## OVERVIEW

In this tutorial you will design a 40° beam medium flood reflector using the Parametric Optical Design Tools (PODT) and the CREE CXA 3050 COB LED. This tutorial assumes you know how to run the raytrace and assign optical materials to geometry in your model. If you need to review those steps, then start with the first 2 beginner tutorials.

Skills Covered:

- Designing a reflector
- Analyzing the reflector
- Modifying the reflector to obtain the desired beam shape

Skill Level: Intermediate
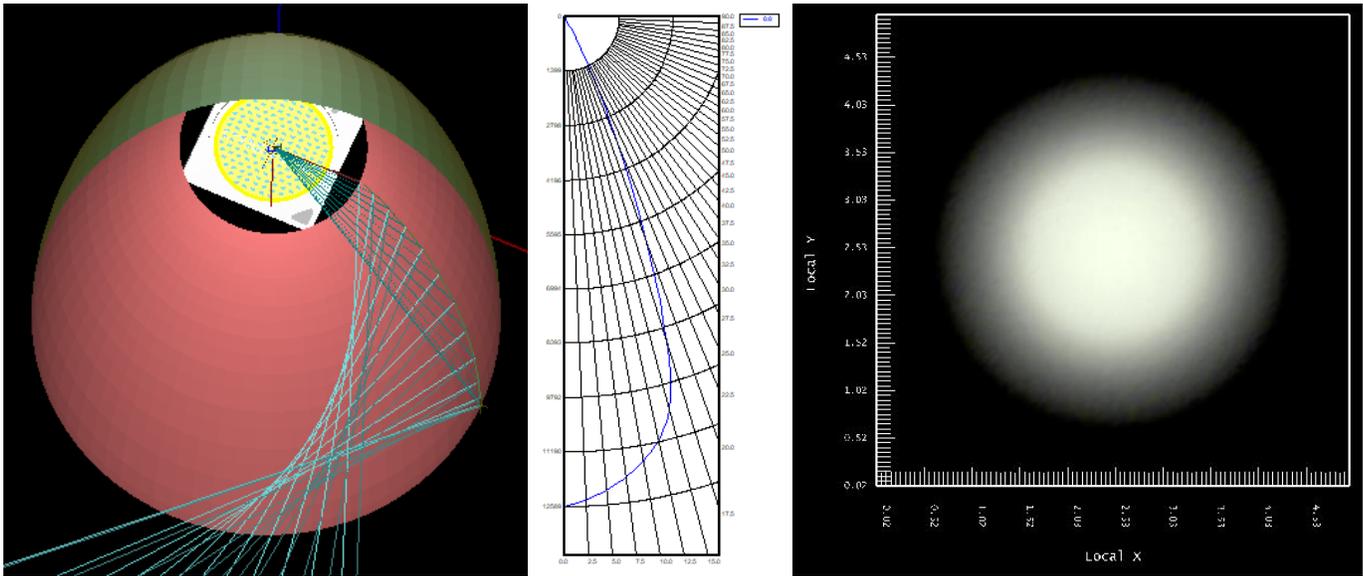
1. Start a New Project

Start Photopia and click **File > New**. Set the units for the project to be in mm. This can be done under **Settings / Project Settings** or by typing **Units** at the command line. To make object selection behave like most other CAD software, we also recommend that you choose **Settings / Application Settings**, then go to the **CAD** tab. Change **Selection Method** to **Replace**.

Photopia's PODT module creates reflector and lens profiles as well as 3D revolved and extruded mesh geometry. The profiles are based on some geometric constraints you enter at the command line including the aiming parameters. The 3D mesh geometry can be modified by changing their profiles using the parametric reflector and lens design tools.

## 2. Go to the Front View in the CAD System

Go to the Front View in Photopia's CAD view by clicking this icon:
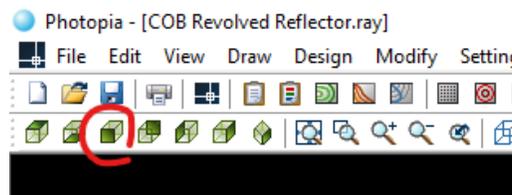
This will set the Construction Plane in line with the world XZ plane and put you in this view as well. This is the plane in which the profile should be created so the light will be directed toward world -Z axis, which is the 0° vertical angle in the intensity distribution.

