MAGIC Status & Results

Tomislav Terzić
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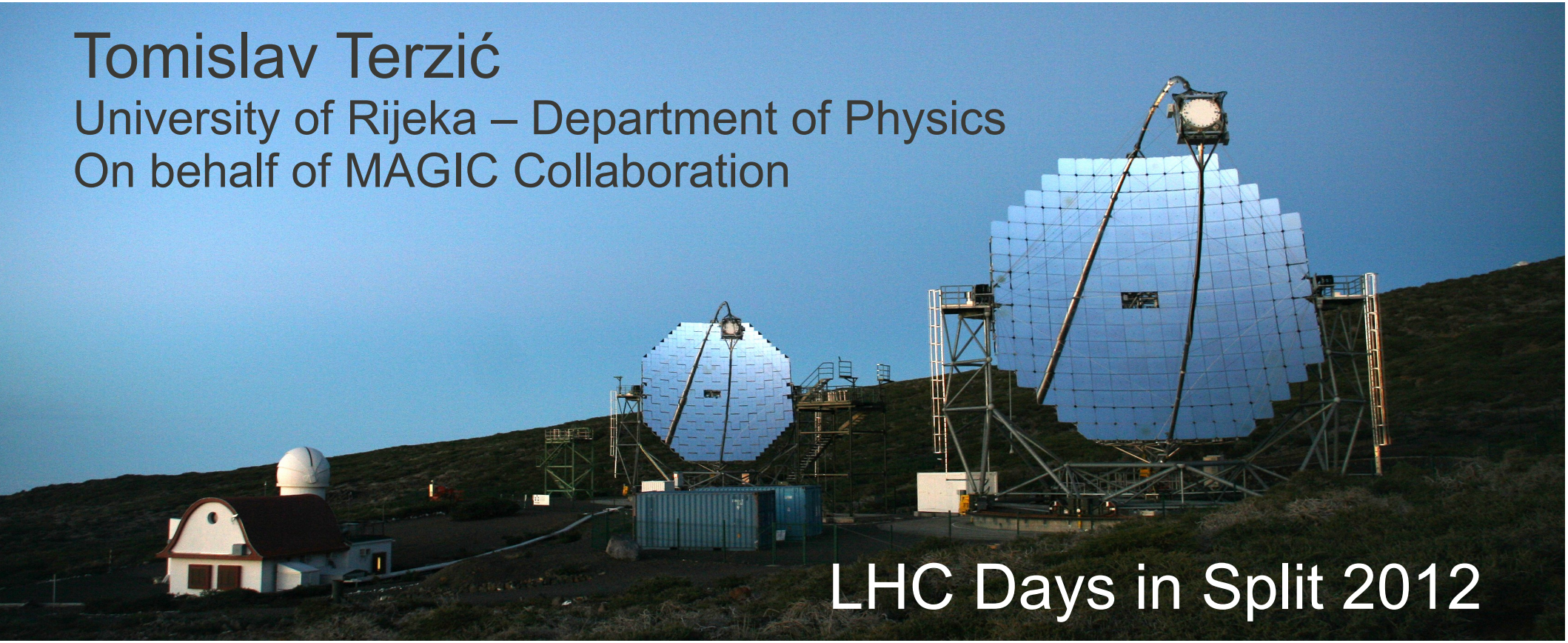
On behalf of MAGIC Collaboration

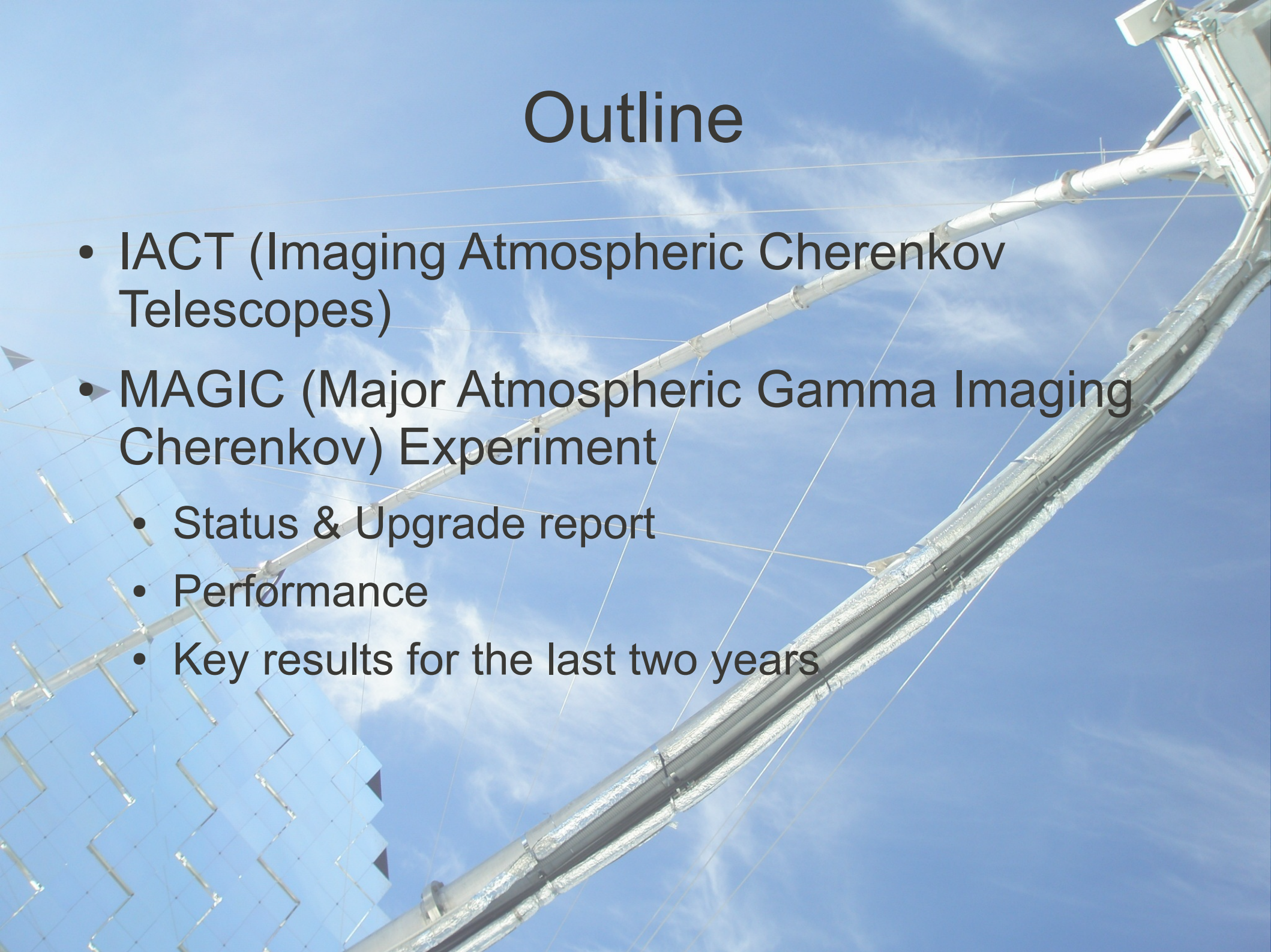


LHC Days in Split 2012

MAGIC
Major Atmospheric
Gamma Imaging
Cerenkov Telescopes

UNIVERSITAS STUDIORUM FLUMINENSIS

ODJEL ZA FIZIKU
SVEUČILIŠTE U RIJECI



Outline

- IACT (Imaging Atmospheric Cherenkov Telescopes)
- MAGIC (Major Atmospheric Gamma Imaging Cherenkov) Experiment
  - Status & Upgrade report
  - Performance
  - Key results for the last two years

- Imaging Atmospheric Cherenkov Telescopes
  - Ground based y-ray detectors
  - Atmosphere – detector (calorimeter)
  - y-rays & cosmic-rays deposit energy in atmosphere – particle shower
  - Telescope – detector of Cherenkov radiation – shower image in camera

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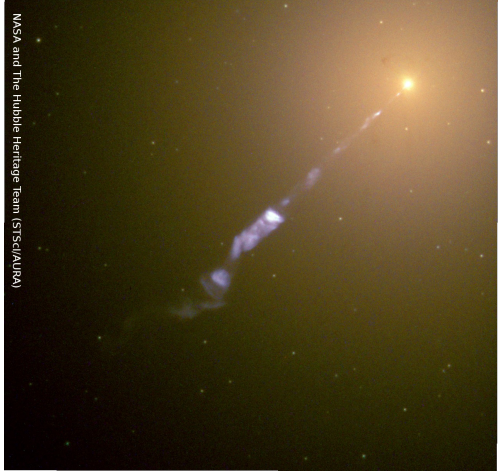

