NISP-IOT: NISP Data Trend Analysis

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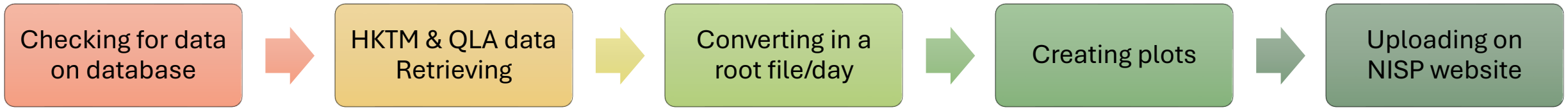
Outline:

- HKTM and QLA daily monitoring
- Cosmic Detection On Slew Dark
- Flat-field (F-007) Detectors Analysis
- Persistence Detection On Slew Dark Using Autoencoders
- Work In Progress

HKTM and QLA daily monitoring

Developed an automatic pipeline:



http://nisp01.oas.inaf.it:20080/

Daily health checks and **long-term monitoring** of:

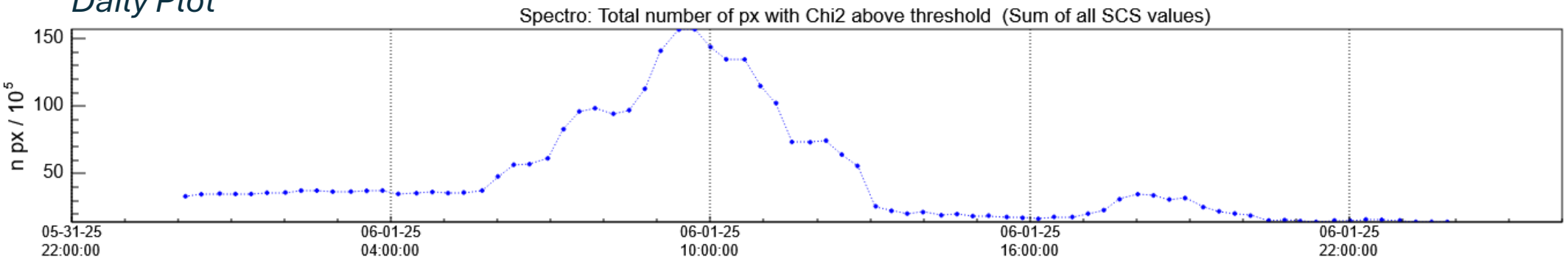
HKTM

- Temperatures, voltages, current, power for:
  - Mechanical Assembly (OMA – e.g. FWA and GWA)
  - Warm Electronics (ICU, DPUs)

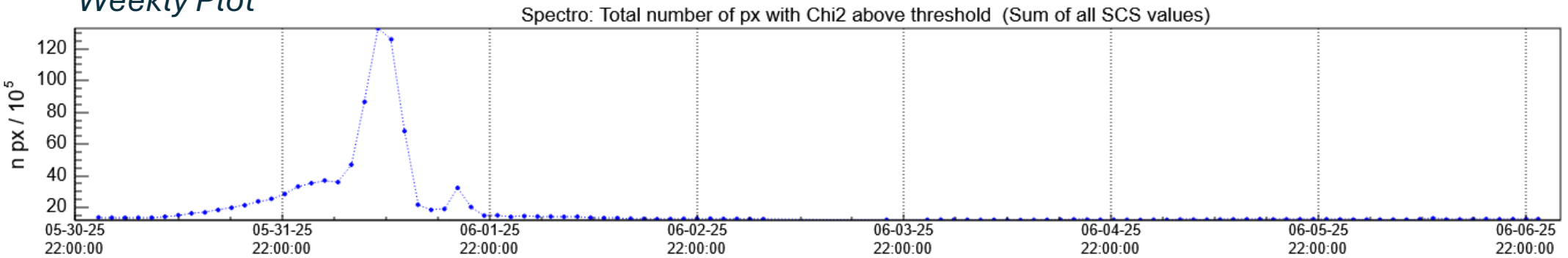
QLA

- Baseline
- Saturated pixels
- Number of px/s with cosmics
- Number of sources
- Number of spectra
- PSF
- Chi2
- Spectrum Angle
- SCI px statistics
- REF px statistics

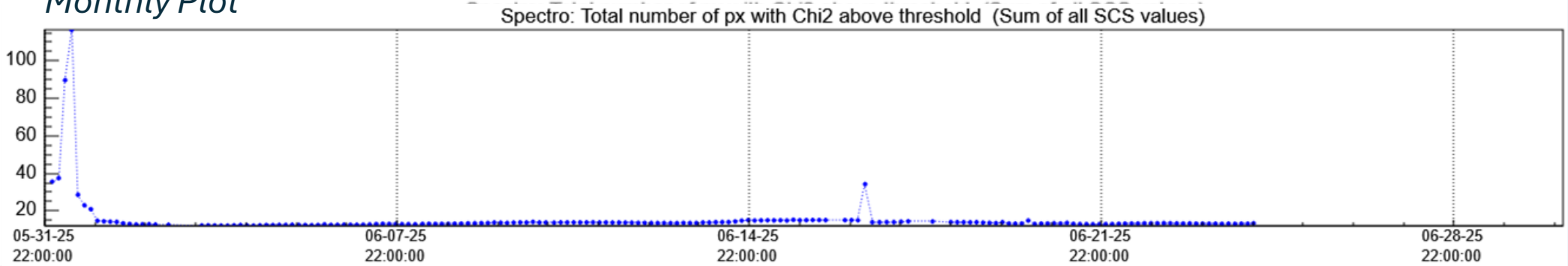
Daily Plot



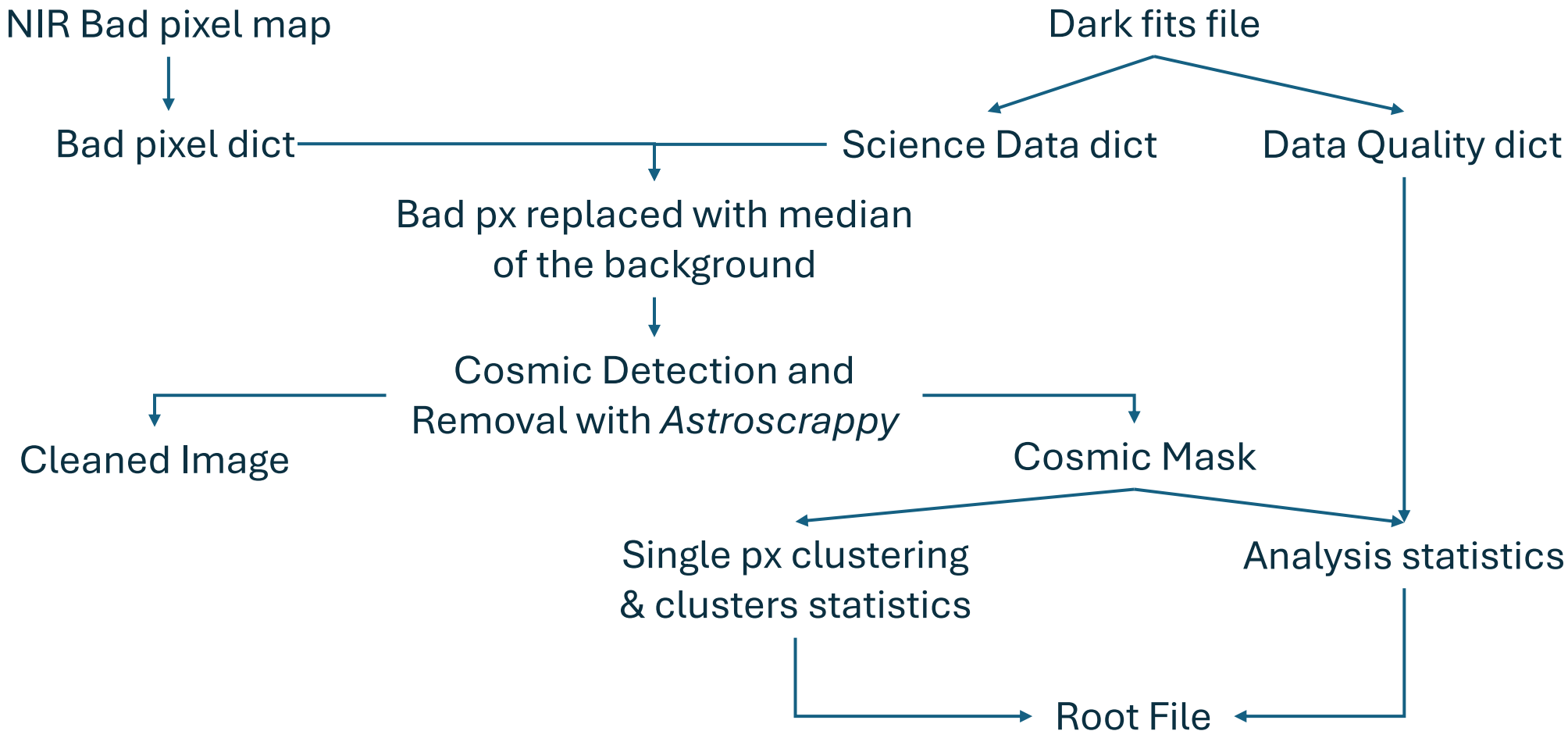
Weekly Plot



Monthly Plot



Cosmic Detection On Slew Dark: Developed Pipeline

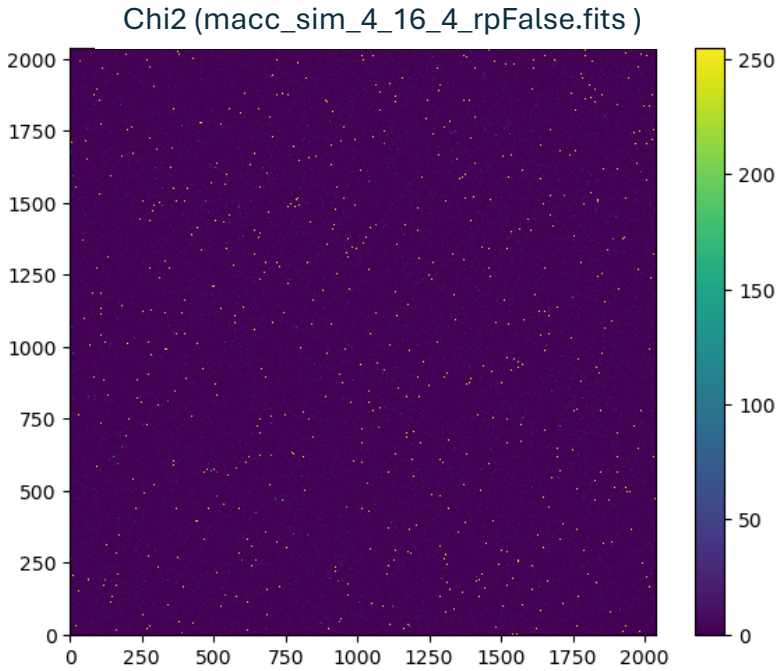


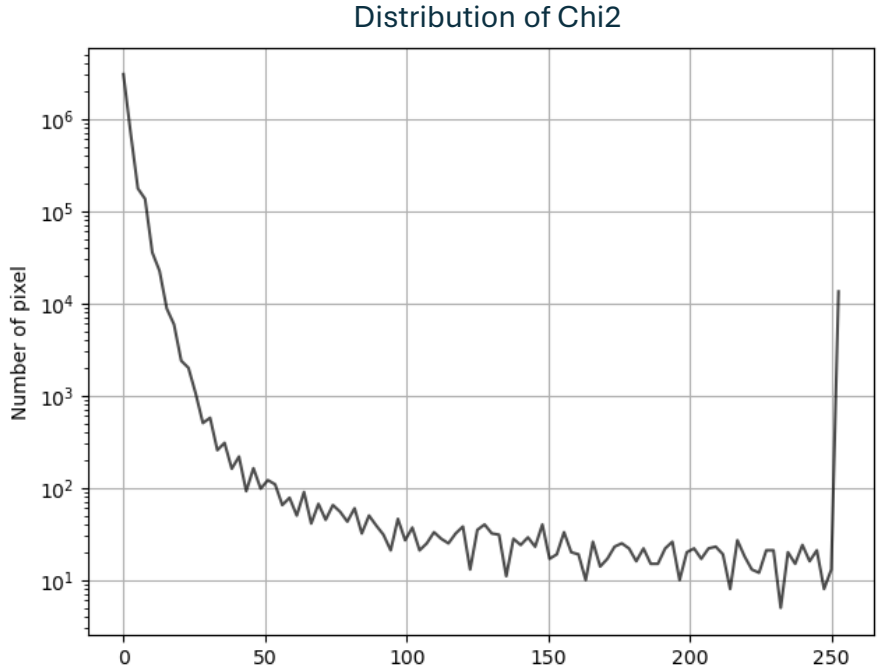
Astroscrappy

- **Improvement of L.A.Cosmic**: python-based algorithm that uses Laplacian to detect cosmic rays (van Dokkum 2001)
- Key speedups lies in the application of a **separable median filter** instead of the original LA Cosmic median filter. Filters are not identical but produce comparable results and the separable version is **much faster** (factor of 28).
- Numerous successful **tests** have been conducted on **synthetic** products and on **real** acquisition to verify the **performance** of the algorithm
- Input parameters of *Astroscrappy* were **progressively tuned to achieve the most suitable set up** for NISP slew dark products.

```
inmask=None
inbkg=None
invar=None
sigclip=4.5
sigfrac=0.3
objlim=4.0
gain=1.95
readnoise= 6
satlevel=65536.0
niter=6
sepmed=True
cleantype='meanmask'
fsmode='median'
psfmodel='gauss'
psffwhm=1.5
psfsize=5
psfk=None
psfbeta=4.765
verbose=False
```

- In the case of macc_sim_4_16_4_rpFalse.fits the n° of simulated cosmics (chi2>49) is 15 849





- *Astroscrappy* flagged 15 562 px as cosmics, the goodness of the analysis can be derived by:

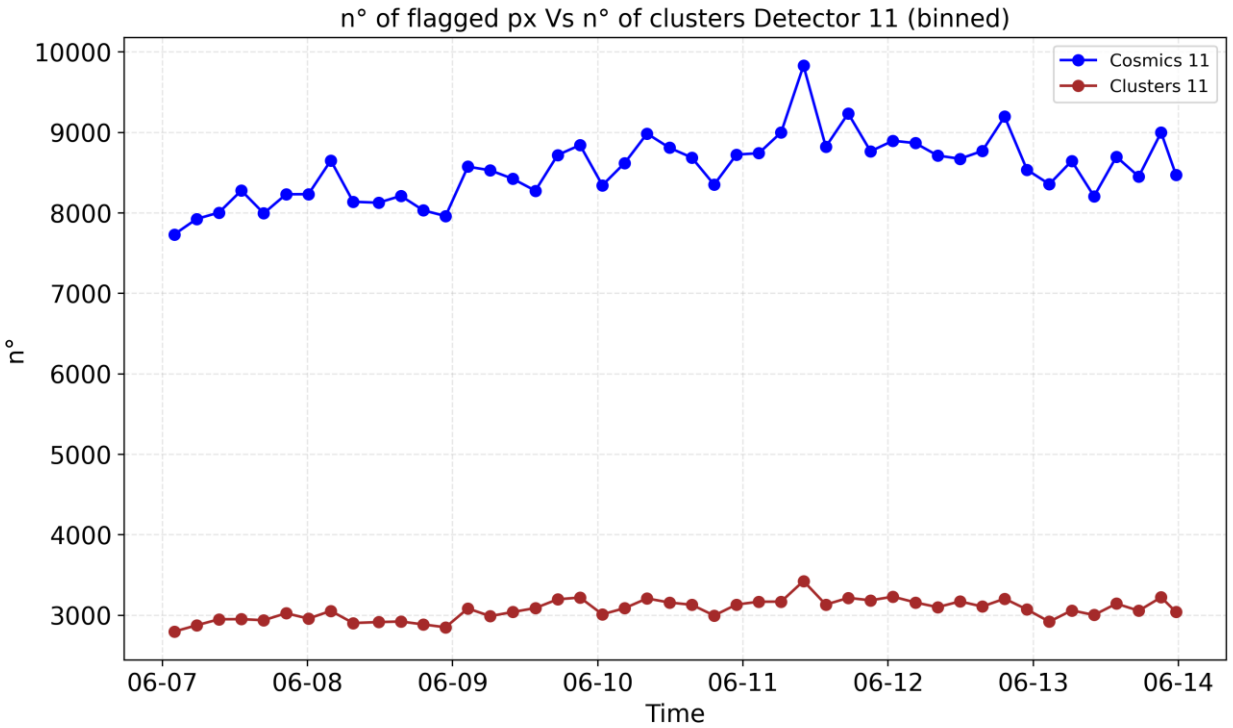
$$\frac{True\ Positive}{True\ positive + False\ positive} = \frac{14\ 418}{14\ 418+1\ 431} = 0.91$$

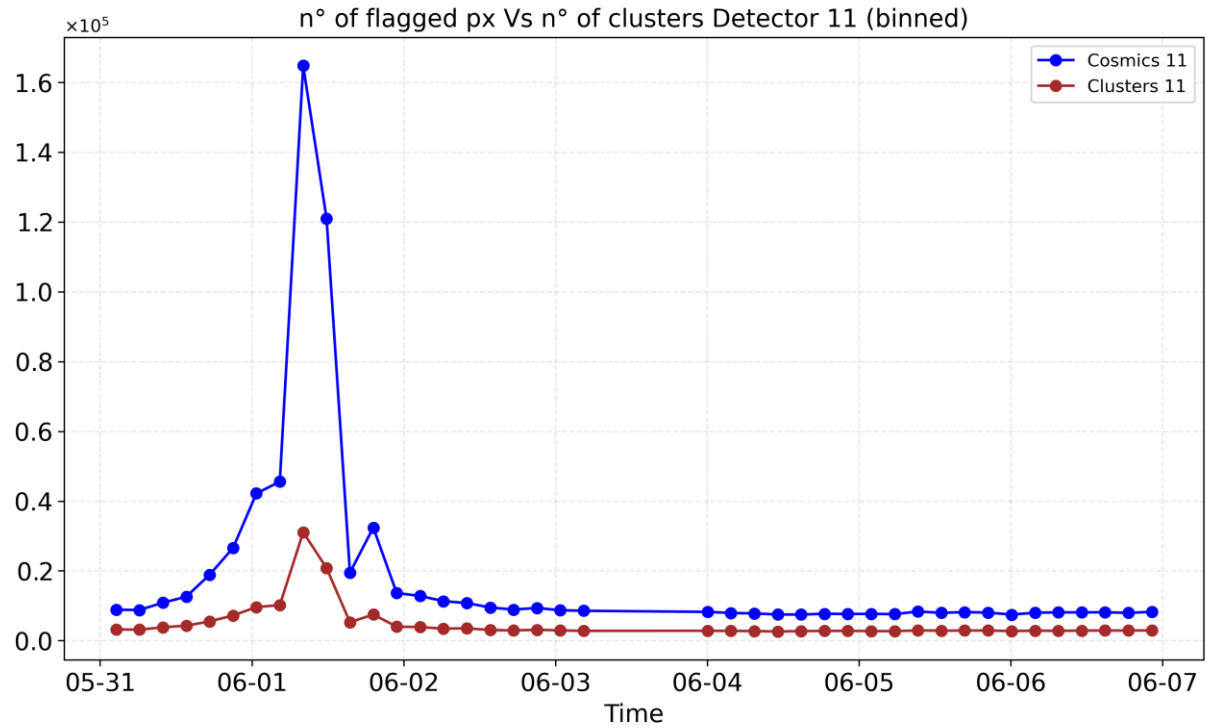
- Tests on simulations proved the capability of the pipeline to detect pixels affected by cosmics with high precision (>90%)

Results

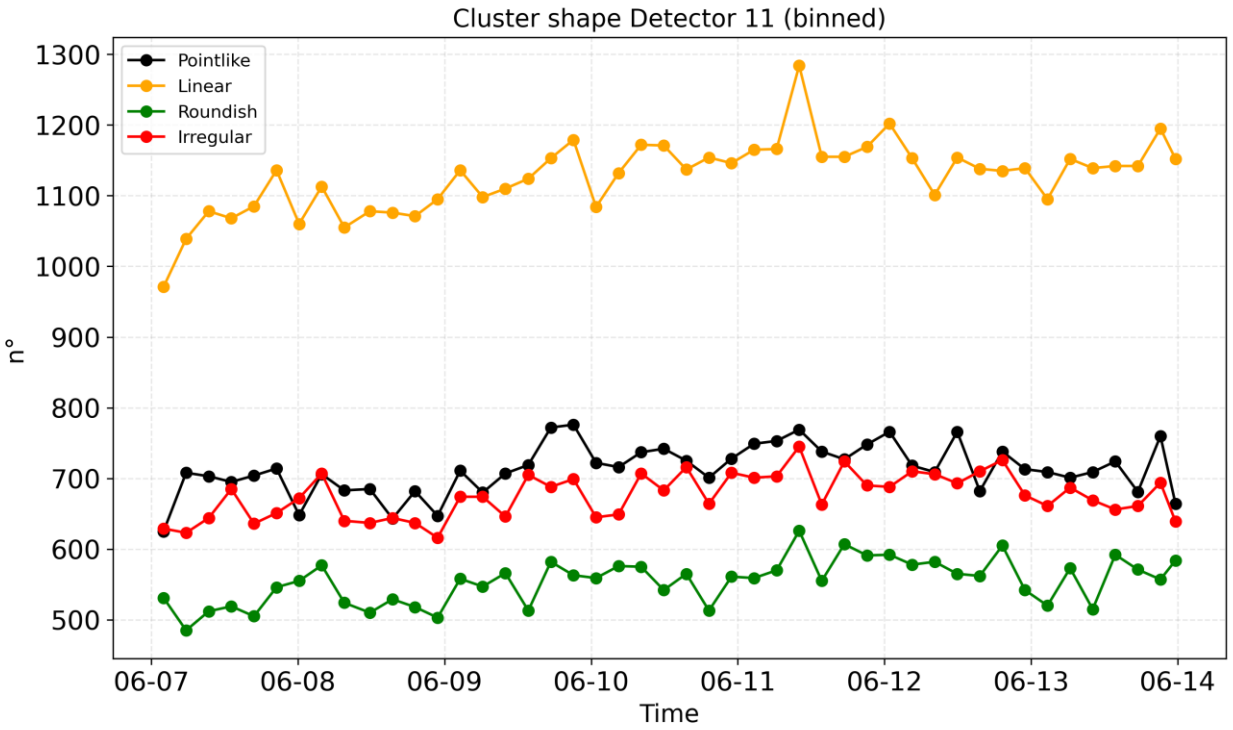
- *Astroscrappy* provides the n° of **flagged pixels**. For each px **coordinates** (x, y) and **intensity** are derived

