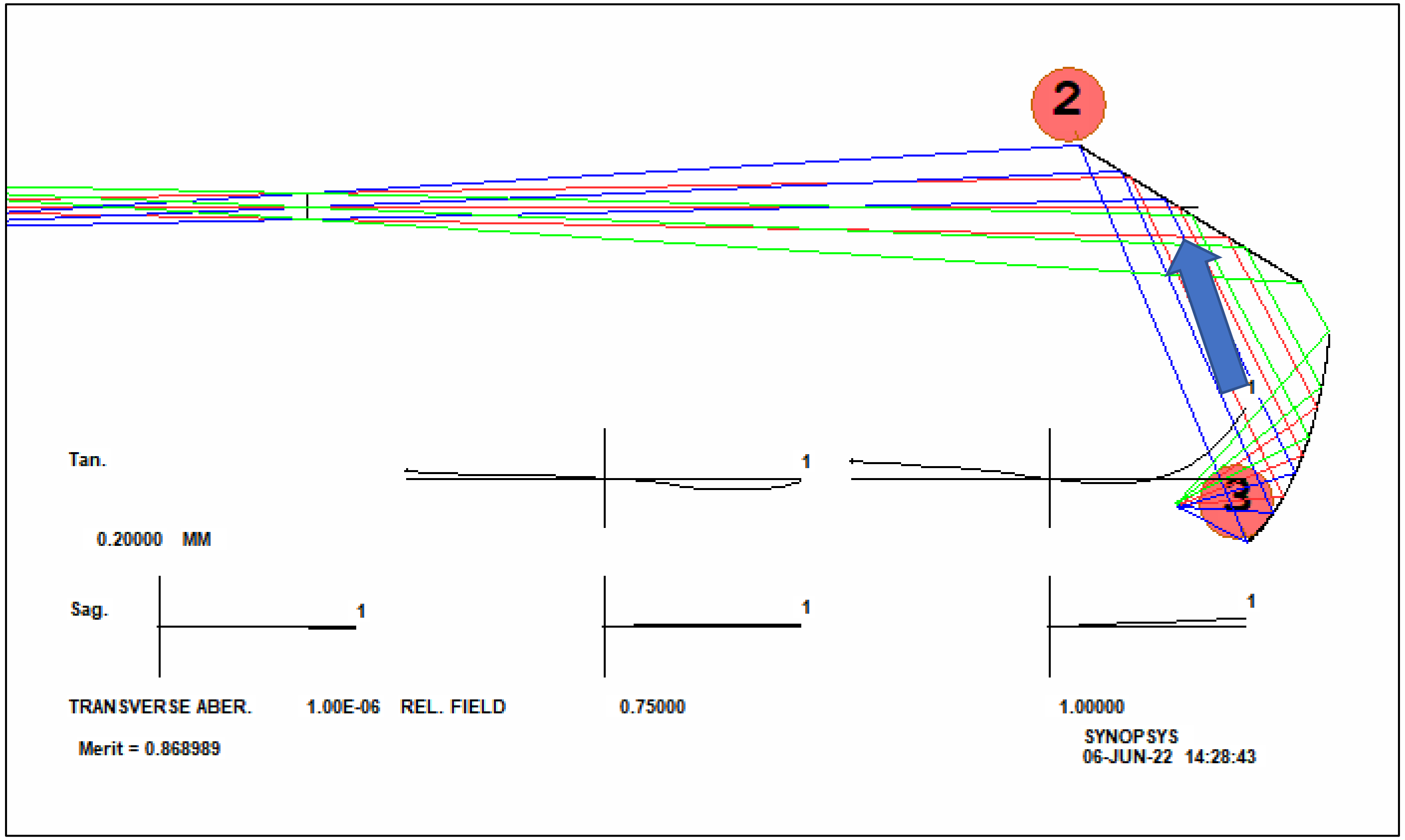
Virtual Image Plane Analysis

Step 1: Launch the system

Launch the lens system (see Appendix B for lens data file):

