

# The MAGIC Telescopes in 2015

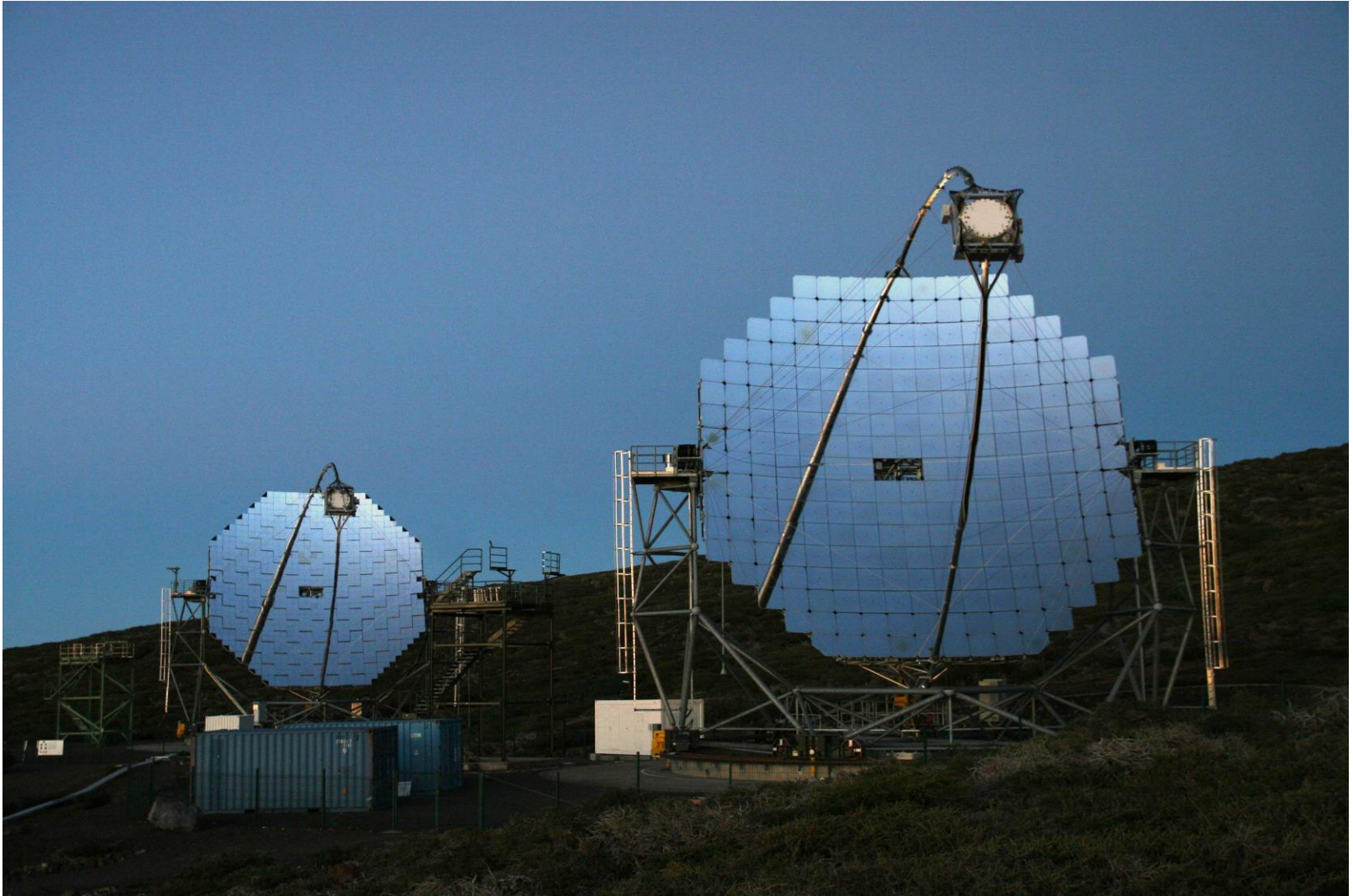
Razmik Mirzoyan  
for the MPP MAGIC group

# Rudy Bock, long-term enthusiastic MAGIC member



- Rudy Bock, former CERN staff, joined MAGIC short after the experiment became official project
- Real expert on statistics and treatment of data, he shared his know-how and educated generations of newcomers
- He lead the activity of creating software for data analysis of MAGIC
- Expert for multidimensional analysis of data, he has major contribution in today's analysis chain of the MAGIC data
- Suddenly passed away @ home

# The Two 17m $\emptyset$ MAGIC Telescopes



# System of 2 MAGICs: the main parameters

- Energy threshold (trigger):  $\sim 50$  GeV
- Current energy threshold in “*Sum-Trigger*” modus:  $\sim 35$  GeV
- Energy resolution: 20 % @ 100 GeV;  $< 15$  % @ 1 TeV
- Angular resolution:  $0.1^\circ$  @ 100 GeV;  $0.05^\circ$  @ 1 TeV
- Sensitivity: 6/1000 of Crab Nebula in 50h observations
- Light-weight construction, only  $\sim 70$  T
- Fast re-positioning to any coordinates in the sky:  $\sim 25$ s/ $180^\circ$
- Electro-optical design optimized to provide  $\sim 2.5$ ns FWHM pulses
- Data digitized by using DRS4 chips run @ 1.64 GSample/s
- Producing  $\sim 1$  TB data per observation night & telescope

# ~170 Collaborating Astro-Physicists from 10 Countries

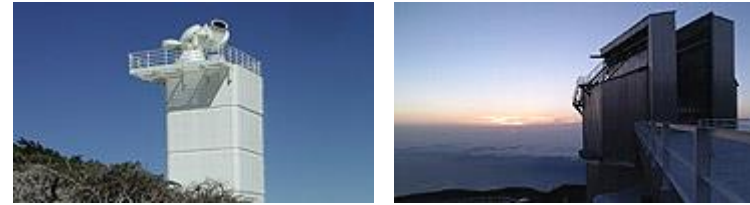


- Bulgaria** Sofia
- Croatia** Consortium (Zagreb, +...)
- Finland** Consortium (Tuorla, +...)
- Germany** DESY Zeuthen, U. Dortmund, MPI Munich, U. Würzburg
- Japan** Consortium (Kyoto, +...)
- Italy** INFN & U. Padova, INFN Pisa & U. Siena, INFN Como/Milano Bicocca, INFN Udine/Trieste & U. Udine, INAF (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
- India** Saha Inst. Nucl. Physics, Kolkata, India

# The Main Telescopes of the “*Roque de los Muchachos*” European Northern Observatory



ORM is located on the Canary island of La Palma, at a height of 2200-2400 m a.s.l.

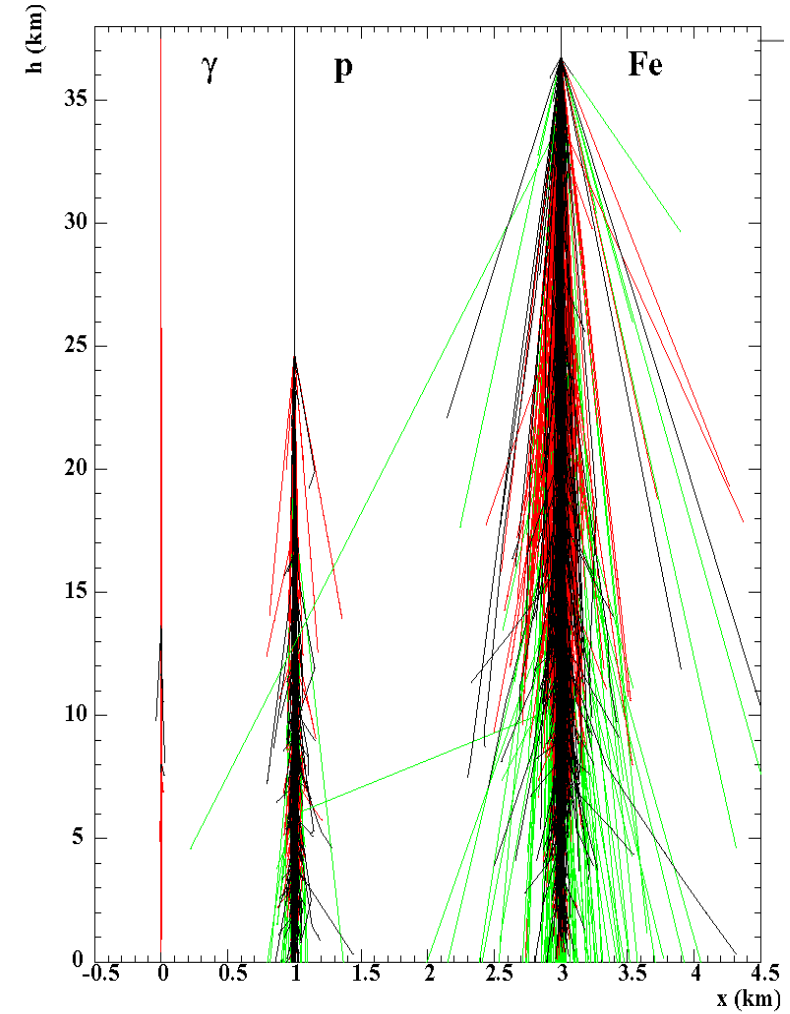
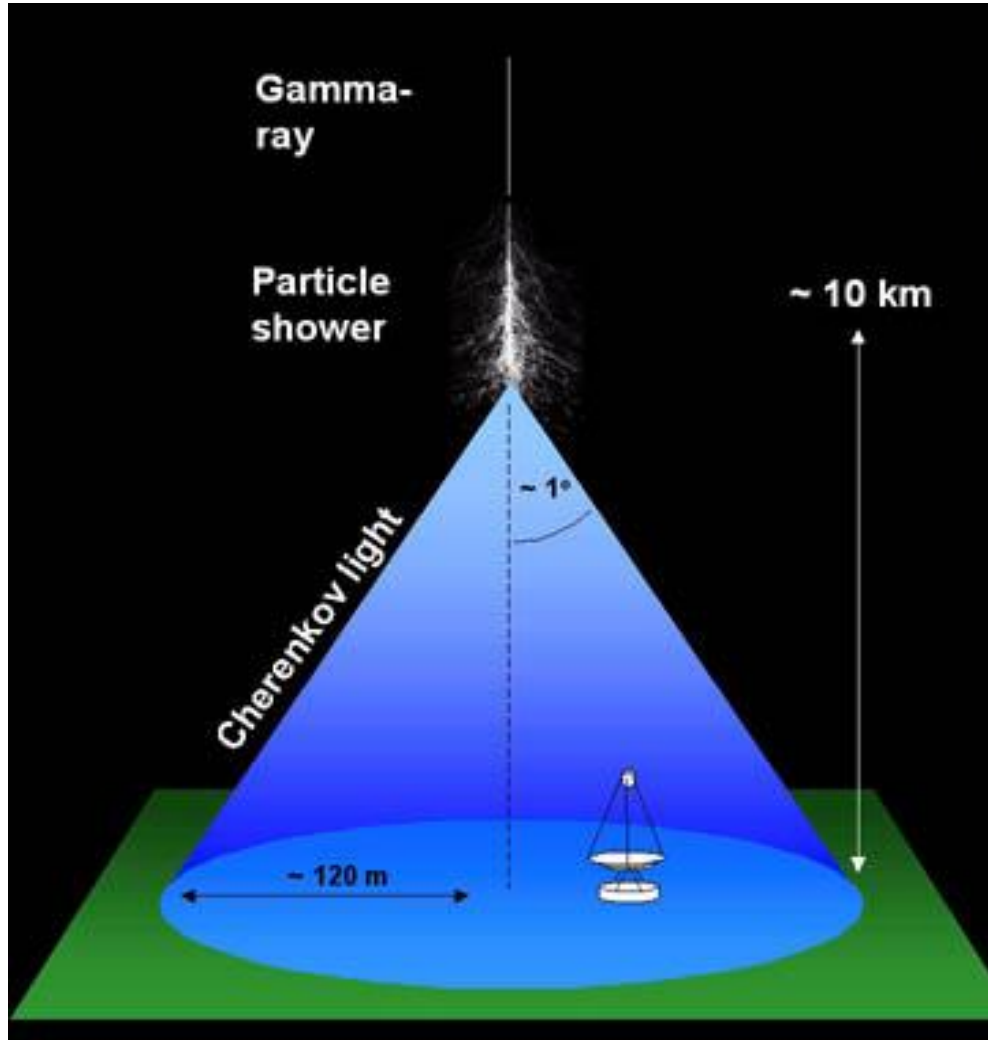


