MAGIC
Major Atmospheric Gamma Imaging Cerenkov Telescopes

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Recent highlights of the MAGIC telescopes

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for the MAGIC Collaboration

20.05.2019, Astroparticle physics in Poland, Warsaw

Photo credits:
wwwmagic.mppmu.mpg.de

MAGIC telescopes

- Two 17m diameter Imaging Atmospheric Cherenkov Telescopes located in La Palma, Canary Islands at the height of 2200 m.a.s.l.
- Scientific operations (first telescope) since 2004
- Energy range: a few tens of GeV to a few tens of TeV
- Detection of Crab (>100 GeV) in ~70s.
- Angular resolution ~0.1 deg
- Energy resolution ~15%

The MAGIC Collaboration

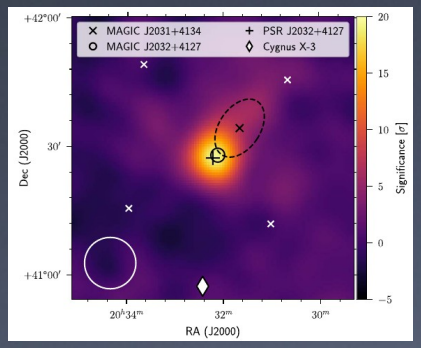
El Roque de los Muchachos Observatory (La Palma, Spain)

The MAGIC Collaboration is composed of ~150 members (~230 in total, including engineers, technicians and other staff) from 12 countries

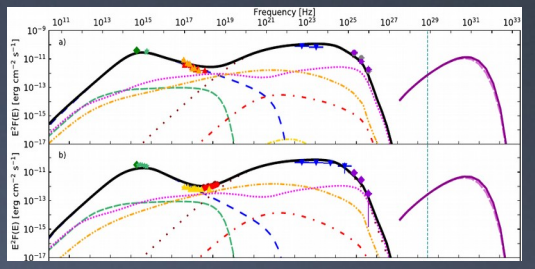
Polish participation in MAGIC

- A group in University of Łódź is a MAGIC Collaboration member since its beginning
- Currently the group consists of:
  - W. Bednarek (member of Time Allocation Committee)
  - P. Gliwny
  - J. Sitarek (Software coordinator, AGN convener)
  - D. Sobczyńska (member of Software Board)

