Observing AGN with the MAGIC γ-ray telescopes

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MAGIC
Major Atmospheric
Gamma Imaging
Cerenkov Telescope

The MAGIC telescopes

System of two IACT (Imaging Atmospheric Cherenkov telescopes) → γ-ray
Canary Island of La Palma

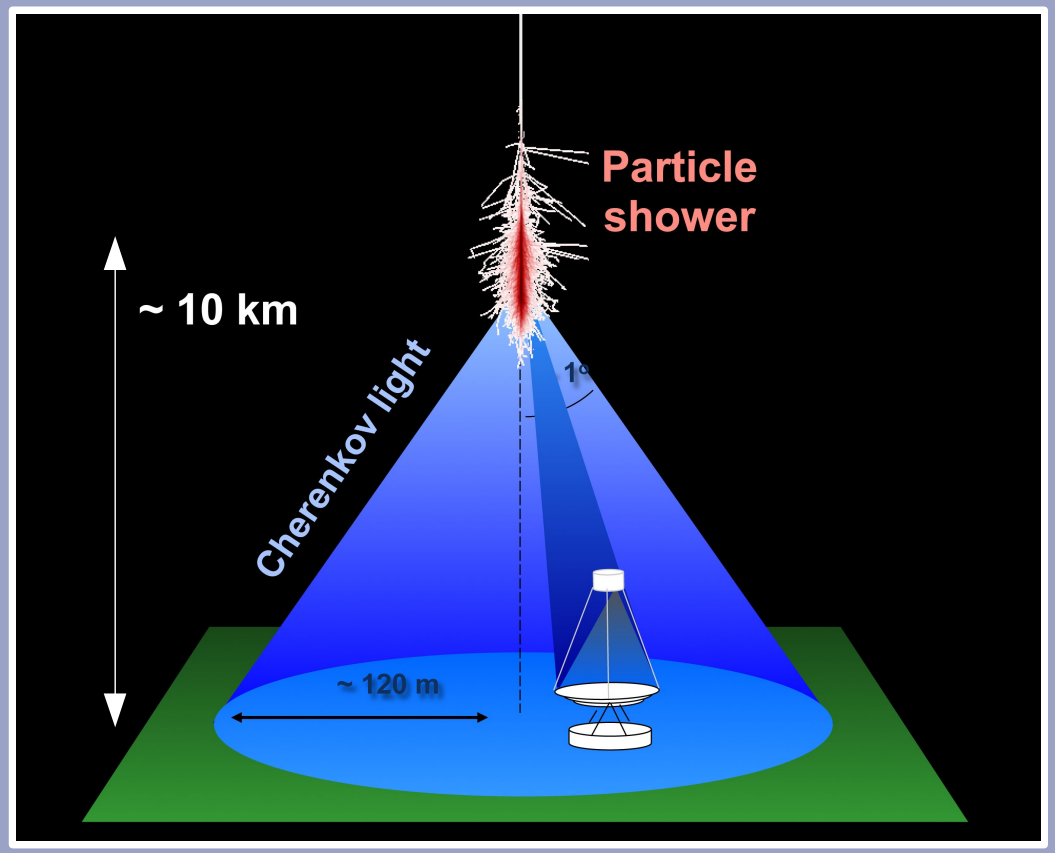
International Collaboration:
≈ 150 scientists from 9 countries

MAGIC-I started routine operation in 2004, construction of MAGIC-II has been completed in early 2009

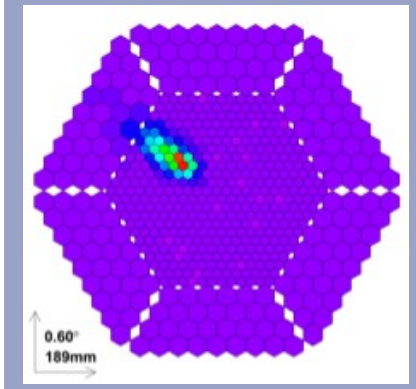
<u>Each MAGIC telescope:</u>
- 17m diameter mirror surface of 236 m² (world largest)
- 60 tons
- 0.1° high resolution camera

Threshold ≈ 50 GeV (resp. 30 GeV)

