SAND2006-5090C

Final Optical Design for the NESSI Survey Telescope

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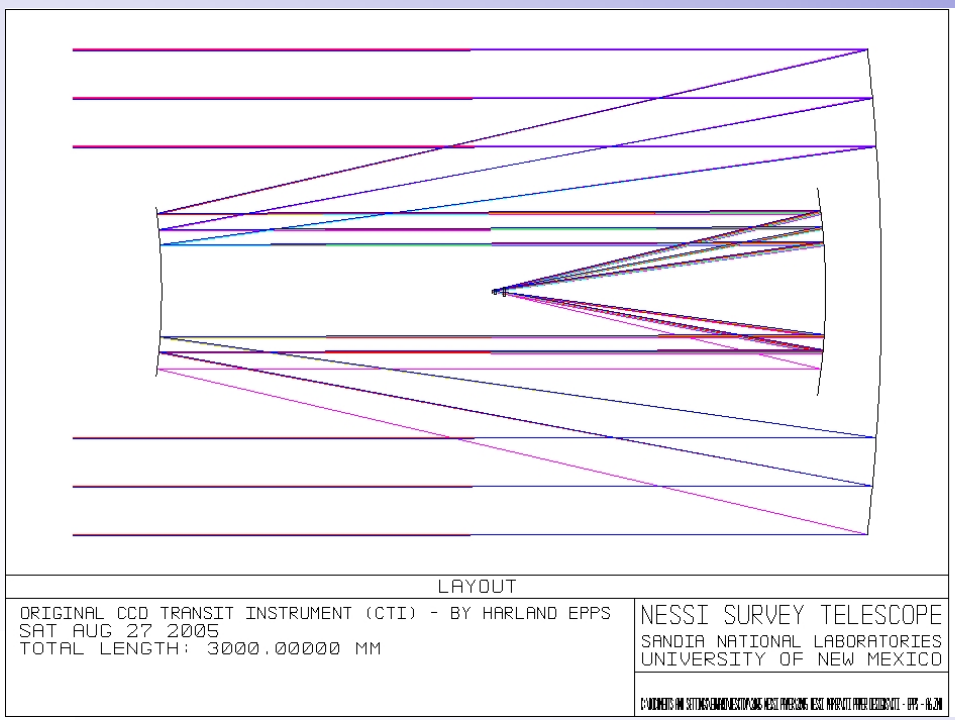
The Original CTI Telescope

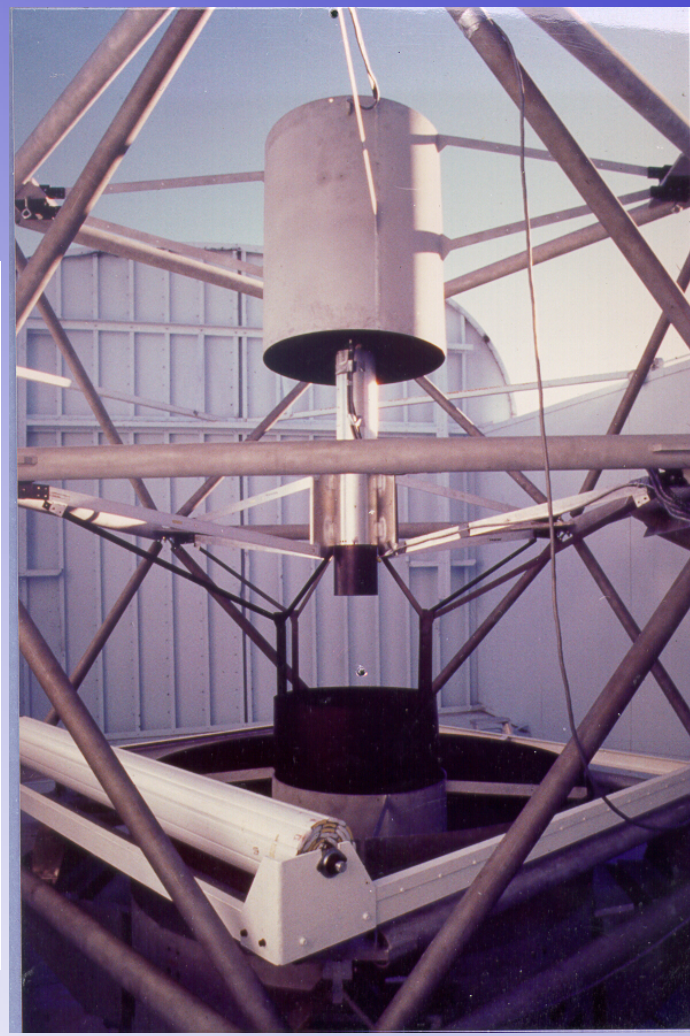
Paul-Baker design

Drift-Scan Operation

Functioned on Kitt Peak for 7 Years

8 arcmin field





The Texas-New Mexico Sky Survey Telescope:
aka: Near Earth Space Surveillance Initiative Survey Telescope

NESSI Survey Telescope will be based on the original CTI Survey telescope

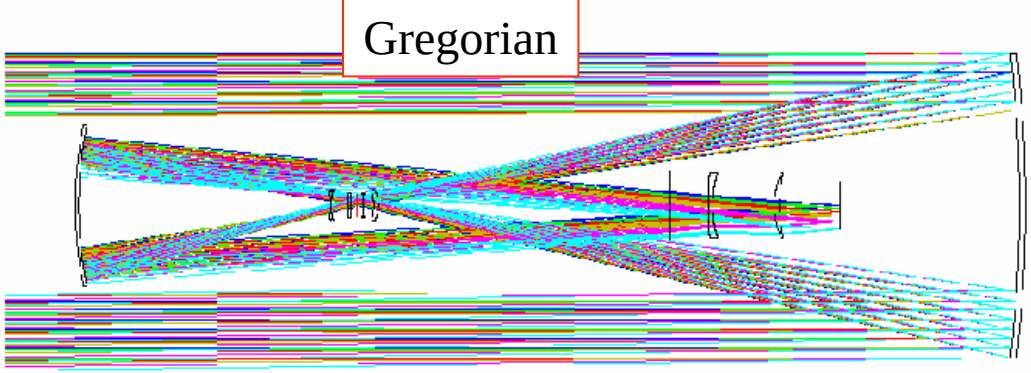
Relocated to McDonald Observatory

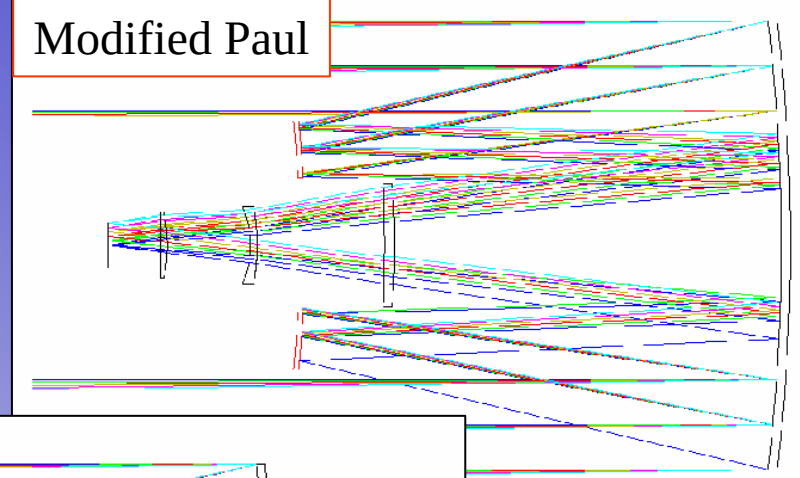
Observe 1 deg wide strip at 28 deg N every night with simultaneous observation in five color bands (BVRIZ or equivalent)

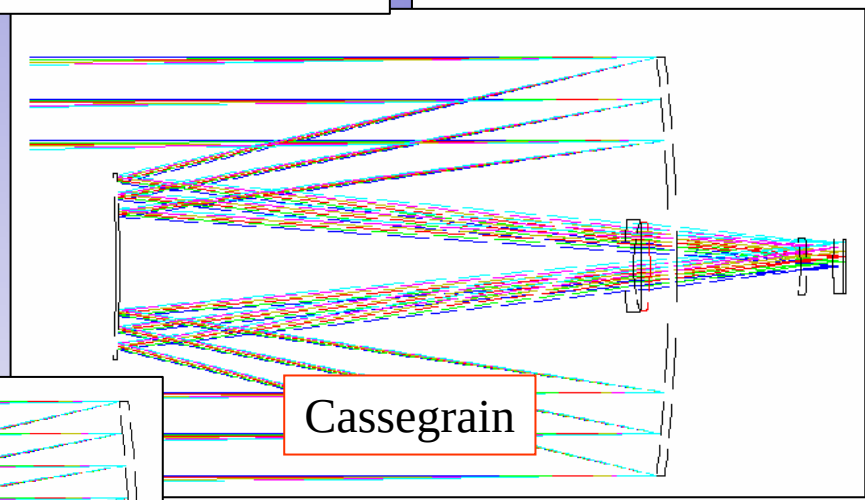
Deep spectroscopic follow-on observation of targets of interest with HET

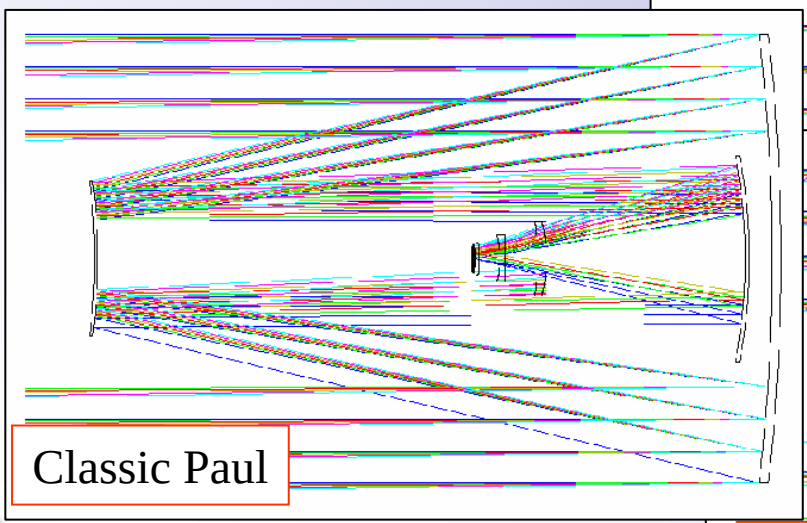
Optimized for precision astrometric and photometric survey

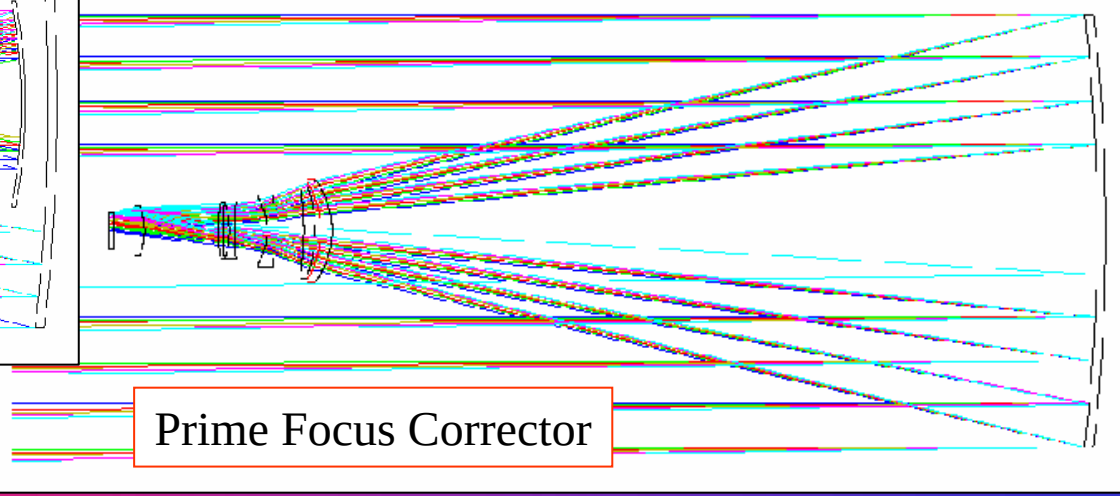
Early Designs Considered for CTI-2











Refined Science Require Improved Optics

Precision astrometry requires low distortion and approximately 3 pixels sampling FWHM of PSF at 10% best seeing.

