AFTA WFIRST
Detector Development Status Summary

January 2014

Background

- The current AFTA WFIRST Wide-Field Imager configuration is based on a mosaic of 4K x 4K near-infrared detectors.
- The Project initiated detector development in FY11 with a successful Pilot Run Lot of detectors at Teledyne Imaging Sensors that were then characterized during FY12.
  - 4K x 4K, 10 μm pixel pitch, H4RG-10 ROIC, 2.1 μm cutoff.
  - The results pointed to the need for some minor process improvements that are now put in place.
- A series of small process development experiments were put in place to address the issues identified during the Pilot Run.
- In FY13, the Project started a more extensive Process Optimization Lot of detectors that will be used to optimize the potential flight recipes.
  - 4K x 4K, 10 μm pixel pitch, H4RG-10 ROIC, 2.5 μm cutoff.
  - These devices are just starting to be delivered, with the final device near the end of FY14.

Development Plan – Current Lot – Process Optimization

- The current lot is intended to sample the parameter space for several key parameters in the recipe in order to optimize performance and yield.
  - These detectors are "banded," meaning that the 4K x 4K area is split into 8 distinct pixel geometries.
  - The growth and processing of the detector material is also varied.
- The experiment matrix allows for sampling three major variants with some additional lot splits.
  - Not all variants are expected to perform well.
  - They are intended to bracket the desirable process ranges.
- In parallel, some devices are being subjected to life testing (long-term cold soak) in order to establish detector reliability.

Current Status

- Roughly half of the planned detectors have been completed, and testing is in progress.
- Performance continues to look very promising.
- Evaluating the material used for the mounting bases.
  - The original material may result in channel cracking in some devices.
  - An alternative base material is being explored
- Testing of all the devices from the Process Optimization Lot will be complete by the end of FY14.

Notional Detector Performance Targets

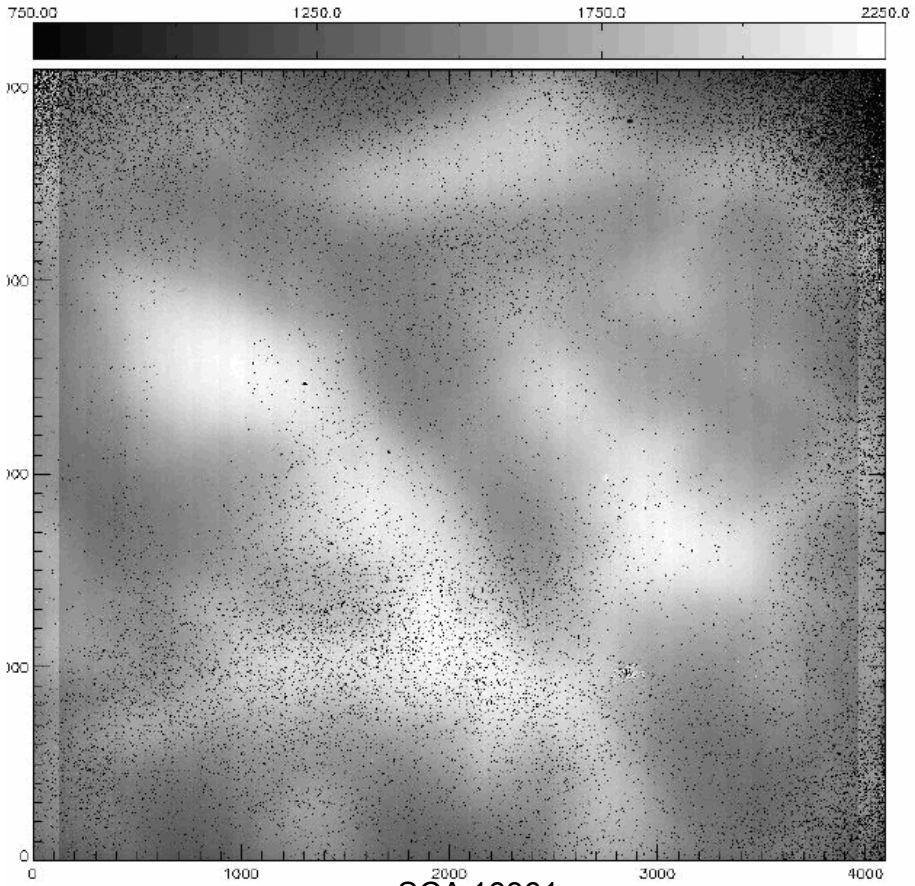
- Detailed flowdown of scientific requirements is in progress, including important simulations using the planned observation strategies.
- Until these detailed requirements are completed, a notional set of performance targets are used.
- Operating temperature is still an open trade, but is expected to be in the 80-100K range.
- Dark Current: < 0.05 e-/sec
- CDS Readout Noise: < 20 e-
- Total Noise: < 5 e- (in 150 sec)
- Quantum Efficiency: > 70%
- Persistence: < 0.01% (after 150 sec)
- Inter-Pixel Crosstalk: < 8% (total)

