MAGIC observations of VHE gamma-ray flare from PKS 1510-089 in May 2015

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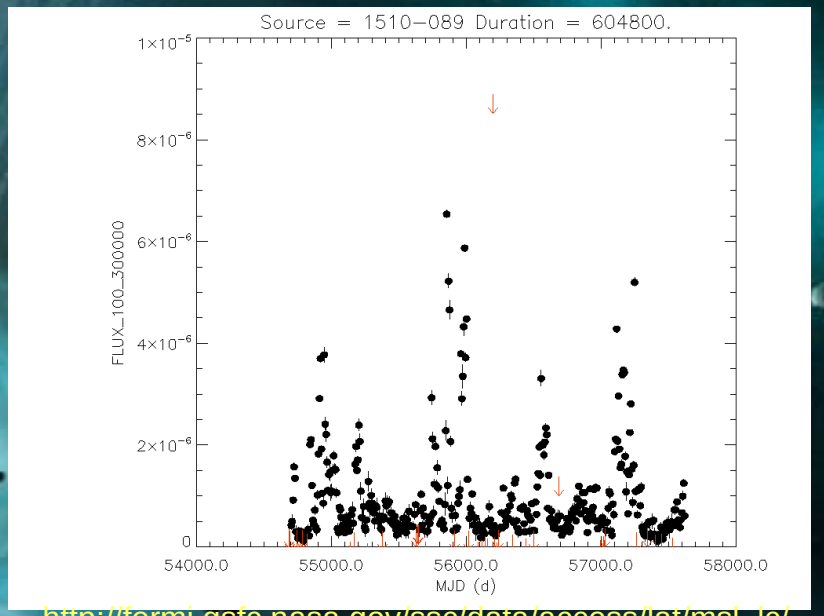
The MAGIC telescopes

- Two 17m diameter Imaging Atmospheric Cherenkov Telescopes located in La Palma, Canary Islands

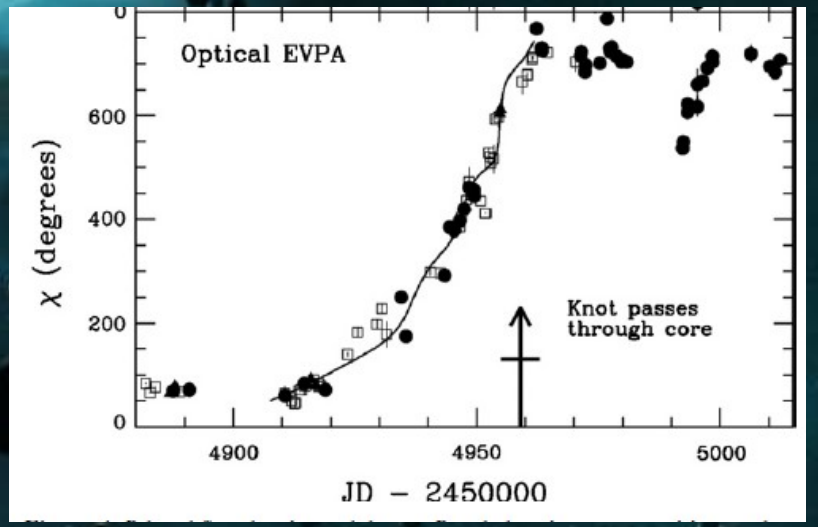
- Observing gamma rays between 50 GeV and a few tens of TeV
- FoV: ~3.5°
- Angular resolution: ~0.1°
- Energy resolution: ~15-23%
- Sensitivity: 10% of Crab in 1h above 100 GeV

PKS 1510-089

- One of only a few FSRQs detected in VHE gamma rays
- Moderately distant (z=0.36)
- Highly variable in optical and GeV gamma rays
- One of the highest apparent speeds of superluminal motion, up to 46c
- Large swings (up to 720°) of optical polarization vector



