Large Synoptic Survey Telescope

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Performance of the LSST Camera

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The LSST camera will be the largest digital camera ever built. As such, its design presents a number of challenges. The field of view will be 3.5 degrees in diameter and will be sampled by a 3.2 billion pixel array of sensors. The entire array will be read-out in under 2 seconds, which all lead to demanding constraints on the sensor architecture and the read-out electronics. In addition, given the fast, optical beam (f/1.2), the camera tolerances on the assembly and alignment of the focal plane and optics are tight. The camera also incorporates three large refractive lenses, an array of five, wide-band large filters mounted on a carrousel, and a mechanical shutter. We present an overview of the baseline camera design, with an emphasis on the requirements and expected performance of the design that will allow the camera to meet its scientific objectives.

LSST Sensor Characterization Results

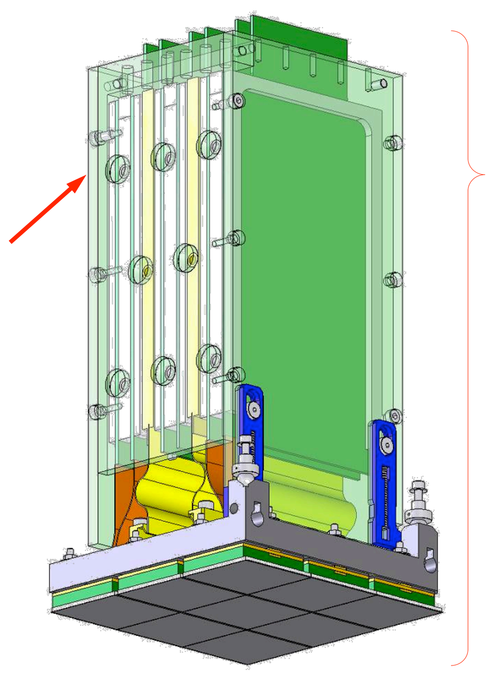
Study of silicon thickness optimization for LSST, Proc. SPIE Vol. 6276, No. 1. (2006), 62761W by P. O'Connor, V. Radeka, D. Figer, et al.
The LSST sensor technologies studies, Proc. SPIE Vol. 6276, No. 1. (2006), 627601, by J. Geary, D. Figer, D. K. Gilmore, et al.
Characterization of prototype LSST CCDs, Proc. SPIE Vol. 7021, No. 1. (2008), 702106, by P. O'Connor, J. Frank, J. C. Geary, et al.
LSST sensor requirements and characterization of the prototype LSST CCDs, *Journal of Instrumentation*, Vol. 4, No. 03. (01 March 2009), P03002, by V. Radeka, J. Frank, J. C. Geary, et al.
Study of pixel area variations in fully depleted thick CCD, Proc. SPIE Vol. 7742, No. 1. (2010), 774206, by I. V. Kotov, A. I. Kotov, J. Frank, et al.
PSF and MTF measurement methods for thick CCD sensor characterization, Proc. SPIE Vol. 7742, No. 1. (2010), 774207, by P. Z. Takacs, I. Kotov, J. Frank

Large field of view implies physically large focal plane (64cm Φ)	Modular mosaic focal plane construction	21 rafts × 9 4K x 4k CCDs/raft 189 science CCDs total 3.2 Gpix
Fast f/1.2 beam, shallow depth of focus	Tight alignment and flatness tolerance	Flatness: 5μm Alignment (z axis): 10μm
Plate scale 20"/mm	Small pixels, close butting	Pixel: 10μm Chip-chip gap: 250μm
Fast readout (2s) with low noise (5 e-)	Highly parallel readout electronics	16 amplifiers/4K CCD
Broadband, high spectral sensitivity	Thick silicon sensor, back illuminated, AR coat	100μm thickness for IR sensitivity Thin conductive window
Seeing-limited image quality	Internal electric field to minimize diffusion	High resistivity, biased silicon (> 3 kΩ-cm, -50V)

Science Goals Drive Sensor Requirements

Front-End Electronics

- Clocking of science CCDs is synchronous and global throughout the focal plane
- Read-out rate = 500 kpix/sec * 16 outputs/CCD * 189 CCDs = 3.2 Gpix/2sec
- 16-bit dynamic range is handled by a single-gain readout
- LSST-specific ASICs are being developed to handle analog front-end functions

