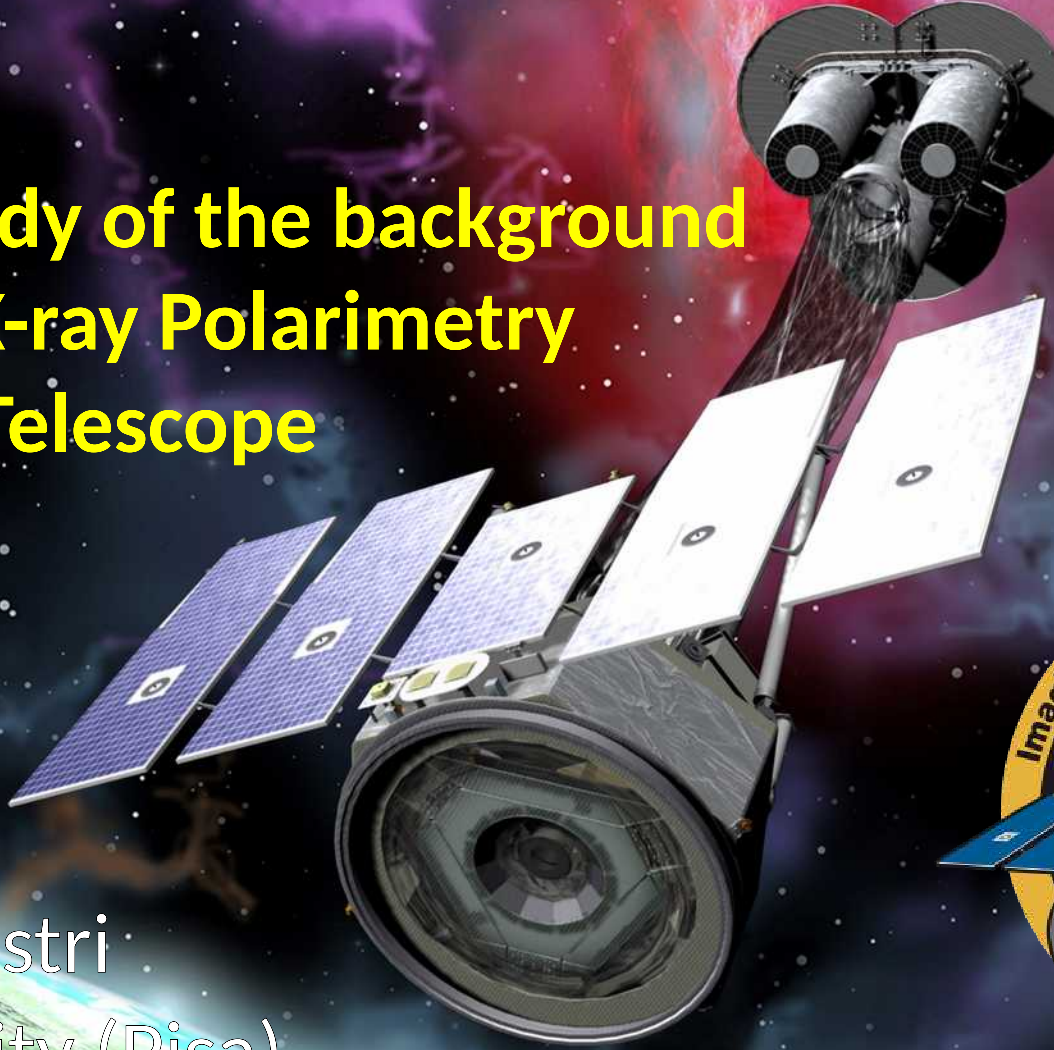
A large scale study of the background of the Imaging X-ray Polarimetry Explorer (IXPE) Telescope



Stefano Silvestri
INFN and University (Pisa)

Our background components

Over the course of the first two years we identified several background components, each requiring specific care

Rejected

- **Easily identifiable** cosmic rays triggering the detector directly
  → Tracks are morphologically distinct from X-rays, radial trend

Residual (Easy)

- An isotropic X-ray-indistinguishable background of instrumental origin
  → Coordinate independent, indistinguishable from other events

- A DU-dependent time variable X-ray background of unknown origin
  → Showing a clear peak around 1.5 keV, which sinks below the stationary component at ~3keV

Residual (Hard)

The *residual* background

An isotropic X-ray-indistinguishable background of instrumental origin

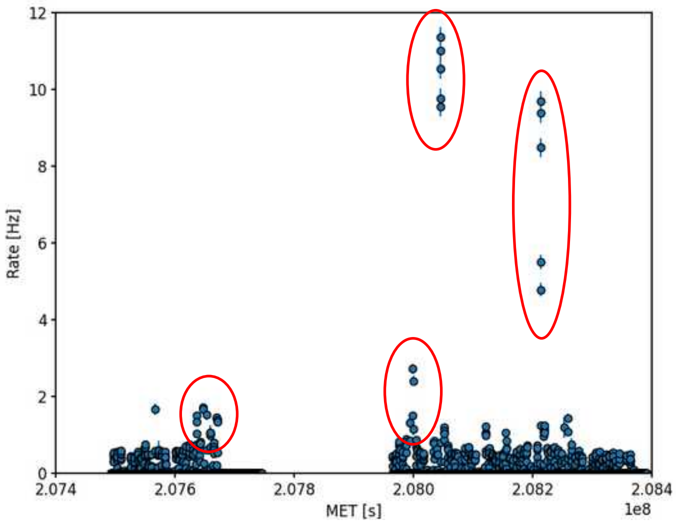
→ Coordinate independent, indistinguishable from other events

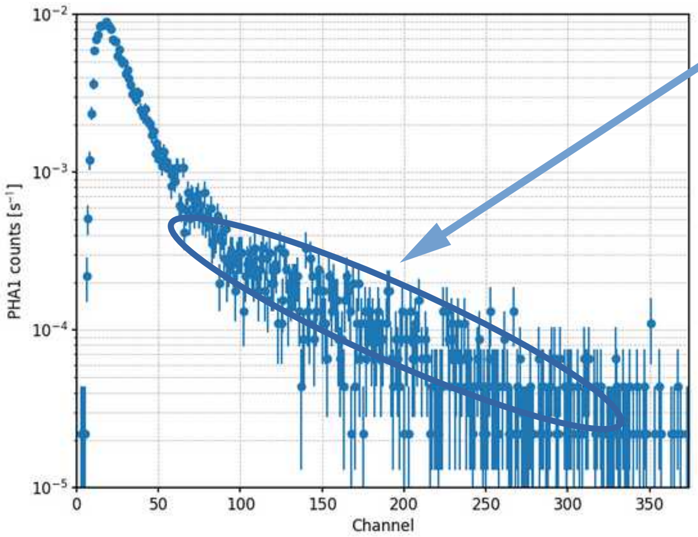
Residual (Easy)

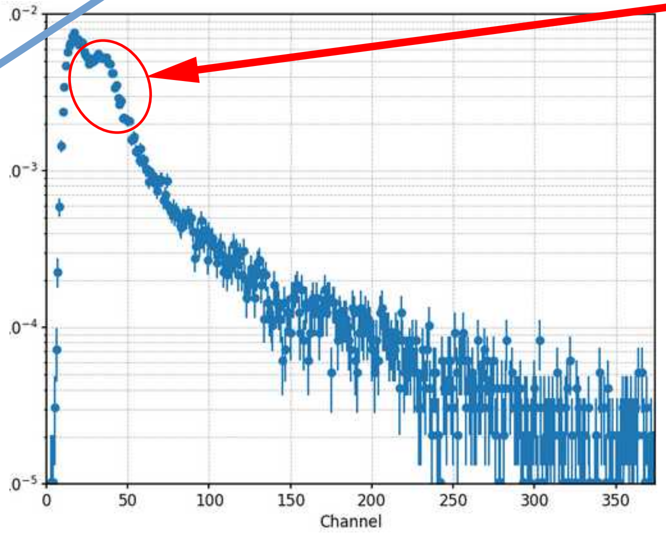
- A DU-dependent time variable X-ray background of unknown origin

  → Compatible with a line at ~1.5 keV (aluminium fluorescence from solar activity?), affecting the three DUs differently