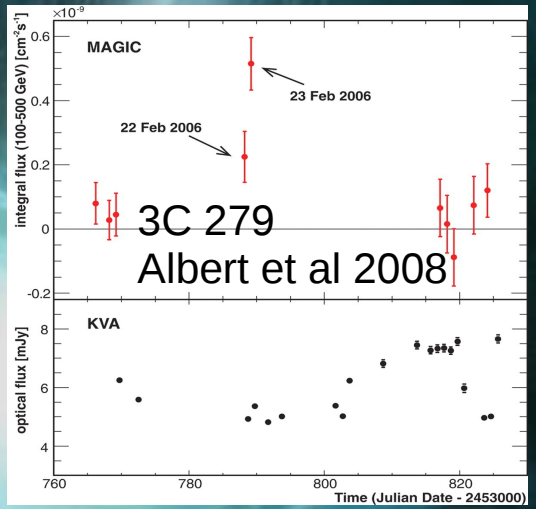
http://fermi.gsfc.nasa.gov/ssc/data/access/lat/msl_lc/

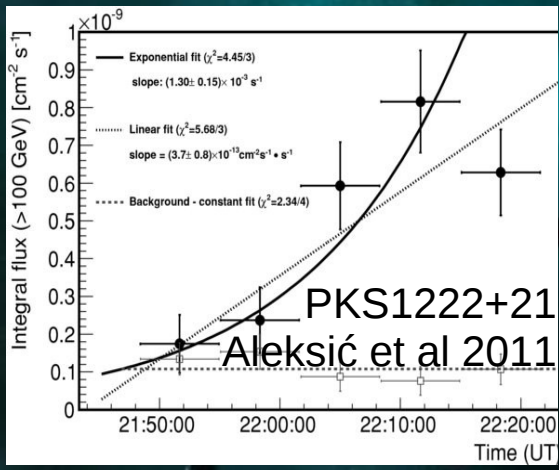


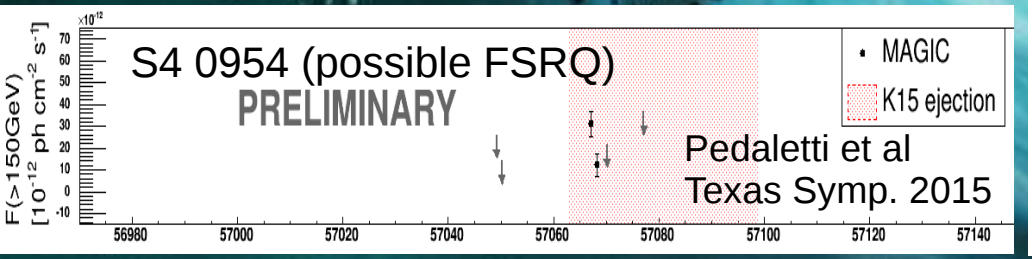
Marscher et al. 2010

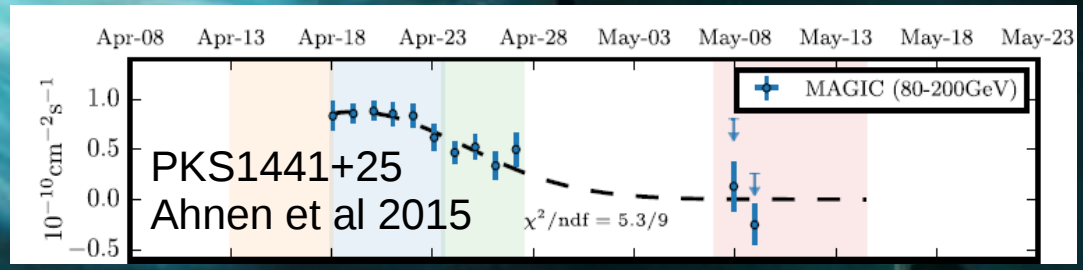
The odd one out in VHE FSRQ family

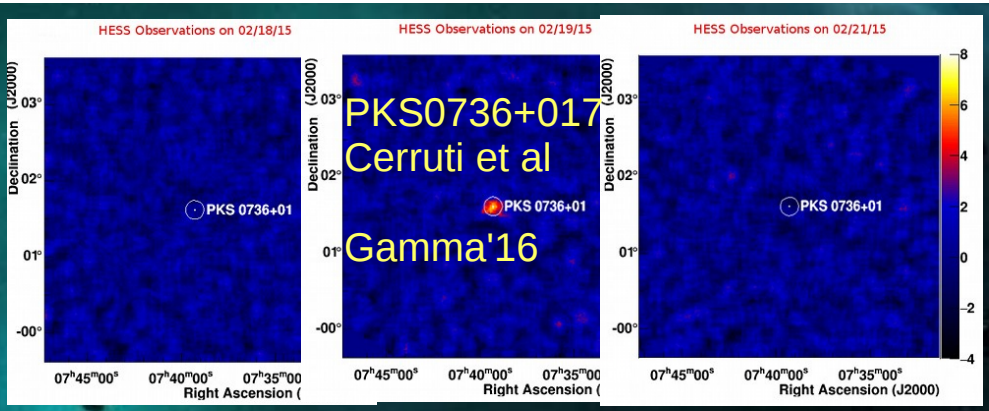
All other FSRQs known in VHE gamma-ray range have been detected first in short flares (from tens of min to a few days)

