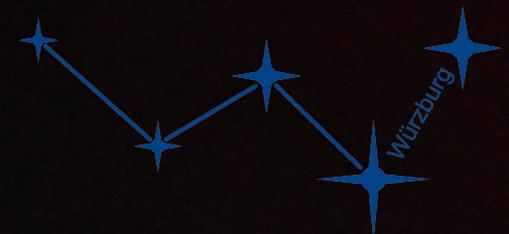


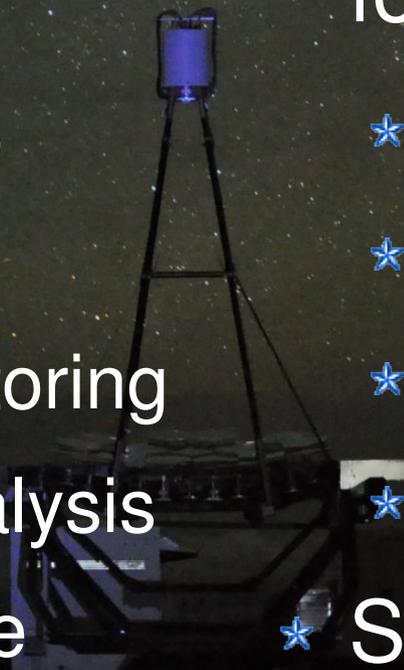
First G-APD Cherenkov Telescope (FACT)



Daniela Dorner for the FACT Collaboration



Outline

- * Reminder:
What is FACT?
 - * What can we do with FACT?
 - * Longterm Monitoring
 - * Quick Look Analysis
 - * Sensitivity of the Instrument
 - * What can FACT offer for AMON?
 - * Observing strategy
 - * Real-time capabilities
 - * Sending alerts
 - * Receiving alerts
 - * Status in AMON
- 

First G-APD Cherenkov Telescope

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

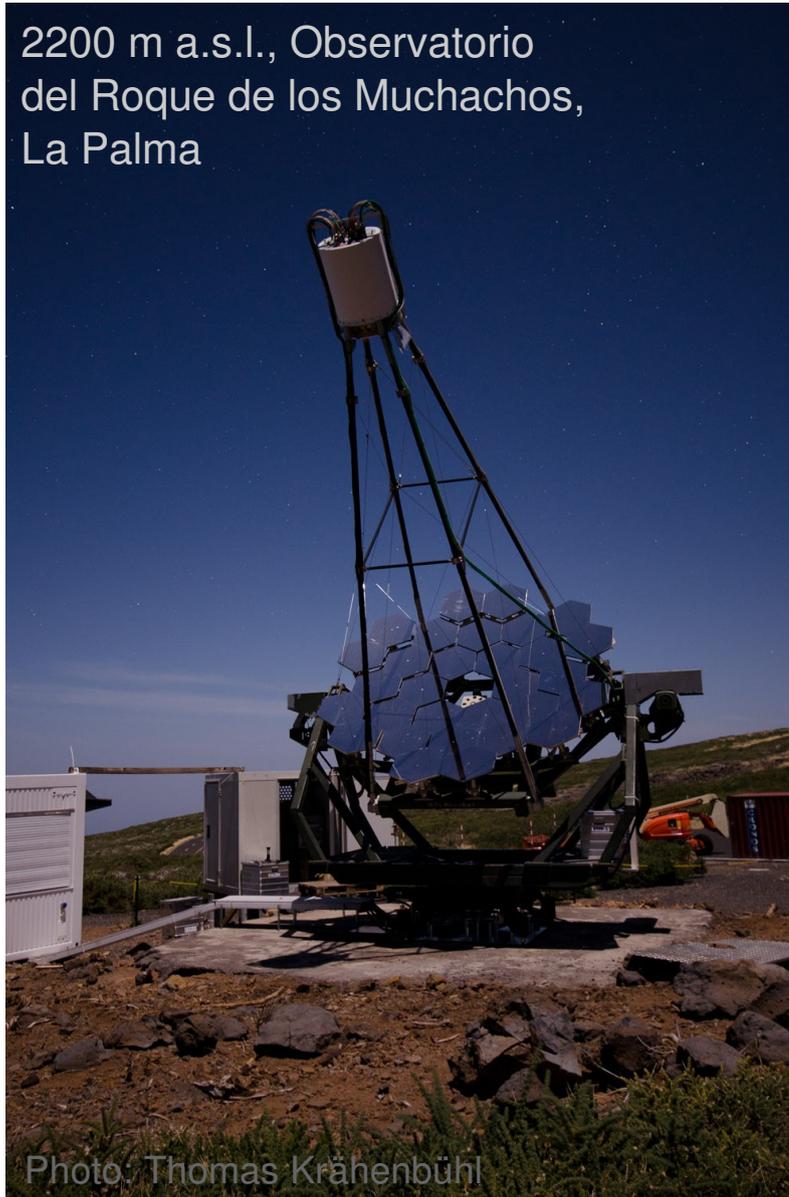
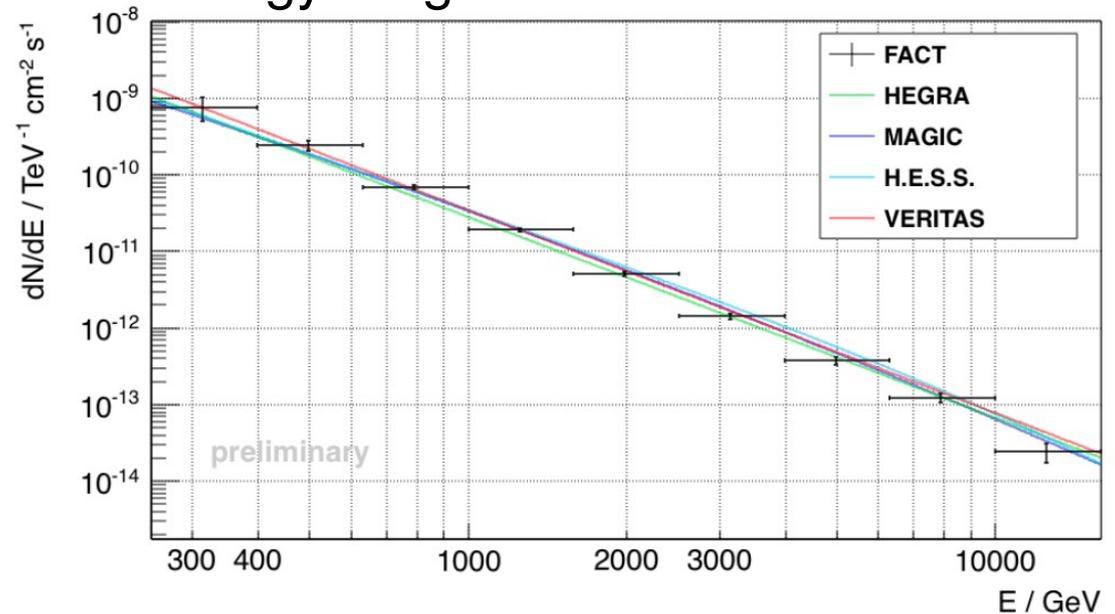


Photo: Thomas Krähenbühl

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



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

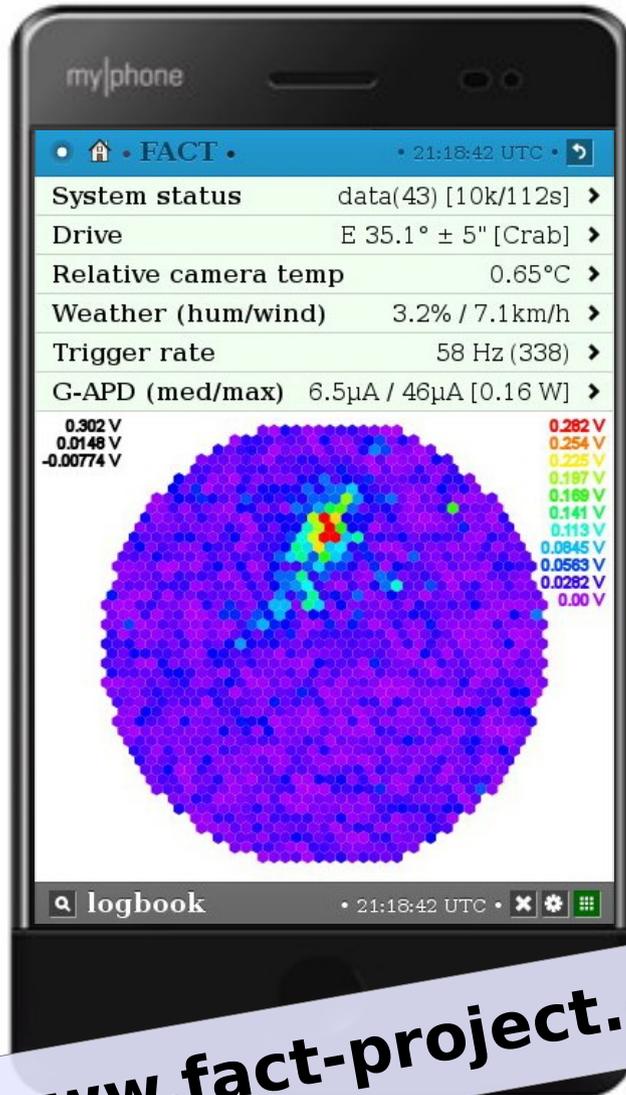
- More information

H Anderhub et al 2013 JINST 8 P06008

A Biland et al 2014 JINST 9 P10012



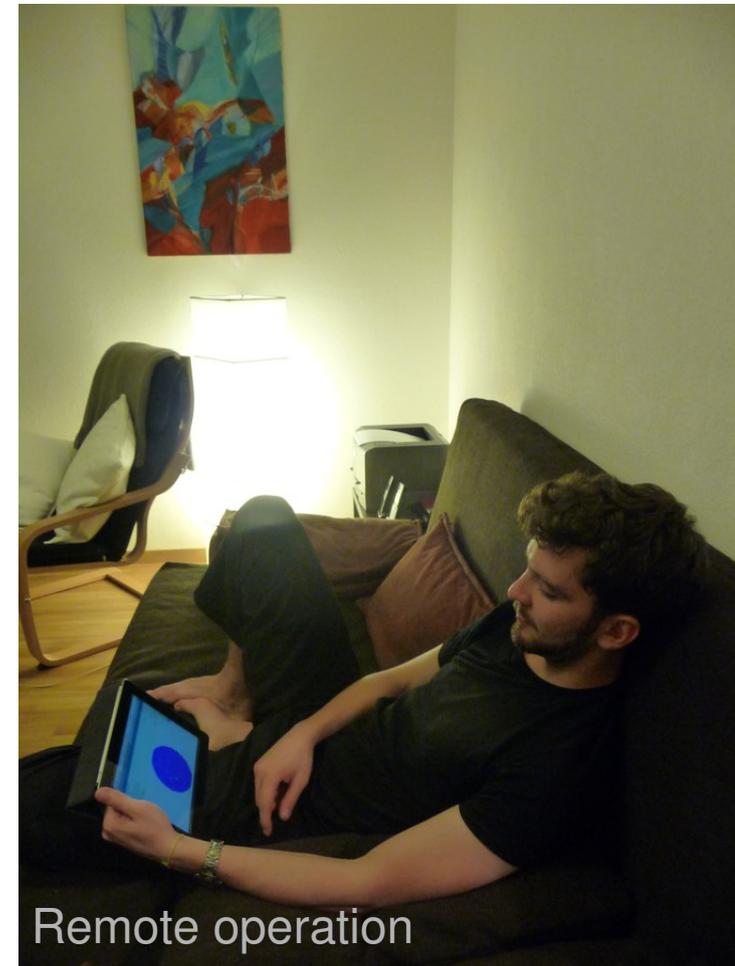
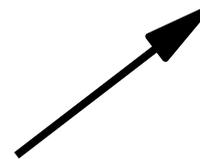
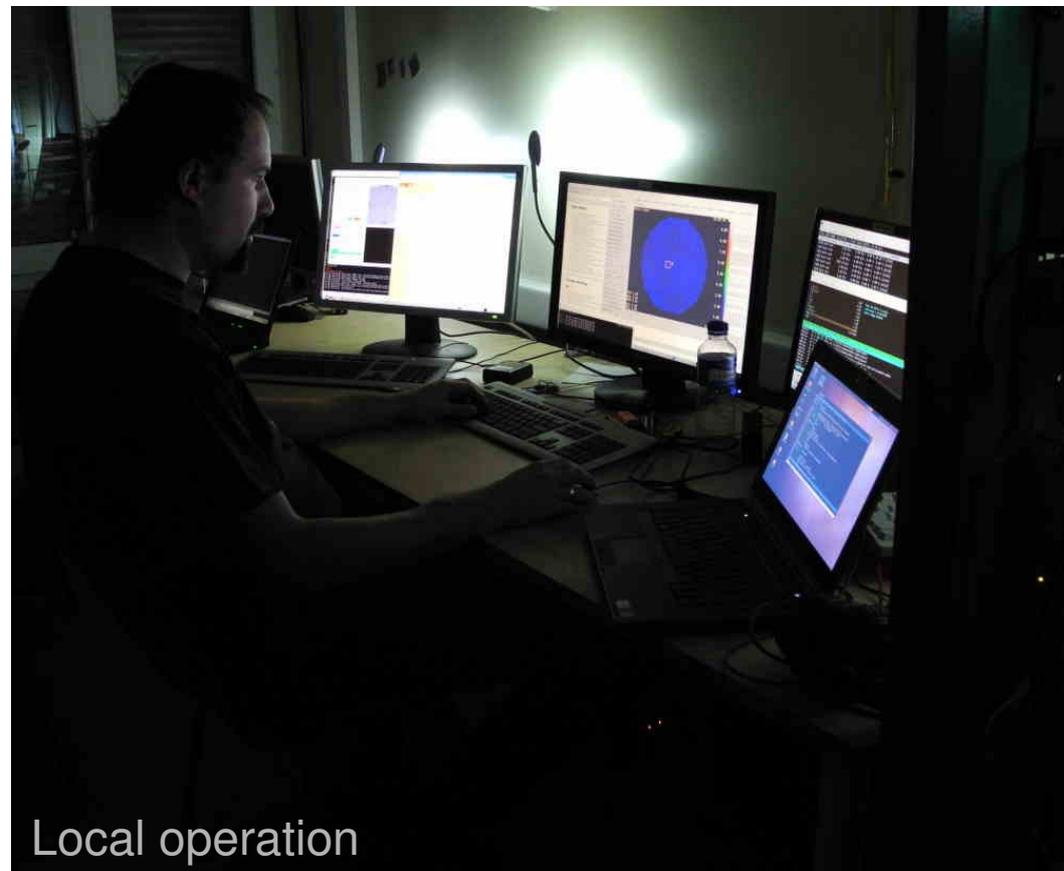
FACT – Ideal Monitoring Telescope