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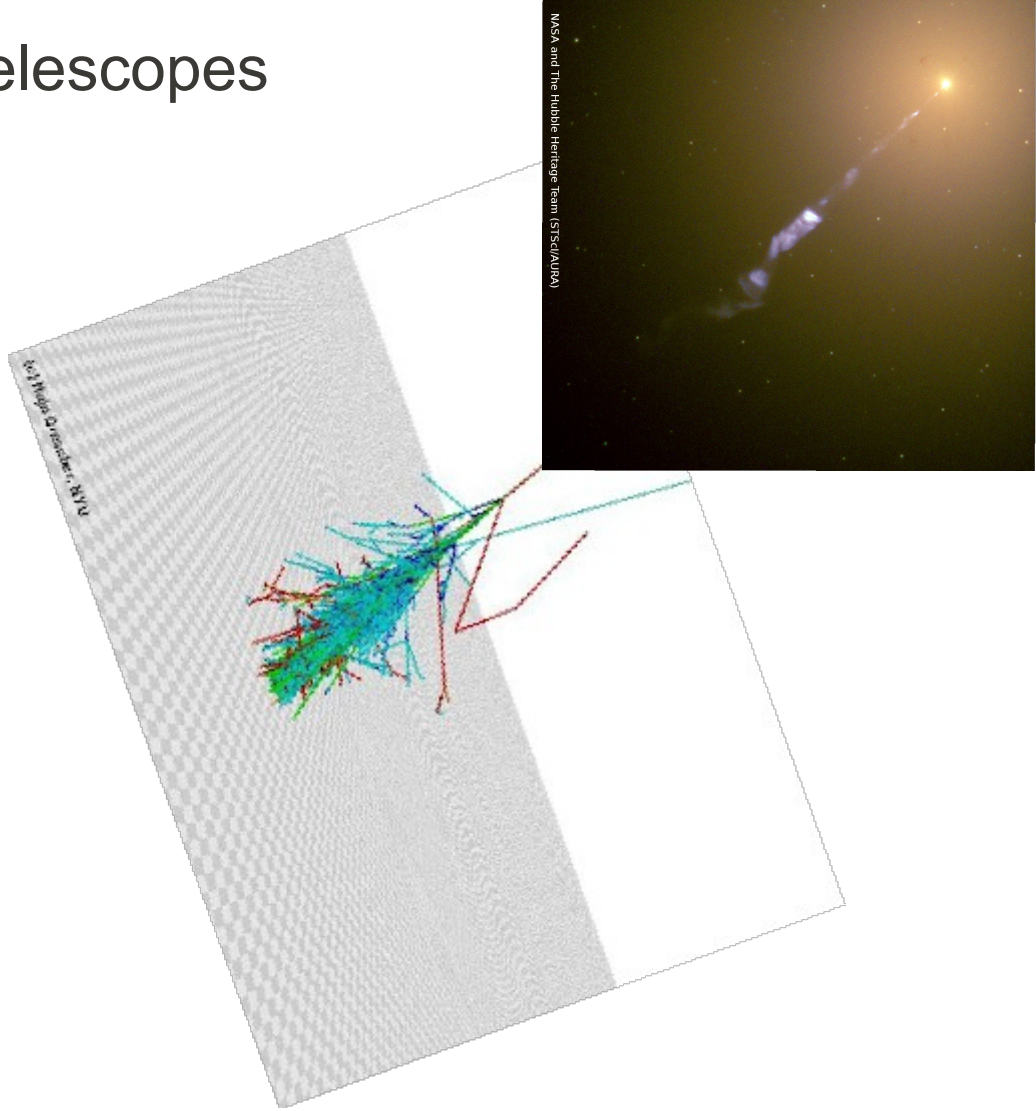

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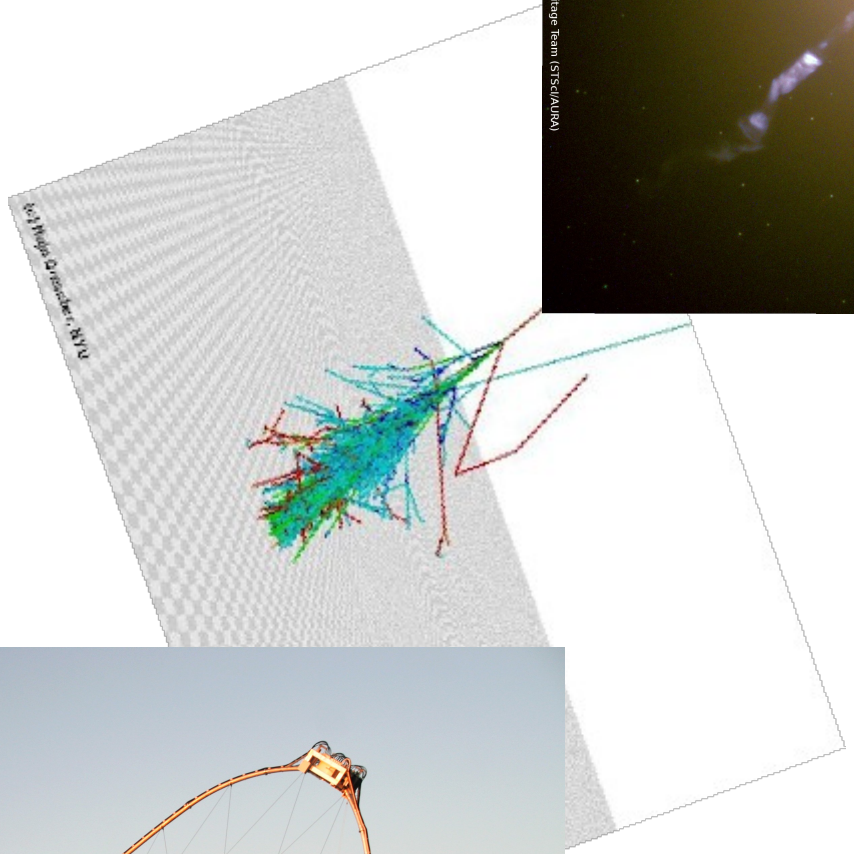

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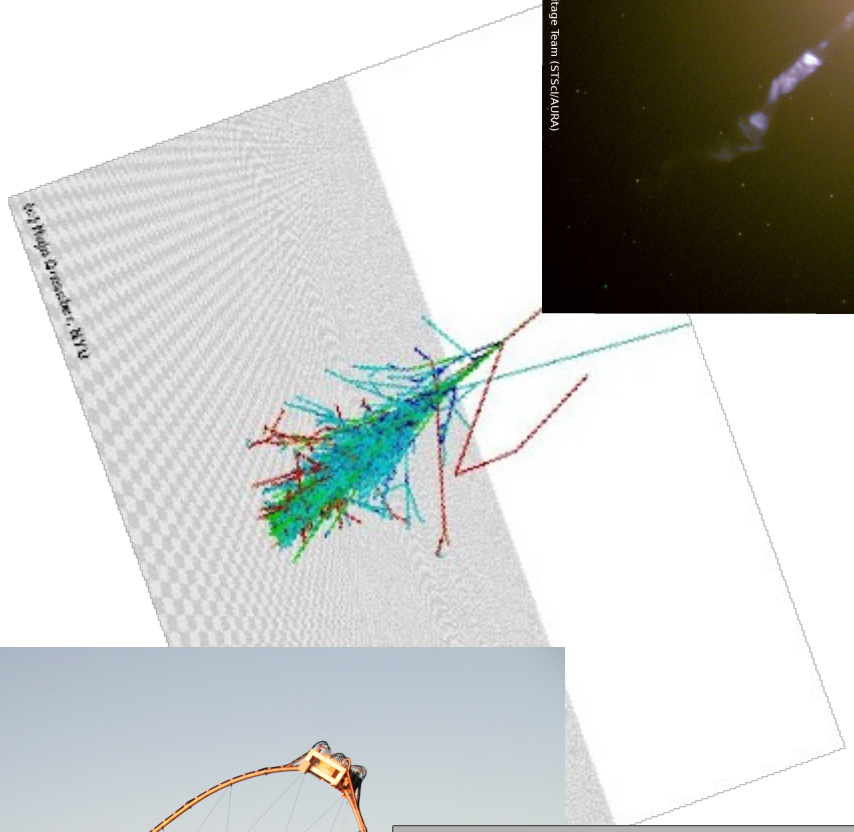
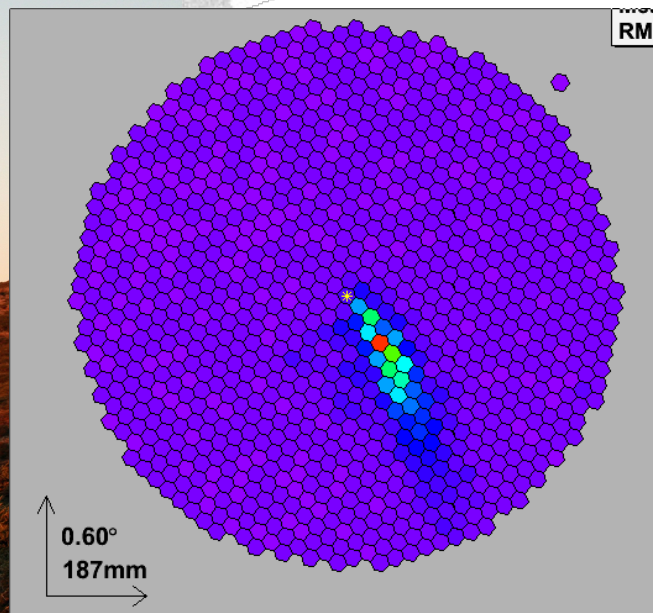




