The LSST CCD Test Stands

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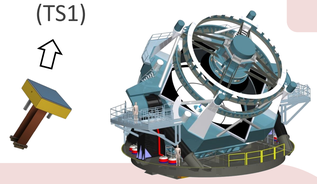
Introduction:

The LSST science sensor production clean room at Brookhaven National Laboratory will be the "factory floor" for testing and integrating sensors and electronics into 21 9-CCD camera modules, called Raft Tower Modules (RTMs). The production environment is organized into enumerated test stands involving the requisite compliment of cryostats, optics, tooling, and metrology apparatus.

The CCD tests and associated custom hardware are highlighted here.

Summary of test stands:

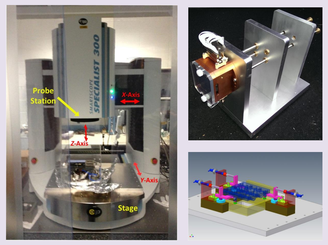
Acceptance (TS1) ⇦ **Height metrology (TS2)** ⇨ **Single-CCD EO Test (TS3)** ⇨ CCD-Raft Integration (TS4) ⇨ **In-vacuum Height Metrology (TS5)** ⇨ RTM Assembly (TS6) ⇨ **RTM Cryostat (TS7)** ⇨ **RTM EO Test (TS8)** ⇨ RTM Ships to SLAC



LSST Sensor Cleanroom

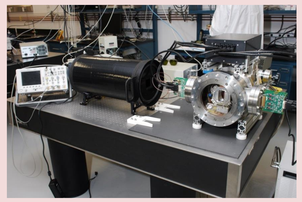
Height Metrology

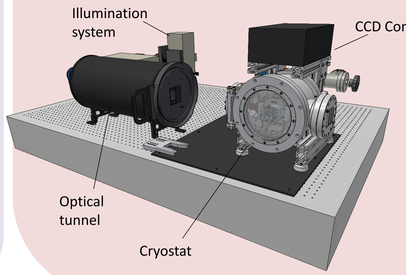
- Measurement of CCD flatness and the absolute height of the imaging surface using a medical CMM
- All tests done in air with CCDs electrically inactive
- Test setup also used for CCD baseplate and 9-CCD array



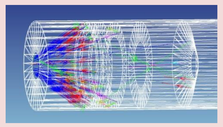
Single-CCD EO Testing

- Initial electro-optical test is most important test a single sensor will undergo. Two instances built.
- Flat field illumination system comprising arc lamp, filters, shutter, monochromator, and integrating sphere feeds optical tunnel.
- CCD read out by commercial controller.
- Linux interface runs test suite, monitors pressure and temperature.
- Cooling provided by Polycold closed-cycle cryocooler
- Chamber supports CCD within its handling jig
- Fe-55 exposure for Charge Transfer Efficiency measurement provided by in-vacuum source-carrier/actuator





Optical tunnel baffle design / analysis



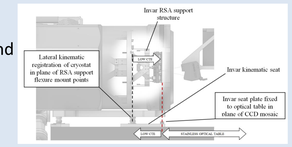
Baffles w/ source

Illumination on output bulkhead

Conical knife-edge primary baffle

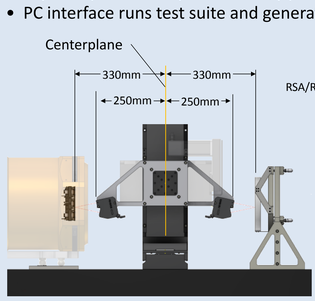
9-CCD In-Vacuum Height Metrology

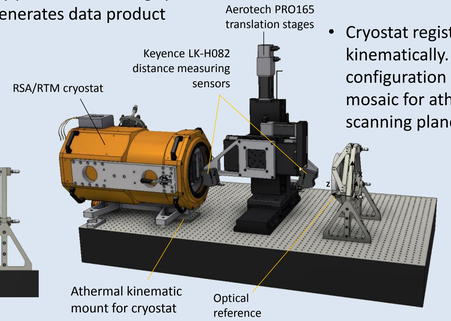
- In-vacuum flatness metrology for the RSA imaging surface (9 CCD mosaic)
- Measures relative deviation in mosaic's surface height to ~.5µm
- Tests Raft Sensor Assembly flatness before integration into Raft Tower Module and again as a complete RTM. Tests occur both at room temperature and at -100°C
- Differential measurement uses optical reference flat and two Keyence LK-H082 triangulation sensors
- Symmetrical design, material choice, and cryostat mounting arrangement are athermalization features.
- Cryostat placed on optical table by powered handling system
- PC interface runs test suite and generates data product



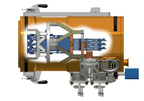
Athermal cryostat support:

- Cryostat registers to optical table kinematically. Flat-Vee-Cone configuration laterally constrains CCD mosaic for athermal spacing with scanning plane
- Thermal movement of mechanical support inside cryostat is counteracted by equivalent-CTE external compensator plate



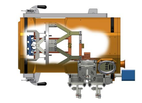


Cryostat configured with complete RTM



RTM installed to cryoplate, RSA held to kinematic balls by pre-loaded RTM hold-down arms