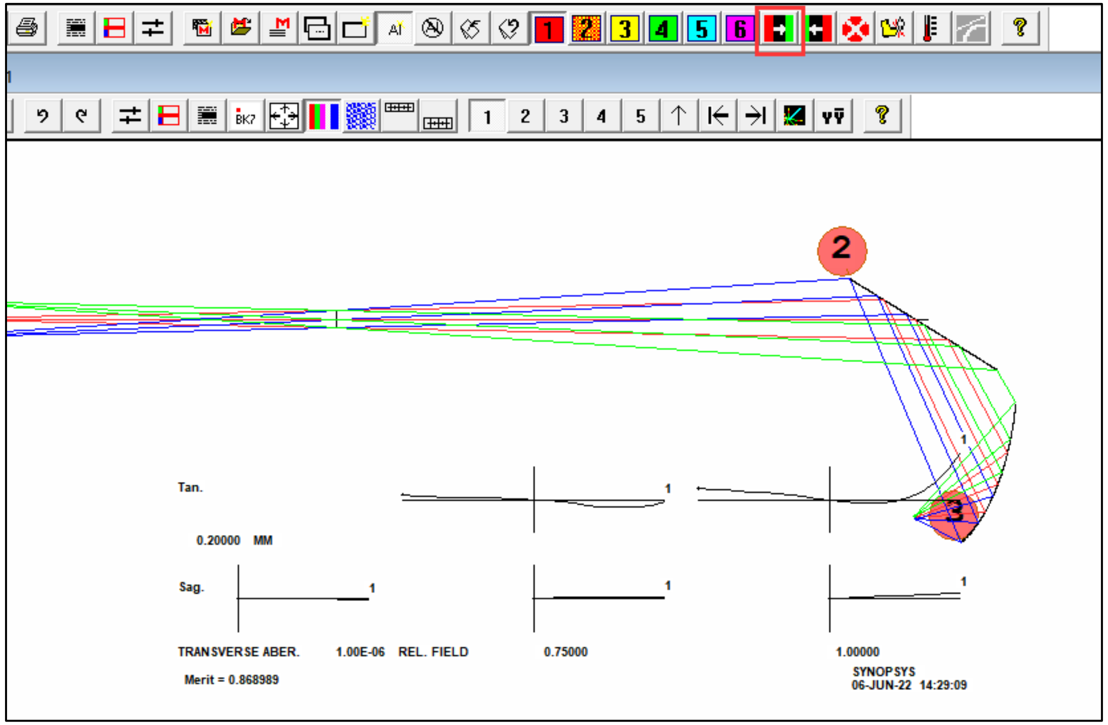
HUD_TEST.RLE

We want to find out the virtual image plane after surface 2 (ie, looking into surface 2 from the direction of surface 3 along the blue bold arrow).

