

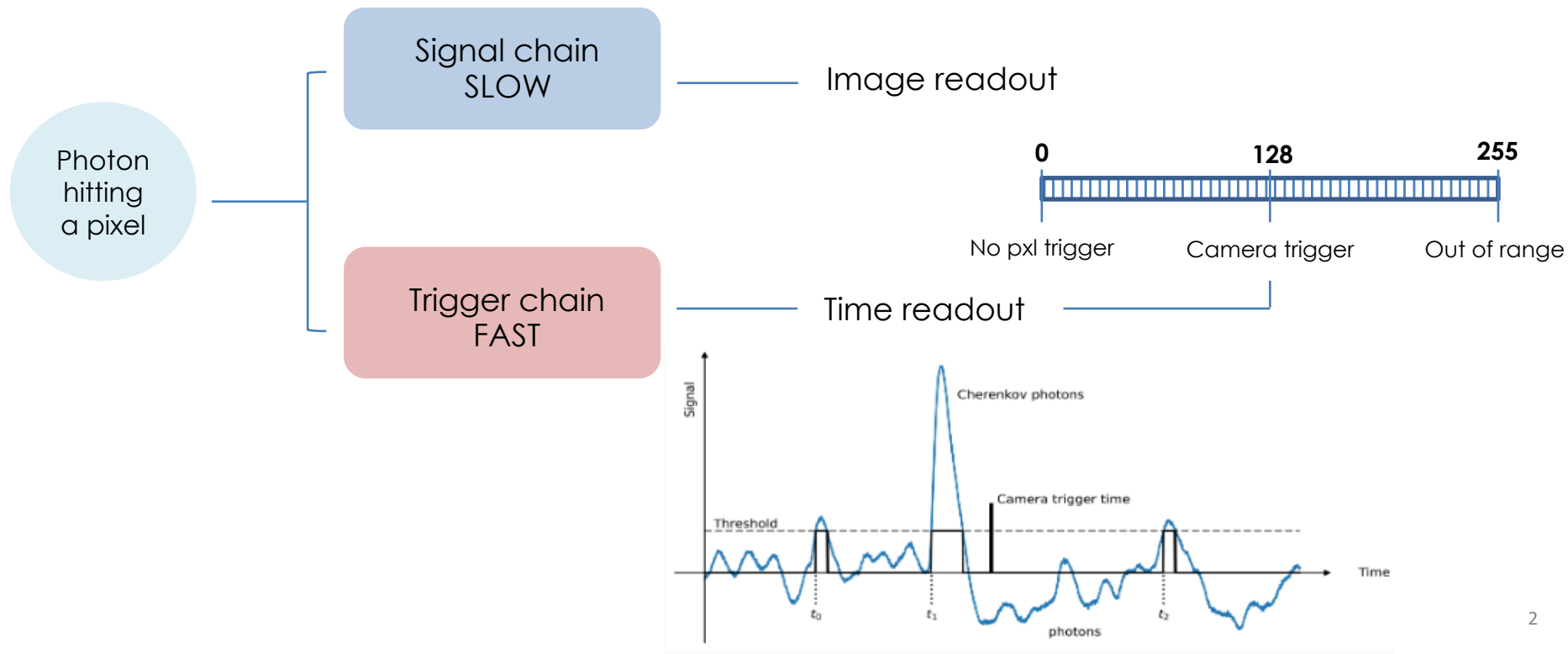


New time-based parameters for the ASTRI Mini-Array gamma/hadron discrimination

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[INAF IASF Palermo]
for the ASTRI project

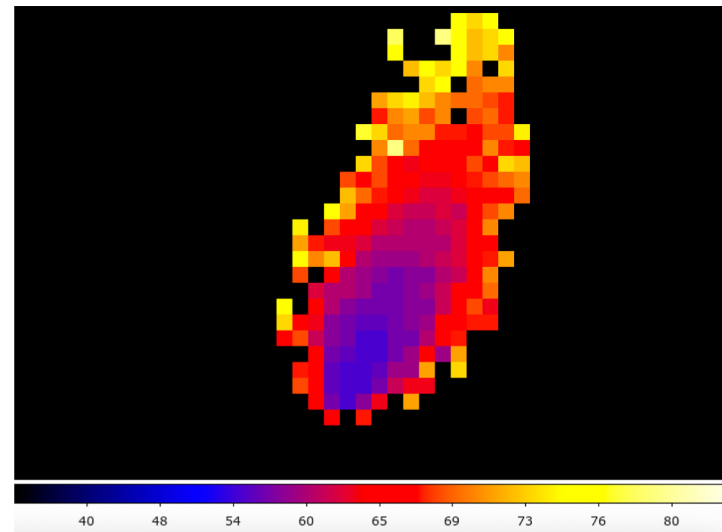


Pixel time tag readout in the ASTRI camera



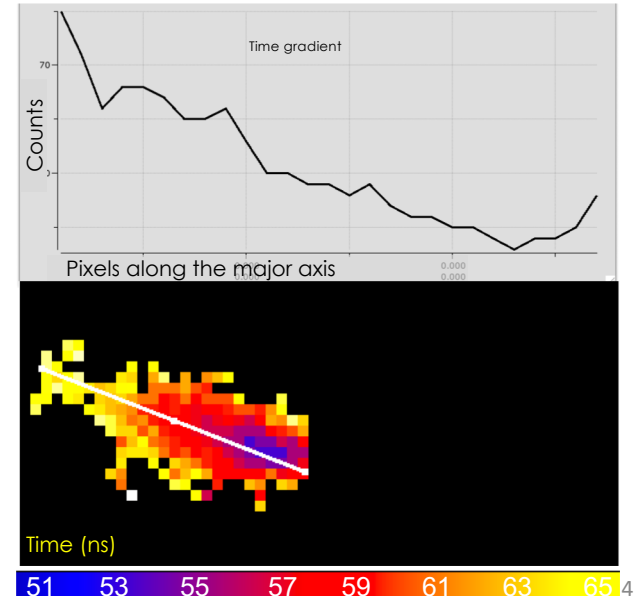
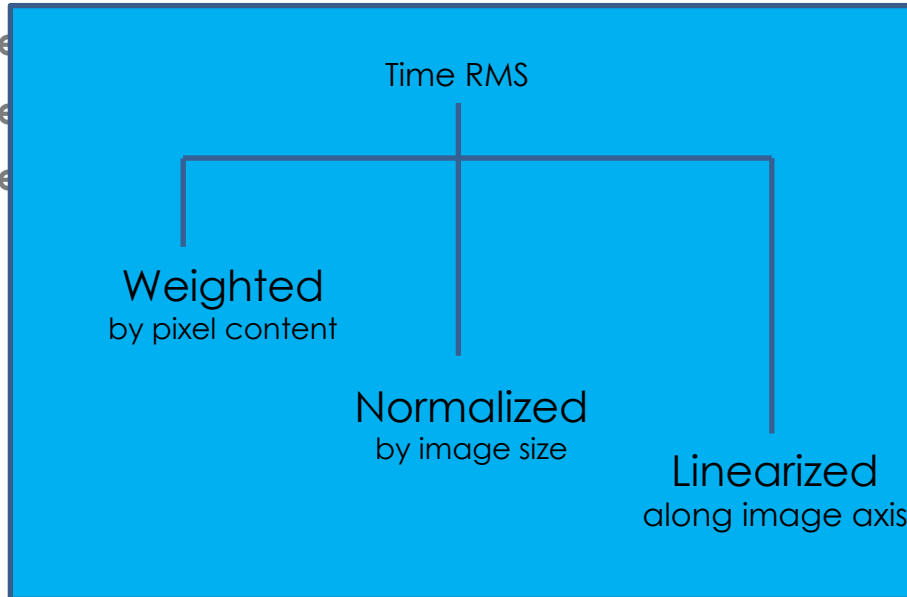
Exploration of time-based parameters spaces