# 2 MAGICs @ ORM in La Palma

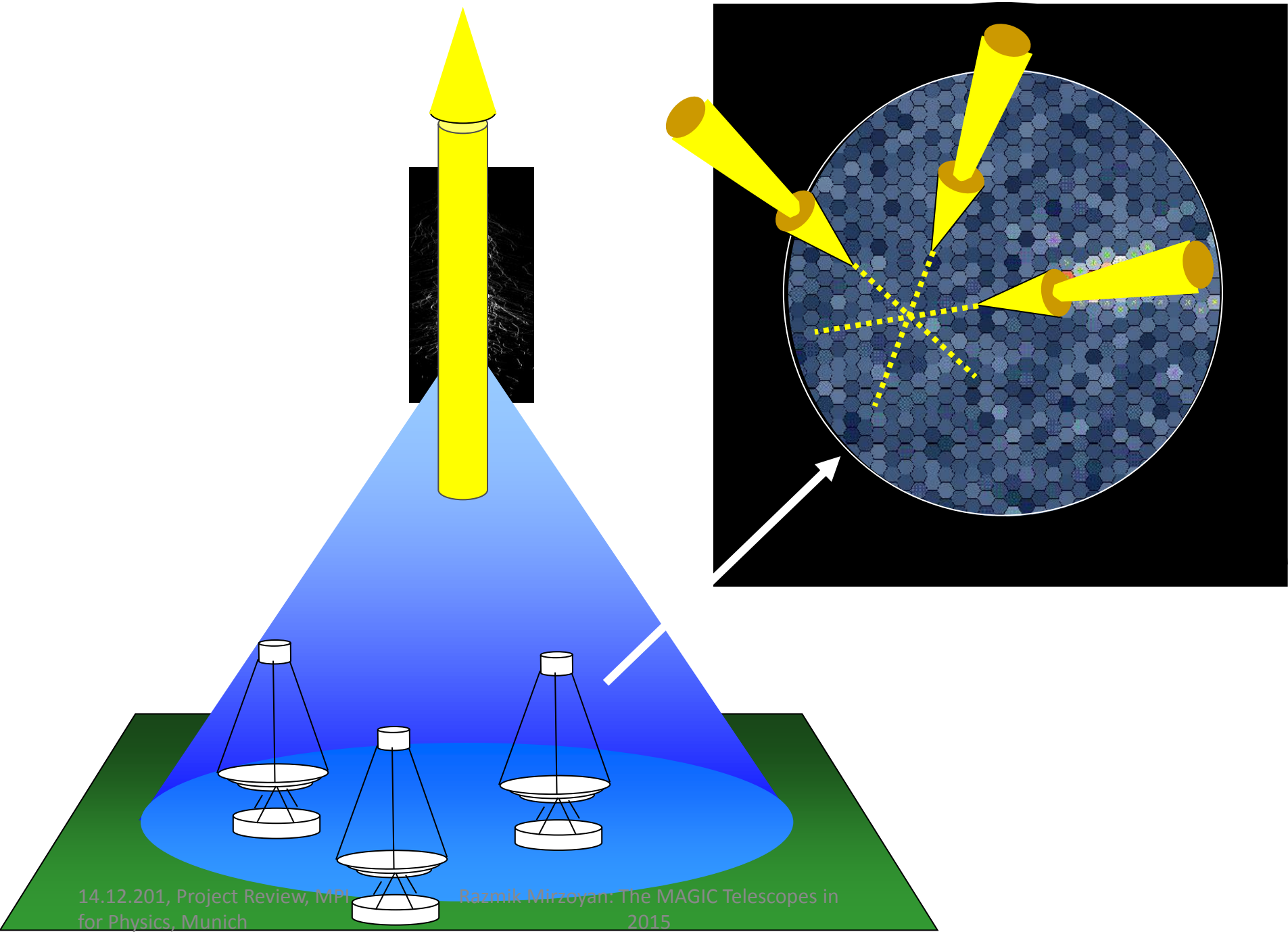


**Cherenkov-light-hitting-Magic.mp4**

# Images of Extensive Air Showers in Cherenkov Light

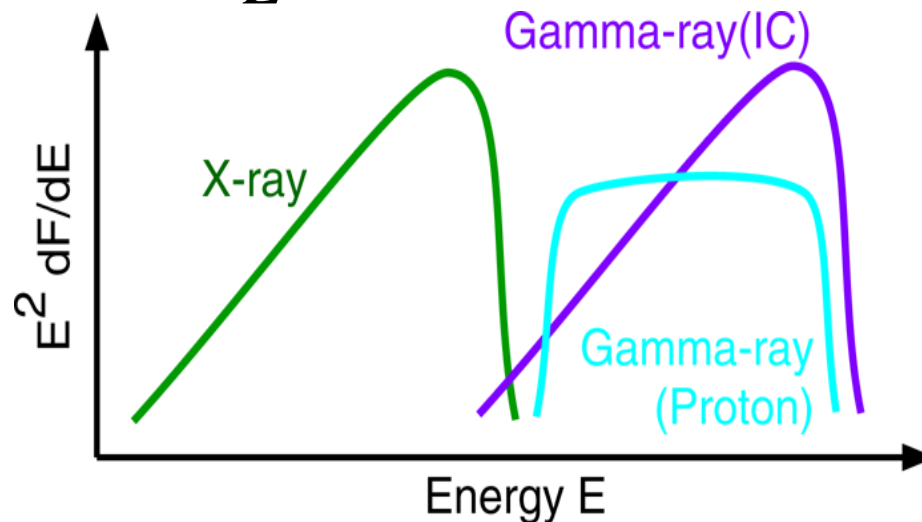
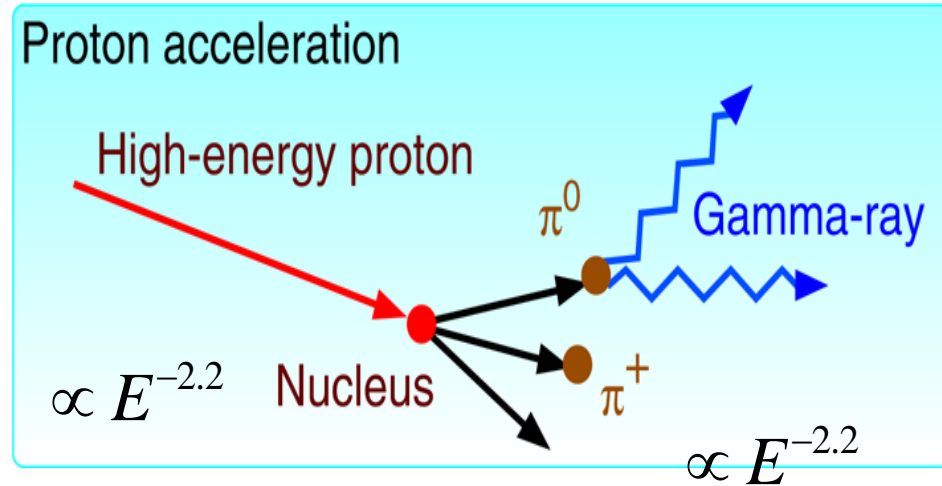
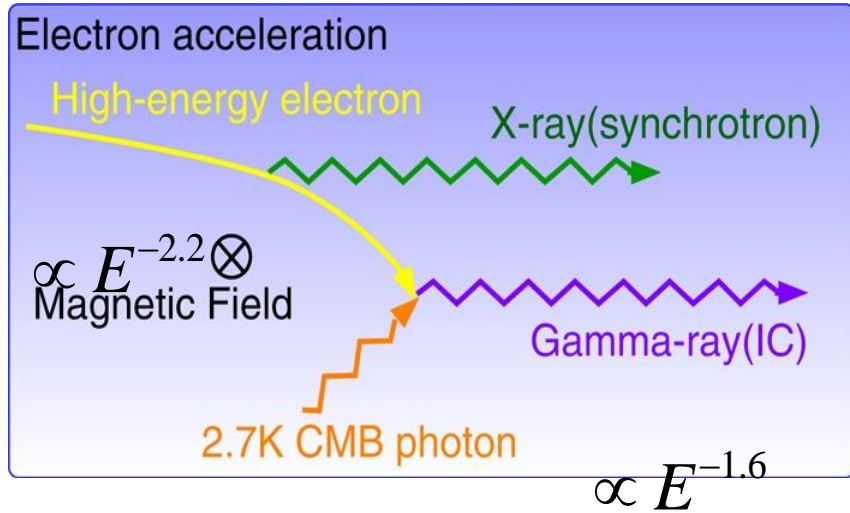






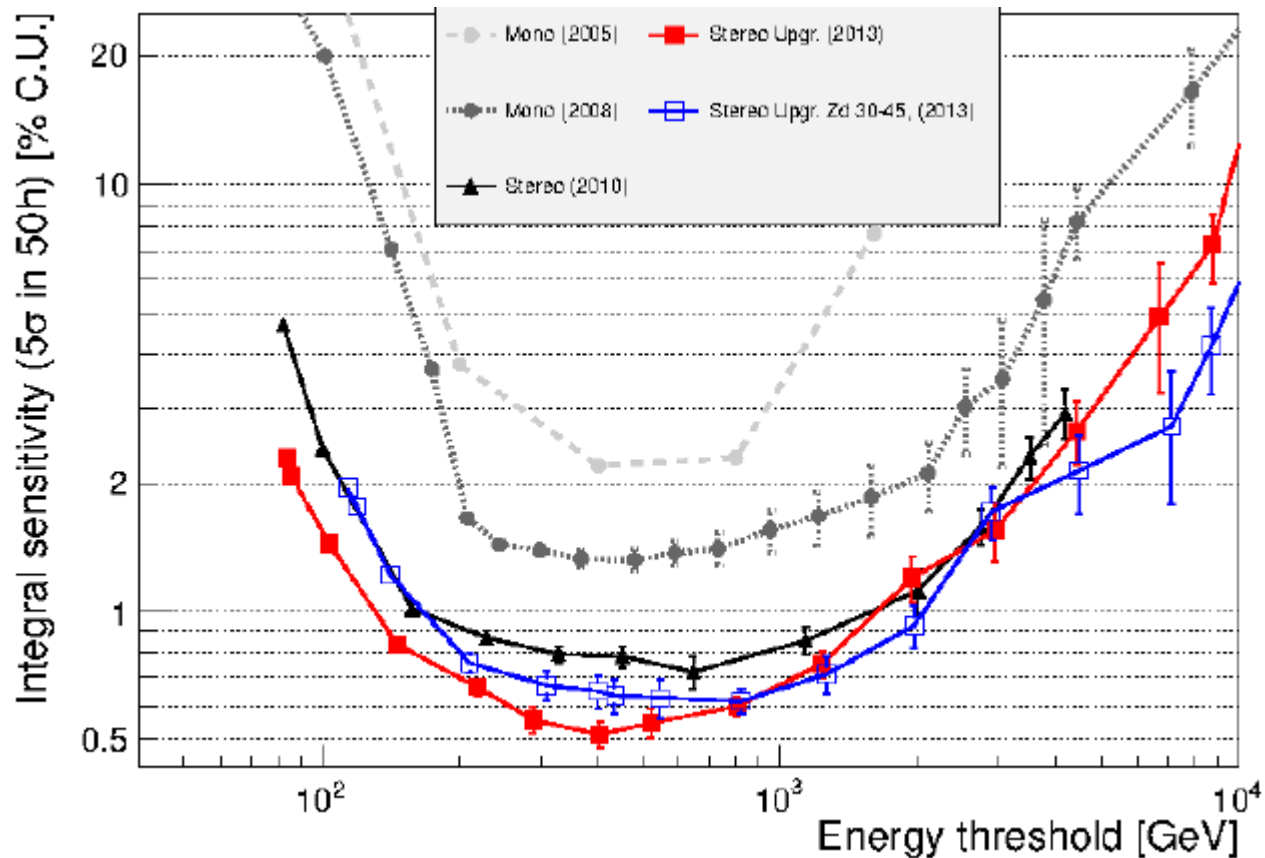
# Gamma-Ray Emission Processes

## Astrophysical process



# MAGIC Progress in 2015

- Also in 2015 MAGIC yielded a remarkable scientific harvest in. Current sensitivity:  $\sim 60$  mCrab in 50h for  $E_\gamma \geq 400$  GeV



# MPP's decisive role in MAGIC

- Strongest and largest group in MAGIC
- In the structure of the collaboration the MPP group provides
  - Spokesperson (myself)
  - Physics Coordinator (Masahiro Teshima)
  - Publication Manager (David Paneque)
- Providing 3 out of 9 members in Executive Board (responsible for the day-to-day decisions to run the experiment)
  - Co-convener AGN WG (Daniel Mazin: ICRR @ Tokyo & MPP)
  - Co-convener Galactic WG: Christian Fruck
  - Co-convener Astroparticle and Fundamental physics WG: Pierre Colin

# MPP's decisive role in MAGIC

- The group includes about 18 physicists
- Director: Masahiro Teshima
- 3 permanent positions: R. Mirzoyan, T. Schweizer, D. Paneque
- 5 postdocs, 7 PhD students, 2 undergraduates
- We greatly acknowledge the strong and friendly support from the MPP workshops: O. Reimann, T. Haubold, D. Fink, H. Wetteskind, C. Jablonski, M. Fras, W. Haberer, S. Schmidl, A. Dettlaff, S. Horn, J. Schlammer, ...,
- Providing 30-40 % of all resources in the collaboration

# The Astronomer's Telegram

- MAGIC detects Very High Energy gamma-rays from **S5 0716+714**  
#6999
- Discovery of Very High Energy Gamma-Ray Emission from the **FSRQ S4 0954+65** with the MAGIC telescopes  
#7080
- Discovery of Very High Energy Gamma-Ray Emission from the distant **FSRQ PKS 1441+25** with the MAGIC telescopes  
#7416
- MAGIC detects an increased activity from **PKS 1510-089** at very high energy  $\gamma$ -rays  
#7542
- MAGIC detects an increased activity from **BL Lacertae** at very high energy  $\gamma$  rays  
#7660
- Discovery of Very High Energy Gamma-Ray Emission from the intermediate **BL Lac S2 0109+22** with the MAGIC telescopes  
#7844
- MAGIC observation of ANTARES detected neutrino sky region  
#8203

# MAGIC publication pipeline for 2015

**Papers in peer-reviewed journals in 2015:**

**15 published + 9 submitted**

**24 papers = 14 AGNs + 6 Gal + 2 DM + 2 Technical**

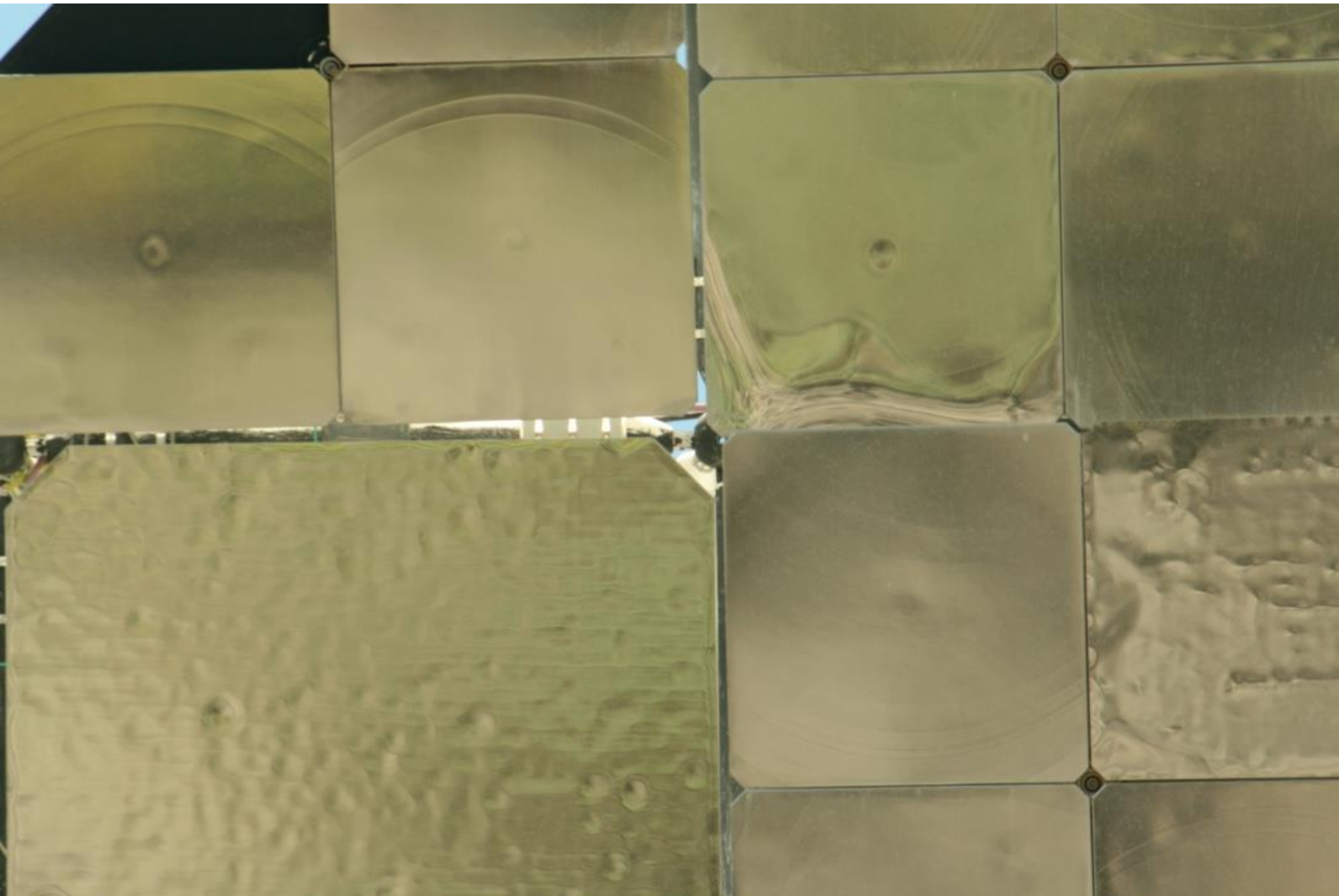
Out of **15** papers **8** are led by MPP people and  
out the **9** submitted **3** are led by MPP

