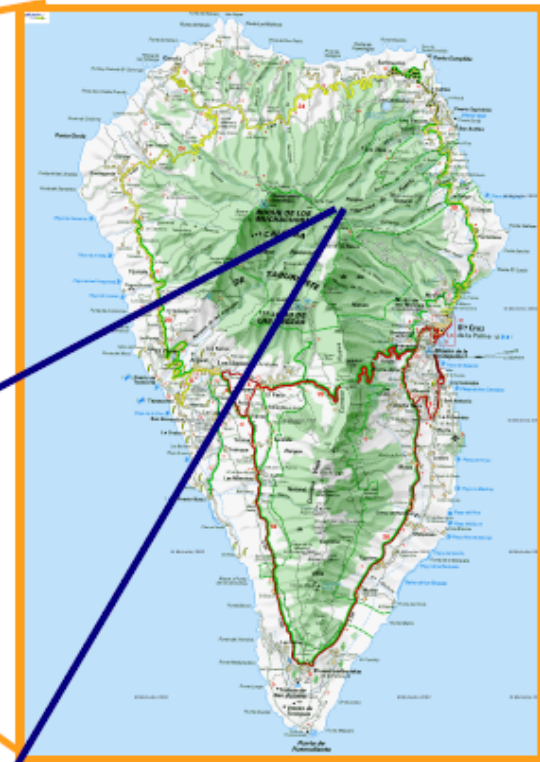


# The MAGIC Telescope System: Recent results and future perspectives

Dominik Elsaesser (Universitaet Wuerzburg)  
for the MAGIC Collaboration



# 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)**

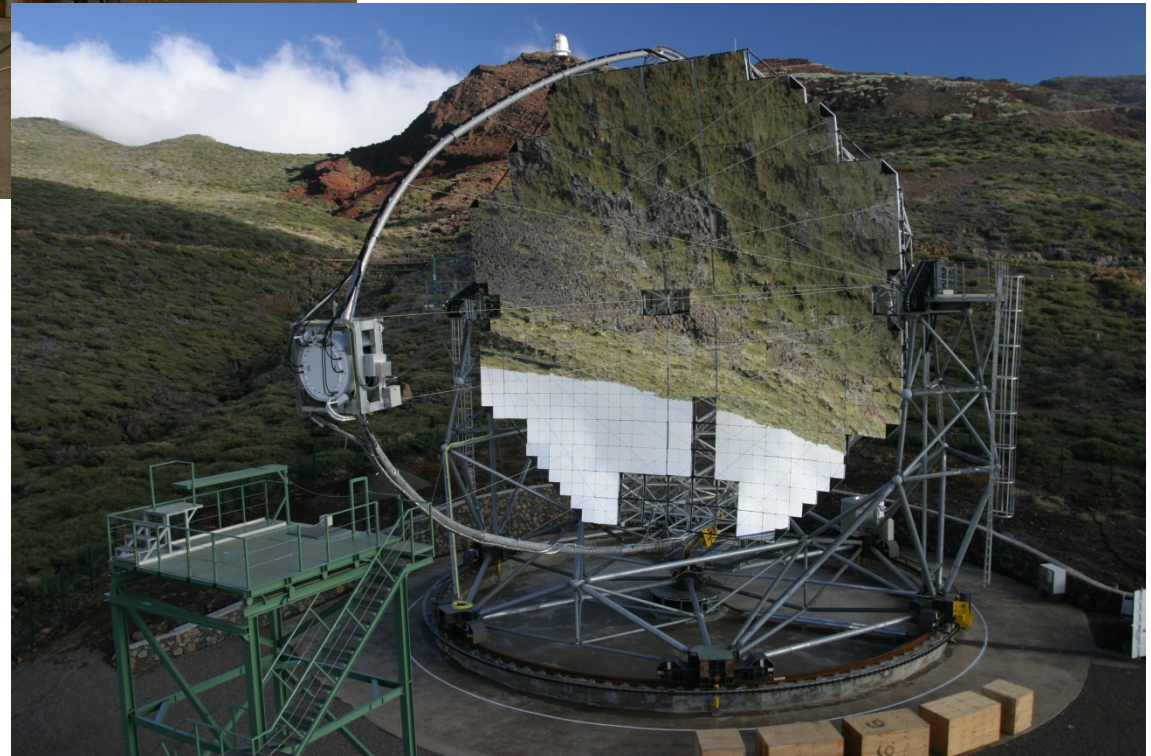


# MAGIC inauguration occurred ~10 years ago



October 10, 2003  
MAGIC Site  
(Roque de los Muchachos,  
La Palma)

The basic elements were there, but telescope was actually not fully operational at that moment



