fermi Gamma-ray Space Telescope

A Statistical Approach to Recognizing Source Classes for Unassociated Sources in the Second Fermi-LAT Catalog

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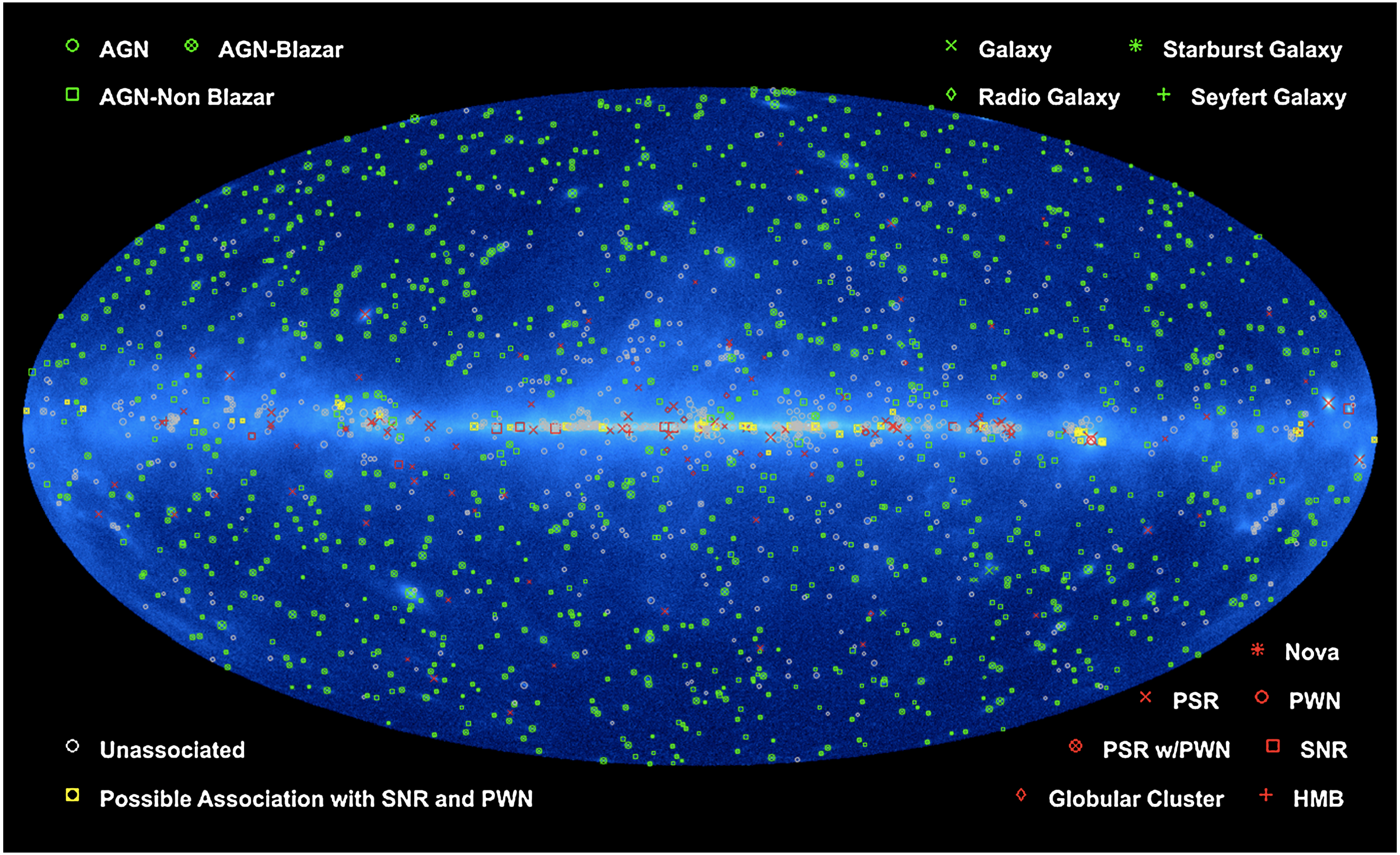
Unassociated Sources in 2FGL

1873 sources in 2FGL; 573 unassociated after all association efforts (~30%)



