The bias shift in LSST sensors

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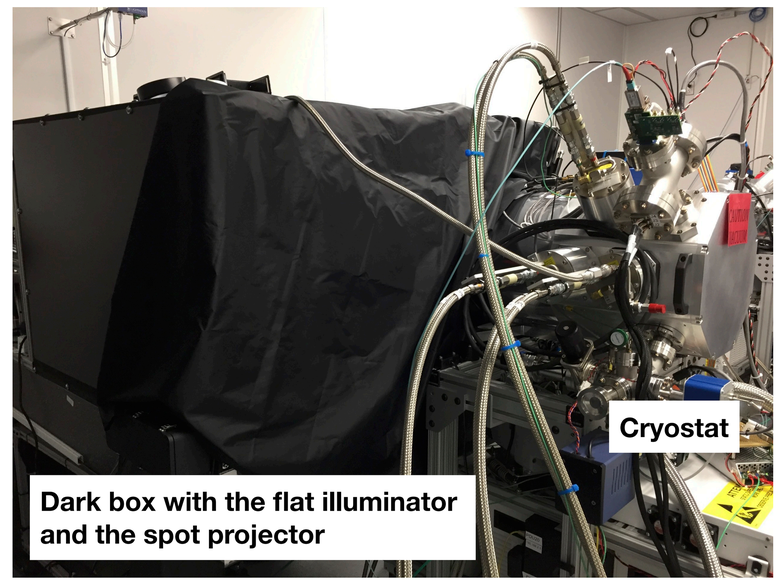
1. Introduction

The Large Synoptic Survey Telescope (LSST) will conduct a ten-year optical imaging survey of the Southern hemisphere, covering approximately 20,000 square degree. The one of key challenges of this project is to measure faint distant galaxy shapes to study Dark Energy, which requires accurate background estimation.

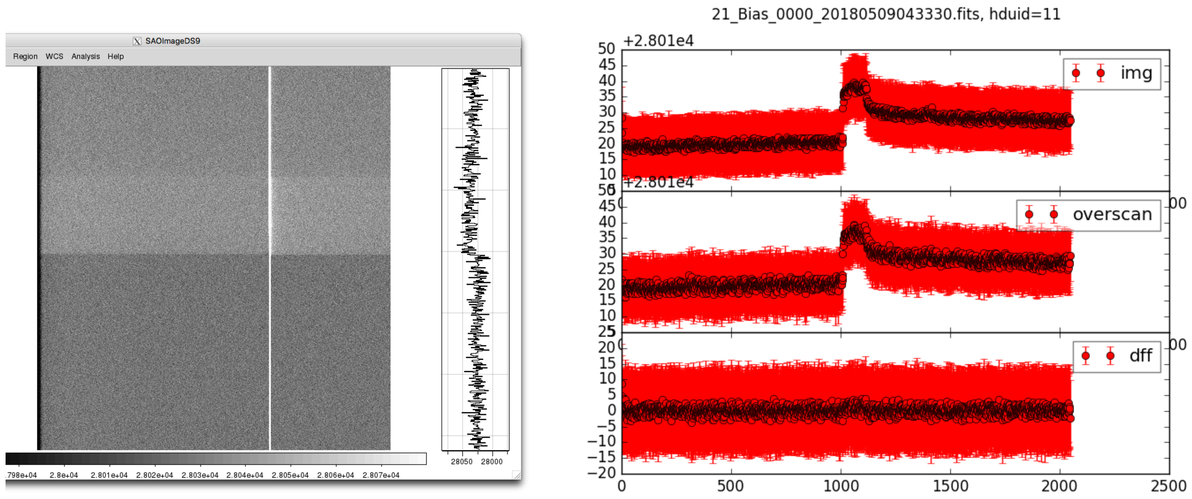
The LSST Camera will be the largest astronomical digital camera with a 3.2 giga-pixel focal plane mosaic of 189 CCDs. The focal plane, in a vacuum chamber maintaining CCD temperature at -100C, consists of 21 science rafts and 4 corner rafts. Each science raft is a module made up with 3 x 3 CCDs and its electronics, sending serialized digital data over optical fibers.

At SLAC National Accelerator Laboratory, the LSST Camera Integration and Testing (I&T) team is receiving Science Rafts constructed at Brookhaven National Laboratory by conducting electro-optical (EO) tests in a cryostat for a single raft and conducting optimization in preparation for focal plane level operation (Roodman et al. 2018, SPIE). Bias, dark and flat images are collected to evaluate read noise, dark current, and dead or bright pixels and columns. Also Quantum efficiency (QE), and charge-transfer-inefficiency (CTI) are measured by using monochromator mounted on to one side of a dark box.

This poster describes the current activity to understand the bias shift identified during the process.



