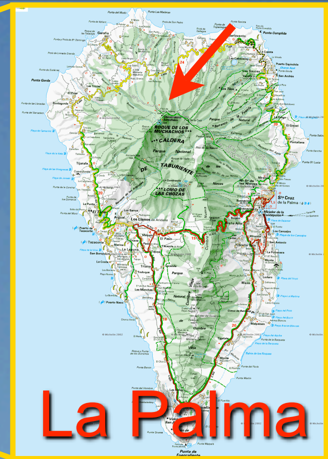
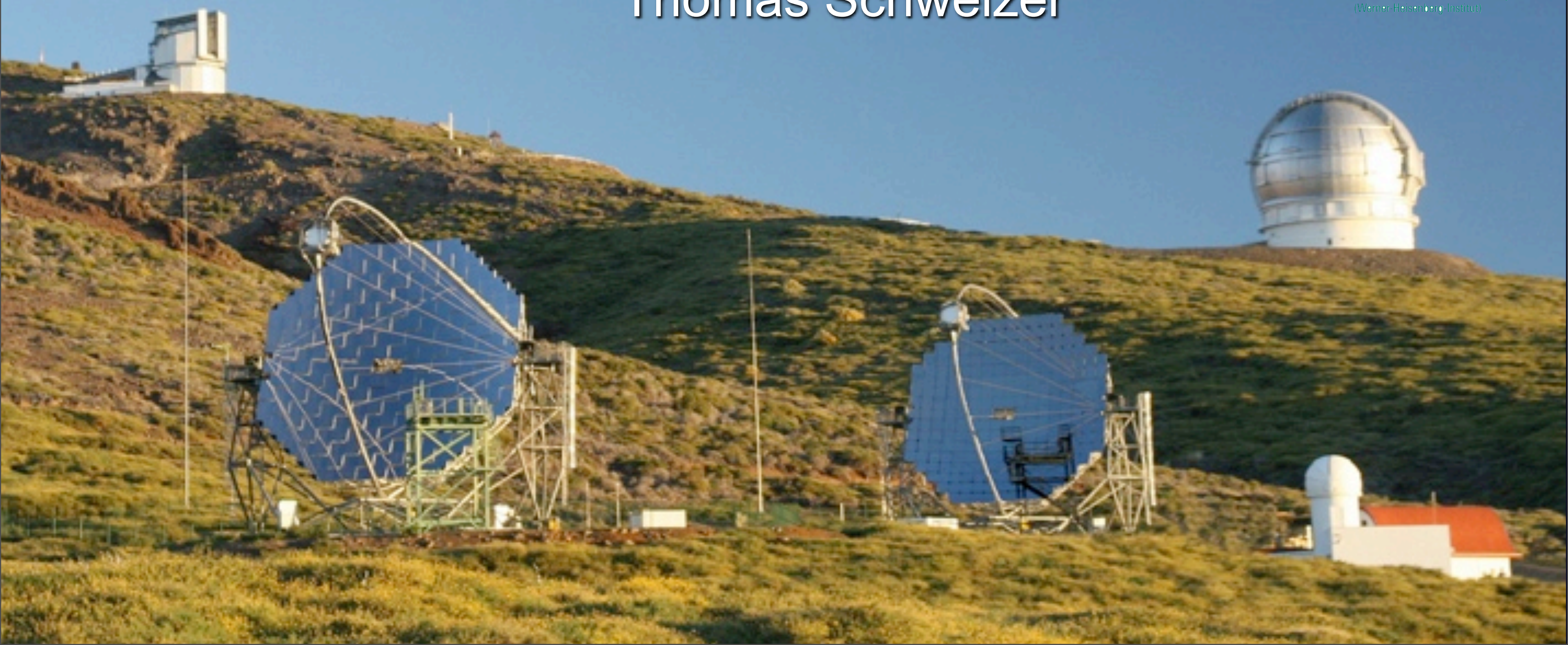




# MAGIC

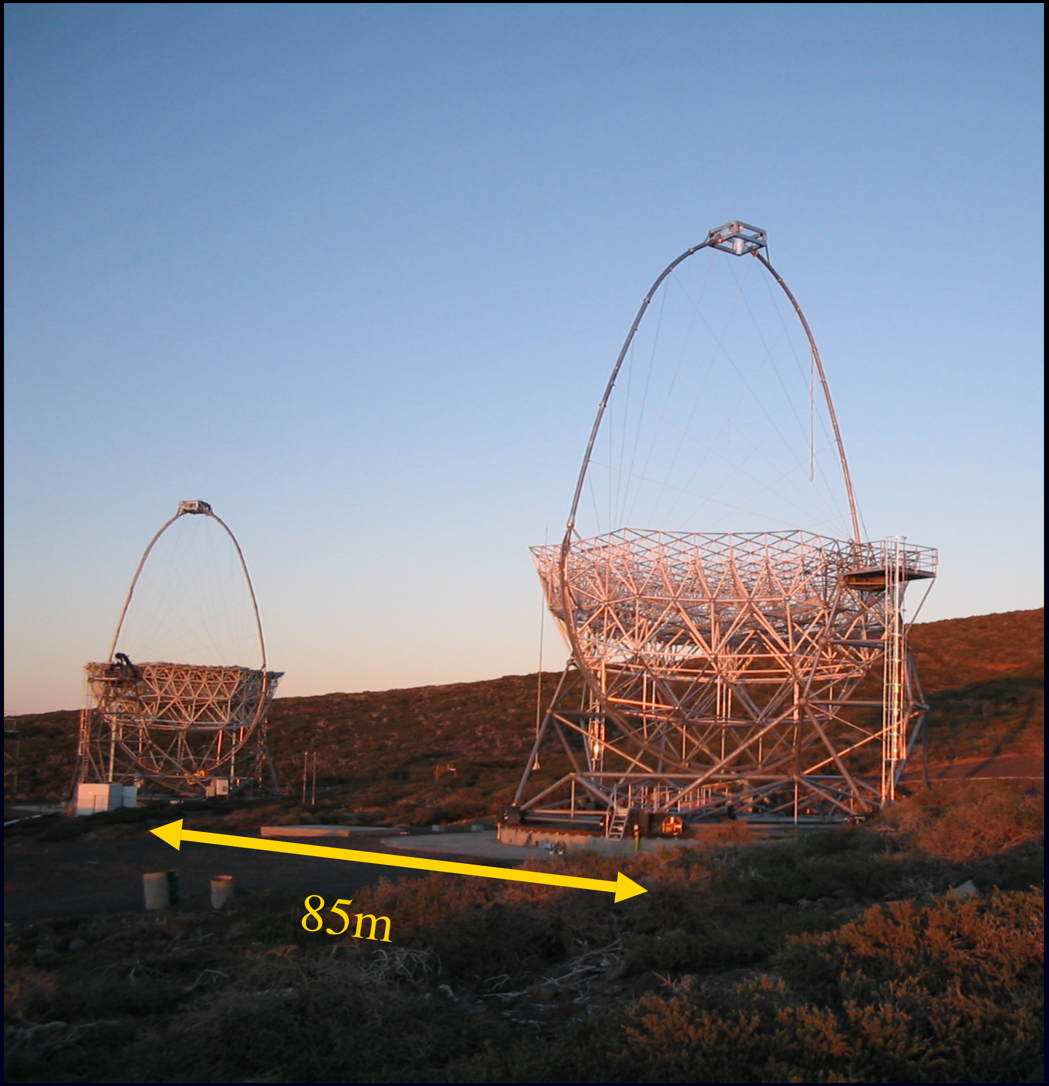
## Project Review


Thomas Schweizer

Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

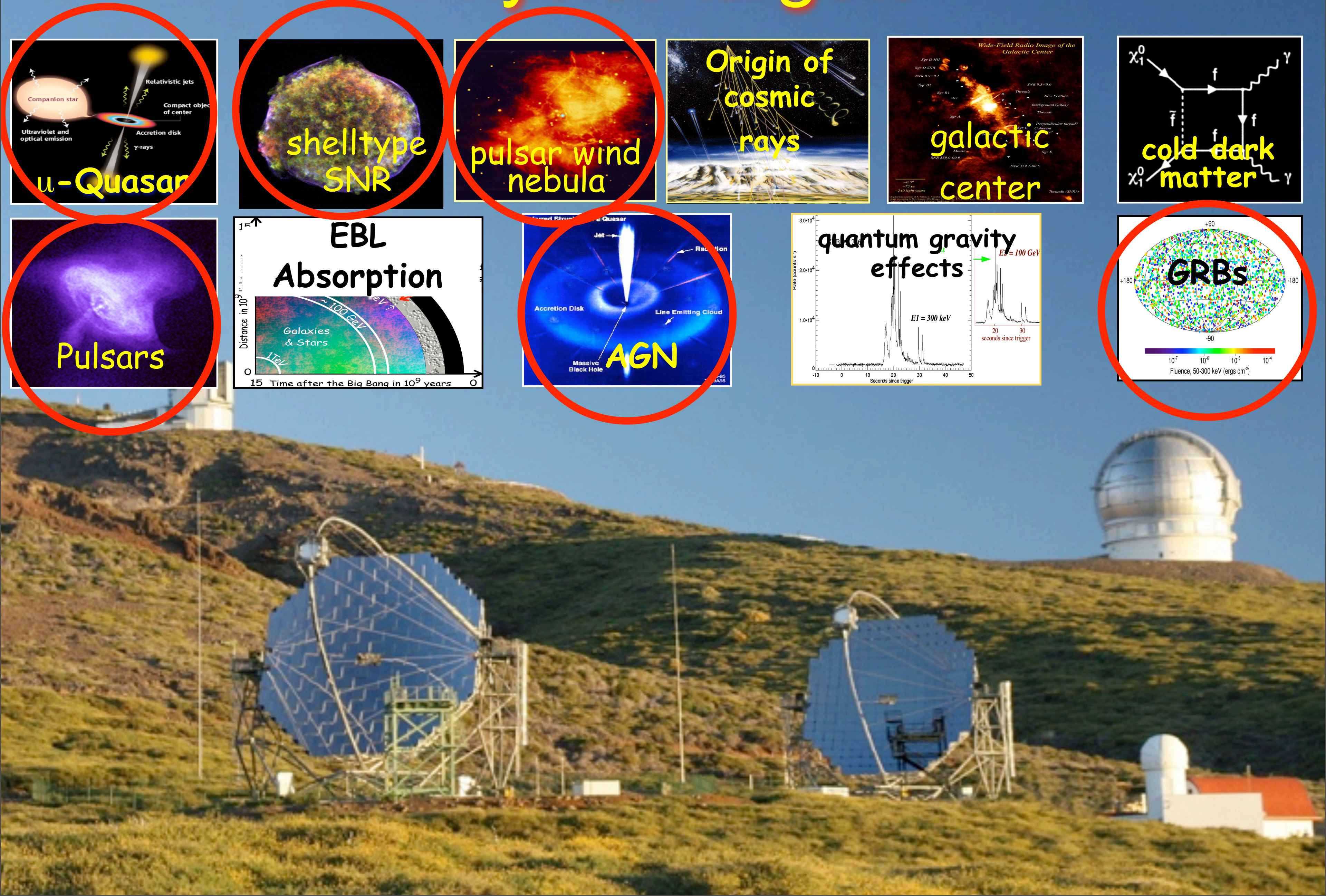



# MAGIC Telescopes



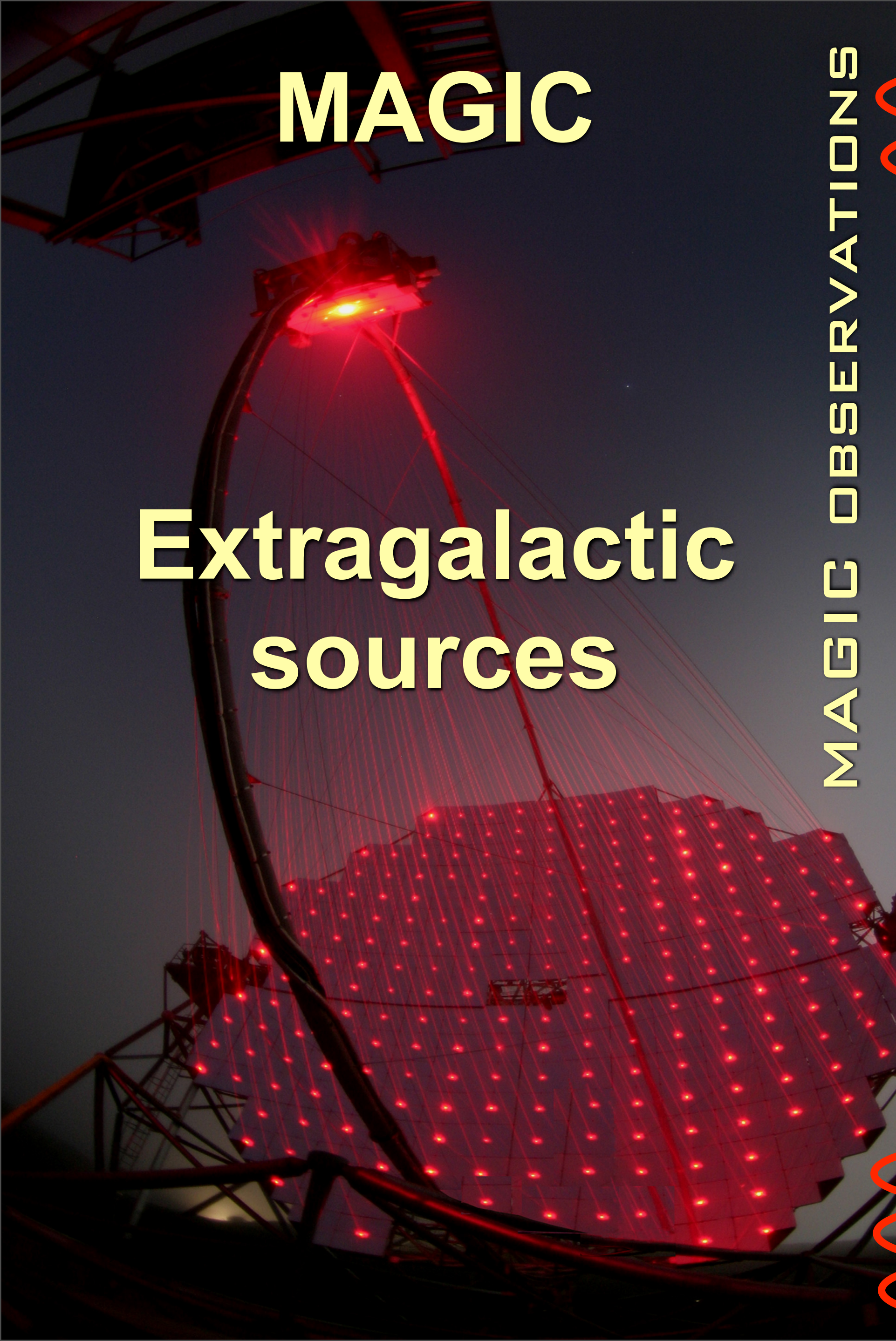

- 17 m Ø reflector, Al mirrors
- CF frame, fast rotation
  Upgrade !! <180°/20s
- Active mirror control
- Analogue signal transport via 162m long optical fibres
- 2 GSample/s readout,...
- MAGIC I: 1.6 % Crab/50h
  MAGIC stereo: <1% C./50h
- World lowest trigger threshold: (25) 50 GeV

# Physics targets



# MAGIC

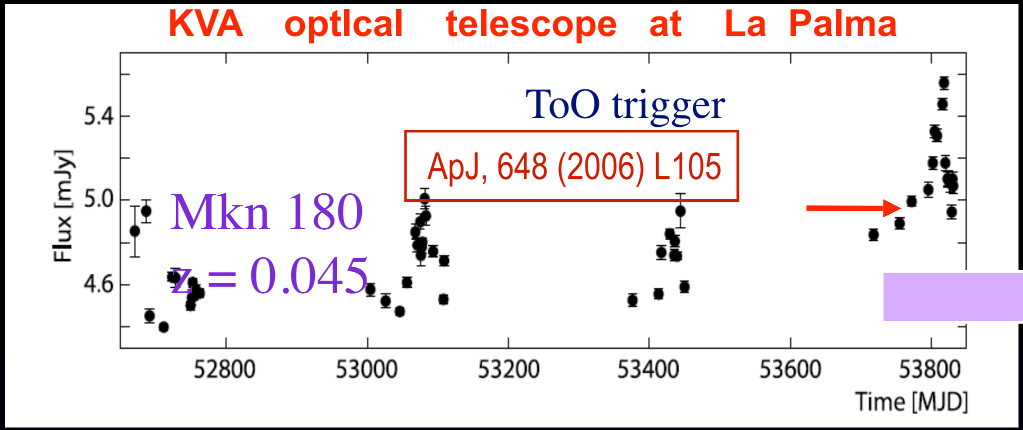
# Extragalactic sources

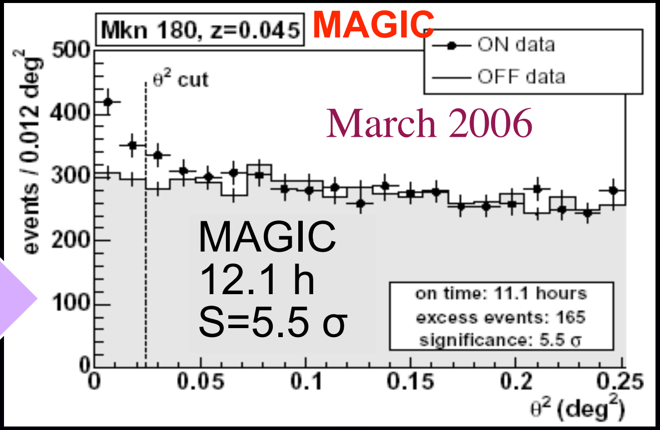


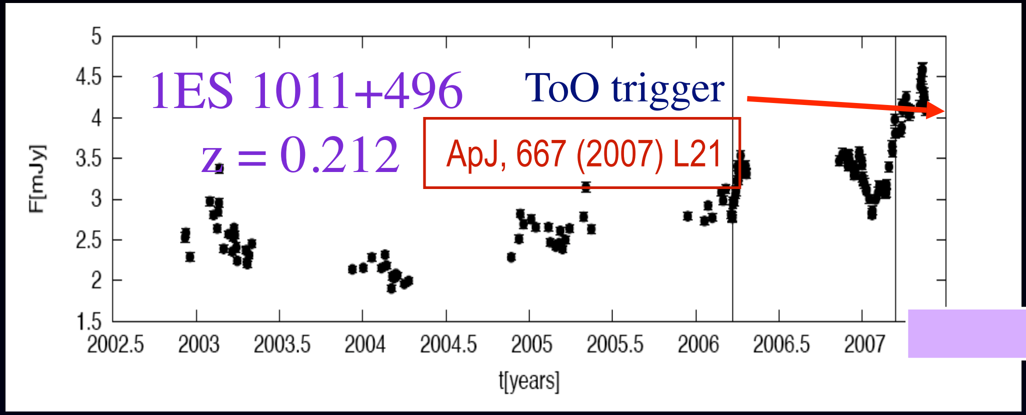
MAGIC OBSERVATIONS

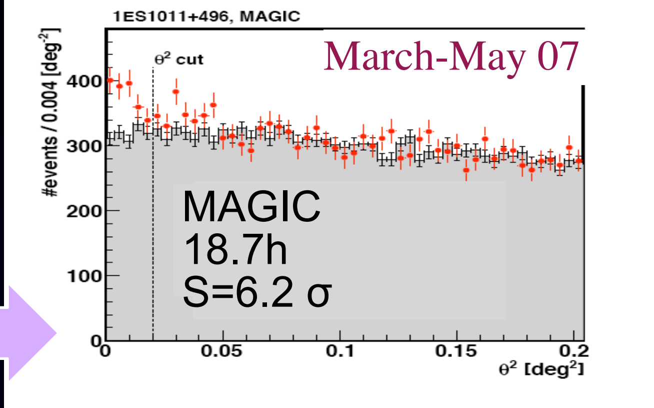
| Source | z | Sp. | Type | Discovery |
|---|---|---|---|---|
| M 87 | 0.004 | 2.9 | FR-I | HEGRA |
| Mkn 421 | 0.031 | 2.2 | HBL | Whipple |
| Mkn 501 | 0.034 | 2.4 | HBL | Whipple |
| 1ES 2344+514 | 0.044 | 2.9 | HBL | Whipple |
| Mkn 180 | 0.045 | 3.3 | HBL | MAGIC |
| 1ES 1959+650 | 0.047 | 2.4 | HBL | 7TA |
| PKS 0548-322 | 0.069 | | HBL | HESS |
| BL Lac | 0.069 | 3.6 | LBL | MAGIC |
| PKS 2005-489 | 0.071 | 4.0 | HBL | HESS |
| PG 1553 | >0.09 | 4.0 | HBL | HESS/MAGIC |
| PKS 2155-304 | 0.116 | 3.3 | HBL | Durham |
| 1ES 1426+428 | 0.129 | 3.3 | HBL | Whipple |
| 1ES 0229+200 | 0.139 | | HBL | HESS |
| H 2356-309 | 0.165 | 3.1 | HBL | HESS |
| 1ES 1218+304 | 0.182 | 3.0 | HBL | MAGIC |
| 1ES 1101-232 | 0.186 | 2.9 | HBL | HESS |
| 1ES 0347-121 | 0.188 | | HBL | HESS |
| 1ES 1011+496 | 0.212 | 4.0 | HBL | MAGIC |
| 3C 279 | 0.538 | 4.1 | FSRQ | MAGIC |
| 3C 66A/B | ? | | ? | MAGIC |
| S5 0716+714 | 0.31 | 3.5 | HBL | MAGIC |

# Do optical triggers work ?



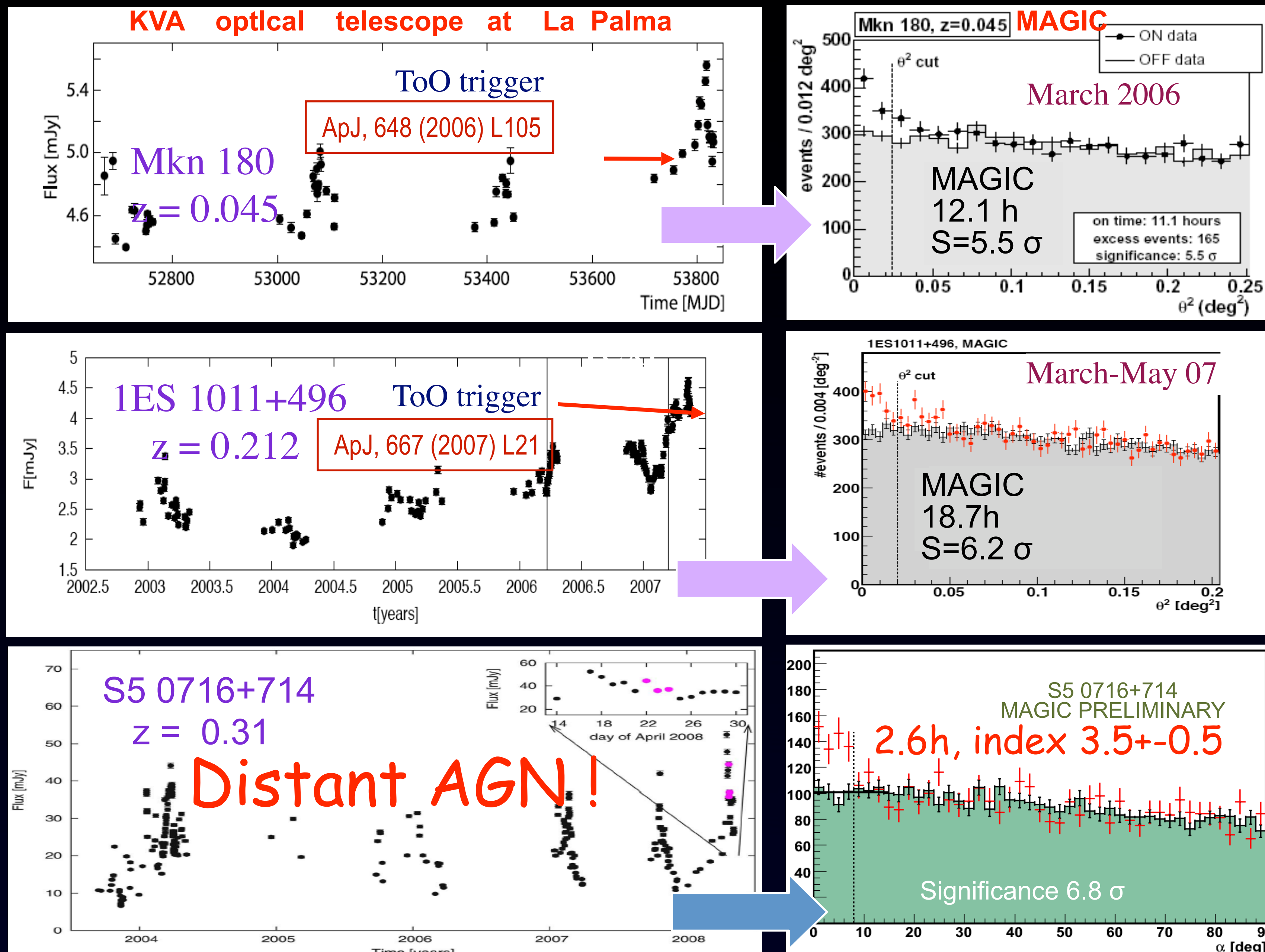




. ? .

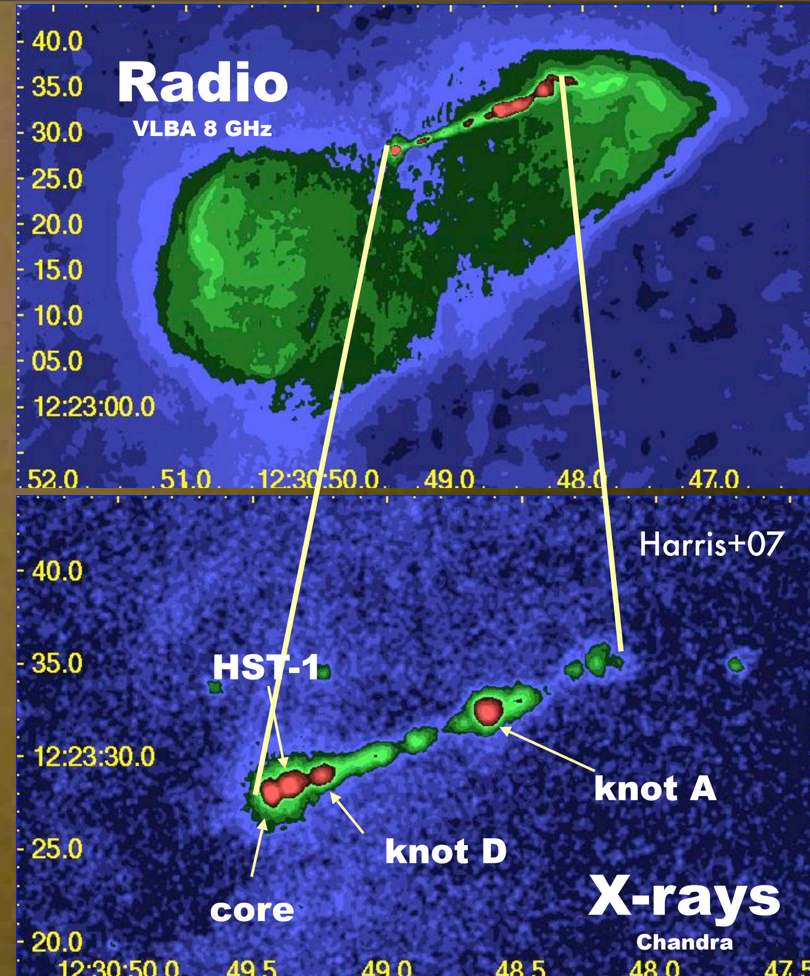
Thomas Schweizer , Project Review MPI December 2009

# Discovery !!



KVA optical telescope at La Palma
ToO trigger
ApJ, 648 (2006) L105
Mkn 180
z = 0.045
Flux [mJy]
Time [MJD]
Mkn 180, z=0.045
MAGIC
ON data
OFF data
$\theta^2$ cut
March 2006
MAGIC
12.1 h
S=5.5 σ
on time: 11.1 hours
excess events: 165
significance: 5.5 σ
events / 0.012 deg$^2$
$\theta^2$ (deg$^2$)
1ES 1011+496
z = 0.212
ToO trigger
ApJ, 667 (2007) L21
F[mJy]
t[years]
1ES1011+496, MAGIC
$\theta^2$ cut
March-May 07
MAGIC
18.7h
S=6.2 σ
#events / 0.004 [deg$^{-2}$]
$\theta^2$ [deg$^2$]
S5 0716+714
z = 0.31
Distant AGN !
Flux [mJy]
day of April 2008
Time [years]
S5 0716+714
MAGIC PRELIMINARY
2.6h, index 3.5+-0.5
Significance 6.8 σ
α [deg]

# Giant radio galaxy M87: A Unique Astrophysical Laboratory

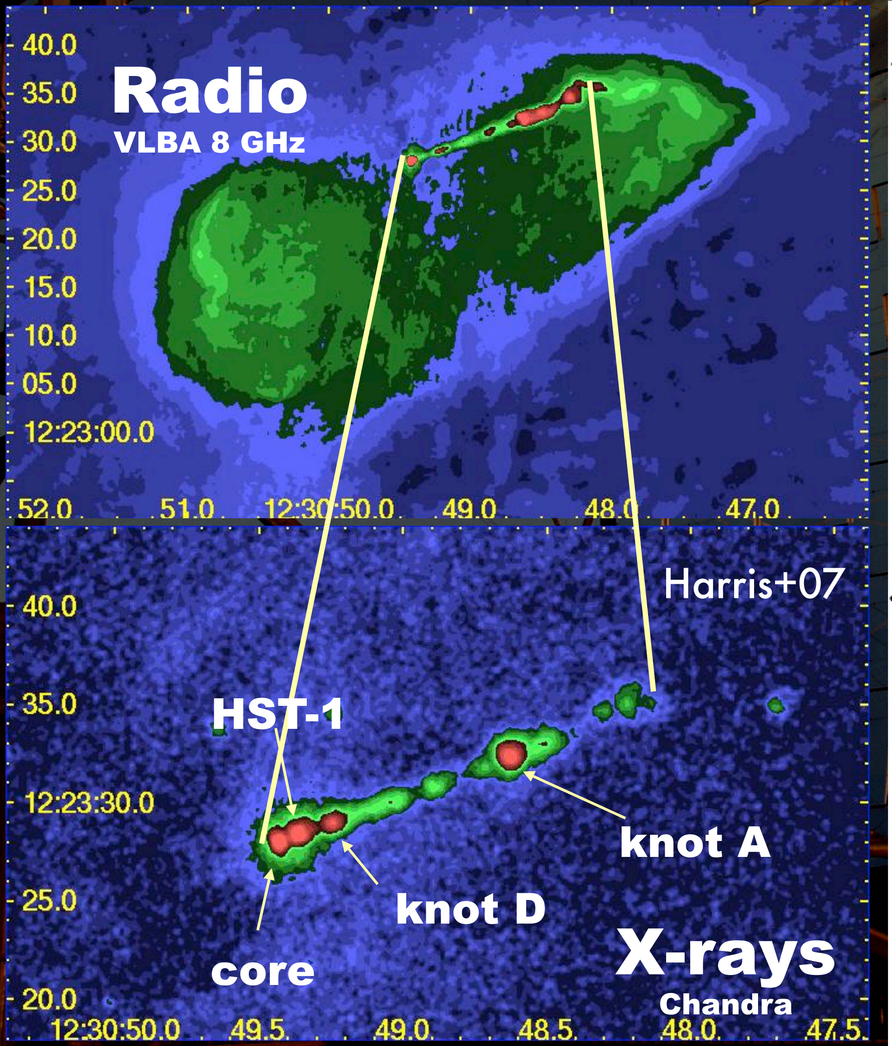


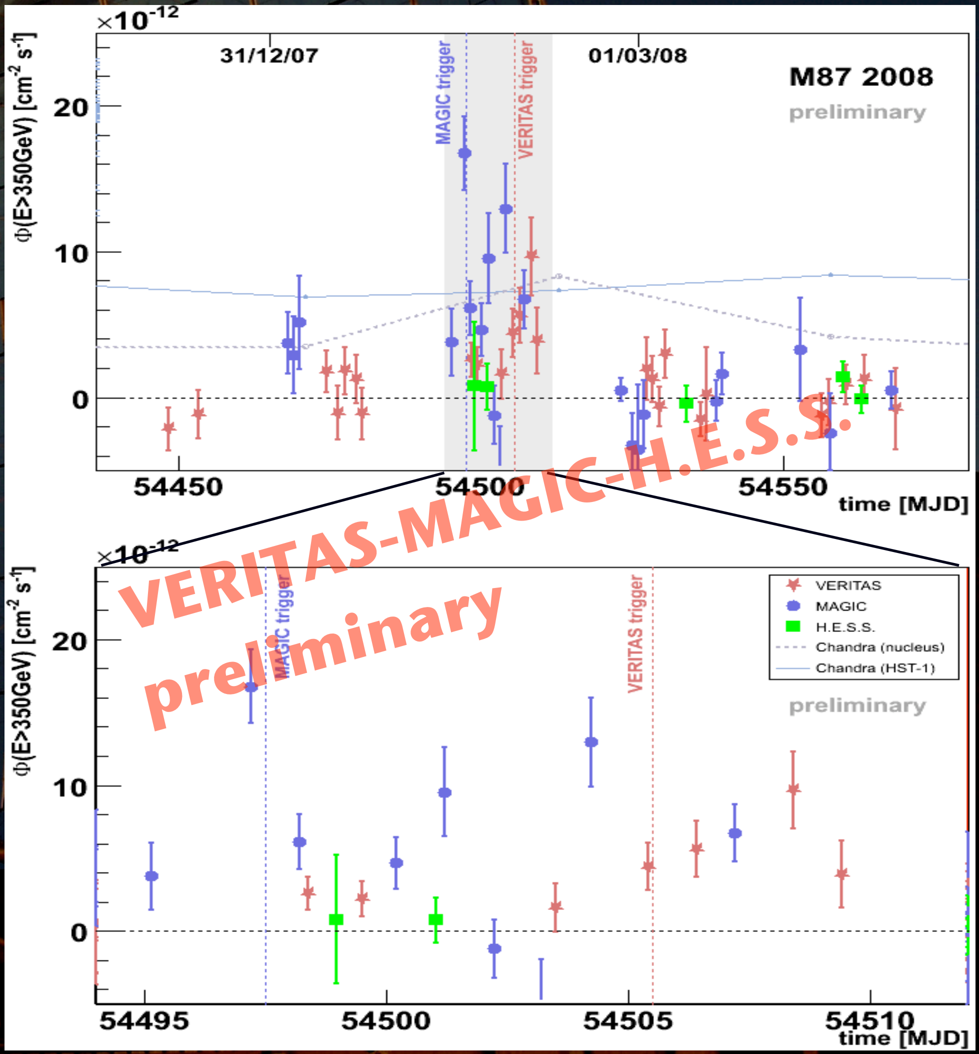

## From which location originates the VHE gamma emission ?

z=0.00436
Viewing angle 10°-19°

- VERITAS/MAGIC/H.E.S.S. monitoring 120 h of observation
- Simultanous VLBA radio imaging and Chandra monitoring

# VERITAS-MAGIC-HESS monitoring compain 2007

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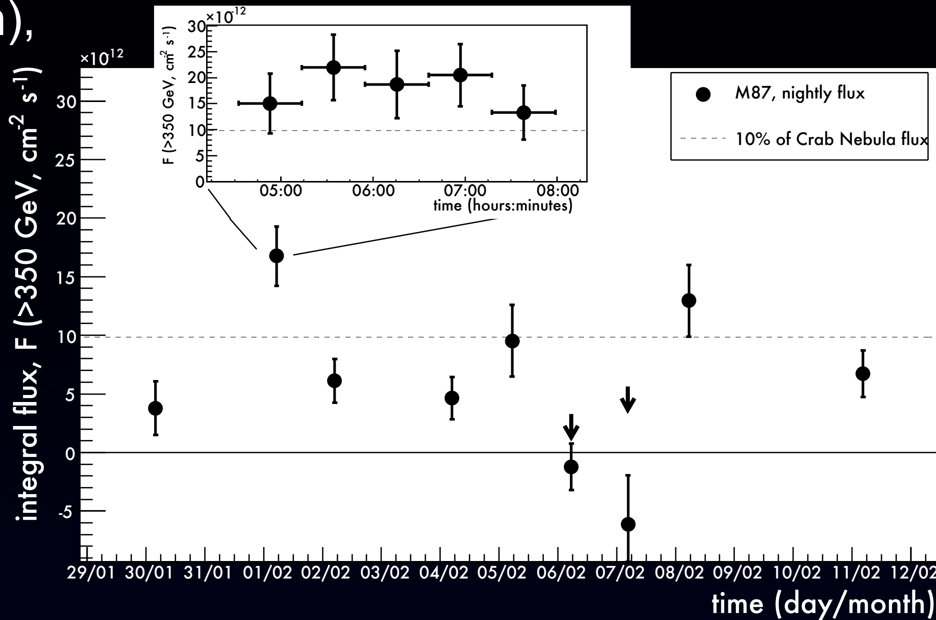
Beilicke, Mazin, Raue, RMW et al. 2008
Colin, RMW, Beilicke et al. 2008

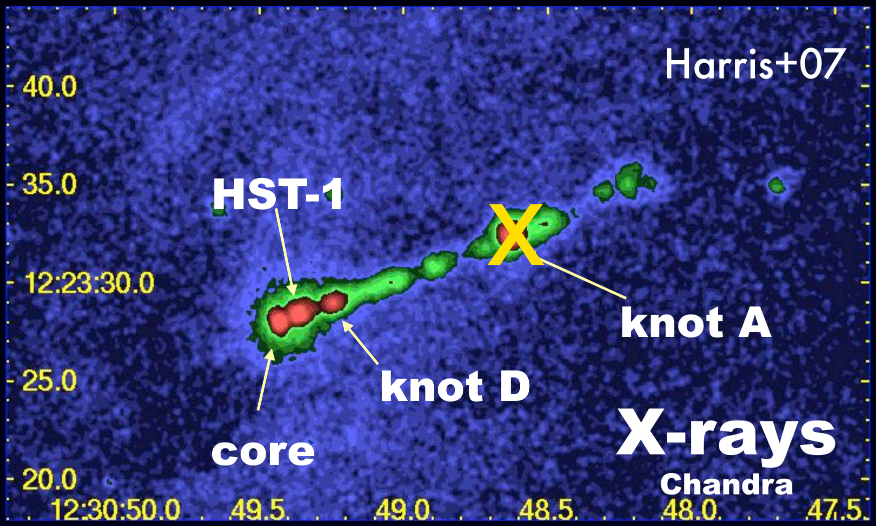
# High variability of M87

MAGIC Coll., ApJ 685 (2008) L23

Beginning of 2008:

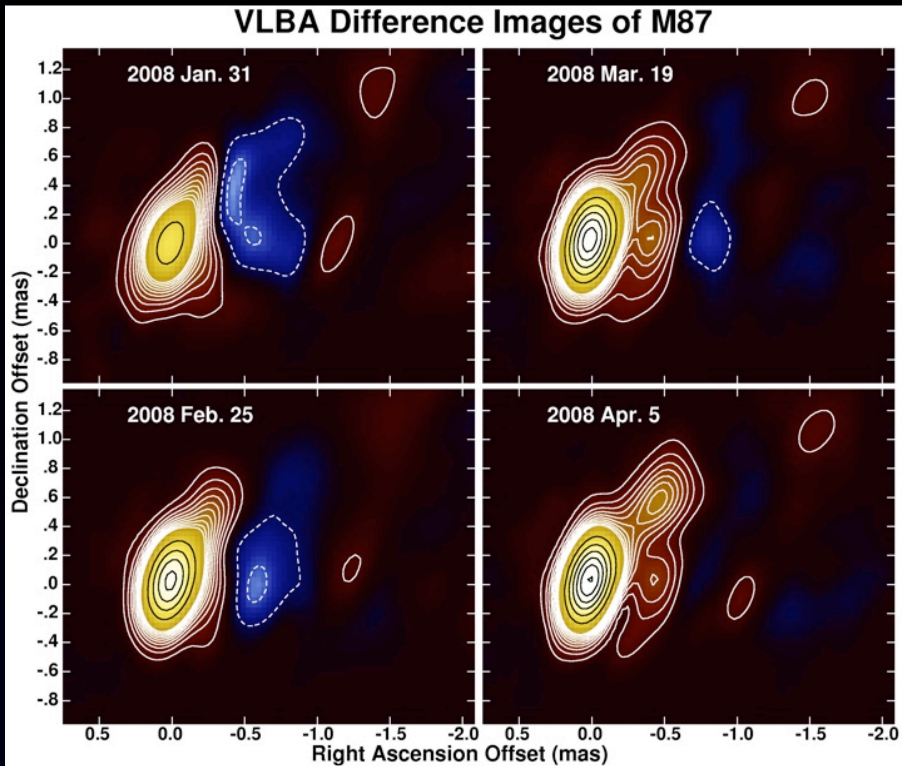
- Nucleus bright in X-rays (at all-time high), while HST-1 rather dim
- MAGIC: 8 σ on 2008 Feb 1:
- 9.9 σ in overall sample (22.8 h) 2008 Jan 30−Feb 11

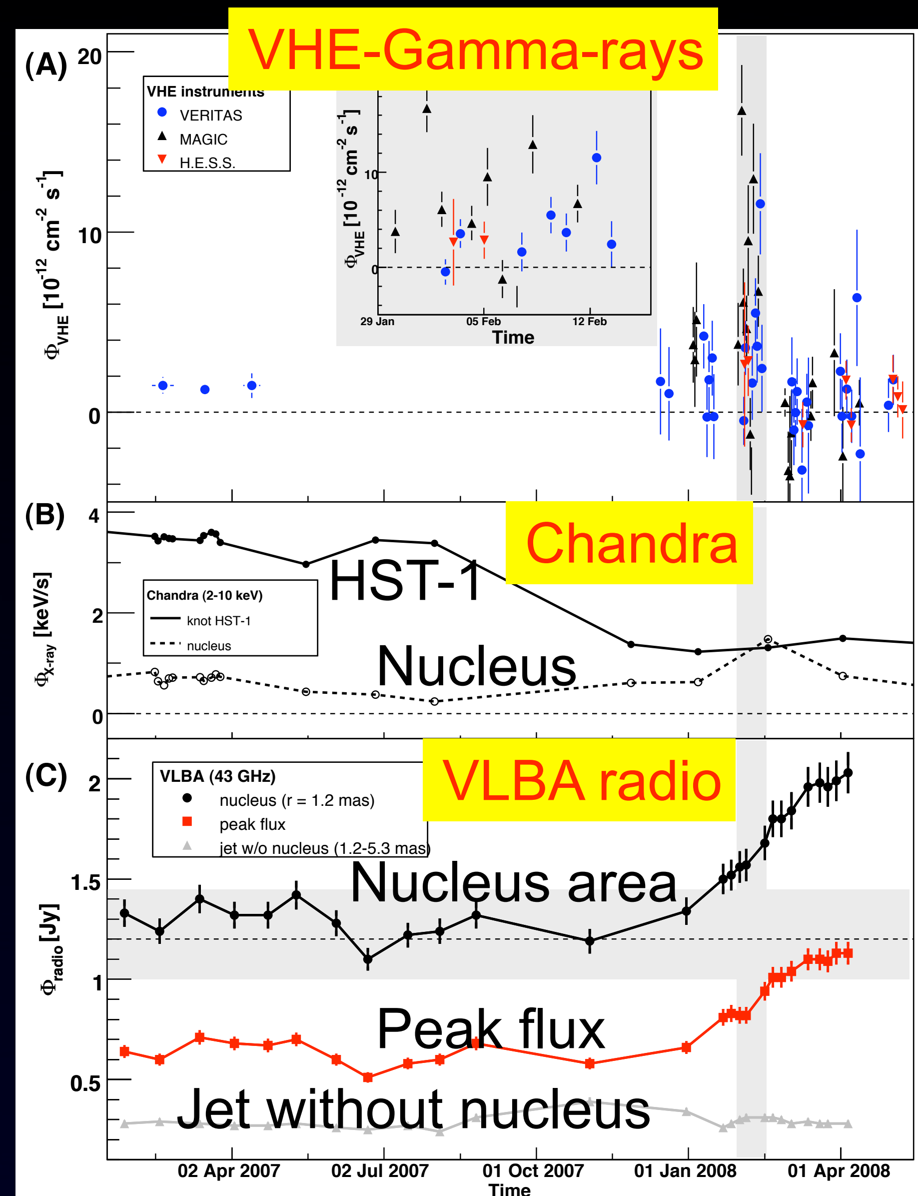



- TeV flux variable 3%−15% Crab
- Day-scale variability (5.6 σ)
- Fast variability
  ➙ Knot A as VHE γ-ray source excluded

# Increased radio activity at core during gamma ray high state

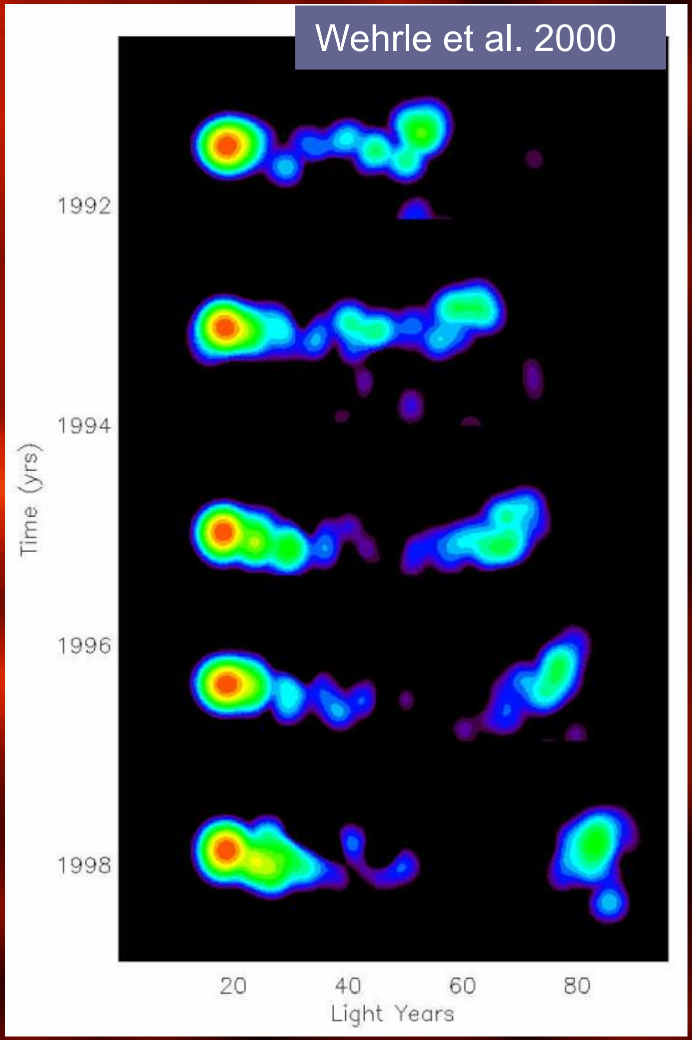



- Gamma emission originates from region close to the core of M87
- Science express, July 2, 2009
  DOI: 10.1126/science.1175406

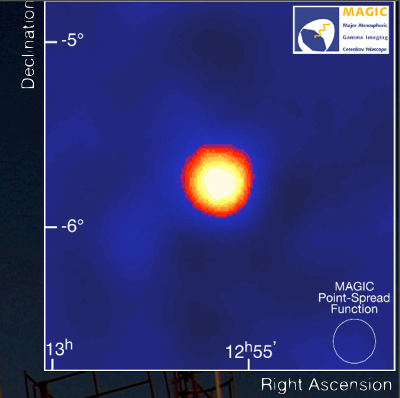
# High-z Observations: Need low energy sensitivity 3C 279

- First Flat Spectrum Radio Quasar !!
- Redshift z=0.536
- Apparent luminosity ≈ $10^{48}$ erg/s
- Brightest EGRET AGN (Wehrle+97,98)
- Gamma-ray flares in 1991 and 1996: High dynamical range in EGRET data
- Fast time variation: $\Delta T$ ~ 6hr in 1996 flare

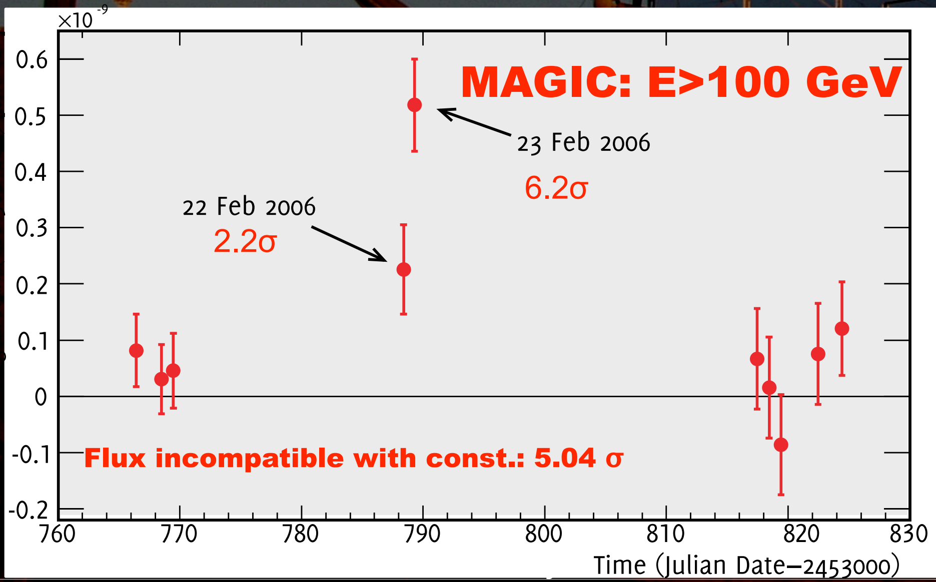


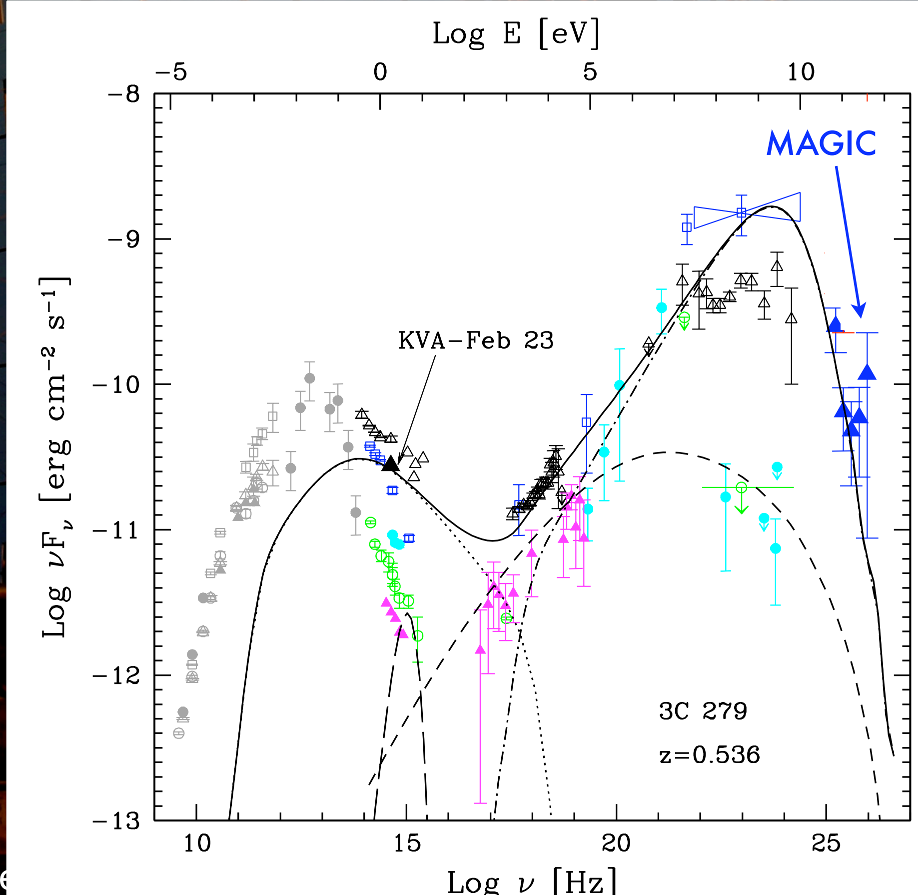
# 3C 279 MAGIC observations Jan -April 2006

- Modeling of 3C 279 non-trivial:
  - FSRQ → bright emission lines: External photon fields important (Dermer+93, Sikora+94)
  - External-Inverse Compton Modeling required, more free parameters
  - VHE provides vital input!



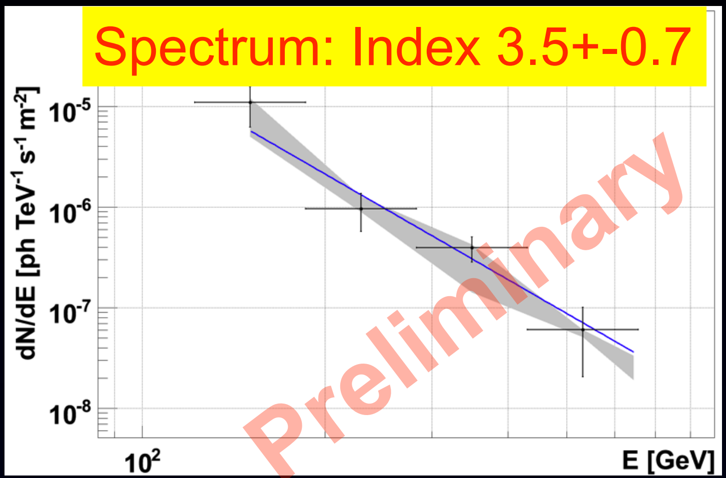

MAGIC Coll., Science 320 (2008) 1752

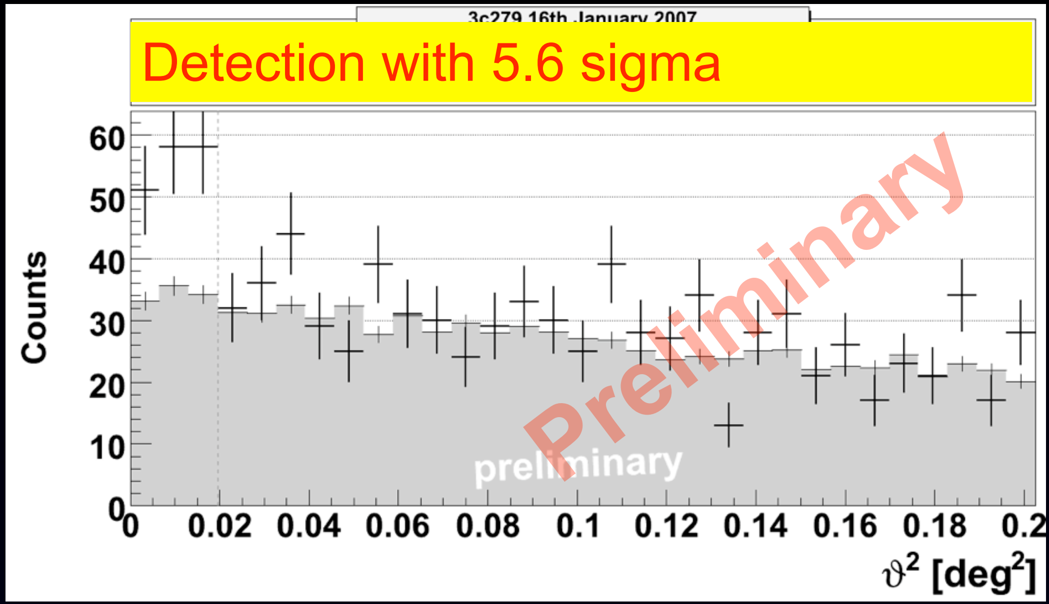


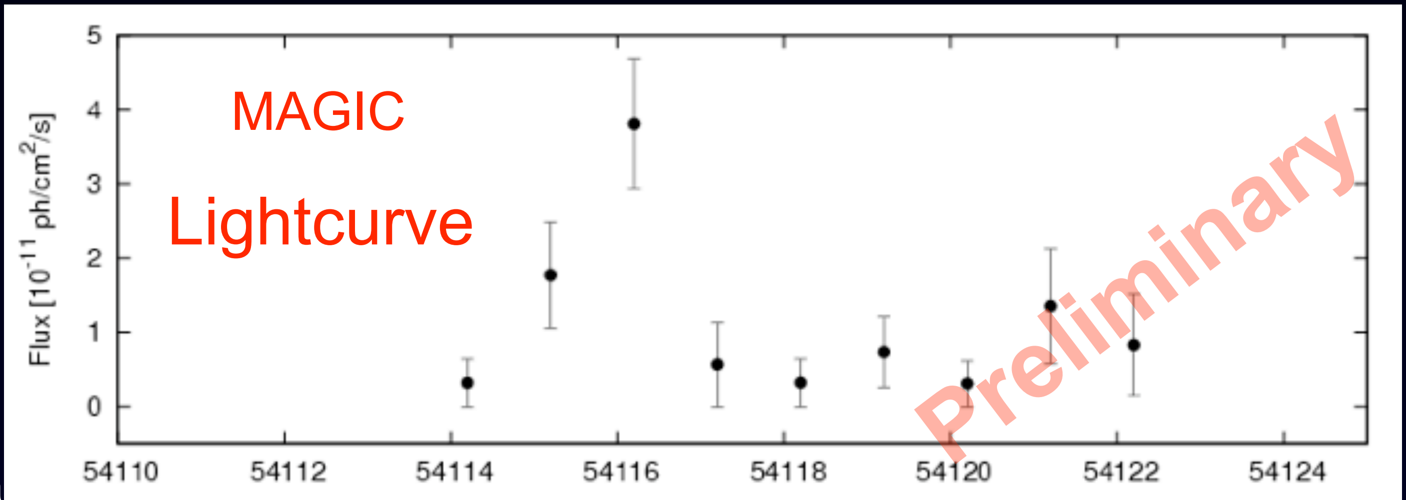



# 3C279 follow-up observations:
# Signal is still there !

- Observation: January 16, 2007

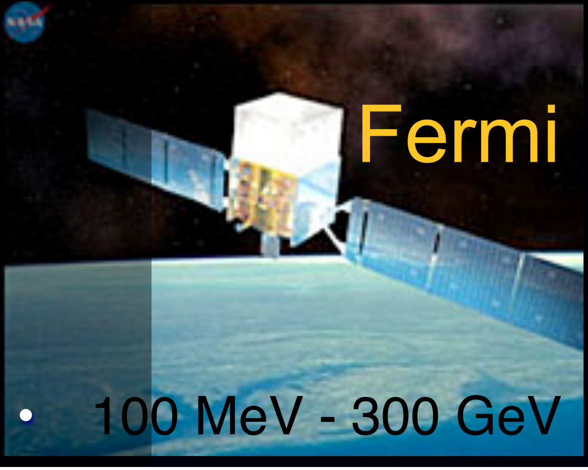


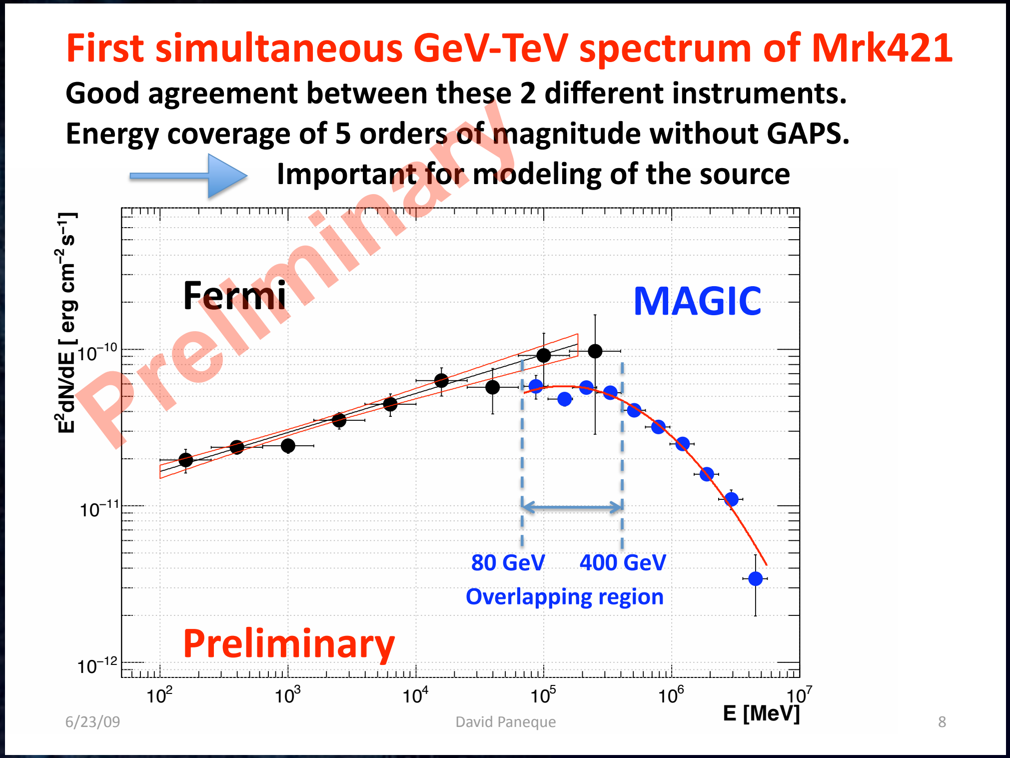




Thoma

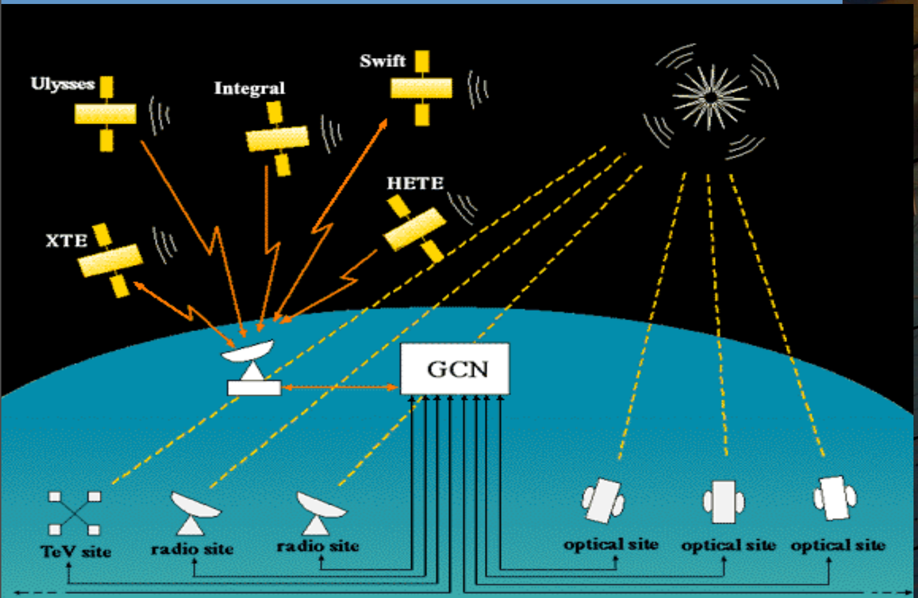
# Mkn 421: First combined spectrum of IC peak: Fermi and MAGIC




- 10 day multiwavelength campain Jan 20 - May 31, 2009
- Radio:OVRO, Effelsberg, Noto…
  Infrared: WIRO,
  Optical: GASP, GRT, MITSuMe…
  X-ray: Swift, RXTE
  Gamma-ray: Fermi
  VHE: MAGIC, VERITAS
- Small offset:
  (Bins are not exactly time-coincident because Fermi observes 24h)



# GRBs with MAGIC



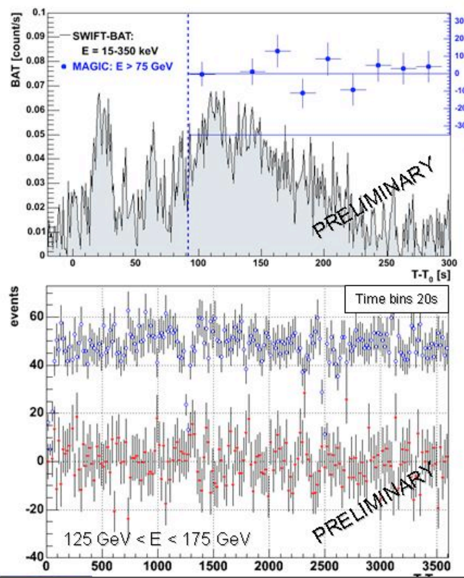

Missed also 080319B at z=0.937, biggest GRB ever !

Next BIG ONE awaited !

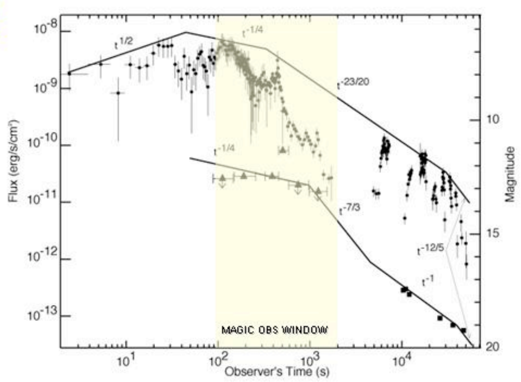
Drive upgrade:
Repositioning time:
MAGIC II: 17 sec/180 deg
MAGIC I:  20 sec/180 deg

Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

## The Case of GRB050904




z=6.1...



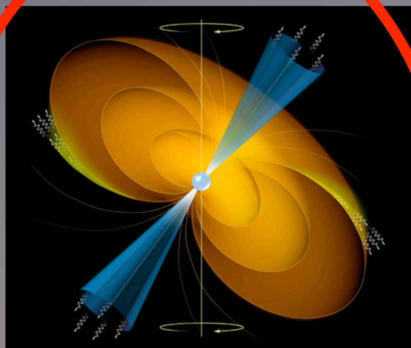

GRB – Observed GRB locations

GRB WG: ApJ 667, 358

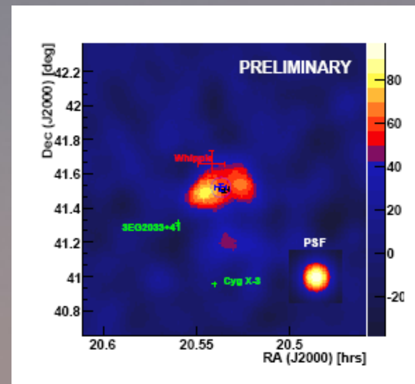
| GRB | $t_0$ | $\Delta t_{alert}$ | $\Delta t_{oss}$ | $t_{90}$ | <ZA> |
|---|---|---|---|---|---|
| 050421 | 04:11:52 | 58 s | 83 s | 10 s | 50° |
| 050502a | 02:14:18 | 18 s | 990 s | 20 s | 42° |
| 050505 | 23 | | | 0 s | 55° |
| 050509a | 01 | | | 2 s | 50° |
| 050509b | 04 | | | 13 s | 49° |
| 050528 | 04:06:45 | 43 s | 77 s | 11 s | 50° |
| 050713a | 04:29:02 | 13 s | 40 s | 27 s | 49° |
| 050904 | 01:51:44 | 82 s | 92 s | 225 s | 20° |
| 060121 | 22:24:54 | 15 s | 583 s | 2 s | 42° |
| 060203 | 23:53:35 | 171 s | 185 s | 83 s | 40° |
| 060206 | 04:46:53 | 16 s | 25 s | 11 s | 10° |

Typical repointing 10÷30 s

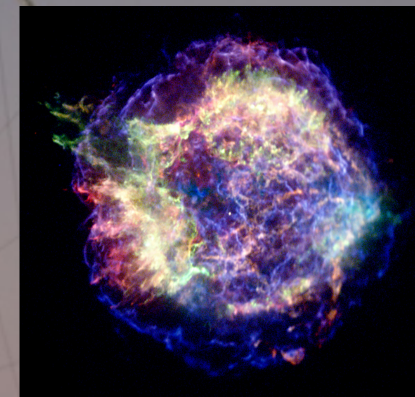
# Some Galactic Source Highlights



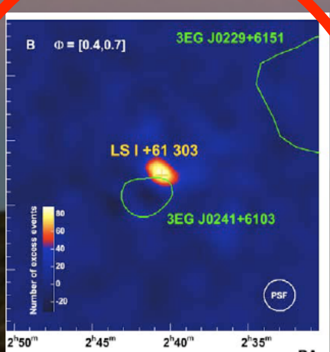
Crab Nebula/
Crab pulsar



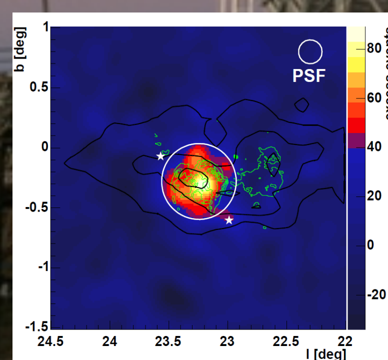

J2032+4130



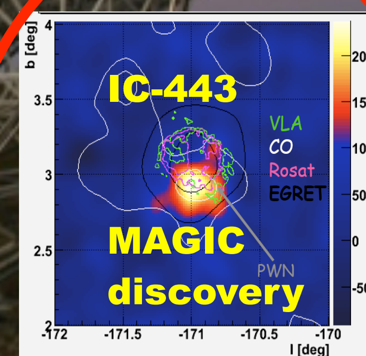
Caseopeia A




LSI+61 303 Binary
Discovered by MAGIC

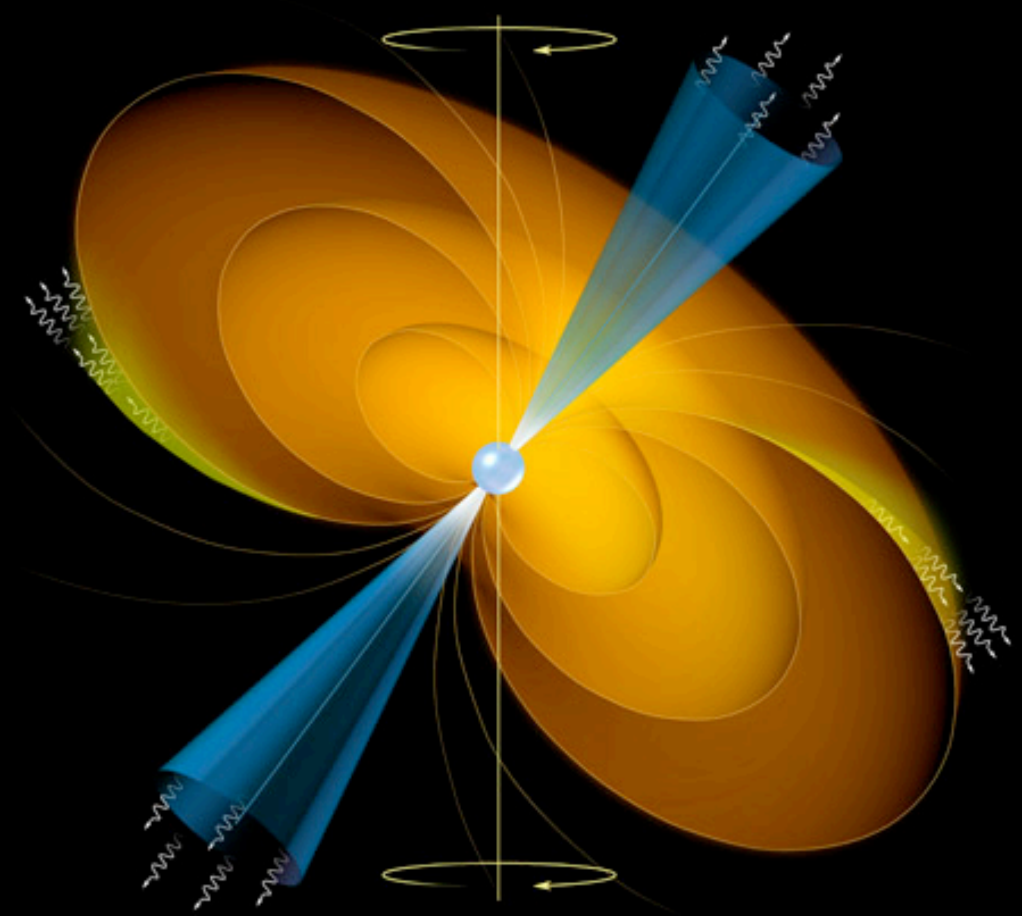


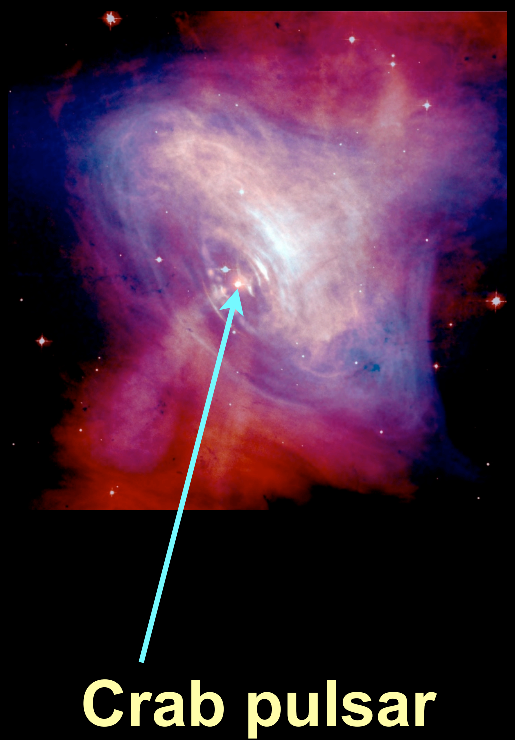

HESS J1834
$^{13}$CO cloud




Confirmed by Veritas !

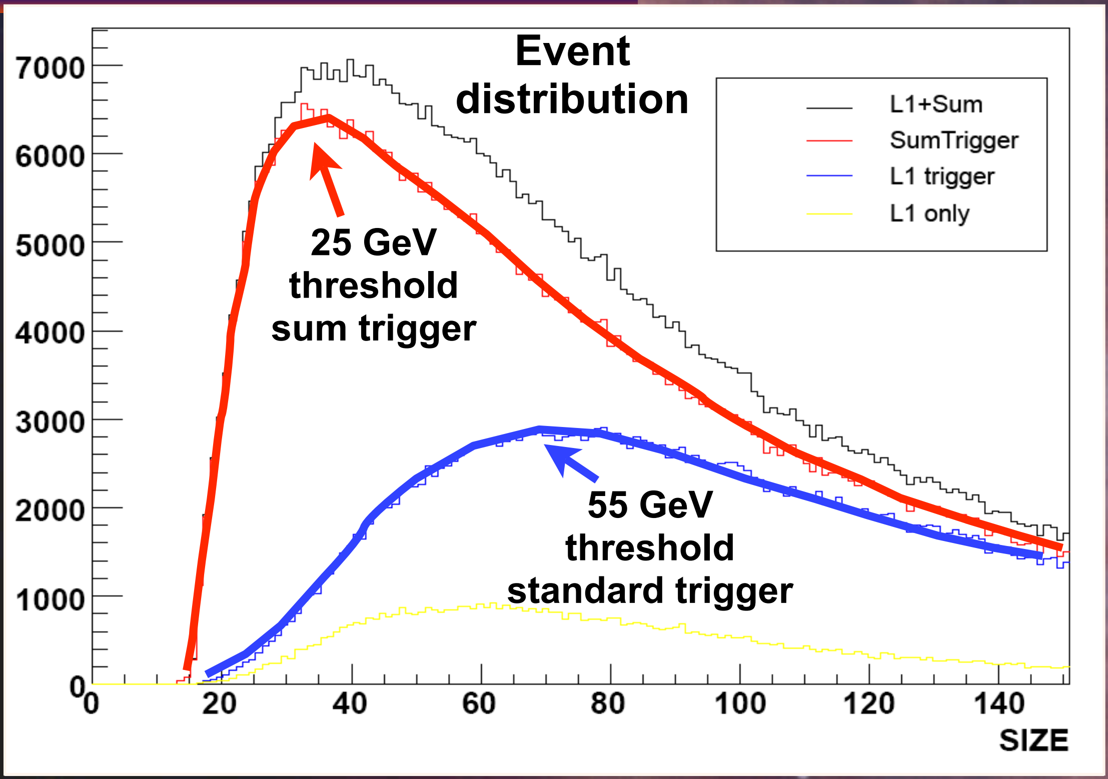
# Pulsar observations with MAGIC

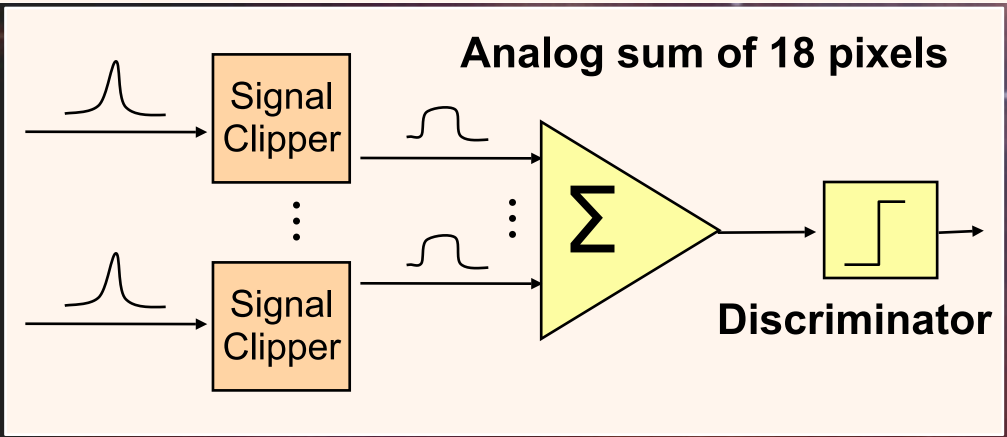


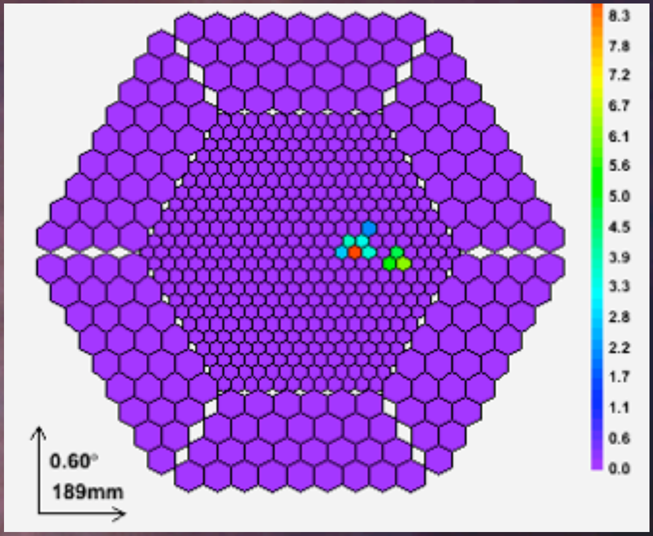


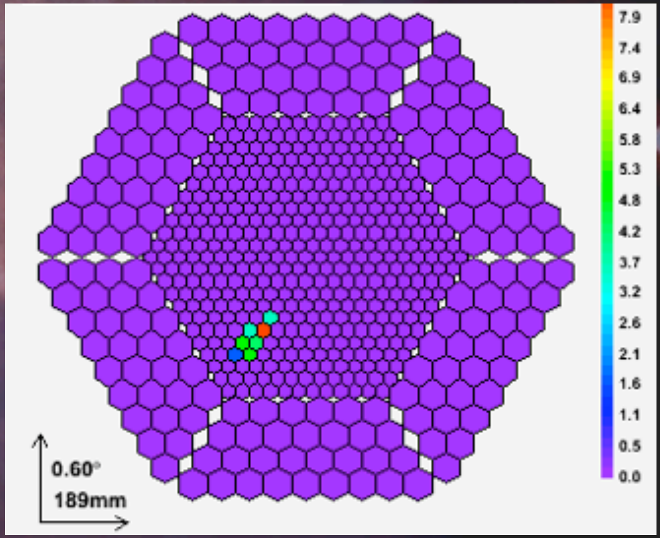

- Huge magnetic field of $10^8$T
- Absorption of gamma rays through magnetic pair production
- Polar cap model, outer gap model & slot gap model

# New Sum trigger
# --> Lower trigger threshold 25 GeV !!



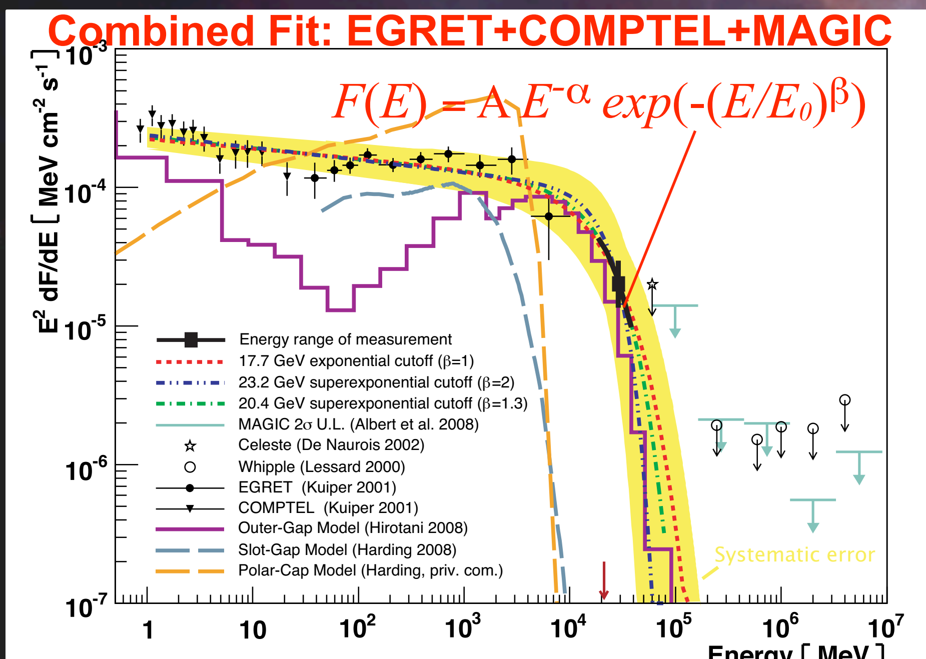




- Examples of 25 GeV showers

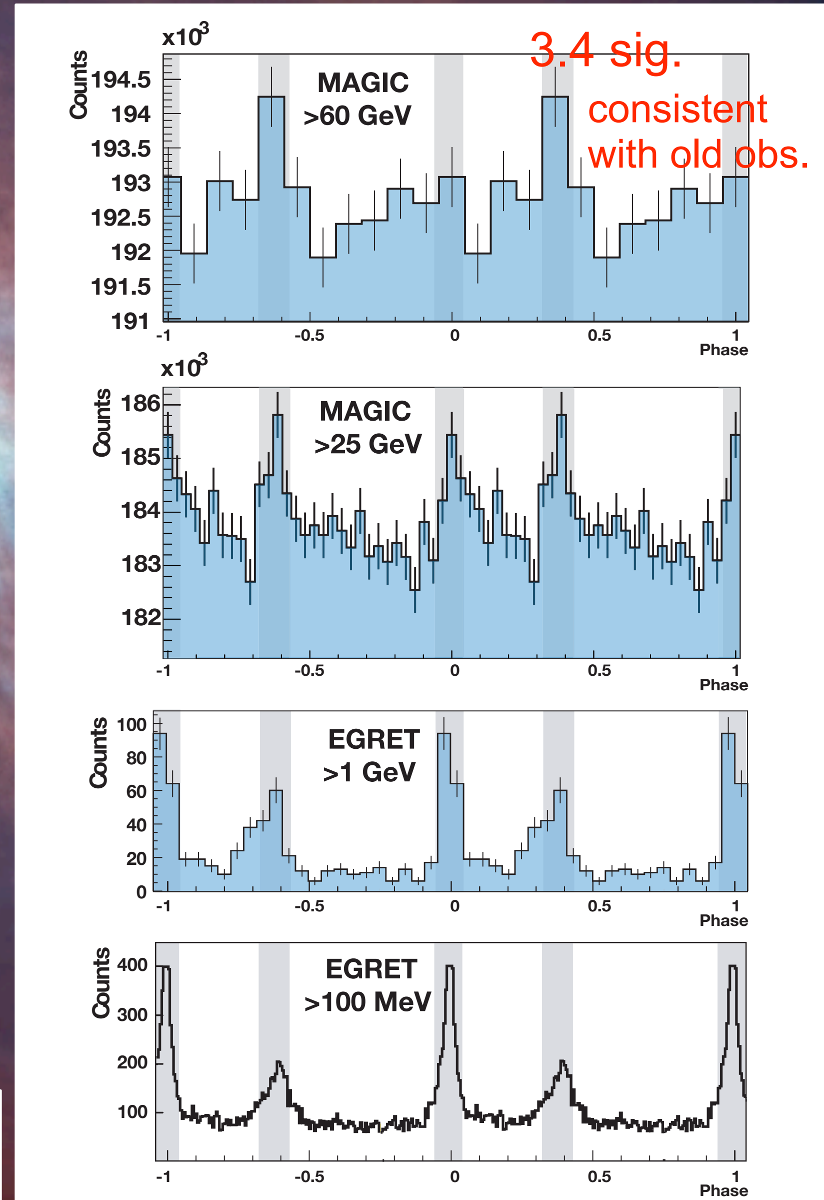
# Detection of the Crab pulsar above 25 GeV at 6.4 sigma !

- Crab observation from October 2007 until Febrary 2007: 22.3h good hours/40 hours: 8500+-1330 Excess events
- Pulses in phase with EGRET
- P1 = P2 !! at 25 GeV




$E0=17.7 \pm 2.8_{stat} \pm 5.0_{syst}$ GeV for $\beta = 1$ (exp.)

$E0=23.2 \pm 2.9_{stat} \pm 6.6_{syst}$ GeV for $\beta = 2$ (super-exp.)



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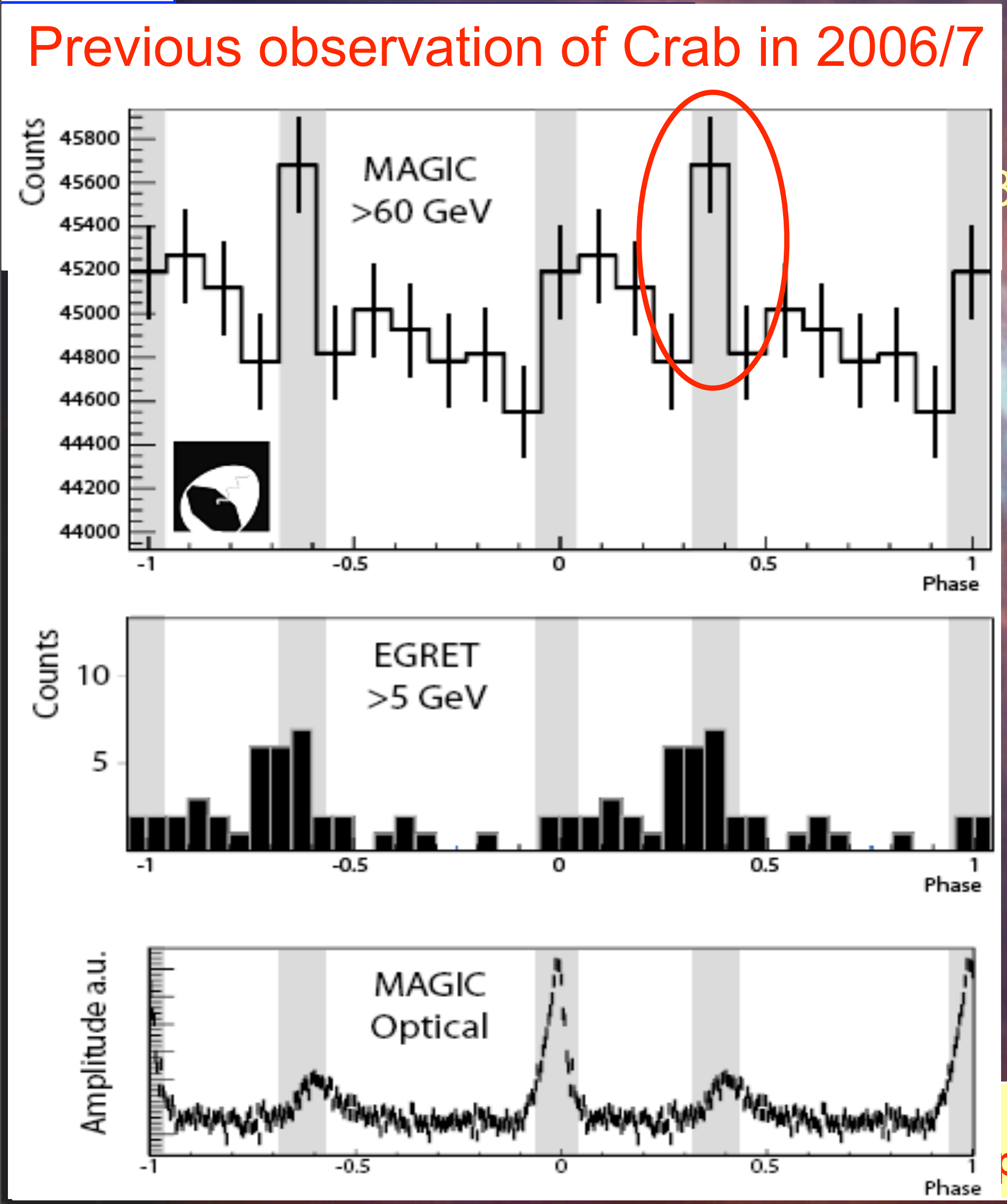


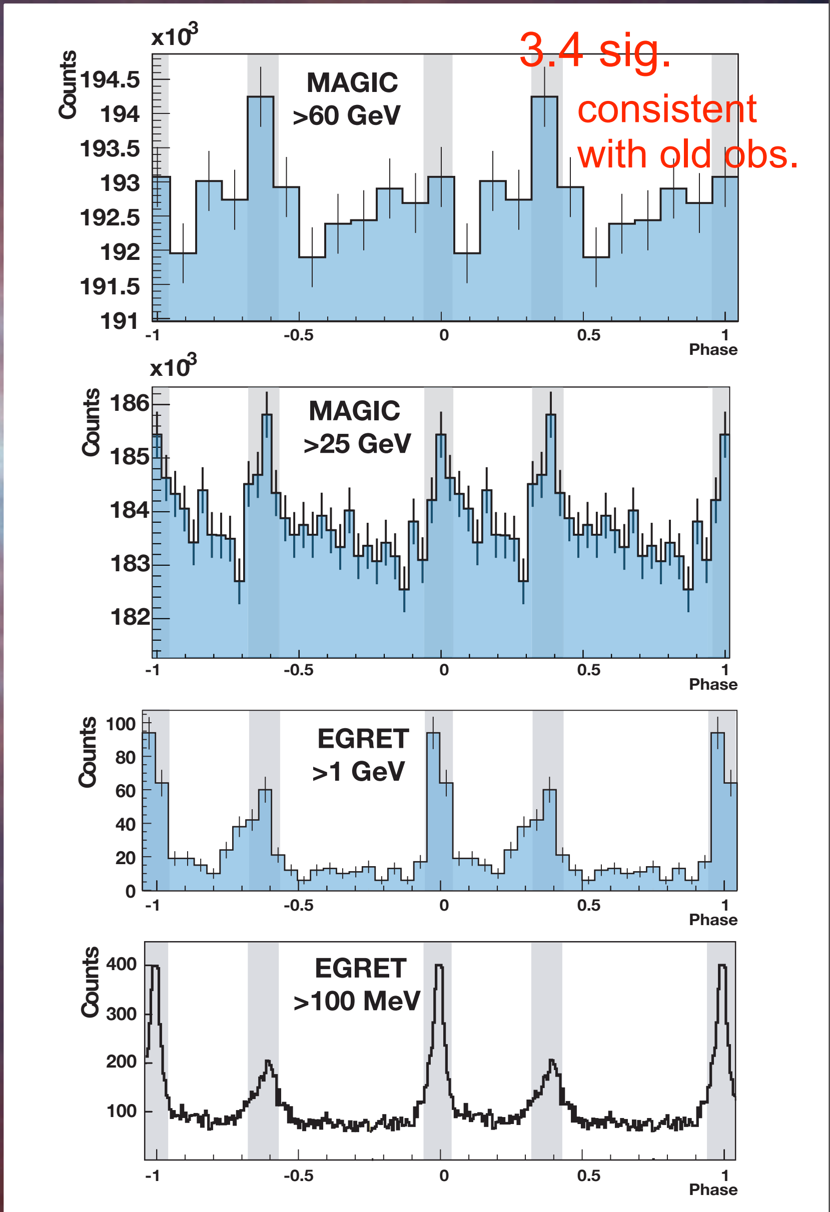

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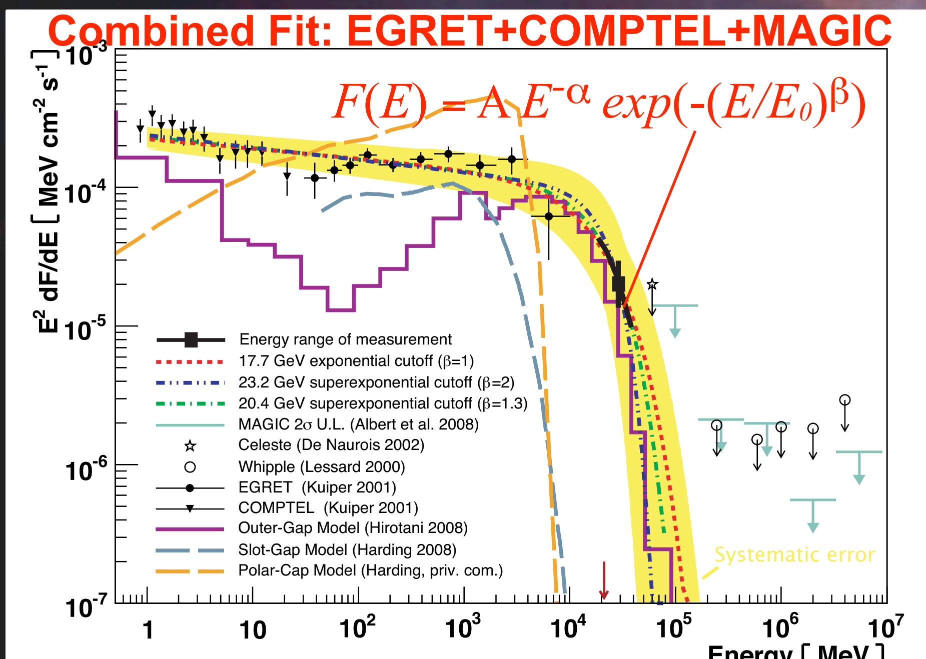
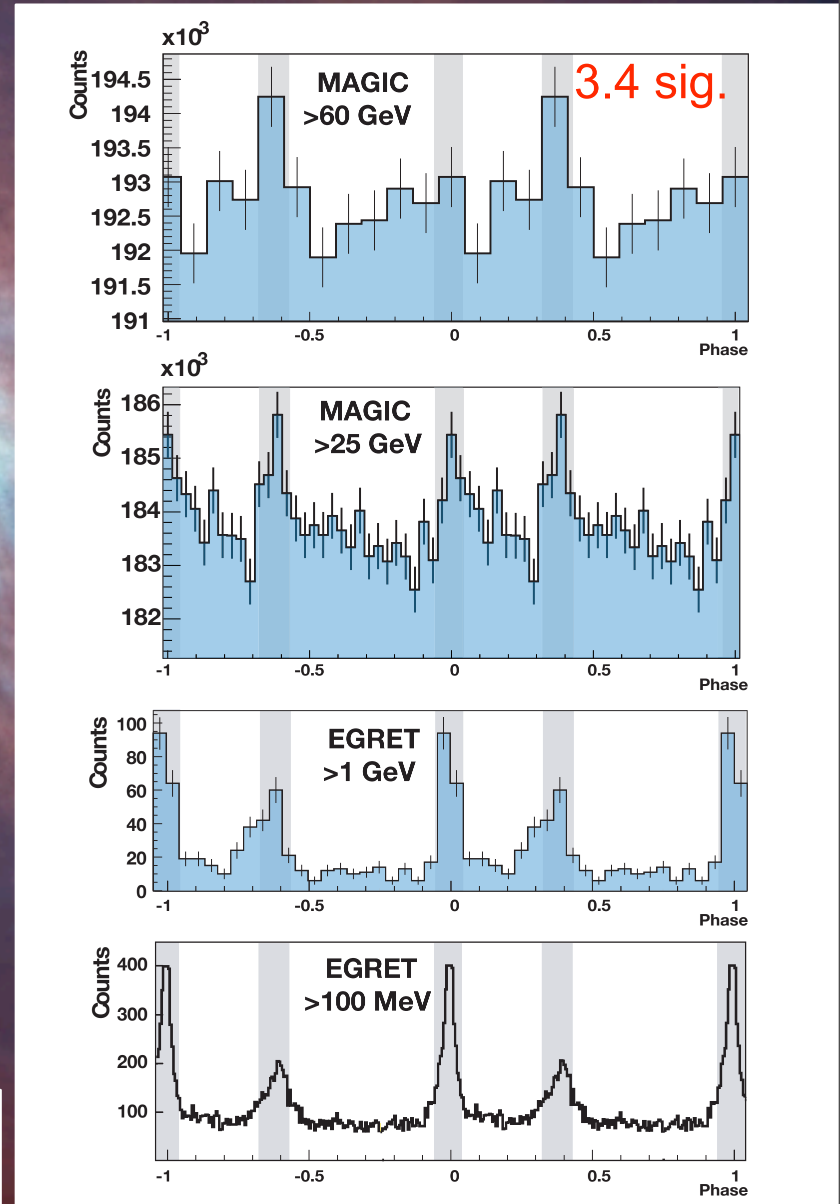


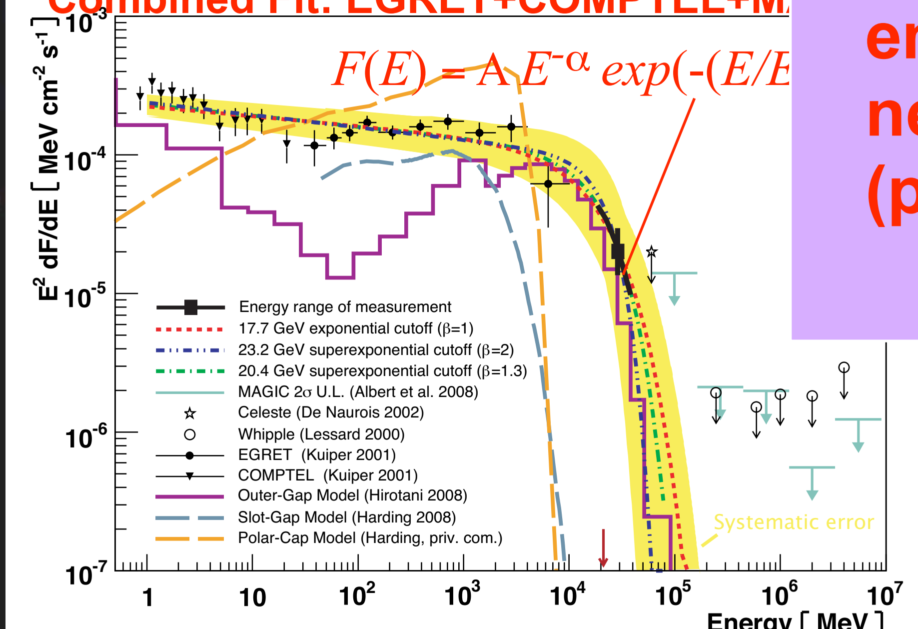



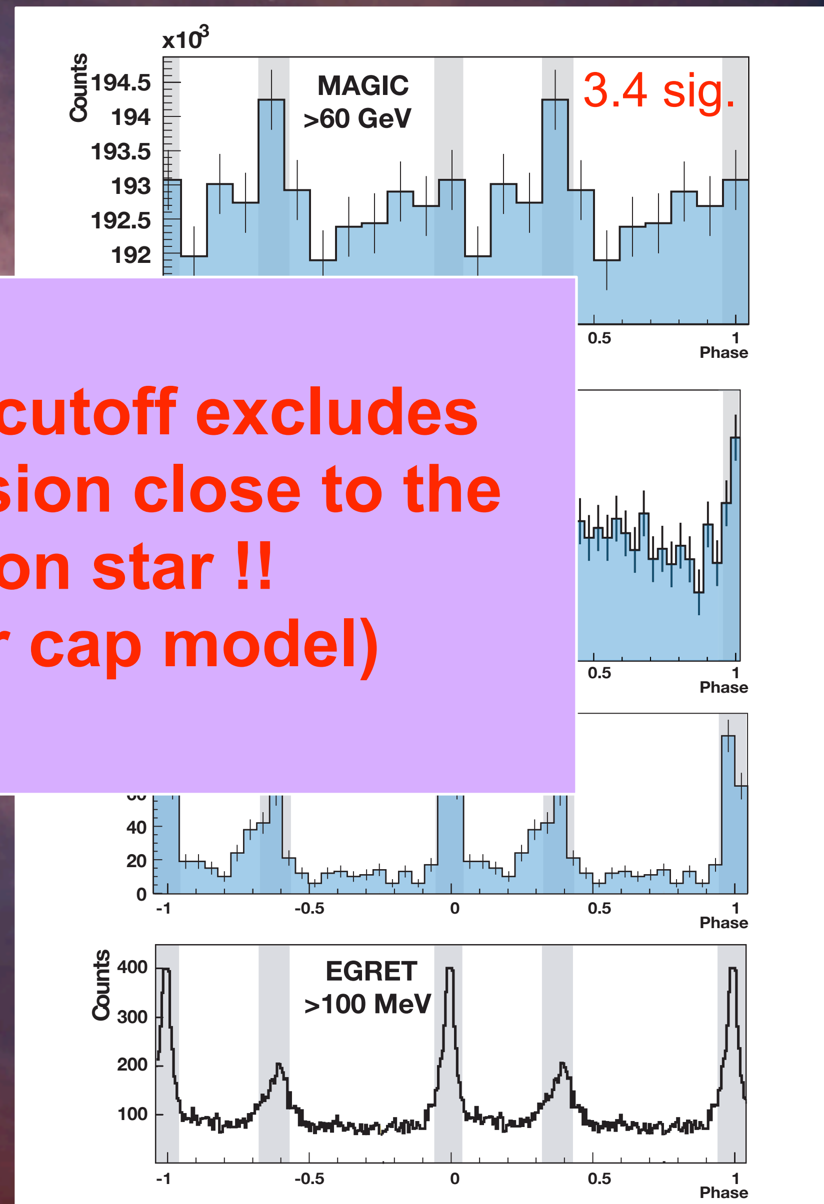

**$E_0 = 17.7 \pm 2.8_{stat} \pm 5.0_{syst}$ GeV for $\beta = 1$ (exp.)**
**$E_0 = 23.2 \pm 2.9_{stat} \pm 6.6_{syst}$ GeV for $\beta = 2$ (super-exp.)**

# Detection of the Crab pulsar above 25 GeV at 6.4 sigma !

- Crab observation from October 2007 until Febrary 2007: 22.3h good hours/40 hours: 8500+-1330 Excess events
- Pulses in phase with EGRET
- P1 = P2 !! at 25 GeV

Combined Fit: EGRET+COMPTEL+M...



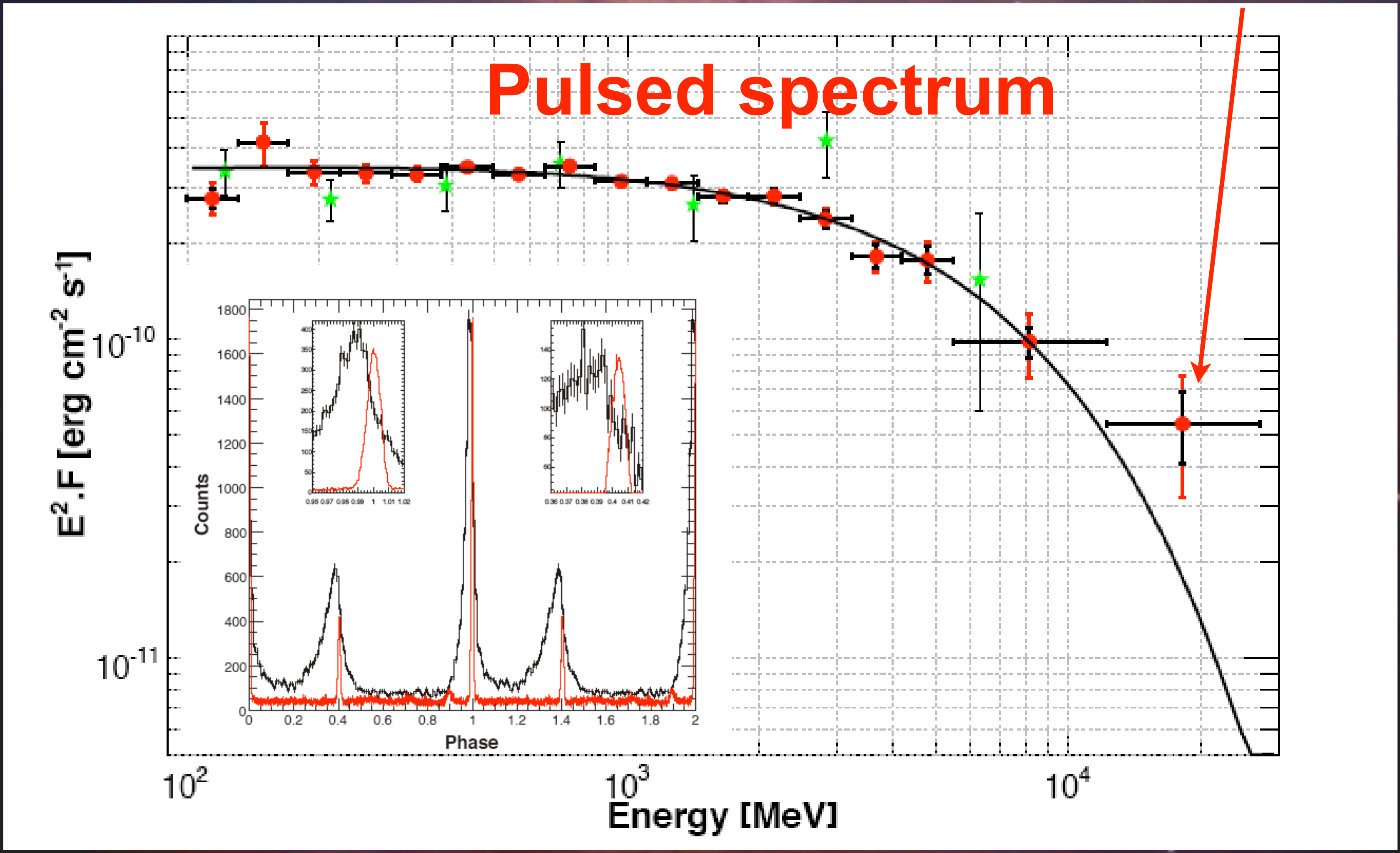




**High cutoff excludes emission close to the neutron star !!**
**(polar cap model)**

**$E0=17.7 \pm 2.8_{stat} \pm 5.0_{syst}$ GeV for $\beta = 1$ (exp.)**
**$E0=23.2 \pm 2.9_{stat} \pm 6.6_{syst}$ GeV for $\beta = 2$ (super-exp.)**

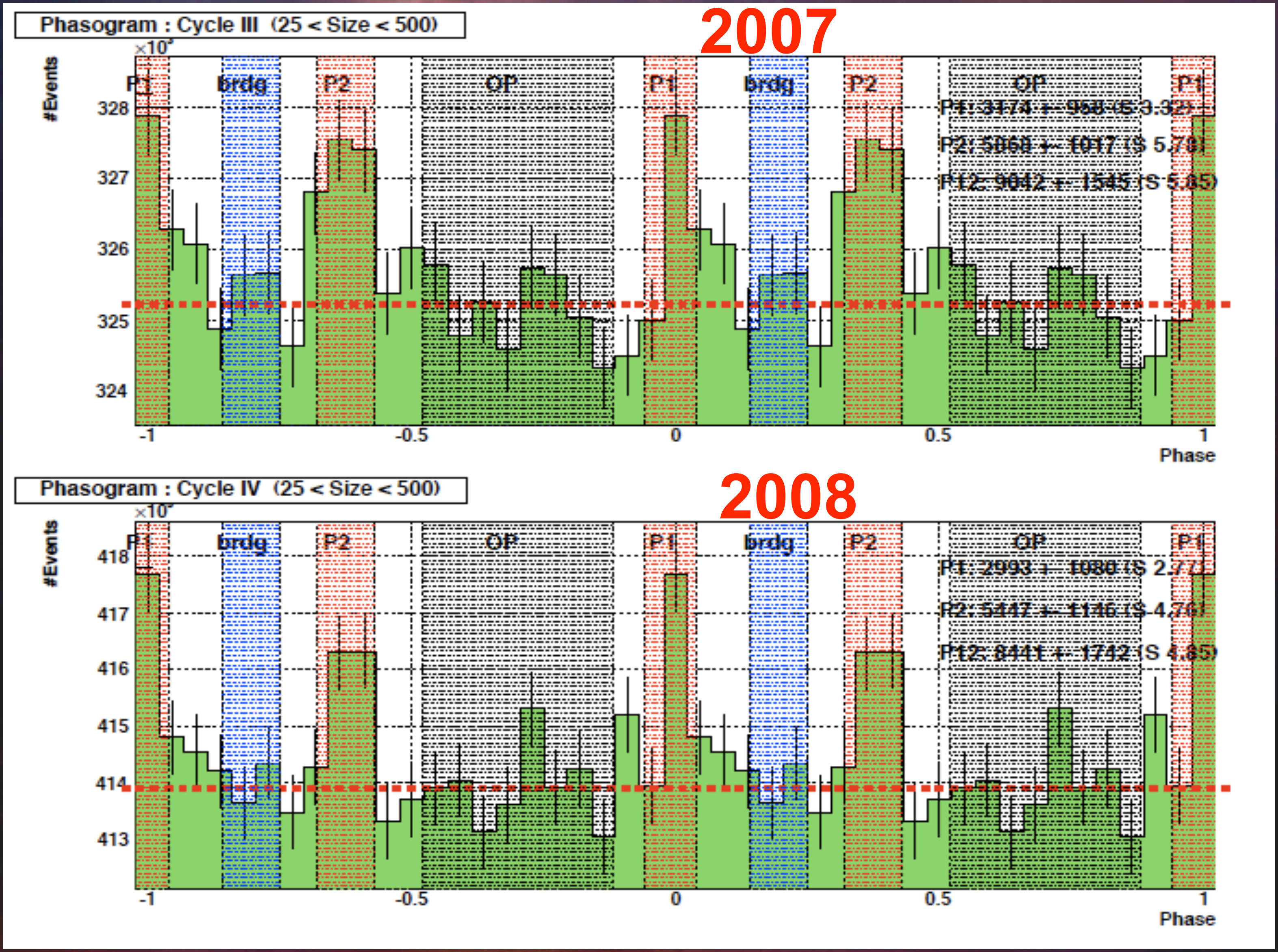
# Fermi observation of Crab pulsar

- Exponential cutoff at $E_c$ = (5.8 ± 0.5 ± 1.2 GeV) (neglecting the last point)

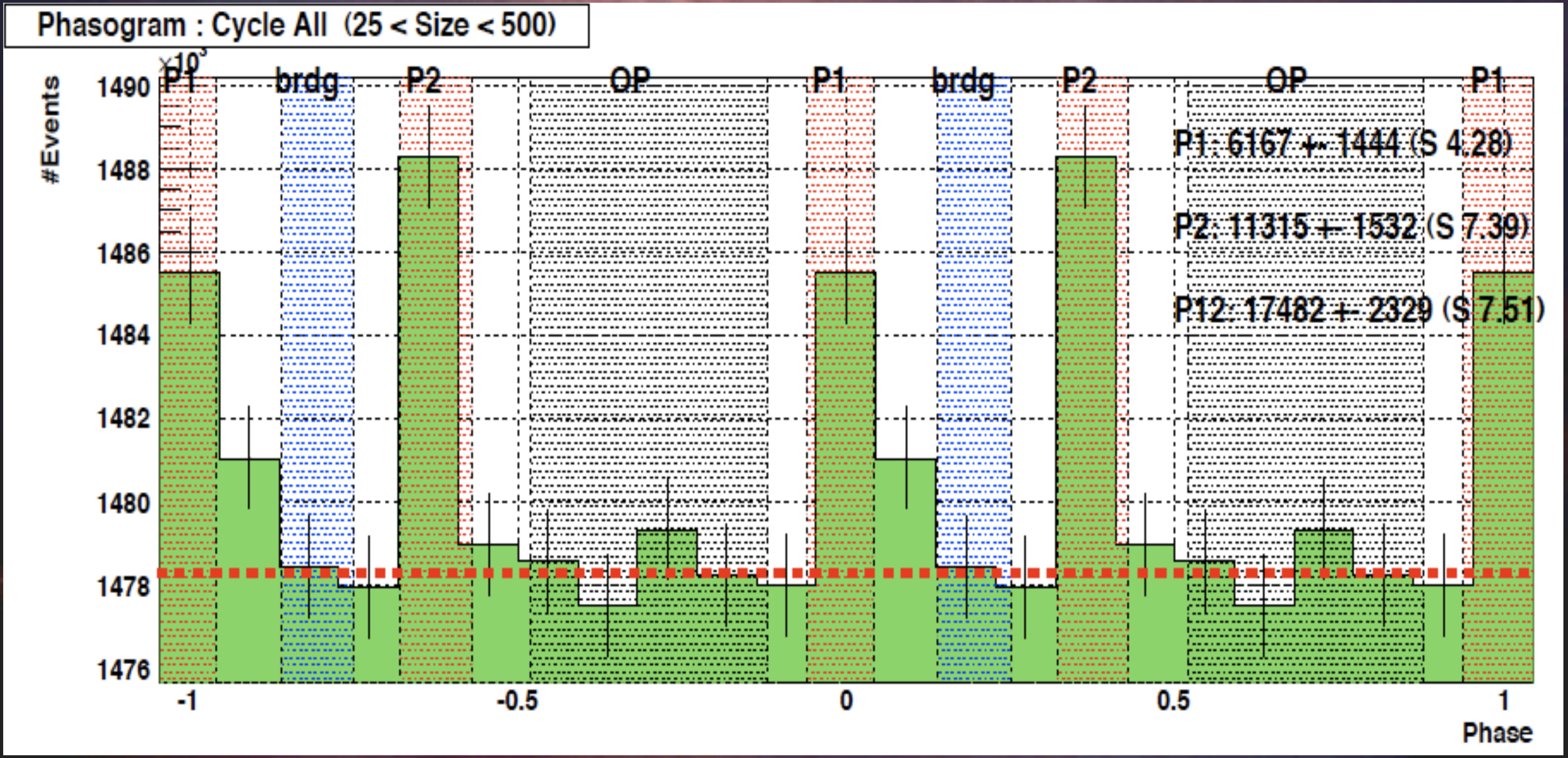


# MAGIC follow-up observations 2008

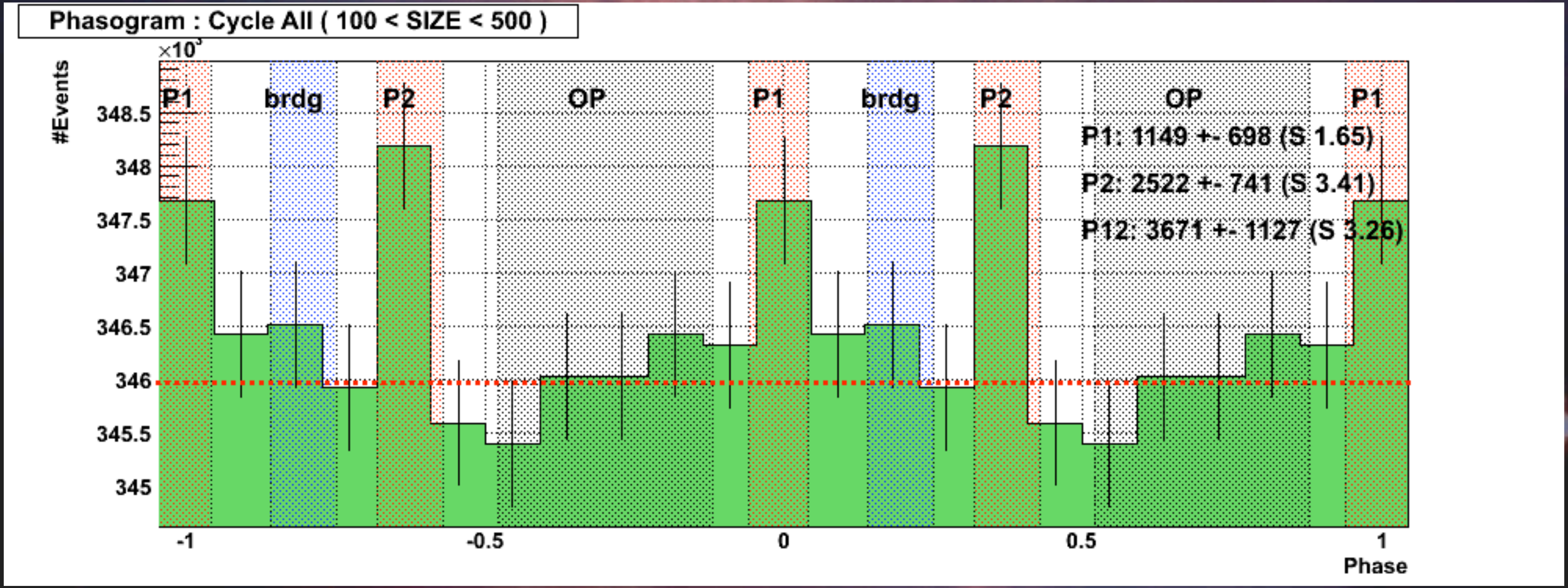
(work of Takayuki Saito)



# All data: 7.5 Sigma above 25 GeV

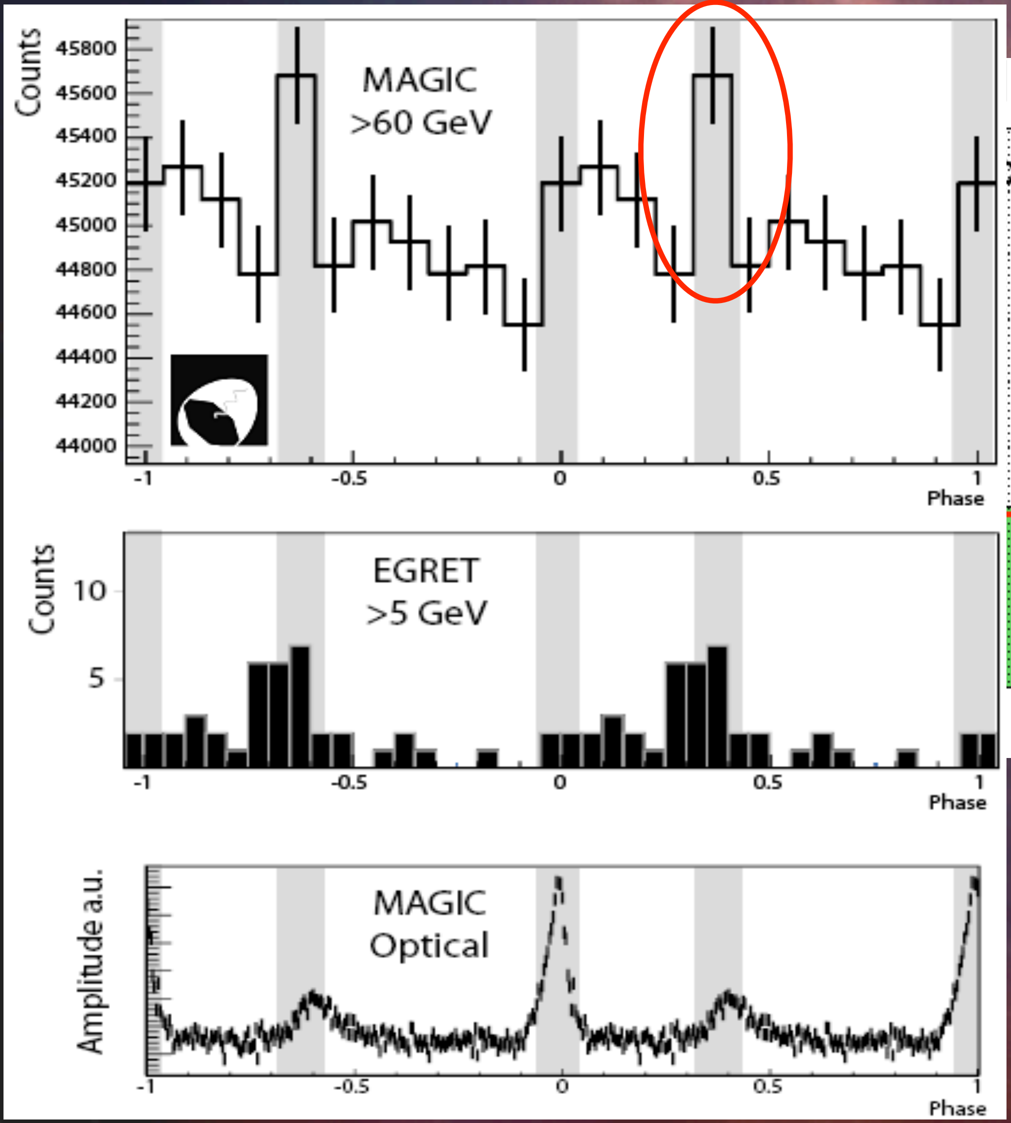


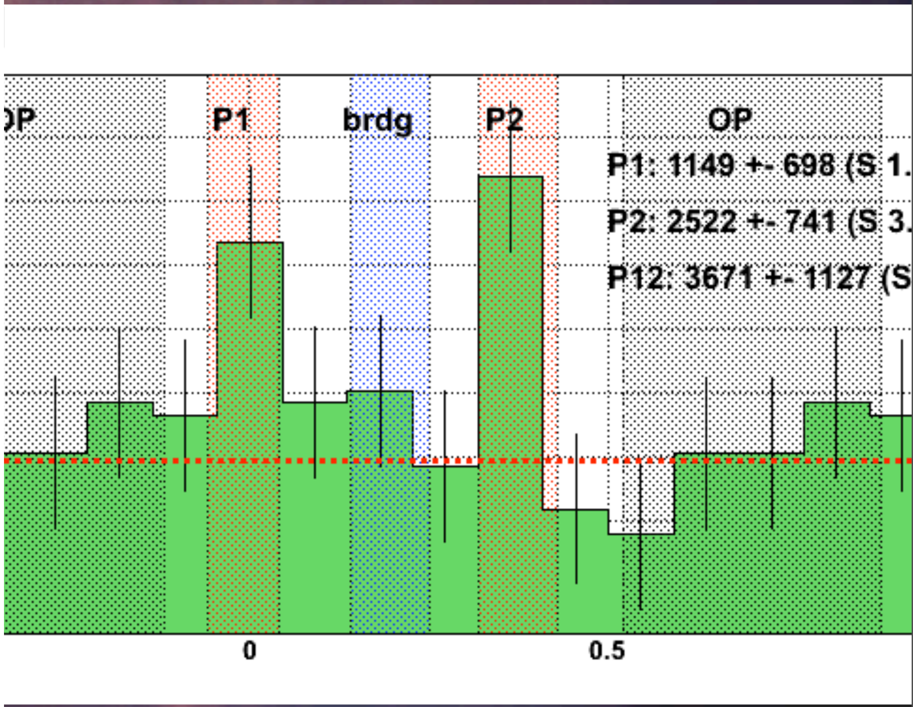
# Emission above 60 GeV ?



# Emission above 60 GeV ?

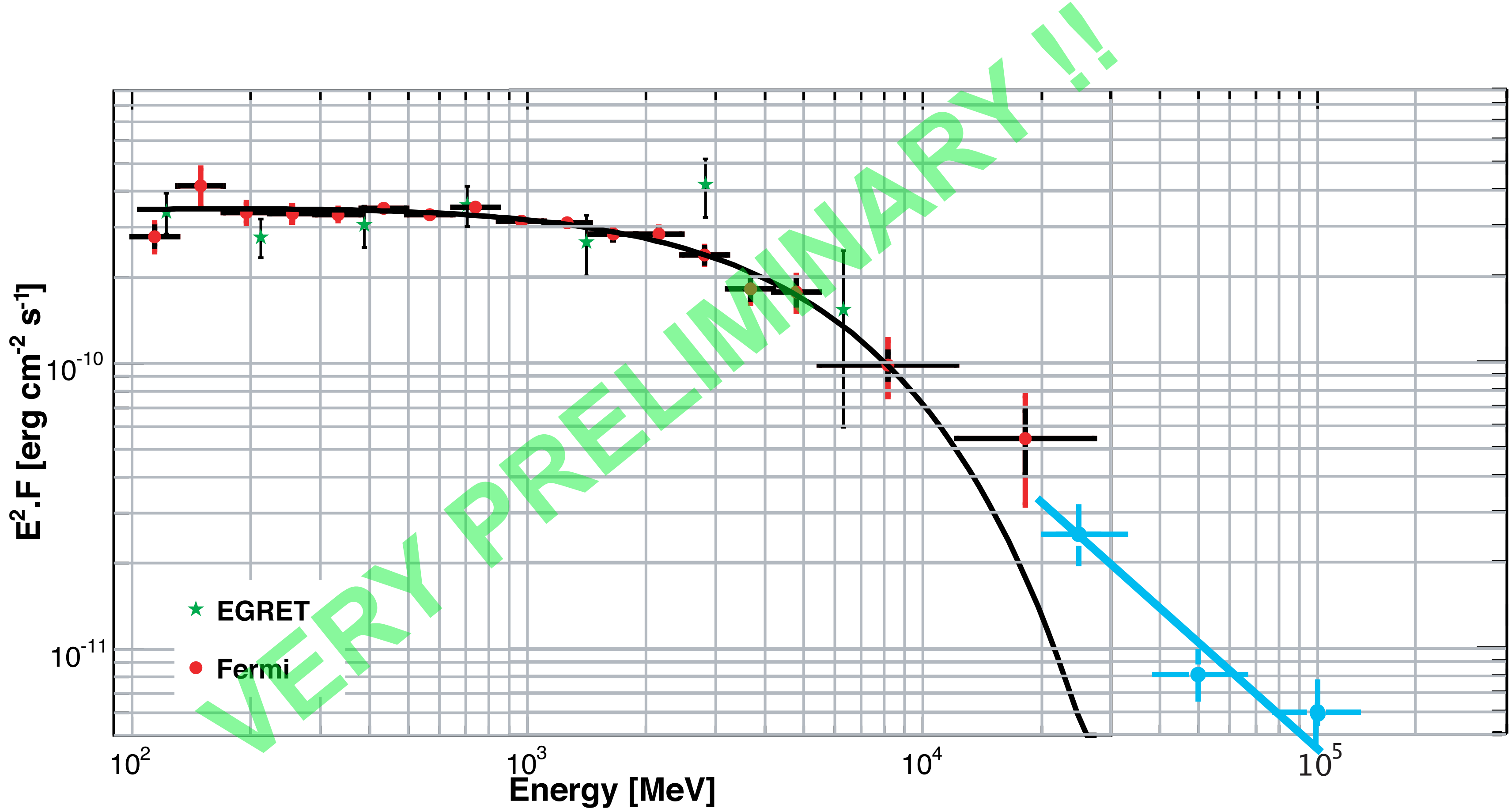
Previous observation of Crab in 2006/7



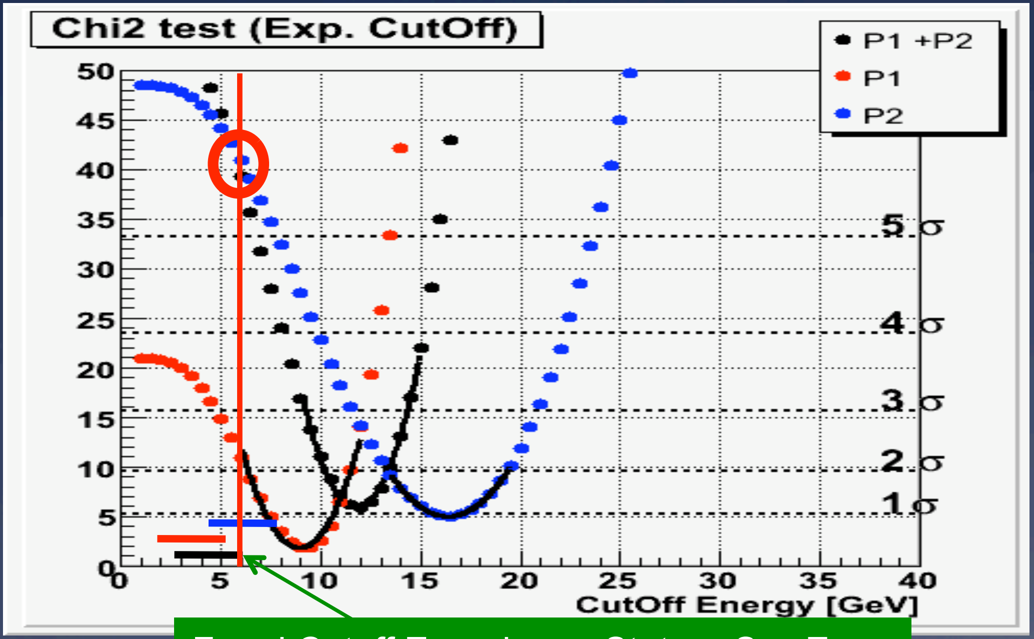



# MAGIC Crab pulsar spectrum

## (work of Takayuki Saito)



# Is MAGIC excess consistent with Exponential Cutoff?

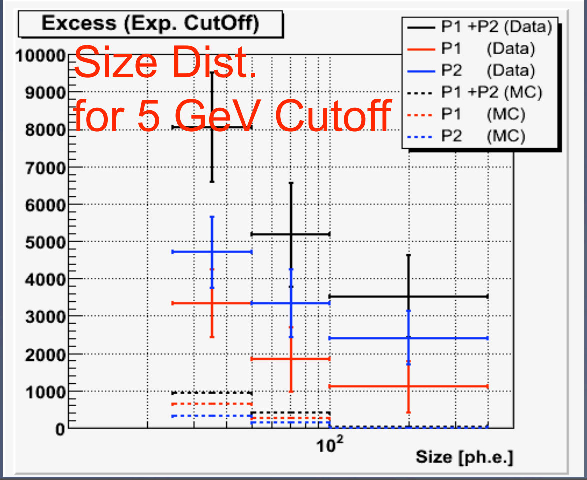


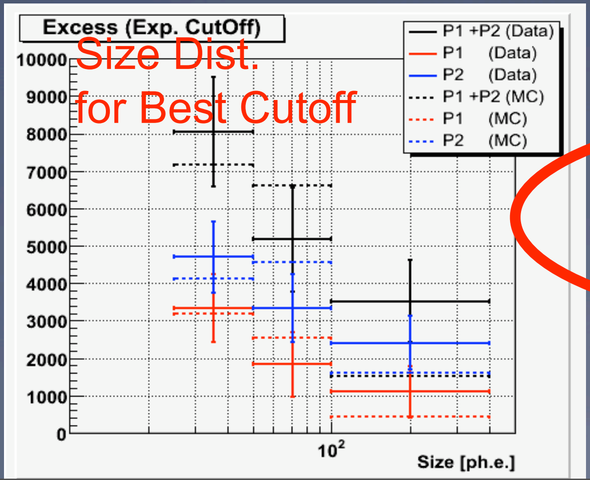

Fermi Cutoff Energies +- Stat. +- Sys Error

Assuming the power law part of Fermi spectrum, scanning Cutoff Energy, the Size distribution is compared

Best Exponential Cutoff Energies

P12 (11.8 +- 0.82) GeV
P1 (8.9 +- 0.92) GeV
P2 (16.4 +- 1.4) GeV

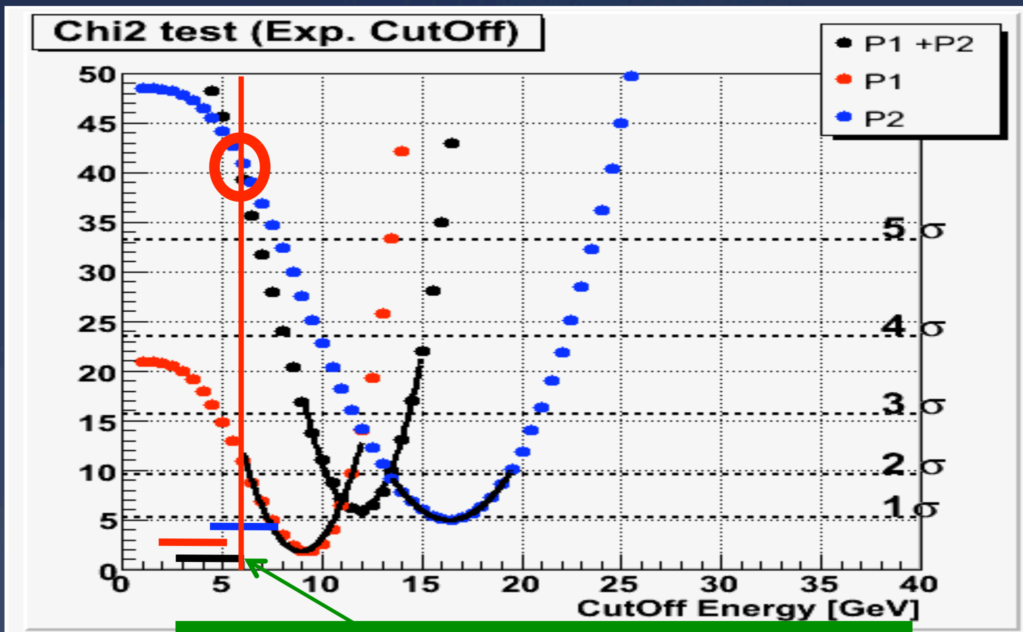



Expoential cutoff spectra fitting to Fermi data are not consistent with MAGIC!! by > 5 sigma

Super Exponential Cutoff is already ruled out by Fermi Data

# Is MAGIC excess consistent with Exponential Cutoff?




Fermi Cutoff Energies ± Stat. ± Sys Error

Assuming the power law part of Fermi spectrum, scanning Cutoff Energy, the Size distribution is compared

Best Exponential Cutoff Energies

P12 (11.8 +- 0.82) GeV
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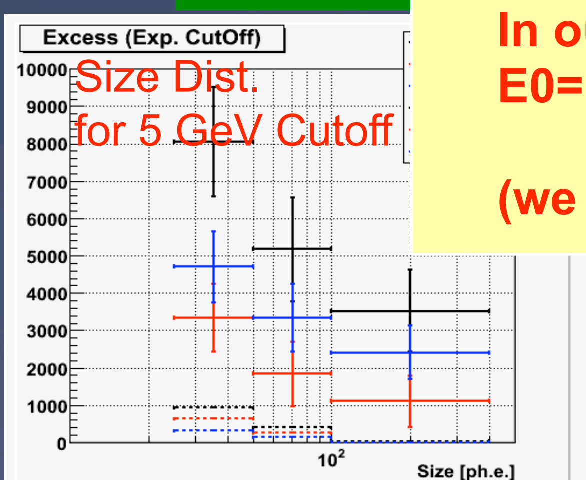
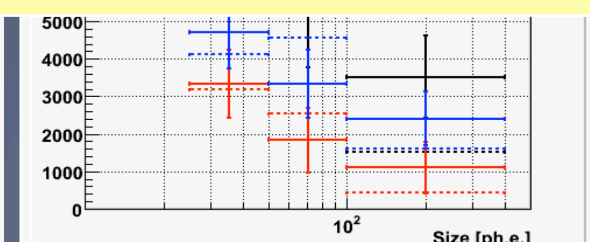



**In our publication:**
**$E0 = 17.7 \pm 2.8_{stat} \pm 5.0_{syst}$ GeV for $\beta = 1$ (exp.)**

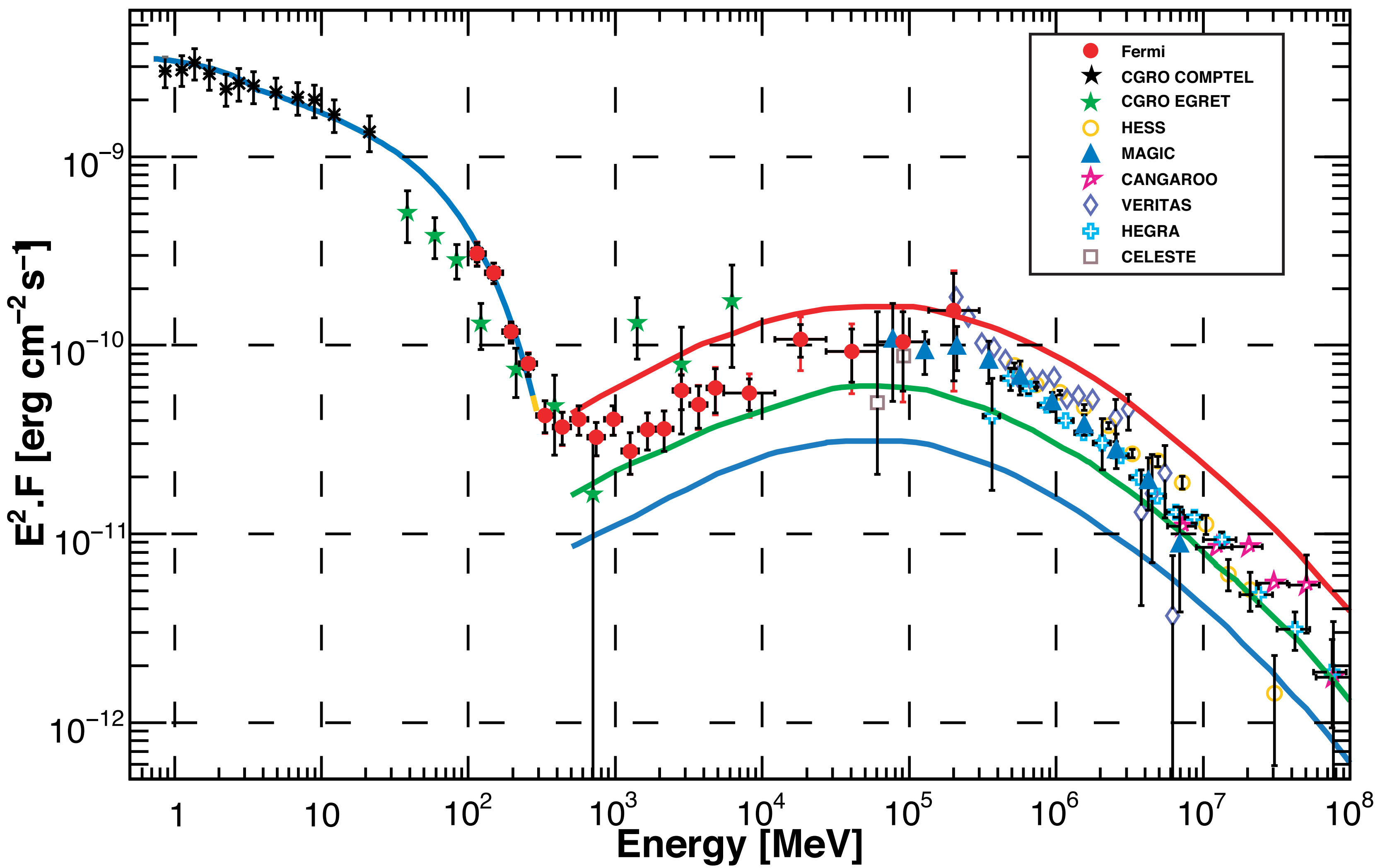
**(we used EGRET data first --> Fermi slightly different)**




...ng to
...t
with MAGIC!! by > 5 sigma

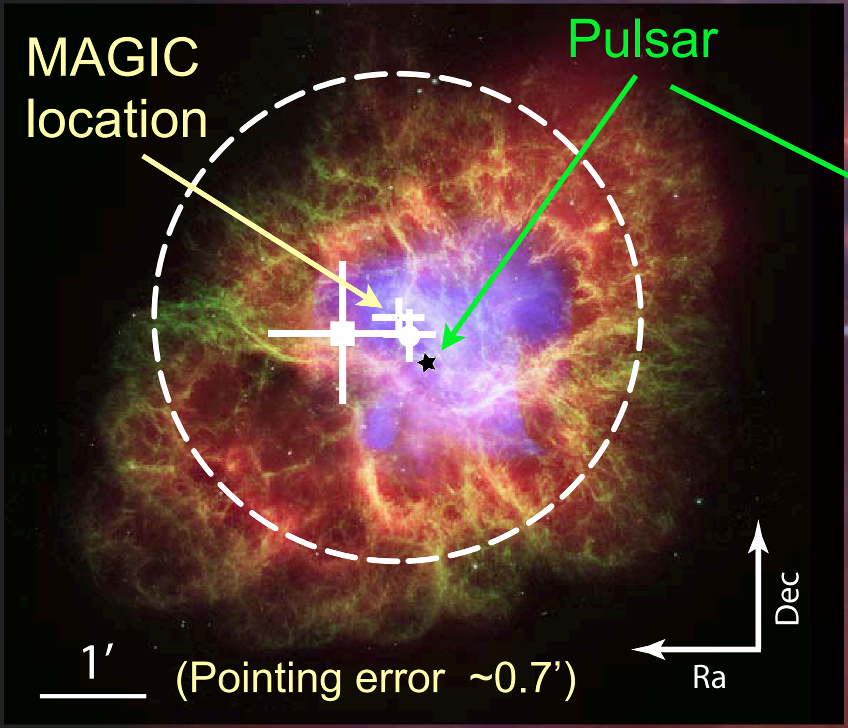
Super Exponential Cutoff is already ruled out by Fermi Data

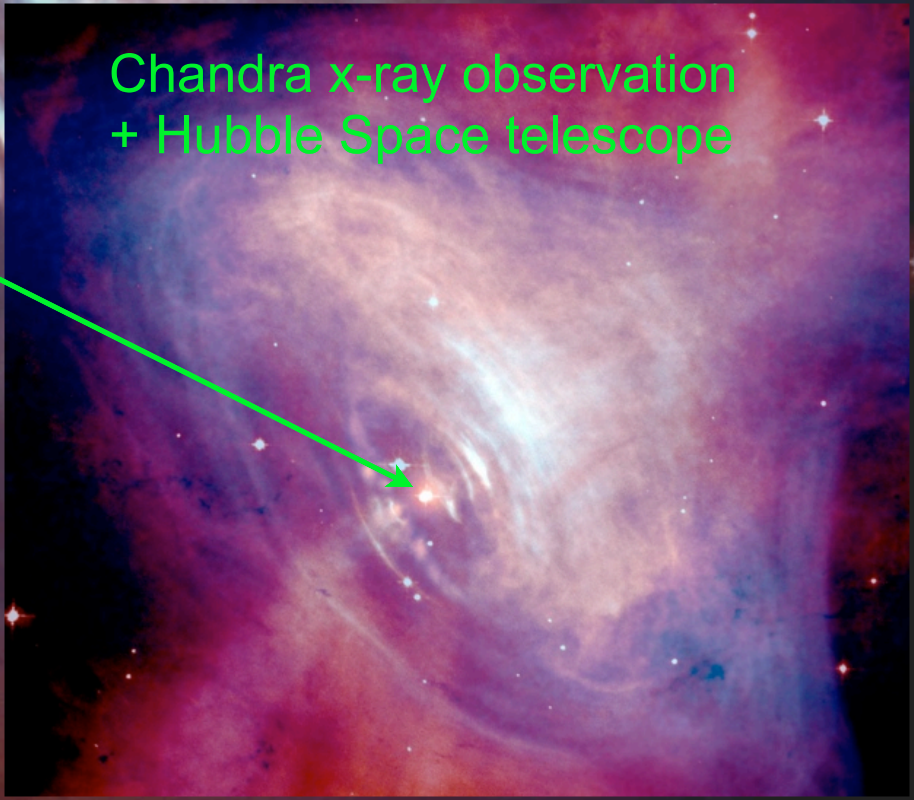
# Fermi Crab Nebula measurements



# What is the connection between pulsar and nebula ?

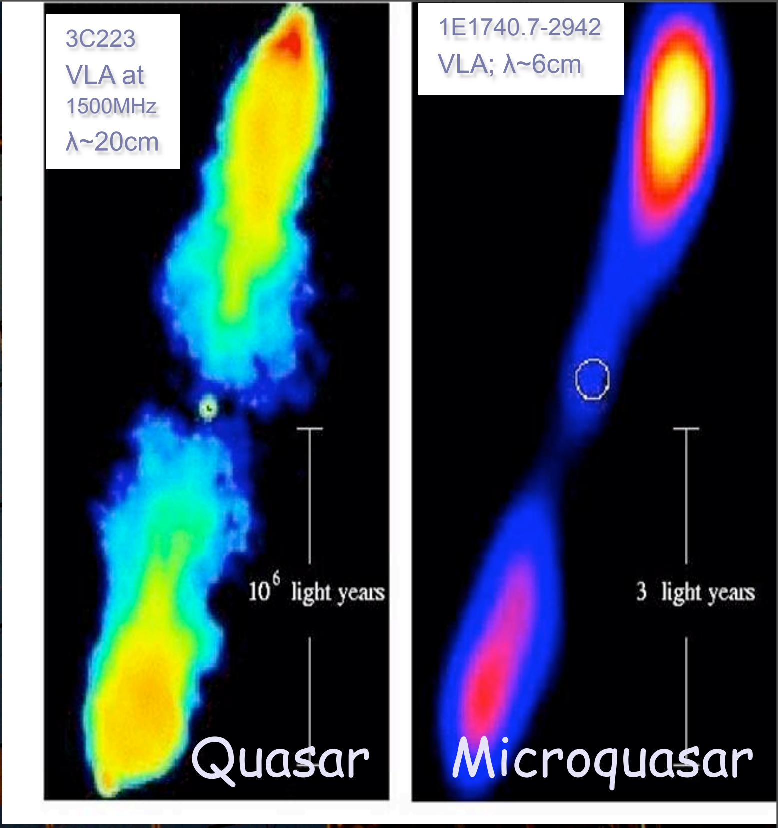
- Exact location of VHE gamma nebula emission ? Emission point-like!
- Variability in pulsar wind
- Pulsar spectrum variable ? Spectrum of nebula (slightly) variable ?
- Pulsar spectrum to high energies might give clues

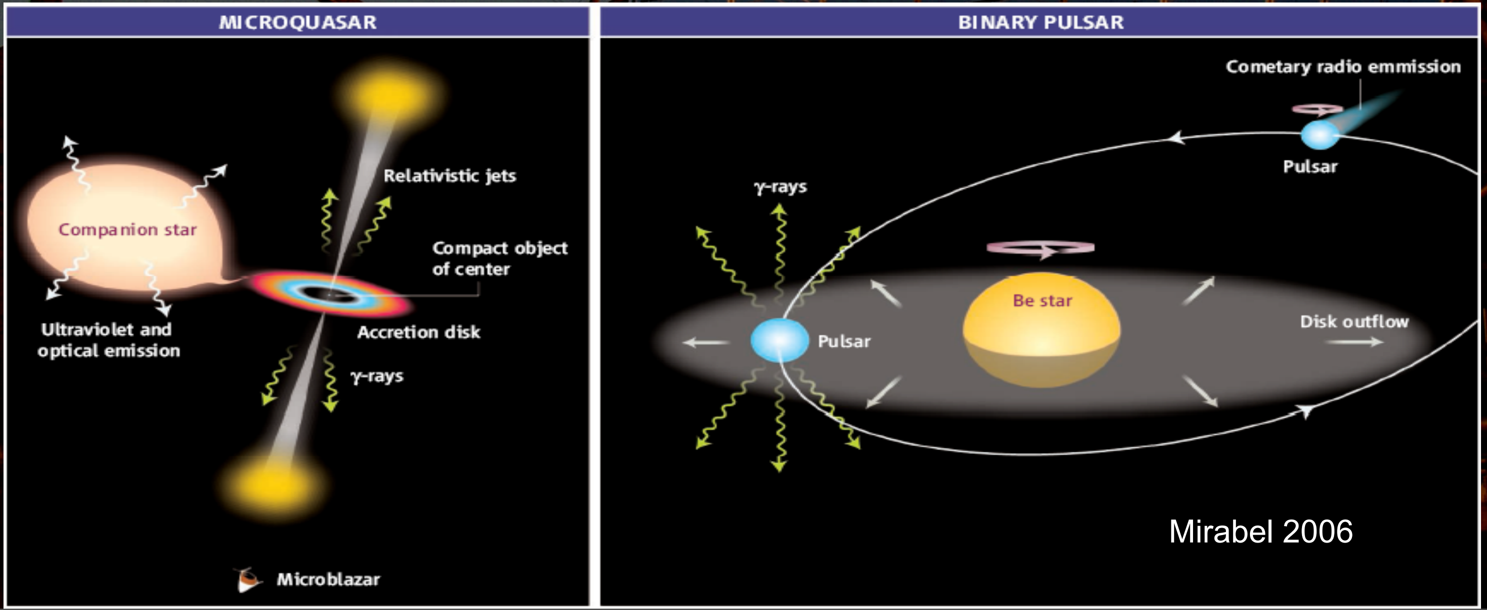


# X-ray binary system LS I +61 303

- Radio jet; 26.5 days orbital period;
- d ~2kpc;
- Companion star: Be star ~18M◎, with a circumstellar disc.
- Compact star: Black hole/neutron star < 4M◎
- High eccentric orbit (ε~0.7)

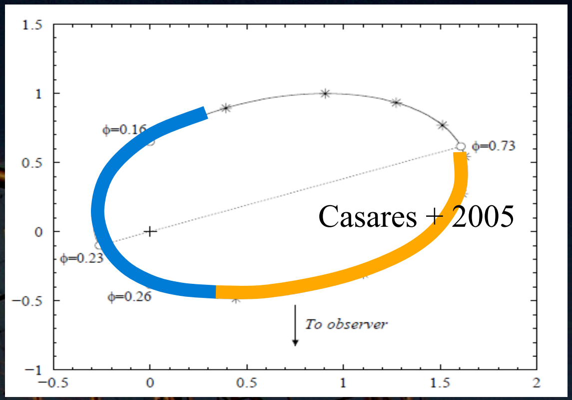


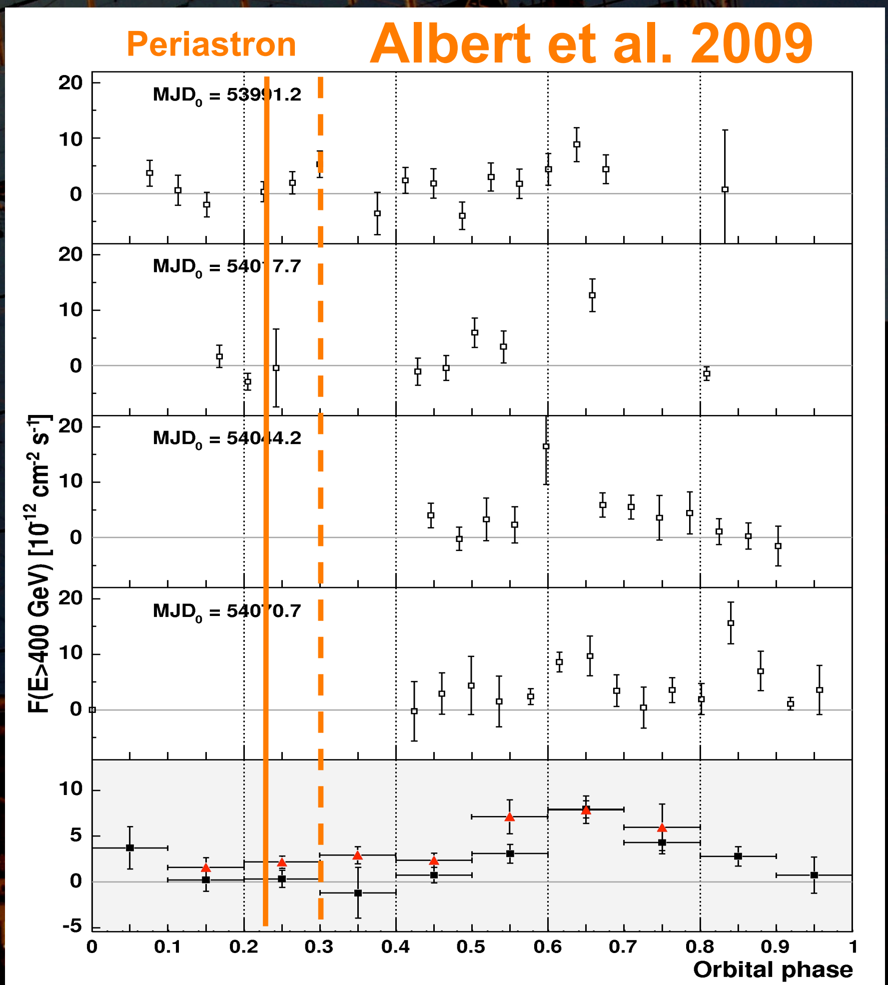

Mirabel 2006

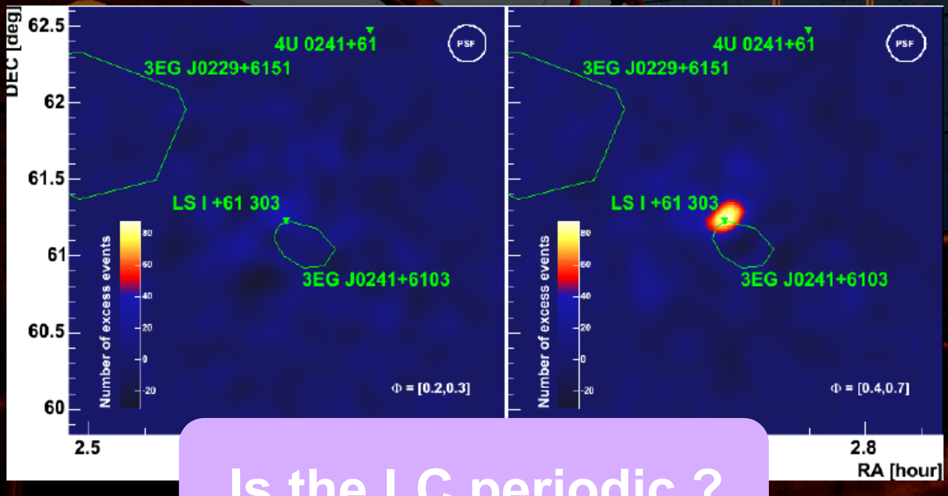
# LS I +61 303: Period 26.5d

## 166 h observation




- Gamma ray binary discovered by MAGIC
- Periodic emission in Optical, Radio and X-ray
- VHE emission strongly variable
- Quiet at periastron
- Highest emission at phase 0.6-0.7
- Second peak at 0.8-0.9
- VHE emission mechanism controversial




**Is the LC periodic ?**

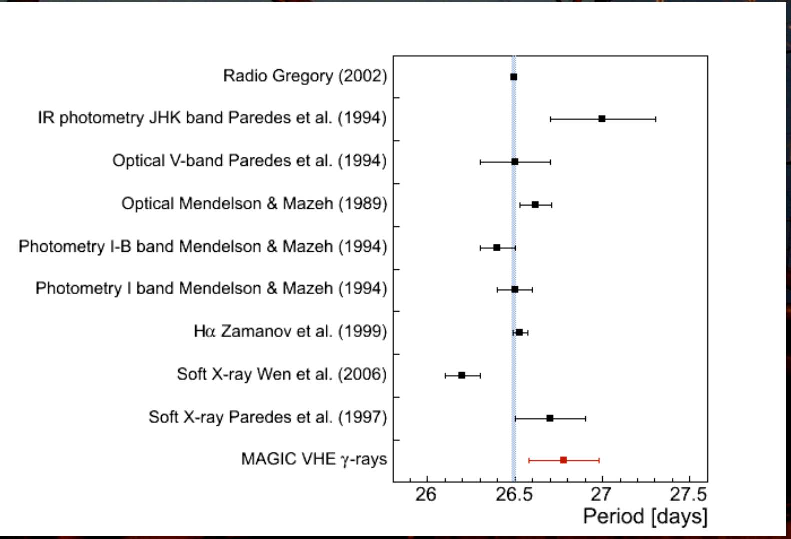
# MAGIC periodicity test

All data up to December 2006 tested with the Lomb Scargle method

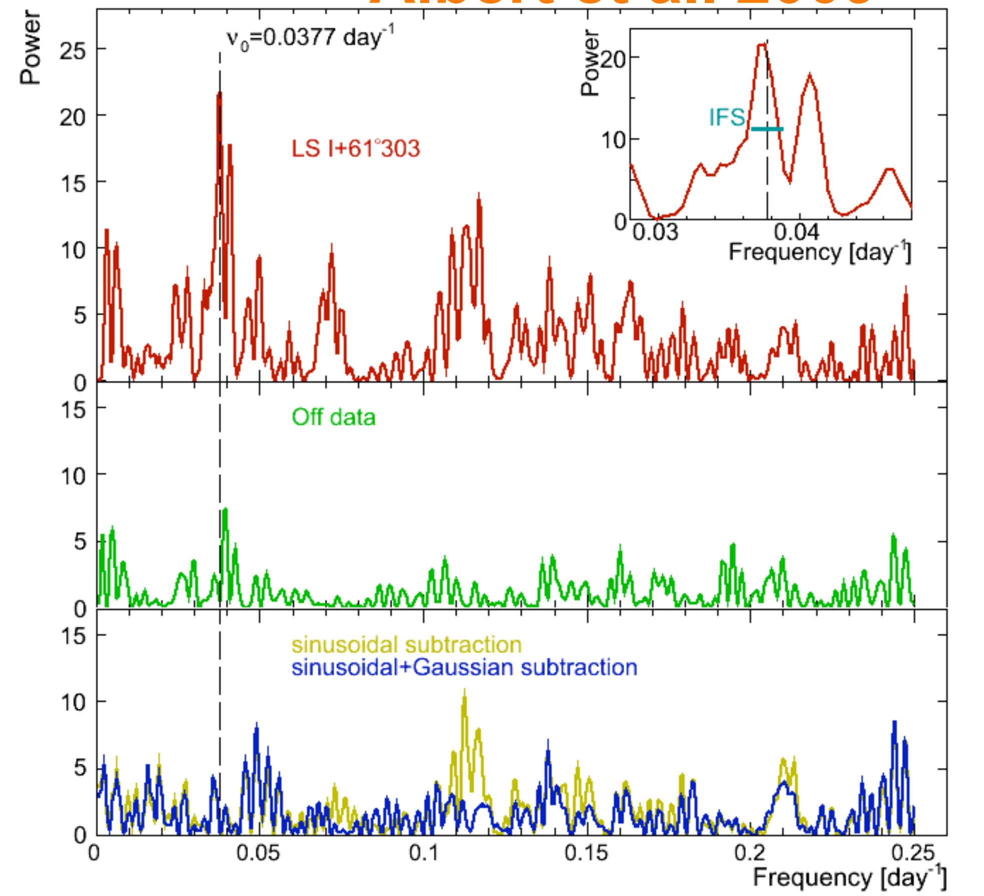
**Periodic in VHE**

**P = 26.8 ± 0.2 days**

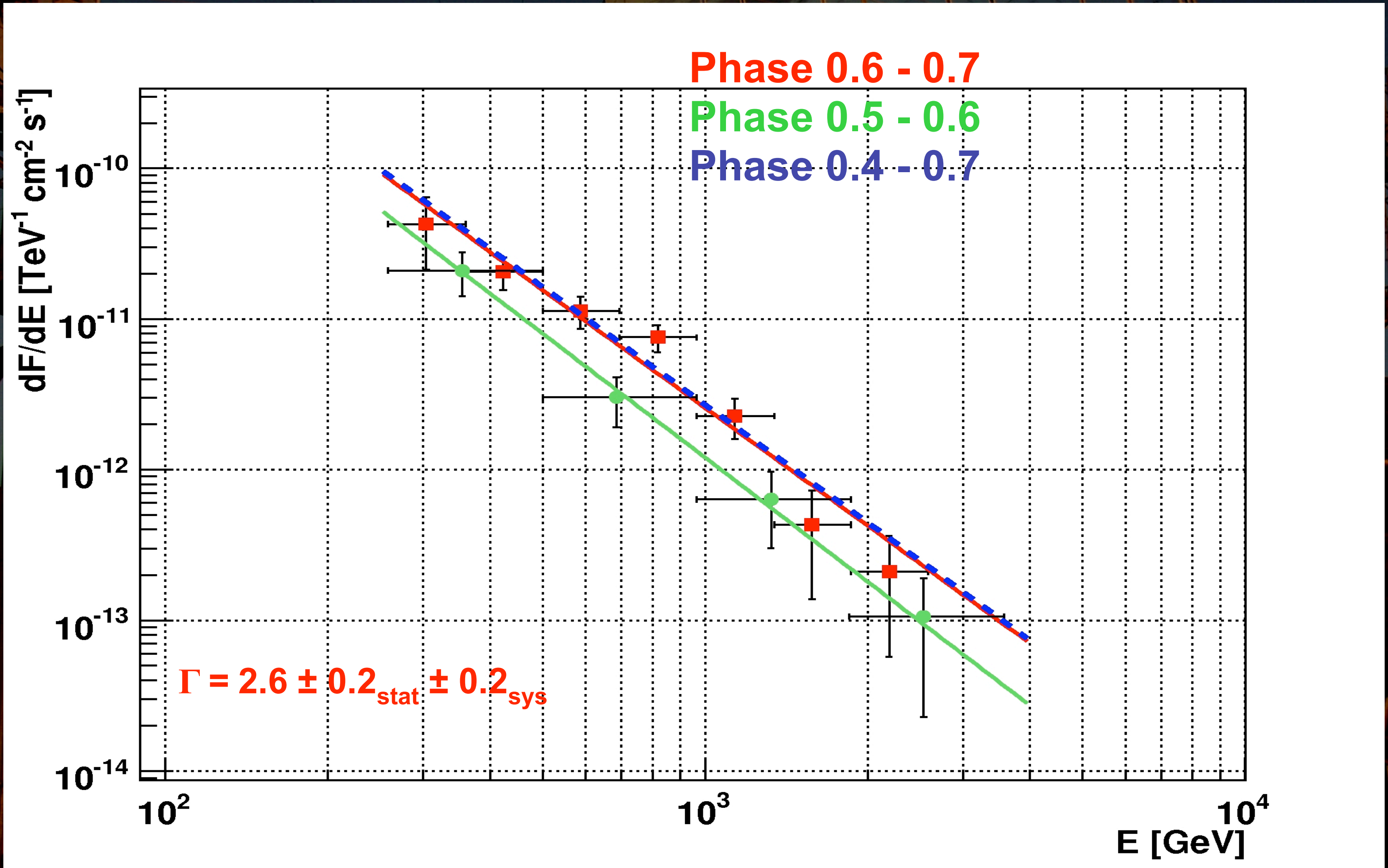
Same period in all energies




Albert et al. 2009

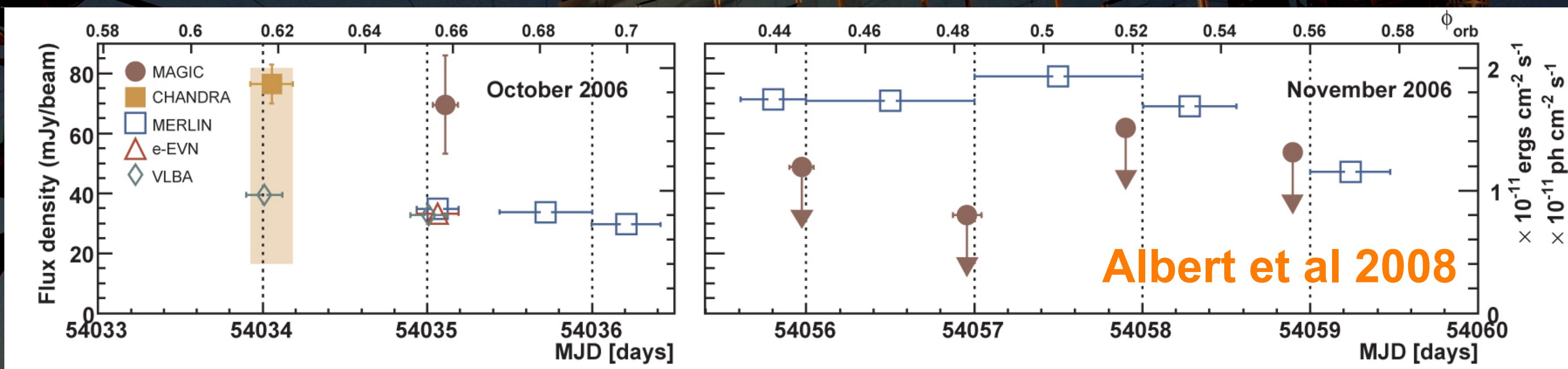


# Spectrum unchanged during phases



# γ-ray / radio correlation ?

MW campaign in Oct/ Nov 2006 involving radio, X-ray and VHE data




No direct correlation between radio and VHE gamma–ray emission !

Indication that different particle populations might be responsible for the radio emission on one side and for VHE gamma-ray emission on the other side ?

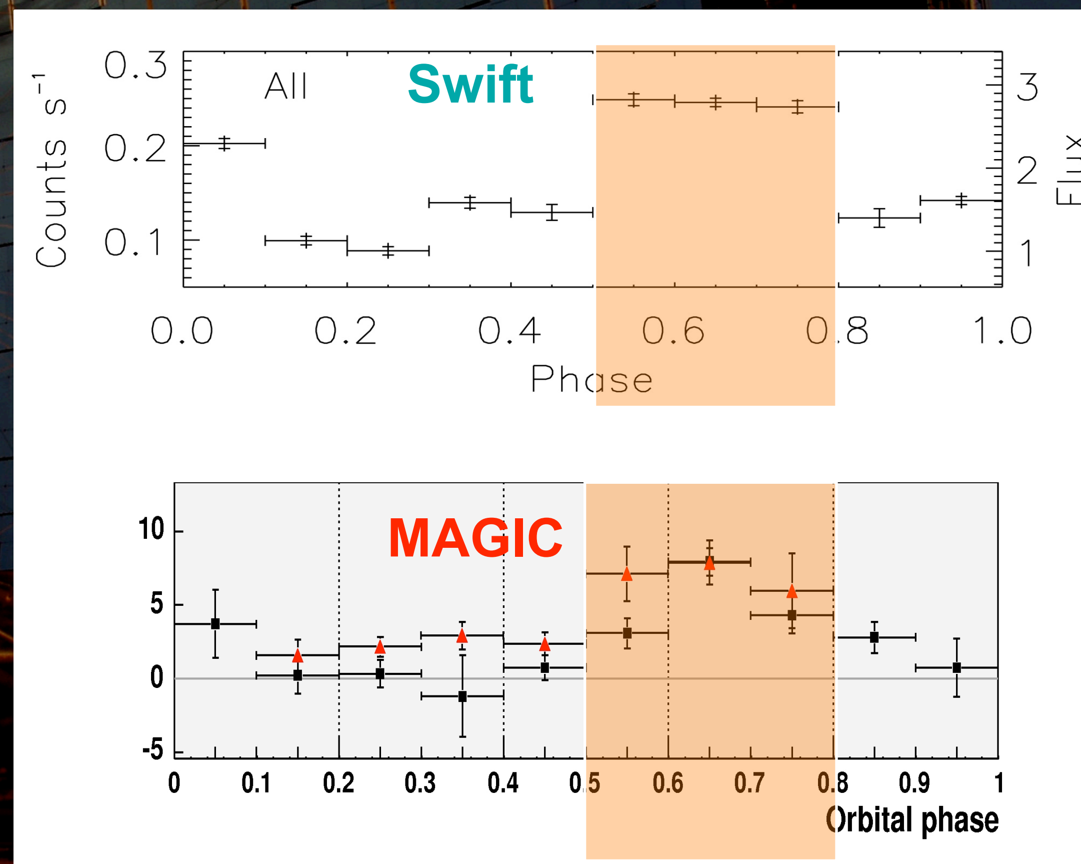
# Hint on γ-ray / X-ray correlation

Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

**Swift observed LS I from Sep to Dec 2006 with XRT instrument using 24 pointings**

**Not strictly simultaneous measurement**

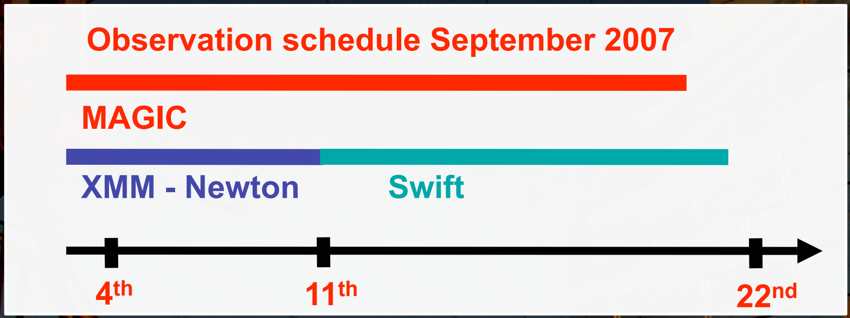
P.Esposito et al 2007




**Very interesting**

**Dedicated MW in 2007**

# MWL campain: VHE / X-ray correlation

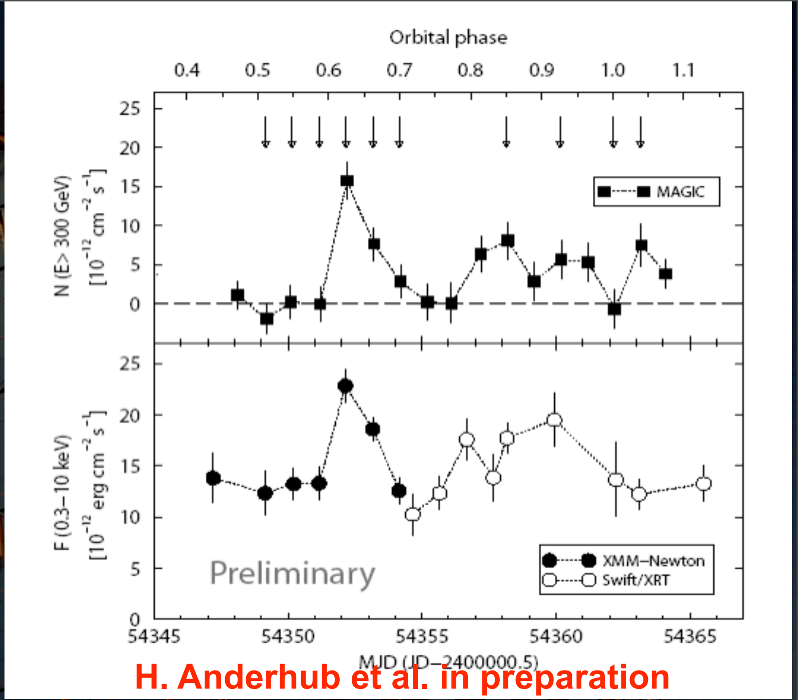



VHE gamma rays: E > 300 GeV
MAGIC observed $T_{obs}$ = 54 hours
4th – 21st September

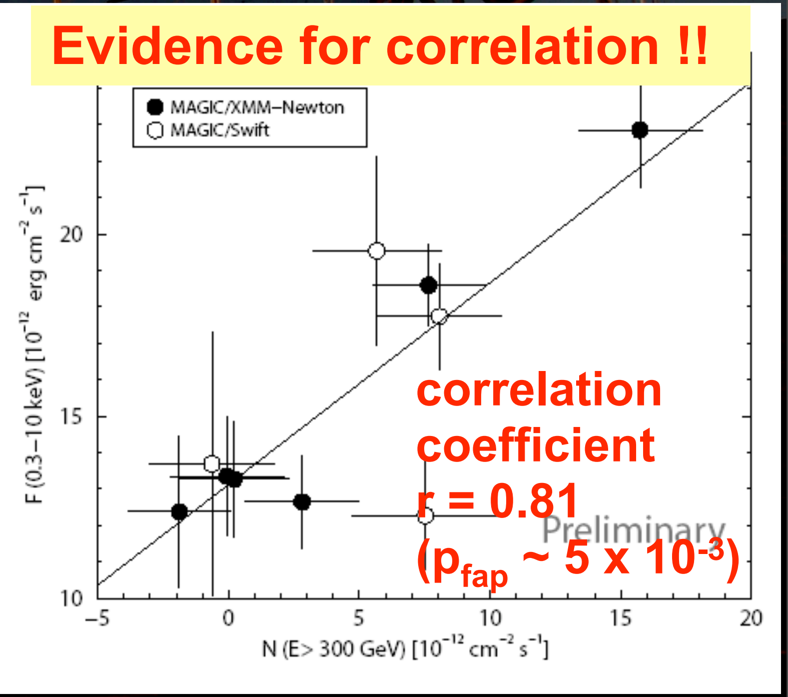
X-Rays: 0.3 keV < E < 10 keV
XMM-Newton $T_{obs}$ = 104 ks
4th – 11th September

Swift $T_{obs}$= 29 ks (XRT)
11th - 22nd September

**Same particle population x-ray/ gamma --> leptonic production mechanism ?**




H. Anderhub et al. in preparation

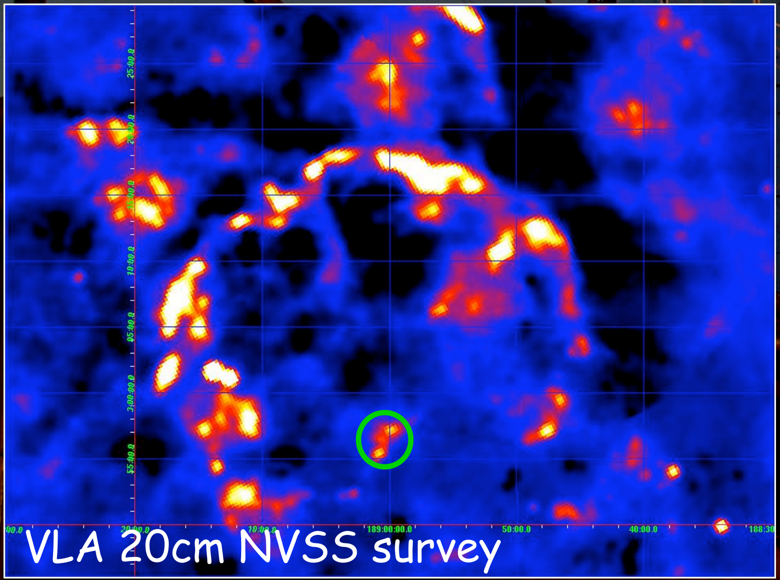


# Supernova remnant: IC 443

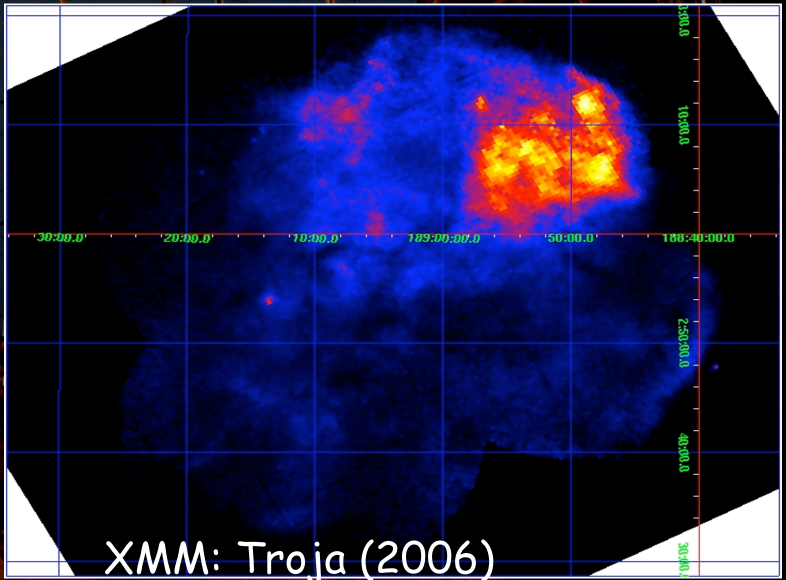
Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

- Asymmetric shell-type SNR, 45' diameter (distance ~1.5 kpc)
- Complex morphology at different wavelength
- Unidentified EGRET source inside
- Only upper limits in VHE gamma rays

**Radio, shows MASER emission**




**High soft X-ray flux (no shell)**



# MAGIC J0616+225 (inside IC 443)

## Recently confirmed by VERITAS

Point-like source

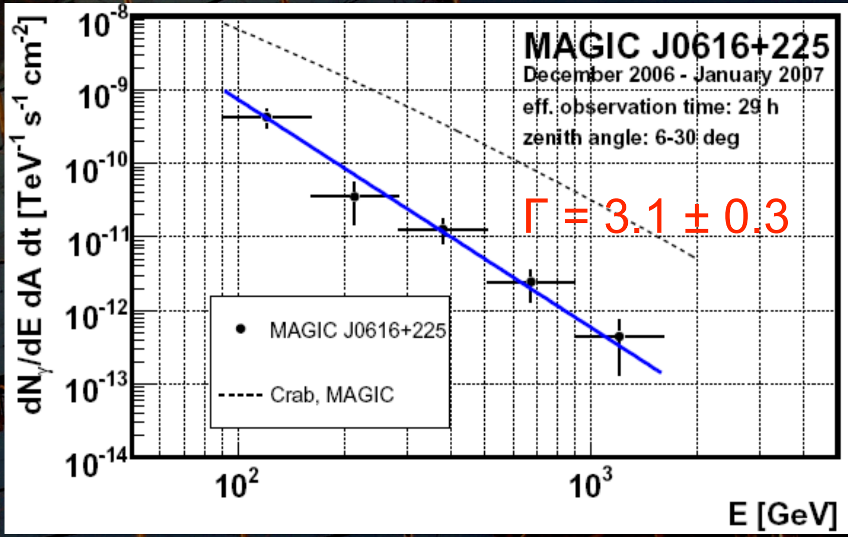
Significance: 5.7 σ

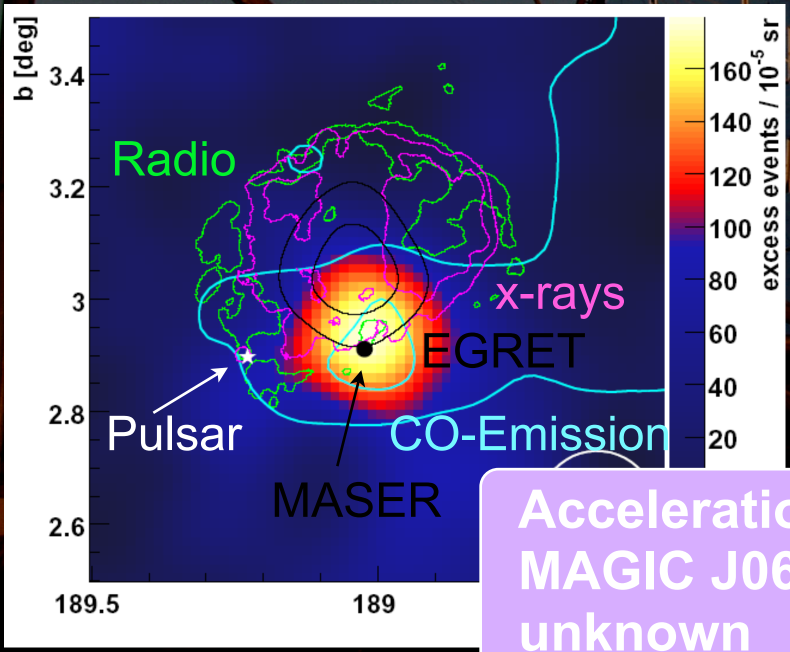
Flux of MAGIC J0616+225:

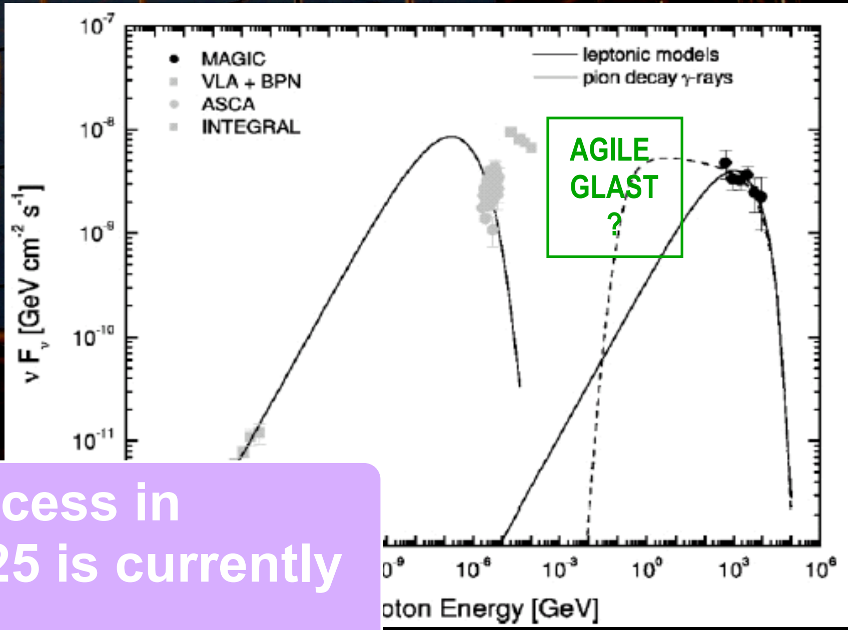
above 100 GeV ~ 6.5% Crab

above 300 GeV ~ 2.8% Crab

Soft spectrum, compatible with power law ( $\Gamma = 3.1 \pm 0.3 \pm 0.2$)



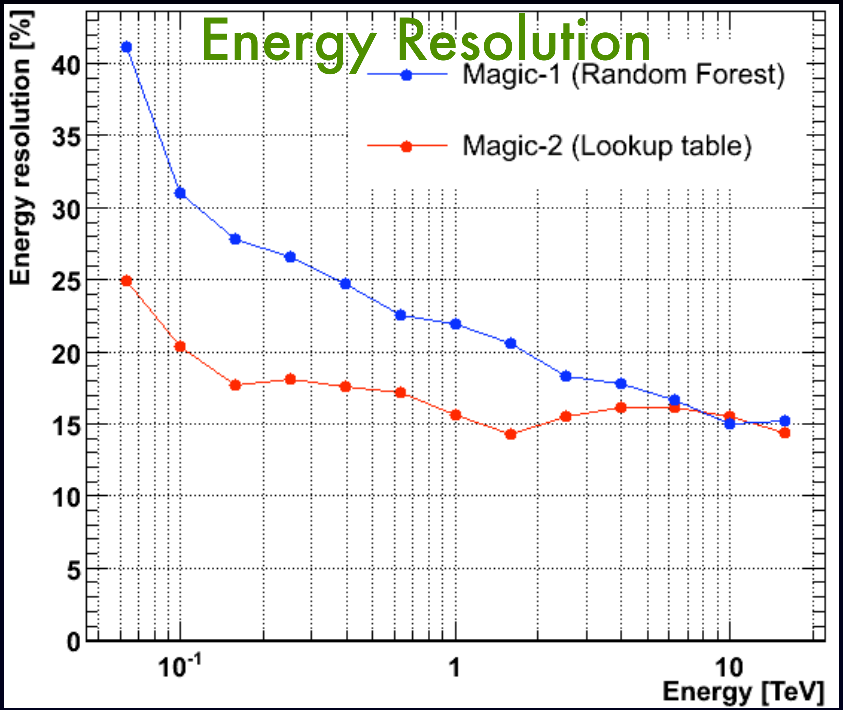

**Acceleration process in MAGIC J0616+225 is currently unknown**

# MAGIC II commissioning Status

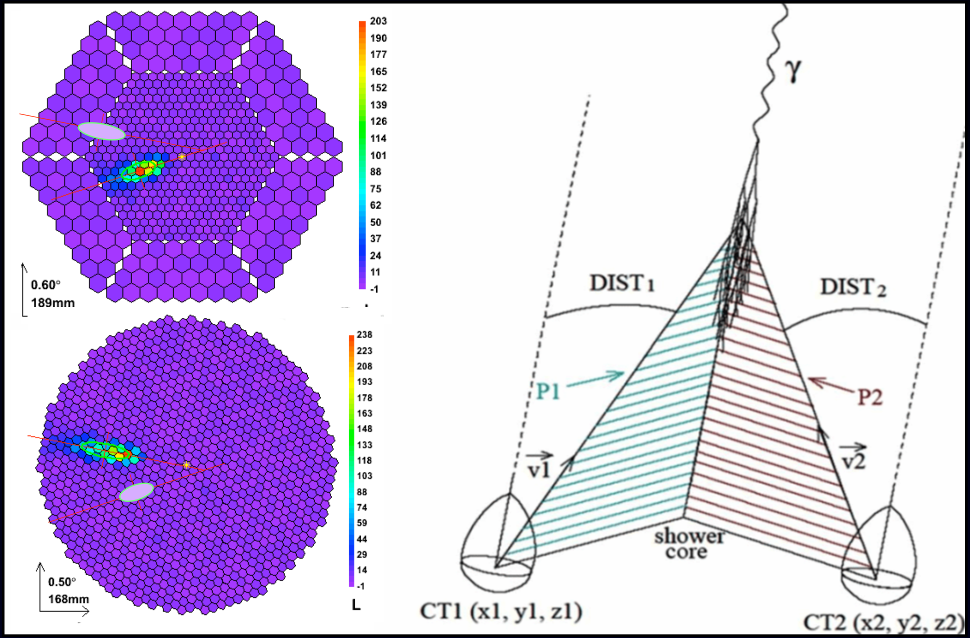
# Stereoscopic Observations

3D shower reconstruction

- ☑ Better hadron rejection
- ☑ Better angular resolution (50% better)
- ☑ Better energy resolution (25%-25%)
- ☑ Enhance the sensitivity over the whole energy range




**Simultaneous Observation of air showers with 2 telescopes**



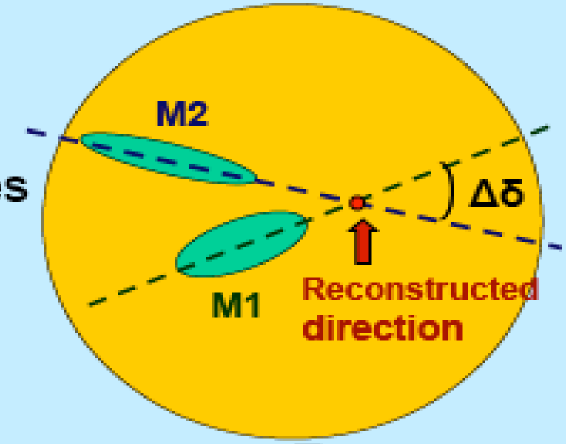
# Angular resolution

- 2 methods of determining originating direction

## Direction reconstruction

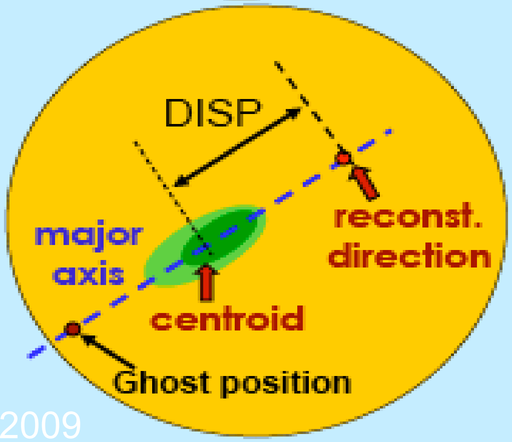
2 independent and performing techniques :

➢ <u>Stereo</u>: Intersection of 2 major axes
- independent of any MC
- not good for small angle Δδ

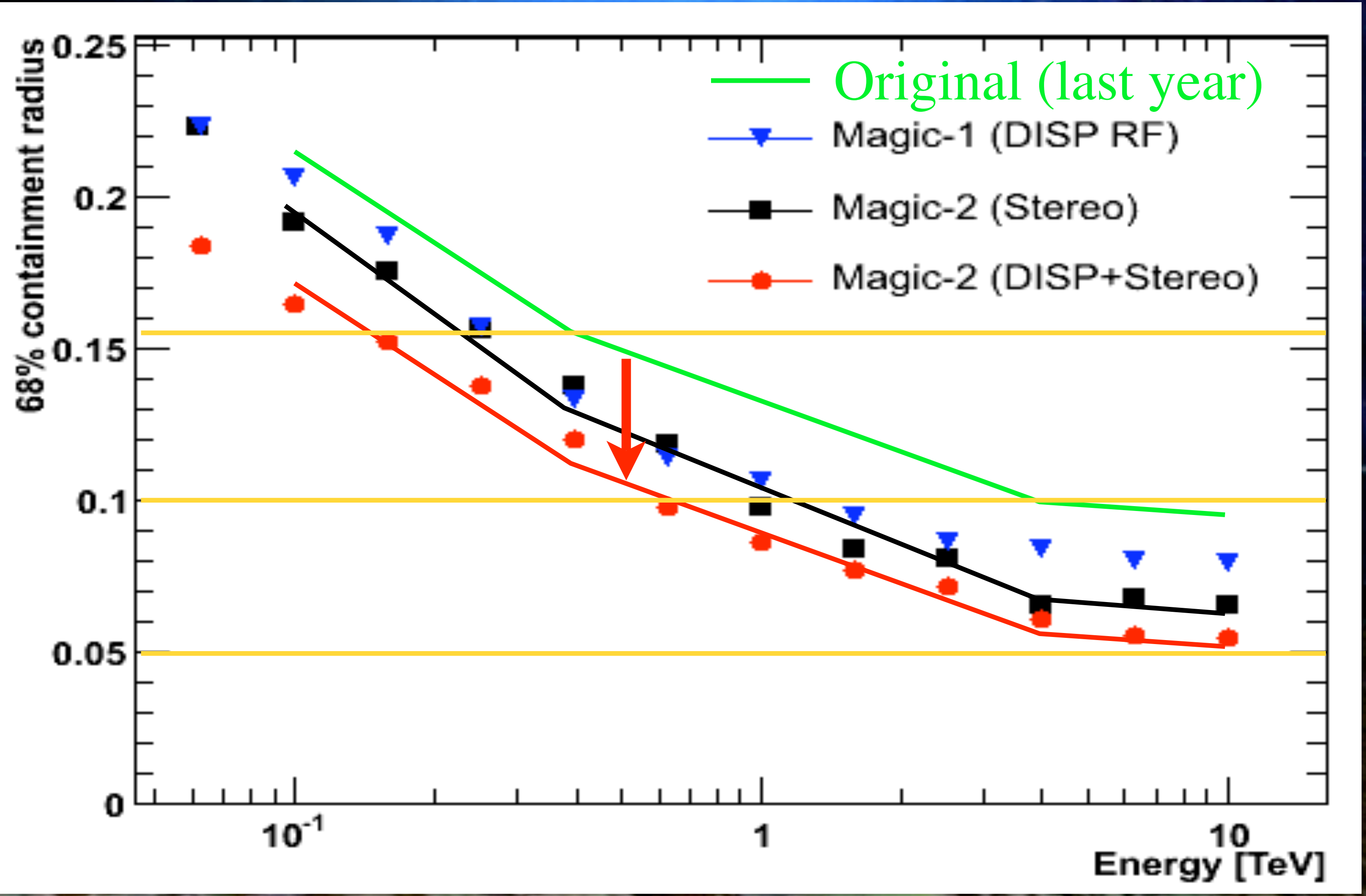



➢ <u>DISP</u> using RF method
- MC dependent
- a reconstructed direction for each tel.

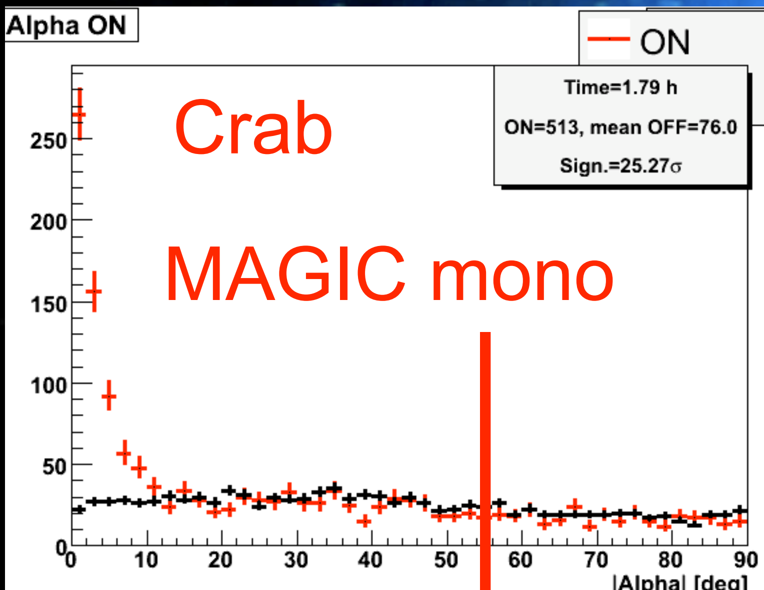
**We should combine**
**- Stereo**
**- DISP_M1**
**- DISP_M2**

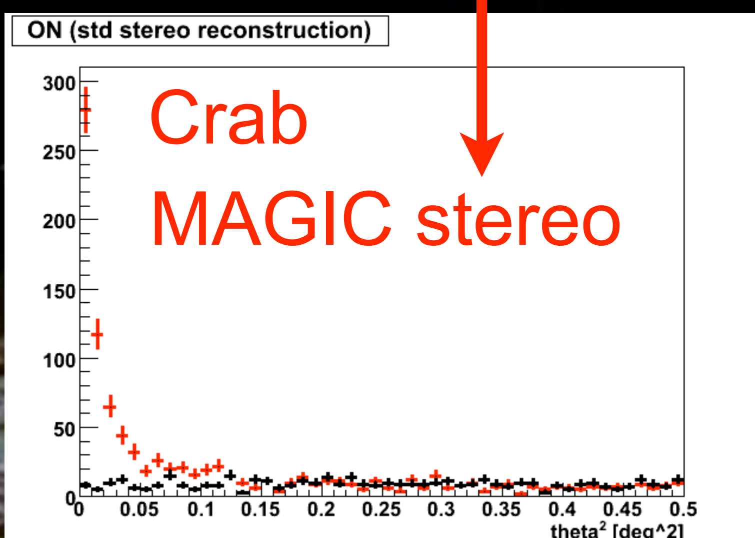


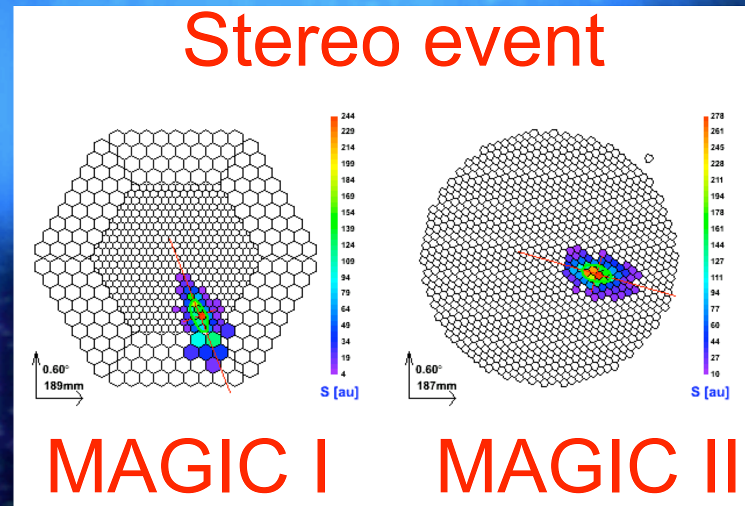
# Significant improvement with 2 telecscopes

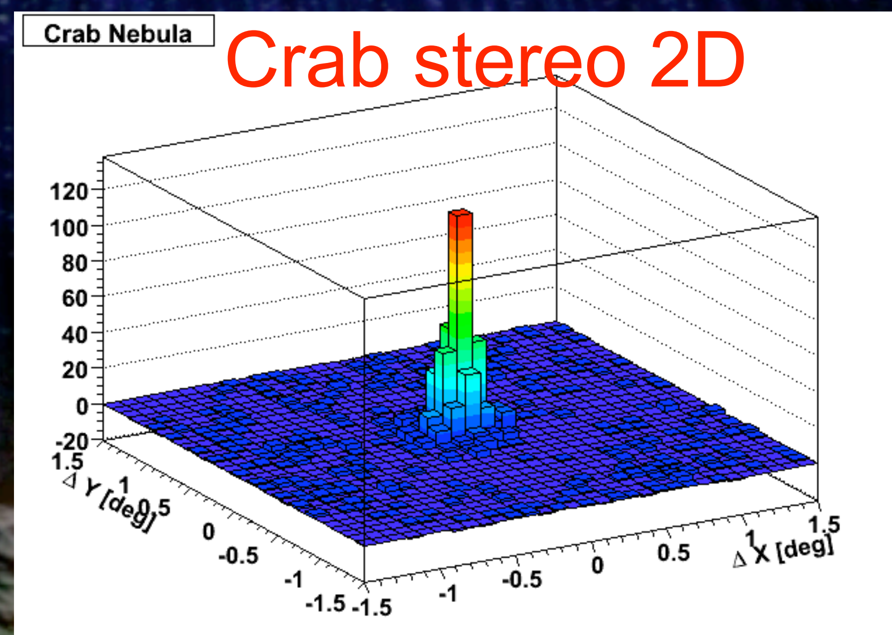


# First stereo signals !!
# Started regular observations already

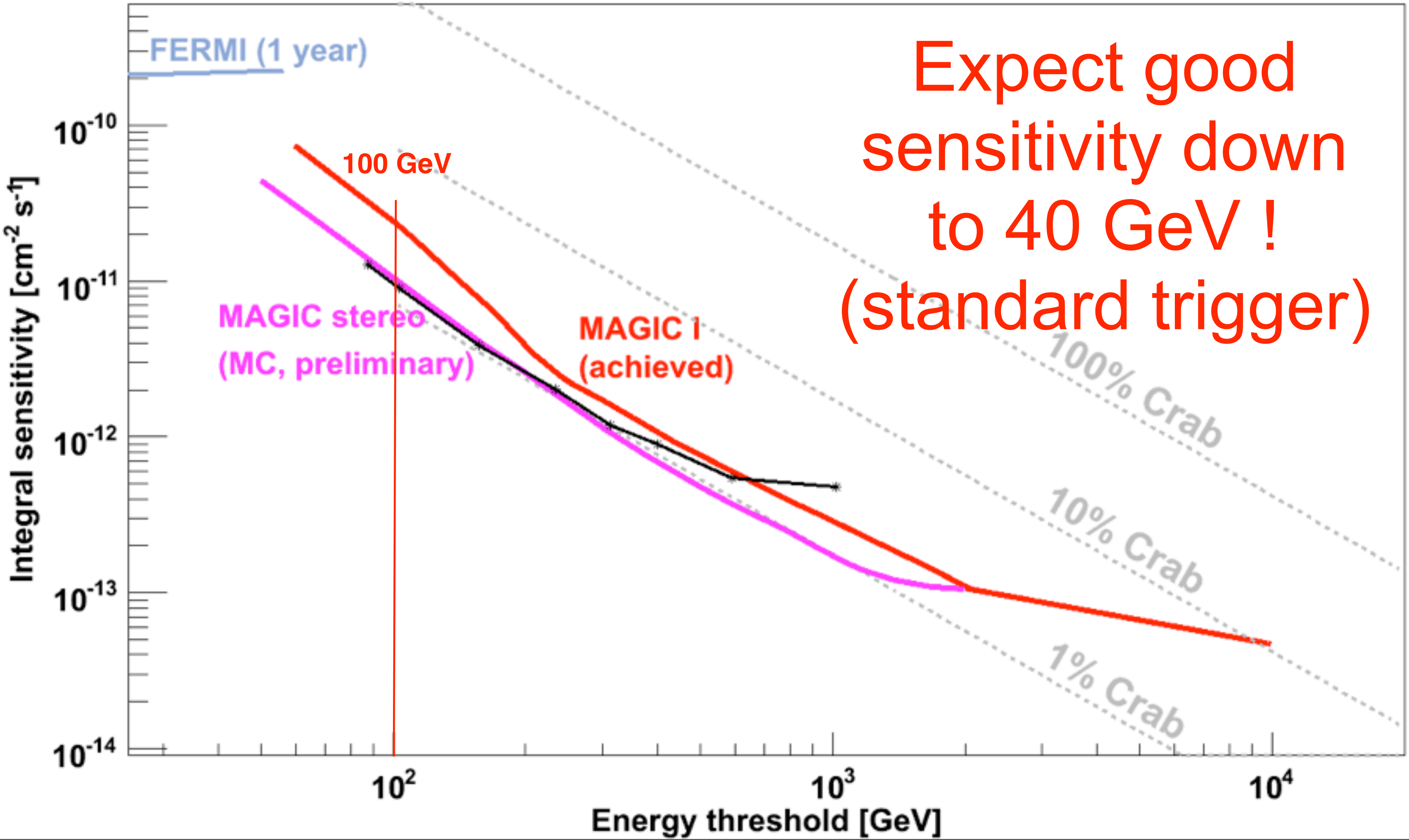


# Already achieved Sensitivity

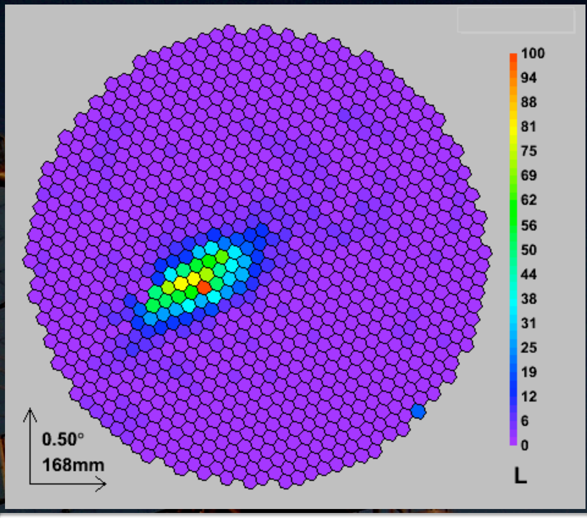



Expect good sensitivity down to 40 GeV ! (standard trigger)

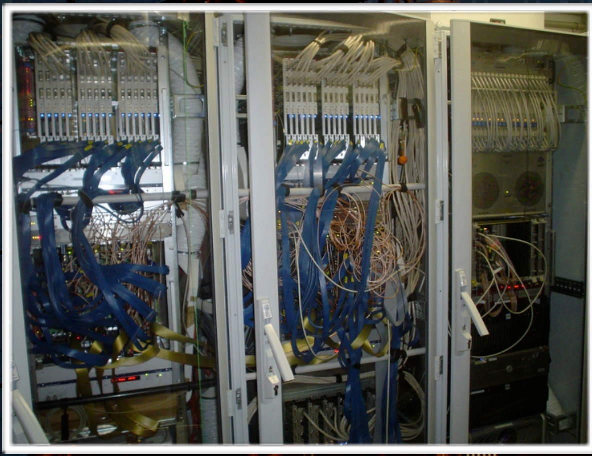
# MAGIC stereo is a low energy instrument !

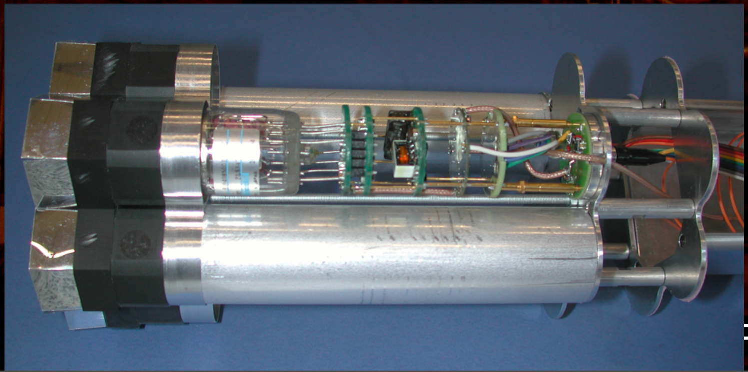
**There we are unique**

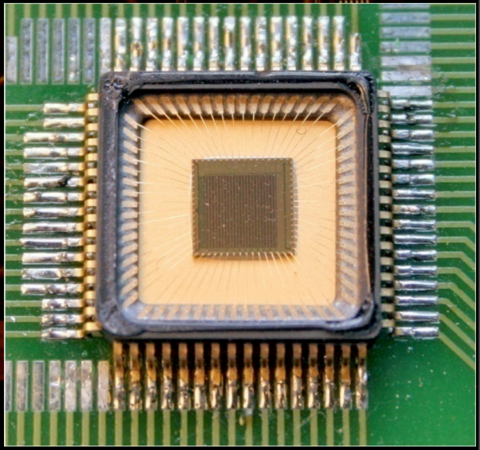
# Upgrade of MAGIC I March 2011




- We plan to upgrade MAGIC I such that it is equal to MAGIC II
- New camera with 1039 channels, same as MAGIC II with a larger trigger area. Camera is in construction already. --> Improved sensitivity !
- Same domino (DRS4) readout system as MAGIC II.

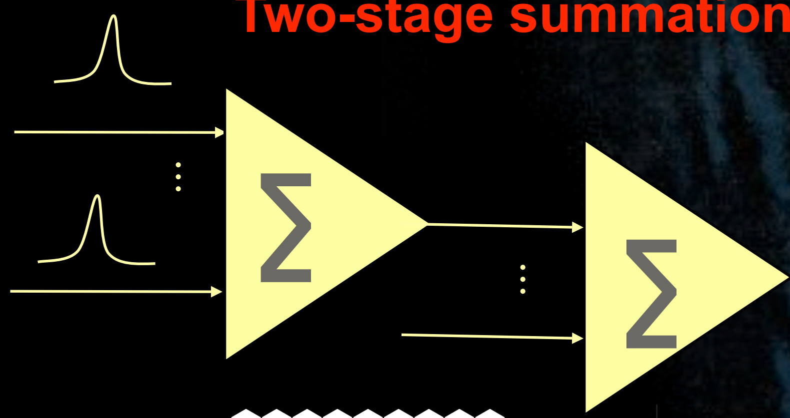


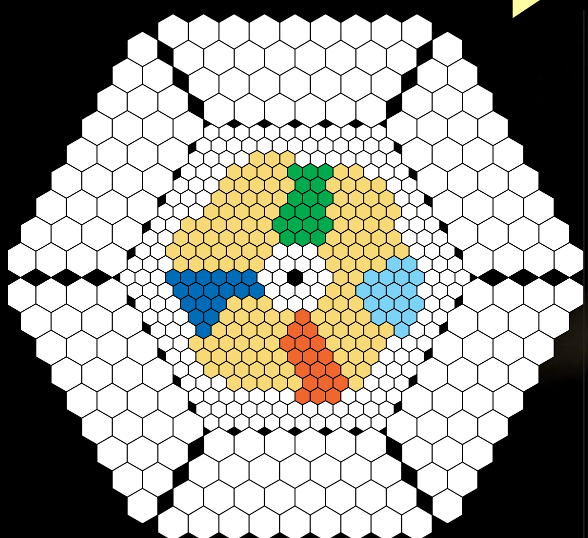




# New sumtrigger with larger trigger area and low threshold for both telescopes

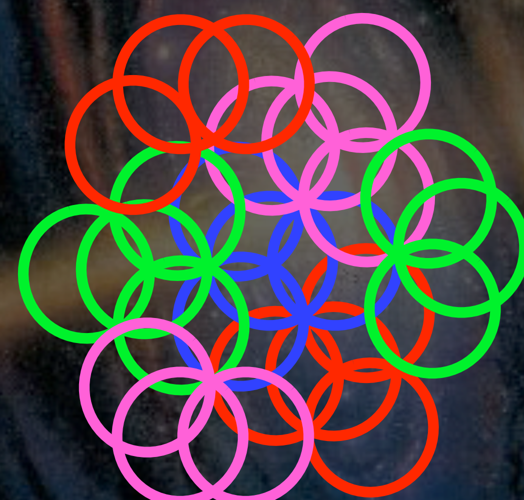
Two-stage summation



old trigger topology

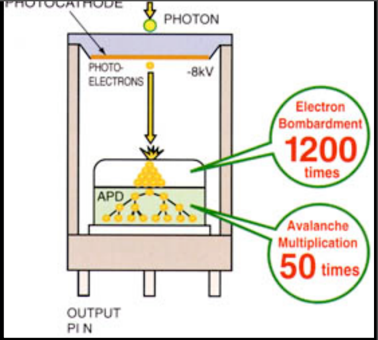
- overlapping patches
- Two-stage summation
- First stage: 6 (7) pixels
- Sum of 3 sub-patches to 19 pixels



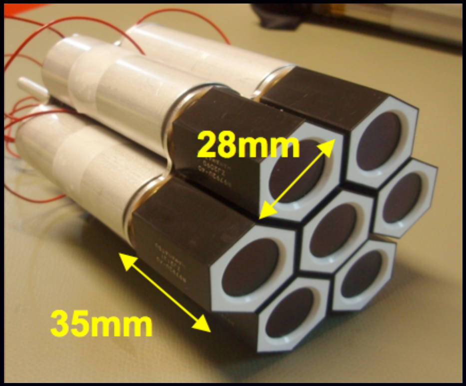
new trigger topology

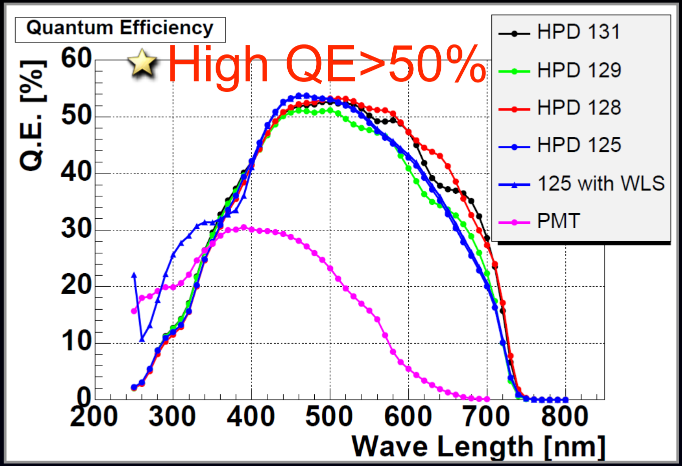
# Near Future: Upgrade with HPDs

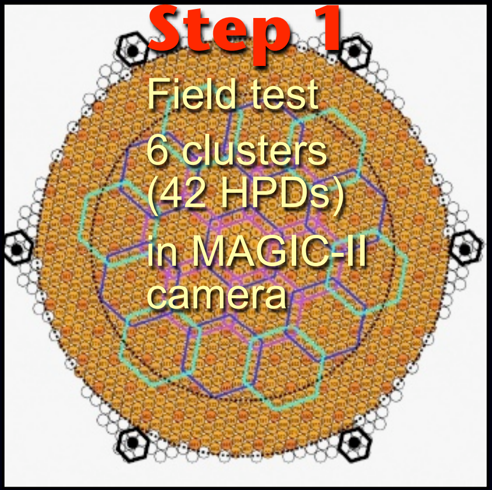
## Decrease trigger threshold down to 15 GeV (sumtrigger)

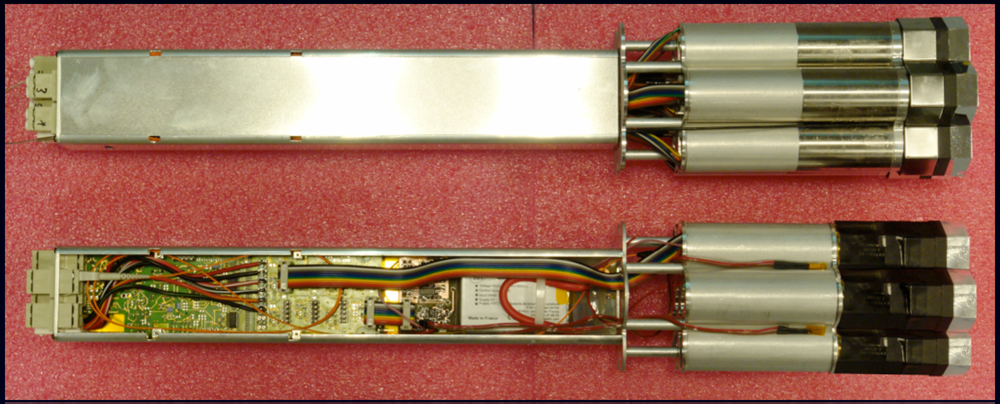



HPD clusters have the same geometrical shape as PMT clusters: easy to exchange

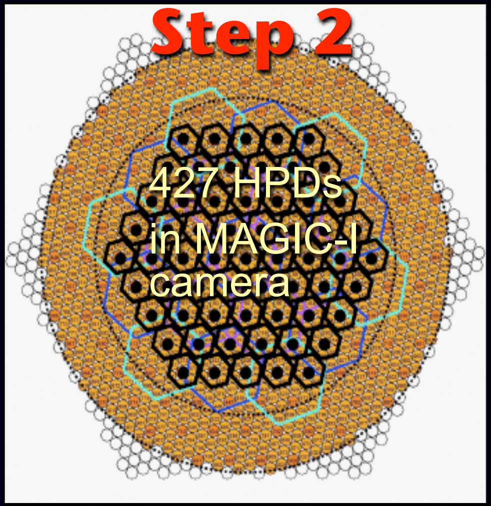


VCSEL | 8kV power supply | Amplifier and APD HV generator | HPD | Winston Cone




Thomas Schweizer , Project Review MPI December 2009

# Conclusions

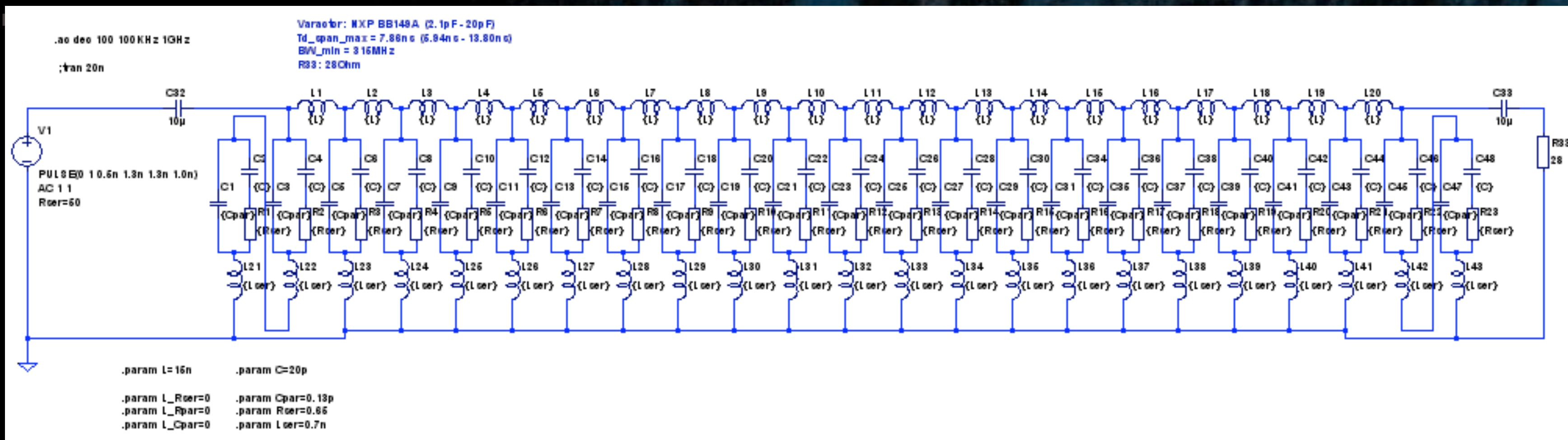
- MAGIC has many interesting results (most distant source 3C279, IC443, S5 0716, LSI +61 303, ...), especially in the low energy domain down to 25 GeV (Crab pulsar detection)
- The energy range below 150 GeV can be currently observed only by the MAGIC experiment !!
- The upgrade of the MAGIC observatory with a second telescope improved the sensitivity and the angular resolution

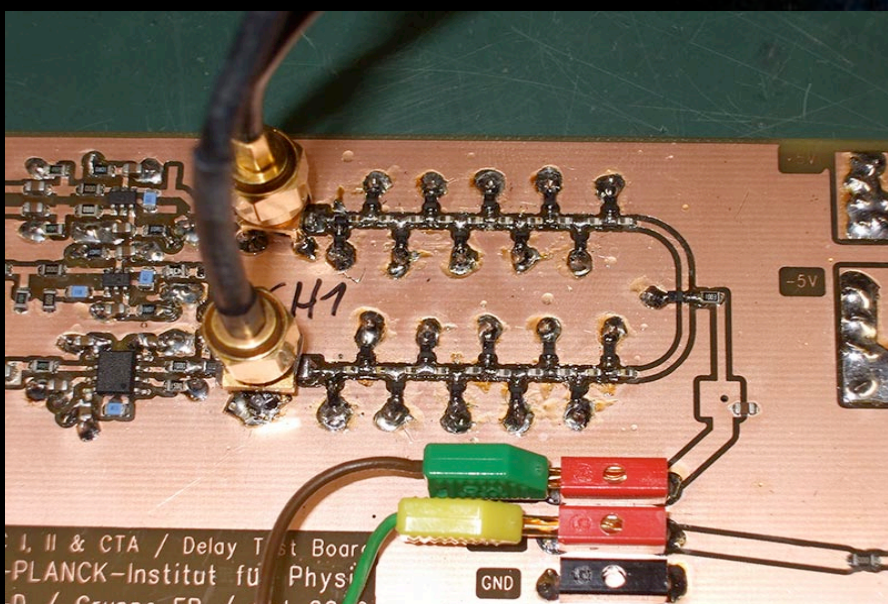
- We expect very exciting discoveries with stereoscopic observations very soon !!


The end

# Backup slides

# Designing a continuously adjustable analog delay line by 7ns



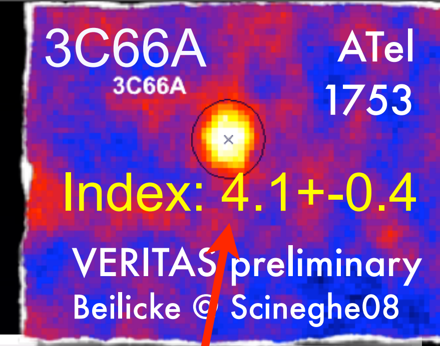


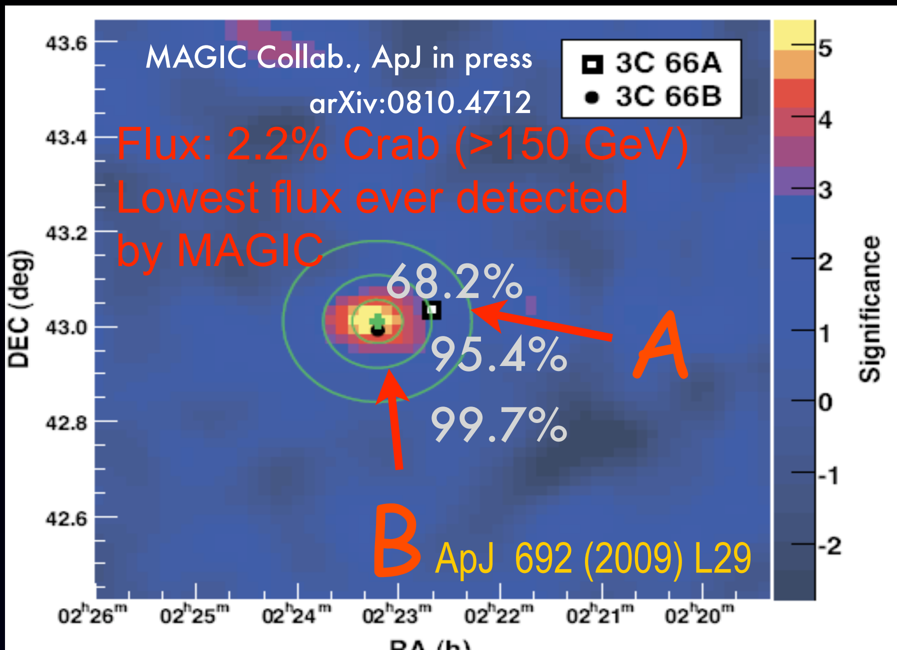
# 3C 66A/B region: MAGIC J0223+430

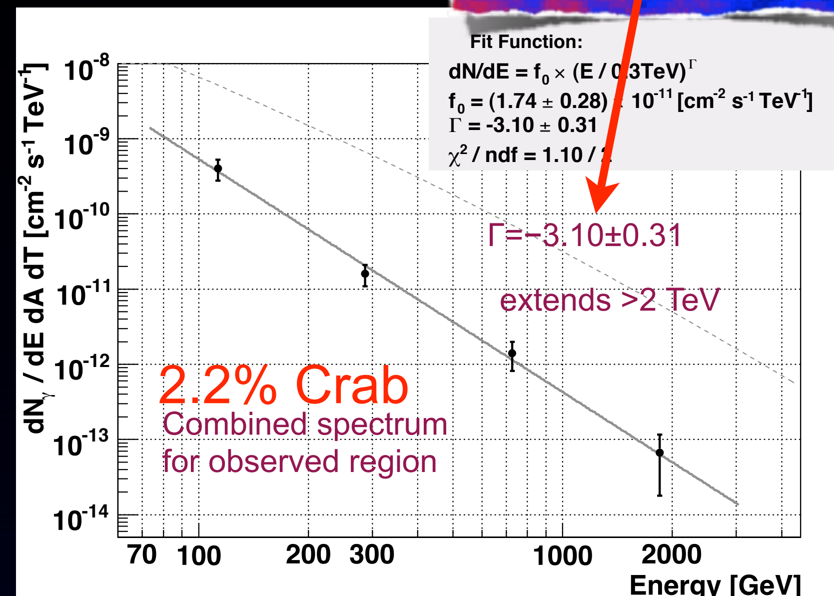
(EGRET SOURCE)

B: Nearby FR-I Radio Galaxy

A: Distant blazar, z=0.44 ?




→ 3C66B is the most likely identification

3C66A exclude by 85% (including systematics)

- If 3C66A (unlikely): → distance cannot be z > 0.23 (no > 1 TeV γ-rays, EBL)

Mazin+Raue 08, Aharonian+06

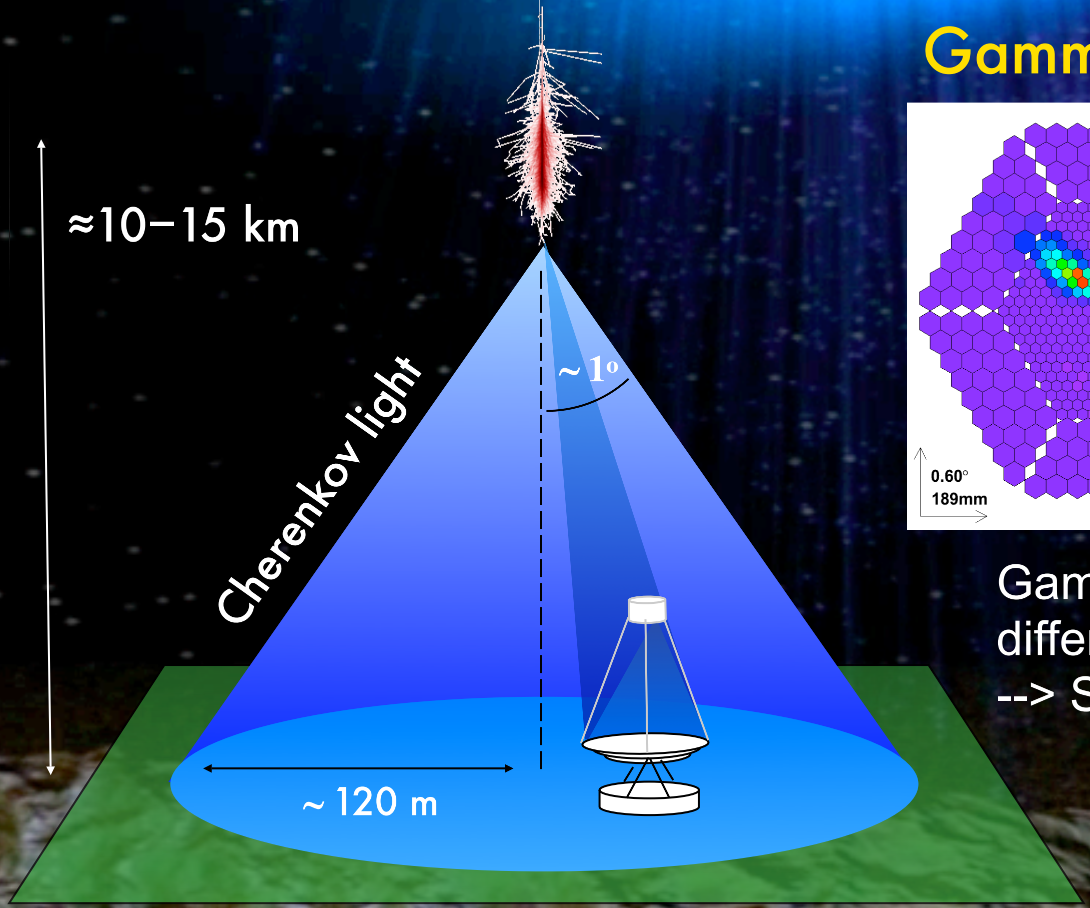
# MAGIC collaboration
# ~150 Scientists / 10 countries


**Armenia** Yerevan
**Bulgaria** Sofia
**Croatia** Consortium
**Finland** Tuorla Observatory
**Germany** DESY, Dortmund
MPI Munich, Wuerzburg
**Italy** INFN Padova, INFN Siena
INFN Udine,
INAF Rome, INAF Trieste
**Poland** INRNE Lodz
**Spain** U. Barcelona, UAB Barcelona
IEEC-CSIC Barcelona
IFAE Barcelona, IAA Granada
IAC Tenerife
U Compultense, Madrid
**Switzerland** ETH
**USA** UC Davis

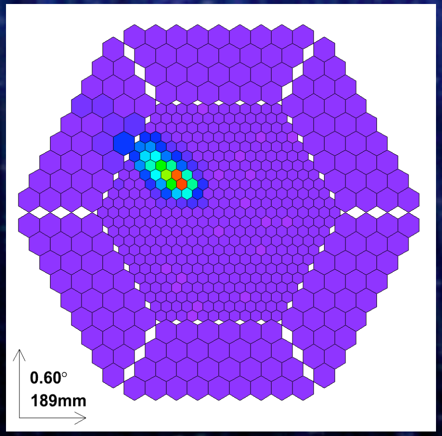
# Ground-based gamma-ray astronomy

# The Imaging Air Cherenkov Technique

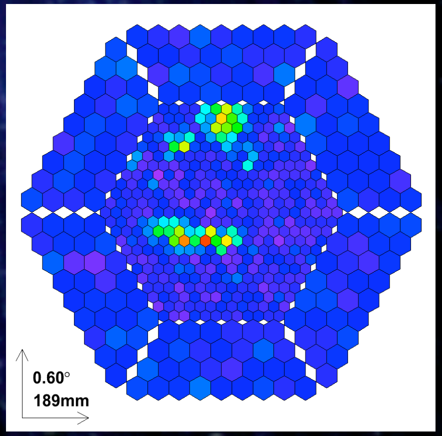
* Extended Air Shower initiated in atmosphere
* Detect the Cherenkov radiation from charged particles in EAS
* A mirror reflects and concentrates the light
* An image of the shower formed in the camera




Gamma event



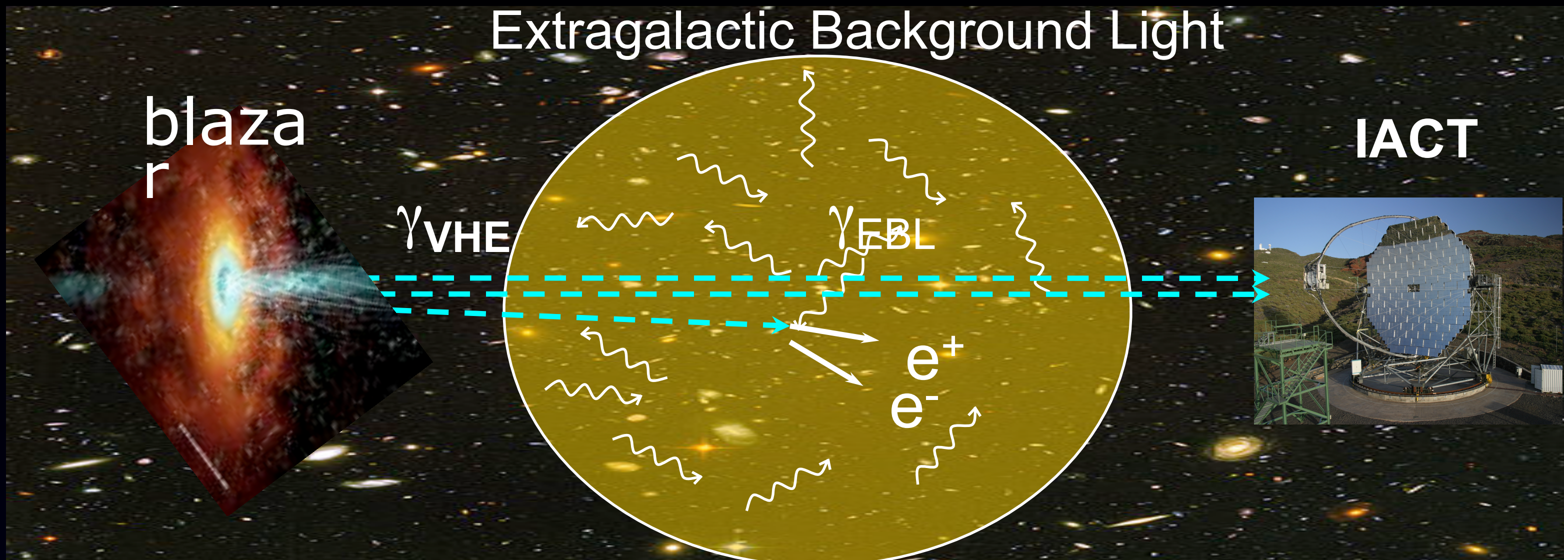

Hadron event

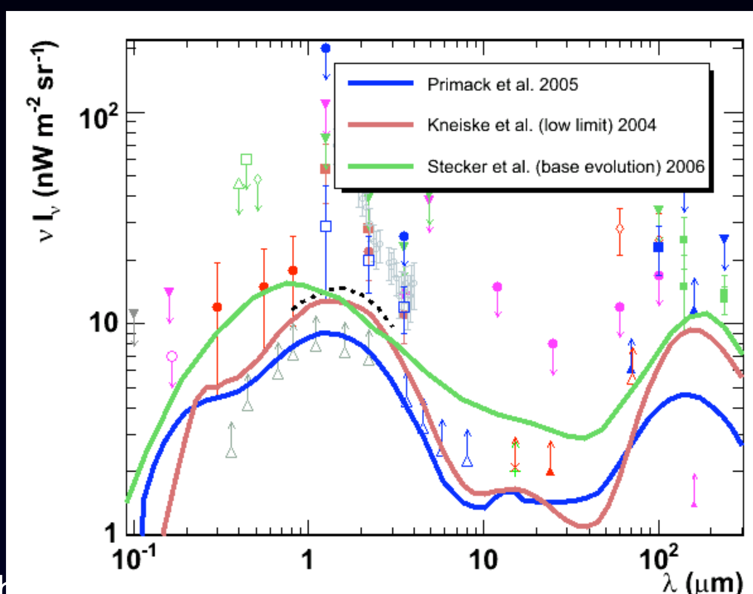


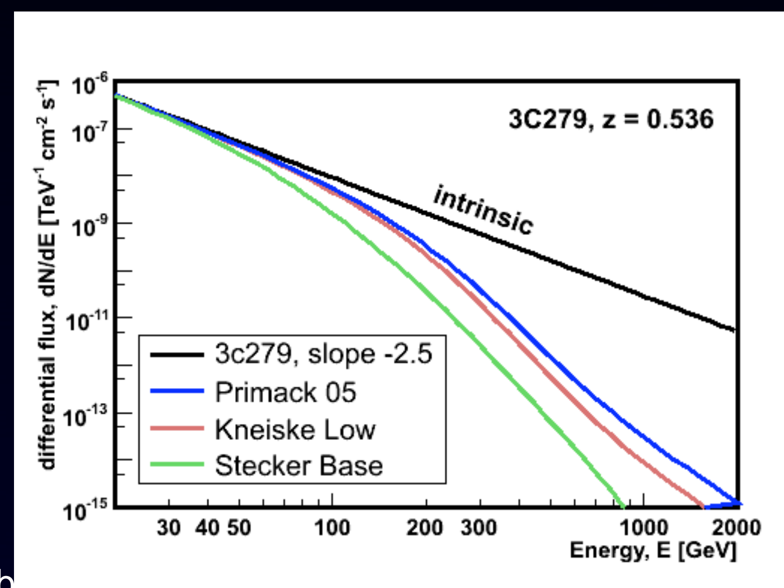

Gammas and Hadrons have different shower image shapes
--> Suppression of Background

Estimation of energy and direction from shower reconstruction

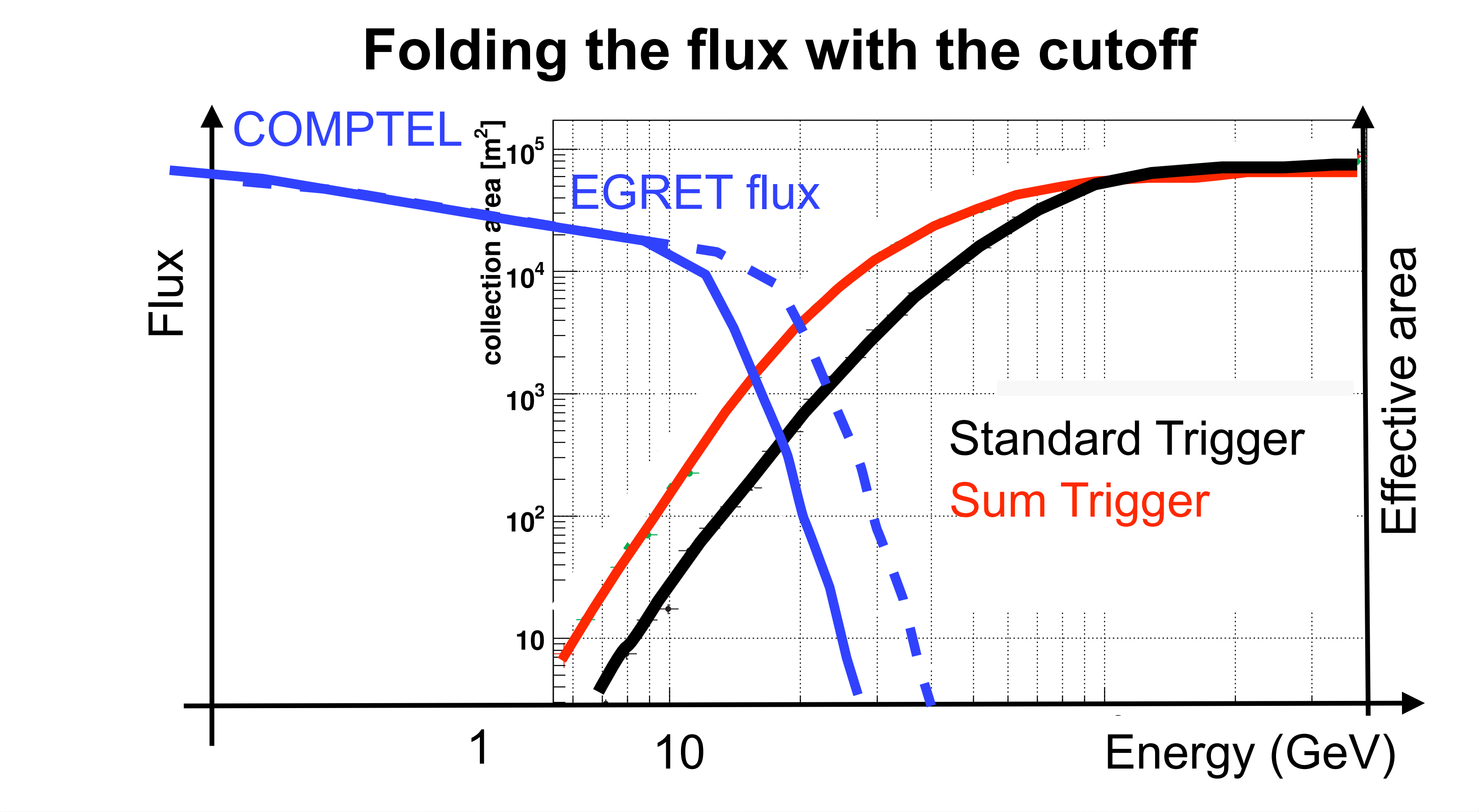
# EBL Absorption



# How do we measure the cutoff ?

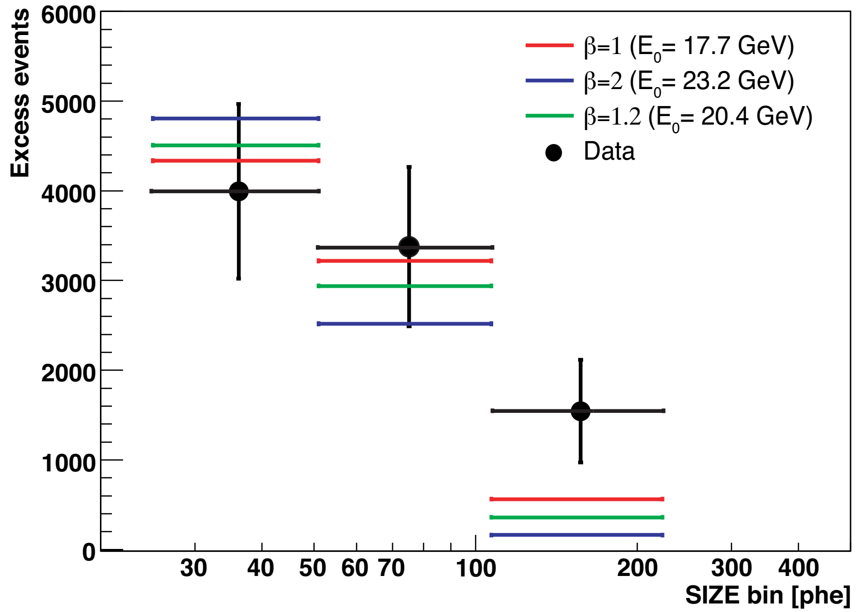



- Method: Combined fit: COMPTEL + EGRET data and MAGIC data
- Fold function $F(E) = A\,E^{-\alpha}\,exp(-(E/E_0)^{\beta})$ with eff. area (forward unfolding):
- Calculate the Chi² between expected excess and measurement
- Minimize Total Chi²

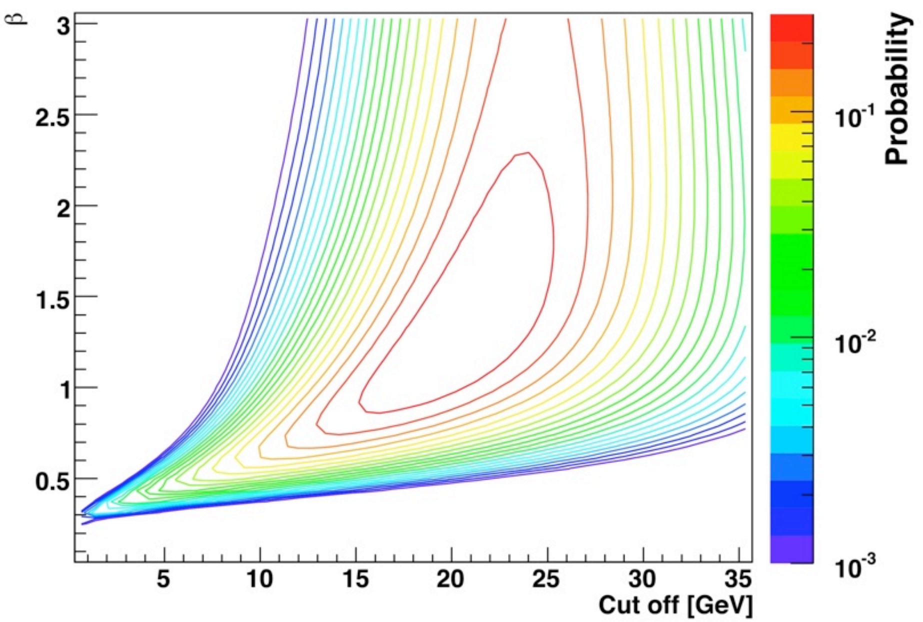
# Model fit to signal event distribution

## Model fit to signal event distribution
## Total P1 + P2

$F(E) = A\,E^{-\alpha}\,exp(-(E/E_0)^{\beta})$ folded with eff. area




**Probability of cutoff energy**




**E0=17.7 ± 2.8$_{stat}$ ± 5.0$_{syst}$ GeV for β =1 (exponential)**
**E0=23.2 ± 2.9$_{stat}$ ± 6.6$_{syst}$ GeV for β =2 (super-exponential)**
**E0=20.4 ± 3.9$_{stat}$ ± 7.4$_{syst}$ GeV for β =1.2**

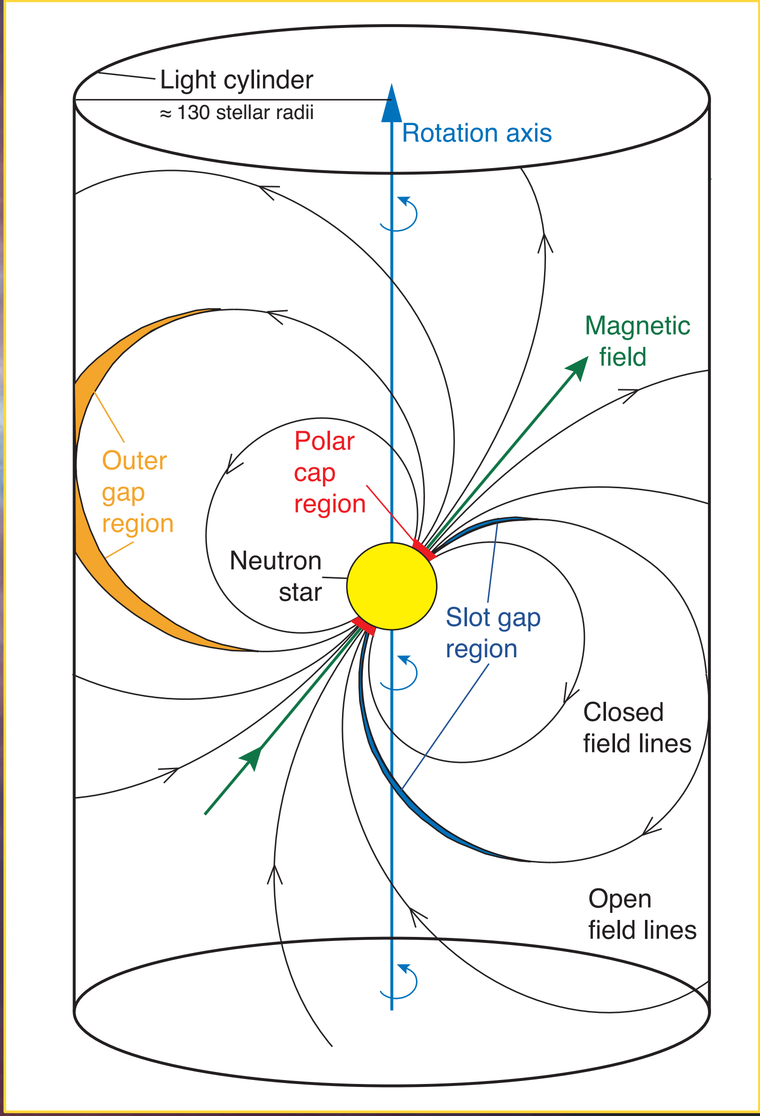
# Relatively high cutoff >20 GeV !
# Comparison with pulsar models

- Magnetic pair production introduces a super-exponential cutoff at low energies

- Our superexponential cutoff is 23.2 GeV+-2.9$_{stat}$ GeV+-6.6$_{syst}$ GeV

- Lower limit on the distance of the emitting region of ***6.2 +- 0.2$_{stat}$ +- 0.4$_{syst}$ stellar radii***

- **The high location of the emission region excludes the *classical* polar cap model (emission distance < 1 stellar radius) and challenges the slot gap model**

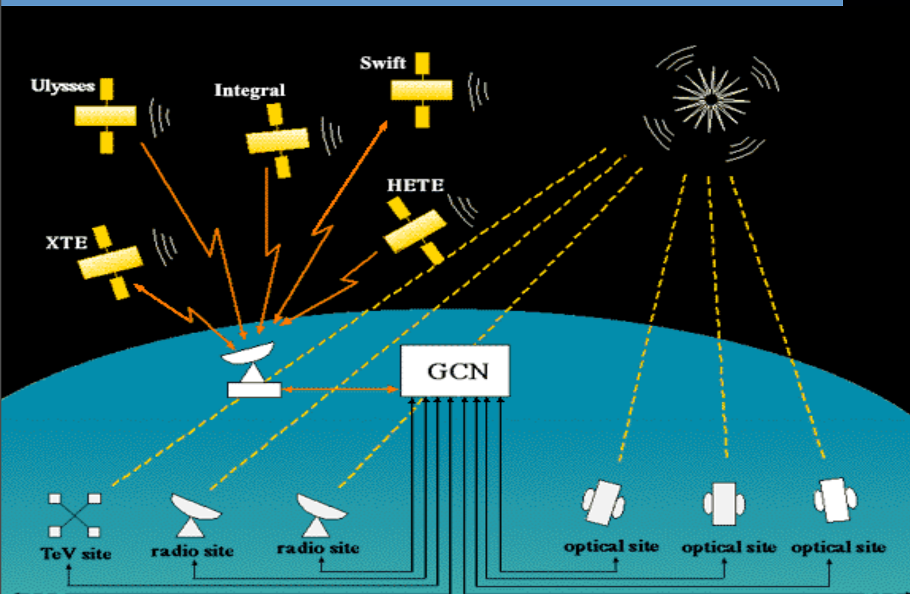


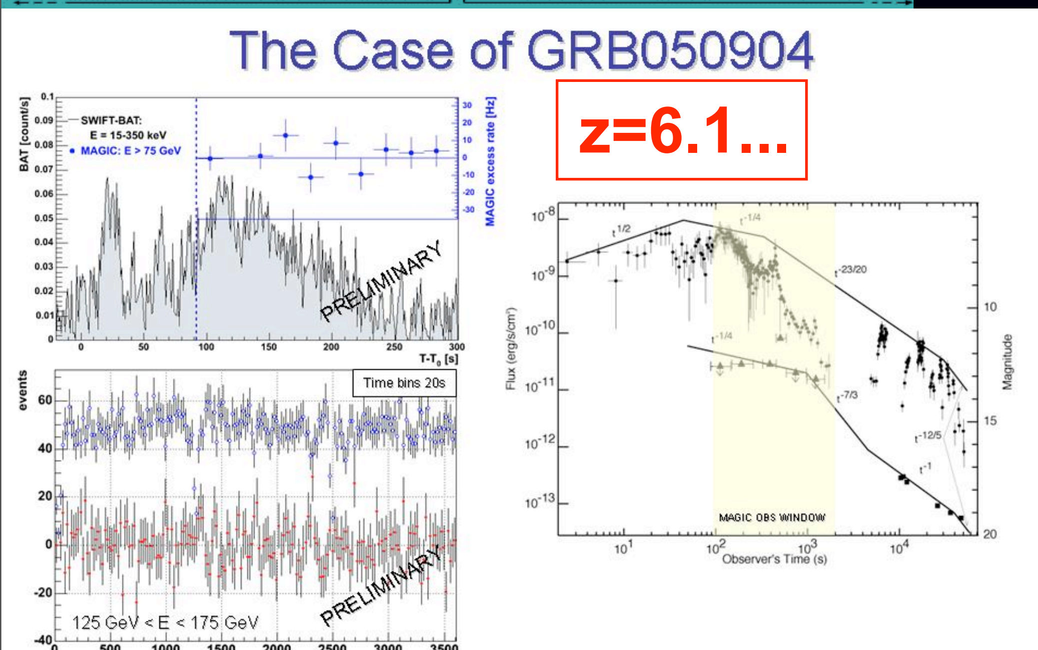
# GRBs with

Missed also 080319B at z=0.937, biggest GRB ever !

Next BIG ONE awaited !

Drive upgrade:
Repositioning time:
MAGIC II: 17 sec/180 deg
MAGIC I:  20 sec/180 deg




## GRB – Observed GRB locations

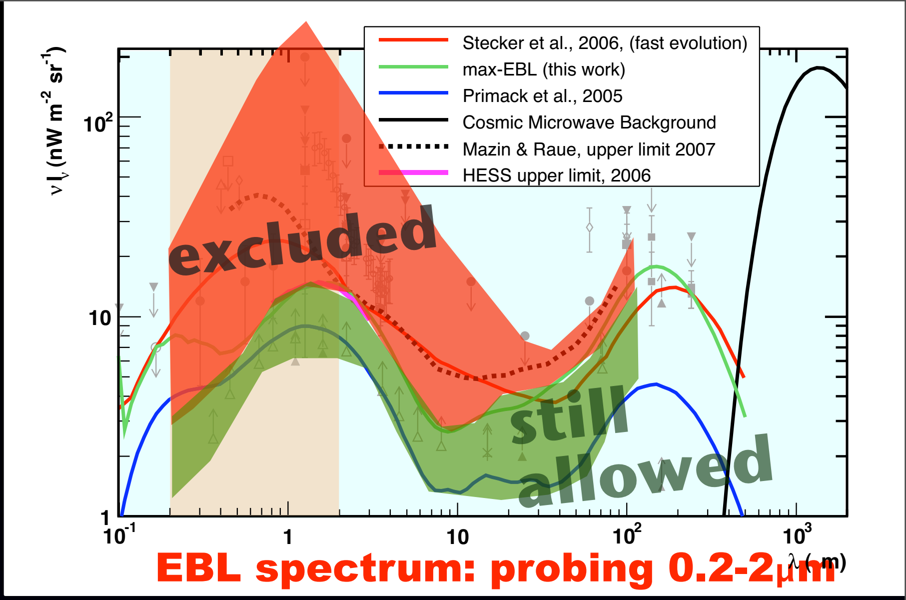
GRB WG: ApJ 667, 358

| GRB | $t_0$ | $\Delta t_{alert}$ | $\Delta t_{oss}$ | $t_{90}$ | <ZA> |
|---|---|---|---|---|---|
| 050421 | 04:11:52 | 58 s | 83 s | 10 s | 50° |
| 050502a | 02:14:18 | 18 s | 990 s | 20 s | 42° |
| 050505 | 23 |  |  | 0 s | 55° |
| 050509a | 01 |  |  | 2 s | 50° |
| 050509b | 04 |  |  | 13 s | 49° |
| 050528 | 04:06:45 | 43 s | 77 s | 11 s | 50° |
| 050713a | 04:29:02 | 13 s | 40 s | 27 s | 49° |
| 050904 | 01:51:44 | 82 s | 92 s | 225 s | 20° |
| 060121 | 22:24:54 | 15 s | 583 s | 2 s | 42° |
| 060203 | 23:53:35 | 171 s | 185 s | 83 s | 40° |
| 060206 | 04:46:53 | 16 s | 25 s | 11 s | 10° |

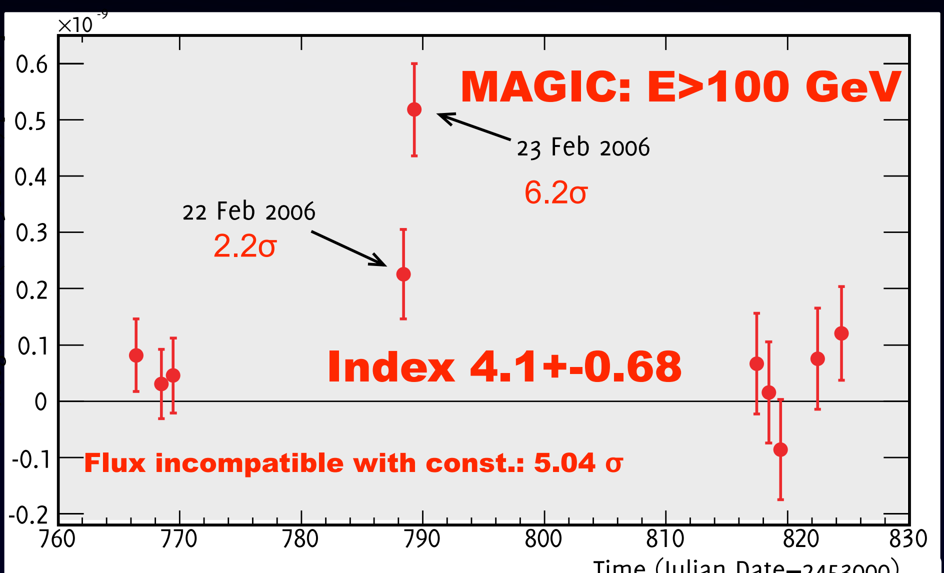
Typical repointing 10÷30 s

# 3C 279 observations
# Jan -April 2006

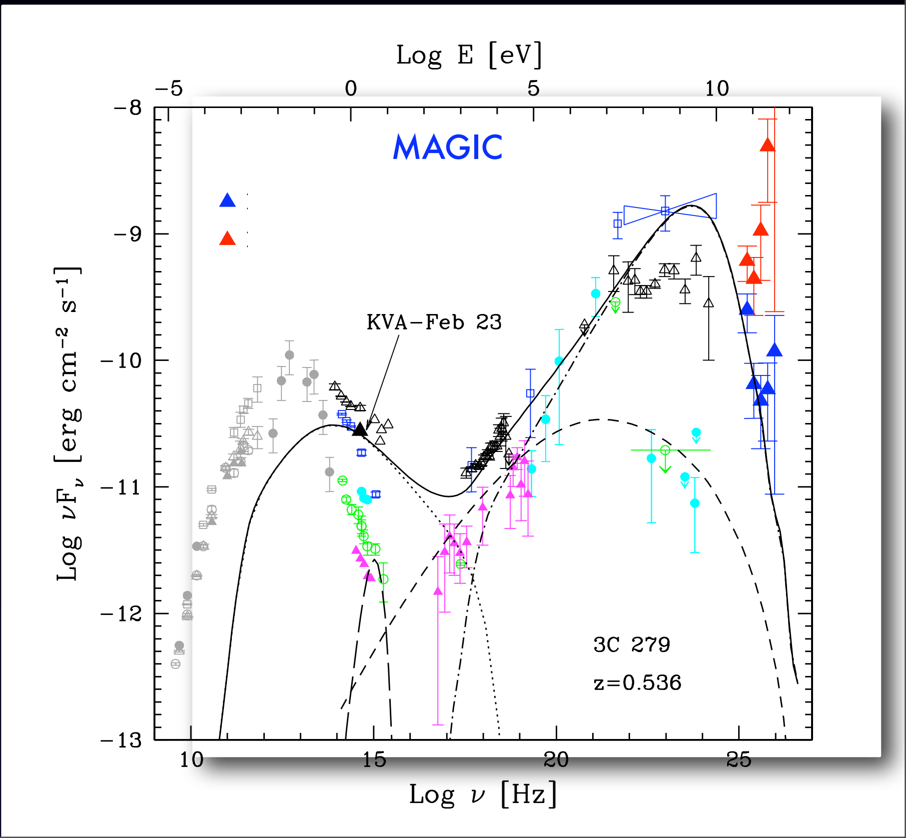
- Modeling of 3C 279 non-trivial:
  - FSRQ → bright emission lines: External photon fields important (Dermer+93, Sikora+94)
  - External-Inverse Compton Modeling required, more free parameters
  - VHE provides vital input!




MAGIC Coll.,
Science 320 (2008) 1752

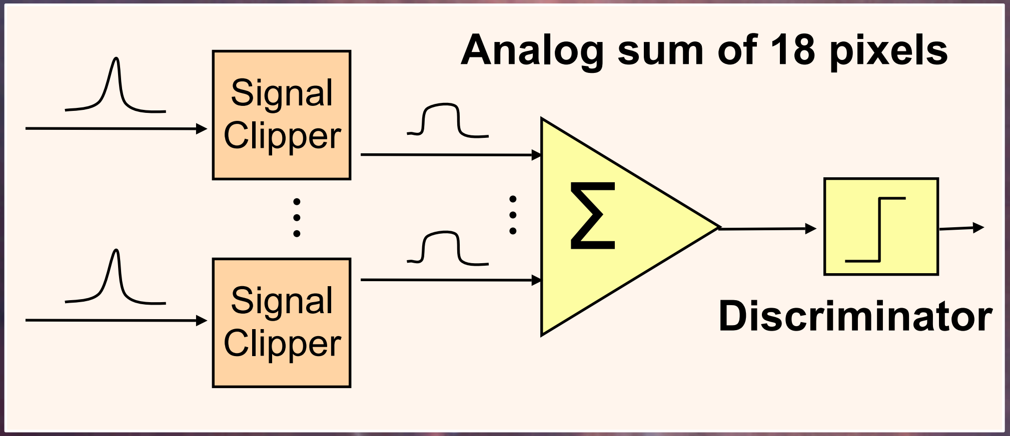


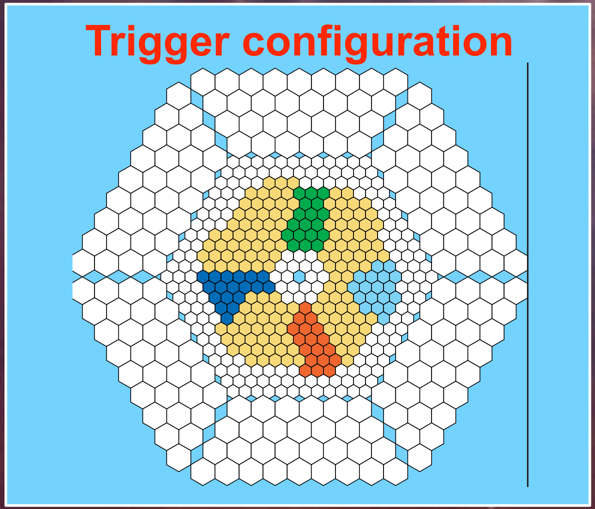

ber



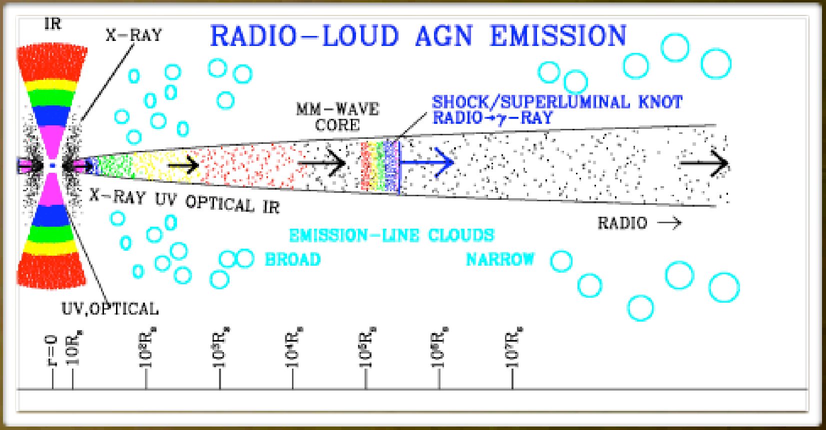
# Analogue sum trigger: Decreasing the threshold from 55 GeV to 25 GeV

- Design, development and production of a new low energy trigger
- Installation in La Palma in October 2007



# Giant radio galaxy M87: A Unique Astrophysical Laboratory

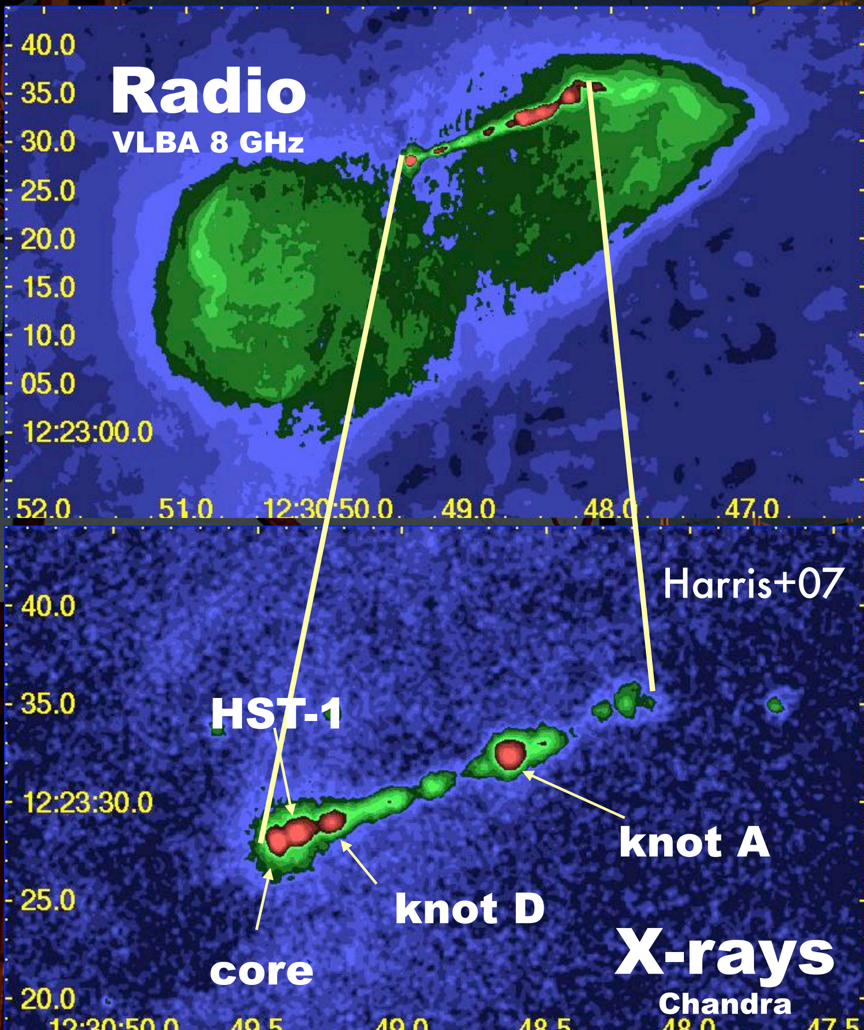



- VERITAS/MAGIC/H.E.S.S. monitoring 120 h of observation
- Simultanous VLBA radio imaging and Chandra monitoring

# From which location originates the gamma radiation ?

MAGIC

Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)




- **X-rays: HST-1 sometimes brighter than nucleus**
- **Nature of the TeV emission?**
  - Leptonic or hadronic acceleration?
  - Proton-induced cascades (Mannheim 93)
  - synchrotron proton radiation (Mücke+Protheroe 01; Aharonian 00)
  - Might also account for parts of the UHECR (Protheroe+03)
- **Location of TeV emission? Core, HST-1, Knot A?**
  - close to the core (Georganopoulos+05; Ghisellini+05; Lenain+08; Tavecchio+Ghisellini+08)
  - large-scale jet (Stawarz+03; Honda07),
  - in the vicinity of BH (Neronov+Aharonian 07; Rieger+Aharonian 08)

Beilicke, Mazin, Raue, RMW et al. 2008
Colin, RMW, Beilicke et al. 2008

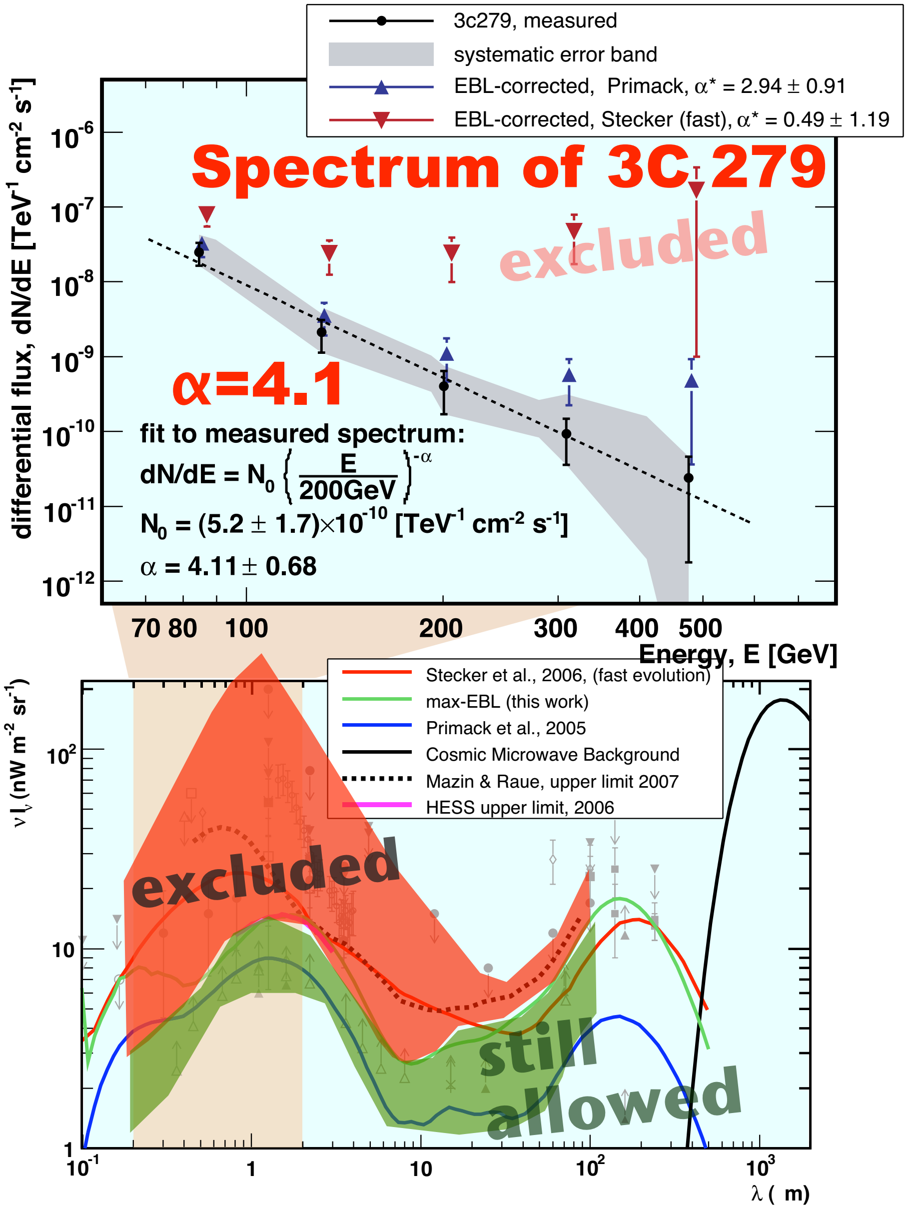
# Measuring the EBL

- Reconstruct intrinsic spectrum using state-of-the-art EBL models:
  - Stecker fast-evol. → α*=0.5±1.2
  - Primack: → α*=2.9±0.9

- Generic acceleration mechanism arguments, e.g. Aharonian+06: Assume α*<1.5 unreasonable
- Formation of hard spectra possible Aharonian+08, Sitarek+Bednarek 08, Liu+08
- Internal absorption in 3C279 does not produce important hardening Tavecchio+Mazin 08

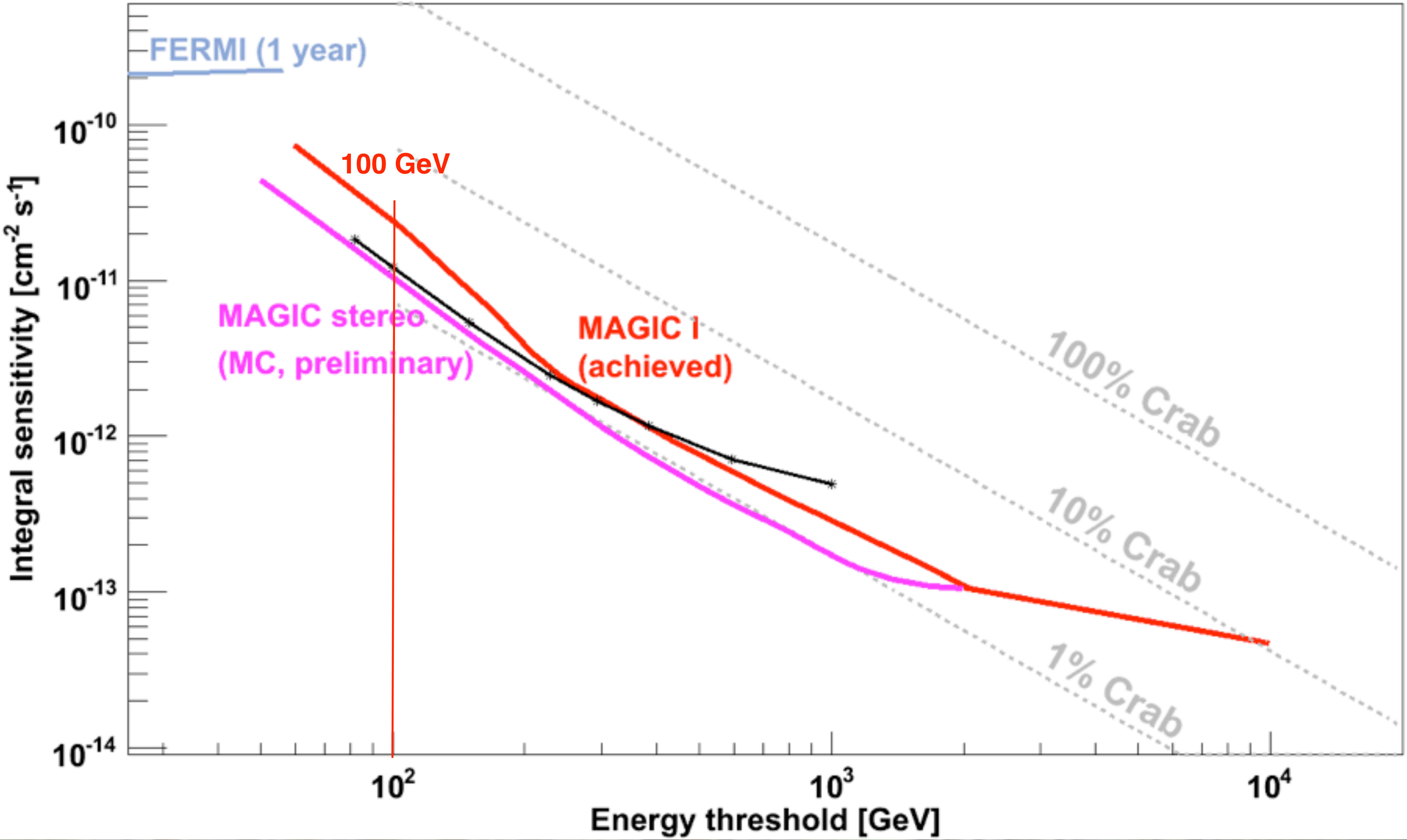
➡ Infer maximum tolerable EBL

➡ Gamma-ray horizon

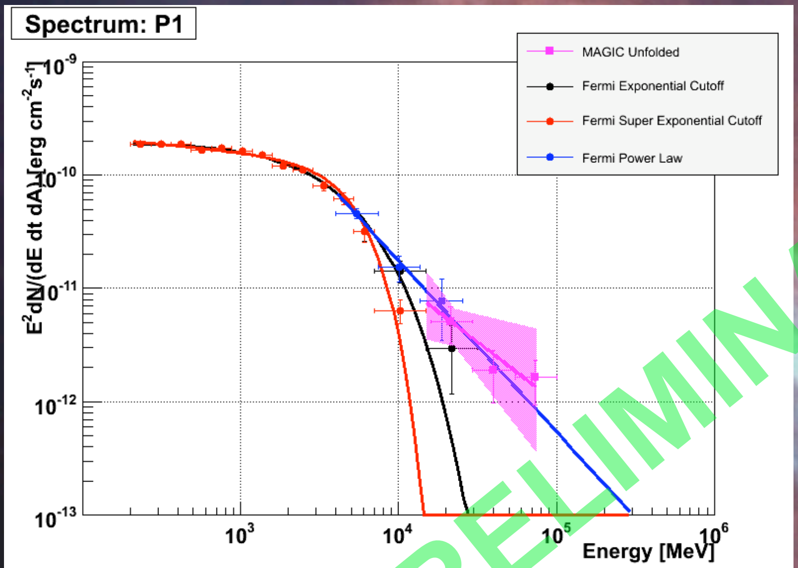


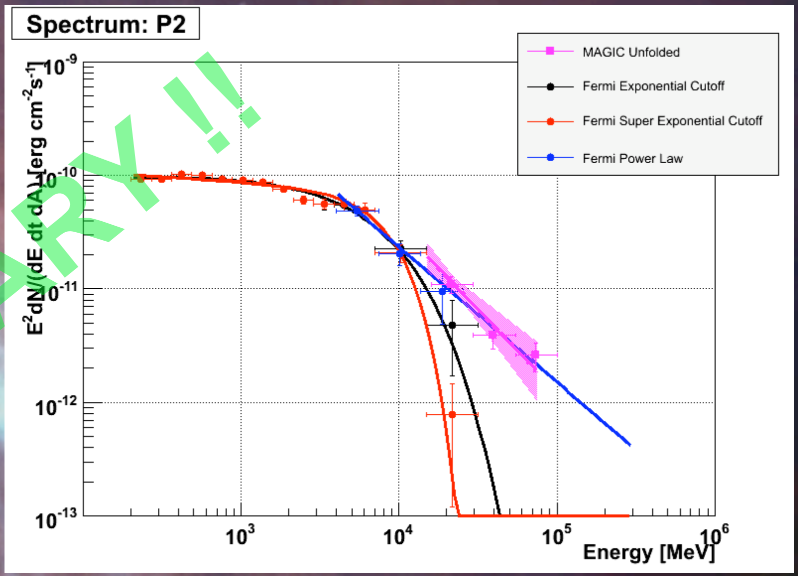

MAGIC Coll., Science 320 (2008) 1752

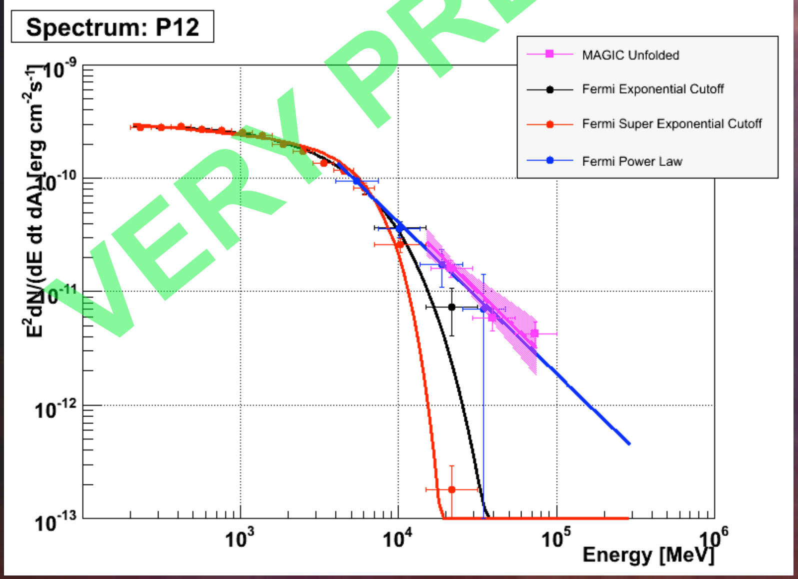
# Already achieved Sensitivity



# Mismatch in energy scale ?
## Cross-calibration to Fermi

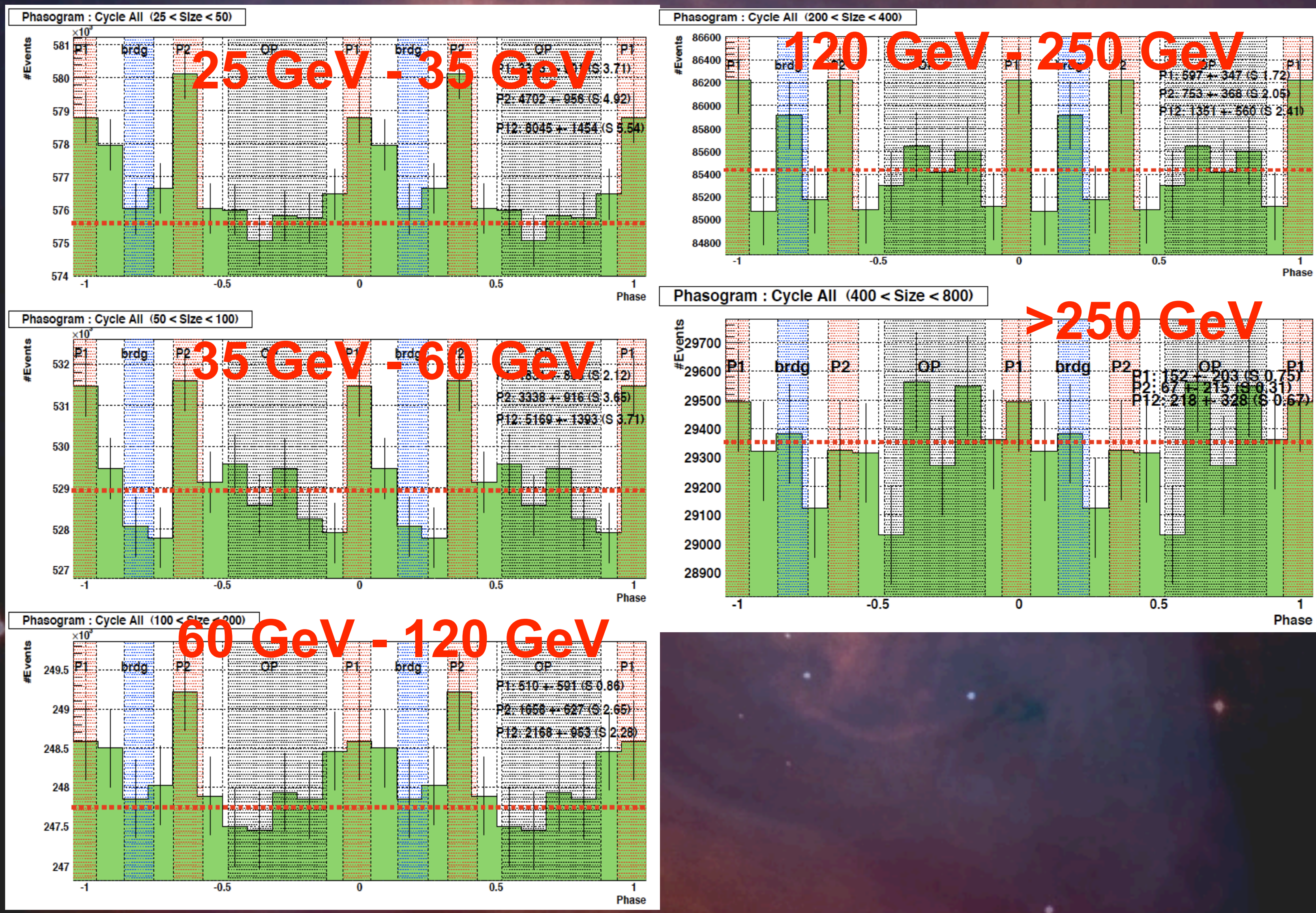


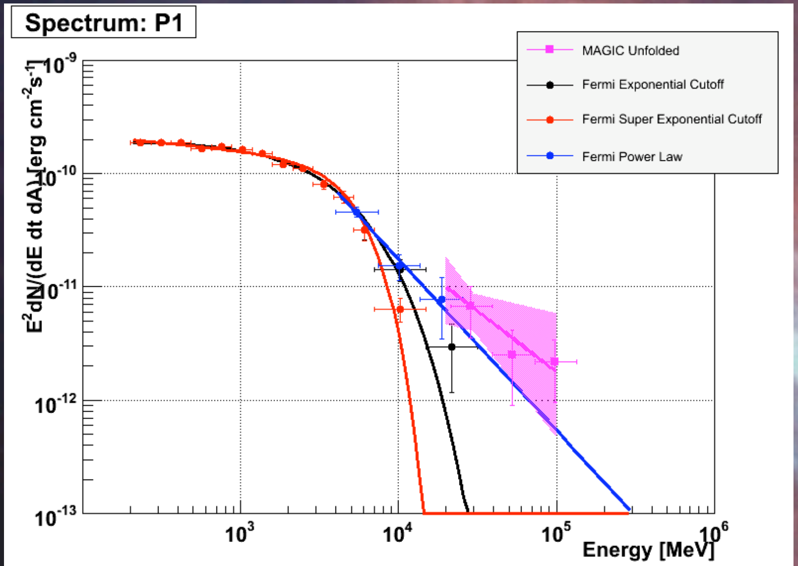



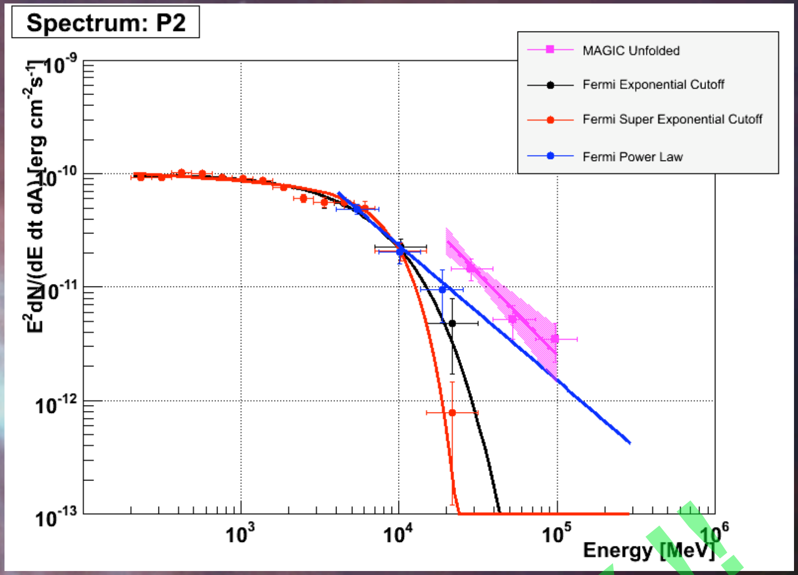

VERY PRELIMINARY !!

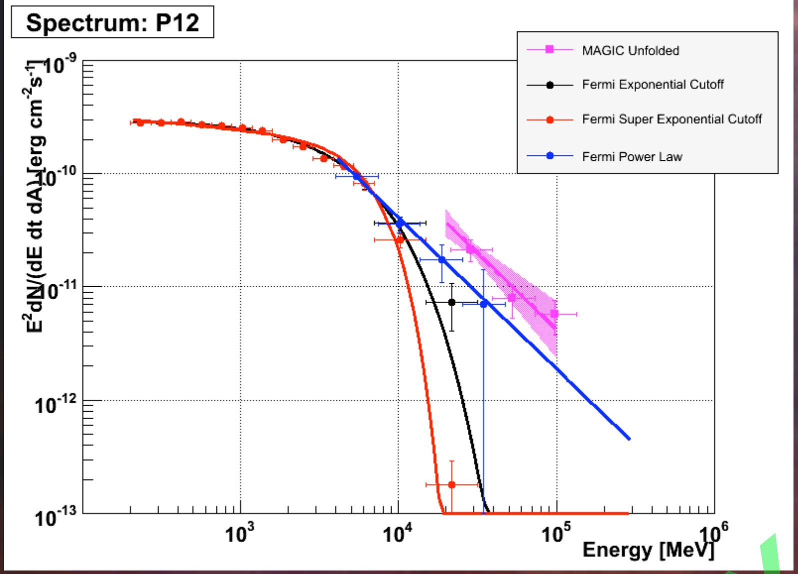
# Emission in different energy bands



# MAGIC spectrum
## (work of Takayuki Saito)

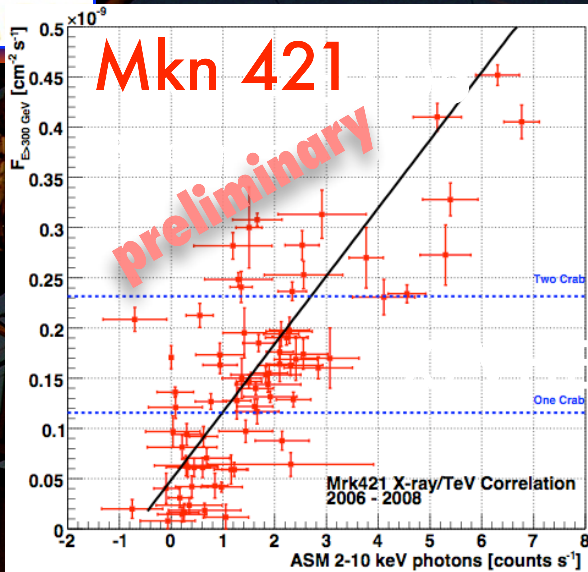


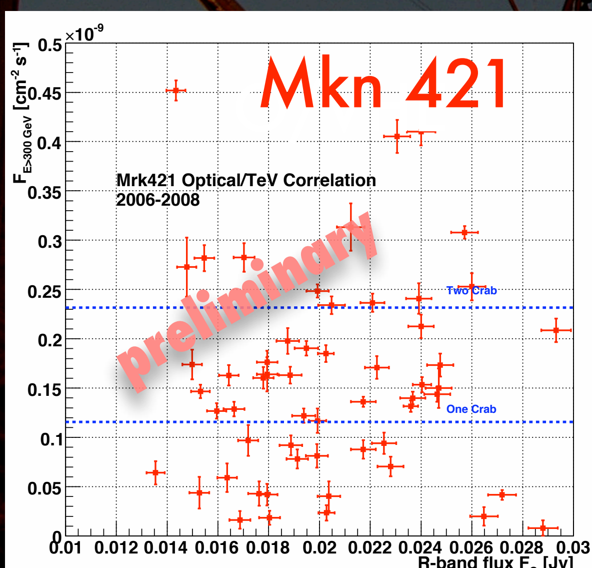



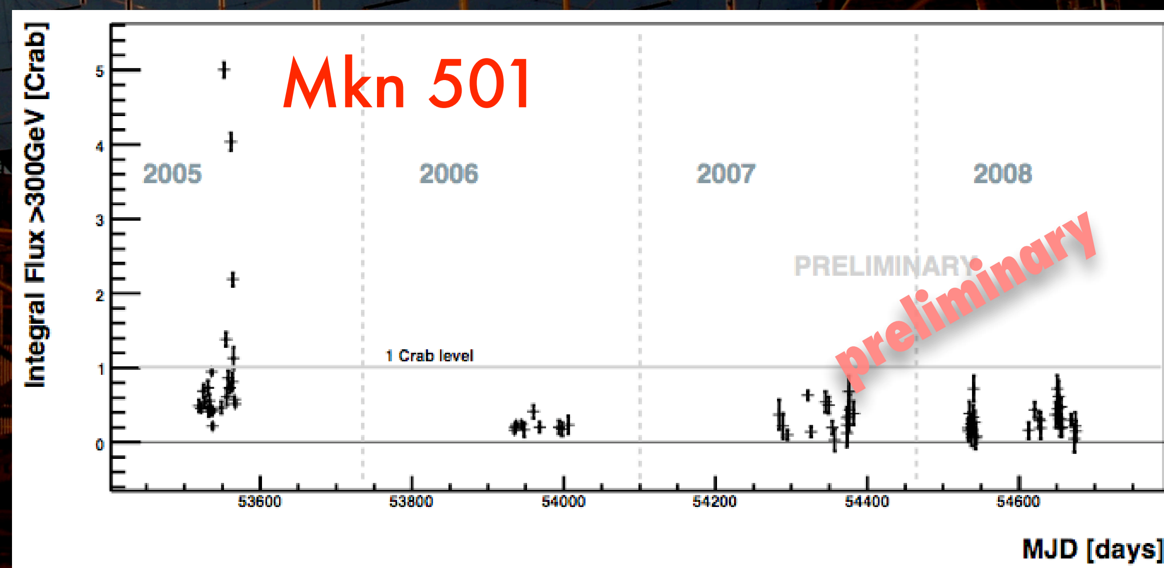

PRELIMINARY !!!

# Bright Blazar Monitoring








Satelecka et al. (MAGIC Collab.), ASP Conf. Ser. in press

Thomas Schweizer , Project Review MPI December 2009