The MAGIC Telescope System: Recent results and future perspectives

Dominik Elsässer (Universität Würzburg)
for the MAGIC Collaboration

MAGIC
Major Atmospheric
Gamma Imaging
Cerenkov Telescope

Bundesministerium
für Bildung
und Forschung

The MAGIC Telescopes

~170 Collaborating Astro-Physicists from 9 Countries

Bulgaria Sofia

Croatia Consortium (Zagreb, +...)

Finland Consortium (Tuorla, +...)

Germany DESY Zeuthen, U. Dortmund, MPI Munich, U. Würzburg

Japan Consortium (Kyoto, +...)

Italy INFN & U. Padova, INFN Pisa & U. Siena, INFN Como/Milano Bicocca, INFN Udine/Trieste & U. Udine, INAF (Consortium: Rome, +...)

Poland Lodz

Spain U. Barcelona, UAB Barcelona, IEEC-CSIC Barcelona, IFAE Barcelona, IAA Granada, IAC Tenerife, U. Complutense Madrid, CIEMAT Madrid

Switzerland ETH Zurich

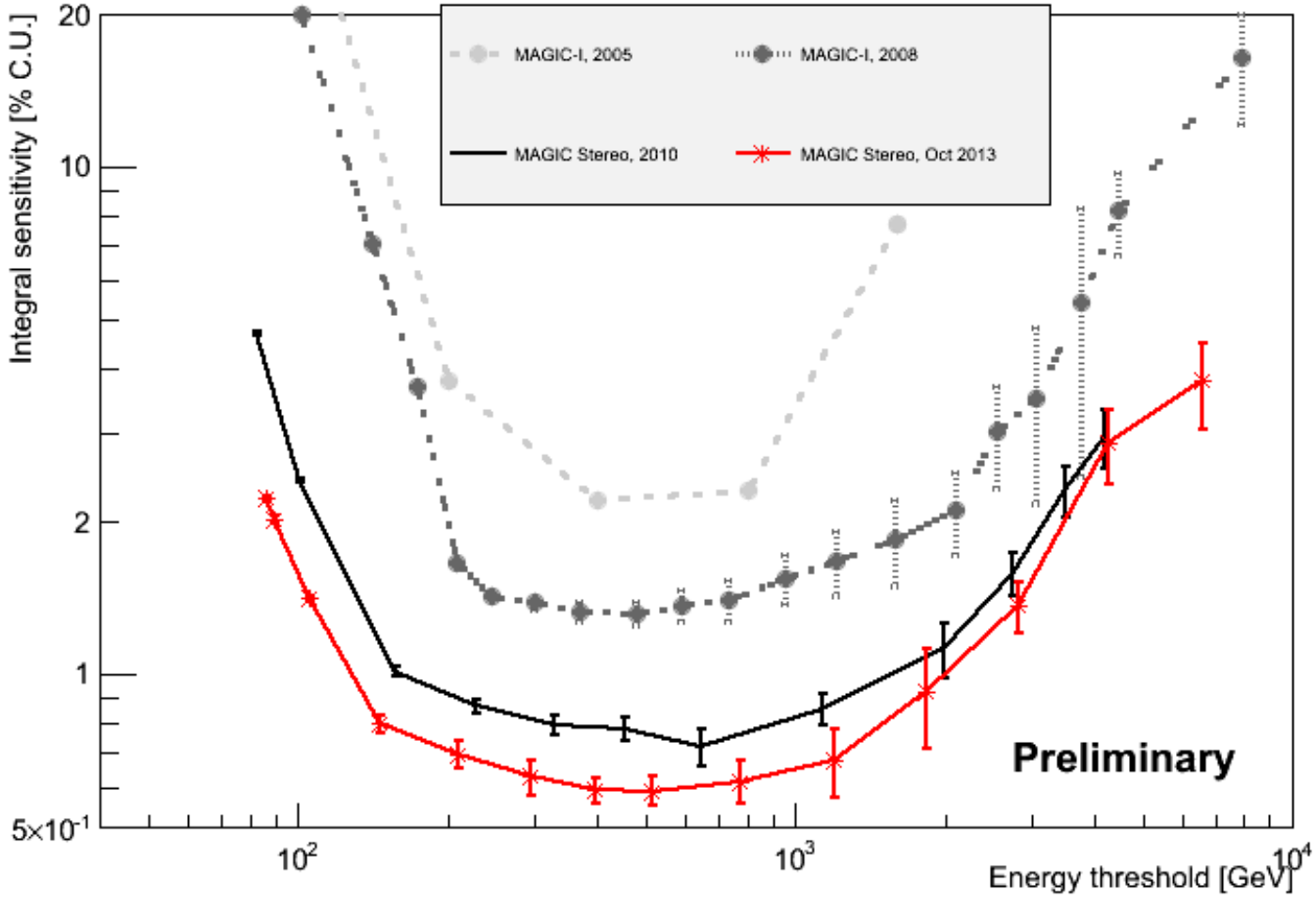
The MAGIC Stereoscopic system

