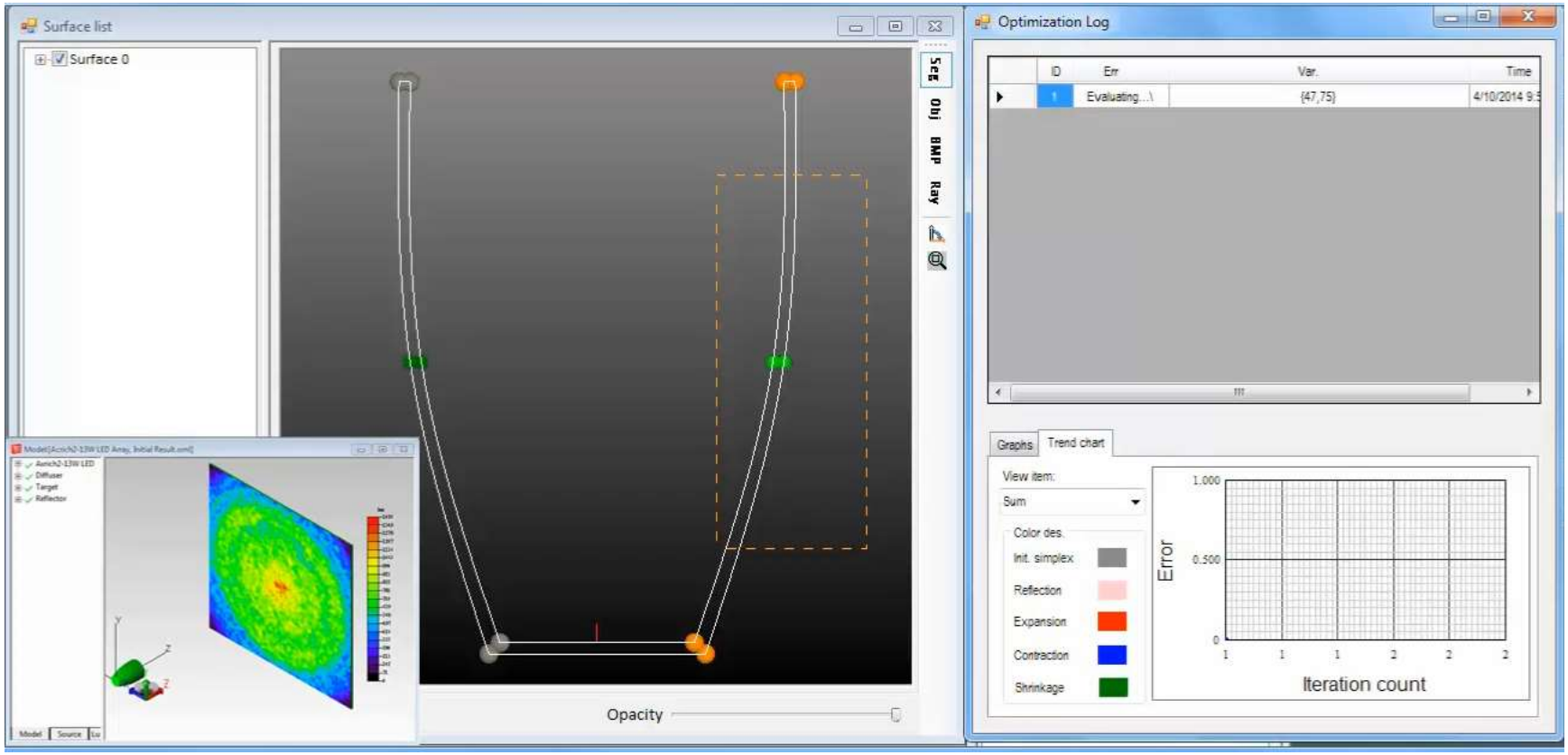
- Optimization Log after 14 hours of raytracing



TracePro

Why do we need optimization? A better approach.

- Using an optimization algorithm the total time was reduced to about 2 hours 20 minutes, with more rays traced for each iteration - Video

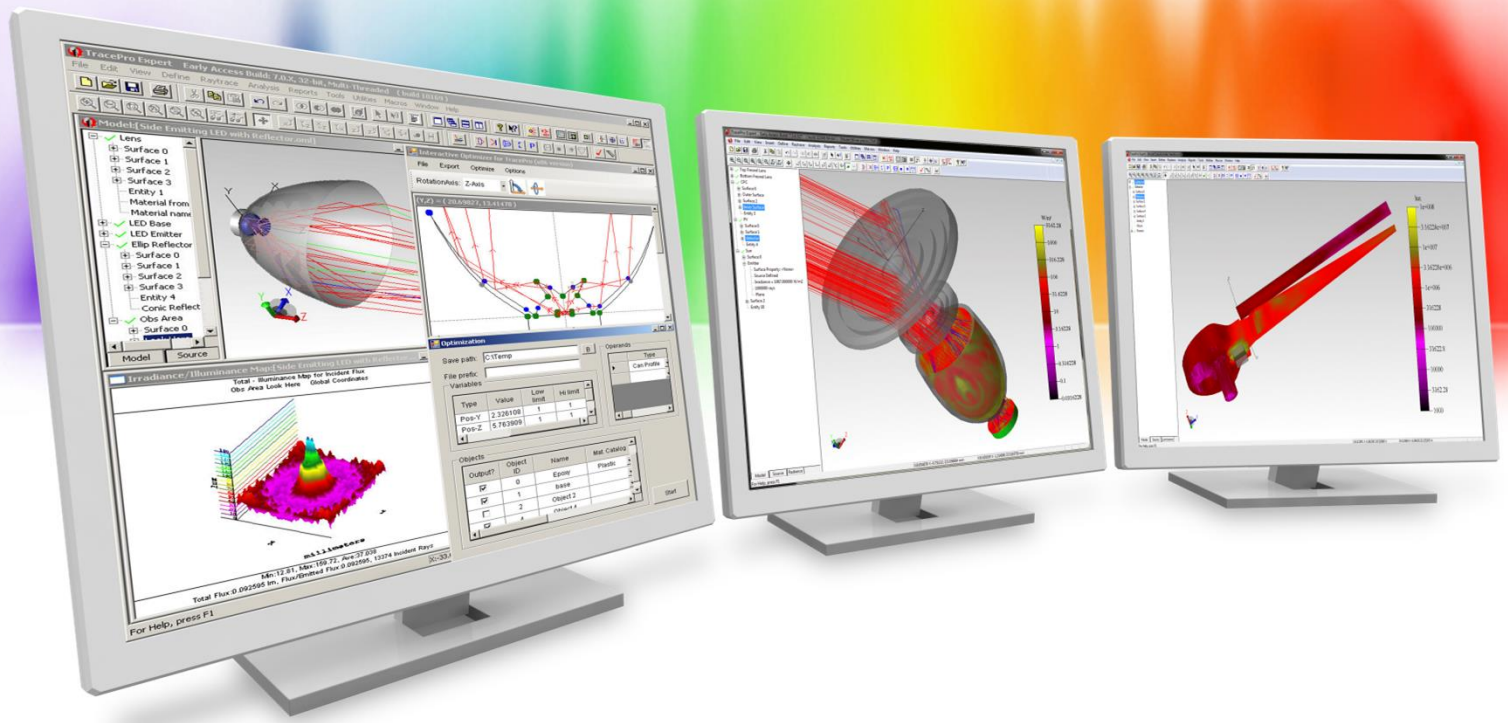


TracePro

Optimization methods

- Generally there are 2 types of optimizers: Global and Local.
- Global optimizers will search the entire solution space to find the best solution based on the optimization goal or merit function. Typically used in lens design programs.
  - Global Explorer, Adaptive Simulated Annealing, Global Synthesis, Hammer Optimization
- Local optimizers will find the solution closest to the starting point of the optimization process. Changing the starting conditions can change the results of the optimization process. Typically used in illumination design programs.
  - Downhill Simplex or Nelder-Mead, Damped least squares, Powell's Method

TracePro



Examples

LAMBDA RESEARCH CORPORATION

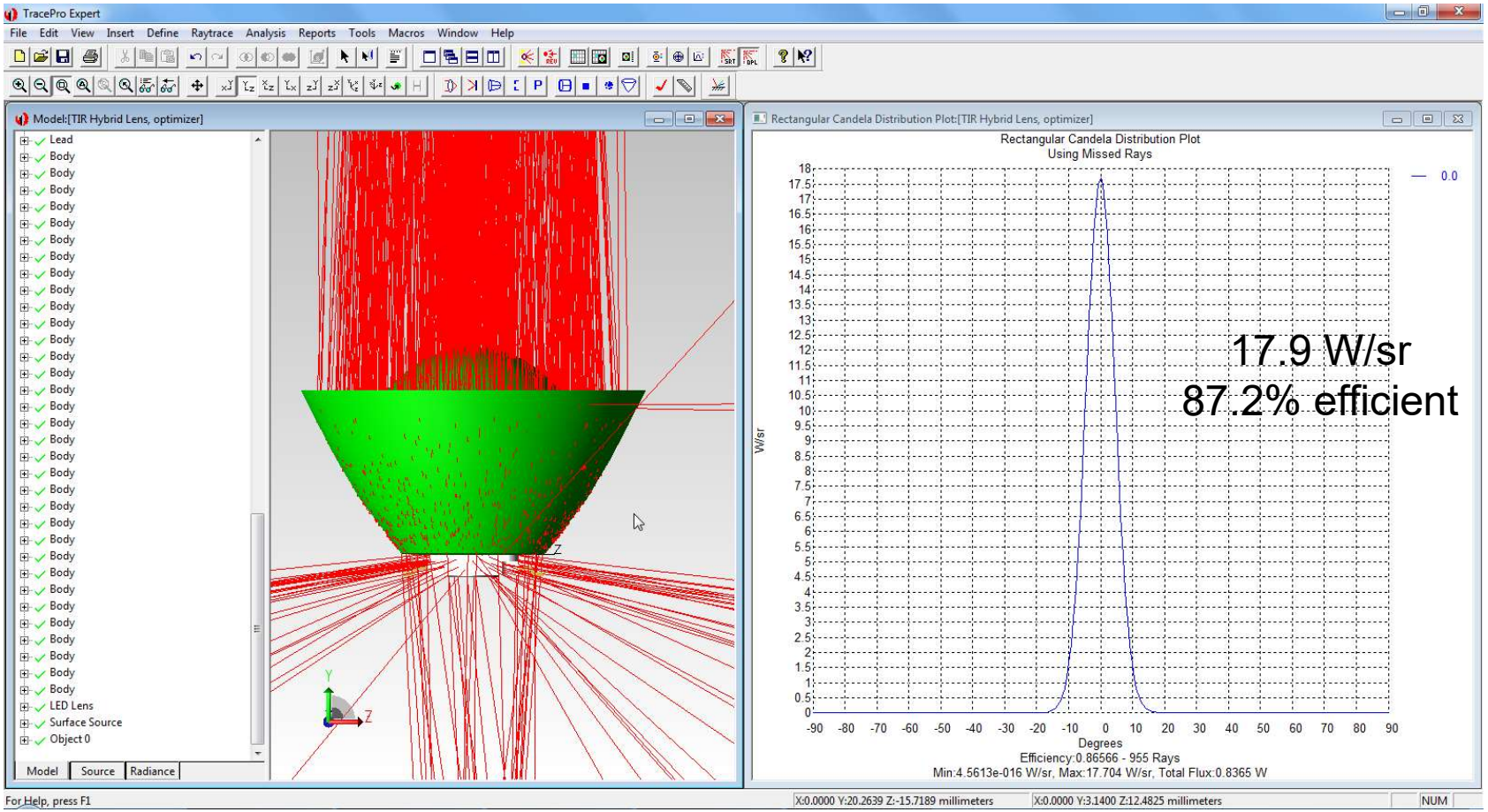
Examples

- TIR Hybrid lens – manual vs automatic optimization
- Side emitting LED lens and reflector combination
  - One part at a time
  - Both parts at same time
- Curved Facet Reflector

TracePro

TIR hybrid LED lens

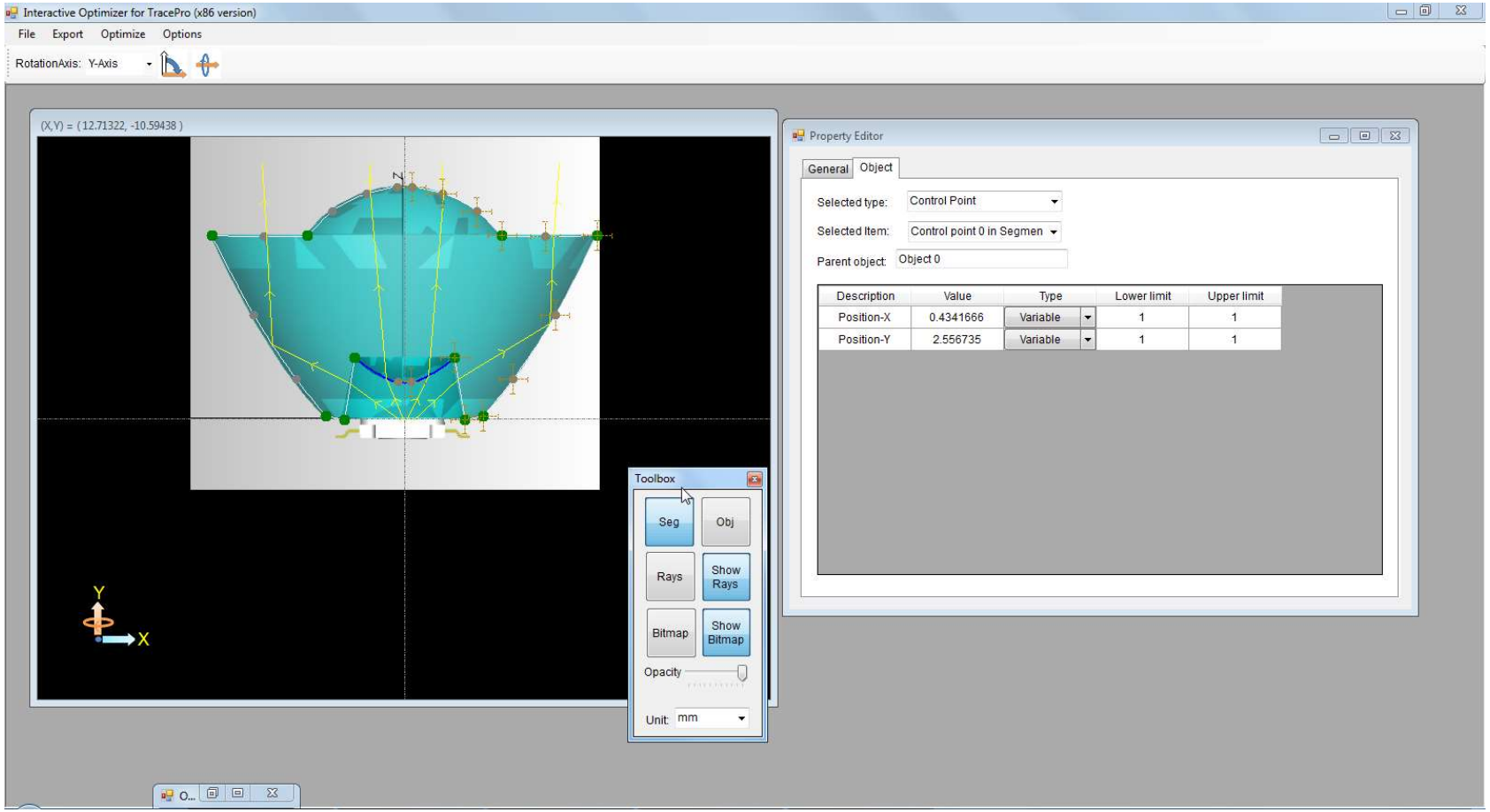
- TIR Hybrid lens – Initially optimized by a trial and error process. Total time spent optimizing, about 3 days.