See Elizabeth C. Ferrara, session 103.04 and http://arxiv.org/abs/1108.1435

How to predict possible classifications

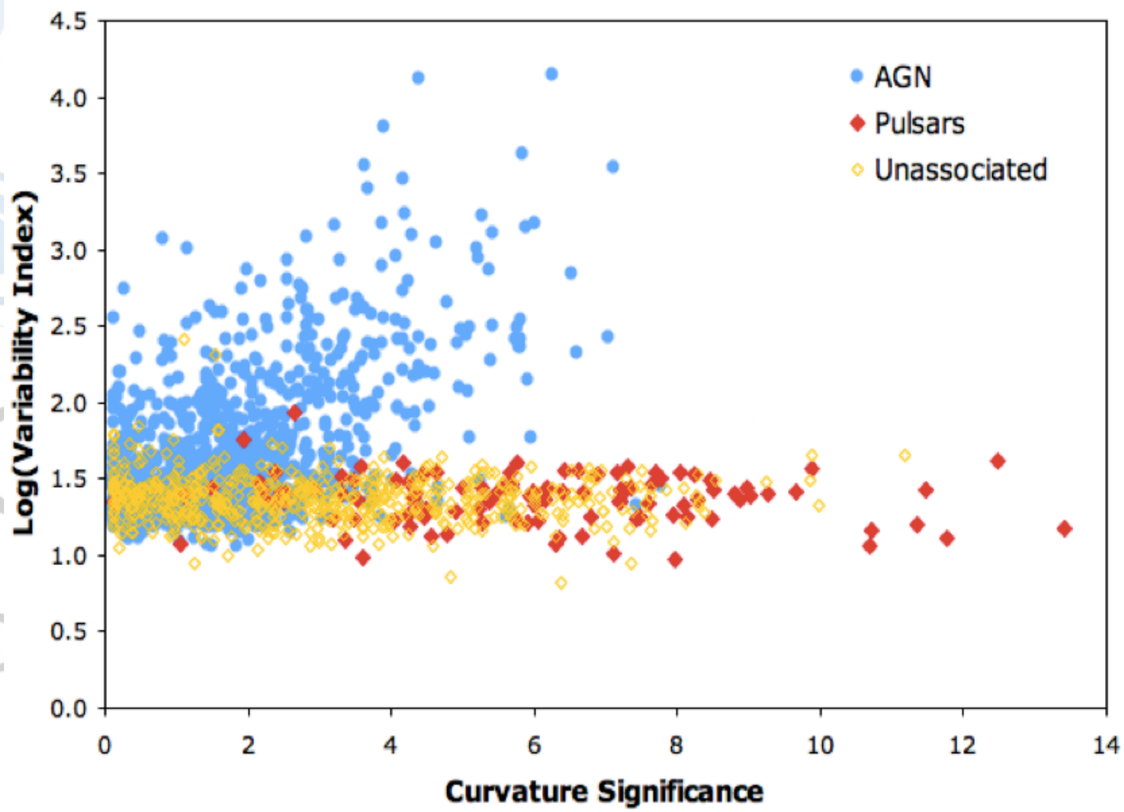
- **Implement statistical methods to determine likely source classifications for 2FGL unassociated sources**
  - goal: predict the likely classification of Fermi sources based solely on their observed gamma-ray properties
  - principle: use the properties of known objects to implement a classification analysis which provides the probability for an unidentified source to belong to a given astronomical class
  - examples: Classification Trees (this work), Logistic Regression and Artificial Neural Networks (see David Salvetti, poster 117.07)
  - input sample: all the associated AGN and blazars (1077 sources, 60% of total); all the associated/identified pulsar and pulsar-like objects (includes SNR and potential associations: 180 sources, 10% of total)

- **Classification Trees are a well-established class of algorithms in the general framework of data mining and machine learning**
  - definition: Classification Trees are built through a process known as binary recursive partitioning, an iterative process of splitting the data into partitions using *if-then* logical conditions
  - advantage: Classification Trees are especially flexible in handling sparse or uneven distributions

