Advanced Tutorial – Designing a Wall Wash Reflector with a Fluorescent Source

This tutorial demonstrates the design theory of an asymmetric wall wash reflector. The goal is to create a reflector within realistic size constraints that achieves a smooth illuminance onto a wall. It is a good idea to complete the beginner tutorials before attempting this advanced tutorial, since many of the more basic functions and concepts are not explained in this tutorial.

Setup the Project

1. Start a new project and choose **File > Save As** to give it a name such as *T5HO Wall Wash*.

2. This tutorial will be in metric units, so be sure that the length units are set to millimeters. (Set the units by typing *units* in the command prompt.)

3. Choose **File > Import Lamp** and then browse for the lamp file named *F54T5HO.LAMP*, which is a 54W 4' T5HO linear fluorescent lamp. Insert the lamp at 0,0.

Since we will be creating an asymmetric reflector, the lamp needs to be rotated in order for the photometry to be correct. For bilaterally symmetric luminaires (called "asymmetric"), the asymmetric punch of light should be in the +Y direction of the WCS.
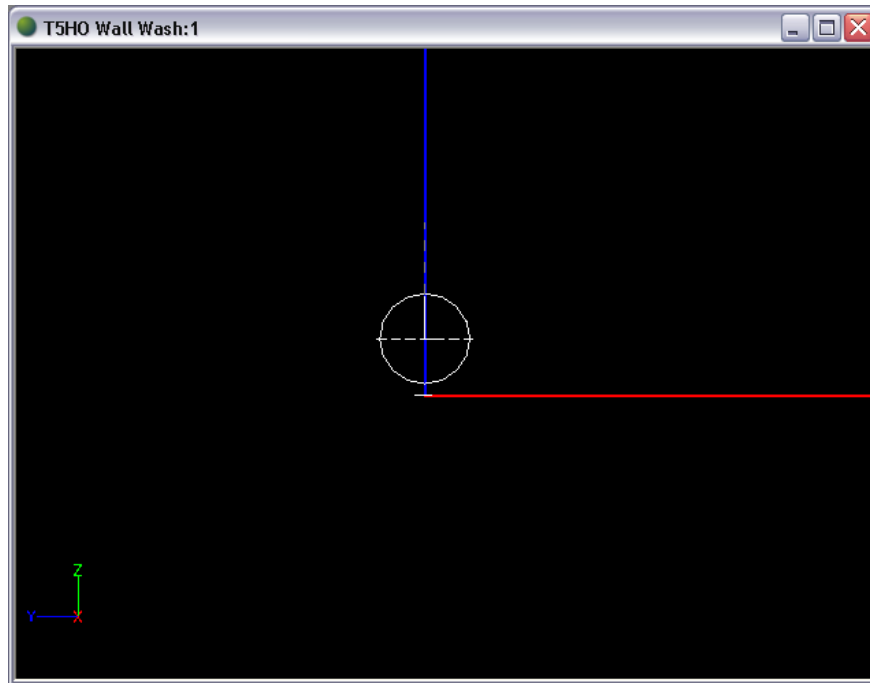
4. From the top view, rotate (**Modify > Rotate**) the lamp 90 degrees around the Z axis of the WCS.
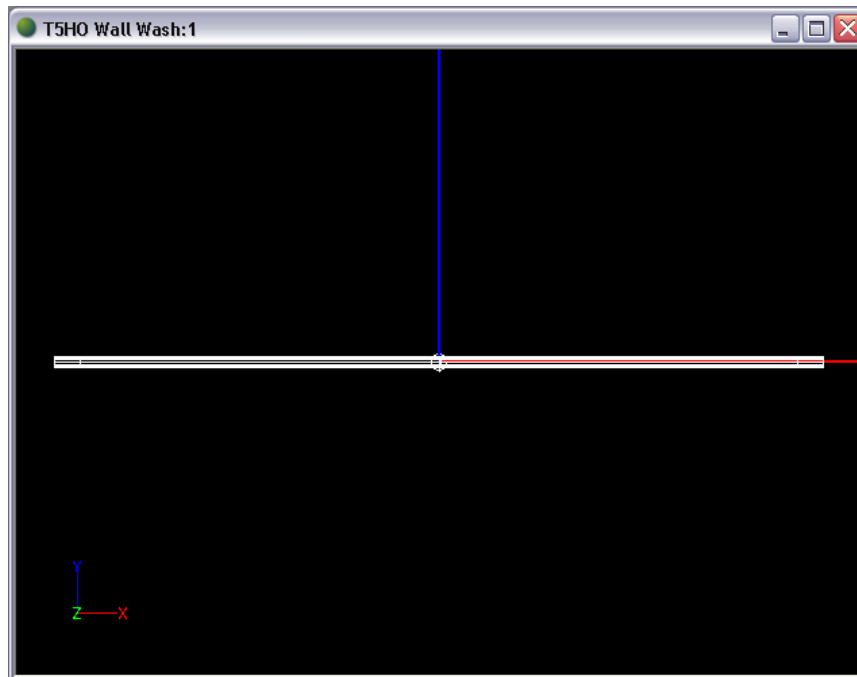

5. Go to the left side view.

We will consider the ceiling plane to be at the level of the CPlane's X-axis. So, to make this optic a recessed reflector, we need to move the lamp up.

