Optical Design for the 8.4m Large Synoptic Survey Telescope

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Large Synoptic Survey Telescope

ABSTRACT

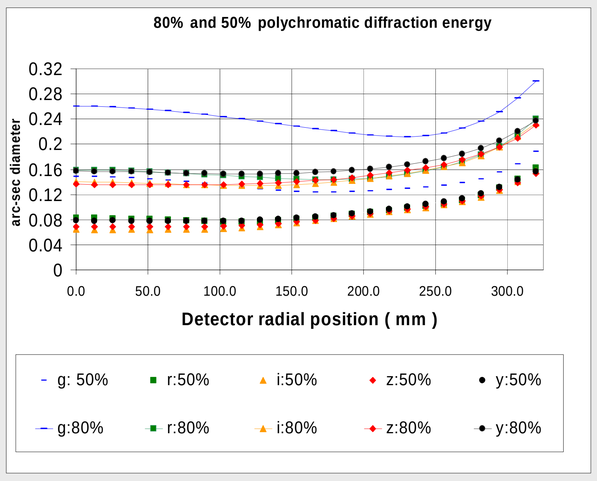
We present the design of a modified 8.4m Paul-Baker or Laux [(1)] telescope that expands the etendue ("A - Omega") product to >300m²deg², a factor of >50 beyond any existing facility. This evolved telescope design has increased etendue to meet the demanding science requirements for the LSST and simplifications in the optical prescription to enhance manufacturability. The optical design delivers a 3.5-degree diameter field of view (9.62 deg²) with superb < 0.2 arcsec FWHM images over 5 spectral bands covering 400-1030 nm. The flat focal surface has a plate scale of 51 microns/arcsec (f/1.25), chosen to match the 10 microns pixel size of a large 0.65 m diameter mosaic digital detector. The f/1.14 primary can be made using polishing techniques and metrology methods pioneered at the University of Arizona Mirror Lab for the 8.4 m f/1.1 Large Binocular Telescope primaries. The 3.4 m convex secondary is twice the size of the largest convex secondary yet manufactured; the 1.7 m MMT f/5 secondary. We show a fabrication and testing plan for this optic. The corrective camera optics are significantly simplified from earlier designs in that all refractive elements have spherical surfaces. In addition the 3 mirror telescope system delivers, without the camera corrector optics, a spherical wavefront on axis that greatly helps in initial assembly and alignment.

1. *R. N. Wilson, "Reflecting Optical Telescopes I ", Springer A&A Library, 2000, Chapter 3.6.5.*

Key Features of LSST Baseline Design

- 8.36 m diameter beam
- Full field of view : 3.5 degrees
- Etendue of 318 m^2 deg^2
- Focal ratio f/1.25:
  - EFL: 10.45 m
  - Plate scale: 50.7 μm/arc-sec
- Flat focal plane
- Five photometric filters:
  - g r i z Y pass bands, 400 nm - 1030 nm
- Spherical surfaces on all lenses and filters
- 11% vignetting at full field
- CCD array in vacuum; L_3 is vacuum barrier

