

# FACT – Monitoring of Blazars at Very High Energies



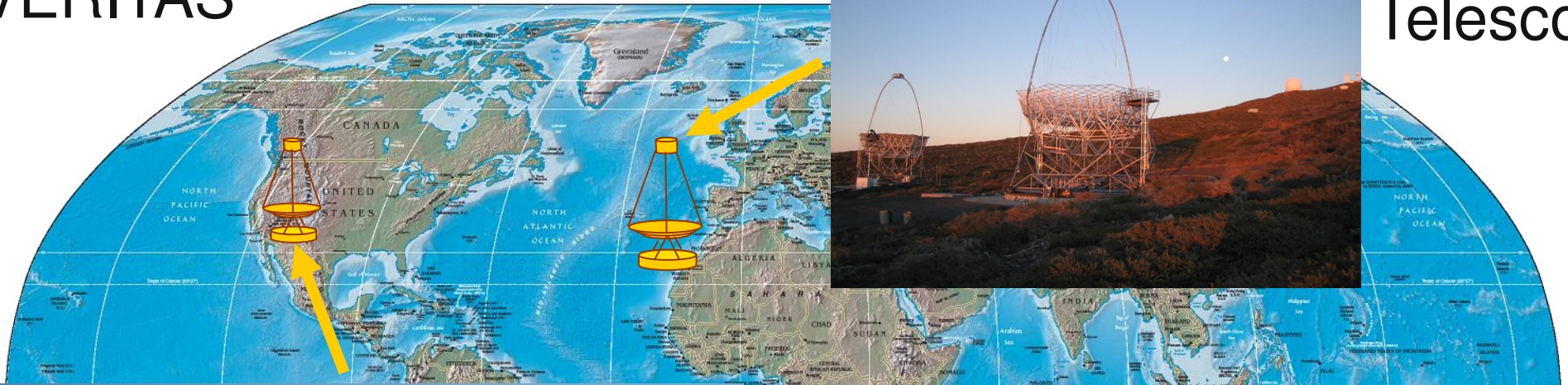
Daniela Dorner for the FACT Collaboration





# IACTs – Current Instruments

VERITAS



MAGIC  
Telescopes



H.E.S.S.





# First G-APD Cherenkov Telescope

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

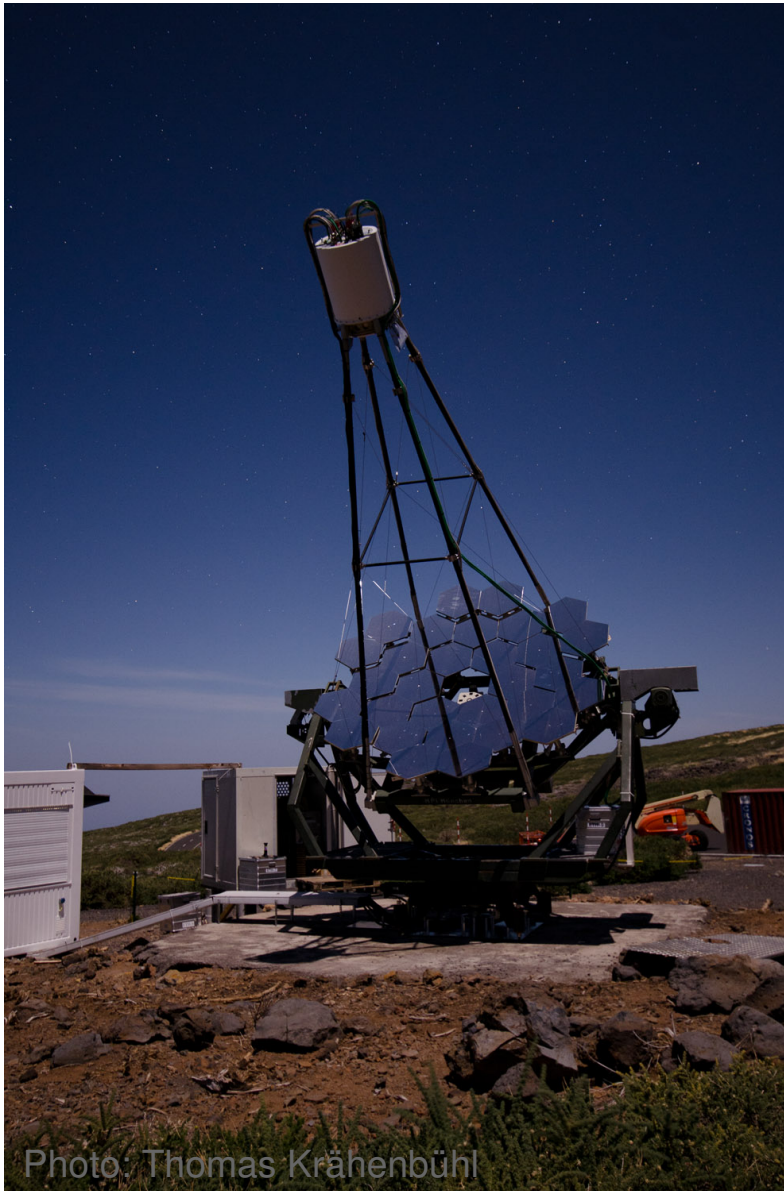
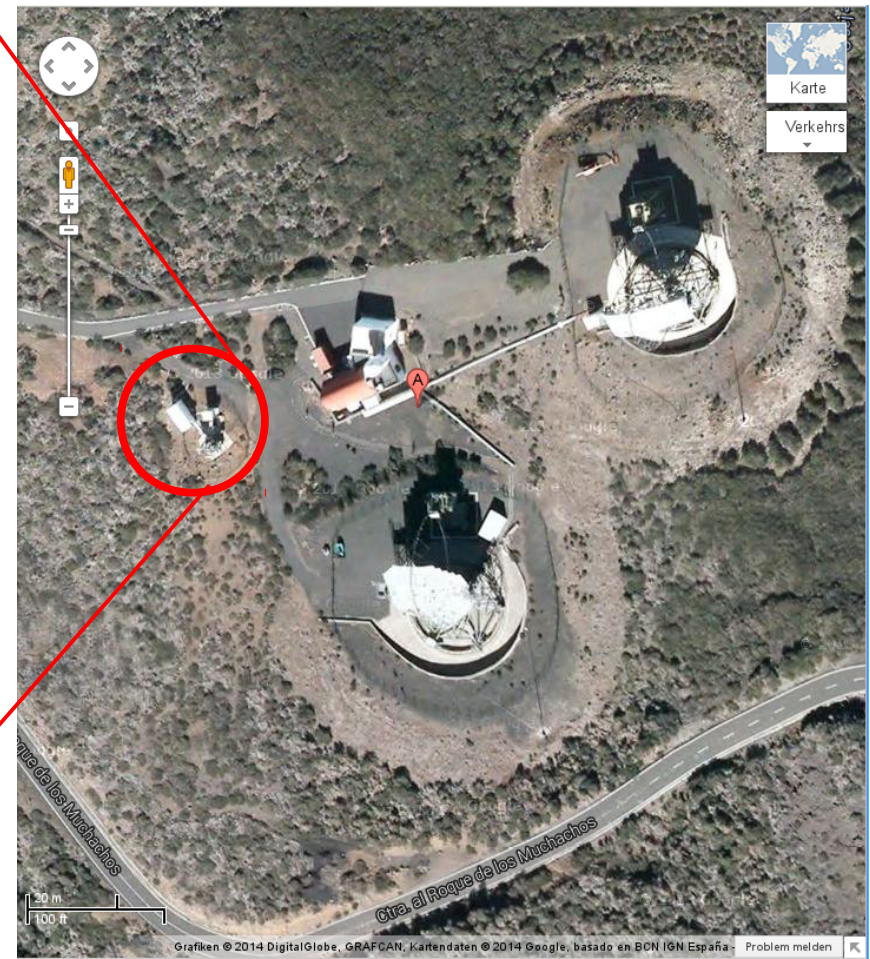


Photo: Thomas Krähenbühl





# Facts about FACT

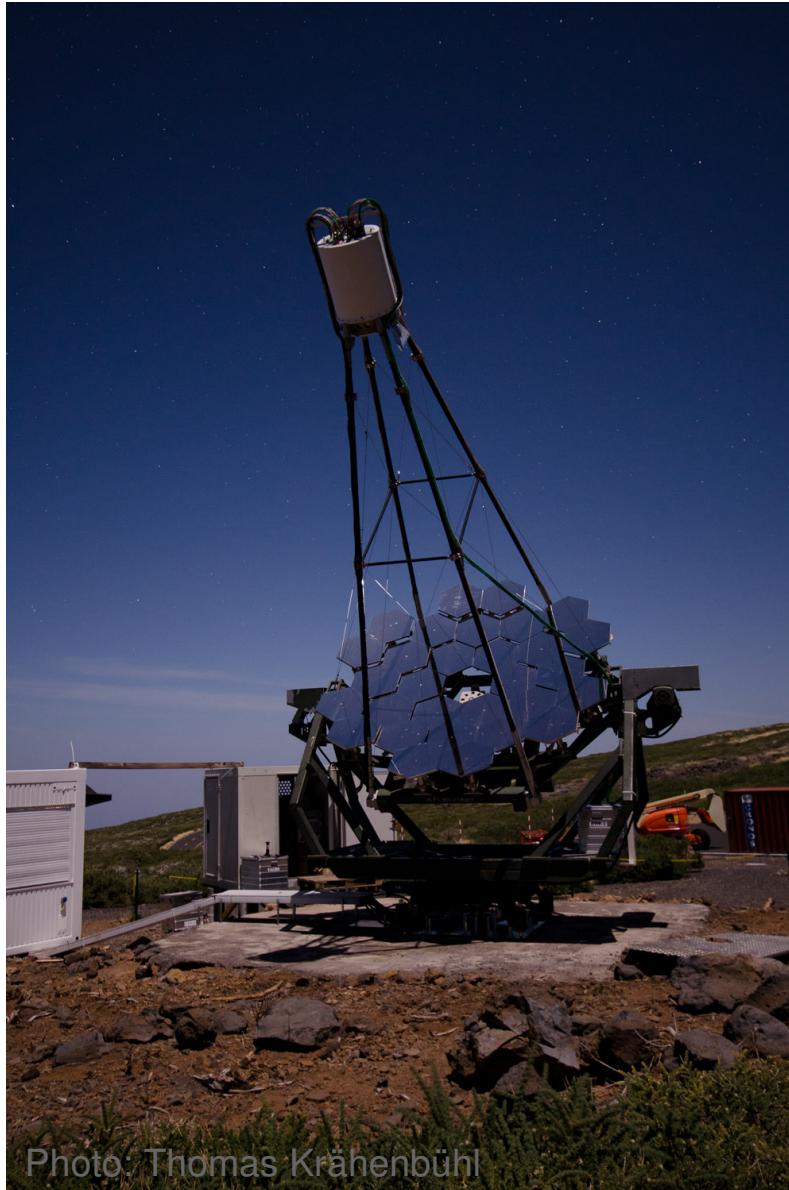


Photo: Thomas Krähenbühl

- 2200 m a.s.l.  
Observatorio del Roque de los Muchachos, La Palma
- 9.5 m<sup>2</sup> mirror area
- G-APD camera
  - Silicon based photosensors
  - 4.5° FoV, 1440 pixels à 0.11°
- Operational since Oct 2011
- More Details:

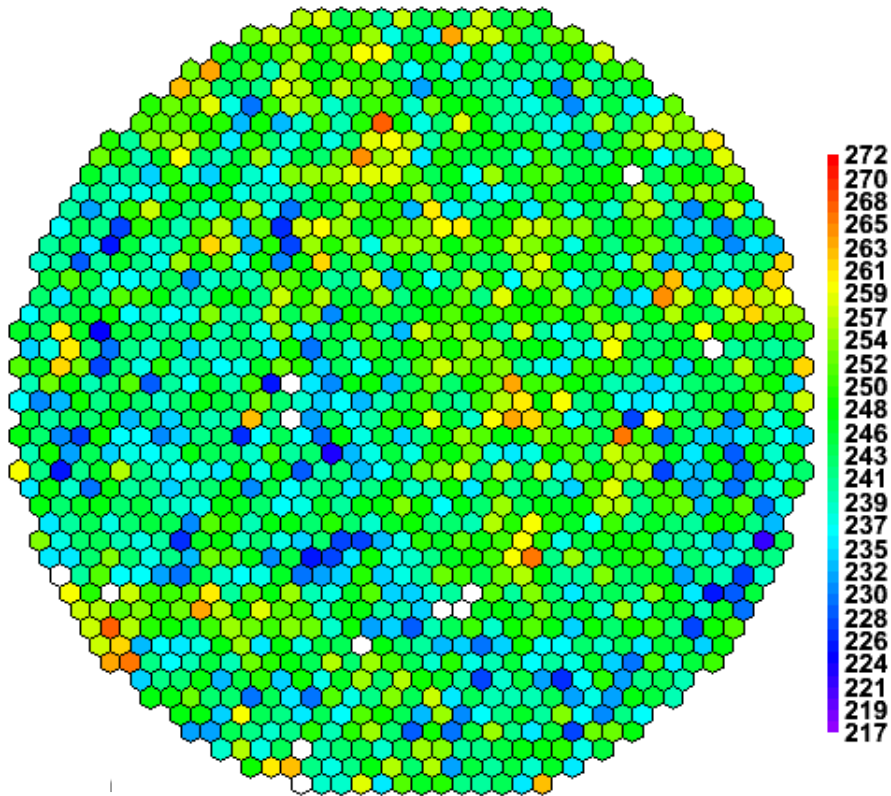
**Design and operation of  
FACT – the first G-APD  
Cherenkov telescope**