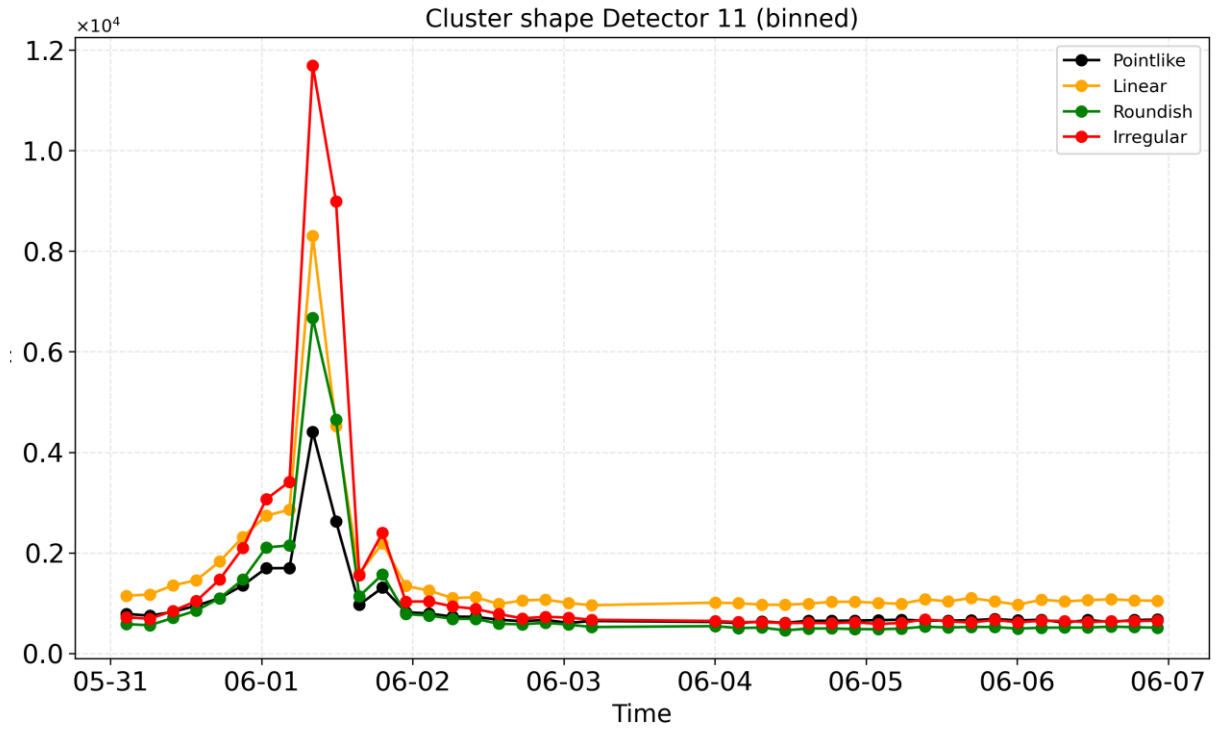
- Neighbouring pixels flagged as cosmics are grouped into **clusters**. For each cluster centroid **position** (x, y), **shape**, **n° of px**, total **intensity** (sum) are derived





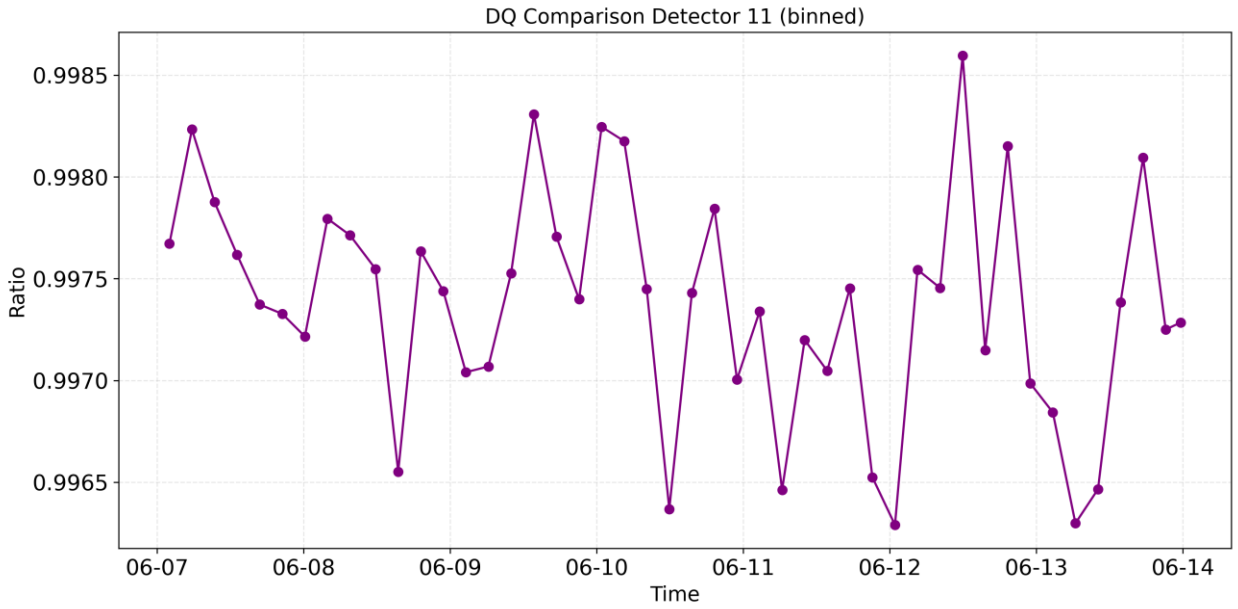
- Increasing in the n° of clusters with **>1 px** (pointlike clusters are less numerous during the peak)
- High solar activity leads to **different topology in energy deposit**

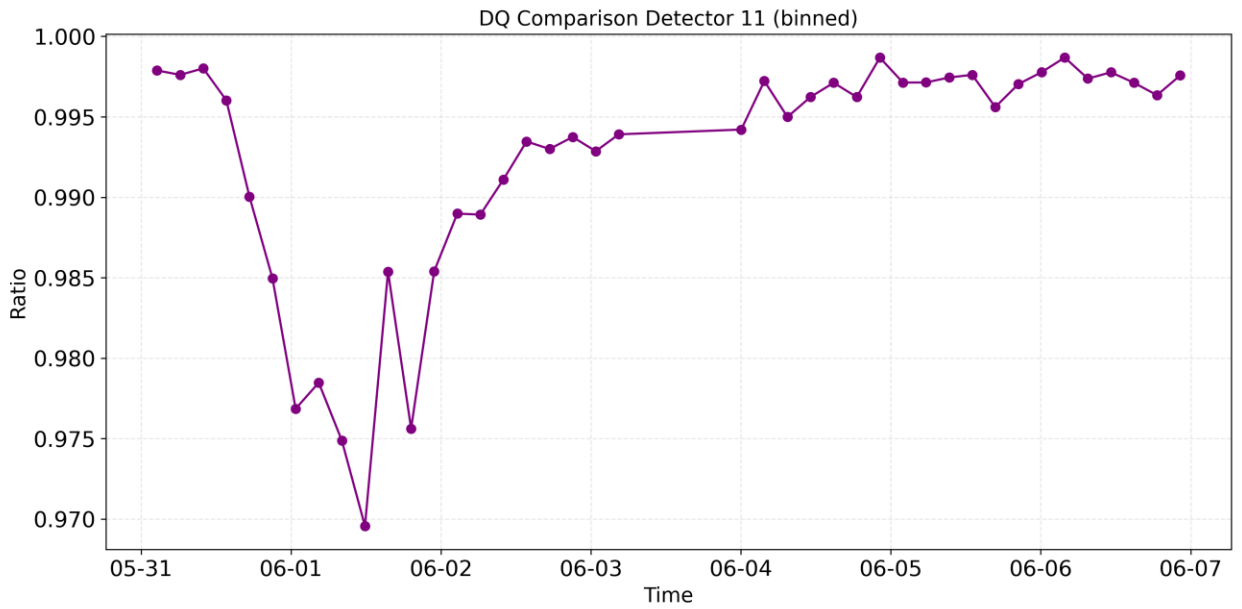




- We compared the number of pixels flagged as cosmics with the number of pixels flagged as bad DQ by the OnBoardSoftware

$$\frac{True\ Positive}{True\ positive\ +\ False\ positive}$$



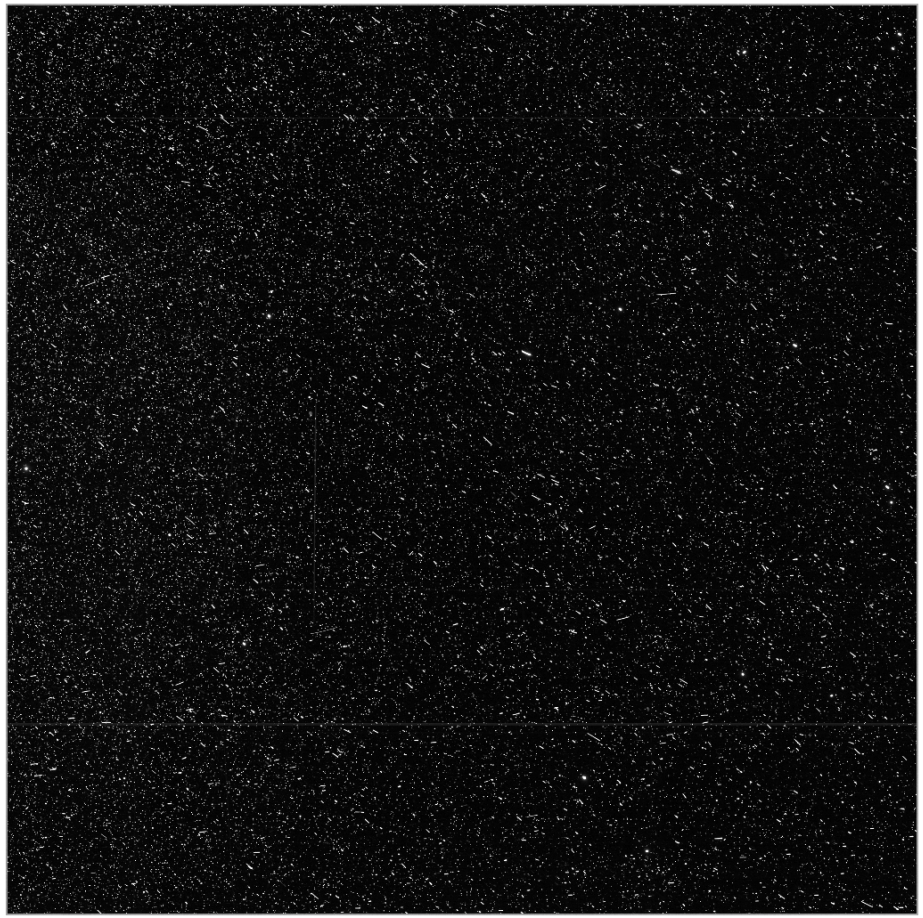


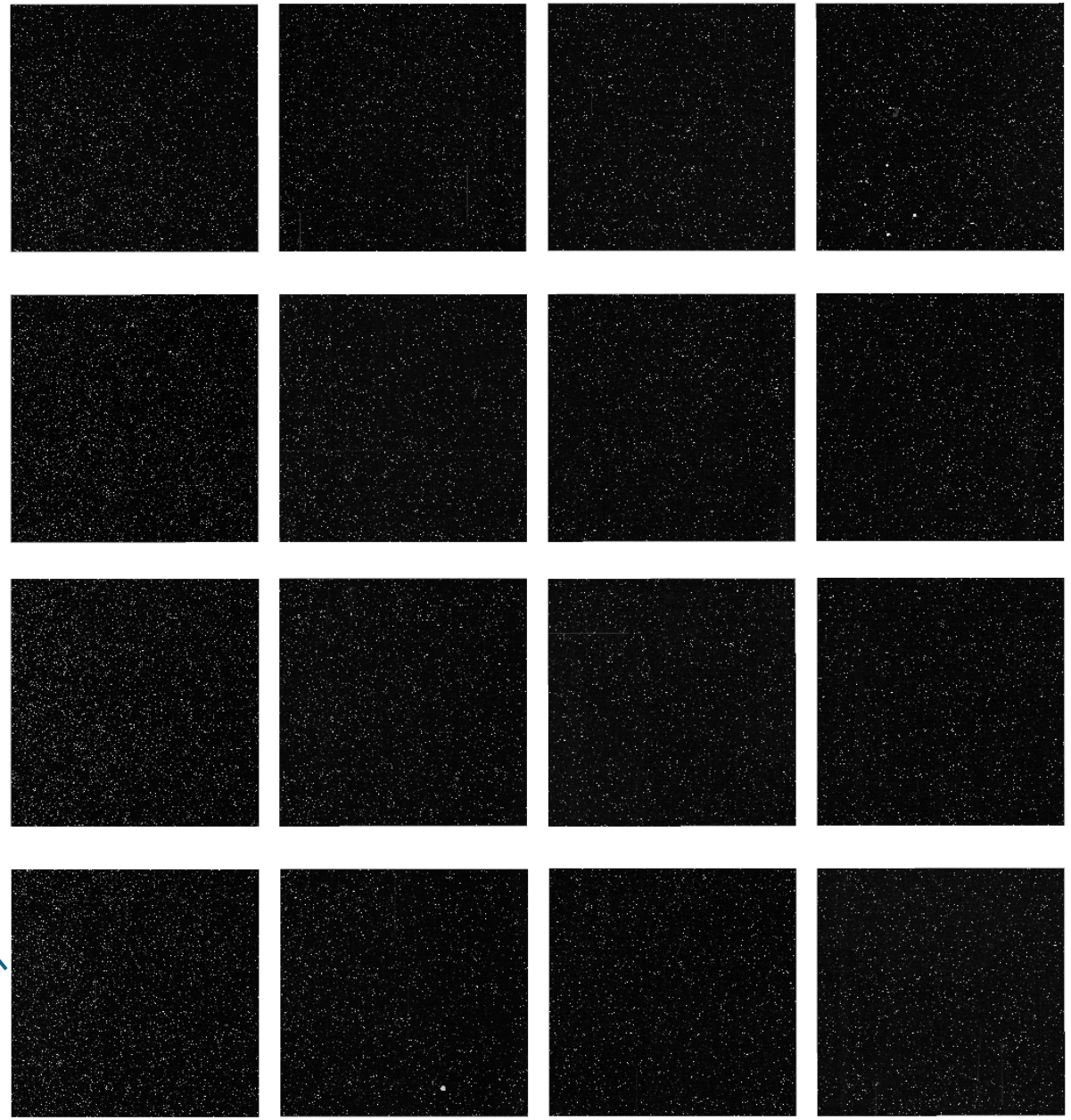
- During high solar activity the metric decreases but remains >95% strengthening the reliability of the pipeline

Original Image 01/06/2025 (corresponding to the peak)

