

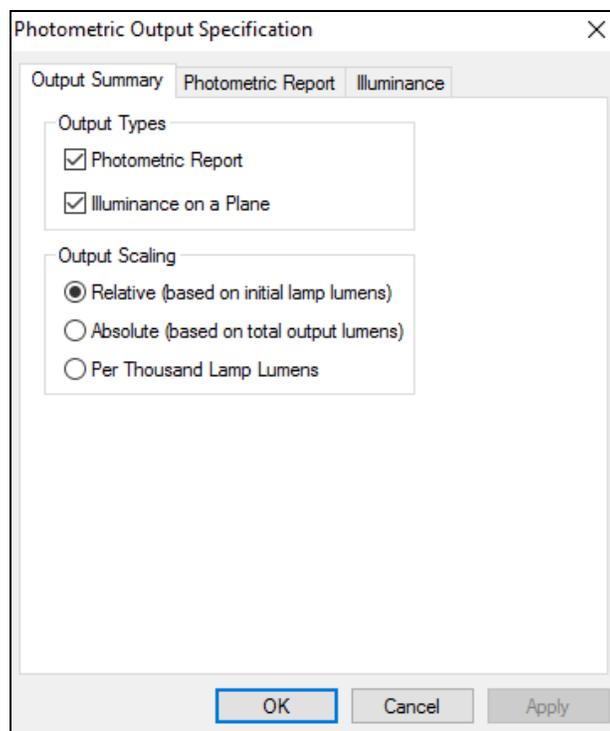
Beginner Tutorial 2 – Analyze a Luminaire

Once a 3D luminaire model is inside Photopia and its materials are assigned, it is ready to be analyzed. Photopia allows you to specify a range of settings that control the analysis process and also dictate the type and format of the photometric output produced. The following sections lead you through the details of specifying the photometric output and raytrace settings.

1. Before starting, choose **Help > Open Sample Project** and find *Beginner Tutorial – LED Collimator.ray*, if it is not already open from Tutorial 1.

Photometric Output

2. Select **Analysis > Specify Photometric Output** from the main menu. This screen allows you to select the type(s) of output Photopia will generate. Your choices include a Photometric Report and Illuminance on a Plane. Additionally, you can specify whether the photometry will be Relative, Absolute, or Per Thousand Lamp Lumens.



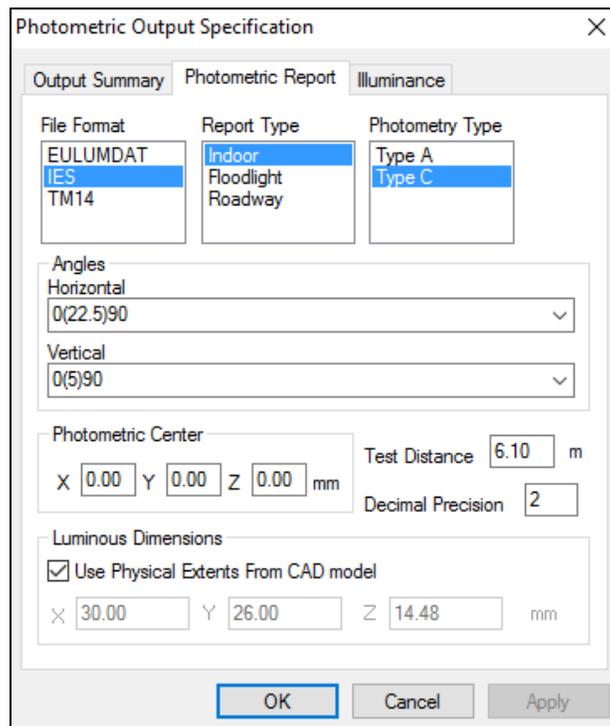
Relative photometry is based on the lamp lumens specified in the Design Properties screen (the rated lamp lumens). Absolute photometry is based on the total output lumens (the rated lamp lumens, decreased by the system optical efficiency). Photometry reported per thousand lamp lumens is scaled so 1000 total lumens were input into the luminaire. If the luminaire in this tutorial were photometered using per thousand lamp lumens, it would be assumed that each of the two lamps generated only 500 lumens.

3. For this tutorial, choose Photometric Report and Illuminance on a Plane for the output types, and Relative for the output scaling.

Photometric Report

4. Select the **Photometric Report** tab to specify the details of your photometric report.

This screen allows you to choose a report type, photometry type, the horizontal and vertical angles in the distribution, test distance, decimal precision, photometric center, and luminous dimensions. The following sections provide a brief description of each of these items.



