Interactions between FACT and HAWC

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First G-**A**PD **C**herenkov **T**elescope
Major Goals

Proof of principle:

Silicon based photo sensors (G-APDs*) in Cherenkov Telescopes

✓ Successful operation since October 2011

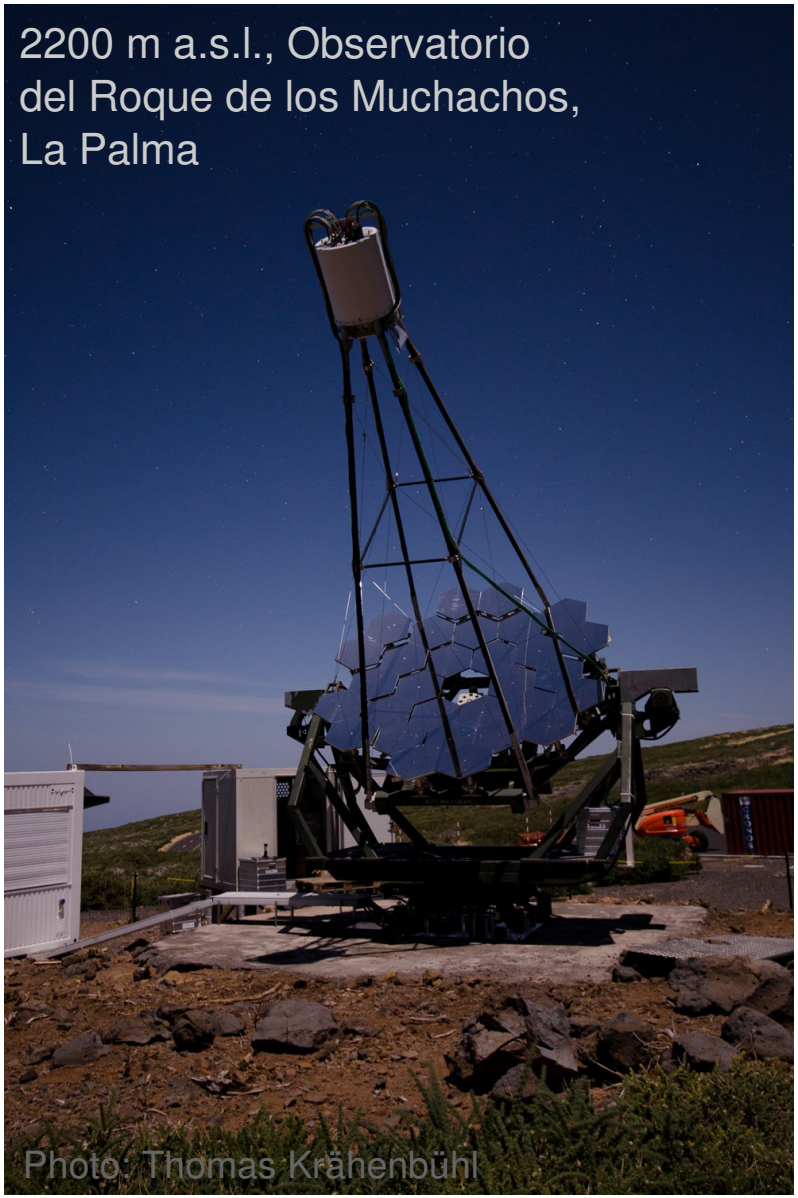
Long-term monitoring of bright TeV Blazars

→ Flare studies Active Galactic Nuclei
→ Multi-wavelength studies
→ Flare alerts to other instruments

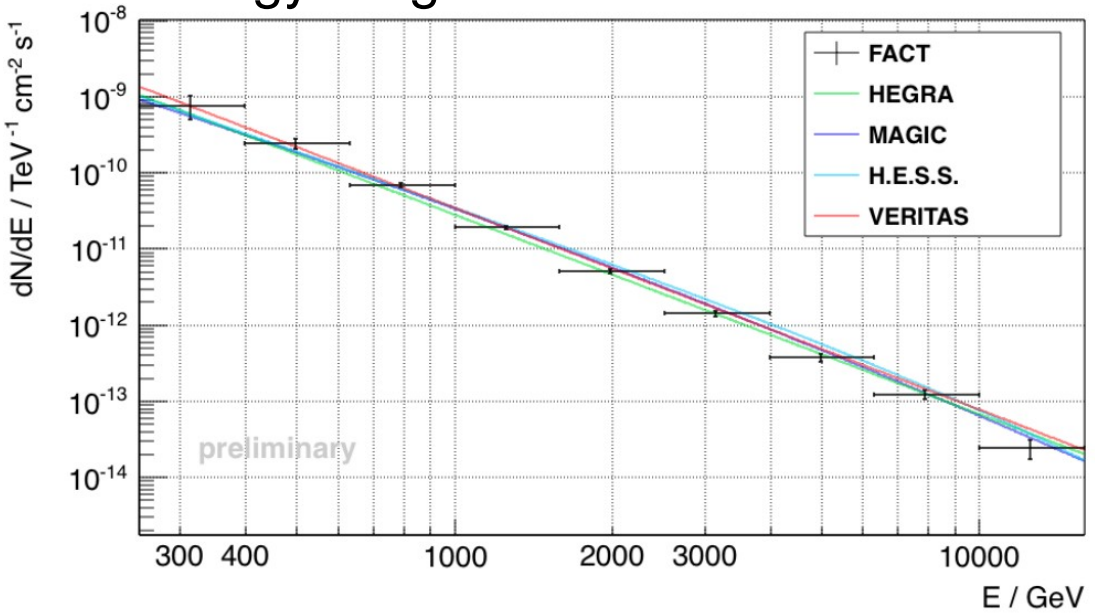
* Geiger-mode Avalanche Photodiodes

Photo: Thomas Bretz

First G-APD Cherenkov Telescope



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

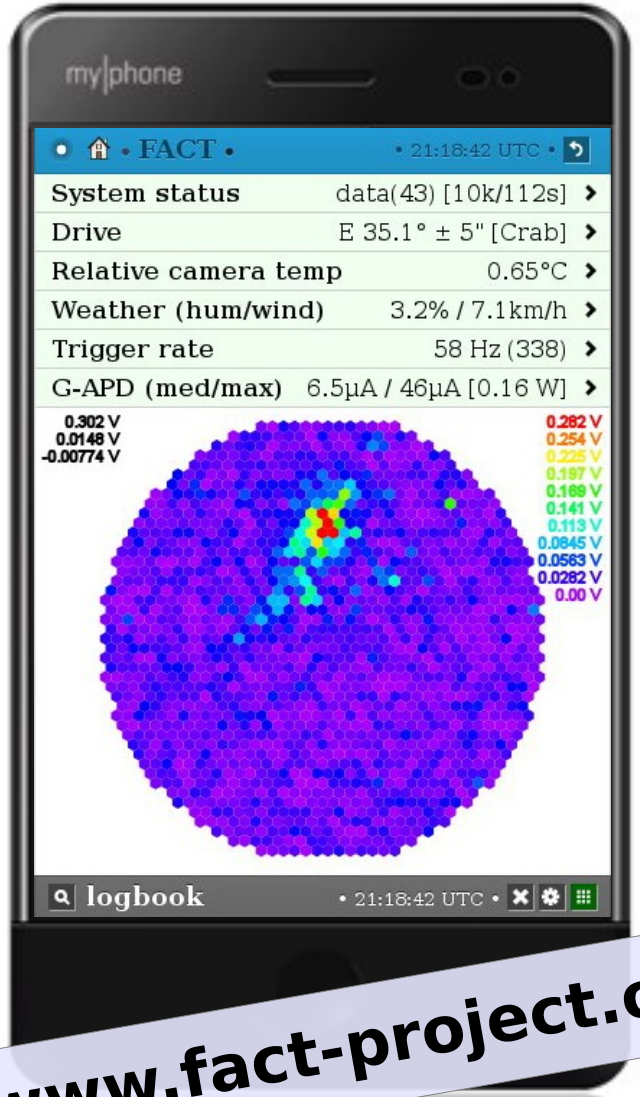


F. Temme et al. (FACT Collaboration), ICRC 2015

- More information

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

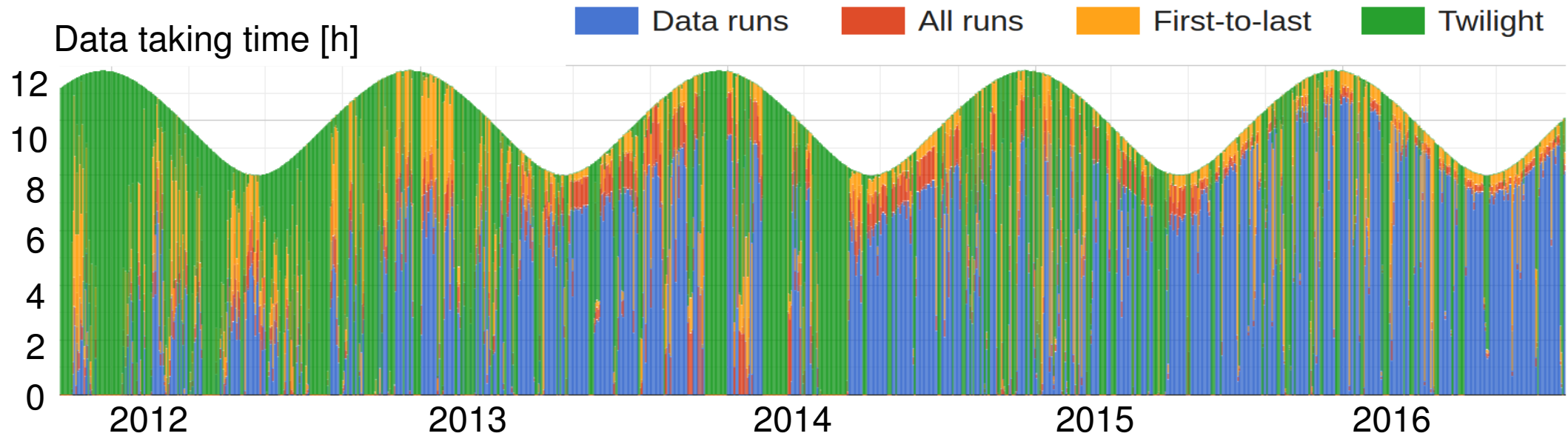
FACT – Ideal Monitoring Telescope

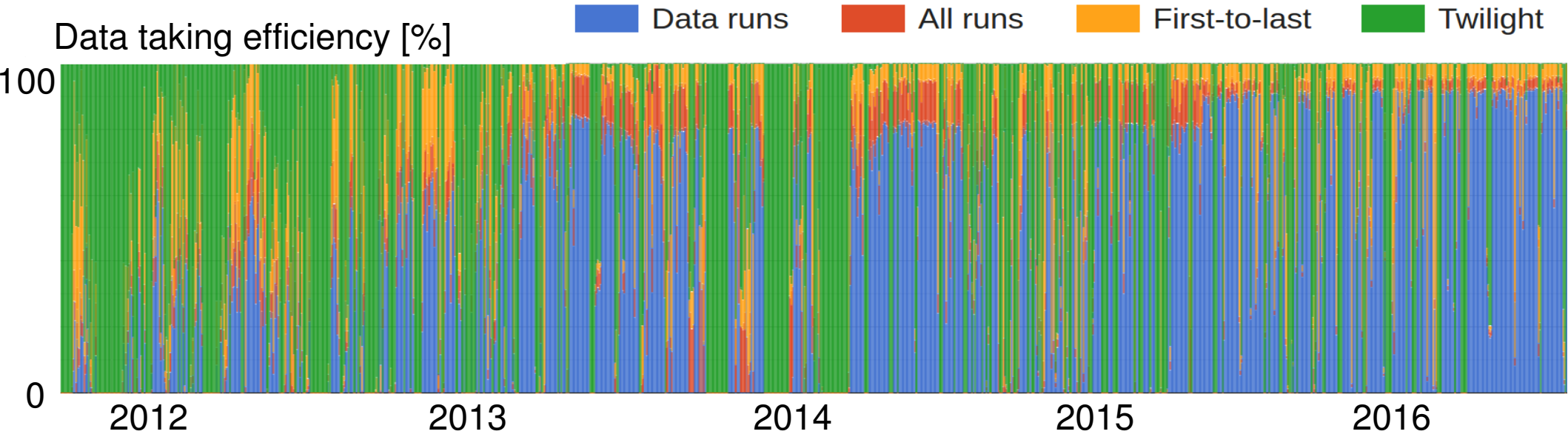


- SiPMs robust and stable
  - → Stable telescope performance
  - → Remote and automatic operation
  - → High data taking efficiency