- Standard parameters
- Parameters based on the time sequence
- Parameters based on the size/time space
- Parameters based on the distance/time space
- Parameters based on the size/time/distance space



Exploration of time-based parameters spaces

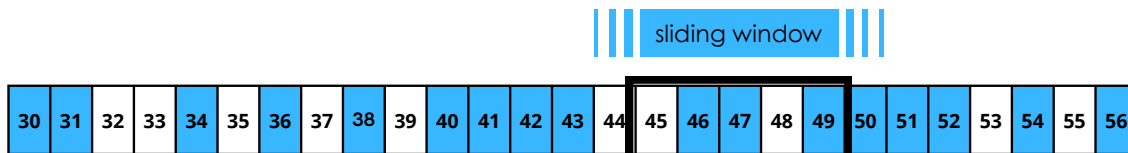
- Standard parameters [e.g. Aliu et al 2009]
- Parameters based on the time sequence
- Parameters based on the time gradient
- Parameters based on the time RMS
- Parameters based on the time gradient



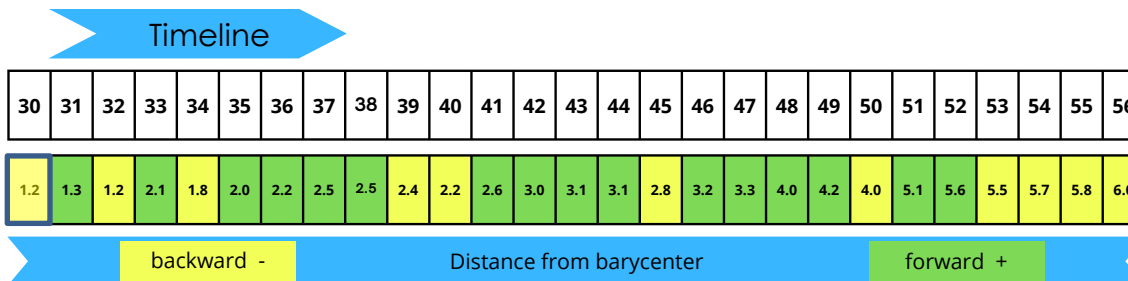
Exploration of time-based parameters spaces

- Standard parameters
- Parameters based on the time sequence
- Parameters based on the size/time space
- Parameters based on the distance/time space
- Parameters based on the size/time/distance space

Lacunarity

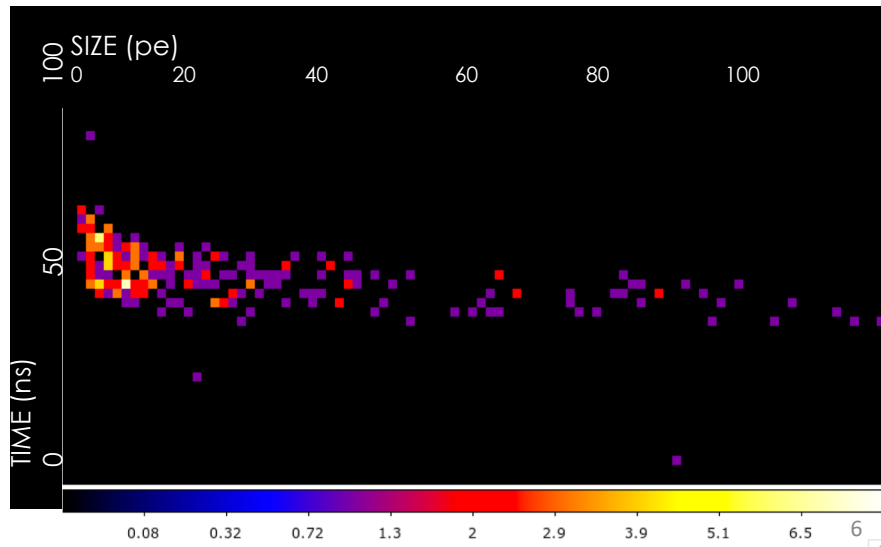


Temporal coherence



Exploration of time-based parameters spaces

- Standard parameters
- Parameters based on the time sequence
- Parameters based on the size/time space
- Parameters based on the distance/time space
- Parameters based on the size/time/distance space