*H Anderhub et al 2013 JINST 8 P06008*



# G-APD Camera

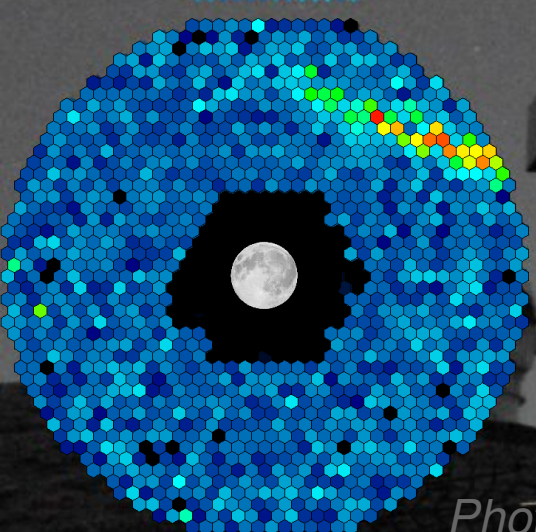
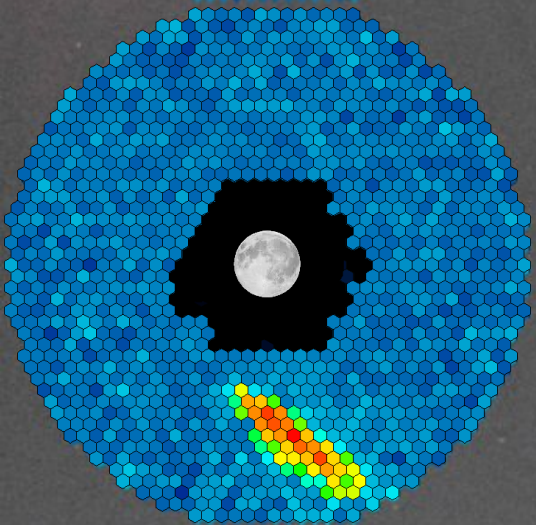
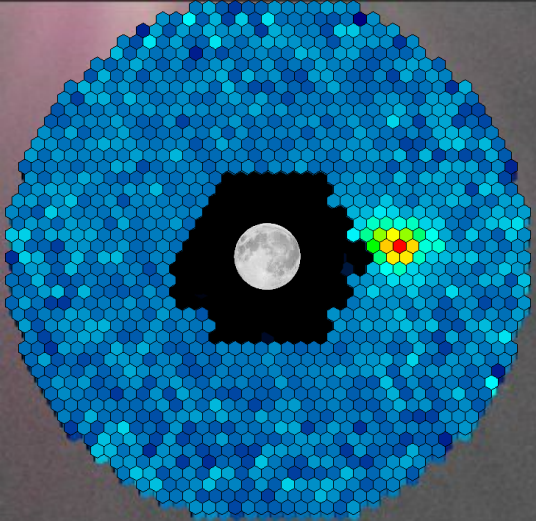
Voltage  
correction applied



$\sigma \sim 2.3\%$

- Keep the G-APD gain stable (feedback system)  
→ Stable observation conditions
- No aging from strong ambient light  
→ Observations during strong moon light possible
- More Details:  
**Calibration and performance of the photo sensor response of FACT**  
*A Biland et al. 2014 JINST 9 P10012*  
**arXiv:1403.5747**





**Showers images recorded pointing to brightest moon in 2013.**

*Photos: D. Dorner, T. Krähenbühl*



# G-APDs – the Revolution in Cherenkov Astronomy



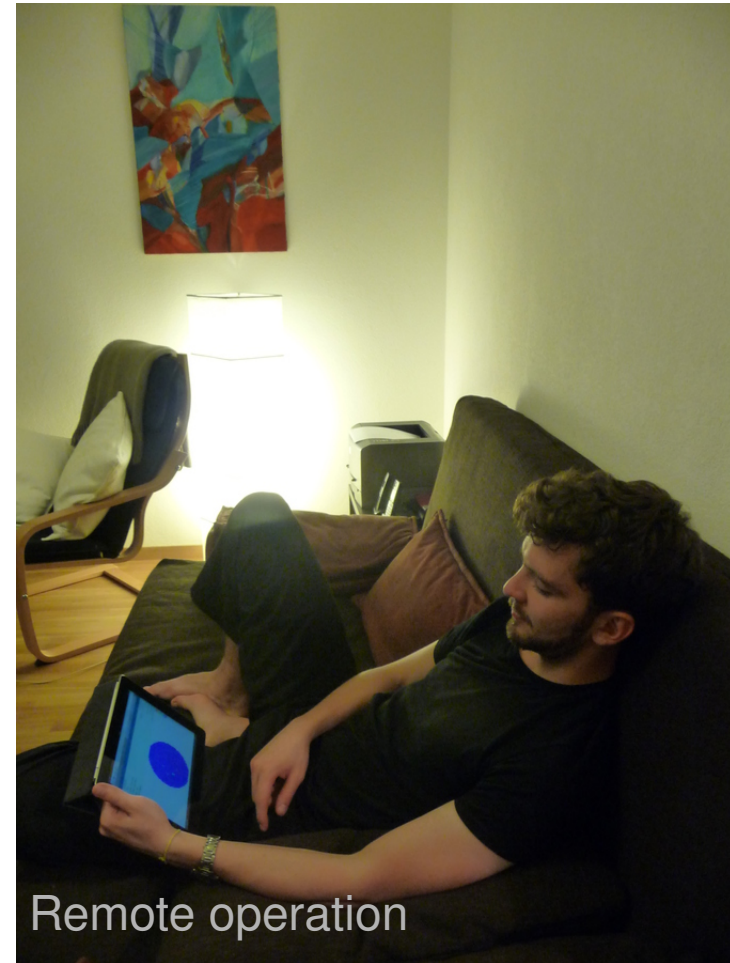
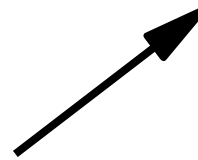
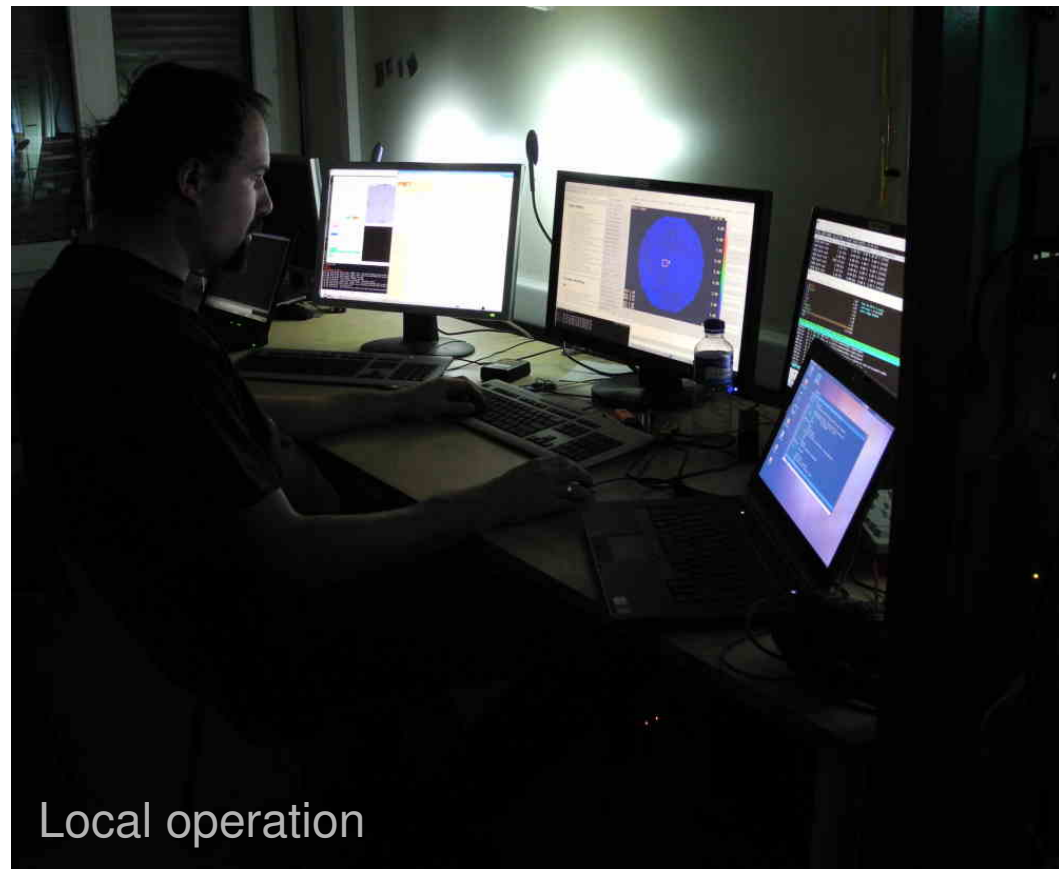
- Observations during strong moon light
  - Larger duty cycle
  - More complete data sample
- Robust and stable
  - Stable telescope performance

Photo: Daniela Dorner





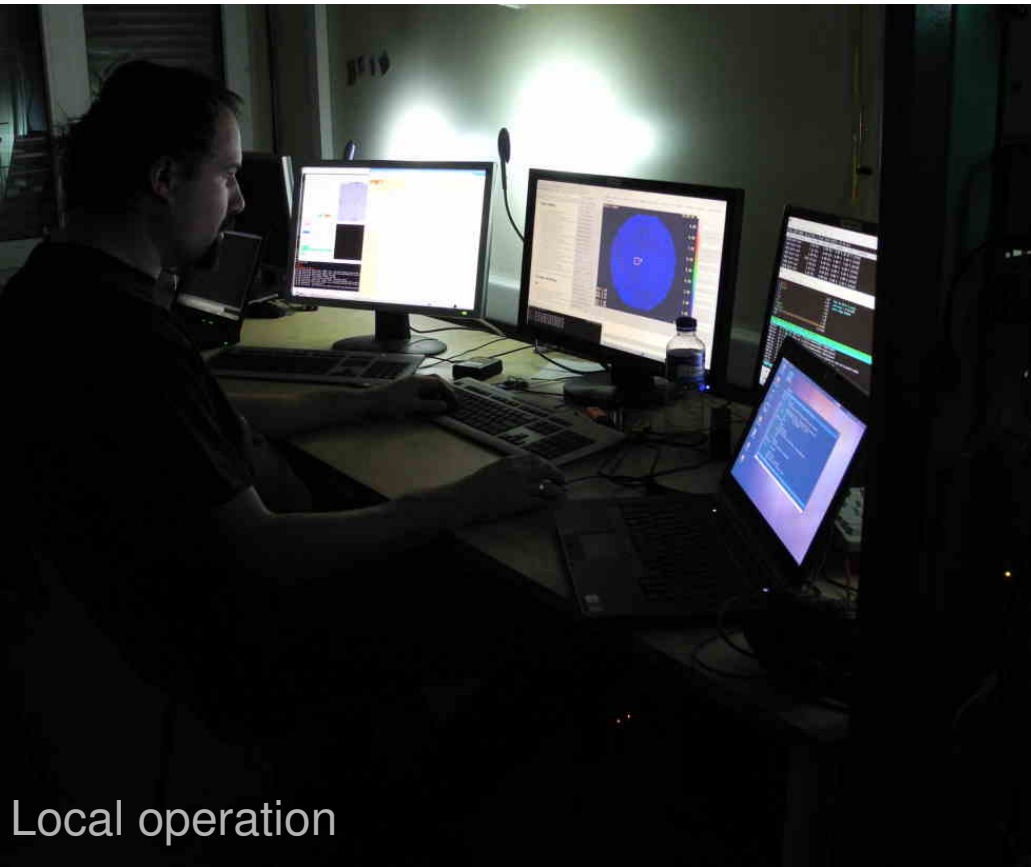
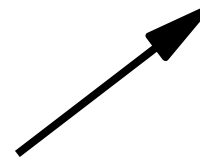
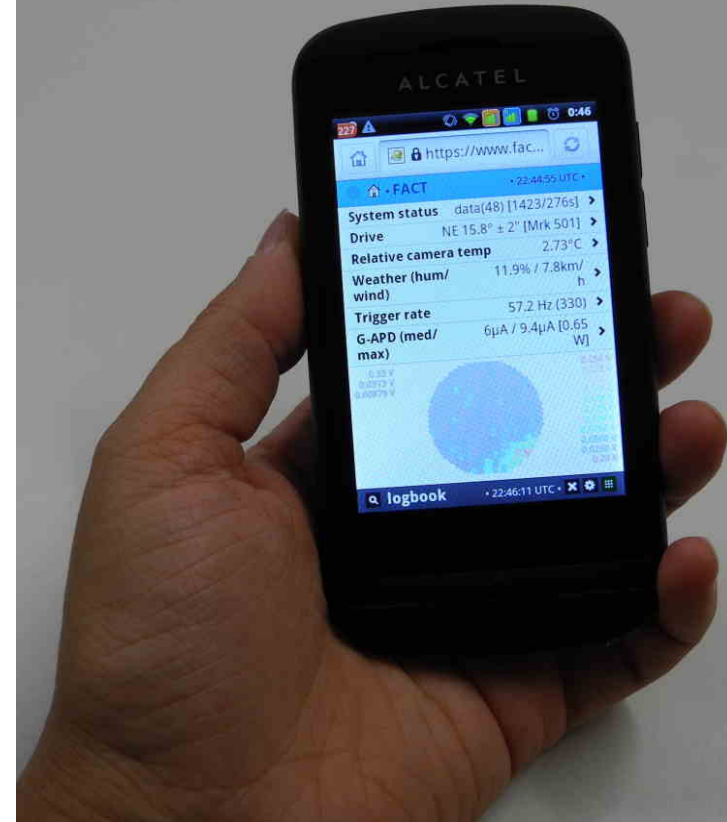
# Towards Robotic Operation



