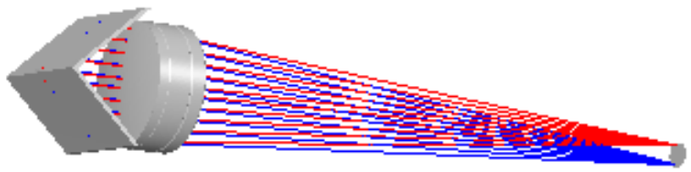
Modeling 2-glass Stitched-Optical-Windows in SYNOPSYS

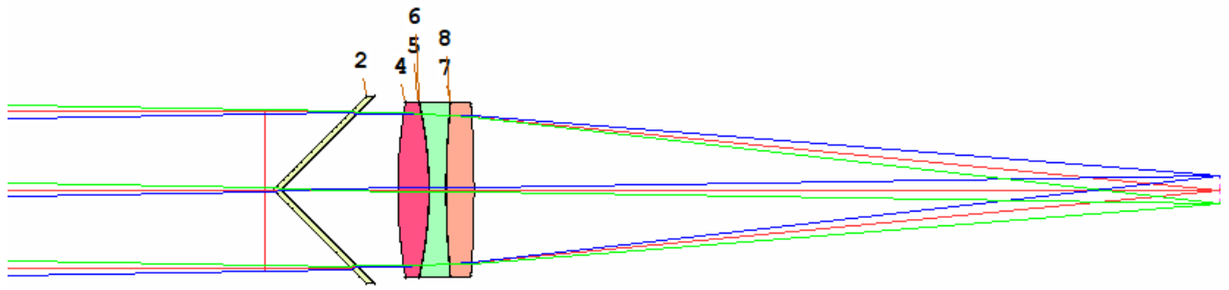
11/15/2023

This Application Note illustrates how to use the Unusual Surface Type 2 (USS 2, Aspheric Power Series with Cross-Terms) to model a 2-glass stitched optical window.

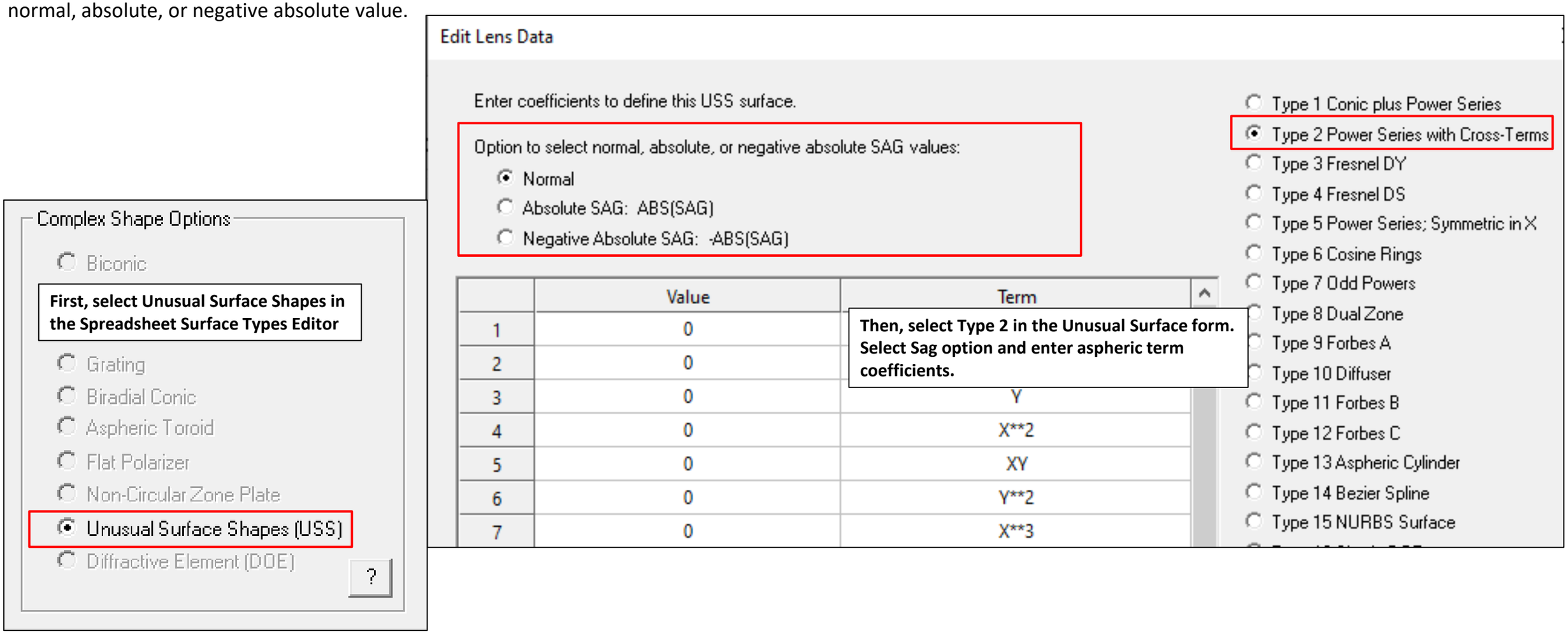
High-speed aircrafts which use splicing optical windows can reduce the drag and radar reflectivity. But they will cause the incident wave at the front of the various window glass splited, and may cause the degradation of the optical system modulation transfer function (MTF) and the decline and splitting of the point spread function (PSF). In severe cases it will affect the resolution of the system. Therefore, analysis of the effect of stitched windows on the optical systems has an important reference value to the optical system design using stitched windows.