- Designing for 10% best seeing at McDonald Observatory (~0.6 arcsec)
- Optics should minimally contribute to PSF (roughly ¼ arcsec optics)
- Designing for 60um/arcsec plate scale

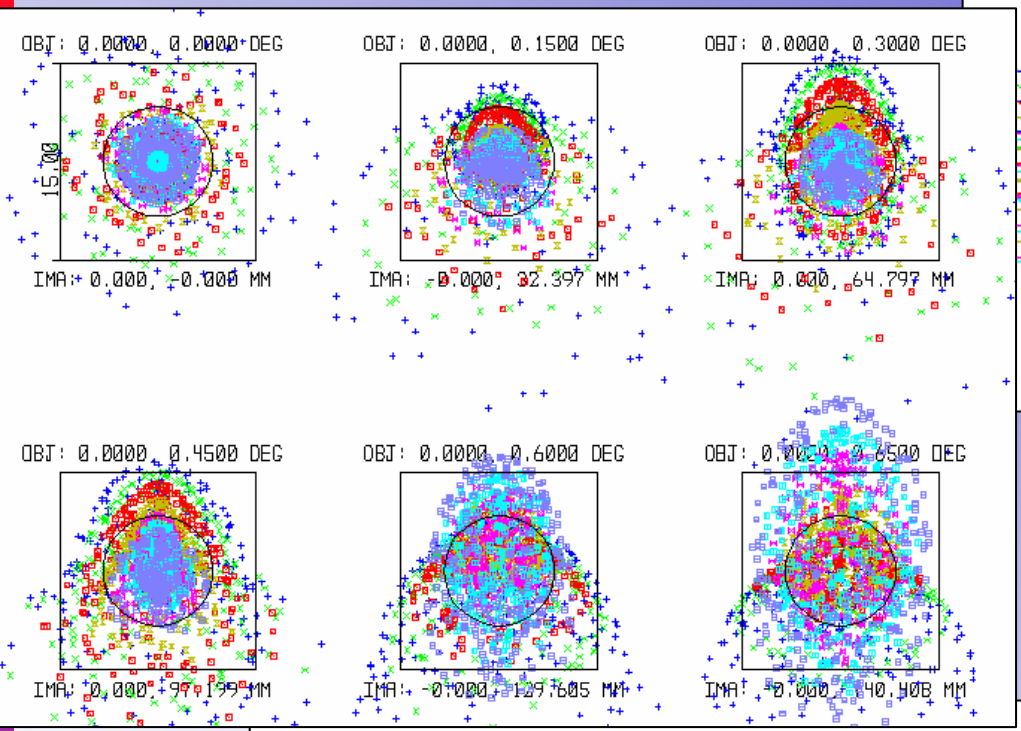
Low distortion requirement

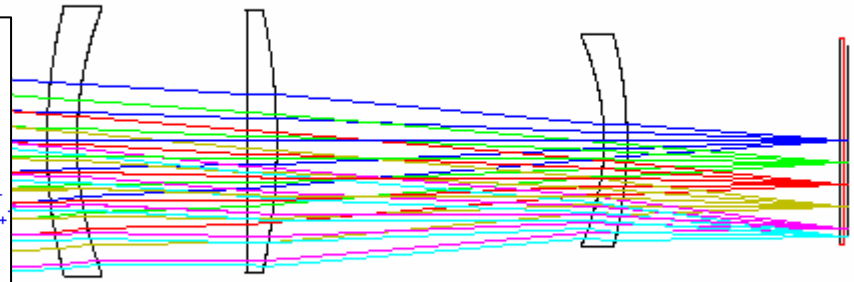
- Minimize PSF spreading in drift-scan operation
- Minimize variation in individual filter band images as they will be made at different locations on the focal plane

One degree wide image strip desired to maximize science output

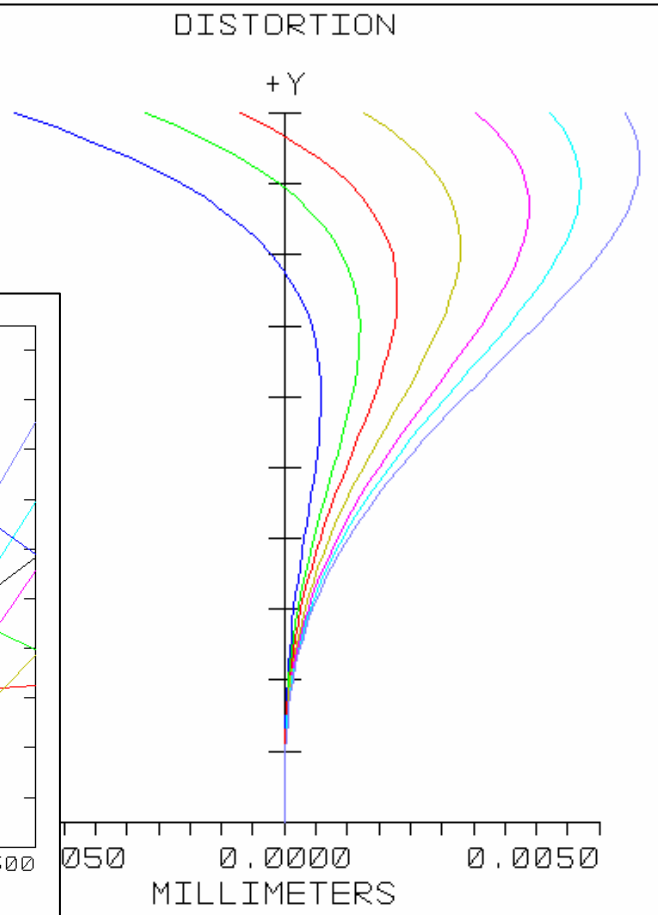
- Requires well corrected images over 1.42 deg wide image circle

