



FACT - the First G-APD Cherenkov Telescope

Results from Eight Years of Unbiased Monitoring at TeV Energies

D. Dorner¹, A. Arbet-Engels³, D. Baack², M. Balbo⁴, N. Biederbeck², A. Biland³, T. Bretz^{3a}, J. Buss², L. Eisenberger¹, D. Elsaesser², D. Hildebrand³, R. Iotov¹, A. Kalenski¹, K. Mannheim¹, D. Neise³, M. Noethe², A. Paravac¹, W. Rhode², B. Schleicher¹, V. Sliusar⁴, R. Walter⁴ (FACT Collaboration)

First G-APD Cherenkov Telescope [1,2]

- Operation since October 2011 @ Observatorio Roque de los Muchachos, La Palma, Spain (2200 m a.s.l.)
- Imaging Atmospheric Cherenkov Telescope (IACT)
- Camera with silicon photosensor (SiPM, aka G-APDs*)
 - 4.5° field of view (FoV)
 - 1440 pixels (0.11° FoV each)
- 9.5 m² mirror surface
- Robotic operation
- Quick-Look Analysis (QLA):
 - Low latency results
 - 20-minute and nightly binning
 - **105 flare alerts** since March 2014
 - **Results publicly available:**
<http://www.fact-project.org/monitoring>

Data Sample:	14736 h
Mrk 501:	2994 h
Mrk 421:	3197 h
Crab Nebula:	2386 h
1ES 2344+51.4:	1976 h
1ES 1959+650:	2231 h
1H0323+341:	1179 h
PKS 0736+01:	151 h

