Run 6 plan

6th EO testing in I&T and Commissioning

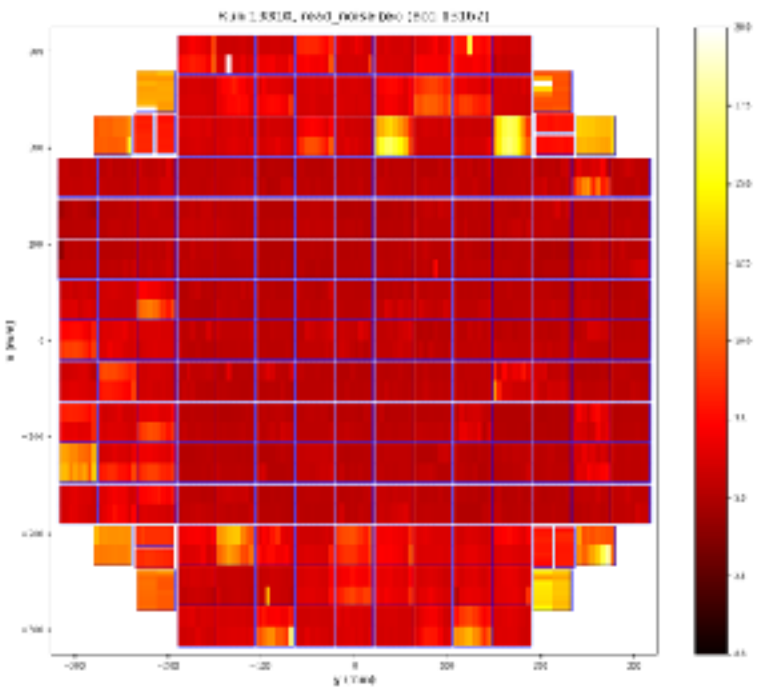
Yousuke Utsumi (SLAC)

Recap of Run 5

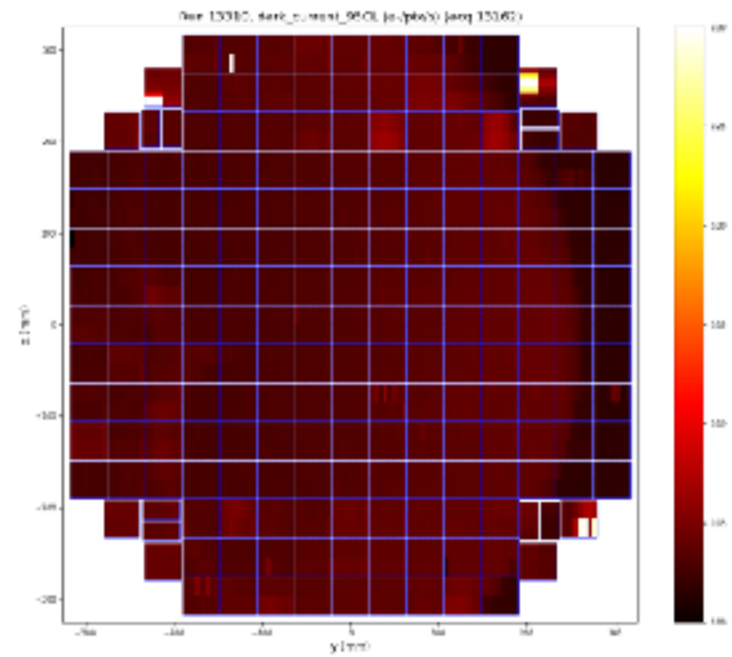
- 2021 Autum—Winter
- Optimization
  - v26 sequencer and new voltage were determined
    - **ITL gain stability** by OD=26.9
    - **Tearing mitigation** for e2v by dPclk=9.3
    - **Noise reduction** by a longer ramp time and ASPIC gain was changed for mitigating bias shift
    - **Improved full well** for ITL by increased Parallel timing (TimeP/OverP)
- Characterize full focal plane performance
  - read noise, dark, full well, linearity
- Detailed study with speciality projectors
- **Cold system major instability…**

