High Energy Gamma-ray Observations with CALET

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Outline

CALET-CAL

Photon candidate selection

Gamma-ray observations
  Overview
  Galactic diffuse
  Point sources
  Transient counterparts
CALET-CAL Detector

- Geometric factor:
  - 1200 cm\(^2\)sr for e\(^{\pm}\), light nuc.
  - 1000 cm\(^2\)sr for photons
- Energy resolution:
  - \(\sim 2\%\) for e\(^{\pm}\), gamma
- Charge resolution:
  - 0.15 - 0.3 e
- Angular resolution:
  - \(\sim 0.4^\circ\) (1 GeV - 10 GeV)
  - \(\sim 0.3^\circ\) (10 GeV - 1 TeV)
- Minimum photon energies:
  - \(\sim 10\) GeV (HE trigger)
  - \(\sim 1\) GeV (LEG trigger)

<table>
<thead>
<tr>
<th>CHD</th>
<th>CHarge Detector</th>
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<tbody>
<tr>
<td></td>
<td>14 x 2 plastic scintillators</td>
</tr>
<tr>
<td>IMC</td>
<td>IMaging Calorimeter</td>
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<tr>
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<td>448 x 8 x 2 scintillating fibers</td>
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<tr>
<td>TASC</td>
<td>Total AbSorption Cal.</td>
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<tr>
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<td>16 x 6 x 2 PbWO(_4) logs</td>
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</tbody>
</table>
Sample Event $\sim 15$ GeV
Event selection

- Pre-selection
  - Offline trigger
    - IMC 7X+8X
    - IMC 7Y+8Y
    - TASC 1X
  - Track reconstruction
    - $N_{\text{layers}}$ in fit
    - Reduced $\chi^2$
    - IMC EDep concentration
      - IMC 8X
      - IMC 8Y
  - Charge $Z=0$
    - Mean of CHD clusters
    - Mean of IMC1 clusters

On-axis LEG-trigger effective area

Mean of CHD clusters (±1 strip)
Primary energy reconstruction

- $E > 6$ GeV:
  - Sum of all TASC logs
  - $\frac{\Delta E}{E} \approx 3\%$
- $E < 6$ GeV:
  - Sum of TASC logs in upper layers near track
  - $\frac{\Delta E}{E} \approx 10\%$
  - Improvement using deposits in IMC in development

Reconstructed energy vs. true MC energy.
Sky Exposure

Exposure on sky (for each event)

- Pointing determined by calibrated ASC/ISS quaternions
- Geometric area projected as function of $\theta$, $\phi$
- Projection scaled by live time

Exposure generated for LEG trigger 1511-1704
Angular Resolution

Angular response

- Photon candidates within $2^\circ$ of known Crab position isolated
- Flat background contribution removed
- Gaussian profile fit with $\sigma = 0.4^\circ$

PSF derived from observations of the known Crab position.
Gamma-ray Candidates
Projection of signal from $|\ell| < 80^\circ$ onto galactic latitude for the period 2015/11 to 2017/04. A preliminary removal of a background component which scales with exposure has been applied.
Preliminary Crab and Geminga Fluxes

- **Crab**
  - 46 candidates
  - $\sim 4 \times 10^8 \text{ cm}^2\text{s}$

- **Geminga**
  - 119 candidates
  - $\sim 5 \times 10^8 \text{ cm}^2\text{s}$

CAL observations from 2015/11 to 2017/04 (red points, statistical errors only) alongside Fermi-LAT 3FGL fluxes (black lines).
Transient Counterparts

- Search for EM counterparts to LIGO/Virgo events
  - Mori, M. for the CALET Collaboration, #637
- Search for high-energy counterparts to GRB detections
  - Follow-up triggers by CGBM
    - Preliminary analysis searches ±60s around CGBM trigger time
    - Currently no significant signals above background
    - Increased sensitivity and time windows in development
  - Follow-up triggers by Swift, Fermi-GBM, et al.
    - In development
- Other flaring systems
  - CTA 102 flares in 2016/11 ~ 2017/04
CTA 102 Flare

CAL observations of CTA 102 in the months 2015/10 through 2017/04.

Fermi-LAT CTA 102 light curve including the months of interest.
Event viewer display for 44 GeV event candidate in CAL associated with 2017/04 CTA 102 flare.
Summary

- High-energy ($\gtrsim 300$ MeV) gamma-ray events are being isolated in the CALET-CAL dataset.
- Point-source analysis demonstrates the angular resolution of the instrument at low energies on-orbit and consistency of flux measurements.
- Analysis of the galactic diffuse emission is underway for energies $\gtrsim 1$ GeV.
- Searches for transient signals from GRBs, LVC triggers, and other systems are in preliminary stages, with more results coming soon.