

Highlight results from the MAGIC telescopes

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MAGIC-1

MAGIC-2

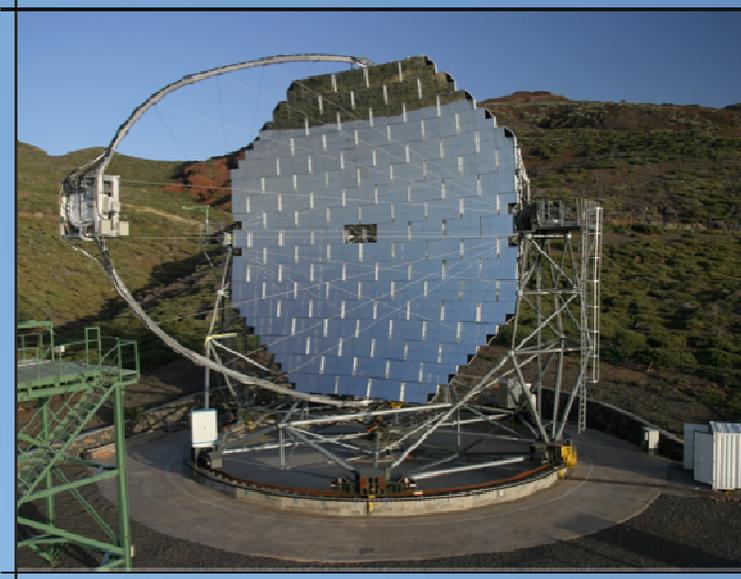


23rd Rencontres de Blois – 1st June 2011

Outline

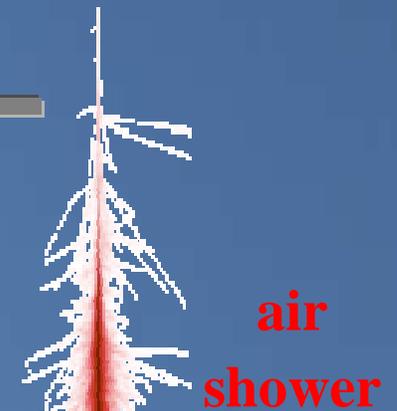
- From one to two telescopes
- Performance in stereo
- Recent results
 - Galactic
 - Extra-galactic
 - Astroparticle physics
- Final remarks

MAGIC phase I



World Largest IACT

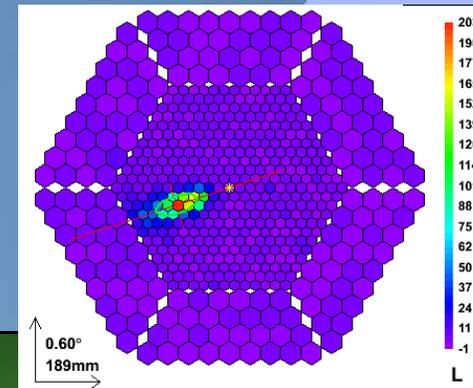
- 17 m diameter
- 3.5° FOV
- 577 pixels
- 2 GSample/s
- Repositioning <40s



Site: Canary Island La Palma, 2200 m asl.

Performance

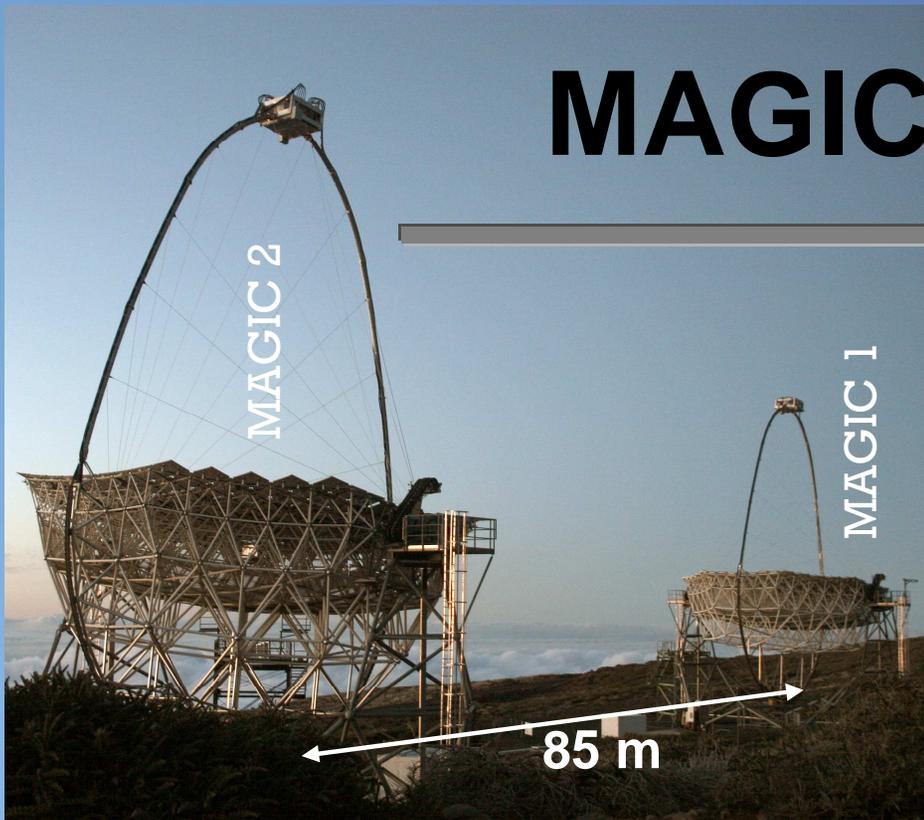
- Energy threshold: **55 GeV**
(pulsar trigger: 25 GeV)
- Sensitivity: **1.6%** Crab in 50 h
- Angular resolution: **0.1°**
- Energy resolution: **~20%**



~120 m

Cherenkov Light Pool

MAGIC phase II

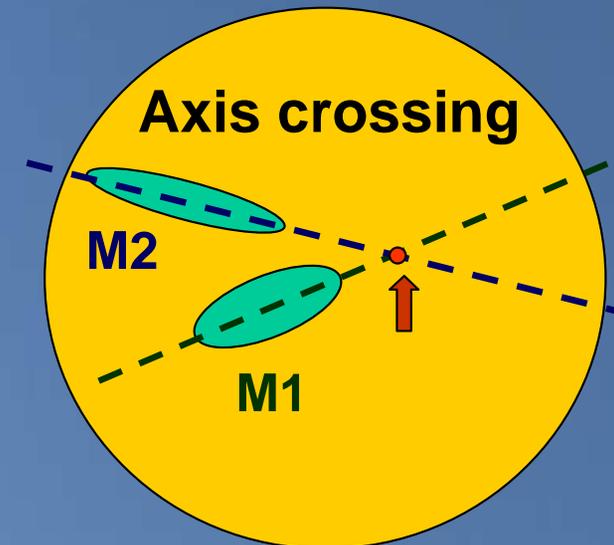
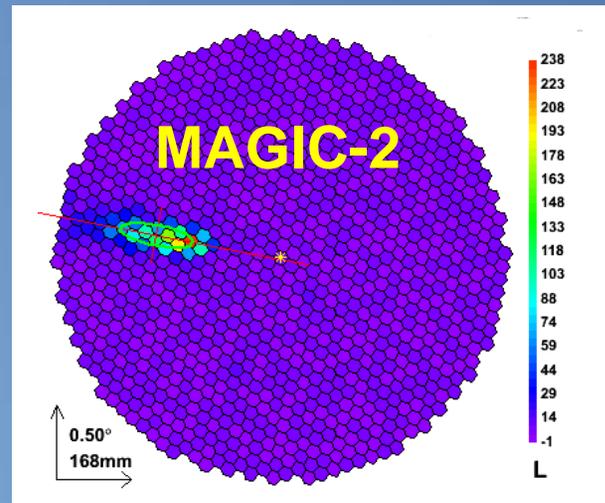
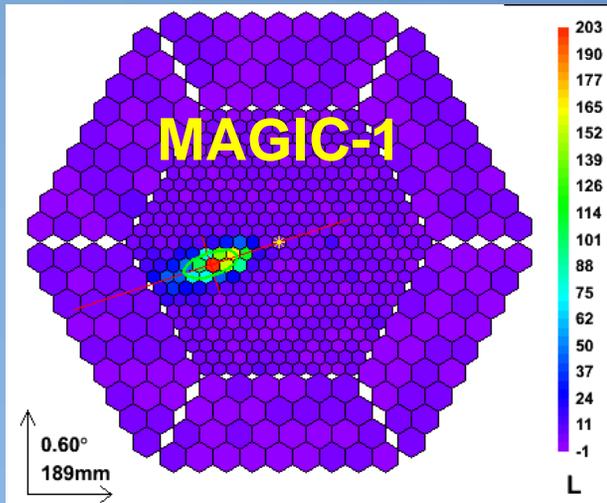


Two 17m telescopes observing in stereoscopic mode

- Improved drive system: repositioning <20s (both telescopes)
- **MAGIC-2 camera:**
 - 3.5° FOV with 1039 pixels
 - Higher PMT QE
 - Larger Trigger area
 - Readout: DRS2 - 2 GSample/s
- **Stereo Trigger (Level 3)**
 - Energy threshold: ~50 GeV

**MAGIC-2 =
Improved clone
of MAGIC-1**

Improvement from Stereo observation



Stereo trigger:

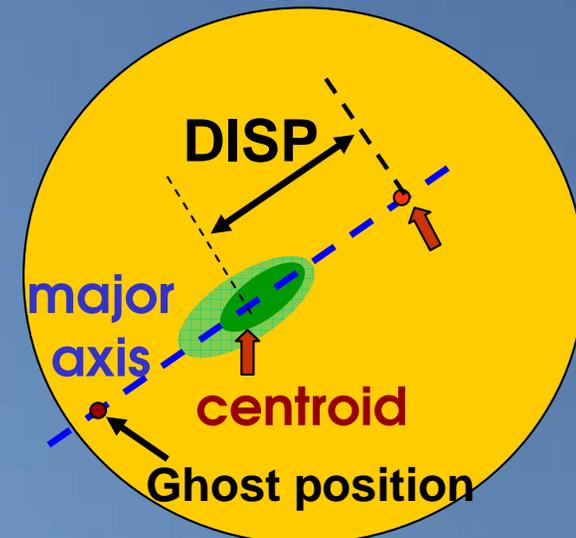
- Reduce dramatically the background at low E