- **MAGIC: Two Imaging Atmospheric Cherenkov Telescopes (IACTs) of 17 meter diameter mirror dish to perform Very High Energy (VHE) gamma-ray astronomy**
  - **Operational energy range ; 50 GeV – >30 TeV**
  - **Sensitivity: 6/1000 the Crab Nebula flux (above 250 GeV) after 50 hours observation**
  - **Angular resolution: ~0.12-0.08 deg (energy dependent)**
  - **Energy resolution: ~17-22% (energy dependent)**
  - **Fast movement (points to any direction of the sky in less than 20 seconds)**
  - **Optical link system for transmission of analogue signals over long distances (160 m)with minimal deterioration (FWHM < 3ns)**
  - **2GSample/s digitization of signals with DRS4 chips**

Observatorio Roque de los Muchachos (2200 meter a.s.l.)
La Palma, Canary islands (Spain)

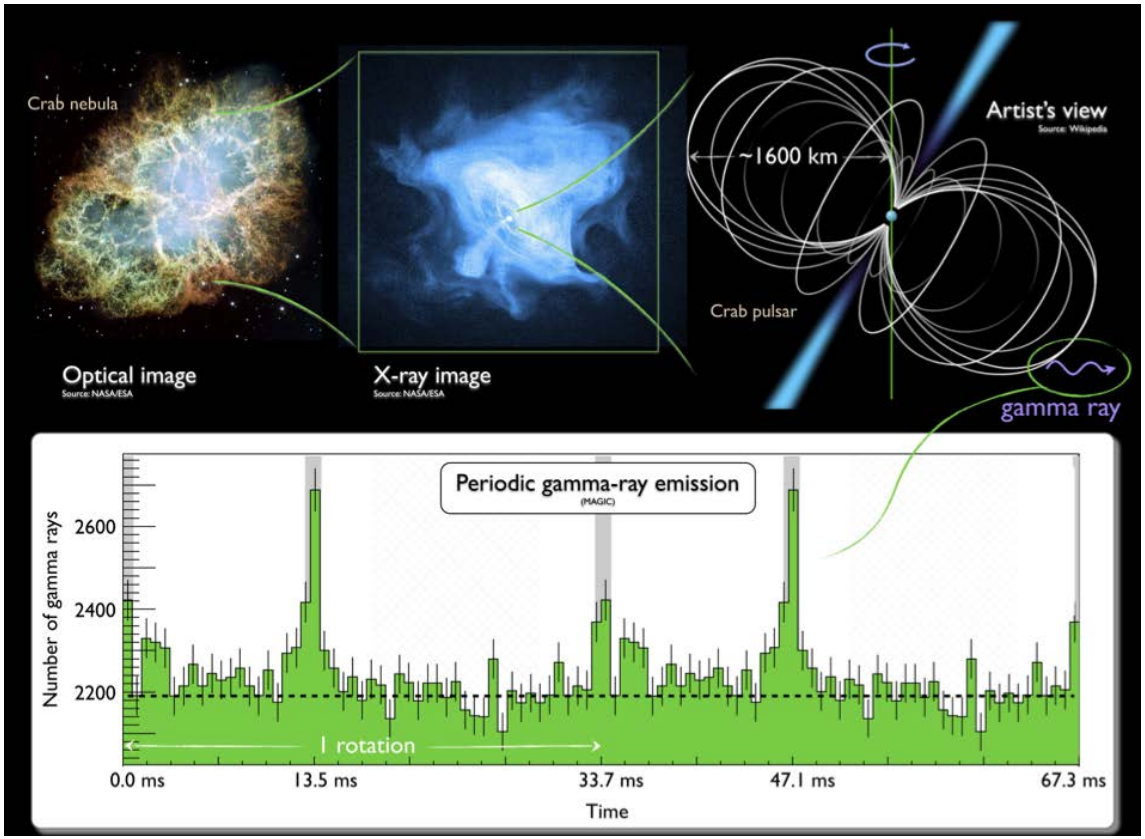
Overall evolution during the last 10 years