Ref: Analysis Method of the Effect of Stitched Windows on the Optical Systems, Z. Xing et. al., Acta Optica Sinica, Vol. 35, No. 10, 2015





Starting from version V2.102 of the User-Interface Plus edition released in November 2023, a feature is available to the USS 2 that provides users the option to calculate the surface sag in its normal, absolute, or negative absolute value.



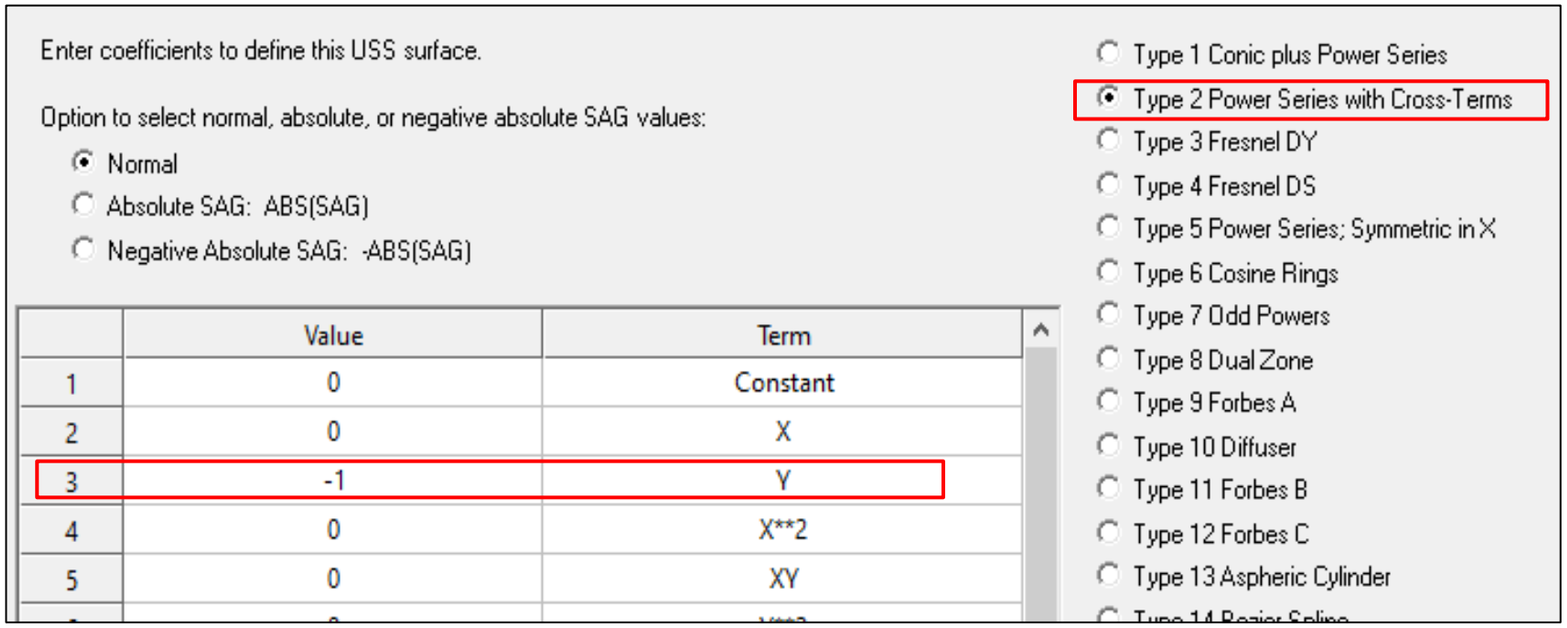
In the script, the sag option selection is controlled via the 16 element in the AT input block (ie, the 4th element in the AT4 line).
Enter 0 for normal sag; 1 for absolute sag, and -1 for negative absolute sag.

