Gamma-ray Pulsars with DAMPE

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On behalf of the DAMPE Collaboration
July 27th, 2019
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Outline

- DAMPE mission
- Data Selection
- Pulsars Search
- Preliminary results
- Conclusions & Outlook

DArk Matter Particle Explorer | DAMPE| WUKONG

ALTITUDE: 500 km

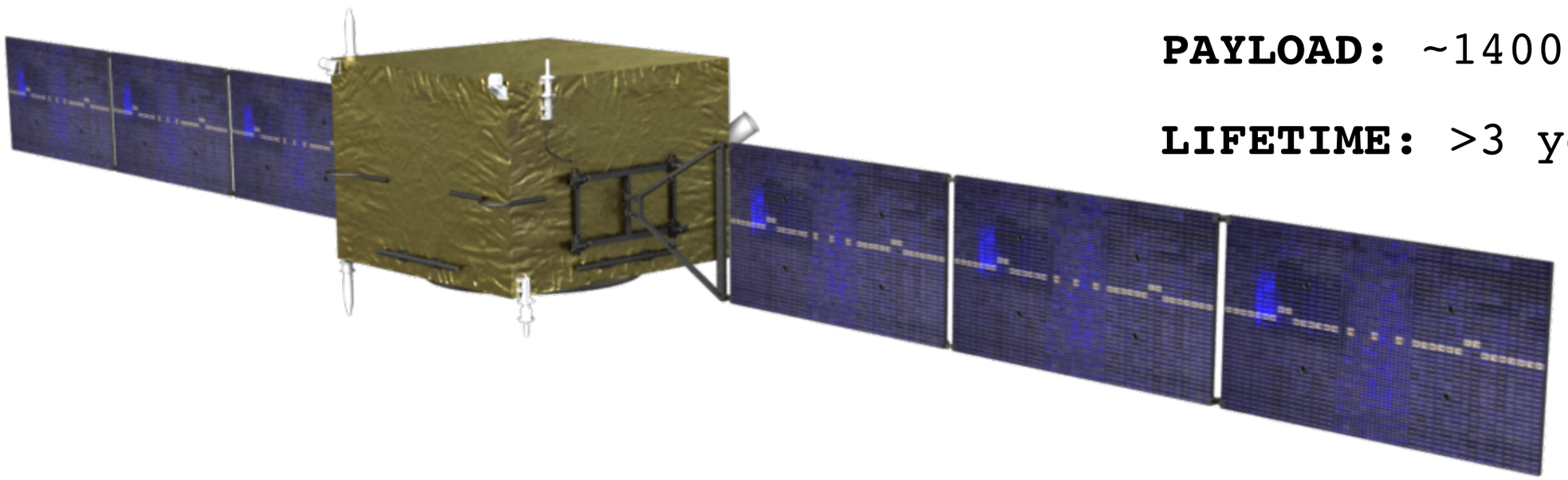
INCLINATION: 97.4065°

PERIOD: 95 minutes

ORBIT: sun-synchronous

PAYLOAD: ~1400 Kg, 400 KW

LIFETIME: >3 years



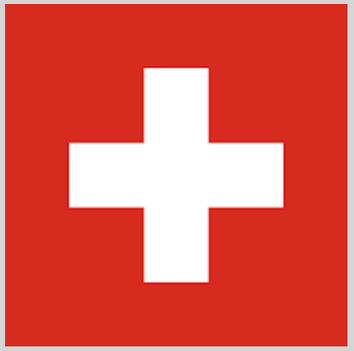
China's first Astronomical Satellite

- Launched the 17th of December 2015
- Instrument turned on 3 days after launch

DAMPE taking good data since 10 days after the launch

The Collaboration

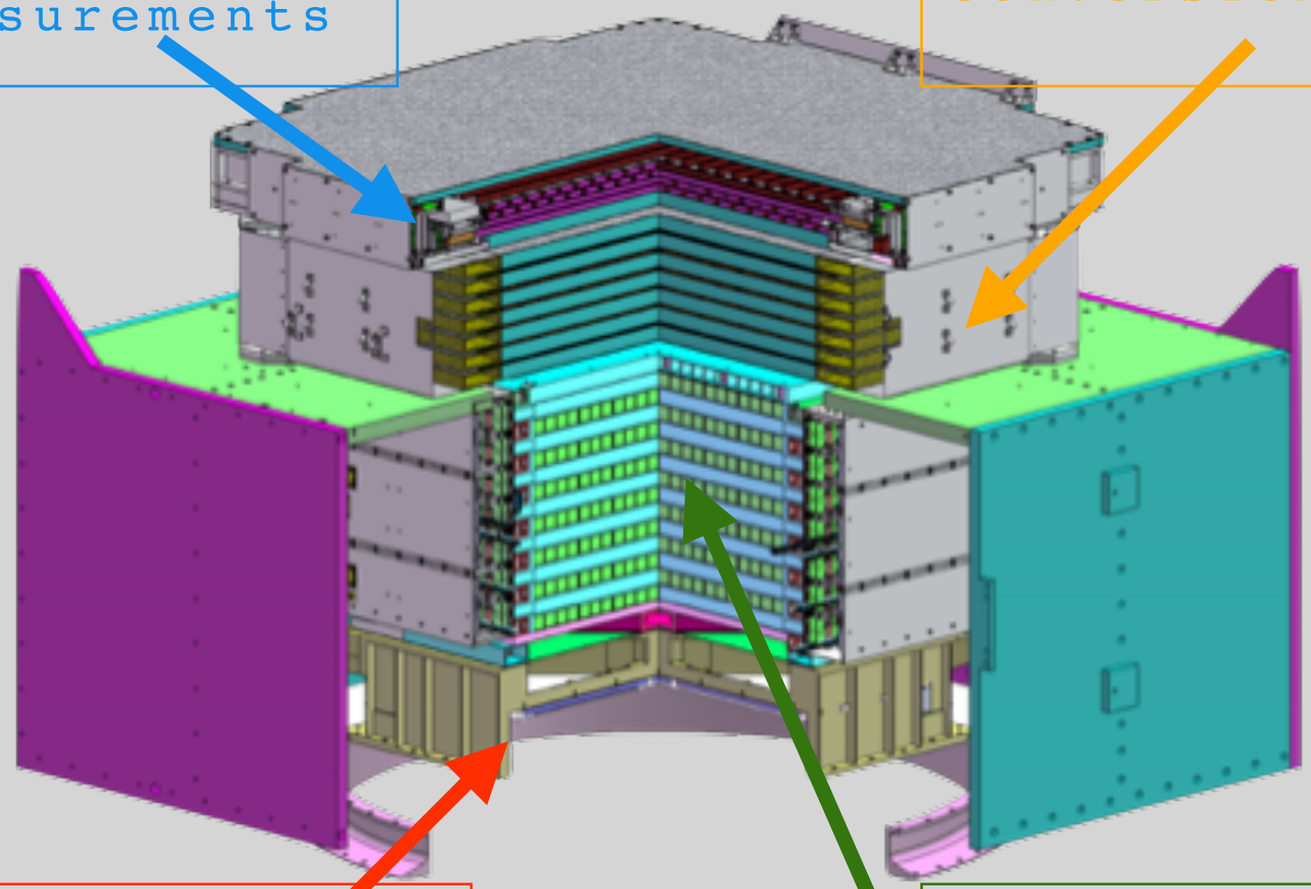
- China:
  - Purple Mountain Observatory, CAS, Nanjing.
  - University of Science and Technology of China, Hefei
  - Institute of High Energy Physics,CAS,Beijing
  - Institute of Modern Physics,CAS,Lanzhou
  - National Space Science Centre, CAS, Beijing
- Switzerland
  - University of Geneva, Switzerland
- Italy:
  - INFN Perugia and University of Perugia
  - INFN Bari and University of Bari
  - INFN Lecce and University of Salento



Instrument Design

Plastic Scintillator Detector (PSD):which is used both as an anti-coincidence detector and for charge measurements

Silicon TracKer(STK): six double layers, the first layers are interspaced with tungsten for pair conversion of Gamma-Rays.



NeUtron Detector(NUD): 4 blocks of boron-loaded plastics scintillators, for hadrons identification for energies above 150 GeV.

BGO Electromagnetic Calorimeter for electron/proton separation, and energy measurements.

Scientific Objectives

Cosmic-ray physics. DAMPE can provide measurements of various nuclei fluxes to better understand the origin and the acceleration of Cosmic-rays.

Gamma-ray physics. DAMPE can reveal the engimatic nature of high energy γ-ray phenomena, such as violent GeV-TeV transients;

Probing the nature of the DM :Search of gamma-ray line emission which can be expected in the DM annihilation channel.The CR electron/positron spectra can also be used to probe DM.

