Spectral Index in the Unknown $\gamma$-Ray Sky

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Candidacy
MJD 58900
1. Background
Fermi Gamma-Ray Space Telescope

- Launched 06-2008
  - Mission: 5-10 years
  - Extended: 2 years (or more)
  - Elapsed: 11.4 years
- Two primary instruments
  - LAT - Directional “telescope”
  - GBM - Burst monitoring
- Main data product: TOAs

Credit: Nasa Spacecraft Icons
The Gamma-Ray Sky

Credit: NASA Goddard Media Studios
The FGL Catalogs

- FGL = Fermi Gamma-ray LAT
- Releases about every $2^n$ years
  - Delta ➔ 5FGL
- 3 Groups:
  - Identified
  - Unassociated
  - Associated

Data from 4FGL Paper arXiv:1902.10045
Gamma-Ray Pie
2. Unassociate Field Searches
Previous Work

- VLA/ATCA survey of unassociated sources at 5/7 GHz
- Hunting for AGN
  - 10x deeper than previous surveys
- AIPS Source Fitting
- Two sub-bands
  - Spectral index
Previous Pointings
Getting to Spectral Information
Date Product 1: Sources

- For AGN
  - Flat spectrum
  - Follow-up
  - More on that soon

- For PSRs
  - Frail 2017
  - ‘Image based’
  - Spectral Index
    - Bates et al 2013
    - arXiv:1302.2053
Data Product 2: Missed Field Catalog

- Two problems:
  - Sources ‘move’
  - Big sources

- Generate list of fractional coverages

- Know what to hit with follow-up
Data Product 3: Empty Fields

Recreated from Schinzel et al 2017
3. Follow-up
AGN Follow-up

- VLBA/LBA targets sources inside ellipses
- Expect parsec scale emission from AGN
- Associate via likelihood ($\Lambda > 8$)

$$\Lambda \propto e^{-\frac{d^2}{2\sigma^2}} S^{1.2088}$$
Pulsar Follow-up

- Find steep-spectrum PSR candidate
- Work with Pulsar Search Consortium
  - arXiv:1205.3089
- E@H can search gamma-ray better
- Can search for pulsations with:
  - Single Dish: Arecibo, Effelsberg, GBT
  - Arrays: LWA!
Future Prospects
8. Questions?
### Bonus Slide: Source Breakdown

<table>
<thead>
<tr>
<th>Description</th>
<th>Identified</th>
<th>Associated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulsar, identified by pulsations</td>
<td>PSR</td>
<td>...</td>
</tr>
<tr>
<td>Pulsar, no pulsations seen in LAT yet</td>
<td>...</td>
<td>psr</td>
</tr>
<tr>
<td>Pulsar wind nebula</td>
<td>PWN</td>
<td>pwn</td>
</tr>
<tr>
<td>Supernova remnant</td>
<td>SNR</td>
<td>snr</td>
</tr>
<tr>
<td>Supernova remnant / Pulsar wind nebula</td>
<td>SPP</td>
<td>spp</td>
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<tr>
<td>Globular cluster</td>
<td>GLC</td>
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<td>Star-forming region</td>
<td>SFR</td>
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<tr>
<td>High-mass binary</td>
<td>HMB</td>
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<tr>
<td>Low-mass binary</td>
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<tr>
<td>Binary</td>
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<tr>
<td>Nova</td>
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<tr>
<td>BL Lac type of blazar</td>
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<td>FSRQ type of blazar</td>
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<td>Radio galaxy</td>
<td>RDG</td>
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<tr>
<td>Non-blazar active galaxy</td>
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<td>Steep spectrum radio quasar</td>
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<td>Compact Steep Spectrum radio source</td>
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<tr>
<td>Blazar candidate of uncertain type</td>
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<td>Narrow line Seyfert 1</td>
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<td>Seyfert galaxy</td>
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<td>Starburst galaxy</td>
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<tr>
<td>Normal galaxy (or part)</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>357</strong></td>
<td><strong>3217</strong></td>
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<tr>
<td><strong>Unassociated</strong></td>
<td><strong>...</strong></td>
<td><strong>1525</strong></td>
</tr>
</tbody>
</table>

**NOTE**—The designation ‘spp’ indicates potential association with SNR or PWN. Designations shown in capital letters are firm identifications; lower case letters indicate associations.
Bonus Slide: Pulsars at Multi-Wavelength
Bonus Slide: Frail 2018 Method
Bonus Slide: VLASS Statistics
Bonus Slide: SED Best Fit
Bonus Slide: Literally Just Cool Spacecraft Pictures