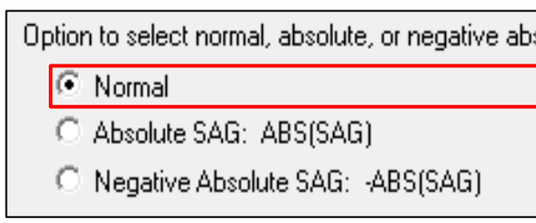
```
  1 USS   2
  1 AT1  0.000000000E+00  0.000000000E+00 -1.000000000E+00  0.000000000E+00
  1 AT2  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00
  1 AT3  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00
  1 AT4  0.000000000E+00  0.000000000E+00  0.000000000E+00  1.000000000E+00  0.000000000E+00
```

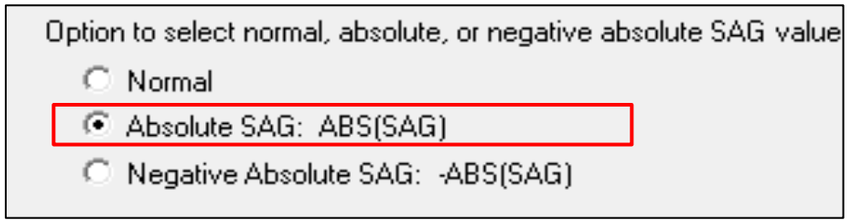
For example, if we set the coefficient for the Y term to -1, with the Normal option, we get the normal slanted surface shown on the left.

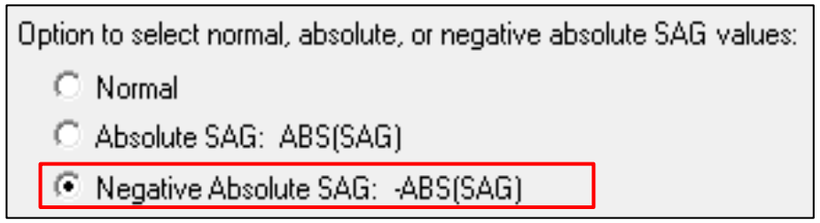
If we select the Absolute Sag, we get the V-shape surface as shown in the middle. The negative value in the normal sag is replaced by its absolute value.

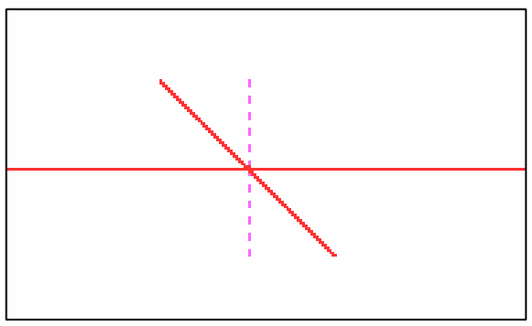
Similarly, if we select the Negative Absolute SAG option, the positive sag is replaced by its negative value as shown on the right.