ASTRI
Mini-Array



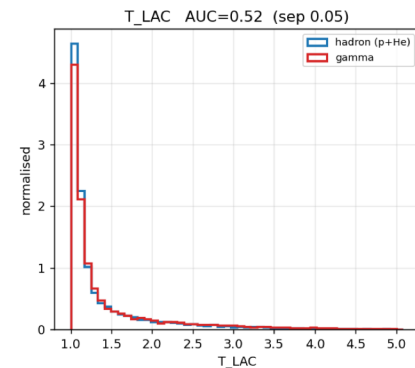
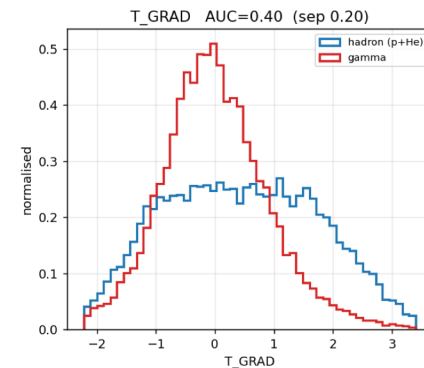
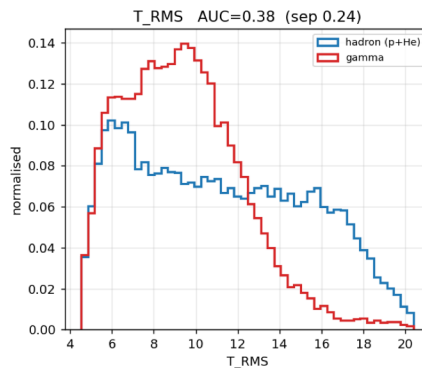
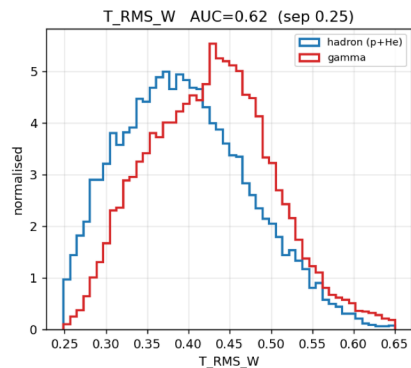
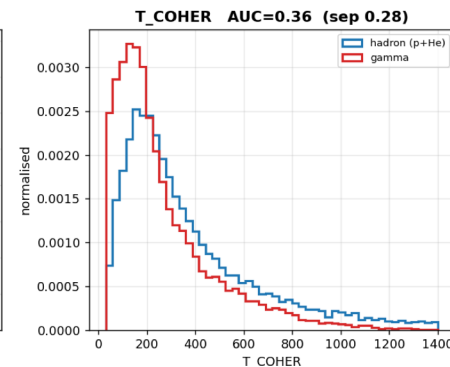
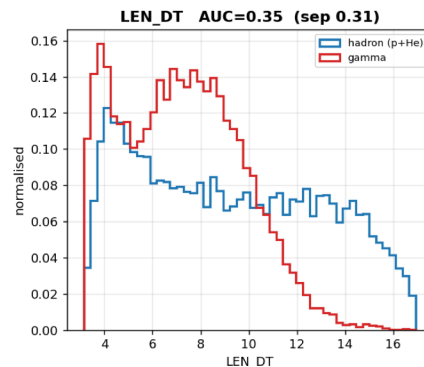
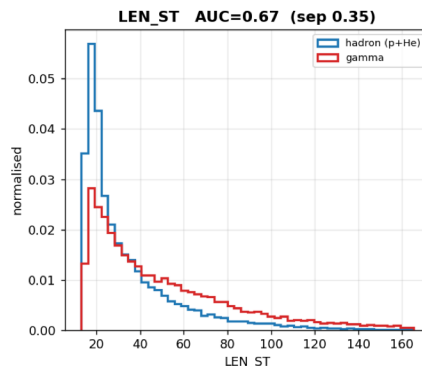
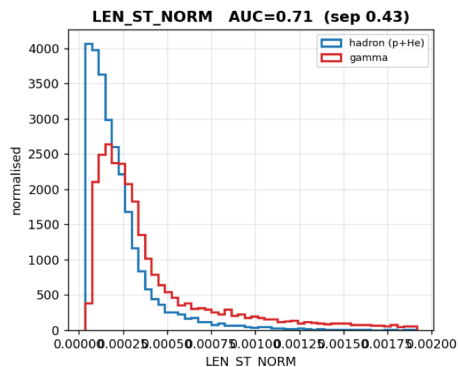
- Diversity of information
- Low redundancy
- Feature importance



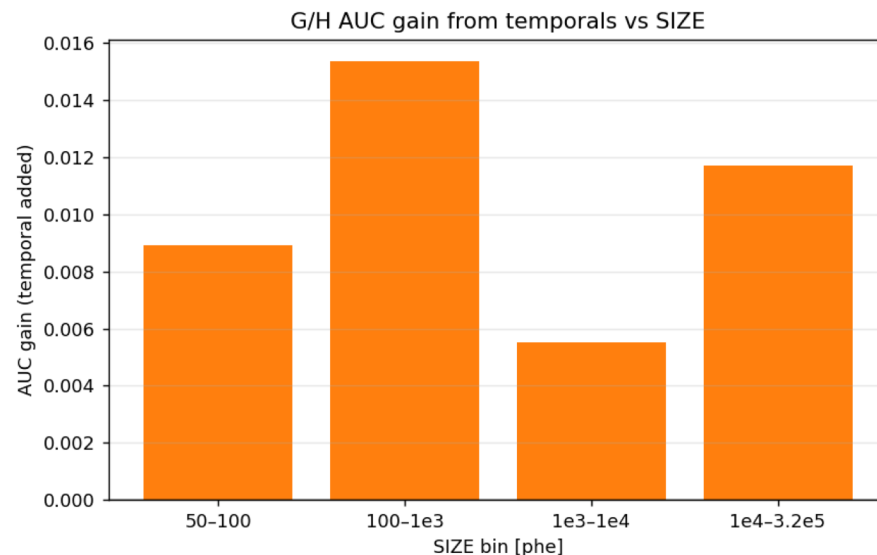
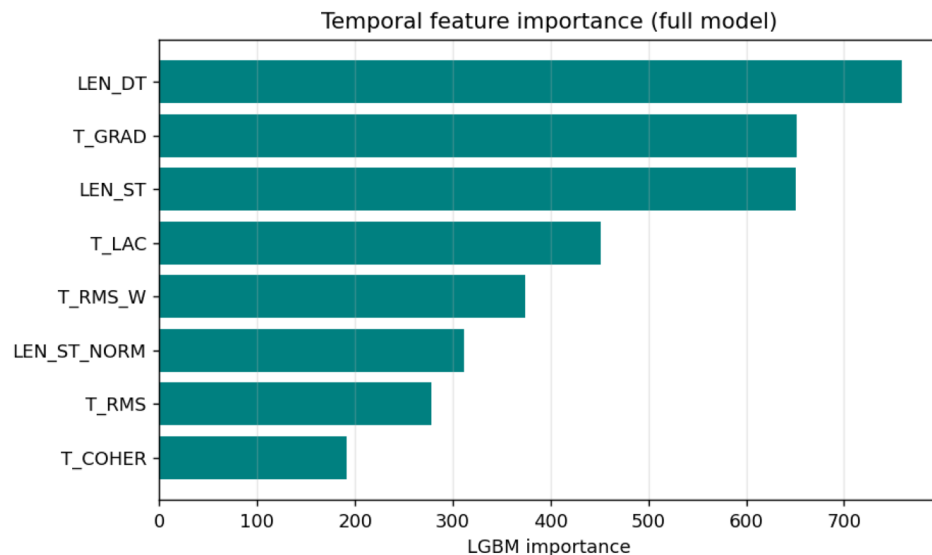
Selected time-based parameters

