FACT

Alerts from TeV Gamma-Rays in the Context of Multi-Messenger Astrophysics

Daniela Dorner for the FACT Collaboration

Julius-Maximilians-
UNIVERSITÄT
WÜRZBURG

Würzburg

First G-APD Cherenkov Telescope
Major Goals

Proof of principle:

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

✓ Successful operation since October 2011

Observing Strategy:
Longterm monitoring

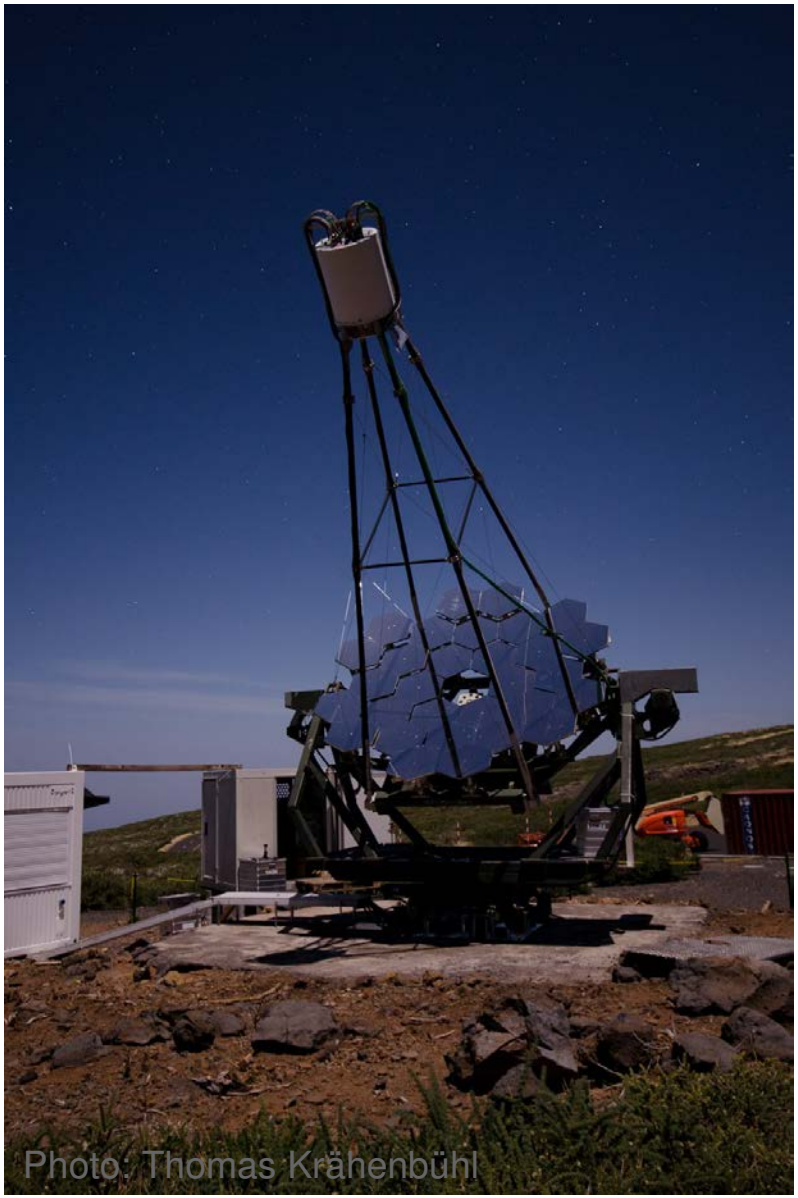
Sample:
Few bright TeV Blazars

→ Variability studies
→ Multi-wavelength correlations
→ Flare alerts to other instruments

* Geiger-mode Avalanche Photodiodes

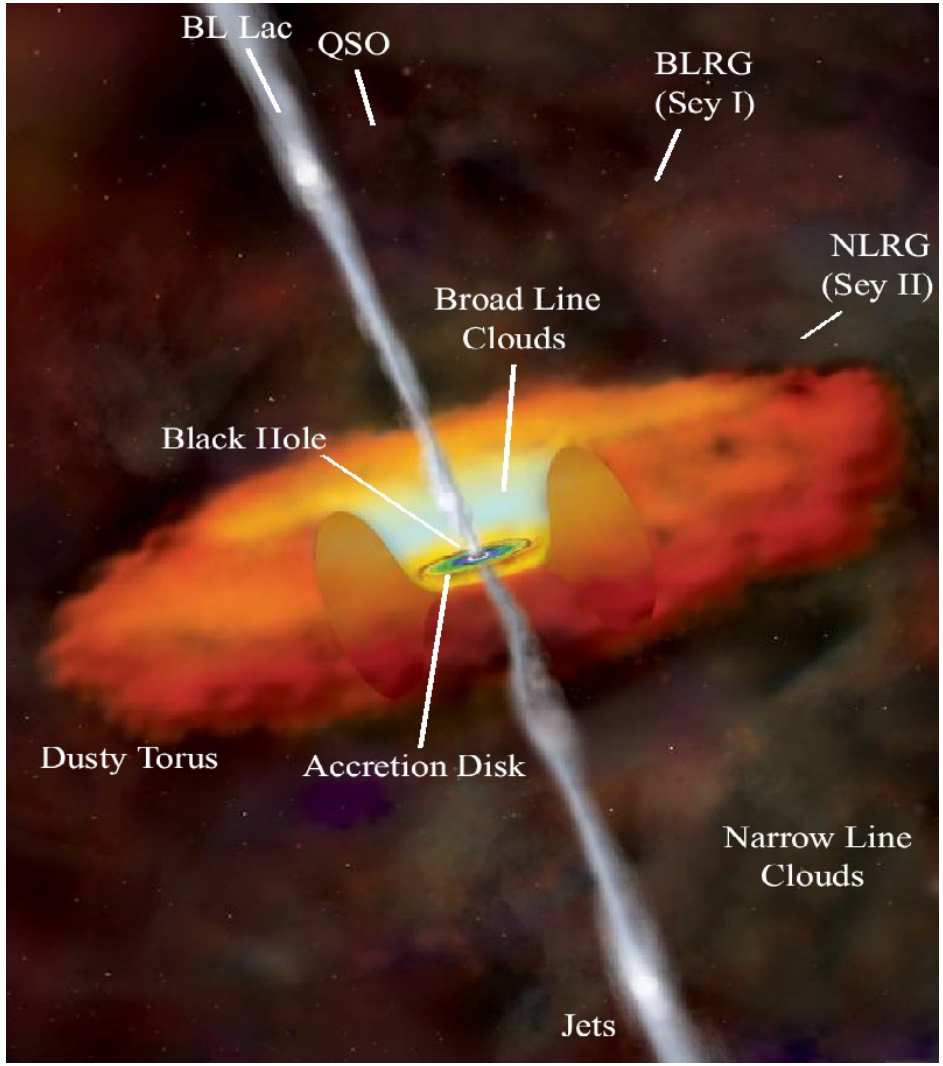
Photo: Thomas Bretz

Facts about FACT



- 2200 m a.s.l.
  Observatorio del Roque de los Muchachos, La Palma
- HEGRA CT3 mount
- 9.5 m² mirror area
- G-APD camera
  - Silicon based photosensors
  - 4.5° FoV, 1440 pixels à 0.11°
  - *H Anderhub et al 2013 JINST 8 P06008*
- Operational since Oct 2011
- Excellent performance
  - *A Biland et al 2014 JINST 9 P10012*

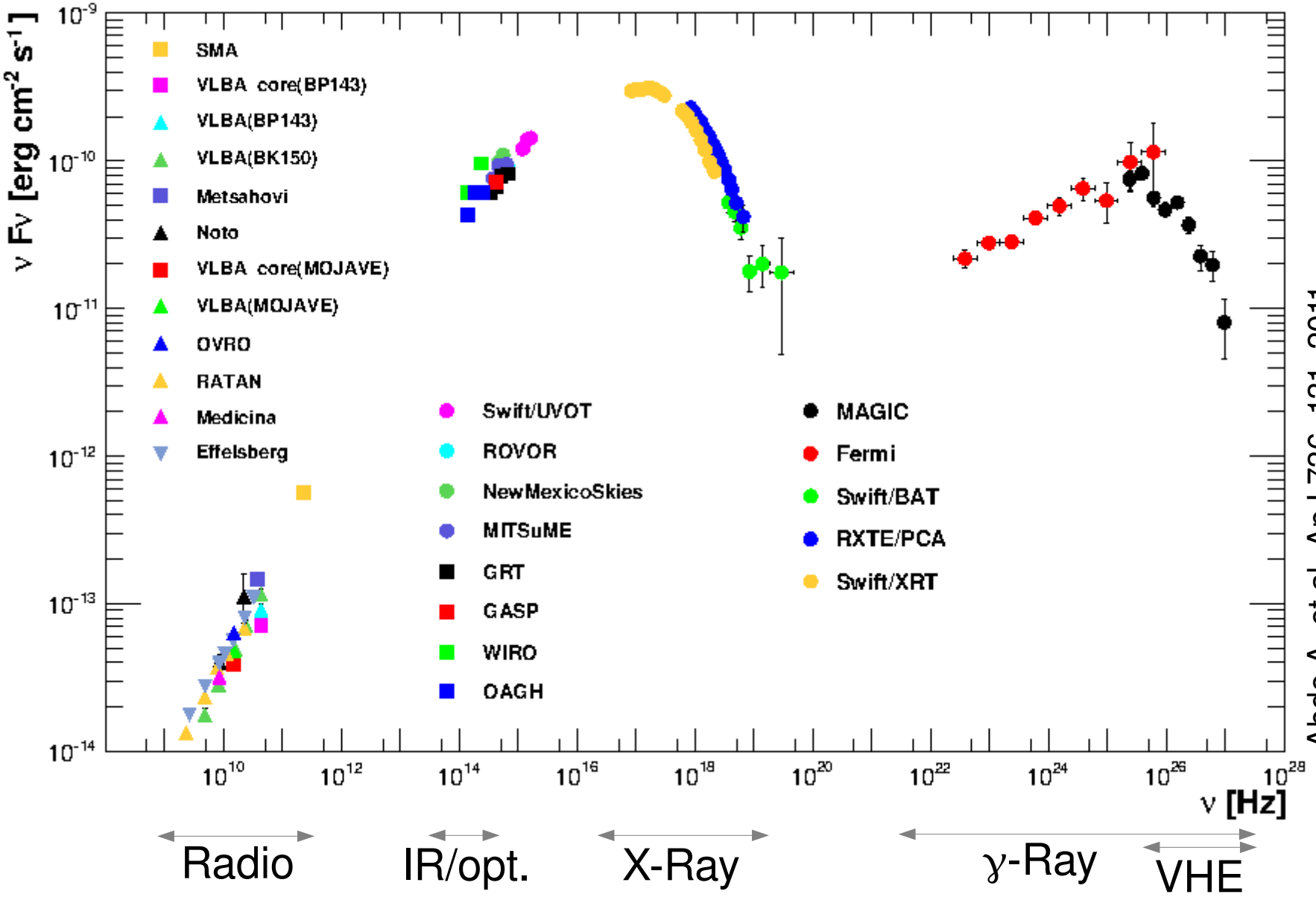
Targets for FACT: Blazars



http://chandra.harvard.edu/resources/illustrations/quasar.html

- Spectral energy distribution: Two-peak structure
  → Multi-wavelength observations crucial

Spectral Energy Distribution



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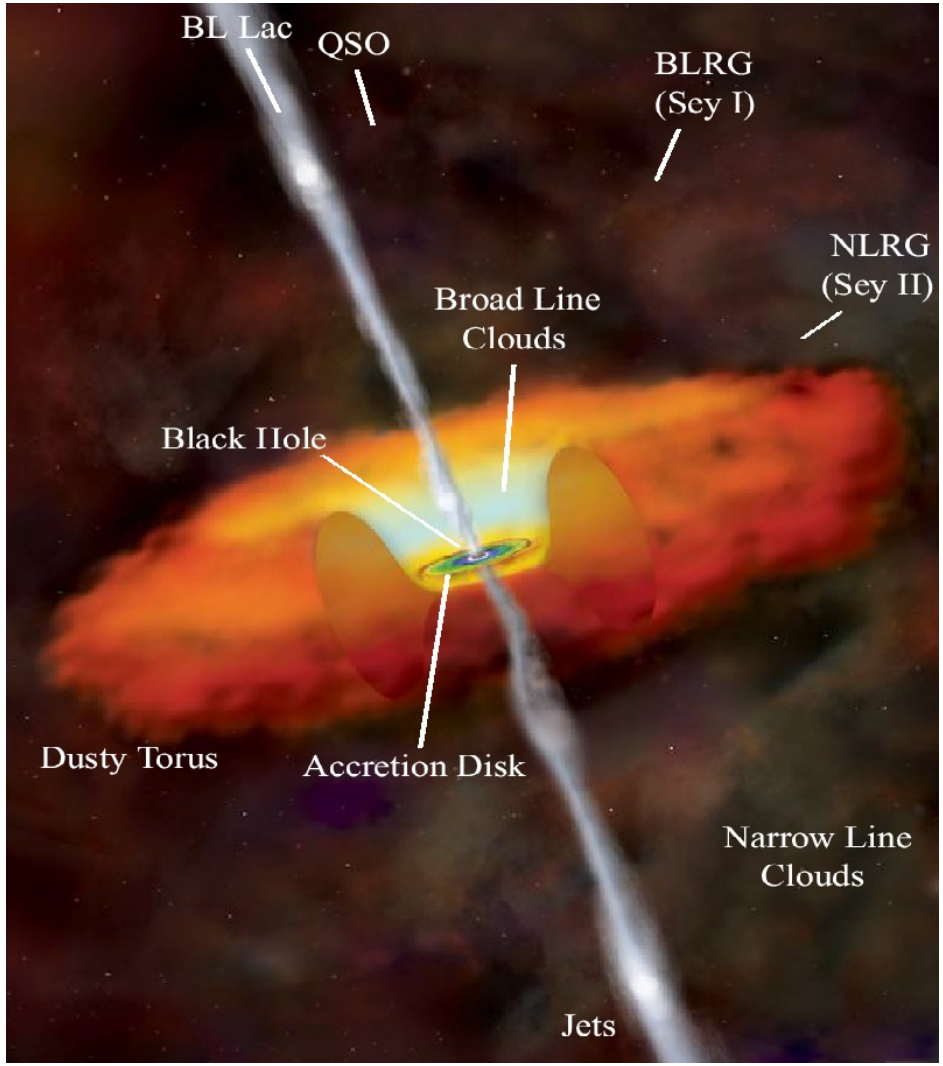

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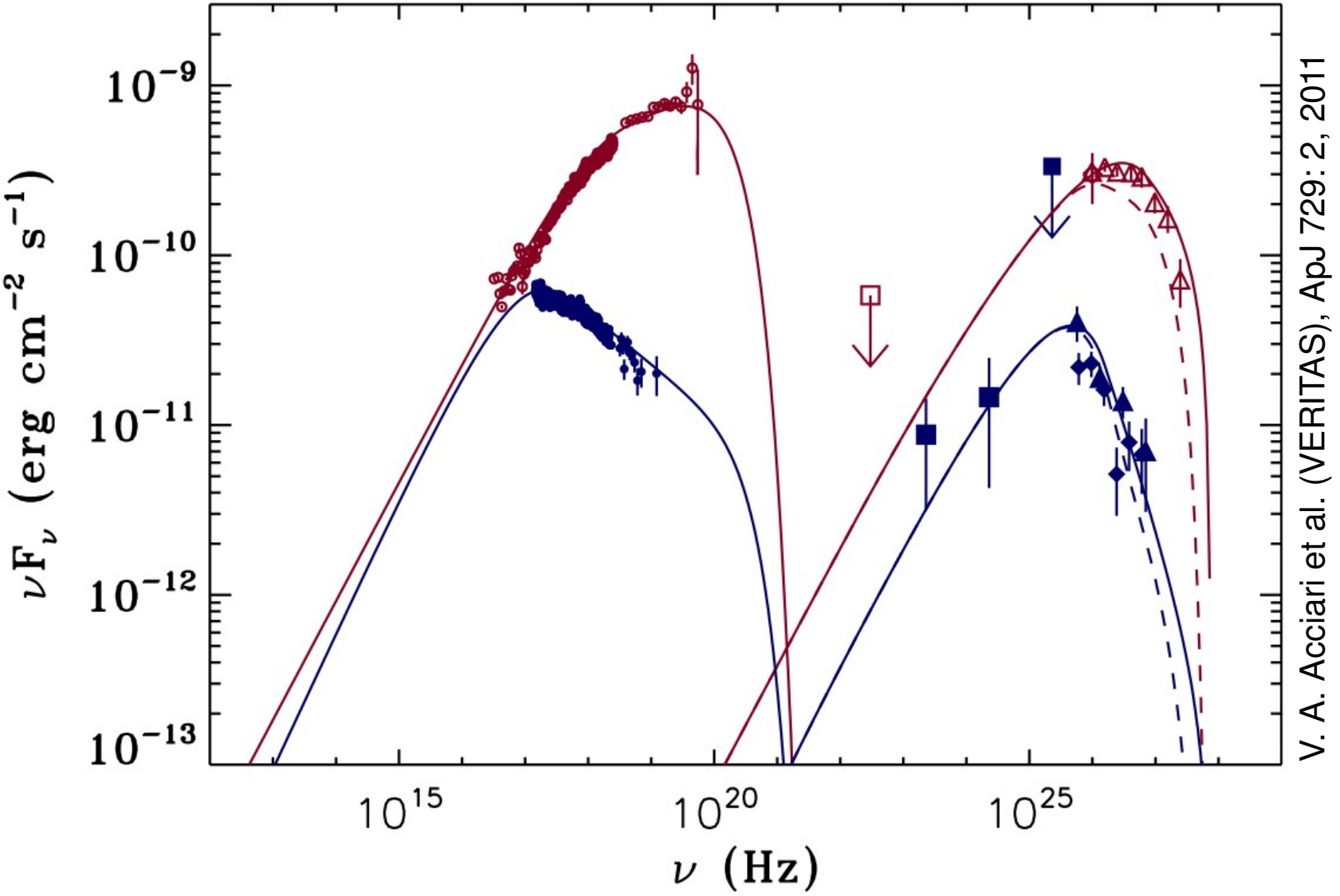
- Spectral energy distribution: Two-peak structure
  → Multi-wavelength observations crucial
- Extreme variability on different time scales
  → unbiased data sampling vital

