Viaspec Guiding and Wavefront Sensing

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1 Mechanical Layout

Guiding and wavefront sensing is an area where Viaspec must differ significantly from the SDSS-V design. Firstly, SDSS-V does not provide wavefront sensing at either the Sloan or DuPont 2.5m telescope. Secondly, the fields of view of both telescopes are quite large, so sacrificing significant area for large, fixed guiders is a tolerable tradeoff. For Viaspec we propose to move much smaller guiders and wavefront sensors along a circular track just outside the nominal 1° diameter science field of view, sacrificing none of the prime science field of view. All four cameras are identical except the WFS cameras are operated out of focus. The only mechanical motion is movement around the circular track.

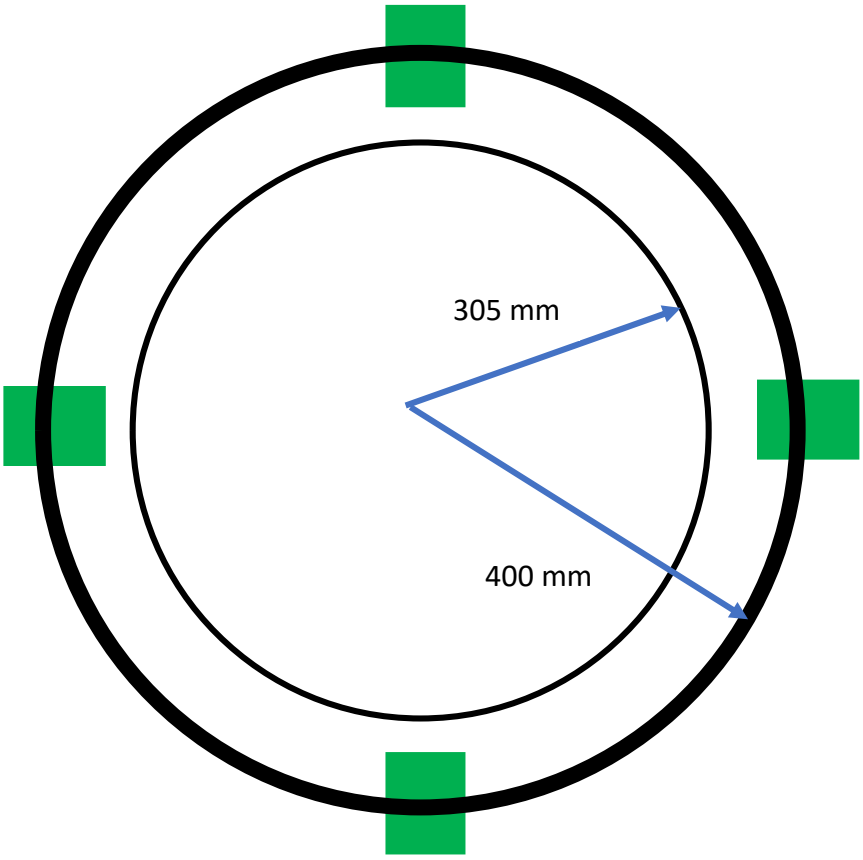

Figure 1. The science field of view is 60 arcminutes or 610 mm in diameter. An 800 mm diameter circular THK track carries four guider/WFS cameras along ±40° arcs. The WFS cameras are identical to the guider cameras except that they are operated out of focus for curvature sensing.