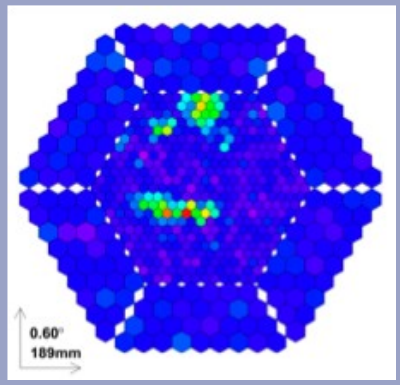
Imaging Air Cherenkov Technique



γ event

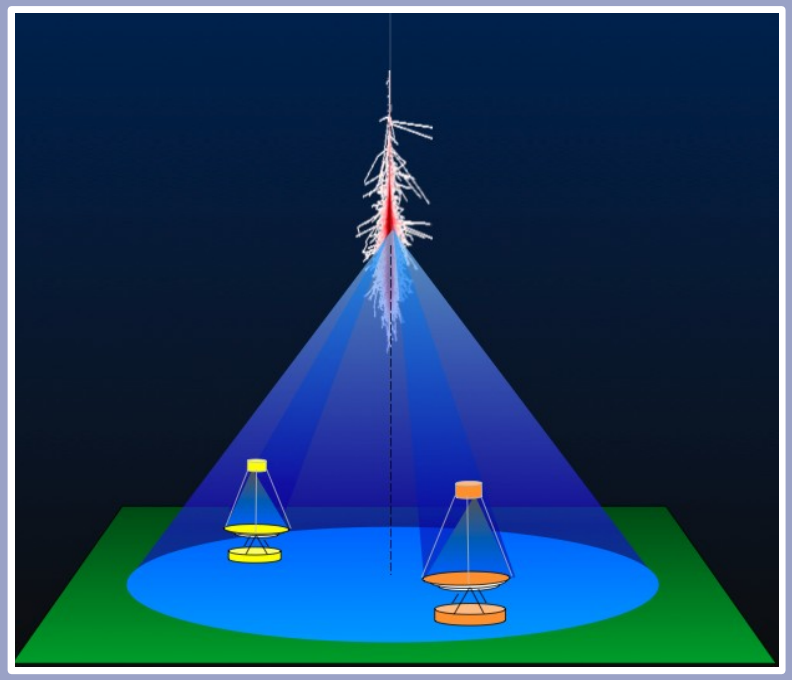


Hadron event

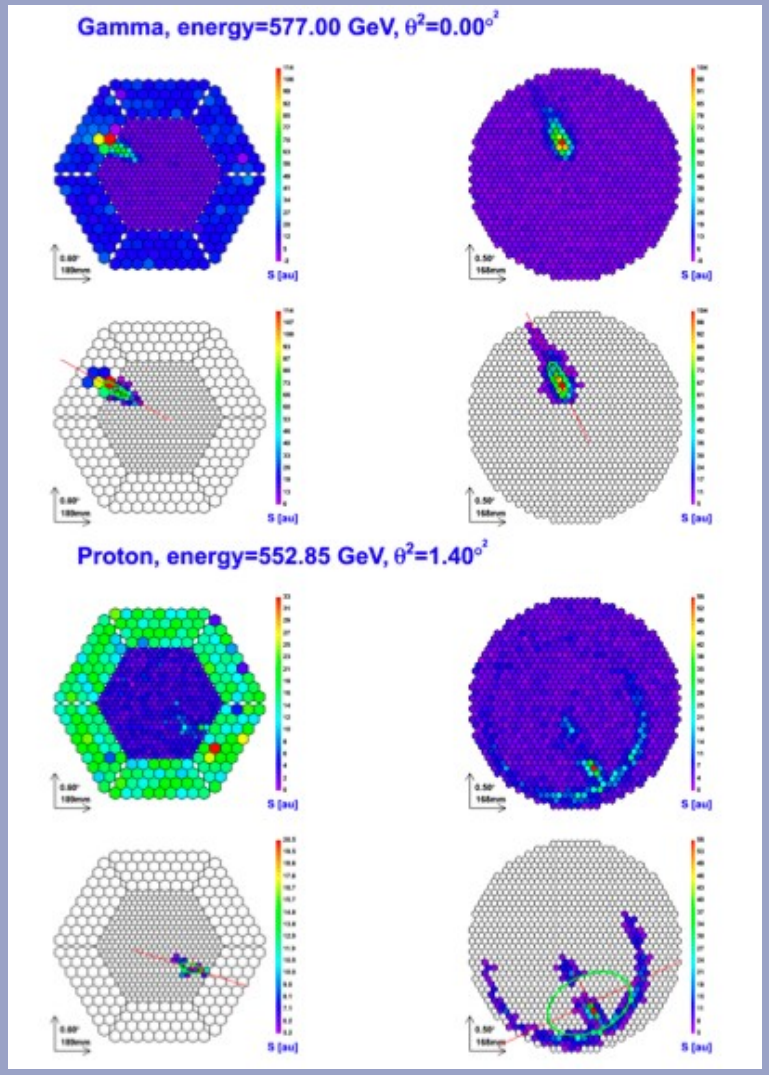


Hadrons (background) dominate over γ (signal). They are rejected in the analysis.