Other projects (not necessarily yet drafts, those may include recent data)  
in preparation: **~50**

# Mirror status of M-1 and M-2

- The mirrors on M1 are used since 2003 (for **13** years by now)
- The mirrors on M2 are used since 2009 (for **7** years by now)
- **Our collaboration started considering about renovation and proper maintenance of the reflectors of both telescopes for coming years**
- Mirrors made by using an alternative technology, as for example, from glass, can provide focused reflectivity of  $\sim 70\text{-}80\%$
- Moving from current  $\sim 50\%$  of light to  $80\%$  of light in a PSF will provide a strong boost (up to  $\sim 60\%$  more light in a pixel) on the trigger level
- In the next slide I show a photo of a degraded mirrors on M1, taken in August 2015 by Angelo Antonelli in La Palma

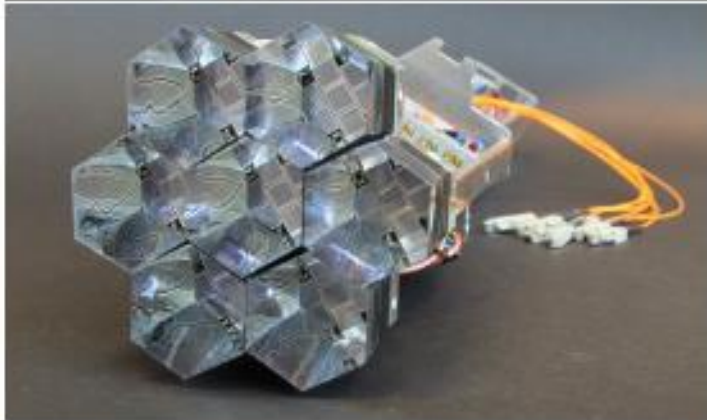




14.12.201, Project Review, MPI  
for Physics, Munich

Razmik Mirzoyan: The MAGIC Telescopes in  
2015

# MPP SiPM cluster in MAGIC-I camera



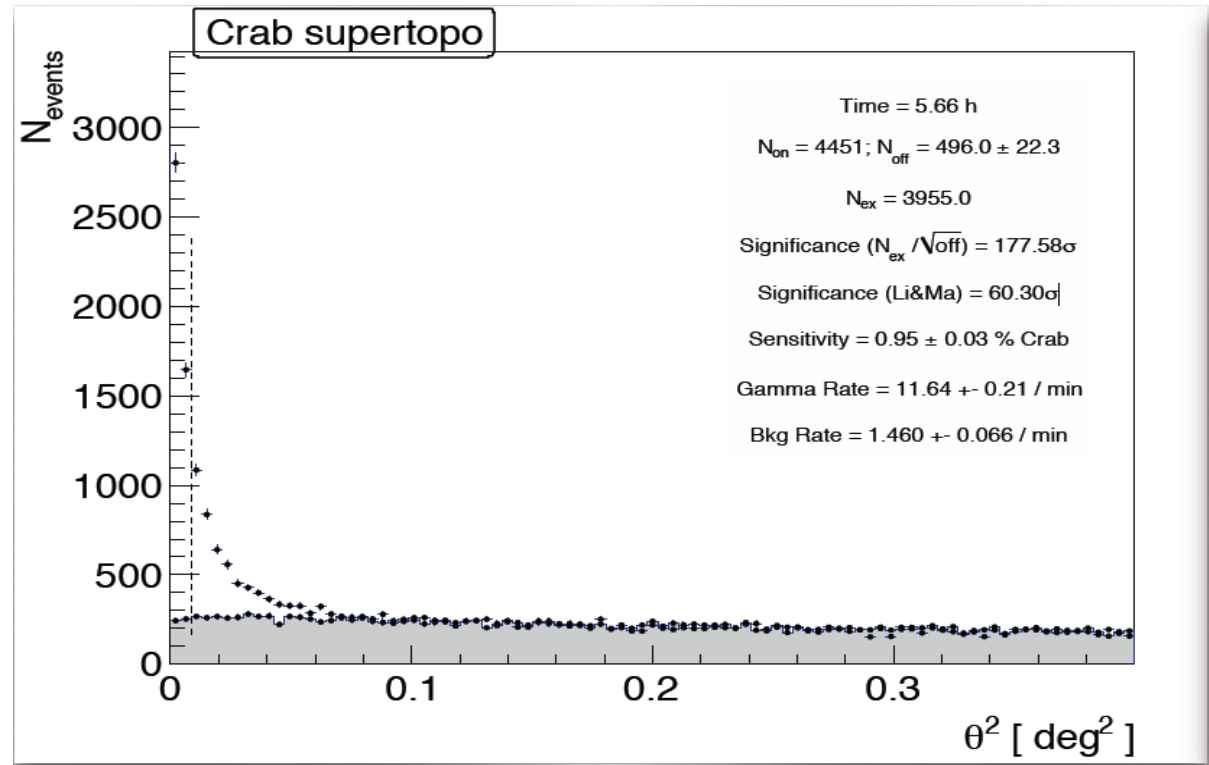
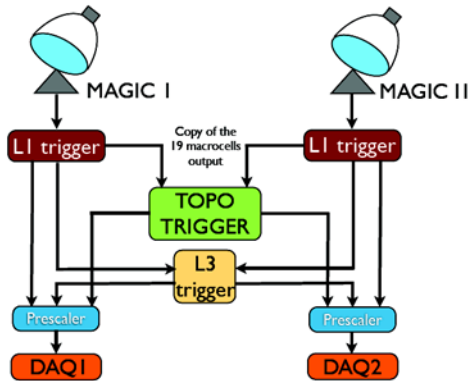
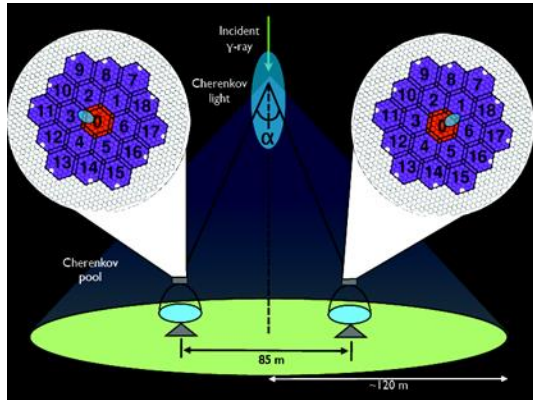
## Achievements

- Developed,
- Built,
- Tested,
- and Installed the first SiPM cluster
- Modified CaCo for controlling
- Cluster is running since July 2015
- Included in standard data taking

## Future tasks

- Detailed comparison to PMT clusters
- Long-term stability test in MAGIC
- Characterize new SiPMs
- More Winston cone simulations and measurements
- Build two new prototype clusters
  
- ASIC approach with David Gascon et al. from the University of Barcelona

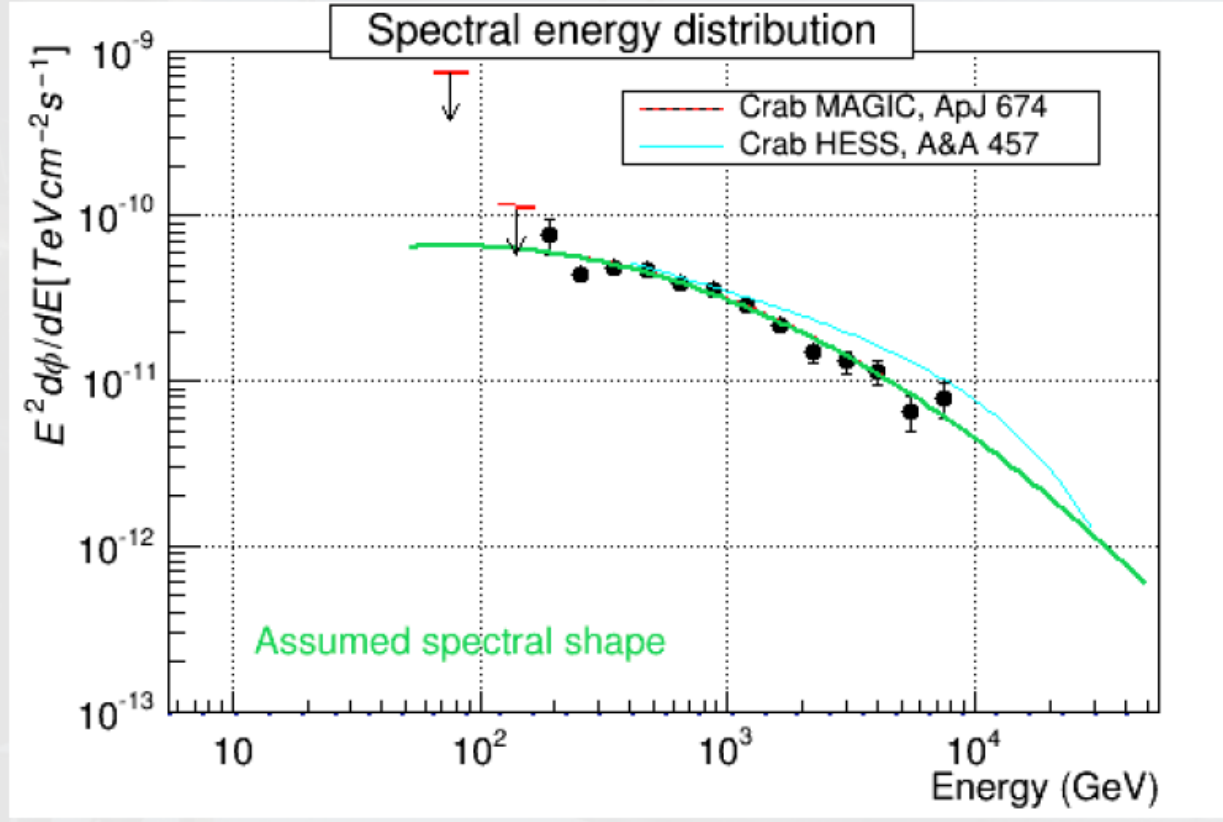
# Super-Topo Trigger



Hardware operative, first performance numbers based on real data show ~10% improvement on sensitivity at low energies (1.10% Crab → 0.95% Crab) Further improvement expected with Super-Topo MC instead of standard MC

# Increased duty cycle by using blue filter

- **4-8  $\mu\text{A}$  ~ 20-60 x Dark NSB (~ 10 hr)**

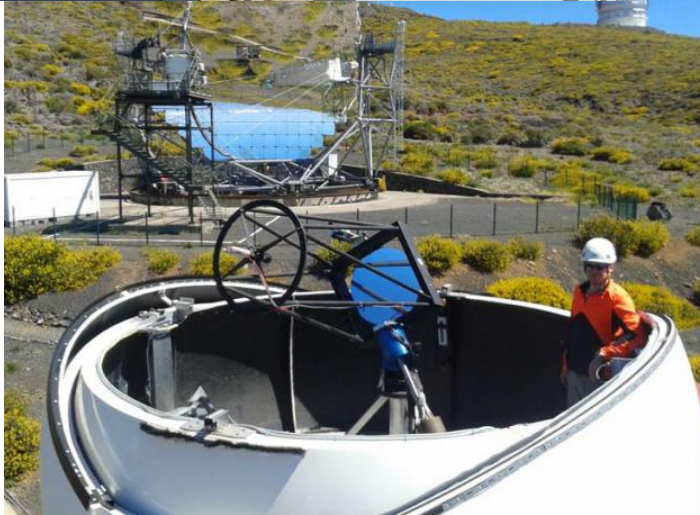
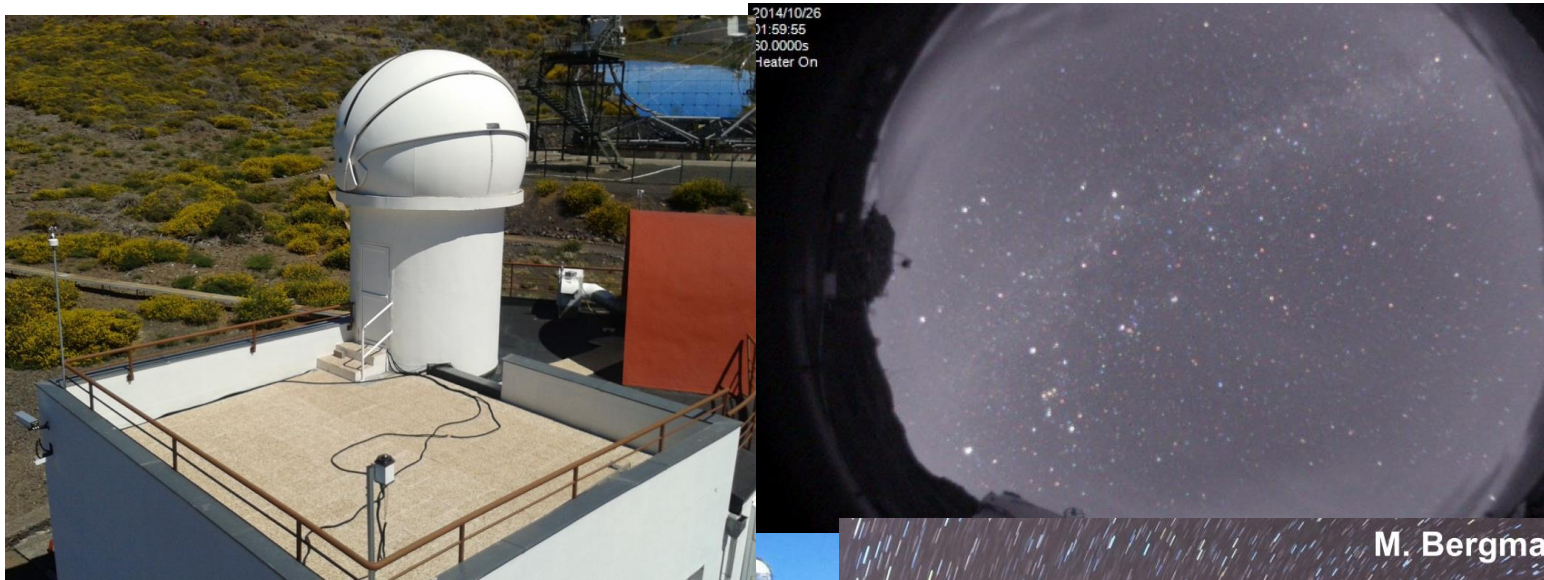


Significantly increase of duty cycle, +50 hours on CasA



Although, if brightness allows reduced HV is better.

