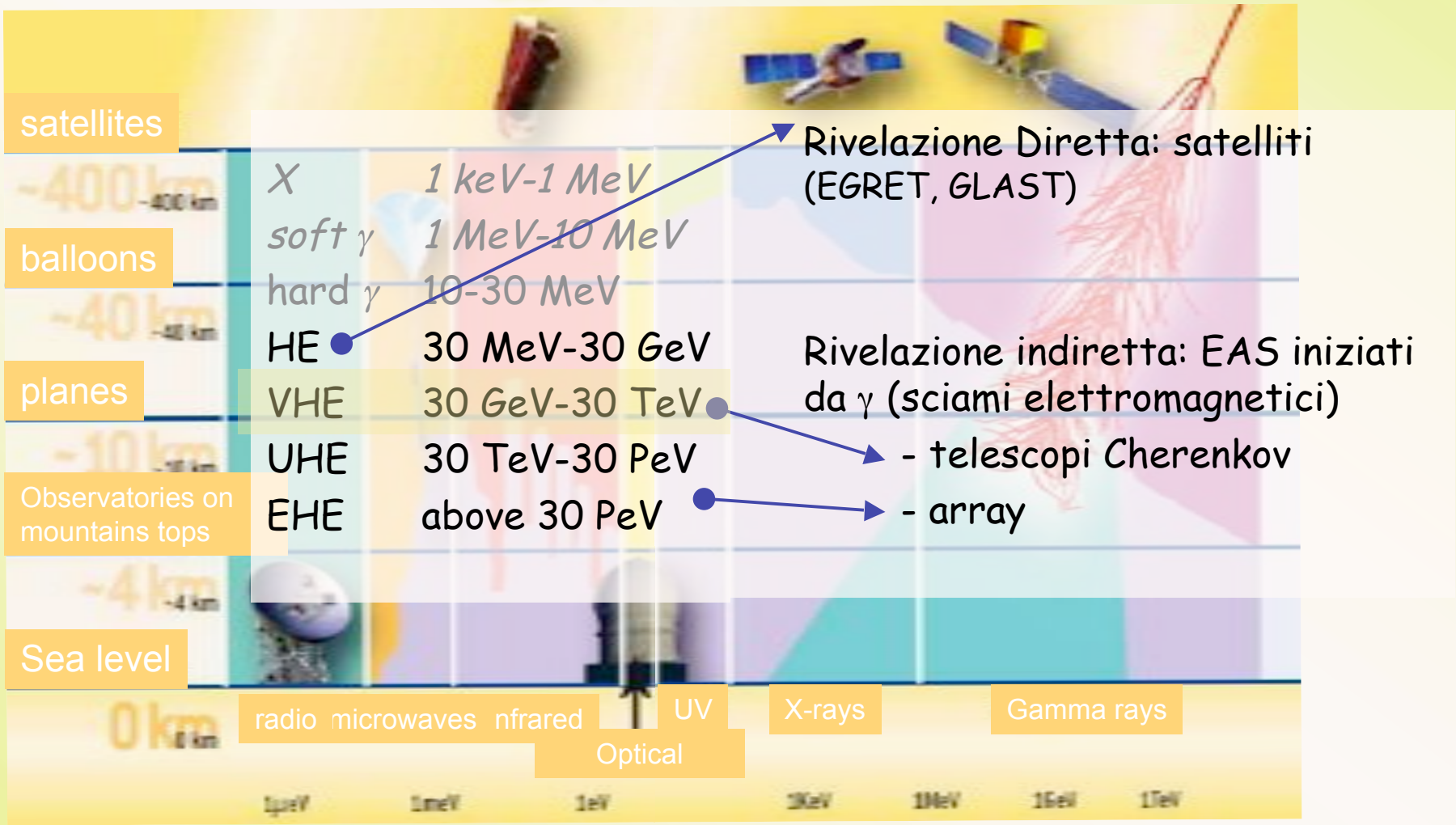
A MAGIC view of the Very High-Energy γ-ray sky