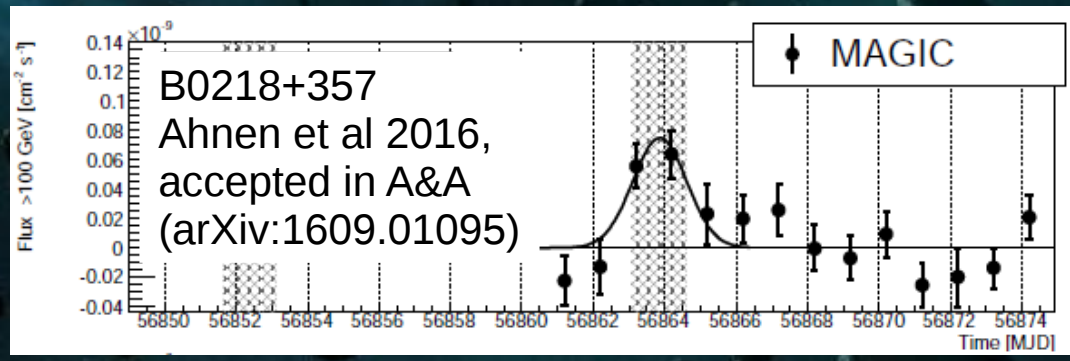






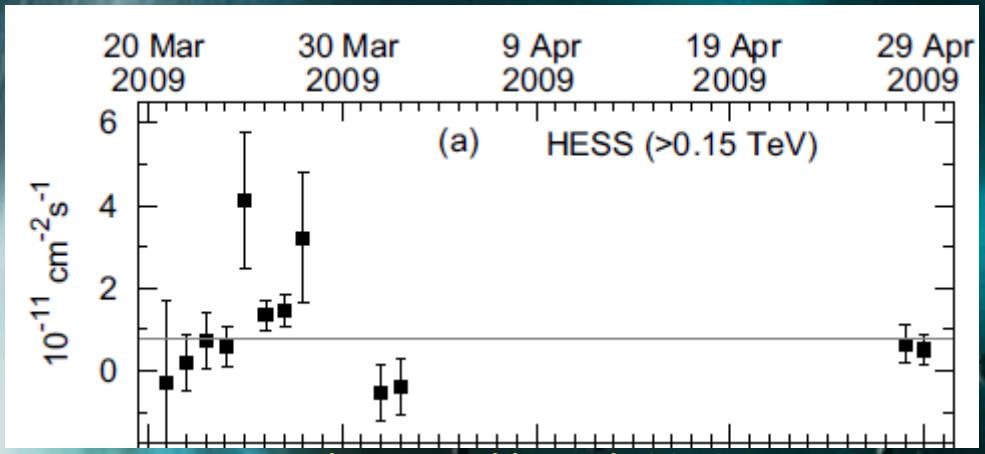




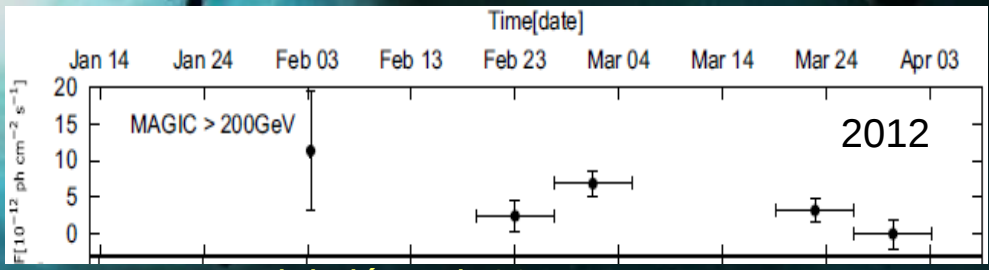


PKS1510-089 in VHE gamma rays

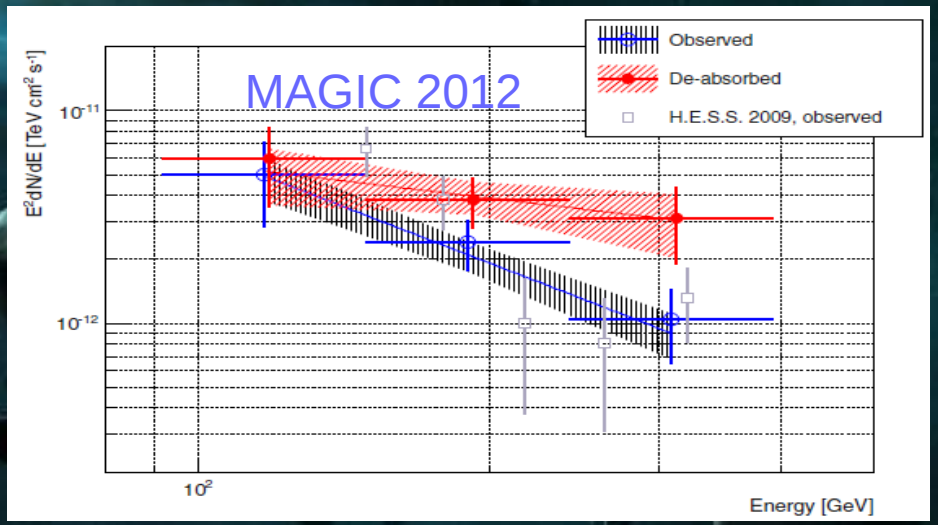
- Detected by H.E.S.S. during high optical and GeV state in 2009
- Confirmed by MAGIC during another high state in 2012
- Neither short-term nor long-term variability has been observed at VHE until 2015



