Fermi-LAT view of Intermediate Synchrotron Peaked blazars

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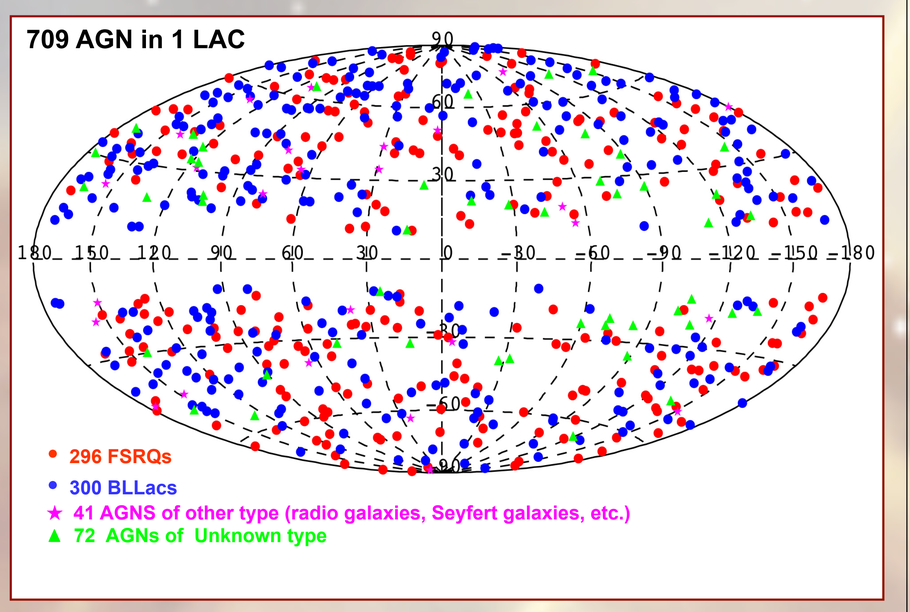
After the first year of scientific activity with the Large Area Telescope (LAT), i.e. the primary instrument onboard Fermi, a catalog of Active Galactic Nuclei has been published. The First LAT AGN Catalog (1LAC) includes 671 gamma-ray sources located at high Galactic latitudes, detected with a test statistic (TS) > 25. Among these sources, an interesting group of objects is the one composed by Intermediate Synchrotron Peaked (ISP) blazars, i.e. sources for which the synchrotron emission peaks at intermediate frequencies (from 10^{14} Hz to 10^{15} Hz). These objects are expected to have their Spectral Energy Distribution (SED) high-energy peak centered on the Fermi-LAT band (from 20 MeV to 300 GeV). For the brightest 1LAC ISP sources the analysis has been extended to 22 months data in order to constrain better their spectral features and characterize the temporal evolution of their gamma-ray spectra.

The First Large Area Telescope AGN Catalog (1 LAC)

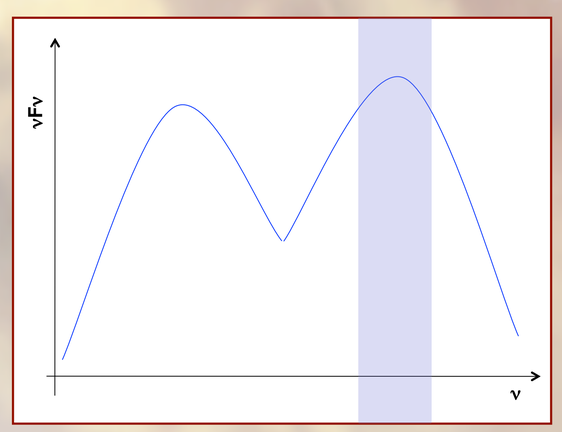
The Fermi Gamma-ray Large Area Space Telescope satellite was successfully launched on June 11, 2008 into a low Earth circular orbit at an altitude of 550 km and an inclination of 25.6°. The Large Area Telescope (LAT), the main instrument on board Fermi, is a pair-production telescope with large effective area (~8000 cm^2, on axis for E > 1 GeV) and field of view (~2.4 sr at 1 GeV), sensitive to gamma-rays in the energy range from 20 MeV to more than 300 GeV [1].