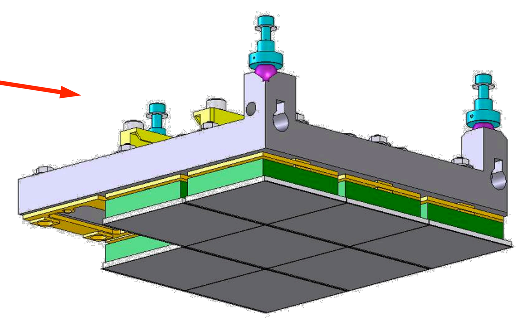


Raft Tower

- Sensors are organized into identical Rafts of 3 x 3 sensors
- 144 channels/raft
- A Raft Tower is an autonomous object and can function as a complete camera
- Electronics fit in the "shadow" of the sensors on a Raft

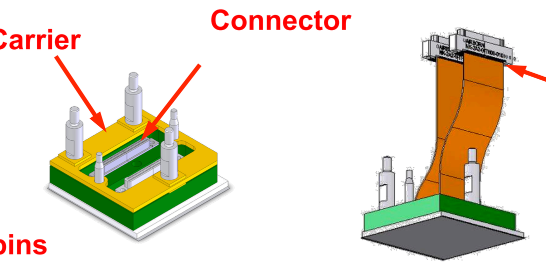
Raft

- 3 x 3 array of 16 M-pixel CCD sensors
- Rigid, low-expansion structural support—SiC or Invar
- Kinematically supported off of Grid
- Required flatness across Raft: 6.5 microns

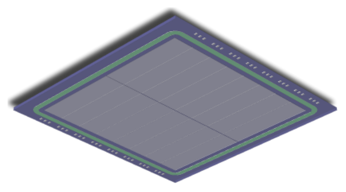


Sensor

- 4K x 4K CCD sensors
- 2 sec readout at 500 kHz → ~1M pixels per output
- Fill factor must approach unity, which favors a fairly large area footprint of ~16 cm²
- Bond pads only on periphery
- < ~500 pixels per segment for blooming control of bright stars
- Contiguous imaging area should be at least 500 pixels
- Required flatness across sensor: 5 microns