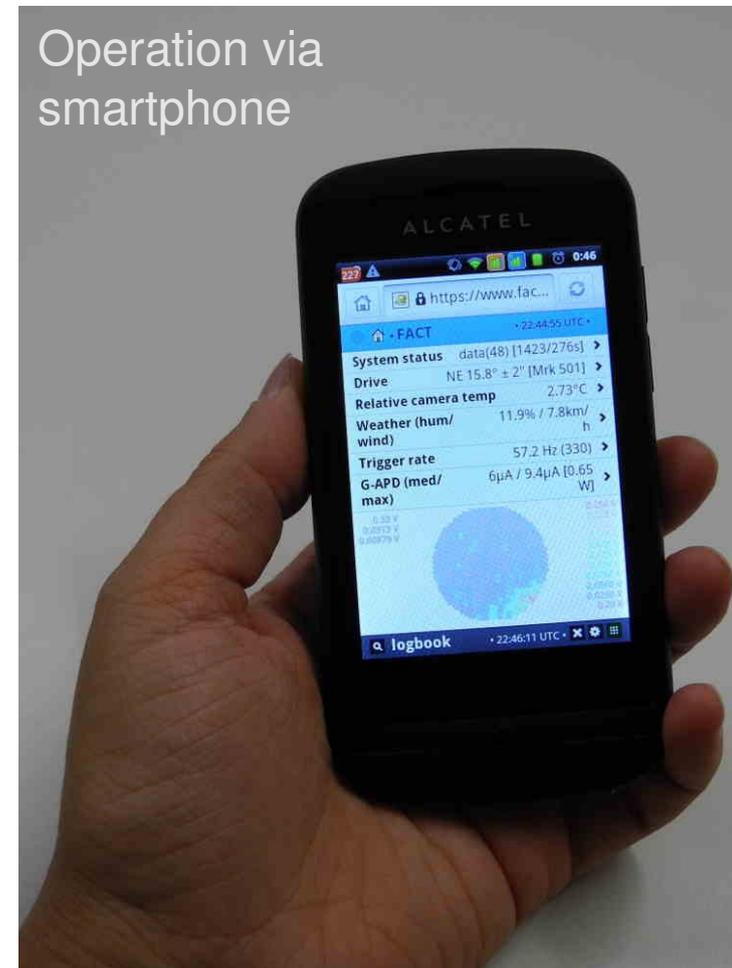
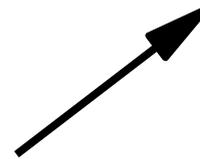
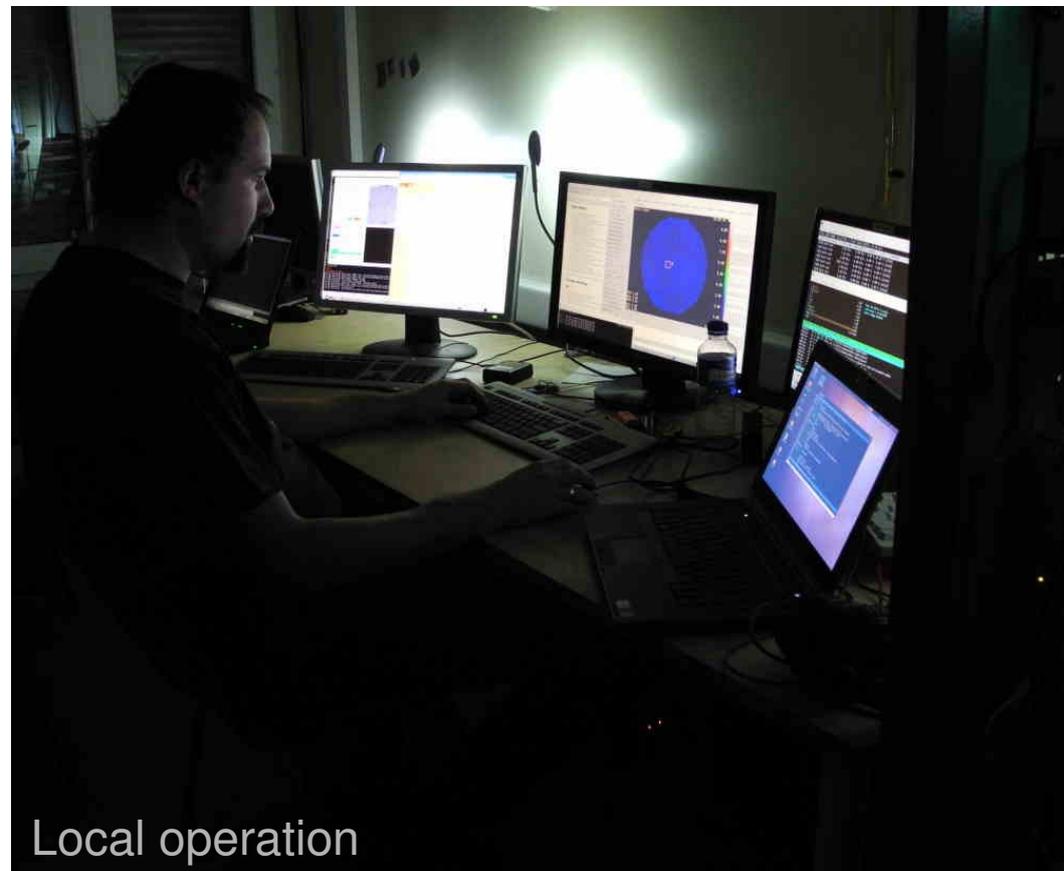
- SiPMs robust and stable
→ Stable telescope performance
→ Remote and automatic operation