Parameter name	Description	Involves	Type
T_GRAD	Time gradient (defined as in MAGIC)	Time, position	Standard
T_RMS	Root mean square	Time	Standard
T_RMS_W	Root mean square weighted for pixel content	Time, pixel content	Standard/mod
T_LAC	Lacunarity (a measure of <i>time density</i>)	Time	Time sequence
T_COHER	Coherence (correlation between space and time evolution of the shower)	Time, position	Time sequence
LEN_ST	Dispersion (in length) in the <i>time/pixel content</i> space	Time, pixel content	Size/time space
LEN_ST_N	As above, normalized for the total image size	Time, pixel content	Size/time space
LEN_DT	Dispersion (in length) in the <i>time/distance from barycenter</i> space	Time, position	Distance/time space

G/H discriminating power on MC production



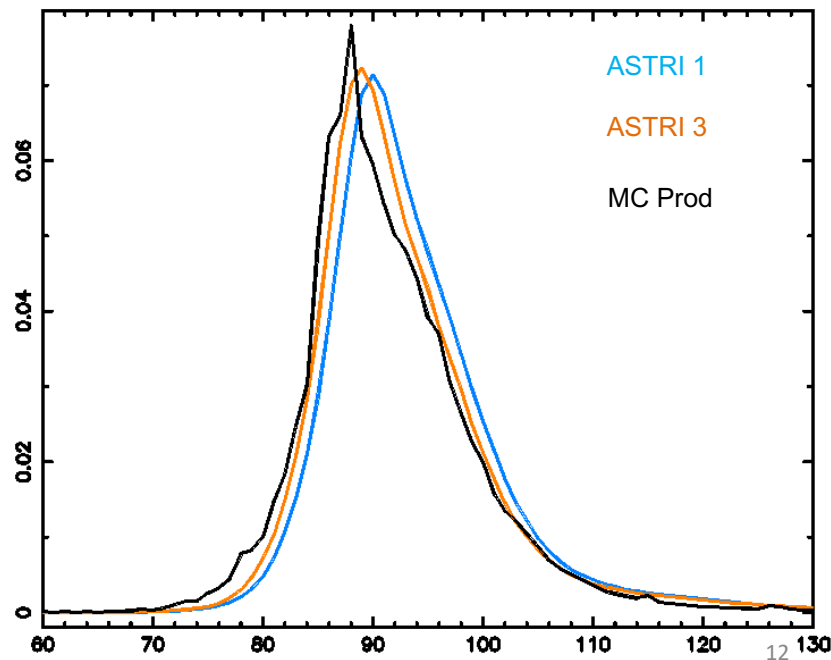
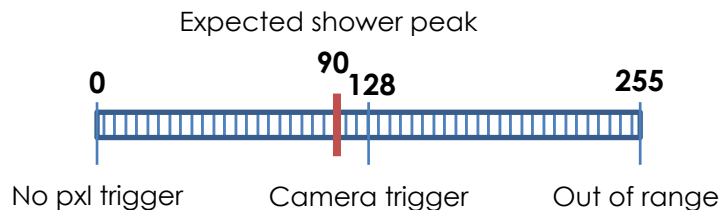
Discriminating power on updated MC production



- Check on pixel time distribution (Real data vs MC)
- Comparison between real data and MC production
- Consistency check between ASTRI1 and ASTRI3
- On/Off comparison in real data

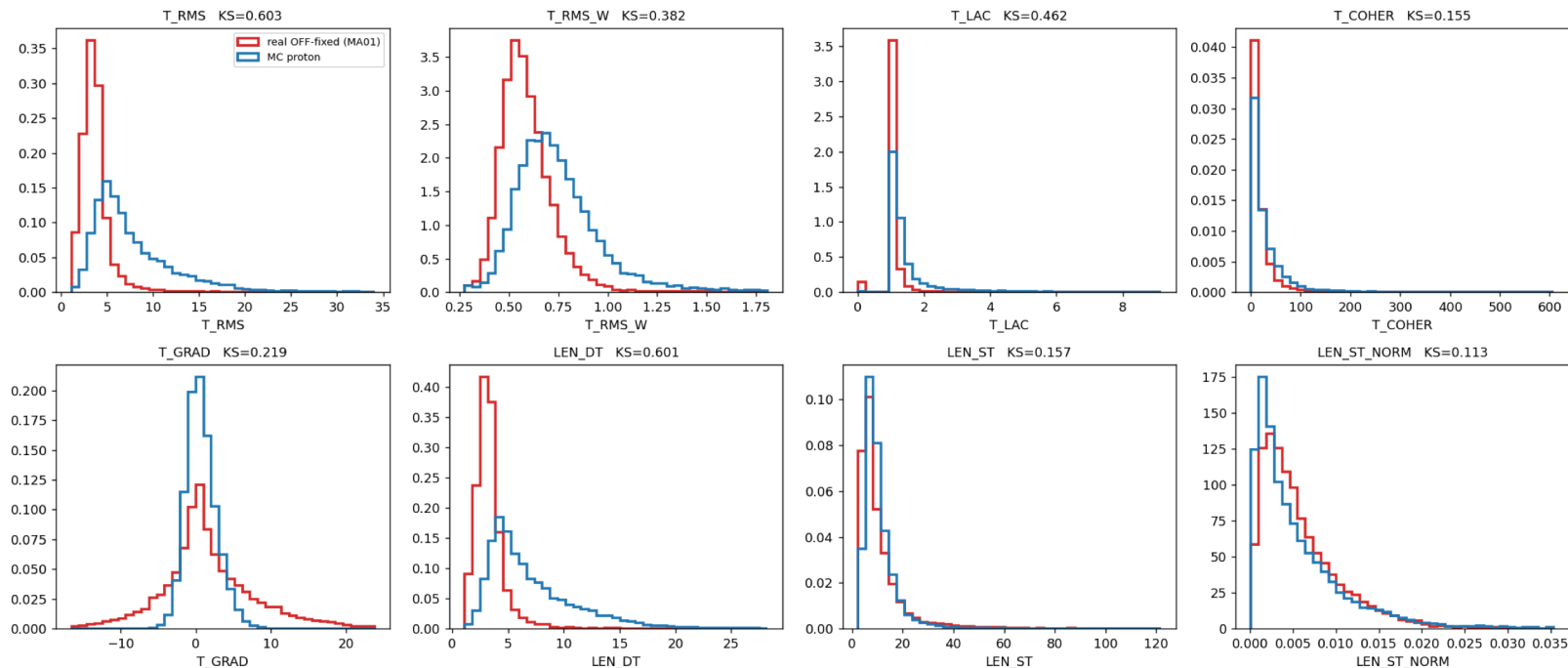
Check on pixel time distribution – real vs MC