TracePro

TIR hybrid LED lens

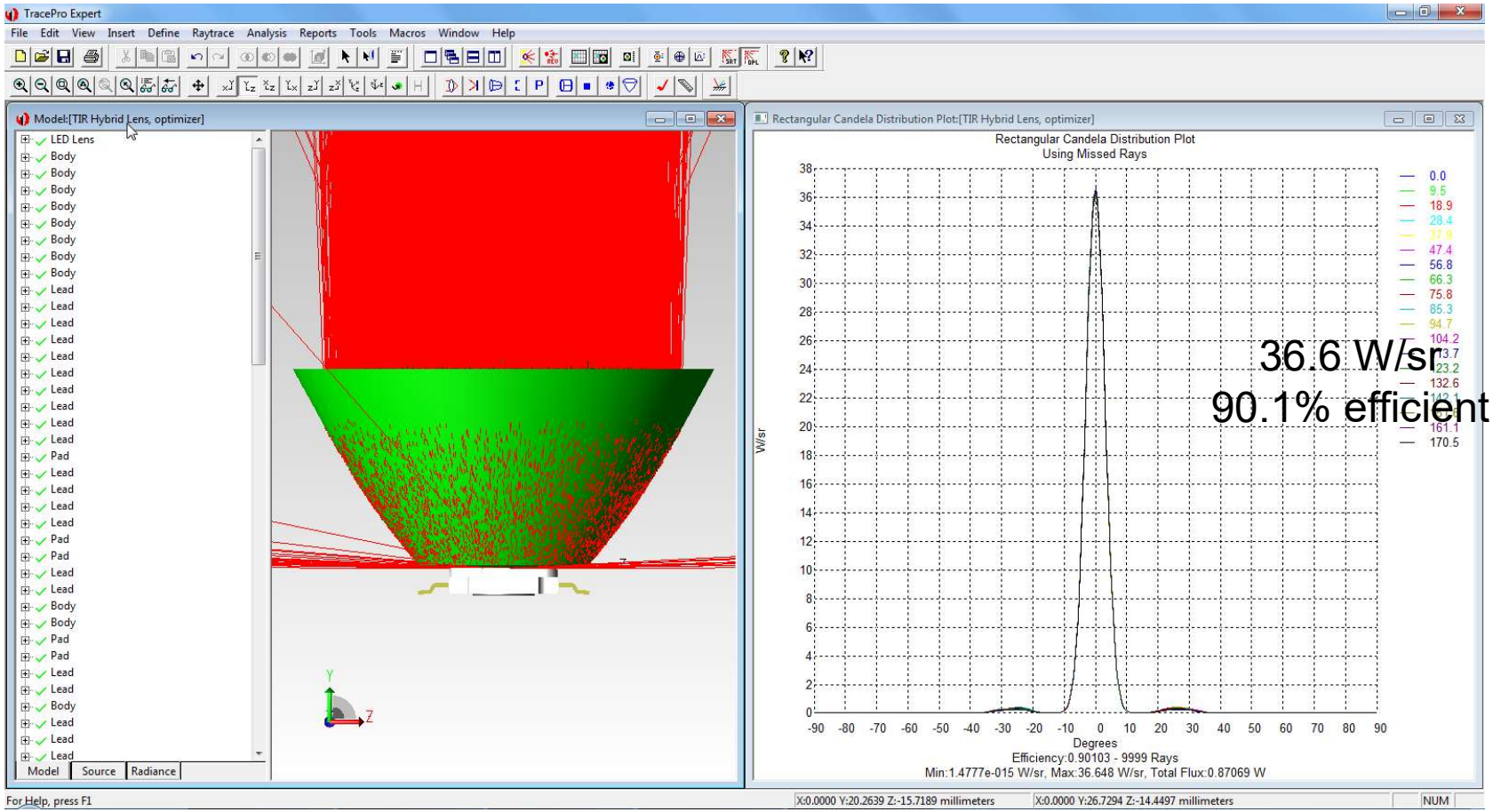
- TIR Hybrid lens – Optimized using optimizer in TracePro – 12 variables in 2 axes each.



TracePro

TIR hybrid LED lens

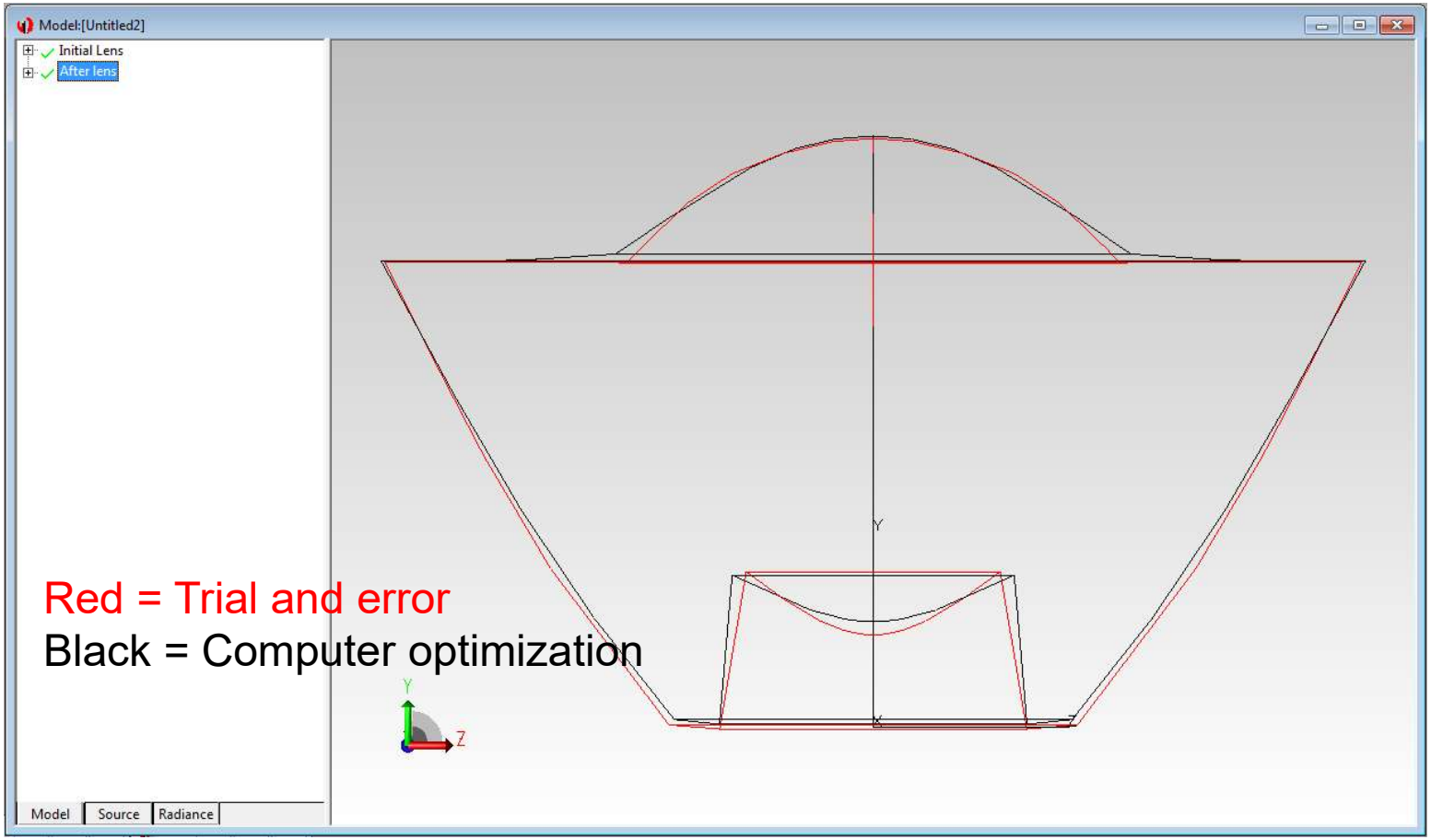
- TIR Hybrid lens – Optimized using optimizer in TracePro. Total time spent optimizing, about 1 ½ hours.



TracePro

TIR hybrid LED lens

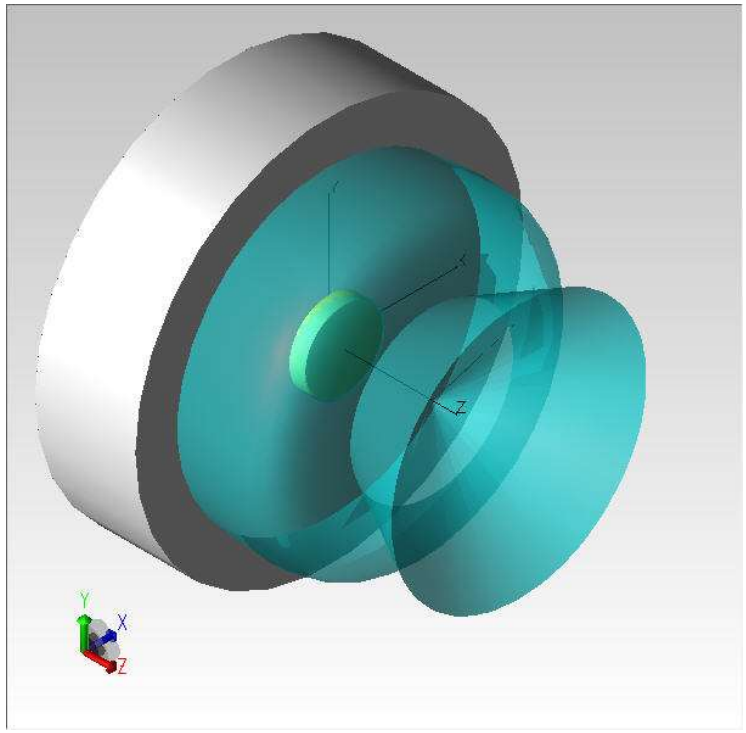
- TIR Hybrid lens – Trial and error vs. computerized optimization

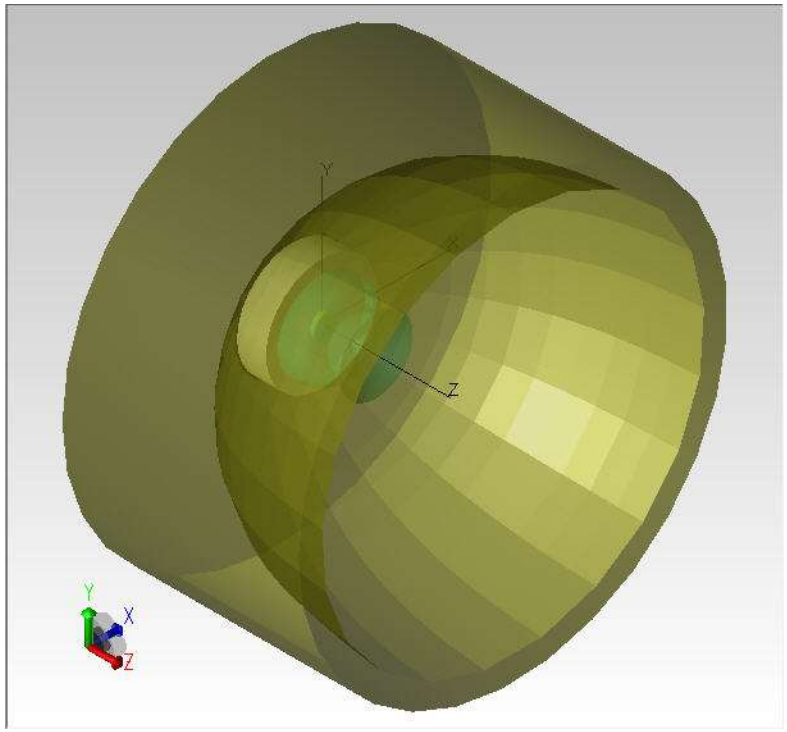


TracePro

Side emitting LED lens and reflector combination

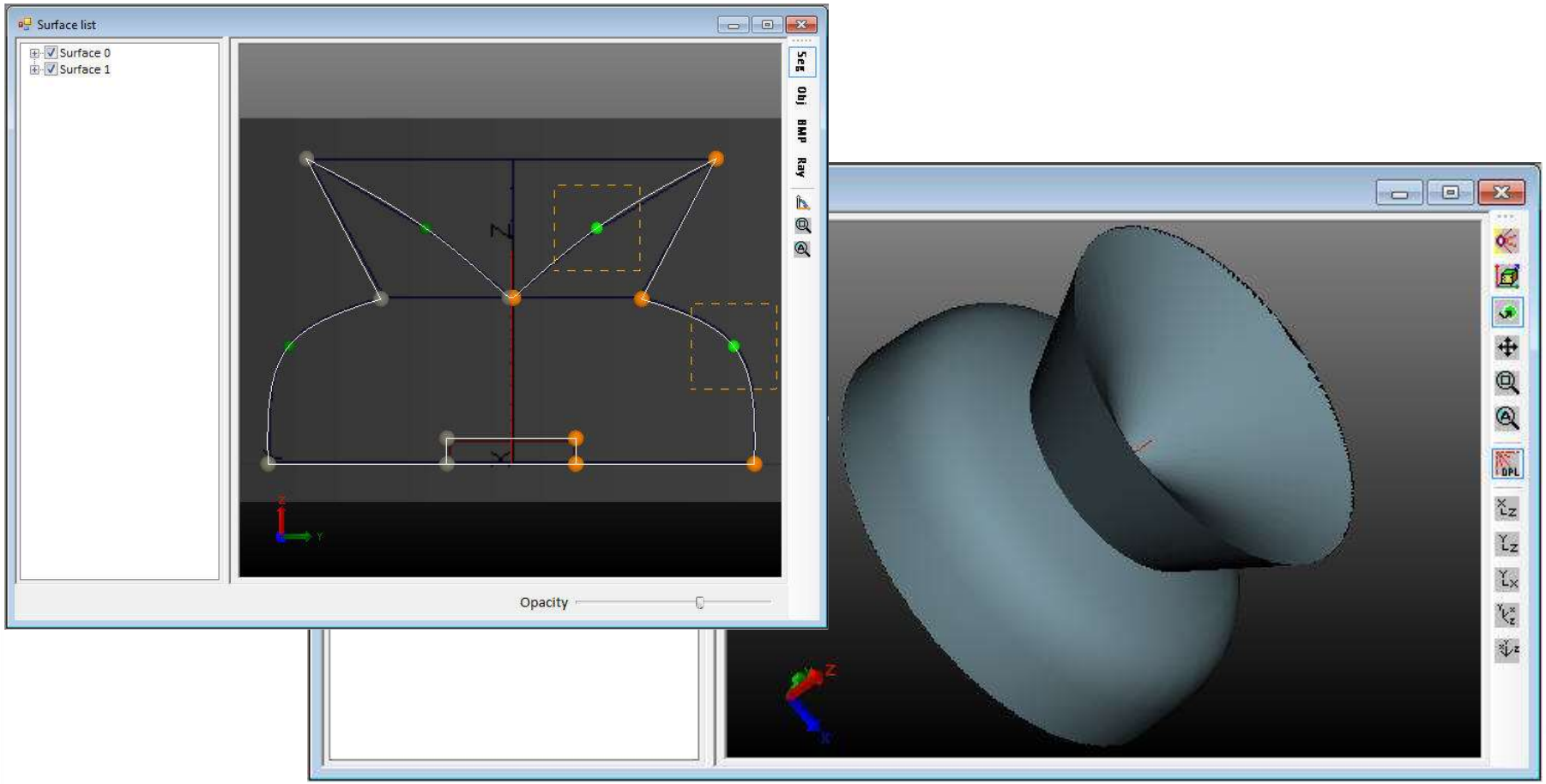
- Side emitting LED lens and reflector combination
  - Is it better to optimize each part separately, or to optimize both parts at the same time?





Side emitting LED lens and reflector combination

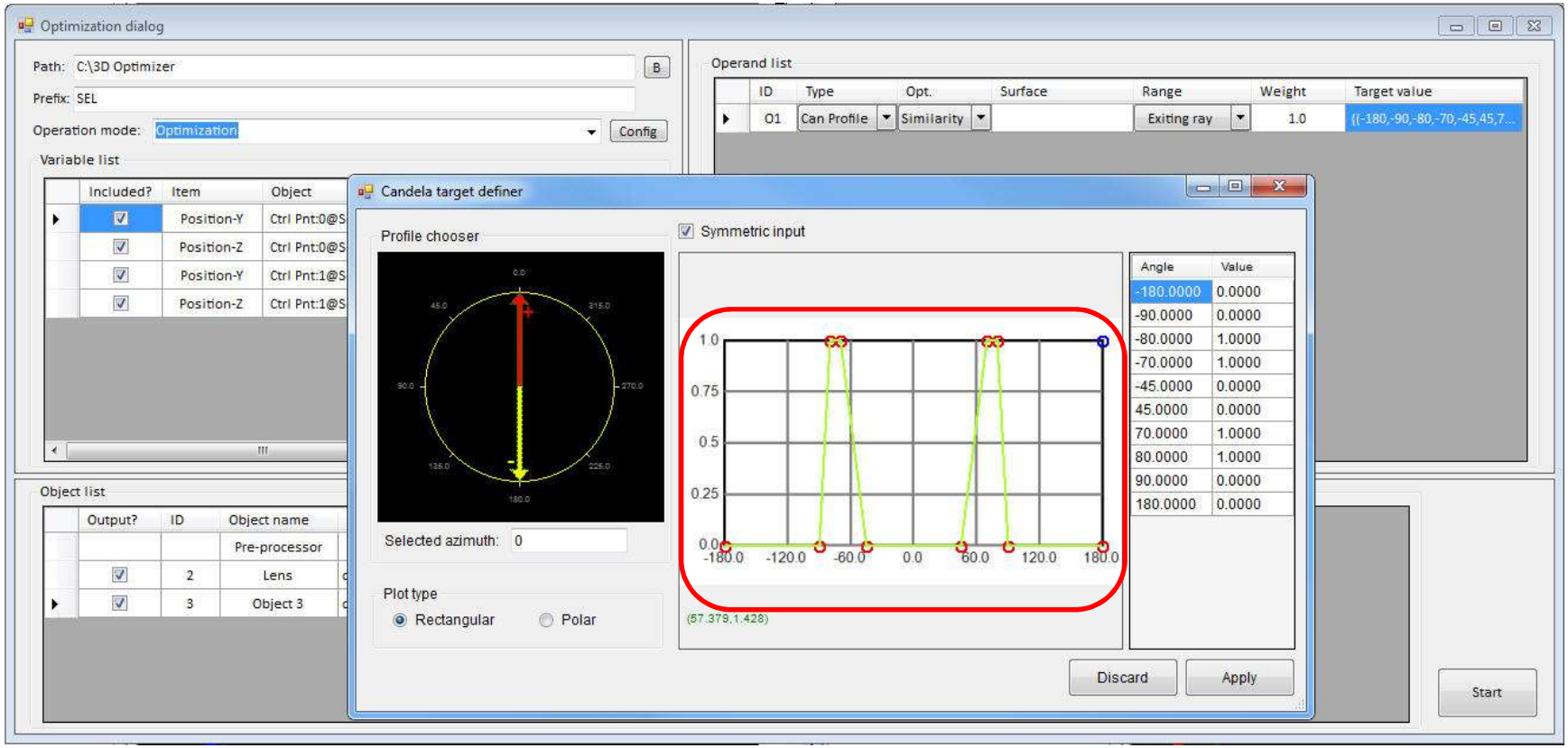
- Optimizing the optical elements separately – Setting up the LED side emitting lens – 2 control points in 2 axes each