MAGIC

MAGIC

Major Atmospheric

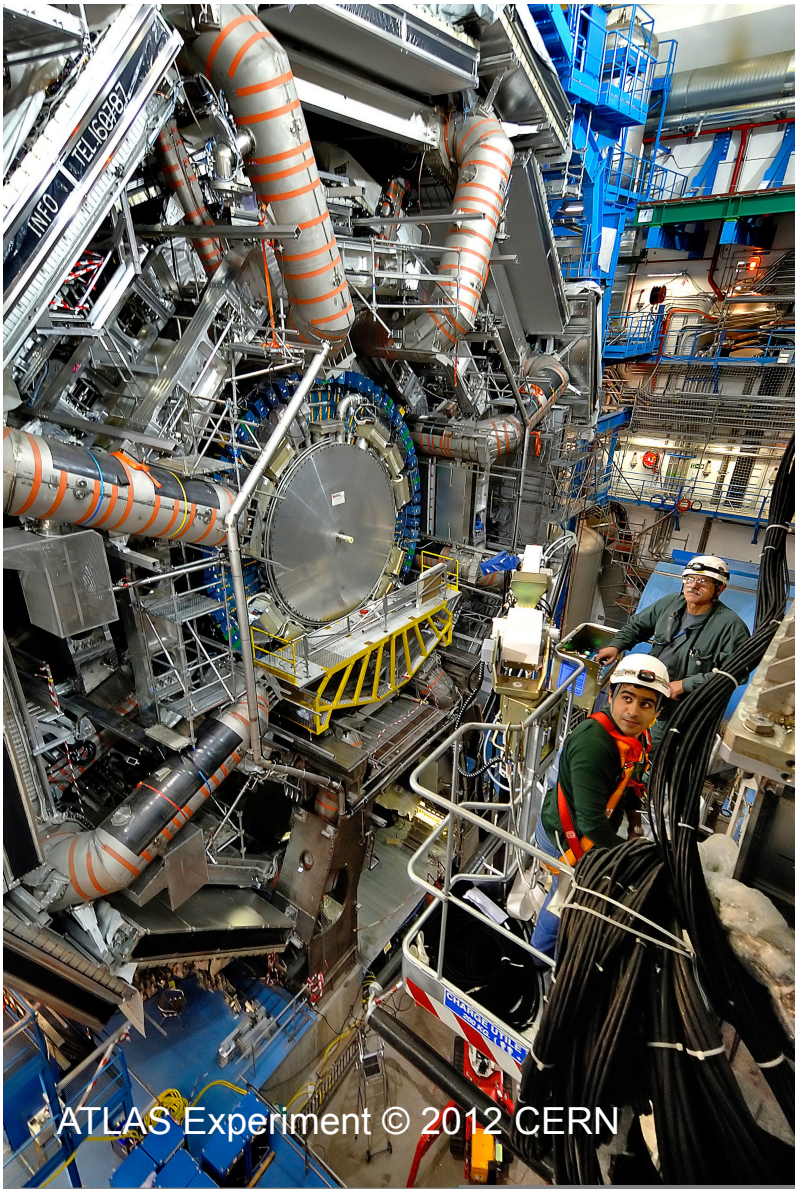
Gamma Imaging

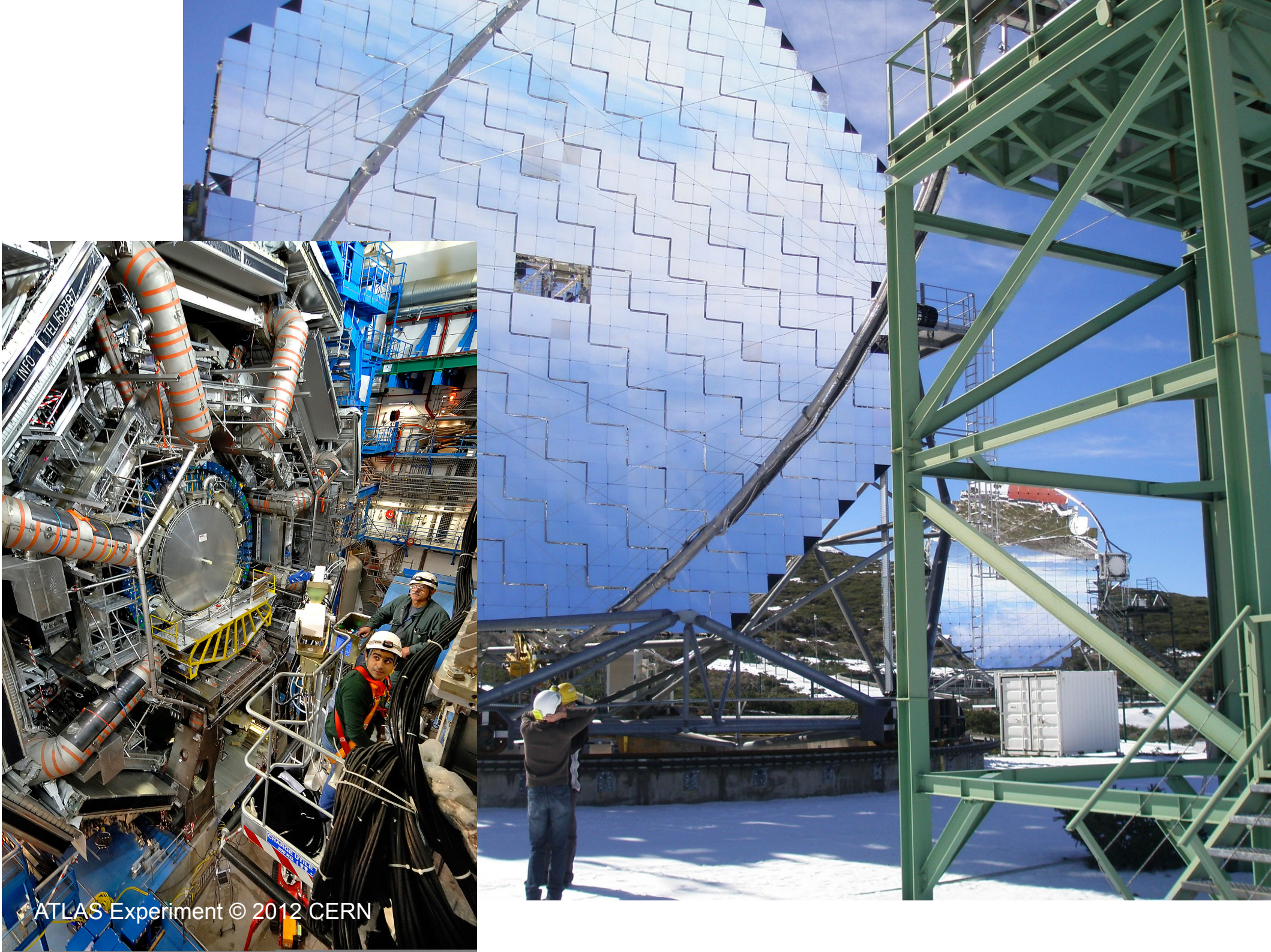
Cerenkov Telescopes

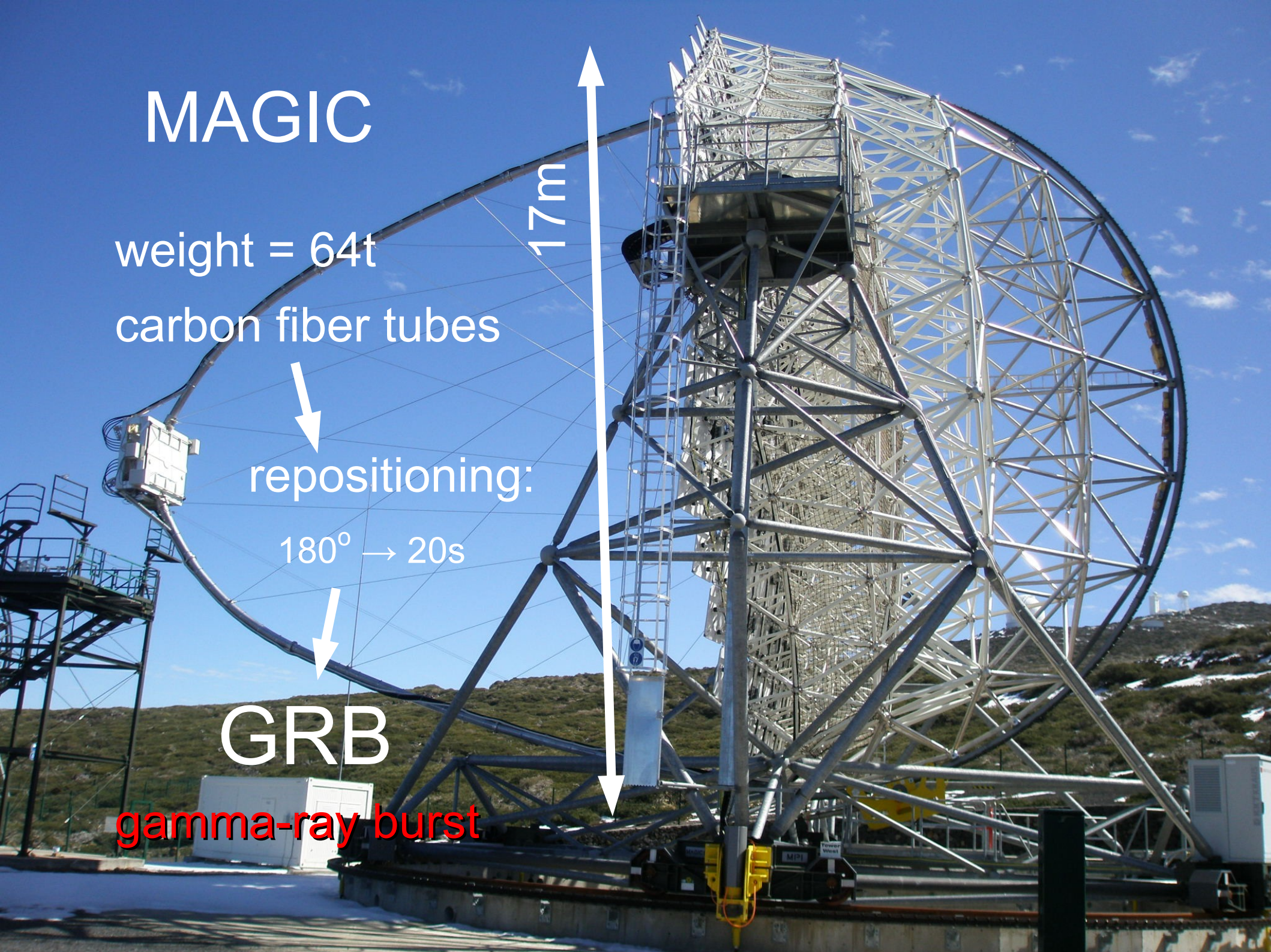
- Major Atmospheric Gamma Imaging Cherenkov
- Stereoscopic system – two **identical** 17m IACT

- Observatorio del Roque de los Muchachos, La Palma, Canary Islands, Spain, 2200 a.s.l.
- wwwmagic.mppmu.mpg.de

Does size matter?






MAGIC
weight = 64t
carbon fiber tubes
17m
repositioning:
180° → 20s
GRB
gamma-ray burst

Recently upgraded system