6. Click on the lamp. Change its Origin Y in the property control to 10 mm.

Build the Reflector

7. From the left side view, choose **Design > Reflector: Aiming Based > Extruded Asymmetric**.

   a. Press Enter to accept the default lamp center of 0,10, in mm.

   b. Choose a start point of -60,0, in mm.

   c. Enter -240 for the reflector extent, in degrees. This will allow a small part of the reflector to extend below the ceiling plane.

   d. Enter -1000,-2500, in mm, for the aiming of the first section. The section will be aimed at the bottom of a 2.5 m high wall that is 1 m away.

   e. Enter -1000,0, in mm, for the aiming of the last section. The section will be aimed at the top of a wall that is 1 m away.

   f. Enter 40 for the number of aiming points so that we get a smoothly transitioning rolled reflector.

   g. Enter 1200 for the extrusion length, in mm.
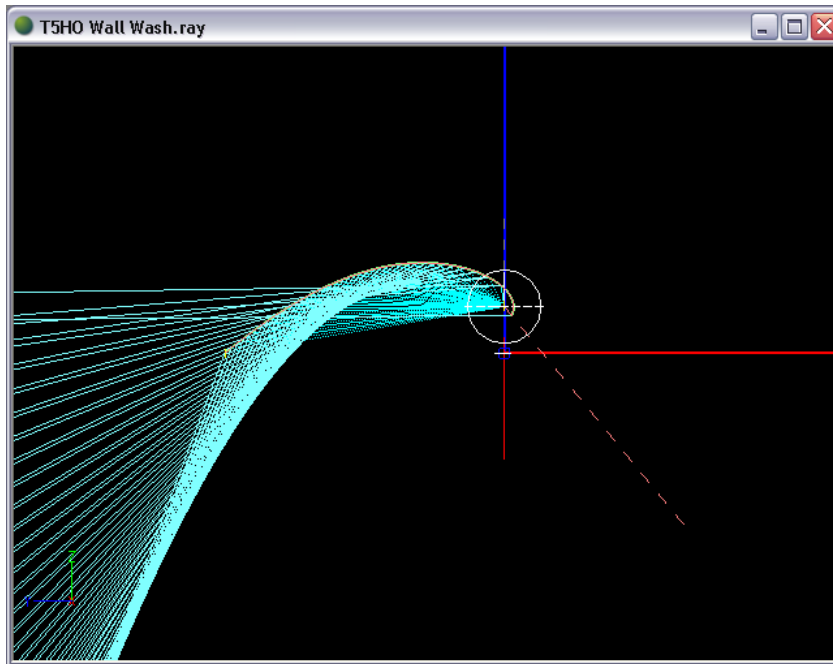
At this point, the reflector looks strange because it is cutting into the lamp. However, the reflector's automatic weighting of its sections is shifted for this application.

8. With the reflector selected, open the Parametric Optical Design View (**View > Parametric Optical Design**).

Notice that the Total Weight column shows the reflector sections getting heavier weighting as the aiming points reach the top of the wall. However, we want heavier weighting at the *bottom* of the wall since it is further away from the reflector. Further distances need higher luminous intensity to give the overall wall uniform illuminance. So, we will use the Weight Shift factor to adjust the weighting function.

9. With the reflector selected, find the Weight Shift factor in the property control under **Weighting**. Change the value from 0 to 90 degrees, and the weighting function will shift.

Notice that the weight value for each aiming section has now updated in the Parametric Optical Design View. The weights toward the bottom of the wall are heavier, as desired. Also notice that the shape of the reflector has changed to accommodate the new weighting, and it happens to have become a realistic shape at this point.
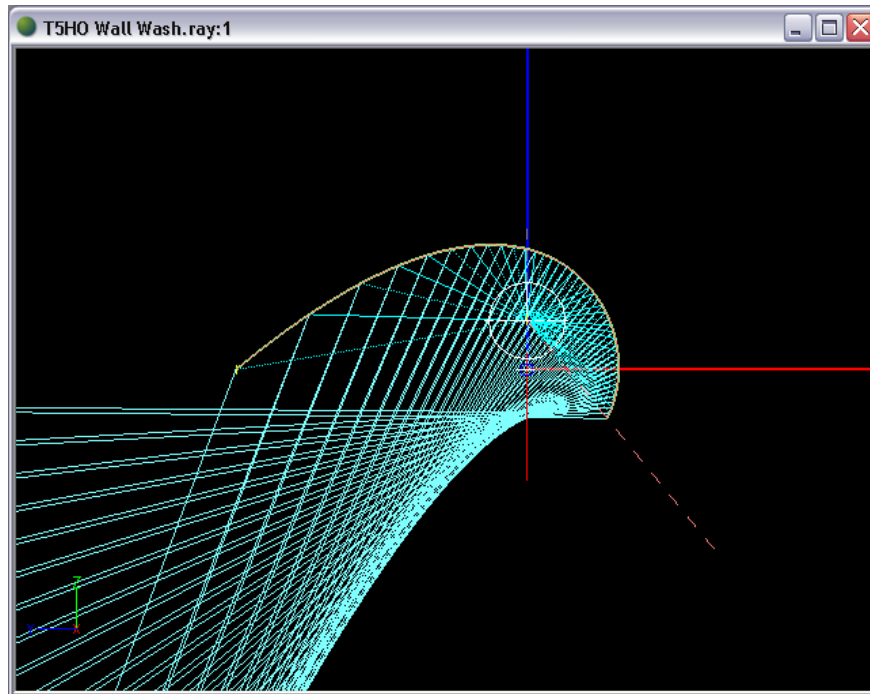
10. Create an end-cap by selecting **Draw > Polygon Surface**. Enter coordinates so that the end-cap is taller and wider than the reflector profile, allowing room as the reflector may grow during design. Make the bottom of the end-cap level with the ceiling line, at Y=0.

