Sensor Anomalies Working Group (a.k.a SAWG)

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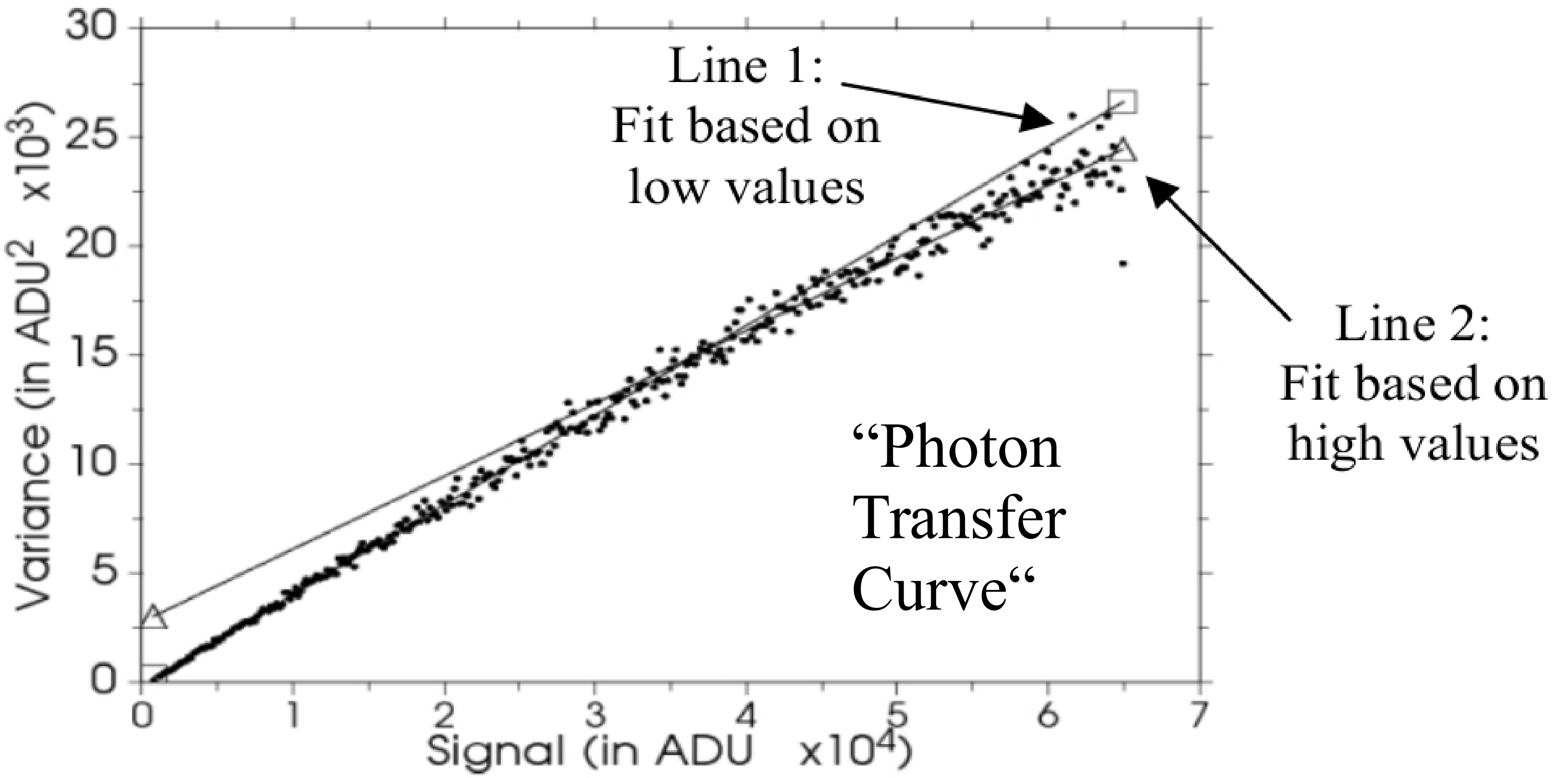
Historical perspective: CCDs are not perfect