2 Optics

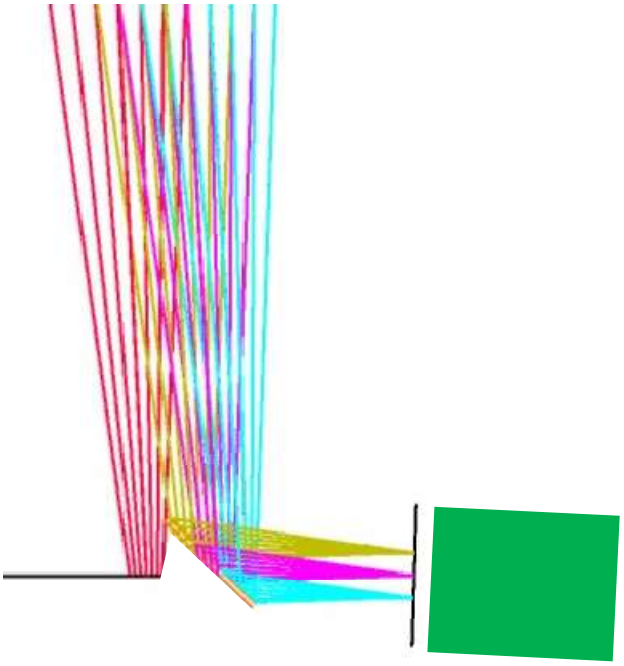

Figure 2. A pickoff mirror diverts light for the guider or WFS to the camera further off-axis. The red beam is at the edge of the science focal surface.

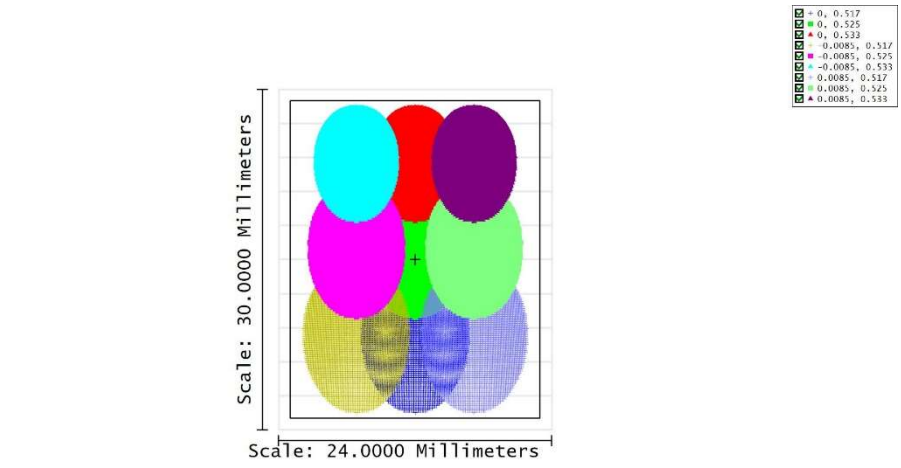

Figure 3. The footprint on the fold mirror.

The field of view of the fold mirror is 10 x 10mm, and the pickoff mirror center is at a radius of 316.8 mm. An 80 degree arc is 442.3 mm long, giving a total field of view of ~4423 sq. mm, or 42.5 sq. arcmin for each camera. The average scale across the field is about 0.170 mm/arcsec.

