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First results on AGNs from the Fermi LAT bright gamma-ray source List

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on behalf of the Fermi LAT collaboration

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Abstract. The *Fermi* Gamma-Ray Space Telescope is opening the violent and high-energy view of active galactic nuclei to exploration. The first three months of all sky-survey operation revealed 132 bright sources at $|b| > 10°$ (with test statistic greater than 100, about 10σ), where 106 of these sources have high-confidence associations with known AGNs (104 blazars and radio galaxies Cen A and NGC 1275). Only 33 of the sources (plus two at $|b| < 10°$) were previously detected with *EGRET*.

Key words. gamma rays: AGNs, blazars — gamma rays: observations — quasars: general – BL Lac objects: general

1. Introduction

The *Fermi* Gamma-Ray Space Telescope[1,2] (Ritz 2007) (successfully launched in June 11, 2008) is an international effort bringing together the astrophysics and high-energy particle physics communities. The Large Area Telescope instrument (LAT)[3,4] on board of *Fermi* is a pair tracker-converter telescope comprising a modular array of 16 towers, each with a tracker based on silicon micro-strip detector technology, and a calorimeter based on a hodoscopic array of 96 CsI(Tl) crystals, surrounded by an Anti-Coincidence Detector capable of measuring the directions and energies of cosmic γ-ray photons with energies between about 20 MeV and > 300 GeV (for details, see, e.g. Atwood et al. 2007, 2009). One of the major scientific goals of this mission is to find new sources and provide new data on the γ-ray activity of AGNs. The LAT Bright AGN Sample (LBAS), assembled with data collected during the first 3 months of all-sky survey (Fig. 1), comprises 58 flat spectrum radio quasars (FSRQs), 42 BL Lacs, 4 blazars of unknown type and 2 radio galaxies (Abdo et al. 2009a,b, and Fig. 2). For comparison, the Third *EGRET* Catalog (3EG; Hartman et al. 1999) contains 66 high-confidence blazars, with ~77% identified as FSRQs and the remaining ~23% identified as BL Lac objects, while the high-confidence *AGILE* γ-ray sources catalog (Pittori et al. 2009) shows a somewhat higher percentage of BL Lacs. The success rate at correlating the bright γ-ray

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[4] http://fgst.slac.stanford.edu

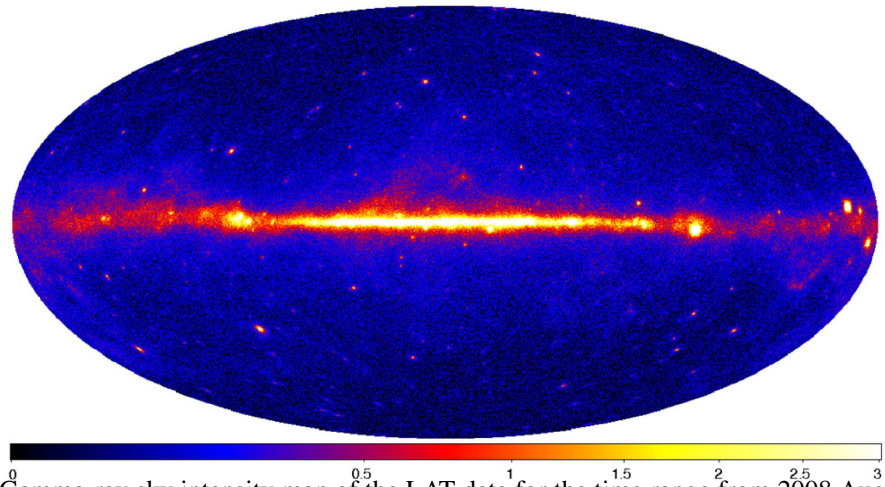

Fig. 1. Gamma-ray sky intensity map of the LAT data for the time range from 2008 August 4 to 2008 October 30 (LAT runs 239503624 - 247081608, where the numbers refer to the Mission Elapsed Time, or MET, in seconds since 00:00 UTC on 2001 January 1). The map is shown in Aitoff projection and Galactic coordinates. The image shows γ-ray intensity for energies > 300 MeV, in units of photons m^{-2} s^{-1} sr^{-1} (from Abdo et al. 2009b).