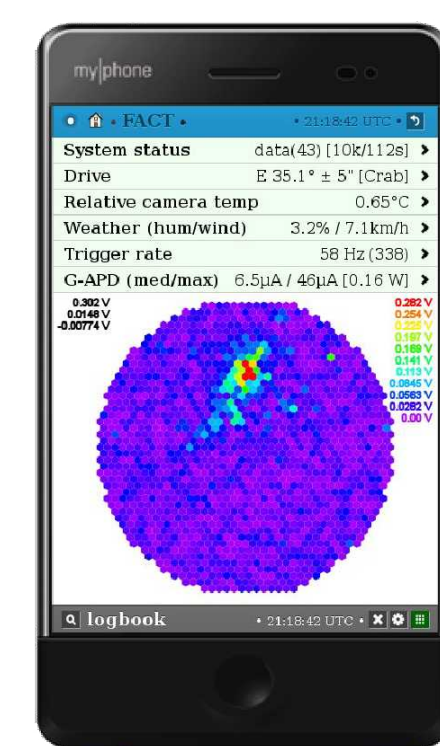
status 6.4.2021



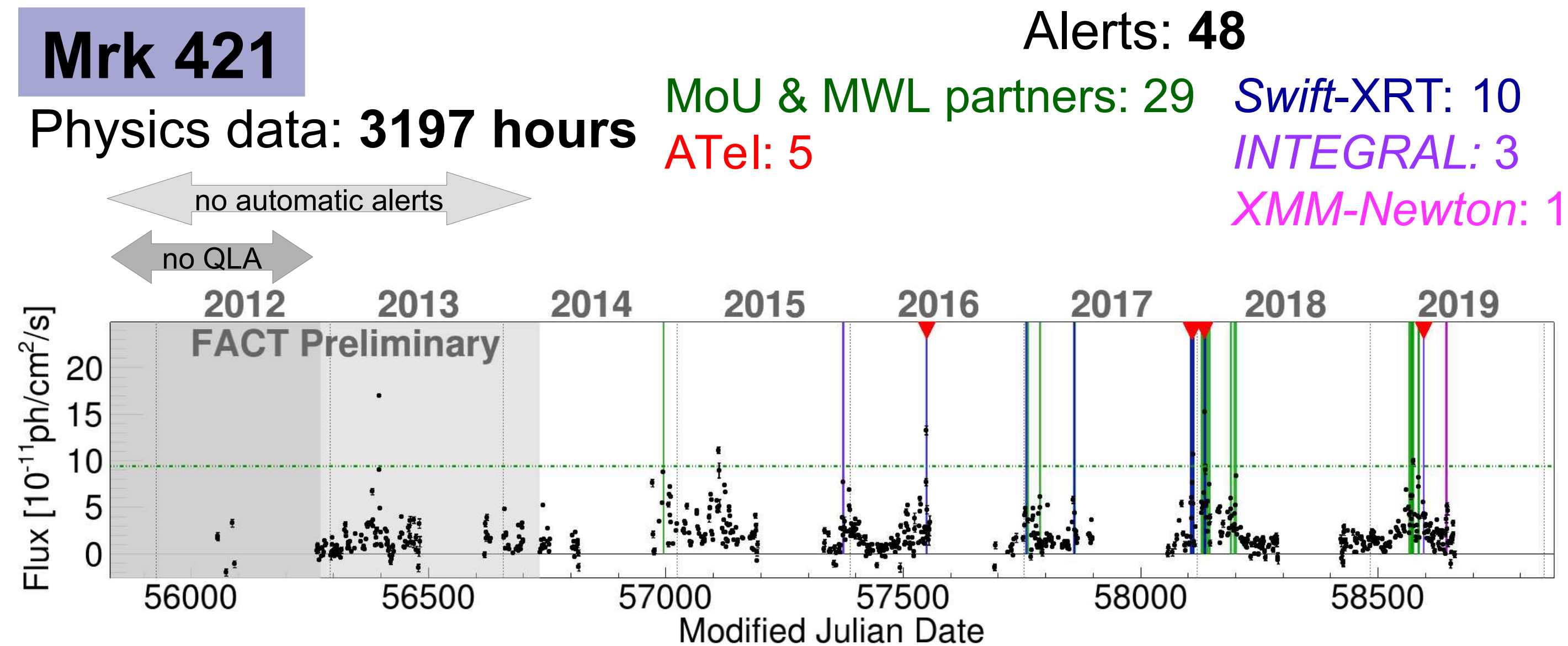
First G-APD Cherenkov Telescope (FACT) located on the Canary Island La Palma: This photo shows the telescope during a special measurement demonstrating the capabilities of SiPMs [3]: Showers could be recorded while pointing to the full moon. Image credit: D. Dorner

