Model and Predict the Performance of LEDs for Solid State Lighting – Accurately and Quickly

TracePro's Surface Source Property Generator helps users set up the Surface Source property – quickly and accurately. The macro tool reads the spectrum and angular radiation pattern from the manufacturer's datasheet. While useful for LEDs, this tool can also be used to generate a Surface Source property for any type of light source.

The setup files and instructions for installation of the Surface Source Property Generator may be downloaded from:

http://www.lambdares.com/technical_support/tracepro/utilities/

LEDs for Solid State Lighting

The use of LEDs for solid-state lighting to address applications in the automotive, architectural and general illumination markets is just emerging. LEDs promise greater energy efficiency and lower maintenance costs. However, there is a significant amount of design and cost optimization to be done while semiconductor companies continue to improve manufacturing processes. Furthermore, there is a lack of standards definitions and metrics - many definitions in the commercial lighting industry are simply not applicable to LED technology.

Predictive modeling of solid state lighting with TracePro opto-mechanical design software enables adherence to performance, consistency, cost, and aesthetic criteria without the cost and time associated with iterative hardware prototyping.

Predictive Modeling of LED Sources with TracePro

TracePro

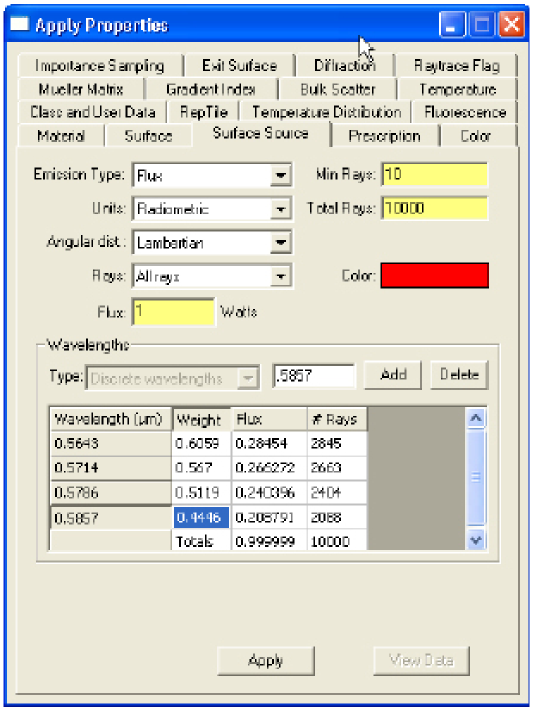
TracePro is a comprehensive, versatile software tool for modeling the propagation of light in opto-mechanical systems. Models are created by importing design files from a lens design program or a CAD program or by directly creating the solid geometry in TracePro. Optical and mechanical properties are applied to materials and surfaces. Source rays propagate through the model with portions of the flux of each ray allocated for absorption, specular reflection and transmission, phosphorescence, and scattering.
From the model, analyze:

- Light distributions in illumination and imaging systems
- Lumens exiting, absorbing, and incident at the component and system levels
- Candela distributions
- Optical efficiency, luminance and radiance metrics
- Luminance effects and lit appearance
- Fluorescence effects of phosphors

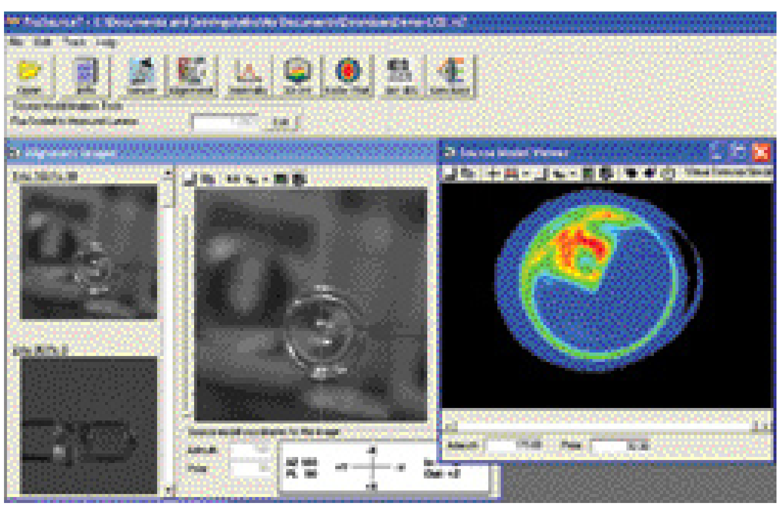
Modeling Optical Sources in TracePro

There are three methods of defining rays that launch into the model for ray trace – Grid, Surface and File sources. Most useful for modeling LEDs are Surface and File sources.

A Surface Source emits rays from a user-defined source type in an angular distribution and spectrum from one or more surfaces of a solid object. The example that follows makes use of the Surface Source method of defining rays that launch into the model for ray trace.



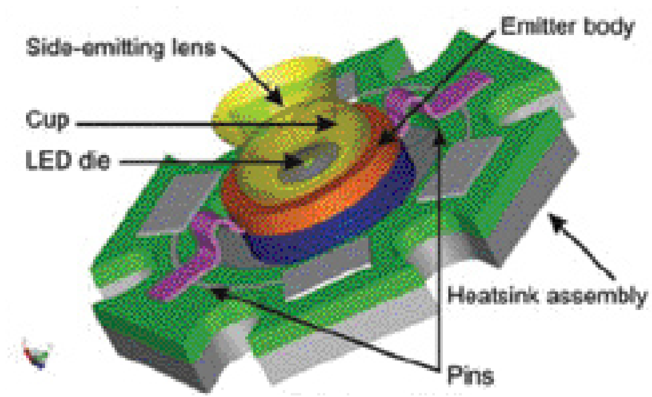
A File Source contains ray data and can be inserted into a TracePro model. Data consists of XYZ starting points for each ray, XYZ direction vectors for each ray, and a flux. A File Source allows the user to include actual measured source distribution data from companies offering LED characterization services such as Radiant Imaging, Inc. (www.radiantimaging.com) or to include theoretical and measured data from other software modeling applications such as Radiant Imaging's ProSource™ program.



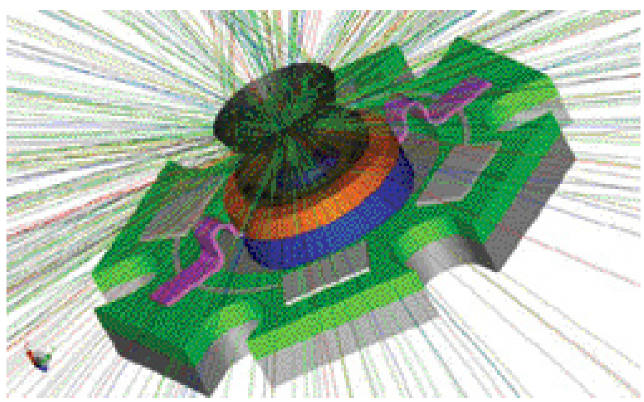
Modeling Opto-Mechanical Systems in TracePro

TracePro can accommodate a true 3-D model of an LED that provides not only an accurate optical model based on the source modeling described above, but also provides an accurate opto-mechanical model. The opto-mechanical model is created by importing the geometry from mechanical CAD files available from commercial manufacturers or by directly creating the geometry in TracePro based on manufacturers' datasheets.

The user can model the complete packaged LED. Create or import the geometry for the LED cup, LED lens, LED die, etc. and then apply material and surface properties.



In the opto-mechanical model, define a surface of the die object as the Surface Source. In the Surface Source editor, define the angular distribution and spectrum.

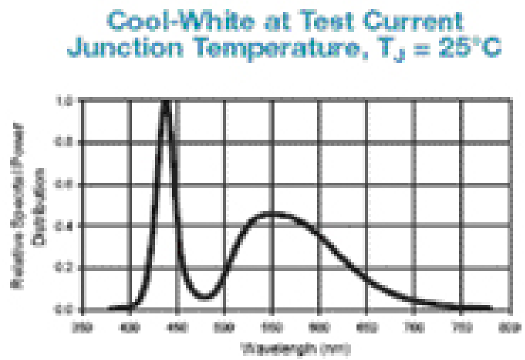


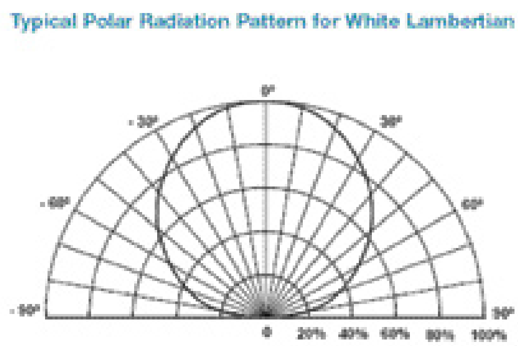
For higher level system modeling, the user can simply incorporate additional optics and mechanics to the packaged LED source models.

