MODEL PSF EFECTS OF PILE-UP ON 3D

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- Selection of the observations.
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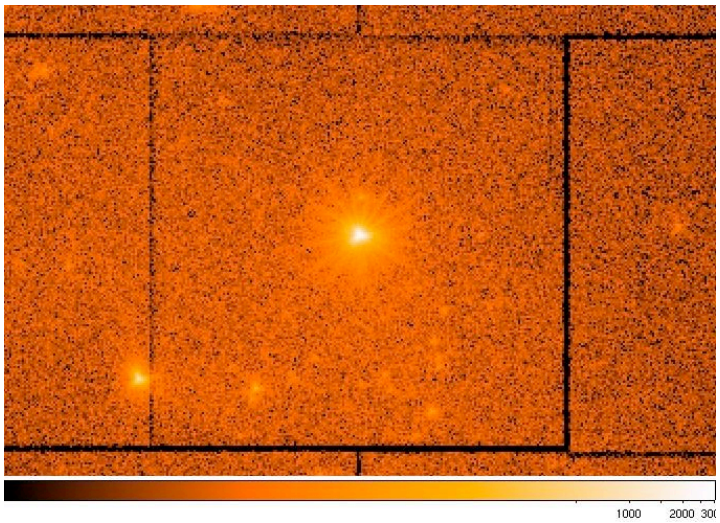
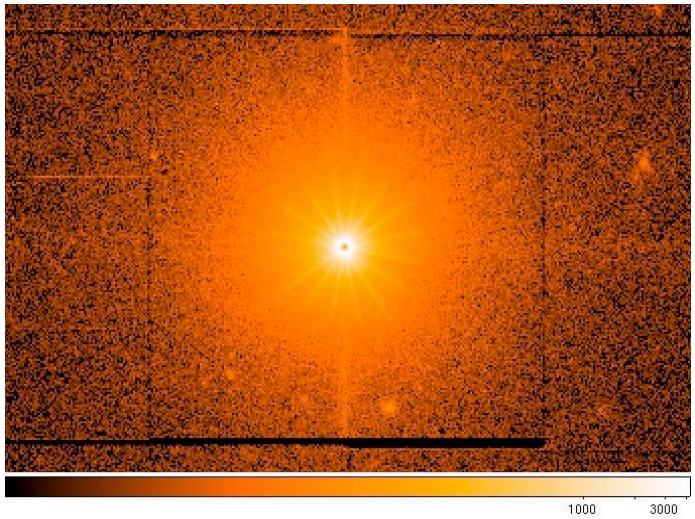
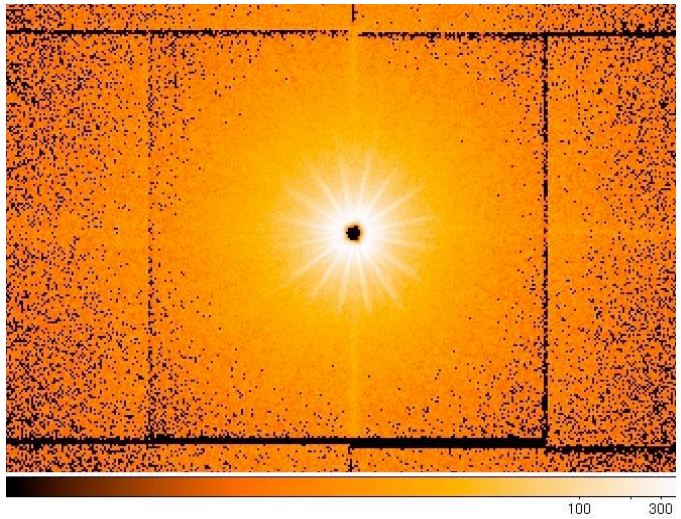
Aim of the project:

- Pile-up: Arrival of two or more photons within the readout time of the detectors.
- For very bright sources there is a considerable amount of pile-up.
- The centre of the PSF (Point Spread Function) gets distorted:



Clean PSF.