EUC_LE1_NISP-08033-1-W_20250601T090351.000000Z_01_05_01.00.fits

DET 11

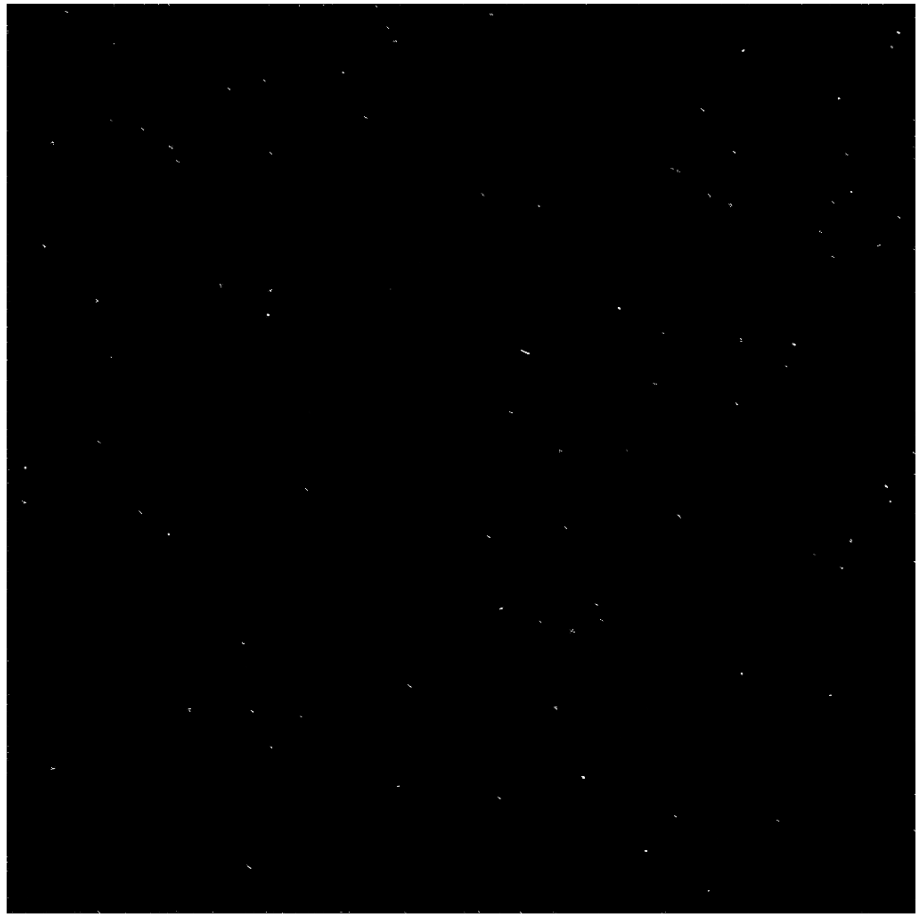


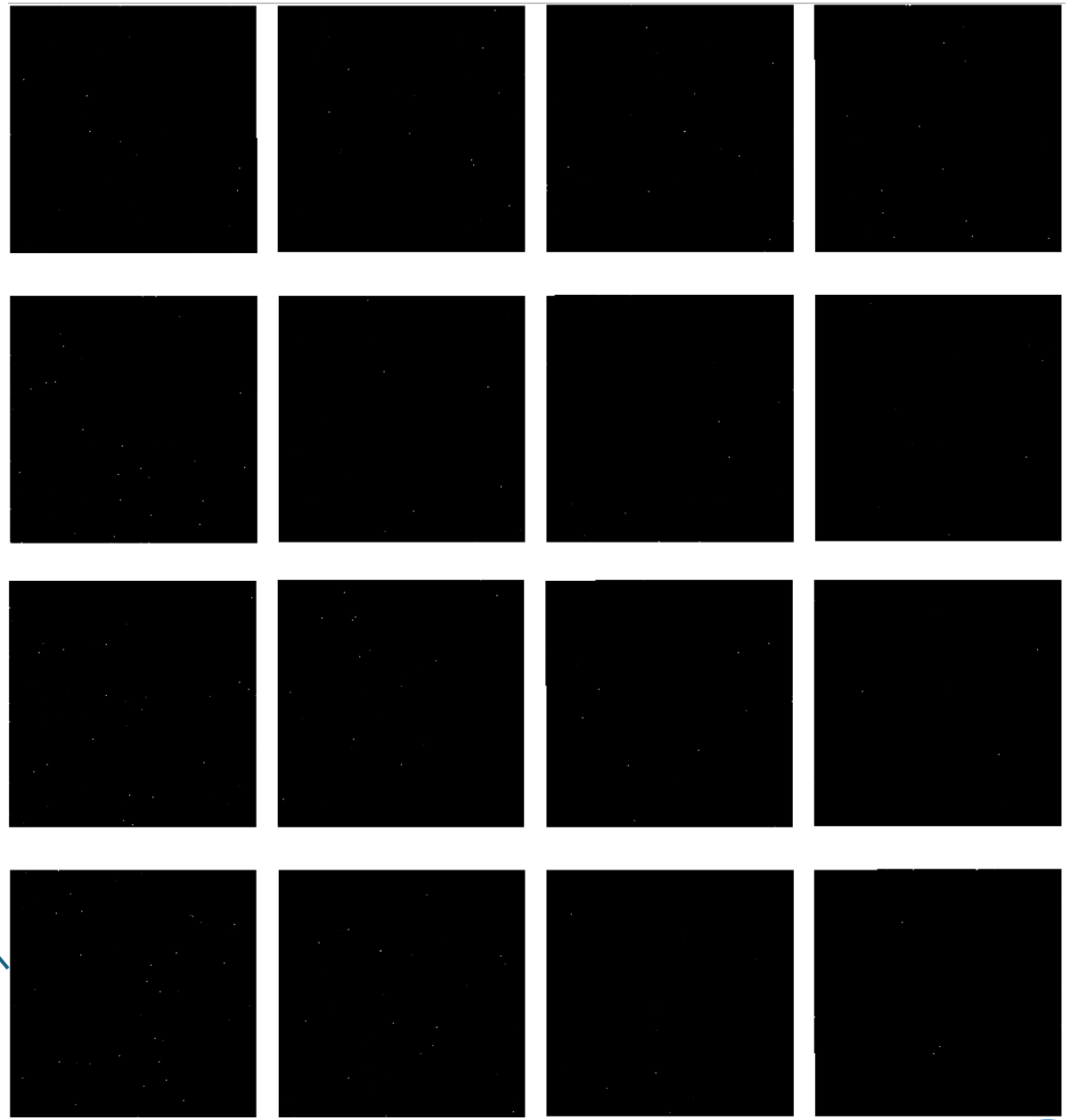


Cleaned Image 01/06/2025

EUC_LE1_NISP-08033-1-W_20250601T090351.000000Z_01_05_01.00.fits

DET 11

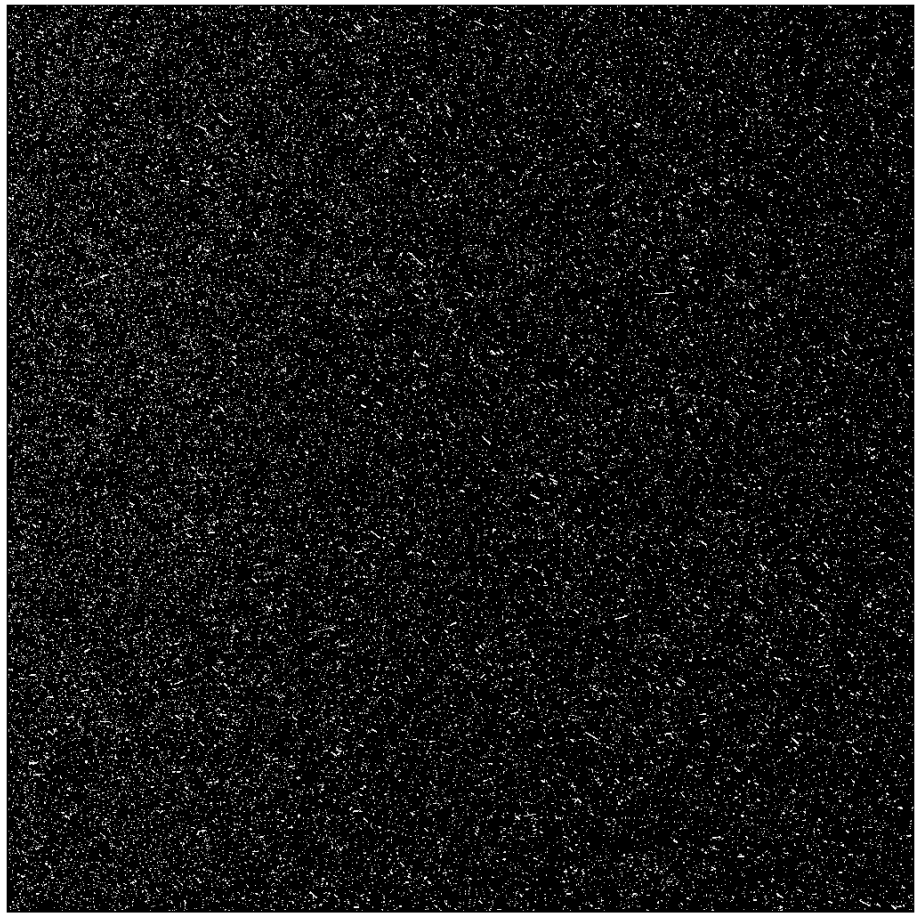


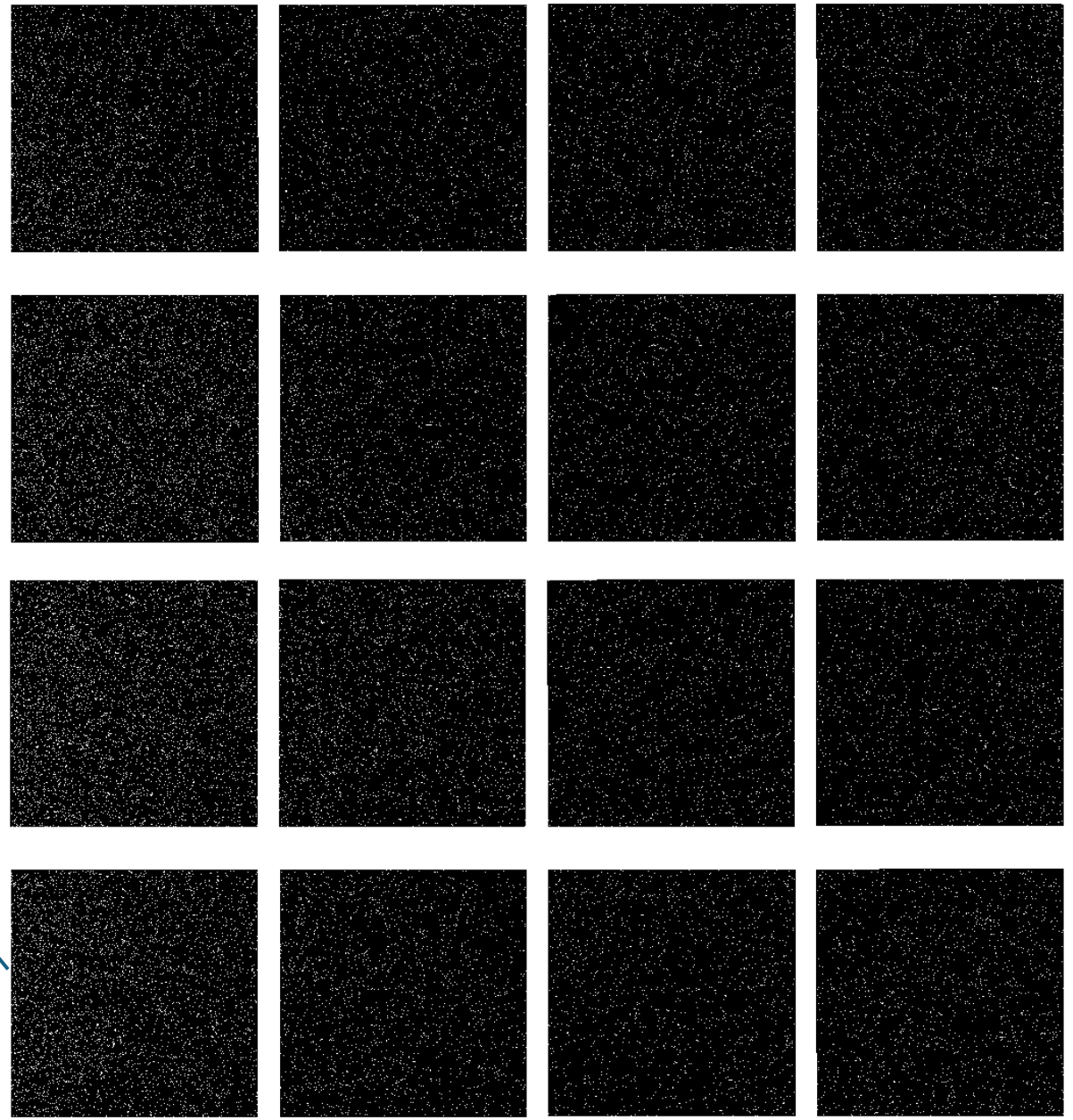


Cosmic Mask 01/06/2025

EUC_LE1_NISP-08033-1-W_20250601T090351.000000Z_01_05_01.00.fits

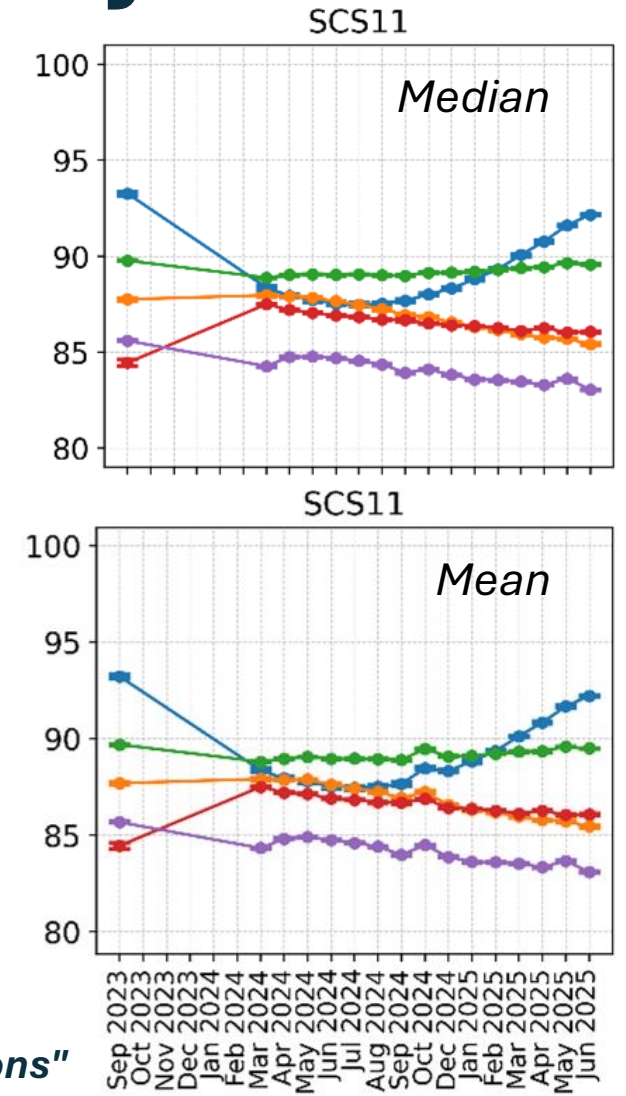
DET 11





Flat-field (F-007) Detectors Analysis

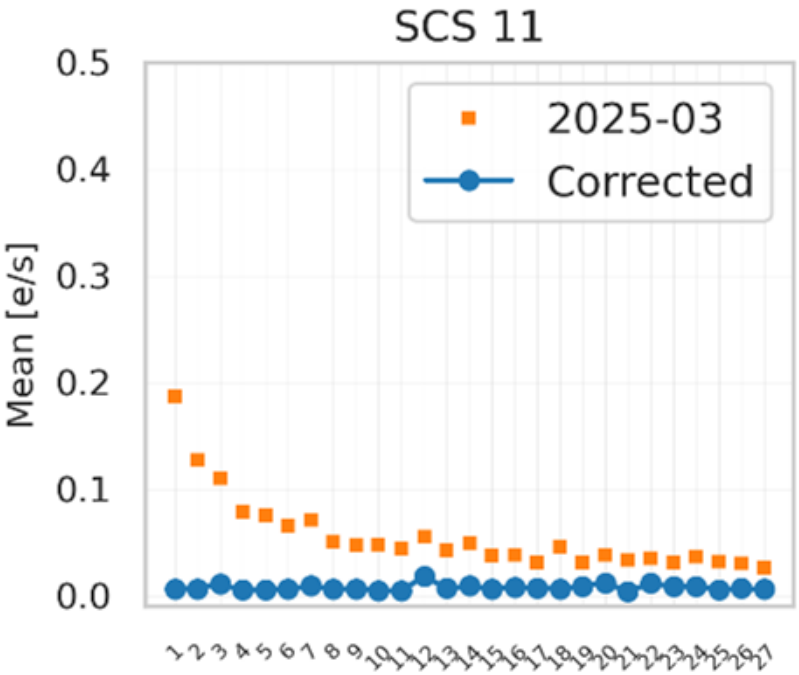
- **Mean and median** signal values for each LED provide a comprehensive view of the detector's response **uniformity and consistency**
- **Variations** in signal strength (e.g., outliers) between different LEDs are critical to understand **detector's performance** under various illumination conditions
- **Consistent** mean and median values suggest **stable performance**
- Plotted trends allow us to compare the behavior of LEDs A through E, emphasizing the importance of cross-calibration for reliable data acquisition
- Use these insights to refine calibration pipelines or flag detectors needing additional analysis, ensuring robust data quality for scientific use.



*For details: poster Chegeni et al., **"Monitoring of NISP Flat-Field Stability using Monthly Calibrations"***

Persistence Decay in Dark Images (F-007)

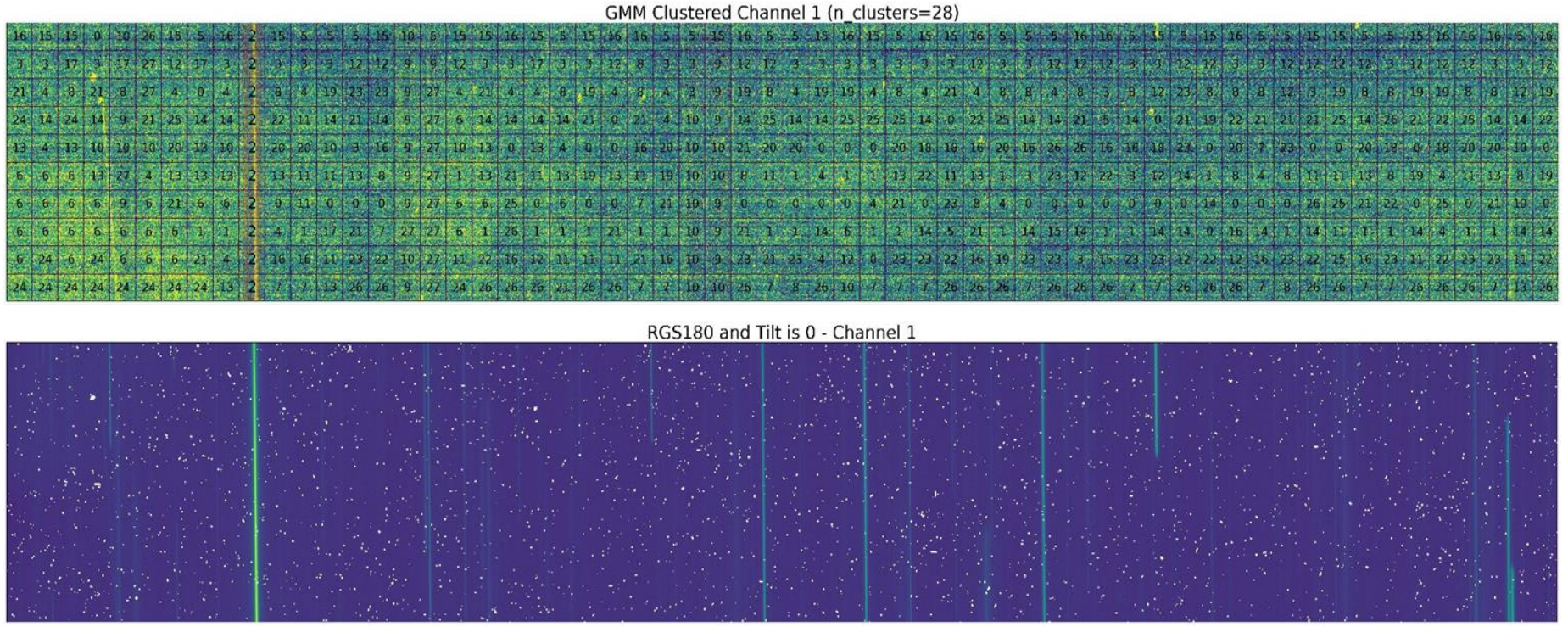
- **Impact of persistence correction on dark exposures** (mean about the 27 dark exposures at the end of F-007)
- Persistence is **modeled as a power-law decay** (from ground segment) and after subtracting it from the original signal (orange line) we have the calibrated/corrected signal (blue line)
- Plot quantifies how p**ersistence subtraction improves detector signal consistency**, particularly in dark exposures compared to master dark threshold
- Model **will be refined** to be applied to remove persistence on slew dark data



Persistence Detection On Slew Dark Using Autoencoders

- Patches flagged by Gaussian Mixture Model are mapped to detector coordinates. Clusters like C2 may correlate with persistence, given their spatial coherence and intensity profiles.

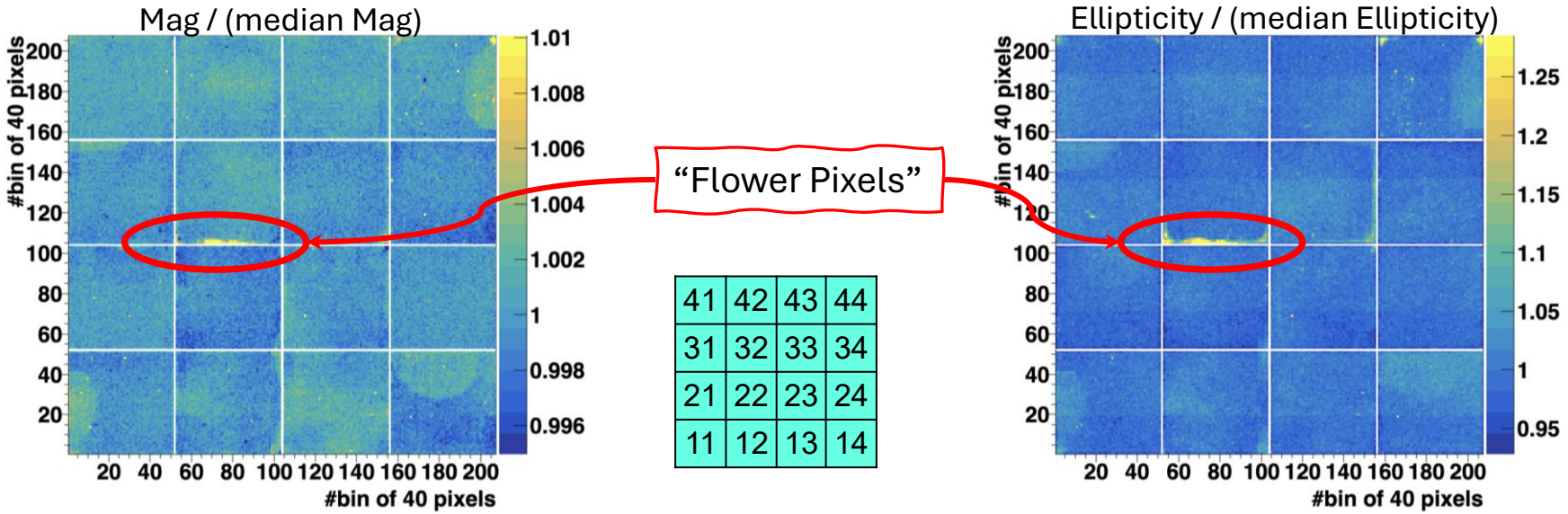
- To verify patches found by ML are persistence, we compared them with the "RGS180 and Tilt 0" exposure



Work In Progress...

➢ Study of NISP uniformity response using NIR Calibrated Catalog

- Galaxies are **randomly distributed** on the NISP focal plane (flat distribution of any feature of the NIR catalog)
- Differences in the mean values relates to a **non-uniform response** of NISP instrument, calibration, reconstruction
- Using NIR Calibrated Catalog - REGREPROC2_R1 we can verify the uniformity at % level over area of 40x40 pixels



*For details see poster from Dusini et al., **"Measure the uniformity of NISP instrument using NIR calibrated catalogue"***

➢ DPU-ASWv1.4 new release (September 2025)

- Two minor issues fixed:

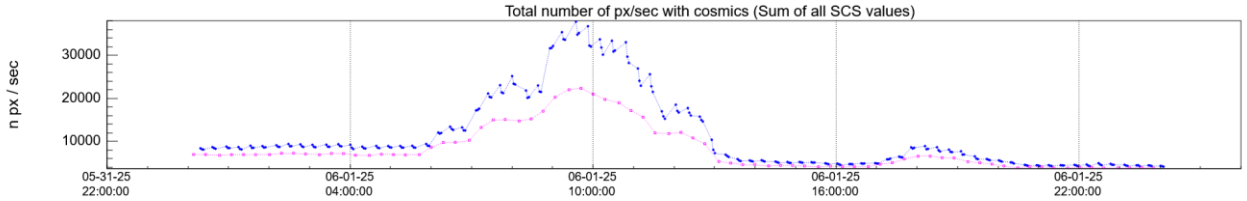
1. NISP **status undefined** (because is reset before changing state) once every six months (per DPU) for few milliseconds while HKTM is prepared. This **did not cause scientific data loss**.

2. During Calblock-F009 (non-linearity) a **LED illumination configuration** leads to a **very small size of the NISP data** product. This exception was not correctly handled by the functions transferring the data internally in the DPU. A work-around was defined (disabling the compression) and the Calblock-F009 was successfully completed.

Thank you for your attention!