# Overall instrument evolution during the last 10years

**Telescope commissioning in 2004**

**Start of scientific operations in 2005**

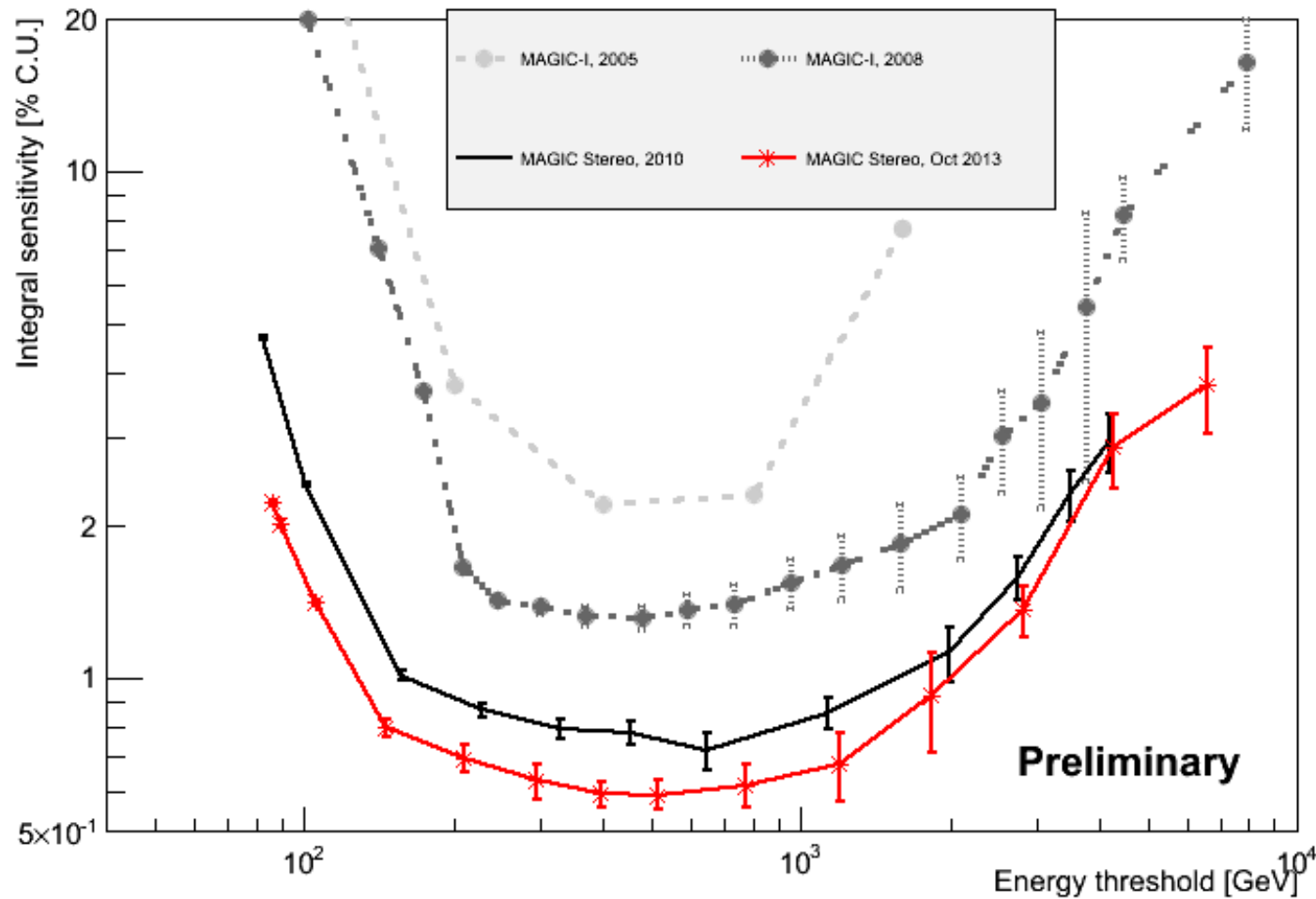
**In 2007 the DAQ system was upgraded from “custom 300 MHz FADC” to multiplexer (16x1)system using a commercial (Acqiris) 2GSample/s FADC system**