TracePro

Side emitting LED lens and reflector combination

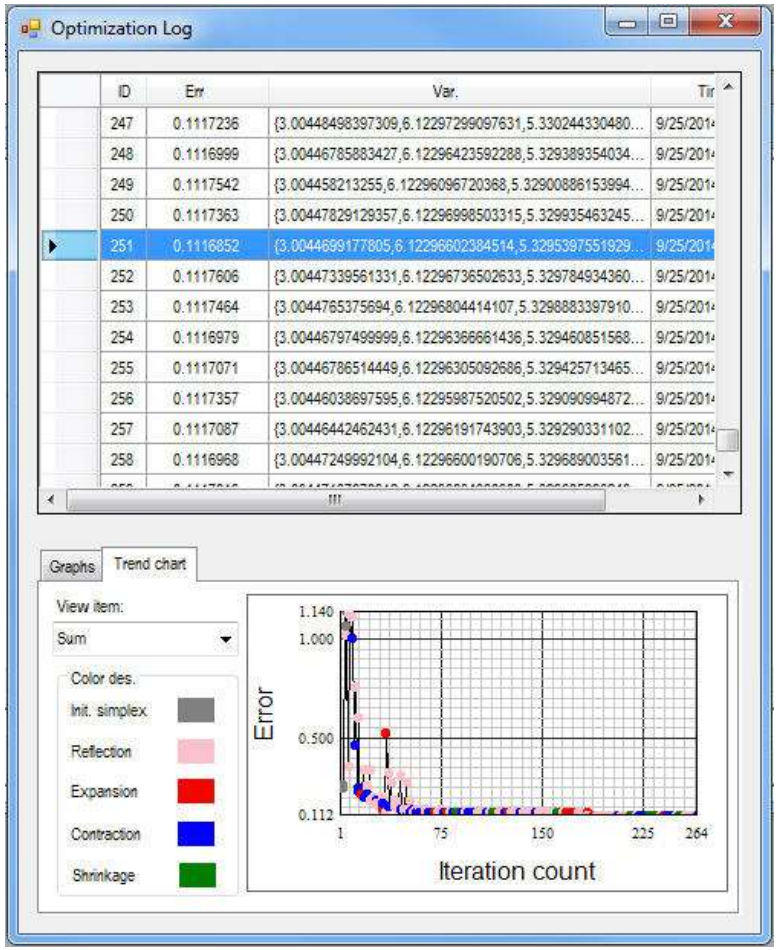
- Optimization Goal – Candela profile from 45 to 80 degrees and from -45 to -80 degrees with as little output between those lobes as possible



