GeV/TeV blazar population studies

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Summary

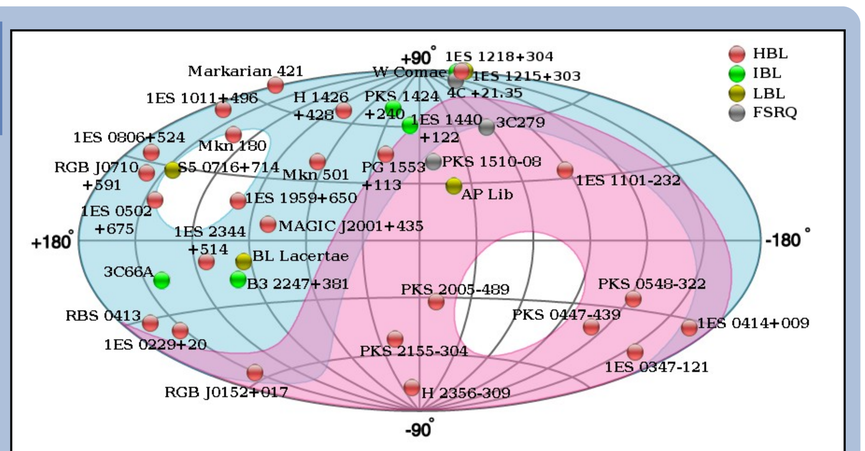
The synergy between the Fermi-LAT and ground-based Cherenkov telescope arrays gives us the opportunity for the first time to characterize the high energy emission (100 MeV – 10 TeV) from more than 30 blazars. In this study we performed a Fermi-LAT spectral analysis for all TeV-detected blazars and combined it with archival TeV spectra.

Results

Our results for low synchrotron-peaked BL Lacs (LBL) show hints of absorption features in the GeV band that could be interpreted as internal opacity at the source. We note that simple or broken power laws can not describe all the observed GeV/TeV spectra and more complex spectral shapes seem required.

(a) Source Sample

- All blazars with TeV spectrum (26 sources).
  - 24 BL Lacs and 2 quasars.
  - All except for 4 are in Fermi 1-year catalog.
  - 23 have known redshift.
- GeV spectra generated from the analysis of 27-months of Fermi data.
- TeV spectra is archival, corrected for EBL absorption using [1].
- Includes 6 contemporaneous GeV/TeV spectra.

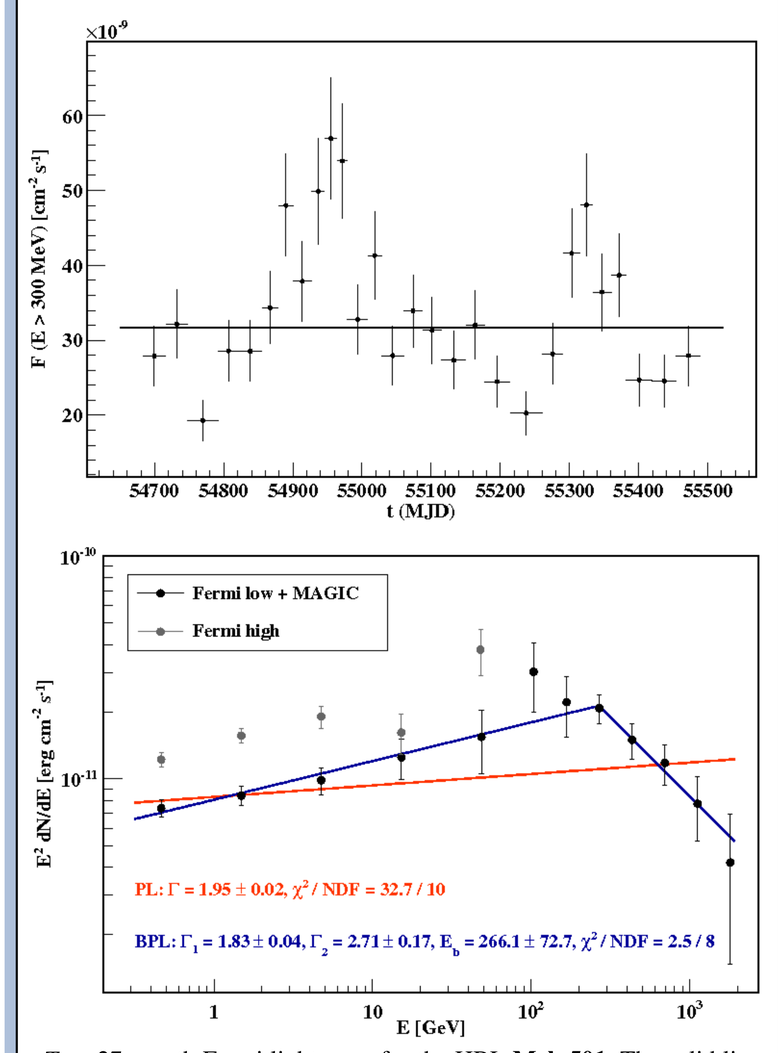


Skymap for TeV blazars [2]. Blue and pink regions represent VERITAS/MAGIC and HESS visibilities respectively.