Characterization

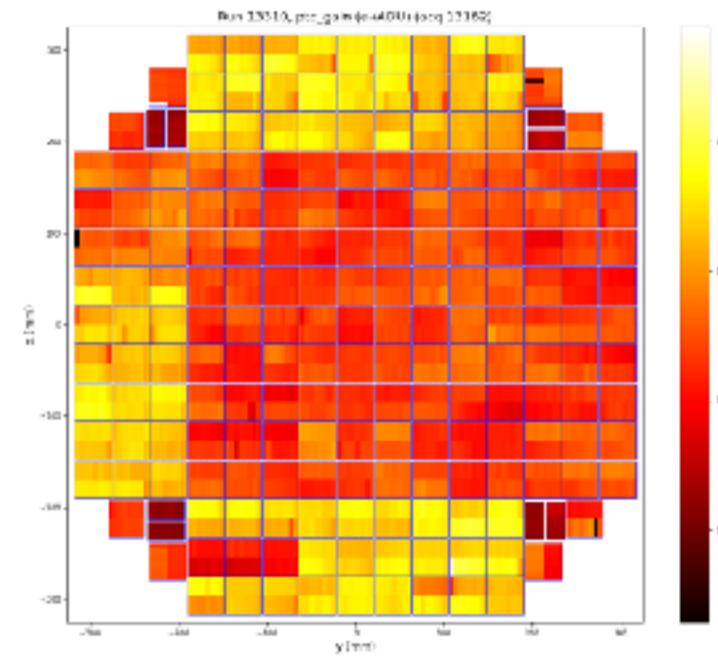
Read noise



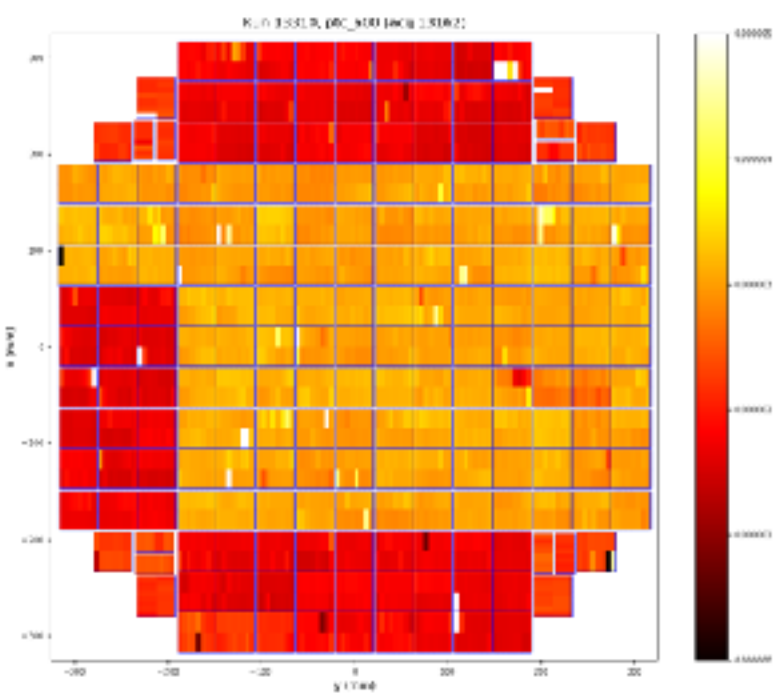
Dark current



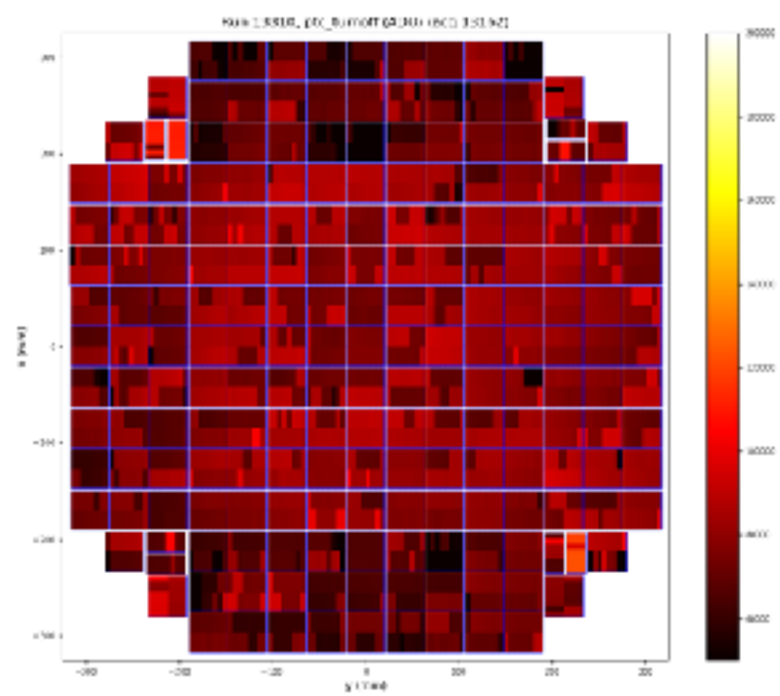
PTC gain



PTC a00



PTC turnoff



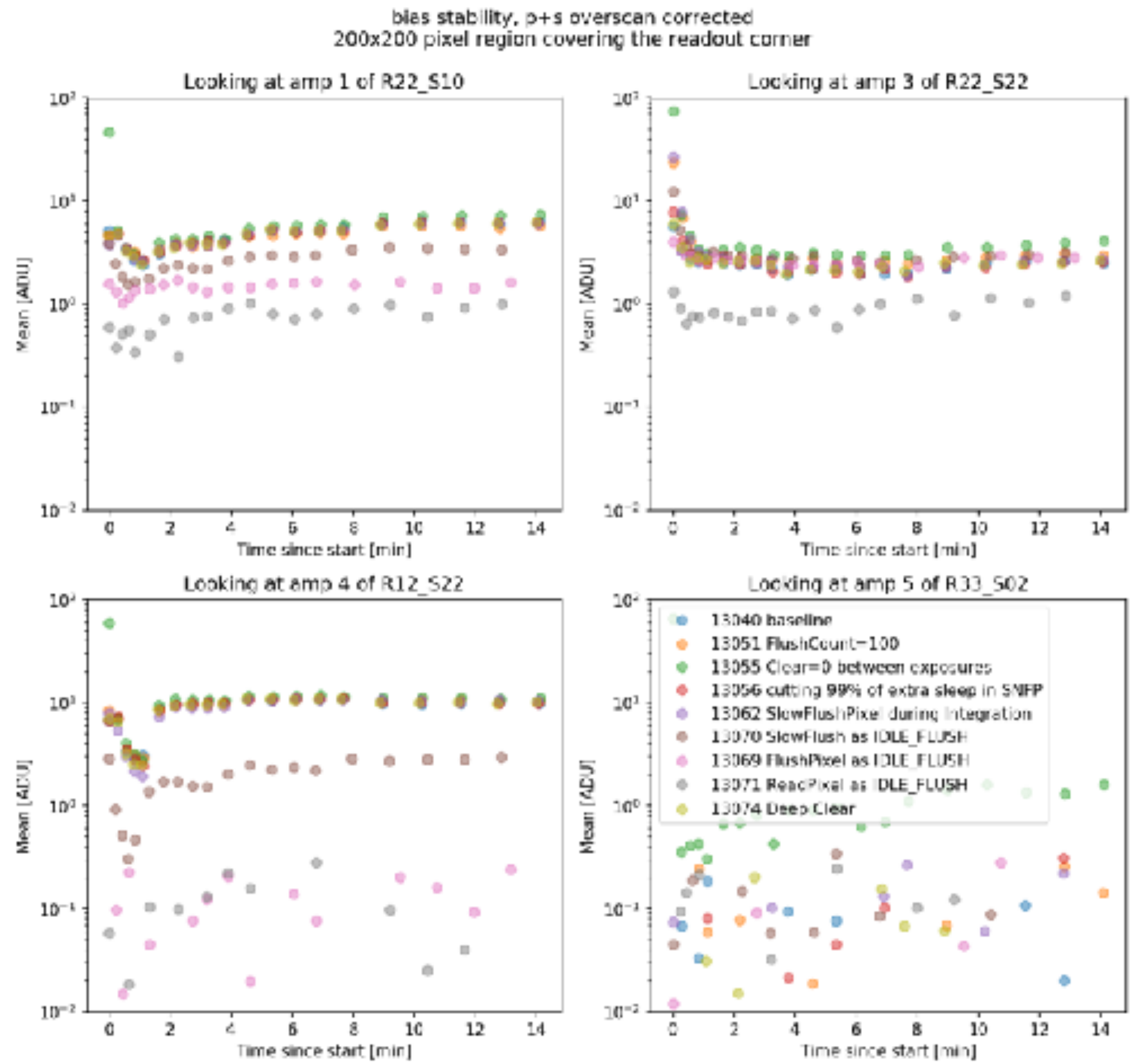
- 45 plots in focal plane level
- 14 plots in Raft level
- 8 plots in sensor level
- ~2000 plots