TracePro

Side emitting LED lens and reflector combination

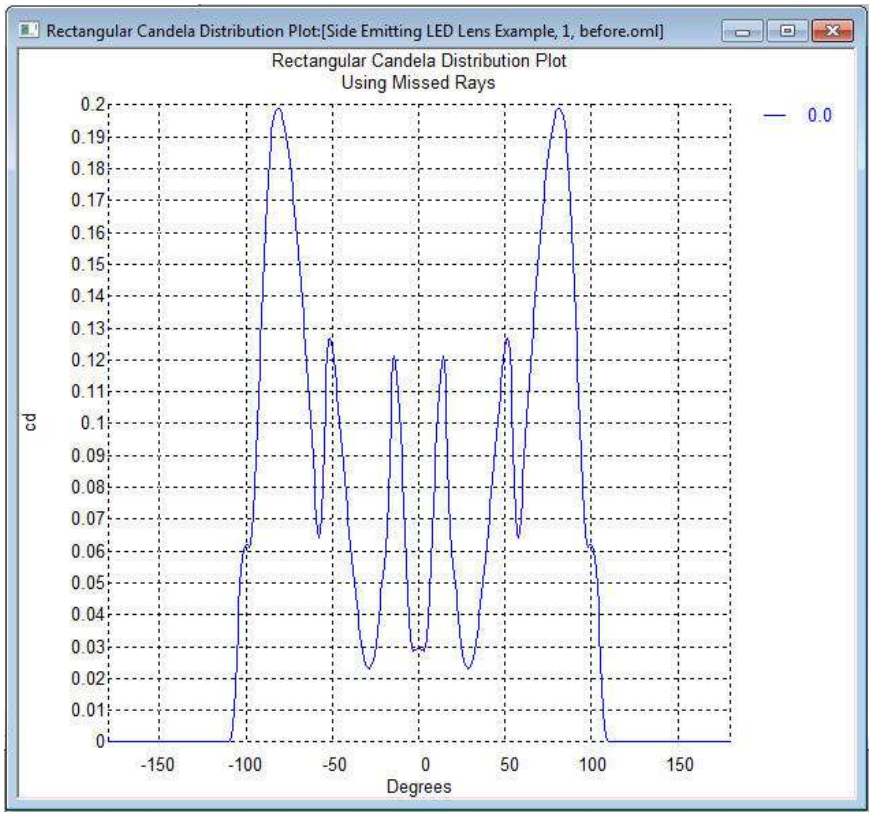
- Optimization Log – 264 iterations



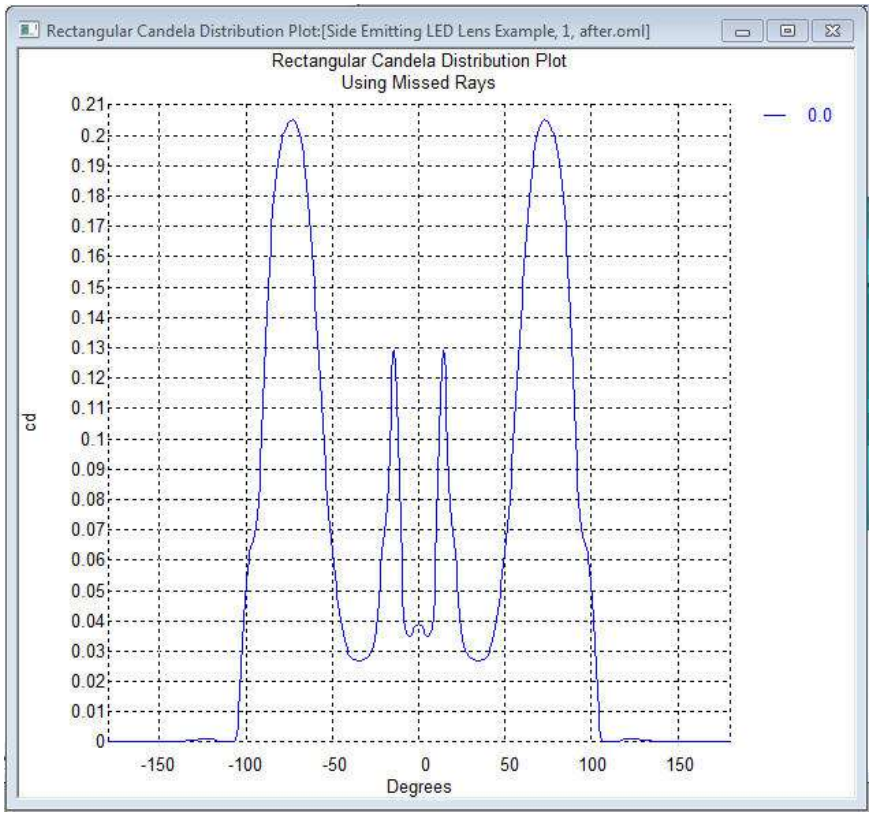
TracePro

Side emitting LED lens and reflector combination

- Candela Profile– Before and after optimization



Before optimization

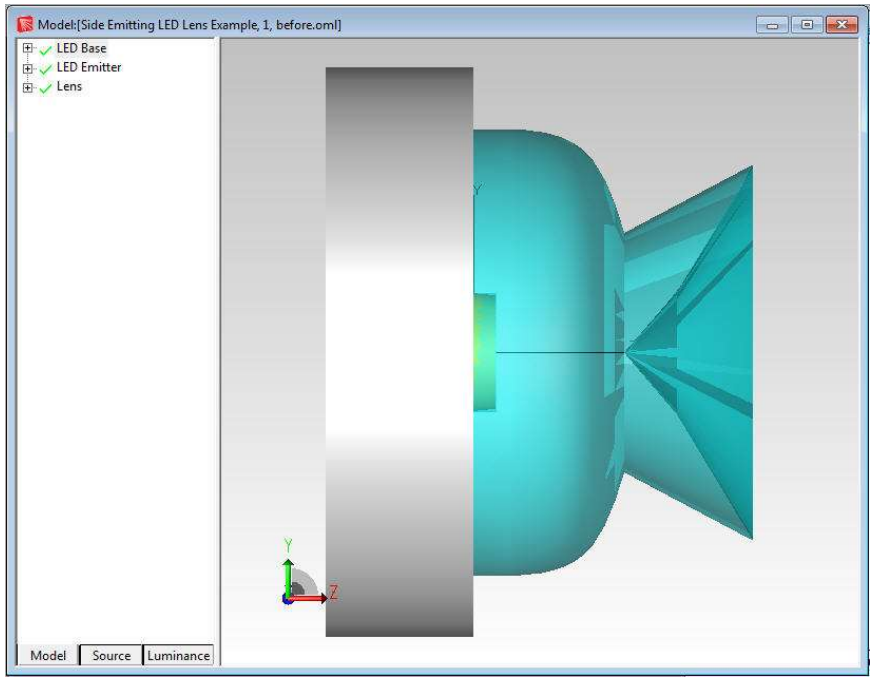


After optimization

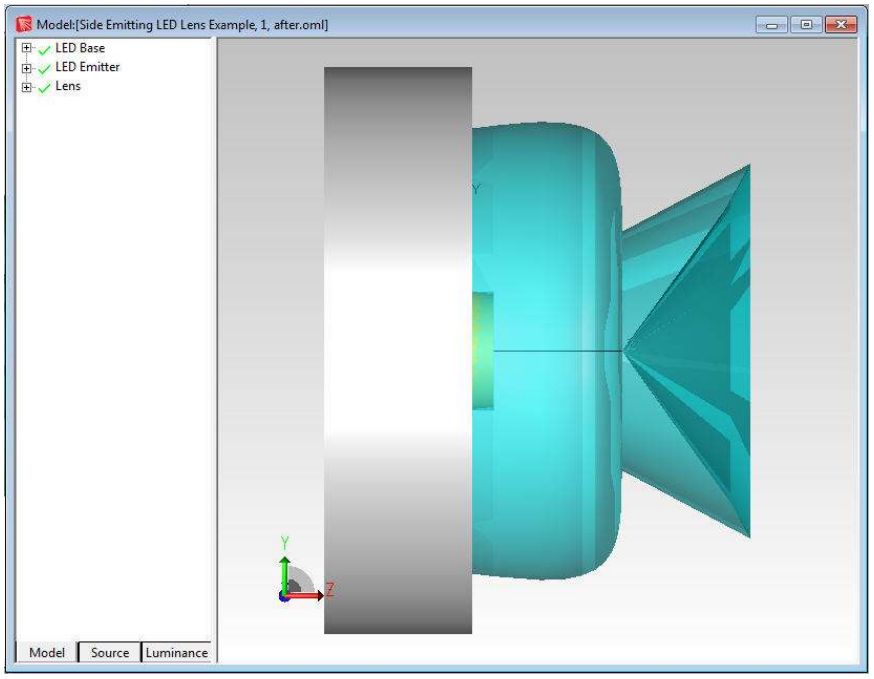
TracePro

Side emitting LED lens and reflector combination

- Lens Profile – Before and after optimization



Before optimization

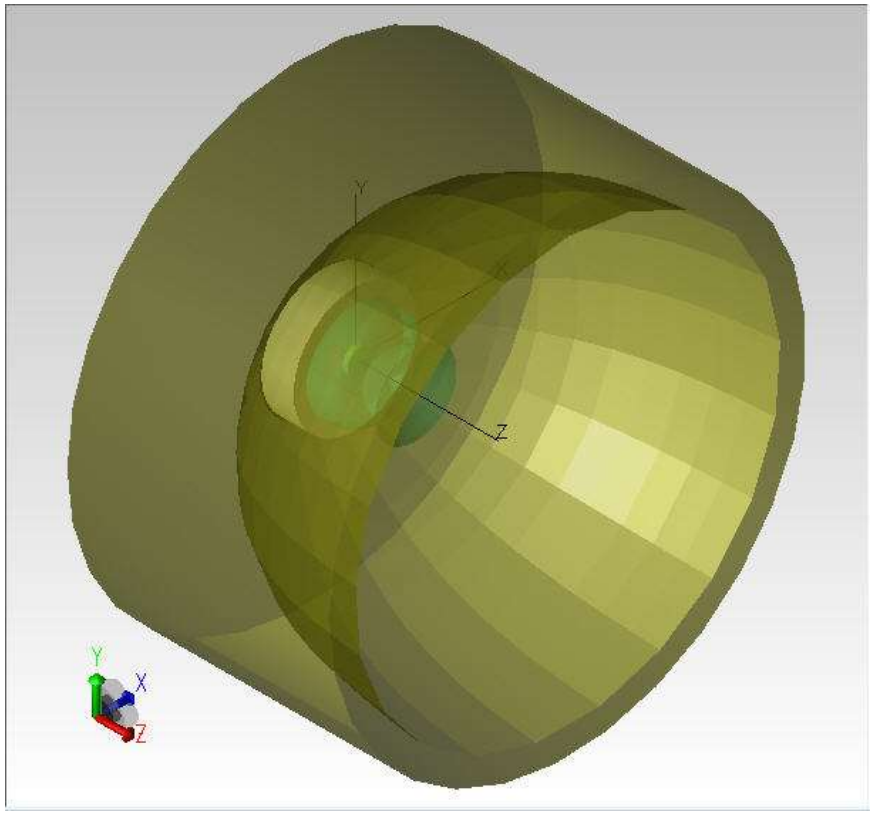


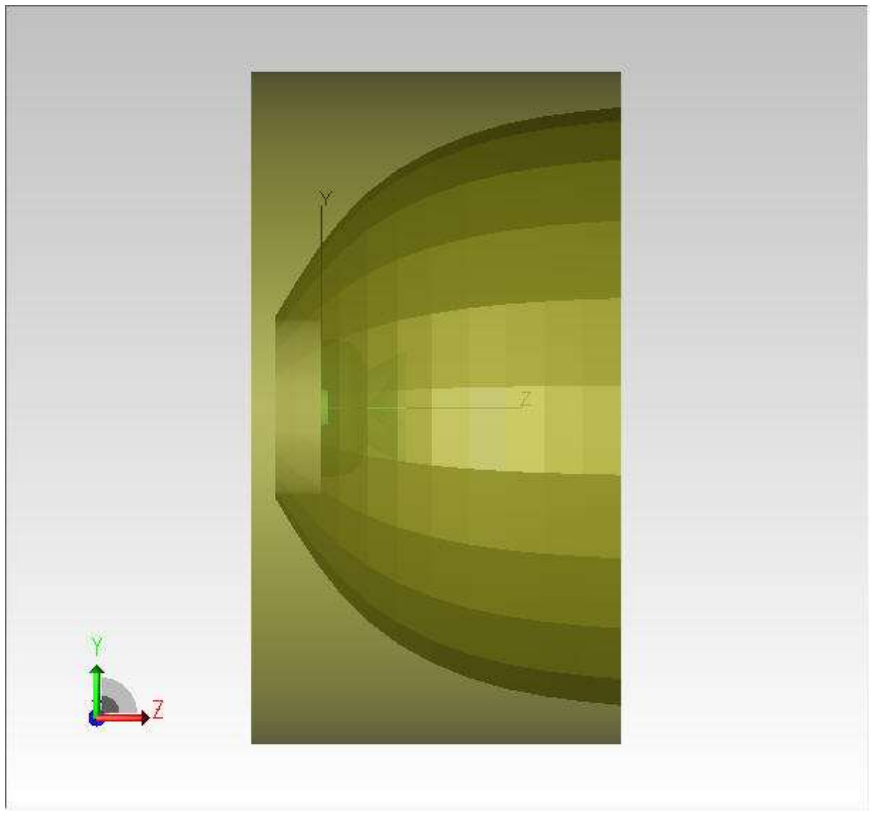
After optimization

TracePro

Side emitting LED lens and reflector combination

- Add a reflector to the lens assembly

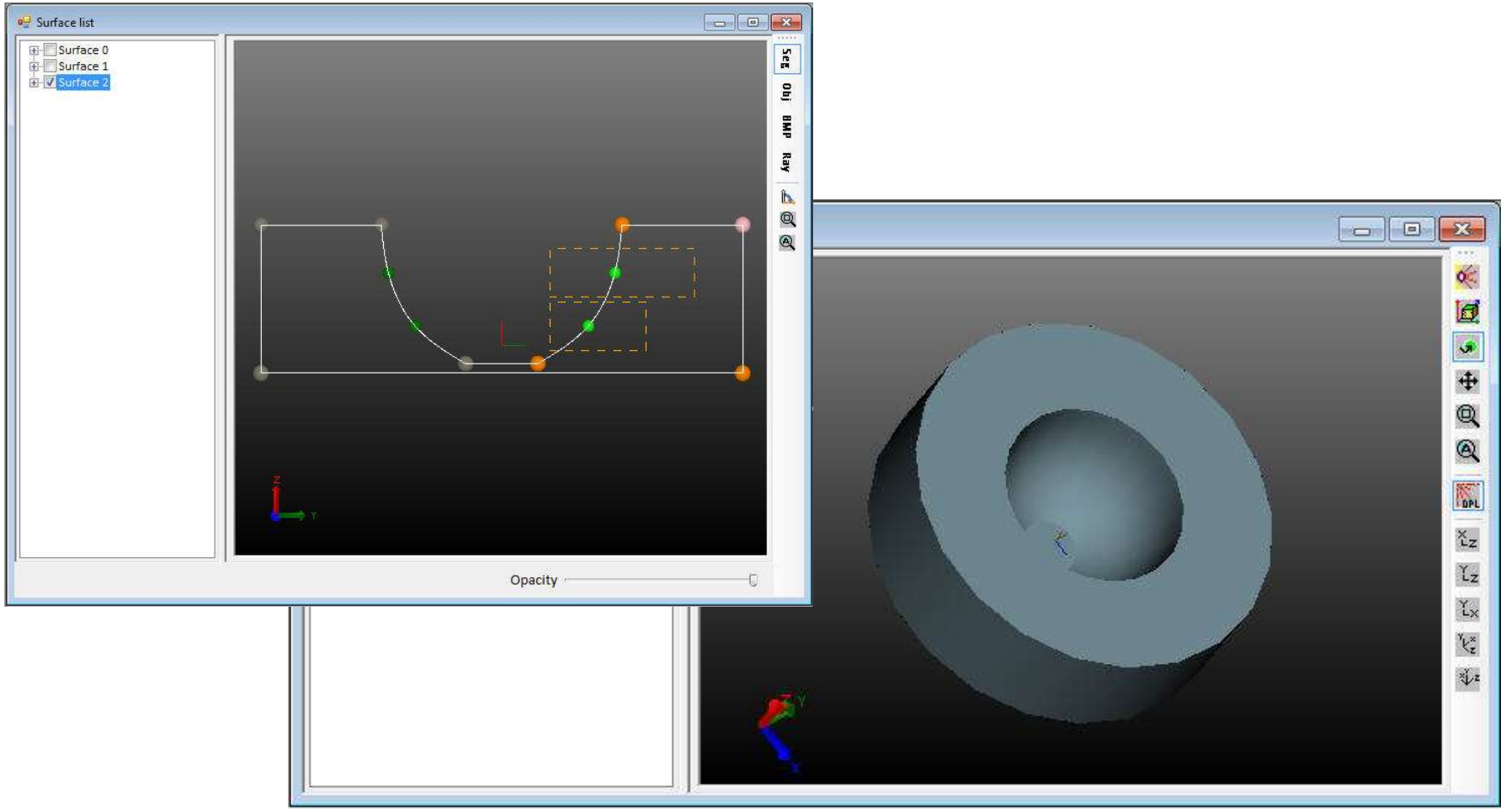




TracePro

Side emitting LED lens and reflector combination

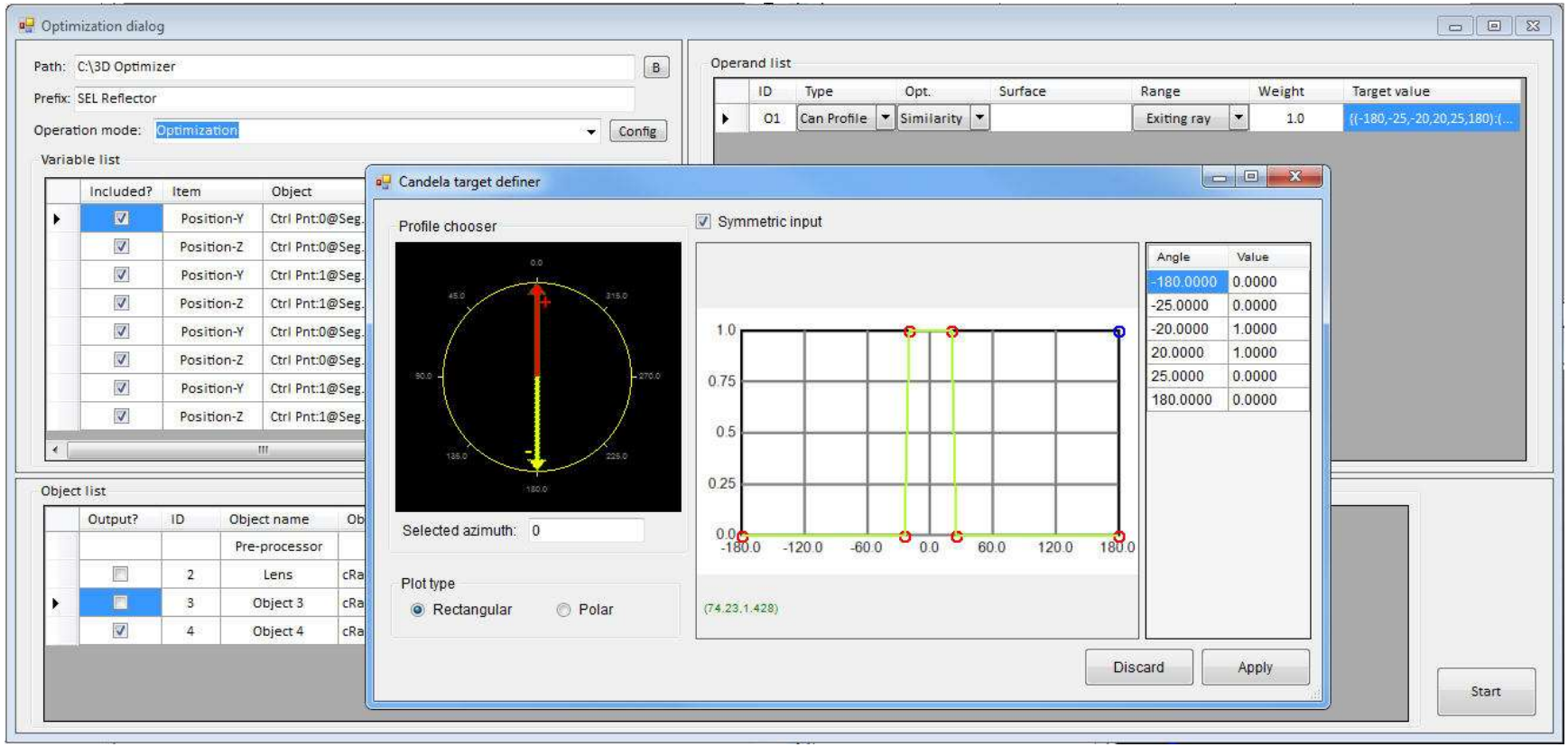
- Reflector set-up for optimization – 2 control points in 2 axes each



TracePro

Side emitting LED lens and reflector combination

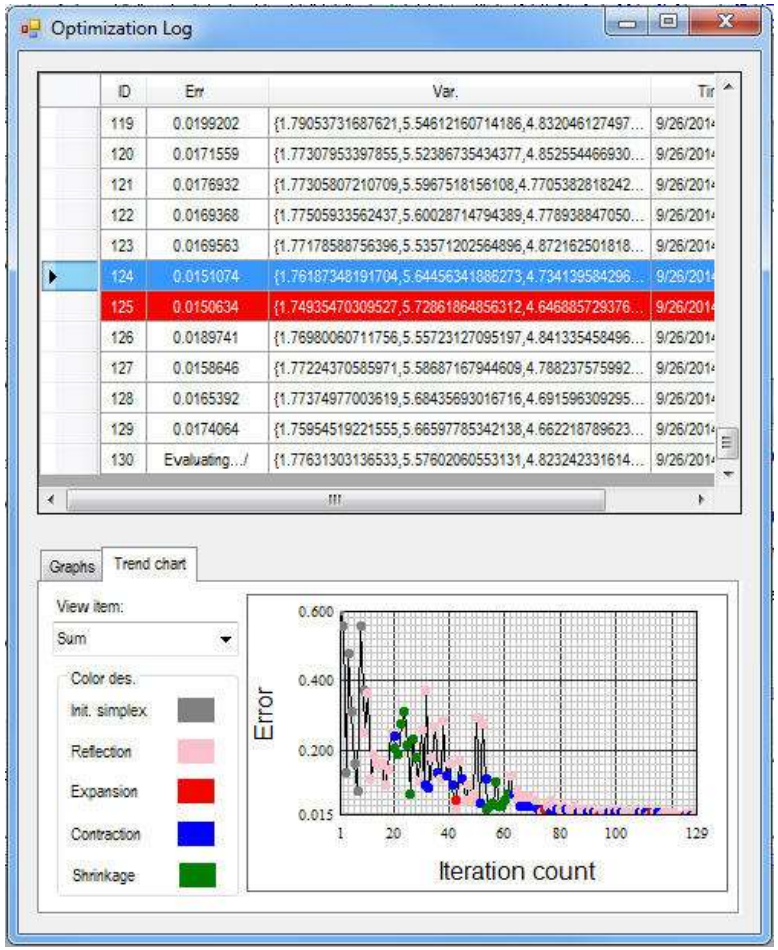
- Optimization Goal – Uniform Candela Profile from +/- 20-degrees falling to zero at +/- 25-degrees



