




## Lesson 2. Achromatizing the lens


Now we will add a second element and try to control the chromatic aberration of our singlet.

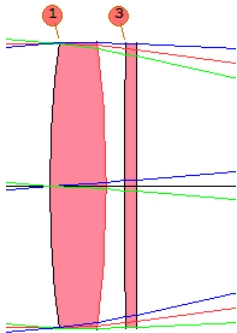
```

RLE
ID SINGLET                                33
FNAME 'L1L1.RLE'
MERIT 0.625687E-07
LOG    33
WAVL .6562700 .5875600 .4861300
WT1 1.00000 .001000 1.00000
APS    1
UNITS MM
OBB 0.000000    5.00000    12.70000    0.00000    0.00000    0.00000    12.70000
 0 AIR
 1 RAD 100.00000000000000 TH 5.00000000
 1 N1 1.51431710 N2 1.51679451 N3 1.52237021
 1 CTE 0.710000E-05
 1 GTB S 'N-BK7'
 2 RAD -100.00000000000000 TH 95.91906767 AIR
 2 TH 95.91906767
 2 YMT 0.00000000
 3 CV 0.00000000000000 TH 0.00000000 AIR
END
    
```

First we make a checkpoint, by clicking the Checkpoint button on the PAD toolbar . It is always a good idea to save a checkpoint before you start changing a lens. That way, if things don't work out, you can instantly go back, with the  button. (You can also press the **F3** key to cycle back through previous versions, but we prefer the button since then

we have total control.) Now click the WorkSheet button . Click in the drawing on surface 1, and then 2. See how the RLE data for the selected surface show up in the edit pane. This is where you will do most of your lens editing.

Now we add a second element. Click the button  on the toolbar near the top of the window. Then click in the lens drawing on the PAD display just behind the singlet. A second element shows up.



The program has removed the YMT solve from surface 2 and added an index pickup on surface 3 (3 **PIN 1**). Click on surface 3, and type **3 GLM 1.6 44** in the edit pane. Then click the Update button.


```

WS -- WorkSheet Lens-Edit Window
 3 CV 1.00000000000000E-04 TH 1.00000000
 3 N1 1.51431710 N2 1.51679451 N3 1.52237021
 3 CTE 0.710000E-05
 3 GID 'N-BK7'
 3 PIN 1
 3 GLM 1.6 44
    
```

We are going to vary the glass types in order to correct color, and we don't want surface 3 to always pick up the index values from surface 1. So we assign it a glass model of its own, somewhere in the flint part of the glass map. Now type, in the edit pane.

```
4 UMC -.125 YMT
```


and click Update again. Now the lens has a curvature solve on 4, yielding an F/number of 4.0, and surface 5 is at the paraxial focus because of the YMT solve. Simple enough. Make a new checkpoint and close WS.

Now type **EE** to go back to the editor, and click the Clear MACro button  to erase what you typed earlier. We are going to make an optimization MACro. Type in the editor:

```
PANT
VLIST RAD ALL
VLIST TH ALL
VLIST GLM 1 3
END
```

```
AANT
```

```
END
SNAP
SYNO 20
```

Optimization in SYNOPSIS requires a parameter file (**PANT**), a merit function file (**AANT**), and then some optimization commands. Now put the cursor *in the blank line after the AANT command* and click the button  on the PAD toolbar. This opens a dialog where you can select one of nine ready-made merit functions. Number 6 is the default and is the one we want, so just click the **Back to MACro editor** button. Now your MACro looks like this:

```
PANT
VLIST RAD ALL
VLIST TH ALL
VLIST GLM 1 3
END

AANT
AEC
ACC
GSR .5 10 5 M 0
GNR .5 2 3 M .7
GNR .5 1 3 M 1

END
SNAP
SYNO 20
```

The editor has created a simple set of optimization requests. You can read the meaning of these lines in the help file. For example, if you type in the CW

