Charge induced Electrostatic distorsions of charge collection in CCDs

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Data

- LSST candidate sensors (E2V, 100 μm)
  - Lab flatfields
  - Lab spots
- MegaCam (thinned CCDs)
  - LED flatfields
  - science exposures
- DES exposures (Berkeley, 300 μm)
  - DECal flatfields
  - Star flat exposures

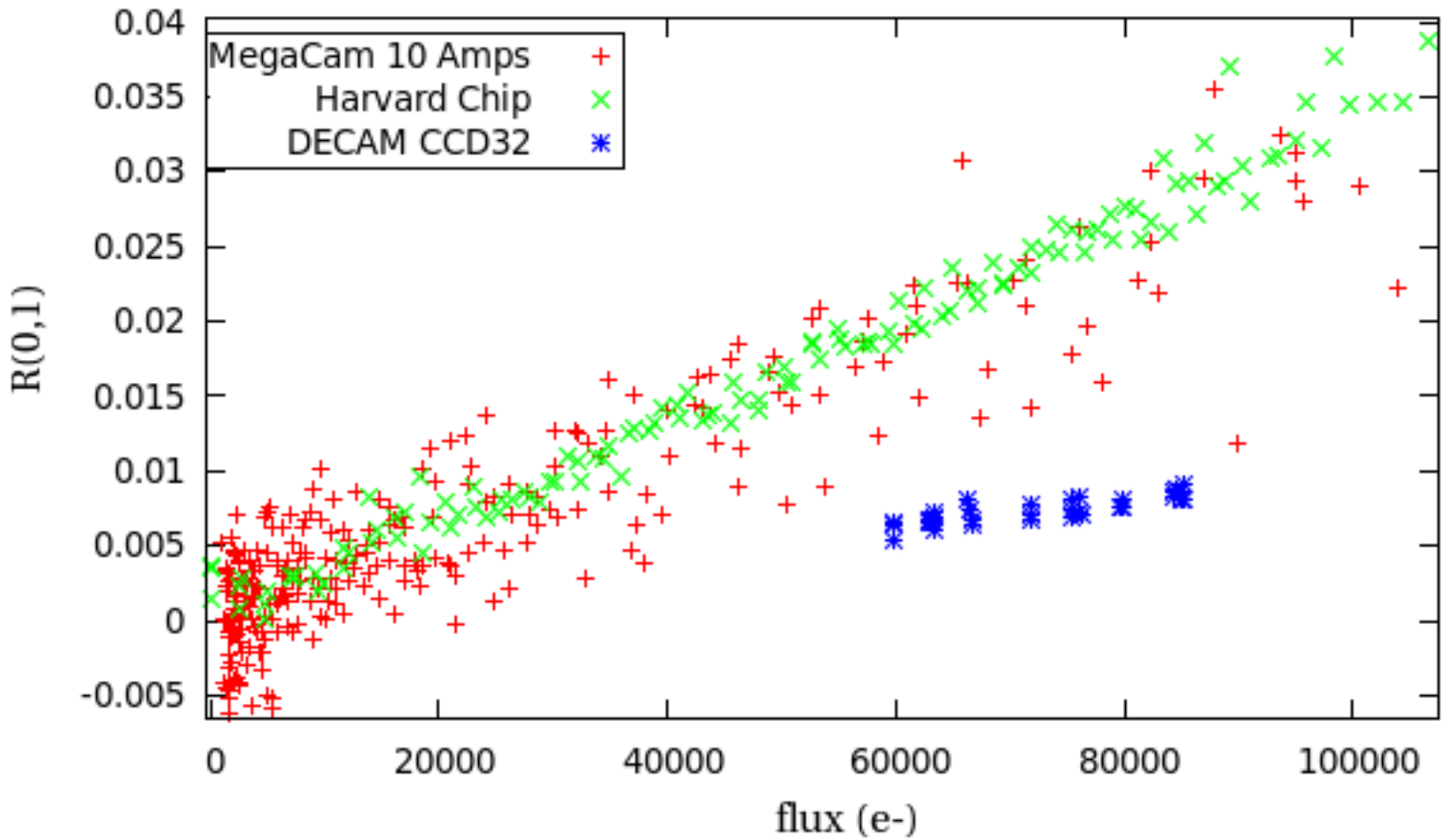
(Gary and Douglas informed of this)

Facts

- There are statistical correlations in flat fields
  - decay rapidly with distance
  - Pixel-to-pixel covariances grow quadratically with flux

    → photon transfer curve not linear
- PSF seems to vary with flux
  - Brighter stars are fatter than fainter stars
  - Small impact on SN photometry (see P. El-Hage's talk)
  - Potentially strong impact on galaxy shape measurements

