Observing Proposal 2010/2011

Proposal Title : Fermi triggered ToO observations of selected flat spectrum radio quasars
Science Group : Blazar Science Working Group
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LIST OF OBJECTS

Source Name	R.A (J2000)	Dec (J2000)	redshift
CGRaBS J0017-0512	00 17 35.82	-05 12 41.7	0.227
CRATES J0422-0643	04 22 10.80	-06 43 45.3	0.242
4C +06.21	04 57 07.71	+06 45 07.3	0.405
PKS 0507+17	05 10 02.37	+18 00 41.6	0.416
CLASS J0517+0858	05 17 40.06	+08 58 35.8	0.328
CLASS J0713+1935	07 13 55.68	+19 35 00.4	0.534
PKS 0736+01	07 39 18.03	+01 37 04.6	0.191
CGRaBS J0948+0022	09 48 57.32	+00 22 25.6	0.585
4C +21.35	12 24 54.46	+21 22 46.4	0.435
3C 273	12 29 06.70	+02 03 08.6	0.158
3C 279	12 56 11.17	-05 47 21.5	0.536
CGRaBS J1312+4828	13 12 43.35	+48 28 30.9	0.501
PKS 1509+022	15 12 15.74	+02 03 17.0	0.219
PKS 1546+027	15 49 29.44	+02 37 01.2	0.414
3C 345	16 42 58.81	+39 48 37.0	0.593
CGRaBS J1700+6830	17 00 09.30	+68 30 07.0	0.301
PKS 1725+044	17 28 24.95	+04 27 04.9	0.293
CRATES J1818+0903	18 18 40.06	+09 03 46.2	0.354
OX 169	21 43 35.54	+17 43 48.7	0.211
CGRaBS J2334+0736	23 34 12.82	+07 36 27.5	0.401

OBSERVING MODE AND EXPOSURE

Source	Total (hours)	Pair Mode	Wobble Mode	Minimum (hours)	No. of Tels	Weather	Moonlight OK?	Months Visible
ToO	2	0	2	2	2/3/4	A/B/C	Yes	all

Comments:
We plan on monitoring 20 FSRQs using an automated Fermi-LAT analysis to trigger short VERITAS exposures when the objects exhibit very bright flares.

Who will analyse these data and when?
The authors will analyze the data. Manel Errando (VEGAS) and Heike Prokoph (Eventdisplay) will provide a preliminary analysis the day after observations are made.

Are there multiwavelength requirements or obligations for this proposal?
Observations are based on Fermi-LAT triggers.

Are these data the subject of a thesis?
No.

JUSTIFICATION STATEMENT

Flat Spectrum Radio Quasars (FSRQs) represent 75% of the extragalactic sources detected by EGRET [1] and 40% of sources in the Fermi-LAT AGN catalog [2]. Even if they are easily detected in the GeV band, they remain elusive to TeV instruments. So far, only 3 FSRQs have been detected by Cherenkov telescopes.

One of the main characteristics of FSRQs is their variability. Fermi-LAT observations in survey mode have shown that quasars show very fast and bright flaring episodes. PKS 1222+216 has been detected by MAGIC during a flare [3, 4], PKS 1510-089 was detected by H.E.S.S. during observations motivated by high states in the Fermi band [5], and the detection of 3C 279 was reported before the launch of Fermi but also happened during a one night flare.

Given that Fermi supplies a continuous picture of the gamma-ray sky, VERITAS observations of FSRQs triggered by Fermi high states seem the best strategy to increase the population of TeV quasars and better understand the properties of their emission in the gamma-ray band.

Scientific goals

- *Increase our knowledge of TeV emission from FSRQs* by *detecting more sources of this class. Confirm TeV emission from 3C 279 and PKS 1222+216* (aka 4C +21.35) that have been detected only once and in short flaring episodes.
- *Study the variability time scale in FSRQs.* The variability time scale (t_{var}) restricts the size of the emission region to $R < ct_{var}\delta(1+z)$, where δ is the Doppler factor. Fermi-LAT has observed variability in timescales of $5-6$ hours in the cases of 3C 454.3, PKS B1510-089 [6] and 3C 273 [7]. Those values are in agreement with the common paradigm that the spatial scale of the emitting region is of the order of the gravitational radius $r_g = GM/c^2$ of the central black hole. However, BL Lac type objects have shown TeV flaring episodes with variability timescales as short as a few minutes [8, 9]. Such fast variability can still be accommodated in classical synchrotron self-Compton models. However, if sub-hour variability would be detected in an FSRQ a strong revision of present day models and understanding of relativistic jets would be needed, as the broad-band emission from quasars is typically explained by leptonic models with the contribution of external photons fields that can be at fairly large distances from the core. *Searches for sub-hour variability time scales in FSRQs have been the main scientific goal of the only Fermi pointed observations performed so far (during a 3C 454.3 flare in April 2010). The larger collection area of VERITAS compared to Fermi makes it more sensitive to fast variability (Fermi-LAT detects ~ 3 γs/hour from Crab while VERITAS sees ~ 10 γs/min).*
- Potential *EBL studies constraining EBL density in the UV-optical band* in case of detection. Due to the moderate redshift of most of the candidates, and the relatively high photon fluxes expected by flaring FSRQs in the VHE band significant detections up to energies of only few hundred GeV can provide valid constraints to the EBL density in the optical region of the spectrum.
- A VERITAS detection of an FSRQ coincident with a Fermi high state would naturally trigger *multi-wavelength observations* that would be very useful to increase our knowledge about the origin of the gamma-ray emission in quasars. In particular, *leptonic models have been challenged by the observed spectral energy distribution of 3C 279 during its TeV detection, suggesting a possible hadronic origin of the emission [10].*

Selection criteria

For this proposal we selected sources from the Fermi 1-year AGN catalog [2], classified as FSRQ, and with $F_{1-100\text{GeV}} > 1 \times 10^{-9}\,\text{ph}\,\text{cm}^{-2}\text{s}^{-1}$. A cut in redshift of z < 0.6 was imposed to avoid observations of too distant objects, where EBL absorption would dramatically affect the chances of a detection. To ensure a low energy threshold of the VERITAS observations, objects with $-8 < \delta < 72$ were selected to guarantee observations at elevation $> 45°$. A table with the 20 selected candidates is shown in the first page. In addition, 2 years of Fermi data were inspected to find high energy photons within the PSF of the selected FSRQs, to ensure that a detection in the VHE could be feasible.

Trigger criteria and observations

The trigger criteria are based on an automated analysis of the Fermi data running at Barnard College that will provide triggers $\sim 6\,\text{h}$ after a flux increase happens (mainly due to the delay associated to Fermi data to become public). The alert will be notified by an automatic email to the observers and the TAC $\sim 2\,\text{h}$ before the flaring object can be observed that night. This automatic triggers will be issued without human interaction and we ask the TAC to pre-aprove them in order to avoid having an extra 1 day delay for the observations to take place. On the other hand, these triggers should not override scheduled VERITAS observations of high interest, like simultaneous multiwavelength observations, GRBs, or other flaring sources of special interest.

The required trigger criteria is the presence of *at least 2 photons from the source with* $E > 10\,GeV$ *in the last 2 days*. Additionally, a *combined energy deposit* $> 30\,GeV$ will be required. In the case of PKS 1222+216 the trigger levels will increased to 3 photons and $> 60\,\text{GeV}$ energy deposit to avoid too many triggers. The trigger criteria will be checked every day for every source $\sim 2\,\text{hr}$ before observations are possible (elevation $> 50°$, $> 45°$ in the case of 3C 279). If the trigger is issued, 2 hours of observations in that night are requested. Given the short timescales of quasar flares, we also ask to extend the observations as much as conditions permit in case that a $> 5\sigma$ signal is seen in Quicklook analysis after the nominal $2\,\text{h}$ of observation. Observations in the following nights will only be requested if the trigger criteria based on Fermi data are met again. A study of the arrival time of the photons with $E > 10\,\text{GeV}$ for the selected sources in the first two years of Fermi operations (see Figure 1) estimates that ~ 3 triggers would be expected each season. If one of the monitored sources enters into a prolonged high state, where frequent flares are expected, the trigger thresholds for that source will be accordingly increased.

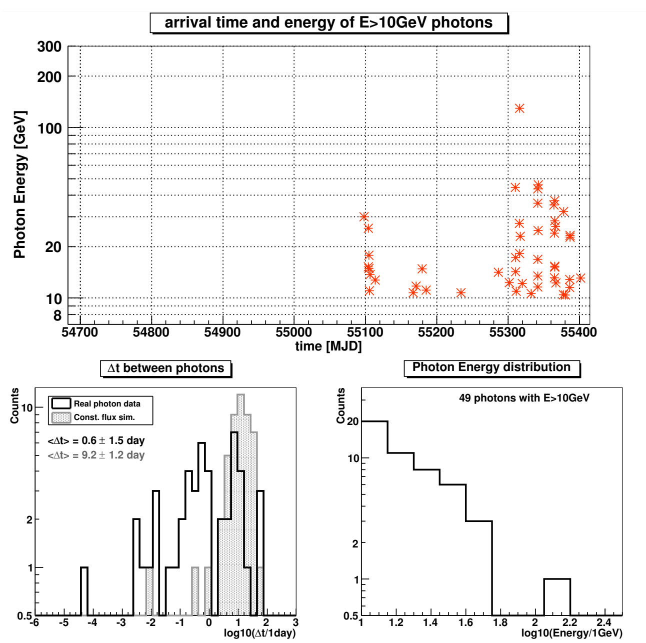

Figure 1: Study of the arrival time of $E > 10\,\text{GeV}$ photons for an FSRQ (PKS 1222+216). In the case of the BL Lac the photons seem to arrive at a constant rate, while for the FSRQ high energy photons come highly clustered, with typical delay time of only $\sim 12\,\text{hr}$.

References

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[7] Abdo, A. A., et al., ApJ 714 (2010) L73

[8] Albert, J., et al., ApJ 669 (2007) 862

[9] Aharonian, F., et al., ApJ 664 (2007) L71

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