Surface Sources for LED Models

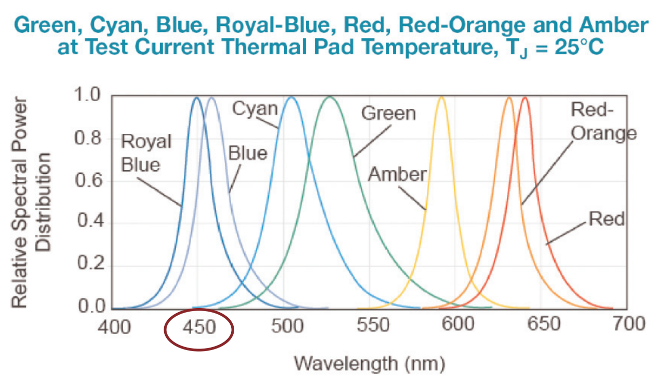
Surface Sources are an efficient means to create the LED model in TracePro when the LED datasheet is the only available reference. There are two ways to define the Surface Source:

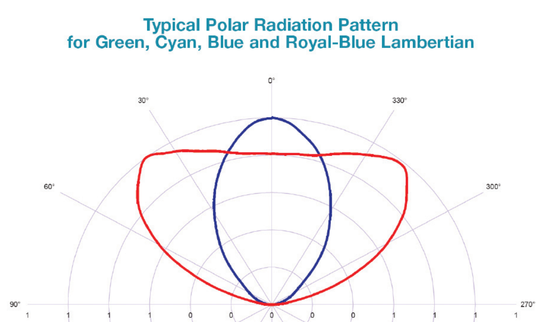
- Spectral distribution and angular intensity distribution are defined





- Peak or dominant wavelength and angular intensity distribution are defined





In the example below, a Surface Source is defined from spectral distribution and angular intensity distribution data.

TracePro Surface Source Property Generator

Surface Source Property Generator

TracePro's Surface Source Property Generator helps users set up the Surface Source property – quickly and accurately. The tool reads the spectrum and angular radiation pattern directly from the manufacturer's datasheet. While useful for LEDs, this tool can also be used to generate a Surface Source property for any type of light source.

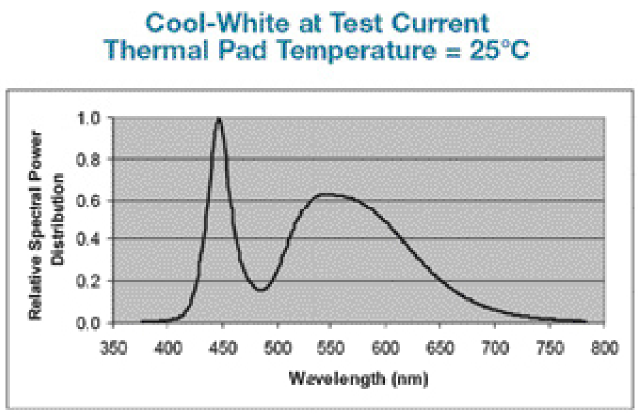
The setup files and instructions for the Utility may be downloaded from Lambda Research's web site:
http://www.lambdares.com/technical_support/tracepro/utilities/

Manufacturer's Datasheet

Specifications from a manufacturer's datasheet can be directly imported to TracePro's Surface Source Property Editor with the Surface Source Property Generator .

Relative Spectral Power Distribution

LED manufacturers typically specify Relative Spectral Power Distribution. Below is representative data from Philips Lumileds for the cool-white Luxeon™ Rebel LED.



This data can be directly imported to TracePro's Raytrace Options input with the Surface Source Property Generator .

Polar Radiation Pattern Distribution

LED manufacturers typically specify Polar Radiation Pattern Distribution. Below is representative data from Philips Lumileds for the cool-white Luxeon Rebel LED.

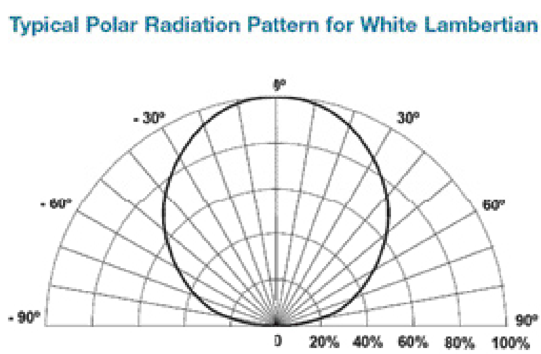


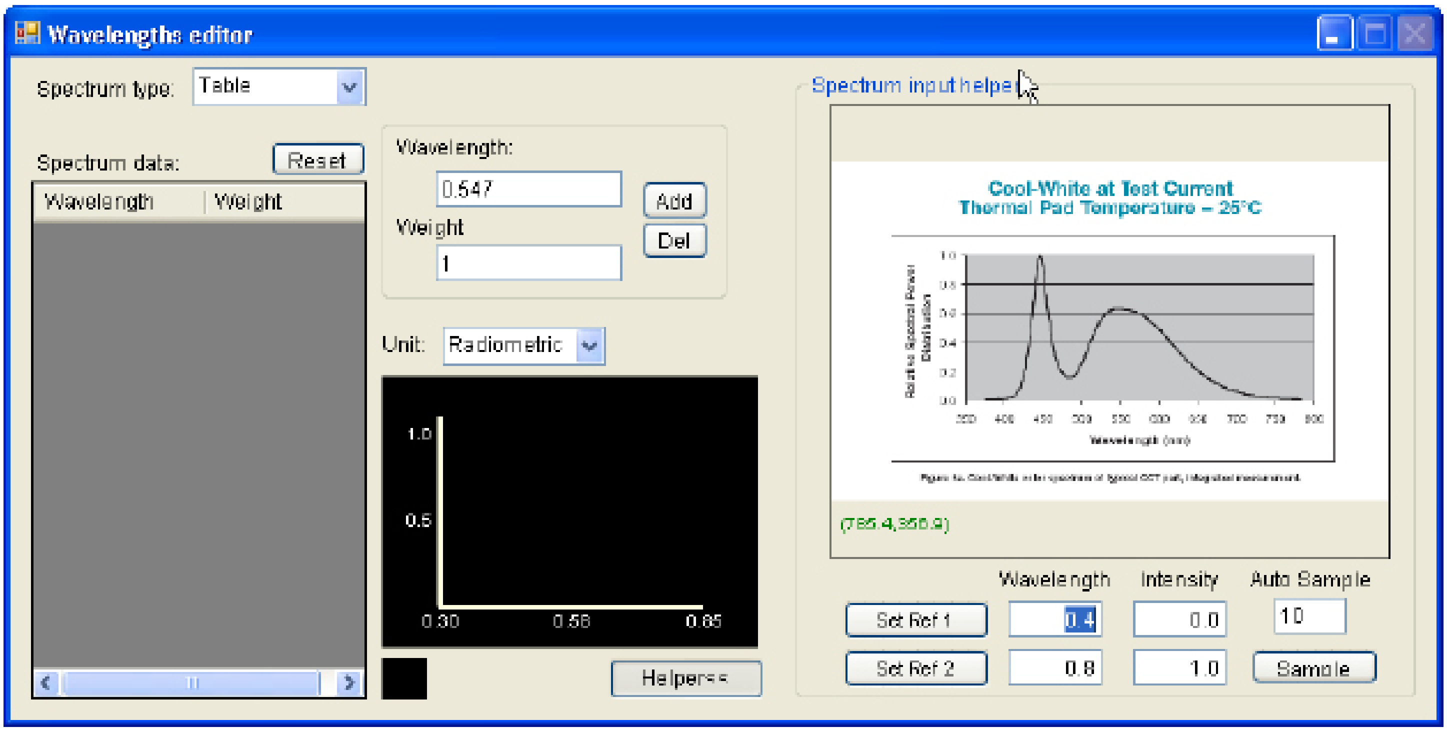
Figure 18: Typical Polar Radiation Pattern for Cool-White, Neutral-White and Warm-White Lambertian.

Model LED as TracePro Surface Source with Utility

A step-by-step example using the Surface Source Property Generator to model an LED from a manufacturer's datasheet is given below. The Surface Source is defined from spectral power distribution and angular intensity distribution data. A surface source is created for the cool-white Luxeon Rebel LED with specifications from the Philips Lumileds' datasheet, http://www.philipslumileds.com/pdfs/DS56.pdf.