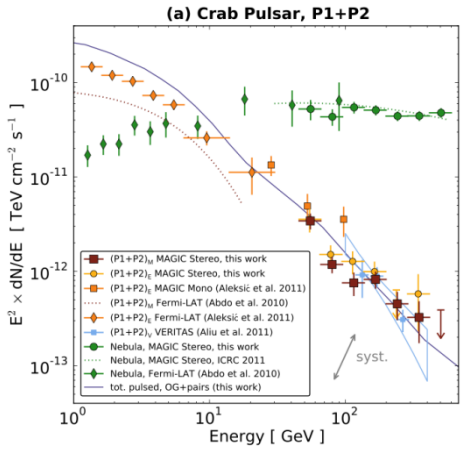
Evolution of the telescope sensitivity over the last decade



Better sensitivity + Lower energy threshold = More science

VHE pulsed emission from the Crab pulsar





Aliu et al. (MAGIC collab.)
Science 322 (2008) 1221
First detection of emission above 25GeV for a pulsar

Aliu et al. (VERITAS collab.)
Science 334 (2011) 69-72
First detection of emission above 100GeV

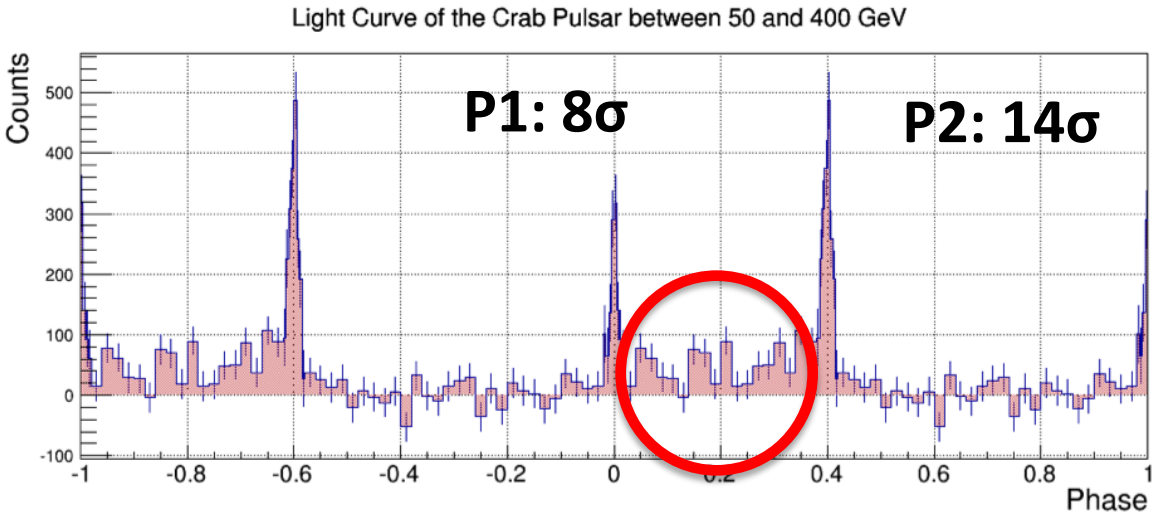
Aleksic et al (MAGIC collab.),
ApJ, 742 (2011) 43,
First spectrum 25-100GeV

