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Blazars: the next gamma-ray view of GLAST

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Abstract. Blazars, the extreme family of AGN, can be strong gamma-ray emitters and constitute the largest fraction of identified point sources of EGRET. The next Gamma-ray Large Area Space Telescope (GLAST) is a high energy (30MeV-300GeV) gamma-ray astronomy mission, planned for launch at the end of 2006. GLAST performances will allow to detect few thousands of gamma-ray blazars, with a broad band coverage and temporal resolution, also in quiescent emission phases, providing probably many answers about these sources.

Key words. gamma ray astronomy – space missions: GLAST – blazars: general

1. The Italian contribution to the Large Area Telescope of GLAST

The Gamma-ray Large Area Space Telescope[1] (GLAST) project is part of NASA's SEU Program, within the Office of Space and Science, funded and realized with the collaboration of NASA, U.S. Department of Energy, institutions and government agencies in France, Germany, Japan, Italy and Sweden. GLAST is a next generation high-energy gamma-ray observatory, designed for making observations of astronomical gamma-ray sources in the energy band extending from 30 MeV to 300 GeV. It follows in the footsteps of the CGRO-EGRET mission[2] (operational between 1991 and 1999), and its launch is scheduled for the end of 2006. GLAST will have two scientific instruments: (1) the Large Area Telescope (LAT), an imaging, wide field-of-view telescope (composed of a tracker based on silicon micro-strip vertex detectors and a calorimeter), sensitive to gamma-rays over the energy range from ∼20-30 MeV to more than 300 GeV, and (2) the Burst Monitor (GBM), sensitive to transient bursts from 10 keV to 25 MeV. The LAT (see Fig. 1) is a pair-conversion telescope, formed by 16 "tower" modules, each with a tracker based on silicon microstrips (EGRET was based on gas spark chambers), a calorimeter (CsI with PIN diode readout) and DAQ module. The array is surrounded by finely segmented Anti Coincidence Detectors (ACD, plastic scintillator with PMT readout). The amount of silicon strip detector used for the tracker is impressive for a space-borne project: it is equivalent to a surface of $83m^2$ (about 11500 Single Strips Detectors

[1] http://glast.gsfc.nasa.gov/ and http://www-glast.stanford.edu/
[2] http://cossc.gsfc.nasa.gov/egret/

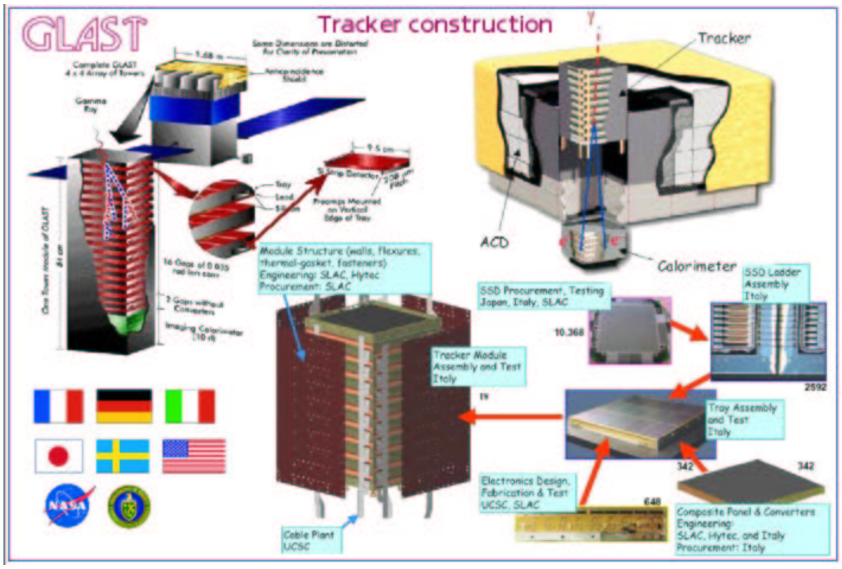

Fig. 1. Scheme of the Large Area Telescope (LAT) of GLAST, formed by an array of 16 identical "tower" modules (+2 for test beam), each with a tracker (silicon micro-strips vertex detectors) a calorimeter (CsI with PIN diode readout), and DAQ module. The array is surrounded by finely segmented ACD (plastic scintillator with PMT readout). A very big amount of silicon microstrips will be used for the tracker, equivalent to a total surface of 83m^2 of silicon detector (11500 SSDs).

