Notes on the Design of the PISCO ADC

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Abstract.

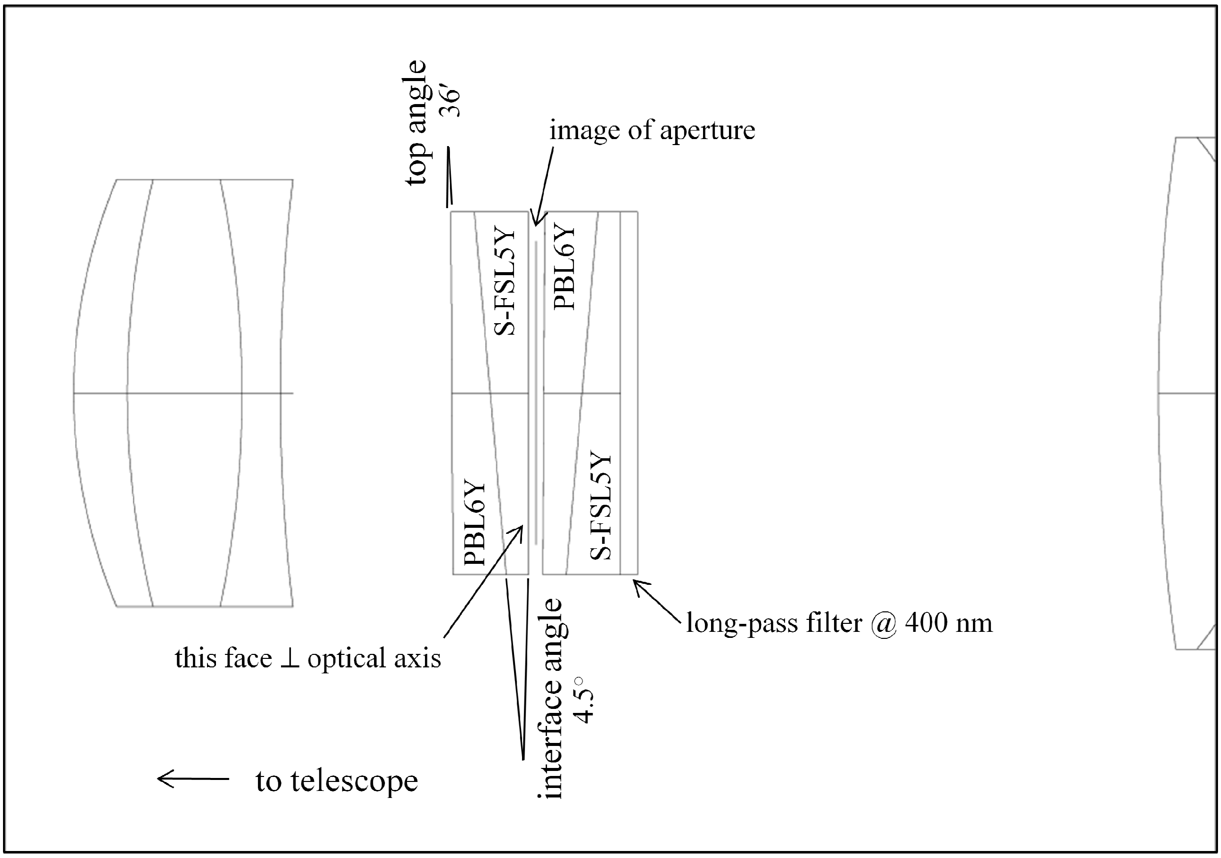
The Atmospheric Dispersion Compensator for the Parallel Imager for Southern Cosmology Observations is described. This instrument will be used on the Magellan telescopes at Las Campanas. The ADC is a standard design, consisting of two counter-rotating prisms made of PBL6Y and S-FSL5Y glass. All optical surfaces are flat. With the ADC in use, ZEMAX modeling indicates that point spread function is not significantly degraded for zenith angles as large as 45°, and the operation is satisfactory for zenith angles up to 70°.

1. Introduction

The Parallel Imager for Southern Cosmology Observations (PISCO) incorporates an Atmospheric Dispersion Compensator (ADC). This will allow PISCO to be used on the Clay Telescope at Magellan, which lacks a built-in ADC. This memo will briefly describe an ADC design for PISCO, some of the design considerations, and the modeled performance. It is in no way a description of the ADC design problem. ADC design is treated in a memo by A. Szentgyorgyi, "Notes on the Design of an ADC for the WHT".