Aleksic et al (MAGIC collab.),
A&A, 540 (2012) A69
First spectrum 50-400 GeV

Fermi + MAGIC → Spectrum from 0.1 GeV up to >400 GeV

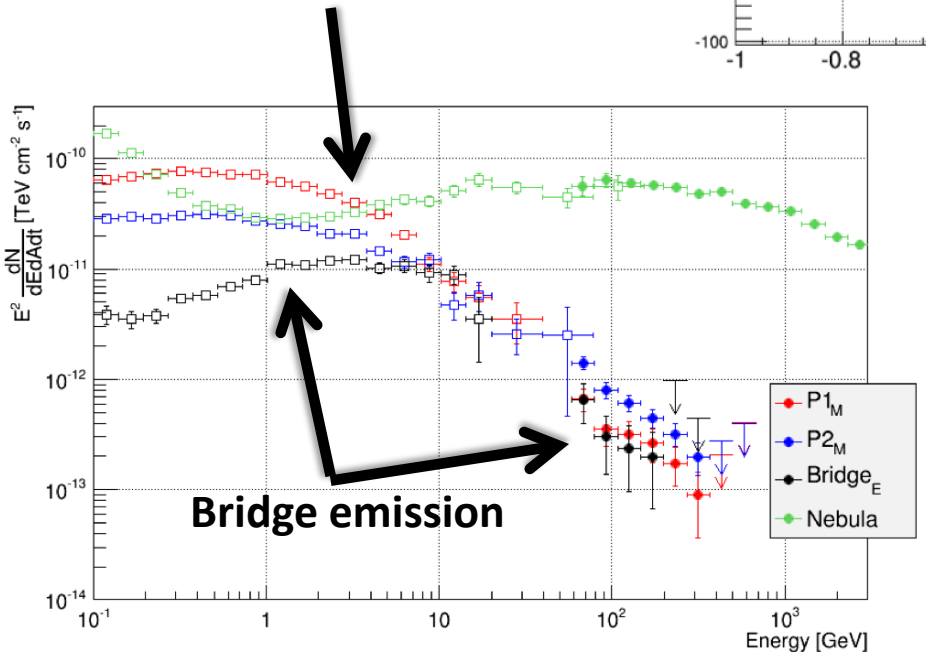
The VHE pulsed emission from the Crab pulsar was totally unexpected, and posed many challenges for conventional pulse emission theories. **VHE had to be produced close to the light cylinder, or even outside the light cylinder**