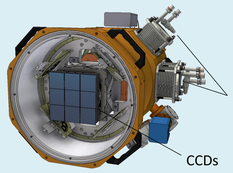
Cryostat configured with RSA only

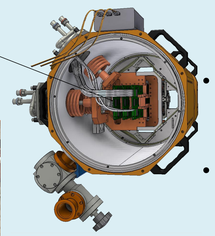


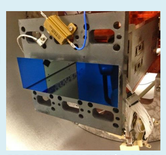
RSA installed alone, held to kinematic balls by tension springs

RTM Cryostat

• For operating complete Raft Tower Modules (RTM) without LSSTCam
• Serves as RTM acceptance test chamber in BNL production cleanroom via test stands 5 and 8
• Self-contained test camera:
-Mechanical interface emulates LSST
-Thermally equivalent to LSST (two thermal zones)
-Rear and front access to RTM for installation/de-installation
• Fe-55 exposure capability provided by 4 X-ray Exposure Devices
• First copy in use now with sensor and electronics development program:
• Operates with closed-loop cooling systems
• Serves as production EO camera (in TS8), cold metrology test chamber (in TS5) for completed RTMs, and for various project-wide testing, including the Commissioning Camera

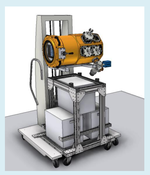




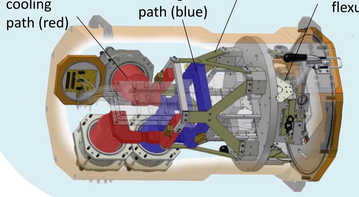


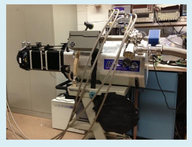
PROTOTYPE RAFT W/ 3 CCDS

- Each RTM cryostat has a dedicated handling cart:
  - Carries cryostat as well as cryocooler compressors
  - Cryostats not to be disconnected from cryocooler compressors for normal operations: cart remains tethered during cryostat handling operations
  - Cart allows cryostat to be rolled and docked to TS8 without special handling
- Commercial (Alum-a-Lift) handling device used to maneuver cryostat for operation with TS5 and for RTM integration
- Cryostat remains on cart (horizontal) for integration of RSA alone for TS5

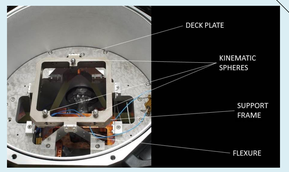


Alum-a-Lift handling device





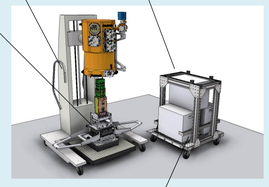
1st RTM Cryostat



CCD raft baseplate kinematic support structure

RTM installation tooling

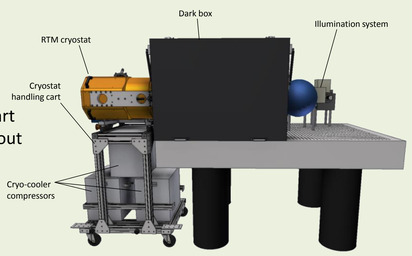
Handling cart



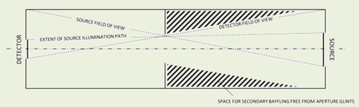
Handling cart carries Polycold compressors, which remain tethered to the cryostat

RTM EO Testing

- 9-CCD (full RTM) version of Test Stand 3. Flat field illumination system comprising arc lamp, filters, shutter, monochromator, and integrating sphere feeds dark box (optical tunnel)
- RTM cryostat docks to dark box, supported by handling cart
- RTM tested as complete/self contained imaging and readout system for first time after final assembly
- Data fed from cryostat to DAQ optically
- PC interface (CCS) controls RTM and runs test suite
- RTM cryostat (also Commissioning Camera cryostat) provides LSSTCam-like dual thermal zone operating environment for RTM
- Fe-55 exposure provided by four X-ray Exposure Devices (XEDs): in-vacuum source-carriers/actuators

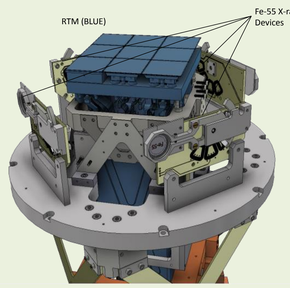


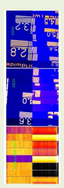
PRIMARY BAFFLE SCALING AND PLACEMENT



RTM (BLUE)

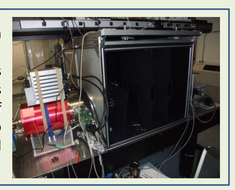
Fe-55 X-ray Exposure Devices





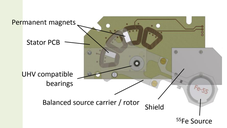
Current RTM Testing Program

Primary custom opto-mechanical component is dark box, which is revised version of dark box setup previously used for R&D testing.



X-ray Exposure Devices

Custom in-vacuum radioisotope source carrier and actuator, present in all electro-optical cryostats.



- Fabricated using conventional printed circuit board manufacturing methods.
- To eliminate the possibility of virtual leaks from normal motor windings, stator coils were designed into a monolithic PCB, making an intrinsically vacuum-compatible foundation for a motor, as well as mechanical baseplate.

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