- Jim's eotools automated characterized the focal plane

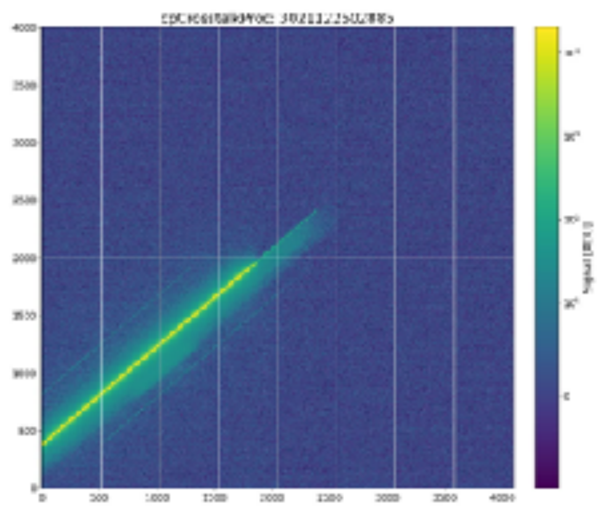
e2v bias stability improvement

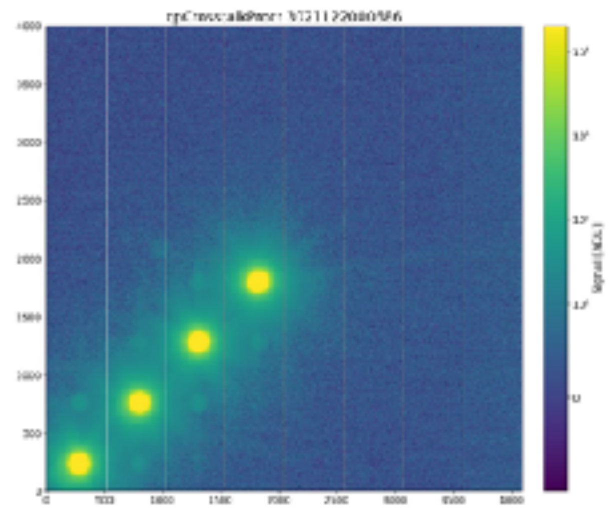
v26 sequencer

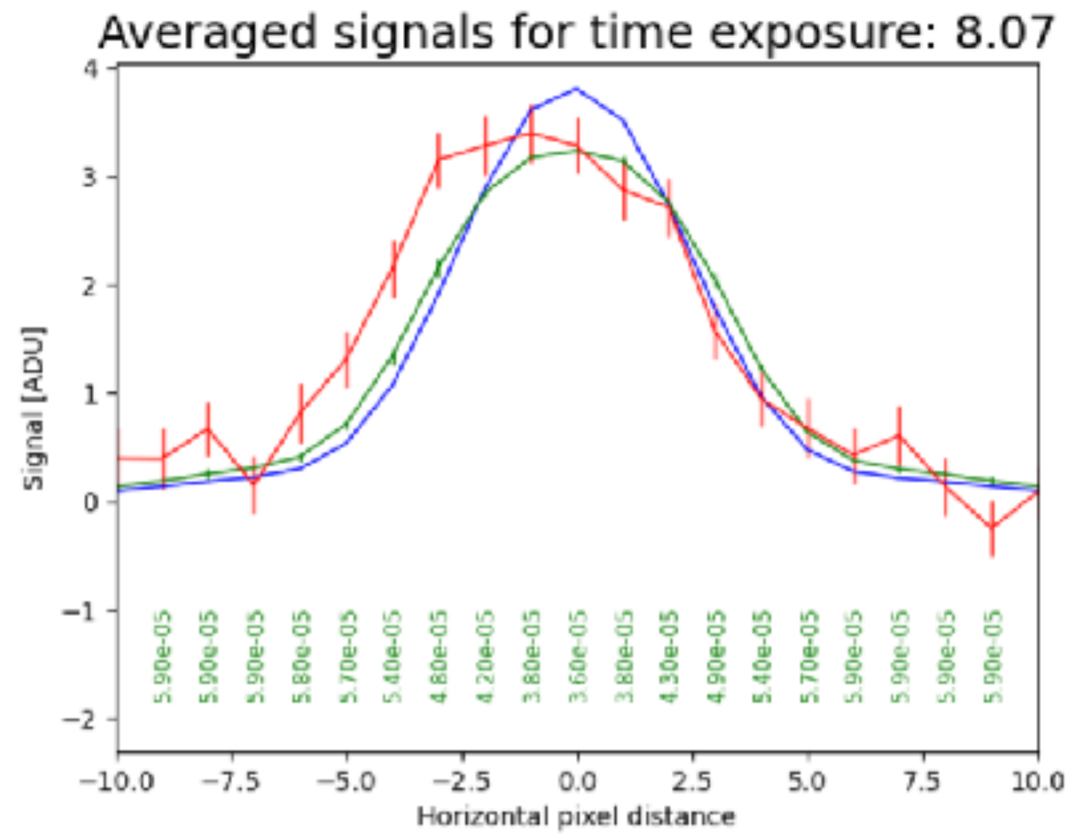
- **No effect**
  - **FlushCount: 10->100**
    - # of serial register flushes before readout
  - **Clear=0**
    - No clear between exp
  - **Cutting 50, 90, 99% of extra sleep in SlowNoFlushPixel**
    - faster toggling of CL during integration
  - **SlowFlushPixel during Integration**
    - flushing serial register continuously during integration
  - **Lamp was off**
  - **Changing Temp**
  - **Deep Clear**
- **IDLE_FLUSH improved, especially ReadPixel as IDLE_FLUSH worked well**
  - **IDLE_FLUSH**
    - Running the sequencer between exposures
    - **SlowFlush / FlushPixel / ReadPixel**



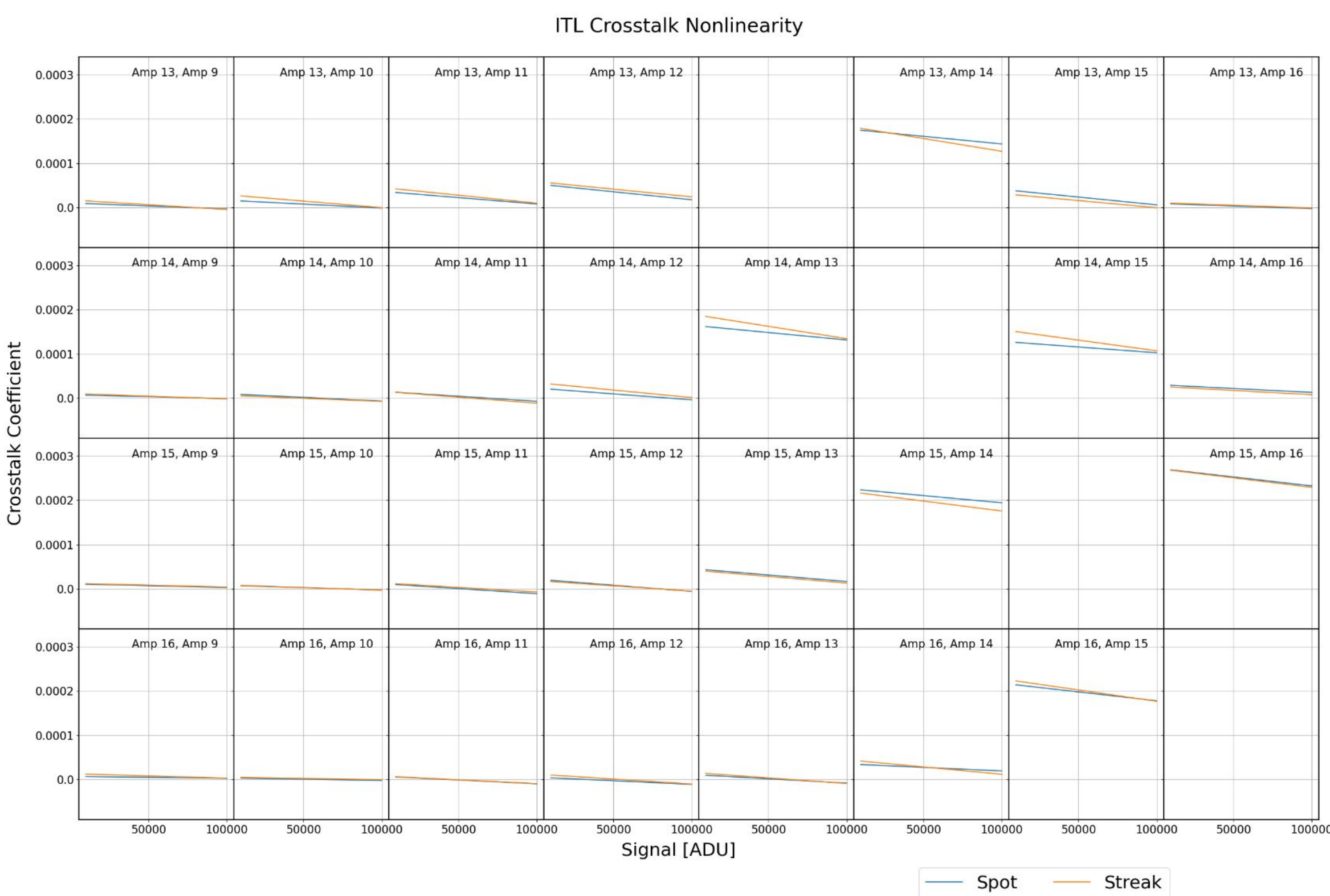
X talk study

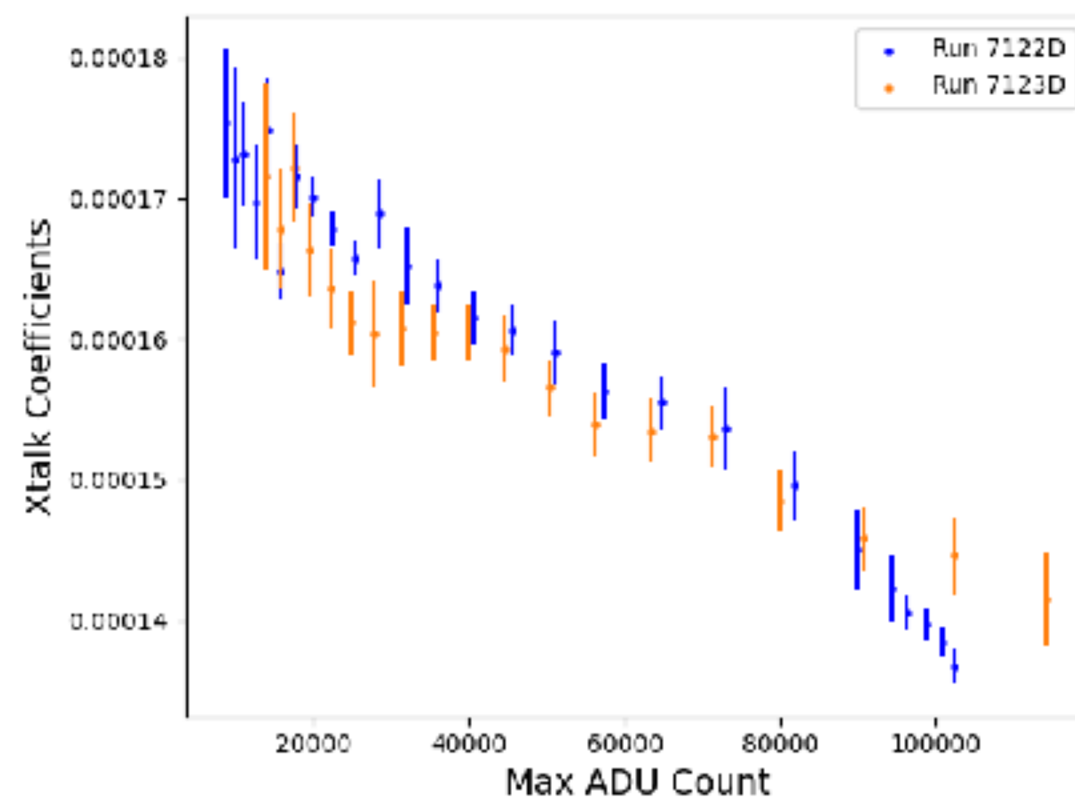






Berni Confirmed P. Astier's delayed X talk component.

