Thermal and Vacuum Design of the LSST Camera

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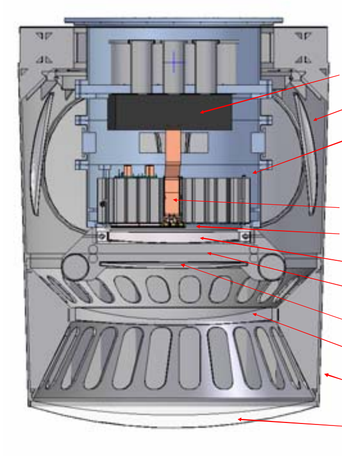
Large Synoptic Survey Telescope

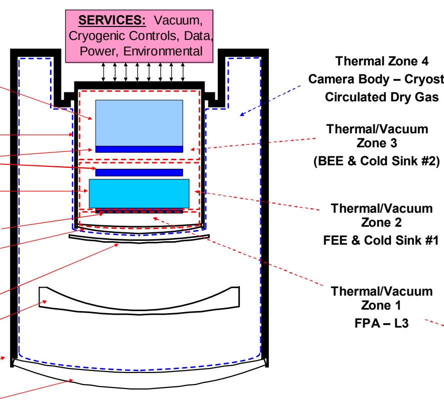
The LSST Camera will be the largest and most complex digital camera ever built. Unlike previous instruments, its design is fully integrated with the optics and mechanics of the telescope to optimally address the science mission. The ~1.6m diameter, ~3.4 ton camera body contains three large refractive optical elements, a carousel of five color filters with an auto-change mechanism, possible provision for a 6th filter, and a large aperture mechanical shutter. These elements lie outside the vacuum vessel (cryostat) housing the 0.64m diameter focal plane array. The focal plane array is comprised of >200 CCD or CMOS sensors operating at 173K in addition to an array of embedded wave front and guide sensors.

The design of a camera meeting the LSST science requirements poses numerous technical challenges for the thermal and vacuum design. In particular, the need for fast (~2 s) image readout implies a high degree of parallelism that demands a complex high density packaging of front end and digitizing electronics that must be located largely within the cryostat. Control of the thermal uniformity across each sensor (for uniform QE) in the presence of environmental radiation and a large electronics heat load, while maintaining a contamination free environment within the cryostat, poses a significant challenge in thermal and vacuum engineering. This poster addresses our present conceptual design of the camera and ongoing work to develop and test the critical mechanical, thermal and vacuum design elements.

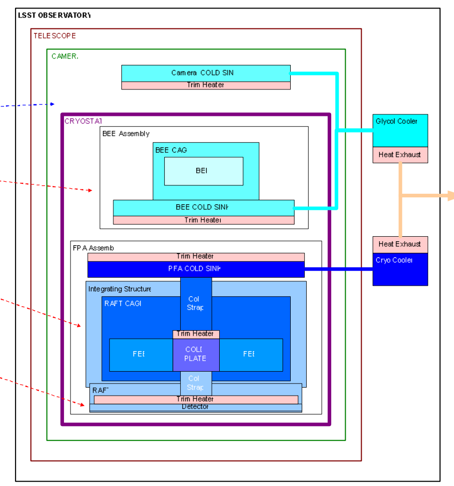
CAMERA ASSEMBLY CROSS SECTION



CAMERA SCHEMATIC



THERMAL & VACUUM SYSTEM SCHEMATIC



PRINCIPLE THERMAL & VACUUM REQUIREMENTS

Maintain focal plane array (FPA) sensor temperature, flatness, alignment and cleanliness in presence of radiative heat load through L3 and proximate heat and vacuum loads of amplifying and digitizing electronics.