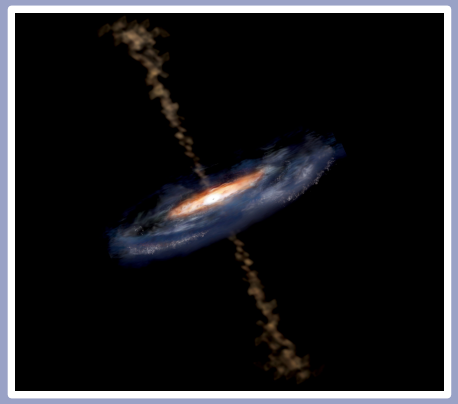
Stereo Observation



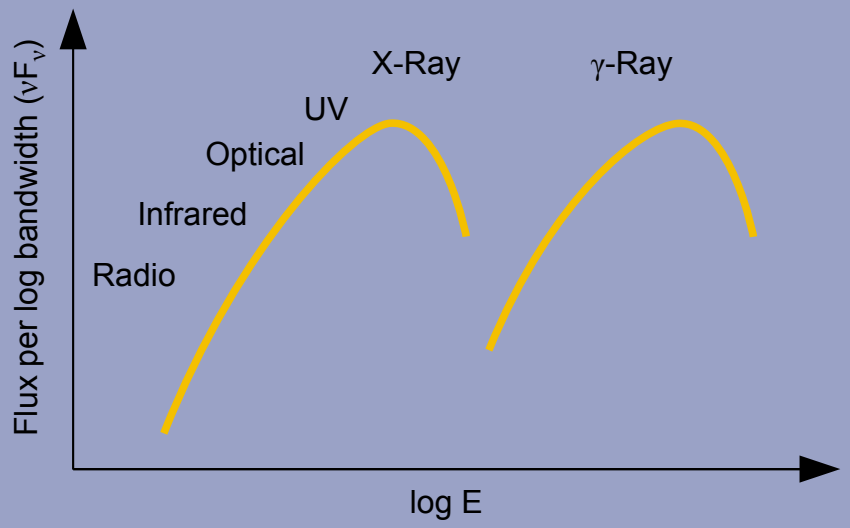
- 3D reconstruction of shower parameters
- Better source position determination
- Improved background reduction



AGN Monitoring



Active Galactic Nuclei



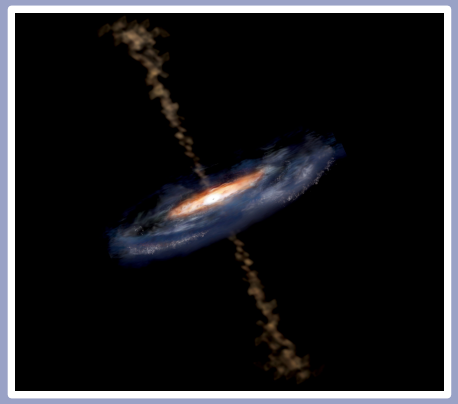
Continuous Spectral Energy Distribution (SED)

Numerous multiwavelength campaigns in recent years:
Aim of explaining the acceleration and emission mechanisms

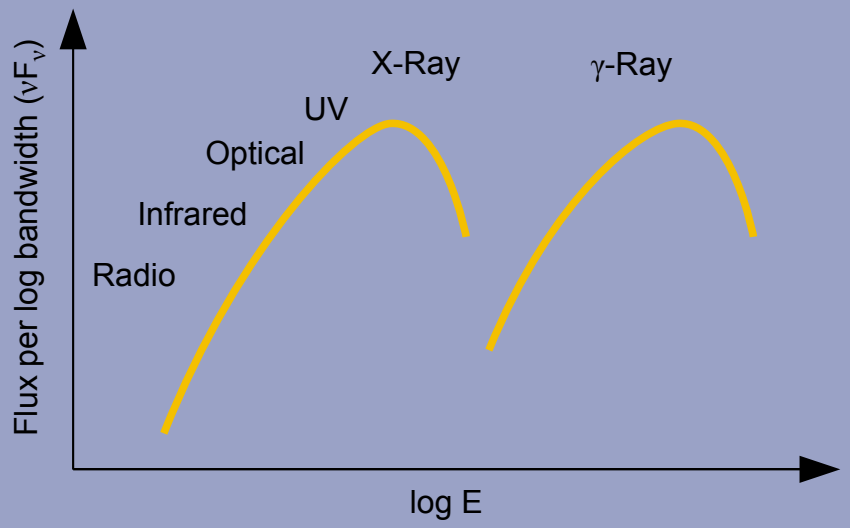
Data collected so far not yet enough to fully constrain the theoretical models (leptonic or hadronic processes? …)

Flux variable at all observed frequencies, but on different time scales ranging from years to minutes

AGN Monitoring



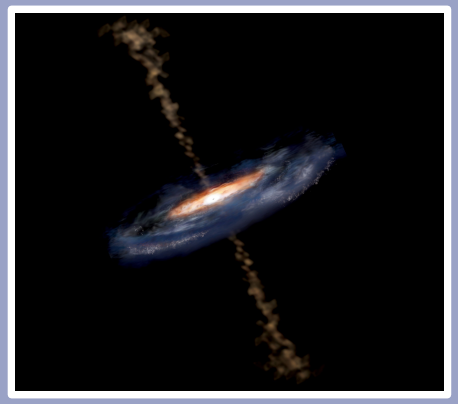
Active Galactic Nuclei



Continuous Spectral Energy Distribution (SED)

More observation needed to answer fundamental questions!