Unbiased Long-Term Monitoring

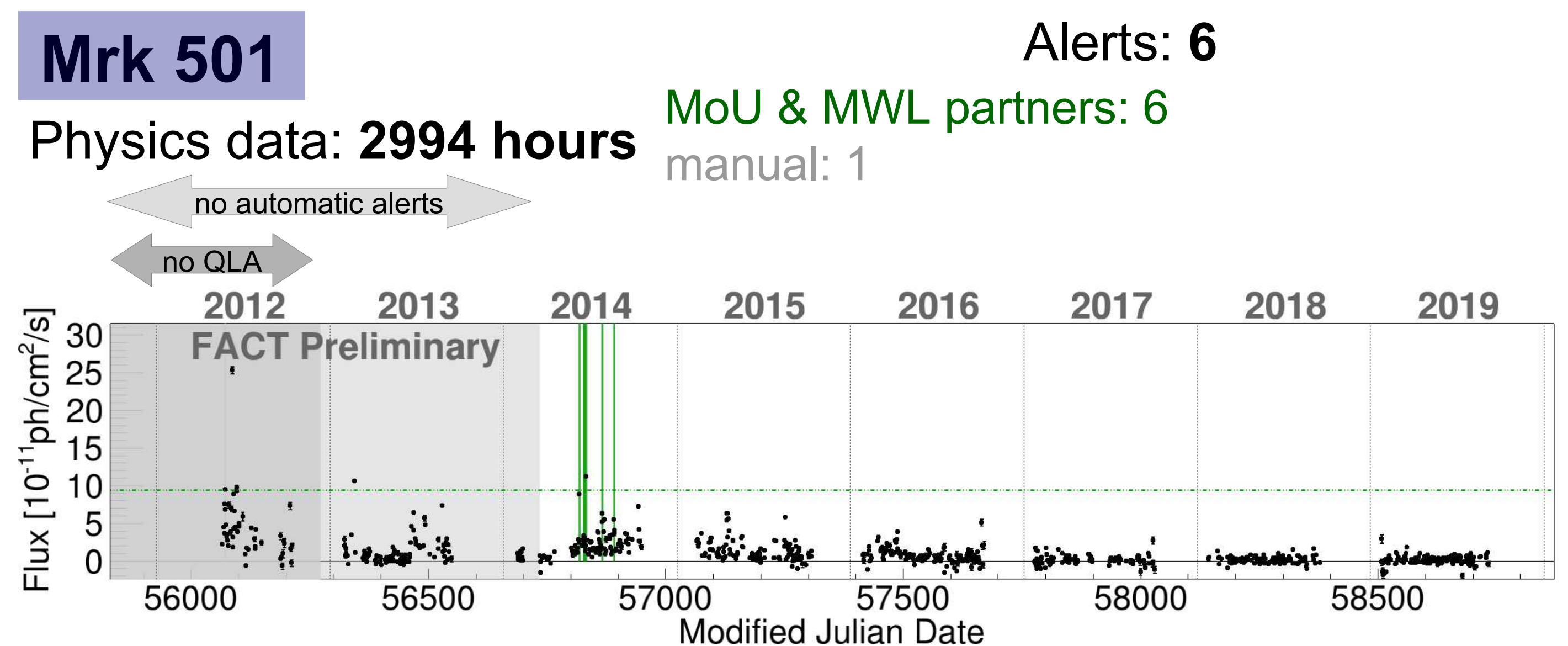
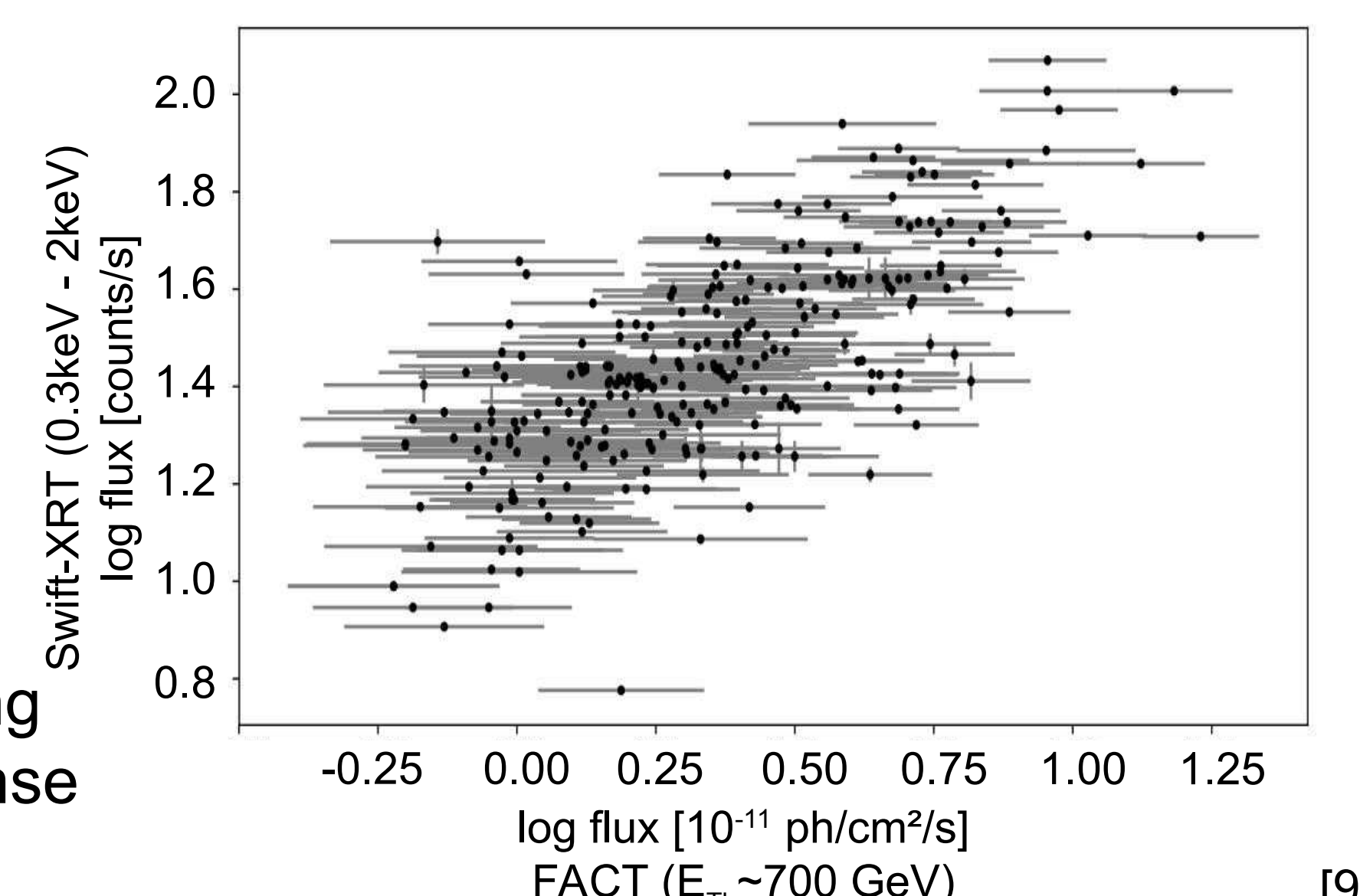
- Source sample: bright TeV blazars
- Strategy: observe small sample of sources as much as possible
 - **Unbiased monitoring: >14700 h of physics data**
- SiPMs – Ideal for Monitoring:
 - Robust and stable, excellent performance [2]
 - No aging effect due to bright light
 - Observations during strong moon [left]
 - Remote and automatic operation [right]
 - <http://www.fact-project.org/smartfact>
 - Stable, consistent data taking
 - High data taking efficiency
- **Maximized duty cycle, minimized observational gaps, dense sampling**