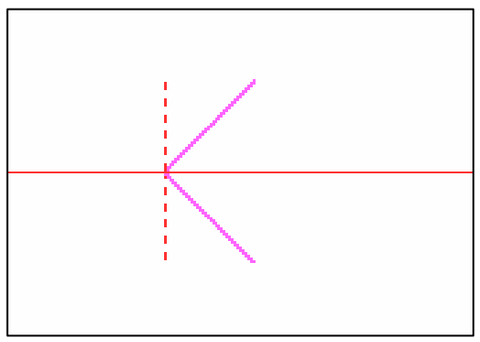


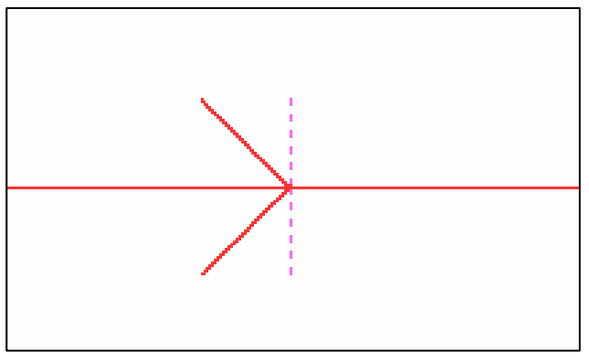




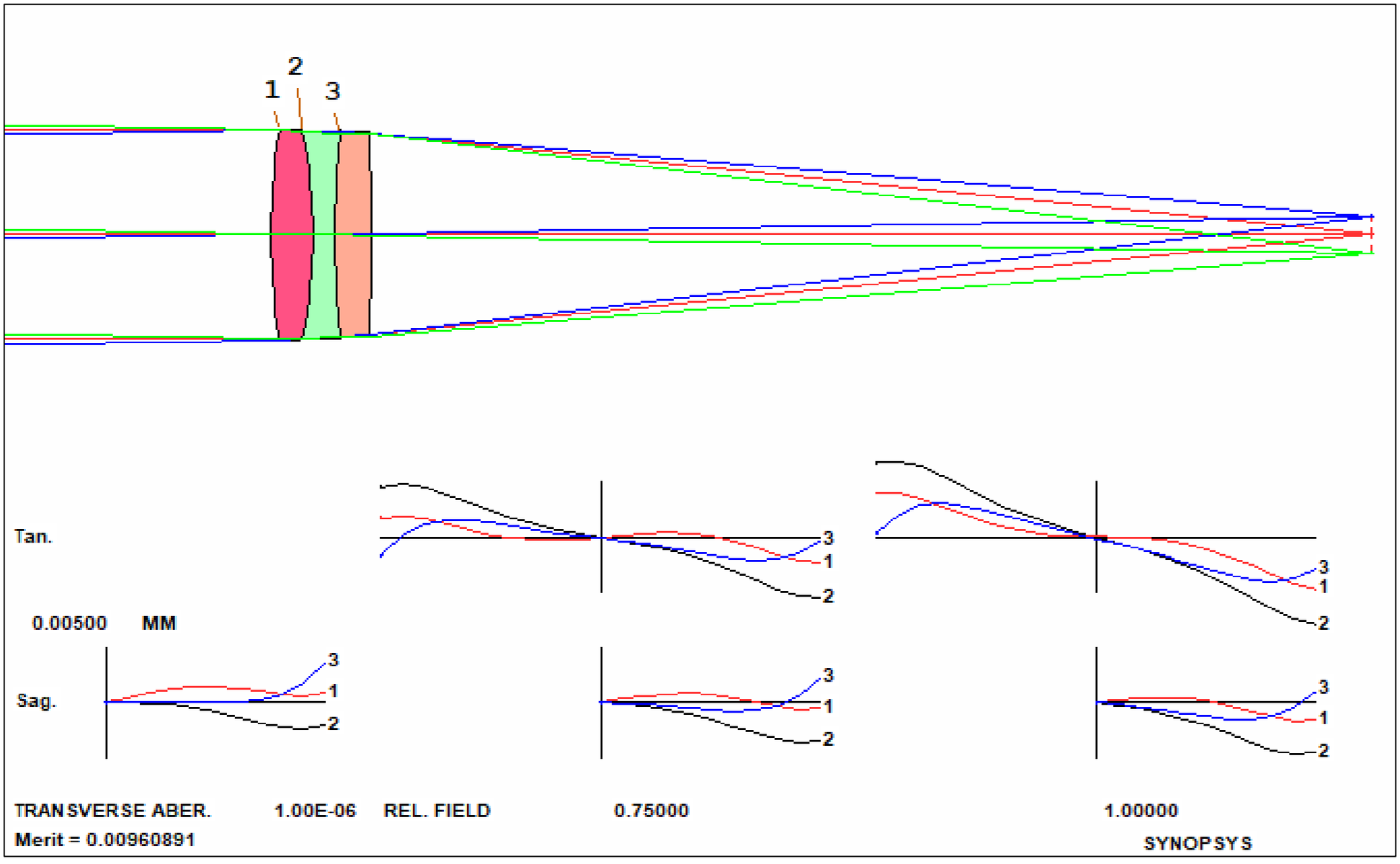




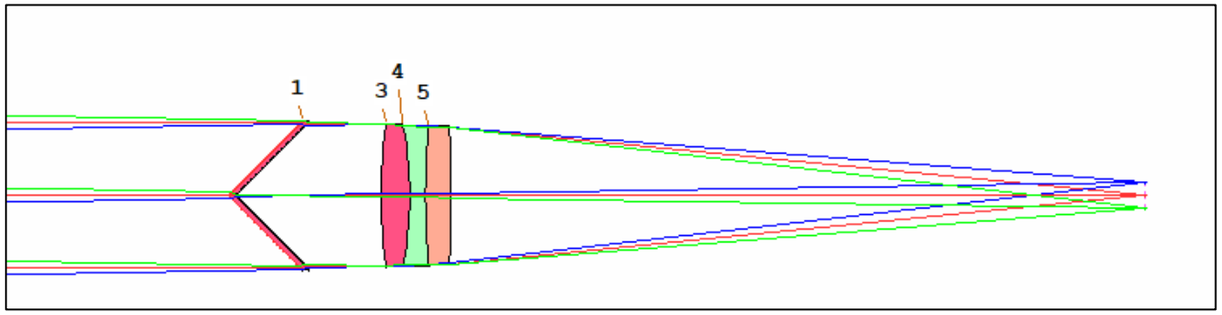




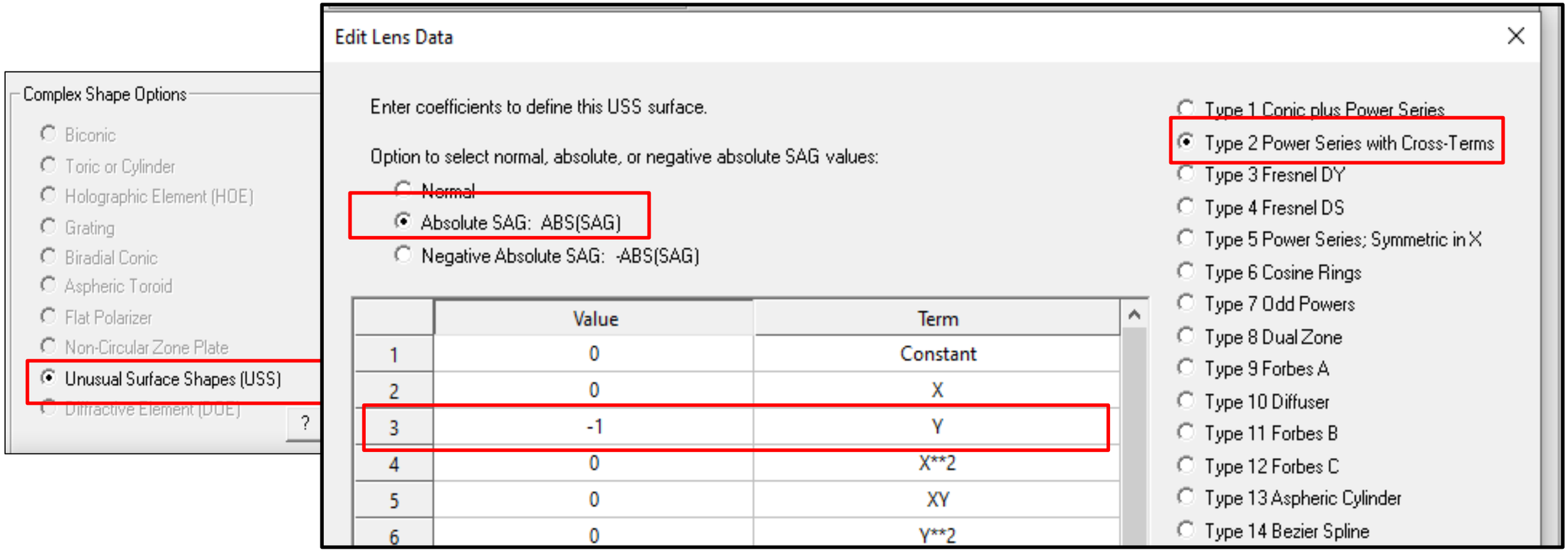
Now, let’s look at an example with a cemented triplet (cemented_triplet.rle):



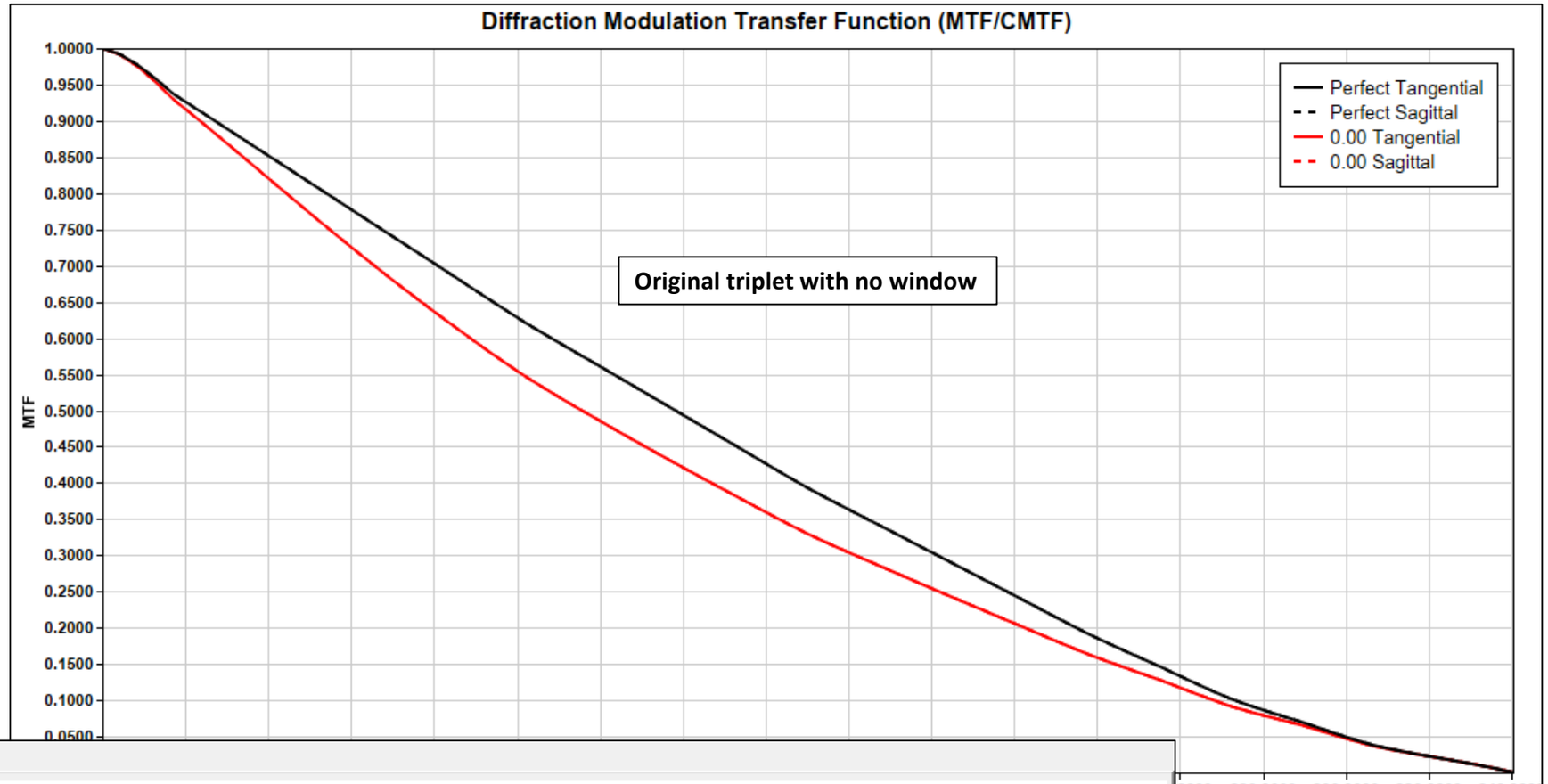
This is the system with the 2-glass stitched window inserted before the triplet. The front surface of the stitched window (surface 1) is modeled using the USS 2, with the Absolute Sag Value option selected. The back surface (surface 2) picks-up the definition of the front surface. We arbitrary assigned the glass as Shott, N-LAK2, with Nd = 1.64049, same as the first element in the triplet.

