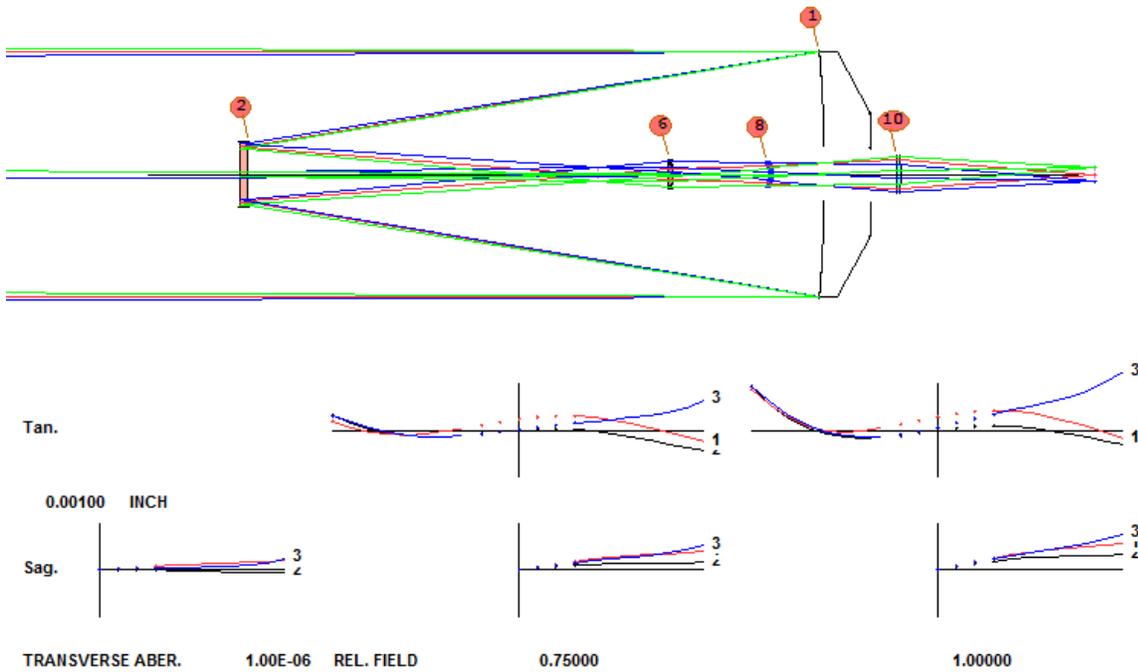


Lesson 45: Using the Artificial Intelligence Feature for a Parametric Study

In this lesson we will show how to use a unique feature of SYNOPSIS™ to do a parametric study. We will get out the relay telescope bundled as the file 4.RLE. Type

FETCH 4 ,

and then type PAD to see it in the PAD window.



For this study we first get the multicolor wavefront variance at full field, which is of course very easy to do with the MDI dialog, or with the command

VAR M 1 600

```
THE STREHL RATIO CALCULATION IS VALID FOR A UNIFORM UNOBSURED APERTURE ONLY.
VARIANCE   STD. DEV.   STREHL R.   XIP   YIP
0.905016E-01 0.295467   0.569518E-01 0.143302E-14 -0.140397E-03
```

Here, we asked for 600 rays, and you might wonder if that is enough. Some people use many thousands. Is that really necessary?

Here's how to find out. First, type in the Command Window

AIP: 600

(Be sure to leave a space between the colon and the number 6.) You have just assigned a string to the AI symbol, "AIP".

Now we will use the AI program to make a plot showing how the variance changes as a function of the number of rays requested. In the MACro editor, type

```
VAR M 1 AIP
```

and then click the Run button. In the VARIANCE command, word 4 is the number of rays to be traced, but here we give it the *symbol* instead, which gets converted to the characters "600" when it runs. Now the Variance analysis runs again, with the same results as before. We are halfway there, but we need to tell AI where to pick up the resulting variance number, since that is what we need to examine for each case. Type

BUFFER?

```
The current FILE BUFFER contains
 1      0.09050163  VARIANCE
 2      0.29546656  STD. DEVIA.
 3      0.05695178  STREHL R.
 4      1.43302071E-15  X IM. POINT
 5     -0.00014040  Y IM. POINT
 6      0.95667244  TRANS. FRAC.
 7      0.08849291  VARIANCE
 8      0.29747758  STD. DEVIA.
 9      0.03039248  STREHL R.
10      0.58756000  WAVEL.
11      0.05070989  VARIANCE
12      0.22518857  STD. DEVIA.
13      0.13507214  STREHL R.
14      0.65627000  WAVEL.
15      0.13230208  VARIANCE
16      0.36373353  STD. DEVIA.
17      0.00539072  STREHL R.
18      0.48613000  WAVEL.
```