AGN Monitoring



Active Galactic Nuclei

Normal way to observe AGN:
Trigger on high flux states by other wavelengths, e.g. optical

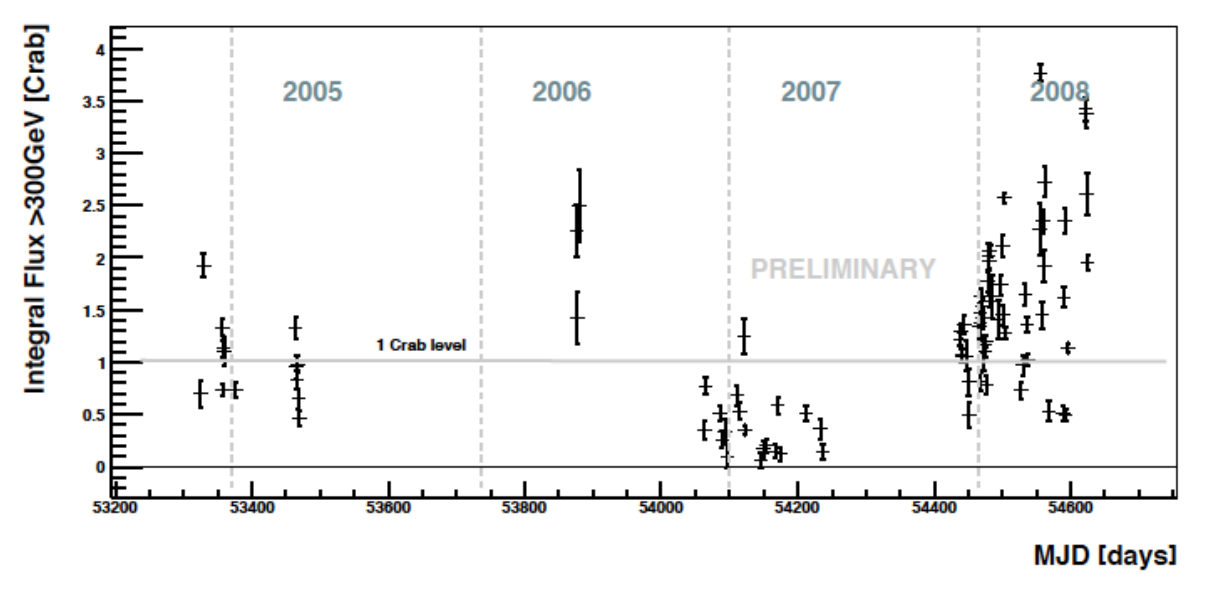
Problem:
This way is not unbiased, since low flux states are under-represented in such samples

Monitoring strategy:
Up to 40 short observations per source are scheduled, evenly distributed over the observable time by MAGIC

Regular sources of the last seasons:
Mrk 421 and Mrk 501: relatively bright, 15-30 min
1ES 1959+650: fainter, requires at least 30 min per single exposure

AGN Monitoring

Mrk 421:



[C.-C. Hsu *et al*, „Monitoring of Bright Blazars with MAGIC“, ICRC proceeding 2009]

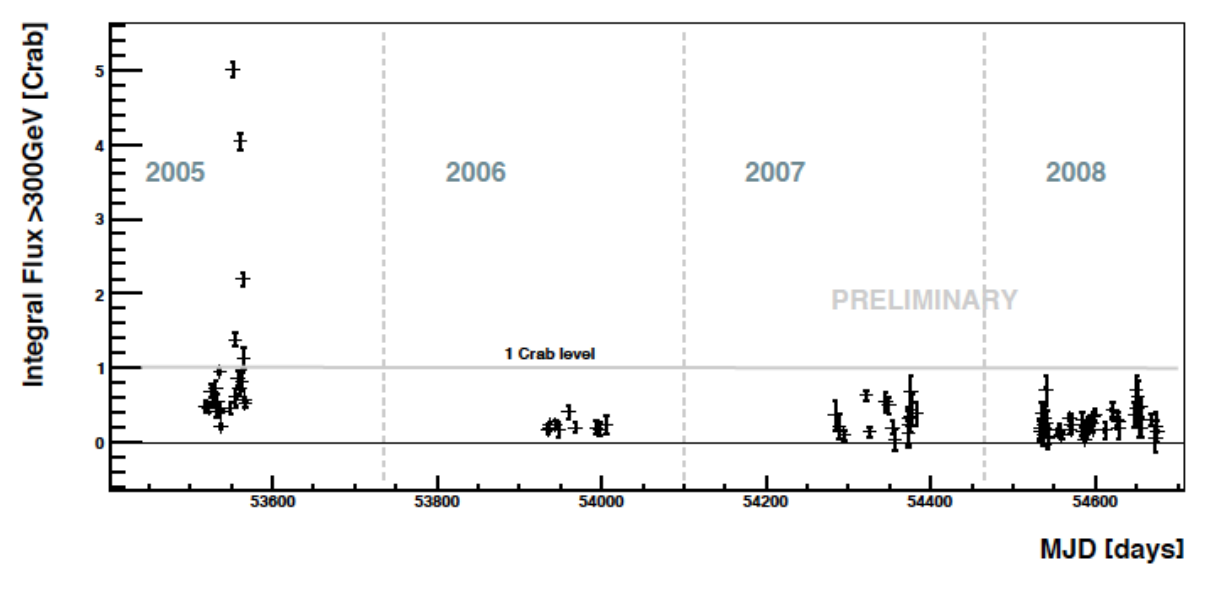
Feb 2007 – Jun 2008:
82 hours of data, 66 hours of good quality

Very active in 2008:
Many flares,
flux rarely decreased below 1 Crab level
($1.2 \cdot 10^{-10}$ ph/cm^{-2}s^{-1})