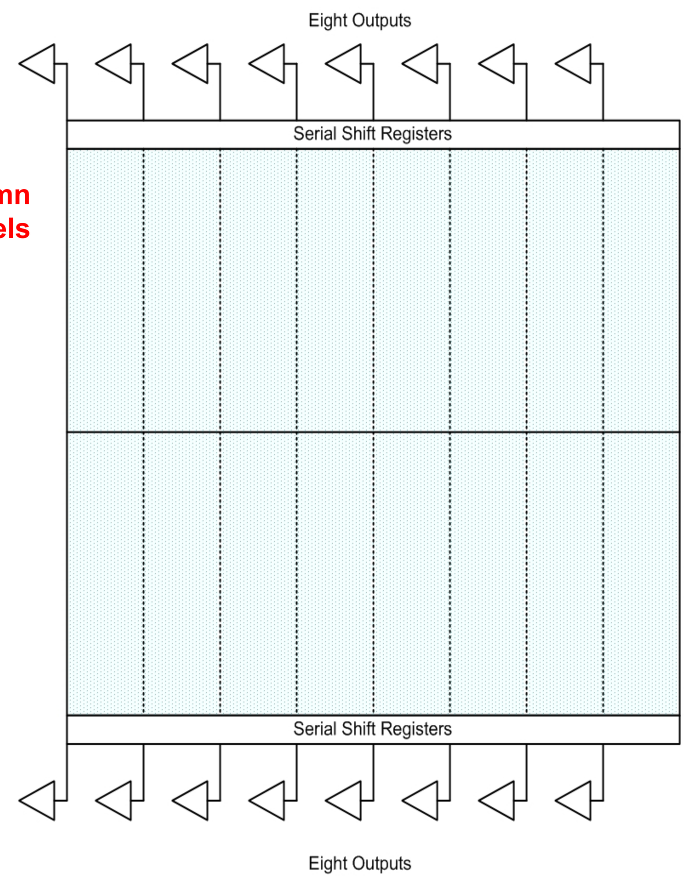


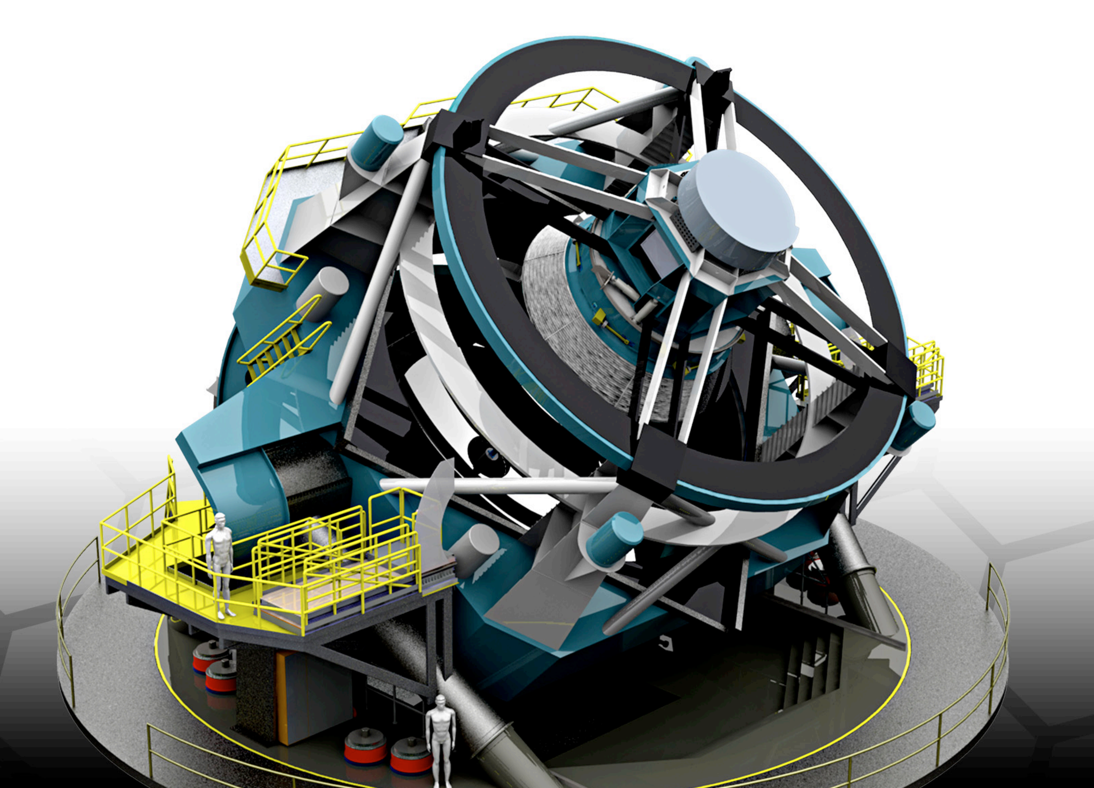
Sensor Package



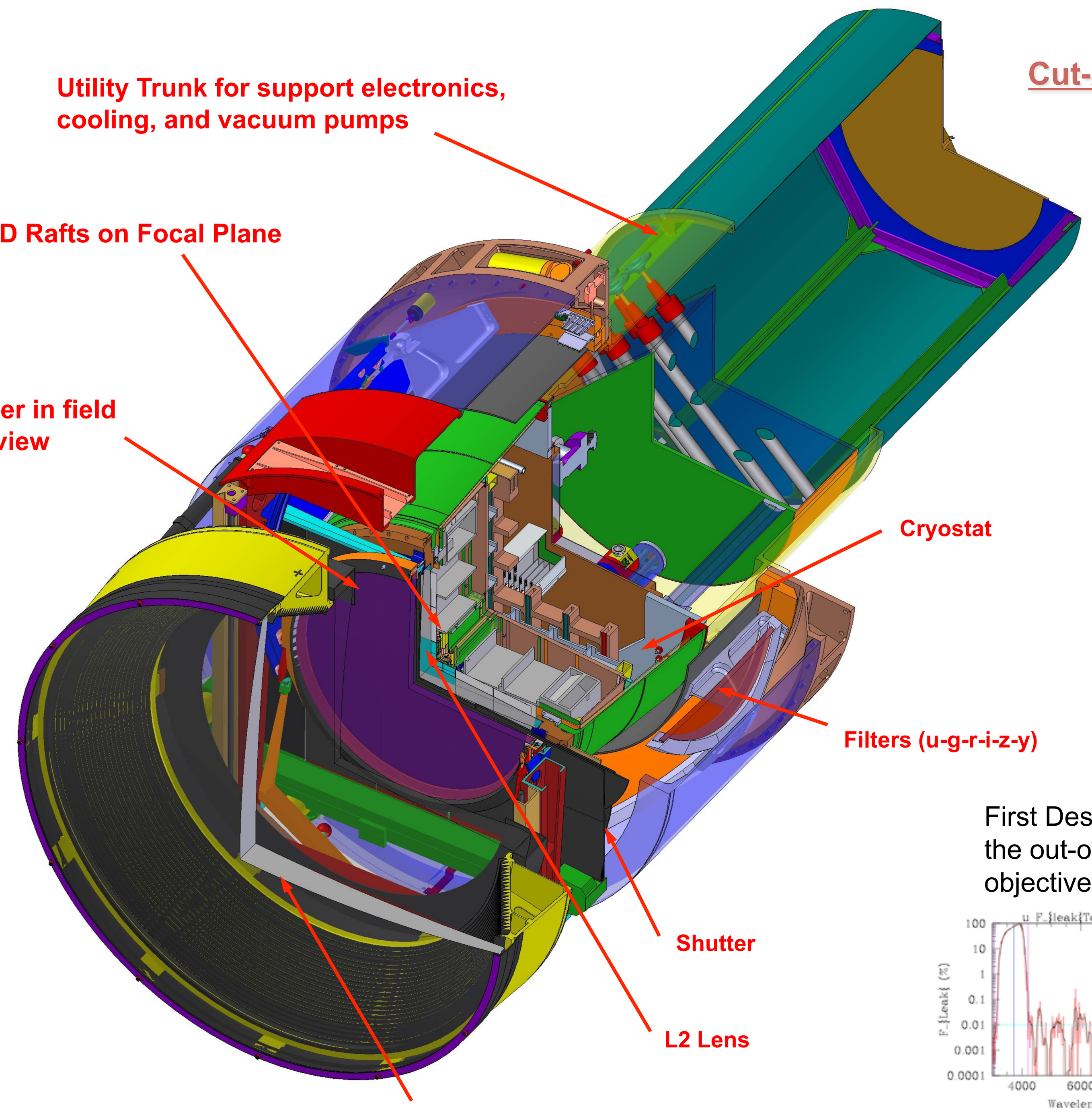
Sensor

Blooming column length: 2000 pixels

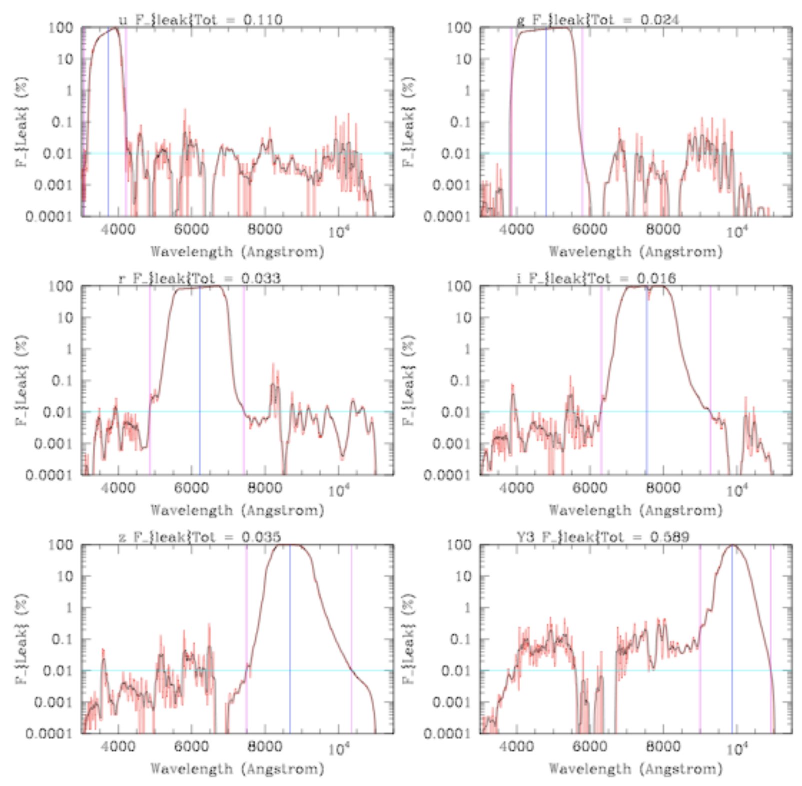




Cut-Away View of LSST Camera Assembly

