FACT – Status and Results from almost 5 Years of Monitoring

Daniela Dorner for the FACT Collaboration

FRIEDRICH-ALEXANDER
UNIVERSITÄT
ERLANGEN-NÜRNBERG

Julius-Maximilians-
UNIVERSITÄT
WÜRZBURG

FACT – Major Goals

Proof of principle:

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

✓ Successful operation since October 2011

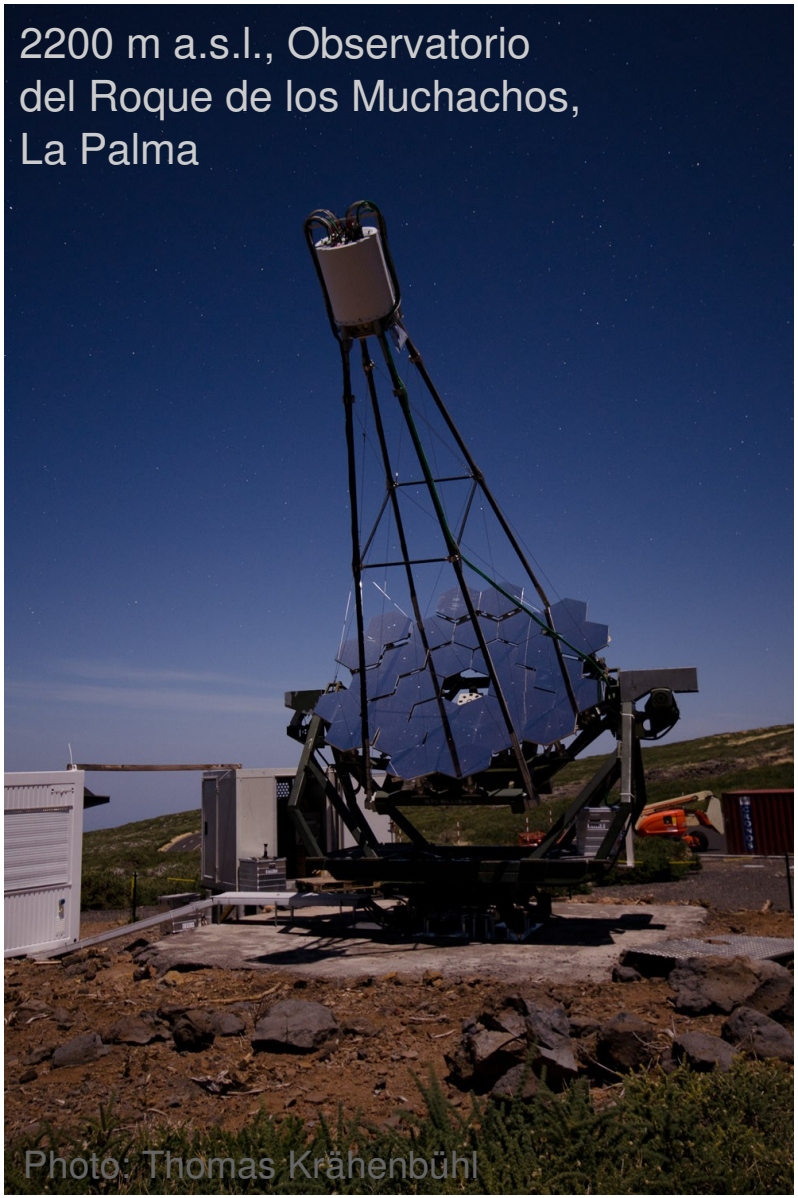
Longterm monitoring of bright TeV Blazars

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

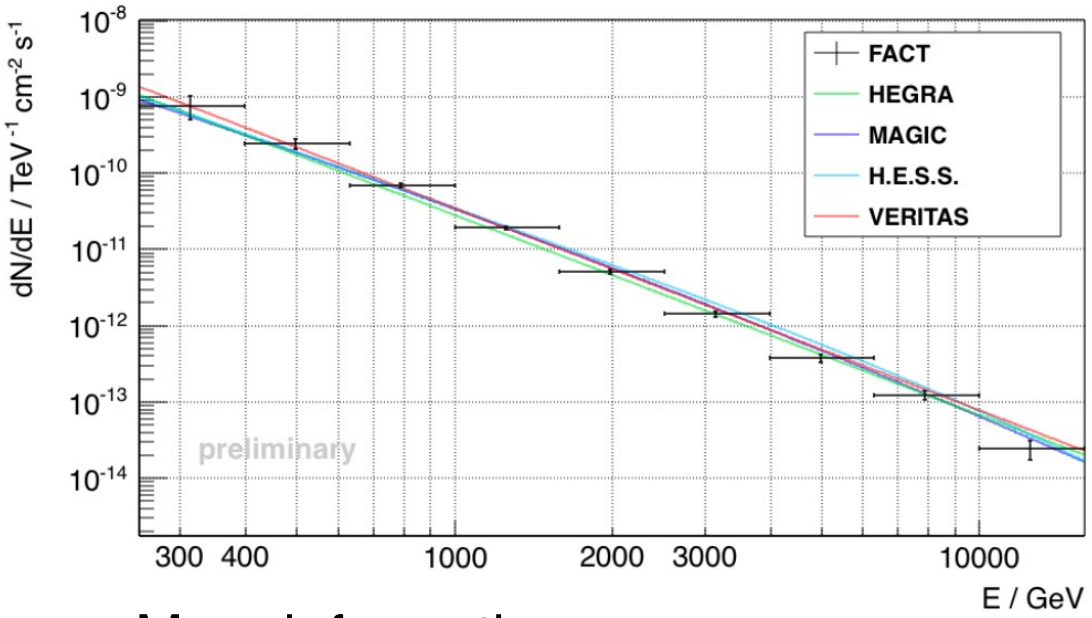
* Geiger-mode Avalanche Photodiodes

Photo: Thomas Bretz

First G-APD Cherenkov Telescope



- Operational since Oct 2011
- 9.5 m² mirror area
- 4.5° FoV, 1440 pixels à 0.11°
- Energy range: 300 GeV – 10 TeV

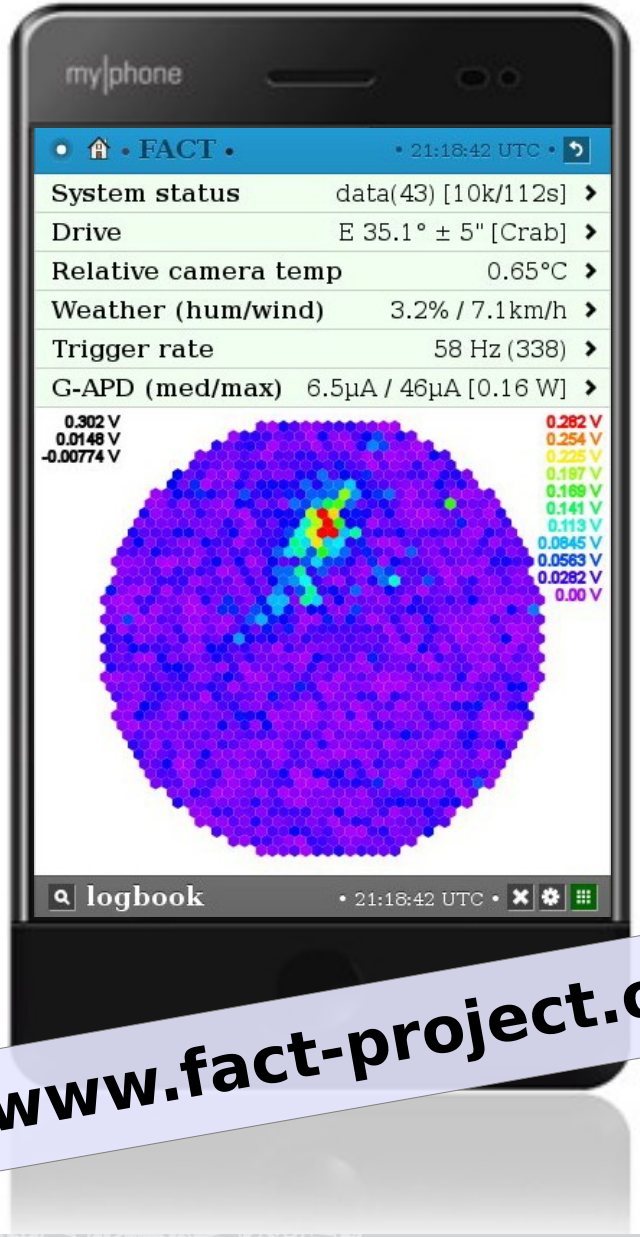


F. Temme et al. (FACT Collaboration), ICRC 2015

- More information

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

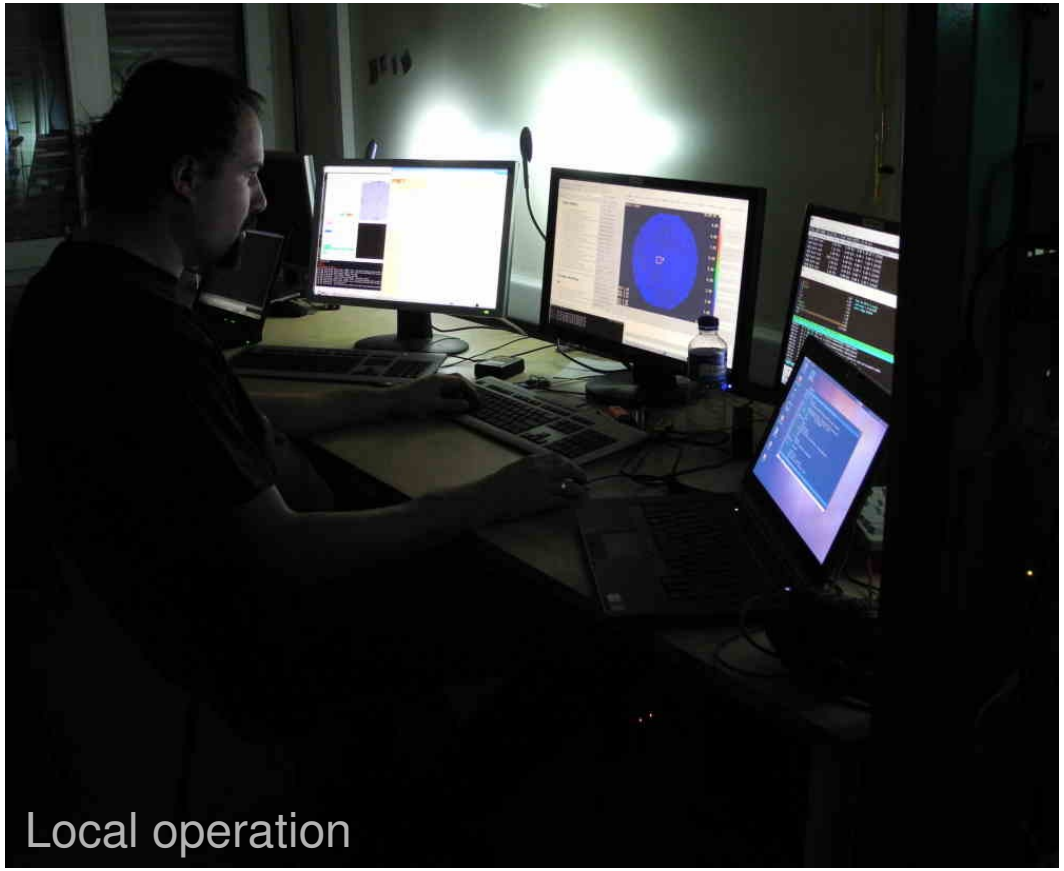
FACT – Ideal Monitoring Telescope

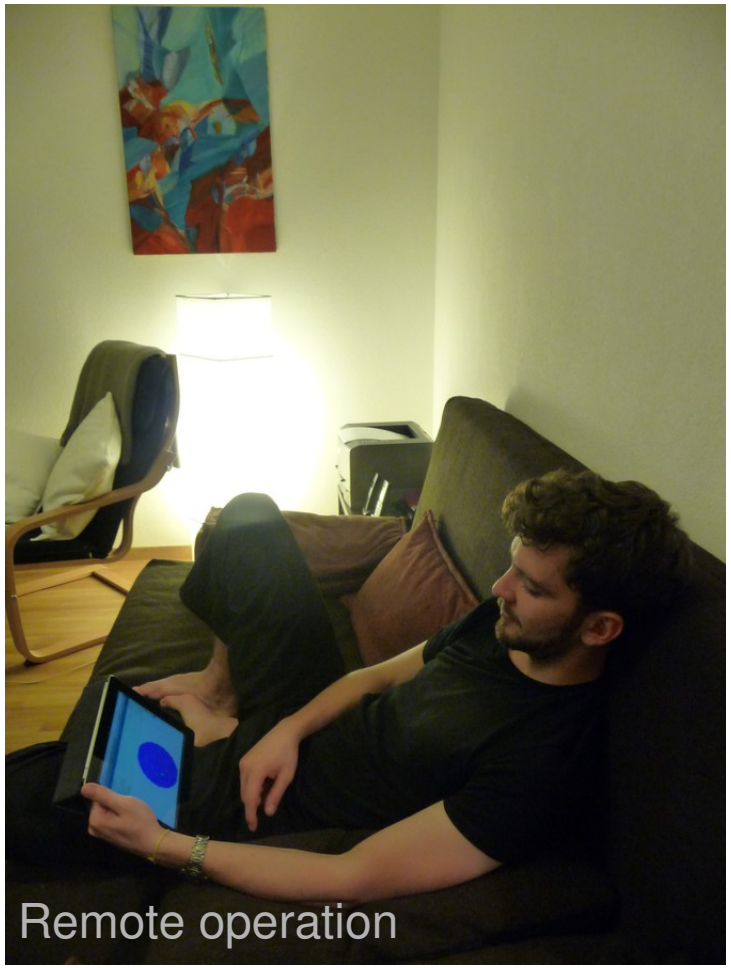


- SiPMs robust and stable
  → Stable telescope performance
  → Remote and automatic operation