Import Relative Spectral Power Distribution

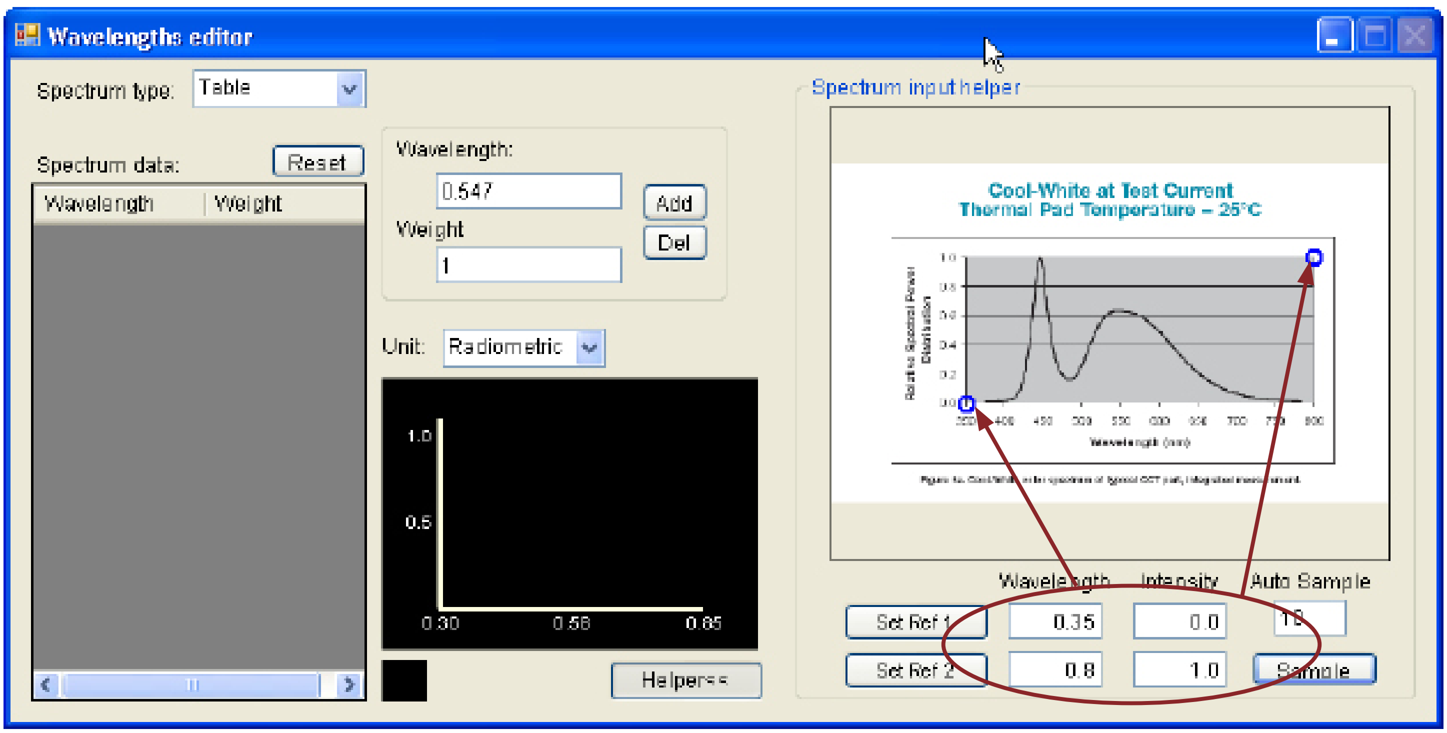
Import "Relative Spectral Power Distribution" by copying data directly from the datasheet and pasting it into the "Wavelengths Editor" window. Depending on the security properties of the datasheet document, it may be necessary to screen capture the graphic, save as a *.bmp file, and then copy the data from the *.bmp file. To paste, click the "Helper" button to expand the window, then right click in the "Wavelengths Editor" window, and select "Paste Background" from the menu.



Coordinate System

On the imported "Relative Spectral Power Distribution" curve in the "Wavelengths Editor" window, identify two reference points. Click "Set Ref 1" button in "Coordinate System", go to the graphic window, and click on a reference point. Repeat for "Set Ref 2". It is recommended to set the reference points as far apart as feasible for best accuracy. Specify the "Wavelength" and "Intensity" values for the reference points in the "Coordinate System" input cells. Notice that wavelengths are specified in the Utility and in TracePro as microns, while LED datasheets typically specify wavelength as nanometers (nm).

Referencing below, the two points identified for the imported cool-white Luxeon Rebel LED are at the extremes of wavelength and intensity.



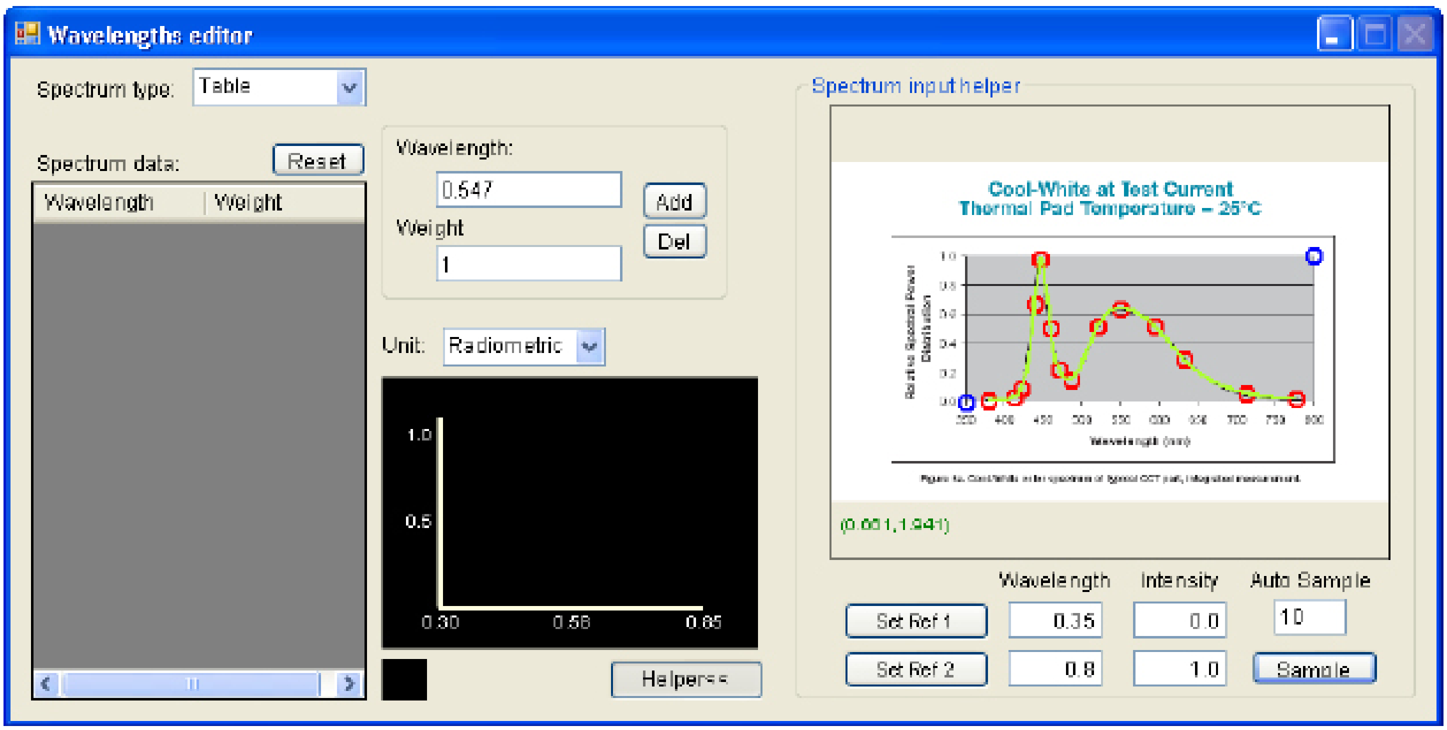
Set Spectrum Control Points

"Spectrum Control Points" are identified on the imported "Relative Spectral Power Distribution" curve in the "Spectrum Picker" window. "Set Data Points" by clicking on the curve in the graphic window. Accuracy improves with the number and representative position of data points.

Additional features for editing and viewing the "Spectrum Control Points" include:

> Move data point by clicking and dragging the it directly in the graphic window

> If an erroneous data point is plotted, right-click and "Clear All" delets all data points.