Selection of the training variables

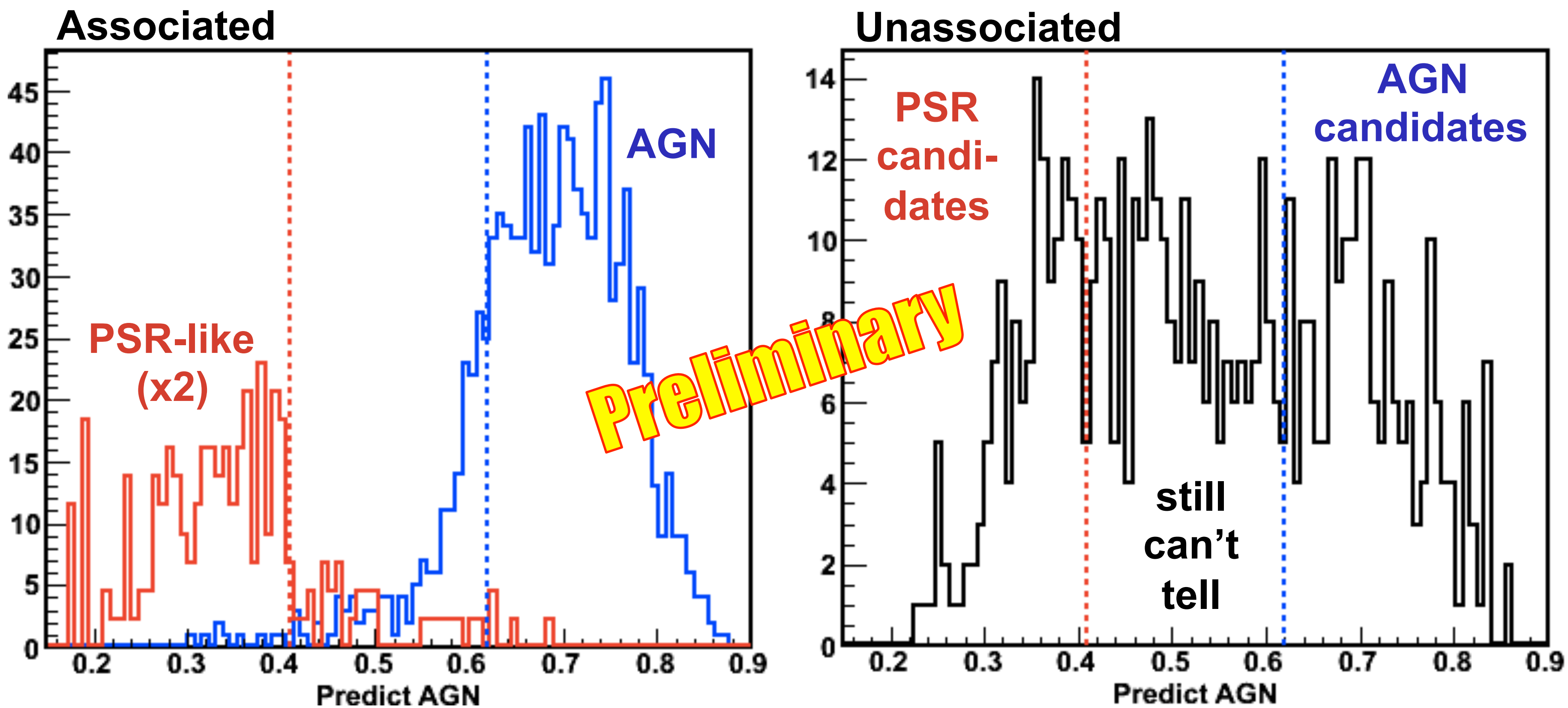
- This is a crucial step in the analysis:
  - physical considerations about the gamma-ray properties of each class
  - ensure that the selected variables are not dependent on the flux, the location or the significance of the source
  - avoid using the Galactic coordinates of the sources

- Ranking of the selected variables after training:
  - variability index (20%)
  - spectral index (16%)
  - curvature signif. (13%)
  - low energy flux (10%)
  - low and high energy hardness ratios (15%)
  - 3-band curvature (7%)
  - intermediate energy hardness ratios (10%)
  - 4-band fluxes (9%)



Output of the training process

The result of the training process is the Predictor, a parameter describing the probability for any given source to be either an AGN or a pulsar-like source

