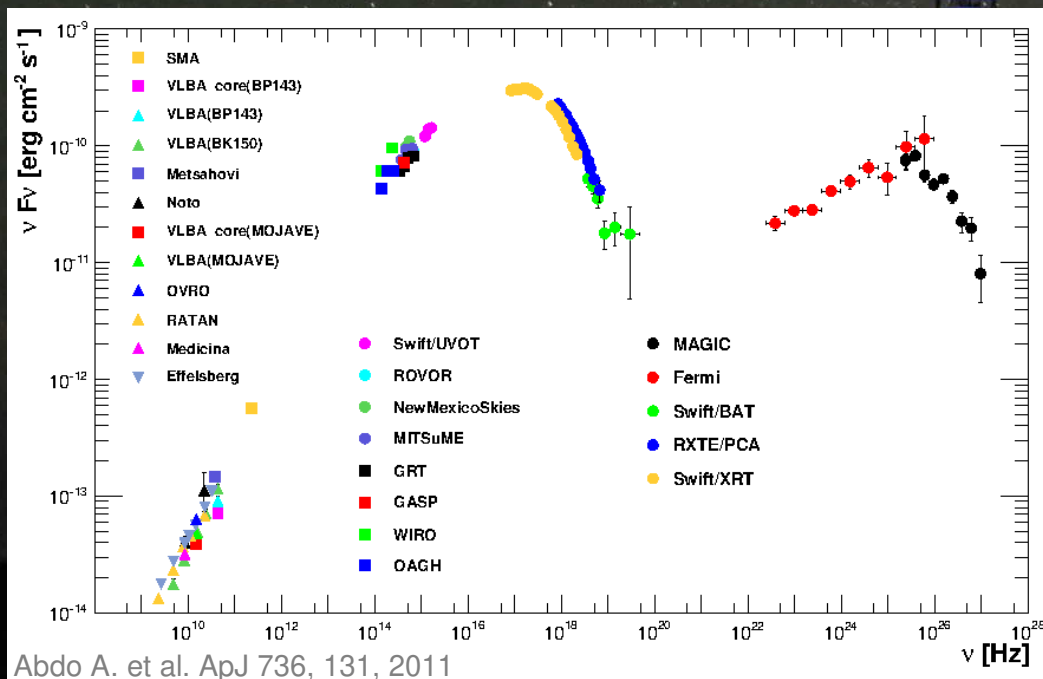


Unbiased Monitoring of Active Galactic Nuclei in Gamma Rays



Unbiased Monitoring of Active Galactic Nuclei

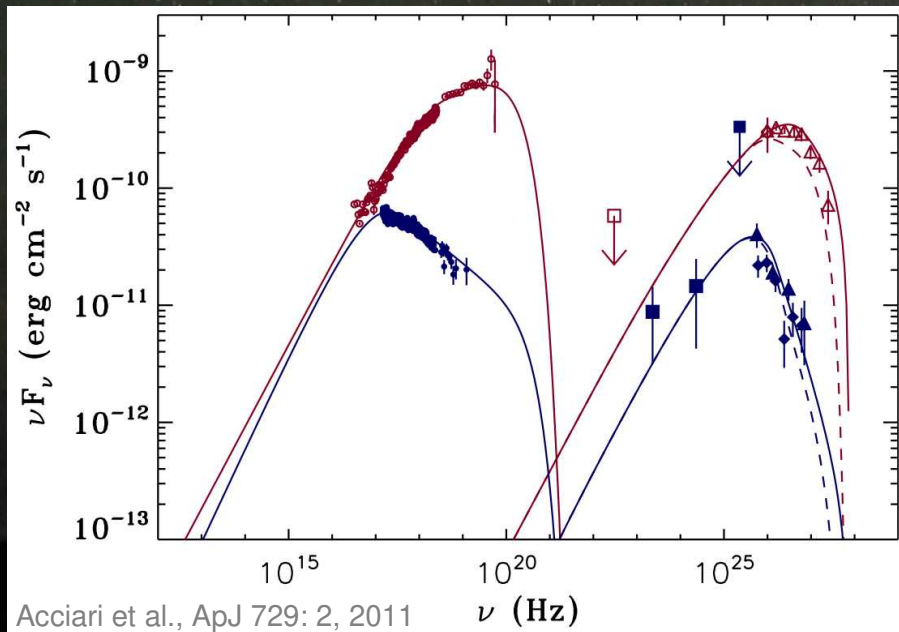
emission along
electromagnetic spectrum



Unbiased Monitoring of Active Galactic Nuclei

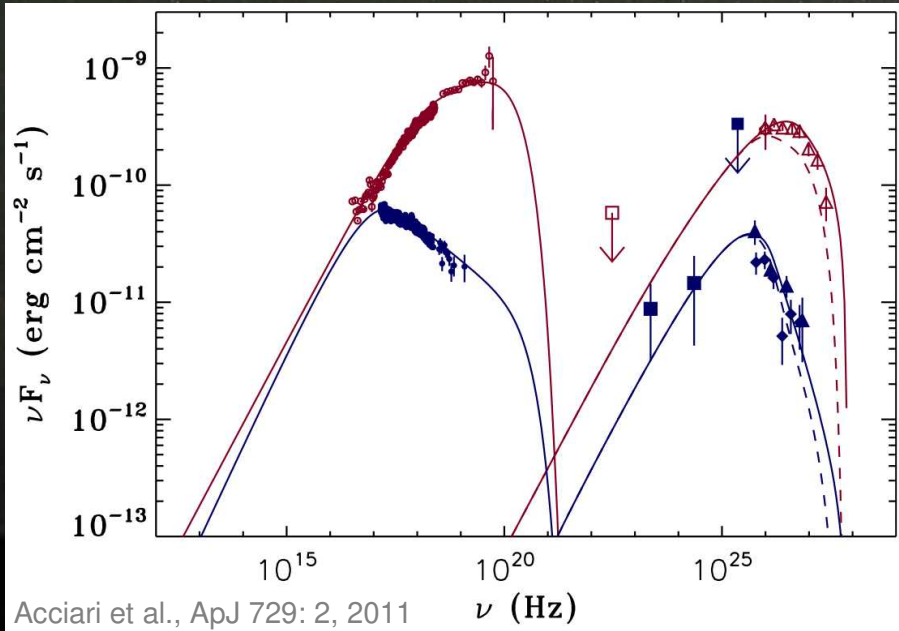
emission along
electromagnetic spectrum

highly variable
on all time scales

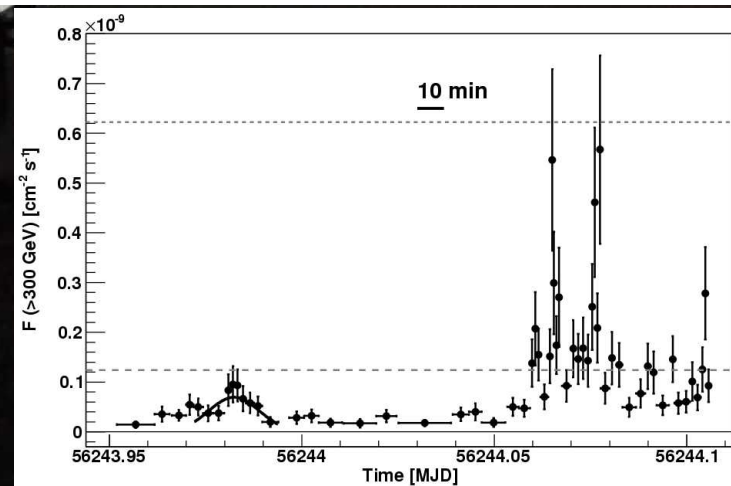
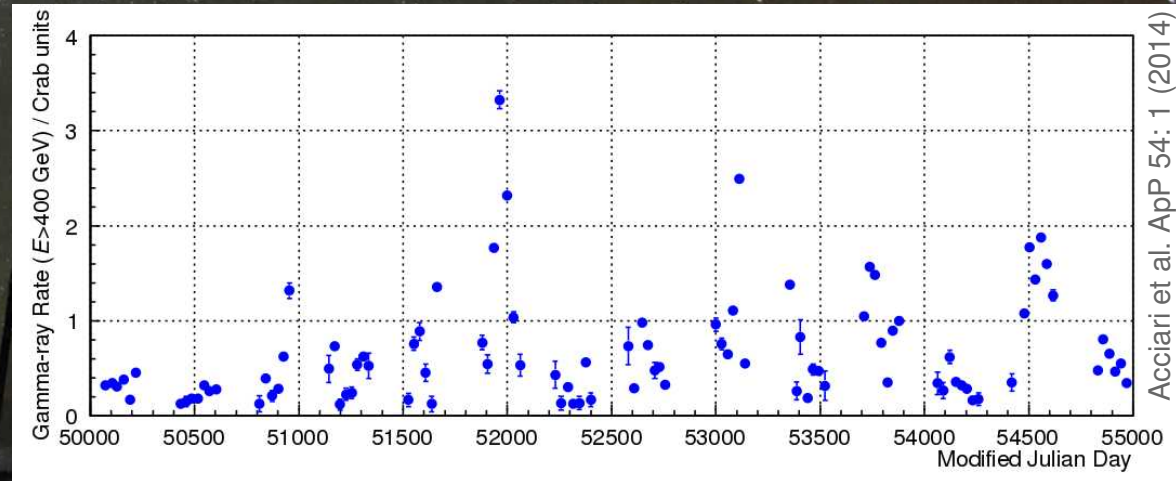