One instrument - many scientific targets



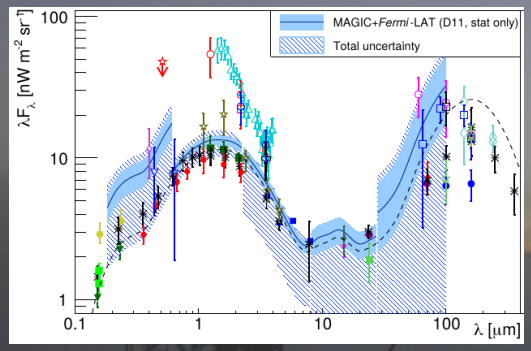
Abeysekara et al. ApJL (2018), 867, L19



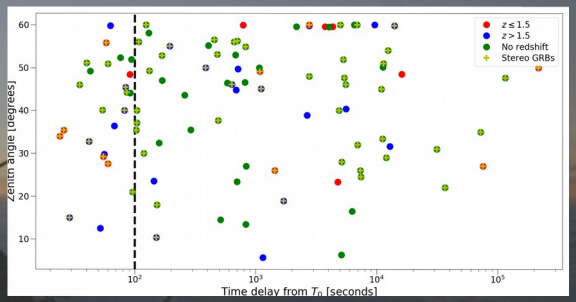
Ansoldi et al., ApJL (2018), 863, L10

Galactic sources:
Pulsars, PWN,
SNR, Binaries

AGNs:
BL Lacs, FSRQs,
Radio galaxies



Acciari et al., MNRAS 2019

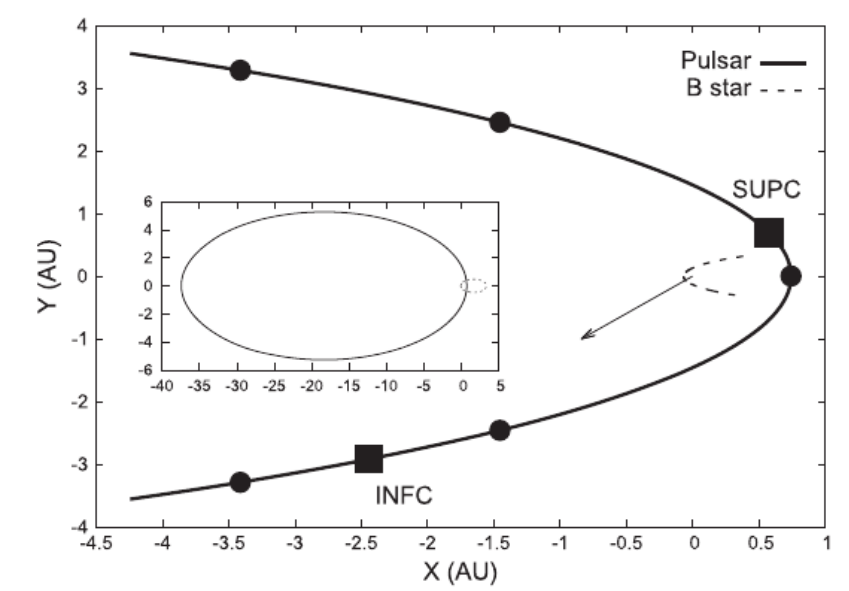


Fundamental physics:
Dark matter, LIV,
EBL, IGMF & cosmology

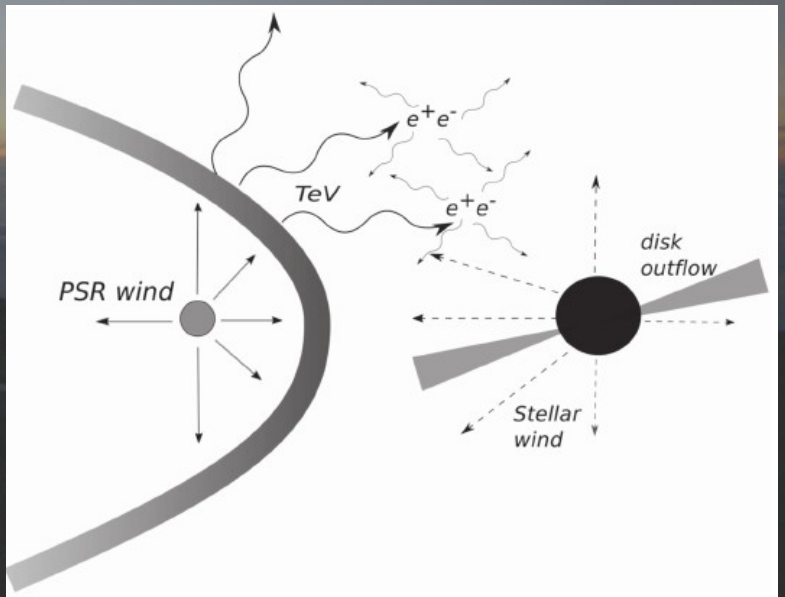
GRBs

PSR J2032+4127/MT91 213 binary - once in a lifetime encounter

- PSR J2032+4127/MT91 213 is a binary system of a pulsar with a Be star.
- The period of the binary is ~50 years with the most recent periastron passage on 13th of Nov 2017
- Close encounter of the pulsar and the star provides unique conditions for acceleration of particles and gamma ray emission
- MAGIC and VERITAS telescopes observed the source during the encounter

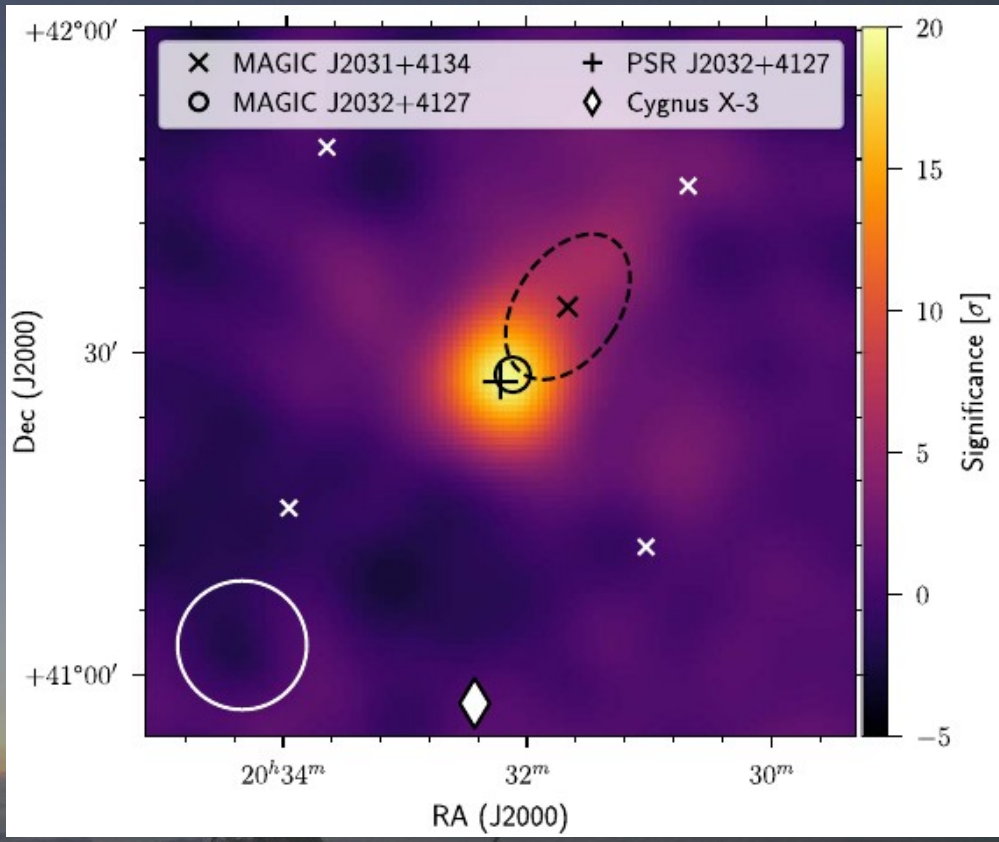


Takata et al. 2017



PSR J2032+4127/MT91 213 vs TeV J2032+4130

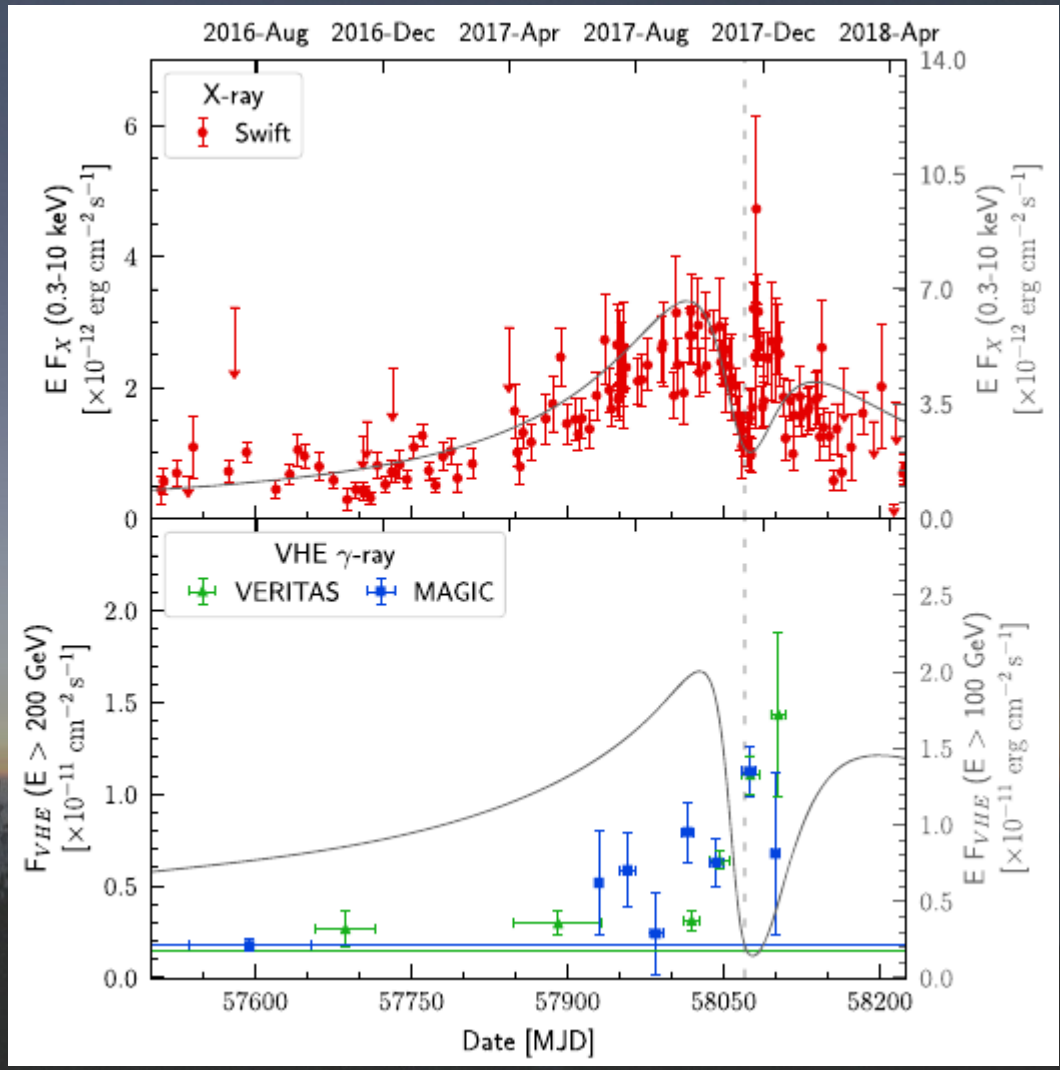
- The binary system lies at the edge of an extended steady gamma ray source TeV J2032+4130 (possibly the nebula of the pulsar)
- One of only a few TeV binaries known, and only a second one with the nature and properties of the compact object firmly established



