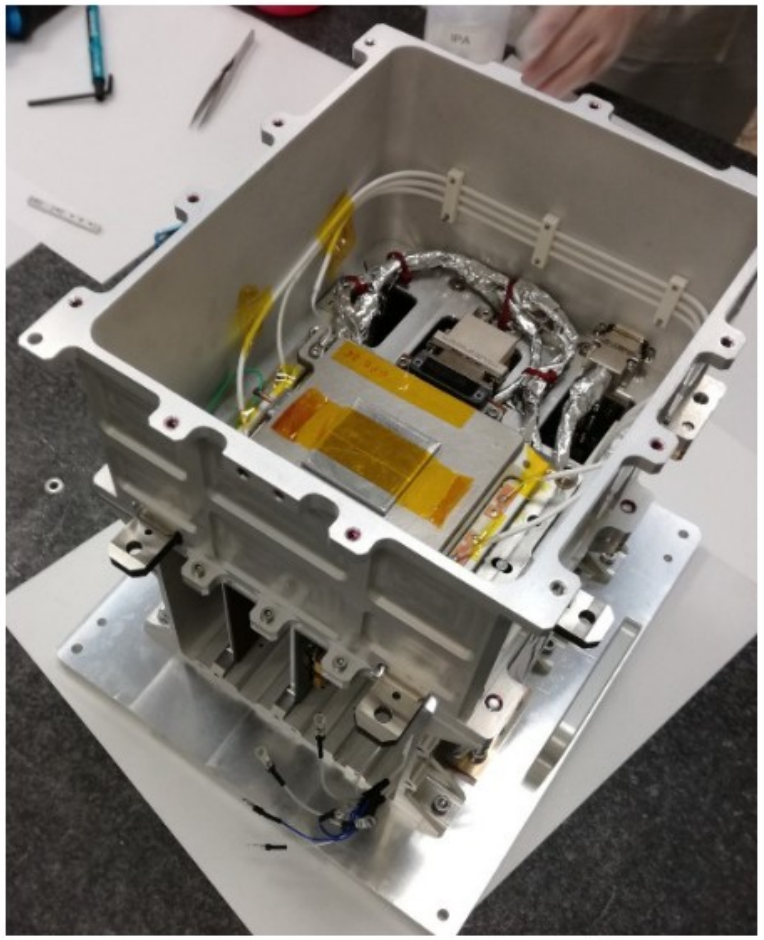
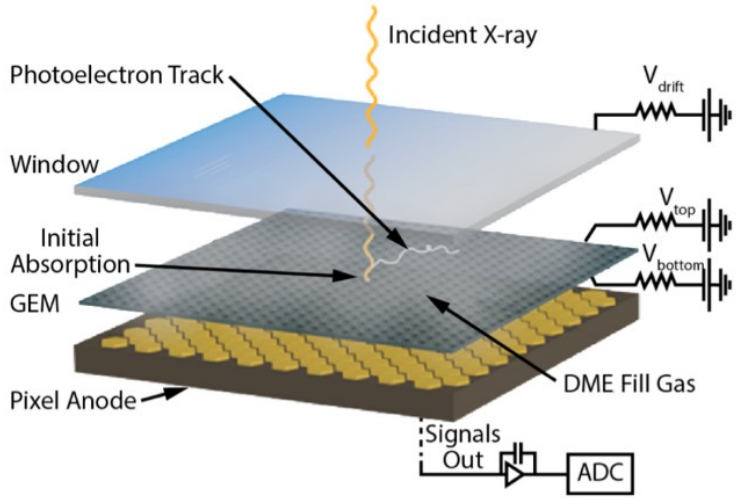
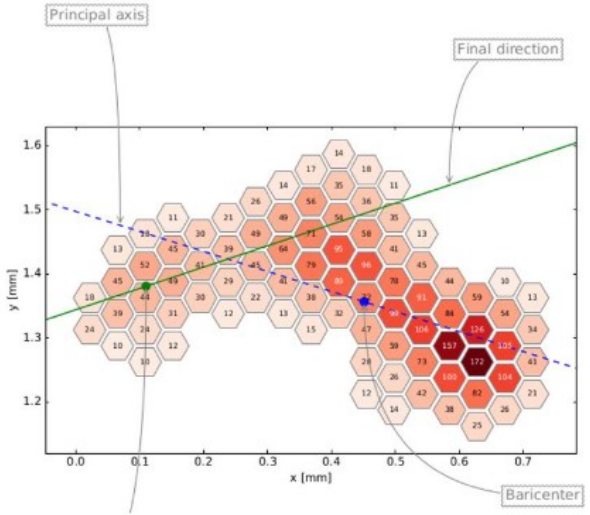
IXPE mission status update

Stefano Silvestri (on behalf of the IXPE team)
INFN (Pisa)

IXPE




Incident X-ray
Photoelectron Track
V_{drift}
Window
V_{top}
Initial
Absorption
V_{bottom}
GEM
DME Fill Gas
Pixel Anode
Signals
Out
ADC


Principal axis
Final direction
y [mm]
x [mm]
Baricenter

Preface

In the previous episodes

- **DU2 had an anomaly before last IACHEC**
  - No guarantee that it would have been recovered
  - No time estimation for a recovery
  - DU2 data delivery has been suspended

- **Residual background has been shown to be polarized enough to alter extended source analysis**
  - Strong solar activity affected some observations
  - In some cases background polarization very high (>50%)
  - Sigma clipping solutions were no longer working (see Bucciantini+ 2025, 3c58, Silvestri+2026, RCW86)

- Gas pressure is slowly decreasing in the gas cells
  - Gauge gas pressure from the track length
  - Updae ARFs consistently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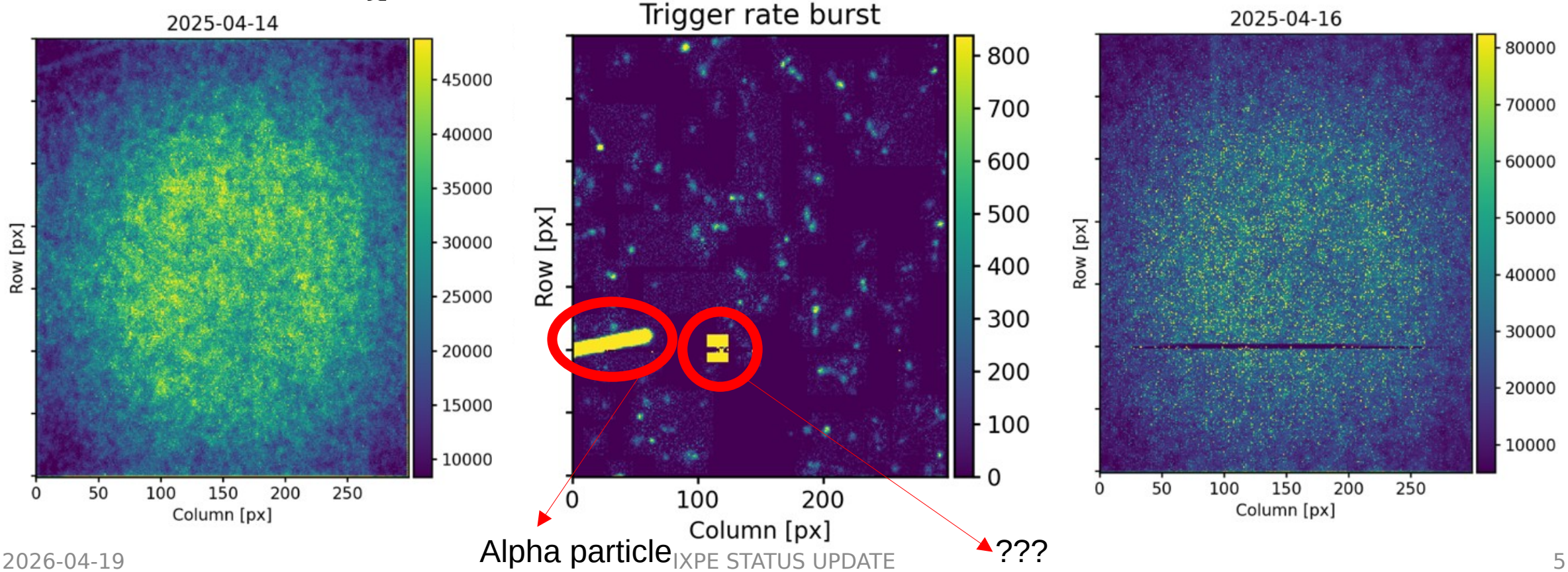
DU2 issues