**In 2009 the second MAGIC telescope started regular operation**

**In 2011 and 2012 the first MAGIC telescope was upgraded**

# Overall evolution during the last 10 years

Evolution of the telescope sensitivity over the last decade

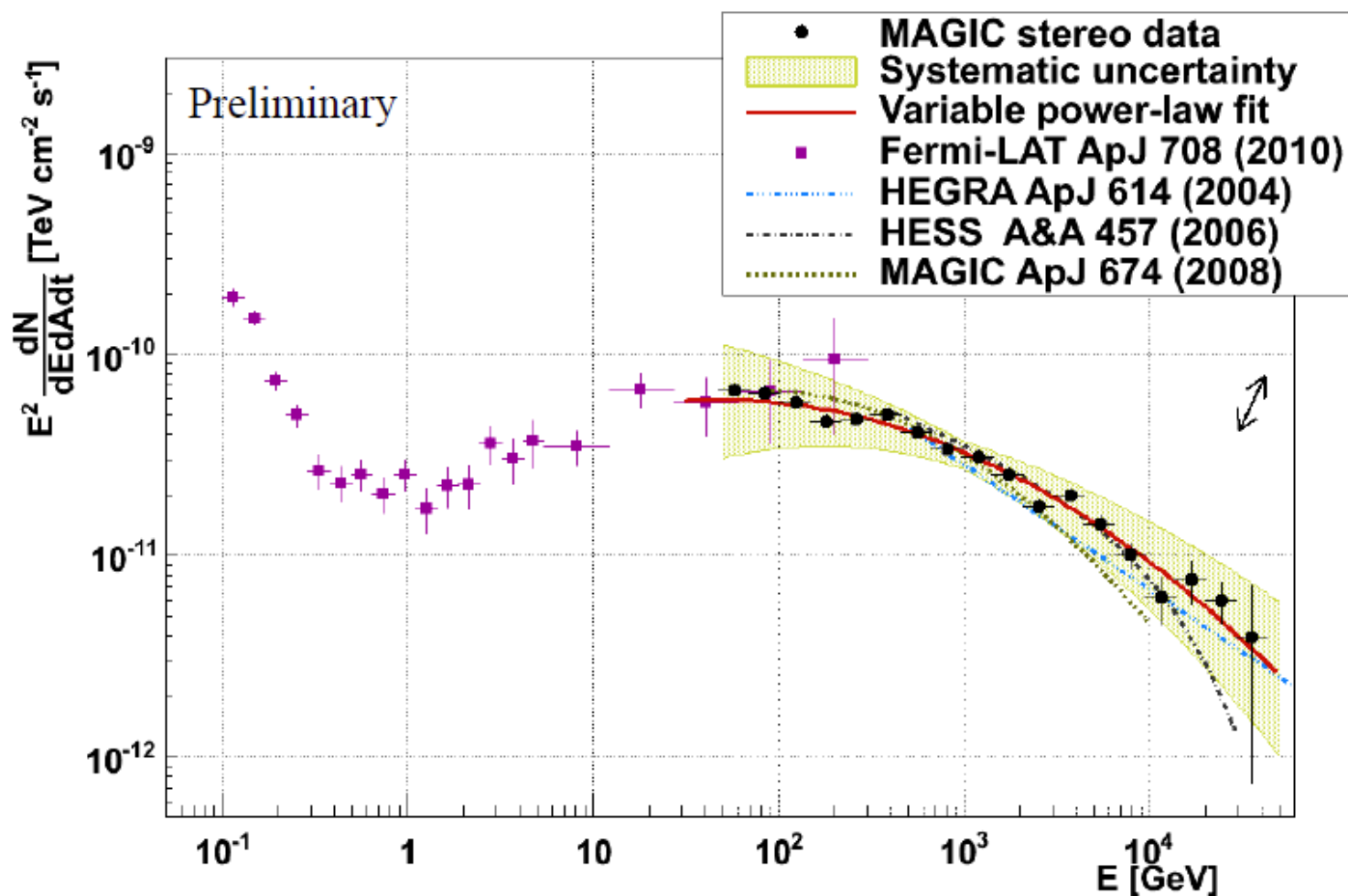


**Better sensitivity + Lower energy threshold = More