Abeysekara et al. ApJL (2018), 867, L19

Light curve of gamma ray emission

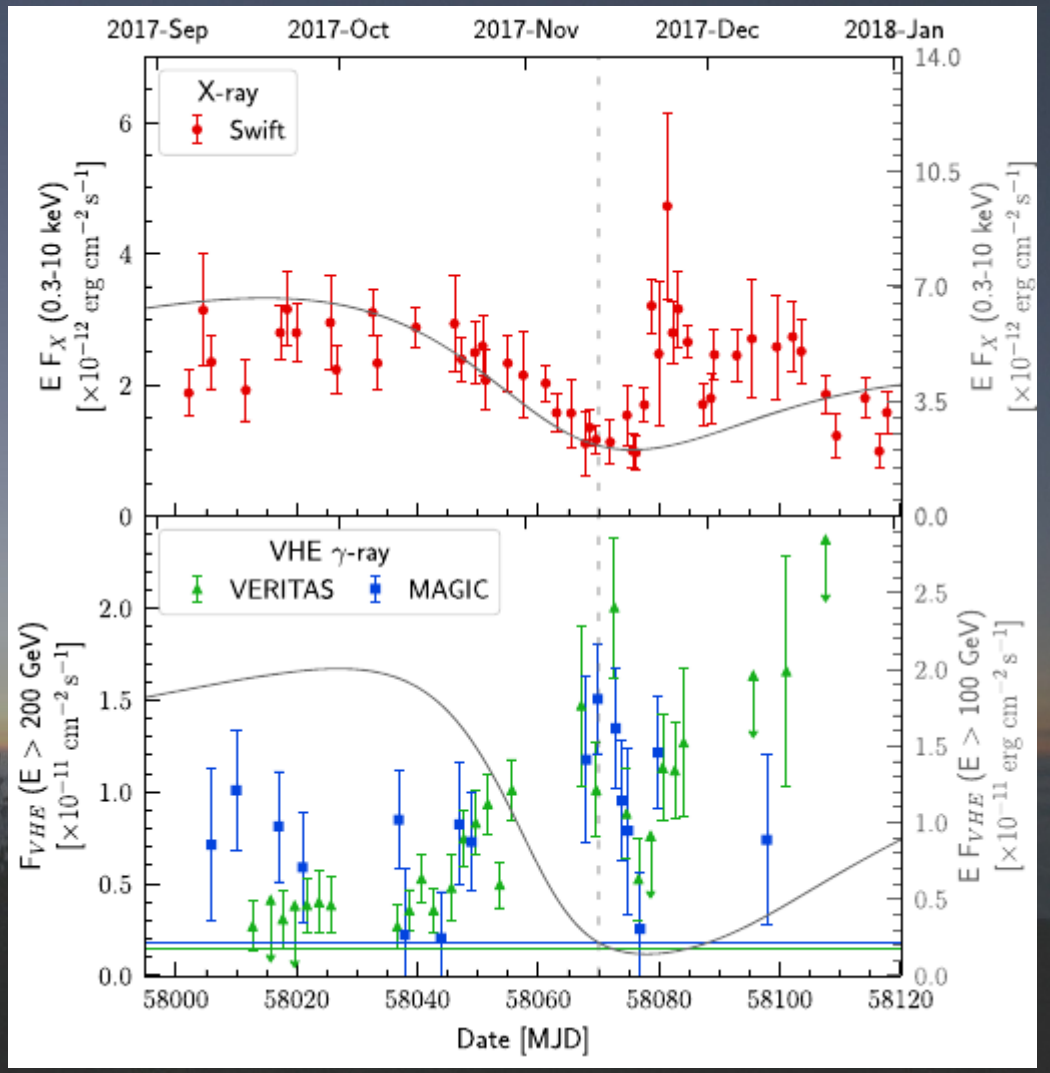
- Strong enhancement of gamma-ray emission during the periastron (variability by an order of magnitude in flux)
- The gamma-ray light curve does not strictly follow the shape of the X-ray one