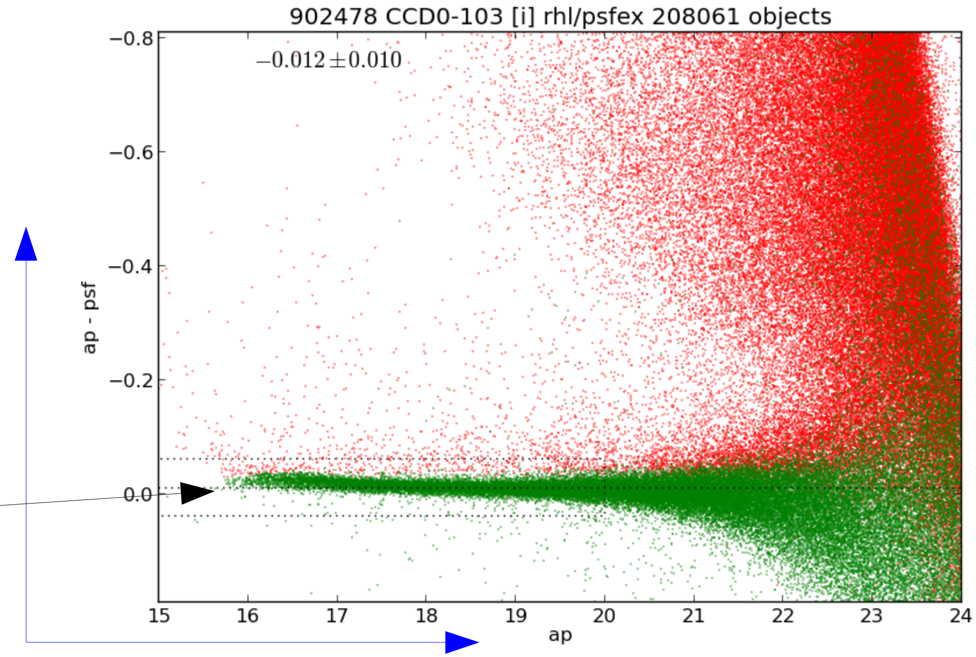
Downing et al (2006) : The variance of flatfields is not proportional to their average. Observe statistical correlations between nearby pixels, decaying with separation. No reasons identified.

Immediate consequence : the first and second half of the charge collection are not statistically independent.

Episode 2 (~2011): shape plots are strange

Standard plot used for star/galaxy separation (Hamamatsu HSC chips) (R. Lupton)