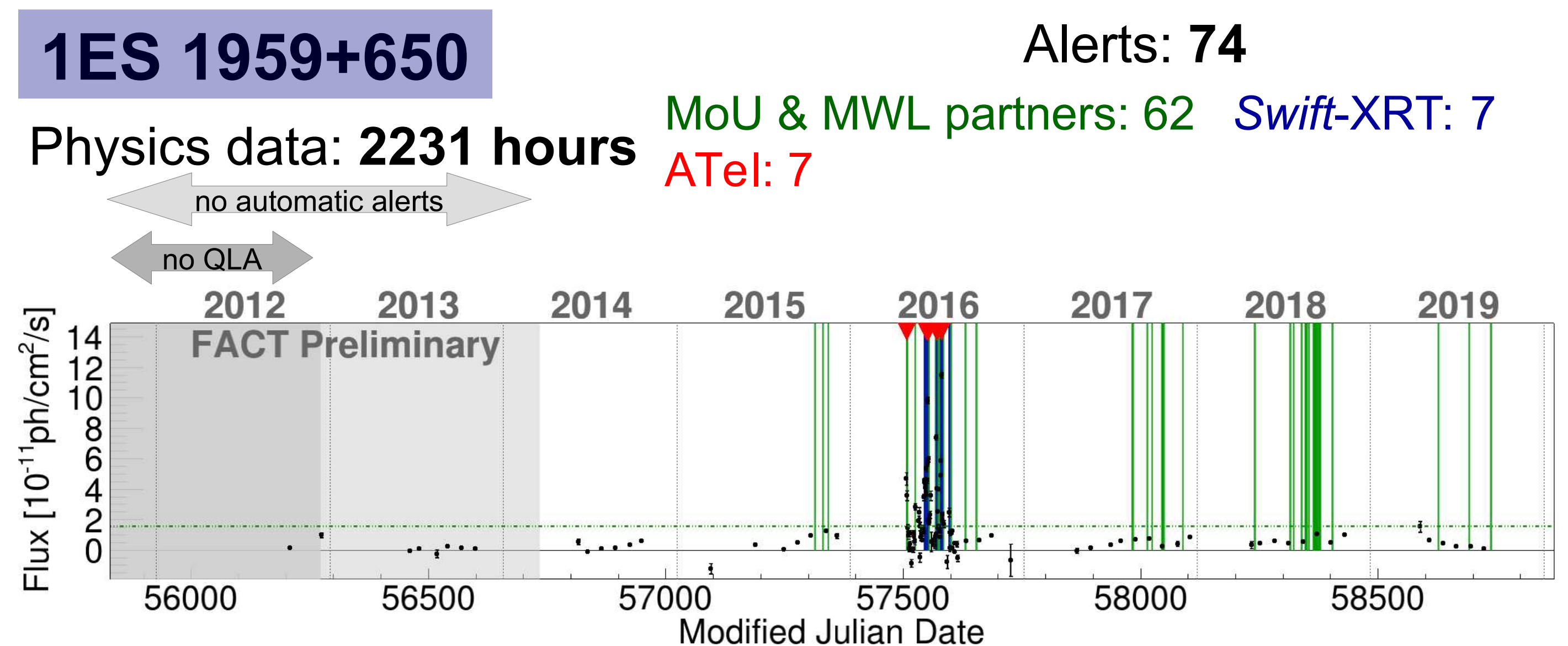
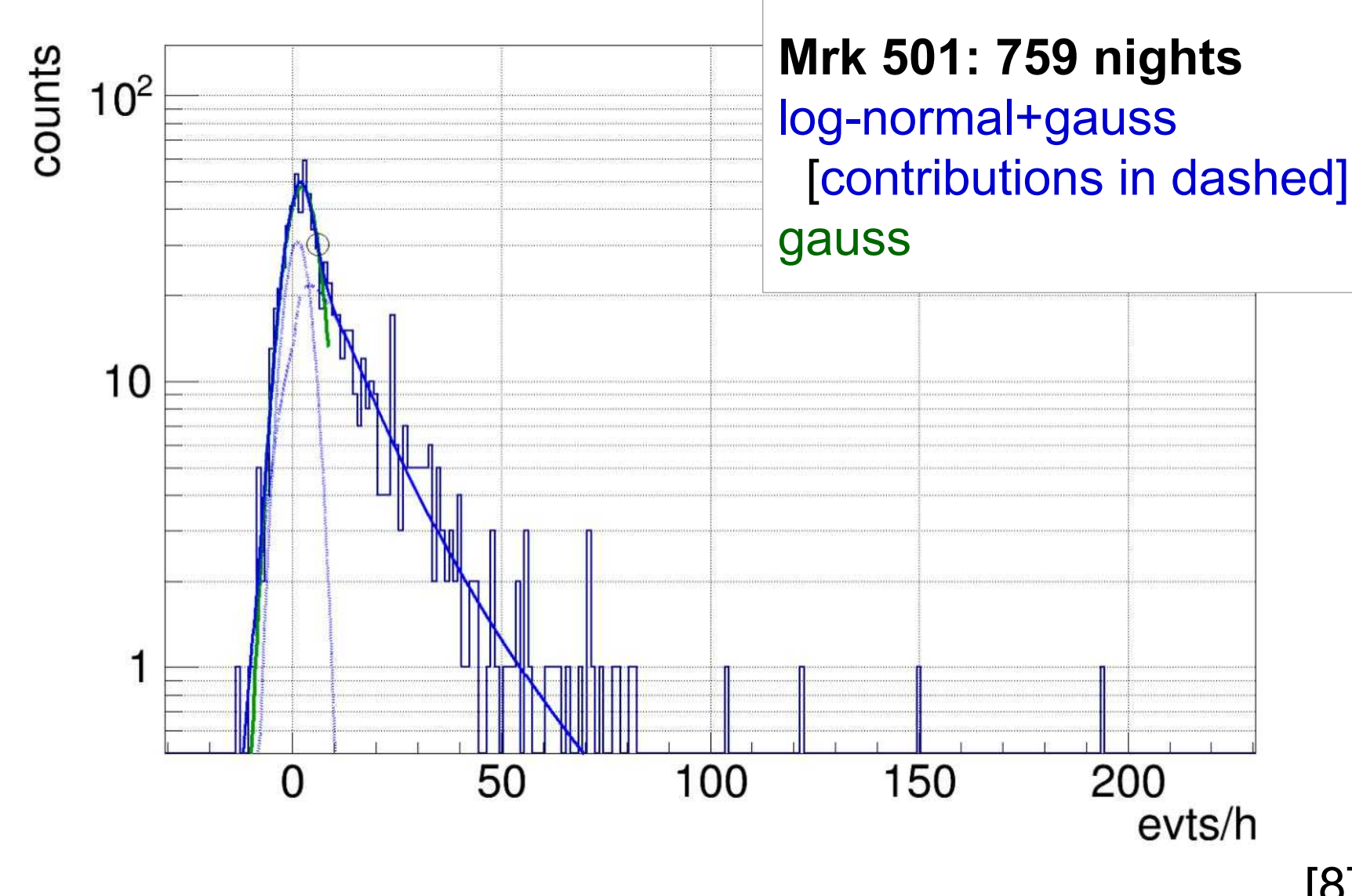
*: G-APD: Geiger-mode Avalanche Photo-Diode