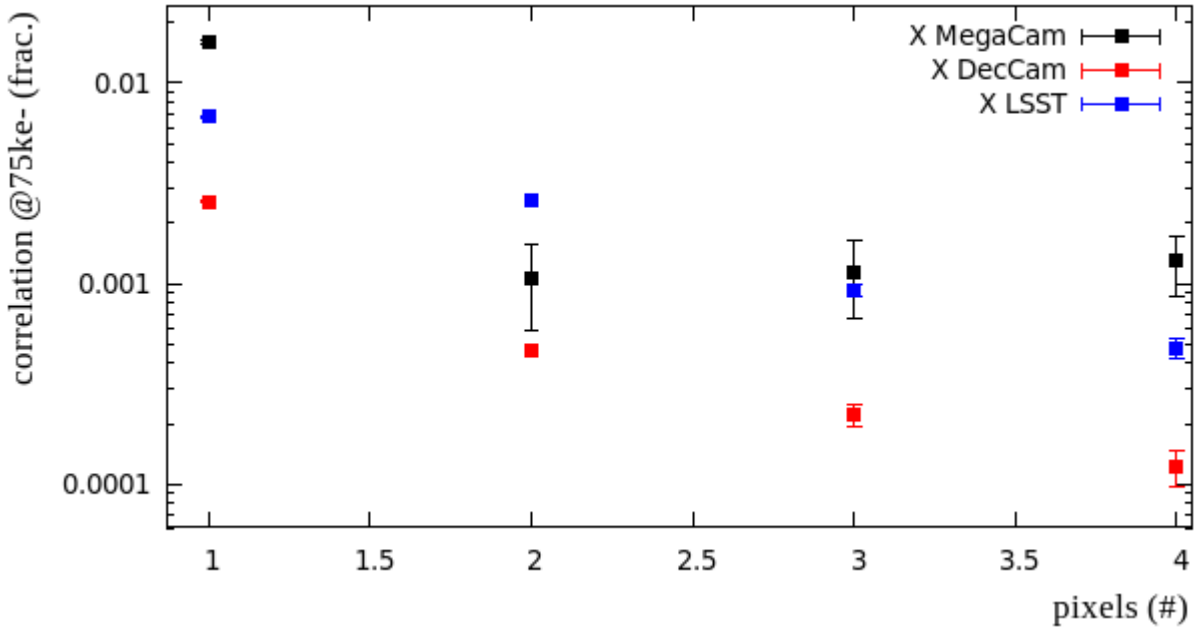
Flatfield correlations

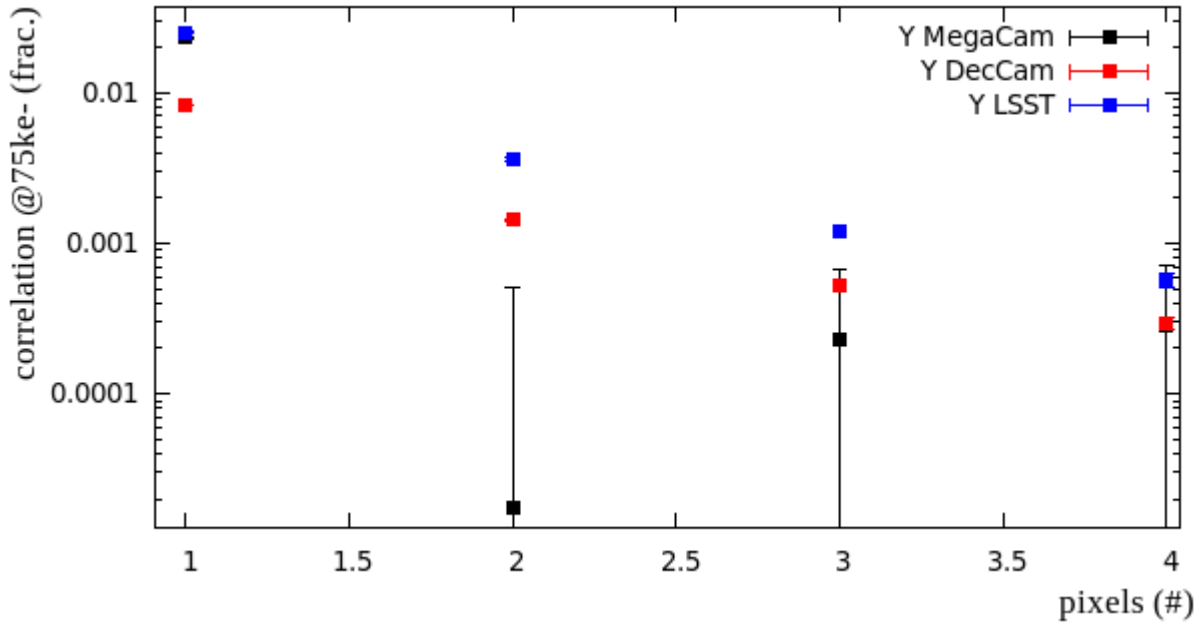


$$R(0,1) = \frac{\mathrm{cov}(I_{ij}, I_{ij+1})}{Var}$$

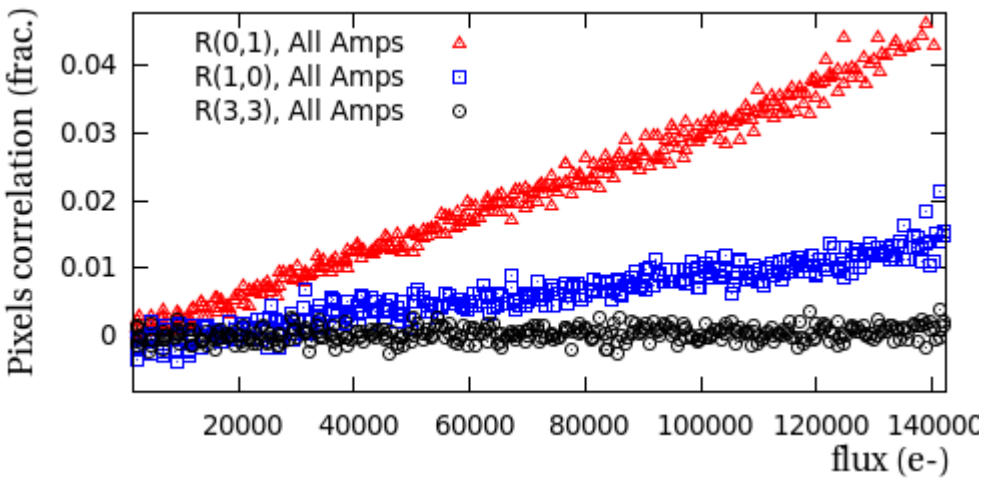
Measured on flatfield *differences*

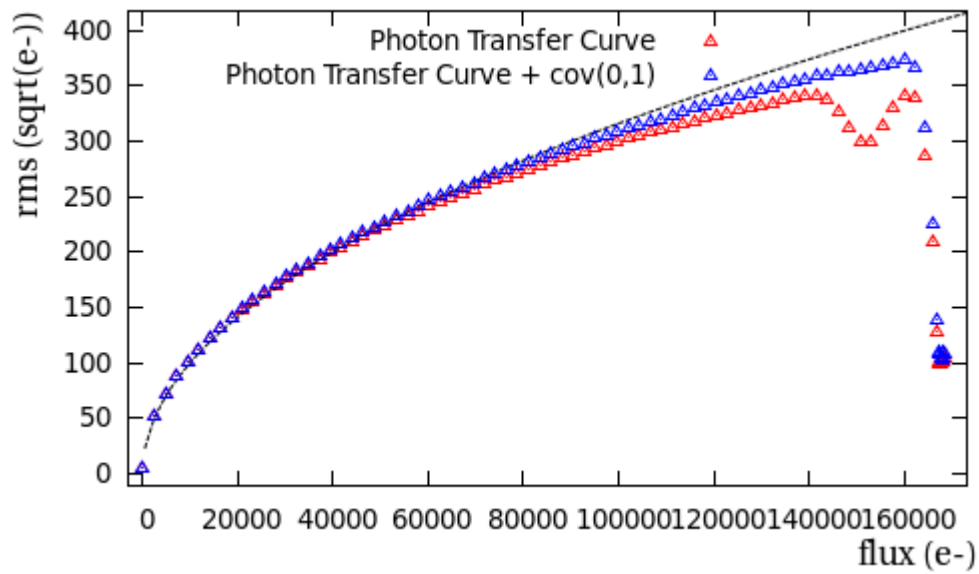
Correlations vs. distance

