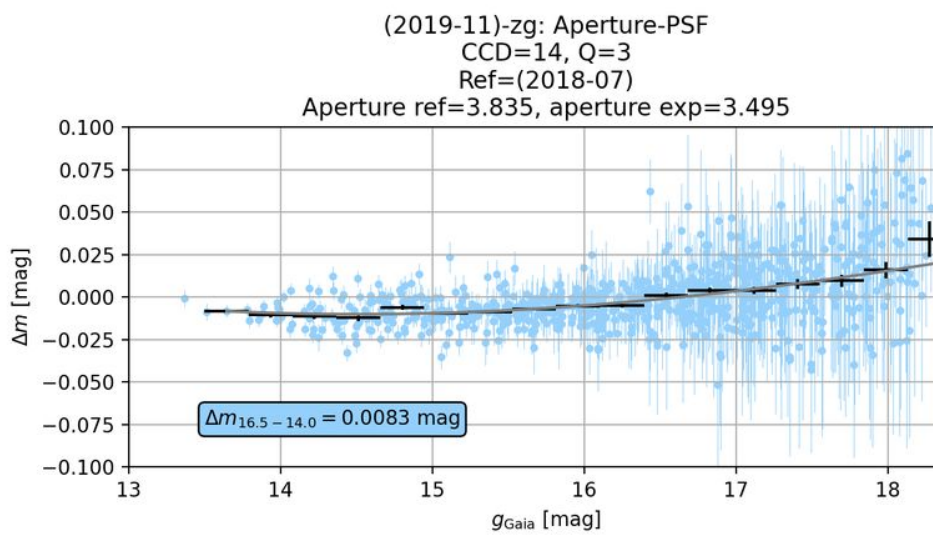
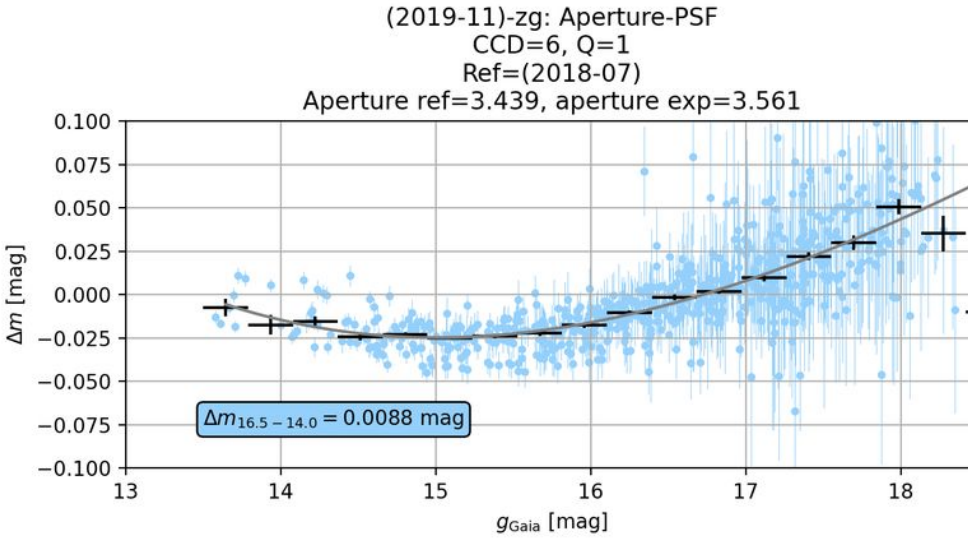
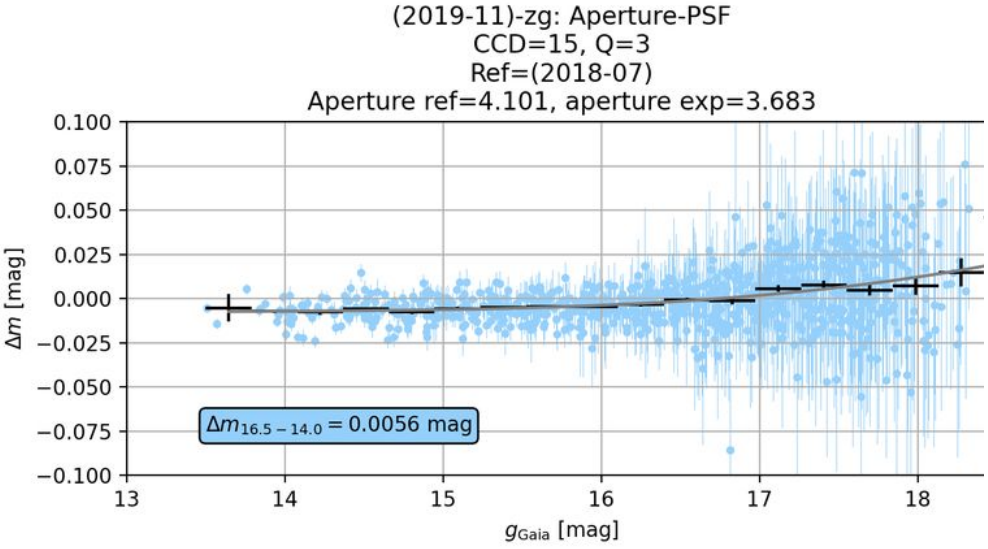
Update on pocket effect

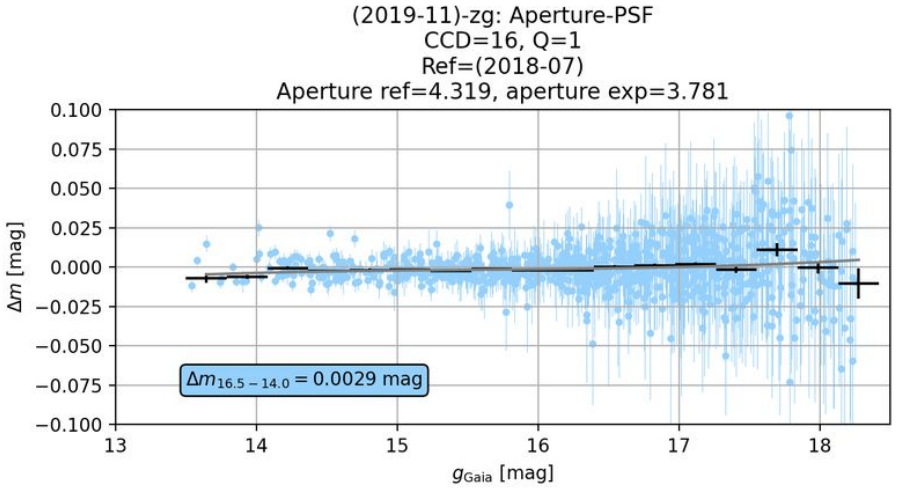
N. Regnault

PSF vs APER


(2019-11)-zg: Aperture-PSF
CCD=14, Q=3
Ref=(2018-07)
Aperture ref=3.835, aperture exp=3.495
$\Delta m_{16.5-14.0} = 0.0083$ mag
Δm [mag]
g_{Gaia} [mag]

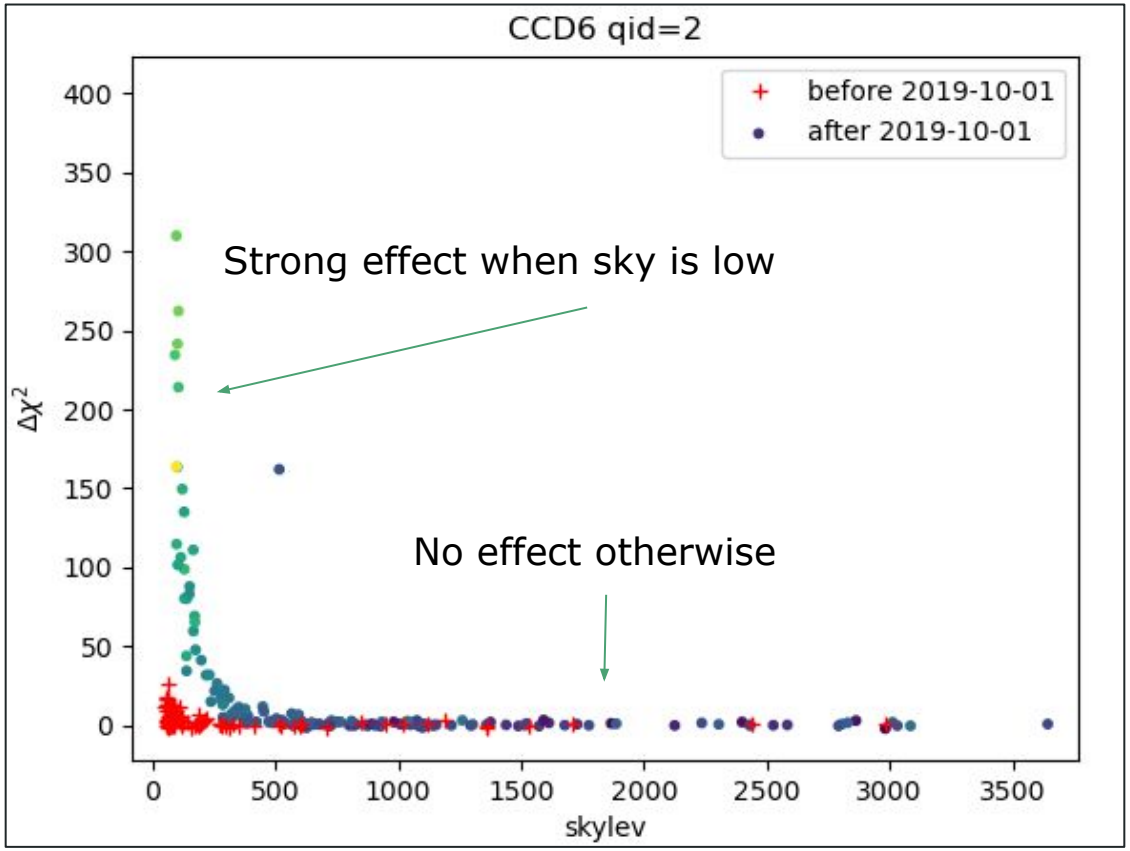

(2019-11)-zg: Aperture-PSF
CCD=6, Q=1
Ref=(2018-07)
Aperture ref=3.439, aperture exp=3.561
$\Delta m_{16.5-14.0} = 0.0088$ mag
Δm [mag]
g_{Gaia} [mag]