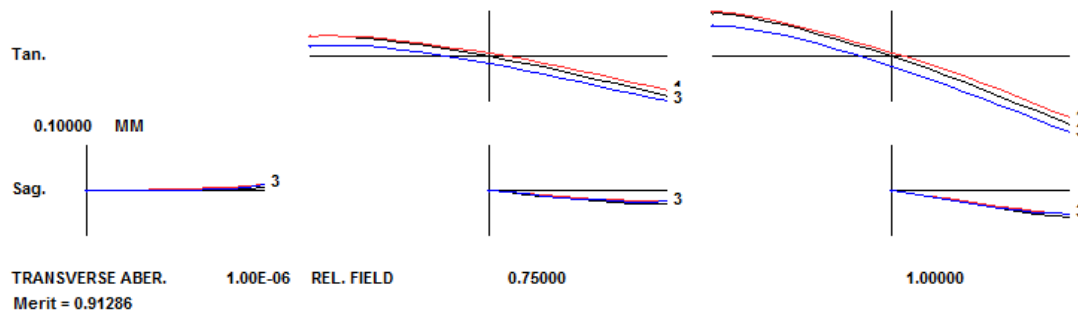
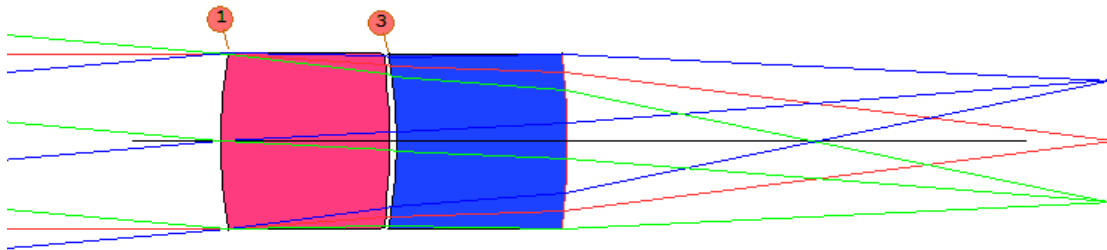
```
HELP AEC
```

you will learn about the Auto Edge Control monitor. Now just *select* the characters **GSR** in the editor window, and look down at the tray, near the bottom of the screen.

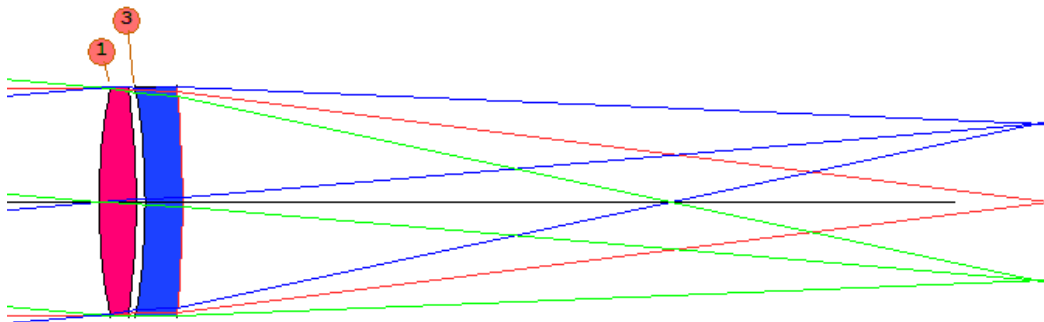
```
GSR rt wt del {icol/P/M} hbar gbar [sn [F]]
```

That gives you an instant summary of the syntax of the GSR ray-grid request. Press the **F2** key when you see something in the tray and you want more information, and you go right to the help file on that topic. That would probably be a good thing to do right now.

So much for the basics. Now click the Run button  on the editor and watch the display change.



Oops! What happened? The image looks much better, but the lenses are way too thick! There's a lesson here. The program will do *absolutely anything* it can to bring down the value of the **merit function**, which is just the sum of the squares of the items in the AANT file. Sometimes it does things that you don't want (and did not tell it about). But it's just doing its job. The AANT file includes an **ACC** monitor, which is intended to prevent lenses from getting too thick (which they usually want to do), but the default limit is one inch, or 25.4 mm. That's what we got. Now edit the AANT file, changing that monitor to **ACC 4 1**, and run it again, giving a target of four mm. Much better!



