Fermi Gamma-ray Space Telescope

Application of Classification Trees to Fermi Unidentified Sources

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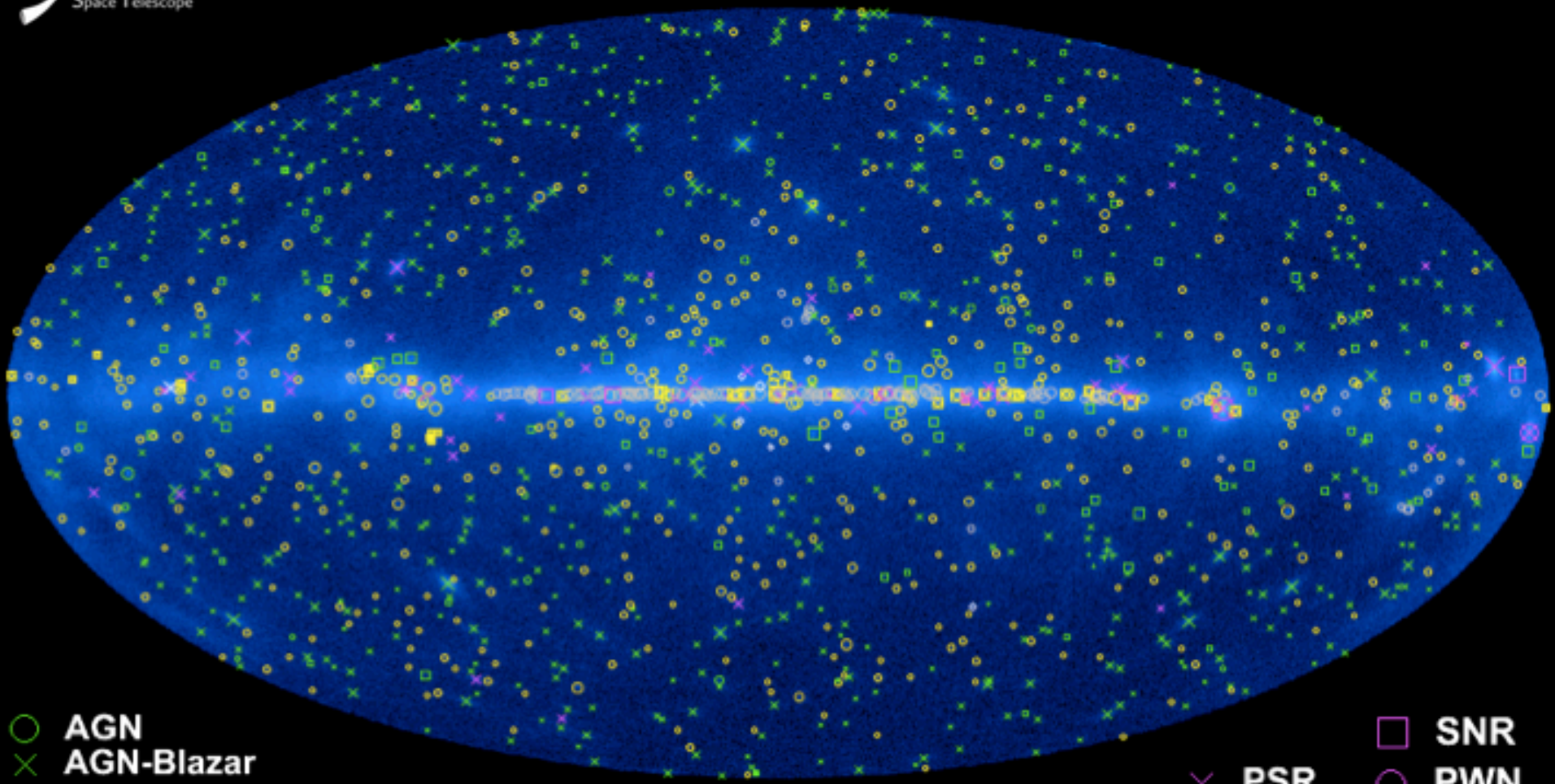
The Fermi LAT 1FGL Source Catalog