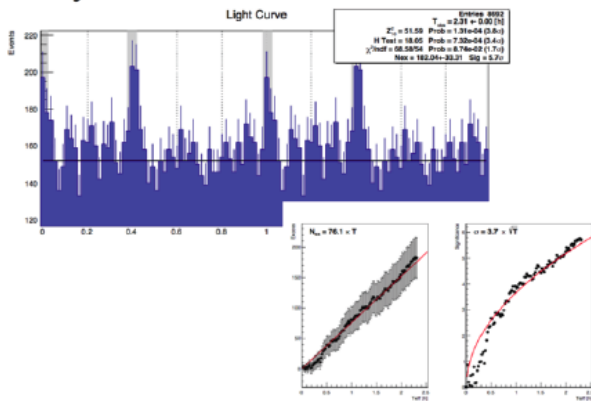
# MAGIC LIDAR & the ATCA group



# SUM-Trigger started producing 1<sup>st</sup> exciting results on Crab pulsar

First analysis from new data in October  
(Marcos Lopez, standard cleaning)  
2.3h  $\rightarrow$  5.7 sigma

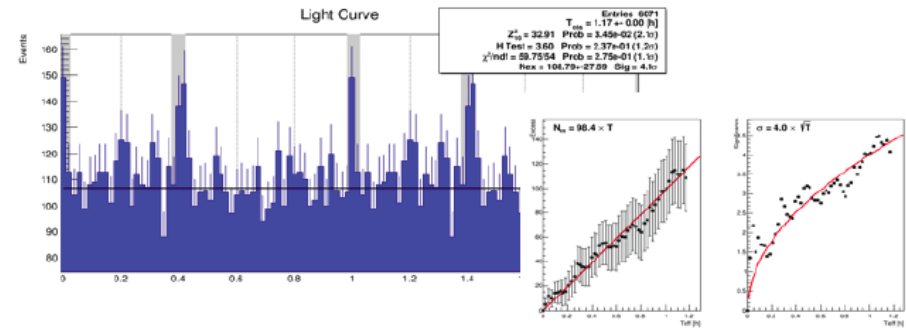
Only 14<sup>th</sup> October



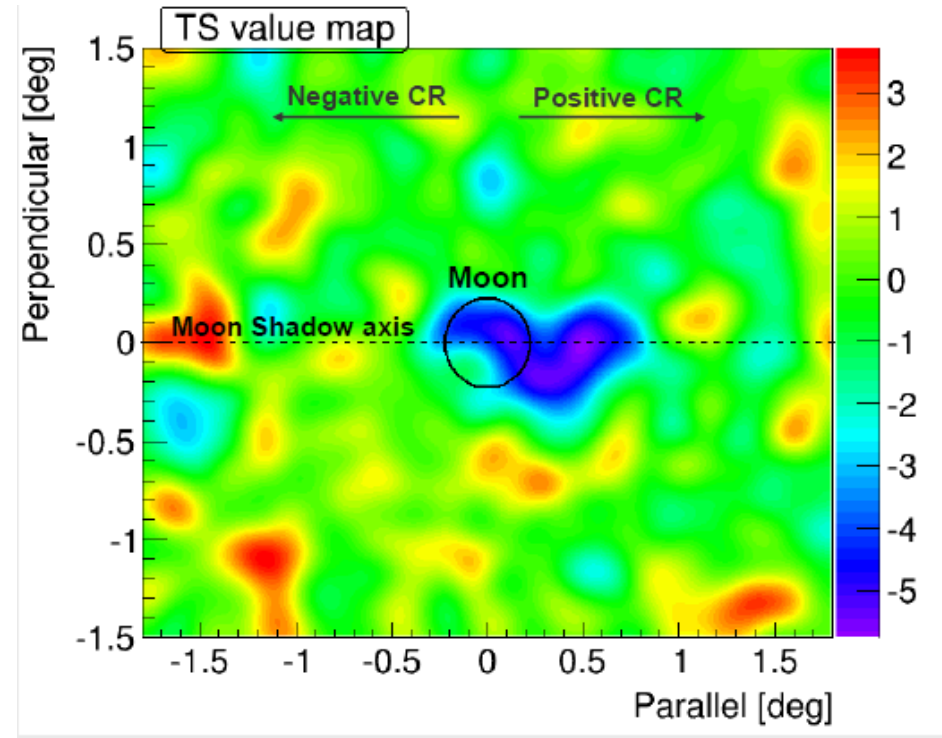
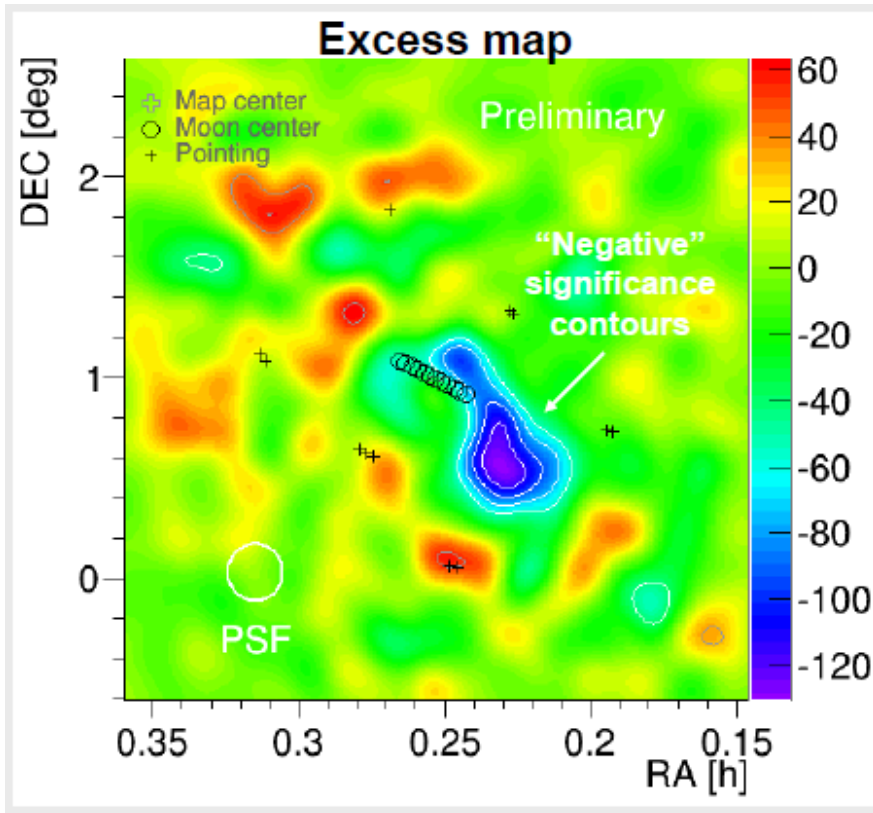
Tailored ST MC, standard cleaning  
1.2h  $\rightarrow$  4.1 sigma

Timing analysis: A closer look to 2015\_10\_14

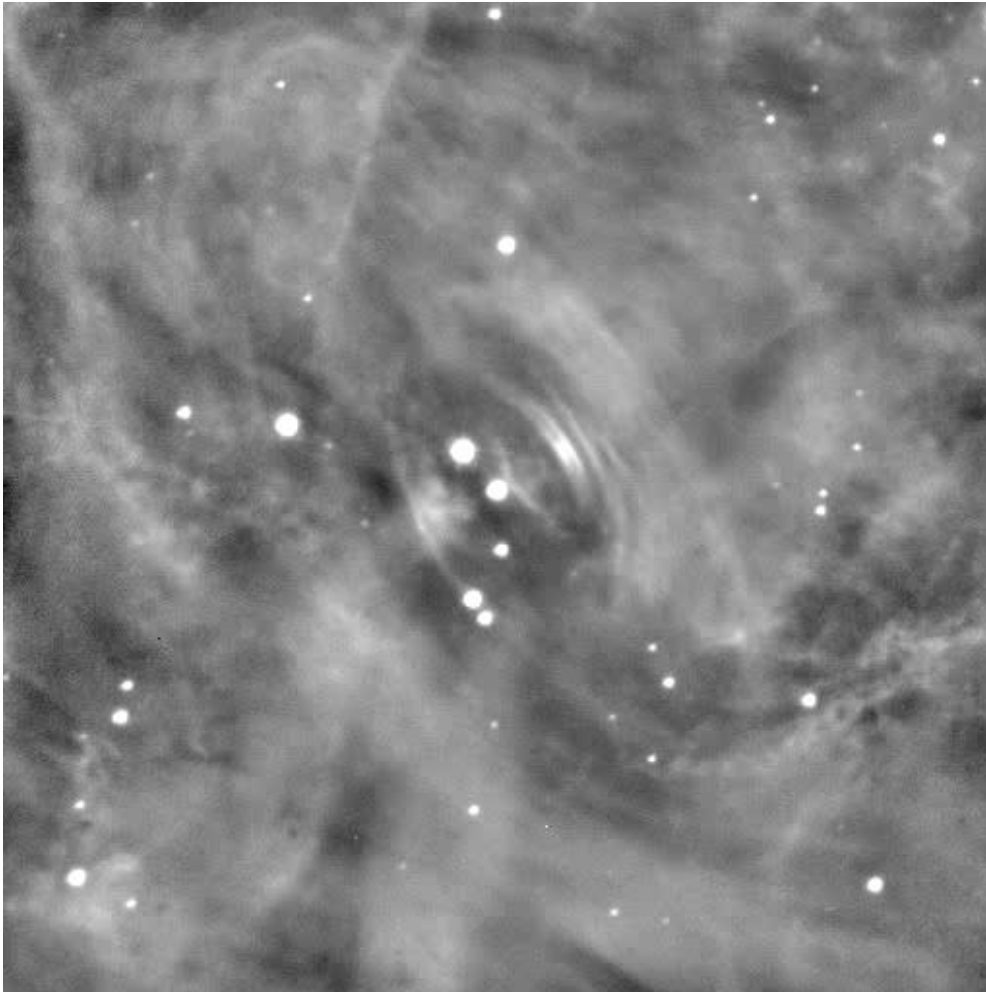
- Using SumT MC's and  $Z_d < 11^\circ$  to match available MC's (cut away half of the night)
- 4.1 sigma in 1.2 hour
- ~100 pulsed photons / h (to be compared with 41 ph. / h obtained in 2014)
- $\rightarrow$  The strongest pulsed signal ever get with MAGIC



# Sept. 28<sup>th</sup> observations during Lunar eclipse



# 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*

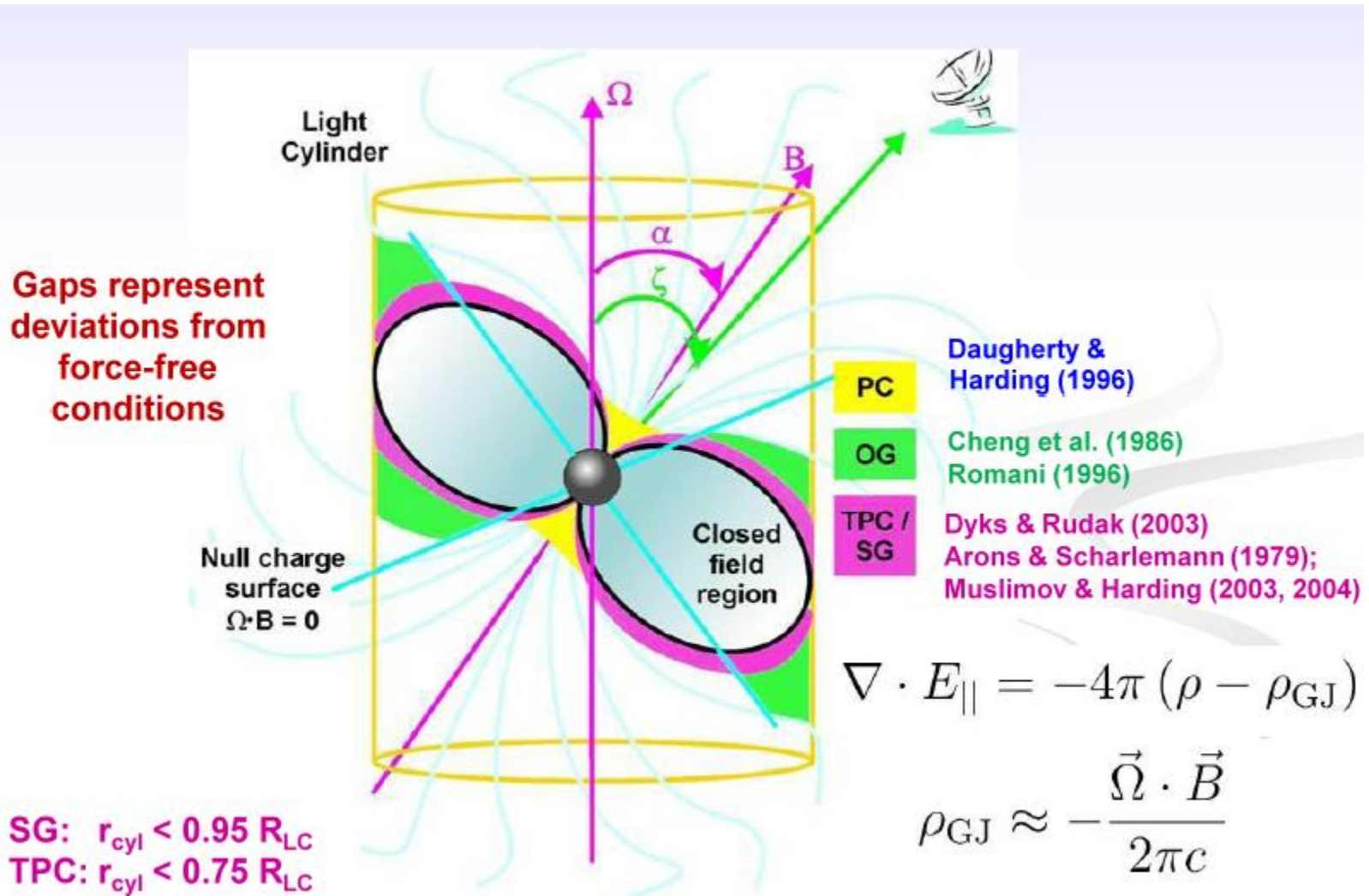
**Aleksic et al (MAGIC collab.),  
ApJ, 742 (2011) 43,**  
*First spectrum 25-100GeV*