The image shows a dialog box titled "Photometric Output Specification" with three tabs: "Output Summary", "Photometric Report", and "Illuminance". The "Photometric Report" tab is active. It contains several sections:

- File Format:** A list box with options EULUMDAT, IES, and TM14. IES is selected.
- Report Type:** A list box with options Indoor, Floodlight, and Roadway. Indoor is selected.
- Photometry Type:** A list box with options Type A and Type C. Type C is selected.
- Angles:** Two dropdown menus. Horizontal is set to 0(22.5)90 and Vertical is set to 0(5)90.
- Photometric Center:** Input fields for X (0.00), Y (0.00), and Z (0.00) mm. Test Distance is 6.10 m and Decimal Precision is 2.
- Luminous Dimensions:** A checked checkbox "Use Physical Extents From CAD model" and input fields for X (30.00), Y (26.00), and Z (14.48) mm.

Buttons for "OK", "Cancel", and "Apply" are at the bottom.

File Format

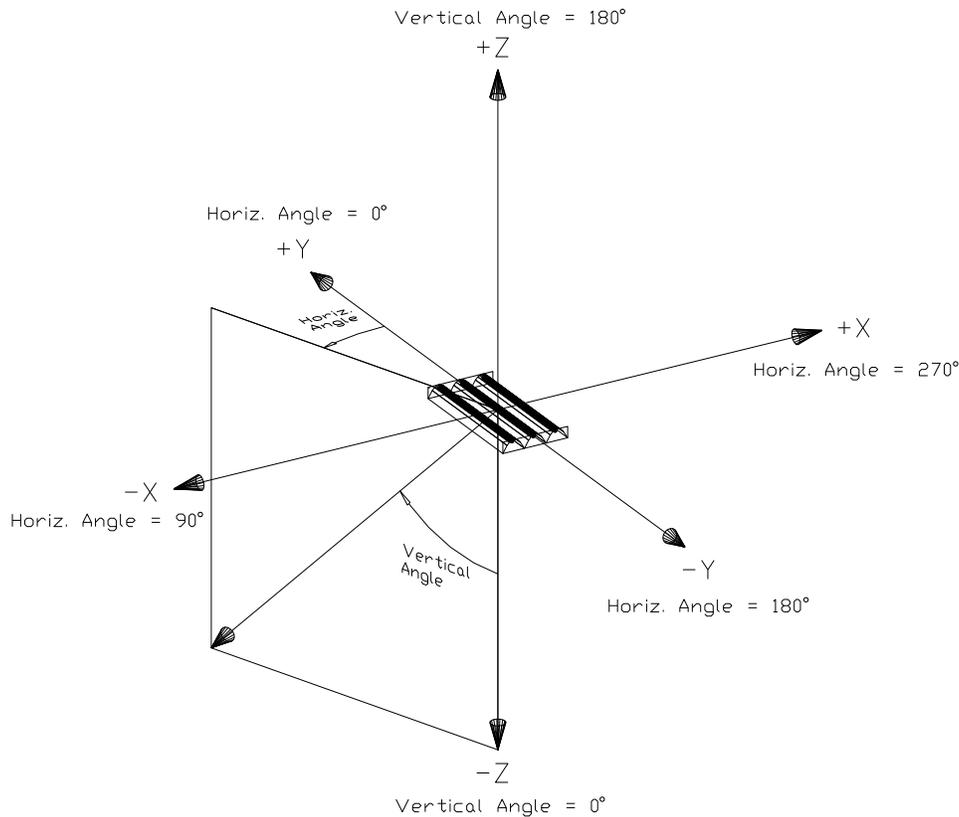
Photopia will create standard format photometric files as part of its output. Even though you may specify a file format in this screen, Photopia automatically creates all formats when you run a raytrace. The files created are an IES file (North American standard), EULUMDAT files (European standard) and a TM-14 file (British standard). The files are stored with your project files in the folder you specified, using the name of your project as its filename prefix. In this tutorial, Photopia will create files named *Beginner Tutorial – LED Collimator.IES* (IES file format), *Beginner Tutorial – LED Collimator.T14* (TM-14 file format), *Beginner Tutorial – LED Collimator.LDT* and *Beginner Tutorial – LED Collimator.ELX* (both EULUMDAT file formats).