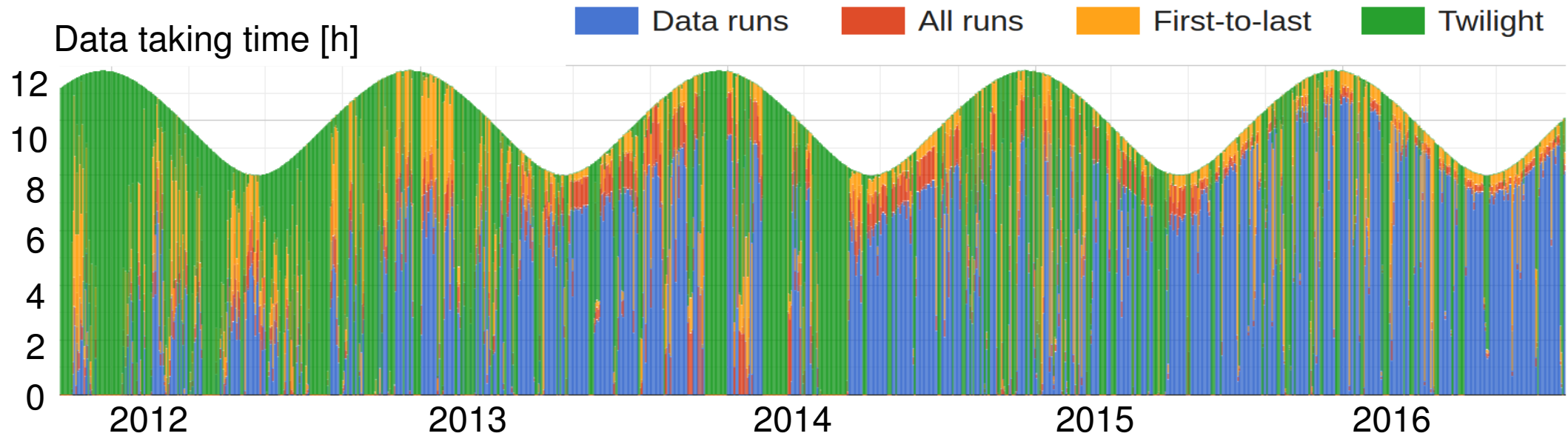
http://www.fact-project.org/smartfact

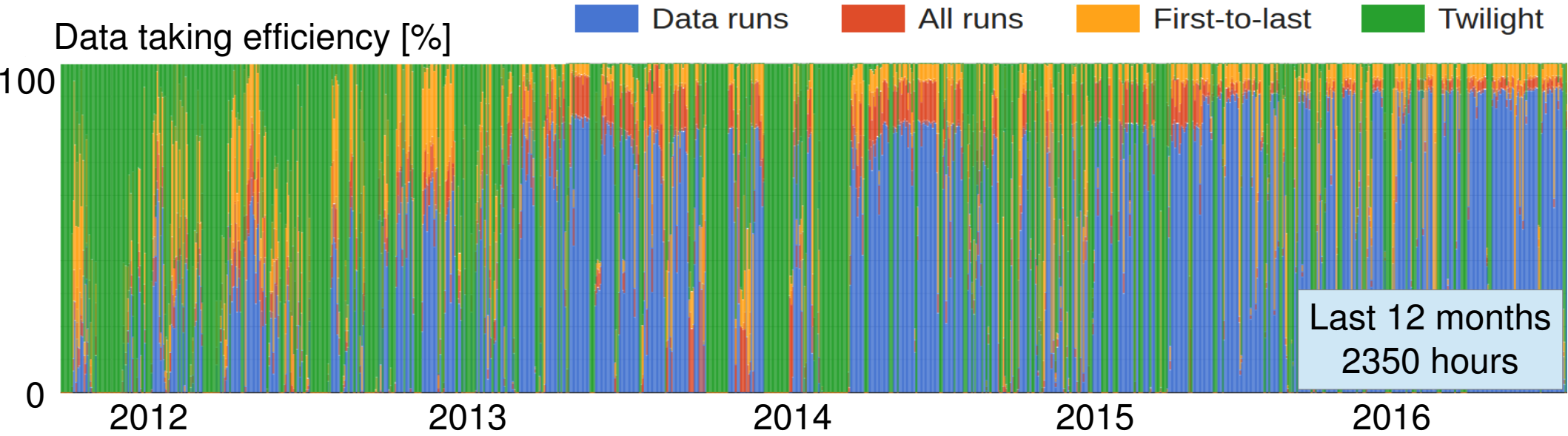
FACT – Data Taking Efficiency





FACT – Data Taking Efficiency

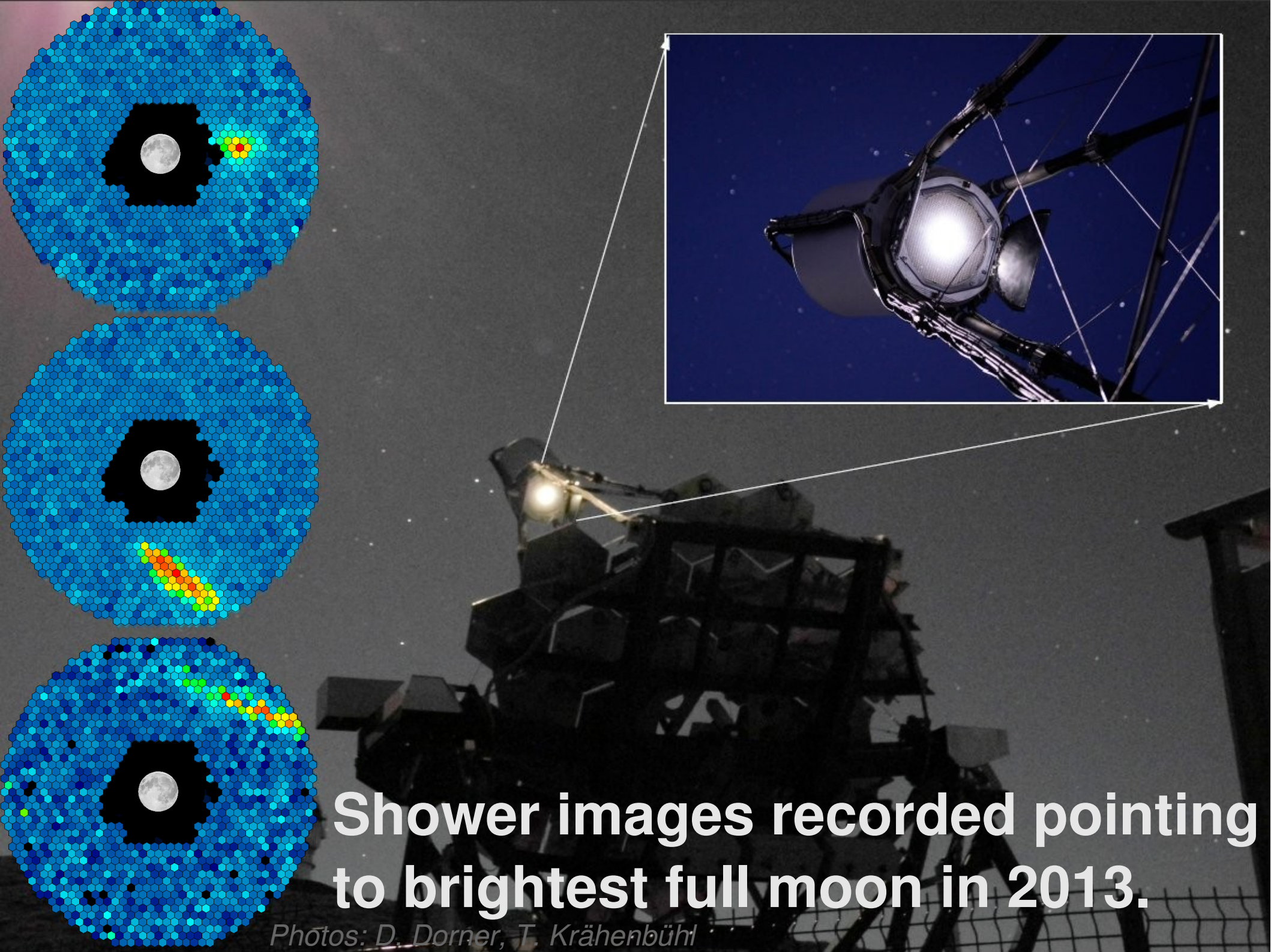




FACT – Ideal Monitoring Telescope


Photo: Daniela Dorner

- SiPMs robust and stable
  → Stable telescope performance
  → Remote and automatic operation
  → High data taking efficiency
- Gain of SiPMs does not degrade when exposed to bright light
  → Observations during strong moon light possible


Shower images recorded pointing to brightest full moon in 2013.
Photos: D. Dorner, T. Krähenbühl

