The role of GLAST in multiwavelength observations of bright TeV blazars

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on behalf of the GLAST/LAT collaboration

OUTLINE
1- Motivation to observe “the classical TeV blazars”
2-Expectations from GLAST/LAT observations
The physics related to TeV blazars (and AGNs in general) is not yet understood, despite some of these objects having been studied for >10 years.

Current experimental data allows for a big inter-model and intra-model degeneracy. *More and “higher quality” data required to constrain models.*

- Leptonic vs hadronic emission models
- Intrinsic spectra vs EBL-affected spectra
- Production of flares (which are the shortest timescales)
- Acceleration/cooling in single or multi-zone; close or far from BH
- Role of external photon fields
- Time-resolve emission models
- etc, etc, etc …
1- Motivation to observe (again) the classical TeV blazars

Culprits for the relatively poor knowledge of these objects

1 - Time-evolving broad band spectra
   Coordination of instruments covering different energies needed

2 - Poor sensitivity to study high-energy part (E>0.1 GeV)
   Large observation times (with EGRET and “old” IACTs) were required for signal detection. *Data NOT truly simultaneous*, and *most of our HBL knowledge relates to the high state*

Present and near future (two “performance jumps”):

New Generation of IACTs online (low $E_{th}$, high sensitivity)

GLAST operation in 2008 (~25 more sensitive than EGRET)
1- Motivation to observe (again) the classical TeV blazars

**Mrk 421, Mrk 501, PKS 2155-304, 1ES1959+650**

Excellent laboratory for studying High Energy blazar emission

Strong gamma ray sources (0.1-0.5 crabs in VHE “low state”) 

\[ z \approx 0.1; \text{ low EBL absorption, we see “almost” intrinsic features} \]

Knowledge acquired with those objects could (in principle) be applied to other objects (fainter and/or larger \( z \))

Things we know about those blazars (and HBLs in general)

Dominant gamma-ray emission mechanism is believed to have a leptonic origin (SSC, EC) , at least in high (flaring) state

- Fast variations (down to hours and sub-hours in VHE)
- X rays- Gamma-rays correlation (in general)
2- LAT capabilities on the bright TeV blazars

For a detailed description of the performance of LAT:

- See talks (this conf.) by Michelson and Longo
- Visit page

http://www-glast.slac.stanford.edu/software/IS/glast_lat_performance.htm

Here, only shown the time required by GLAST/LAT (survey mode) to get a 5 sigma detection by assuming photon fluxes derived from past experimental data (X-rays/VHE) and extrapolations to the LAT energy range from reasonable/standard published SSC modelling

The uncertainties in flux and spectral index are also given for the observation time corresponding to this 5 sigma detection
2- LAT capabilities on the bright TeV blazars

Mrk 501

High
K = 1.4x10^{-8} \text{ GeV}^{-1}\text{cm}^{-2}\text{s}^{-1} ; a = 1.45
F(>0.1\text{GeV}) = 9.0 \times 10^{-8} \text{ ph cm}^{-2} \text{ s}^{-1}
Time for 5 sigma detection: 0.9 days
\Delta F_{>0.1\text{GeV}} \sim 68% ; \Delta a \sim 21%

Low
K = 2.3x10^{-9} \text{ GeV}^{-1}\text{cm}^{-2}\text{s}^{-1} ; a = 1.45
F(>0.1\text{GeV}) = 1.42 \times 10^{-8} \text{ ph cm}^{-2} \text{ s}^{-1}
Time for 5 sigma detection: 9 days
\Delta F_{>0.1\text{GeV}} \sim 74% ; \Delta a \sim 21%

This is the ONLY measurement of Mrk501 at these energies; it is a \sim5 sigma detection
K = 2.7x10^{-8} \text{ GeV}^{-1}\text{cm}^{-2}\text{s}^{-1} ; a = 1.3
F(>0.1\text{GeV}) = 1.8\times10^{-7} \text{ ph cm}^{-2} \text{ s}^{-1}
Time for 5 sigma detection: 0.3 days
\Delta F_{>0.1\text{GeV}} \sim 62% ; \Delta a \sim 25%

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2- LAT capabilities on the bright TeV blazars

Mrk 421

K = 2.13x10^{-8} \text{GeV}^{-1}\text{cm}^{-2}\text{s}^{-1} ; a = 1.60
F(>0.1\text{GeV}) = 13.9 \times 10^{-8} \text{ph cm}^{-2} \text{s}^{-1}
Time for 5 sigma detection: 0.8 days
$\Delta F_{>0.1\text{GeV}} \sim 63\% ; \Delta a \sim 19\%$

High
K = 6.0 \times 10^{-8} \text{GeV}^{-1}\text{cm}^{-2}\text{s}^{-1} ; a = 1.60
F(>0.1\text{GeV}) = 3.9 \times 10^{-7} \text{ph cm}^{-2} \text{s}^{-1}
Time for 5 sigma detection: 0.2 days
$\Delta F_{>0.1\text{GeV}} \sim 63\% ; \Delta a \sim 20\%$