New parameters:

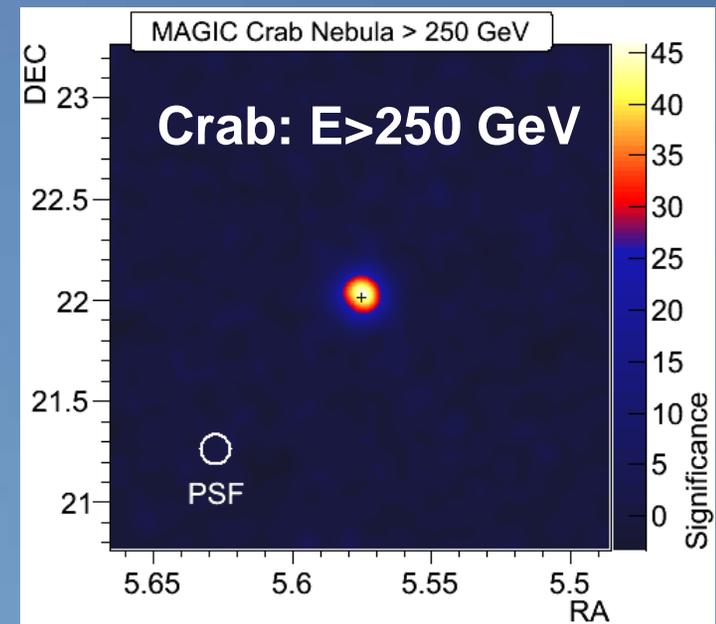
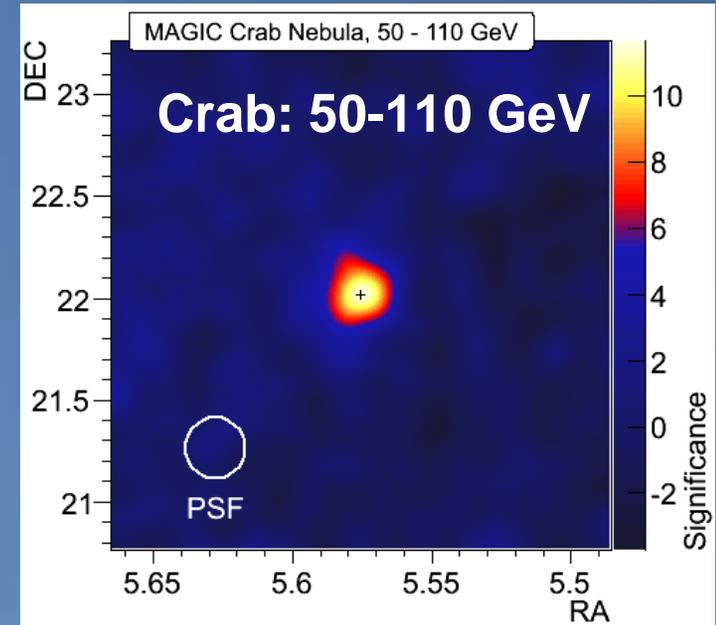
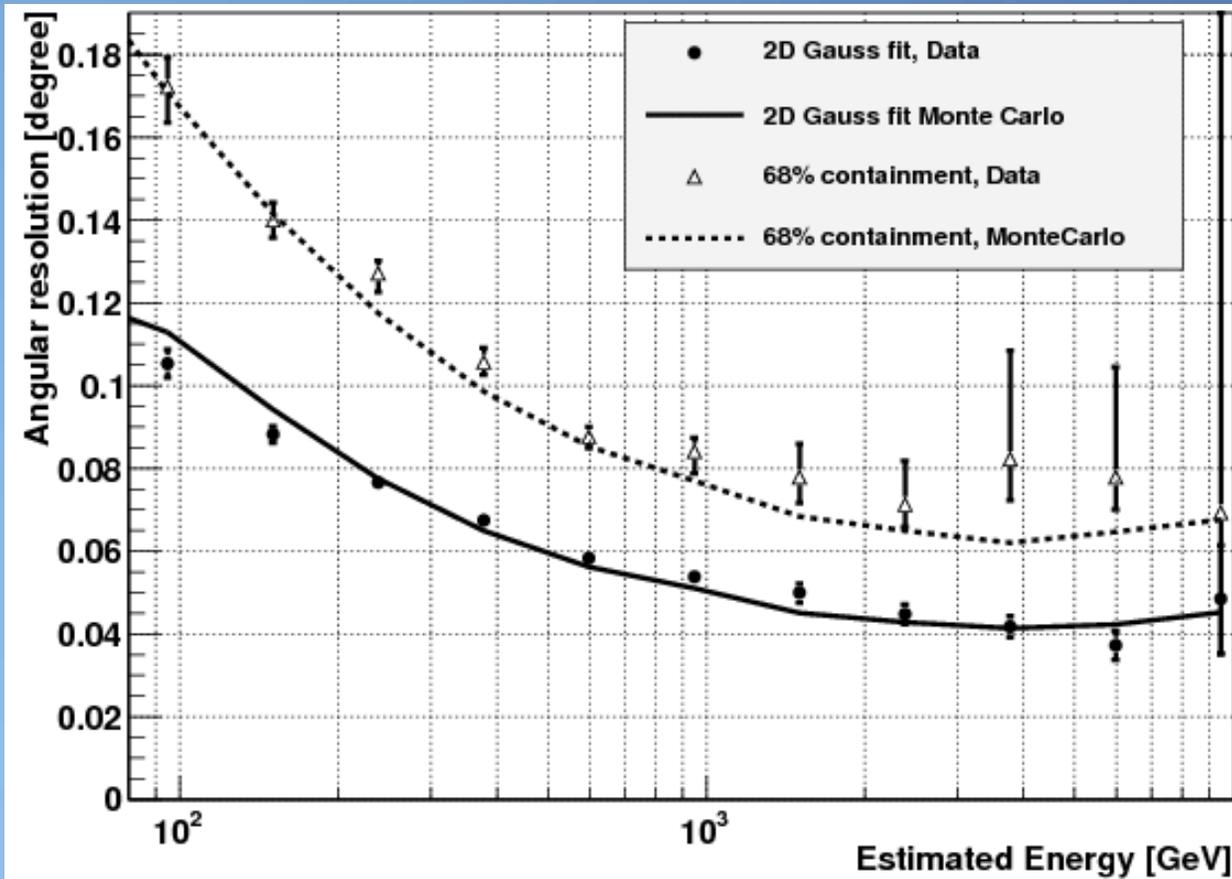
- Geometrical reconstruction (axis crossing)
- Shower impact parameter
- Height of the shower max

Double reconstruction:

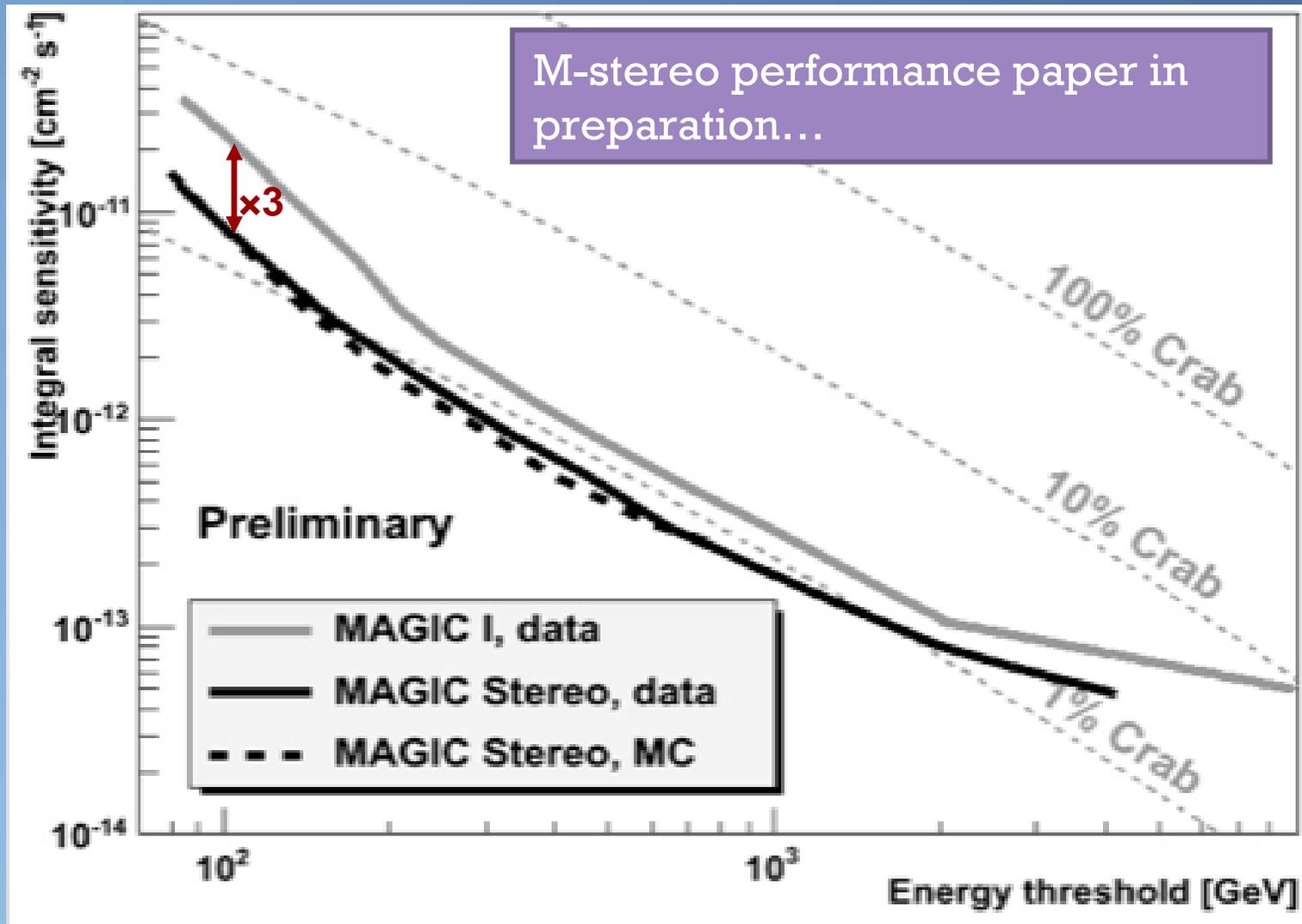
- Energy (using lookup tables)
- Direction (DISP method)