Residual (Hard)







Our previous knowledge

Our most standard procedure to extract the residual background is detailed in Di Marco et al. 2023 (but you can imagine it)

- It's inefficient for extended sources
- It's statistics limited because it relies on a relatively small extraction area

➔ Stack it from many observations of point-like sources

➢ **Are they the same populations?**

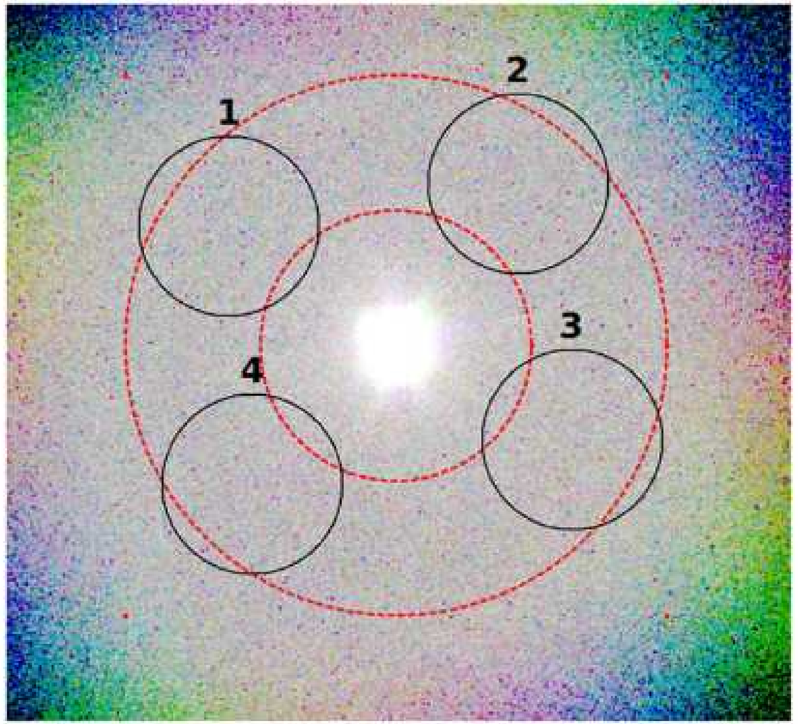
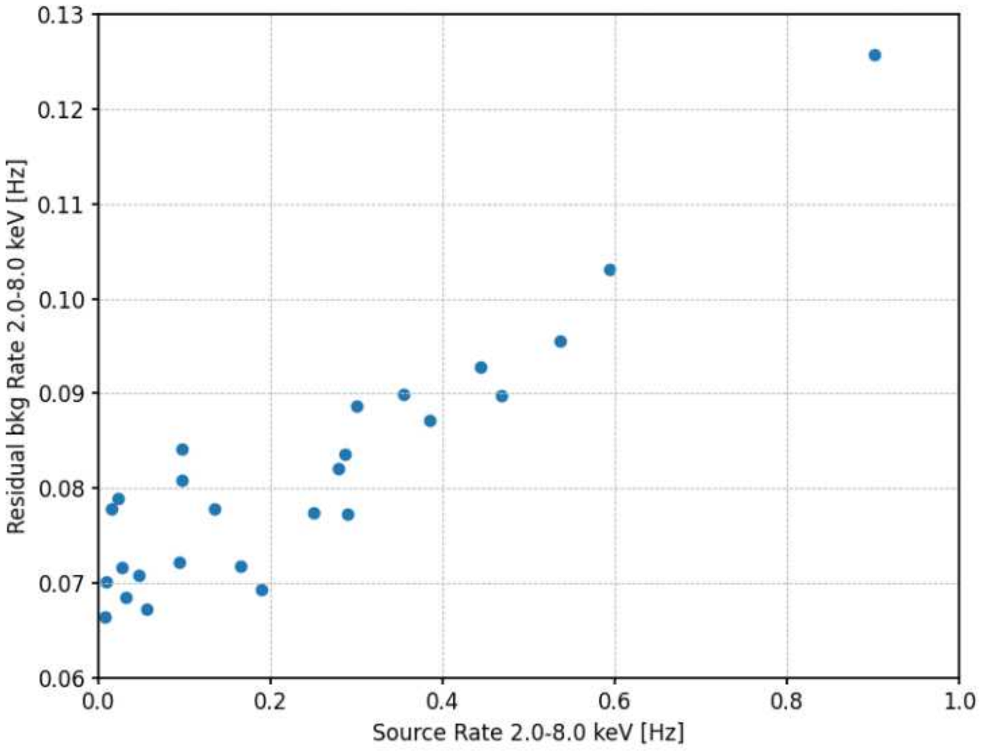
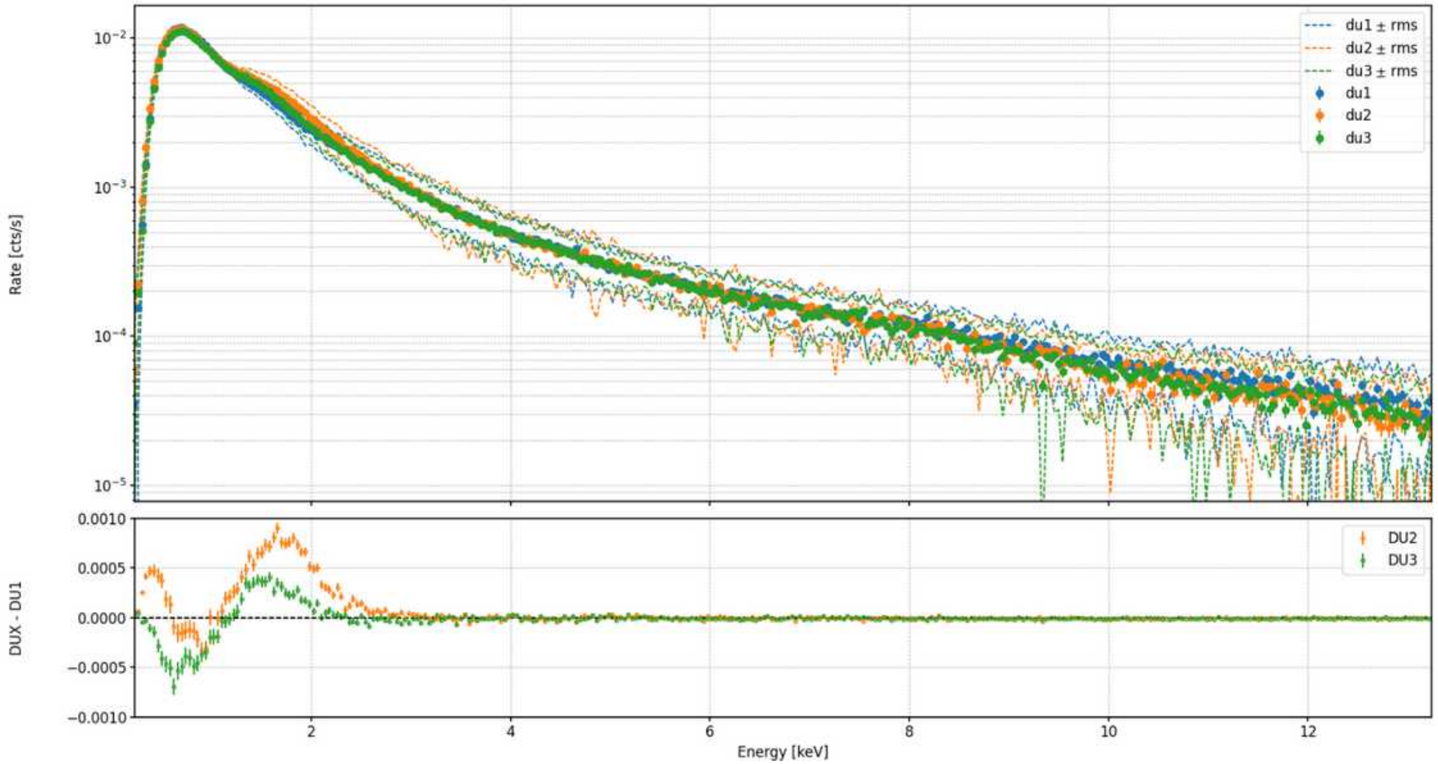


Figure 3. IXPE observation of 4U 0142+61 overimposed with four circular regions, in black, with radius 100″ and an annular region, dotted line in red, with inner radius 2.′5 and outer radius 5′. These regions are used to test and compare different background selections in this analysis.