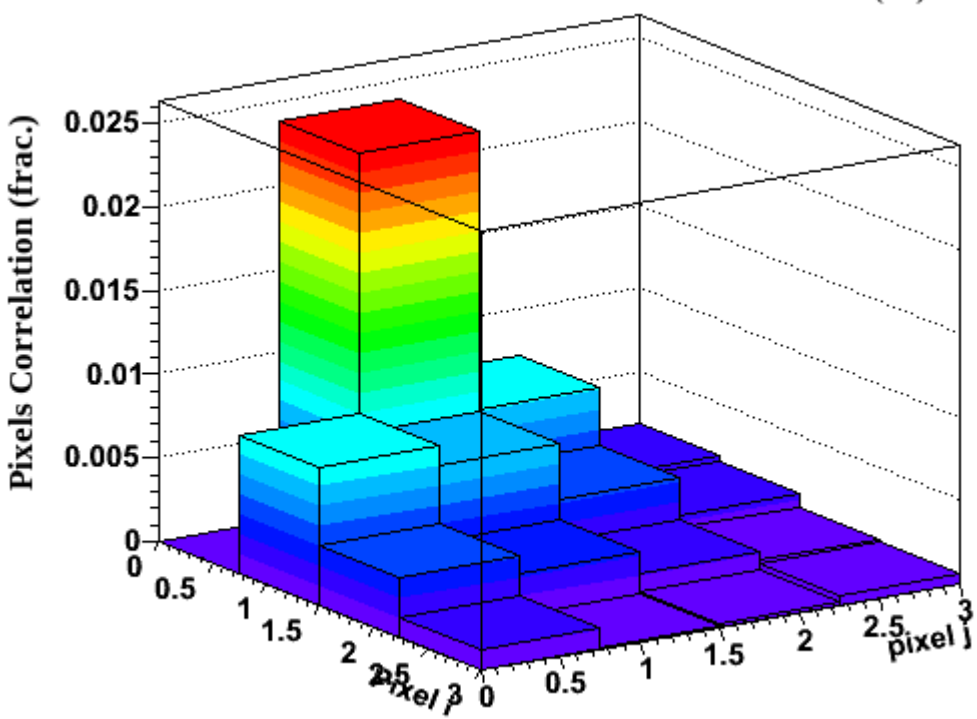


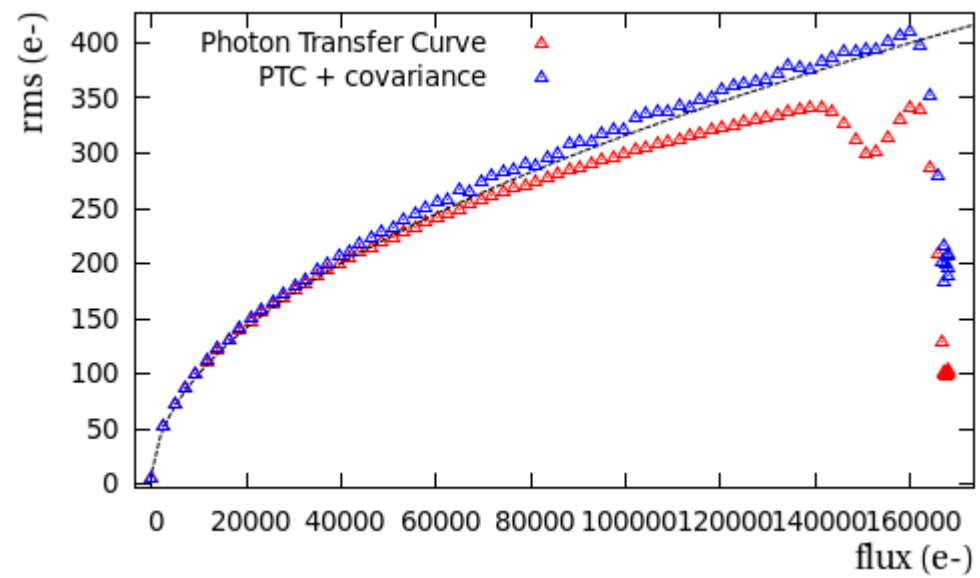


Photon Transfer Curve / correlations









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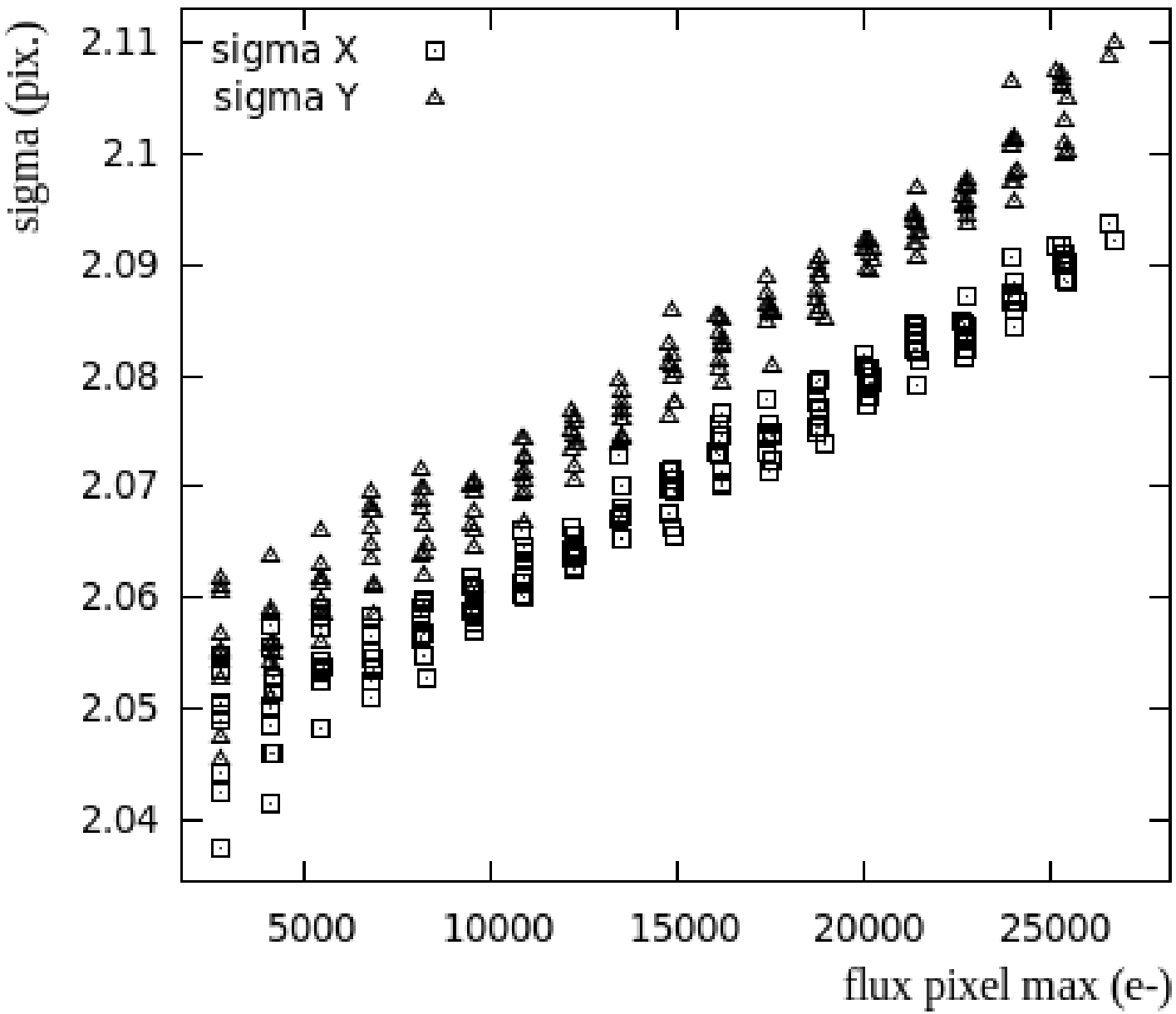
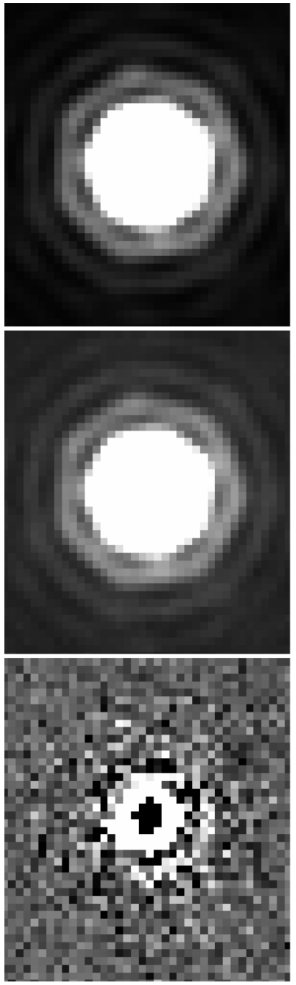