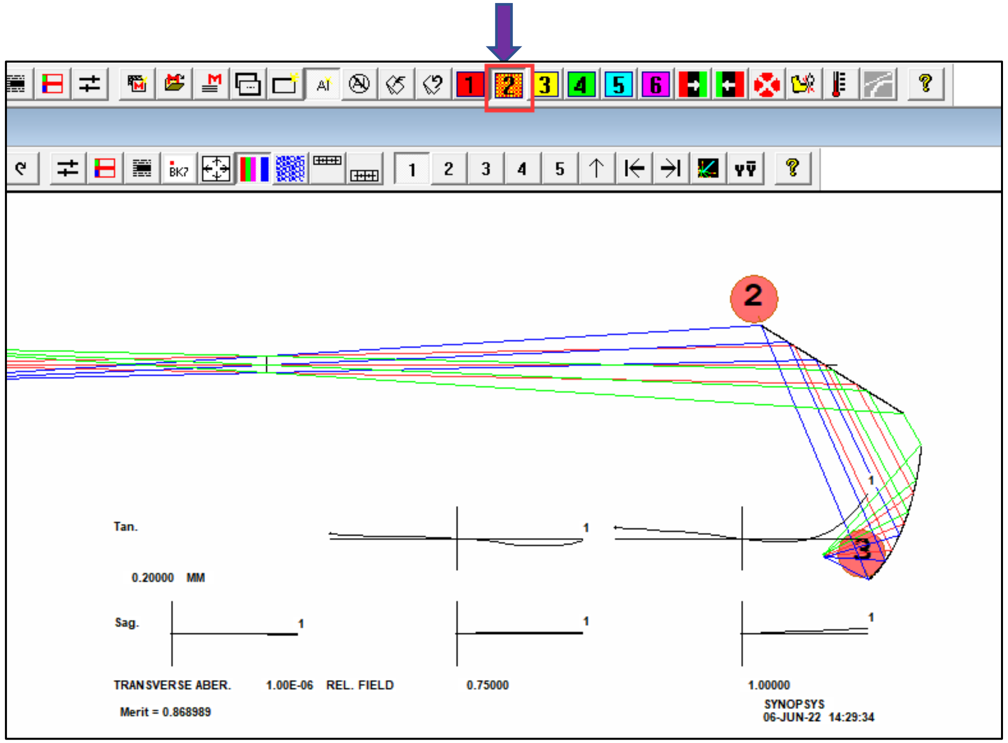


Step 2: Push the system to Config 2 for virtual image analysis

Click the ‘Acon copy’ button at the top toolbar to copy and push the current system from config 1 to 2



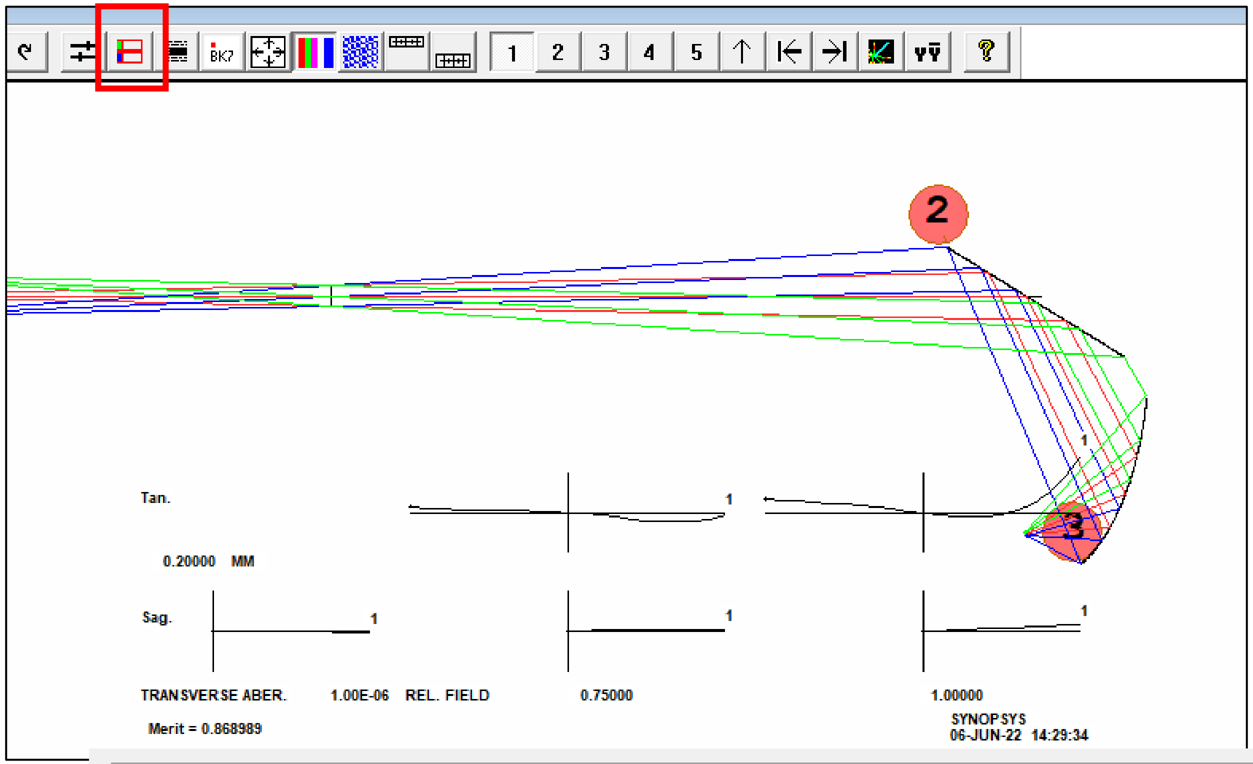
Then you will notice that the ‘ACON 2’ button is pressed down, signaling that you are working with the 2nd configuration. You can go back to the Config 1 by simply clicking at the ‘ACON 1’ button to the left.