Backup

Daily


Total number of px/sec with cosmics (Sum of all SCS values)
n px / sec
30000
20000
10000
05-31-25 22:00:00
06-01-25 04:00:00
06-01-25 10:00:00
06-01-25 16:00:00
06-01-25 22:00:00

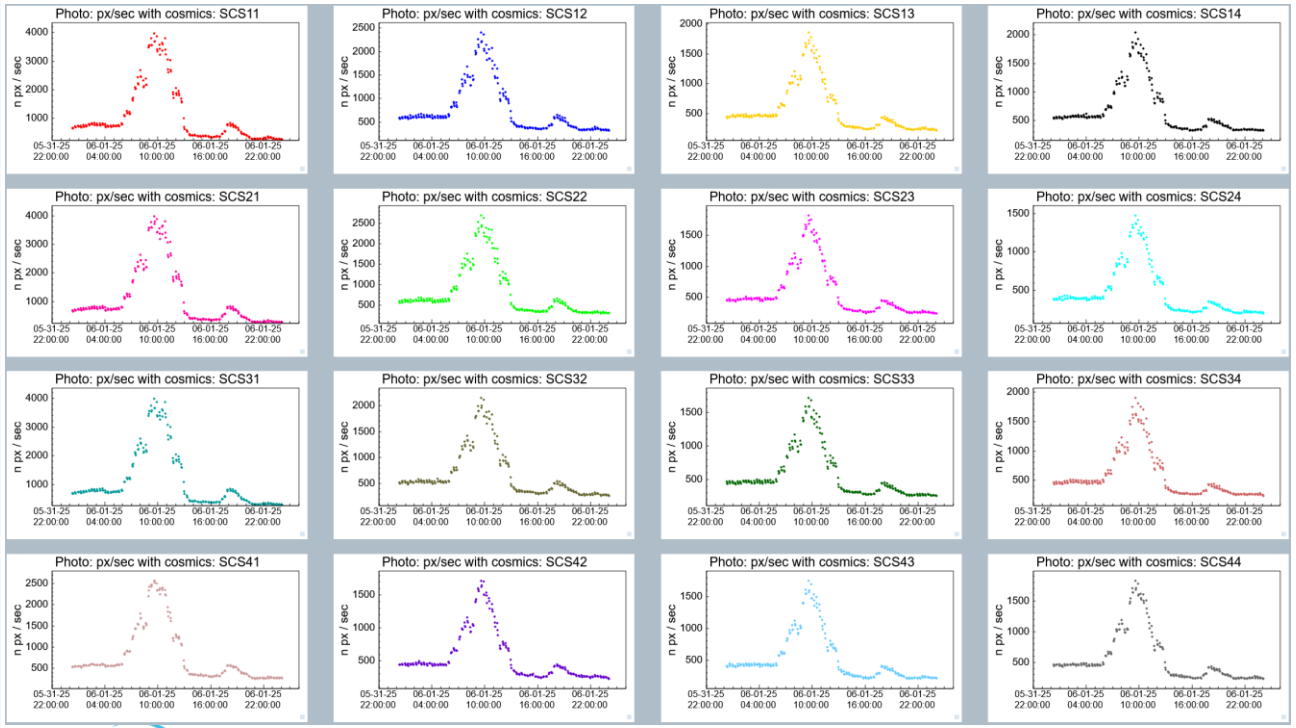
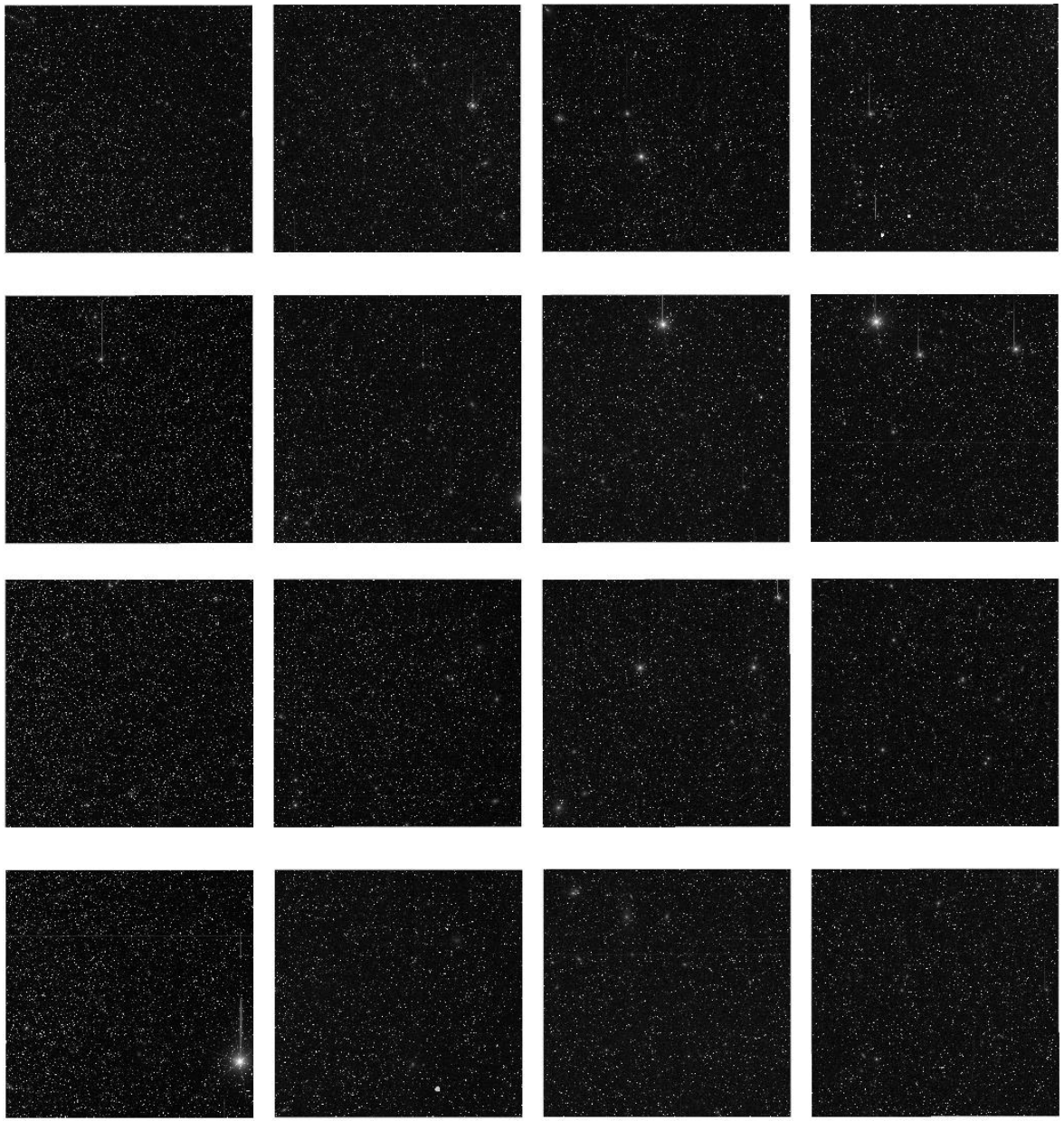
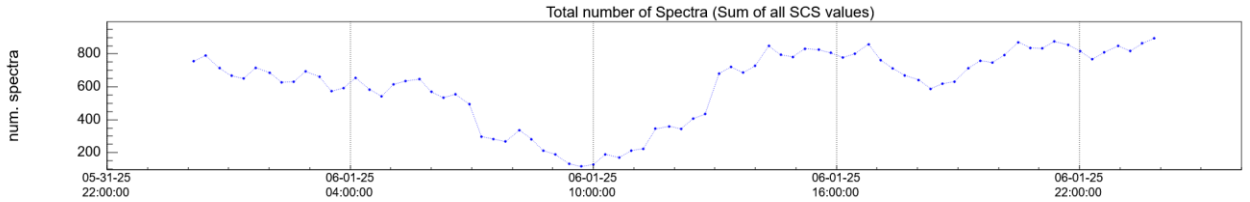
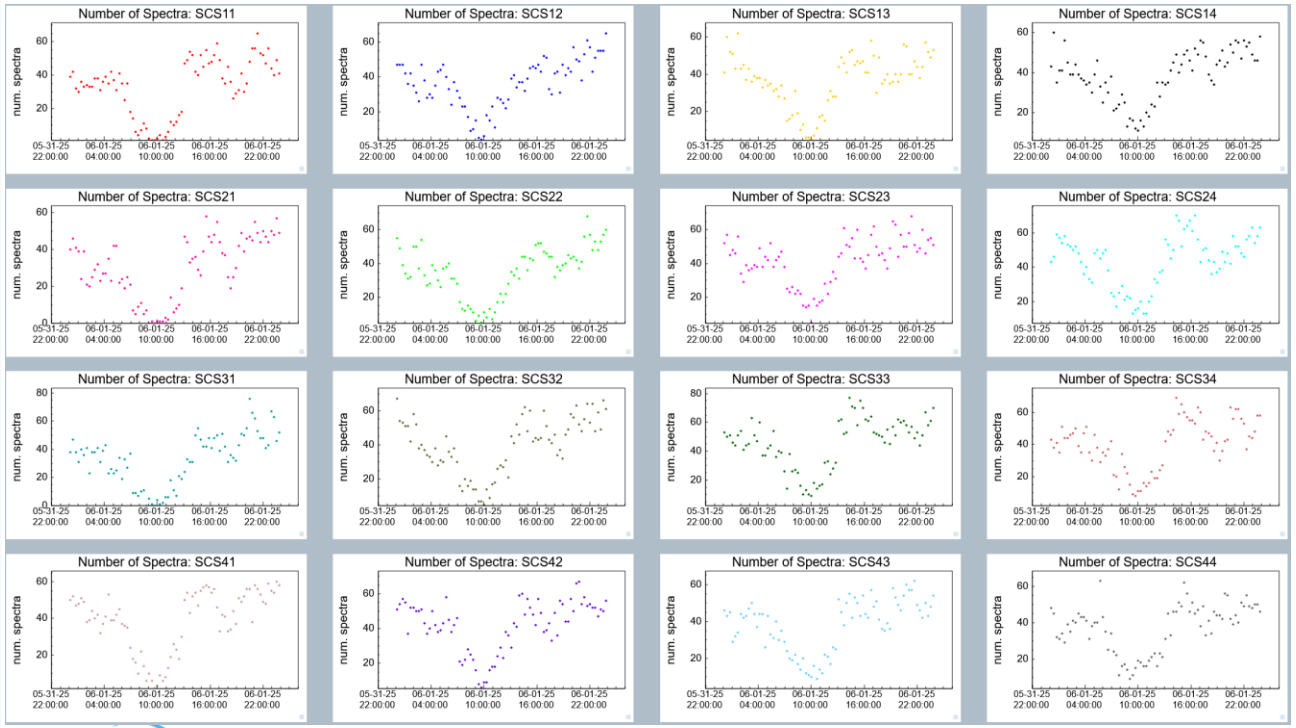


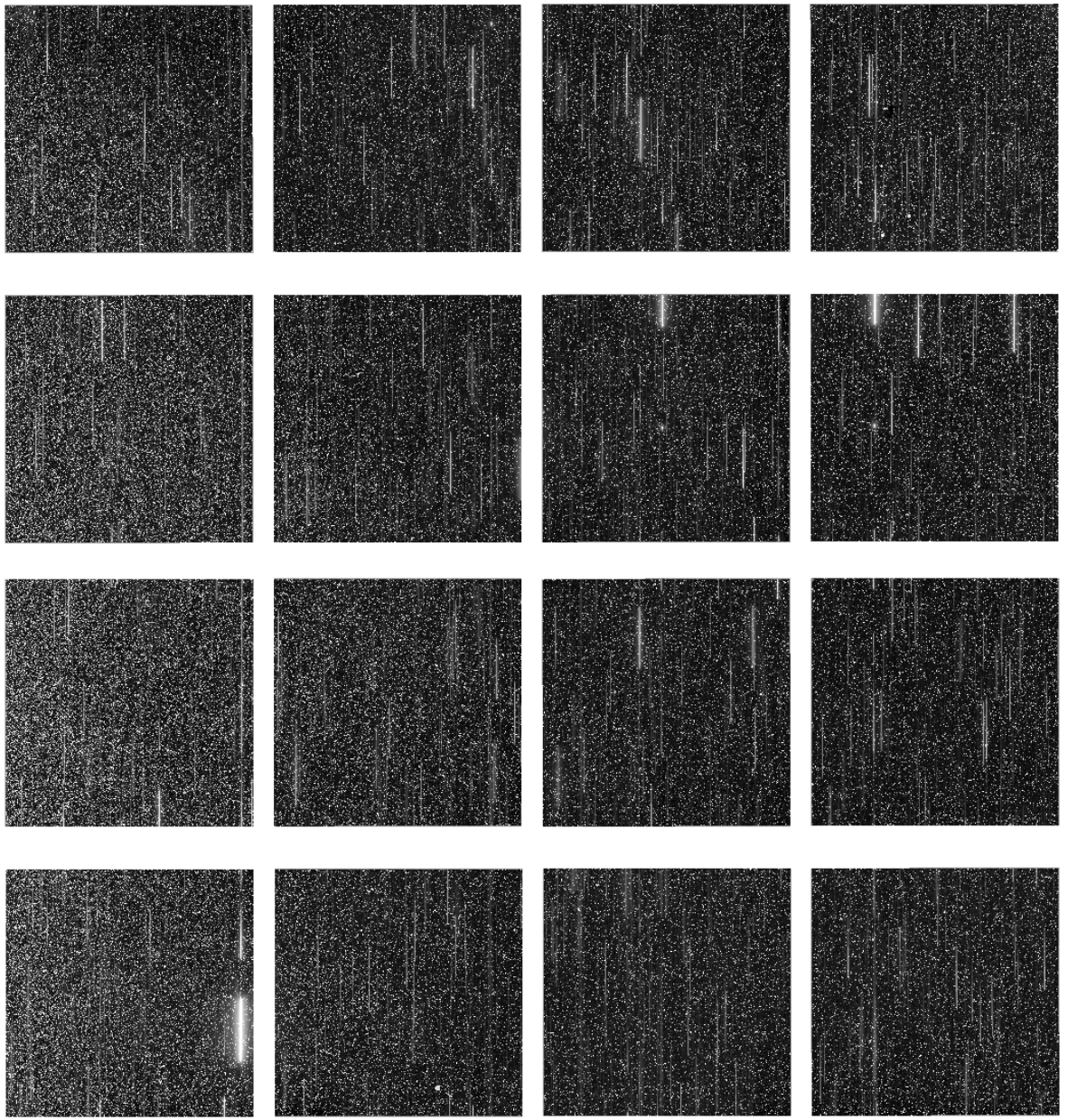
Photo: px/sec with cosmics: SCS11
Photo: px/sec with cosmics: SCS12
Photo: px/sec with cosmics: SCS13
Photo: px/sec with cosmics: SCS14
Photo: px/sec with cosmics: SCS21
Photo: px/sec with cosmics: SCS22
Photo: px/sec with cosmics: SCS23
Photo: px/sec with cosmics: SCS24
Photo: px/sec with cosmics: SCS31
Photo: px/sec with cosmics: SCS32
Photo: px/sec with cosmics: SCS33
Photo: px/sec with cosmics: SCS34
Photo: px/sec with cosmics: SCS41
Photo: px/sec with cosmics: SCS42
Photo: px/sec with cosmics: SCS43
Photo: px/sec with cosmics: SCS44
n px / sec



Daily


Total number of Spectra (Sum of all SCS values)
num. spectra
800
600
400
200
05-31-25 22:00:00
06-01-25 04:00:00
06-01-25 10:00:00
06-01-25 16:00:00
06-01-25 22:00:00


Number of Spectra: SCS11
Number of Spectra: SCS12
Number of Spectra: SCS13
Number of Spectra: SCS14
Number of Spectra: SCS21
Number of Spectra: SCS22
Number of Spectra: SCS23
Number of Spectra: SCS24
Number of Spectra: SCS31
Number of Spectra: SCS32
Number of Spectra: SCS33
Number of Spectra: SCS34
Number of Spectra: SCS41
Number of Spectra: SCS42
Number of Spectra: SCS43
Number of Spectra: SCS44
num. spectra



Daily

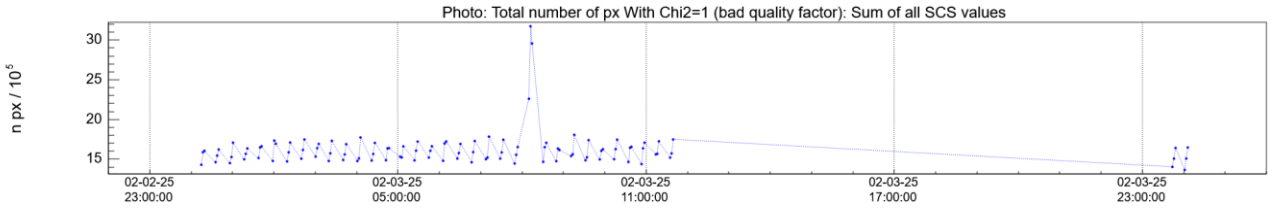
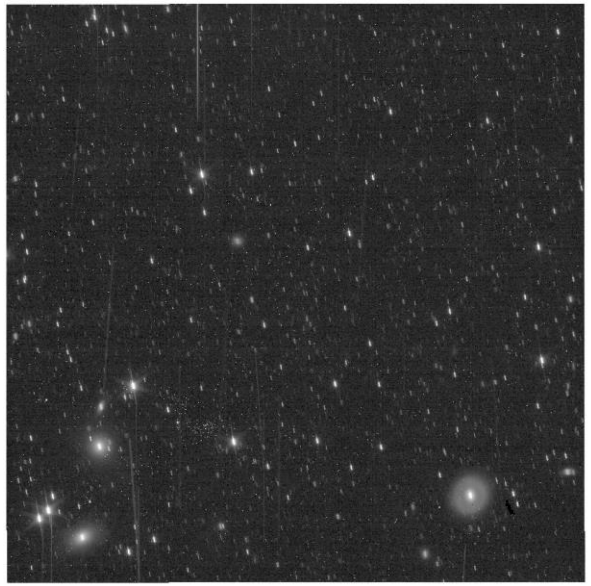
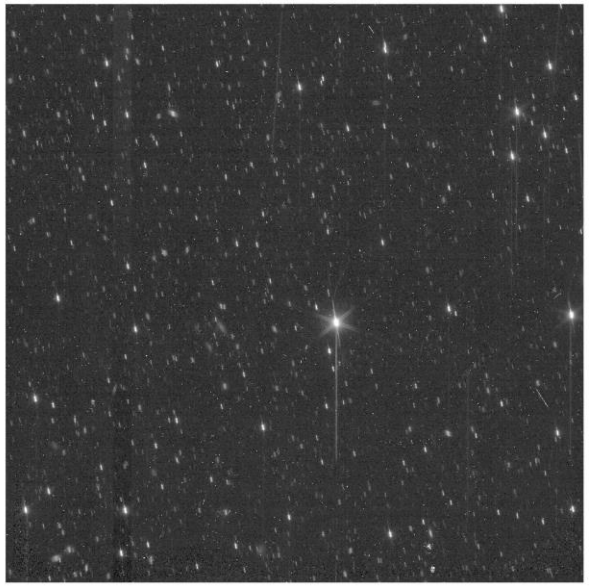
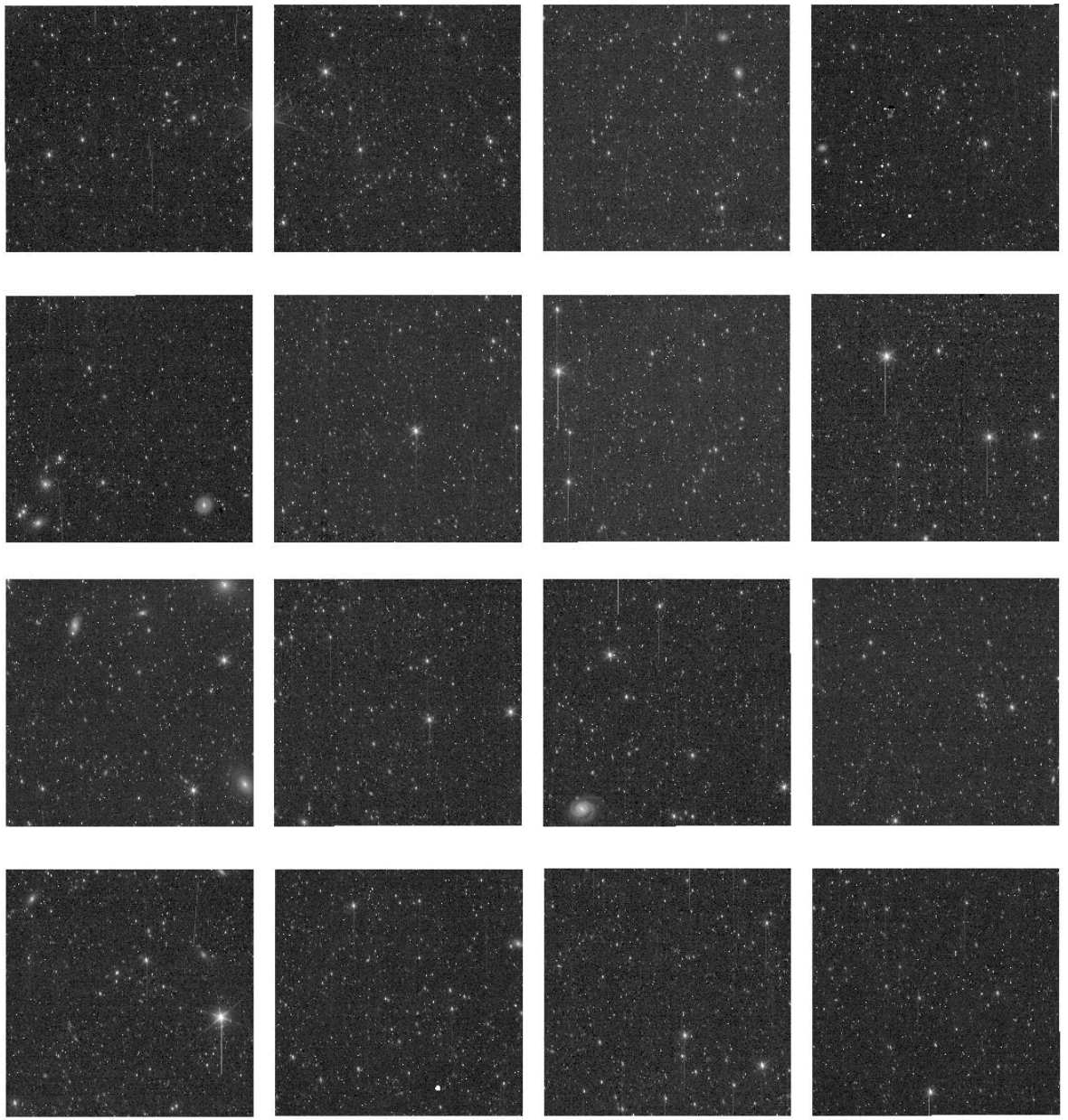
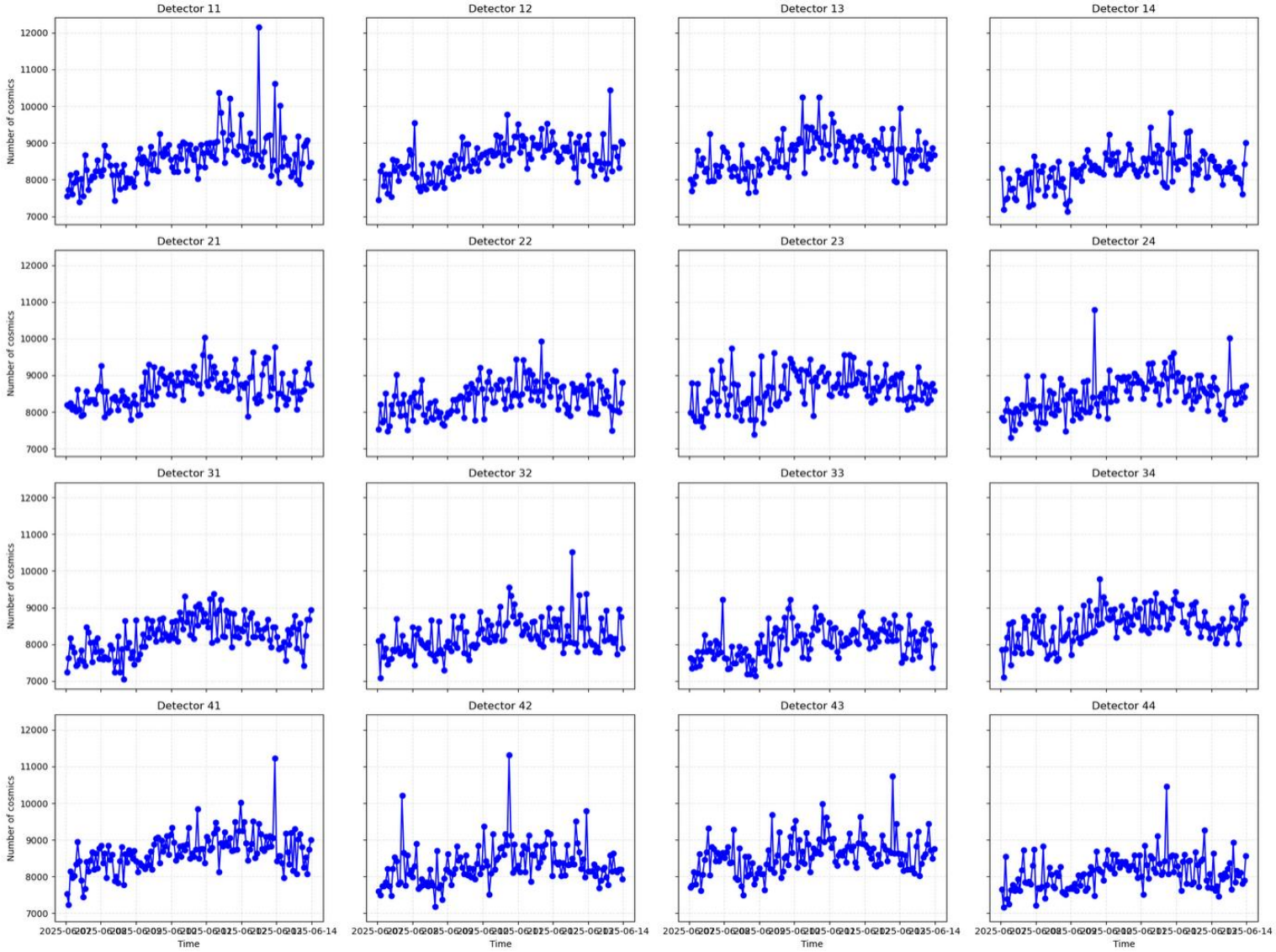