Unbiased Monitoring of Active Galactic Nuclei

emission along
electromagnetic spectrum

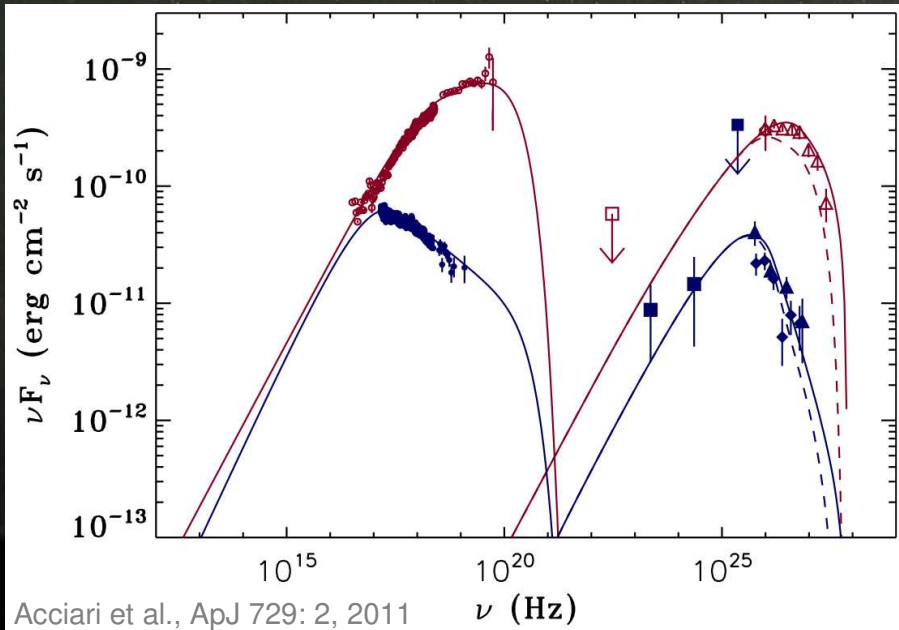


highly variable
on all time scales

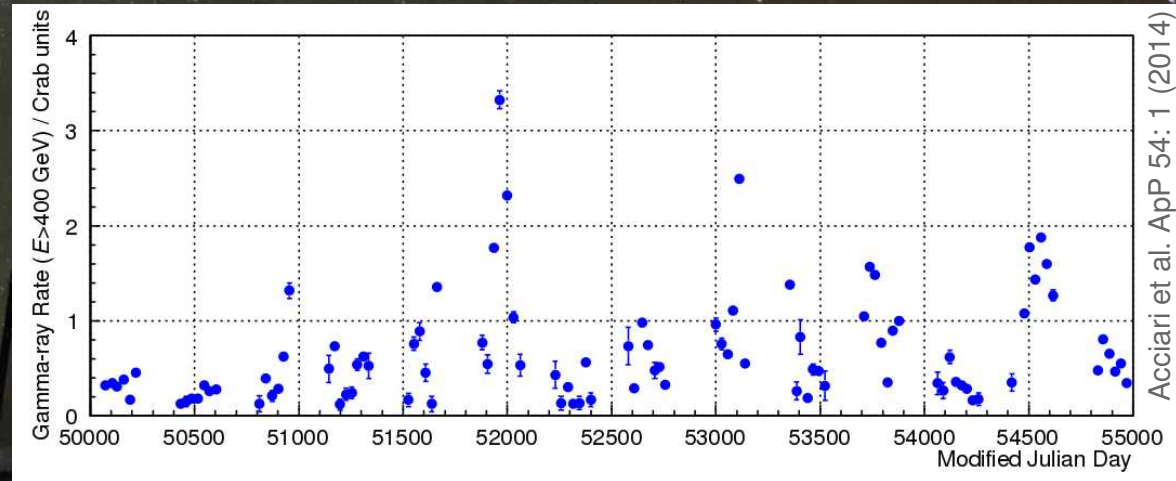


Unbiased Monitoring of Active Galactic Nuclei

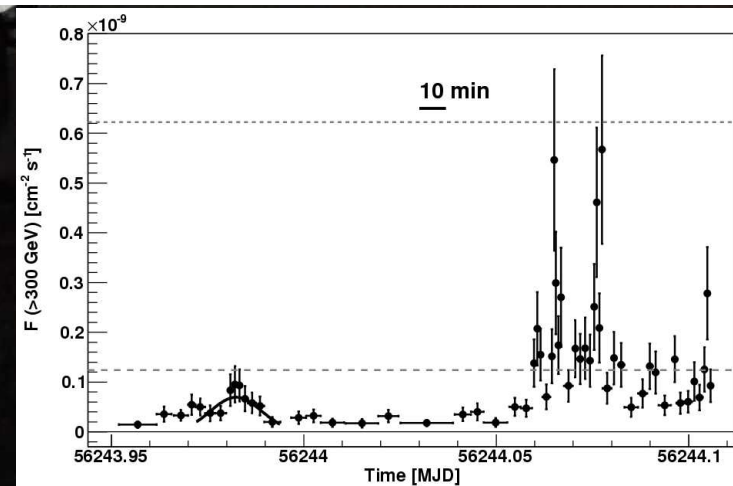
emission along
electromagnetic spectrum



highly variable
on all time scales

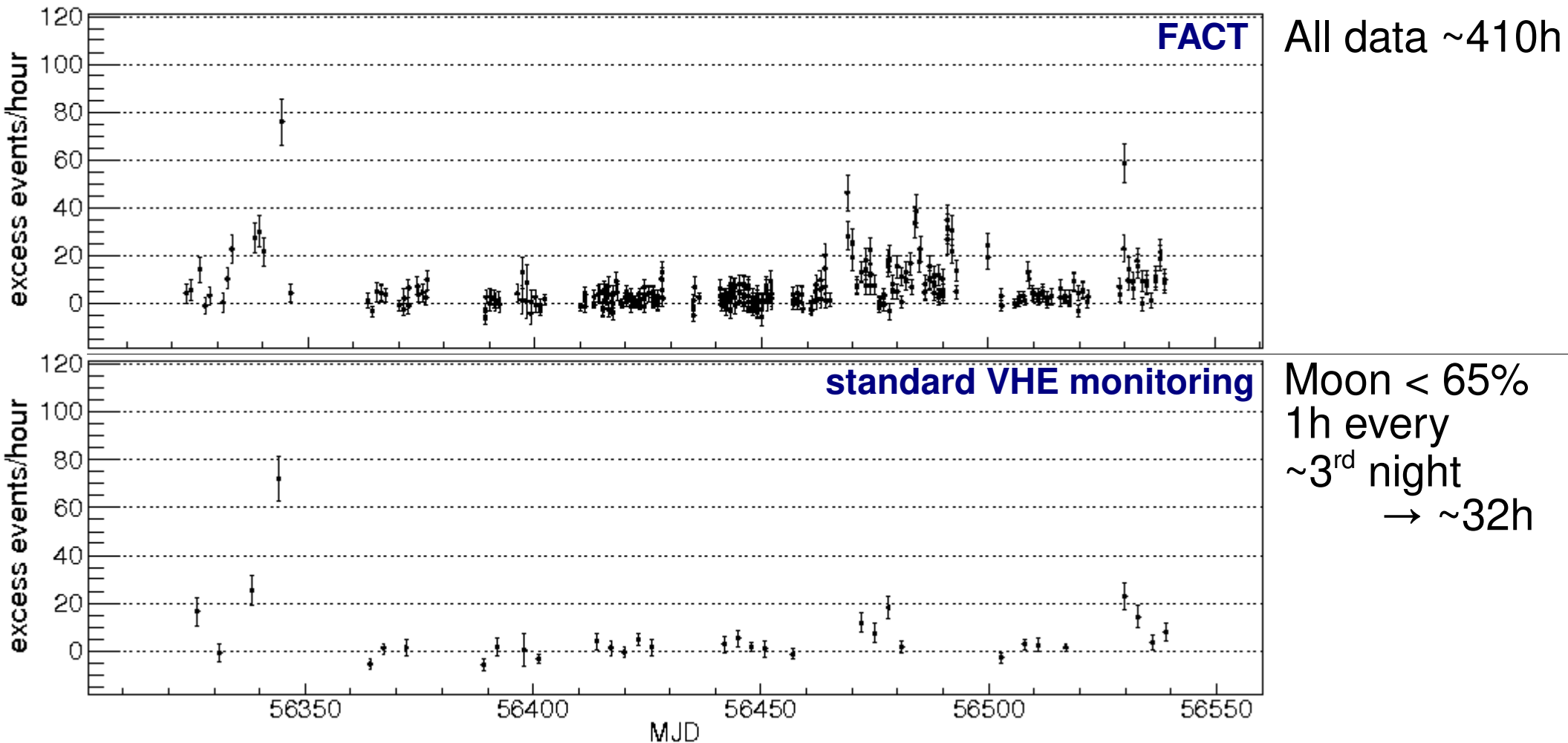


=> MWL Monitoring needed
=> Unbiased observations



Unbiased Monitoring at VHE

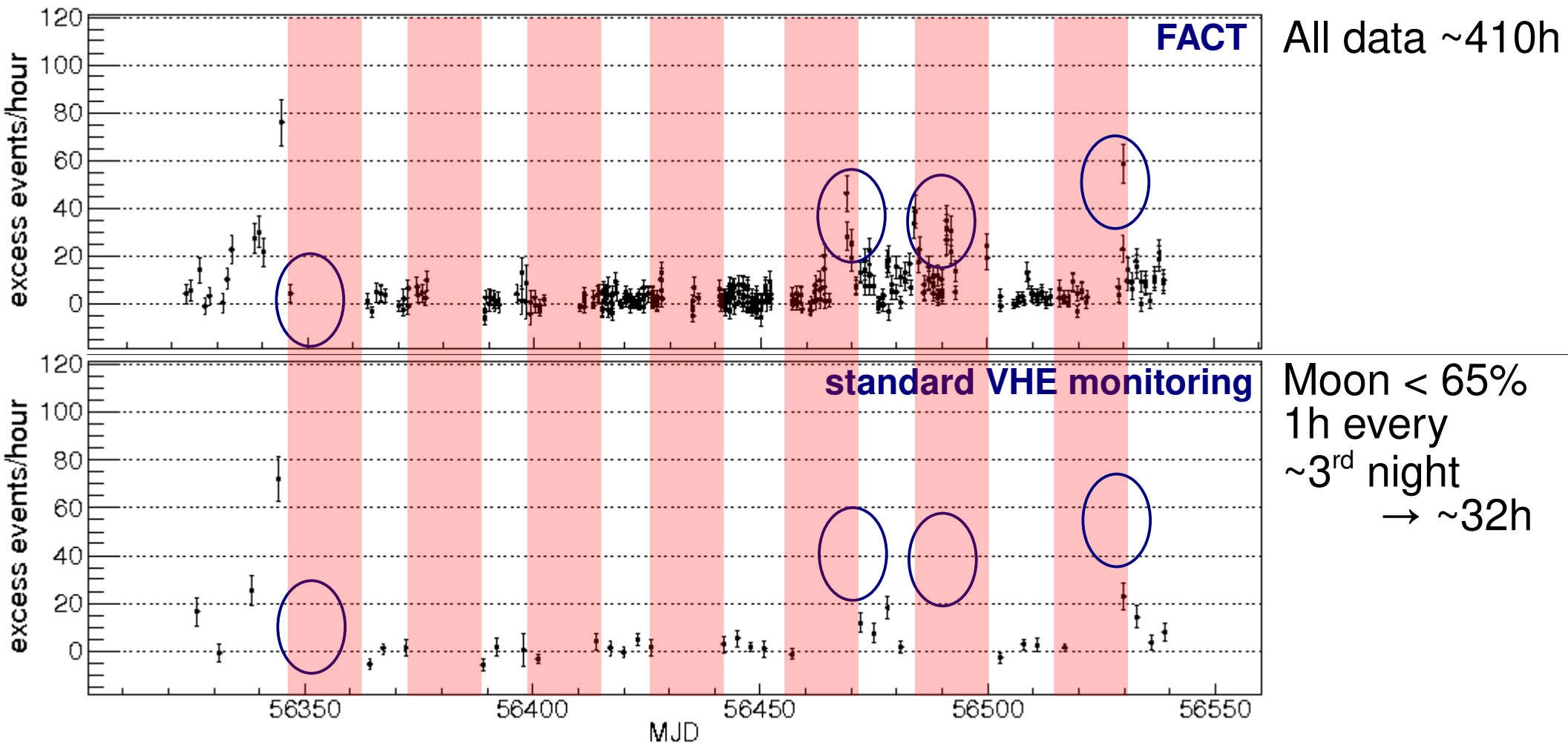
Mrk 501 (2013) 1-hour-binning



Dorner et al. (FACT Collaboration), Proceedings of 34th ICRC

Unbiased Monitoring at VHE

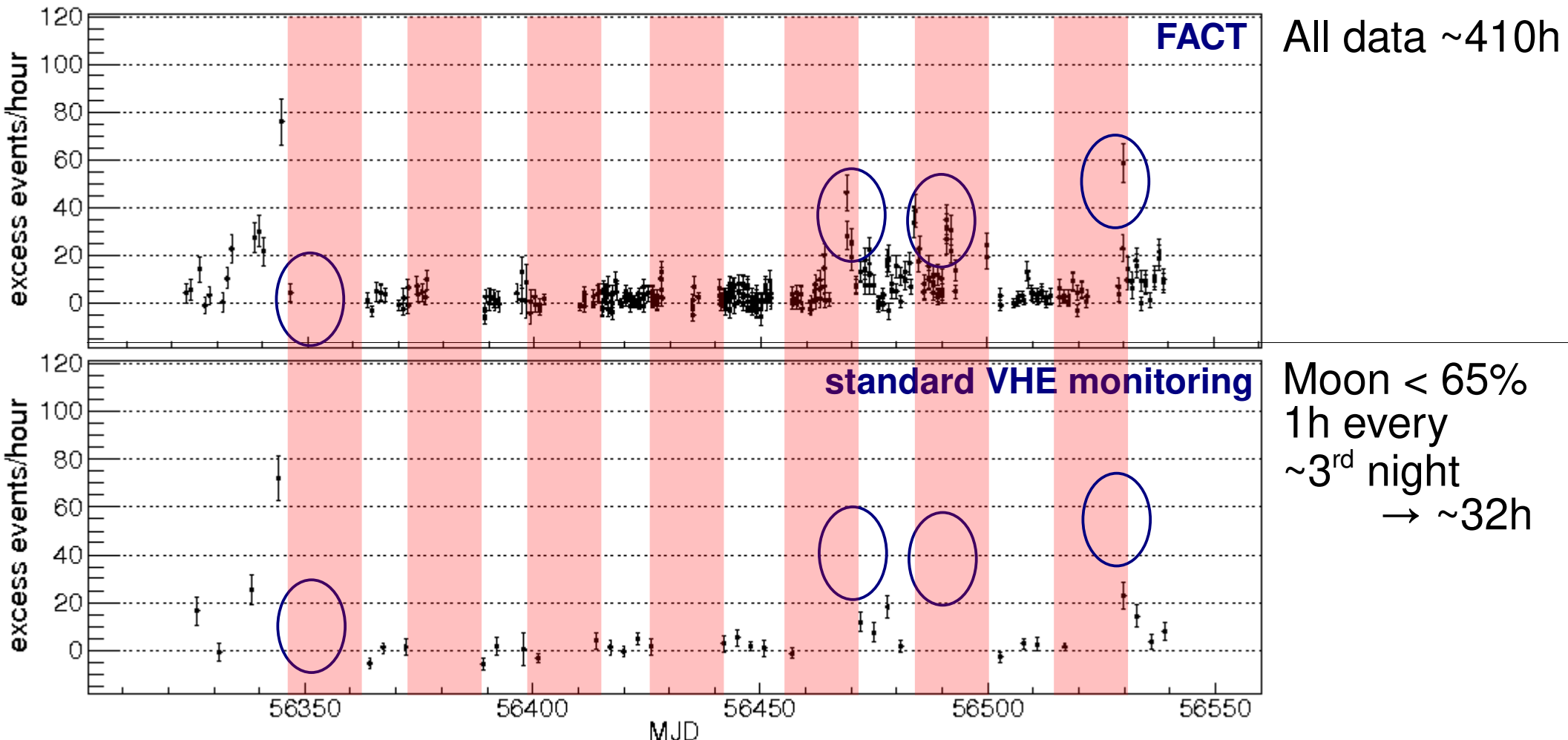
Mrk 501 (2013) 1-hour-binning



Unbiased Monitoring at VHE

FACT monitoring strategy
→ Unbiased observations

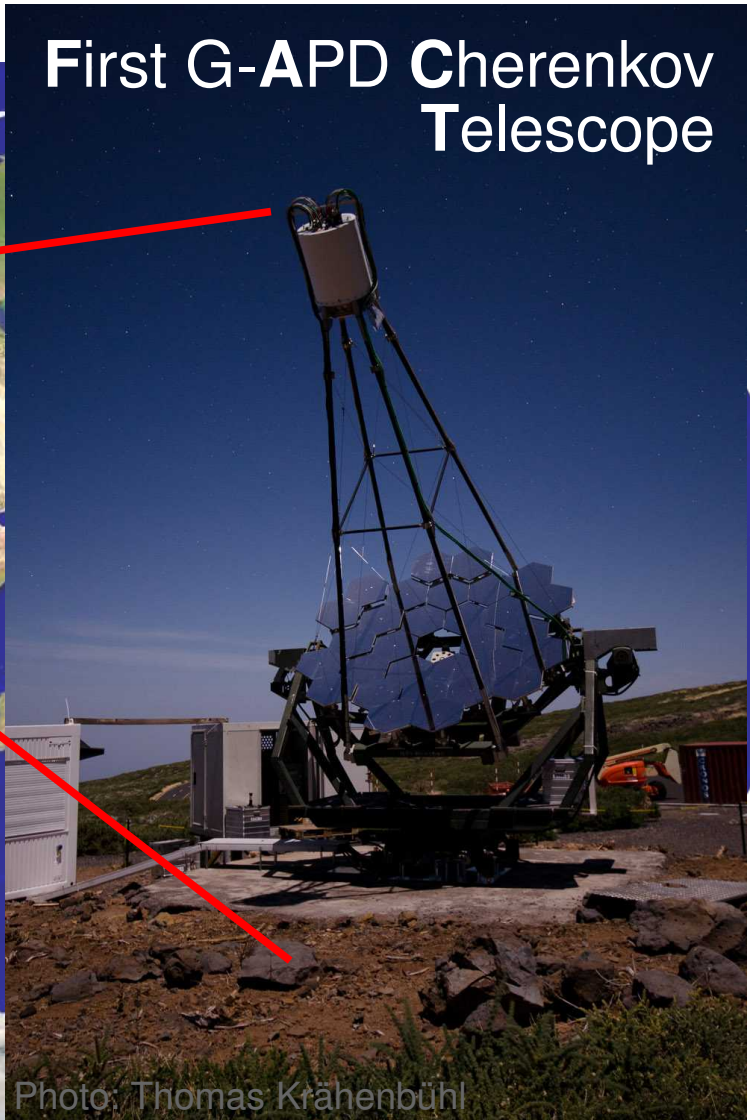
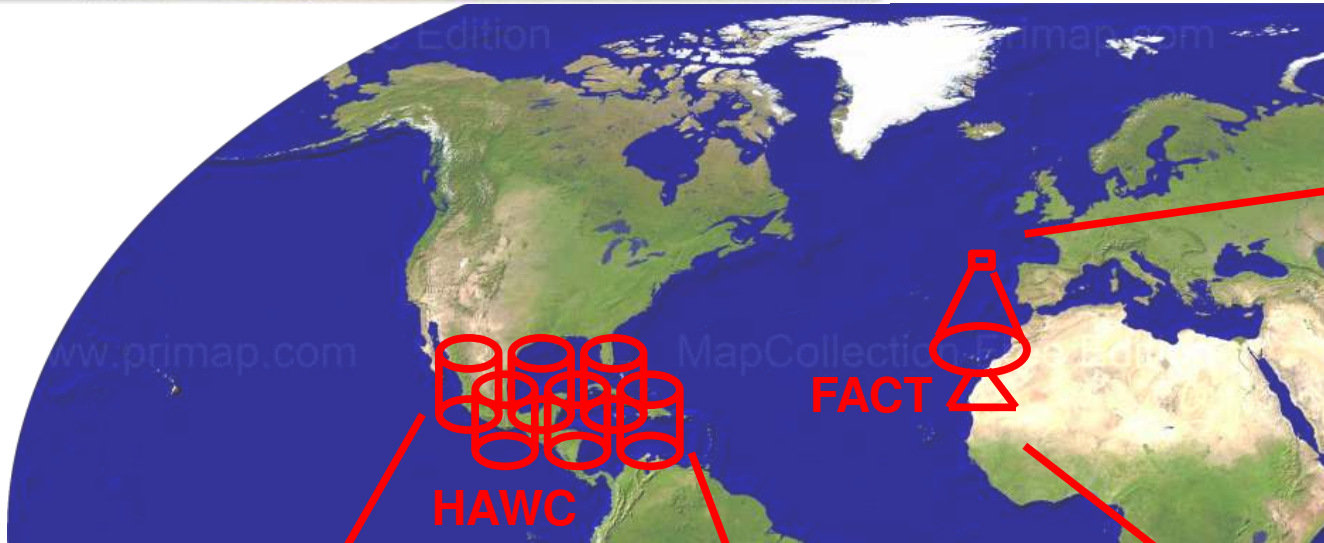
Mrk 501 (2013) 1-hour-binning



Standard VHE: Follow-up of flares → bias toward high fluxes



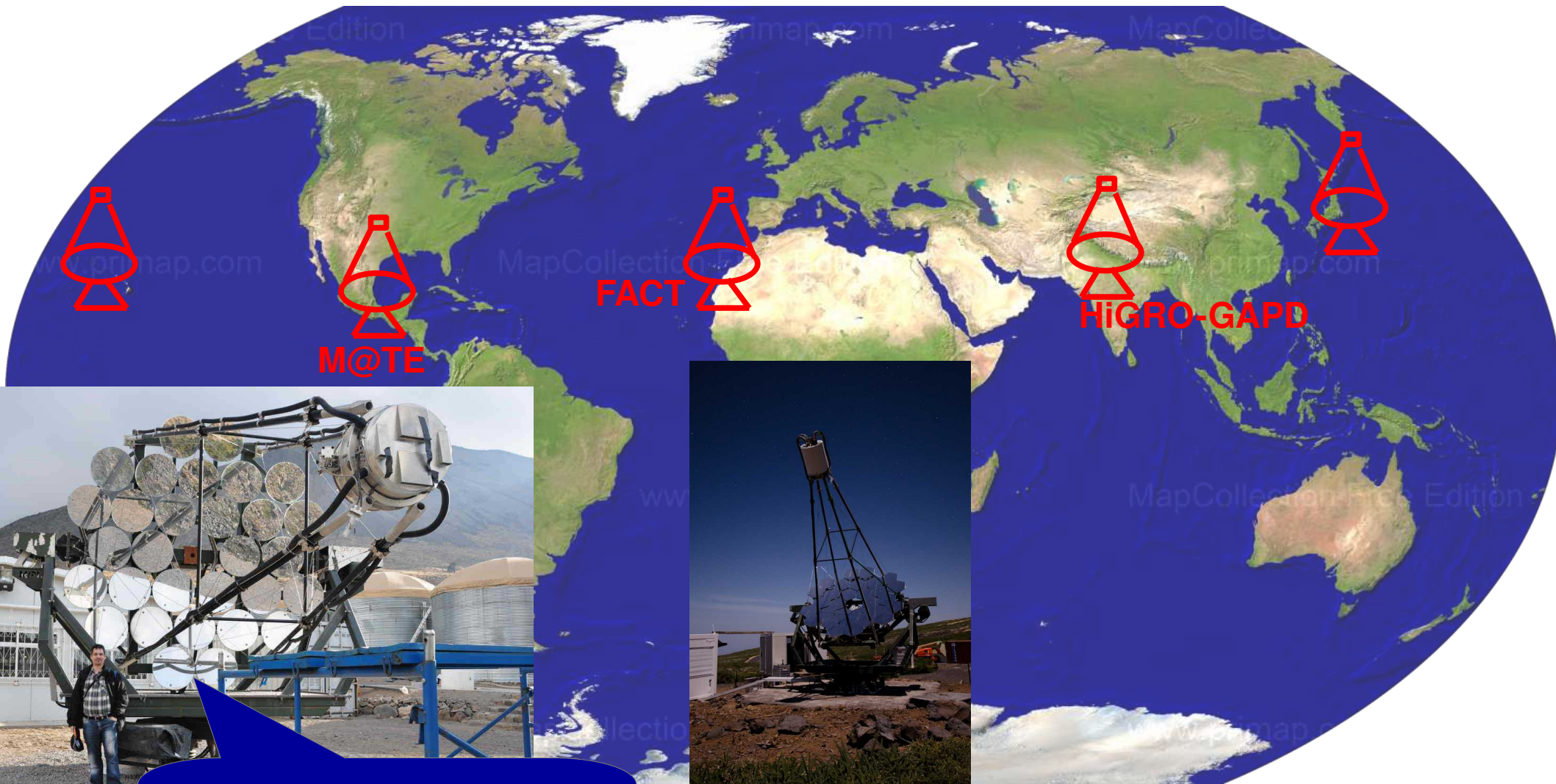
Unbiased Monitoring



Large High Altitude Air Shower Observatory



Future Monitoring



Poster:
M@TE – Extending the
Coverage of TeV Monitoring

Global monitoring network (M. Backes et. al ICRC 2009)