(2019-11)-zg: Aperture-PSF
CCD=15, Q=3
Ref=(2018-07)
Aperture ref=4.101, aperture exp=3.683
$\Delta m_{16.5-14.0} = 0.0056$ mag
Δm [mag]
g_{Gaia} [mag]

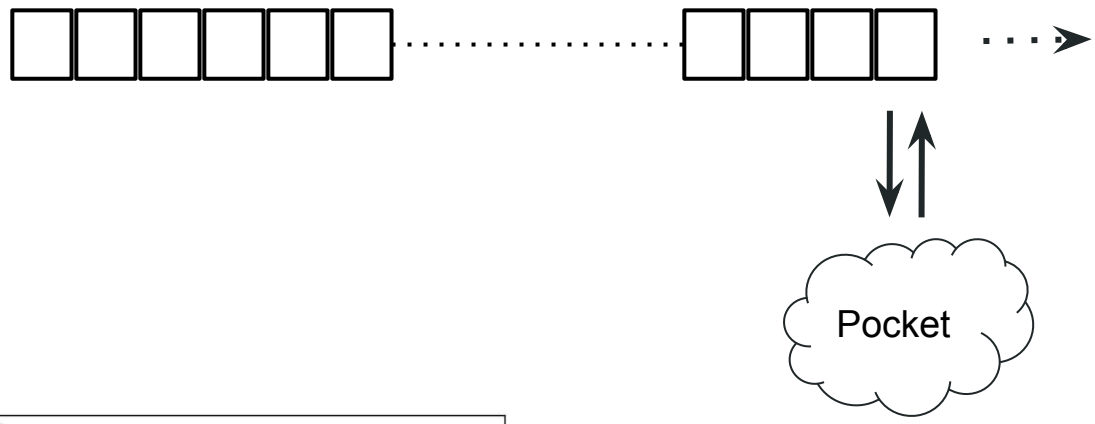

(2019-11)-zg: Aperture-PSF
CCD=16, Q=1
Ref=(2018-07)
Aperture ref=4.319, aperture exp=3.781
$\Delta m_{16.5-14.0} = 0.0029$ mag
Δm [mag]
g_{Gaia} [mag]

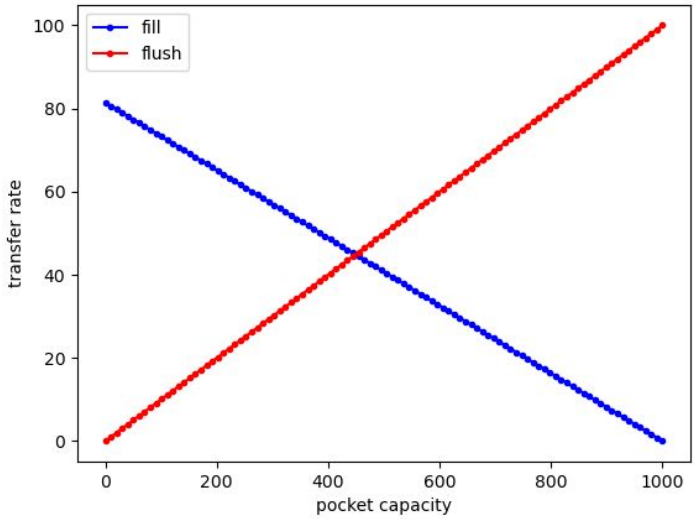
Detecting the effect on real data

- PSF - aper versus flux
  - Fit deg0, deg1, deg2 polynomials
  - Compare the chi2’s
  - -> allows to detect if the effect is present or not



Tentative model





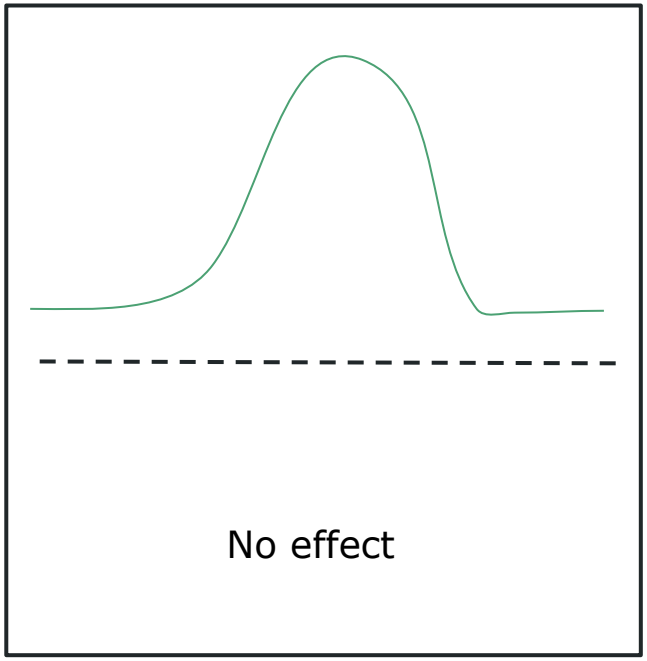
$$\mathrm{flush}(c) = c_{\max}\left(\frac{c}{c_{\max}}\right)^{\alpha}$$

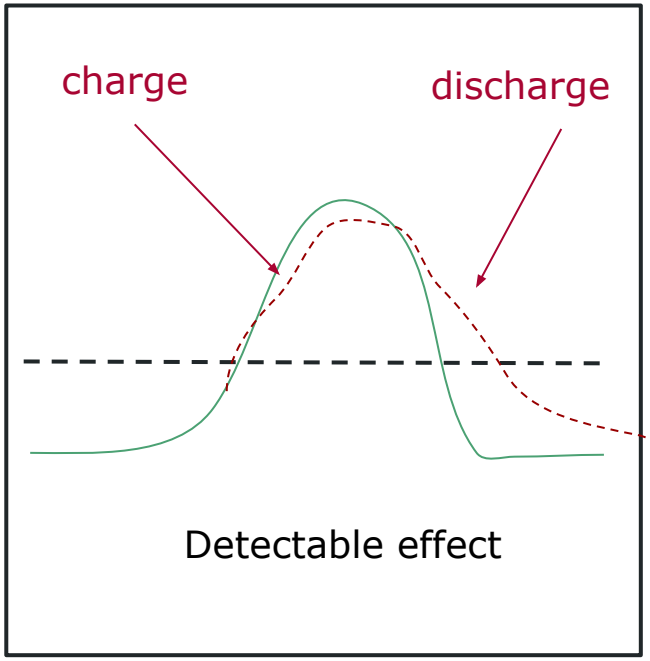
$$\mathrm{fill}(c,n) = c_{\max}\left(\frac{c}{c_{\max}}\right)^{\alpha}\left(\frac{n}{n_{\max}}\right)^{\beta}$$

$$\delta(c,n) = \mathrm{flush}(c) - \mathrm{fill}(c,n)$$

Do we have a (qualitative) model ?

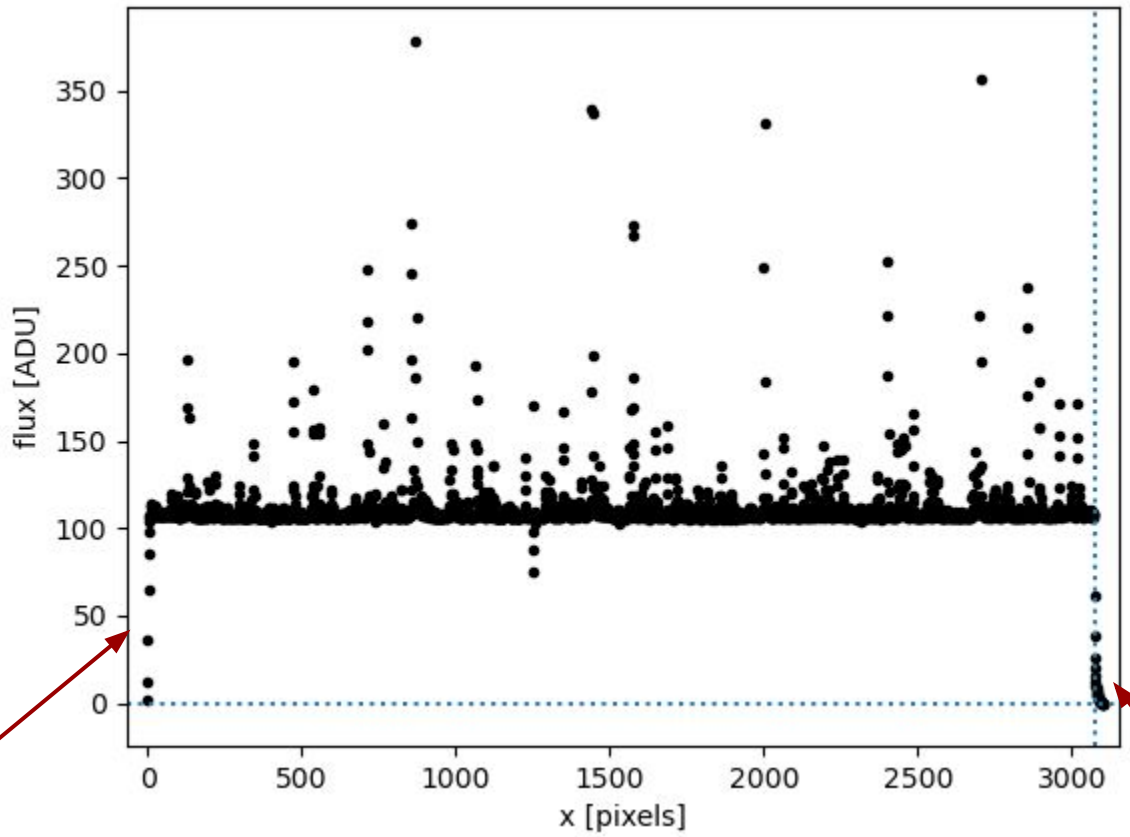
- Everything happens as if we had either traps, or a “pocket”
  - -> delayed charge
- When background is high, pocket is full -> no detectable effect
- When background is low, we detect something