Abramowski et al. 2013

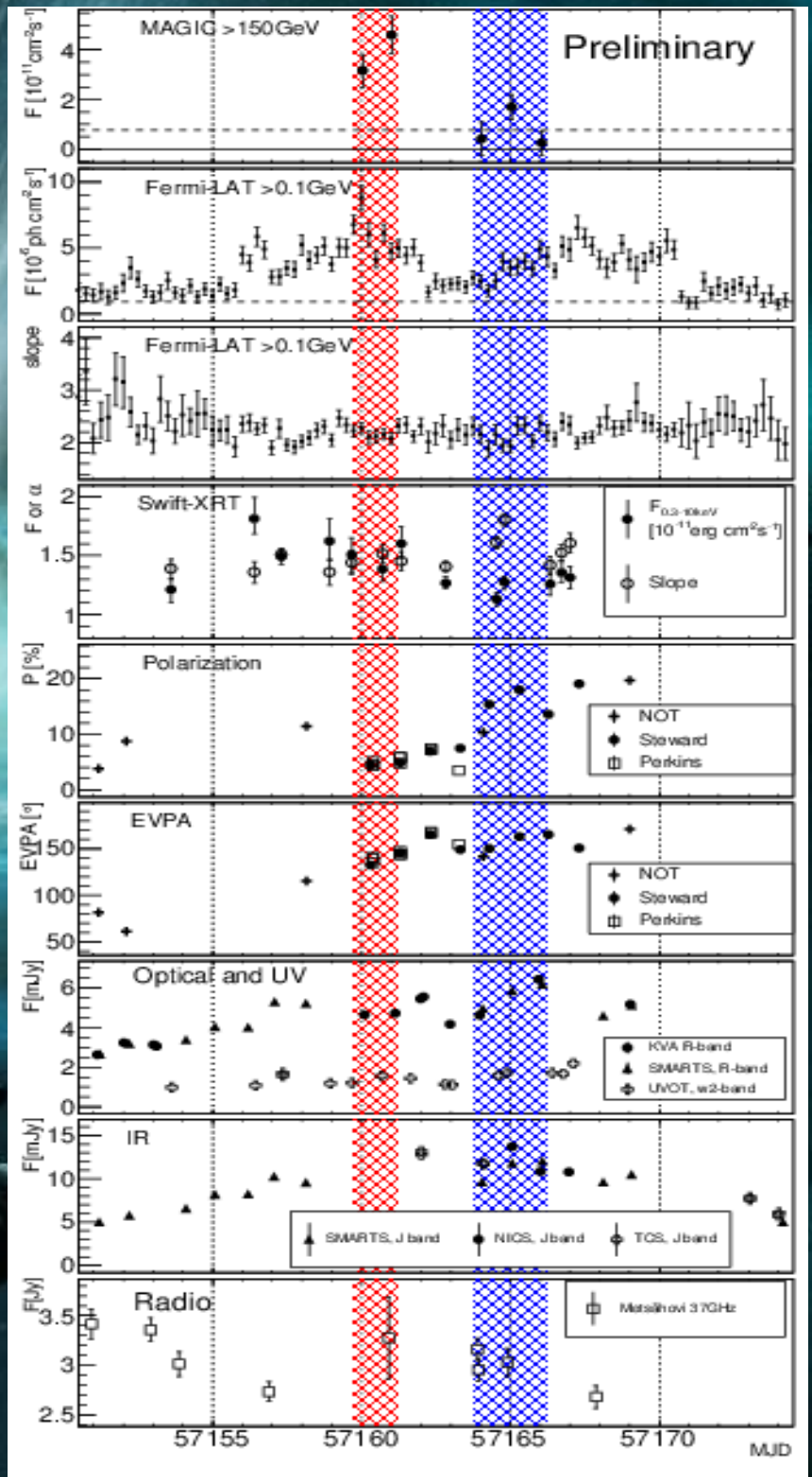


Aleksić et al. 2014



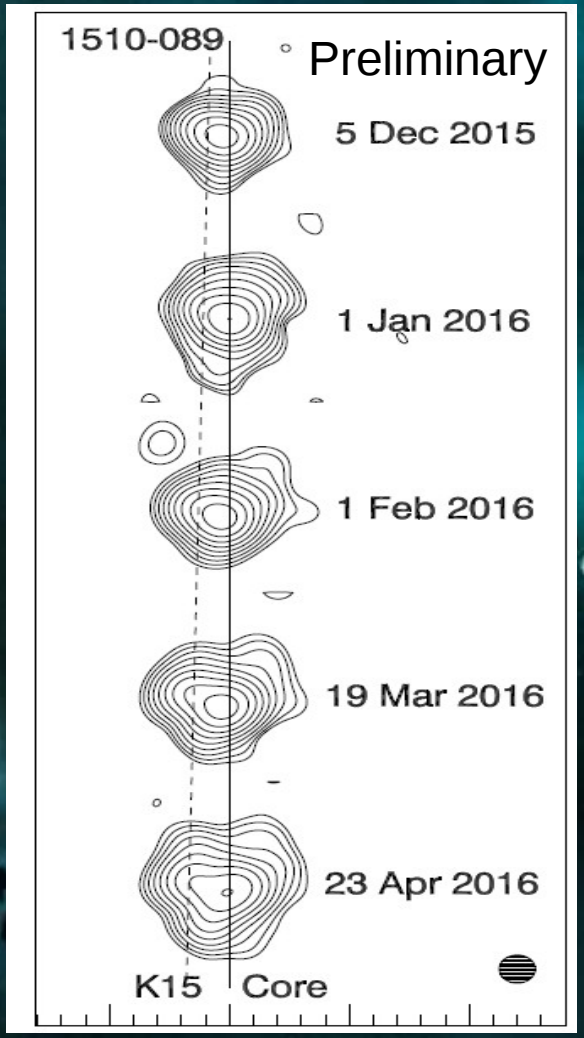
May 2015 flare

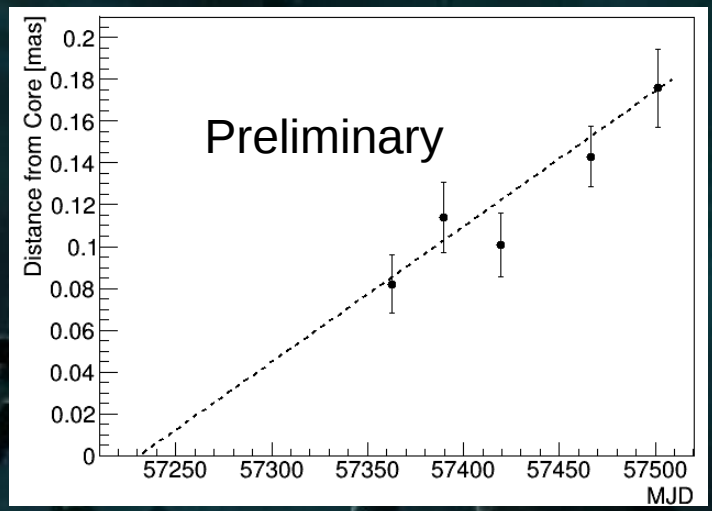
- The source showed another high optical and GeV state in May 2015
- MAGIC detected elevated VHE emission during two nights (constant fit prob. of 1.6 10^{-6})