11. Under **Settings > Layers** make a new layer called *REFL-End-caps* with a color such as cyan. Put the new polygon on that layer.
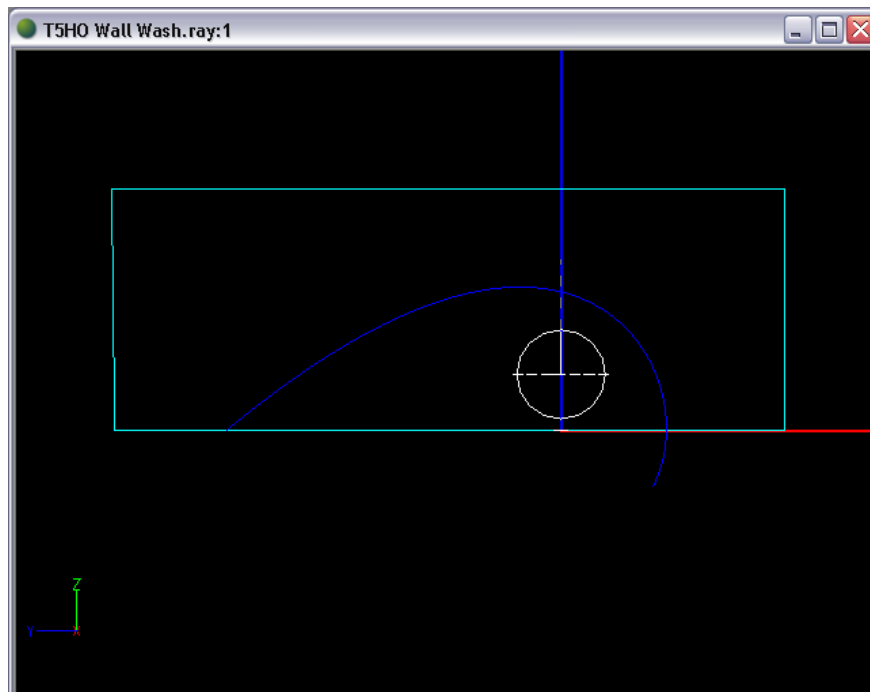
12. From the top view, select the end-cap and move it (**Modify > Move**) 600 mm to the right.
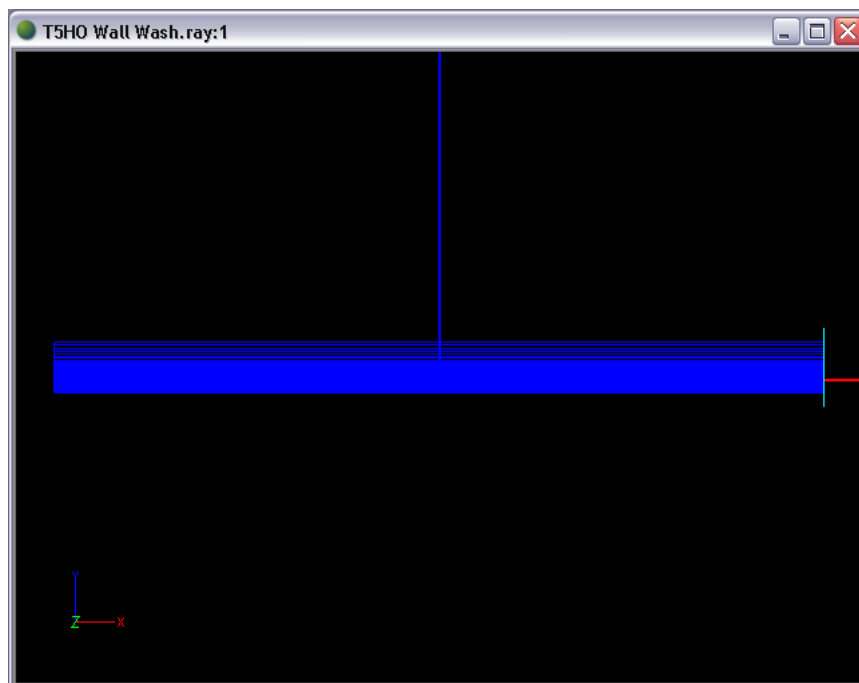
13. Select the end-cap again and mirror it (**Modify > Mirror**) about 0,0 to 0,1 to create the other end-cap.

14. Use Show Surface Orientation (right click in CAD view, **View Style > Show Surface Orientation**) and orbit (right click in CAD view, **Dynamic Views > Orbit**) to make sure that the end-caps are oriented correctly. The cyan sides should be facing the lamp.
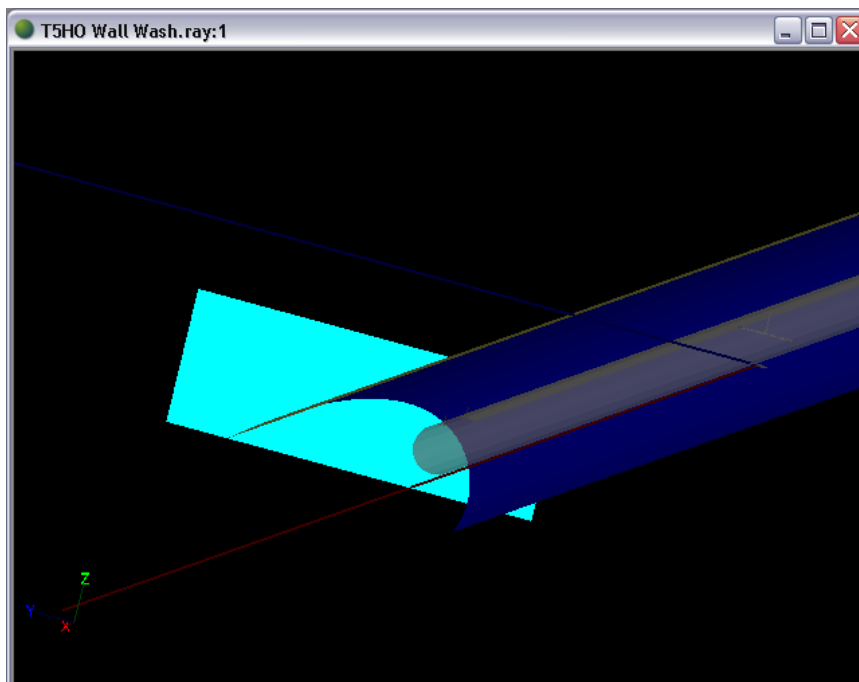
Setup the Materials and Output