Pocket saturation level

Image profile (after bias subtraction)



First pixels read

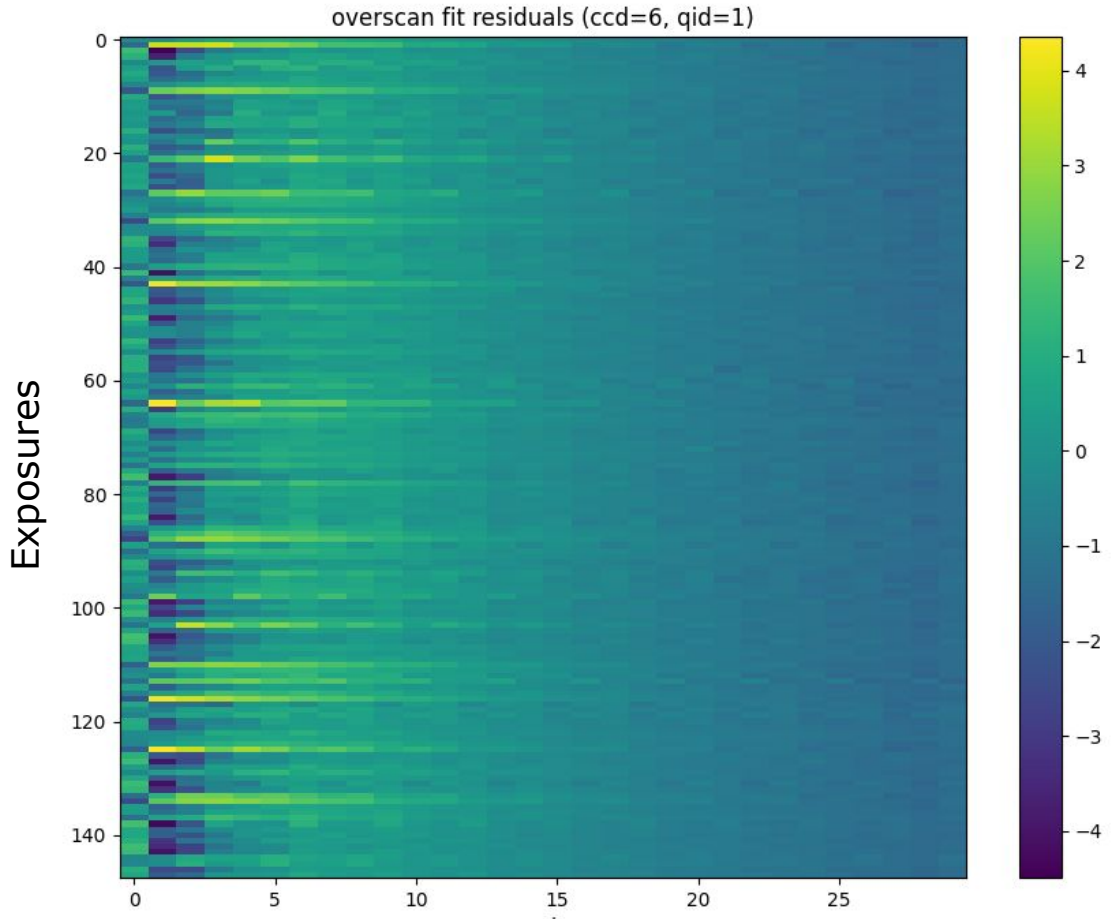
overscan

How to train the model ?

- Overscans
  - Direct measure of pocket flush function
  - From science exposures and/or flat field ramps
- First pixels
  - Direct measure of pocket fill function
  - Not sure of what we measure near the physical side of CCD
- Pixel-to-pixel correlations on flat field pairs
  - Sensitive to pocket effect (low flux)
  - Sensitive to brighter-fatter (high flux)
    - -> flat field ramps

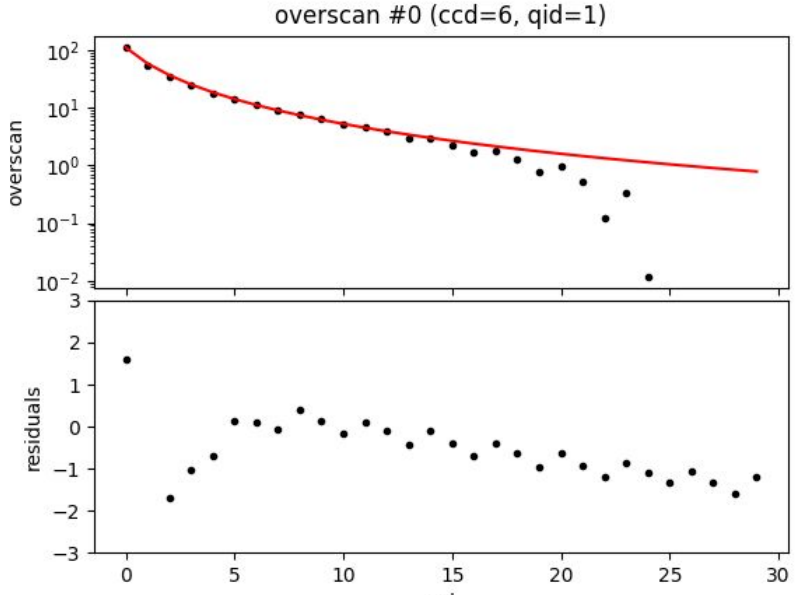
Constraining the flush function on overscans

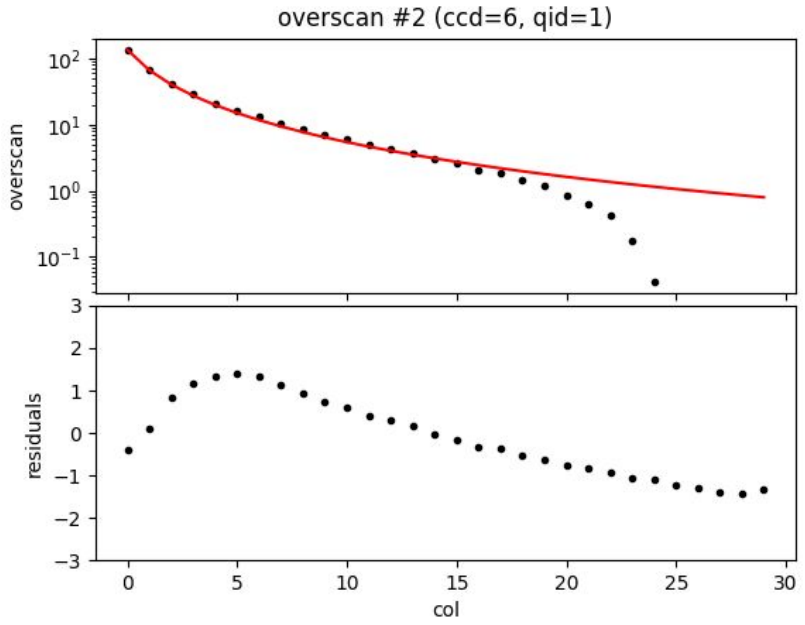
- 148 exposures of field #600, taken after 2019-12-01

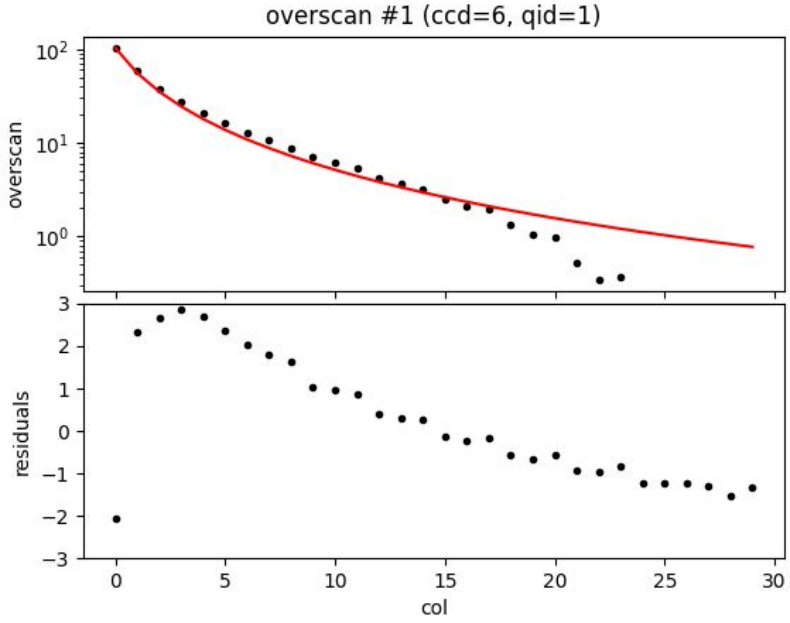


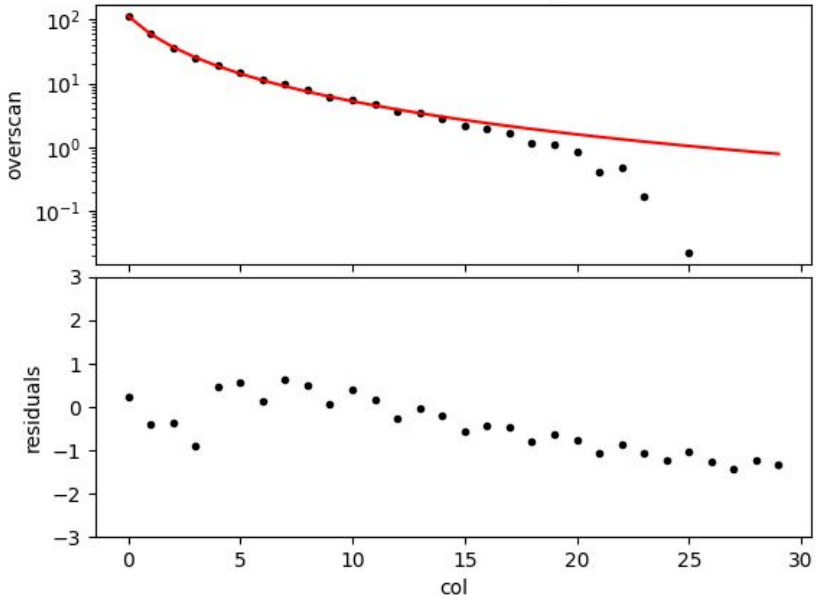
$$\begin{pmatrix} \alpha \\ c_{max} \\ \beta \\ n_{max} \\ c_1 \\ \vdots \\ c_n \end{pmatrix}$$