EG J1104+3809

Krawczynski 2001 (Apj 559)

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2- LAT capabilities on the bright TeV blazars

PKS 2155-304

EGRET flux HIGH
K = 3.4x10^{-8} \text{GeV}^{-1}\text{cm}^{-2}\text{s}^{-1} ; a = 1.70
F(>0.1\text{GeV}) = 2.4 \times 10^{-7} \text{ph cm}^{-2} \text{ s}^{-1}
Time for 5 sigma detection: 0.6 days
\Delta F_{>0.1\text{GeV}} \sim 55\% ; \Delta a \sim 9\%

EGRET flux LOW Hartman 1999
, ApJS 123
K = 8.0x10^{-9} \text{GeV}^{-1}\text{cm}^{-2}\text{s}^{-1} ; a = 2.35
F(>0.1\text{GeV}) = 13.2 \times 10^{-8} \text{ph cm}^{-2} \text{ s}^{-1}
Time for 5 sigma detection: 6 days
\Delta F_{>0.1\text{GeV}} \sim 34\% ; \Delta a \sim 10\%

Low
K = 3.6x10^{-9} \text{GeV}^{-1}\text{cm}^{-2}\text{s}^{-1} ; a = 1.40
F(>0.1\text{GeV}) = 2.3 \times 10^{-8} \text{ph cm}^{-2} \text{ s}^{-1}
Time for 5 sigma detection: 5 days
\Delta F_{>0.1\text{GeV}} \sim 68\% ; \Delta a \sim 21\%
The EGRET source 3EG J1959+6342 is located ∼1.5 degrees away from 1ES1959+650, and can be considered as an upper limit for the average emission of this blazar.

**High**

K = 2.1 x 10^{-9} \text{ GeV}^{-1}\text{cm}^{-2}\text{s}^{-1} ; a = 1.60

F(>0.1\text{GeV}) = 1.3 \times 10^{-8} \text{ ph cm}^{-2} \text{ s}^{-1}

Time for 5 sigma detection: 20 days

ΔF_{>0.1\text{GeV}} \sim 81% ; Δa \sim 19%

**Low**

K = 1.5 \times 10^{-9} \text{ GeV}^{-1}\text{cm}^{-2}\text{s}^{-1} ; a = 1.65

F(>0.1\text{GeV}) = 1.0 \times 10^{-8} \text{ ph cm}^{-2} \text{ s}^{-1}

Time for 5 sigma detection: 40 days

ΔF_{>0.1\text{GeV}} \sim 75% ; Δa \sim 16%


The EGRET source 3EG J1959+6342 is located ∼1.5 degrees away from 1ES1959+650, and can be considered as an upper limit for the average emission of this blazar.

K = 6.8 \times 10^{-9} \text{ GeV}^{-1}\text{cm}^{-2}\text{s}^{-1} ; a = 2.45

F(>0.1\text{GeV}) = 13.3 \times 10^{-8} \text{ ph cm}^{-2} \text{ s}^{-1}

Time for 5 sigma detection: 10 days

ΔF_{>0.1\text{GeV}} \sim 29% ; Δa \sim 9%

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2- LAT capabilities on the bright TeV blazars

Complement TeV obs. to cover entirely (and “close-to-simultaneously”) the high-energy peak in the SED

Together with simultaneous observations at X-ray frequencies, these new data will permit to study:

- Evolution of spectra with time, displacement of peaks …

**GLAST/LAT will be “always” watching !!!**

Notify the community when things get hot

LAT data (<10 GeV) will not be affected by the EBL, which will permit disentangling the intrinsic spectra of the sources. This will help to rule out/confirm emission models, as well as EBL models
3- Concluding remarks

The LAT instrument has been assembled and working for >1 year. Currently being characterized/validated. **LAT operation (beginning 2008) will boost our current capabilities to study blazars.**

LAT will bring key data from a poorly sampled energy range (0.02-100 GeV). However, **simultaneous MW observations are needed to understand the broad spectra of these objects.**

Campaigns on these four bright TeV blazars are being planned for 2008; **agreements with instruments covering radio to TeV energies are currently being made.** Campaigns on other non-HBL AGNs (like BLLac and 3C279) will be also performed. **Do not hesitate to contact us if you are interested in participating.** More information on multiwavelength campaigns with GLAST/LAT on these and other objects can be obtained at [http://glast.gsfc.nasa.gov/science/multi/](http://glast.gsfc.nasa.gov/science/multi/)
Backup
LAT Performance

Single-energy-bin sensitivity plot

5-sigma sensitivity to a high-latitude source whose spectrum is integrated over 1/4 decade in energy centered on the energy shown on the horizontal axis.

http://www-glast.slac.stanford.edu/software/IS/glast_lat_performance.htm