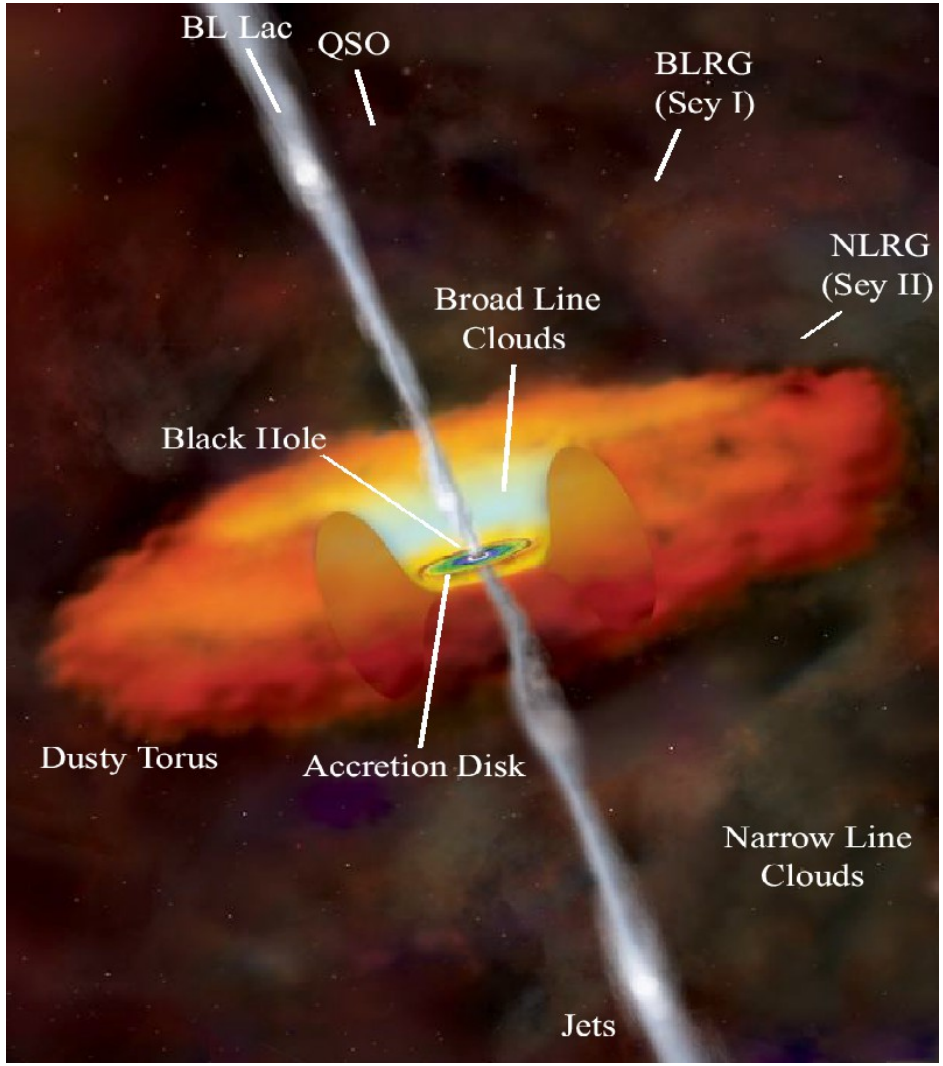
Extreme Variability



Mrk 501

V. A. Acciari et al. (VERITAS), ApJ 729: 2, 2011

Targets for FACT: Blazars



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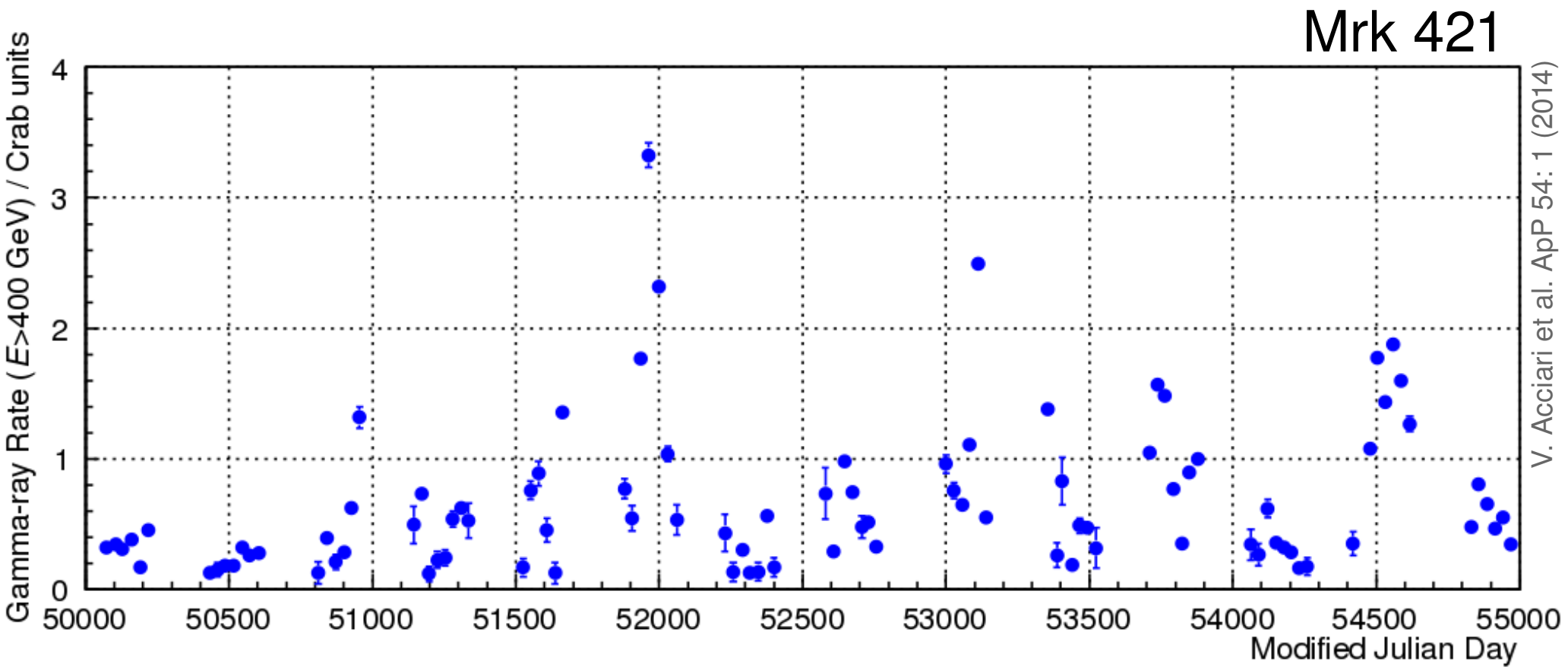
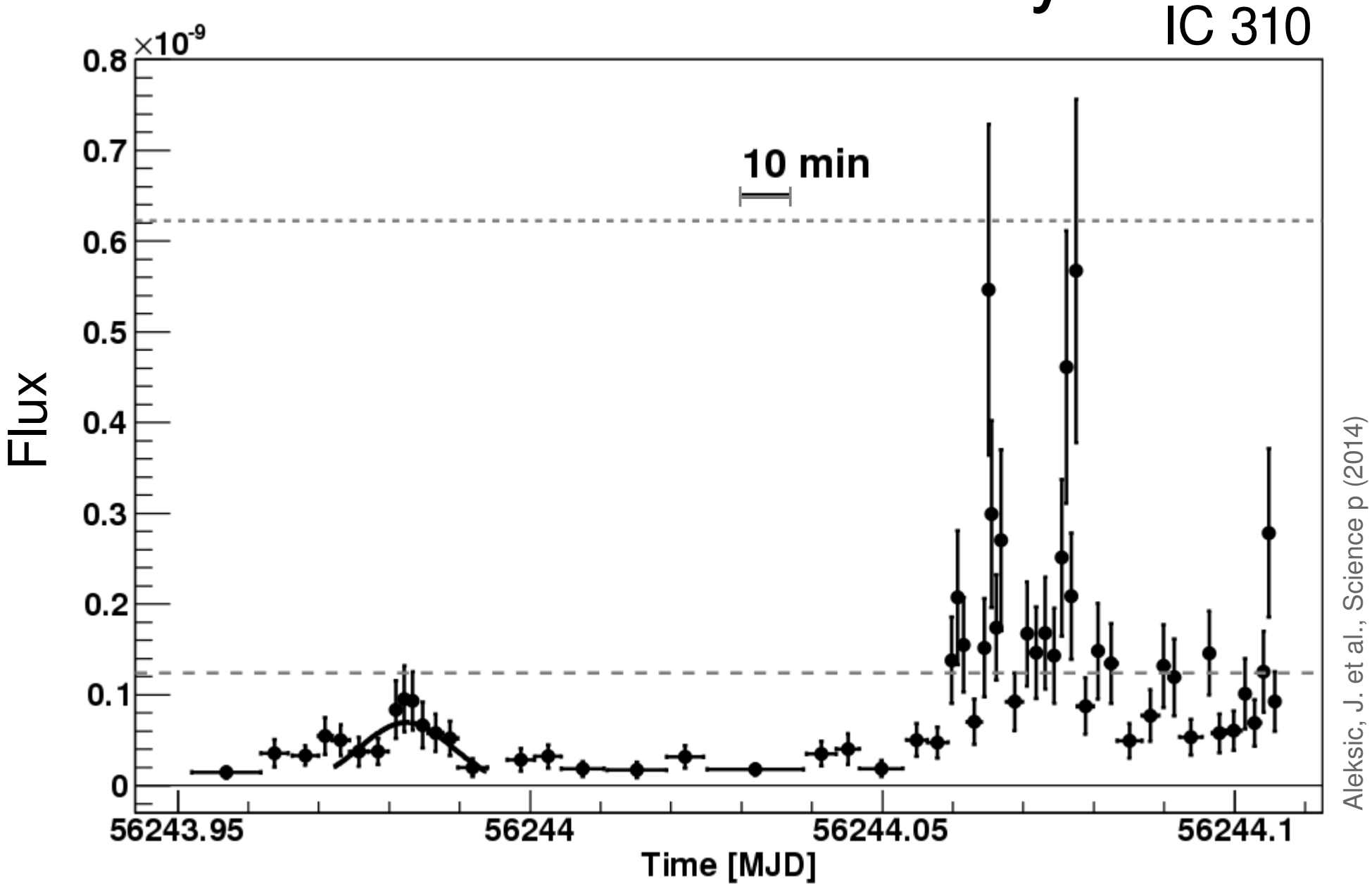
Long-term Variability



Whipple Monitoring 14 years, monthly binning

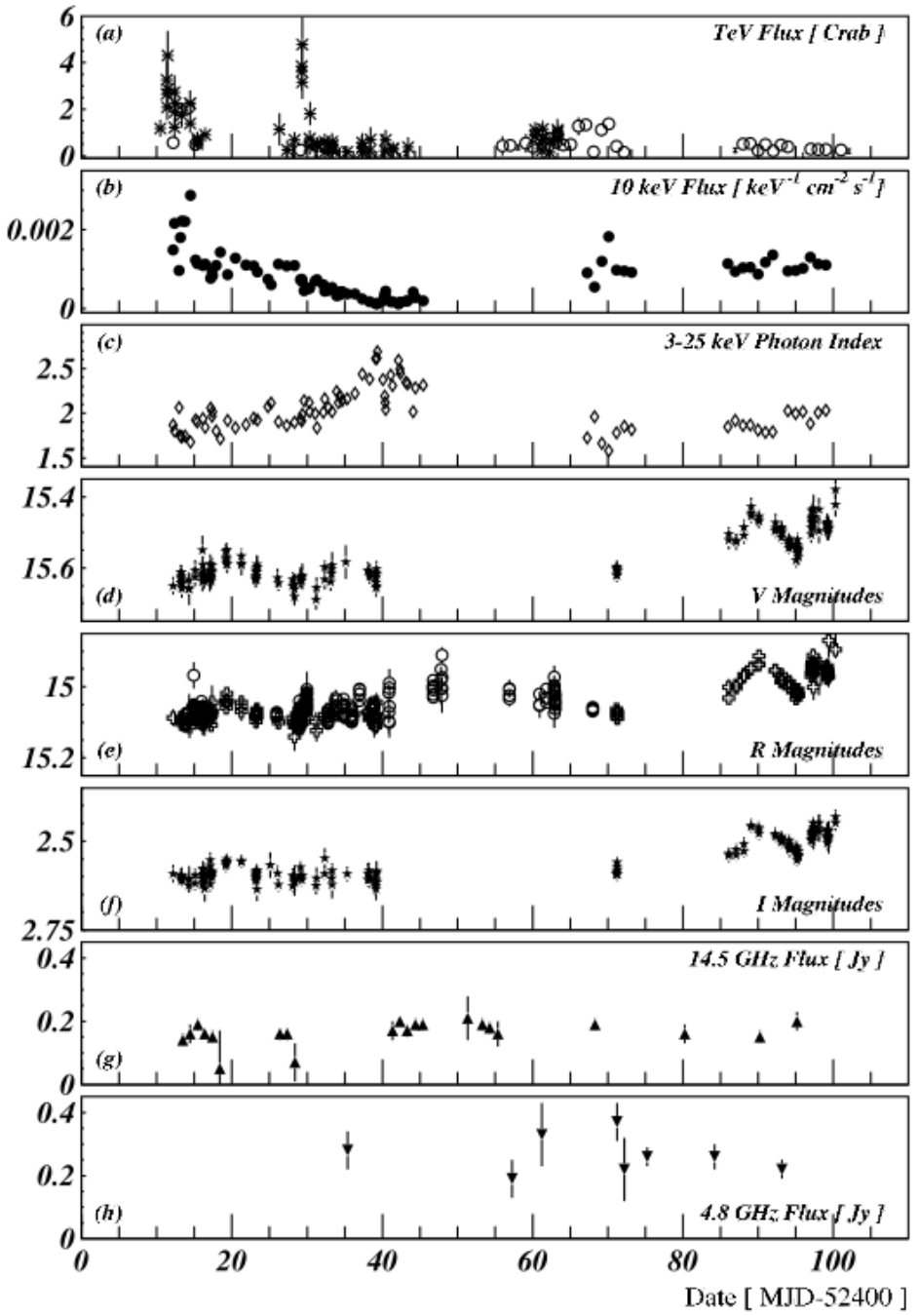
Short-term Variability



Aleksic, J. et al., Science p (2014)

Orphan Flare

1ES 1959+650



Krawczynski, H. et al., ApJ 601 p151-164 (2004)

Orphan Flare

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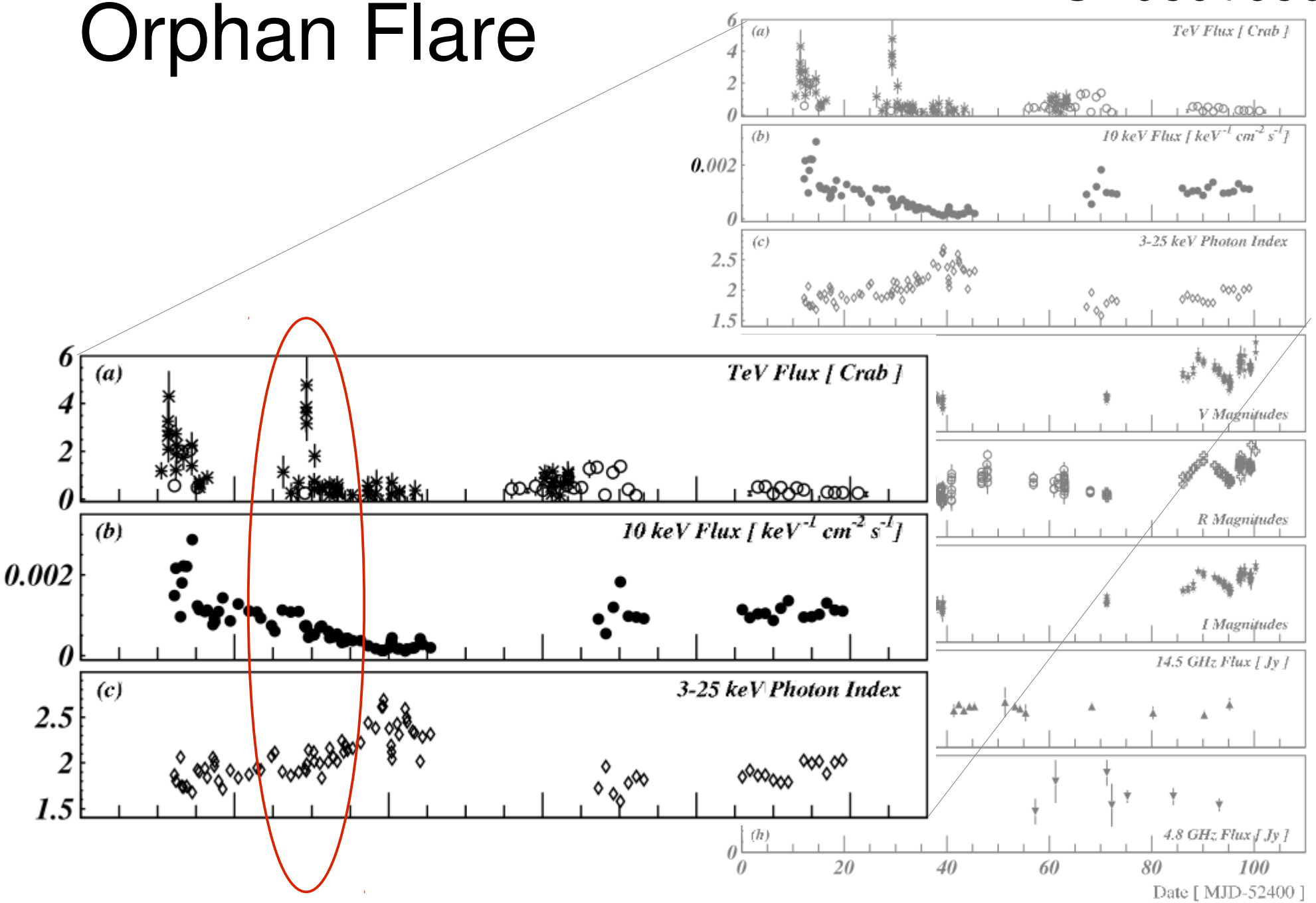
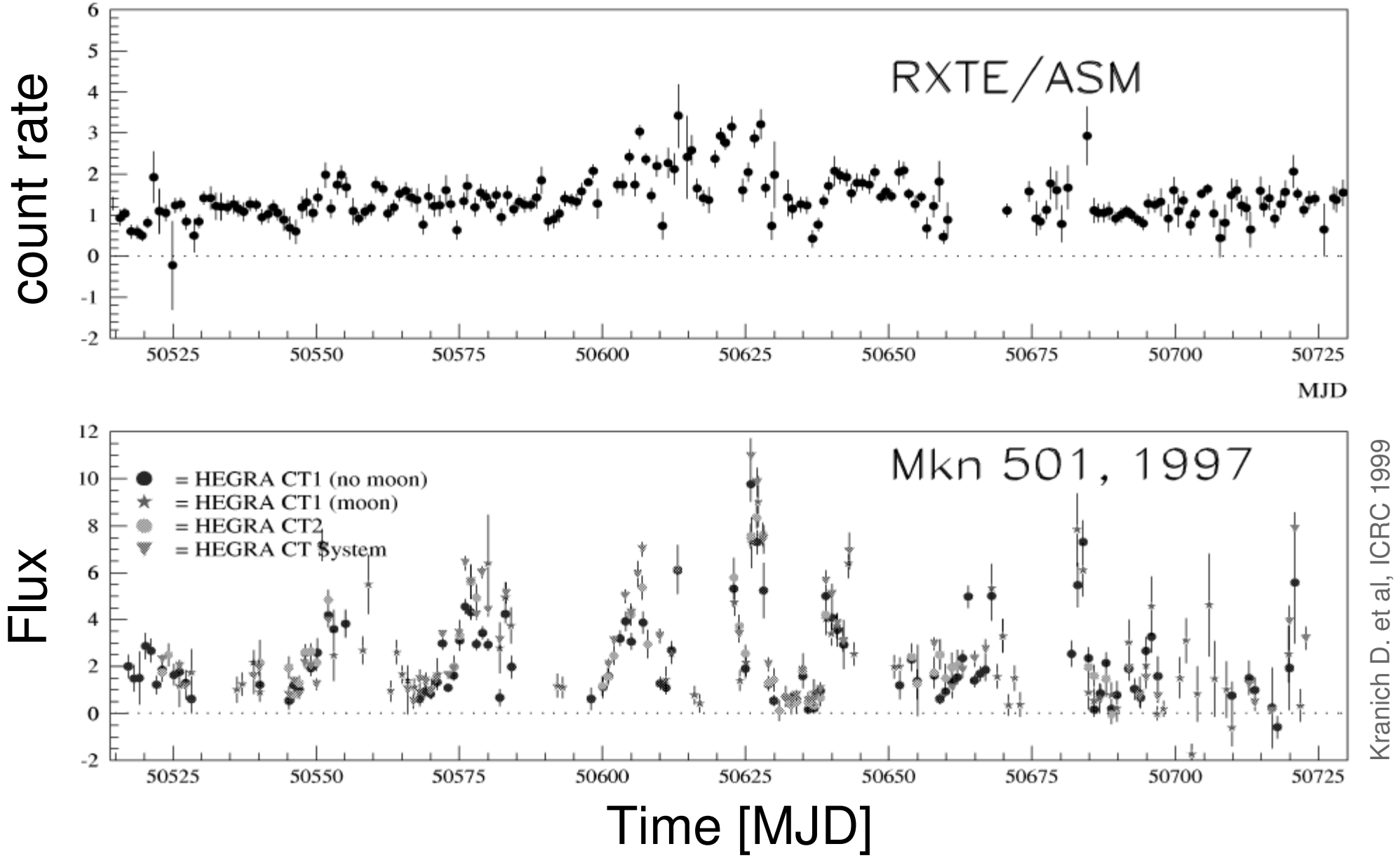
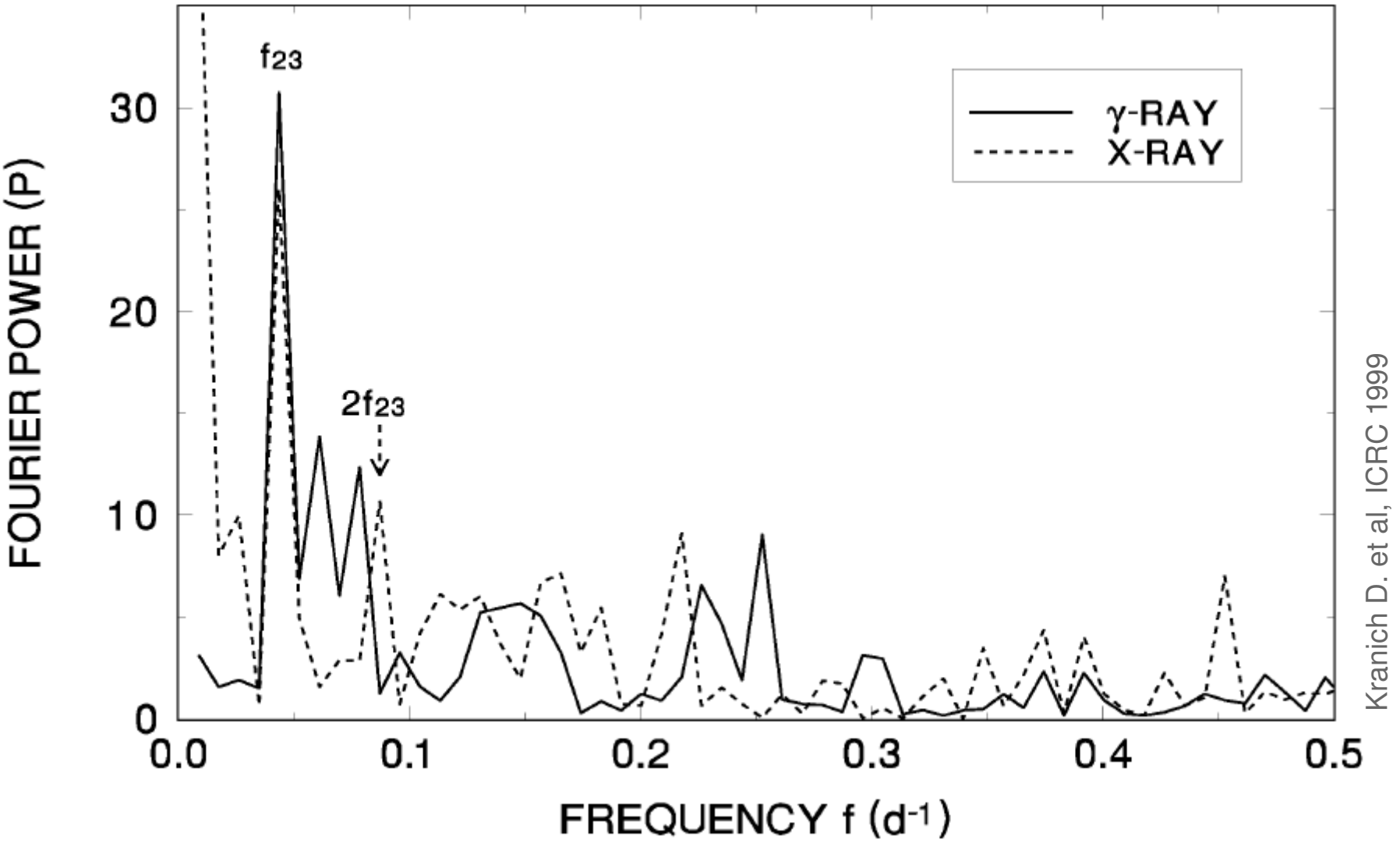


