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The new γ-ray satellite **GLAST** foreseen for May 2008 provides a tremendous opportunity for future blazar studies. In order to fully benefit from the offered capabilities of this instrument and to interpret the high energy emission, a **multi-frequency campaign has been initiated**. It produces comprehensive measurements prior to and after the GLAST launch for a sample of roughly **60 blazars that appear highly interesting**. The campaign covers a **unprecedented frequency range** including radio, mm, optical and infrared wavelengths bringing together some state-of-the-art facilities. There is a tight coordination of the observations so that simultaneity of the order of a few days is achieved. Apart from total intensity, the study also focuses on polarization mode. This effort will eventually allow the study of the **long-term variability** and **spectral shape evolution** of blazars. Combined with future GLAST γ-ray data, the detailed study of (i) the γ-radio connection (e.g. variability, flares, γ-production site including VLBI) and (ii) the broad band emission of blazars will become possible.

The GAMMA-project:
GLAST AGN Multi-frequency Monitoring Alliance

Max-Planck-Institut für Radioastronomie

GLAST *The Gamma Ray Large Area Space Telescope*

MAX-PLANCK-GESELLSCHAFT

Introduction

"Blazars" a major sub-class of radio-loud Active Galactic Nuclei (AGN) differs significantly from all other types of extragalactic objects showing extreme phenomenological characteristics: intense **flux density variability** due to outbursts occurring throughout the whole electromagnetic spectrum, **high degree of linear polarization**, almost uniquely **broad-band emission characteristics** with a prominent high energy component (X-ray, γ-ray), **high super-luminal motions** and **brightness temperatures exceeding** the inverse Compton limit (e.g. Urry 1999). These properties are collectively interpreted within the context of emission originating in **relativistic jets oriented very close (≤ 20 – 30°) to the line-of-sight** (e.g. Urry & Padovani 1995).

Their overall spectral energy distribution (SED) shows **two clearly distinct broad components** of non-thermal emission. The low-energy component starts in the radio regime and shows its maximum between the far-infrared and soft X-ray band. The high energy one extends into the γ -ray or TeV band with its maximum occurring at hard X-rays or even higher energies as shown in Figure 1.

As long as the blazar variability is concerned, several models have been suggested. Among them, **shock in jets** (e.g. Marscher 1996), **colliding relativistic plasma shells** (e.g. Guetta et al. 2004), **rotating helical jets** (e.g. Camenzind & Krockenberger 1992, Begelman et al. In any case, the variability studies provide important clues about the sizthe structure, the physics and the dynamics of the emitting region.

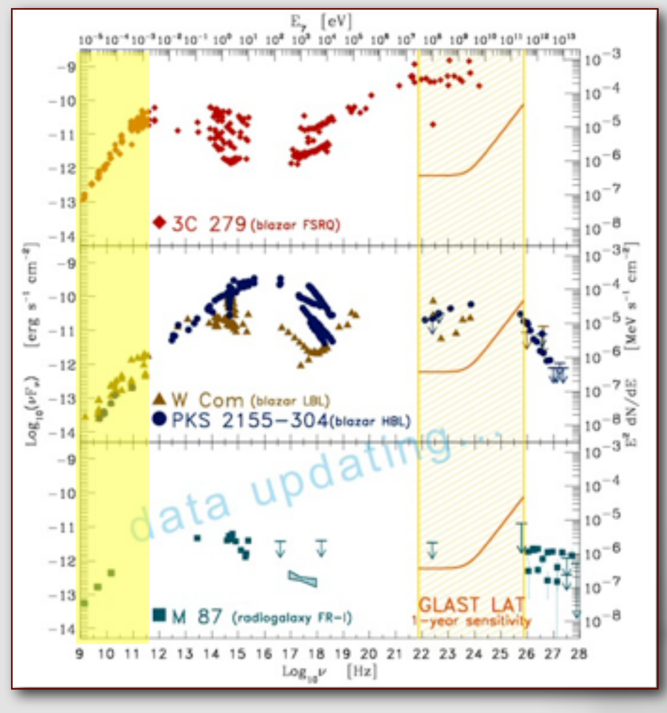


Figure 1: Examples of blazar SEDs. The double-bump overall SED of blazar 3C 279 is shown in comparison to e.g. W Com and PKS 2155-304. All the sources show strong spectral variations in time.

The Goal

From the above, it is clear that a powerful tool for understanding the physics of relativistic jets is the analysis of the **spectral** and **temporal** behavior of blazars, over frequency ranges as broad as possible. Ultimately, it can assist the **discrimination between different emission mechanisms** and **variability scenarios**.

Essential in this direction of study is the high energy regime and particularly the γ-ray band. The **Gamma-ray Large Area Space Telescope (GLAST)** satellite, having onboard the **Large Area Telescope (LAT)** detector will be, of vital importance. It will study several thousand sources in a systematic manner with very broad energy coverage (20 MeV–300 GeV) and a sensitivity > 30 times better than that of the predecessor EGRET.

However, in order to fully benefit from the offered capabilities it is important to conduct **multi-frequency campaigns** that will produce comprehensive observations prior to and after the GLAST launch.