3. Create the Reflector

Select **Design / Reflector: Aiming Based > Revolved** from the main menu. You will then be prompted for the initial design parameters for this reflector. The input values are shown in this image:
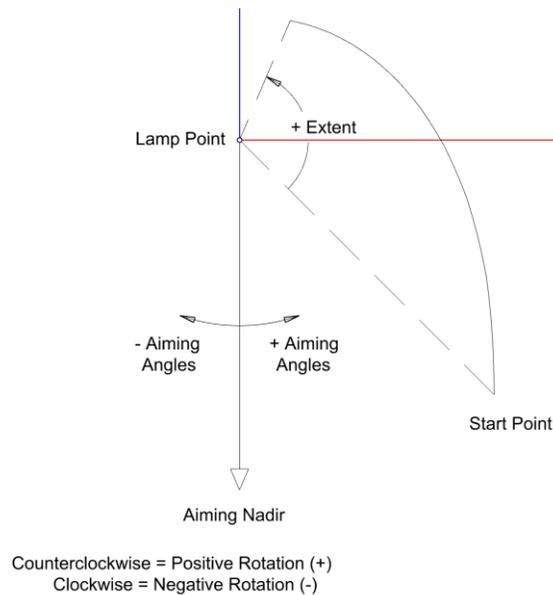
Some of the input values will X,Y coordinates. The format of these values depends on your regional settings in Windows. The format assumed in this tutorial use the period character as the decimal point and a comma as a data delimiter. This is common in North America. In other locales such as Europe, the comma is the decimal point and a space character is the data delimiter.

Enter the following values at the prompts:

Lamp center: 0,0

Start Point: 45,-90

Reflector Extent: 63.4 (You can also move your mouse until the previewed angle is shown to be in line with the X-axis and then left click, assuming your zoom level is out far enough to show the previewed reflector.)

**Aiming direction for first section**: -27.5

Aiming direction for last section: 0

Aiming angle increment: 2.5

Number of Revolve Segments: 72

The aiming angles define how you want to aim the light from the reflector. The goal of this design is to create a 40° full beam angle, which means the 50% intensity values will be 20° to either side of the beam center. The peak intensity for this design is also intended to be in the beam center at 0°. In order to achieve 50% of the peak intensity at 20°, you'll need to aim light beyond that angle since the beam will continue to taper past 20°. Light will also spread beyond the angles at which it is aimed due to the large extent of the COB LED. Finally, we want to aim light to about the same angle it emits directly, which is 90 - 63.4 = 26.6°. So we started with aiming the light toward -27.5° from the beam center, the closest value to 26.6° on an even multiple of our chosen increment. We can change the range of aiming angles if desired later once we see how the reflector performs. The aiming angle increment defines the number of aiming sections (stitched together parabolas) from which the reflector profile is built. It is helpful to use as few as possible in case you want to manipulate them individually, but we also need enough to create a smooth beam without dips between the angles toward which each parabola is aimed. For this design, 2.5° is a good starting compromise.