2. Description of design

The PISCO ADC consists of two counter-rotating cylindrically-shaped prisms made of PBL6Y and S-FSL5Y glass. The two prisms are identical, except that one has a long-pass filter cemented to one face. The ADC is shown in the figure below.



All glass surfaces and interfaces are flat, but the top and bottom planes of the prisms are not parallel ─ they deviate by 36 minutes of arc, so that the thickness of the higher-index PBL6Y glass is a little less than that of the S-FSL5Y. This "top angle" is critical for reducing aberrations. The bottom surface of the S-FSL5Y glass is perpendicular to the optical axis, and the prisms rotate around the optical axis. The prisms are 102 mm in diameter, and 20 mm thick. The thickness is divided equally between the two constituent glass pieces, although the thickness dimensions have a relatively large error tolerance (± 0.3 mm). The two prisms are separated by 4 mm, and an image of the aperture is located between them.

3. Choice of angles

The amount of dispersion correction that can be achieved depends primarily on the choice of the interface angle between the two glasses in each prism. For zenith angles, z_a, that are not too large, the angular displacement as a result of refraction is:

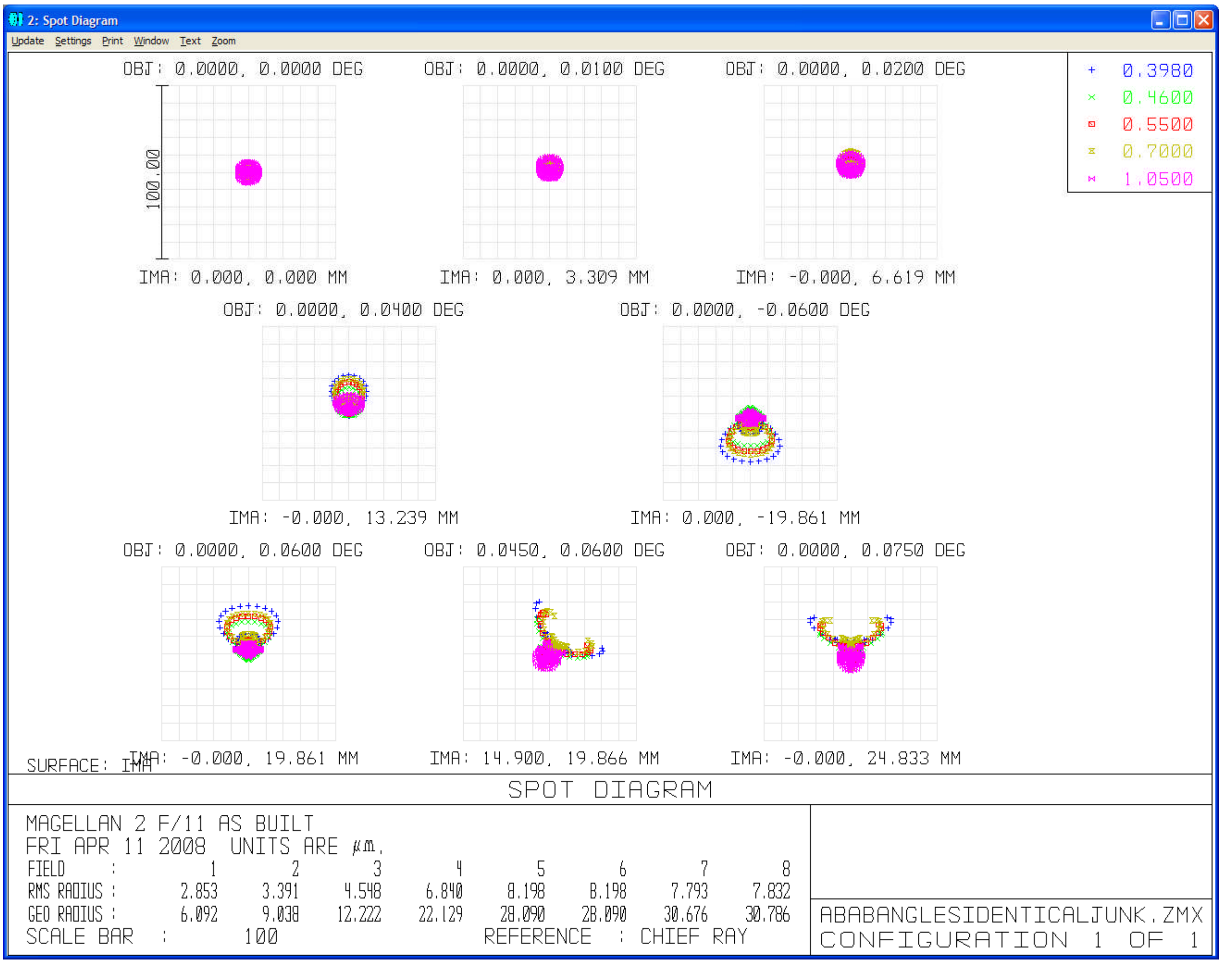
$$R(\lambda) = R_0(\lambda)\ [p\ /\ 760\text{mm Hg}]\ \tan z_a$$