Krawczynski, H. et al., ApJ 601 p151-164 (2004)

Periodicity

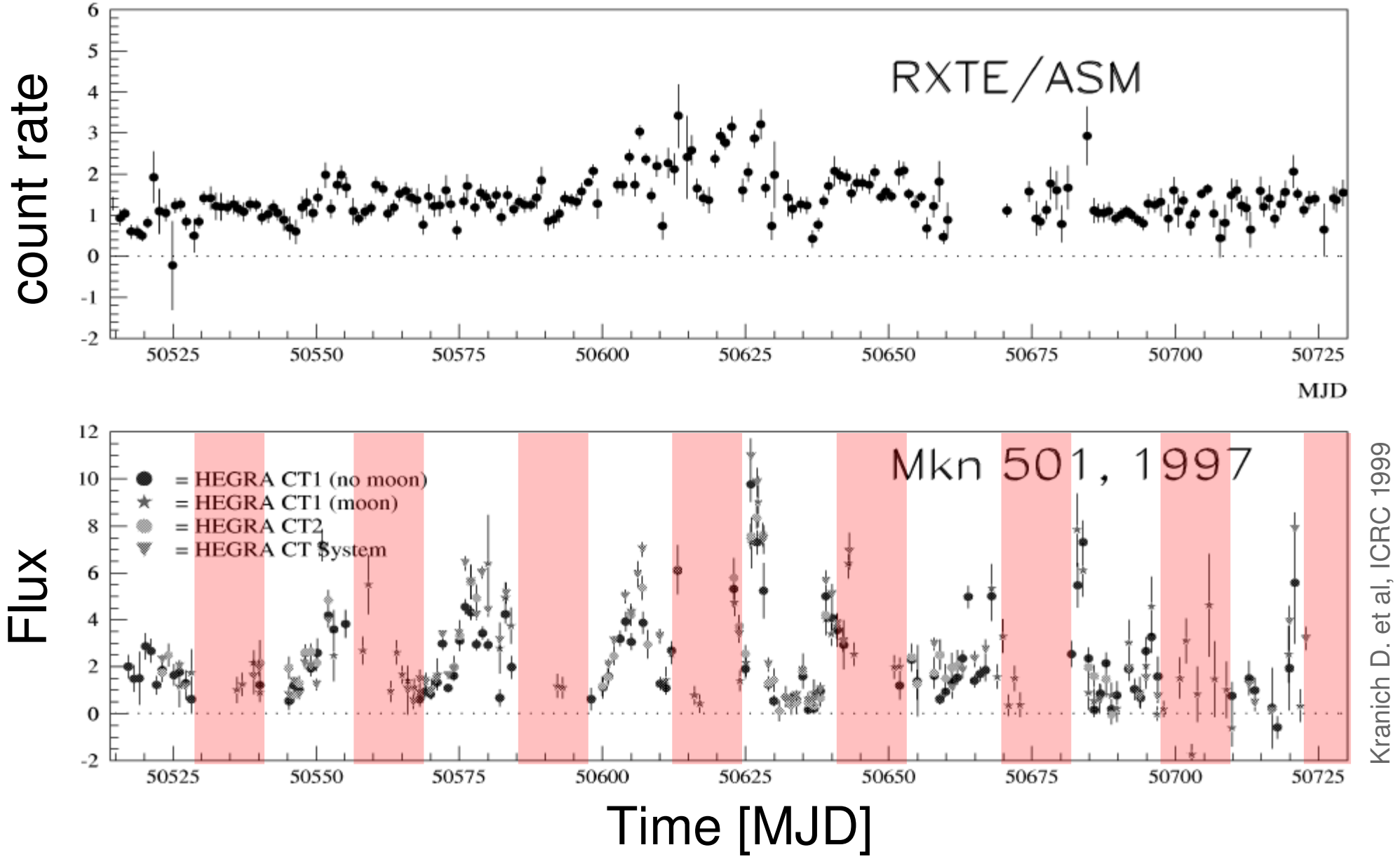


Periodicity



Kranich D. et al, ICRC 1999

Periodicity



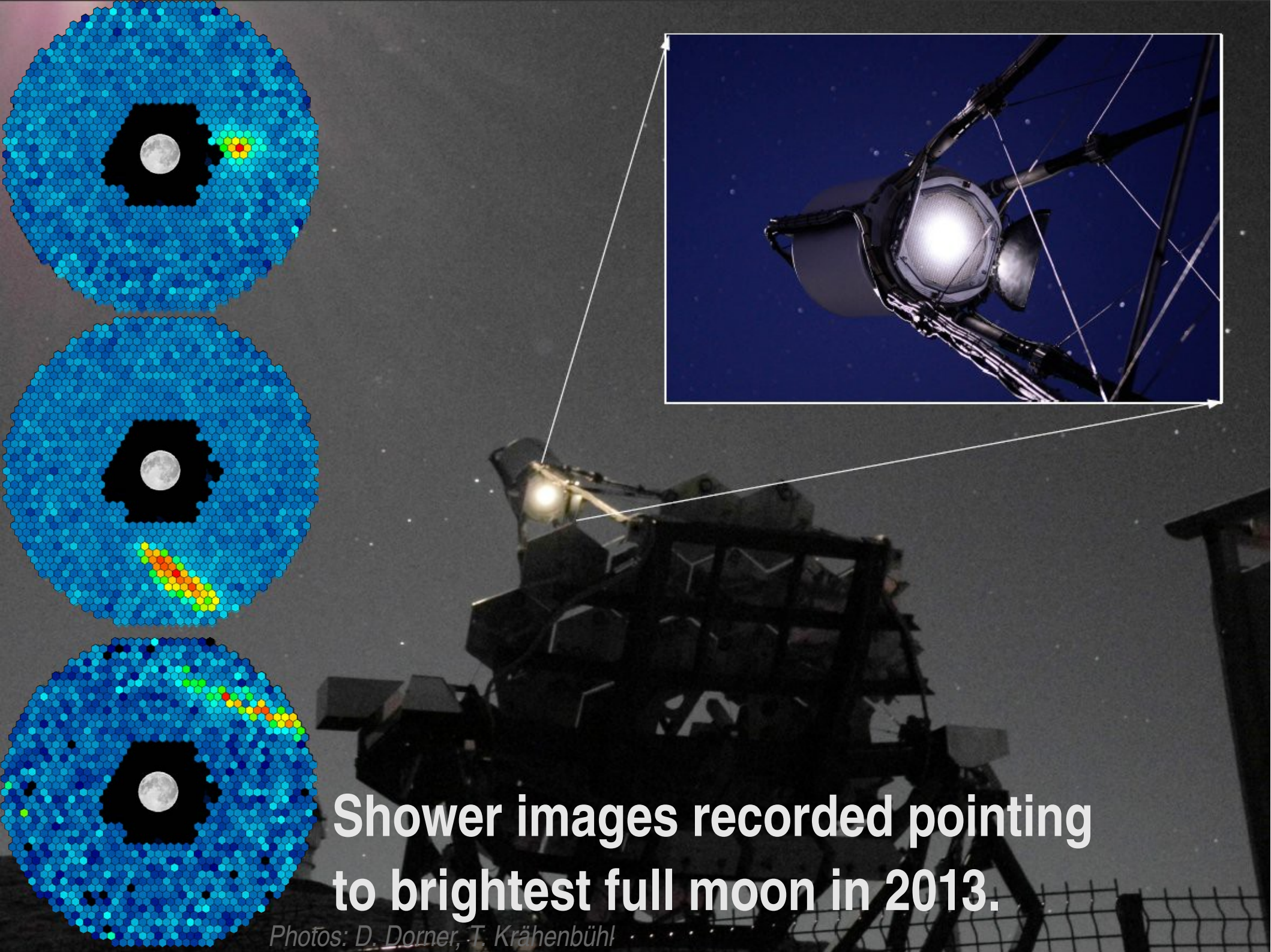
Requirements Monitoring

- No gaps
- Unbiased sample
- Stable monitoring

FACT – Ideal Monitoring Telescope


Photo: Daniela Dorner

- Observations during strong moon light


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

FACT – Ideal Monitoring Telescope


Photo: Daniela Dorner

- Observations during strong moon light

  → Larger duty cycle

  → More complete data sample

FACT – Ideal Monitoring Telescope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- Observations during strong moon light