Report Type

Photopia also automatically creates photometric reports. The specific format of the photometric reports generated by Photopia can be tailored to the needs of the specific type of luminaire you have. Photopia generates reports appropriate for indoor luminaires, floodlight luminaires, and roadway luminaires. Since the luminaire in this tutorial is a fluorescent troffer, we will leave the default of *Indoor* report type.

Photometry Type

The photometry type you select determines the orientation of the horizontal and vertical angles in the candela distribution as well as the constraints on these angles (as a matter of convention) set forth by the Illuminating Engineering Society of North America (IESNA). Indoor luminaires can be photometered with either Type A or Type C photometry. These photometric types define spherical coordinate systems with the poles of the coordinate system directly below (at nadir) and directly above (at zenith) the luminaire. The IES recommends that indoor luminaires be photometered as Type C. For more details about photometric types and the horizontal and vertical angles associated with them, see Chapter 6.



Type A & C Coordinate System

Specifying Horizontal and Vertical Angles

The horizontal and vertical angles determine the exact mesh or web of points to be sampled in the spherical coordinate system. Both the horizontal and vertical angles are specified as a list of angles using the following syntax: Start Angle (Angular Increment) Stop Angle. Commas are used to separate individual angles or ranges of angles, thus (0,5(10)85,90) is the same as (0,5,15,25,35,45,55,65,75,85,90). Spaces are not allowed. You can choose pre-defined angle sets from the lists provided, or define your own by typing them in using this convention.

5. Choose 0 for the horizontal angle set and 0(2.5)90 for the vertical angle set.

The complete range of the horizontal angles runs from 0° to 360°. We chose 0° since our luminaire is essentially axially symmetric. This means that all horizontal angle data will be averaged with symmetry.

The complete range of vertical angles runs from 0° to 180°. We chose 90° as a stopping point since our luminaire is a direct luminaire (it directs all of the light downward). No symmetry is assumed with vertical angles. If we had a completely indirect luminaire (one that directs the light toward the ceiling), then we would have selected vertical angles ranging from 90° to 180°. If we had a direct/indirect luminaire (one that directs light up and down), then we would have selected an angle set ranging from 0° to 180°.

Test Distance

The test distance refers to the distance from the photometric center to the virtual photocell used to measure the amount of light in a given direction. Luminous intensity distributions (candela distributions) can vary depending on the test distance used. In general, candela distributions stabilize and approach a constant shape if the test distance is greater than five times the maximum dimension of the luminaire. Thus the luminaire in this tutorial, which is about 10mm in diameter, may be kept at the default of 6.1m.

Decimal Precision

The decimal precision refers to the number of decimal places that will be written to the photometric files. For most luminaires, two decimal places will suffice. However, if you have a low output luminaire, such as an emergency luminaire where the expected candela values are all quite low, then you may want to choose a higher number for the decimal precision to obtain the proper resolution in your calculated data. Keep the default of 2 for this tutorial.

Photometric Center

The default value for the photometric center is usually 0, 0, 0. If you wish to change the default photometric center, then enter the desired location in the cells provided. For this tutorial, the photometric center should be located in the aperture of the luminous opening. In this drawing, this location is at a Z height of about -7.2 mm.

- So enter a Z value of -7.2 and leave the X and Y values both at 0 for this tutorial.

Luminous Dimensions

Photopia uses the luminous dimensions of the luminaire and the calculated candela values to estimate average luminaire brightness values for certain viewing angles. By default Photopia uses the physical extents of the luminaire for these dimensions. However, there are many cases where this assumption is not correct, and you may therefore enter the dimensions that should be used. Any recessed luminaire such as the downlight in our tutorial is an example of a luminaire for which you would want to modify the dimensions. In particular, you need to change the luminous height (Z dimension) to 0 since the sides are not luminous.

- Uncheck the checkbox for Use Physical Extents from CAD Model and enter a Z value of 0.