where p is atmospheric pressure at the telescope, and $R_0(\lambda)$ is given in *Astrophysical Quantities,* by C. W. Allen:

λ in nm	$R_0(\lambda)$ in arcsec	$R_0(\lambda)$ [565/760]	$R_0(\lambda)$ [565/760] tan 65°	$R_0(\lambda)$ [565/760] tan 70°
0.40	61.48	45.70	98.02	125.57
0.70	59.93	44.55	95.54	122.41
1.00	59.58	44.29	94.99	121.69

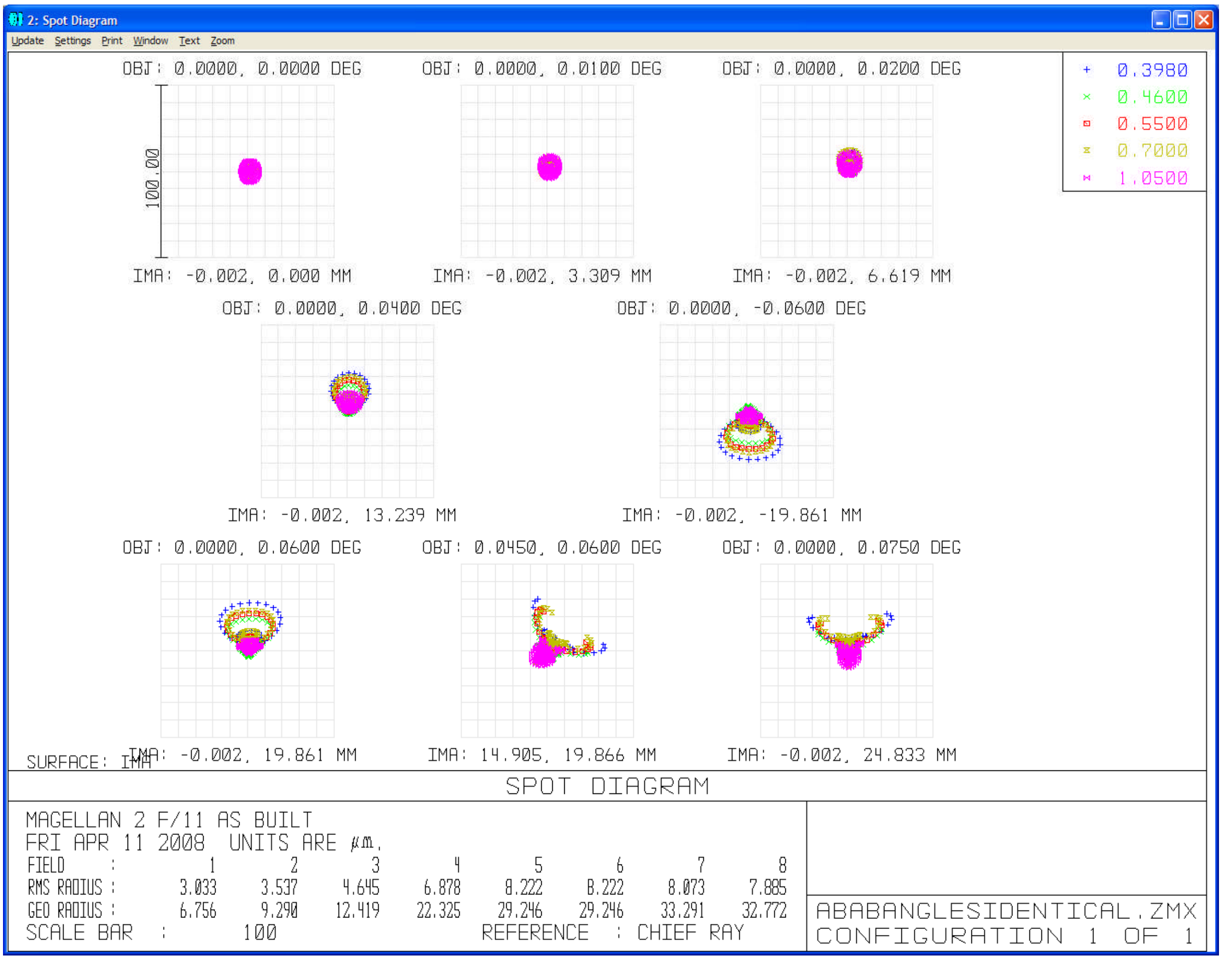
Here we adopt a typical atmospheric pressure for Magellan's altitude of 2450 m, of 565 mm Hg. We see that for large zenith angles, near 70°, that the amount of differential dispersion is less than 4″. The plate scale of PISCO is 10.8″ per mm, so this corresponds to a displacement of about 350μm at the CCD.