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

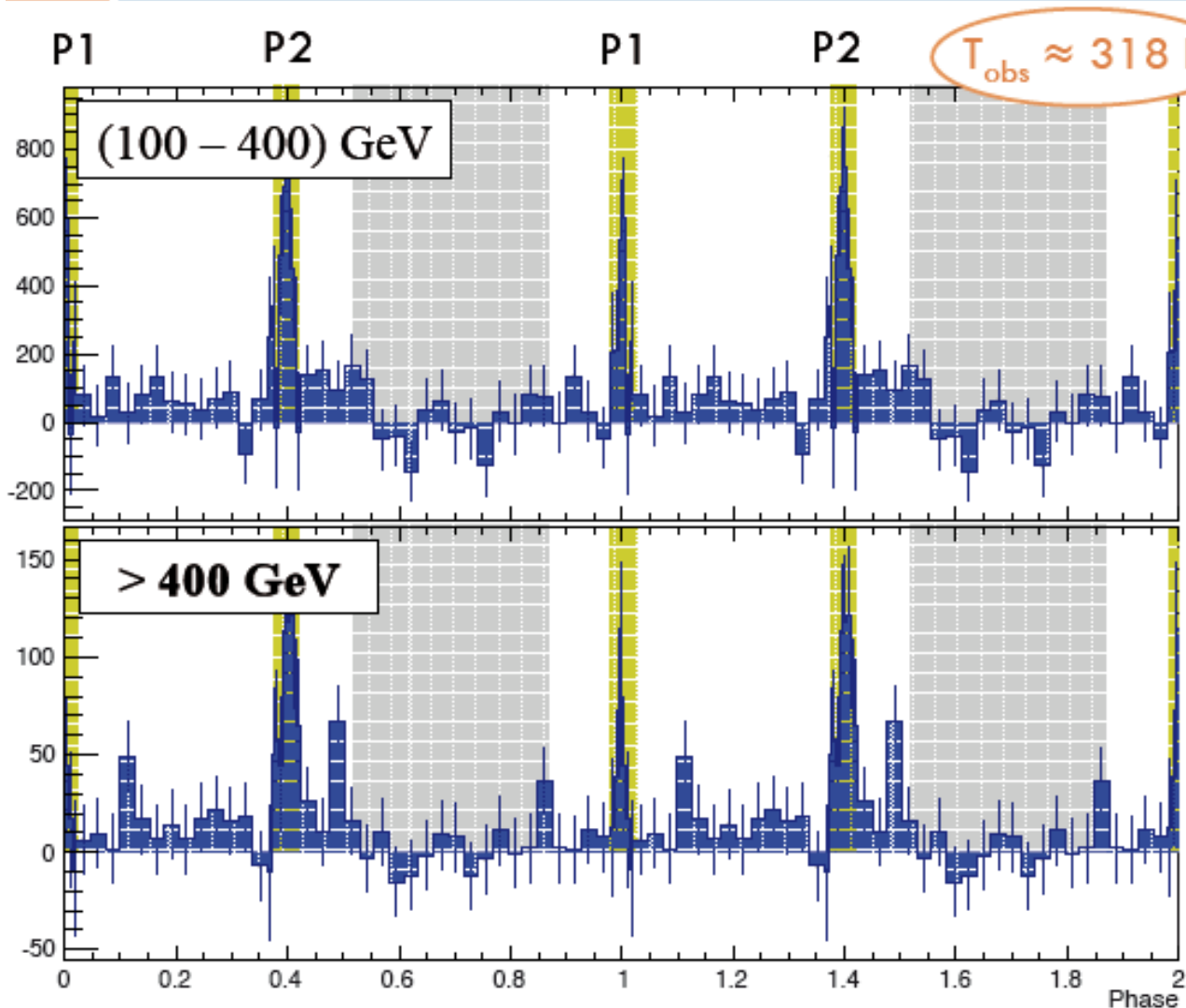
**Aleksic et al (MAGIC collab.),  
A&A, 565, L12 (2014)**  
*Detection of Bridge Emission  
 $\geq 50$  GeV from the Crab pulsar*



# Cartoon of a pulsar



# Pulsed emission measured for $E \geq 400$ GeV

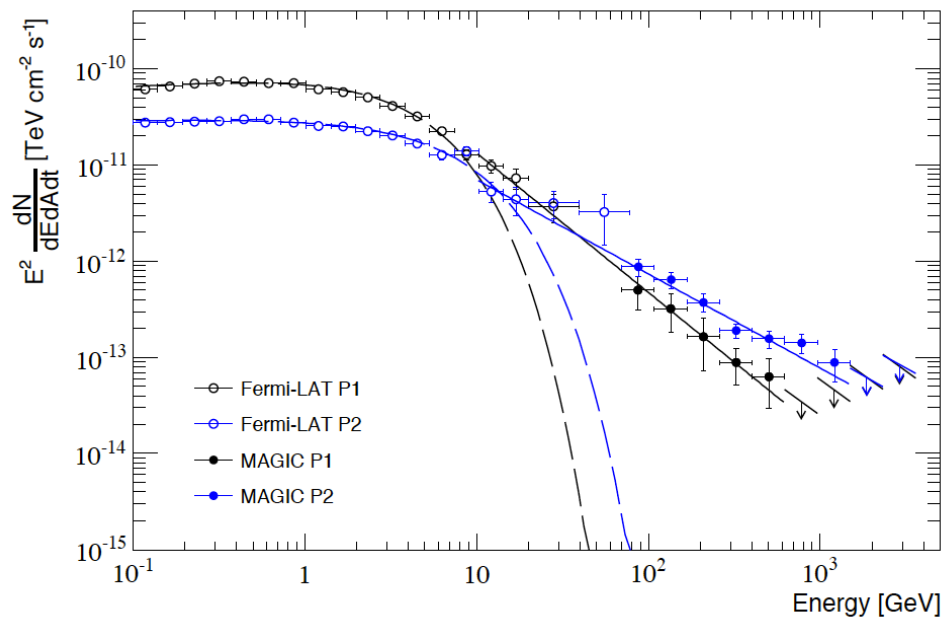


- Below 400 GeV:  
very large background  
due to mono and  
high zenith data

- **Above 400 GeV:**  
**Detection of pulsed  
emission!**

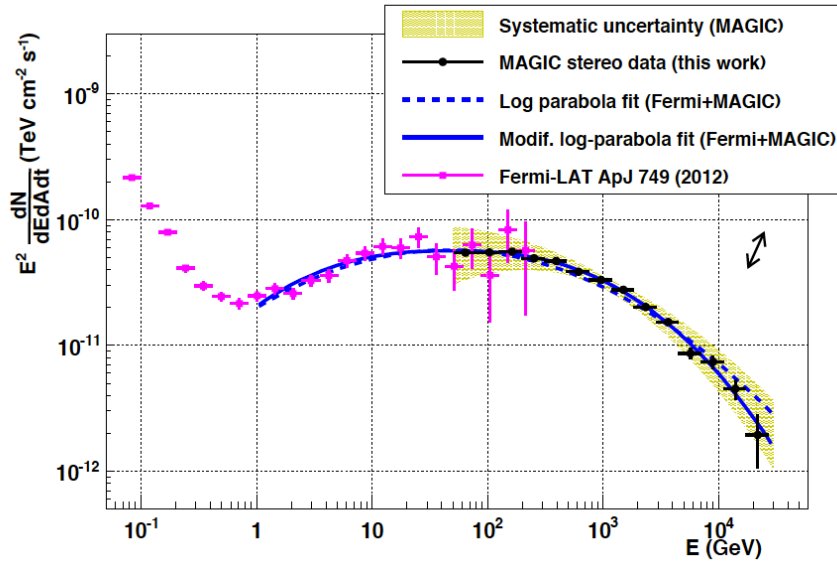
- Significances:  
P1:  $2.2 \sigma$  | P2:  $6.0 \sigma$

# MAGIC established the Crab pulsar as the most compact accelerator of TeV $\gamma$ rays



- Discovered pulsed emission from Crab, **spectrum extending  $\geq 1.2$  TeV**
- Challenging the emission models
- MAGIC-Fermi fit shows IC emission from  $\sim 10$  GeV to  $\geq 1$  TeV
- Emission from the neighborhood of Light Cylinder ( $r \sim 1600$ km)
- TeV pulsation is used to put quadratic limits for Lorentz Invariance Violation (LIV):  
EQG2  $> 4.4 \times 10^{10}$  GeV: this is only factor 3 below current best limit from Fermi

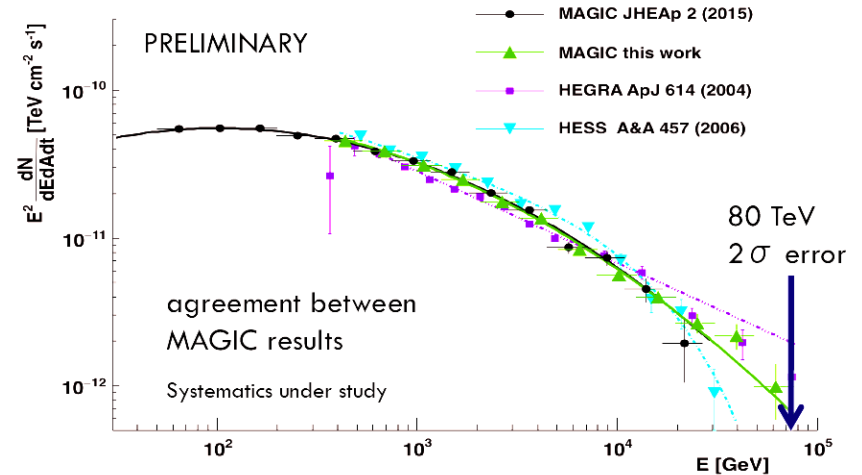
# MAGIC & Crab Nebula



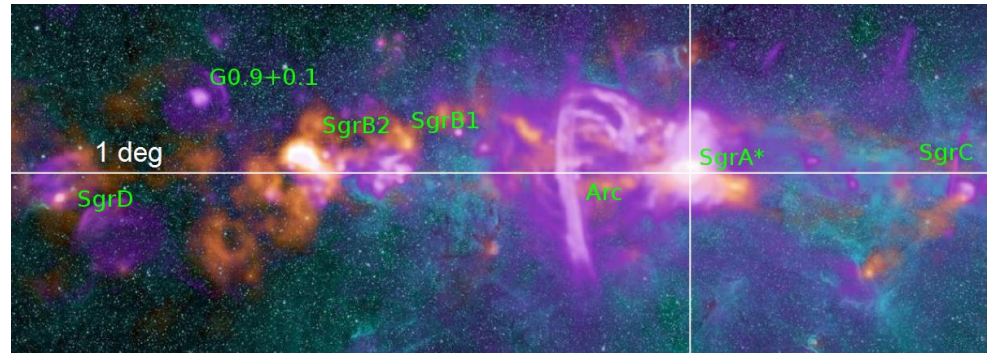
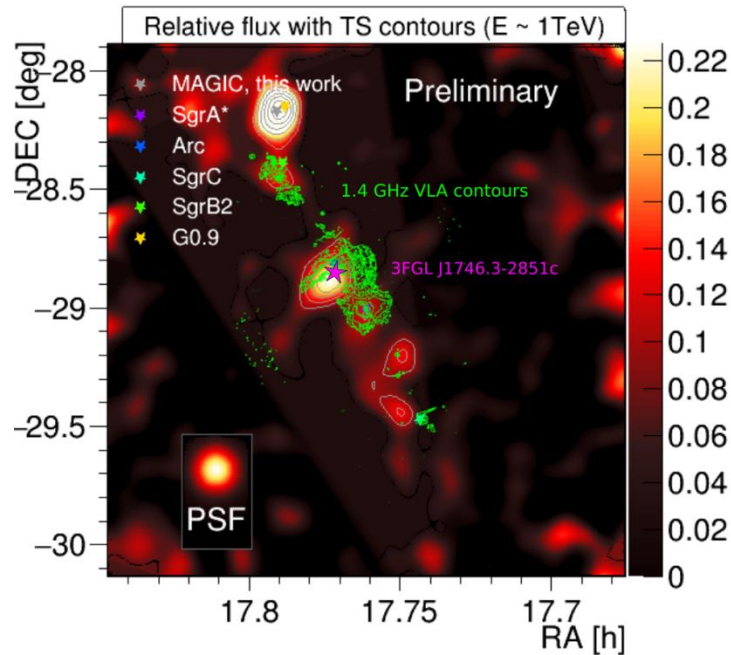
Aleksic et al. (MAGIC) JHEAP, 5, 2015

- Crab Nebula spectrum from 60 GeV till 30 TeV
- Together with Fermi LAT precision definition of the IC peak

Large zenith angle observations  
 $\theta \leq 70^\circ$   
 for exploring the E range  $\sim 80$  TeV



