

LED LUMINAIRE DESIGN: OPTIMIZATION AND ANALYSIS

LED Professional Magazine Webinar

May 7, 2014

Presenter

- Dave Jacobsen

Senior Application Engineer at Lambda Research Corporation for over 5 years. Prior to that 20+ years at PerkinElmer, formerly EG&G, as a Principal Optical Engineer working with xenon light sources and systems.



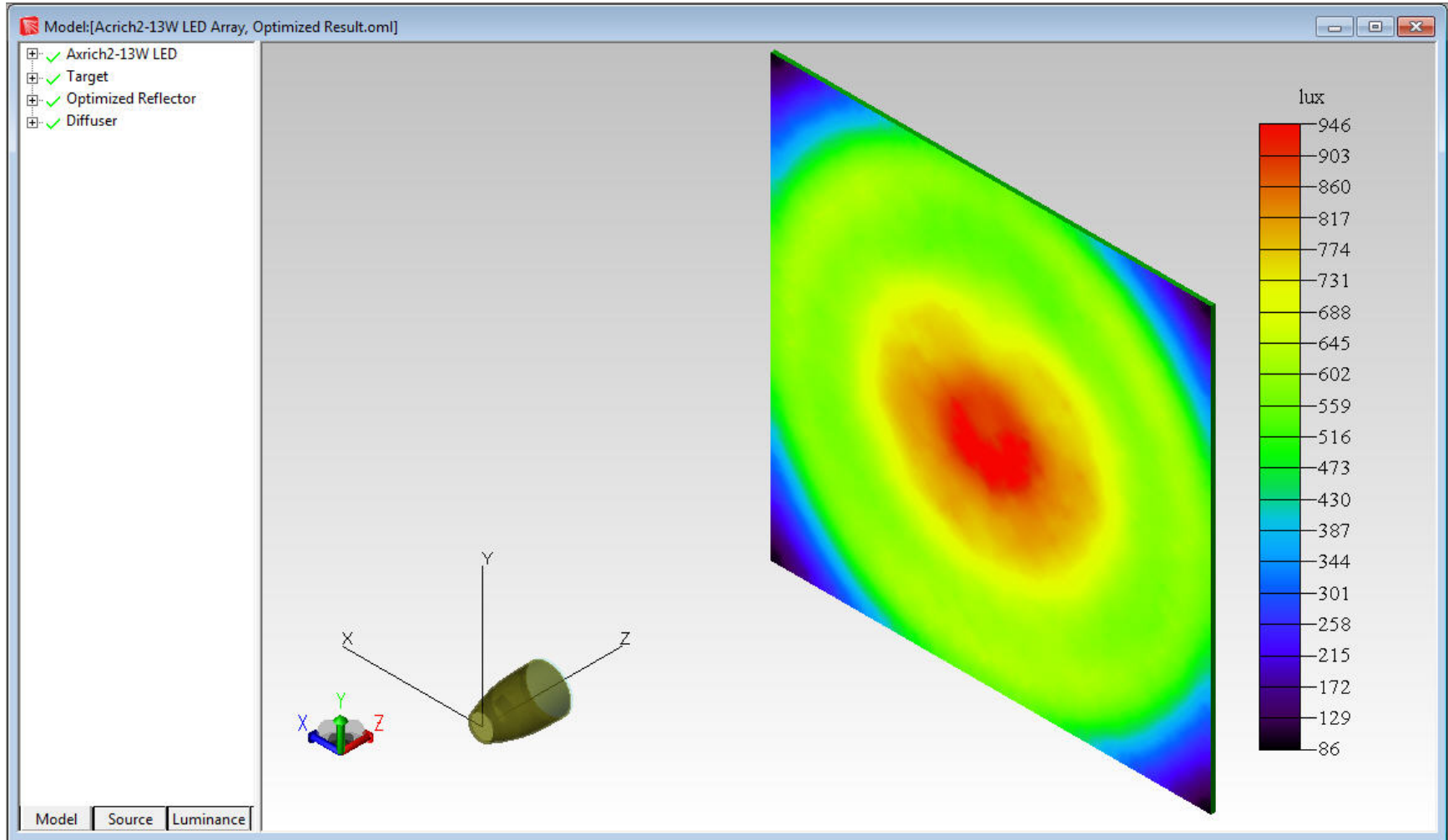
- Lambda Research Corporation

Celebrating our 21st year. Makers of TracePro, TracePro Bridge for SolidWorks, and OSLO optical design and analysis software.

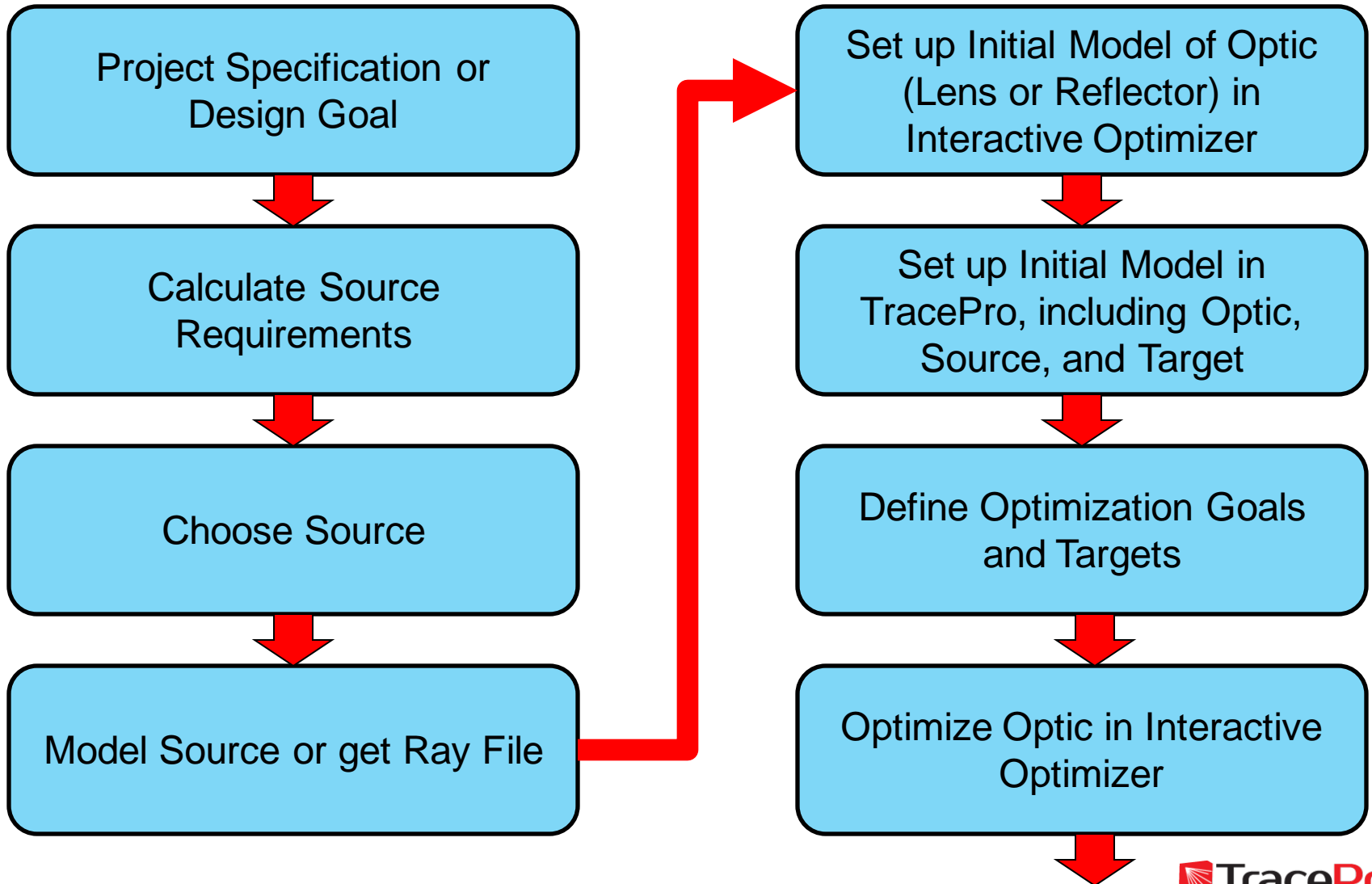
Agenda

- Designing LED lighting systems using SolidWorks and the TracePro Bridge for SolidWorks
- Making a LED property source property using the information from an LED datasheet
- Setting up and defining a 3D optical model for analysis and optimization
- Optimization methods
- Reflector optimization
- Diffuser optimization
- Creating IES files from the raytrace results
- Photorealistic rendering

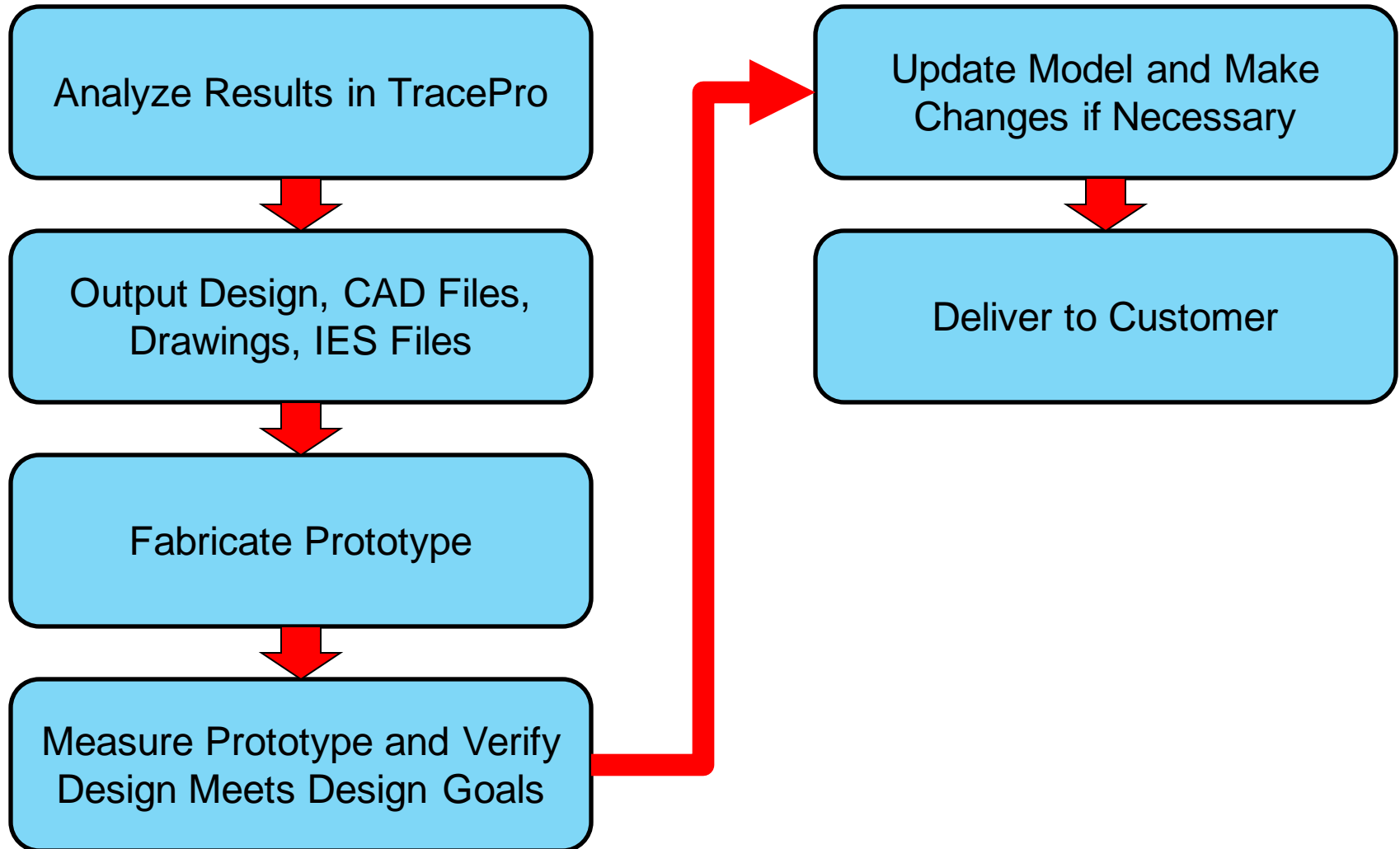
The Goal – Design and Optimize a LED reflector and diffuser combination



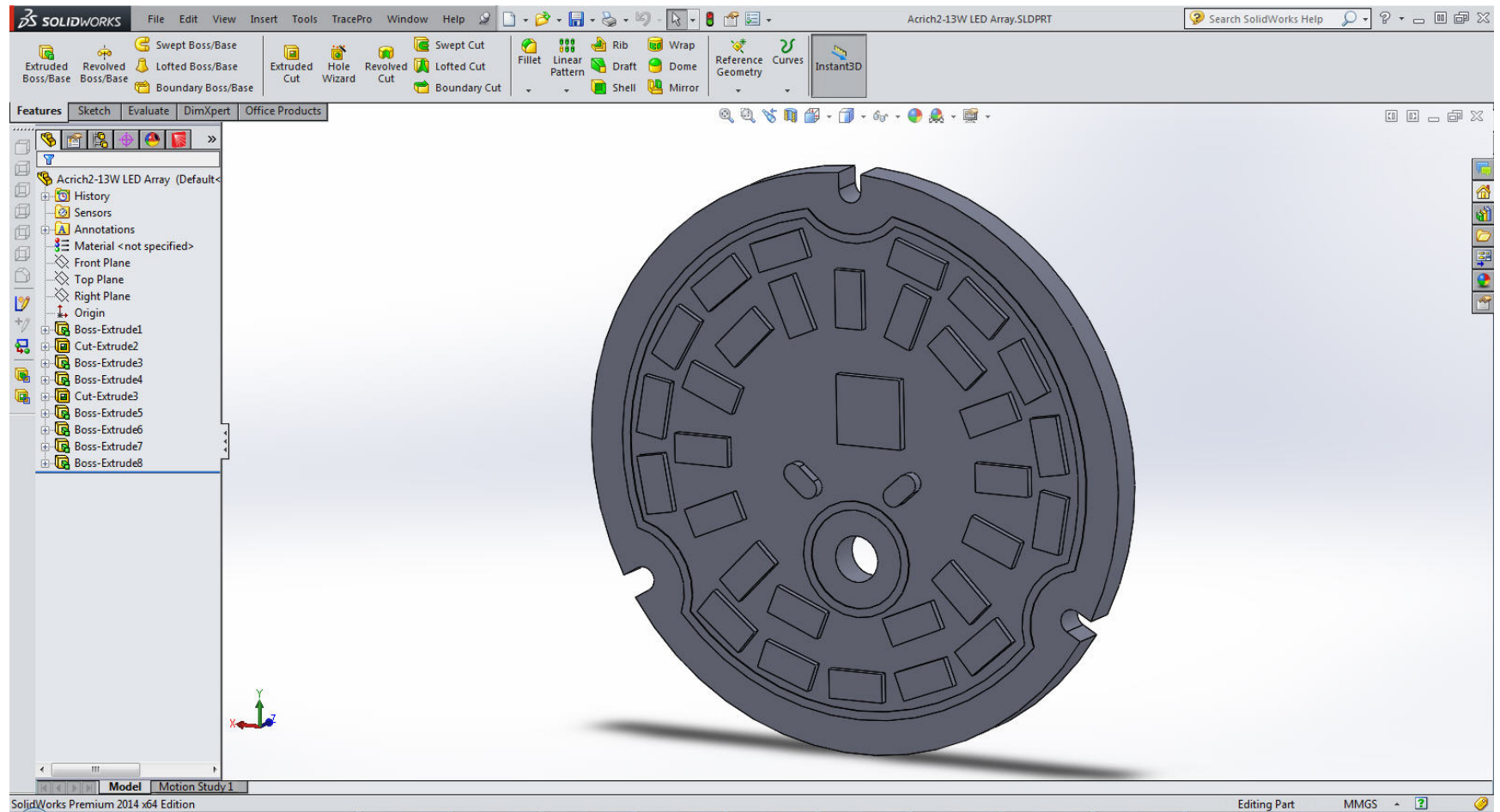
LED Luminaire Design Process – Typical Workflow



