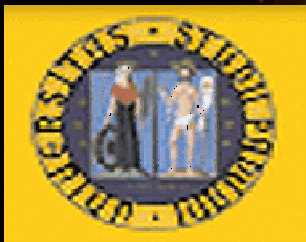




Observations of AGNs by MAGIC Telescope

**Ciro Bigongiari, Università di Padova and I.N.F.N. Padova
For the MAGIC Collaboration**

<http://wwwmagic.mppmu.mpg.de/>



C. Bigongiari, AGN7 Montagnana



Outline

1. Status of the field

2. MAGIC first year observation summary

3. Results

1. 1ES 1959+650
2. 1ES 1218+304
3. MKN 421
4. MKN 501
5. PG 1553+350

4. Conclusions & Outlook



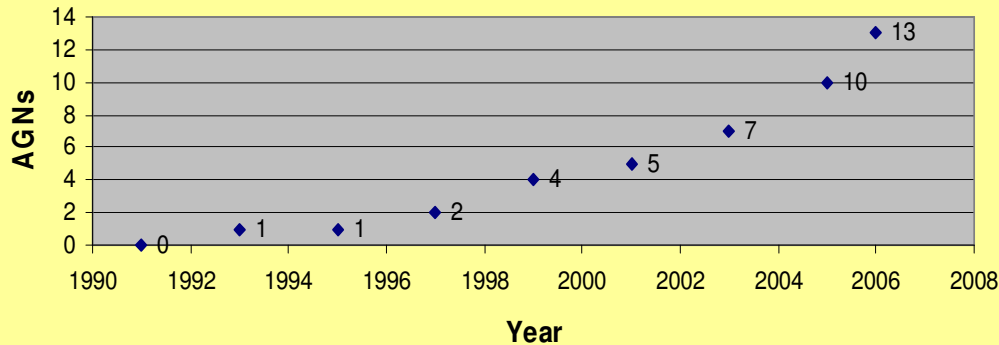
Status of the field

- Present generation Cherenkov telescopes have:
 - better sensitivity
 - The number of AGN detected as VHE gamma-ray emitter increases
 - High time resolution data analysis is possible
 - lower energy threshold
 - The AGN spectra can be measured down to 100 GeV
- A better sensitivity and a lower threshold allow the detection of gamma-rays from distant AGNs
 - The redshift of detected AGNs is growing quickly.

Gamma-rays from distant AGNs can be used to probe the EBL

Status of the field

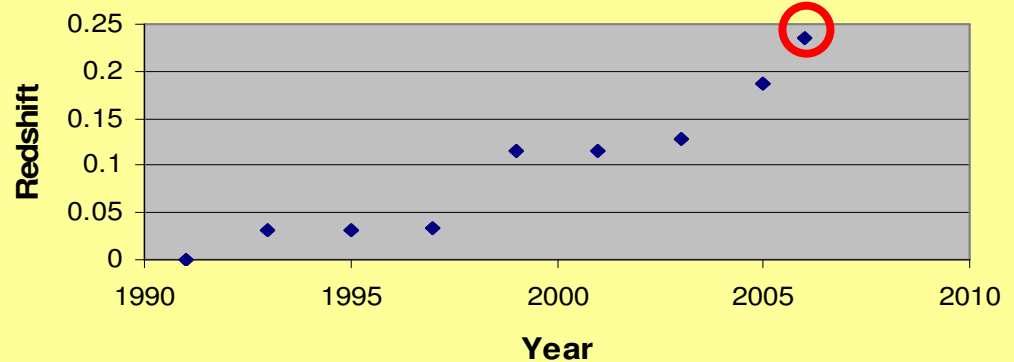
Kifune's Plot for AGNs



The number of detected AGNs is increasing more than linearly.

The redshift of furthest detected AGN is increasing too.

Highest Redshift





AGNs emitting VHE γ -rays

Source	Redshift	Type	First Detection	Confirmation
M87	0.004	FR I	HEGRA	HESS
Mkn 421	0.031	BL Lac	Whipple	Many
Mkn 501	0.034	BL Lac	Whipple	Many
1ES 2344+514	0.044	BL Lac	Whipple	HEGRA
XXX	XXXX	BL Lac	MAGIC	
1ES 1959+650	0.047	BL Lac	7 Tel.Array	Many
PKS 2005-489	0.071	BL Lac	HESS	
PKS 2155-304	0.116	BL Lac	Mark VI	HESS
H1426+428	0.129	BL Lac	Whipple	Many
H2356-309	0.165	BL Lac	HESS	
1ES 1218+304	0.182	BL Lac	MAGIC	
1ES 1101-232	0.186	BL Lac	HESS	
PG 1553+113	0.236(?)	BL Lac	HESS	MAGIC



MAGIC AGN observation summary

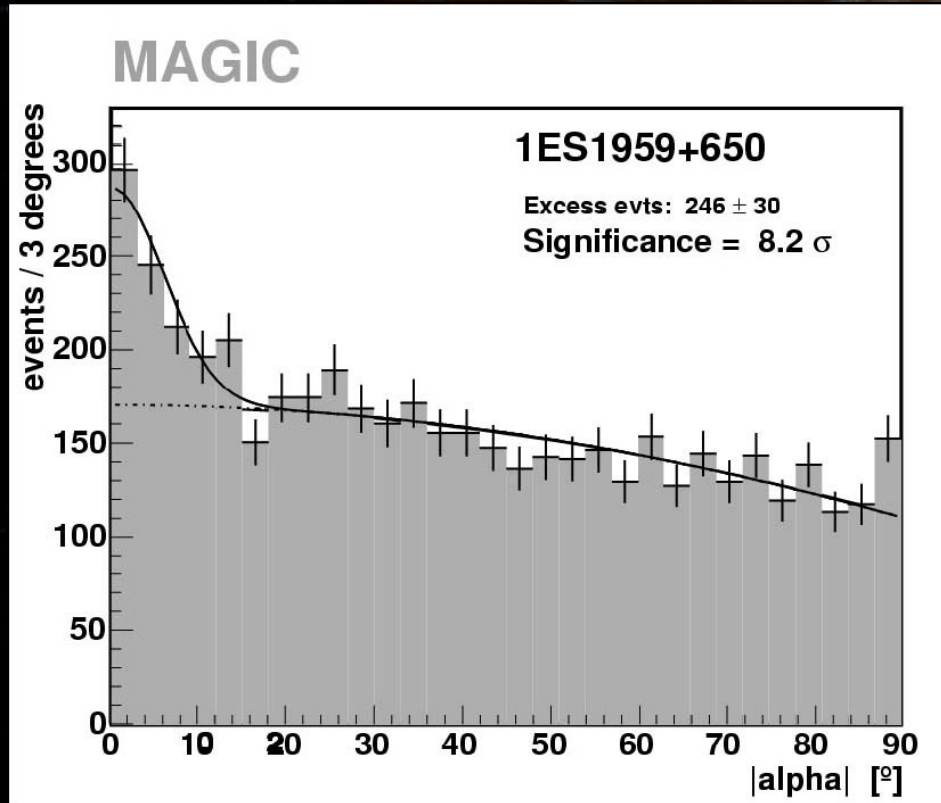
- MAGIC was inaugurated in October 2003
- It started to take data immediately thereafter even if it was still in the commissioning phase
- First regular observation period (Cycle-I) started in May 2005
- Cycle-I just concluded:
 - 30 AGNs observed for a total of about 700 hours
 - 7 AGNs clearly detected (Significance $> 5\sigma$), **2 for the first time.**
 - 1ES 1218+304 @ $z = 0.182$ & XXX
 - 3 more detected at lower significance.
 - Many data analysis still ongoing.

Cycle-II just started

About 800 hours will be dedicated to AGN observations



1ES1959+650 ($z = 0.047$)



Gamma-ray emission discovered in 1999 by Seven Telescope Array (Nishiyama 2000)

Confirmed by Whipple (Holder 2003) and HEGRA (Aharonian 2003)

6h Observation time Sep/Oct 2004

$\langle \theta \rangle = 40^\circ$

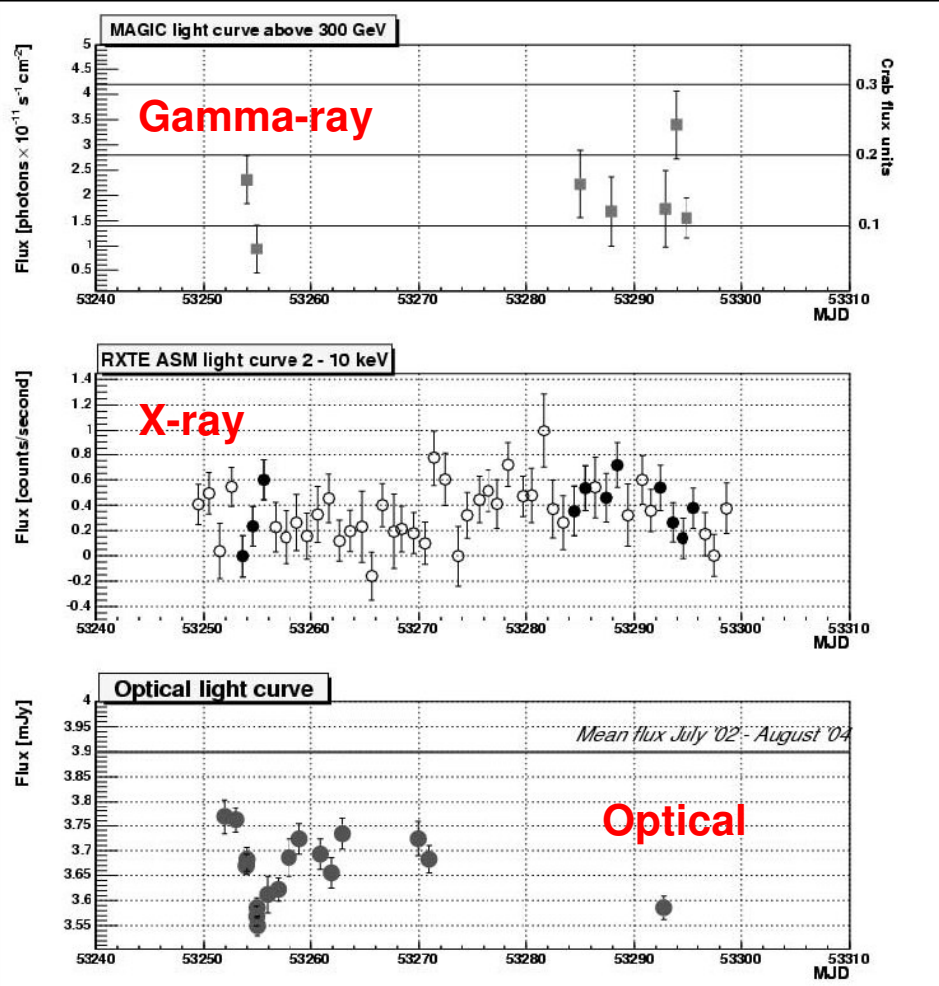
$E_{th} = 250 \text{ GeV}$

Significance 8.2σ

J. Albert et al. ApJ **639**, 761 (2006)



1ES 1959+650 ($z = 0.047$)