Constraining the flush function on overscans

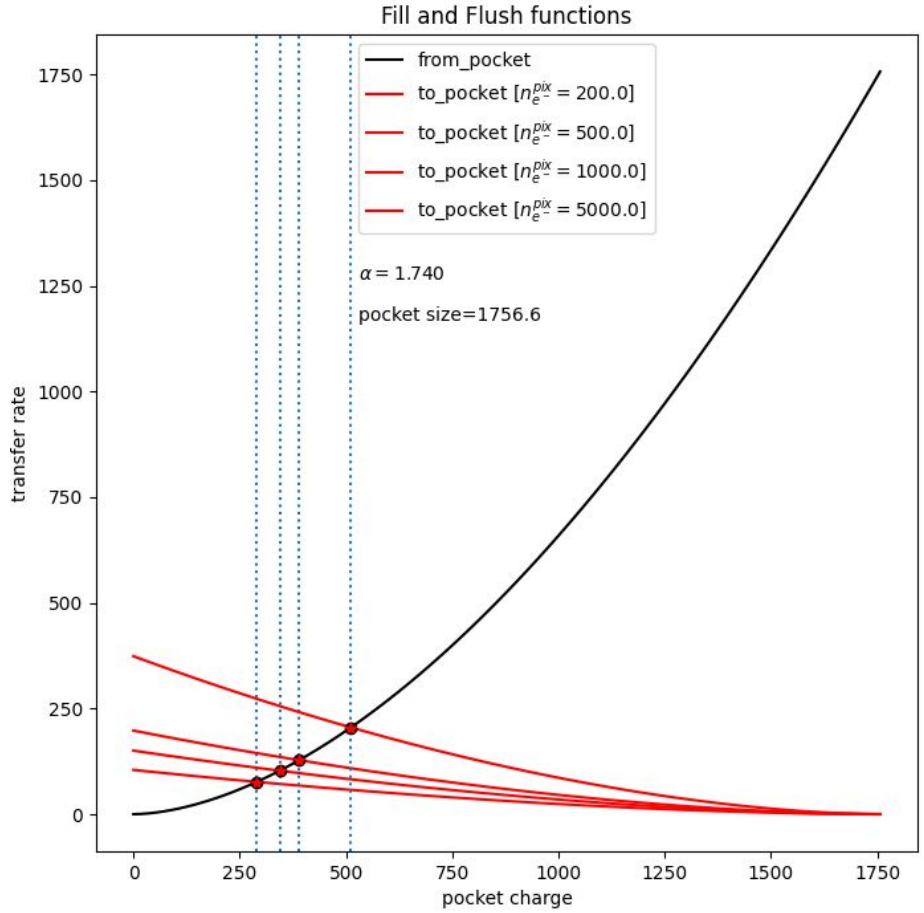


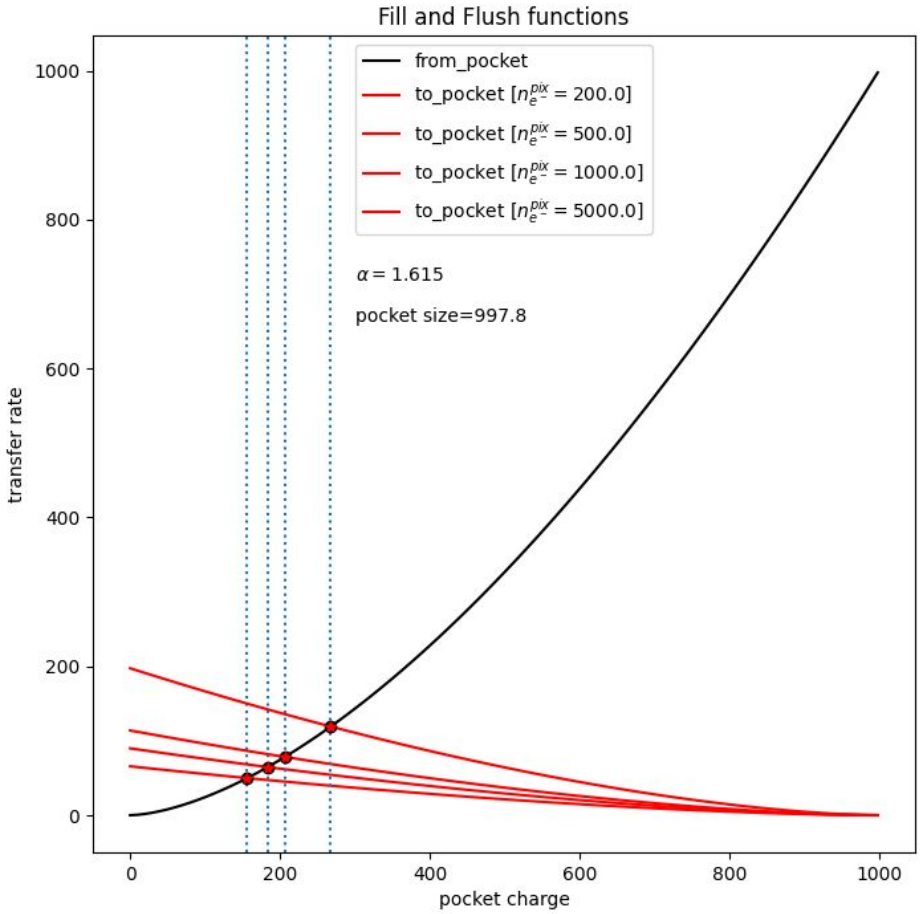




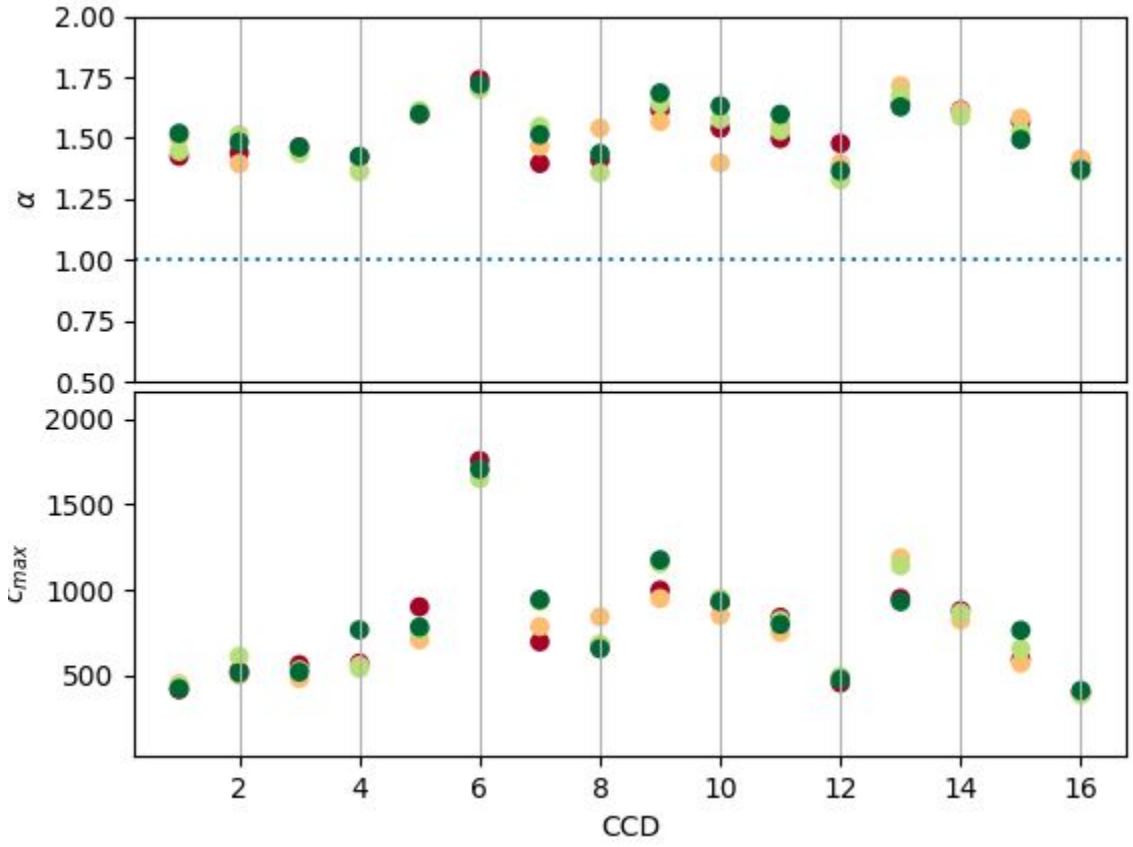


Fill and flush functions

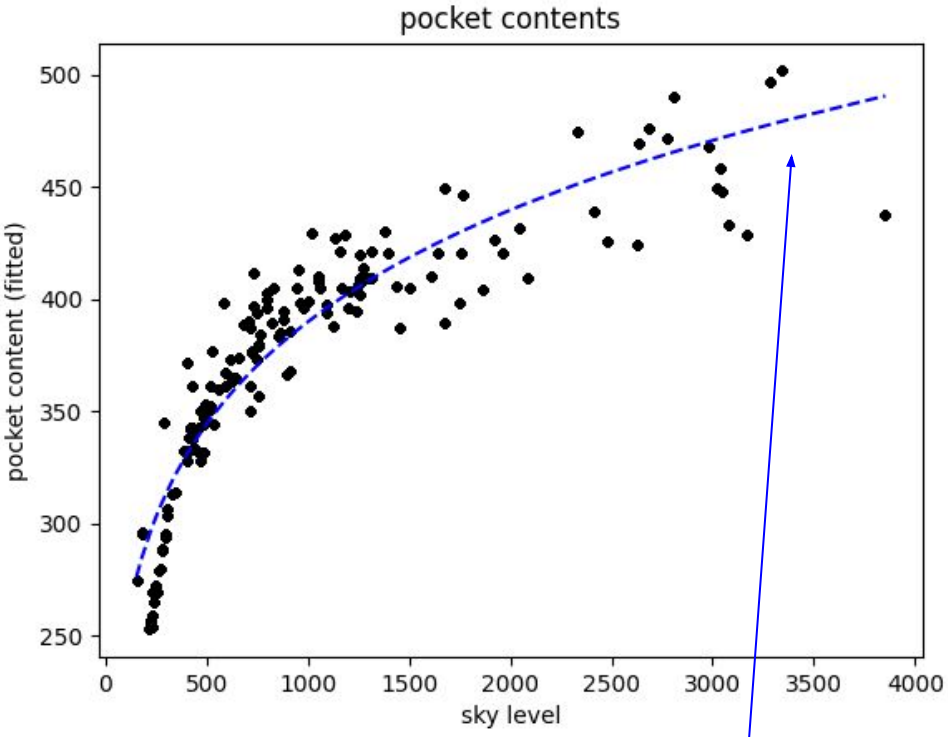


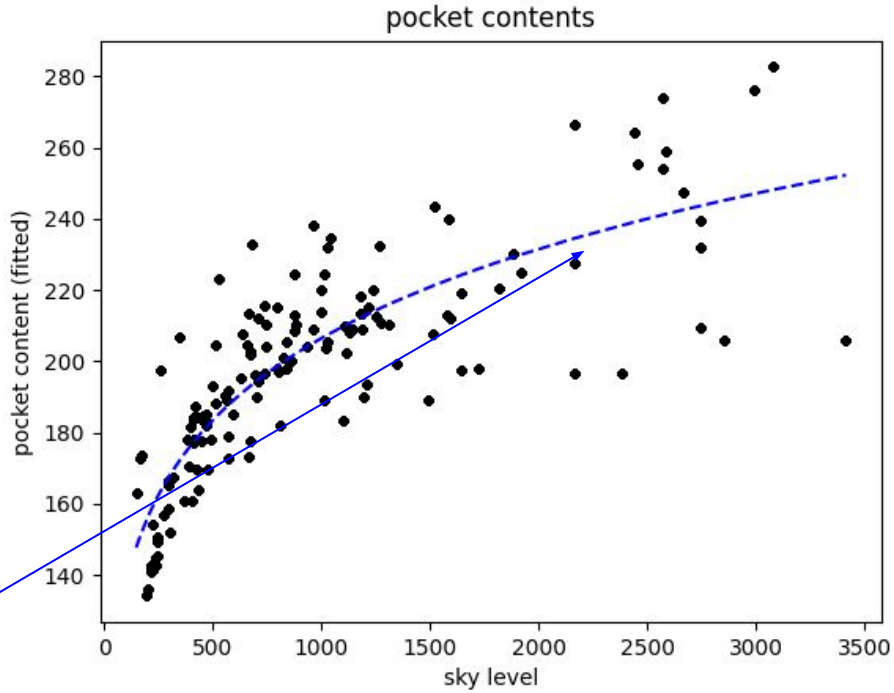


Model parameters (α and c_{max})



Indirect constraints on fill function

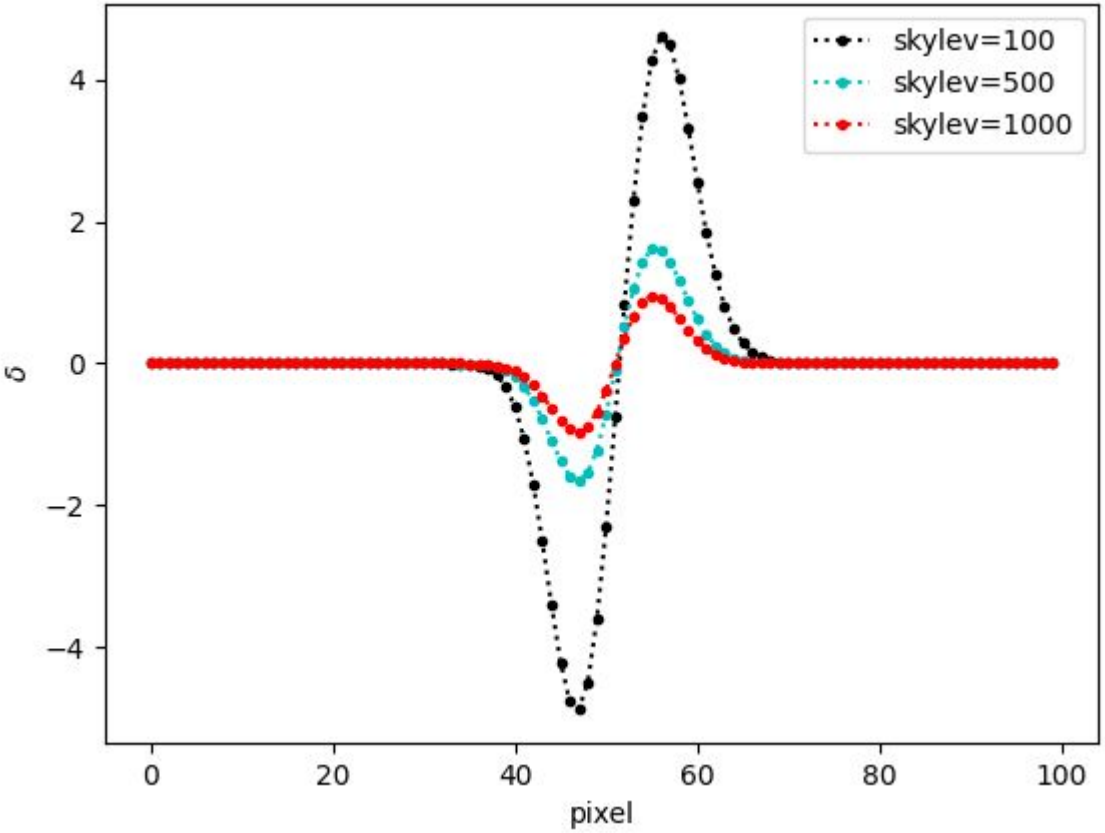




Pocket fill level is a function of sky background.

- Constrained by the overscans
- Prediction of the model

Fitted model behaves as expected



Inverting the effect

- Strategy 1