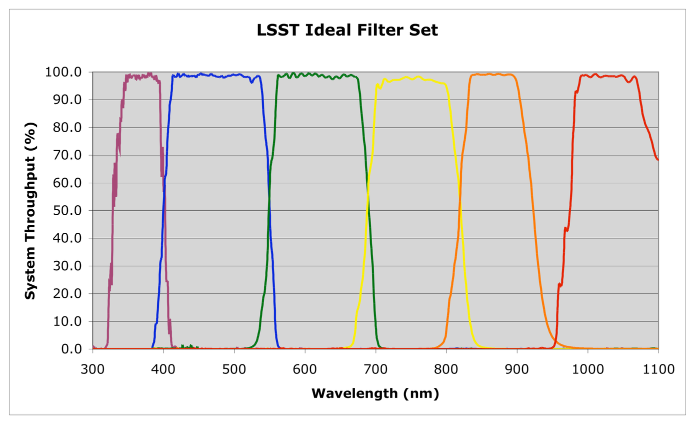


First Design of the LSST filters showing the out-of-band leaks and threshold objectives

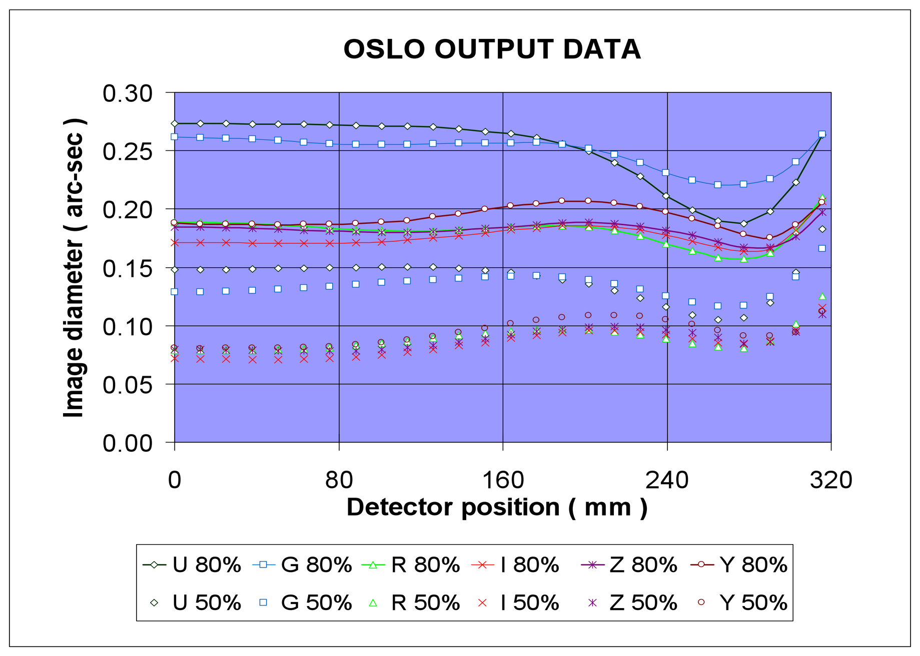


Half-Maximum Transmission Wavelength

Filter	λ_1	λ_2
u	330	400
g	402	552
r	552	691
i	691	818
z	818	922
y	950	1070



- 75 cm dia.
- Curved surface
- Filter is concentric about the chief ray so that all portions of the filter see the same angle of incidence range, 14.2° to 23.6°



Encircled Energy (80%) and (50%)

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