If the interface and top angles in the PISCO ADC are set to zero, effectively eliminating the ADC from the system, the spot diagram looks like this:

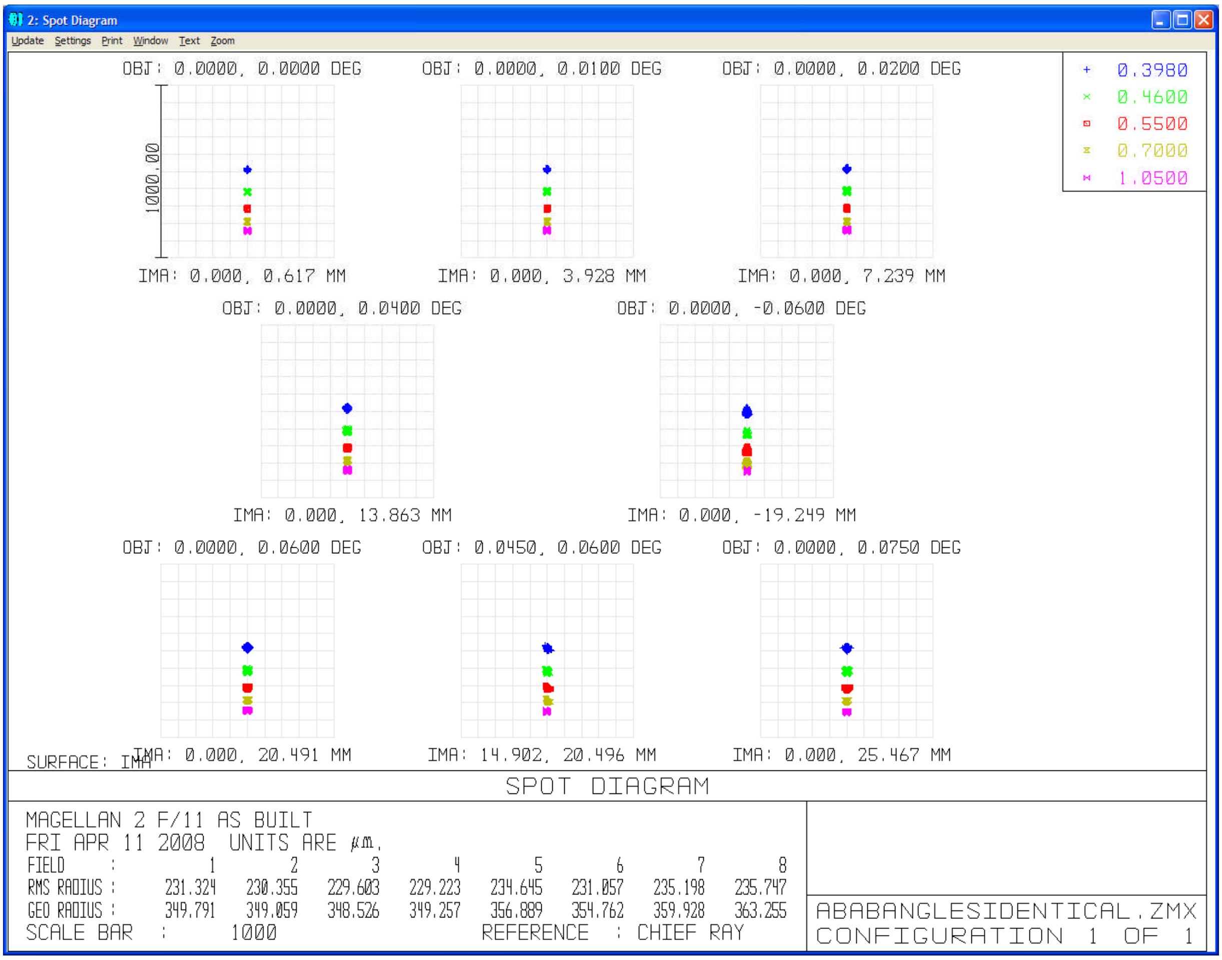


A distance of 10µm on the CCD corresponds to 0.1 arcseconds. This PISCO model is called `Hoya10April08.ZMX`