Note: 70% of these data were taken due to ongoing flare activity

AGN Monitoring

Mrk 501:



[C.-C. Hsu *et al*, „Monitoring of Bright Blazars with MAGIC“, ICRC proceeding 2009]

Feb 2007 – Jun 2008:
16 hours of good quality

Thanks to good weather a dense sampling was obtained

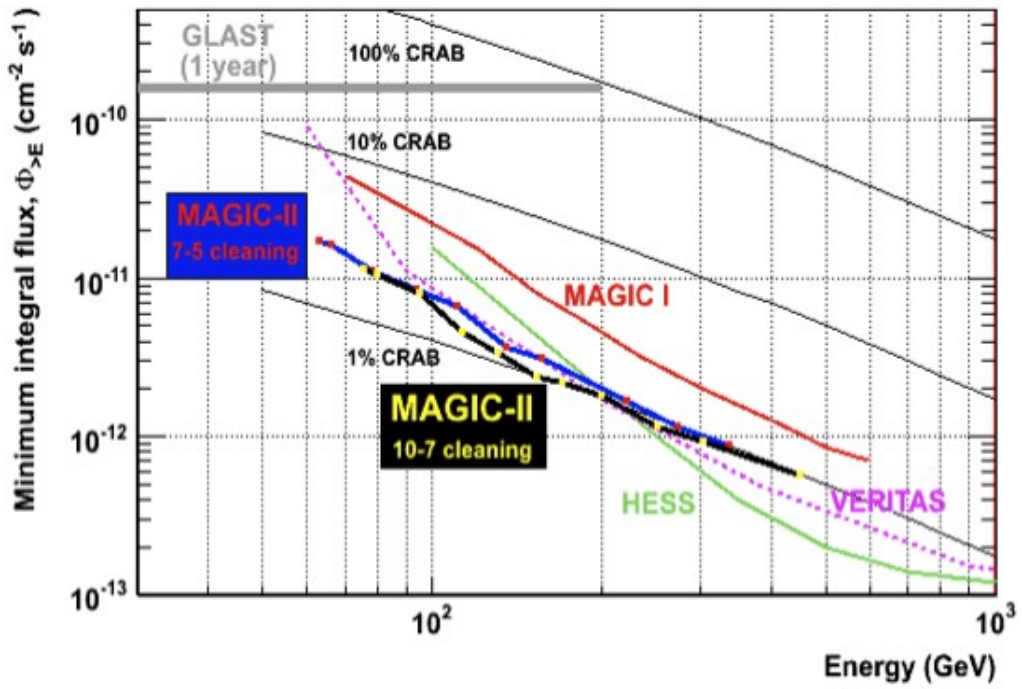
Low state in 2007 and 2008:
flux below 1 Crab level

Conclusion and Outlook

- Monitoring provides unbiased observation at low and high states
- More observation needed to answer fundamental questions
- **Future strategy:**
  - More sources
    Mrk 421, Mrk 501, 1ES 1959+650, M87, PG 1553+113, S5 0716+714, 3C 279, 3C 66B, H 1426+428
  - Extending exposure time in case of flares
  - Comparisons with other wavelength have to round the analyses...


Thank you for your attention
wwwmagic.mppmu.mpg.de

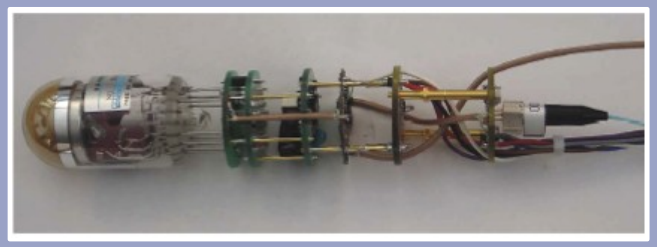
Sensitivity



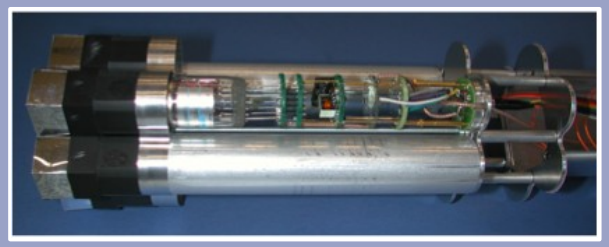
Integral Sensitivity of the MAGIC-II (for a cleaning with 7 core pixels and 5 boundary pixels and 10-7 cleaning) is compared with MAGIC-I (300MHz FADC) and other experiments. The sensitivity is defined as integral flux of gamma events, exceeding the background fluctuation by factor 5, in 50 hours of observation.