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

Towards Robotic Operation



Towards Robotic Operation



Automatic Operation

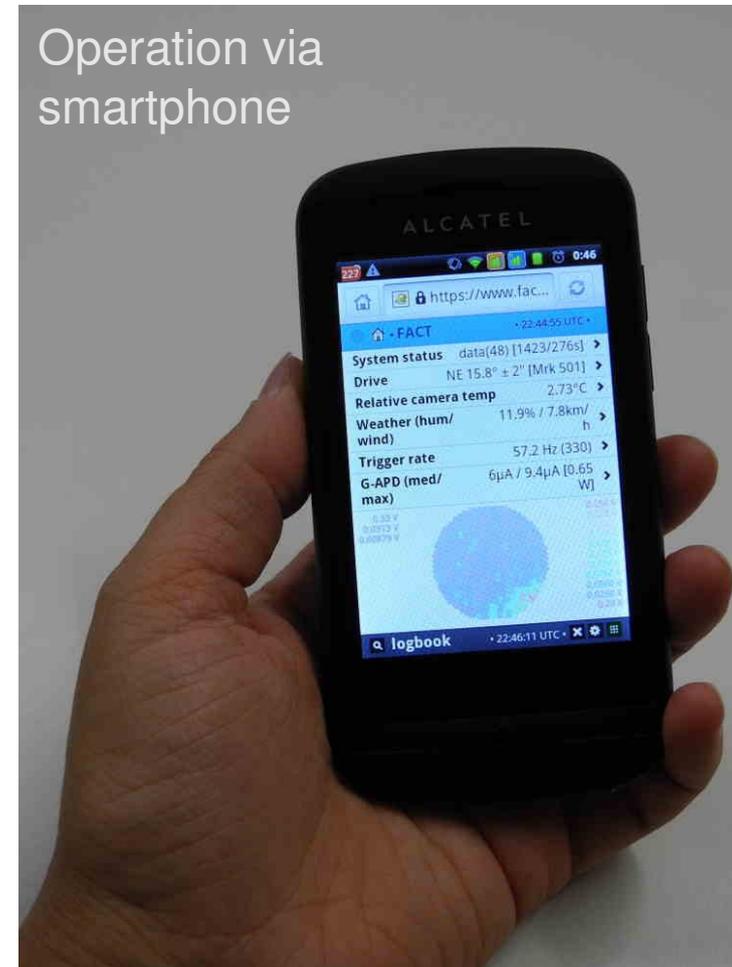


Towards Robotic Operation

Next Step:
Shifter-on-Call



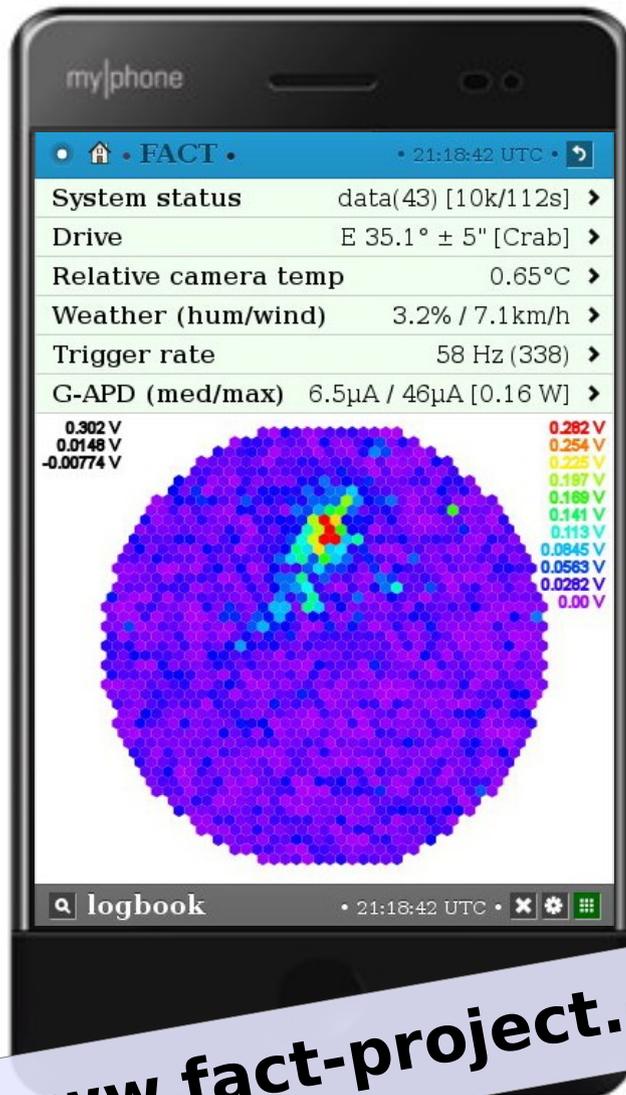
Operation via
smartphone



Automatic Operation



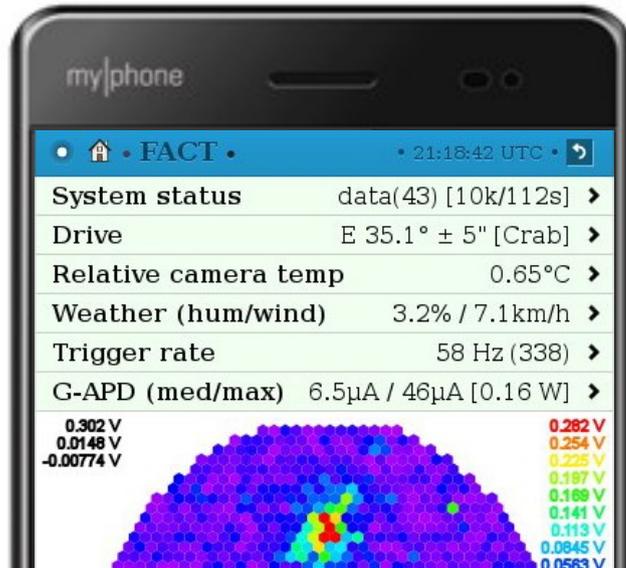
FACT – Ideal Monitoring Telescope



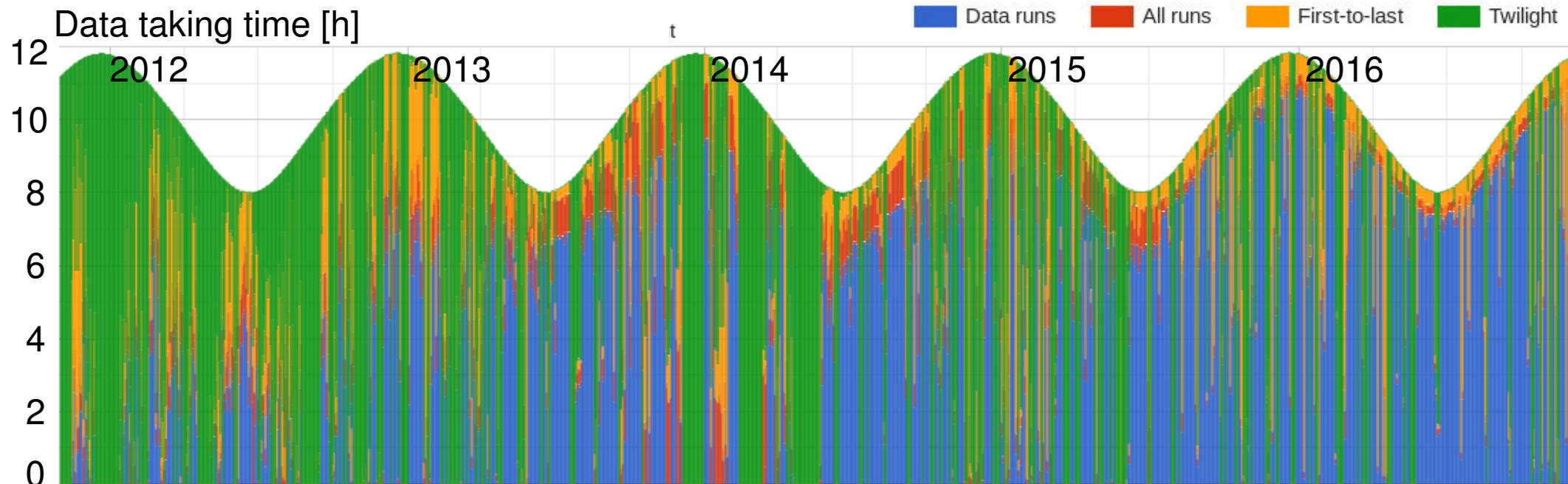
- SiPMs robust and stable
 - Stable telescope performance
 - Remote and automatic operation
 - High data taking efficiency

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

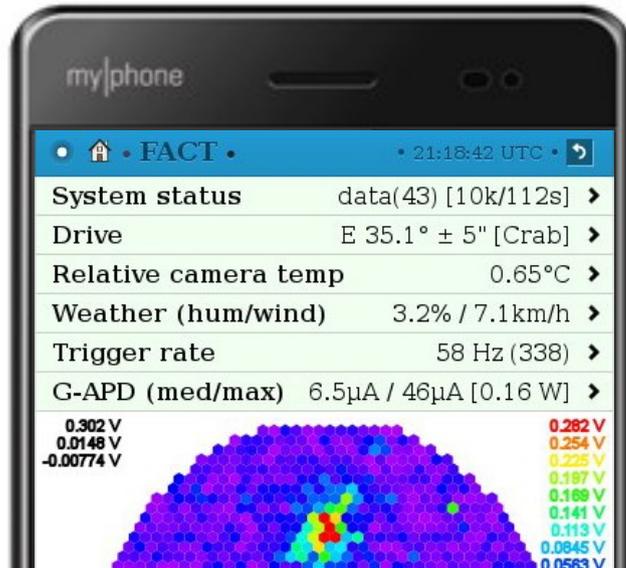
FACT – Ideal Monitoring Telescope



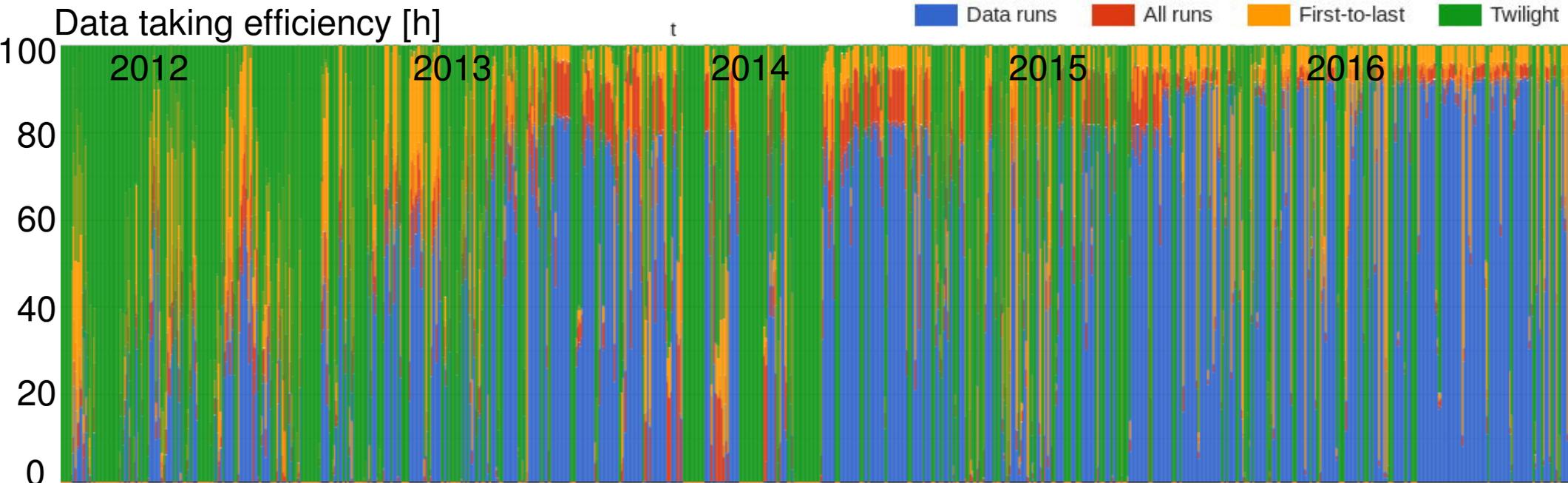
- SiPMs robust and stable
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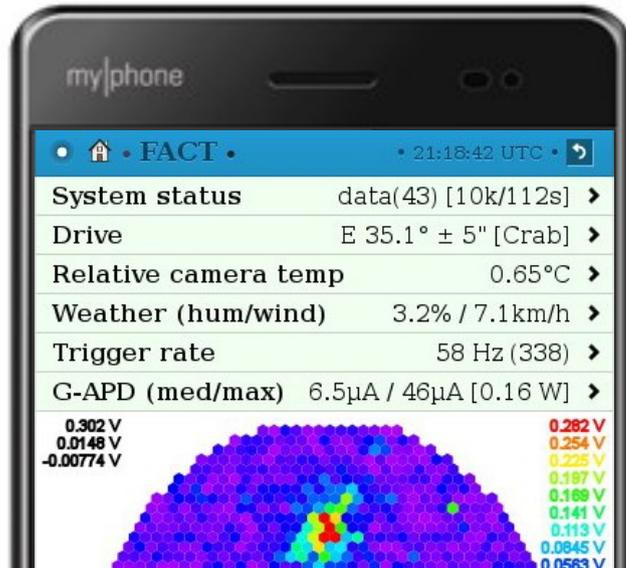
FACT – Ideal Monitoring Telescope



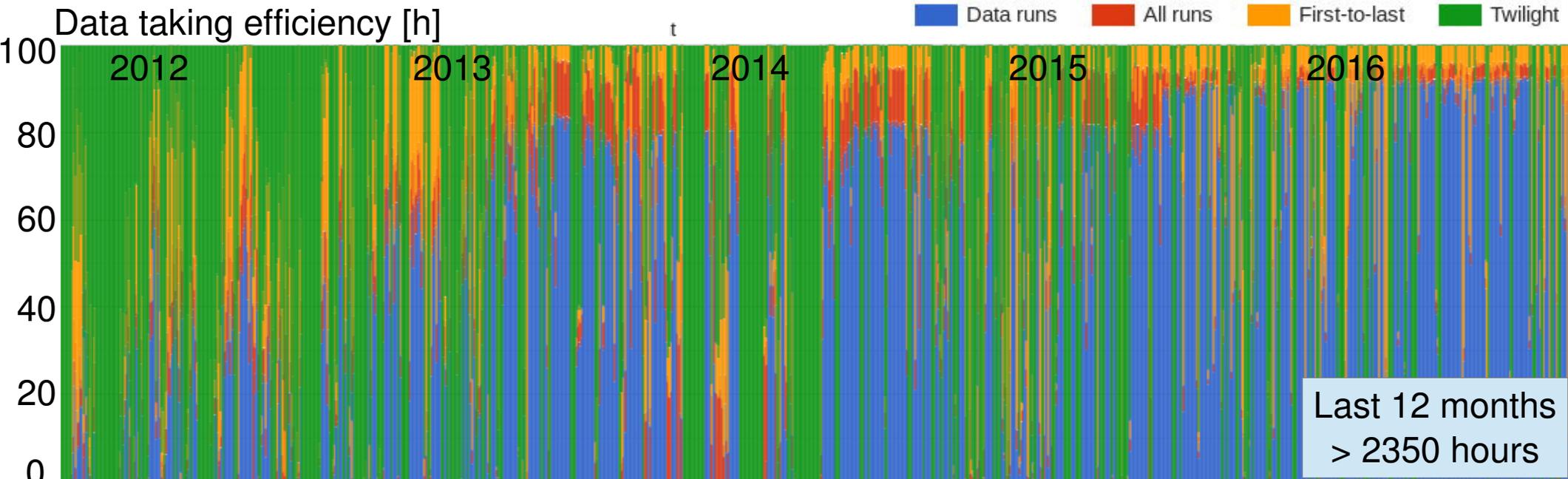
- SiPMs robust and stable
 - Stable telescope performance
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FACT – Ideal Monitoring Telescope



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

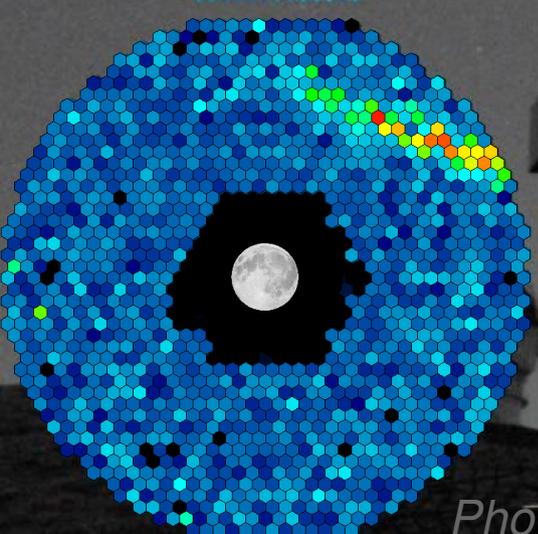
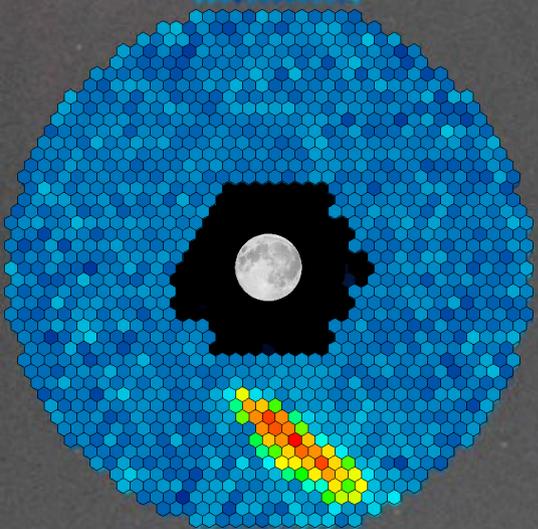
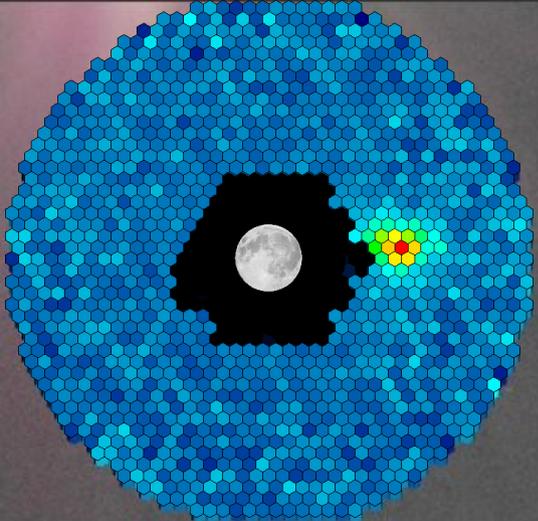


FACT – Ideal Monitoring Telescope



- 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

Photo: Daniela Dorner



Showers images recorded pointing to brightest full moon in 2013.