Antonio Stamerra
Università di Siena & INFN Pisa

On behalf of the MAGIC collaboration

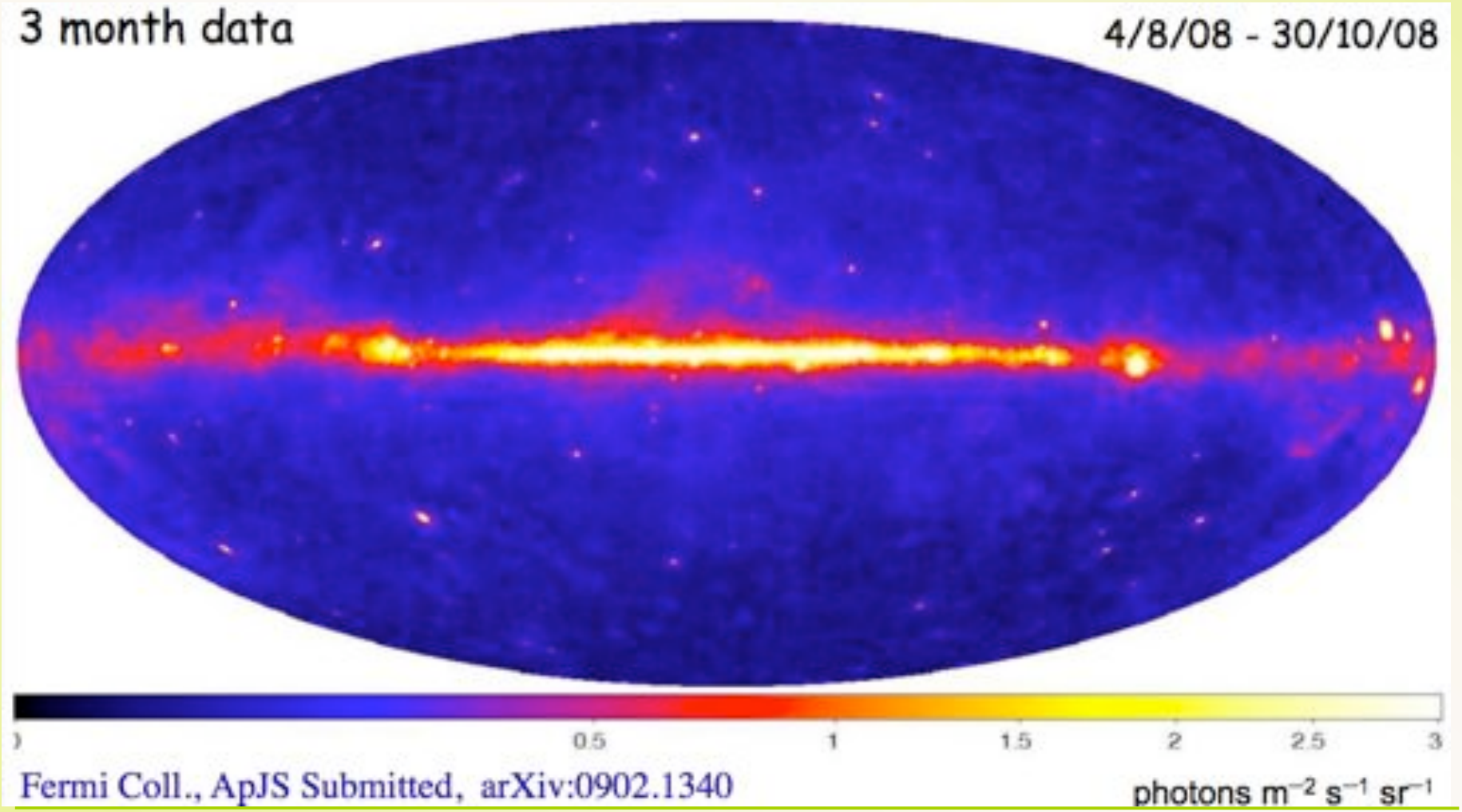
antonio.stamerra@pi.infn.it

Rivelazione raggi-γ



The γ-ray sky

$100\ MeV < E_\gamma < 100\ GeV$



The γ-ray sky

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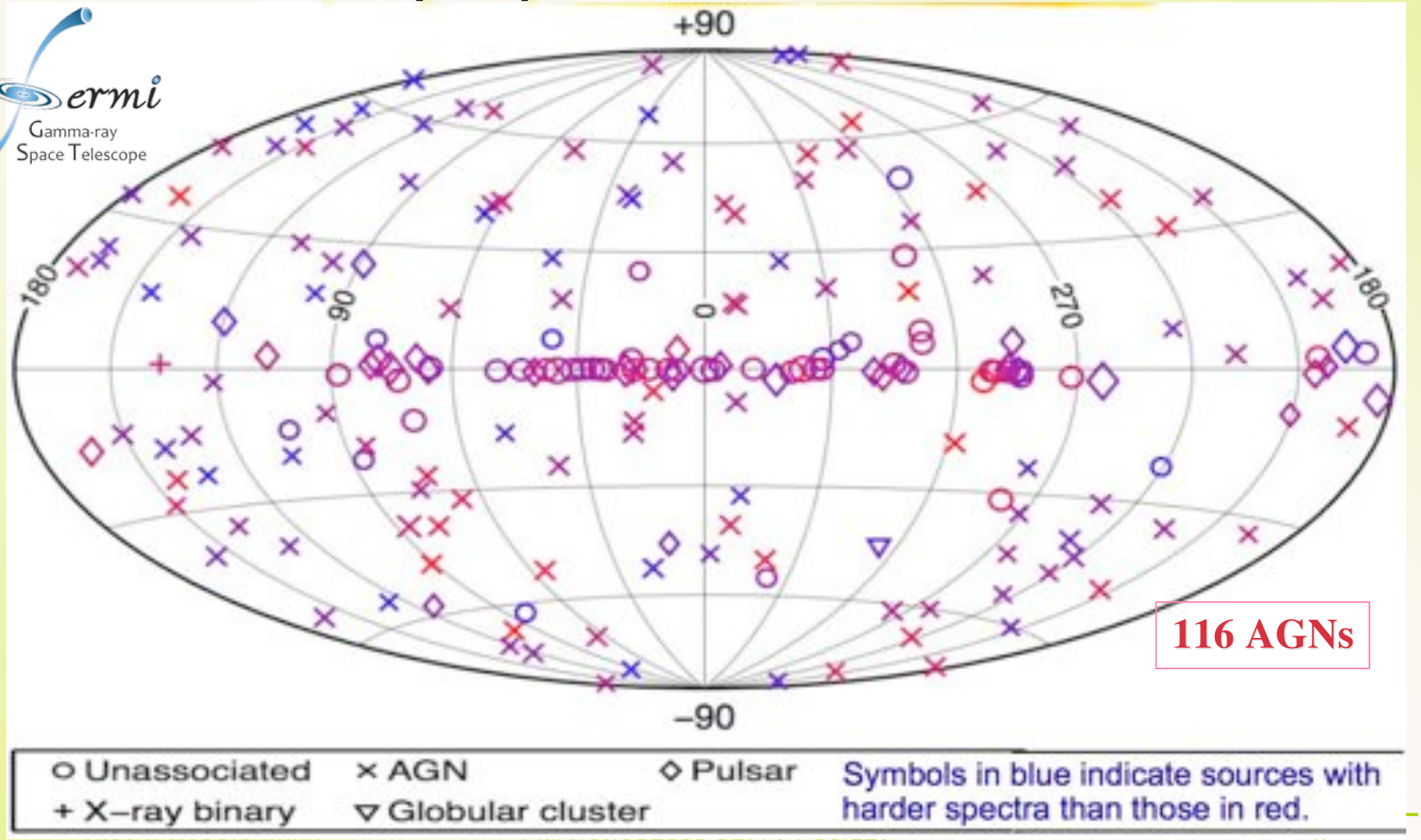
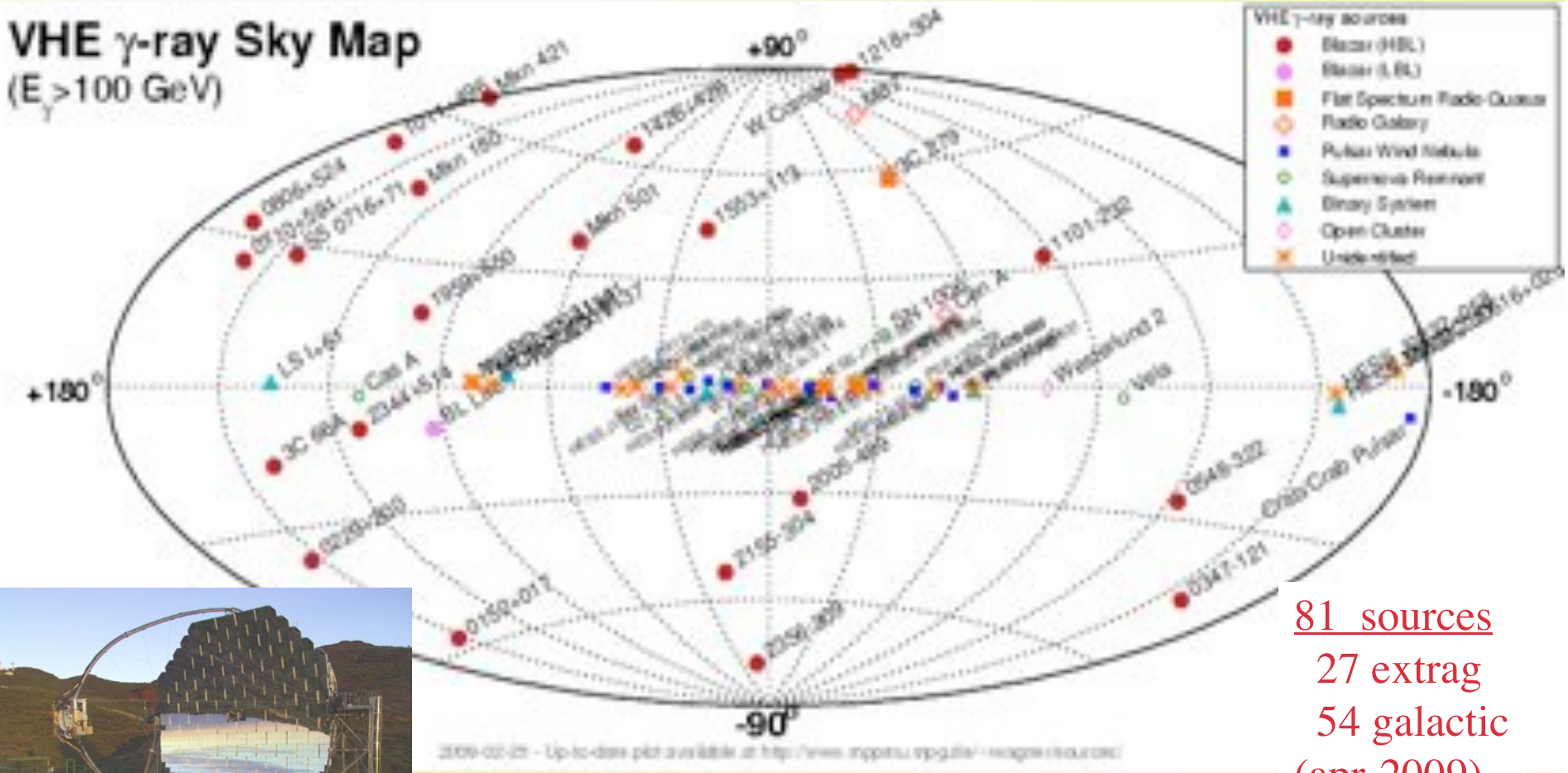