Abeysekara et al. ApJL (2018), 867, L19

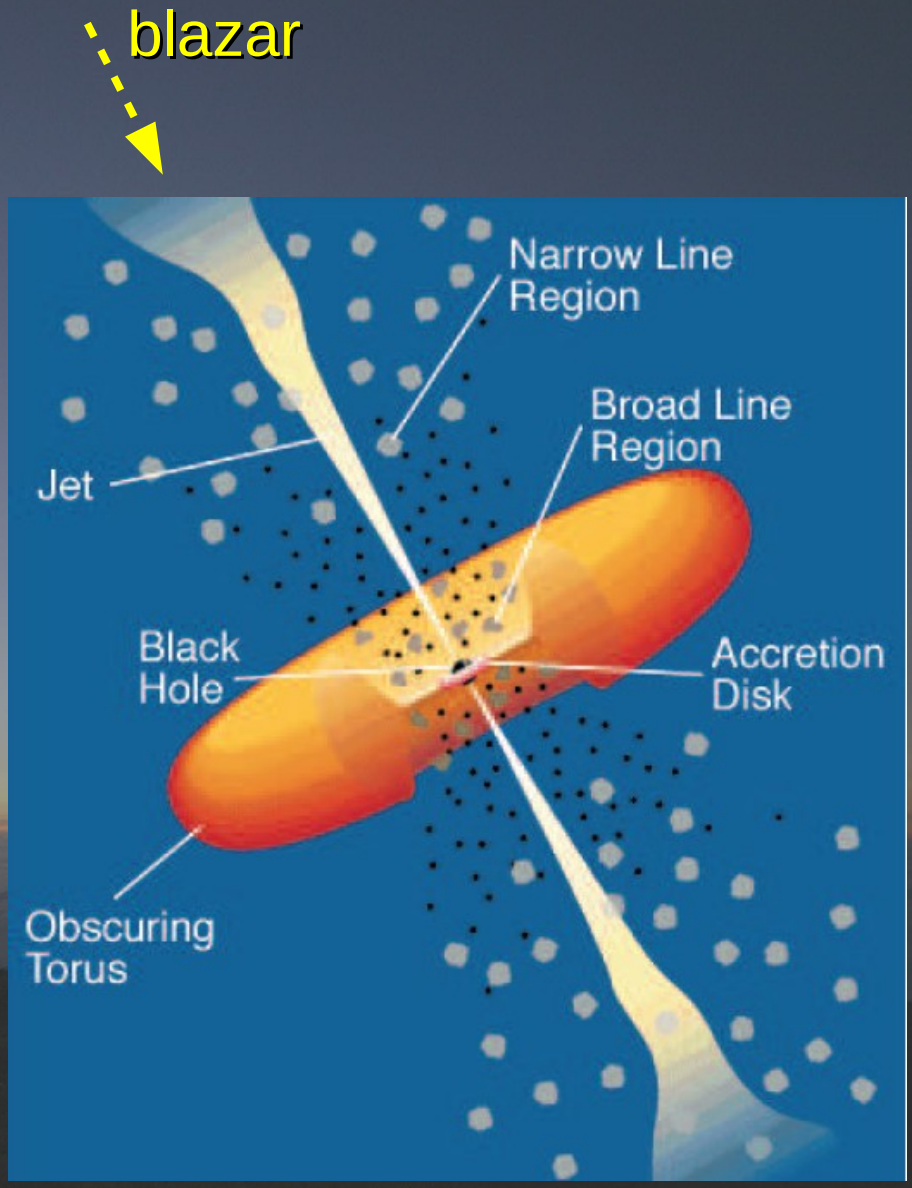
Closer look

- A drop in VHE gamma-ray light curve 7 days after periastron is similar to the dip in PSR B1259-63/LS 2883, which was attributed to photon-photon absorption



Active Galactic Nuclei

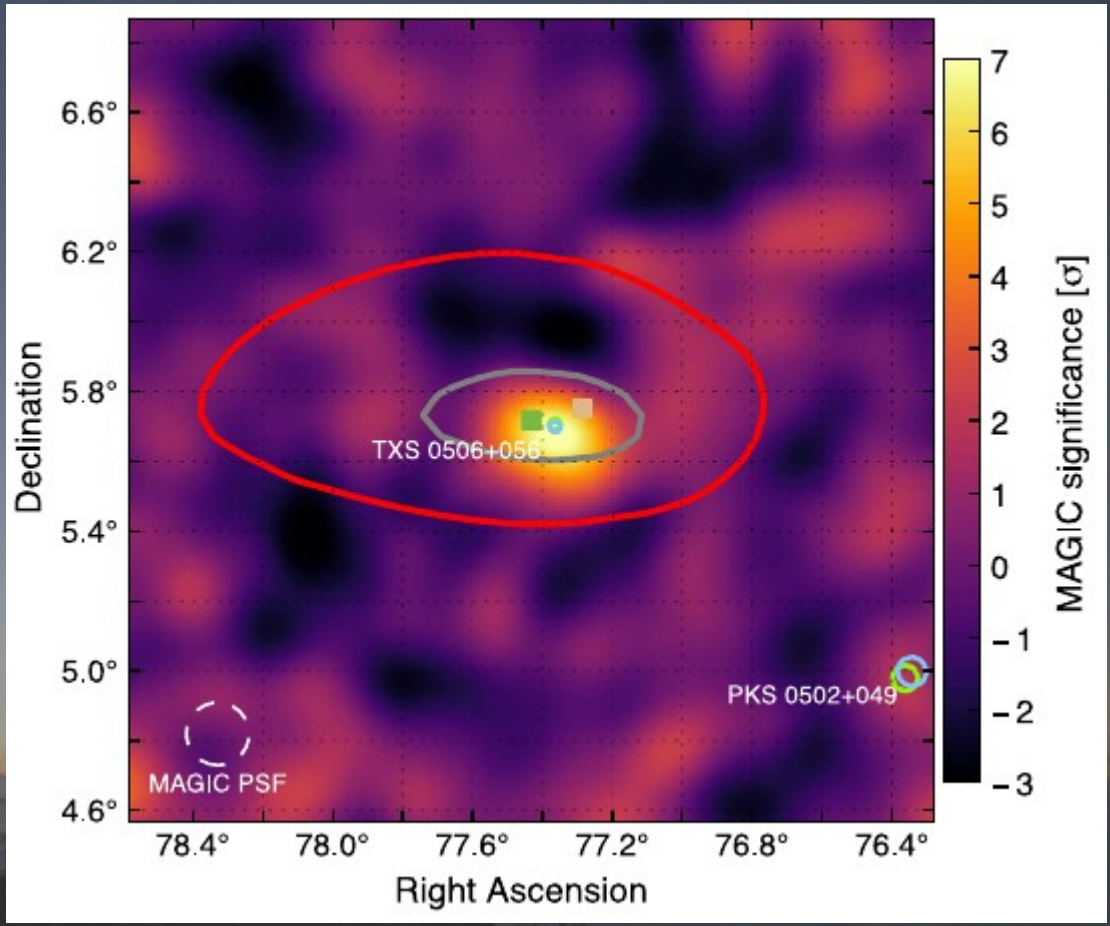
- AGNs are central parts of some galaxies
- Very bright and very variable non-thermal emission from radio up to TeV energies
- AGN seen along the barrel of the jet is called a blazar, characterized by enhanced and strongly variable emission
- Classical model for VHE emission: active regions moving along the jet in which charged particles (leptons and possibly also hadrons) are accelerated in shocks