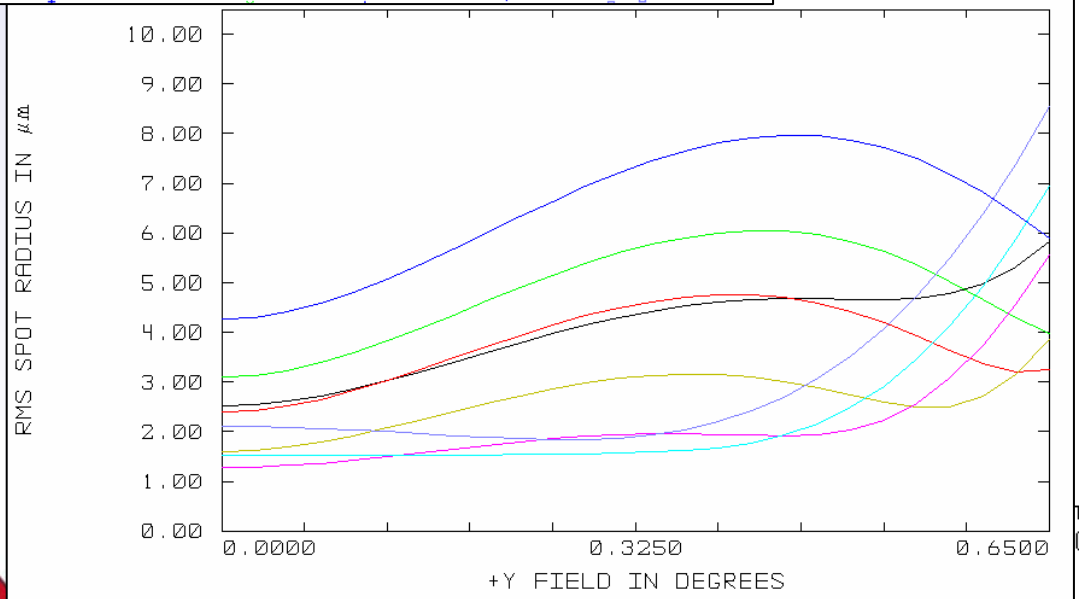
3 Lens, 1Asph, Bent Cassegrain



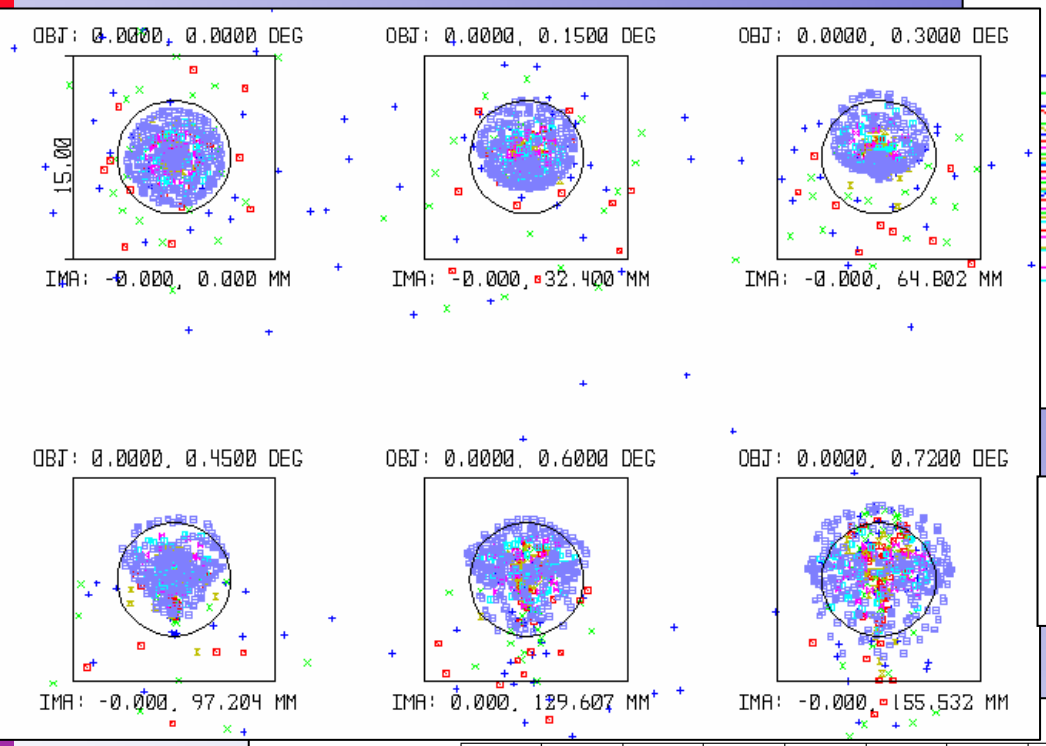


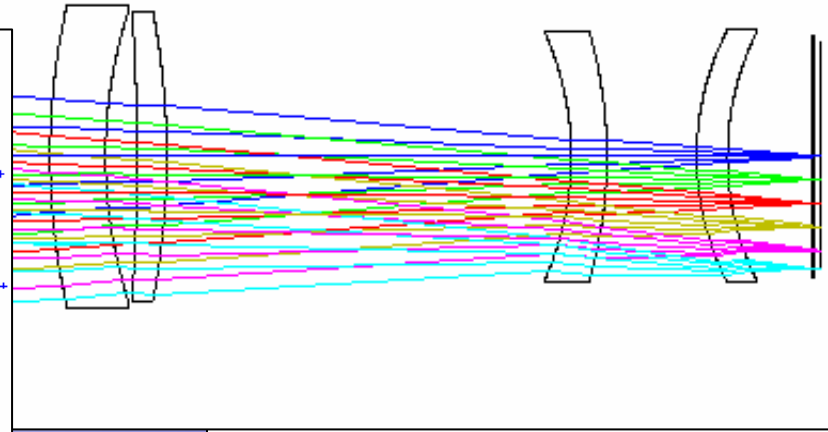
1.3deg Field



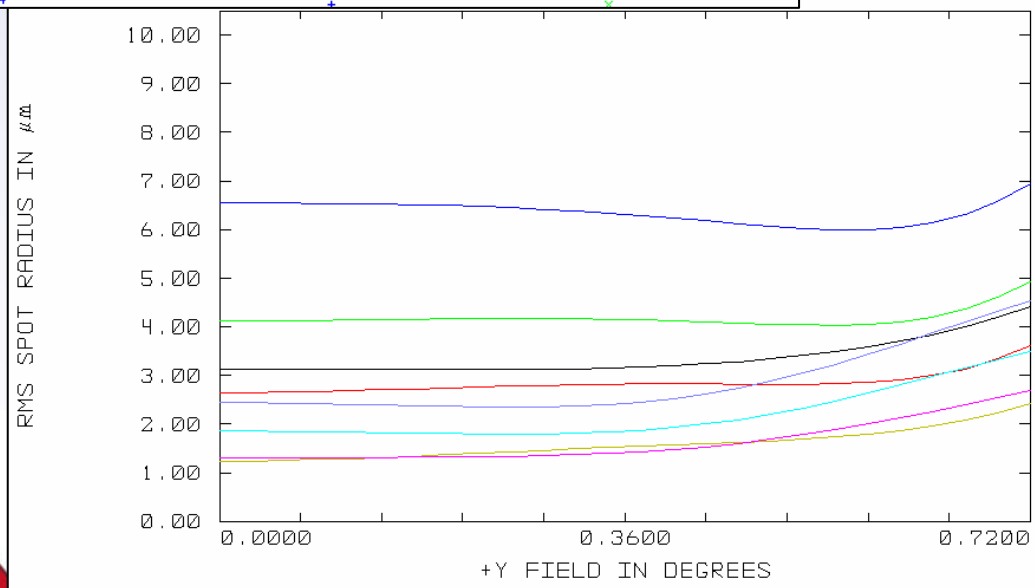


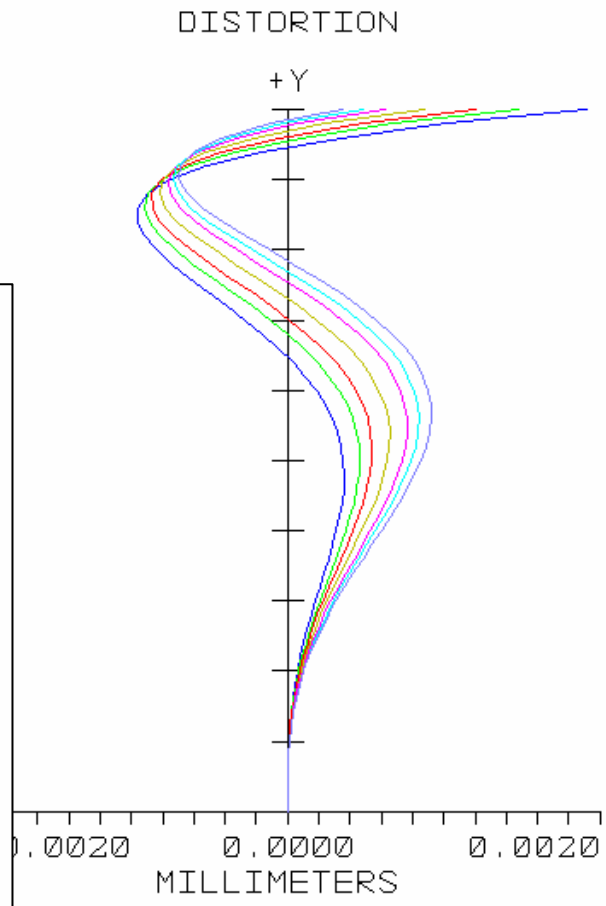
4 Lens, 1Asph, Bent Cassegrain



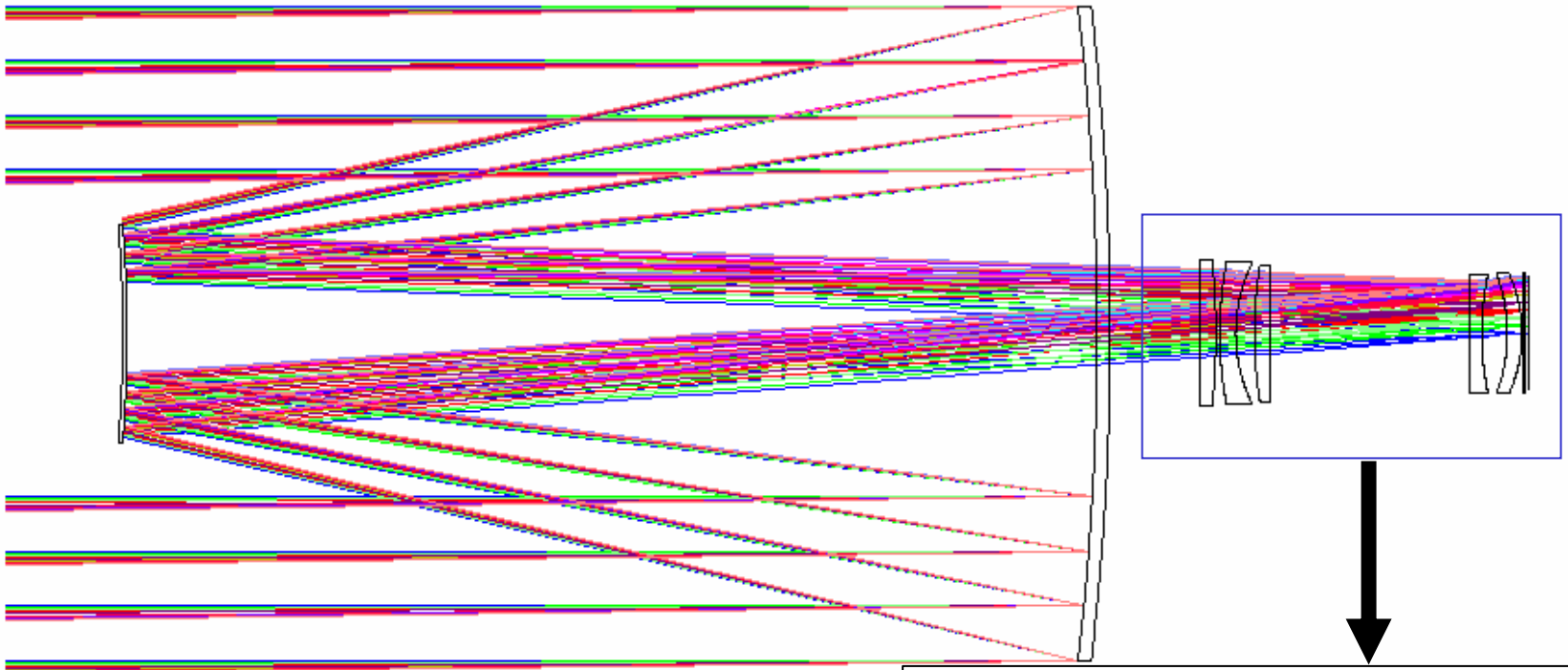


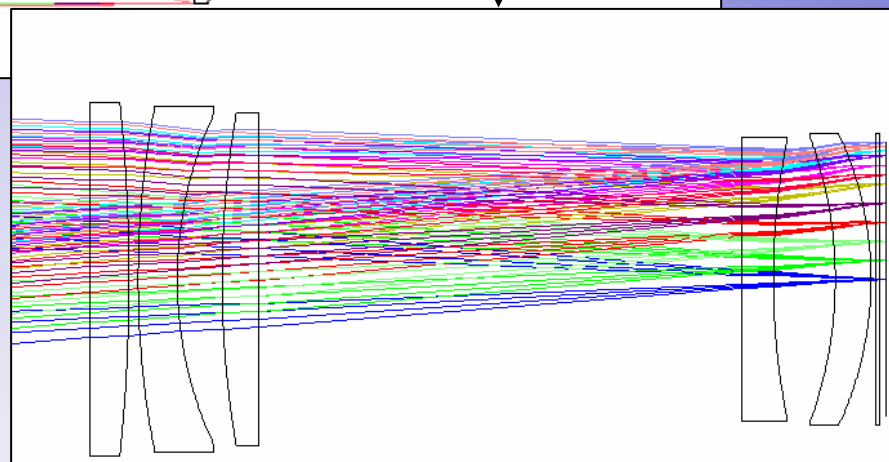
1.44deg Field





Cassegrain Corrector with 5 Spherical Lenses and 3 Plano Surfaces

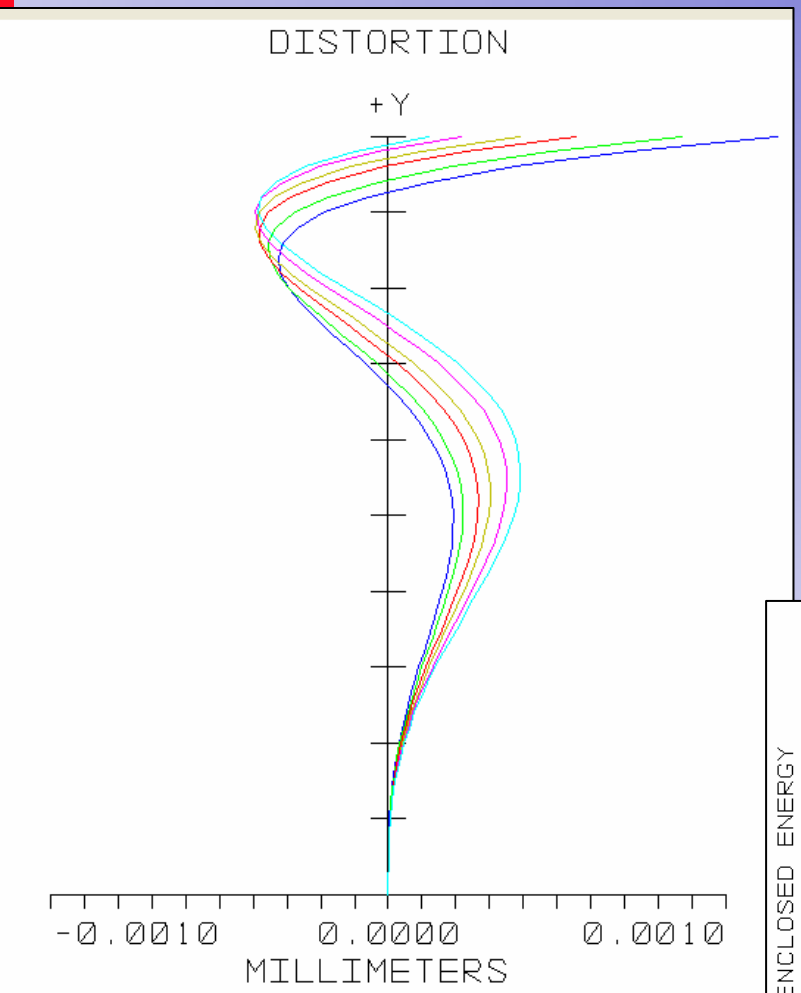




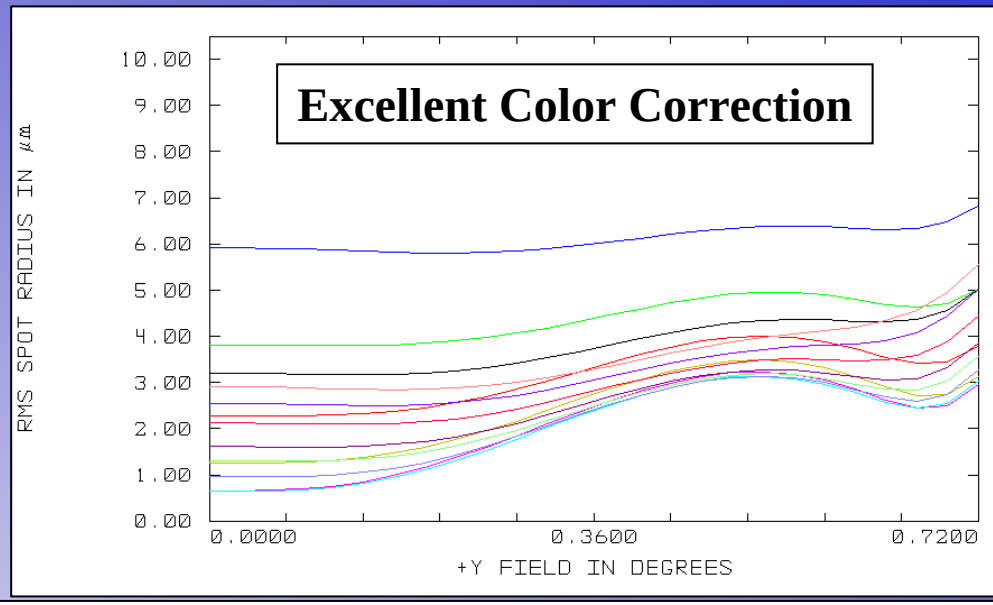
1.44deg Field

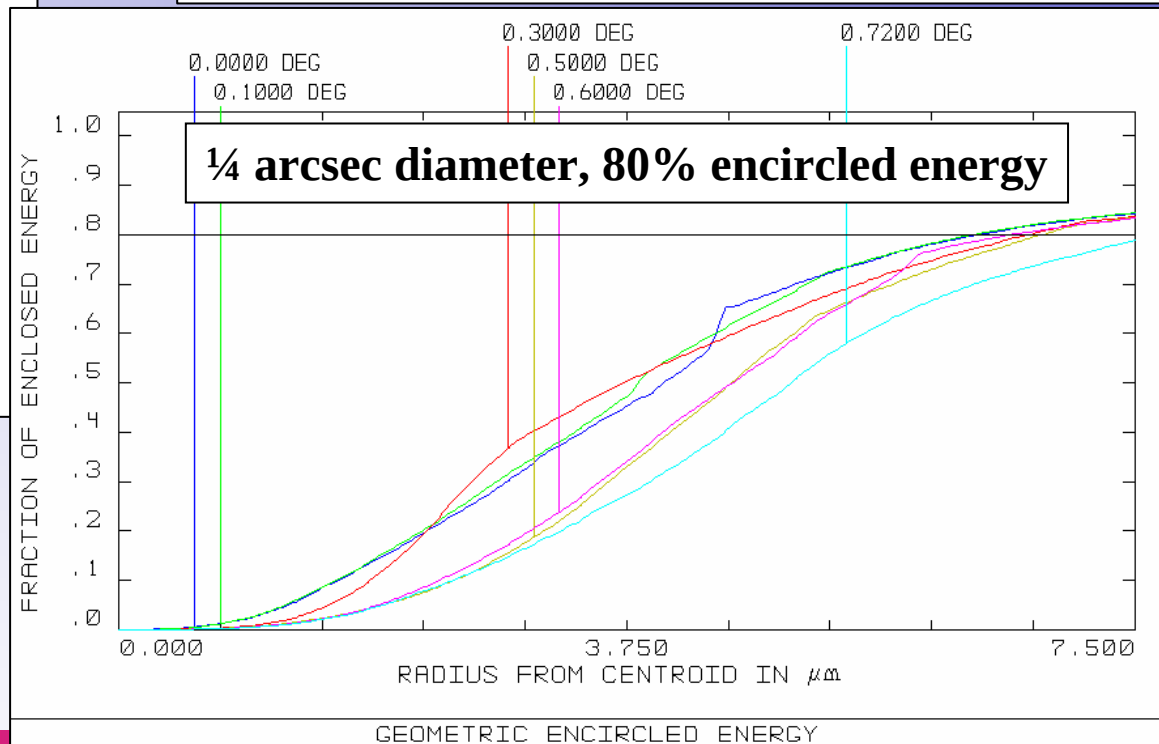
All fused silica or all N-BK7

Performance of the 5 Lens Corrector

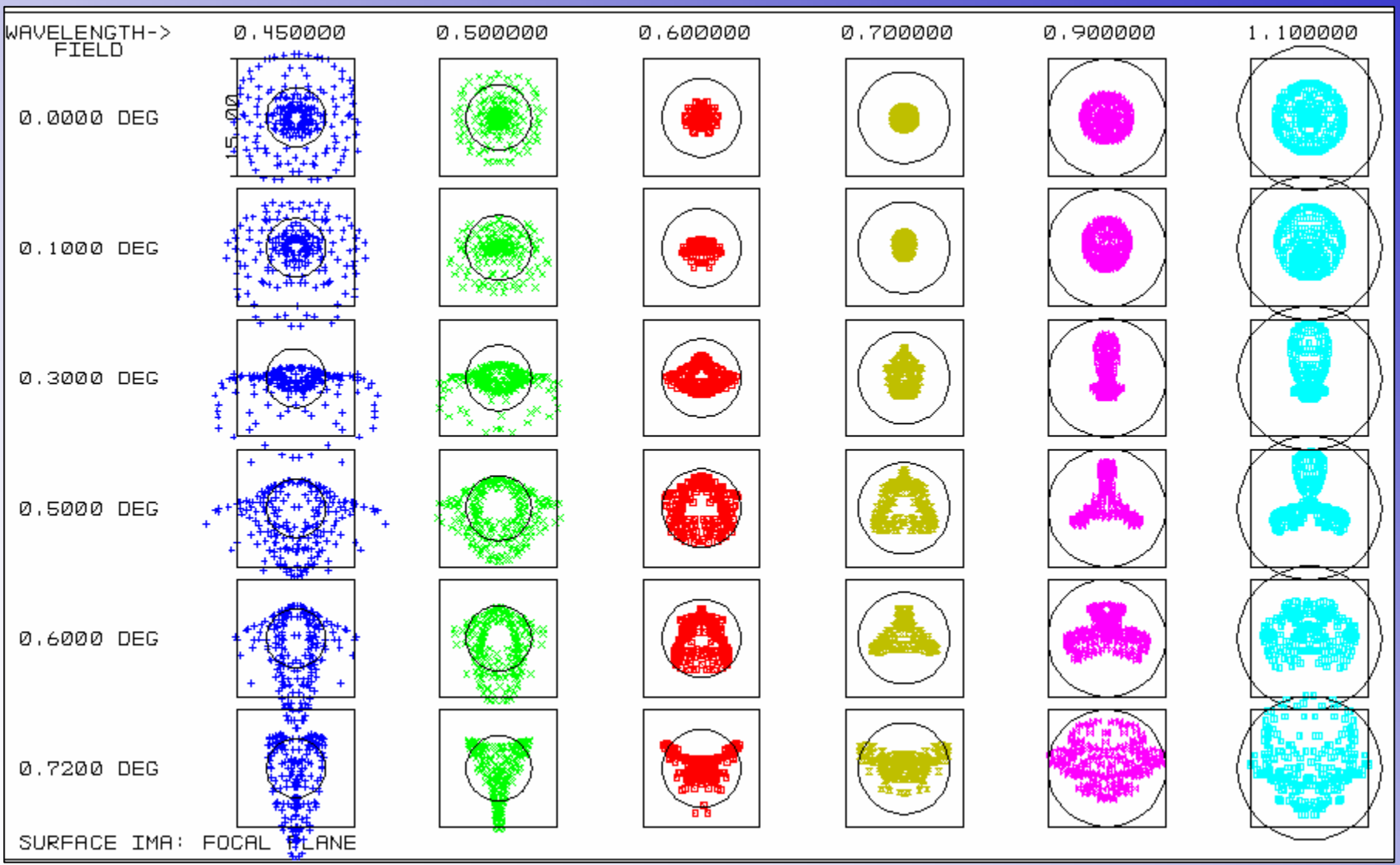


Maximum distortion of about 1 micron at extreme edge of field





Performance of the 5 Lens Corrector



15 micron boxes = ¼ arcsec across. Circles show diffraction limit.

Why Not Use a More Conventional and Proven Optical Design?

Well known expert asked why we did not pursue a conventional design
- published 2, 3 or 4 lens correctors for RC Cassegrains?

Answer: **We did** and those designs did not perform or were difficult and expensive to manufacture and test.

Starting with our constraints:
- f=2.2 parabolic primary, simultaneous 400-1100nm imaging, ¼ arcsec PSF, low distortion, unperforated primary

conventional designs did not perform, or morphed to look like our designs after extensive optimization.