The 3D revolved reflector should look like the left image below. If you select it by left clicking on it, then you'll see its aiming lines like in the right image. If you don't see it fully displayed, then click on the Zoom Extents 🔍 icon on the toolbar. You can click the Escape key to deselect the reflector.
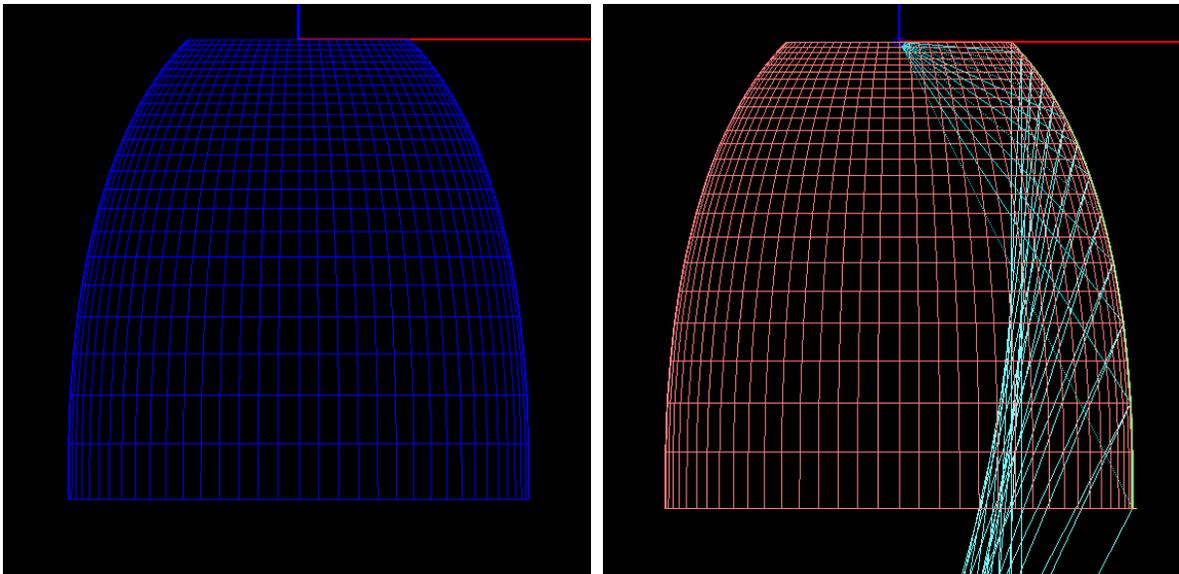
The revolved reflector mesh. The 72 entered defined the number of segments around the circumference.

4. Import the COB LED

Save the project and name it "COB Revolved Reflector.ray." Then choose **File / Add Lamp** from the main menu. This will open a file dialog. Scroll down to the following lamp in the list, then click enter at the command line prompt asking for the insertion point:

CXA3050-5100K.LAMP

You'll see the lamp added to the model, as shown here. To see the isometric view like shown on the right, click the following icons on the toolbar:
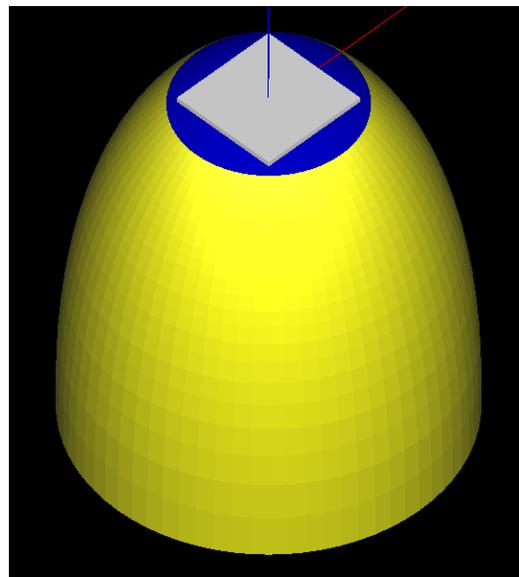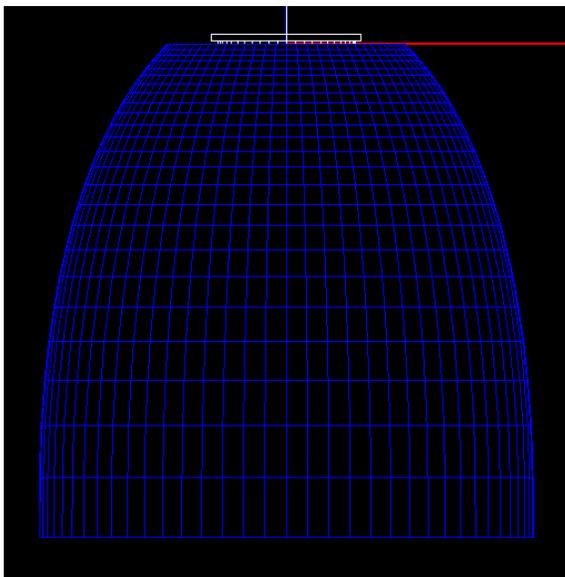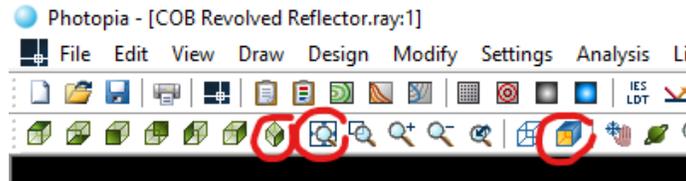
5. Prepare & Run the Photometric Simulation

