MAGIC:
Possible optical-TeV correlation in blazars and new constraints on extragalactic background light

Daniel Mazin
(IAFE, Barcelona)

for the MAGIC collaboration
1. TeV blazars
   - Sources
     - Mkn 180 (z = 0.045)
     - 1ES 1011+496 (z = 0.212)
     - 3C279 (z = 0.536)
2. EBL “status” and intrinsic TeV blazar spectra
• AGNs with ultrarelativistic jet pointing to us
• VHE gamma-rays:
  - where in the jet?
  - what mechanism?
• 19 known sources: 16 HBL + 1 LBL + 1 FSRQ + 1 radio galaxy
• Correlations:
  - X-ray - TeV: yes, but ...
  - Optical - GeV: yes, but ...

• TeV photons are attenuated via pair production with UV to IR photons from the extragalactic background light (EBL)
• $\gamma$-ray horizon depends on energy threshold of the experiment
• How far can we see above 100GeV?
Markarian 180: trigger, correlations

- Historical high in optical!
- No significant detection in ASM (3 \( \sigma \) on one of the nights)
- No clear correlation found: 7 MAGIC nights with a flux compatible with a constant
Markarian 180 ($z=0.045$) optical trigger

- April 2006: optical flare triggered MAGIC observations (11.1 h)
- $5.5 \, \sigma$: DISCOVERY
- $F_{(>200\text{GeV})} = 11\%$ crab units
  index: $-3.3 \pm 0.7$
- No significant variability
- Re-observations in May 2006 (optically low state) did not succeed due to bad weather
- December 2006: lower $\gamma$-ray flux during a lower optical state
- More observations are planned


MAGIC: AGNs, TeV-optical correlation and EBL
1ES 1011+496 ($z=0.212$) optical trigger

- 1ES 1011+496: HBL, possibly an EGRET source, too low X-ray flux to be detected by RXTE/ASM or Swift/BAT
- Redshift of $z=0.200$ was “guessed” because of a possible association with Abell 950 (Wisniewski et al. 1986)
- From the optical spectrum (E. Perlman), we determined the redshift to be $z = 0.212 \pm 0.002$

- Soft spectrum: $\Gamma=3.3$ after deabsorption
- 10% crab at 200 GeV
- No significant variability
- 3 $\sigma$ in 2006 data. If it was due to genuine signal, then 40% lower flux then in 2007
3C279, z=0.536

- EGRET brightest AGN (Flat spectrum radio quasar)
  - Gamma-ray flares in 1991 and 1996
  - Apparent luminosity $\sim 10^{48}\text{erg/s}$
  - First time variation $\Delta T \sim 6\text{hr}$ in 1996 flare
- Typical OVV (Optically violent variable)
- Superluminal motion
  - $\gamma \sim 20-30$, $B \sim 0.3\text{Gauss}$
- $z = 0.536$, $L_d \sim 3\text{Gpc}$
MAGIC observation:
- In the period of January - April 2006
- Observation of 9.5 hrs
- Zenith angle range is between 32 and 40 degrees
- Discovery on 2006 February 23: 5.4 $\sigma$ in standard analysis
- Not coincident with optical flare
What does it mean for the EBL?

- Upper EBL limits get tighter: just factor 2 above the lower limits (galaxy counts)

Limits:
- LL galaxy counts (HST, Spitzer, ISOCAM)

Models:
- Primack et al. (2005) AIP Proc. 745, 23
- Raue & Mazin (2007), generic shape

Using the generic shape for all GeV-TeV spectra

MAGIC: AGNs, TeV-optical correlation and EBL
Intrinsic spectra of TeV blazars

- Whipple, CAT and HEGRA have put some constraints in the past

A possible pile-up at energies above 10 TeV in the HEGRA spectrum of Mkn 501
Intrinsic spectra of TeV blazars

- H.E.S.S: hard spectra, difficult to model, strong constraints on the EBL

Spectral slope close to the theoretical maximum of $\Gamma = 1.5$ ($dN/dE \sim E^{-\Gamma}$) for several sources at different redshifts

$\Gamma = 1.5$
Intrinsic spectra of TeV blazars

- MAGIC: no pile-ups at high energies, spectra are not too hard, “easy” to model

However, significant signal from 3C279 ($z=0.536$) above 200 GeV means already that the intrinsic spectrum must be hard.

MAGIC spectra
Summary of intrinsic TeV blazar spectra

Generic shape

CAT, HEGRA, Whipple

H.E.S.S spectra

MAGIC spectra

MAGIC: AGNs, TeV-optical correlation and EBL
Conclusions

- ToO strategy using optical triggers is very successful
- Out of 2 good optical triggers discovered 2 new VHE γ-ray emitters:
  - Markarian 180 (z=0.045)
  - 1ES1011+496 (z=0.212)
- Optical-TeV connection does exist?
- Discovery of 3C279 between 80 GeV and >200 GeV
- EBL: constraints get tighter. Either all galaxies have been already resolved or TeV blazar physics is wrong
- Outlook 1: monitor sources in optical + ASM + Swift + AGILE. Also GLAST triggers in 2008!
- Outlook 2: more sources at high redshifts, stay tuned!
ToO strategy

Sources are variable, field of view of Cherenkov telescopes is small (3-5 deg) → external triggers!

- Optical flux increases by more than 50%
  - Monitoring by 35cm KVA (La Palma) and by 1m Tuorla telescope (Finland)
- ASM (2-10 keV) is above 20 mCrab
  - Data are public
- H.E.S.S. or VERITAS report a TeV γ-ray flux above 0.5 crab units (2 crab units for Mkn 421 and Mkn 501)
  - Bi-polar agreements between the collaborations
PKS 2155-304 (z=0.117)
H.E.S.S. trigger

- Multiwavelength campaign triggered by H.E.S.S. Atel #867 on 27 Jul 2006
- MAGIC large zenith angle observations from 28 July to 2 Aug
- Soft spectrum, index 3.7 even after deabsorption
- Clear detection on all nights, no significant variability
MAGIC: AGNs, TeV-optical correlation and EBL

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