Photon Selection

Electron/Proton Separation

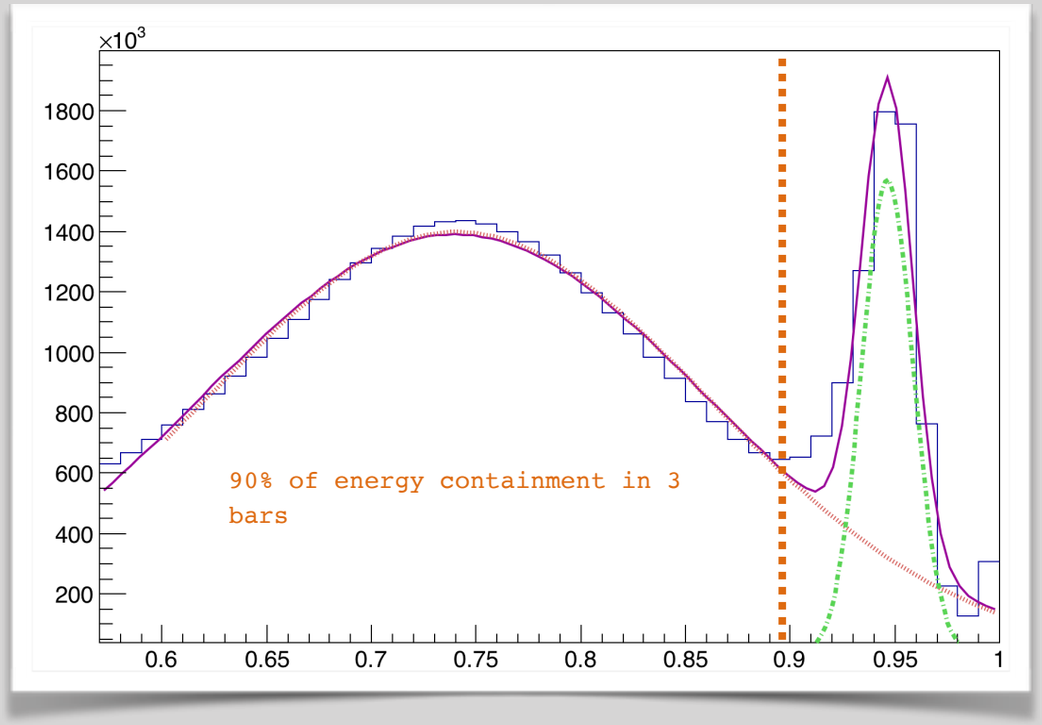
Different signatures in the BGO

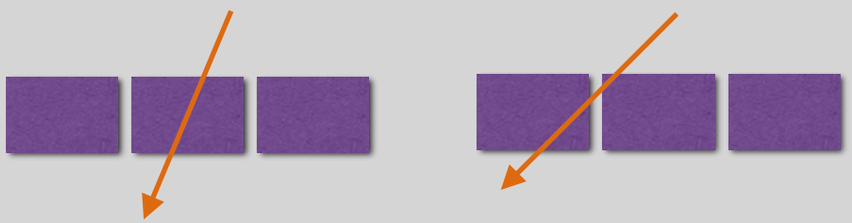
Between Hadronic and EM shower

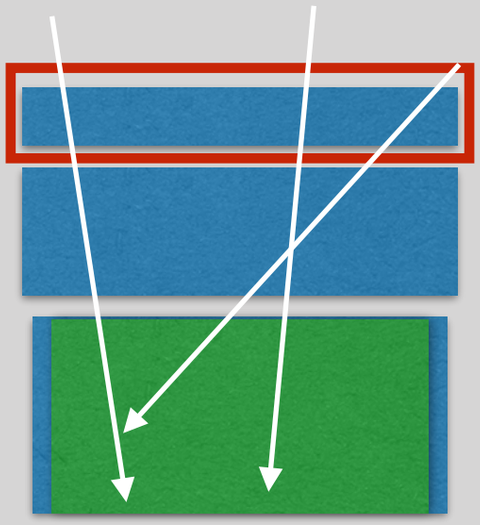
Moliere Radius:

1 MR->90% EM Shower Containment

3MR->95% EM Shower Containment





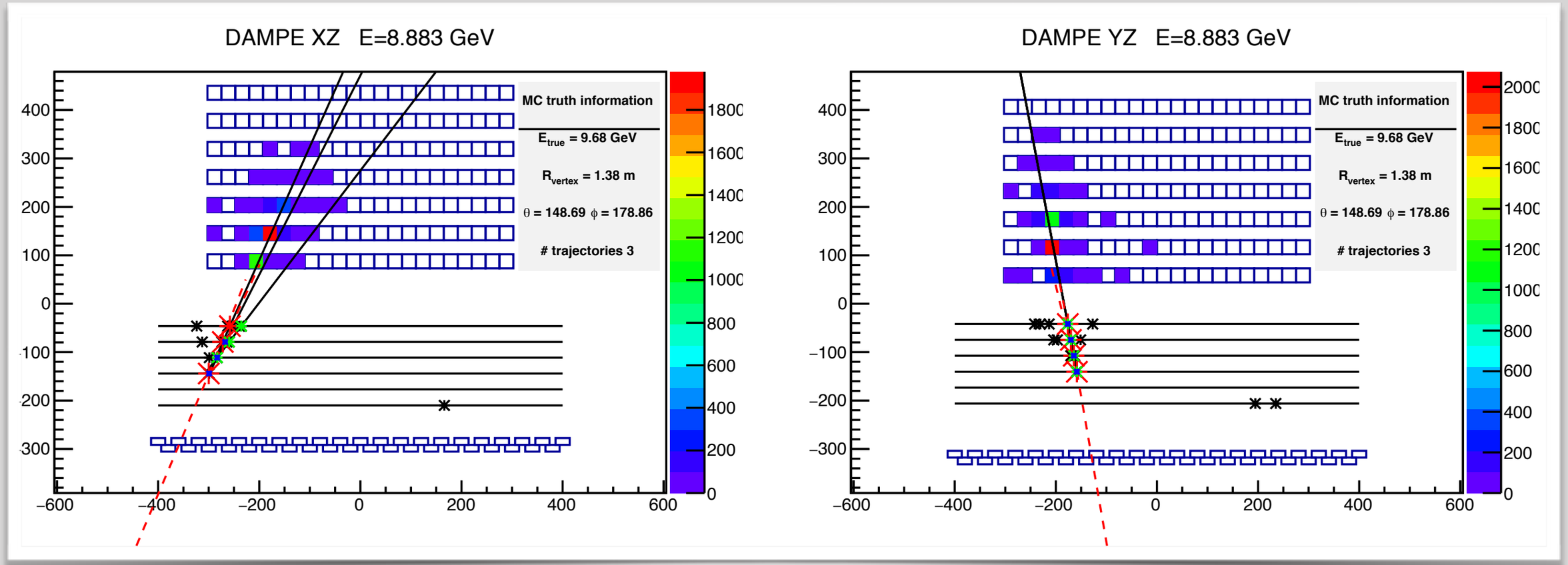


Electron/Gamma Separation

Requires track to cross PSD

Photon conversion after the 1st tungsten Layer

No hit PSD


DAMPE XZ E=8.883 GeV
MC truth information
E_true = 9.68 GeV
R_vertex = 1.38 m
θ = 148.69 ϕ = 178.86
trajectories 3
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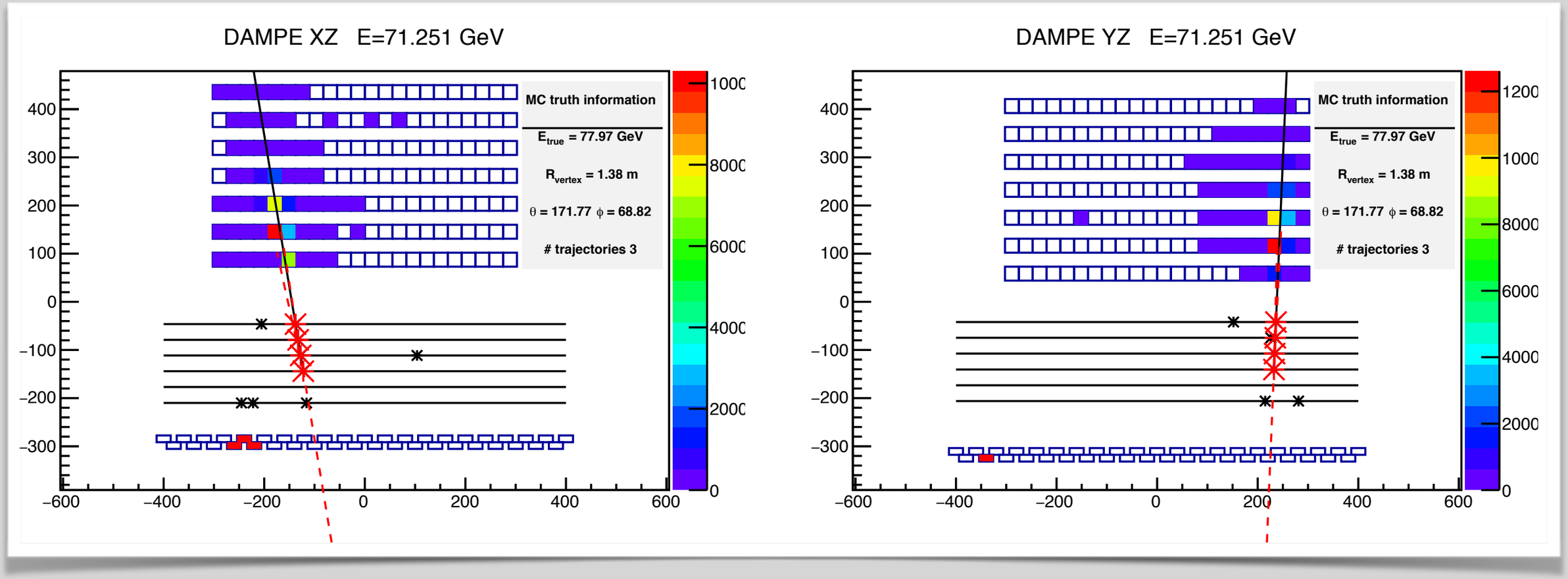
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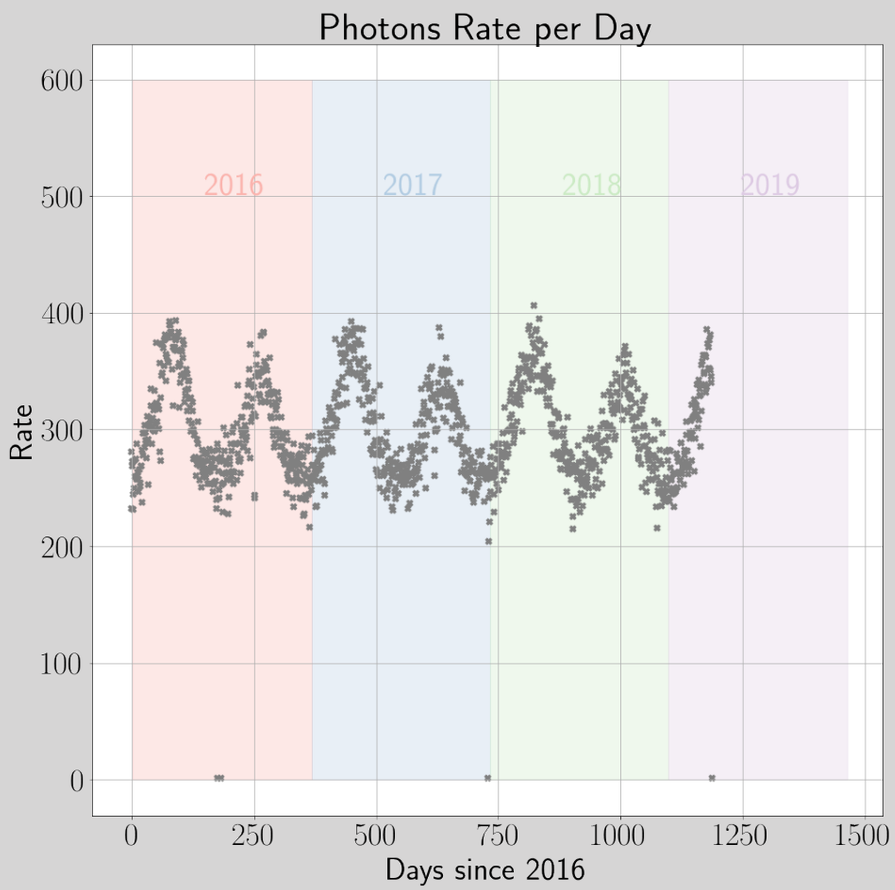
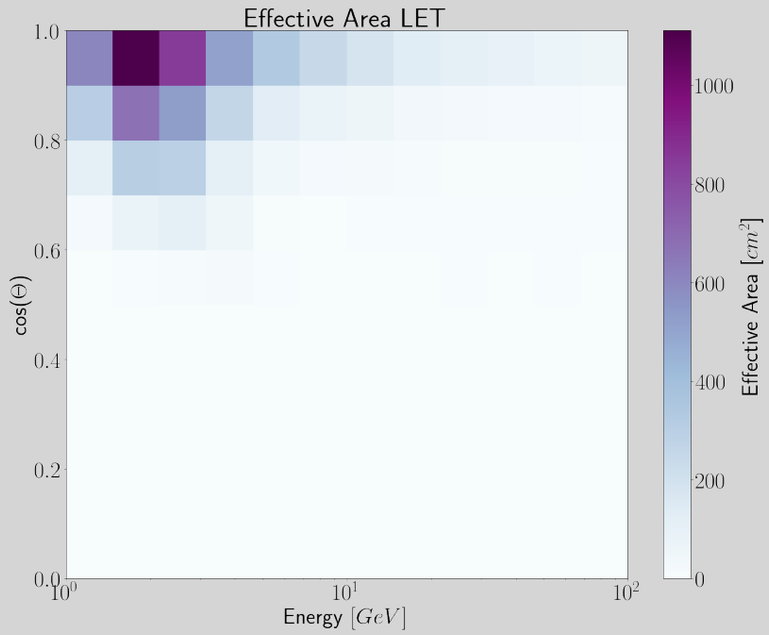
Selection

