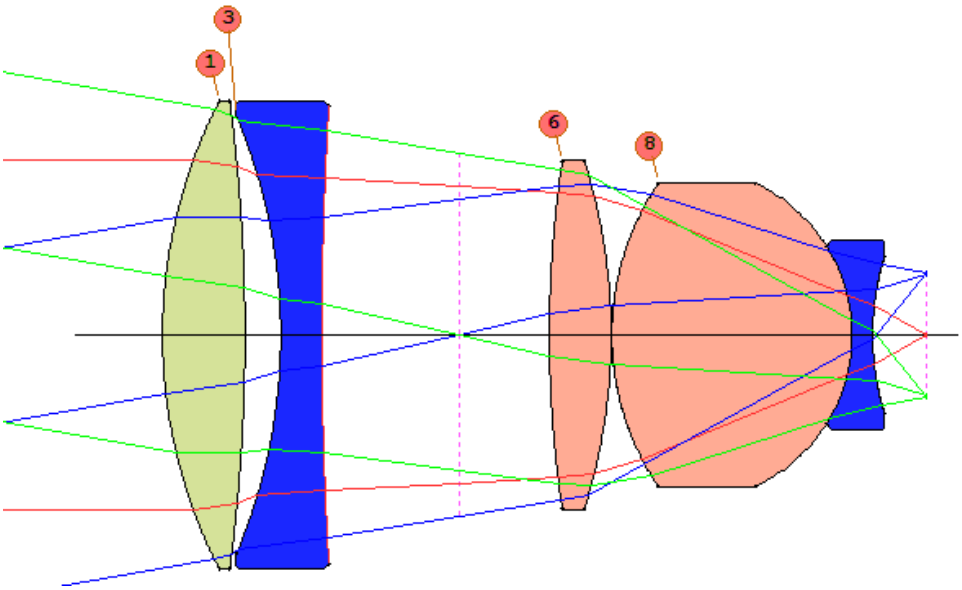
Lesson 36. Edges

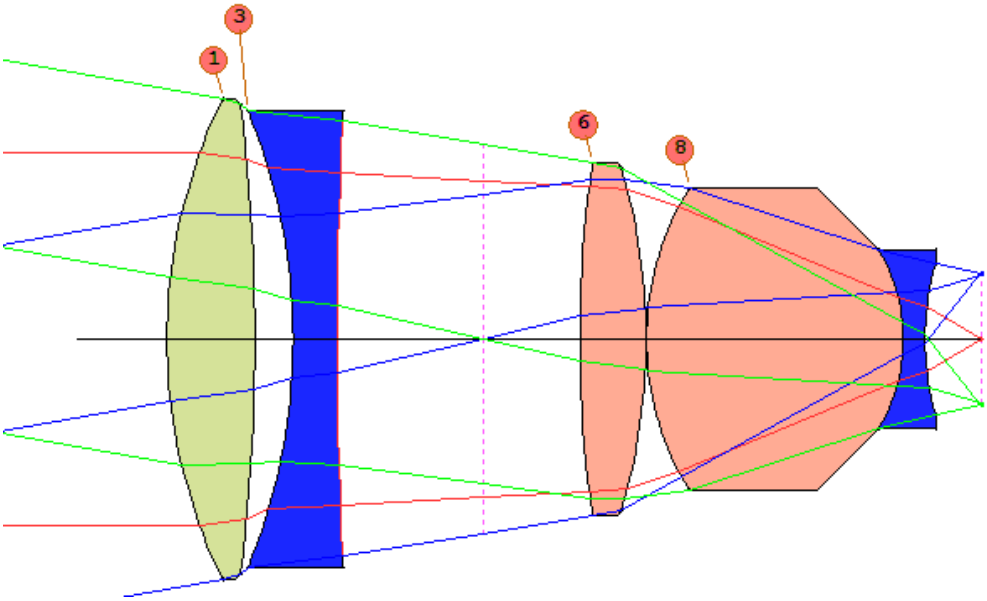
Users of other lens design codes have to make do with some rather primitive edges on their lenses, while SYNOPSYS™ has a powerful feature that lets you specify the shapes and dimensions exactly as you want them. This lesson will show some of the possibilities and teach you how to use them.

Get out the lens bundled as X25.RLE and look at it in the SketchPad display:

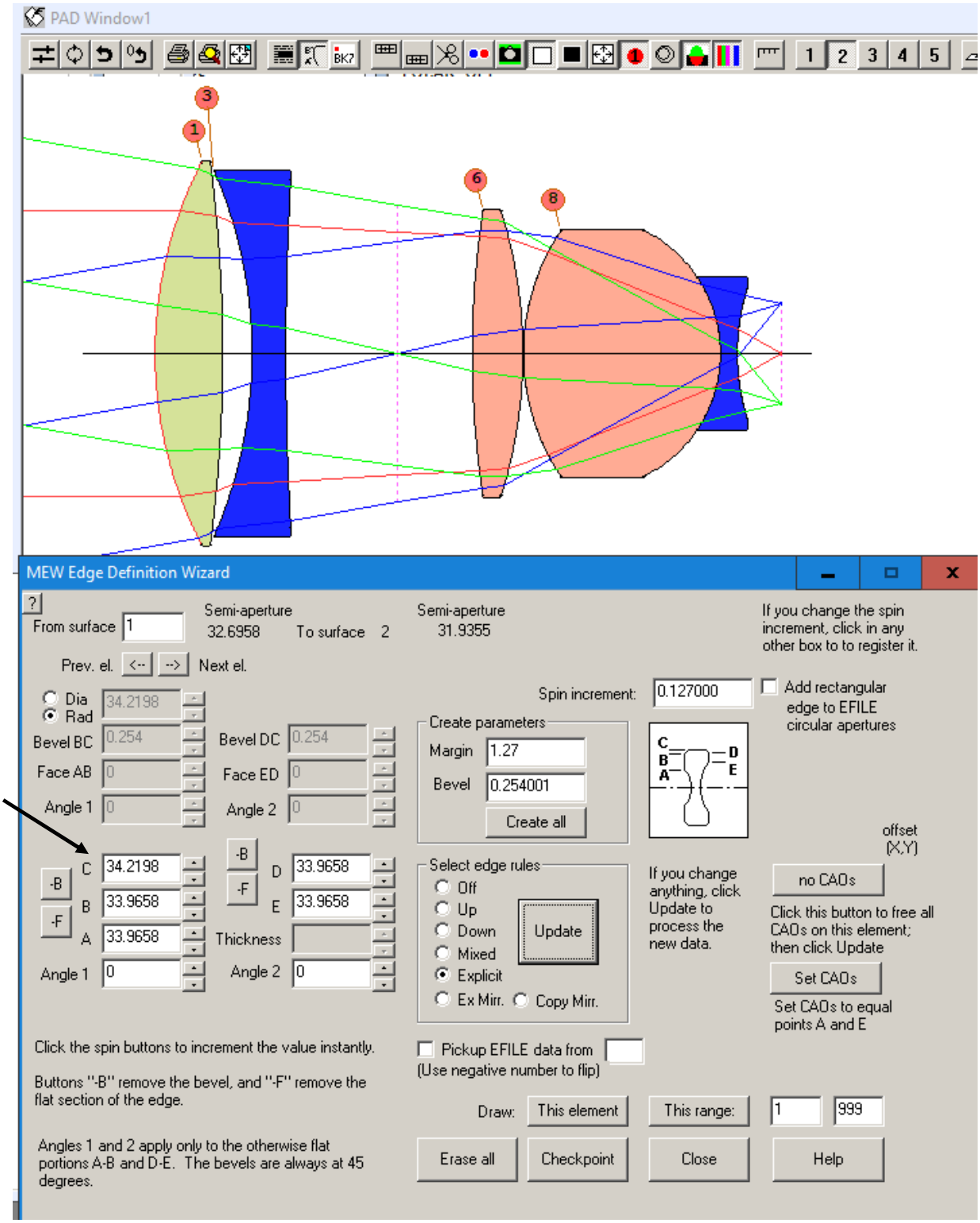


This lens has already been assigned reasonable edges with the Edge Wizard. To show how it works, we will first delete all the edge definitions – and then show how to put them back. Type in the Command Window

EFILE
ERASE
END



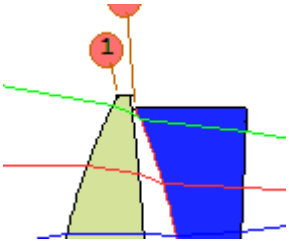
Now you see the default edges, assigned by the program so they clear the upper and lower marginal rays. Those are reasonable edges to use during lens optimization, since you can see what is going on – but when you manufacture the elements you need something better. Now open the Edge Wizard, either by typing **MEW** or by clicking the button  in the PAD toolbar. At the moment, the lens has no edge definitions anymore. Click the **Create all** button, and you get a set of reasonable edges. Click **Yes** to the prompt, and the picture has changed. Enter the number 1 in the surface-number box and you can see the dimensions that have been applied to the first element.



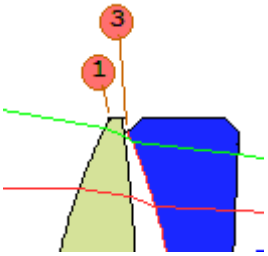
The program creates five reference points at the edge of the element, labeled A through E in the diagram on the dialog. You usually have to edit those default dimensions, and the data for element 1 show one reason why. The first surface is convex, and you may not want a bevel on that surface. The program defined the default edges and put into effect the Explicit rules, which work for most lenses and for which you can edit the data with the edit boxes and spin buttons on the dialog.