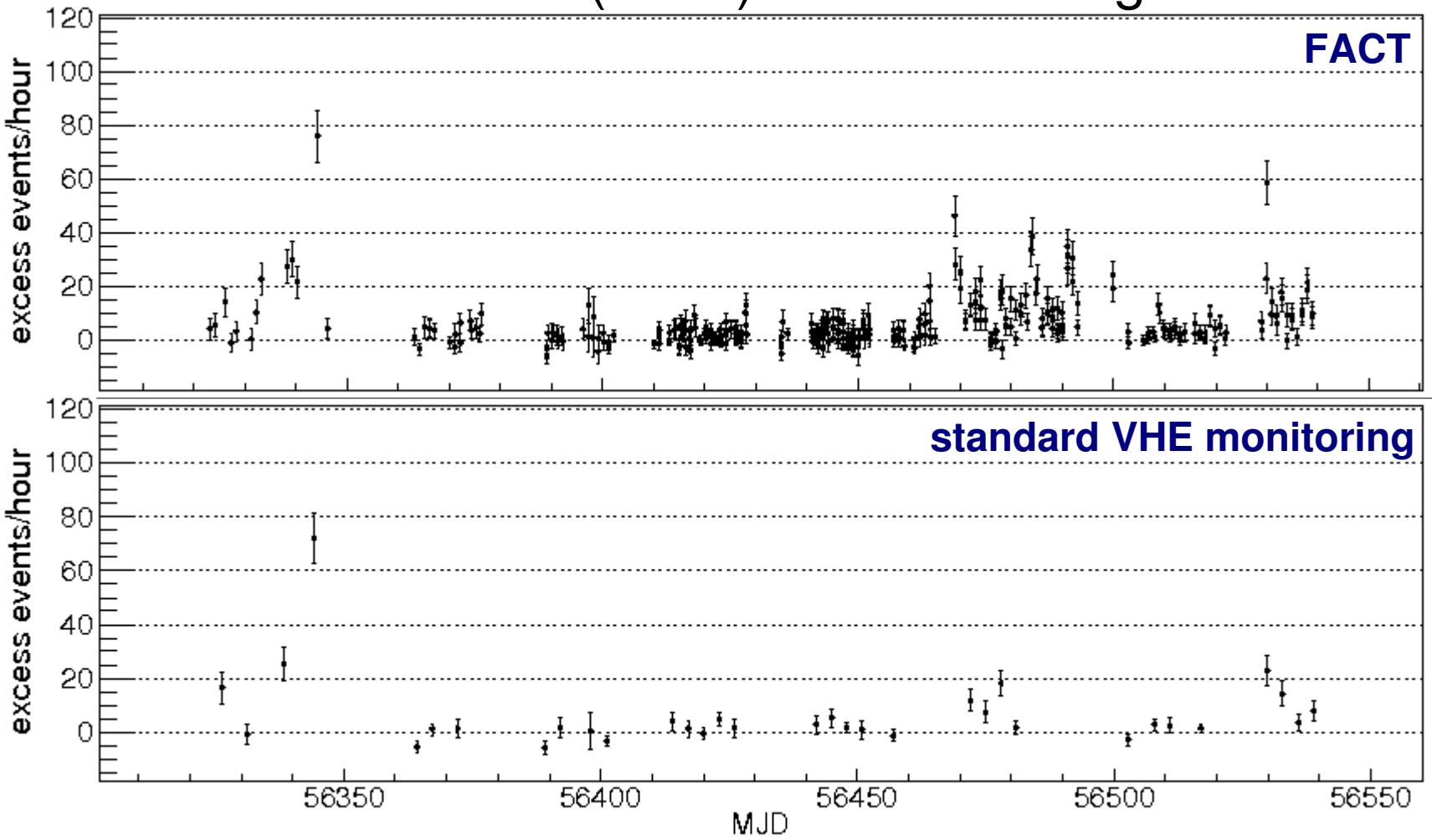
FACT – Ideal Monitoring Telescope


Photo: Daniela Dorner

- SiPMs robust and stable
  → Stable telescope performance
  → Remote and automatic operation
  → High data taking efficiency
- Gain of SiPMs does not degrade when exposed to bright light
  → Observations during strong moon light possible
  → Larger duty cycle
  → More complete data sample

Long-term Monitoring at VHE

Mrk 501 (2013) 1-hour-binning



All data ~410h

Moon < 65%
1h every
~3rd night
→ ~32h

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

Long-term Monitoring at VHE

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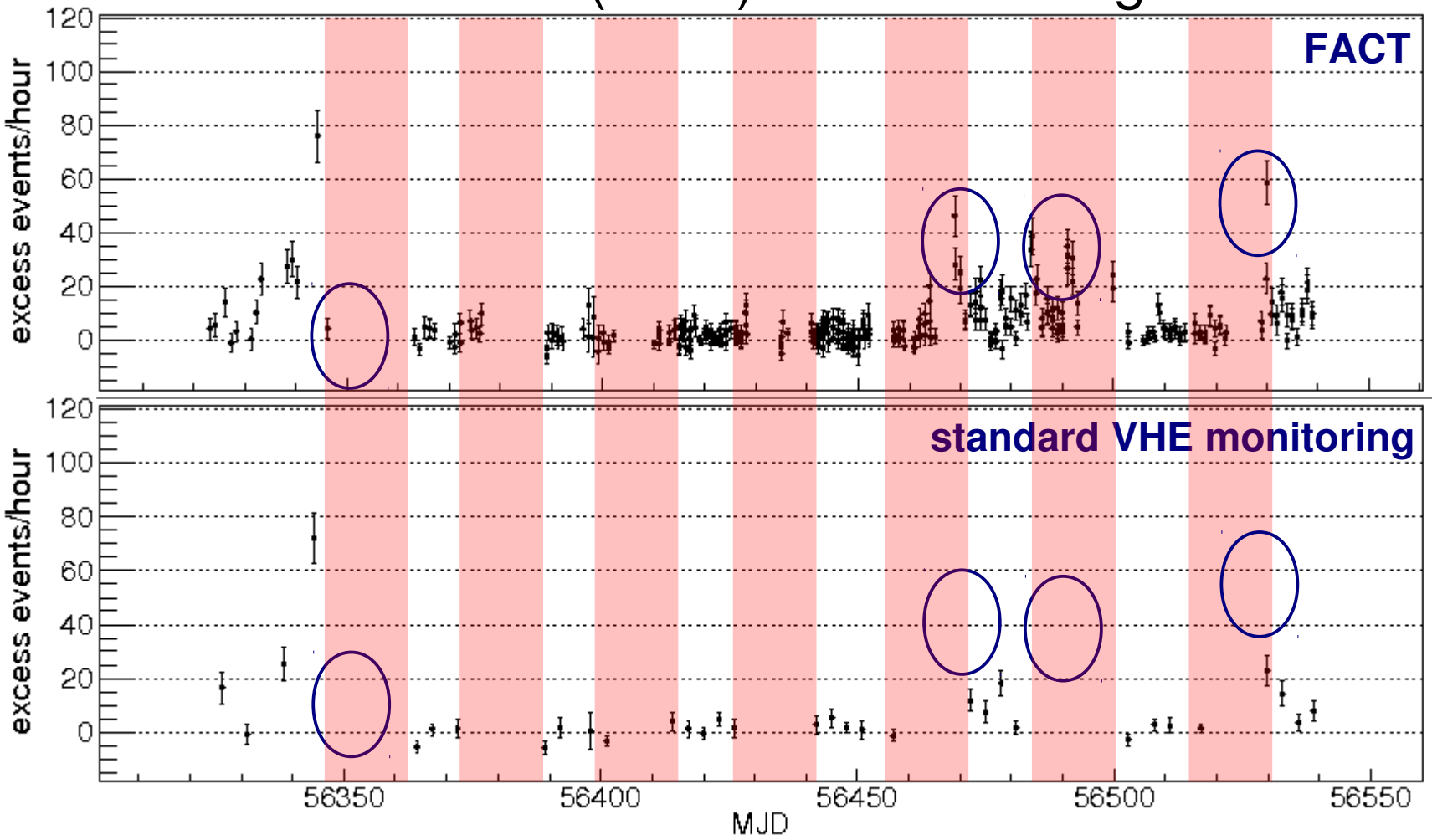