The VHE γ-ray sky

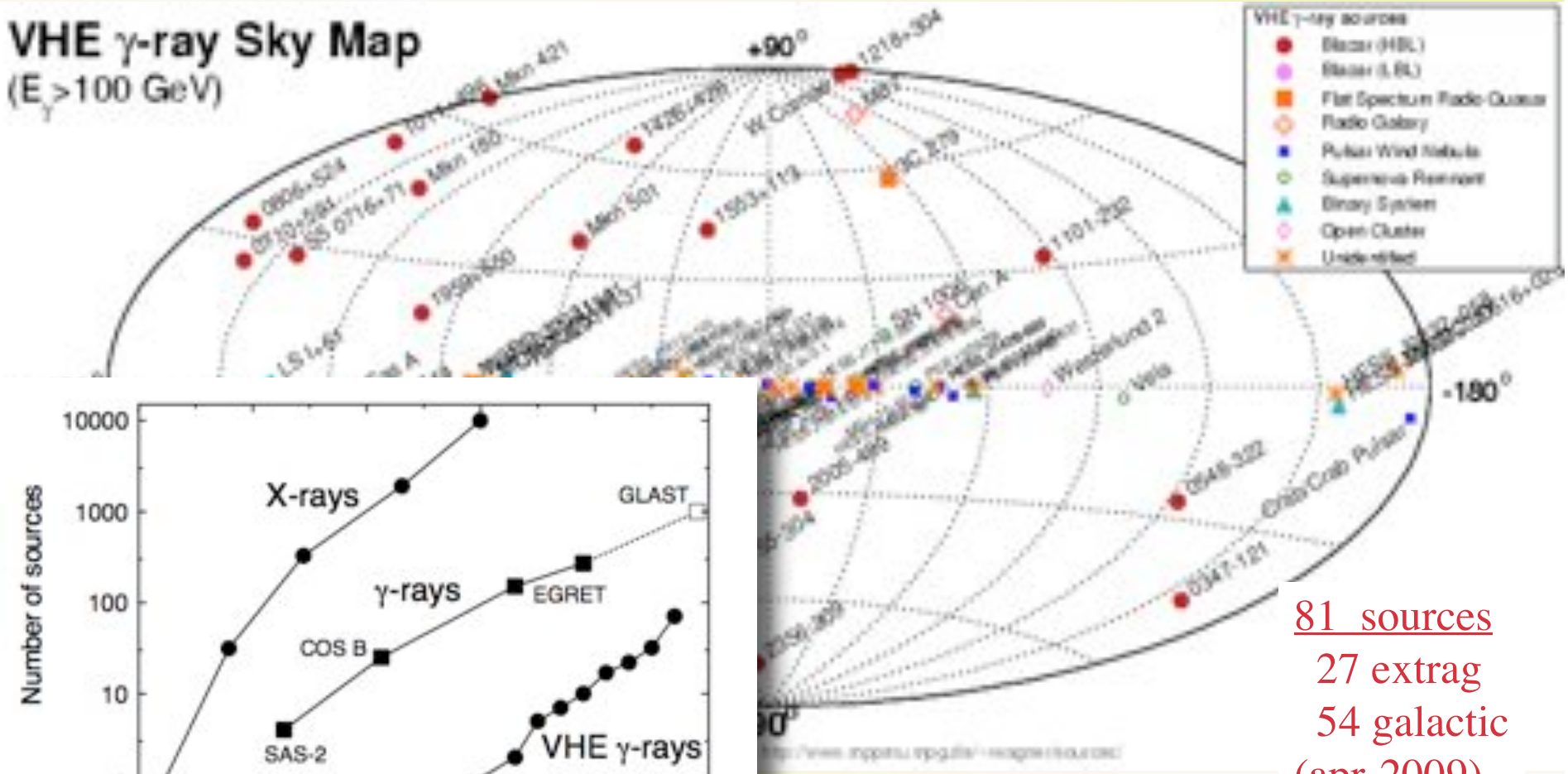
$E_\gamma > 100\ GeV$



81 sources
27 extrag
54 galactic
(apr-2009)

The γ-ray sky

$E_\gamma > 100\ GeV$



81 sources
27 extrag
54 galactic
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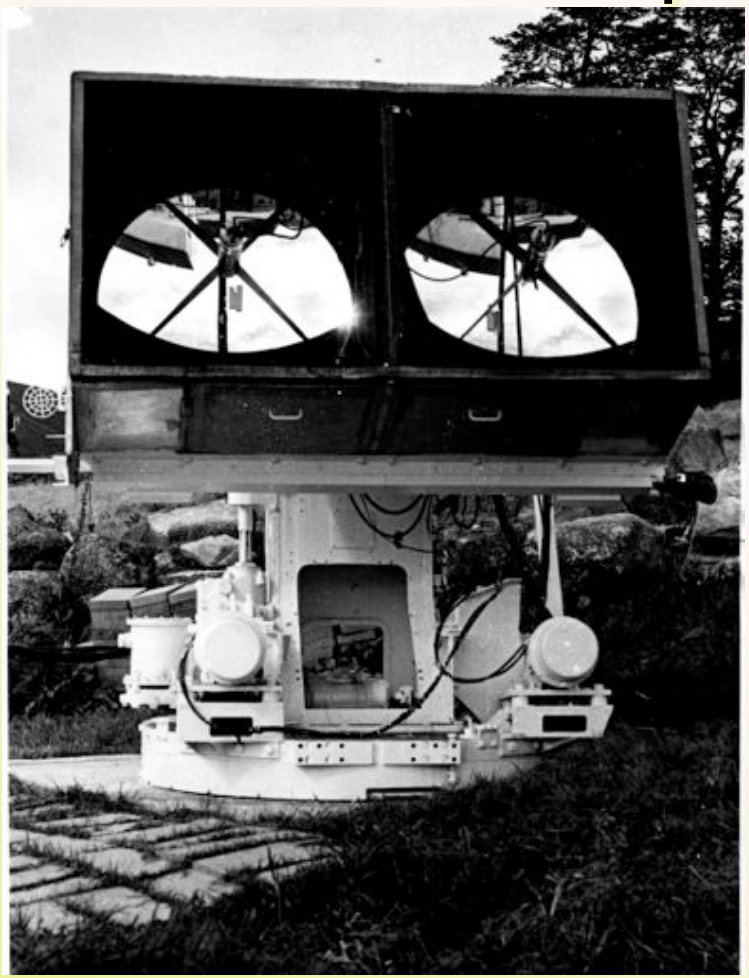
0th generation of Cherenkov telescopes



Glencullen, Ireland ~1962

Nessuna discriminazione dal fondo di raggi cosmici !

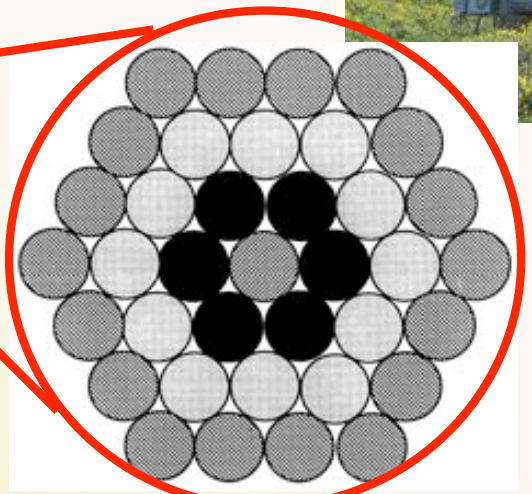
Whipple: singolo fototubo

1972: prima indicazione di TeV γ-rays dalla Crab Nebula (Fazio et al.)

- ON-OFF (direzione)
- 3σ in 3 anni di osservazione!

Imaging technique: 1st and 2nd generation of IACT

- 1984: viene utilizzata la prima camera multi-PMTs da Whipple
- 1989: Emissione γ significativa identificata dalla Crab Nebula (Whipple '89)
  - E_{thr} = 700 GeV
  - 9σ in 50 h di osservazione