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

# Towards Robotic Operation

Operation via  
smartphone



Local operation

Automatic Operation

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





# G-APDs – the Revolution in Cherenkov Astronomy



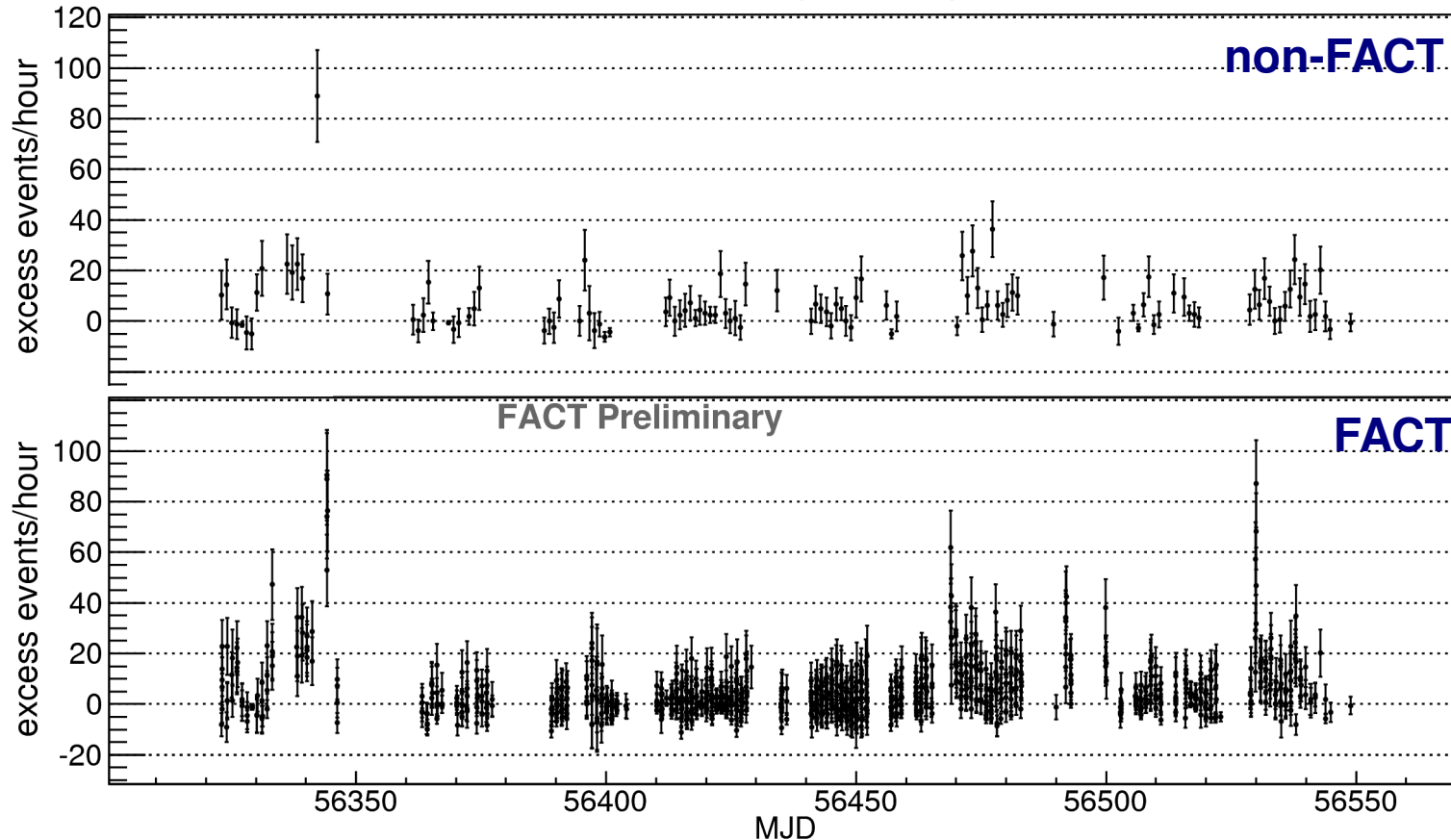
- Observations during strong moon light
  - Larger duty cycle
  - More complete data sample
- Robust and stable
  - Stable telescope performance
  - High data taking efficiency

**Ideal for Monitoring**

Photo: Daniela Dorner

# Longterm Monitoring

Mrk 501 (2013)



Limited to:

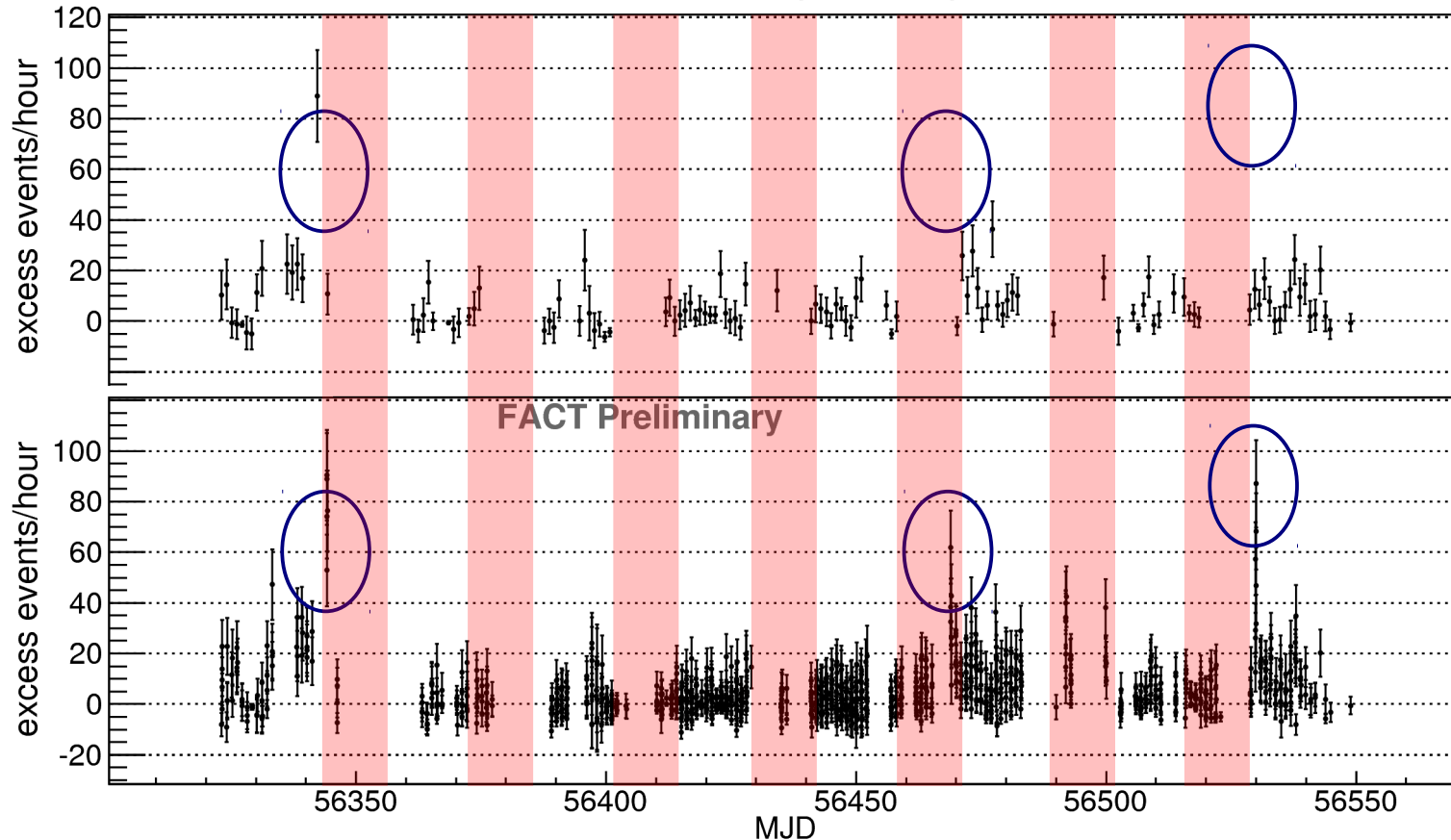
- moon disk < 65%  
~320h
- 1 · 20min / night  
~43h

All data ~430h



# Longterm Monitoring

## Mrk 501 (2013)



Limited to:

- moon disk < 65%  
~320h
- 1 · 20min / night  
~43h

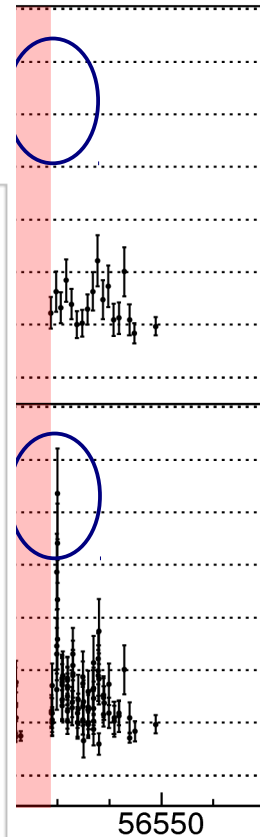
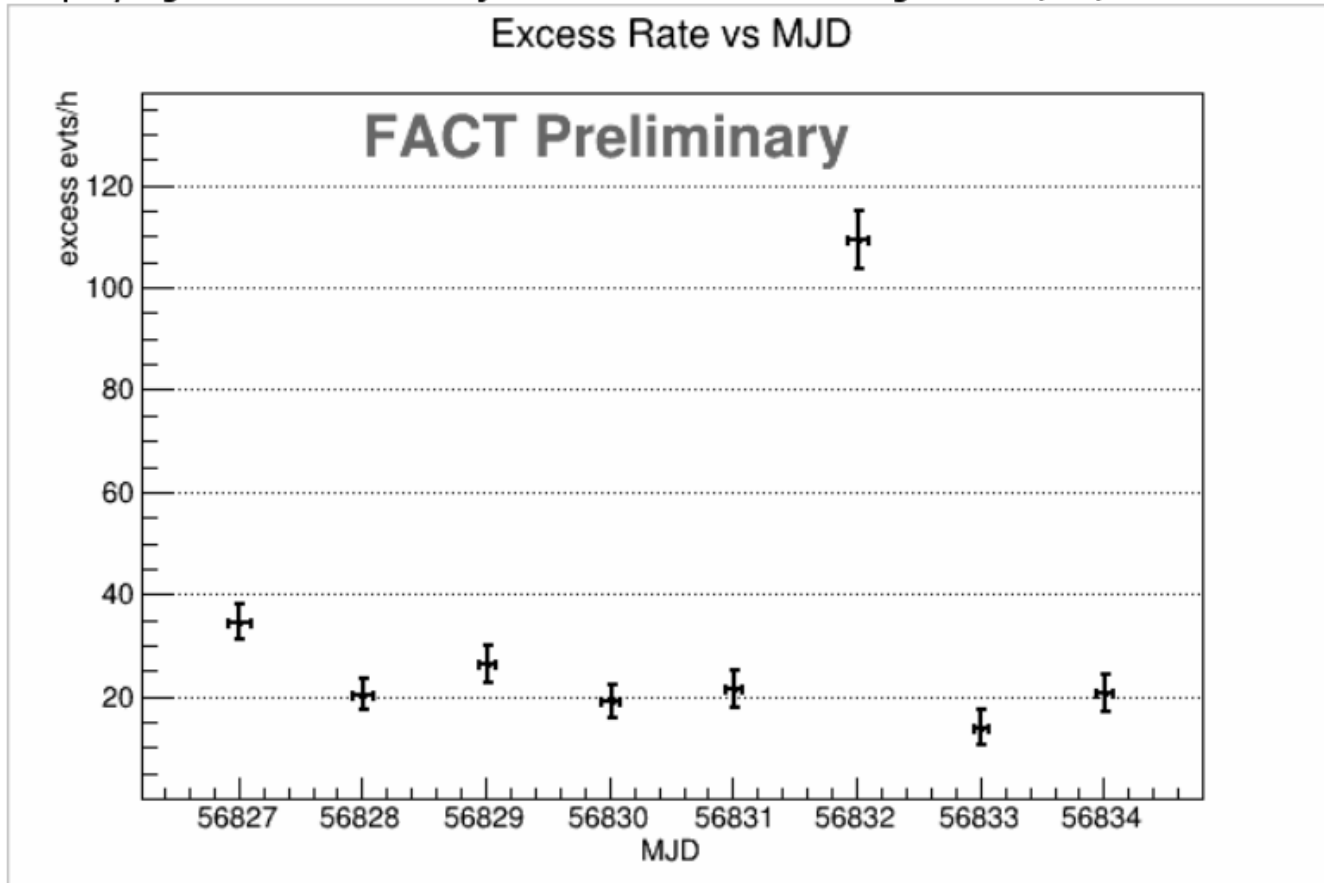
All data ~430h

# Longterm Monitoring

## FACT Quick Look Analysis

Select date    source   
Select time binning  and range

Displaying 'excess rate vs mjd' for Mrk 501 for the night 2014/06/25.