Note: This step is optional. You can do everything in Config 1. However, using Config 2 will allow you to work on two systems at the same time. For example, you can keep designing your reflector system in Config 1, and only push it to Config 2 when you want to do the image plane analysis

Step 3: change the system in config 2 in the SpreadSheet

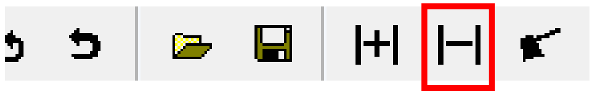
First, click the SpreadSheet button at the PAD Window toolbar to launch it:



	Surface Type	Surface ID	Radius	Thickness	Material	Index	Coating	Aperture Type (Outer/Inner)	Y Semi-Width (Outer/Inner)	X Semi-Width (Outer/Inner)	Conic	Tilt/Decenter
0	Finite Object (angular)		infinite	250	Air	1		Def (Circ)/none	0/0	0/0		
1	Flat		infinite	184.005889	Air	1	None	Def (Circ)/none	5/0	5/0		
2	USS Type 2		infinite	-82.2741408	Air	1	None	Def (Circ)/none	52.4487/0	52.4487/0		Global
3	Zernike		116.84637	53.851648	Air	1	None	Def (Circ)/none	45.5288/0	45.5288/0		Global
4	Flat		infinite	0	Air	1	None	Def (Circ)/none	1.04767/0	1.04767/0		Global

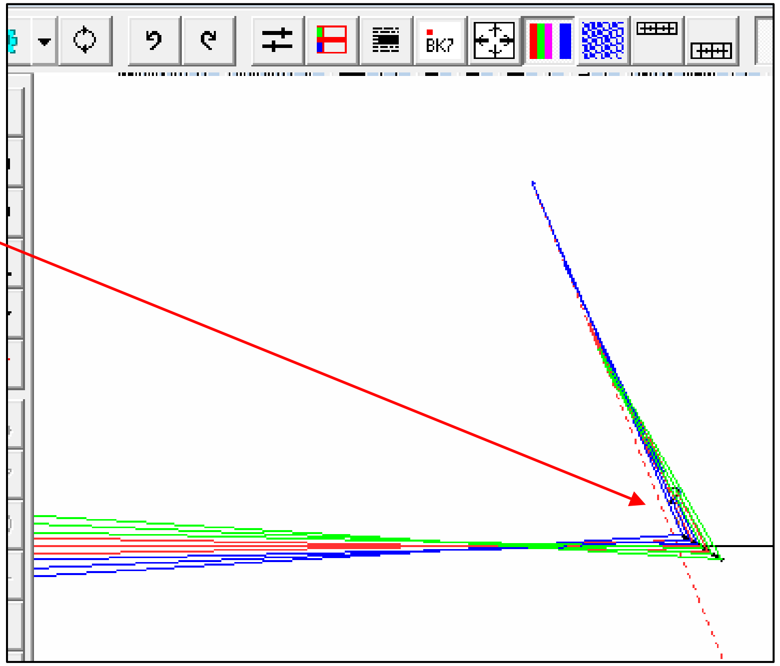
Step 3: change the system in config 2 in the SpreadSheet

Click at row 3 to highlight surface 3. Then click the delete surface button to remove it.