FPA COMPOSITION: ~200 4k X 4k x 10µm PIXEL CCD (CMOS)

173 K Sensor Operating Temperature (QE and Noise)
±0.30 K Uniformity Across Sensors (QE)
±0.15 K Absolute Across 64 cm Diameter Array
10µm P-V Deviation Across Array (PSF)

200 K FEE Operating Temperature
260 K BEE Operating Temperature
300 K Camera Body Operating Temperature

FPA Contamination Control

EXPECTED THERMAL & VACUUM LOADS

HEAT SOURCE	FPA COLD PLATE	BEE COLD PLATE
Generated (Electronics)	650 Watts	350 Watts
Conductive (Mechanical)	40 Watts	40 Watts
Radiation (Through L3)	140 Watts	10 Watts
Control Heaters	70 Watts	0 Watts
Total Heat Load	900 Watts	400 Watts
Budgeted Capacity	1800 Watts	800 Watts

ZONE	MATERIALS	EXPOSED AREA	OUT GASSING	PRESSURE (10 Hrs @500 L/s)
		m^2	10^{-6} Torr-L/sec	Torr
1	Metals/Glass/ Ceramic	4.7	907	1.8E-06
	Coated PCB's/ Plastics	0.89	3	
2	Metals/Glass/ Ceramic	18	10602	3.4E-05
	Super Insulation	263	293	
	Cu Thermal Straps	11280	122	
	Coated PCB's/ Plastics	7.9	5761	
3	Metals/Glass/ Ceramic	12	0.28	5.4E-06
	Super Insulation	178	220	
	Coated PCB's/ Plastics	7.3	2468	

THERMAL SYSTEM DESIGN PHILOSOPHY

Focal plane in ~10^{-6} Torr vacuum to eliminate convective transfer.

60mm thick L3 Serves as a vacuum window to the cryostat.

Sensors thermally isolated (except from radiation through L3) & cooled individually by conduction to a cold sink with trim heaters under closed loop control.

Sensor surface not the coldest surface within the cryostat.

Separate cooling loop for digitizing (BEE) & monitoring electronics.

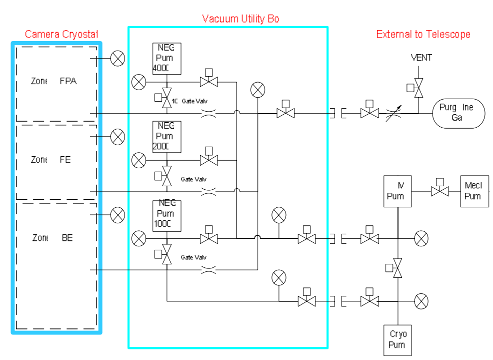
Avoid heat transfer through structural elements to minimize thermal distortions. Use of multi-layer-insulation to reduce radiation.

Cryostat develops simple isotherms along its length and is naturally divided into three thermal zones with barriers in between to reduce molecular flow.

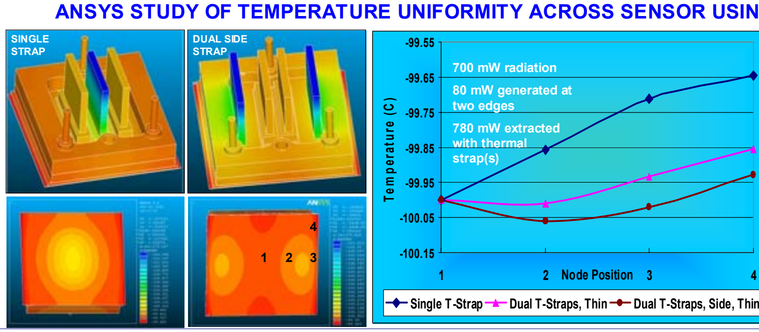
Aluminum Nitride and sintered Silicon Carbide structures chosen for their thermal, mechanical and vacuum properties.

Zone division of the vacuum system is being considered to further improve control of contaminant flow.

ZONED VACUUM SYSTEM CONCEPT



ANSYS STUDY OF TEMPERATURE UNIFORMITY ACROSS SENSOR USING THERMAL STRAPS



4x4 cm^2 Silicon Sensor on Al Nitride Base. 2 X 80 Pin Connectors.

Uniform Radiation Load

Readout Transistors on Two Edges

Studied Cooling of Several Configurations of Thin Cu Straps Braised to AlN Base

All Meet Temperature Uniformity Requirement of ±0.30 K

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