1995: HEGRA array di telescopi

Crab detection time: 15 min

Third generation

Crab detection time: 2/4 min

Crab detection time: 2-4 min

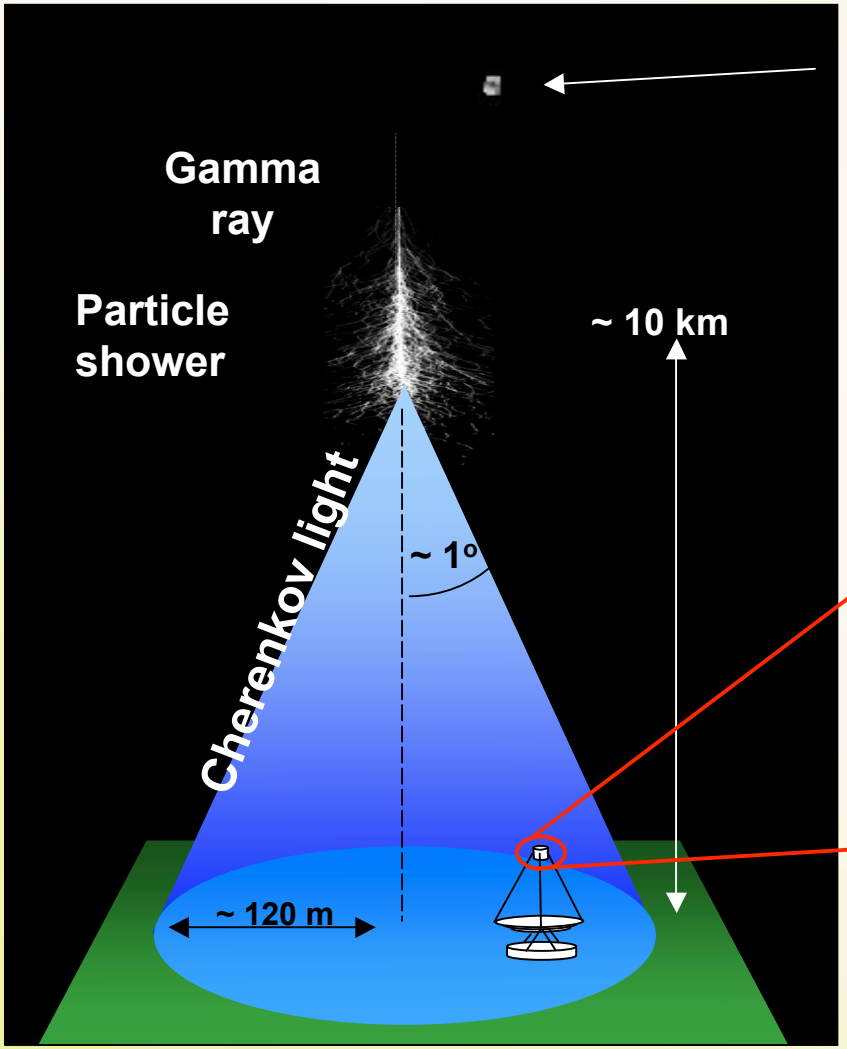
MAGIC

- Largest single dish Cherenkov Telescope: 17 m Ø mirror dish, **mirror surface (241 m²)**
- 3.5° FoV Camera with 577 enhanced QE PMT's
- Fast repositioning for GRBs: average < 40 s
- Low energy trigger threshold: 50 - 60 GeV
- Sensitivity: 1.6% Crab / 50 h

  (improvement with 2 GHz sampling and timing parameters in g/h separation)
- γ-PSF: ~ 0.1° (E > 500 GeV)
- Energy resolution: 20 - 30%
- Observations during moonlight (duty cycle improved ~50%)

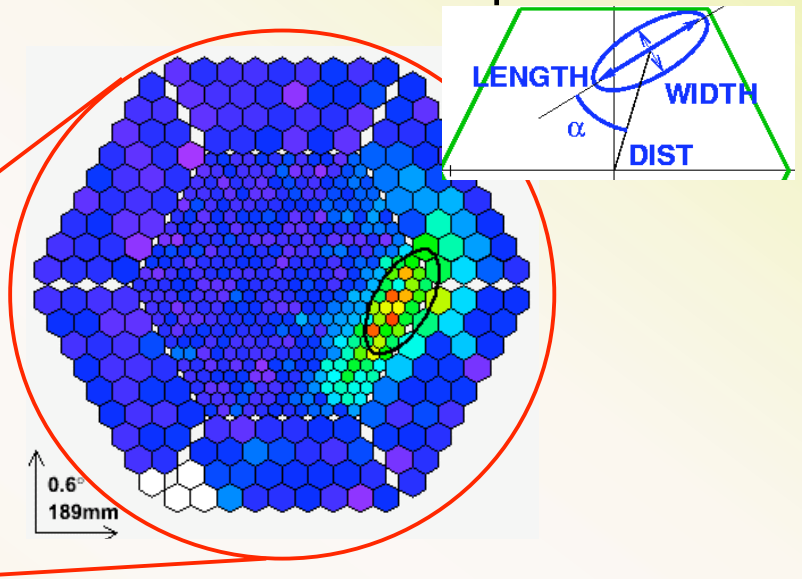
Imaging Air Cherenkov Telescopes

IACT



GLAST (ingrandito)

Immagine del flash Cherenkov sulla camera del telescopio



- Ricostruzione del primario
  - particle id: discriminazione dal fondo di adroni
  - direzione, energia…

Galactic sources

4 new sources

IC443/MAGICJ0616+225 (SNR)

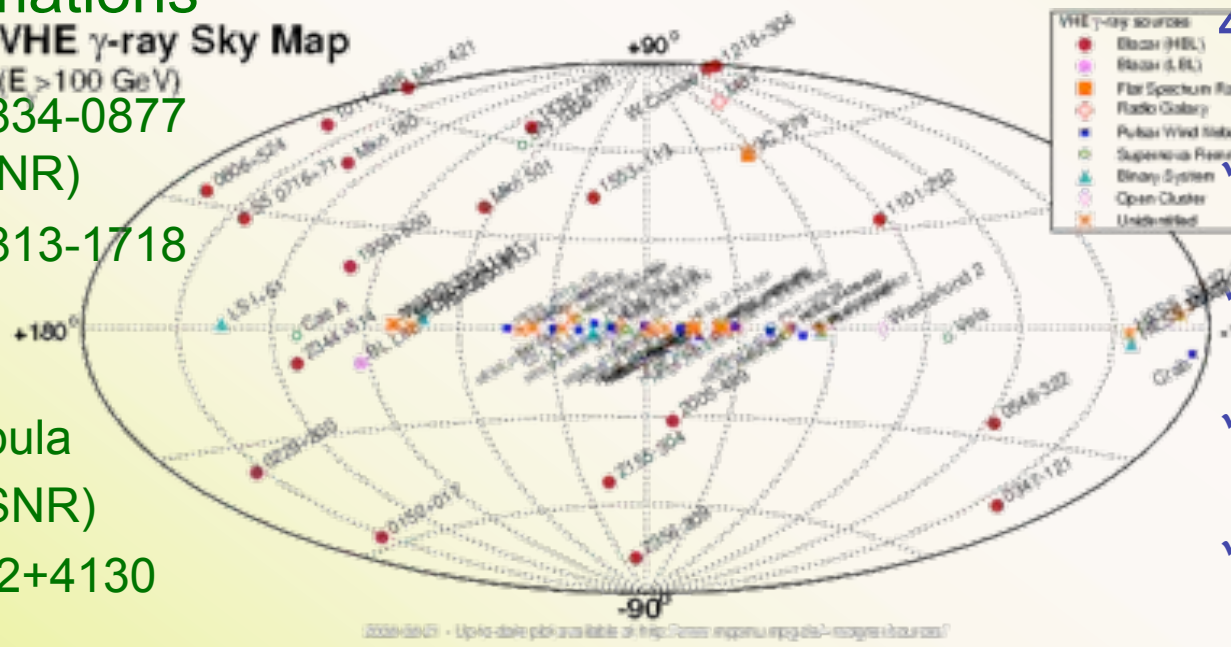
PSRB0531+21 (Crab-pulsar)

LSI+61 30 (X-ray binary)

Cyg X-1 (X-ray binary)

6 confirmations

- ✓HESSJ1834-0877 (W41 - SNR)
- ✓HESSJ1813-1718 (SNR)
- ✓GC
- ✓Crab Nebula
- ✓Cas-A (SNR)
- ✓TeVJ2032+4130 (UNID)