Limited to:

- moon disk < 65%  
~320h
- 1 · 20min / night  
~43h

All data ~430h

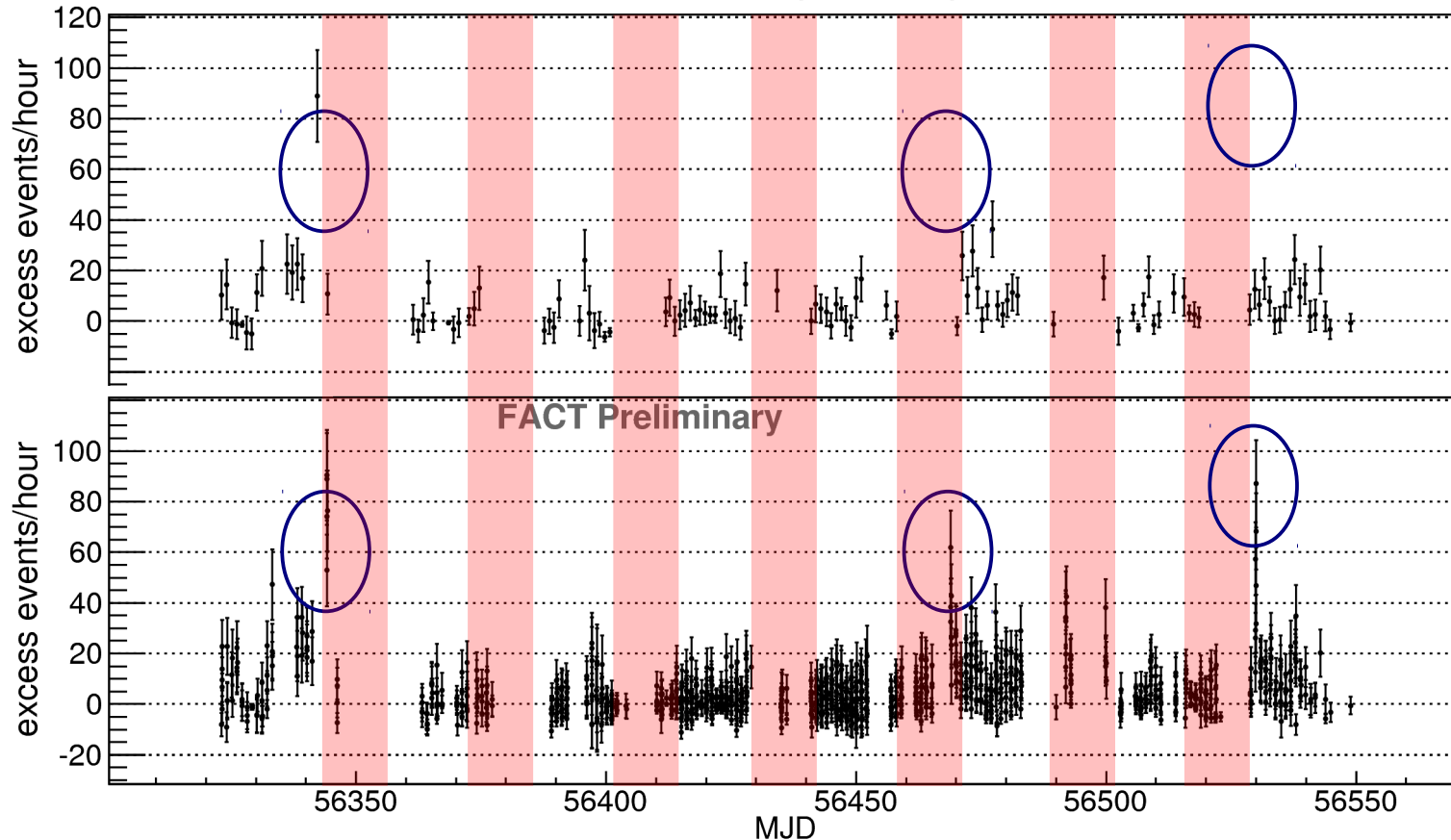
short flares might remain undiscovered





# Longterm Monitoring

Mrk 501 (2013)



Limited to:

- moon disk < 65%  
~320h
- 1 · 20min / night  
~43h

All data ~430h

→ Collect enough statistics to study flare probabilities and flare properties

# Ideal Case: 24/7 Monitoring



**D**edicated **W**orldwide **A**gn **R**esearch **F**acility  
**DWARF**



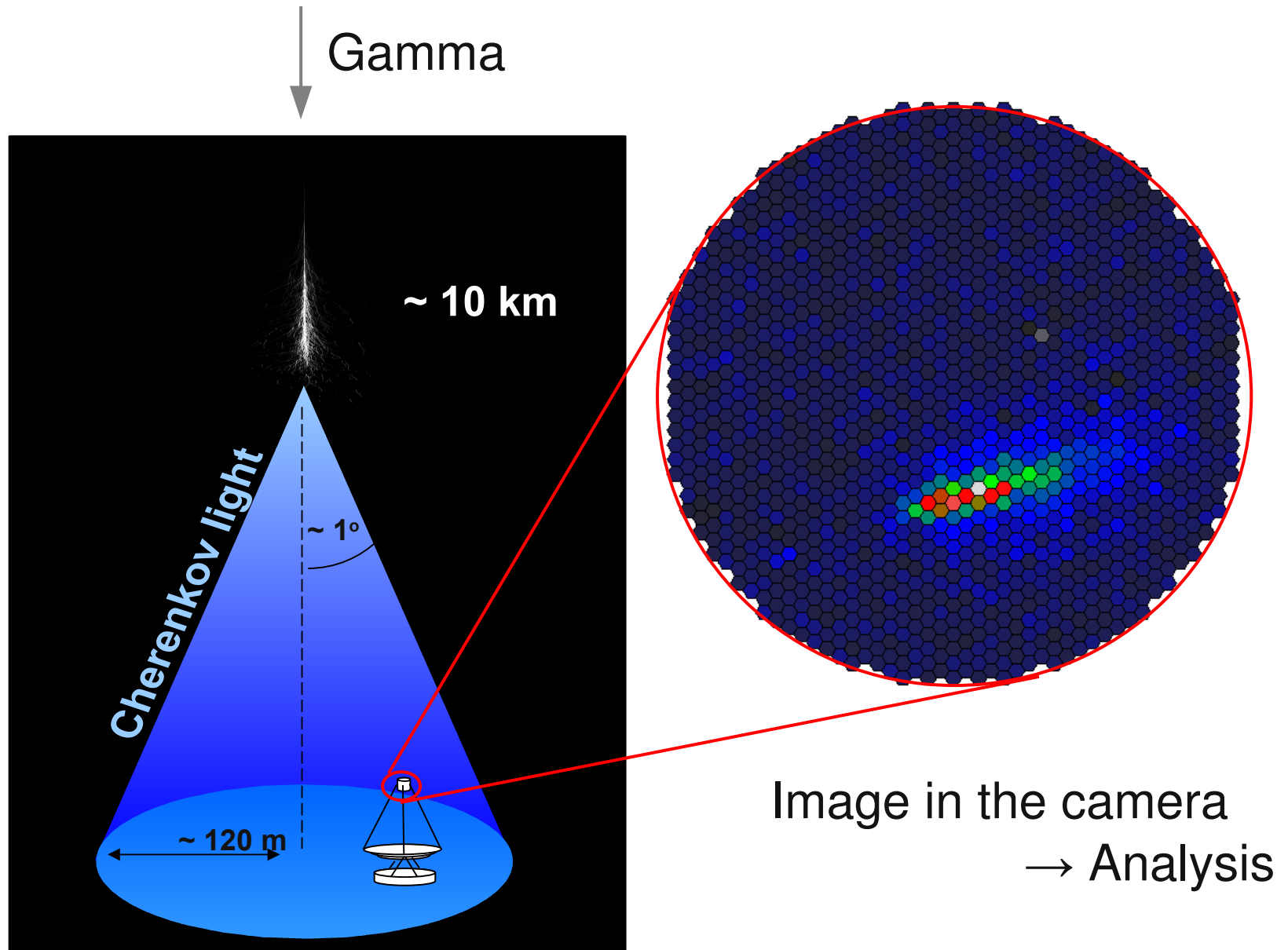


# FACT: Observed Sources

- Crab Nebula
  - Study detector performance
- Blazars bright at TeV energies
  - Flare studies
  - MWL observations
  - Alerts to other instruments
- Current source list
  - Crab Nebula
  - Mrk 421
  - Mrk 501
  - 1ES 1959+650
  - 1ES 2344+51.4
  - 1ES 1218+304
  - IC 310