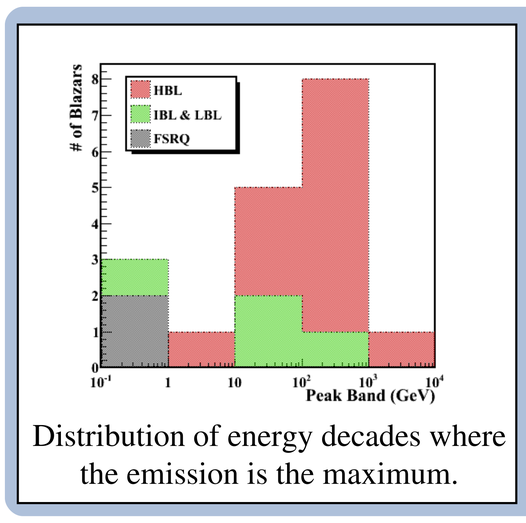
(b) Fermi Analysis

Simultaneity Issue

- Most of the GeV/TeV data are not simultaneous.
- Fermi data is split into different flux states and then the corresponding GeV spectra are calculated for each state.



Top: 27-month Fermi lightcurve for the HBL **Mrk 501**. The solid line shows the average flux, which was used as a reference point to split the whole data into subsets "high" and "low". *Bottom*: *Fermi* spectra and MAGIC TeV spectrum [3]. As the TeV spectrum represents a low state, it was matched with the "low" state Fermi spectral points (5 black circles on the left). A broken power law (blue) provides a better fit than a simple power law (red).



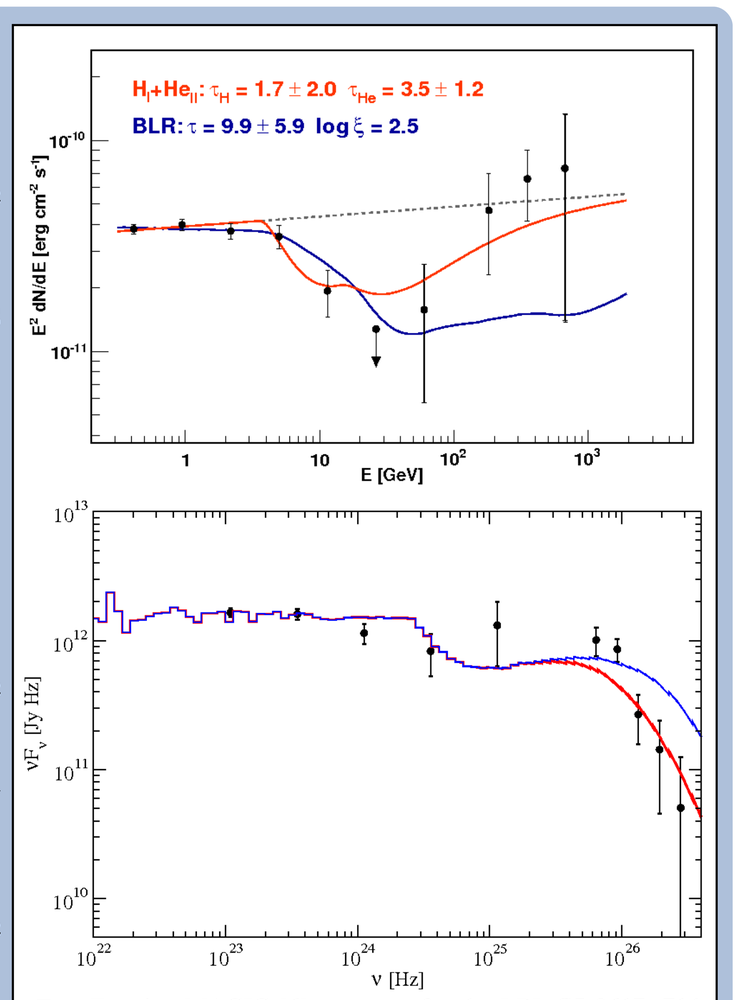
Distribution of energy decades where the emission is the maximum.

(c) IC Component

- Identified the energy decade in which the largest amount of power is emitted.
- Low synchrotron-peaked objects have the maximum of their emission mostly below 1 GeV.
- HBLs tend to peak in the TeV range.
- This verifies the expected relation between the synchrotron and the IC peak locations.

(d) Internal Absorption

- LBL objects display absorption-like features in the 10-100 GeV range.
- We considered the following absorption scenarios from the **broad line region** (BLR) [4]:
  - H I line (13.6 eV)
  - He II line (54.4 eV)
  - H I & He II combined
  - Full BLR spectrum
- Absorption from the **He II** complex seems to be dominant.
- Full BLR absorption underproduces the TeV emission.
- Also modeled a full BLR absorption + cascade emission from the γ-γ absorption [5].
  - No significant contribution from cascading effects in the Fermi band.



Top: Fermi + MAGIC [6] spectrum for the LBL **S5 0617+714**. The GeV spectrum is from the "high" data subset. The red curve represents H I + He II absorption only and the blue one the full BLR absorption. *Bottom*: Fermi +VERITAS [7] spectrum for the LBL **W Comae**, with absorption of a pure power-law (blue) and a power-law with exponential cut-off (red), by the full BLR emission, with cascading effects taken into account.

Summary

- Analyzed 27-months of Fermi data & combined it with archival TeV data.
- Absorption-like features are seen in LBL spectra.
- These features are best described as BLR absorption from the He II complex.
- The peak location in the GeV/TeV region is related to the synchrotron peak location.
- Modeling is ongoing for all TeV-detected blazars [8].

References

[1] Domìnguez, A. et al. 2011 MNRAS 410: 2556
[2] http://tevcat.uchicago.edu/
[3] Anderhub, H. et al. 2009 ApJ 705:1624-1631
[4] Poutanen, J. et al. 2010 ApJ 711: 118
[5] Roustazadeh, P. et al. 2010 ApJ 717: 468-473
[6] Anderhub, H. et al. 2009 ApJL 704: 129-133
[7] Acciari, V. A. et al. 2008 ApJL 684: 73-77
[8] Şentürk, G.D. et al. 2011

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