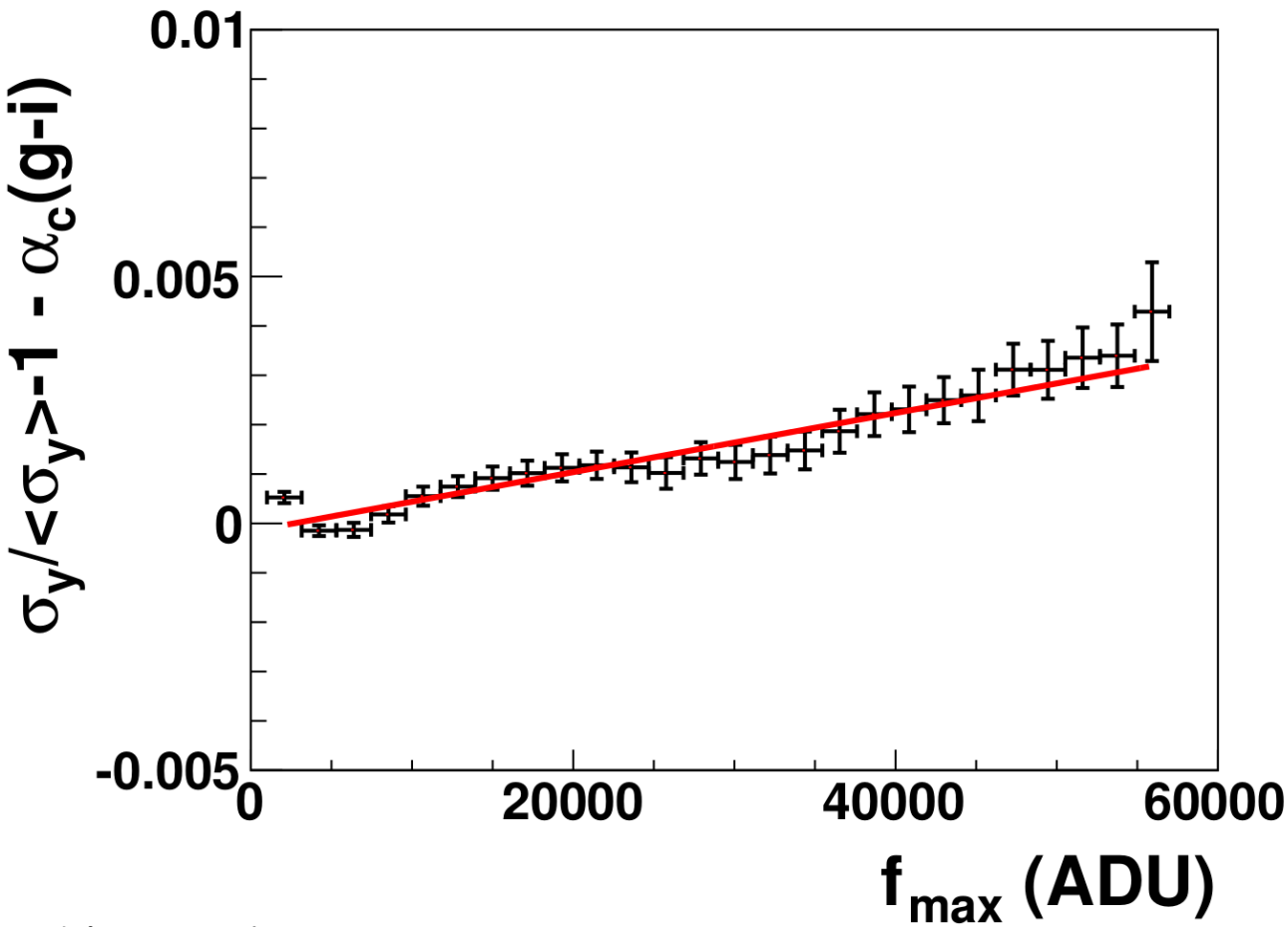
On LSST candidate sensors





On MegaCam exposures



- Stars on MegaCam exposures
- Effect also present on DECam exposures

Are these effects related ?

- Charge accumulated in CCD pixels perturbs the drift electric field

  → subsequent electrons won't drift the same way.