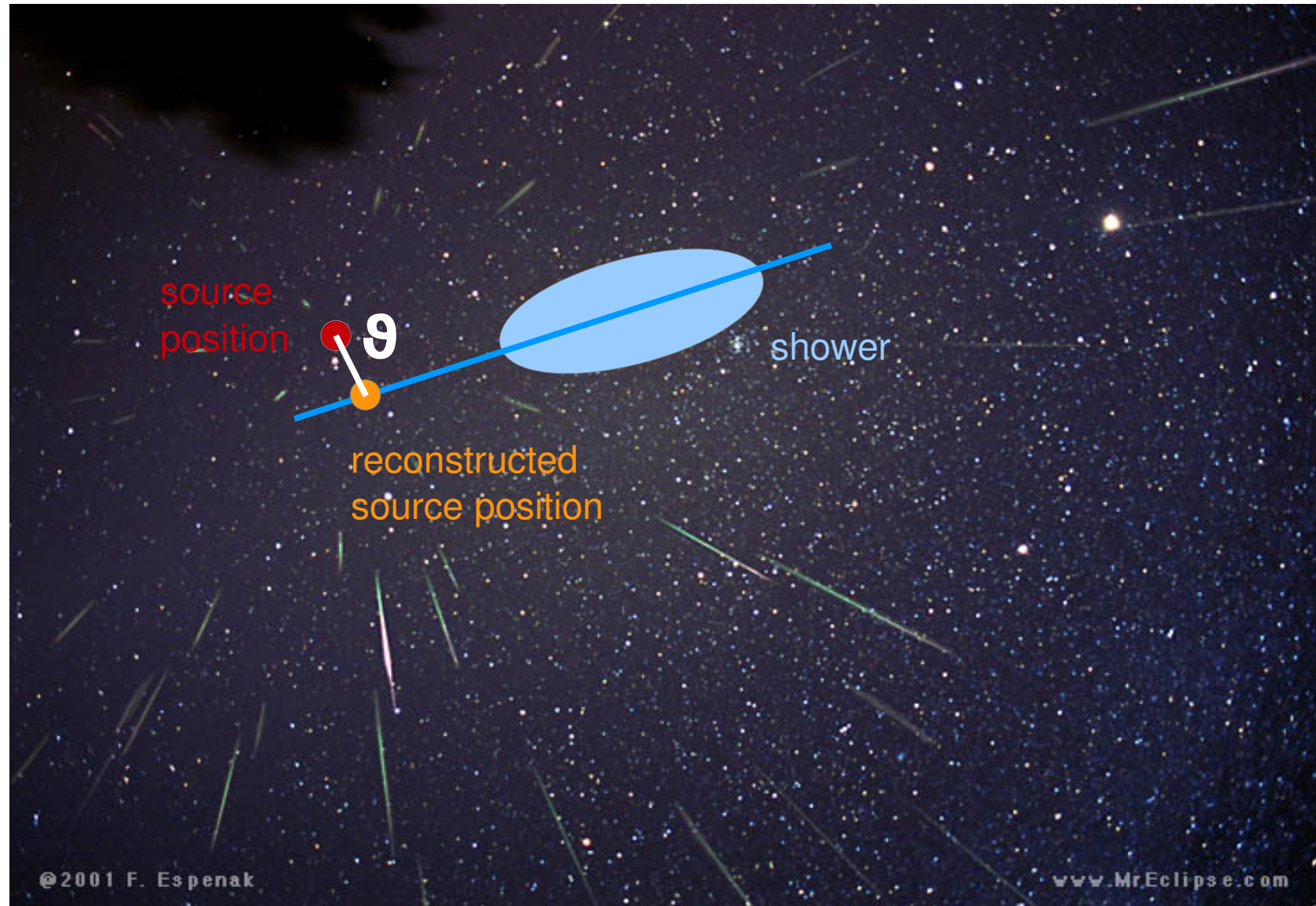


# Imaging Air Cherenkov Technique

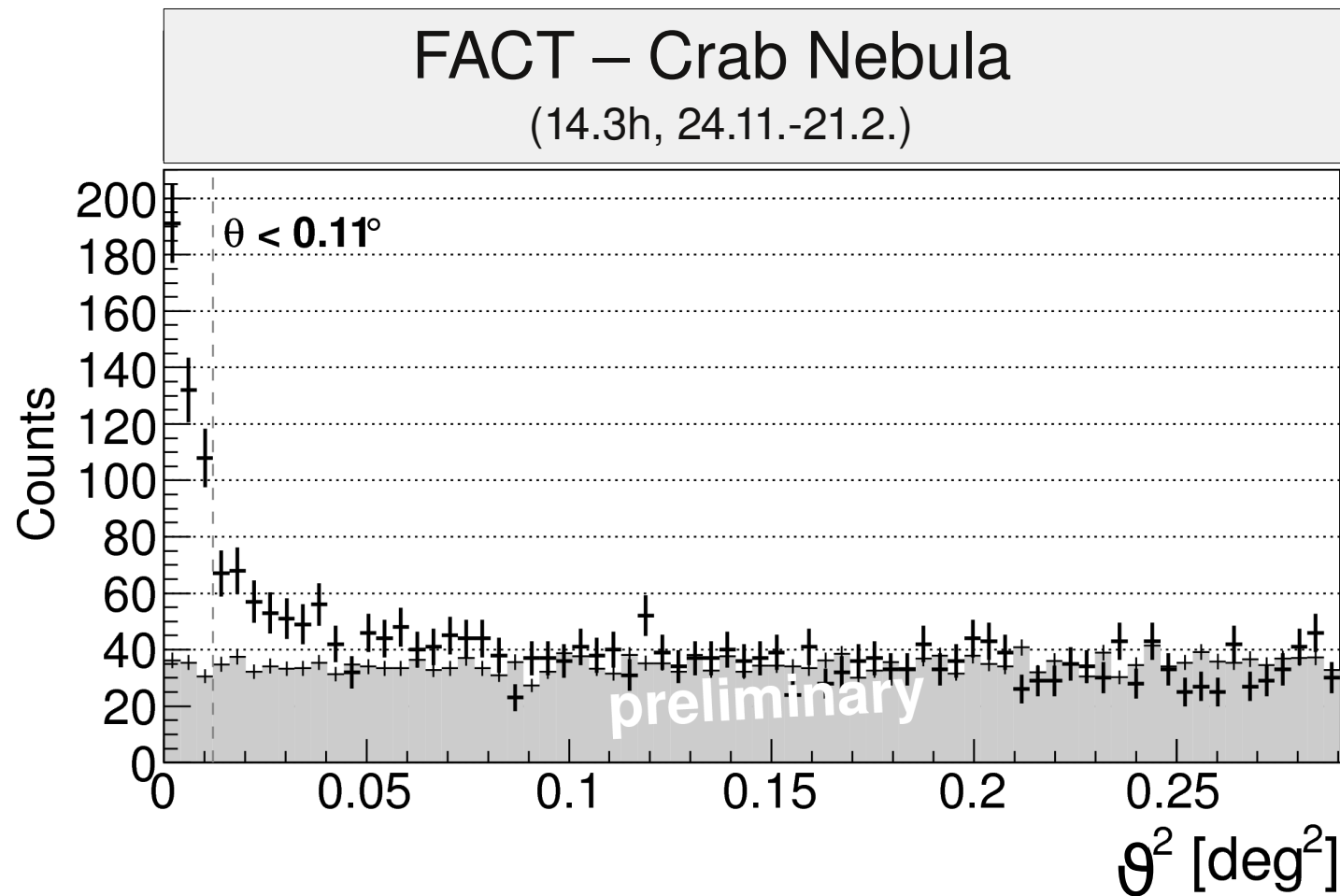




# IACT: Shower Origin



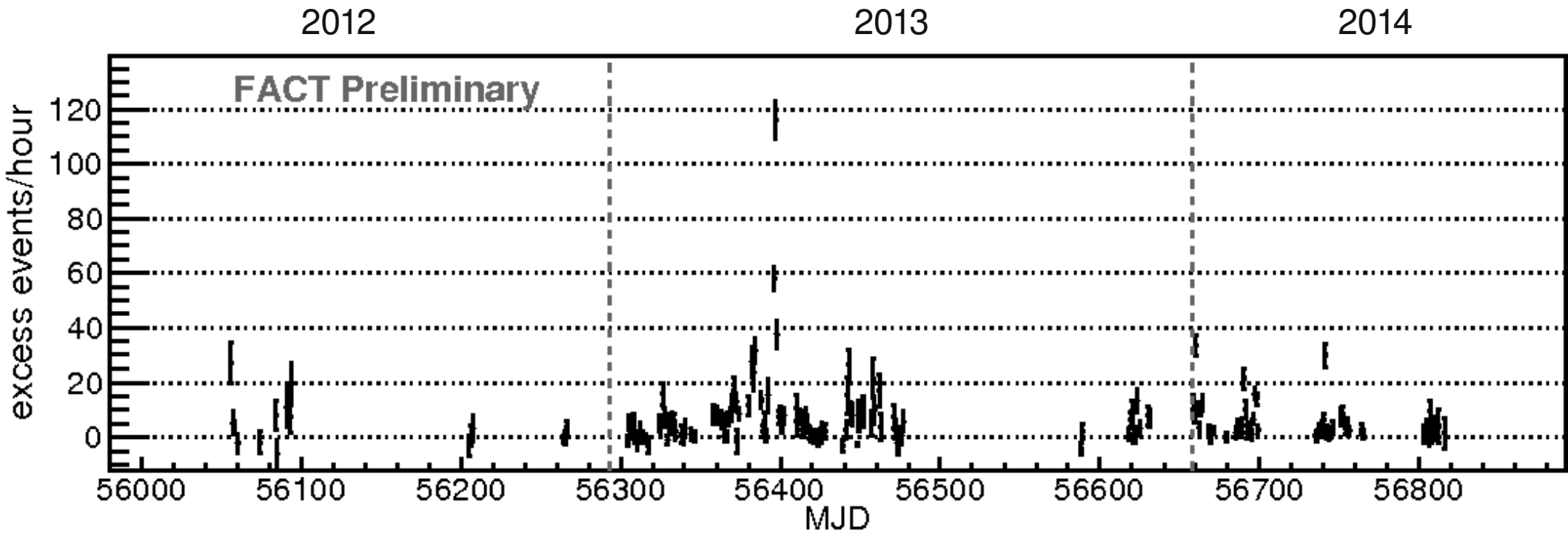
# IACT: Signal Detection



Angle between reconstructed shower origin and target position → Excess in signal region