Assign the **Generic Spec 85** material to the reflector. To do this, choose Edit / Design Properties from the main menu, then click the Reflective tab. You'll see that a new layer named REFL-Main was created for the PODT reflector. Select this layer name and then click the **Assign Material** button. Then scroll down the list to the **Generic** materials and choose **SPEC 85** and click OK. You'll see the material assignment like shown in the next image. Click OK on this screen.
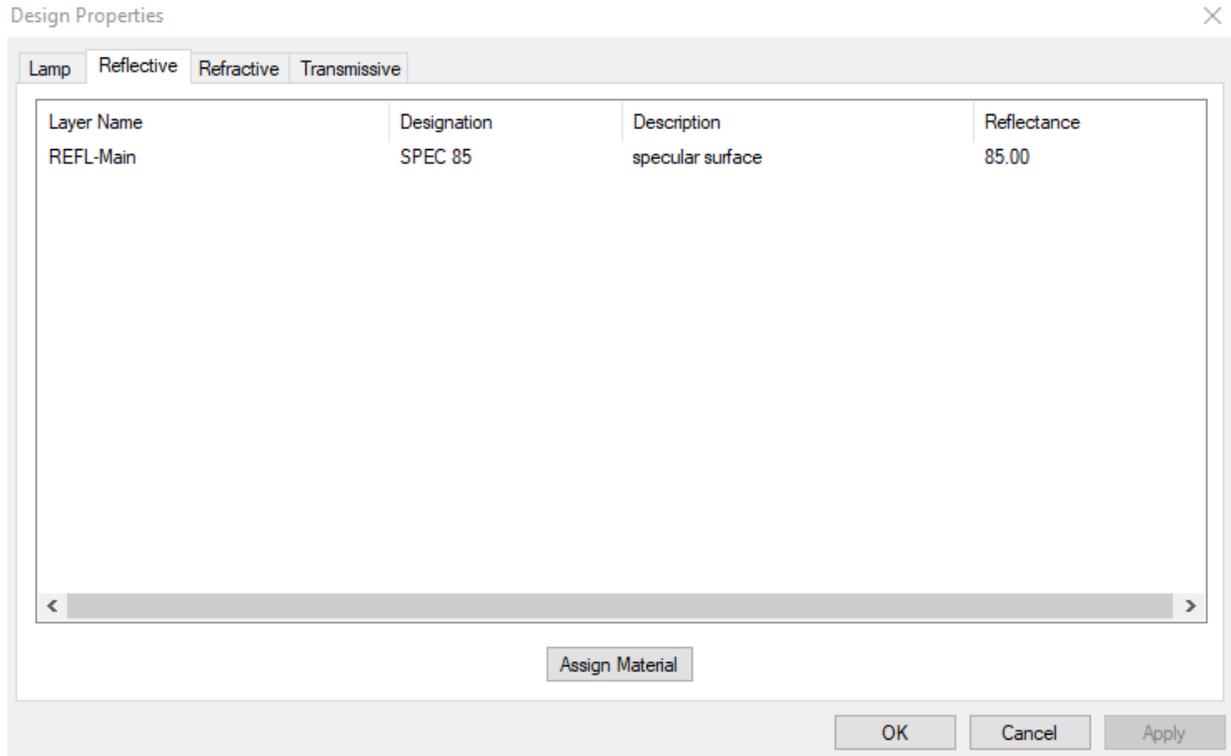
Choose **Analysis / Specify Photometric Output** and then click the **Photometric Report** tab. Choose the following angle sets from the drop-down menus:

Horizontal angles: 0

Vertical angles: (0(2.5)90)

Enter -90 for the **Photometric Center Z** value since the photometric center should always be placed in the center of the luminous opening of the optic. Uncheck the "**Use Physical Extents From CAD Model**" open and ether 0 for the Z value, since light only emits out of the XY extents of this reflector. Note that the dimensions in this dialog refer to the CAD system world coordinates, not the local construction plane. You can keep the rest of the default values.