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

Towards Robotic Operation





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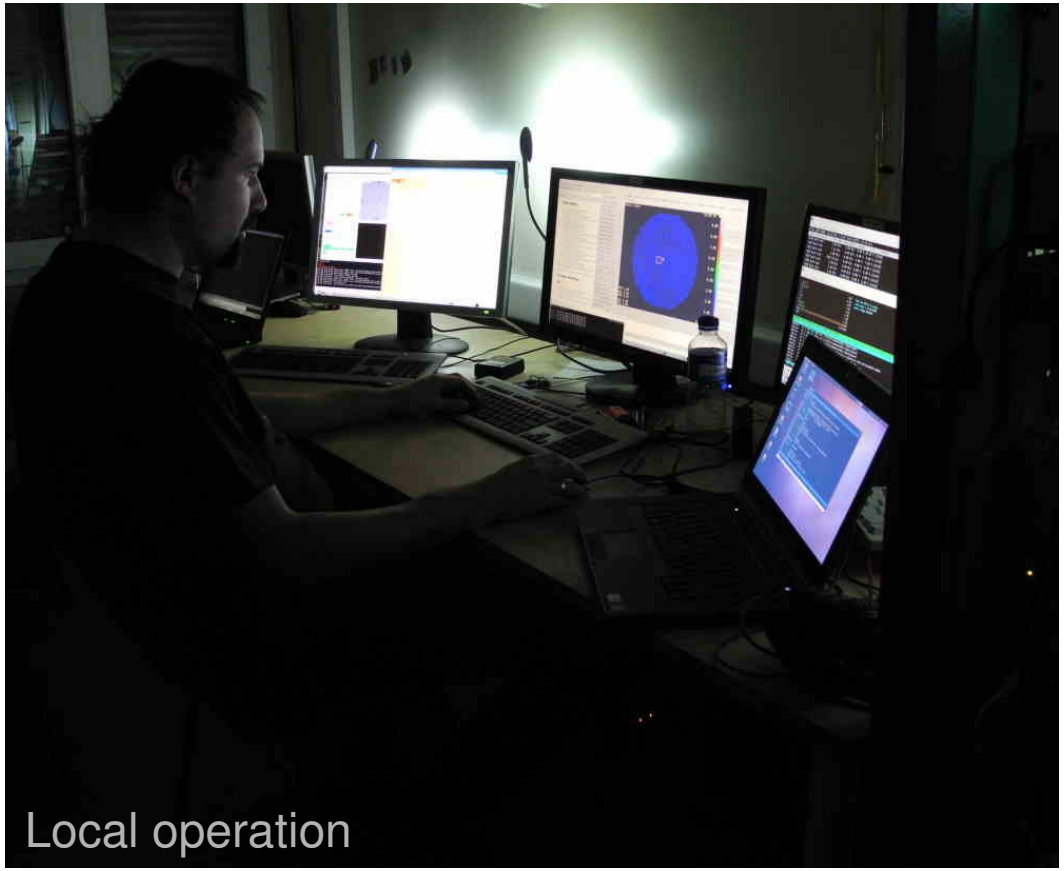
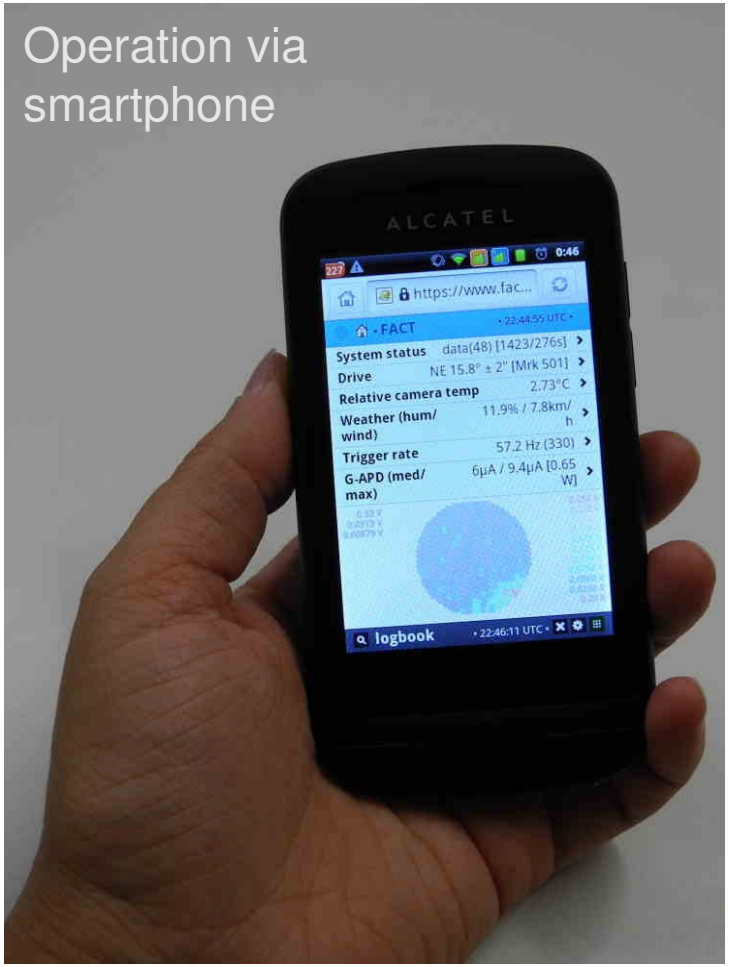
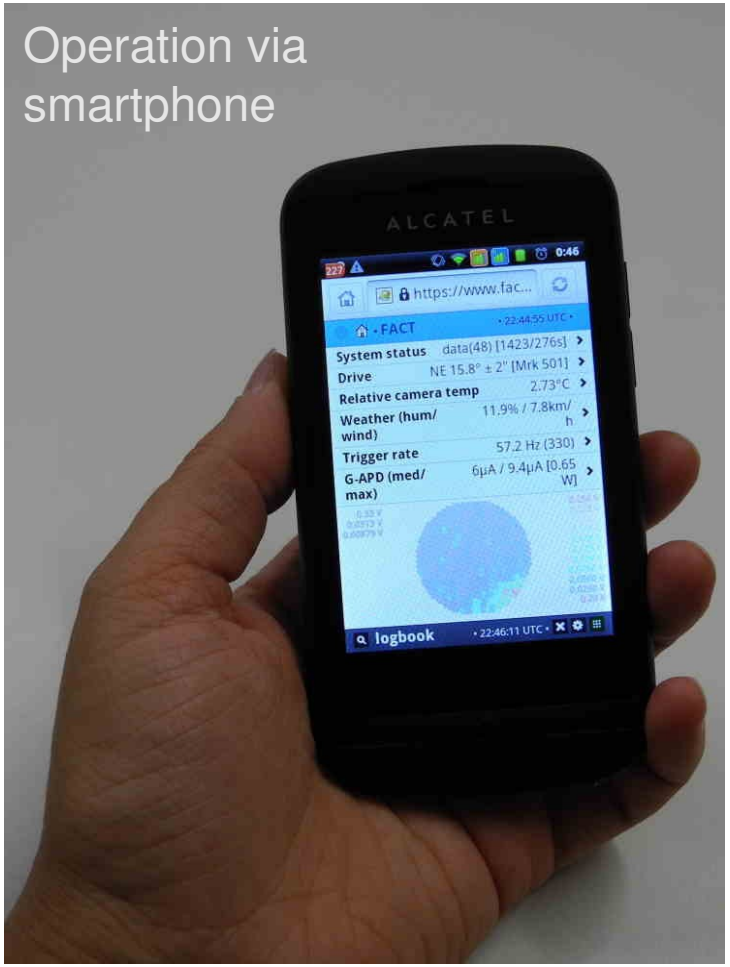




Automatic Operation

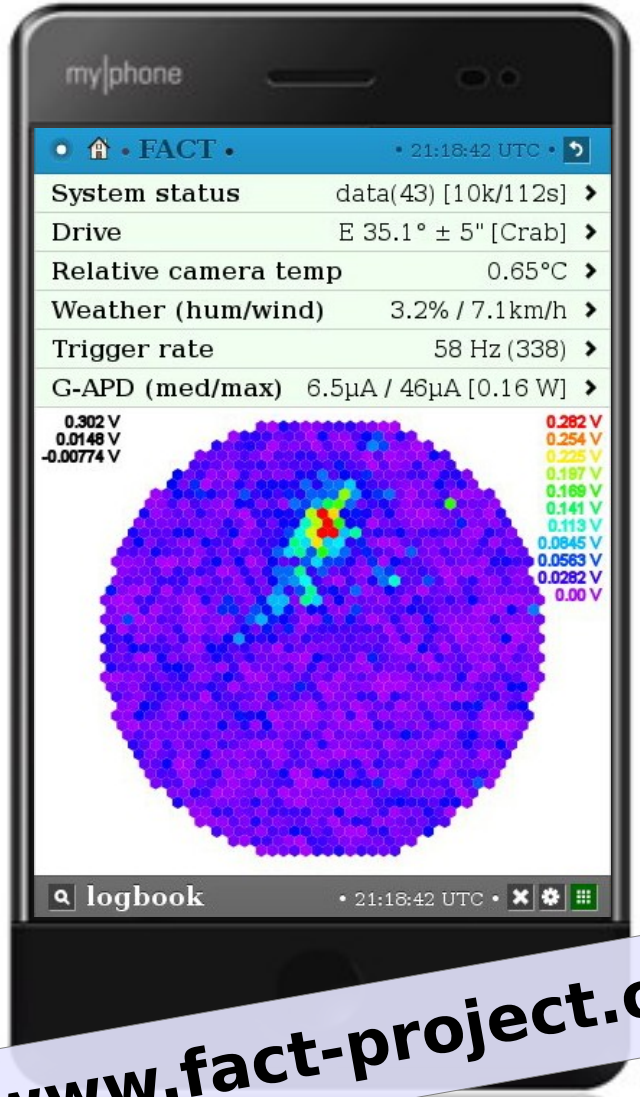
Towards Robotic Operation

Next Step:
Shifter-on-Call



Automatic Operation

FACT – Ideal Monitoring Telescope



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  → Stable telescope performance
  → Remote and automatic operation
  → High data taking efficiency

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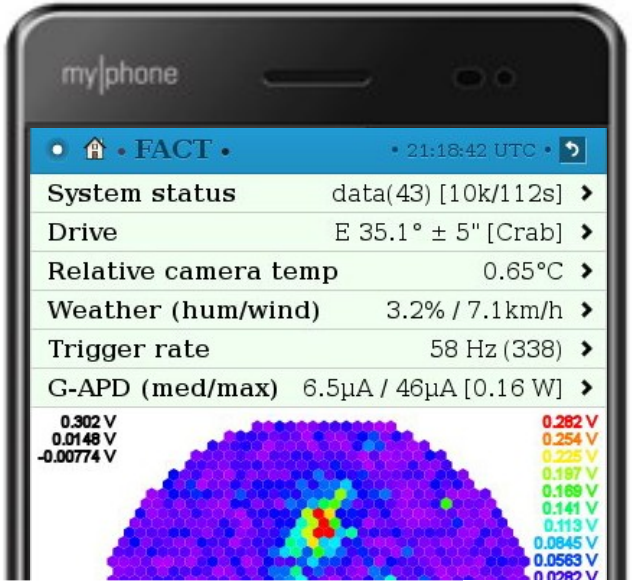

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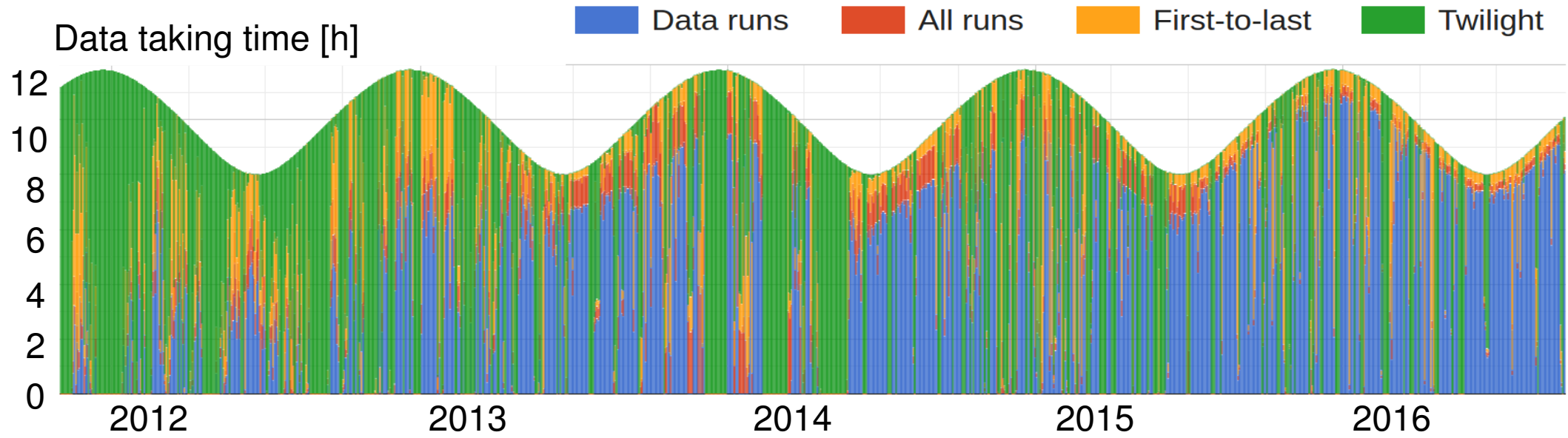

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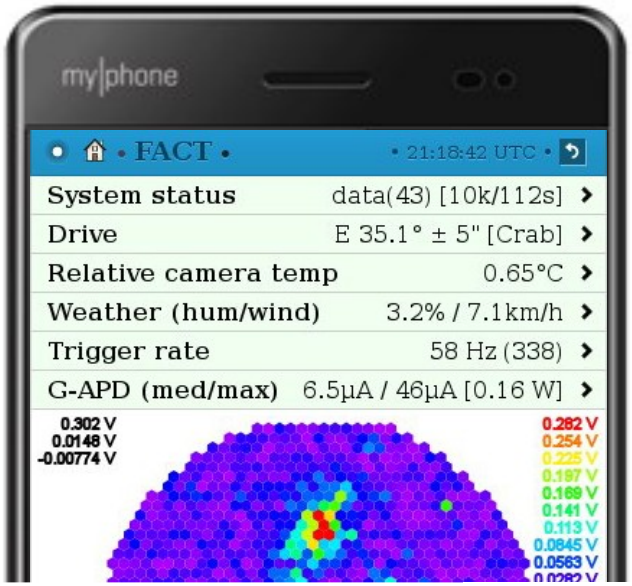

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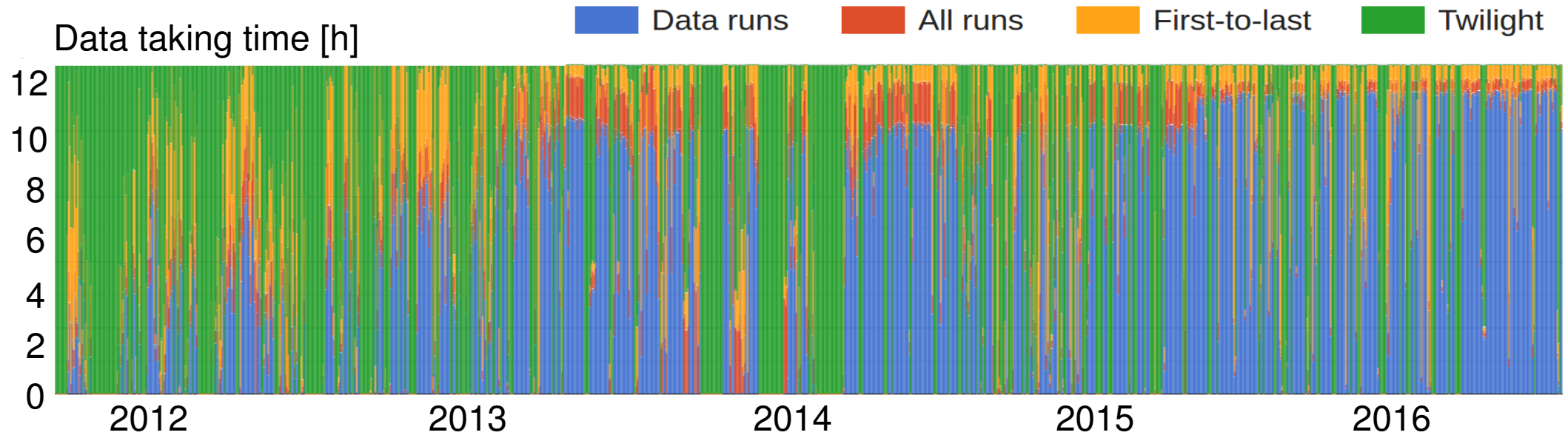