size

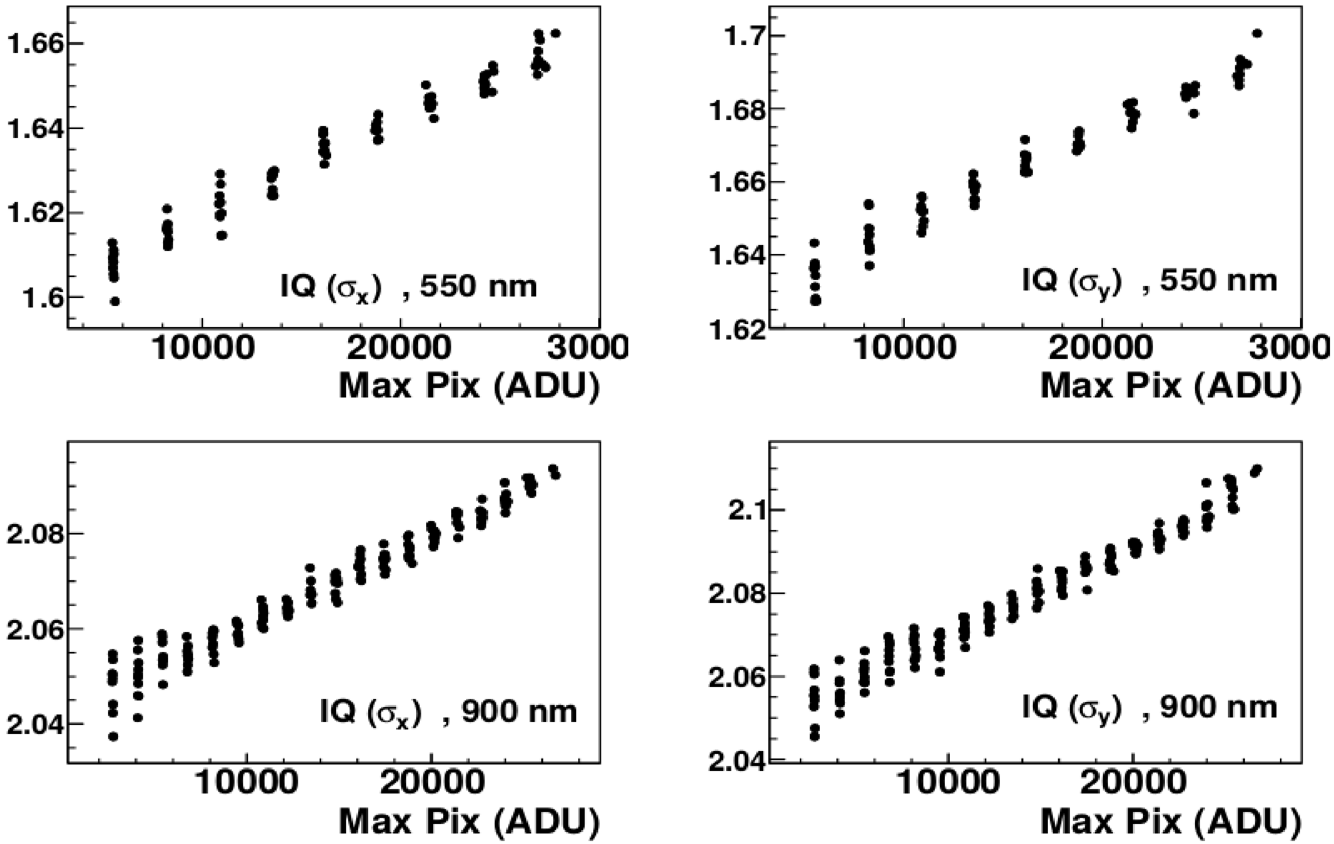


mag

Bright stars are slightly "bigger" than fainter ones.

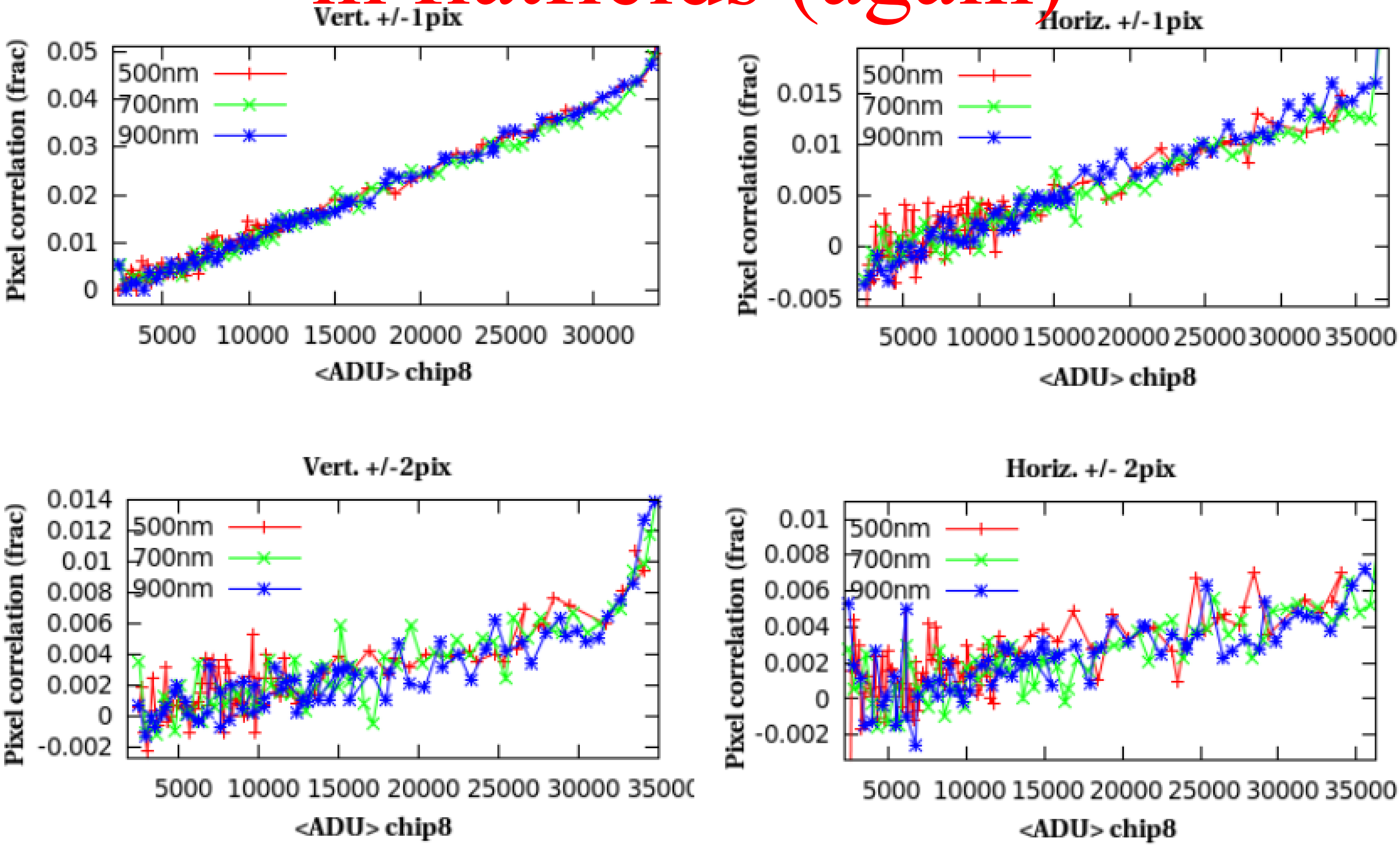
- R. Lupton (2013, my recollection) : this problem has been around for about 2 years.
- In 2012, the same plot from DECam shows exactly the same behavior.
- These plots remained "hidden" until 2013.
- Some people call it "non-linearity". But the total flux just scales.