science**

# Crab Nebula

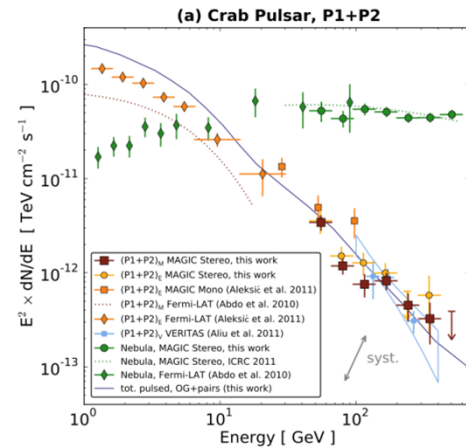
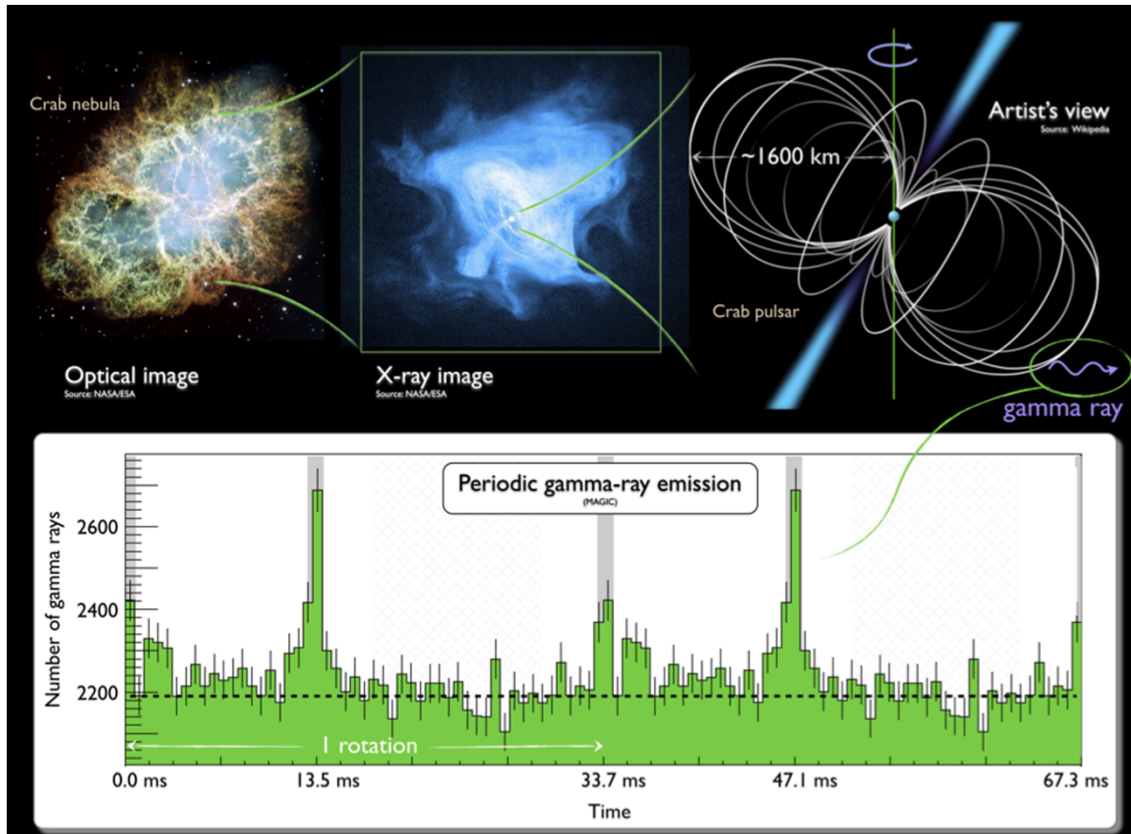
- MAGIC spectrum for 50 GeV to 45 TeV
  - About 50 hours in stereo mode, already dominated by systematics
  - Very good overlap with Fermi/LAT data → IC peak

No flux enhancement observed during Crab Flares (ATel #2967)