- Summer 2011:
- M-I readout: MUX-FADC → DRS4
- M-II readout: DRS2 → DRS4 (DRS = Domino Ring Sampler)
- New electronics and computer room
- Decreased readout dead-time from 10% to <1% at stereo rate of 300Hz
- Smaller cross-talk
- More linear response

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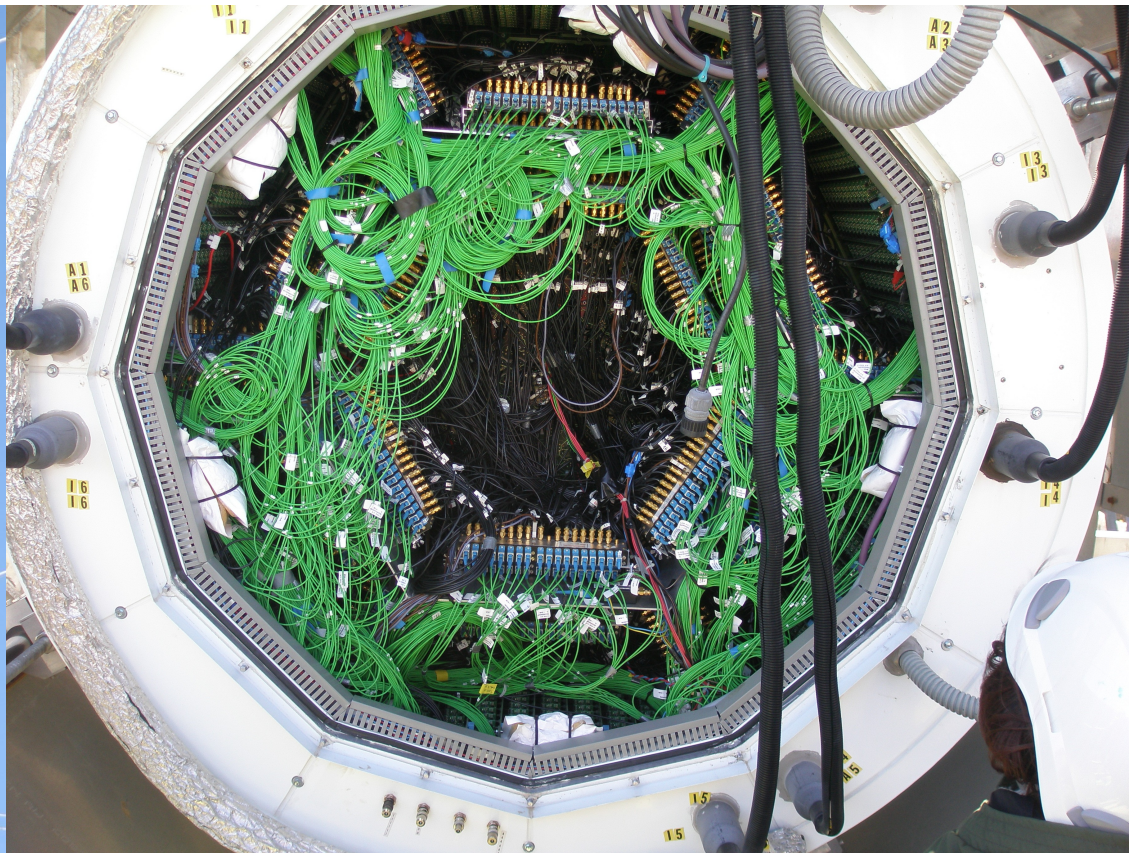
Photo by Daniel Mazin

Recently upgraded system

- Summer 2012: new fresh from the oven M-I Camera:
  - 576 → 1039 pixels → trigger area increased by ~70%
  - identical to M-II Camera