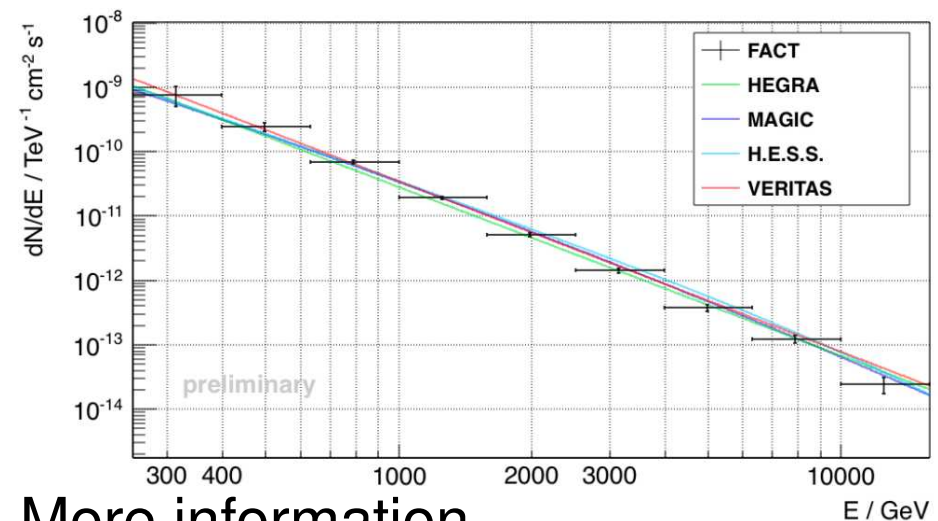
First G-APD Cherenkov Telescope

2200 m a.s.l., Observatorio del Roque de los Muchachos, La Palma



Photo: Thomas Krähenbühl

- Operational since Oct 2011
- 9.5 m² mirror area
- Camera: Silicon based photosensors (SiPM), 4.5° FoV, 1440 pixels à 0.11°
- Imaging Air-Cherenkov Technique
- Energy range: 300 GeV – 10 TeV



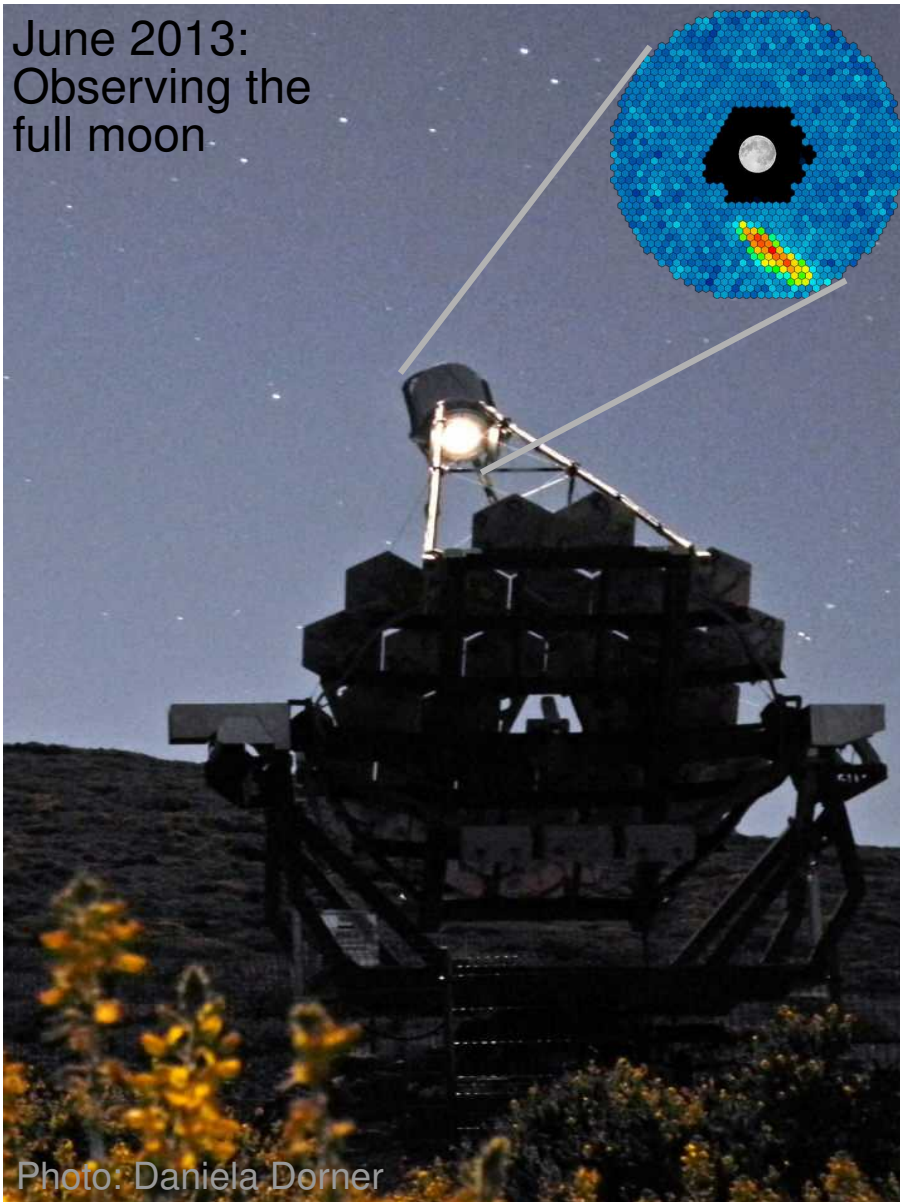
F. Temme et al. (FACT Collaboration), ICRC 2015

- More information

H Anderhub et al 2013 JINST 8 P06008
A Biland et al 2014 JINST 9 P10012

Poster:
FACT
Highlights

FACT – Ideal Monitoring Telescope



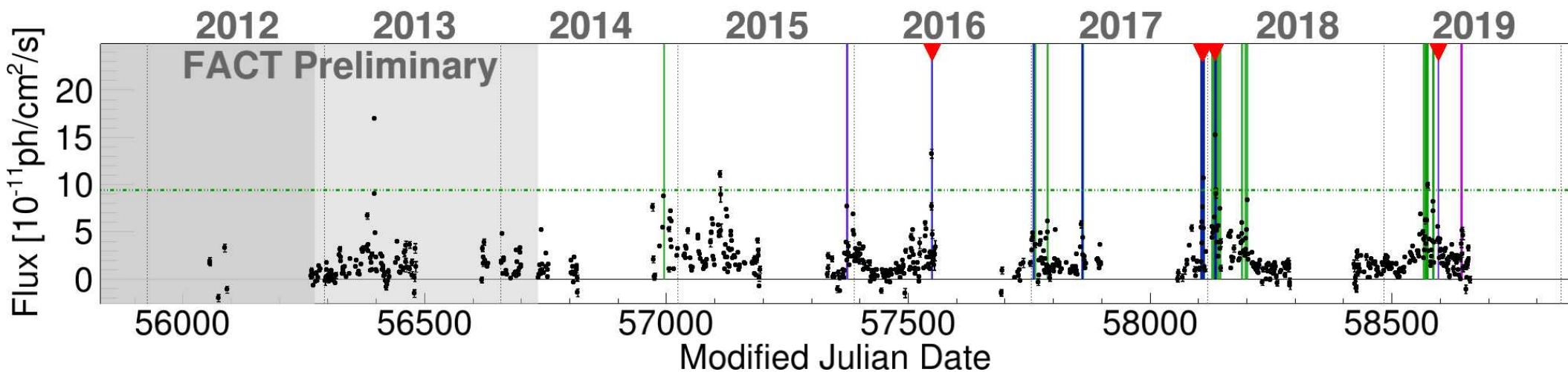
- Gain of SiPMs: no degradation when exposed to bright light
→ **Observations during strong moon light possible**
- SiPMs robust and stable
→ Stable telescope performance
→ Robotic operation
<https://www.fact-project.org/smartfact>
→ High data taking efficiency
- **More complete data sample**
→ Maximized duty cycle
→ Minimized gaps
→ Denser light curve
- FACT Observation Strategy
→ **Unbiased Monitoring**



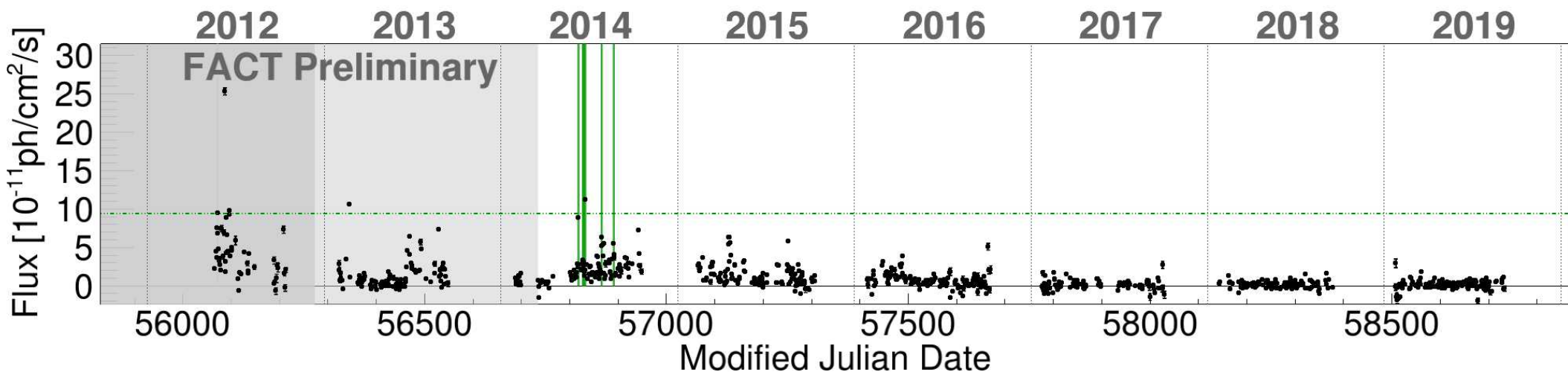
MoU & MWL partners
Swift-XRT
INTEGRAL
XMM-Newton
ATels

8 Years of Monitoring

Mrk 421



Mrk 501



MoU & MWL partners

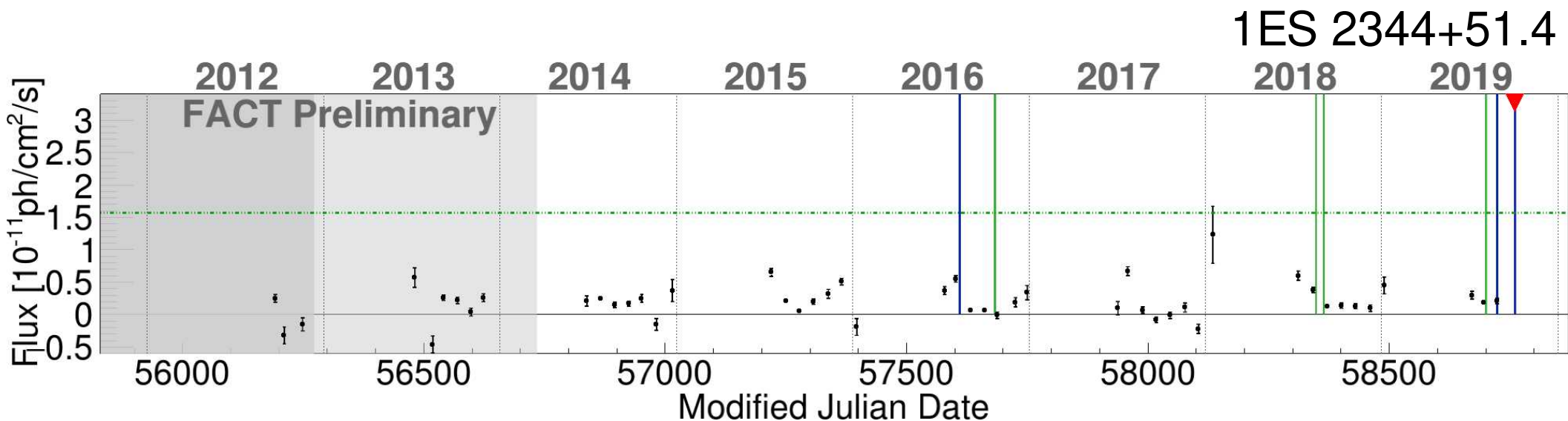
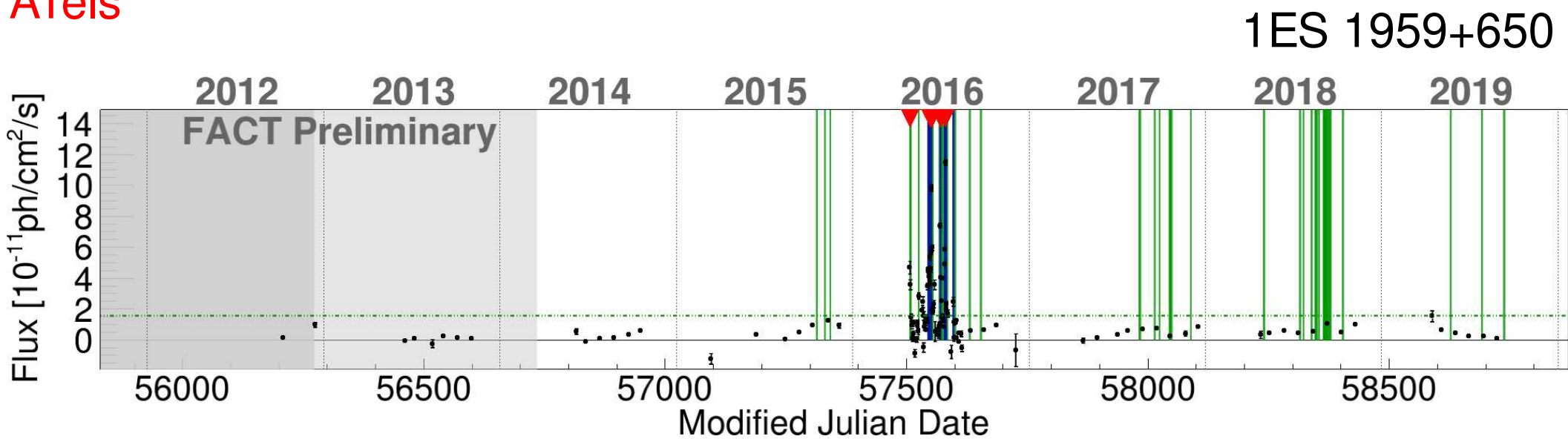
Swift-XRT

INTEGRAL

XMM-Newton

ATels

8 Years of Monitoring



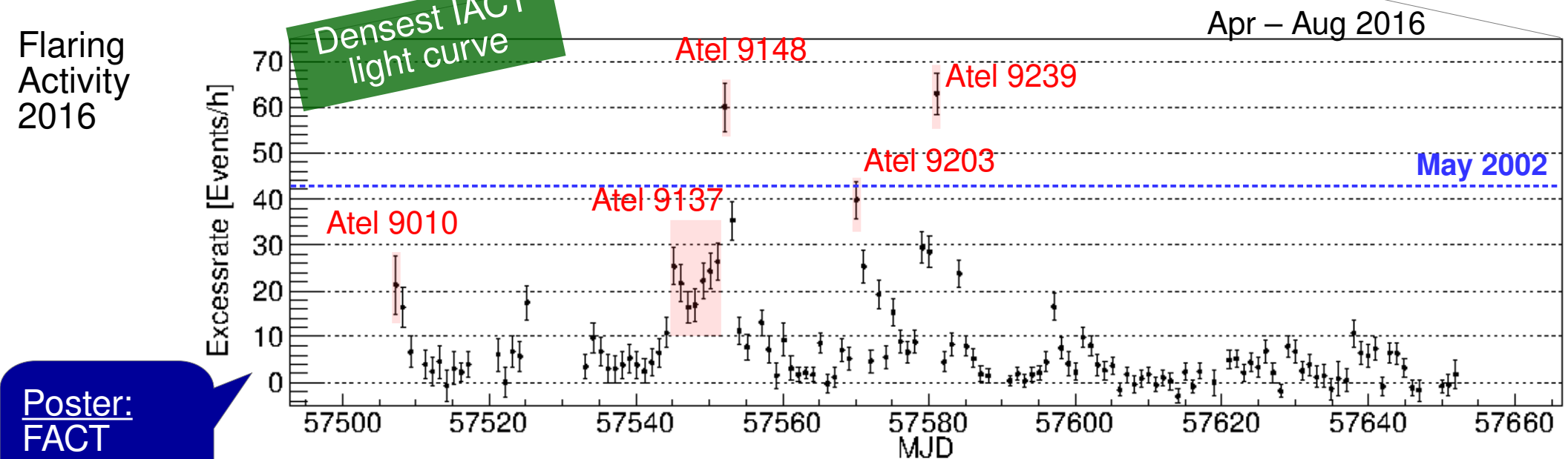
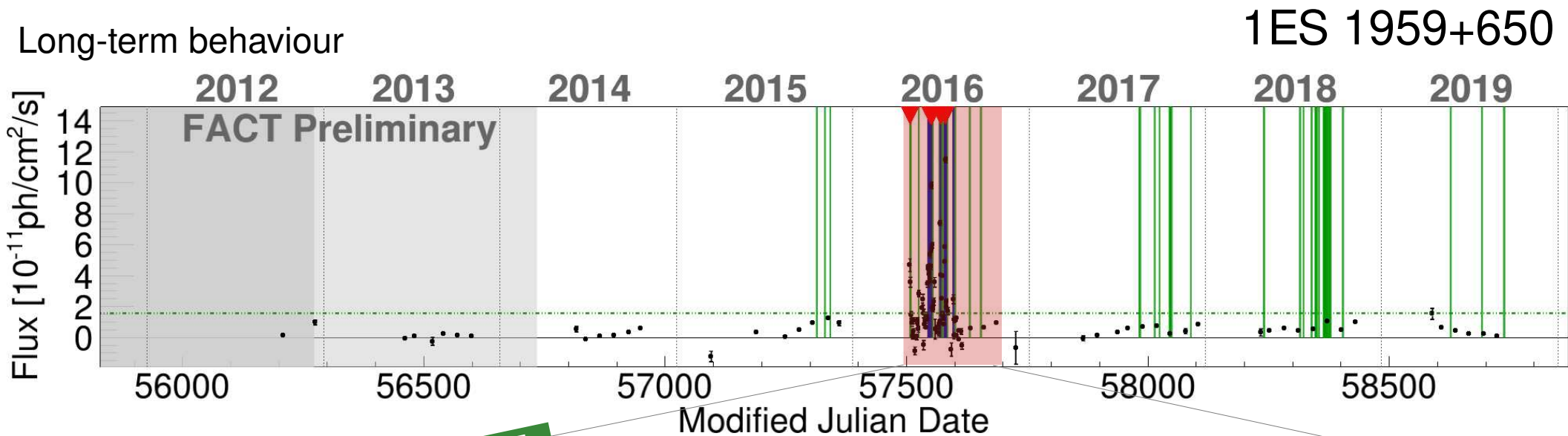
MWL and ToO Activities