We see that the default point C is at 34.2198 mm from the axis, while the clear aperture on surface 1 is 31.9355. This is a rather thin edge, so let us reduce the diameter slightly. Enter the number 34 in the box for dimension C and click Update. We will also remove the bevel on that surface. Click the box "-B" to the left of the C dimension. "-B" means remove the bevel on that side. Then click the "-F" button too. When you removed the bevel, you left point A where it was, which may be appropriate for some plastic elements that have a mounting flange molded in place, but is not welcome here. That button removes the flat portion from A to B. Side 1 is now reasonable, and you may want to remove the bevel and flat on side 2. (For thicker elements, we usually leave the bevels in place on positive elements if the curves are shallow.)

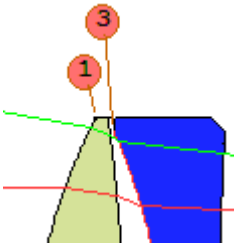
Element 2 is negative, and here we want a flat portion on side 1 and a bevel – but no flat – on side 2. Click the **Next el.** button to see the data on that element.



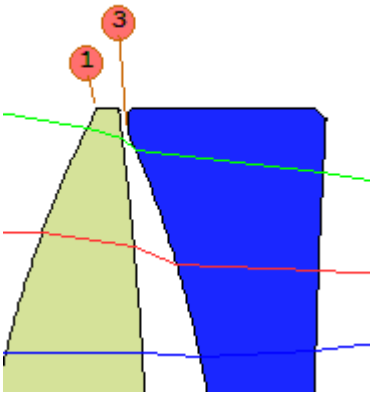
Let us assume you want the outer diameter of element 2 the same as on element 1. Just enter the same dimension, 34 in the C box and click **Update**.



This increases the element diameter, but again has left dimensions A and B where they were. Let us reduce the size of the bevel on surface 3. To the right of the edit box for dimension B there are two spin buttons. Click the upper of the two about eleven times, watching the bevel get smaller and the flat portion getting larger. By clicking on the two spin buttons while watching the picture, you can quickly define exactly the edge you want.



If you also want a smaller bevel on side 2, adjust it with the spin buttons for points D, and then click the **–F** button for that side to remove the flat portion.



Now the edges of the first two elements look about right. It would be a good idea at this point to click the **Checkpoint** button on the MEW dialog. As you work on the other elements, you might make a mistake and want to go back to a previous setup. That's easy to do by clicking the **Restore** button on the PAD toolbar  .

Proceeding in this fashion you can define all the edges just as you want them. When you have finished, close the Wizard and type **ELIST** in the Command Window.

```
SYNOPSYS AI>ELIST

CURRENT EFILE DATA:

Surf.    A           AB          BC          C           ANG         CAO     TYPE
         E           ED          DC          C           ANG2        CAO

-------------------------------------------------------------------------------
  1    34.000      0.0000       0.0000      34.000      0.0000      32.696    EXPL
       33.966      0.0000     0.34200E-01   34.000      0.0000      31.936

  3    32.345      1.5240      0.13071      34.000      0.0000      31.075    EXPL
       33.615    0.12192E-05   0.38471      34.000      0.0000      29.602

  6    25.242      0.0000      0.25400      25.496      0.0000      23.972    EXPL
       25.242      0.0000      0.25400      25.496      0.0000      23.349

  8    21.809      0.0000      0.25400      22.063      0.0000      20.539    EXPL
       21.809      0.0000      0.25400      22.063      0.0000      12.174

  9    13.444      0.0000      0.25400      13.698      0.0000      12.174    EXPL
       11.590      1.8532      0.25400      13.698      0.0000      10.320

CURRENT BEVEL IS    0.2540010
CURRENT MARGIN IS     1.270000
SYNOPSYS AI>
```

These edges become part of the lens file and show up in the RLE data as EFILE parameters. For element 2, those data look like this:

```
…
   3 RAD     -81.3505230000000    TH       6.00000000
   3 N1 1.83648474 N2 1.84664080 N3 1.87201161
   3 CTE    0.830000E-05
   3 GTB S     'SF57             '
```

```
   3 EFILE EX1     32.345300     33.869287     34.000000      0.000000
   3 EFILE EX2     33.615288     33.615289      0.000000
   4 RAD     553.8617899999995    TH      19.92504900 AIR
   4 AIR
   4 EFILE EX1     33.615288     33.615289     34.000000
…
```