15. Choose **Edit > Design Properties** to assign the materials. Assign *Alanod Miro 4* to REFL-Main and REFL-End-caps. Click OK.
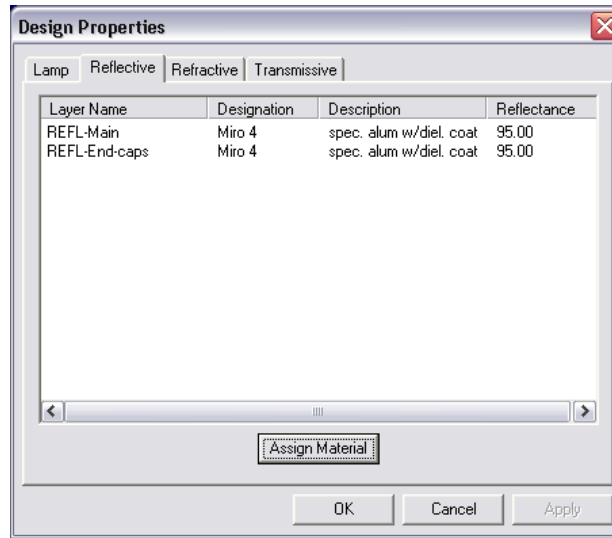
16. Choose **Analysis > Specify Photometric Output** and go to the Photometric Report tab. Change the Horizontal angles to 0(10)180 since this is a bilaterally symmetric optic. Use Vertical angles of 0(5)180. Even though there will only be a small amount of light that is directed upward, we should still account for it for complete results.
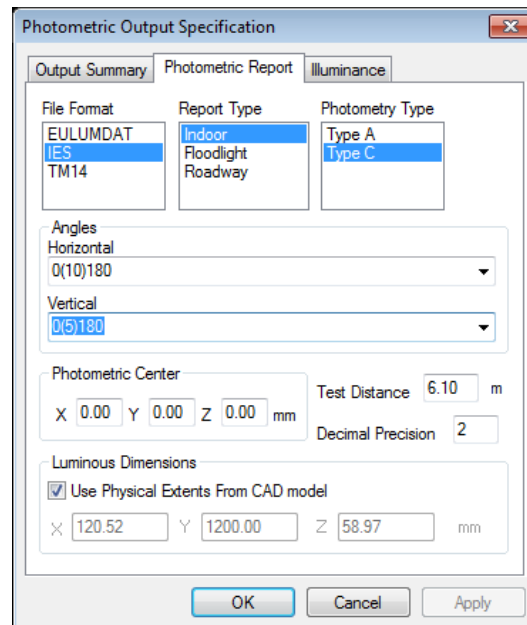

17. Under the Illuminance tab, create an illuminance plane 1 m wide by 2.5 m tall, 1 m in front of the luminaire. Use Column and Row Spacings of 0.02 m (these fields are under Calculation Points).
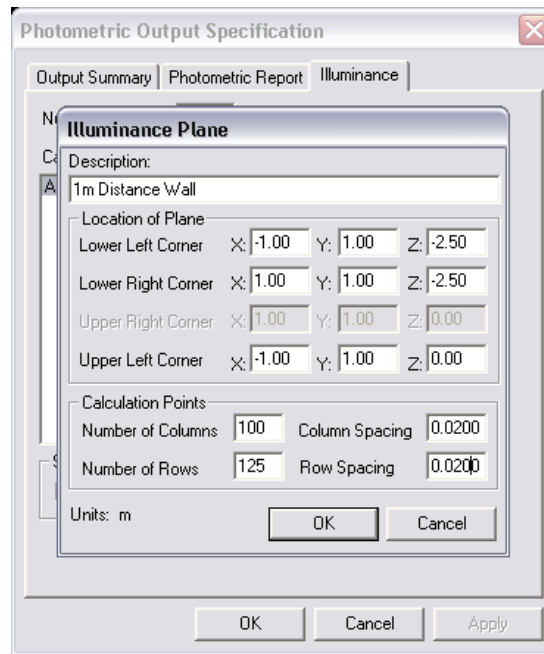
The default Raytrace Settings are appropriate for now, so we won't adjust them at this point.