Example: MMT 4 Lens Corrector by Harland Epps
- When applied to CTI-2 and allowing one surface to be a conic, MMT corrector design morphed into our 4 Lens corrector.

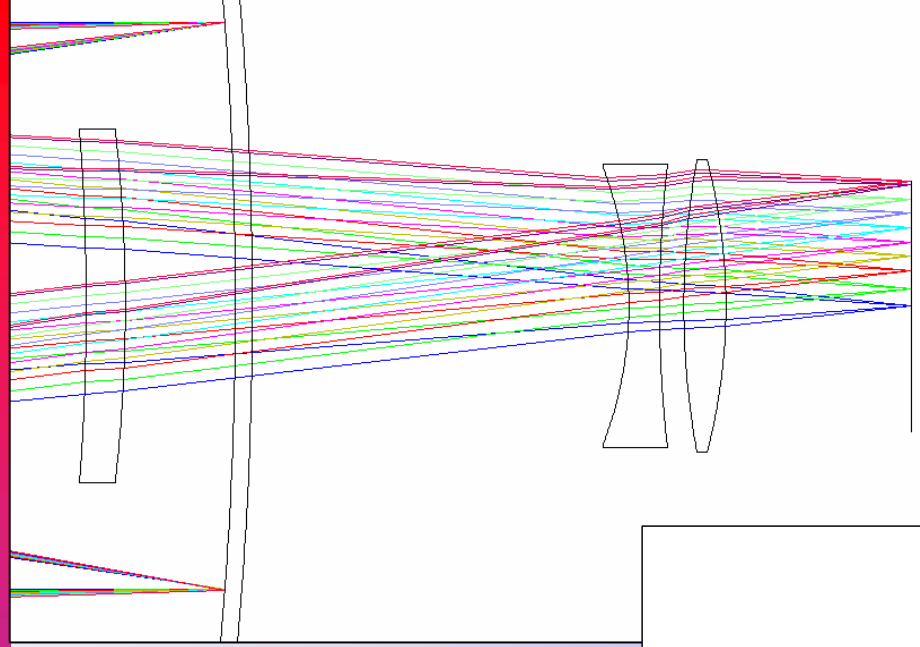
Why Not Use a More Conventional and Proven Optical Design?

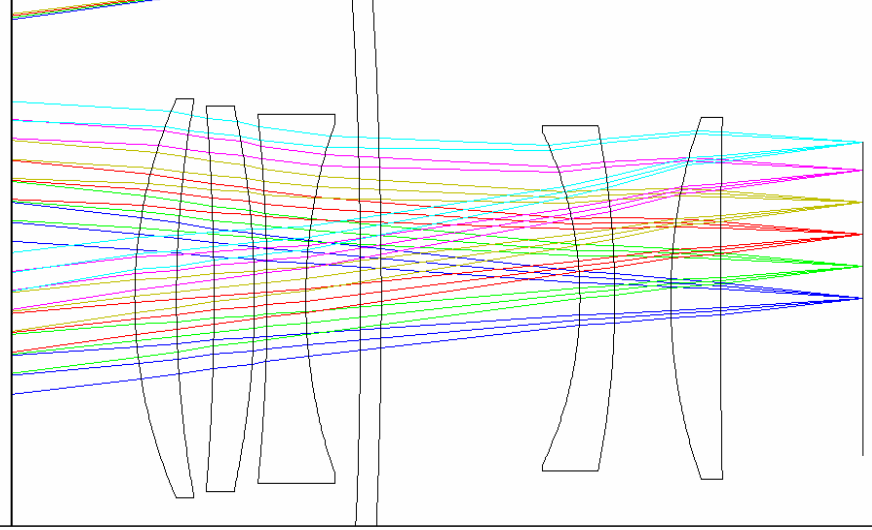
5 Lens corrector has numerous benefits

- All spherical surfaces
- Easy to fabricate and test
- One material (fused silica or N-BK7)
- Capable of very high performance with low distortion

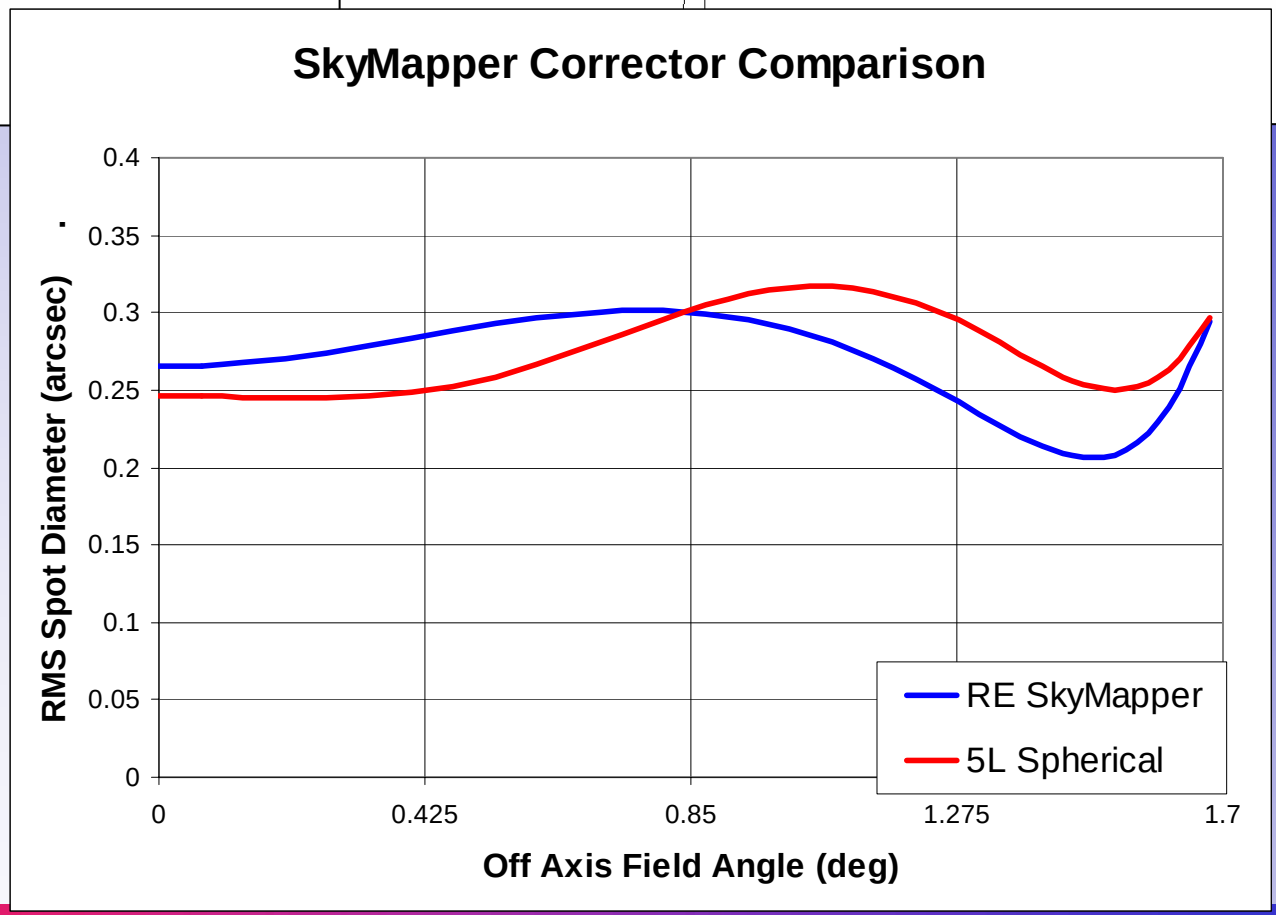
5 lens design can be applied to other telescope projects

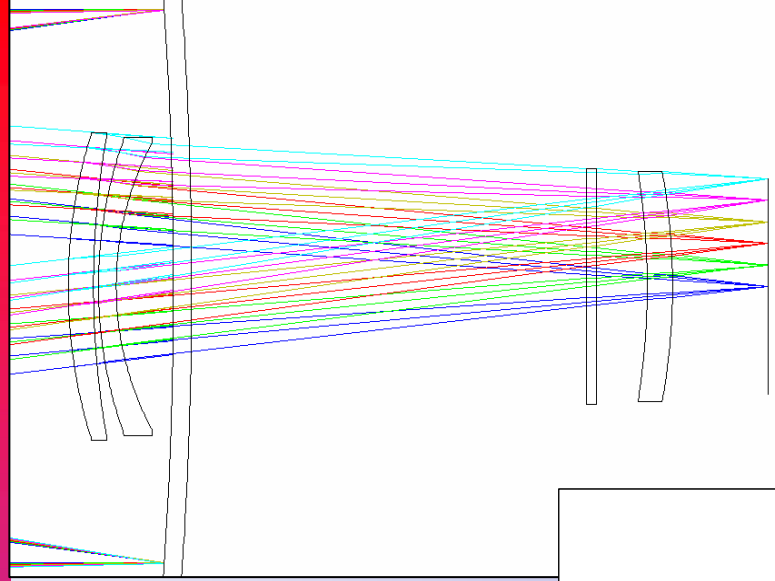
- 1.3m, 3.4deg FOV SkyMapper
- 1.8m, 3.0deg FOV PanStarrs
- 2.5m, 3.0deg FOV SDSS
- 3.5m, 1.42deg FOV WIYN ODI
- 6.5m, 1.0deg FOV MMT
- 1.25m, 4.25deg FOV Space Surveillance Telescope Concept