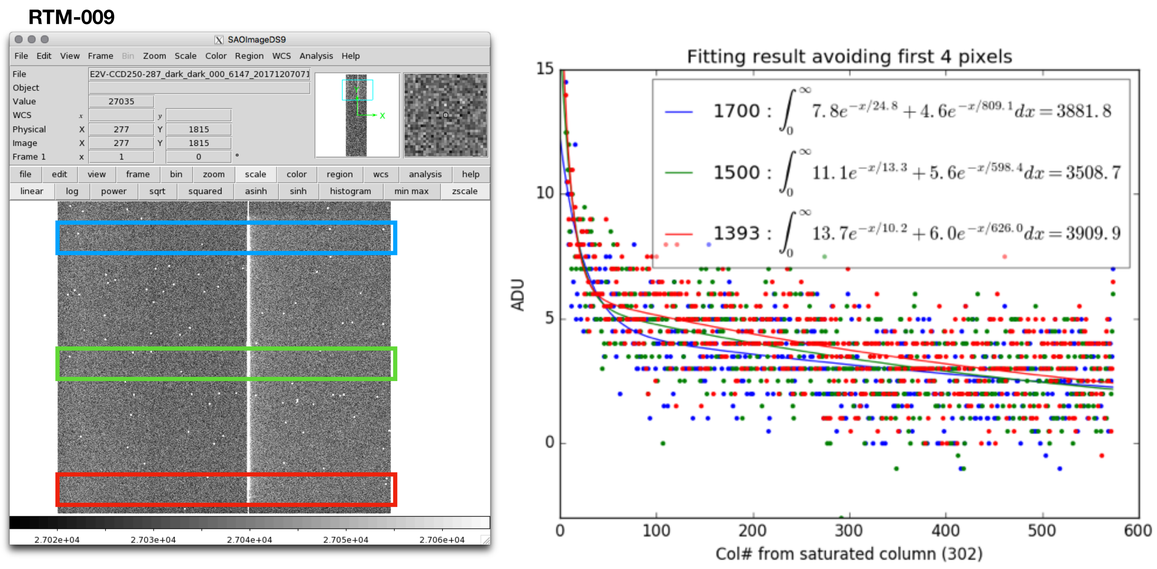
2. Bias shift associated with column defect



**A bias image with RTM-008 using unipolar setting.
~20 and then dropped to 10 ADU level**

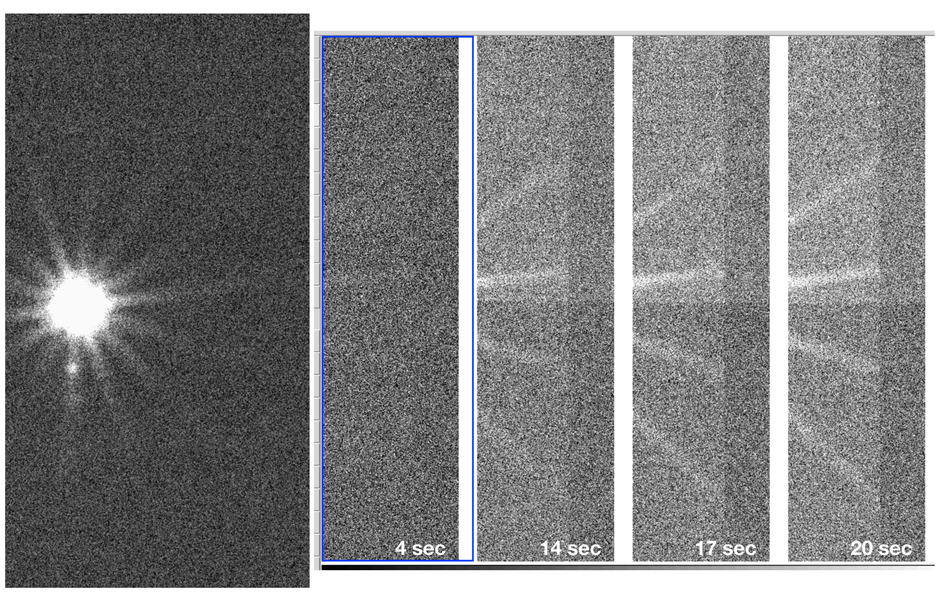
A left picture above shows a small patch of a bias image around a bright column defect. Charges are shifted towards bottom. The bright column defect in middle lifts the bias level across a row in where the defect exists. **This is the bias shift.** A right plot shows column plots averaged over rows in image and overscan sections. Subtracting overscan works to get rid of the bias shift in general.

3. Evolution in row direction



However, a folded row plot starting from where the bright column defect exists to the defect on the next row shows exponential-like evolution of the bias shift. The model used to fit is two exponentials with different decaying times. This evolution complicates the bias subtraction using the overscan section in a row where saturated pixels exist.