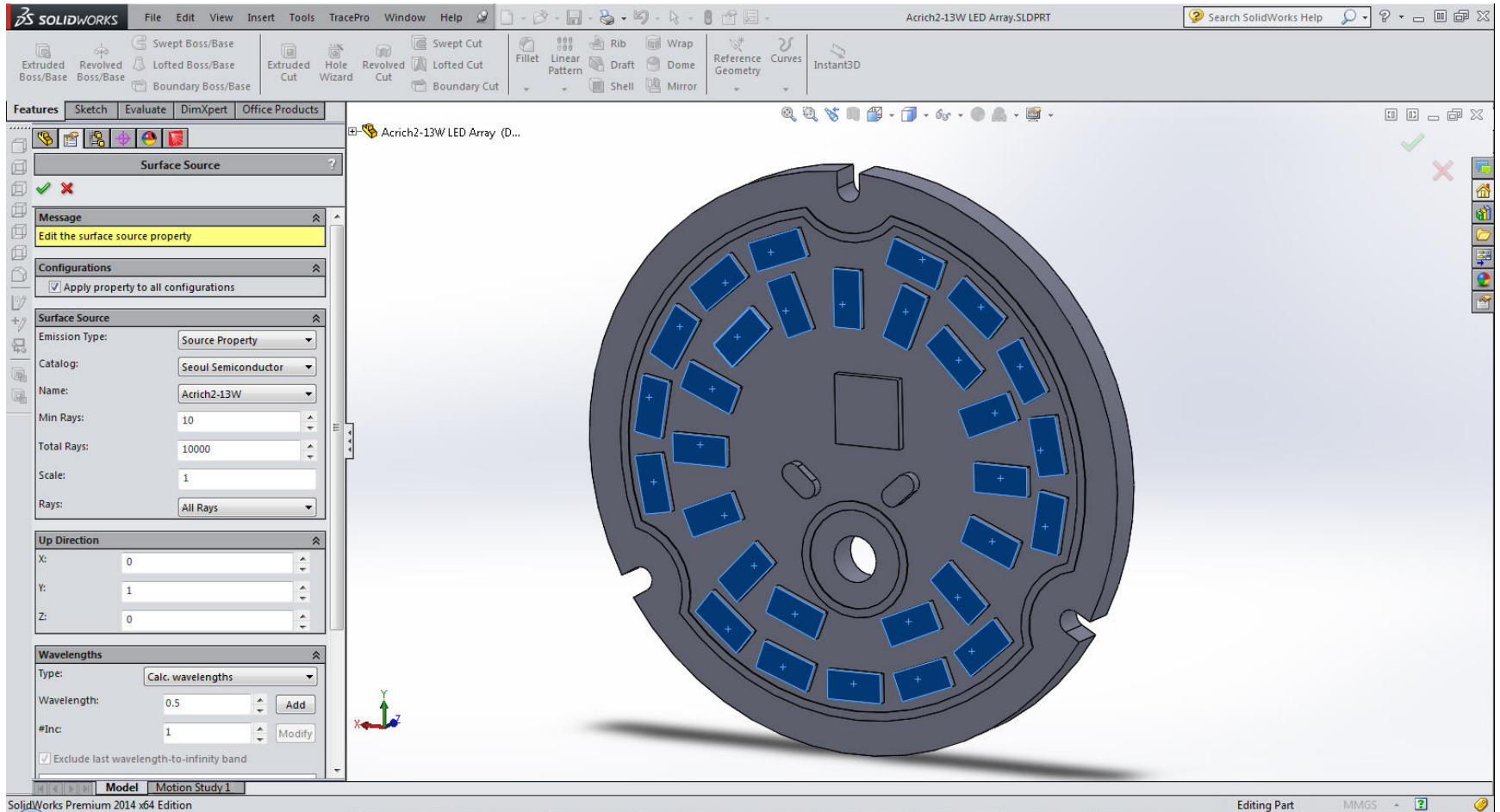
LED Luminaire Design Process – Typical Workflow



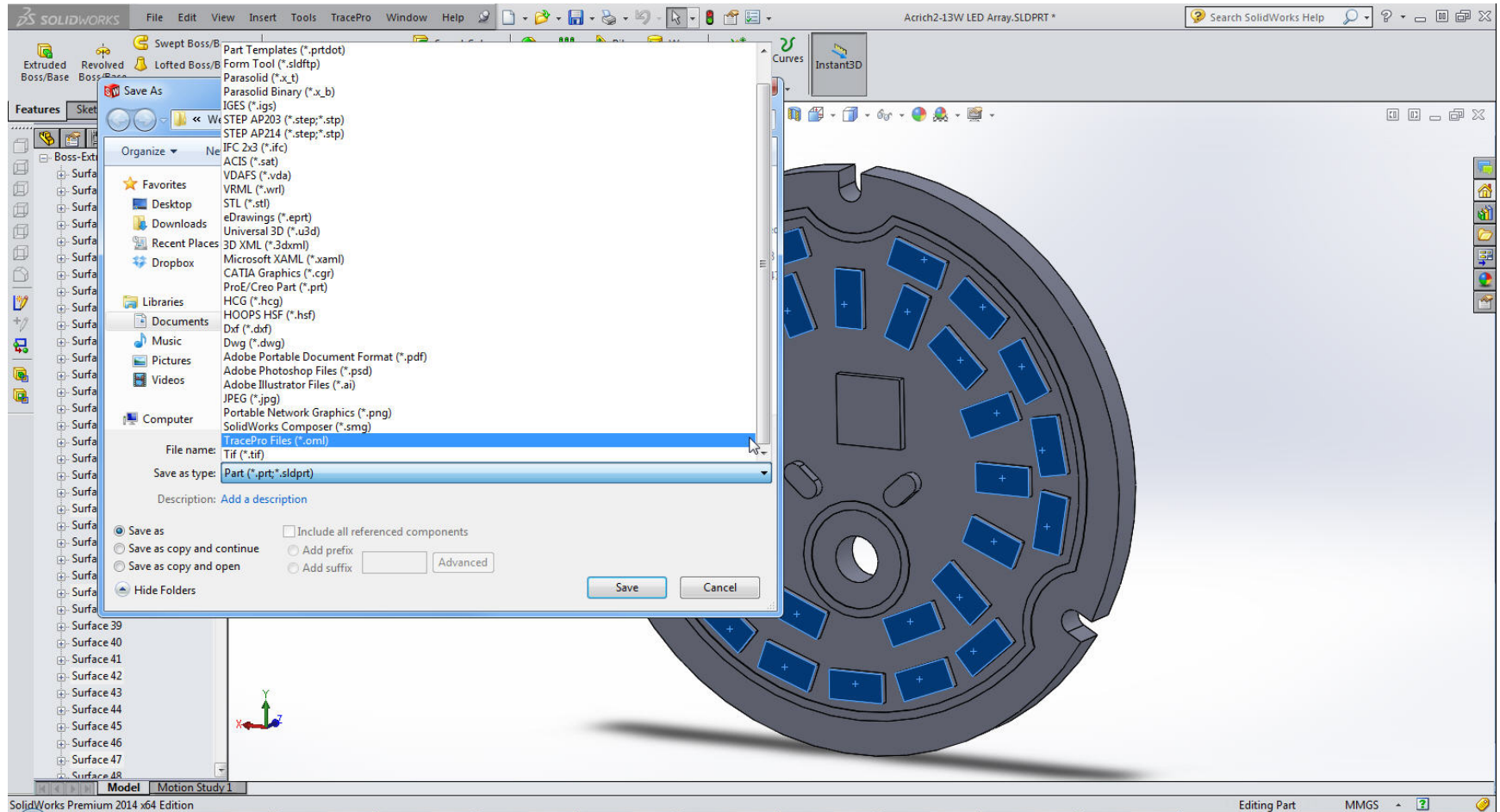
Using SolidWorks to make the LED model – Seoul Semiconductor Acrich2-13W



Assigning optical properties to the LED model using the TracePro Bridge for SolidWorks



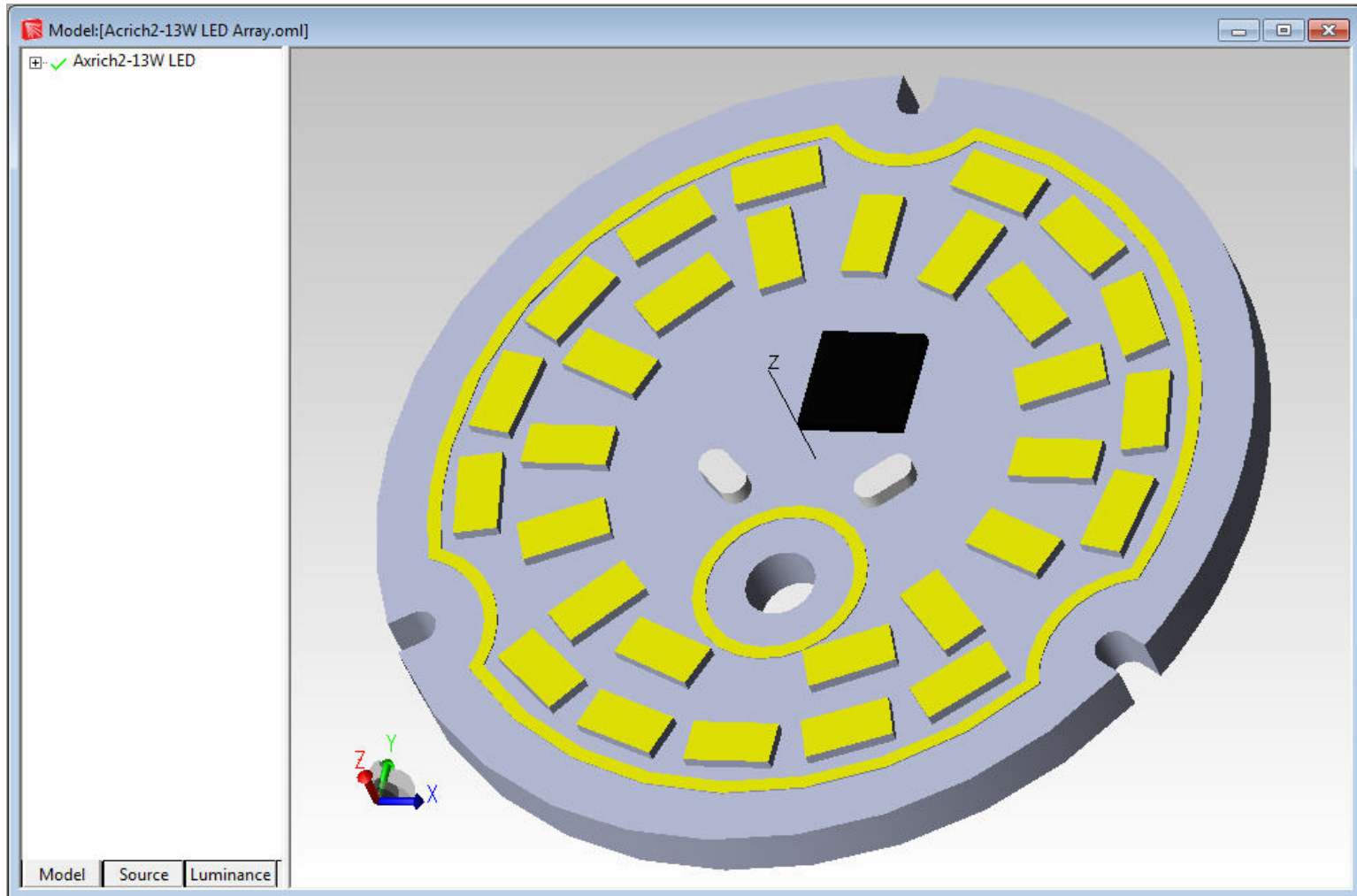
Exporting the model for analysis using the TracePro Bridge for SolidWorks



TracePro Bridge for SolidWorks

Live Demo


LED model with color properties applied



LED Datasheet – Seoul Semiconductor Acrich2-13W

SEOUL SEMICONDUCTOR **Product Data Sheet**
Acrich2 – 13W

Integrated AC LED Solution
Acrich2 – 13W
SMJE-XV12W2P3



MaoAdam 3-Step, RoHS

Product Brief

Description

- The Acrich2 series of products are designed to be driven directly off of AC line voltage, therefore they do not need the standard converter essential for conventional general lighting products.
- The converter or driver found in most general lighting products can limit the overall life of the product, but with the Acrich2 series of products the life of the product can more closely be estimated from the LED itself. This will also allow for a much smaller form factor from an overall fixture design allowing for higher creativity in the fixture.
- The modules have a high power factor which can contribute to a higher energy savings in the end application.