Our previous knowledge

The number of sources for which this can be done is very small (15 for the first observation cycle), and we identified variability (EVEN DISCARDING THE MOST FLARED ONES!)

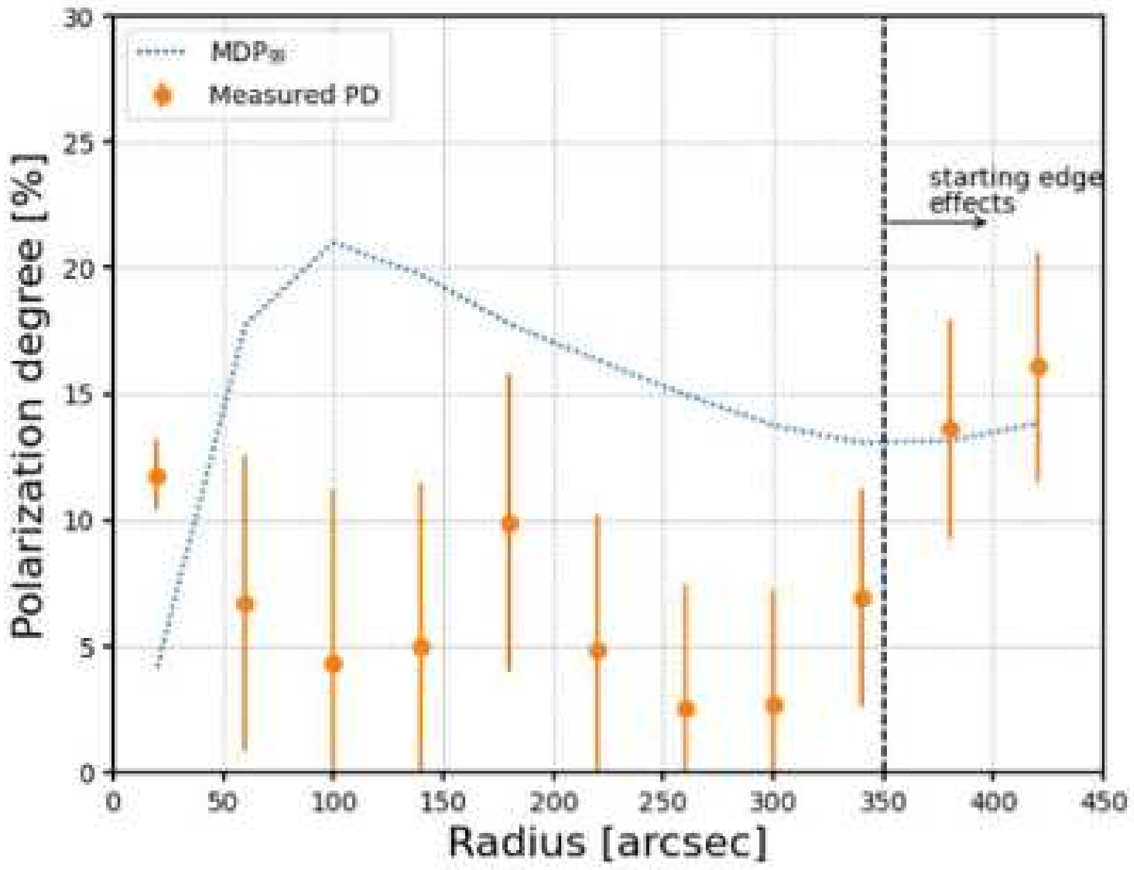




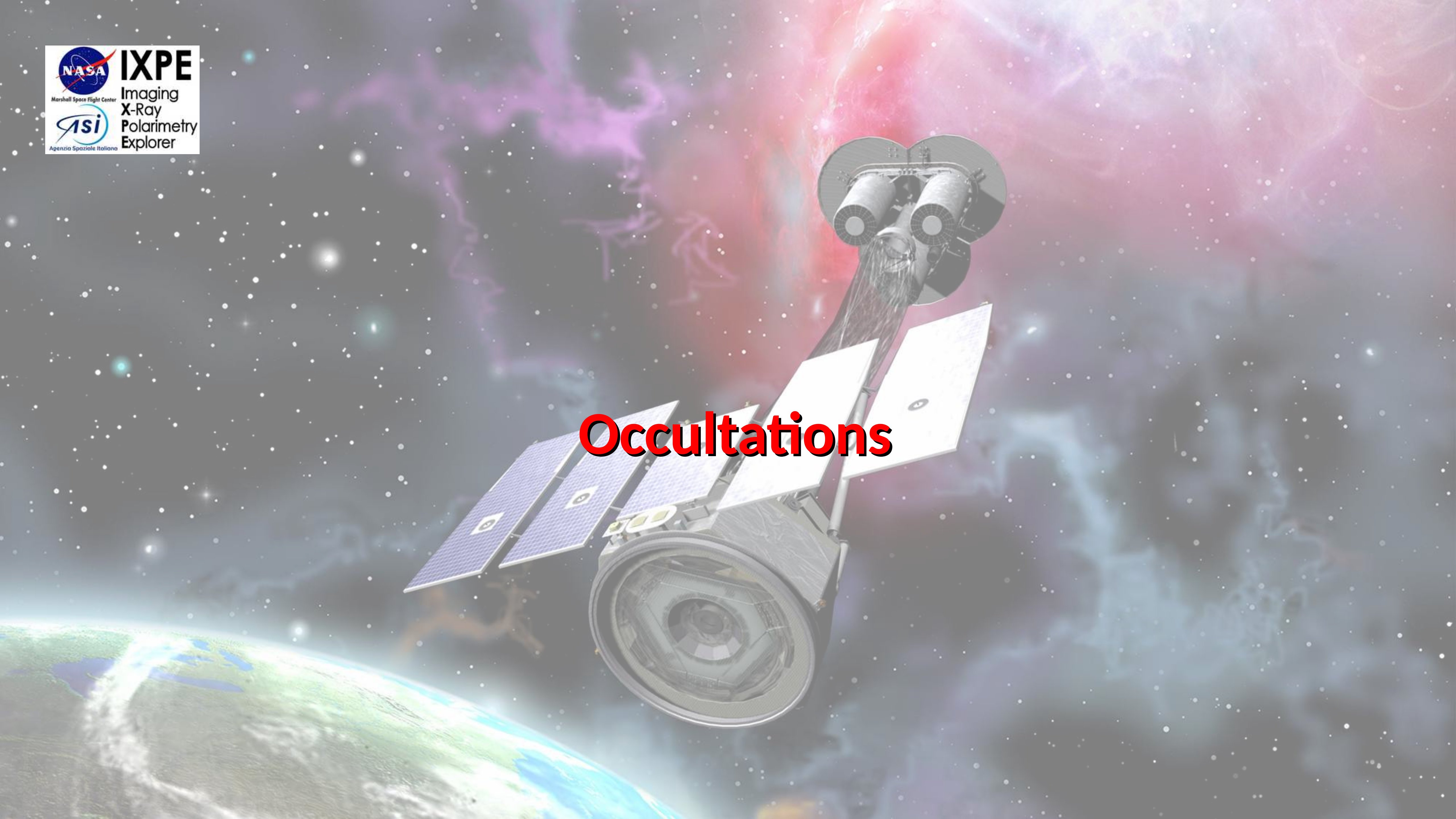
Our previous knowledge

Still contained in Di Marco 2023, our initial knowledge of the background was that of an unpolarized one

As you leave the contamination radius of the source, PD<MDP



IXPE
Imaging X-Ray Polarimetry Explorer



Occultations

IXPE Imaging X-Ray Polarimetry Explorer

Occultations

We spend an average of **35% of our observing time** occulted by the earth, with the lid open, and we store the data on level 1 files. A small amount of this time is also spent on calibration. All of these events are not reconstructed but **contain a lot of information about instrumental background.**

Main Search Form — Data Products Retrieval for Selected Rows — Tip Archive | Hera | HELP

Tar file size is expected to be 448 GB. We have set a limit of 2 GB per tar file. Please go back and reduce the number of observations or files selected, or select Create Download Script to create a editable script of download commands.