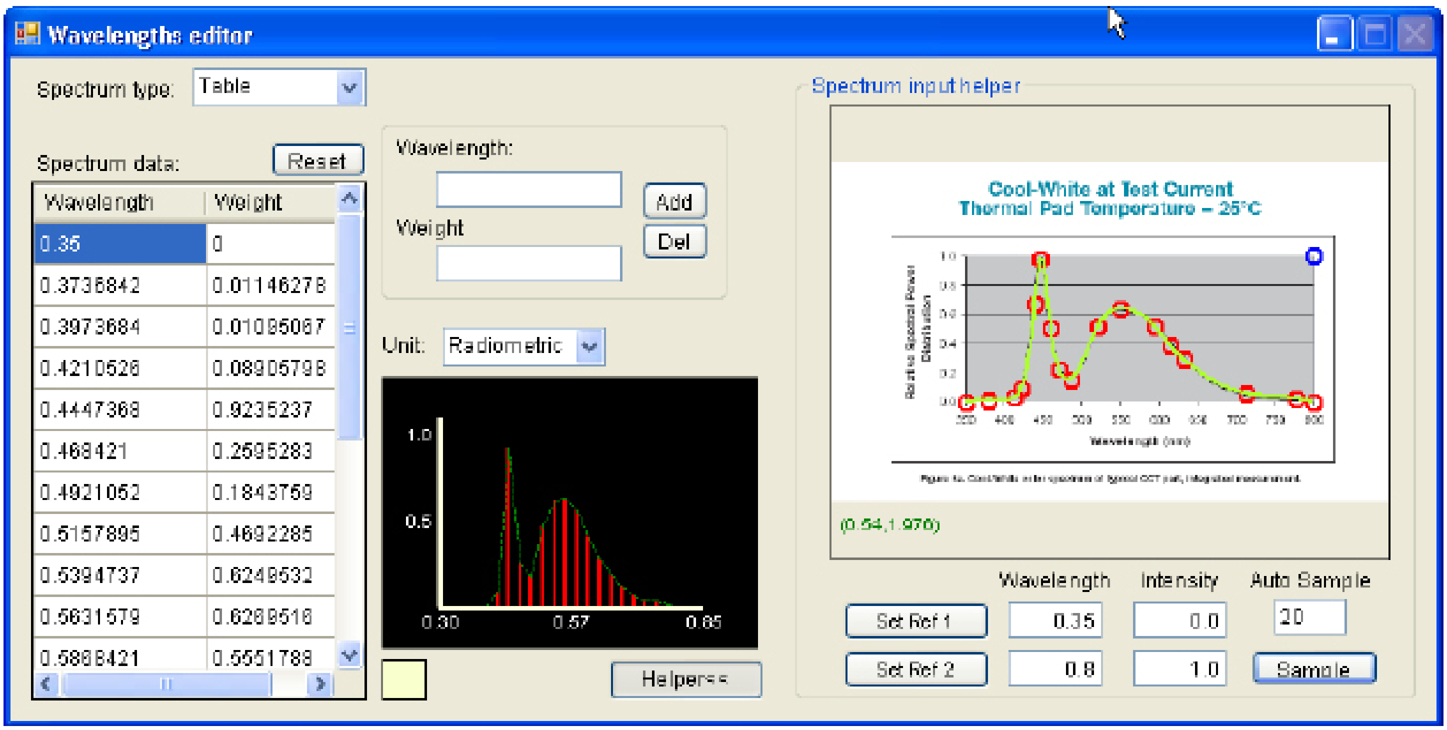


Define Spectrum

In the lower right of the Wavelengths Editor window, specify the number of equally spaced points to be plotted in the "Auto Sample" field. Click on the "Sample" button to populate the table of wavelengths and weights.

Units

TracePro and the Surface Source Property Generator can accommodate photometric units (cd/m^2, foot-lambert, or millilamber) or radiometric units (W/m^2). Select the Units of the input data here, and there will be an opportunity later on to independently specify the units for the final TracePro Surface Source Property.

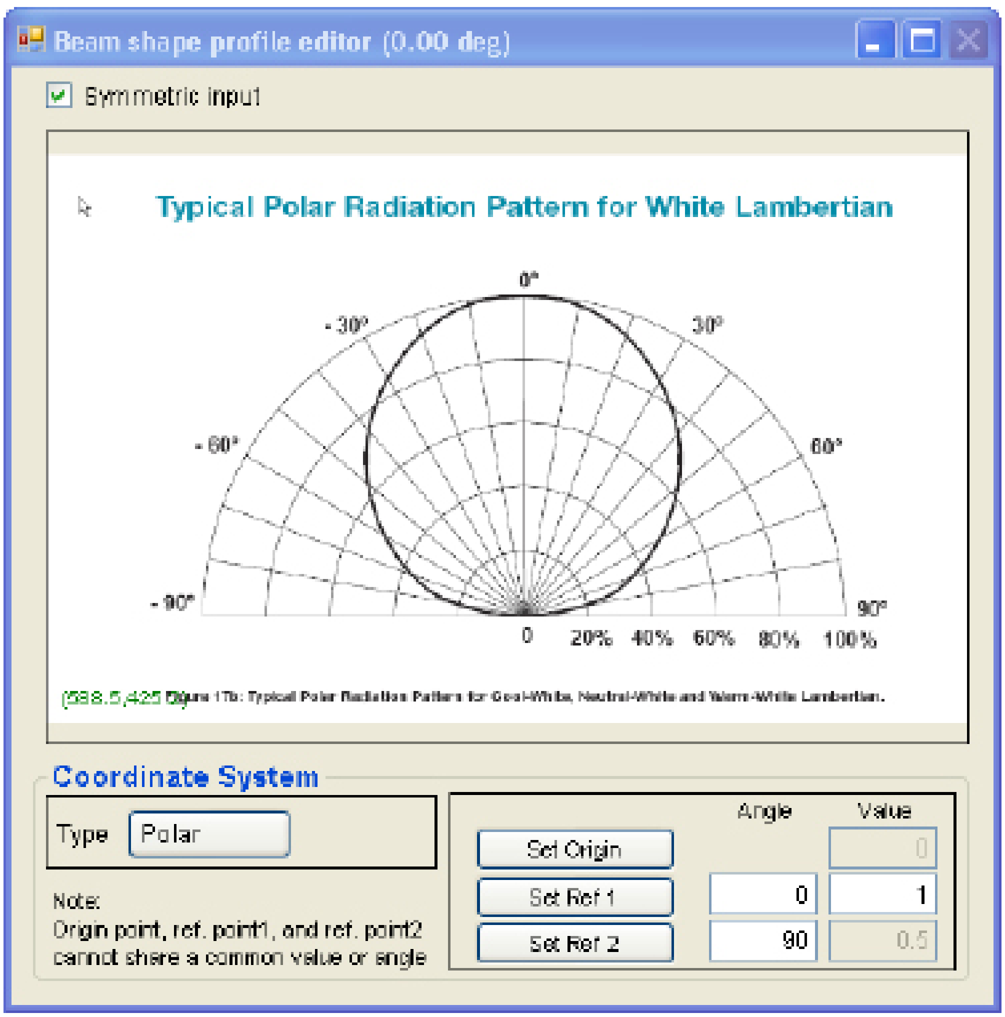


Angular Intensity Distribution

To import the "Angular Intensity Distribution", first make active the "Beam Shape Profile Editor" window.

Import Angular Intensity Distribution

Import "Angular Intensity Distribution" by copying data directly from the datasheet and pasting it into the "Beam shape profile editor" window. Depending on the security properties of the datasheet document, it may be necessary to screen capture the graphic, save as a *.bmp file, and then copy the data from the *.bmp file. To paste, right click in the window, and select "Paste" from the menu.

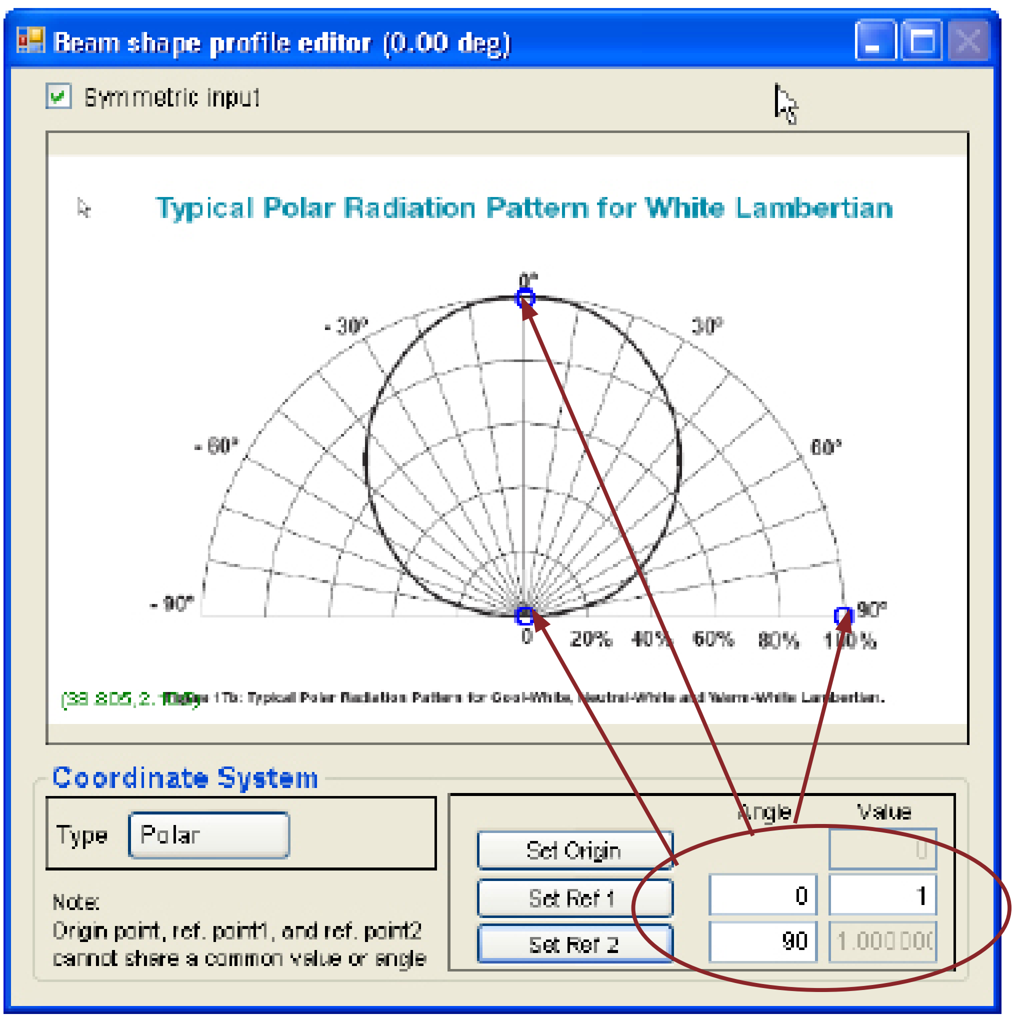


Coordinate System

The Surface Source Property Generator supports two coordinate systems: "Polar" and "Rectangular". "Polar" and "Rectangular" coordinate systems require three and two reference points respectively. The imported Angular Distribution Curve for the cool-white Luxeon Rebel LED makes use of polar coordinates.

