



MODEL PSF EFFECTS OF PILE-UP ON 3D

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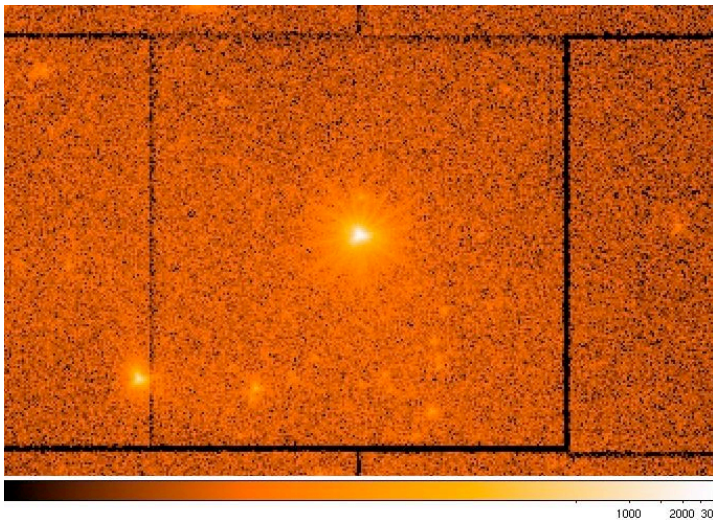
Index:

- Aim of the project.
- Selection of the observations.
- Selection of point sources.
- Determination of the counts per second.
- Determination of pile-up.
- Next steps.

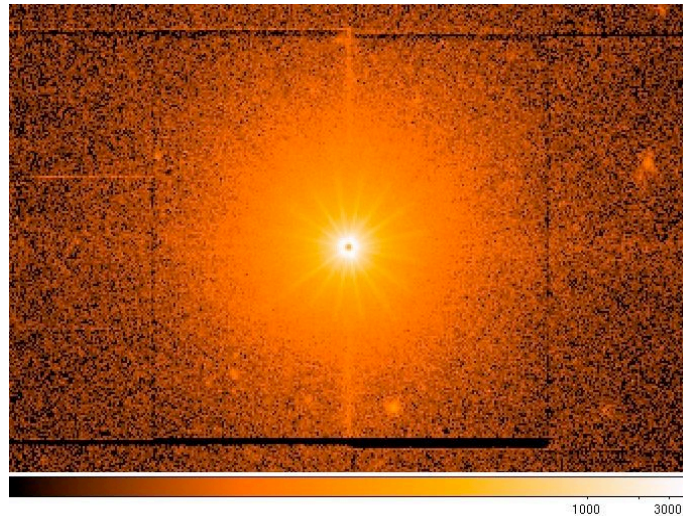


Aim of the project:

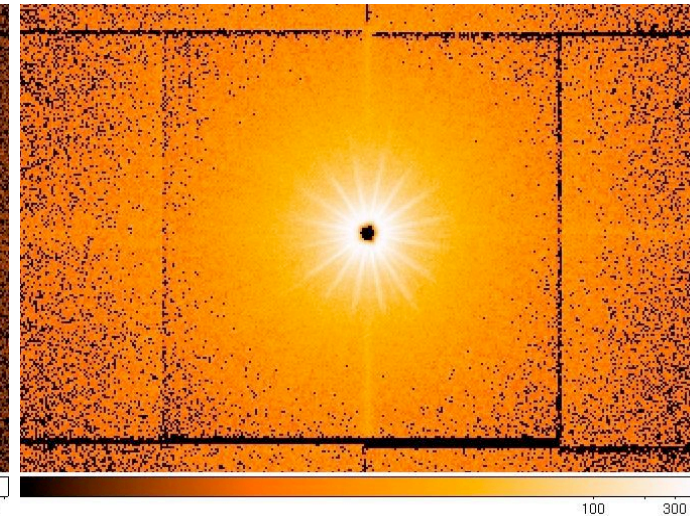
- Pile-up: Arrival of two or more photons within the readout time of the detectors.
- For very bright sources there is a considerable amount of pile-up.
- The centre of the PSF (Point Spread Function) gets distorted:



Clean PSF.