Raytrace Results & Design Iterations

18. Start the analysis by choosing **Analysis > Begin Analysis**.

19. Open the shaded illuminance plot by choosing **View > Illuminance > Shaded Plot** and choosing the wall illuminance plane. Open the candela plot by choosing **View > Candela Distribution > Polar Plot**.
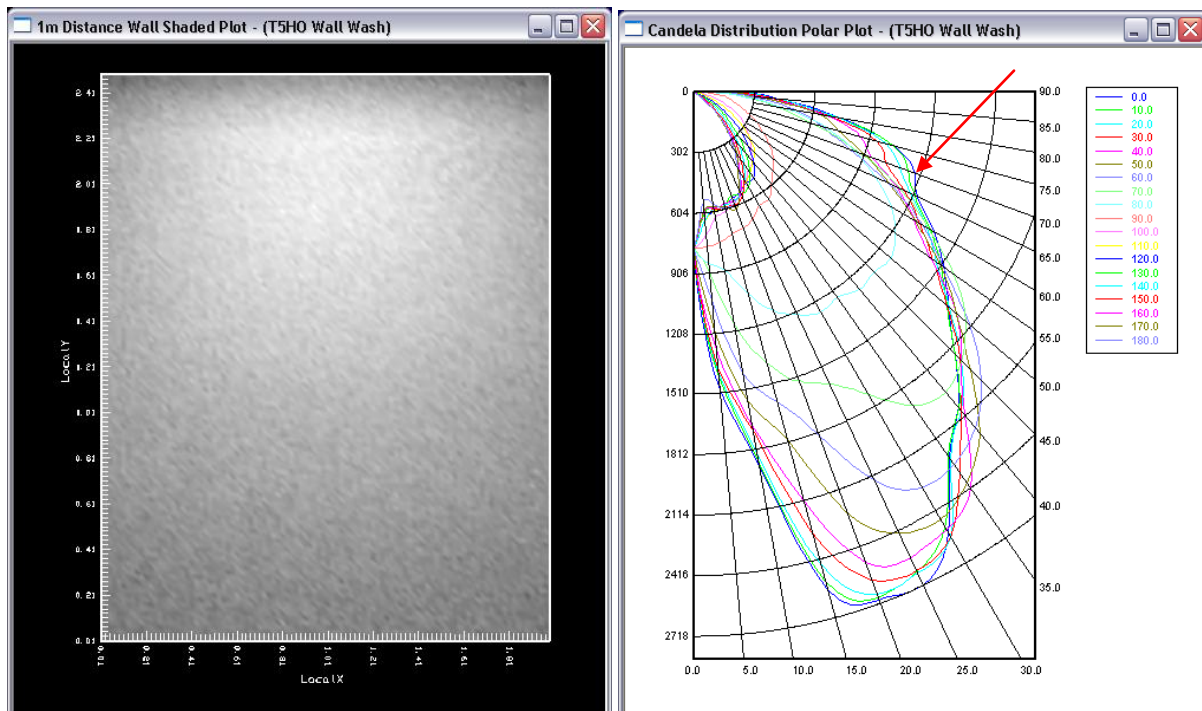
The shaded plot looks very uniform and even, but on the candela plot, there is a questionable dip at about 70º vertical angle. This dip is a warning sign that there could be a striation in the pattern. To further investigate, we will do another run with more rays.

20. Select **Analysis > Specify Raytrace Settings** and change the Initial source rays to 5,000,000 rays. Run the analysis and check the results again.
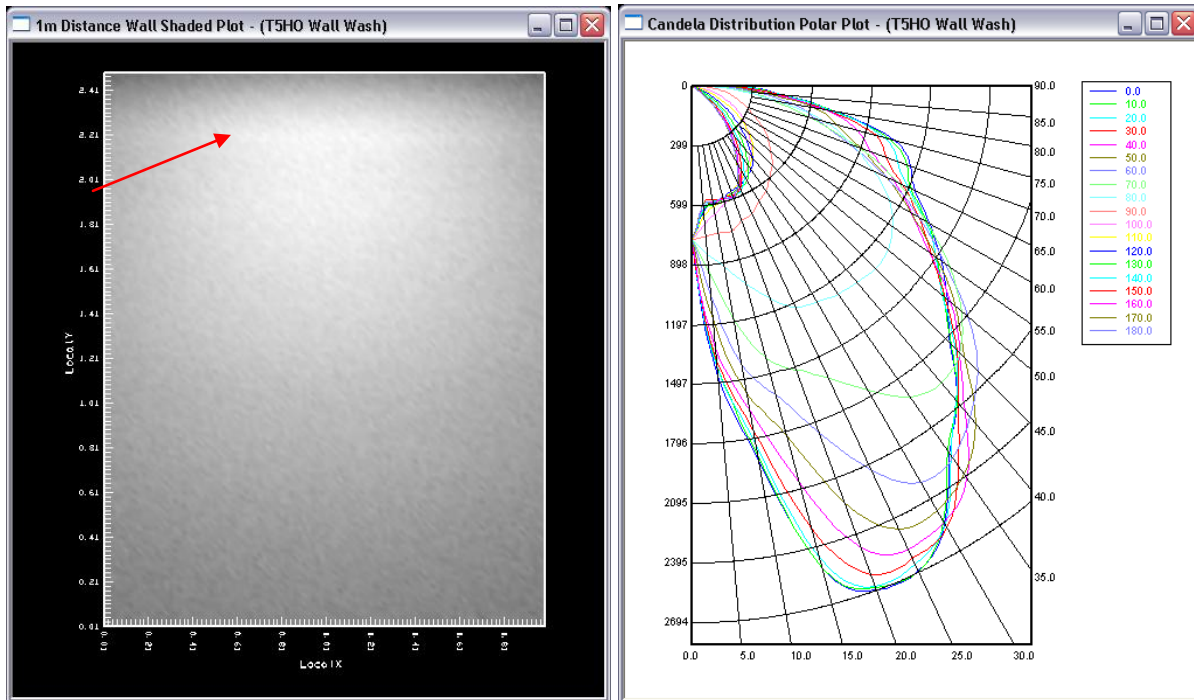

Now we can see that there is a very subtle bright band near the top of the shaded illuminance plot. Even though the bright band is subtle, the more rays we run, the more prominent the band will become. In physical reality, the band is likely to be even more prominent. In an application such as a wall wash, where the distribution is clearly visible, even subtle bands can hurt a design. A simple way to smooth out a subtle striation like this one is to change the reflector material.

