Observation of the AGN 1ES1959+650 with the MAGIC telescope

Nadia Tonello, on behalf of the MAGIC Collaboration
Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), Föhringer Ring, 6, D-80805 München, Germany
E-mail: nadia@mppmu.mpg.de

Abstract. The AGN 1ES1959+650 has been observed with the MAGIC telescope in September and October 2004. The MAGIC Telescope is a low energy threshold IACT with, which is well suited for observations of weak γ-ray sources with soft spectra. During the first observations by MAGIC, 1ES1959+650 was in a low state of activity both in X-ray and in optical wavelengths. The analysis of VHE γ-ray data showed a ∼ 8σ significant signal, while no strong variation of emission during the examined period has been found. The mean measured γ-ray flux was ∼17% of Crab Nebula above 300 GeV. The measured differential energy spectrum between 150 GeV and 2 TeV can be described by a power law function of spectral index α = (2.72±0.14).

1. Introduction
The active galactic nucleus 1ES1959+650 is part of an elliptical galaxy at a redshift distance z = 0.047. It was first detected as a TeV γ-ray emitter in 1998 by the Seven Telescope Array collaboration [1] with 3.9σ significance. The Whipple collaboration reported an upper limit of ∼10% the Crab flux above 350 GeV from the observations in the years 1995-1998 [2]. For the observation campaign from 2000 until early 2002, the HEGRA collaboration reported a signal from 1ES1959+650 in quiescent state of 5.2σ significance [3]. In May 2002, the X-ray and VHE γ-ray emissions of the source had increased and the VERITAS collaboration triggered a successful multi-wavelength observational campaign. In the same year further periods of high γ-ray activity followed. The HEGRA and CAT collaborations subsequently confirmed the high VHE γ-emission state of the source in that period.

The MAGIC telescope is a new generation IACT for γ-ray astronomy. For the description of the MAGIC telescope and its performance see [4]. From the observatory Roque de los Muchachos (La Palma Canary Island, Spain), the AGN 1ES1959+650 can be observed with the MAGIC telescope from May to October under a mean zenith angle of ∼40°.

2. Analysis of data
The 1ES1959+650 data has been taken with the MAGIC telescope during September-October 2004. That period corresponds to the end of the MAGIC commissioning phase. After quality cuts, ∼6 hours of observation data (out of ∼7 hours of exposure time) from 1ES1959+650 were selected and analyzed. The full analysis results can be found in [5].

The optimal subspace of image parameters [6] for the γ-hadron separation was obtained with the Random Forest method [7], using MC γ and hadrons recorded during normal ON-source data taking. The cut in the discriminant variable provided by the Random Forest (the so-called
**3. Results**

**Figure 1.** 1ES1959+650 ALPHA plot, for an energy threshold of 300 GeV.

**Figure 2.** MAGIC light curve of 1ES1959+650: integral γ-ray flux above 300 GeV.

In Figure 1 the ALPHA distribution of the 1ES1959+650 data sample is shown for images with large values of SIZE> 1800 photons. The peak energy of the surviving γs is 300 GeV. The significance of the 1ES1959+650 detection is 8.2σ, with 246±30 excess events. The estimated 1ES1959+650 flux above 300 GeV corresponds to ~17% of the Crab flux.

The data sample of 1ES1959+650 has been analyzed separately for every night of observation. The resulting γ-ray light curve is shown in Figure 2. The results did not show any significant flux variation, indicating that the source was basically in the same state during the time covered by our observation and no flaring activity is responsible of the recorded signal with MAGIC.

Informations on the X-ray activity level are based on quick-look results provided by the ASM/RXTE team (http://heasarc.gsfc.nasa.gov/xte_weather/), the optical light curve being provided by the Tuorla Observatory Blazar Monitoring Program (http://users.utu.fi/kani/1m/1ES1959+650.html). No strong activity in X-ray or in optical was observed during the period of our VHE γ-ray studies.

The differential spectrum of 1ES1959+650 measured by MAGIC extends from 150 GeV to 2 TeV and can be described by a simple power law function: dN/dE = f₀ (E/TeV)^-α, with f₀ = (0.43 ± 0.05) · 10^-11 photons/(cm² s) and α = (2.72 ± 0.14), steeper than that of the Crab in the same energy range. Figure 3 shows the differential energy spectrum of 1ES1959+650 multiplied by E², as measured in 2004 with MAGIC and the high and low state spectra as measured with the HEGRA System [3]. The MAGIC measurements permit to remarkably extend the low state spectrum towards lower energy, revealing that no curvature of the spectrum was present.
down to 200 GeV. The new measurement by MAGIC has been compared with the fit of the spectral energy distribution (SED) reported in [9] which uses a simple one zone Synchrotron-Self Compton model. The grey dashed curve in Figure 4 represents the intrinsic spectrum while for the dash-dotted and solid black curves the EBL absorption models in [10] and [11] respectively have been assumed. The MAGIC measurements can still be described with this model, but indicating a shift of the inverse Compton hump towards lower frequencies.

4. Conclusions

The AGN 1ES1959+650 has been clearly detected with the MAGIC telescope after a few hours of observation in September-October 2004, at a mean zenith angle of 40°. During that period the AGN was in quiescent state both in X-rays and at optical wavelengths. The absence of significant variations in the night-by-night flux and the comparison with previous measurements reveal that the source was observed in a period of low and quiescent γ-ray emission. The mean flux above 300 GeV corresponds to ∼17% the Crab flux. The spectrum can be described with a simple power law function of spectral index $\alpha = (2.72 \pm 0.14)$, steeper than that of the Crab in the same energy range.

Acknowledgments

We would like to thank the IAC for the excellent working conditions on the La Palma Observatory Roque de los Muchachos. The support of the German BMBF and MPG, the Italian INFN and the Spanish CICYT is gratefully acknowledged. This work was also supported by ETH Research Grant TH-34/04-3 and by Polish Grant MNiI 1P03D01028.

References

[1] Nishiyama T et al 1999 Proc. 26th ICRC (Salt Lake City) vol 3 p 370
[2] Horan D et al 2004 ApJ 603 51
[3] Aharonian F et al 2003 A&A 406 L9
[4] Rico J 2005 these Proceedings
[5] Albert J et al 2005 Preprint astro-ph/0508543 (accepted for publication in ApJ)
[6] Hillas A 1985 Proc. 19th ICRC (La Jolla) vol 3 pp 445-8
[7] Breimann L, Friedmann J H, Olshen R A and Stone C J 1984 Classification and Regression Trees (Pacific Grove, CA: Wadsworth and Brooks)
[8] Li T P and Ma Y Q 1983 ApJ 272 314
[9] Krawczynski H et al 2004 ApJ 601 151
[10] MacMinn D and Primack J R 1996 Space Sci. Rev. 75 413
[11] Kneiske T M et al 2002 A&A 386 1