DRAFT: actual values pending SDT inputs.

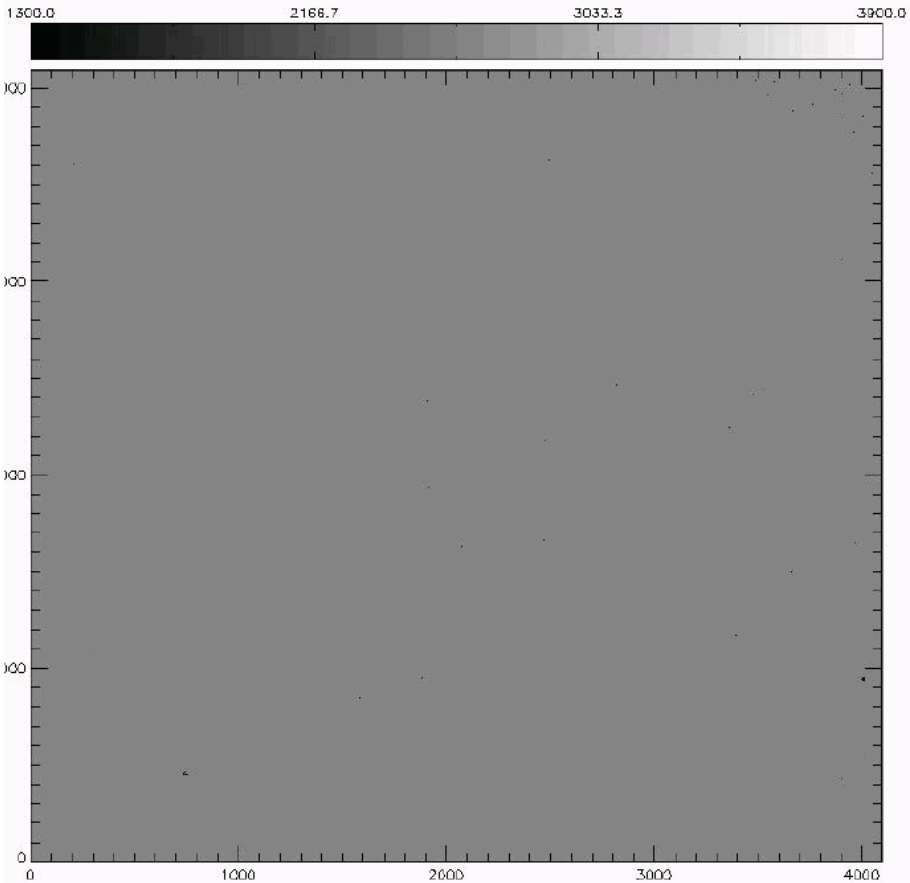
Initial Results

- Results are preliminary, based on testing an incomplete sample of variants and the parallel development/debugging of test procedures.
- Previously discovered interconnect issue appears to be resolved.
- Previously discovered high CDS noise appears to be resolved.
- Dark current looks very good.
  - See attached plots.
- Some edge effects in dark current may be process-induced or a result of ROIC glow.
  - Cause is under investigation, and potential ROIC modifications are being explored.