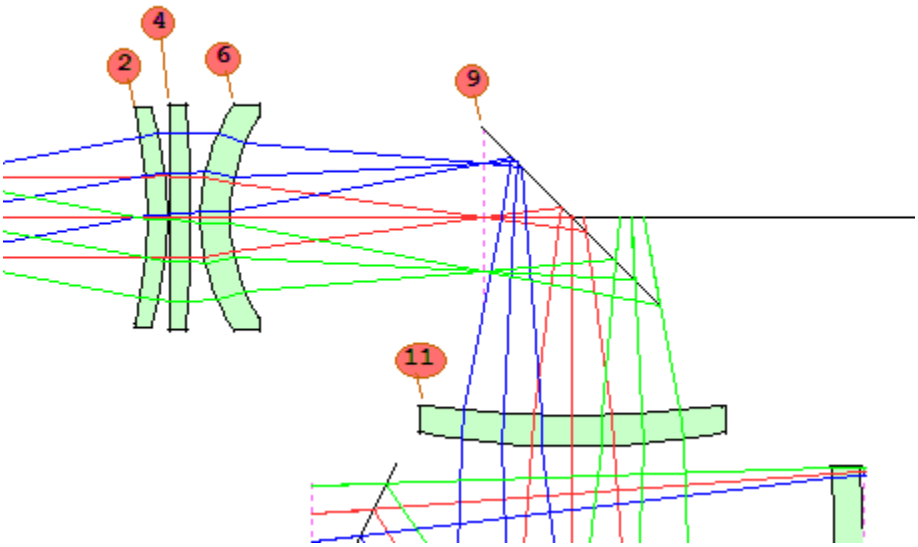
While it is *possible* to edit the edge dimensions in the WorkSheet, we don't recommend it. Some of them are coupled to others and the result is not always intuitive. Use the Wizard to edit the data if you need to! Everything is shown on the dialog and it is very simple to use.

A Mirror Example

This has been a useful example, but now we'll look at a system with fold mirrors. Those can be assigned edges – and thicknesses – too. The lens is in FOLDS.RLE.

FETCH FOLDS

and then open the Edge Wizard again. This system also has EFILE edges, and for this lesson again you should first click the **Erase all** button on the Wizard to revert to default edges. A portion of the system is shown below.

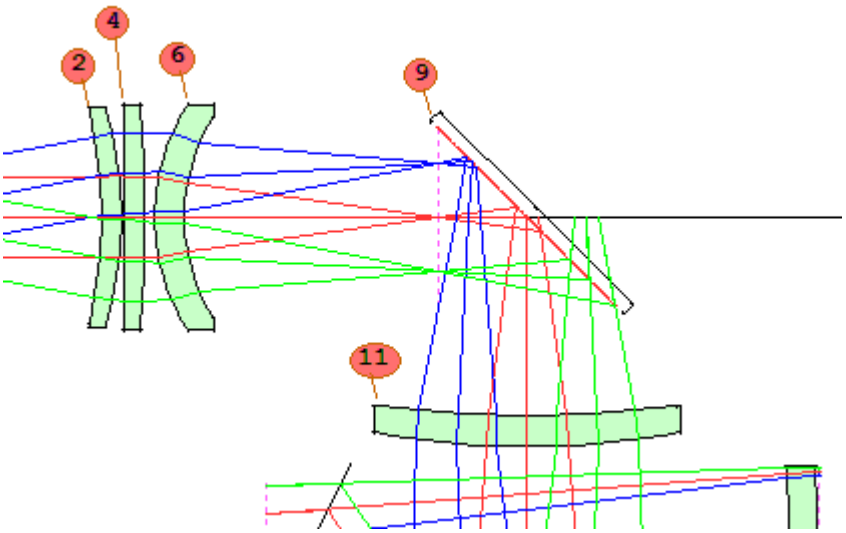


Close the Wizard and type **CAP**.

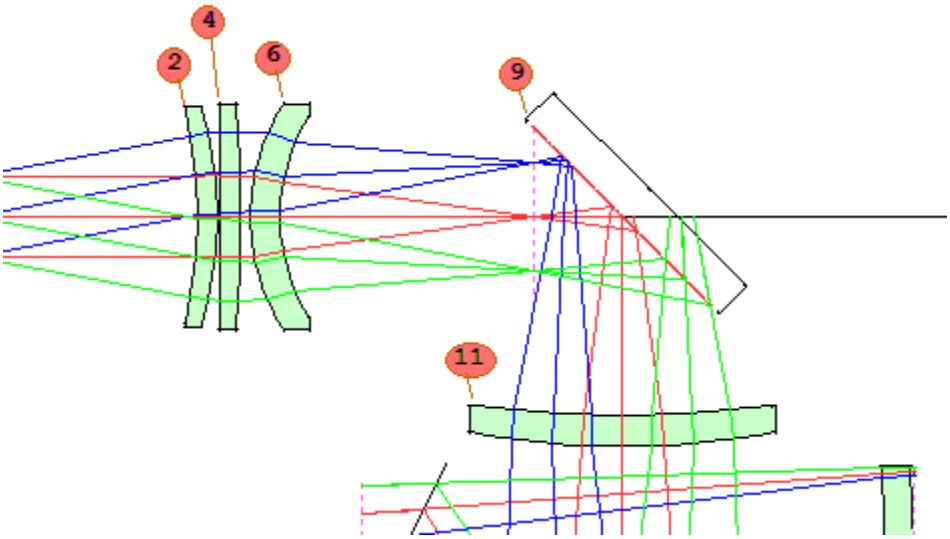
```
SYNOPSYS AI>CAP

ID EXAMPLE FOLDED SYSTEM

CLEAR APERTURE DATA
(Y-coordinate only)

SURF     X OR R-APER.      Y-APER.     REMARK      X-OFFSET     Y-OFFSET  EFILE?
_____________________________________________________________________________
   1          0.2621              *User CAO
   2          0.6611               Soft CAO
   3          0.6870               Soft CAO
   4          0.7014               Soft CAO
   5          0.7064               Soft CAO
   6          0.7072               Soft CAO
   7          0.6303               Soft CAO
```

```
  8          0.5568                Soft CAO
  9          1.2000       1.6000 *User RAO
 10          0.6781                Soft CAO
 11          0.9361                Soft CAO
 12          0.9598                Soft CAO
 13          1.5000       2.2000 *User RAO
 14          0.9714                Soft CAO
 15          2.0000       2.4000 *User RAO
 16          0.9807                Soft CAO
 17          1.0283                Soft CAO
 18          1.0383                Soft CAO
 19          1.0402                Soft CAO
 20          1.0402                Soft CAO

NOTE: CAO, CAI, EAO, and EAI input is semi-aperture.
      RAO and RAI input is full aperture.
SYNOPSYS AI>
```