Angular Resolution

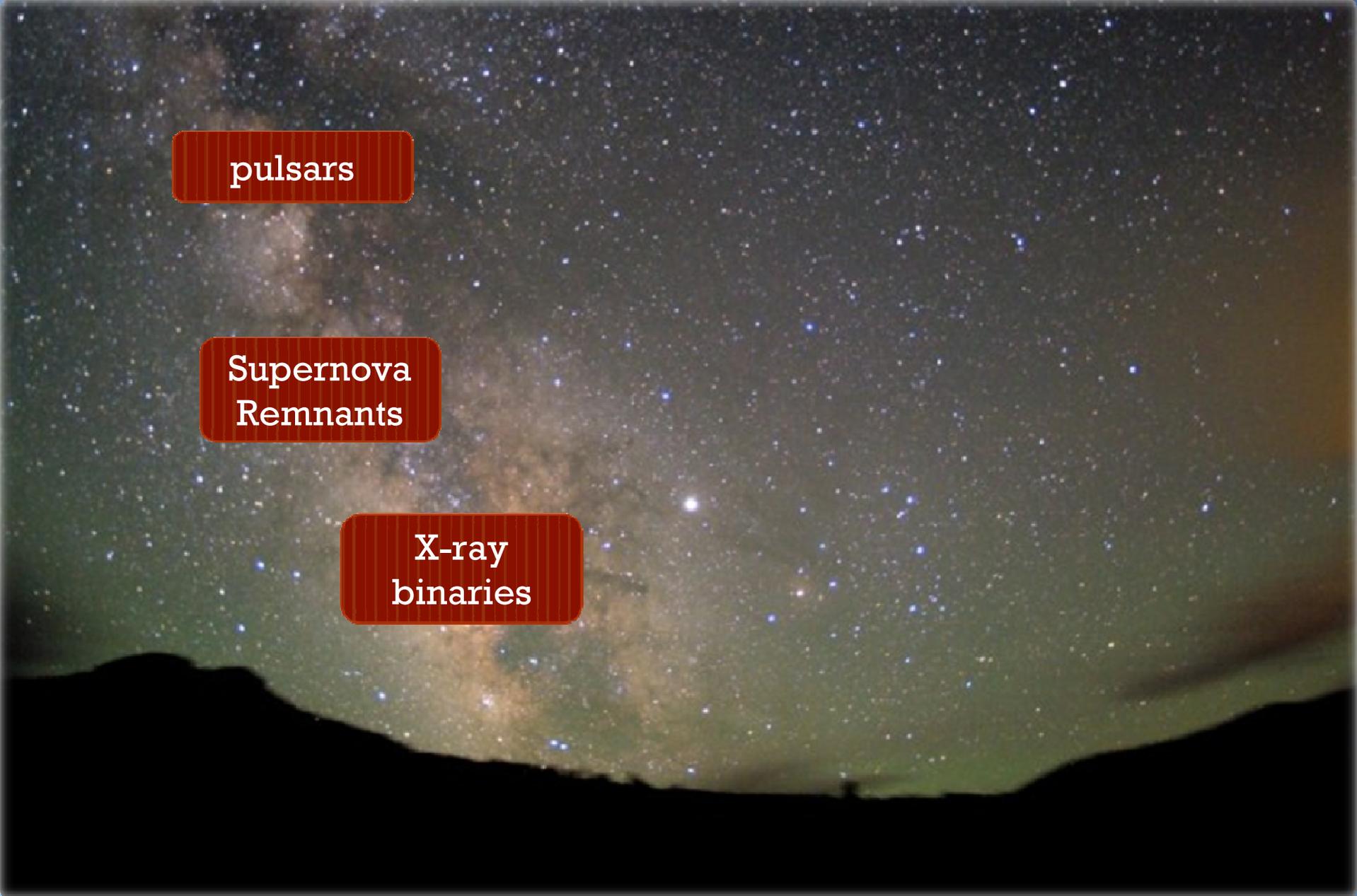


Sensitivity



Most sensitive observatory in the range: 50-200 GeV

Galactic sources



pulsars

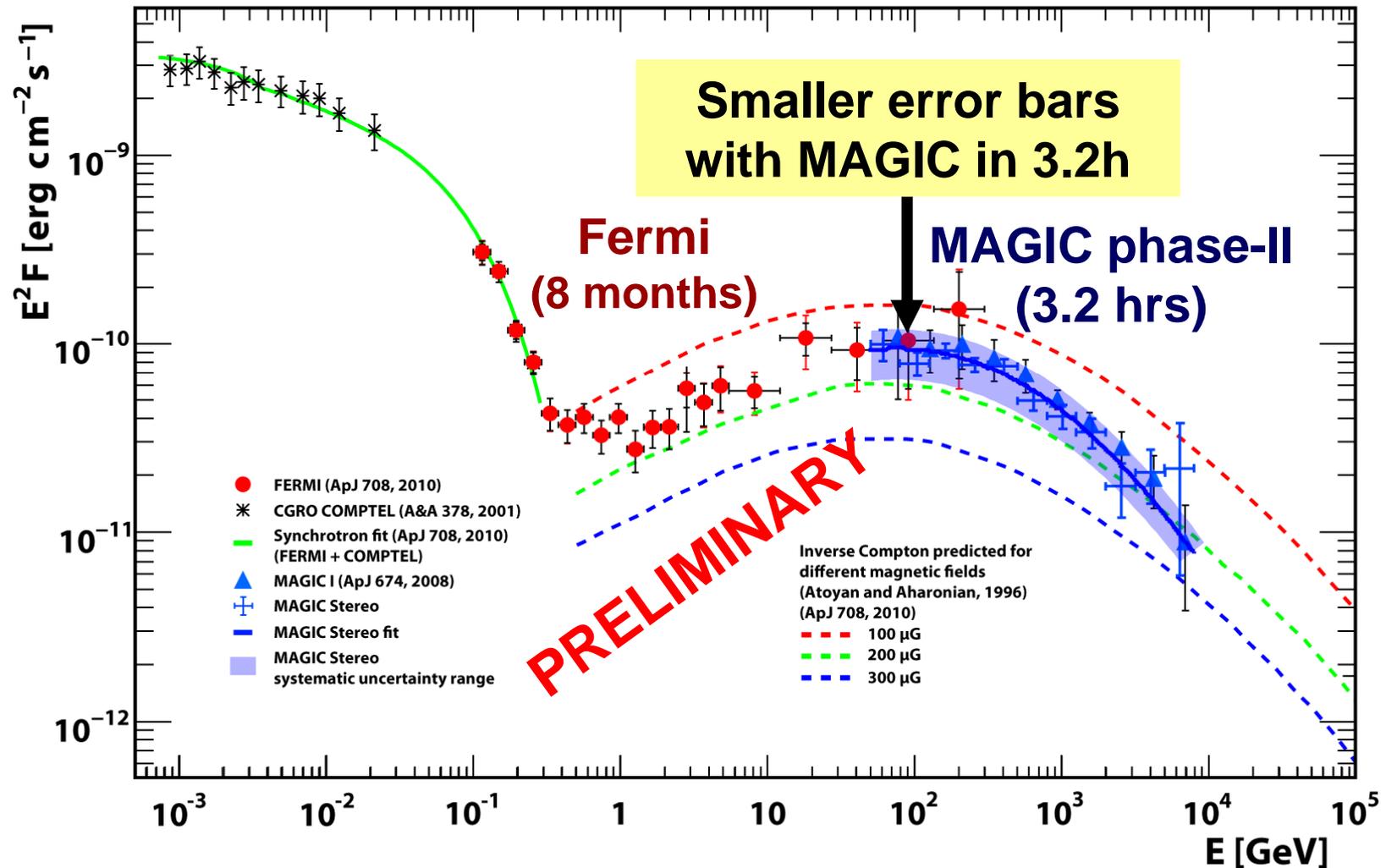
Supernova
Remnants

X-ray
binaries

Crab Nebula: full HE-VHE coverage

Crab Nebula Spectrum

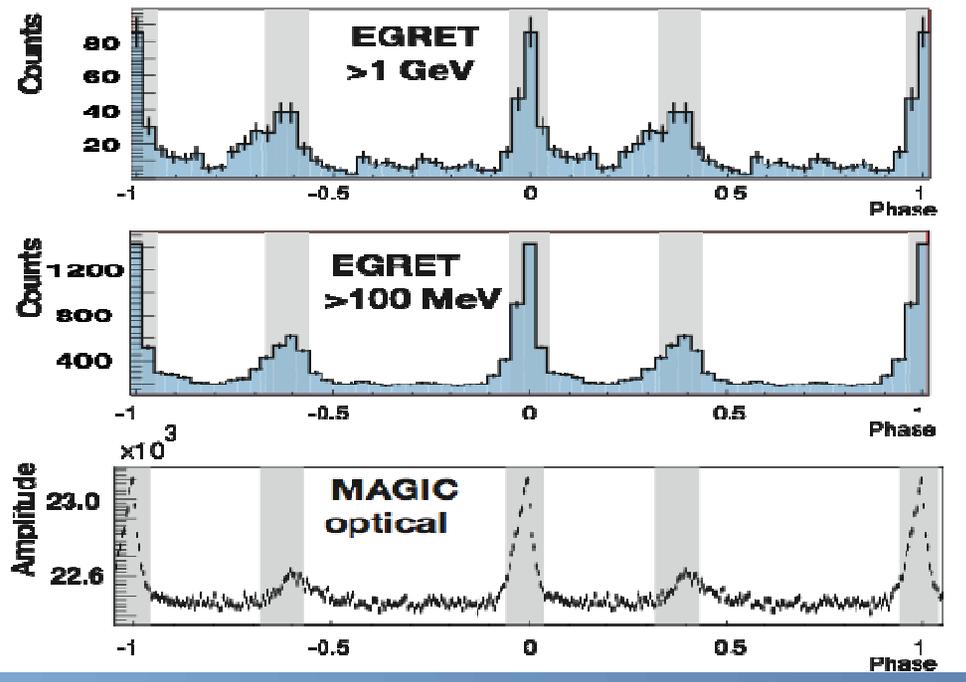
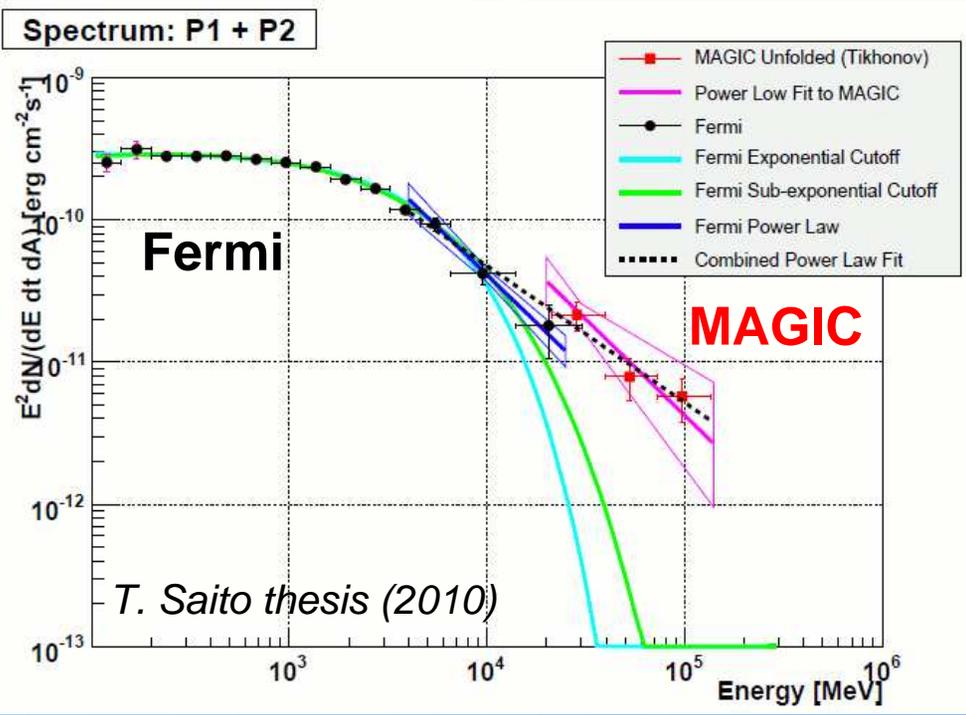
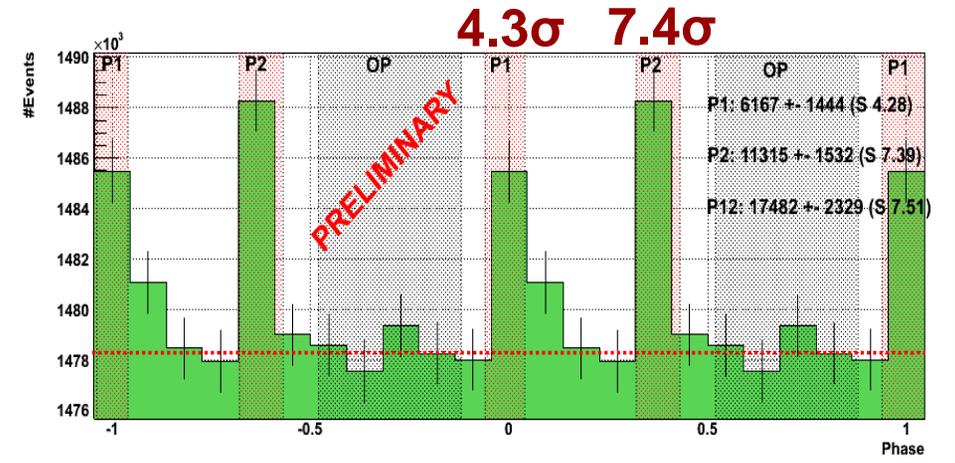
MAGIC Stereo in combination with neighbouring wavelengths



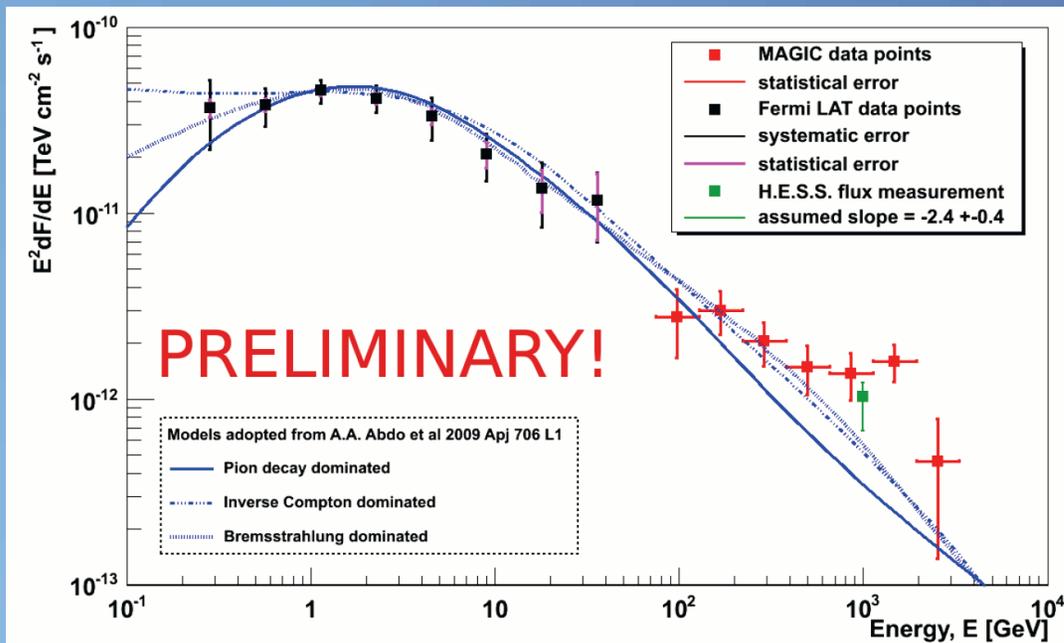
Crab Pulsar

- Special trigger (sum trigger) with threshold = 25 GeV
- First detection of a pulsar above 25 GeV.
- Flux Compatible with Fermi
- Recently confirmed by VERITAS and extended to higher energies