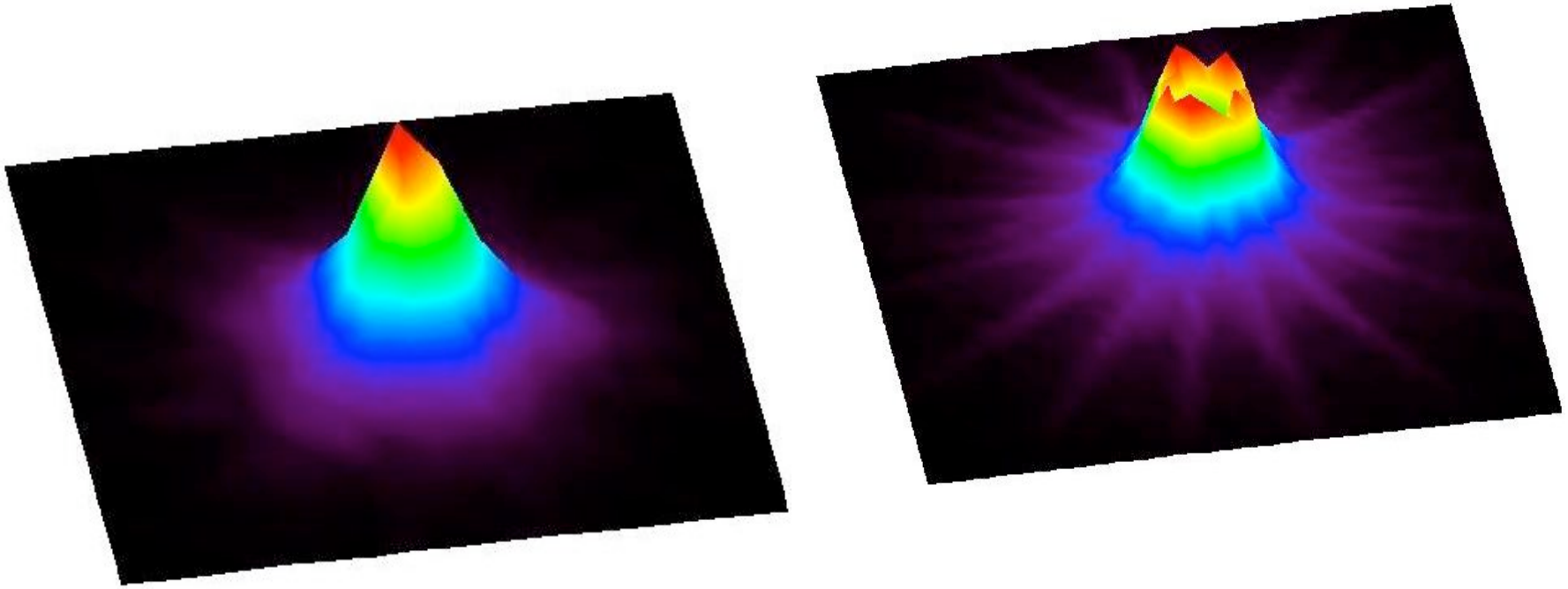




Loss of counts at the centre of the PSF.

Aim of the project:

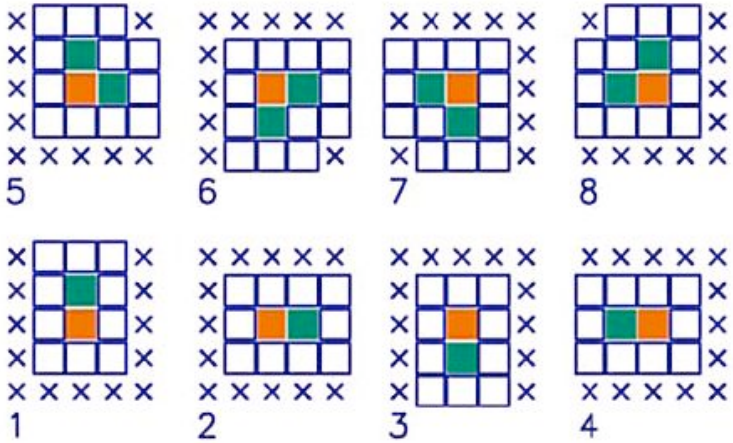
Finally a 3D model of the PSF will be created:

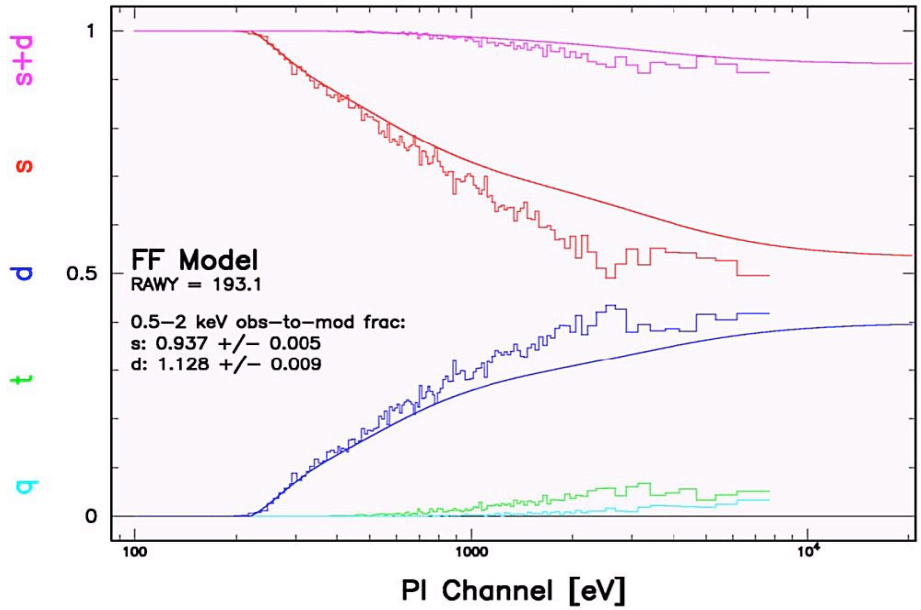


What is pile-up?

Pattern pile-up: Two or more photons arriving next to each other in the same readout time.

Photon pile-up: One single photon causes multiple pixel activation





SAS task *Epatplot* output

Consequences:

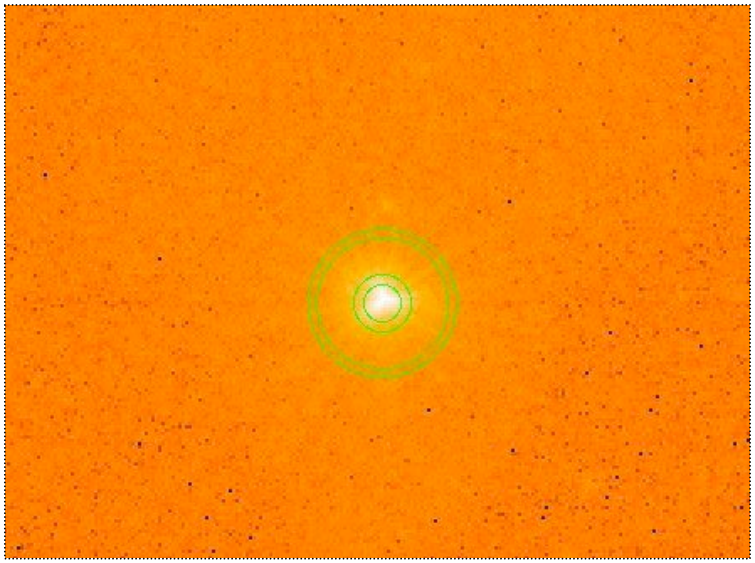
- Less counts at the PSF centre.
- Shifts the spectrum towards higher energies.

