THE MAGIC VIEW OF PG 1553+113

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ABSTRACT -- We present the results of five years (2005-2009) of MAGIC observations of the BL Lac object PG 1553+113 at very high energies (VHEs). Adding the new data set (2007-2009) to previous observations, this source becomes one of the best long-term followed sources at energies above 100 GeV. In the last three years of data, the flux level above 150 GeV shows a marginal variability. Simultaneous optical data also show only modest variability that seems to be correlated with VHE gamma-ray variability. We also performed a temporal analysis of all available *Fermi*/LAT data of PG 1553+113 above 1 GeV. Finally, we present a combination of the mean spectrum measured at VHE with archival data available for other wavelengths. The mean Spectral Energy Distribution (SED) can be modeled with a one-zone SSC model, which gives the main physical parameters governing the VHE emission in the blazar jet.

THE MAGIC TELESCOPES

MAGIC is a stereo system composed of two new generation Imaging Atmospheric Cherenkov Telescopes located on La Palma, Canary Islands, Spain at ~2200 m asl. MAGIC observes the VHE γ-ray sky at energies above 60 GeV. Data presented here were collected before Autumn 2009, when MAGIC was operating with a single telescope, referred as MAGIC I.

Fig 1 – The MAGIC Telescopes.

MAGIC I PARAMETERS

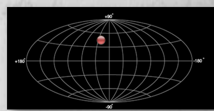
- Energy threshold: 60 GeV (25 GeV with a special trigger for pulsar observations)
- Sensitivity (t_{obs} = 50 h /5σ significant signal): 1.6 % Crab Nebula flux
- Energy resolution: < 20 % at E> 200 GeV
- Angular resolution: ~0.1 deg

DATA TAKING CONDITIONS

The energy threshold is ~90 and ~80 GeV for 2006 and 2007 observations respectively, ~150/160 GeV for 2008 (poor observing conditions) and 2009 data (moderate moon light observation). The zenith angle of the observations extends to 36 deg.

PG 1553+113

- PG 1553+113 is a BL Lac object (extremely WEAK EMISSION LINES in the optical spectra), located in the Northern hemisphere
- Discovered in 1986 by Green et al., its REDSHIFT IS UNCERTAIN
- Several attempts to determine its redshift were done in the past [e.g. 10]
- Recent z determinations: z~0.4 [6,8]
- Bright *Fermi*/LAT source [1]



VHE OBSERVATIONS:

The blazar PG 1553+113 was detected at VHE by the MAGIC I and H.E.S.S. telescopes in 2005 [2,3]. Since then, the source was MONITORED by MAGIC I [4,5].

Table 1 reports the details of the good quality data selected after severe quality cuts. Due to changes in the yearly performance, data were analyzed year by year.

RESULTS

INTEGRAL FLUX

- The VHE integral flux state, upper panel Fig 3, shows modest variations (4% to 11% of the Crab Nebula flux above 150 GeV , Table 1)
- Moderate variability in OPTICAL and VHE γ-RAYS, with hints of CORRELATION (Fig. 2)
- High variability in X-RAYS
- Hints of variability in HIGH ENERGY (HE) γ-RAYS

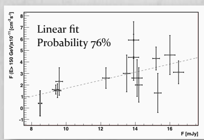


Fig 2 – Optical-VHE γ-rays correlation study.

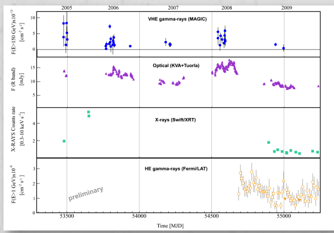


Fig 3 – Lightcurves of PG 1553+113 from 2005 to 2009.

Year	Observations [hours]	Energy Threshold [GeV]	Flux (> 150 GeV) [cm⁻² s⁻¹]	Flux (> 150 GeV) [Crab %]	Slope Γ
2005+06	19	90	(2.8 ± 0.5)*10⁻¹¹	~9%	4.2 ± 0.2
2007	11.5	80	(1.40 ± 0.38)*10⁻¹¹	~4%	4.1 ± 0.3
2008	8.7 (6.9 flux)	150 (Calima)	(3.70 ± 0.47)*10⁻¹¹	~11%	4.3 ± 0.3
2009	8.5 (6.9 flux)	160 (Moon Obs)	(1.63 ± 0.45)*10⁻¹¹	~5 %	3.6 ± 0.5

Table 1 – PG 1553+113 datasets collected by MAGIC and analyses results.

DIFFERENTIAL FLUX

- Yearly flux state: marginal variations of the flux level (Tab 1, Fig 4), slope stable Γ ≈ 4 within the errors (large in 2009, smaller signal)
- MEAN FLUX compatible with a power law of index Γ = 4.27 ± 0.14 (Fig 5)
- De-absorbed differential energy spectrum (EBL model [7]) is compatible with a power law of index 3.09 ± 0.20 (assuming z = 0.4; Fig 5)

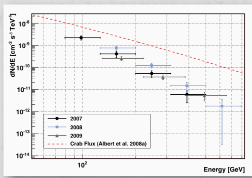


Fig 4 – 2007-2009 differential energy spectra.

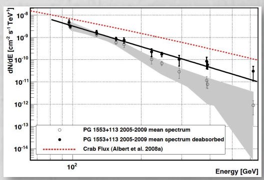


Fig 5 – Mean observed and de-absorbed spectrum.

MODELING THE SED

The MEAN overall SED can be fitted with a simple one-zone SSC model [9] (Fig 6, model parameters listed in Tab 2).

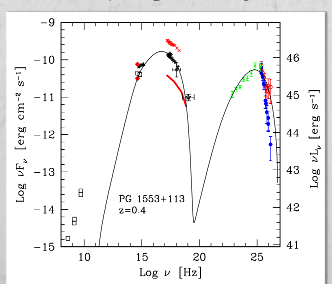


Fig 6 – Mean SED of PG 1553+113.

Parameter		Value
γ_{min}	[10³]	2.5
γ_b	[10⁴]	3.2
γ_{max}	[10⁵]	2.2
n_1		2.0
n_2		4.0
B	[G]	0.5
K	[10⁻³ cm⁻³]	5.35
R	[10¹⁶ cm]	1
δ		35
P_e	[10⁴⁴ erg/s]	2.2
P_B	[10⁴⁴ erg/s]	1.5
P_p	[10⁴⁴ erg/s]	0.34
L_r	[10⁴⁴ erg/s]	6.3

Tab 2 – SSC model parameters.

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