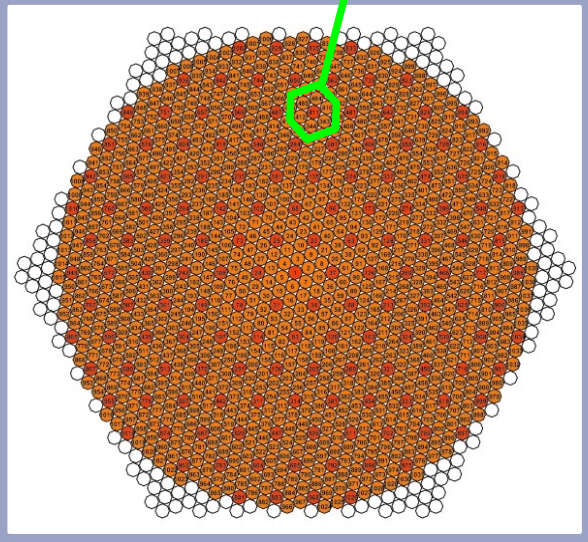
The MAGIC II camera

Hemispherical High QE PMT



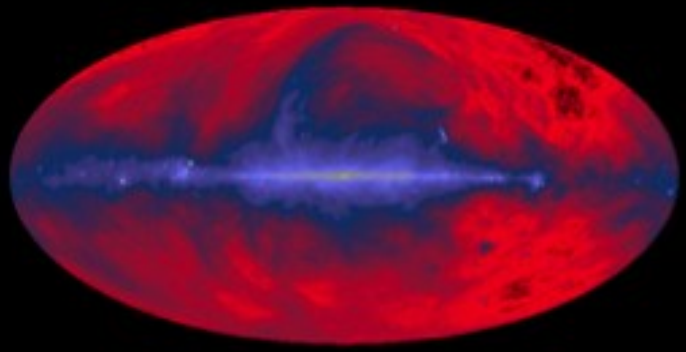
7 PMT grouped in a cluster



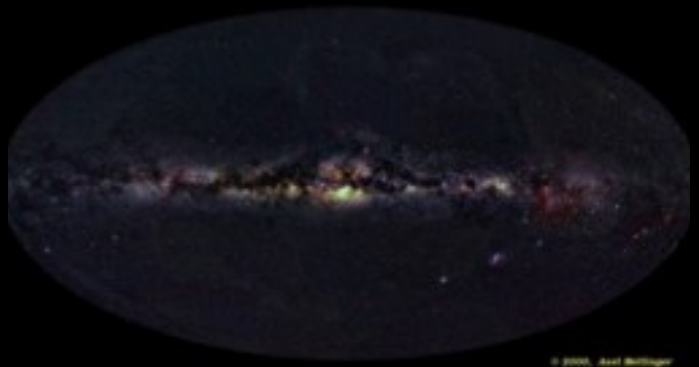


1039 PMT in total

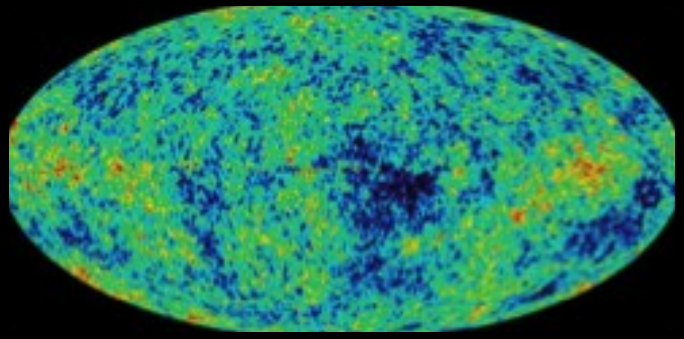
Universe in different energies



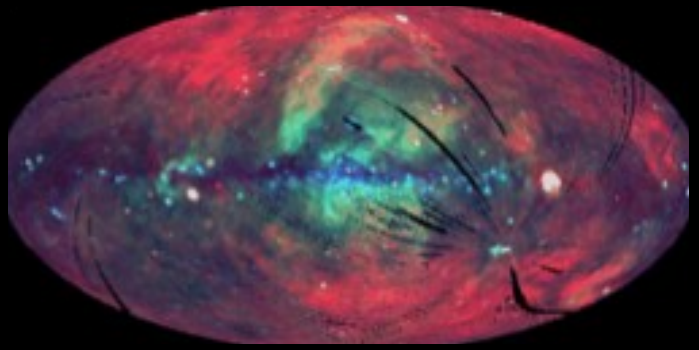
Radio
10^{-6} eV



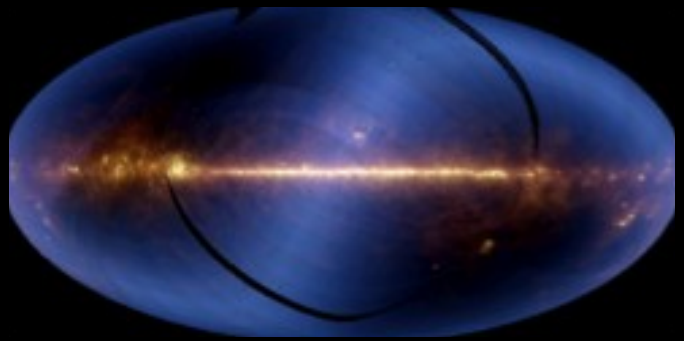
Optical
1 eV



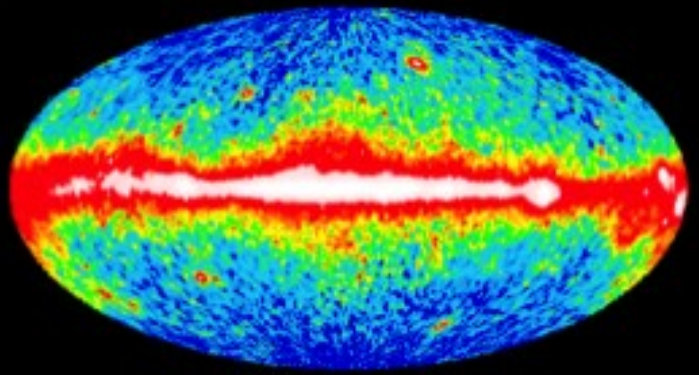