- X-rays: slow drop of the flux starting from one of the gamma-ray flares
- A smooth rotation of EVPA by ~100° was detected throughout May 2015
- In optical and IR slow raise and fall of the flux, no obvious correlation with other wavelengths



Emission of a new radio component

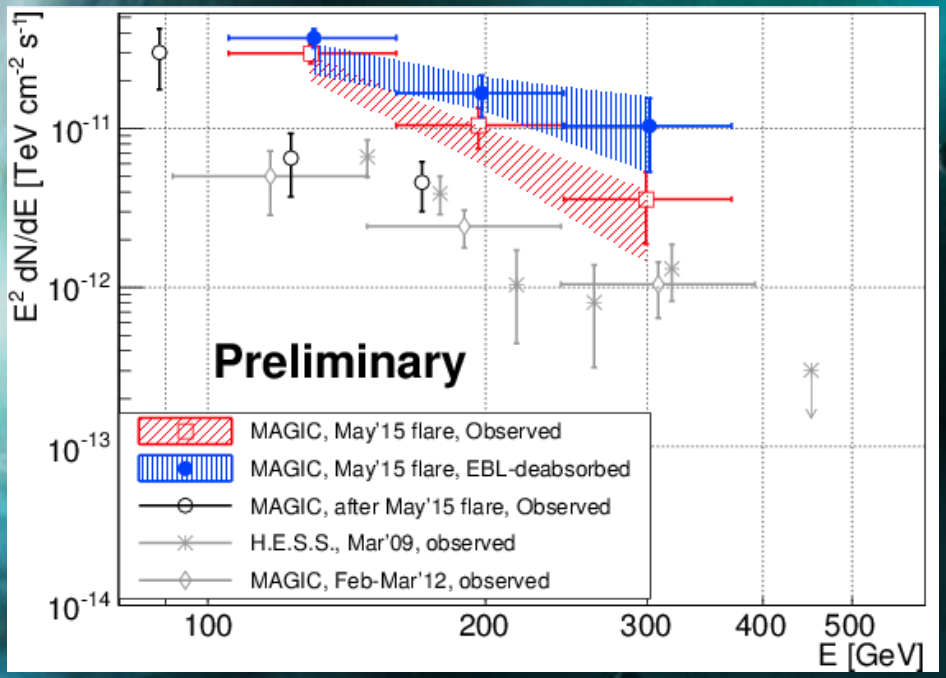
- Follow-up radio observations show a new jet component
- The zero separation epoch overlaps with the May 2015 high state, however with a large uncertainty
- Similar situation to that of 2012 (VHE gamma rays + EVPA rotation + new radio component)





