High-Energy Survey Observatories

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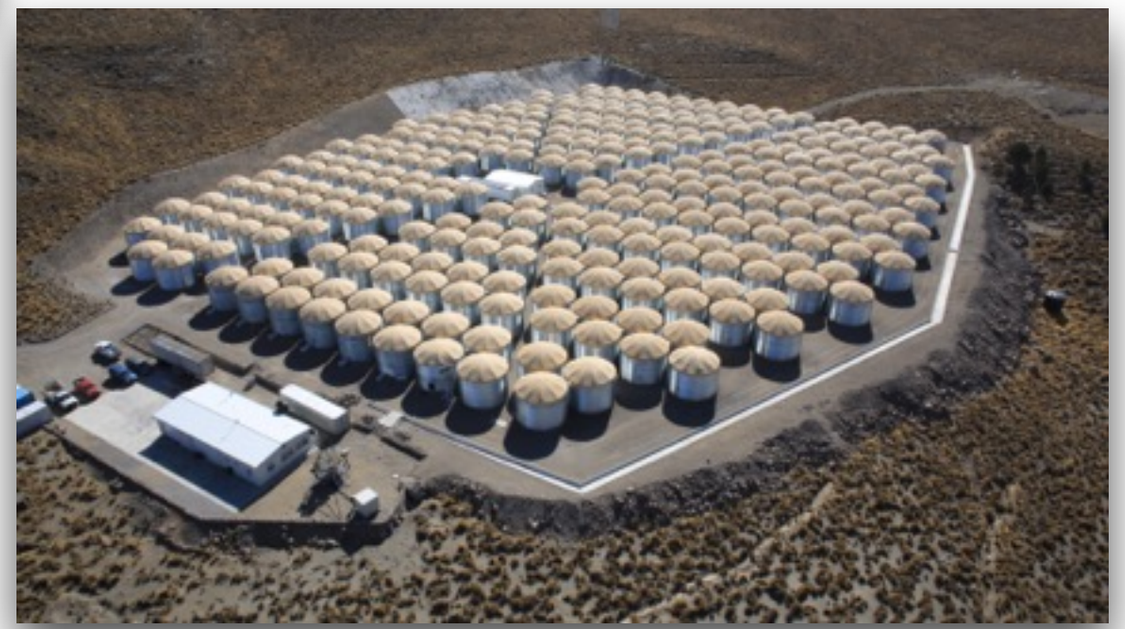
Transient events: need for monitoring instruments

Fermi-LAT

FACT

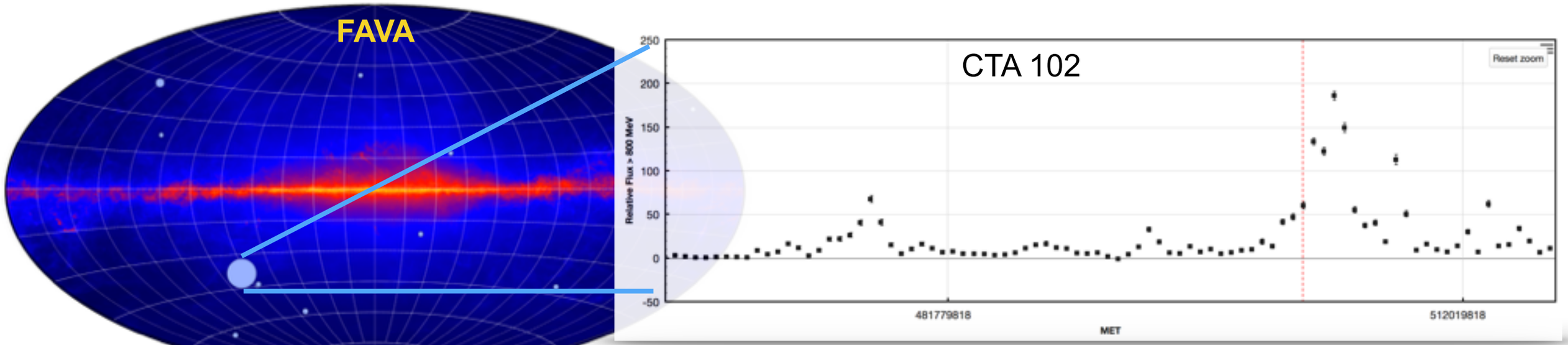
- trigger MWL follow-ups
- long-term light curves
- archival data for follow-up analyses

HAWC + LHAASO

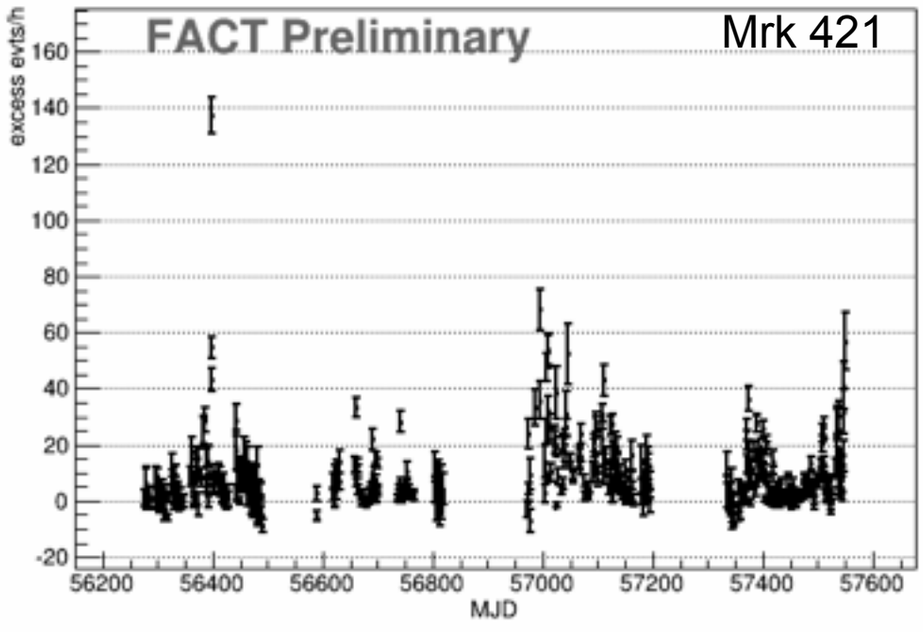


Overview

- best current example: **Fermi-LAT**
  - all-sky monitoring at GeV energies, important input to many ToO programs