The first LAT catalog of active galactic nuclei (1LAC) [2], corresponding to 11 months (from August, 4 2008 to July, 4 2009) of scientific data collected with standard sky-survey observation, includes 671 gamma-ray sources located at high galactic latitudes (|b|> 10°), detected with a test statistic greater than 25 and statistically associated with 709 AGNs (due to some multiple associations). The 1LAC includes 300 BL Lacertae objects (BL Lacs), 296 Flat-Spectrum Radio Quasars (FSRQs), 41 AGNs of other types and 72 AGNs of unknown type, distributed in the sky as shown in the above figure.

The SED based classification of blazars

AGNs are highly variable objects, therefore simultaneous observations in different energy bands are essential to understand the emission processes that take place in these objects. For 48 sources of the LBAS (LAT Bright AGN Sample) [3] it has been possible to combine Fermi-LAT three months (August, 4 2008 to October, 31 2008) gamma-rays data with simultaneous observations at other wavelengths, in order to assemble high-quality and quasi-simultaneous Spectral Energy Distributions (SEDs) [4]. All the SEDs clearly show the typical two-bump signature attributed to Synchrotron and Inverse Compton emission and the study of this unprecedented collection of blazars has allowed to estimate a certain number of parameters characterizing the SED of blazars, as the frequency of the synchrotron (ν^S_{peak}) and of the Inverse Compton peak (ν^{IC}_{peak}).



The determination of ν^S_{peak} for a large number of blazars has permitted to develop a new SED-based classification scheme for all blazars. *Low Synchrotron Peaked* (LSP) blazars are sources with the Synchrotron peak at low energy (i.e. in the far IR or IR band or $\nu^S_{peak} \leq 10^{14}$Hz); *High Synchrotron Peaked* (HSP) blazars have the Synchrotron peak at UV or higher energies ($\nu^S_{peak} \geq 10^{15}$Hz).

A very interesting group of objects is the one composed by *Intermediate Synchrotron Peaked* (ISP) blazars, i.e. sources for which the synchrotron emission peaks at intermediate frequencies (from 10^{14} Hz to 10^{15}Hz). For these objects the Inverse Compton peak is expected to be exactly inside the Fermi-LAT energy band, i.e. in the shaded area shown in the figure above.

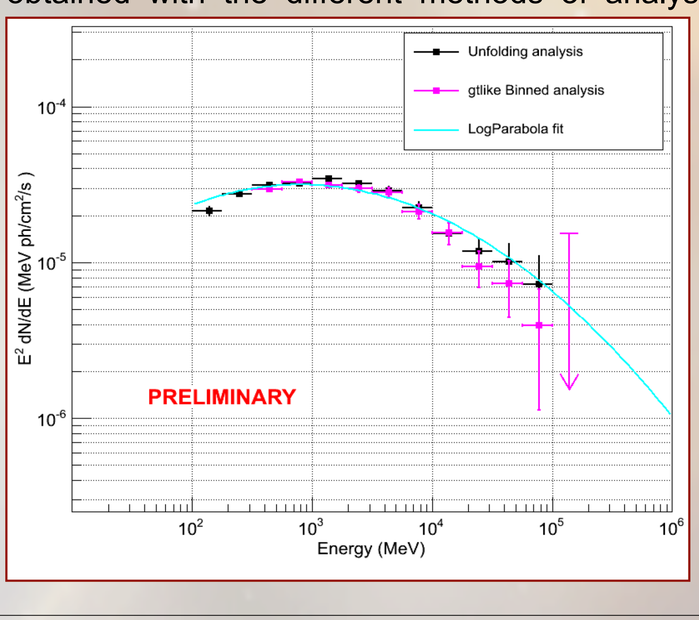
Fermi LAT ISP blazars study

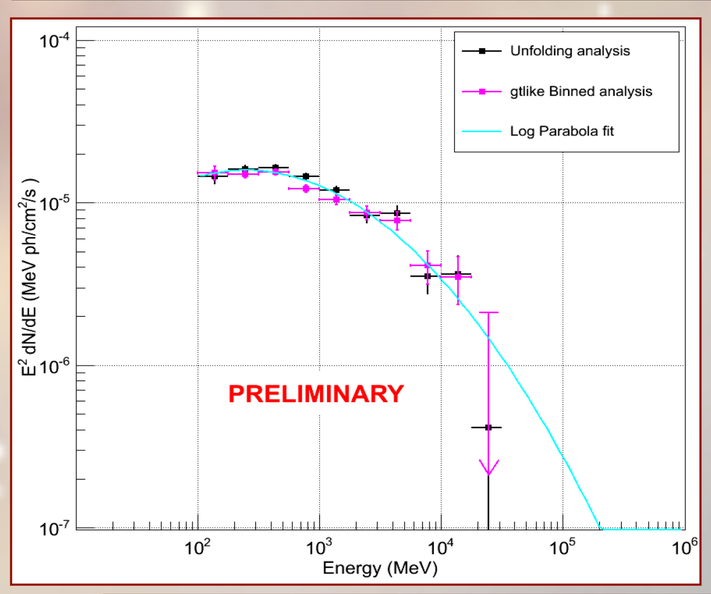
Looking at the gamma-ray spectra of 1LAC blazars [2], a preliminary list of about 30 sources showing the SED high energy peak centered in the Fermi-LAT energy band has been built. For these sources, that are ISP candidates, Fermi-LAT 22 months data have been analyzed using different methods.