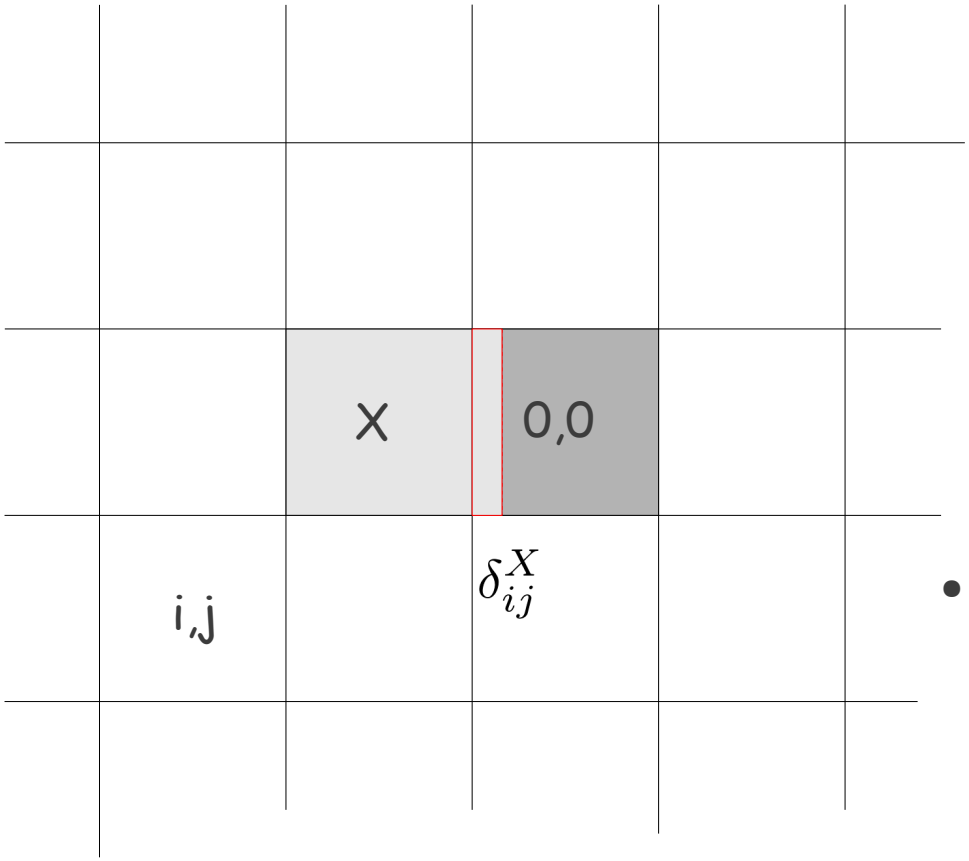
  → pixel size “shrinks” as charge accumulates.

  → correlations between pixels

  → stars / spots seem to “widen” as flux increases

- Goals
  - Empirical model to reproduce this ?
  - Alter the average PSF models to account for the effect

Model



$$\delta_{ij}^X = a_{ij}^X \times q_{ij}$$

- Drift field perturbed by pixel charges
  - Pixel "boundaries" move slightly
  - e- drift to adjacent pixels

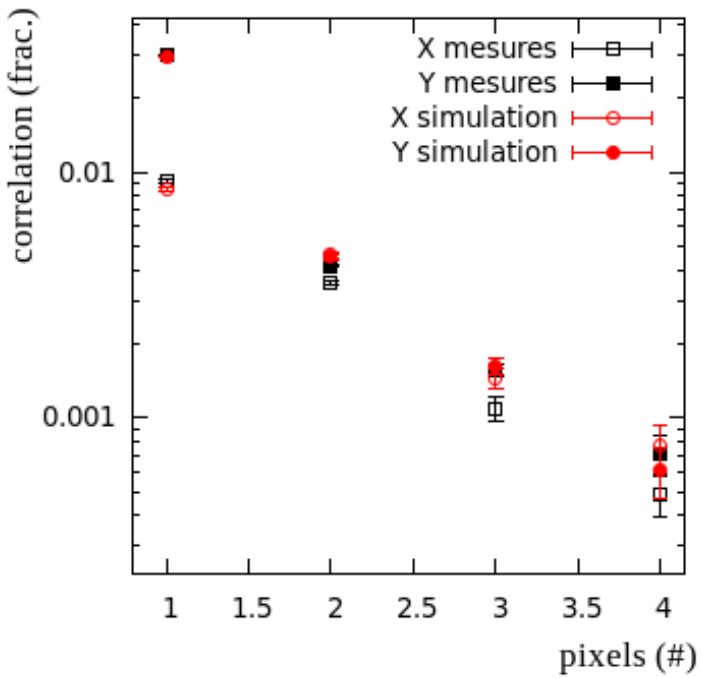
$$\delta q_{00}^X = \sum_{ij} a_{ij}^X q_{ij} (q_{00} + q_X)$$

- One can show that (flat field)

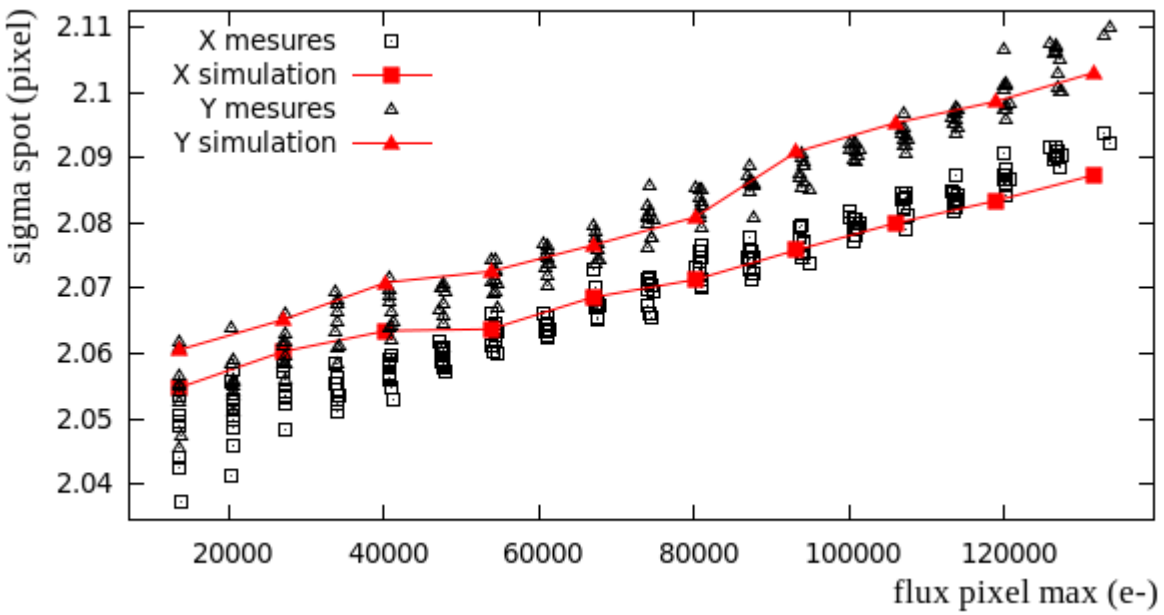
$$\mathrm{cov}(q'_{i,j}, q'_{00}) = 4V\mu \sum_X a_{ij}^X$$