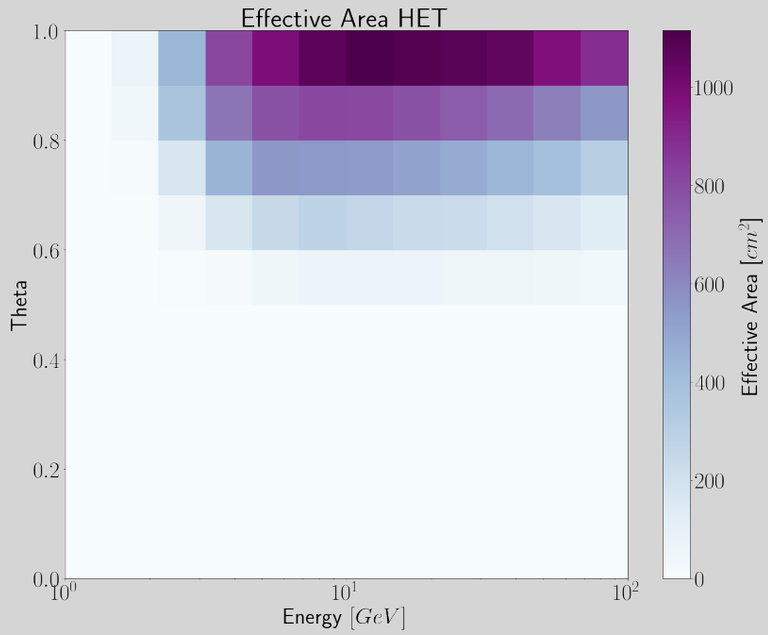


Total amount of events selected in ~39 Months of search—>354,985

Event Rate since 28/12/2015 till 31/01/2019

~300 photons per day





The Effective Area is trigger dependent LET->Pre-scaled ->~9% Events Selected HET->~90% Events Selected

How to Detect Pulsars with DAMPE?

- Current way:
  - Folding gamma-ray photons according to a known pulsar timing model, from radio, X-rays or gamma-rays. Ephemerides obtained by D.Smith.

Obtained from: https://apod.nasa.gov/apod/ap180317.html

- Search window of 3 degree radius.

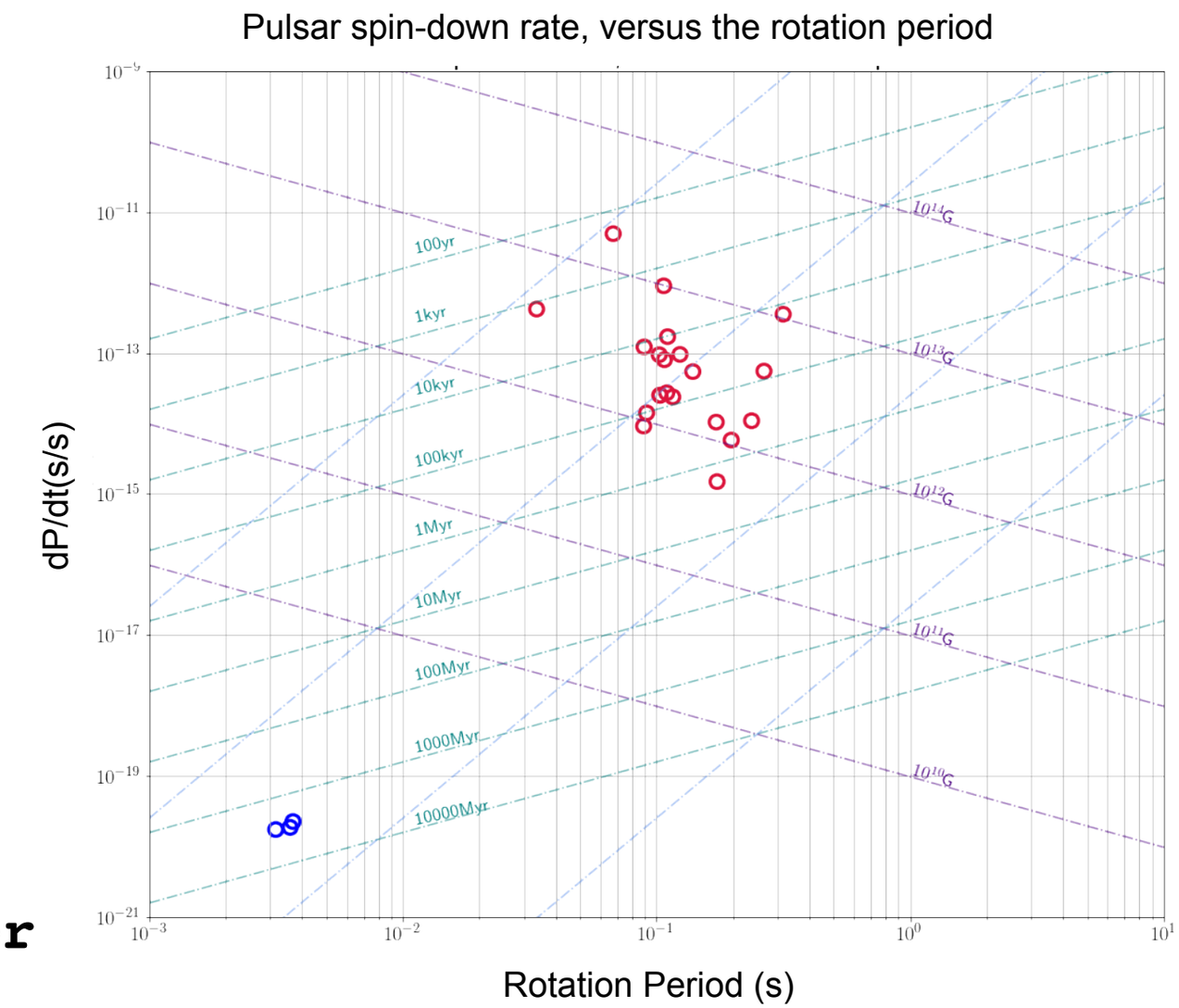
Pulsars search

Data used is smaller than the Lifetime -> ~2 years, Limited by the validity of the ephemerides.

More than 20 pulsars studied at the moment.

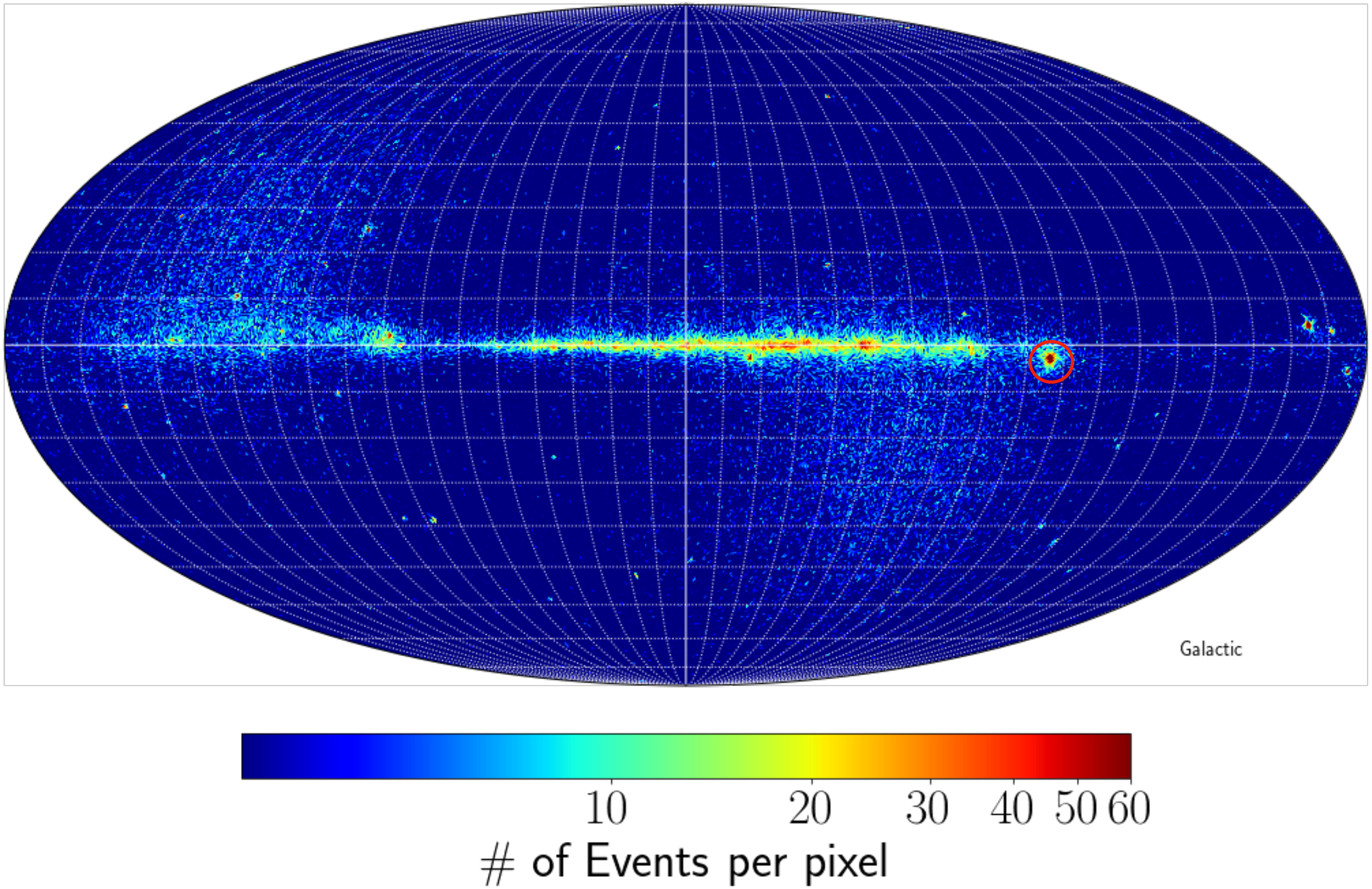
Pulsars Validation H-Test.

