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Blazar Monitoring with the Whipple 10 m Gamma-ray Telescope

J. Kildea for the Whipple 10 m telescope's Blazar Monitoring Program[1]

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Abstract. Since September 2005, the Whipple 10 m Gamma-ray Telescope has been used primarily to monitor known TeV AGN. The five Northern Hemisphere blazars that have been previously detected at Whipple, Markarian 421, H1426+428, Markarian 501, 1ES 1959+650 and 1ES 2344+514, are monitored each night that they are visible. To encourage and coordinate observations of these AGN at other wavelengths, the observing timetable and preliminary light curves for the TeV observations are provided on a publicly accessible website: veritas.sao.arizona.edu/content/blogsection/6/40. A number of multiwavelength observing campaigns have been undertaken by numerous collaborators in conjunction with the Whipple program and a significant amount of data has been accumulated. We report here on the status of these multiwavelength observations and present light curves of radio, optical, X-ray and gamma-ray data.

Keywords: AGN, Whipple Blazar Monitoring, Atmospheric Cherenkov Technique
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INTRODUCTION

Blazars are a subclass of Active Galactic Nuclei (AGN), in which the viewing angle of the jet is very small ($\lesssim 10^\circ$), such that the observer is looking straight down the jet, and the jet is the most obvious feature of the galaxy. They are characterised by their high luminosity and exhibit rapid and irregular variablity across the electromagnetic spectrum. Multiwavelength observations of blazars are important in order to test models that attempt to explain their non-thermal emission. Measurements of the temporal correlation between flux variations at different wavelengths during flares are particularly useful, simultaneously providing constraints on the emission models in various energy regimes.

In September 2005, the observing program of the Whipple 10 m gamma-ray telescope was redefined and it was dedicated almost exclusively to blazar monitoring. The five Northern Hemisphere blazars that had already been detected by the 10 m telescope, Markarian 421, H1426+428, Markarian 501, 1ES 1959+650 and 1ES 2344+514, were selected for routine observation whenever they are visible. For the first time this has provided long-term and well-sampled TeV lightcurves of these objects.

THE WHIPPLE 10 M GAMMA-RAY TELESCOPE

The Whipple 10 m telescope [1] is situated at the Fred Lawrence Whipple Observatory on Mount Hopkins, Arizona (altitude: 2,300 m a.s.l.). It has been operated as an imaging atmospheric Cherenkov telescope since the mid 1980s and was used to discover the first Galactic [2] and extra-galactic [3] sources of TeV gamma rays. To date, it has detected nine gamma-ray sources and it remains a sensitive telescope for ground-based gamma-ray astronomy above $\sim$400 GeV. The Whipple telescope is currently operated by the VERITAS collaboration, which operates the stereoscopic VERITAS array of telescopes [4], also situated at the Fred Lawrence Whipple Observatory.

THE BLAZAR MONITORING PROGRAM

The Blazar monitoring program has been very successful, with multiwavelength observations performed in five wave bands. Since 2005 a total of 18 telescopes have participated in the program. A breakdown of the participating telescopes

[1] A complete list of the scientists involved in the Blazar Monitoring Program is available at: http://veritas.sao.arizona.edu/content/blogsection/6/40/

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TABLE 1. The telescopes participating in the Blazar Monitoring Program.

Spectral Band	Telescopes
VHE Gamma-rays	Whipple 10 m telescope (> 400 GeV) and VERITAS (>100 GeV)
X-rays	All Sky Monitor (2-10 keV) and Proportional Counter Array (3-25 keV)
Optical (R, B, V)	SAO 48-inch, Mt Hopkins, Arizona
	Boltwood, Ontario, Canada
	Antipodal, Arizona and India
	Bordeaux, France
	0.6m Bell Observatory
	Coyote Hill Observatory
	Sbadell
	Tenagra 32-inch
	Tuorla, Finland
	Perugia, Italy
	WIYN, Kitt Peak, Arizona
Infrared (H, J, K)	PAIRITEL, Mt Hopkins, Arizona
Radio	UMRAO, Michigan (4.8 GHz, 8 GHz, 14.5 GHz)
	Metsahovi, Finland (37 GHz)
	RATAN, Russia (0.99-21.7 GHz)

by spectral band is provided in table 1. At the time of writing the 2006/2007 blazar monitoring campaign is ongoing.

RESULTS AND CONCLUSIONS

A total of 424 hours of data were obtained on the five blazars monitored during 2005/2006. Table 2 provides the coordinates and redshifts of the observed blazars along with their observation exposures. Markarian 421 exhibited significant variability over all wave bands, particularly in the optical, X-ray and gamma-ray regimes. At least two publications detailing these observations are in preparation, one on Markarian 421 and the other on Markarian 501 and the remaining three blazars.

TABLE 2. The 5 blazars observed in the Blazar Monitoring Program, their coordinates, redshifts and observing exposures with the 10 m telescope during 2005-2006.

Name	R.A.	Dec.	z	Exposure (hrs)
Markarian 421	11 04 27.3	38 12 32	0.031	168
H 1426+428	14 28 32.7	42 40 20	0.129	60
Markarian 501	16 53 52.2	39 45 36	0.033	31
1ES 1959+650	19 59 59.9	65 08 55	0.048	110
1ES 2344+514	23 47 04.8	51 42 18	0.044	55

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