  - Assume the pocket is empty at the end of the overscan
  - Play the model backwards

    -> this strategy turns out to be unstable

- Strategy 2
  - Build a model that predicts the (distorted) pixel values as a function of the un-distorted pixel values
  - Fit the model on each line (least-squares)

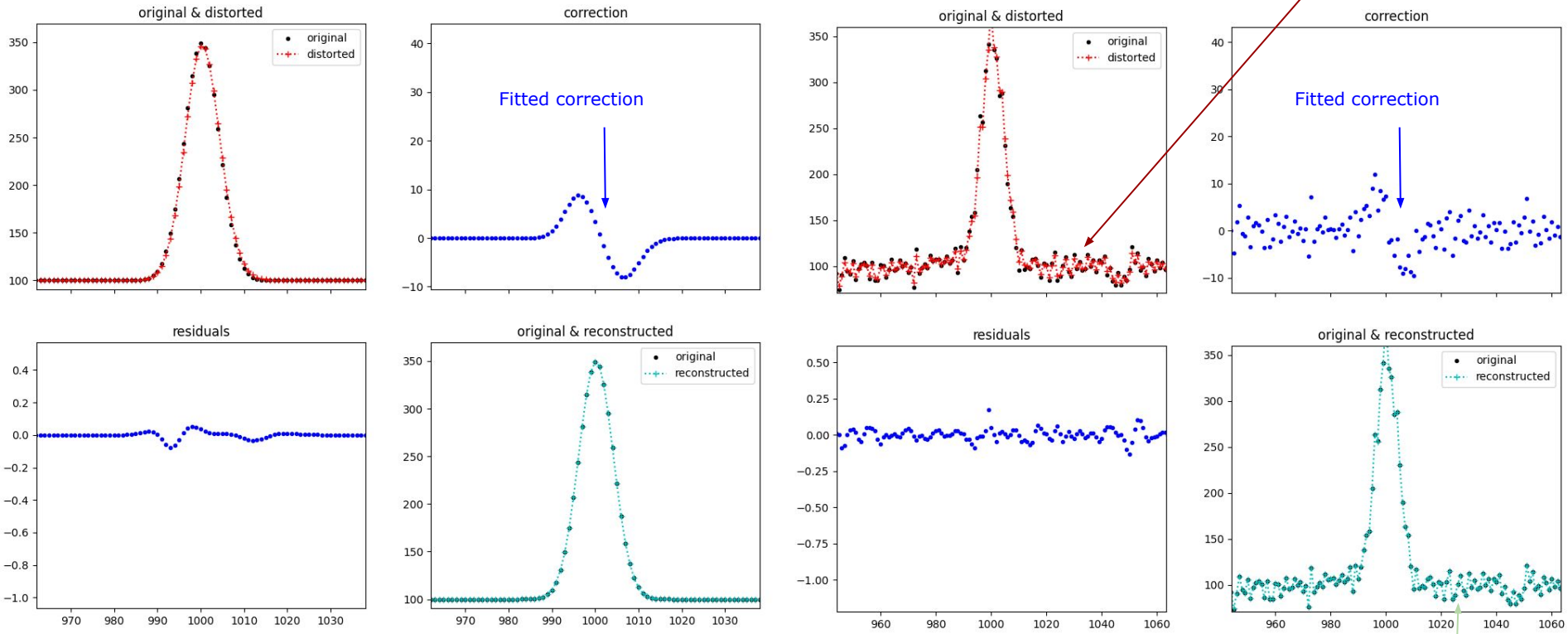
    -> much more stable

  - This strategy implies one fit (3030 parameters) per line.
  - Turns out that the fit matrix (and its factorization) can be recycled from line to line, we are at about ~ 1.5 ms per line -> quadrant corrected in seconds.