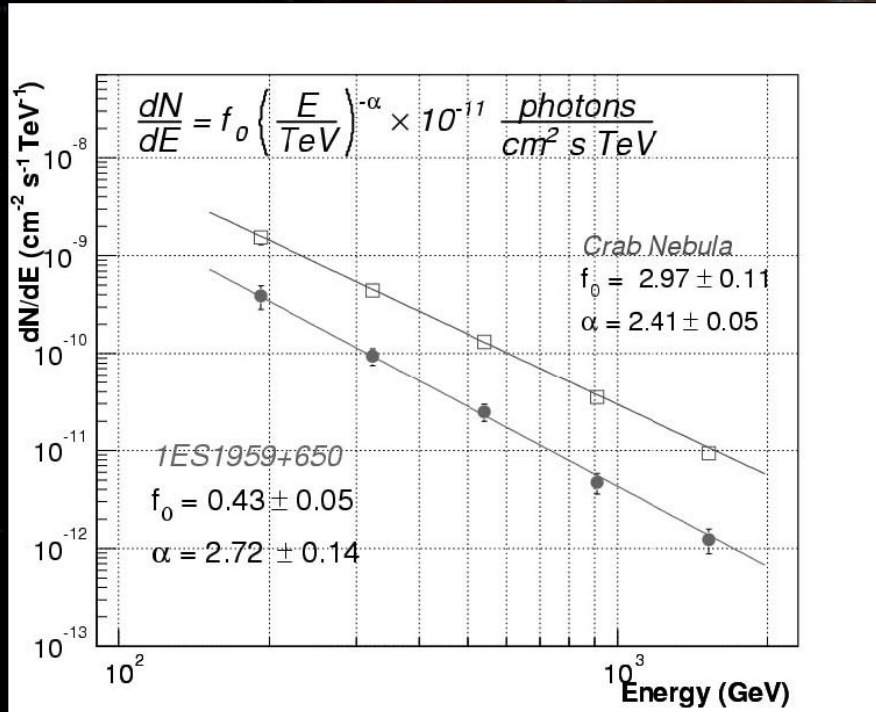
No hint of flux variations during the observation period. (Only 6 hours !)

No strong activity in X-rays (RXTE/ASM) or the optical (KVA) was observed during the period of MAGIC observations.

During MAGIC observations, the optical activity was particularly low.

Data taking continued in 2005 and will go on in 2006 too.

1ES 1959+650 ($z = 0.047$)



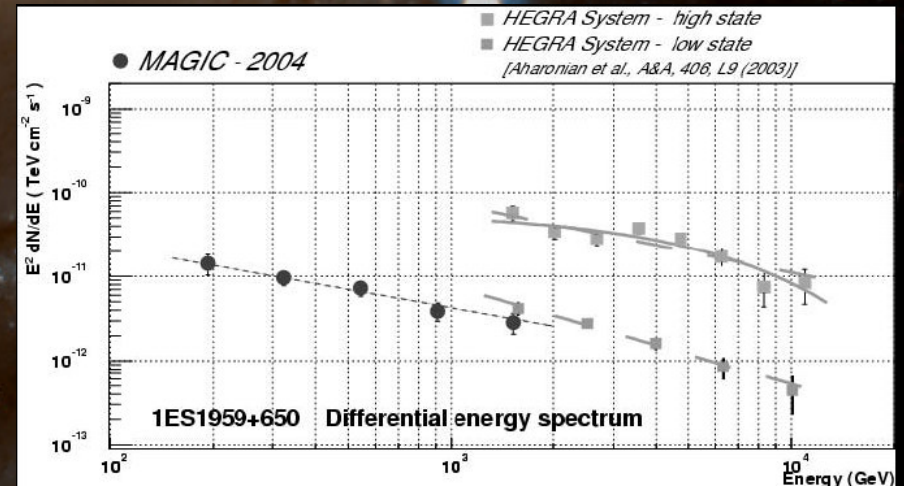
The flux level is roughly consistent with low state flux measured by HEGRA

The differential energy spectrum can be fitted with a power law.

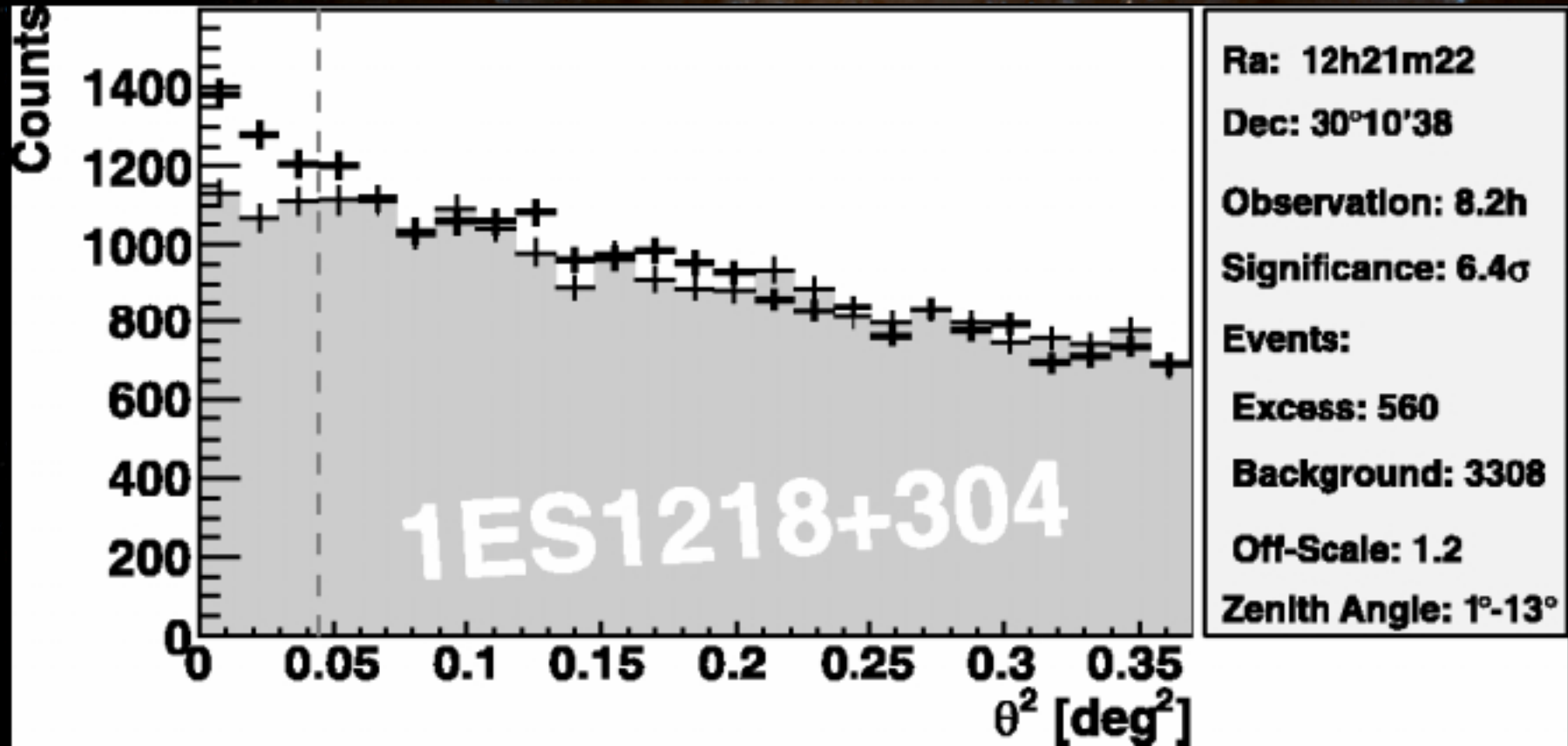
$$\Phi(E > 200 \text{ GeV}) \approx 0.2 * \Phi_{\text{Crab}}$$

The spectral slope is lower than the one reported in Aharonian 2003

2.72 ± 0.14 instead of 3.18 ± 0.17

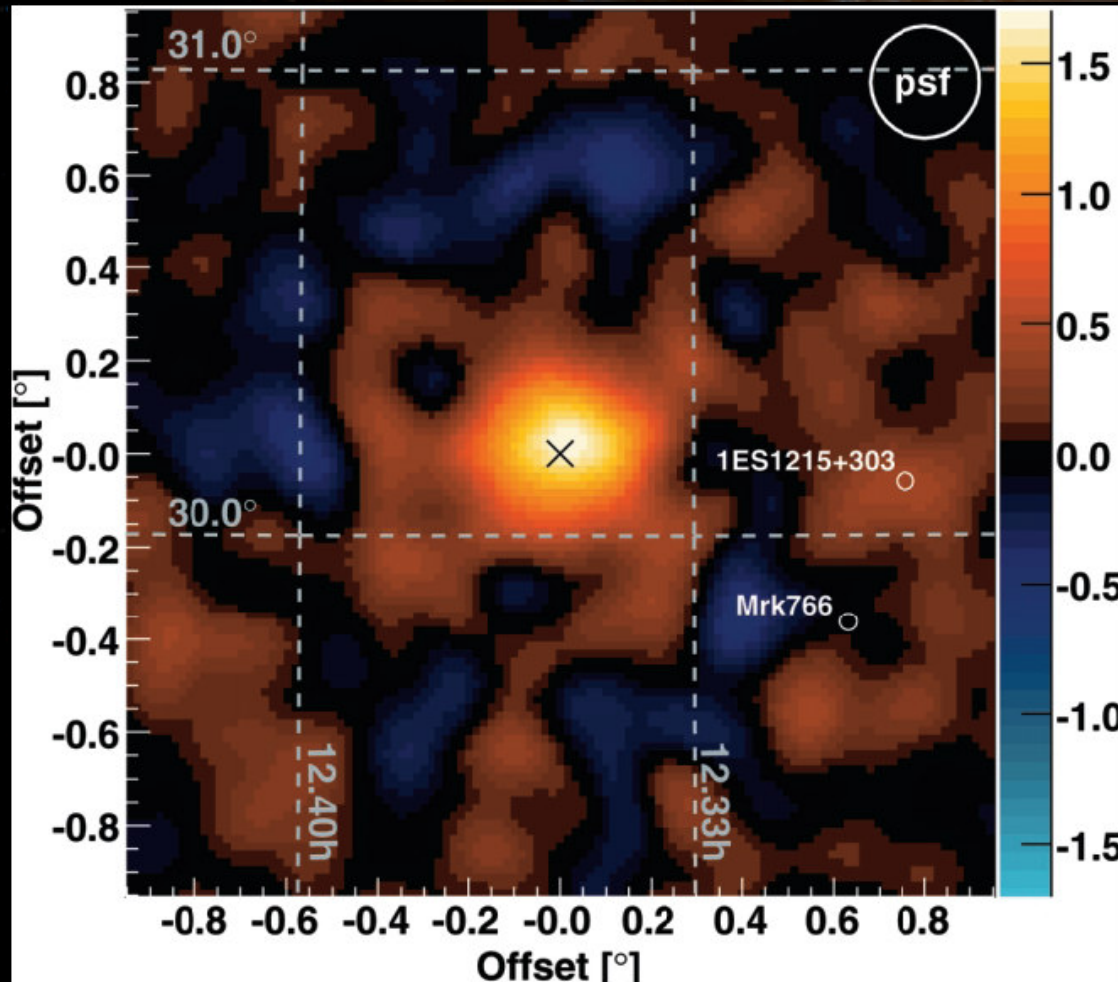


1ES 1218+304 ($z=0.182$)



First detection of VHE gamma-ray emission from this source !

1ES 1218+304 ($z=0.182$)



Sky map of the region around the position of 1ES 1218+304 (cross).

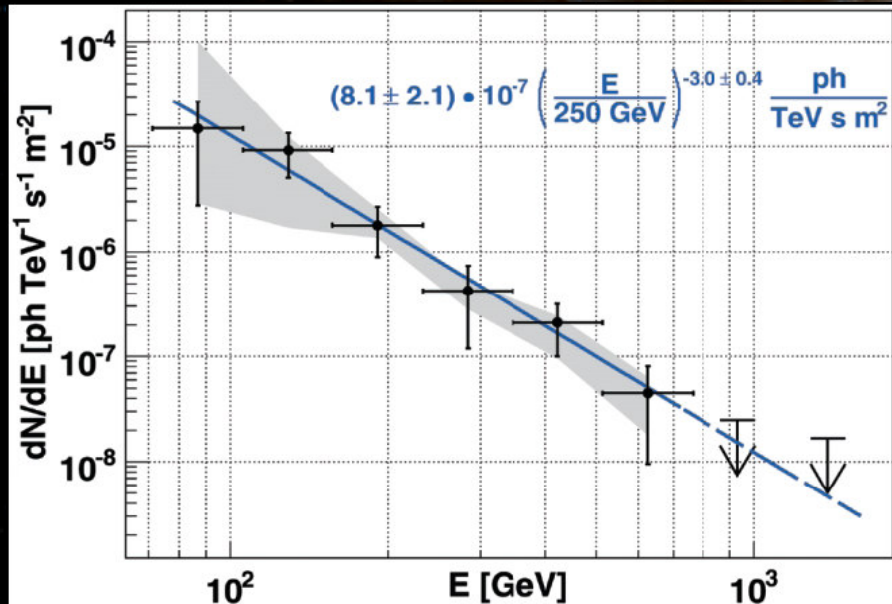
The energy threshold is about 140 GeV.

The scale is in units of events/10 for square arcminute.

J. Albert et al.

ApJL **642**, L119 (2006)

1ES 1218+304 (z=0.182)



The error bars show the (1σ) statistical error only.

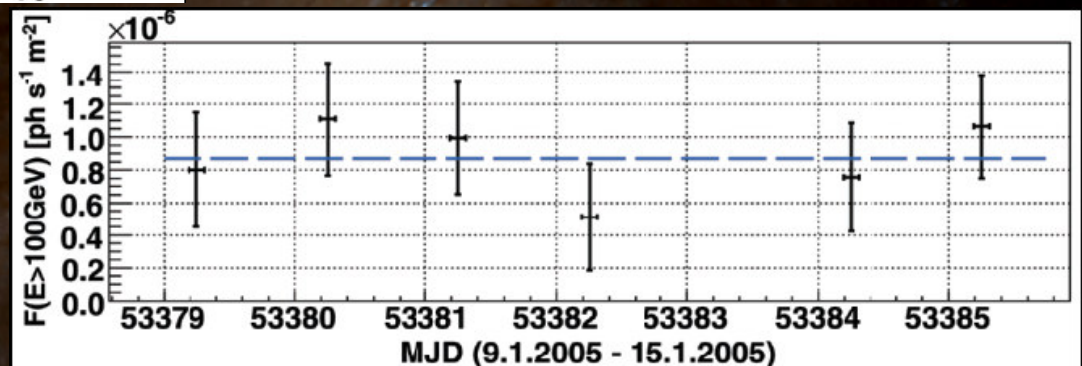
The upper limits correspond to the 90% confidence level.

Shaded region shows the systematic error resulting from the analysis.

The total systematic error for the slope is estimated to be $+0.7 -0.4$

Integral flux ($E > 100$ GeV) for each night.

No hint of flux variations.



Mkn 421 ($z = 0.031$)

Discovered by Whipple
(Punch 1992)

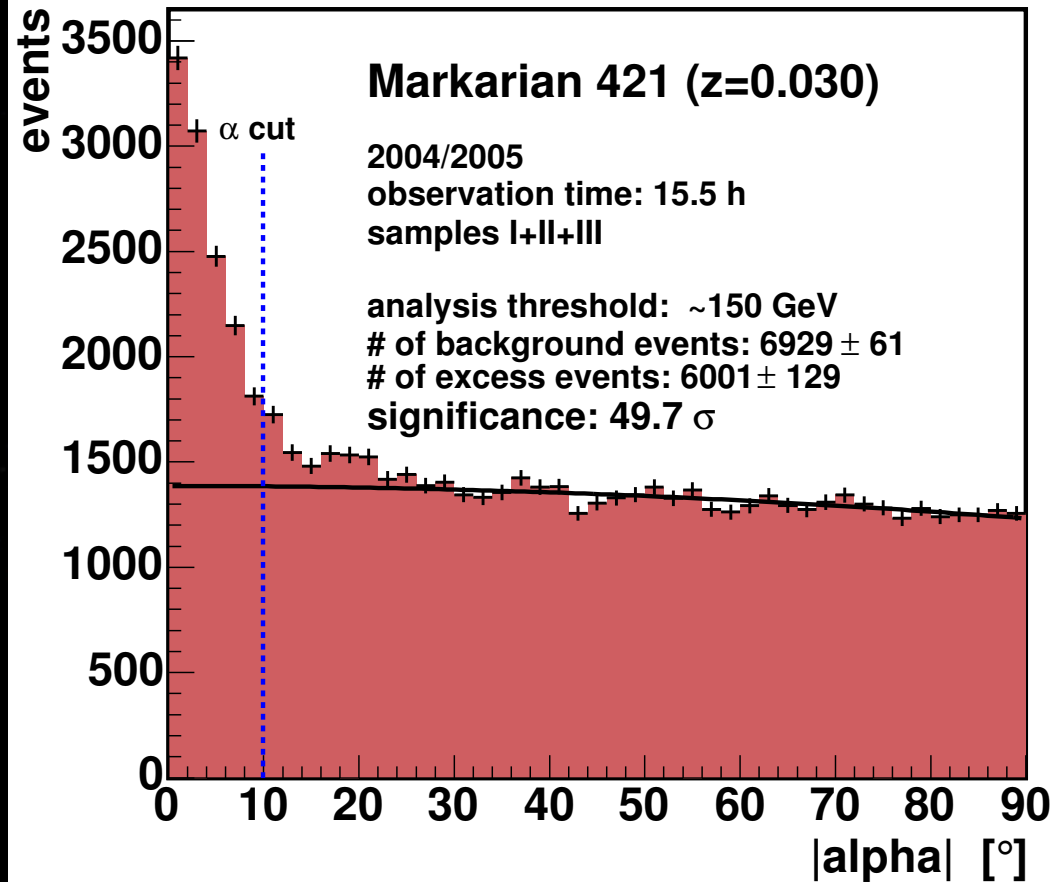
J. Albert et al. submitted to
ApJ

astro-ph/0603478

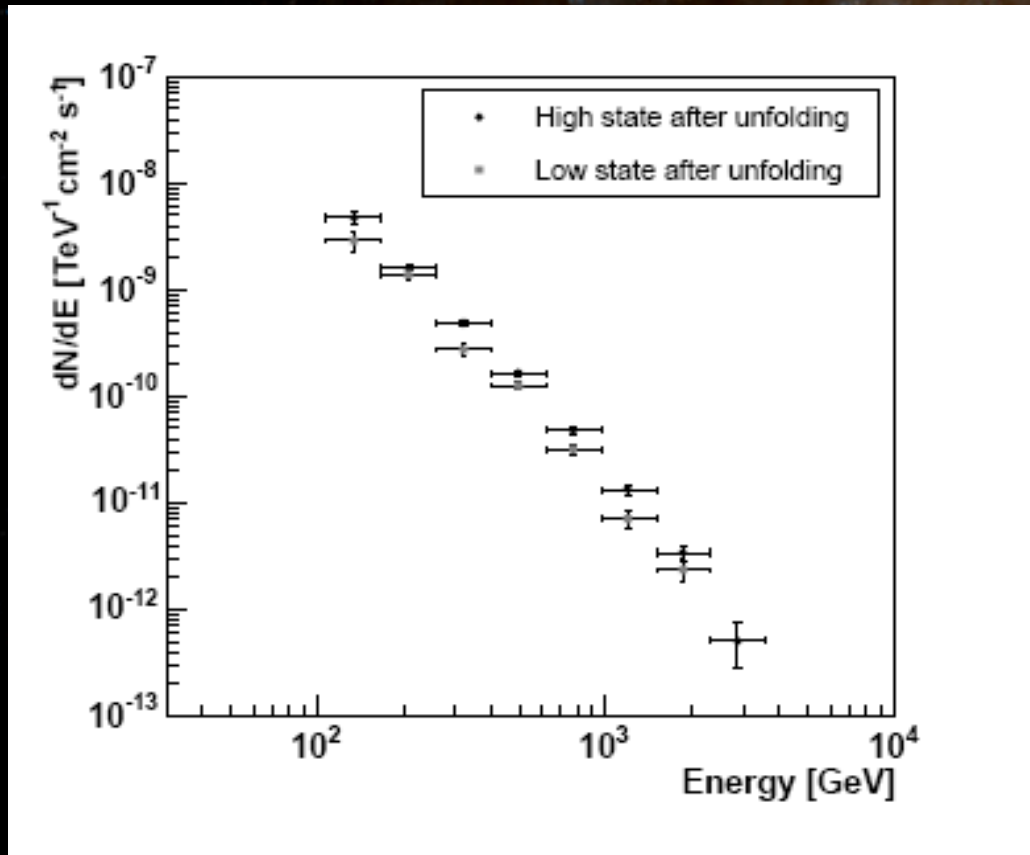
Observed both in 2004
and 2005

Nearly 50σ in 15.5 h

$E_{Th} = 150 \text{ GeV}$



Mkn 421 Spectrum



Differential energy spectrum in the 5 highest flux nights and 8 lowest flux nights.

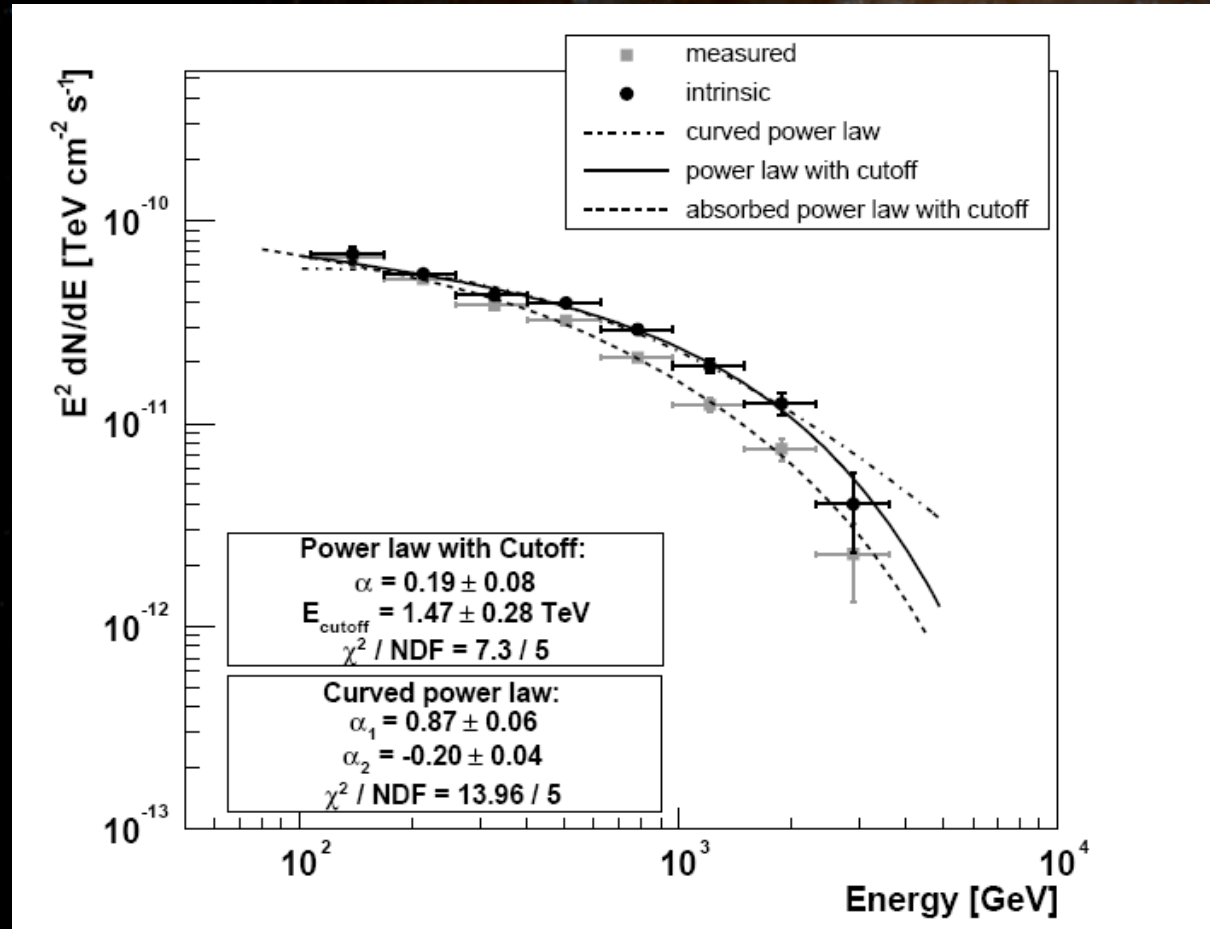
The flux level changes about a factor 1.45 while the slope remains unchanged within errors between high and low activity states.

The single power law doesn't fit very well. Better power law with exp. cutoff

$$\alpha = 2.19 \pm 0.08$$

$$E_{\text{cutoff}} = 1.47 \pm 0.28 \text{ TeV}$$

Mkn 421 Intrinsic SED

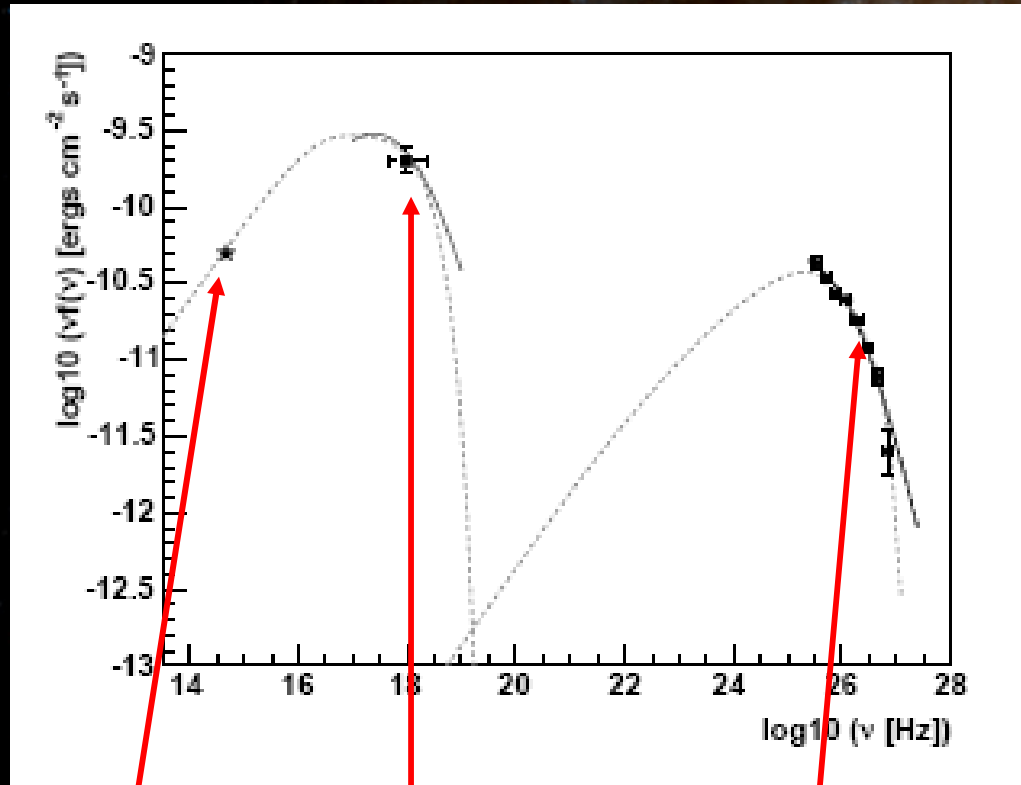


Grey points -> measured SED

Black points -> deabsorbed (intrinsic) SED

The intrinsic SED is fitted better by a Power Law with an exponential cut-off at $1.5 \pm 0.3 \text{ TeV}$.

Mkn 421 Broadband SED



KVA

RXTE/ASM

MAGIC

Optical data from KVA (star), X-rays from RXTE/ASM (full square), de-absorbed gamma-rays from MAGIC (full points).

The grey curve in the X-rays correspond to the log-parabolic fit taken from Massaro et al. (2004) using BeppoSAX (Boella 1997) data of Mkn 421 taken on April 21, 1998.

The dashed line is SSC model as in Krawczynski et al. (2004).

Mkn 421

Light curve

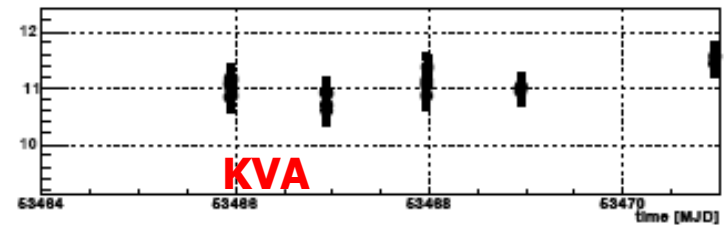
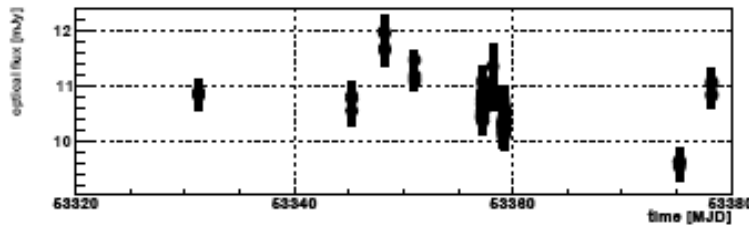
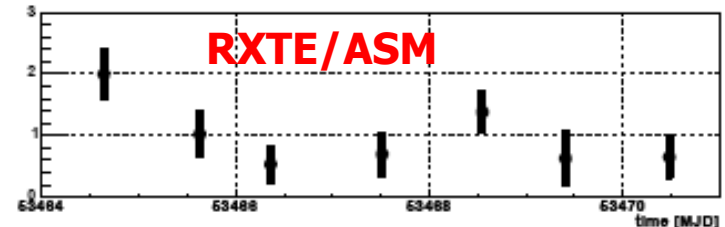
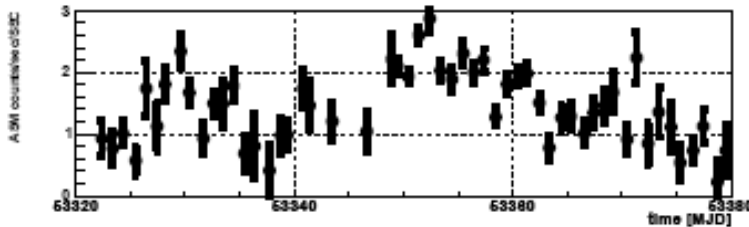
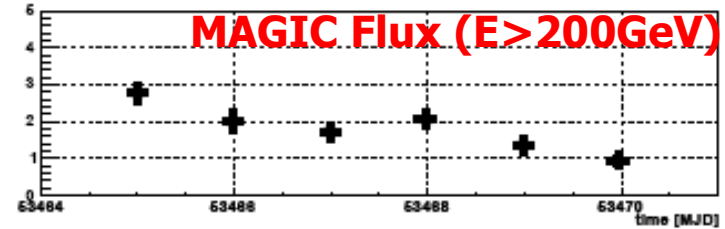
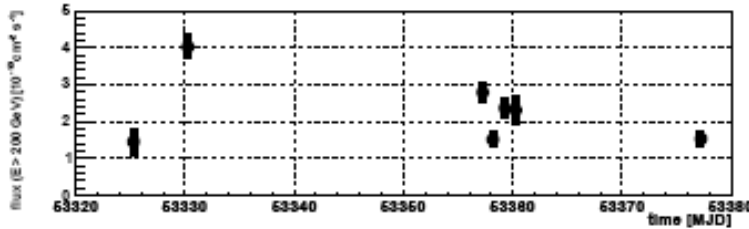
Nov 2004 – Jan 2005

Apr 2005

Y

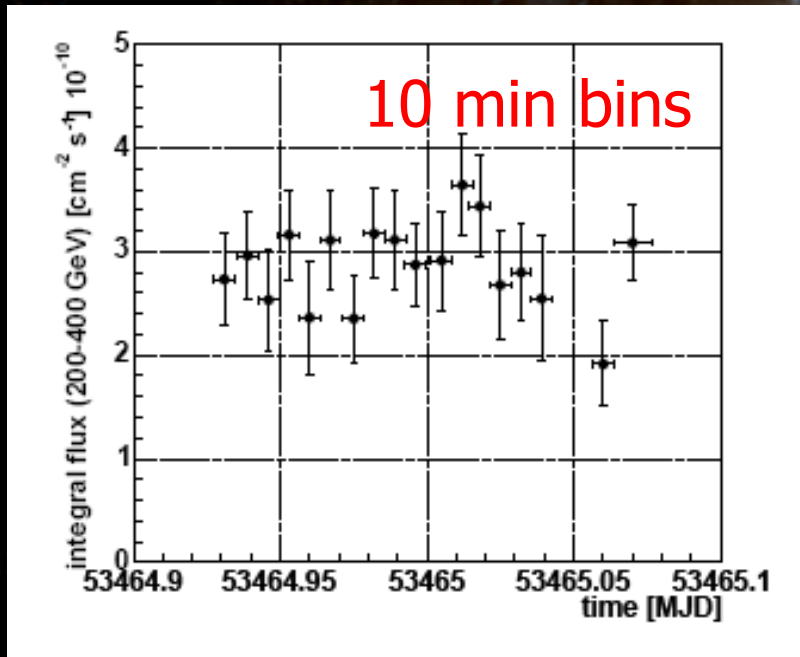
X

O

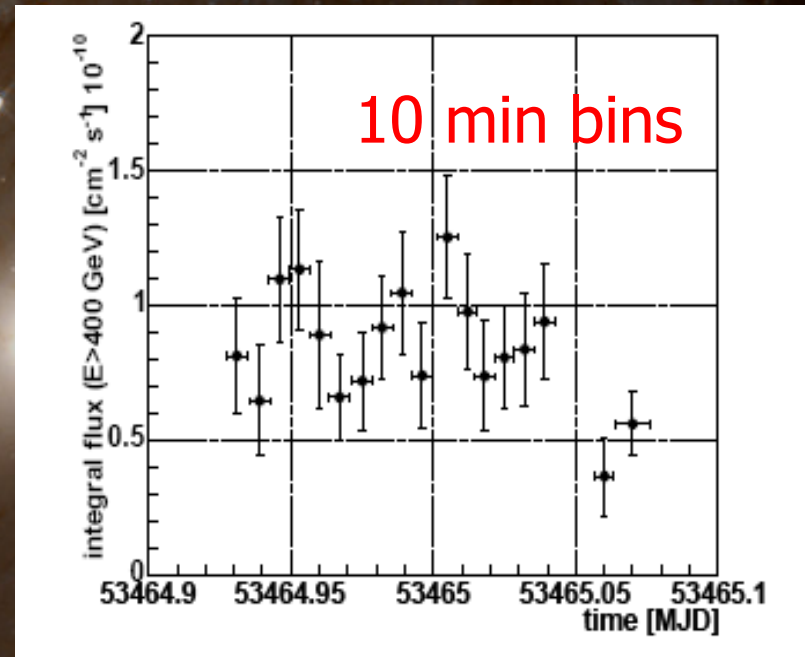


Gamma flux variations up to nearly a factor 4

Mkn 421 Intraday light curve



MJD 53465 200-400 GeV

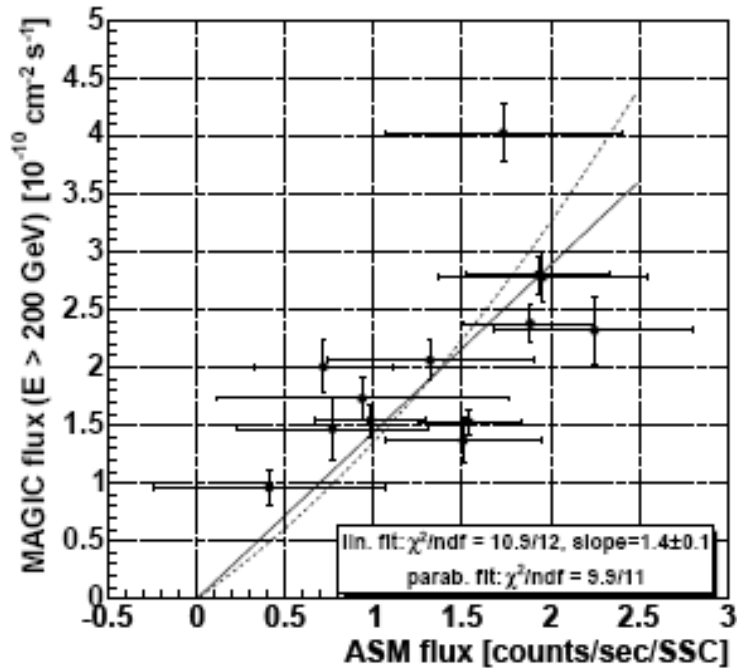


MJD 53465 > 400 GeV

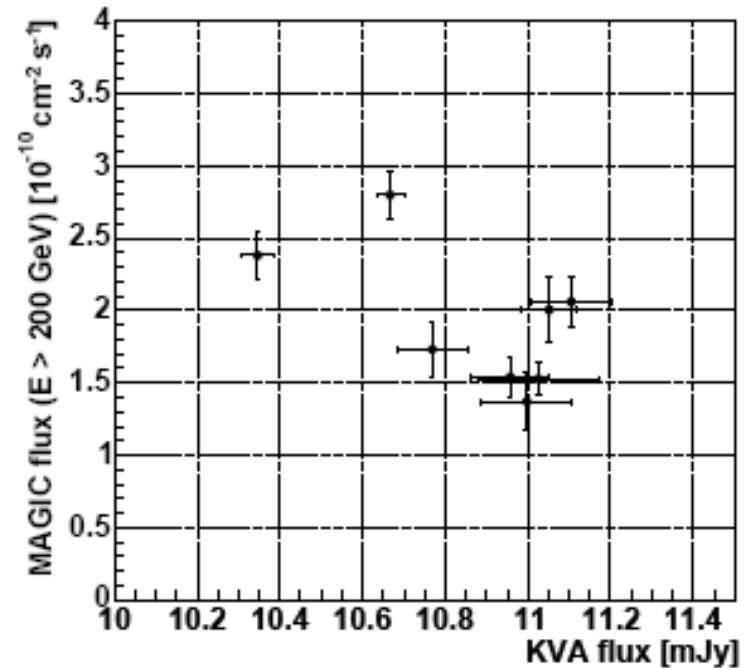
MJD 53465 = Highest Flux day

Mkn 421 Flux Correlations

Mrk 421, correlation X-ray - GeV ($E > 200$ GeV)



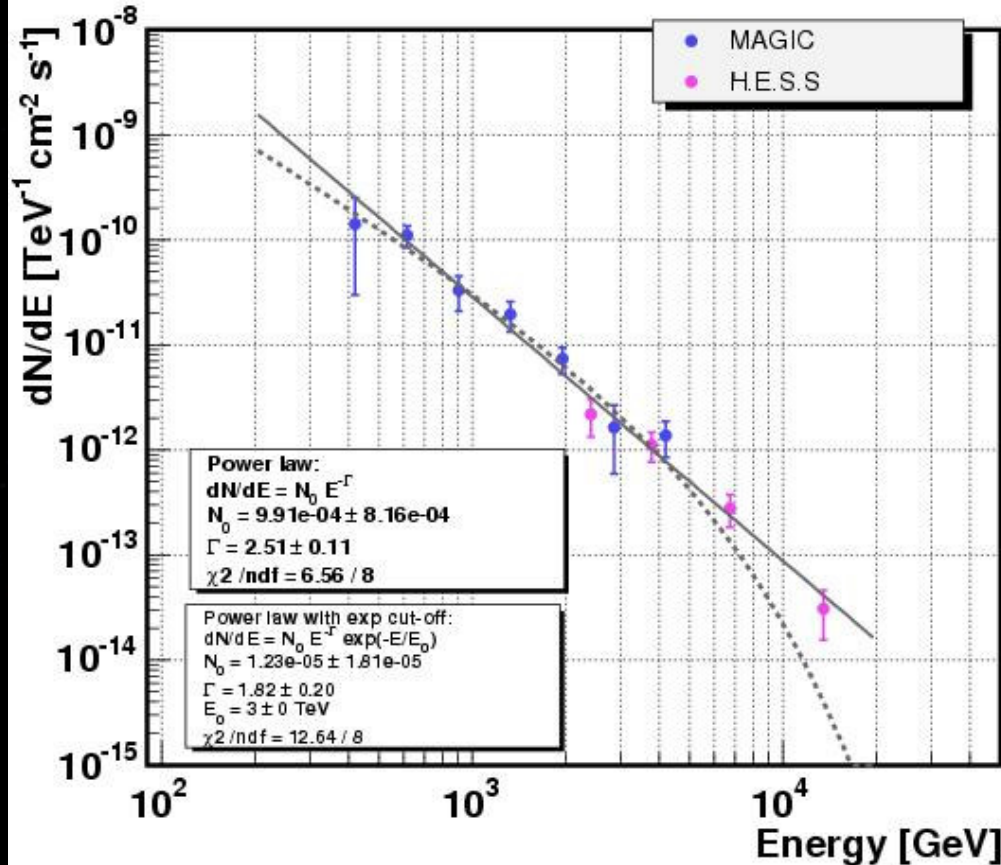
Mrk 421, correlation Optical - GeV ($E > 200$ GeV)



Clear correlation gamma-X ! Anticorrelation gamma-Opt ?

Mkn 421 with HESS

Mkn 421, 18 December 2004, simultaneous



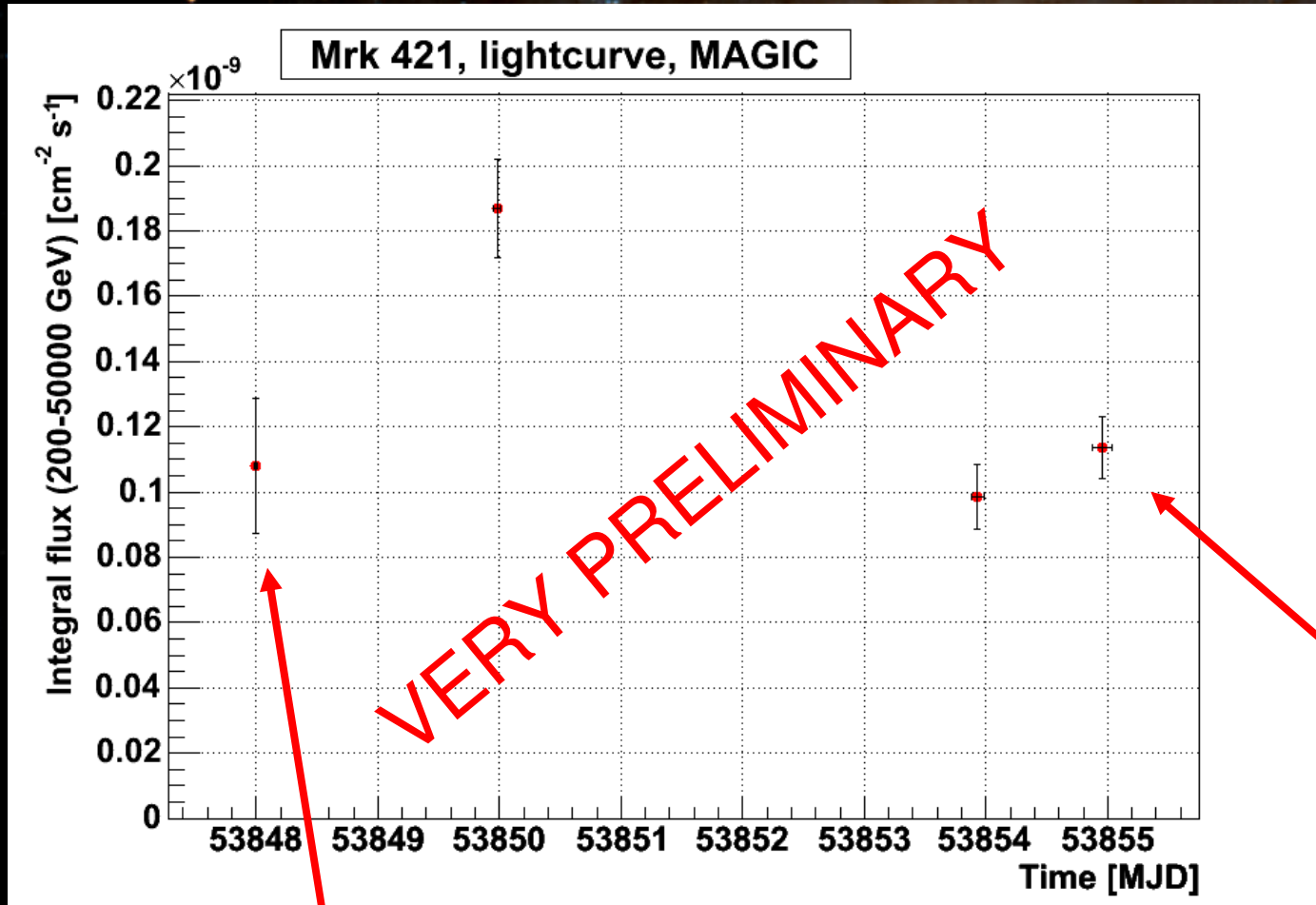
Simultaneous observation with HESS on 18 Dec 2004 (Only one night !)

HESS observed Mkn 421 at high zenith angle → Higher Energy Threshold

Simultaneous observations →

- Cross calibration
- Extended energy range

Mkn 421 Swift trigger



Swift/BAT alert for Mkn421 on Jun 22

Don't take seriously the Y axis units !!!

MW with Suzaku

Jun 22 -> 23 night

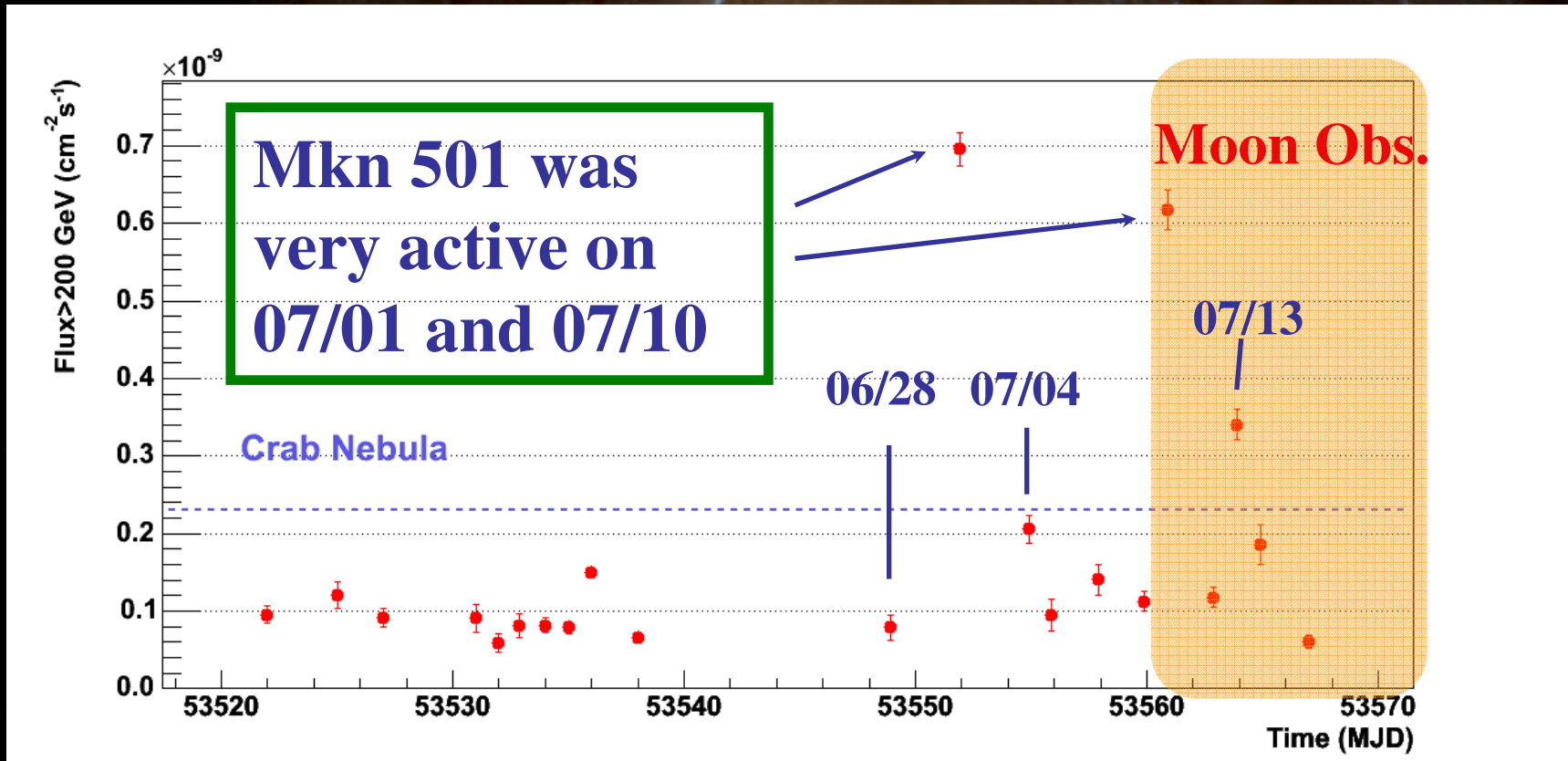
May 25th, 2006

C. Bigongiari, AGN7 Montagnana

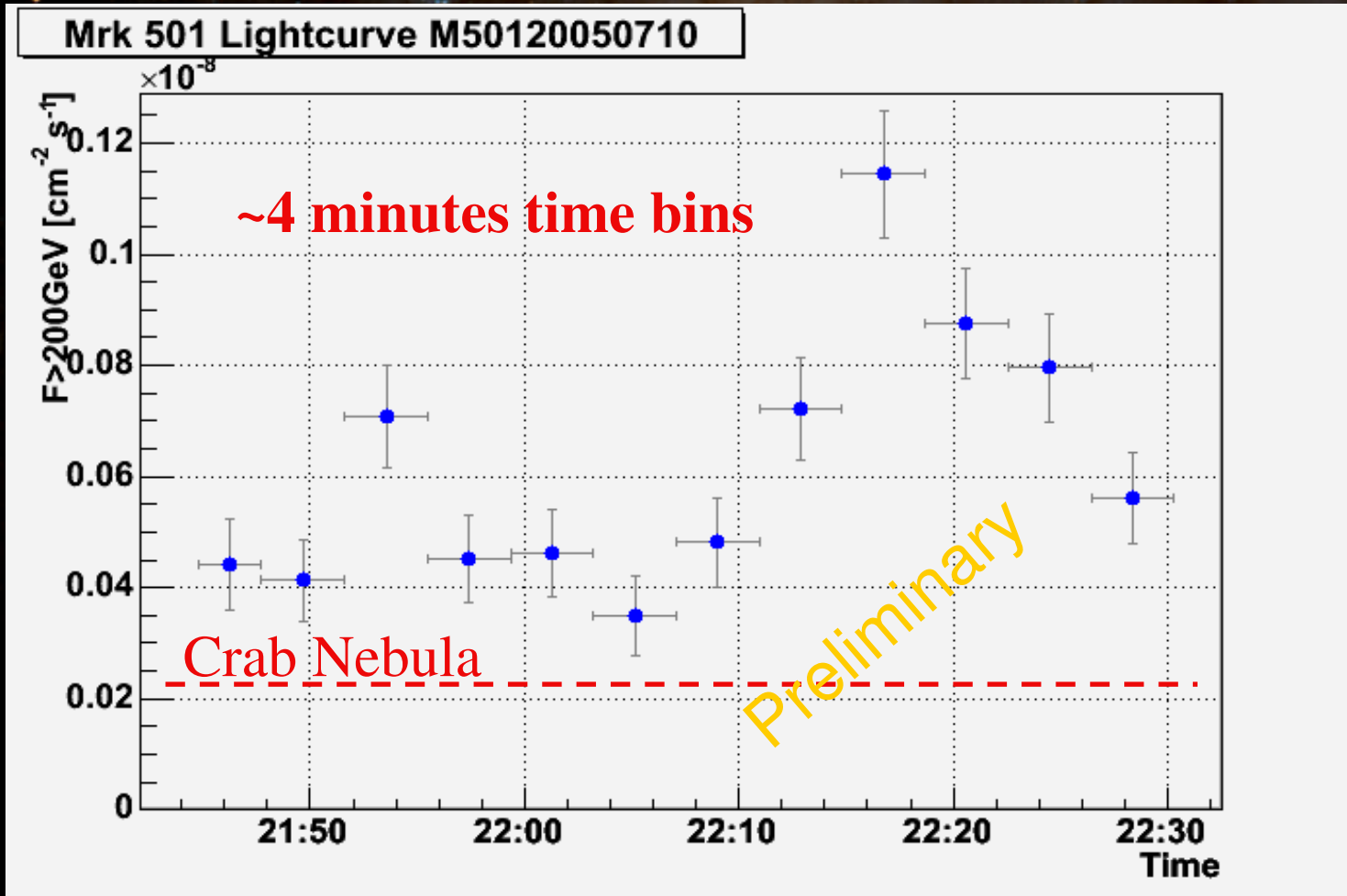
Mrk501 ($z = 0.034$)

MAGIC observed a flare on Jun 30, 2005

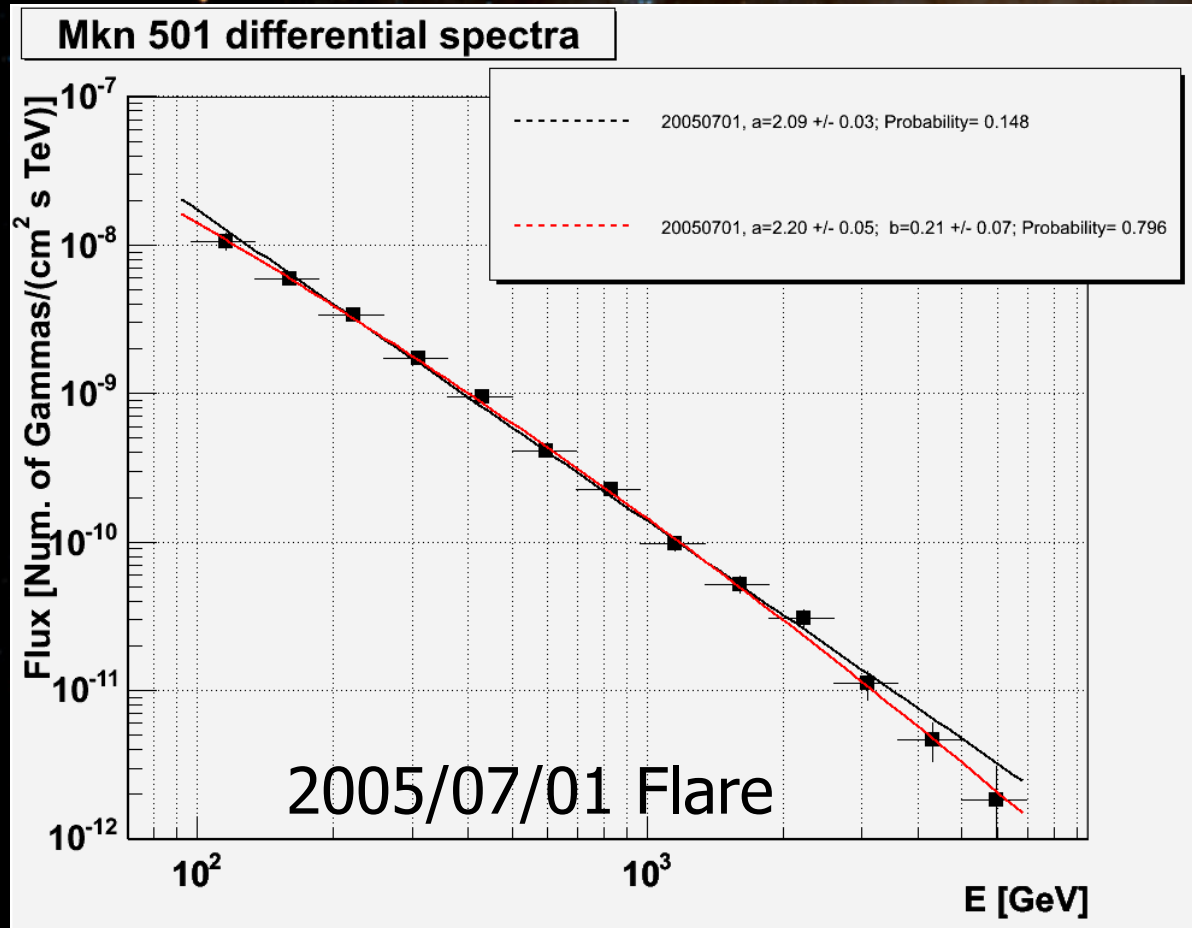
IAU circular N° 8562



Mkn 501 Jul 10 flare



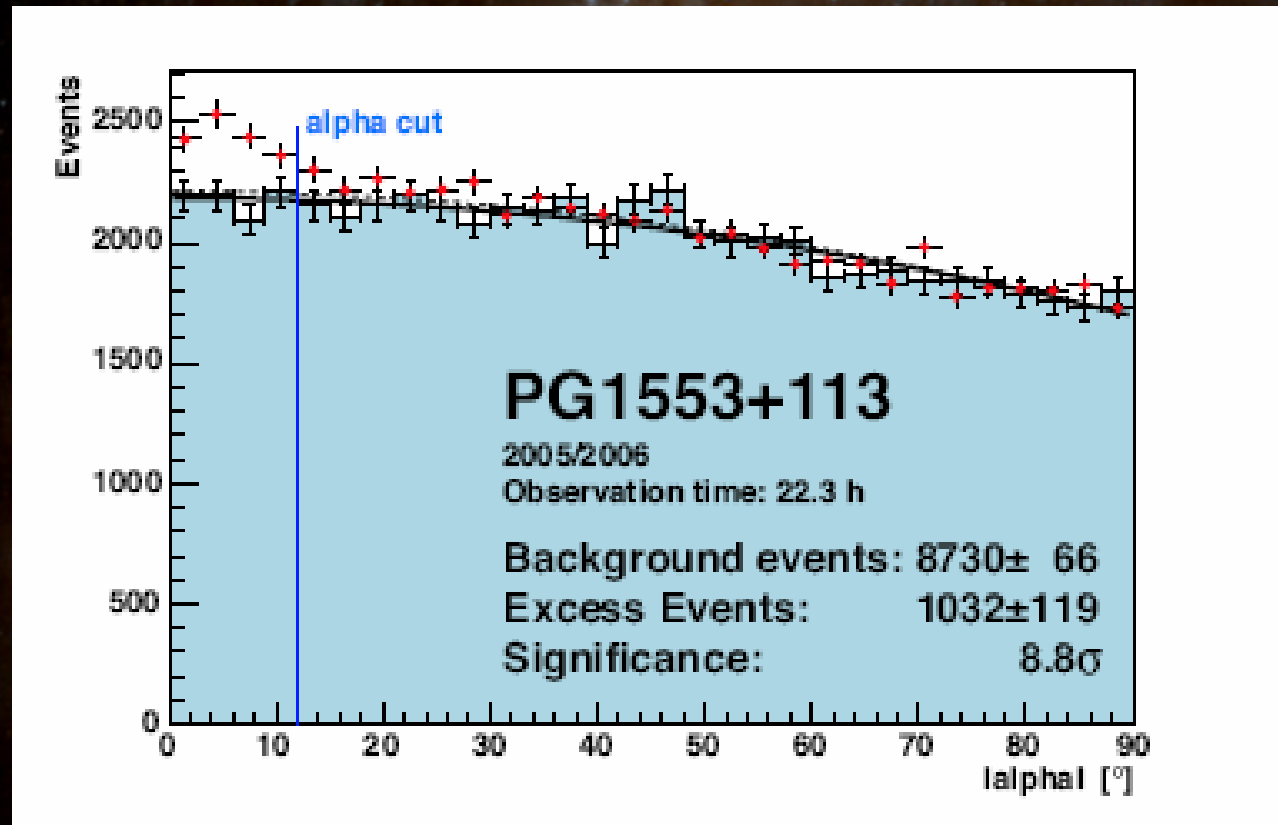
Mkn 501 Spectrum



The single power law doesn't fit very well. Prob = 15%

Power law with energy dependent slope fits better. Prob = 80%

PG 1553+350 ($z = ? 0.236 ?$)



Alpha plot for ON data (red) and OFF data (blue) after cuts.

PG 1553+113 Spectrum

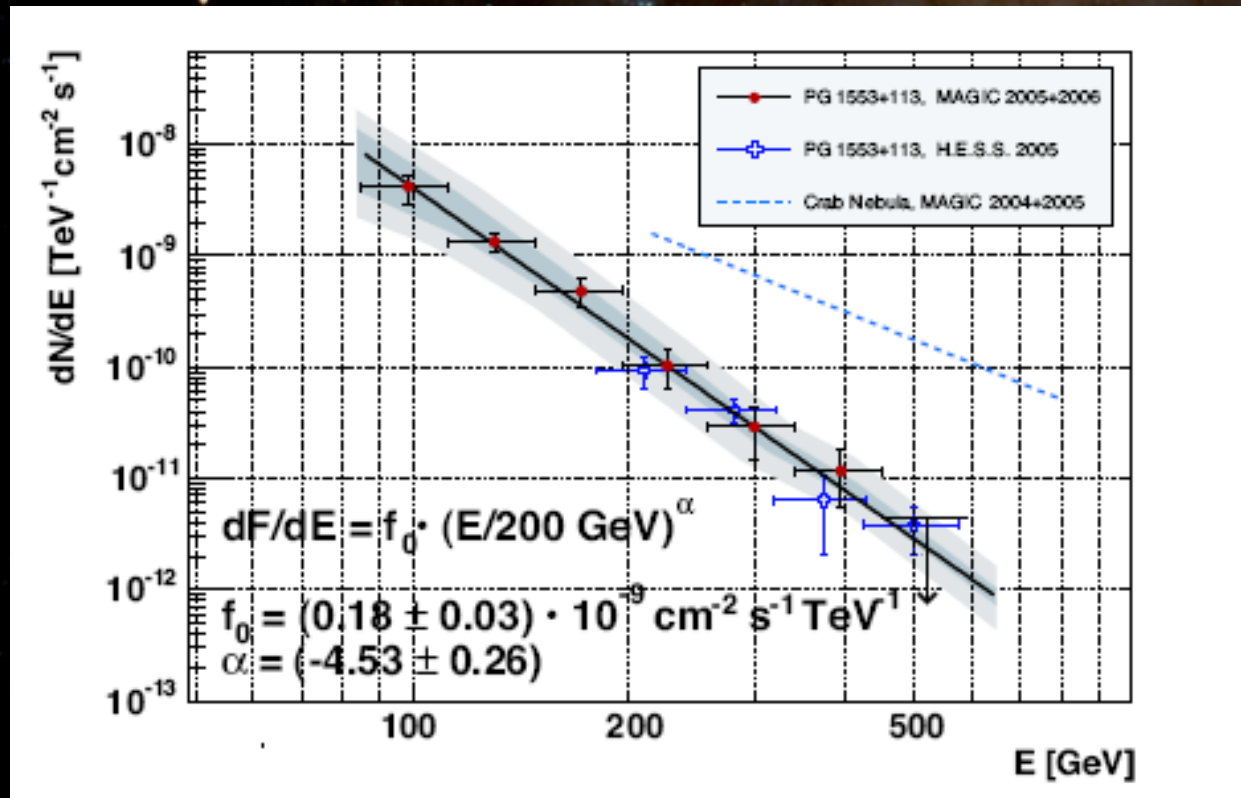
Source clearly detected both in 2005 and 2006.

8.8 σ in 22.3 h

Very steep spectrum:

$$\alpha = 4.5 \pm 0.3$$

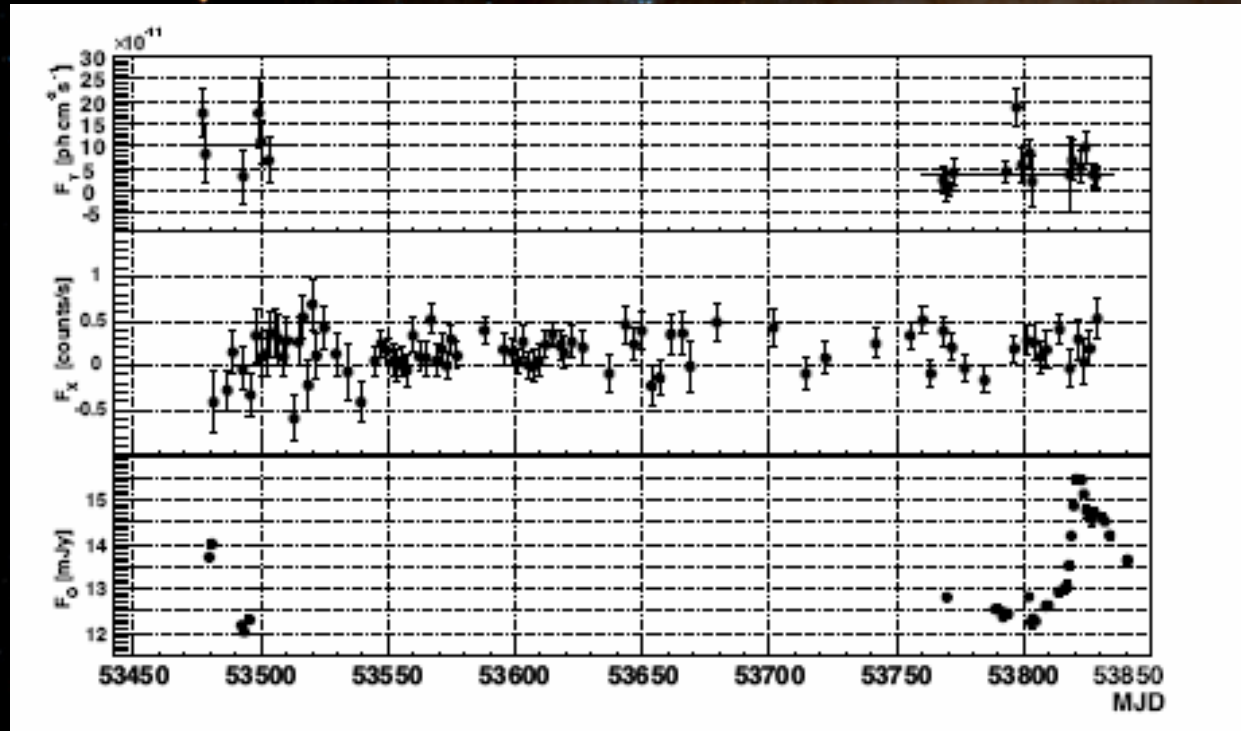
Slope consistent with HESS. Not the flux ! Factor 4.



$$F(E > 200 \text{ GeV}) = 2.0 \pm 0.6 \quad 2005$$

$$F(E > 200 \text{ GeV}) = 0.6 \pm 0.2 \quad 2006$$

PG 1553+113 Light curve



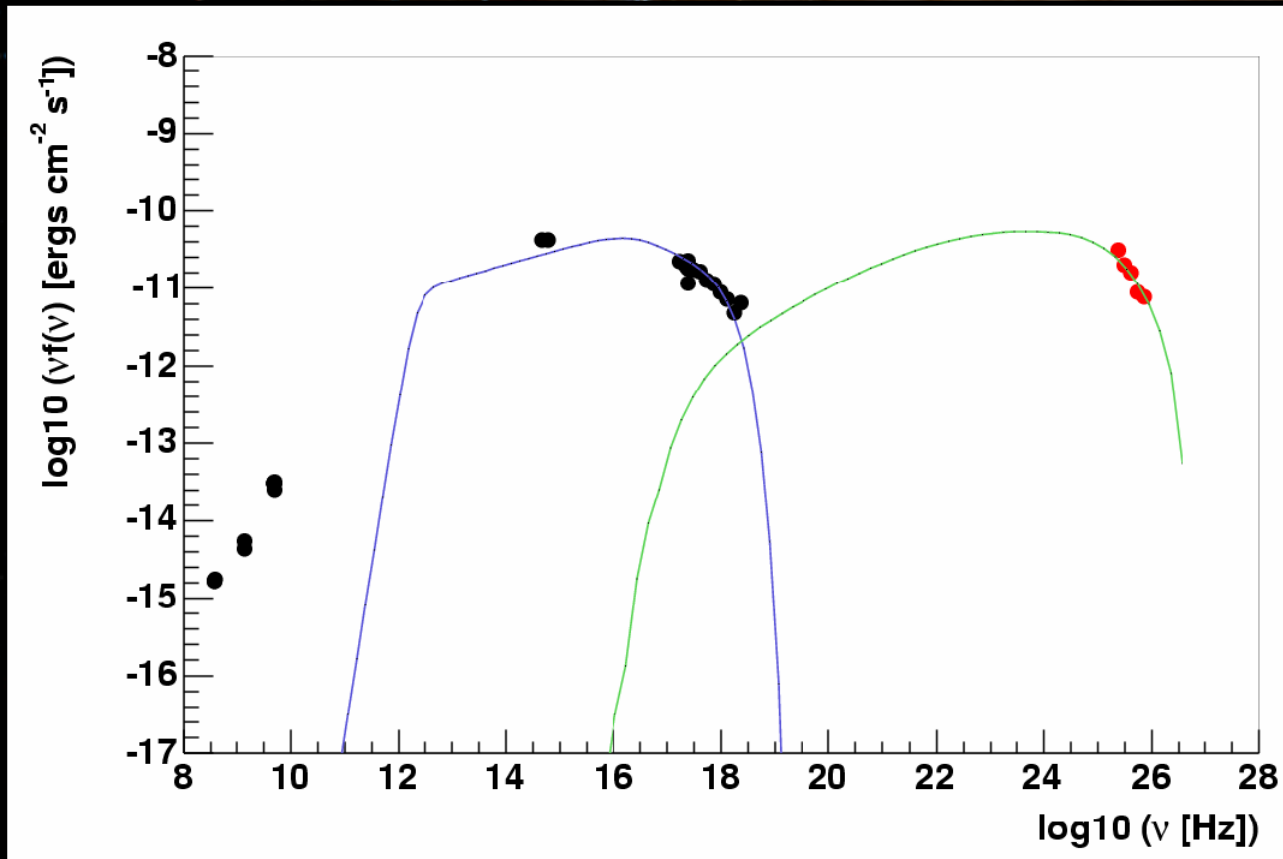
While the optical data shows significant short term variability on the 25% level the X-ray data is consistent with a constant emission.

In gamma-rays there is no evidence for short term variability, but a significant change in the flux level from 2005 to 2006 is found.

PG 1553+113 SED

Radio, optical and X-ray data (black points) from Giommi et al. 2002.

Red points are MAGIC measurements.



The solid lines are the result of a SSC model fit to the data using the code provided by Krawczynski et al. (2004).



Conclusions & Outlook

- **Very active field. A lot of new data are coming.**
- **MAGIC first year of regular data taking just concluded.**
- **30 AGNs observed.**
- **5 AGNs known as gamma sources detected.**
- **Gamma-ray emission from 2 more AGNs discovered.**
- **High time resolution study of AGN flares possible.**
- **Multi- λ campaigns performed and planned for Cycle-II.**
- **Better constraints on emission models.**
- **New analysis methods under investigation \rightarrow Lower E_{th}**
- **New MAGIC observation cycle just started, 800h on AGNs**
- **Many data analysis are ongoing. Stay tuned.**