First Detection of bridge emission (between P1 and P2) at VHE



Bridge: 7σ

Fermi spectra show that the bridge emission is prominent above few GeV

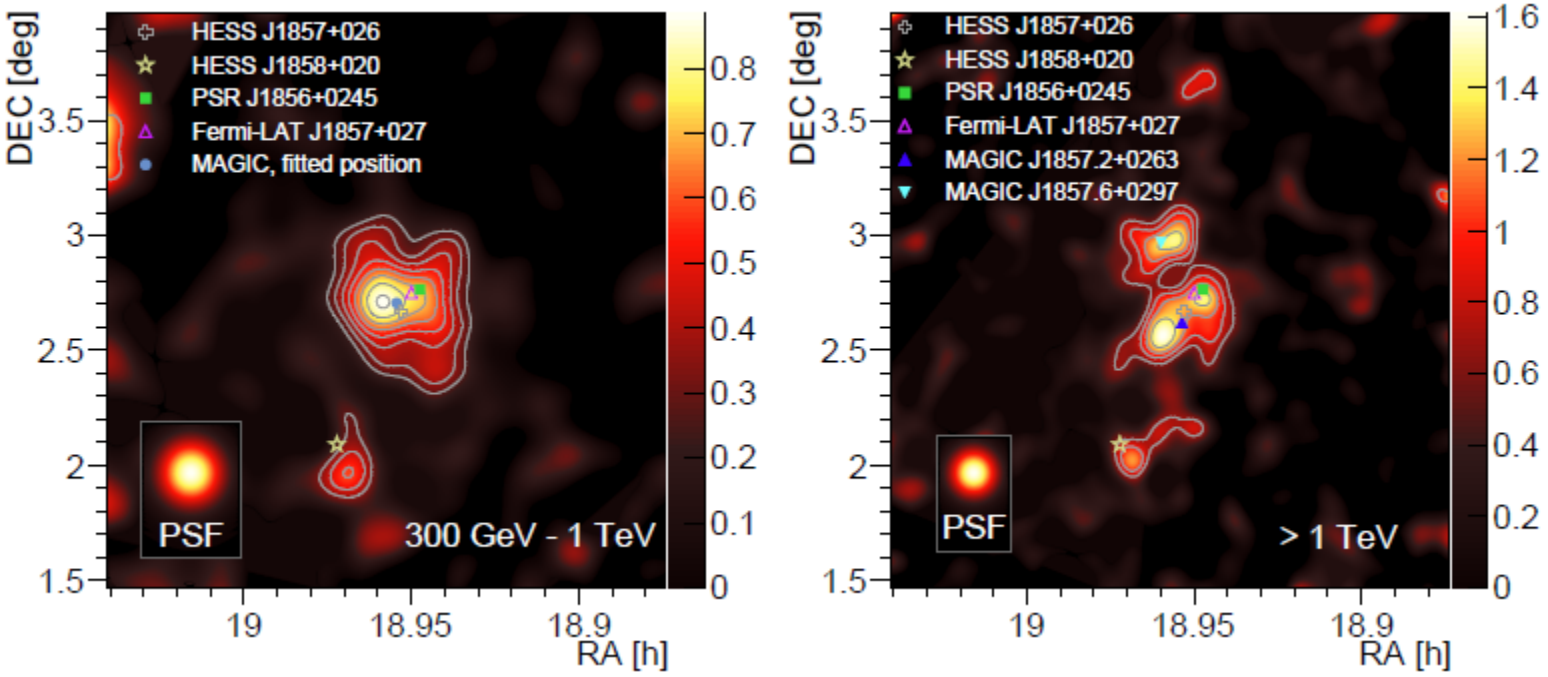


The VHE emission from the bridge might bring information about the toroidal bending of the magnetic lines near the light cylinder

Astronomy & Astrophysics, Volume 565 (2014)

HESS J1857+026

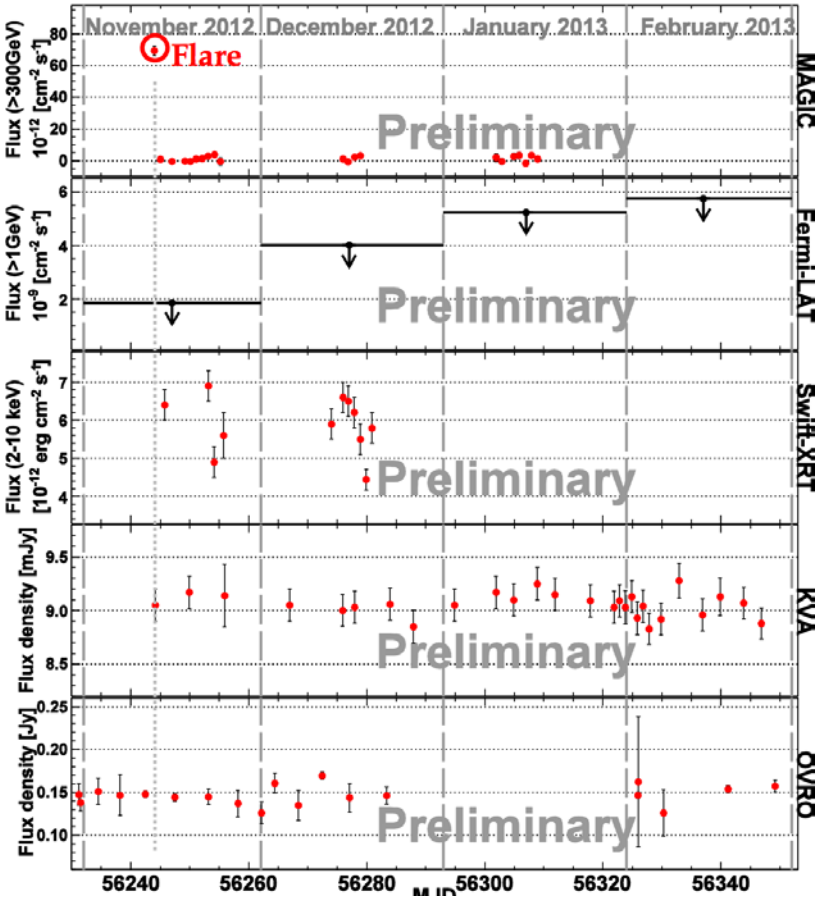
- **Extended TeV source discovered during the H.E.S.S. galactic plane survey**
- **Spatial proximity of young pulsar** PSR J1856+0245 -> PWN candidate?
- **MAGIC observations bridge the gap between GeV (Fermi-LAT) and TeV (H.E.S.S.)**
- **Favour 2-source scenario: PWN + molecular cloud complex**