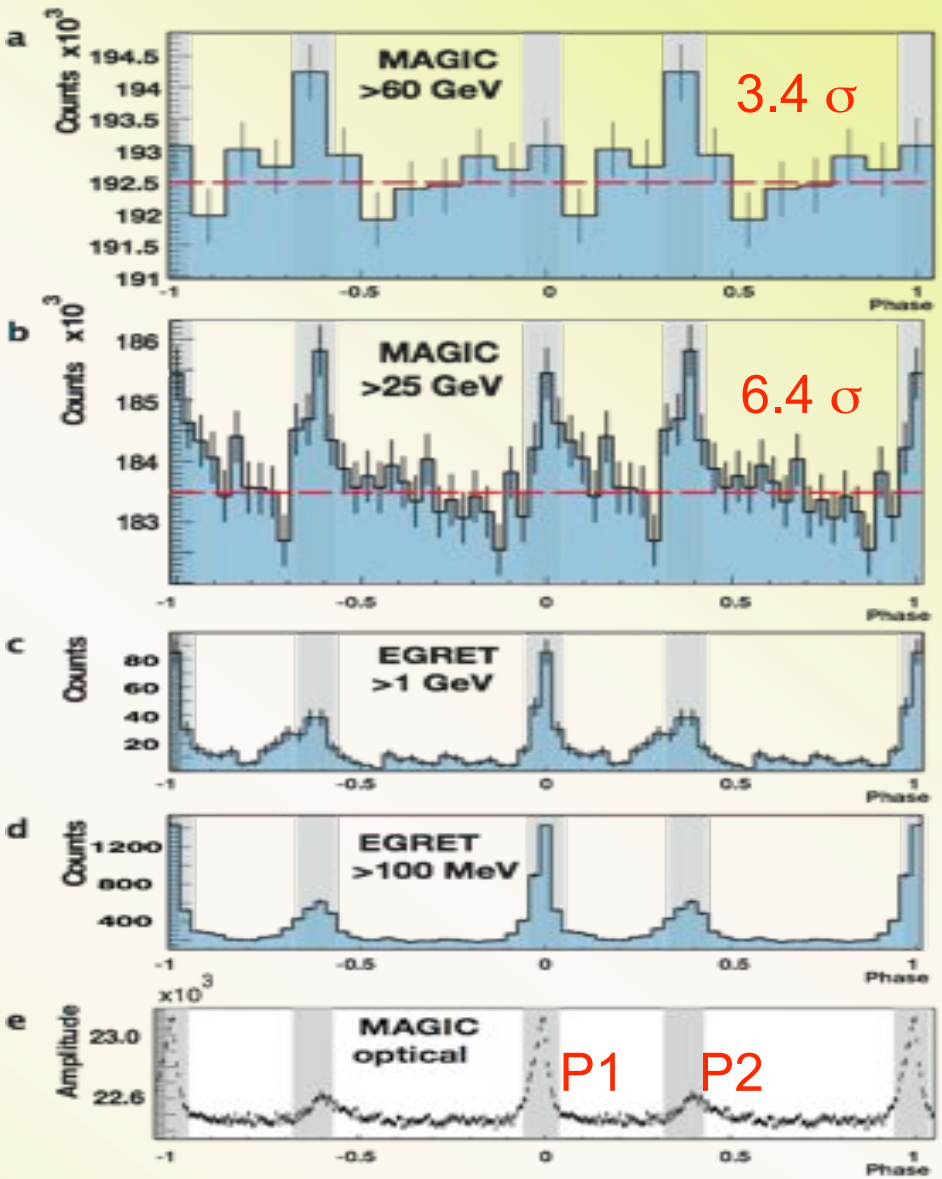
4 upper limits

- ✓PSRB 1951+32 (pulsar/SNR)
- ✓Cyg X-3 (X-ray binary)
- ✓WR146 (WR star)
- ✓WR147 (WR star)

Crab pulsar

- P=33 ms; Pulsed emission at E<10 GeV
- First hint at E~>60 GeV
- Lower trigger threshold: new trigger system (*sum-trigger*)

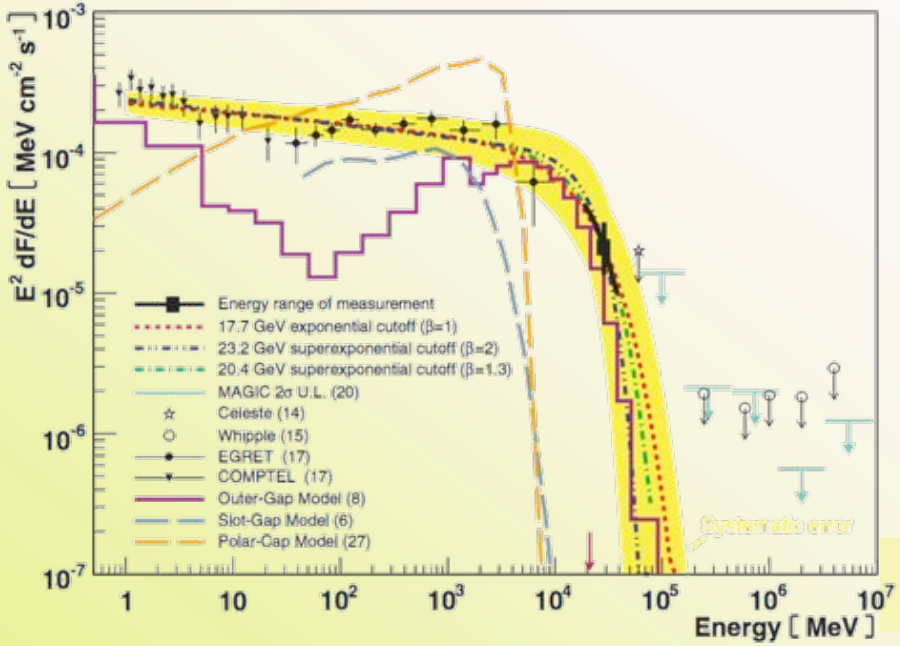
Science 322 (2008) 1221

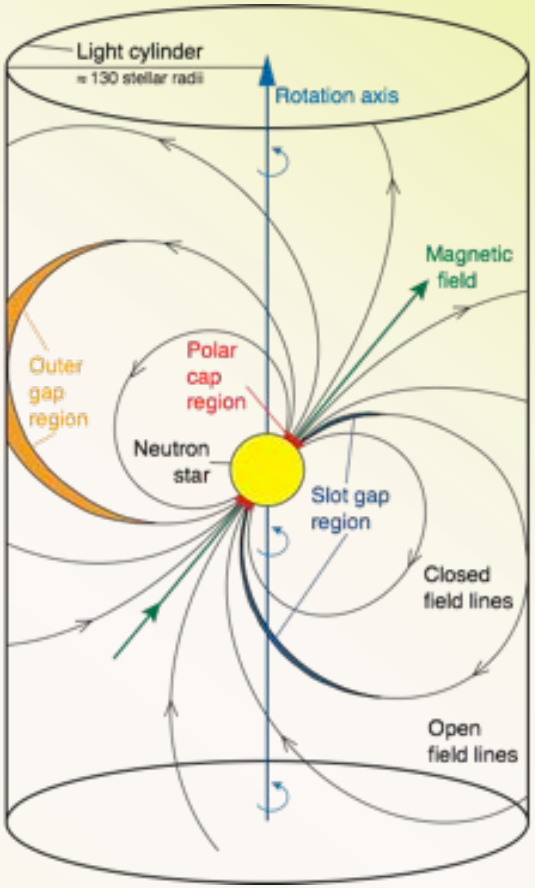


Crab pulsar

Science 322 (2008) 1221

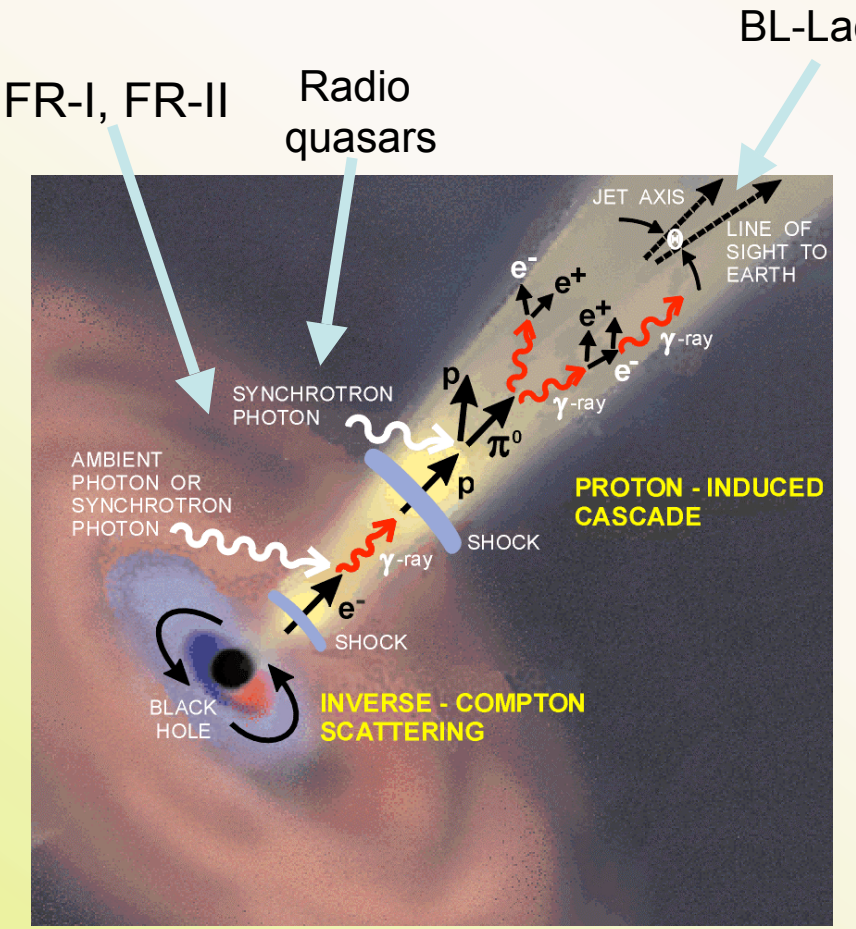
- Cutoff ⇐ acceleration and radiation process (outer gap/polar cap)
  - Absorption in magnetosphere (magnetic/photon pair production)
  - Maximum acceleration energy