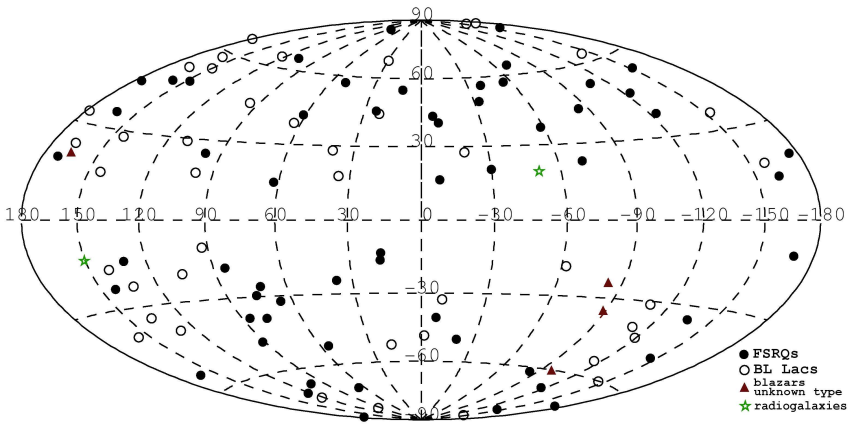

Fig. 2. Locations of the LBAS sources. Filled circles: FSRQs; open circles: BL Lacs; triangles: blazars of unknown type; stars: radio galaxies (from Abdo et al. 2009a)

source list with AGN radio/multifrequency catalogs (CRATES, CGRaBS, BZCAT) is around 90%, and the bright extragalactic gamma-ray sky appeared to be dominated by radio-loud AGNs in agreement with previous findings.

2. Some gamma-ray properties of the LAT Bright AGN Sample

The GeV spectral index distribution for all LBAS sources looks fairly similar to that observed for the EGRET sample, being roughly symmetric and centered at spectral index Γ = 2.25 (range 1.4-2.9). The corresponding distributions for FSRQs and BL Lacs appear clearly distinct, with little overlap between them. Although indications of the existence of two spectrally distinct populations in the EGRET blazar sample were mentioned in the literature, this is the first time that such high energy spectral separation appears so clearly, with evidence for FSRQs having significantly

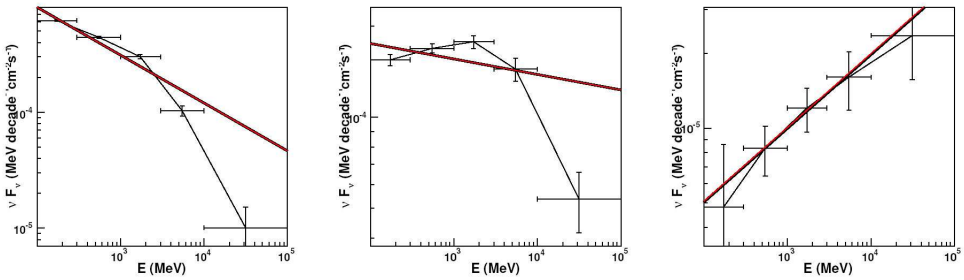

Fig. 3. γ-ray SEDs of 3 bright blazars obtained in five energy bands, compared with the power law fitted over the whole energy range. Left: 3C 454.3 (FSRQ). Middle: AO 0235+164 (intermediate-energy peaked BL Lac object). Right: Mkn 501 (high-energy peaked BL Lac object). From Abdo et al. (2009a).