Quadratic behavior in flux
(as observed)

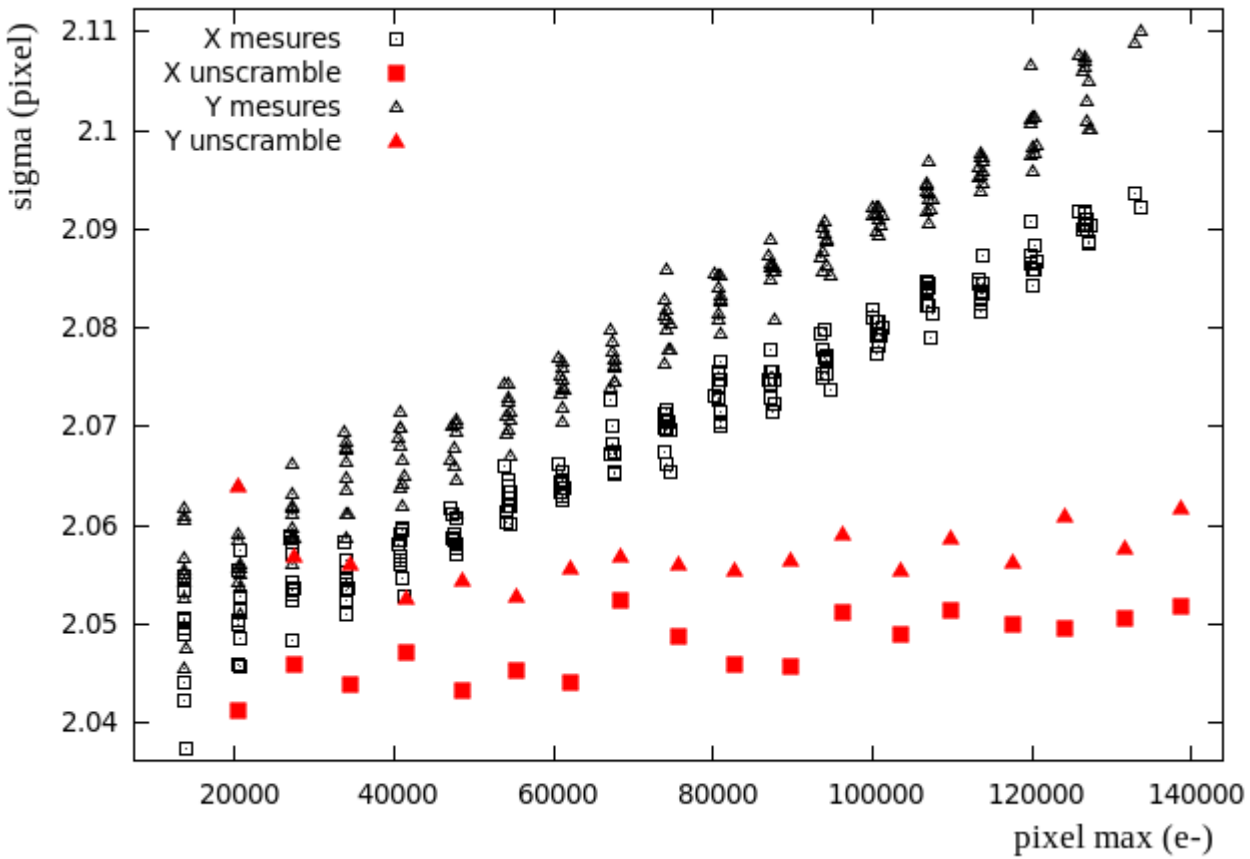
Testing the model on the LSST sensors



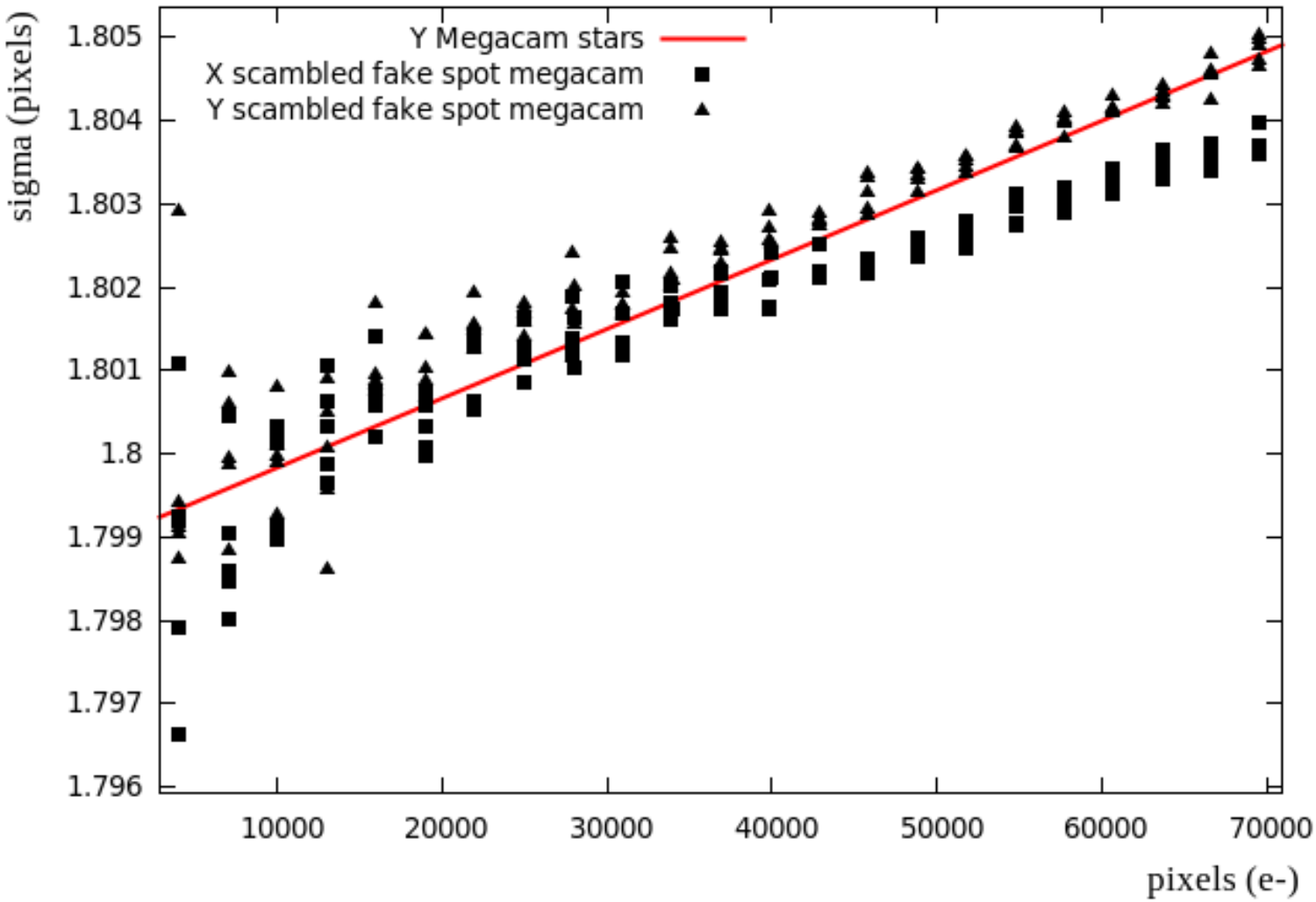
1) Parametrize the a_ij (~ 3 coefficients)
2) Constrain parametrization on flatfields
3) Apply model to (stacked) low flux spots
→ does reproduce the BF relation !