TracePro

Side emitting LED lens and reflector combination

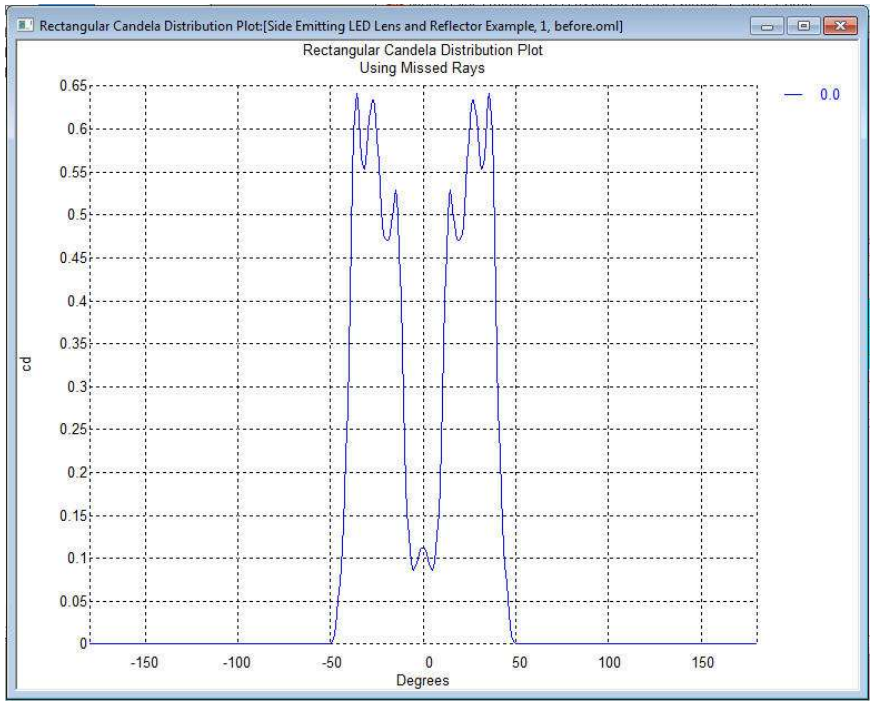
- Optimization Log – 129 iteration



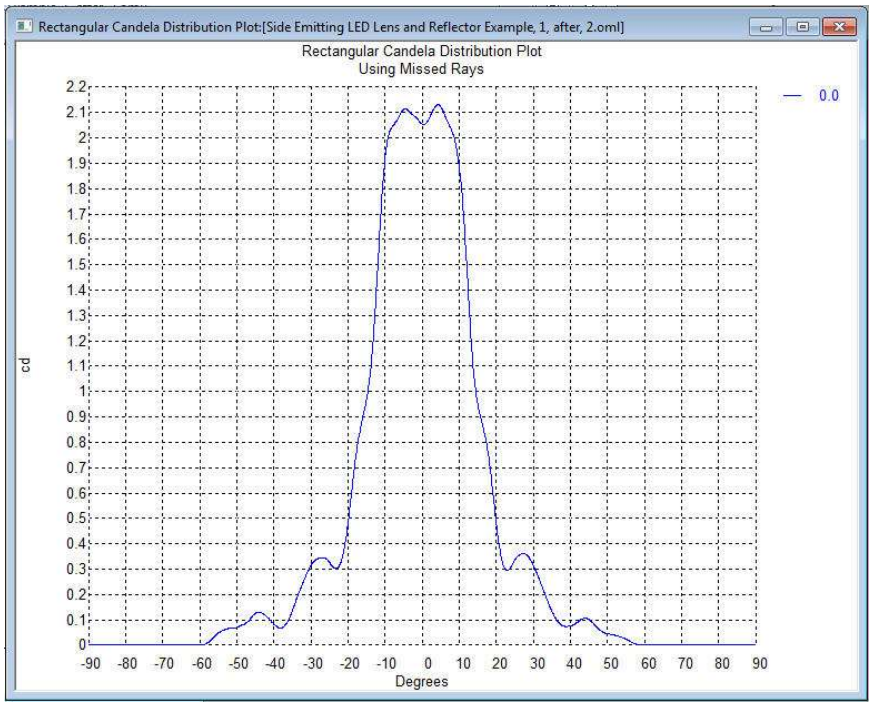
TracePro

Side emitting LED lens and reflector combination

- Candela Profile – before and after optimization



Before optimization

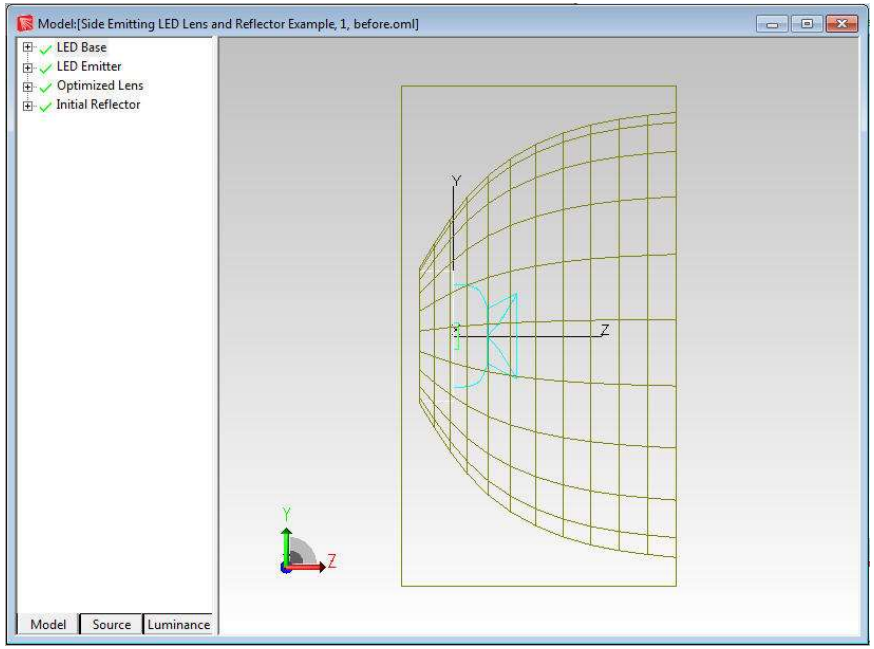


After optimization

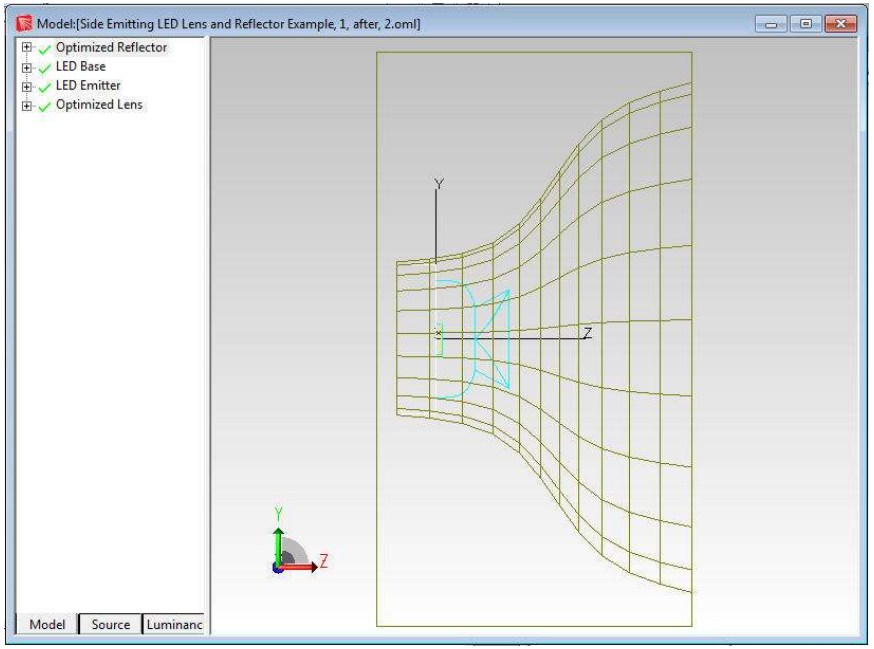
TracePro

Side emitting LED lens and reflector combination

- Reflector Profile – before and after optimization



Before optimization

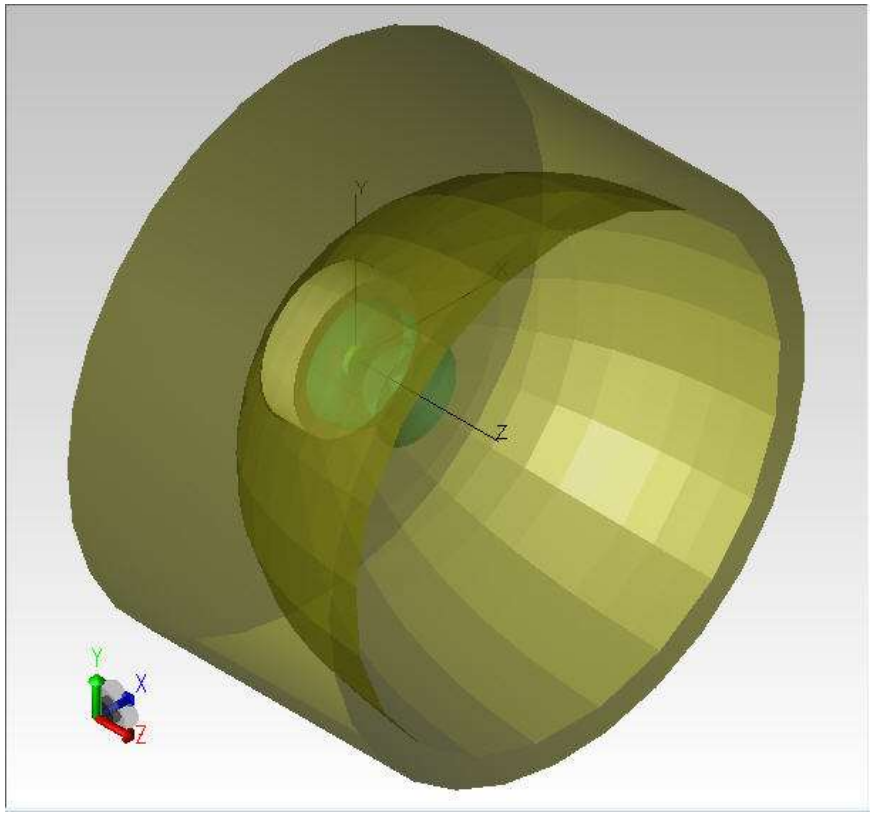


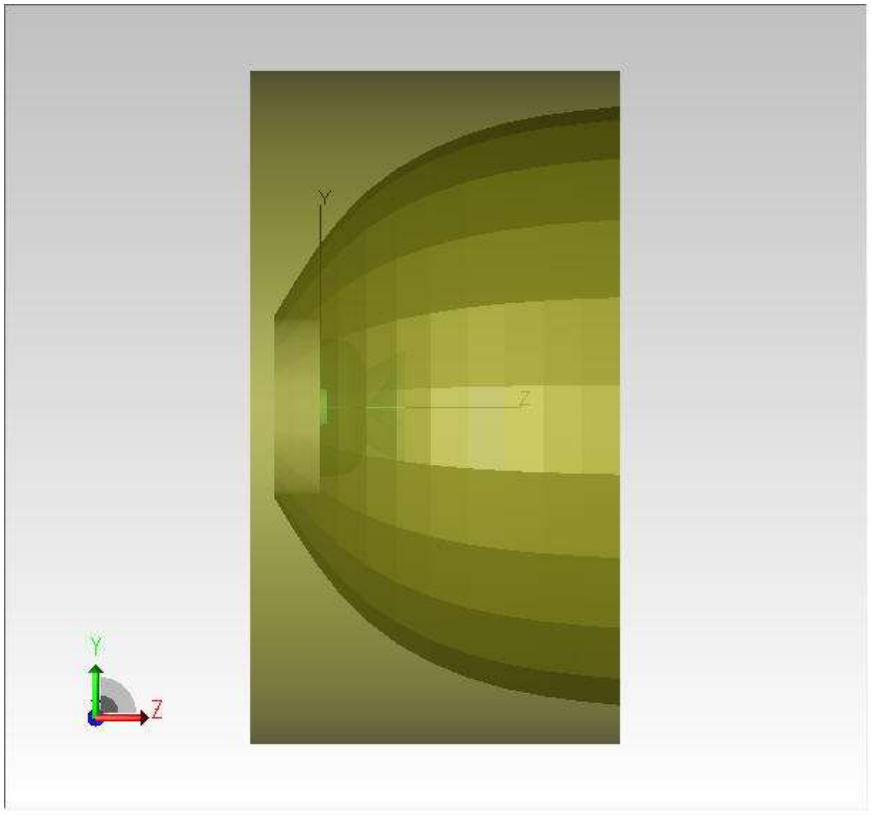
After optimization

TracePro

Side emitting LED lens and reflector combination

- What about optimizing the lens and reflector at the same time?

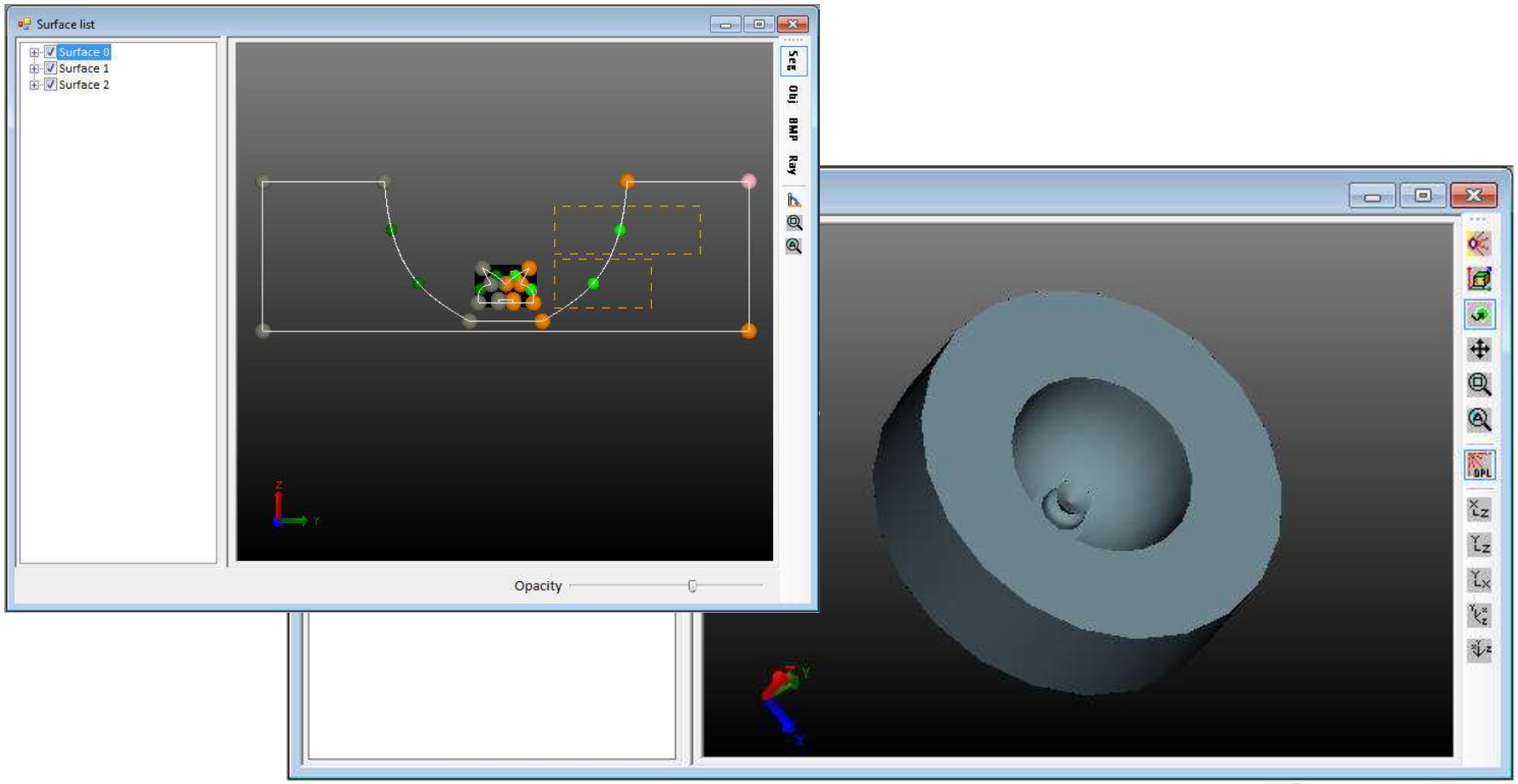




TracePro

Side emitting LED lens and reflector combination

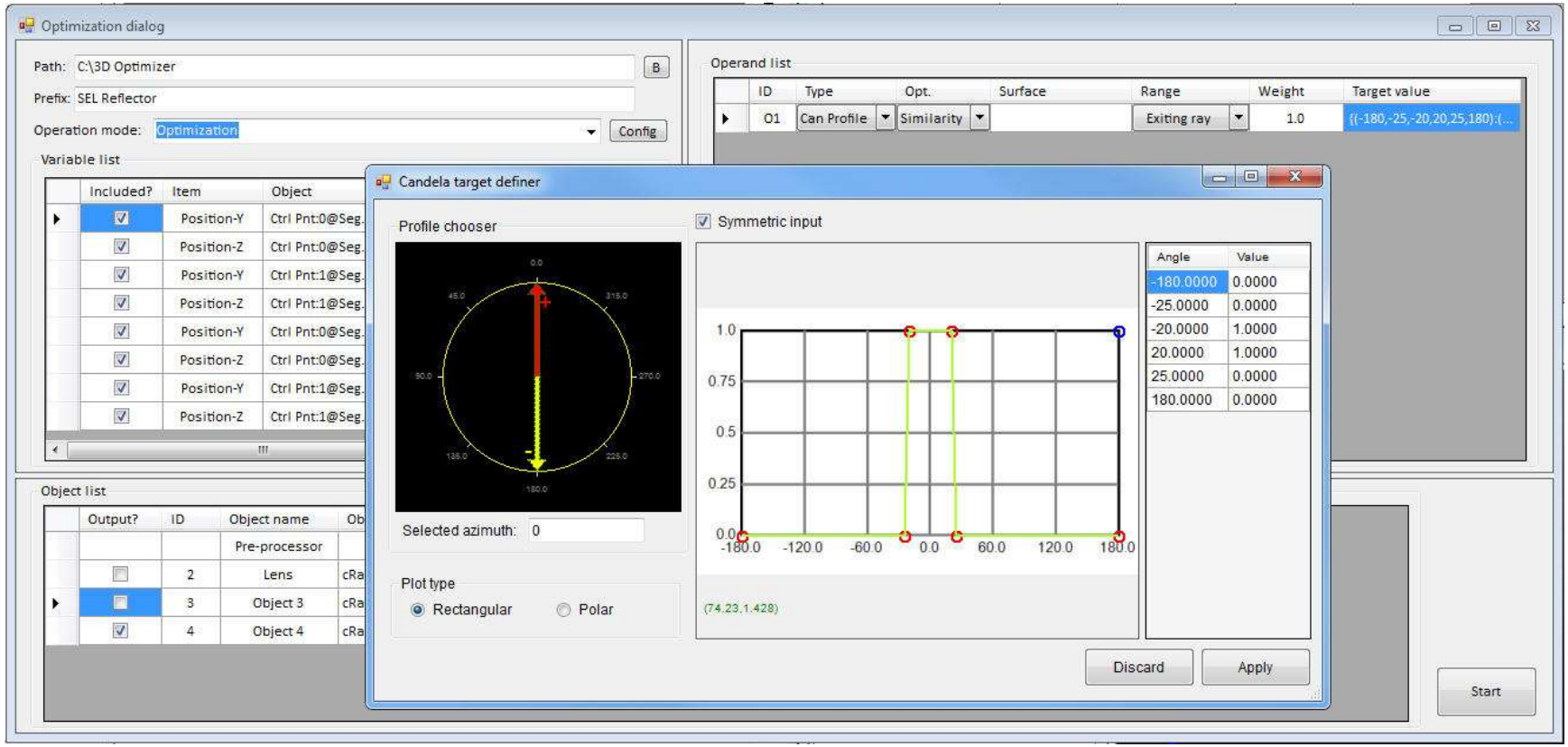
- Setting up the lens and reflector for optimization – 4 control points in 2 axes each



TracePro

Side emitting LED lens and reflector combination

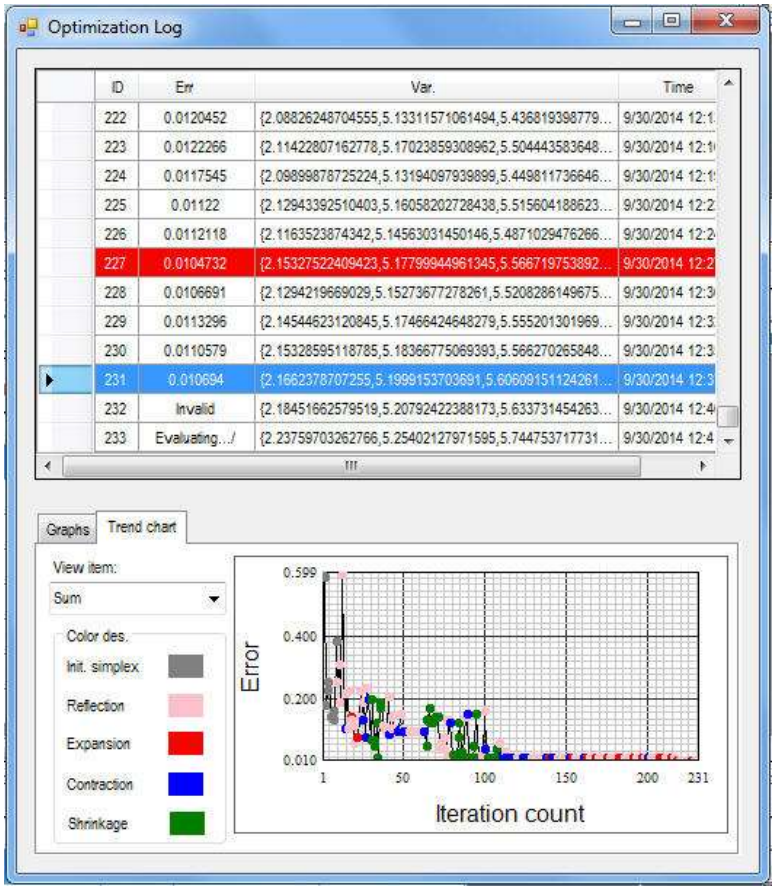
- Optimization Goal – Uniform Candela Profile from +/- 20-degrees falling to zero at +/- 25-degrees



TracePro

Side emitting LED lens and reflector combination

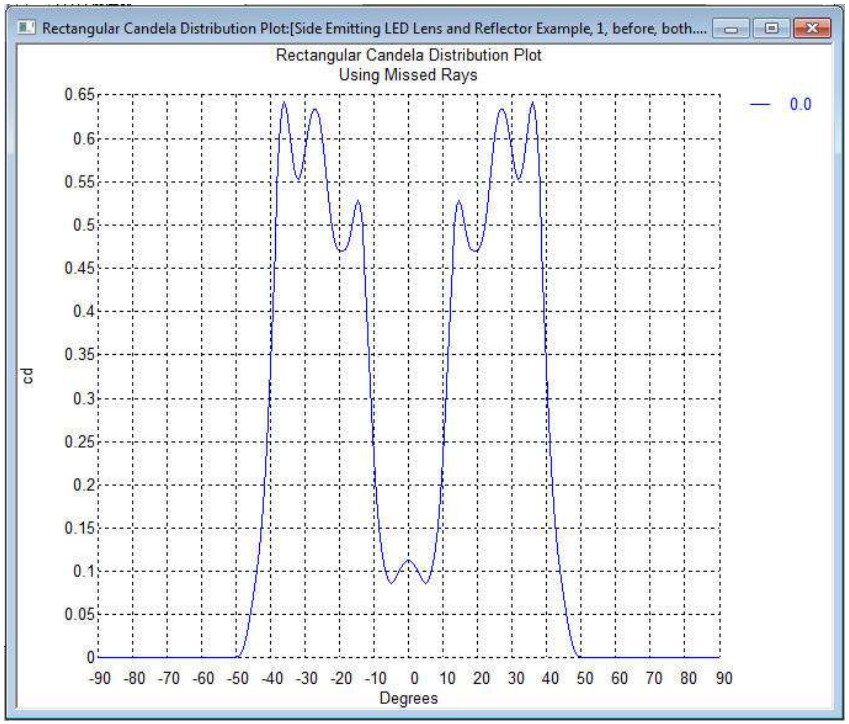
- Optimization Log – combined optimization – 231 iterations