SSDs), approximatively the same used in the next ATLAS experiment at CERN (for a description of the LAT see for example Michelson , 2003; Bellazzini et al. , 2002). Recent descriptions of some scientific topics and software for GLAST can be found in (Ciprini et al. , 2003).

Funding and participating Italian institution to GLAST, is mainly *Istituto Nazionale di Fisica Nucleare* (INFN, Bari, Padova, Perugia, Pisa, Rome2 and Trieste-Udine sections) for the LAT project, joined to the Italian Space Agency (ASI) and IASF-CNR of Milan. ASI is preparing a compact γ-ray mission at this energy bands AGILE[3], which will anticipate GLAST and then cooperate overlapping with it. Moreover Italy is a traditional partner for important NASA astrophysics exploration missions (Swift, Constellation X, JWST etc.). In the case of GLAST, the participation also of INFN to construction and testing, will permit an astrophysics and particle physics partnership. In this view the project is open to the Italian astronomical community.

[3] `http://agile.mi.iasf.cnr.it/`

2. GLAST and gamma-ray blazars

The GLAST LAT is a considerable improvement over its successful predecessor EGRET, with its broad energy range (0.03-300GeV), the 10000cm^2 of effective area (at 10 GeV), the 9% of energy resolution (at 0.1-100 GeV), with 2.4sterad of FOV, and an angular resolution of 3.4° at 100 MeV, 0.086° at 10 GeV. This gives a point source sensitivity (at 5σ) above 100 MeV, better than 3×10^{-9} photons cm^{-2} s^{-1}, for the first year of all-sky observing mode, at high Galactic latitude b, and for sources with E^{-2} photon spectra (Digel , 2003), 20-30 times better than EGRET. Source location determination is 0.4' at 1σ ra-

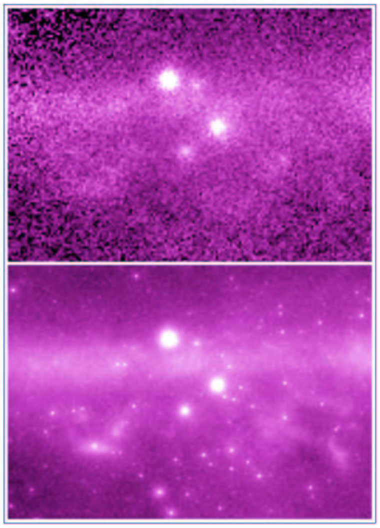

Fig. 2. EGRET observed (upper panel, CGRO Phases 1-5) and GLAST-LAT simulated (lower panel, one-year all sky survey) views of the Galactic Anticenter in gamma-rays above 100 MeV. Field is about 80 degree x 54 degree. (Reproduced with the permission of S. Digel, SLAC).

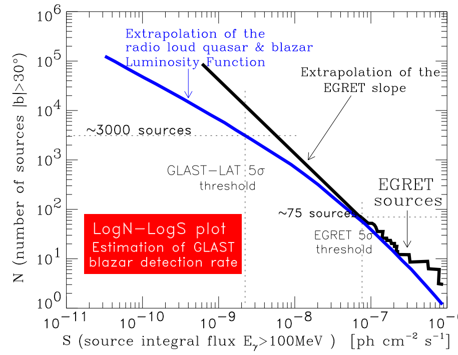

Fig. 3. LogN-LogS plot with the estimated GLAST detection rate of blazars. In black the curve of the EGRET observations and the extrapolated slope. The blue(gray) curved line is an extrapolation based on the radio-loud quasars-blazars Luminosity Function (after Stecker & Salamon , 1996; Gehrels & Michelson , 1999).

dius, (source flux 10^{-7} photons cm^{-2} s^{-1}, $E > 100$MeV. In Fig. 2 is showed a comparison of the Anticenter region at $E >$ 100MeV, observed by EGRET, and the expected GLAST-LAT view. The PSF and effective area are still under calculation, but Fig. 2 provide an adequate and correct visual impression of the quality of LAT data, which will permit a strong improvement in our knowledge on the γ-ray sky, (for a topics review see, e.g. the *GLAST science document*, Michelson et al. , 2001).