# Excess Rate Curve Mrk421

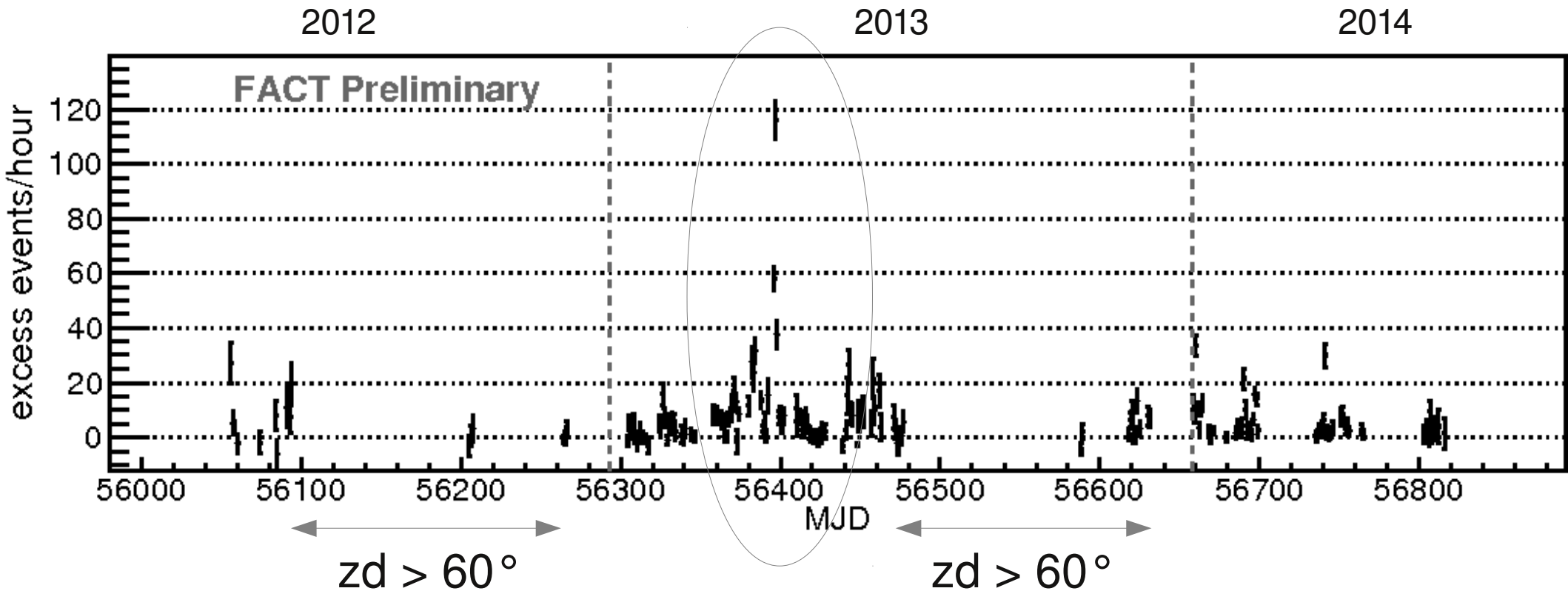
May 2012 – Now





# Excess Rate Curve Mrk421

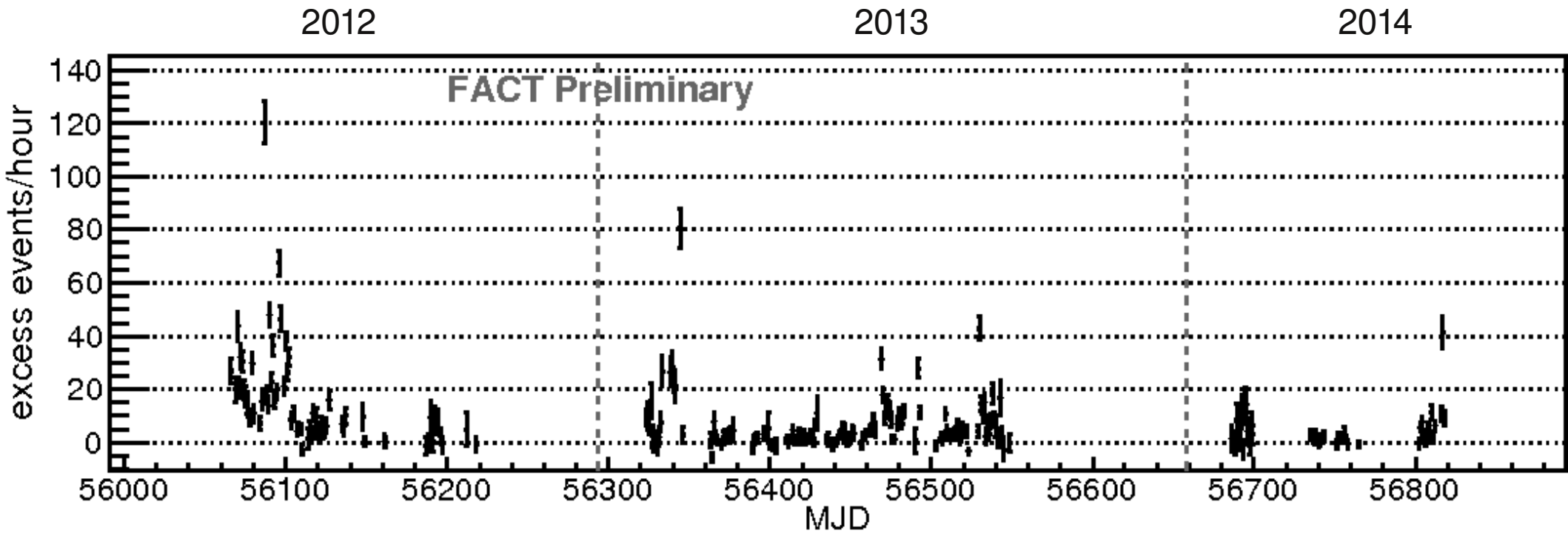
May 2012 – Now



Flare in April 2013

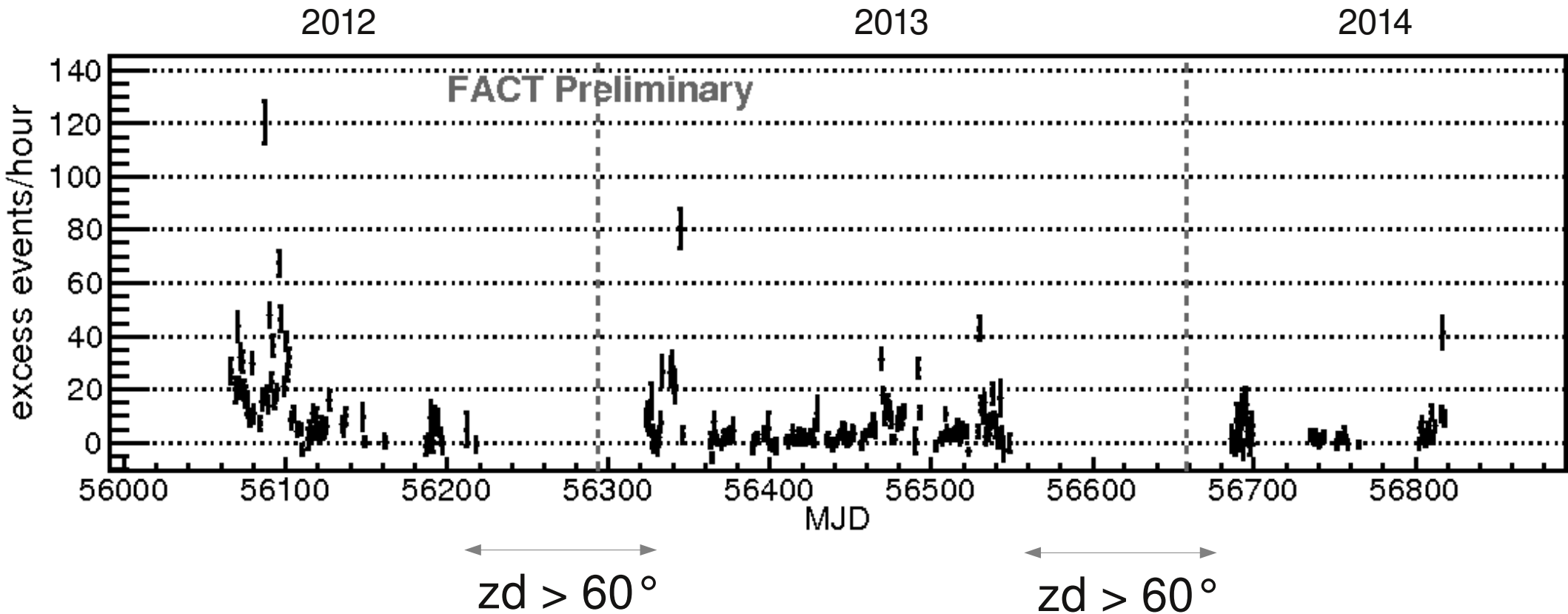
# Excess Rate Curve Mrk501

May 2012 – Now



# Excess Rate Curve Mrk501

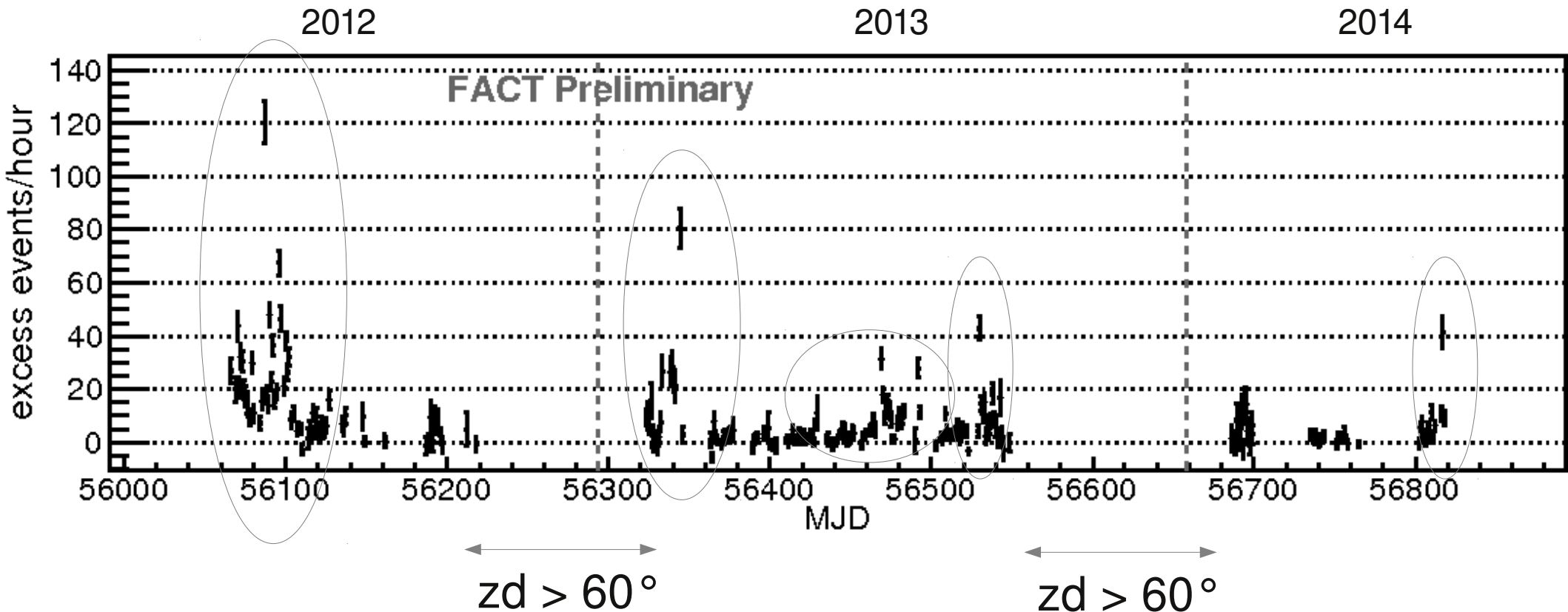
May 2012 – Now





# Excess Rate Curve Mrk501

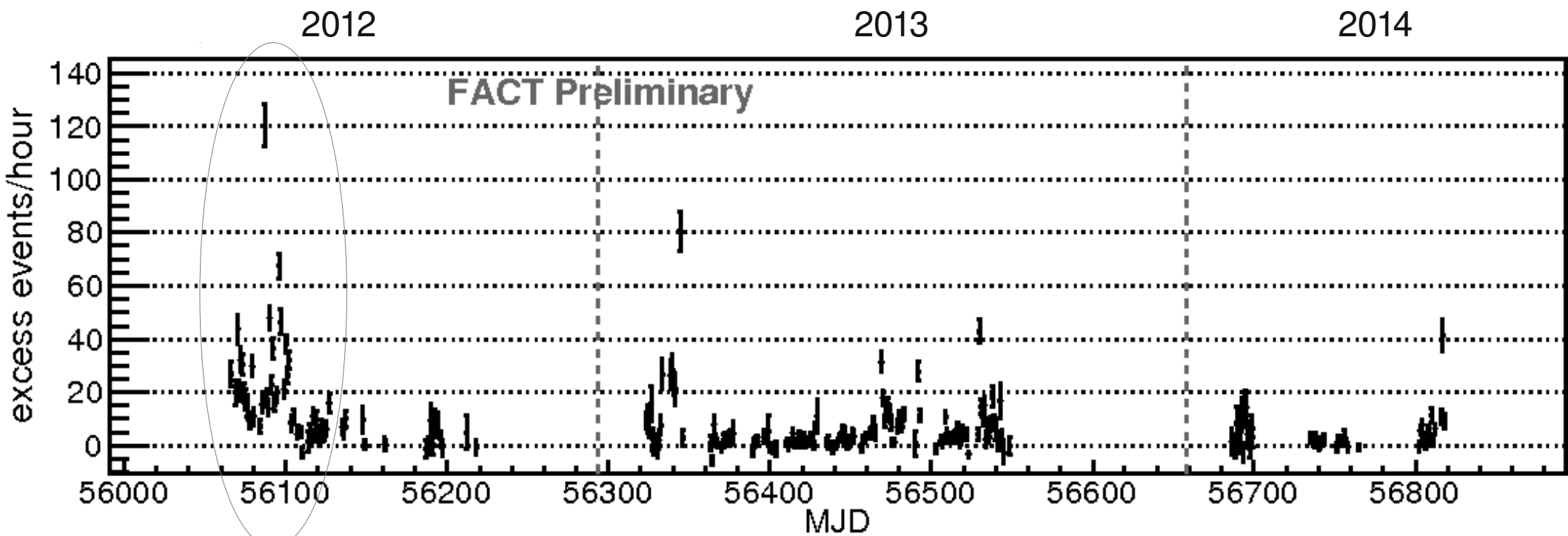
May 2012 – Now



Several flaring activities within 3 years

# Excess Rate Curve Mrk501

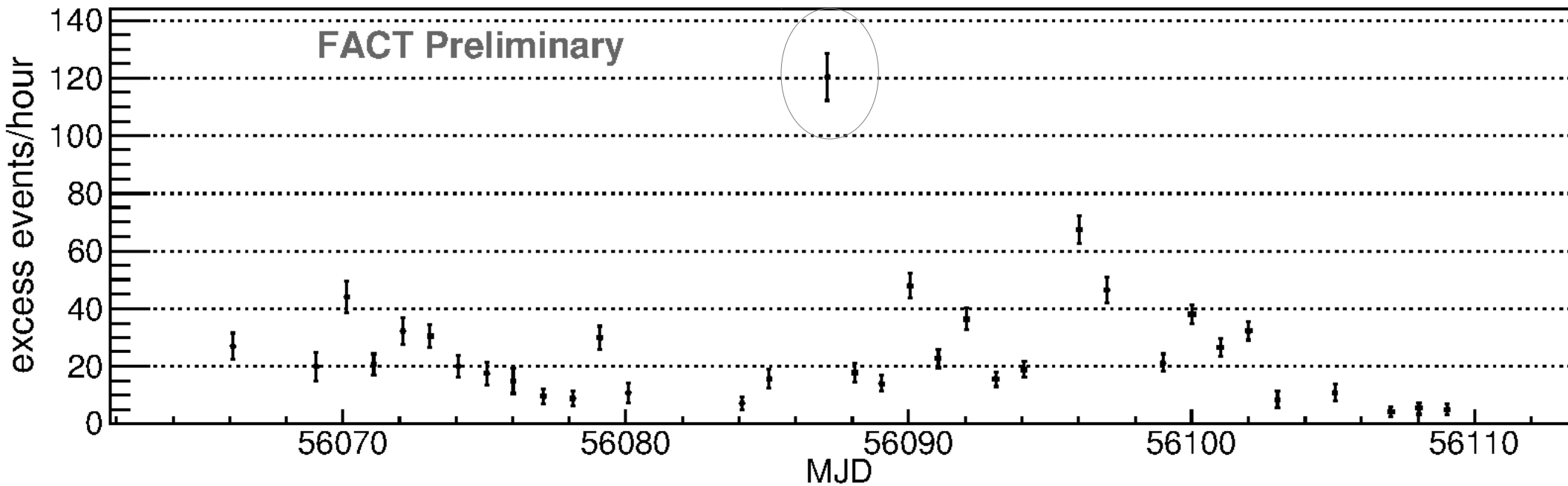
May 2012 – Now



Flare in  
June 2012

# Excess Rate Curve Mrk501

18.5.-30.6.2012

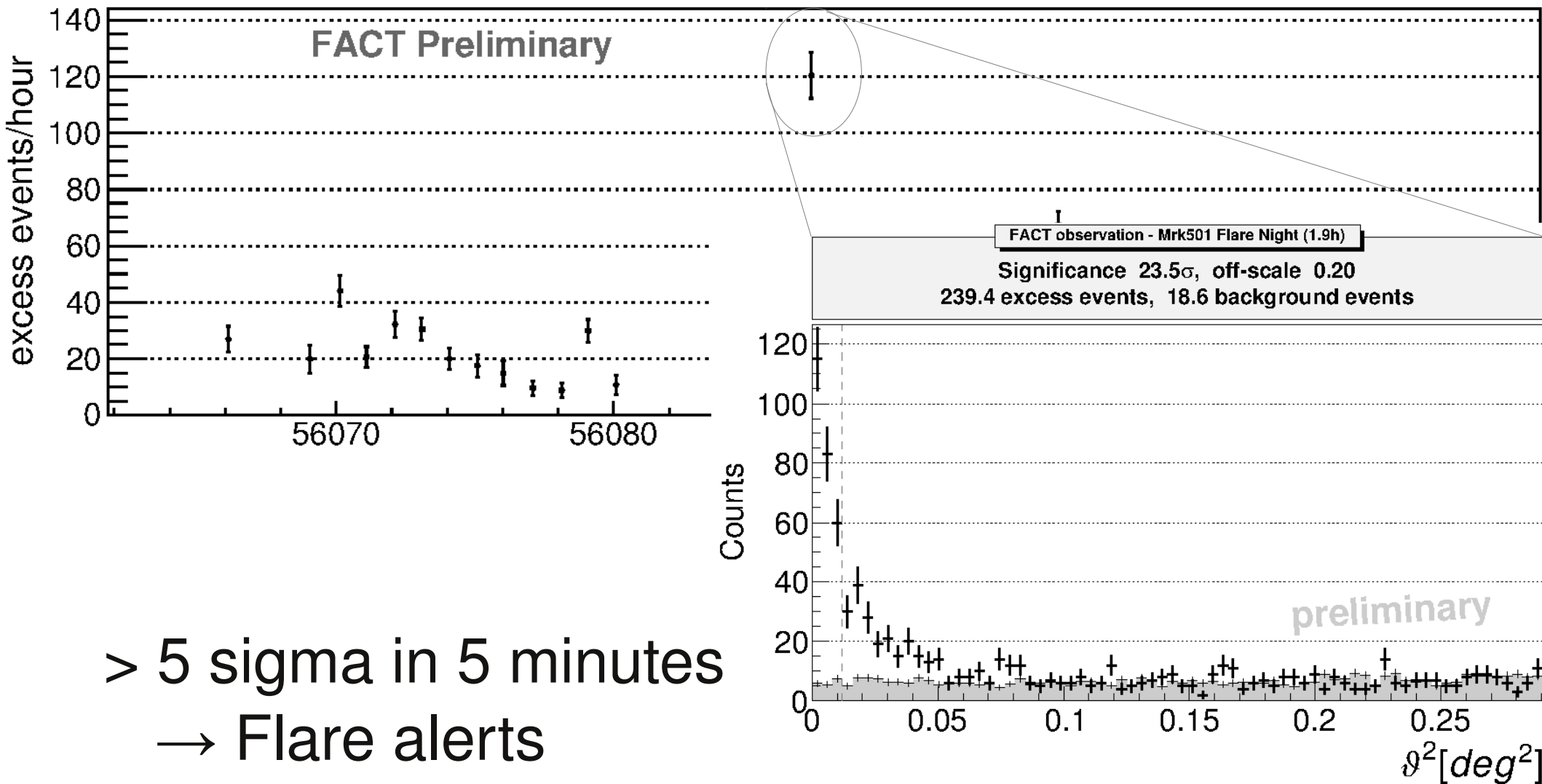


Increase in excess rate by factor 6  
> 5 sigma in 5 minutes



# Excess Rate Curve Mrk501

18.5.-30.6.2012



> 5 sigma in 5 minutes  
→ Flare alerts



# Quick Look Analysis: Flare Alerts

- Fast processing on site: Excess rate curves
- Results in almost real time
  - Flare alerts to other telescopes within the same night
- Not including:
  - Correction for dependence of threshold on zenith distance and ambient light
  - Detailed data check

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

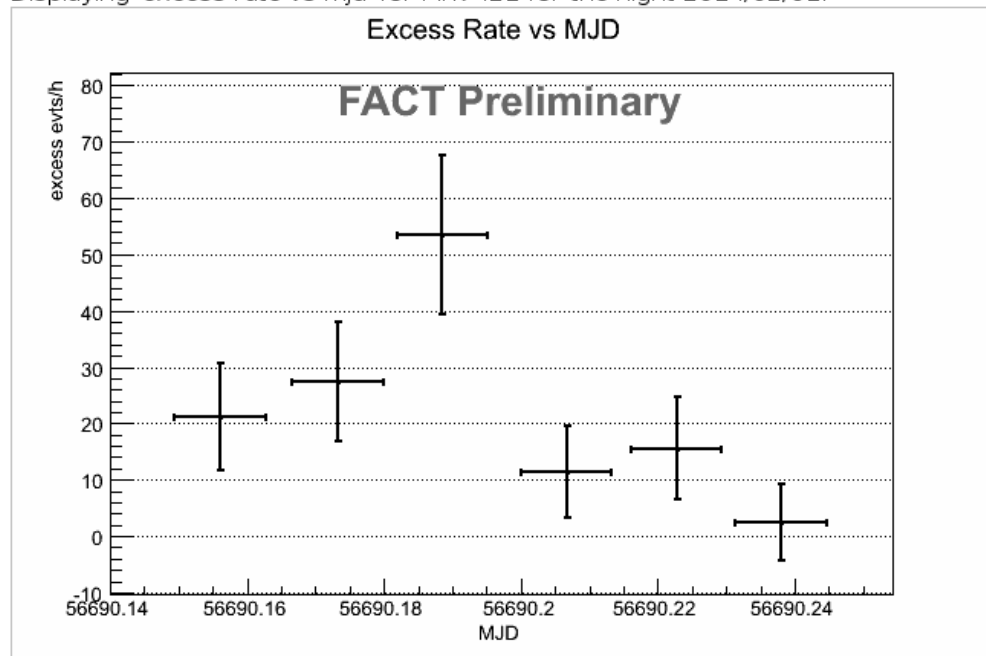


## FACT Quick Look Analysis

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

Select date    source   
Select time binning  and range

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



### REMARKS:

- These are the results of a **fast quick look analysis** on site, i.e. they are **preliminary**.
- The quick look analysis includes all data, i.e. no data selection done.
- The shown curves are not fluxes but **excess rates** (number of excess events per effective ontime), i.e. there is a dependence on trigger threshold and zenith distance of the observation (with the current analysis for zenith distance > 40 degree and trigger threshold > 500 DAC counts).
- The curves are provided with 20 min binning and nightly binning.
- In case, you need further details about the data or a different binning, please do not hesitate to contact us.
- Time range 'all' refers to all data since 12.12.2012. For older data, please contact us.