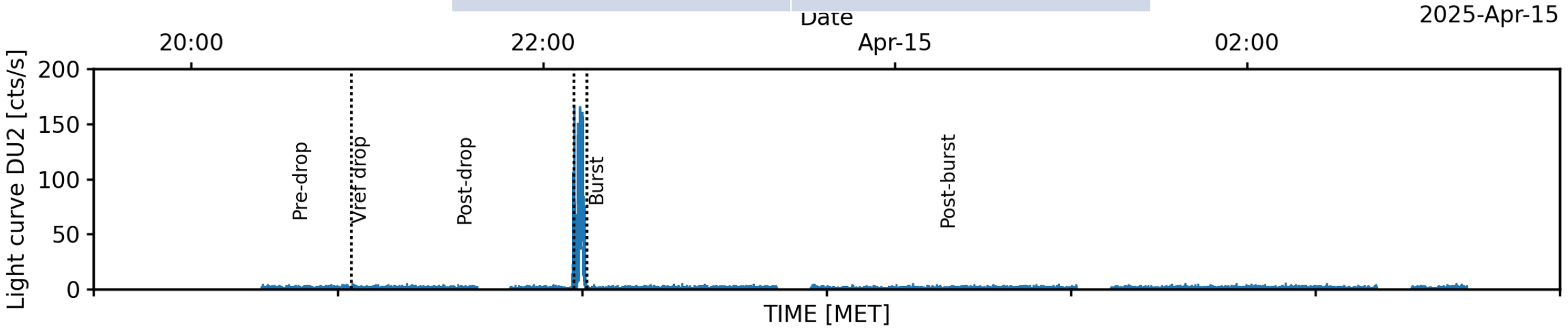
DU2 anomaly

On April 15, 2025, some pixels of DU2 failed and Vref dropped. This triggered a recalibration campaign. DU2 files have no longer been distributed for about a year



DU2 anomaly

Date-time (UTC)	Event
2025-04-14T20:54:31.0	Drop of Vref on DU2
2025-04-14T22:09:57.0	Start of burst phase
2025-04-14T22:14:49.0	End of burst phase

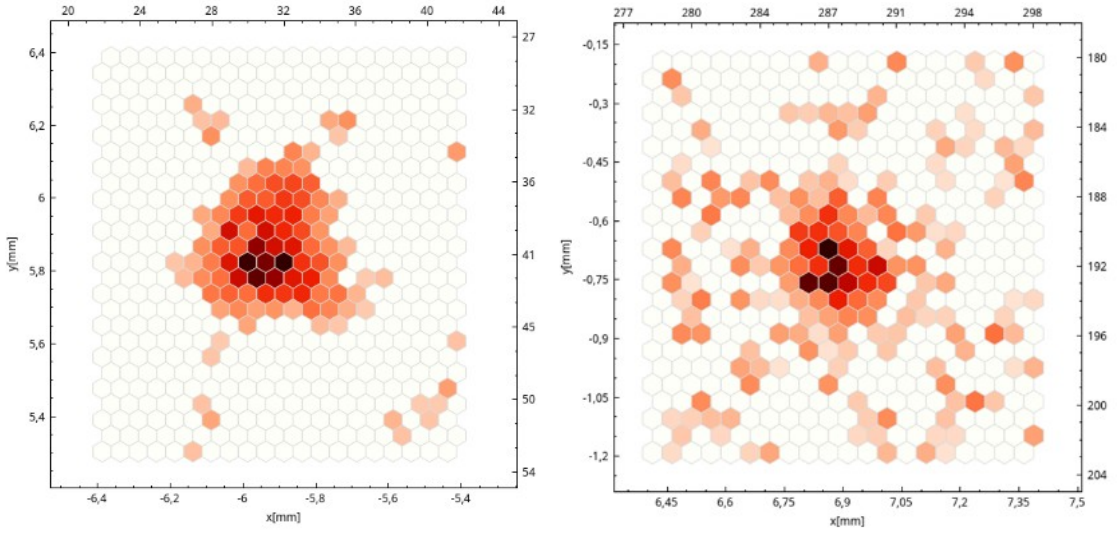


Please Note: IXPE is not designed for in flight recalibration.

DU2 anomaly

Pedestals and trigger were affected

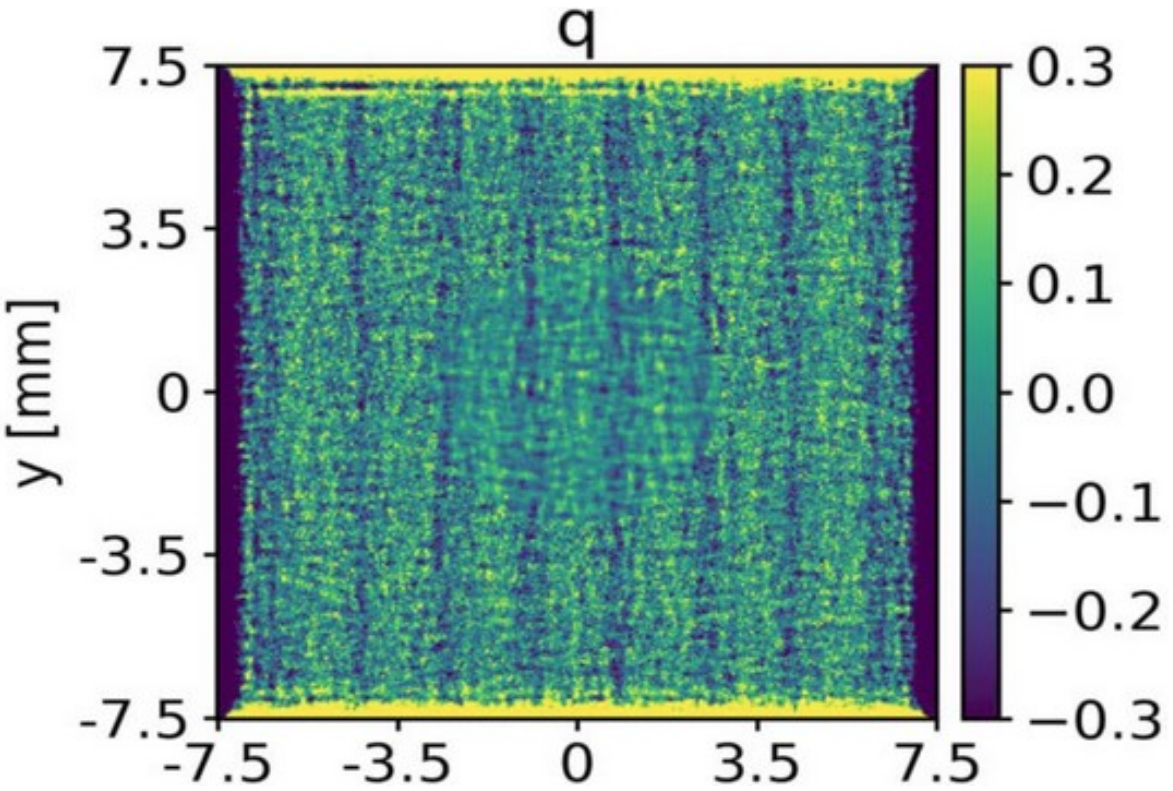
- Trigger happens on summed clusters
- Image is acquired
- Another image is then used for online pedestal subtraction
- Residual fluctuations show both coherent offset and residual fluctiations
- This alters the ADC counts
- ADC counts alter the energy recon
    - Recalibrate with onboard sources



Spurious modulation

New spurious modulation maps

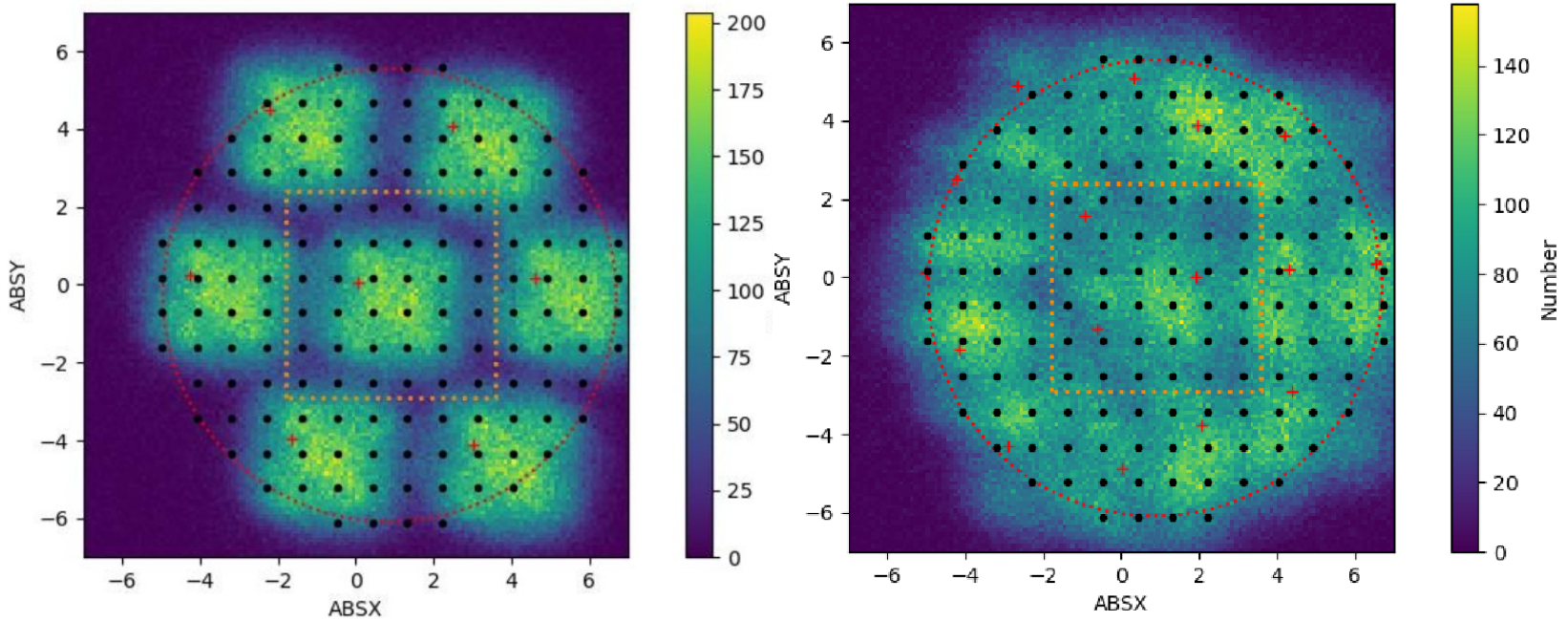
- Spurious modulation is the result in inhomogeneities in the laser etching of the GEM
- This is both energy AND position dependent