Interconnect Issues Appear To Be Resolved

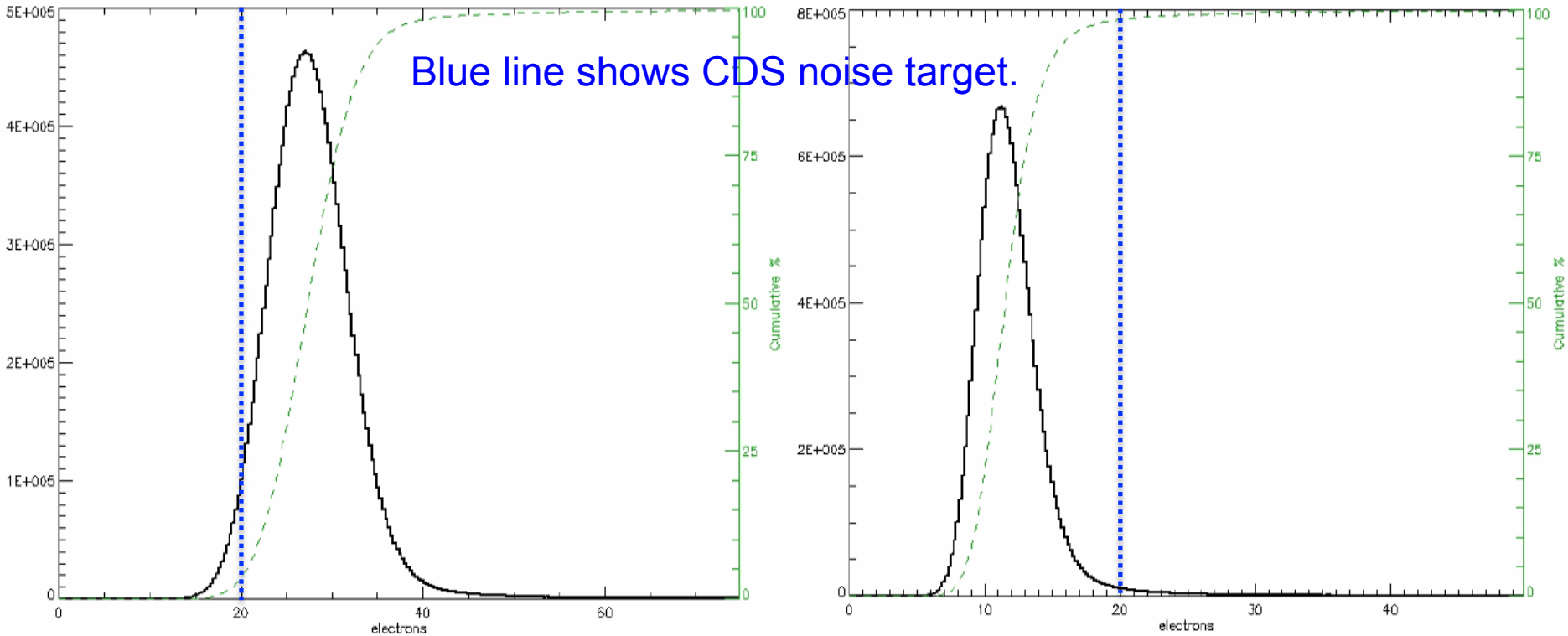


SCA 16361
(Previous Pilot Run Lot
Ignore the “cloudy” pattern which is an illumination artifact.
Black dots indicate interconnect failures, ~5%)



SCA 17429
(Current Process Optimization Lot;
< 0.5% interconnect failures)