Photometric Output Specification

Output Summary | Photometric Report | Illuminance

File Format: EULUMDAT, IES, TM14

Report Type: Indoor, Floodlight, Roadway

Photometry Type: Type A, Type C

Angles

Horizontal: 0

Vertical: 0(2.5)90

Photometric Center

X: 0.00 Y: 0.00 Z: -7.2 mm

Test Distance: 6.10 m

Decimal Precision: 2

Luminous Dimensions

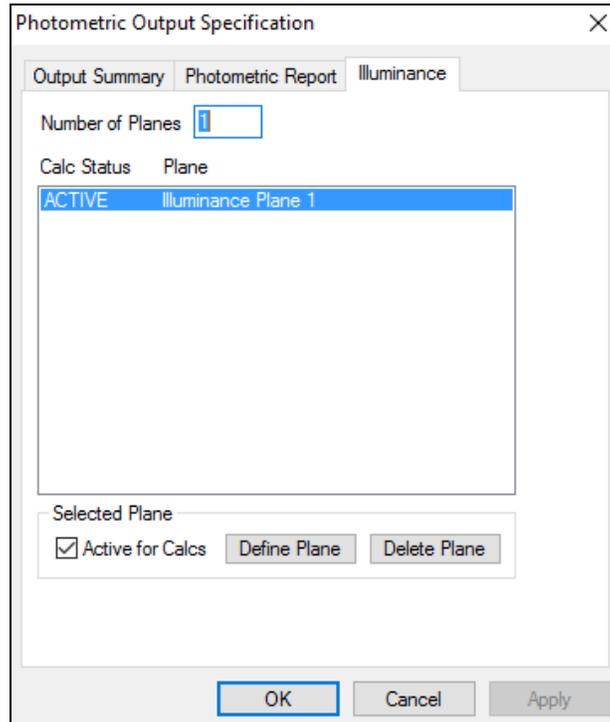
Use Physical Extents From CAD model

X: 30.00 Y: 26.00 Z: 0 mm

OK Cancel Apply

Illuminance on a Plane

- Once you have entered all of the photometric report information, select the **Illuminance** tab.

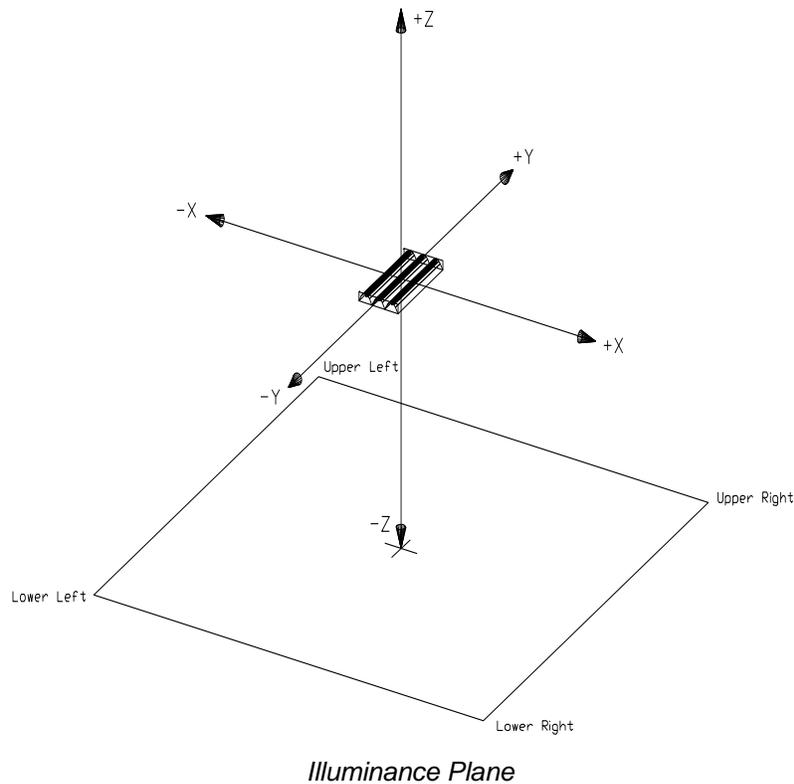


Photopia allows you to specify as many illuminance planes as you like. For each plane you must define its location and grid density. Additionally, you can deactivate planes you do not wish to participate in calculations using the checkbox at the bottom of this screen.

- We will specify only one plane for this tutorial, so enter a 1 into the Number of Planes cell.

Illuminance planes are defined relative to the absolute location and orientation of the luminaire in the CAD drawing. The luminaire in this tutorial is centered near 0, 0, 0 and the light is directed in the -Z direction. This is the orientation the luminaire should have in order for the horizontal and vertical angles, specified in the photometric report, to have meaning. For more details on the construction of a luminaire in the CAD program, see Chapter 4.

Illuminance planes are defined by four corner points, three of which you must provide, as shown in the following illustration. For more information on illuminance planes, see Chapter 6.