If you intend to use the data or information from this website, please let us know for reference.

**Please cite this webpage and the [FACT design paper](#) when using information from this webpage or any FACT data.**

Reference FACT Design Paper: H. Anderhub et al. JINST 8 P6008 [ADS open access](#)

Contact: Daniela Dorner [dorner@astro.uni-wuerzburg.de](mailto:dorner@astro.uni-wuerzburg.de).



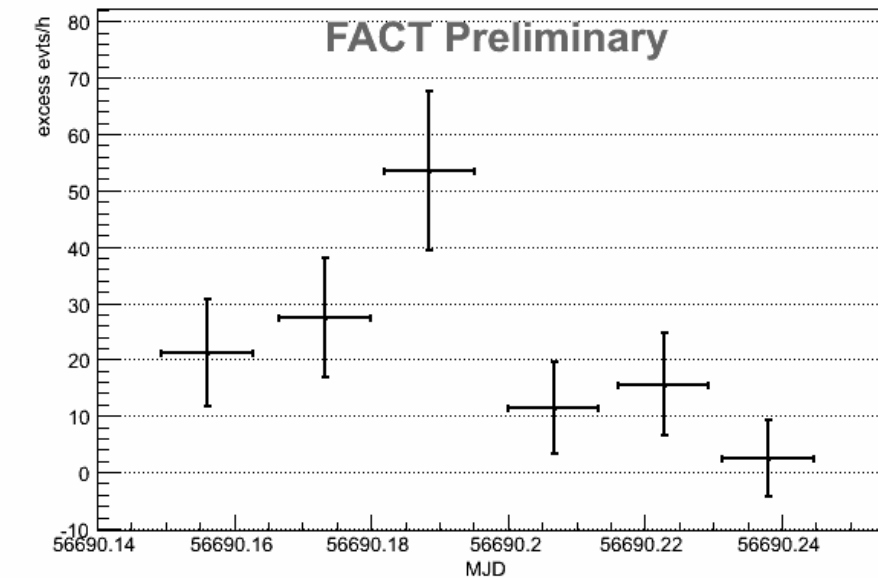
# FACT Quick Look Analysis

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

Select date    source   
 Select time binning  and range

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

Excess Rate vs MJD



Select

- date
- time range
- source
- binning

### REMARKS:

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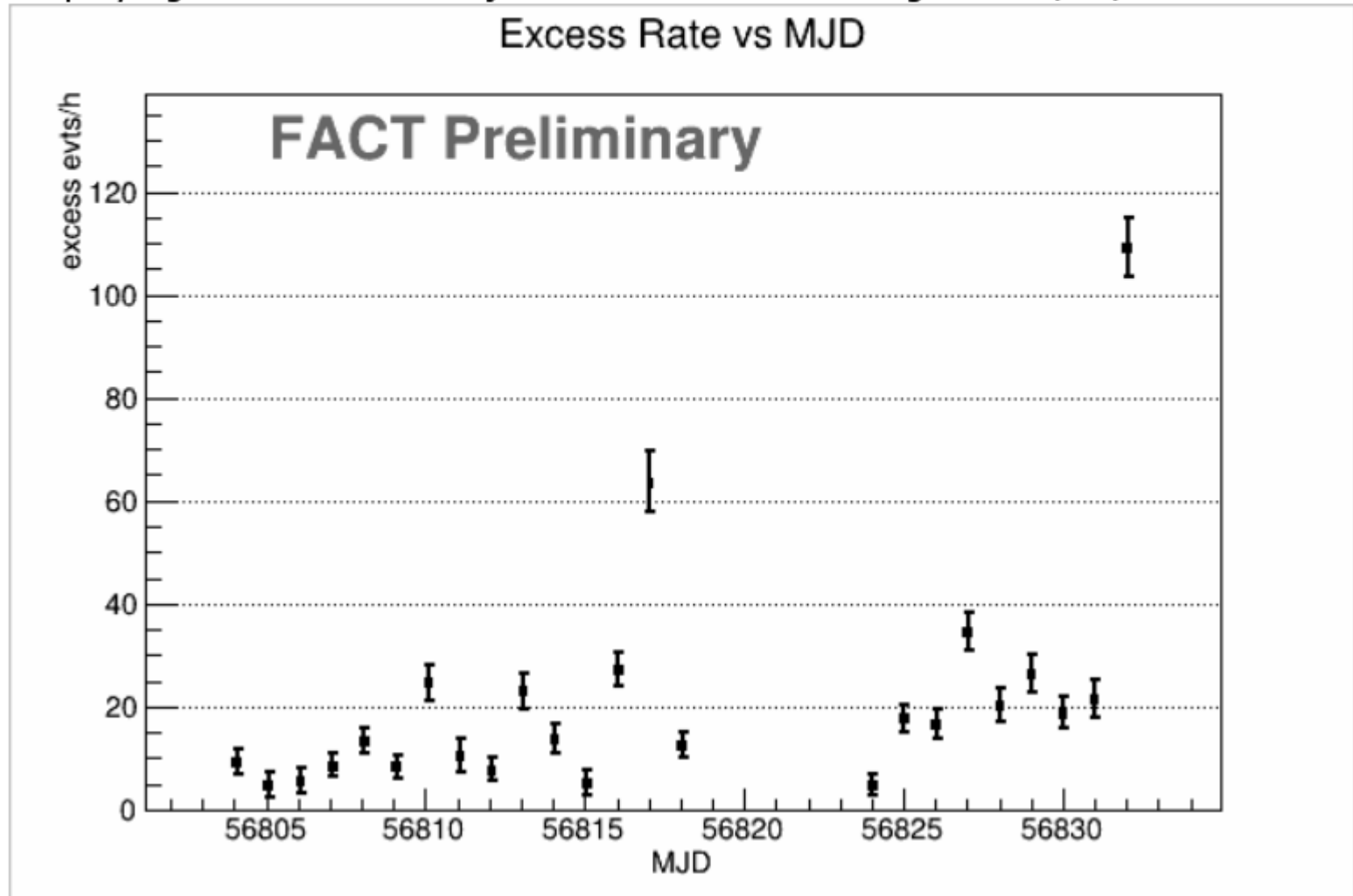
Contact: Daniela Dorner [dorner<at>astro.uni-wuerzburg.de](mailto:dorner@astro.uni-wuerzburg.de).

# Mrk501 – Flare Alerts in Summer 2014

## FACT Quick Look Analysis

Select date    source   
Select time binning  and range

Displaying 'excess rate vs mjd' for Mrk 501 for the night 2014/06/23.

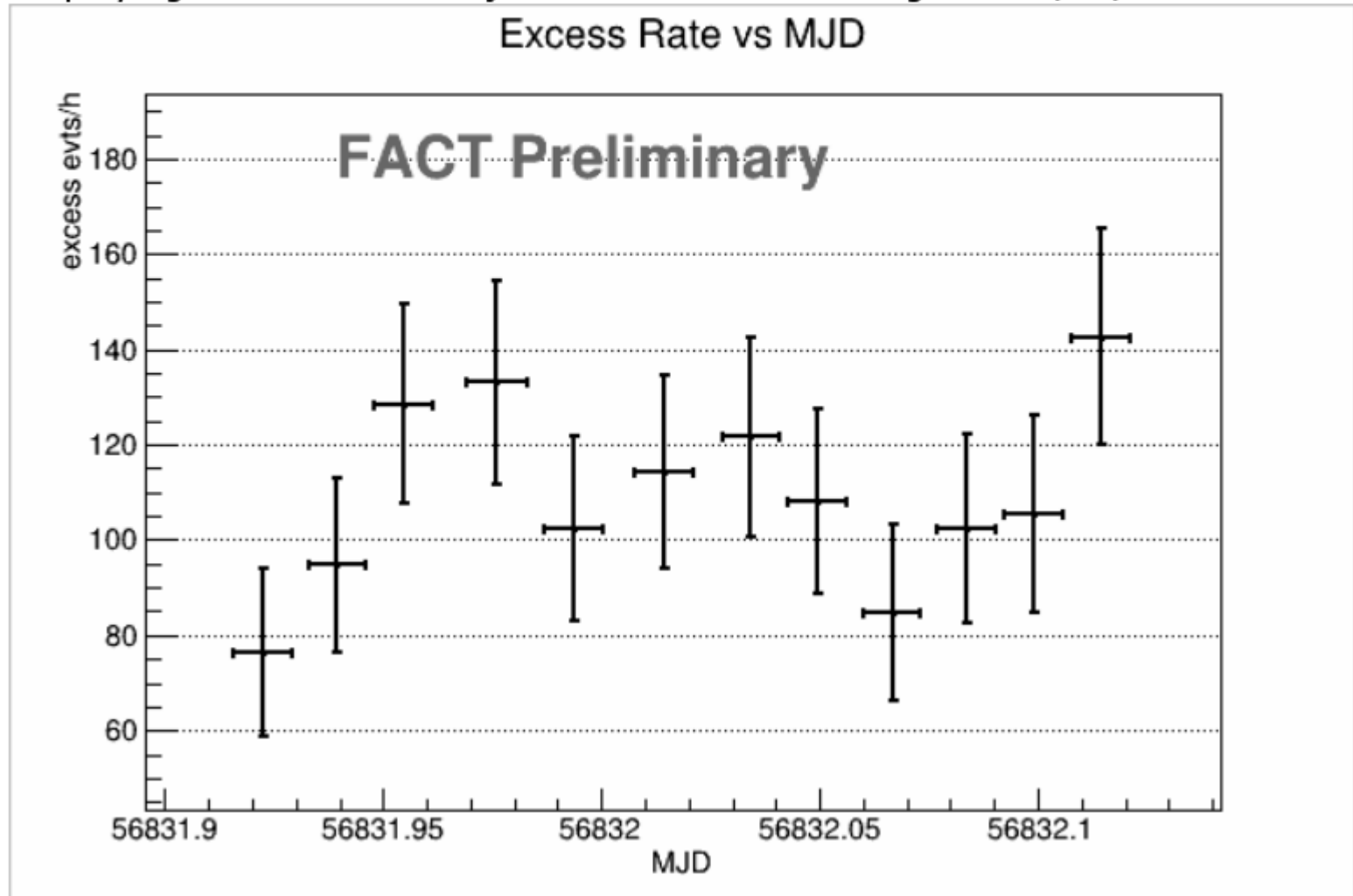


# Mrk501 – Flare Alerts in Summer 2014

## FACT Quick Look Analysis

Select date    source   
Select time binning  and range

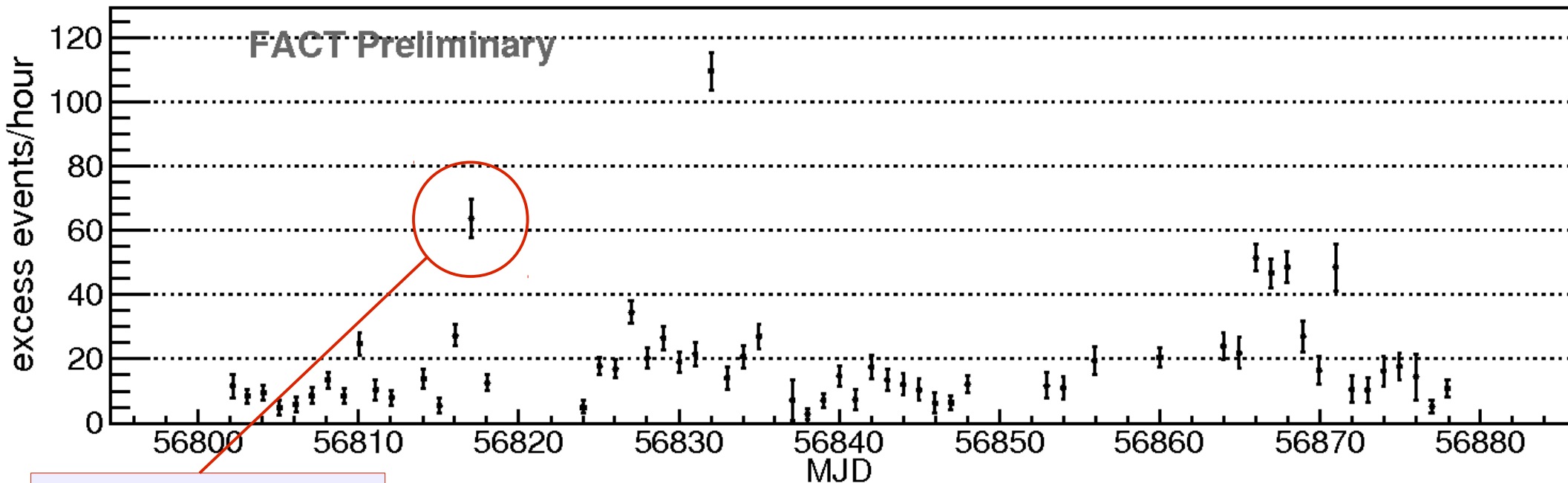
Displaying 'excess rate vs mjd' for Mrk 501 for the night 2014/06/23.