Inverting the effect (II)

Fit results (4 iterations, 1.4 ms / line)

Note the deficit of variance in distorted image (went into pixel-to-pixel covariances)

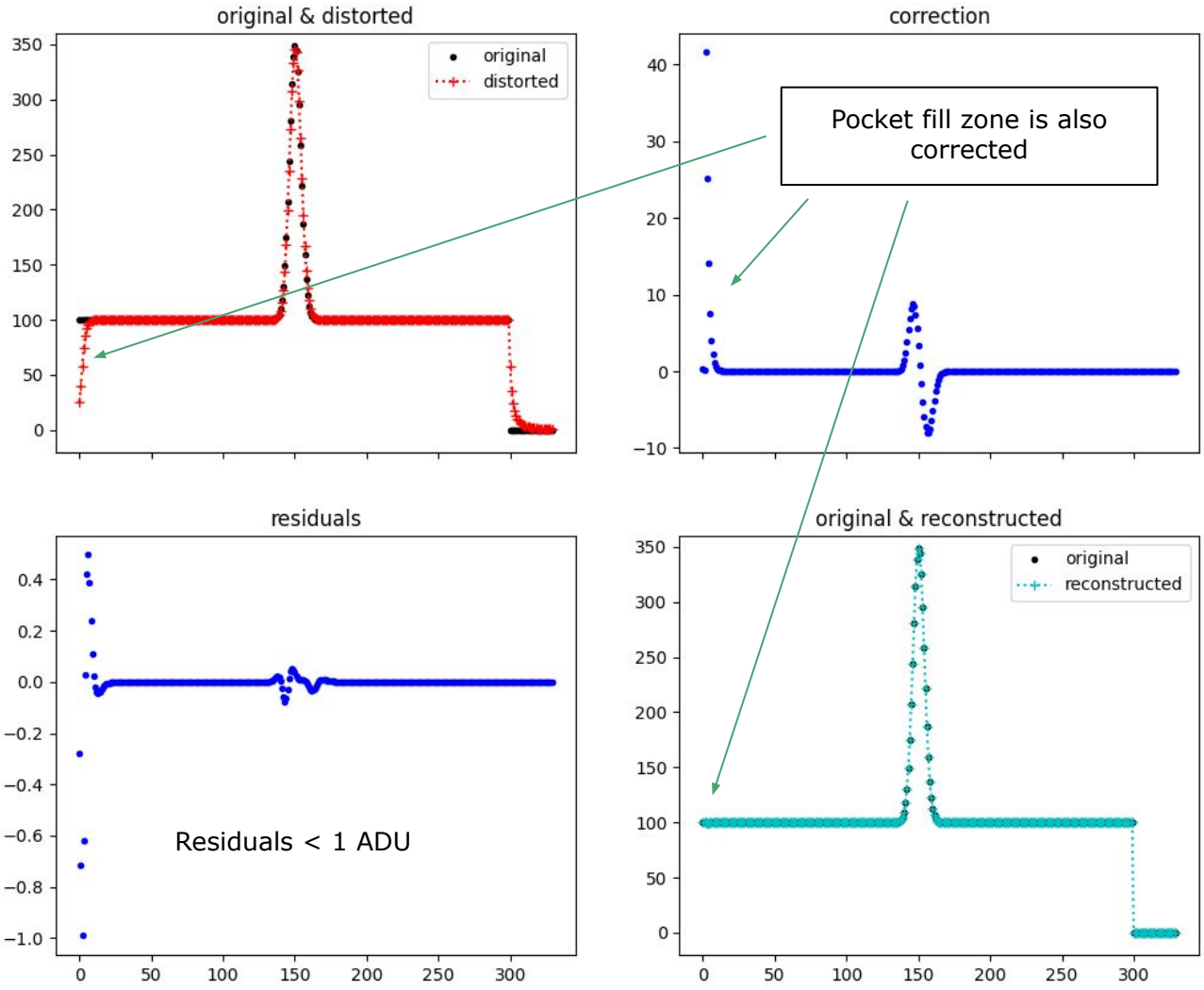


No noise

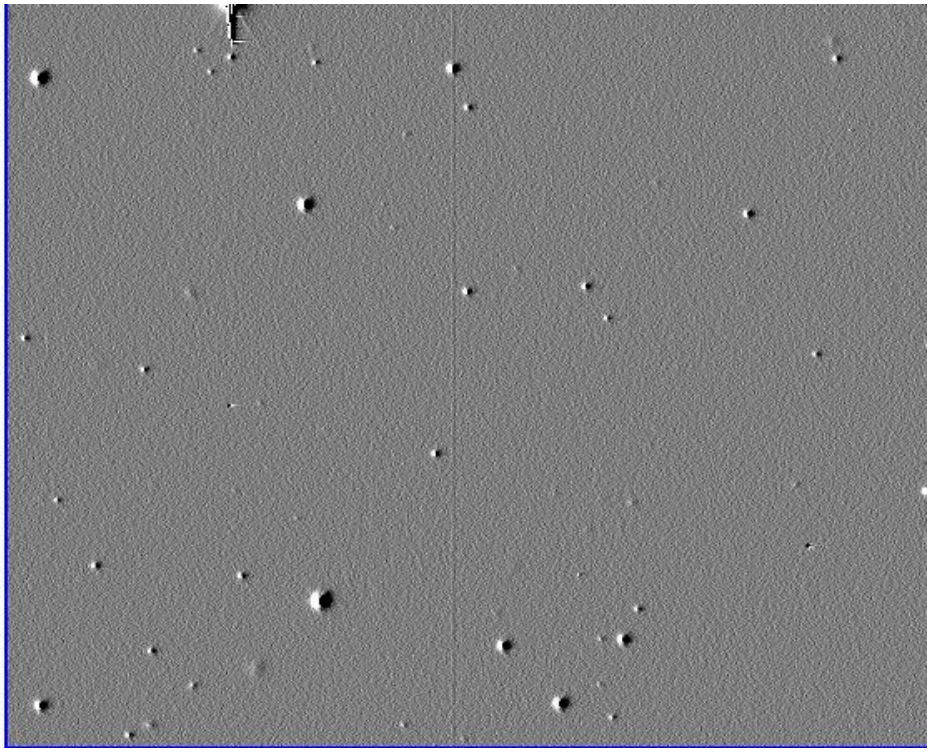
With noise

Looks like correct variance / covariances could be recovered

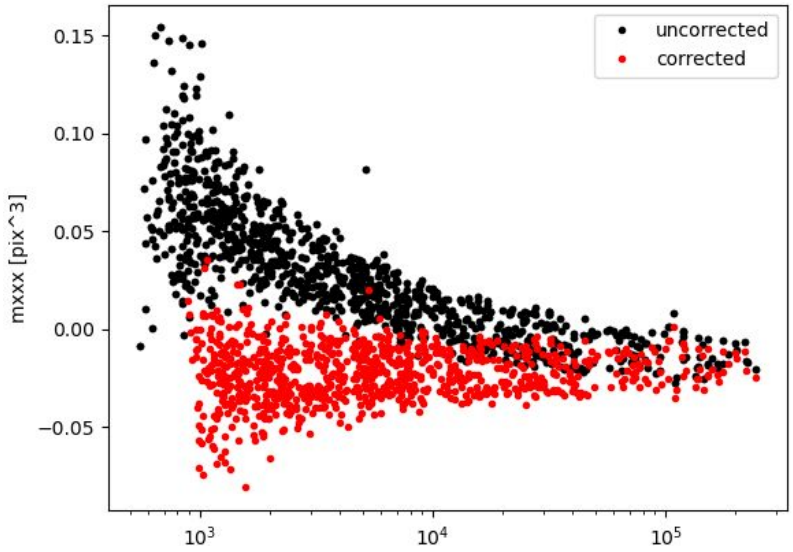
A more global view (entire line)