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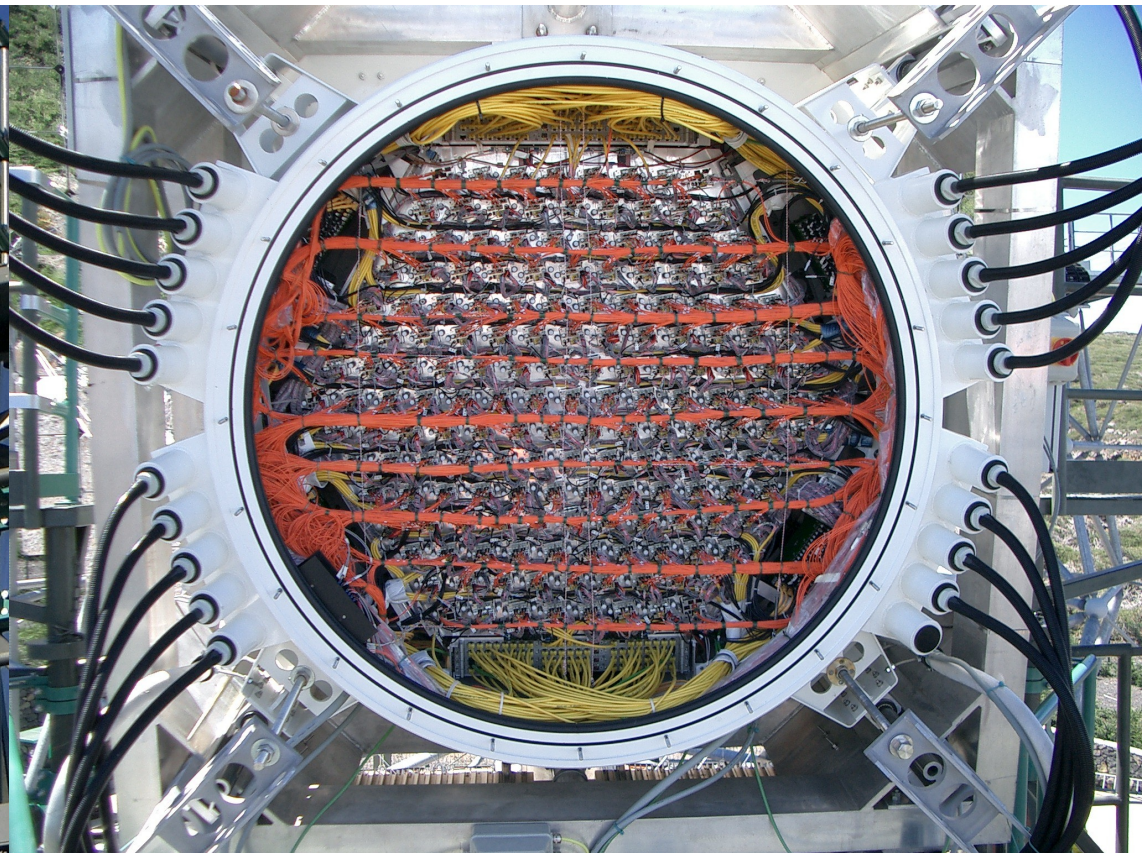
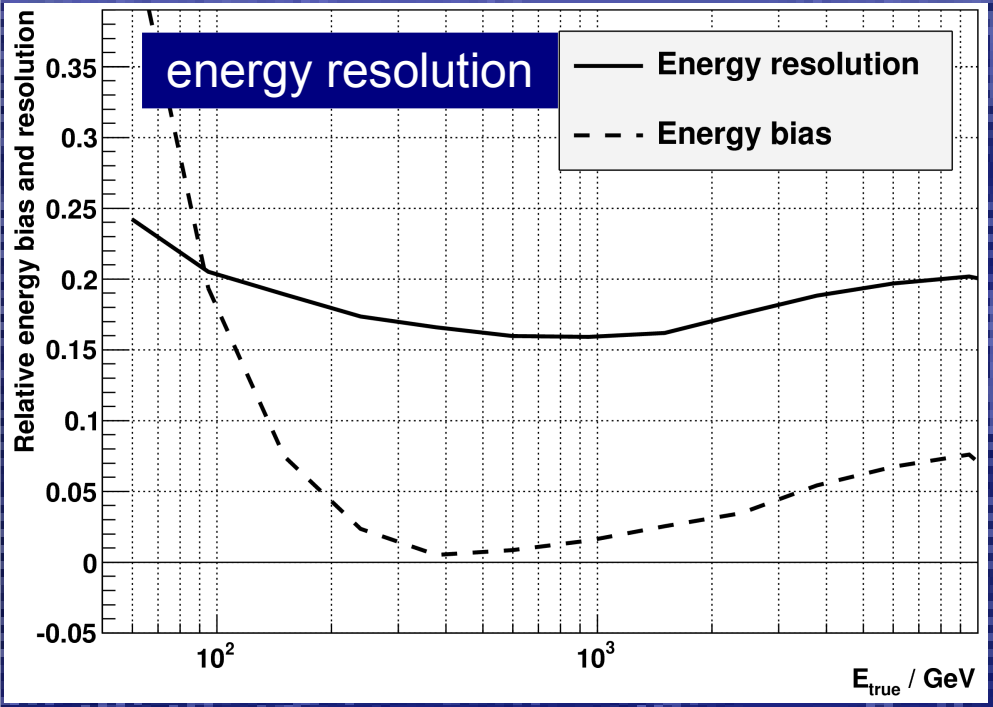
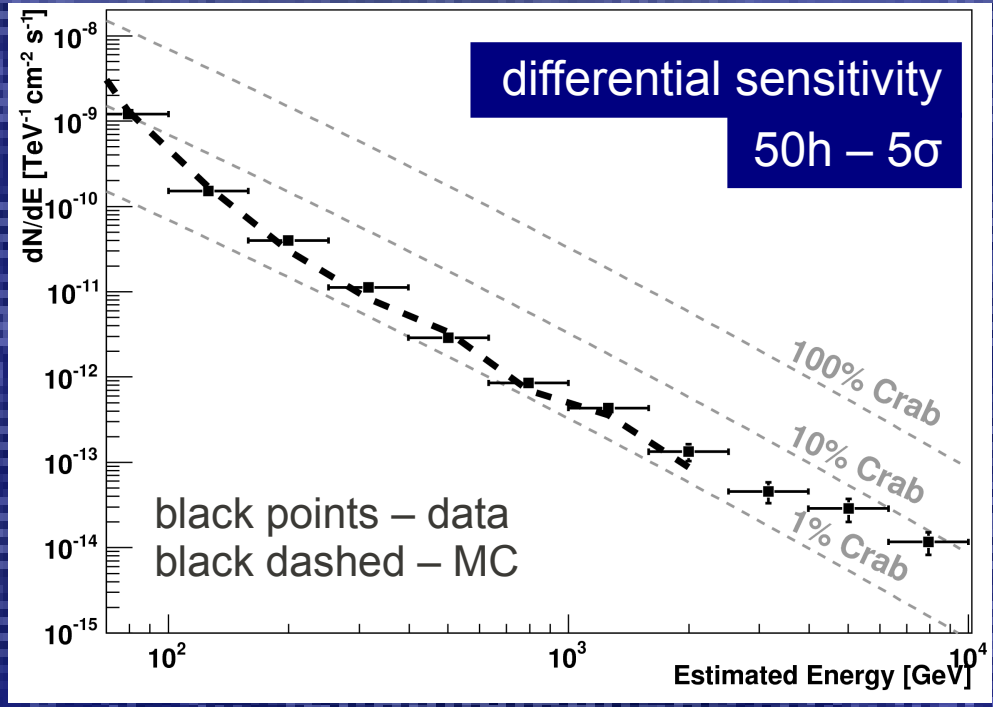
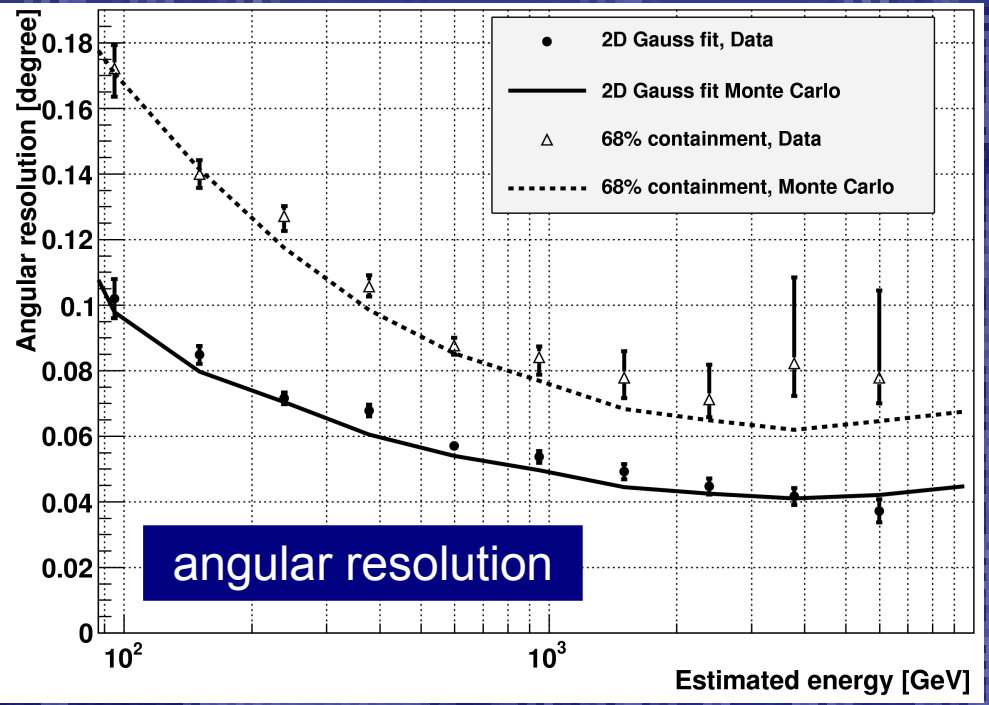


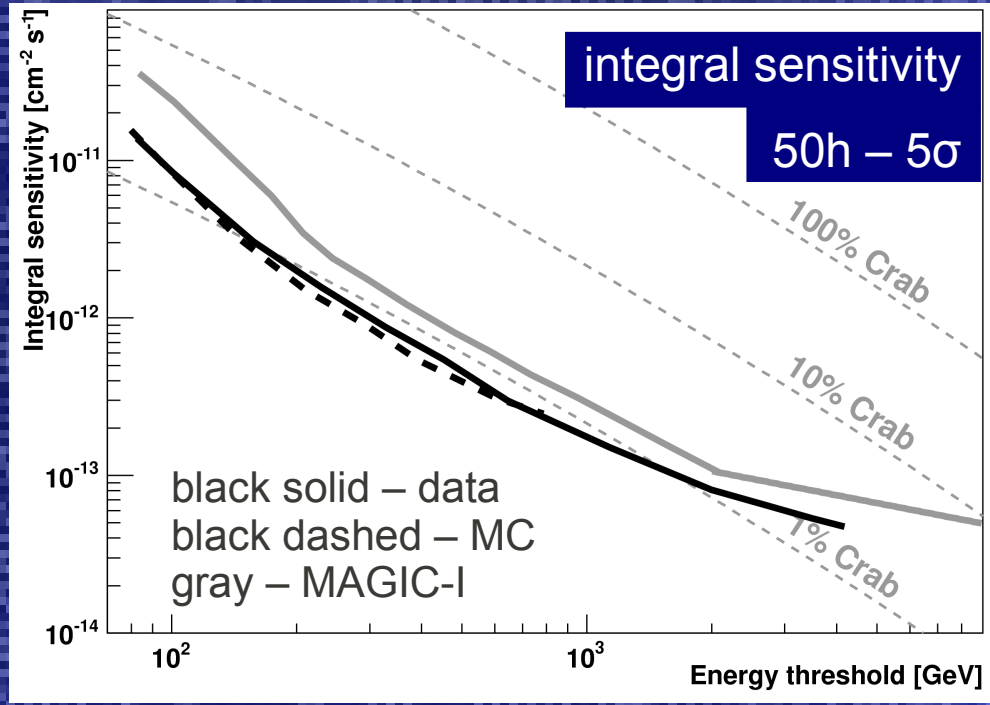
Performance

Aleksić et al., APh, 35, 435 (2012)