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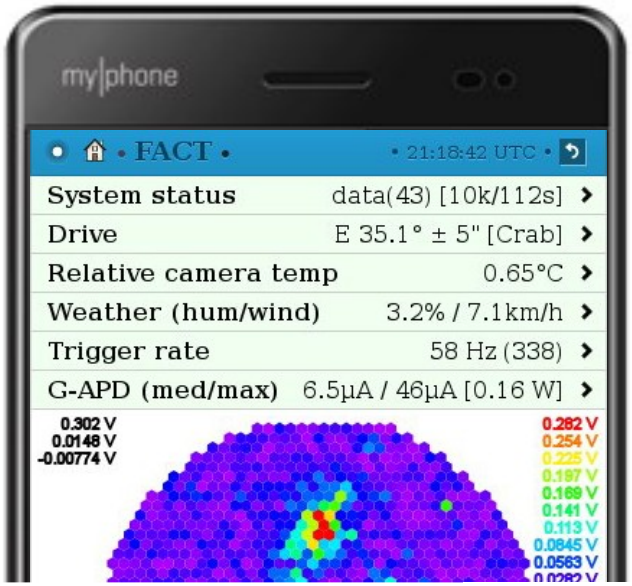

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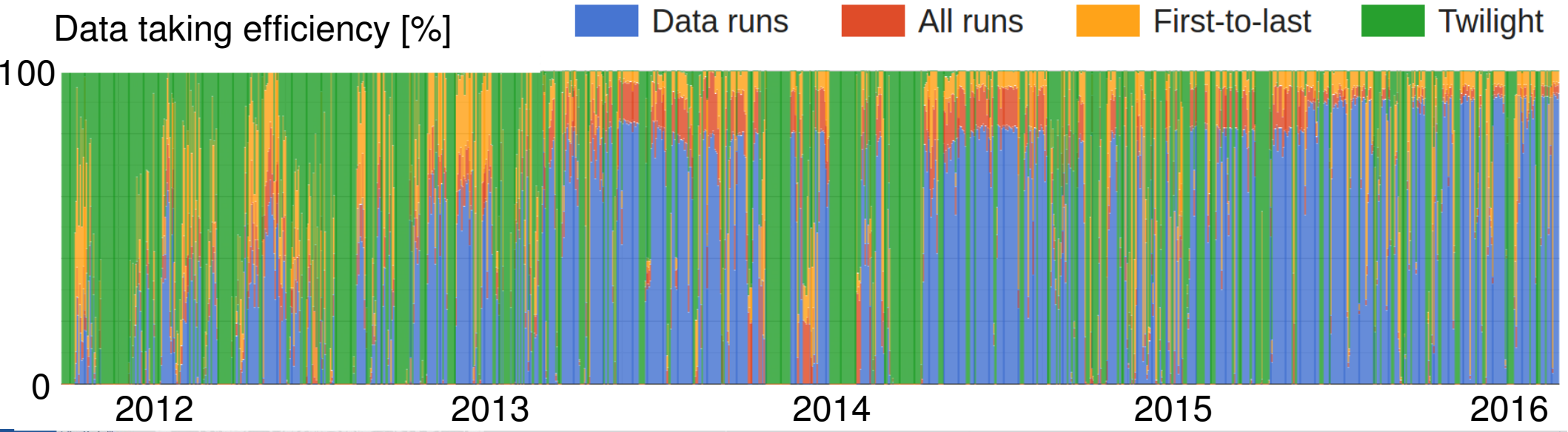
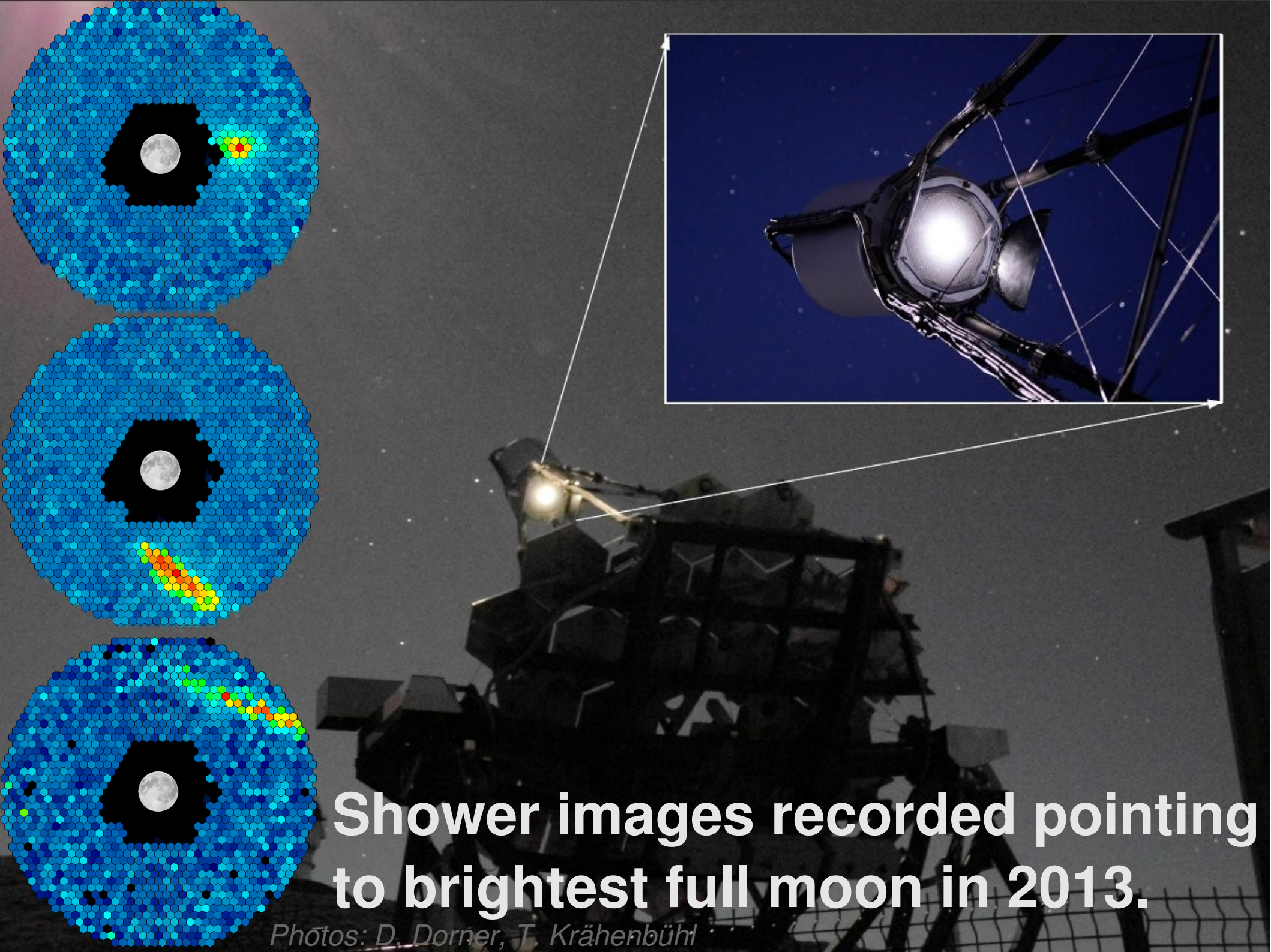


FACT – Ideal Monitoring Telescope


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

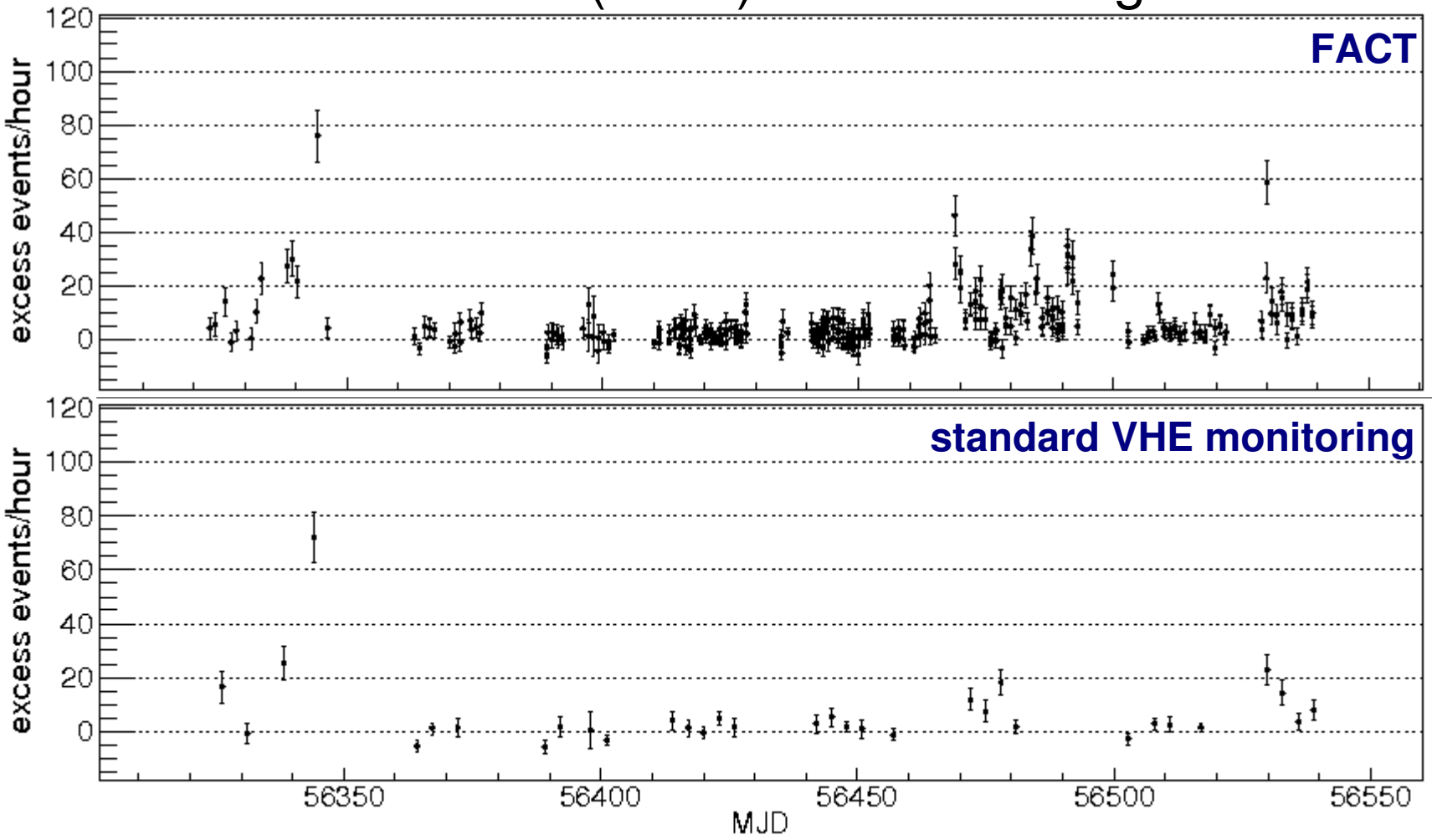
FACT – Ideal Monitoring Telescope


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

Long-term Monitoring at VHE

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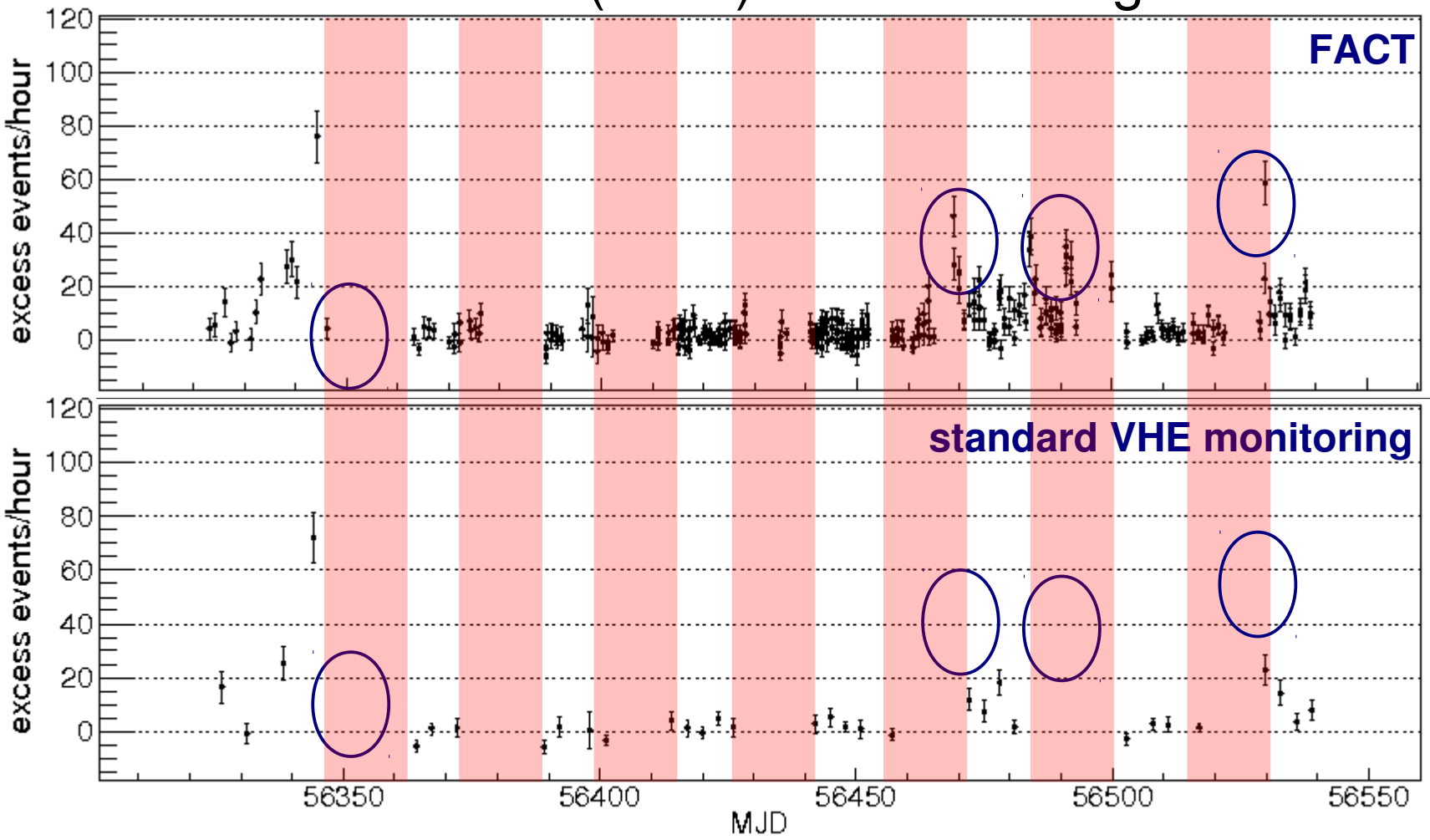