Photos: D. Dorner, T. Krähenbühl

FACT – Ideal Monitoring Telescope

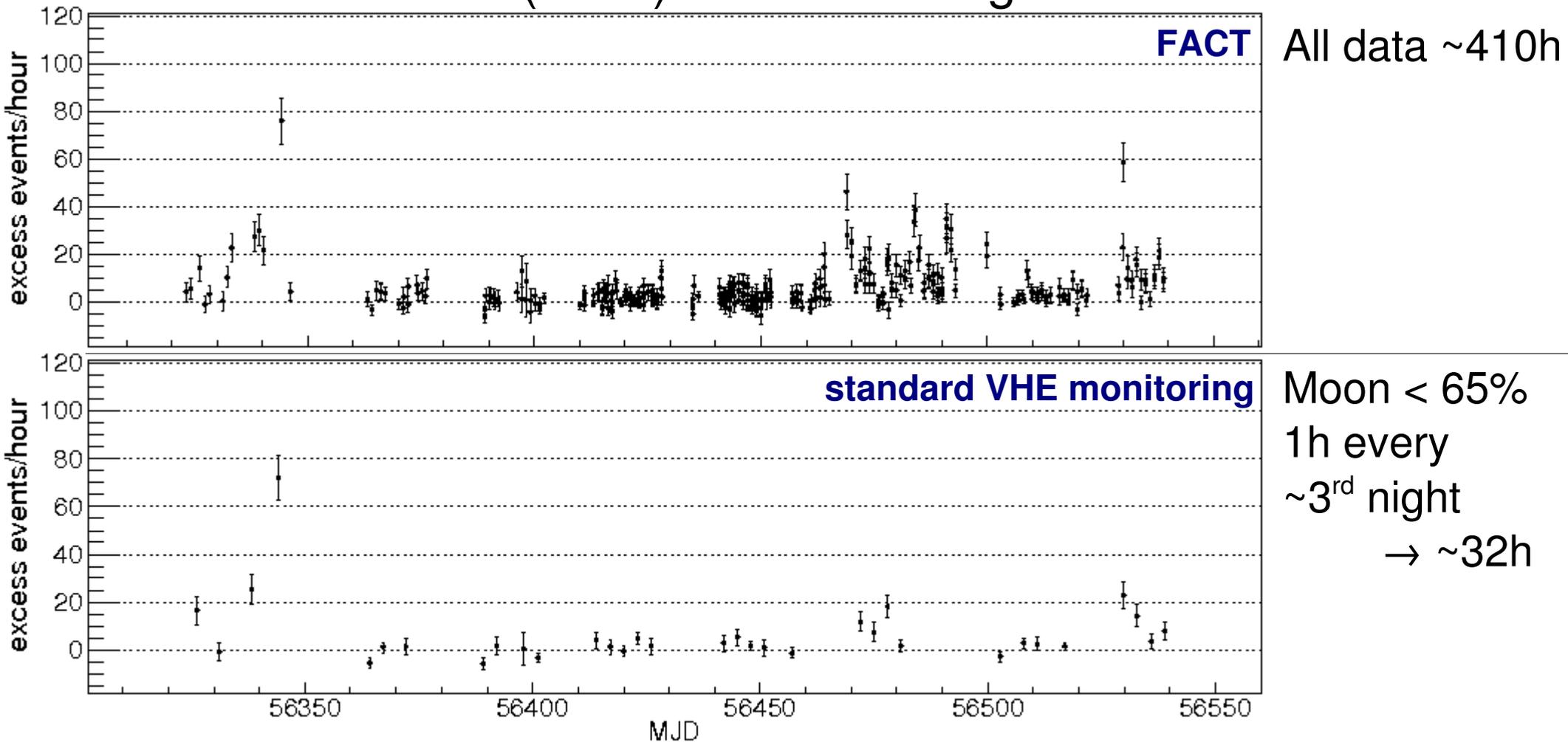


- SiPMs robust and stable
 - Stable telescope performance
 - Remote and automatic operation
 - High data taking efficiency
- Gain of SiPMs does not degrade when exposed to bright light
 - Observations during strong moon light possible
 - Larger duty cycle
 - More complete data sample

Photo: Daniela Dorner

Long-term Monitoring at VHE

Mrk 501 (2013) 1-hour-binning

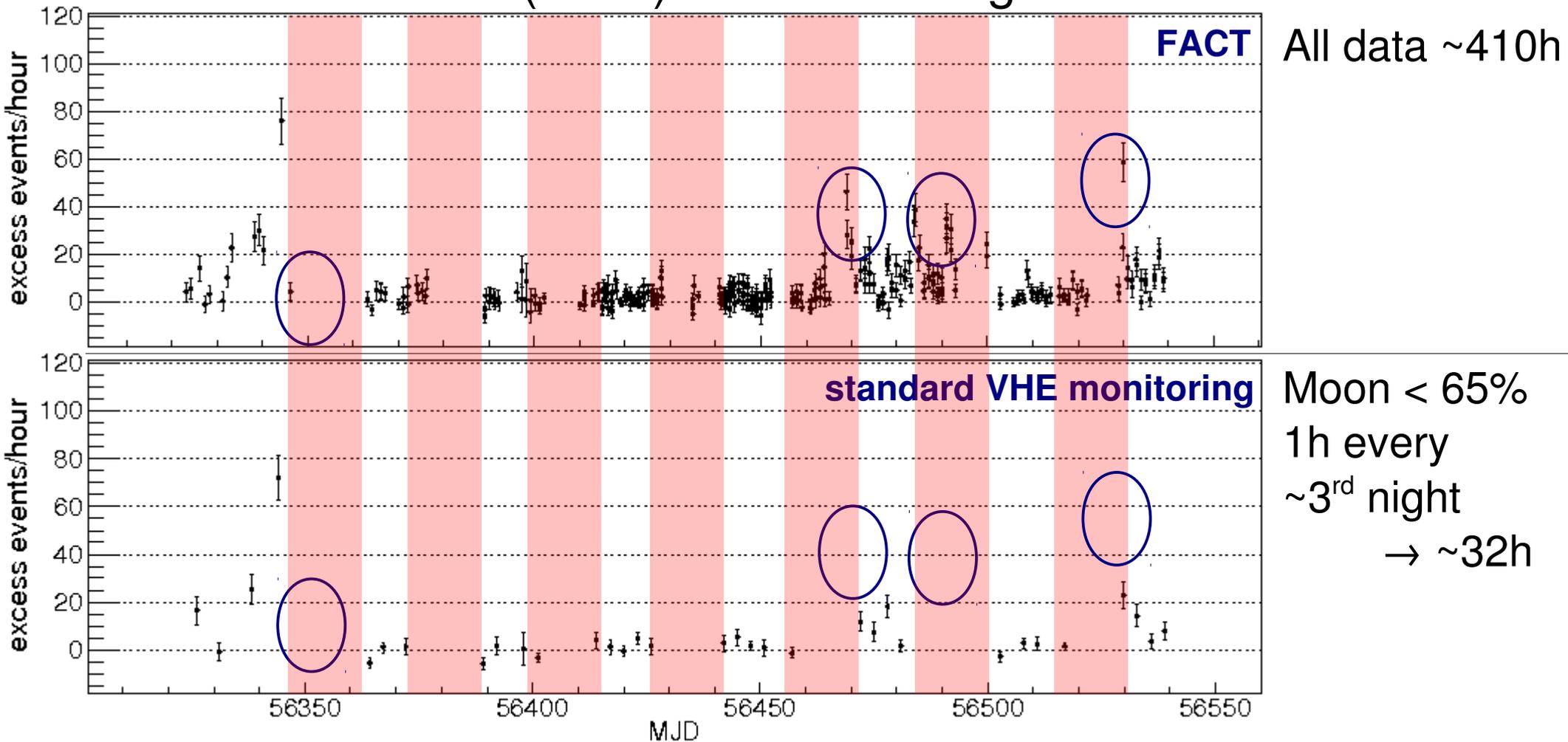


Dorner et al. (FACT Collaboration), Proceedings of 34th ICRC



Long-term Monitoring at VHE

Mrk 501 (2013) 1-hour-binning



FACT monitoring strategy → Unbiased data sample

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

What can FACT offer in AMON?

- Receiving alerts:
 - Anytime
 - Observations carried out on best effort
 - FACT follow-up not needed, if other, more sensitive VHE instrument does follow-up



What can FACT offer in AMON?

- Receiving alerts:
 - Anytime
 - Observations carried out on best effort
 - FACT follow-up not needed, if other, more sensitive VHE instrument does follow-up

2016: 4 follow-up
3 times data, 1 bad weather
2 gcn circulars



What can FACT offer in AMON?

- Receiving alerts:
 - Anytime
 - Observations carried out on best effort
 - FACT follow-up not needed, if other, more sensitive VHE instrument does follow-up
- Sending alerts:
 - Anytime for our source sample
 - Trigger criteria need to be defined
 - Significant detection within 20 minutes for flux > 1 Crab Unit (current analysis, small zenith distance, dark night)



What can FACT offer in AMON?

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- Sending alerts:
 - Anytime for our source sample
 - Trigger criteria need to be defined
 - Significant detection within 20 minutes for flux > 1 Crab Unit (current analysis, small zenith distance, dark night)

Large duty cycle

High data taking efficiency

Total observation time: 7880 hours
> 2350 hours in last 12 months



What can FACT offer in AMON?

- Receiving alerts:
 - Anytime
 - Observations carried out on best effort
 - FACT follow-up not needed, if other, more sensitive VHE instrument does follow-up
- Sending alerts:
 - Anytime for our source sample
 - Trigger criteria need to be defined
 - Significant detection within 20 minutes for flux > 1 Crab Unit (current analysis, small zenith distance, dark night)

Level in evts/h or Crab Units
Time binning



FACT – Observing Strategy

- Goal: Unbiased light curves of few selected sources
- Sample: Sources bright at TeV energies
 - Mrk 501, Mrk 421, 1ES 1959+650
- Optimize sensitivity: observations preferably at small zenith distance (usually $< 45^\circ$)
- Multi-wavelength observations:
MWL campaigns, follow-up of alerts
- Target-of-opportunity programs: Alerts to other instruments
- Rest of time: flexible use for
 - performance studies (Crab Nebula)
 - monitor other sources, e.g. 1ES 2344+51.4, 1ES 1218+304, ...



FACT – Observed Sources

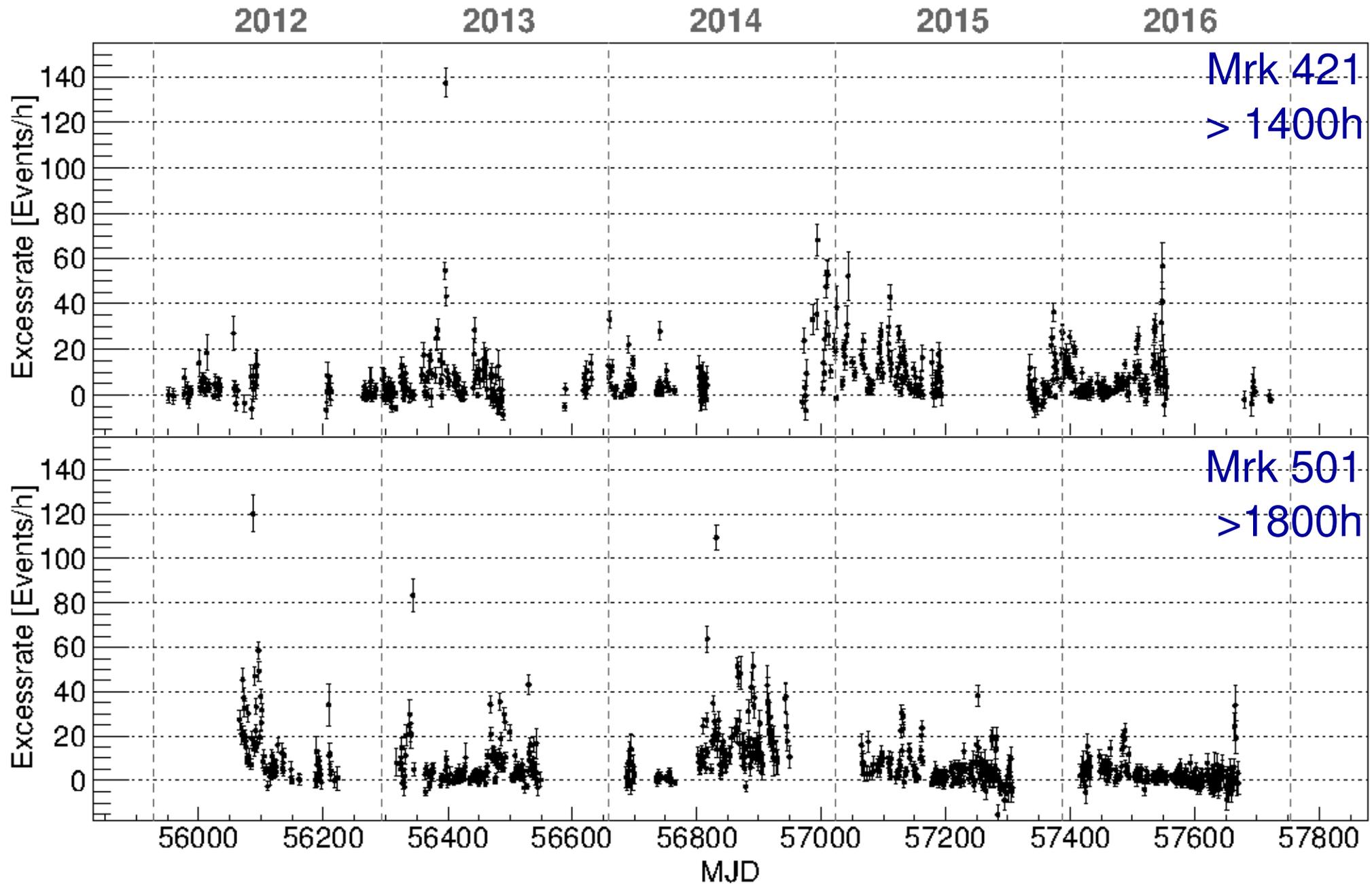
- Standard monitoring
 - Mrk 421
 - Mrk 501
 - 1ES 1959+650
- Other Sources
 - Crab Nebula
 - 1ES 2344+51.4
 - 1H0323+342
- Follow-Up
 - MWL alerts (e.g. V404 Cygni)
 - Neutrino/AMON alerts