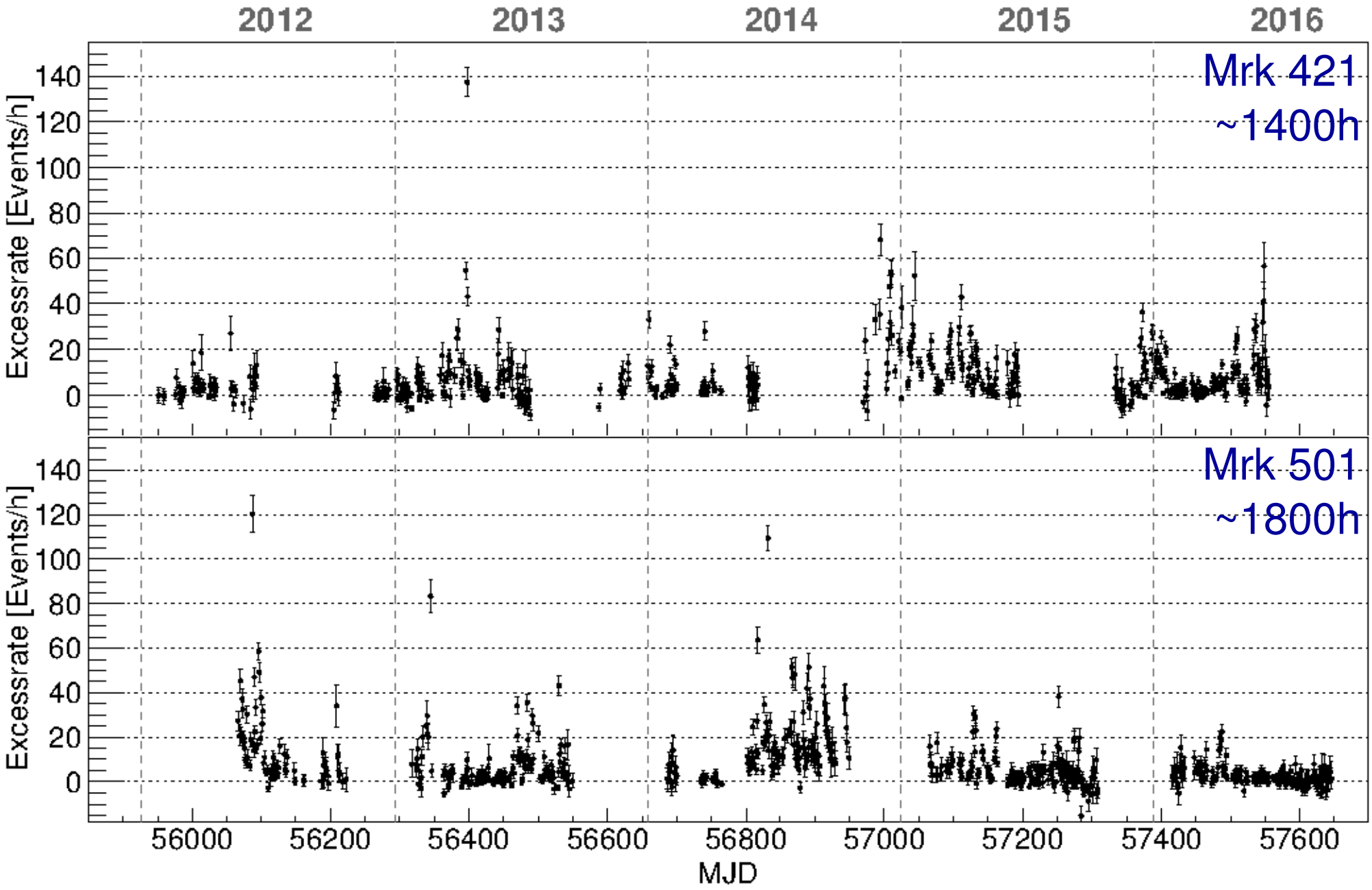
All data ~410h

Moon < 65%
1h every
~3rd night
→ ~32h

FACT monitoring strategy → Unbiased data sample

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

Five Years of Monitoring



QLA

www.fact-project.org/monitoring/index.php

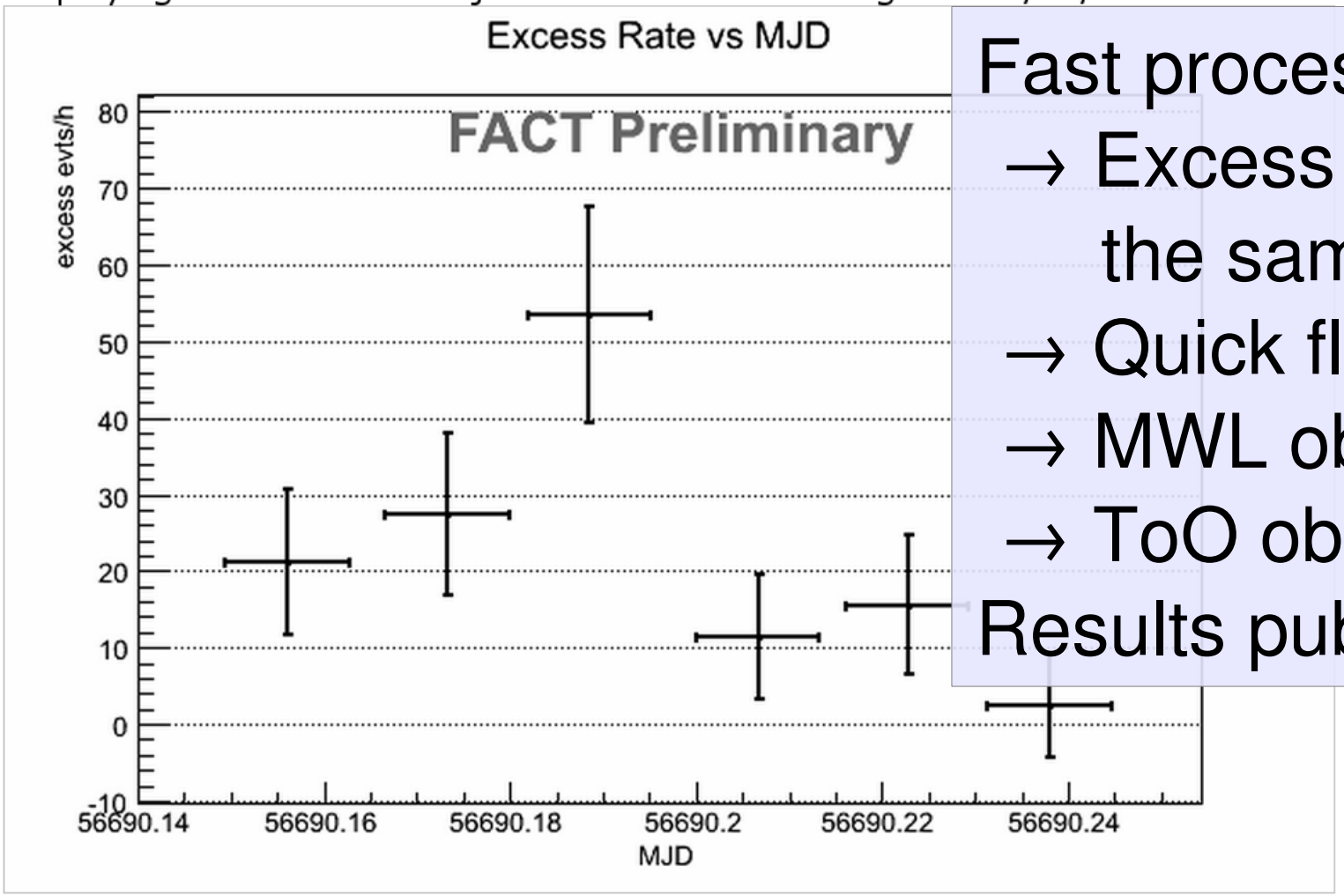
http://www.fact-project.org/monitoring

FACT Quick Look Analysis

Select date 2014 02 01 source Mrk 421

Select time binning 20min and range night Reset

Displaying 'excess rate vs mjd' for Mrk 421 for the night 2014/02/01.



Fast processing

→ Excess rates within the same night

→ Quick flare alerts

→ MWL observations

→ ToO observations

Results publicly available

MWL and ToO Activities

- Target-of Opportunity Campaigns
  - 2013: *XMM-Newton / Swift*
  - 2015: *INTEGRAL / Swift*
  - Ongoing in 2016: *INTEGRAL*, *Swift* and *XMM-Newton*
  - Granted for 2017:
    - *INTEGRAL, Swift*
    - *AstroSAT*

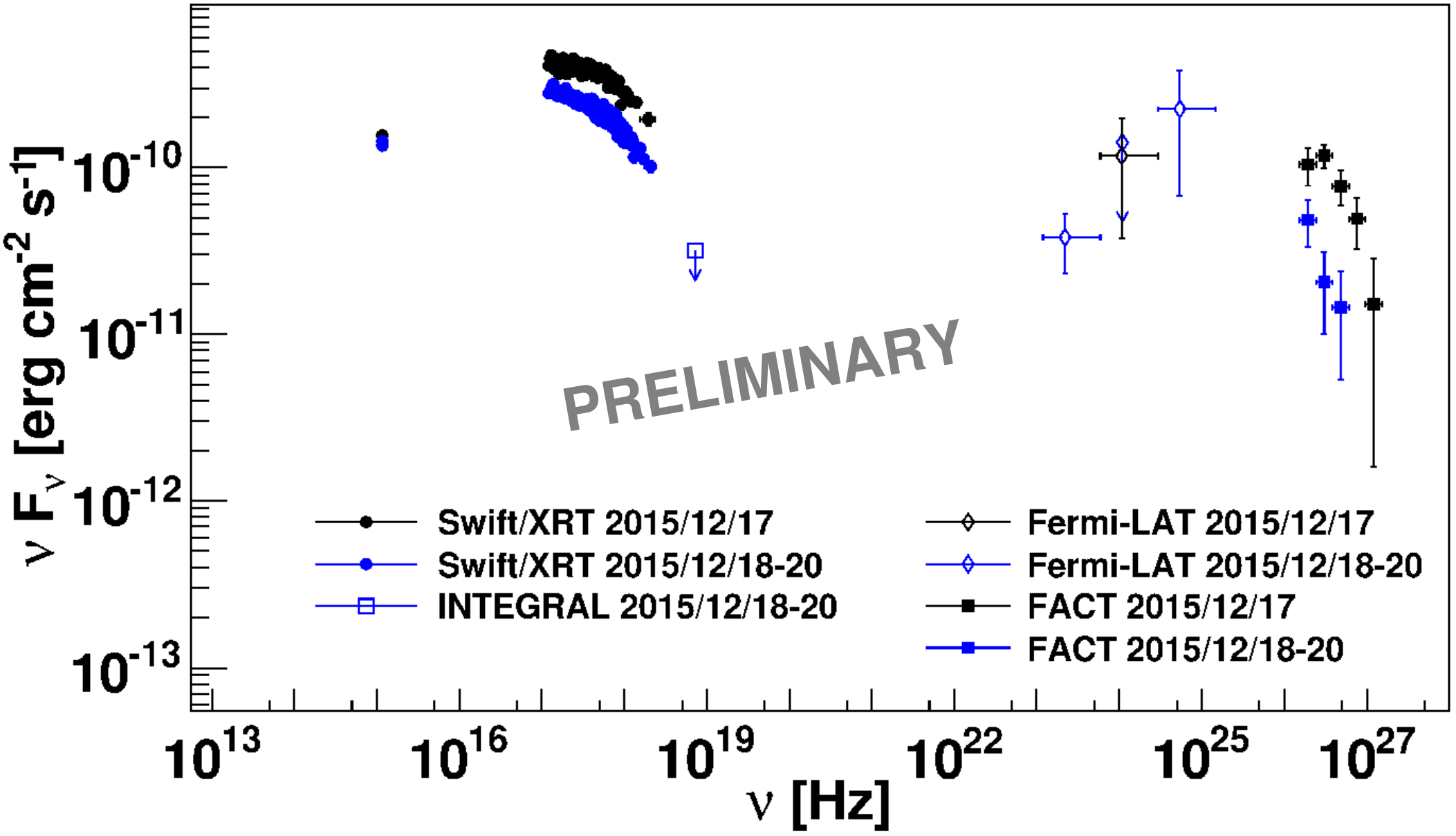
Successful ToO Dec 2015

- Multi-Wavelength Observations
  - Multi-Messenger: AMON Network
  - MWL campaigns
  - Observations triggered by FACT alerts

6 Atels in 2016

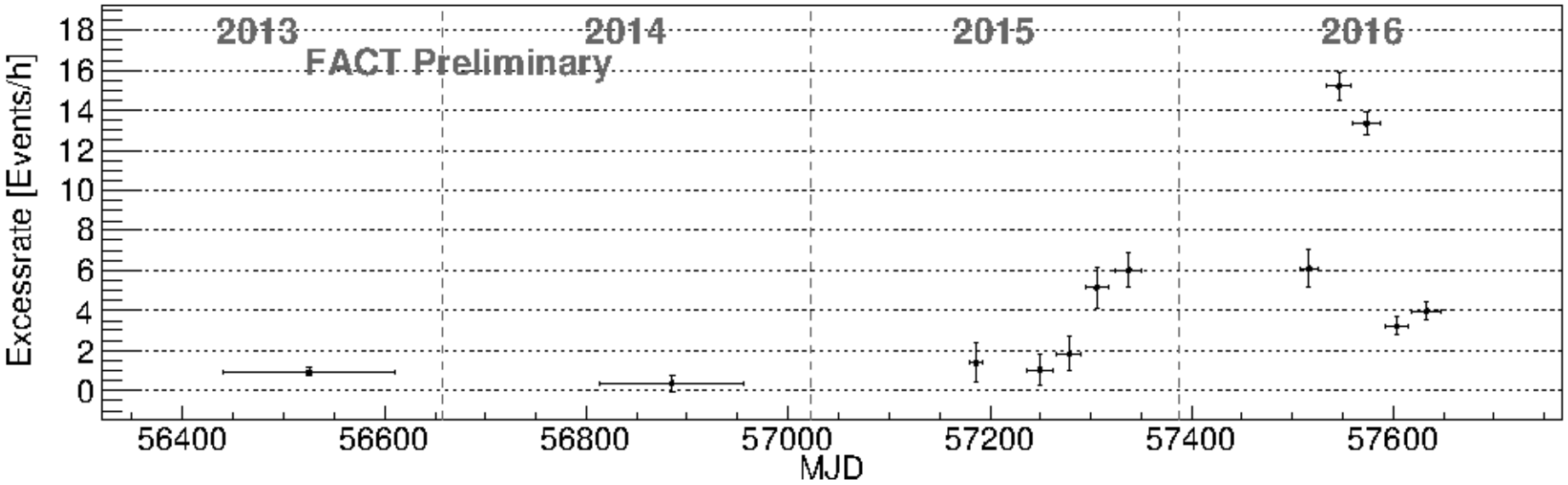
40 alerts since March 2014

Mrk 421 – Flare December 2015



1ES 1959+650

Long-term Behaviour



1ES 1959+650

[Previous | Next | ADS]

FACT measures new maximum flux from the HBL 1ES 1959+650 at TeV energies

ATel #9239; ***A. Biland (ETH Zurich) on behalf of the FACT Collaboration***
*on **12 Jul 2016; 09:31 UT***
Credential Certification: Daniela Dorner (dorner@astro.uni-wuerzburg.de)

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

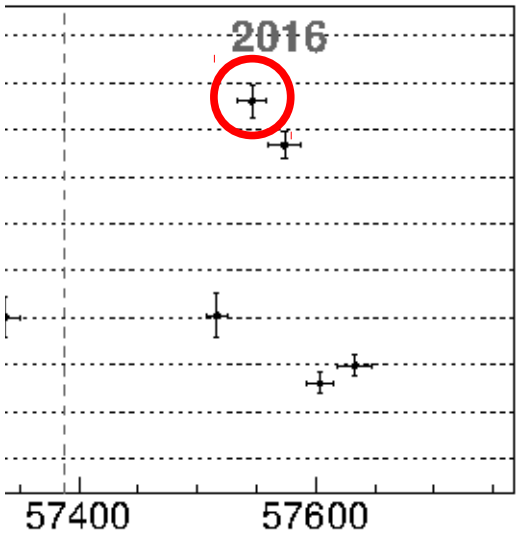
The FACT collaboration reports the measurement of an enhanced gamma-ray flux at about 1 TeV from a position consistent with the HBL 1ES 1959+650 (z=0.047, Schachter et al. 1993, ApJ, 412, 541).