# 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**

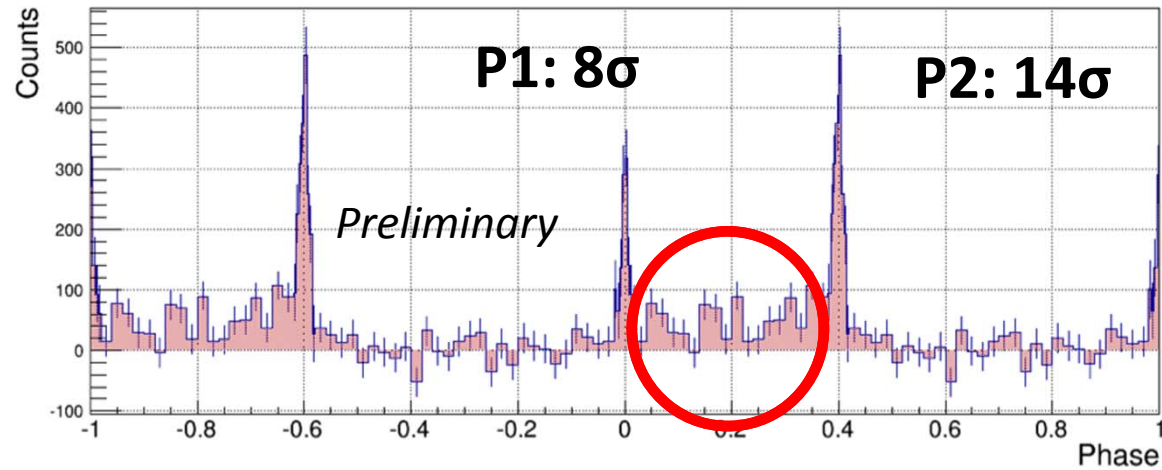
*First spectrum 50-400 GeV*

**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**

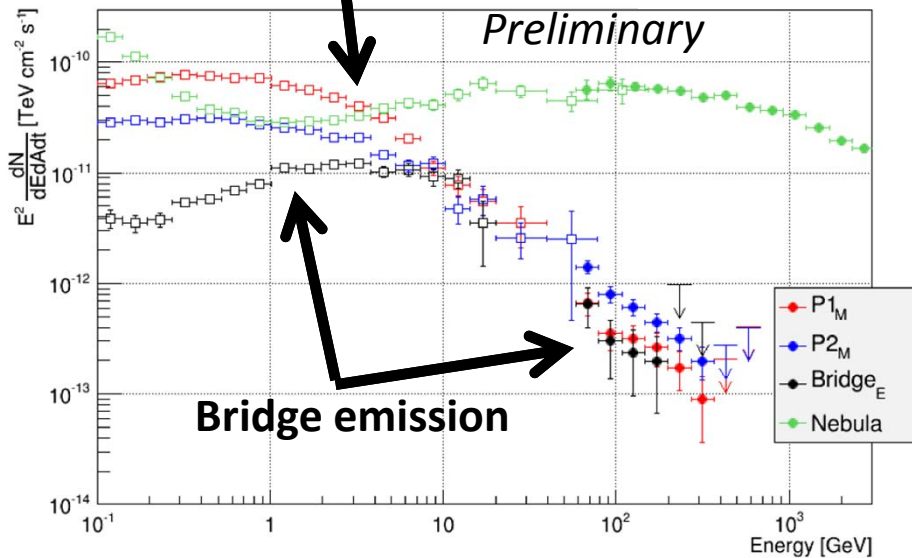
# First Detection of bridge emission (between P1 and P2) at VHE

Light Curve of the Crab Pulsar between 50 and 400 GeV



**Bridge:  $7\sigma$**

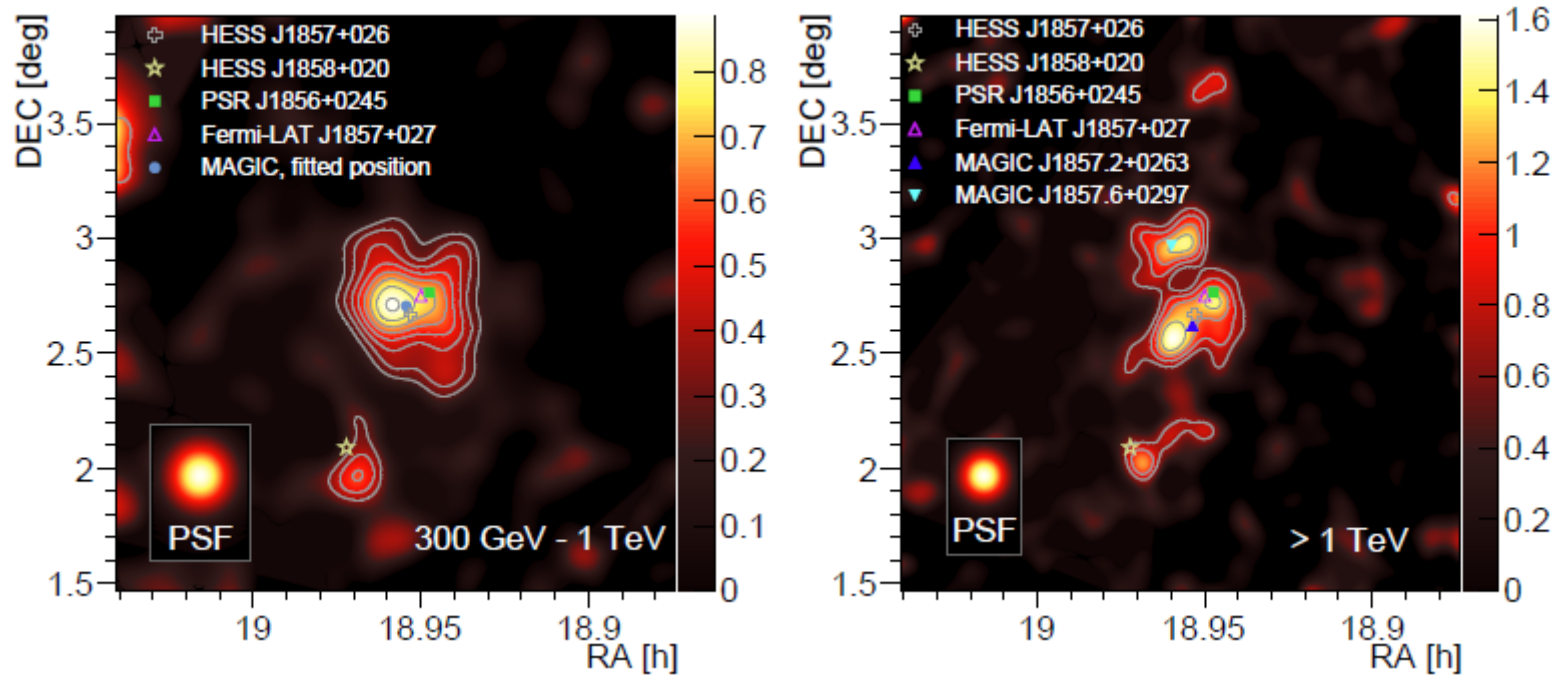
Fermi spectra show that the bridge emission is prominent above few GeV