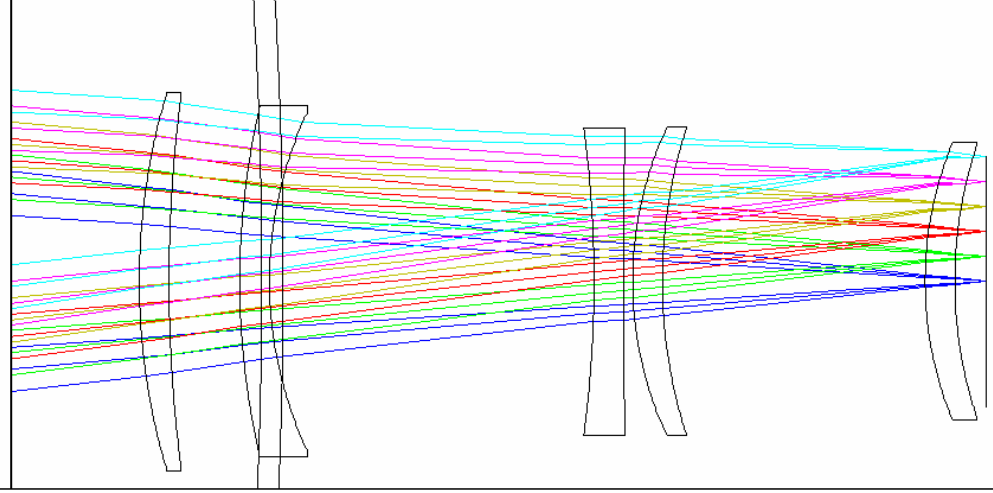




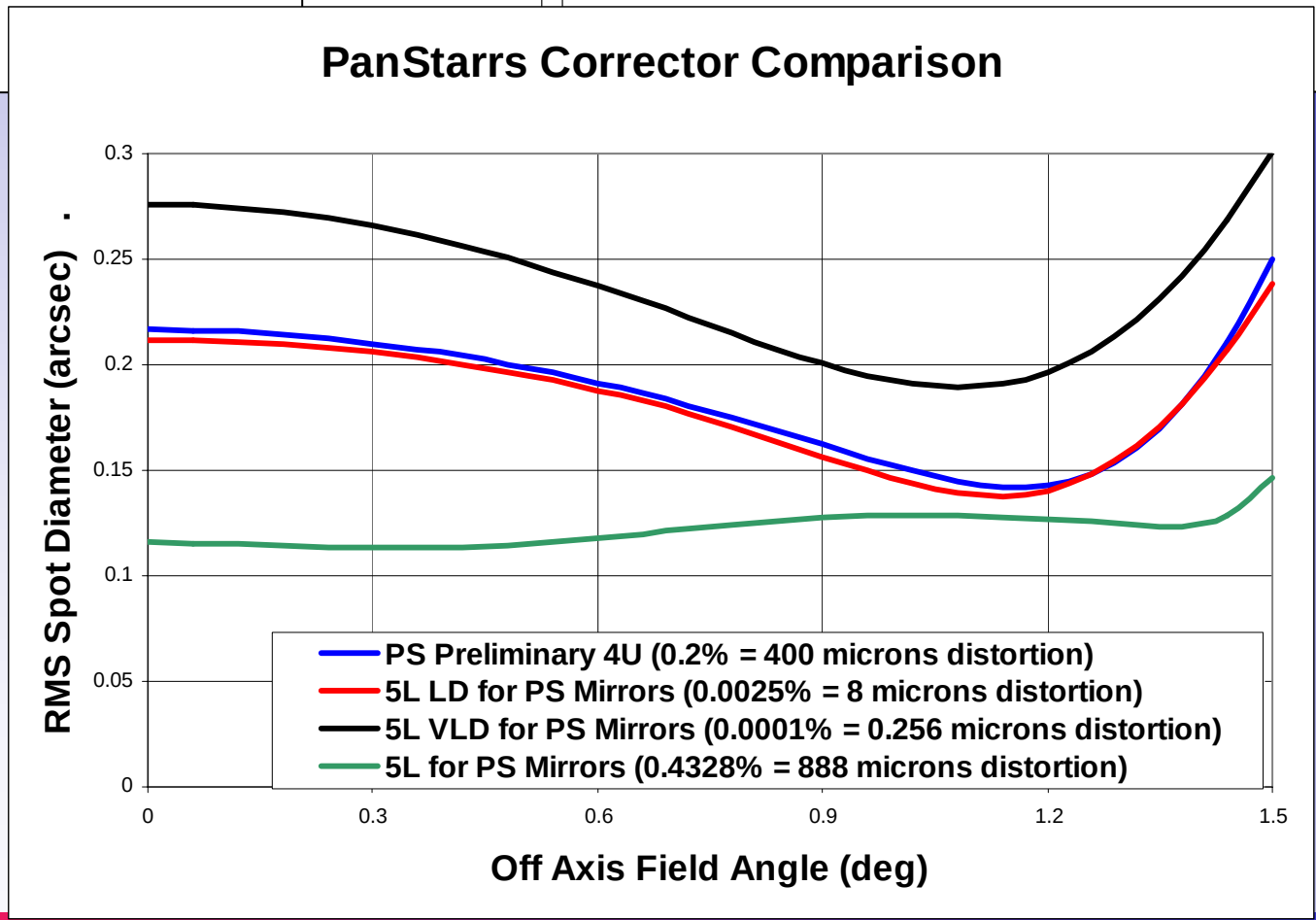
5 Lens corrector design compared to the highly innovative 3 Lens (1 asph) design used for the SkyMapper corrector.

