HSP-Ø11

Effect of Centering and Jitter Errors in HSP photometry
R. White, 1990 August 1

This report describes how errors from centering targets in HSP apertures affect the accuracy of HSP photometry. This preliminary version of the report applies only to the VIS, UV1, and UV2 detectors; a final version which also includes the POL detector will be ready soon.

These results are based on PSFs calculated using Chris Burrows' TIM software. The PSFs include everything which should affect the images at the HSP focal plane apertures, including:

(1) obscuration by the ST secondary, spiders, and support pads
(2) all diffraction effects
(3) astigmatism at the HSP focal plane positions
(4) microroughness of the primary mirror surface (uses a fractal model of the roughness with parameters chosen to match the measurements of the mirror)

PSFs were calculated at 5 wavelengths ranging from 1500 A to 7500 A and at 3 focal plane positions:

(1) F1 = -0.95 waves at 550 nm, nominal best focus
(2) F2 = -1.4 waves, largest UV encircled energy at 0.1 arcsec
(3) F3 = 0.0, diffraction focus

The PSFs were integrated over a 1 arcsecond diameter aperture with centering errors ranging from -0.1 to 0.1 arcseconds in x and y. The detailed results are given in the table below. The throughput is calculated for the target centered in the aperture; it decreases in the UV mainly because of mirror roughness, which scatters an increasing amount of light to large angles for shorter wavelengths. The "centering error" is the maximum photometric error (%) which results from miscentering of 0.07-0.08" (typical errors for onboard HSP target acquisition.) The "fine jitter error" is the maximum photometric error (%) which results from excursions of 0.007" (fine lock jitter) and the "coarse jitter error" is for 0.015" motions (coarse track jitter).

Briefly summarized, the throughput is best for the diffraction focus (as found by Dan Schroeder) but the diffraction focus is by far most sensitive to centering and jitter. I believe that this is probably due to the diffraction focus having a lot of energy in the PSF just inside 1 arcsec diameter, so that small pointing errors lead to a lot of light spilling out of the aperture.

The photometric errors are smallest in the UV because the diffraction effects are smallest there and microroughness scatters light to considerably larger radii than 0.5". This argues that our best photometry, both short and long term, will be done in the UV. In the UV the jitter errors should be less than 0.01%; if we can use the FGS output to take out some part of the jitter-induced variations, I think we may reasonably hope to get short-term photometry accurate to 1 part in 10**5 -- this is considerably better than I indicated at the IDT meeting in Madison. The errors in the visible are a factor of 10 bigger than in the UV.

I think it is clear from the results given below that of these 3 foci, focus 1 is clearly the best for HSP. The throughput is reduced by about 17-20% compared to the diffraction focus (F3), but the centering and jitter errors are smaller by a factor of 3-10. Focus 2 has comparable photometric errors to F1 but a reduced throughput.

	Throughput			Centering Errors		
Wavelength	F1	F2	F3	F1	F2	F3
1500 A	0.343	0.282	0.413	0.4%	0.4%	4.5%
2250 A	0.412	0.333	0.506	0.5%	0.5%	4.0%
3400 A	0.454	0.367	0.564	0.8%	1.0%	4.2%
5000 A	0.476	0.384	0.587	1.2%	1.2%	3.0%
7500 A	0.482	0.382	0.602	1.5%	0.8%	3.7%

	Fine Jitter Errors			Coarse Jitter Errors		
Wavelength	F1	F2	F3	F1	F2	F3
1500 A	0.008%	0.008%	0.07%	0.025%	0.010%	0.16 %
2250 A	0.015%	0.010%	0.09%	0.05 %	0.024%	0.22 %
3400 A	0.05 %	0.10 %	0.20%	0.12 %	0.20 %	0.45 %
5000 A	0.04 %	0.04 %	0.20%	0.16 %	0.15 %	0.65 %
7500 A	0.05 %	0.02 %	0.12%	0.18 %	0.09 %	0.45 %