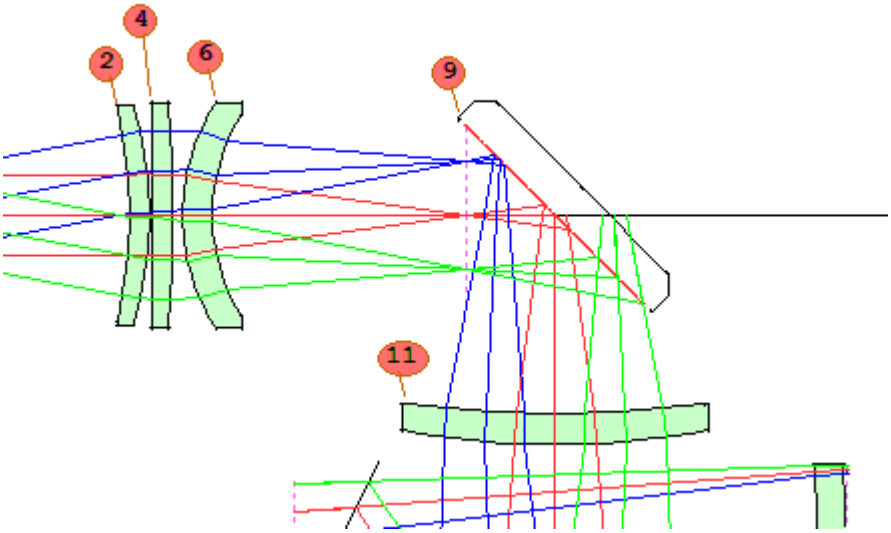
Surface 9 is a fold mirror that has been assigned a rectangular outside aperture of dimensions 1.2 x 1.6 inches. (Those are the full dimensions of the rectangle. Circular apertures are given by the radius, rectangular by the side lengths.), but without assigned EFILE data, it shows up as just a straight line on the PAD display. The Edge Wizard can create suitable dimensions on this mirror, with the aspect ratio taken from the RAO data. Open the Wizard, navigate to surface 9, and you see that nothing is assigned yet. Select the **Ex Mirr** option and click Update. A default edge is created, and now the mirror has a thickness.