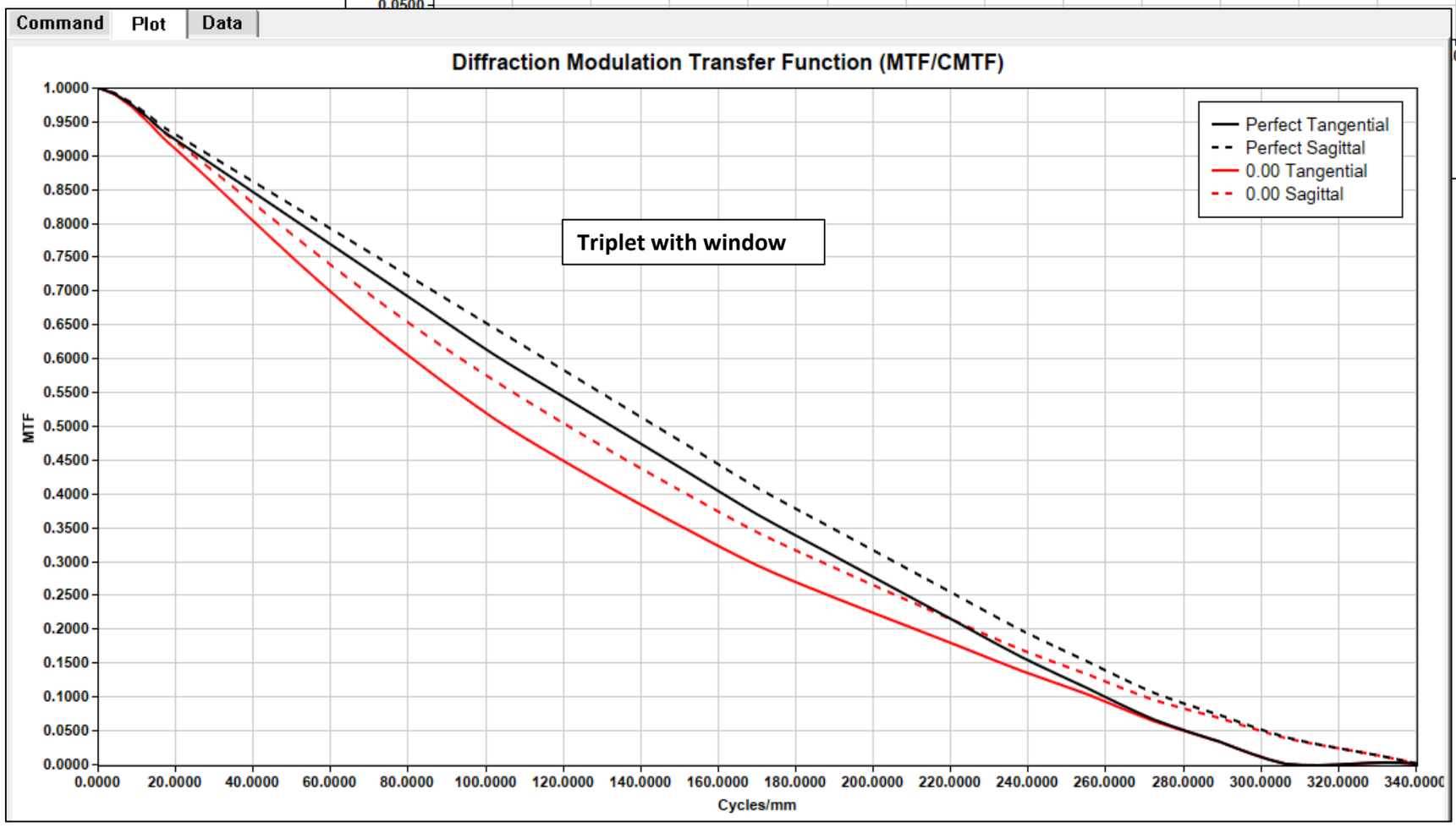


	Surface Type	Surface ID	Radius	Thickness	Material	Index	Coating
0	Infinite Object (angular)		infinite	infinite	Air	1	
1	USS Type 2		infinite	1	N-LAK21	1.64049	None
2	USS Type 2		infinite	20	Air	1	None
3	Spherical		64.5359864	3.96000004	N-LAK21	1.64049	None