- Challenging result of pulsar models

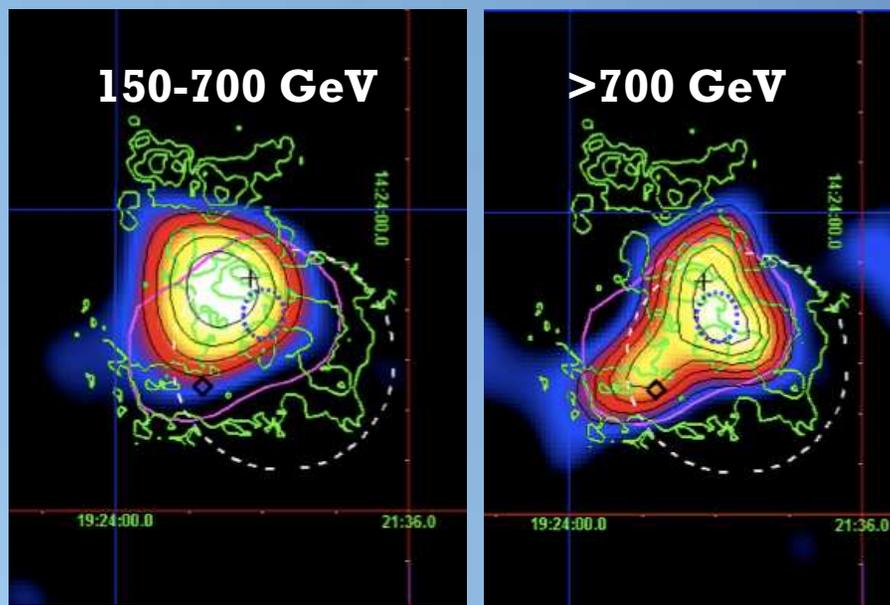
MAGIC: E >25 GeV
 59 h of data from Oct-2007 to Jan-2009



MAGIC results for W51C



Relative Flux Maps

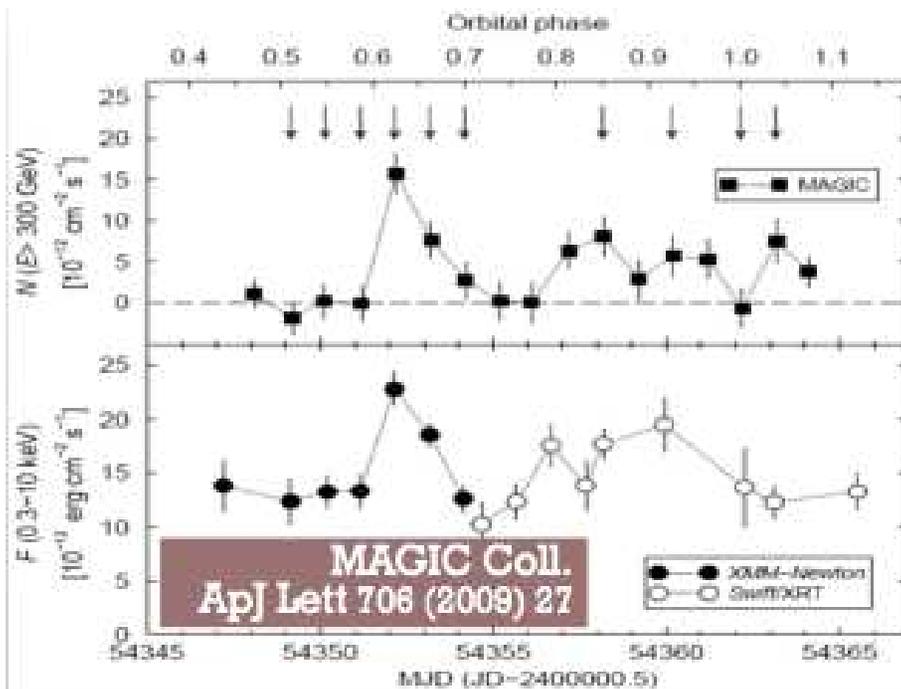


- Observation: 31.1 h in 2010
- Extended emission: 0.16°
- Maximum of the emission coincides with the shocked cloud regions
- Models based on Fermi / LAT + radio data predict a too softer spectrum than MAGIC sees: spectral index = 2.4 ± 0.14
- Morphology suggests hadronic or other mechanisms:
 - particle spectrum hardens at high energies
 - High energy particles penetrate more effectively dense regions
 - other sources > 100 GeV