Spurious modulation

New spurious modulation maps

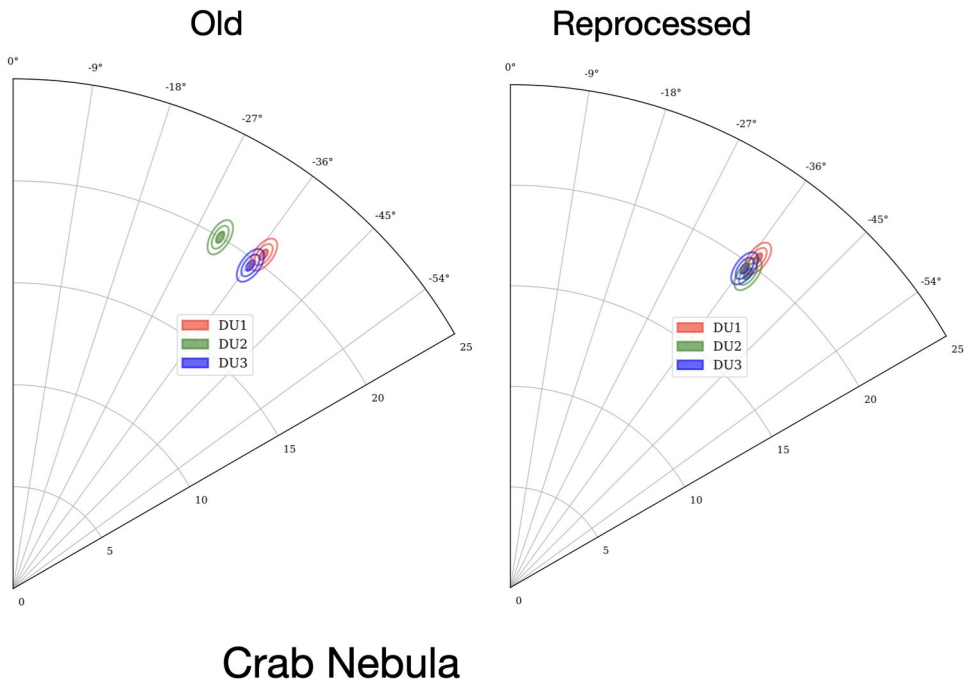
- Cross calibrated with other DUs (Overlapping FoV of DUs)
- Used a few point sources, off-axis