Phase shape validation with other experiments



Blue circles correspond to MSP

J0835-4510->Vela



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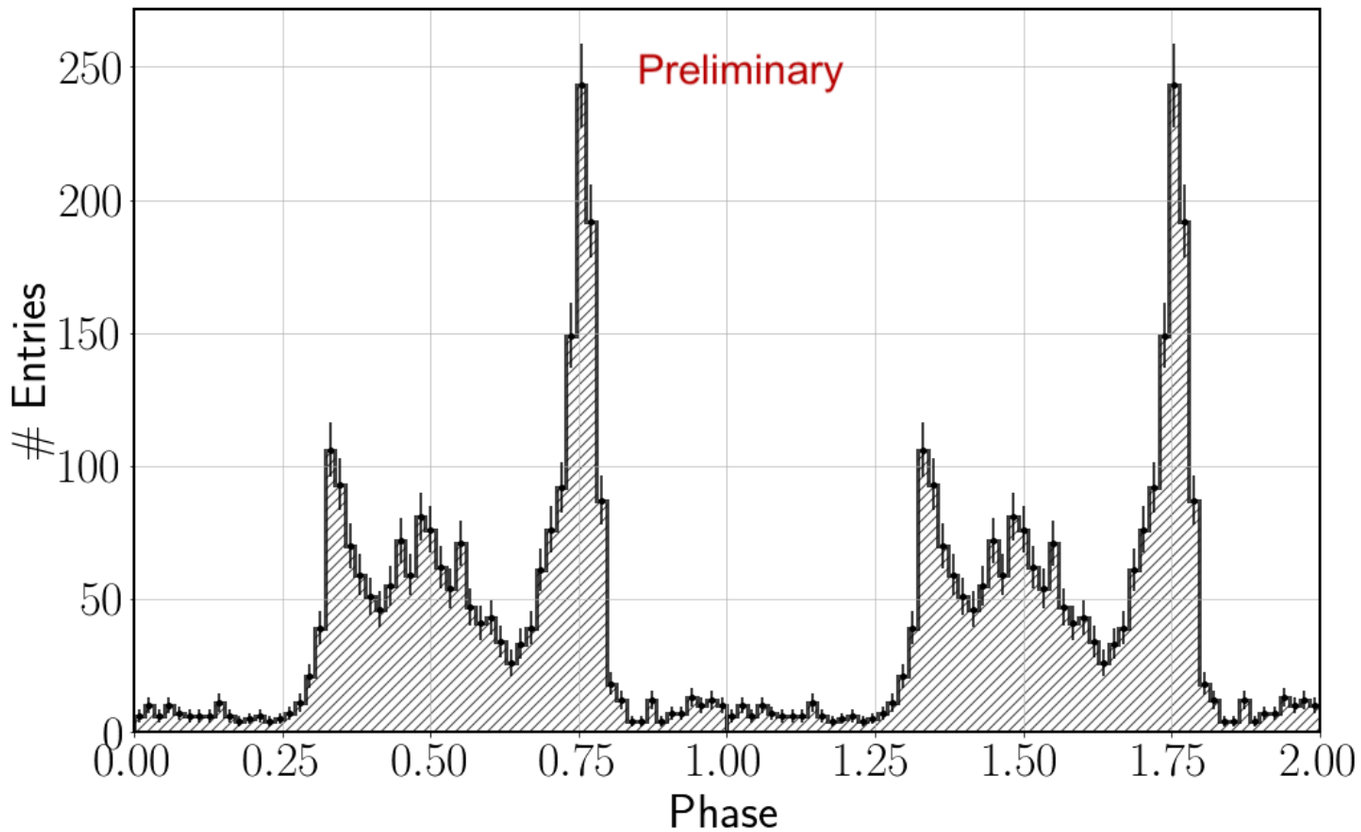
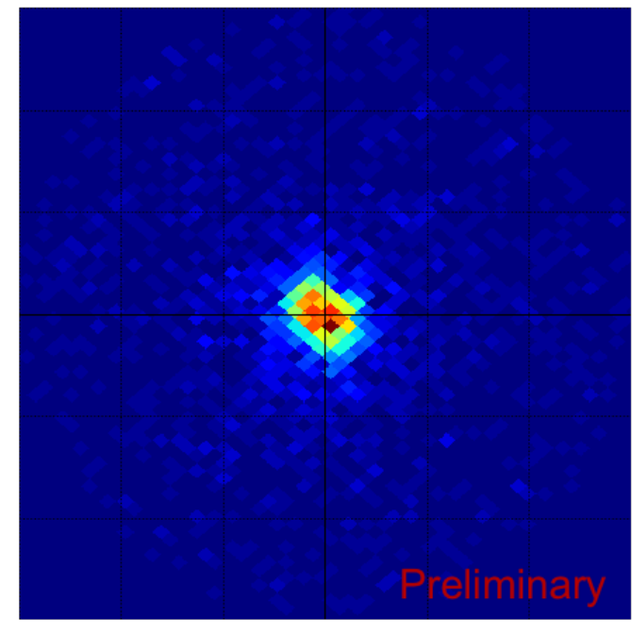
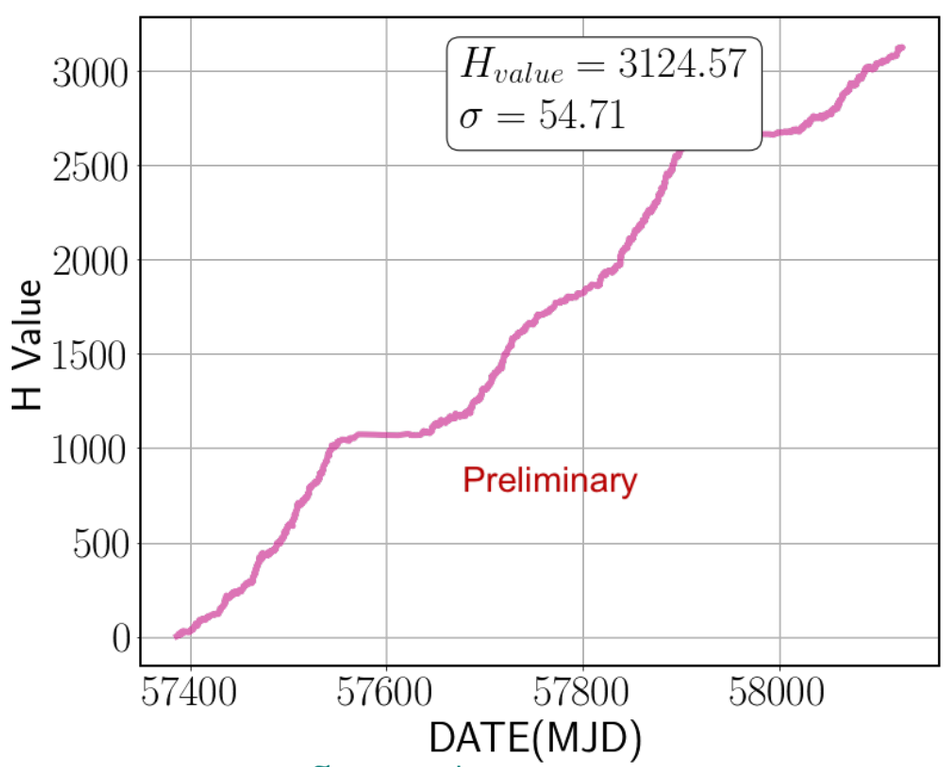
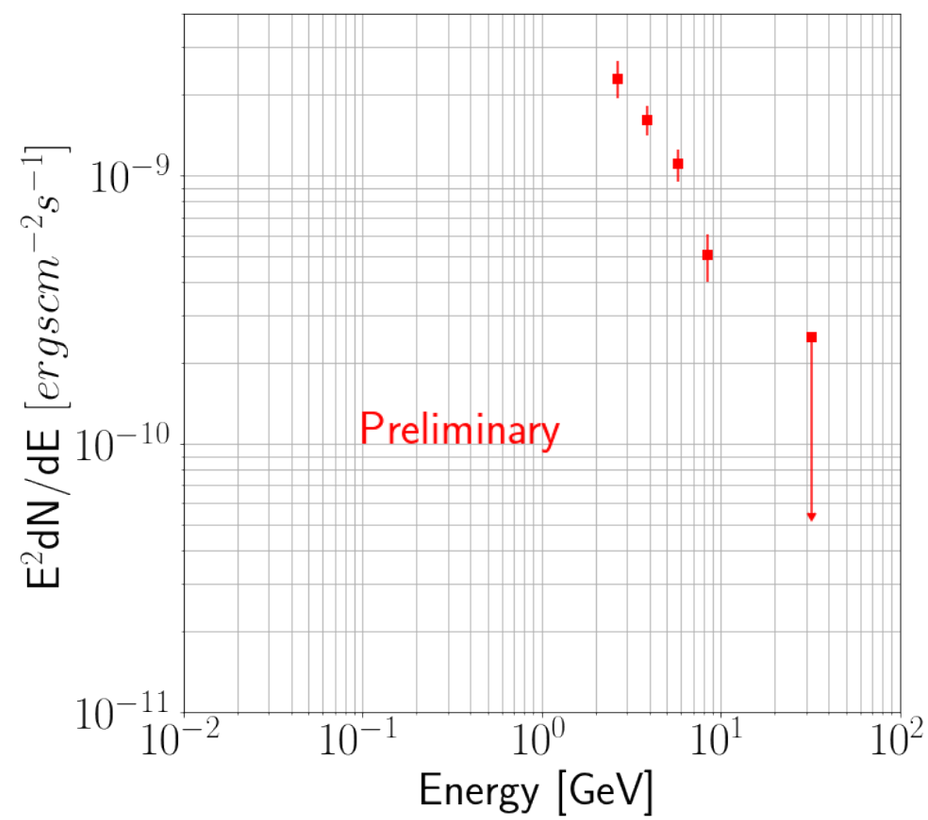
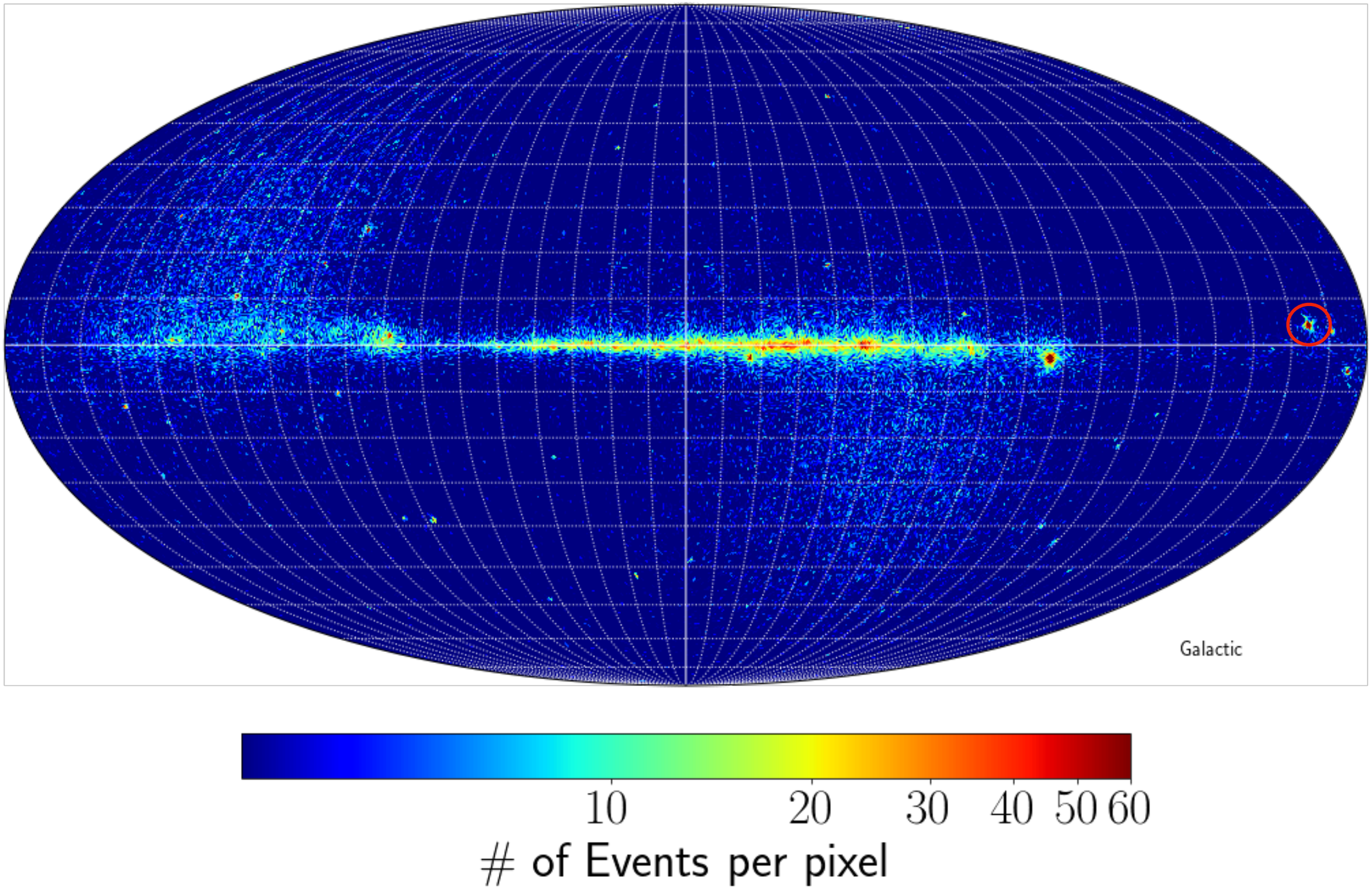