# Discovery of the Arc @ Galactic Center

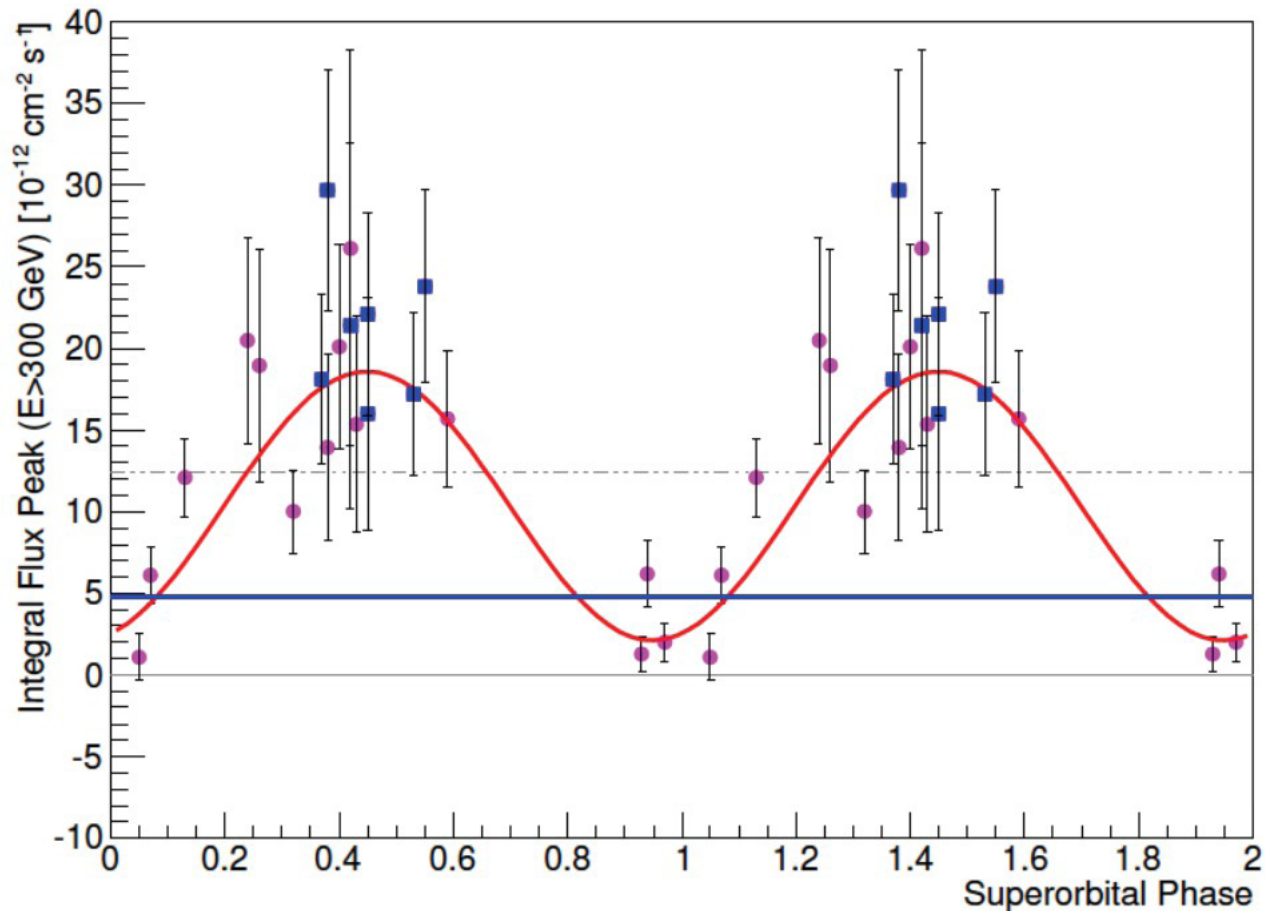


By using the very large zenith angle observation technique:  $\theta_{\text{obs.}} \sim 58^\circ - 70^\circ$ , MAGIC collected very significant statistics at the high energy end

- Good correlation: 90 cm radio image and TeV skymap ( $E \geq 1\text{TeV}$ )
- Detected significant TeV gamma-ray excess apparently coincident with the radio Arc
- MAGIC source is coincident with the Fermi 3FGL J1746.3-2851c

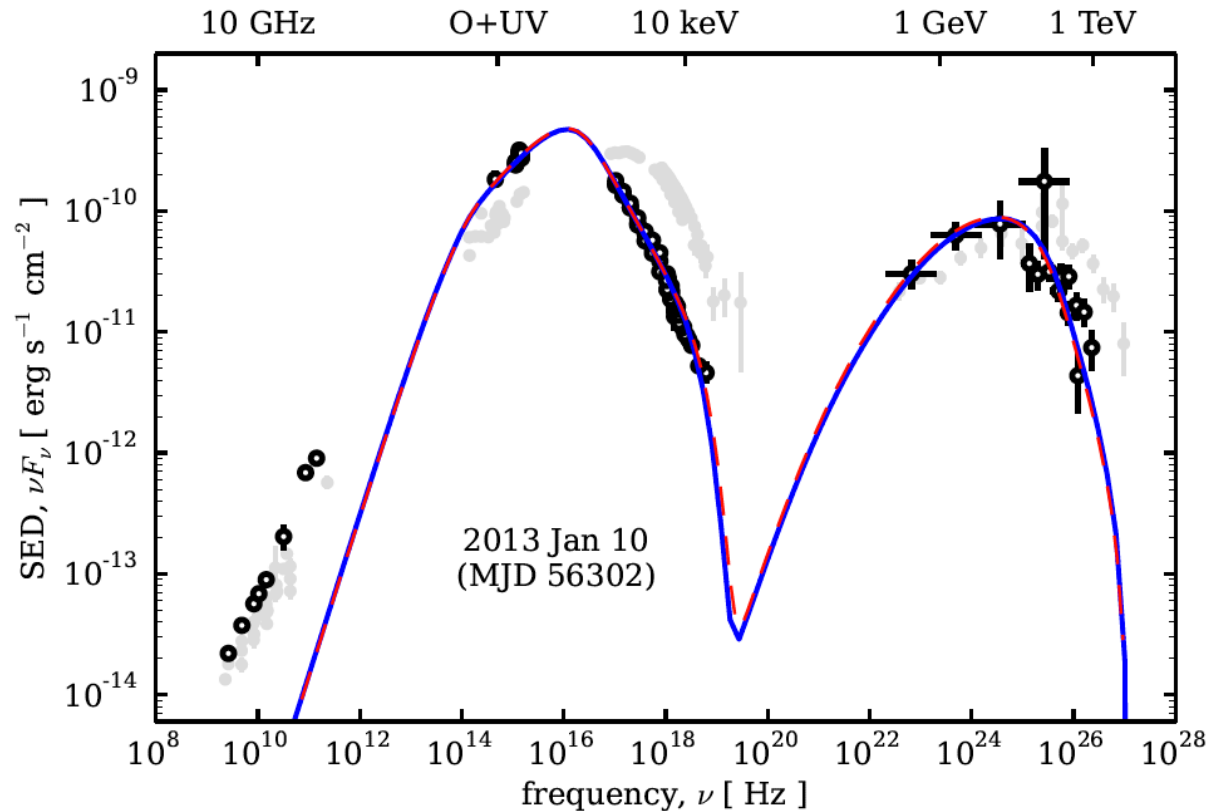
# LSI-61 +303

VHE data collected over 8 years → yearly variability consistent with the 4.5 years long-term modulation

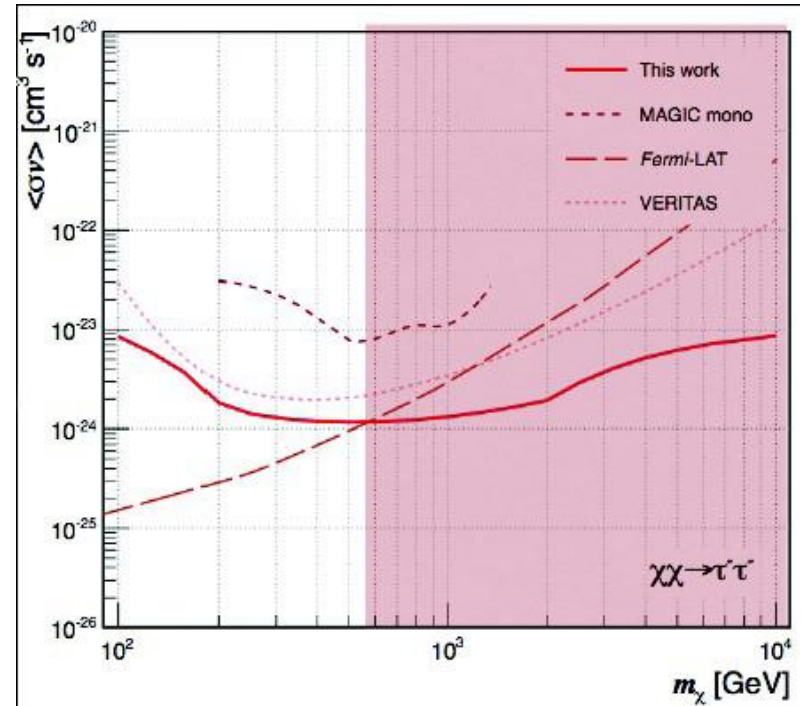
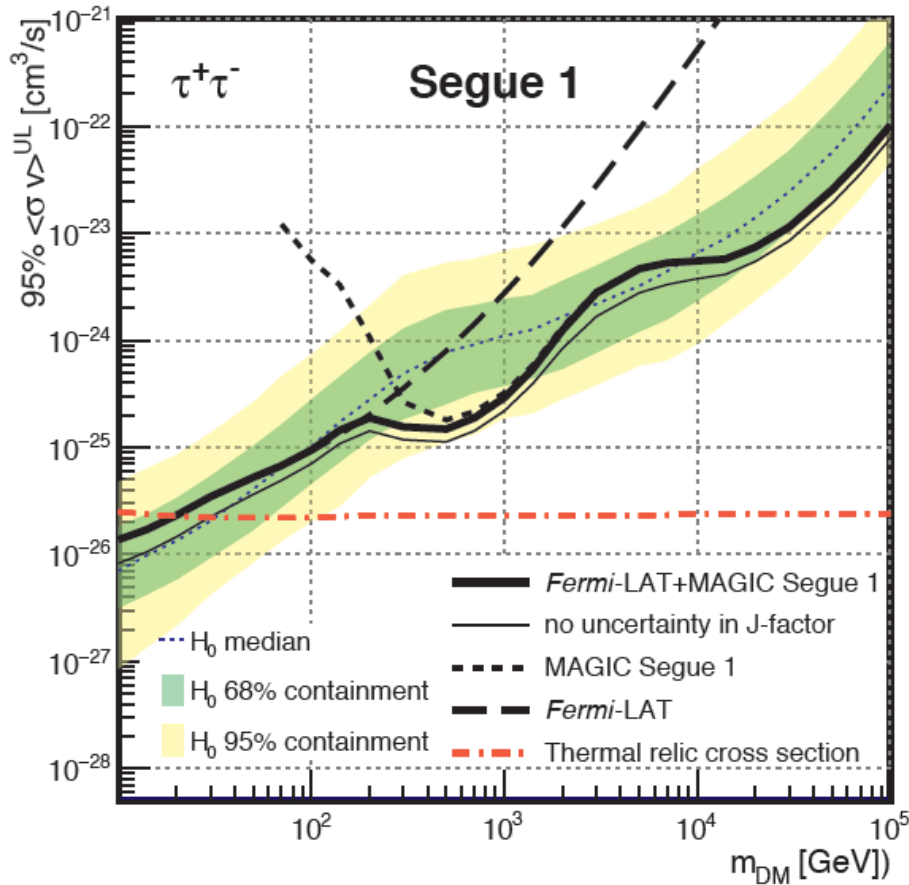


# MWL SED of Mrk-421 in Jan. 2013

- MWL campaign in a low (steady) state
- shift of Synchrotron and IC peaks to lower energies
- A canonical HBL moving to IBL, observed for the first time



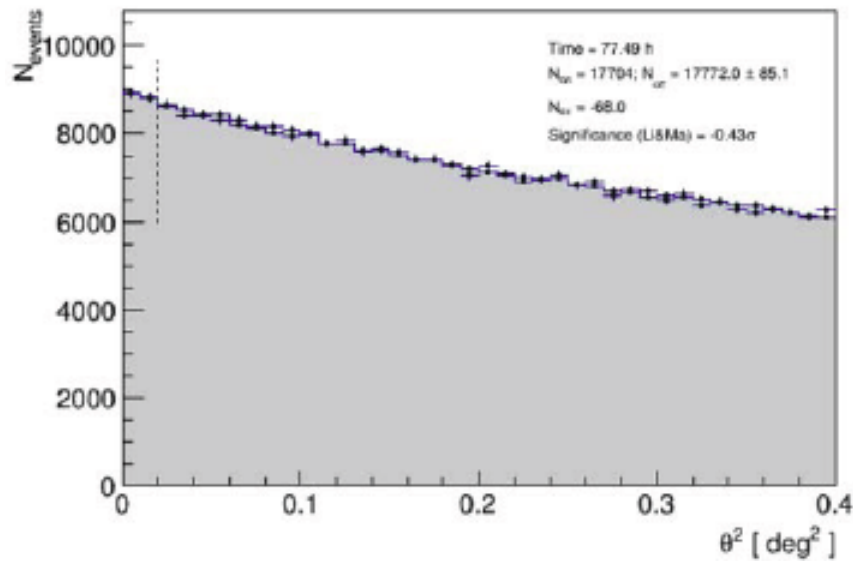
# DM searches with MAGIC



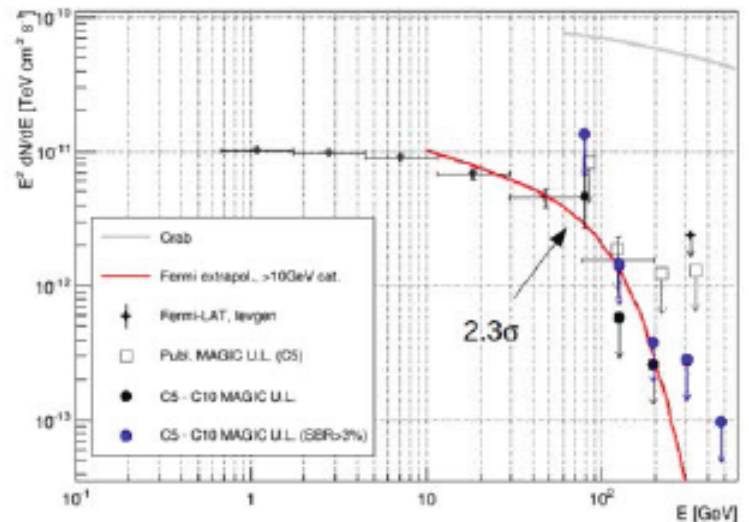


# 4C55.17 at red shift 0.9

● 78h, no signal whatsoever



● used extra min 3% of background for 95% UL: too conservative?