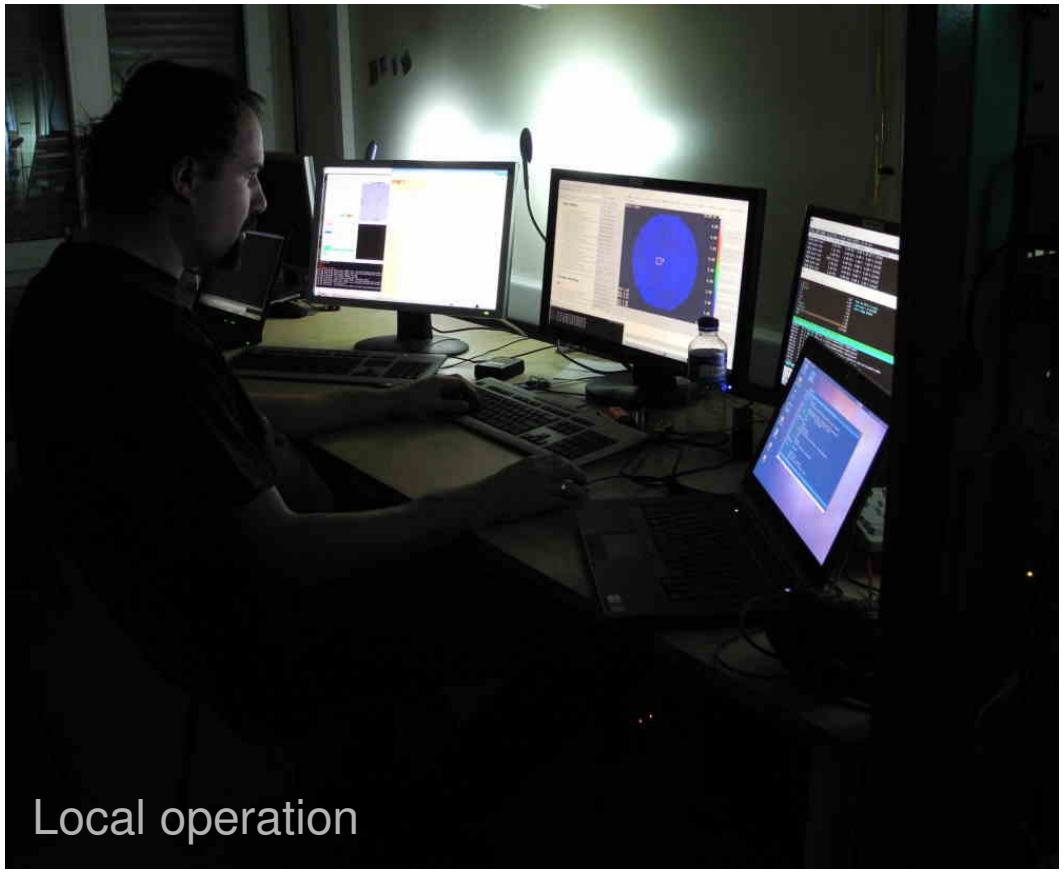
  → Larger duty cycle

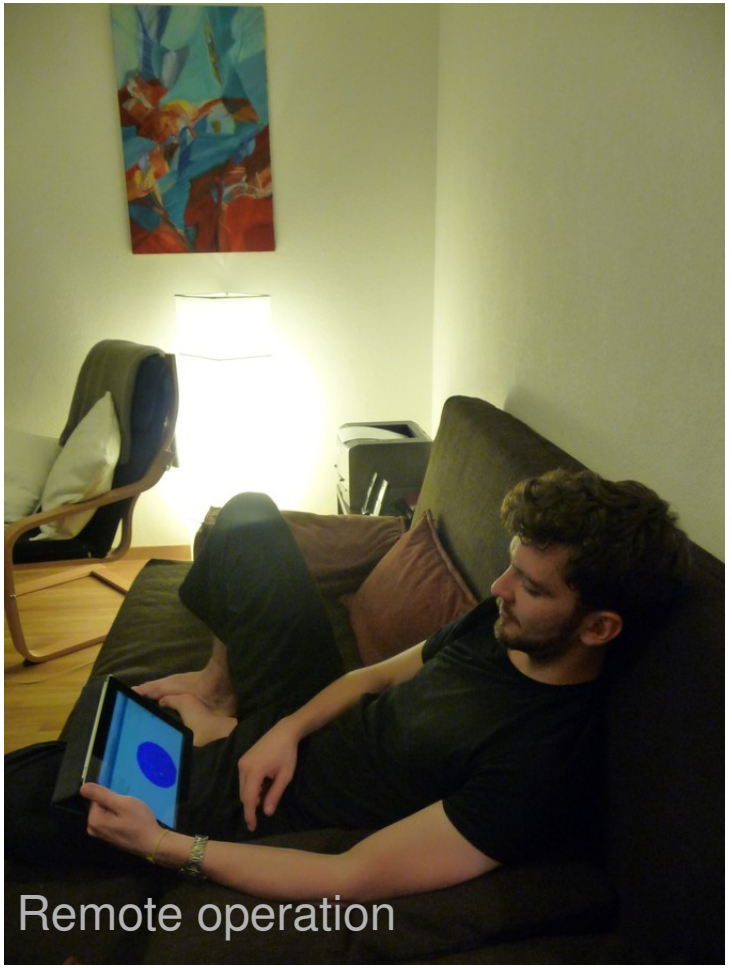
  → More complete data sample

- G-APDs robust and stable

  → Stable telescope

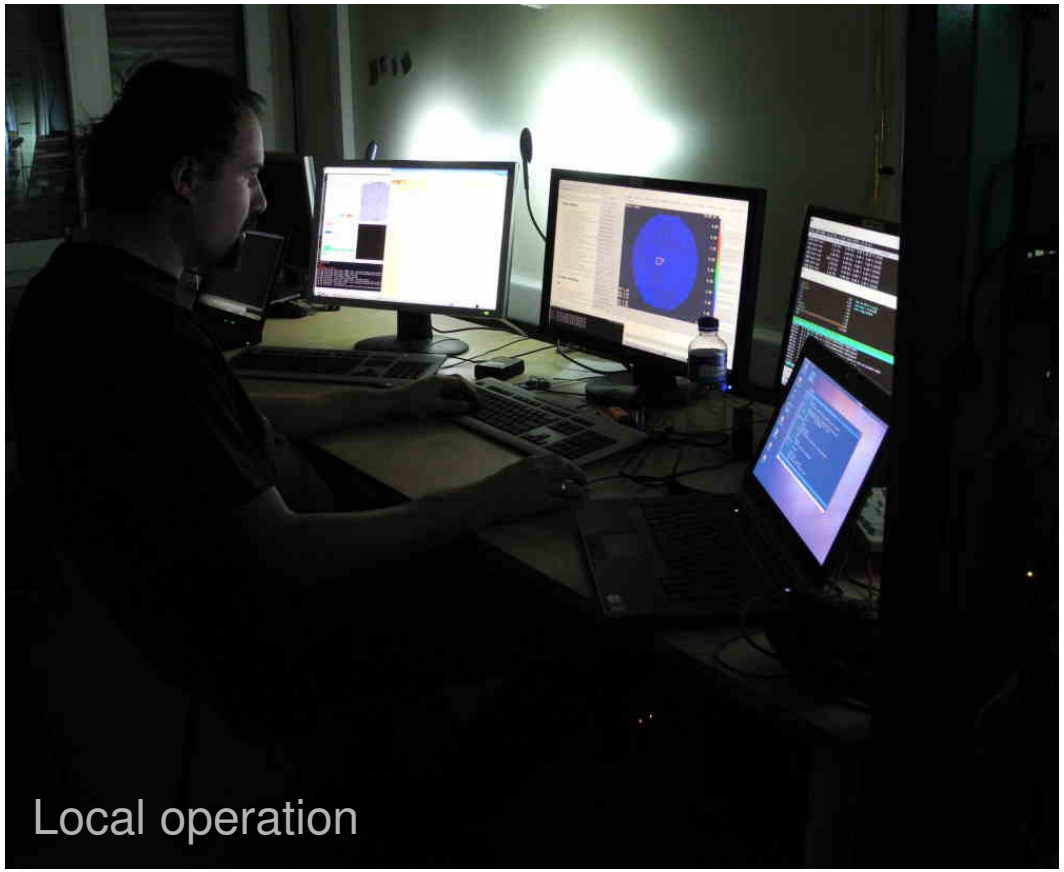
Towards Robotic Operation

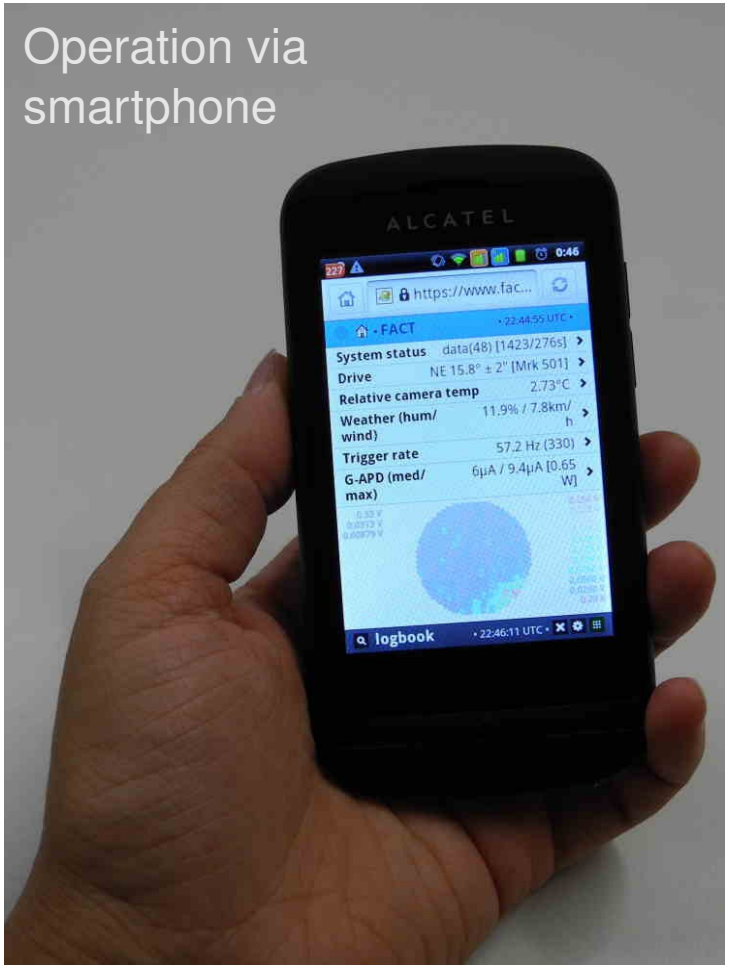




http://www.fact-project.org/smartfact

Towards Robotic Operation

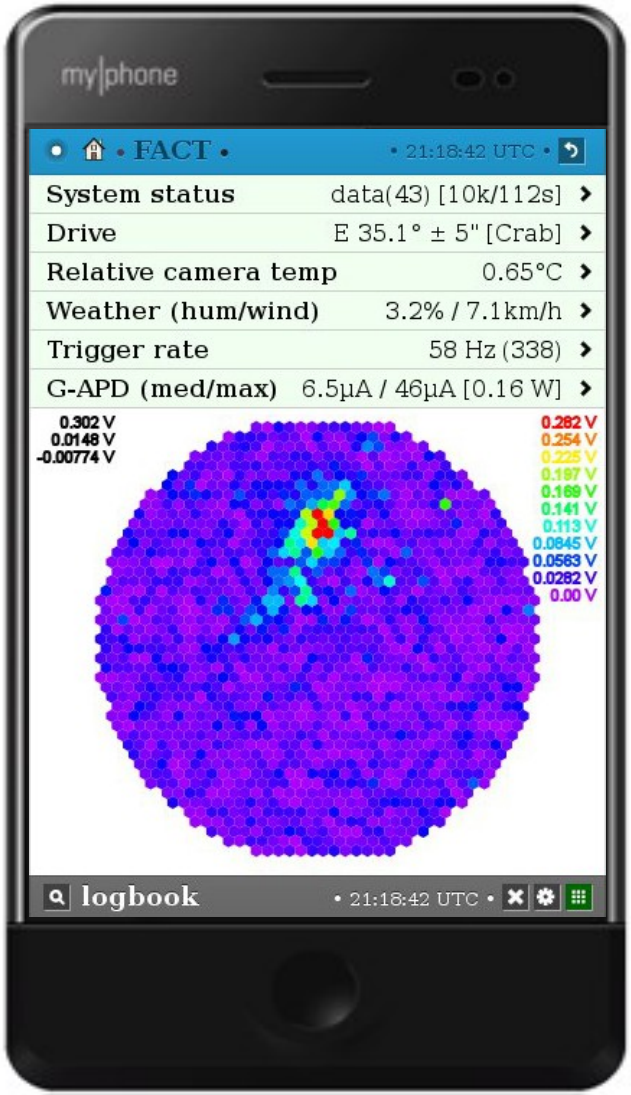




Automatic Operation

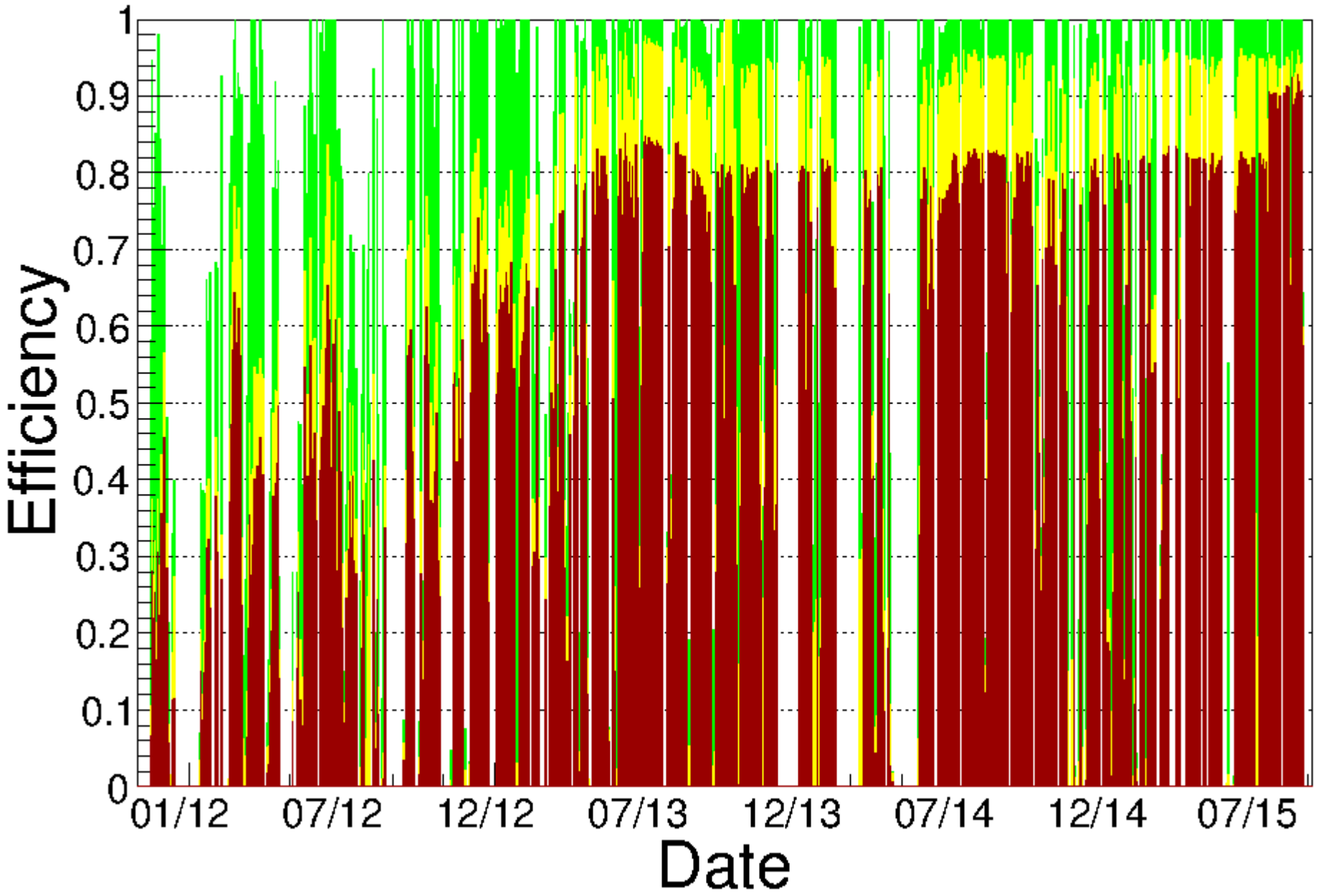
http://www.fact-project.org/smartfact

FACT – Ideal Monitoring Telescope

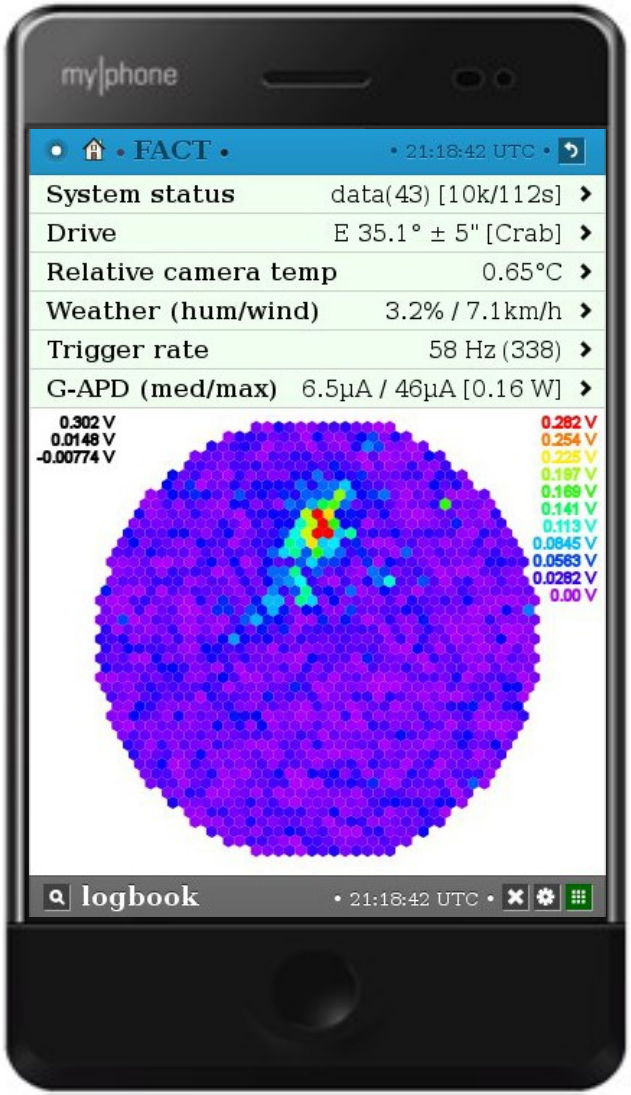


- Observations during strong moon light
  → Larger duty cycle
  → More complete data sample
- G-APDs robust and stable
  → Stable telescope performance
  → Remote and automatic operation

Data Taking Efficiency



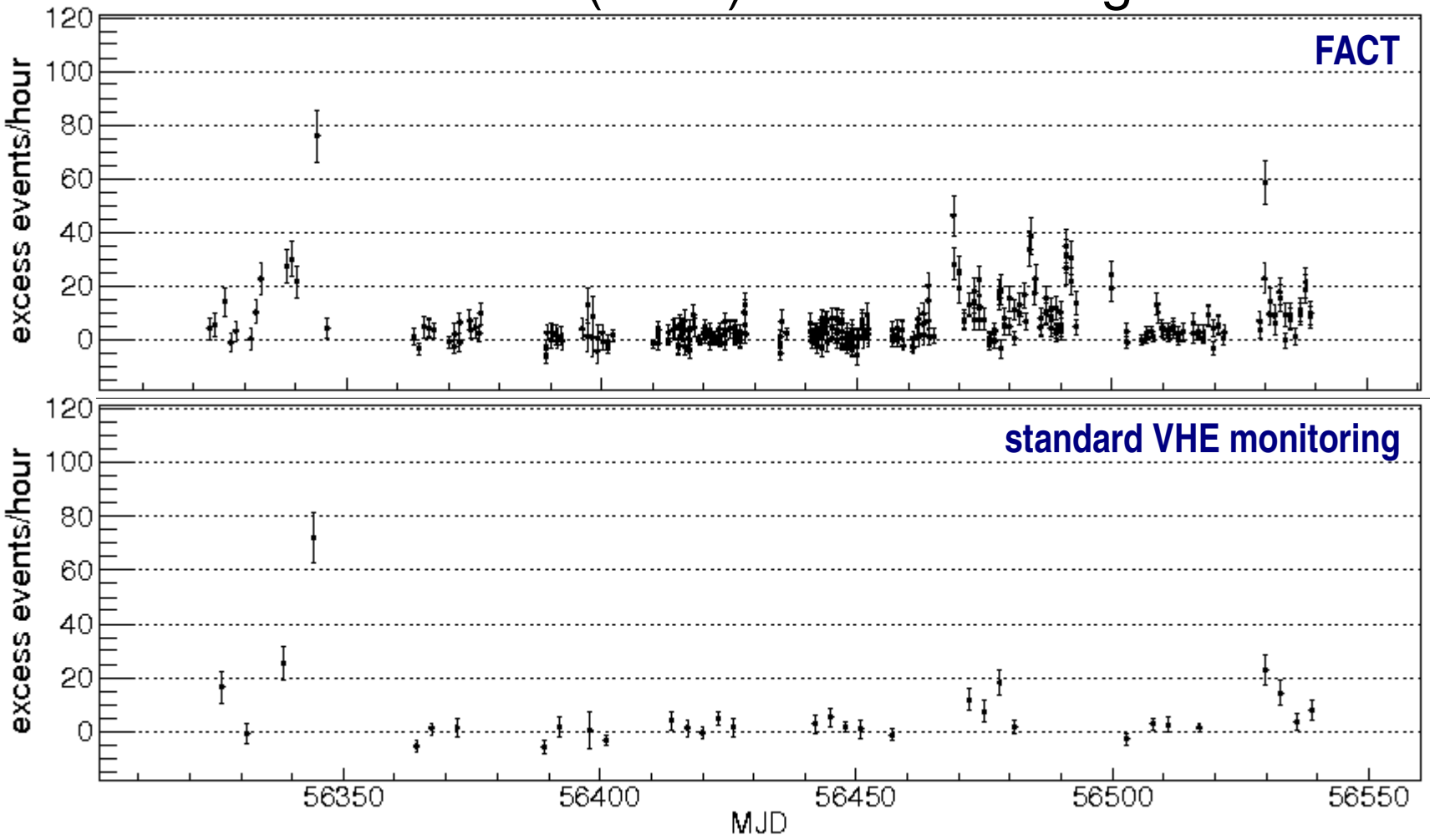
FACT – Ideal Monitoring Telescope



- Observations during strong moon light
  → Larger duty cycle
  → More complete data sample
- G-APDs robust and stable
  → Stable telescope performance
  → Remote and automatic operation
  → High data taking efficiency

Monitoring at TeV Energies

Mrk 501 (2013) 1-hour-binning



All data ~410h

Moon < 65%
1h every
~ 3rd night
→ ~32h

Monitoring at TeV Energies

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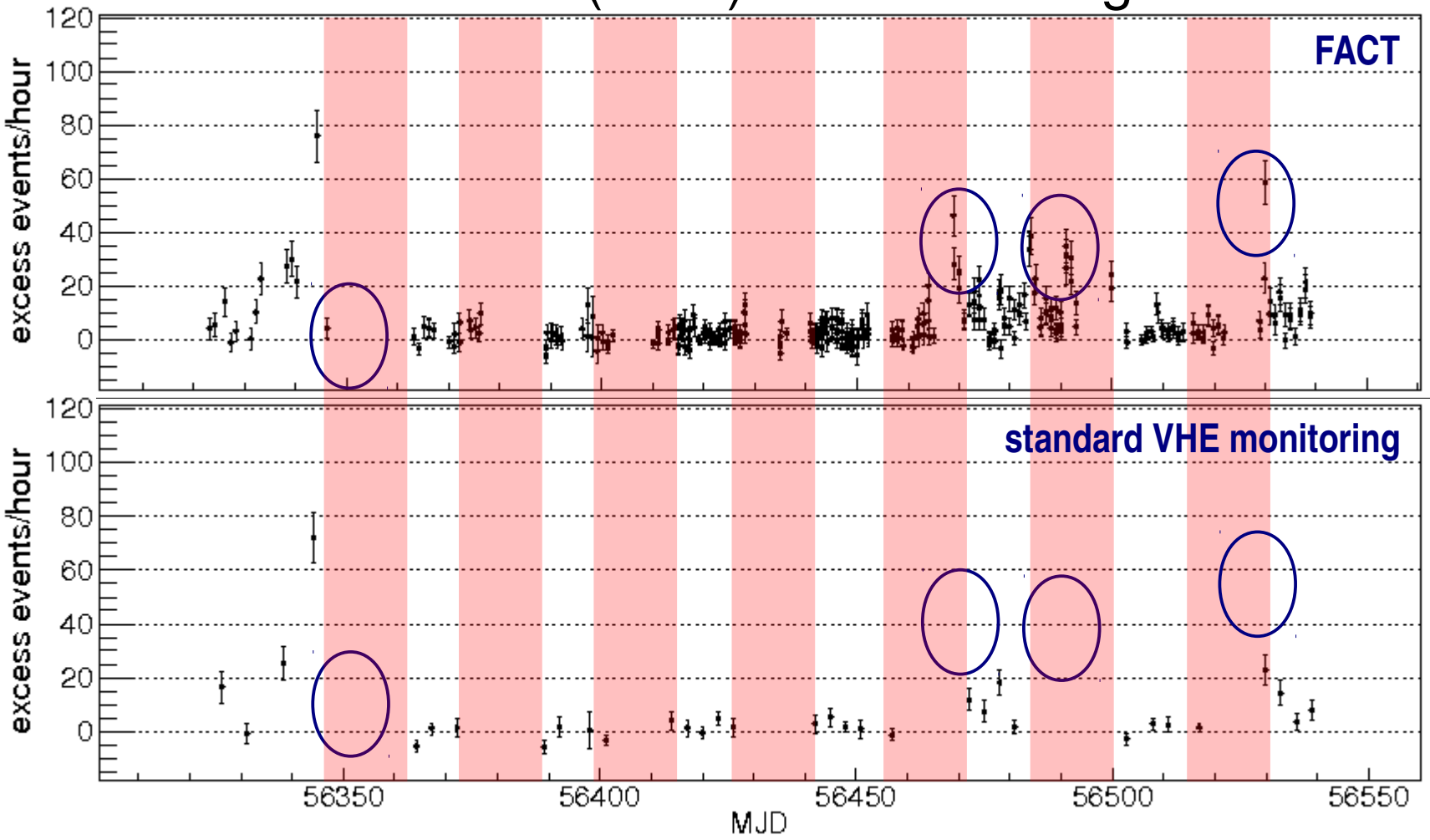

