Large Synoptic Survey Telescope

The LSST CCD Development Program

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The LSST focal plane array (FPA) will be the largest ever made. The sensors must produce low read noise, high QE in the red, and a very tight PSF. This will all be necessary to do the science at the LSST. The principle underlying the development plan is that for an FPA involving about 200 large format (4k x 4k) sensors, an industrial approach has to be developed and adopted. In this initial phase of CCD development, we have targeted specific technology challenges at competitively selected vendors, with the goal of establishing both the technical characteristics of actual sensors, based on our projected requirements, and the industrial feasibility of their production. The CCD technology challenges we have targeted in particular are over-depleted high resistivity devices in the 100 micron thickness range with a biased conductive window. Initial test results from the first devices in a smaller format resulting from this study program will be presented, demonstrating that these challenges can be overcome..

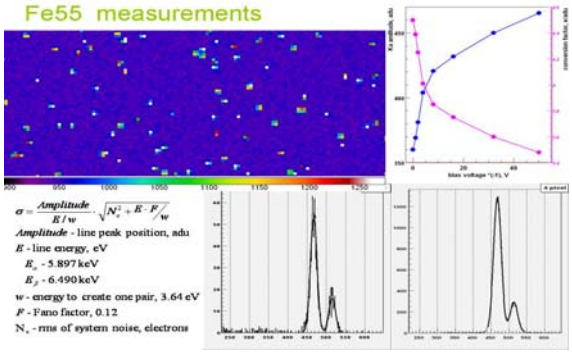
CCD sensors development program

- industrial approach
  - study devices from industrial vendors are already available for testing
- technology challenges
  - thick ~100um devices with biased conductive window
  - high resistivity silicon substrate
  - over-depletion to create high E field
- sensor characterization
  - optimized setups for specific tests
  - data acquisition automation
  - data analysis packages

Sensor characterization procedures

- QE measurements
  - monochromator setup
- PSF measurement techniques development:
  - virtual knife edge technique
  - modulation transfer function MTF
- Fe55 measurements
  - gain, CTE, noise
- Dark current and defects characterization
- Linearity and Well capacity
- Afterglow (residual image)
- Flatness measurement station

Fe55 measurements



$$\sigma = \frac{Amplitude}{E\,l\,w}\sqrt{N_e^2 + E\cdot F/w}$$

Amplitude - line peak position, adu
E - line energy, eV
E_{α} - 5.897 keV
E_{β} - 6.490 keV
w - energy to create one pair, 3.64 eV
F - Fano factor, 0.12
N_e - rms of system noise, electrons

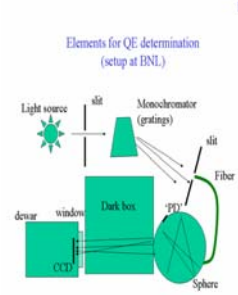
Sensors key performance requirements:

- Quantum Efficiency (QE)

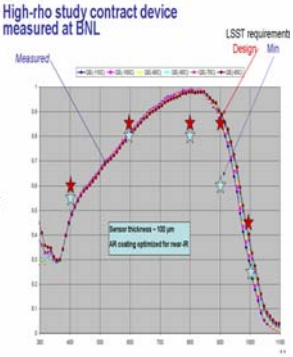
Sensor Quantum Efficiency			
Wavelength	Design	Min	Unit
400 nm	60	55	%
500 nm	85	80	%
800 nm	85	80	%
900 nm	85	60	%
1000 nm	45	25	%

- Point Spread Function (PSF)
  - PSF << 0.7" (0.2")
  - → pixel size (0.2" = 10 μm)
  - → high internal field in the sensor → bias voltage ~50V
  - → high resistivity substrate (> 5 kOhm·cm)
- Dark current and defects
- Afterglow (residual image)
- Gain, Linearity, Noise, Crosstalk, Charge Transfer Efficiency CTE, Flatness, Operating temperature, Temperature uniformity & stability, etc.....

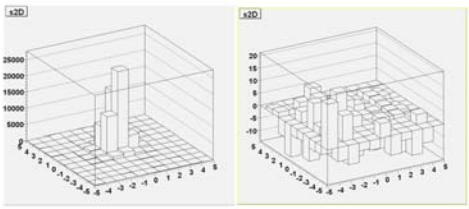
QE setup and results



High-rho study contract device measured at BNL



Afterglow (residual image)

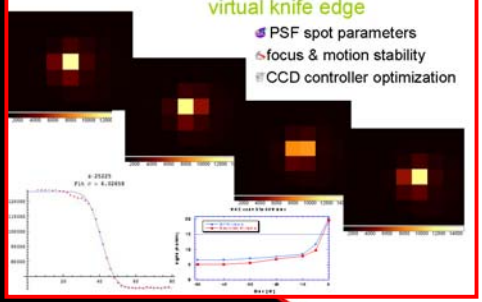


- bias subtracted using zero exposures
- no "after glow" signal on the level of 0.03% (measurement accuracy)

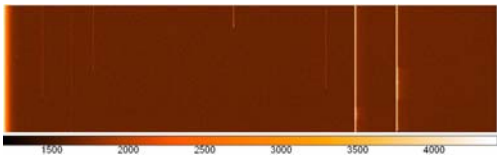
PSF measurement techniques:

virtual knife edge

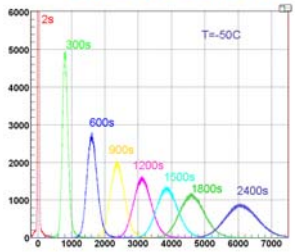
- PSF spot parameters
- focus & motion stability
- CCD controller optimization



Leakage Current measurements



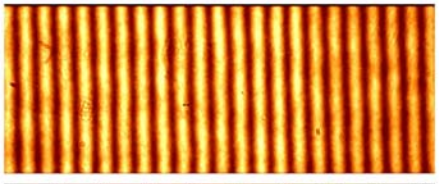
Leakage Current

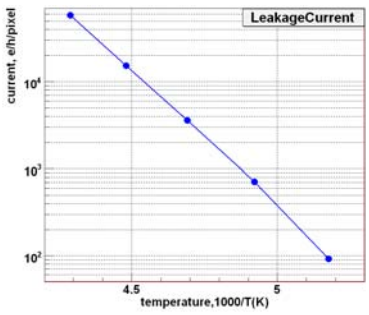


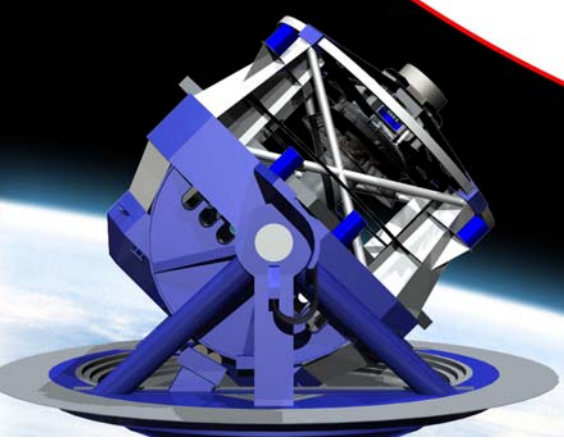
PSF measurement techniques:

modulation transfer function MTF

- MTF projector
- stabilities & vibrations
- analysis







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