Weekes 2003

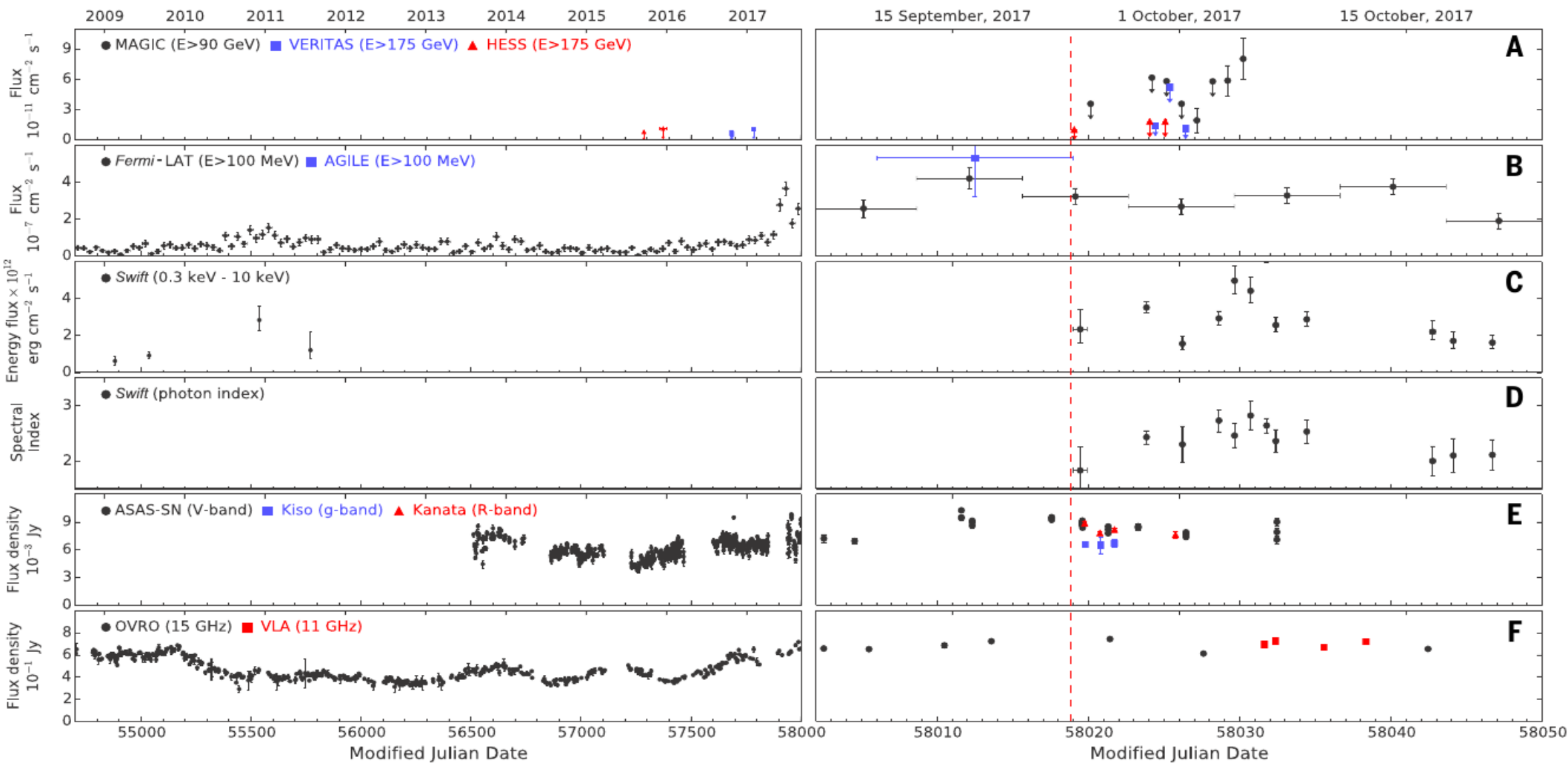
Follow up of IceCube-170922A

- MAGIC has an ongoing follow-up of multiwavelength and multimessanger alerts
- Follow up of IceCube-170922A resulted in the detection of TXS 0506+056 blazar by MAGIC



Aartsen et al., Science (2018), 361, eaat1378

Rich MWL follow up (and historical observations) of TXS 0506+056

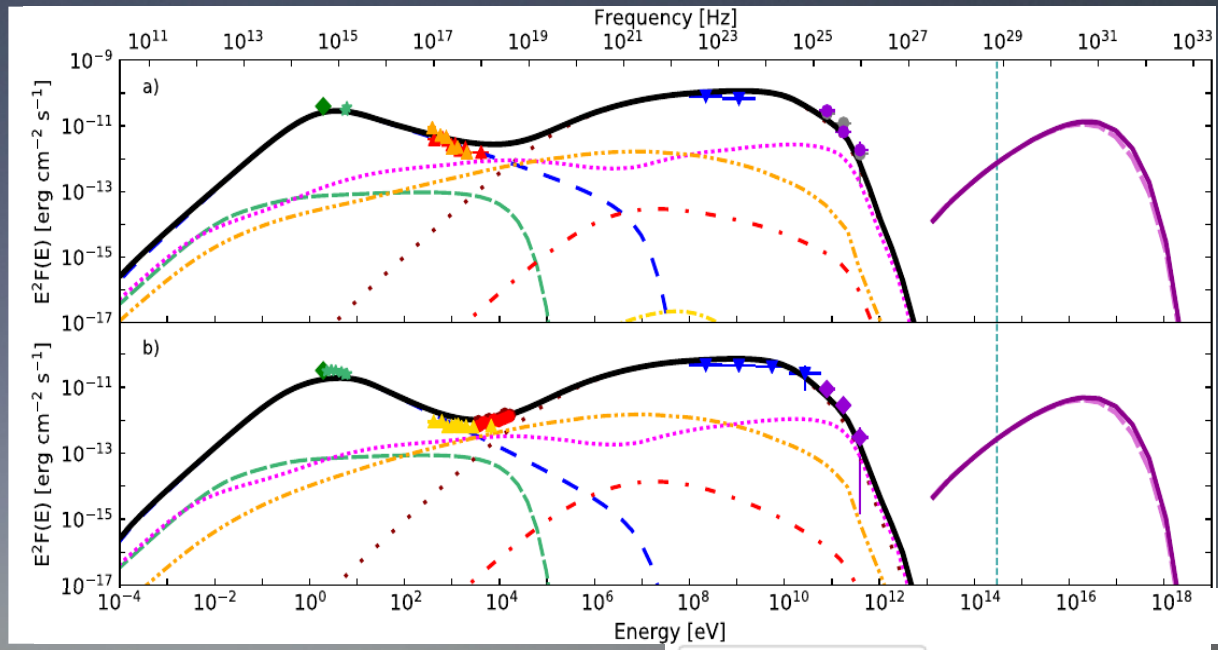


Aartsen et al., Science (2018), 361, eaat1378

- VHE detection during a high HE state
- Chance coincidence of gamma-ray flare with neutrino is disfavoured at 3σ level (including look elsewhere effect of previous alerts) – first such high association probability of a neutrino with a blazar