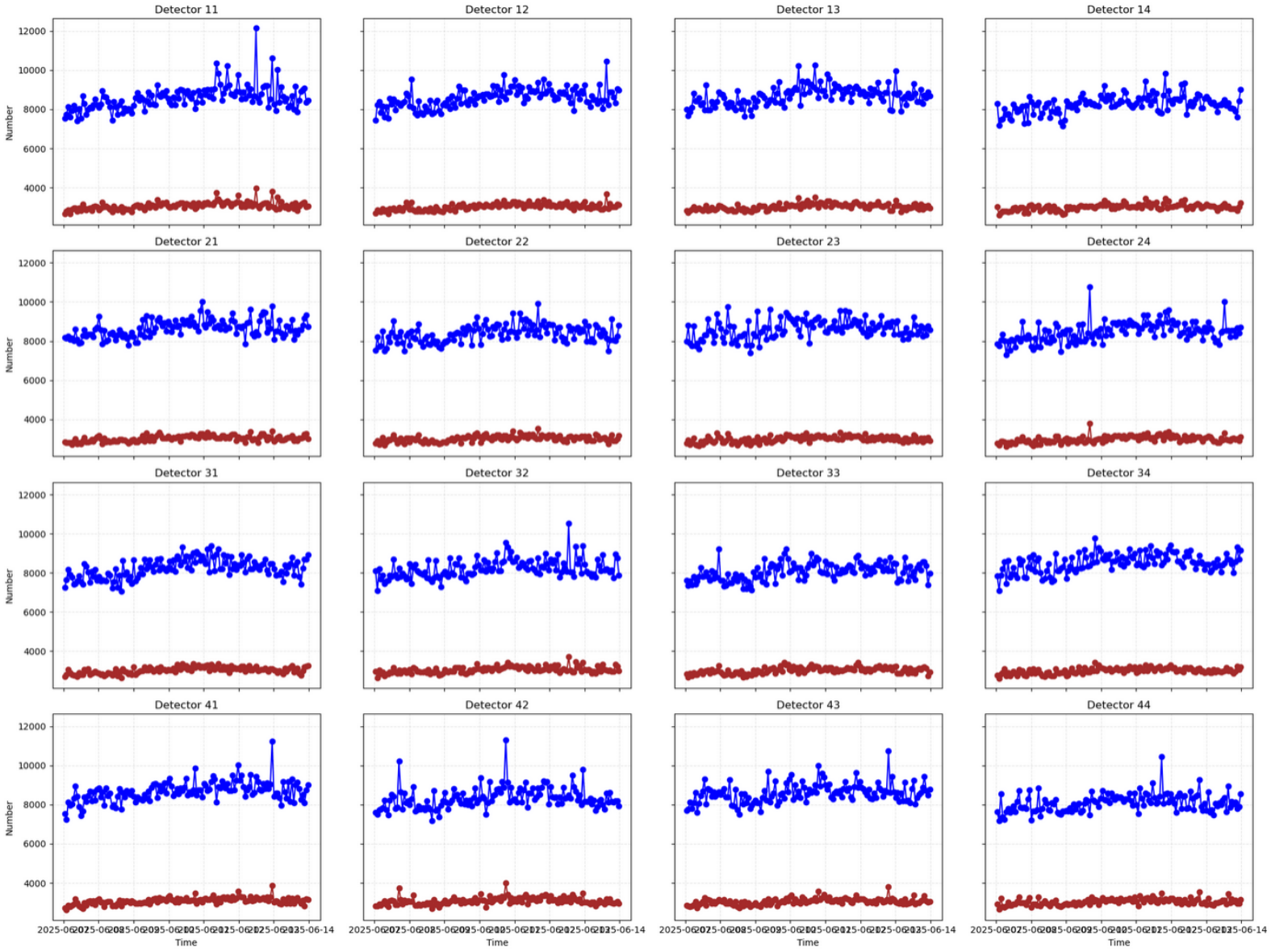
Photo: Total number of px With Chi2=1 (bad quality factor): Sum of all SCS values
n px / 10^5
30
25
20
15
02-02-25 23:00:00
02-03-25 05:00:00
02-03-25 11:00:00
02-03-25 17:00:00
02-03-25 23:00:00

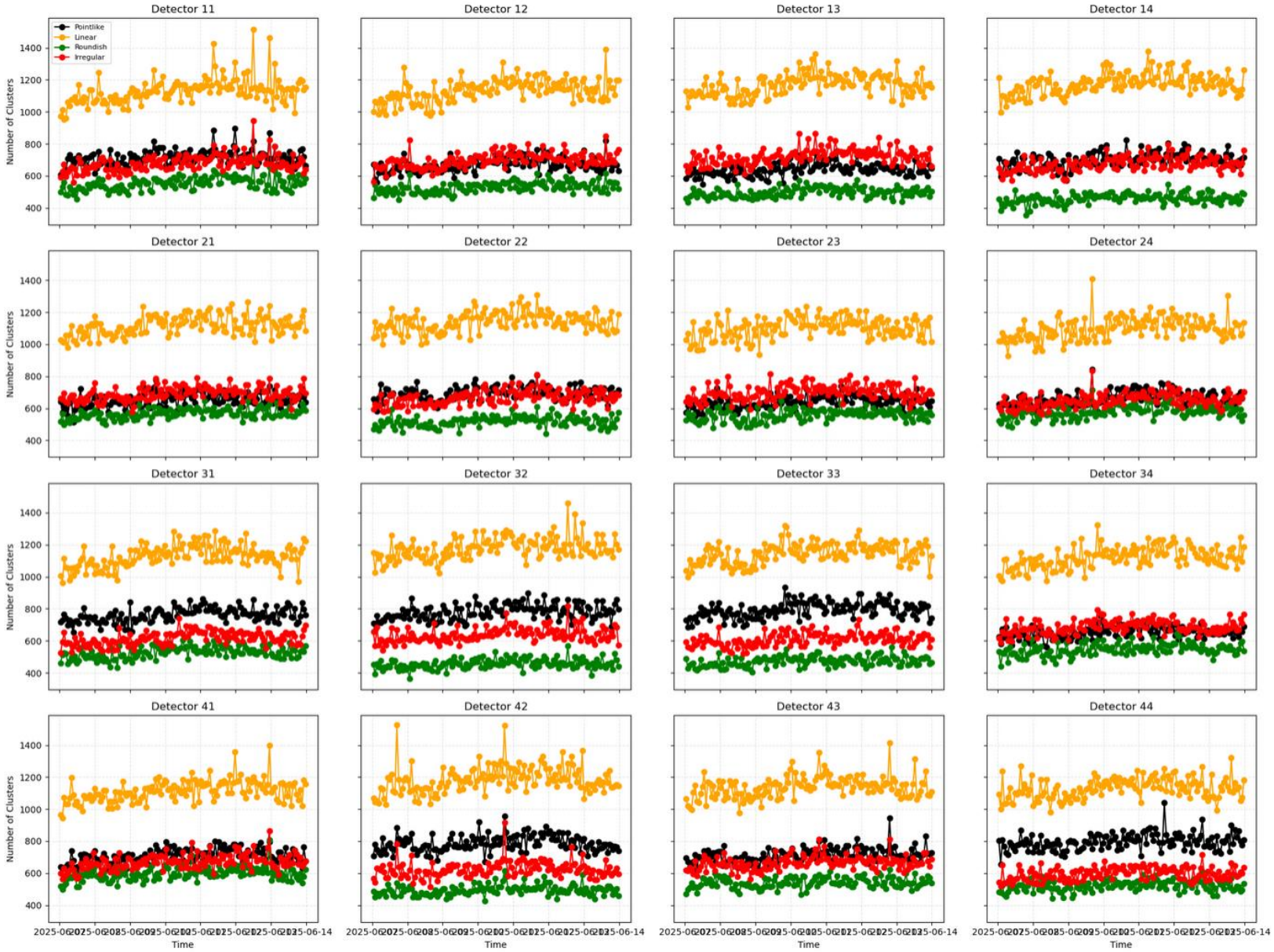


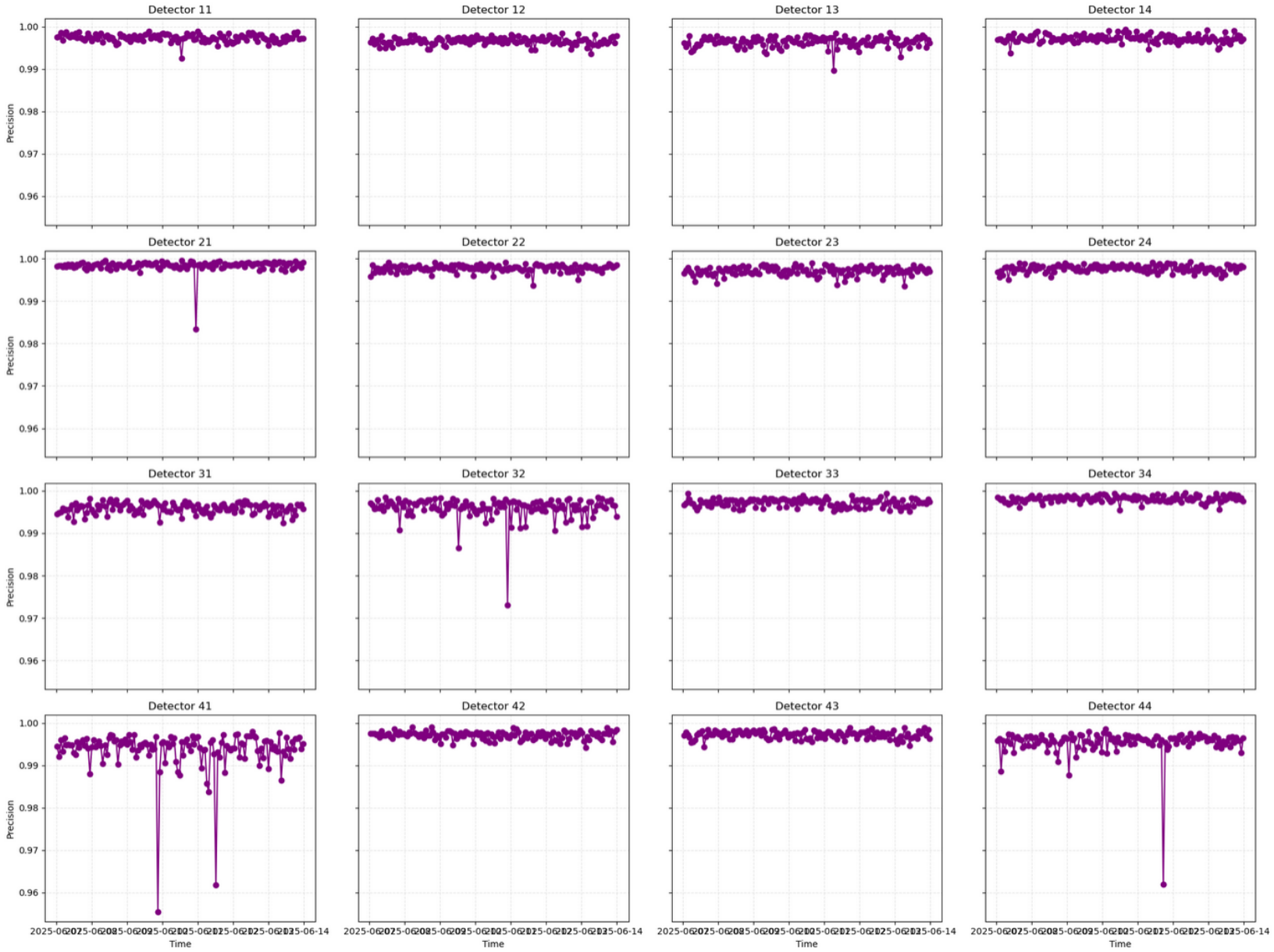


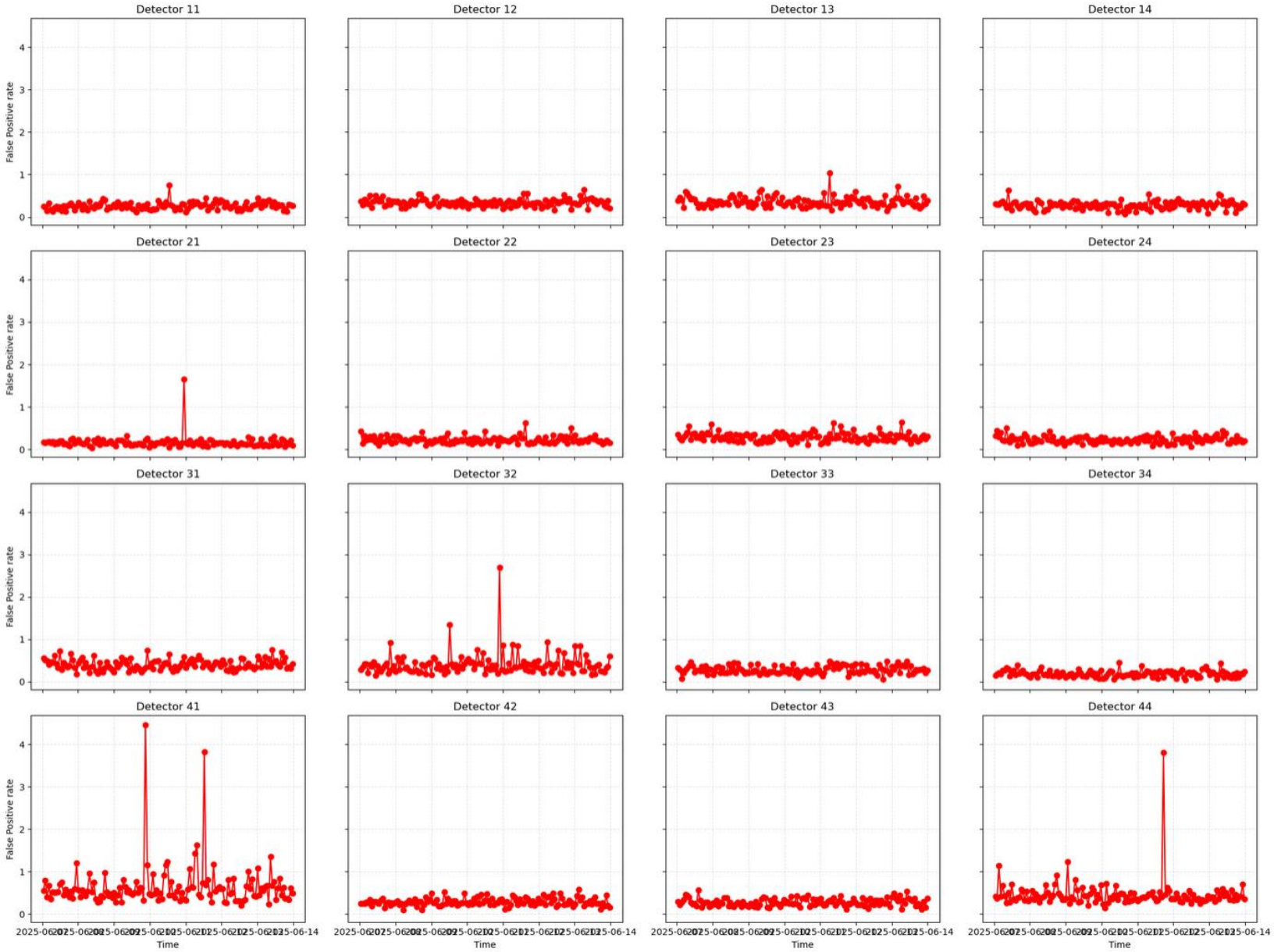


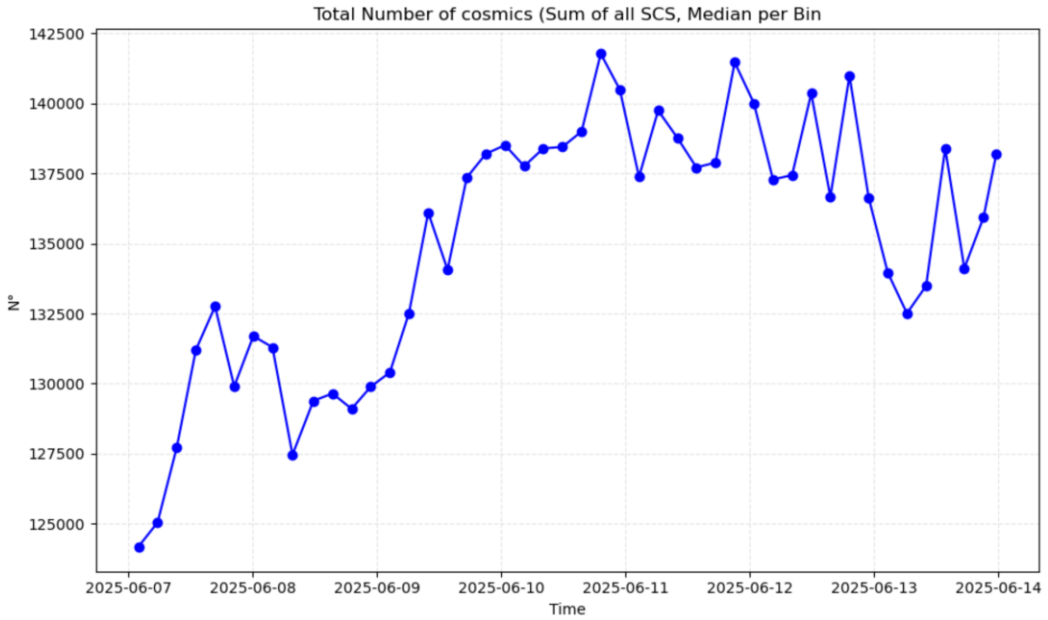

Detector 11
Detector 12
Detector 13
Detector 14
Detector 21
Detector 22
Detector 23
Detector 24
Detector 31
Detector 32
Detector 33
Detector 34
Detector 41
Detector 42
Detector 43
Detector 44
Number of cosmics
Time