Binary systems

LS I +61 303

- Discovered by MAGIC in 2006 (Periodic VHE emission)
- Correlation between X and VHE gamma-ray in 2008 suggests leptonic processes are at work.
- Faint VHE state detected in 2009

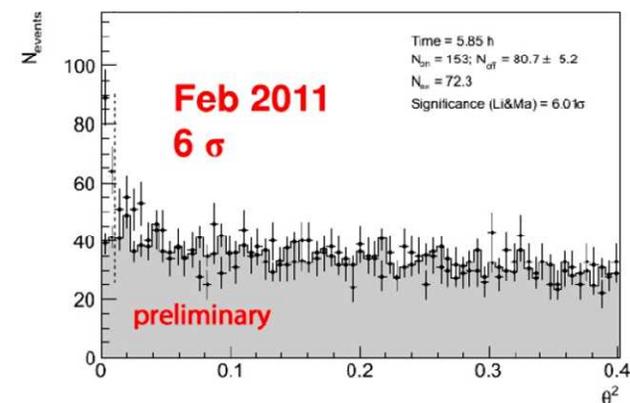


Cygnus X-3

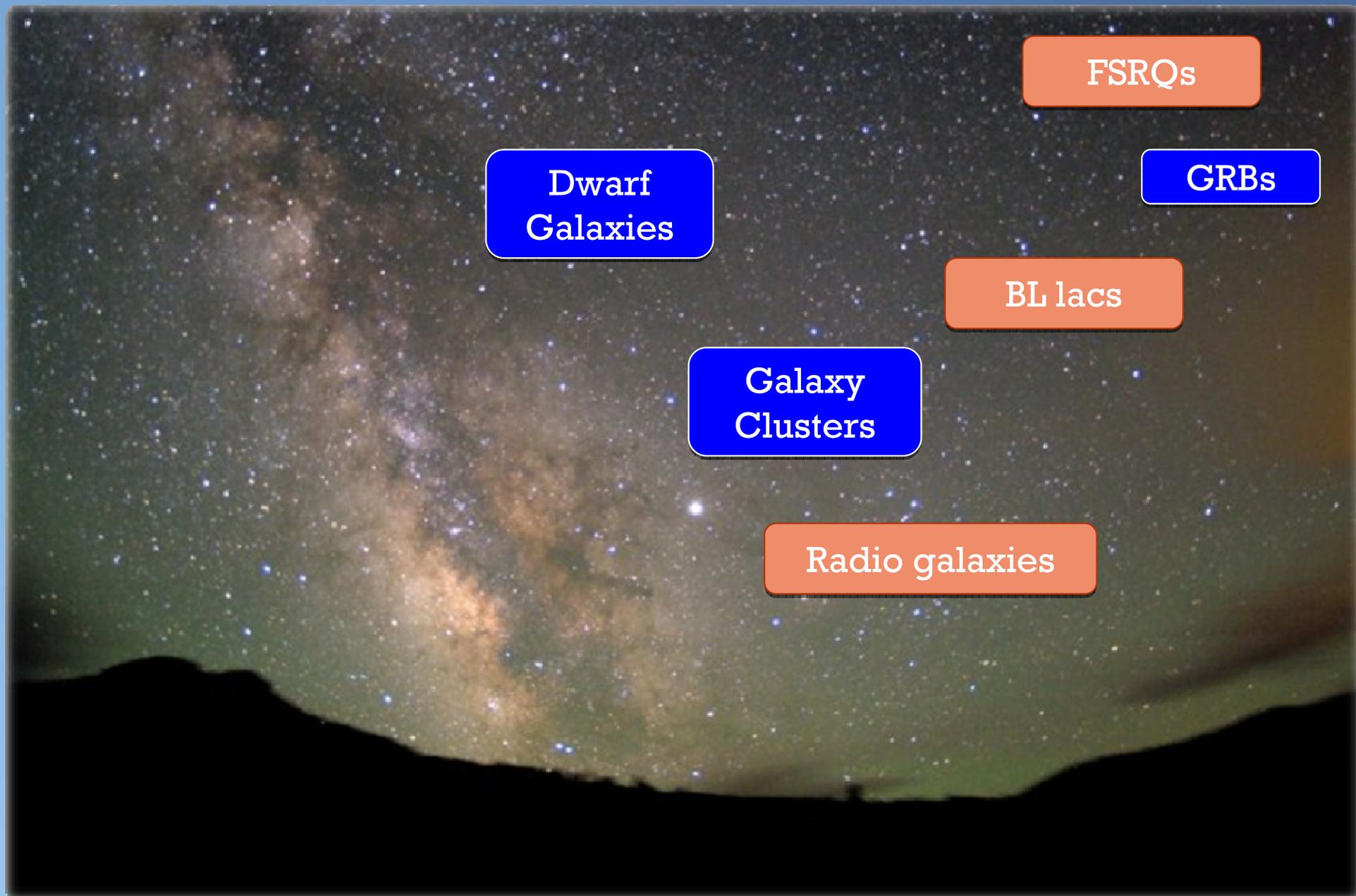
- Large MWL efforts!
- 56.7 hours of MAGIC-phase I data results in upper limits at every X-ray or γ -ray states

HESS J0632+57

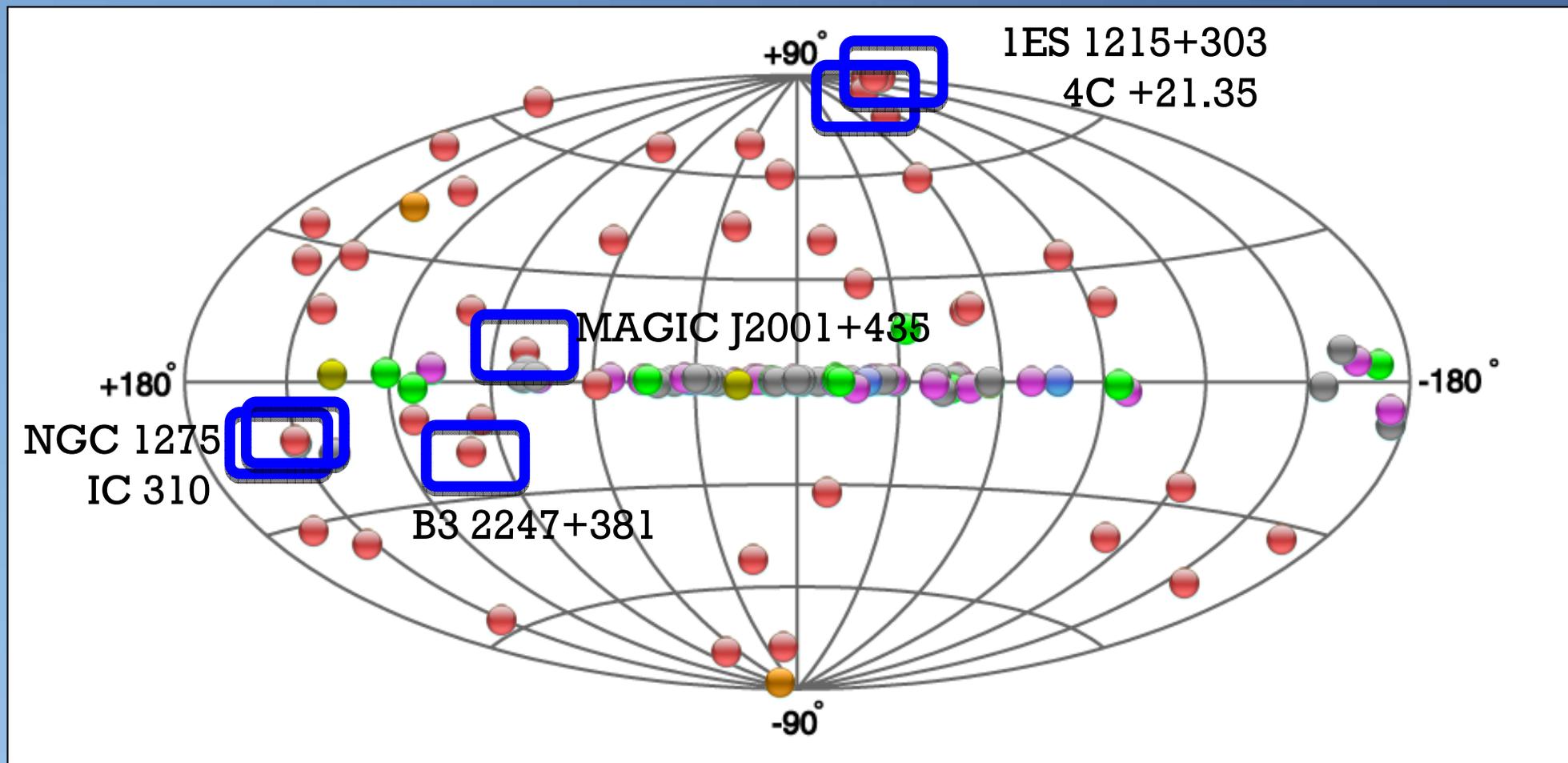
- Variable source at VHE
- Detection by MAGIC in 2011 (ATEL #3161), coincident with high X-ray activity period



Extragalactic objects



MAGIC discoveries during phase-II



6 new extragalactic objects in 12 months !