Episode 3 (1) : brighter-fatter (again)



Size of laboratory spots as a function of their peak flux, along x and y and for 2 different wavelengths. Presented by the LPNHE folks at some LSST phone conference in early 2013.

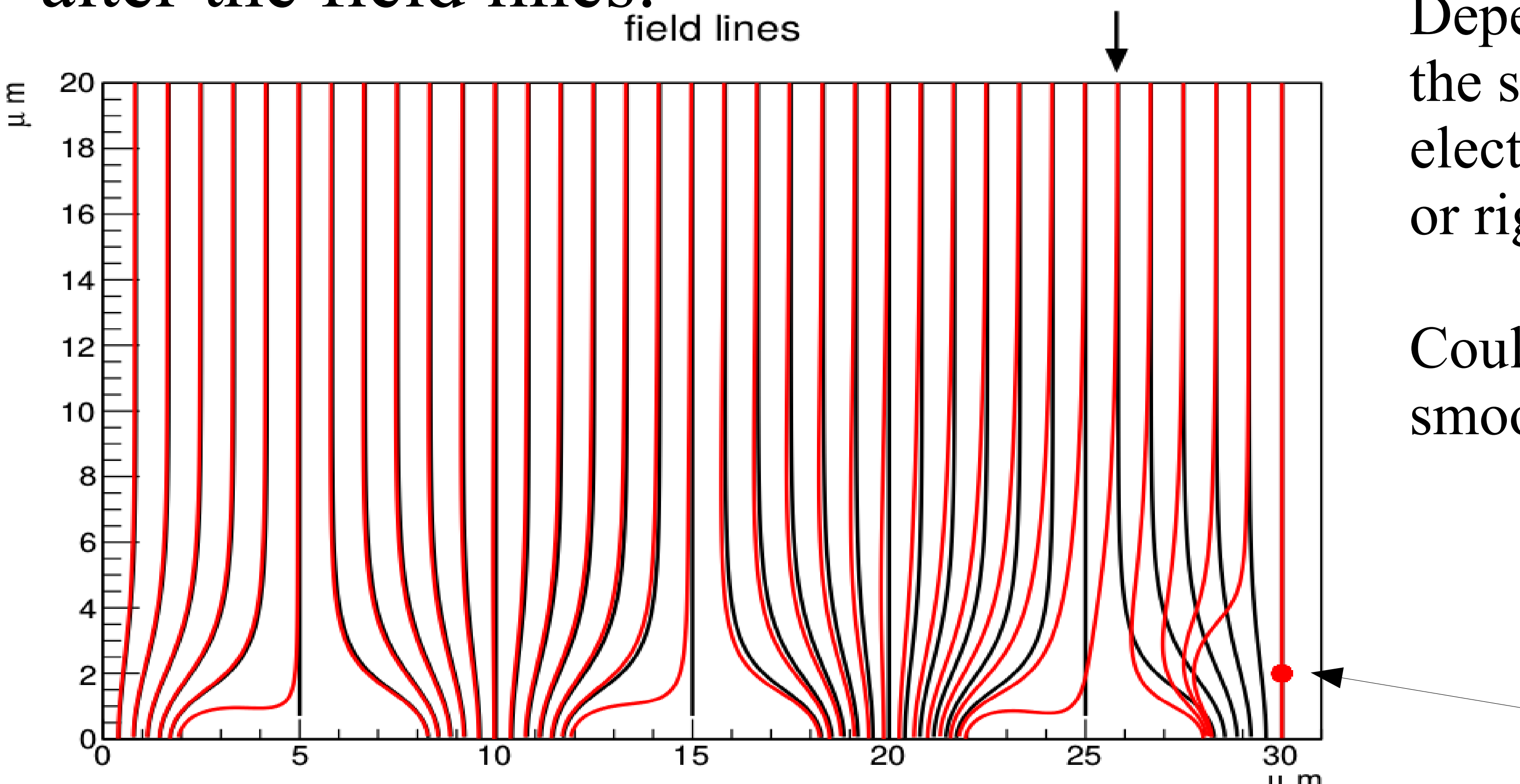
Episode 3 (2) : statistical correlations in flatfields (again)