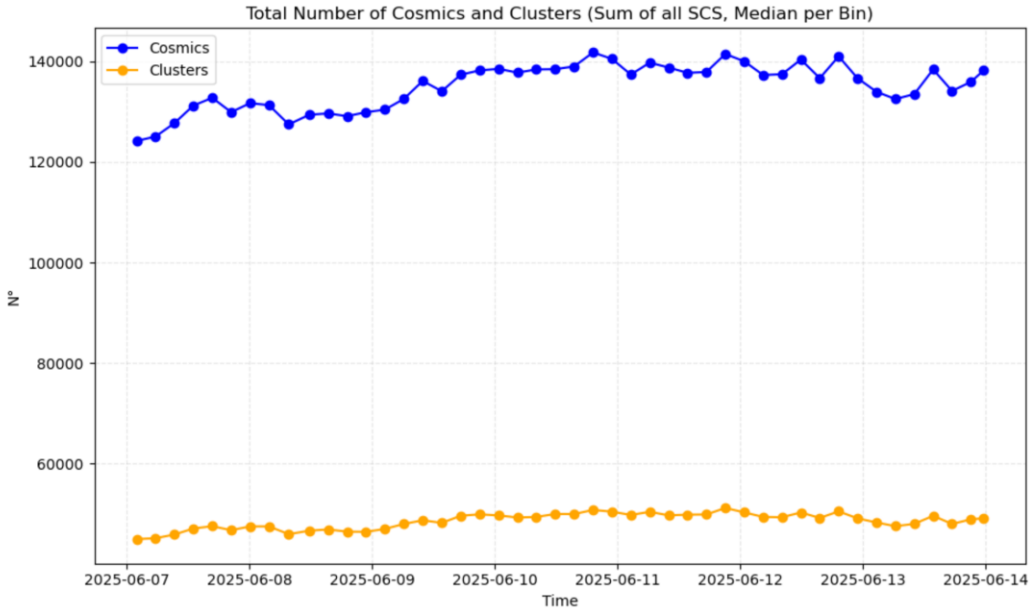

Detector 11
Detector 12
Detector 13
Detector 14
Detector 21
Detector 22
Detector 23
Detector 24
Detector 31
Detector 32
Detector 33
Detector 34
Detector 41
Detector 42
Detector 43
Detector 44
Number
Time

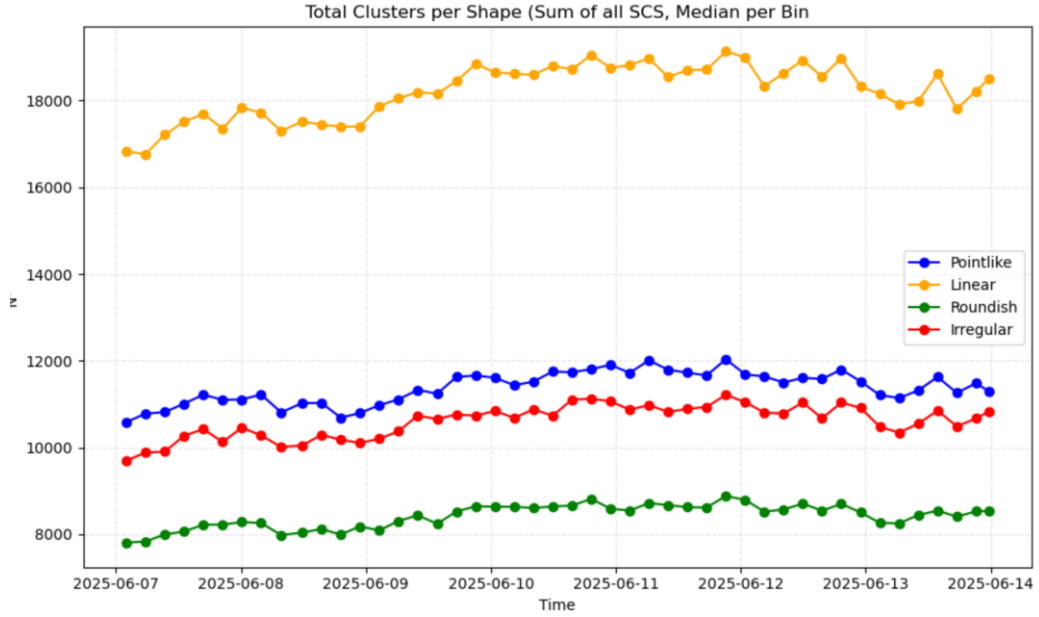

Detector 11
Detector 12
Detector 13
Detector 14
Detector 21
Detector 22
Detector 23
Detector 24
Detector 31
Detector 32
Detector 33
Detector 34
Detector 41
Detector 42
Detector 43
Detector 44
Pointlike
Linear
Roundish
Irregular
Number of Clusters
Time

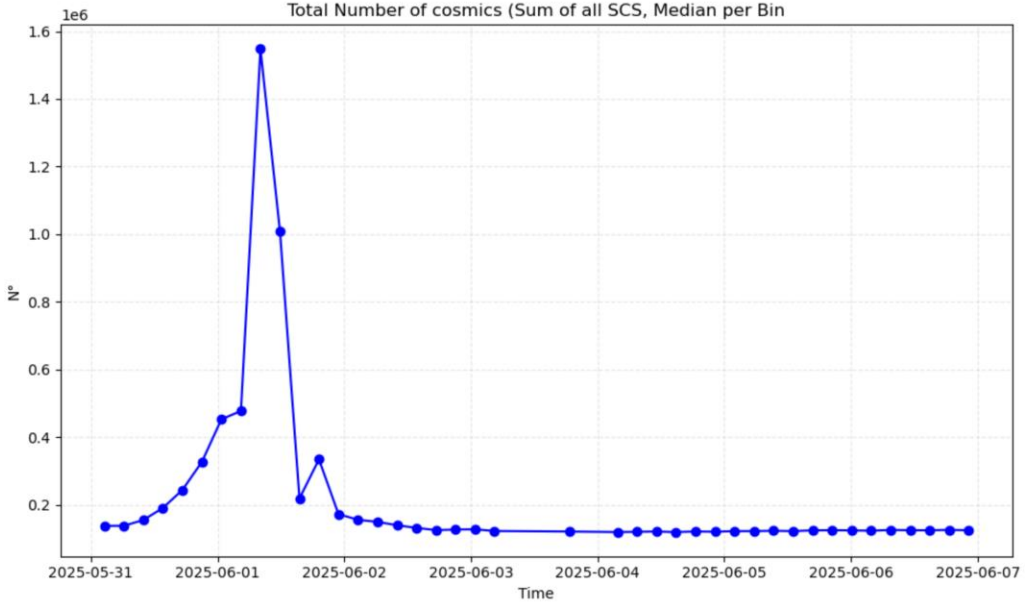

Detector 11
Detector 12
Detector 13
Detector 14
Detector 21
Detector 22
Detector 23
Detector 24
Detector 31
Detector 32
Detector 33
Detector 34
Detector 41
Detector 42
Detector 43
Detector 44
Precision
Time

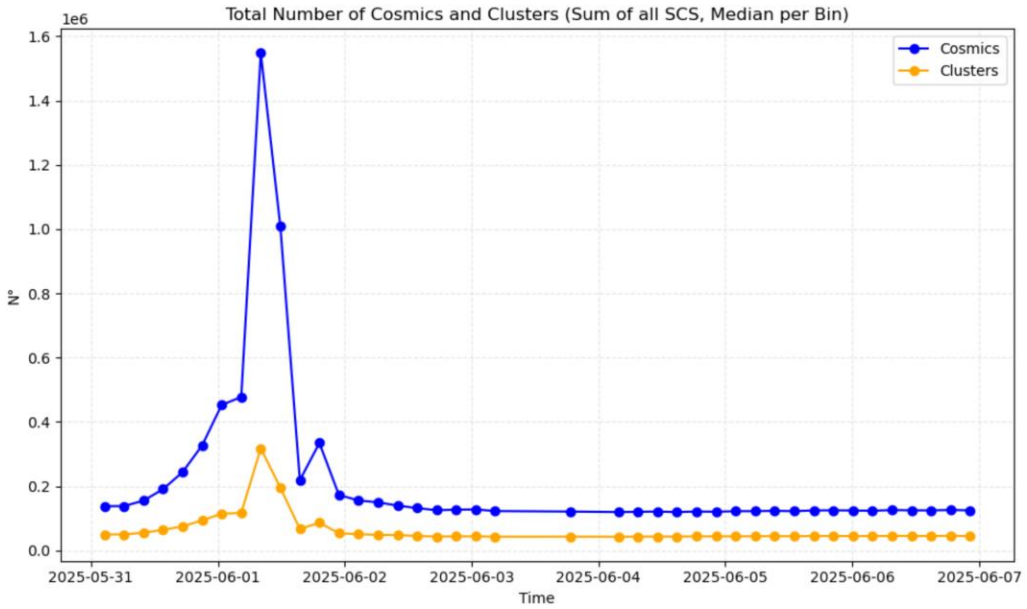

Detector 11
Detector 12
Detector 13
Detector 14
Detector 21
Detector 22
Detector 23
Detector 24
Detector 31
Detector 32
Detector 33
Detector 34
Detector 41
Detector 42
Detector 43
Detector 44
False Positive rate
Time


Total Number of cosmics (Sum of all SCS, Median per Bin
N°
Time
142500
140000
137500
135000
132500
130000
127500
125000
2025-06-07
2025-06-08
2025-06-09
2025-06-10
2025-06-11
2025-06-12
2025-06-13
2025-06-14

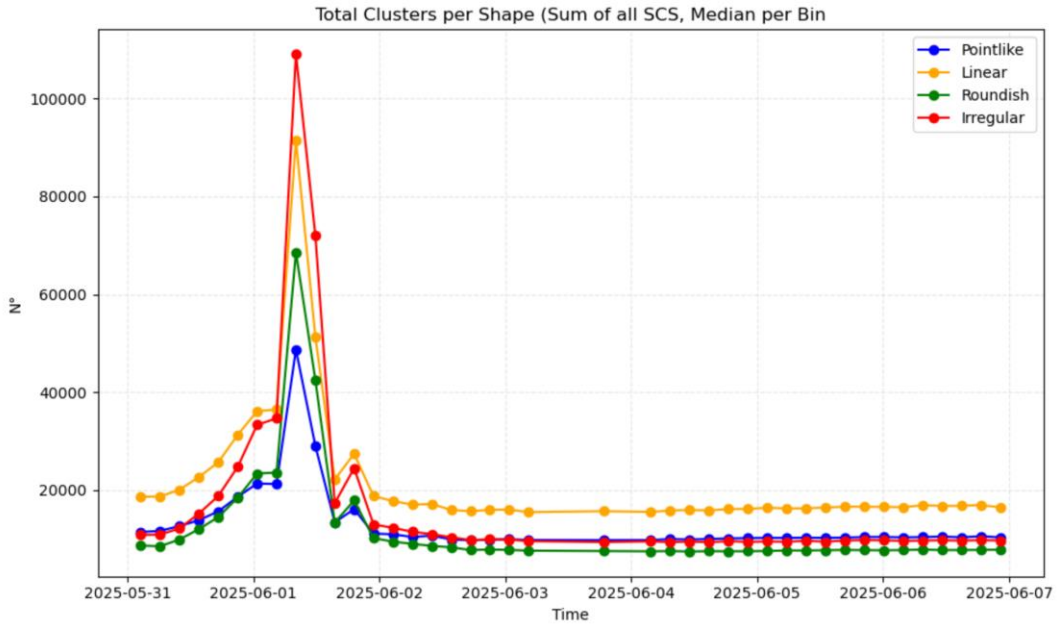

Total Number of Cosmics and Clusters (Sum of all SCS, Median per Bin)
Cosmics
Clusters
N°
Time
140000
120000
100000
80000
60000
2025-06-07
2025-06-08
2025-06-09
2025-06-10
2025-06-11
2025-06-12
2025-06-13
2025-06-14


Total Clusters per Shape (Sum of all SCS, Median per Bin
N
Time
Pointlike
Linear
Roundish
Irregular
18000
16000
14000
12000
10000
8000
2025-06-07
2025-06-08
2025-06-09
2025-06-10
2025-06-11
2025-06-12
2025-06-13
2025-06-14

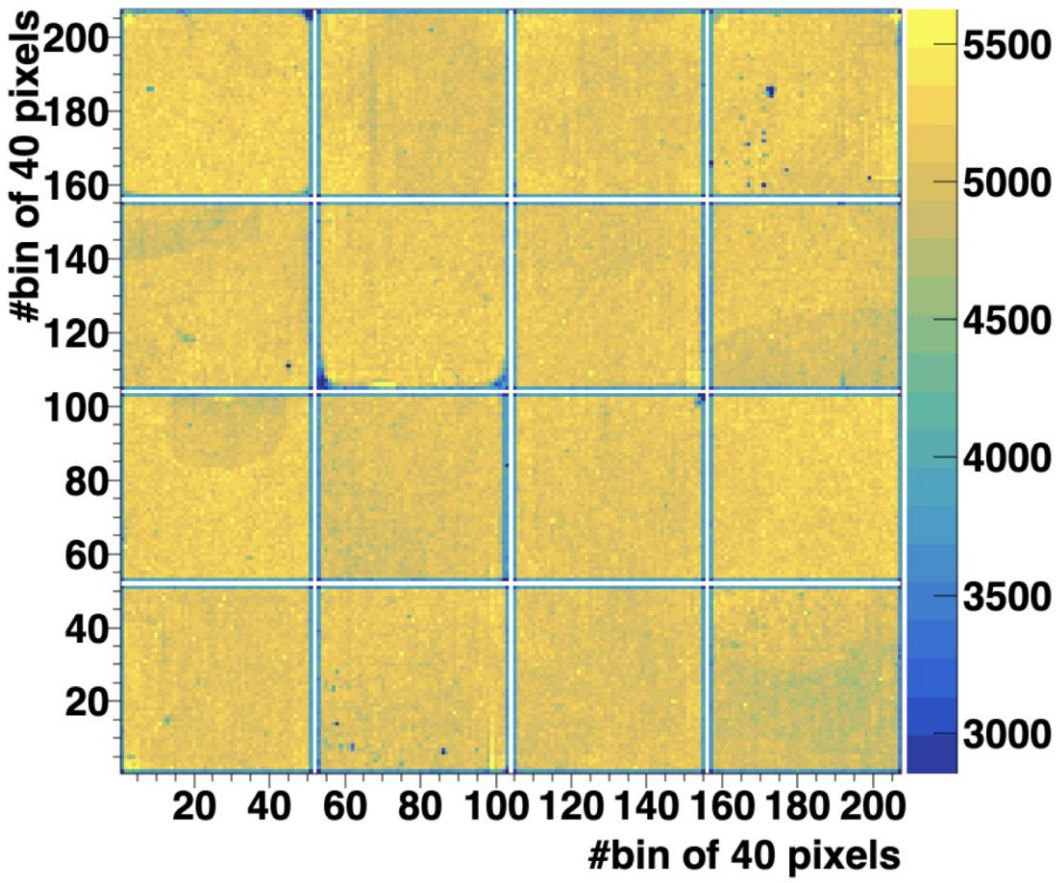




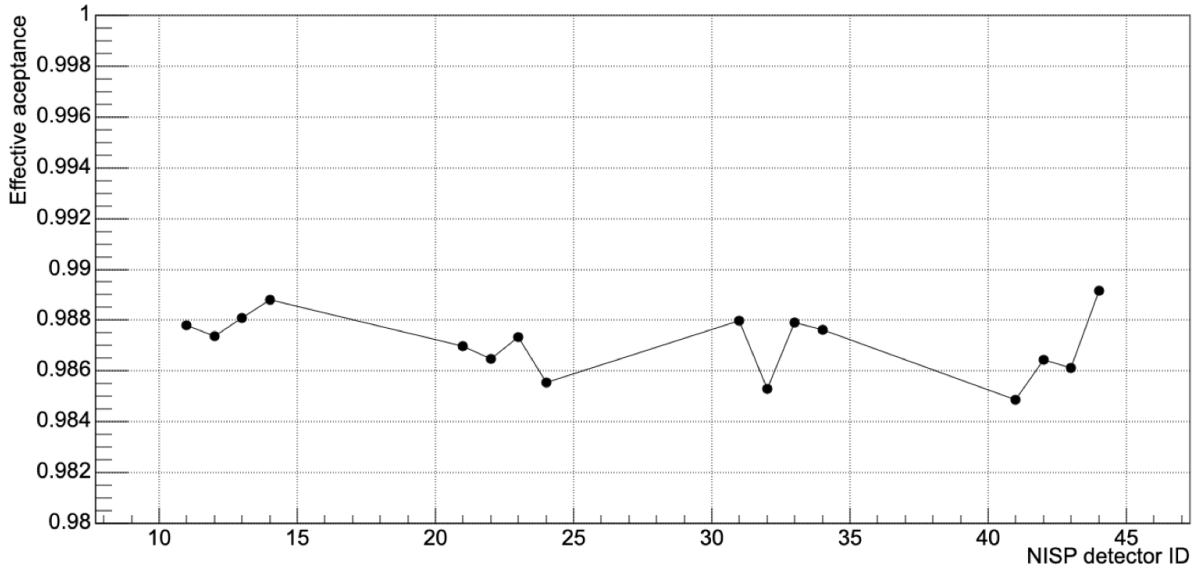
Weekly/History plots

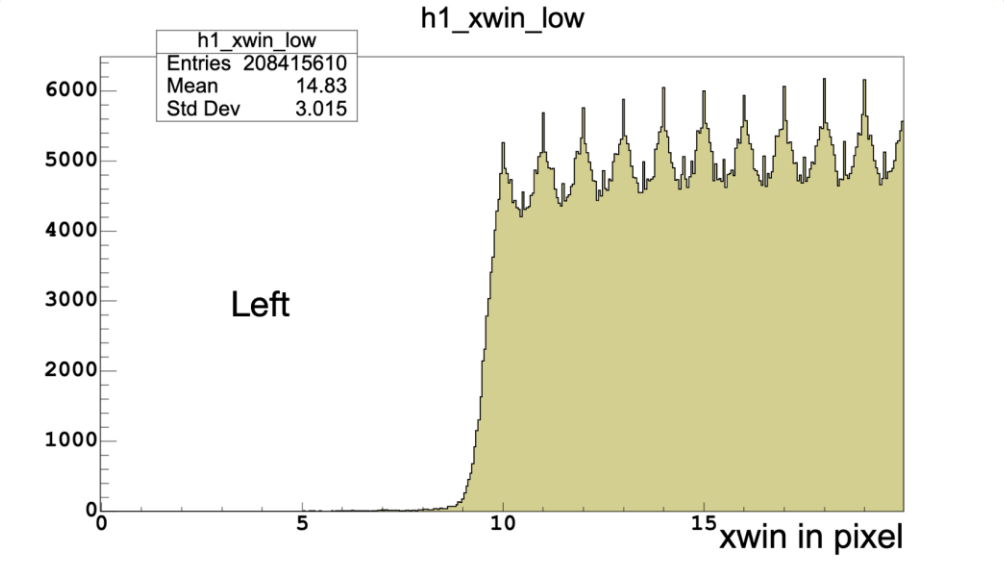


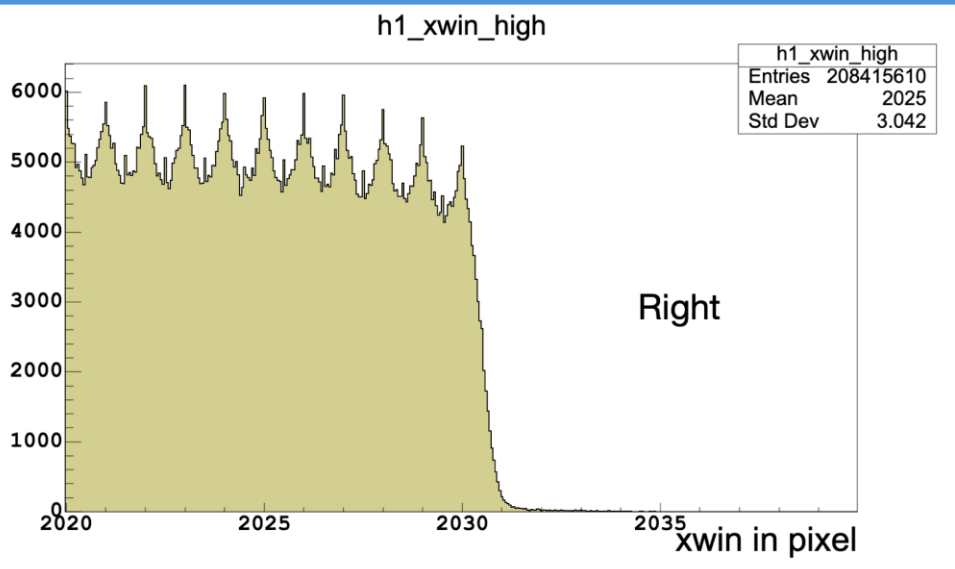
Less sources are reconstructed close to detector border.