Status 3.12.2016

<u>Source</u>	<u>NumRuns</u> ▼	<u>Time[h]</u>
Mrk 501	27832	1813.10
Crab	21011	1548.83
Mrk 421	20769	1444.76
1ES 2344+51.4	15481	1098.34
1ES 1959+650	15405	1047.59
1H0323+342	6358	443.40
PKS 0736+01	1698	112.95
V404 Cyg	953	71.46
IC 310	549	40.97
1ES 1218+304	189	15.37
AMON20160218	101	4.33
RGB J0521.8+2112	93	6.12
PKS 1749+096	82	5.32
HESE20160427	52	4.24
H 1426+428	36	2.94
PKS 2155-304	9	0.75
AMON20160731	8	0.67



Five Years of Monitoring



FACT – Quick Look Analysis

- Fast processing on site
→ Excess rate curves

Since 12/2012

- Results in almost real time
→ Publicly available on

Since 09/2013

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

- Flare alerts to other telescopes

6 Atels in 2016

- Not including:

Since 03/2014

- Detailed data check

ToO: Dec 2015

40 Alerts

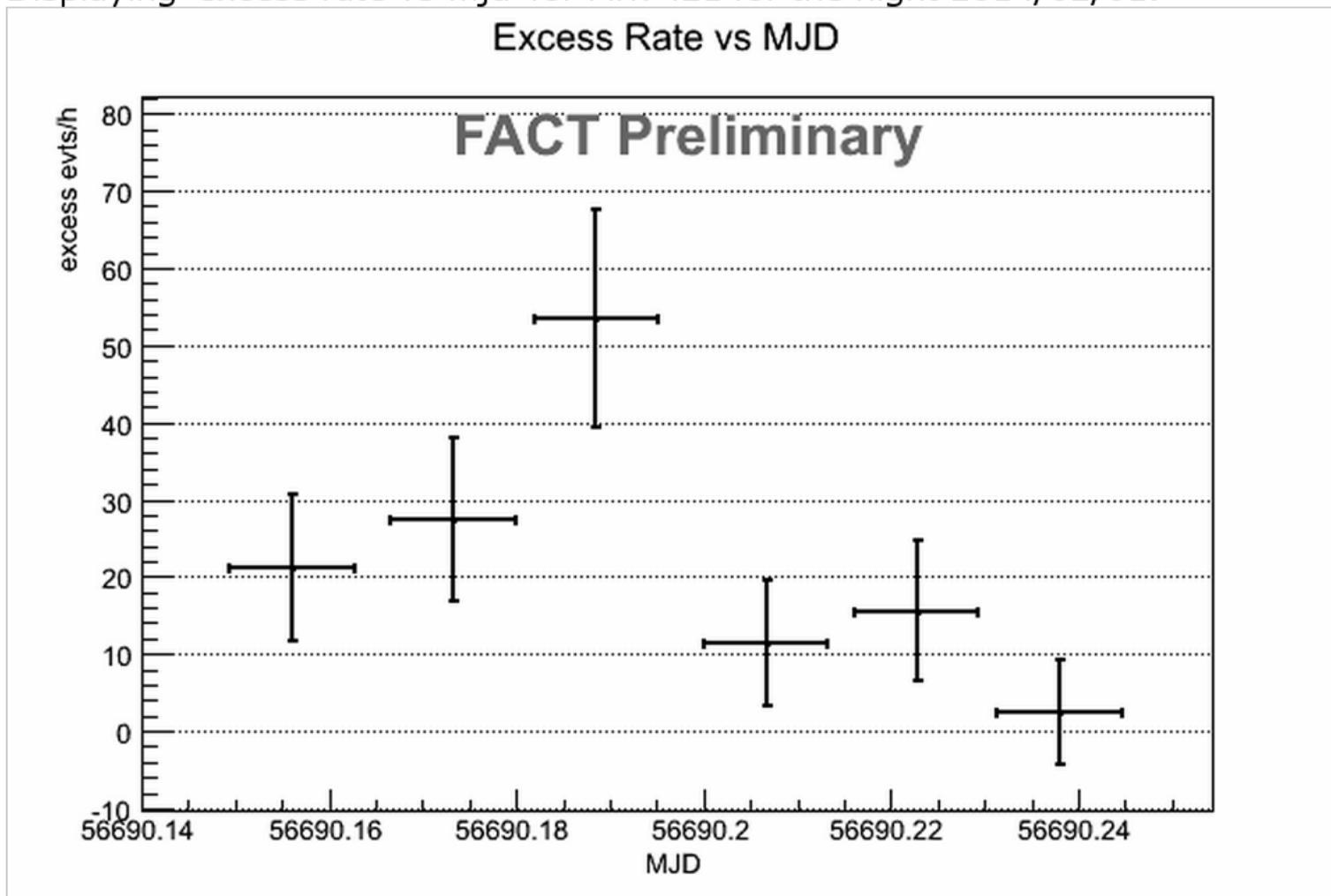
- Correction for dependence of threshold on zenith distance and ambient light



FACT Quick Look Analysis

Select date source
Select time binning and range

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

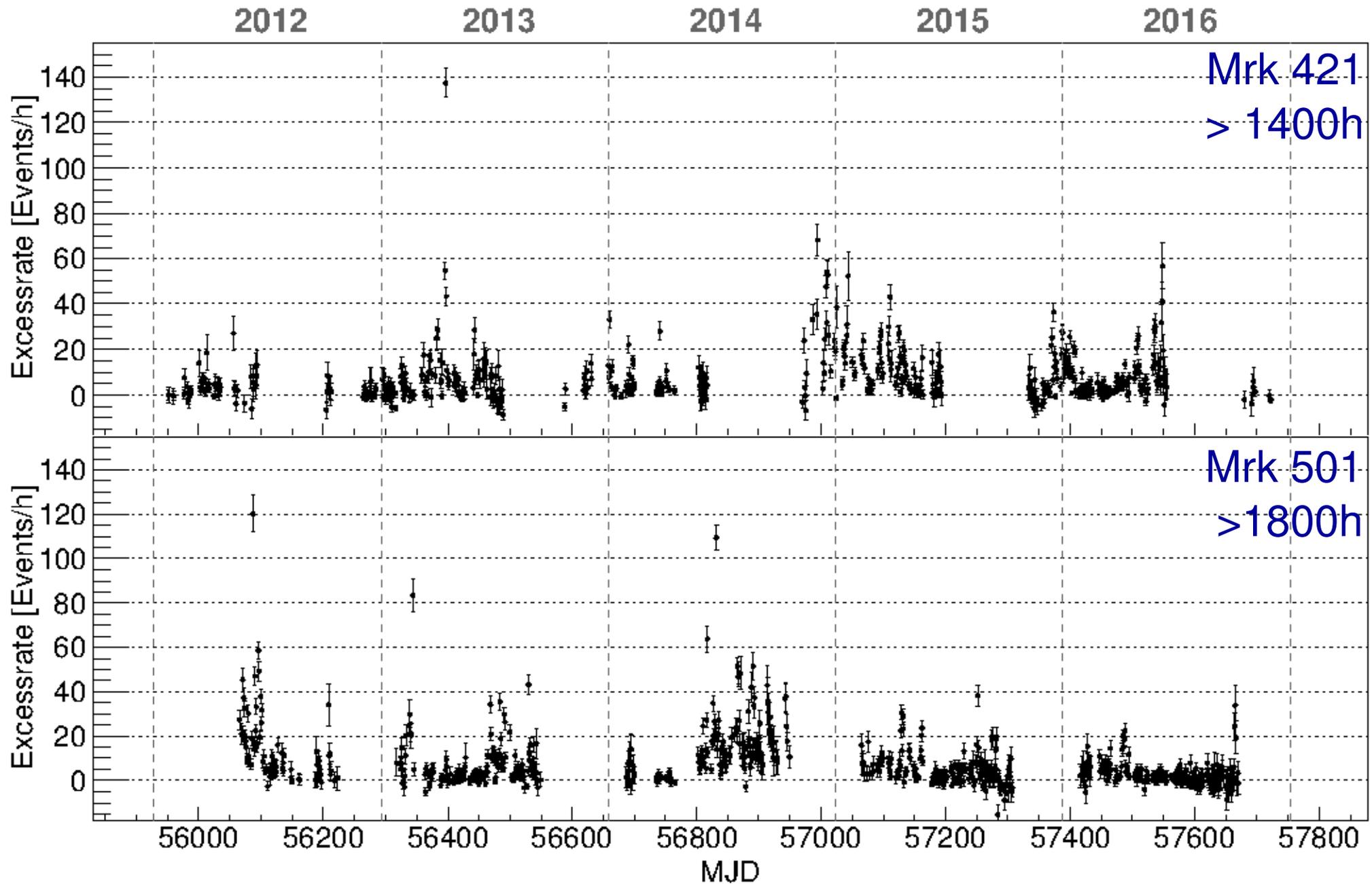


What can the QLA provide?

- Excess rates available after ~ 20 minutes
- Detection speed depending on flux
 - Detection in 5 minutes of data, e.g.
Mrk 501: 8.6.2012, 23.6.2014; Mrk 421: 14.4.2013
 - Detection of Crab Nebula in ~ 20 minutes (dark night, small zd)
- Flare alerts
 - Currently manual, in the future automatic
 - Trigger criteria
 - Gamma-ray: Mrk 501/421: 3 CU; Other blazars: 0.5 CU + > 3 sigma
 - X-ray ToO program: 70 evts/h (motivated by X-ray flux of sources)



Five Years of Monitoring



Long-Term Monitoring

FACT (since 2012)

- daily VHE observations
- provides detailed variability information
- provides flare alerts

Trigger criterium:
VHE FACT rate > 70 evts/hour

Swift (since 2014)

- weekly scheduled (~1ks)
- monitoring of the low-E emission
- test for orphan flares & time lags
- public data

MWL ToO Program

Upon FACT trigger:

Swift/ XRT ~20ks total

5 x 2 ks / day, then
10 x 1 ks / 2nd day follow-up

XMM-Newton/ EPIC ~100 ks total

1 x 80 ks, then
4 x 5 ks / day follow-up

INTEGRAL / JEM-X / IBIS ~500 ks total

1 x 500 ks
(~200 ks / revolution)

