ISTITUTO DI RADIOASTRONOMIA

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TITLE

Monitoring blazar radio variability in two multi-wavelength intensive campaigns

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Is this a resubmission of a previous proposal ? no ● yes ○ – proposal number(s): ....
Is this a continuation of (a) previous proposal(s) ? no ● yes ○ – proposal number(s): ....
Is this part of a Ph.D. project ? no ● yes ○ – Student's Name: ....

Hours requested for this period: **192**

LST range(s):	from	to	number of intervals
	08	14	24
	11	15	12

Number of hours foreseen for full completion of this proposal: [ ] of which [ ] were already allocated

Receivers:

primary focus: 1.4 GHz ○ 1.6 GHz ○ 2.3 GHz ○ 8.3 GHz ● 22 GHz ●
secondary focus: 5.0 GHz ○ 6.0 GHz ○ 6.6 GHz ○

Backends:

continuum backend ● ARCOS ○ digital spectrometer ○ polarimeter ○ pulsar backend ○
guest instrument ○ specify: ....

ABSTRACT

We ask for a densely sampled single dish monitoring of the two highly active blazars Mrk 421 and 3C 279. Intensive multi-wavelength observational campaigns on these sources are currently planned by the *Fermi* Large Area Telescope (LAT) team from the second half of December 2008 till mid March 2009. We ask to monitor the flux and spectral evolution of the sources with 8 and 22 GHz observations, in order to optimize the compromise between receiver sensitivity and dominance of the flat-spectrum, variable, compact component which is most likely to be related to the high energy activity. These observations will be used in coordination with the high energy observations and will provide insights on the correlated multi-λ activity and on possible intra-day variability.

join to this form: scientific aims ≤ 2 typed pages and ≤ 2 of Figs., Tables and list of related publications

Introduction

Mrk 421 (1101+384) and 3C 279 (1253-055) are two well known and highly active blazars. Blazars display extremely intense and rapidly varying electromagnetic emission, from radio to γ-rays. This emission is thought to originate in a relativistic plasma jet, probably powered and accelerated by a super-massive black hole. Blazars are divided into Flat Spectrum Radio Quasars (FSRQ) and BL Lac objects.

FSRQ are usually brighter than BL Lacs in the radio and tend to be MeV/GeV sources. 3C 279 is a typical FSRQ, with a flux density of several Janskys at centimeter wavelengths and one of the most prominent EGRET sources (Hartman et al. 1992). Its parsec scale morphology consists of a bright, compact VLBI core ($T_B \sim 10^{13} K$) and an inner jet with relatively short-lived and superluminal jet components; variations in the total radio flux are due primarily to changes in the VLBI core flux (Wehrle et al. 2001).

BL Lacs have somehow lower radio luminosities and their SED extends up to the TeV regime, while in the MeV/GeV domain they are less prominent than FSRQ. As a prototypical BL Lac, Mrk 421 has been one of the first sources detected at TeV energies (Punch et al. 1992) and is also one of the few HBLs (High energy peaked BL Lacs) present in the 3rd EGRET catalog (Hartman et al. 1999). Several works have discussed the properties of the radio jet emerging from the active nucleus, and found a bright core, with one-sided jet emission extending for several hundred milliarcseconds and characterized by limb brightening and lack of superluminal motion of components (see Fig. 1 and, e.g., Piner et al. 1999, Giroletti et al. 2006). Monitoring of the total flux has also been done in the past on timescales of a month or more, showing structure functions with both maxima and minima, corresponding to clear recurrent variability (Venturi et al. 2001).

Both sources have been observed extensively in multi-λ campaigns in the past (e.g. Rebillot et al. 2006, Takahashi et al. 2000, Maraschi et al. 1994, Böttcher et al. 2007) and they have been caught both in outburst and in lower states, giving rise to a large production of models and interpretations (e.g. Katarzyński et al. 2000, Hartman et al. 2001). The development of the high energy instrumentation has also largely improved the quality of the data and hence our understanding of the physics of blazars. The availability of the *Fermi Gamma-ray Space Telescope* (formerly *GLAST*) is now a great opportunity not to be missed by the astrophysical community.

Requested observations

New multi-λ campaigns are now being planned, with the main goal of studying the flux and spectral evolution of the broad-band emission, from radio to multi-TeV, of Mrk 421 and 3C 279. The strongest motivation for new campaigns comes from the operation of the Large Area Telescope (LAT) on board the recently launched (June 2008) *Fermi Gamma-ray Space Telescope*. The *Fermi* LAT is a pair conversion telescope designed to cover the energy band from 20 MeV to greater than 300 GeV. *Fermi* operates in an all-sky scanning mode, providing regular γ-ray monitoring of the source. Mrk 421 and 3C 279 are among the "LAT Monitored Sources"[1], and preliminary, uncalibrated estimation of the γ-ray flux observed by *Fermi* LAT will be publicly available[2]. Preliminary public uncalibrated LAT data are shown in Fig. 2, and clearly indicate that LAT can detect the sources and see variability.

The sources are well visible at all energy ranges, which makes them very interesting laboratories to study physical processes in blazars. Flux and spectral variations can easily be studied over the duration of the campaigns. In particular, it is anticipated that the Mrk 421 campaign shall last almost 3 months. The source is clearly visible with *Fermi*, often on day time scales; therefore a 2-day sampling at other energies seems appropriate. This is already granted in X-rays (with RXTE) and TeV (with MAGIC). VERITAS and Swift are also likely to be obtained, making the opportunity for good multi-wavelength coverage of the sources excellent at all wavelengths.

We therefore ask for monitoring observations of Mrk 421 and 3C 279 with the Medicina telescope at 8 and 22 GHz. In particular, we ask for 24 observations on Mrk 421 (one every 4 days between mid-December and mid-March), and 12 for 3C 279, starting in February 2009.

Our main goal is to monitor the flux and spectral evolution of the sources, coordinated with the high energy observations. In particular, we are interested in the short timescales (around a day, or so), in order to look for fast variations and possible lags with respect to the high energy episodes of activity. Intra Day Variability (IDV) is often reported in sources with high brightness temperature cores (e.g., Kraus et al. 1999); given their parsec scale properties, our targets could definitely show some IDV.

Our requested frequencies are those ones in which flux density variations are most likely to be detected. In fact, variability generally takes place in the compact core, which is also supposed to be the region responsible of

[1] `http://fermi.gsfc.nasa.gov/ssc/data/policy/LAT_Monitored_Sources.html`

[2] `http://fermi.gsfc.nasa.gov/ssc/data/access/`

the high energy emission. Multi-frequency observations of blazars (e.g. Giroletti et al. 2004) have revealed that the VLBI cores have spectral peaks at ~ 8 GHz. Observations at 22 GHz are also important: the sources have a significant amount of extended steep spectrum emission, which contaminates the compact core flux density at lower frequency and which becomes less relevant at 22 GHz ($S_C/S_{\rm ext} \sim 0.5$ at 22 GHz).

Monitoring of the parsec scale structure at 15 GHz and of the total flux density at centimeter wavelengths are also underway as part of the MOJAVE[3] and GASP[4] programs. Therefore, it will be interesting to monitor the evolution of the flux density on short scales also in comparison to the longest term behavior.

Technical details

The total flux density of Mrk 421 at 8 and 22 GHz is (0.75±0.07) Jy and (0.6±0.1) Jy, respectively. The reported error has been estimated by the standard mean deviation of the measurements reported by Venturi et al. (2001) and Teräsranta et al. (2005). These works show that the source can easily be detected with the Medicina radio telescope at 8.4 GHz; moreover, given the flat spectrum nature of the source and the anticipated high performance of the new receiver, the source should be detectable also at 22 GHz, with flux density measurements accurate enough for a variability study. 3C 279 is much brighter ($S_{8,22} > 10$ Jy) and therefore easily detectable in both bands. We have also recently conducted a monitoring of Mrk 501 (May 2008), producing encouraging results about the telescope performances.

Since the targets are bright enough to determine significant flux variations on hours time scale in high energy bands, we would maximize the scientific return of all those observations if we kept simultaneity (as much as possible) at all energies. Therefore, we will ask to coordinate with the Medicina scheduler in order to attain simultaneity with the high energy observations, whose exact time ranges should be made available starting about 2 months before the observations take place.

Accounting for overhead due to pointing, focusing, and ON-OFF position switching, our request for Mrk 421 is of two hours at X band and 4 hours at K band for each epoch. For 3C 279, which is brighter and has a lower declination transit, we will only observe for 4 hours in total (e.g. 1.5 hrs at X band, 2.5 hrs at K band).

References

Böttcher, M., et al. 2007, ApJ, 670, 968
Giroletti, M., et al. 2004, ApJ, 600, 127
Giroletti, M., et al. 2006, ApJ, 646, 801
Hartman, R. C., et al. 1992, ApJL, 385, 1
Hartman, R. C., et al. 1999, ApJS, 123, 79
Hartman, R. C., et al. 2001, ApJ, 553, 683
Katarzyński, K., Sol, H., & Kus, A. 2003, A&A, 410, 101
Kraus, A., Witzel, A., & Krichbaum, T. P. 1999, NewAR, 43, 685
Maraschi, L., et al. 1994, ApJL, 435, 91
Piner, B. G., et al. 1999, ApJ, 525, 176
Punch, M., et al. 1992, Nature, 358, 477
Rebillot, P. F., et al. 2006, ApJ, 641, 740
Takahashi, T. et al. 2000, ApJL, 542, 105
Teräsranta H., et al., 2005, A&A, 440, 409
Venturi, T. et al. 2001, A&A, 379, 755
Wehrle, A. E., et al. 2001, ApJS, 133, 297

[3] http://www.physics.purdue.edu/astro/MOJAVE/
[4] http://www.to.astro.it/blazars/webt/gasp/homepage.html

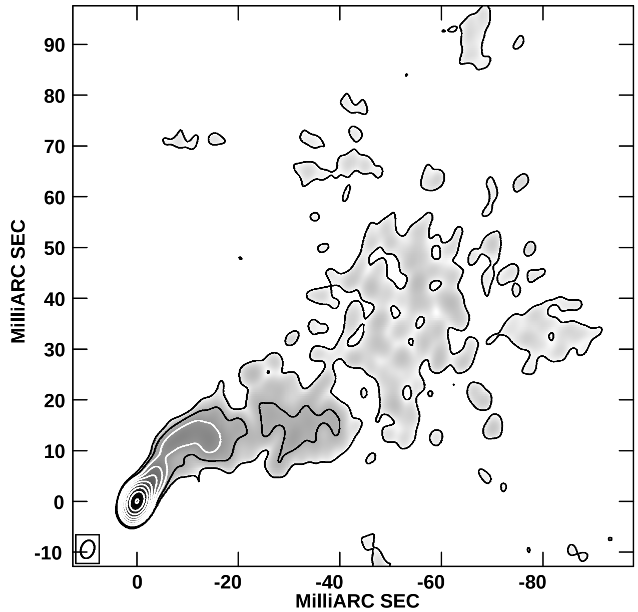

Figure 1: A VLBA+Y1 5 GHz image of Mrk 421 from Giroletti et al. (2006). Contours are traced at $(-1, 1, 2, 4, ...) \times 0.64$ mJy beam^{-1} (3σ noise level); the beam is 3.6×2.6 mas in PA $-19°$, and the peak brightness is 338 mJy beam^{-1}.

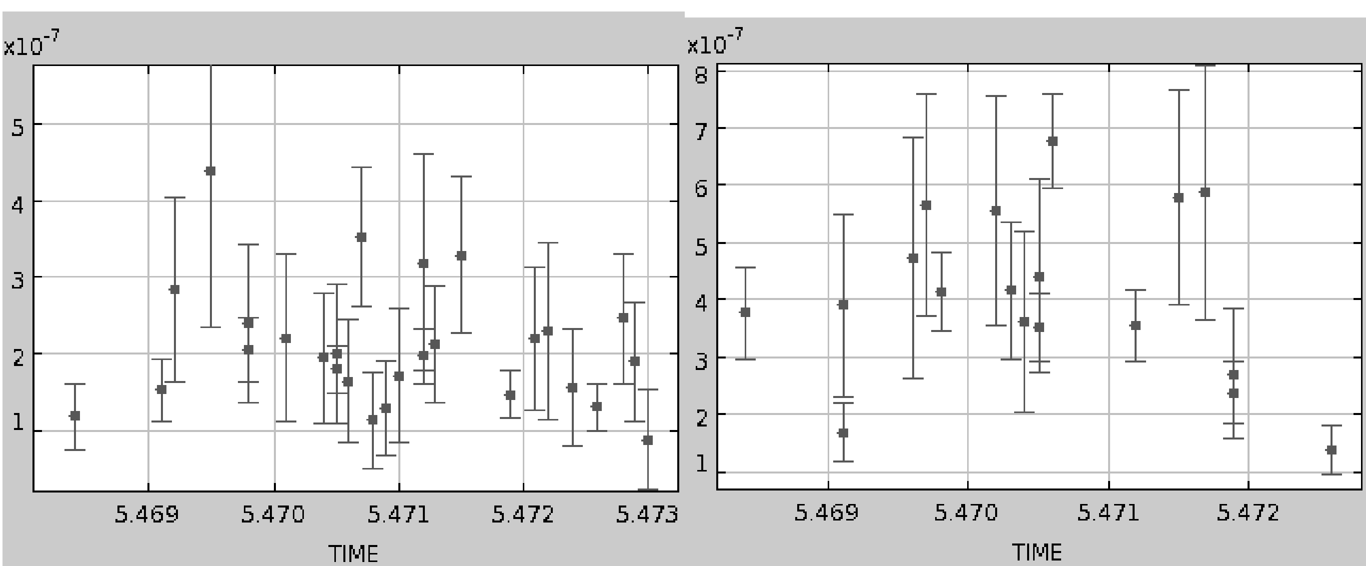

Figure 2: Preliminary light curves showing uncalibrated fluxes in the 0.1-300 GeV range (photons s^{-1} cm^{-2}) vs time (Julian days $\times 10^4$). Left: Mrk 421; right: 3C 279