All data ~410h

Moon < 65%
1h every
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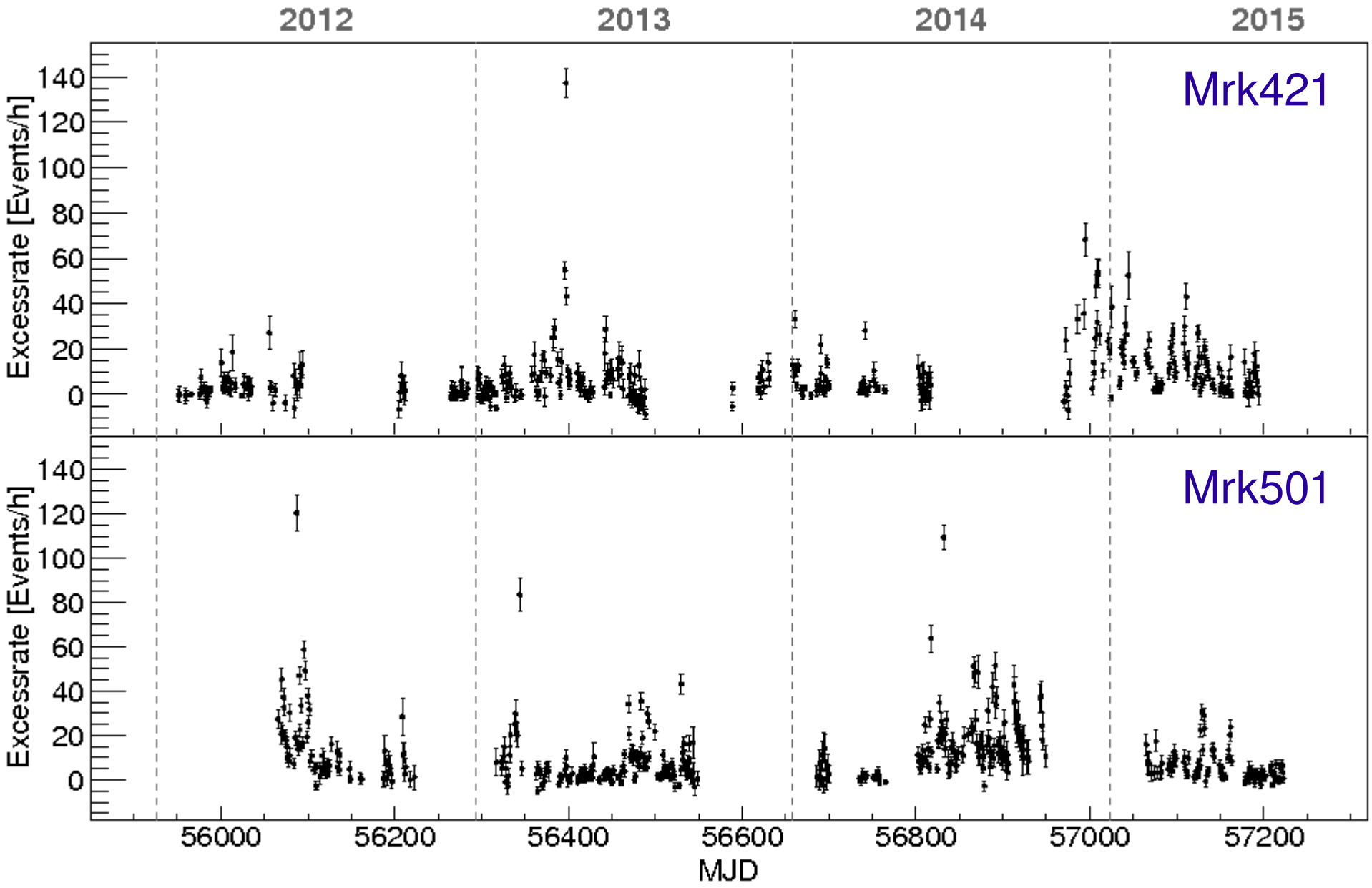
3.5 Years of Monitoring



Quick Look Analysis

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

QLA

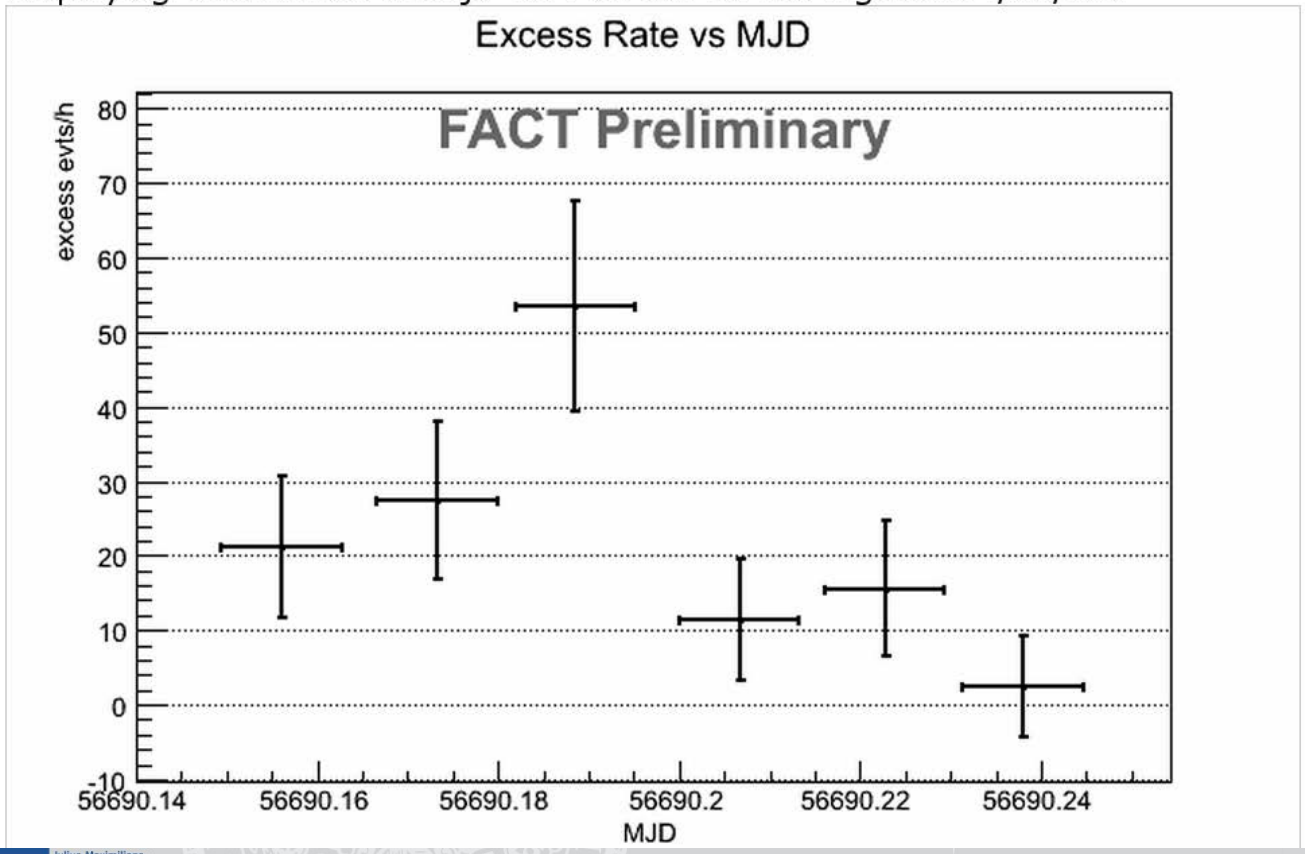
www.fact-project.org/monitoring/index.php?y=2014&m

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.



Quick Look Analysis

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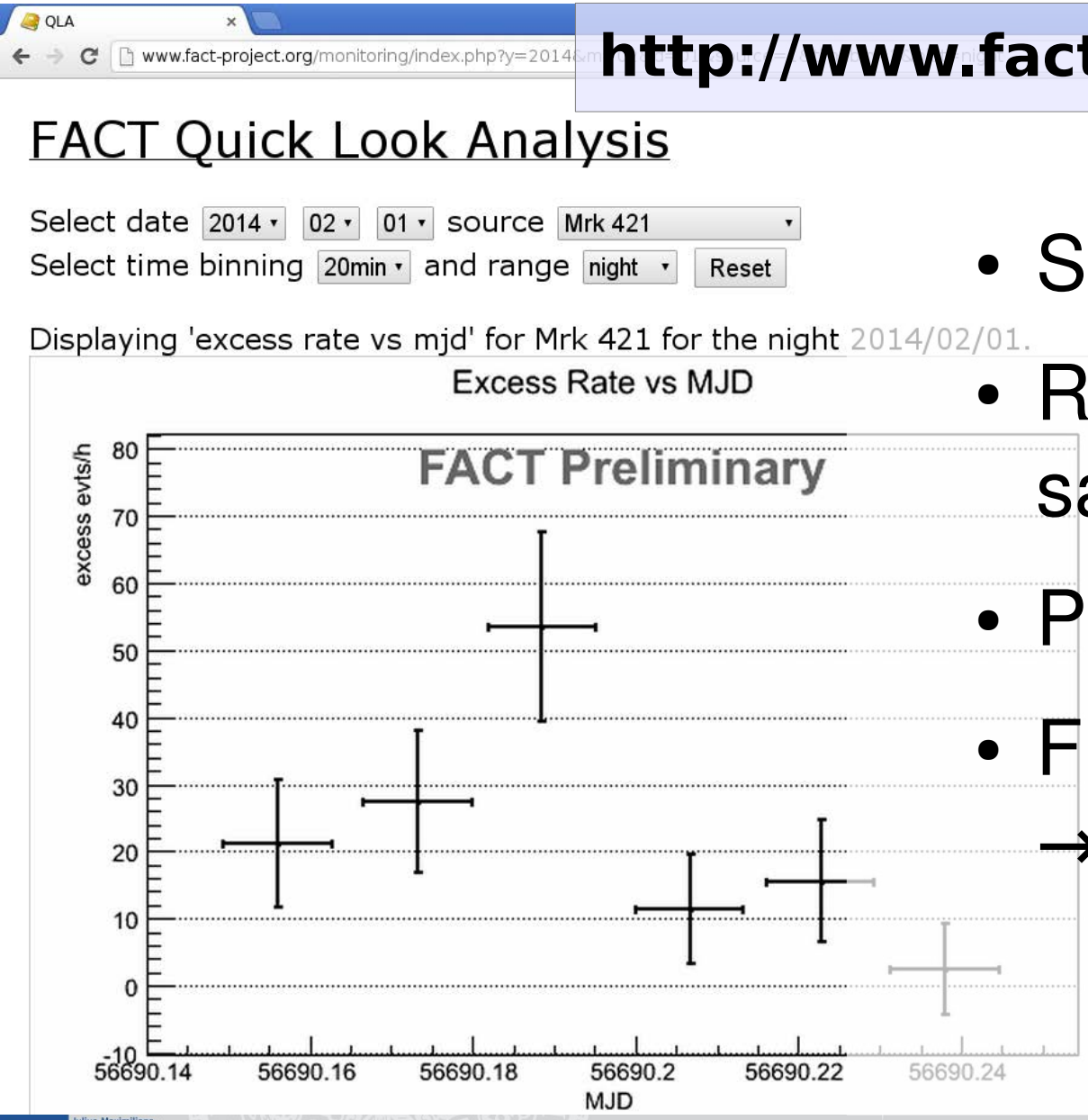
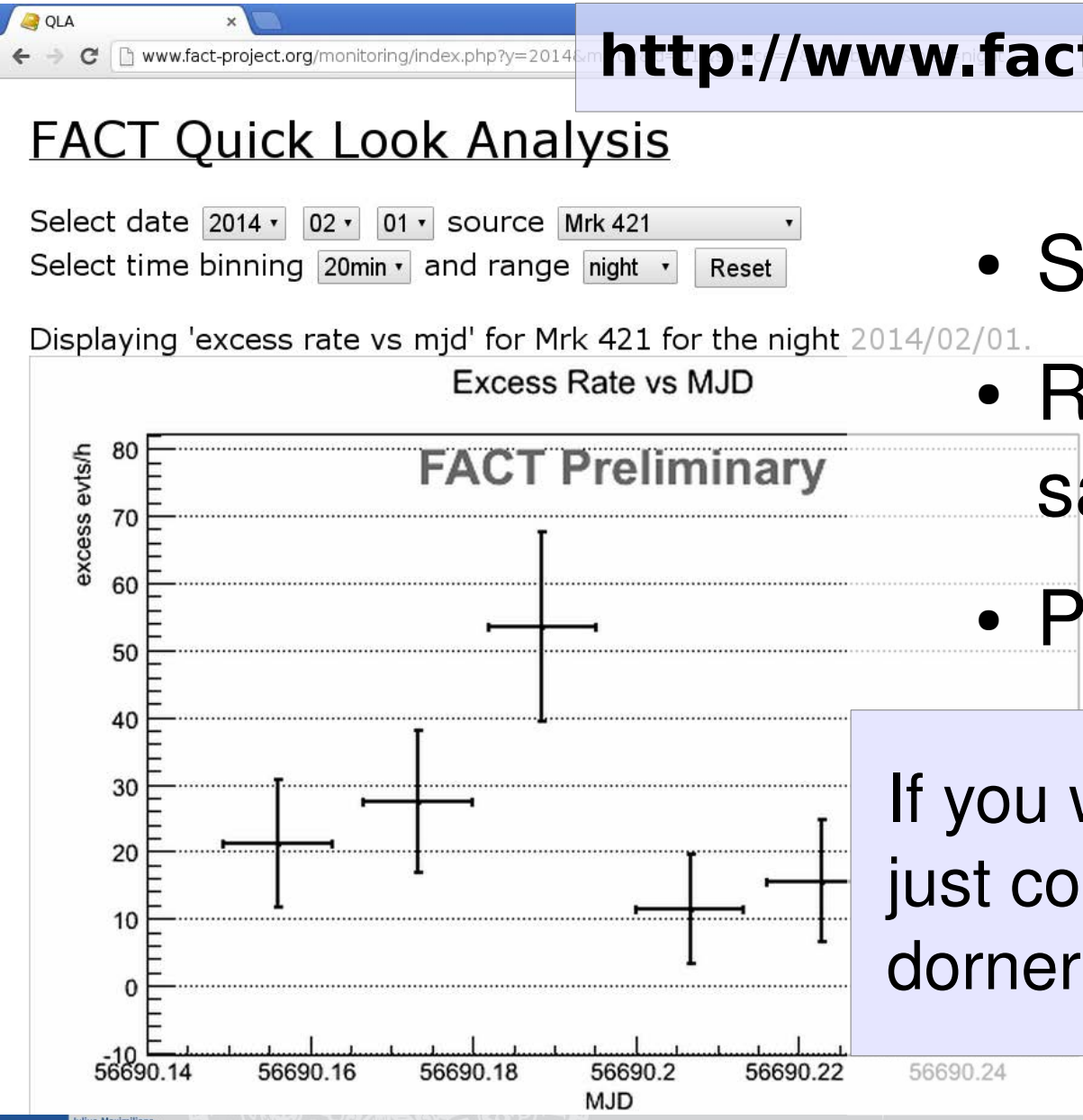


- Since 2012/12/12
- Results within the same night
- Publicly available
- Flare alerts