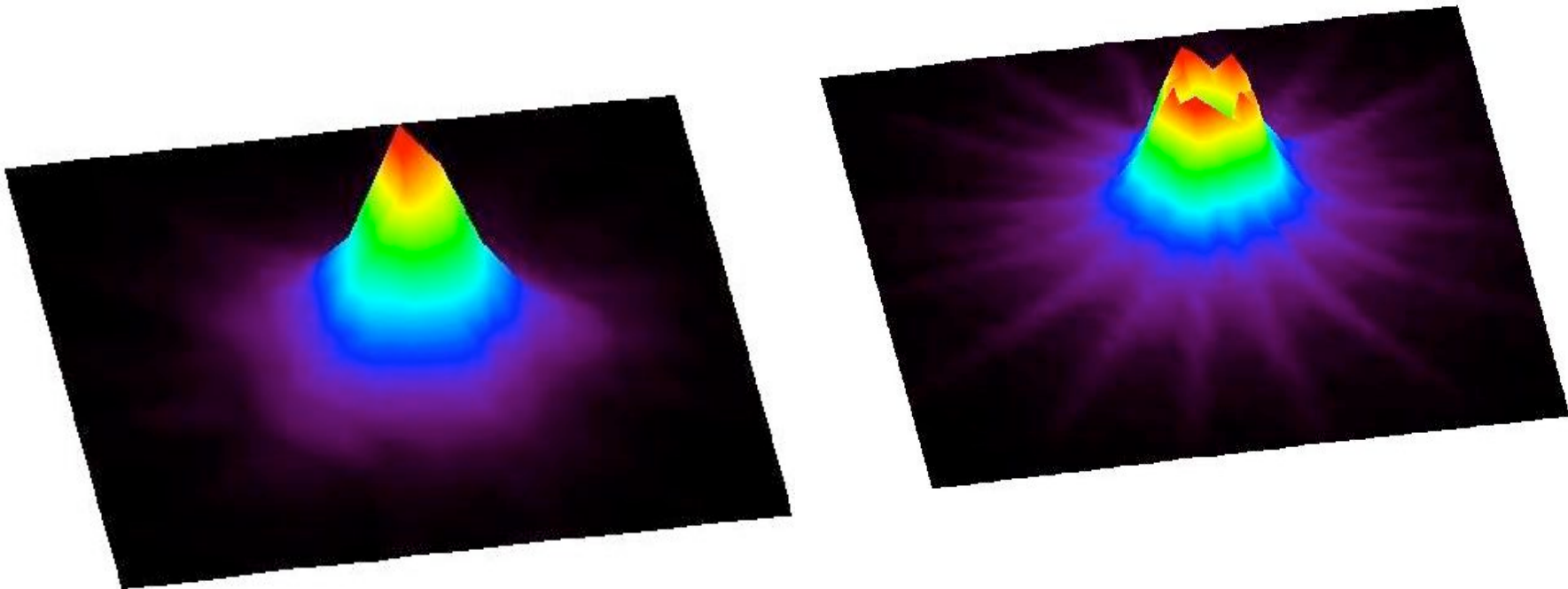
Loss of counts at the centre of the PSF.





Aim of the project:

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

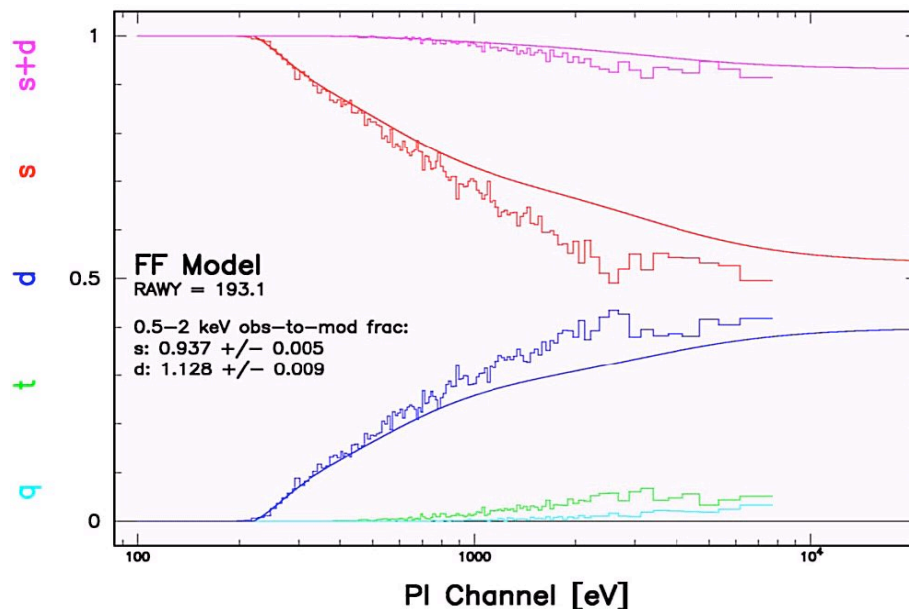
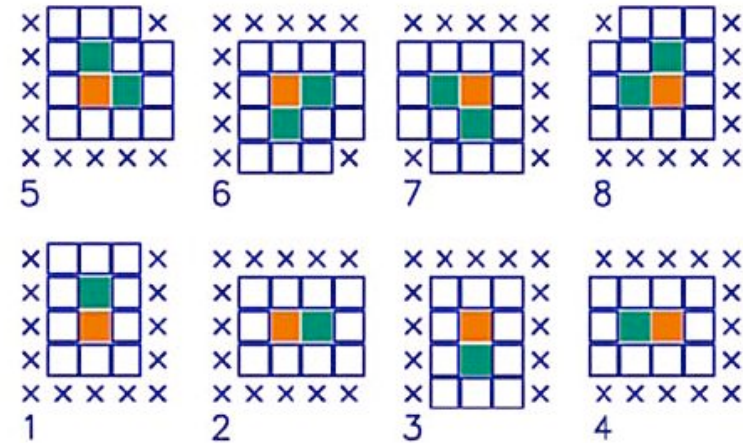




What is pile-up?

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 *Fnatplot* output

Consequences:

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

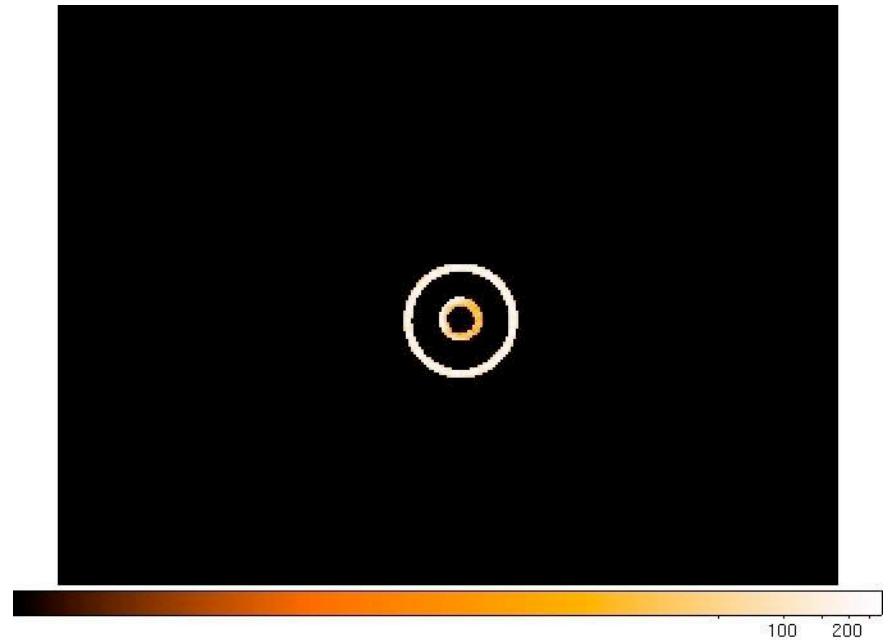
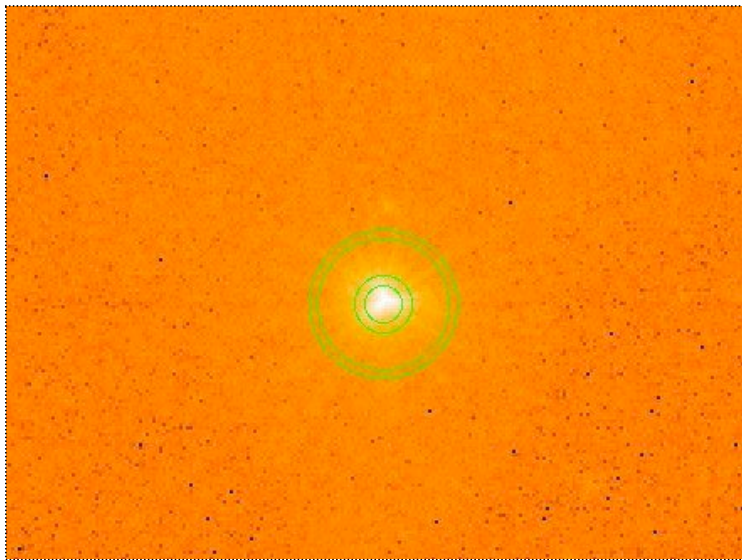