All data ~410h

Moon < 65%
1h every
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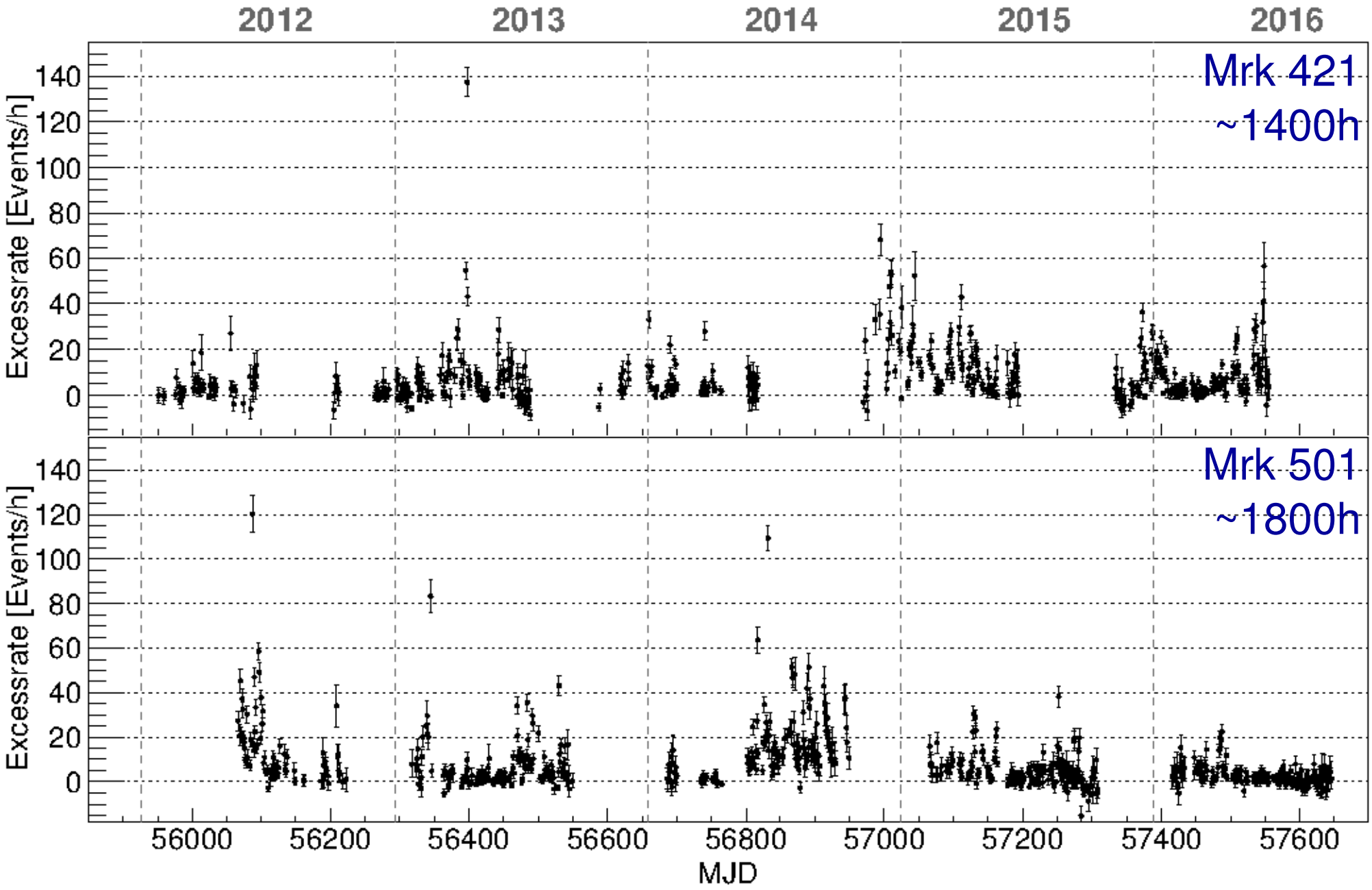
→ ~32h

FACT monitoring strategy → Unbiased data sample

Almost 5 Years of Monitoring



QLA

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

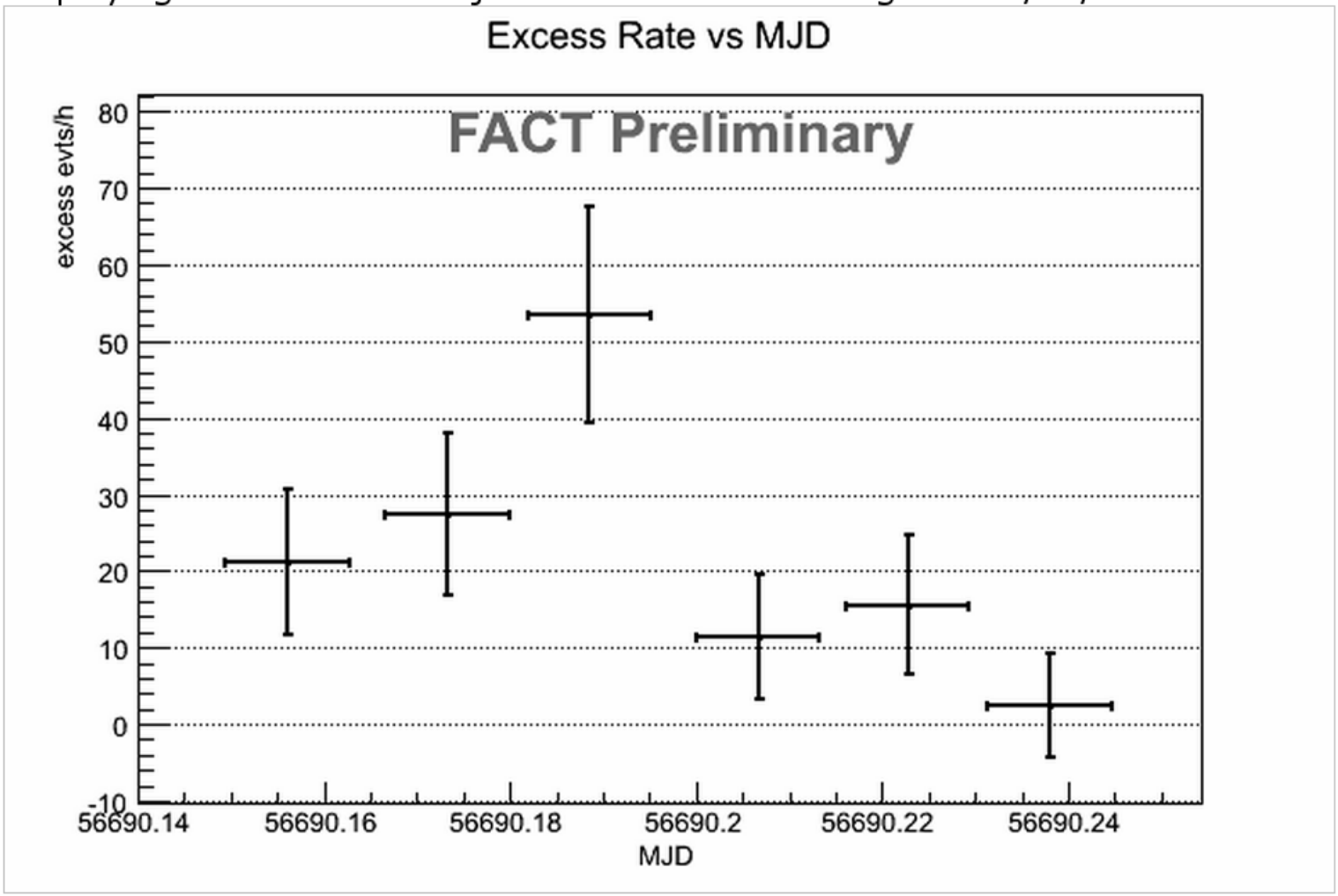
http://www.fact-project.org/monitoring

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.



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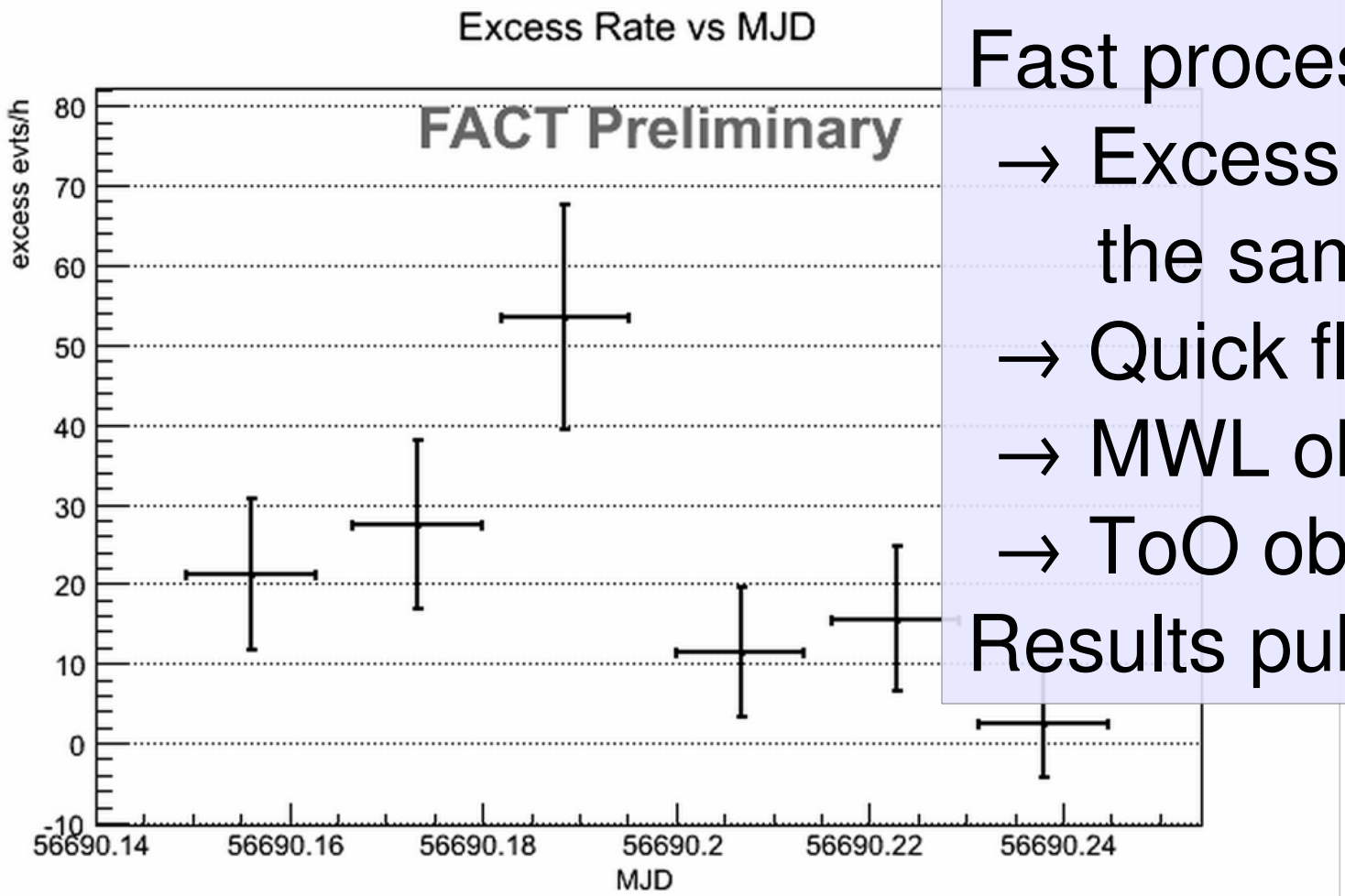