CMB
10^{-4} eV



X-Ray
10^{3} eV

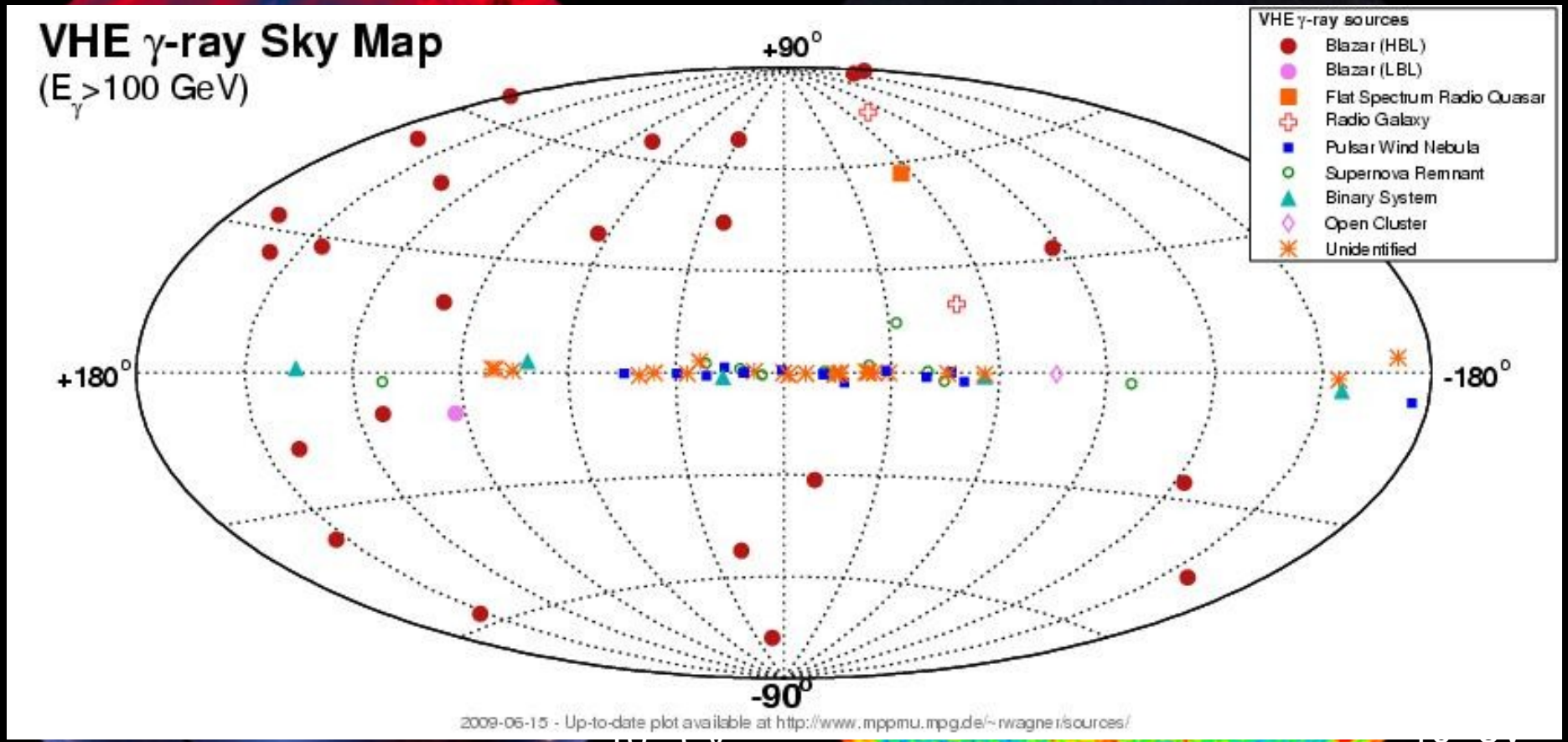


IR
10^{-2} eV

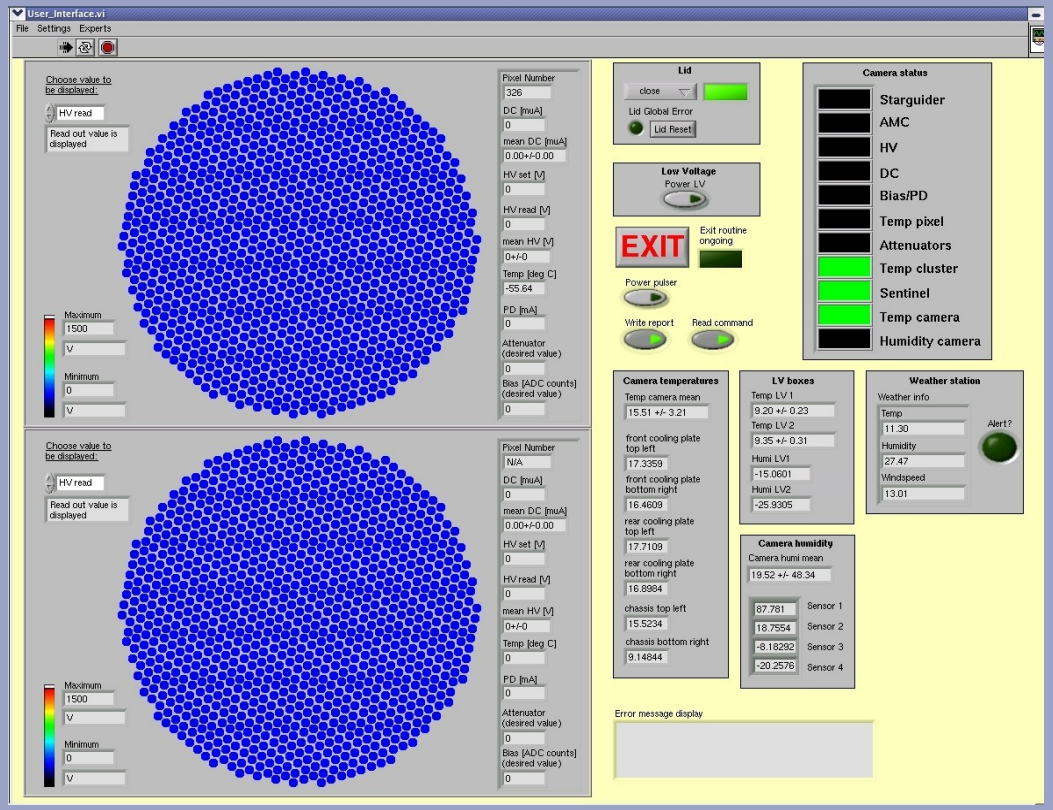


γ-Ray
10^{8} eV

Universe in different energies



The MAGIC II camera

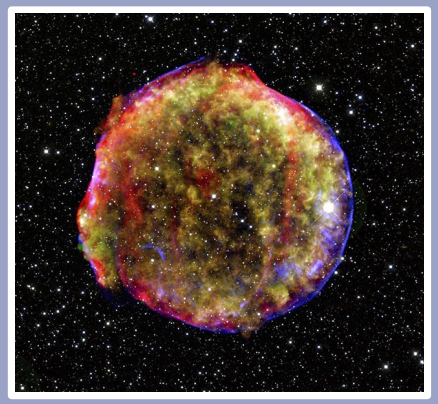


Contribution to ICRC 2009 arXiv:0906.5259

Slow Control Software:

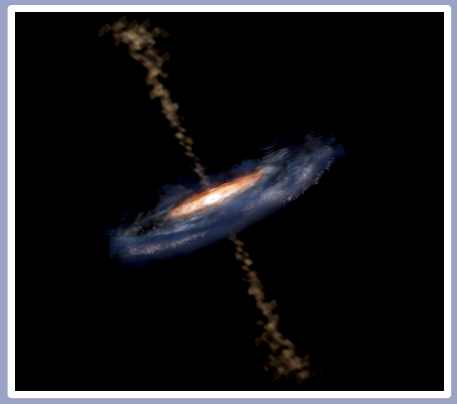
- written in LabVIEW
- controls user settings