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

# HESS J1857+026

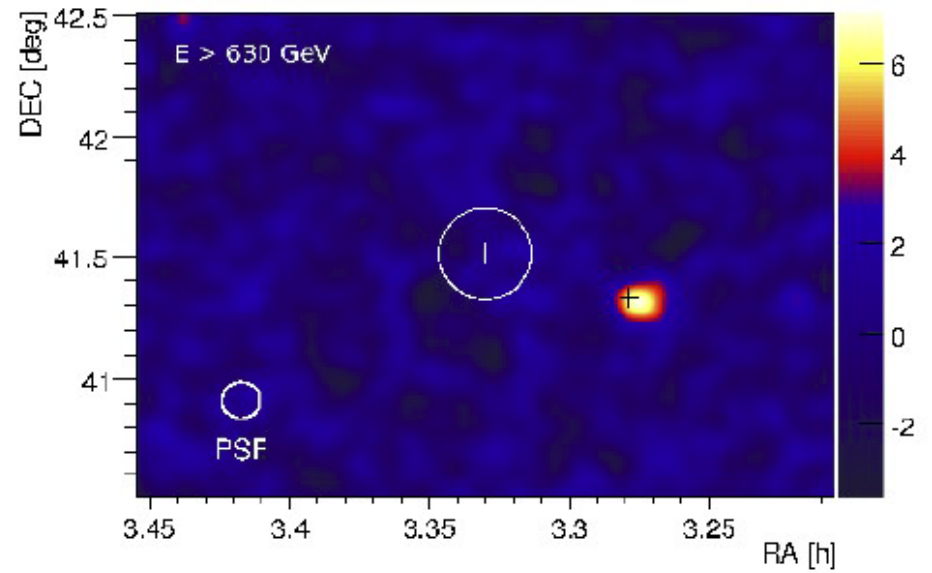
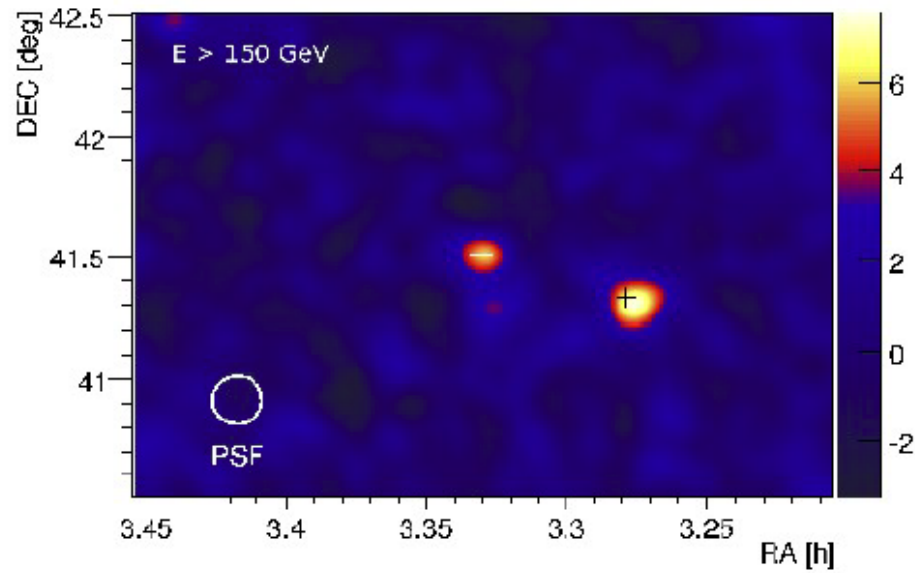
- Extended TeV source discovered during the H.E.S.S. galactic plane survey
- Spatial proximity of young pulsar PSR J1856+0245 -> PWN candidate?
- MAGIC observations bridge the gap between GeV (Fermi-LAT) and TeV (H.E.S.S.)
- Favour 2-source scenario: PWN + molecular cloud complex