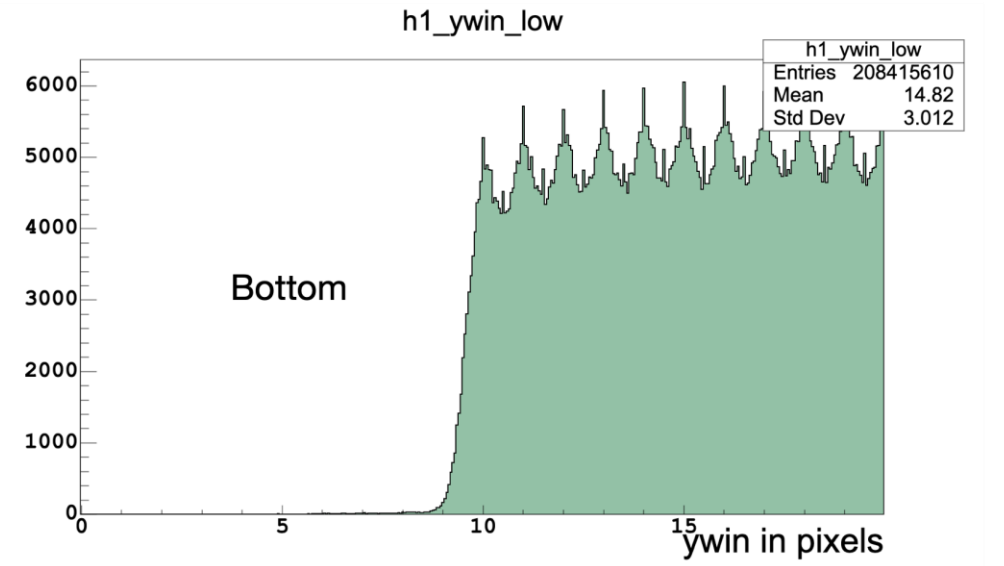


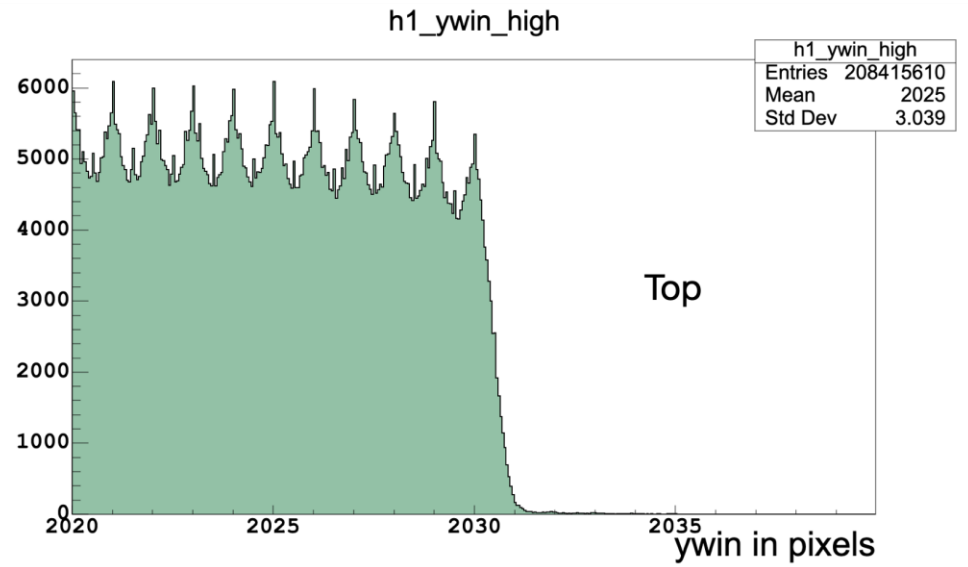
NIR effective detector area detector acceptance (area) ~98.7 %

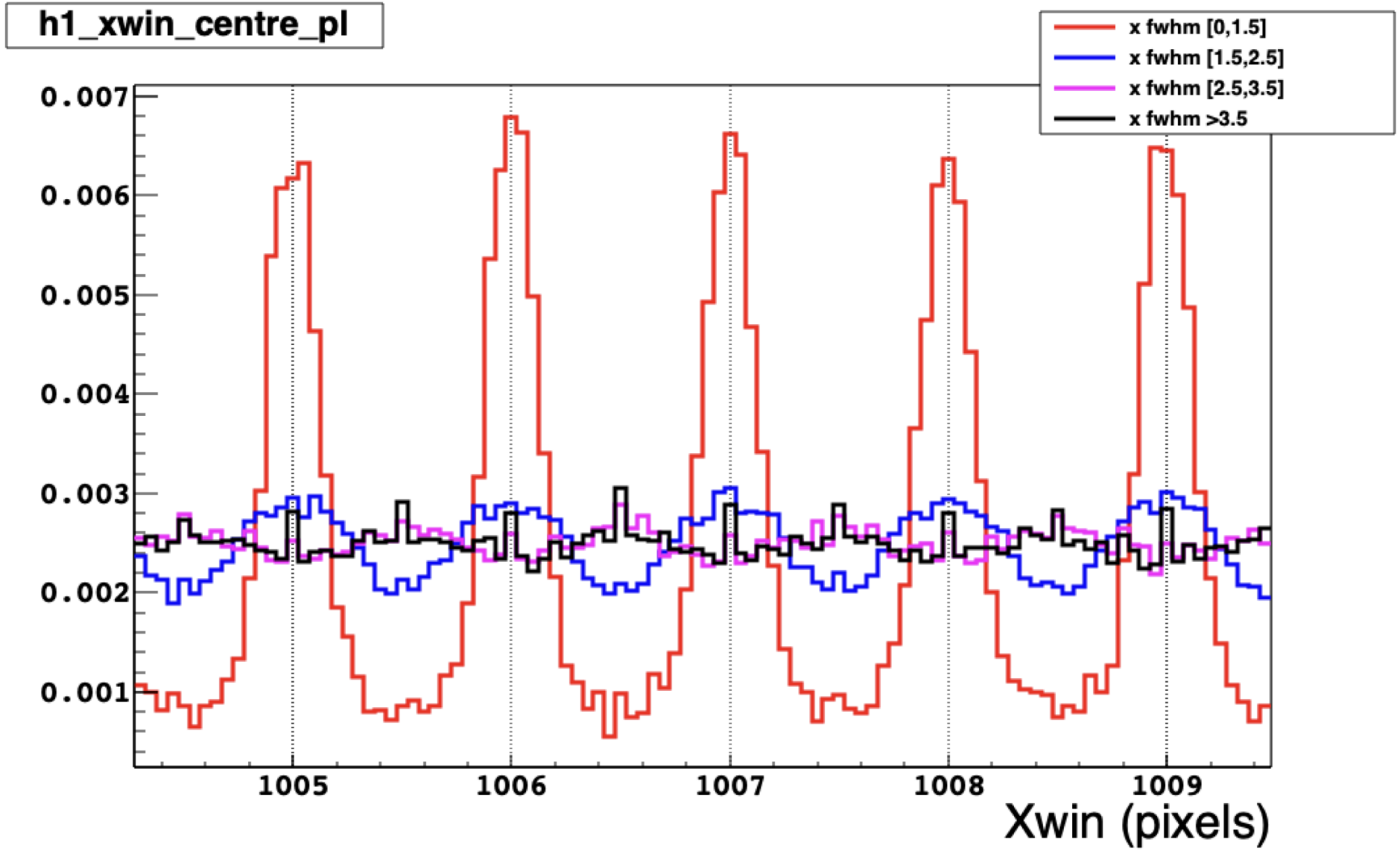



h1_xwin_low
h1_xwin_low
Entries 208415610
Mean 14.83
Std Dev 3.015
Left
xwin in pixel


h1_xwin_high
h1_xwin_high
Entries 208415610
Mean 2025
Std Dev 3.042
Right
xwin in pixel

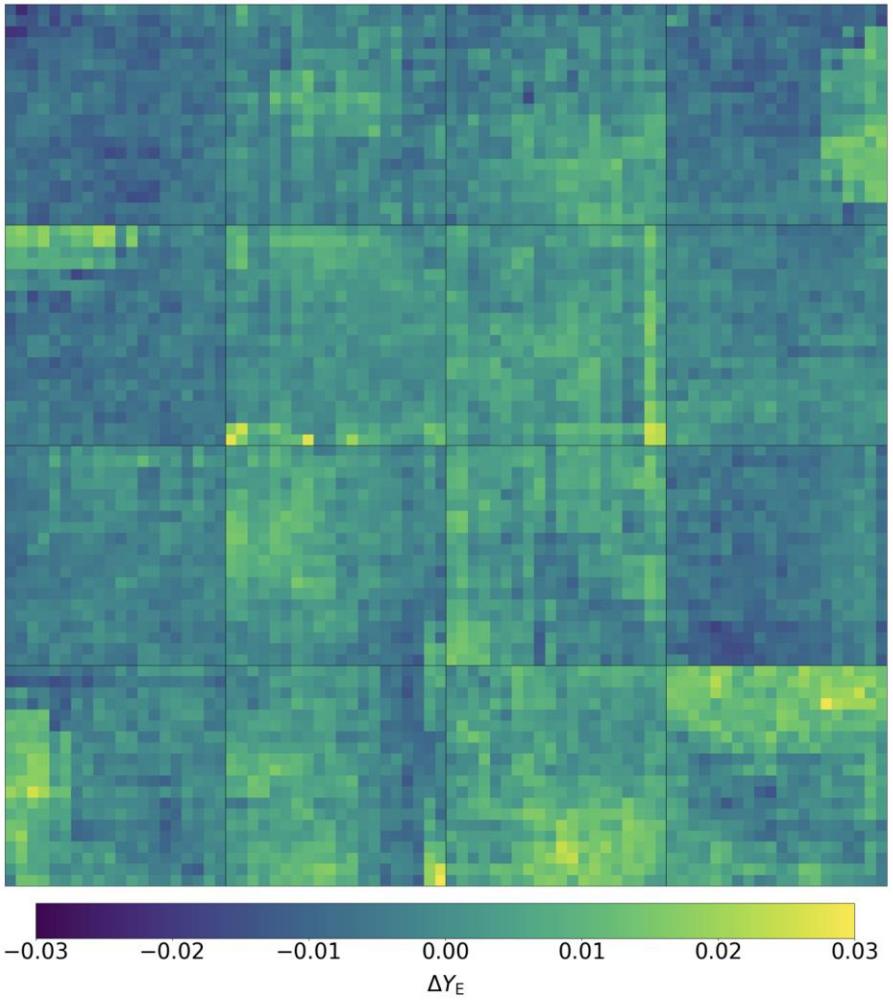

h1_ywin_low
h1_ywin_low
Entries 208415610
Mean 14.82
Std Dev 3.012
Bottom
ywin in pixels


h1_ywin_high
h1_ywin_high
Entries 208415610
Mean 2025
Std Dev 3.039
Top
ywin in pixels

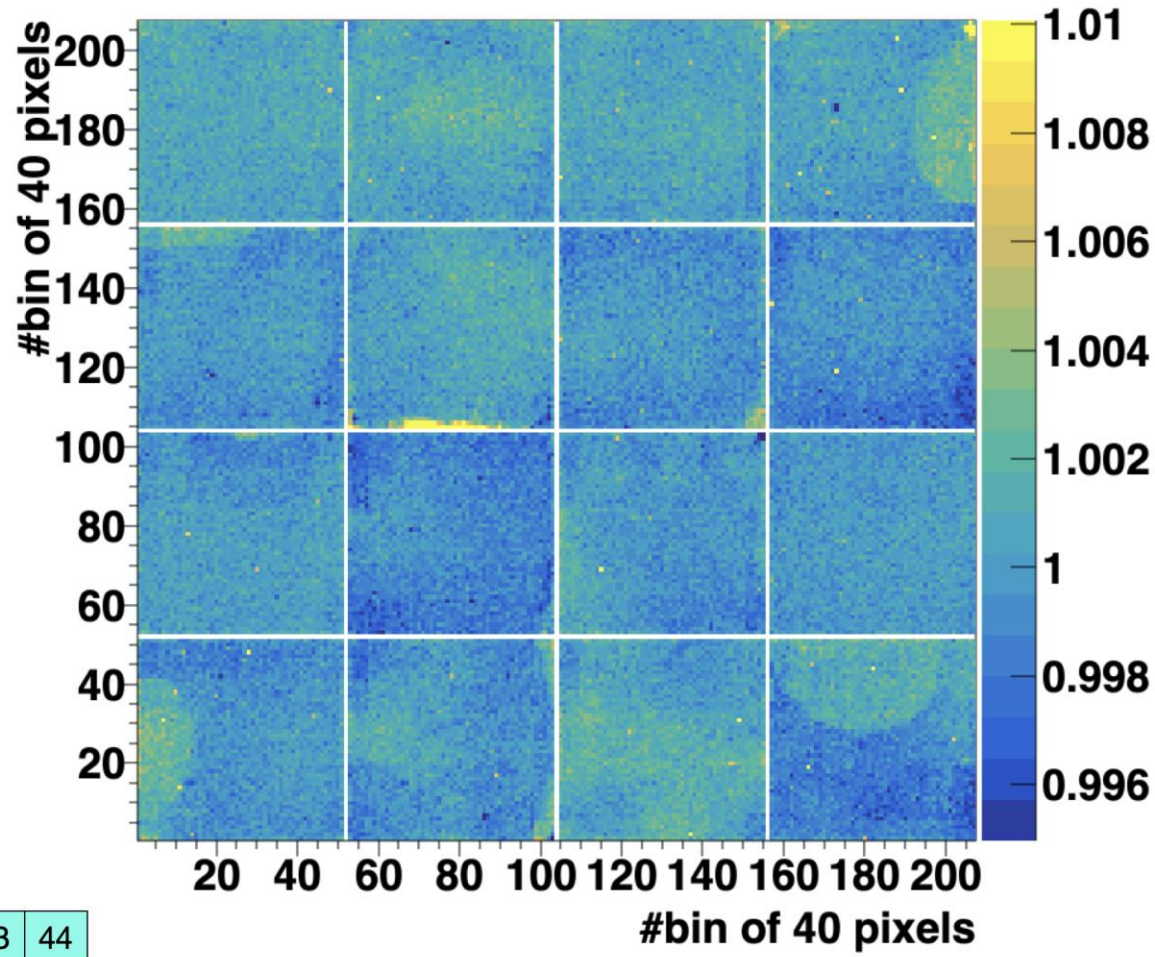

h1_xwin_centre_pl
x fwhm [0,1.5]
x fwhm [1.5,2.5]
x fwhm [2.5,3.5]
x fwhm >3.5
0.007
0.006
0.005
0.004
0.003
0.002
0.001
1005
1006
1007
1008
1009
Xwin (pixels)

Magnitude_frac

NIR residual from selfcal



Magnitude / (FP media)

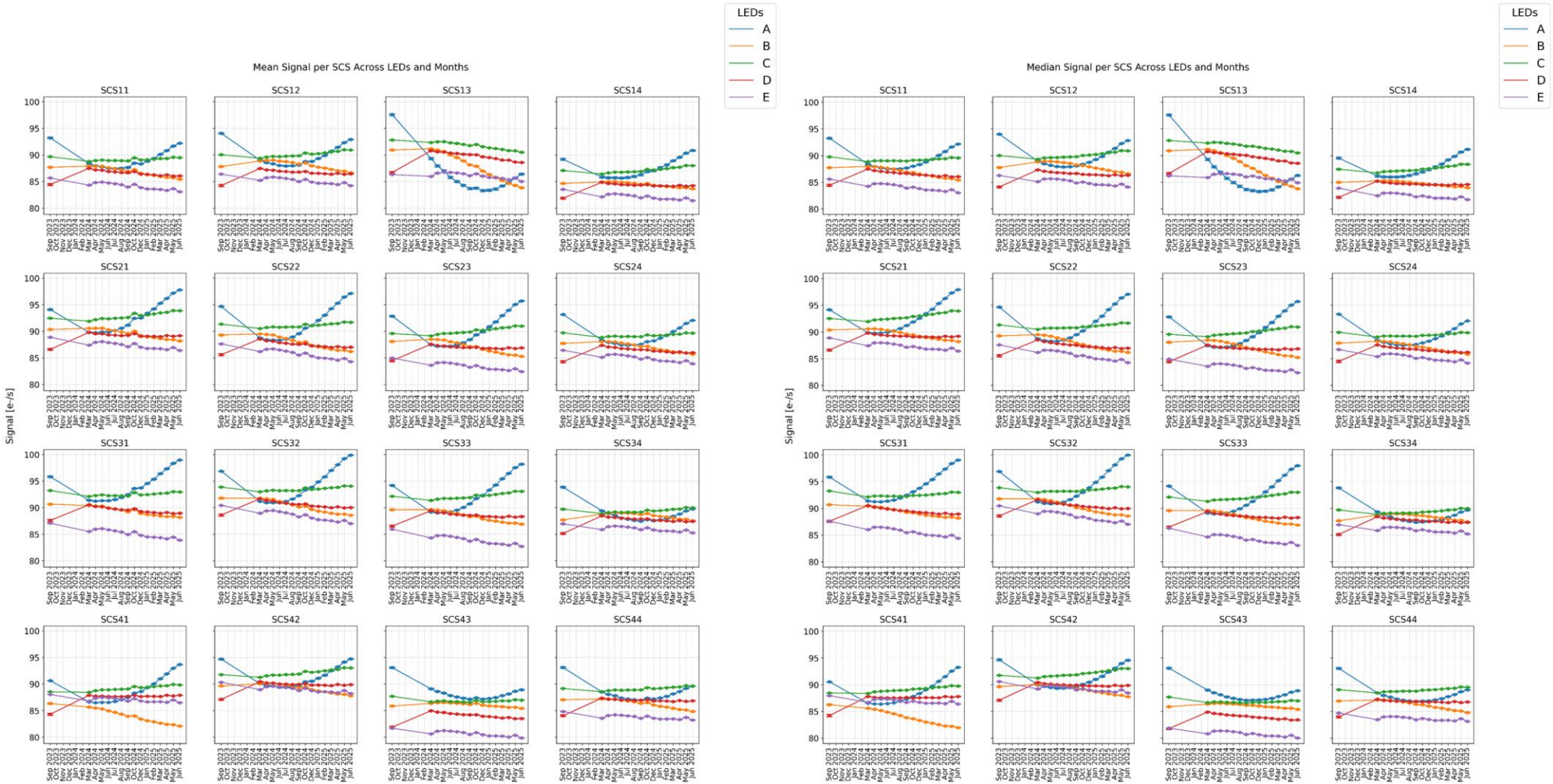


41	42	43	44
31	32	33	34
21	22	23	24
11	12	13	14

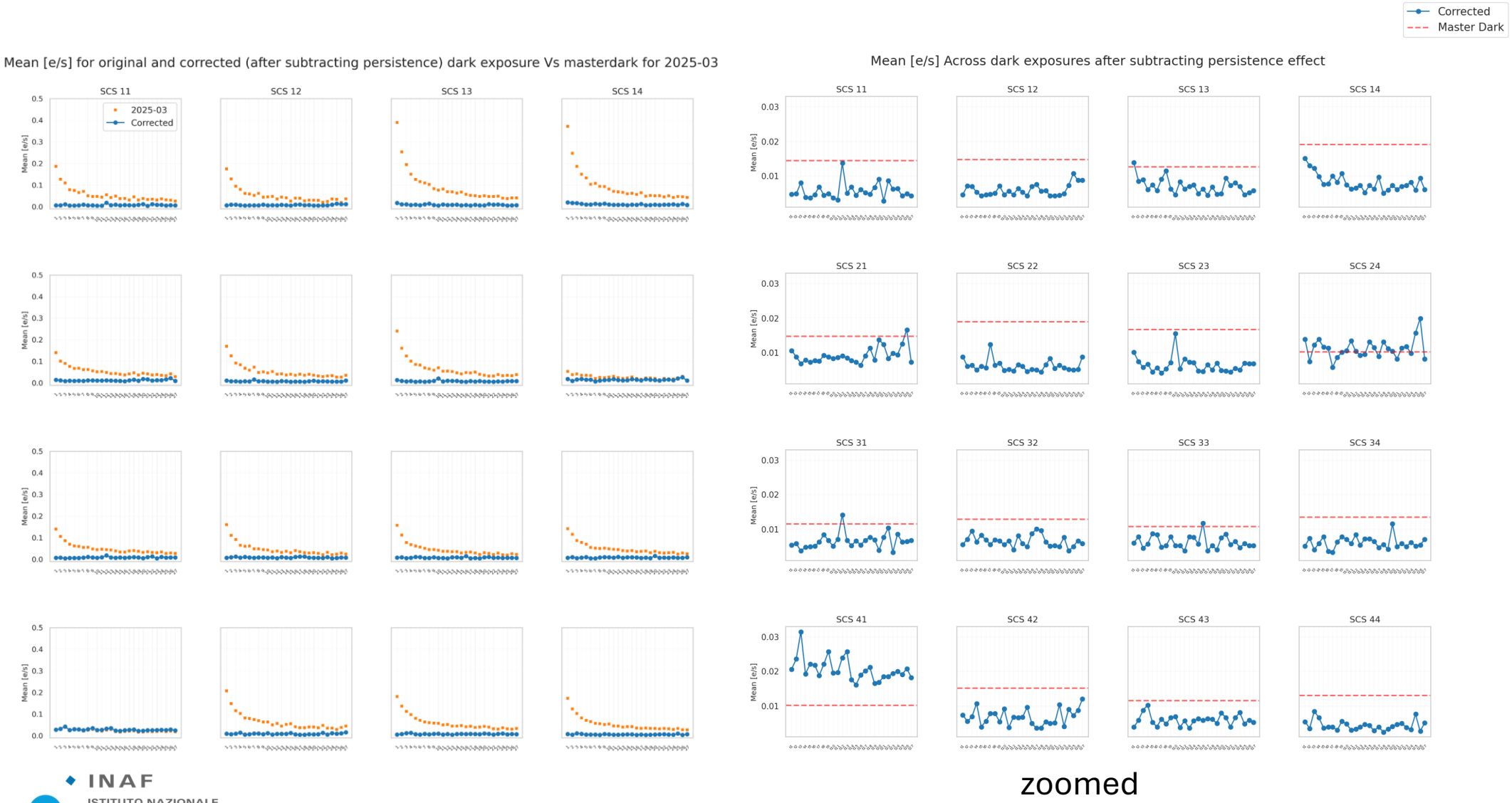
Indat	Input data array
inmask=None	Boolean mask with px to be avoided for the analysis (e.g., bad px, saturated px,...) [OPTIONAL]
inbkg=None	Mask with pre-determined background values to be subtracted from the input image [OPTIONAL]
invar=None	Mask with pre-determined variance per px (i.e., noise squared) [OPTIONAL]
sigclip=4.5	Laplacian-to-noise limit for cosmic ray detection (i.e., ratio between px and neighboring intensities). Influence the most FP. [range: 3 - 6]
sigfrac=0.3	Fractional detection limit for neighboring pixels. For cosmic ray neighbor pixels, a lapacian-to-noise detection limit of sigfrac * sigclip is applied [range: 0.2 - 0.5)]
objlim=4.0	Minimum contrast between Laplacian image and the fine structure image. [range: 1 to 500]
gain=1.95	Gain of the image (electrons / ADU). [form header]
readnoise= 6	Read noise of the image (electrons) [from header]
satlevel=65536.0	Saturation level. Default 65536 for 16bit images
niter=6	Number of iterations

sepmed=True	True: used a seprable median filter rather than a full median filter. Faster and with the same efficiency.
cleantype='meanmask'	Cleaning algorithm: 'median': An umasked 5x5 median filter; 'medmask': A masked 5x5 median filter; 'meanmask': A masked 5x5 mean filter; 'idw': A masked 5x5 inverse distance weighted interpolation.
fsmode='median'	Methodo to rebuild the fine structure image. "median": standard median filter of LACosmic. "convolve" convolution bu using the psf kernel. Default: median
psfmodel='gauss'	Model used to generate pdf kernel if smode = 'convolve' e psfk = None. Options: "gauss" or "moffat" producing circular kernels. "gaussx" o "gaussy" producing gaussian kernel on x o y. Default: gauss
psffwhm=1.5	Length at mid height (Full Width Half Maximum) of psf to generate kernel. Default: 2.5
psfsize=5	Dimension of the kernel (psfsize x psfsize). Default: 7 (other values 3, 5, 7, 9)
psfk=None	pdf kernel array to be used for the fine structure image if fsmode = "convolve". If psfk=None and fsmode=convolve, psf kernel calculated wuth psfmodel
psfbeta=4.765	Moffat beta parameter. Used if fsmode = convolve and psfmodel=moffat. Defalut: 4.765
verbose=True	If true print processing information