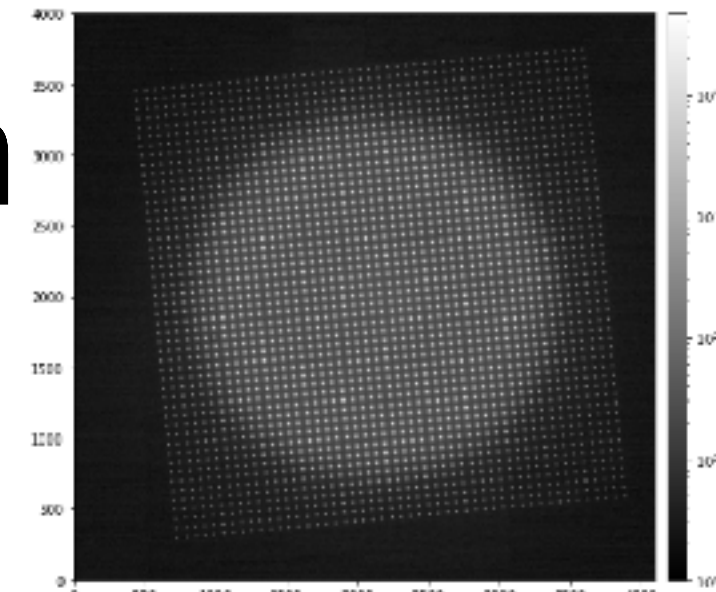




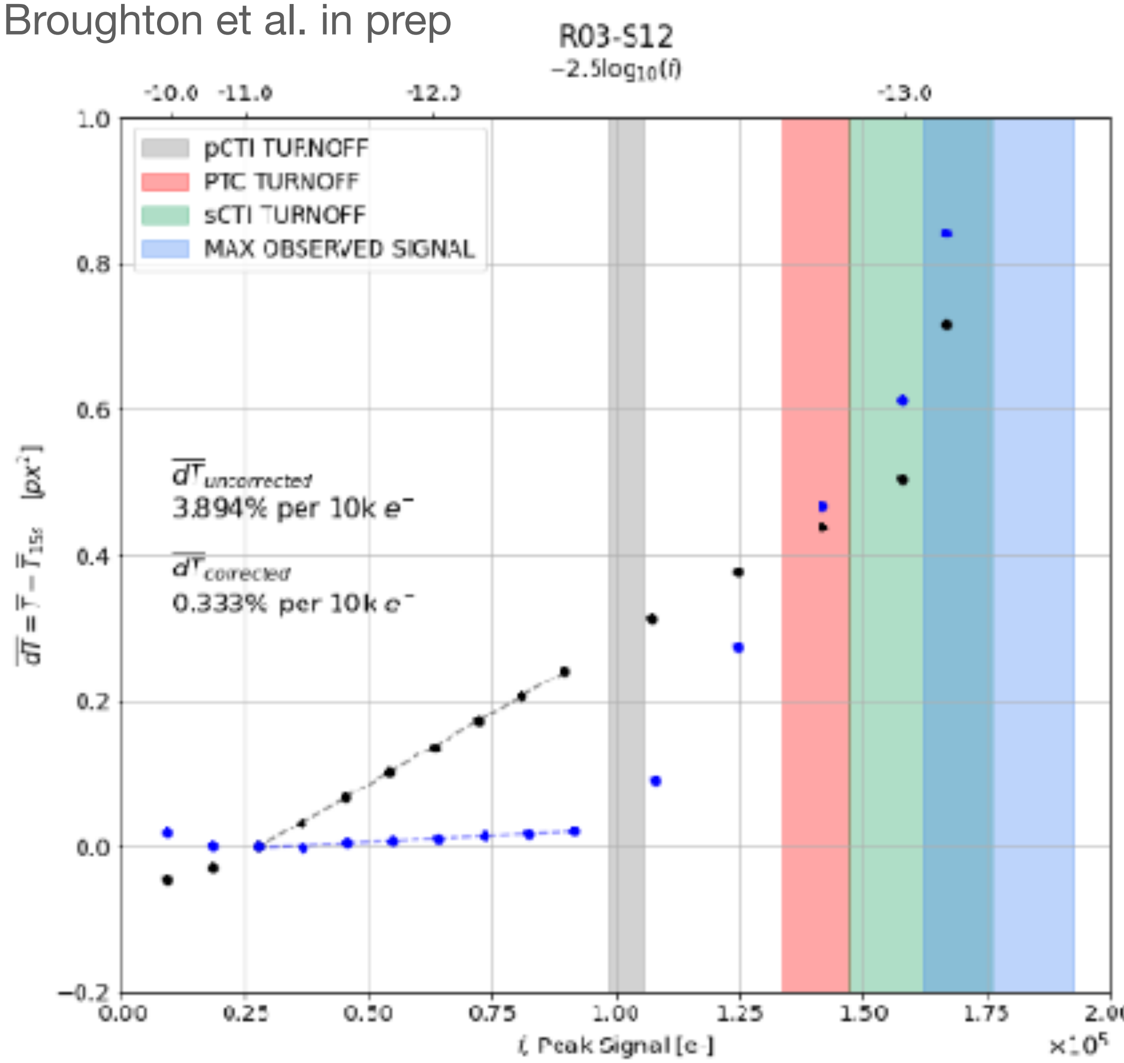
Adam & Andrew derived Xtalk coefficients for all sensors from different methods using **spots** and **streak** based on **model fit** and **pixel basis**

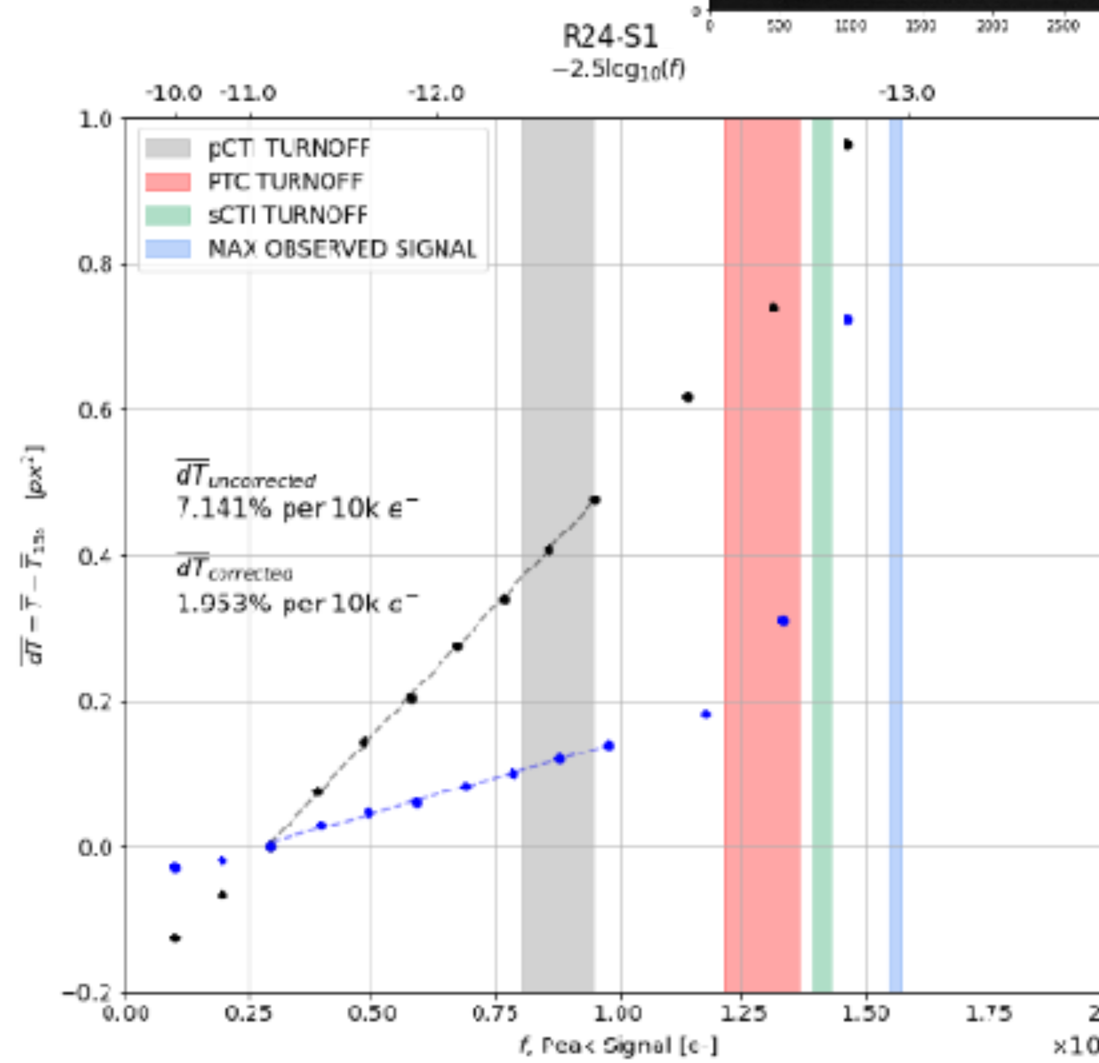
Shuang finds *almost* consistent X-talk with different ASPIC gain

