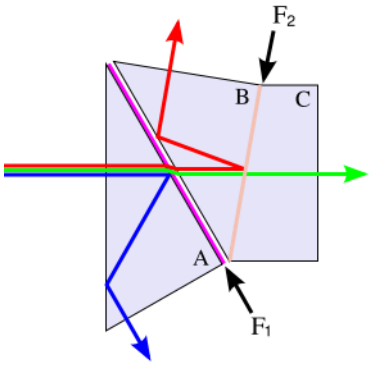
Q: I have a lens which I'd like to use with a Phillips-type color splitting prism (shown below). The physical thickness of the prism is about 10 mm. If I test the lens without the prism will the results be valid?



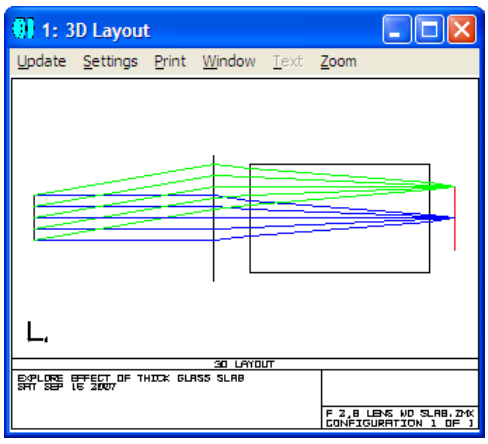
A: The answer depends on both the working F-number and the chief ray angle:

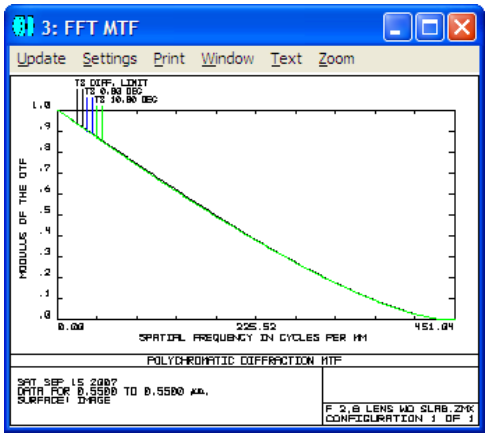
- If the F-number is higher than F4, and if the chief ray angle is close to 90 degrees, you can probably ignore the prism.

- However, if the lens is faster than F4, or if the lens is not telecentric, then the prism will introduce significant wavefront aberration. Testing without the prism will not correctly represent the intended use. Some examples are given below.

Example 1:

A lens operating at F4, with chief ray angle close to 90 degrees:





The left picture shows a Zemax layout used to model the system. The lens is modeled as a perfect diffraction limited lens, operating at F4. (The "lens" is the thin vertical line near the center of the picture.)

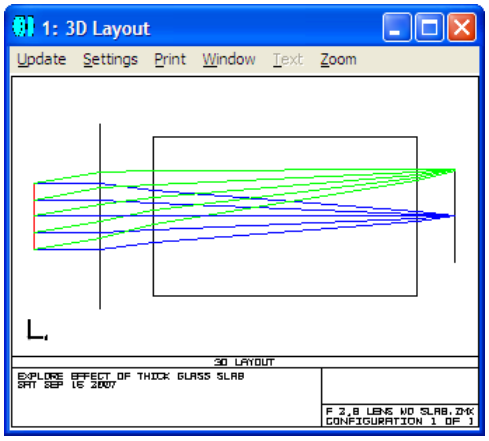
The prism is modeled as a 10 mm thick slab of BK7 (the slab is the rectangle between the lens and the image plane at far right). The lens is modeled as having a chief ray angle close to 90 degrees. (In other words the lens is nearly telecentric.)

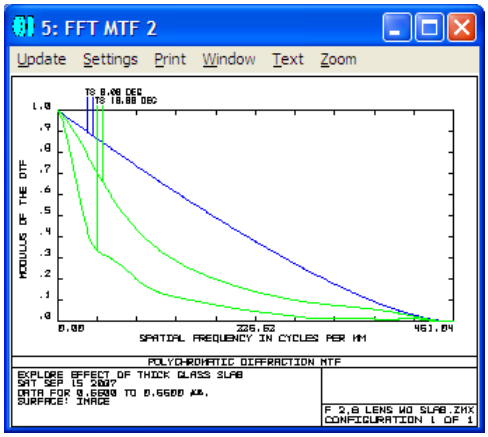
The right picture shows the MTF of this system. The predicted performance is excellent. The actual MTF curves are almost indistinguishable from the theoretical diffraction limit, which is plotted as a black line.

Conclusion:
In this example the glass slab does not have noticeable effect on the system MTF.

Example 2:

Lens still operating at F4, but the chief ray angle is NOT close to 90 degrees





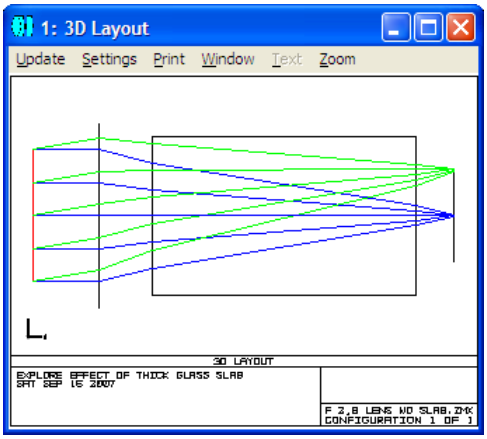
The stop location has been changed, to represent a lens which is not especially telecentric. In other words, the ray bundle of off-axis rays does not hit the image plane at an angle of 90 degrees.

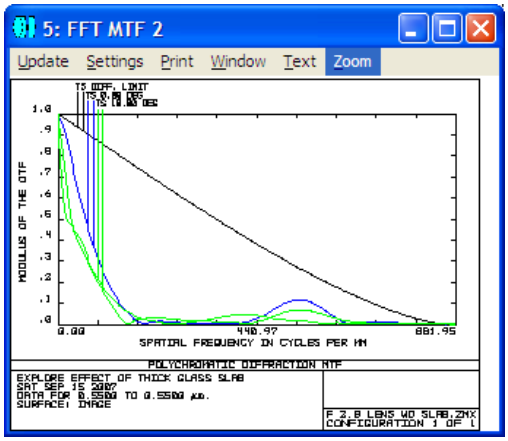
The MTF of the on-axis image is still excellent. However, the off-axis MTF has dropped dramatically.

Conclusion:
Even when operating at high F number, you have to worry about the chief ray angle. Or to put it more simply, you would be wise to test both with and without the prism block!

Example 3:

A lens operating at F2:





Now the working F number is F2. Both on- and off-axis MTF have fallen very dramatically.
Remember that the lens in this simulation is absolutely perfect. The poor MTF comes solely from adding a 10 mm thick slab of BK7.

Conclusion:
At low F numbers you absolutely must consider the effect of the prism.

Comments:

(1) The examples are not meant to suggest a Phillips-prism must always cause poor images! However, to get good performance you must use a lens that was designed to work in cooperation with the prism. Such a lens design incorporates *intentional* wavefront errors which will (hopefully) exactly cancel out the wavefront error introduced by the prism.

(2) The examples are rather simple, and are not meant to give an absolute answer. Their purpose is to alert you to the issue.