FACT - the First G-APD Cherenkov Telescope
Blazar Monitoring at TeV Energies

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First G-APD Cherenkov Telescope

Facts about FACT [1,2]

- Operation since October 2011
- Using Imaging Atmospheric Cherenkov Technique
- Site: Observatorio Roque de los Muchachos, La Palma, Spain (2200 m a.s.l.)
- 9.5 m² mirror surface
- Silicon photosensor (SiPM, aka G-APD)
- 4.5° field of view
- 1440 pixels (0.11° FoV each)

SiPMs Ideal for Long-term Monitoring

- SiPMs: robust and stable no aging effects due to bright light
  - → Observations during strong moon (s. photo, [3])
  - → Stable detector performance
- Remote and automatic operation http://www.fact-project.org/smartfact
  - → Stable and consistent data taking
  - → High data taking efficiency

→ Larger duty cycle
→ Less gaps
→ In combination with observing strategy: denser sampling

Data Sample:

Mrk 501:	1649 h
Mrk 421:	1415 h
1ES 1959+650:	655 h
Crab Nebula:	1462 h

(status 19.6.2016)

First G-APD Cherenkov Telescope (FACT) on the Canary Island La Palma: This photo shows the telescope during a special measurement demonstrating the capability of SiPMs: Showers could be recorded while pointing to the full moon.

Long-term Monitoring

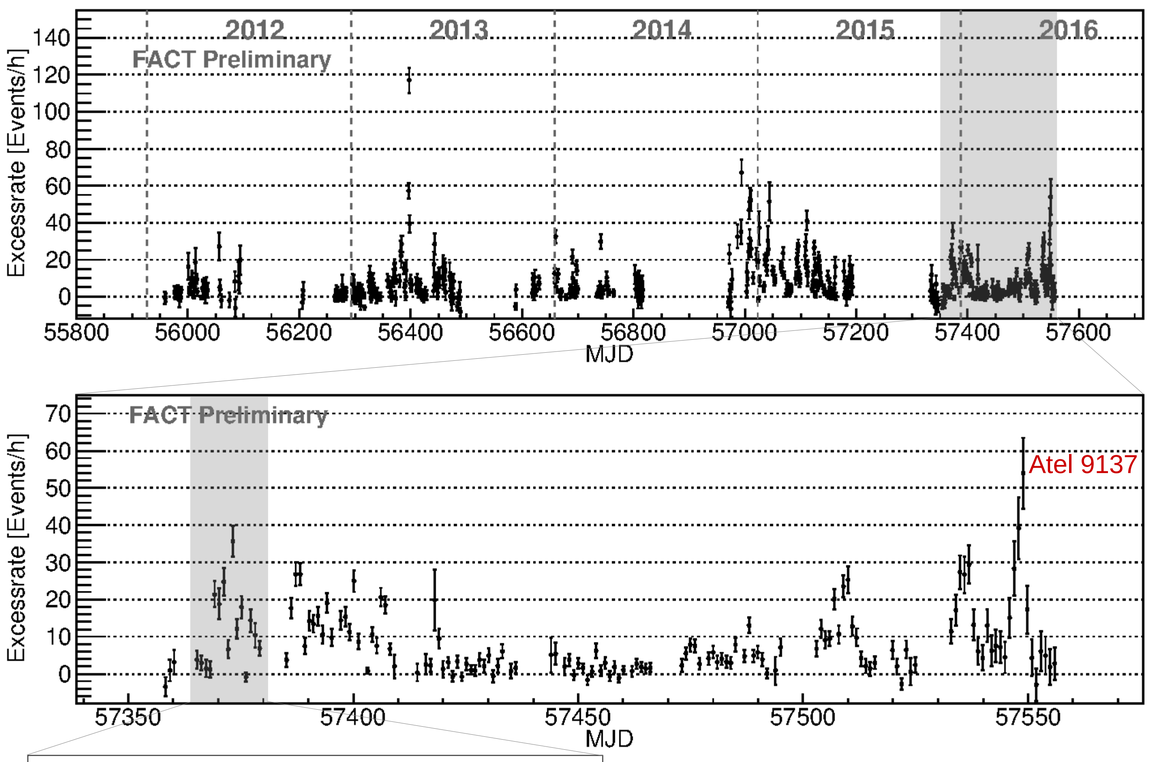
- Source sample: bright TeV blazars
- Blazars: extremely variable on time scales from minutes to years
  - → dense sampling needed
  - → multi-wavelength (MWL) observations vital
- Strategy: observe small sample of sources as much as possible
- Send alerts to other instruments in case of flares
  - → simultaneous MWL observations
  - → better understand emission mechanism