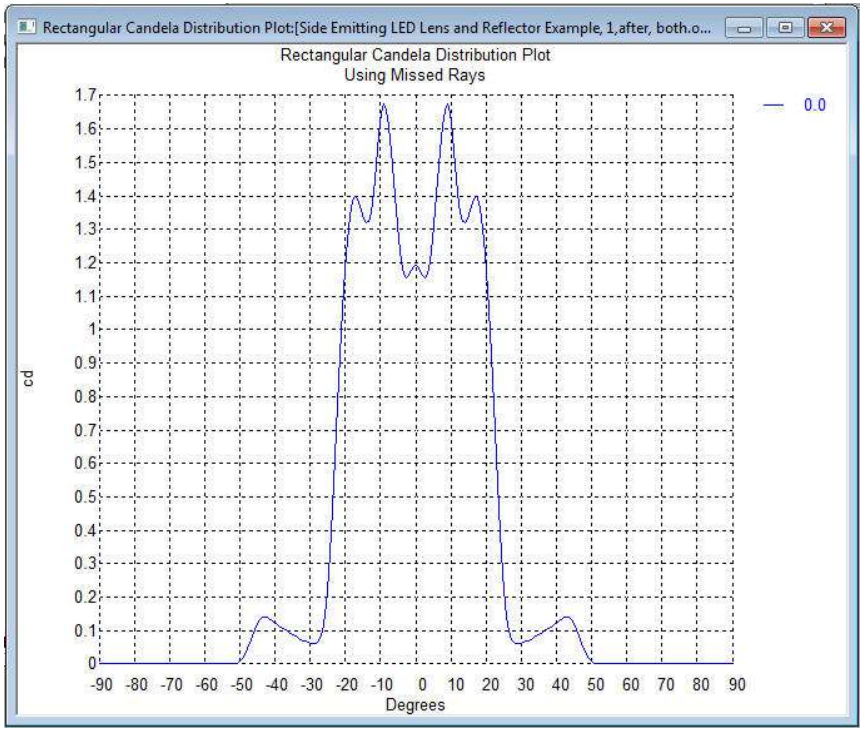
TracePro

Side emitting LED lens and reflector combination

- Candela Profile – before and after combined optimization



Before optimization

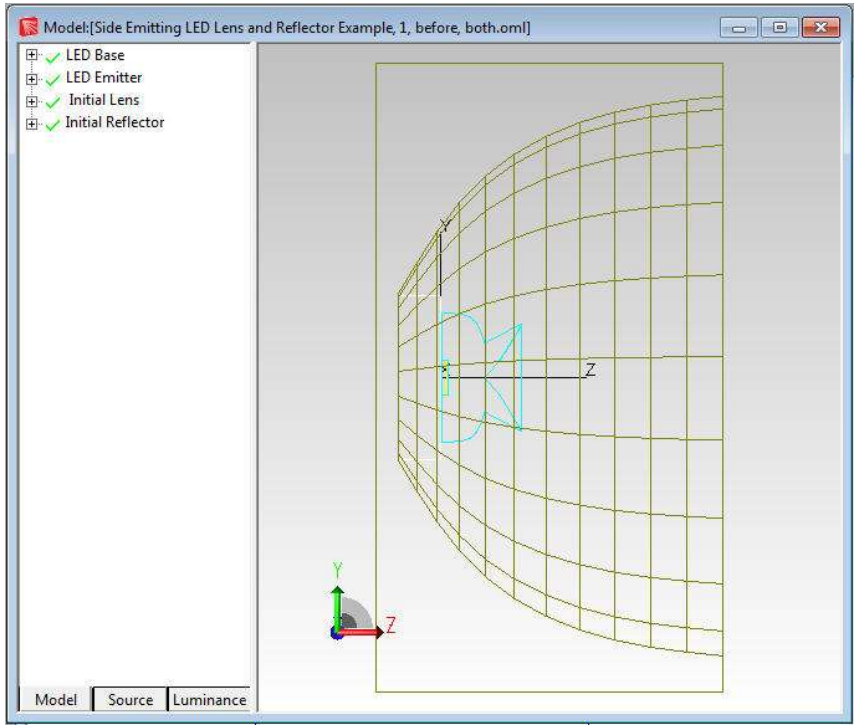


After optimization

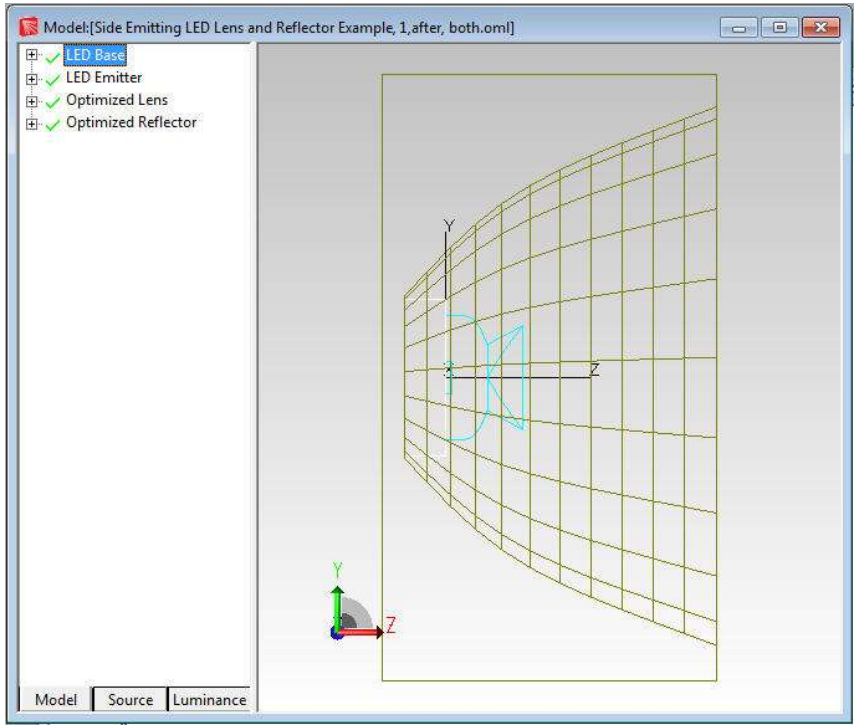
TracePro

Side emitting LED lens and reflector combination

- Lens and Reflector Profiles – before and after combined optimization



Before optimization

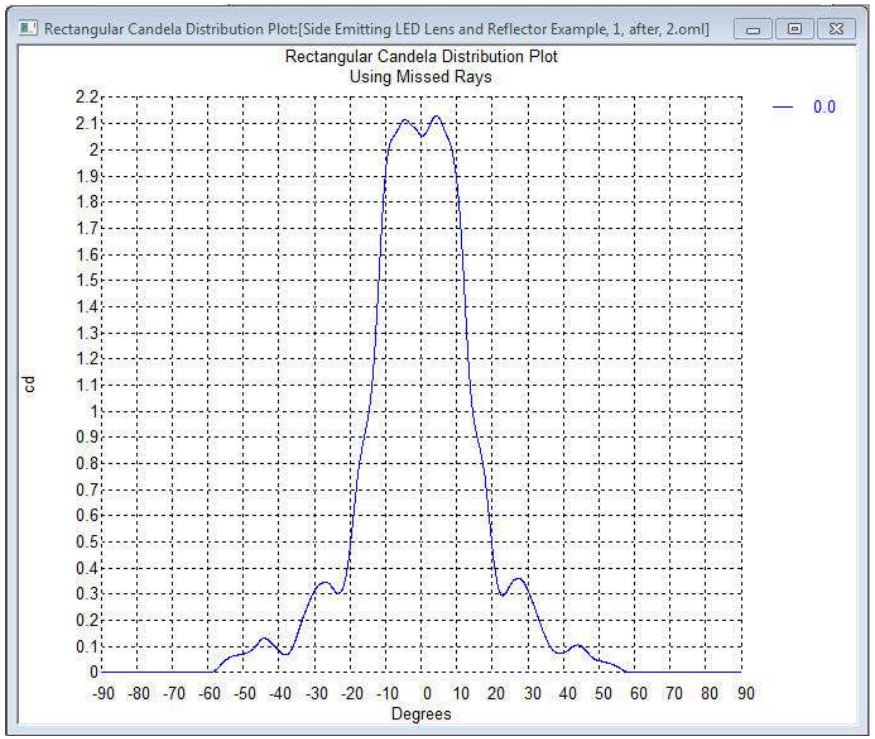


After optimization

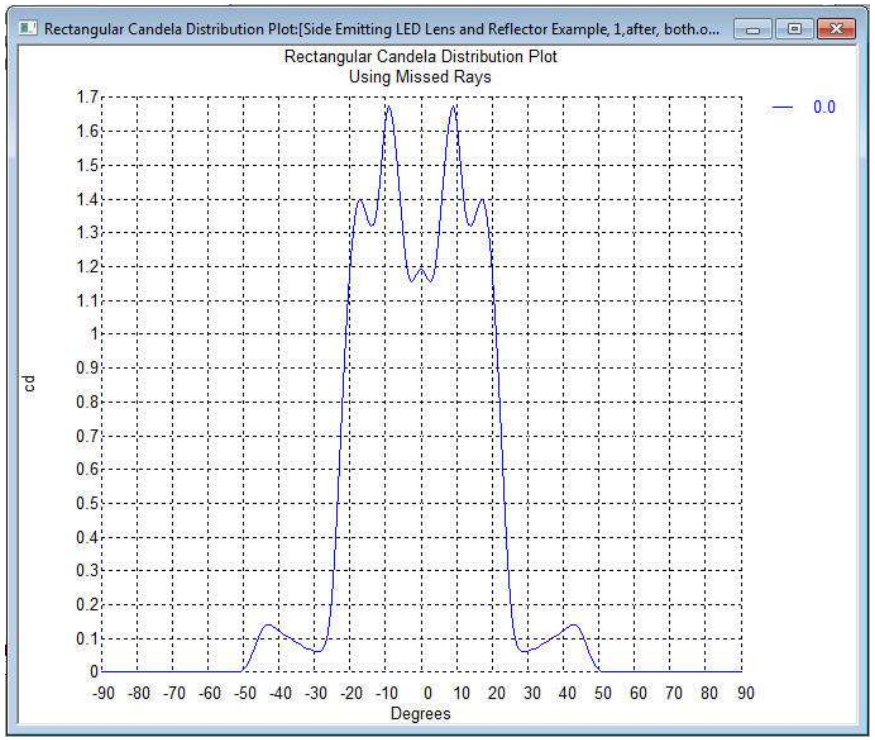
TracePro

Side emitting LED lens and reflector combination

- Candela Profile – 2 different optimization procedures



Separate optimization

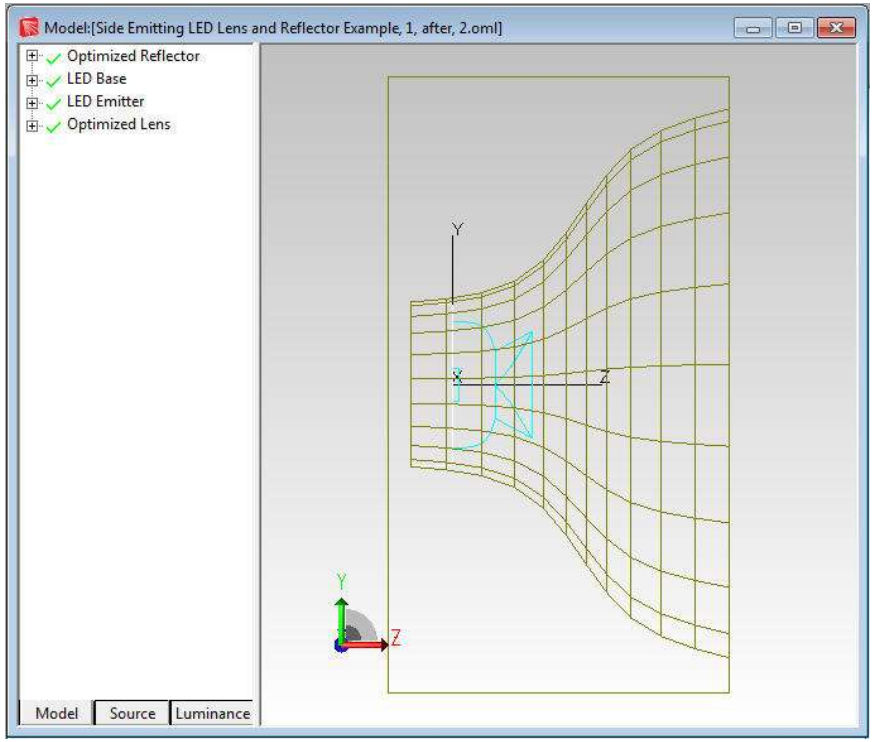


Combined optimization

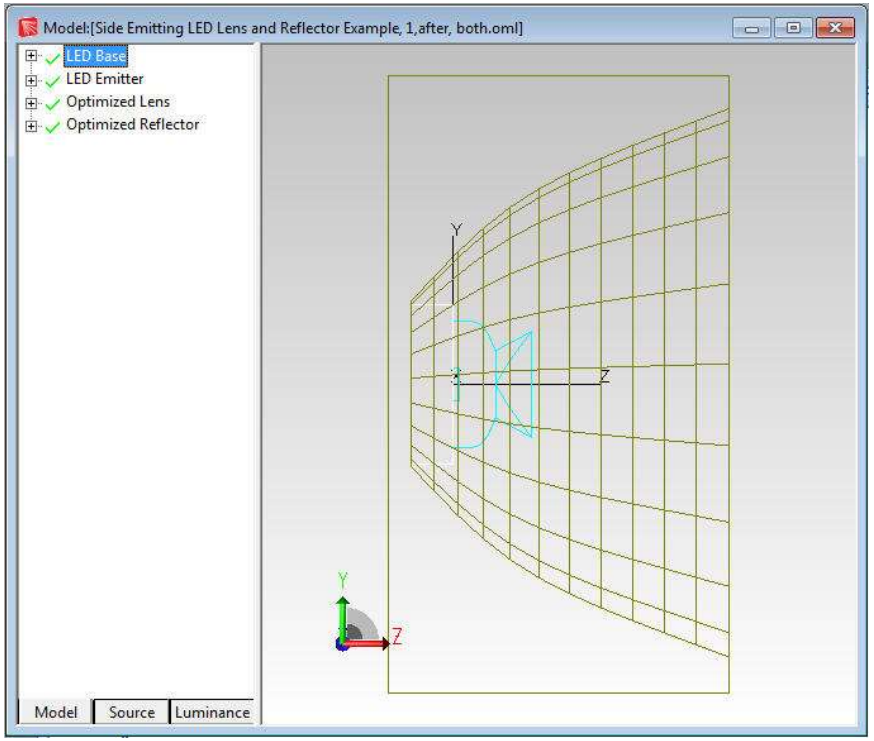
TracePro

Side emitting LED lens and reflector combination

- Lens and Reflector Profiles – 2 different optimization procedures