Time recorded in each pixel.
The three curves in each plot refer to ASTRI1, ASTRI3,
and the MC production



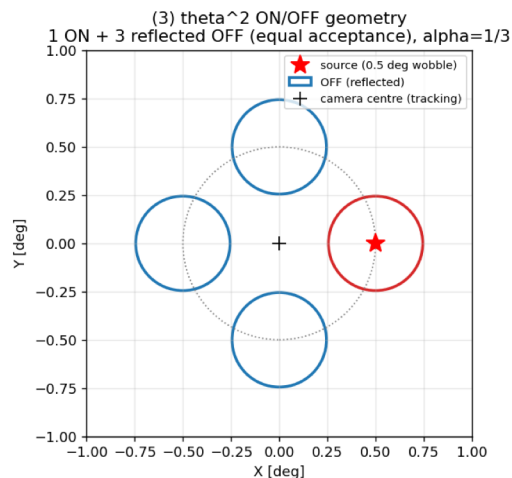
Comparison between real data and MC production

Hadronic bkg selected on a 20-180 fixed pointing run, coherent with the simulation

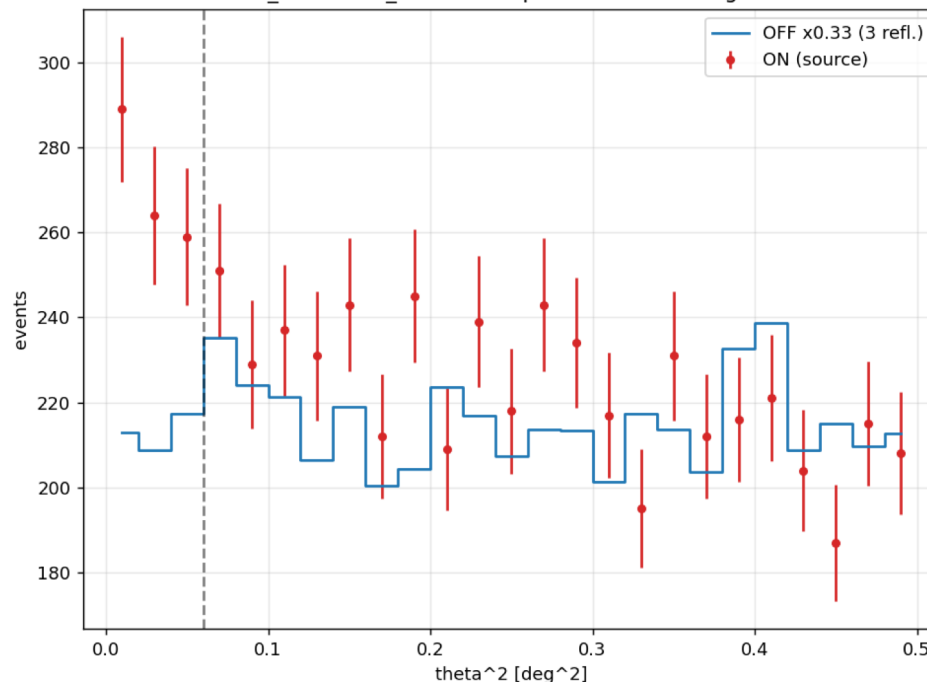


Comparison between real data and MC production

Source and background selection regions