Selection of observations:

- 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:

```

fv: Header of P0112990101M1U002MIEVLI0000.FTZ[1] in /home/jgi
File Edit Tools Help
Search for: expos Find Case sensitive? No
XTENSION= 'BINTABLE' / binary table extension
BITPIX = 8 / 8-bit bytes
NAXIS = 2 / 2-dimensional binary table
NAXIS1 = 34 / width of table in bytes
NAXIS2 = 889311 / number of rows in table
PCOUNT = 0 / size of special data area
GCOUNT = 1 / one data group (required keyword)
TFIELDS = 12 / number of fields in each row
TTYPE1 = 'TIME' / time of the center of the frame
TFORM1 = 'D' / data format of field: 8-byte DOUBL
number of rows in table
    
```

```

fv: Header of P0112990101M1U002MIEVLI0000.FTZ[1] in /home/jgimeno/
File Edit Tools Help
Search for: expos Find Case sensitive? No
XMMEA_25= '(FLAG & 0x2000000) != 0' / OUT OF CCD WINDOW
XMMEA_26= '(FLAG & 0x4000000) != 0' / OUTSIDE_THRESHOLDS
XMMEA_28= '(FLAG & 0x10000000) != 0' / ON BADROW
XMMEA_29= '(FLAG & 0x20000000) != 0' / BAD_E3E4
XMMEA_30= '(FLAG & 0x40000000) != 0' / UNDERSHOOT
XMMEA_EM= '(FLAG & 0x766b0000) == 0' / Select good MOS events
TELAPSE = 7.01493958202004E+03 / [s] Full time interval for the exposure
DATAMODE= 'IMAGING' / Instrument mode (IMAGING or TIMING)
TELESCOP= 'XMM' / XMM mission
INSTRUME= 'EMOS1' / EPIC MOS Instrument
OBS_ID = '0112990101' / Observation Identifier
EXP_ID = '0112990101002' / Exposure Identifier
DATE-OBS= '2003-03-29T15:56:21' / Start time of exposure
TELAPSE = 7.01493958202004E+03 / [s] Full time interval for the exposure
    
```

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 sky2det

Header sky coordinates



Detector coordinates

```

fv: Header of P0160160101M1S001MIEVLI0000.FTZ[0] in /home/jg
File Edit Tools Help
Search for: [ ] Find Case sensitive No
DATE-OBS= '2003-06-08T13:30:32' / Start time of exposure
DATE-END= '2003-06-08T21:26:29' / End time of exposure
OBS_MODE= 'POINTING' / Observation mode (pointing or slew)
REVOLUT = '640' / Satellite Revolution Number
OBJECT = 'Eta Car' / Name of observed object
OBSERVER= 'Dr Fred Jansen' / Name of observer
RA_OBJ = 1.612666665000000E+02 / [deg] RA of target
DEC_OBJ = -5.968444440000000E+01 / [deg] Dec of target
RA NOM = 1.612666665000000E+02 / [deg] RA of nominal boresight
DEC NOM = -5.968444440000000E+01 / [deg] Dec of nominal boresight
EXPIDST = 'S001' / Exposure ID
FILTER = 'Thick' / Filter ID
ATT_SRC = 'AHF' / Source of attitude data (AHF|RAF|J)
ORB_RCNS= T / Constructed orbit data used?
TFIT_RPD= F / Recalculated signal propagation delay
TFIT_DEG= 4 / Degree of PERT-MET fit polynomial
DEC_OBJ = -5.968444440000000E+01 / [deg] Dec of target

