Analysis of the Spectral Energy Distributions of Fermi bright blazars

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This contribution reports the results of a Spectral Energy Distribution Analysis performed on a sample of 48 LBAS (LAT Bright AGN Sample) blazars observed by the Fermi LAT in its first three months of data taking. Combined data from radio, optical, UV, X-ray and up to TeV energy bands have been combined creating an unprecedented sample of quasi-simultaneous multi-wavelength observations.

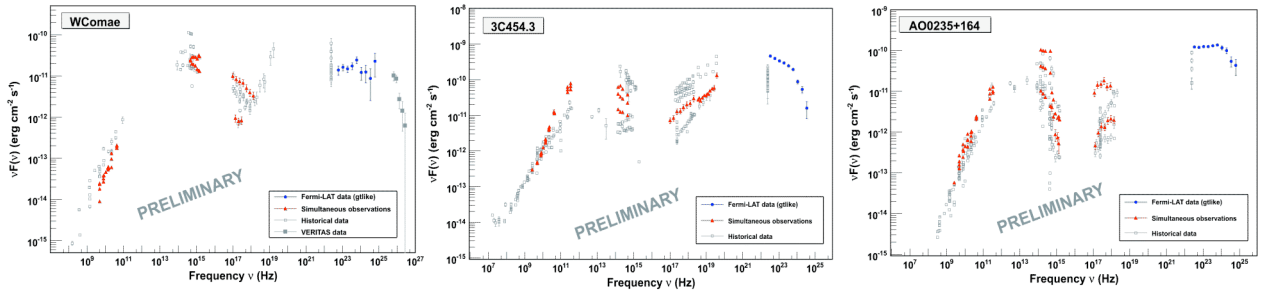
Abstract

Blazars are a small fraction of all extragalactic sources but, unlike other objects, they are strong emitters across the entire electromagnetic spectrum. In this study we have conducted a detailed investigation of the broad-band spectral properties of the gamma-ray selected blazars of the Fermi LAT Bright AGN Sample (LBAS). By combining the accurately estimated Fermi gamma-ray spectra with Swift , radio, NIR-Optical and hard-X/gamma-ray data, collected within three months of the LBAS data taking period, we were able to assemble high-quality and quasi-simultaneous Spectral Energy Distributions (SED) for 48 LBAS blazars.

Along with the author list many people of the Fermi-LAT collaboration participated to this work: Elisabetta Cavazzuti, Andrea Tramacere, Claudia Monte, Massimo Villata, Lars Fuhrmann, Joey Richards and Sergio Colafrancesco

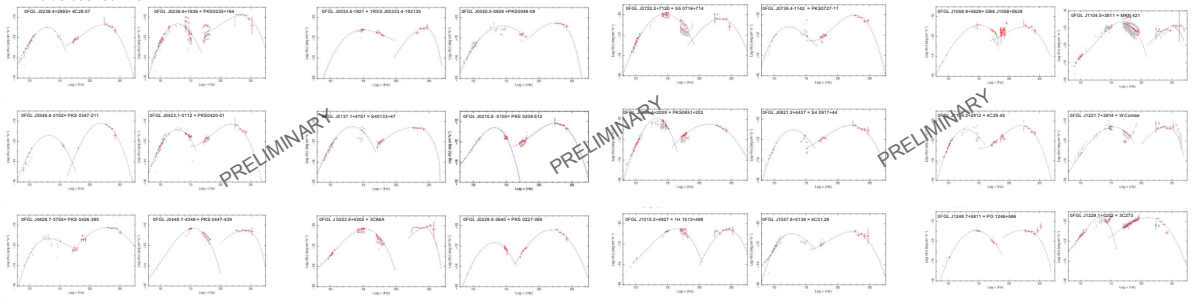
The sample:
The first results of the initial three months of operations of the Fermi gamma-ray observatory, from 4 August to 31 October 2008 are described in [1] who presented a list of 205 bright (>10σ) gamma-ray sources. A companion publication[2] studied the AGN content of this list associating 106 sources at |b| > 10° with AGN. This sample has been named the "LAT Bright AGN Sample" or LBAS. For 48 sources of the LBAS, we were able to combine Fermi-LAT three months gamma-rays data with simultaneous observations at other wavelengths [3].

Multi-frequency observations and Fermi-LAT analysis:
Radio data come from OVRO [4] 40-m telescope (15 GHz), Effelsberg 100-m Radio Telescope (2.6 to 42 GHz, F-GAMMA project [5]), GASP-WEBT[6] (5 to 43 GHz and 230 to 345 GHz), RATAN-600[7] (1 to 22 GHz) and VLBI (8.4GHz). NIR-Optical data come from GASP-WEBT collaboration, mid-infrared data come from VISIR [16], optical/UV data come from the Swift-UVOT [8], X-ray data come from Swift-XRT [8] and hard X-ray data from Swift-BAT survey[9].
Fermi-LAT data from 4 August to 30 October 2008 have been analyzed following two different methods. In the first case, spectra are reconstructed using Fermi science tool gtlike [10], where a parametric model is assumed in each individual energy bin for the source spectrum and for the background components and a maximum likelihood fit is performed. With the second method (whose results are not shown here), the spectra are evaluated using a deconvolution (unfolding) technique [11] based on the Bayes theorem, that allows to take energy dispersion into account. The results of the two different methods are consistent.



The figures above shows the SED of the intermediated synchrotron peak BL Lac object Wcomae, the SED of the well known Flat Spectrum Radio Quasar 3C 454.3 and the low synchrotron peak BL Lac object AO0235+164

Spectral Energy Distribution Parameters:
In all cases the overall shape of the SEDs exhibit the typical broad double hump distribution, where the first bump is attributed to synchrotron radiation and the second one is likely due to one or more components related to inverse Compton emission.
We estimate some key observational parameters that characterize the SED of our blazars: the peak frequency and peak flux of the synchrotron component (ν^S_{peak} , $\nu^S_{peak}F(\nu^S_{peak})$), and the peak frequency and flux of the inverse Compton part of the SED (ν^{IC}_{peak} and $\nu^{IC}_{peak}F(\nu^{IC}_{peak})$. The estimation of both the peak frequency and flux is obtained from the 48 SED fitting the single bump (synchrotron or Inverse Compton) with a 3rd degree polynomial function.
In the case of high redshift sources (e.g. J0229.5-3640 and J0921.0+4437), we excluded from the fitting procedure all points in the optical/UV bands that are likely to be significantly affected by Lyman-alpha forest absorption. For HBL objects, where the soft X-ray band is still dominated by synchrotron radiation, and only the fermi data can be used to constrain the inverse Compton component, the above method is subject to large uncertainties. For this reason, in these cases (e.g. J0722.0+7120, J0033.6-1921, J1015.2+4927 and J1248.7+5811), we have used the ASDC SED tool (http://tools.asdc.asi.it/SED/) interface to fit the simultaneous data points to a SSC model with a log-parabolic electron spectrum [17]. The figures below represent the SEDs data with the fit function shown in blue dashed line .



Conclusions:
✓For the first time high-quality quasi-simultaneous SED of blazars are available for a considerable number of blazars and this subset is representative of the entire LBAS.
✓All Fermi bright blazars have broad-band spectral properties similar to radio and X-ray selected blazars (double bump SEDs)
✓The distribution of the synchrotron peak frequency is very different for the FSRQ and BL Lac subsamples with values of ν^S_{peak} located between $10^{12.5}$ and $10^{14.5}$ Hz in FSRQ and between 10^{13} and 10^{17} Hz in BL Lacs.

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