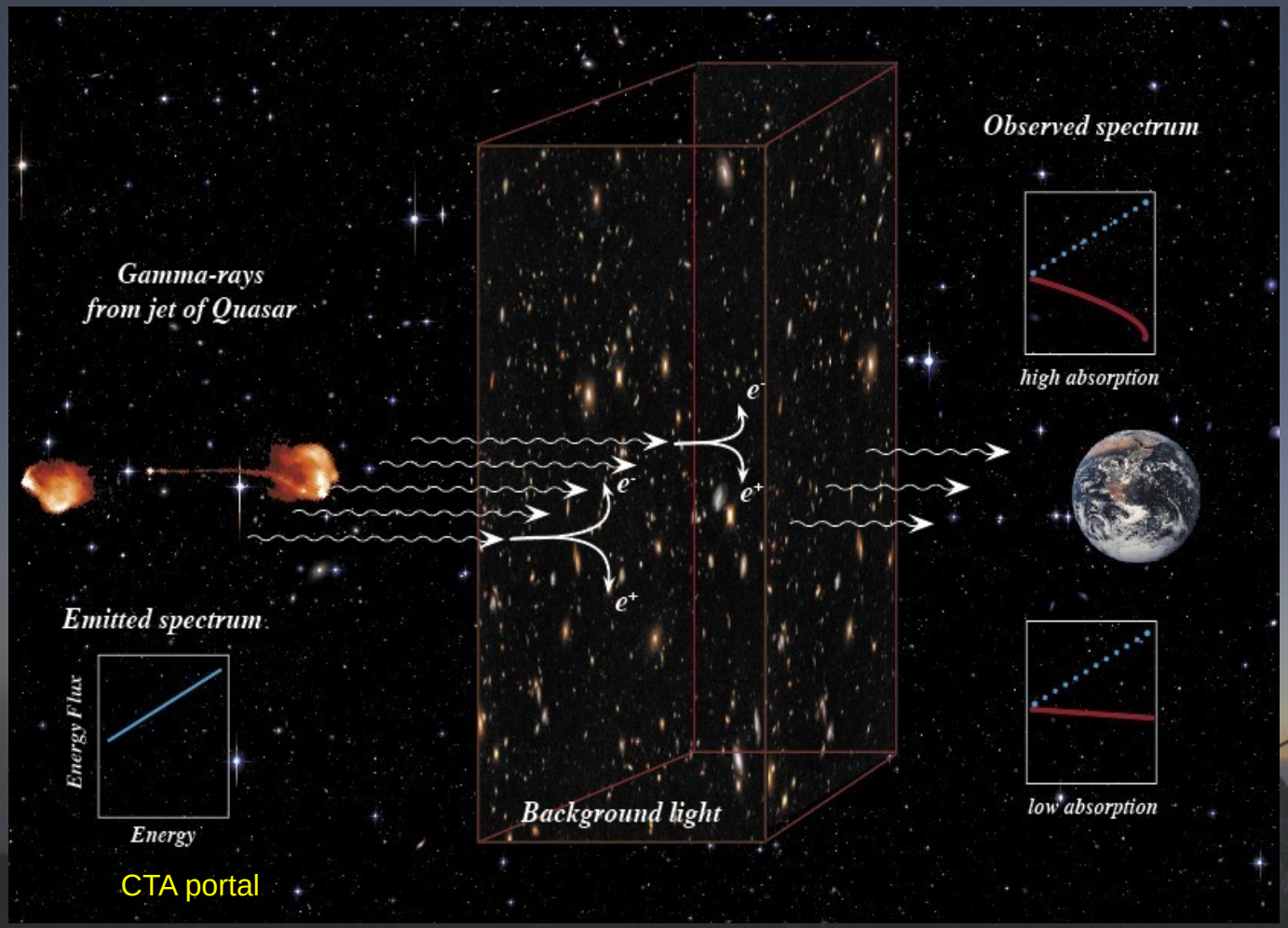
Looking deeper in VHE emission of TXS0506+056

- MWL modelling shows that despite association with the neutrino most of the HE and VHE emission is produced by leptonic processes