Fast processing

→ 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

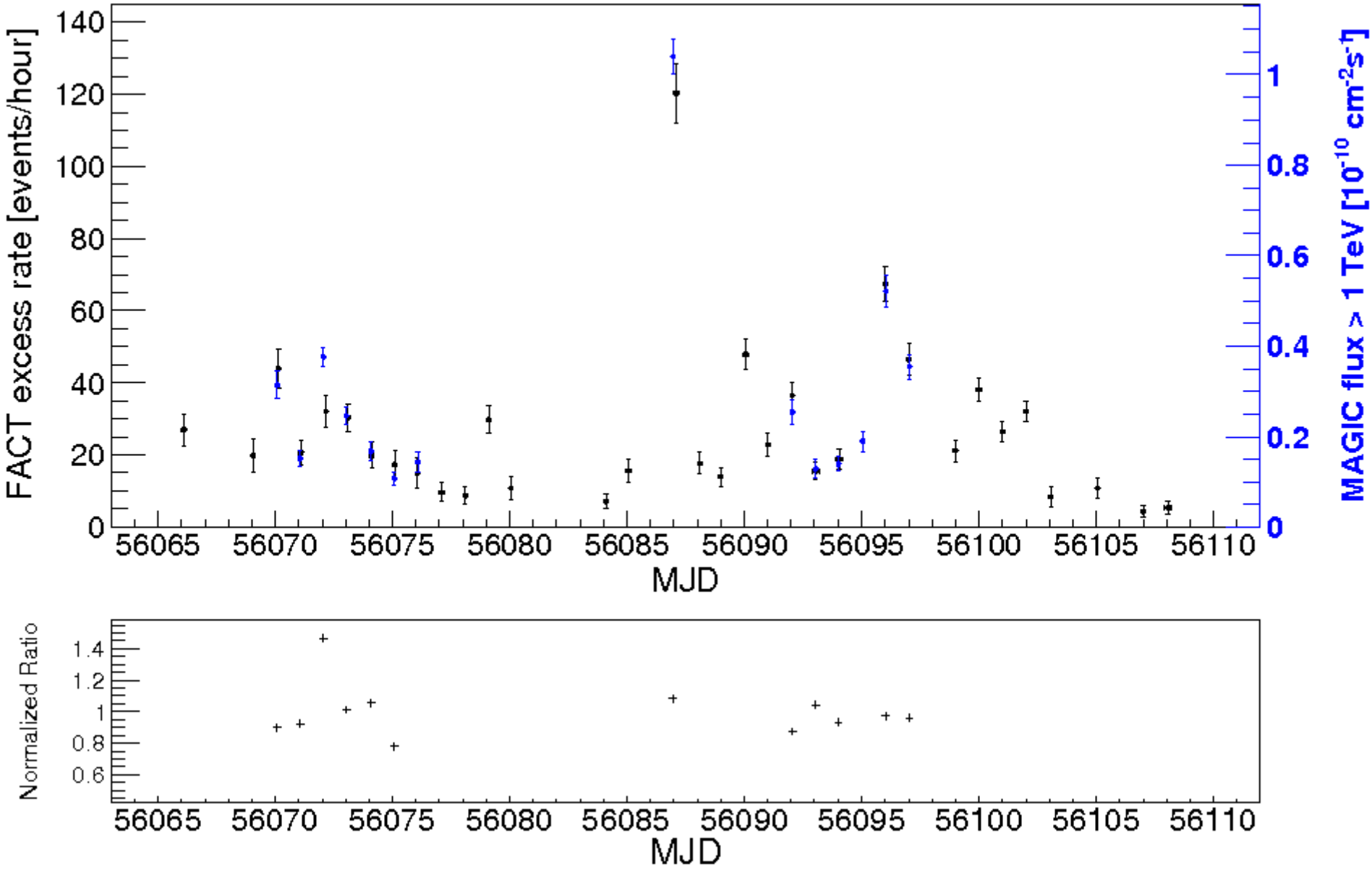
@ 17:30h

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

6 Atels in 2016

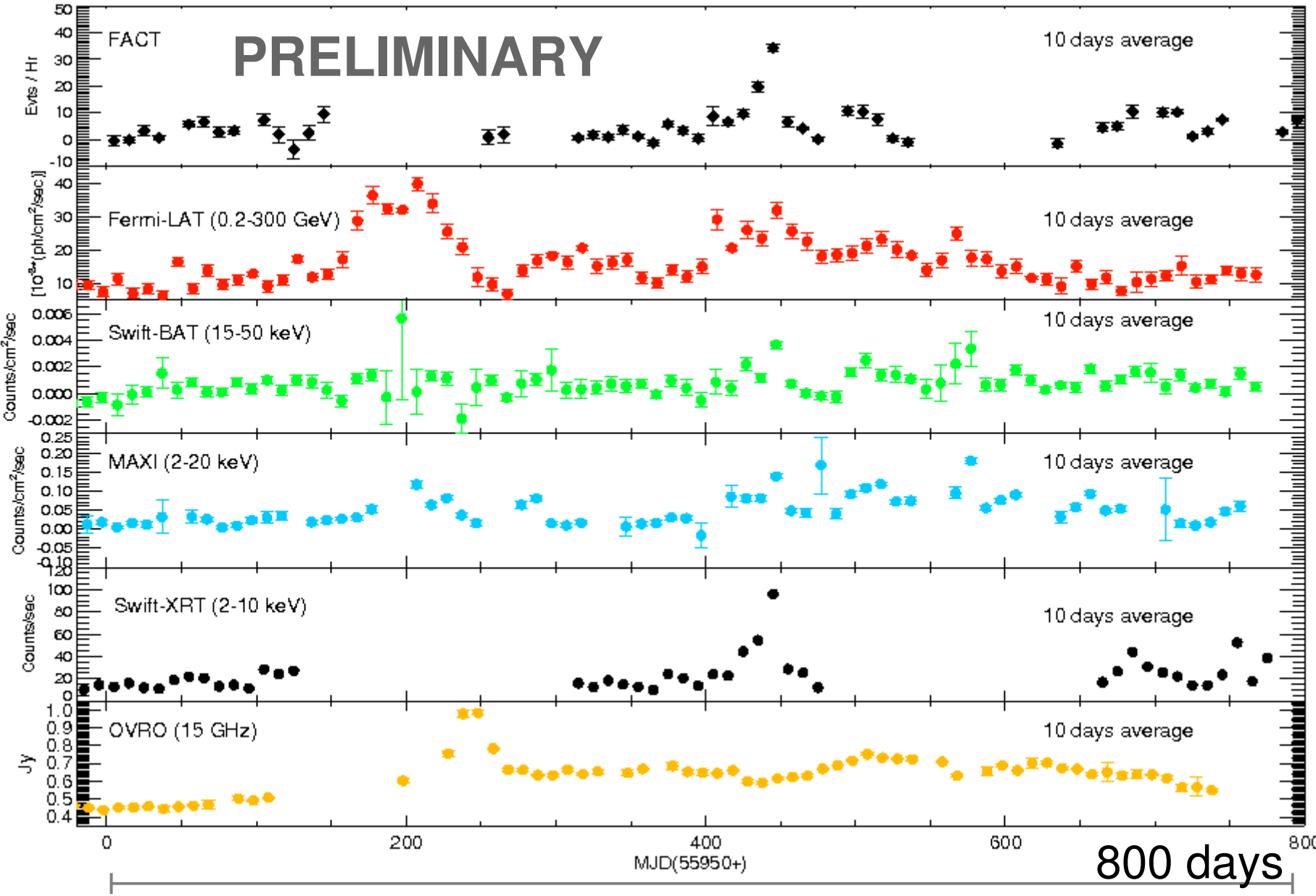
38 alerts since March 2014

Mrk 501 – Flares May/June 2012



MAGIC: http://143.107.180.38/indico/contributionDisplay.py?contribId=934&sessionId=3&confId=0

Mrk 421 from Radio to TeV Energies



FACT

GeV

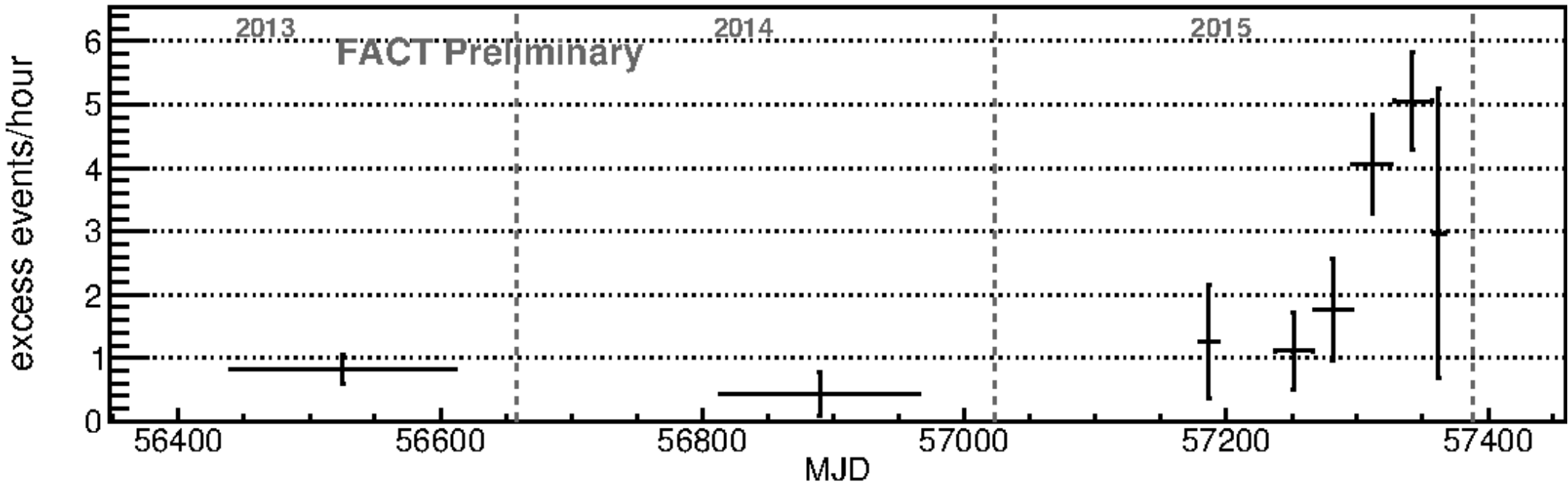
15-50 keV

2-20 keV

2-10 keV

15 GHz

1ES 1959+650 – the last Years



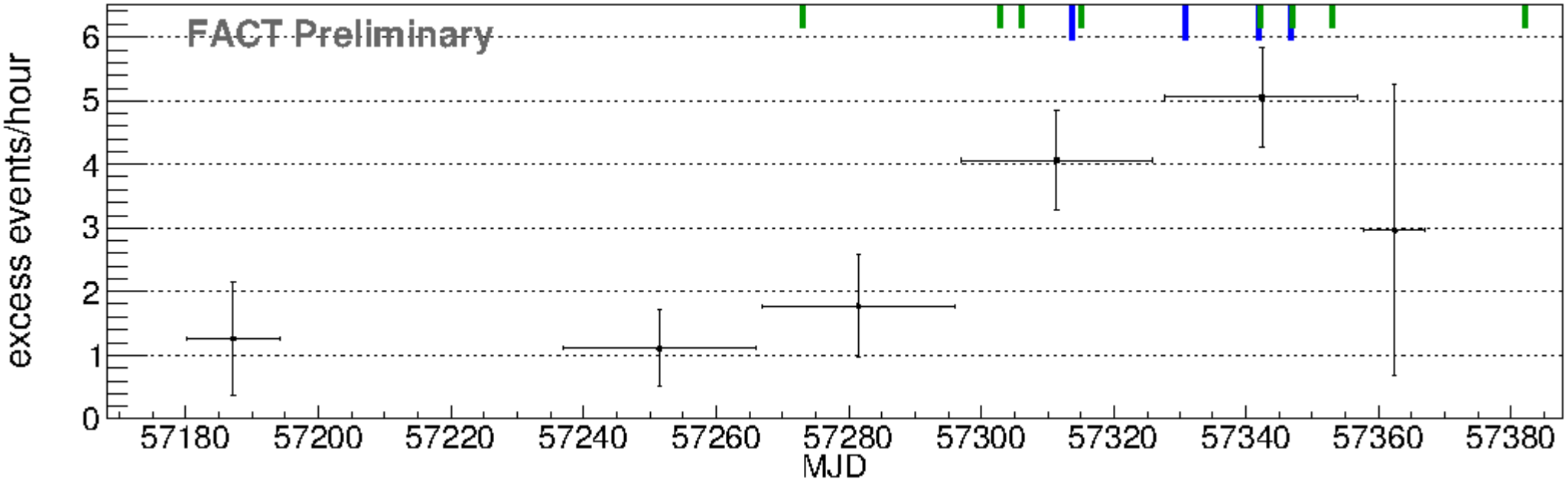
1ES 1959+650:

Zenith distance > 35°

Total observation time 2013-2015: > 550 hours

1ES 1959+650 – Activity in 2015

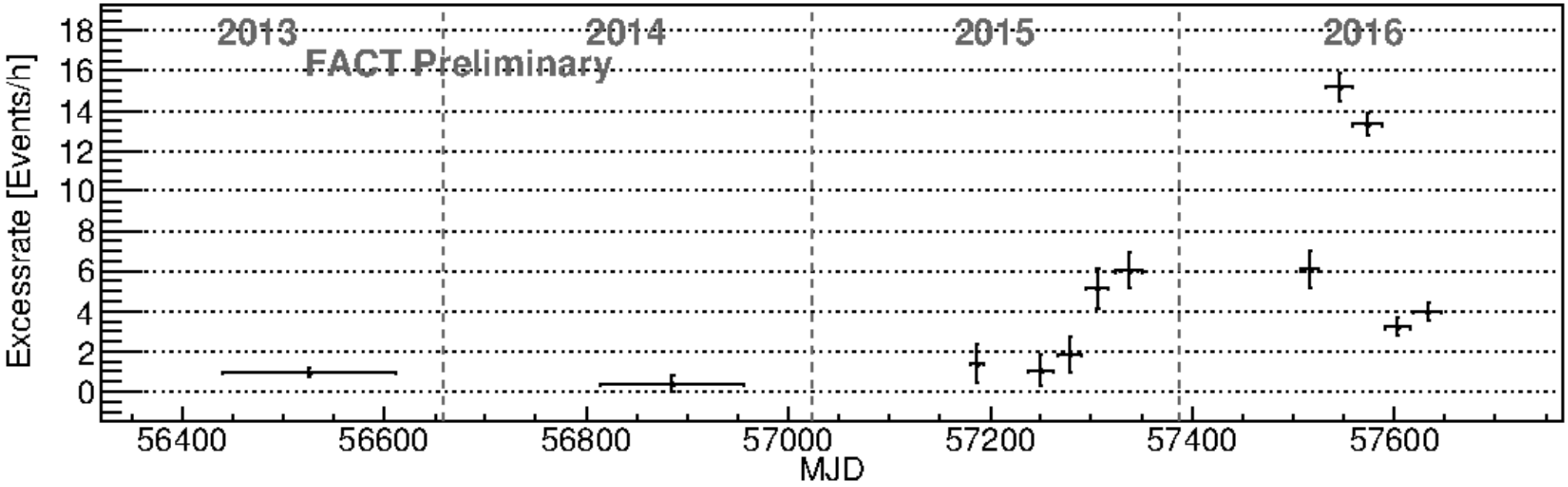
2.8.-10.12.2015



FACT flare alerts / nights with > 3 σ

ATels: Swift, VERITAS, MAXI, Fermi, Swift, Ratan, Swift, Swift

1ES 1959+650 – This Year



1ES 1959+650 – This Year

[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

Tweet | Recommend 8

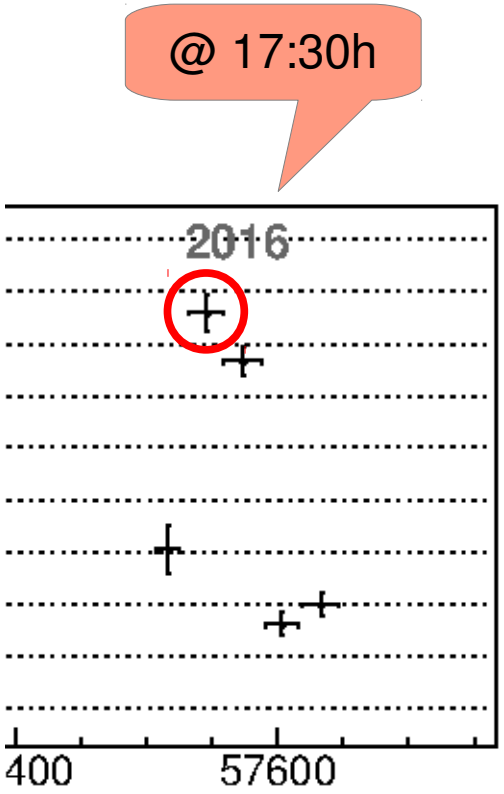
The FACT collaboration reports the measurement of an enhanced gamma-ray flux at about 1 TeV from a position consistent with the HBL 1ES 1959+650 (z=0.047, Schachter et al. 1993, ApJ, 412, 541).