MAGIC, A&A (2014)

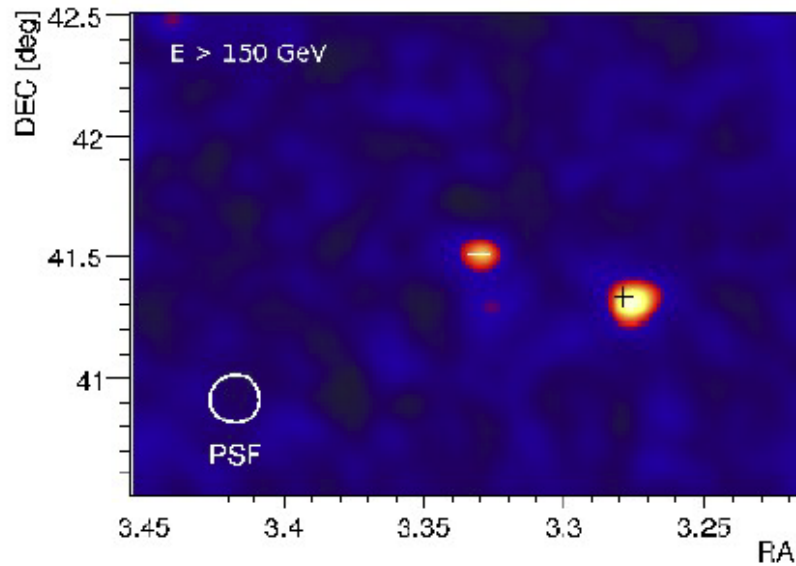
# Perseus cluster

Perseus is the brightest cluster of galaxies in X-rays



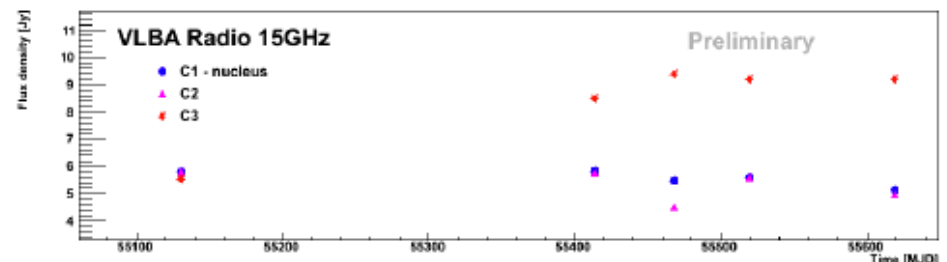
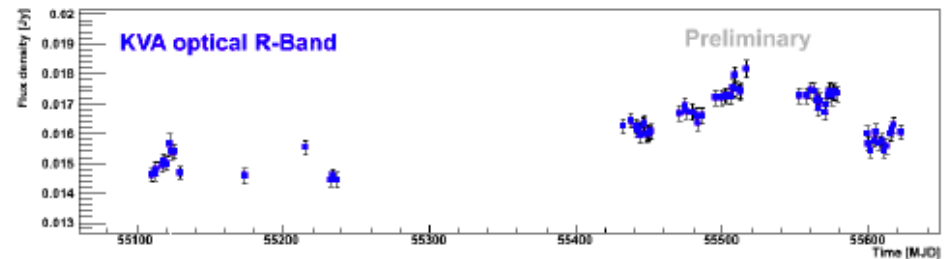
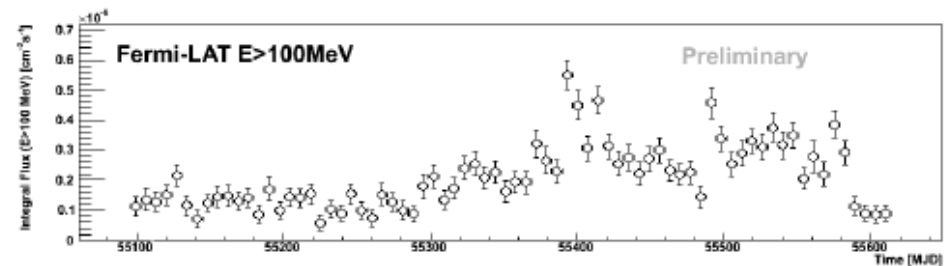
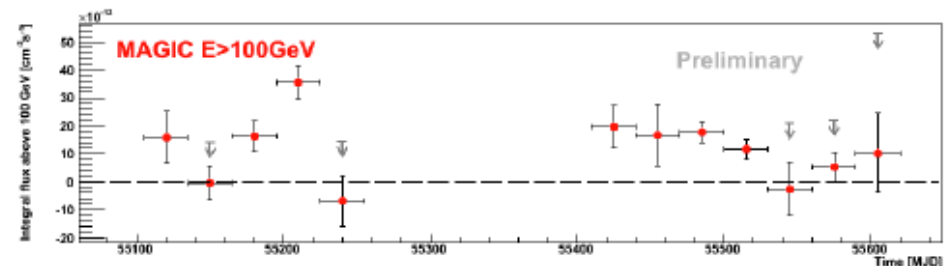
# Perseus cluster