- 3 BL lac objects
- 1 Flat Spectrum Radio Quasar
- 2 radio galaxies (or unclear classification)

Optical trigger discoveries

Monitoring of good VHE candidates with the KVA telescope.
MAGIC observation during high optical state (ToO)

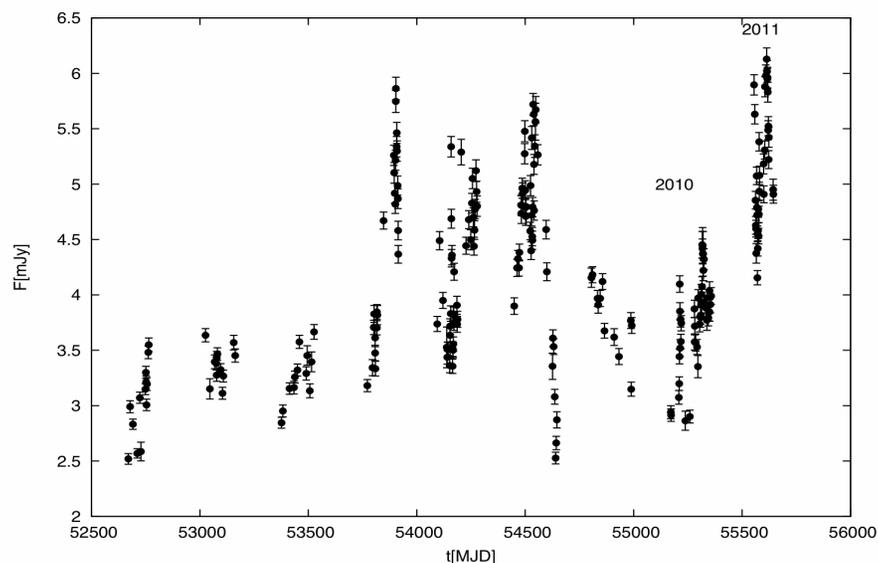
MAGIC phase-I:

- Mrk180: HBL ($z = 0.045$)
- 1ES1011+496: HBL ($z = 0.212$)
- S5 0716+714: LBL ($z = \sim 0.31$)

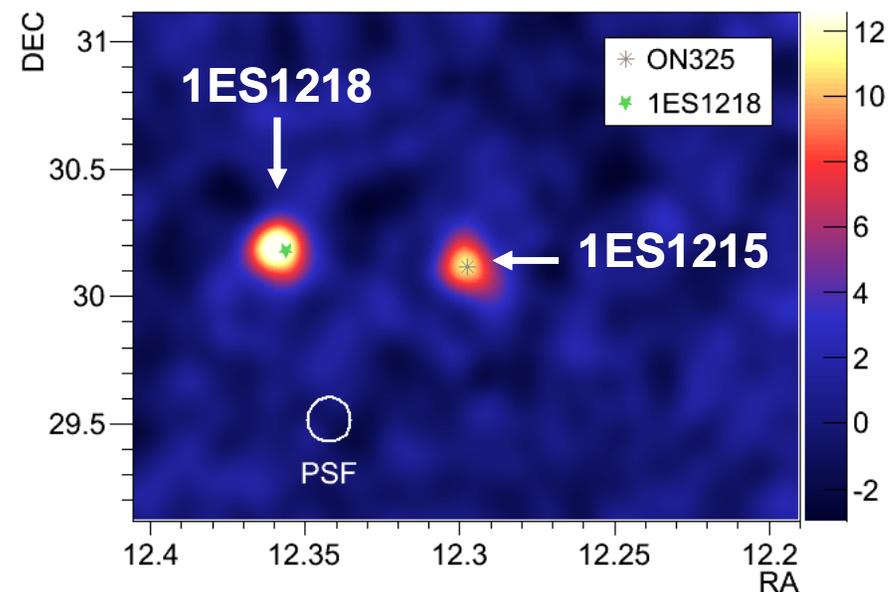
MAGIC phase-II:

- B3 2247+381: HBL ($z = 0.119$)
- 1ES1215+303: HBL ($z=0.130$ or $z=0.237$)
- (Flare of 1ES0806+524, HBL $z=0.138$)

KVA light curve of 1ES1215+303



Significance sky map of 1ES1215+303 observation with MAGIC in 2011

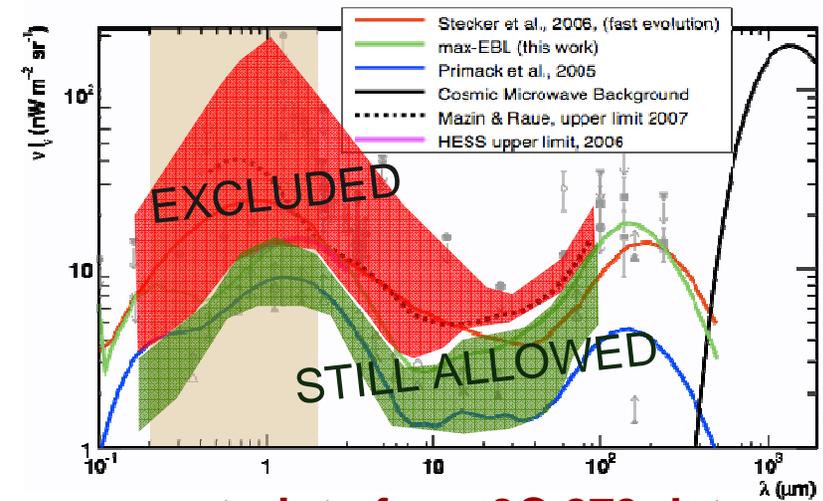


Flat Spectrum Radio Quasars

3C 279

- Discovered by MAGIC in Feb 2006
- The farthest TeV object ($z=0.54$)
(Best object to constrain EBL models)
- Another flare detected in Jan 2007
(during a optical high state)

Probing EBL spectrum 0.2-2 μ m

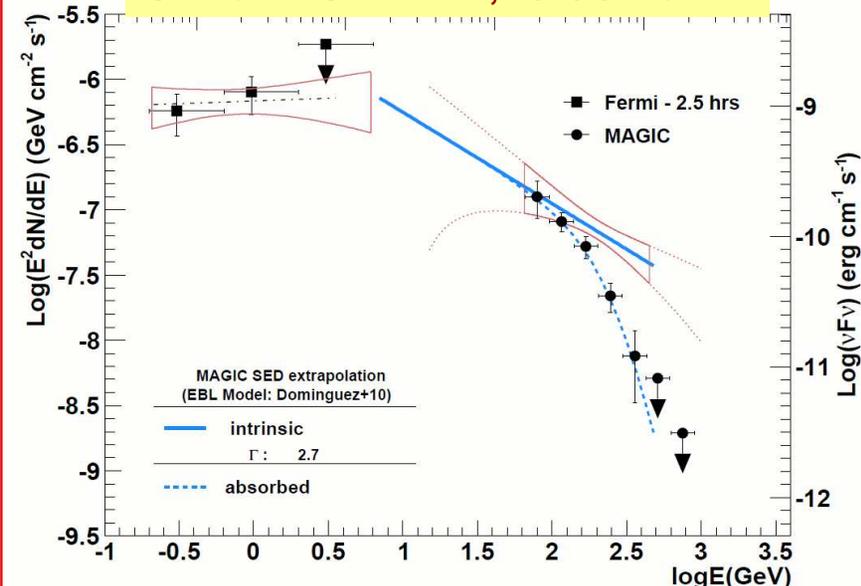


constraints from 3C 279 data

PKS 1222+21 (4C21.35)

- Discovered by MAGIC in June 2010
- Second farthest TeV object ($z=0.432$)
- Fast variability: doubling time=8.6 min
- No sign of any cutoff
- Very challenging for emission models

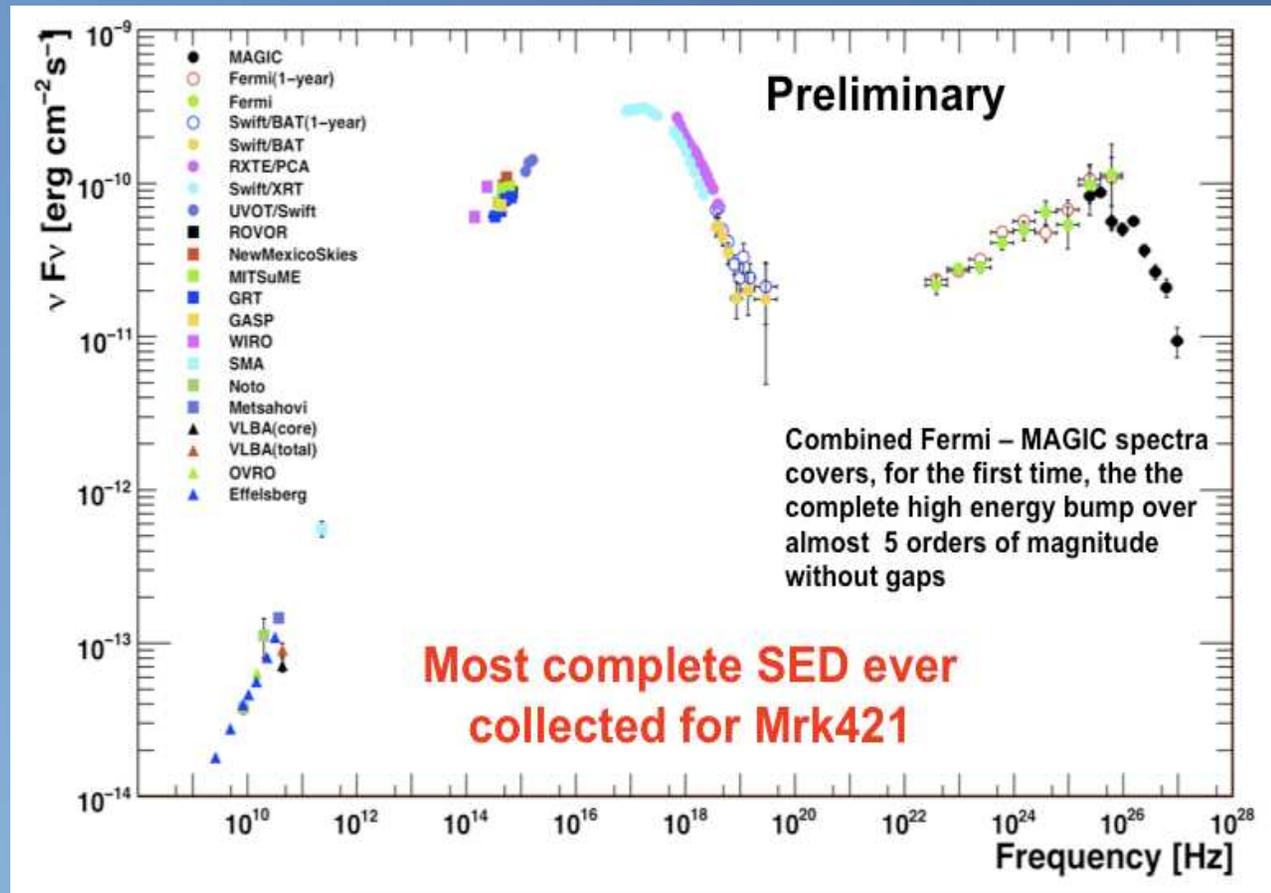
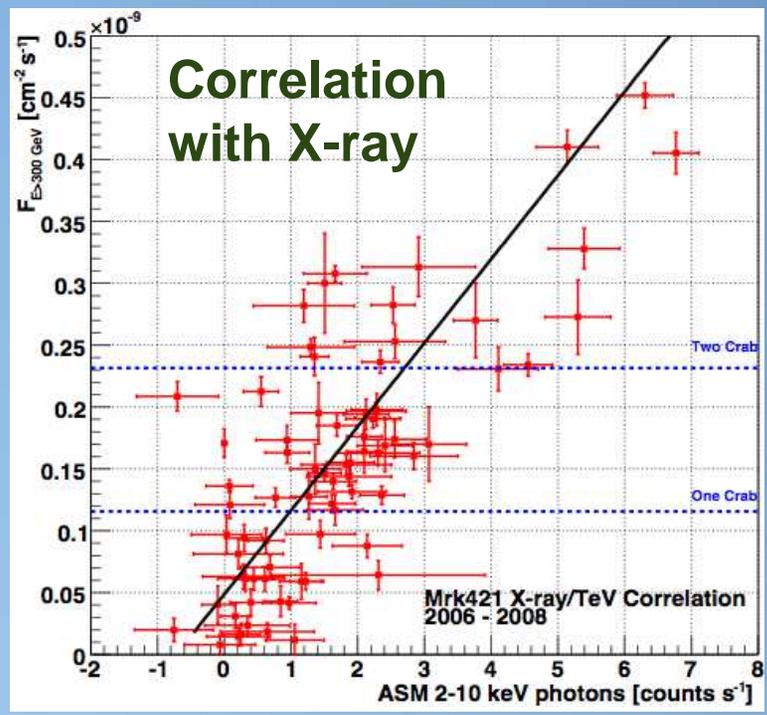
SED of PKS 1222+21, 2010 June 17th