The illuminance plane for this tutorial will be 5m x 5m in size, centered 3m below the luminaire. The grid density will be 100x100 bins. With this information you can now define the illuminance plane:

10. Select the *Illuminance Plane 1* from the list.
11. Click the **Define Plane** button. Photopia displays an Illuminance Plane pop-up screen.
12. Edit the Description by typing in *5m x 5m Plane, 3m Below*.
13. The location of the plane is specified by four corner points. The descriptions of these points, for example, Lower Left Corner, refers to the location of the point you wish to view on a page. Be aware of the units for the illuminance plane coordinates, shown in the bottom left corner of this screen. Assuming the units for this tutorial are in meters, enter -2.5, -2.5, -3 for the Lower Left Corner point.
14. Enter 2.5, -2.5, -3 for the Lower Right Corner point.
15. Enter -2.5, 2.5, -3 for the Upper Left Corner point.
16. The Upper Right Corner point will be calculated automatically.
17. The default number of columns and rows gives a grid density of 100x100.

Illuminance Plane

Description:
5m x 5m Plane, 3m Below

Location of Plane

Lower Left Corner X: -2.5 Y: -2.5 Z: -3

Lower Right Corner X: 2.5 Y: -2.5 Z: -3

Upper Right Corner X: 2.5000 Y: 2.5000 Z: -3.0000

Upper Left Corner X: -2.5 Y: 2.5 Z: -3

Calculation Points

Number of Columns: 100 Column Spacing: 0.0500

Number of Rows: 100 Row Spacing: 0.0500

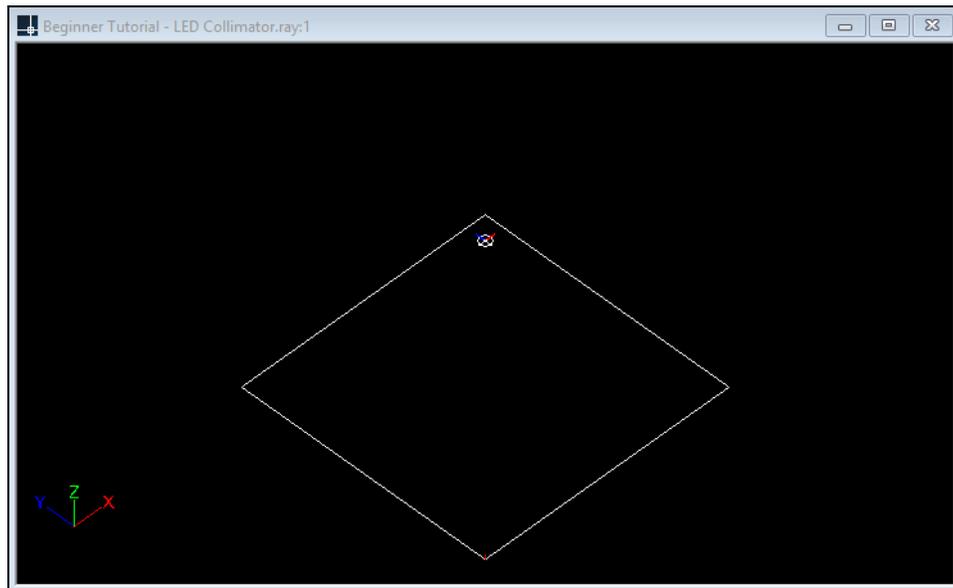
Units: m

OK Cancel

18. Once you have all of your values properly entered, click the **OK** button on the Illuminance Plane pop-up window. Once you have finished with all of the photometric output specifications, click the **OK** button.

Note that you will be able to see your illuminance plane in the CAD view inside Photopia, so it should be clear if you did not enter your coordinates properly.

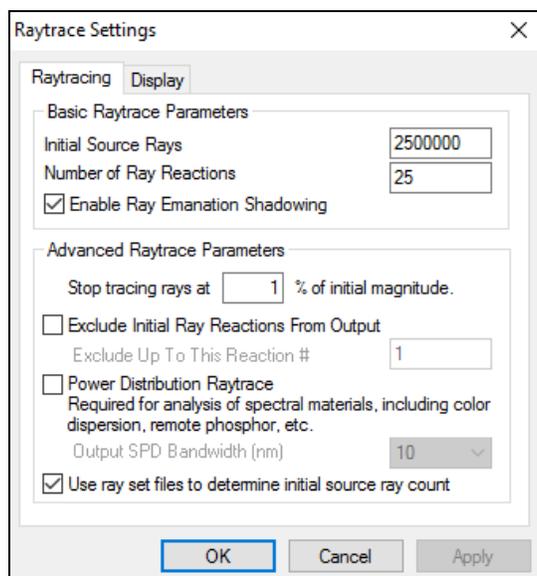
19. Click the Isometric View icon and the Zoom Extents icon  |  to view the model.