	Surface Type	Surface ID	Radius	Thickness	Material	Index	Coating	Aperture Type (Outer/Inner)	Y Semi-Width (Outer/Inner)	X Semi-Width (Outer/Inner)	Conic	Tilt/Decenter
0	Finite Object (angular)		infinite	250	Air	1		Def (Circ)/none	0/0	0/0		
1	Flat		infinite	184.005889	Air	1	None	Def (Circ)/none	5/0	5/0		
2	USS Type 2		infinite	44.5620512	Air	1	None	Def (Circ)/none	52.4487/0	52.4487/0		Global
3	Flat		infinite	0	Air	1	None	Def (Circ)/none	995.095/0	995.095/0		Global

After removal, the third surface is a flat surface (magenta dashed line in the PAD window). We will then put it at the virtual image plane by running an optimization macro (see next page).



Note 1: For more details on how to use the Tilt and Decenter Editor in the SYNOPSYS™ Spreadsheet, see the section 'Tilt/Decenter Editor' in the 'Manual for User Interface Plus'. (Manual for User Interface Plus > Surface Data Editors > Tilt/Decenter Editor)

Note 2: See Appendix C on how to do this using script.

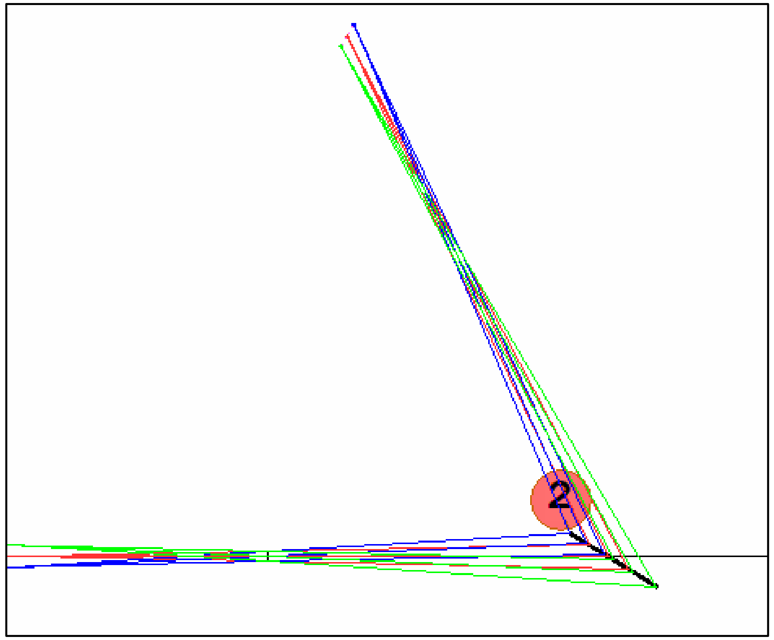
Step 4: put surface 3 at the virtual image plane by doing optimization

We will let SYNOPSYS find the virtual image plane for us by running the following optimization macro (you can copy and paste the following script into the Macro editor and run it):

```
PANT
VY 3 YG    !make surface 3 global Y coordinate a variable
VY 3 ZG    !make surface 3 global Z coordinate a variable
VY 3 AG    !make surface 3 global Alpha tilt angle a variable
END

AANT
M 0 1 A P YA 0 0 0 0  !control real height of axis ray to zero at surface 3
M 0 1 A P HH 0 0 0 0  !control axis ray hit surface 3 with HH = 0
M 0 1 A P YC 0 0 .1 0 !put surface 3 at the paraxial focus
END

SYNO 20
```