In the first case (unfolding method) the spectra are evaluated using a deconvolution technique [5] based on the Bayes theorem, that allows to take into account the energy dispersion. In the second case, spectra are reconstructed using Fermi science tool gtlike [6], where a parametric model (Power Law, PL) is assumed in each individual energy bin for the source spectrum and for the background components and a maximum likelihood fit is performed for each energy bin.

A very simple analytical function that can model the shape of the peak in the gamma-ray band with nearly symmetric curvature around the maximum is the Log-Parabola (LP) [7]. In the third method of analysis, we model the source under investigation using the Log-Parabola function in the whole energy band (100 MeV – 300 GeV) and than a maximum likelihood fit is performed.

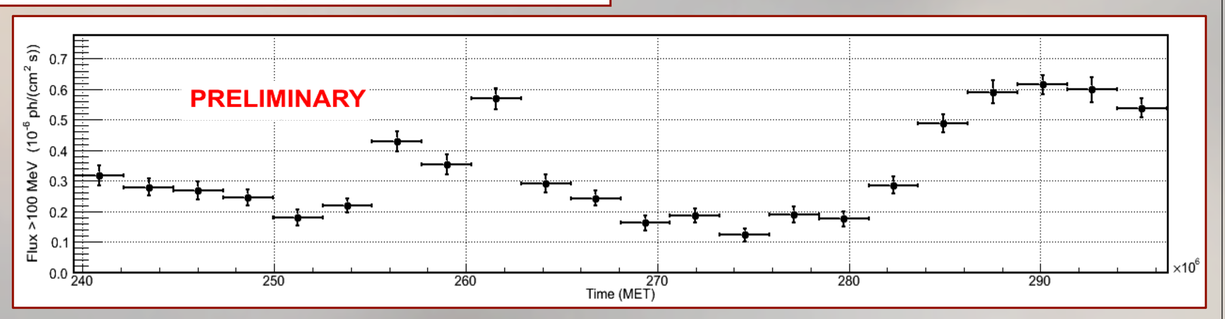
As an example, the results of the analysis for two sources are shown here. The plot below and the plot on the right show the gamma-rays SED respectively for the PKS 0426-380 (RA = 67.1552°, DEC = -37.9436°) and for the B3 0917+449 (RA = 140.2436°, DEC= 44.6983°), obtained with the different methods of analysis: the unfolding (black points), gtlike with the source modeled with a PL in each energy bin (magenta points) and gtlike with the source modeled with a LP in the whole energy band (cyan line). It is evident that the results of the different methods are consistent and that the source can be modeled with a Log Parabola function with the peak at about 1 GeV, exactly in the Fermi-LAT energy band.





The plot below shows the light curve for the integral flux > 100 MeV just for the PKS 0426-380, as a representative example of the work done for all sources in the sample of ISP candidates.

The light curves have been obtained dividing the entire 22 M data set in time intervals of 1 month each. For each time interval, a maximum likelihood fit has been performed considering a Region of Interest of 15 degrees around the source under investigation and modeling the source with a PL.



Conclusions

A sample of about 30 ISP candidates has been selected from the 1LAC. Preliminary spectral analysis performed over a period of 22 months seems to show that the Log Parabola function can be used to model the shape of the SED high-energy peak in the gamma-ray energy range for these sources. The study of the temporal evolution has started with the construction of the light curves with 1 month time intervals. A further analysis will be performed in order to study the temporal evolution of the Log Parabola spectral parameters.

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[3] A. A. Abdo et al, (2009) *ApJ* 700, 597
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[5] M. N. Mazziotta, Proc. of the 31° ICRC, LODZ 2009
[6] http://fermi.gsfc.nasa.gov/ssc/data/analysis/documentation/Cicerone/
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