→ MWL and ToO observations

Quick Look Analysis

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

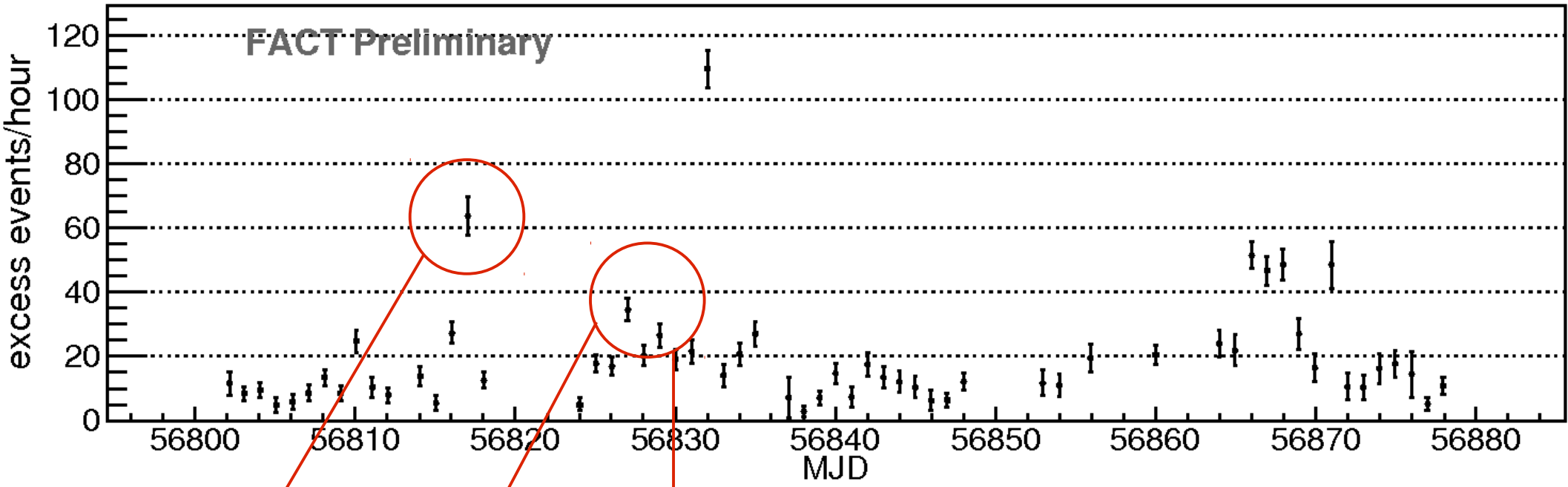


- Since 2012/12/12
- Results within the same night
- Publicly available

If you want to have the data, just contact me:
dorner@astro.uni-wuerzburg.de

Mrk 501 – Flare Alerts

Excess rate curve from QLA: 1.6.-10.8.2014



Flare Alert
8./9. June 2014

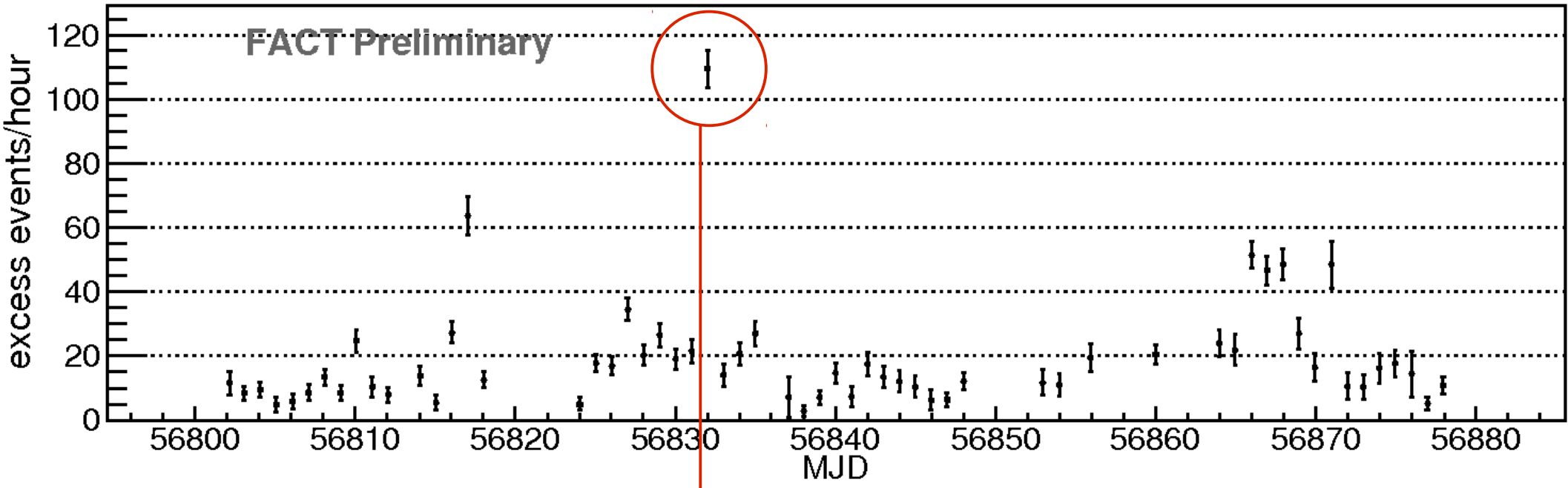
Flare Alert
20./21. June 2014

Flare Alert
18./19. June 2014

→ Observations with other instruments

Mrk 501 – Flare Alerts

Excess rate curve from QLA: 1.6.-10.8.2014

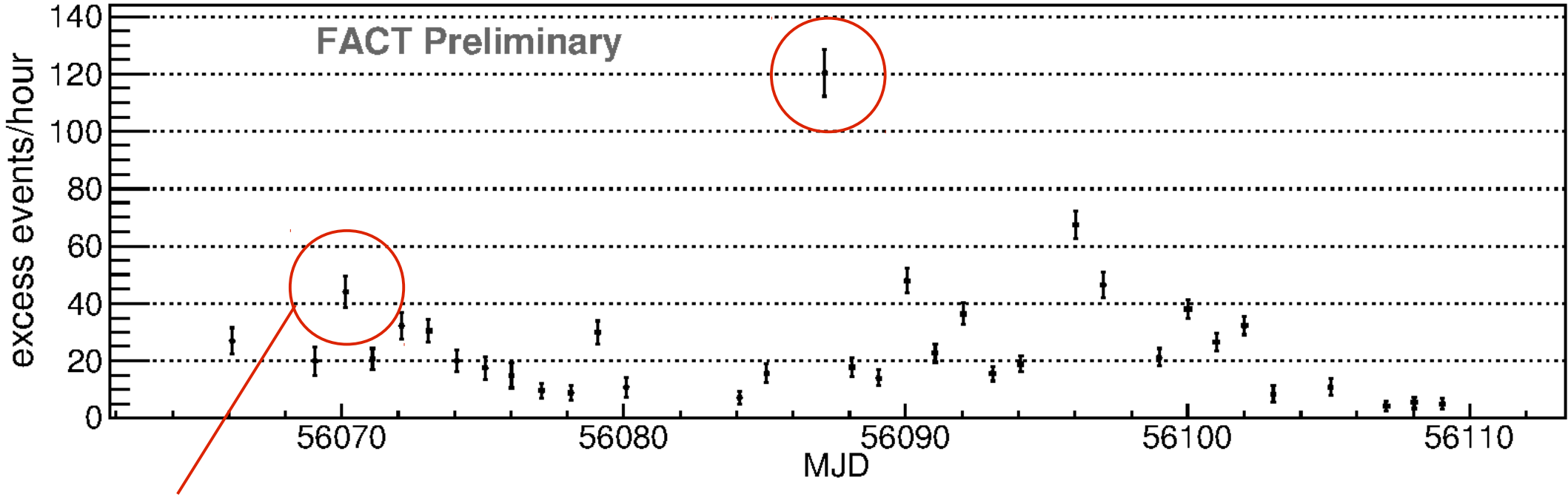


Flare Alert
23./24. June 2014

→ Astronomer's Telegram #6268

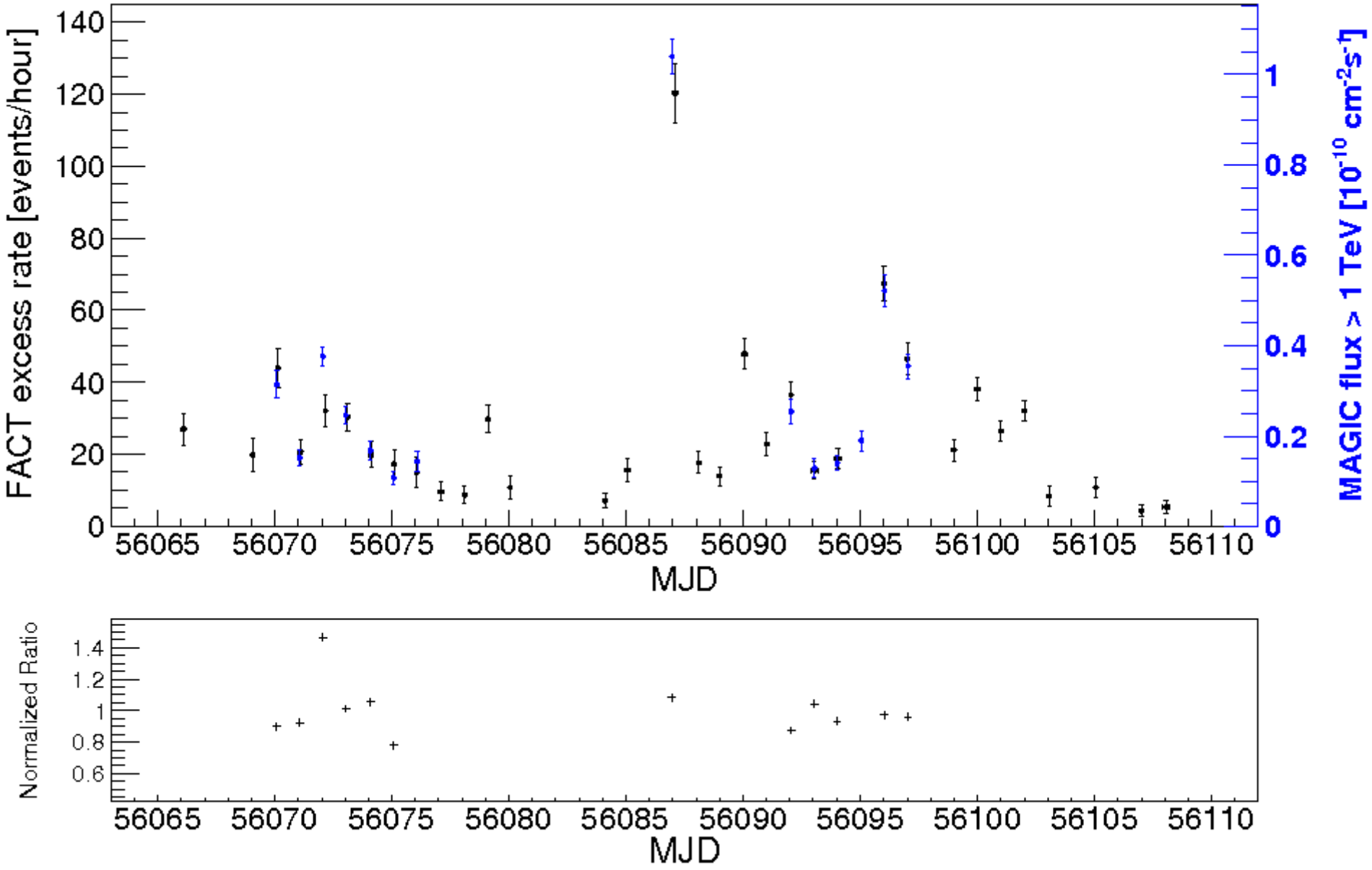
Mrk 501 – Flares May/June 2012

18.5.-30.6.2012



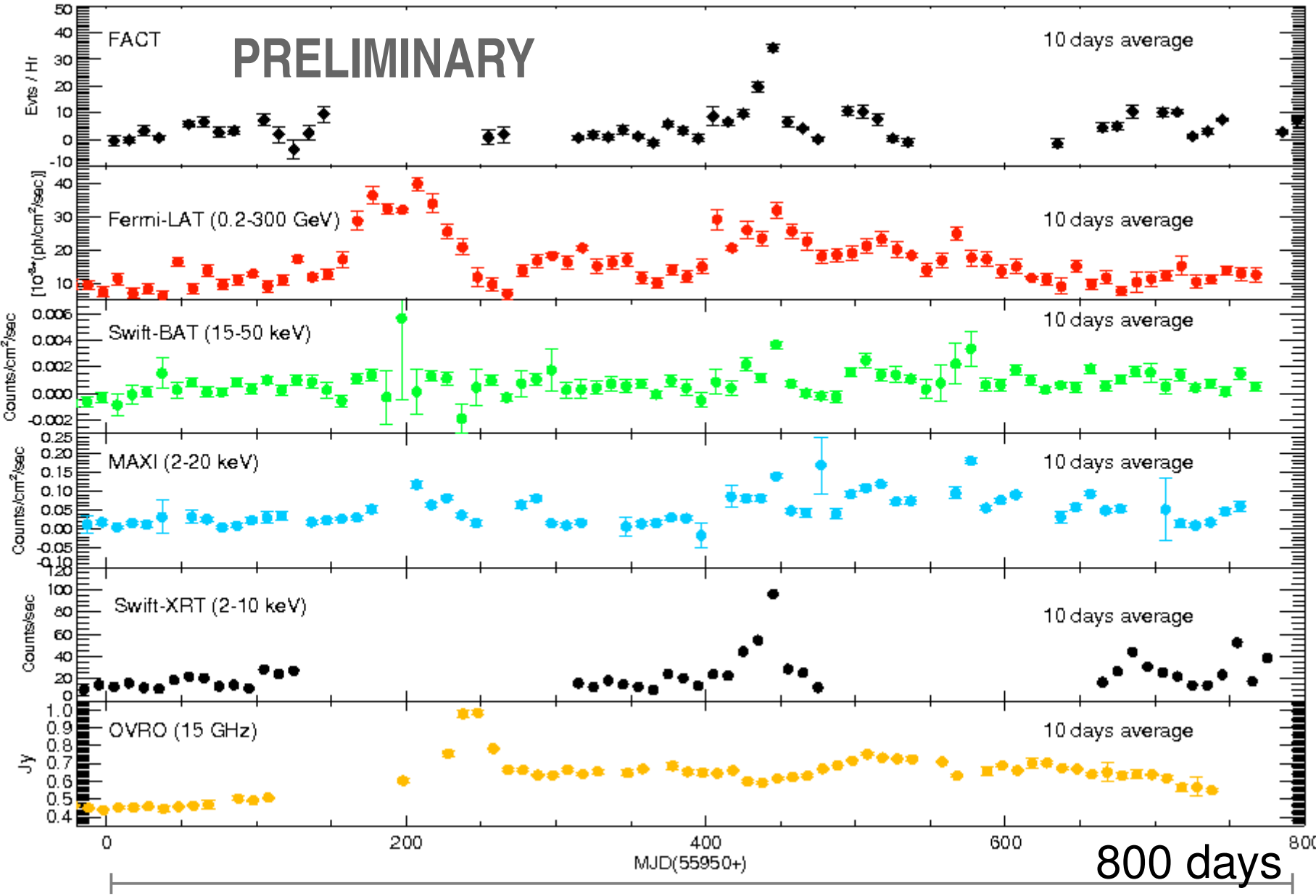
Triggered MAGIC observations

Mrk 501 – Flares May/June 2012



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

Multi-Wavelength Campaign Mrk 421



FACT

GeV

15-50 keV

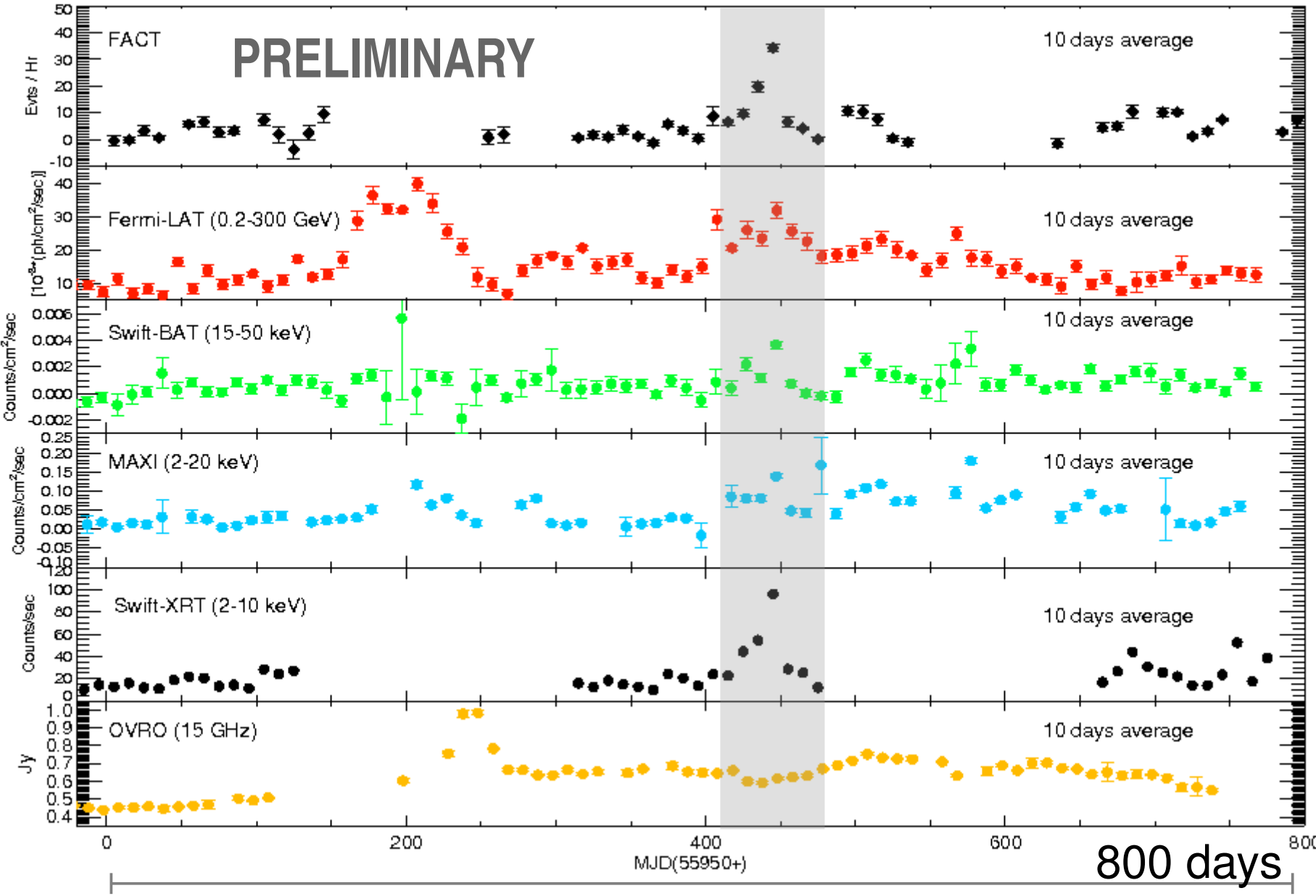
2-20 keV

2-10 keV

15 GHz

Amit Shukla

Multi-Wavelength Campaign Mrk 421



FACT

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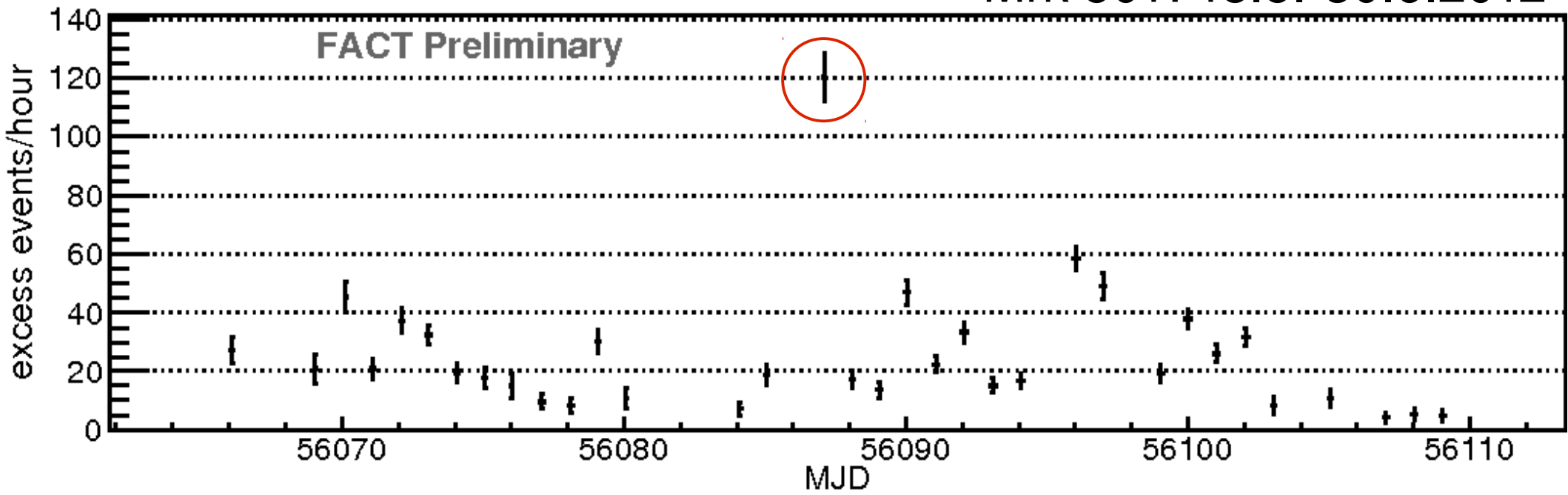
Amit Shukla