On the imported "Angular Intensity Distribution" curve in the window, identify three reference points. Click "Set Origin" button in "Coordinate System", go to the graphic window, and click on the origin. Click "Set Ref. 1", go to the graphic window, and click on a reference point. Repeat for "Set Ref. 2". It is recommended to set the reference points as far apart as feasible for best accuracy. Specify the "Angle" and Relative Intensity "Value" for the reference points in the "Coordinate System" section of the Utility interface.

Referencing below, three points are identified for the imported cool-white Luxeon Rebel LED – at the origin, at an angular and relative intensity extreme from the origin, and at 0° and a relative intensity far from the origin.

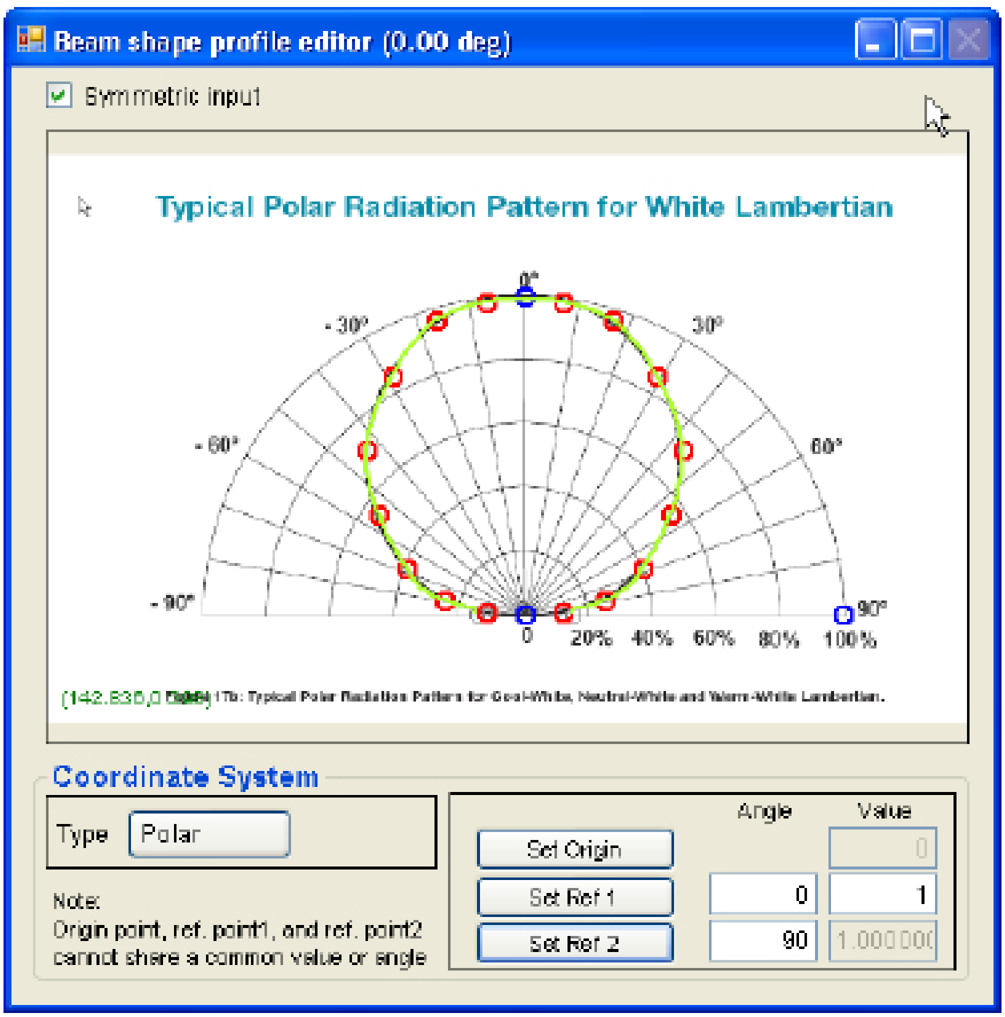


Set Radiation Pattern Control Points

“Radiation Pattern Control Points” are identified on the imported “Angular Intensity Distribution” curve in the “Beam shape profile editor” window. “Set Data Points” by clicking on curve in the graphic window. Accuracy improves with the number and representative position of data points.

Note that in this example the “Symmetric Input” box is checked, so each data point selected also plots a symmetric mate.

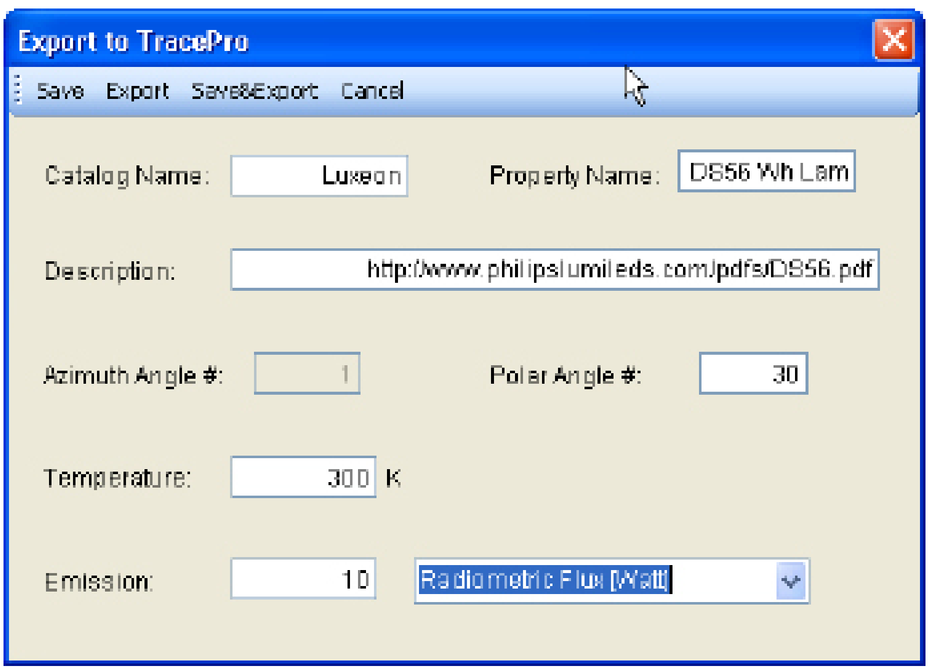
Data points can be moved by clicking and dragging directly in the graphics window.



Export to TracePro

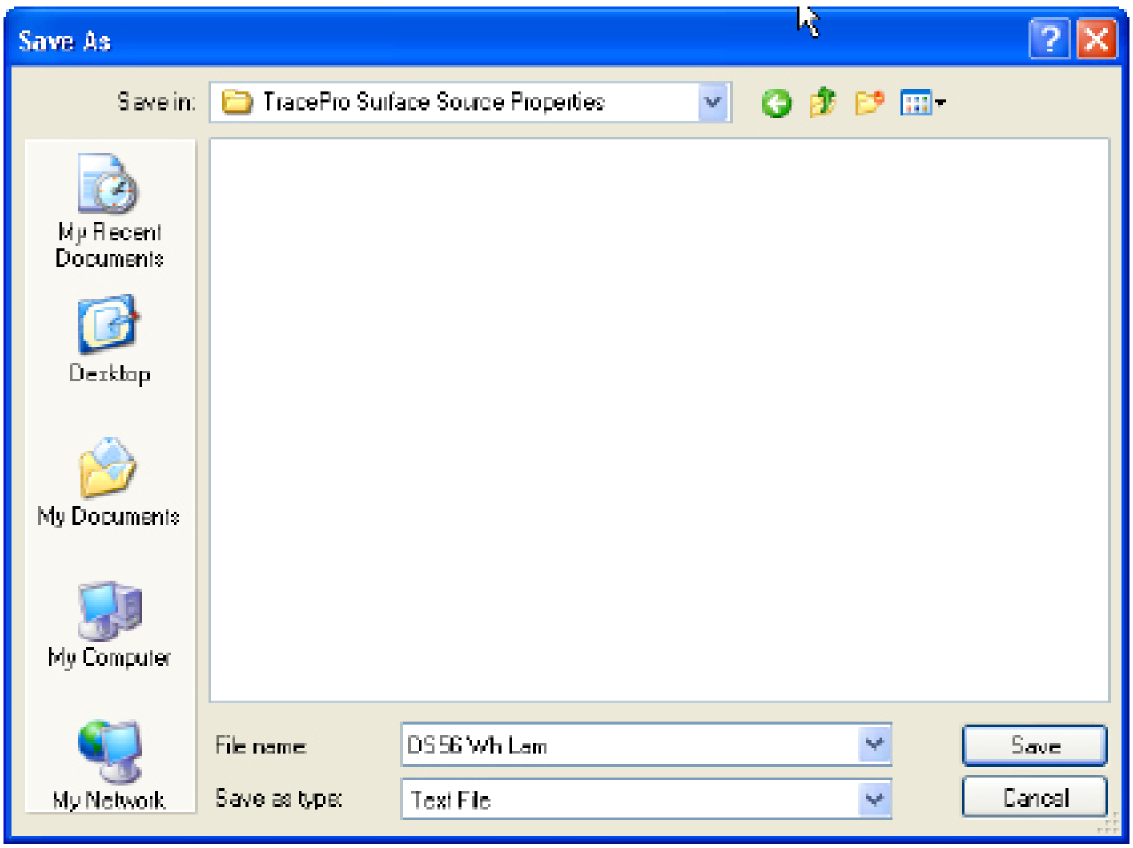
"Select "Export" from the Main Menu, then enter data in the following fields:

Catalog Name - the name of the catalog where the Surface Source Property will appear in the TracePro Property Editor
Property Name - the name of the Surface Source Property as it will appear in the TracePro Property Editor
Description (optional)
Azimuth Angle - the number of equally spaced azimuth angles between 0 and 360 deg
Polar Angle - the number of equally spaced polar angles between 0 and 90 deg
Temperature -
Emission / Units - the first field is for the value of the magnitude of the emission, the second field is the selection of the emission units (Radiometric or Photometric / Flux or Irradiance)



There are four menu options in the "Export to TracePro" window:

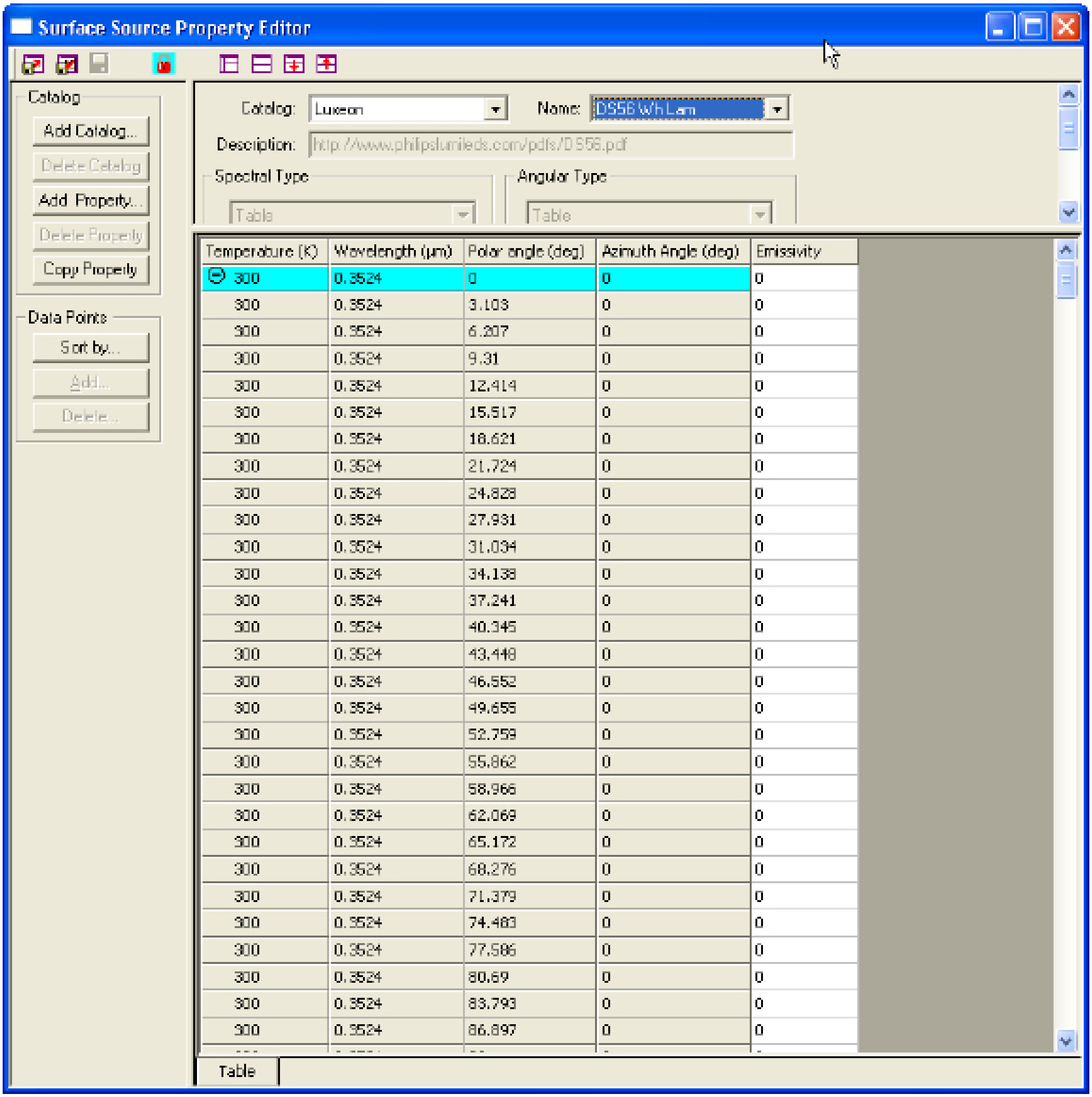
Select "Save" to save the Surface Source Property as a text file
Select "Export" to export the Surface Source Property directly into TracePro Properties Database
Select "Save and Export" to do both of the above in a single step
Select "Cancel to close the window without performing any action.



Verify Surface Source Property Data in TracePro

Once a property has been exported into TracePro, select Defin|Edit Property Data| Surface Source Properties, then select the Catalog and Name to view the property.

If the property was saved as a text file, it can be imported by selecting File/Import, or by clicking the "Import" icon in the Surface Source Property Editor.