Ansoldi et al., ApJL (2018), 863, L10

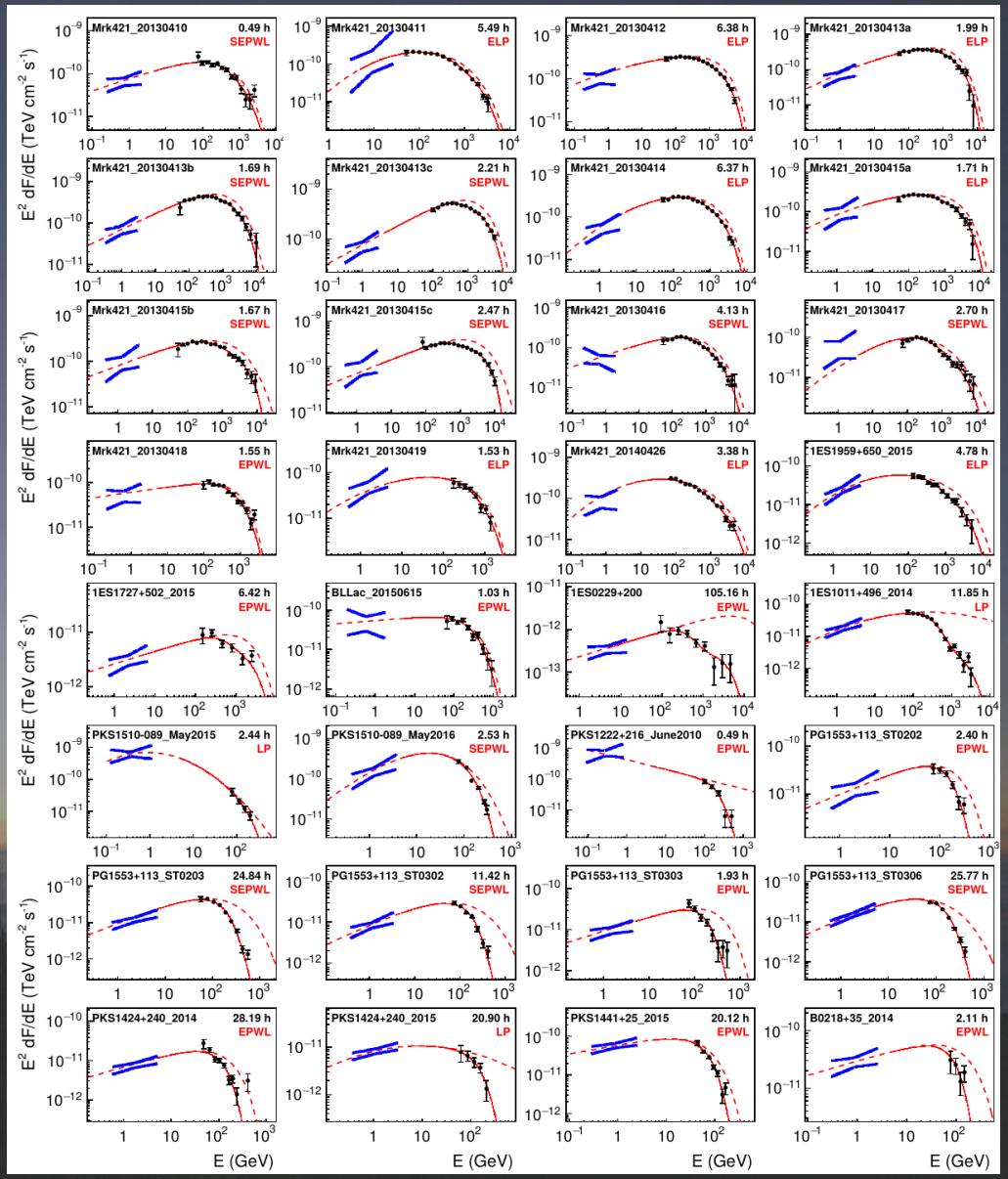
Absorption in EBL



- During the propagation through intergalactic space the gamma-ray spectra get attenuated in extragalactic background light
- By making some basic assumptions about the intrinsic spectrum the effect can be used for studies of EBL and thus of evolution of galaxies

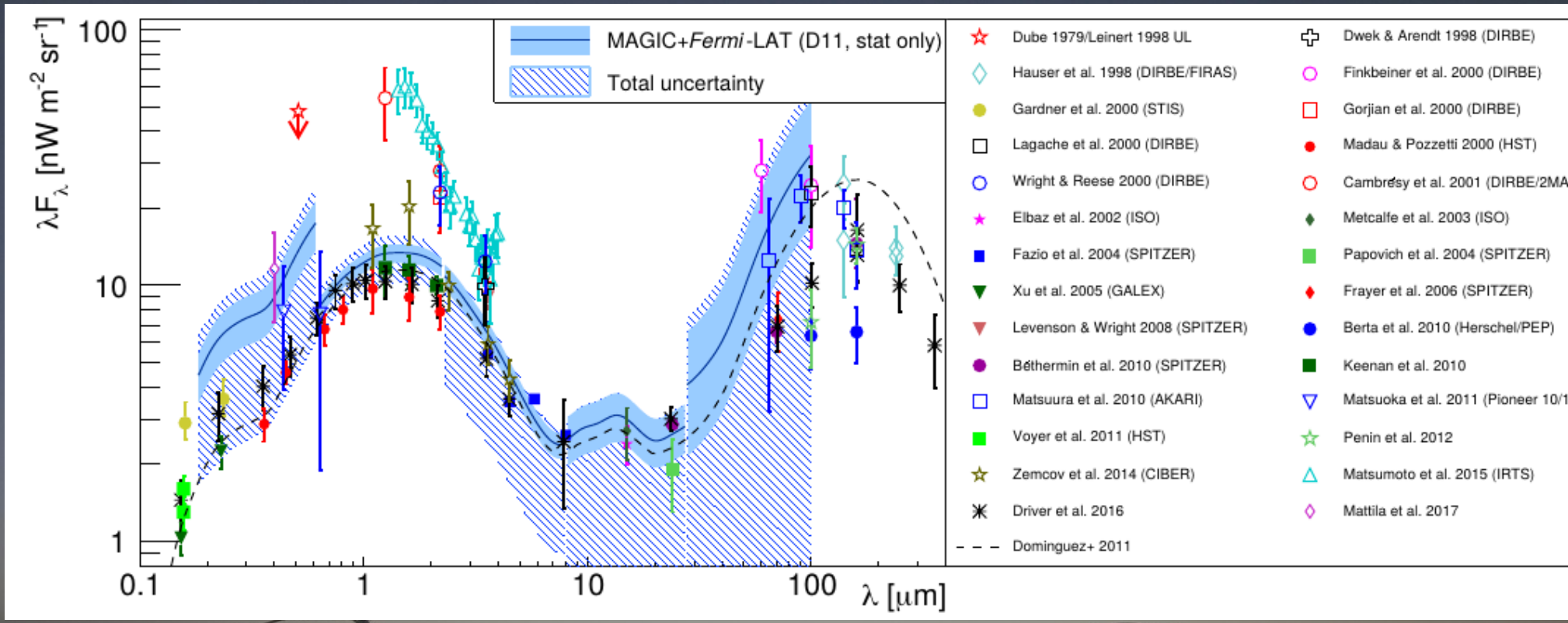
EBL effect on a population of blazars

- 32 individual spectra of 12 blazars covering redshift up to ~1 observed with MAGIC
- Analysis of contemporaneous *Fermi*-LAT data in GeV range
- Careful analysis of systematic effects (energy scale of telescope, choice of intrinsic spectral type, EBL evolution model, ...)