J0633+1746-> Geminga



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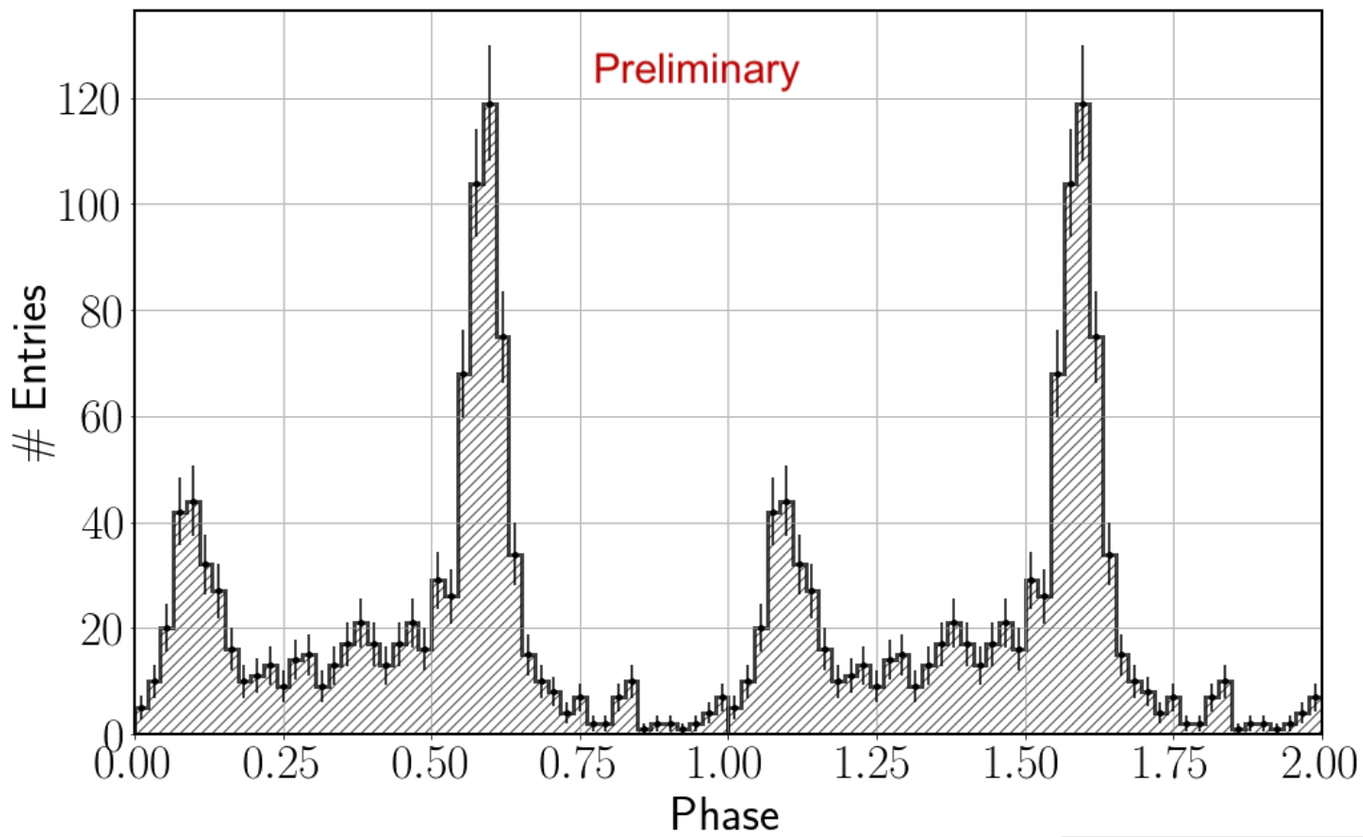
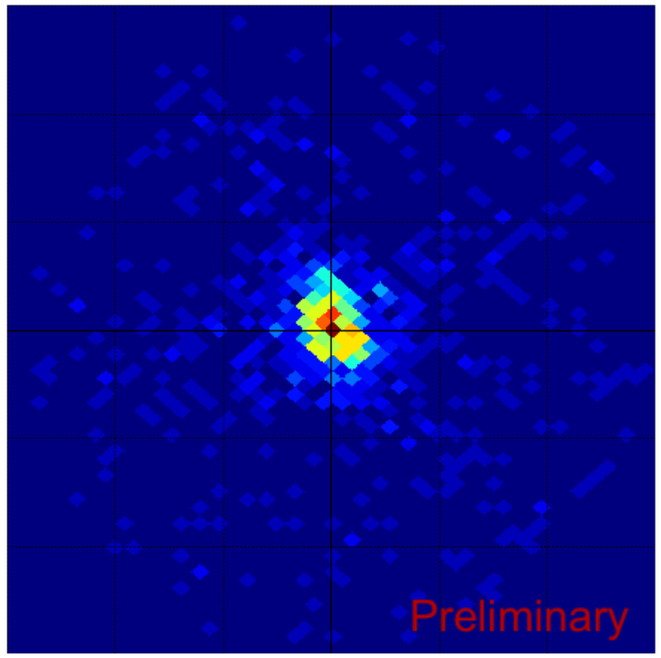
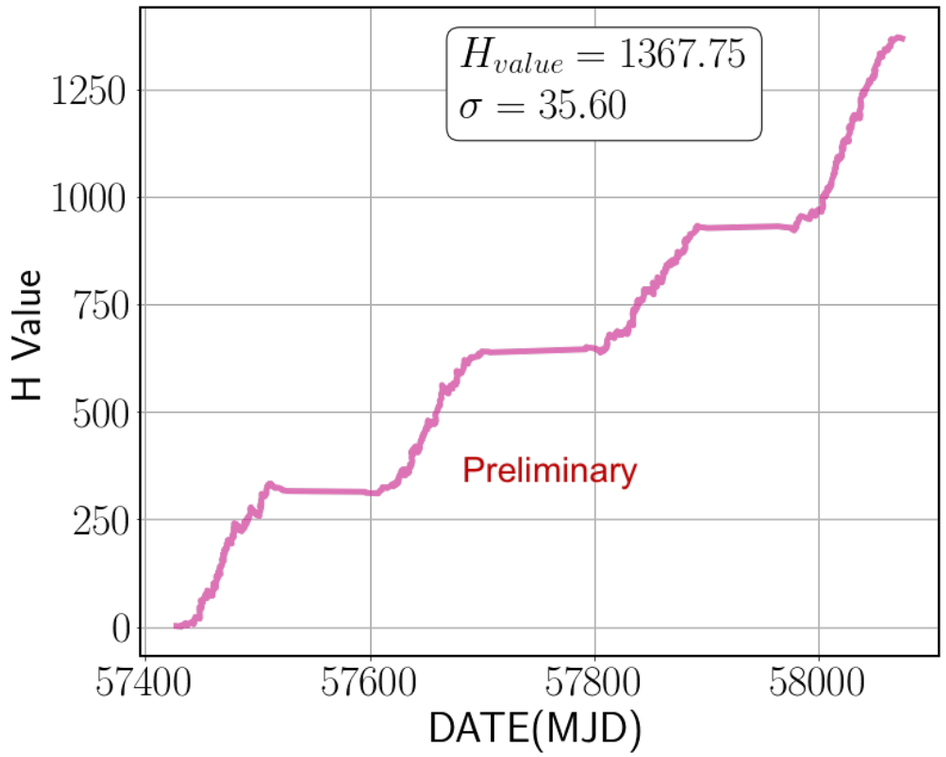
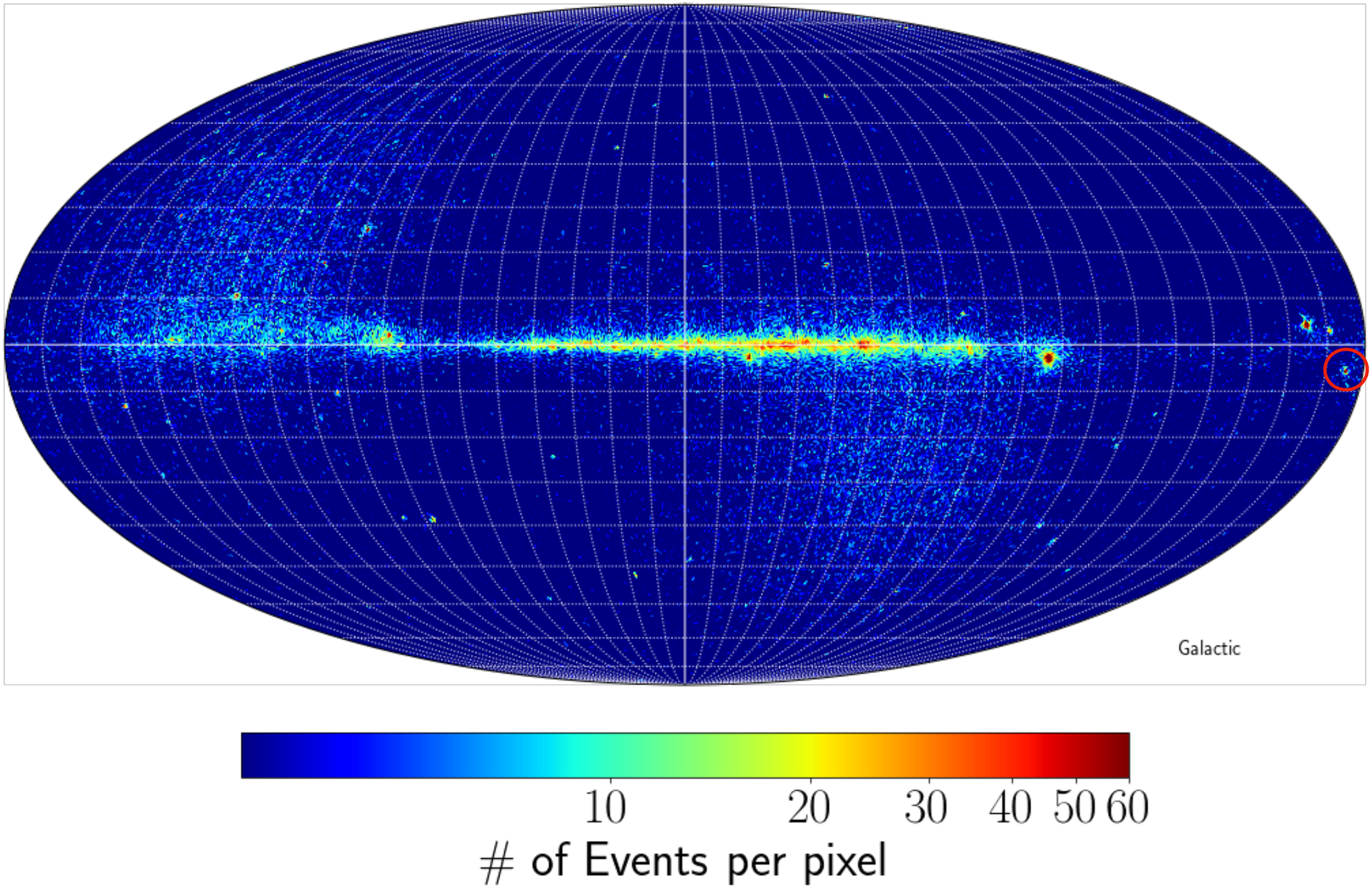