# Flat Spectrum Radio Quasars

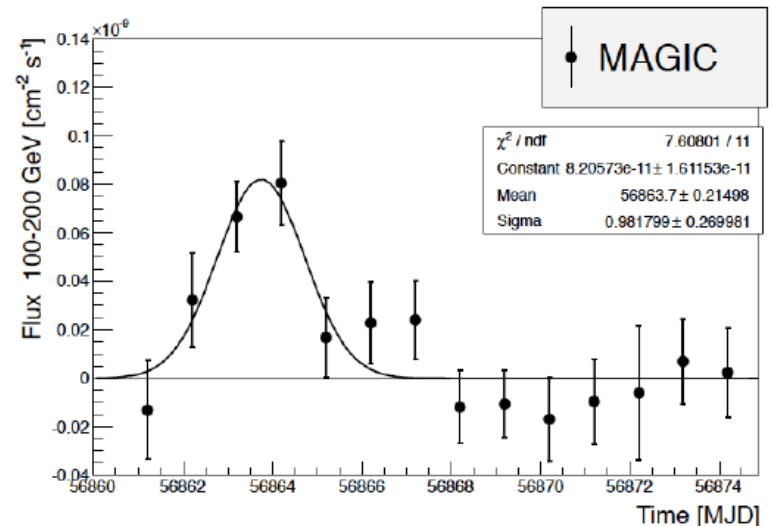
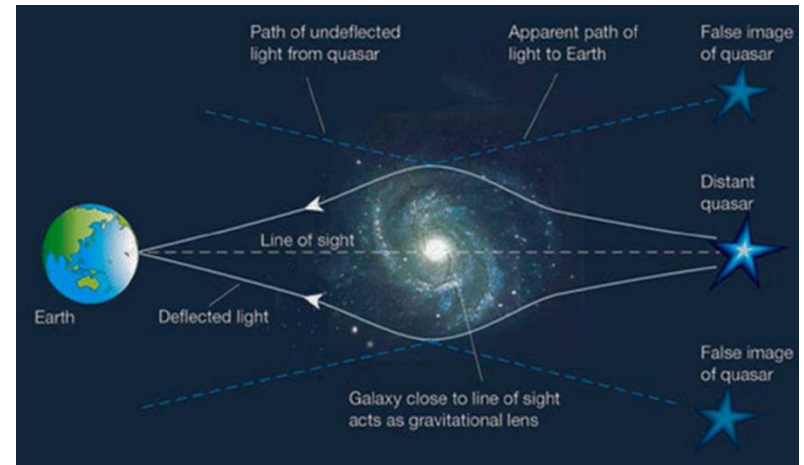
- The most luminous sources:  $\gamma$ -ray emitting AGN class
  - the VLBA jets with high Doppler factors, “knots” in the jet
  - optical spectrum shows broad emission lines
  - SED: low synchrotron peak frequencies (infrared)

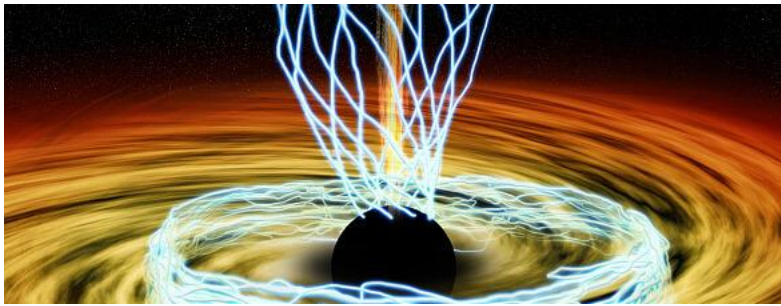
## **In VHE (>100GeV) gamma-rays 7(?) known, 6-MAGIC:**

- 3C279 (MAGIC in Feb 2006 and Jan 2007, single night detections, MAGIC in Feb 2014 detection of weak signal)
- PKS1510-089 (H.E.S.S. in March-Apr 2009, MAGIC in Feb-Apr 2012, March-June 2013 no VHE variability)
- PKS1222+216 (MAGIC single night in June 2010, VERITAS and MAGIC several nights in Feb 2014)
- PKS1441+25 and B0218+357 the newbies
- S4 0954+65 and BL Lac disputed classifications

# Discovery of Gravitationally Lensed Blazar S3 0218+357 residing at the red shift 0.944

- In 2012 Fermi observed high state, with many overlapping flares
- Fermi claimed  $11.46 \pm 0.16$  days delay for the lensed component
- On July 13/14 2014 Fermi again observed a high state
- Magic started observing 2 days before the predicted delayed signal and kept on-going till 5th of August





# Discovery of FSRQ PKS-1441 +25

- Along with S3 0218 +357,  $z = 0.944$ , this is the most distant VHE source:  **$z = 0.939$**
- Started observing on April 17<sup>th</sup> after alert from Fermi, for 10 days

[ Previous | Next | ADS ]

## Discovery of Very High Energy Gamma-Ray Emission from the distant FSRQ PKS 1441+25 with the MAGIC telescopes

ATel #7416; *R. Mirzoyan (Max-Planck-Institute for Physics) on 20 Apr 2015; 02:09 UT*  
 Credential Certification: Masahiro Teshima (*mteshima@mppmu.mpg.de*)

Subjects: Gamma Ray, TeV, VHE, AGN, Blazar

Referred to by ATel #: 7417, 7433, 7459

[Tweet](#) 9 [Recommend](#) 22

The MAGIC collaboration reports the discovery of very high energy (VHE;  $E > 100$  GeV) gamma-ray emission from the FSRQ PKS 1441+25 (RA=14h43m56.9s DEC=+25d01m44s), located at redshift  $z=0.939$  (Shaw et al. 2012, ApJ, 748, 49). The object was observed with the MAGIC telescopes for ~2 hours during the night 2015 April 17/18, and for ~4 hours during 18/19. A preliminary analysis of the data yields a detection with a statistical significance of more than 6 standard deviations for the night of April 17/18, and more than 11 standard deviations for 18/19. This is the first time a significant signal at VHE gamma rays has been seen from PKS 1441+25. The flux above 80 GeV is estimated to be about  $8 \cdot 10^{-11} \text{ cm}^{-2} \text{ s}^{-1}$  (16% of Crab Nebula flux). PKS 1441+25 has entered an exceptionally high state at optical, X-, and Gamma-ray frequencies (ATel #7402), which triggered the MAGIC observations. The Swift Follow-up observation from April 18/19 revealed that the high state in X-rays is continuing: <http://www.swift.psu.edu/monitoring/source.php?source=PKS1441+25> MAGIC observations on PKS1441+25 will continue during the following nights, and multiwavelength observations are encouraged. The MAGIC contact persons for these observations are R. Mirzoyan ([Razmik.Mirzoyan@mpp.mpg.de](mailto:Razmik.Mirzoyan@mpp.mpg.de)) and E. Lindfors ([elilin@utu.fi](mailto:elilin@utu.fi)). MAGIC is a system of two 17m-diameter Imaging Atmospheric Cherenkov Telescopes located at the Canary island of La Palma, Spain, and designed to perform gamma-ray astronomy in the energy range from 50 GeV to greater than 50 TeV.

**Related**

7459 A Giant NIR flare of the FROGS PKS1441+25

7433 Very-high-energy gamma-ray emission from PKS 1441+25 detected with VERITAS

7429 ASAS-SN Detection of an Optical Brightening in FSRQ PKS 1441+25

7417 High Optical Polarization Detected in PKS 1441+25

7416 Discovery of Very High Energy Gamma-Ray Emission from the distant FSRQ PKS 1441+25 with the MAGIC telescopes

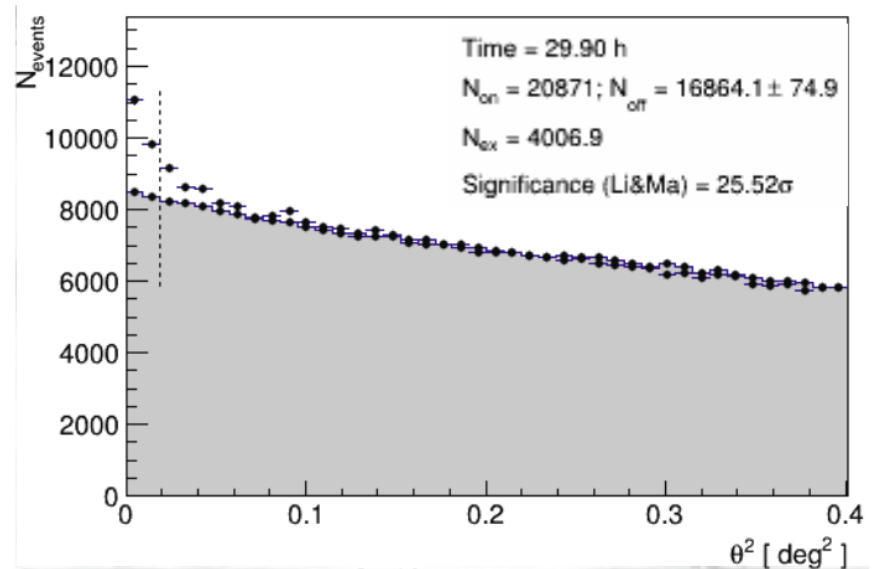
7402 Optical, X-, Gamma-ray flare of the FSRQ PKS 1441+25

6923 Optical Activity of the Flaring Gamma-ray Blazar PKS 1441+25

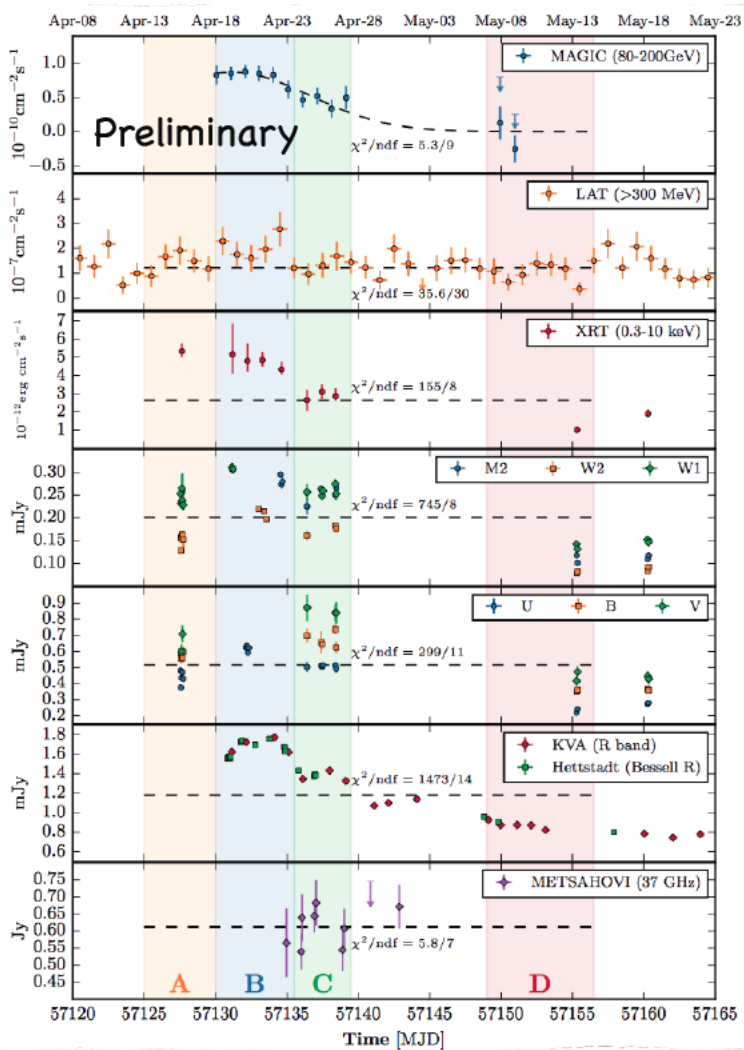
6895 NIR Photometry of the FROGS PKD1441+25

6878 Fermi LAT Detection of a Bright GeV Flare from the FSRQ PKS 1441+25

**25  $\sigma$ , > 4000  $\gamma$  events**  
**Spectrum measured in**  
**40 – 250 GeV energy range**

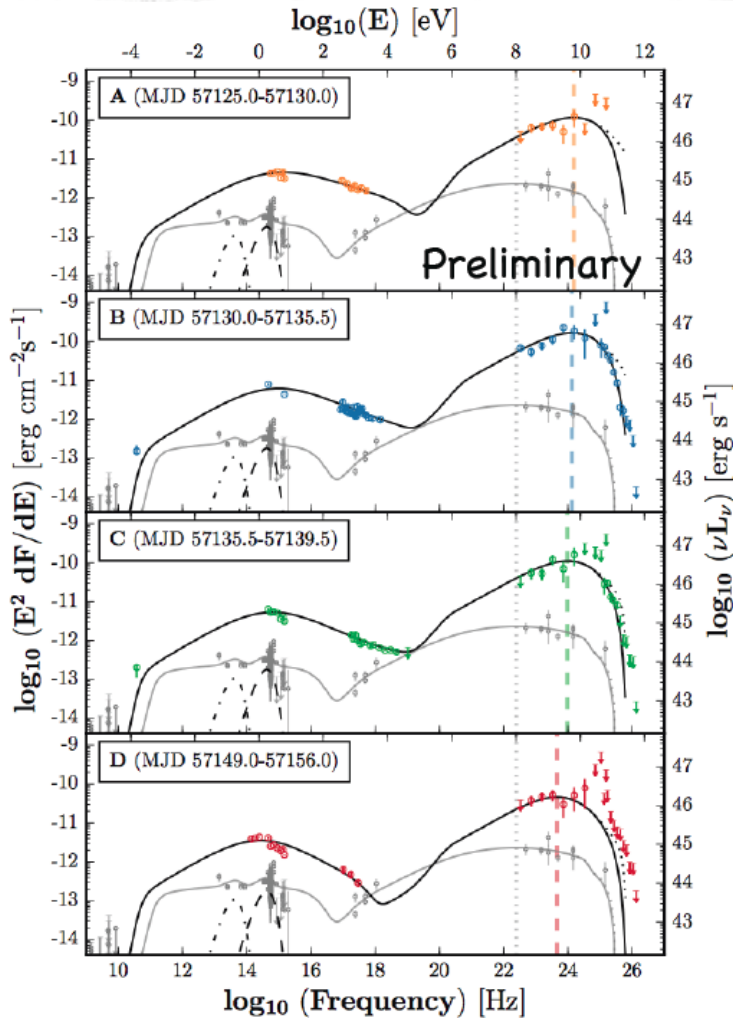


# PKS-1441 +25

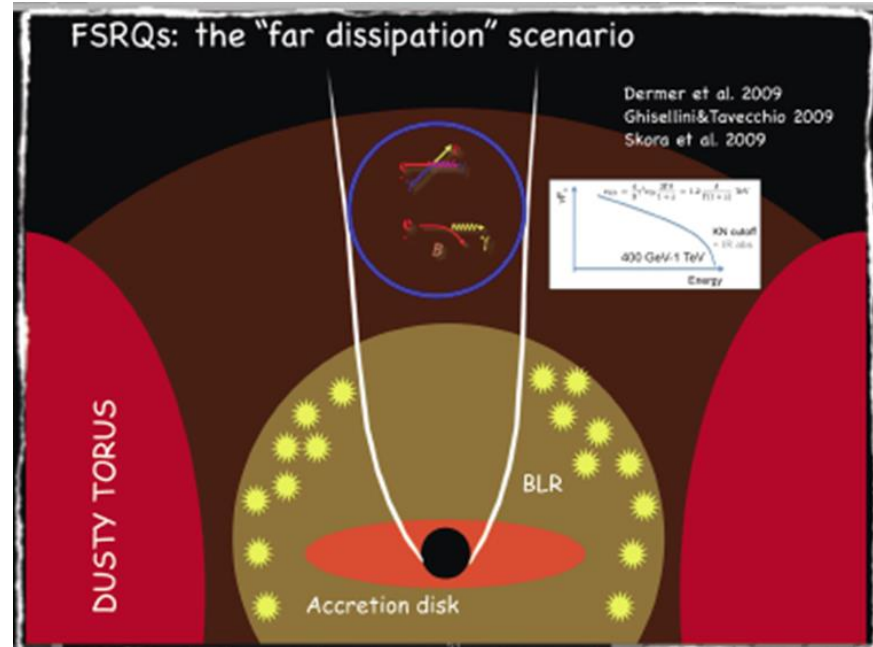


- Two flux states can be distinguished during the flare
- Flux halving time is  $\sim 6$  days
- No signal after the moon-break period