Exponential cutoff: $16.4 \pm 1.5_{stat} \pm 4.5_{syst}$ GeV
Superexponential cutoff: $20.5 \pm 1.5_{stat} \pm 5.0_{syst}$ GeV

AGN - blazars

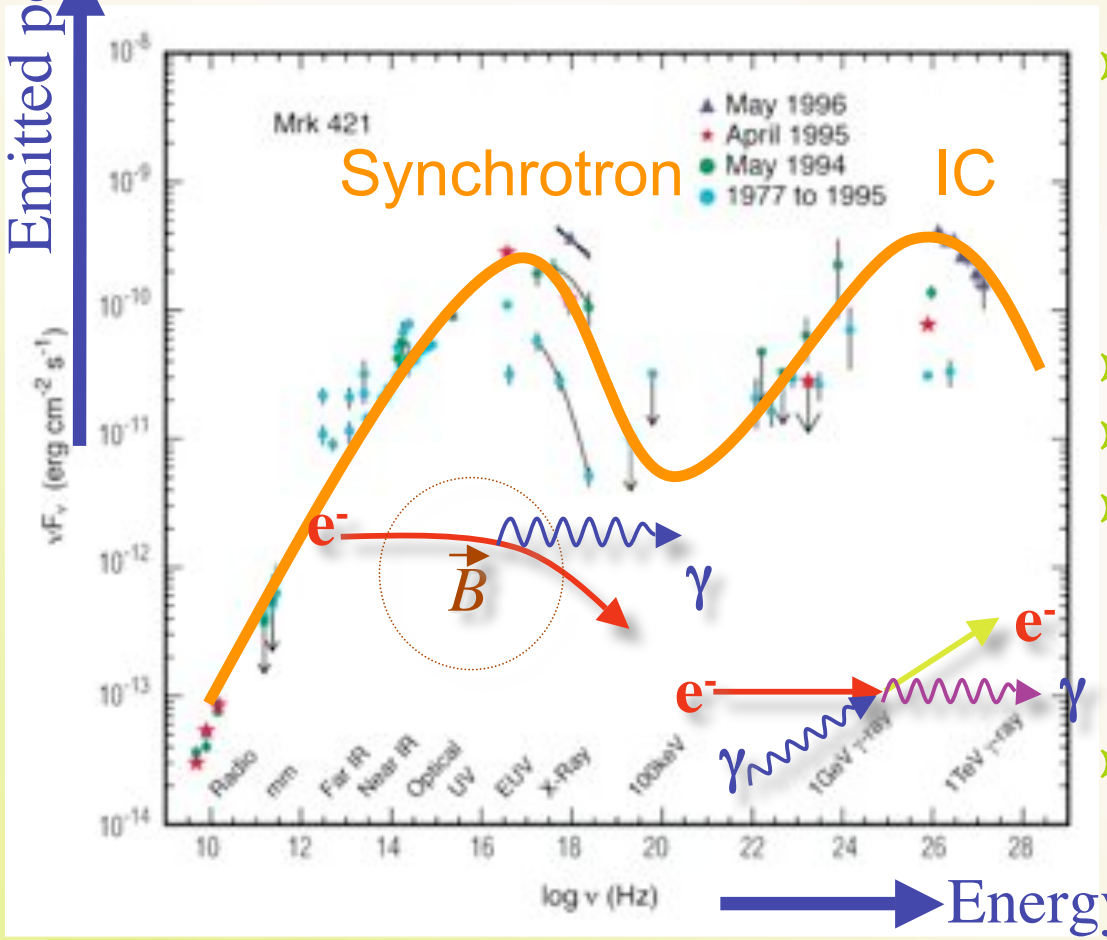


- Intense and variable emission up to ~10 TeV

  Observed structures:
  - accretion disk; obscuring thorus
  - Relativistic Jet
  - Broad/Narrow line regions (NLR, BLR)
- TeV emitting zone: jet with high relativistic bulk motion
  - Particle acceleration at shock boundaries bundled in a magnetic field (Fermi acceleration processes)
  - Gamma-ray emission from accelerated electrons (synchrotron and inverse-Compton scattering) or hadronic interactions
- Unified AGN model: different AGN classes depending on viewing angle
  - FRI, FR-II, Radio quasars, BL-Lac (HBL-LBL)

γ-ray emission from AGN:

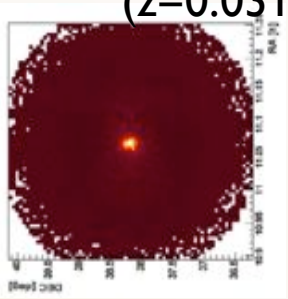
SSC a (minimal) standard model



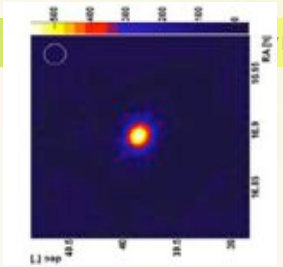
- Observed emission well described by leptonic models, such as SSC and EC.
  - Expected X-ray / Tev time correlation
- Synchrotron peak: IR to x-ray
- IC peak: UV to γ-rays
- Seed photons for Compton scattering:
  - Synchrotron radiation (SSC)
  - External radiation field (EC)
- Blazar: collimated emission from jet (relativistic amplification)

AGNs detected by MAGIC

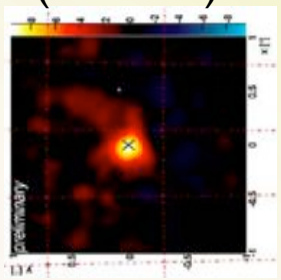
Mrk421
(z=0.031)



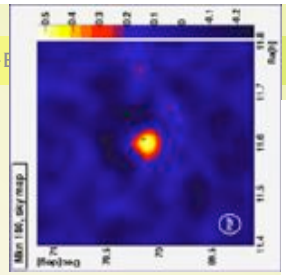
Mrk501
(z=0.034)
Very fast flare



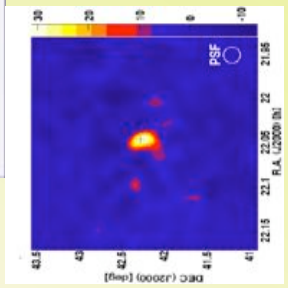
1ES2344
(z=0.044)



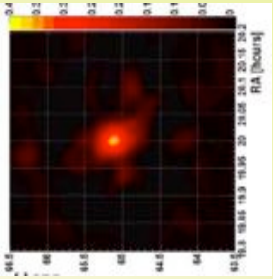
Mrk180
(z=0.045)
Discovery



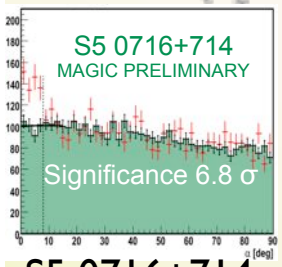
BL-Lac
(z=0.069)
Discovery



1ES1959
(z=0.047)

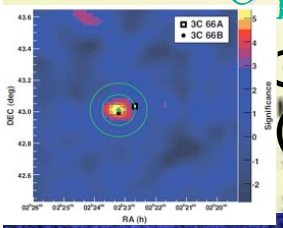


(E>100 GeV)