Brighter Fatter Correction



Broughton et al. in prep

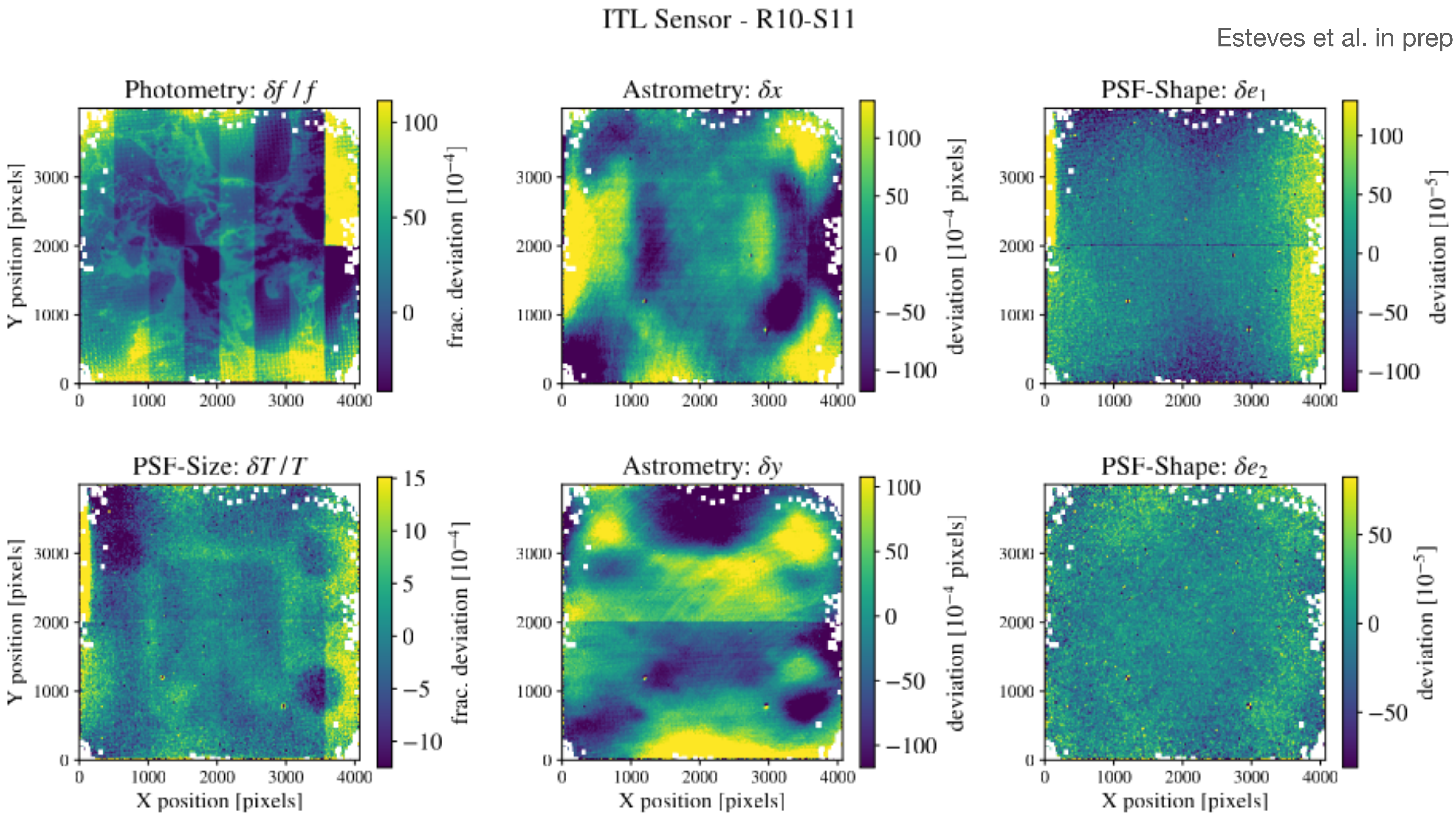




- Preliminary result
- The current implementation works for ITL but not for e2v

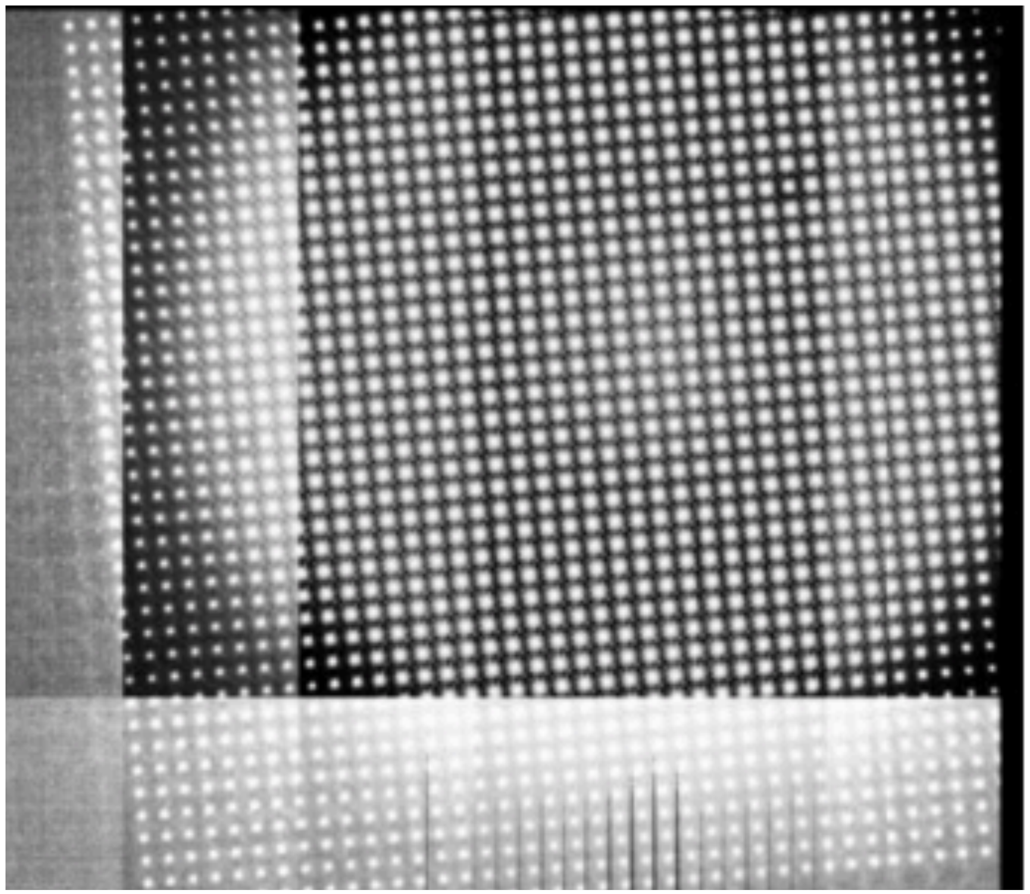
Artificial star measurements

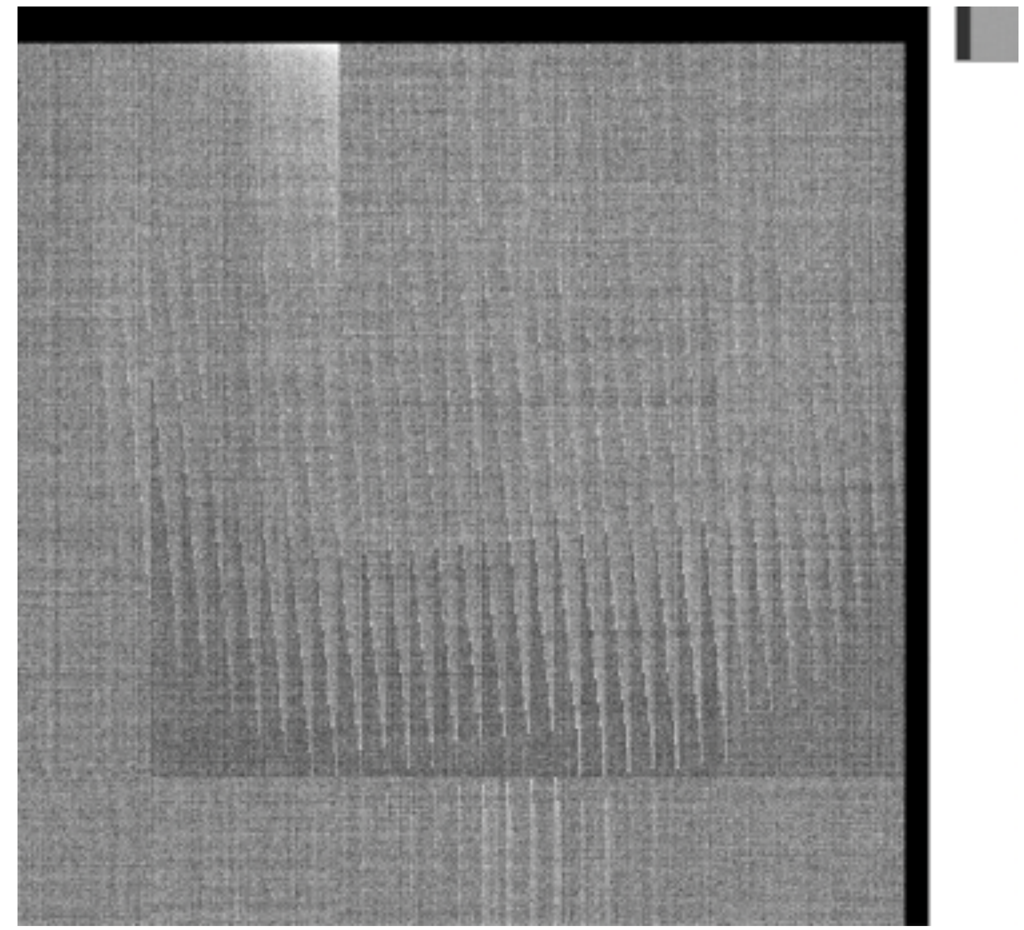
Esteves et al. in prep



- Features induced by tree-ring, mounting support stress, surface finish
- Sensors are not arrays of perfect rectangular pixels

Persistence with the spot projector

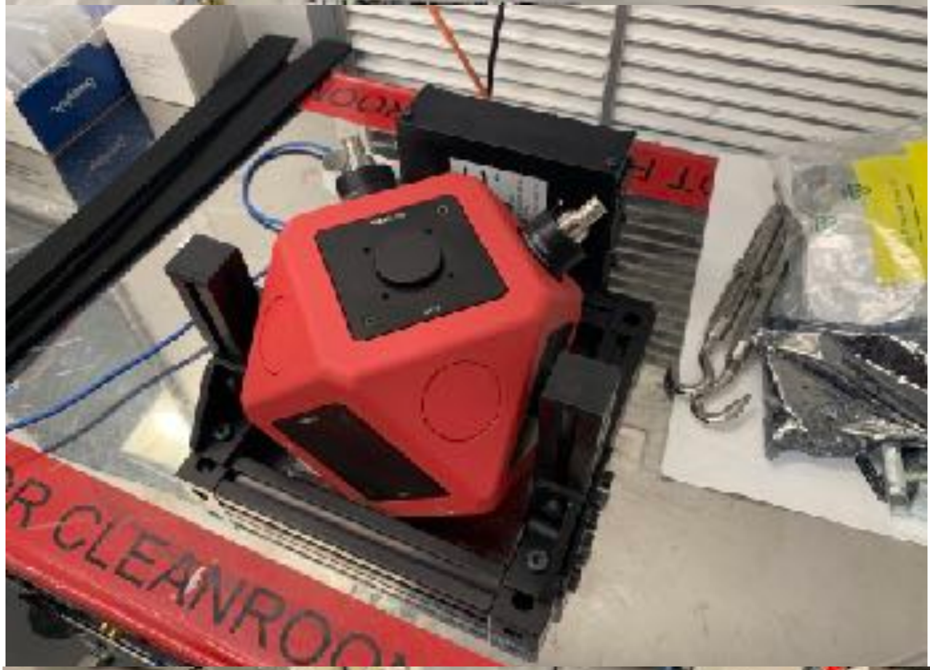


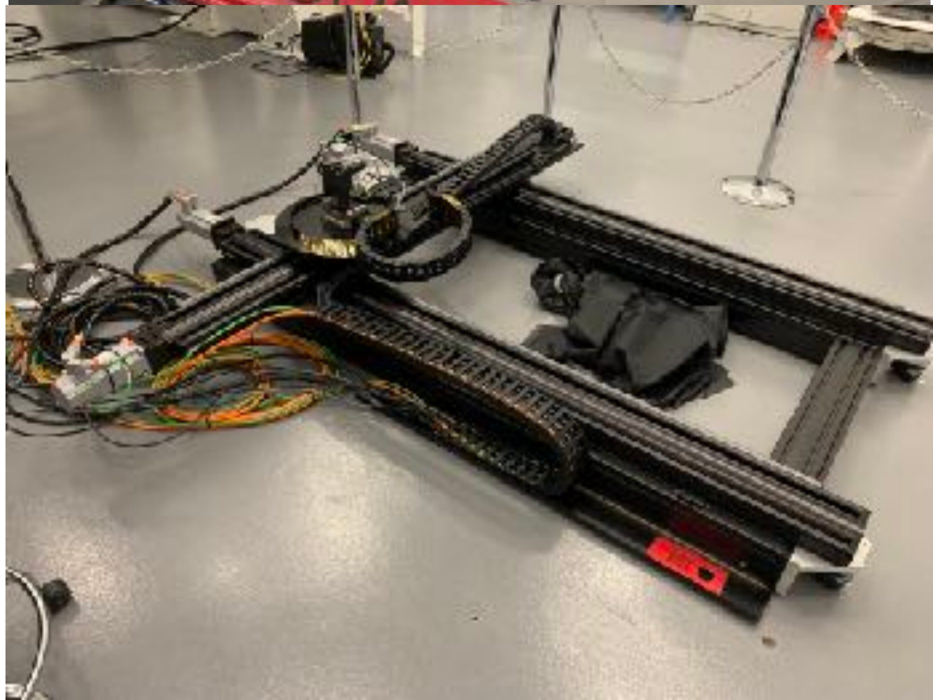


- Saturated artificial spots in e2v sensors left persistence
- Lower parallel voltage could prevent charges trapped in the surface layer
  - We couldn’t do this for a concern on leakage current between BS and FS
- A 3ms inverting clocks before an exposure takes place already…
- We need a correction in DM
  - Only a few electrons in magnitude but has multi-image time constant

Run 6

- 2023 May—Aug?
- Hardware change
  - New chiller
  - Fully assembled
    - Lenses are on / Shutter is on / Filters are on / Guider will be tested
- Light sources
  - CCOB wide beam (flat illuminator)
  - CCOB narrow beam (a single spot light source)
- Transitioning to DM based cp_pipe / eo_pipe for automated analysis
- RubinTV





Optimization targets

Step	Description	Images	Analysis	Notes	
1	CCD temperature control	No images needed	Custom telemetry analysis		
2	ITL row-by-row noise	Biases	Row-by-row Bias stability/variance plots to be developed	(solved?)	
3	adjustment of HVBias for R01/Reb0 to control current emanating from scratch on R01_S00	darks	compare against R01_S10 performance which was brought under control by same mechanism		
4	Sequencer for Guider/GREBs	Any	Test running Guider together with regular Images		
5	Persistence issue on e2v sensors (dependence on parallel swing voltage => channel stop barrier properties) - may also modulate blooming characteristics as a prompt feedback	CCOB-NB, 1 spot, couple darks at a time	John Banovetz's persistence notebooks accessing USDF		
6	stabilization of "wave" feature (analog of what's seen in ITL sensors on AuxTelCam with temperature instability)	darks vs. e.g. temperature or Camera activity preceding DAQ	1-D trace of bias structure along serial axis		
7	Improvement of DNL response	ramp exposure images, exposures started with flat projector on, readout beginning after variable pause	ramp elements arranged by pause variable to stitch together global linearity response		
8	yellow corner on e2v sensors	bias	Looking at the amp corner with P+S overscan subtraction enabled		