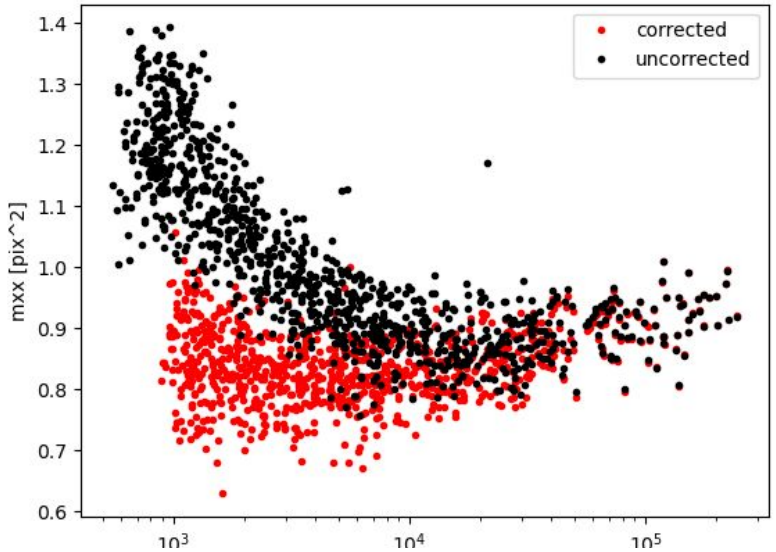


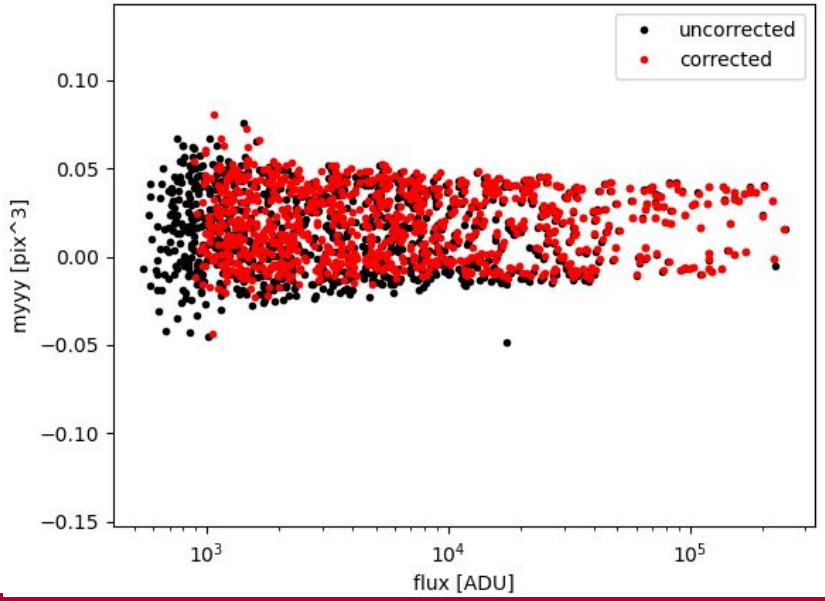
Correction in 2D

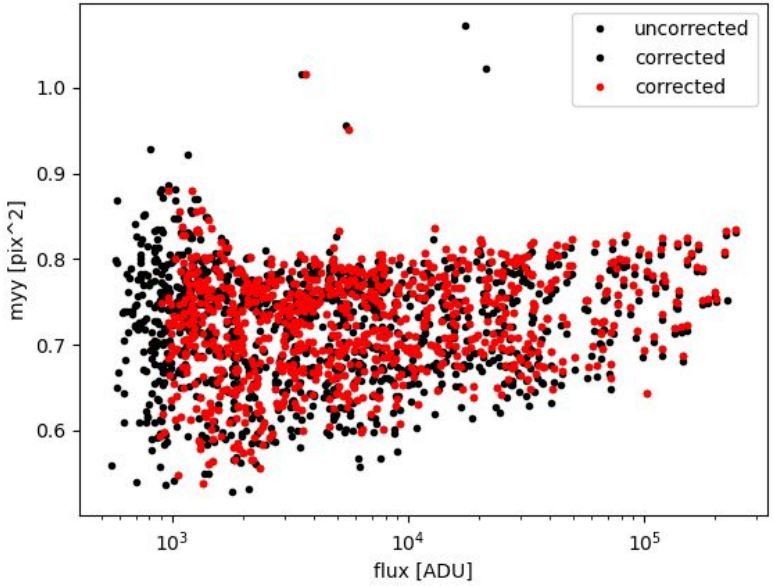


Raw / corrected skewness

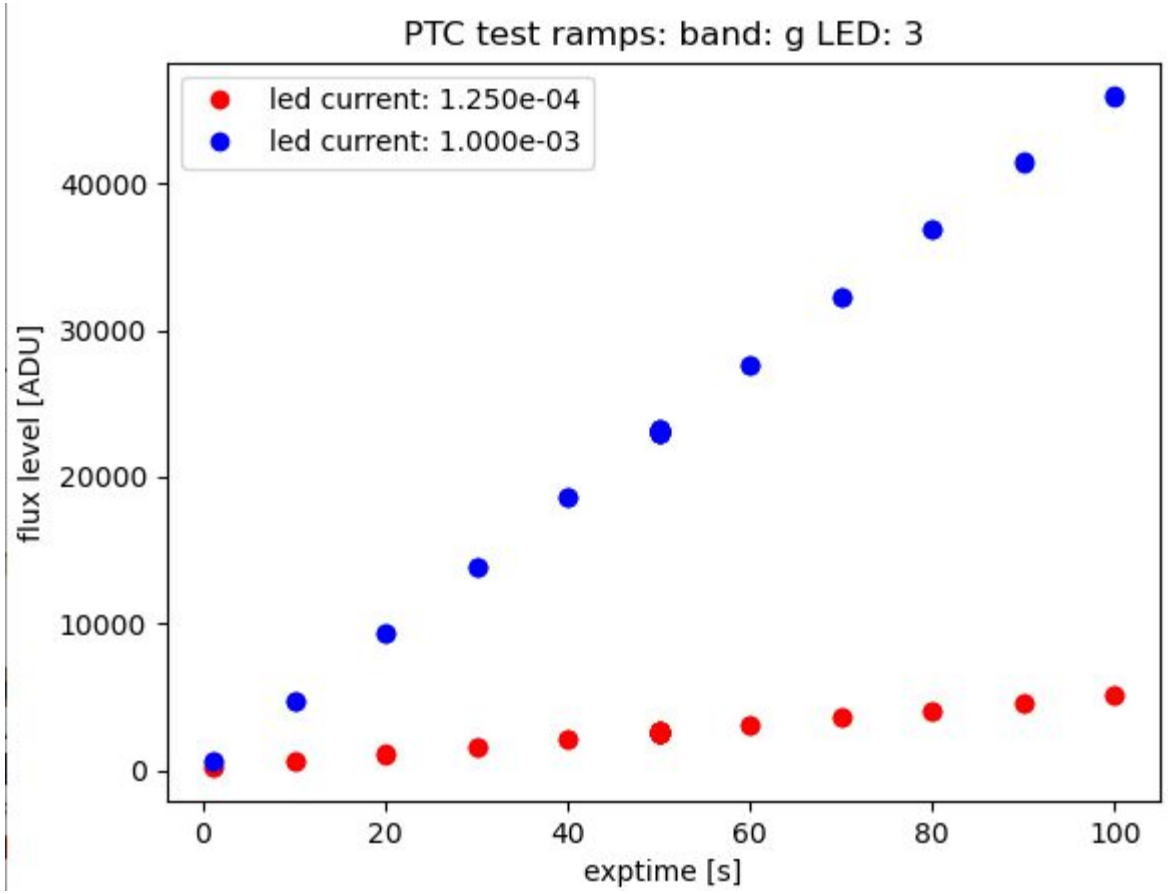




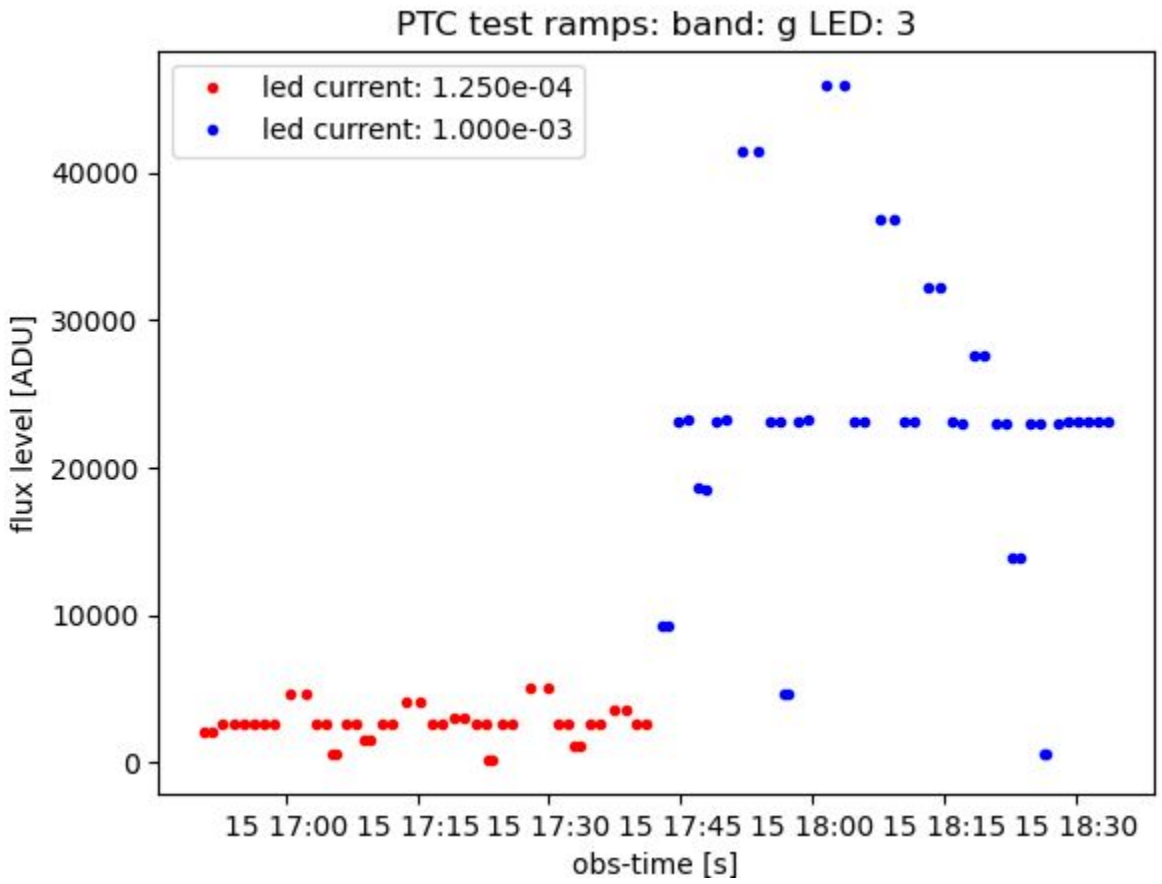




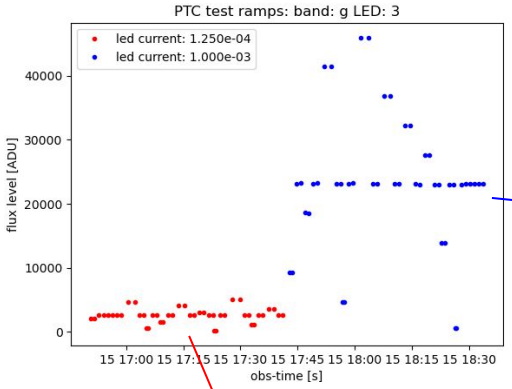
g-band

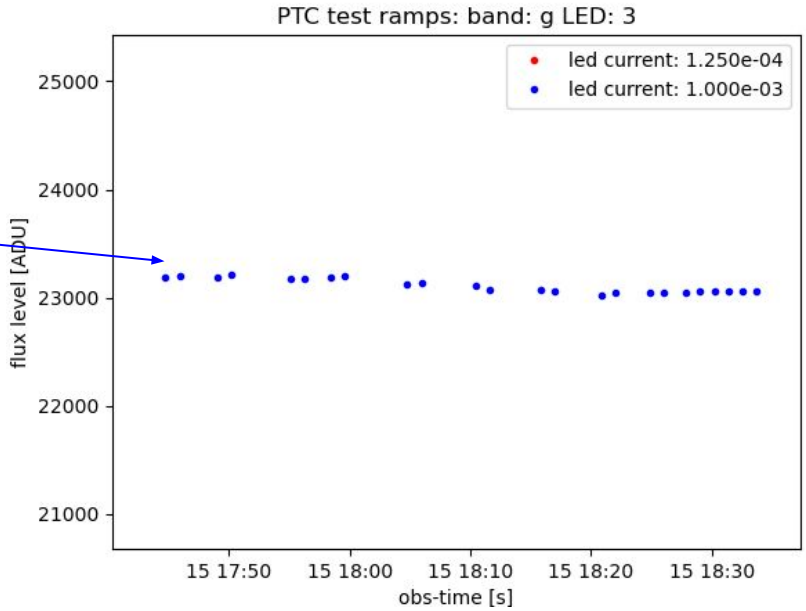

PTC test ramps: band: g LED: 3
led current: 1.250e-04
led current: 1.000e-03
flux level [ADU]
0
10000
20000
30000
40000
0
20
40
60
80
100
exptime [s]