Selection of observations:

- Distinguish point sources:
  - Observation Modes
  - Filters

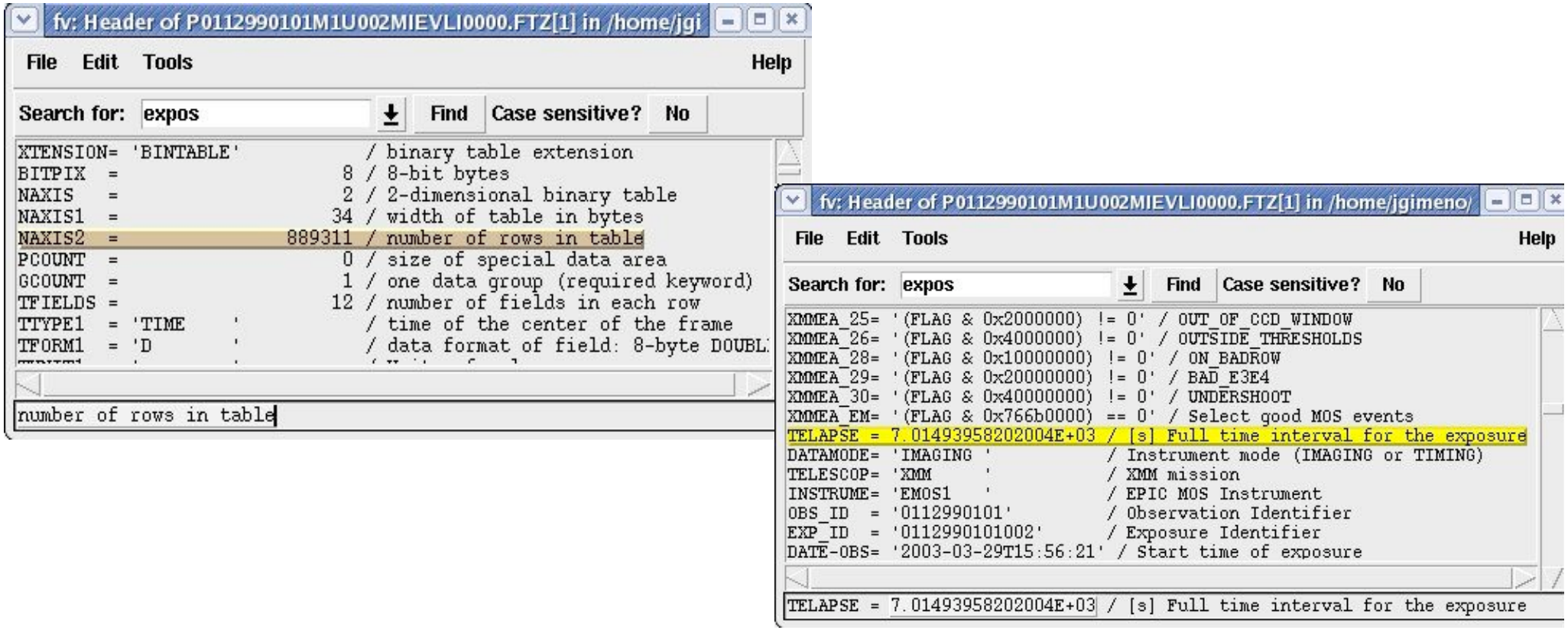
Selection of point sources:

In order to **automatically** determine if an observation is of an extended source or a point source the **counts per second of two annuli around the source** were calculated and then the **ratio** of these two count-rates.



Point source: ratio=[5% , 15%] **Extended source: >X%**

Determination of counts per second:



Once the number of events registered by the detectors and the exposure time is known, the count rate is determined.

Source coordinates determination:

Annuli extraction needs ⟶ PSF centre, position of the source in the detector.