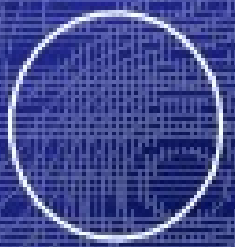






Recent results

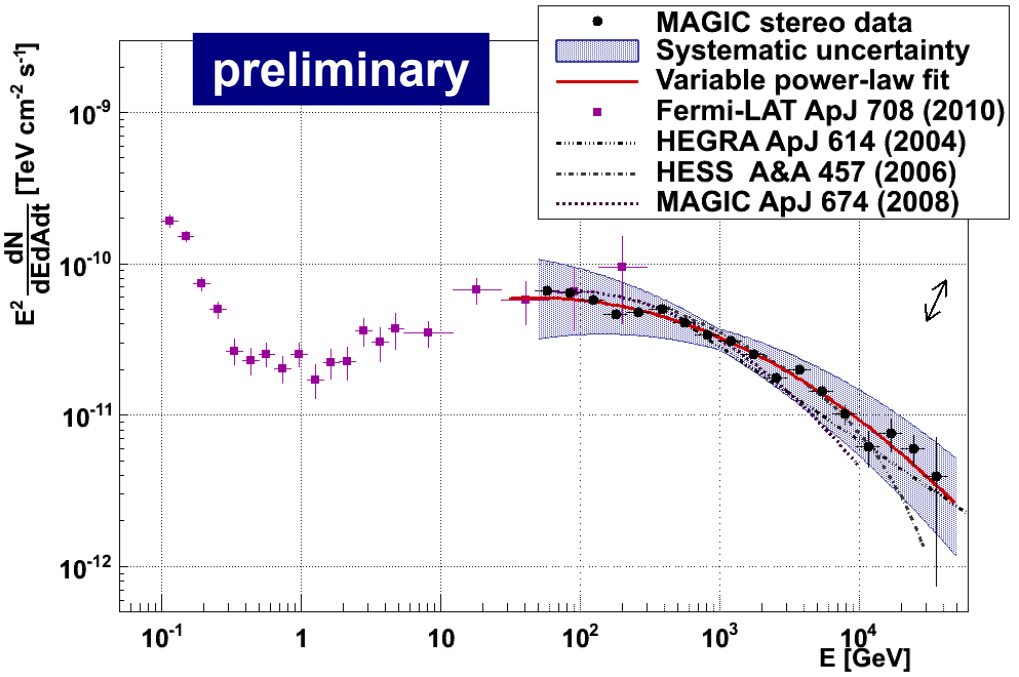
- Galactic science
  - Supernova Remnants
  - Pulsars
  - Pulsar Wind Nebulae
  - y-ray binaries
  - Magnetars
- Extragalactic science
  - Active Galactic Nuclei
    - MAGIC detected 29/53
    - 6 in last 1.5 year
  - Extragalactic Background Light (EBL)
  - Gamma-ray Bursts
  - Astroparticle Physics
  - Dark matter



PSF

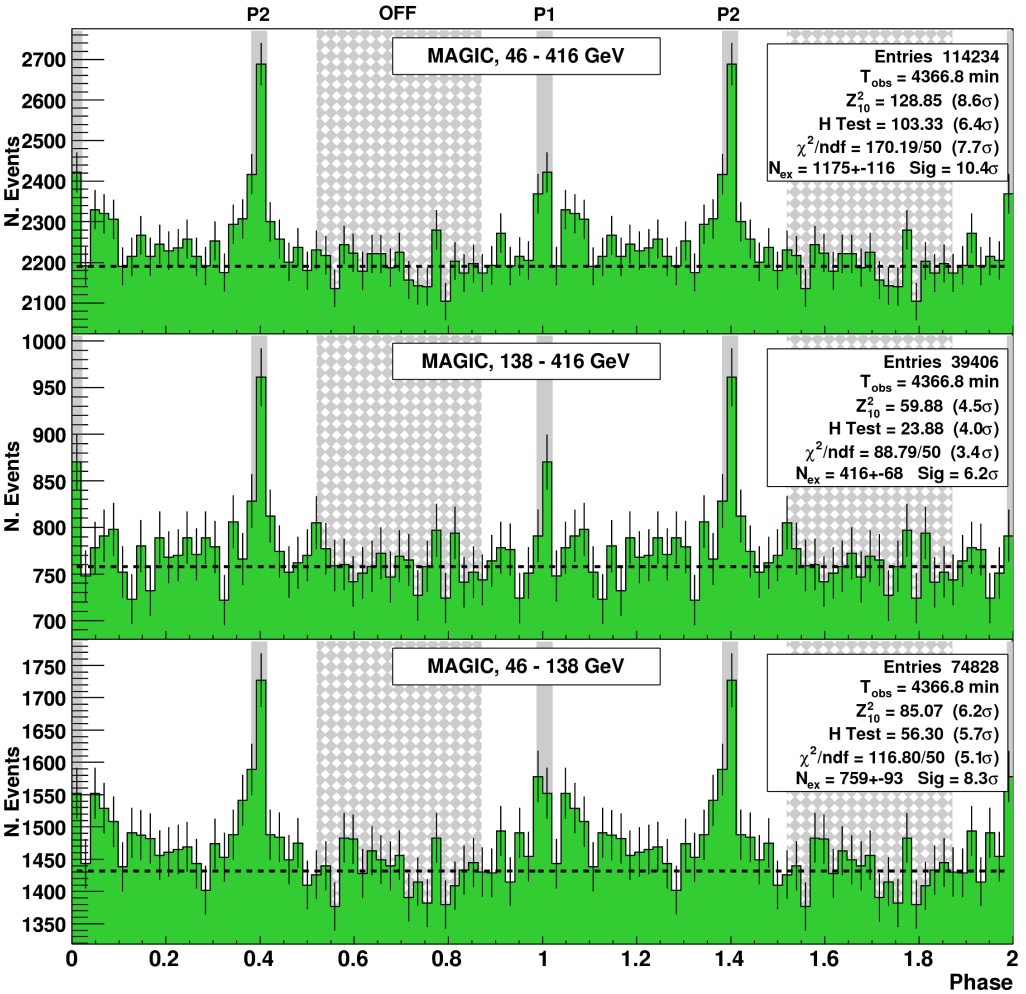
Crab Nebula

- most stable source in y-ray sky – standard candle
- Daily light curve at E>300 GeV constant within systematic uncertainty
- No enhanced emission during Fermi and Agile flares in the energy range 1-10TeV
- MAGIC spectrum: 50GeV–45TeV
- very good overlap with *Fermi*-LAT



Crab Pulsar

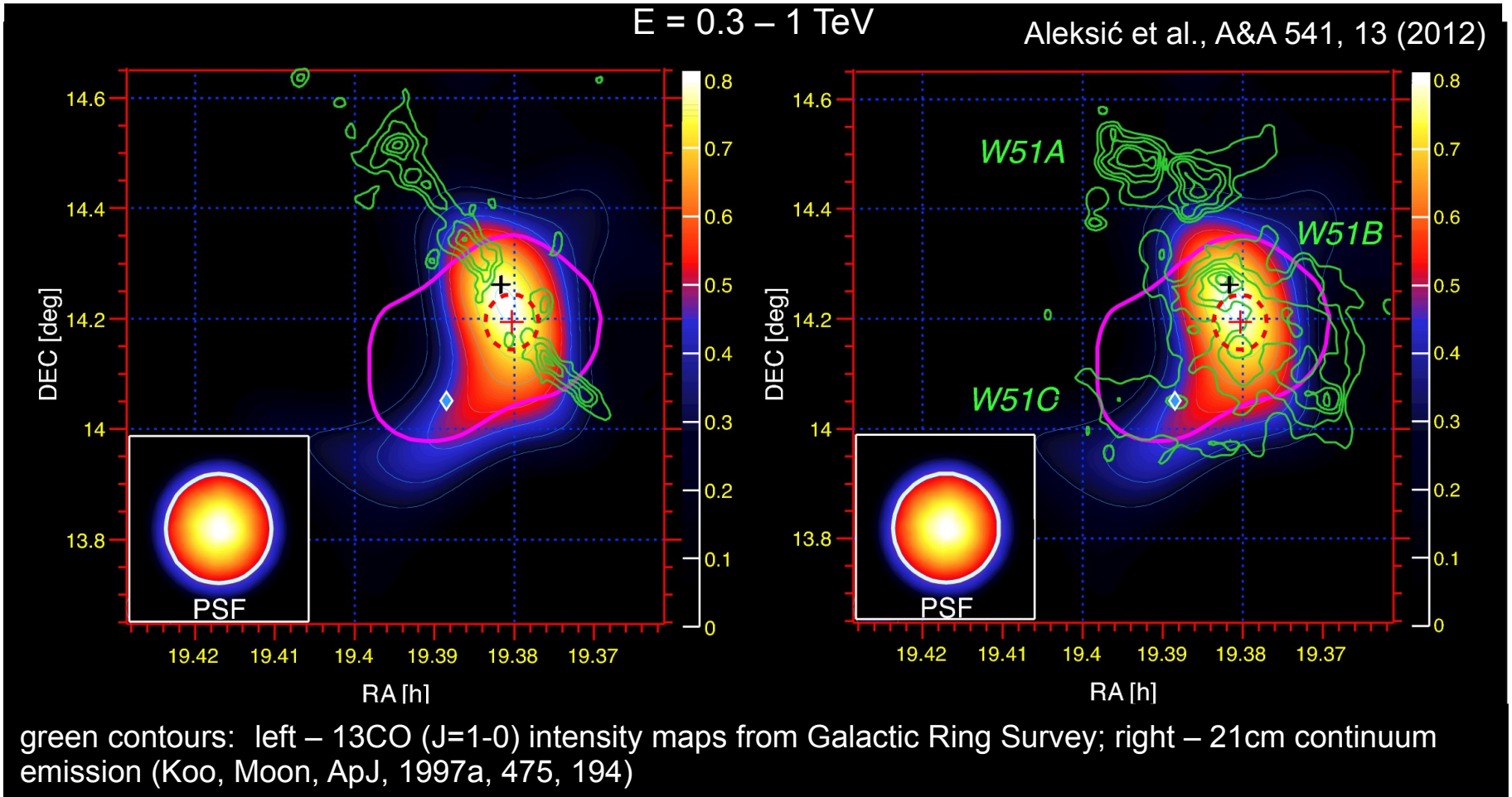
- the only pulsar detected above 25GeV
- MAGIC → phase resolved (P1 and P2) spectra for 25-400 GeV
- Constraints on emission models (polar cap models excluded, emission must come from outer regions)