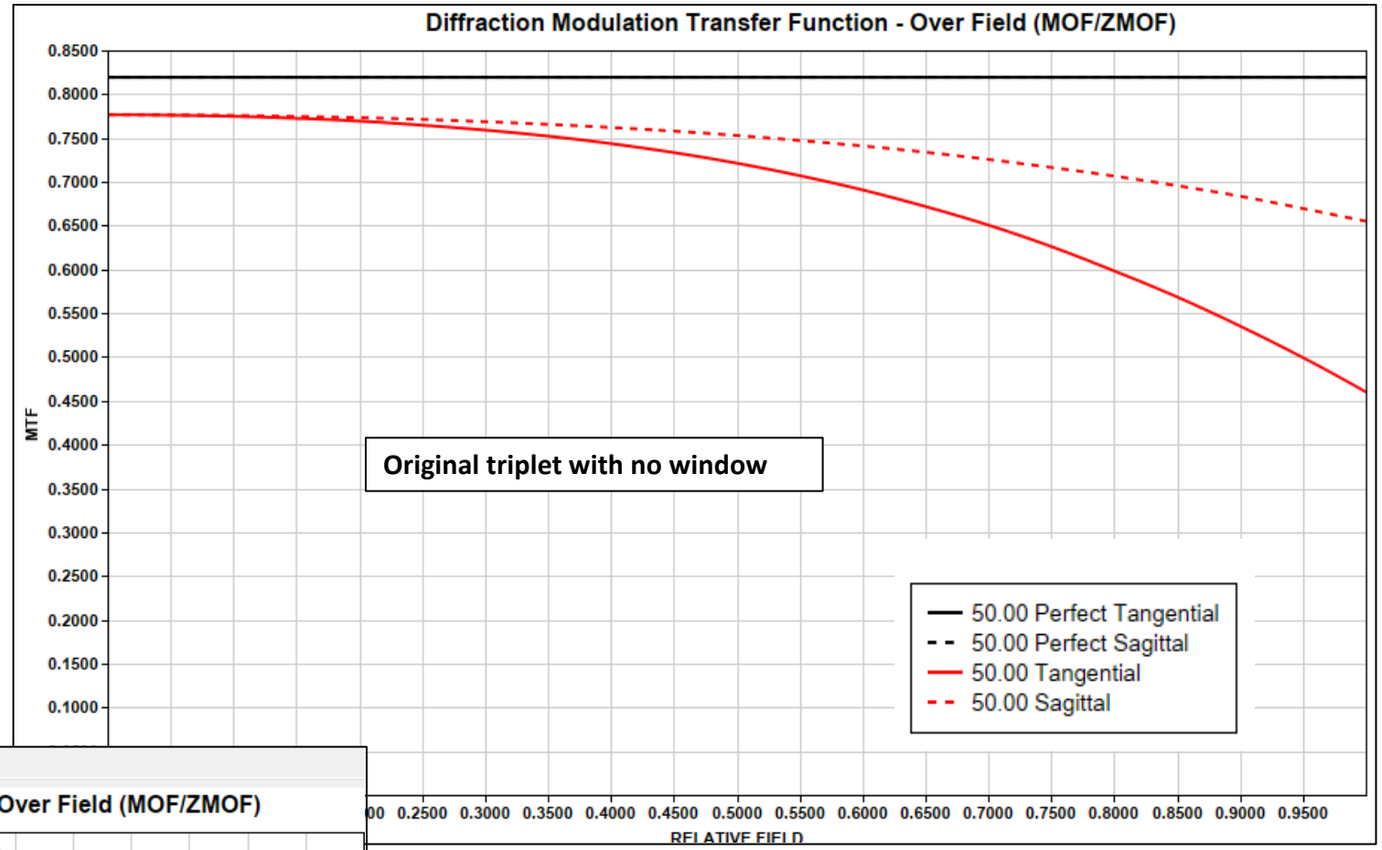


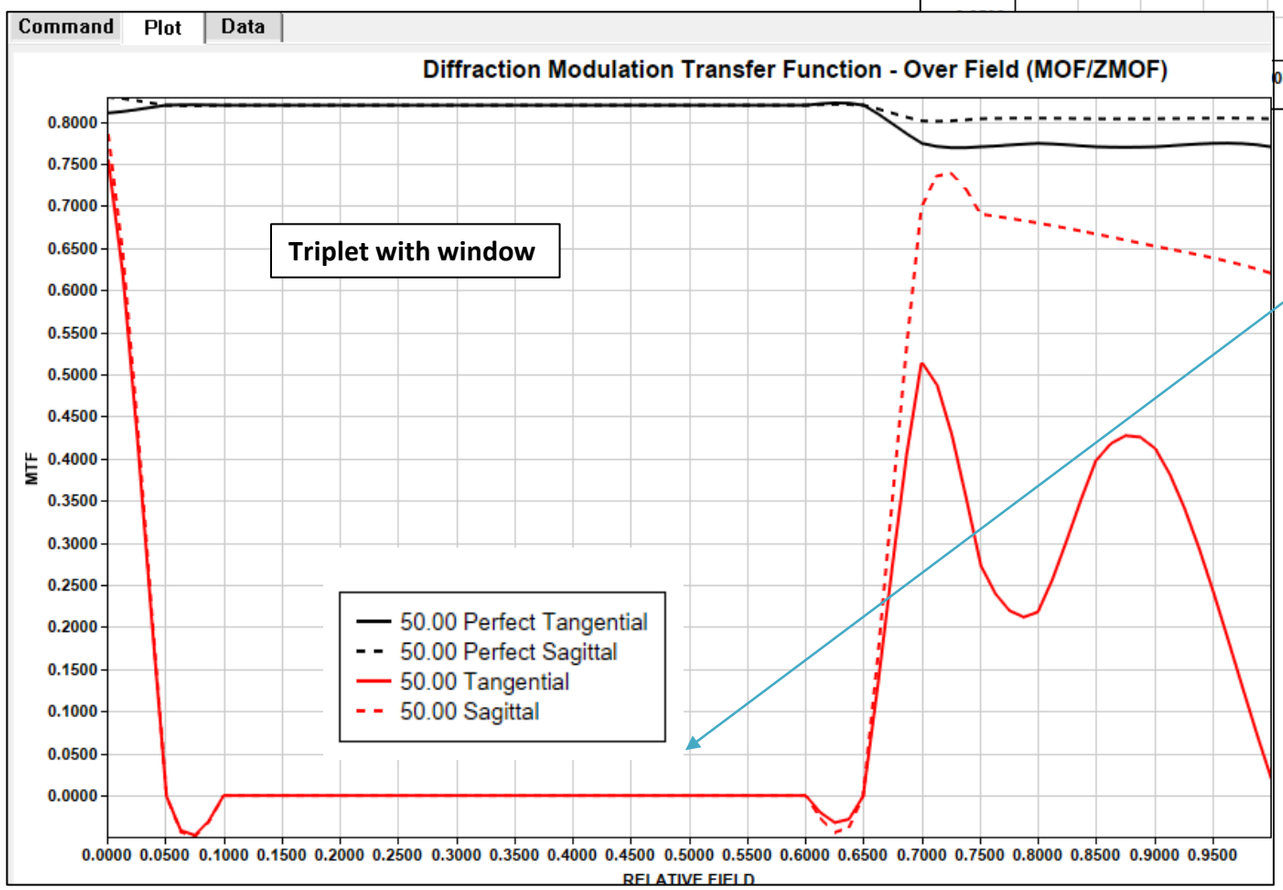
On-axis MTF



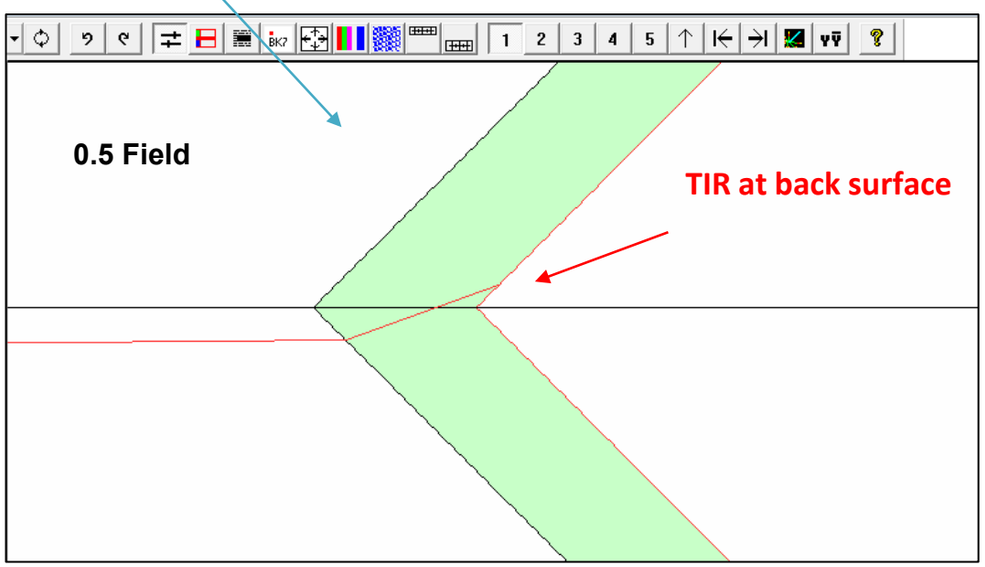


MTF over field, spatial frequency = 50 cycles/mm





MTF is zero in this range because chief rays encounter TIR at the back surface of the stitched window.



As a demonstration, we arbitrary apply a Y-decenter of 1mm to the stitched window to avoid TIR, . The MTF over-field curve (for spatial frequency 50 cycles/mm) is non-zero over the whole field as shown below at the upper left corner. The on-axis MTF is shown at the lower right corner.