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

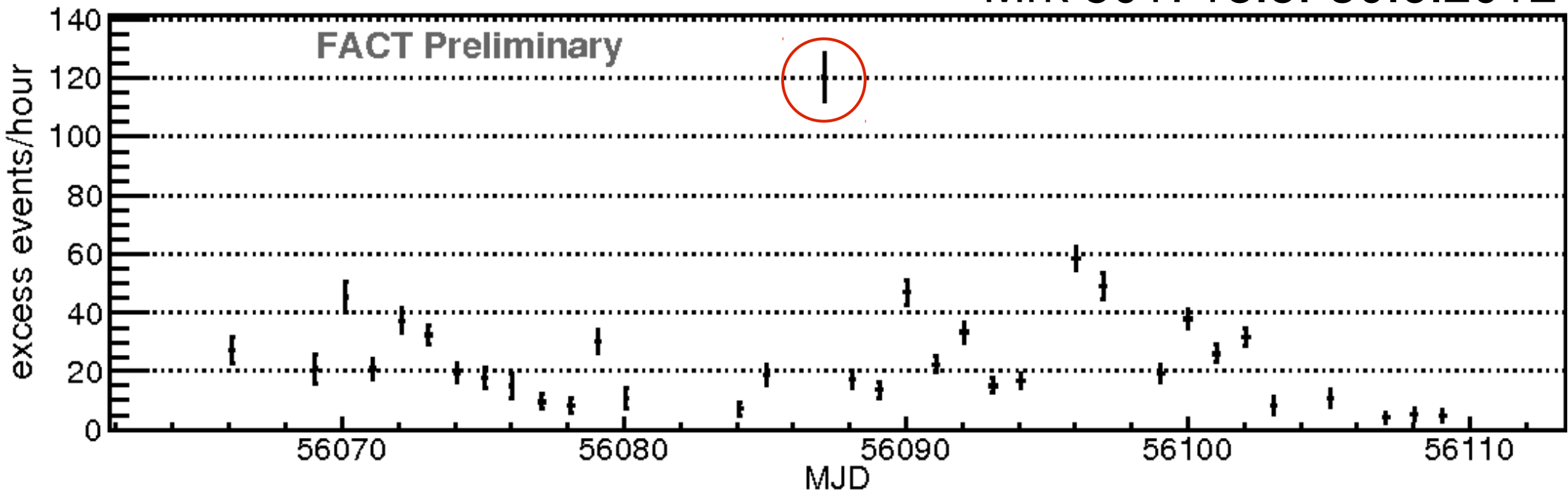
Related

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



Continuous Monitoring

Mrk 501: 18.5.-30.6.2012



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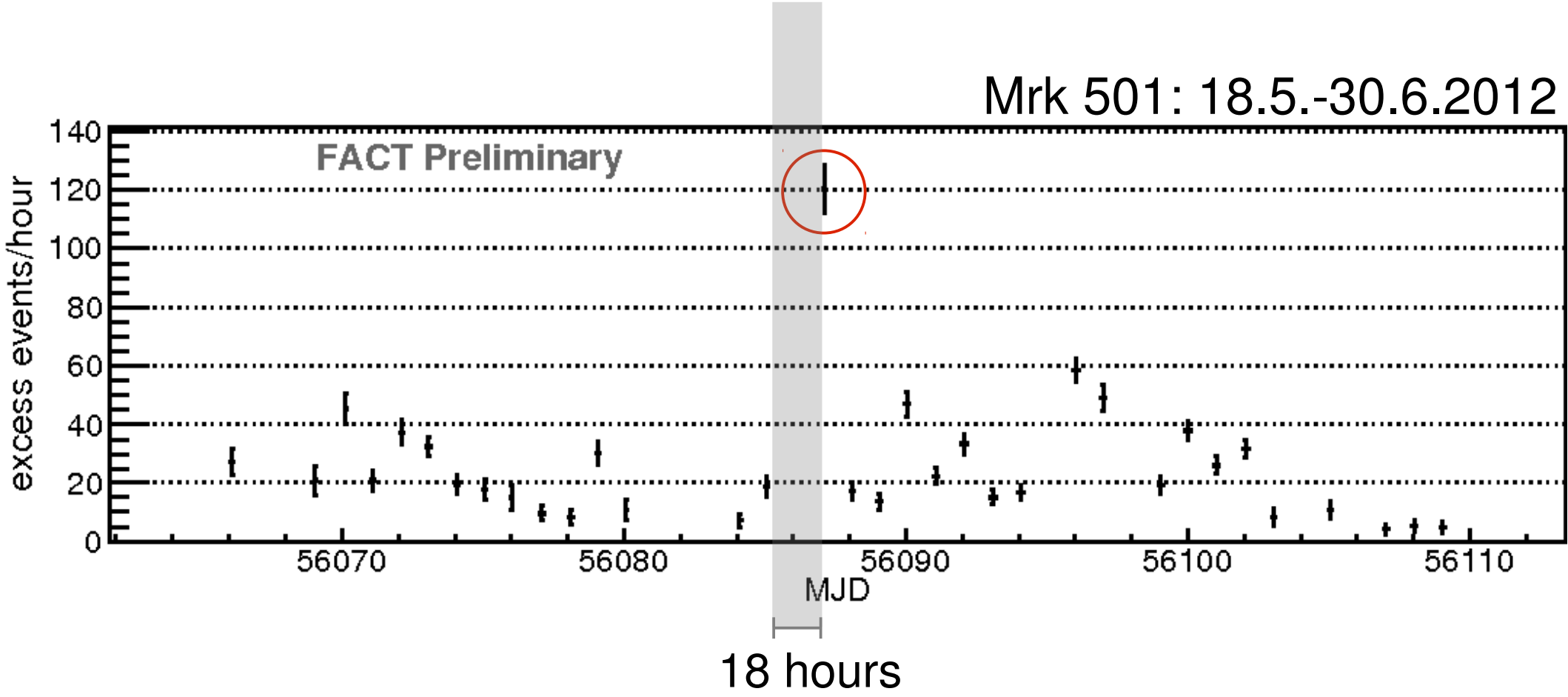
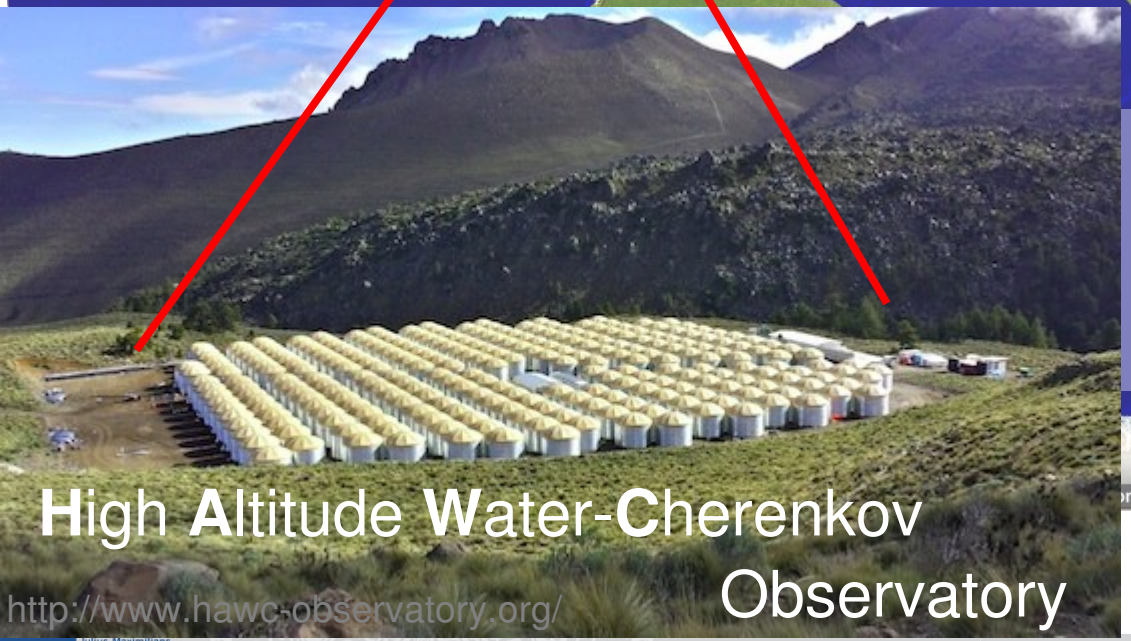


Observations at TeV Energies

Gaps due to daytime

Observations at TeV Energies



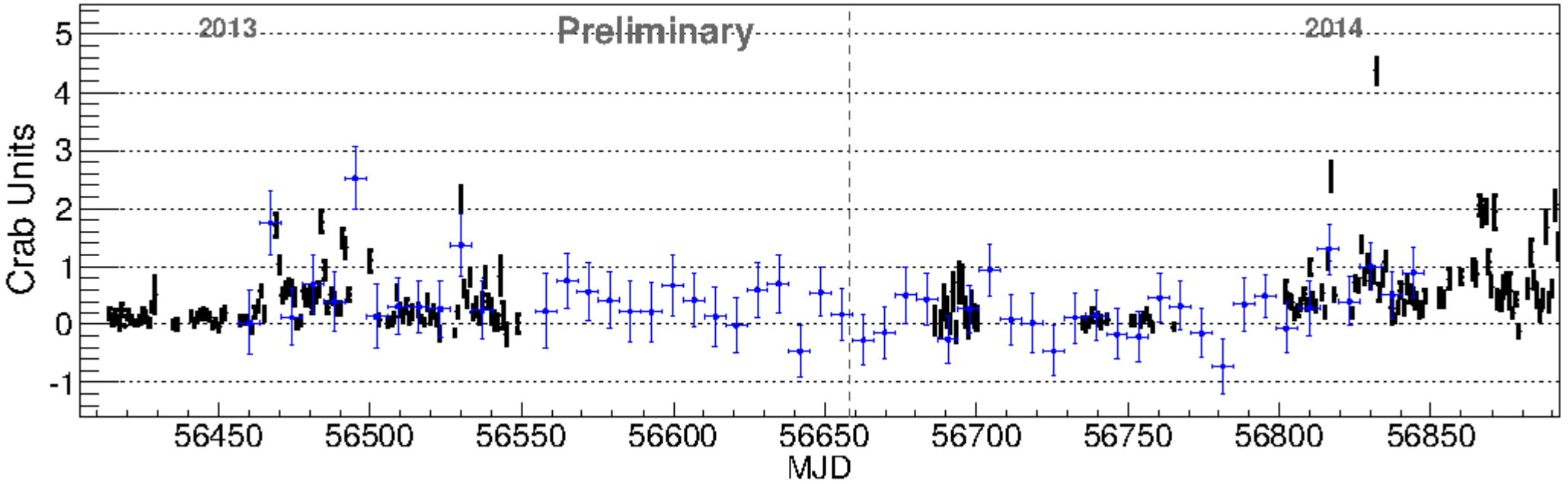
High **A**ltitude **W**ater-**C**herenkov Observatory

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

Photo: Thomas Krähenbühl

Combine with Data from HAWC

Mrk 501, 1.5.2013 – 31.8.2014 FACT HAWC



FACT:

nightly binning

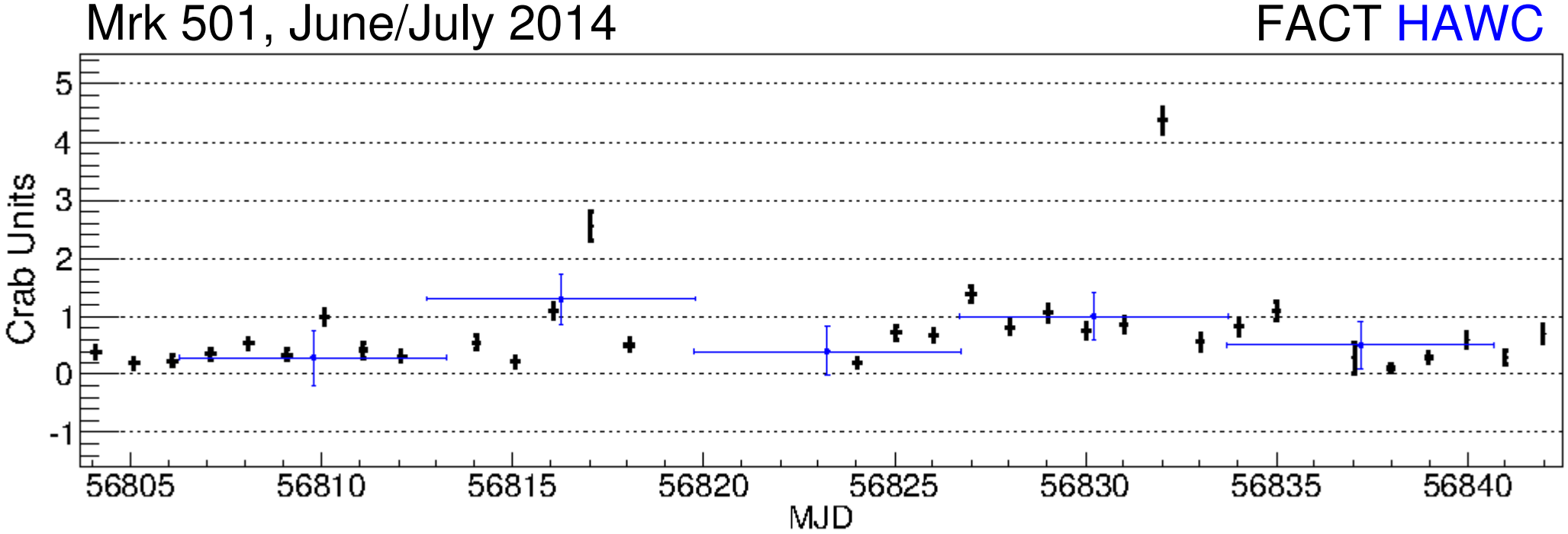
HAWC:

Data from HAWC-111

7-day binning with ~6 hours observation per transit

R.J. Lauer et al. (HAWC collaboration), 34th ICRC, arXiv:1508.04479

Combine with Data from HAWC



FACT: La Palma
nightly binning
HAWC: Mexiko

→ $\Delta t \sim$ 5.5 hours

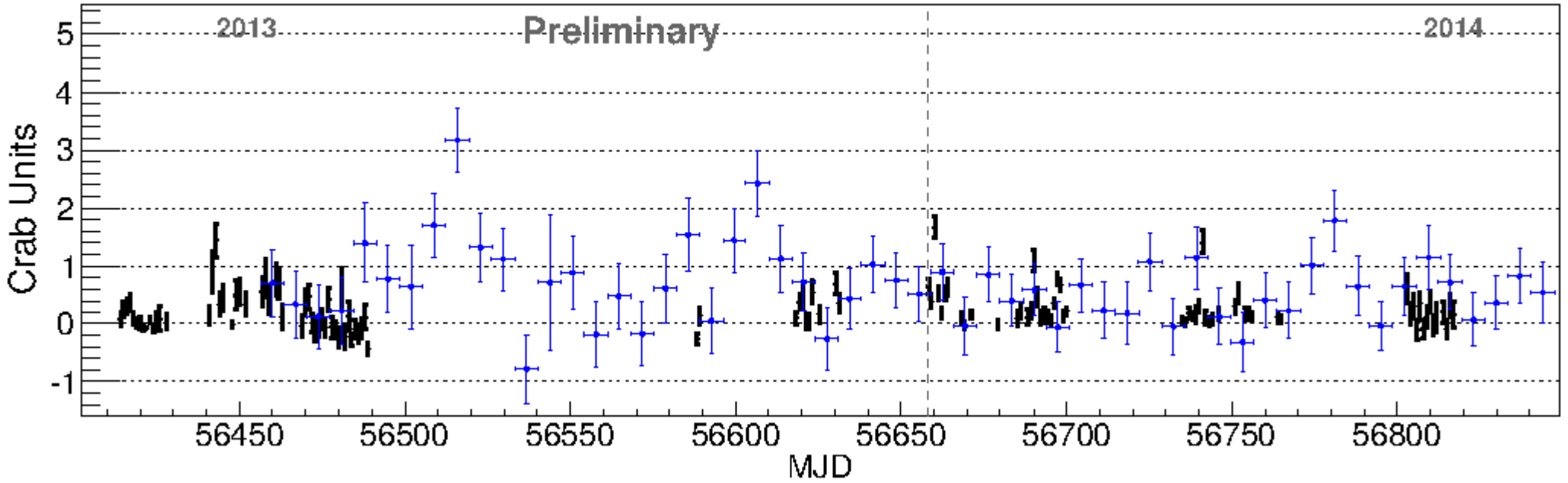
Data from HAWC-111

7-day binning with ~6 hours observation per transit

R.J. Lauer et al. (HAWC collaboration), 34th ICRC, arXiv:1508.04479

Combine with Data from HAWC

Mrk 421, 1.5.2013 – 21.8.2014 FACT HAWC



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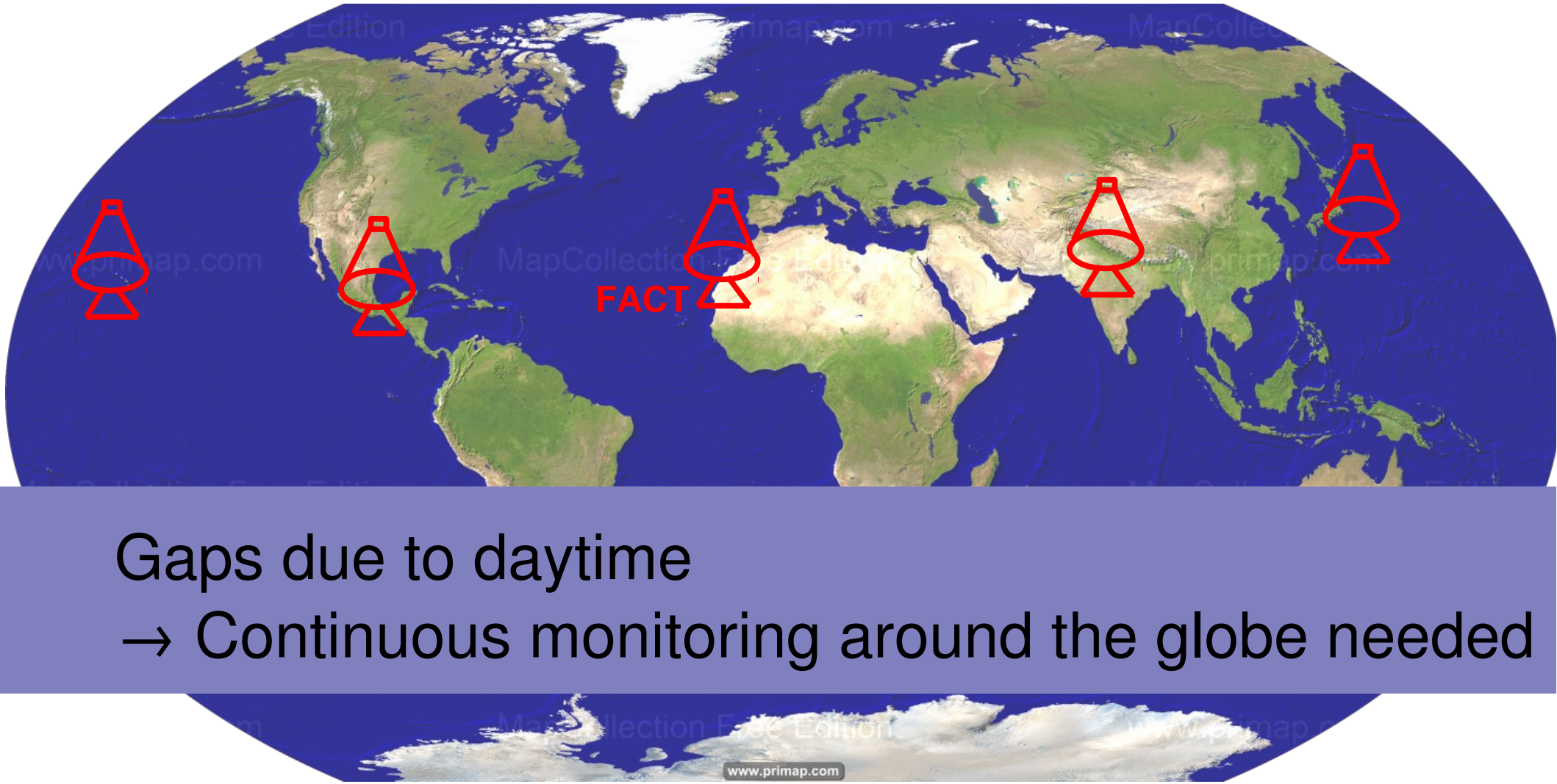
Global Monitoring Network

Gaps due to daytime

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

Global Monitoring Network

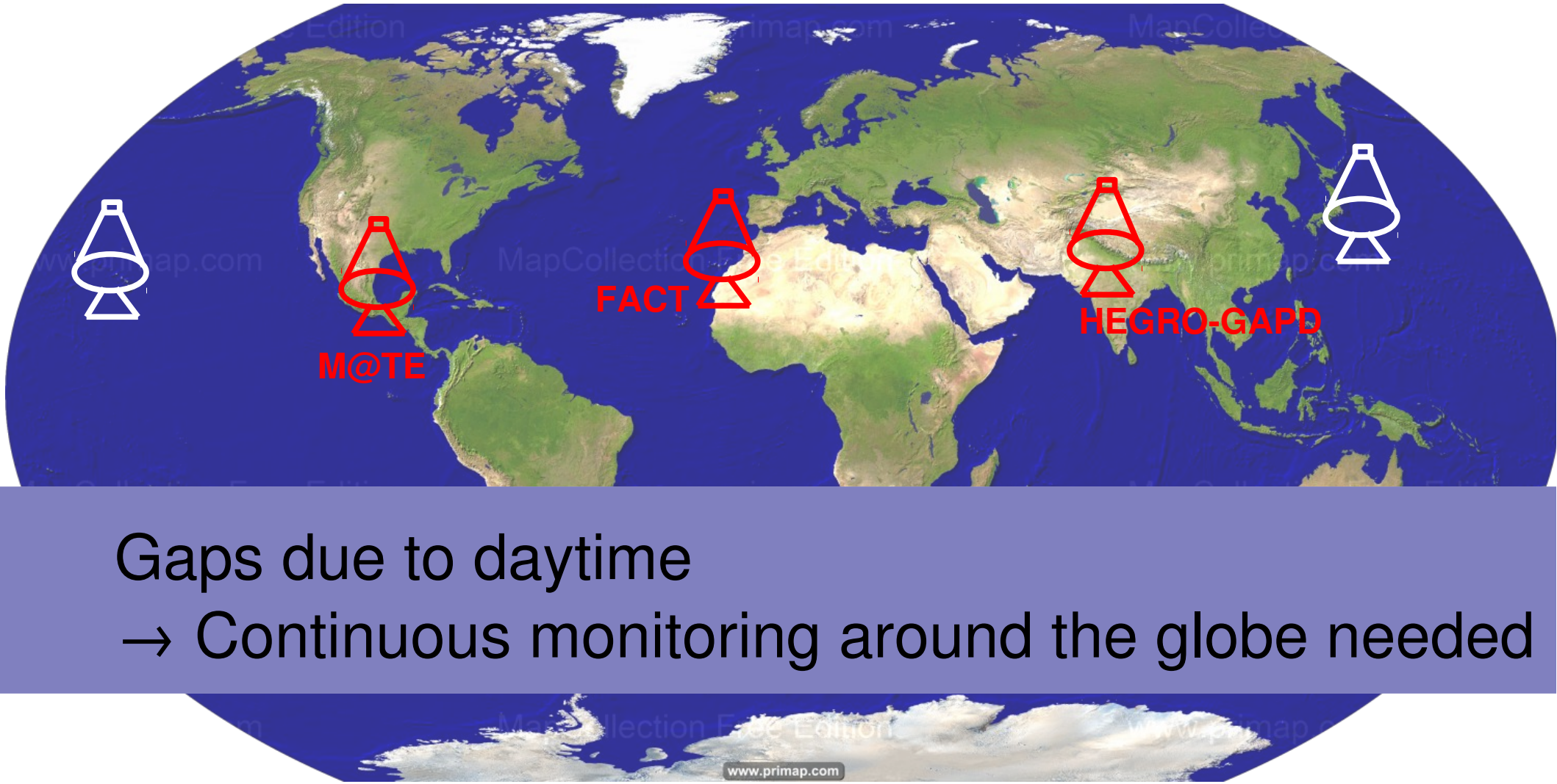


Gaps due to daytime

→ Continuous monitoring around the globe needed

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

Global Monitoring Network



Gaps due to daytime

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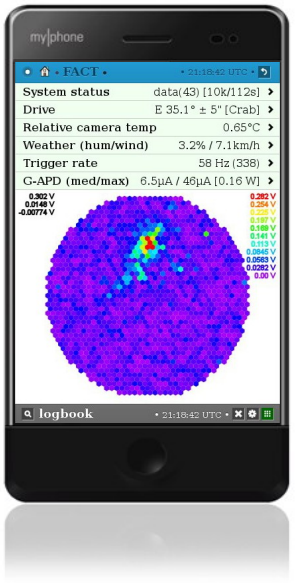
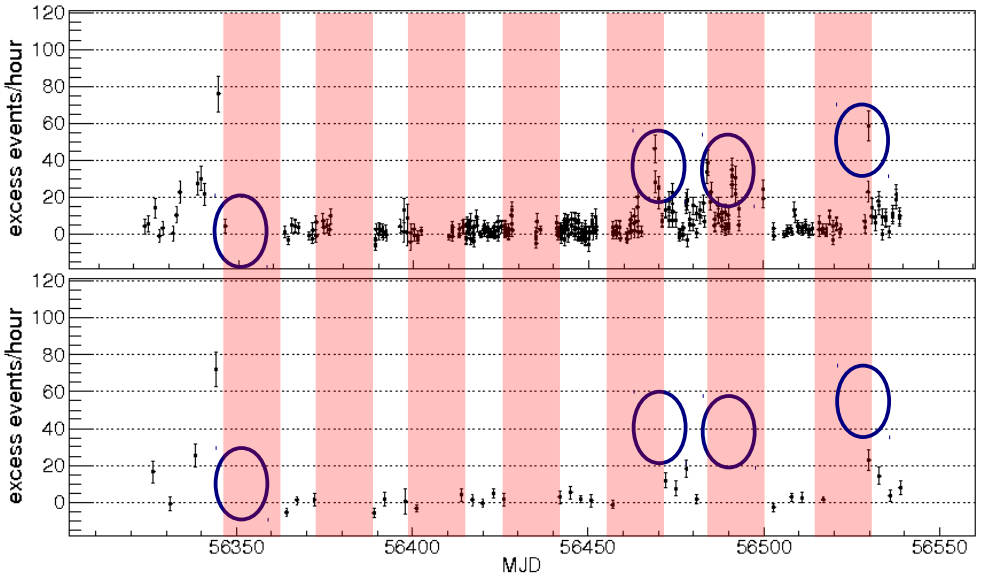
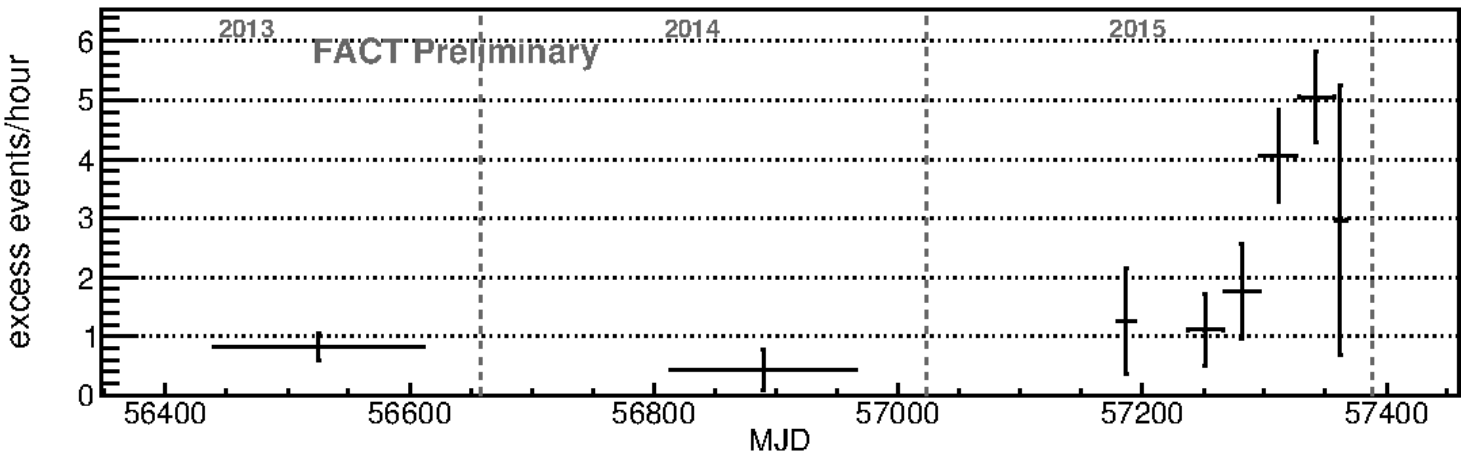
DWARF Network (M. Backes et. al ICRC 2009)

Summary





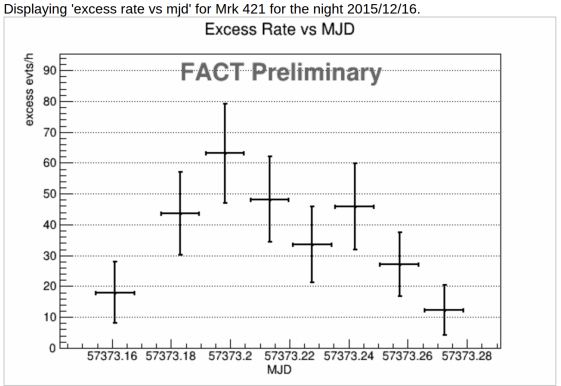
http://www.fact-project.org/monitoring



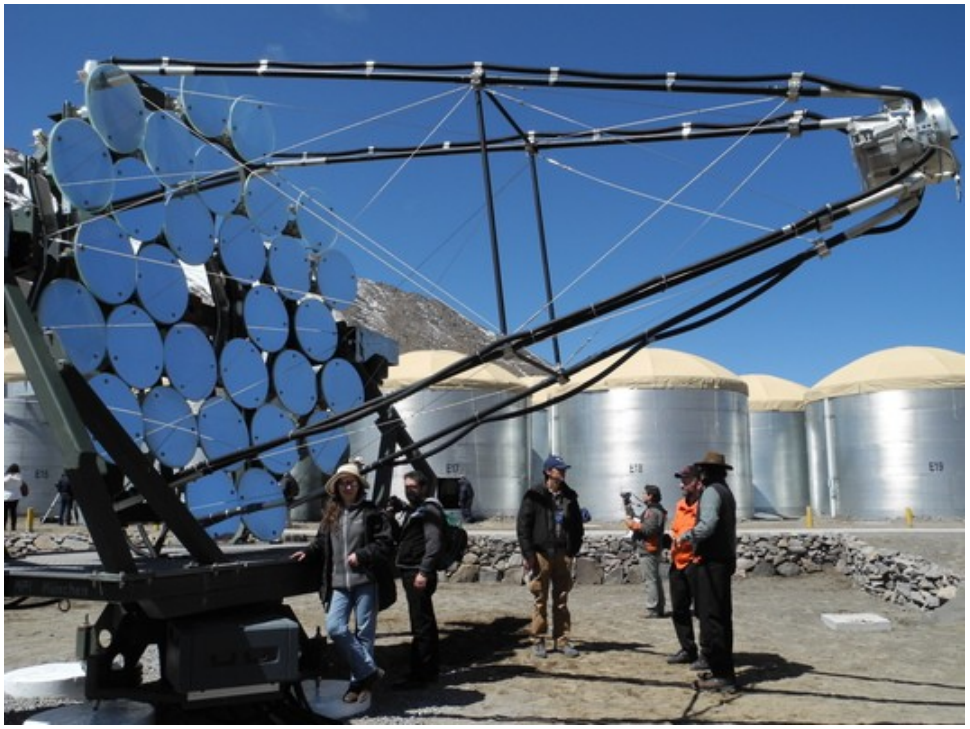
FACT Quick Look Analysis

Select date 2015 : 12 : 16 : source Mrk 421 :
Select time binning 20min : and range night : Reset

Displaying 'excess rate vs mjd' for Mrk 421 for the night 2015/12/16.