One of the main research fields for GLAST are the AGN, especially blazars (flat spectrum radio quasars, FSRQs, and BL Lac objects), for number of sources, and data quality. Gamma-rays provide a precious probe to investigate the extreme physical conditions in blazars jets, at sub-parsec scales and relativistic regimes. Over 3000 γ-ray blazars, are expected to be detected (Stecker & Salamon , 1996; Gehrels & Michelson , 1999) (prudential number based on the LogN-LogS relation assuming, a luminosity function proportional to that of radio-loud quasars–blazars, Fig. 3). The GLAST–LAT will measure the continuum spectral energy distribution (SED) of blazars, in uncovered γ-ray energy bands (overlapping in the higher energy tail with ground–based Cherenkov telescopes). GLAST with its broand band coverage and temporal resolution will alow to identify and to constrain leptonic (SSC, EC, pairs) and hadronic (π^0 decay, proton) emission processes. It will be able to track γ-ray flares and variability, to correlate γ-ray emission with simultaneous multiwavelength observations, and will investigate the relations between γ-ray flares and the VLBI superluminal radio components and plasma blobs, shedding light on the disk-jet connection and on the nuclear activity. Moreover it will probe the extragalactic background light (EBL) through the absorption of γ-rays from blazars at higher z. The rate of the blazar flare emission detectable with GLAST, should be favoured at energies around 100 MeV (Dermer & Schlickeiser , 2002).

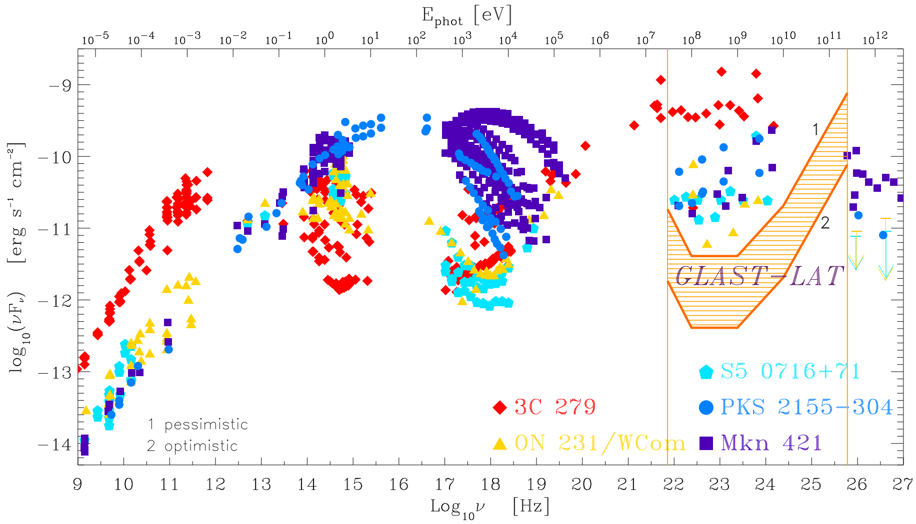

Fig. 4. Overall SEDs of some blazars, and a qualitative representation of the expected GLAST Large Area Telescope sensitivity (prudential estimations based on 80 hours at 5σ, and mean $dN(E)/dE \propto E^{-2}$). The limits are only qualitative because response functions (i.e. effective area, PSF, energy resolution etc.) are under calculation. SED data refers to different epochs (error bars not reported for clarity).

The SED of blazars show a two-bump structure, produced by synchrotron emission and inverse Compton (IC) scattering of soft photons in leptonic descriptions (see Fig. 4). In the synchrotron self-Compton scenario (SSC), the diffusive shock acceleration of electrons within a relativistic jet pointing toward the observer, produces synchrotron radiation, which is upscattered by IC by the same relativistic particles population. This description seems to account well for the emission of the HBL group (e.g. PKS 2155-304 and Mkn 421 in Fig. 4), that are usually also TeV emitters. On the other hand, in the leptonic scenario, FSRQs needs of thermal components and external–jet seed photons (external IC descriptions), to explain the relevant gamma–ray dominance (e.g. 3C 279 in Fig. 4). In the picture is sketched the qualitative sensitivity of the LAT. During flaring GLAST will be able to track the spectral evolution of the IC bump (MeV-GeV peaked), as for the synchrotron one (peaked in the IR-soft-X range), detecting also the quiescent emission of blazars. This will remove the current degeneracy in theoretical models, providing strong constraints.

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