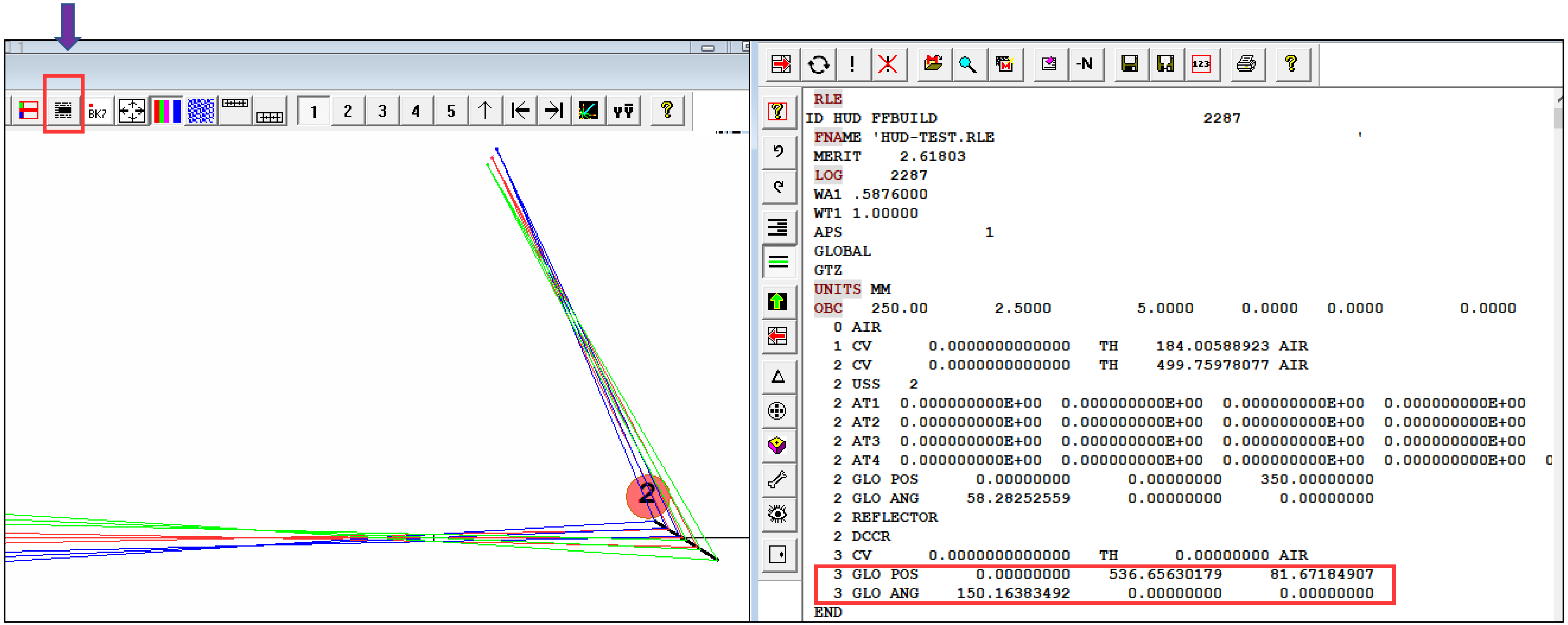


After running the optimization, the system in Config 2 is updated as shown here.

Note: for the 3rd control M 0 1 A P YC 0 0 .1 0, we use YEN = 0.1 to locate the paraxial focus. You can also use YEN = 1 to put image plane at the real marginal ray focus.
For more information of the YA, HH, YC control, please see the Appendix and refer to the User Manual: 10.3.1.2 User-specified ray aberrations

Step 4: put surface 3 at the virtual image plane by doing optimization

You can click the Lens Edit button at the SketchPad window to view the lens data of surface 3



Note: Your optimized surface 3 may have different GLOBAL positions or angles due to the stochastic nature of optimization, but should be similar.