M@TE
Monitoring at TeV Energies



Daniela Dorner, Thomas Bretz,
Magdalena González, Ruben Alfaro,
Gagik Tovmassian

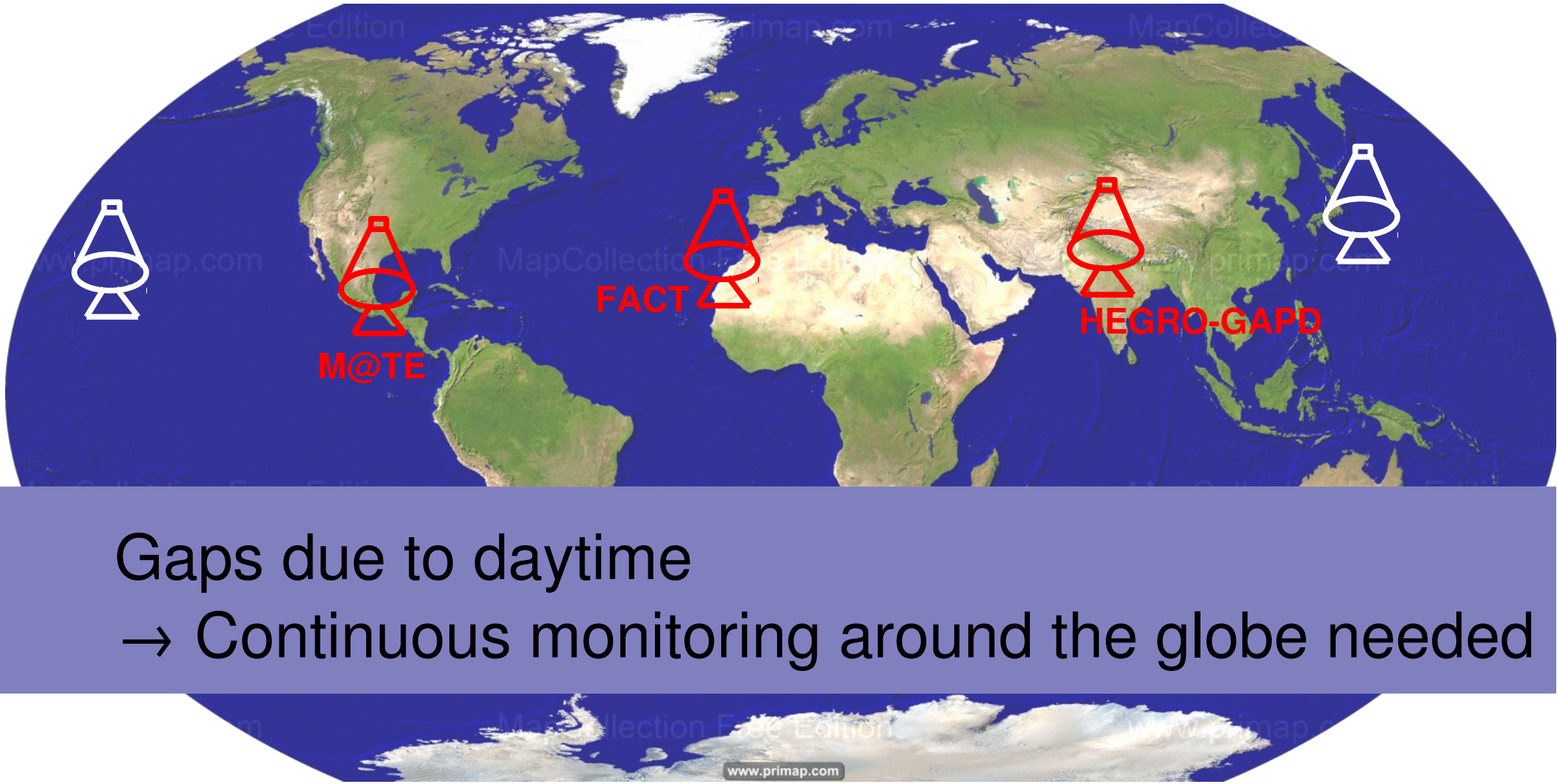
FRIEDRICH-ALEXANDER
UNIVERSITÄT
ERLANGEN-NÜRNBERG

Julius-Maximilians-
UNIVERSITÄT
WÜRZBURG

Outline

- Motivation
- Project
- Goals
- Status

Global Monitoring Network

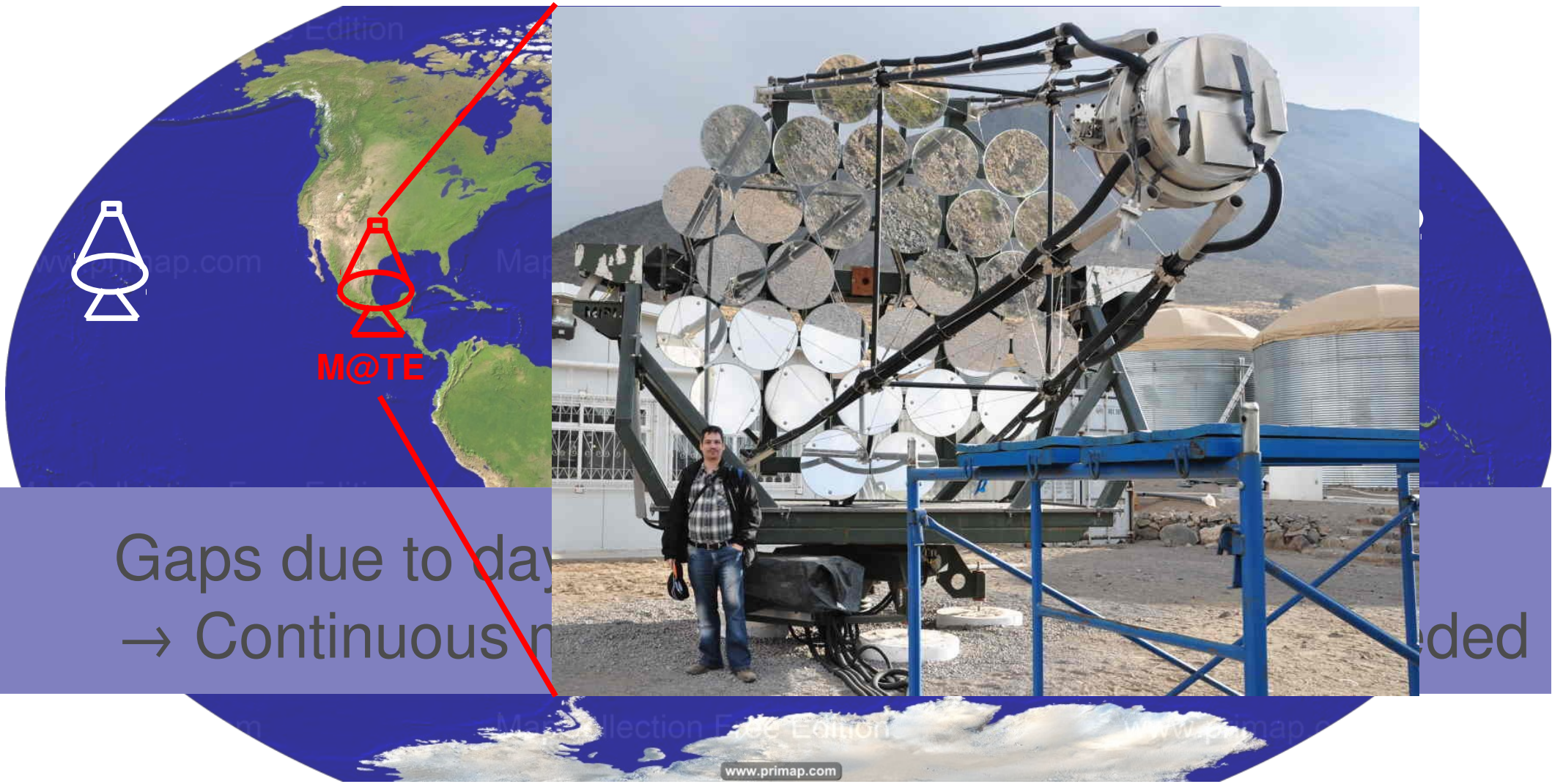


Gaps due to daytime

→ Continuous monitoring around the globe needed

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

Monitoring @ **T**eV **E**nergies



Gaps due to day

→ Continuous m ded

M@TE – The Project

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

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
  - 2800 m a.s.l.
  - Excellent weather conditions

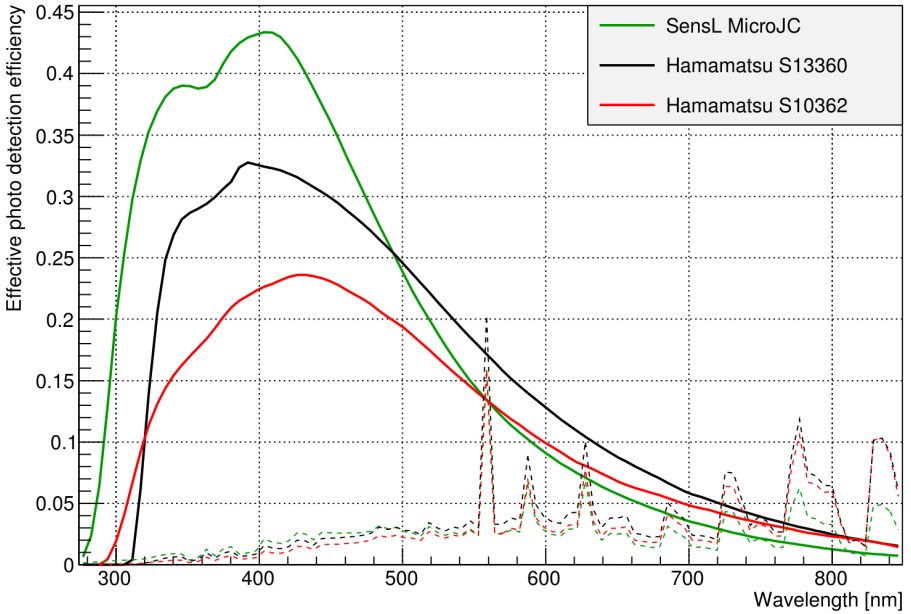
→ San Pedro Martir better for long-term monitoring

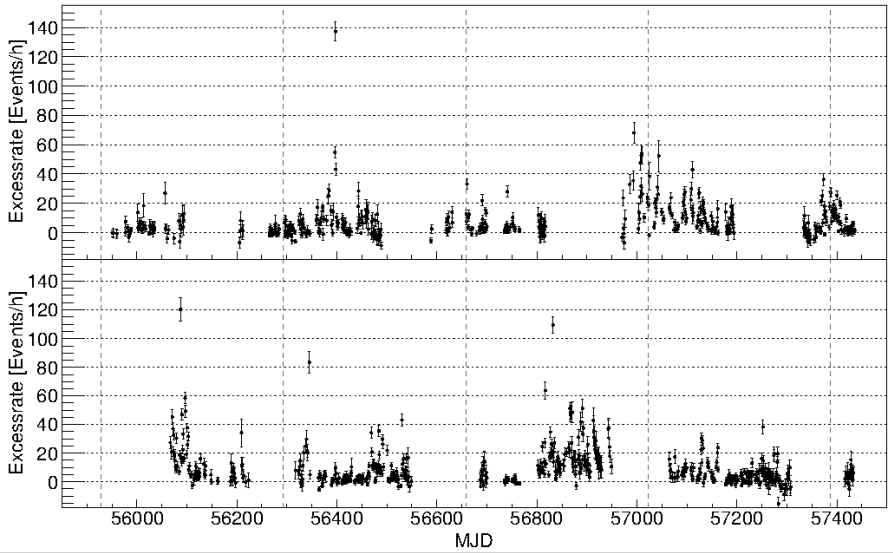
M@TE – Goals

- Improved SiPM camera
  - Increased PDE
  - Cherenkov light yield increased by factor 1.2-1.6 compared to FACT

  → Lower energy threshold
- Possibly cross-calibration with HAWC
- Long-term monitoring in San Pedro Martir

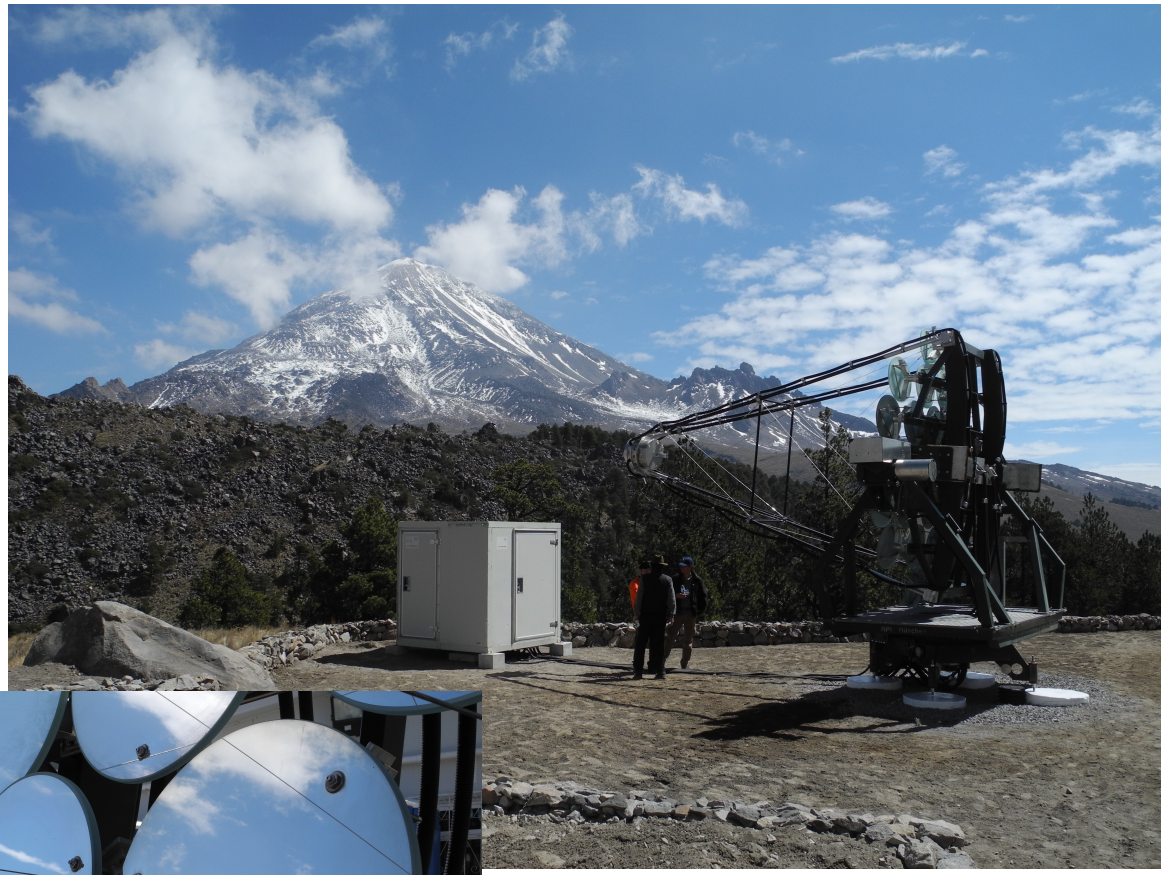
  → extend continuous observation to 12 hours





M@TE – Status

- 2 mounts from HEGRA available in Mexico
- 1st telescope installed at HAWC site (OMEGA project)
- 2nd mount ready to be installed in San Pedro Martir (M@TE)
- New drive system: ready to be installed
- Mirrors ordered



M@TE – 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