There are correlations in flatfields, linearly increasing with illumination and decaying with distance. They are achromatic. Their slope depends on the applied voltages (Guyonnet & co, early 2013).

Episode 4: PACCD workshop :
(BNL, Dec. 2013)

Correlations and brighter-fatter share the same physical origin: charges accumulated in the CCD alter the field lines:



Depending on the stored charge, electrons turn left or right:

Coulomb forces smooth contrast

50 ke

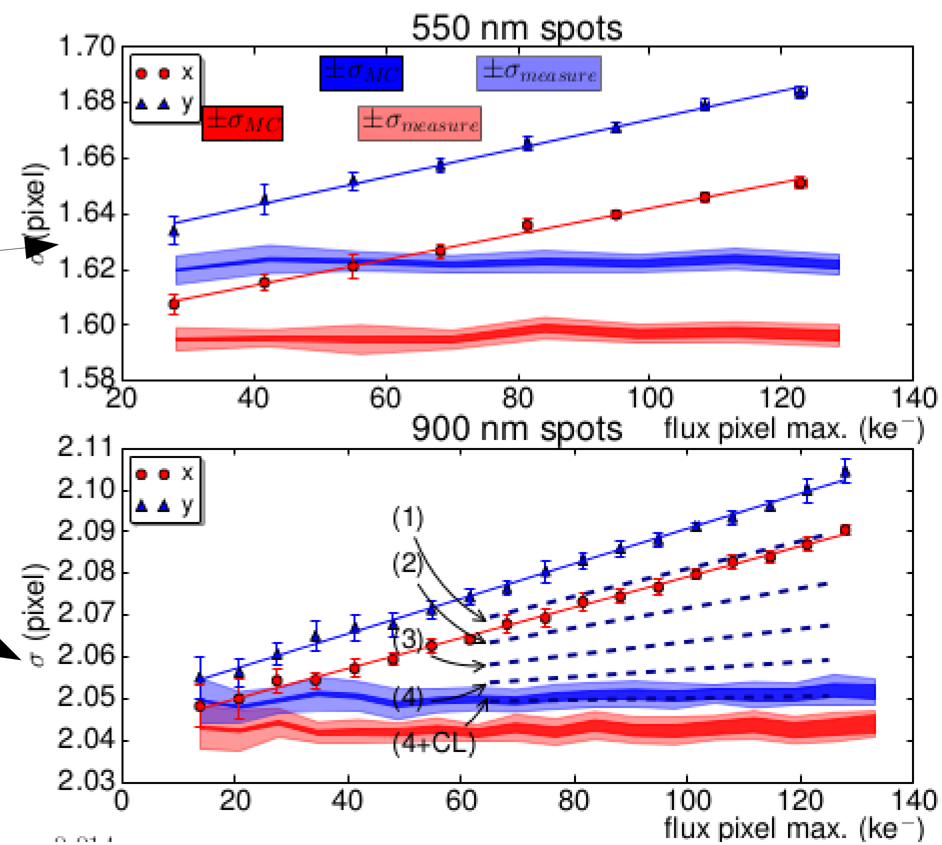
Properties of the “electrostatic model”