21. Under **Edit > Design Properties**, change the material for both reflective layers to *Alanod Miro 7*. While Miro 4 is specular, Miro 7 is semi-specular and so reflected light scatters a little more.
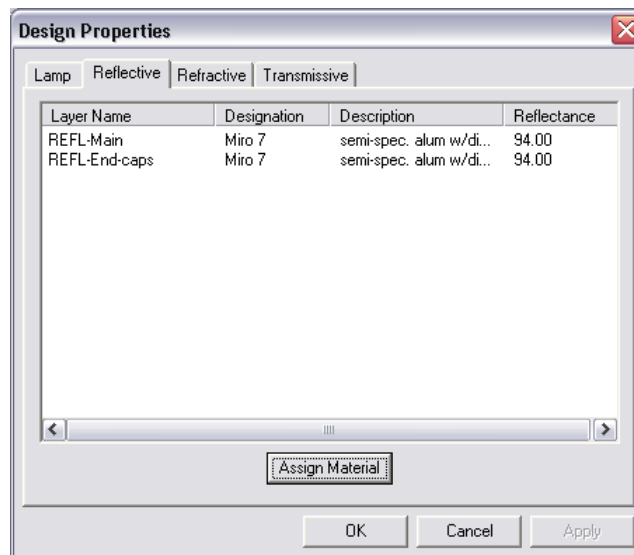
22. Run the analysis and check the results again.
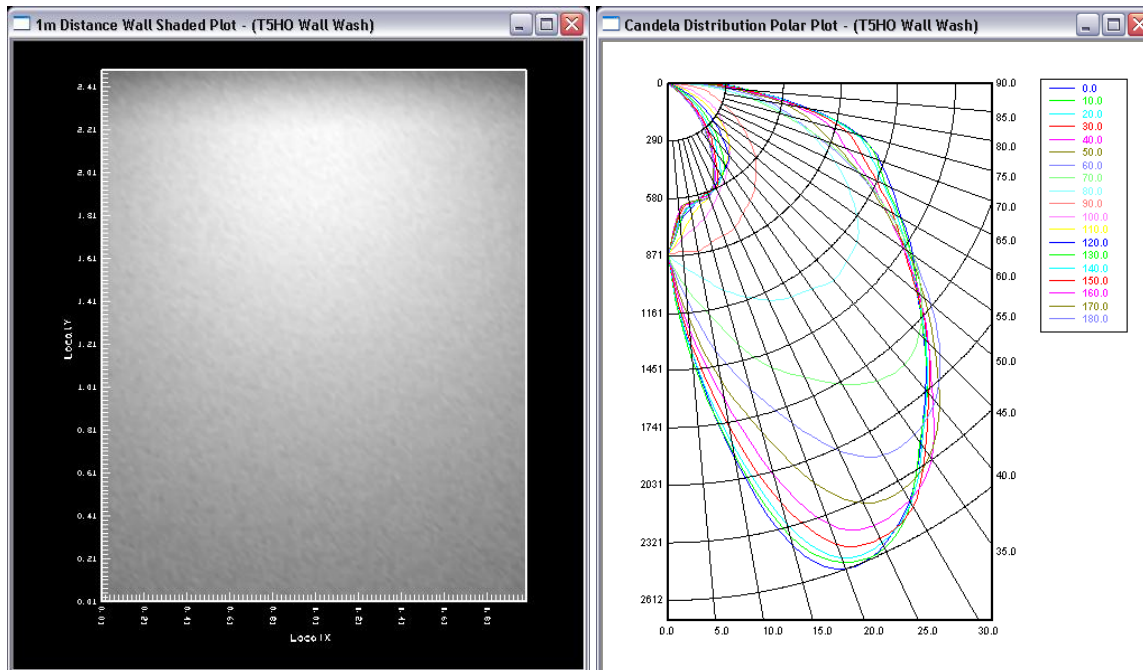
The candela plot no longer has a dip at 70º, and the shaded illuminance plot looks smooth and uniform. We can also check the illuminance values by choosing **View > Illuminance > Text**. The ratio of the max illuminance to the bottom of the wall is less than 8 to 1, so the wall is very uniform.

At this point, we have a good design that works well for a wall wash application.