Features and Benefits

- Connects directly to AC line voltage
- High Power Efficiency & Factor
- Low THD
- Long Life Time
- Simple BOM
- Miniaturization
- Lead Free Product
- RoHS Compliant

Key Applications

- Bulb light
- Down light
- Factory Ceiling light
- Industrial Light

Table 1. Product Selection (CCT)

Part No.	Vin [Vac]	P [W]	Color	CCT [K]	CRI	
					Min.	Max.
SMJE-2V12W2P3	120	13	Cool	4700 – 6000	80	
			Neutral	3700 – 4200		
SMJE-3V12W2P3	220		Warm	2600 – 3700		

Table 2. Product Selection (Flux)

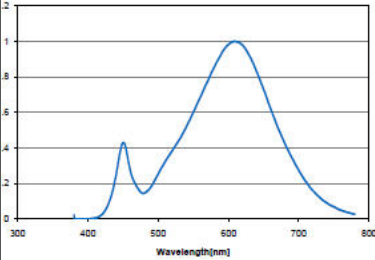
Part No.	Vin [Vac]	P [W]	Flux Bin	Flux [lm]	
				Min.	Typ.
SMJE-2V12W2P3	120	13	13a	880	1000
				13b	1140

Rev2.1, January 15, 2014 1 www.seoulsemicon.com

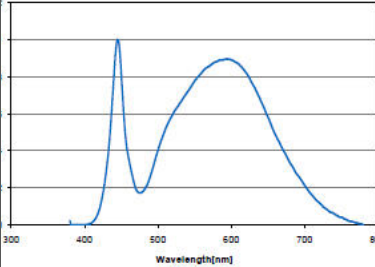
SEOUL SEMICONDUCTOR **Product Data Sheet**
Acrich2 – 13W

Spectral Distribution

Relative Spectral Distribution vs. Wavelength Characteristic – G, H



Relative Spectral Distribution vs. Wavelength Characteristic – E, F

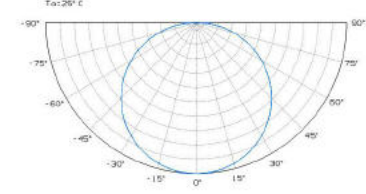


Rev2.1, January 15, 2014 6 www.seoulsemicon.com

SEOUL SEMICONDUCTOR **Product Data Sheet**
Acrich2 – 13W

Beam Flux Characteristics

Radiant Pattern, T_a = 25°C



Rev2.1, January 15, 2014 10 www.seoulsemicon.com

Making a LED source property using the graphs on the LED datasheet

The screenshot displays the 'Surface Source Property Generator' software interface. It features several panels for configuring light source properties:

- Beam shape profile editor:** Shows a radiation pattern graph with control points and a table of values.
- Angular profiles selector:** Displays available angular profiles.
- Wavelengths editor:** Contains a table of wavelength and weight data, a spectrum graph, and a 'Spectrum input helper' graph.
- Coordinate System:** Allows setting the origin and angle for the beam.
- Source beam shape 3D preview:** Provides a 3D visualization of the beam shape.

Control Points Table:

Deg	Value
-90	0
-65.96595	0.417094
-49.7618...	0.648937
-25.3384...	0.897245
25.338459	0.897245
49.761898	0.648937
65.96595	0.417094
90	0

Wavelengths Editor Table:

Wavelength	Weight	Pattern
0.338206	0	Pattern #1
0.347596	0.004337	Pattern #1
0.356987	0.010538	Pattern #1
0.366377	0.007243	Pattern #1
0.375768	0	Pattern #1
0.385158	0	Pattern #1
0.394549	0	Pattern #1
0.403939	0	Pattern #1
0.41333	0.058065	Pattern #1
0.42272	0.170606	Pattern #1
0.432111	0.337222	Pattern #1
0.441501	0.874431	Pattern #1

Wavelengths Editor Parameters:

- Spectrum type: Table
- Relative Center Intensity:
- Wavelength: 0.547
- Weight: 1
- Unit: Radiometric
- Ref CCT=3879K CRI=84.0

Spectrum Input Helper Graph:

Relative Spectral Power Distribution vs Wavelength (nm). The graph shows a multi-peaked distribution with a peak at approximately 450 nm and a broader peak around 600 nm. A data point is highlighted at (0.408, 1.702).

Wavelength Intensity Auto Sample:

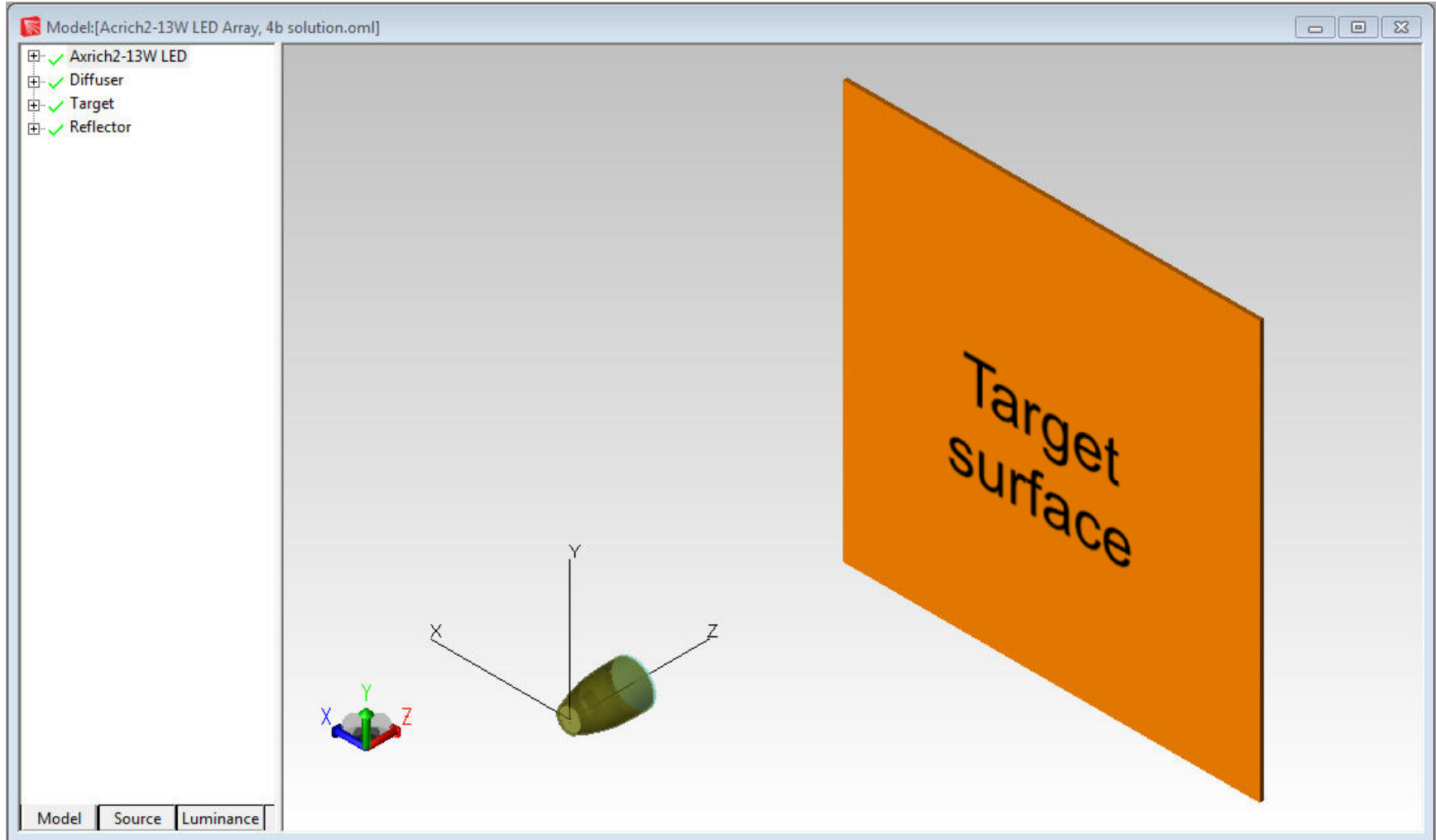
Set Ref	Intensity	Auto	Sample
Set Ref 1	0.3	0	50
Set Ref 2	0.8	1	Sample

TracePro

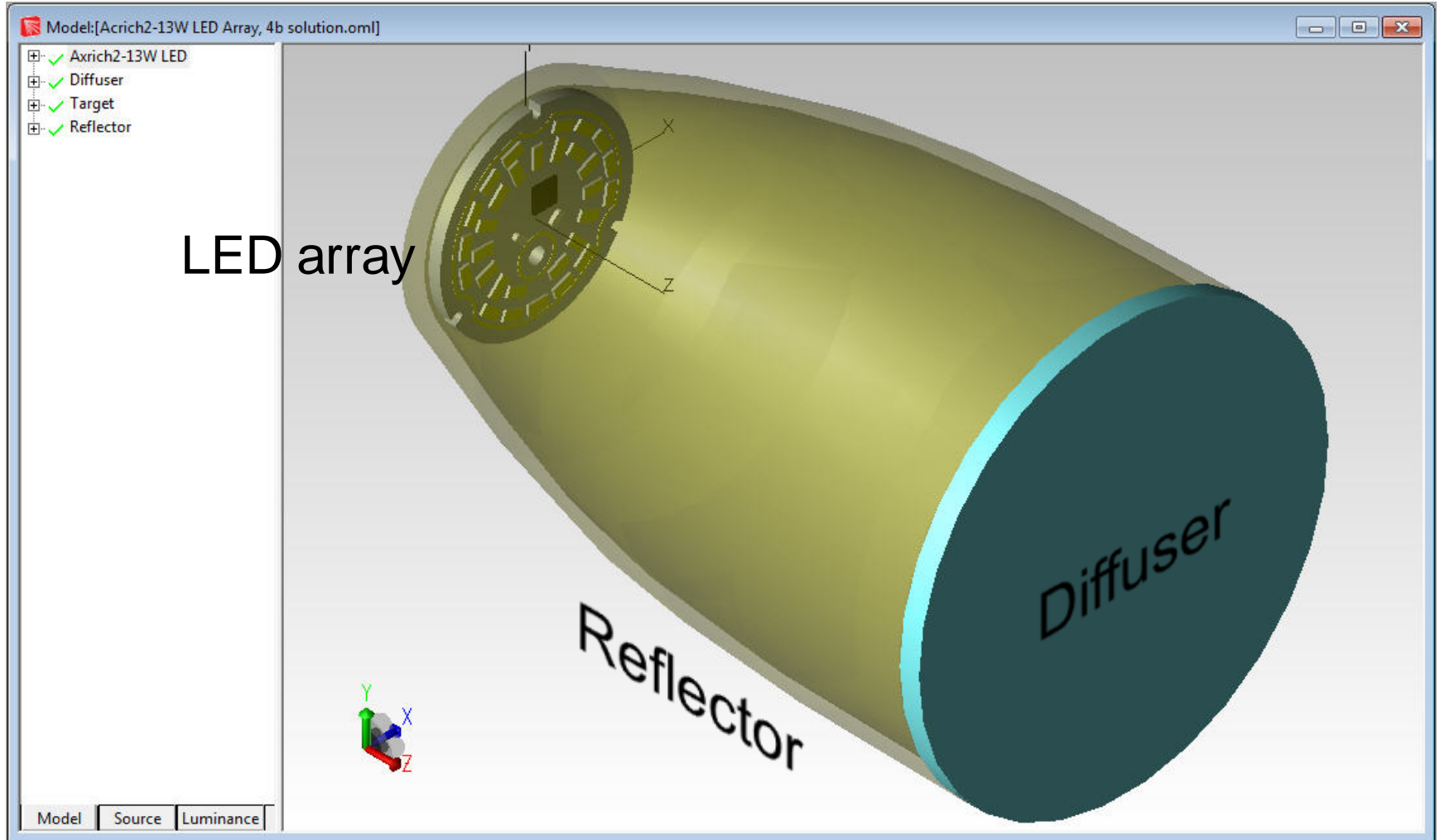
Making a LED source property using the graphs on the LED datasheet

Live Demo

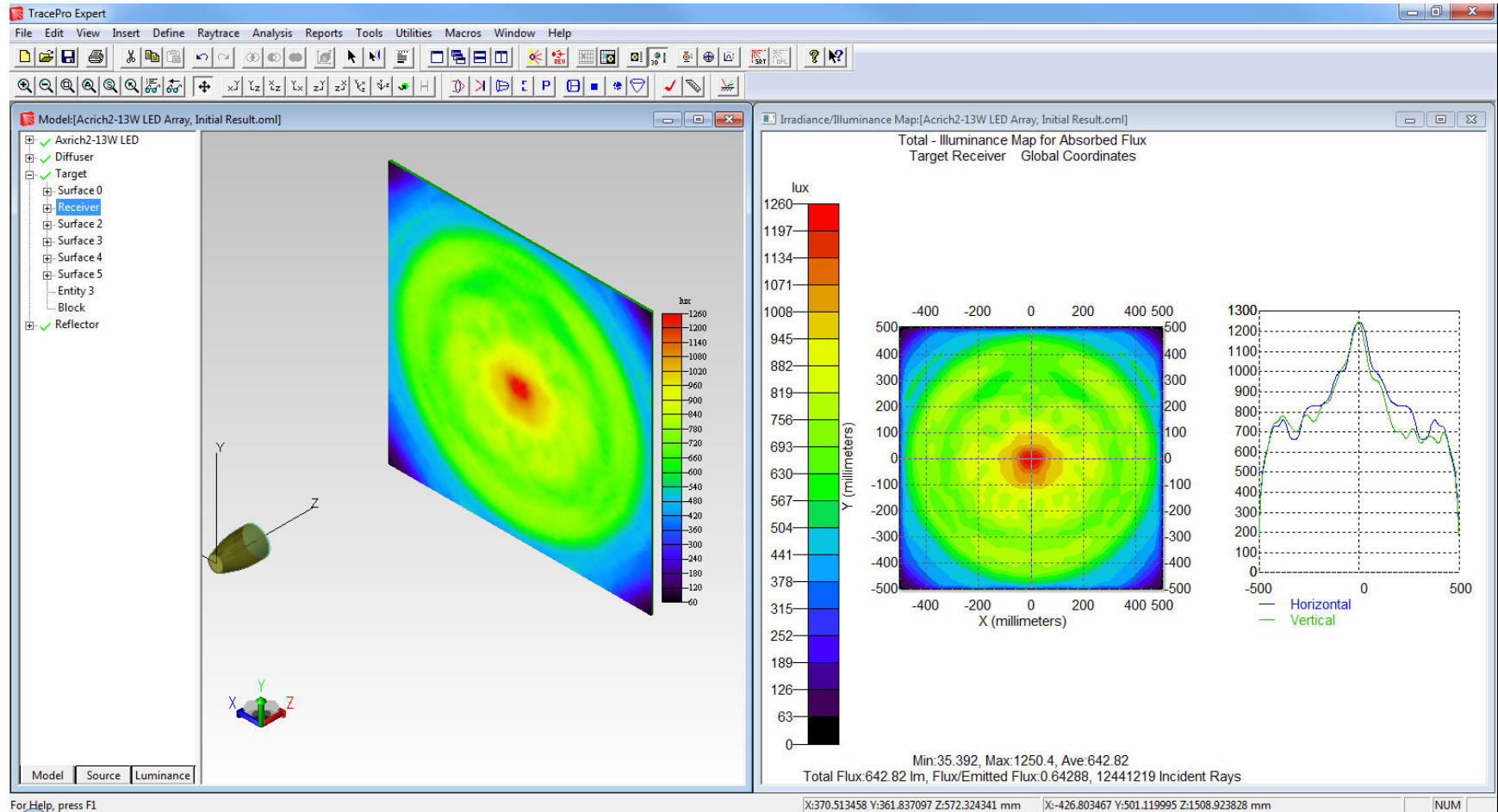
Setting up the system for analysis and optimization