- Variance of flatfields is a ~~linear~~ quadratic function of their average.
- Correlations between nearby pixels increase linearly with the flatfield average.
- Sizes of spots increase linearly with their flux.
- The extra electric field strength can explain the size of the observed effects.
- The x-y anisotropy is natural.
- The effect should be essentially achromatic.

The proposal:
(Guyonnet et al, 2014)

- Use the correlations to constrain some empirical perturbation (i.e. leading order) model of the pixel distortions, and correct images at the pixel level.

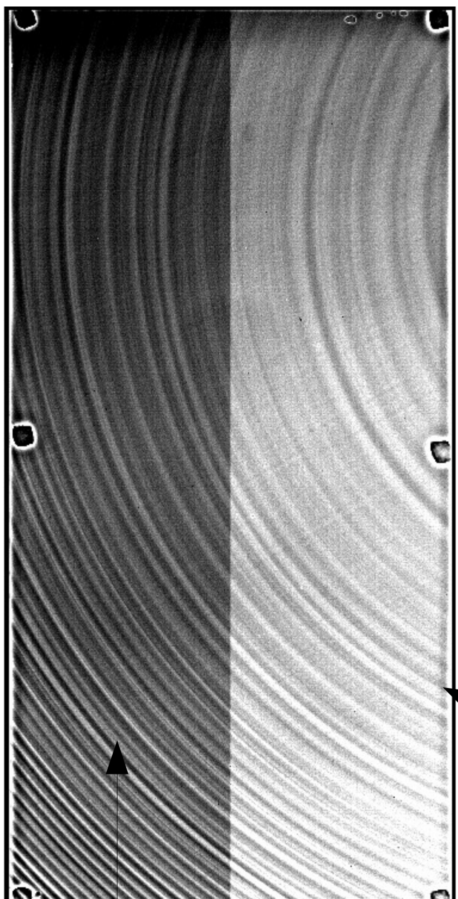
After correction



>90% of the effect is gone.

The sensor “anomalies”