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 `-90.0(` mm

Test Distance `6.10` m
Decimal Precision `2`

Luminous Dimensions
☐ Use Physical Extents From CAD model
X `90.00` Y `90.00` Z `0.00` mm

OK   Cancel   Apply

Now click the **Illuminance** tab. Enter 1 for the **Number of Planes** and then click the **Define Plane** button. Enter the following corner point coordinates to define a 5m x 5m plane, 3m below the reflector. Note that after you enter the first value, you can press Tab to continue to the next cell.

Illuminance Plane

Description:
`5m x 5m Plane, 3m Mounting Height`

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 `050000`
Number of Rows `100` Row Spacing `050000`

Units: m   OK   Cancel
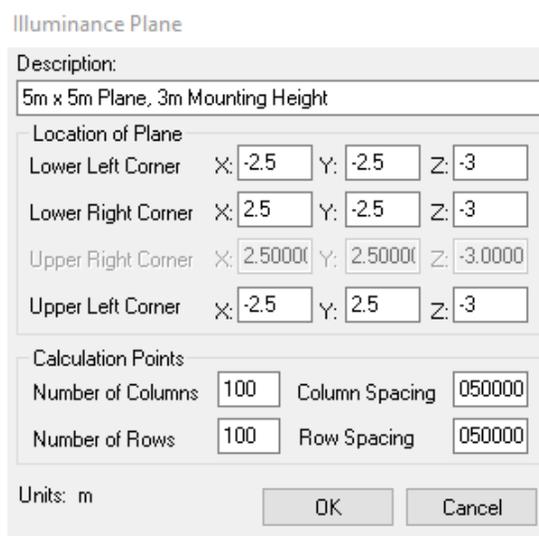
Click OK on this screen and the next. Then click the Zoom Extents button on the toolbar and you should see the illuminance plane added to the CAD view like this:
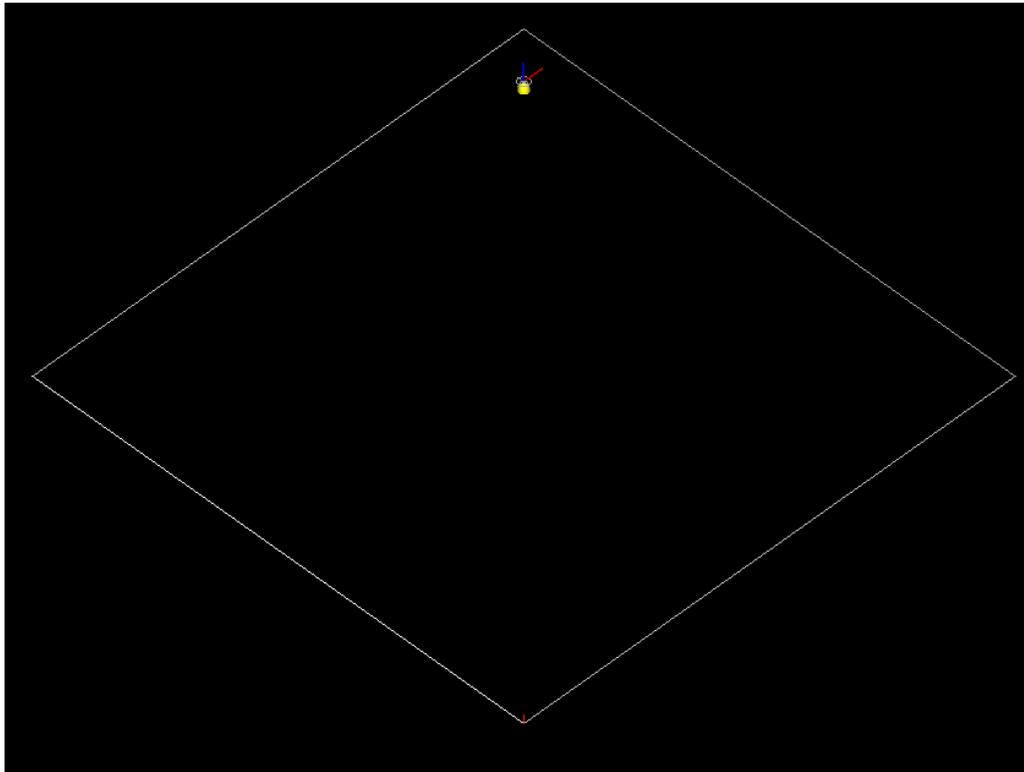
Select the illuminance plane in the CAD view and set its **Display Plot** property to **True**. Click the Escape key to deselect the plane.