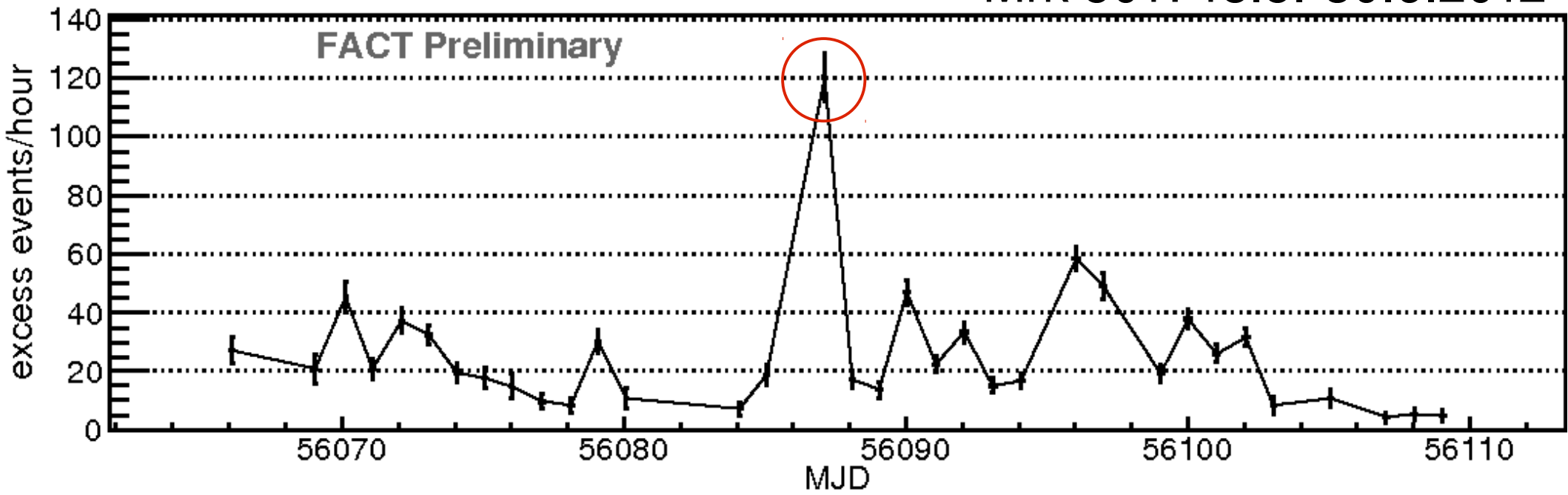
Outlook

Mrk 501: 18.5.-30.6.2012

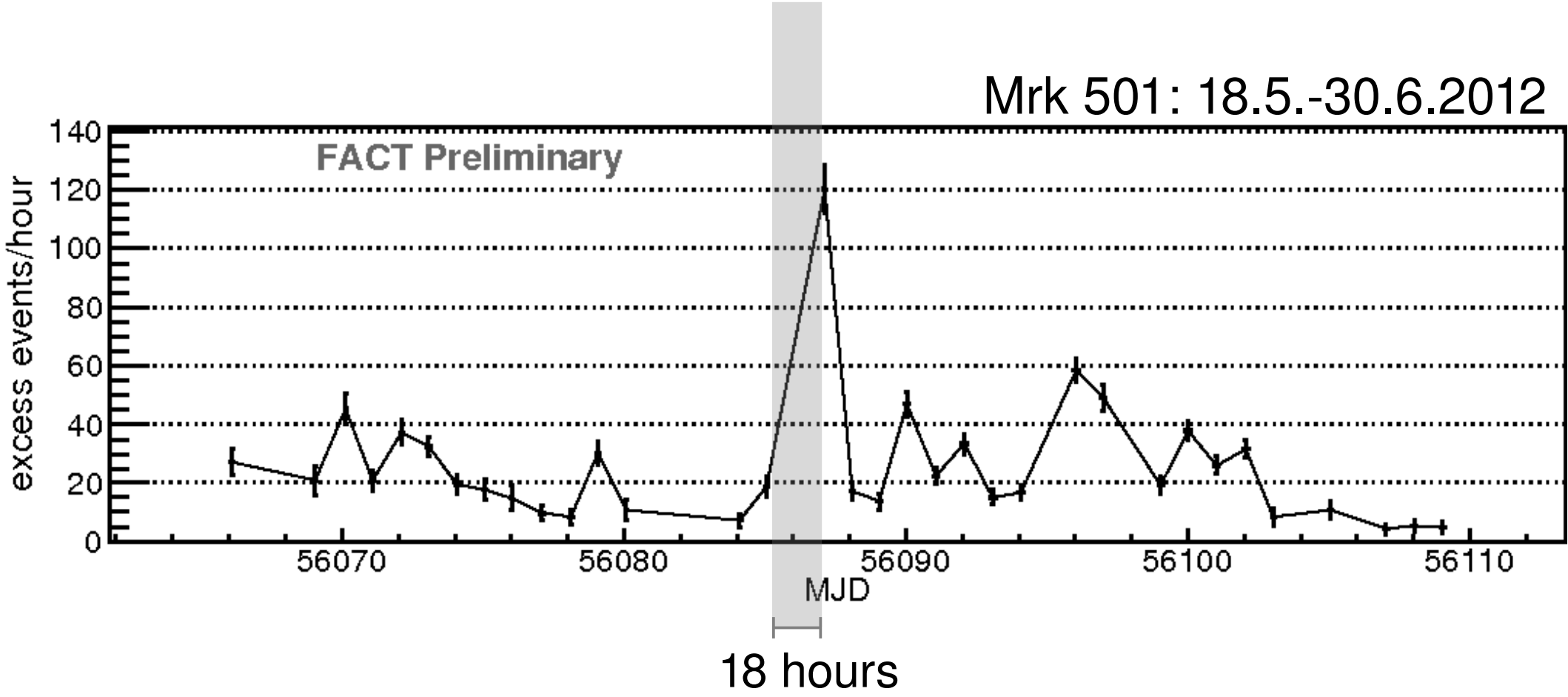


Outlook

Mrk 501: 18.5.-30.6.2012

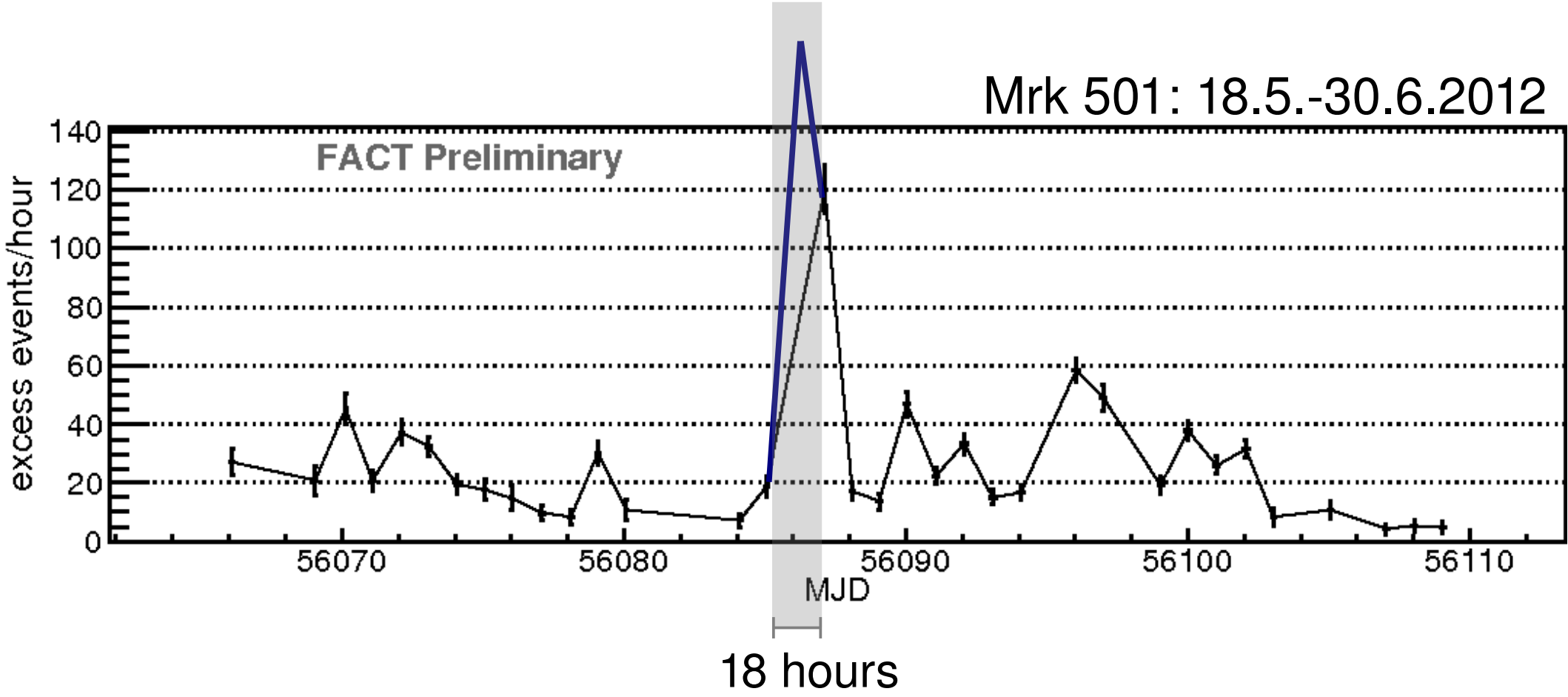


Outlook



Gaps due to daytime

Outlook



Gaps due to daytime

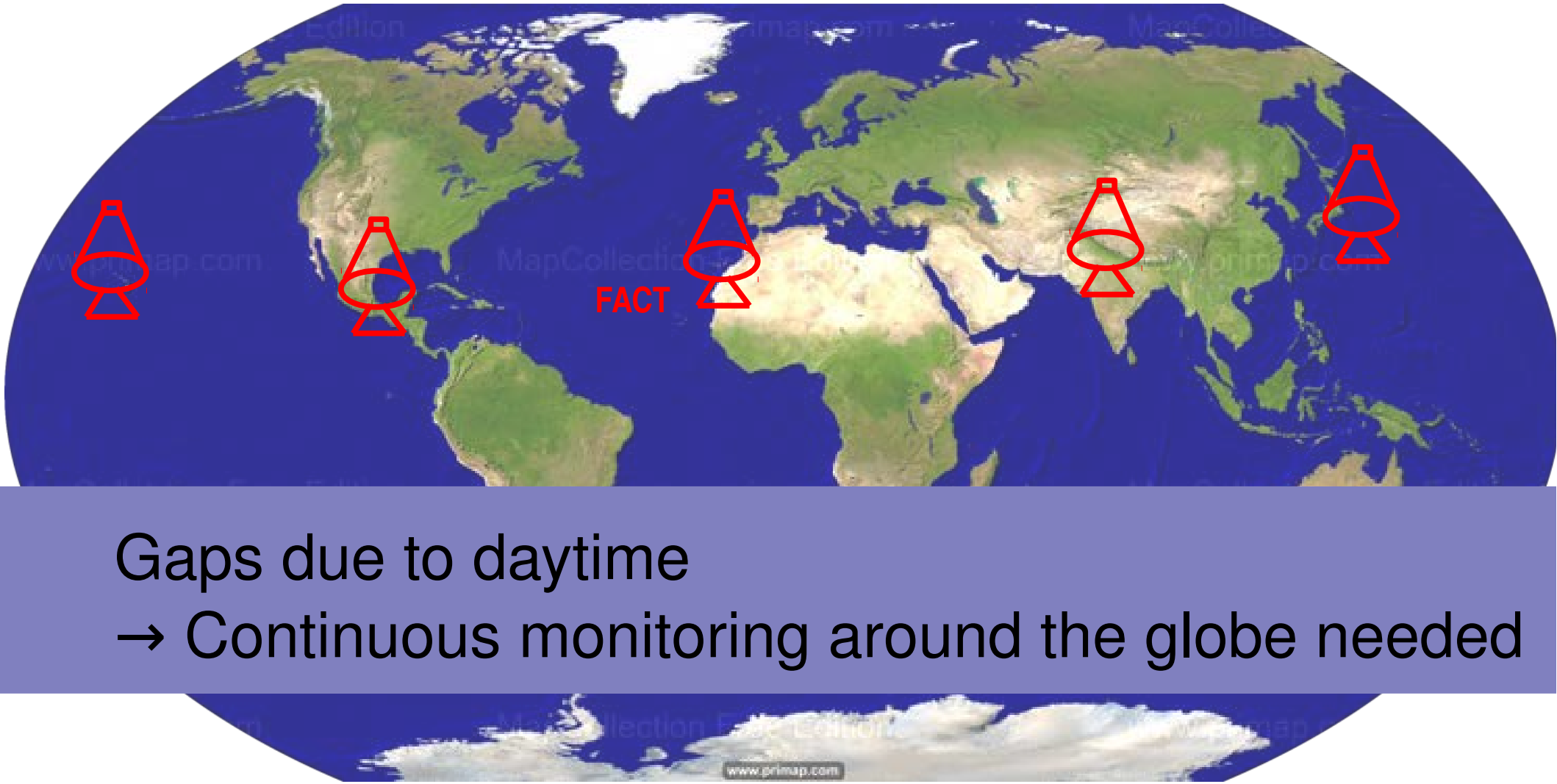
→ continuous monitoring around the globe needed

Continuous Monitoring

Gaps due to daytime

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

Continuous Monitoring



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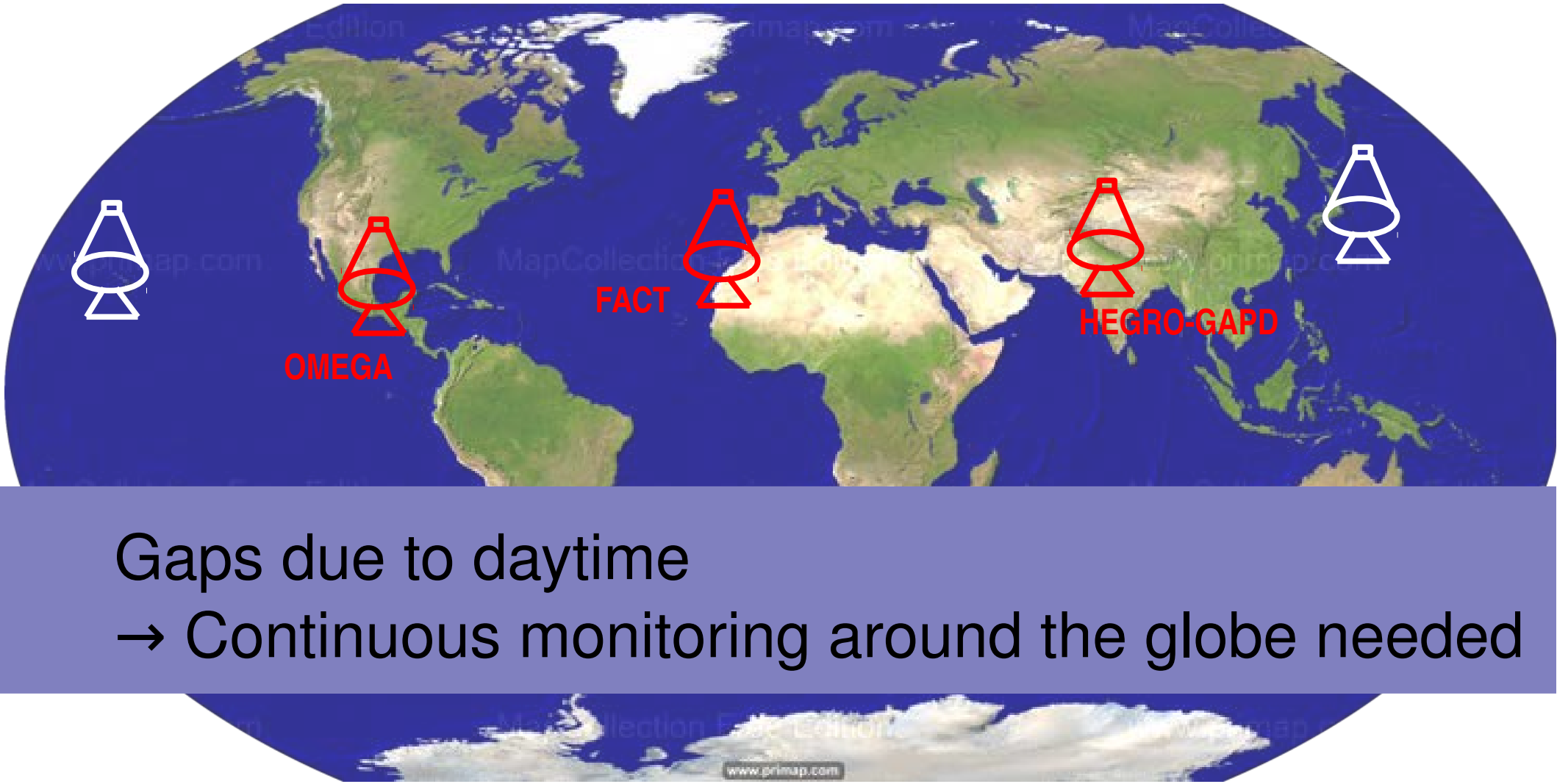

Gaps due to daytime

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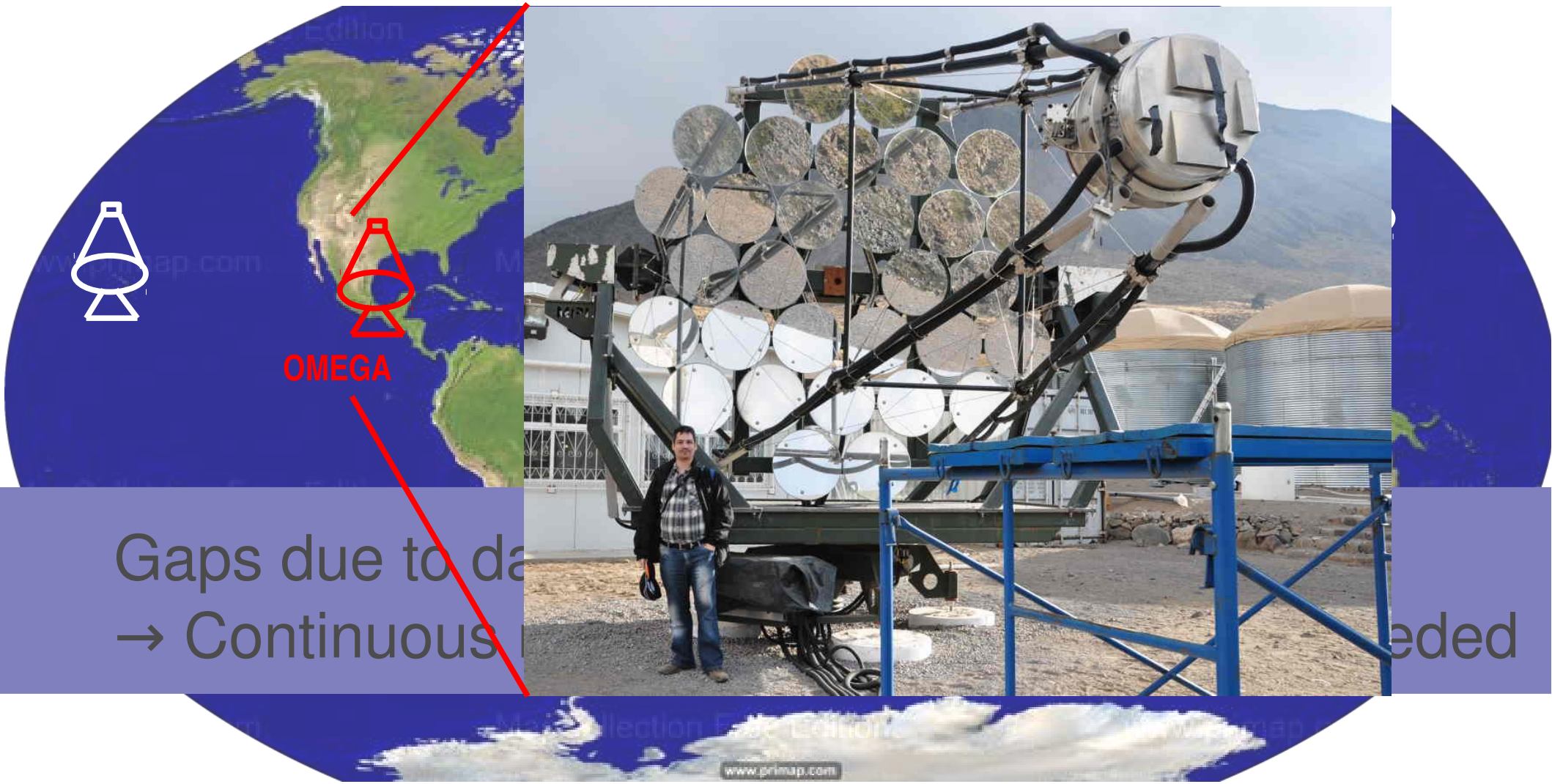
Continuous Monitoring