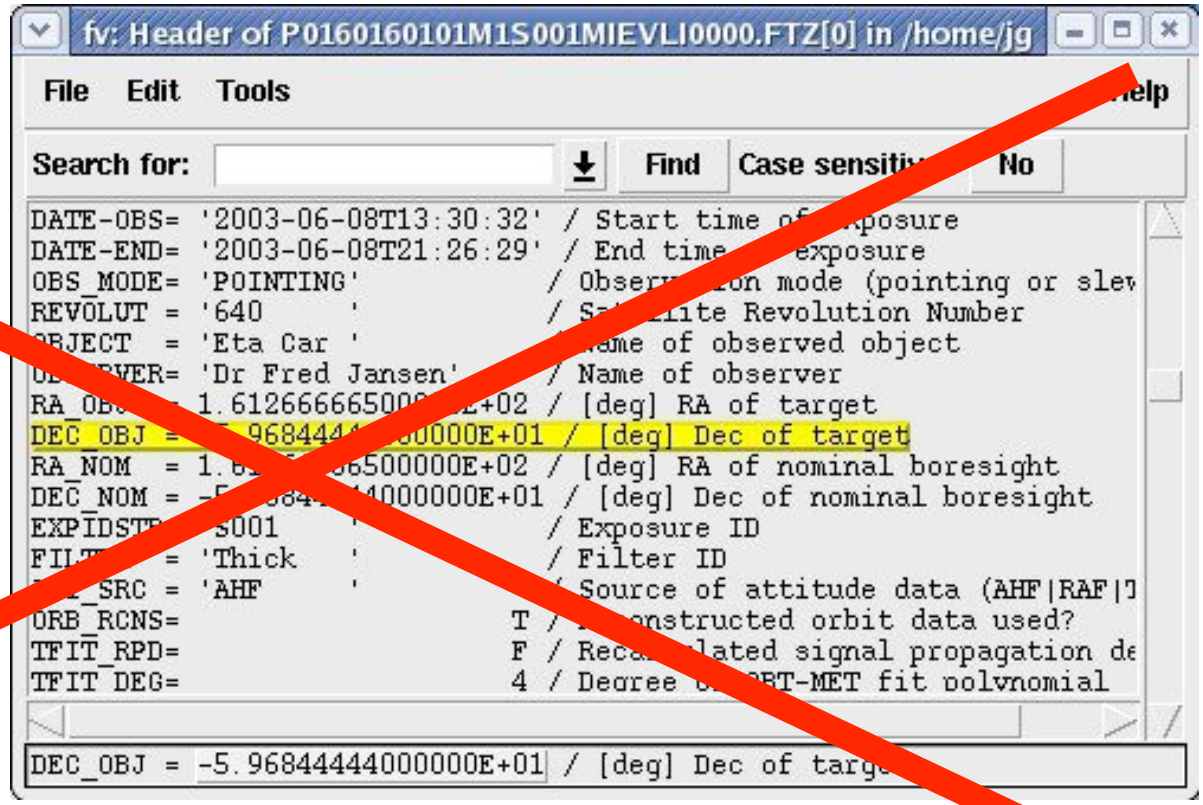
First Attempt:

SAS task *ecsky2det*

Header sky coordinates

↓

Detector coordinates



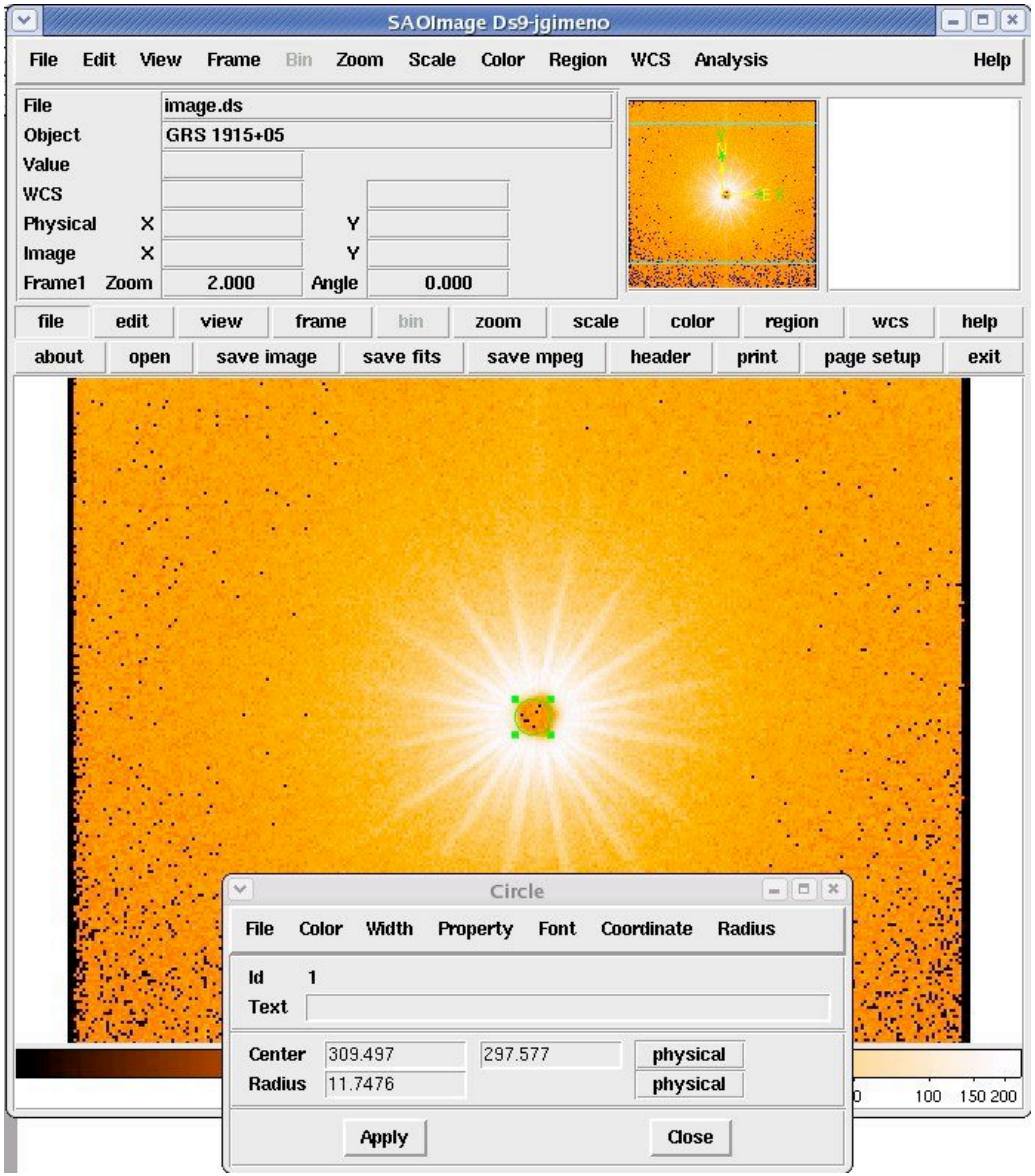
Chosen Solution:

- **Work on the Generated Image**

Find the centre of mass using IDL software

$$\langle x \rangle = \frac{\int I(x,y)\,x\,dxdy}{\int I(x,y)\,dxdy} = \frac{\sum I_{ij}\,i}{\sum I_{ij}}$$

$$\langle y \rangle = \frac{\int I(x,y)\,y\,dxdy}{\int I(x,y)\,dxdy} = \frac{\sum I_{ij}\,j}{\sum I_{ij}}$$