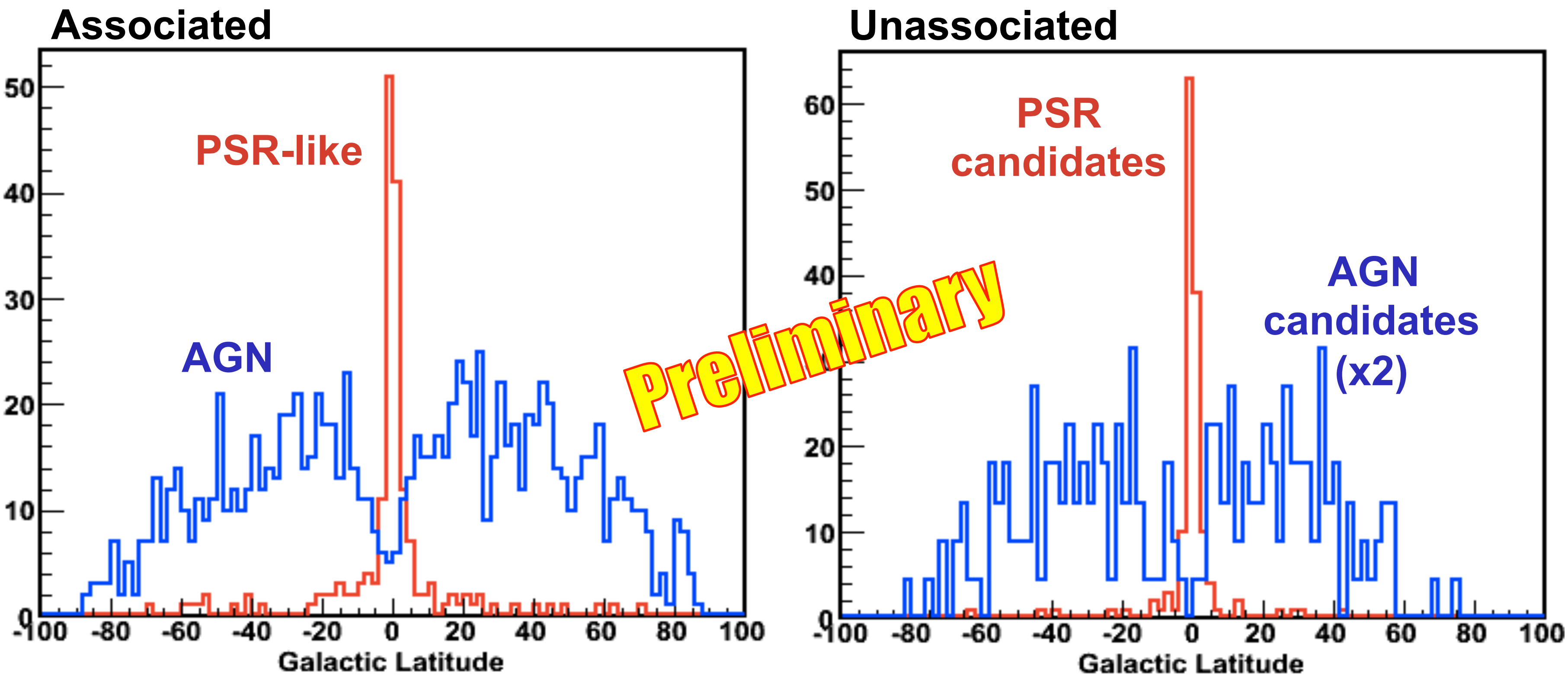


2 fiducial thresholds: PSR candidates - P<0.41, AGN candidates - P>0.62

fiducial regions: 82% efficiency and <5% contamination on input samples

Validation of the Classification Analysis

- 30% of input sources, randomly selected from AGN and pulsar samples, were set aside for internal validation (KS test and efficiency comparisons)
- the Galactic latitude distribution for pulsar and AGN candidates mirrors the expected one (as observed for the Associated sources)



- further validation will be performed using input from multi-wavelength observations (now in progress; was successfully implemented for 1FGL)

Conclusions

- We implemented a method to predict likely source classifications for 2FGL unassociated sources, based solely on their gamma-ray properties
  - the performance of the method has been validated in several ways
  - the results from this technique have been used to help inform the next set of multi-wavelength observations