Aleksić et al., A&A 540, 69 (2012)

W 51

- W 51C – a medium age (~30ky) Supernova Remnant (SNR)
- possible Pulsar Wind Nebula (PWN) CXO J192318.5+140305 associated with W 51C
- interaction between W 51C and the molecular cloud in star forming region W 51B
- MAGIC data from 2010 and 2011 → extension of spectrum from *Fermi*-LAT range (0.2-50 GeV) to ~5TeV
- y-ray emission region restricted to the zone of interaction between SNR (W 51C) and the molecular cloud (W 51B)
- y-ray emission most probably of hadronic origin – a significant contribution to solving the problem of the contribution to galactic cosmic rays by supernova remnants



green contours: left – 13CO (J=1-0) intensity maps from Galactic Ring Survey; right – 21cm continuum emission (Koo, Moon, ApJ, 1997a, 475, 194)

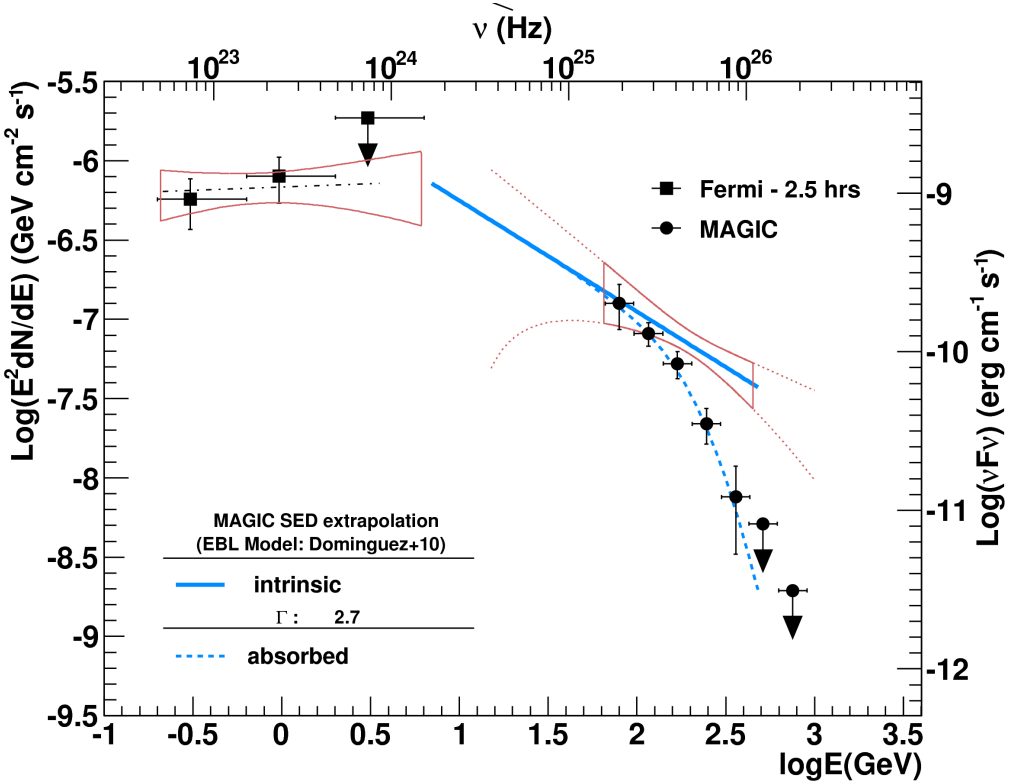
Other galactic sources

- γ-ray binaries – only 4 discovered so far; 2 visible in the Northern sky
  - LS I+61 303 – MAGIC observations since 2005
    Aleksić et al., ApJ, 746, L80
    - no spectral variability detected
    - distinctive low and high state
  - HESS J0632+057
    Aleksić et al., ApJ, 754, L10
    - discovered by H.E.S.S. in 2007 as an unidentified point-like source; suspected γ-ray binary
    - detected by MAGIC in 2011 → confirmed γ-ray binary
- Magnetars
  Aleksić et al., 2012, to be submitted
  - 4U 0142+61 (17h of mono data in 2008)
  - IE 2259+586 (8h stereo data in 2010)

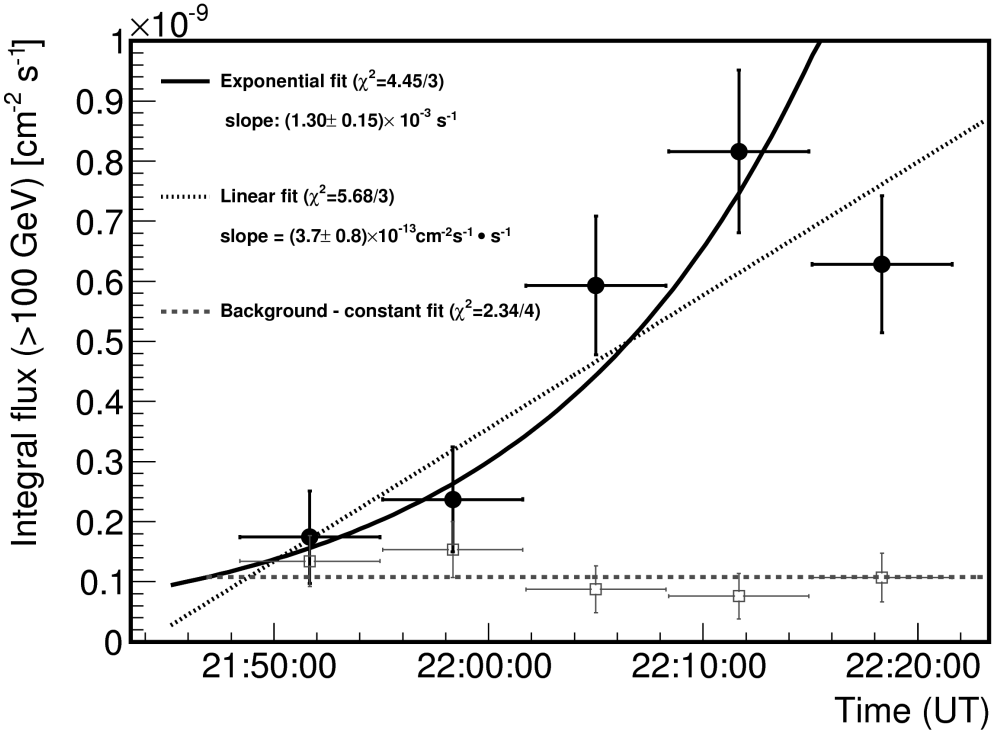
} no detection so far, set upper limits

PKS 1222+216

- ~30min. observation → 10.2σ (6 γ/min)
- flux doubled in $8.9^{+1.1}_{-0.9}$ min (exp. fit) → quickest variation ever observed in FSRQ
- unexplainable by existing emission models



- discovered by MAGIC in 2010
- 3rd FSRQ detected in VHE γ-ray (PKS 1510-08, 3C 279)
- z=0.432 – 2nd most distant VHE γ-ray source with well known redshift