Astronomy & Astrophysics, in press (2014)

Detection of the largest flare from a new TeV radio galaxy: IC 310

Astronomy & Astrophysics, Volume 563, id.A91, 9 pp. (2014)



TeV

GeV

keV

eV

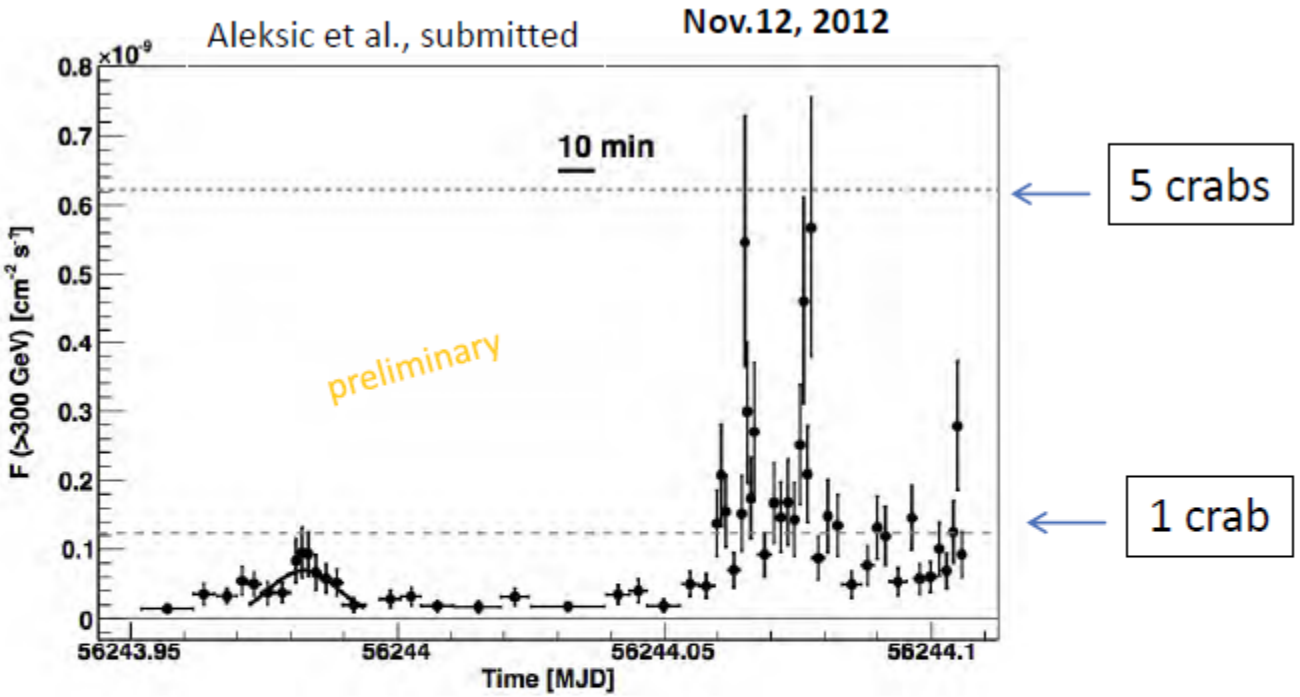
~0.1 meV

IC 310 is an object classified as radio galaxy detected, for the first time at VHE, with MAGIC in 2010