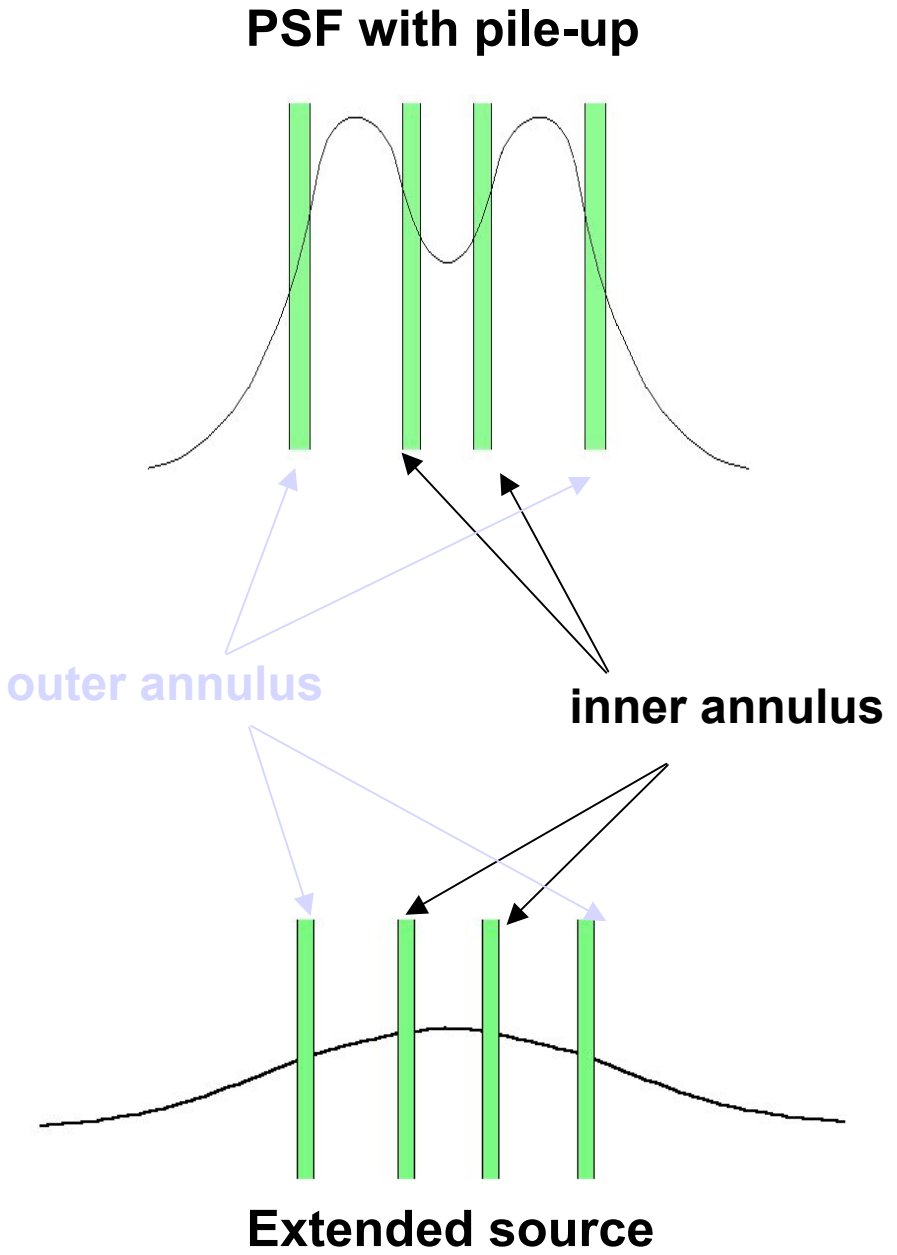
Chosen Solution:

Strong pile-up case

Similar ratio as in the extended source case:

Avoid the identification of **extended sources** as **strong pile-up observations**

ratio: $\frac{\text{singles}}{\text{doubles}}$

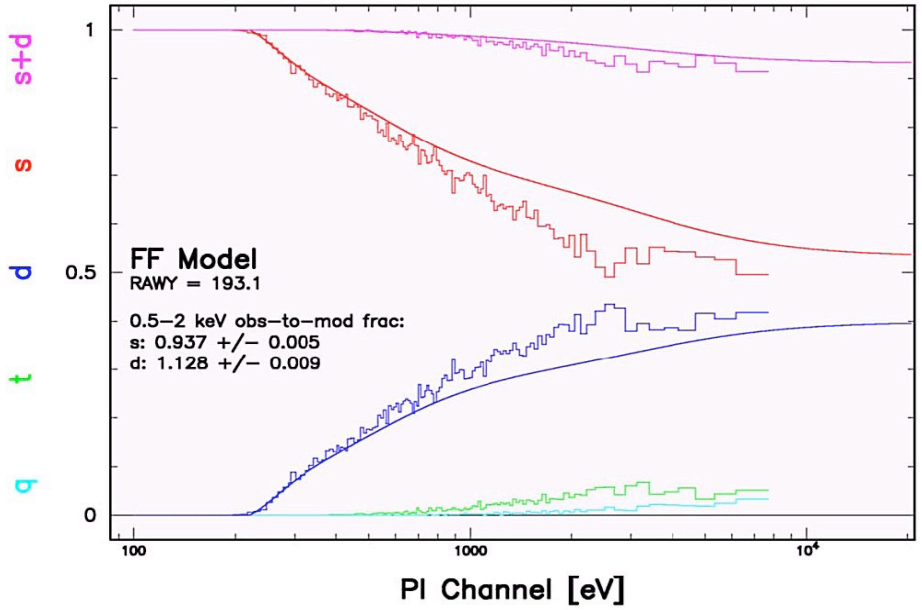


Determination of pile-up:

Ratio between the single events and double events in energy band of 1keV to 1.8keV. (TBD)

Clean PSF: $\frac{\text{singles}}{\text{doubles}} \sim = 2$

Pile-up ↑ → $\frac{\text{singles}}{\text{doubles}}$ ↓

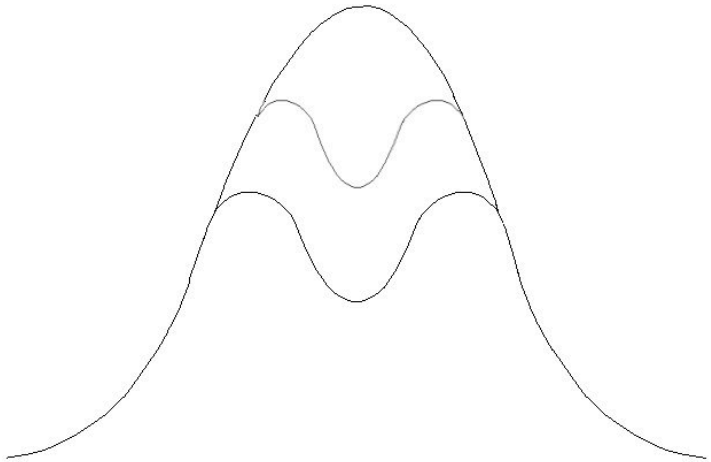


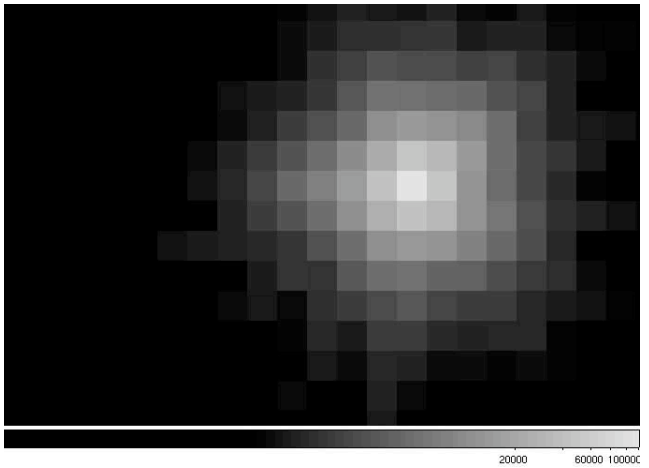
Next steps:

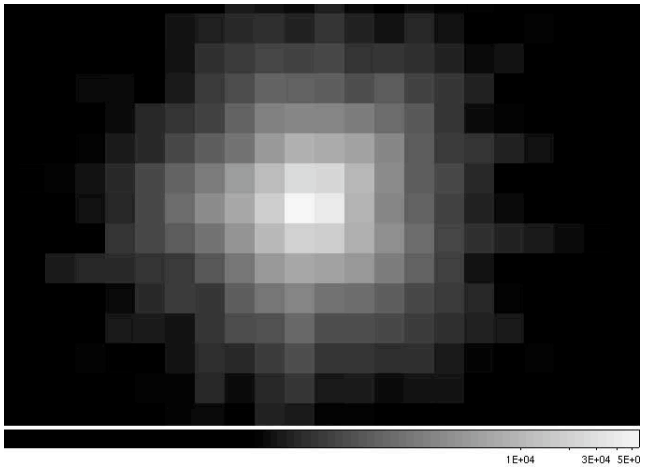
Sum up observations with clean PSF:

- Change position of source.
- Superposition.
- Normalize.

Summing up observations in different pile-ups and comparison with clean PSF:







MOS camera examples.

Questions?