FLAT-FIELD (F-007) DETECTORS ANALYSIS



Persistence Decay in Dark Images (F-007)

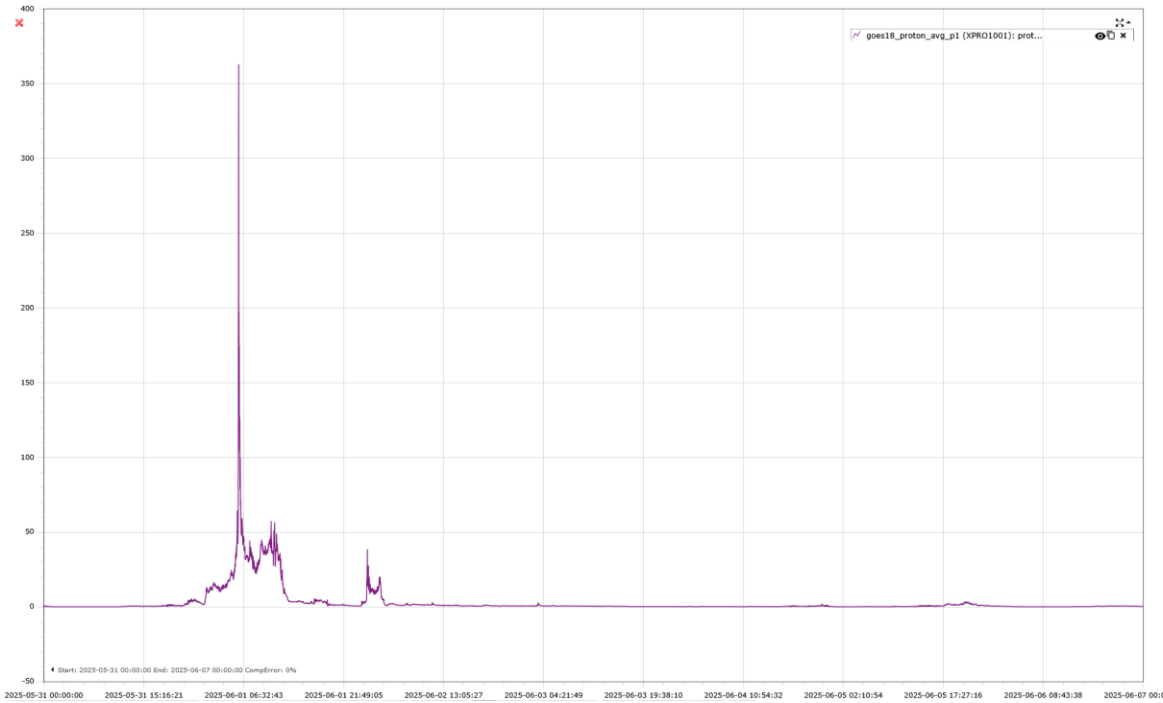


zoomed

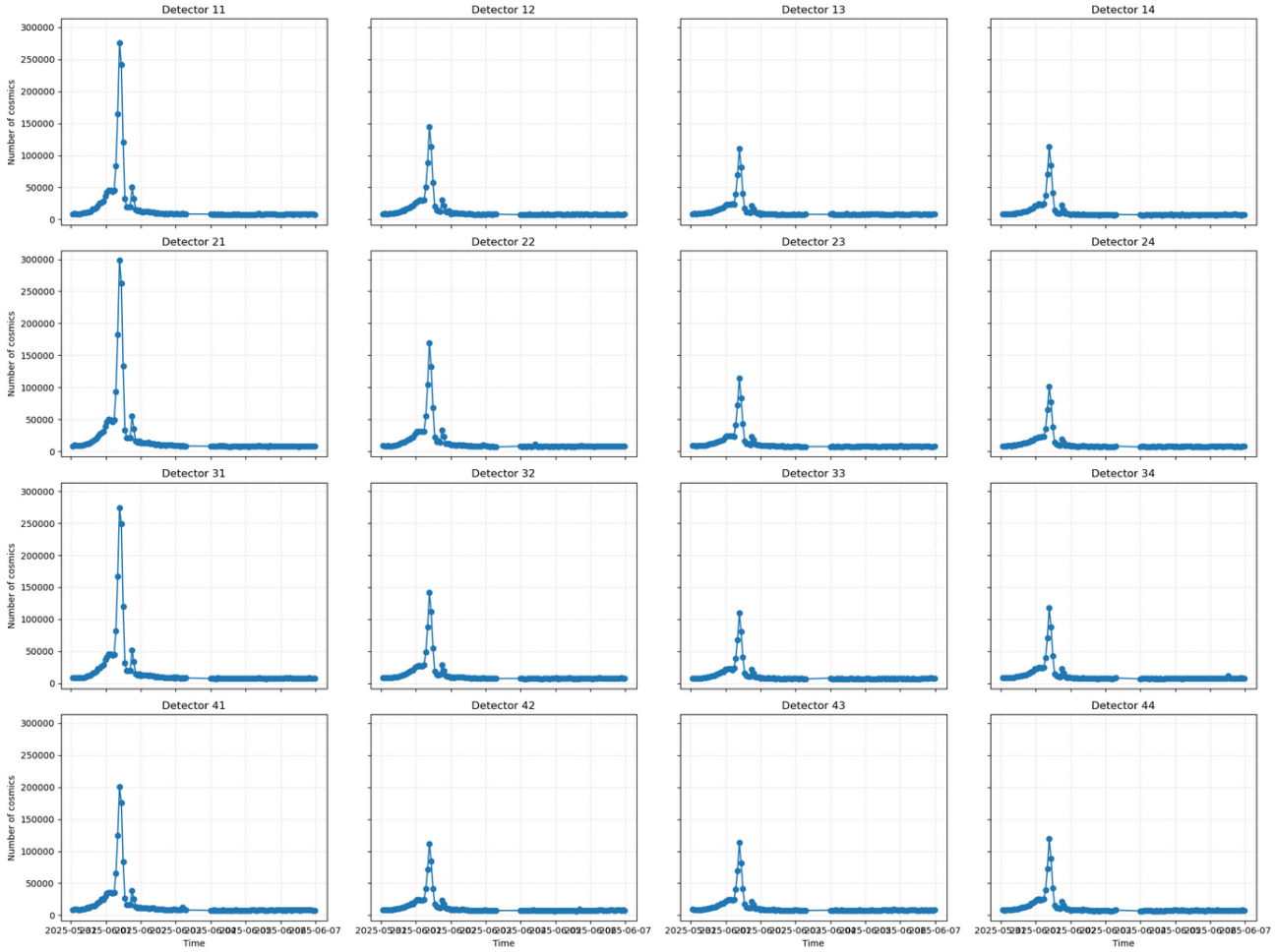
Week 07/06 - 13/06/2025 (No solar events)

Week 31/05 - 06/06/2025
Solar flare 31/05 - 01/06

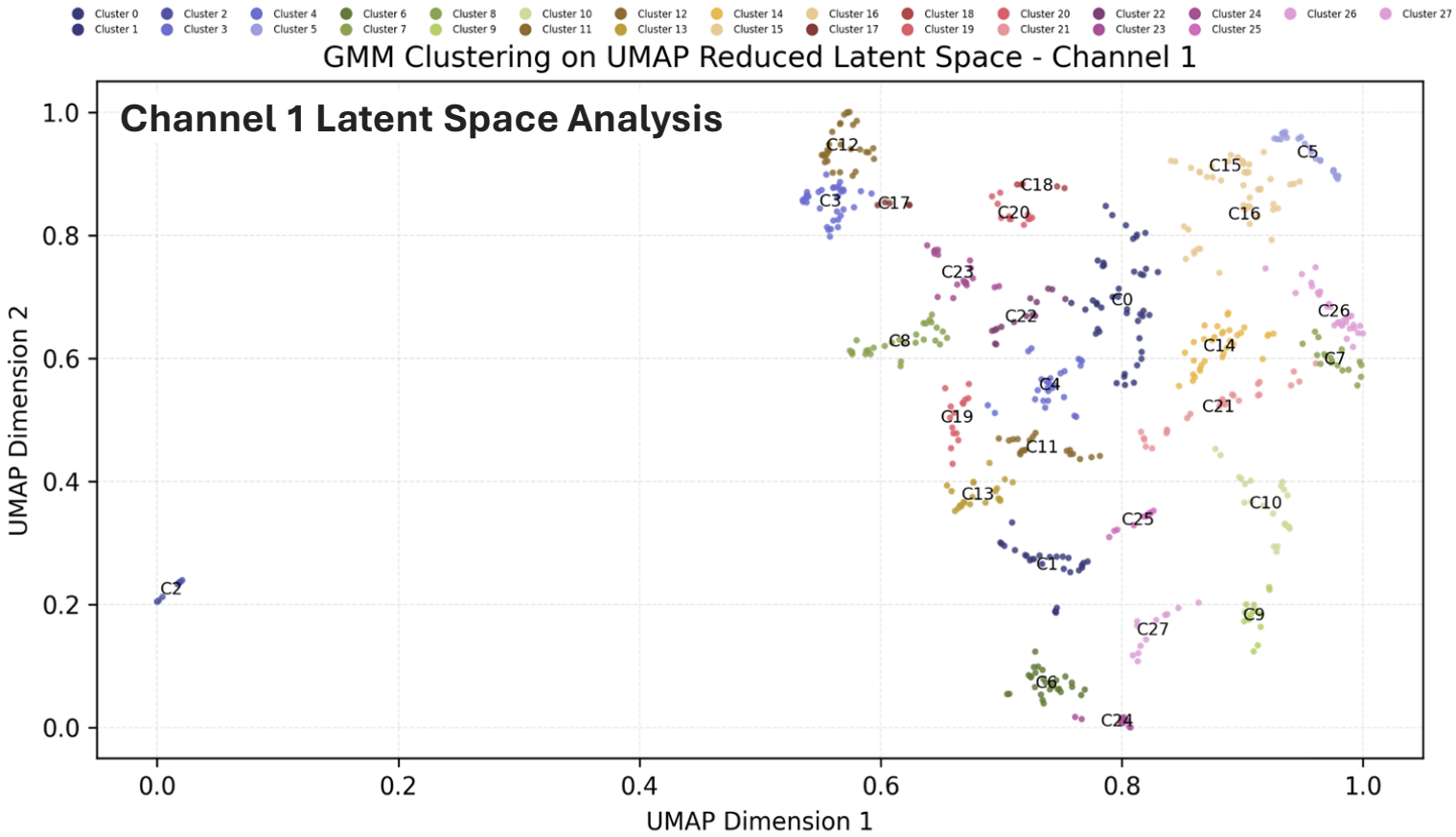
GOES proton flux



n° of px flagged as cosmic per detector



PERSISTENCE DETECTION ON SLEW DARK USING AUTOENCODERS

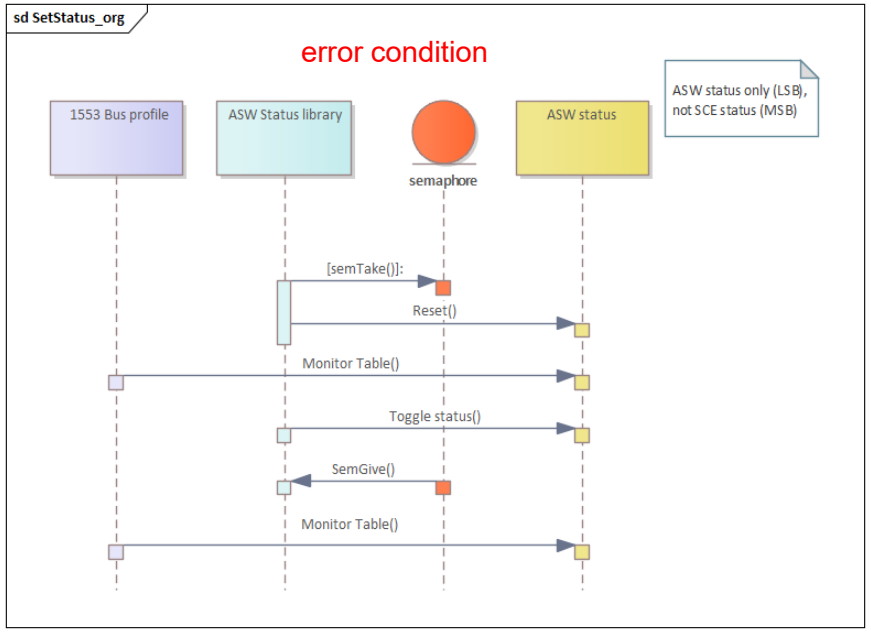


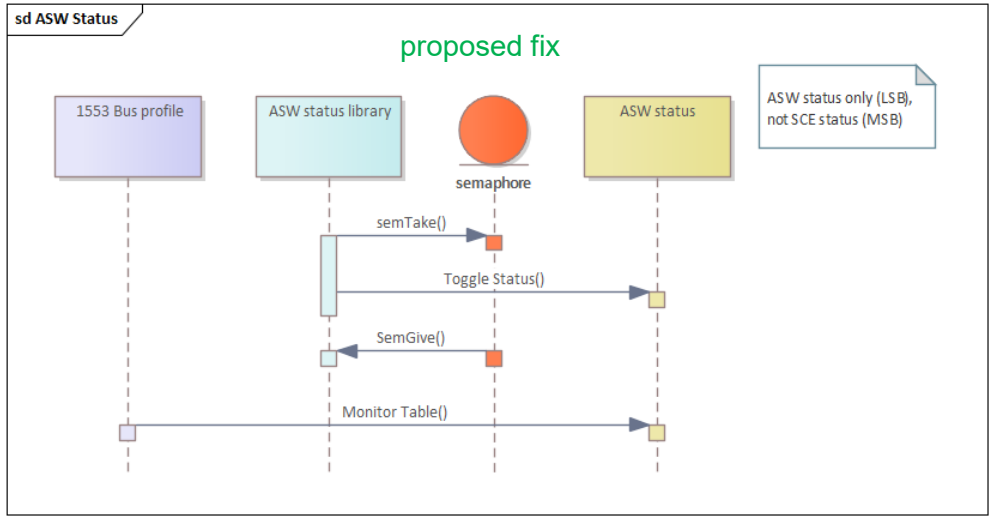
2. UMAP's ability to preserve local and global structures helps us identify meaningful groupings. Here, we used GMM with 28 clusters (optimal per AIC/BIC) to capture the diversity of features in Channel 1.

➢ DPU-ASWv1.4 new release (September 2025)

- Two minor issues fixed:

1. **NISP status undefined** (because is reset before changing state) once every six months (per DPU) for few milliseconds while HKTM is prepared. This **did not cause scientific data loss**.

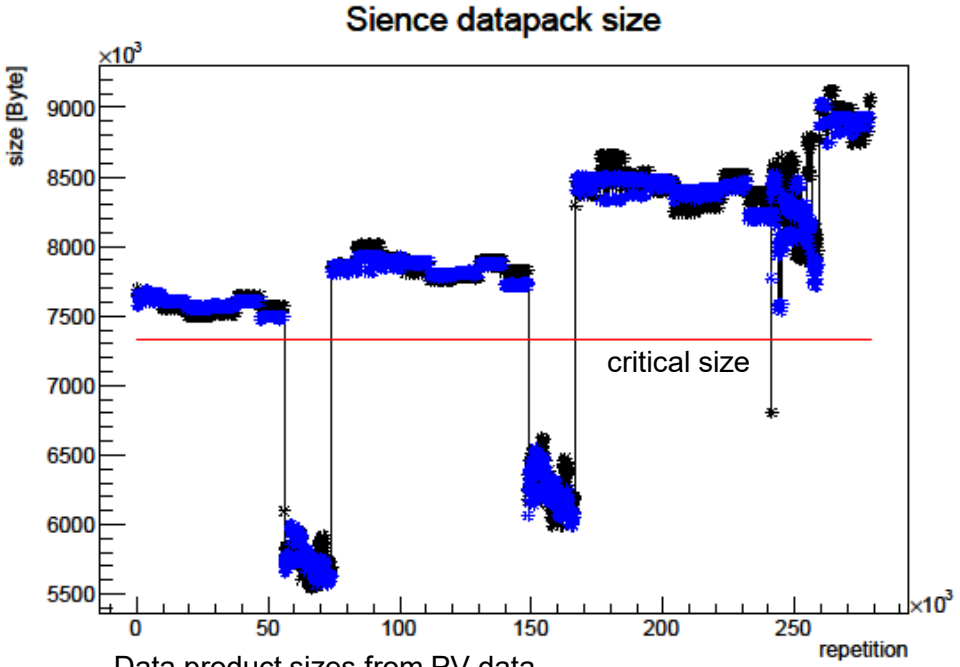




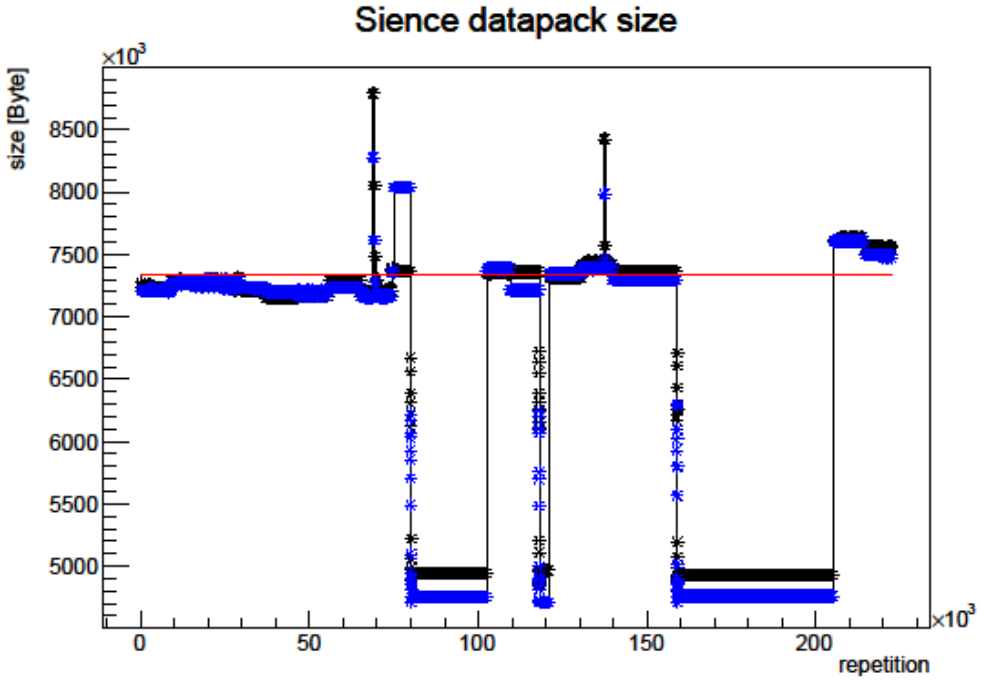
2. During Calblock-F009 (non-linearity) a LED illumination configuration leads to a very small size of the NISP data product.

   This exception was not correctly handled by the functions transferring the data internally in the DPU.

   A work-around was defined (disabling the compression) and the Calblock-F009 was successfully completed.



Data product sizes from PV data
(for the same type of calibration PV-18)



Data product sizes during CalBlock-F009
(causing the internal error)

➢ DPU hardware: on-going investigation

- Since February 2025, the mass memory (Data Buffer Board - DBB) of the DPU2 signals continuously a **single bit error corrected by the EDAC algorithm**

- A single EDAC (1 bit corrupted) is generated every ~20 days (i.e., 1 every ROS), specifically 1 every 4 spectrometric acquisitions

  → In every ROS we have a single bit corrupted but **fully recovered**

- A correction procedure will be tested this summer