General Help can be found on the Browse Help Page
Coordinate Format Help can be found in the Explanation of Name/Coordinates Input Formats section
Parameter Search Help can be found in the Search by Parameter section

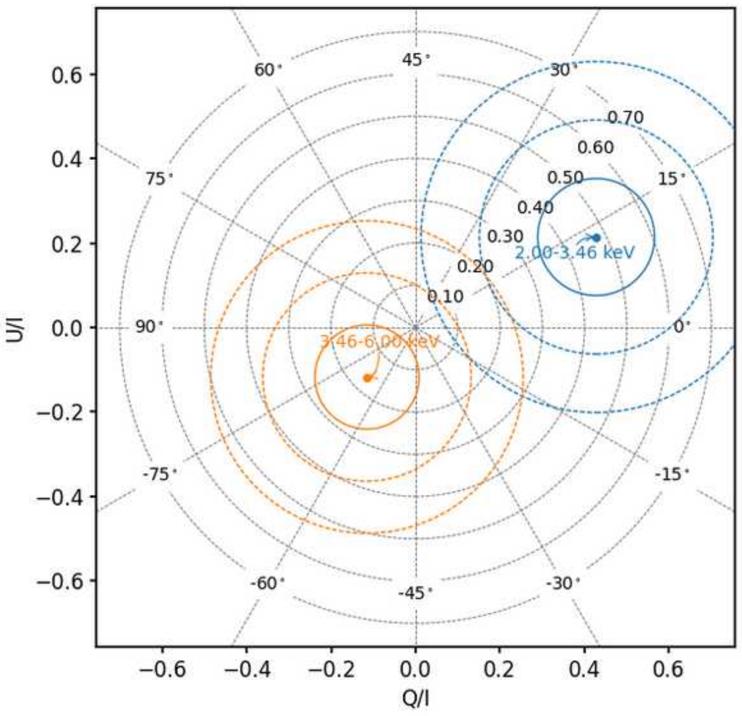
Browse Feedback

Spoiler: not all of those could Be reconstructed, only have 39/70, still pretty good!

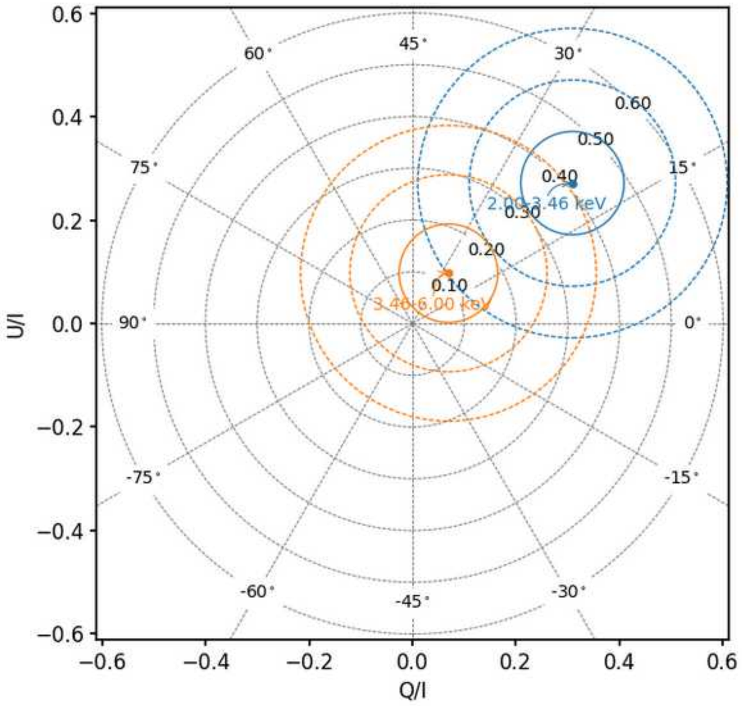
Occultations

I started looking at the occultation data for the first observation of RCW86 (obsid 02001599) for, say, personal reasons, and this came up

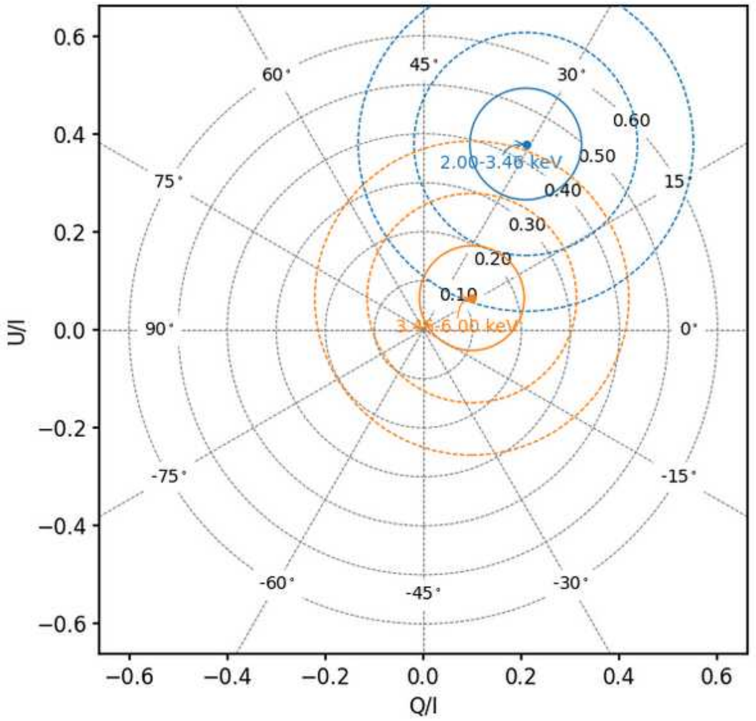
DU1 PD=0.47, MDP99=0.42



DU2 PD=0.41, MDP99=0.30

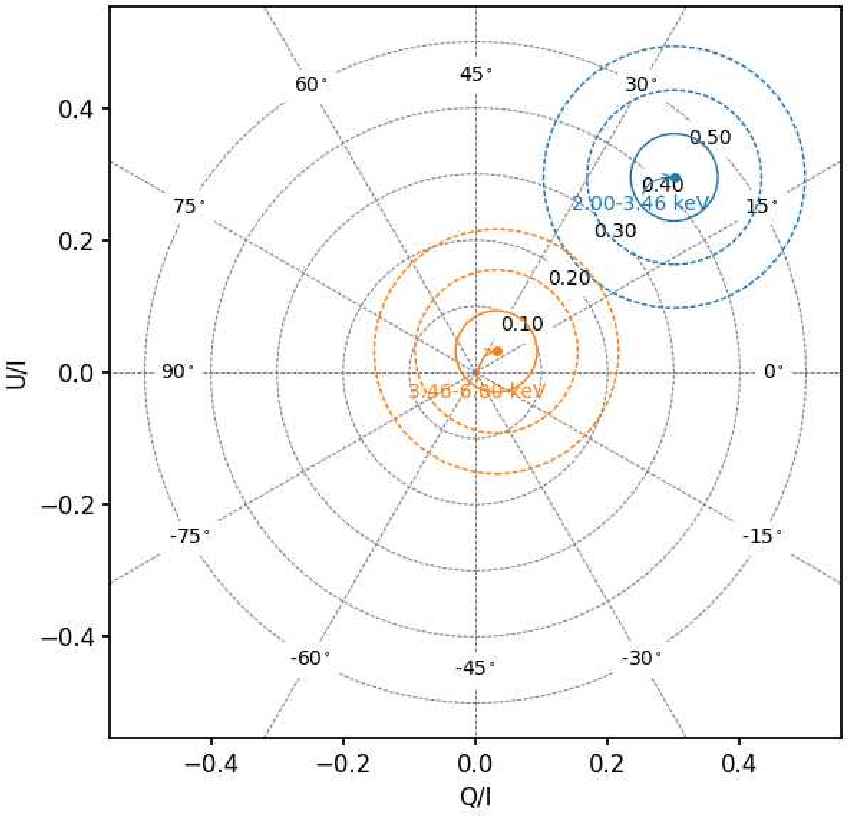


DU3 PD=0.43, MDP99=0.34



Occultations

They also stack pretty well, and give a much stronger signal than the source (when looked at in pointing data of course)