Time-Resolved SEDs

Include *Fermi*/ LAT data

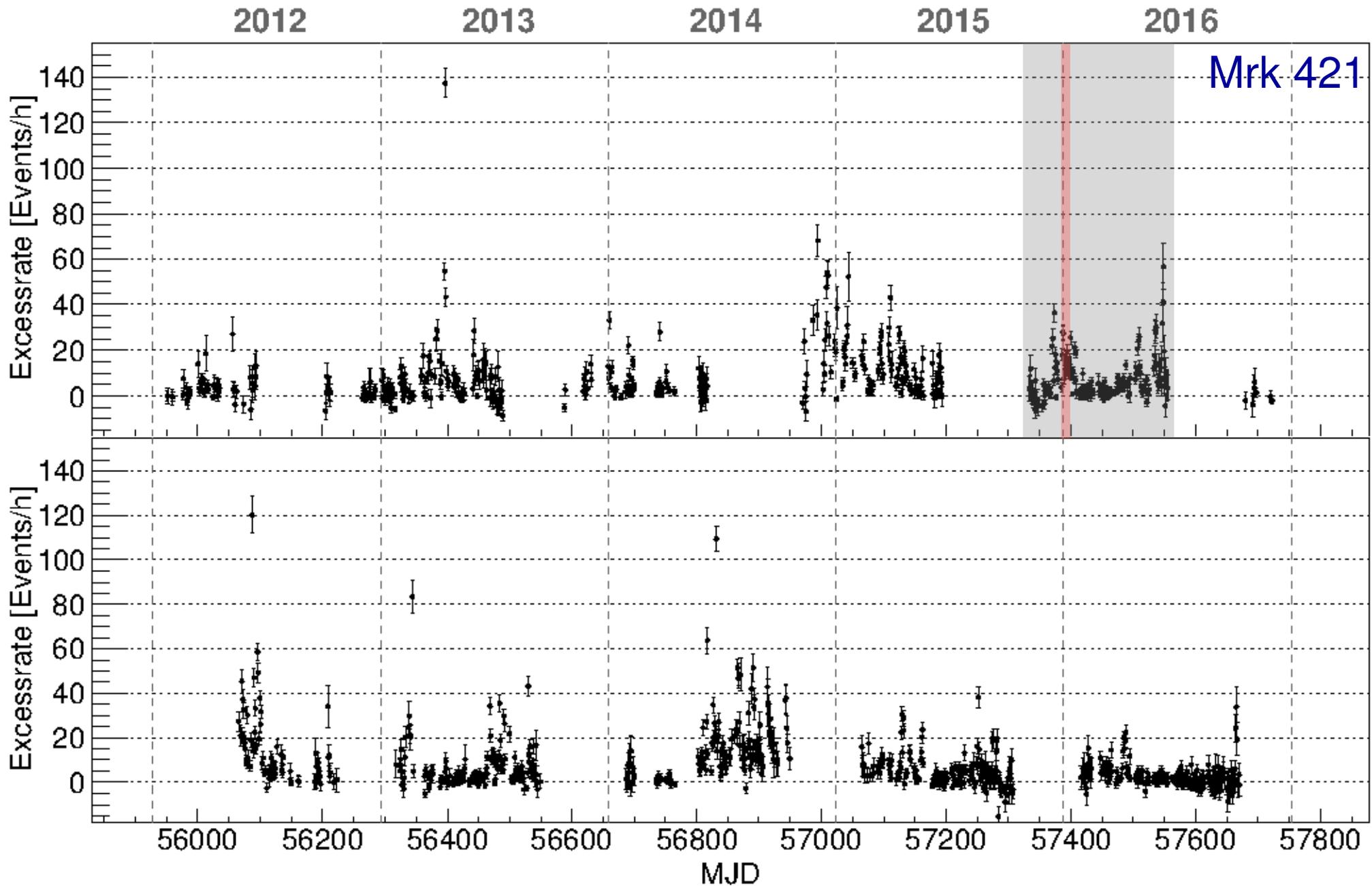
Apply time-resolved jet emission modes

(e.g. Spanier & Weidinger 2012)

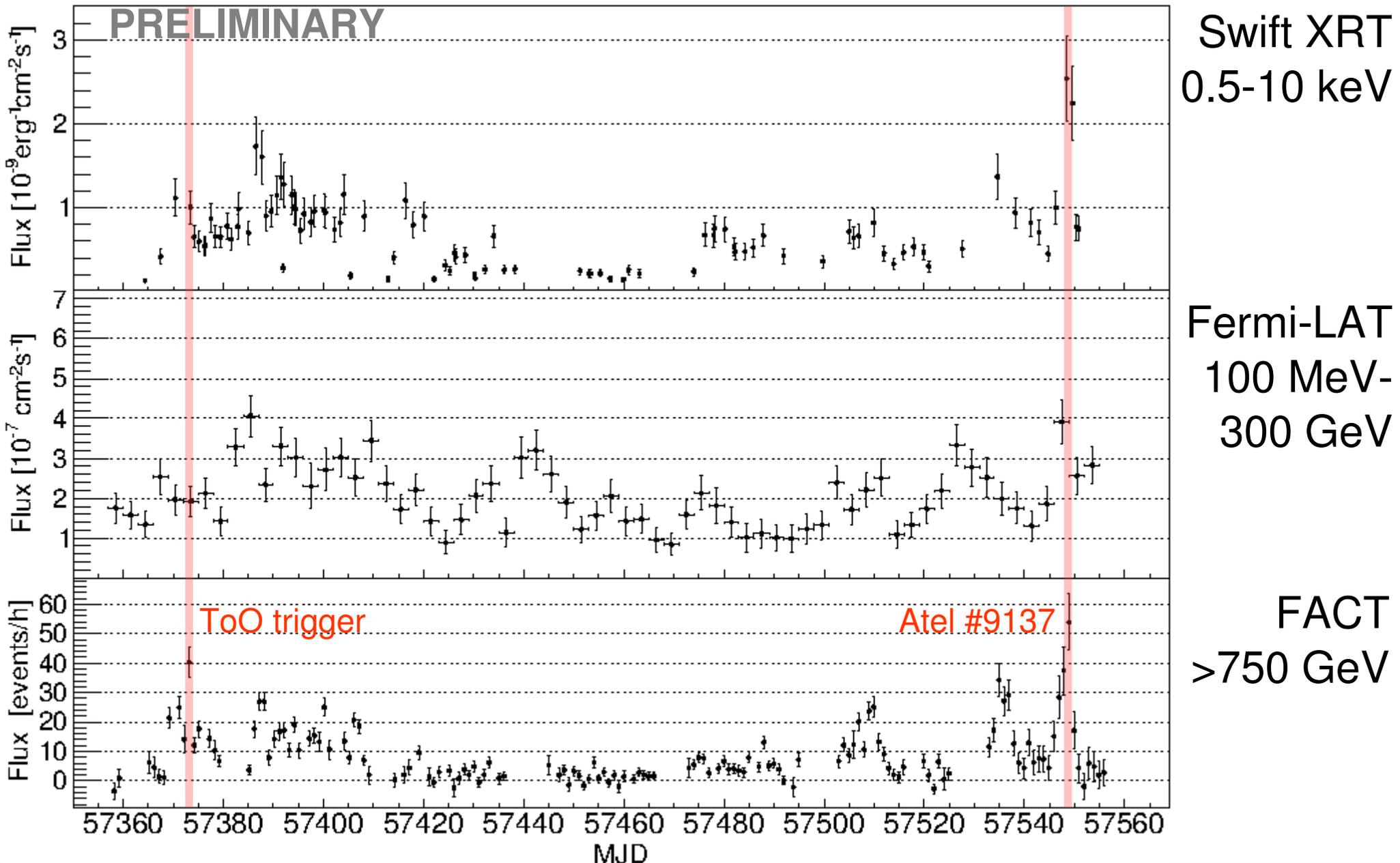
Provide constraints on jet emission models



Mrk 421: Recent Flaring Activity



Mrk 421: Dec 2015 – Jun 2016



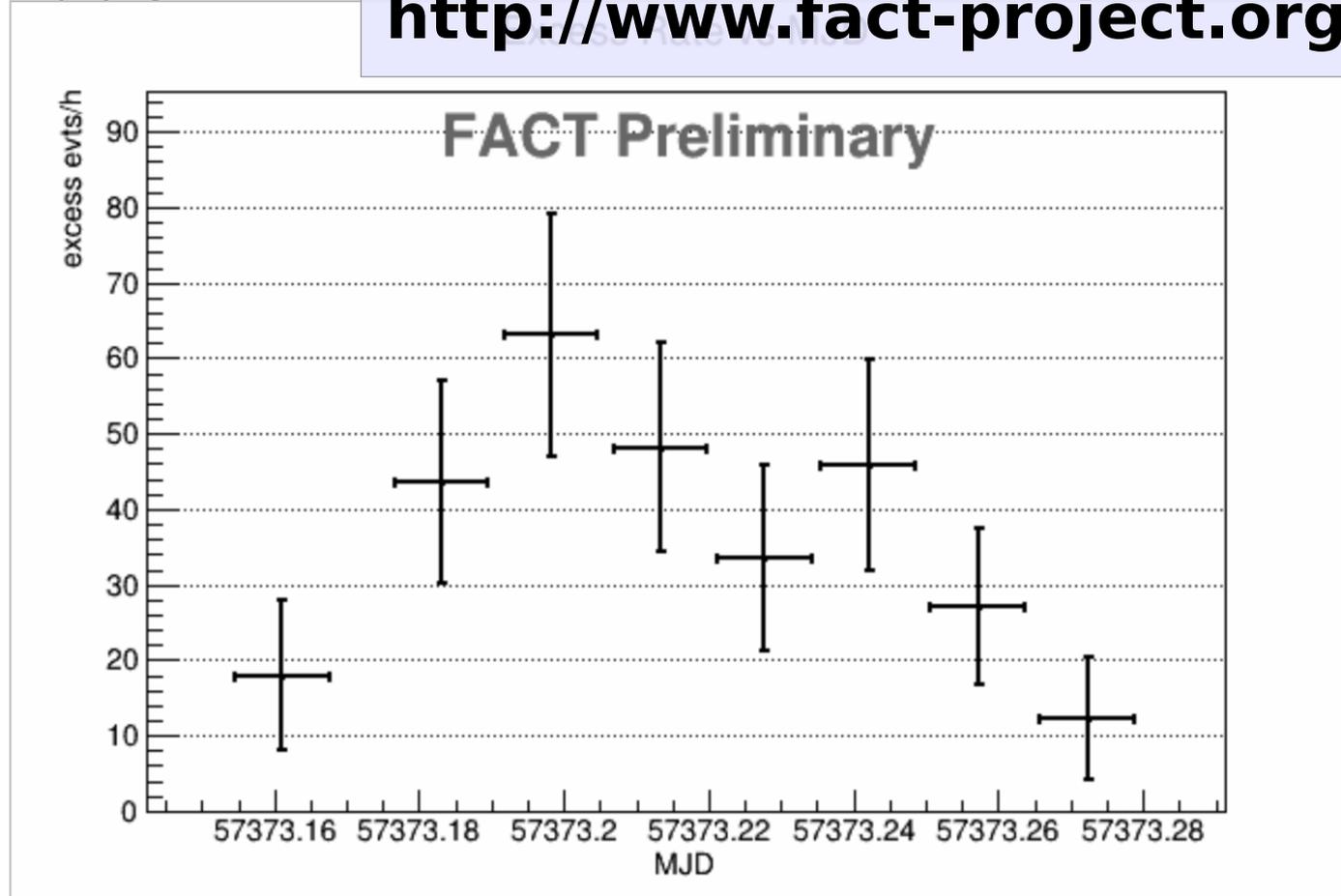
Mrk 421 – Flare December 2015

FACT Quick Look Analysis

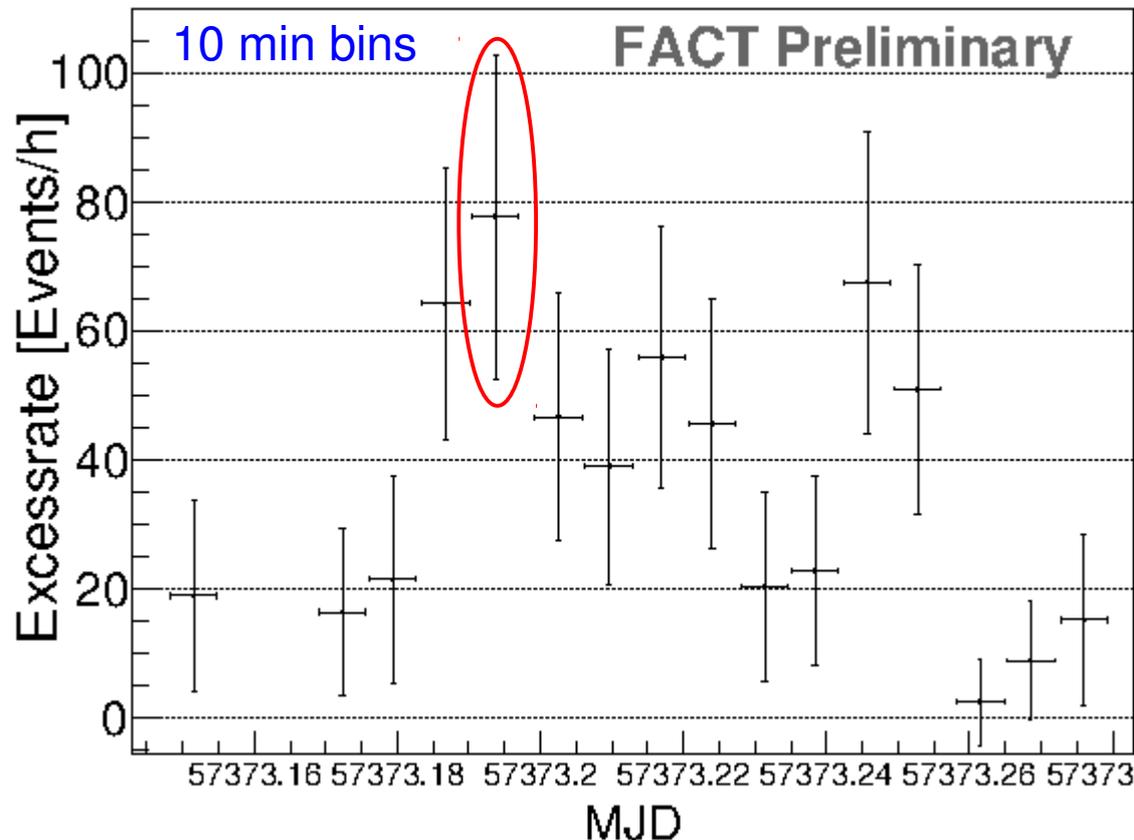
Select date 2015 : 12 : 16 : source Mrk 421 :
Select time binning 20min : and range night : Reset