MAGIC (+interferometric radio observations) show that this object behaves like a blazar

- Super-fast variability
- No counter-jet close to central engine

In November 2012 we started a multi-instrument campaign, and on the first MAGIC observation, we detected the largest (by far!) activity to date.



- Light curve with 9 events/bins shows a few min. variability; unusual for a radio galaxy
- Still, spectral shape in the VHE remains constant
- No curvature in spectrum from 60 GeV – 10 TeV
- Difficult to explain with current (standard) theoretical scenarios !!

Paper submitted

S3 0218+357: Gravitationally lensed blazar at a redshift of ~0.94

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29 Sep 2014; 12:21 UT

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Discovery of Very High Energy Gamma-Ray Emission From Gravitationally Lensed Blazar S3 0218+357 With the MAGIC Telescopes

ATel #6349; *Razmik Mirzoyan (Max-Planck-Institute for Physics) On Behalf of the MAGIC Collaboration*
*on **28 Jul 2014; 14:20 UT***
Credential Certification: Razmik Mirzoyan (Razmik.Mirzoyan@mpp.mpg.de)

Subjects: Gamma Ray, >GeV, TeV, VHE, UHE, AGN, Blazar, Cosmic Rays, Microlensing Event

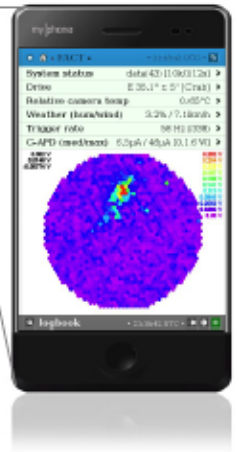
Related
6349 Discovery of Very High Energy Gamma-Ray Emission From Gravitationally Lensed Blazar S3 0218+357 With the MAGIC Telescopes
6316 Fermi LAT Detection of a Hard Spectrum Gamma-ray Flare from Gravitationally Lensed Blazar S3 0218+357
4411 Fermi LAT Detection of New Gamma-ray Flaring from Gravitationally Lensed Blazar S3 0218+35 and Scheduled Fermi Pointed Observations from 2012 September 24 - October 1
4371 Fermi LAT detection of a potential echo gamma-ray

ATel 6349 (2014)

First G-**A**PD **C**herenkov **T**elescope

G-APD camera:
SiPM as photosensors

- Stable detector performance
  → High data taking efficiency
  → remote and automatic operation
  www.fact-project.org/smartfact
- Observations during strong moon light
  → Larger duty cycle
  → More complete data sample
  → Ideal for Longterm Monitoring
- More details:
  - design report: *H. Anderhub et al. JINST 8 (2013) P6008*
  - Performance paper: *A. Biland et al. 2014 arXiv:1403.5747*