Setting up the system for analysis and optimization



Analyzing the initial raytrace results

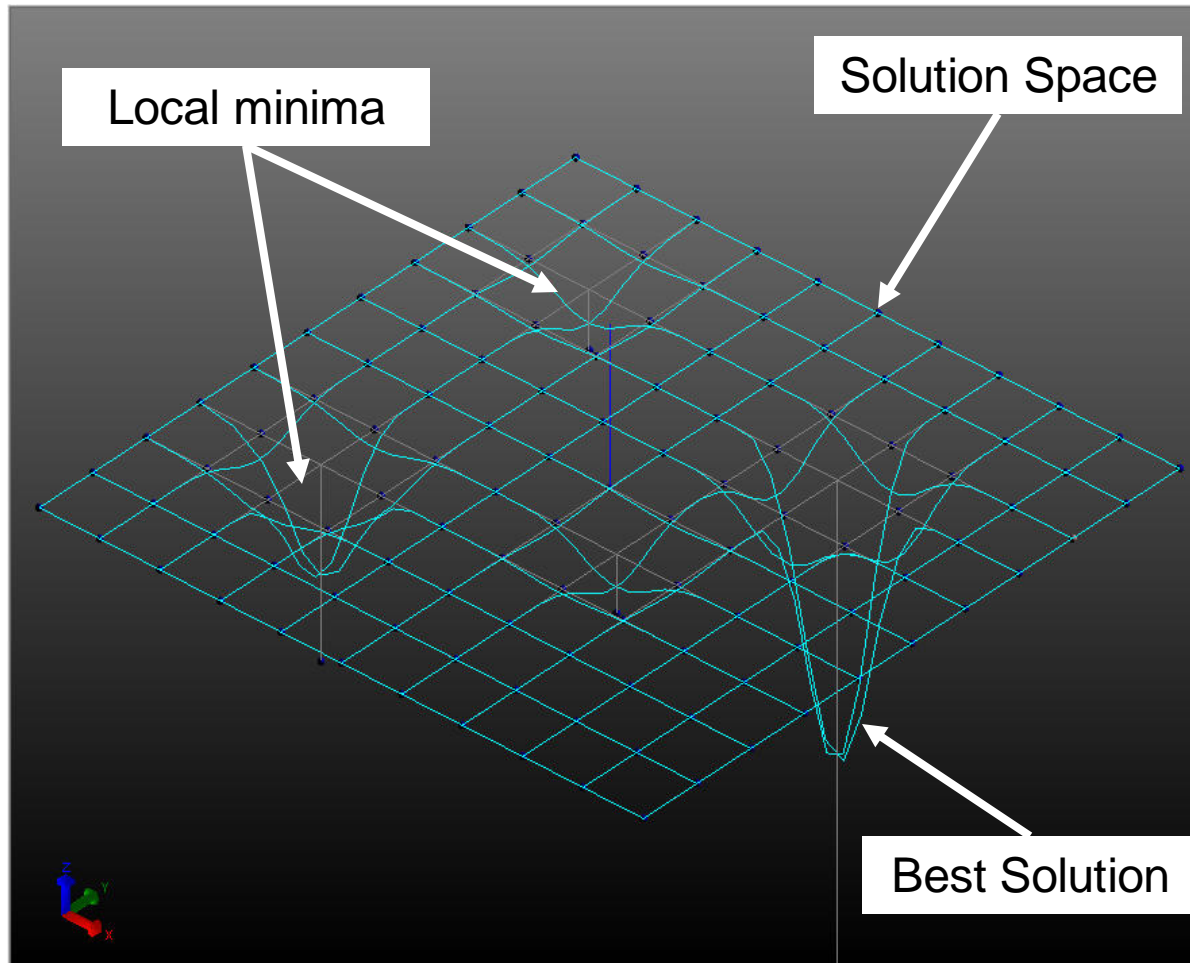


Optimization methods– Downhill Simplex vs. Variable Scanning

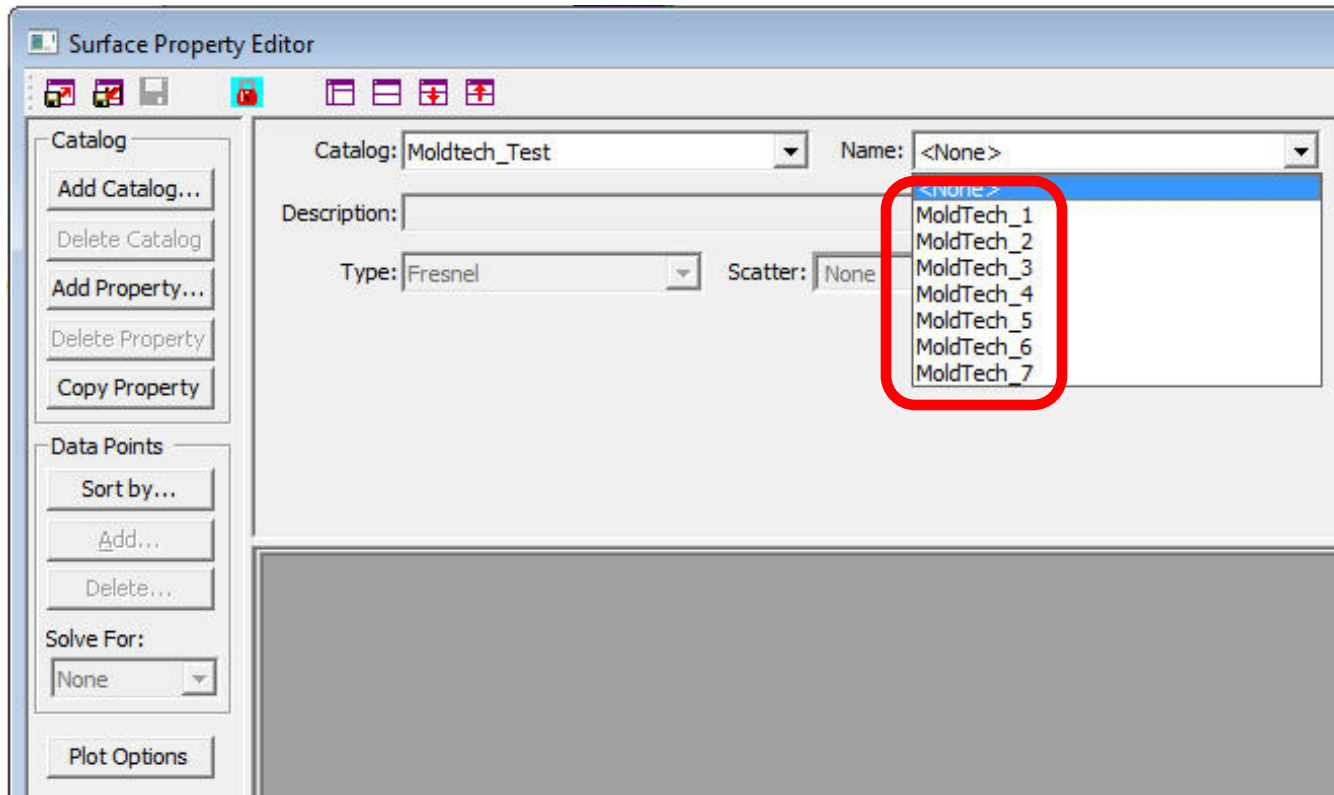
The Downhill Simplex method is a local optimization method, meaning it will converge to the solution closest to the starting point. It's possible that a better solution is available. Changing the initial starting conditions can be used as a test to see if a better solution is available. This is a good choice when optimizing geometry, position, and rotation where it is desirable to “jump” around the solution space to find and then refine the best choices for variable values.

The Variable Scanning method is used to scan or step through all possible variable combinations. This can be used to define an appropriate range of variables before starting a Downhill Simplex optimization, or in the example used in today's webinar, to step through diffuser properties in a catalog to find the best option.

Optimization methods– Downhill Simplex Method



Optimization methods– Variable Scanning Method



The Variable Scanning method can be used to step through each of the properties in a catalog of properties, in this case Mold-Tech profiles, to find the best match for the optimization goal.

LED Professional Symposium and Expo

Lambda Research Corporation will be presenting a symposium on

LED Luminaire Design Optimization - Theory, Methods, and Applications

at the LED Professional Symposium and Expo
Bregenz, Austria, Sept. 30th-Oct. 2nd

Optimizing the reflector – Downhill Simplex Method

3D Interactive Optimizer - C:\Users\djacobsen\Documents\Webinars\May 2014 - LED Professional Webinar\Webinar Reflector.io2

File Edit Optimization Window Tools Help

Surface list

- Surface 0

Property editor

Description	Value	Type	Lower limit / Pickup	Upper limit
ID	7			
Segment type	Spline			
Surface catalog	ALANOD			
Surface property	MIRO 27			
Reflective?	<input type="checkbox"/>			
Fresnelized?	<input type="checkbox"/>			

Object View

- Reflector

Opacity

The property database had been linked to C:\Users\djacobsen\AppData\Roaming\Lambda Research Corporation\TracePro\TracePro.db.

X:-0.0009765625 Y:113.2555 Z:88.73966

Optimizing the reflector

The screenshot displays the 3D Interactive Optimizer software interface. A red box highlights the 'Operand list' table, which is used to define optimization goals. The table contains the following data:

ID	Type	Opt.	Surface	Range	Weight	Target value
O1	Irr Profile	Similarity	Receiver		1.0	{0:0:H:(-0.5,-0.4499999880...
O2	Flux	Sum	Receiver		0.0033	750

The 'Irradiance target profile definer' dialog box is open, showing a graph of the irradiance profile. The graph plots relative position (x-axis) against relative position (y-axis). The x-axis ranges from -0.5 to 0.5, and the y-axis ranges from 0.0 to 1.0. The profile is defined by a series of points: (-0.5, 0.0), (-0.45, 0.0), (-0.333, 1.0), (0.333, 1.0), (0.45, 0.0), and (0.5, 0.0). A red dashed line indicates the target profile. The 'Irradiance target profile definer' dialog box also includes a table of relative positions and values:

Relative Pos.	Value
-0.5000	0.0000
-0.4500	0.0000
-0.3330	1.0000
0.3330	1.0000
0.4500	0.0000
0.5000	0.0000

The 'Optimization dialog' shows the path 'C:\3D Optimizer', prefix 'LEDPro', and operation mode 'Optimization'. The 'Variable list' table shows the following data:

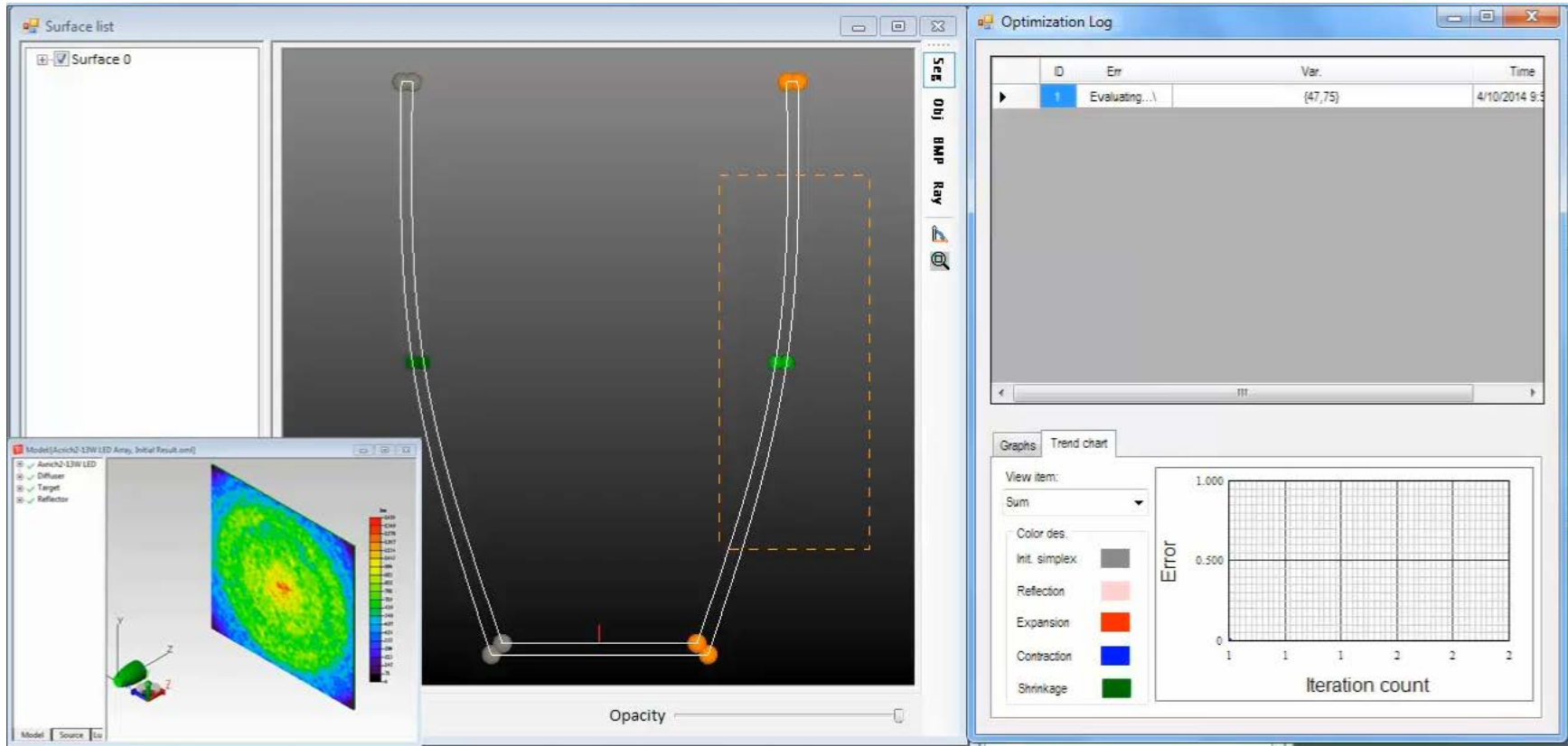
Included?	Item	Object	Var. type	Value
✓	Position-Y	Ctrl Pnt:0@Seg...	RelativeVariable	47
✓	Position-Z	Ctrl Pnt:0@Seg...	RelativeVariable	75

The 'Object list' table shows the following data:

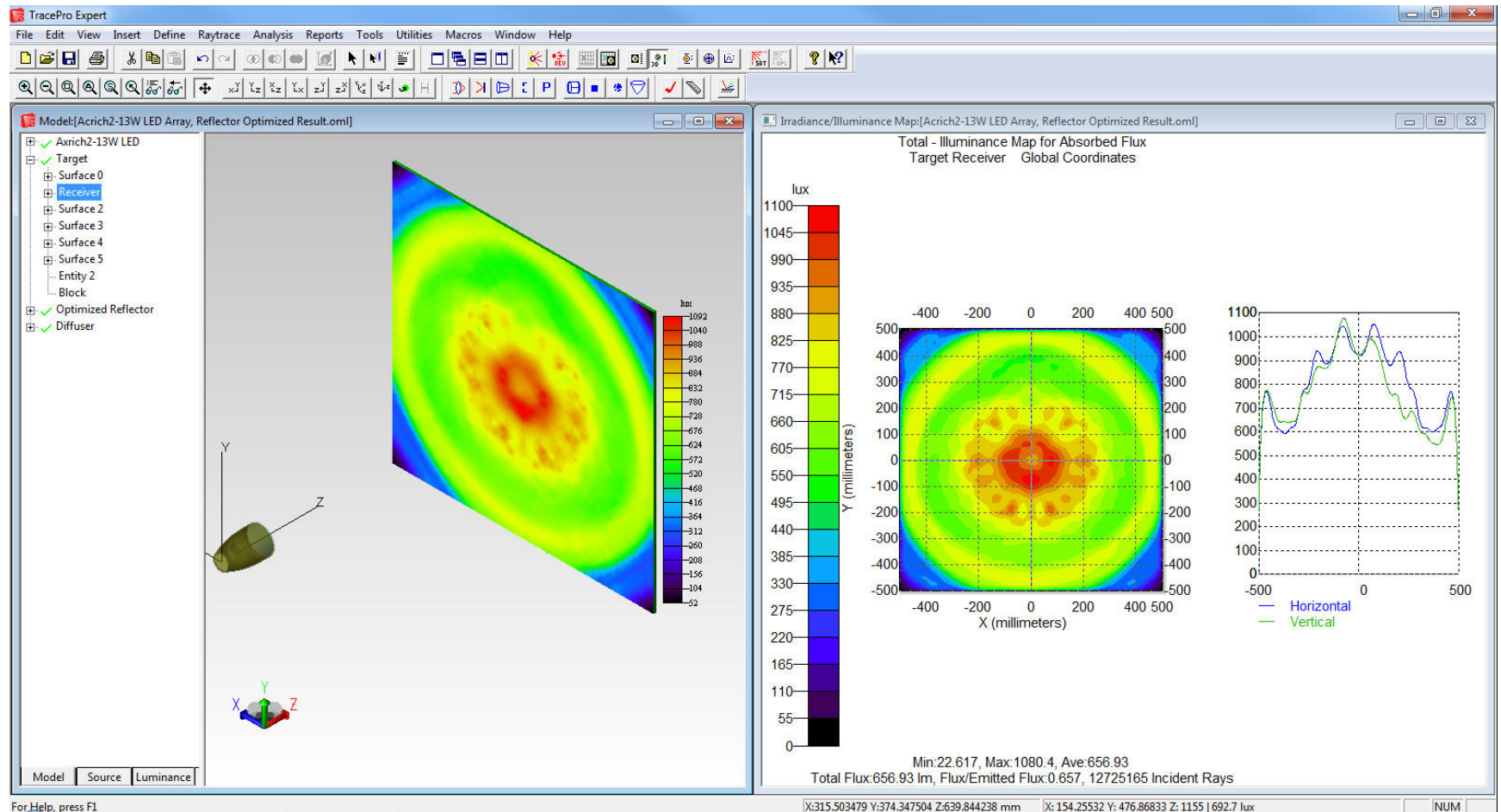
Output?	ID	Object name	Object type	Mat. Catalog
		Pre-processor		
✓	1	Reflector	cRadialSymmet...	None

The status bar at the bottom indicates: 'The property database had been linked to C:\Users\djacobsen\AppData\Roaming\Lambda Research Corporation\TracePro\TracePro.db.' and 'X-1.008606 Y4.014992 Z:5.02359'.

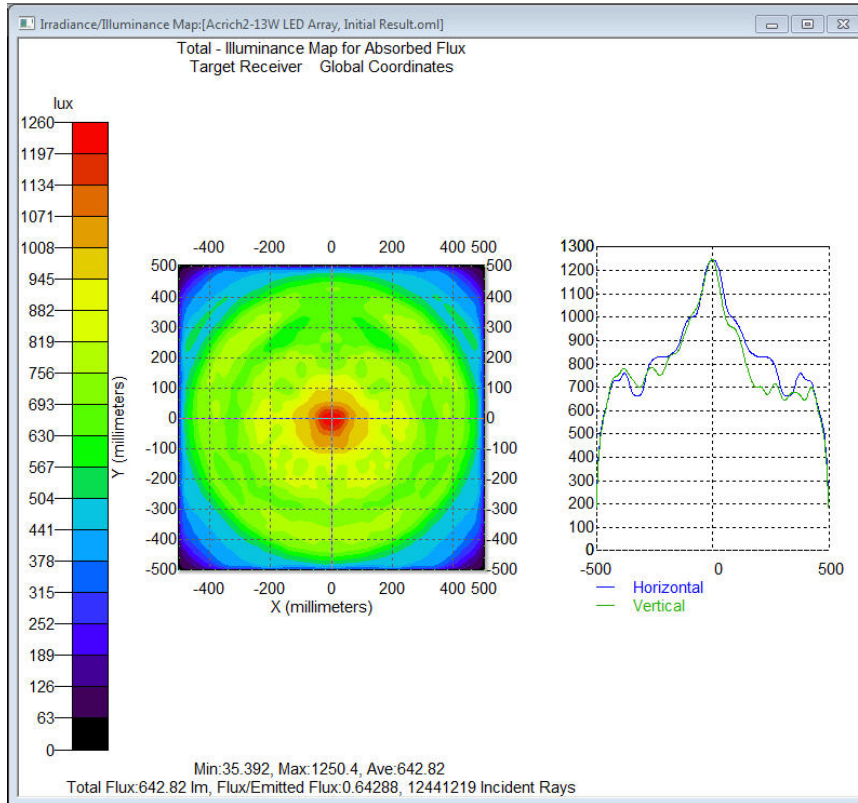
Optimizing the reflector - Video



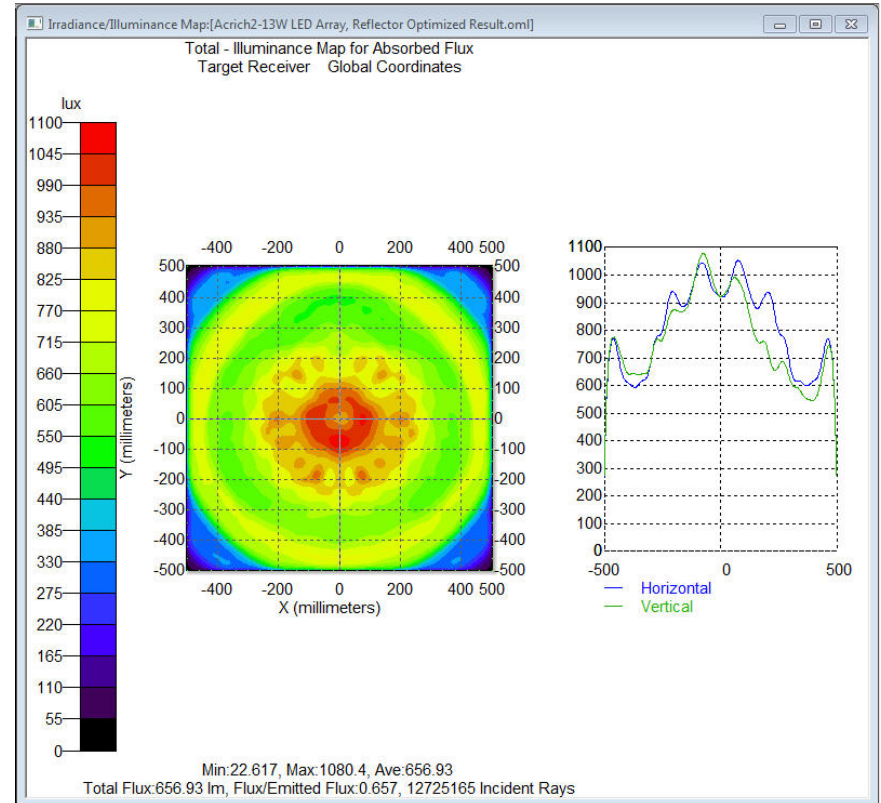
Analyzing the raytrace results after reflector optimization



Analyzing the raytrace results after reflector optimization

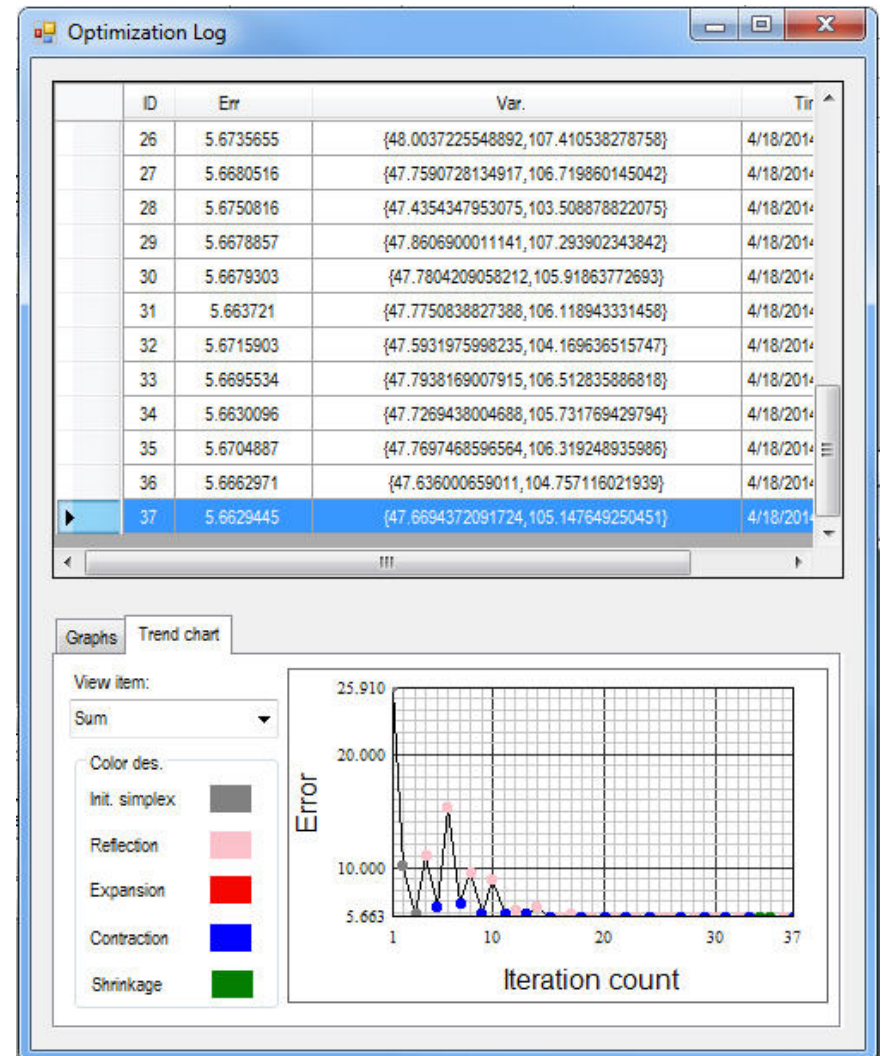
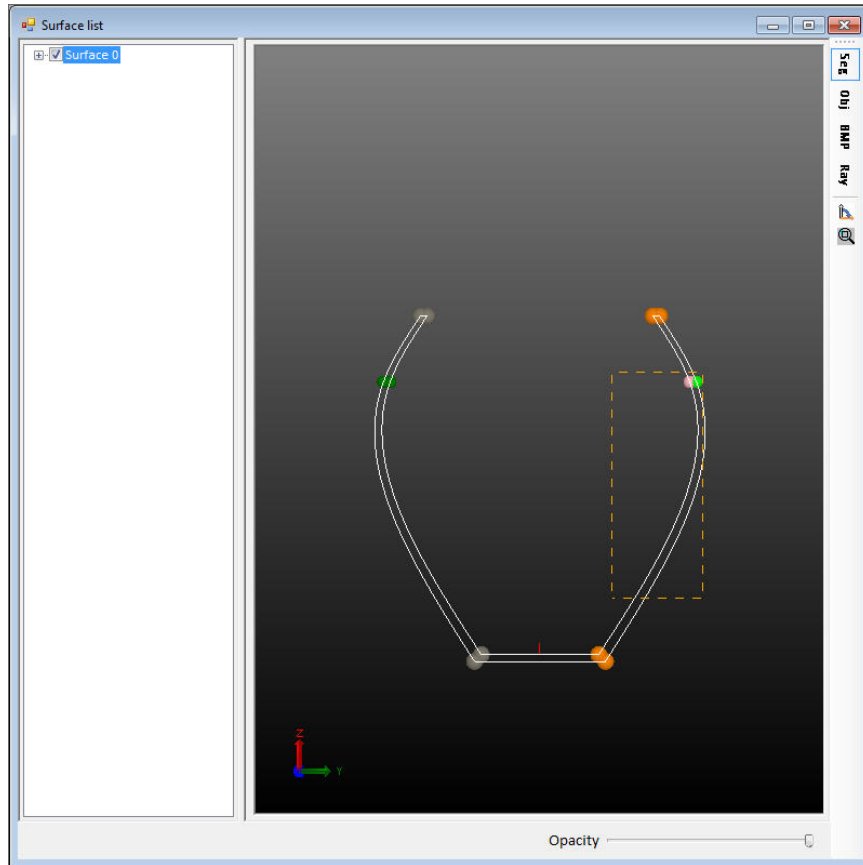