Now, if we set the interface angle to 4.5°, the top angle to 0.6°, and the counter-rotation angle to zero (to produce zero dispersion) the spot diagram remains very similar:

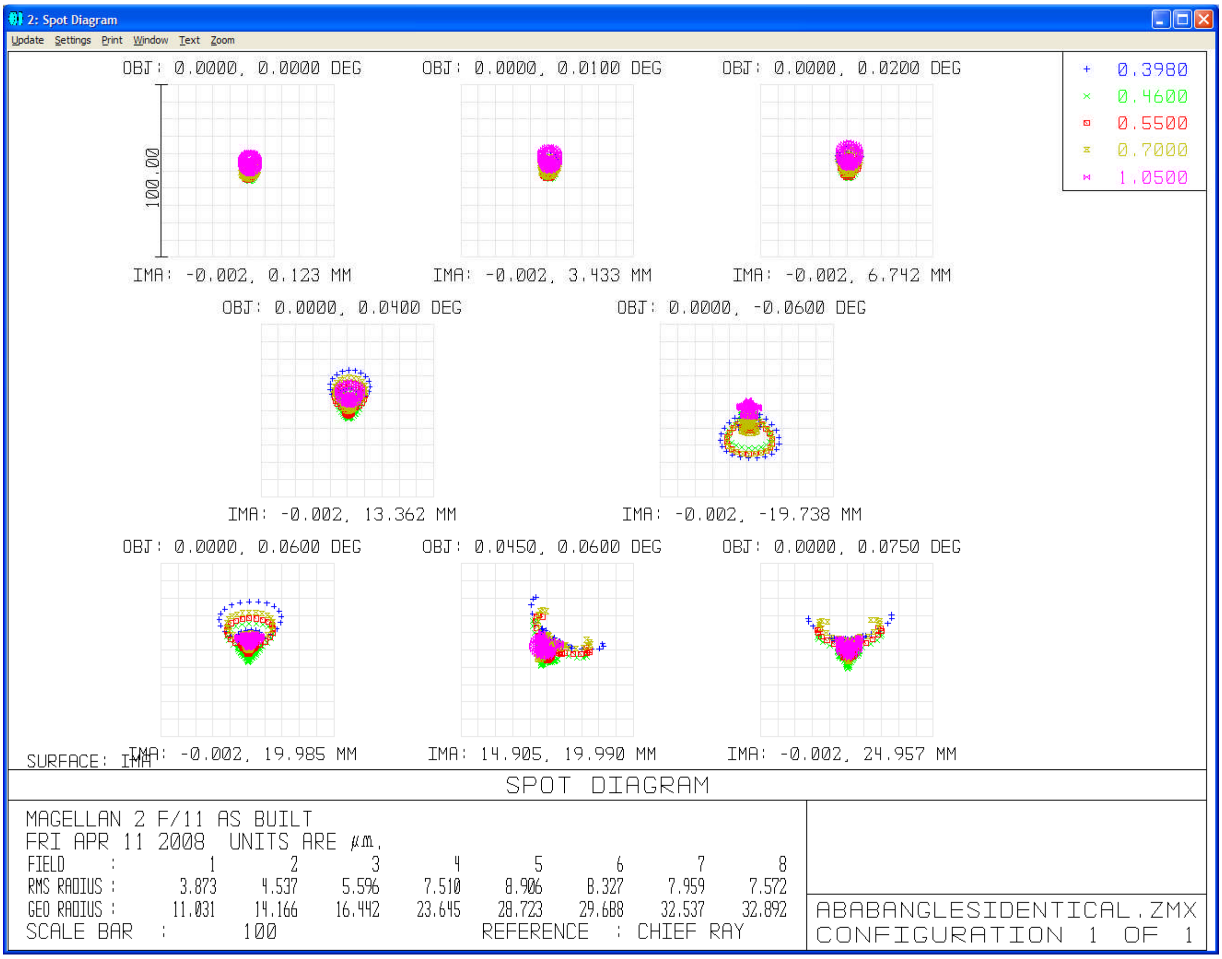


Introduce maximum dispersion, setting the counter-rotation angle to 90°, each prism turning in opposite directions, for a total angle of 180°:

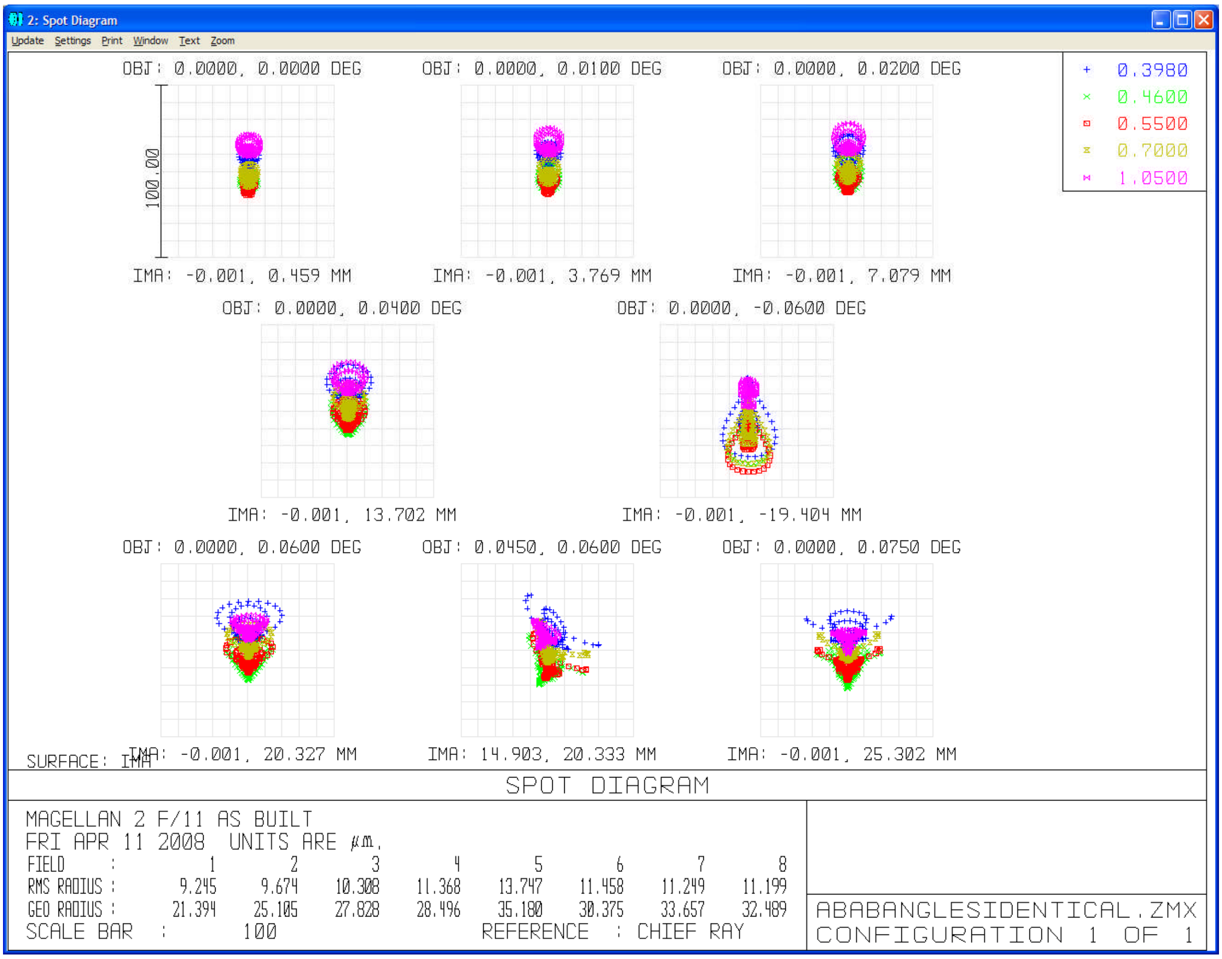


and we see we can achieved a dispersion of about 350µm across the wavelengths in the PISCO bandpass.