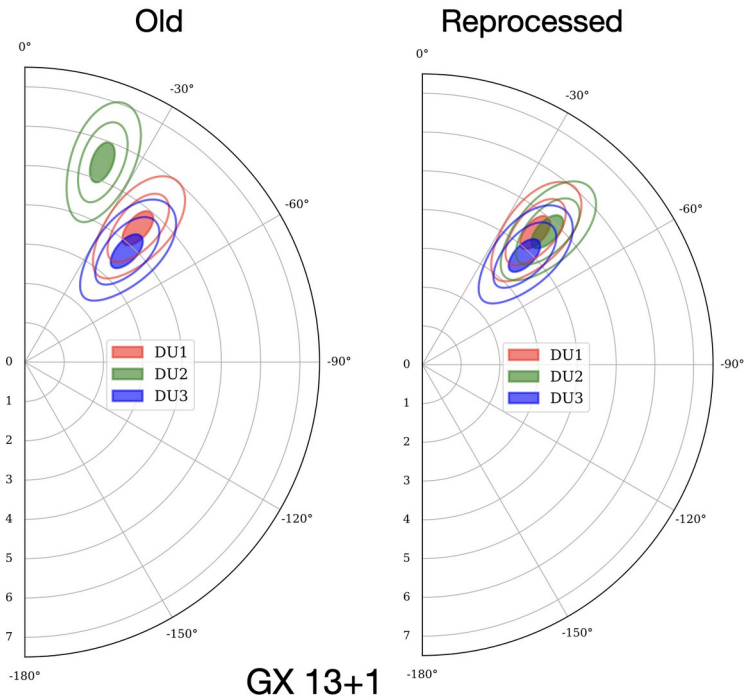


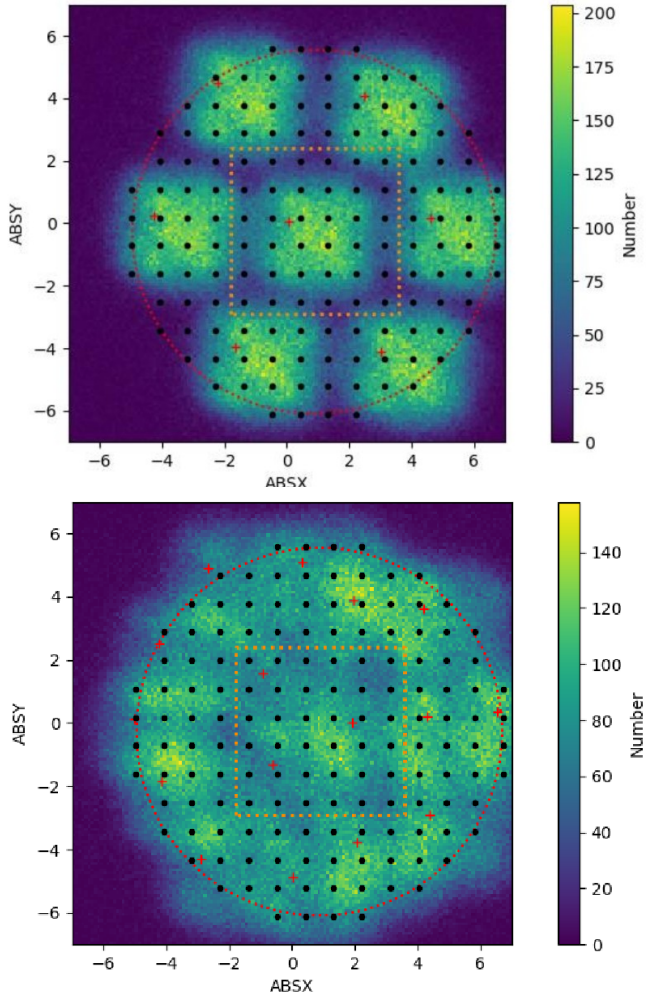
Spurious modulation

New spurious modulation maps

- Upon calibration the agreement improved



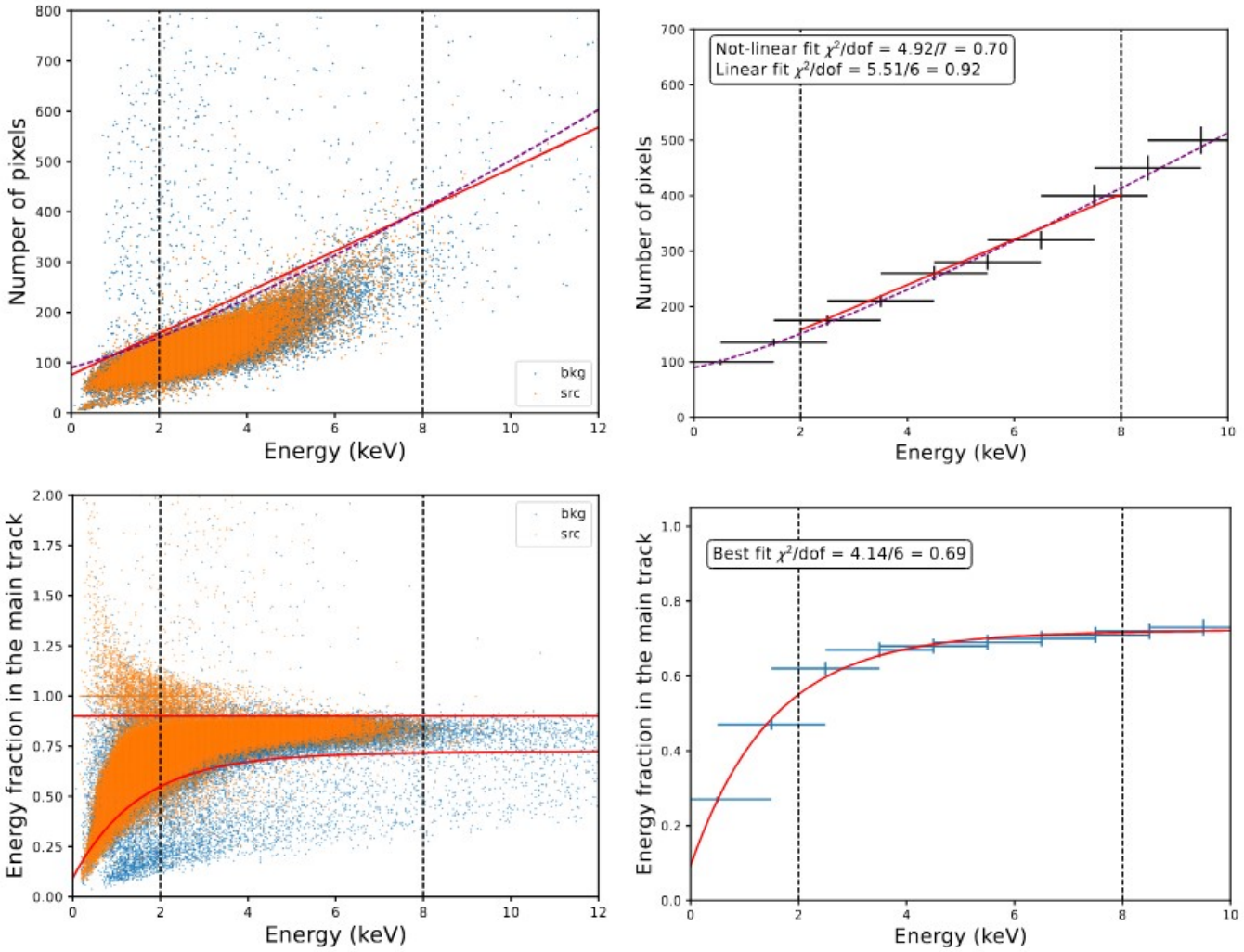




Particle background

Updated particle background rejection (arxiv:2604.03366)

- Particles leave “bunched” tracks
- The main track “blob” has a smaller relative amount of counts for a particle
- In some cases, the events in the area of the anomaly
- Threshold values for source events being negligible have been refit

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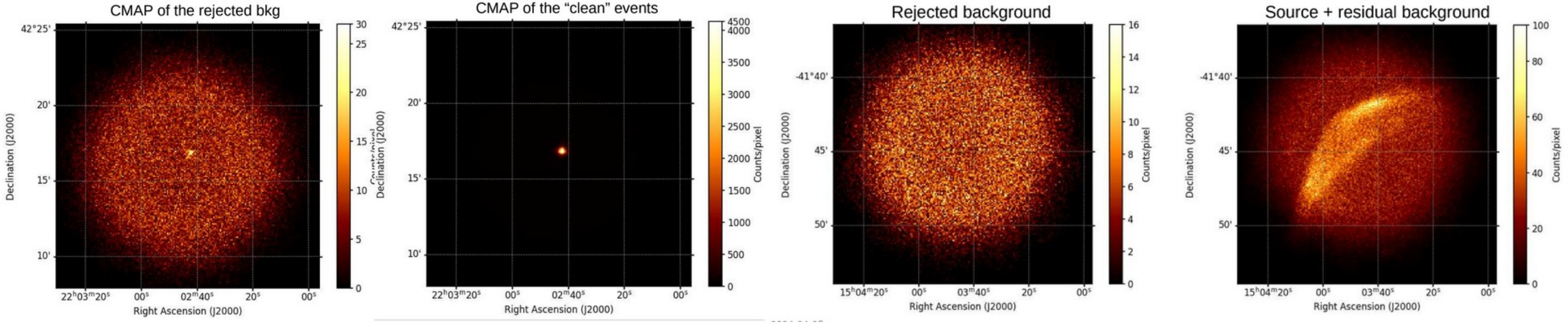
Residual background

Residual background

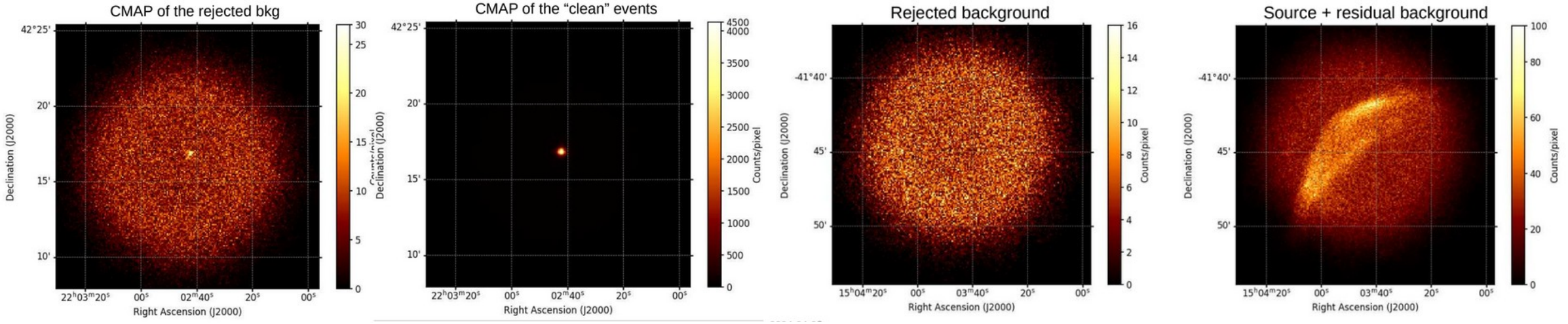
Particle rejection works really well



- **Particle** contamination may have **strong spurious effects** on polarization
- **Very small amount of false positives** (~1% source counts in background sample)
- About 40 % of residual **X-ray indistinguishable** background
- **Always apply** on faint sources: not worth recovering 1% counts and risking spurious effect