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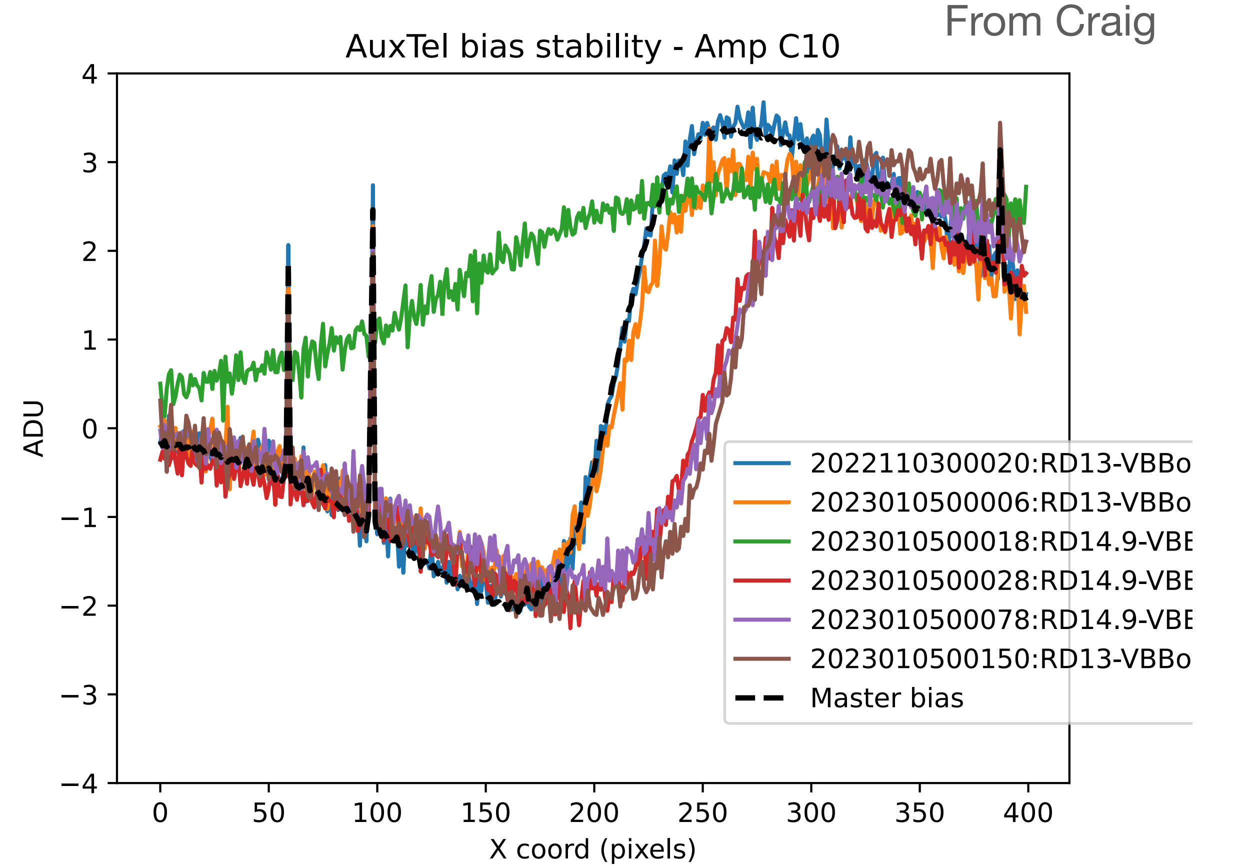
Wave in bias

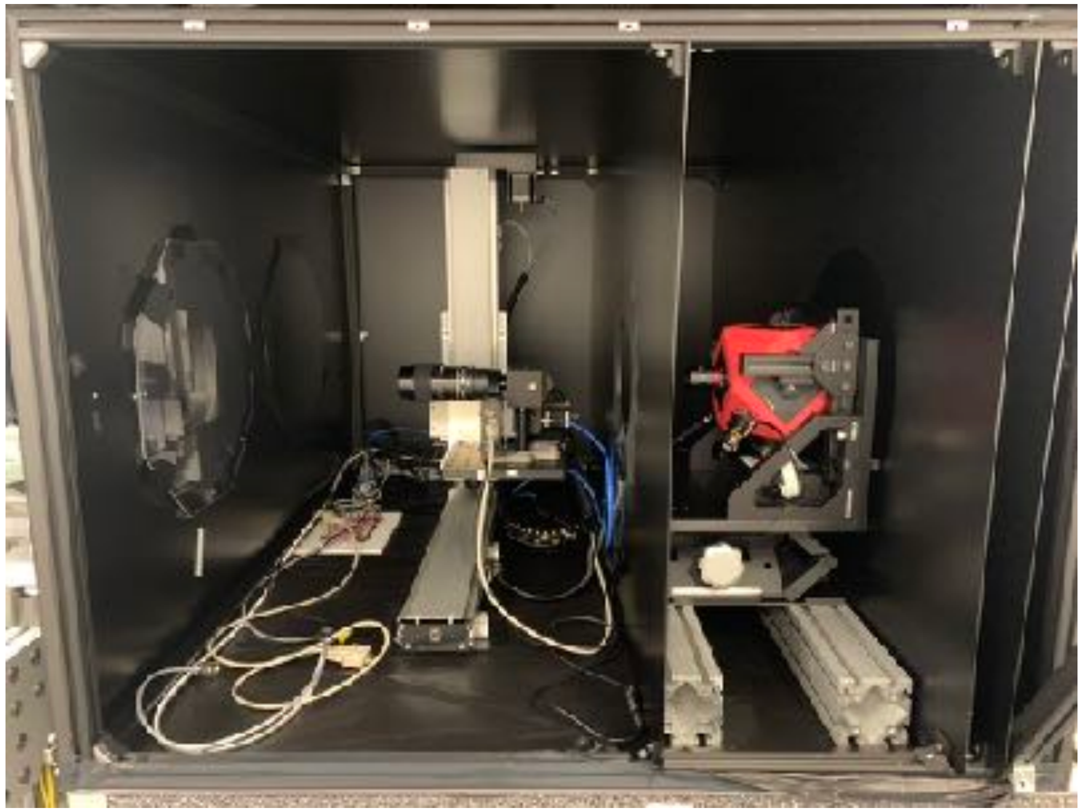
- LATISS observation found wave in bias structure after new voltage after Run 5 and v26 sequencer were introduced
    - od was increased by 1.9V to improve gain stability
    - Parallel timing was tweaked to improve full well
    - Aspic Gain was adjusted not to hit the Aspic limit
- Depends on Reb temperature
- RG toggle in Parallel Transfer seems to cause this
    - some sensor got worse
    - So far not clear why it is in the sequencer timing
- We will test “noRG”

From Craig



EO Run plan

- CCOB wide beam — Flat illuminator using the repurposed LED board
    - bias/dark/flat
    - gain stability
    - dense PTC flat in different wavelengths (denser than Run 5)
    - open shutter flat (for studying DNL)
    - What we did in Run5



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EO Run plan

- CCOB narrow beam — a single beam projector
  - X/Y positions, U/B angles, wavelengths
  - Throughput at central sensor / each of 21 central sensor
  - Optical alignment by looking at reflections
  - Xtalk study (different illumination, less systematics?)
  - Guider functionality test
  - Opsim cadence test