- Multi-Messenger:
AMON Network
- Multi-Wavelength (MWL)
Projects: [joint with]
 - Mrk 501 Jun 2012 [MAGIC, MWL]
 - Mrk 501 Jun 2014 [H.E.S.S.]
 - Mrk 501 Jul 2014 [MAGIC, MWL]
 - Mrk 421 2015/2016 [MAGIC, MWL]
 - 1ES 1959+650 2016 [Fermi-LAT, VERITAS, IceCube, MAGIC, MWL]
 - Mrk 421 Dec 2015 [X-ray ToO]
 - 1ES 2344+51.4 [MAGIC, MWL]
 - Mrk 421 Jan 2018 [MAGIC, HAWC]
 - Mrk 421 Jan 2019 [AstroSAT, WEBT]
 - ...

- MWL Observations triggered by FACT
11 Atels
- Target-of-Opportunity (ToO) campaigns with X-ray satellites
101 alerts since March 2014
 - 2013: *XMM-Newton* / *Swift*
Successful ToO Dec 2015
 - 2015/6: *INTEGRAL* / *Swift*
Successful ToO June 2019
 - Ongoing: *INTEGRAL*, *Swift* and *XMM-Newton*



1ES 1959+650 @ TeV Energies

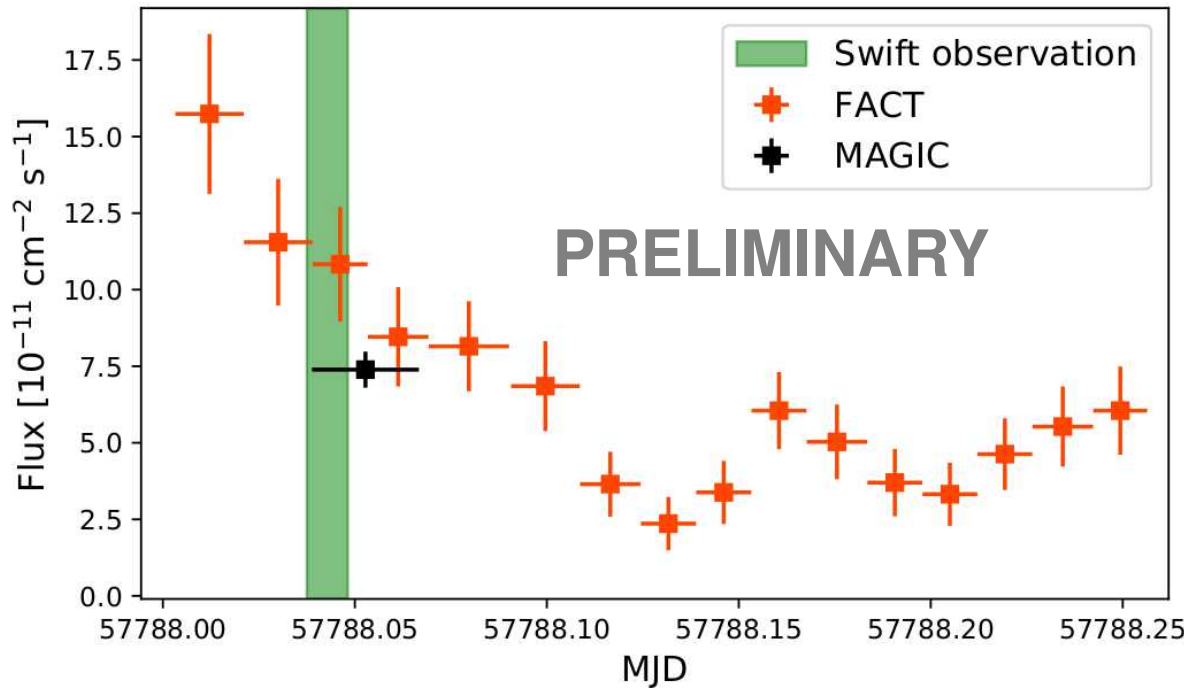
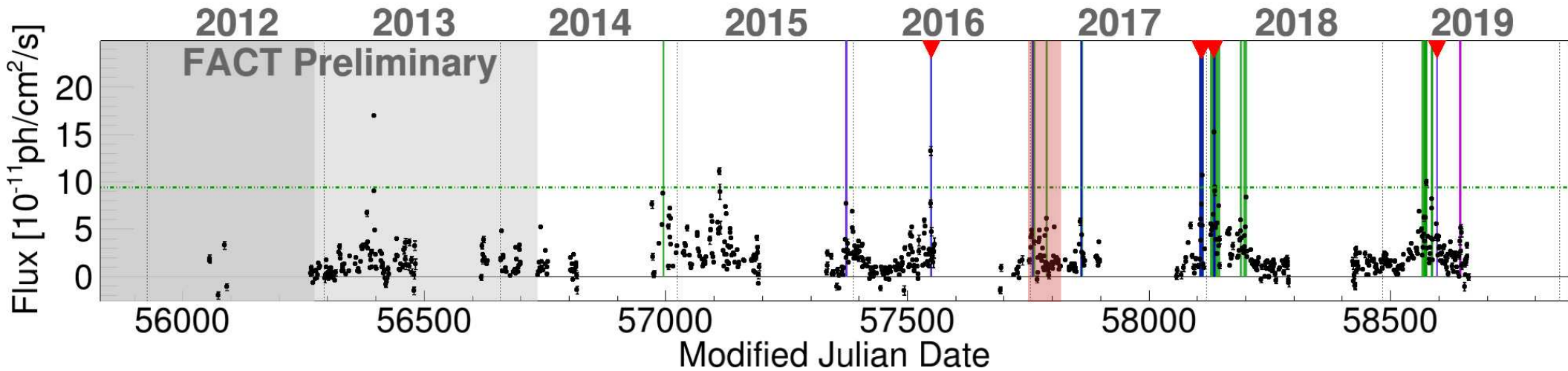