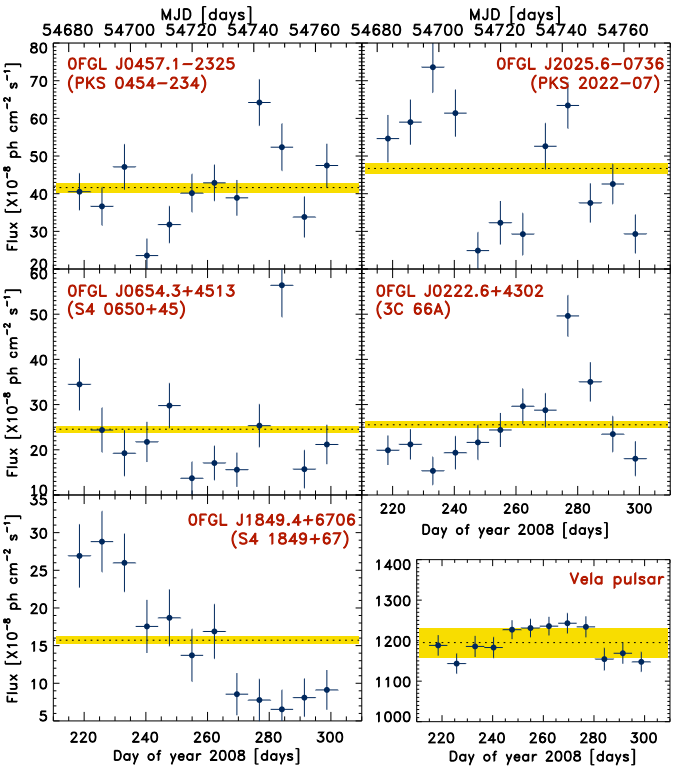

Fig. 4. Examples of weekly-averaged bin light curves for five bright blazars detected by the *Fermi*-LAT and the Vela light curve for comparison. The flux is given in units of 10^{-8} photons cm^{-2} s^{-1}; note the different scales on the vertical axis. The dashed line is the average value, and the yellow area shows the 3% systematic error we have adopted. Different flux variability amplitudes and timescales are clearly visible by these plots. Adapted from Abdo et al. (2009a).

softer γ-ray spectra than BL Lac objects: the average spectral index is 1.99 ± 0.22 (rms) for BL Lacs, with a tendency for the HBLs to display even harder spectra, and 2.40 ± 0.17 (rms) for FSRQs. A KS test gives a probability of 2×10^{-12} that the two index samples are drawn

from the same parent distribution (Abdo et al. 2009a).

Figure 3 shows the *Fermi* LAT SEDs for 3 bright sources of different classes: 3C454.3 (FSRQ); AO 0235+164 (IBL); and Mkn501 (HBL). Significant deviations from a pure power-law are observed in some cases, specifically for FSRQs, LBL, and IBL. A more complete spectral analysis of the LBAS sources and the presentation of simultaneous multi-frequency SEDs are reported respectively in Abdo et al. (2009c,d).

FSRQs in the bright source list are, on average, more luminous and more distant than the BL Lac objects in the list; i.e., FSRQs exhibit a broad redshift distribution, starting with $z = 0.158$ (3C 273), peaking at $z \simeq 1$, and extending up to $z \simeq 3$ while BL Lacs are mostly found in the $z \simeq 0.1$ redshift bin with a tail extending up to $z \simeq 1$. No significant relation between the γ-ray spectral index and redshift is found within either source class, in agreement with the corresponding studies based on the EGRET AGN sample (Abdo et al. 2009a).

Figure 4 shows a few representative flux ($E > 100$ MeV) light curves extracted with a weekly time bin, and spanning a 12 week period. In Abdo et al. (2009a) the 3-month weekly peak fluxes as well as variability indices (corresponding to a χ^2 test criterion for the constancy hypothesis) were derived, while a more complete presentation of the γ-ray light curves of these LBAS sources on a longer (11 months) interval will be reported in Abdo et al. (2009e).

3. Final remarks

The early results from the first 3 months of all-sky survey of the *Fermi* Gamma-ray Space Telescope demonstrate its exceptional capabilities to provide new insights for the extragalactic gamma-ray sky, as reported in more detail in Abdo et al. (2009a). During the following months more AGNs at lower flux levels have been detected, as well as other flaring AGNs, and part of these interesting results are presented in several papers already published and submitted by the LAT collaboration during the first year of mission. With the continuous all-sky monitoring of *Fermi* LAT other surprises in AGN/blazar science are expected in the next months and years.

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