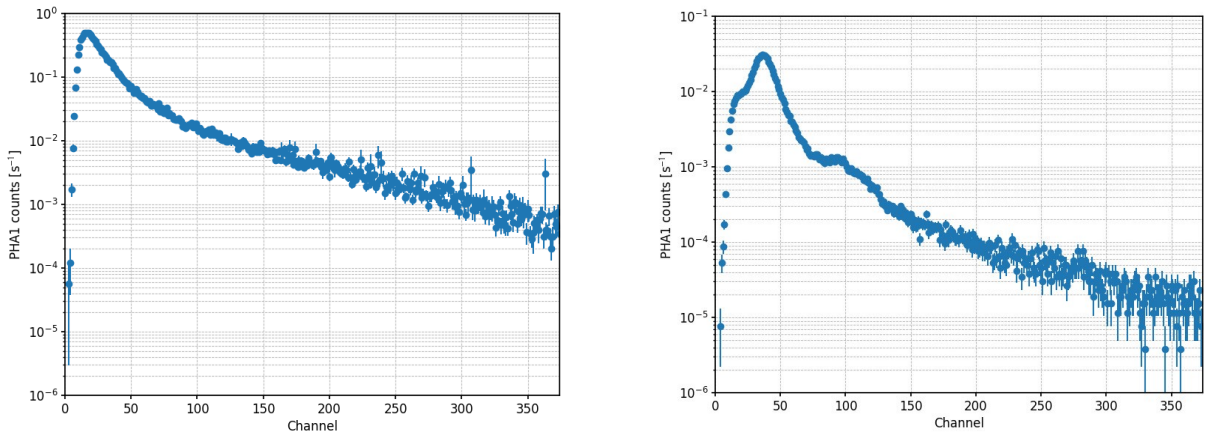
Residual background

Particle rejection works really well



We have now characterized the **residual background**

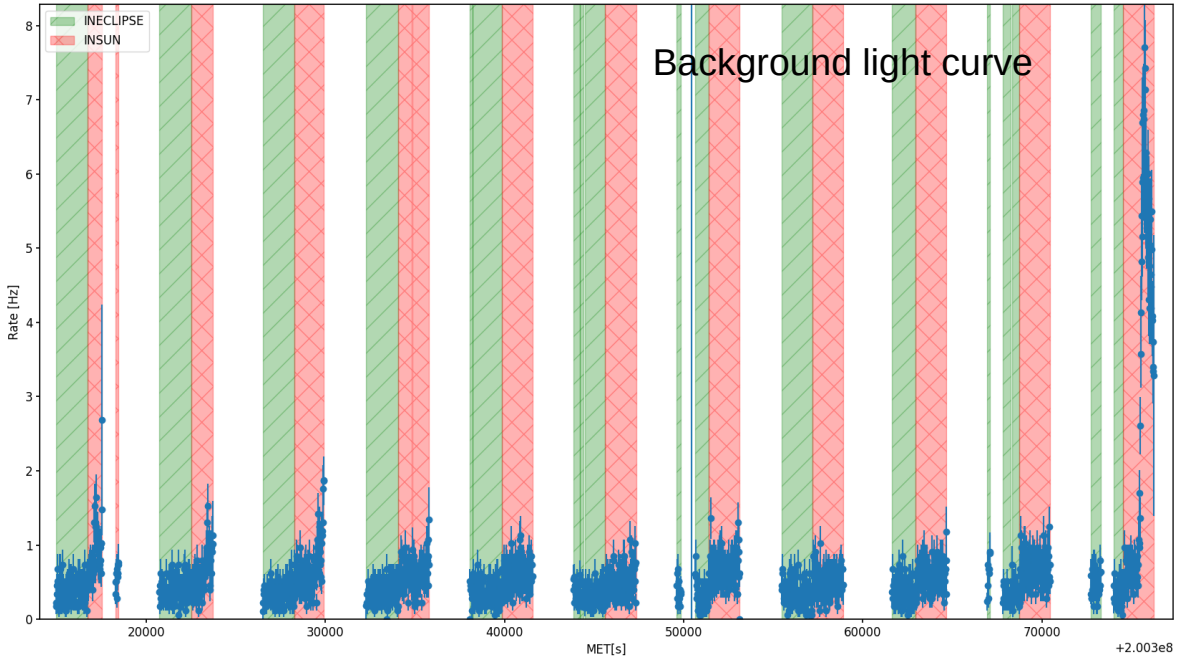
- Static component (left)
- Time/DU-dependent (right)

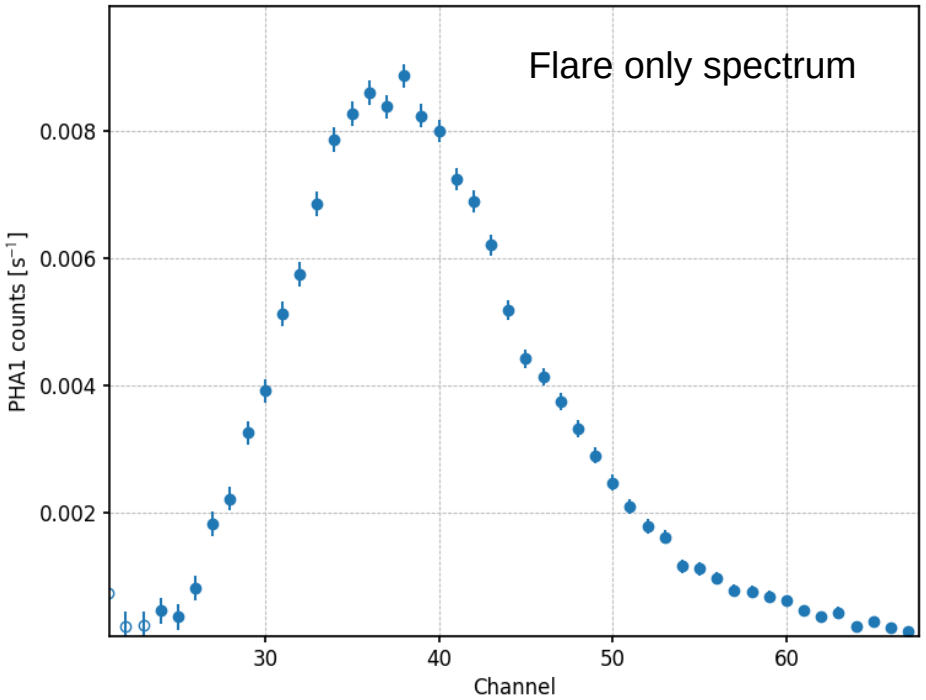


Residual background

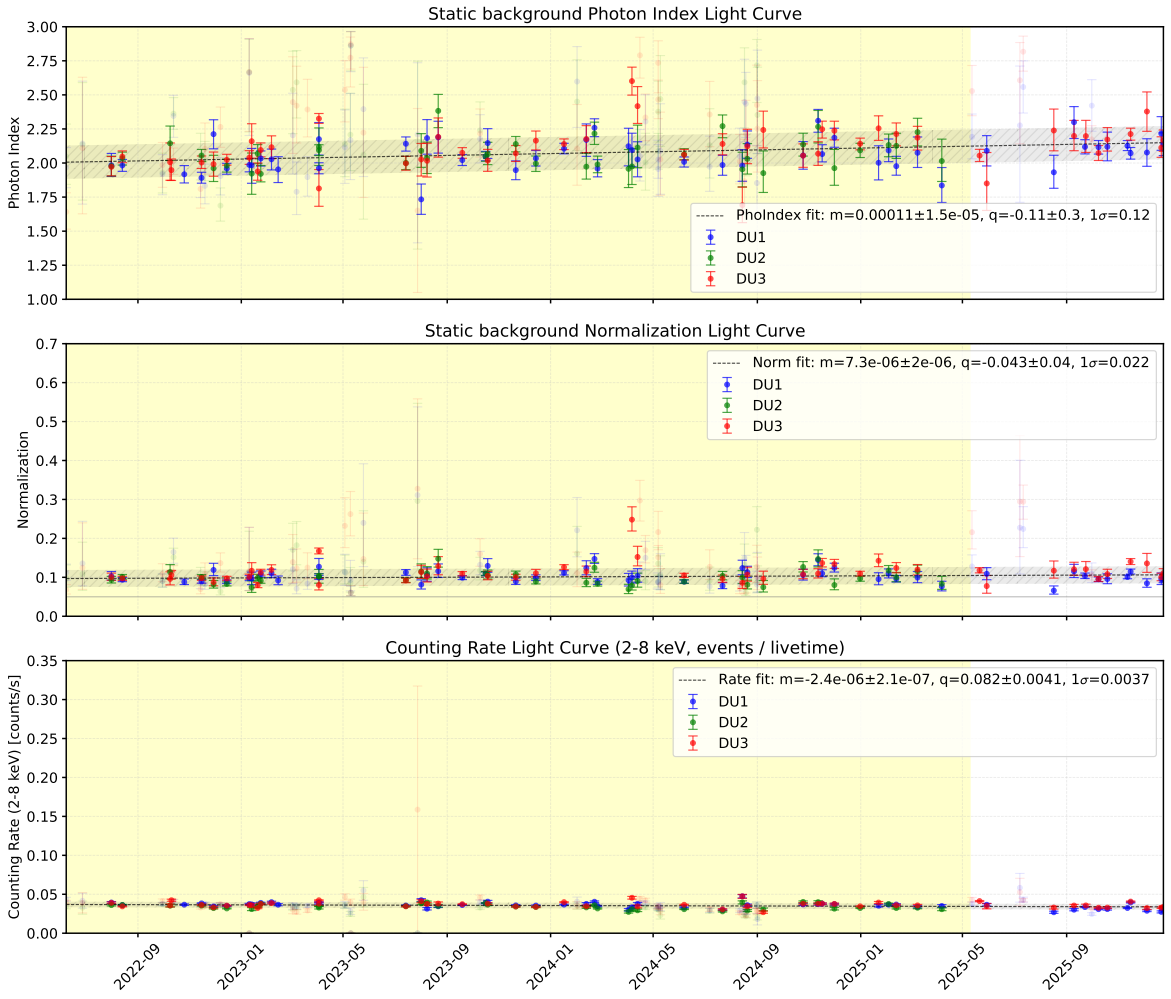
“Bump” associated with variability, variability associated with solar activity

- Binned data products can be “flare free” if we estimate the flare from insun-ineclipse
- Ineclipse background is static
- Flare spectrum looks asymmetric (**not** a line?)
- Flares have a (spurious?) polarization