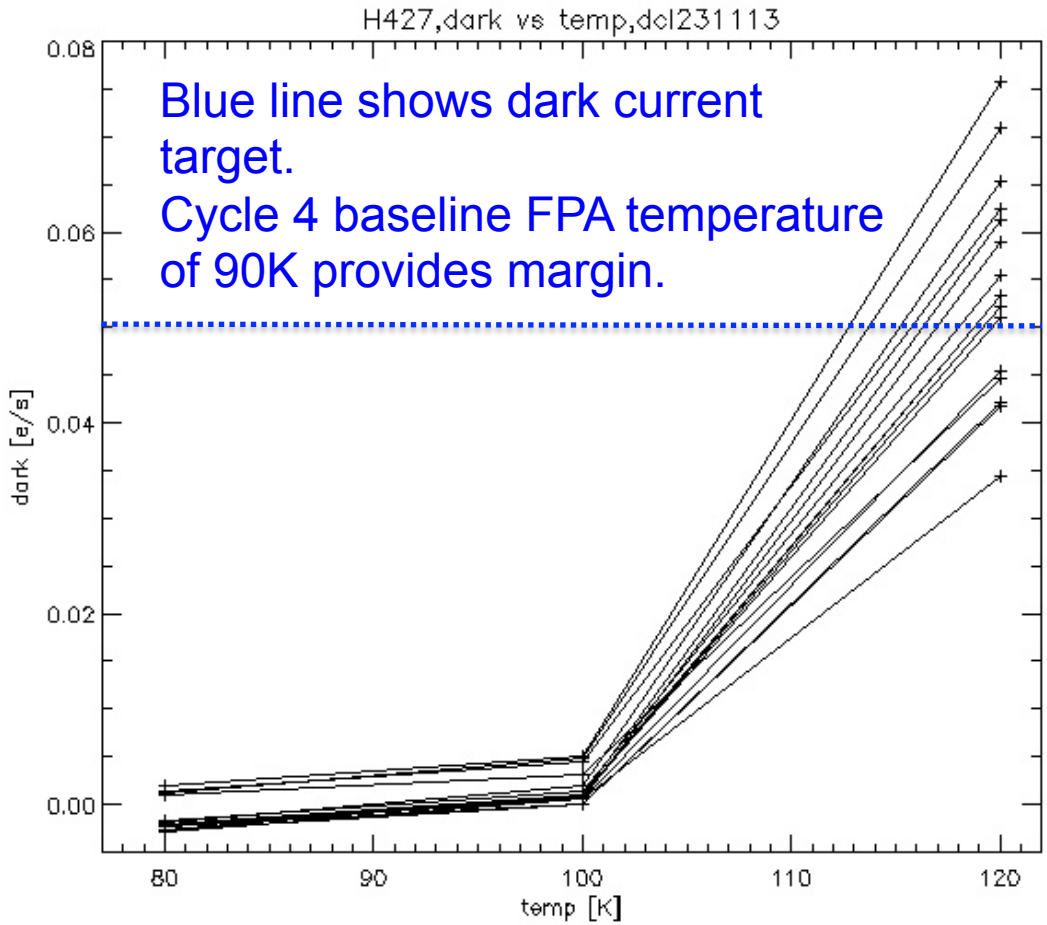
CDS Noise Is Much Improved



SCA 16360
(Previous Pilot Run Lot)

SCA 17427
(Current Process Optimization Lot)