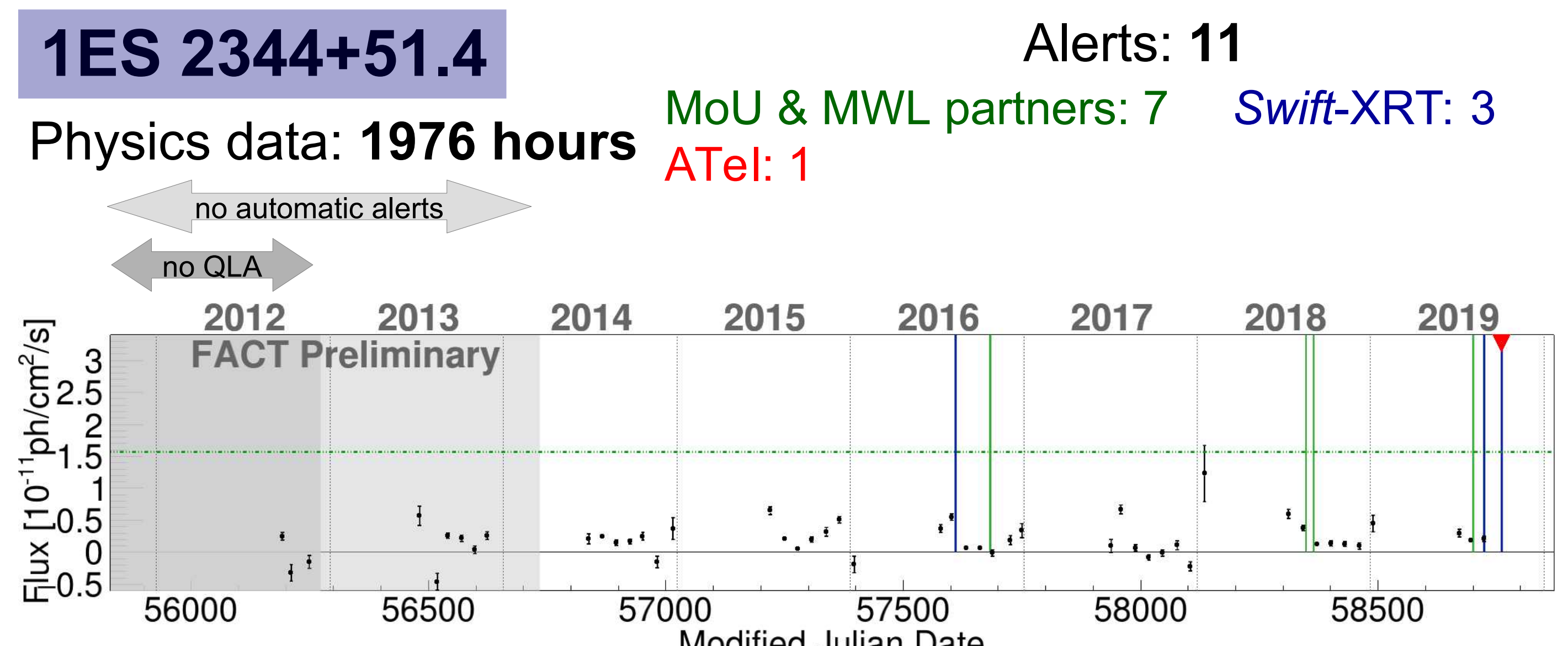
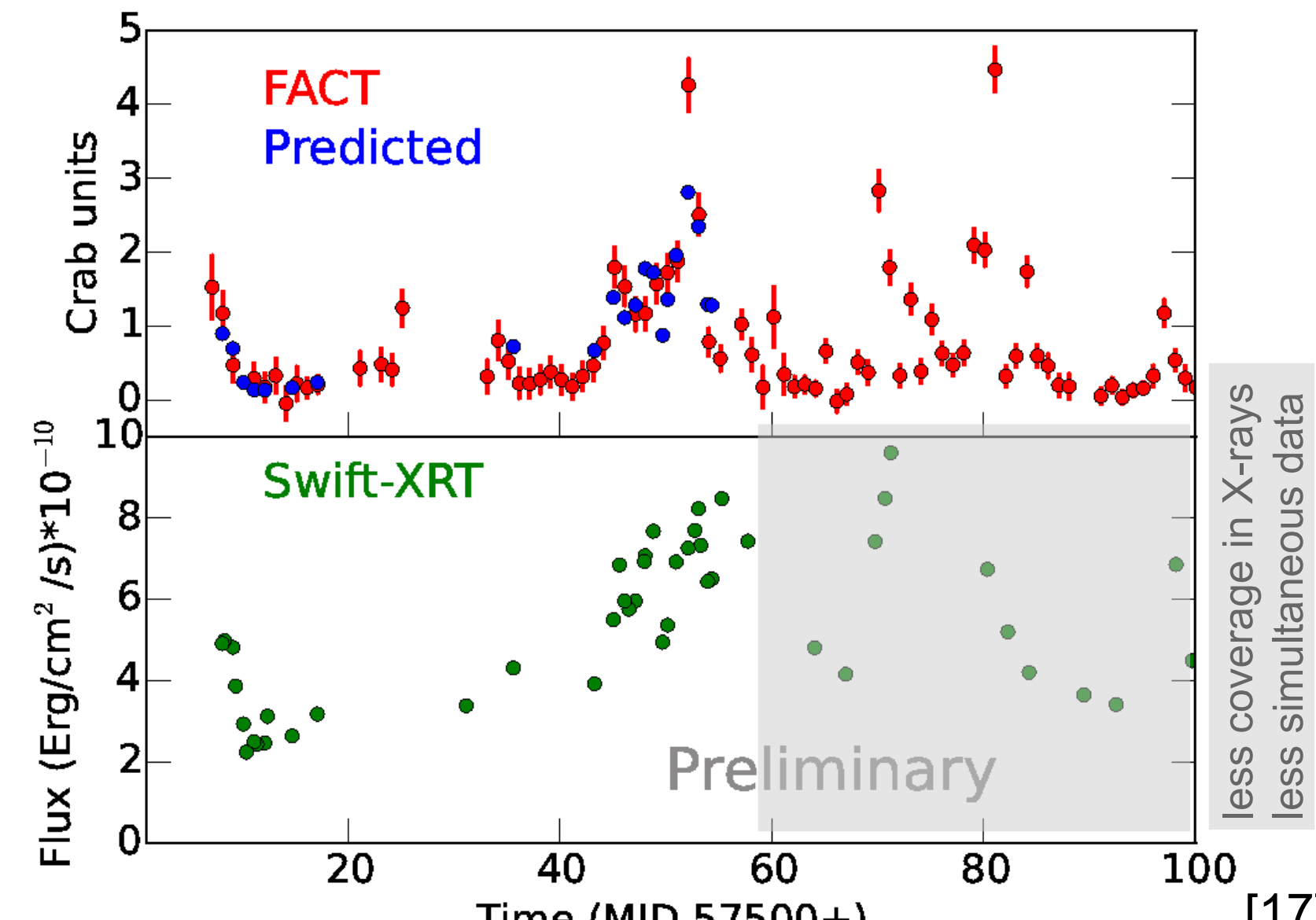
- Bright flares Apr 2013, June 2016 [4], Dec 2017 / Jan 2018 [5]
- X-ray ToOs (*INTEGRAL*, *XMM-Newton*) activated: Dec 2019, Jun 2019 [5, 6]
- Flux distribution not following normal distribution [8]
- 5.5 years multi-wavelength study [9]
 - TeV-X-ray correlation [right]
 - Radio emission reproduced convolving the GeV variations by delayed response
- Results favouring leptonic scenario