Acciari et al., MNRAS 2019

Constraints on EBL

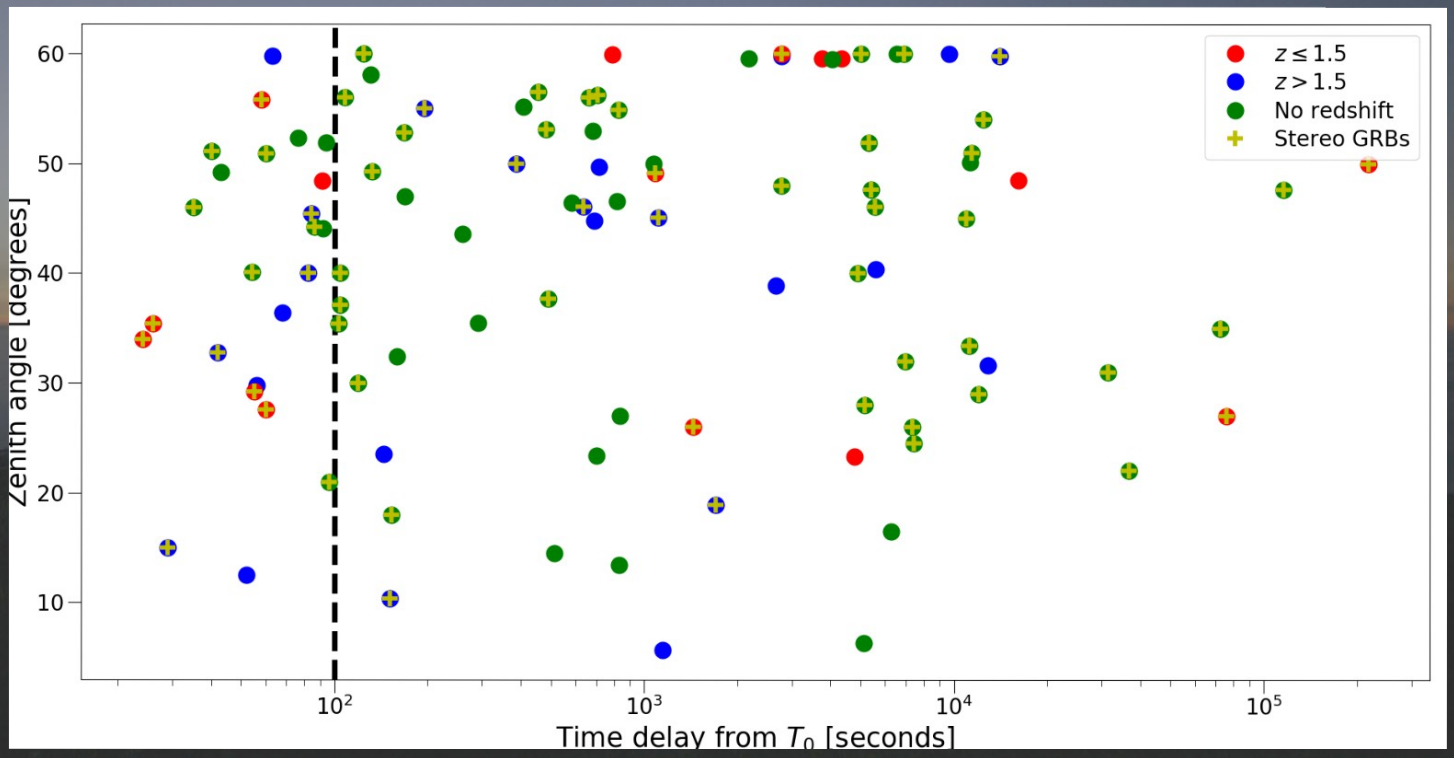


Acciari et al., MNRAS 2019

- EBL density consistent with state-of-art models
- 1σ upper bounds on the EBL density (including systematic uncertainties) is 13-23% above the nominal value from the model

MAGIC observations of GRBs

- MAGIC from the start was designed for rapid follow up of GRBs.
- It can perform a half-turn in Azimuth direction in about 25s
- Over 100 GRBs observed by MAGIC so far, but many:
  - At high redshift (strong absorption)
  - At high zenith (high threshold)
  - > 100 s after alert



The first GRB detected by IACT

Thanks to the low redshift of the GRB (z=0.42, GCN #23708) we were able to detect a strong signal from it even with increased energy threshold due to high zenith angle observations during moon time

First time detection of a GRB at sub-TeV energies; MAGIC detects the GRB 190114C

ATel #12390; ***Razmik Mirzoyan on behalf of the MAGIC Collaboration*** *on* ***15 Jan 2019; 01:03 UT***
Credential Certification: Razmik Mirzoyan (Razmik.Mirzoyan@mpp.mpg.de)

Subjects: Gamma Ray, >GeV, TeV, VHE, Request for Observations, Gamma-Ray Burst

Referred to by ATel #: 12395, 12475

Tweet

The MAGIC telescopes performed a rapid follow-up observation of GRB 190114C (Gropp et al., GCN 23688; Tyurina et al., GCN 23690, de Ugarte Postigo et al., GCN 23692, Lipunov et al. GCN 23693, Selsing et al. GCN 23695). This observation was triggered by the Swift-BAT alert; we started observing at about 50s after Swift T0: 20:57:03.19. The MAGIC real-time analysis shows a significance >20 sigma in the first 20 min of observations (starting at T0+50s) for energies >300GeV. The relatively high detection threshold is due to the large zenith angle of observations (>60 degrees) and the presence of partial Moon. Given the brightness of the event, MAGIC will continue the observation of GRB 190114C until it is observable tonight and also in the next days. We strongly encourage follow-up observations by other instruments. The MAGIC contact persons for these observations are R. Mirzoyan (Razmik.Mirzoyan@mpp.mpg.de) and K. Noda (nodak@icrr.u-tokyo.ac.jp). MAGIC is a system of two 17m-diameter Imaging Atmospheric Cherenkov Telescopes located at the Observatory Roque de los Muchachos on the Canary island La Palma, Spain, and designed to perform gamma-ray astronomy in the energy range from 50 GeV to greater than 50 TeV.

Stay tuned for more results about GRB 190114C !

Working together with MAGIC: external proposals

- Since two cycles MAGIC Collaboration offers a possibility for external scientists to apply for observation time (last year 5 out of 50 proposals were from external scientists)
- The call for the next cycle is not yet announced, however the submission deadline will be around November
- A prior contact with MAGIC members is strongly encouraged for applying scientists (especially if they are not from VHE gamma-ray field).
- See https://magic.mpp.mpg.de/outsiders/magicop/ for details

Conclusions

- MAGIC telescopes after over 15 years of operations still provide excellent science to the community.
- Two recent milestone results:
  - Detection of emission from TXS 0506+056 following an IC alert
  - First detection of a GRB by a IACT
- Importance of being at the right source in the right moment: follow up of alerts and physics motivated time of observations
- Possibilities to collaborate with MAGIC:
  - MWL programs
  - External observation proposals

Backup

IACT technique

- A gamma-ray entering the atmosphere interacts with a nucleus producing e^+e^- pair
- The e^+e^- pairs create secondary gamma-rays in Bremsstrahlung process
- An electromagnetic cascade propagates through the atmosphere
- As the e^+e^- move faster then light in the atmosphere they produce short and faint flashes of UV-visible light
- Ground telescopes register these flashes and make an image of each event