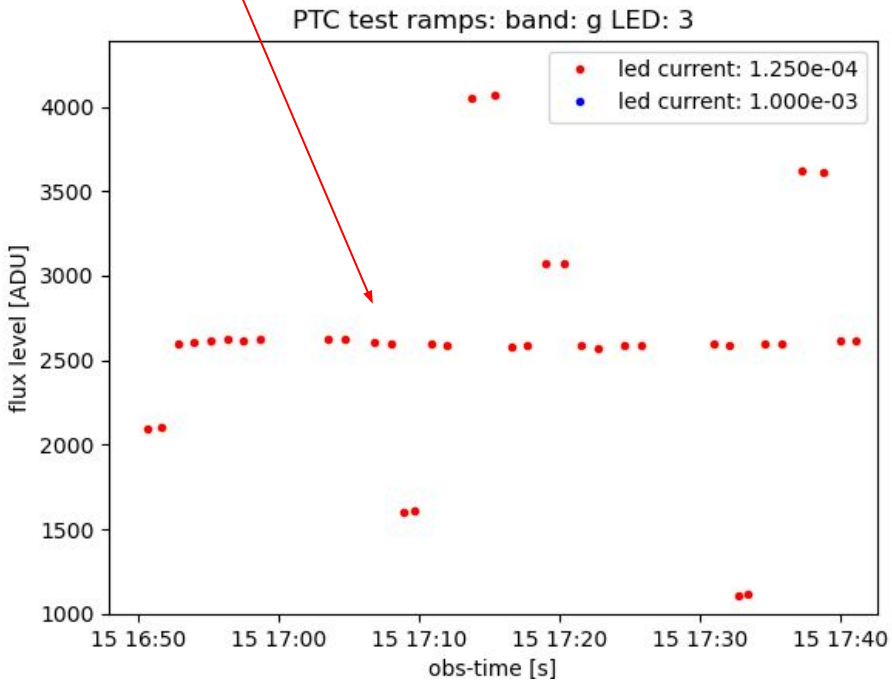
Randomized exposure times



Source stability

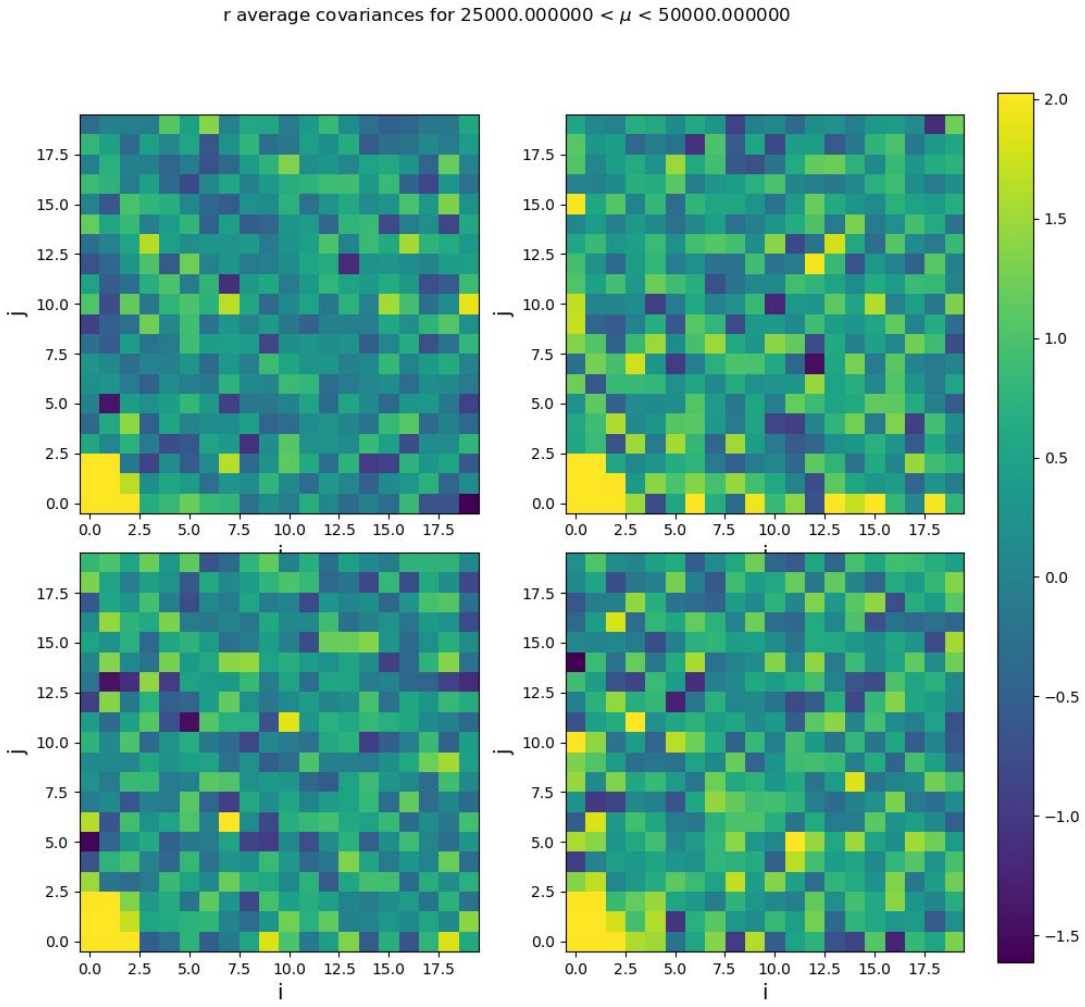






- Easily detectable
- Not accounted for yet
- Will be in the next report

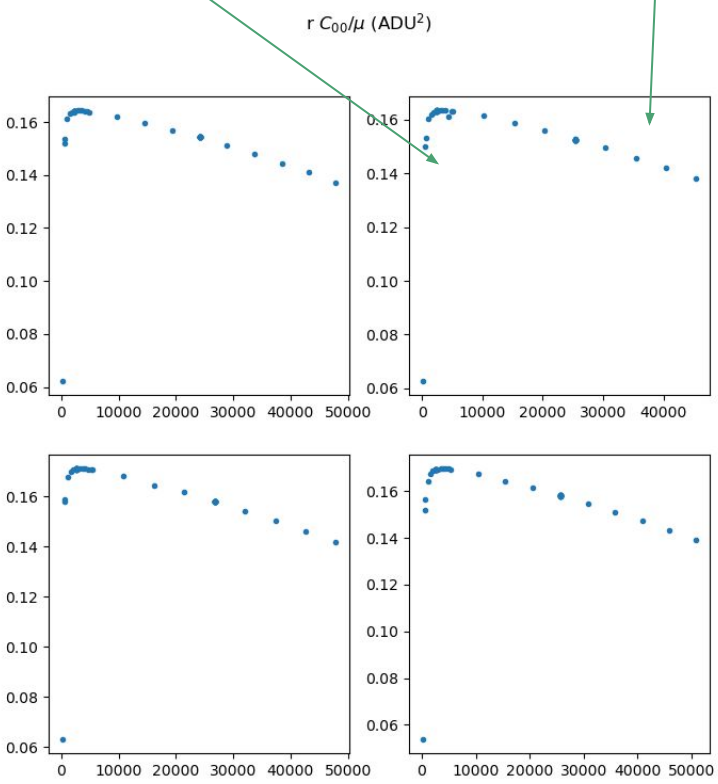
Covariance map @ high flux

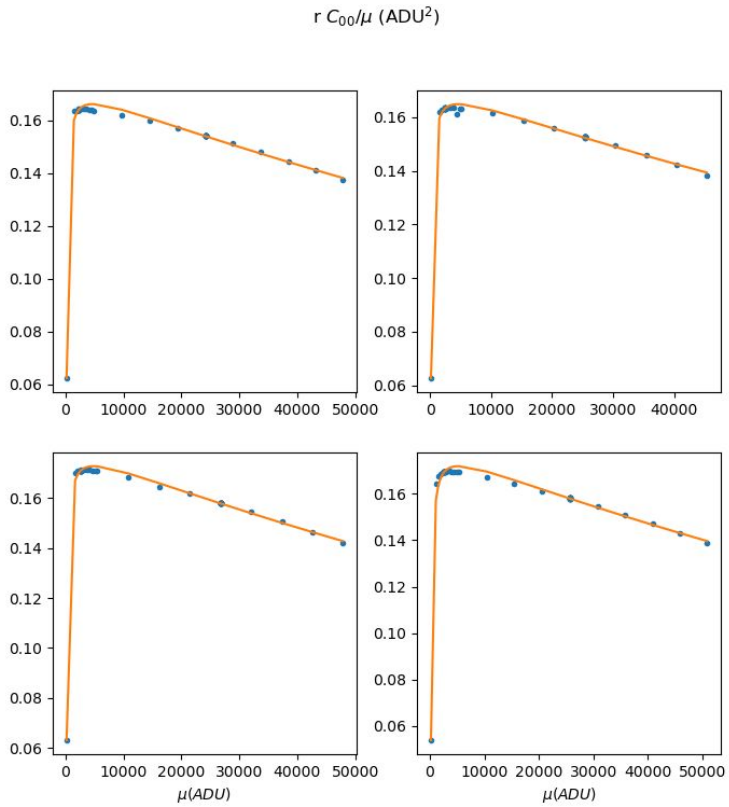


PTC fits : C00 r-band CCD09

Pocket effect

brighter-fatter





Conclusion

- Clear path towards characterizing and correcting
  - Pocket effect
  - brighter -fatter
  - Validate and deploy correction -> full dataset
- High priority
  - (need help)