Recent activities from this source were reported in gamma rays (ATel #9010, #9139, #9148, #9168, #9203), IR (ATel #9070) and X-rays (ATel #9121, #9205). Since July 2015, several periods of enhanced activity have been observed. After the flare of MJD 57570 (ATel #9203), the flux decayed to about 0.5 Crab units within a few nights, then increased to about 1.5 Crab units (MJD 57579 and 57580).

From MJD 57581.01 till 57581.17, FACT measured a flux increasing from 2 Crab units to at least 3.5 Crab units. The source is detected with about 20 standard deviations in 3.8 hours of observation. The results of a preliminary, automatic quick look analysis are publicly available. http://fact-project.org/monitoring/index.php?y=2016&m=07&d=11&source=7&timebin=3&plot=night shows the 20-minute-binned background subtracted light curve. These values are corrected neither for the effect of large zenith distance under which the source is observable nor for the amount of night-sky-background light, with both effects decreasing the measured gamma rate. The evolution of the nightly flux in the last month is available at http://fact-project.org/monitoring/index.php?y=2016&m=07&d=11&source=7&timebin=12&plot=month

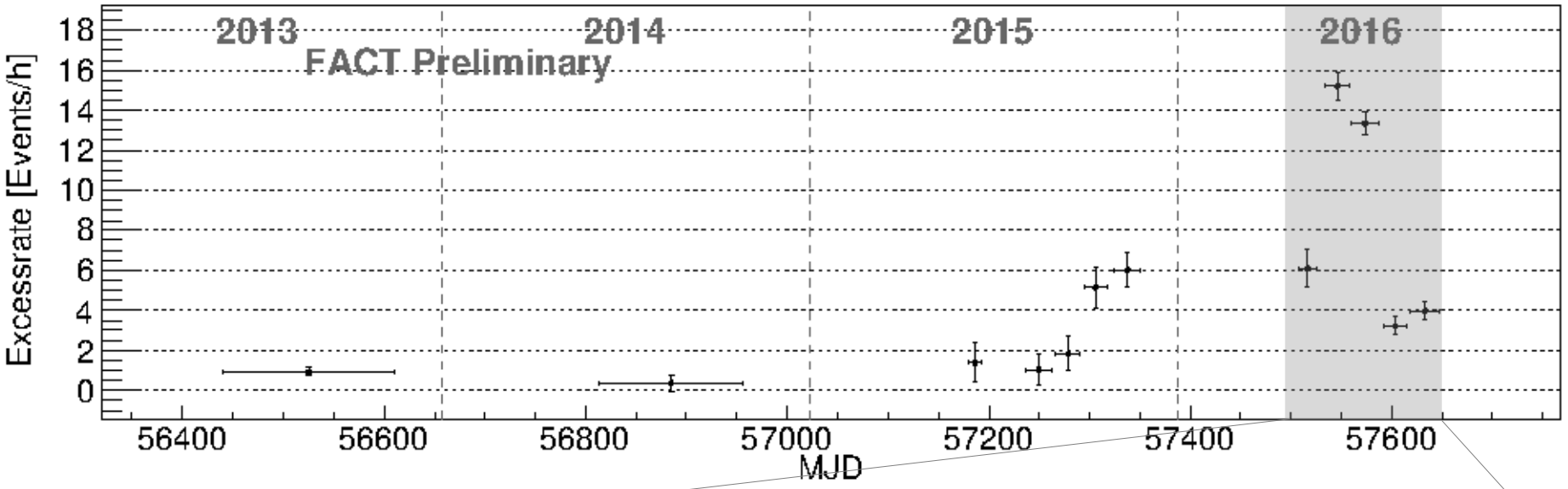
Related

9239	FACT measures new maximum flux from the HBL 1ES 1959+650 at TeV energies
9205	A new highest historical X-ray State in 1ES 1959+650
9203	FACT and MAGIC measure an increased gamma-ray flux from the HBL 1ES 1959+650
9168	AGILE confirmation of enhanced gamma-ray activity from the Blazar 1ES 1959+650
9148	Further increase of gamma-ray emission from the HBL 1ES 1959+650
9139	FACT measures increased gamma-ray flux from the high-energy peaked BL Lac object 1ES 1959+650 since five nights
9121	A strong X-ray Flare in 1ES 1959+650
9070	Optical/NIR Observations of HBL 1ES 1959+625 from Mt Abu IR Observatory(MIRO), India
9010	Fermi-LAT, FACT, MAGIC and VERITAS detection of increasing gamma-ray activity from the high-energy peaked BL Lac object 1ES 1959+650
8468	The highest historical X-ray brightness state in HBL source 1ES 1959+650
8342	The TeV blazar 1ES 1959+650 is very bright in the X-rays again
8337	The RATAN detection of the increased radio emission from 1ES1959+650