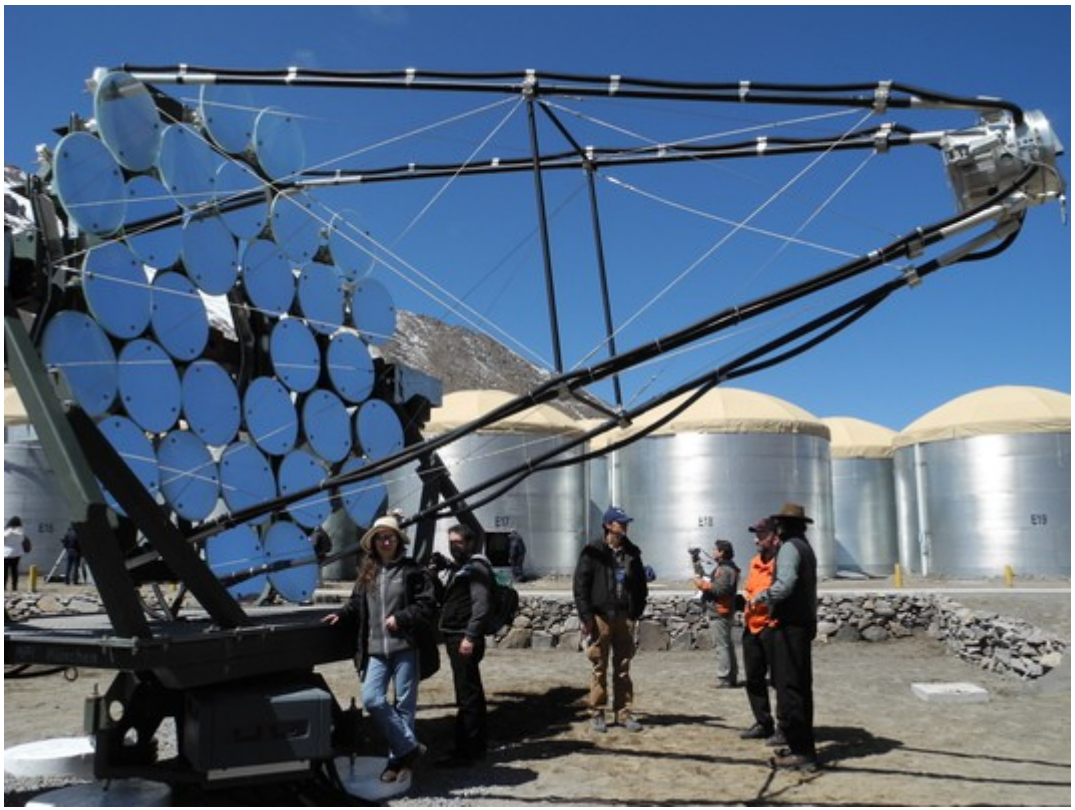
Gaps due to da

→ Continuous

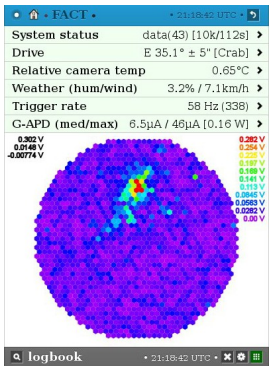
eded

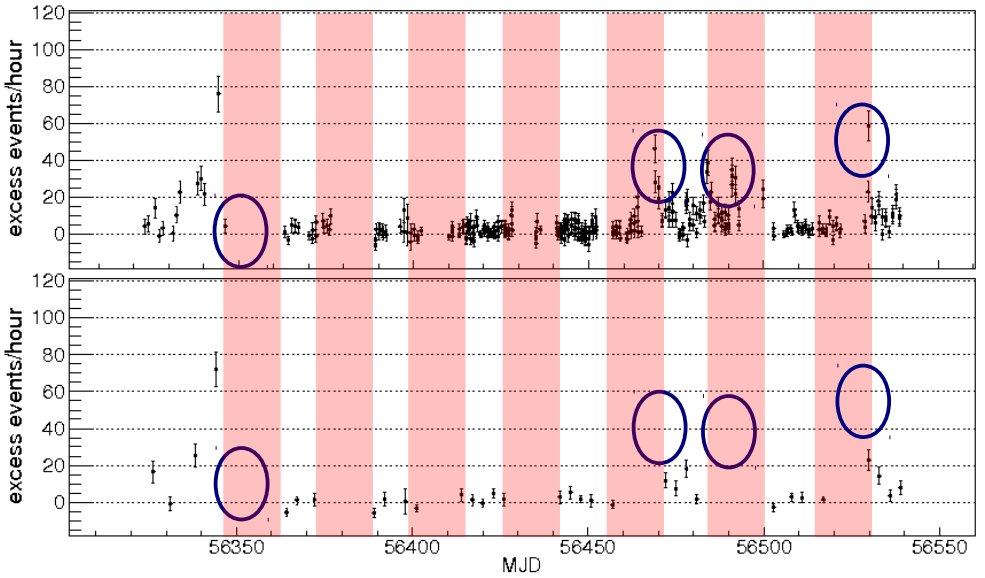
Second Telescope: M@TE

- M@TE:
  Monitoring at TeV Energies
- 2 mounts from OMEGA project available
- Mexico:
  two possible sites:
  5 or 7 hours from La Palma
- Goal: Equip mount with improved SiPM camera
  → close more gaps in TeV monitoring

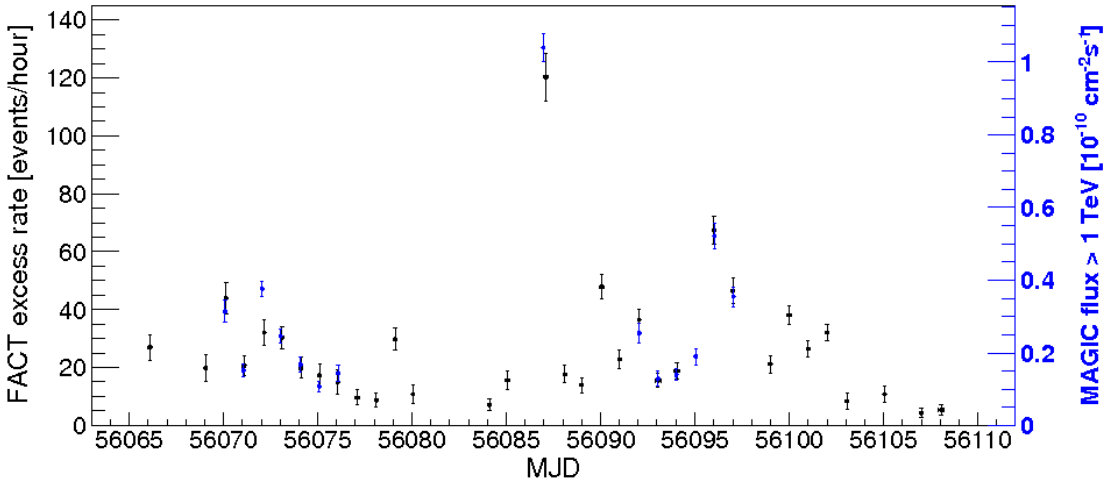


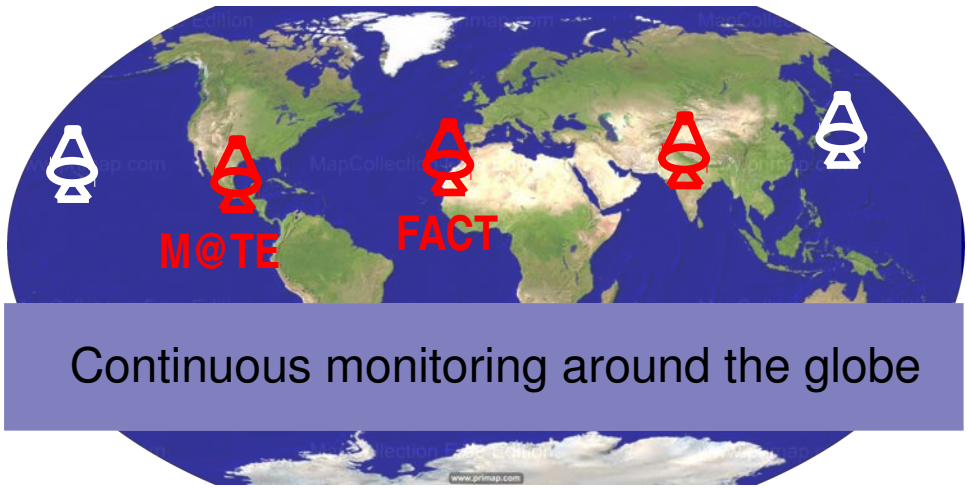
Summary





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

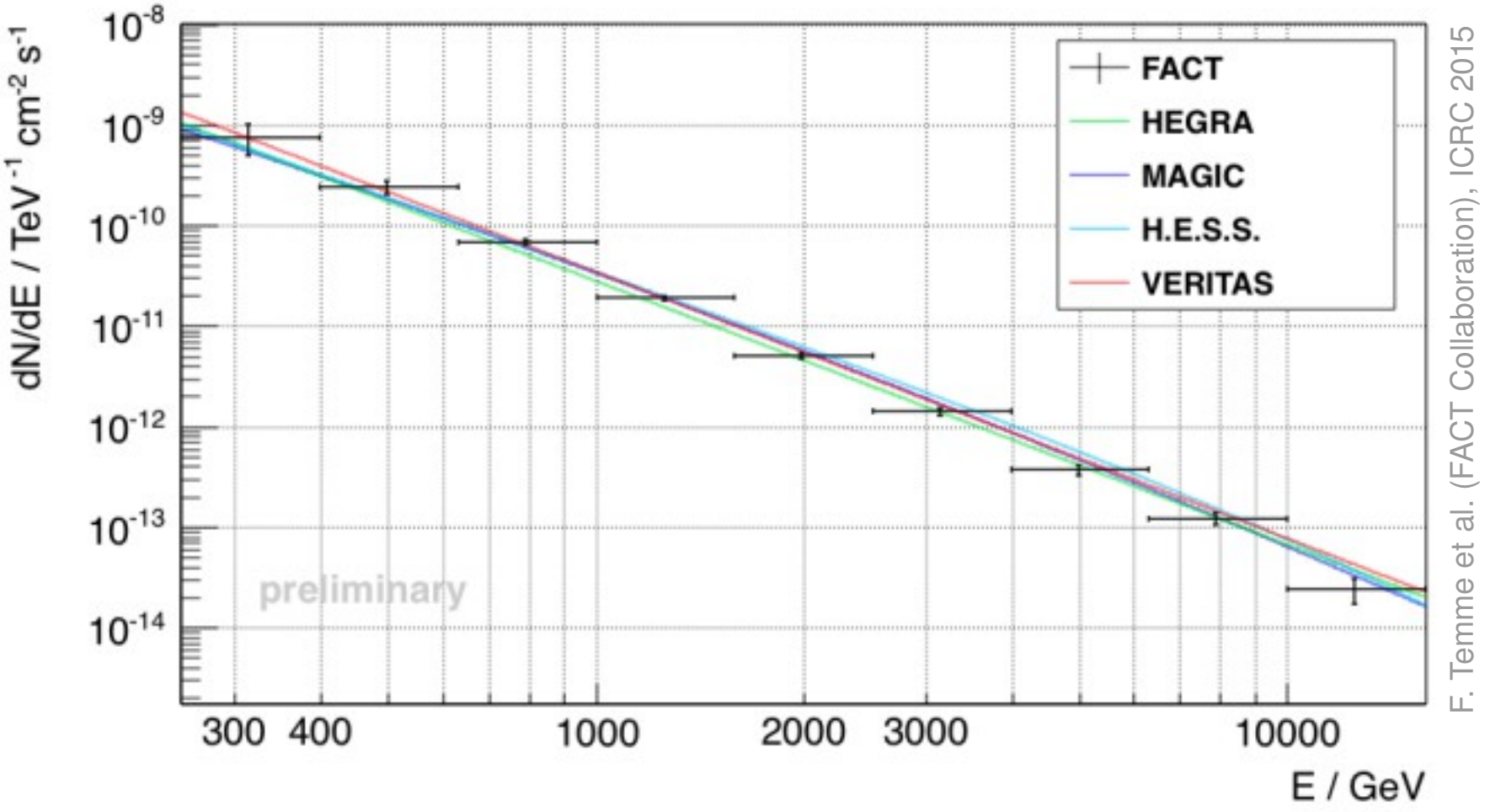




Continuous monitoring around the globe

Backup

Crab Spectrum



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

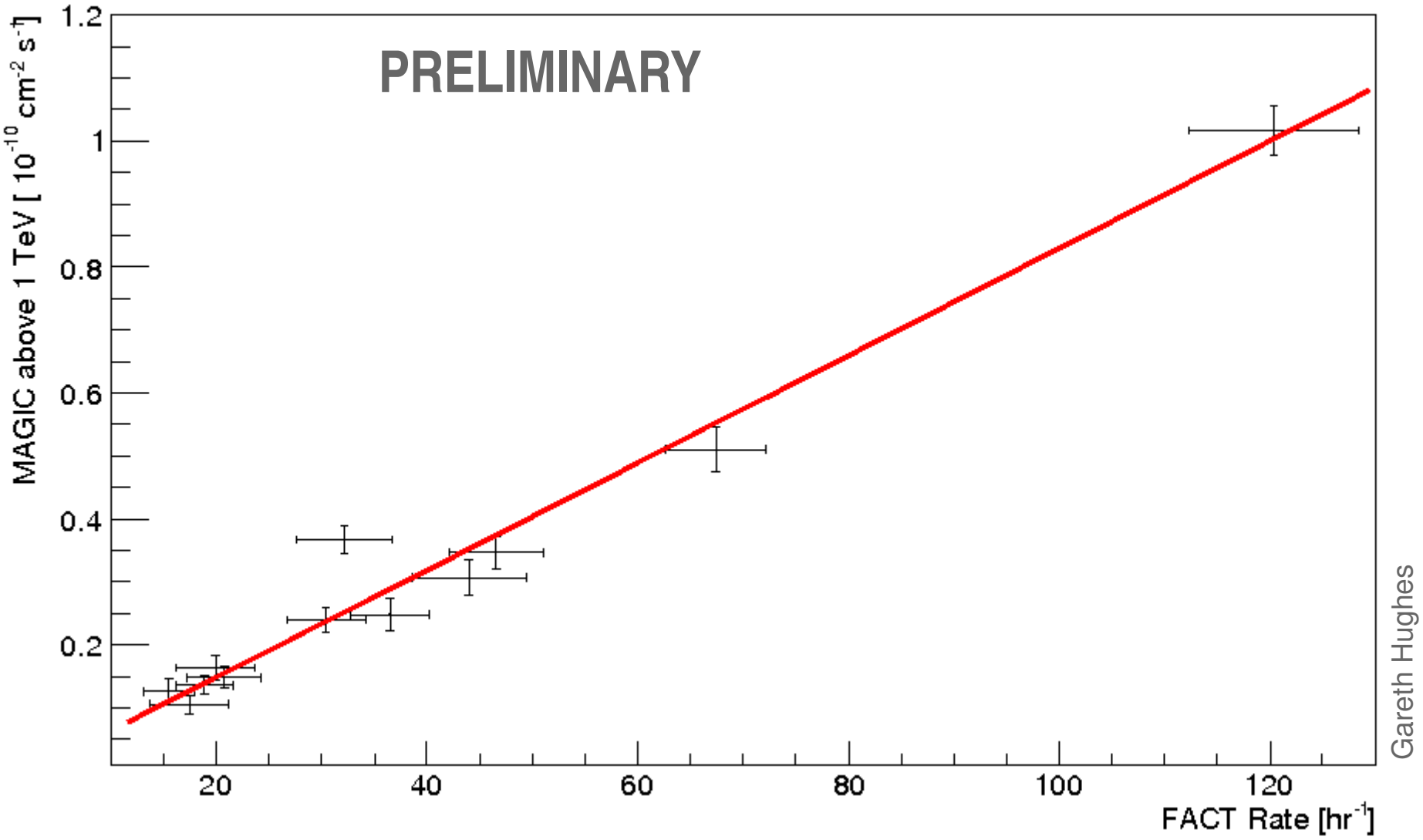
Quick Look Analysis

- Quick look analysis since 2012/12/12
- Results publicly available since 2013/09/01
- Official flare alerts since 2014/03/18

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

- Results available within the same night
- Flare alerts to other instruments
- Target-of-Opportunity programs

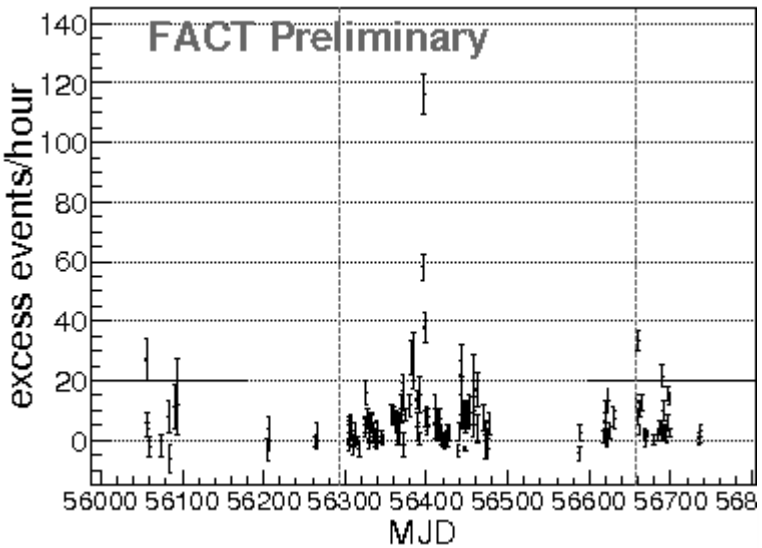
Mrk 501 – Flares May/June 2012



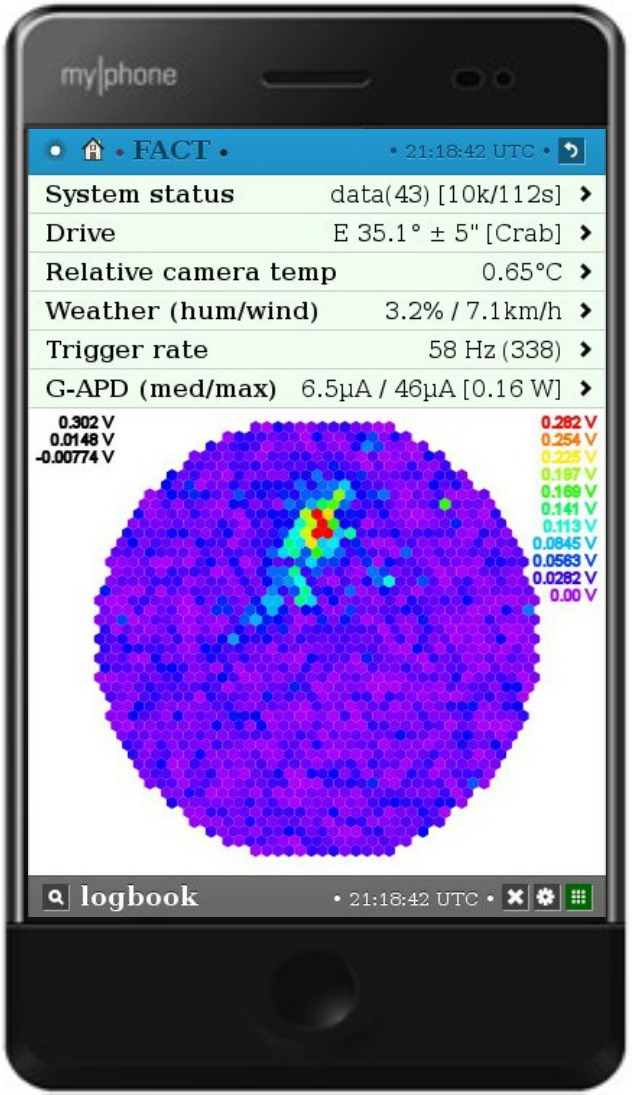
MAGIC: http://143.107.180.38/indico/contributionDisplay.py?contribId=934&sessionId=3&confId=0

Check out our monitoring results!

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



3.5 years monitoring



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arXiv:1502.02582

flare alerts