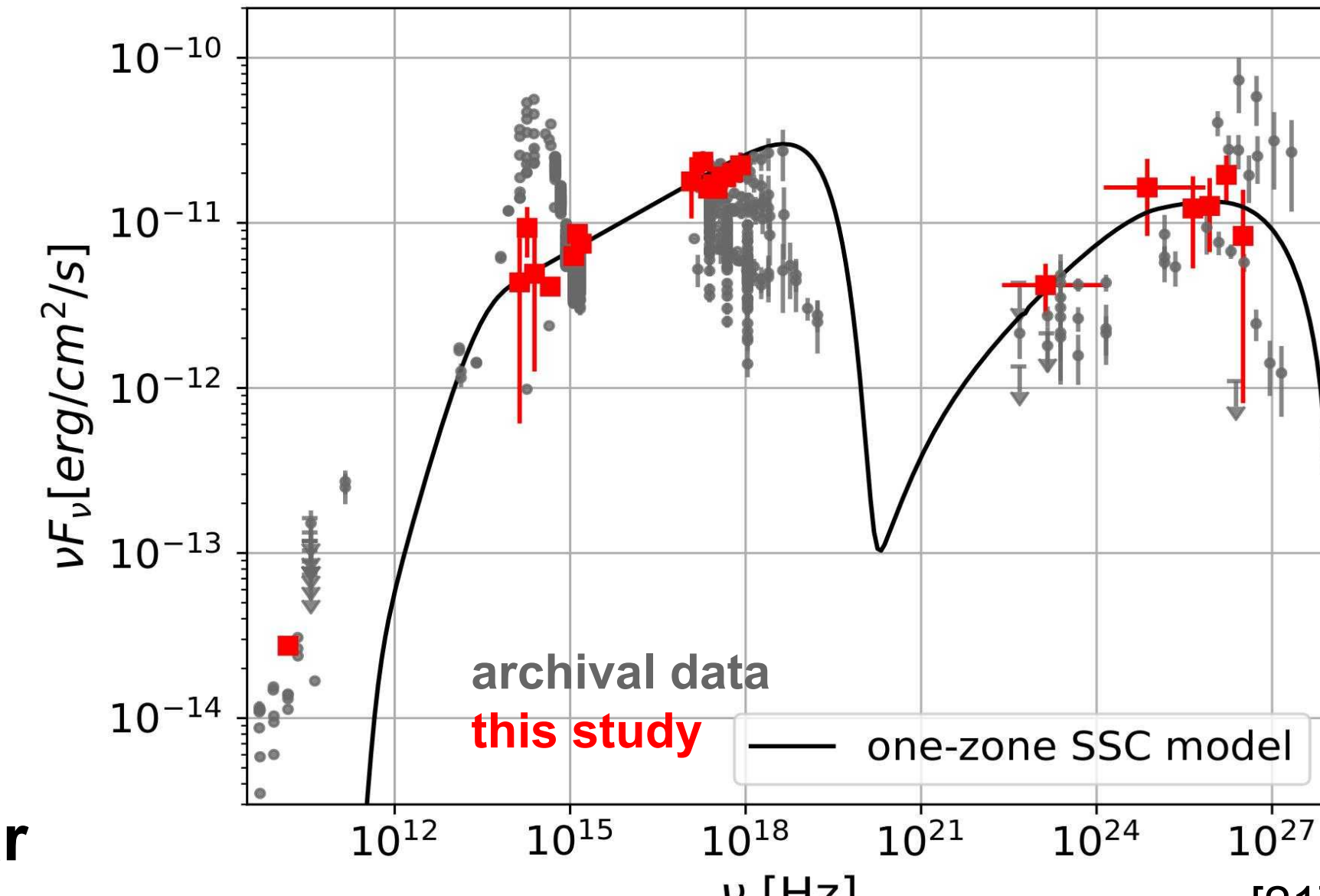
- Bright flare June 2012 showing extreme behaviour [10]
- Flaring activity June 2014 → Alert → H.E.S.S. constraints on LIV [11, 12]
- Study of temporal and spectral behaviour in gamma rays [13]
 - TeV range: log-normal flux distribution
 - Flare night [14]
 - Nightly binning [right, 8]
 - GeV range: no log-normal flux distribution