Displaying 'excess rate

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



Target of Opportunity Observations



FACT Observations:

2015-12-17 3:33-6:50 UTC

Triggered

→ *INTEGRAL*

→ *Swift*

Swift-XRT Observations / Follow-up:

daily ~5ks: 2015/12/19 - 2015/12/20

daily ~1ks: 2015/12/20 - 2016/01/18

every 2nd day ~1ks: 2016/01/29 - 2016/02/20

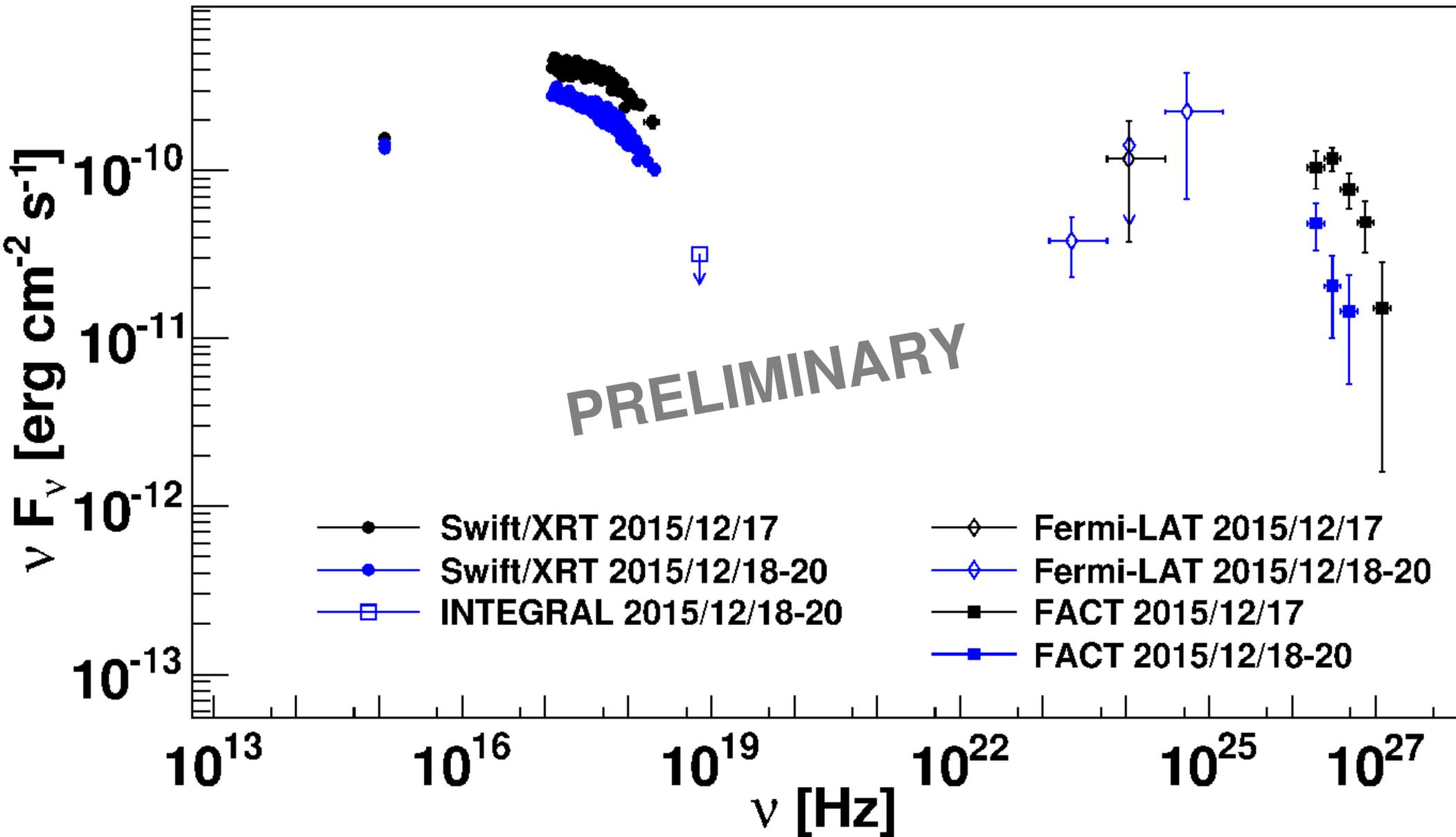
INTEGRAL Observation:

~164ks

start: 2015-12-18 11:00 UTC

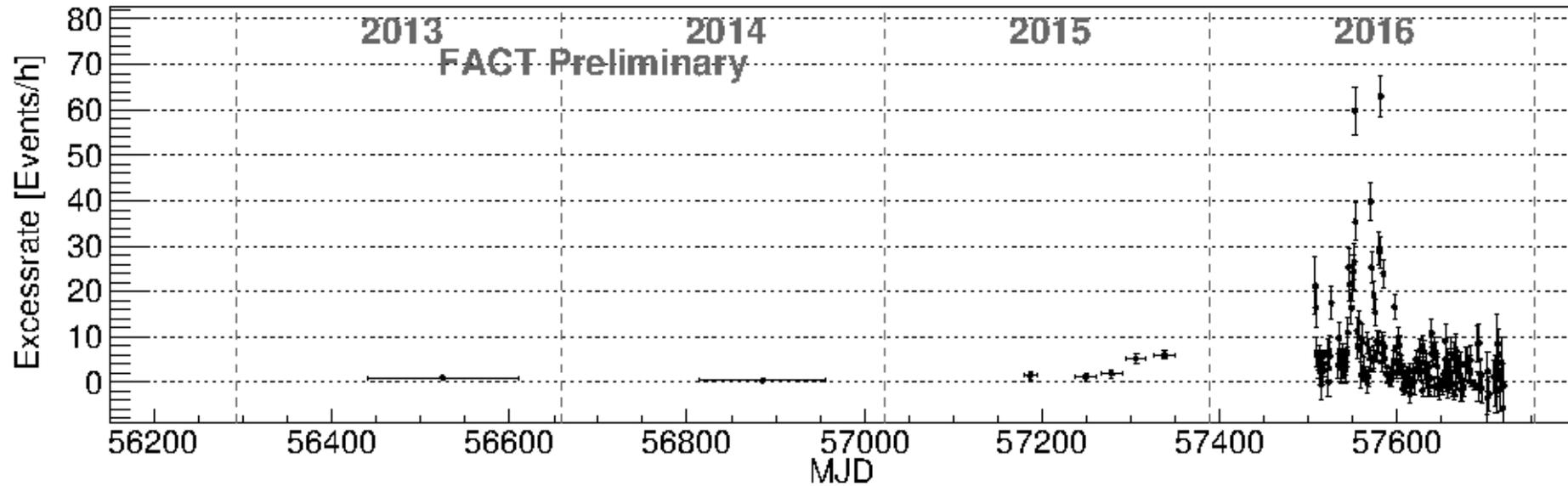
stop: 2015-12-20 10:47 UTC

Mrk 421 – Flare December 2015



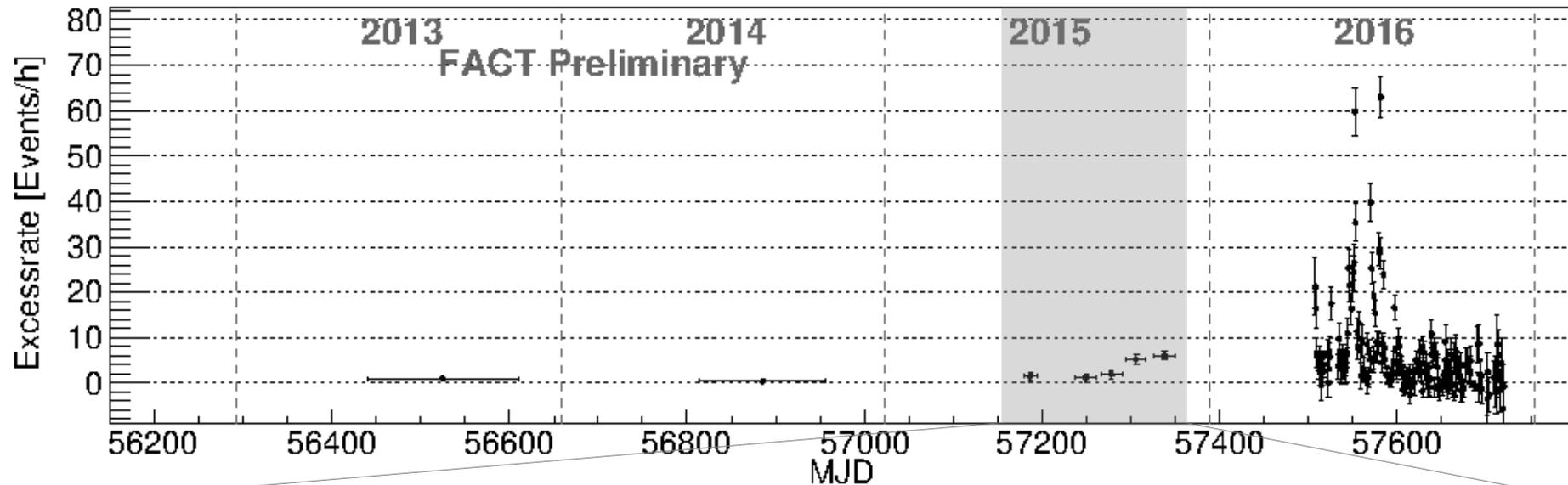
1ES 1959+650

Long-term
Behaviour

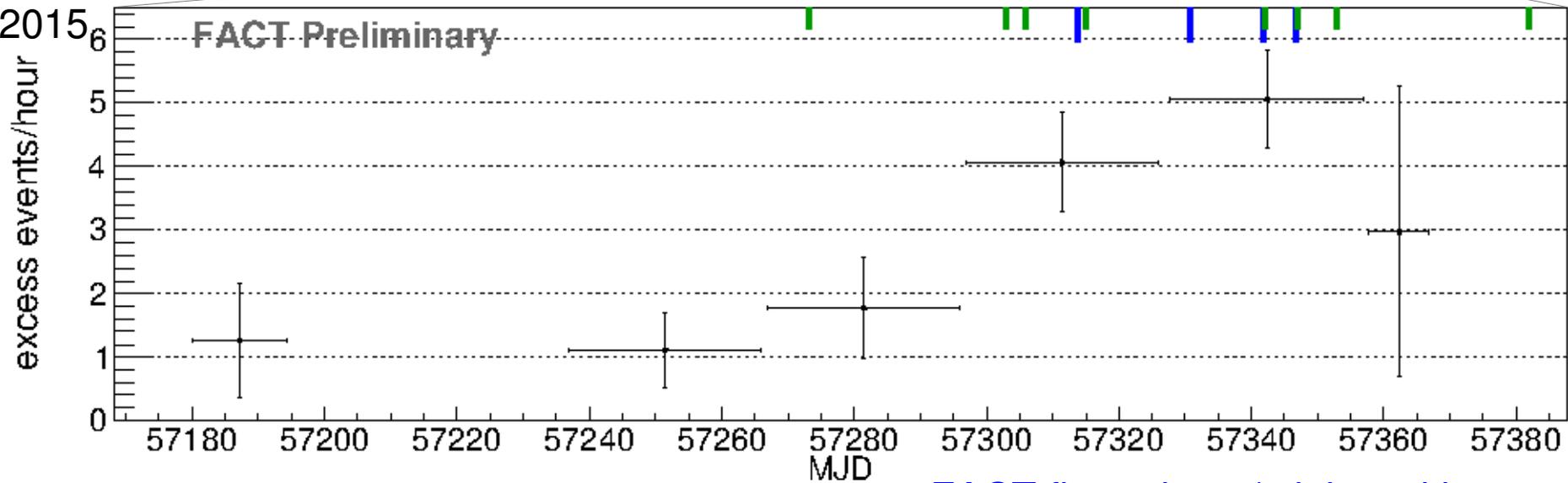


1ES 1959+650

Long-term Behaviour



2.8.-10.12.2015



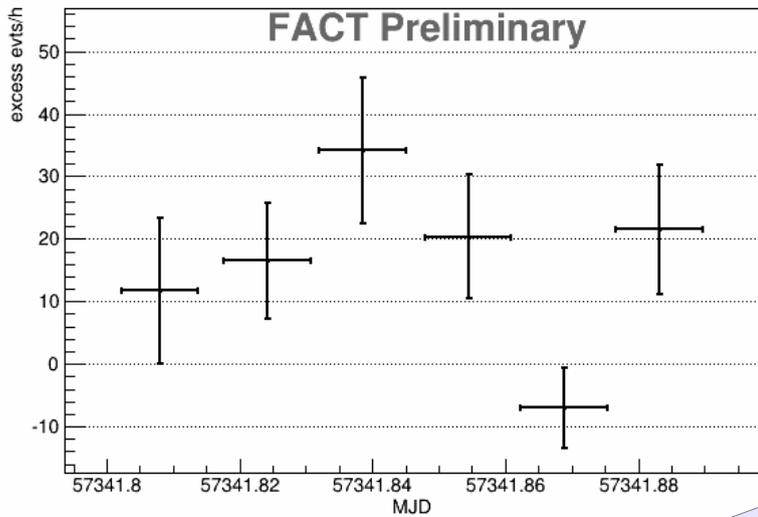
FACT flare alerts / nights with $> 3 \sigma$