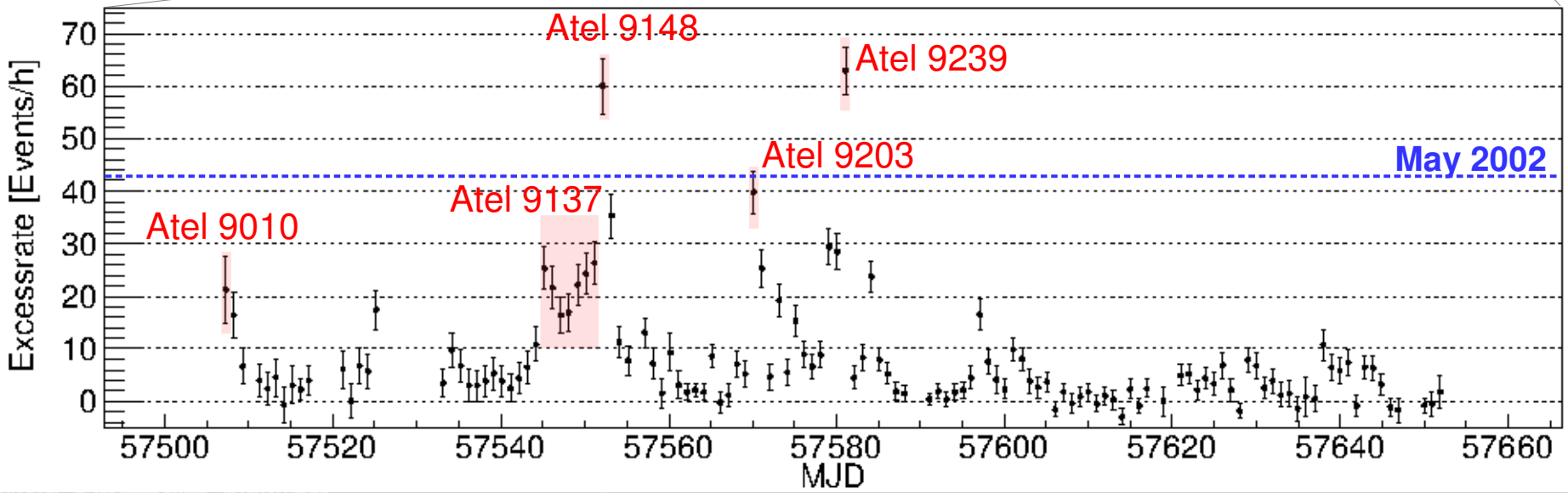
1ES 1959+650

Long-term Behaviour



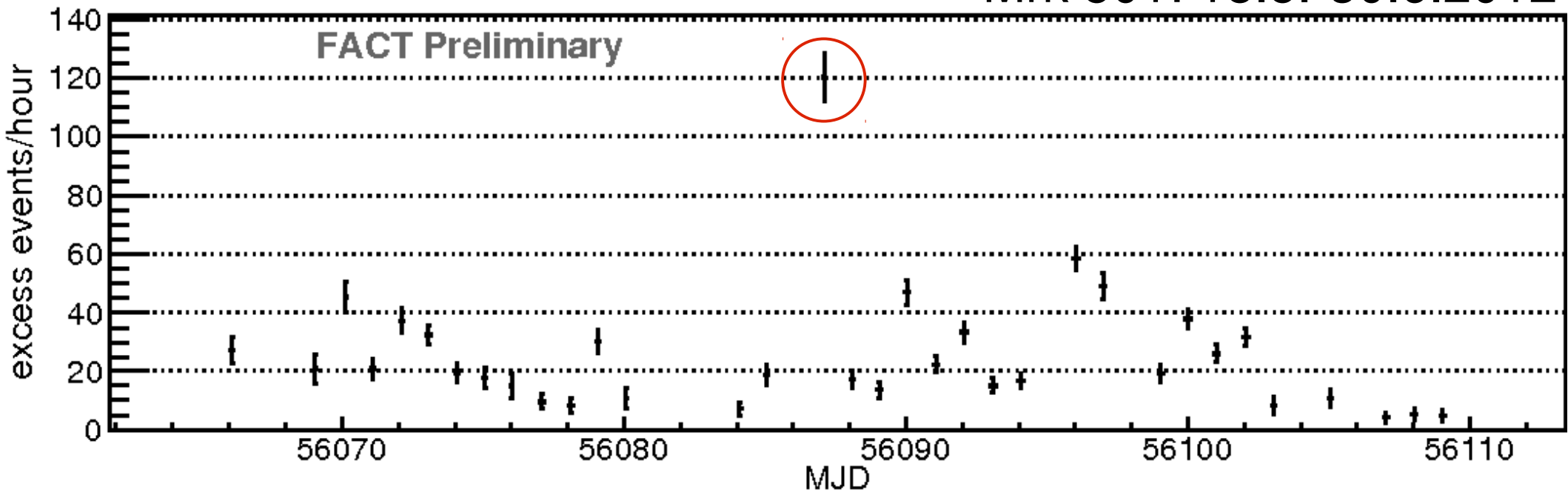
Flaring Activity 2016

28.4.2016 – now



Next Step: Continuous Monitoring

Mrk 501: 18.5.-30.6.2012



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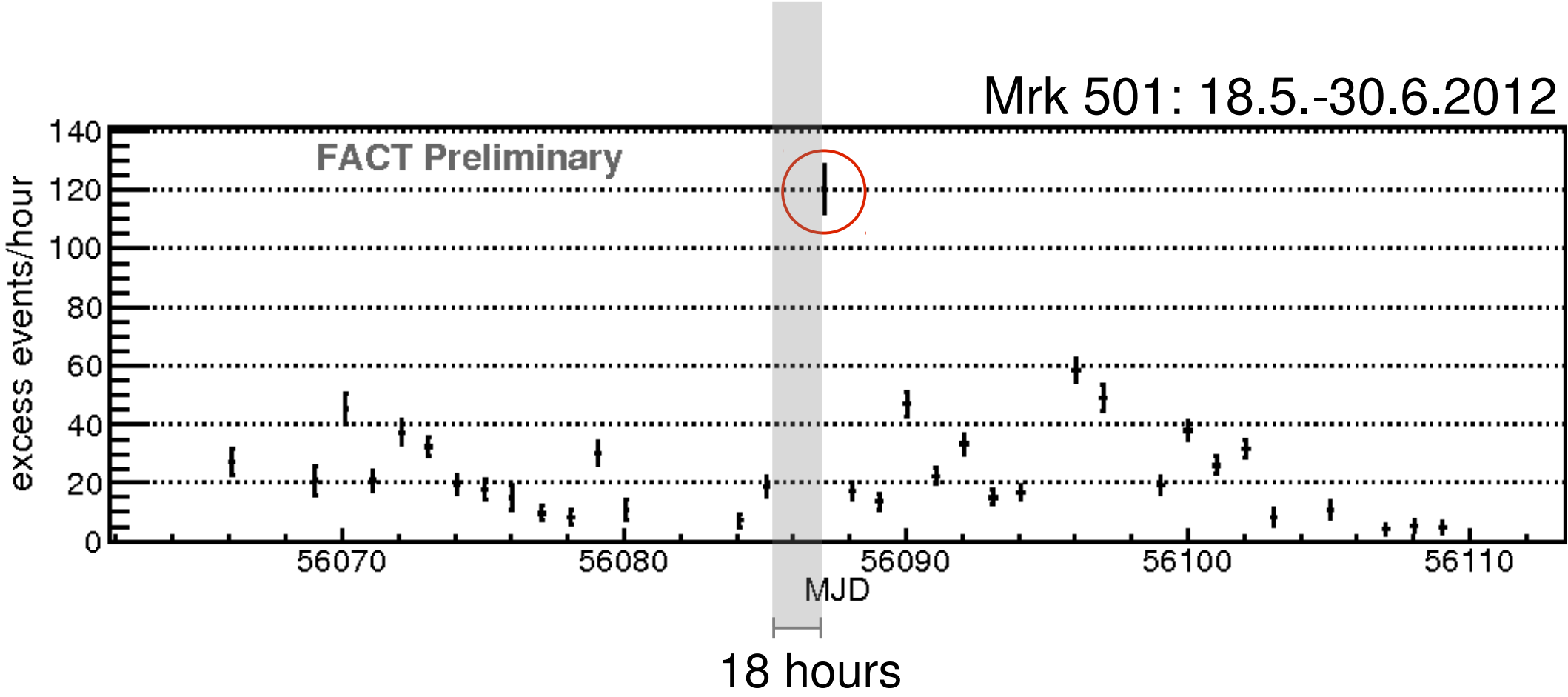
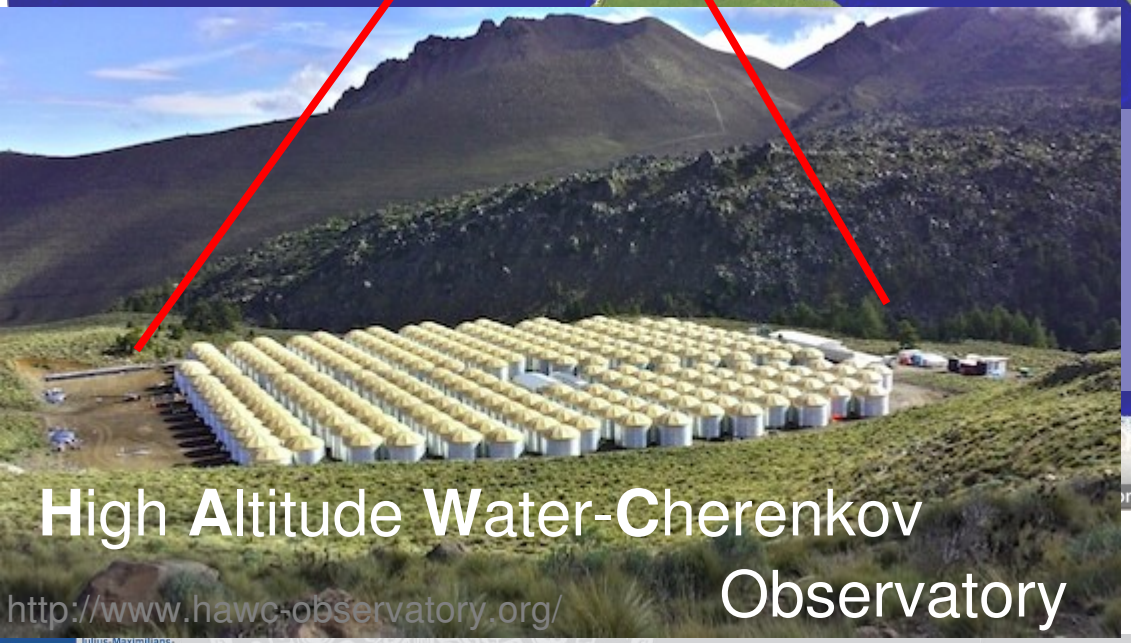


Observations at TeV Energies

Gaps due to daytime

Observations at TeV Energies

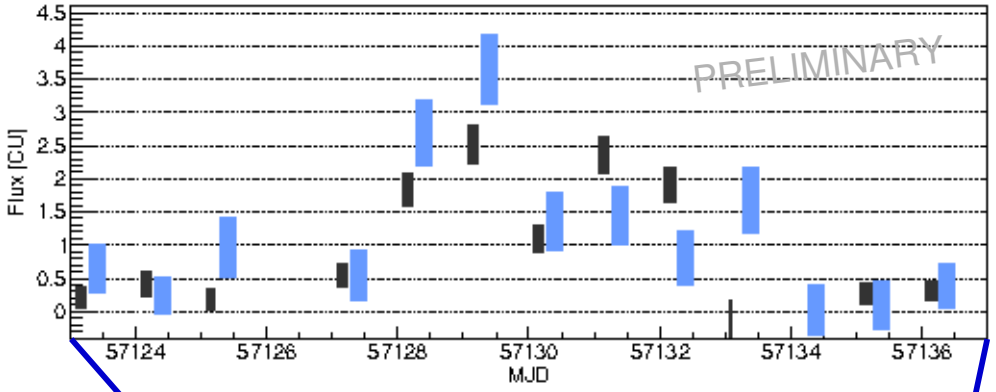


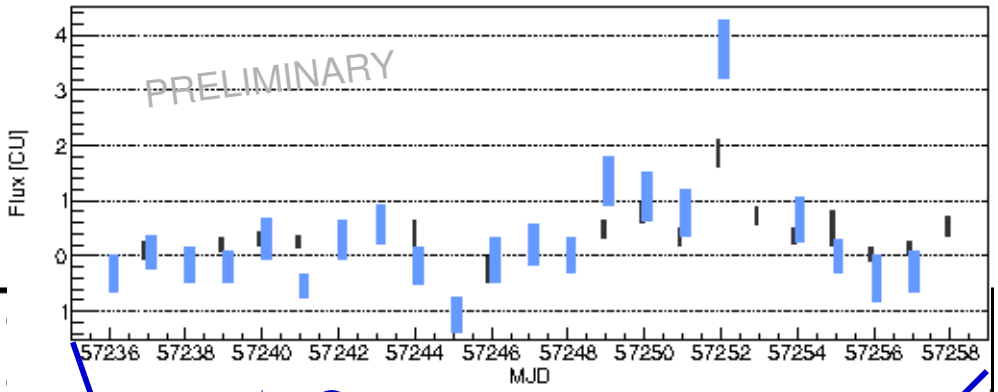
Combined HAWC & FACT Results

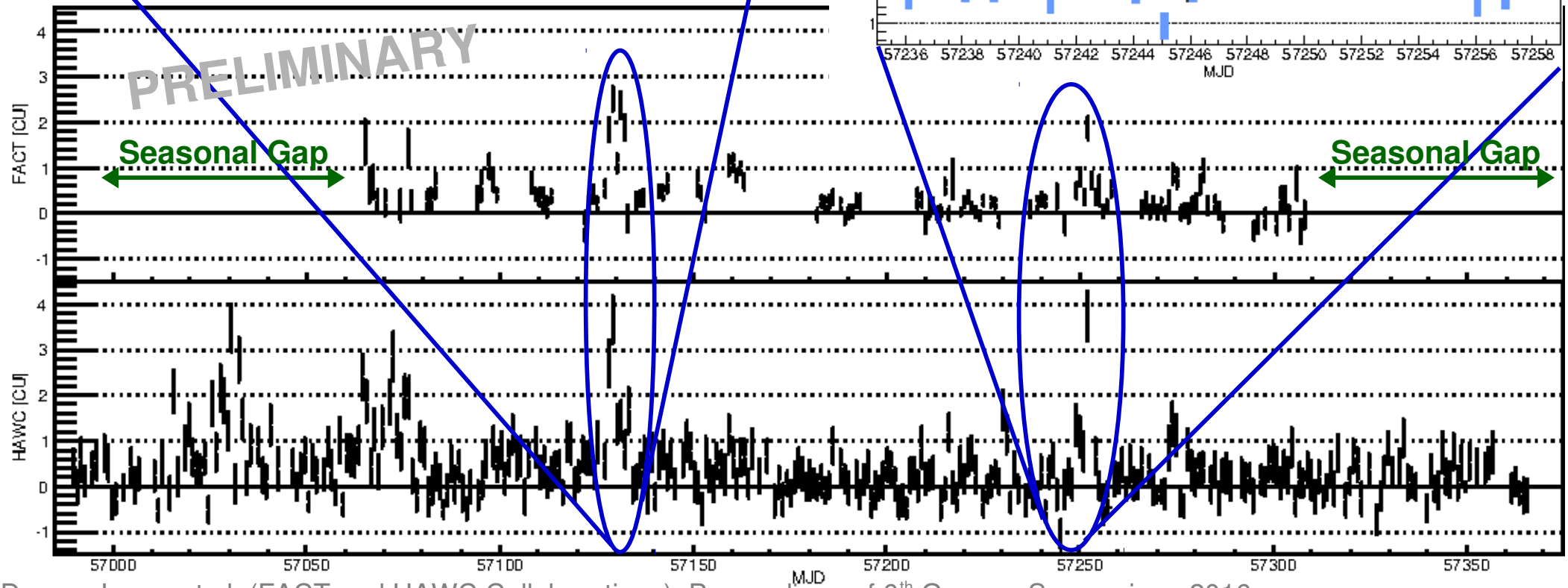
FACT

HAWC

Example Mrk 501



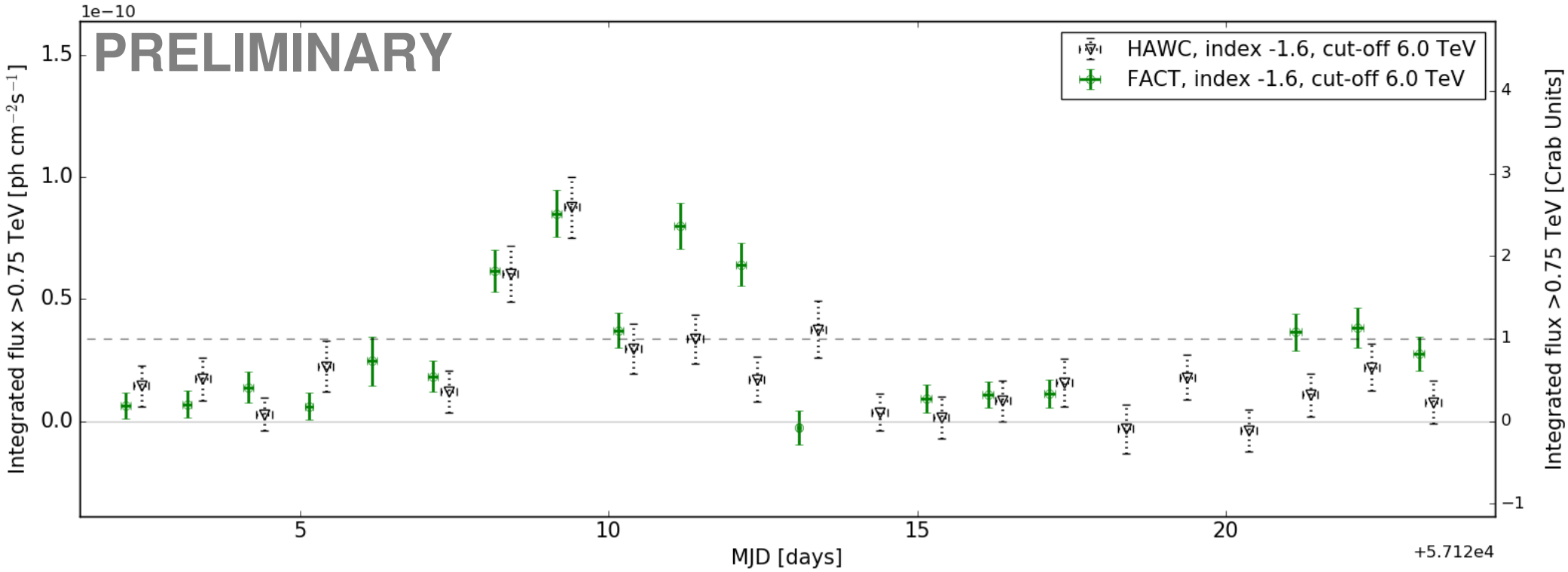




Dorner, Lauer et al. (FACT and HAWC Collaborations), Proceedings of 6th Gamma Symposium, 2016

