Fermi’s view of the gamma-ray sky above 10 GeV

Pablo Saz Parkinson
UCSC/HKU
for the LAT Collaboration

A. Domínguez, M. Ajello, B. Lott, S. Cutini, P. Fortin, et al.

TeV Particle Astrophysics (TeVPA) 2017
Columbus, Ohio, USA
10 August 2017
Fermi LAT
FGL (E>100 MeV) Catalogs (2008-2017)

Credit: M. Ziegler
Fermi LAT
FGL (E>100 MeV) Catalogs

1FHL (2013)
3 yr, Pass 7
514 sources
10-500 GeV

Credit: M. Ziegler
Fermi LAT
FGL (E>100 MeV) Catalogs (2008-2017)

- 0FGL (3 months, 205 high TS sources)
- 1FGL (11 months, 1451 sources)
- 2FGL (24 months, 1873 sources)
- 2FHL (2016) 80 mth, Pass 8
  360 sources 50-2000 GeV
- 3FHL (2017) 7 yr, Pass 8
  1556 sources 10-2000 GeV

Credit: M. Ziegler
2FHL (Ackermann et al. 2016)

360 sources at E>50 GeV in 80 months of Fermi LAT data (~61,000 photons)

Adaptively smoothed

counts per (0.1 deg)$^2$
3FHL (Ajello et al. 2017)

Adaptively smoothed

1,556 sources at E>10 GeV in 84 months of Fermi LAT data (~700,000 photons)

counts per (0.1 deg)$^2$
Galactic Plane
The 3FHL Catalog

- 7 years of Pass 8 data
- 10 GeV - 2 TeV
- PSF types
- 1556 sources
  - 1286 3FGL
  - 476 1FHL
  - 312 2FHL
  - 133 in TeVCat
- > 200 new sources

Extragalactic 79%

Galactic

Unknown

Unassoc.

48 (previously known) extended sources

See Talk by Manuel Meyer on searches for new extended sources
3FHL Associations

3FHL, $E \geq 10 \text{ GeV}$

- SNRs and PWNe
- BL Lacs
- Unc. Blazars
- Other GAL
- Unassociated
- Pulsars
- FSRQs
- Other EGAL
- Unknown
- Extended
New gamma-ray sources

There are 214 sources that are not included in previous LAT catalogs, 3 of these are found by IACTs.
3FHL vs 1FHL

<table>
<thead>
<tr>
<th>Comparison Summary</th>
<th>1FHL (3 years+Pass7)</th>
<th>3FHL (7 years+Pass8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of sources</td>
<td>514</td>
<td>1556</td>
</tr>
<tr>
<td>Number of extended</td>
<td>18</td>
<td>48</td>
</tr>
<tr>
<td>Flux above 10 GeV</td>
<td>1.29 (0.87, 2.74) x 10^-10</td>
<td>5.03 (3.22, 10.33) x 10^-11</td>
</tr>
<tr>
<td>Spectral Index</td>
<td>2.36 (2.01, 2.90)</td>
<td>2.47 (2.13, 2.93)</td>
</tr>
<tr>
<td>Positional Uncertainty</td>
<td>0.079 (0.054, 0.097)</td>
<td>0.038 (0.028, 0.049)</td>
</tr>
<tr>
<td>Significance</td>
<td>6.17 (4.71, 9.37)</td>
<td>7.04 (5.18, 10.88)</td>
</tr>
</tbody>
</table>

- X 3.0 more sources
- X 2.7 more extended sources
- X 2.6 deeper in flux
- X 2.1 better location accuracy

The table shows the median and the 25% and 75% quartiles
3FHL Flux Variability

- Bayesian Block Analysis results in 163 variable sources at E>10 GeV

- 85 BL Lacs, 61 FSRQs, 11 BCUs, 2 RDGs, 1 Narrow-line Seyfert, 1 PSR, 1 PWN, 1 unassociated
Distribution of sources

Distribution of unassociated sources over the sine of the Galactic latitude

PSRs tend to be softer than SNRs+PWNe
Spectral Energy Distributions

3FHL J0617.2+2234e (IC443)

3FGL 4 years
1FHL 3 years
3FHL 7 years

3FHL J0222.6+4302 (3C 66A)

3FHL J1104.4+3812 (Mkn 421, z = 0.03)

3FHL J0007.0+7303 (PSR J0007+7303)
Pulsars in 1FHL Catalog
The search for new HPSRs

<table>
<thead>
<tr>
<th></th>
<th>1FHL</th>
<th>3FHL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Span</td>
<td>3 Years</td>
<td>7 Years</td>
</tr>
<tr>
<td>LAT IRFs</td>
<td>Pass 7</td>
<td>Pass 8</td>
</tr>
<tr>
<td># Sources</td>
<td>514</td>
<td>1556</td>
</tr>
<tr>
<td># Pulsar Associations</td>
<td>27</td>
<td>62</td>
</tr>
<tr>
<td>HPSR (&gt;10 GeV)</td>
<td>20 (+8)</td>
<td>?</td>
</tr>
<tr>
<td>HPSR (&gt;25 GeV)</td>
<td>12 (+1)</td>
<td>?</td>
</tr>
</tbody>
</table>
Updating Spectral Models
Updating timing models

![Graphs showing updates to timing models.](image-url)
Search for the highest pulsations from J0614-3329

E>50 GeV

E>100 GeV

Preliminary 7-yr data set
Pulsars at VHE?

• The Crab pulsar has been detected at energies >1 TeV
• The Vela pulsar has now been detected up to 120 GeV
• Emission mechanism?
• What about other pulsars?

See talk by Jezabel Rodriguez Garcia

Romani 1996

Ansoldi et al. 2016
Summary

- Since launch (2008) Fermi has produced three general (FGL) catalogs in the 100 MeV-100 GeV energy range.
- A number of High Energy (FHL) catalogs have also been generated, using only high-energy (> 10 GeV) events.
- The recent 3FHL Catalog contains > 1500 sources detected in the 10 GeV - 2 TeV energy range.
- 79% of 3FHL sources are extragalactic, ~8% are Galactic (>50 pulsars), and ~13% are unassociated.
- 3FHL is well suited for joint studies with ground-based instruments (HESS, MAGIC, VERITAS, HAWC, CTA).