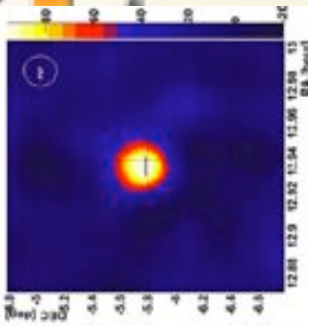


S5 0716+714
Discovery

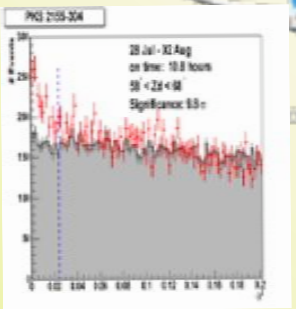
3C66A/B
(z=0.02)
Discovery



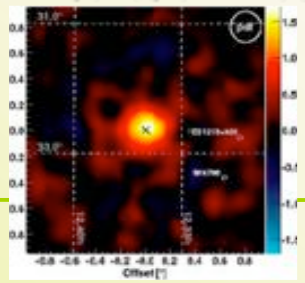
3C279
(z = 0.536)
Discovery

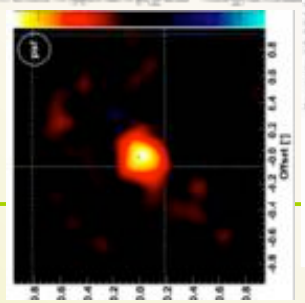


1ES1218 (z= 0.18)
Discovery

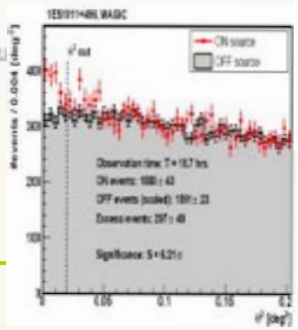


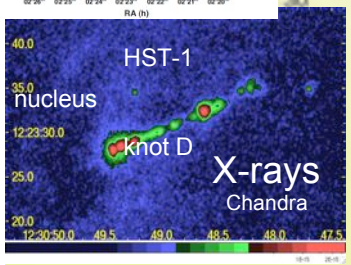
PG 1553 z>0.25
Discovery





1ES1011 z=0.21
Discovery





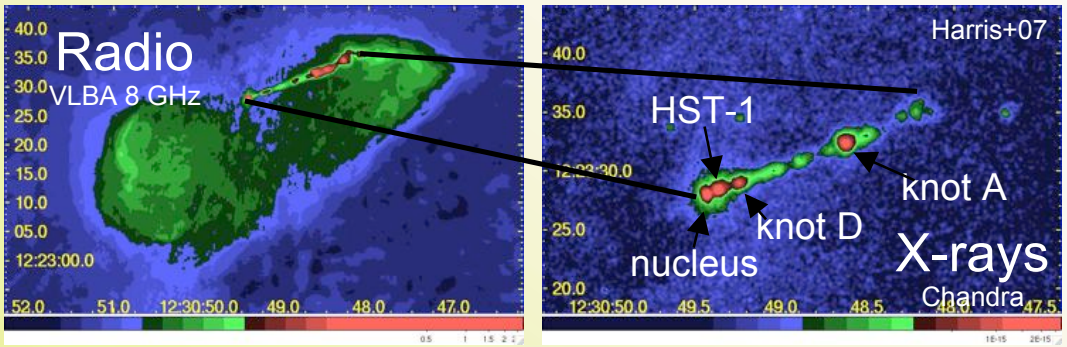
M87
(z=0.0043)

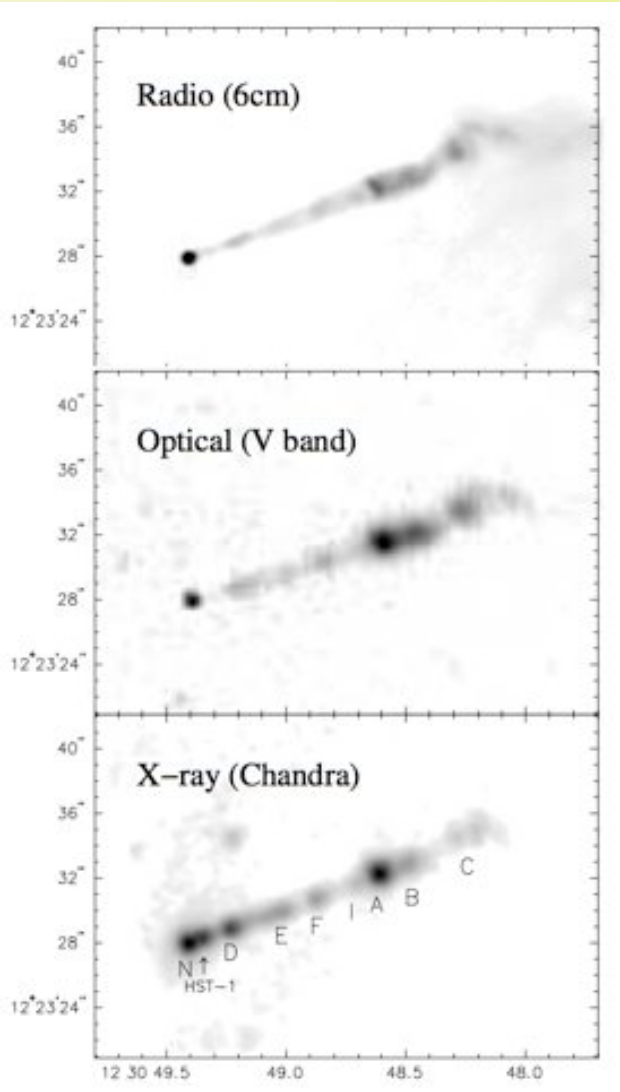
PKS2155
(z=0.116)

M87

RG z=0.0043

- "misaligned blazar" (20-40°); 16 Mpc
- HEGRA hint; HESS/VERITAS detection
- Candidate nearby CR site (hadronic emission?)
- Variability?
- Site for TeV emission (core/HST-1)?

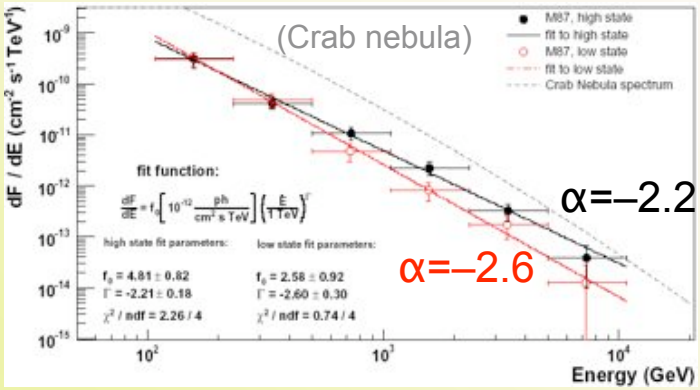


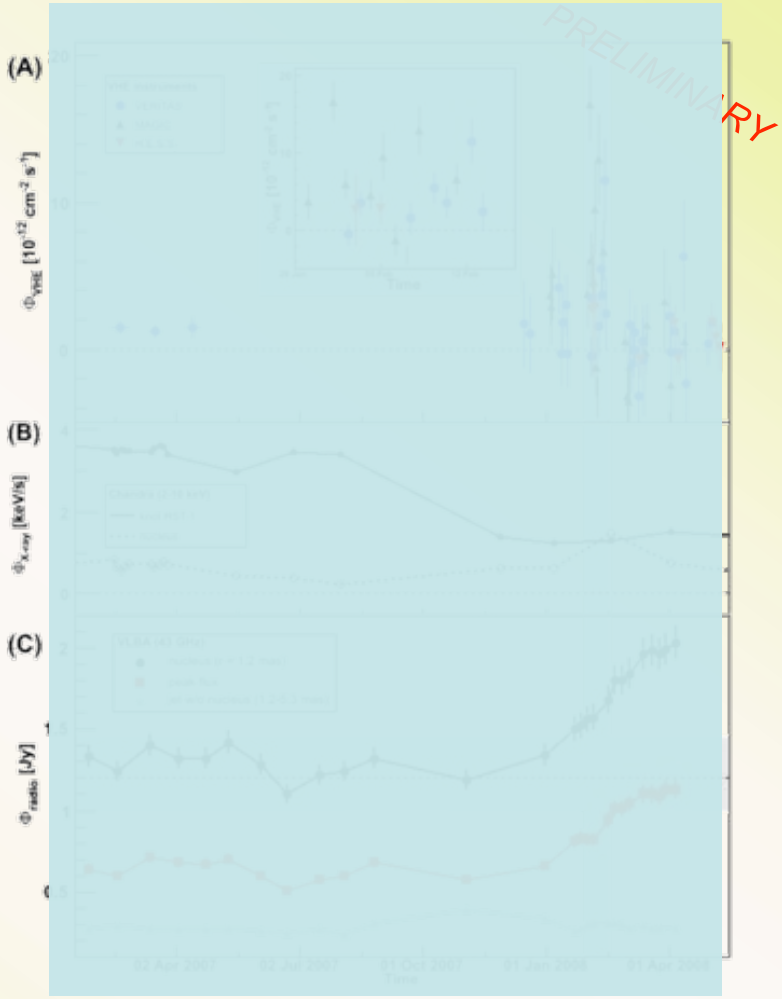


M87

J.Albert et al., ApJL subm., arXiv:0806.0988
Joint paper MAGIC-VERITAS-HESS-VLBI-Chandra - submitted