Perseus is the brightest cluster of galaxies in X-rays



**NGC1275**

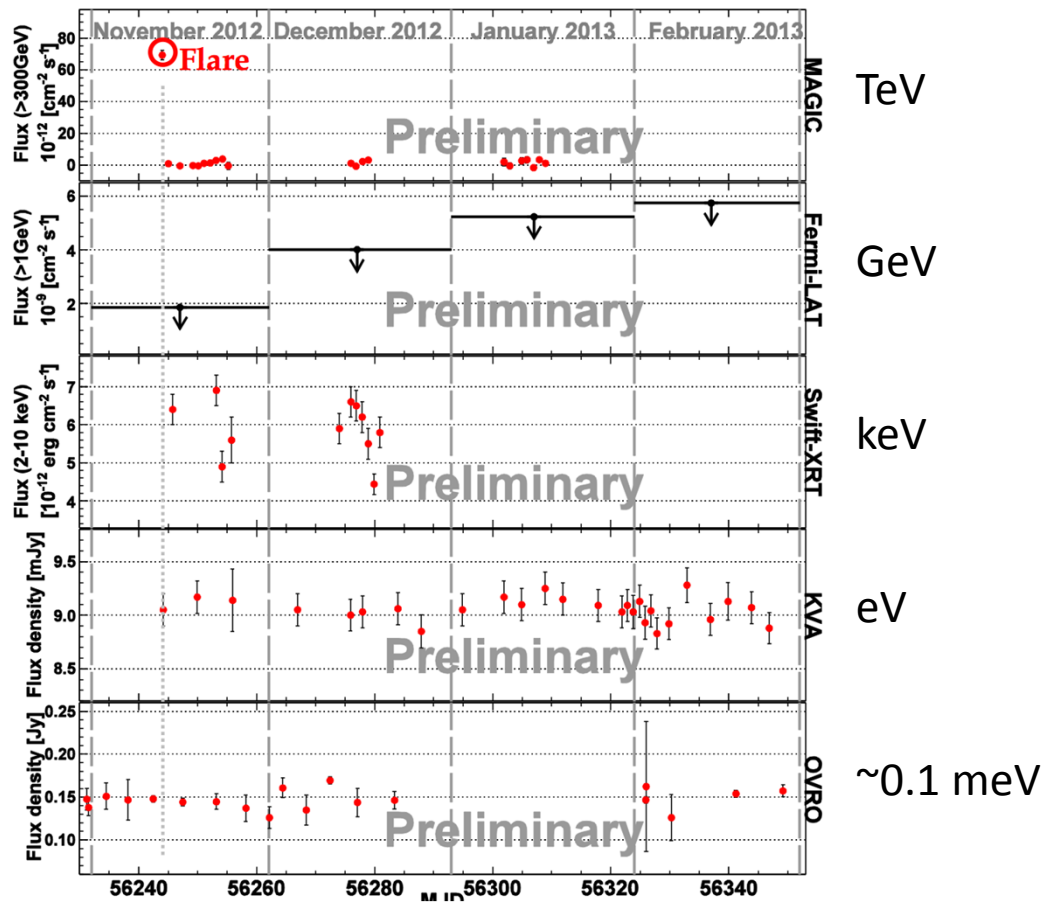
- Dominant central galaxy of Perseus
- Spectrum with MAGIC  
 $\Gamma = 4.1 \pm 0.7$
- MAGIC light curve, with MWL



# Some highlights from MAGIC

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

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



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.

**Paper submitted**

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## **FUTURE:**

- **Sum-Trigger-II already installed.**
- **Further increase in sensitivity and operational stability feasible through SiPM cameras.**

**Our field is already transitioning towards CTA!**