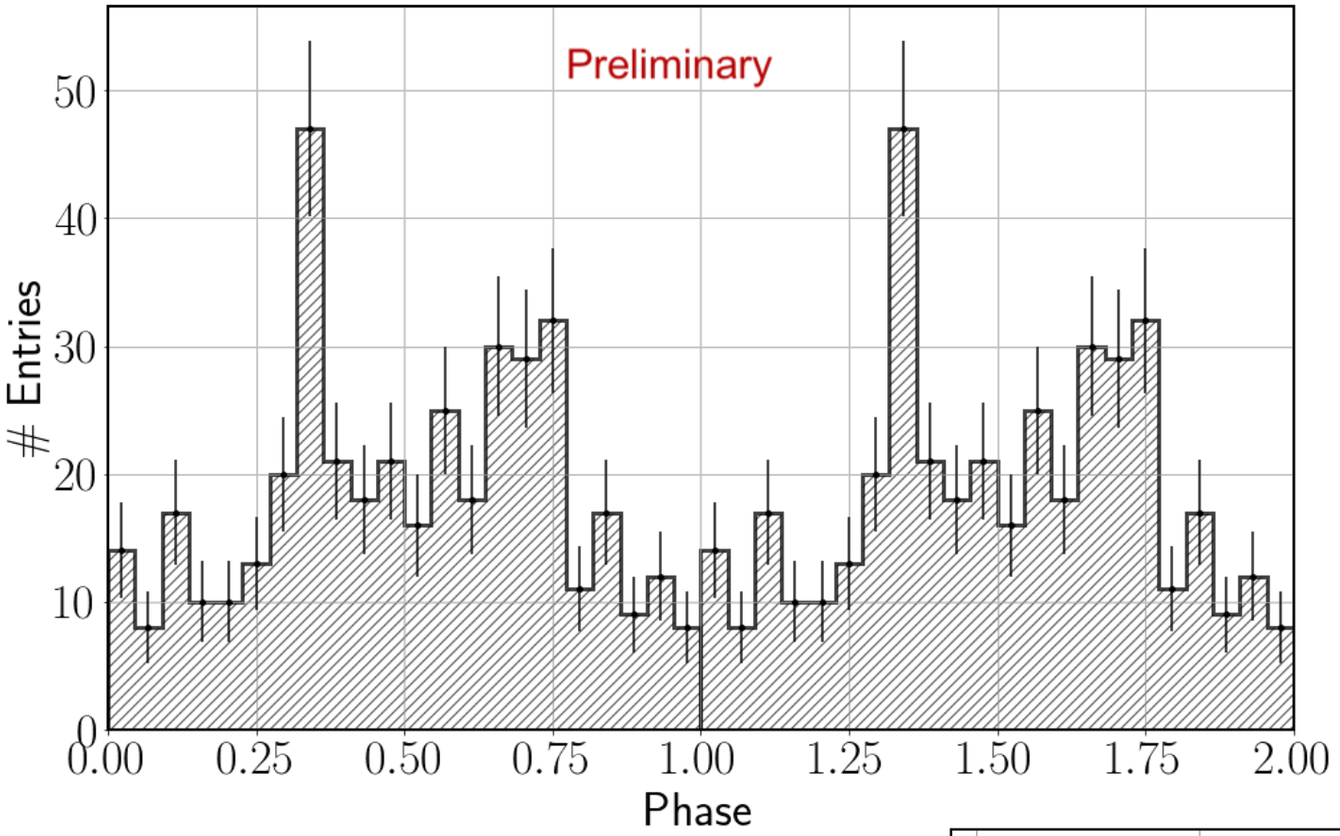


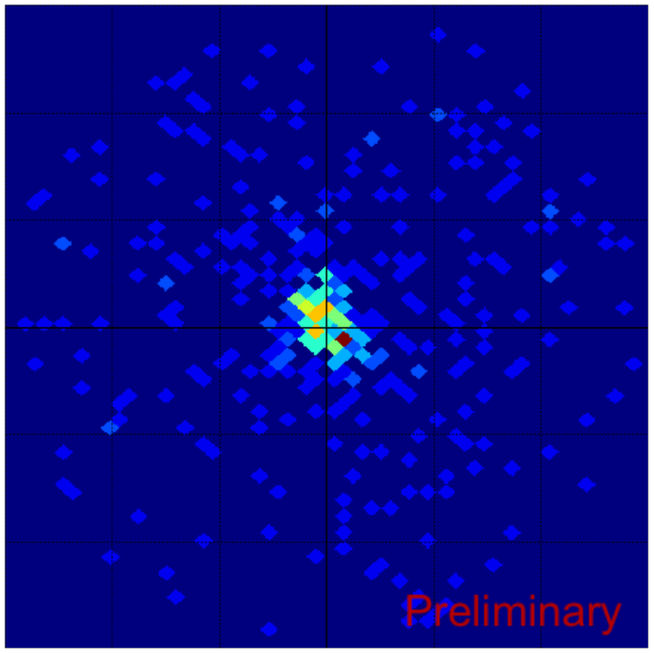


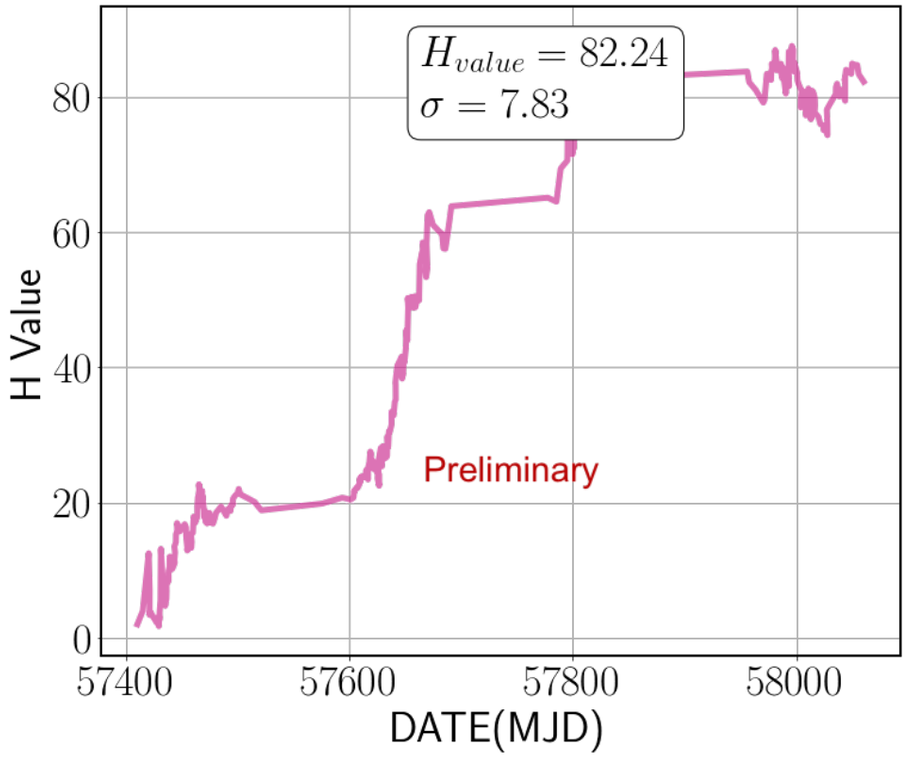
J0534+2200->Crab



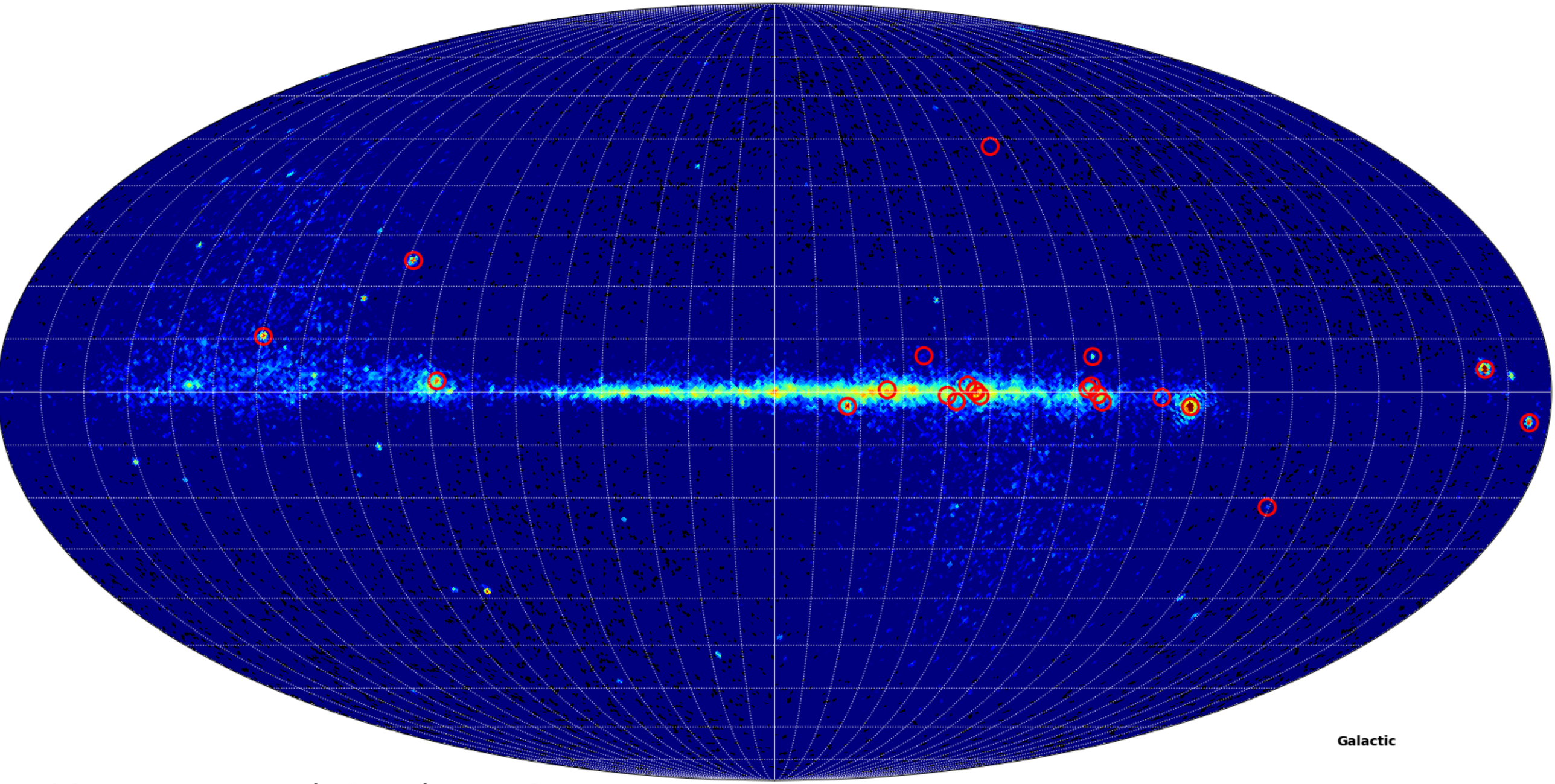
J0534+2200->Crab



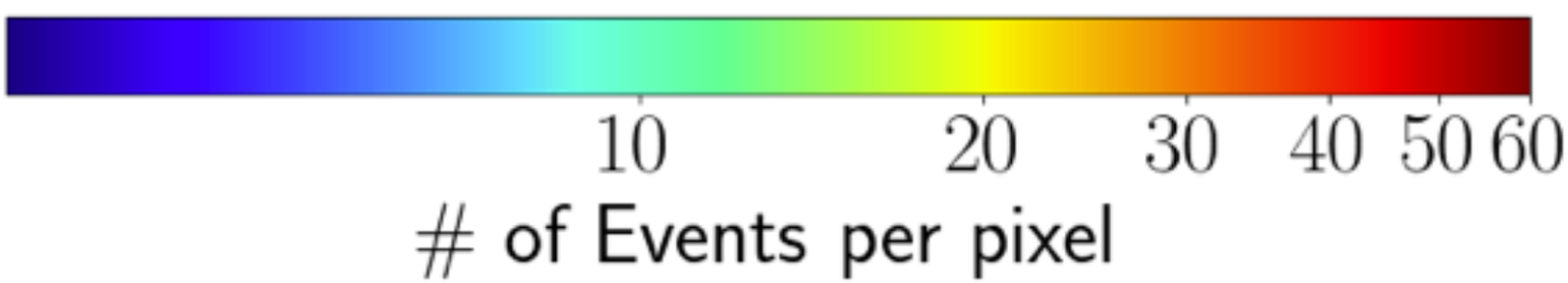


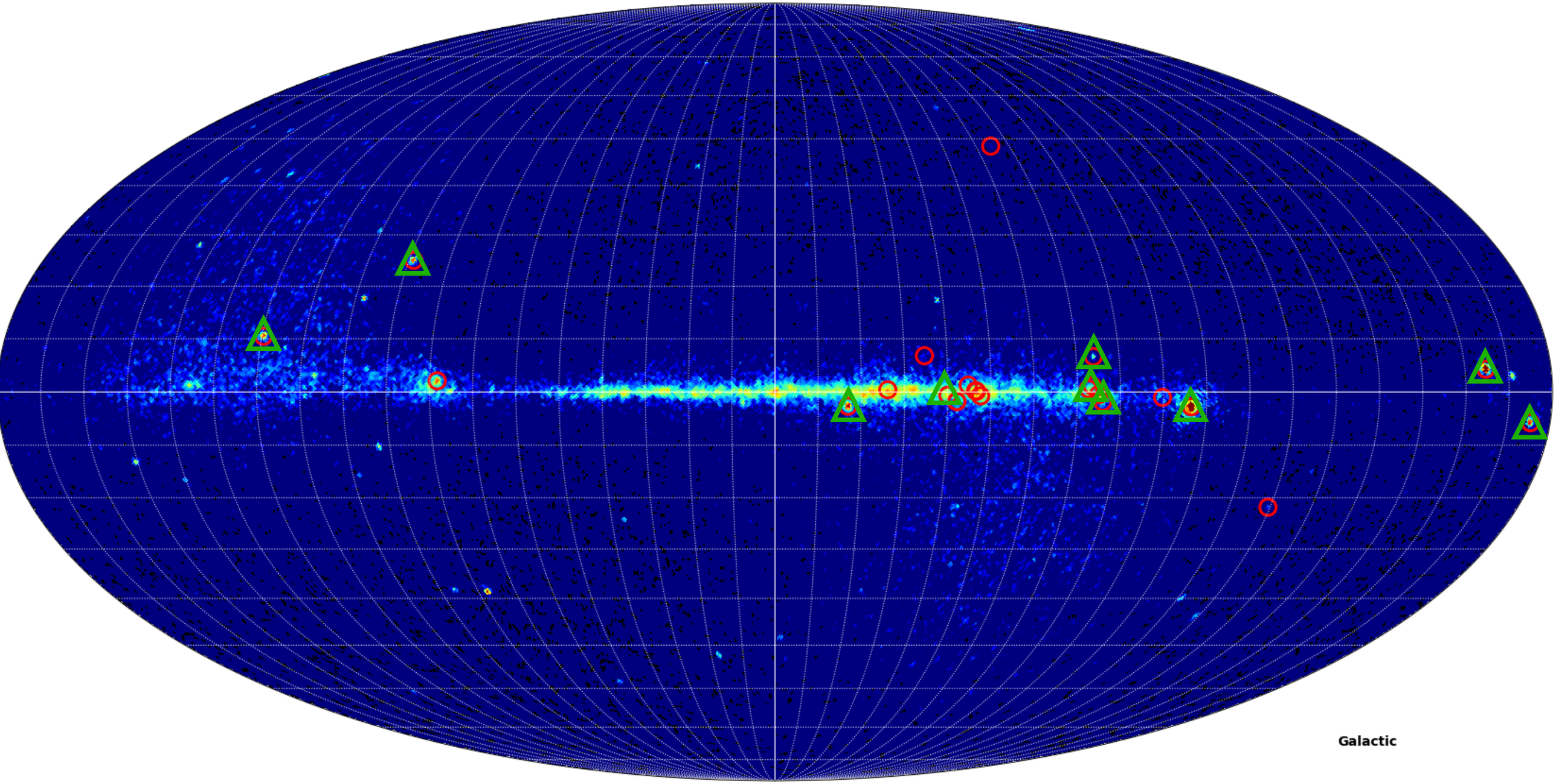


Pulsars searched



10 sources with sigma>3





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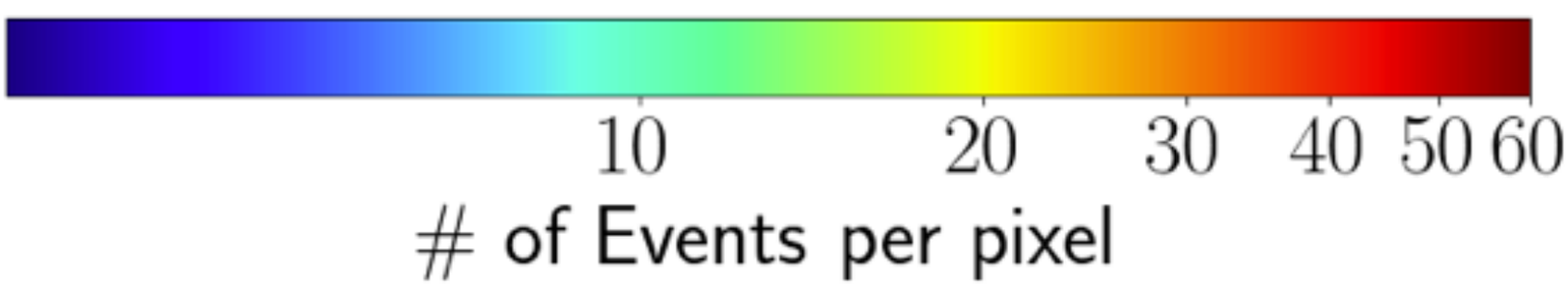


Conclusions

- We showed its ability to measure gamma-rays in an energy range from 2-100 GeV.
- We also show its timing capabilities for the identification and analysis of pulsars.
- Future work will focus on further improving the photon event selection and acquiring more statistics, allowing us to investigate the pulsation of these and potentially more pulsars for energies above 100 GeV.
- Perform spectral analysis in the pulse and off-pulse regions, observe the evolution of light curves as a function of energy.
- We also have shown the broad possibilities for research and study of gamma-ray sources such as the galactic plane, SNRs, AGNs, GRBs among others.