Poster:
FACT
Highlights



FACT: Results from > 8 years

Mrk 421

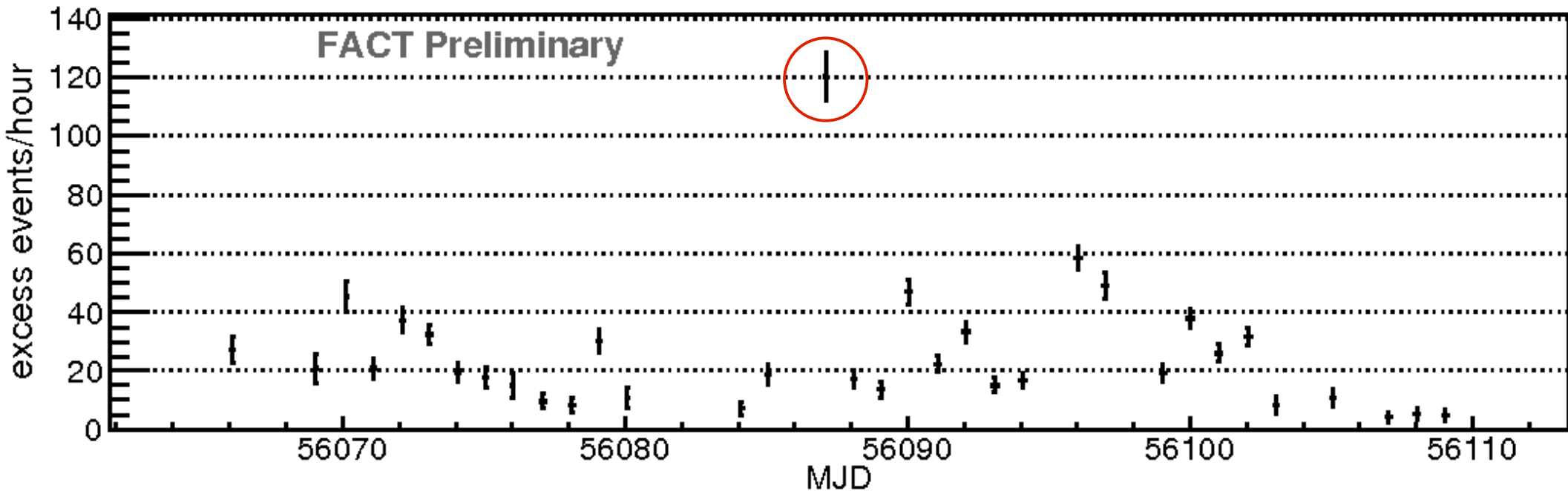


MWL campaign:
- NuStar observations
- Outburst in Feb 2017

paper in preparation

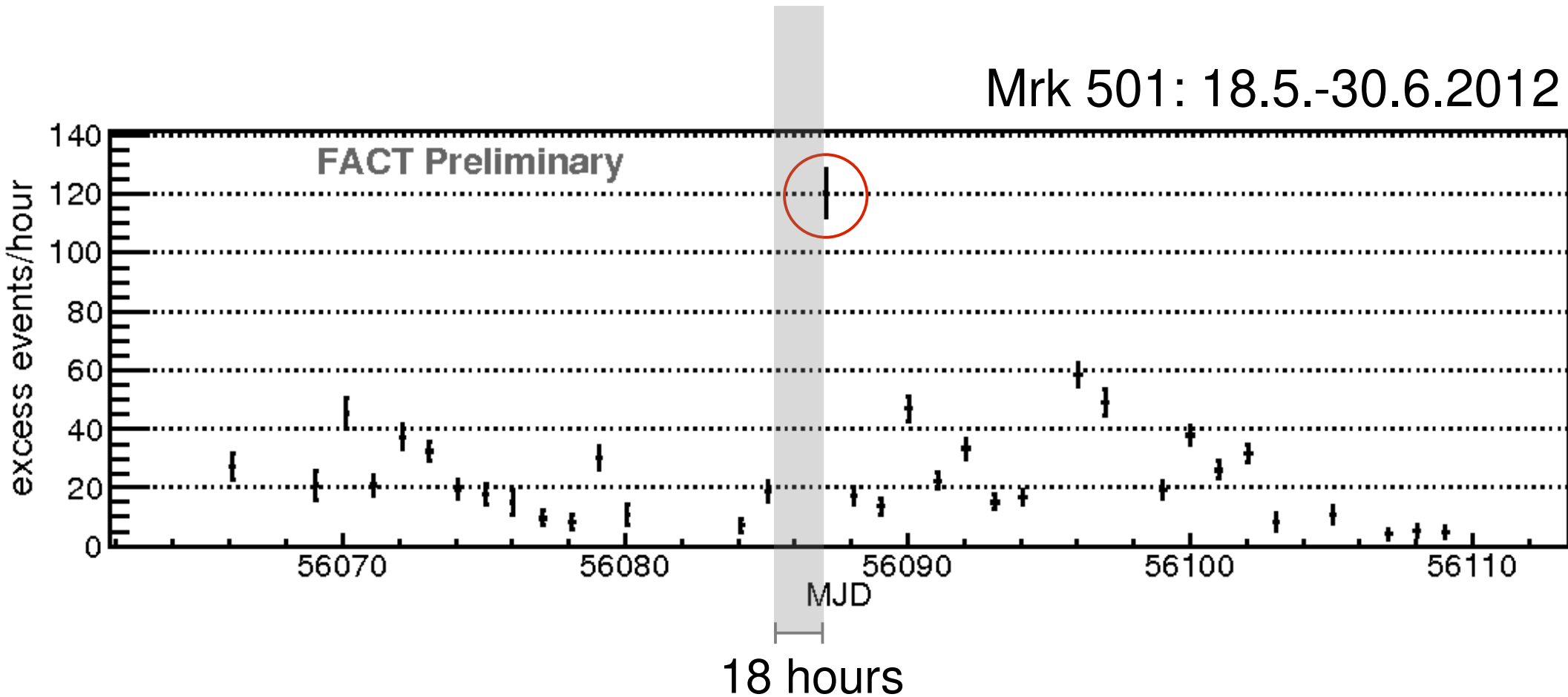
Short-time Variability

Mrk 501: 18.5.-30.6.2012



Short-time Variability

Mrk 501: 18.5.-30.6.2012



Monitoring @ Very High Energies



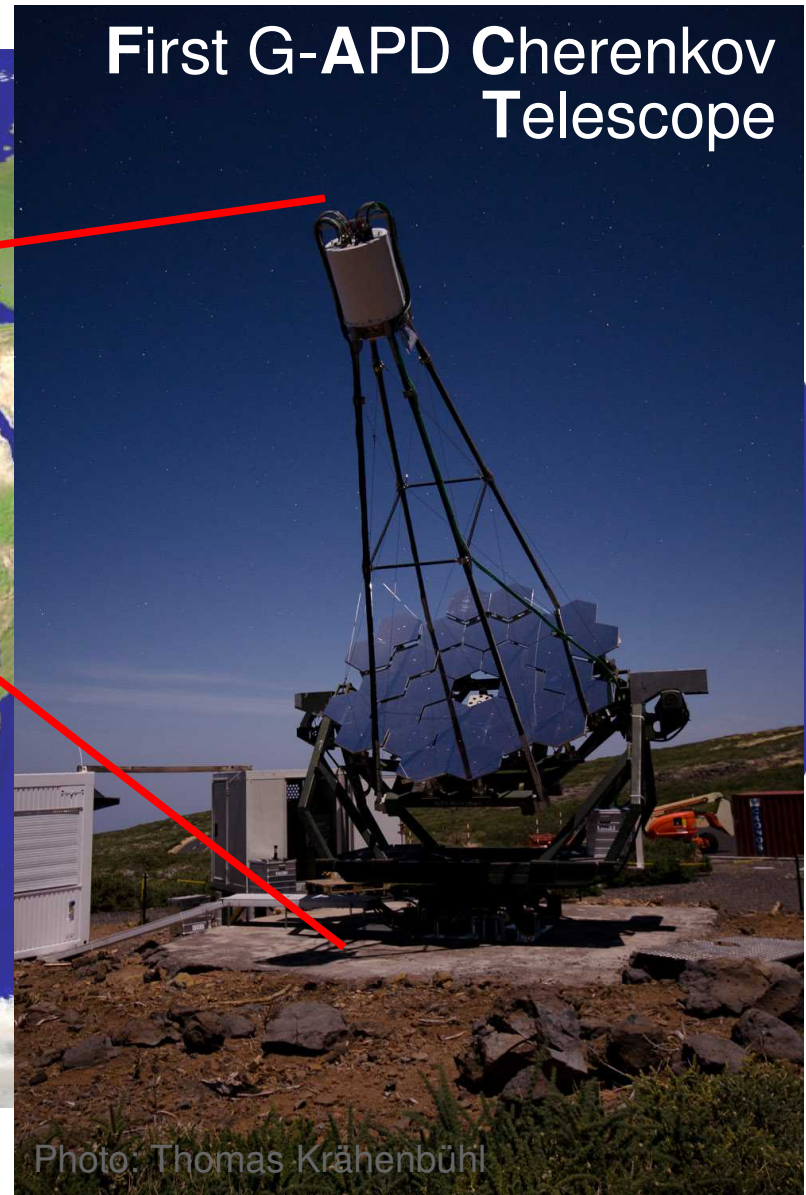
HAWC

FACT



High Altitude Water-Cherenkov Observatory

<http://www.hawc-observatory.org/>

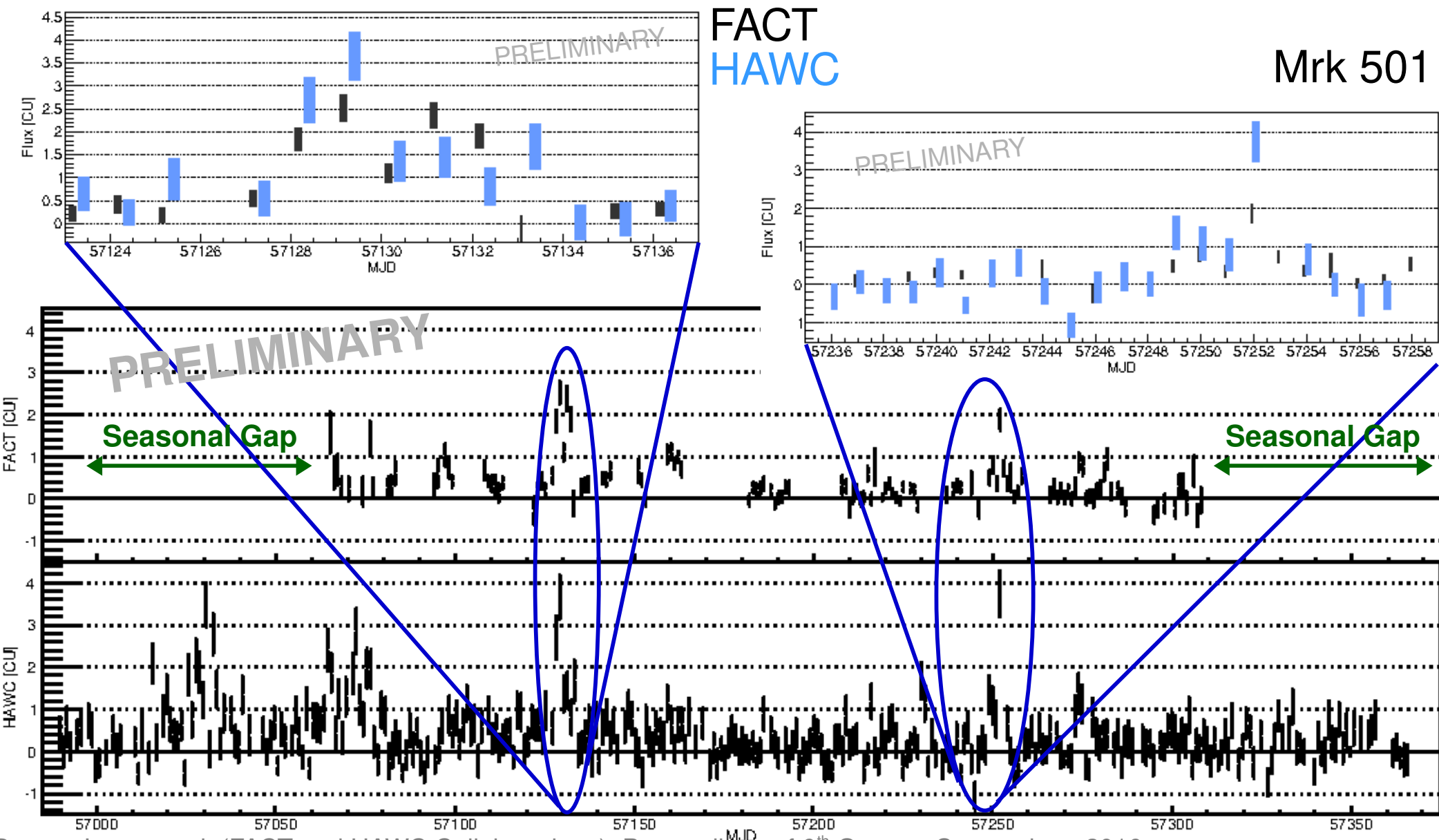


First G-APD Cherenkov Telescope

Photo: Thomas Krähenbühl

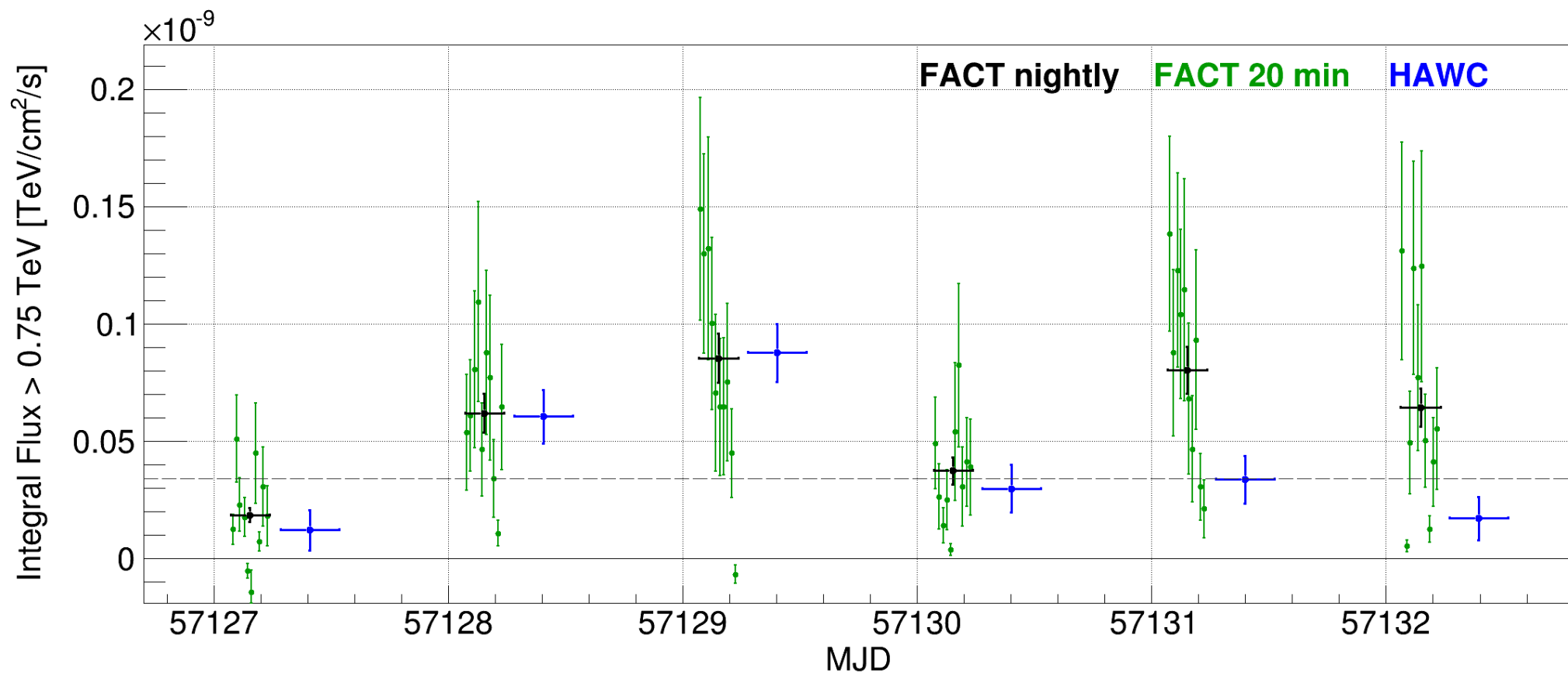


Combined HAWC & FACT Results



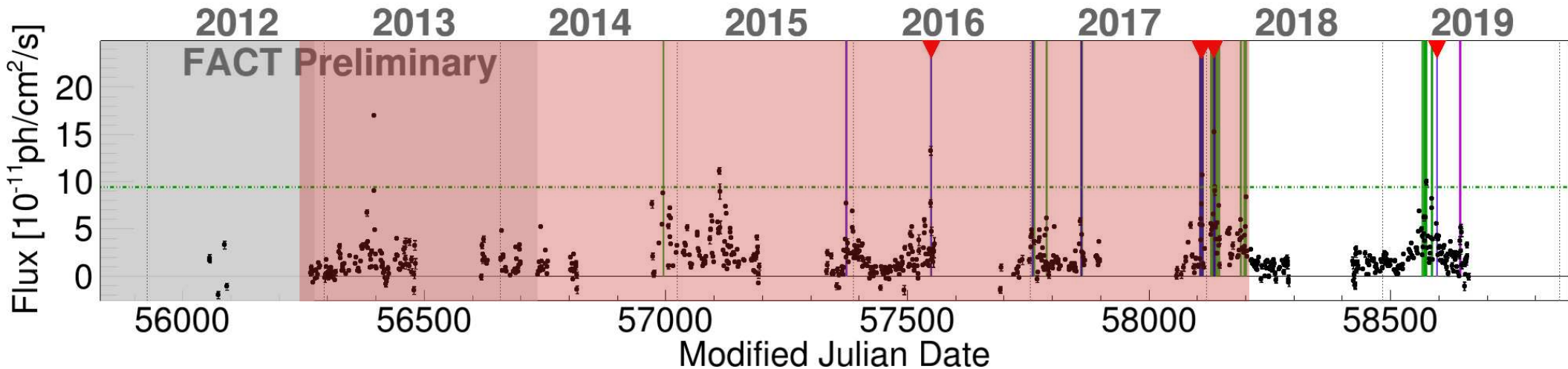
Dorner, Lauer et al. (FACT and HAWC Collaborations), Proceedings of 6th Gamma Symposium, 2016

Combined HAWC & FACT Results



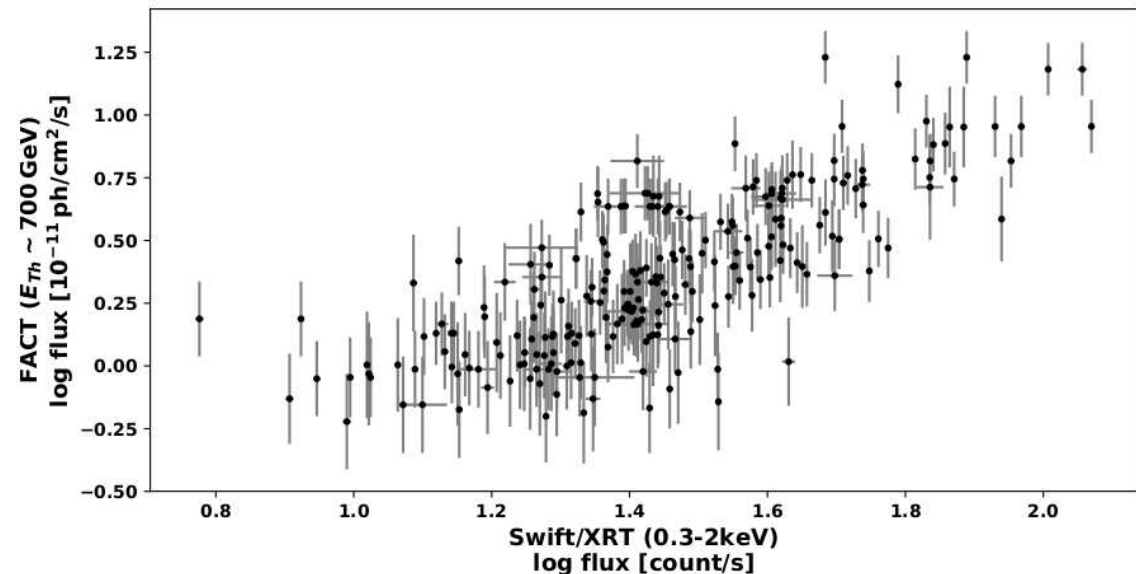
Mrk 421: Long-term Study

Mrk 421



Data sample: 5.5 years
Dec 2012 – April 2018
*FACT, Fermi-LAT, Swift-BAT,
Swift-XRT, Swift-UVOT,
OVRO, optical*

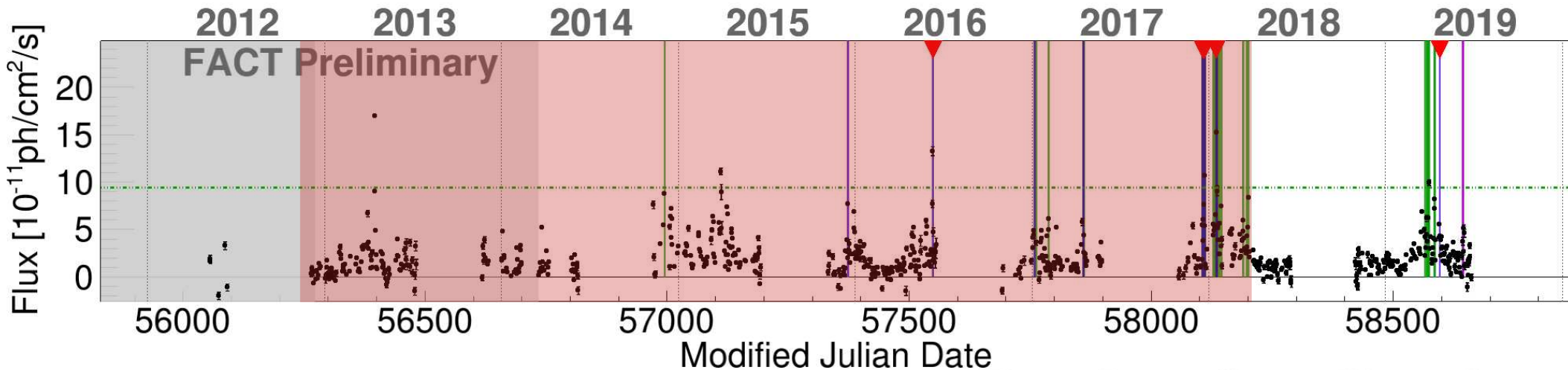
Poster:
FACT
Highlights



Arbet-Engels et al. (FACT Coll.), A&A, 647, 2021

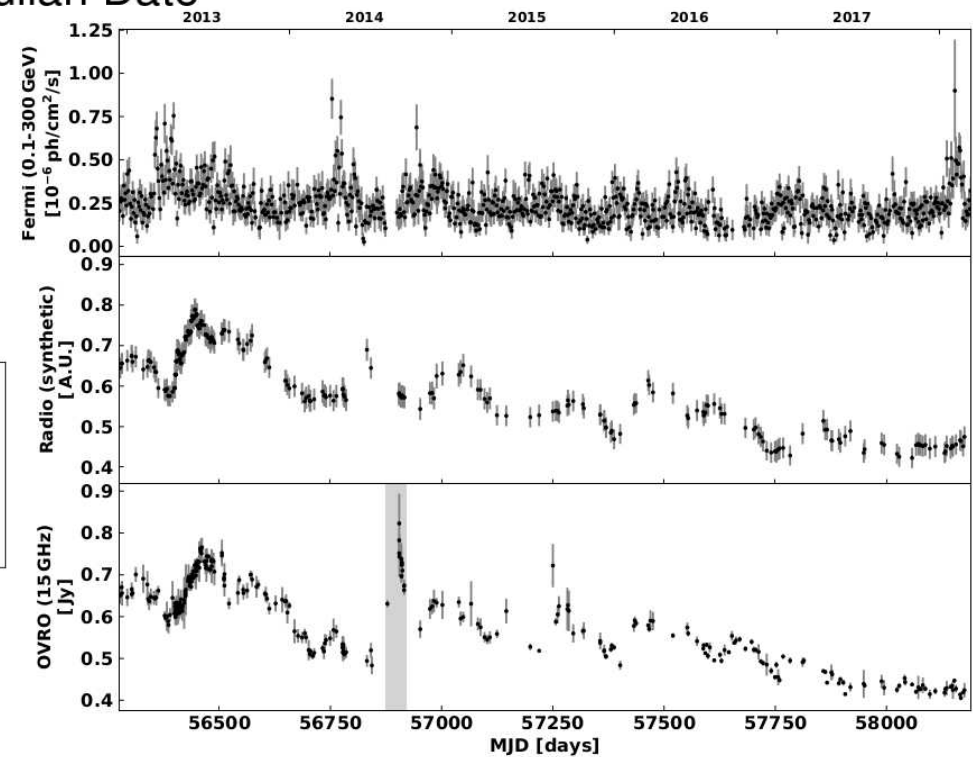
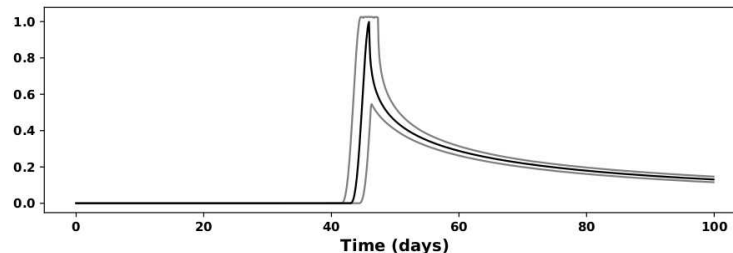
Mrk 421: Long-term Study