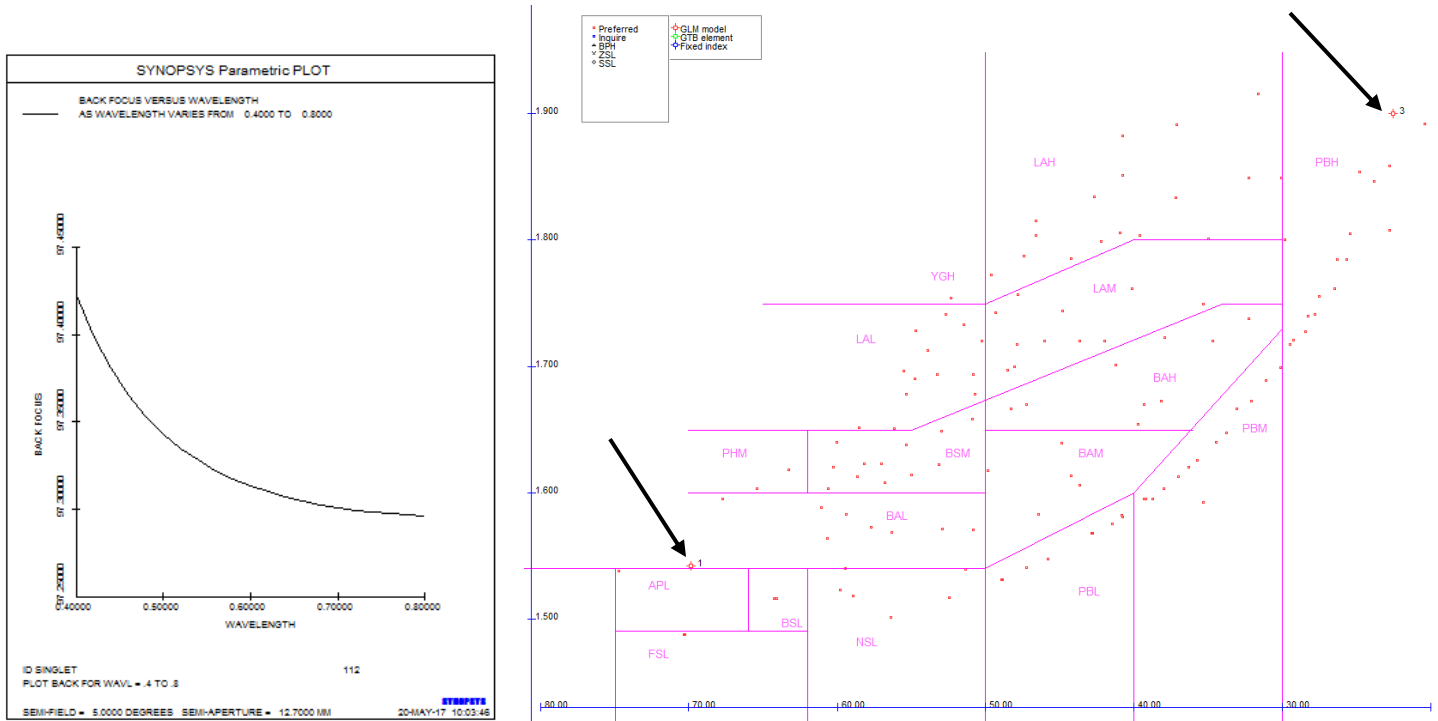
Type **HELP MONITORS** to read about the 12 different kinds of monitors you can use to keep your systems reasonable.

Now we will again ask AI to show us the color correction, but this time we will first define that sentence as a *symbol*. Type the line below in the CW.

**QQ: PLOT BACK FOR WAVL = .4 TO .8**

Now, just type **QQ** and the program processes that sentence. The color correction is much better, as shown below. When you define a symbol this way, you only have to type it once and it remains defined until you exit from the program. (Note the colon and space after the characters “QQ”. That is the flag for a new symbol.)

What kind of glass did the program come up with? Type **MGT** (Menu, Glass Table) in the CW, select the Ohara catalog, and click OK. Surface 1 has been assigned a glass model in the BAL section, and surface 3 is in the PBH section, as you can see in the glass-map picture below. In the next lesson we will develop a 3-element apochromat design with better color correction. But first, let’s save this lens.



Type the command

**SAVE L2L1.**

That will save an RLE file of the lens data on disk with the name L2L1.RLE so you can open it again later if you wish.

You can also store your lens file in the lens library location 4 with the command **STORE 4**. The command **PLB** will list the contents of the library, and **MLB** will open a dialog that gives you another way to access it.