Testing the model on the LSST sensors



Testing the model on MegaCam



Summary

- Model explains LSST data well

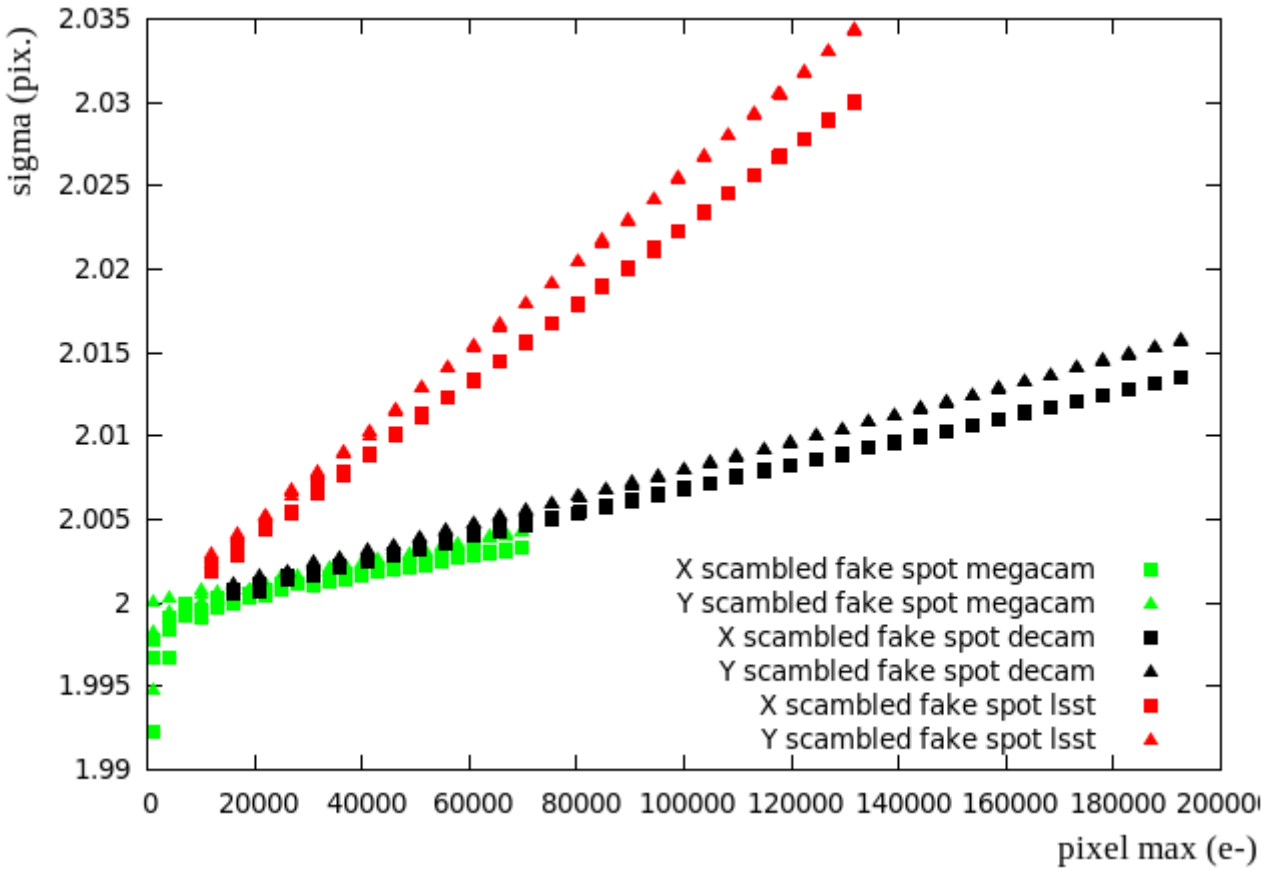
  → Trained on flatfields

  → Explains brighter-fatter relation well

  → We are able to correct the PSF (with no star flux information).

- Checks on MegaCam and DECam data on-going
- Longer term goal
  - Simulation of the CCD drift field

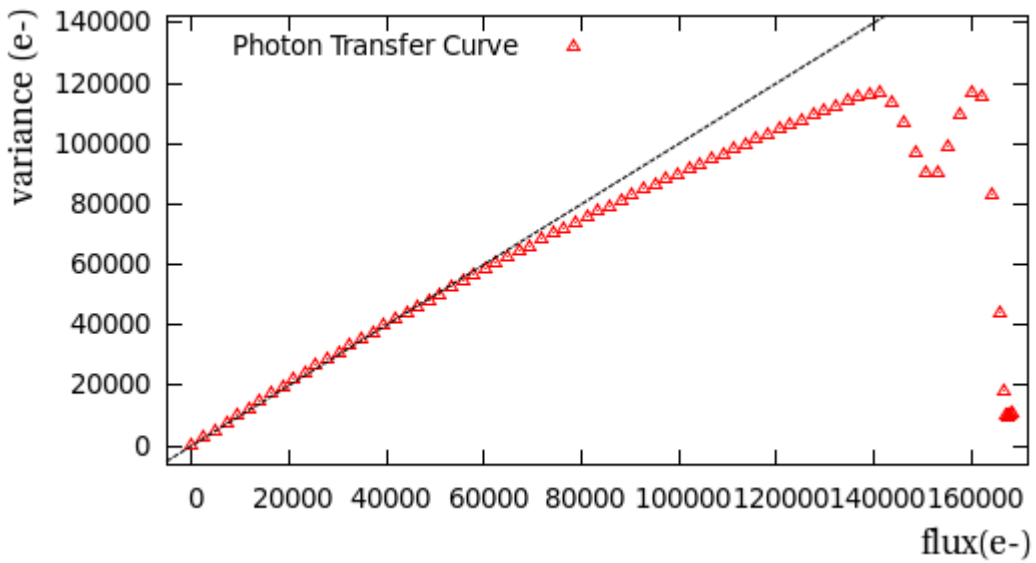
Expected PSF variations with flux (from the flatfield studies)