Mrk 421



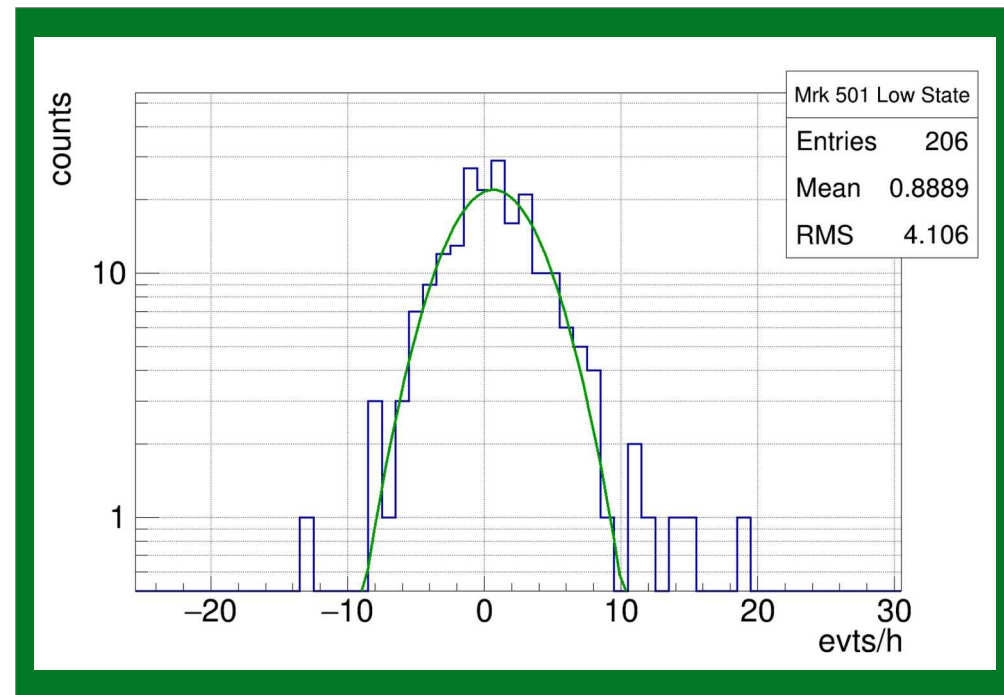
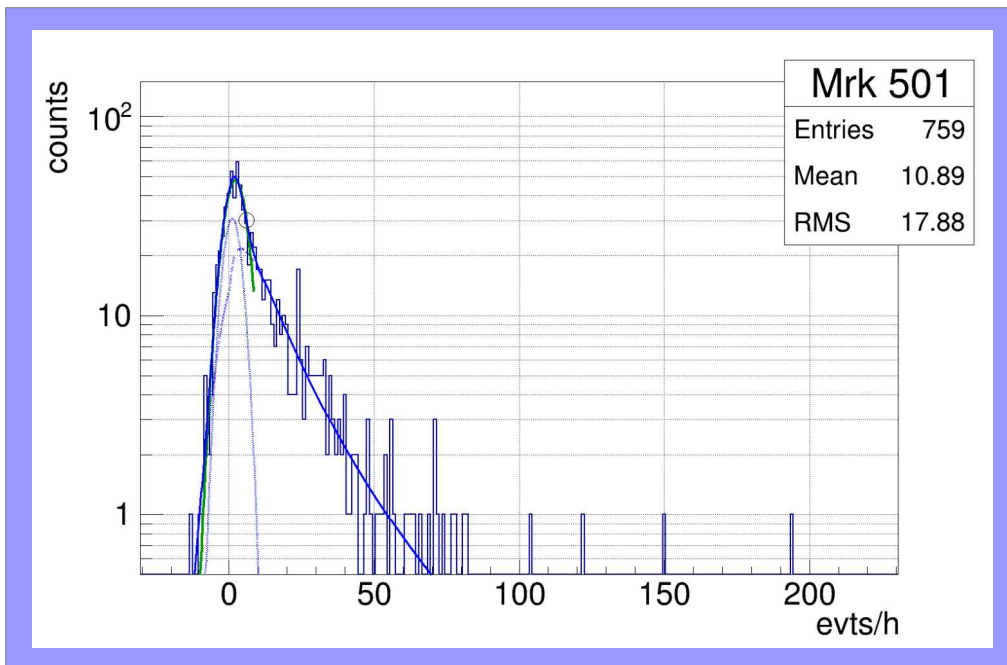
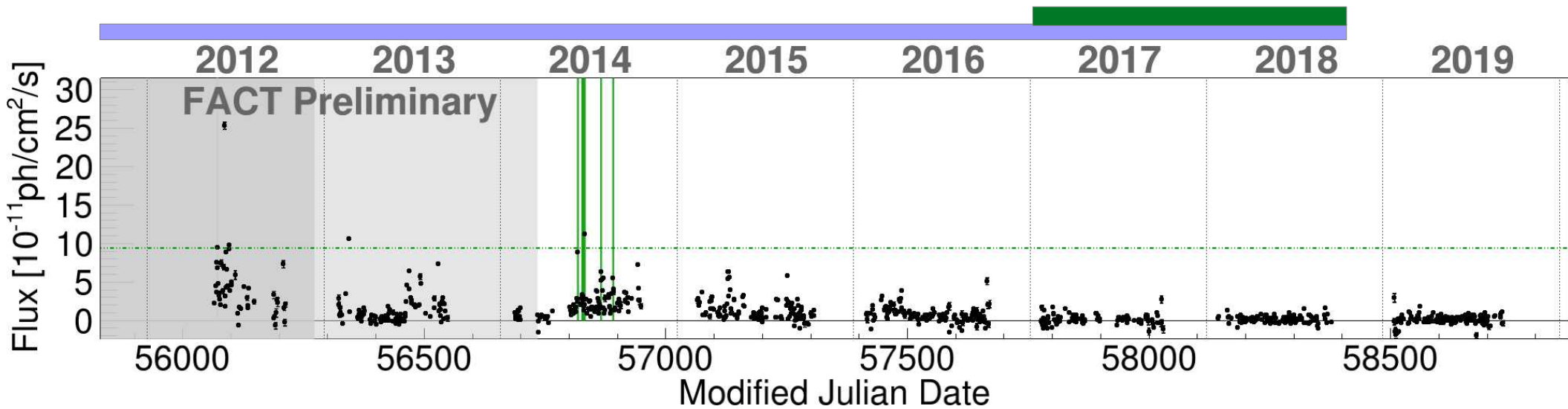
Data sample: 5.5 years
Dec 2012 – April 2018
*FACT, Fermi-LAT, Swift-BAT,
Swift-XRT, Swift-UVOT,
OVRO, optical*

Poster:
FACT
Highlights



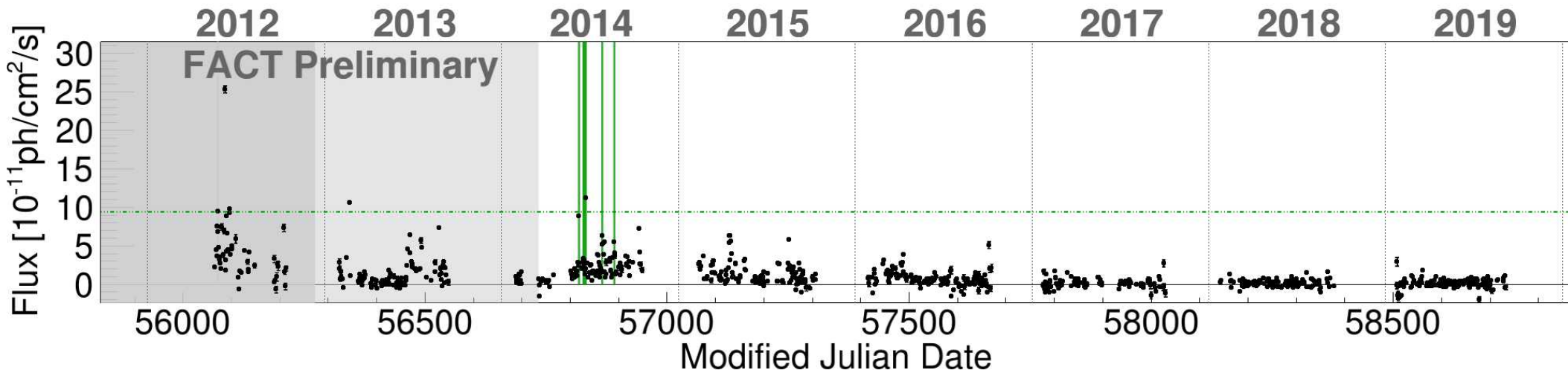
Arbet-Engels et al. (FACT Coll.), A&A, 647, 2021

Mrk 501: Historical Low State

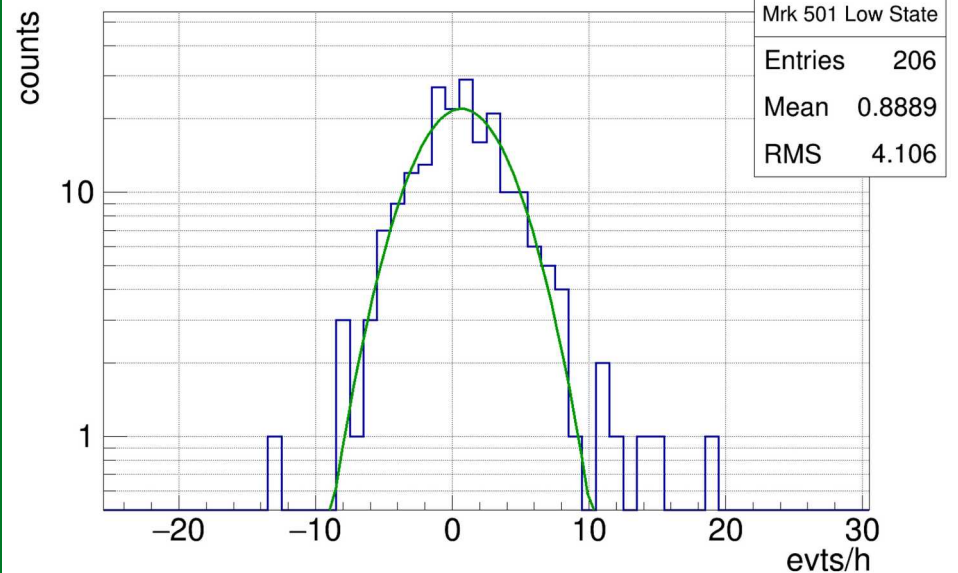


D. Dorner et al. (FACT Collaboration), *Galaxies* 2019, 7(2), 57

Mrk 501: Historical Low State

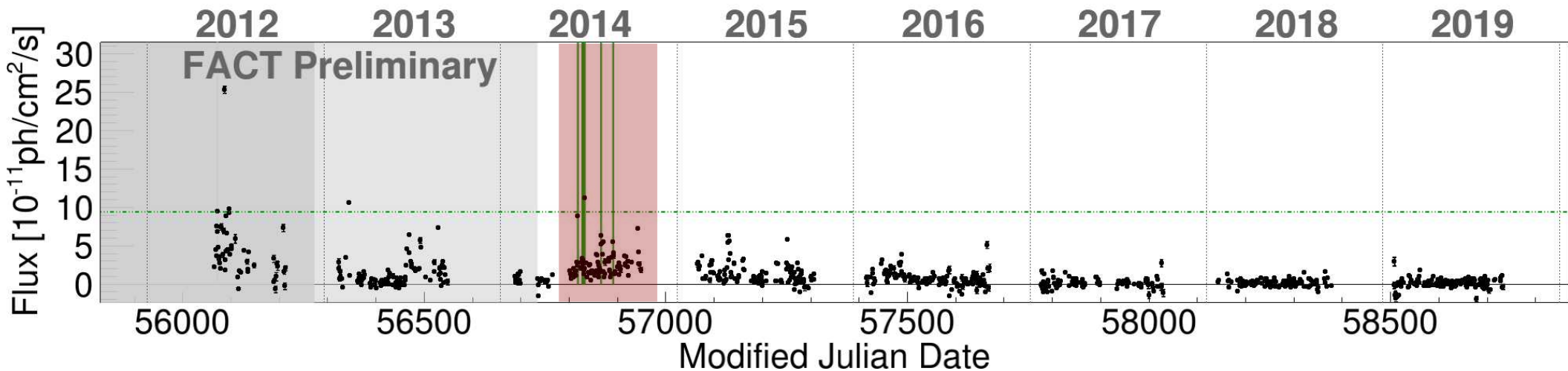


Steady state flux:
Upper limit:
2% of flux of the Crab
Nebula @TeV energies



D. Dorner et al. (FACT Collaboration), *Galaxies* 2019, 7(2), 57

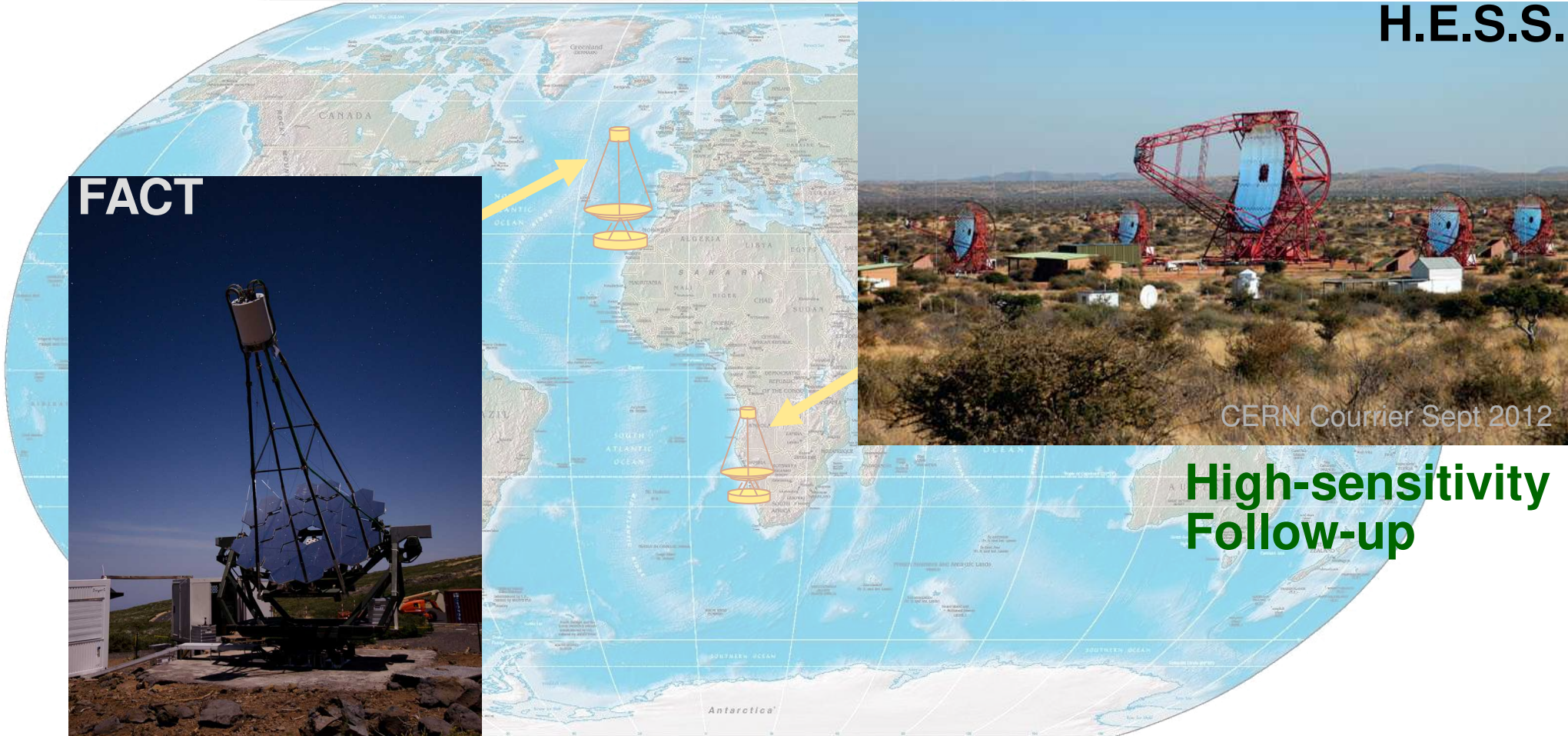
Mrk 501: Flaring Episode 2014



Romoli et al., Galaxies 6 (2018)
H.E.S.S. and FACT Collaborations, in preparation