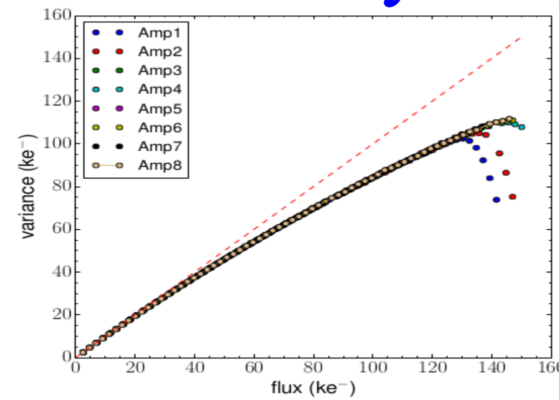
Static



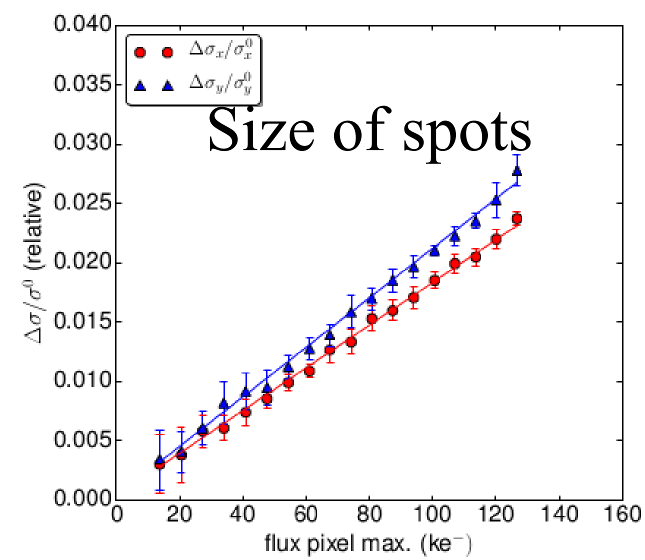
Glowing edges

Tree rings DECam chip flat

Dynamic



$V = f(\mu)$



SAWG

- One of DESC's technical working groups
- Conveners: Andrei Nomerotski (BNL), P. Astier.
- Meeting: every second Thursday, 5 p.m.
  - The other thursday is calibration (PCWG).
- Attendance: 10-20 (~50% common with Calib.)

SAWG's approach (1)

- Highly driven by DM needs: we need the ingredients to “undo the effects”.

At the moment the concept is:

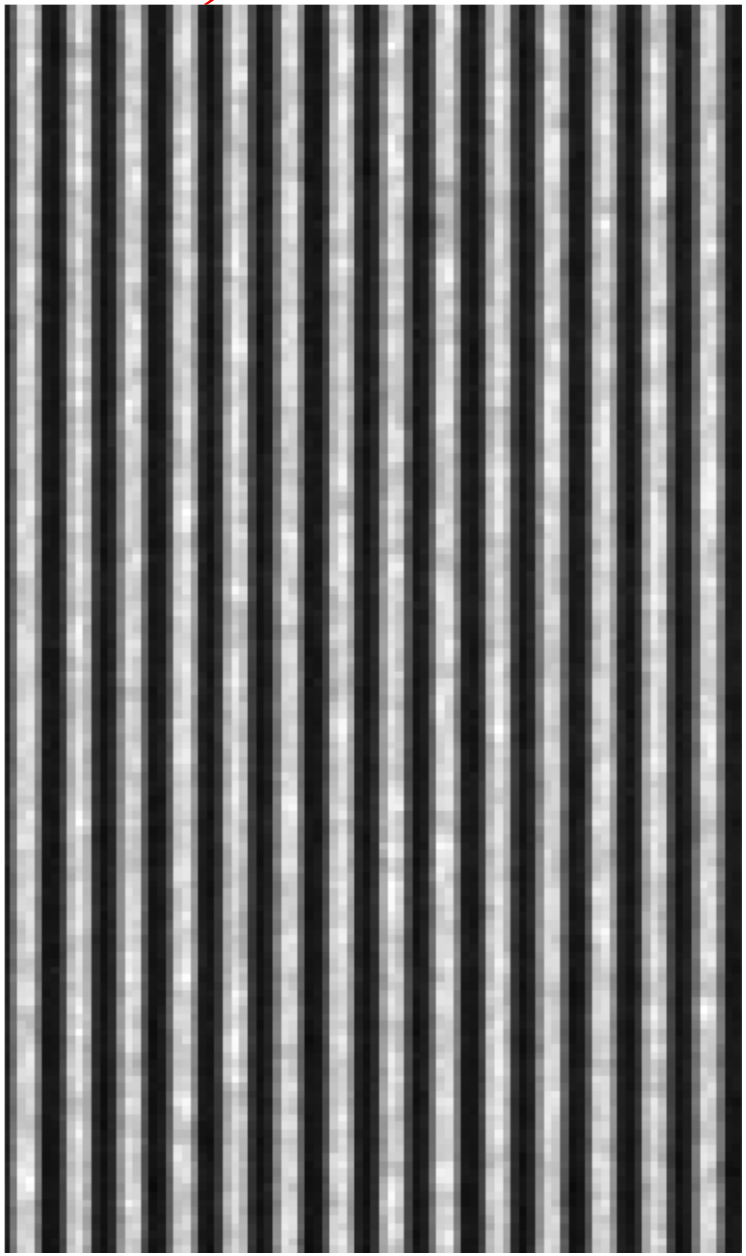
- Static effects are easy to measure and handle
  - For sure, once it is done, i.e. not yet.
- Dynamic effects are scary:
  - Try do develop a 3-D electrostatic model, with update of fields due to incoming charges.
  - Not clear yet if it works, for example because we do not know all the details of CCD fabrication.