Run the simulation with the default raytrace settings and you should get the following results.
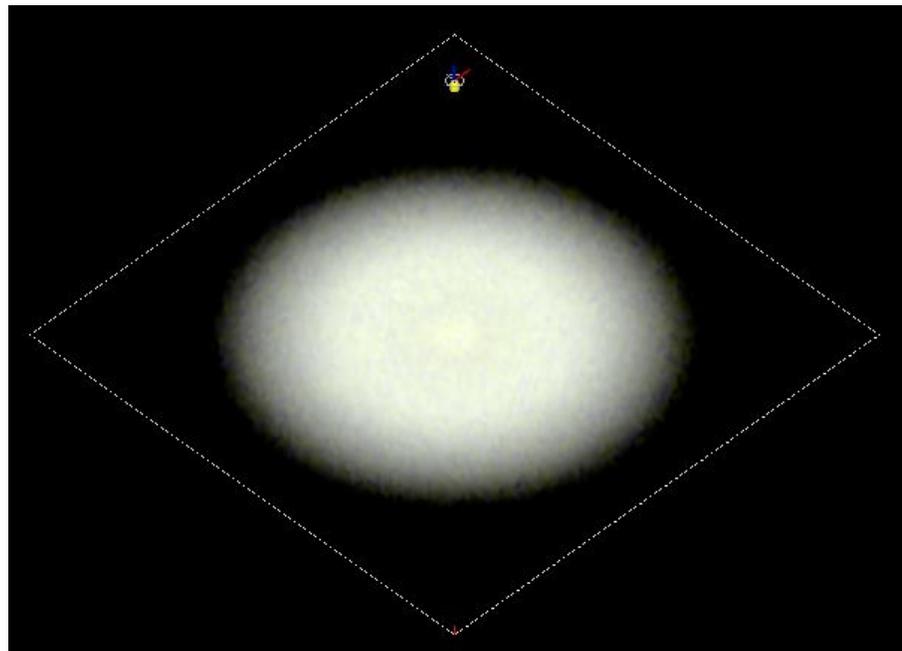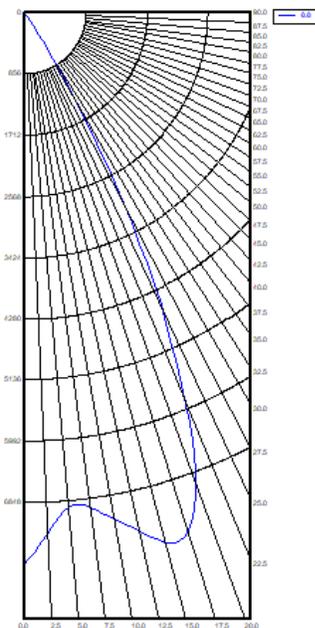
Choose View / Candela Distribution / Polar Plot to view the intensity distribution.

6. Modifying the Reflector

The results for this initial reflector produce a wider beam than desired at about 52° with the peak off center. You can see the Full Beam Angle by choosing **View / Photometric Report** and scrolling down near the end. We'll modify the reflector weighting factors in order to direct more light toward the beam center. To do this, first toggle off the view of the illuminance plane in the CAD view by clicking on the **Illum. Planes** button at the bottom of the screen twice. Then click the Zoom Extents button and then select the reflector.