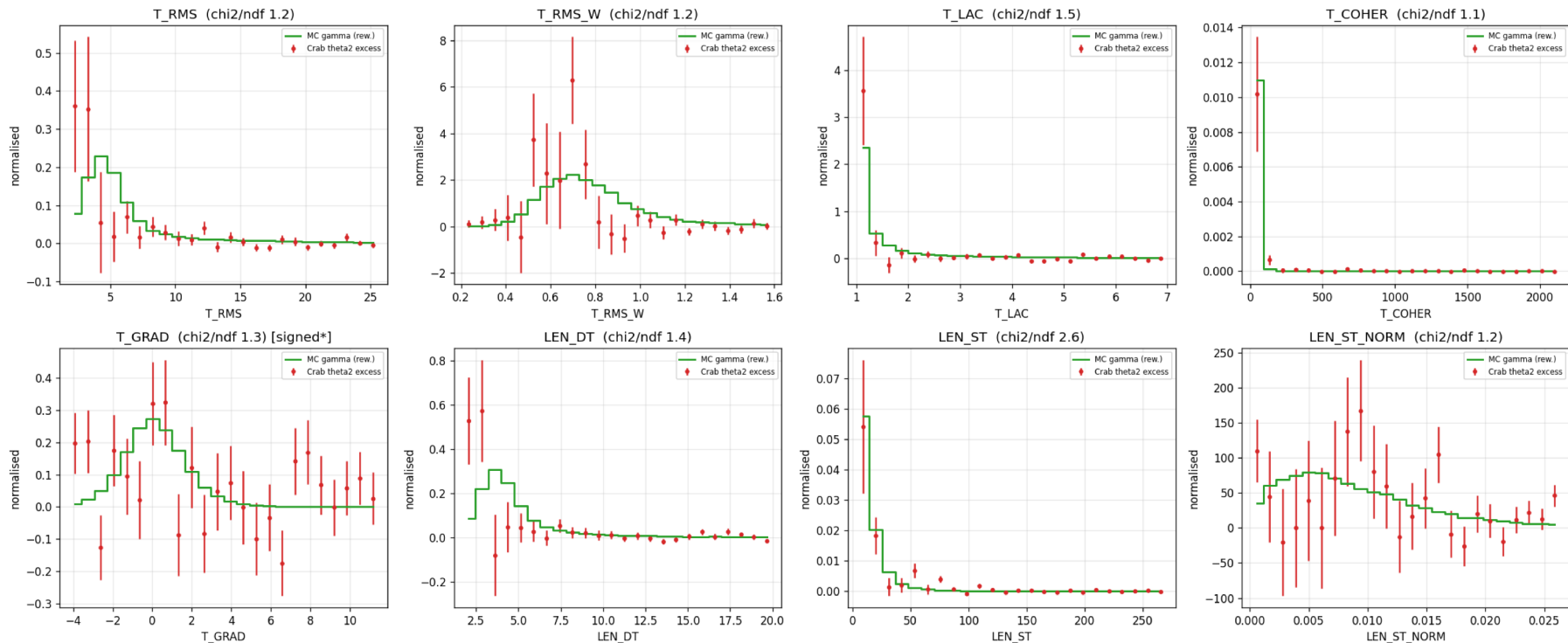


Crab θ^2 (mono, prod 0.21.1, gammaness>0.85)
 $N_{\text{on}}=812$ $N_{\text{off}}=1917$ $\alpha=0.33 \rightarrow 5.6$ sigma



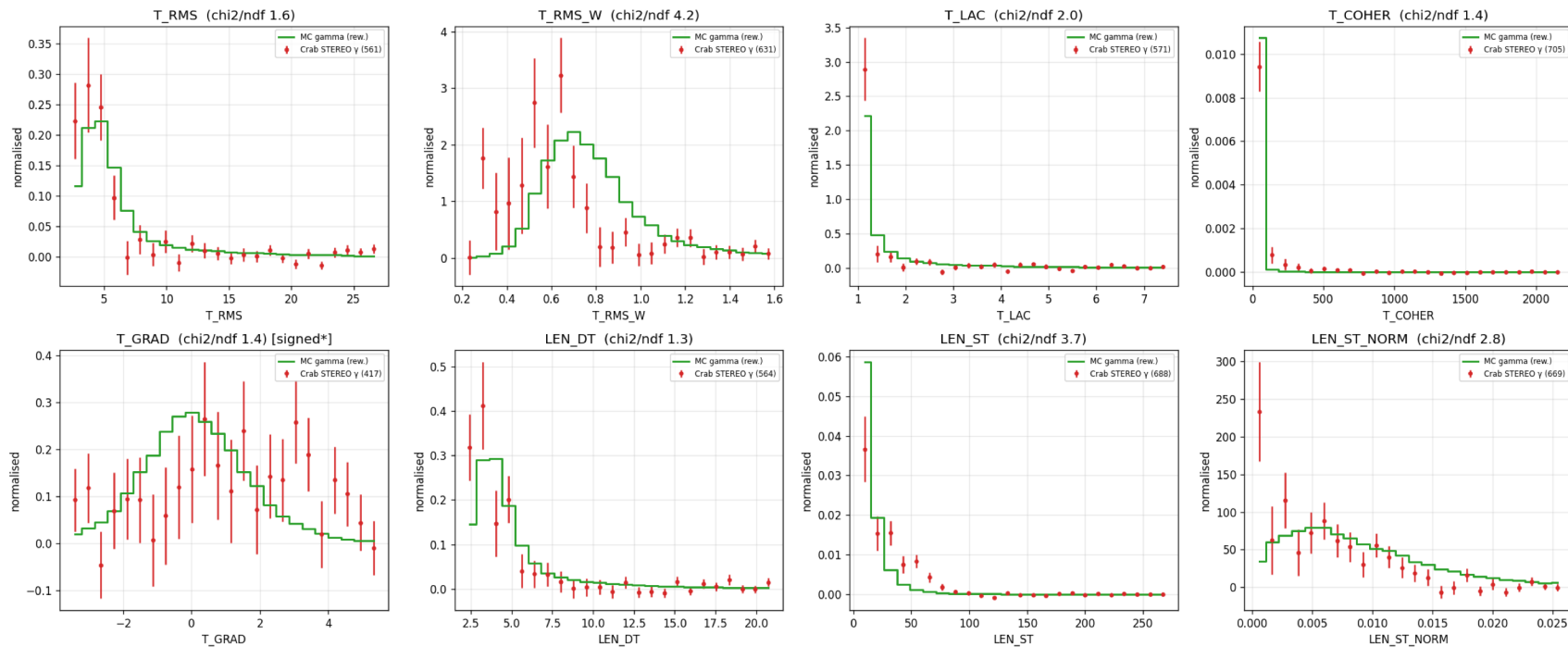
Comparison between real data and MC production

Gamma-like selected with $\text{disp}/\theta^2 < 0.06$ on A1 Crab pointed observations [$\sim 35\text{h}$]
Excess plot over MC Gamma production