Imaging performance of LSST baseline design



Spectral bands

g: 400 nm - 560 nm

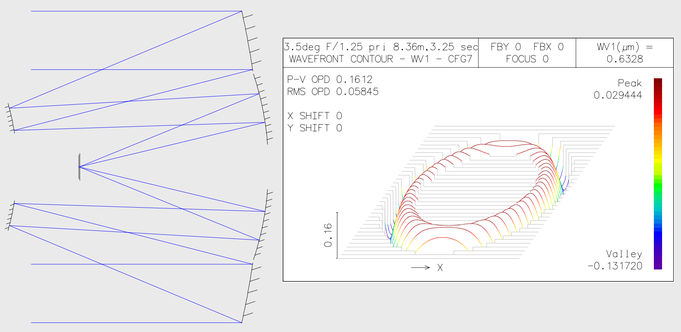
r: 540 nm - 720 nm

i: 685 nm - 870 nm

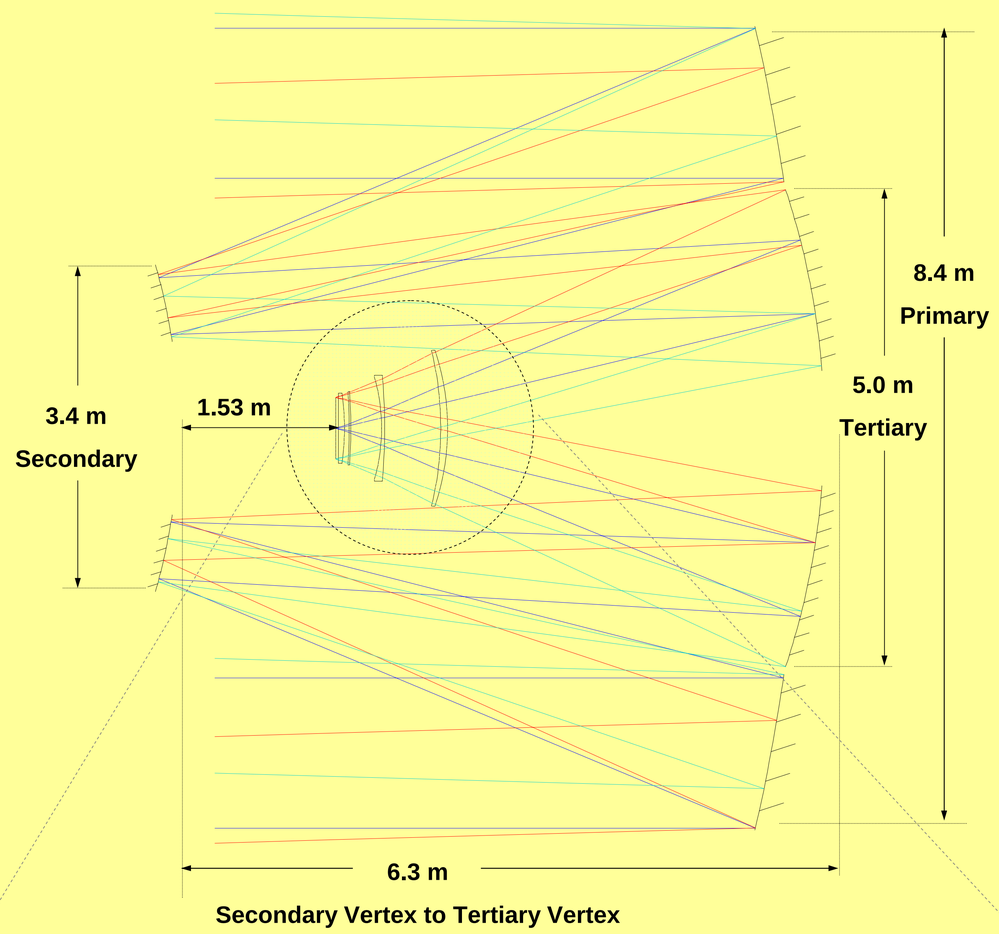
z: 840 nm - 950 nm

y: 945 nm -1030 nm

LSST Baseline Design without Camera is well-corrected on-axis: important for initial alignment