Quick Look Analysis

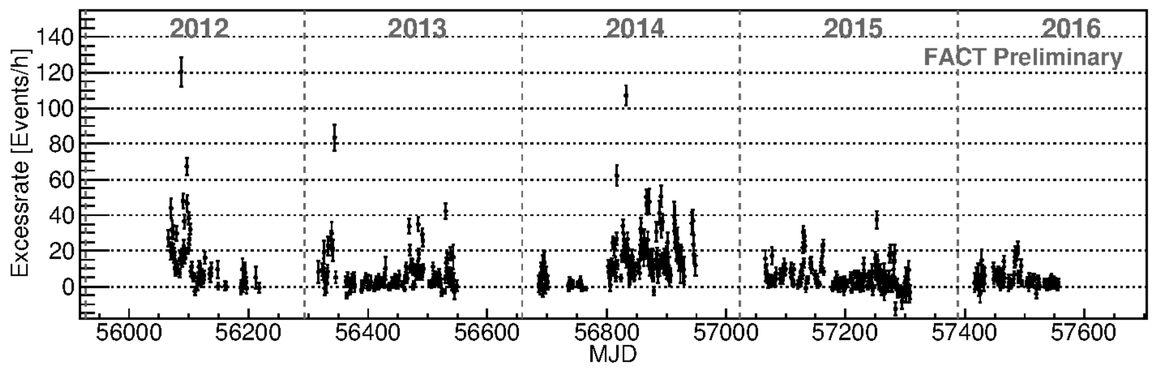
- Immediate processing on-site
- Available since December 2012
- Excess rates publicly available http://www.fact-project.org/monitoring
- Low latency → quick flare detection

→ 24 flare alerts since March 2014
→ Successful trigger of ToO observations with *INTEGRAL* and *Swift* in December 2015
→ 4 Atels
→ Several interesting MWL data sets