- MWL campaign jan-feb 2008 (triggered by MAGIC detection on 1st February flare)
- 9.9σ detection; 8.0σ single night 1st-feb
- First spectrum at E>100 GeV
  - Marginal hint of sectral hardening
- Clear <~daily variability at E>350GeV
- Chandra observations ⇒ core/HST-1 contribution (core active / HST1 dim)





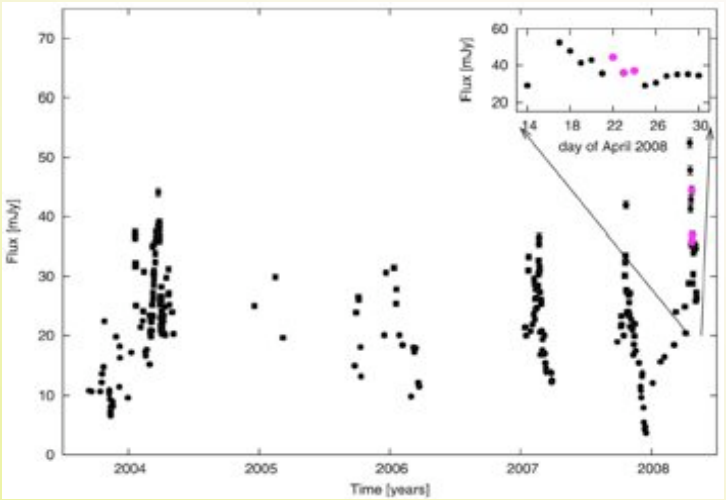
S5 0716+714

IBL z=0.31(?)

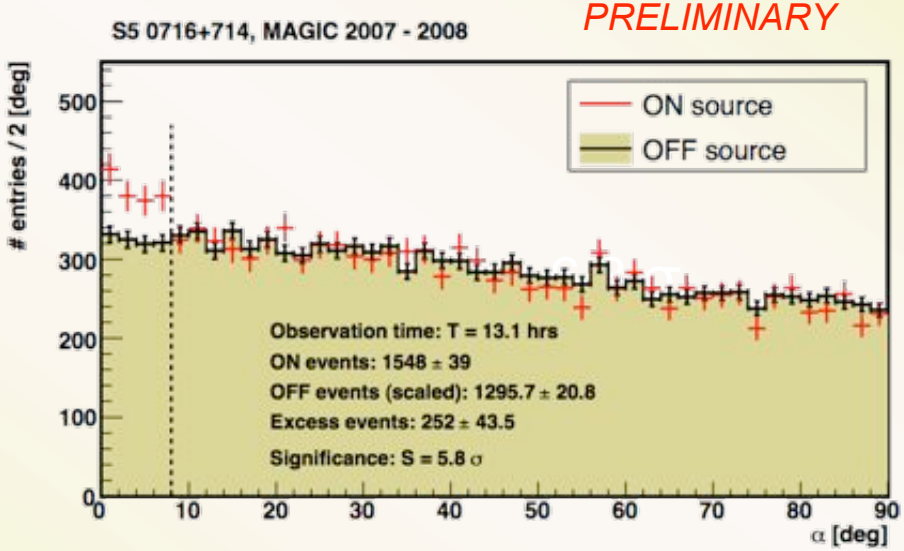
MAGIC coll. 2008, Atel #1500

- Optical triggers (new VHE source: Mrk180; 1ES 1011+496)
- Bright in optical ⇒ trigger
- Clear signal in 2.6 h: 6.9σ

$F_{(>400\ GeV)} \approx 10^{-11}$ ph/cm^2/s (≈25% Crab)



PRELIMINARY

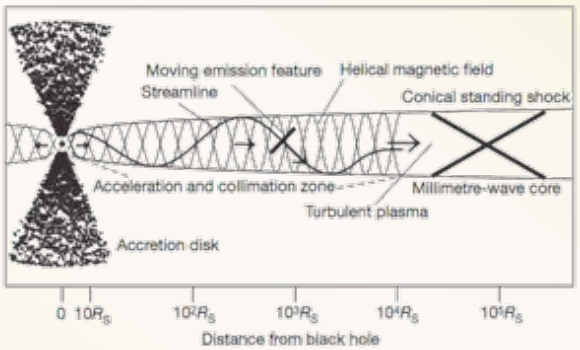


S5 0716+714

IBL z=0.31

- High redshift (unknown since few weeks ago: Nilsson,A&A 487(2008)L29 reports the detection of the host galaxy: z=0.31±0.08)
- Rotation of positional angle of polarization (EVPA) during maximum (60deg/day) *Larionov et al.,ATel #1502*
  - propagation of a polarized knot spiraling down the jet, following helical magnetic field

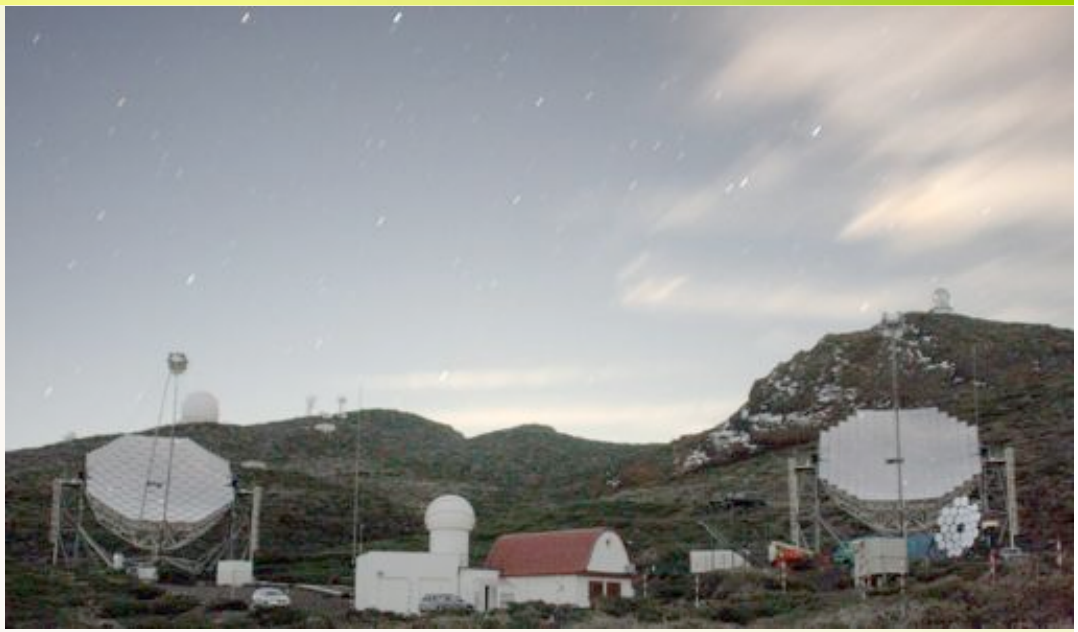
    (e.g. BLLac, *Marscher et al., 2008, Nature, 452, 966*)
- X-ray spectrum shows synchrotron component: transition between LBL-HBL states?
  - E.g. reported on PKS2155- *Y.H.Zhang, ApJ,682(2008)789*



Discovery MAGIC paper - to be submitted

MAGIC-II

First light ceremony
24th-25th April 2009



- Stereoscopic mode:
  - Improved sensitivity
  - Better angular and energy resolution
- Parallel mode:
  - Observation of simultaneous sources (AGNs monitoring)
- New technologies:
  - lower energy threshold
  - Camera: Photo-detectors with higher QE (HPDs in near future)
  - Faster Digitalization: 4 GHz Analogue to Digital Converts (Domino)

MAGIC

Major Atmospheric Gamma Imaging Cherenkov Telescope

INFN

Istituto Nazionale di Fisica Nucleare

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

http://www.pi.infn.it/magic/

antonio.stamerra@pi.infn.it