- 2012-2014: low state, brightening in 2015
- Series of bright outbursts in 2016 [15]
- **Densest daily light curve measured so far by an IACT**
- X-ray monitoring and ToOs [16]
- Correlation study with
 - X-rays [right, 17]
 - Neutrinos [18]
- Bright outburst in 2016 cannot be explained by simple one-zone SSC model [17]



- Overall average flux: $1.6 \cdot 10^{-12}$ erg/s/cm²
- Outbursts of 0.5-1CU* in
 - Aug 2016 [19]
 - Aug, Sep 2018
 - Aug, Oct 2019 [20]
- Multi-wavelength campaign triggered in 2016 [21, right]
 - Follow-up by MAGIC, *Swift*-XRT, ...
 - Hard TeV spectrum
 - Extreme behaviour during outburst
 - Source as **intermittent extreme blazar**



*: CU: Crab Unit, i.e. integral flux of the Crab Nebula above energy threshold

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Affiliations:

¹ Universität Würzburg, Germany – Institute for Theoretical Physics and Astrophysics, Emil-Fischer-Str. 31, 97074 Würzburg
² ETH Zurich, Switzerland – Institute for Particle Physics, Schafmattstr. 20, 8093 Zurich
³ Technische Universität Dortmund, Germany – Experimental Physics 5, Otto-Hahn-Str. 4, 44221 Dortmund
⁴ University of Geneva, Switzerland – Department of Astronomy, Chemin d'Ecogia 16, 1290 Versoix
^a also at RWTH Aachen University

Corresponding author: Daniela Dorner, dorner@astro.uni-wuerzburg.de