Build a Glare Shield (Optional)

Looking at the reflector profile, it is apparent that anyone walking under the light fixture may look up and see a clear view of the lamp. We can build a shield to prevent an easy view of the lamp.
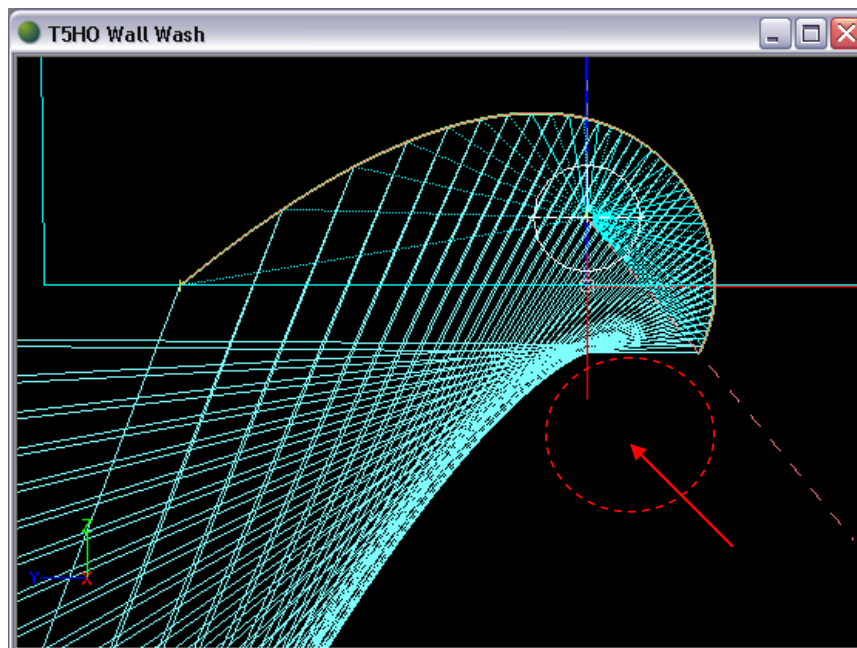
A good location for the shield is a continuation of the current reflector so that it wraps around the bottom of the lamp. You can see that we will be able to avoid interfering with any of the primary reflector's aiming lines.

Since direct lamp light will be incident onto the shield, it is better to harness and control that light than to simply insert a black shield. In this case, we can try directing the light right back to the lamp so that it may interact with the primary reflector.

23. From the left side view, choose **Design > Reflector: Aiming Based > Extruded Asymmetric**.

    a. Press Enter to accept the default lamp center of 0,10, in mm.

    b. Click a start point that is close to the end of the primary reflector (near 16,-10). We will link the two reflectors together later.

    c. Enter -40 for the reflector extent, in degrees. This extent shields part of the view of the lamp while avoiding interference with the primary reflector's aiming lines.

    d. Some versions of Photopia do not allow you to aim the reflector at the lamp center at this point in reflector creation. Click any two points for the aiming of the first and last sections; we will use Parametric Optical Design View to setup the aiming in the next step.

    e. Accept the default of 10 for the number of aiming points.

    f. Enter 1200 for the extrusion length, in mm.

24. Choose **View > Parametric Optical Design** to adjust the aiming. In the text field under Aiming of Sections, enter 0,10(1)0,10 to create a single aiming section that is aimed at the lamp center. Make sure that the "By Point" radio button is selected. Push the Update Aiming button.
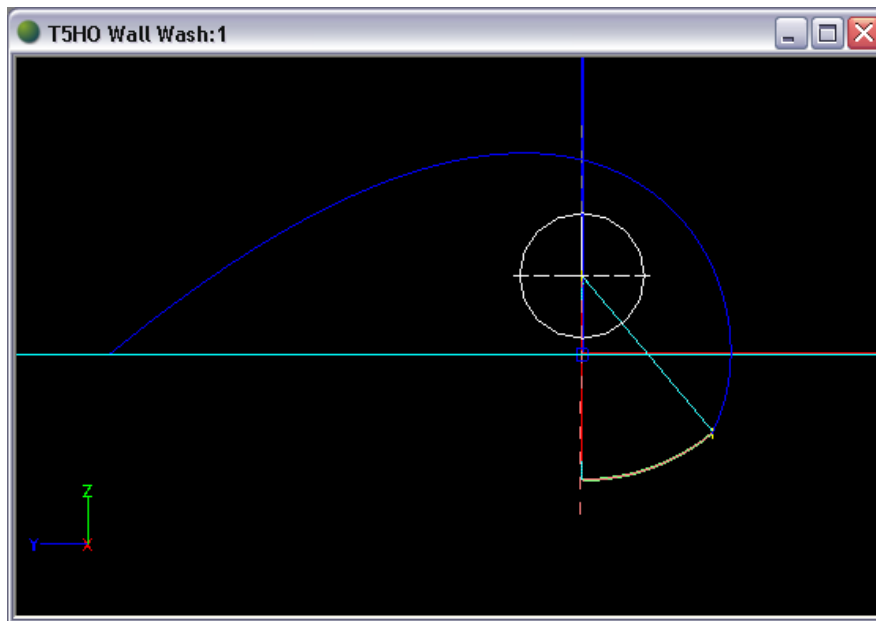

Next, we will link the two reflectors so that they meet perfectly. Linking is also very convenient if you decide to come back and change one of the reflectors because they will remain connected at a point. In order to link the new reflector to the primary reflector, we need to give the primary reflector a Name