Fermi Gamma-ray Space Telescope



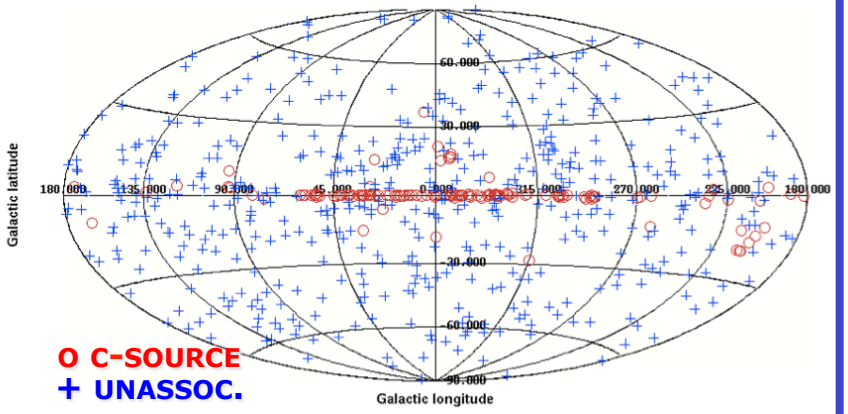
AGN
AGN-Blazar
AGN-Non Blazar
No Association
Possible Association with SNR and PWN
Possible confusion with Galactic diffuse emission
Starburst Galaxy
Galaxy
SNR
PSR
PWN
PSR w/PWN
Globular Cluster
HXB or MQO

Credit: *Fermi* Large Area Telescope Collaboration

UNASSOCIATED SOURCES IN 1FGL

1451 Sources in 1FGL

- source detection based on the average flux in the 100 MeV to 100 GeV range over the 11-month period; threshold likelihood Test Statistic is 25 (≈ 4 σ)
- for individual LAT-detected sources, association with sources in other astronomical catalogs was provided
- 630 of the 1FGL sources turned out to be unassociated, according to catalogs and association criteria selected



Galactic distribution of 1FGL unassociated sources

Idea

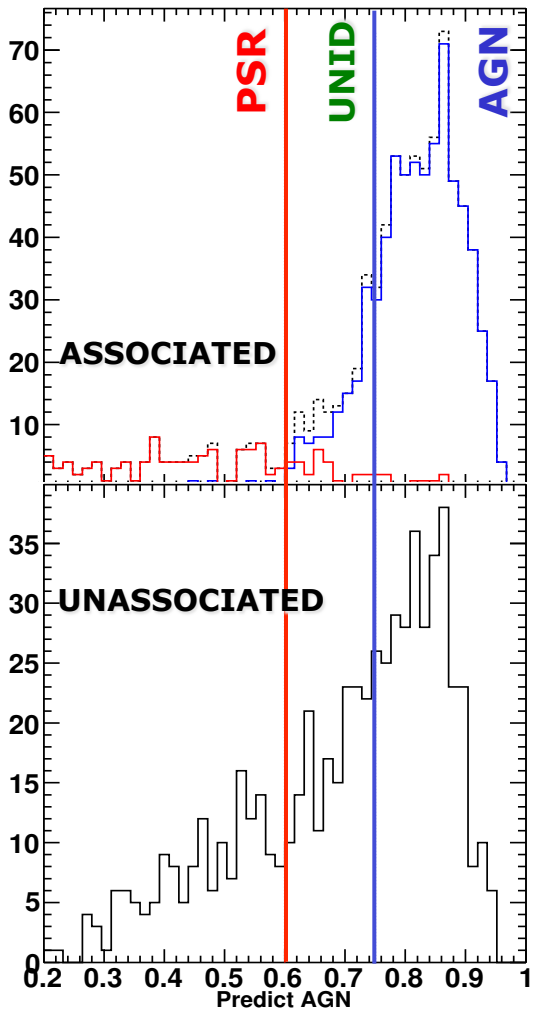
- classify unassociated sources based solely on their gamma-ray properties
- train a Classification Tree on the two most common classes of associated sources in 1FGL (AGNs and pulsars)
- predict the probability for unassociated sources to be either an AGN or a pulsar

Selection of the input variables

- most delicate step in the analysis
- input variables must be independent on source brightness, distance, galactic coordinates, statistical significance…
- good variables: Curvature, Spectral Index, Fractional Variability, Hardness Ratios for 5 energy bands
- NOT used as input: galactic coordinates of the source (will be used as a cross check of our result).

