Gamma-ray Pulsars with DAMPE

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On behalf of the DAMPE Collaboration
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Outline

- DAMPE mission
- Data Selection
- Pulsars Search
- Preliminary results
- Conclusions & Outlook
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 $\gamma$-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
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.

  • Search window of 3 degree radius.

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

# of Events per pixel
J0835-4510->Vela

Preliminary

H_{value} = 3124.57
σ = 54.71

Preliminary

Energy [GeV] vs. E^{dN}/dE [erg/cm^2 s^{-1}]
J0633+1746 -> Geminga
J0633+1746 -> Geminga

Preliminary

H_{value} = 1367.75
\sigma = 35.60

Preliminary

DATE(MJD)

H Value
J0534+2200 -> Crab
J0534+2200 -> Crab

Preliminary
Pulsars searched

10 sources with sigma>3
10 sources with sigma>3

# of Events per pixel
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

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

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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