Residual background: static template



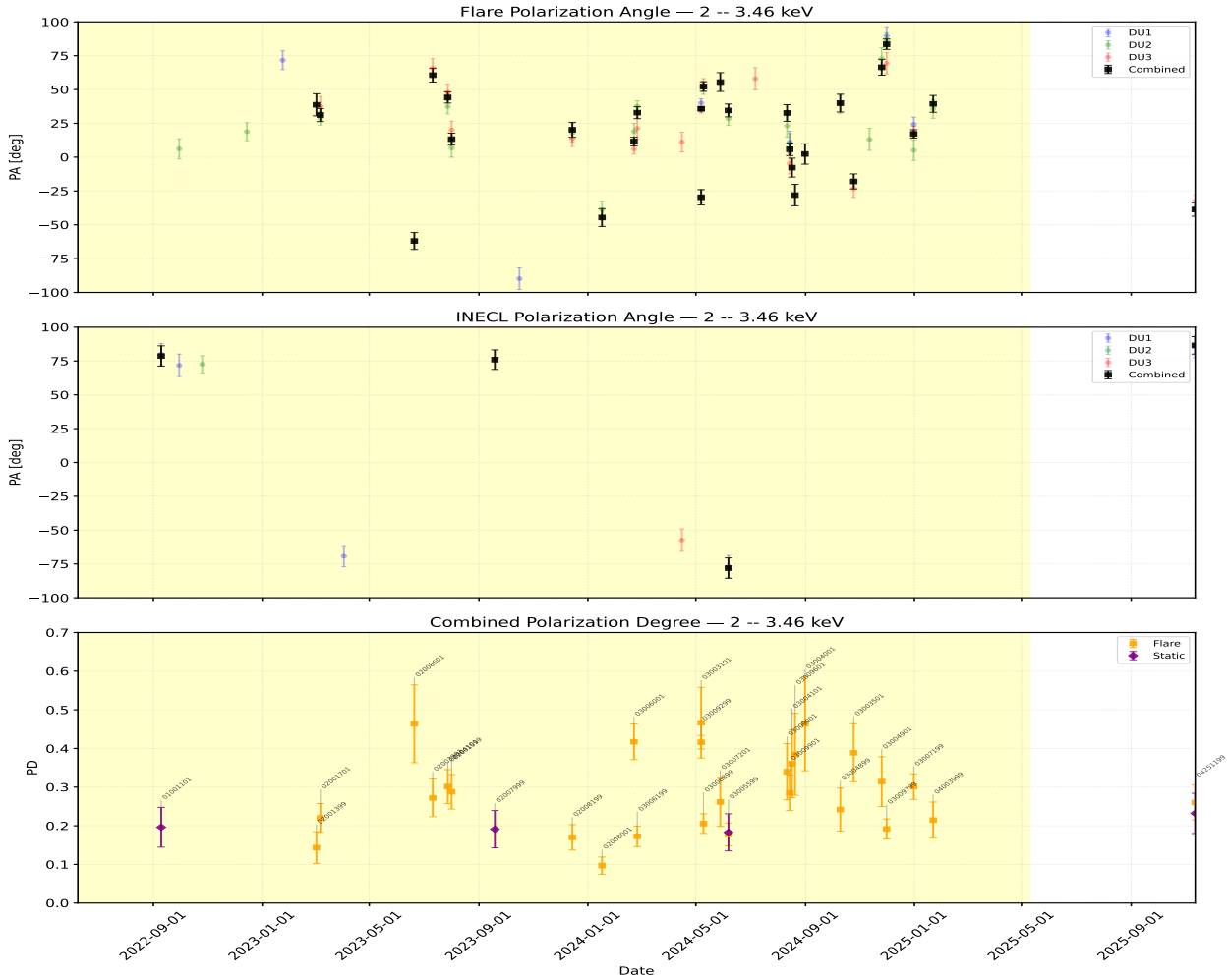
Static component comes from our (in eclipse) background

- All observation that could be reconstructed in occultation and in eclipse
- Low statistics masked out from the fit

- Fits show some trends but Photon index and Normalization are correlated
- The counting rate looks to be mildly decreasing but see the next slides

- Static component comes from the **4y average**!
- Model is included in the software and can be simulated for subtraction

Residual background: flare subtraction



Variable component is polarized

- But data products can be created already deflared with the software

- **xpsun** → Splits the data set in insun/ineclipse
- **xpbin** → Add insun and ineclipse to create deflared

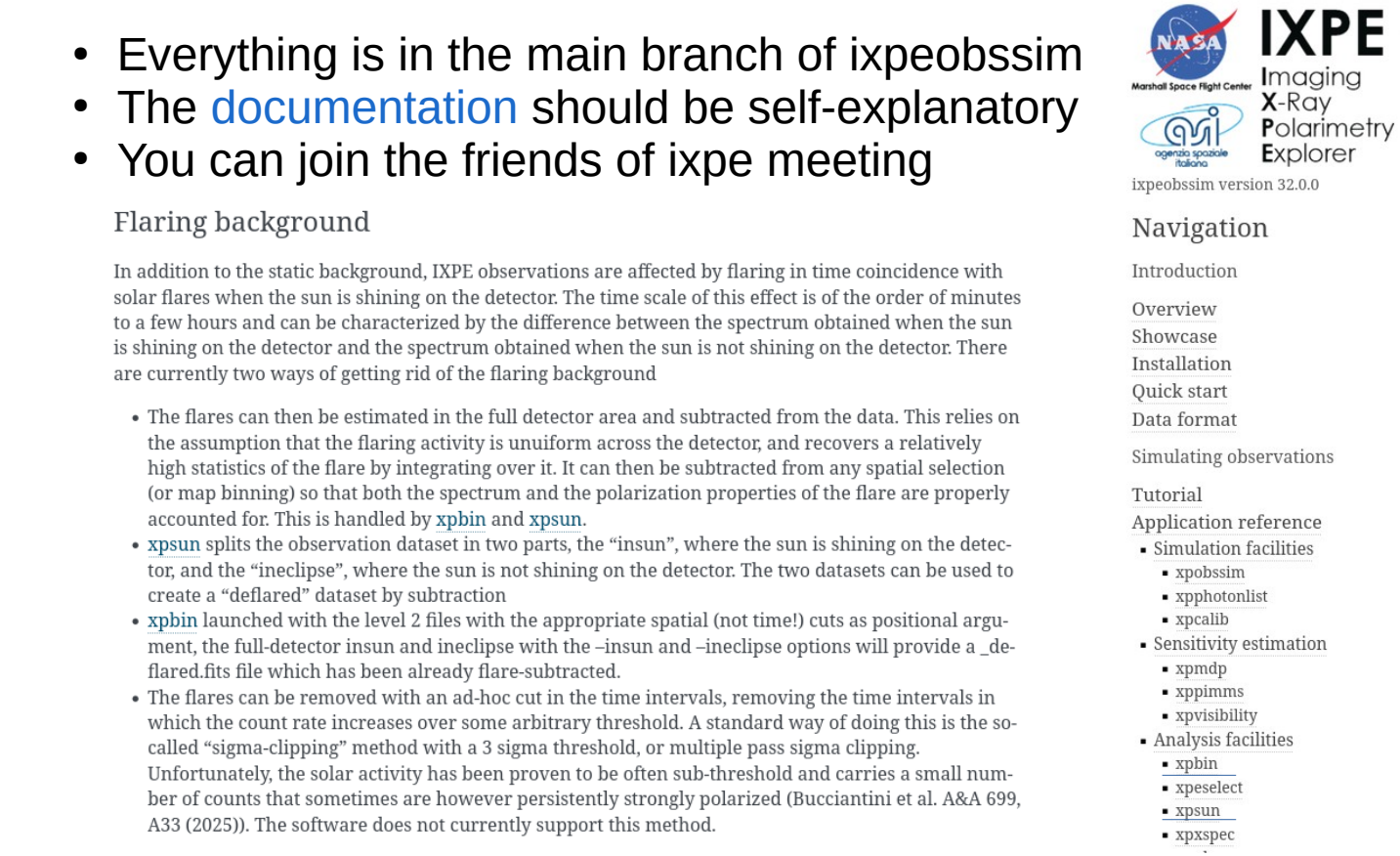
Works with all binned data products that make sense

- Count maps
- Polarization maps
- Polarization cubes
- All spectra (that can then be fed to xspec)

Future

We will be closely monitoring the situation for changes and update when needed (all of my personalities)
DU2 anomaly is expected to create issues but in the meantime

- Everything is in the main branch of ixpeobssim
- The documentation should be self-explanatory
- You can join the friends of ixpe meeting



Flaring background

In addition to the static background, IXPE observations are affected by flaring in time coincidence with solar flares when the sun is shining on the detector. The time scale of this effect is of the order of minutes to a few hours and can be characterized by the difference between the spectrum obtained when the sun is shining on the detector and the spectrum obtained when the sun is not shining on the detector. There are currently two ways of getting rid of the flaring background

- The flares can then be estimated in the full detector area and subtracted from the data. This relies on the assumption that the flaring activity is unuiform across the detector, and recovers a relatively high statistics of the flare by integrating over it. It can then be subtracted from any spatial selection (or map binning) so that both the spectrum and the polarization properties of the flare are properly accounted for. This is handled by xpbin and xpsun.
- xpsun splits the observation dataset in two parts, the “insun”, where the sun is shining on the detector, and the “ineclipse”, where the sun is not shining on the detector. The two datasets can be used to create a “deflared” dataset by subtraction
- xpbin launched with the level 2 files with the appropriate spatial (not time!) cuts as positional argument, the full-detector insun and ineclipse with the –insun and –ineclipse options will provide a _deflared.fits file which has been already flare-subtracted.
- The flares can be removed with an ad-hoc cut in the time intervals, removing the time intervals in which the count rate increases over some arbitrary threshold. A standard way of doing this is the so-called “sigma-clipping” method with a 3 sigma threshold, or multiple pass sigma clipping. Unfortunately, the solar activity has been proven to be often sub-threshold and carries a small number of counts that sometimes are however persistently strongly polarized (Bucciantini et al. A&A 699, A33 (2025)). The software does not currently support this method.