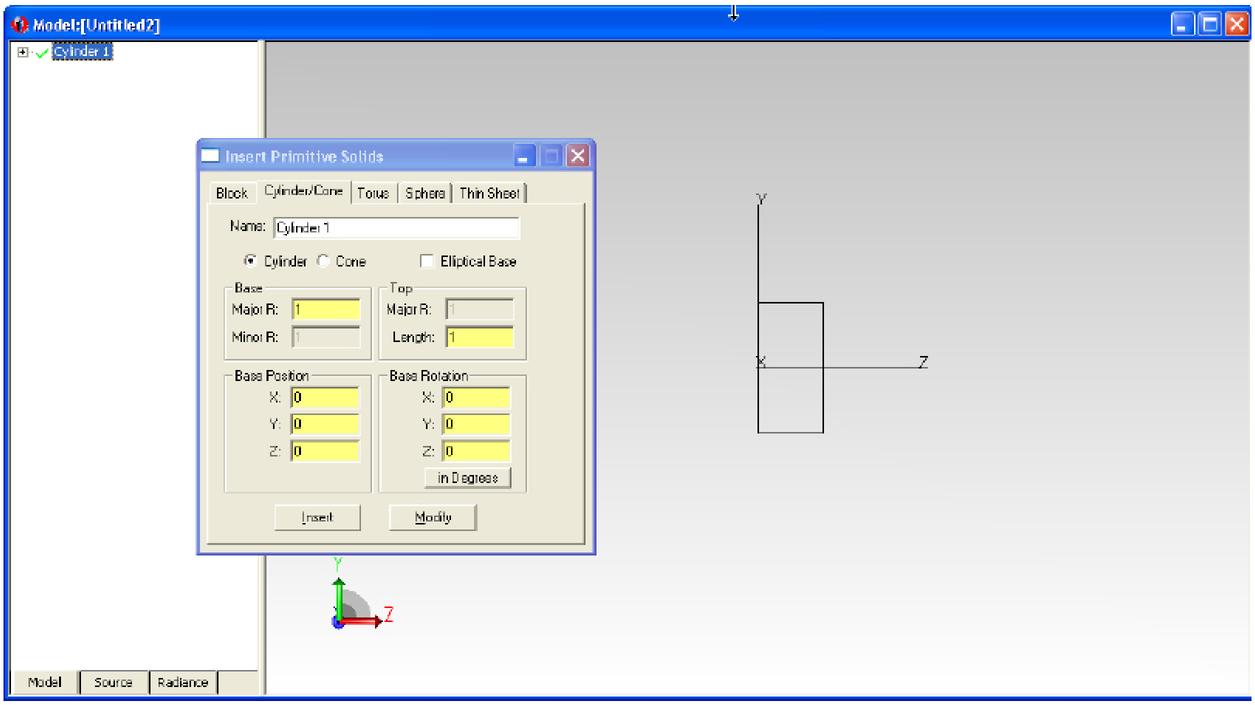


Tracing Rays in TracePro

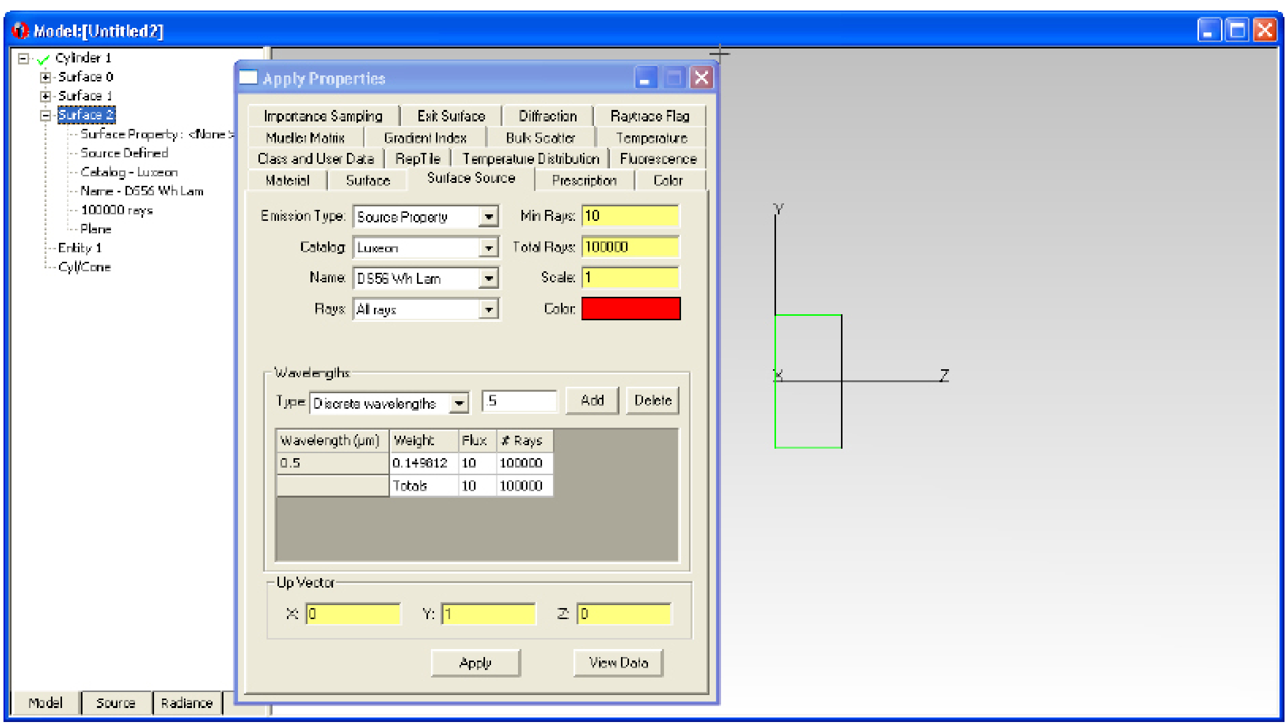
In TracePro:

Select File/New

Select Insert/Primitive Solid/Cylinder-Cone and click "Insert" to create an object.

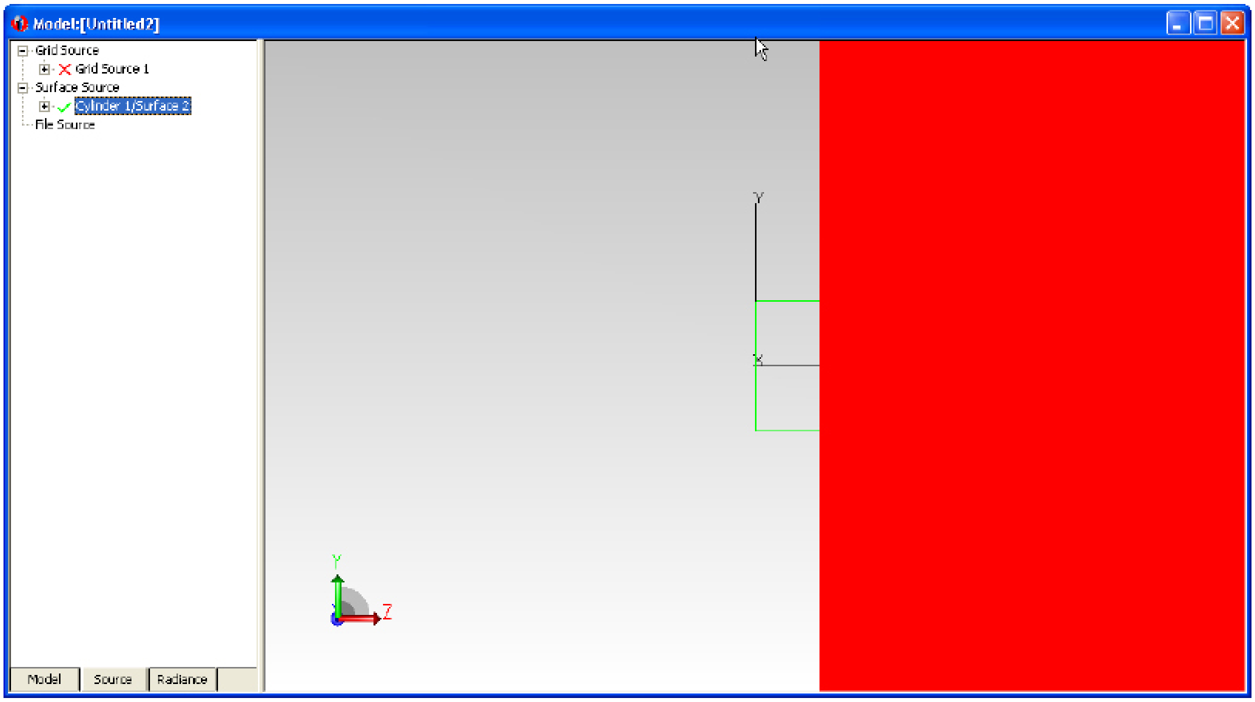


Right-click on Surface 2 of the Cylinder, select Properties, then input the following data in the Apply Properties/Surface Source tab



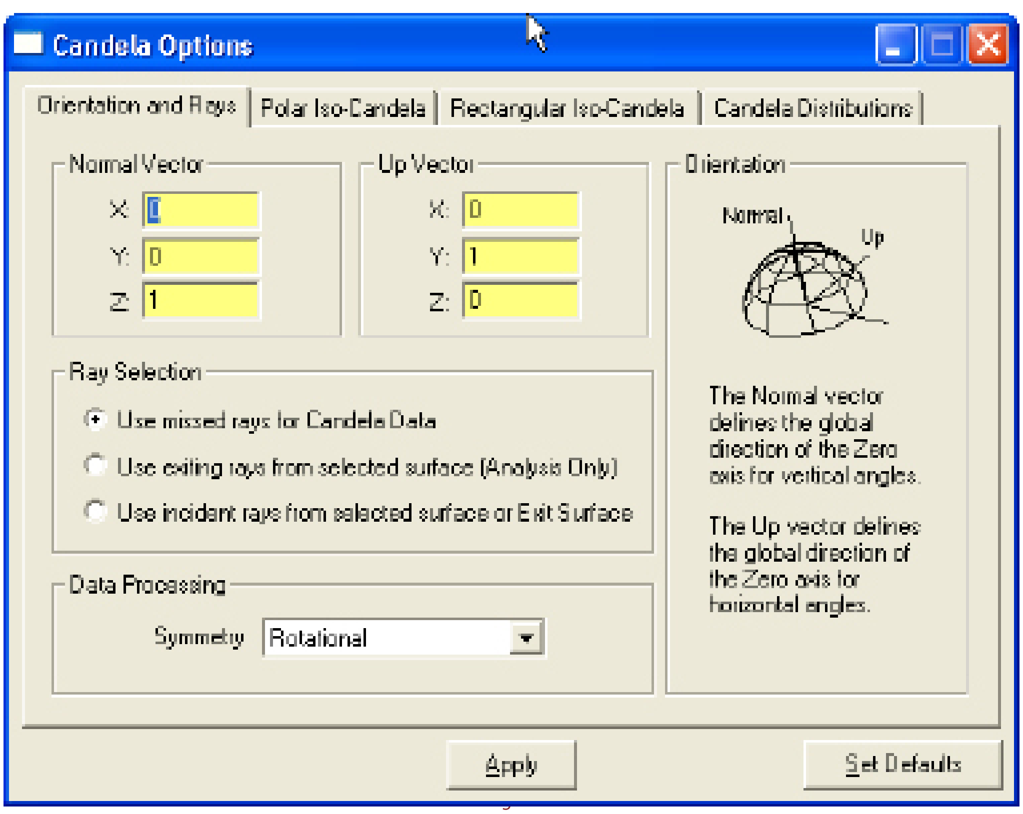
Tracing Rays in TracePro (continued)

Uncheck the Grid Source, then select Raytrace/Trace Rays.