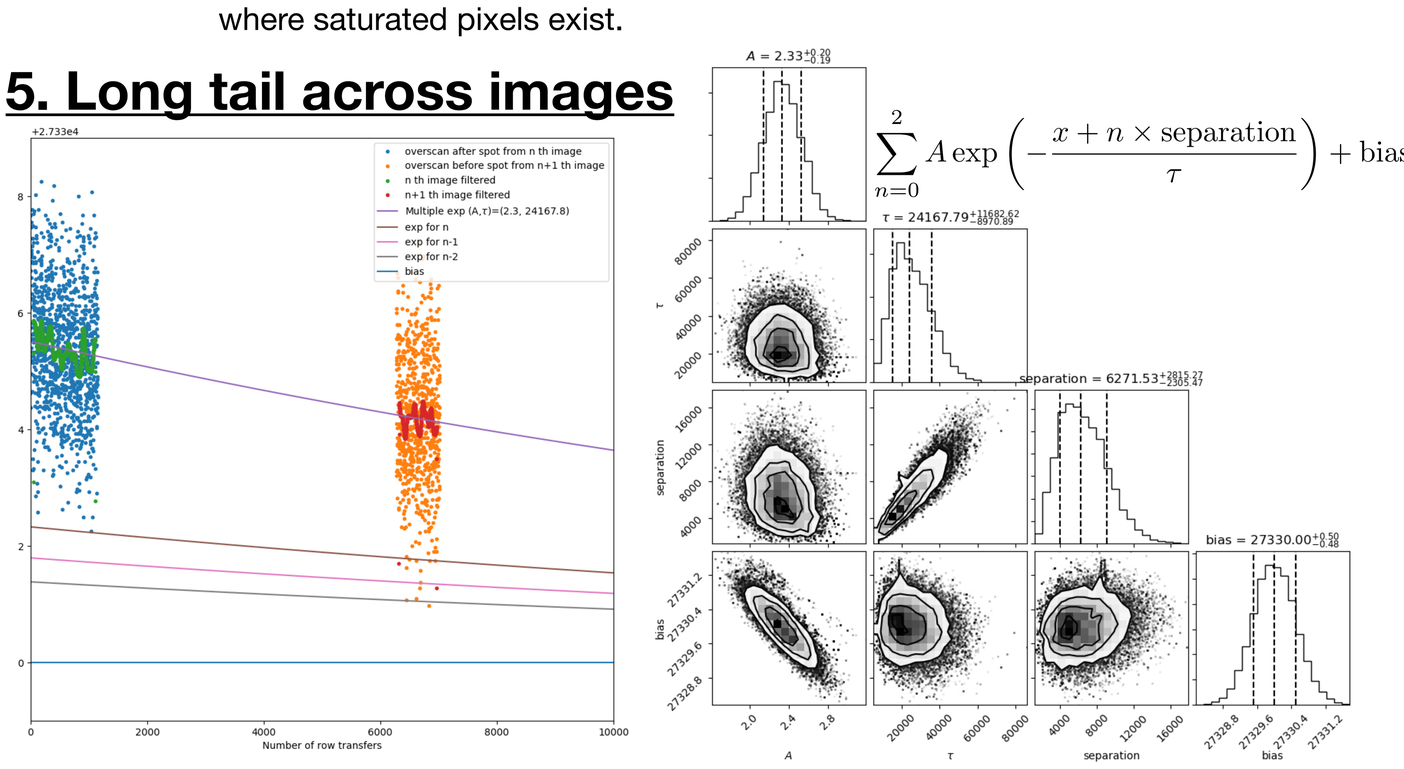
4. Bias shift associated with a spot



RTM-012 Obtained with tag3.0 (bipolar clocking)

The bias shift is a problem not only for the defect but also for bright saturated stars. The series of pictures with increasing exposure time above illustrate the effect. A few to 10 ish ADU bias shift decaying in a row appears on a row where a saturated star exists. A Large FoV of LSST will encounter many bright saturated stars that will produce the bias shift anywhere. Also once the bias level gets lifted, it remains for the rest of image.

5. Long tail across images



To assess how long time constant does the bias shift have, both overscan values after a row where the spot exists and overscan values before the row in the next image with a model are fitted by a model simultaneously. The model is a sum of exponentials (contributions from previous images) having a same decaying time separated by a certain amount of separation time and bias. The separation of both overscan values is the same as the separation time. Fitting with featureless data point is always difficult but the model looks consistent with the Haan filtered data, suggesting that the bias shift has a long time constant exceeding a single image. Surprisingly, the derived separation time is consistent with a number of row transfers by clearing clocking

Summary

- The bias shift happens after a pixel where saturated pixels exist (easily caused by defect or bright star).
- Time constants of ~10 pixels, ~500 pixels and a longer than a single image, implying at least 3 mechanisms?
- Modeling is needed for accurate background estimation

Future work

- More systematic investigation on evolution of bias shift with multiple exposures with fixed light level
- Explore it with different voltage configurations (unipolar or bipolar)
- Investigate the case for any ITL raft

Acknowledgement

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