```



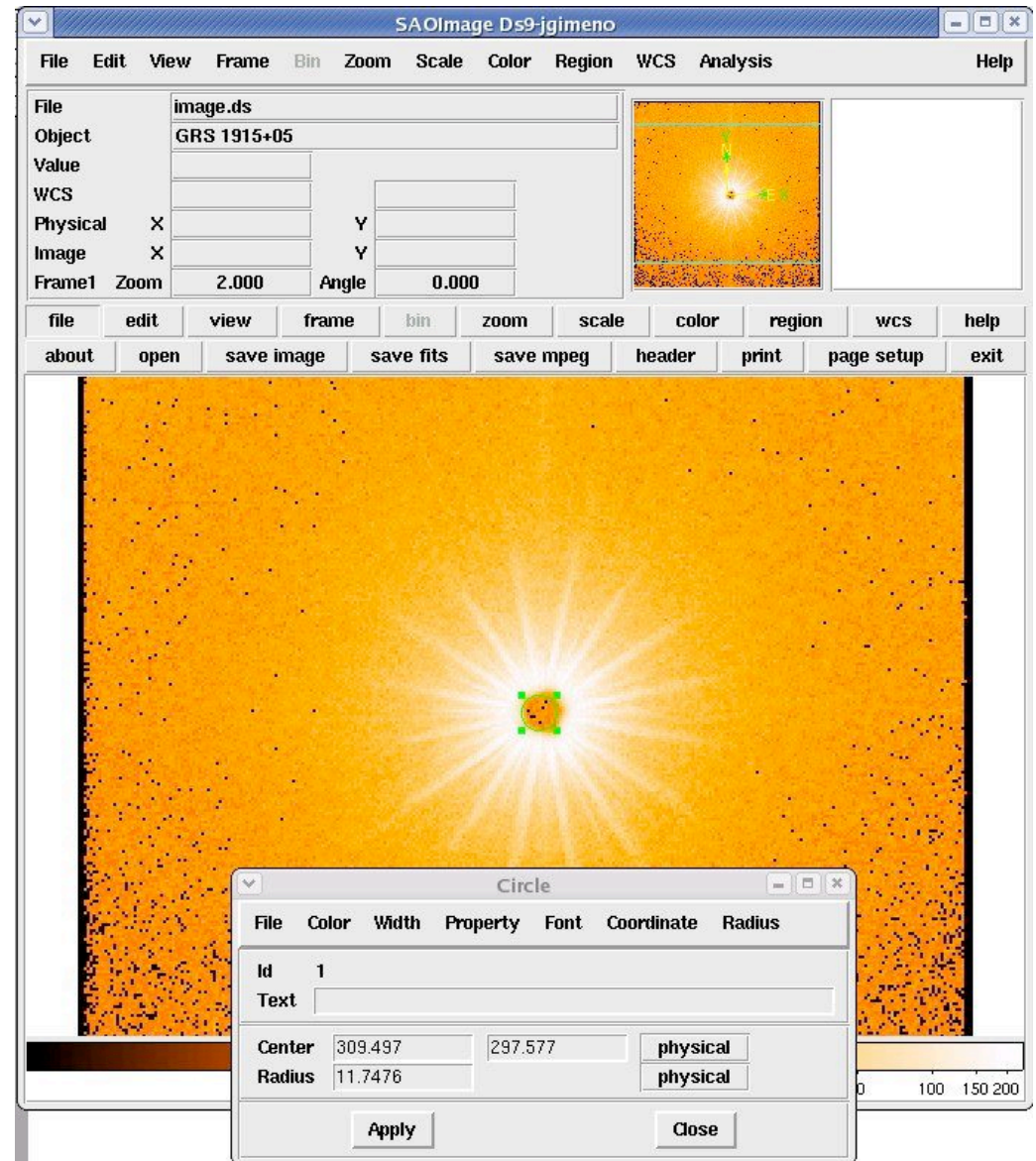
Chosen Solution:

✦ Work on the Generated Image

Find the centre of mass using IDL software

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

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





Chosen Solution:

Strong pile-up case

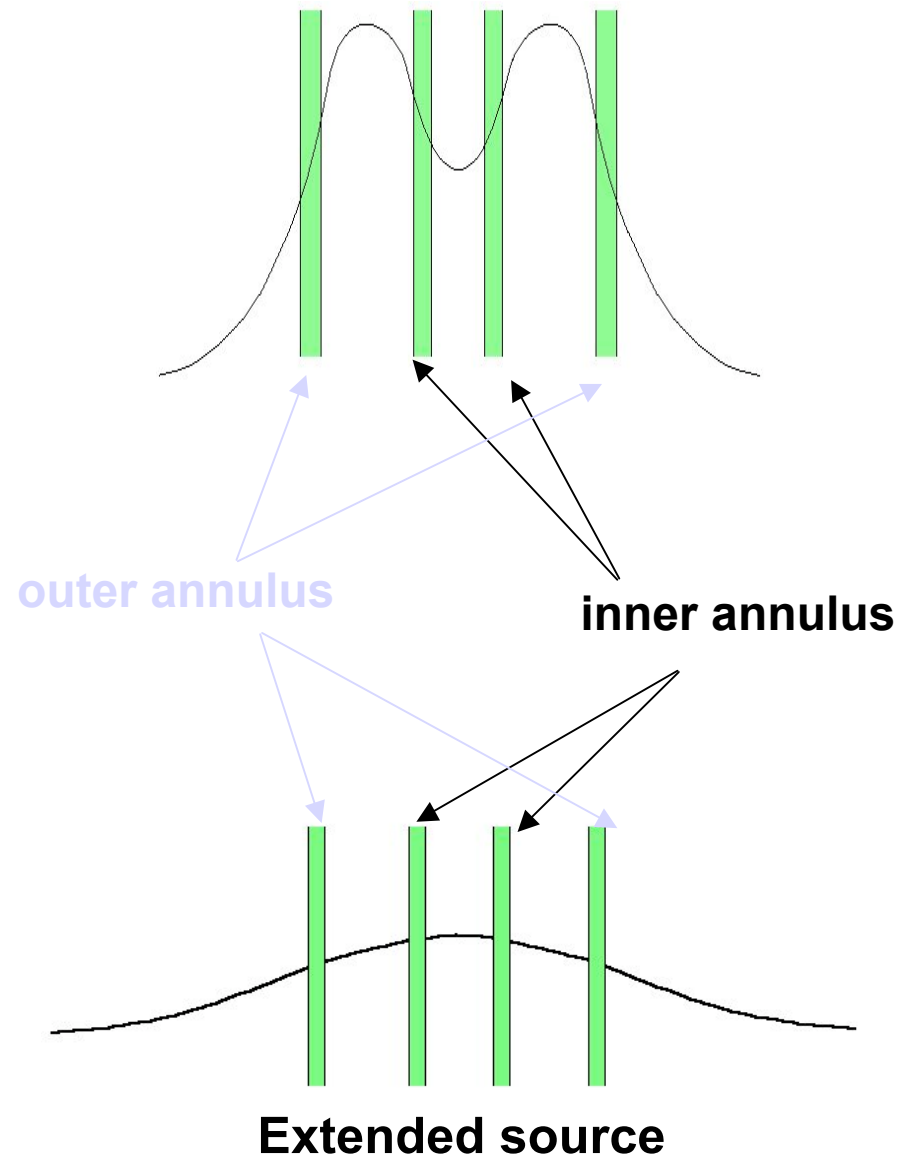
Similar ratio as in the extended source case:

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

↓

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

PSF with pile-up





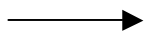
Determination of pile-up:

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

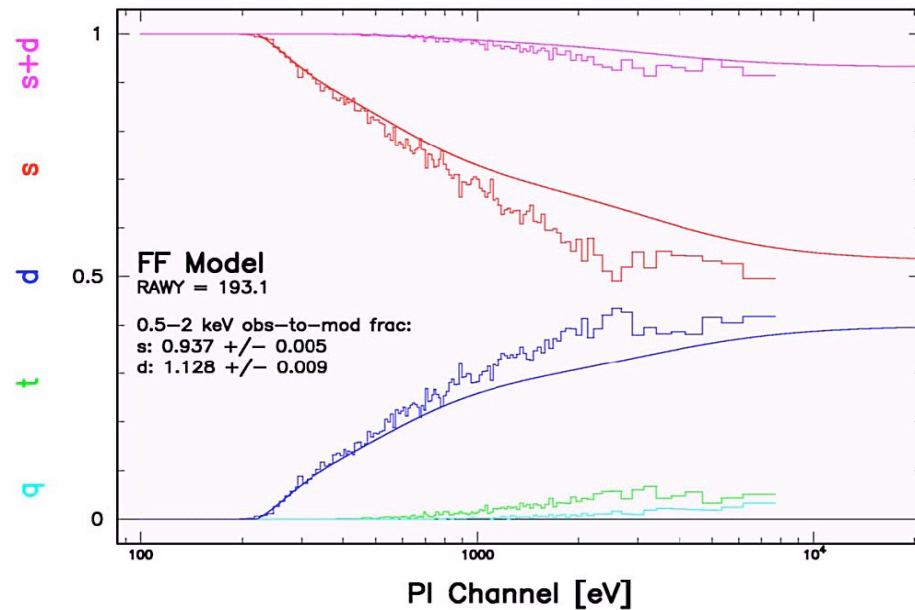
Clean PSF:

$$\frac{\text{singles}}{\text{doubles}} \sim 2$$

Pile-up ↑



$$\frac{\text{singles}}{\text{doubles}} ↓$$



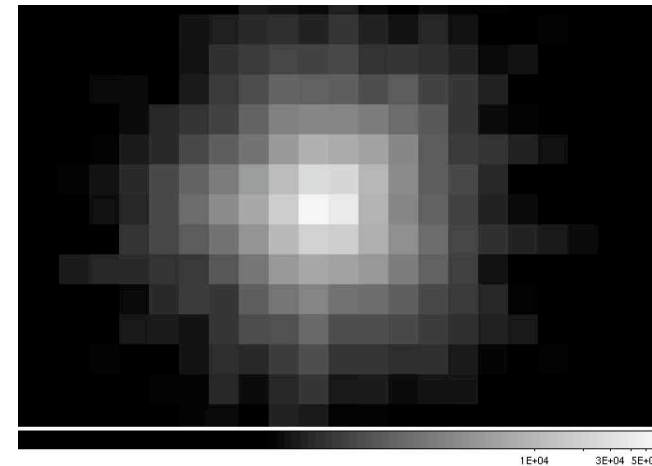
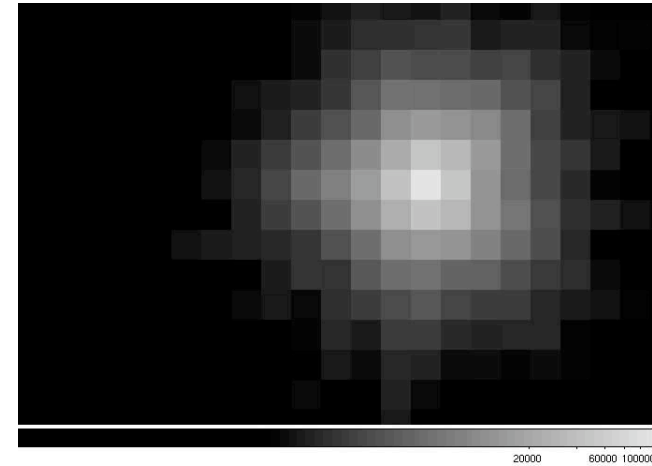
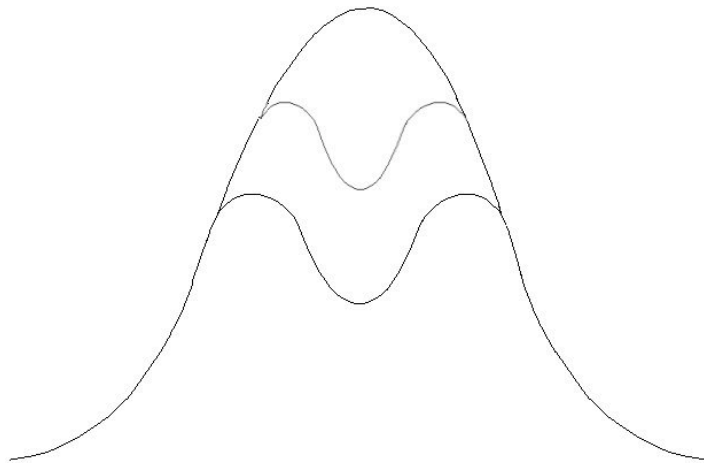


Next steps:

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?