Combined HAWC & FACT Results

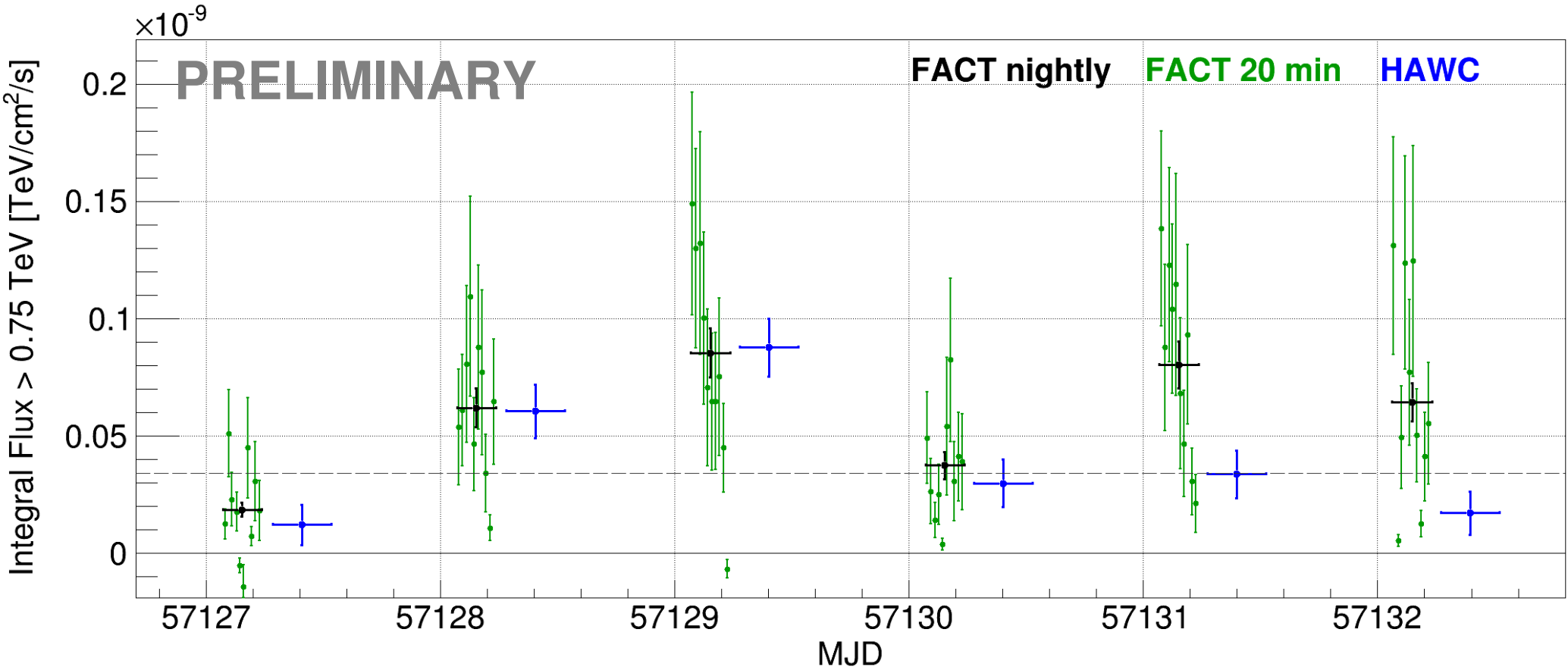
Mrk 501: April 2015



Using the same energy threshold and spectral assumption
→ Better agreement of fluxes

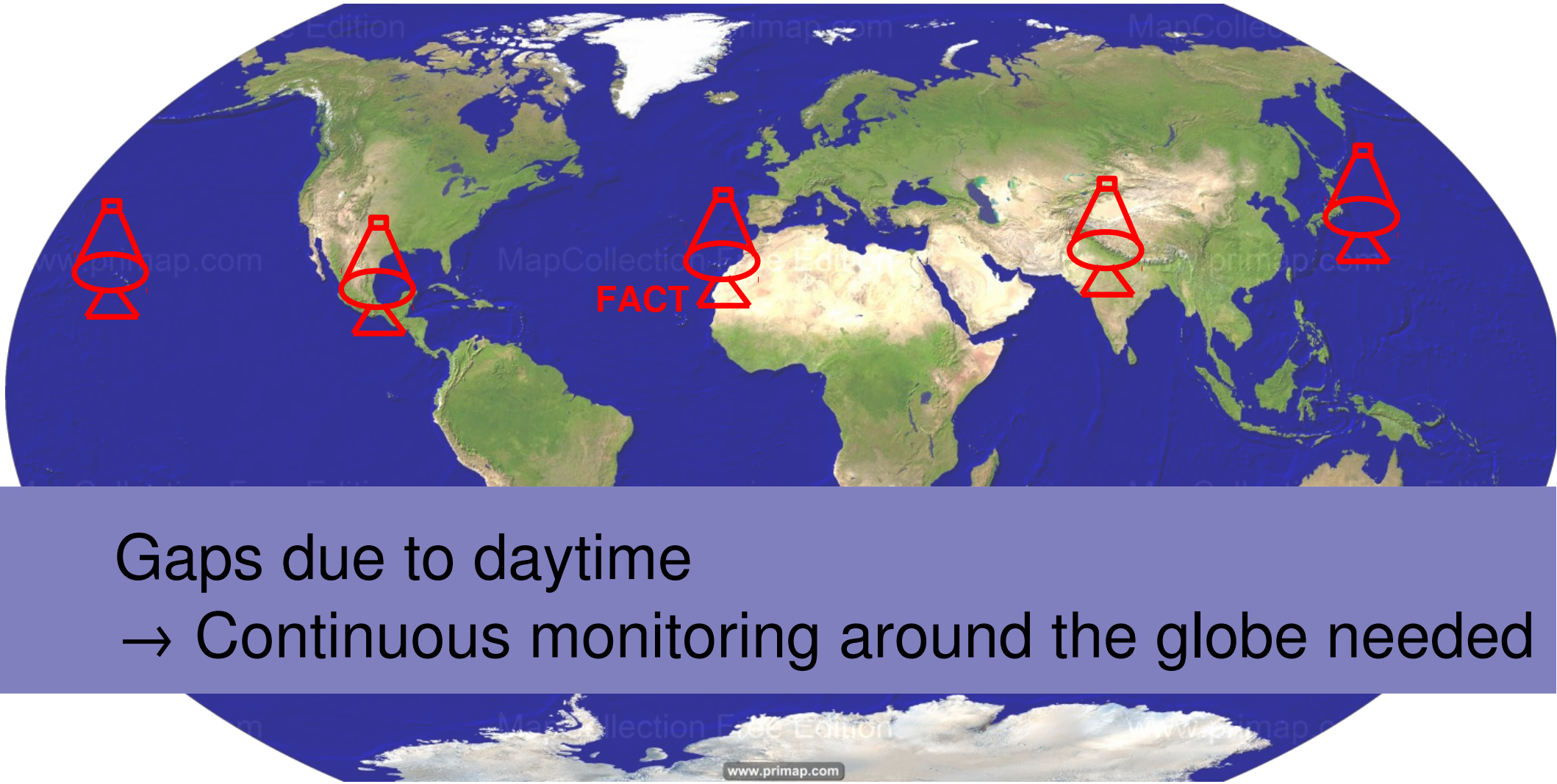
Combined HAWC & FACT Results

Mrk 501: Flare in April 2015



Intra-night variability

Global Monitoring Network

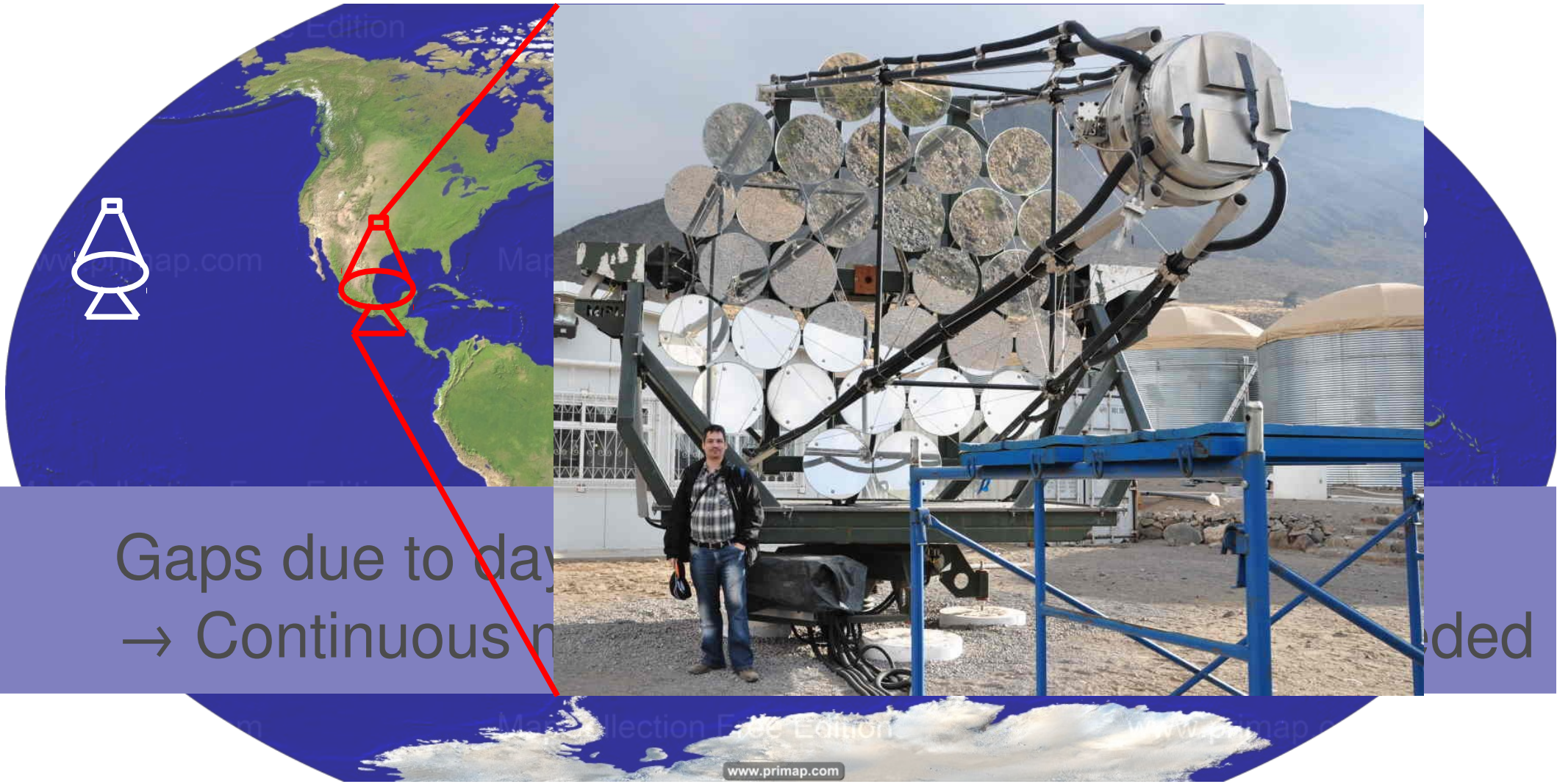


Gaps due to daytime

→ Continuous monitoring around the globe needed

DWARF Network (M. Backes et. al ICRC 2009)