If your plane looks like it is the wrong size or in the wrong location, then check the units of the plane coordinates and ensure you entered numbers appropriately for that unit.

Specify the Raytrace Settings

Select **Analysis > Specify Raytrace Settings** from the main menu. This screen allows you to set the parameters that control the raytrace and the display of the results. The following sections provide a brief description of each of these items.



Initial Source Rays

The Initial Source Rays refers to the total number of rays that will be emitted from all of the light sources. In general, the more rays specified, the more accurate your photometric output. However, the output accuracy becomes asymptotic at some point.

It is generally the case that the resolution of your output defines the level of the raytrace you require. A single value like optical efficiency may be calculated accurately (to the point at which it is not changing any further) in as little as 50,000 rays. Accurate candela distributions can take anywhere from 2,500,000 to 5,000,000 rays, depending on the number of lamps in the luminaire and the size of the angular zones in your candela distribution. A high-resolution image of an illuminance plane using a grid density of 100 x 100 or more, could take 10,000,000 rays or more to produce a smooth looking image.

When a raytrace analysis is done with too few rays, the results are scattered and spiky when the ultimate result is actually smooth and contained. This behavior comes from the nature of the calculations, where the rays are randomly emanated from light sources and scattered upon interactions with materials. The emanation and scattering directions are driven by probabilities, meaning that only after many rays do the patterns embedded in the probabilities become evident. The more rays, the more the final patterns emerge.

A luminaire such as the one in this tutorial will show relatively smooth output at the level we have specified using 2,500,000 rays. You can therefore keep the default number of rays.

Number of Reactions

The number of reactions traced determines how far a ray will be followed before it is disregarded. A reaction is defined to be an intersection with a surface. For surfaces that are purely reflective, one reaction reflects an incident ray into its resulting direction. For surfaces that are transmissive, one reaction intersects the surface, then probabilistically transmits or reflects a ray. For surfaces that are refractive, one reaction intersects the entrance surface, then probabilistically refracts or reflects a ray, and for the refracted rays, a second reaction intersects the exit surface, then probabilistically refracts or reflects a ray, and so on. Keep the default of 25 reactions for this tutorial.

Ray Emanation Shadowing

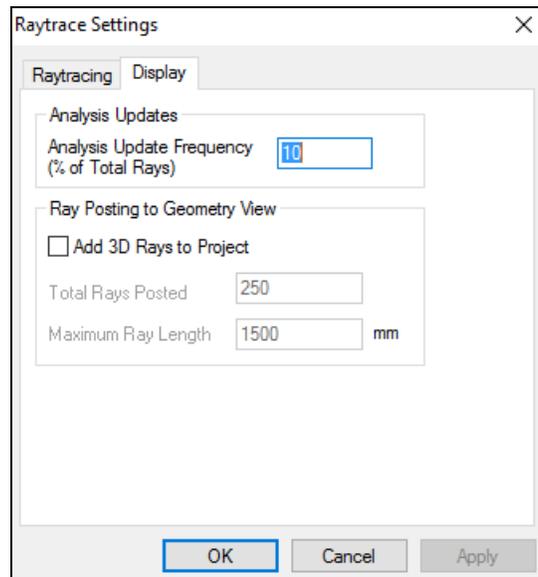
The last item in the Basic Raytrace Parameters section controls the ray emanation shadowing feature in Photopia. Lamps having surfaces that block the view of each other from an outside viewpoint, (e.g. a compact fluorescent lamp with its multiple tubes or the filament support structure in a quartz halogen lamp) need to have special checking enabled in the calculations to ensure light does not pass through any surfaces which shade other surfaces.

Advanced Raytrace Parameters

These will not be used in this tutorial, so keep the default settings.

Display Tab

20. Click the **Display** tab.



Analysis Update Frequency

Under the Display tab, the analysis update frequency specifies how often all of the output you are viewing is updated as the raytrace process proceeds. Keep the default value of 10% for the tutorial and you will get to view your calculated output as soon as 10% of the analysis is completed. You can then observe how the output changes and iterates every 10% toward a smooth result as more rays are traced.

Ray Posting to Geometry View

Photopia can display a sample of 3D rays from the raytrace so that you can view them and how they interact with your luminaire. You can specify the number of rays and the length of the last ray segment after it exits the luminaire. Check the Add 3D Rays to Project checkbox if you want to see the rays in Photopia's CAD view. For this tutorial we will leave this option turned off.