- monitors camera and external conditions
- automatic safety routines

γ-Ray sources and objectives

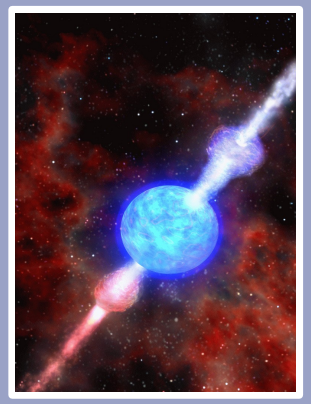


Super Nova Remnants (Tycho's SNR)

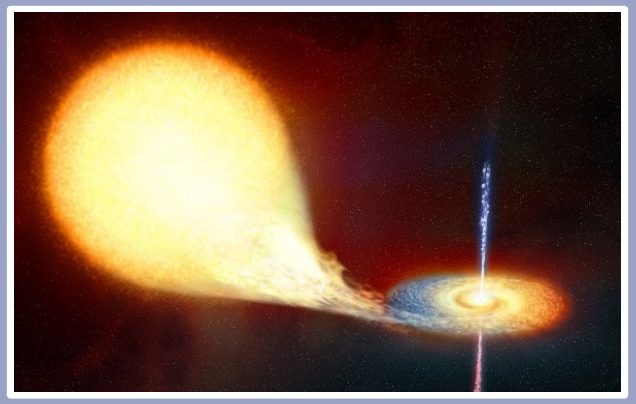
Pulsars (Crab pulsar)



Active Galactic Nuclei



Gamma Ray Bursts



Microquasars
X-Ray binaries

Outline

- Introduction to the MAGIC telescopes
- Imaging Air Cherenkov Technique
- Specific objective for observation: Observing AGN