Global Monitoring Network



Gaps due to day

→ Continuous m ded

Status

- 2 mounts from HEGRA available in Mexico
- 1st telescope installed at HAWC site (OMEGA project)
- 2nd mount available

Monitoring @ TeV Energies

- M@TE:
  Monitoring at TeV Energies
- Use 2nd telescope for long-term monitoring in Mexico
- Collaboration:
  - UNAM Mexico
  - INAOE
  - University of Würzburg
  - RWTH Aachen University

Possible Sites in Mexico

- HAWC Site
  - 19°N 97°W
    ~ 5.3 h to La Palma
  - 4000 m a.s.l.
- San Pedro Martir (Optical site close to CTA candidate site)
  - 31°N 115°W
    ~ 6.5 h to La Palma
    ~ same latitude
  - 2800 m a.s.l.
  - Excellent weather conditions

→ San Pedro Martir better for long-term monitoring

Goals

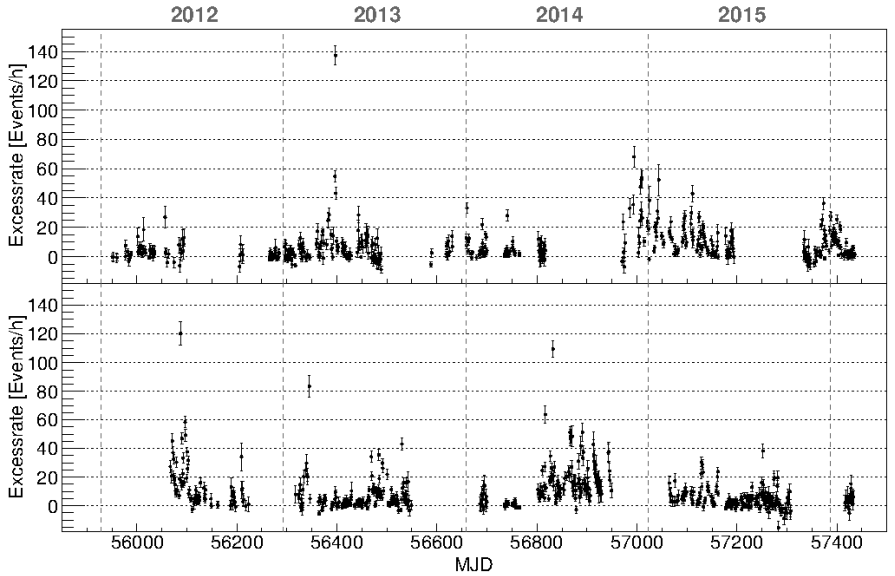
- Cross-calibration with HAWC

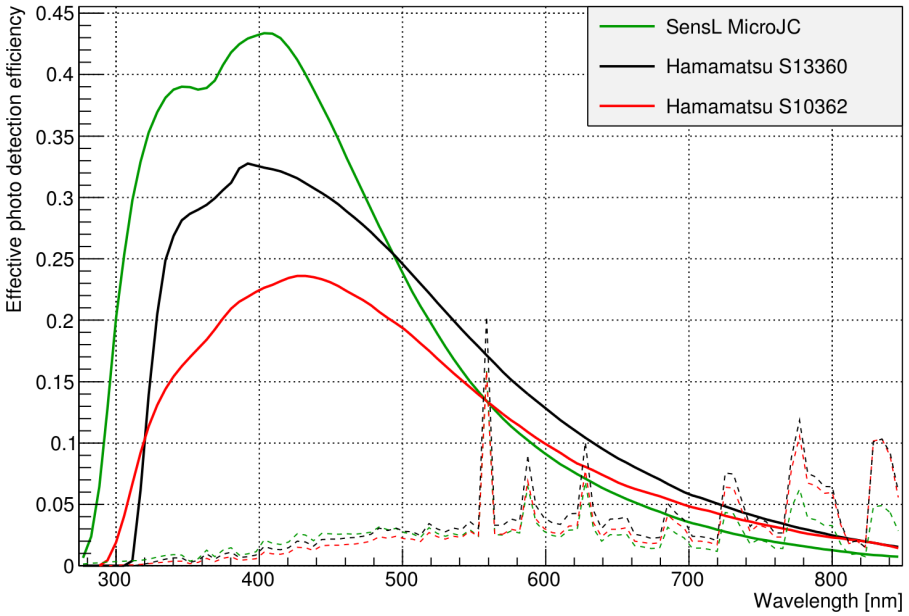
  (HAWC site)
- Long-term monitoring in San Pedro Martir

  → continuous observations

  up to 12 hours
- Improved SiPM camera
  - Increased PDE
  - Cherenkov light yield increased by factor 1.5 compared to FACT

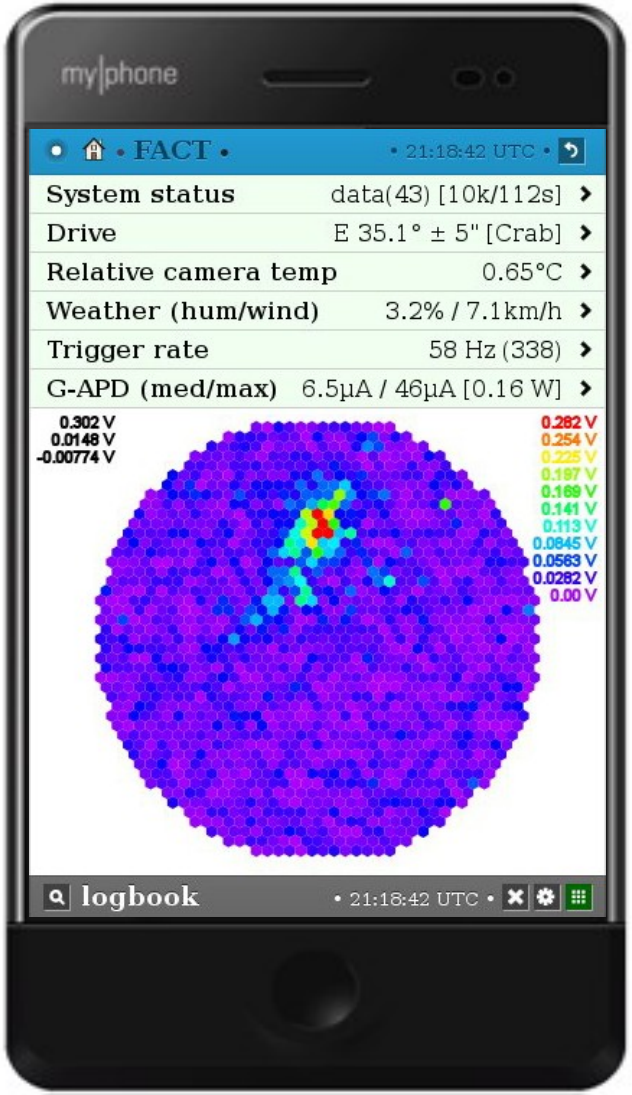
  → Lower energy threshold



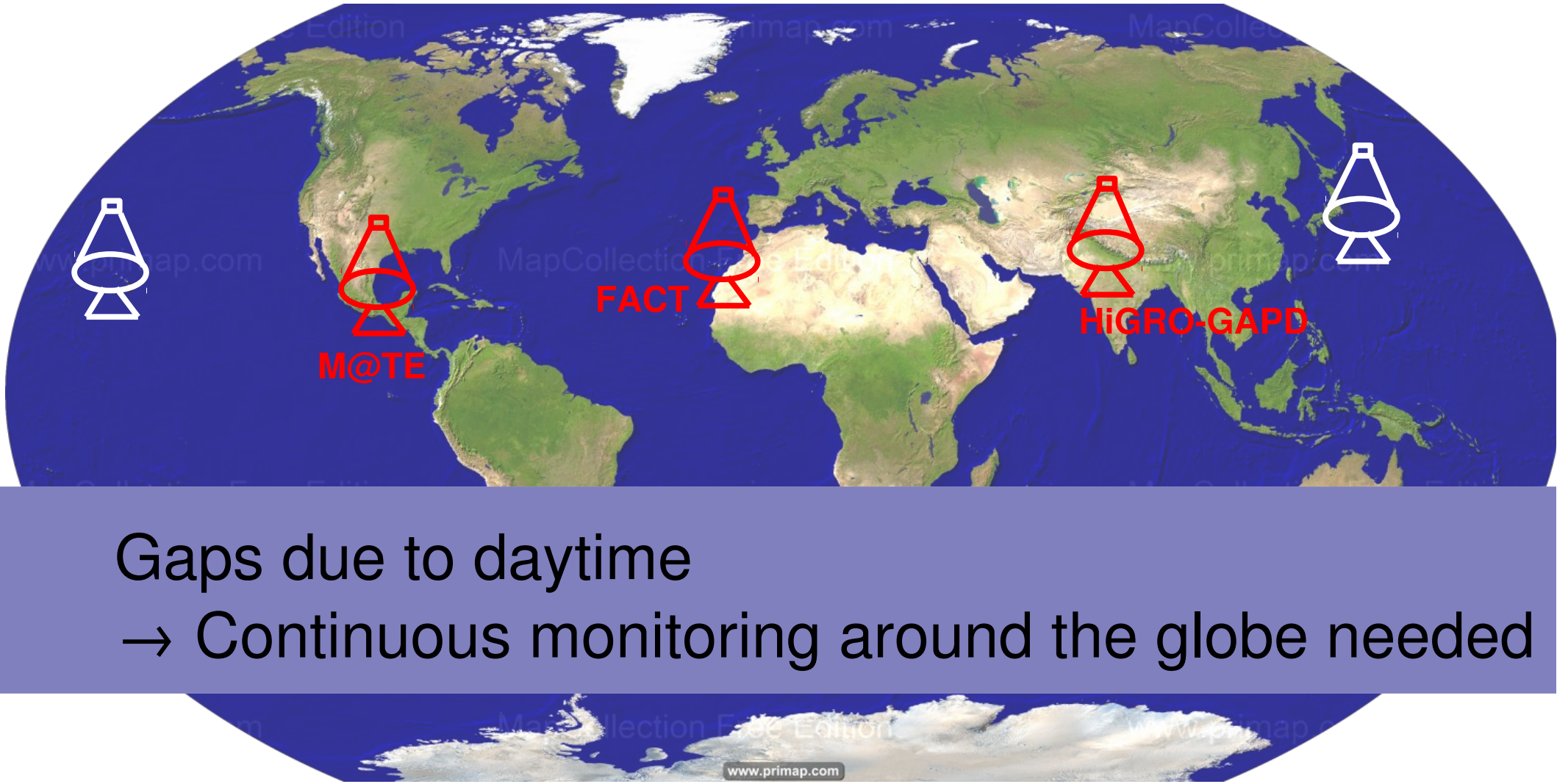


Status

- Goal: Improved SiPM camera
  - New SiPMs
  - Target Electronics
- Software available for most parts from FACT
  - Slow control (FACT++)
  - Analysis software packages (MARS, Fact-Tools)
  - Quick look analysis
  - Web-interfaces e.g. Smartfact



Global Monitoring Network



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Long-term Studies @TeV Energies
Unbiased Monitoring & ToO