21. Click **OK** to exit the Raytrace Settings screen.

Run an Analysis

Now that we have completed all of the necessary steps preparing our analysis, we can start the raytrace.

22. Select **Analysis > Begin Analysis** from the main menu.

On the program's bottom toolbar you can see the progress of the calculations. After the first analysis update, you will see an estimated time of completion. While the analysis is running, you can terminate the analysis at any time. To do so, select the **Analysis > Terminate Analysis** from the main menu. A terminated analysis cannot be resumed and will restart from the beginning once you choose Begin Analysis again.

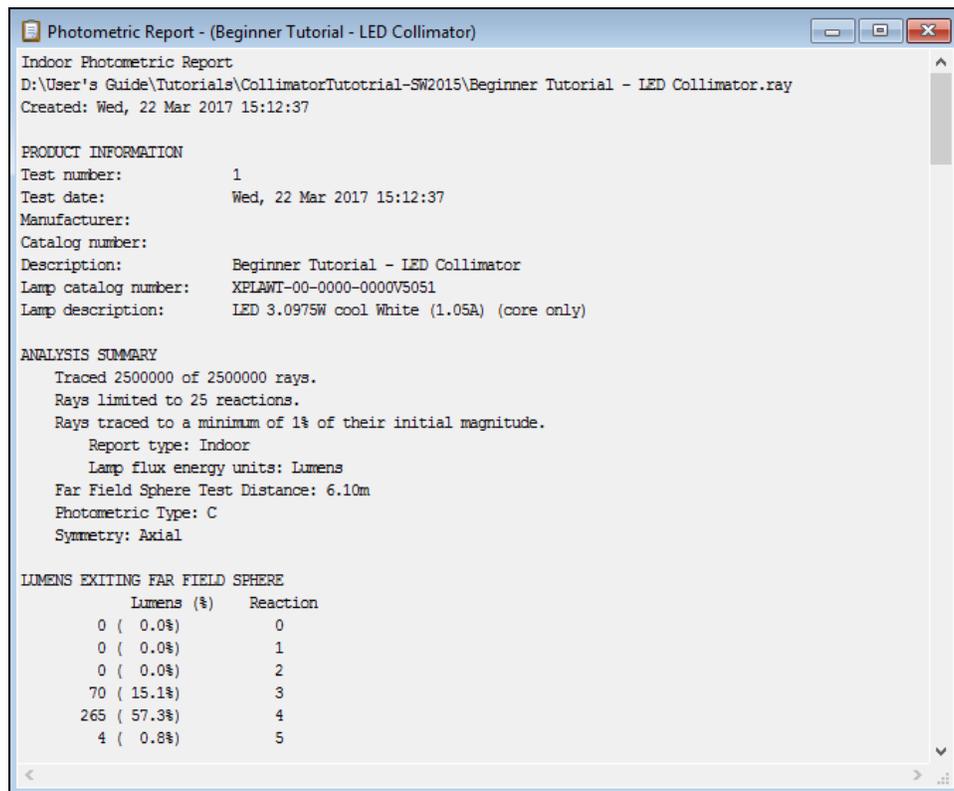
View the Photometric Output

While the analysis is running, we are able to view the calculated output as it updates. The first view of the output will be available after the calculations reach 10% (our specified update frequency).

View the Photometric Report

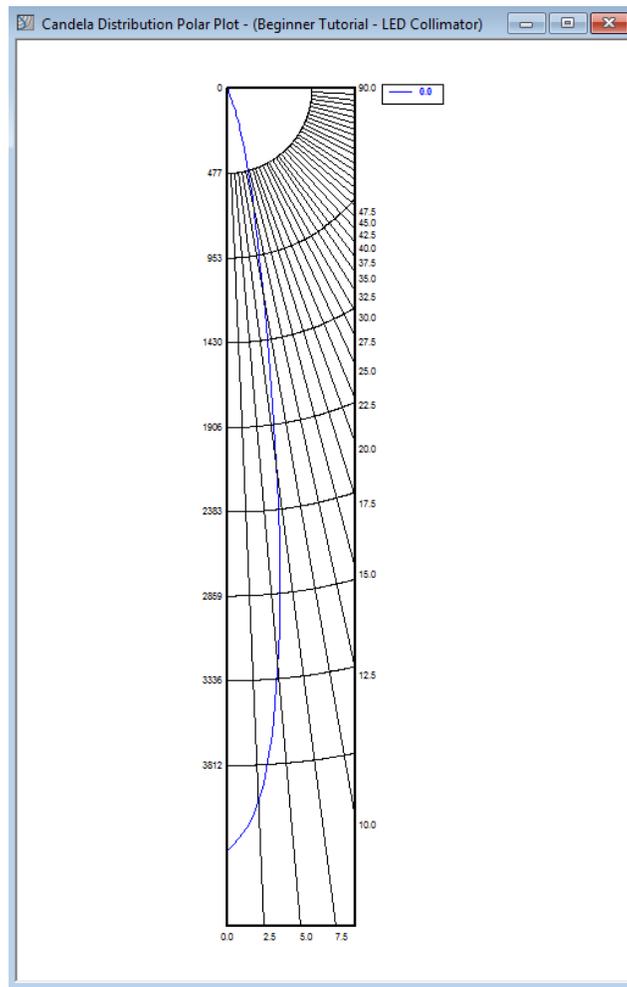
Begin with the photometric report.

