SLAC-PUB-12993

Wide-range multiwavelength observations of northern TeV blazars with MAGIC/HESS, Suzaku and KVA

M. HAYASHIDA[1], S. RÜGAMER[2], D. MAZIN[3], R. FIRPO[3], K. MANNHEIM[2], M. TESHIMA[1] ON BEHALF OF THE MAGIC COLLABORATION.
D. HORNS[4], L. COSTAMANTE[5], S. SCHWARZBURG[4], S. WAGNER[6] ON BEHALF OF THE HESS COLLABORATION.
T. TAKAHASHI[7], J. KATAOKA[8], G. MADEJSKI[9], M. USHIO[7] FOR THE SUZAKU TEAM
[1]*Max-Planck-Institut für Physik, D-80805 München, Germany,* [2]*Universität Würzburg, D-97074 Würzburg, Germany,* [3]*Institut de Física d'Altes Energies, Edifici Cn., E-08193 Bellaterra (Barcelona), Spain,* [4]*Institut für Astronomie und Astrophysik Eberhard Karls Universität, D-72076 Tübingen, Germany,* [5]*Max-Planck-Institut für Kernphysik, D-69029 Heidelberg, Germany,* [6]*Landessternwarte, Universität Heidelberg, Königstuhl, D-69117 Heidelberg, Germany,* [7]*Institute of Space and Astronautical Science/JAXA, Kanagawa, 229-8510, Japan,* [8]*Tokyo Institute of Technology, Tokyo, 152-8551, Japan,* [9]*Stanford Linear Accelerator Center, Stanford, CA, 943099-4349, USA*
mahaya@mppmu.mpg.de

Abstract: We have conducted multiwavelength observations of several northern TeV blazars employing the ground-based γ-ray observatories MAGIC and HESS, the optical KVA telescope, and the Suzaku X-ray satellite. The data taken in 2006 establish measurements of the contemporaneous spectral energy distributions of the rapidly variable blazar emission over a wide range of frequencies. Results allow us to test leptonic and hadronic emission and particle acceleration models which predict different correlations between the optical, X-ray, and very high enery γ-ray emissions. In this presentation, we report on the highlights of the results of these observations.

Introduction

Blazars are radio-loud active galactic nuclei (AGN) viewed at small angles between the jet axis and our line of sight. Being the brightest and most variable high-energy sources among AGNs, they give an excellent opportunity to study particle acceleration mechanisms in jets. Their spectral energy distribution (SED), extending from the radio band up to TeV γ-rays, is apparently characterized by a two-bump structure. The nonthermal, beamed emission is commonly ascribed to synchrotron and inverse-Compton radiation from relativistic electrons, accelerated in jets moving with relativistic bulk speed. At present, it is unclear whether the observed emission is entirely due to accelerated electrons, as in synchrotron-self-Compton (SSC) models [7], or whether the high-energy emission is due to secondary electrons produced by accelerated protons and ions [11]. The results of applying emission models to the data can provide information on physical parameters like the co-moving magnetic field, the cut-off energy of the electrons and protons, the Doppler boosting factor and the size of the emitting region in the jet. Blazars often show strong flux variability down to time scales of a few minutes in the very high energy regime [4]. Hence, simultaneous multiwavelength observations over a wide energy range are essential to study the physics of high-energy radiation emitters.

In the TeV blazars, the correlation between X-ray and GeV-TeV γ-ray fluxes are important because it is well interpreted by the SSC emission models. For instance, the multiwavelength campaign on Mrk 421 in 1994 with the ASCA satellite and the Whipple telescope [15] showed fast variability in both X-rays and TeV γ rays with a good corre-

Contributed to 30th International Cosmic Ray Conference (ICRC 2007), 07/03/2007--7/11/2007, Merida, Yucatan, Mexico

Work supported in part by US Department of Energy contract DE-AC02-76SF00515

lation. The observed SED can be well explained by an SSC model. On the other hand, during the multiwavelength observation on 1ES 1959+650 in 2002 [10], a TeV γ-ray flare without any X-ray counterparts was observed. This so-called "orphan" flare cannot be explained with conventional one-zone SSC models.

However, most of the previous multiwavelength campaigns suffered from low sensitivity of the participating γ-ray telescopes as well as their inability to measure data below 300 GeV. The simultaneous observations were limited to being conducted only during flaring states. The new generation of Imaging Atmospheric Cherenkov Telescopes (IACT), like MAGIC and HESS, can access the energy range from 100 GeV to some tens of TeV. Additionally, the high sensitivity of the new IACTs allow us to detect GeV-TeV γ-ray signals with short observation time even in the quiescent state which was not accessible to previous instruments in the GeV-TeV energy range. The study of the sources in low states of activity may reveal new emission components that are masked during flaring states [3]. Together with wide-range X-ray satellites like Suzaku, those new instruments make it possible to performe multiwavelength observations in much wider range than ever regardless of the activity state of the blazars.

In 2006, multiwavelength campaigns with ground based MAGIC/HESS telescopes, measuring from energies from 100 GeV to several TeV, and the Suzaku satellite, sensitive from soft to hard X-rays, were conducted for several northern TeV blazars.

Involved Instruments

MAGIC

The MAGIC (Major Atmospheric Gamma Imaging Cherenkov) telescope is the world's largest IACT with a 17 m diameter dish, located at the Canary Island of La Palma (28°.2 N, 17°.8 W, 2225 m. a.s.l.). The telescope is operating at a γ-ray trigger threshold of ~ 50 GeV and a spectral threshold of $\sim$100 GeV, representing the lowest energy threshold among IACTs. The telescope parameters and performance are described in detail in [5] and [6].