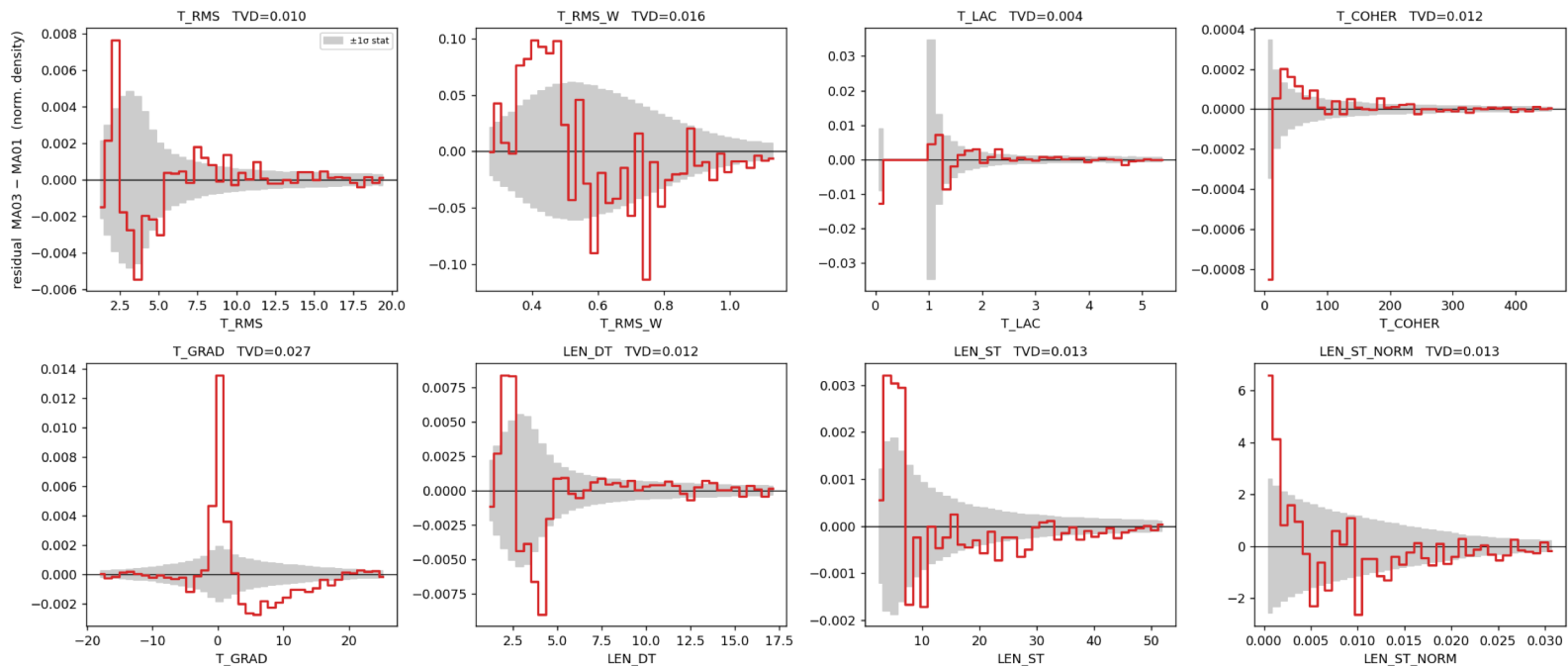
Comparison between real data and MC production

Gamma-like selected with stereo coincidence on A1/A3 Crab pointed observations [~ 26 h]
Excess plot over MC Gamma production



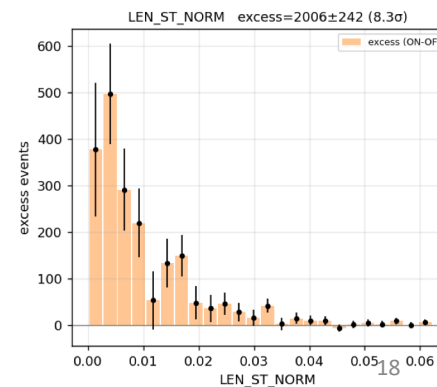
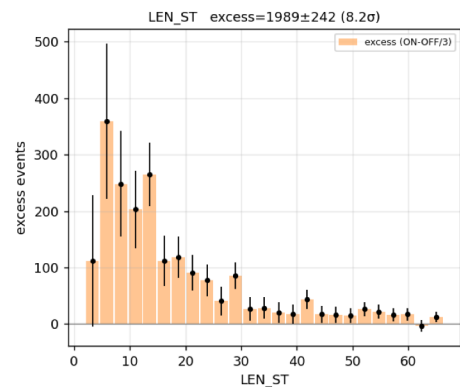
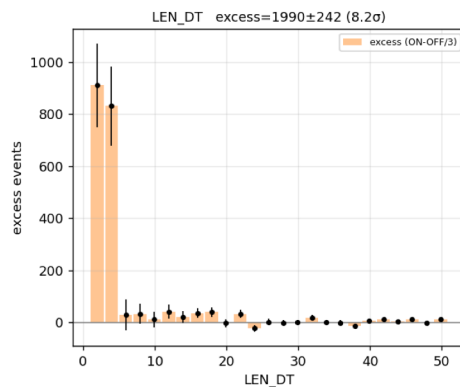
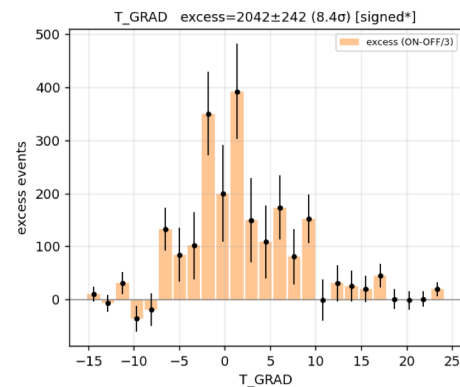
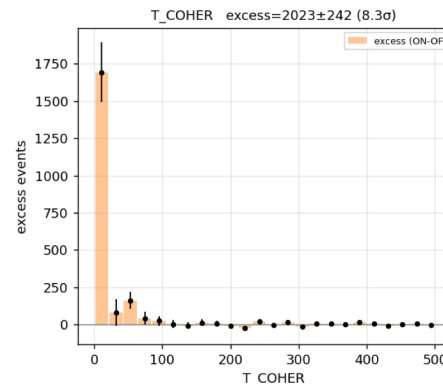
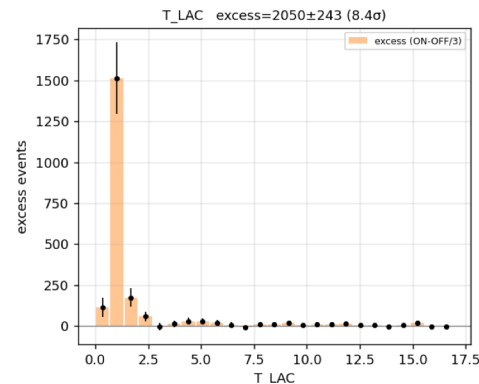
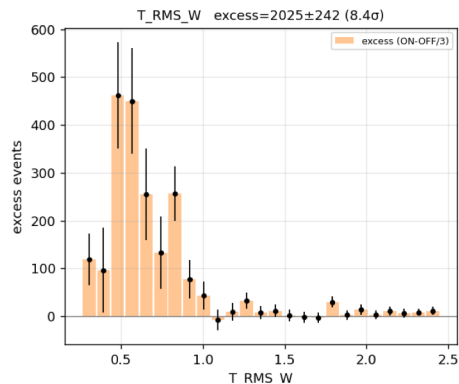
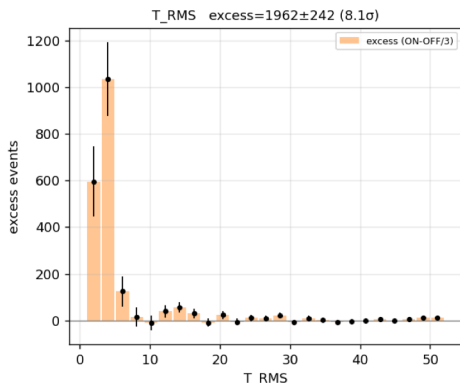
Consistency check between ASTRI1 and ASTRI3