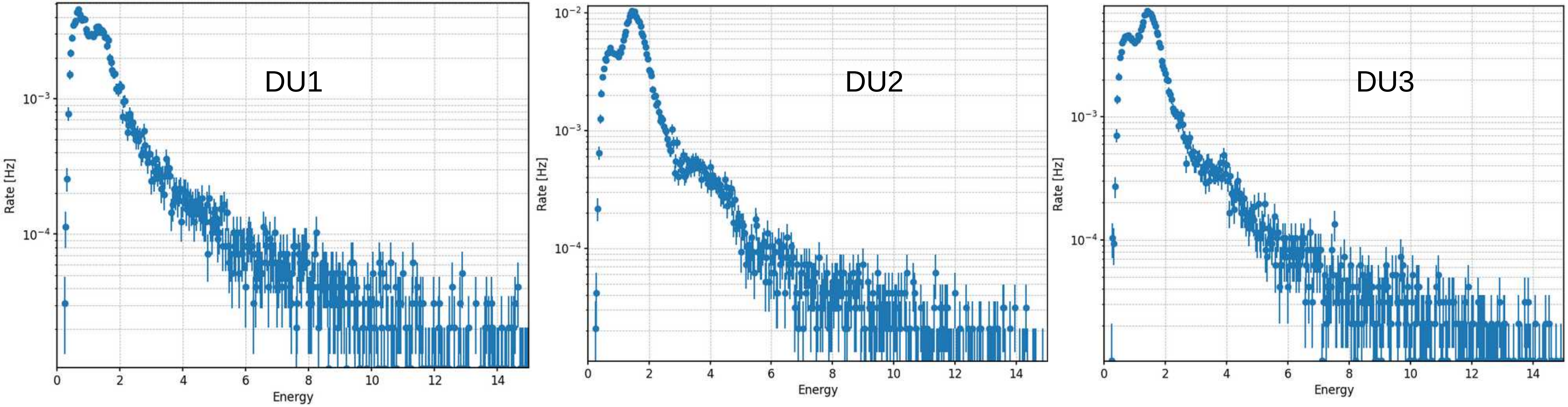


Quantity	2.00--3.46 keV	3.46--6.00 keV
E_MEAN	2.557115998582543	4.650333556596062
COUNTS	8615.0	3652.0
MU	0.2333820806549129	0.40902071708883403
W2	15.926515579223633	54.966590881347656
N_EFF	8424.068359375	3150.929931640625
FRAC_W	0.9778373023070226	0.8627957096496782
MDP_99	0.2002759567298245	0.18684978279807093
...	...	...
PD	0.421309232711792	0.044666230678558335
PD_ERR	0.06595199223377725	0.06166467736444637
PA	22.220943002294916	22.40637239297701
PA_ERR	4.495436011716665	39.55360301088061
P_VALUE	1.367420001166128e-09	0.7687844976784911
CONFID	0.99999999863258	0.2312155023215089
SIGNIF	5.946770759709557	-0.7348497496961501

Occultations

What about the spectrum?

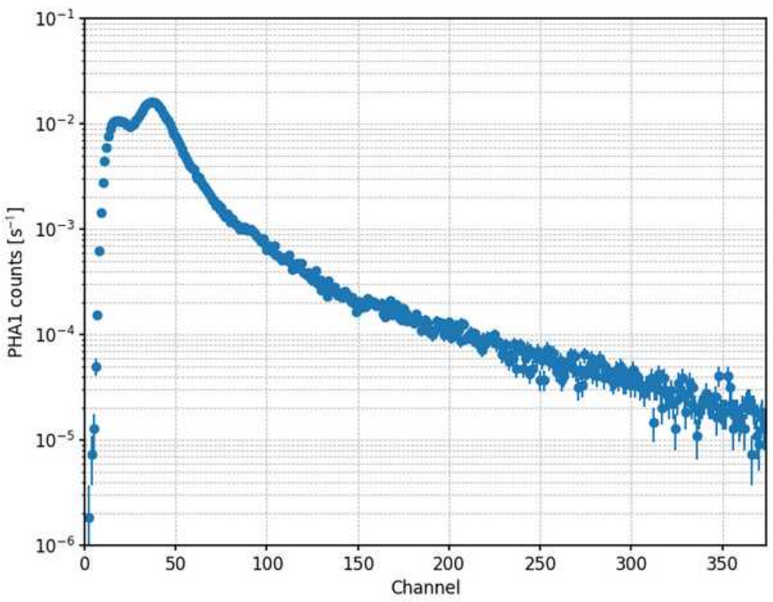
- Flares are quite impressive here (also keep in mind that there is no source)
- Unexpected feature at ~<4keV



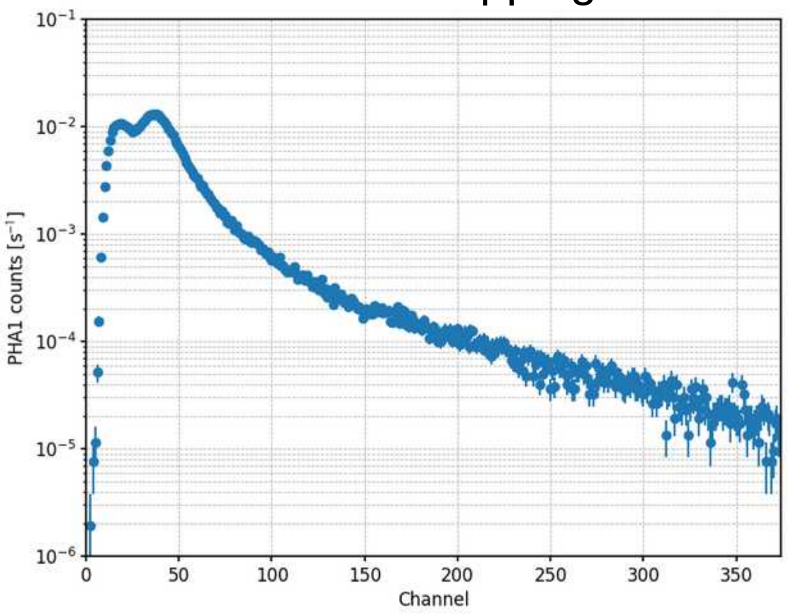
Occultations

Unlike in most of our observations, there is no way to decently get rid of these flares with our typical rate quantile clipping

DU2 spectrum (incl. source)



DU2 spectrum (incl. Source)
AFTER clipping



Not shown here:
After 50% quantile clipping (that means throwing away 50% of our data), the bump still persists!

this source educated me not to rely on rejection anymore

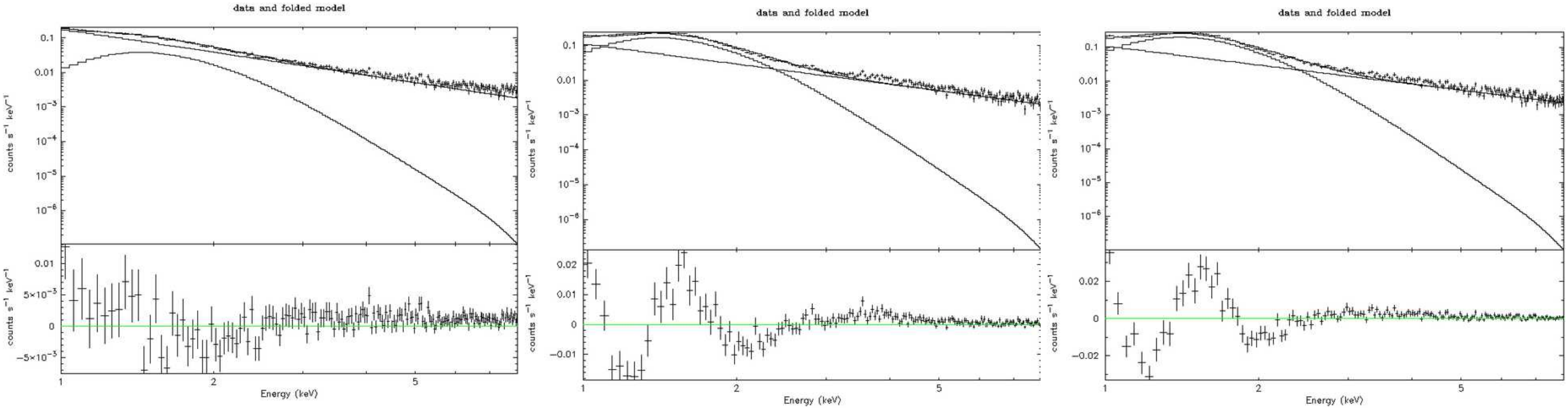
Characterization is the way out

Uncharted territory

Occultations

Can we fit the bump (the case of obsid 02006799)?