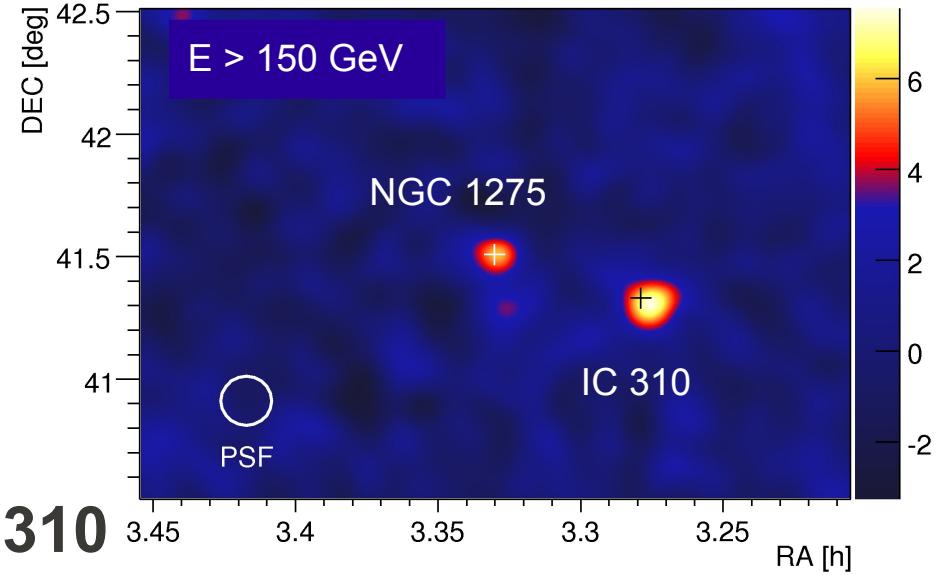


- observed spectrum Γ = 3.75±0.27
- intrinsic spectrum (Dominguez et al. 2011): Γ = 2.72±0.34
- no apparent cut-off for E<130 GeV

Aleksić et al., ApJ 730 (2011) L8

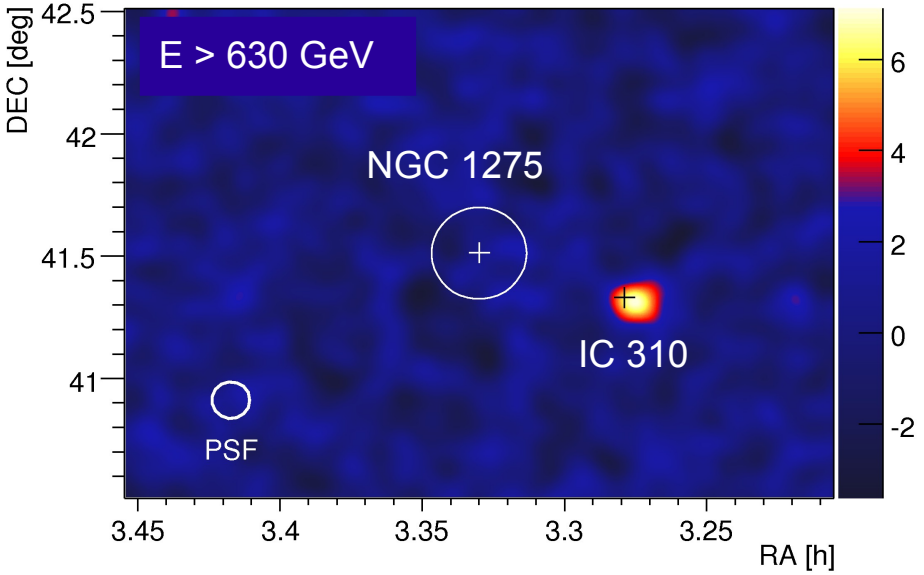
Perseus cluster

- brightest galaxy cluster in X-ray
- first “cluster” of TeV galaxies
- ~85 h effective observing time: expected CR-ISM interactions → y-rays
- 2 point-like sources: NGC 1275, IC 310



NGC 1275

- dominant galaxy in Perseus cluster
- discovered by MAGIC in 2010-2011 campaign
- very soft VHE spectrum: $\Gamma = 4.1 \pm 0.7$



Aleksić et al., A&A 541, 99 (2012)

IC 310

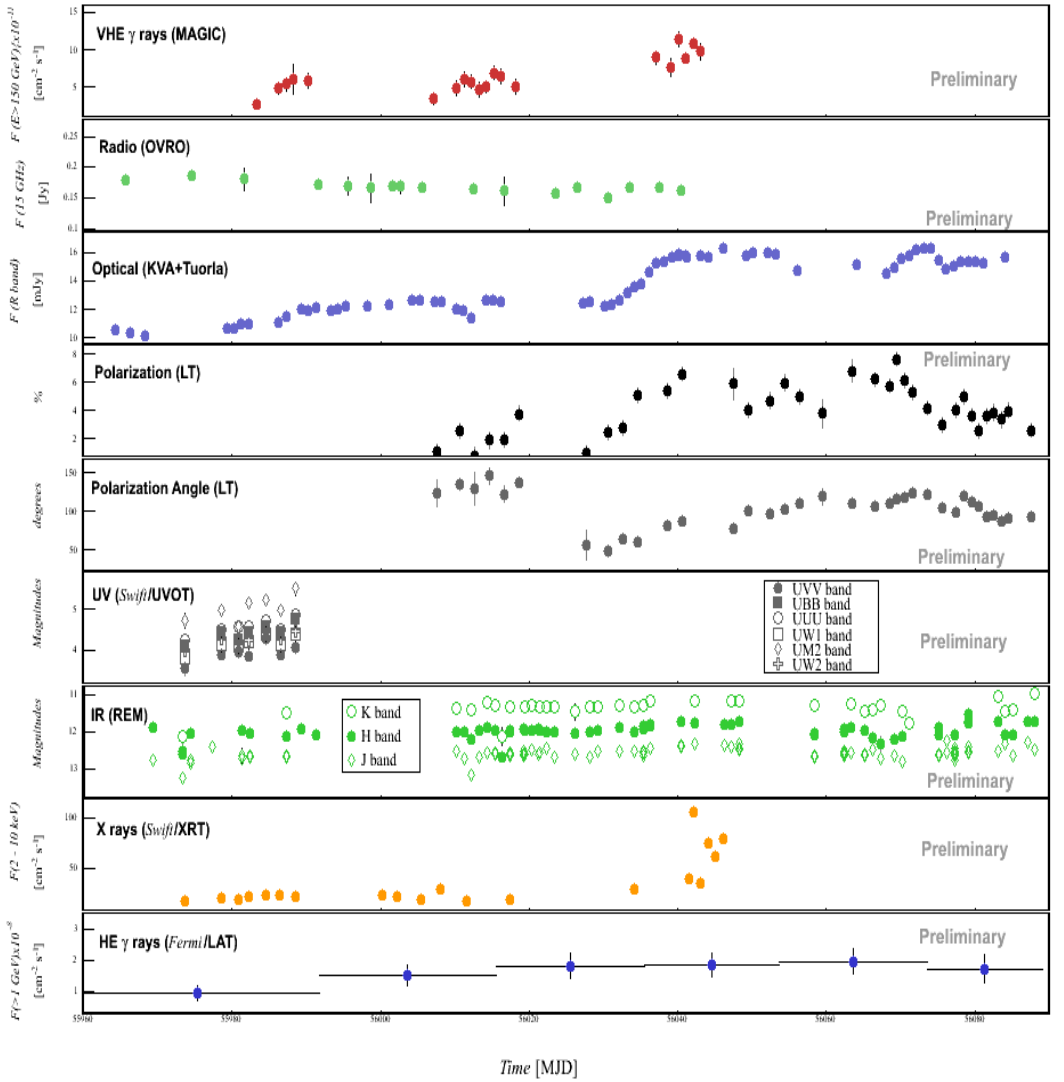
- originally (mis)classified as “head-tail”
- MAGIC results show day-scale variability → compact emission region → blazar type source
- very hard VHE spectrum: $\Gamma = 1.8 \pm 0.1$

Constraints on cosmic rays

- ~60% of CR signal expected from the central region ($r < 0.15°$)
- no y-ray signal above 630 GeV → CR-to-thermal pressure ratio 1–2% → maximum CR acceleration efficiency at structure formation shocks < 50%
- central B-field > 4-9 μG (typical ~16 μG) → Hadronic model of radio mini-halo

PG 1553+113

- BL Lac discovered by MAGIC and H.E.S.S. in 2005
- regularly monitored by MAGIC – strong flare in 2012 (stable in all previous observations) – flux 2-8×higher during flare (reached the Crab Nebula flux at 100GeV)
- unknown redshift – using EBL to measure the distance: z~0.4 (Prandini et al., 2011)
- analysis in progress



Becerra-Gonzales et al., Gamma2012 (poster)

Summary

- MAGIC – stereoscopic IACT system
  - 2 × 17m telescopes
  - sensitive down to 50GeV
  - freshly upgraded system
- Valuable scientific results in galactic and extragalactic y-ray astronomy & astrophysics
  - detailed study of Crab nebula and pulsar
  - constraints on morphology of W51
  - constraints on emission models from FSRQ (PKS 1222)
  - study of cluster of galaxies (Perseus cluster)