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EO Run plan

Step	Description	Cfg File	Analysis Code	Notes
1	Bias frames	bias10.cfg		1. All amps working 2. Read Noise ~ Single Raft testing 3. No signs of ground loops
2	Dark frames	dark.cfg, dark1mx5.cfg		Check for light leaks (dark.cfg is 300s dark. dark1mx5.cfg is five 60s darks)
3	B Run with CCOB wide beam Biases, Darks, Flat Pairs, Flats in 6 LEDs	fp_scripts & cfg files need to switch to CCOB wide beam B_protocol.cfg (starting point)	Current eotest & eotask-gen3	
3b	B Run with CCOB wide beam Biases, Darks, Flat Pairs, Flats in 6 LEDs			Repeat as in Step 3, but now run the Guiders with an arbitrary ROI along with the Science Rafts
4	Gain Stability with CCOB wide beam 24 hours of Flats at constant flux	fp_scripts & cfg files need to switch to CCOB wide beam	Current eotest & eotask-gen3	
4b	Gain Stability with CCOB wide beam 6 hours of Flats at 2nd flux value	fp_scripts & cfg files need to switch to CCOB wide beam	Current eotest & eotask-gen3	Check that Gain jumps are indeed changes in Gain
5	Dense PTC ~300 Flat Pairs from 50 ADU to full well, with ~1.03 logarithmic spacing	fp_scripts & cfg files need to switch to CCOB wide beam	Current eotest & eotask-gen3	
6	Dense PTC in u,g,r,z,y [uv, blue, red, nm750, nm850, nm960] LEDs	fp_scripts & cfg files need to switch to CCOB wide beam	Current eotest & eotask-gen3	
7	Open Shutter Flats ~100s Flats from 0 ADU to full well, with complete DN coverage	fp_scripts & cfg files need to switch to CCOB wide beam need option to keep light on during readout	Custom Code for DNL study	

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EO Run plan

8	CCOB Narrow beam Wavelength*Aperture Throughput Test: 100 Spots in Beam, 15 wavelengths in each of 6 Filters, 1 Focal Plane position	fp_scripts & cfg files update for CCOB Narrow beam		New ccobTask needed	See LCA-283 Section 11.8.2.1 Step8 – CCOB-thin throughput synthesis, greater detail, central sensor only
9	CCOB Narrow beam FocalPlane*Wavelength*Aperture Throughput Test: 10 Spots in Beam, 9 wavelengths in each of 6 Filters, 21 Focal Plane positions	fp_scripts & cfg files update for CCOB Narrow beam		New ccobTask needed	See LCA-283 Section 11.8.2.1 Step9 – CCOB-thin throughput synthesis, each of 21 central sensors
9b	CCOB Narrow beam FocalPlane*Wavelength*Aperture Throughput Test: 1 Spots in Beam, 15 wavelengths in each of 6 Filters, 189 Focal Plane positions				Proposed based on conversation with @Rykoff, Eli S. as desired for DM calibration Need input from Eli on the number of wavelengths needed and placement inside the filter bandpass. Emphasis is to evaluate spatial variability across the filter, not angle, hence one position in Beam and measurements in every CCD
10	CCOB Narrow beam Optical Alignment Test N spots at range of positions & angles,	fp_scripts & cfg files update for CCOB Narrow beam		New ccobReflectionTask	Reference CCOB alignment doc & recent presentation Johan's model uses several pointings with a common primary focal plane. Can use narrowbeam_amplifier_pointings.perl script to plan paraxial pointings to provide this.
11	CCOB Wide beam & Pin Hole Filter	fp_scripts & cfg files need to use CCOB wide beam with Pin Hole Filter		New pinhole Xtalk Task New pinhole Persistence Task	should be able to use straight 1:1 scaling of flash times used for CCOB-Wide/LED
11b	CCOB-Narrow for segment-by-segment source-target studies	fp_scripts & cfg files update for CCOB Narrow beam			signal dependent crosstalk via random access (given pointing fidelity & stray illumination control, TBD) persistence onset measurements via random access for e2v sensors (illumination followed by 2 or 3 darks) – suggest 1 or 2 segments per sensor. blooming evolution may provide insight into persistence differences. shape evolution of saturated images (fraction bloomed across channel stops vs. across clock barriers), 0.5, 0.9, 1.1, 2.0, 3.0x FW per pixel to help identify confinement

EO Run plan

12a	Guider studies, functional tests	fp_scripts & cfg files to specify GS specific ROI windows and GS acquisition mode (full frame vs. ROI time slice array)			copied from notes: • in some cases just the structure of the FITS file appended with Guider data may be enough to verify the requirement: ◦ integration times can be demonstrated by comparing ROI signal levels to full-frame exposures on the same sensor or simply by inspecting FITS files modulo ambiguity in transfer time (C-273). Unsure how this works, though, if each ROI on the 8 guiders require a different number of parallel transfers to read out or are different in size. Synchronization requirement C-278 also needs meeting. Sounds complex. What triggers next ROI exposure, the computer's clock or a logical "and" across all guiders' statuses being operated? I'm exposing my ignorance.
12b	Guider studies with CCOB Wide beam source	fp_scripts & cfg files update for CCOB Wide beam (small ROI corresponds to better time resolution)			copied from notes: • flat illumination is available via CCOB-wide to verify timing related requirements: ◦ Guider acquisition to span and exceed Shuttered exposure & within 10ms of Focal Plane exposure start: flashes might be timed to bracket shutter trajectory (C-380, C-381).

12c	Guider studies with CCOB Narrow beam source	fp_scripts & cfg files update for CCOB Narrow beam (ROI limited to something like 400x400pix)		Guider off-line analysis but require auxiliary images acquired in full frame mode for specific inputs.	CCOB-Narrow needed to estimate ROI exposure times in each slice (compare to full image format with flash illumination). copied from notes:
					• structured illumination is available via CCOB-narrow to provide verification for certain requirements:
					  ◦ signal can be shown to scale with ROI exposure times (C-378), demonstrate full ROI size range 10x10 thru 400x400 pix (C-281), and ROIs that extend past segment boundary within same sensor half (C-379), unique ROI on each Guider (C-328). For some of these, full-frame exposure should be compared to verify physical representation of the ROIs.
					  ◦ how to demonstrate <1ms synchronization of 8 Guide sensor ROIs? Is this met simply by design? (C-278)
					  ◦ Demonstrate coordinate transforms that connect Focal Plane coordinates to Guider pixel addresses using multiple spot positions spanning nearby sensors to guiders (C-336).

13	Sequence of data acquisitions that follow OPSIM output to get a representative cadence (for times between images & time between shutter trajectories). Use shutter to define exposures for representative conditions.	fp_scripts & cfg files appropriate for CCOB Wide beam, with pauses representing back-to-back images, slews, filter changes etc. Commanded (?) options for focal plane **default** mode (idleFlush, CLEARs etc.).		stability analysis applied to flat pair data with shutter actuation directions alternating between exposures: current eotest & eotask-gen3	cf. "intervals_between_visits.txt" generated by extract_times.perl representing observations.csv table extracted using **DB browser for SQLite.exe** on **baseline_v3.0_10yrs.db**. In the above tests, need to decide how to a locate exposure times: standard 15s, standard' 30s, or only as long as needed. Add an extra column for this

EO Run plan

15	Stray light/baffling tests to verify according to LCA-283 requirements	fp_scripts & cfg files appropriate for CCOB Narrow beam pointed e.g. at baffling within L1-L2 Cell or at the opaque pinhole filter. CCOB-Narrow should be bright enough to produce stray light that ends up at focal plane.		full focal plane maps (like dark images generated while pinning down light leaks) are probably most useful for the first type; For second type, raft format images may show pinhole projector like images of stray light in the Camera.	
16	Flat Fields to Test Shutter	fp_scripts & cfg files for Flats with and without LSSTCam Shutter Activation		Standard Flat analysis	1. Flat illuminator images, 15 second CCD readout with 12 second Flat illumination inside that 15 seconds, Camera shutter left open - ie. use the CCOB wide LED timing to set the effective exposure time of 12seconds. 2. Flat illuminator, 15 second CCD readout with Flat illuminator left on for full 15 seconds (or longer, doesn't matter), Camera shutter operated with 12 second exposure time - and do this with both flavors of shutter motion, positive and negative X motion.

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Ways DM folks can follow/participate in Run6

- Attending Tue **CVT** (Seth and Andrei) / **SAWG** (Merlin and Claire) meeting #desc-sawg
- **RubinTV** (Merlin) #cam-rubintv
  - https://roundtable.lsst.codes/rubintv/slac/ts8
- **Static web pages of results** (Jim C.)
  - https://s3df.slac.stanford.edu/data/rubin/lsstcam/13162_13144_13141/ for example
- **Calibration products** (Eli and Chris) #dm-cam-concordance

Summary

- Overview of Run 5
  - Focal plane is characterized
  - **Bias stability** issue —noRG for ITL is proposed, ReadPixel as IDLE_FLUSH for e2v is recommended
  - **BF correction** is not perfect
  - **Sensor anomalies** and **persistence** need attention and correction
- Prospect for Run 6
  - We will verify the Run 5 characterization
  - **EO characterization** with CCOB wide beam
  - **Optimization**: yellow corner, “wave”, differential non-linearity
  - “Ray-trace” for **throughput** (main beam) and **alignment** (reflection)
- Need your help!