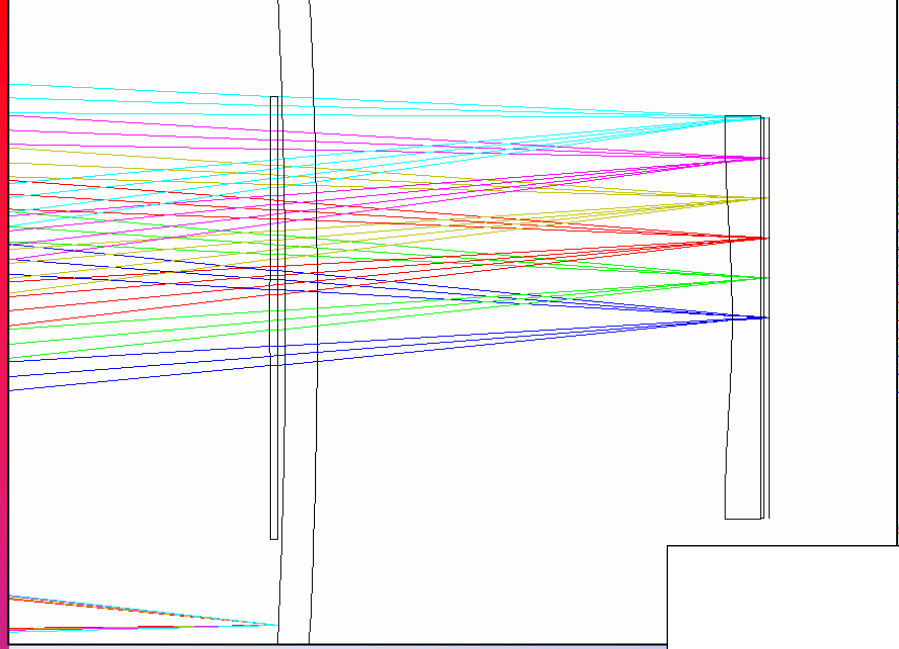


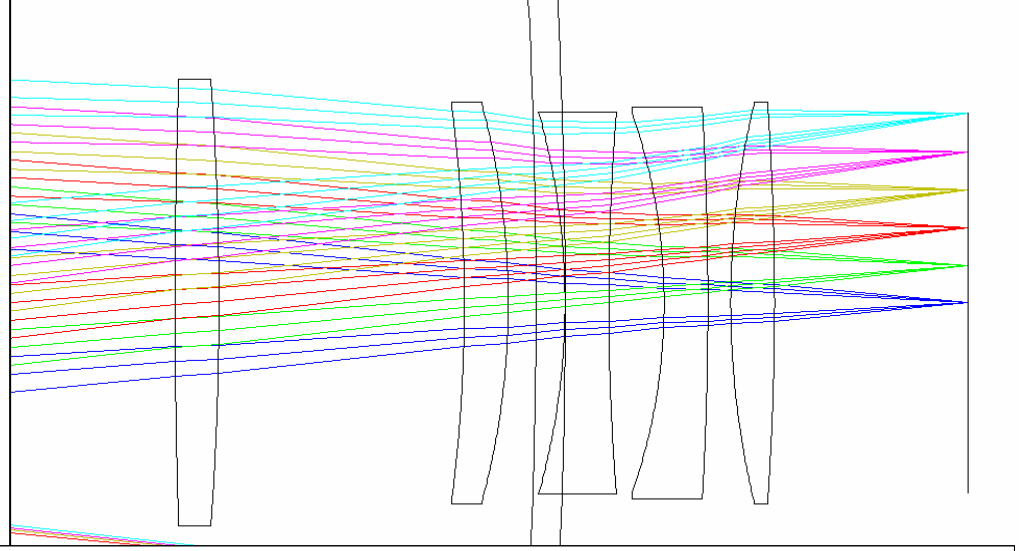




5 Lens corrector design compared to the high performance 3 Lens (1 asph) design used for the PanStarrs corrector.



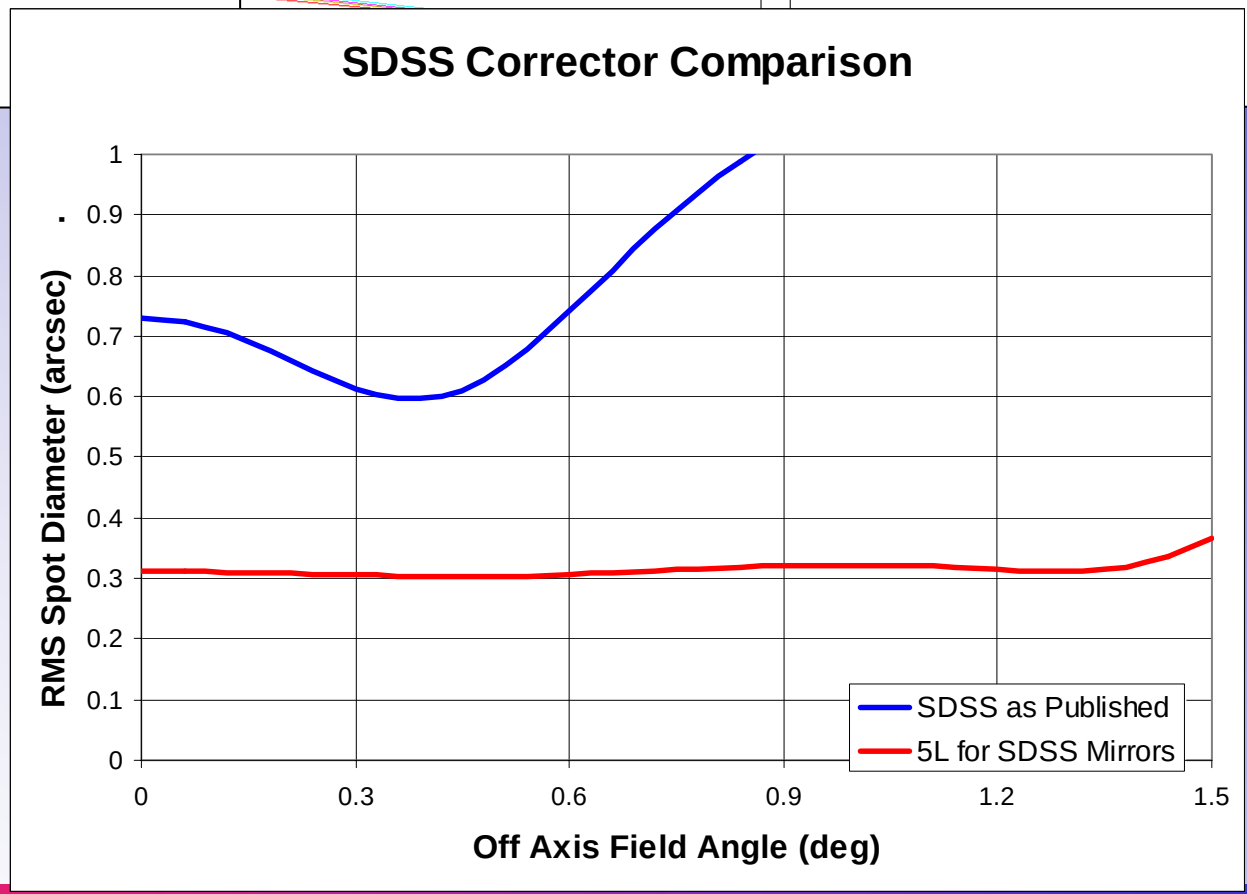


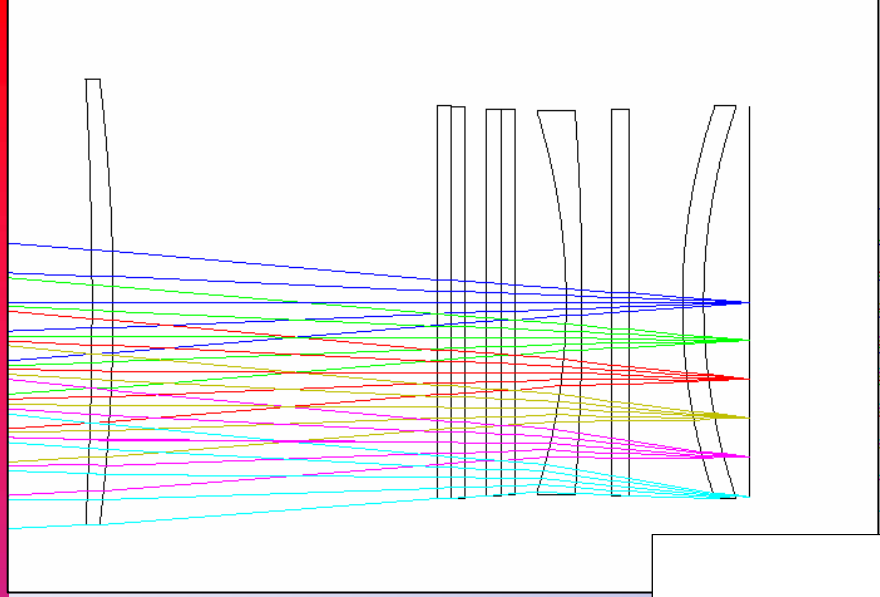


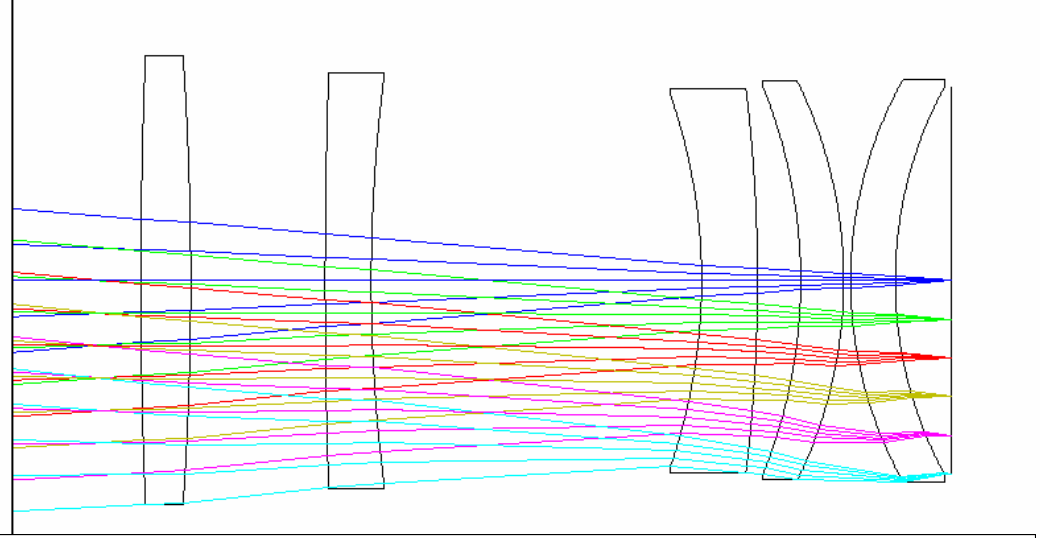
5 Lens corrector design compared to

“more conventional”

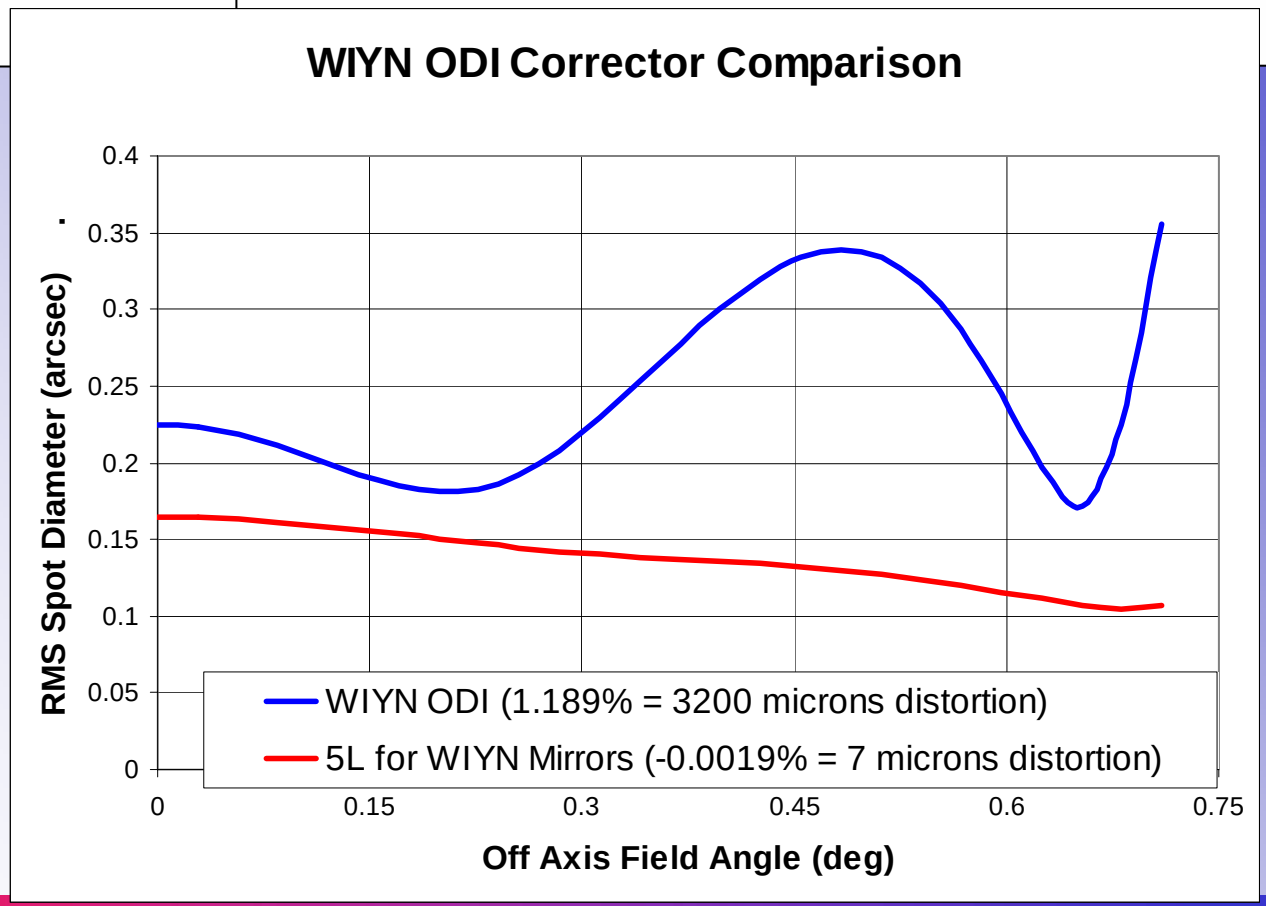
2 Aspheric Plate design used for SDSS corrector.