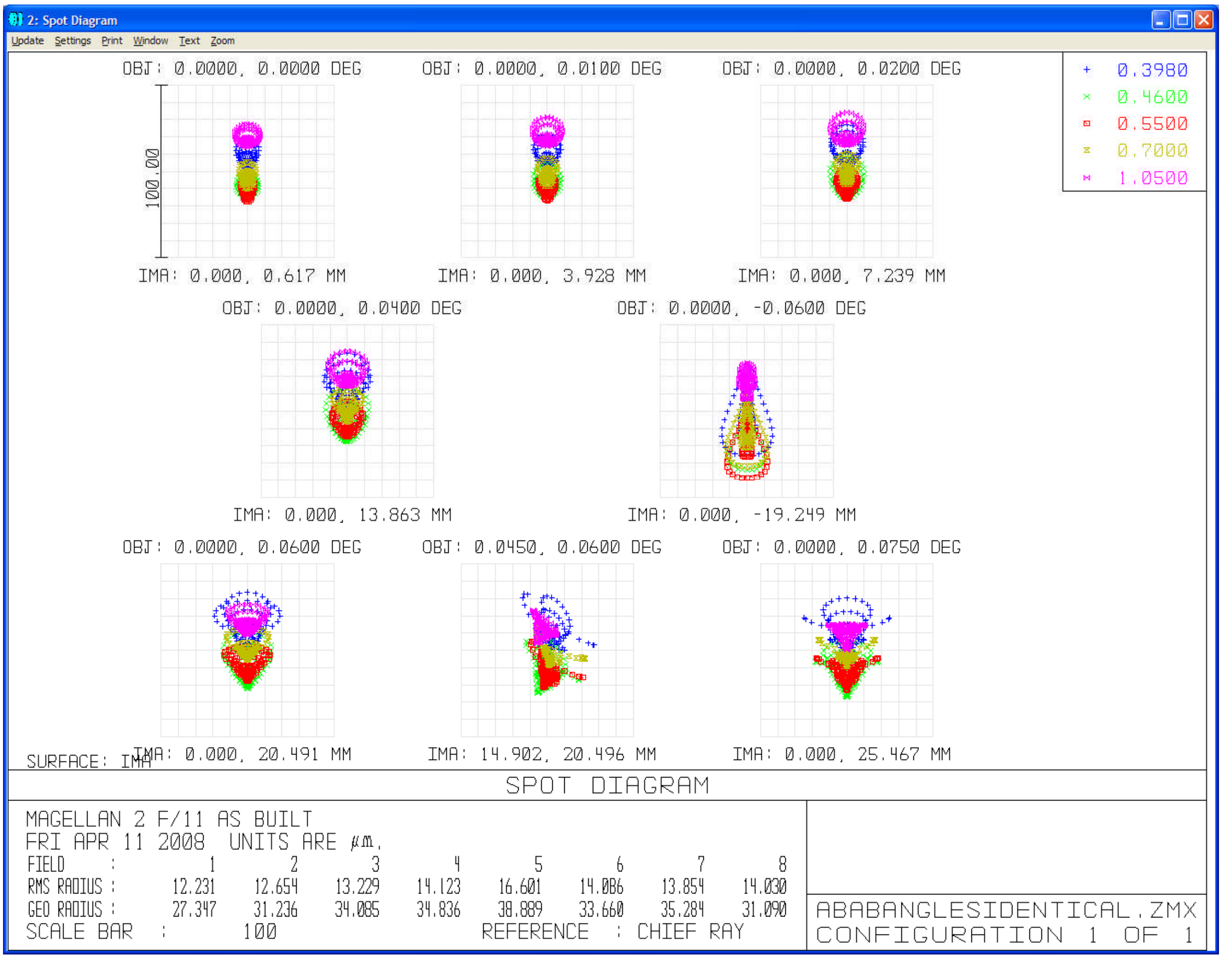
A model of atmospheric dispersion can be introduced in ZEMAX using the "ATMOSPHERIC" surface type in front of the Magellan aperture. Introduce atmospheric dispersion for a zenith angle of 30°, and compensate by a prism counter-rotation angle of 11.5°:



Now, a zenith angle of 65°, and a counter-rotation angle of 48°:



Now, a zenith angle of 71°, and a counter-rotation angle of 90°:



This is the maximum amount of dispersion correction.