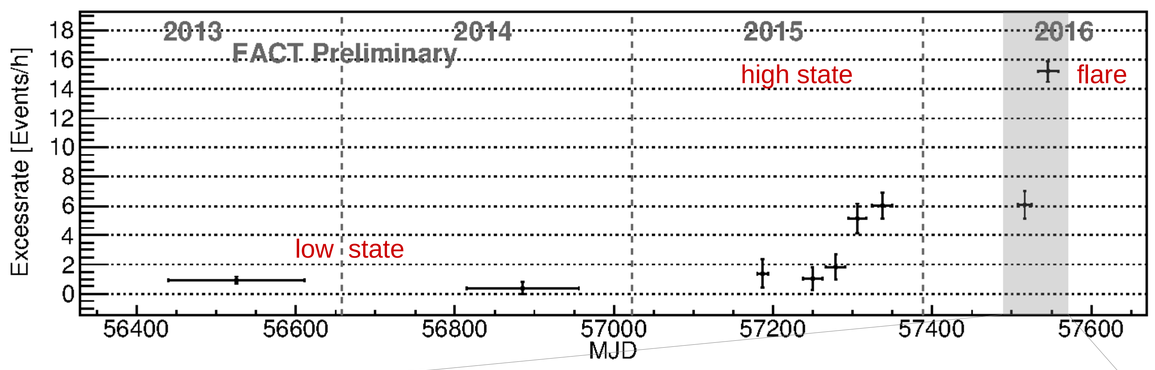
Mrk 421

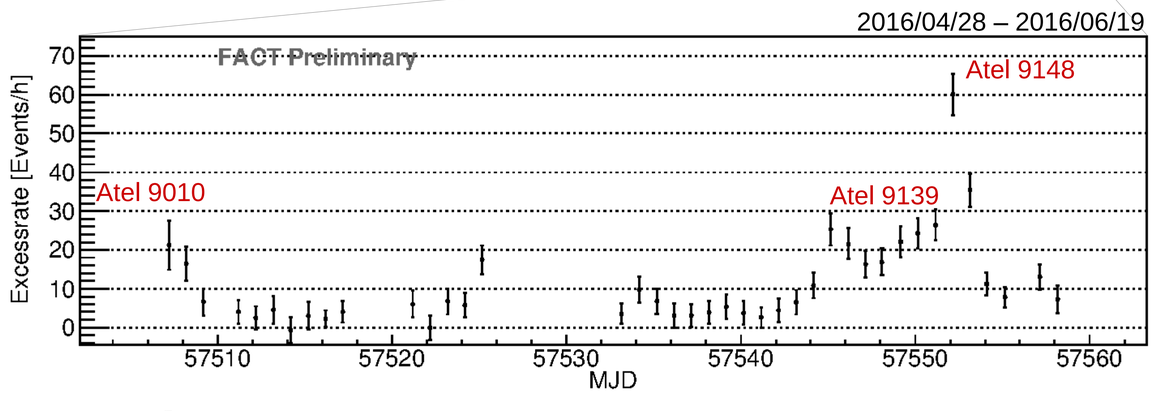


Mrk 501

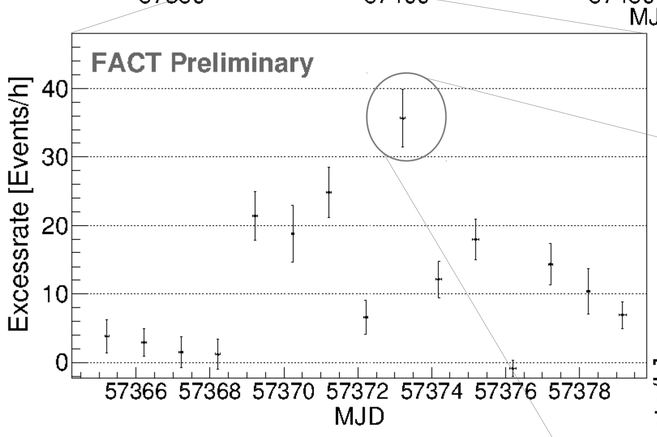


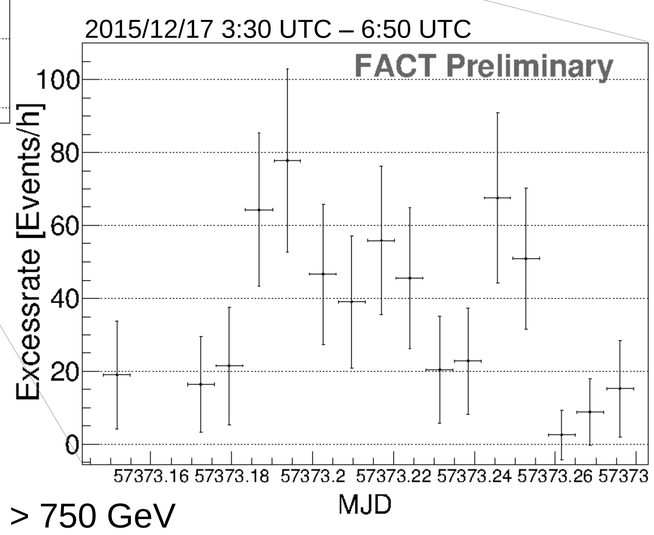
1ES 1959+650





Mrk 421 Flare Dec 2015





Target-of-Opportunity

Flare on 2015 Dec. 17:
INTEGRAL Observations: ~164ks
start: 2015-12-18 10:59:31 UTC
stop: 2015-12-20 10:47:06 UTC
Swift Follow-Up:
daily ~5ks: 2015/12/19 - 2015/12/20
daily ~1ks: 2015/12/20 - 2016/01/11
every 2nd day ~1ks: 2016/02-11 - 2016/02/20

Estimate from FACT QLA: Integrated flux > 750 GeV
Flare night: $(7.1 \pm 1.7) \cdot 10^{-11}$ cm^{-2} s^{-1}
Time range of observation with *INTEGRAL* : $(2.7 \pm 1.8) \cdot 10^{-11}$ cm^{-2} s^{-1}

Results

Mrk 501: Bright flares in 2012 and 2014 [4,5]
Mrk 421: Bright flare in April 2013
Target-of-Opportunity observations with *INTEGRAL*, *Swift* in Dec. 2015
1ES 1959+650: Low state in 2013/4
Enhanced flux in autumn 2015 [6]
Enhanced activity in April-June 2016 [7,8]
Bright flare in June 2016 [9]

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References
[1] H.Anderhub et al. (FACT Collab), JINST 8 (2013) P06008, arXiv:1304.1710
[2] A.Biland et al. (FACT Collab), arXiv:1403.5747
[3] M.L.Knoetig et al. (FACT Collab), ICRC 2013, ID 695, arXiv:1307.6116
[4] M.L.Ahnen et al. (MAGIC, VERITAS, FACT Fermi Collaborations, MWL) in prep.
[5] Stegmann et al. (HESS Collab.) Atel.6268
[6] B.Kapanadze et al. MNRAS, 2016, 461, L25-31
[7] S.Buson et. al (Fermi, FACT, MAGIC, VERITAS) Atel.9010)
[8] A.Biland et. al (FACT Collaboration) Atel.9139
[9] A.Biland et. al (FACT, MAGIC, VERITAS, Fermi) Atel.9148)

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