« SOURCE IDENTIFY » test on the THIRD EGRET CATALOG (3EG)

The third EGRET catalog (Hartman et al. 99)

Vincent LONJOU & Jürgen Knödlseder
EGRET catalog and sources identifications

Hartman et al. 1999

- 170 unidentified sources, 63%
- 66 high confidence Blazars (BL Lac objects, flat-spectrum radio quasars or unidentified flat spectrum radio sources)
- 27 low confidence Blazars
- 5 pulsars
- +1991 solar flare, Large Magellanic Cloud

APJSS, 135, 155

« A quantitative evaluation of potential radio identifications for 3EG EGRET sources »

- 46 high confidence Blazars (45 high confidence from Hartman et al. 1999 + 1 low confidence)
- 37 low confidence Blazars (21 high confidence from Hartman et al. 1999 + 3 low confidence + 15 new)
Method: Bayesian approach. Determine the probability of identification as a function of:
- angular distance between radio counterpart and 3EG source
- spectral index of the radio counterpart
- radio flux

4% (criteria not obvious)

37 low probability blazar identification

46 high probability blazar identification

70%
Creation of a meta-catalog similar to Mattox et al.

- 101226 radio sources (mostly 4.85 GHz and 1.4 GHz)
- 36152 have a spectral index (1/3)
- 6765 have a spectral index > -0.5 (Mattox blazar identification criteria)
Run 1: no constraint, try to make an identification with the 101226 sources

- with a probability threshold of 0.4:
  - √90% of the blazars find by Hartman and Mattox
  - BUT we made also √130 wrong identifications.

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Hartman et al. 1999

Mattox et al. 2001
Spectral index properties of *Mattox et al.* Blazars

<table>
<thead>
<tr>
<th></th>
<th>Mattox radio catalog</th>
<th>Mattox High probability</th>
<th>Mattox low probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min spectral index</td>
<td>-3.76</td>
<td>-0.6</td>
<td>-1</td>
</tr>
<tr>
<td>Mean spectral index</td>
<td>-0.82</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>Max spectral index</td>
<td>2.9</td>
<td>1.1</td>
<td>1.2</td>
</tr>
</tbody>
</table>

*Spectral index distribution in « Mattox radio catalog »*
Run 2: spectral index $>-2$ (suppress about 66% of the sources for which we don’t have any spectral index)

The spectral index plays a crucial role in the blazar identification. By suppressing all the sources with no spectral index or low spectral index we reduce the number of wrong blazar identifications by a factor of 2 or 3.
Test of source identify with 3EG - « Mattox catalog »

**Run 2**: spectral index > -2 (suppress about 66% of the sources for which we don’t have any spectral index)

The spectral index plays a crucial role in the blazar identification. By suppressing all the sources with no spectral index or low spectral index we reduce the number of wrong blazar identifications by a factor of 2 or 3.

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**Hartman et al. 1999**

**Mattox et al. 2001**
Run 3: spectral index > -0.5 (*Mattox* high probability blazar identification criteria)

- With a probability threshold of 0.4
  - ~80% of the high probability blazar
  - ~30-40% of low probability blazar
- BUT we made ~20 wrong identifications.
### Flux properties of *Mattox et al.* Blazars

<table>
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<tr>
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<th><em>Mattox low probability</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Min 4.85 GHz flux (mJy)</td>
<td>0</td>
<td>407</td>
<td>260</td>
</tr>
<tr>
<td>Mean 4.85 GHz flux (mJy)</td>
<td>150</td>
<td>3949</td>
<td>1232</td>
</tr>
<tr>
<td>Max 4.85 GHz flux (mJy)</td>
<td>67600</td>
<td>44940</td>
<td>4506</td>
</tr>
</tbody>
</table>

4.85 GHz flux distribution in « Mattox catalog »
Test of source identify with 3EG - « Mattox catalog »

**Run 5:** spectral index > -0.5 + 4.85 GHz Flux > 400 mJy

Mattox *et al.* high probability identification limits

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**Hartman *et al.* 1999**

![Graph showing Hartman's results.](image)

**Mattox *et al.* 2001**

![Graph showing Mattox's results.](image)
Exact Mattox et al. calculation

\[
p(\text{id/r}) = \left[ \frac{\eta}{1 - \eta} \right]^{\text{LR}} \frac{\eta}{LR + 1}
\]

**Probability of identification**

\[
\text{LR} = 3 \frac{r^2}{\psi^2} e^{-r^2(3\psi^{-2} - R_0^{-2})}
\]

**Likelihood Ratio**

\[
\eta = 0.2(1 - e^{-0.07 \times F_{4.85\text{GHz}}^{2.3}})
\]

« a priori » of EGRET’s detecting a radio source
(cf. Mattox et al. 97)

**With**
- \(F_{4.85\text{GHz}}\) : radio source flux at 4.85 GHz in mJy
- \(\alpha\) : spectral index
- \(R_0\) : \(f(F_{4.85\text{GHz}}, \alpha)\)
  - mean distance between sources which have at least a flux of \(F_{4.85\text{GHz}}\) and at least a spectral index of \(\alpha\)
- \(\psi\) : 95% confidence radius in the direction of the counterpart
Exact *Mattox et al.* calculation

We will provide script examples
**Exact Mattox et al. calculation**

**Run 6:** exact Mattox et al. probability $p(id/r)$

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**Hartman et al. 1999**

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**Mattox et al. 2001**

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![Graphs showing the number of EGRET sources vs probability threshold for Hartman et al. 1999 and Mattox et al. 2001. The graphs display the trends for Hartman unidentified, high probability blazar, and low probability blazar categories.](images/graphs.jpg)
High proba threshold : 4%

High proba threshold : 70%

Exact *Mattox et al.* calculation

![Graph showing number of EGRET sources against probability threshold with labeled thresholds and corresponding counts.]
Exact Mattox et al. calculation

~/glast/mattox/data/3EG_mattox_v4_maxNumCtp100_N100mJySI_GB_mattoxHyp_probamin0_prob_mattox_mattox.ps

- Mattox unidentified
- Mattox high probability blazar
- Mattox low probability blazar

Number of EGRET sources vs. probability threshold

4^ and 37
1 wrong identification with a high probability: LMC rejected by Mattox et al. « …because of the poor resolution of PMN survey »

3 effects can explain the little differences:

- R0 calculation (factor 1 to 5)
- Mattox et al. use elliptic contour / We use circular
- No contraints on \( \alpha \) in this example
No constraint

\[ F_{4.85\text{GHz}} > 400 \text{ mJy} \]
\[ \alpha > -0.6 \]

Exact Mattox at al.

46
37
• Validation of « source identify »:
  • fast (1 to 10 s)
  • modularity

• We are able to reproduce what has been done on EGRET data

• To be done:
  • test others methods:
    • probability method
  • test others catalogs:
    • radio (VLA Sky Survey, …)
    • X (ROSAT, …)
    • Pulsars / AGN …
  • continue the development, find / correct eventual bugs (DC2)