Before Reflector Optimization

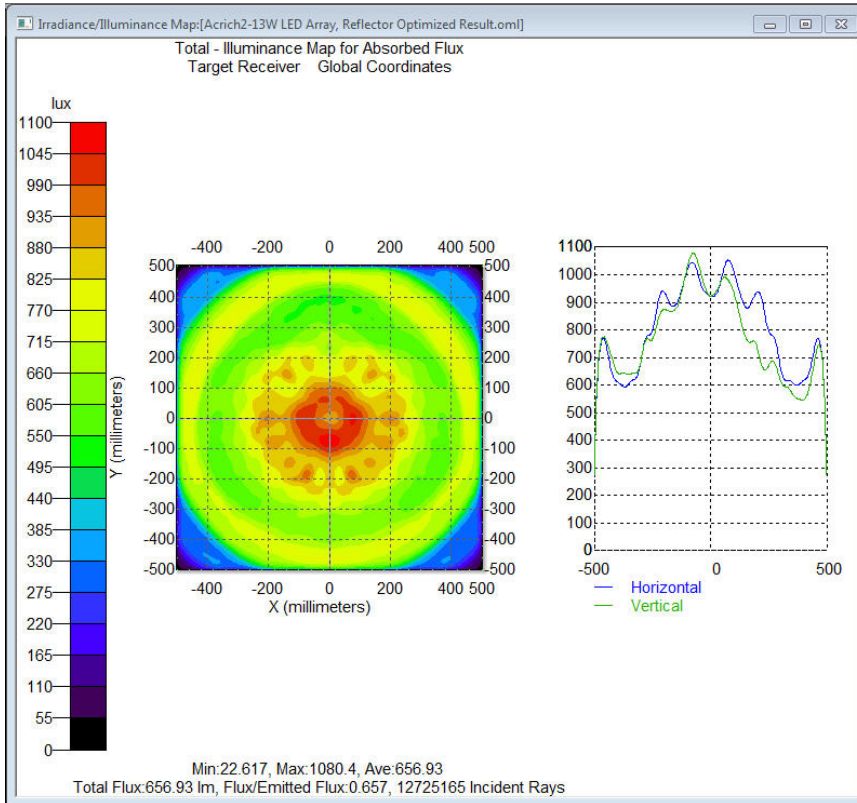


After Reflector Optimization

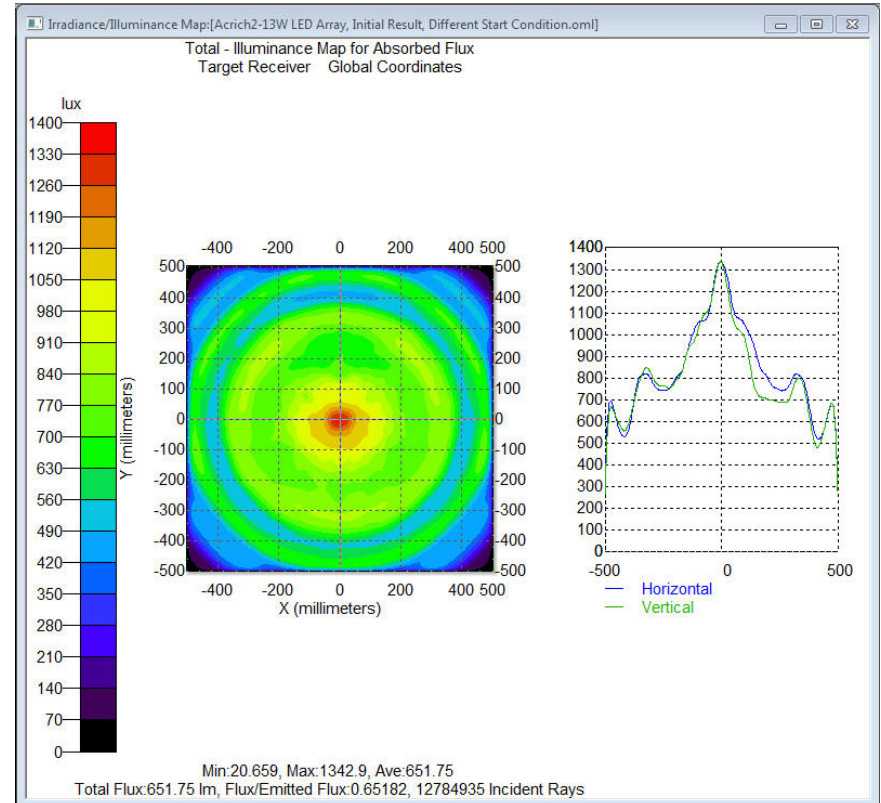
Testing the results by re-optimizing with a different starting condition



Testing the results by re-optimizing with a different starting condition



First Optimization Start Condition



Second Optimization Start Condition

Optimizing the choice of diffusers to improve performance

3D Interactive Optimizer - C:\Users\djacobsen\Documents\Webinars\May 2014 - LED Professional Webinar\Optimizing Surface Property, Video Example.io2

File Edit Optimization Window Tools Help

Surface list

- Surface 0

Property editor

Description	Value	Type	Lower limit / Pickup	Upper limit
Name	Diffuser			
ID	0			
Local origin	(0,0,150)			
Local tilt center	(0,0,0)			
Tilt X Angle	0			
Tilt Y Angle	0			
Tilt Z Angle	0			
Tilt then Shift	<input checked="" type="checkbox"/>			
Material catalog	Plastic			
Material property	Acrylic			
Refractive index	1.5			
Steps	0			

Object View

- Diffuser

Opacity

The property database had been linked to C:\Users\djacobsen\AppData\Roaming\Lambda Research Corporation\TracePro\TracePro.db.

X:0 Y:29.73295 Z:-71.77627

Optimizing the choice of diffusers to improve performance – Variable Scan Method

Optimization dialog

Path: C:\3D Optimizer B

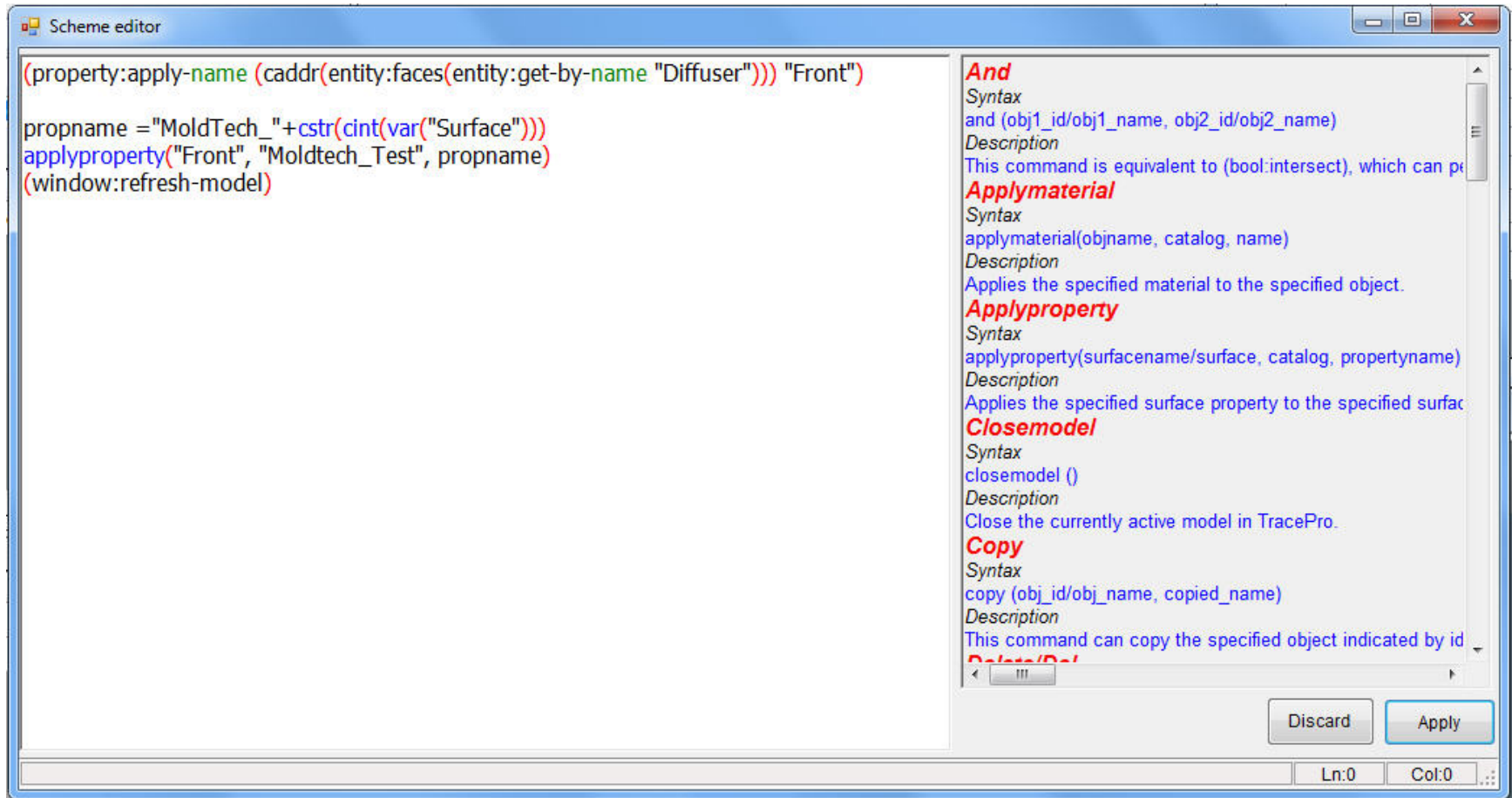
Prefix: VariableSurface

Operation mode: Variable Scan Config

Variable list

	Included?	Item	Object	Var. type	Value	Lo lmt.	Hi lmt.	Steps
▶	<input checked="" type="checkbox"/>	Surface	<Null>	User-defined ▼	1	1	7	7

Optimizing the choice of diffusers to improve performance – Scheme Macro Code



The image shows a screenshot of a 'Scheme editor' window. The main text area contains the following Scheme code:

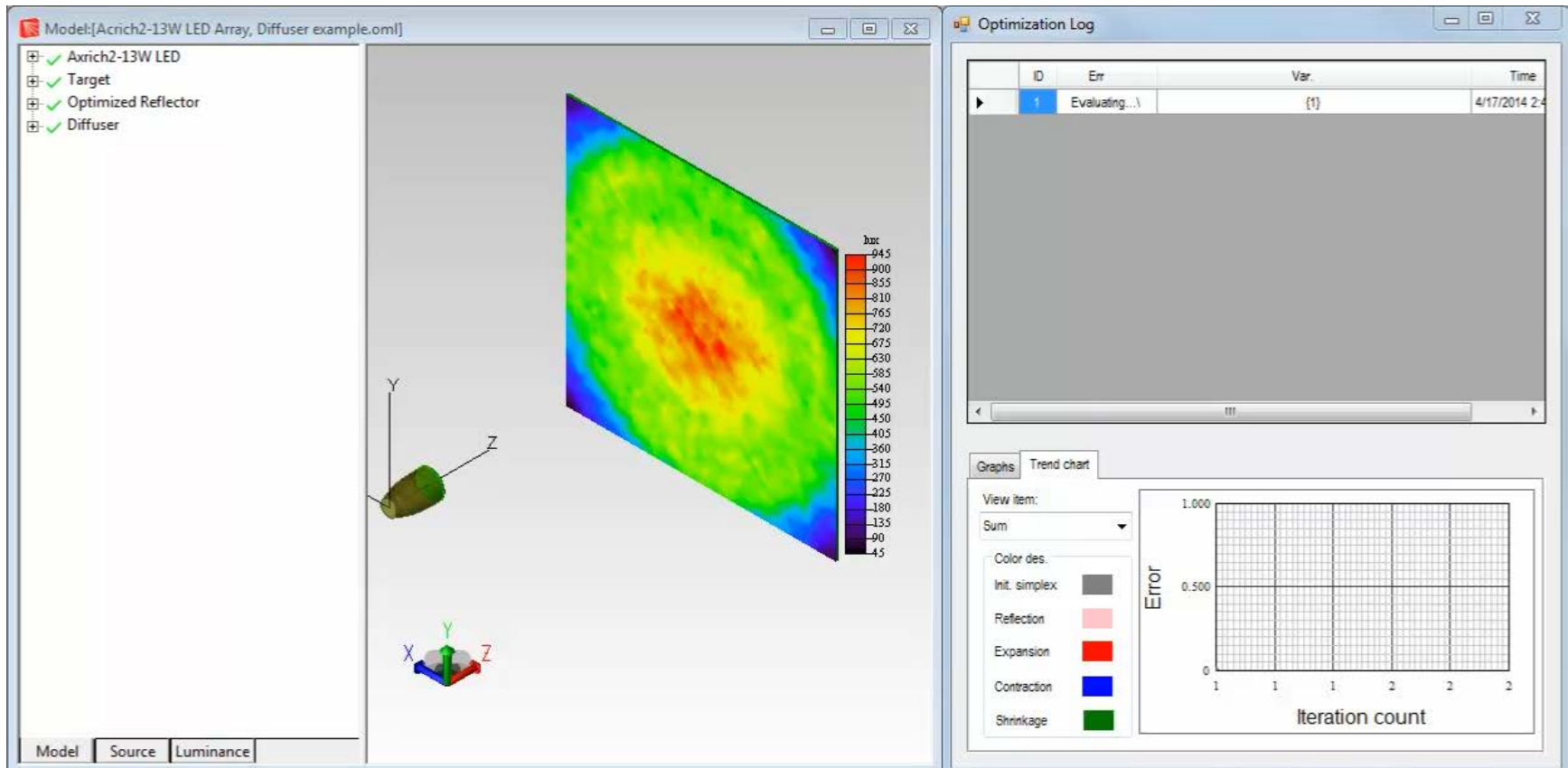
```
(property:apply-name (caddr(entity:faces(entity:get-by-name "Diffuser"))) "Front")  
  
propname = "MoldTech_" + cstr(cint(var("Surface")))  
applyproperty("Front", "Moldtech_Test", propname)  
(window:refresh-model)
```

To the right of the code is a help pane with a scroll bar. It lists several commands:

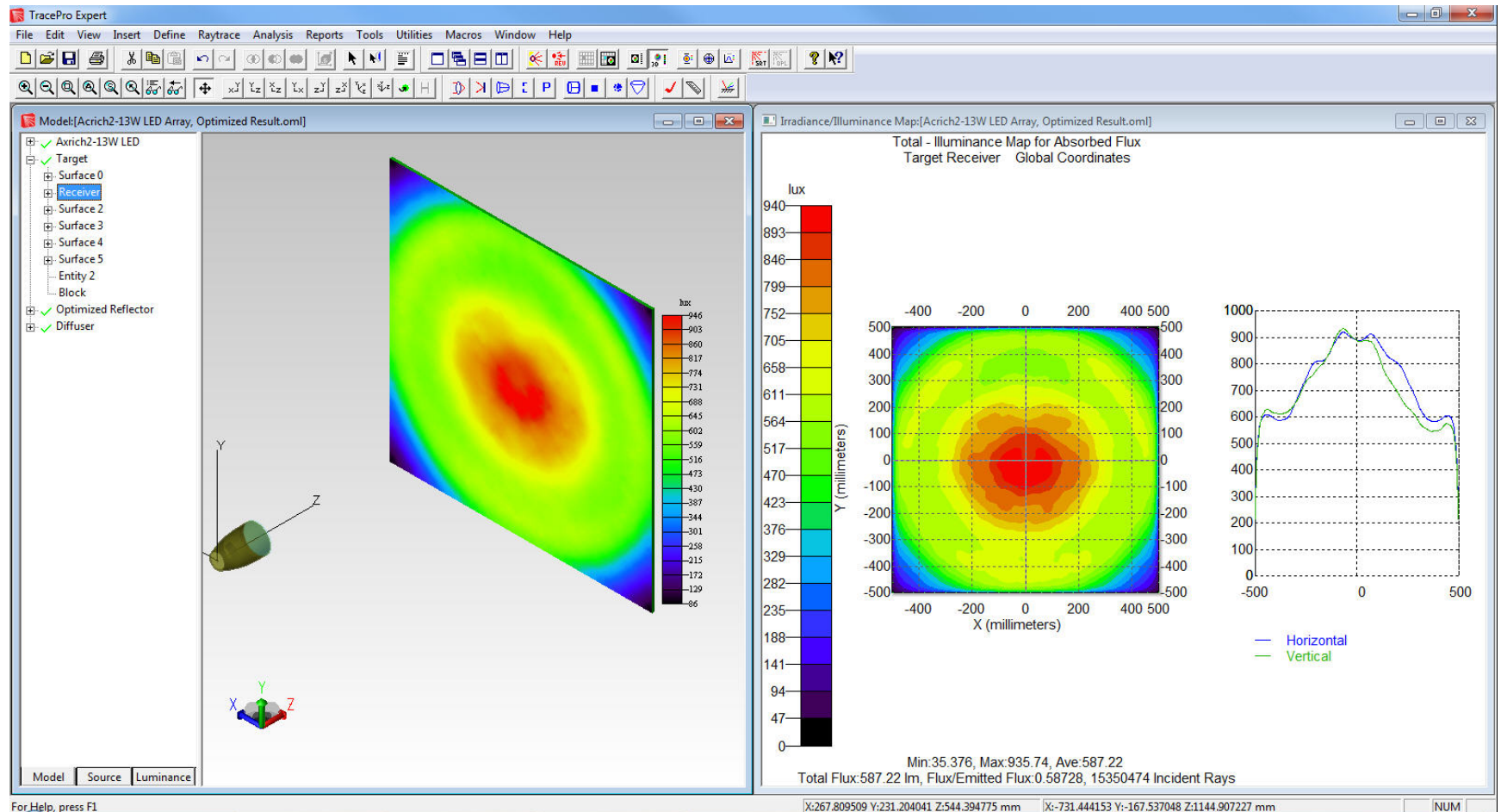
- And**
Syntax
and (obj1_id/obj1_name, obj2_id/obj2_name)
Description
This command is equivalent to (bool:intersect), which can p
- Applymaterial**
Syntax
applymaterial(objname, catalog, name)
Description
Applies the specified material to the specified object.
- Applyproperty**
Syntax
applyproperty(surfacename/surface, catalog, propertyname)
Description
Applies the specified surface property to the specified surfac
- Closemodel**
Syntax
closemodel ()
Description
Close the currently active model in TracePro.
- Copy**
Syntax
copy (obj_id/obj_name, copied_name)
Description
This command can copy the specified object indicated by id
- Delete/Del**

At the bottom right of the help pane are 'Discard' and 'Apply' buttons. The status bar at the bottom of the window shows 'Ln:0 Col:0'.

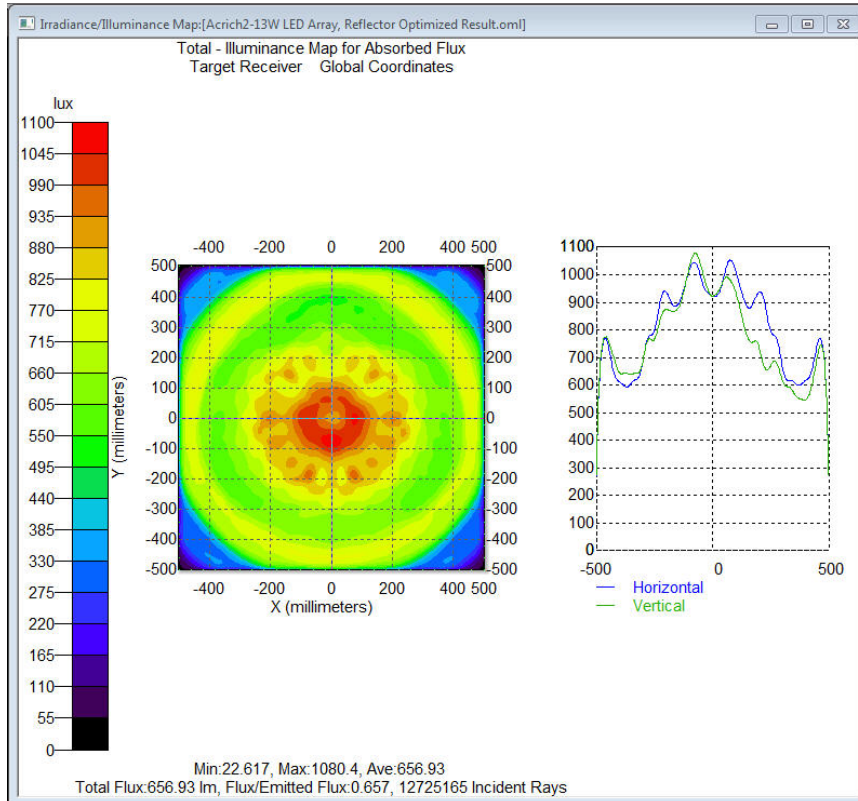
Optimizing the choice of diffusers to improve performance - Video



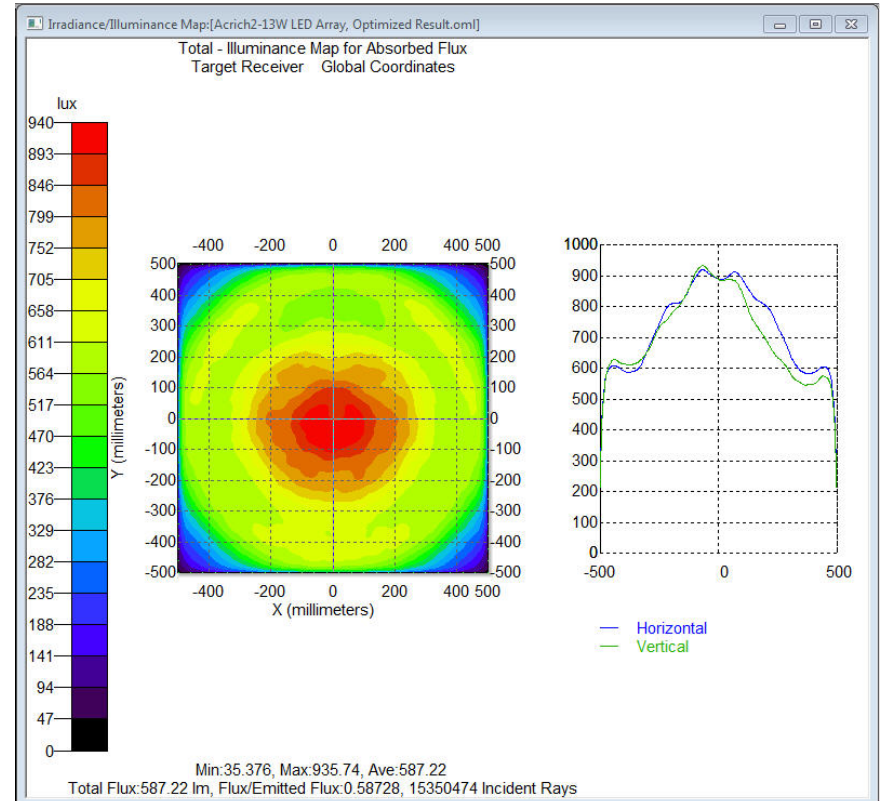
Analyzing the raytrace results after diffuser optimization