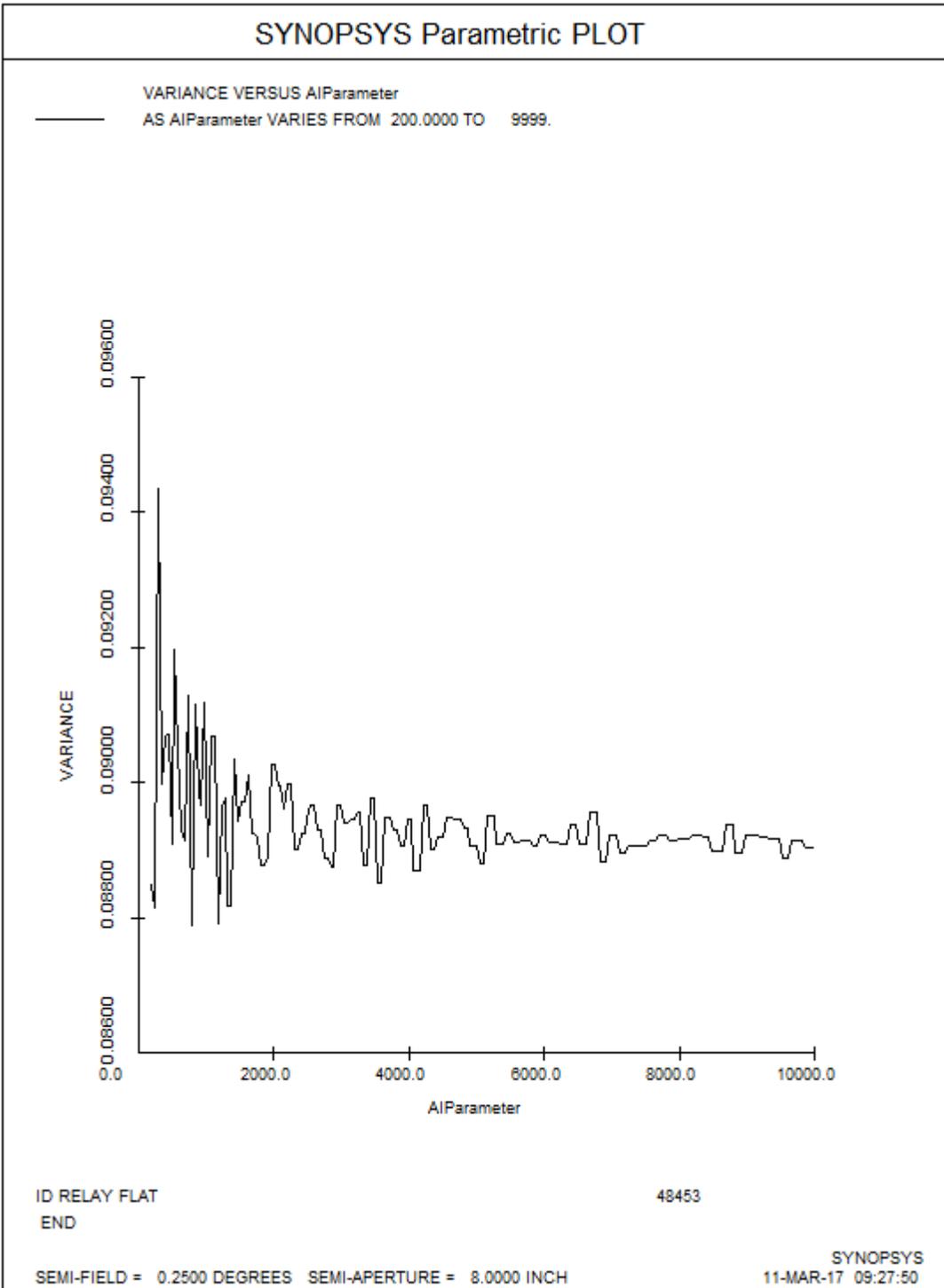
The number we want to examine is the variance, which the program has stored in file location number 1. Edit the MACro so it reads as follows:

```
VARIANCE M 1 AIP
ORD = FILE 1
```

"ORD" means the ordinate data for the analysis, which will come from file location 1. Run this again, because the program has to run a MACro once before it can loop over a variable. Now we're ready. Type

```
STEPS = 200
DO MACRO FOR AIP = 200 TO 9999
```

The program runs the MACro 200 times, and for each case it picks up the variance. When it is done, it makes a plot:



Aha! The variance that comes back does indeed depend on the number of rays requested! But not by all that much; with 600 rays we got a value of 0.0905, while 9999 rays gave a value of 0.08906. Too few rays, on the other hand are certainly not desirable. According to the tabulated results, the highest value came out to 0.09435 for the case where 298 rays were traced. So we have learned a lesson: image analysis routines are more accurate if more rays are requested – but for this example, the results are essentially the same for 6000 and 9999 rays. So there is usually no point in asking for more.

SYNOPTSYS™ makes this kind of parametric study quick and easy.

We should explain a little about the symbol “AIP”. AI can let you define symbols, which are entries of one to three characters, defined so that whenever they appear in your input the program substitutes a string of different characters. But the symbol AIP has special properties that other symbols do not have: it can be used in a MACro loop as we have done here. Each time through the loop, the program assigns the next number in the loop to that symbol; then the commands in the MACro can pick up that number anywhere the symbol shows up instead of a data parameter. In this way you can plot almost anything against almost anything else. You can read about the very powerful Artificial Intelligence feature in the User’s Manual. Just type HELP AI.

Oh, a final word: in this lesson we calculated the *multicolor* wavefront variance. SYNOPTSYS™ is the only optics code that can do that, mainly because nobody else has ever devised a definition of the term. Consider, for example, a lens with a perfect image in three colors but lots of lateral chromatic aberration. The variance in each color is now zero, but the image is obviously terrible. One can’t just add or average the variance values in some way, since that would be very misleading. What to do?

The answer is quite simple. The variance is calculated over a wavefront, of course, and the OPD values depend on where you take the center of the reference wavefront. In the above example, if we take the reference in each color at the principal ray in *that* color, we get a variance of zero in each color. But suppose we take a *single point* as the reference for all three colors. Now the variance is not zero for any of them, unless it happens to coincide with that color’s principal ray. Using that point as the reference, we get a nonzero variance, and by adjusting its location we can find a place that minimizes the resulting multicolor variance. That is how SYNOPTSYS™ defines and calculates it. Only in SYNOPTSYS™.

This is an example of the many unique and friendly features in SYNOPTSYS™. As you learn to use the program you will find many others.