Time parameter residual plots for ASTRI1 and ASTRI3 evaluated on a simultaneous run at fixed pointing (20-180). [RunID 1574 on 2026-02-12]



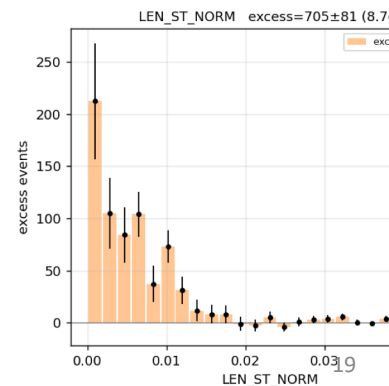
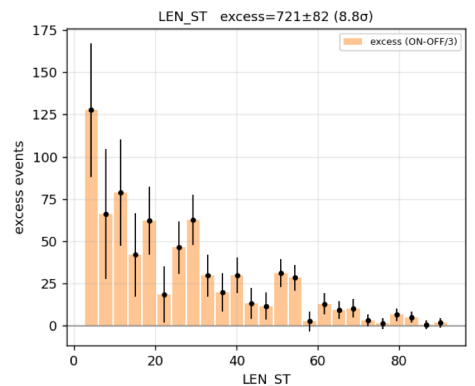
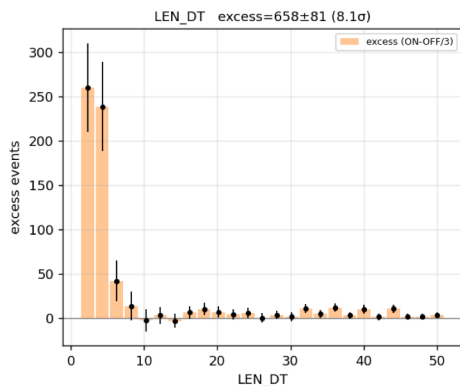
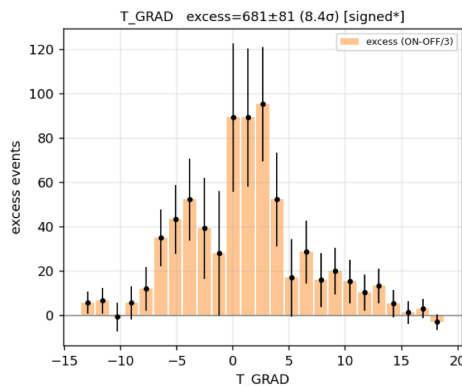
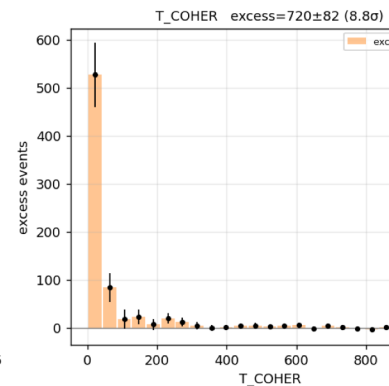
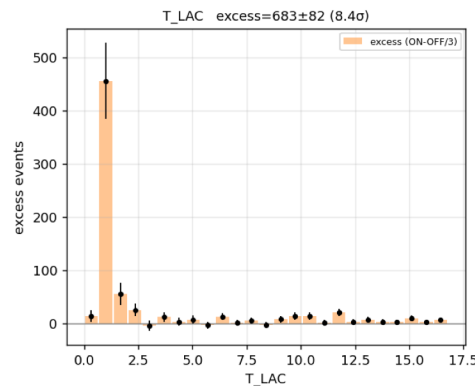
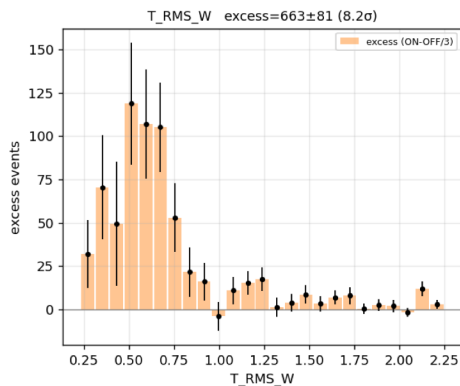
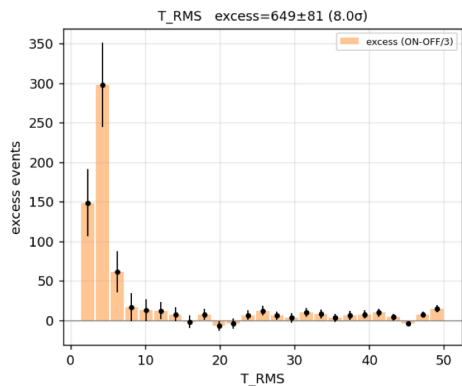
On/Off comparison in real data

Real Crab MONO gamma EXCESS (ON - OFF/3), zoomed per panel — MA03 temporals (data only)



On/Off comparison in real data

Real Crab STEREO gamma EXCESS (ON - OFF/3), zoomed per panel — MA03 temporals (data only)



- The updated MC production confirms the **good discriminating power** of the temporal parameters, mainly at low-to-medium image size
- The distribution of pixel time tags in the MC data is **consistent with real data**. A discrepancy is still visible in pixels with high pe content, that could be due to a residual mismatch waveform representation
- Temporal parameters are **well consistent between ASTRI1 and ASTRI3**
- The distribution for gamma-like events is consistent but still with very low statistics. The distribution for hadronic events still need to be adjusted.
- On/Off comparison in real data show **a significant excess** for all the parameters
- After the last technical tests for the integration of the code into ASciSoft, the time parameters are on their way to be a stable part of the reconstruction procedure.