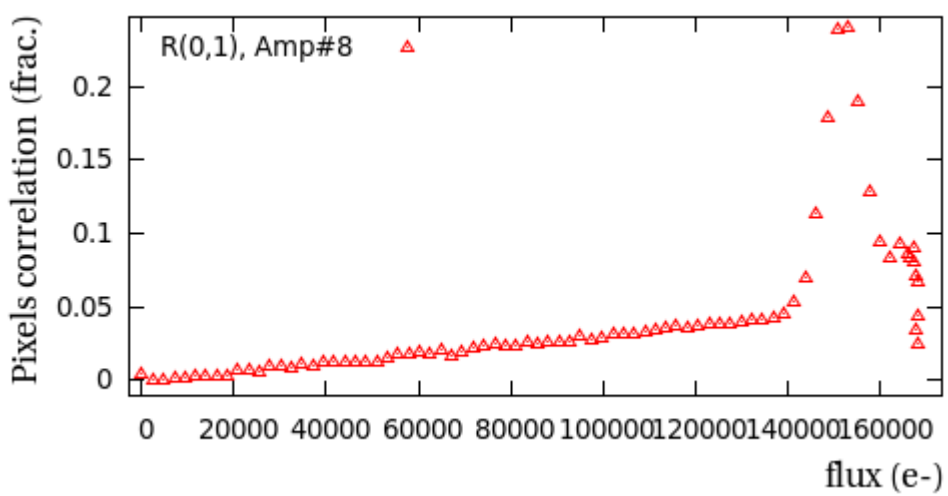


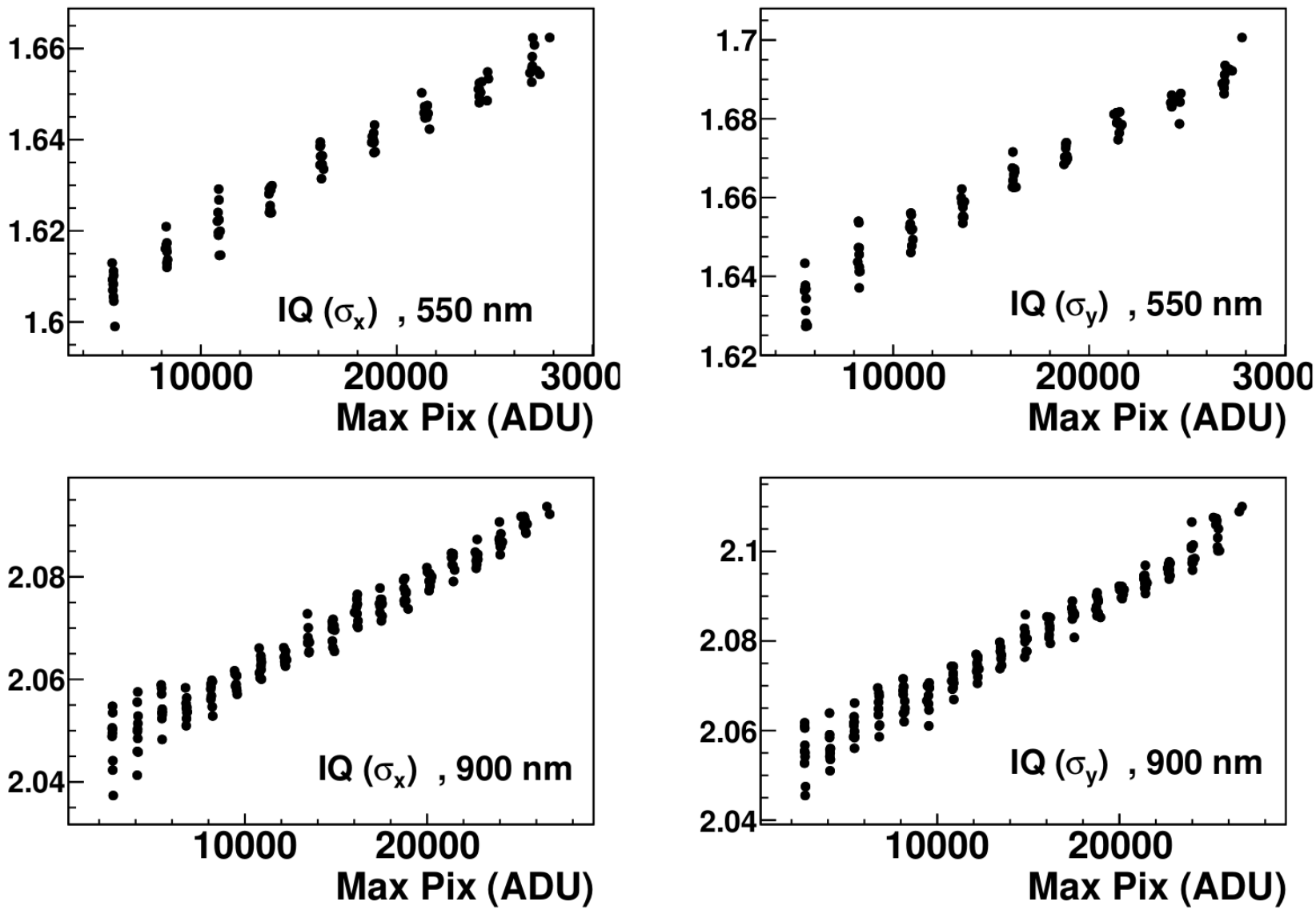
Backup

Photon transfer curve / correlations

$$\int_0^{+\infty} f(x)dx$$






1.66
1.64
1.62
1.6
IQ (σ_x) , 550 nm
10000
20000
3000
Max Pix (ADU)
1.7
1.68
1.66
1.64
1.62
IQ (σ_y) , 550 nm
10000
20000
3000
Max Pix (ADU)
2.08
2.06
2.04
IQ (σ_x) , 900 nm
10000
20000
Max Pix (ADU)
2.1
2.08
2.06
2.04
IQ (σ_y) , 900 nm
10000
20000
Max Pix (ADU)