To fulfill this requirement, a long series of facilities have been recruited in order to conduct:

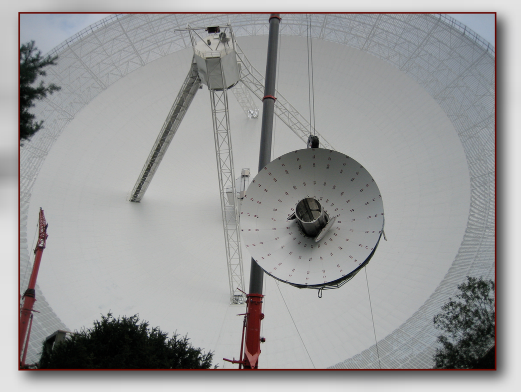
1. **Spectral evolution** of Blazars over unprecedented frequency coverage
2. **Flux density variability** (total intensity and polarization)

on a selected sample of almost 60 blazars that are observed regularly with the following facilities.

Observing Facilities

The essence of the currently reported project is f course the multi-wavelength approach. For that matter a long series of facilities are incorporated in a coordinated campaign:

1. The **100-m Effelsberg** radio telescope (L. Fuhrmann, E. Angelakis, J. A. Zensus, T. P. Krichbaum , N. Marchili). Comprises the most crucial contribution that instantaneous radio spectra (within 30-40 minutes). The observing frequencies are 2.64, 4.85, 8.35, 10.45, 14.60, 23.05, 32.00 and 43.00 GHz. With its newly installed **adaptive secondary surface** results superb sensitivity.



The 100-m telescope is delivering also **polarization** measurements by default.

2. The **30-m Pico Veleta** telescope is in parallel providing coverage in the mm band. In particular it observes at 3 and 1 mm in total intensity and polarization mode.
3. The **Owens Valley Radio Observatory 40-m** (A. C. S. Readhead, T. J. Pearson, R. Bustos) telescope is assigned the task of monitoring at 15 GHz roughly **1000 sources/day** . It Will detect the potentially best GLAST candidates sources. This campaign will provide record of activity.
4. The **2.1-m Kryonerion** telescope (J. H. Seiradakis, J. Nestoras, J. Antoniadis, E. Xilouris, P. Boumis, A. Dapergolas). Covering the optical band.
5. The **REM** IR telescope in La Silla covering the IR band.
6. The **Automatic Imaging Telescope** telescope also covering the optical band.
7. **VLBI (MOJAVE program, GMVA)** The task of VLBI will be providing high-resolution, multi-epoch images of most of the sources.

Results

As it was discussed earlier, owing to its superior sensitivity, the frequency coverage and the rapid system response, the 100-m Effelsberg telescope together with the IRAM 30-m is the most important partner in this campaign. Observing monthly it has already provided a large volume of high quality data. Figure 2 summarizes some typical examples of radio spectra recently reduced. There one can easily see how interesting spectral shapes they may show along with cases of variability.

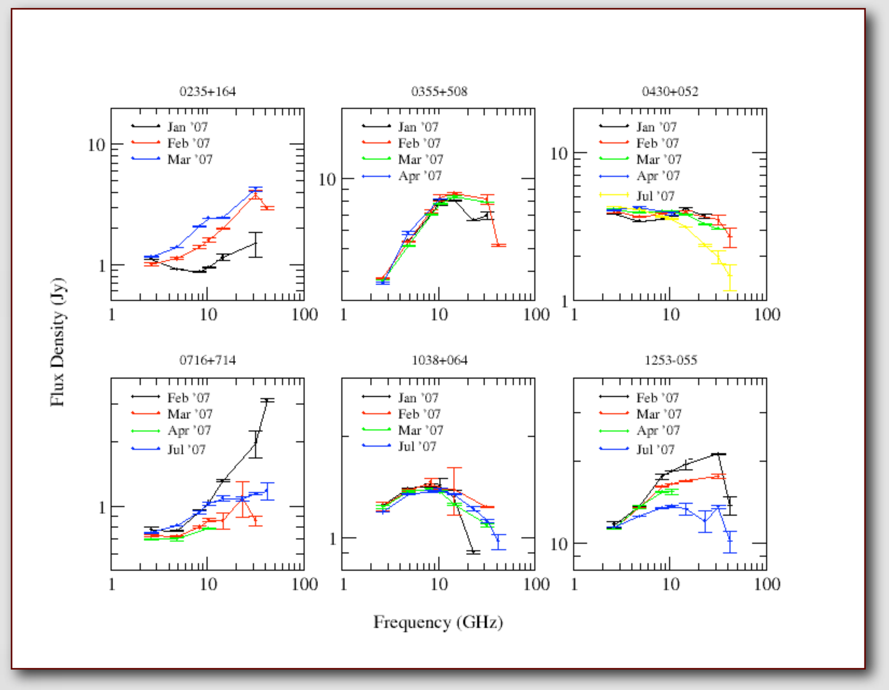


Figure 2: Examples of **preliminary** blazar radio spectra measured at Effelsberg. It is noteworthy the interesting shapes that they may possess. The large errors iat 23.00 GHz is mostly due to weather effects.

Conclusions

The **GAMMA-project** (**G**LAST **A**GN **M**ulti-frequency **M**onitoring **A**lliance) is an ambitious project aiming at monitoring a **number of selected blazars** (~60) that will be targeted by the **GLAST** satellite prior and after its launch. It covers the **radio**, **mm**, **infrared** and **optical** bands in order to study the **temporal** and **spectral** behavior of those sources as well as their **structural evolution** via **VLBI** observations. It is a collaboration among the most prominent facilities and will provide comprehensive observations with an unprecedented frequency coverage. Ultimately, this will allow:

1. Detailed study of the structure of blazars at linear scales unapproachable even to the highest resolution interferometers.
2. Constrains in the variability models.
3. Constraints in the emission mechanisms.
4. Modeling their spectral and temporal variability.

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