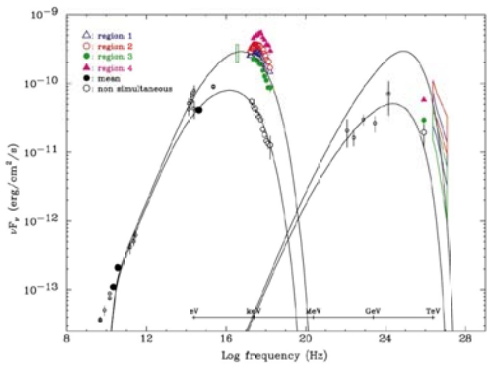

Figure 1: An example of the SED from a previous multiwavelength observation for Mkn421 [16]

HESS

The HESS array consists of four IACTs each with a tessellated 13 m-diameter mirror, located in the Khomas highlands in Namibia (23°.3 S, 16°.5 E, 1800 m. a.s.l.). Due to the large zenith angle observation for northern objects, the HESS array can perform measurements in the TeV energy range with a larger collection area than in low zenith angle observation, extending the accessible energy range towards higher energies. The telescope parameters and performance are described in detail in [9].

Suzaku

The joint Japanese-US satellite Suzaku [12], launched successfully into orbit on 2005 July 10, covers the wide range of 0.2 keV to 600 keV. Its high sensitivity both in the soft and hard X-rays makes it an excellent instrument for studying the SSC component of HBLs, making the detection of the X-ray peak position feasible.

KVA

KVA[1] is a 35-cm optical telescope also situated on La Palma. KVA can be operated remotely via internet e.g. from Finland. It is used for simultaneous monitoring of AGNs with the MAGIC telescope.

1. more information at http://tur3.tur.iac.es/

Observations

Markarian 421

Mkn421 (redshift $z = 0.030$) is the closest known and the first extragalactic source detected in the TeV energy range using IACTs [13], which makes it the best studied TeV γ-ray blazar. The multiwavelength campaign for this source was conducted in the night of 28th of April 2006. The X-ray observation with Suzaku was carried out from 53853.267 to 53854.271 in MJD time. The source showed the high flux level in GeV-TeV energy range around this campaign [8]. The X-ray as well as the very-high energy measurements indicate that the source has been observed in a high state of activity.

Markarian 501

Mrk501 (redshift $z = 0.034$) is the second established TeV blazar [14]. In 1997 this source went into a state of surprisingly high activity and strong variability, becoming 10 times brighter than the Crab Nebula in the TeV range [1]. In 1998-1999 the mean flux dropped by an order of magnitude [2]. Recently, a really strong flux variability with a few minutes time scale have been reported [4]. The multiwavelength campaign for this source was carried out in the night of 18th, 19th and 20th of July 2006. The X-ray observation window of Suzaku was 53934.789 to 53935.727 in MJD time. According to the long term monitoring by the MAGIC telescope, the flux level of this target was corresponding to a low state of activity [8].

The results will be presented at the conference.

Acknowledgements

The MAGIC collaboration thanks the IAC for the excellent working conditions at the ORM. The MAGIC project is supported by German BMBF and MPG, the Italian INFN, the Spanish CICYT, the Swiss ETH the Polish MNiI.

References

[1] F. Aharonian et al. The temporal characteristics of the TeV gamma-radiation from MKN 501 in 1997. I. *A&A*, 342:69, 1999.

[2] F. Aharonian et al. The TeV energy spectrum of Markarian 501 measured with the stereoscopic telescope system of HEGRA during 1998 and 1999. *ApJ*, 546:898, 2001.

[3] F. Aharonian et al. Multi-wavelength observation of PKS2155-304 with HESS. *A&A*, 442:895, 2005.

[4] J. Albert et al. Variable VHE γ-ray emission from Markarian 501. *ApJ*, 2007. submitted (astro-ph/0702008).

[5] C. Baixeras et al. Commissioning and first tests of the MAGIC telescope. *Nucl. Inst. Meth. Physics Res. A.*, 518:188, 2004.

[6] J. Cortina et al. Technical performance of the MAGIC telescope. *Proc. 29th Int. Cosmic Ray Conf. (Pune)*, 5:359, 2005.

[7] L. Costamante and G. Ghisellini. TeV candidate BL Lac objects. *A&A*, 384:56, 2002.

[8] F. Goebel et al. Long term monitoring of bright tev blazars with the magic telescope. *Proc. 30th Int. Cosmic Ray Conf. (Mérida)*, 2007.

[9] J. A. Hinton et al. The status of the HESS project. *New Astron. Rev.*, 48:331, 2004.

[10] H. Krawczynski et al. Multiwavelength observations of strong flare from the TeV blazar 1ES1959+650. *ApJ*, 601:151, 2004.

[11] K. Mannheim. The proton blazar. *A&A*, 269:67, 1993.

[12] K. Mitsuda et al. The X-ray observatory Suzaku. *PASJ*, 59:1, 2007.

[13] M. Punch et al. Detection of TeV photons from the active galaxy Markarian 421. *Nature*, 358:477, 1992.

[14] J. Quinn et al. Detection of gamma rays with E $>$ 300 GeV from Markarian 501. *ApJ*, 456:L83, 1996.

[15] T. Takahashi et al. ASCA observation of an X-ray/TeV flare from the BL Lacertae object Markarian 421. *ApJ*, 470:89, 1996.

[16] T. Takahashi et al. Complex spectral variability from intensive multiwavelength monitoring of Markarian 421 in 1998. *ApJ*, 542:L105, 2000.