ixpeobssim version 32.0.0

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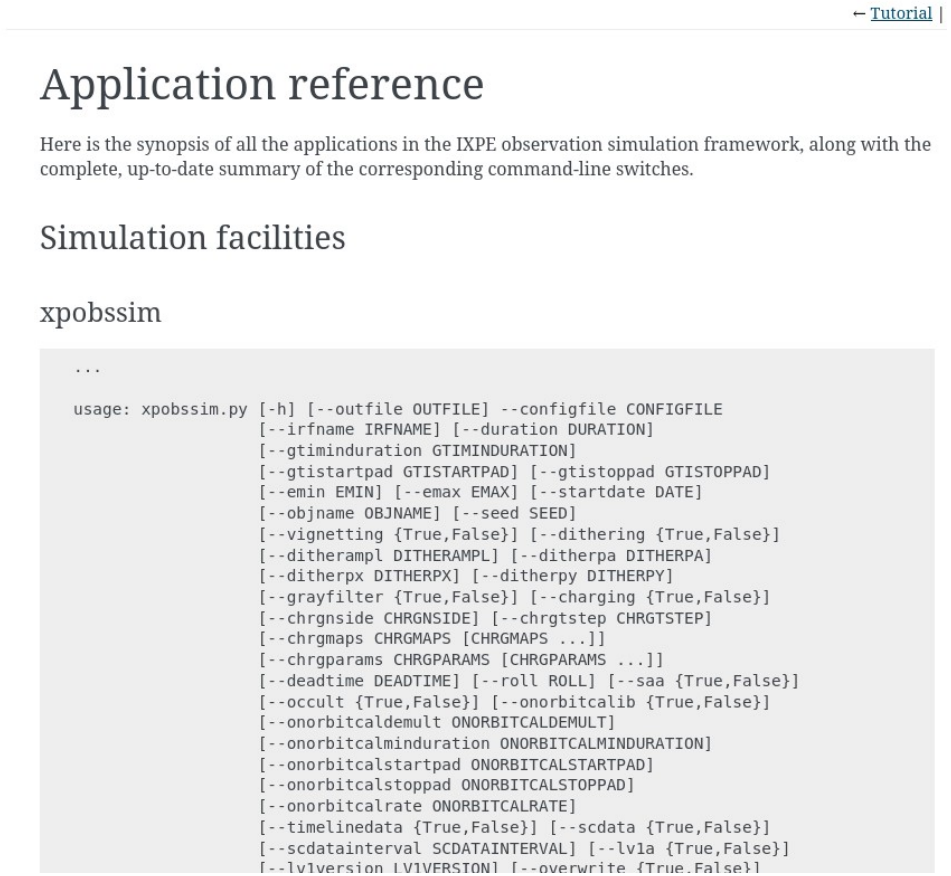

← Tutorial |

Application reference

Here is the synopsis of all the applications in the IXPE observation simulation framework, along with the complete, up-to-date summary of the corresponding command-line switches.

Simulation facilities

xpobssim

```
...

usage: xpobssim.py [-h] [--outfile OUTFILE] --configfile CONFIGFILE
                   [--irfname IRFNAME] [--duration DURATION]
                   [--gtiminduration GTIMINDURATION]
                   [--gtistartpad GTISTARTPAD] [--gtistoppad GTISTOPPAD]
                   [--emin EMIN] [--emax EMAX] [--startdate DATE]
                   [--objname OBJNAME] [--seed SEED]
                   [--vignetting {True,False}] [--dithering {True,False}]
                   [--ditherampl DITHERAMPL] [--ditherpa DITHERPA]
                   [--ditherpx DITHERPX] [--ditherpy DITHERPY]
                   [--grayfilter {True,False}] [--charging {True,False}]
                   [--chrgnside CHRGNSIDE] [--chrgtstep CHRGTSTEP]
                   [--chrgmaps CHRGMAPS [CHRGMAPS ...]]
                   [--chrgparams CHRGPARAMS [CHRGPARAMS ...]]
                   [--deadtime DEADTIME] [--roll ROLL] [--saa {True,False}]
                   [--occult {True,False}] [--onorbitcalib {True,False}]
                   [--onorbitcaldemult ONORBITCALDEMULT]
                   [--onorbitcalminduration ONORBITCALMINDURATION]
                   [--onorbitcalstartpad ONORBITCALSTARTPAD]
                   [--onorbitcalstoppad ONORBITCALSTOPPAD]
                   [--onorbitcalrate ONORBITCALRATE]
                   [--timelinedata {True,False}] [--scdata {True,False}]
                   [--scdatainterval SCDATAINTERVAL] [--lv1a {True,False}]
                   [--lv1version LV1VERSION] [--overwrite {True,False}]
```


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Gas pressure

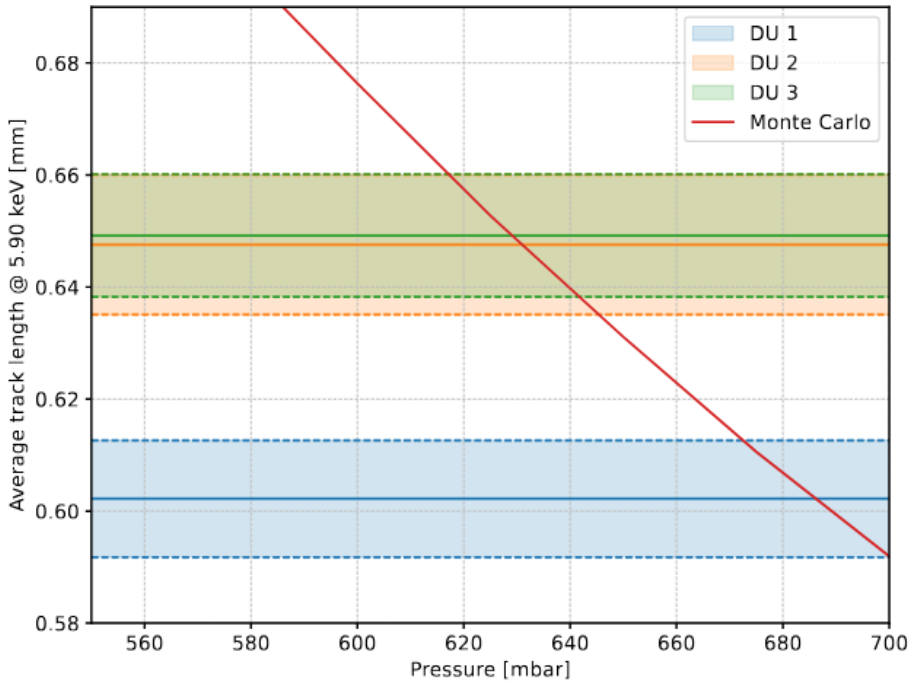
Pressure drop

Secular variation of gas pressure (known pre-flight) has been attributed by glue adsorption

- Alters track length, gain, quantum efficiency
- Initially modeled as a single exponential, more complicated models are now favored

- The track length provides an estimate of the pressure
- The drop is slow (15-20 mbar/yr)
- Get it from bright sources

- Aeff → Aeff(t): **Release of ~two set of IRFs per year**
- Continuous monitoring

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Summary

Summary

IXPE is alive and well-ish as it moves closer to the 5th year of operations (out of 2)

- **DU2 anomaly has been addressed**. A few minor concerns remain
  - Off-axis sampling of the spurious map is not optimal (residuals ~<1% in Q/U)
  - Two dead line of pixels remain (bkg estimation, pol leakage)
  - The **2025-2026 observations are being reprocessed and distributed** to the PIs as i'm talking.

- **Background issue is largely solved.**
  - We still don't know why the background has those properties
  - WHATEVER the reason we know how to subtract it now without having to guess
  - There will be a paper soon (tools are <1 month old)

- We continue to monitor the status of the observatory and to **update the response funcions yearly, and everything is nominal**

- Some reprocessing is being applied to the first year sources with the updated pipeline.