To see all the parametric reflector properties, choose **View / Parametric Optical Design** (PODV) from the main menu. The properties shown in this screen are associated with the individual reflector aiming sections. The properties shown on the right side of the main screen are associated with the entire reflector. All parameters initially entered can be changed through these controls. The yellow plot in the PODV shows the trend of the default weighting factors. See the box below to learn more about the weighting factors. As you can see, they are lowest in the beam center and get larger at the wider angles. That is also the trend in the intensity distribution, shown in blue.

To modify this reflector so that more light is directed toward the beam center, change the Weight Exponent to be -6. You'll see the yellow WF plot now be highest in the beam center. The effect on the reflector is that the aiming sections aimed toward the beam center all increase in their angular extent, thus capturing more lumens, while the sections aimed toward the wider angles reduced in their angular extent.

The properties on the right side of the screen include **Curve Resolution** and **Num Segments**, which control the number of facets along the reflector profile and around its circumference. The Curve Resolution angle defines the angular sweep frequency at which profile points are taken from the reflector section parabolas.

Weighting Factors

The Weighting Factors (WF) determine the relative importance of each reflector aiming section. A higher weight means more of the reflector angular extent will be aimed toward that angle. Increasing the WF exponent generally creates higher WF's at wider angles in the beam. A negative WF exponent creates higher weights in the beam center. The more negative the exponent, the stronger the emphasis at 0°. Note however, that past about -6, the WF's will start to grow again at high angles. Increase the Weight Minimum toward 1 to avoid the dip in the WF distribution. See chapter 4 in the User's Guide for a more complete explanation of the WF equation.

Run the simulation again with 10,000,000 rays and you'll see the following results that now show about a 39.5° beam angle.
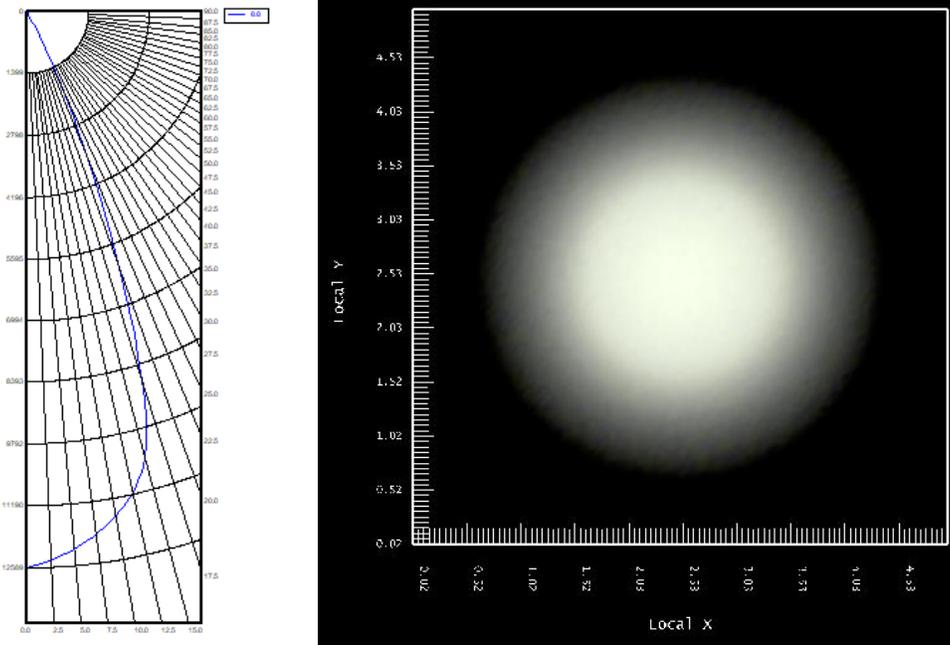
If you want to see how we arrived at the **Weight Exponent** of -6, try a few values in between the default of 1 and this value. Knowing the trend of a more negative value increases the light in the beam center, we just tried a few options and quickly found this solution. We recommend you keep the ray count around 2,500,000 while going through design iterations. Then increase the ray count for final results when your beam looks close to your design requirements.

7. Complete

CONGRATULATIONS! You have completed the PODT reflector design tutorial.

Suggested Next Steps:

- Design a new reflector with your own beam requirements
- Review the documentation under Help / User's Guide
- Complete the tutorial for the parametric lens design