# Mrk501 – Flare Alerts

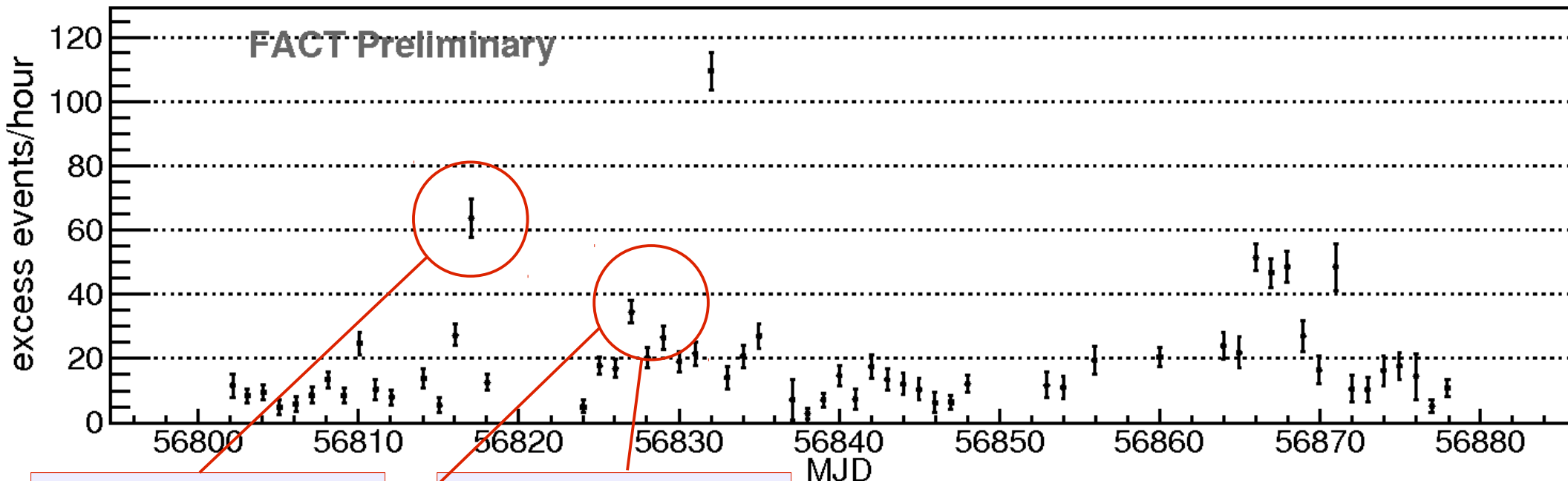
Excess rate curve from QLA: 1.6.-10.8.2014



**Flare Alert**  
**8./9. Jun 2014**

# Mrk501 – Flare Alerts

Excess rate curve from QLA: 1.6.-10.8.2014



Flare Alert  
8./9. Jun 2014

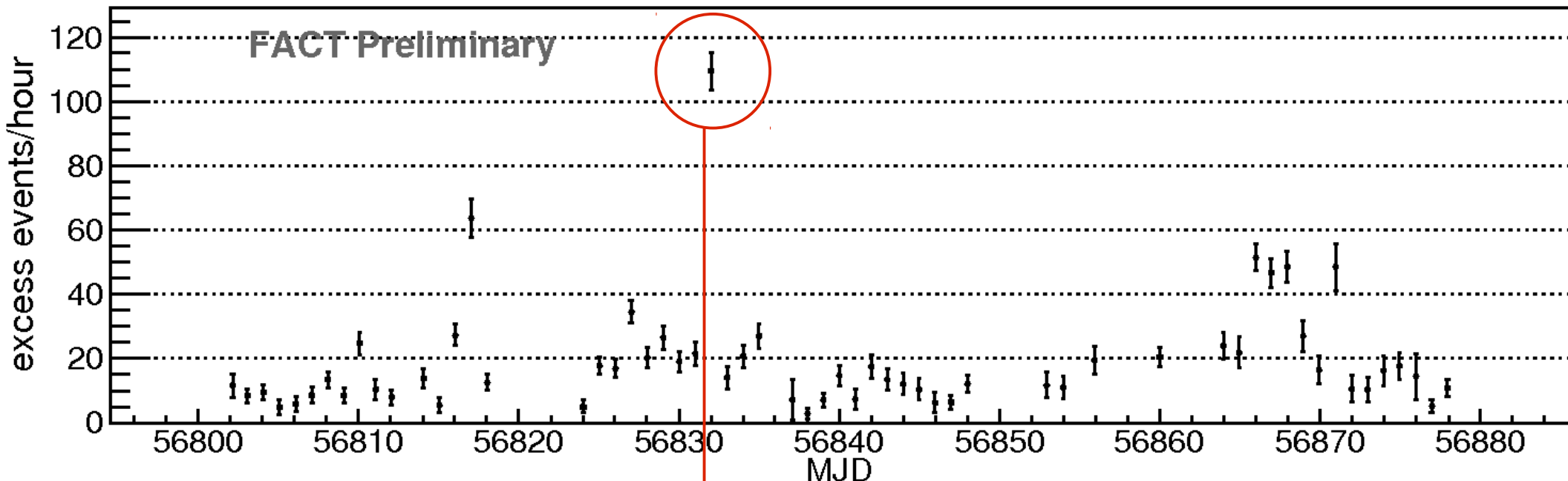
Flare Alert  
20./21. Jun 2014

Flare Alert  
18./19. Jun 2014

→ Observations  
with other instruments

# Mrk501 – Flare Alerts

Excess rate curve from QLA: 1.6.-10.8.2014

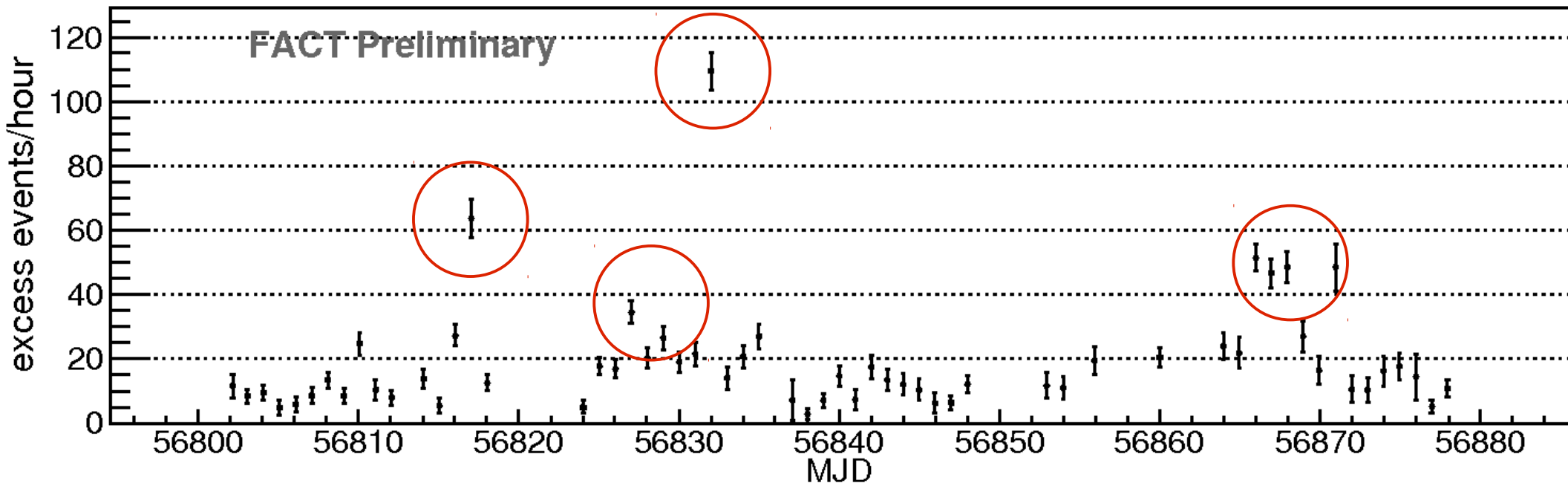


**Flare Alert**  
**23./24. Jun 2014**

→ Atel #6268

# Mrk501 – Flare Alerts

Excess rate curve from QLA: 1.6.-10.8.2014



Several Flare Alerts  
in Summer 2014



# Summary and Outlook

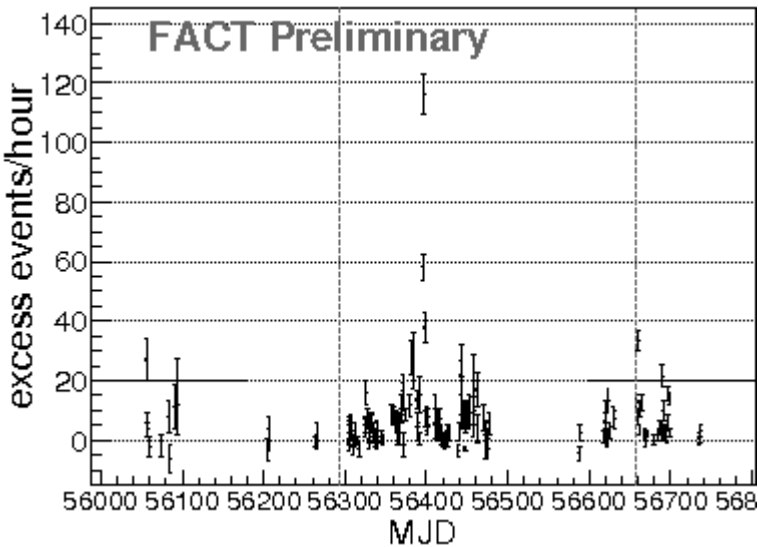
- First G-APD Cherenkov Telescope
  - Stable Performance → Remote and automatic operation
  - No aging → Observations during strong moon light
- Longterm monitoring of bright TeV blazars
  - Quick Look Analysis → Several flare alerts for Mrk501 (summer 2014)
  - Several flaring activities → MWL studies
  - Total observation time: > 3500 h (> 1600 h in 2013)
  - Complete data sample for variability studies, e.g. > 1000h for Mrk501
- Work in progress / Next steps:
  - Spectra and fluxes
  - Robotic operation
  - More telescopes around the globe

Interested in our data  
or in flare alerts?  
→ contact me

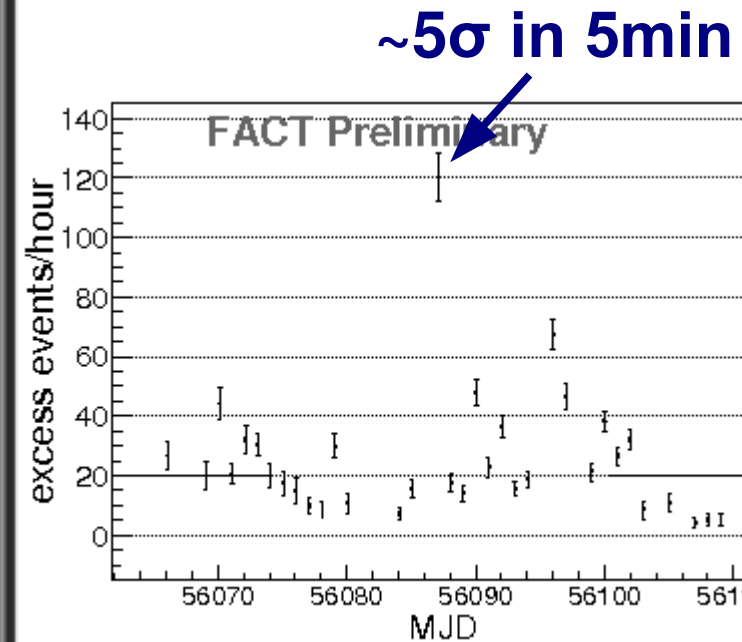
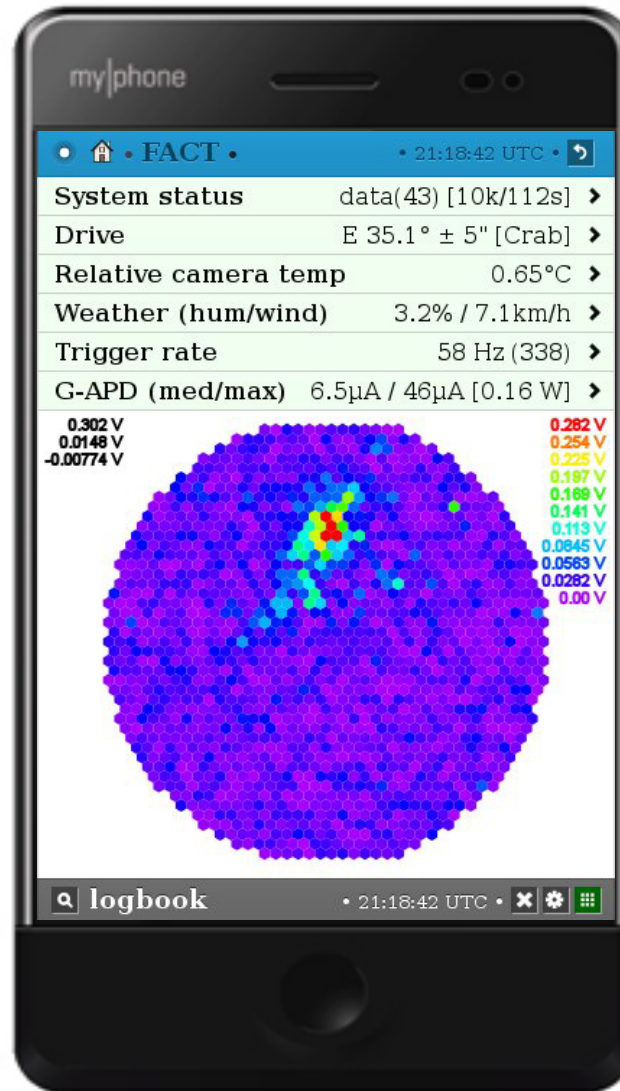


Check out our monitoring results!

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



3 years monitoring



[ JINST 8(2013) P06008 ]  
arXiv:1403.5747