Monitoring at GeV Energies



FACT

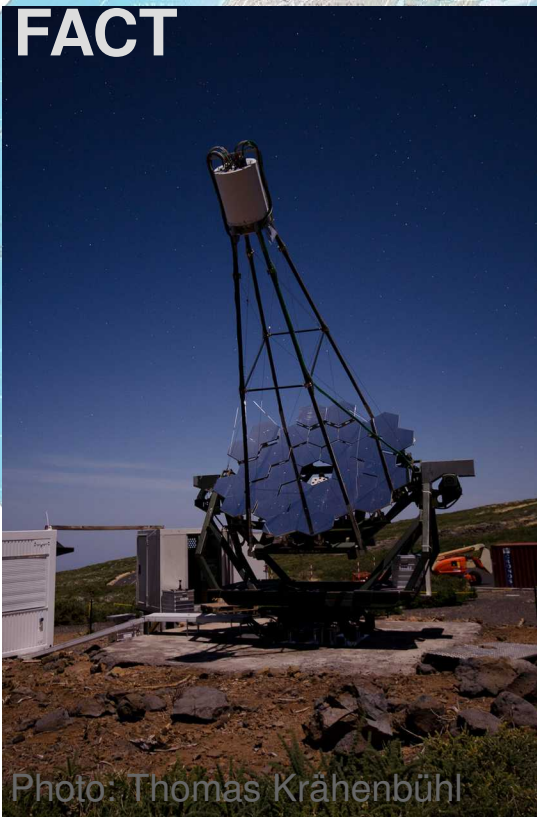


Photo: Thomas Krähenbühl

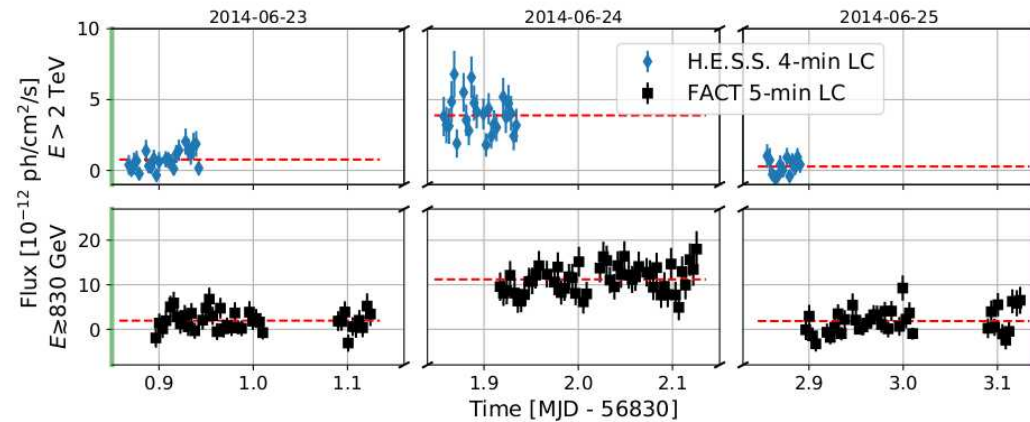
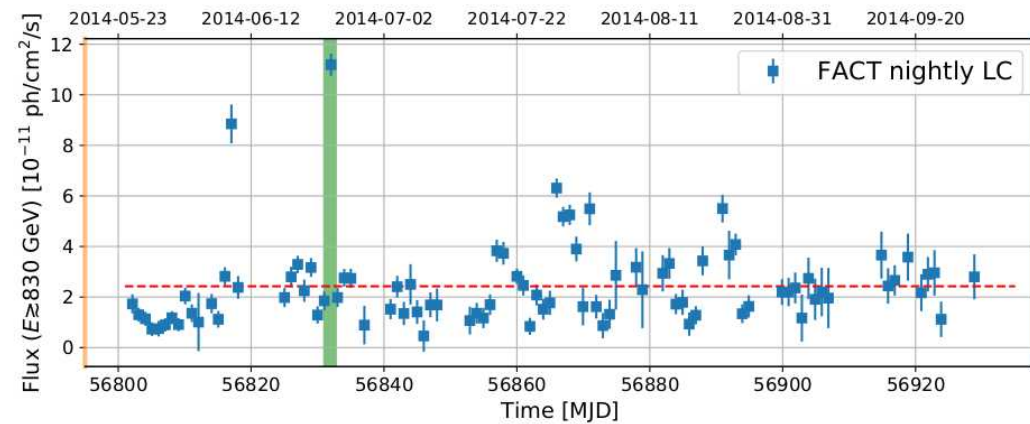
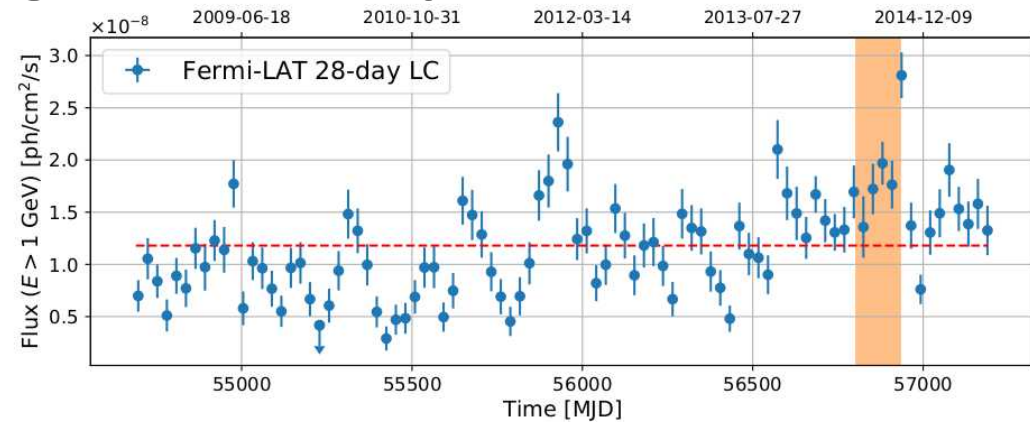
CERN Courier Sept 2012

High-sensitivity Follow-up

Monitoring at TeV Energies

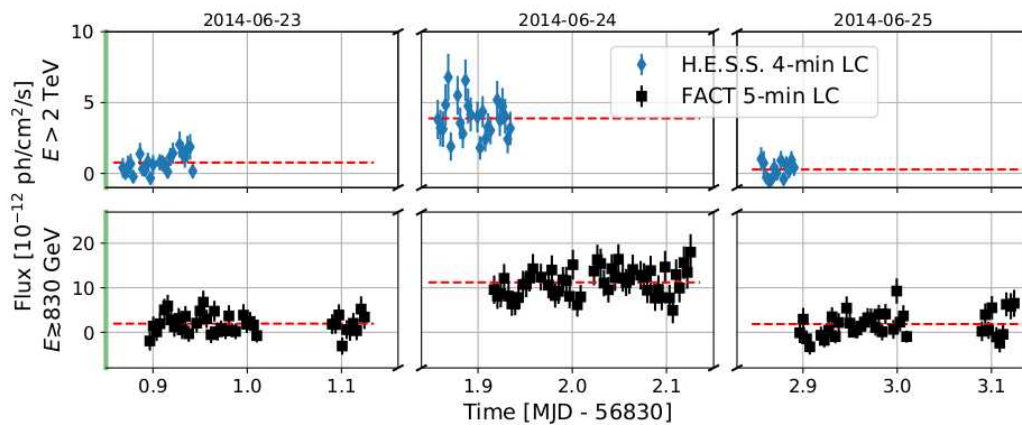
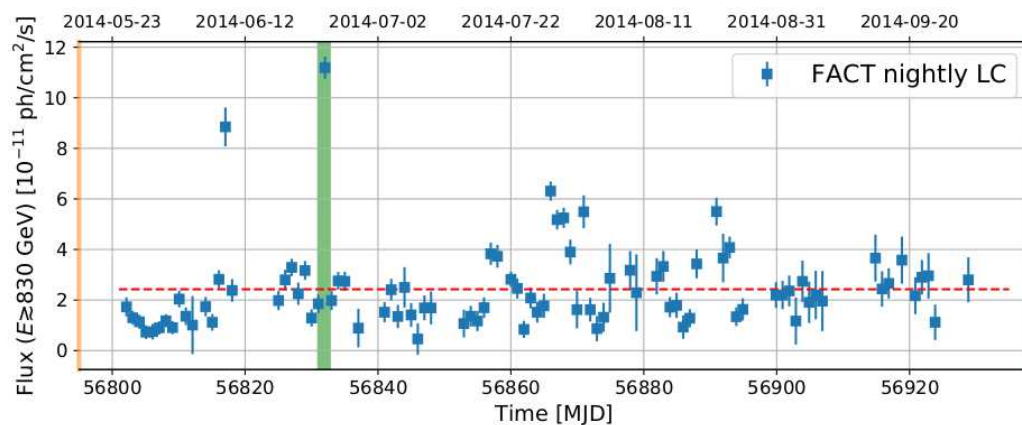
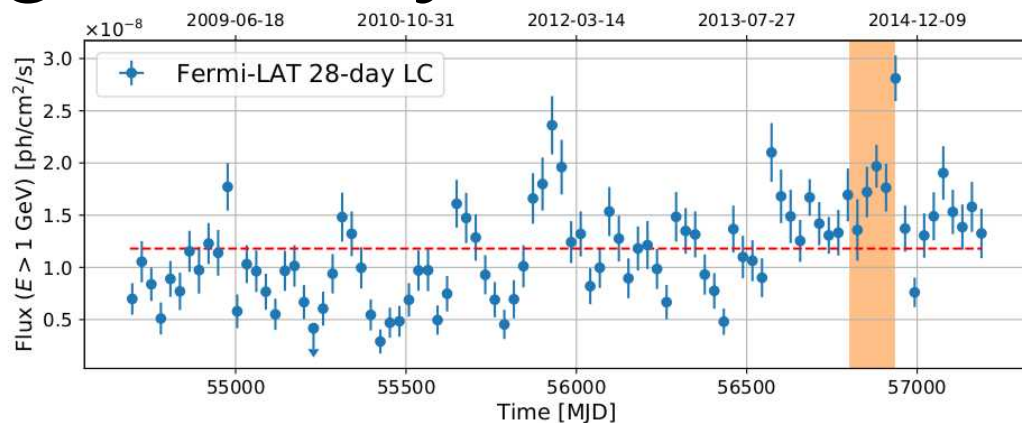
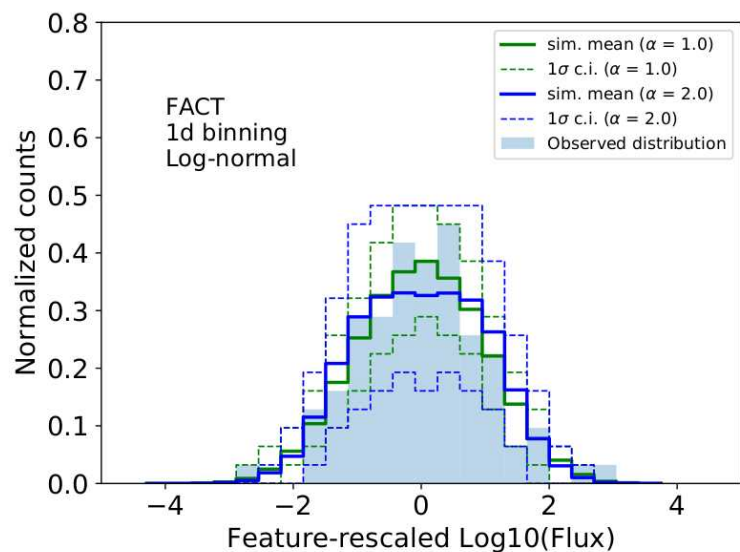
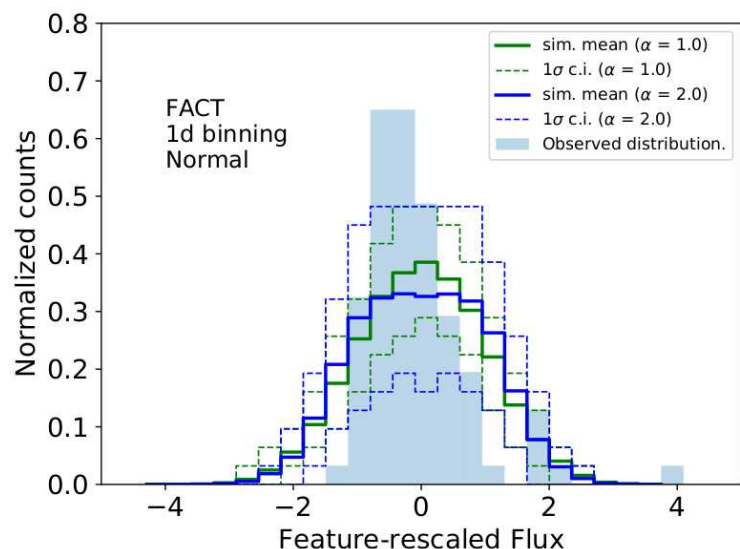


Mrk 501: Flaring Activity 2014



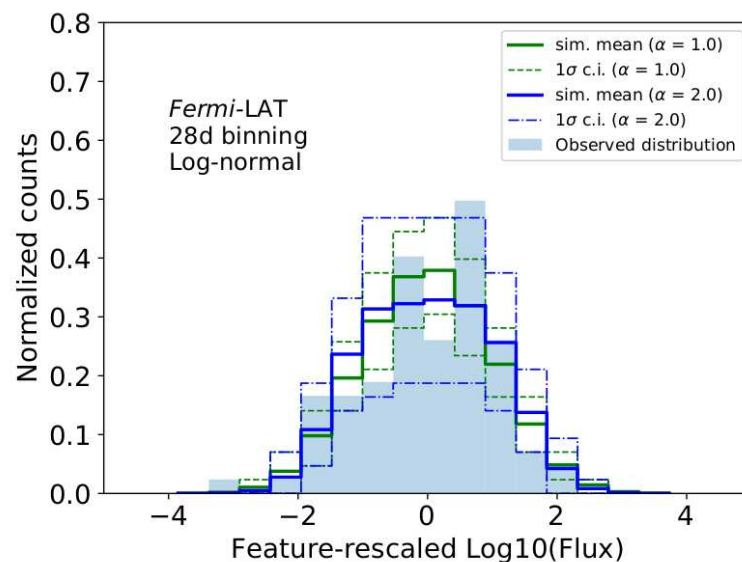
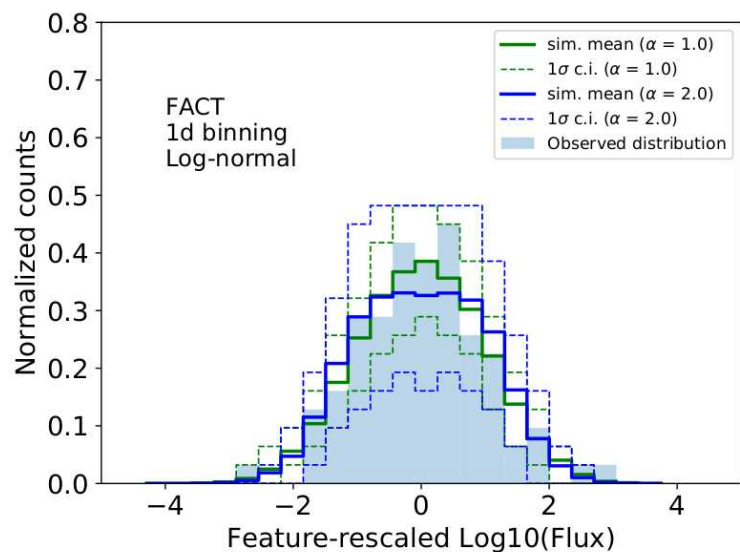
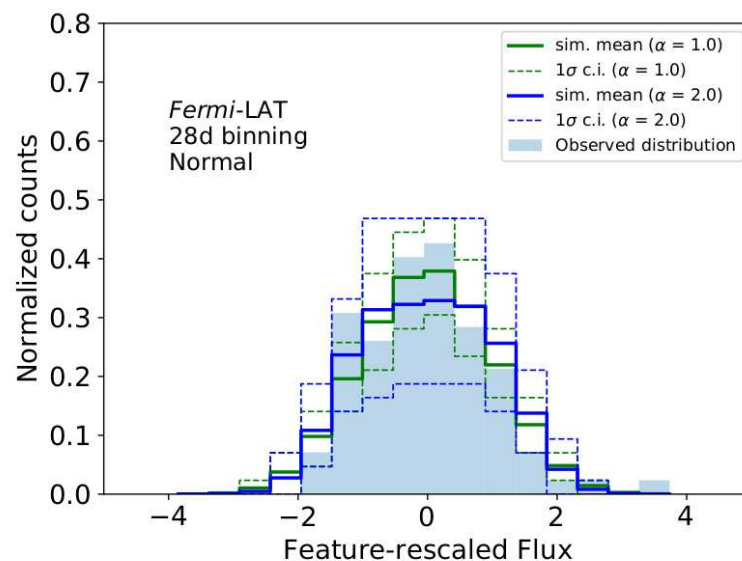
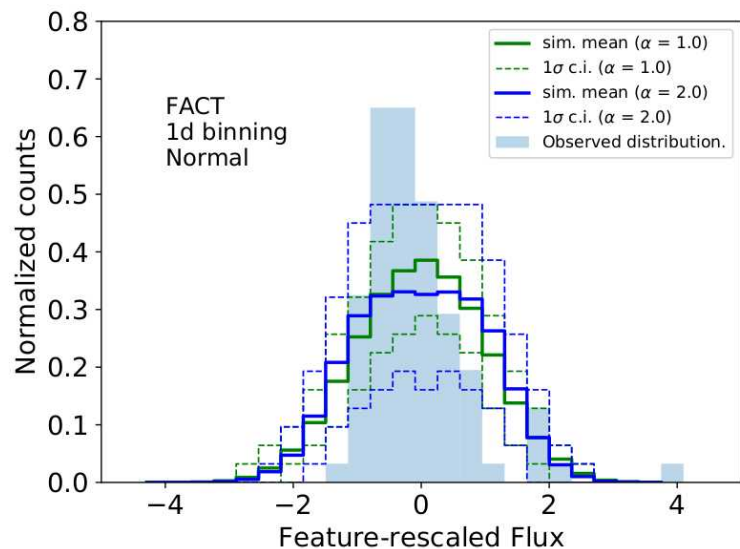
Romoli et al., Galaxies 6 (2018)
H.E.S.S. and FACT Collaborations, in preparation

Mrk 501: Flaring Activity 2014



Romoli et al., Galaxies 6 (2018)
H.E.S.S. and FACT Collaborations, in preparation