APPENDIX

Appendix A: AANT syntax

```
AANT
M 0 1 A P YA 0 0 0 0  !control real height of axis ray to zero at surface 3
M 0 1 A P HH 0 0 0 0  !control axis ray hit surface 3 with HH = 0
M 0 1 A P YC 0 0 .1 0 !put surface 3 at the paraxial focus
END
```

Each aberration control can be broken down into 2 parts: Goal and Details

GOAL → `M 0 1` `A P YA 0 0 0 0` ← DETAILS

The 1st numeric parameter in the GOAL section is the TARGET, and the 2nd is the WEIGHT.
The 1st alphabet M means to Minimize the control item described in the DETAILS section to 0.
For more details, see User Manual 10.3 Aberration Input (AANT)

To understand the DETAILS section, we refer to User Manual: **10.3.1.2 User-specified ray aberrations.** The syntax for the user-specified ray aberration DETAILS is:

{ A / S / MUL / DIV } { <u>ICOL</u> / P } <u>name</u> <u>HBAR</u> <u>XEN</u> <u>YEN</u> <u>GBAR</u> [<u>SN</u>]

In our example, we have:

`M 0 1` `A P YA 0 0 0 0`

It means that you want to control the real ray height (YA) of the ray, for the primary color (P), with HBAR = 0, XEN =0, YEN =0, and GBAR = 0, to be zero (TARGET) at the last surface (ie, surface 3 [SN]). When the SN parameter is not specified, it is default to the last surface. The control M 0 1 A P YA 0 0 0 0 **3** is the same as the previous one.

Appendix B: HUD_TEST.rle

```
 RLE
ID HUD FFBUILD                                      2287
 FNAME 'HUD-TEST.RLE                                          '
 MERIT    0.868989
 LOG      2287
 WA1 .5876000
 WT1 1.00000
 APS                  1
 GLOBAL
 GTZ
 UNITS MM
 OBC    250.00       2.5000         5.0000     0.0000    0.0000        0.0000     5.0000
   0 AIR
   1 CV       0.0000000000000    TH     184.00588923 AIR
   2 CV       0.0000000000000    TH     -82.27414083 AIR
   2 USS    2
   2 AT1   0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00
   2 AT2   0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00
   2 AT3   0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00
   2 AT4   0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00
   2 GLO POS       0.00000000       0.00000000     350.00000000
   2 GLO ANG     58.28252559       0.00000000       0.00000000
   2 REFLECTOR
   2 DCCR
   3 RAD     116.8463696368925    TH      53.85164802 AIR
   3 CC      -0.99372157
```

Continue in next slide

Appendix B: HUD_TEST.rle, Continued

```
   3 ZERNIKE       5.00000000       0.00000000       0.00000000       1.00000000
     ZERNIKE     3 0.11895998568274E-01
     ZERNIKE     4 0.39055104597015E-01
     ZERNIKE     7 0.10749819095818E-02
     ZERNIKE     8 0.21411068249902E-04
     ZERNIKE    10 0.70557614419260E-03
     ZERNIKE    11 0.59524120022872E-06
     ZERNIKE    14 0.86665871025194E-06
     ZERNIKE    15 0.18582289377175E-07
     ZERNIKE    16 -.66641960047047E-05
     ZERNIKE    19 0.18452003094441E-06
     ZERNIKE    20 0.52976160083216E-08
     ZERNIKE    37 0.11874606082313E-01
    3 GLO POS       0.00000000   -100.00000000     400.00000000
    3 GLO ANG     159.18323033      0.00000000       0.00000000
    3 REFLECTOR
    3 DCCR
    3 ZVZ
    4 CV      0.0000000000000   TH       0.00000000 AIR
    4 GLO POS       0.00000000   -120.00000000     350.00000000
    4 GLO ANG    -158.20107429      0.00000000       0.00000000
  END
```

Appendix C: change the system in config 2 with script

In this example, we want to find out the virtual image plane after surface 2. We will first remove surface 3 and 4 in the existing system. Then run the following scripts to change the system:

```
!The following block between CHG...END is the SYNOPSYS
!change file that specifies the changes to be made to the
!original system
CHG
3 SIN    !insert surface 3 (see User Manual 3.6.1.1)
3 GLOB   !specify that surface 3 is a GLOBAL surface (see User Manual 3.8.2)
3 MXSF   !make surface 3 the last surface (ie, only keeps
        !surface 1 and 2 in the original system)(see User Manual 3.6.1.2)
END
```

Now the system in Config 2 is updated as shown here: