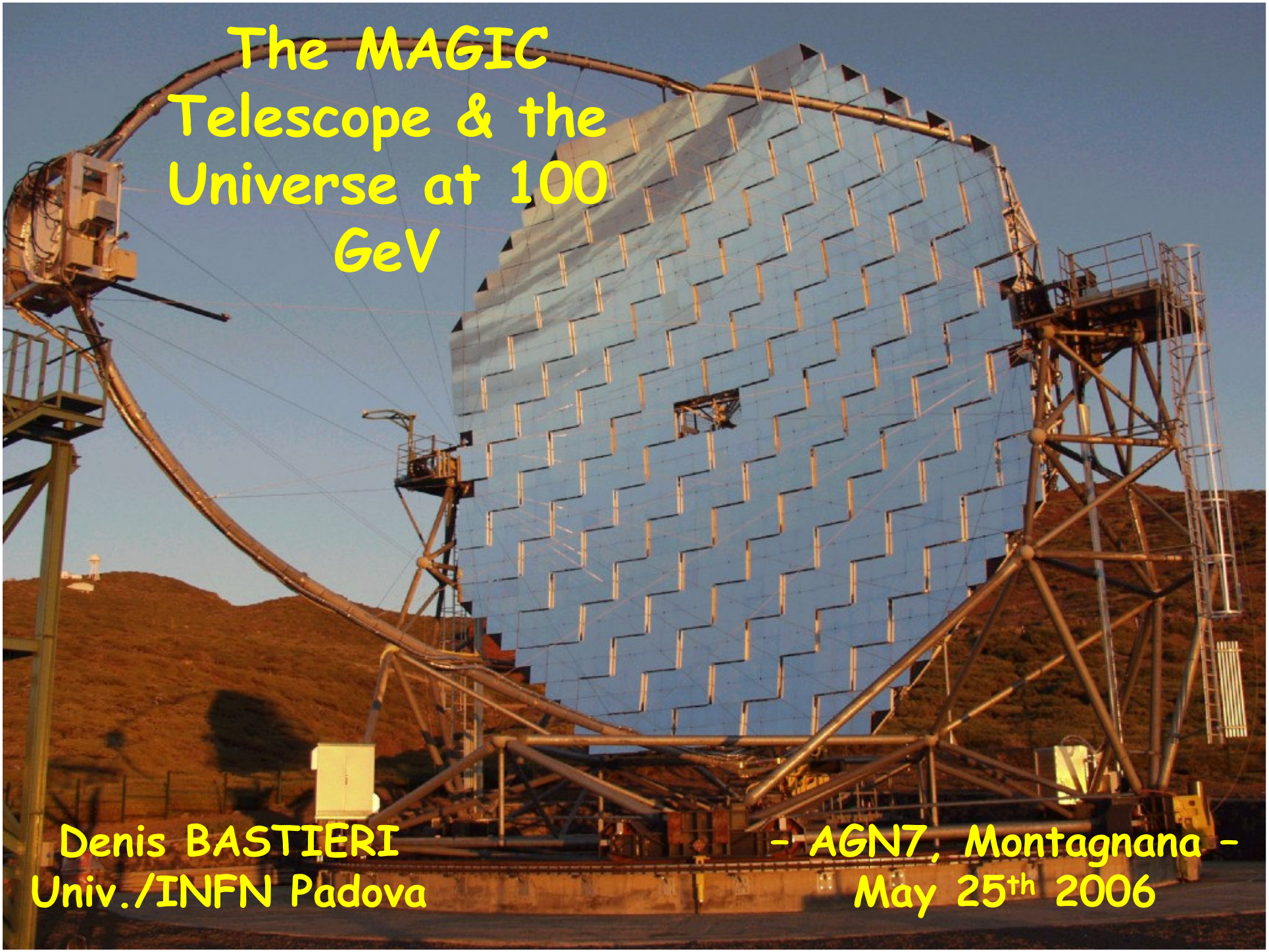

The MAGIC Telescope & the Universe at 100 GeV
Denis BASTIERI
Univ./INFN Padova
– AGN7, Montagnana –
May 25th 2006

Outline

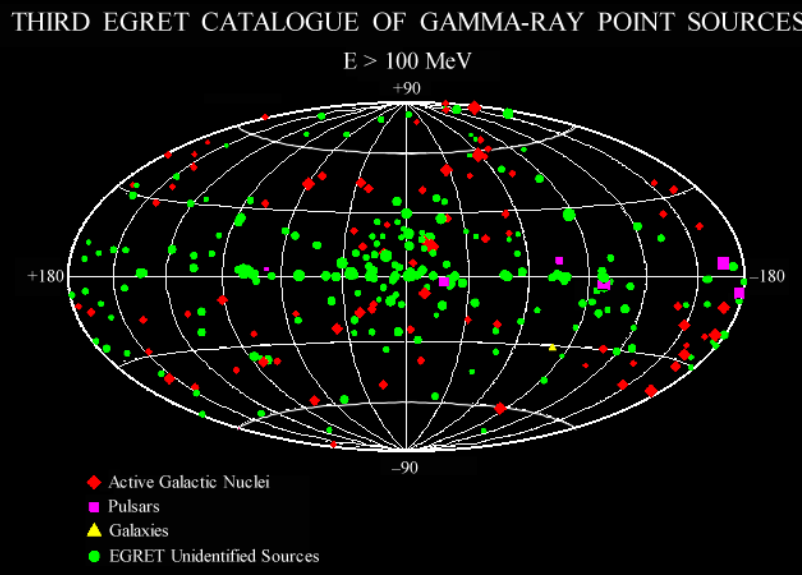
IACT
- the quest for a low energy threshold
- Imaging Atmospheric Cherenkov Technique

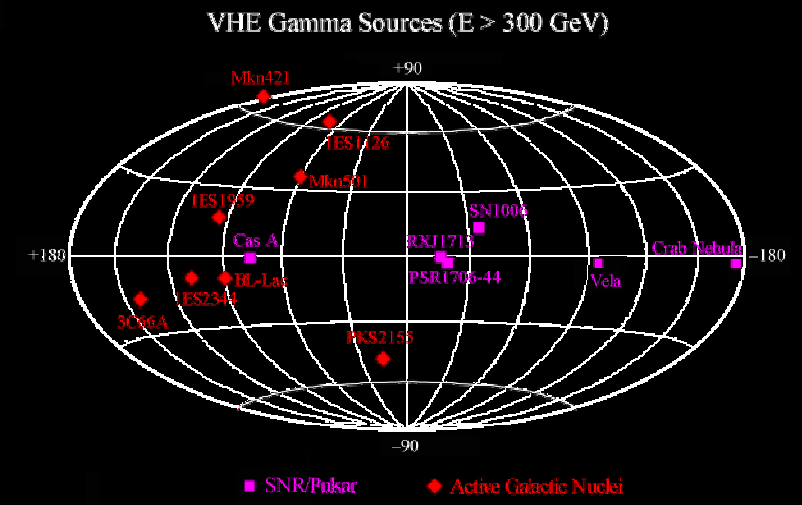
The MAGIC Telescope
- the MAGIC Collaboration
- key building elements

Performances
- standard analysis
- Galactic sources
- Extragalactic sources

Conclusions

The quest for a low energy threshold





- Observations from satellite are below 30 GeV.
- Ground experiments start at ~250 GeV.

⇒ DIFFERENT PICTURE!

?? Intrinsic cut-off?

?? IR/optical/UV absorption?

>>> 171 unid sources <<<

- Lowering E_{th} sheds light on both sources and Extragalactic Background Light (EBL).

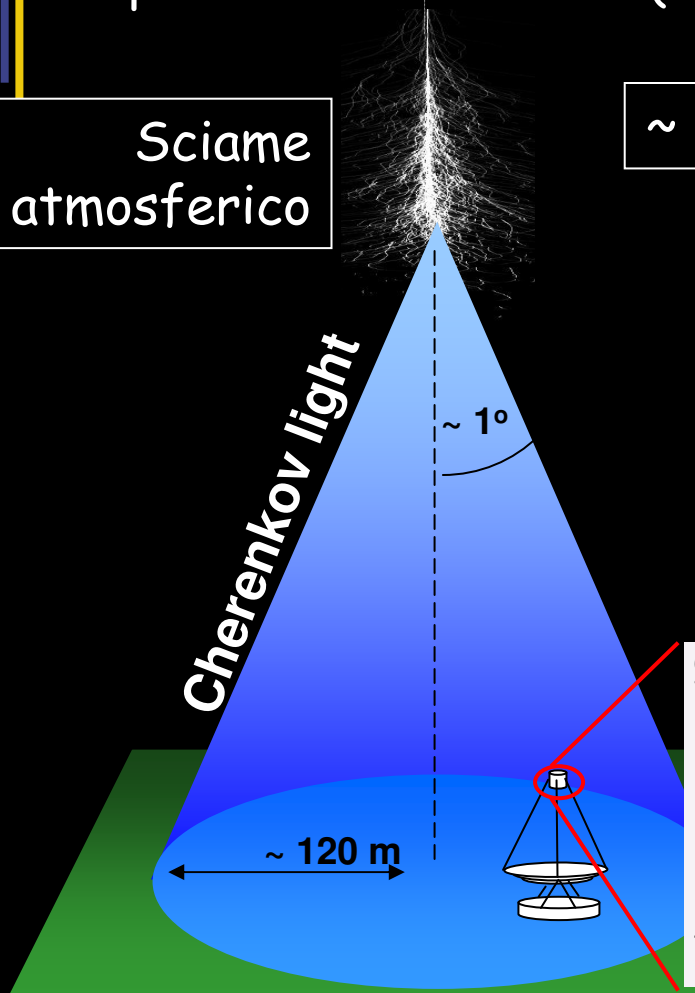
Imaging Atmospheric Cherenkov Technique

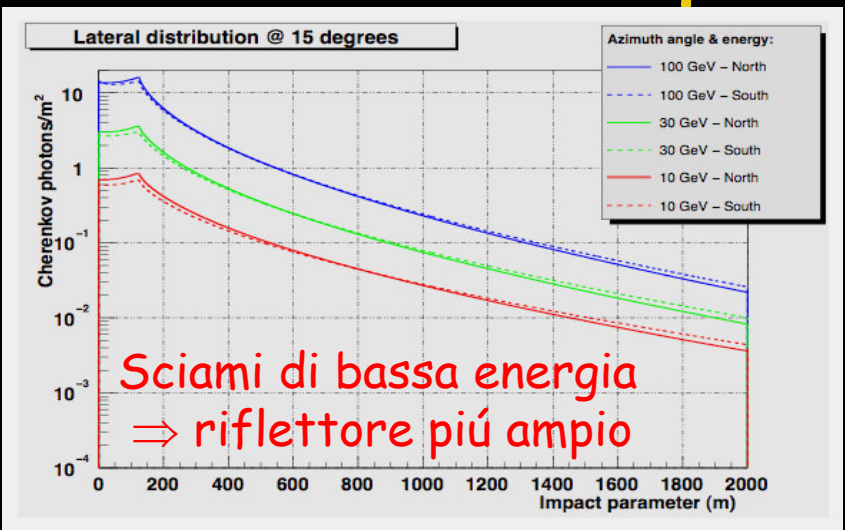
Gamma primario

Satellite (1÷10 m²)

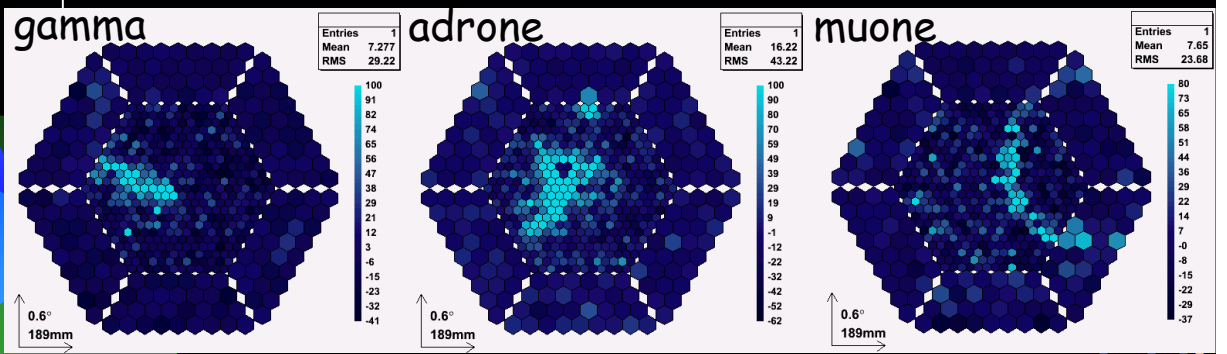
~ 10 km

Sciame atmosferico

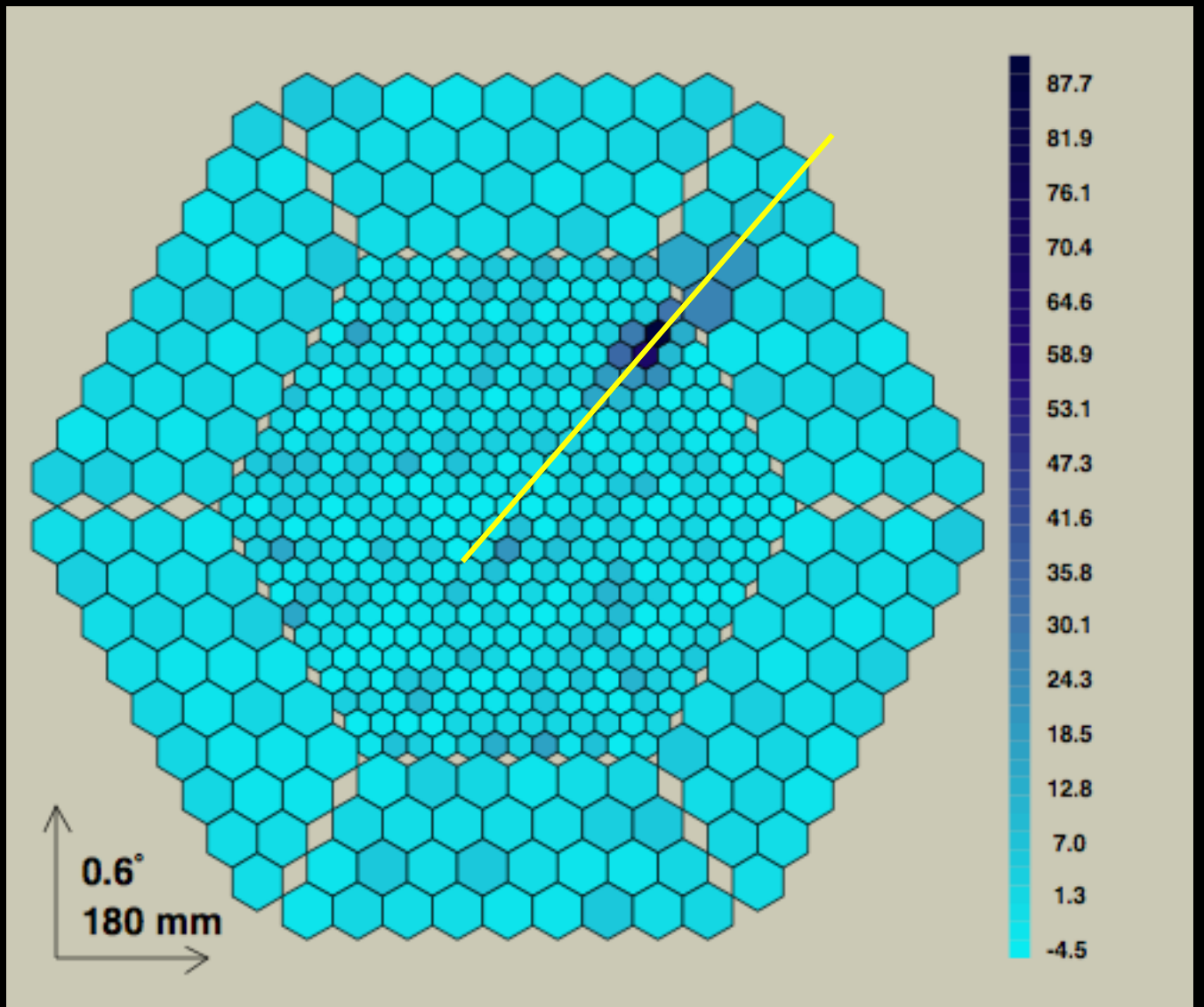




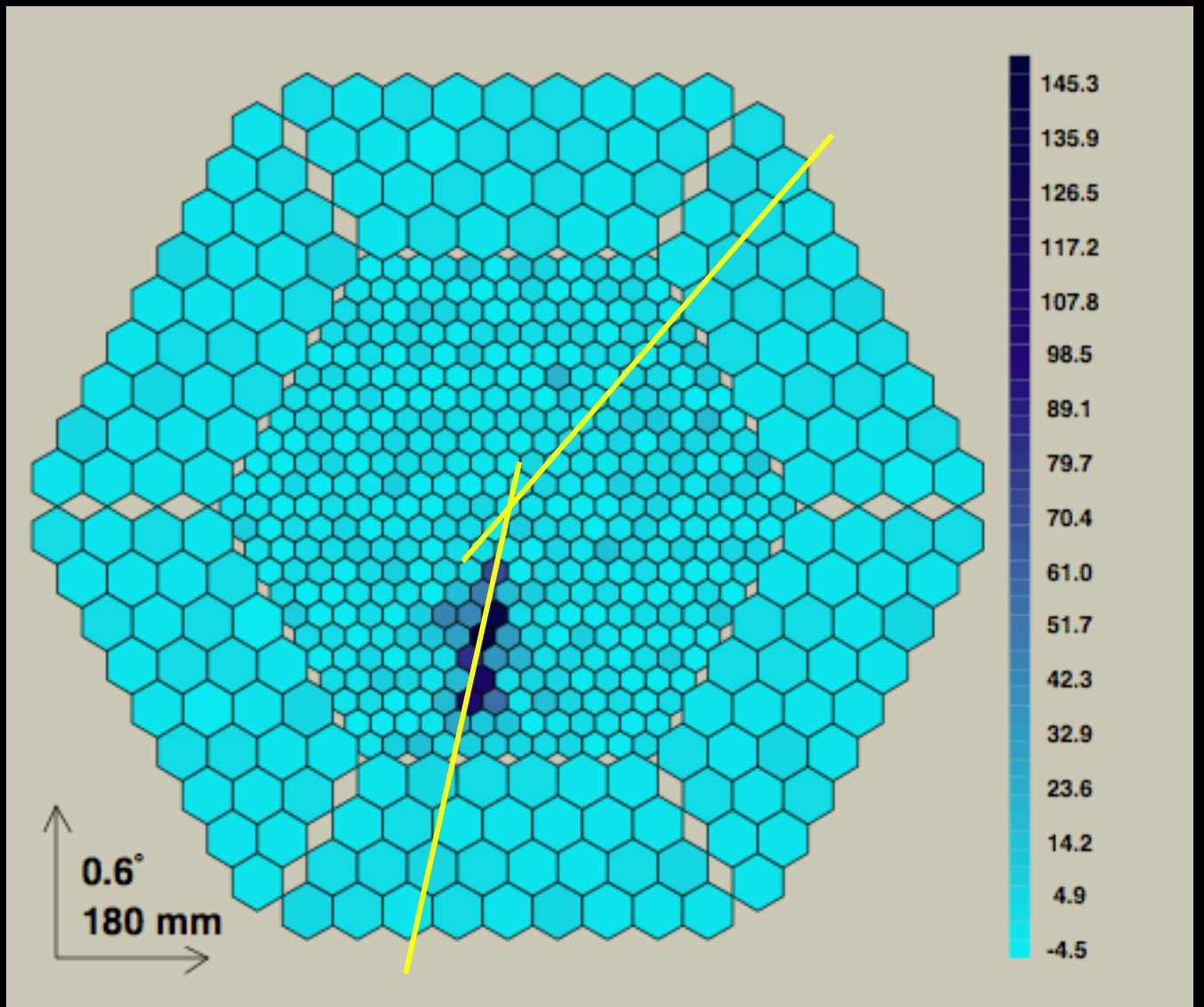
Dall'immagine di uno sciame si può ricostruire: direzione, energia e natura del primario



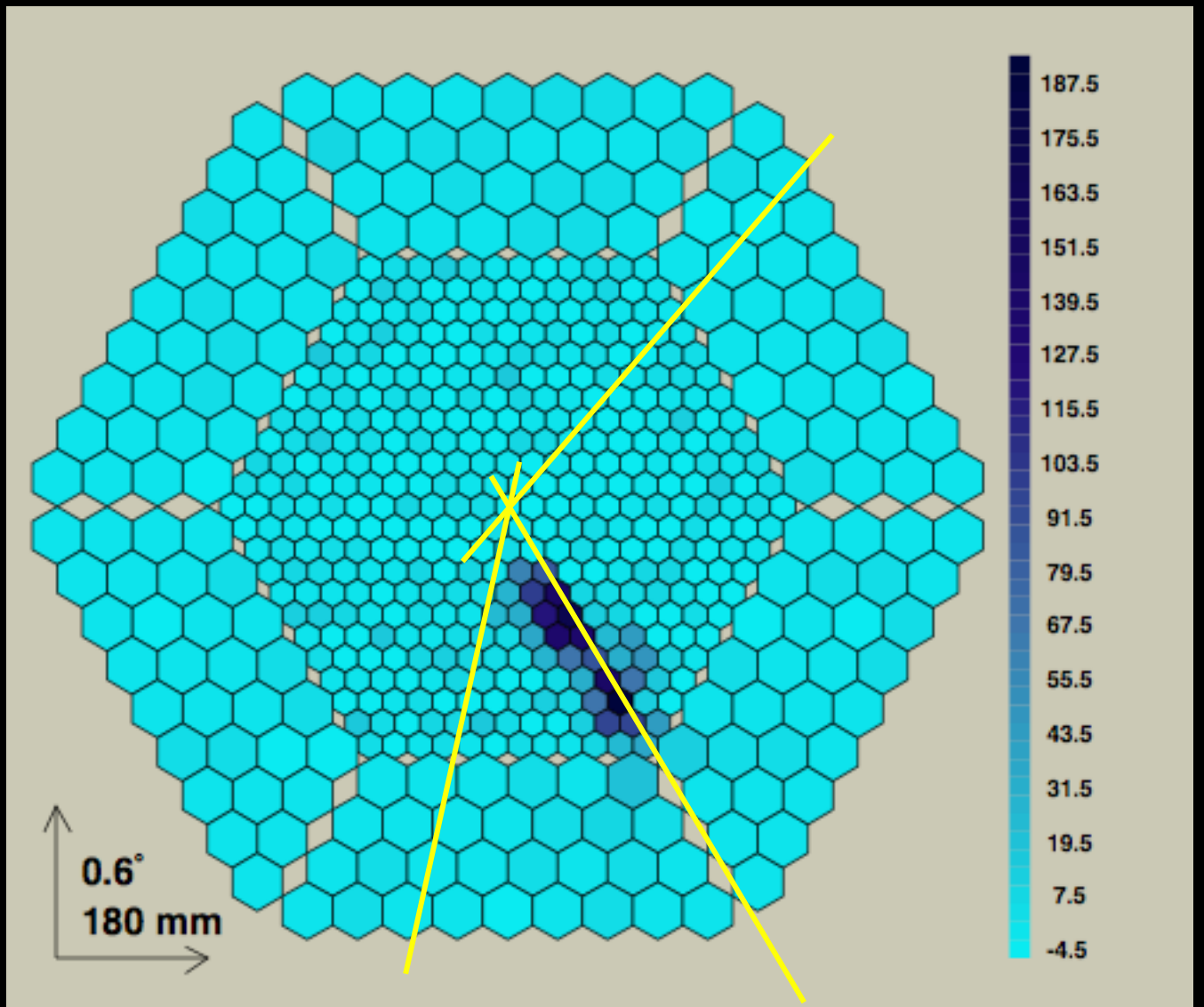
IACT – (MC) E = 38 GeV, b = 130 m



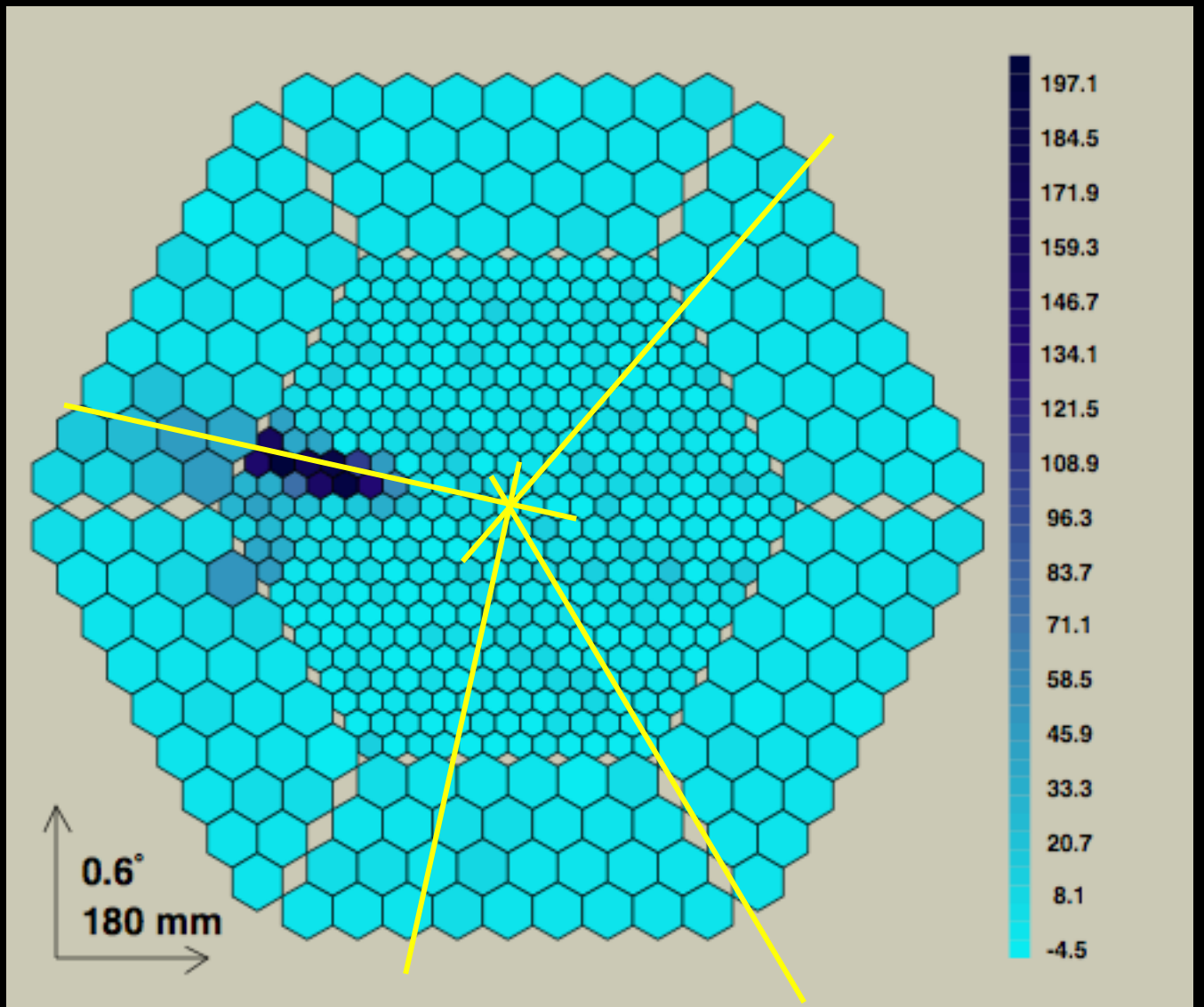
IACT – (MC) E = 76 GeV, b = 100 m



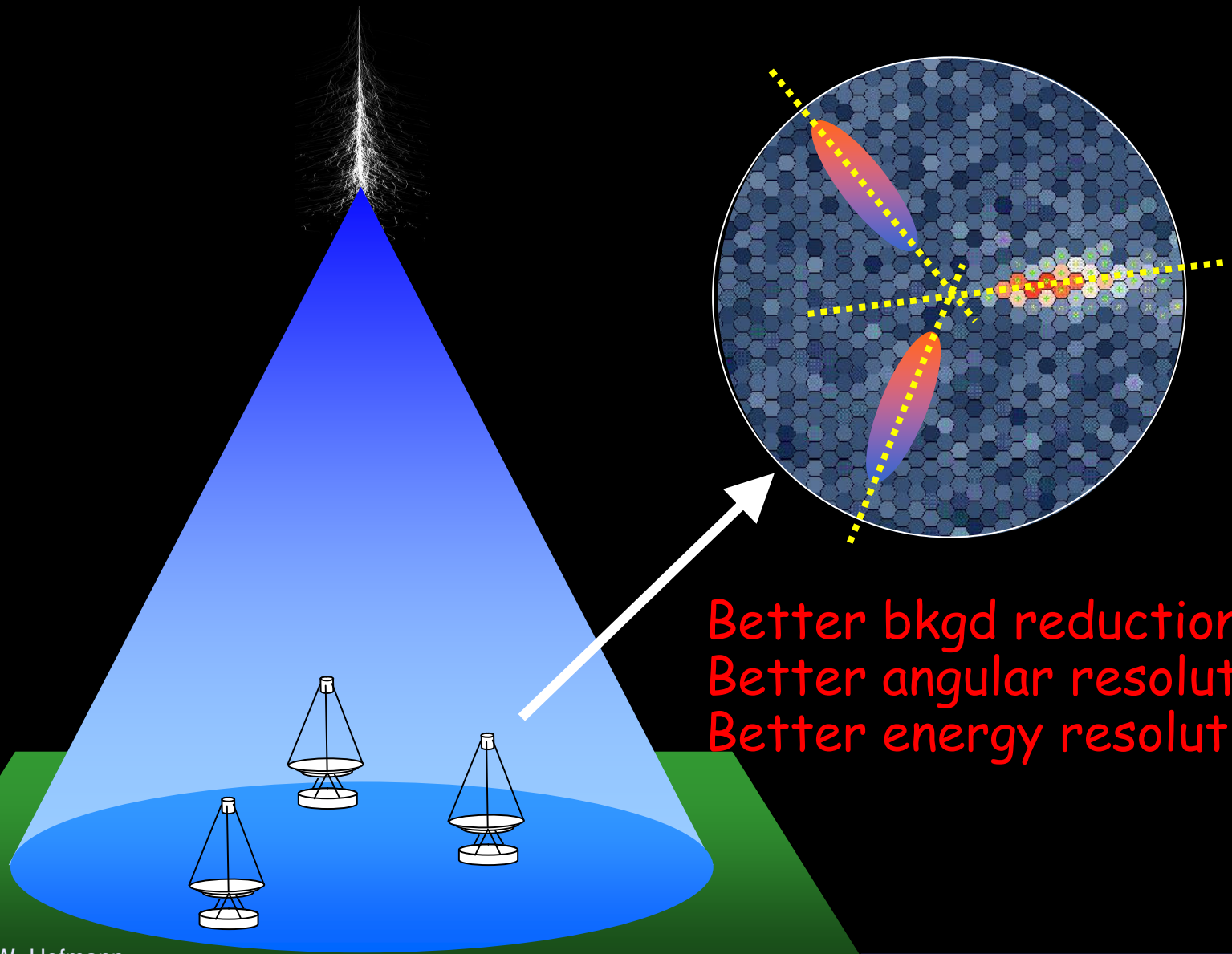
IACT – (MC) E = 120 GeV, b = 107 m



IACT – (MC) E = 286 GeV, b = 119 m



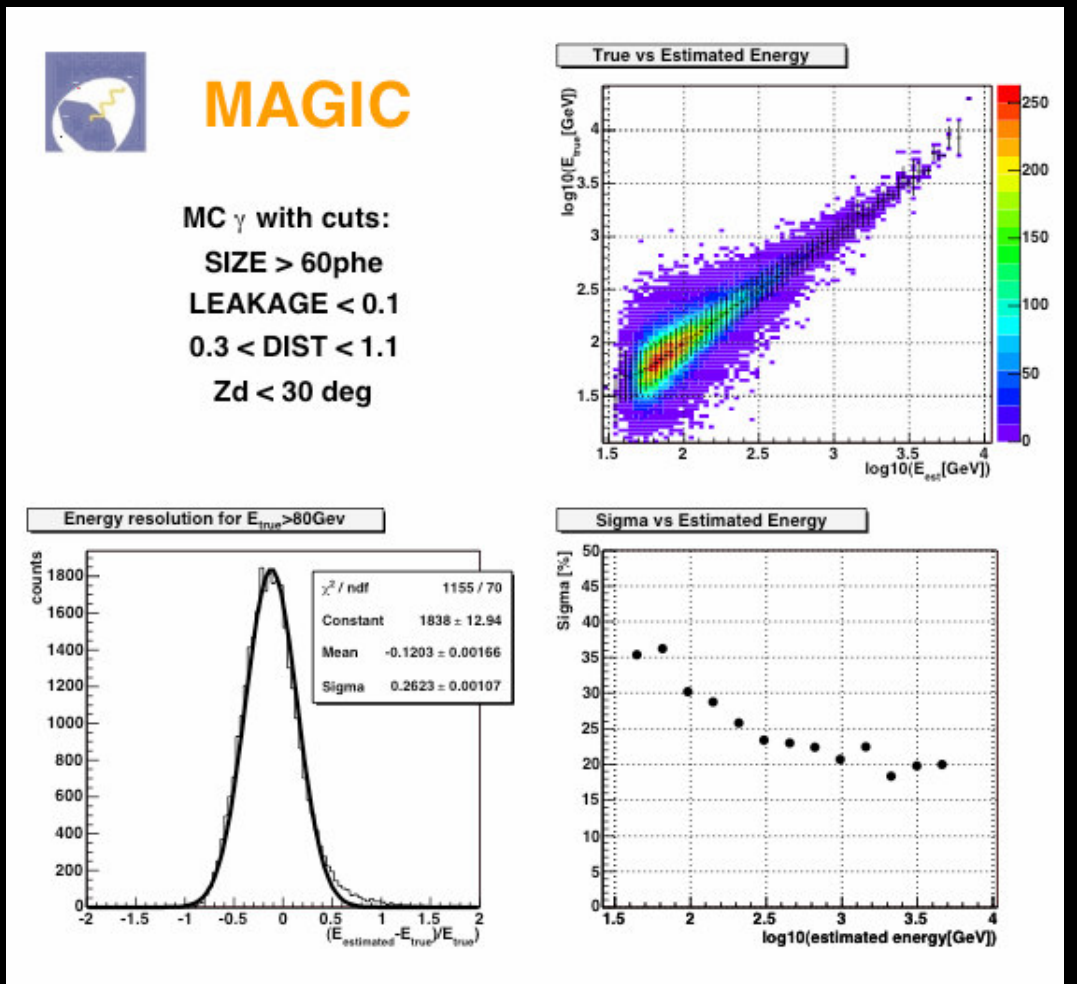
IACT – System of Cherenkov telescopes



Better bkgd reduction
Better angular resolution
Better energy resolution

Slide from W. Hofmann

IACT – Energy resolution



- The simpler estimator is **SIZE** (total number of ph/e)
- Better estimate introducing other image parms
- Optimisation via Random Forest
- 20% @ 1 TeV
  30% @ 100 GeV

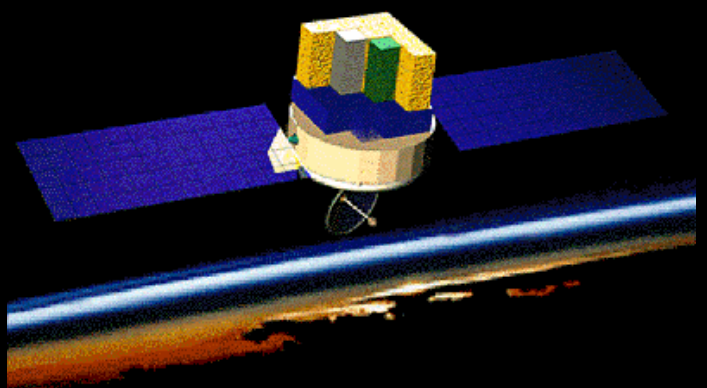
IACT – Satellites & Cherenkov

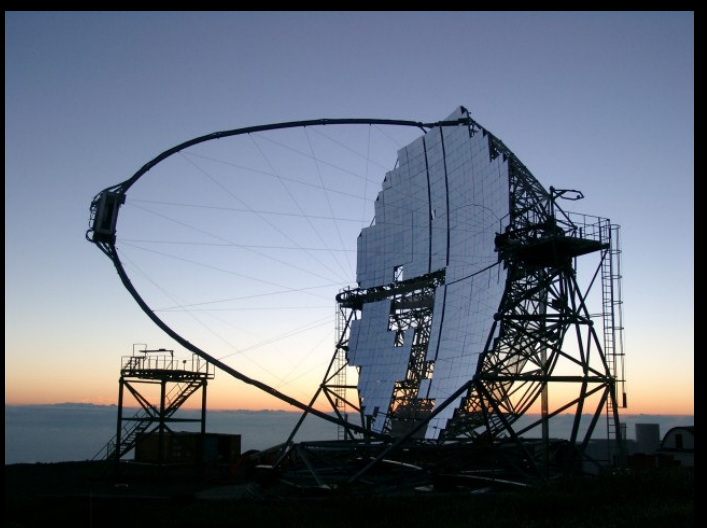
Satellite experiments

- **Primary detection.**
  - Test beam.
  - Low background.
- Energy $\lesssim$ 300 GeV.
- Effective area ~ m^2
- Duty-cycle ~ 100%.
- Field of view ~ 1 sr.
- High cost.

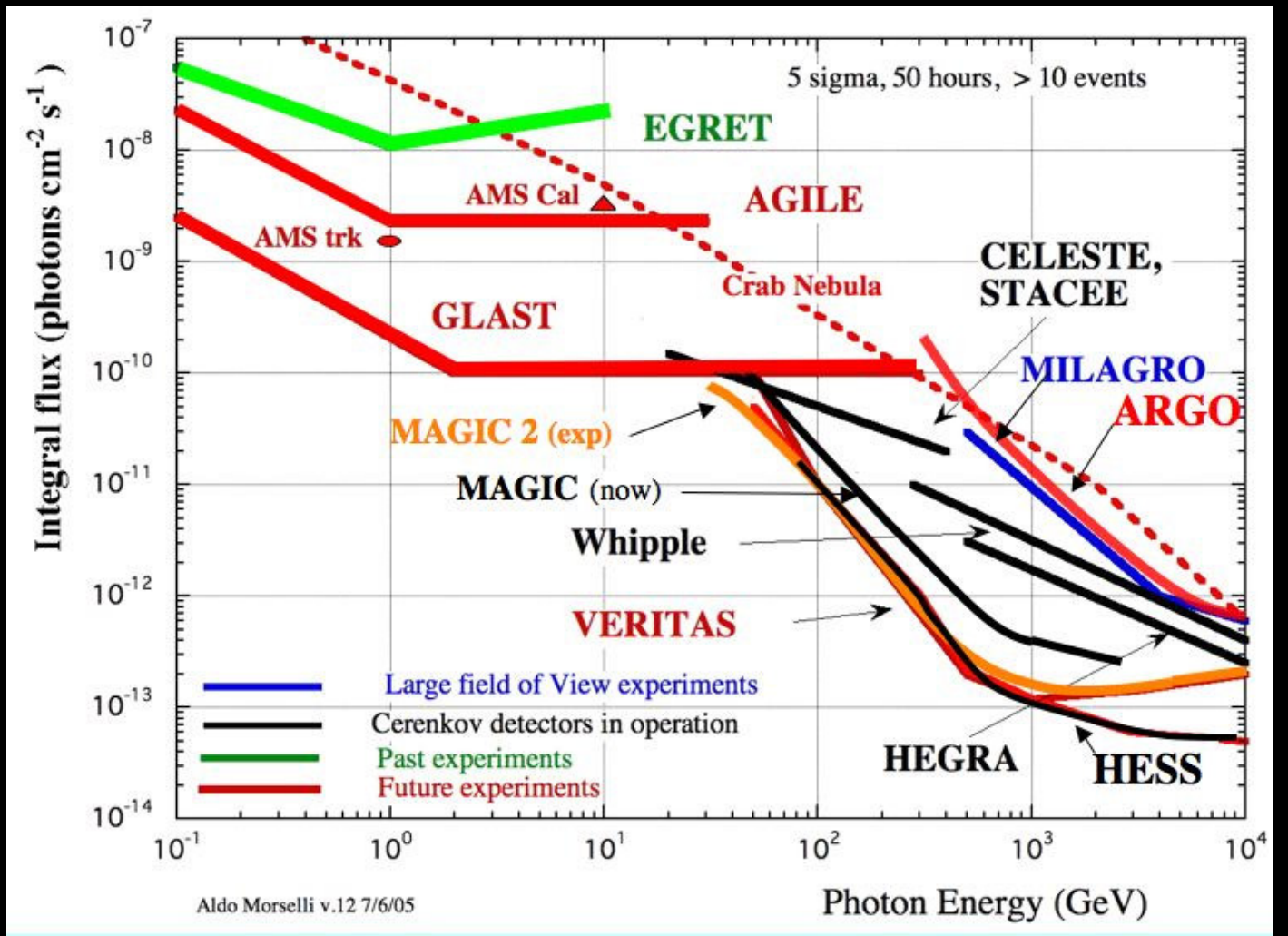
Cherenkov experiments

- **Secondary detection.**
  - Strong MC dependence.
  - High background.
- Energy > 60 GeV.
- Effective area ~ $10^{4\div5} m^2$.
- Duty-cycle ~ 20%.
- Field of view ~ 0.01 sr.
- Low cost.





IACT – Overall flux sensitivity



Cross calibration GLAST/MAGIC

Crab spectrum changes dramatically @ 100 GeV
The spc. feature – det. by GLAST - used to calib. MAGIC
⇒ **reduction of absolute scale uncertainty (15÷30%)**

Crab @30÷300 GeV seen by GLAST in 1st yr (survey mode)
E_{brk} fitted assuming the actual E resln. of GLAST

DB et al.
ApPhys 23 (2005)

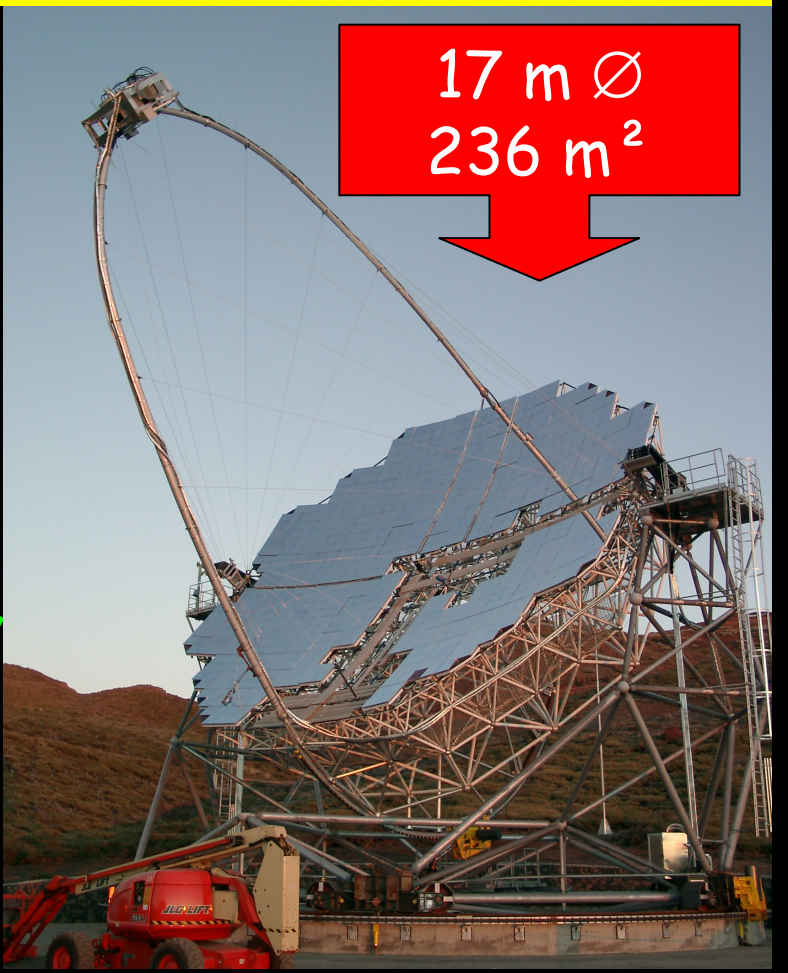
- 90% efficiency
- South Atlantic Anomaly
- Data downlink failures
- Scheduled maintenances

E_{brk}	#phot seen by GLAST	$\delta E_{brk}/E_{brk}$		
		GLAST	MAGIC	MAGIC ⊕GLAST
50	3763	6.2%	40%	26%
100	3249	8.2%	37%	22%
150	2988	12.7%	35%	22%
200	2818	17.2%	34%	24%

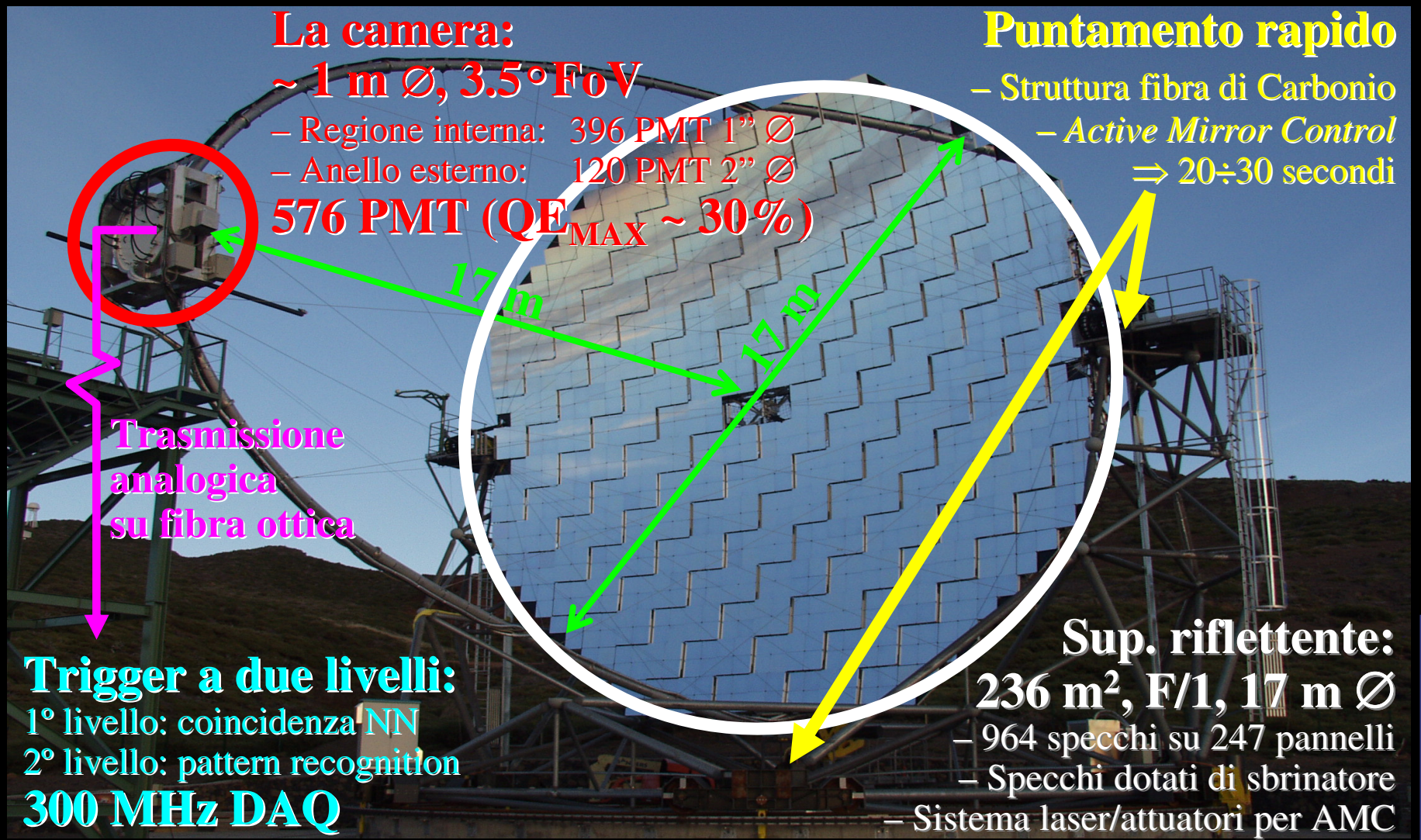
MAGIC – La Collaborazione

IFAE Barcelona, UAB Barcelona, UCM Madrid, MPI München, U. Würzburg, HU Berlin, U. Dortmund, INFN/U. Padova, INFN/U. Siena, INFN/U. Udine, UC Davis, ETH Zürich, U. Lodz, INR Moscow, Tuorla Obs, Yerevan Ph. Inst., CrAO, U. Sofia.

- Scopo: studio sorgenti γ nella banda inesplorata: 30÷250 GeV
- Importanti traguardi tecnologici: piú grande riflettore, trigger topologico, stabilità meccanica e nuova elettronica.
- MAGIC è stato progettato per: bassa soglia energetica ~ 30 GeV puntamento rapido $\lesssim$ 30 sec.
- 18 istituti, 11 nazioni: > 100 fisici.

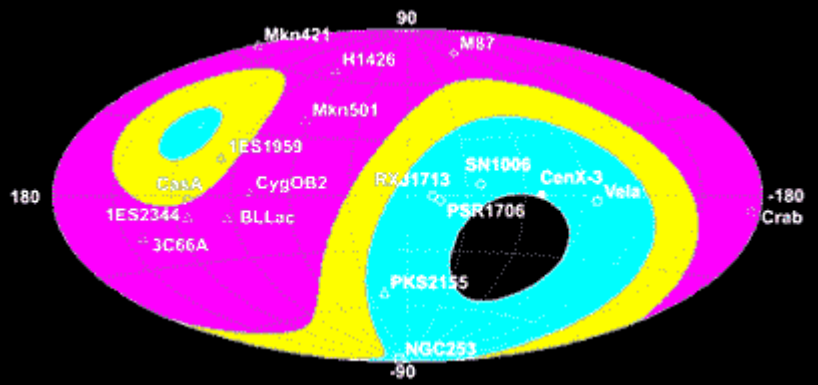


MAGIC – Una visione d'insieme



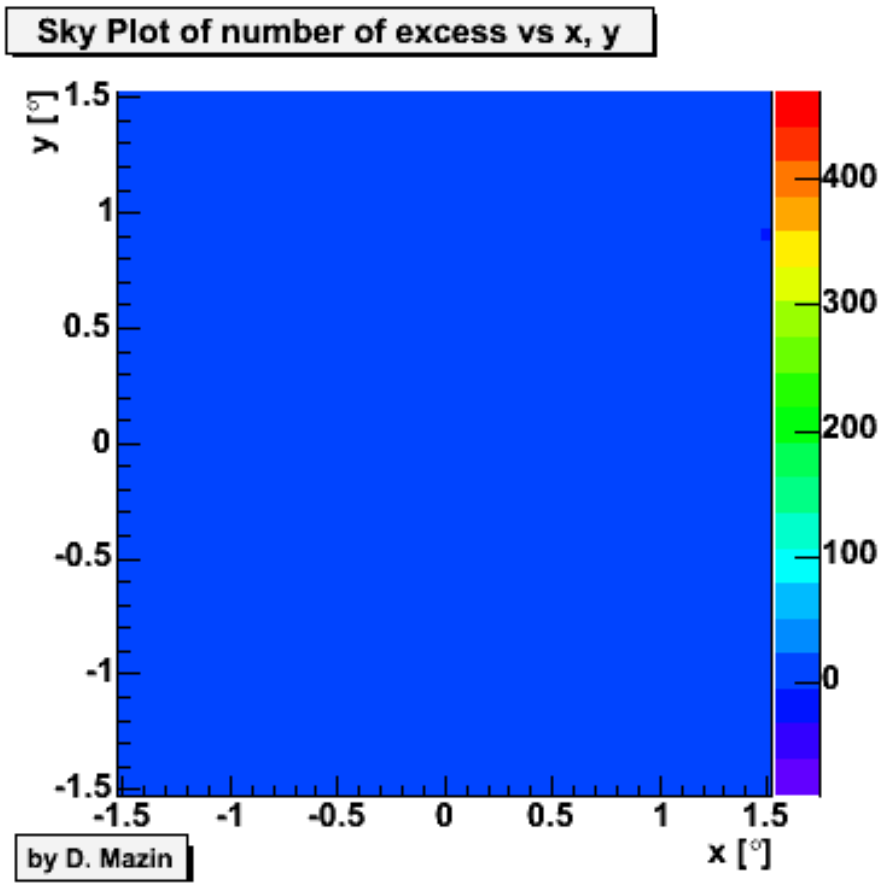
MAGIC – Le osservazioni

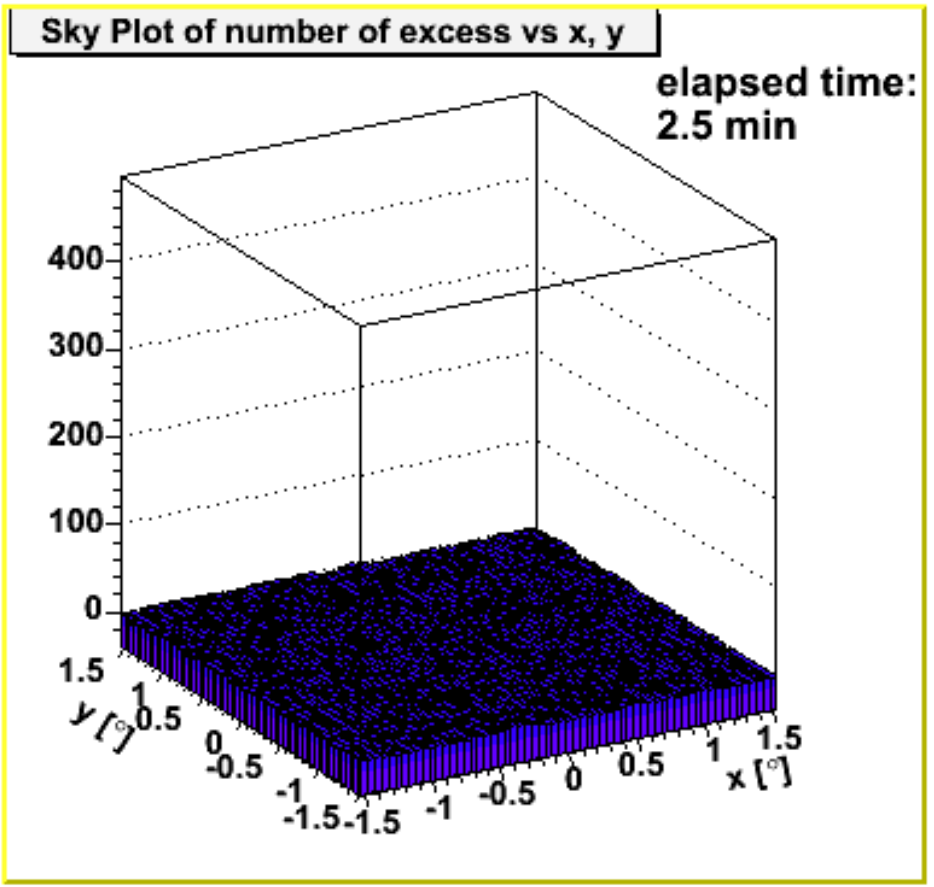
- Molti run sulla Crab
  - » Sistematiche ancora incerte (Nebula sotto i 100 GeV)
- Molti run su Mkn421/501
  - » Orphan flare?
  - » ToO, osservazioni congiunte e multiwavelength
- μQSO (LS I +61 303)
  - » Nuova classe di sorgente VHE
  - » Sorgente variabile!
- Centro Galattico
  - » Osservazione ad alto ZA (>58°)
- Osservazione di GRB
  - » Sviluppo di una procedura completamente automatica per una risposta rapida ai ToO. Vedi osservazione GRB050713a
- Altri oggetti
  - » Extragalattiche: 1ES1959 @0.11 Crab, 1ES1218+304
    Galattiche: HESS1813-178, HESS1834-08



Crab signal in few hours of MAGIC data

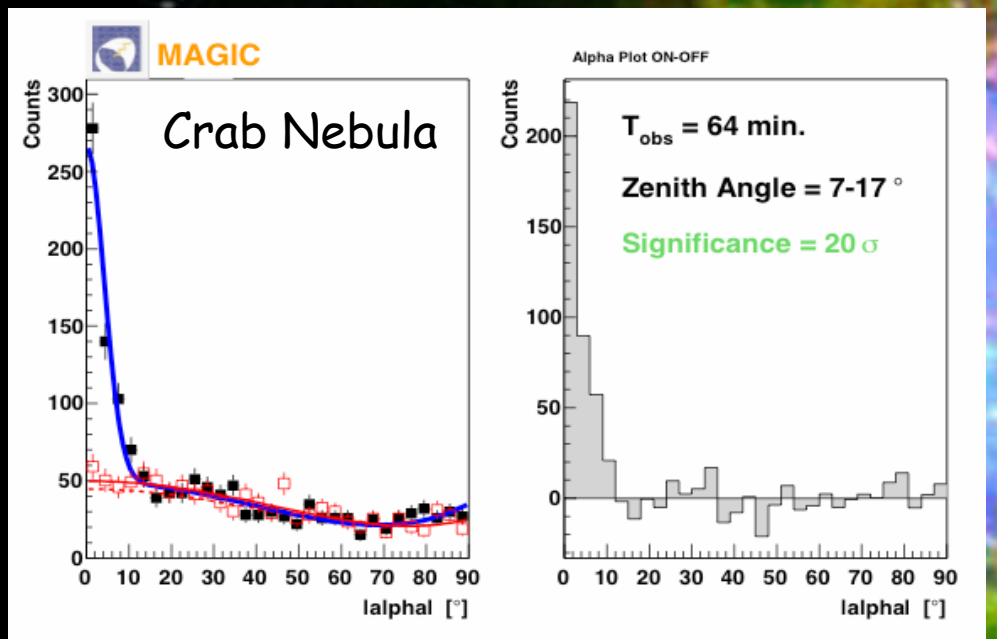
γ event rate: ~1 Hz, after hadron rejection: ~0.5 Hz

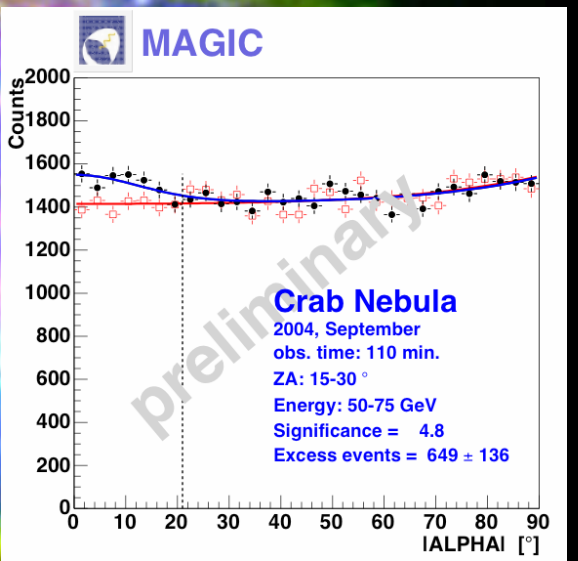




MAGIC - La Crab: candela standard

Sorgente forte e stabile di γ GeV/TeV (Whipple '89).
Candela standard per tutti gli esperimenti di gamma astronomia





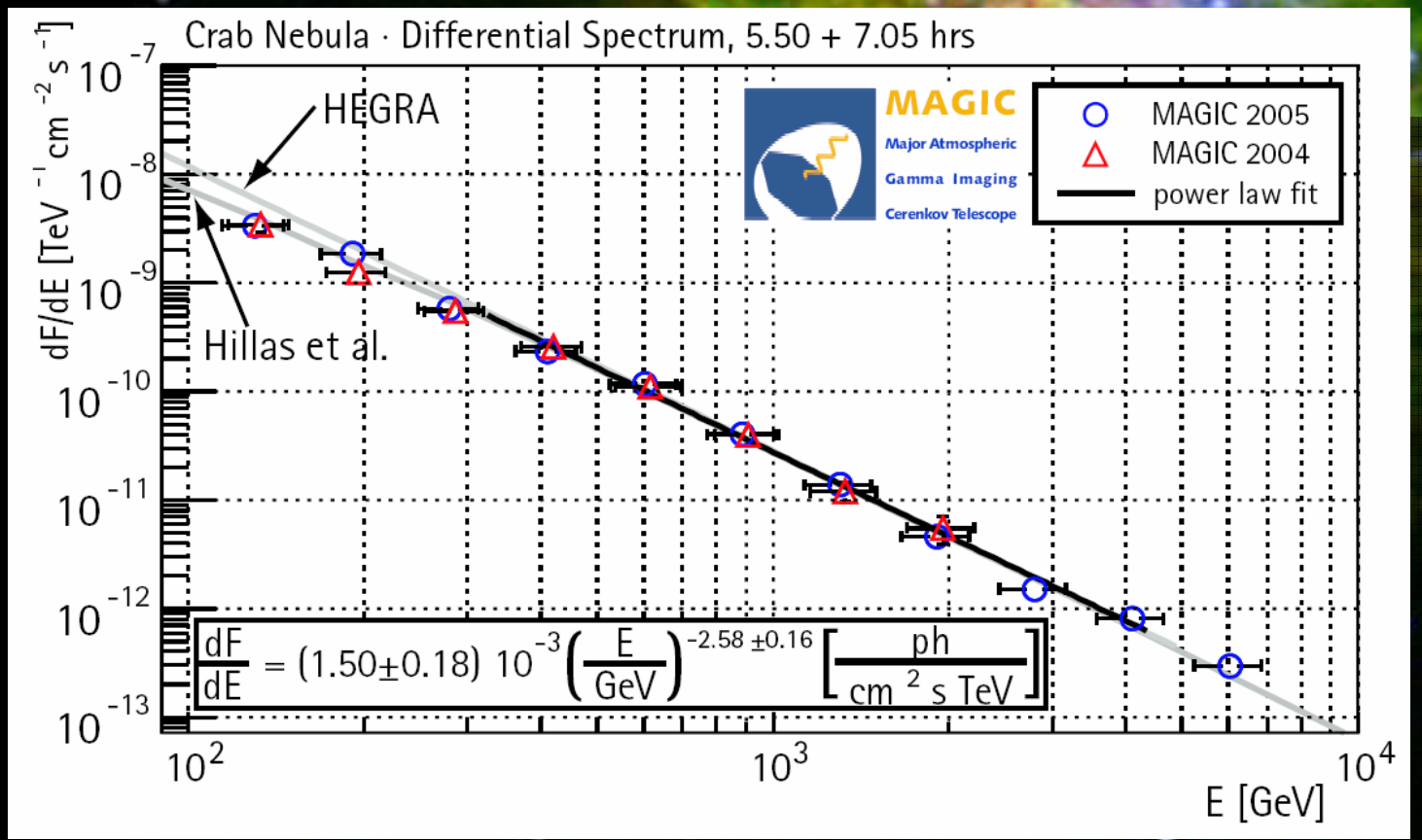
$$\text{Li-Ma}: \quad 20\sigma \times \sqrt{\text{Time(h)}}$$

3% Crab a 5σ in 50 ore

Sotto i 100 GeV serve piú tempo di osservazione. In 2 ore, comunque, è stato osservato un segnale significativo nel bin 50÷75 GeV.

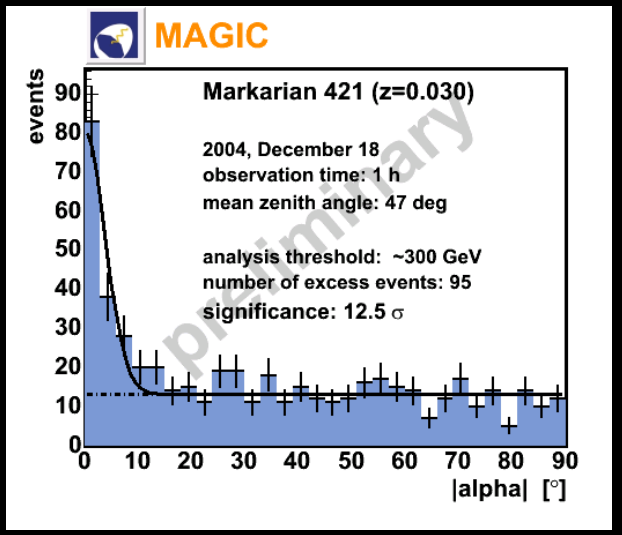
MAGIC – La Crab: spettro energetico

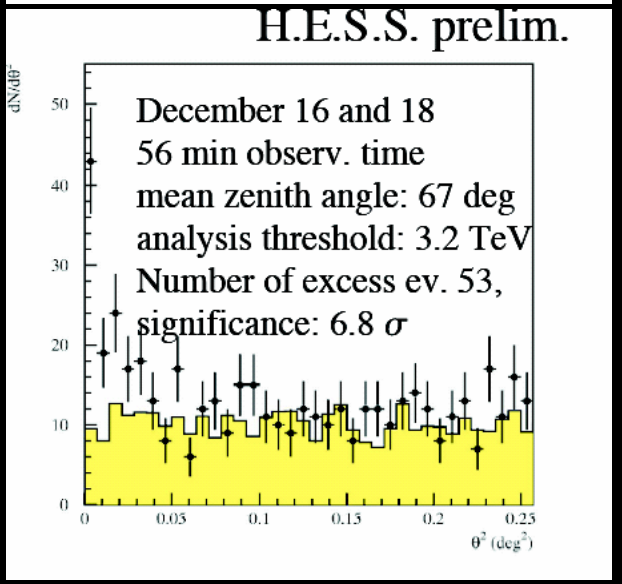
Verso il picco del Compton inverso



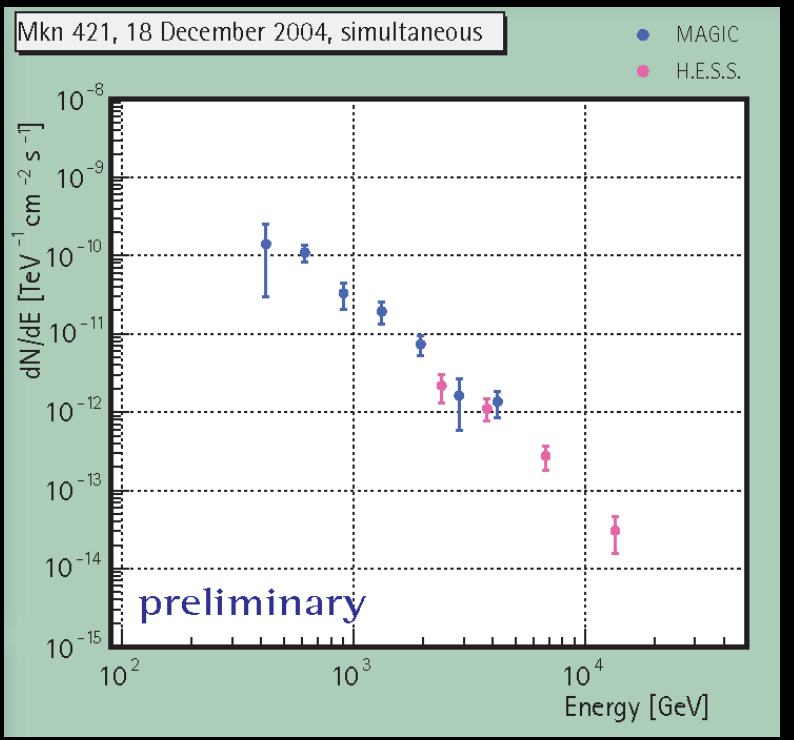
Ancora qualche dubbio sugli errori sistematici sotto i 100 GeV

MAGIC - Mrk421 (z=0.030)





- Dicembre 2004: flare osservato da RXTE
- Flusso ~ 1 Crab @ 300 GeV- (14 ore, >40σ)
- 18/12/04: Osservaz. simultanea con HESS
  - Mutua calibrazione
  - ZA diversi ⇒ diverse energie

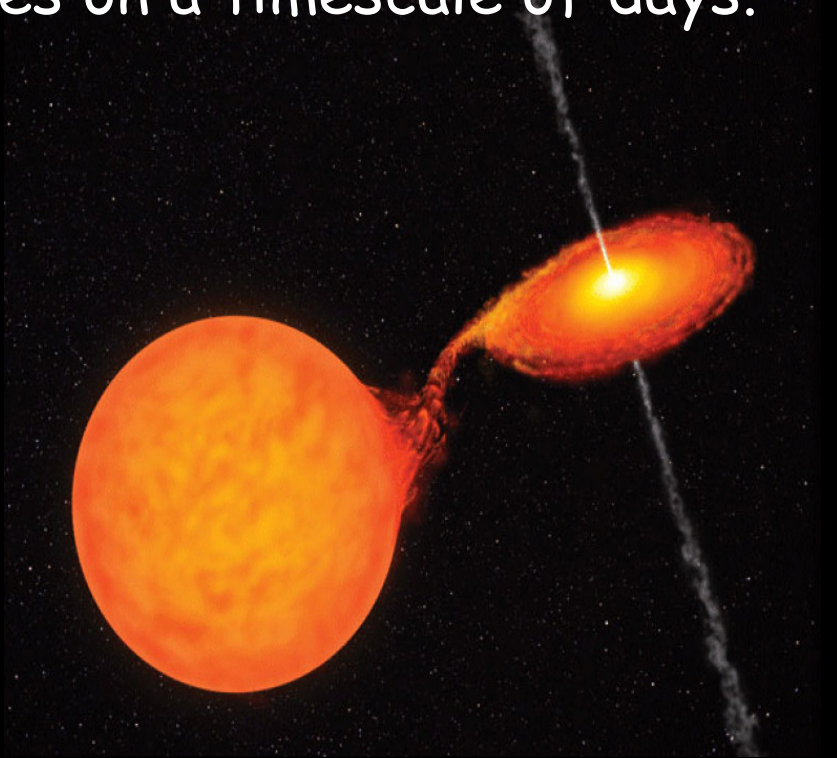


MAGIC – μQSO LS I +61 303

A compact object (BH/NS) orbiting around a massive star. The star "powers" the accretion disk of the compact object. Scaled down version of QSO, very helpful to study jet dynamics, that for μ**QSO** evolves on a timescale of days.

- Matter falling into the compact object is ejected via relativistic jets.
- LS I +61 303:
  a NS orbiting around the massive star every 26 days.

J. Albert et al. (MAGIC)
Science 18/5/2006



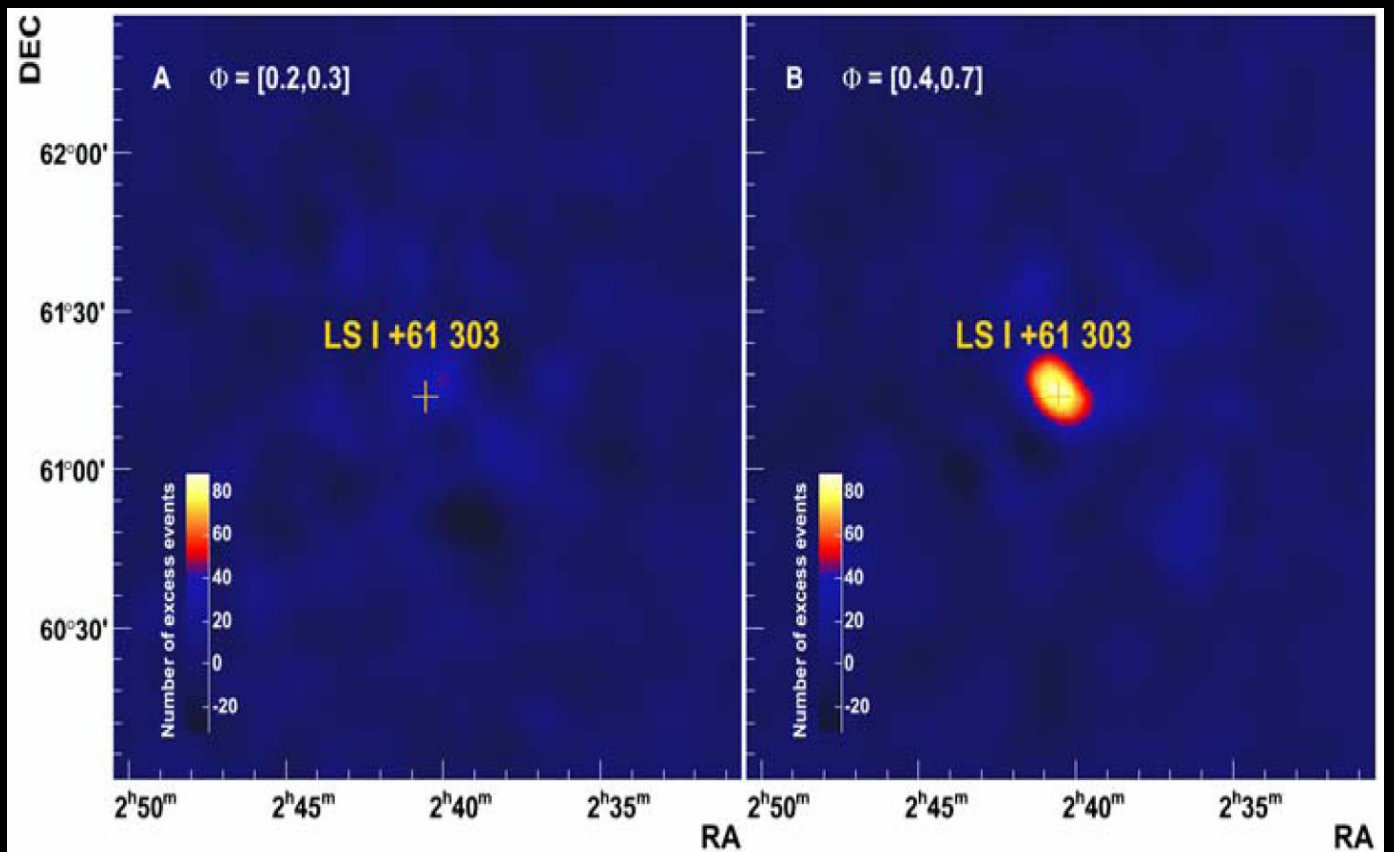
MAGIC – μQSO LS I +61 303 (data)

Observed between Oct. 2005 and March 2006

Left: near periastron

Right: 1/3 of an orbit away

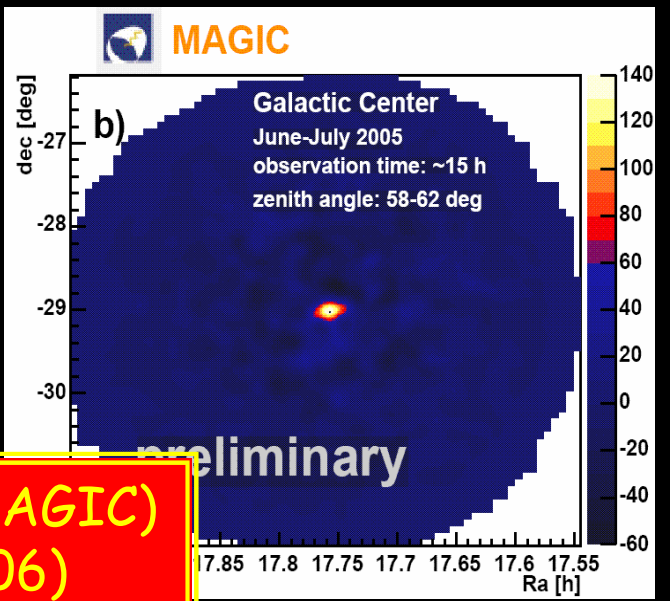
γ emission: a feature of μQSO ?



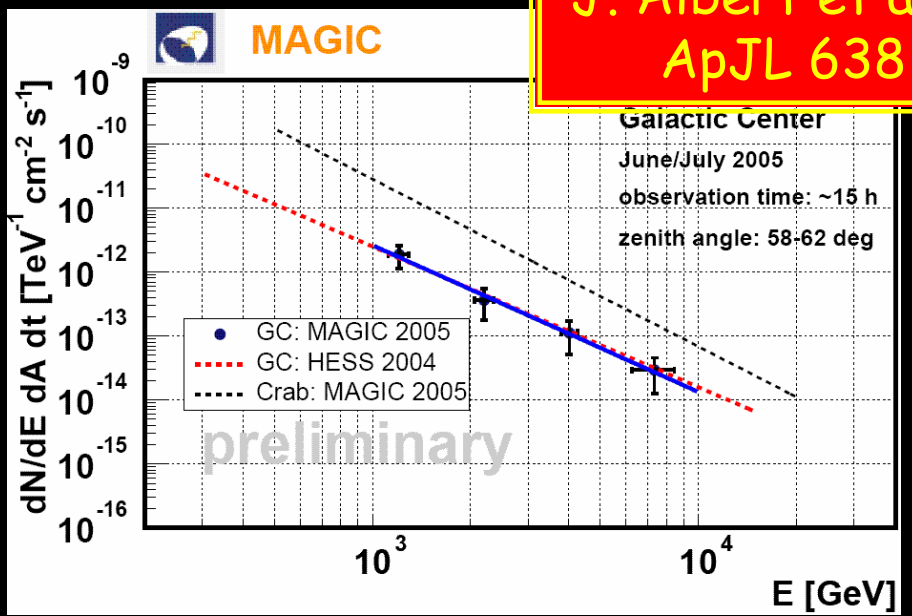
VHE emission: interaction between the two bodies

MAGIC – Centro Galattico

- Osservazione ad alto angolo zenitale (58°-62°)
- Giu/Lug 2005 ~15 h
- Alte energie (> 1 TeV)
- 167 evt. eccesso, 6σ



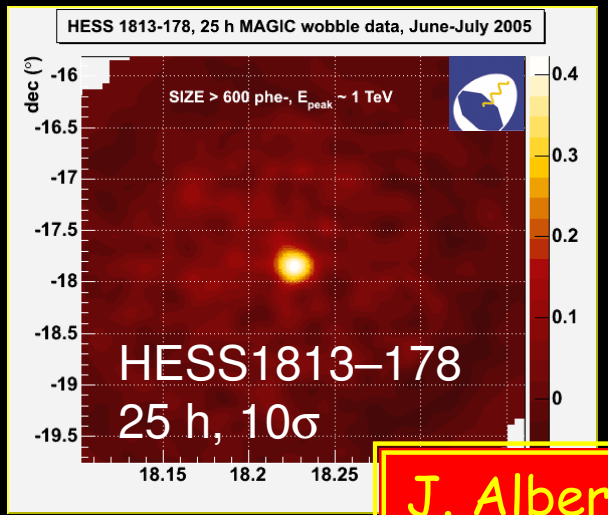
J. Albert et al. (MAGIC)
ApJL 638 (2006)



Buon accordo HESS-MAGIC.

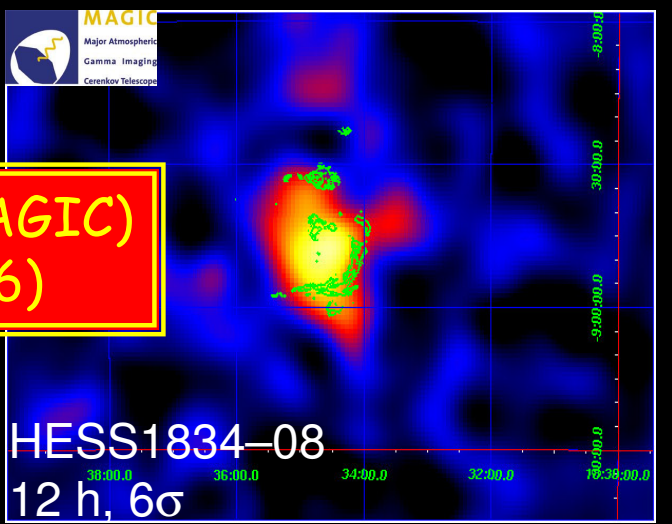
- spettro di potenza: 2.3±0.4 (nessuna annichilazione DM)
- sorgente non variabile (nessuna emiss. BH centrale)

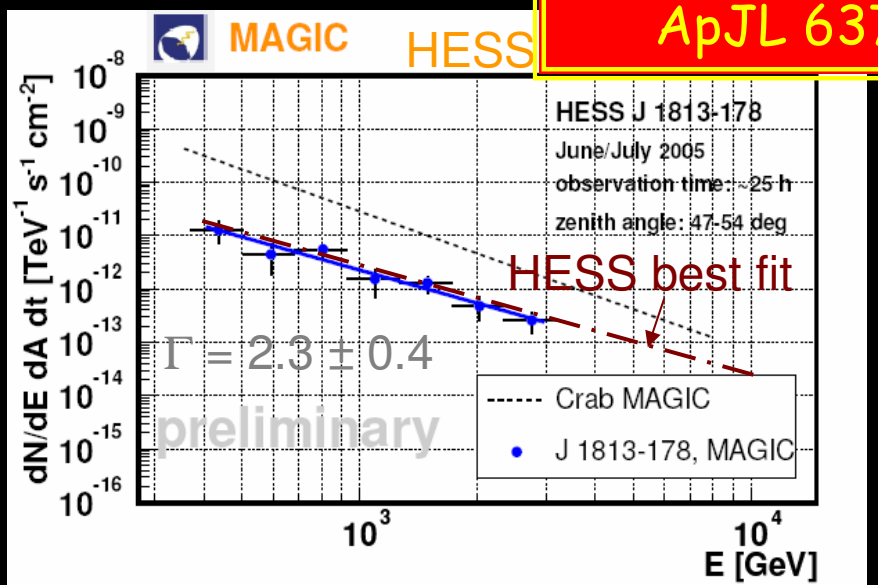
MAGIC – HESS1813, HESS1834



Conferma di due sorgenti (SNR) scoperte da HESS durante la loro osservazione del piano galattico.

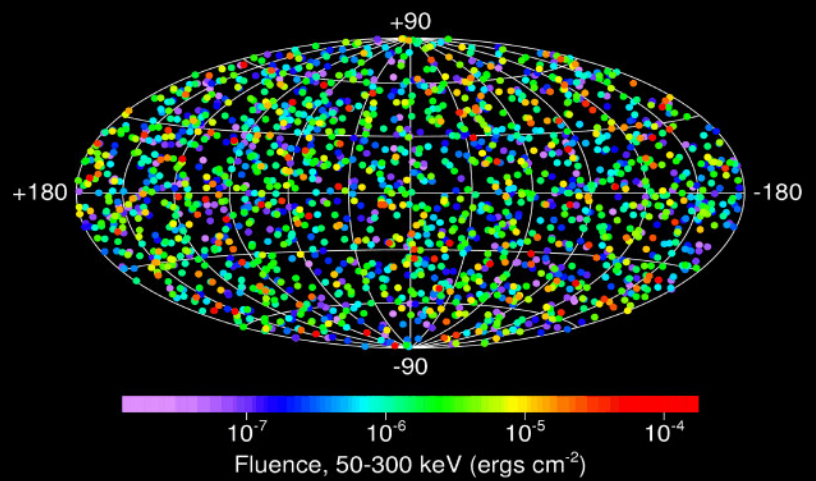
J. Albert et al. (MAGIC)
ApJL 637 (2006)





In sovrapposizione: contorni radio (20 cm VLA) della SNR G23.3-0.3 (White, Becker & Helfand, 2005)

MAGIC – Gamma Ray Bursts

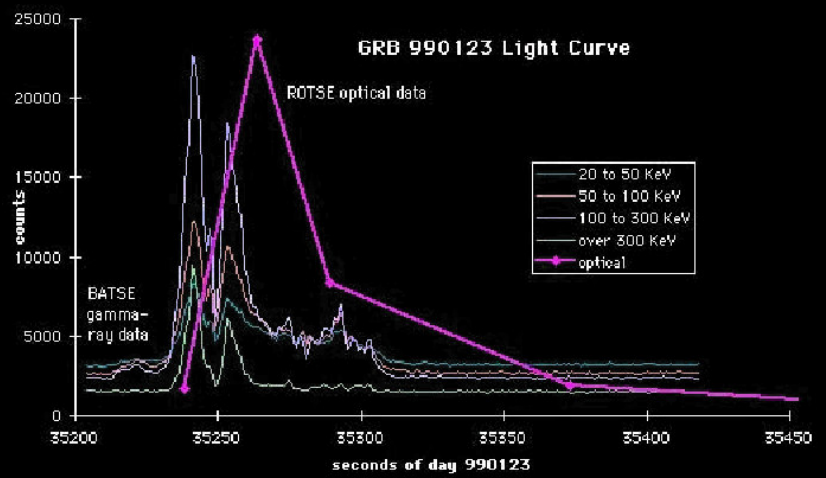


?? Where do they come from?

?? How do they account for such huge energy releases?

?? How do their spectra look like?

⇒ Multiwavelength study!



GeV studies possible if:

- fast repositioning ~20 s.
- low E threshold ~50 GeV.

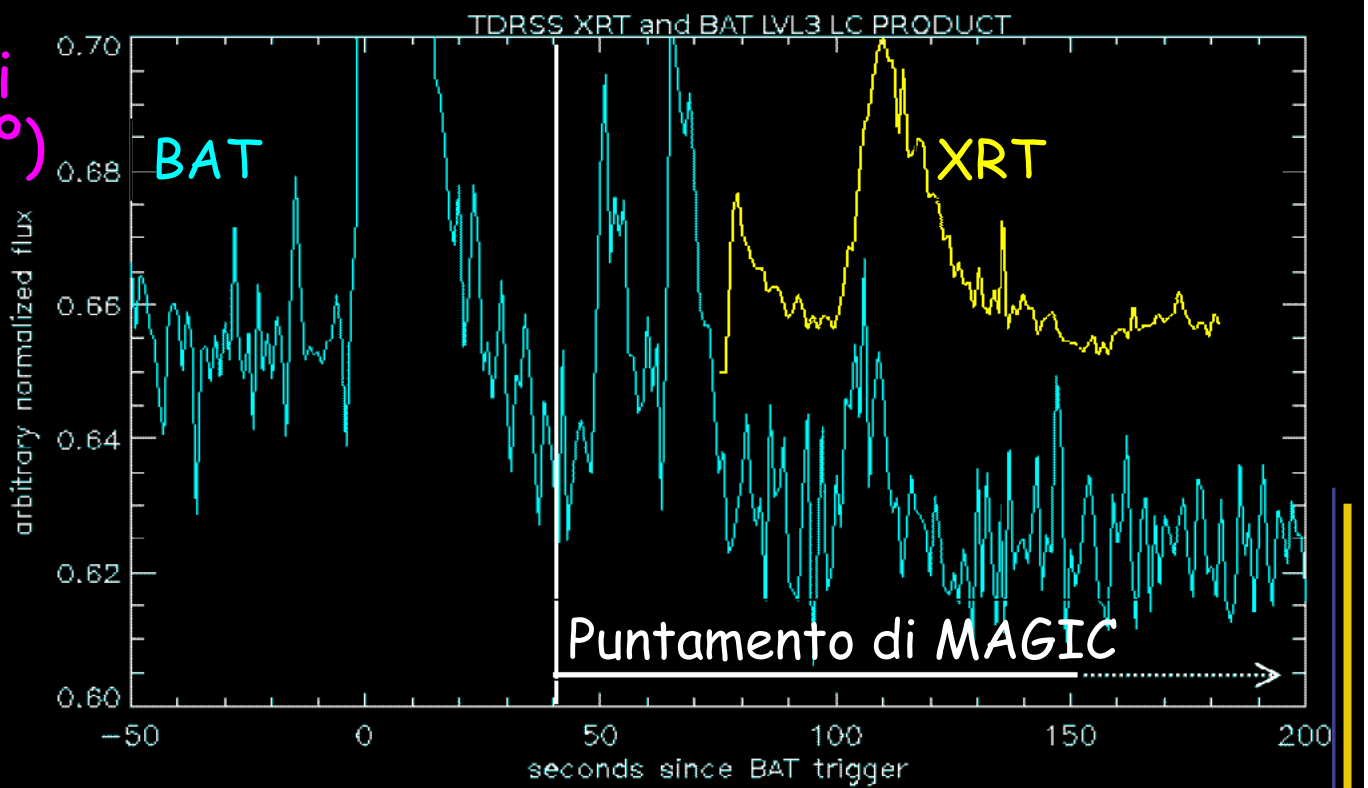
⇒ both available in MAGIC.

MAGIC – GRB 050713a

Il 13 Luglio 2005 MAGIC ha puntato un GRB dopo soli 40s dall'evento, 13s dopo l'allarme trasmesso da SWIFT.

- Buone condizioni osservative (49°) e meteo.
- Prime analisi: nessun segnale > 170 GeV
- Vincoli per i modelli GRB

Flusso del GRB050713A secondo SWIFT

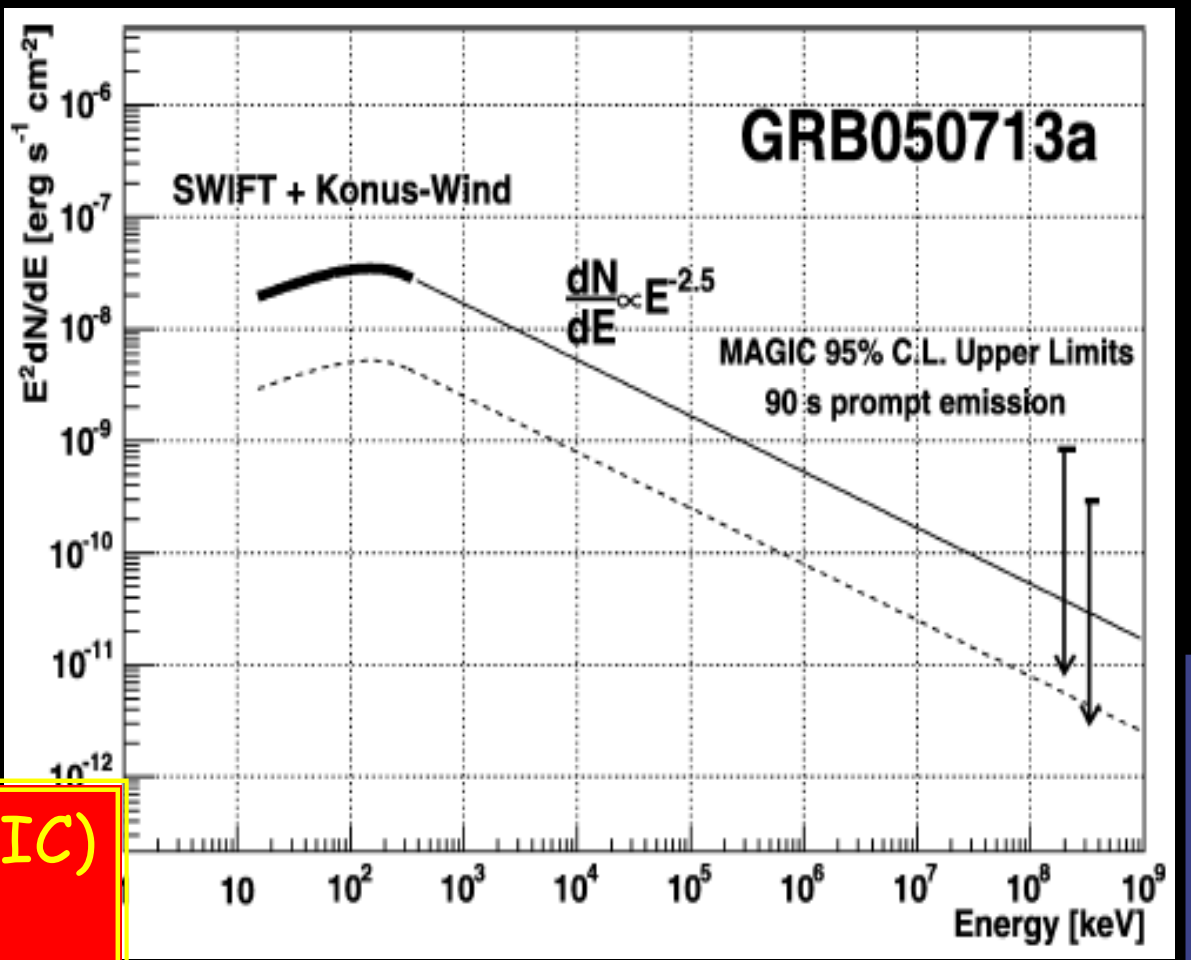


MAGIC – GRB 050713a (data)

Upper limits set by MAGIC with no redshift correction.

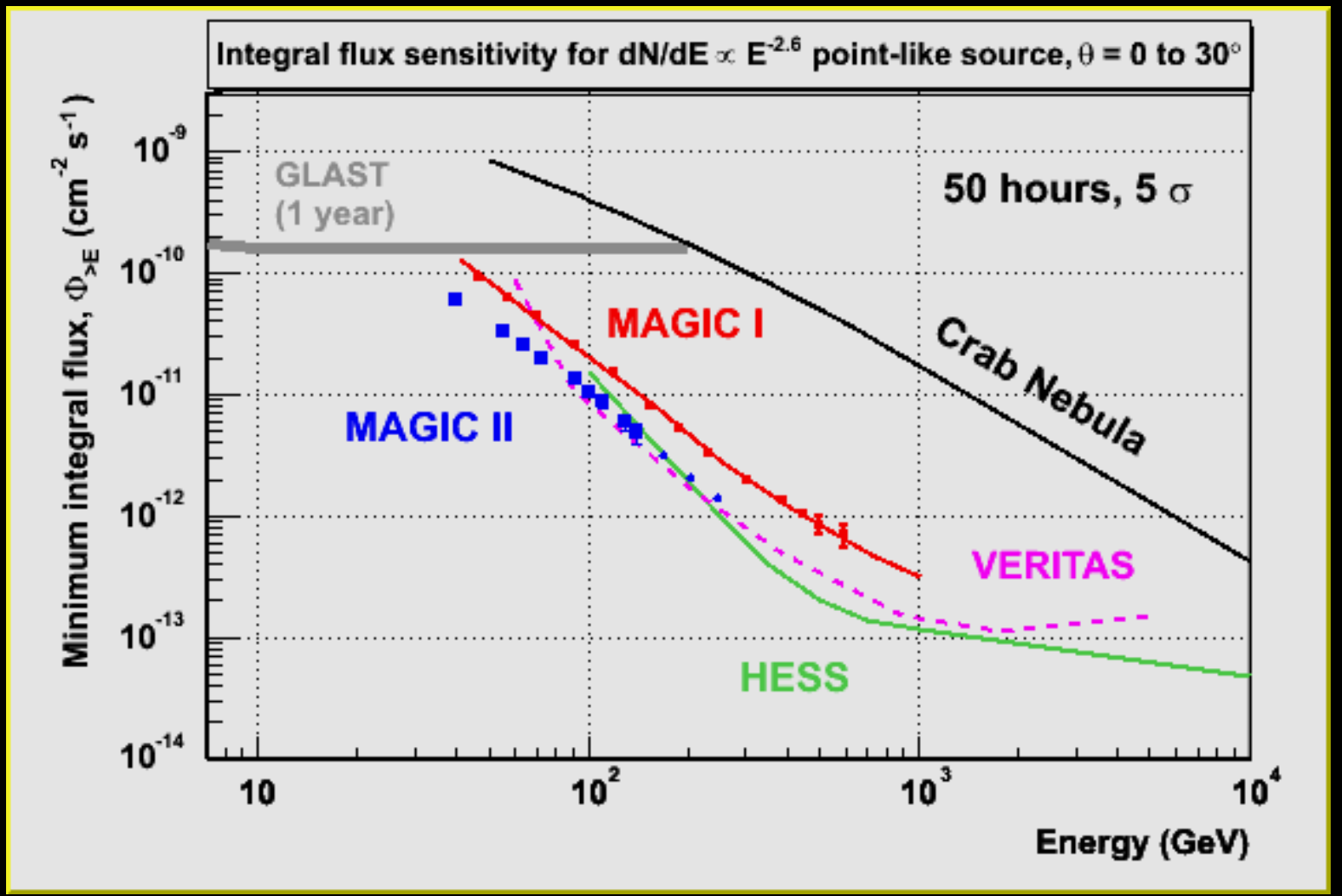
Solid line:
flux measured by Swift averaged over the T90.

Dashed line:
fraction of flux emitted between $[T_0+40s, T_0+130s]$



J. Albert et al. (MAGIC)
ApJ 641 (2006)

The future – MAGIC II



Conclusions

As many new VHE sources discovered in the last year as in the last 20 years
…and likely many more coming !!

The new generation of Cherenkov telescopes is yielding outstanding results, even beyond expectations.

VHE γ-installations are now more astronomical obs. rather than simple expt.

VHE is a new observable band of astronomy.

The future: MAGIC II

- to increase flux sensitivity
- to reduce energy threshold
- equipped with 2GS/s FADC
  ($\rightarrow$ now comm. phase on MAGIC I)
- detector with higher QE