# SED PKS-1441 +25

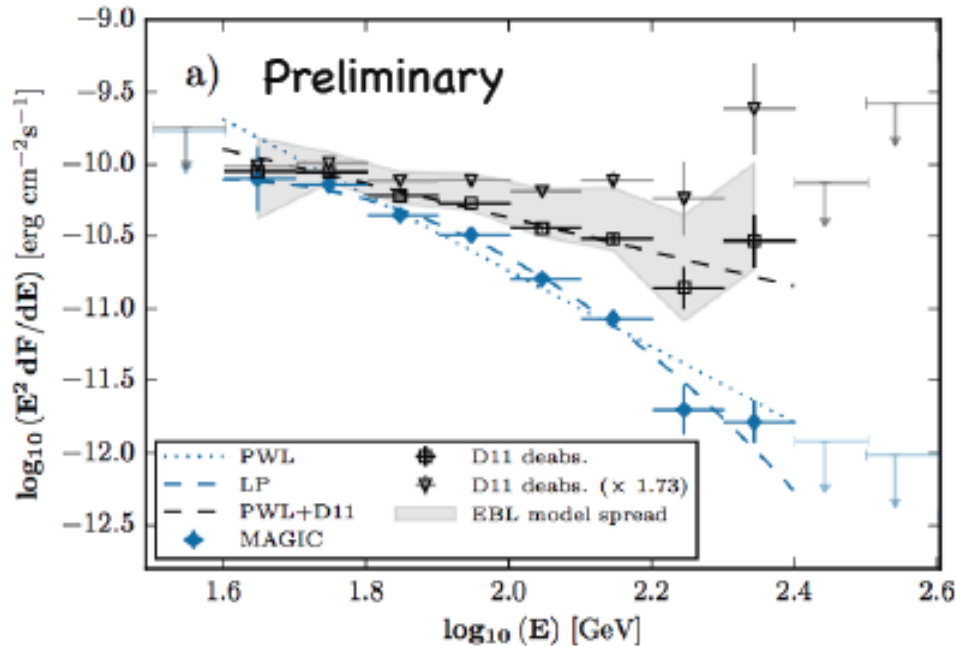


Lack of absorption features in the measured HE - VHE  $\gamma$ -ray spectra allows one to constrain the location of emitting region to be far from the center



External Compton scenario

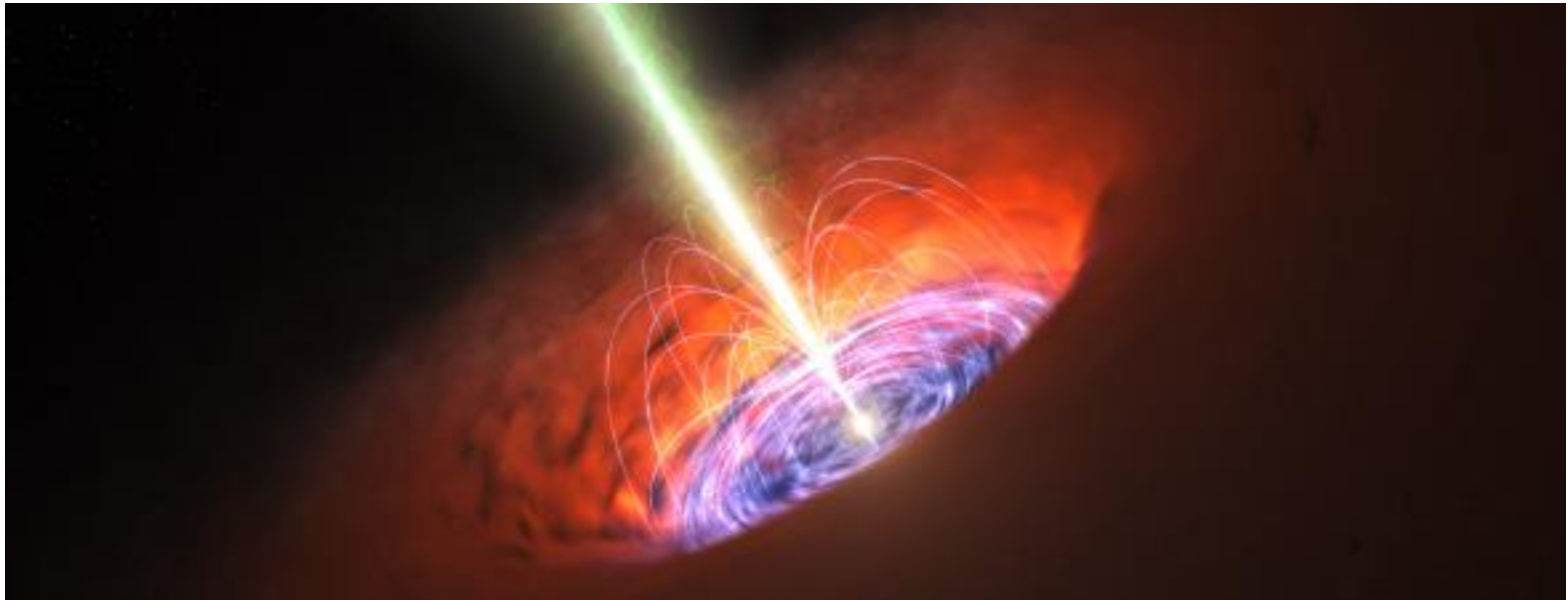
# Probing the EBL models with PKS-1441 +25



- In the 1<sup>st</sup> time we got the opportunity to check the EBL models till the red shift  $z \sim 1$
- The measured spectrum is compatible with current generation of models:  
*Dominguez+11, Franceschini+08, Gilmore+12, Scully+14*



# Joint NASA-MAGIC-VERITAS press-release on PKS-1441 +25 tomorrow, on 15<sup>th</sup> Dec.



FineCut4-NASA-8PM-11-Dec-15.mp4



# Summary-I

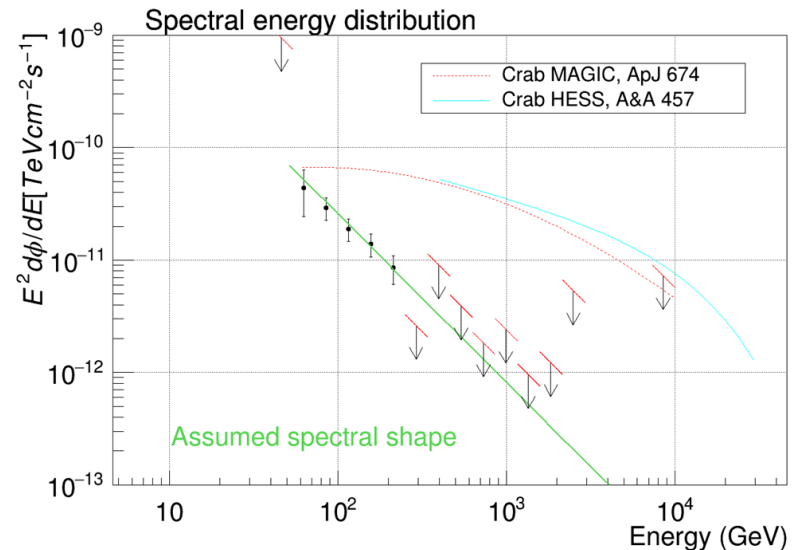
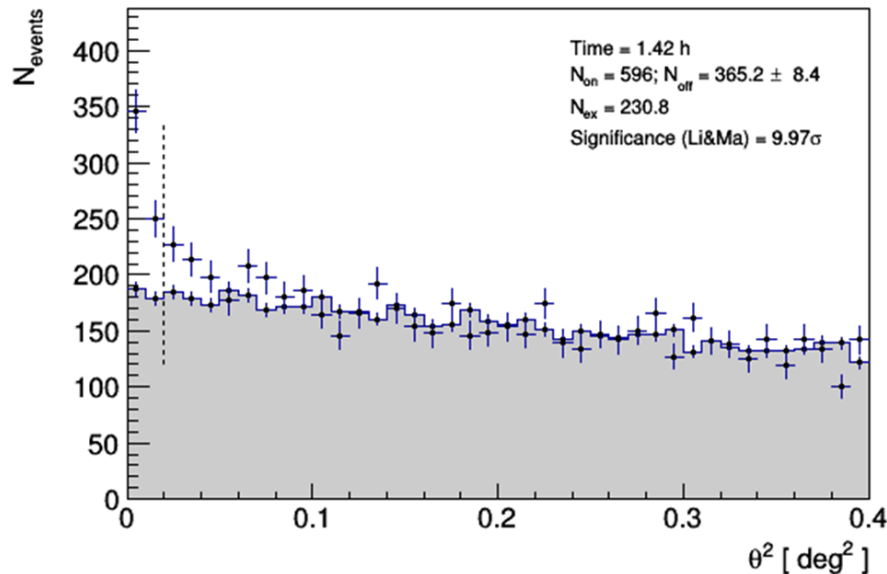
11 years of success story of MAGIC:

- **Discovered 32 new VHE sources (24 AGNs)**
- **Published ~120 peer reviewed papers, 5 in Science**
- **Currently MAGIC is in it's historical most productive phase**
- **Since 2 years operating with the historical best sensitivity**

# Summary-II

- Very strong contribution into the puzzling **pulsar** physics
- **Broad-band** studies of **Crab Nebula** spectrum: 45 GeV – 80 TeV
- Long term behaviour of **binary systems and AGNs**
- **HBL** → **IBL**-like transition for low emission state in **Mrk-421**
- **Ultra fast variability** in **AGNs** (a few minutes time scale)
- Extended **VHE  $\gamma$ -ray reach** in our **Universe** till  **$z \sim 1$**
- **EBL density studies** in the wide range till  **$z \sim 1$**
- **DM searches, best limits** on DM cross-section from dSph

# First detection of VHE gamma rays from the IBL blazar S2 0109+22



E. Prandini estimated the redshift from gamma-ray spectrum using Franceschini EBL model:

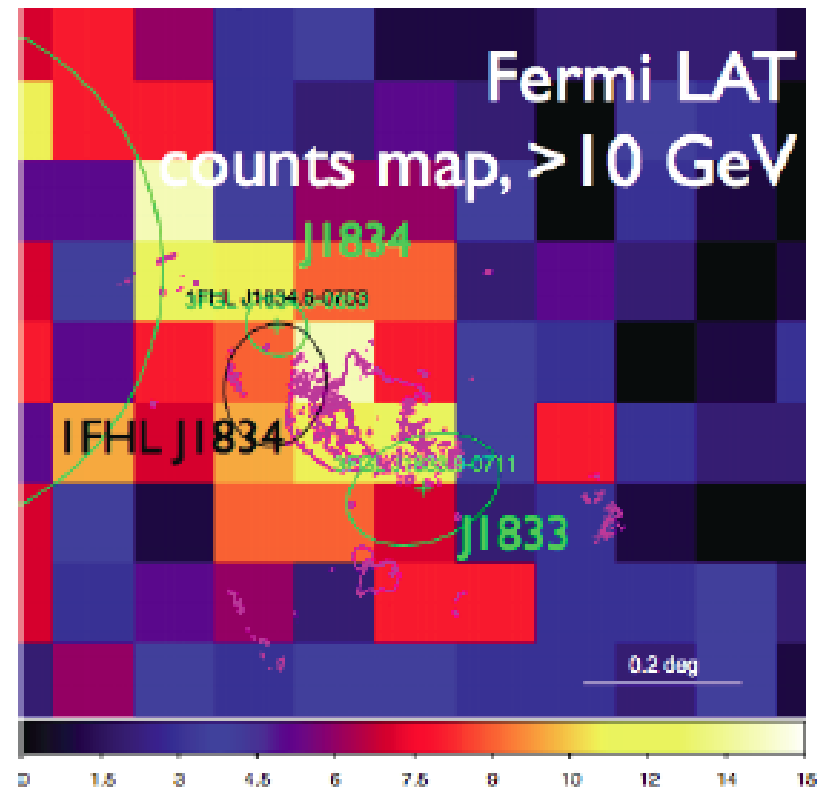
$$z_{\text{est}} = 0.45$$

$$z_{2\sigma\text{U.L.}} = 0.82$$

# SNR G24.7+0.6

- 2 Nearby 3FGL sources
- Crowded field: high confusion!
- Data taken during dark times (DC < 2  $\mu$ A) were used
- $\sim 27$  (Cycle 9) +  $\sim 7$  (Cycle 10) hours after quality cuts
- First observations revealed more than  $\sim 6$  sigma in MAGIC data at low energy
- Not centred on the position of G24: Problem with trials! (nbins on the skymap)
- 10 h observations unreliable
- Using likelihood code to understand the global emission


Wilhelmi, Zanin, Wu, Galindo, Vovk



# Die Zeit online, 18 Nov. 2015


### Studium

Eltern und Studenten  
Jurastudium  
Semesterstart  
mehr Studium >



#### Ist der Hype um Moocs schon vorbei?

Kostenlose Onlinekurse für Millionen der Universität. Doch die Abbrecher machen ihnen Kurse für Kleingruppen.  
Von Christine Brinck / 9 Kommentare



#### Studienorientierung


### Eine Frage, die sich jede sollte

Welches Studium passt zu mir? Der hilft. Sie erhalten Ihr persönliches dazu passender Studiengänge.


### TSCHERENKOW-STRAHLUNG

## Kann man mit einem Teleskop durch den Ätna blicken?


Eigentlich soll es kosmische Phänomene aufspüren. Doch ein Teleskop in Sizilien könnte auch den Vulkanologen dienstbar sein: Es erlaubt einen Blick ins Innere des Vulkans.  
von Jan Dönges



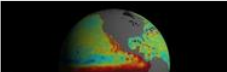
#### Anonymous zieht gegen den IS in den Krieg – was bringt das?



#### Was uns auch im Winter glücklich macht




#### +49 174 276 Nummer an (vielleicht) ü



#### Extremwetter

### Was Sie über den Super-El-Niño 2015 wissen müssen



45

DOWNLOAD ABONNEMENT

### MEISTGELESEN

- 1 P-NP-Problem | Unerwartete Abkürzung hat das Zeug zur Mathematiksensasion
- 2 IT-Revolution | Digitale Demokratie statt Datendiktatur
- 3 Extremwetter | Was Sie über den Super-El-Niño 2015 wissen müssen

### Spektrum.de

Astronomie  
Biologie  
Psychologie

Aktuelles aus der Welt von Wissenschaft und Forschung:  
Spektrum.de >