Comparison with previous measurements

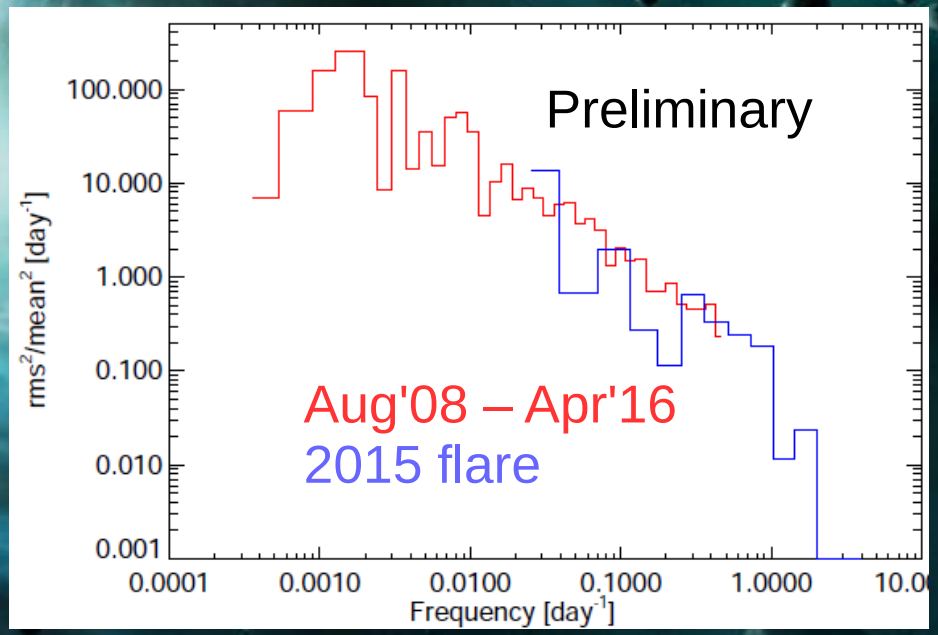
- During the May 2015 flare, the source was ~4 times brighter in VHE gamma rays than in 2009 and 2012, however the spectral shape stayed similar (intrinsic slope of 3.2±0.8)
- Four nights later, the VHE flux was measured to be similar to that reported for previous years



GeV variability in *Fermi*-LAT data

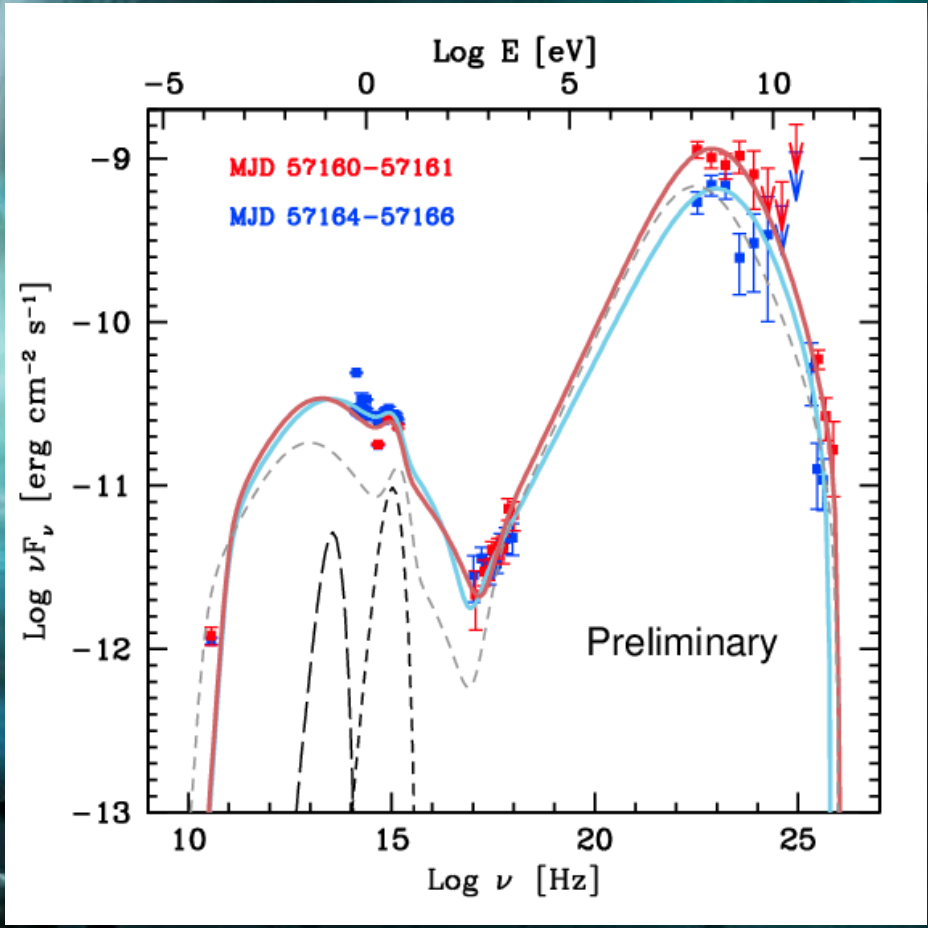
- PDS level is similar for the 2015 flare and the complete *Fermi* data set – the 2015 flares in *Fermi* were not "exceptional"
- PDS index of about -1 (pink noise)