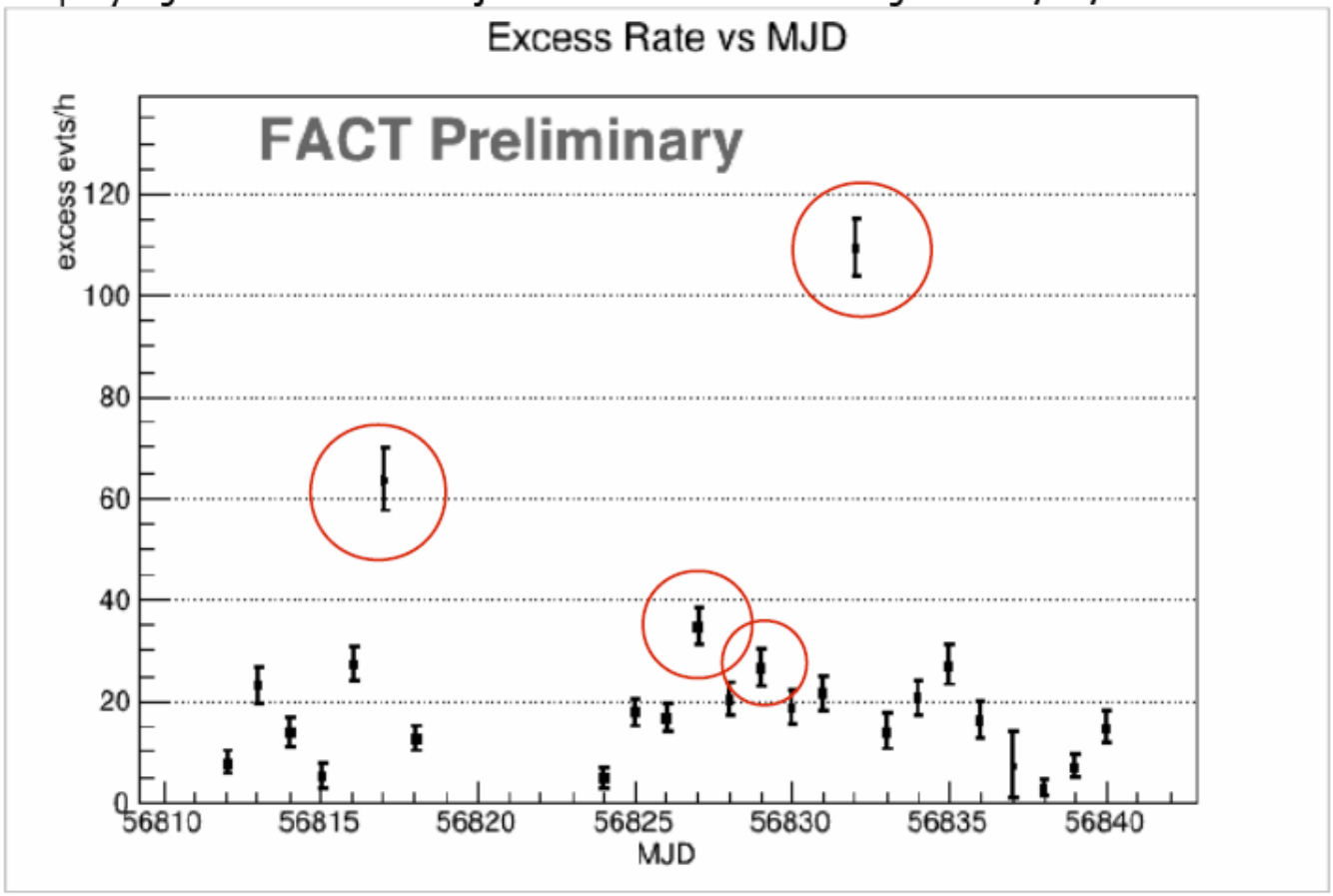


FACT – Longterm Monitoring and Flare Alerts

FACT Quick Look Analysis

Select date 2014 07 01 source Mrk 501
Select time binning 1night and range 28 days Reset

Displaying 'excess rate vs mjd' for Mrk 501 for the night 2014/07/01.



Mrk501:

- Flare Alert 8./9. Jun 2014
- Flare Alert 18./19. Jun 2014
- Flare Alert 20./21. Jun 2014
- Flare Alert 23./24. Jun 2014

public access:

http://www.fact-project.org/monitoring

Overall instrument evolution during the last 10years

Telescope commissioning in 2004

Start of Scientific operation in 2005

In 2007 the DAQ system was upgraded from “custom 300 MHz FADC” to multiplexer (16x1)system using commercial (Acqiris) 2GSample/s FADC system

In 2009 the Second MAGIC telescope started regular operation

In 2011 and 2012 the first MAGIC telescope was upgraded

FUTURE:
- Exchange of mirror panels finished.
- Sum-Trigger-II already installed.
- Further increase in sensitivity and operational stability feasible through SiPM cameras.