Output of the Training Procedure

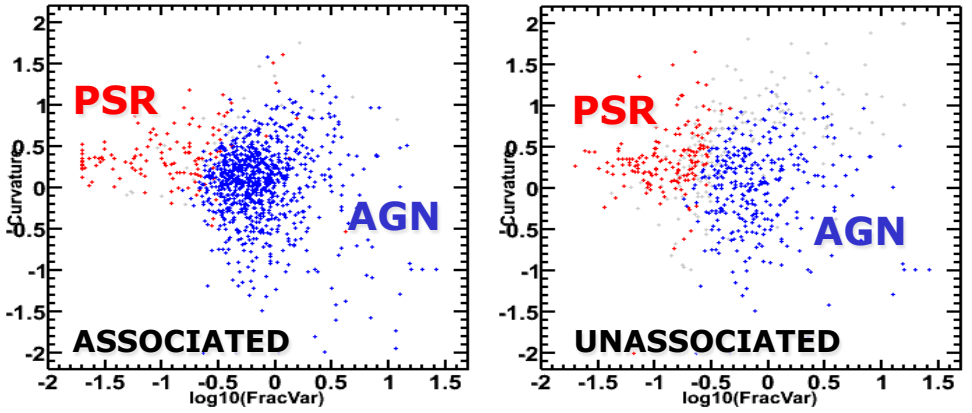
The AGN Predictor



Fiducialization

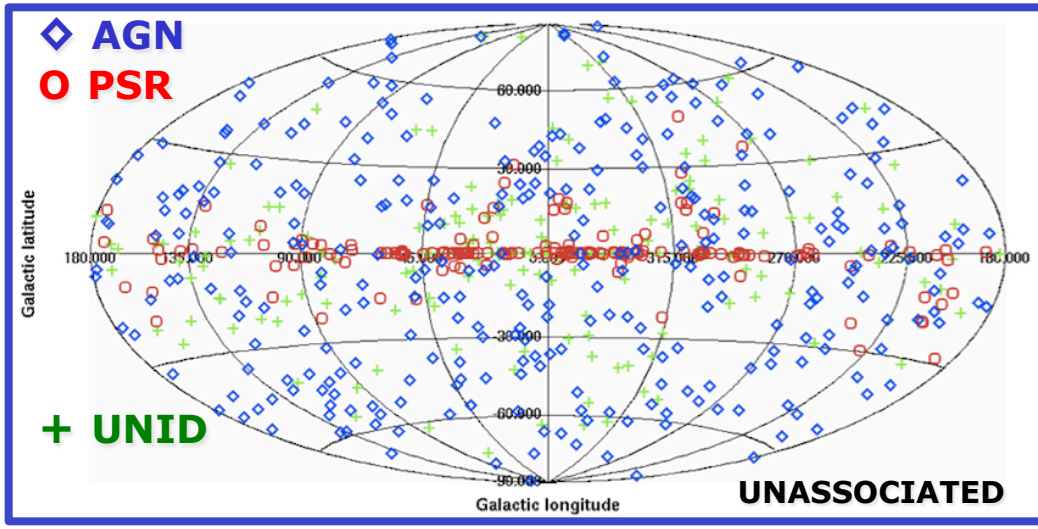
- AGN predictor > 0.75 → AGN candidates
- AGN predictor < 0.6 → pulsar candidates
- intermediate values of predictor → still unclassified
- fiducials optimized for efficiency: 80% of AGN in 1FGL have predictor > 0.75 and 80% of pulsars have predictor < 0.6

Curvature-Variability diagram



- Agreement is not surprising: Curvature & Variability were used as input in the training process

Results from the Classification Tree



Galactic distribution

- we have NOT used the galactic coordinates as input for training
- RESULT: pulsar candidates are likely to be non-variable and to be distributed along the galactic plane
- AGN candidates are likely to be extragalactic, variable sources

Algorithm performance on post-1FGL sources

- applied the CT analysis to the new sources identified after the release of 1FGL
- new AGN detections: 74% of sources classified as AGN candidates; false negative of 5%
- new γ-ray pulsars detections: 75% classified as pulsars, no misclassifications
- new radio pulsar candidates (pulsations not detected by LAT): much worse performance

→ Results from the CT Analysis may be Used to Plan Multi-Wavelength Observations of Fermi Unassociated Sources

→ Technique may be Extended to Other Astrophysical Catalogs