- Everyone is welcome to join the friends of IXPE forum


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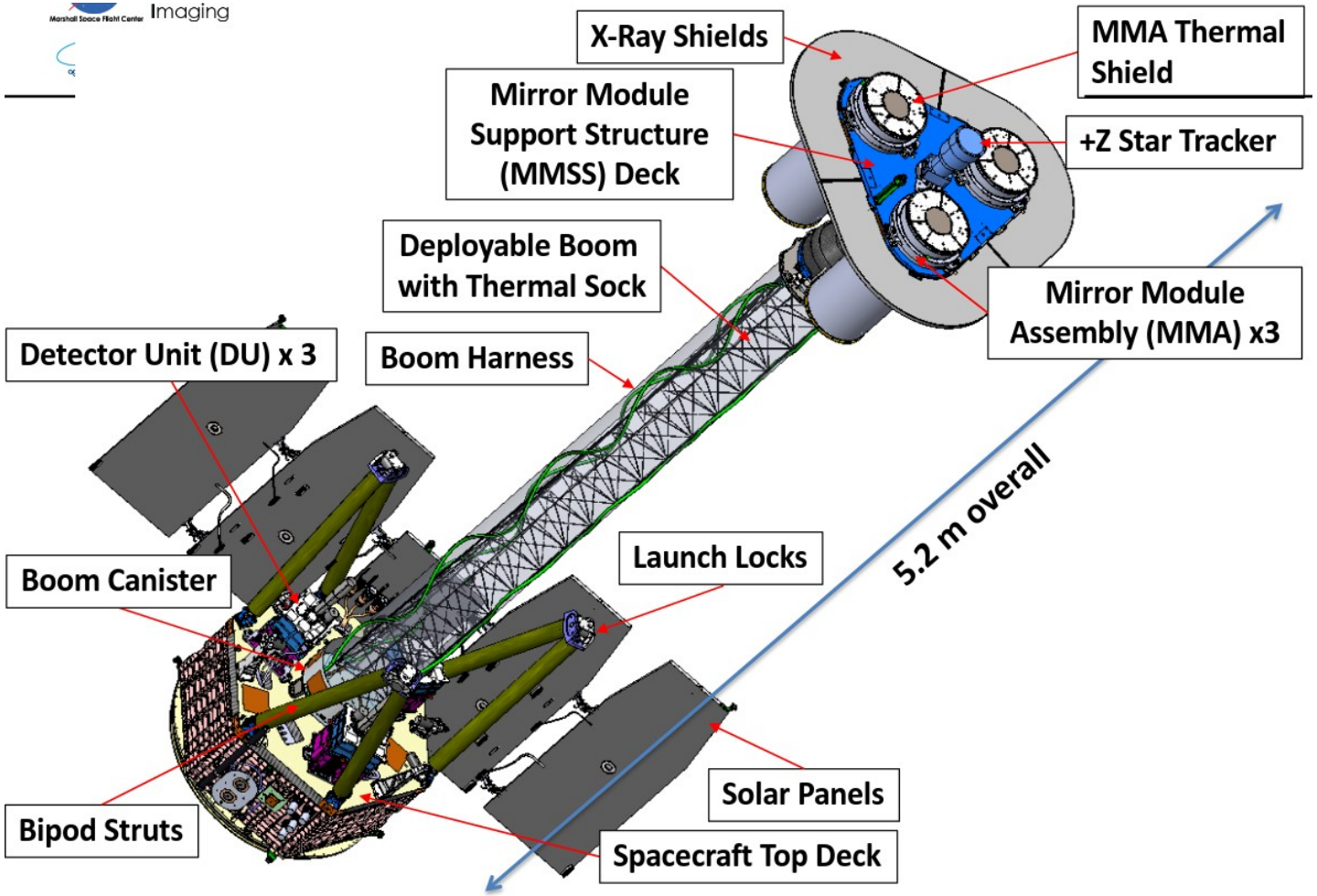
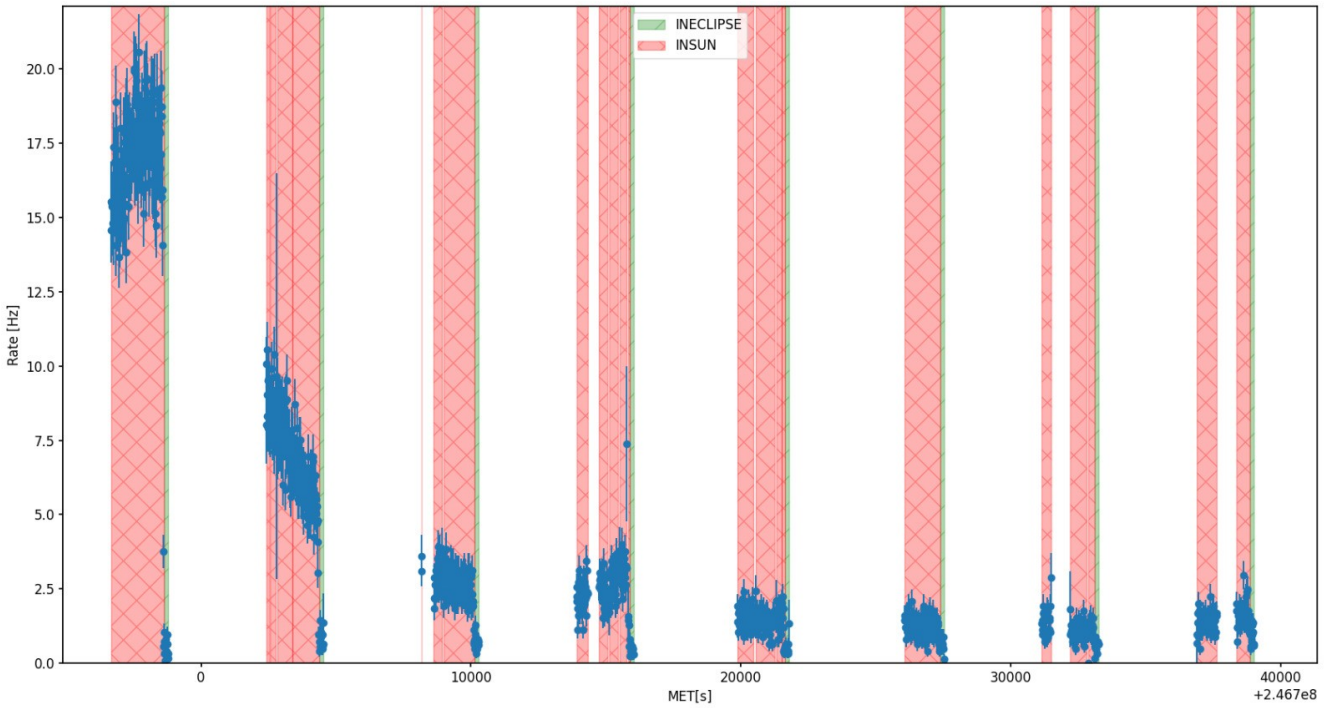
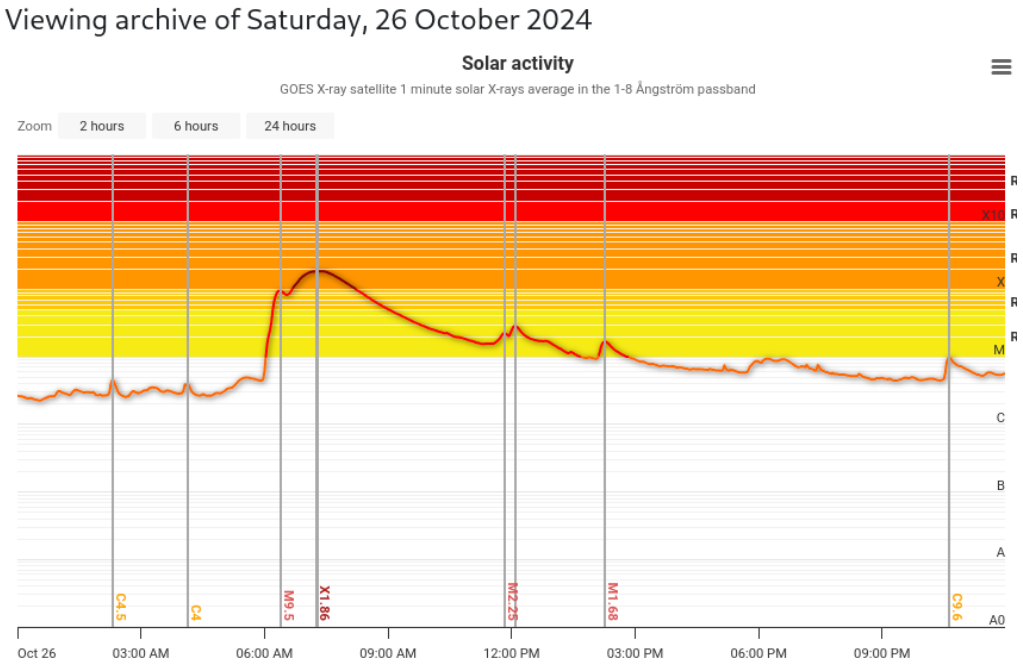
Summary



Parameter	Value
Number of mirror modules	3
Number of shells per mirror module	24
MMA Mass	93 kg (three together)
Focal length	4 m
Total shell length	600 mm
Range of shell diameters	162–272 mm
Range of shell thicknesses	0.16–0.25 mm
Shell material	Electroformed nickel–cobalt alloy
Effective area per mirror module	163 cm^2 (@ 2.3 keV); >192 cm^2 (3–6 keV)
Angular resolution (HPD)	~25 arcsec (MMA alone)
Field of view (detector limited)	12.9 arcmin square

Flares and the sun





Flaring activity is somehow due to the sun, and broadly follow its time evolution
Class X and M flares are visible also in IXPE, but sub-threshod flaring activity can persist and alter IXPE's background