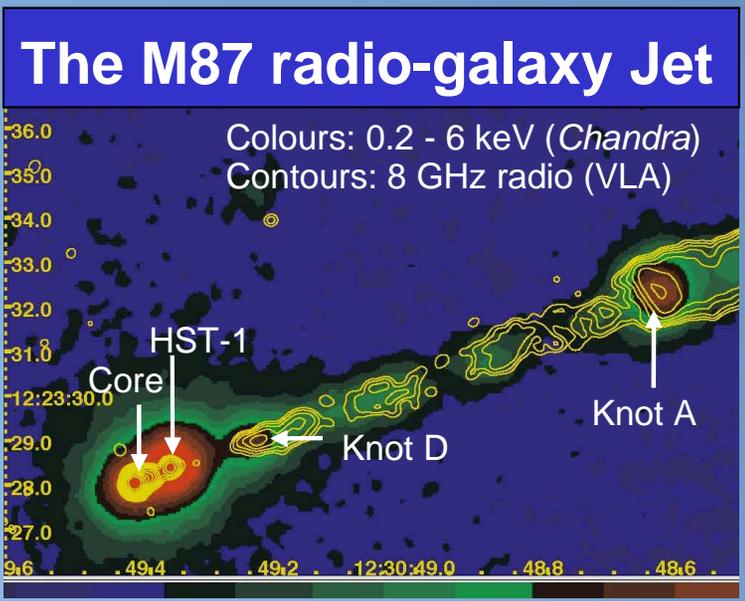
Multiwavelength campaigns

➤ Long term monitoring of bright VHE sources:
Mrk 421, Mrk 501, 1ES 1959+650, 1ES 2344+514

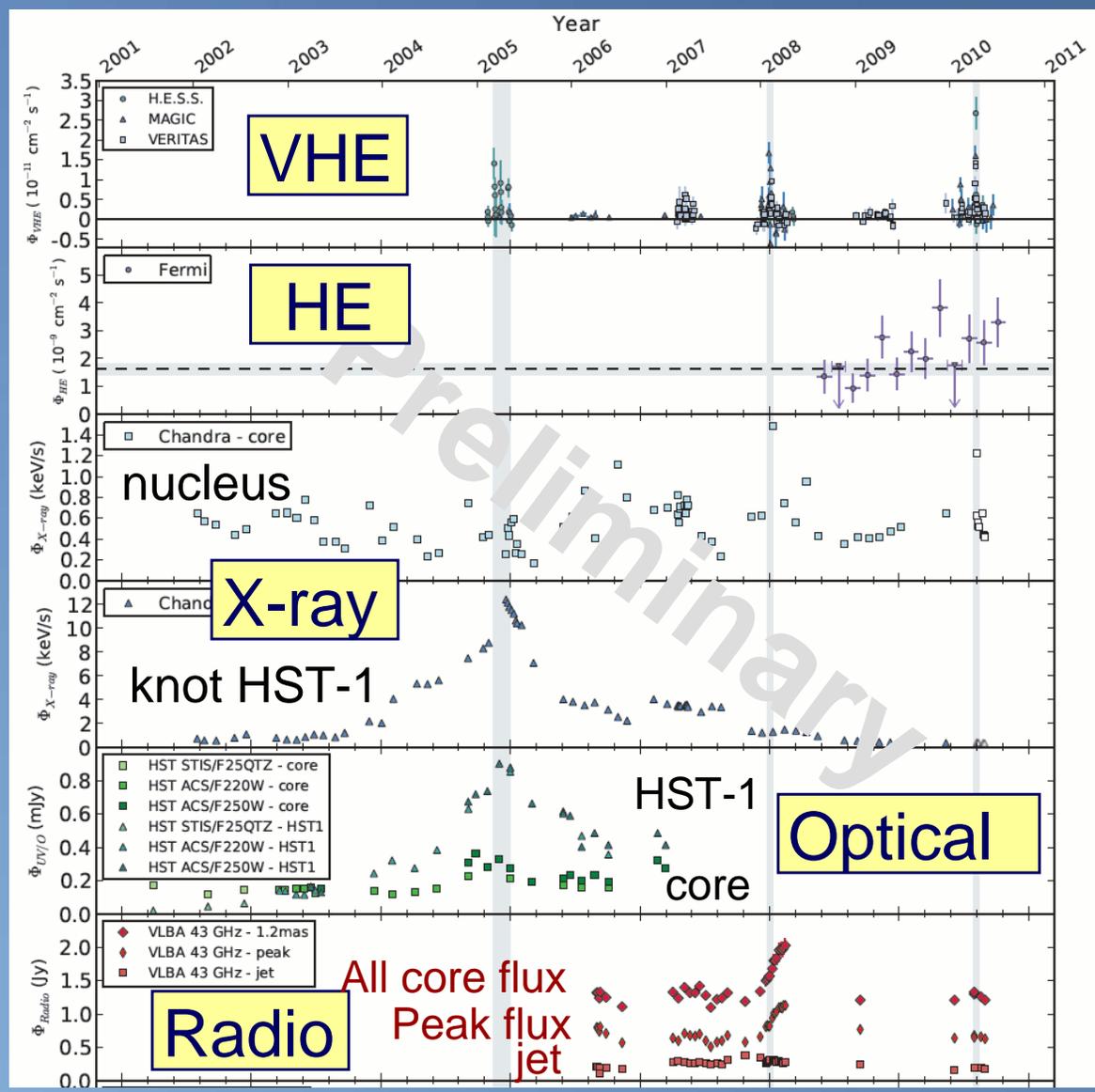
➤ Example with Mrk 421 results:



Joint HESS-MAGIC-VERITAS campaign of the radio galaxy M87



- Shared monitoring between HESS, MAGIC VERITAS
- Day-scale variability at VHE.
- Evidence of correlation with the nucleus in X-ray and Radio.
- Evidence of central origin of the VHE emission (60Rs to theBH)



Perseus cluster galaxies

About 80h of observation with MAGIC in stereo (2009-2010)
 Detections of 2 radio-galaxies inside the cluster:

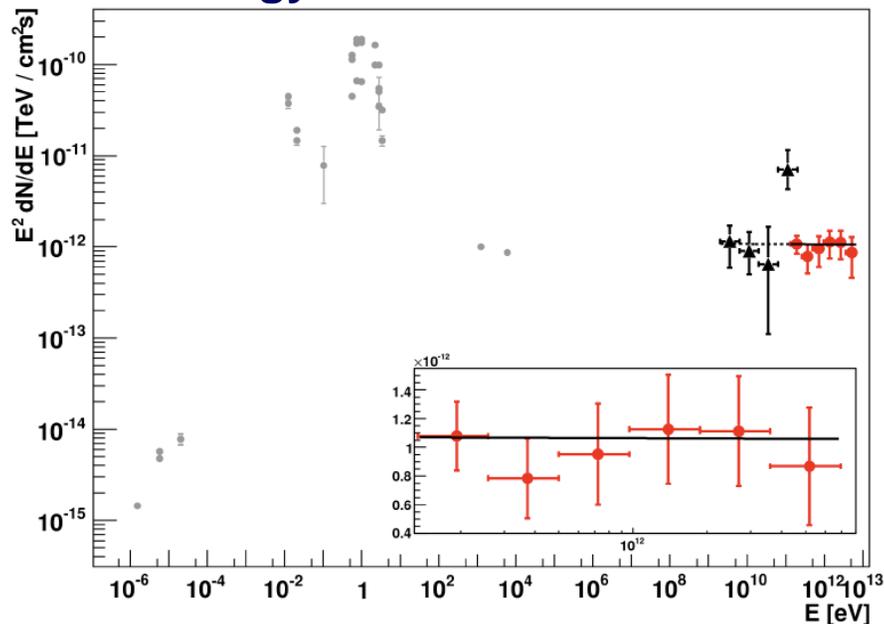
➤ **NGC 1275**

- Central galaxy of the cluster (like M87)