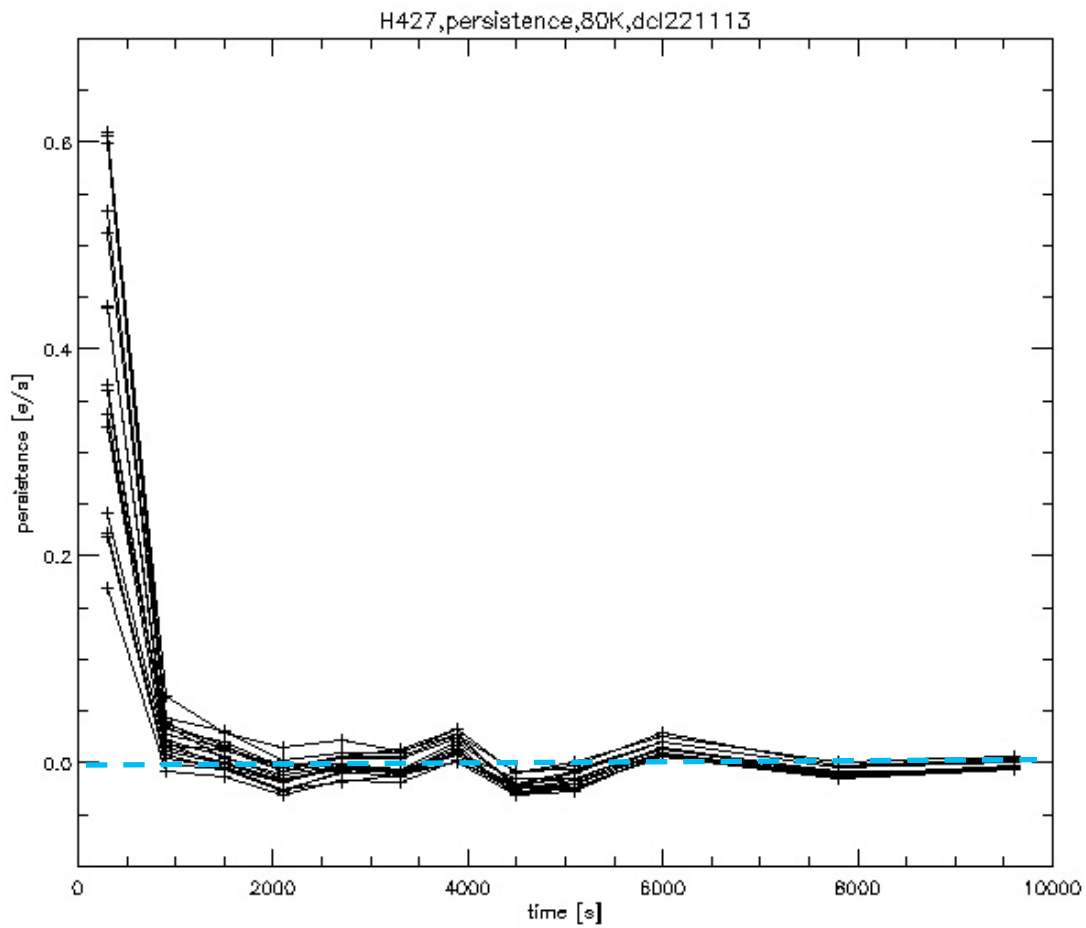
Example Dark Current



The lines are the different “bands.”

Persistence Is Acceptable

- SCA 17427 results are shown.
- Persistence measured using sequence of 10m exposures followed by 3 longer exposures.
- Exposure level is ~ 80,000 e-.
- Low persistence at 100K and below, increasing with temperature.
- Persistence spread within first file requires further investigation.
- Some correction will be required for 150 sec sequential frames.

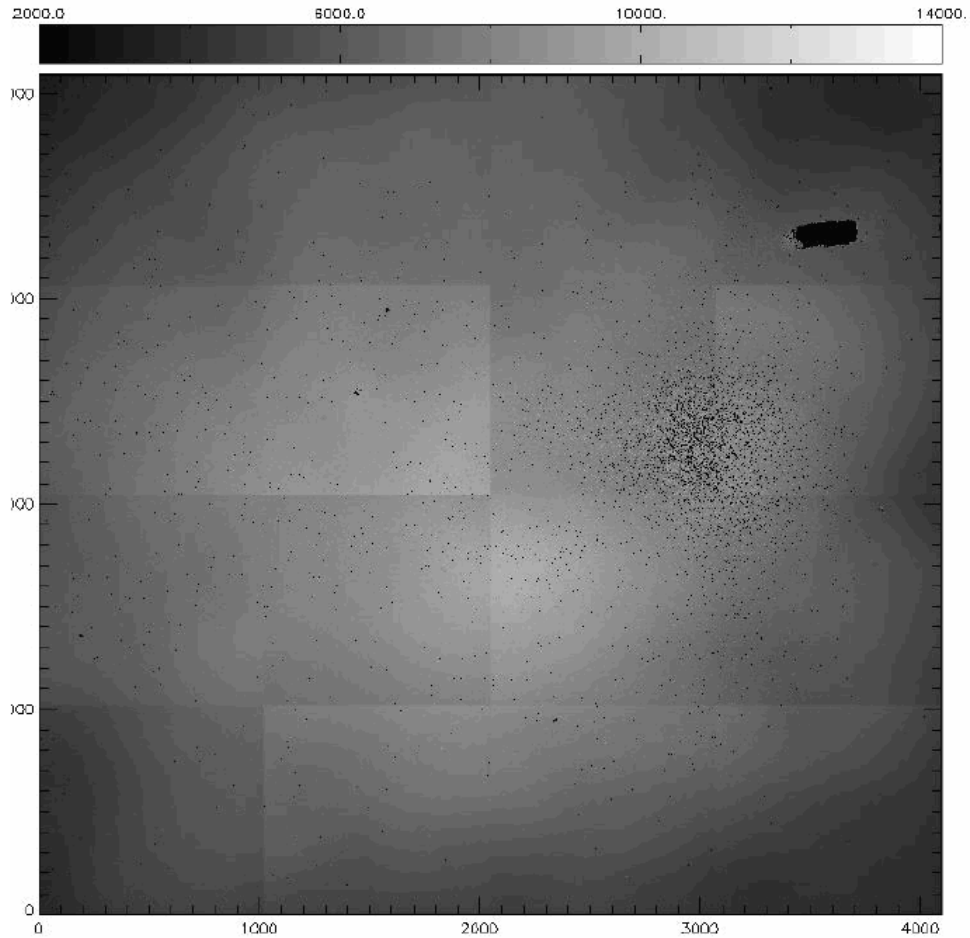


Example Flat Field Response

SCA 17457
(Current Process Optimization Lot)

Note some minor interconnect issues for this device.