- Unpolarized power law + polarized power law with steep index
- Residuals are displeasing but mostly at <2keV



Occultations

Do we get the polarization right?

- Unpolarized power law + polarized power law with steep index
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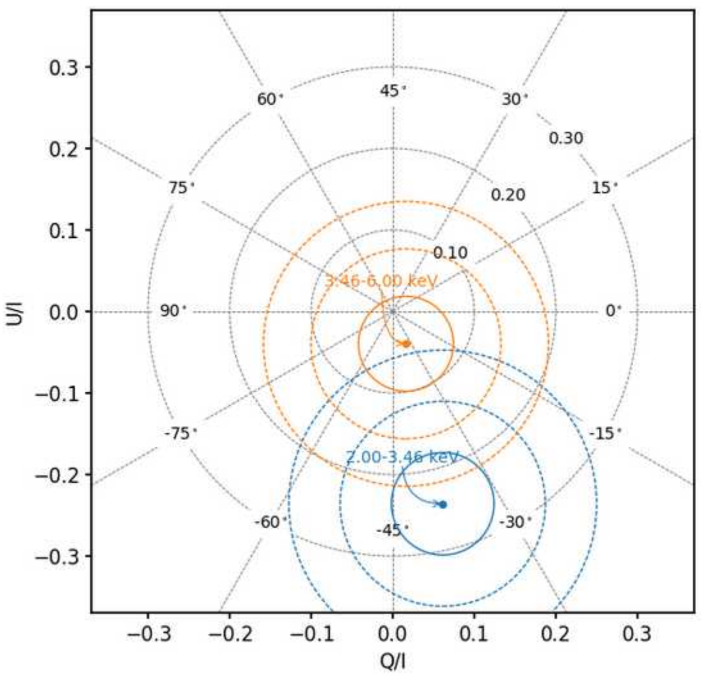