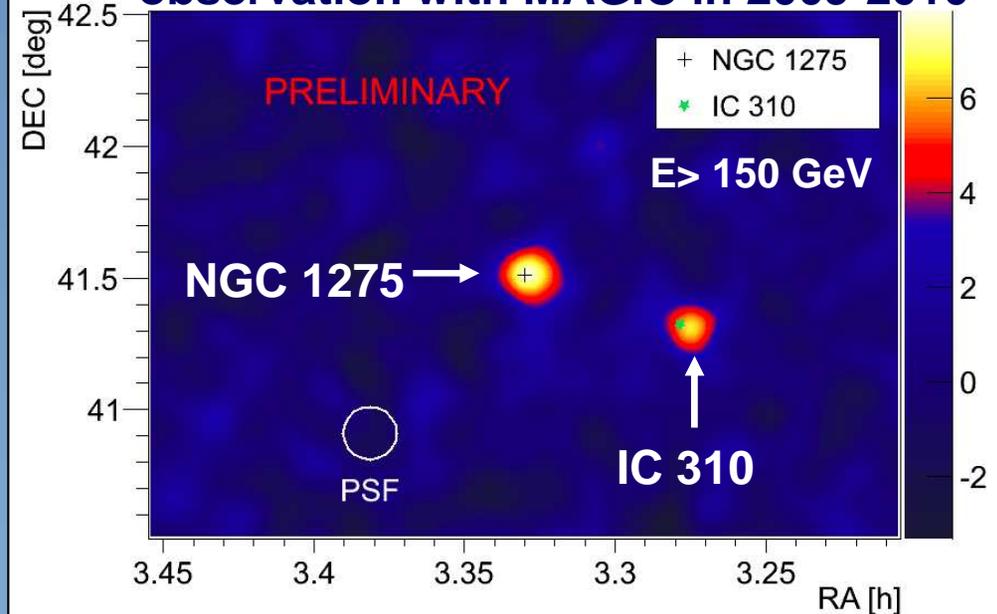
➤ **IC 310**

- First Head-tail radio-galaxy detected at VHE
 - Variable flux (Blazar-like object)

Spectral Energy distribution of IC310 in 2009



Significance sky map of Perseus cluster observation with MAGIC in 2009-2010



Extended emission from Perseus

Cosmological models of galaxy cluster formation predict concentration of

- Dark Matter (80% of the mass)
- Cosmic Rays

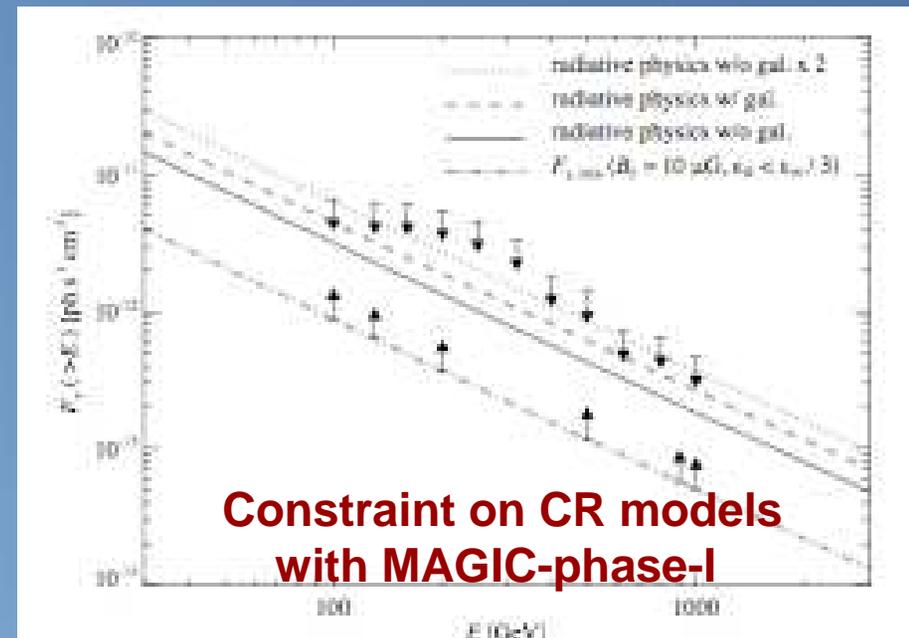
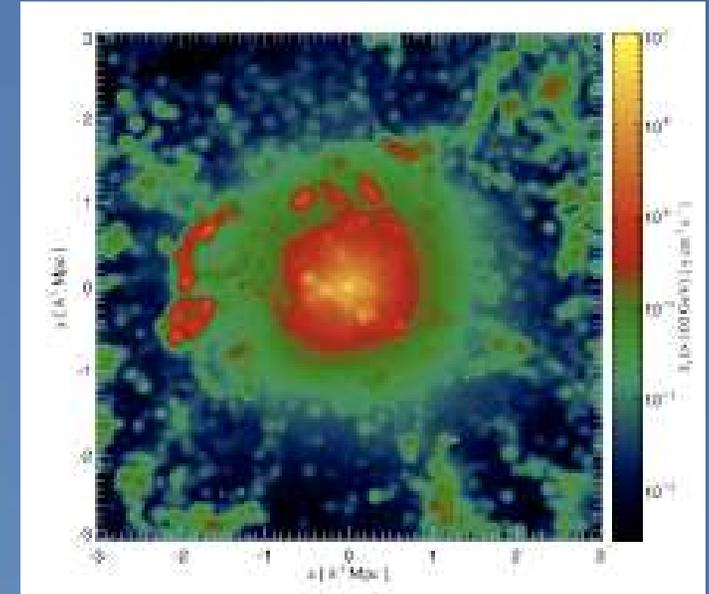
VHE gamma-ray emissions:

- DM Annihilation / decay
- CR interaction with ICM gas (neutral pion decay)

Emission concentrated near the cluster center (NGC 1275).

Extension:

- CR model: 60% within 0.15°
- DM model: 0.2° - few degrees



Dark Matter search in dwarf galaxies

DM annihilation or decay can produce VHE gamma rays

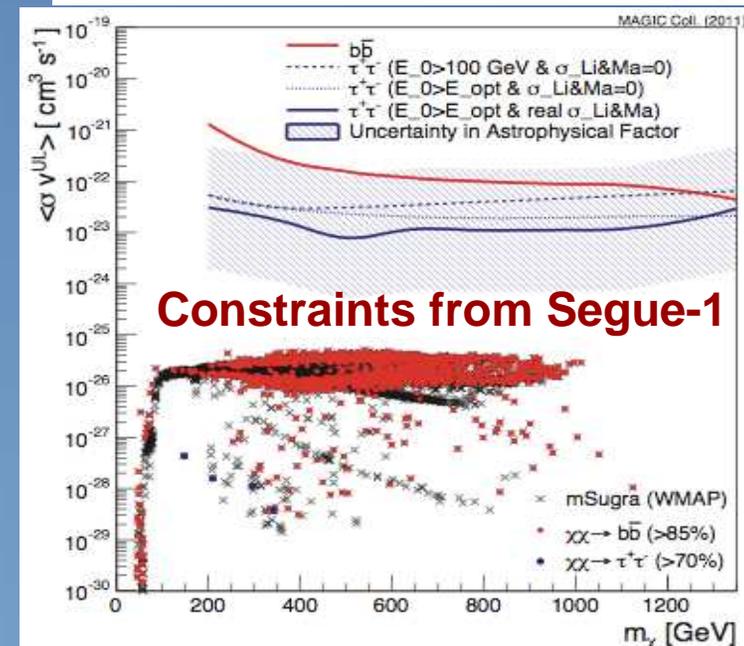
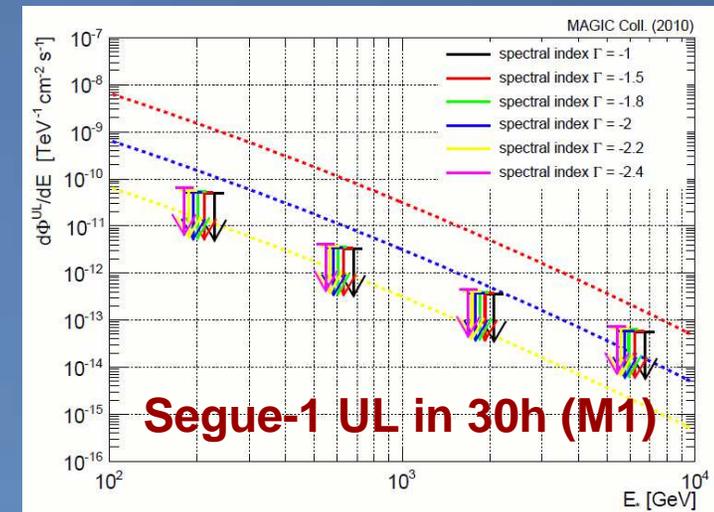
Dwarf galaxy:

- High mass-to-light ratio
- No other VHE emitters expected

Observed galaxies (phase-I):

- Draco
- Willman 1
- **Segue 1 (best candidate)**

With current astrophysical factors of dwarf galaxy, we are 3 decades from models, but uncertainty in the astrophysical factor are high



MAGIC Telescopes upgrade

New MAGIC-1 camera: (clone of Magic-2 camera)

- 1039 pixels (PMT with higher QE)
- possibility of using HPD

New readout system for both telescopes:

- DRS4 running at 2 GSample/s

Improved trigger:

- Larger trigger area for MAGIC-1
- New 'sum' trigger for both telescopes (threshold= ~ 25 GeV)

Easier maintenance with 2 identical telescopes



Upgrade scheduled for Summer 2011

Conclusion

The MAGIC telescopes in phase-II

- Stereo observation since fall 2009
- Sensitivity >300 GeV twice better (0.8% crab in 50h)
- Sensitivity 50-200 GeV 3 times better (best world instrument)
- Improved off-axis performance

Some Recent results:

- Multiple discoveries and results (10 ATELS in one year)
- Detections of distant blazars (FSRQ)
- Very successful optical trigger (5 discoveries +AGN flares)
- Increase TeV radio galaxy catalogue (NGC-1275, IC-310)
- Extended MWL campaigns: Mrk-421, M87, LSI-61, etc.
- Morphological study of SNR (W51C)
- Study of Crab pulsar above 25 GeV