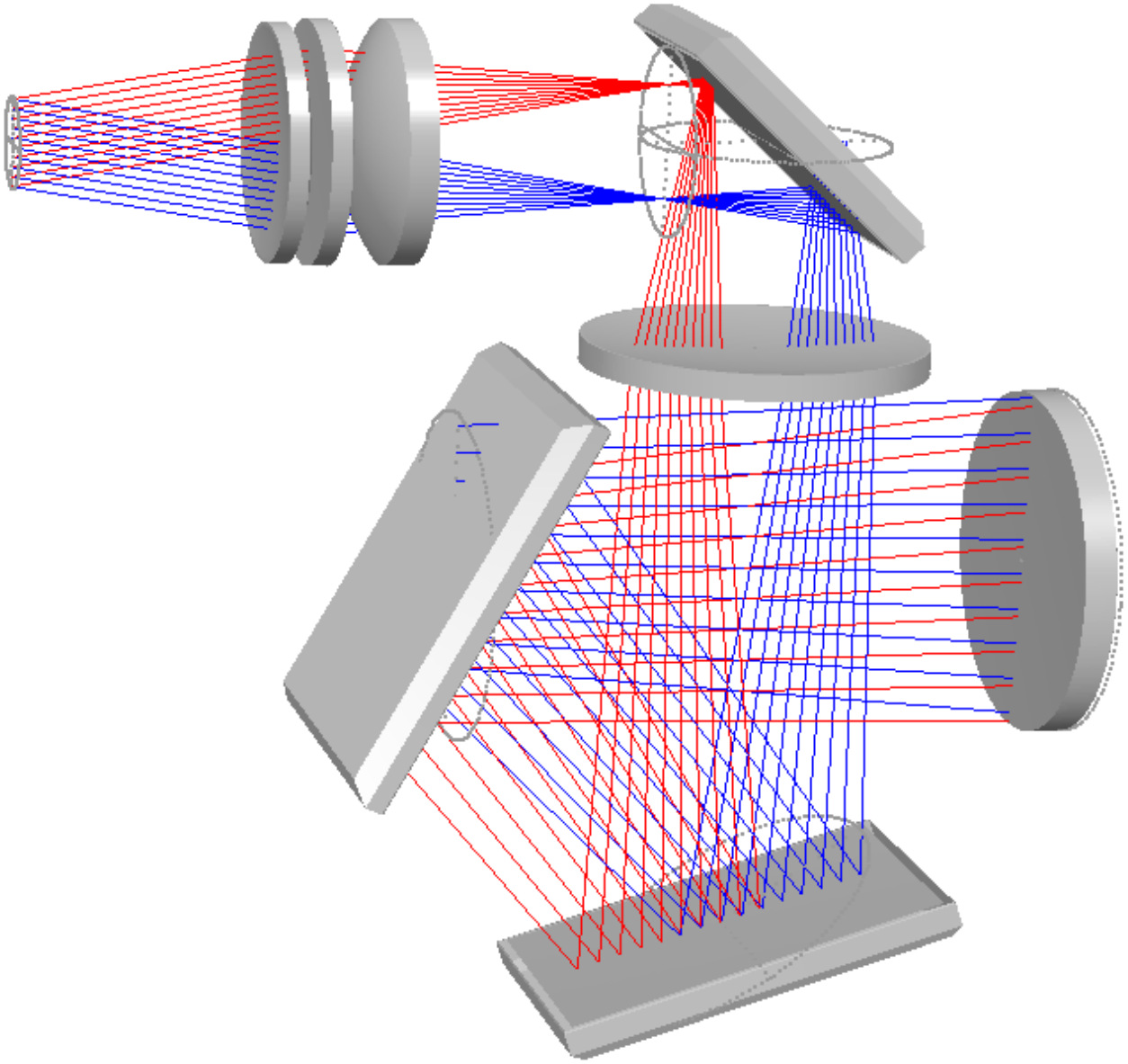
Let's assume you want it to be thicker. Either enter a larger number in the Thickness edit box or click the upper spin button on that box. The thickness increases. The amount by which the spin buttons change the dimension is given in the Spin increment box.



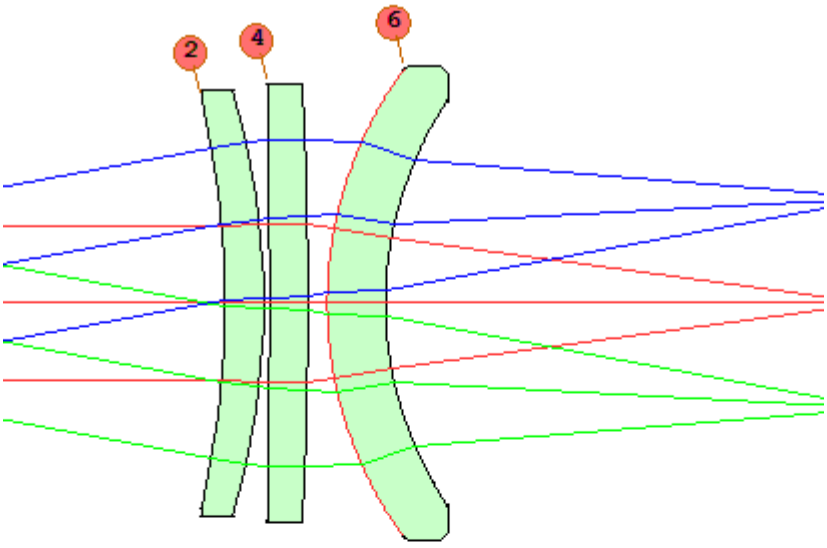
Change the increment to 0.02, click Update, and use the lower spin button in box D to add a bevel to the back side of the mirror.