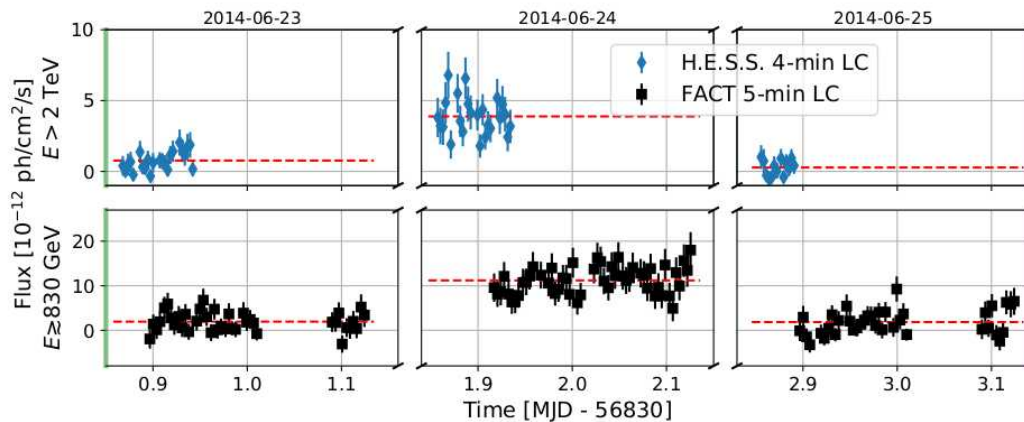
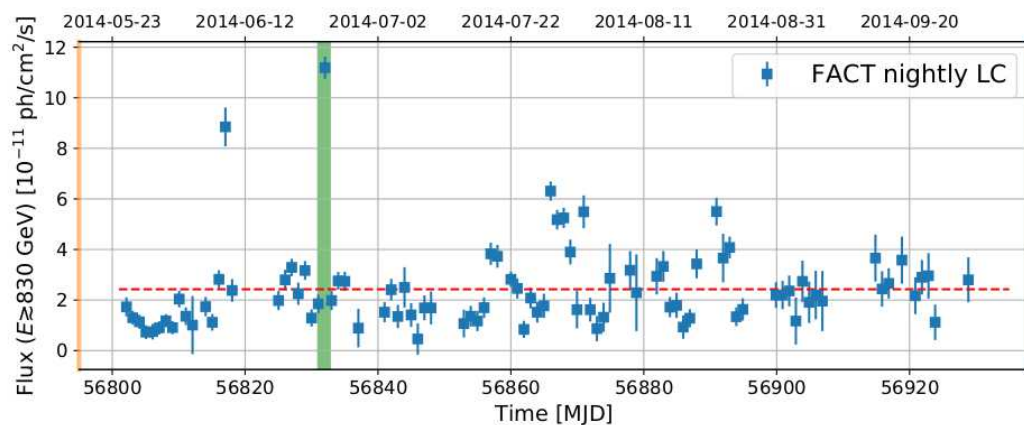
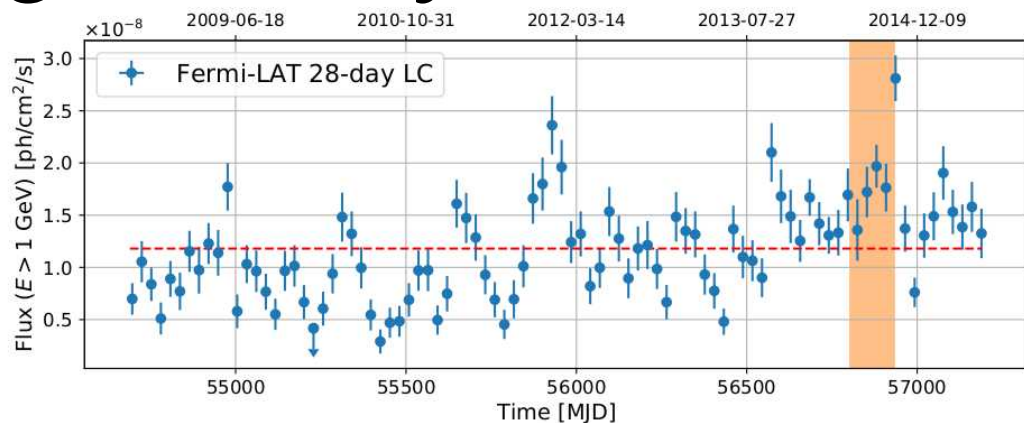
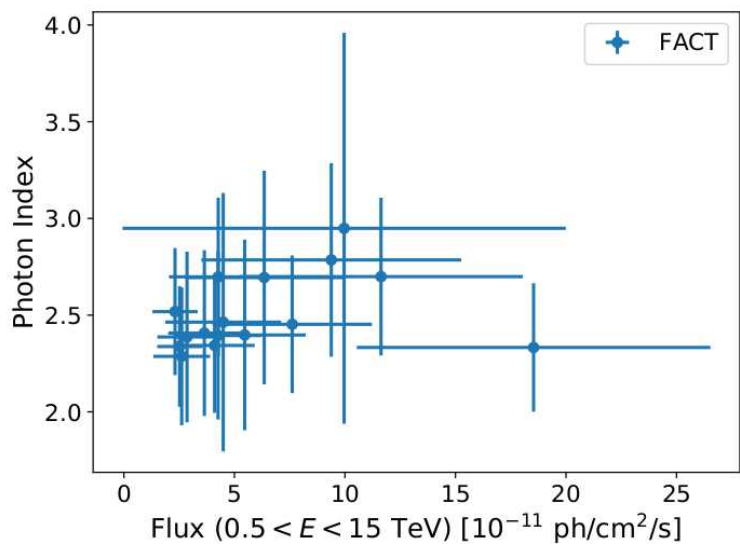
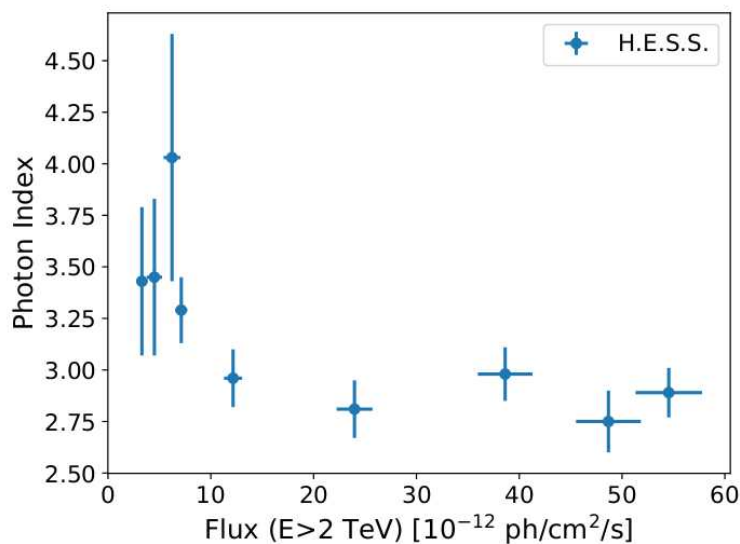
Mrk 501: Flaring Activity 2014



Romoli et al., Galaxies 6 (2018)
H.E.S.S. and FACT Collaborations, in preparation

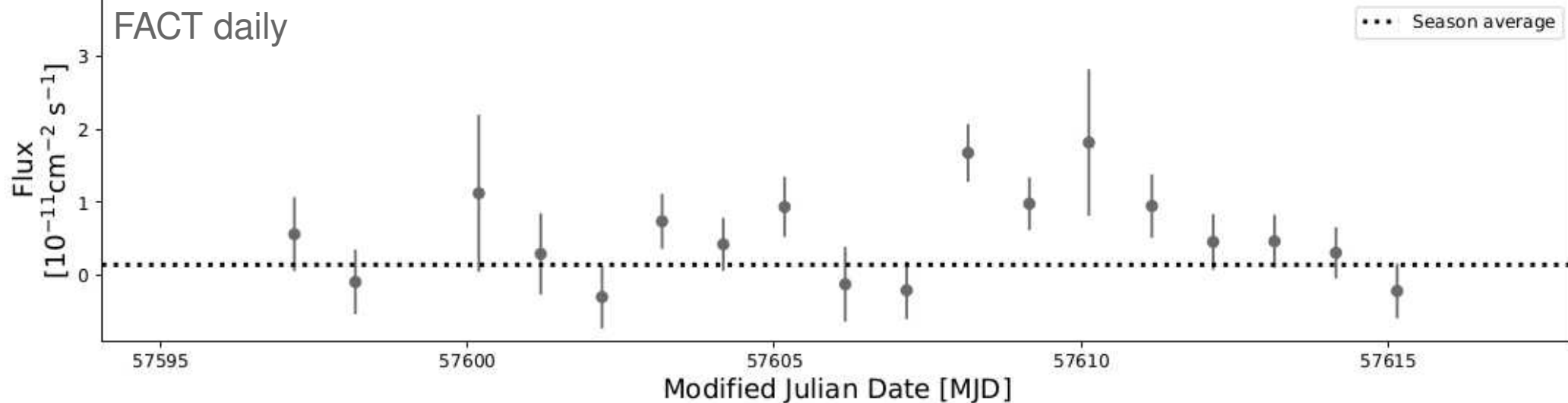
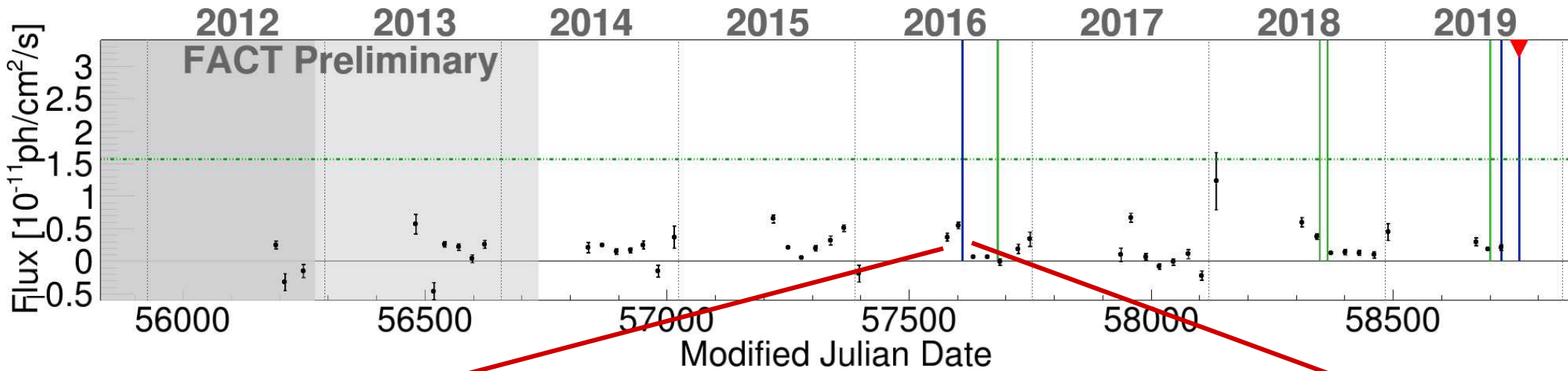


Mrk 501: Flaring Activity 2014



Romoli et al., Galaxies 6 (2018)
H.E.S.S. and FACT Collaborations, in preparation

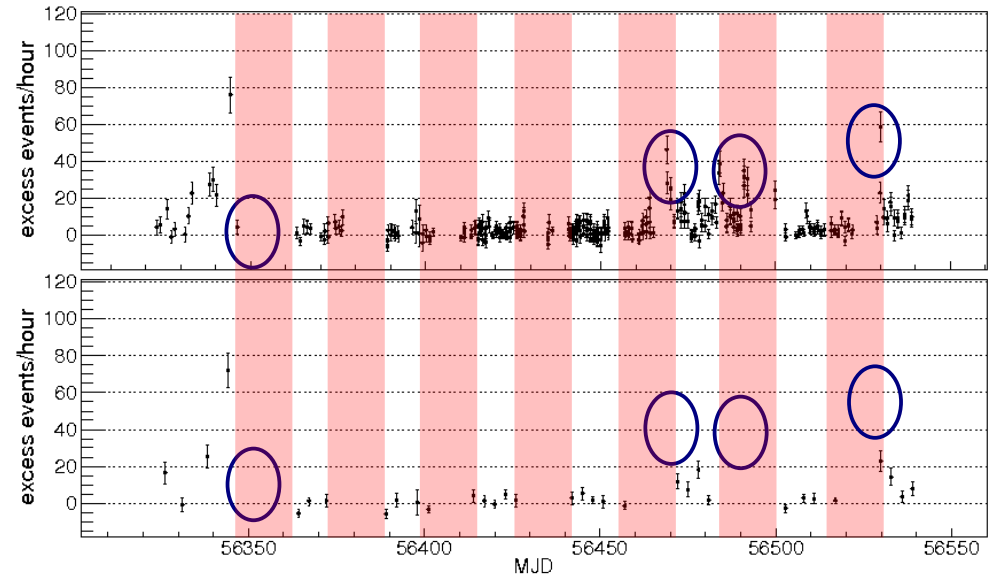
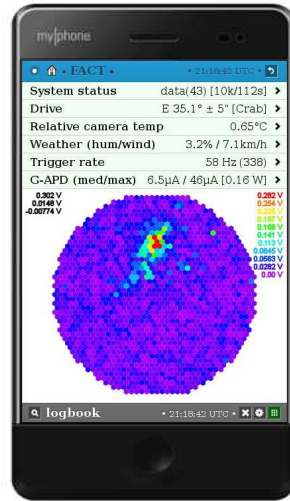
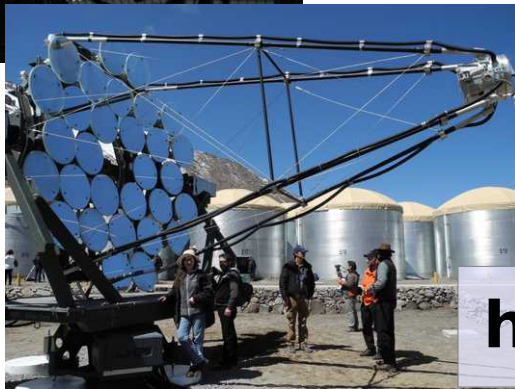
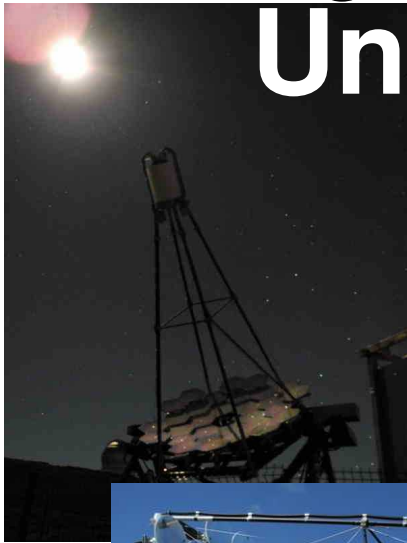
1ES 2344+51.4



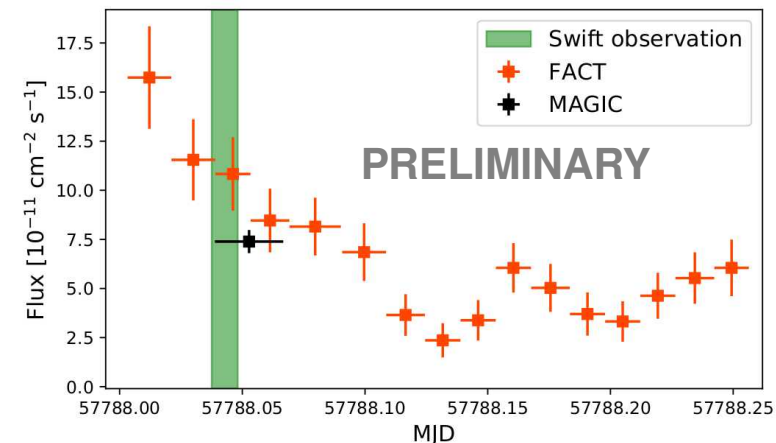
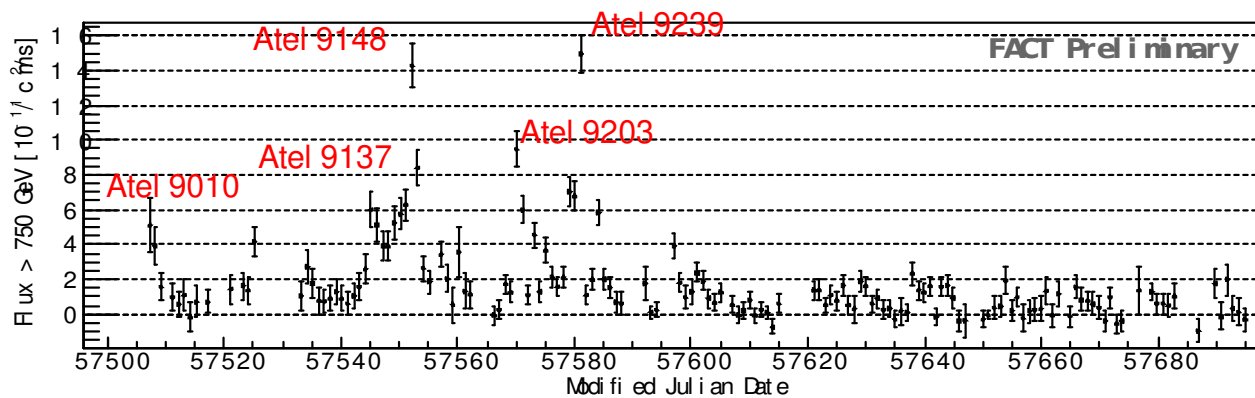
V. A. Acciari et al. (MAGIC, FACT, others), MNRAS 498, 3 (2020)

Long-term Studies @TeV Energies

Unbiased Monitoring & ToO



<http://www.fact-project.org/monitoring>





Thank you for your attention!