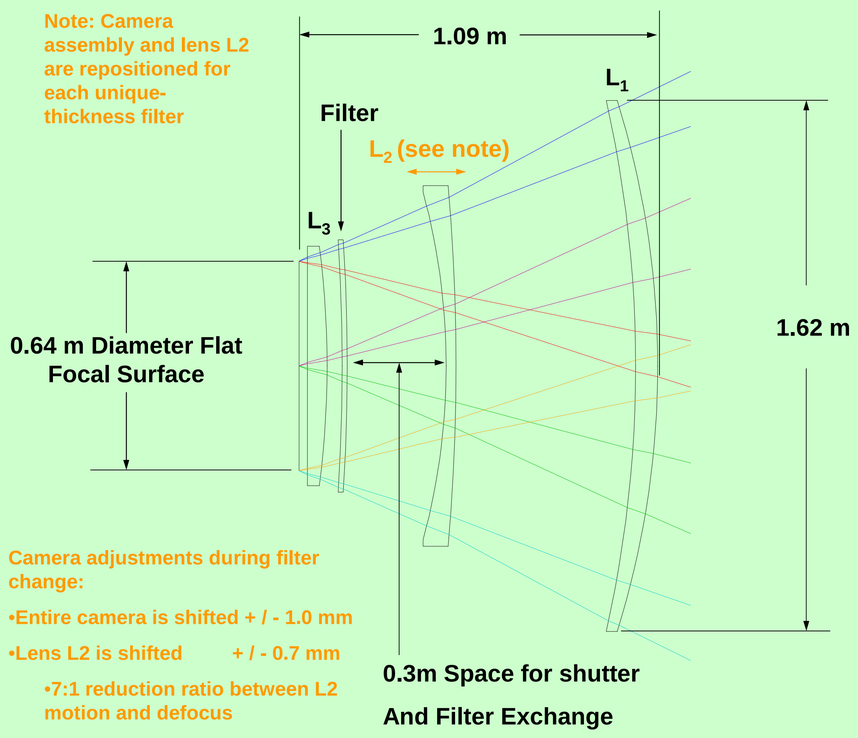


LSST Baseline Optical Layout



Camera Optical Layout

Note: Camera assembly and lens L2 are repositioned for each unique-thickness filter

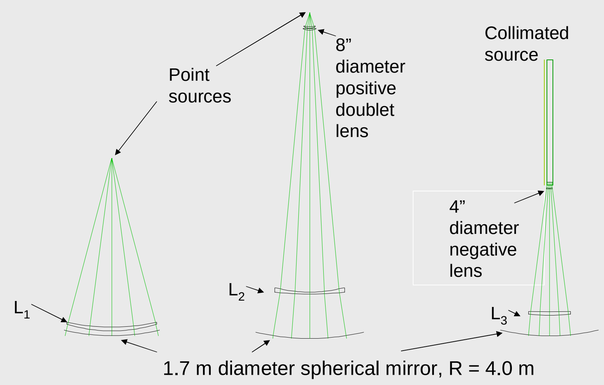


Camera adjustments during filter change:

- Entire camera is shifted + / - 1.0 mm
- Lens L2 is shifted + / - 0.7 mm
  - 7:1 reduction ratio between L2 motion and defocus

Fabrication and Testing

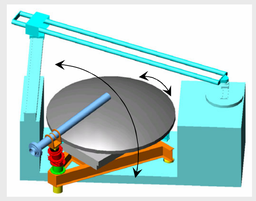
LSST Spherical Lenses Have Simple Null Tests



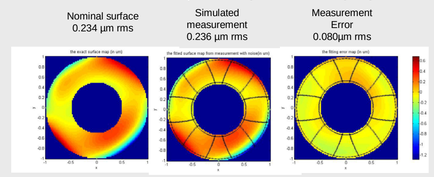
LSST Secondary Mirror Fabrication and Testing

Profilometry is used to measure large scale figure of aspheric shape

Profilometer configuration on the 4-m polishing machine at U Arizona.



Simulated performance, combining 6 swingarm scans and 2 circumferential scans, with 0.1 μm rms noise per point



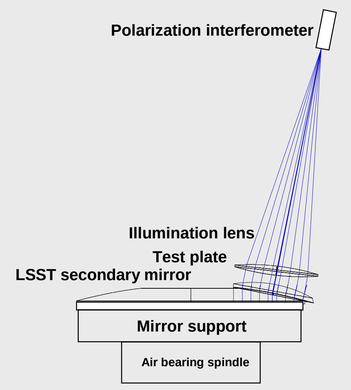
Secondary Fabrication Error Budget

Process step	Tools	Metrology	Accuracy
Fabricate mirror blank	Diamond generate	Direct measure	0.5mm
Grind to best fit sphere	Rigid lap faced tile	Spherometer, test plate	2.0μm
Aspherize	Compliant or stressed lap faced with metal pads	Profilometry	0.1μm
Polish	Stressed lap faced with pitch	Interferometry with stitching	.02μm

Subaperture interferometry to measure final surface And small scale features

Surface measurement with concave test plate, which has the matching aspheric shape. Rotating the secondary mirror allows measurement of full surface.

Use polarization interferometer (commercial product from ODEC or 4D Technologies) for vibration insensitive phase measurement



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