Illumination was not uniform for this test.



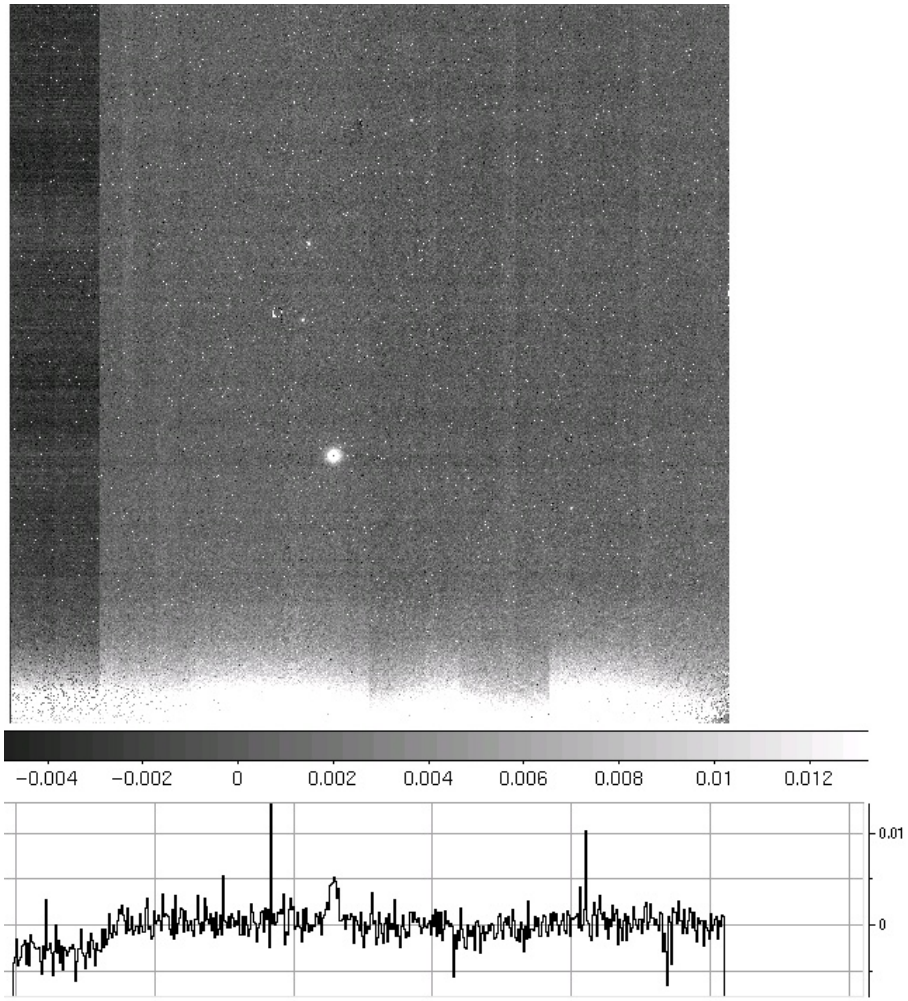
Example Edge Effect

SCA 17427
(Current Process Optimization Lot)

80K

Even the lower edge is below 0.01 e-/sec.

Performance target is 0.05 e-/sec.



Development Plan – Next Lot – Full Arrays

- We anticipate that towards the end of FY14, the data from the current lot will be fully analyzed to support a downselect for the recipe parameters.
- The next lot is intended to be full arrays (not banded) using one major variant with possible minor lot split.
  - This will guide the exact parameters to use for the flight build.
  - It is possible we may build two major variants in case there are still some questions.
- The analysis of the next test lot will be completed by mid-FY15.
  - Assumes that the planned testing infrastructure improvements are realized during FY14.

Development Plan – Yield Demonstration Lot

- The final non-flight lot we plan to build is the Yield Demonstration Lot.
- In this lot, a single flight recipe will be used and will provide confirmation that the necessary yield is achievable (with the appropriate performance).
- These detectors are expected to be of fairly high quality, and will be using during development as engineering devices, for qualification testing, and for detailed performance characterization.
- Completion of the Yield Demonstration Lot is planned to be in FY16, after which the flight build can be started.

Summary

- A plan is being executed for early development work to minimize the risk of using these detectors.
- Initial results look very promising for the current Process Optimization Lot.
- Successful execution requires consistent effort and funding over the next two to three years.