Separate optimization

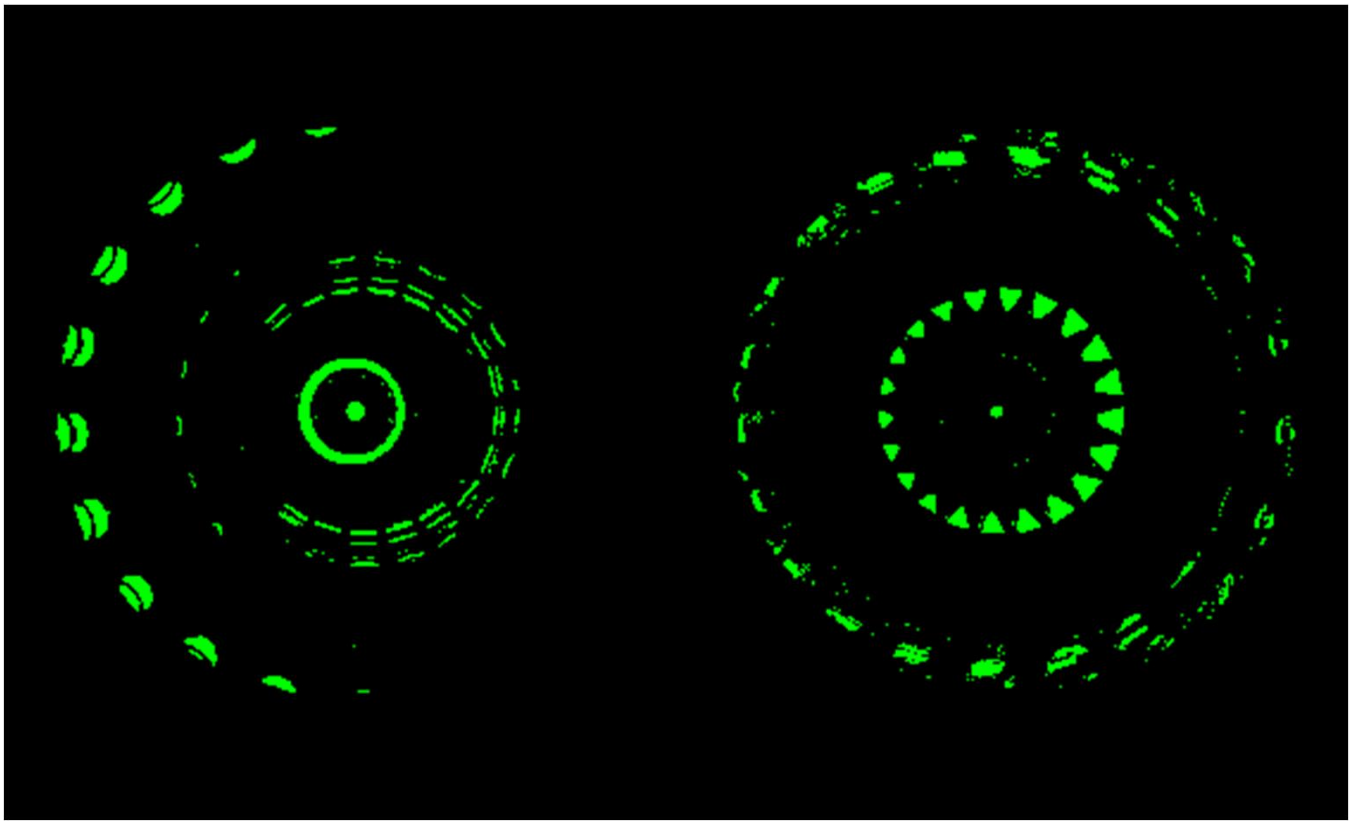


Combined optimization

TracePro

Side emitting LED lens and reflector combination

- Photorealistic Rendering – 2 different optimization procedures

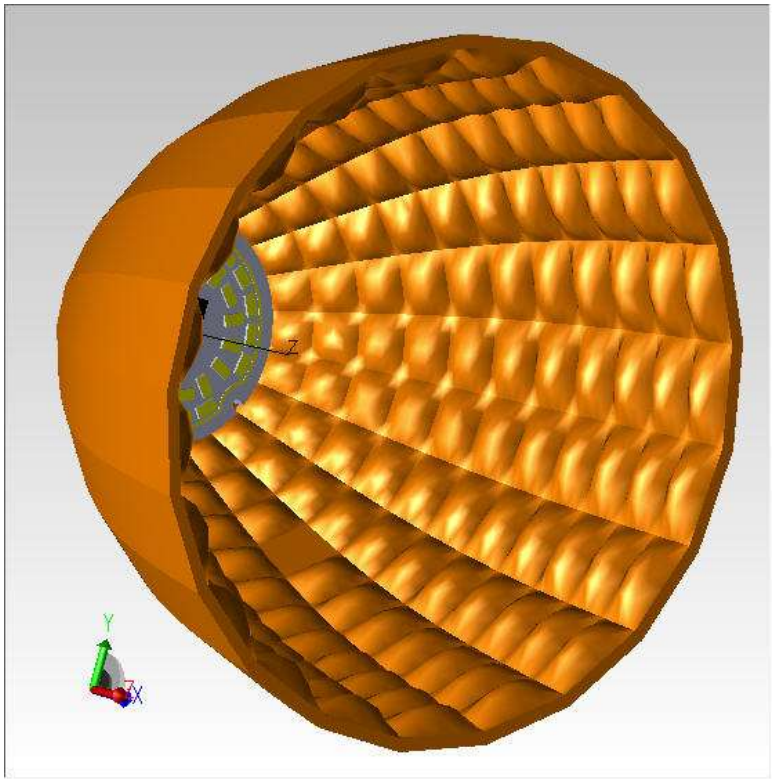


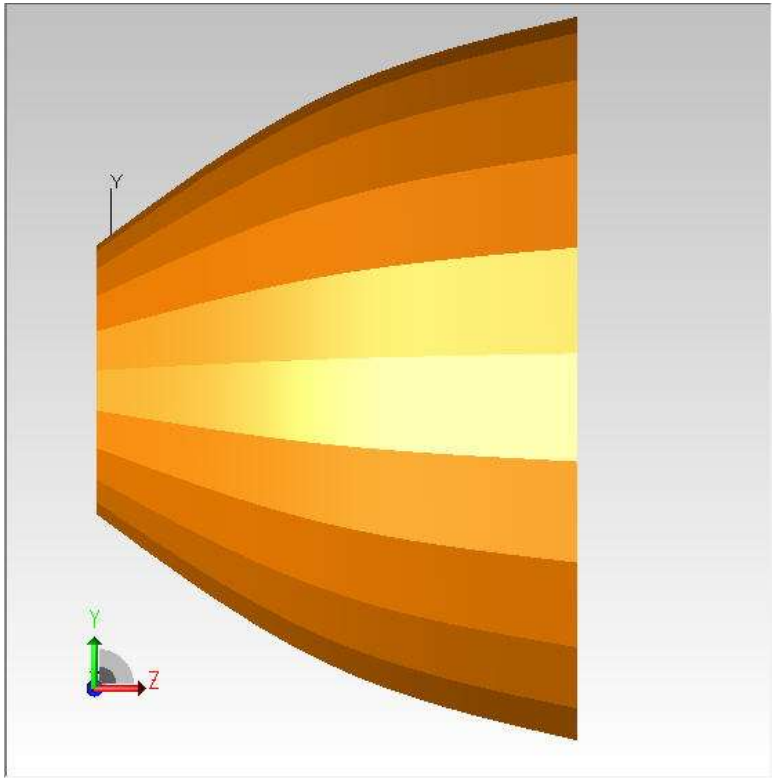
Combined optimization Separate optimization

TracePro

Curved facet reflector

- Reflector with curved facet optimization. Making multiple prototypes of a reflector like this could be quite expensive.

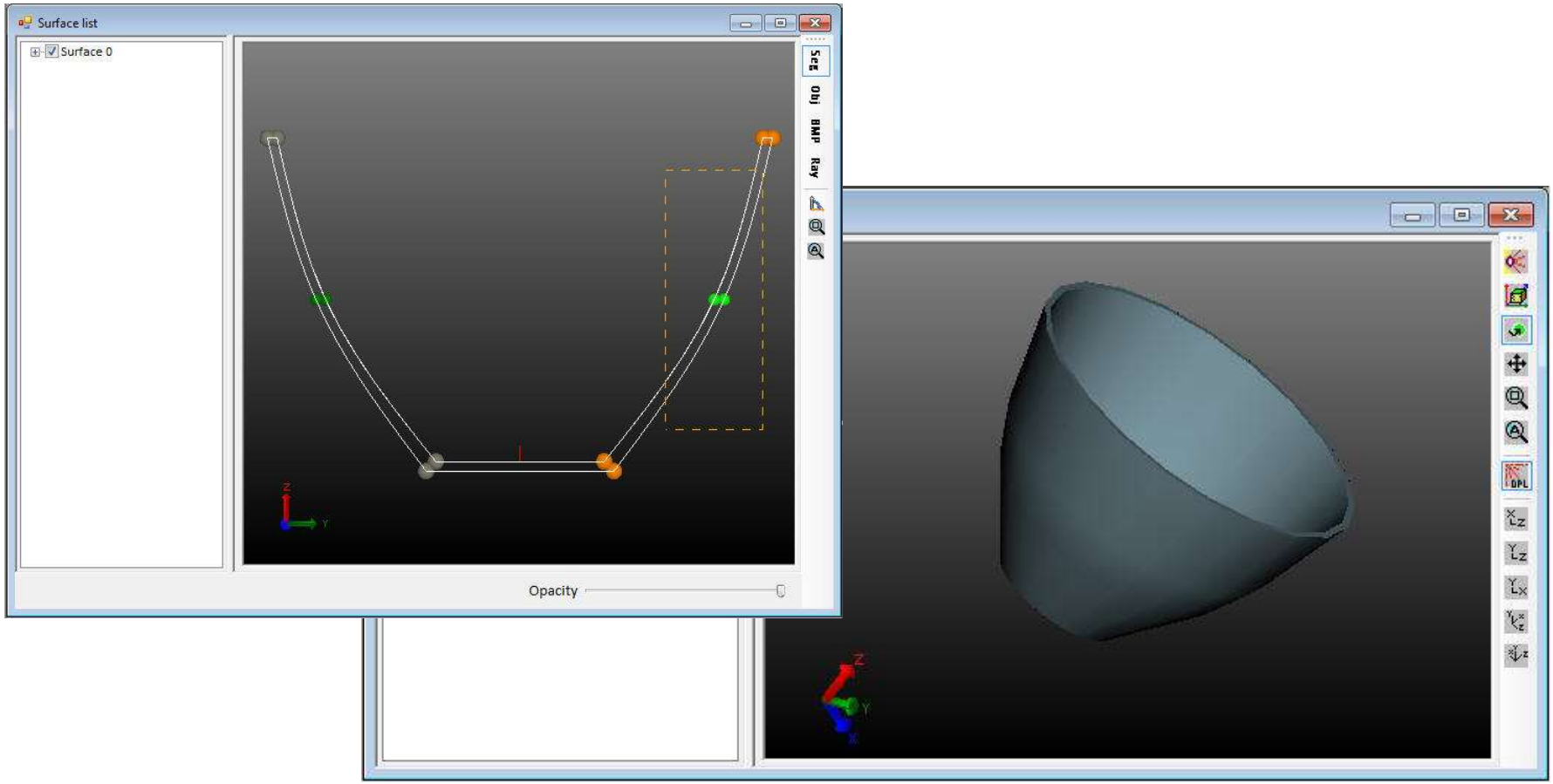




TracePro

Curved facet reflector

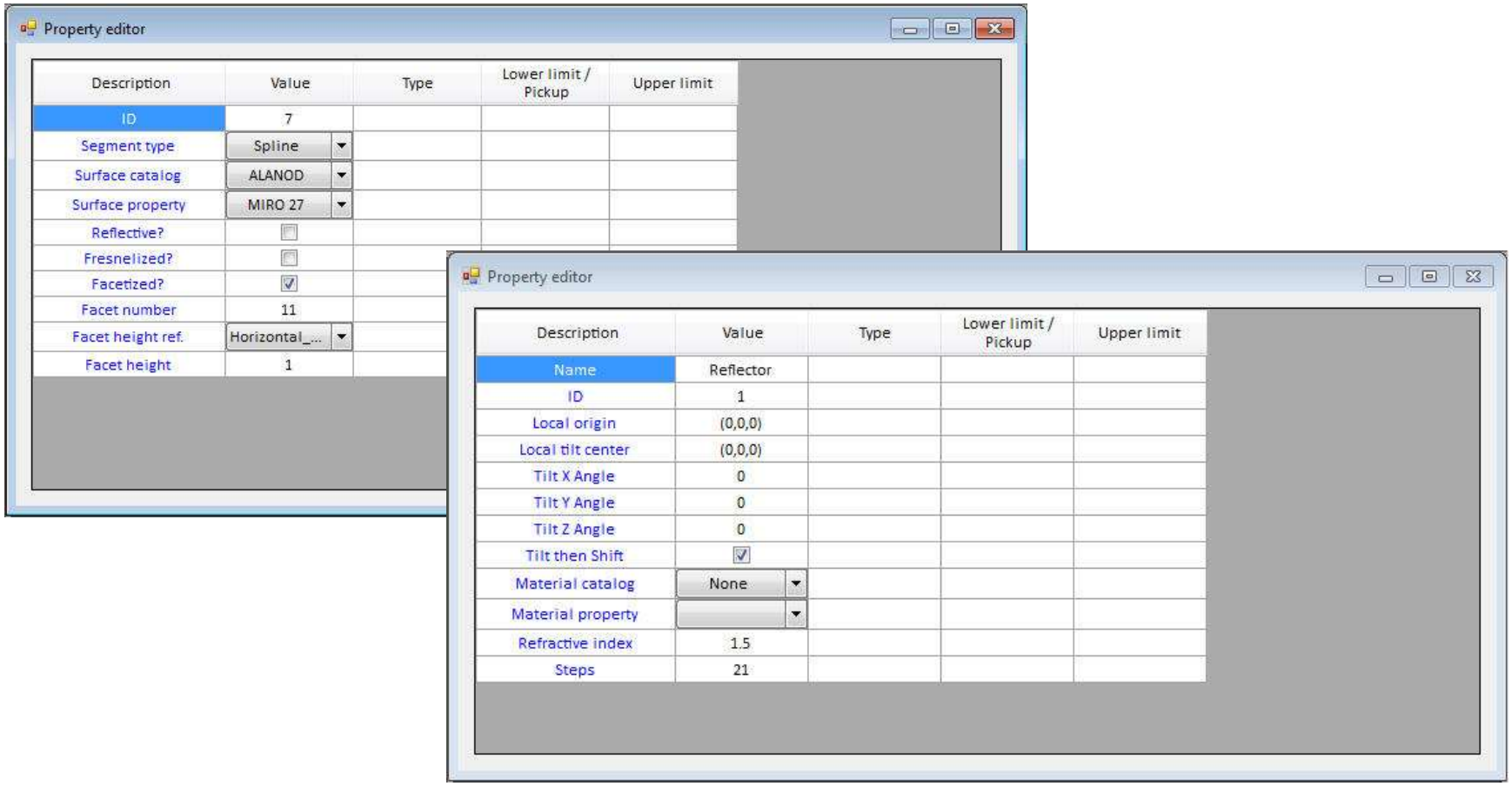
- Defining the initial reflector profile and the variables for the optimization process.



TracePro

Curved facet reflector

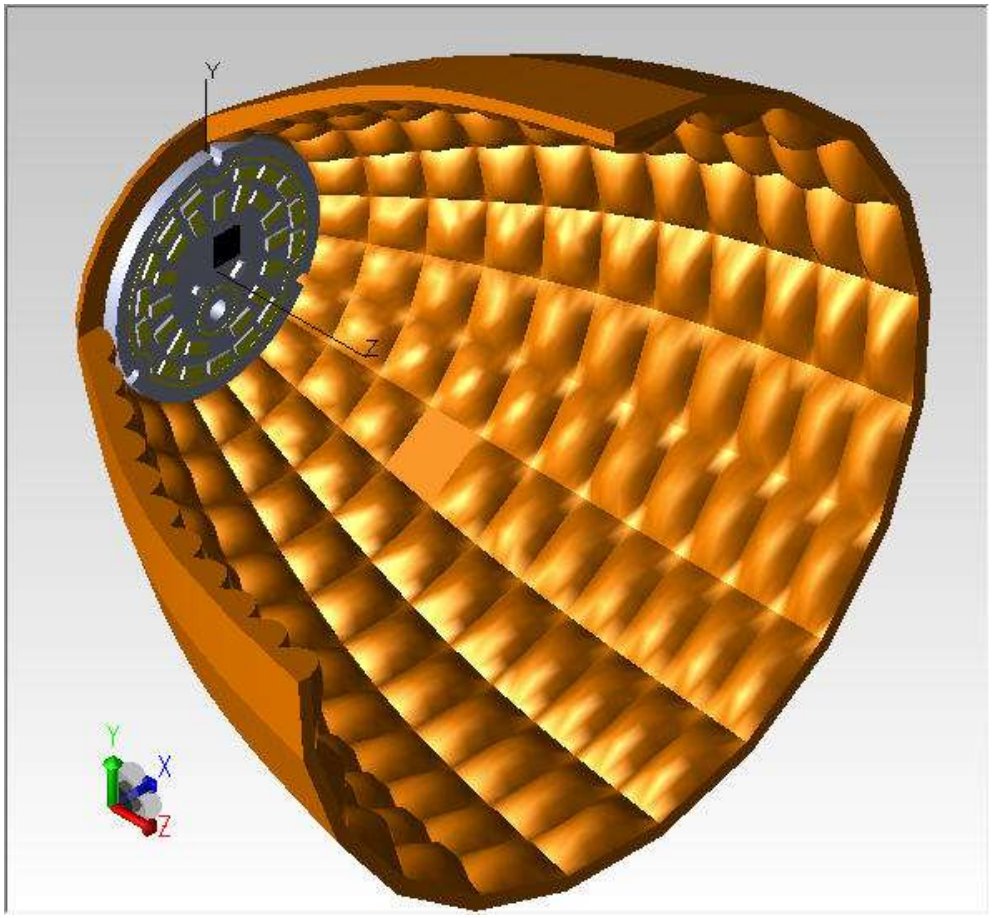
- Defining the curved facets. 11 vertical facets and 21 radial facets with a convex curvature.