Analyzing the raytrace results after diffuser optimization

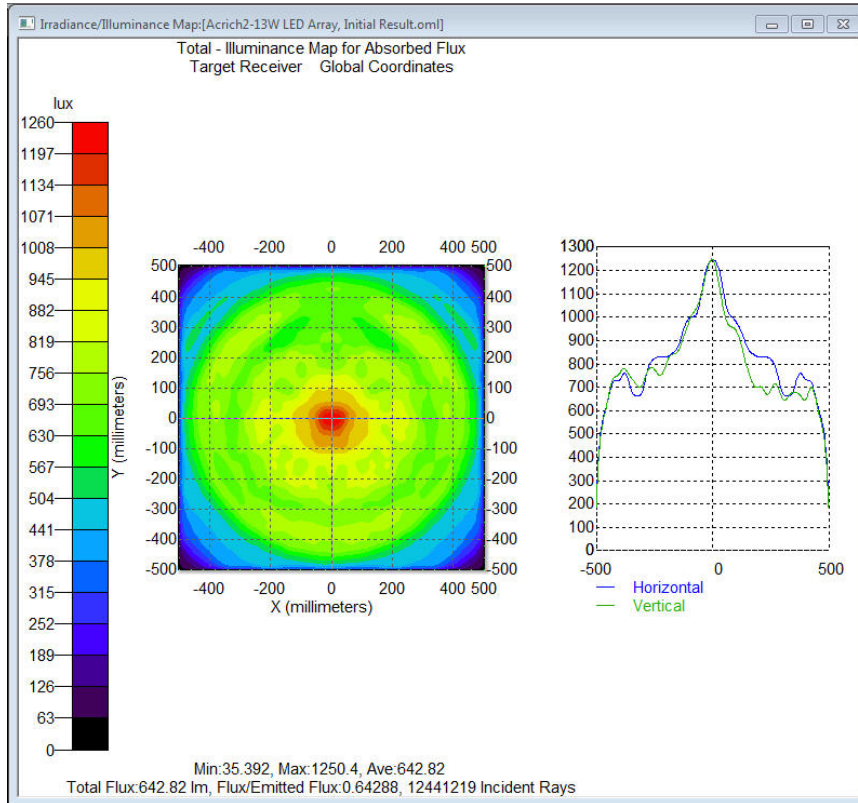


After Reflector Optimization

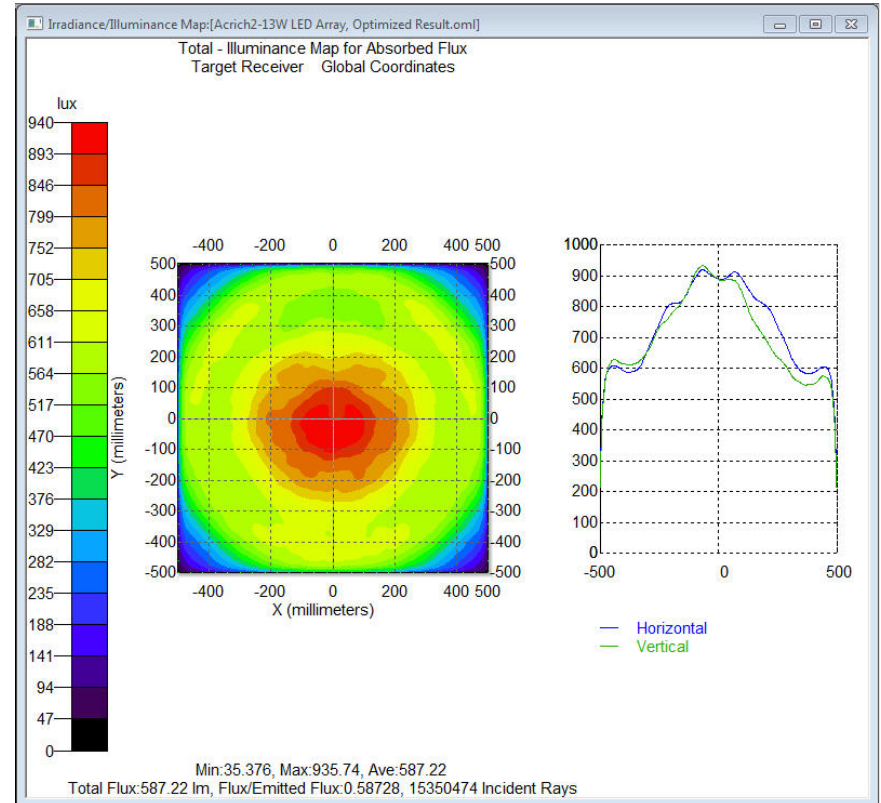


After Diffuser Optimization

Analyzing the raytrace results after optimization

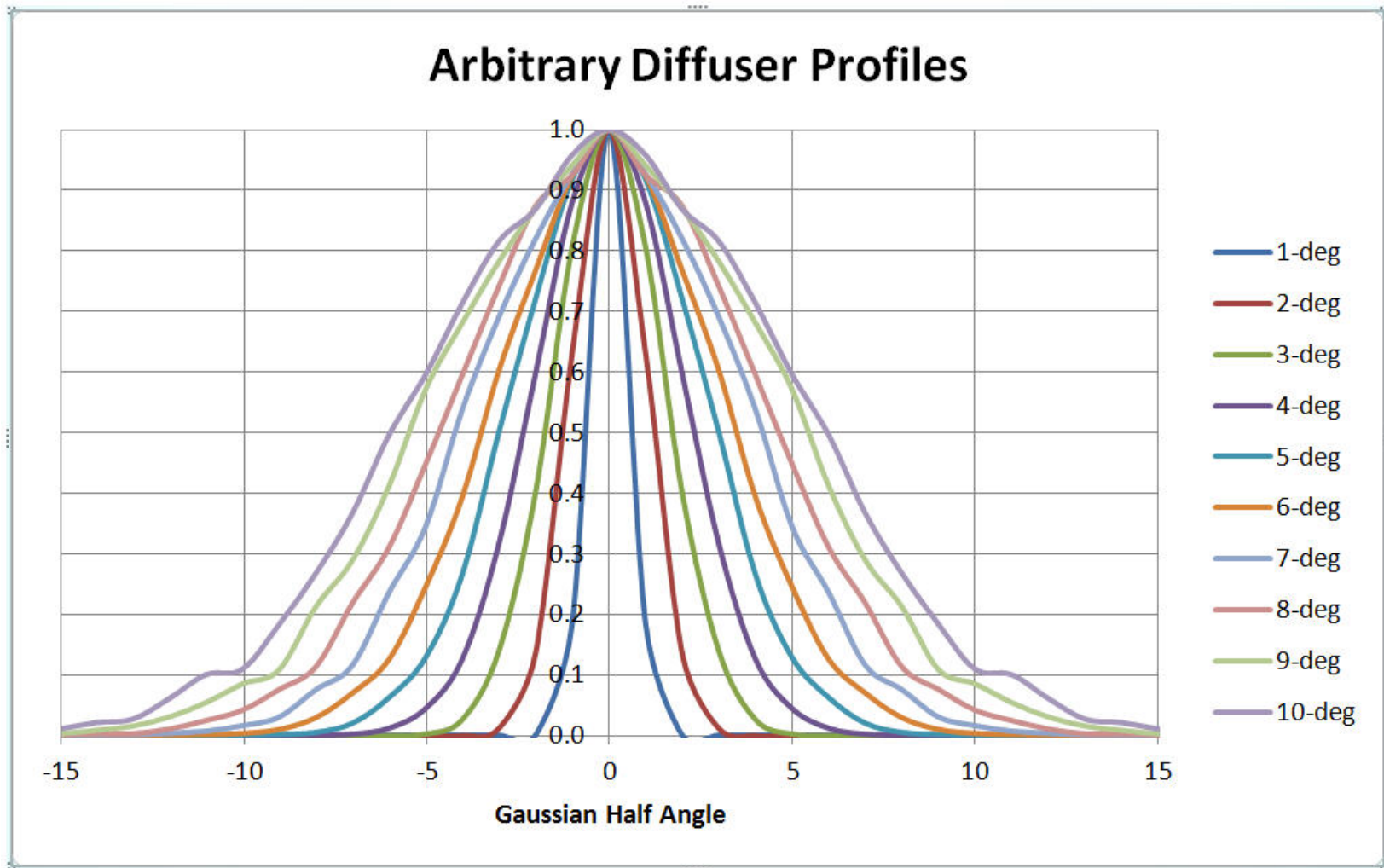


Before Optimization

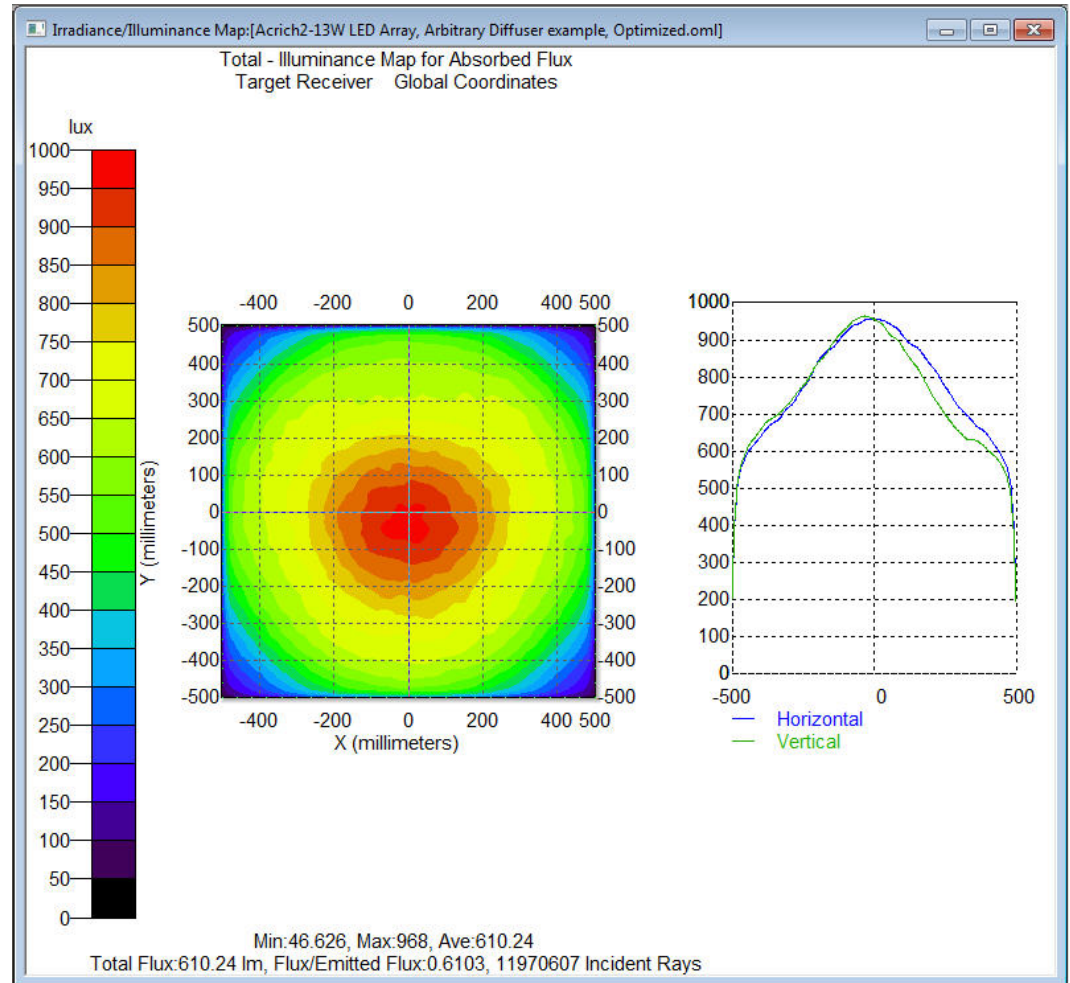
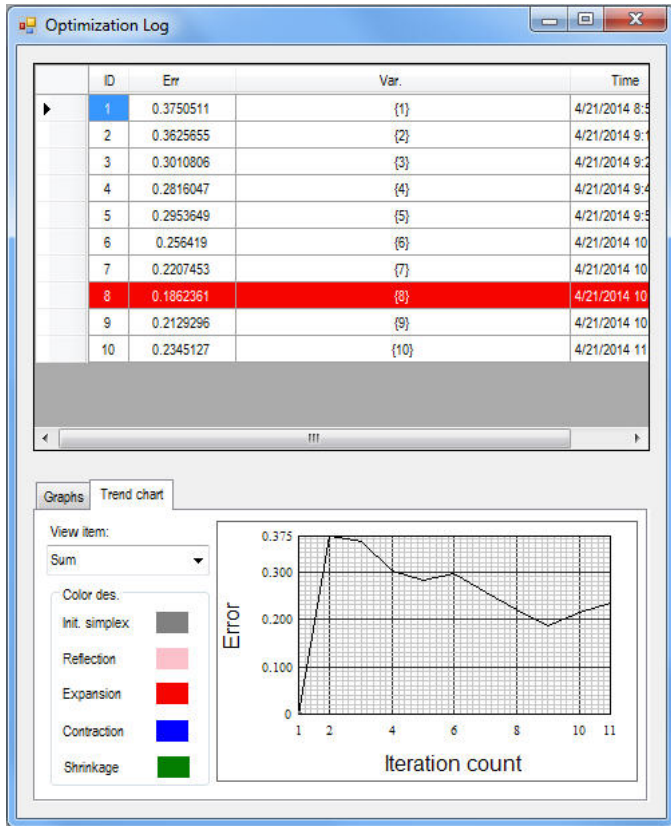


After Reflector & Diffuser Optimization

Choosing from a catalog of arbitrary diffusers



Choosing from a catalog of arbitrary diffusers



Optimizing other parameters

Numerous additional parameters are open to optimization, including:

- Position
- Thickness
- Rotational angle
- Reflector surface properties including reflectivity and scattering
- Diffuser material property

Generating an IES file

The screenshot shows the TracePro Expert software interface. The main window displays a 3D model of an LED array and a Polar Candela Distribution Plot. A 'Save As' dialog box is open, showing the file name 'Webinar IES.ies' and the save type 'IESNA LM-63 (*.ies)'. An 'IES File Defaults' dialog box is also open, showing settings for Photometric Type C, Vertical angles 19, # Lamps 1, and Symmetry options.

IES File Defaults

Photometric: Type C | Vertical angles: 19 | # Lamps: 1

Multiplier: 1 | Symmetry: Horizontal: 0 - 0 degrees | Vertical: 0 - 180 degrees

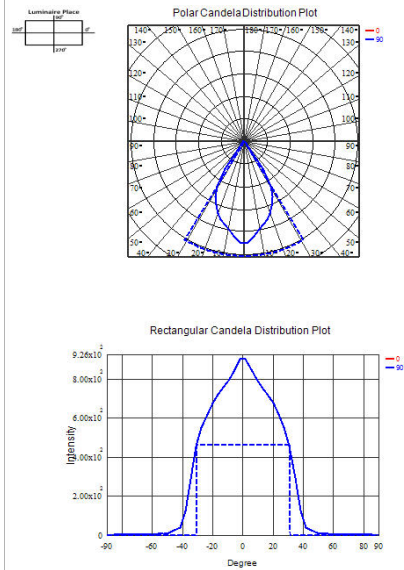
decimals: 6 | Luminous Dimensions: Width 0 | Length 0 | Height 0 | in Feet

Show this dialog automatically for this model

OK | Cancel

Viewing a lighting report in the IES/LDT Analysis Utility in TracePro

Candela Distribution Curves

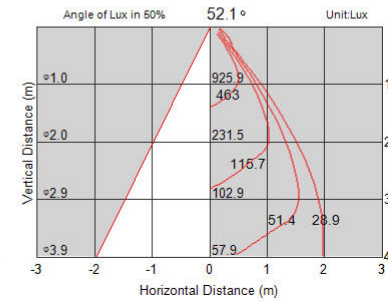
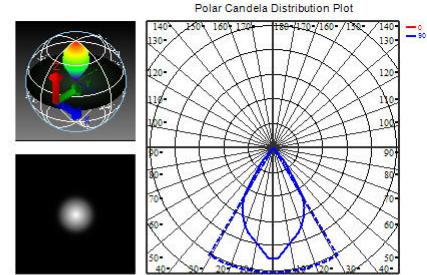


Lamp Information

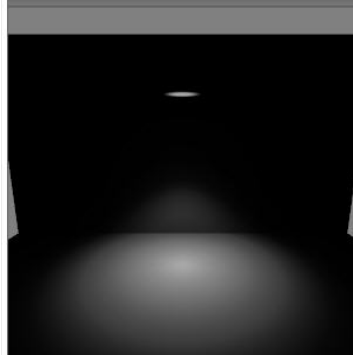
Company:
LUMINAIRE:
IES Type: Type C

[Size Info]
Size Unit: [feet]
Width: 0.0000
Length: 0.0000
Height: 0.0000

[Others]
Input Power: 1.0000
Multiplier: 1.0000
Rated Lumens: 999.9000
Output Lumens: 726.2843
K Value: 0.9260
Efficiency: 0.7264



Illuminance analysis

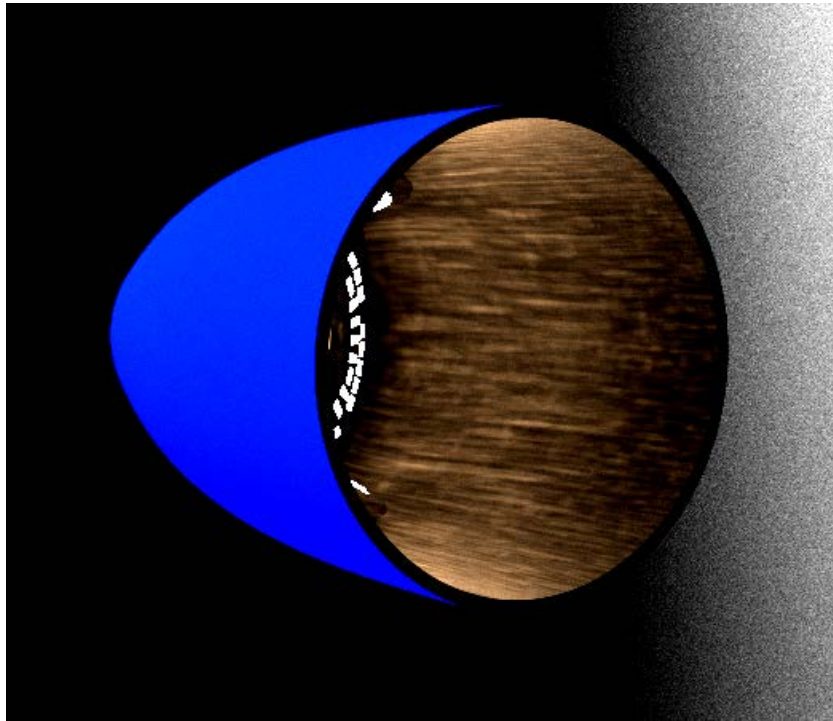


Alpha=24.1° +24.1° G=0.0° Max not at G Beta=24.1° +24.1°

[m]	Max lux	Ave lux
1.00	925.93	687.66
2.00	231.48	171.92
3.00	102.88	76.41
4.00	57.87	42.98
5.00	37.04	27.51



Photorealistic rendering results: with and without diffuser



Without Diffuser



With Diffuser

Summary and Questions

TracePro streamlines the illumination design process and accelerates product time to market with:

- ✓ A familiar CAD interface as well as the TracePro Bridge for SolidWorks
- ✓ Superior raytracing performance
- ✓ Tools and utilities optimized for the lighting and luminaire designer
- ✓ Powerful 2D and 3D optimization capabilities
- ✓ Comprehensive visualization and analysis tools

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

www.lambdares.com

Phone: 978-486-0766

E-mail: sales@lambdares.com

For questions about the topics in this webinar please contact Dave Jacobsen at: djacobsen@lambdares.com