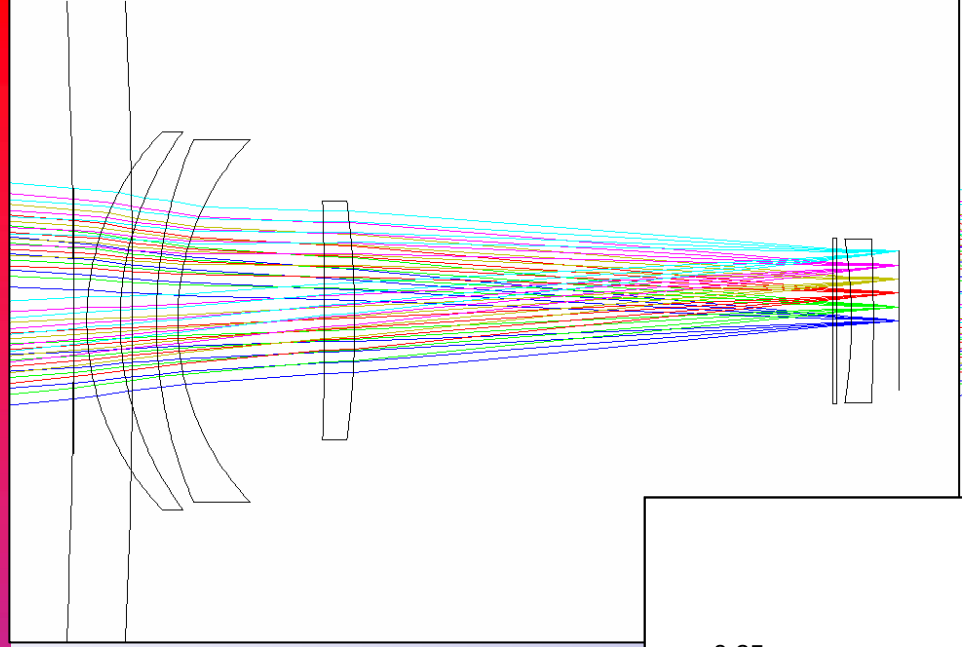


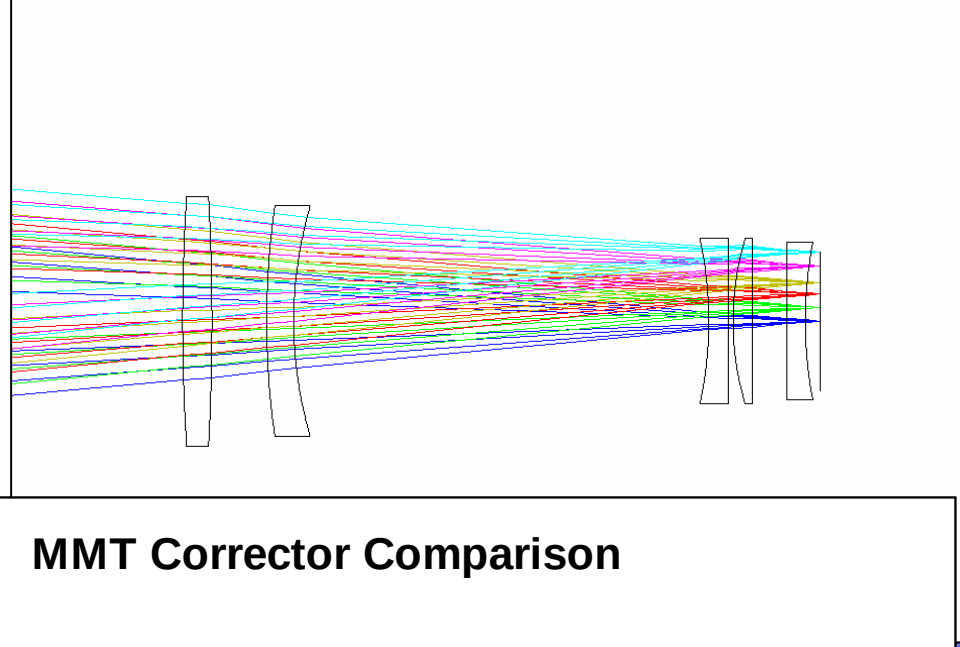




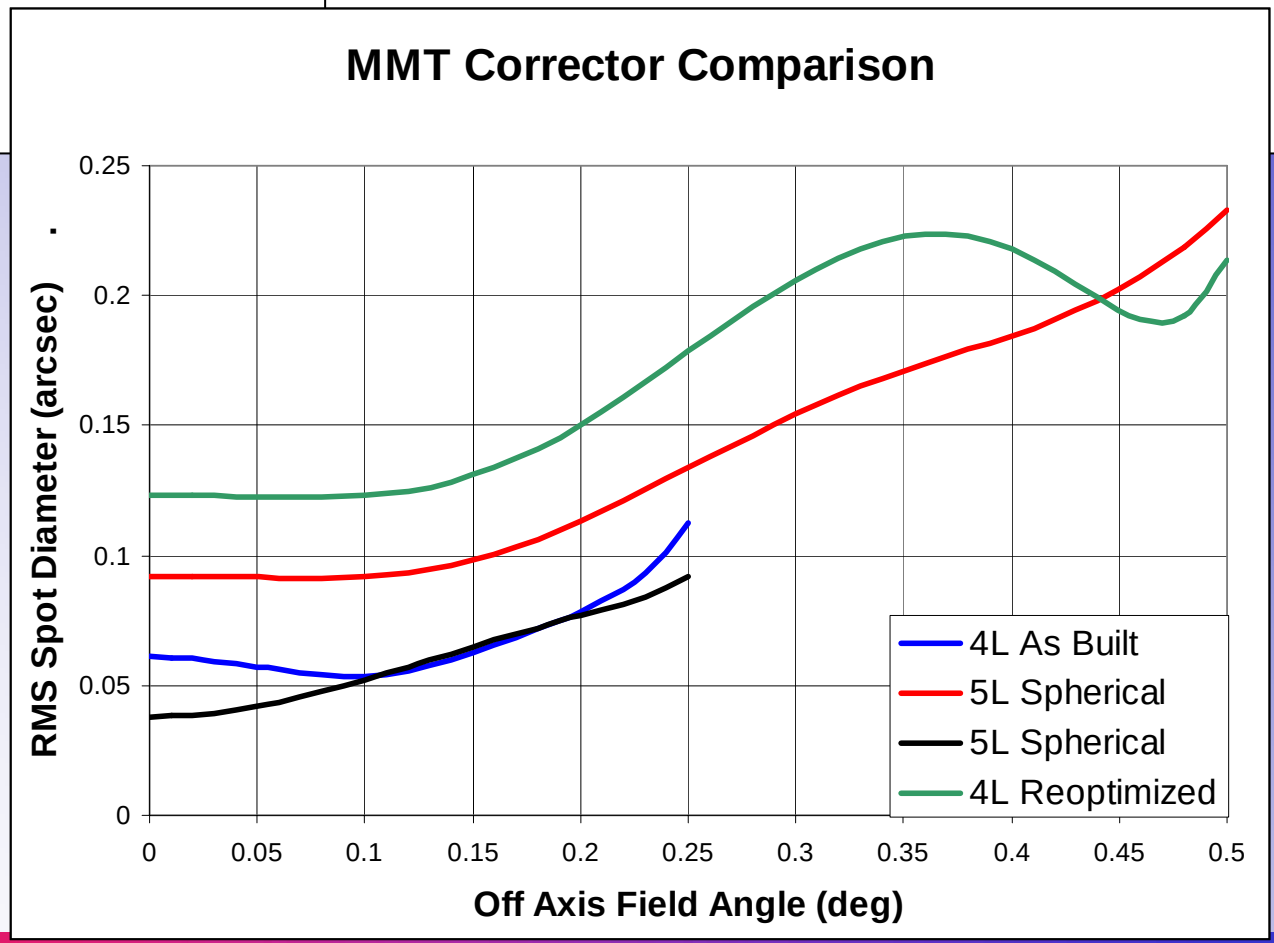
5 Lens corrector design compared to **“more conventional”** 3 lens design used for WIYN ODI corrector.

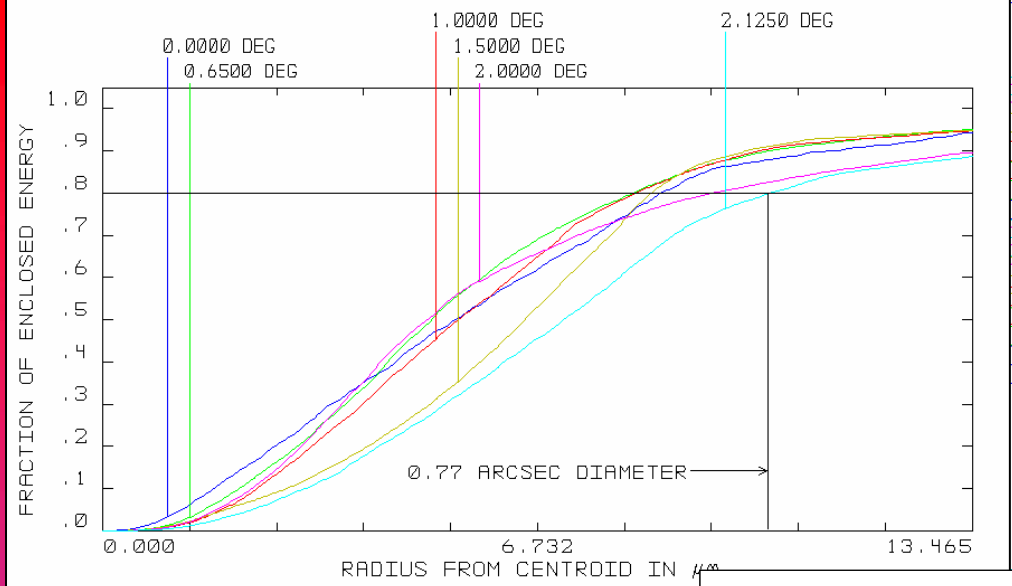


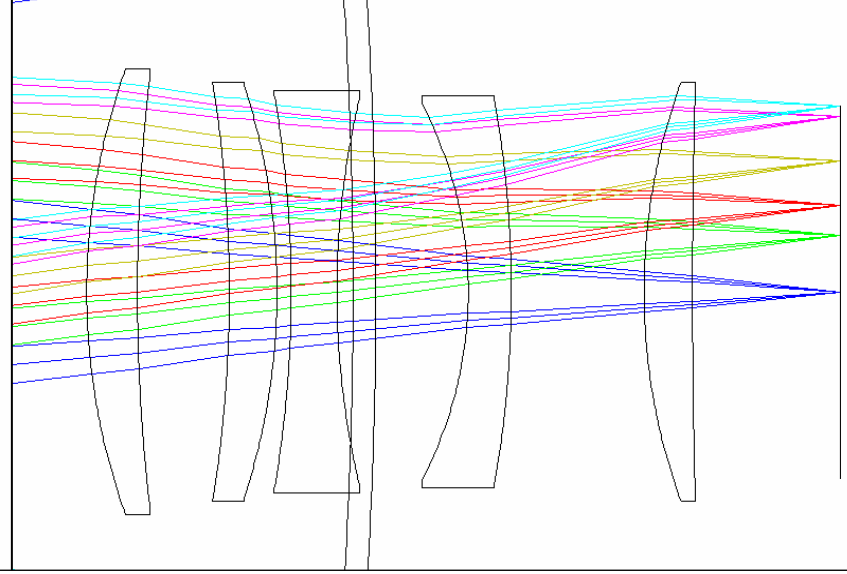




5 Lens corrector design
(with 3 plano surfaces)
compared to
“more conventional”
4 Lens design used
for MMT corrector.



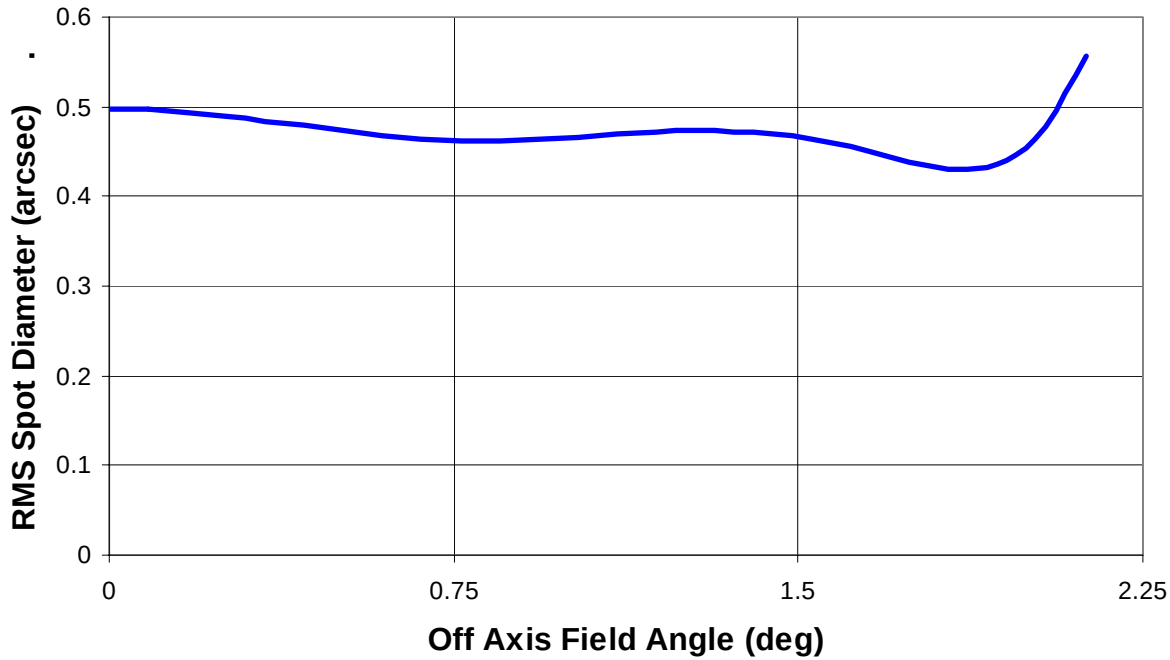




5 Lens corrector design applied to a 1.25m Space Surveillance Telescope.

System scaled to use production PanStarrs Focal Plane Arrays.

1.25m Super RC SST Corrector Performance (4.25 deg Field of View)



Summary

We have selected the final optical design for the CTI-2 telescope.

- Manufactureable and affordable
  - -- 5 Spherical lenses with 3 plano surfaces
- Very high optical performance
  - -- Extremely low distortion
  - -- ¼ arcsec images

5 lens corrector design very robust and applicable to other telescopes

- High image quality
- Low distortion
- Very wide fields