23. Select **View > Photometric Report** from the main menu. Photopia displays the formatted report generated for the luminaire. You can scroll through the report by using the up and down arrow buttons located on the right side of the screen. Chapter 6 provides more details on the data in the report.



View the Candela Distribution Polar Plots

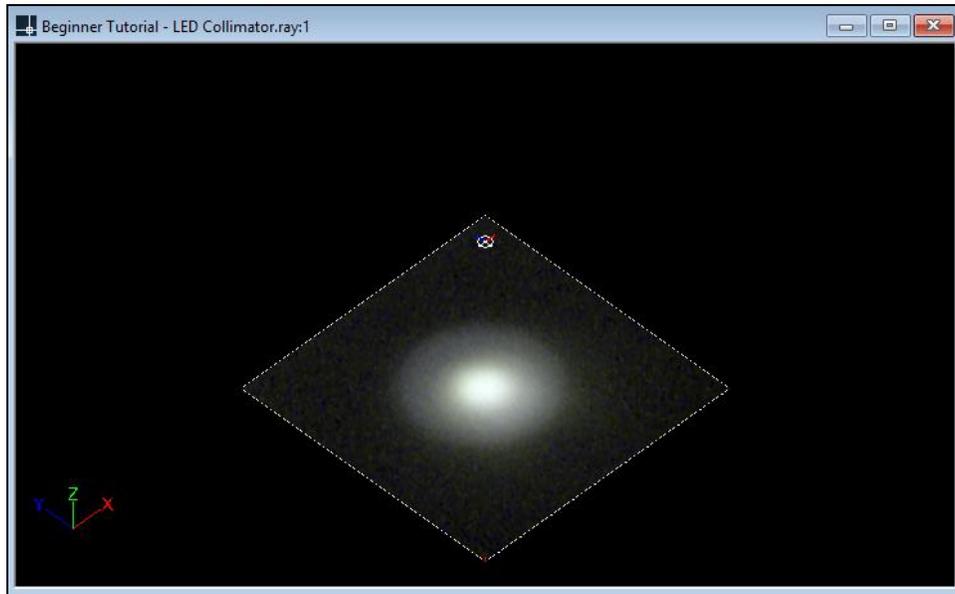
24. To display a polar plot of the candela values, select **View > Candela Distribution > Polar Plot** from the main menu. To watch the polar plots change at each update of the results, bring up the polar plot at the start of the raytrace.



View the Illuminance Plane Data

Photopia gives you the option of viewing the illuminance plane data in several different ways. You can view the data as text in tabular form, a contour plot, a color shaded plot a gray-scale shaded plot, or a false color plot. You can also view the data directly on the illuminance plane shown in the CAD views.

25. To view the data in text form, select **View > Illuminance > Text** from the main menu.
26. To view the data as a color shaded plot select **View > Illuminance > Color Shaded Plot**. Next, select the illuminance plane name and click the **OK** button.
27. To view the color shaded plot in the CAD view, click on the CAD view window for the project. Then pick the edge of the square defining the illuminance plane with your mouse (left-click). It will be shown in pink when it is selected. The properties of the illuminance plane will be shown in the property control at the right side of the screen. Click on the property for **Display Plot** under **Display** and change the default value from *False* to *True*. Then press Esc on your keyboard to de-select the illuminance plane. You will now see the color shaded plot.



Saving the Output

You can print any of the output views by clicking in the view to make it the active view, and selecting **File > Print Active View** from the main menu. You can also save the views to a BMP file or save any vector based view to a DXF or DWG file by right clicking in the view and choosing the export option accordingly.