SAWG's approach (2)

- Simulation of dynamical effects
  - So far, no electrostatic model (we have 2) has shown any prediction for Next to Leading Order effects. If true, measurements remain much simpler.
- SAWG has asked the Lensing WG to provide some feed-back about the needed correction precision. Nothing came back.

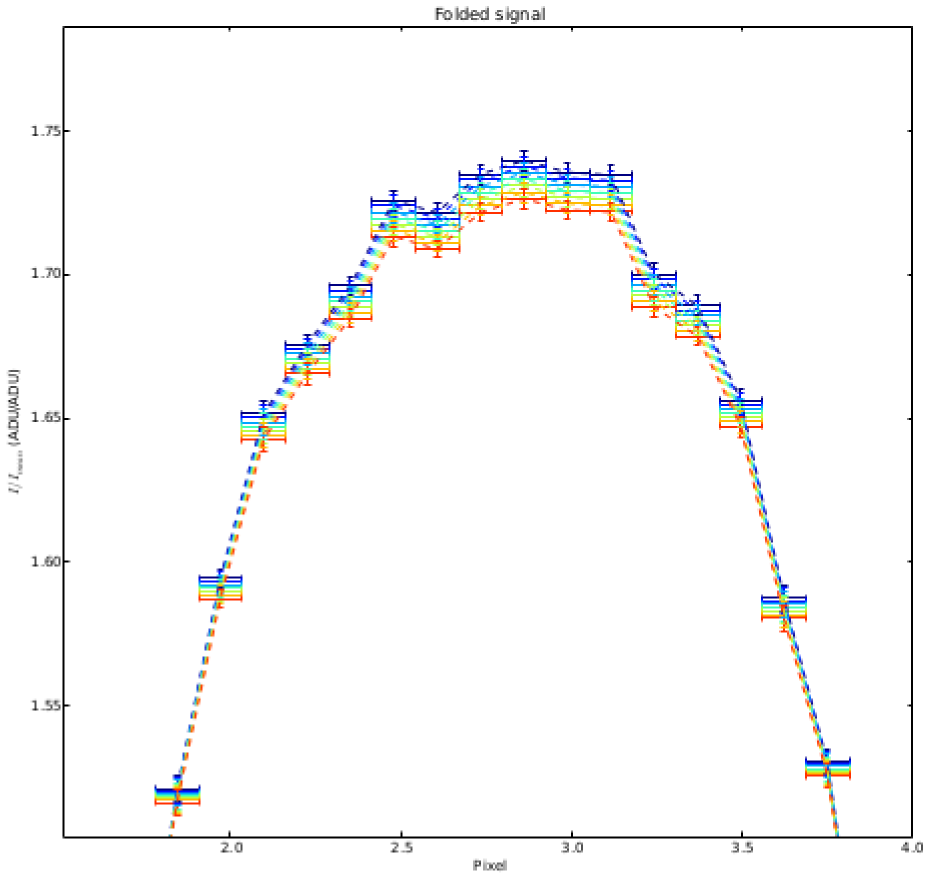
Fringe projector at LPNHE (Rémy Lebreton et al)

- Static effects cause distortions of the "lines". Can be fitted using rotated and shifted images.
- Dynamic effects cause a decaying contrast as exposure time increases. Huge photo-statistics as compared to spots. Can separate orientations.



Brighter-fatter on fringes:

- Flux scaling violation observed on fringes.
- We are now switching to a science-grade sensor...
- … with some version of the LSST readout chain.



Brighter-fatter effect : do we have a problem for cosmology?

- The effect amounts to a <3% size increase of almost saturated stars.
  - Assume:
    - Average PSF stars peak flux is saturation/3,
    - PSF dilution is 3,
    - Correction removes 90% of the effect
  - The shear bias is 3%*3/3*0.1 = 0.3%
  - This is the requirement I remember of.
- PSF Photometry: flux bias is size bias, so:
  - 3%/3 *0.1 = 0.1%

Next steps

- End to end test with monocam data?
  - If not with this data set, hopefully next one.
- We, (LPNHE) are trying to measure useful things in the lab. Other CCD test stands follow related routes.
- 3-D electrostatics of silicon:
  - Not clear yet if we can actually fit the unknowns.
- Backup plan for dynamic effects:
  - Guyonnet et al trick. Can probably be improved.
  - Implemented by DES, and default on HSC.