TracePro

Curved facet reflector

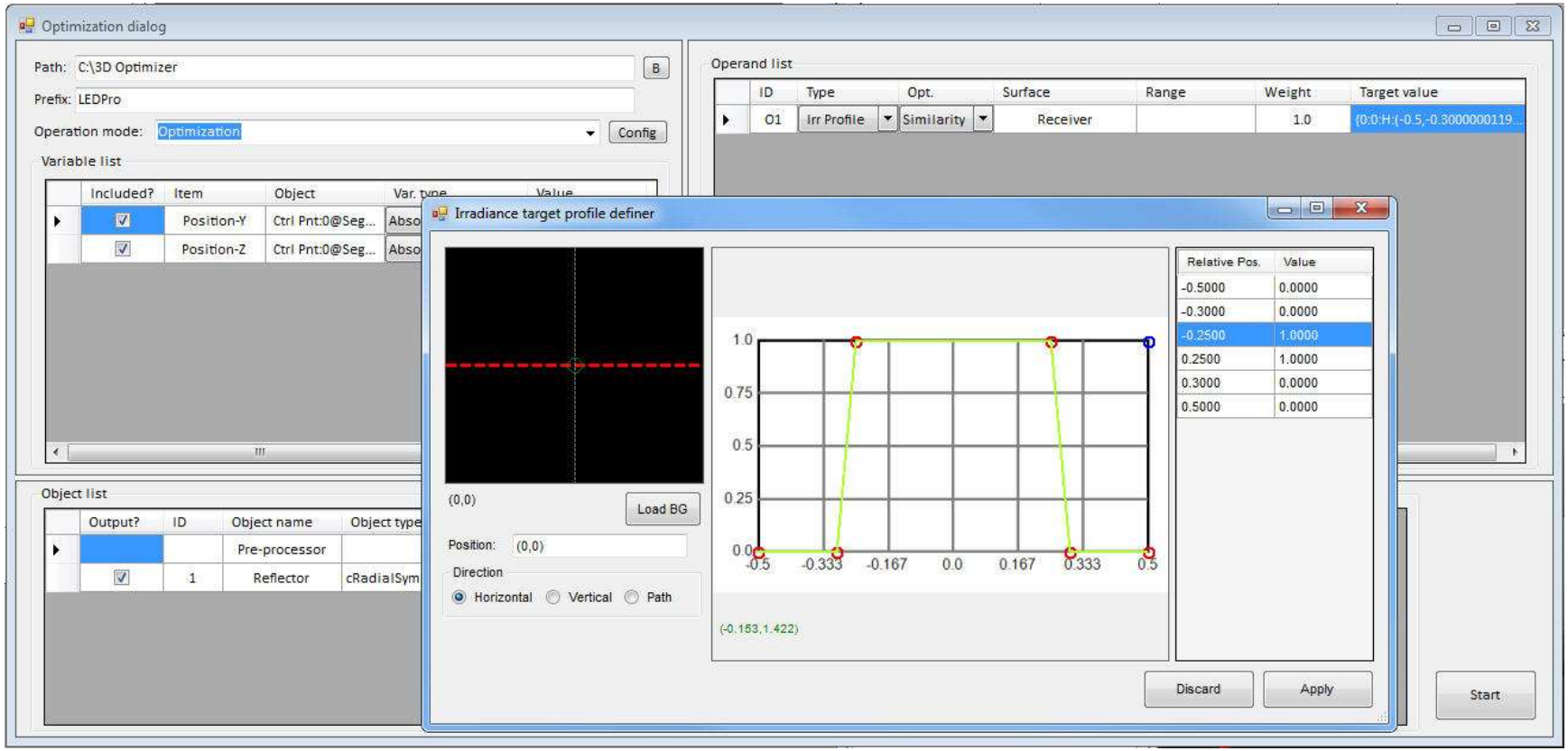
- LED source model – LED array modeled using a 3D solid model and a Surface Source Property



TracePro

Curved facet reflector

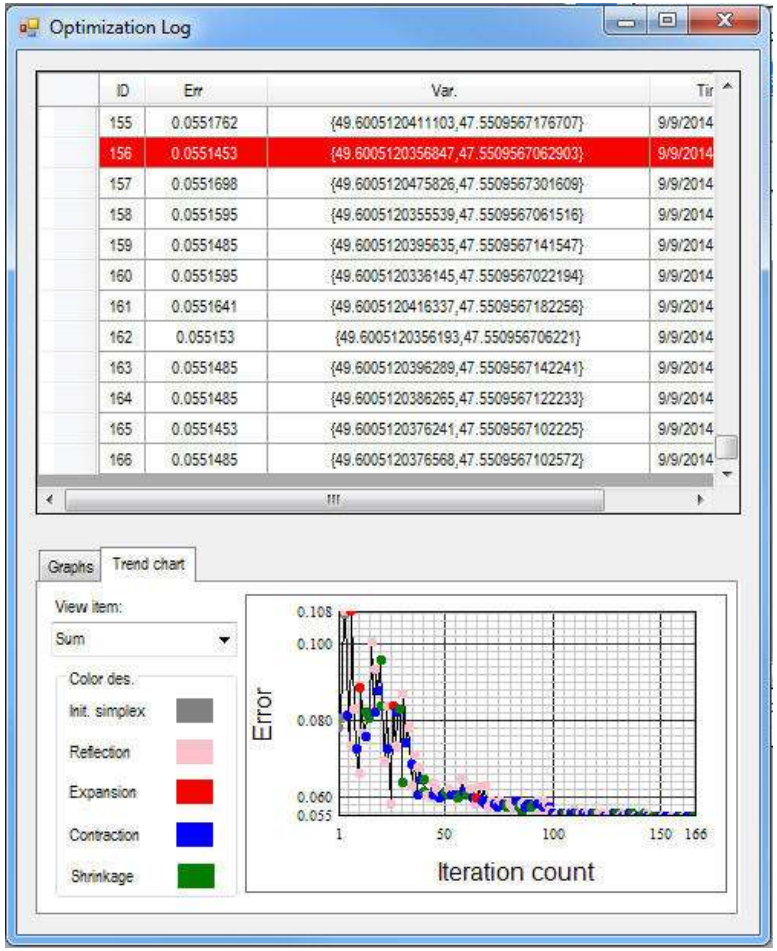
- Optimization Goal - flat irradiance profile across the central 2/3 portion of the target surface



TracePro

Curved facet reflector

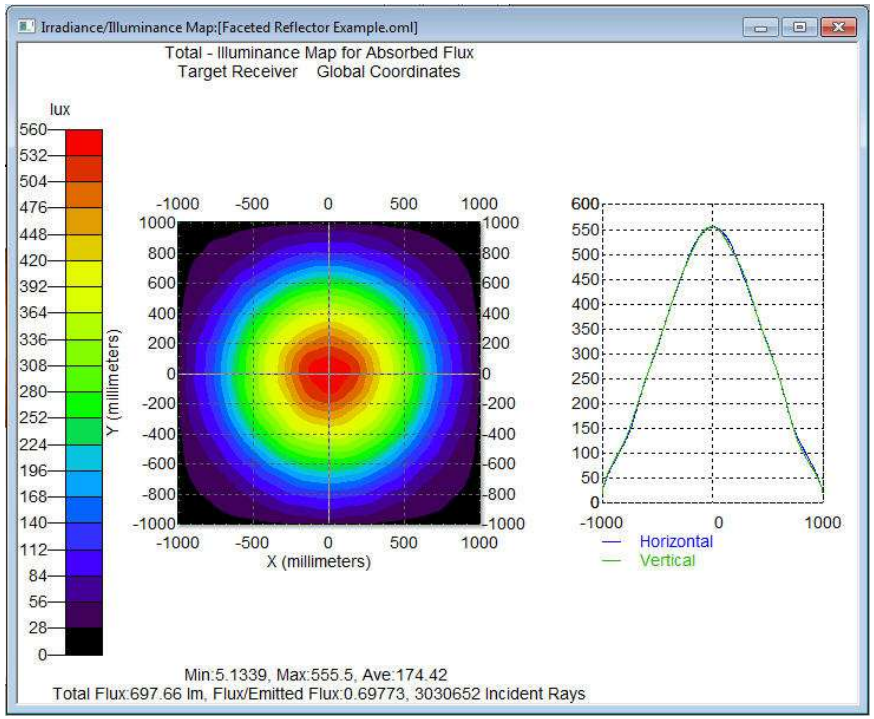
- Optimization Log – 166 iterations

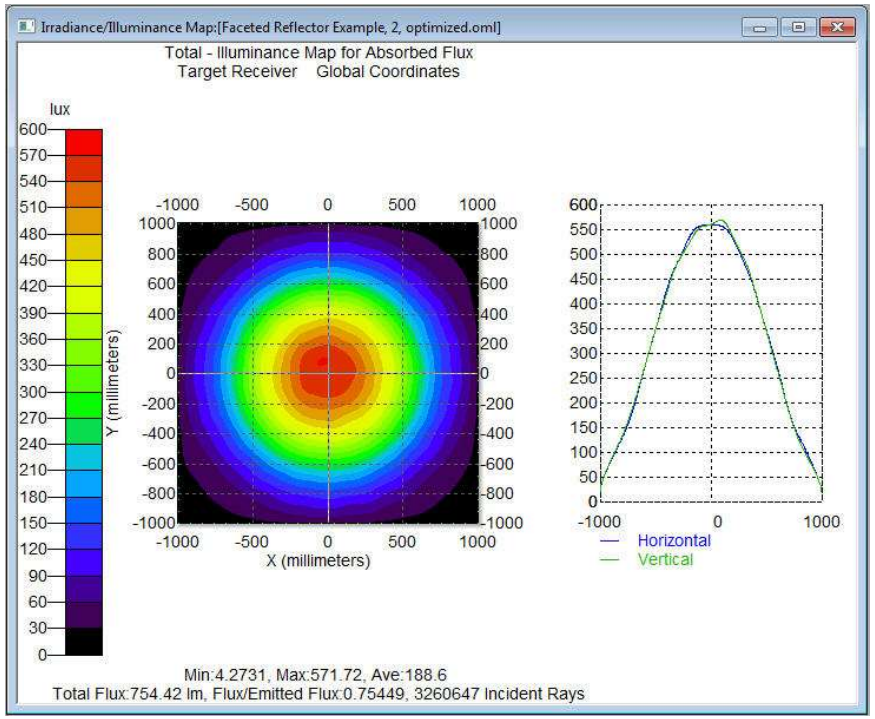


TracePro

Curved facet reflector

- Illuminance Map – Before and after optimization





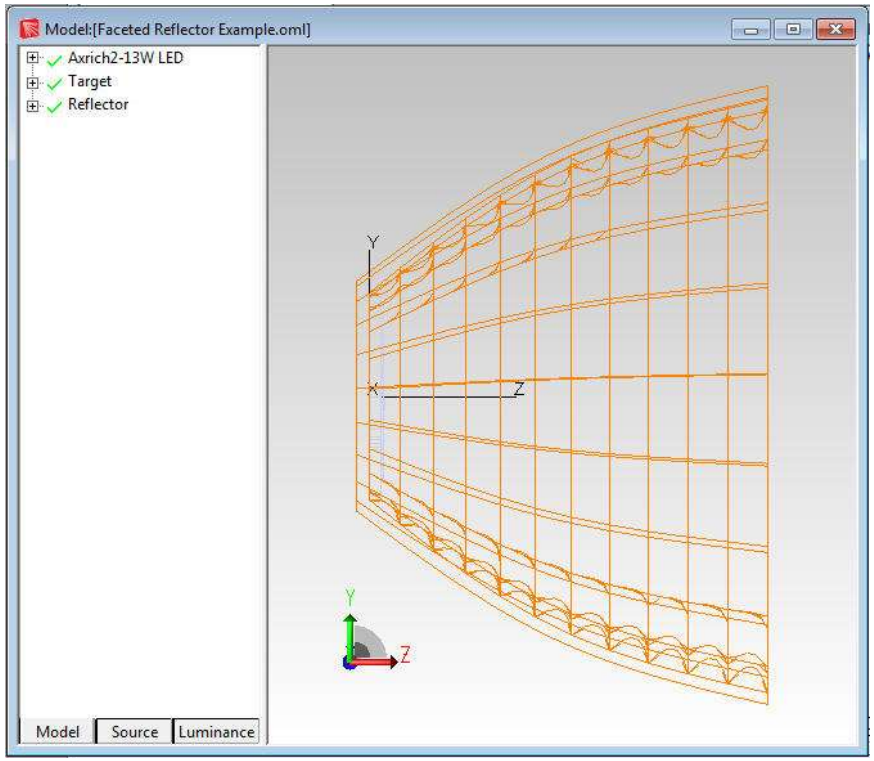
Before optimization

After optimization

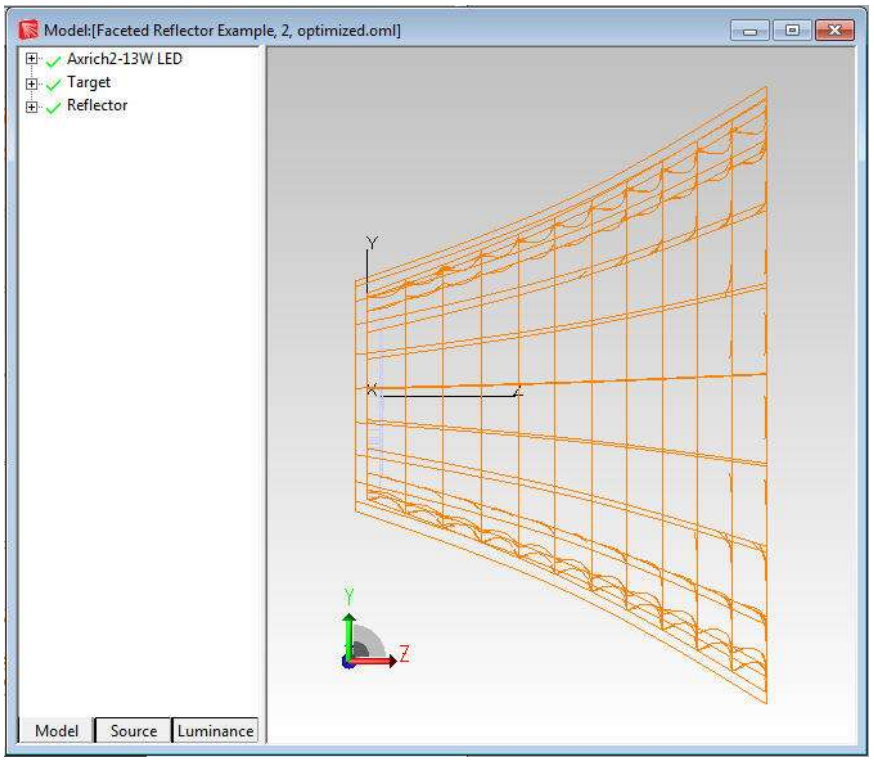
TracePro

Curved facet reflector

- Reflector Profile – Before and after optimization



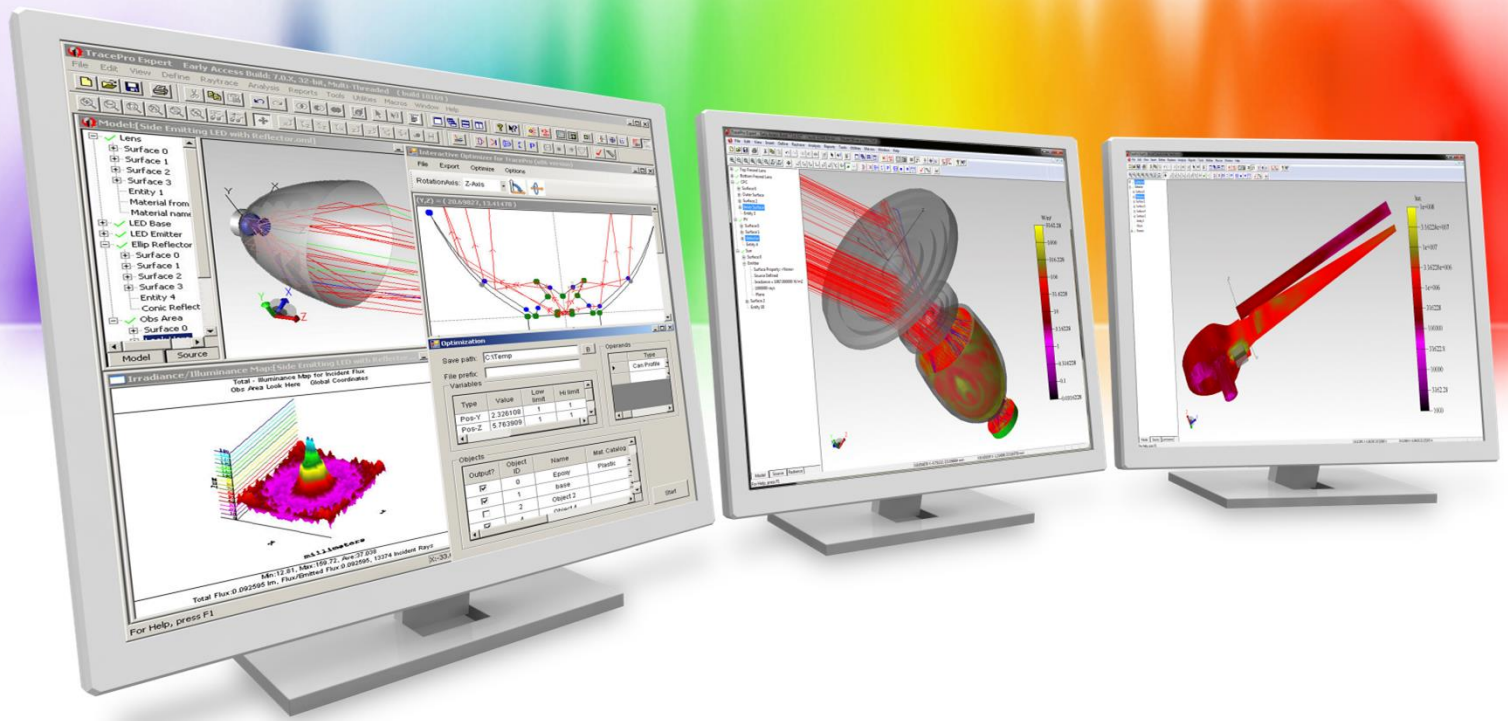
Before optimization



After optimization

TracePro

TracePro



Summary and Questions

LAMBDA RESEARCH CORPORATION

Summary and Questions

Virtual prototyping of luminaire designs using optical design and analysis software allows for:

- ✓ Faster more efficient design process
- ✓ Better designs when compared with a trial and error process
- ✓ Ability to try multiple designs for minimal extra cost
- ✓ Fast and easy analysis of potential designs
- ✓ Lower development cost

For more information or to sign up for our free 30-day trial please visit us at:

www.lambdares.com

Phone: +1 978-486-0766 E-mail: sales@lambdares.com

TracePro