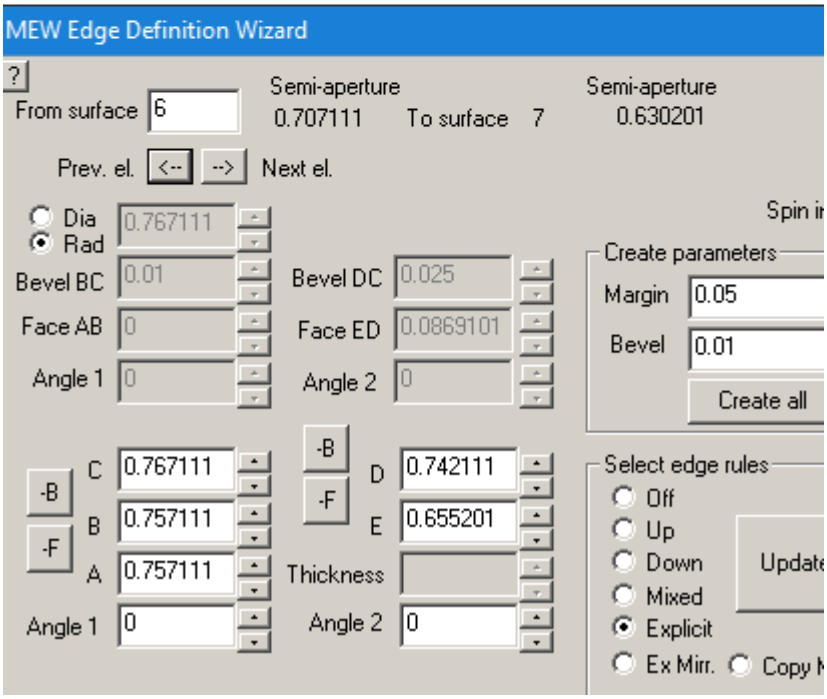


Add default edges to the other fold mirrors, at surfaces 13 and 15, in the same way, and close the Wizard. Now make an RSOLID picture. (Use the dialog **MPE** if you are not familiar with the input for this snazzy feature.)

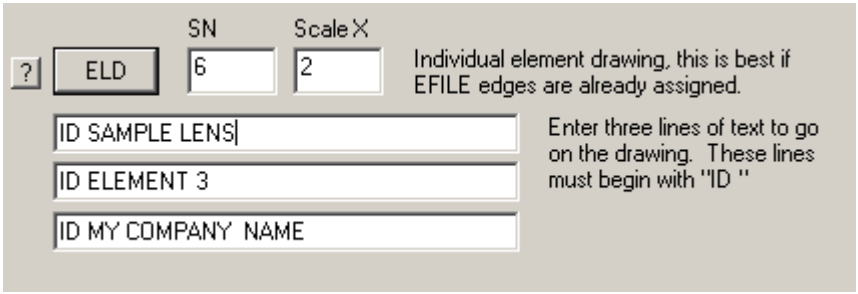


Your mirrors are shown, beveled exactly as you wanted. Go back to the Wizard, and define the edge for element 3, at surface 6.



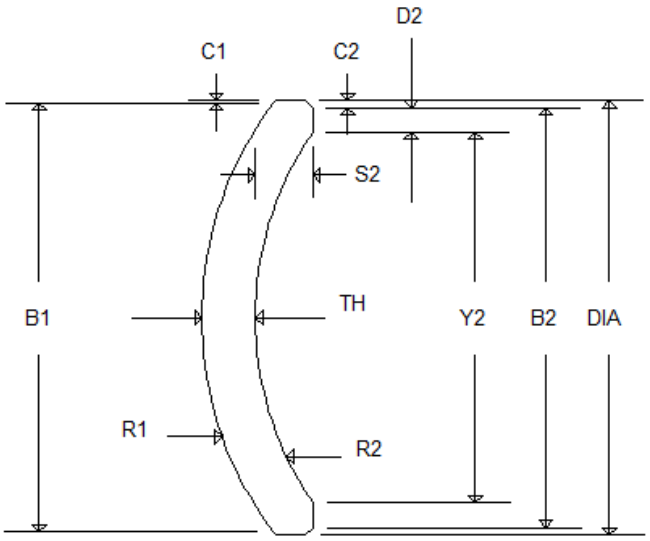


Now open the **MPL** dialog and enter data for an ELD drawing at surface 6:



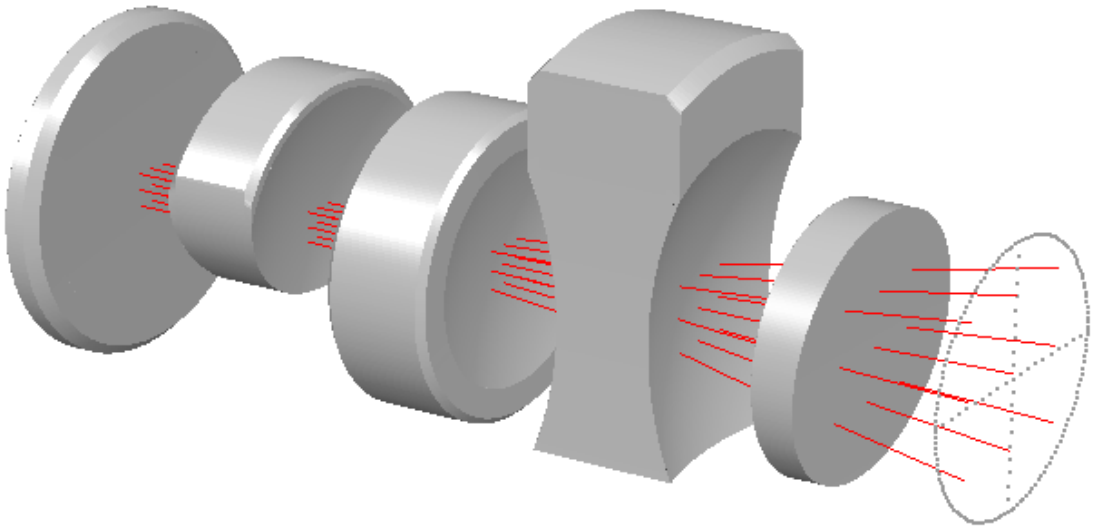
Click the **ELD** button, and your drawing shows up – with all of the edge dimensions nicely shown and documented.