Power Density Spectrum
(normalized to variance per frequency unit)



A possible scenario of emission

- EC scenario on BLR and dust torus photons
- Emission region placed just outside BLR
- Variability due to changes in *B* field and electron distribution flowing through the emission region



In gray: 2012 emission model (Aleksić et al 2014)

PKS 1510-089 keeps on surprising

- In May 2016 another gamma-ray high state happened
- H.E.S.S. and MAGIC observed a giant flare from PKS1510 with intranight variability.
- Stay tuned for more results from this source ...

Increased VHE activity from PKS 1510-089 detected with H.E.S.S.

ATel #9102; ***Mathieu de Naurois, for the H. E.S. S. collaboration***
*on **31 May 2016; 13:07 UT***
Credential Certification: Jean-Philippe Lenain (jlenain@in2p3.fr)

Subjects: Gamma Ray, TeV, VHE, Request for Observations, AGN, Blazar, Quasar

Referred to by ATel #: 9105

Title: MAGIC detects exceptionally high activity from PKS 1510-089 at very high energy gamma-rays

ATel #9105; ***Razmik Mirzoyan (Max-Planck-Institute for Physics, Munich, Germany) on behalf of the MAGIC Collaboration***
*on **1 Jun 2016; 14:37 UT***
Credential Certification: Razmik Mirzoyan (Razmik.Mirzoyan@mpp.mpg.de)

Subjects: Optical, Gamma Ray, TeV, VHE, AGN, Black Hole, Blazar, Cosmic Rays

Referred to by ATel #: 9179

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The MAGIC telescopes have detected an increase in the Very High Energy gamma-ray flux from PKS 1510-089 (RA=15 12 50.5, dec=-09 06 00, J2000.0). The preliminary analysis of the MAGIC data taken on 2016/05/30 for 2.7 hours, indicates a highly significant signal (significance > 60 sigma). The flux at the beginning of the observations (MJD=57538.94) was larger than the flux from the Crab nebula above 150 GeV, and around 50% of the flux from the Crab nebula above 240 GeV, declining towards the end of our observations. This implies an increase of a factor of at least ~5 with respect to the flux reported during the VHE flare detected by MAGIC in May 2015 (http://www.astronomerstelegram.org/?read=7542). We roughly estimate the spectral slope to -4, and the flux at 90 GeV at the beginning of the observations to 5 times the flux from the Crab nebula. Automatic analysis of the MAGIC observations from 2016/05/31 show no significant signal of this source. Quasi-simultaneously to MAGIC observations, we also performed optical observations with a 35cm Celestron telescope at La Palma. The observations confirm the elevated optical state, the R-band magnitude being ~15.1. The light curve is available in the Tuorla Blazar monitoring webpage: http://users.utu.fi/kani/1m/PKS_1510-089_jy.html PKS 1510-089 is a FSRQ at z=0.36 and it is regularly monitored by MAGIC. MAGIC observations on 2016/05/30 were triggered by the alert by the H.E.S.S. collaboration due to a high flux observed on issued on 2016/05/29, and high-state reported in the high energy gamma-ray band as seen by Fermi-LAT (http://fermi.gsfc.nasa.gov/ssc/data/access/lat/msl_lc/source/1510-089). H.E.S.S. observations from the night 2016/05/29 were reported on 2016/05/31: http://www.astronomerstelegram.org/?read=9102. MAGIC observations on PKS1510-089 will continue during the following nights, and multi-wavelength observations are encouraged. The MAGIC contact persons for these observations are R. Mirzoyan (Razmik.Mirzoyan@mpp.mpg.de) and D. Dominis Prester (dijana@phy.uniri.hr). 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.

Conclusions

- May 2015 flare is the first example of VHE gamma-ray variability in PKS 1510-089
- No spectral hardening in VHE emission was seen during the flare
- After the flare the high energy emission returned to a “typical high state”
- Similarly to 2012, the flare was accompanied by EVPA rotation and ejection of a new radio component