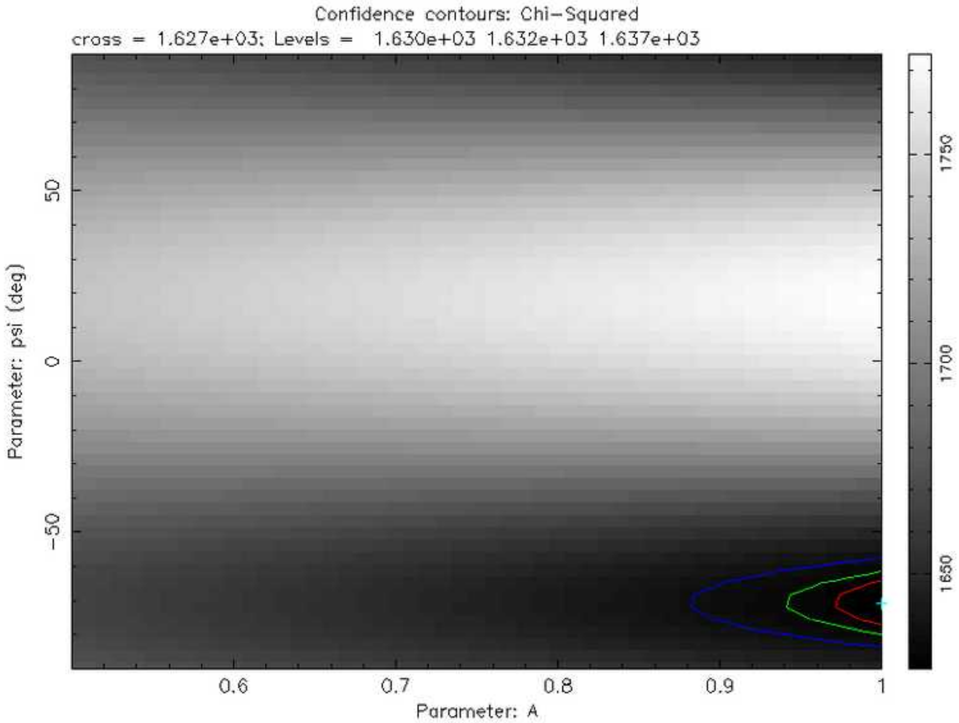

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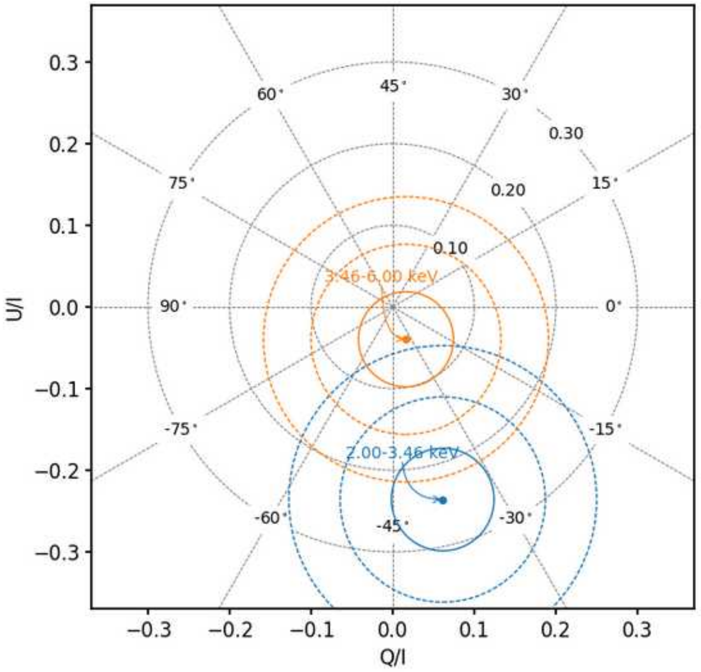
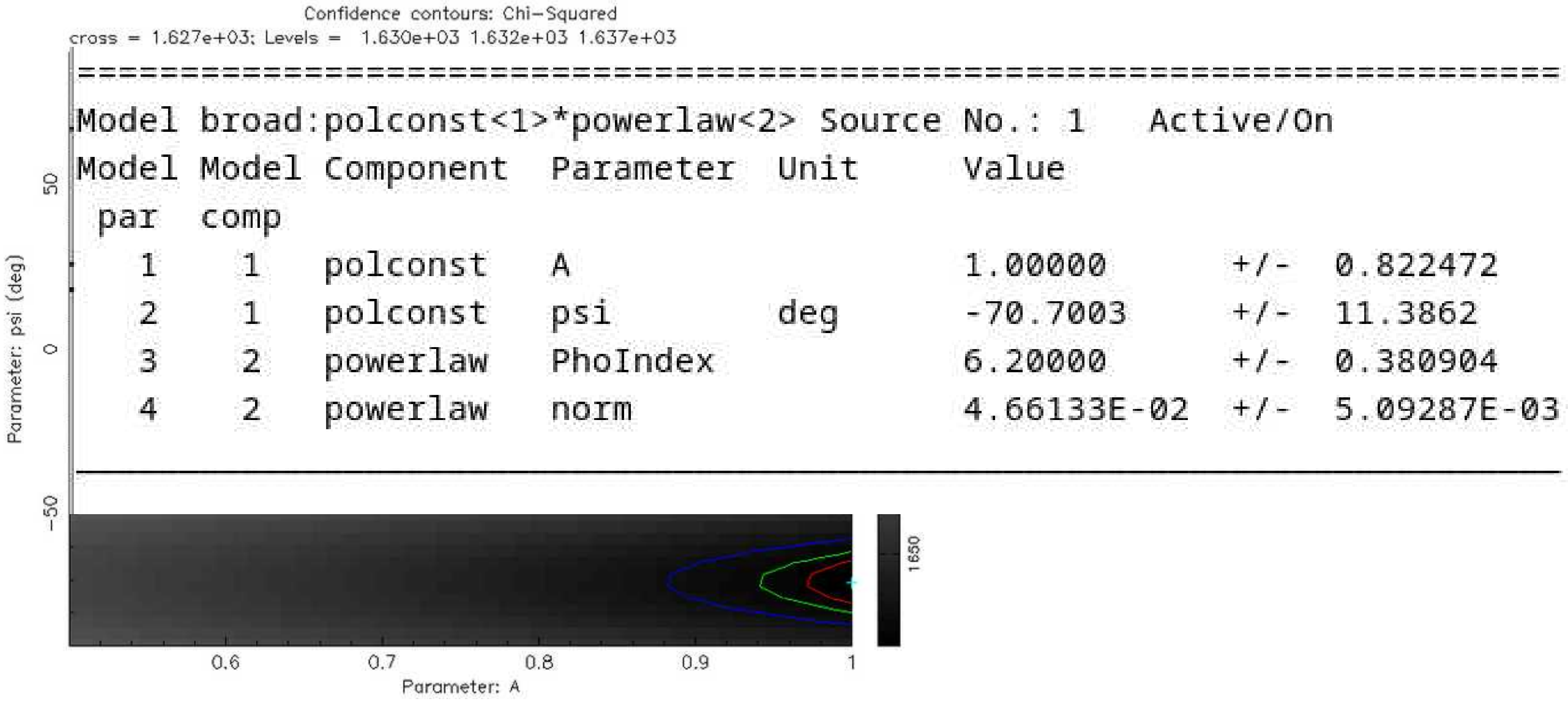
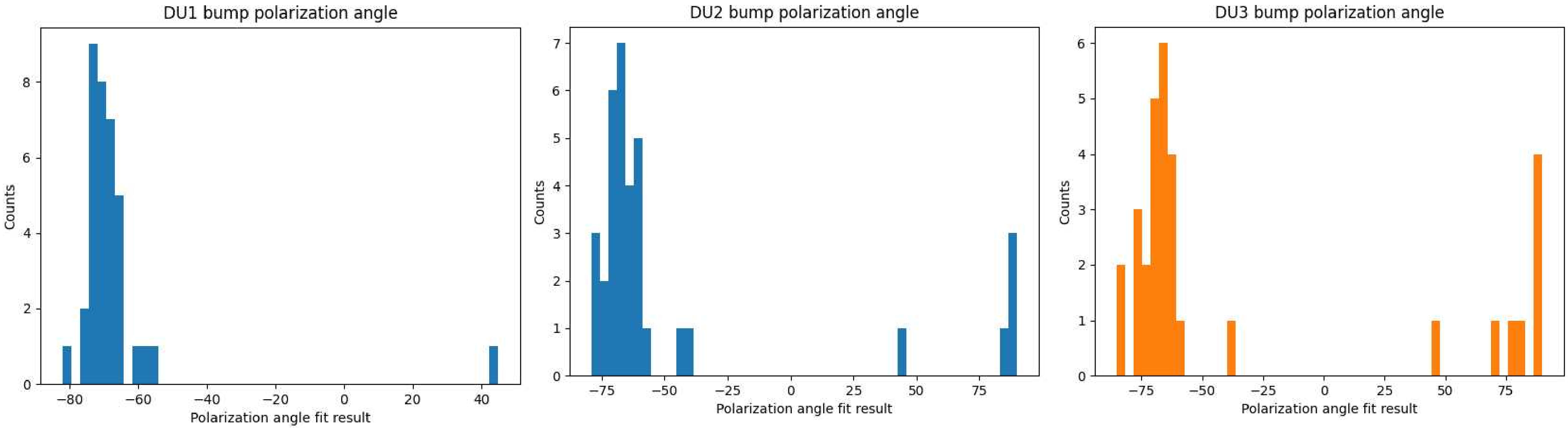




Occultations

That is a rather typical case when we have enough statistics

- I will now assume that this detected polarization angle makes some sense
- …and after filtering out the least significant PA fits….



Interpretation

We are **totally** looking at something that is **not X-rays**

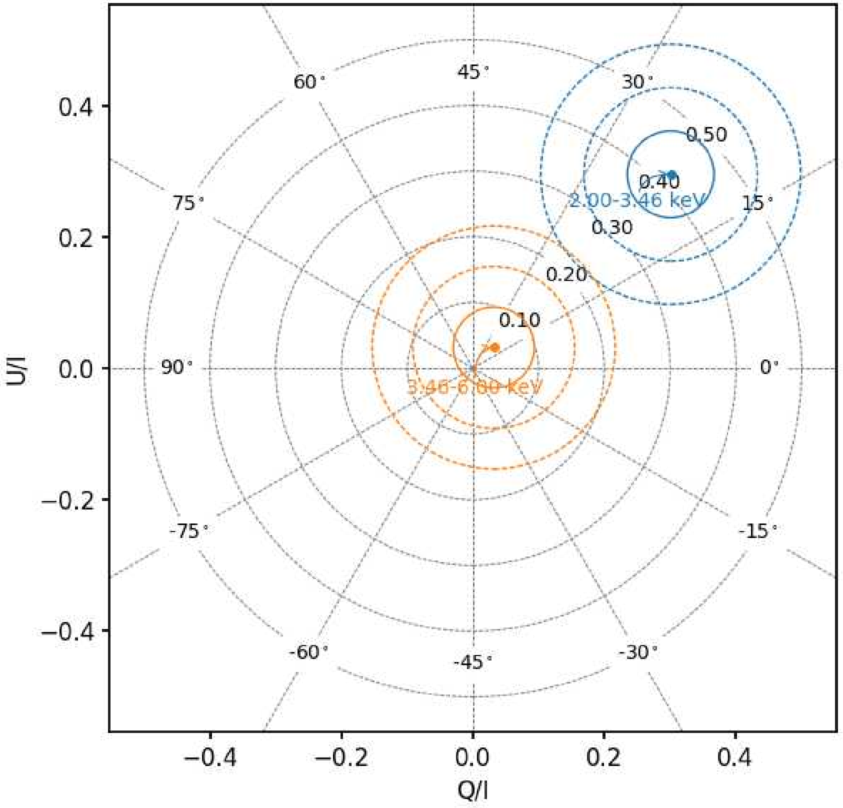
- The <2keV response functions are extrapolated with simulaions and nobody trusts their absolute scientific reliability but they cannot be too much off
- When both pcubes and xspec fits are significant they are compatible one with another in terms of PA

- The polarization degree bashes against the hard limit of 100%. Why?
- Because we are not looking at x-rays and our arf makes no sense at all.

Questions

- There is no trace of the flares nor the spectral feature in the rejected component. Why are all of these CR events so peculi
- What about RCW86?