PARAMETERS	SIDE 1	SIDE 2
RADIUS OF CURVATURE	R1 1.2750	R2 1.1644
RADIUS TOLERANCE		
FRINGE TOLERANCE		
CYLINDER FRINGES		
EDGE ROLL FRINGES		
FINISH		
COATING		
CLEAR AP. DIAMETER	1.4142	1.2604
SAGITTA		S2 0.20183
DIA. TO FACE		Y2 1.3104
DIA. TO BEVEL	B1 1.5142	B2 1.4842
FACE WIDTH TO BEVEL		D2 0.0869
BEVEL WIDTH	C1 0.0100	C2 0.0250
FACE ANGLE		
THICKNESS	TH 0.1886	
TH. TOL.		
WEDGE TOL.		
FLAT TIR		
DIAMETER	DIA 1.5342	
DIA. TOL.		
MATERIAL	GE	
GRADE		
ANNEAL		
SLOPE		

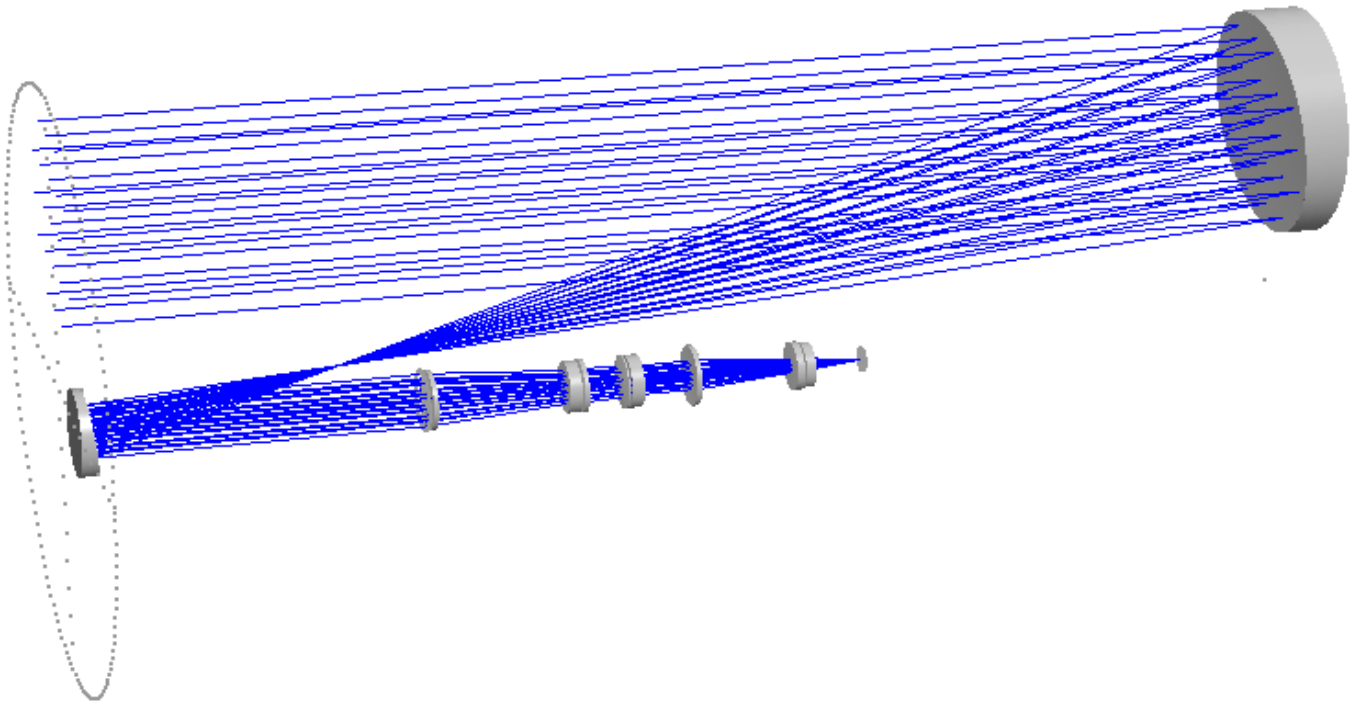


SCALE 2.000 X	NUMBER		SAMPLE LENS ELEMENT 3
DATE 05-JUN-17	REV.		
DESIGNER	APPROVED		
CHECKER			
TEST WAVL			MY COMPANY NAME
DIMENSIONS INCH		SYNOPSYS	

This has been a brief introduction to the power of the Edge Wizard. There are many more options, including some that will automatically change dimension C if the lens CAO changes. You may never need that much horsepower, but by all means read Section 7.8 of the User's Manual. There you will learn how to create edges like this:



And this:



No other optics program in the world has the sophisticated edge-definition capability of SYNOPSYS™.