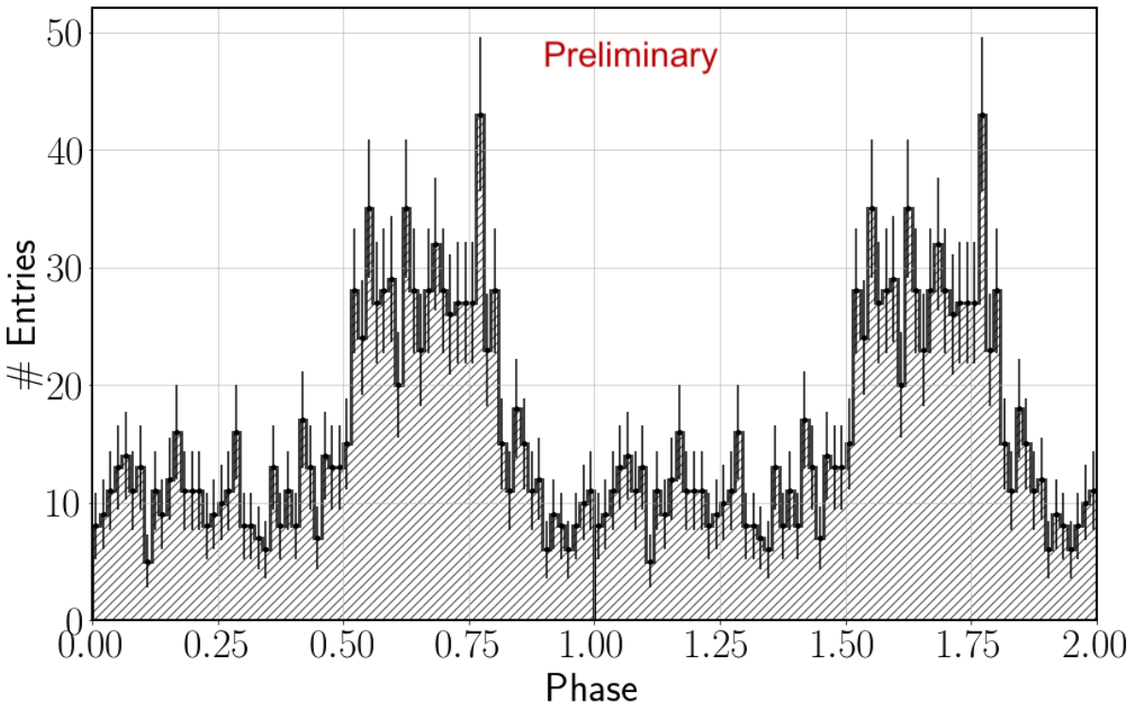
Performance

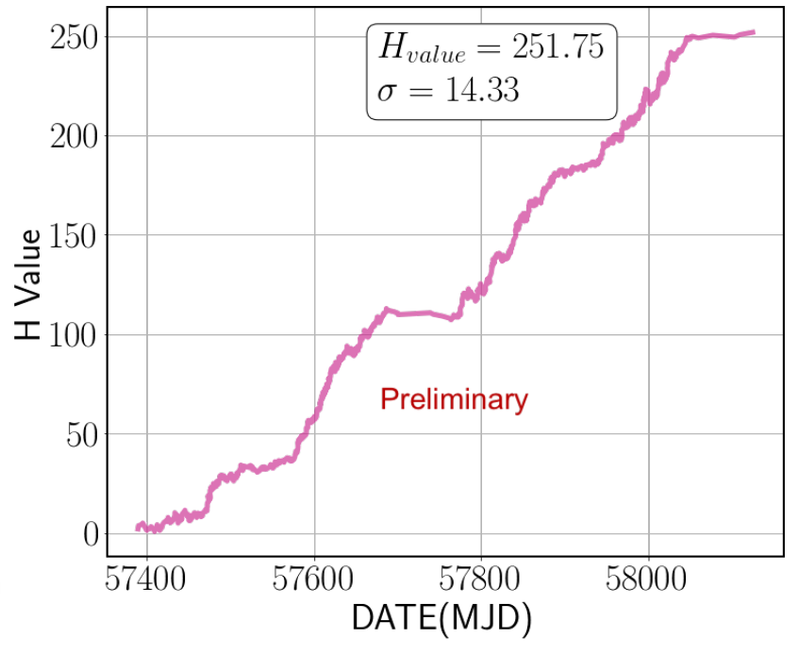
Parameter	Value
Energy range of gamma-rays/electrons	5 GeV to 10 TeV
Energy resolution (electron and gamma)	<1.5% at 800 GeV
Energy range of protons/heavy nuclei	50 GeV to 100 TeV
Energy resolution of protons	<40% at 800 GeV
Eff. area at normal incidence (gamma)	1100 cm^2 at 100 GeV
Geometric factor for electrons	0.3 m^2 sr above 30 GeV
Photon angular resolution	<0.2 degree at 100 GeV
Field of View	1.0 sr

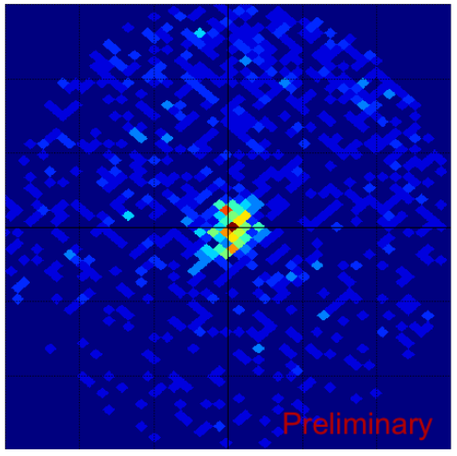
DAMPE Coll. [arXiv:1706.08453]

DAMPE Collaboration, Astroparticle Physics, Volume 95.

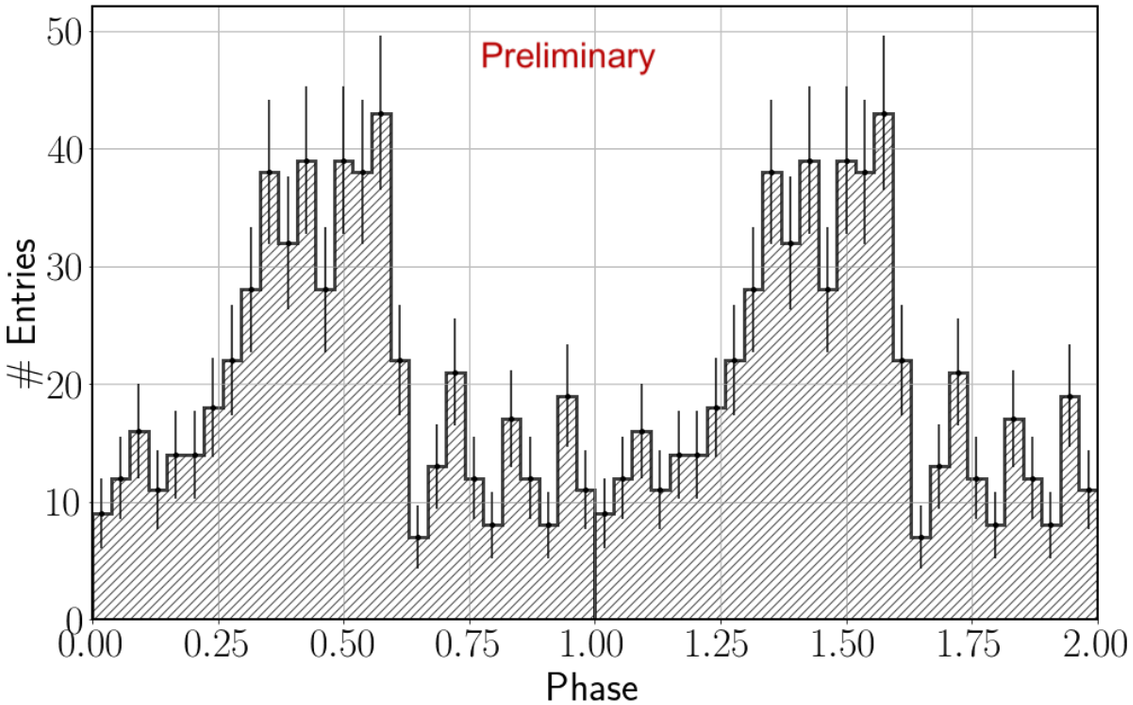
J1709-4429

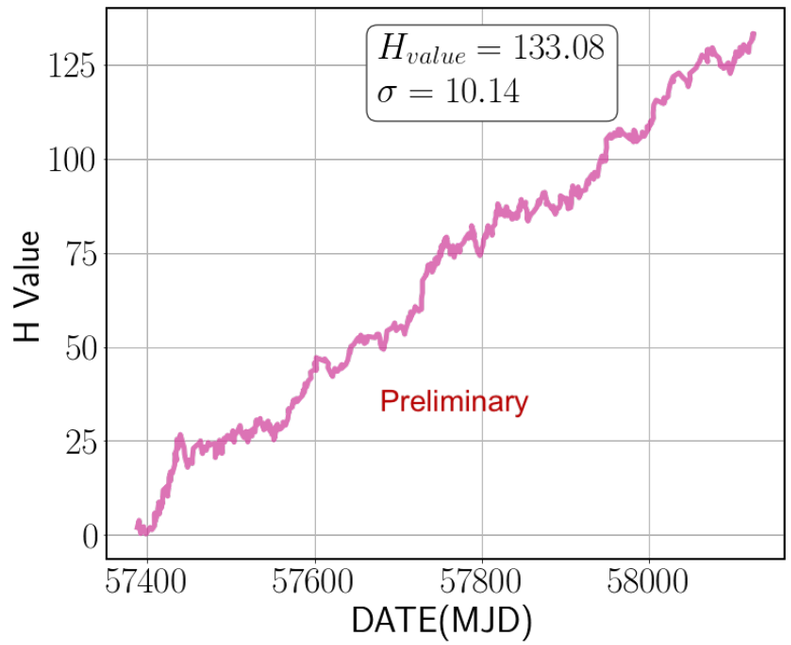


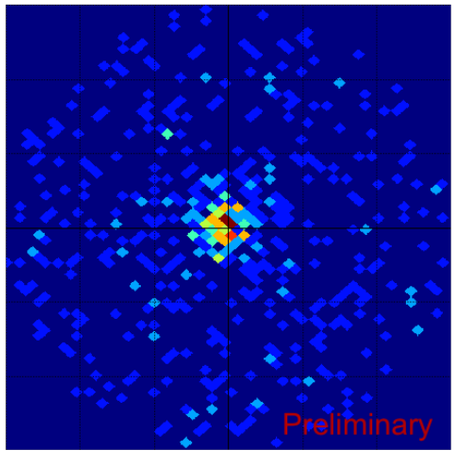




J007+7303







List Pulsars detected

- J0534+2200
- J0835-4510
- J1028-5819
- J1709-4429
- J1413-6205
- J1048-5832
- J1836+5925
- J1057-5226
- J0633+1746
- J0007+7303

3.5 years DAMPE Livetime