Hello po



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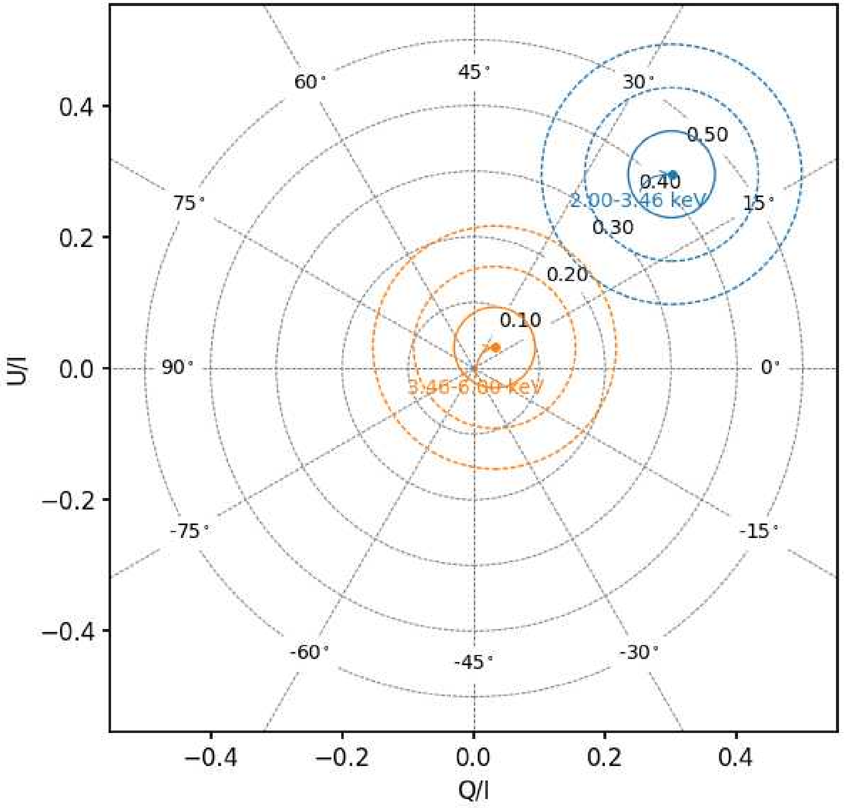
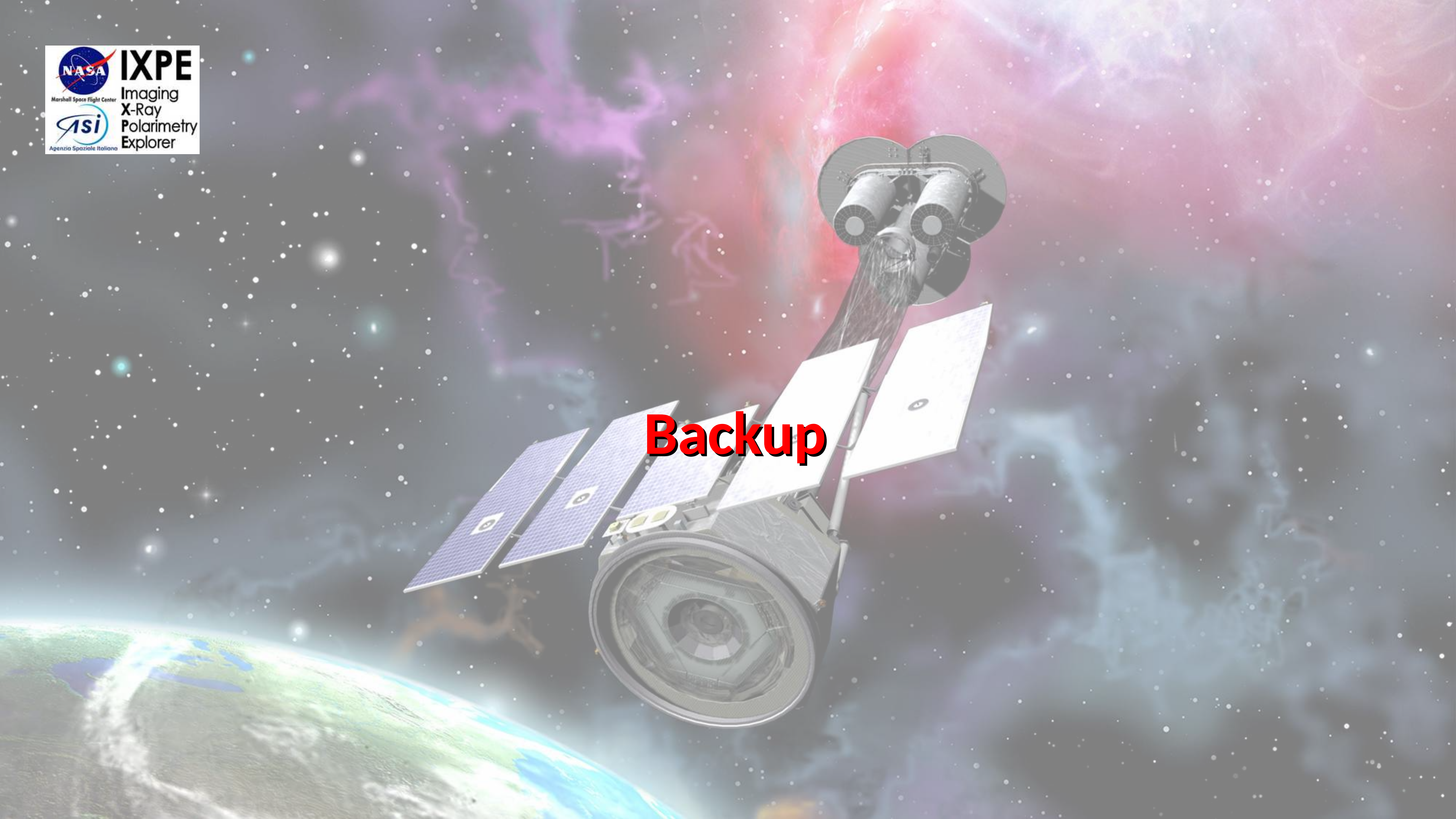
- What about RCW86?
  - ➔ Its peculiar spectrum with the feature at 4 keV is probably responsible of what is happening
  - ➔ DU1 is the only with a detection in xspec, has no such feature. Its PA (-67±12) is compatible with the sample of xspec fits. DU1 pcube is controversial (opposite behaviour of the 2 bins




IXPE
Imaging
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Explorer
Marshall Space Flight Center
Agenzia Spaziale Italiana

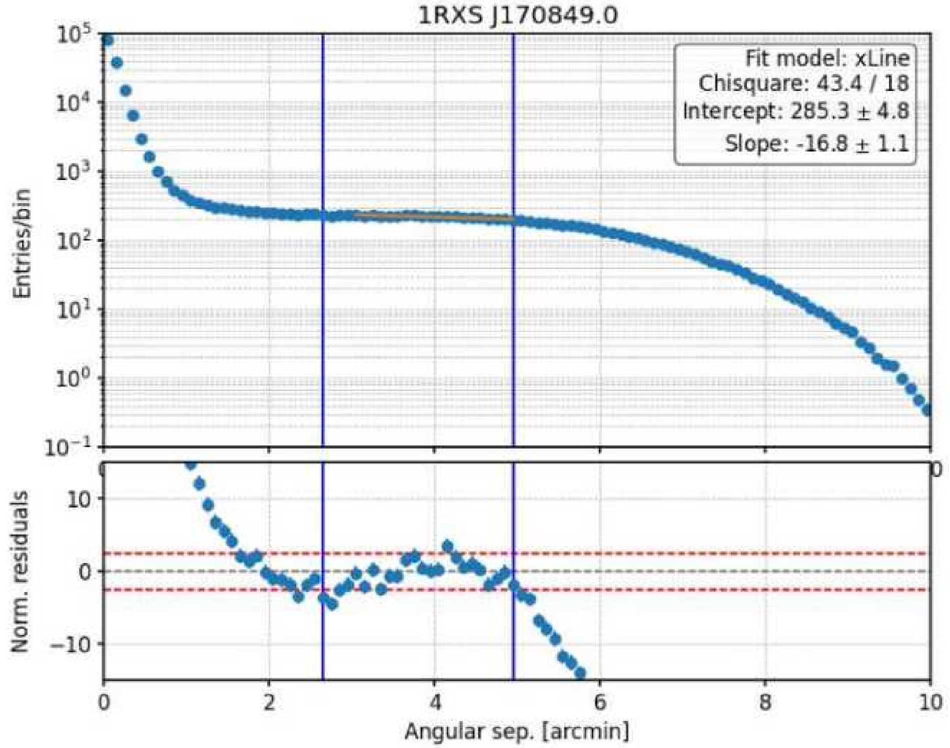
Backup

Our previous knowledge

The old way of extracting background was that of selecting acceptable radii where we were supposedly not contaminate by the background

- Only a few faint source observations were eligible
- The extraction ring has a relatively small area
- Point sources are typically shorter observations

➔ We tipically did not get a large statistics and we still had the question about the population



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