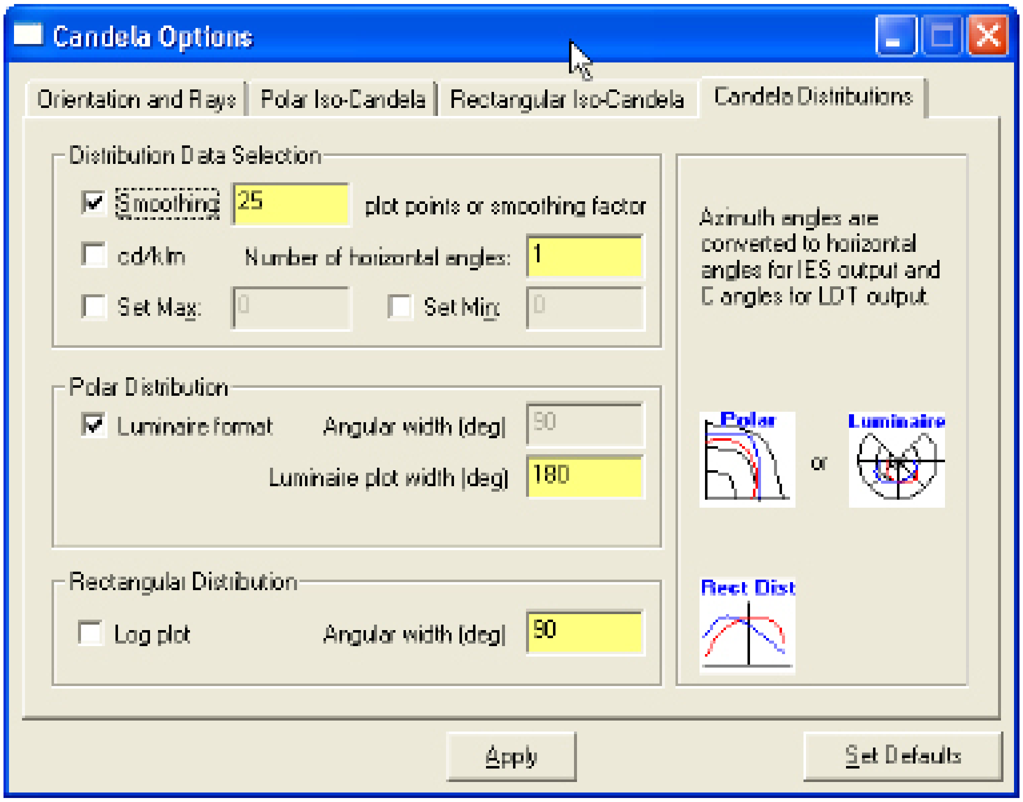
Viewing the Candela Plot

Select Analysis/Candela Options and enter the following in the Orientation and Rays tab:



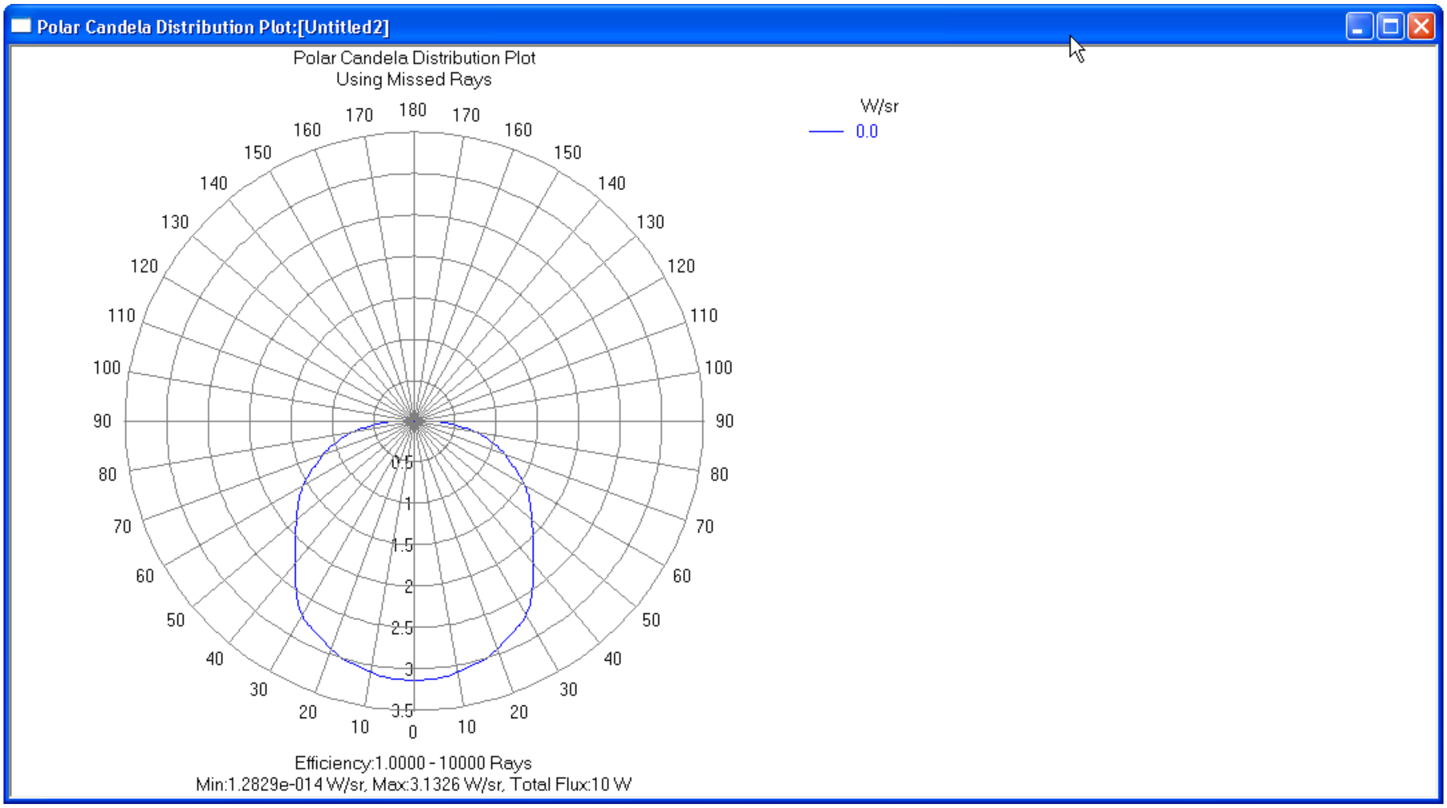
Viewing the Candela Plot (continued)

Enter the following in the Candela Distributions tab:



Viewing the Candela Plot

Select Analysis/Candela Plots/Polar Candela Distribution to view the plot and verify that it matches the angular distribution from the LED Spec Sheet.

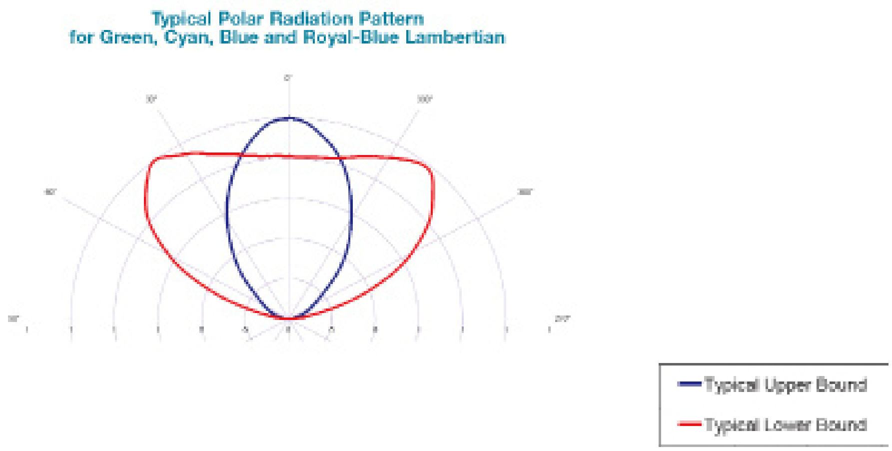


Manufacturing Tolerances

In the manufacturing of semiconductor sources, there is a variation of performance around the average values specified in manufacturers' datasheets. LEDs are "binned" based on performance parameters including variations in luminous flux and color. LED manufacturers typically specify upper and lower bounds and this data can be directly imported to TracePro's Surface Source Property Editor from the datasheet with the Surface Source Property Generator as described above.

Polar Radiation Pattern Distribution: Upper and Lower Bounds

LED manufacturers typically specify the upper and lower bounds of radiation patterns on the datasheet. Below is representative data from Philips Lumileds for its Green and Royal Blue Luxeon Rebel LEDs.



With TracePro's Surface Source Property Generator , quickly and accurately import upper and lower bounds to analyze, test and tolerance the opto-mechanical system.

Summary

In line with TracePro's simple, intuitive interface and short learning curve, the Surface Source Property Generator allows users to quickly create accurate LED models from data that is readily available from LED manufactures' published datasheets. For more information, please contact Lambda Research's Application Engineers at sales@lambdares.com.

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