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

Alerts 2015 on 1ES 1959+650

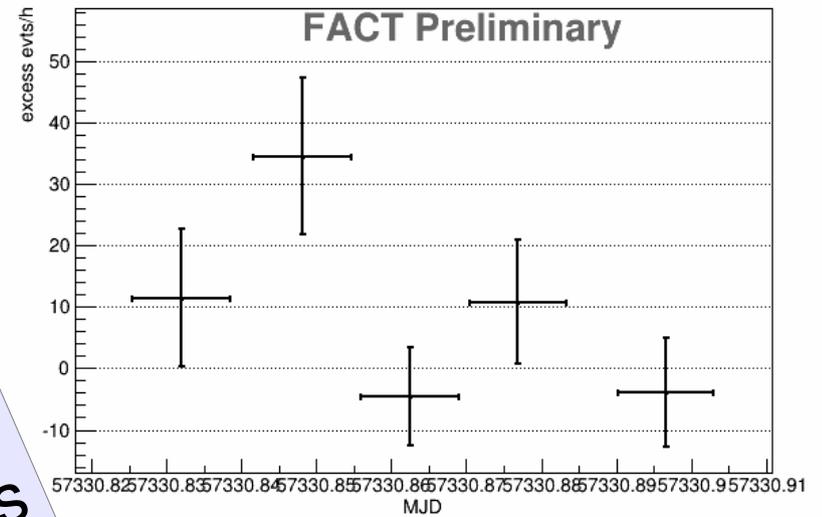
2015/11/15

Excess Rate vs MJD



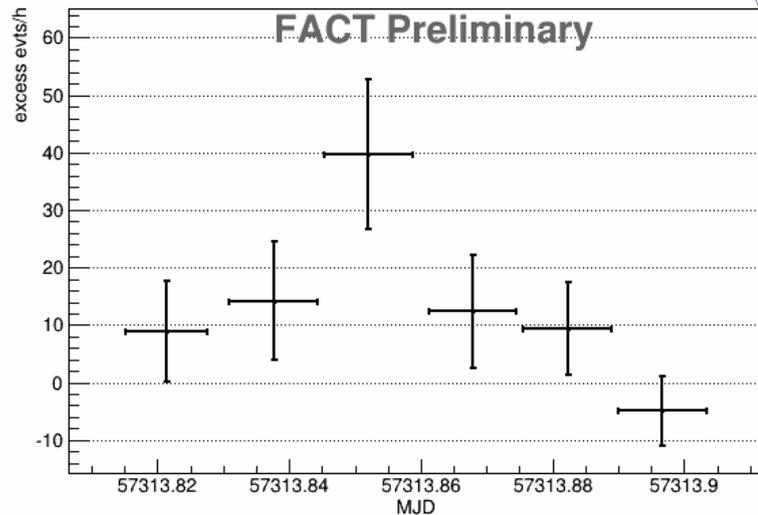
2015/11/04

Excess Rate vs MJD



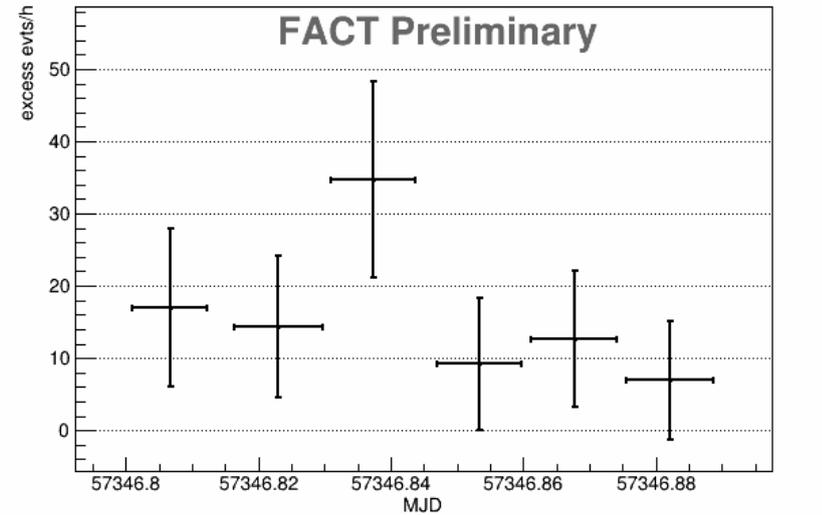
2015/10/18

Excess Rate vs MJD



2015/11/20

Excess Rate vs MJD

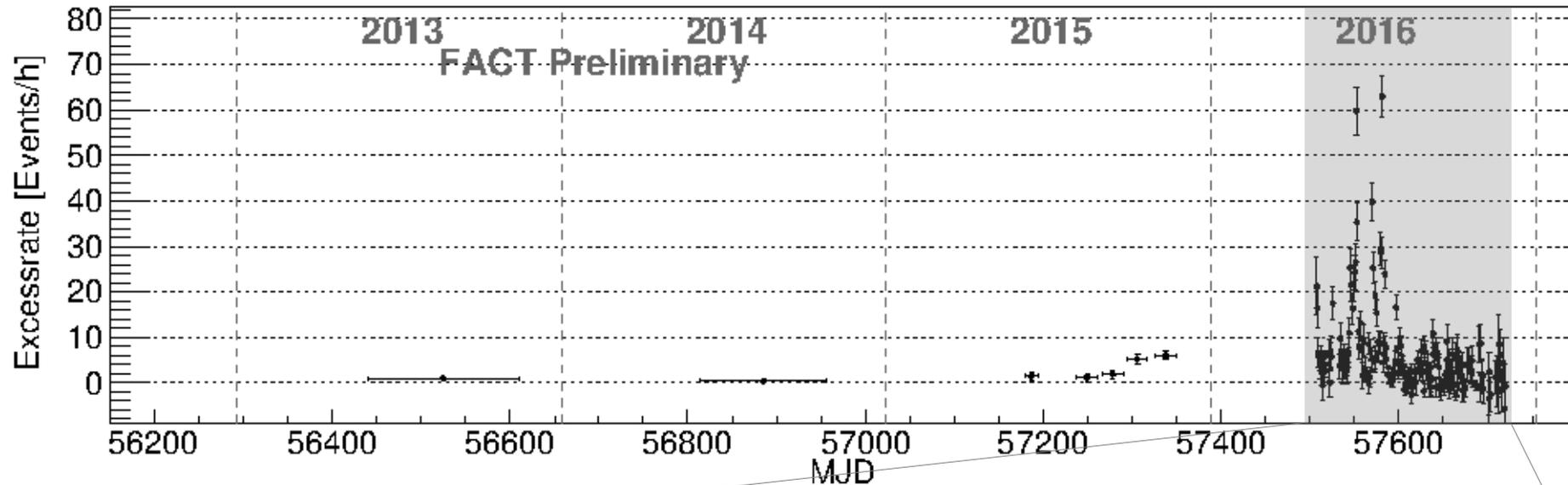


From Quick
Look Analysis

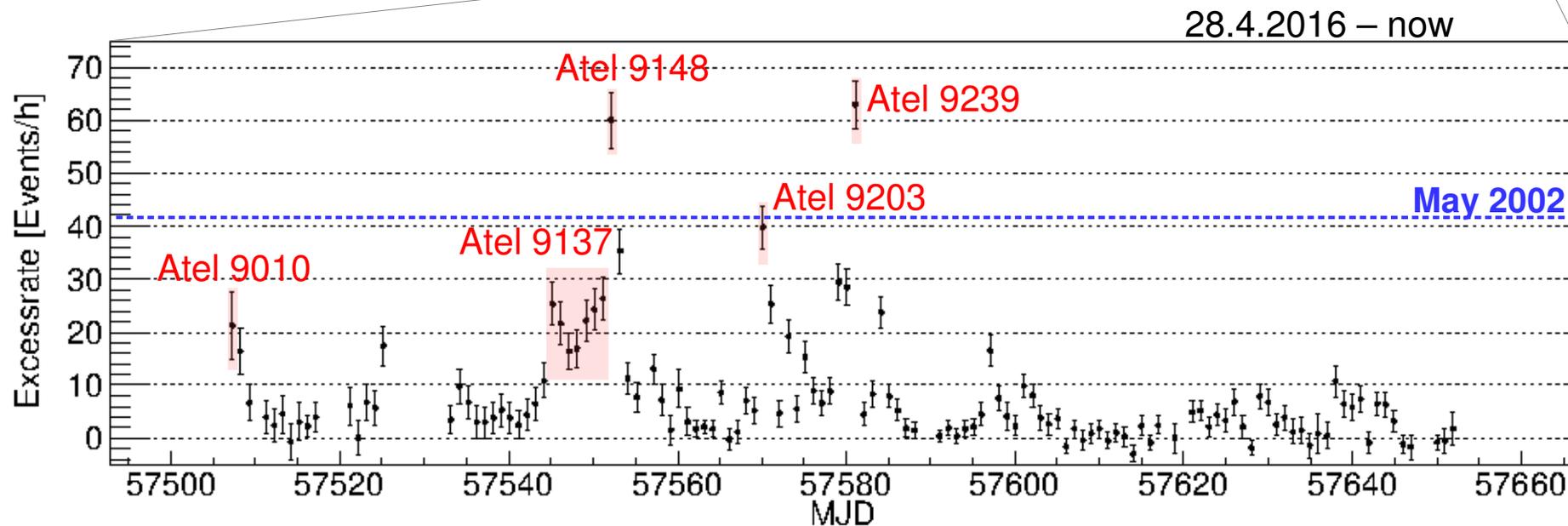


1ES 1959+650

Long-term
Behaviour



Flaring
Activity
2016



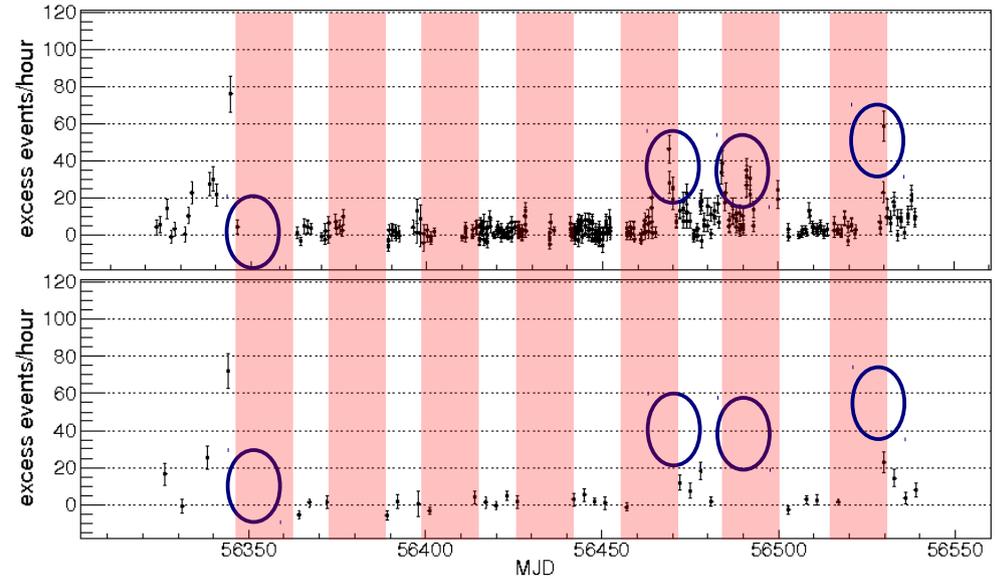
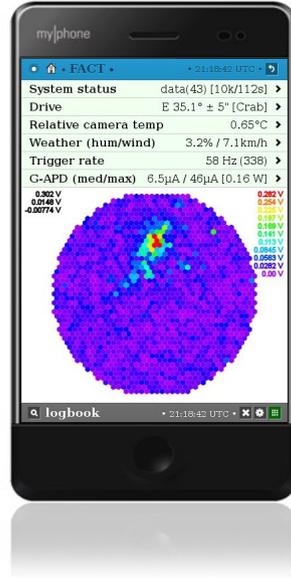
Status in AMON

- Quick Look Analysis ready to send alerts
- Followed-up 3 IceCube alerts in 2016
- Next steps
 - Define flare event and trigger criteria
 - Fill archival data to data base
 - Try software
 - Test sending alerts
 - Implement full procedure

Level in evts/h or Crab Units
Time binning



Summary



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