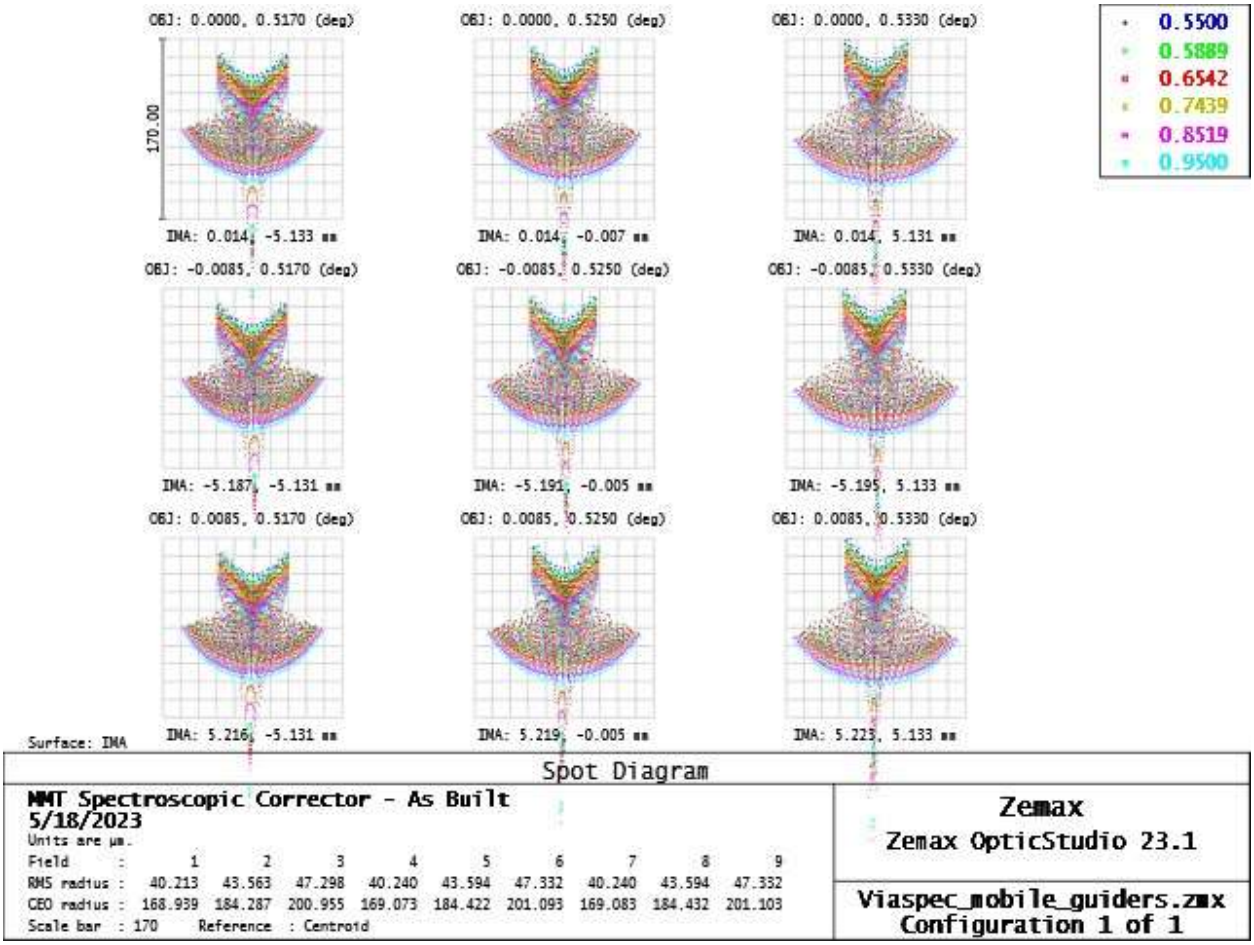

Figure 4. Images across the guider field of view, typically 90 µm RMS diameter or 0.53″ RMS diameter.

3 Curvature Wavefront Sensing S/N

LSST decided to use 1.5mm defocus. Which means LSST would have 16" * 1.5 = 24" dia images. For a 6.5m telescope to get the equivalent sampling, we would need a defocus diameter of 18.5". Assuming we go with 0.2" pixels, then that is 93 pixels across the image or 6250 pixels, including a 1.8m diameter obscuration.

For a 30 second exposure, and 15th mag star, r+i band filter, using Megacam exposure time calculator:

Sky is 16+21 = 37e-/sec * $(0.2/0.16)^2$ = 58 e-/sec/pix

Dark current can be made negligible for a sufficiently cooled camera.

Mag 15 star gives 193000 + 109000 = 302000 e-/sec, or 1450 e-/pix in 30 sec. Dark sky gives 1740 e-/pix in 30 sec. Signal to noise is 26.

For 17th mag, star gives 230 e-/sec/pix, and S/N per pixel = 5. Given that LSST has settled on a minimum S/N of 10, this suggests a magnitude limit of ~16.

4 Star Counts

SELECT count(*) FROM gaia3.gaiadr3 WHERE (b < -60 AND phot_g_mean_mag BETWEEN [Gmag] and [Gmag+1] AND ruwe < 1.4);

GmagBin	NSqDeg	Ntot_Glat_lt_m60
10.5	5.292	14622
11.5	10.051	27770
12.5	22.443	62011
13.5	41.693	115198
14.5	73.981	204410
15.5	122.339	338022
16.5	189.644	523985
17.5	280.701	775577
18.5	410.201	1133385
19.5	611.348	1689155
20.5	738.809	2041329

To GAIA G=16, we get 275.8 stars per sq. deg., or 0.0766 stars per sq. arcmin., or 3.26 stars per 80° long track. Typically G~r so adding light in the r and i bands this calculation should be close or slightly conservative.