25. Select the primary reflector. Type *Primary* in the Name box under **Reflector** in the property control.
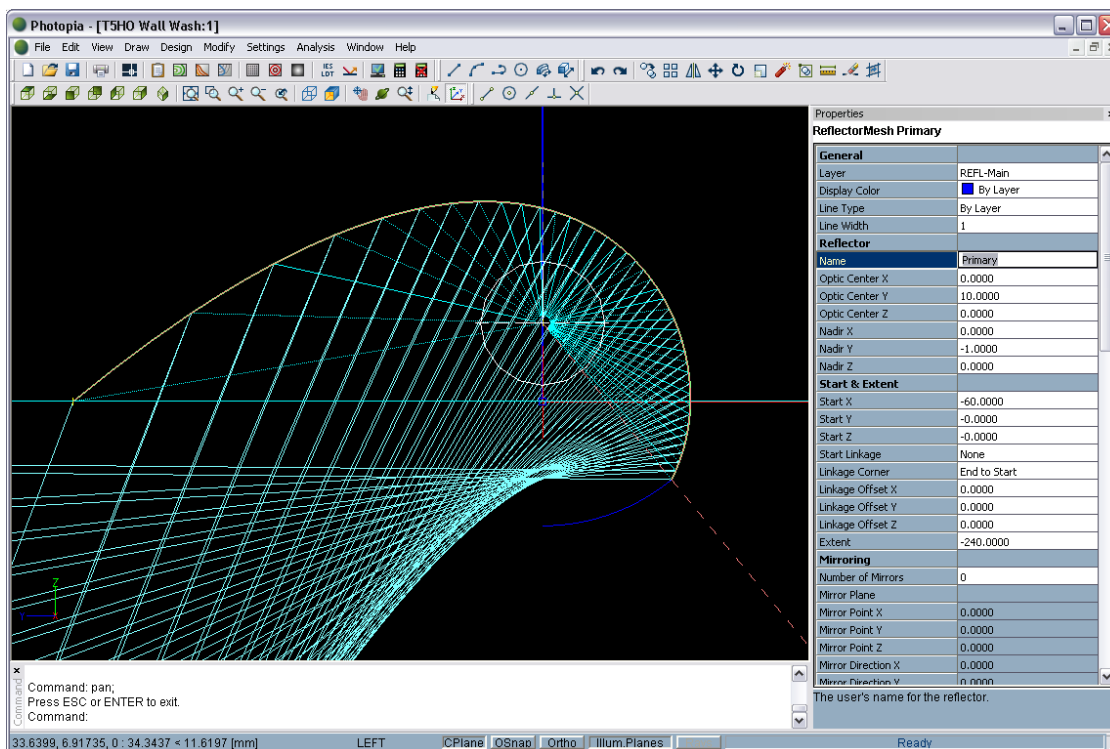
26. Deselect the primary reflector and select the new shield reflector. Under **Start & Extent** in the property control, change the Start Linkage to *Primary*. You may also wish to name this reflector *Shield*.

27. Now that the shield construction is finished, run the analysis to make sure the results are still acceptable.
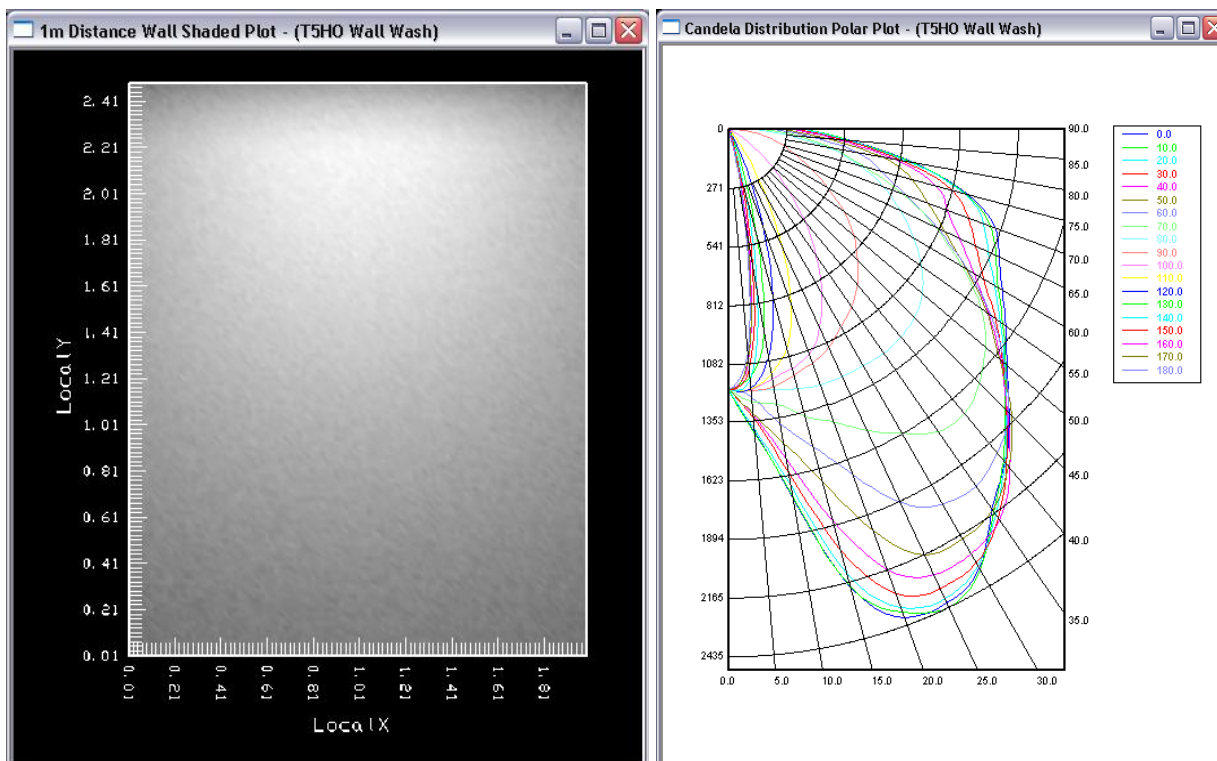
The efficiency has gone down, but this is expected and we were actually able to keep it relatively high by utilizing the shielded light rather than simply blocking it. The shaded illuminance and polar candela plot both maintained the results of a successful wall wash reflector, and now the reflector has partial glare shield as well.