- dedicated IACTs: **FACT**
  - monitoring pre-defined list of AGNs
  - gaps due to weather and moon-light



High-energy monitoring in 2020

- global network of FACT like telescopes (proposed)
  - biased and limited list of monitored sources

- HAWC
  - taking data since 2015
  - upgrade/extension in progress

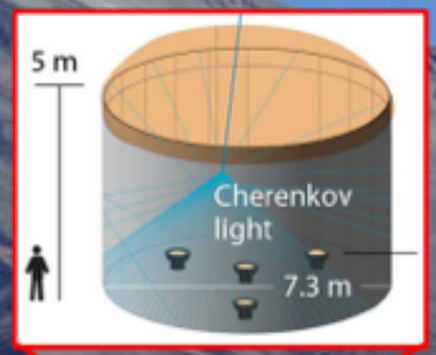
- LHAASO
  - construction started
  - increased sensitivity over HAWC

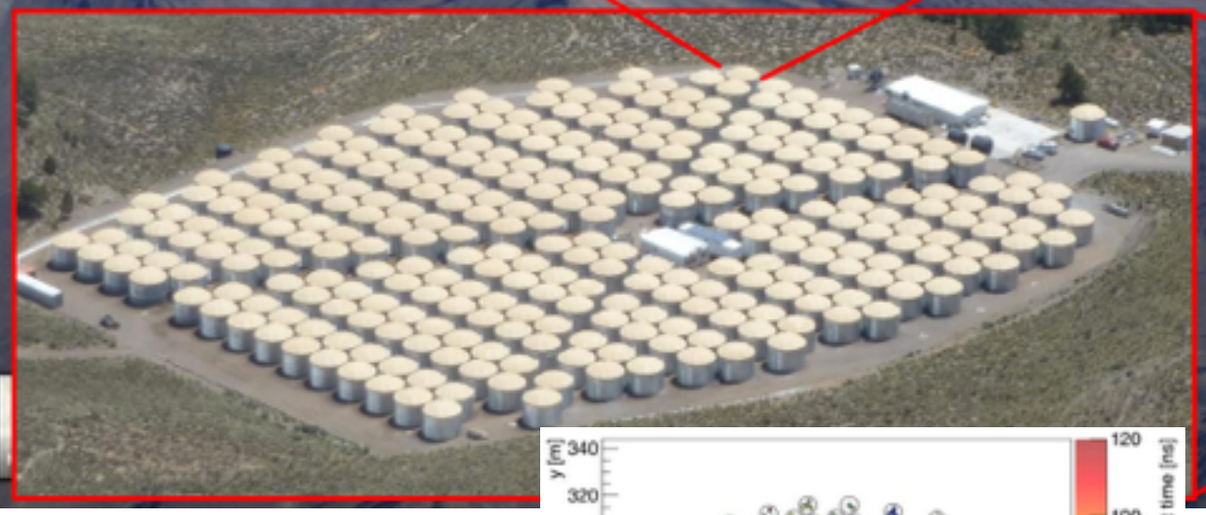
- Next generation instrument in the Southern Hemisphere
  - discussions started

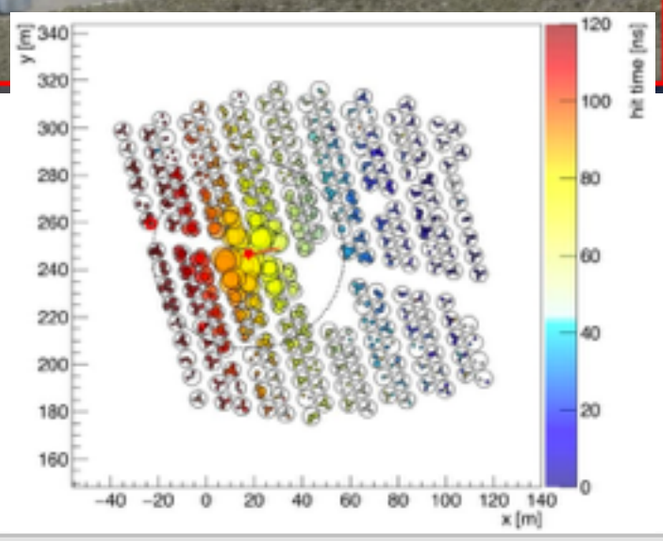
High Altitude Water Cherenkov Observatory (HAWC)

- **22,000 m^2** air shower array
- **300 Water Cherenkov detectors** (WCD)
- **180,000 liters** of purified water **per WCD**
- **4 PMTs per WCD** (3x 8" from Milagro + 1x 10"high QE)
- **Completed March 2015**

Citlaltepetl
Pico de Orizaba
5610m a.s.l.







Large
Millimeter
Telescope
Alfonso Serrano

Tliltepetl
Sierra Negra
4582m a.s.l.

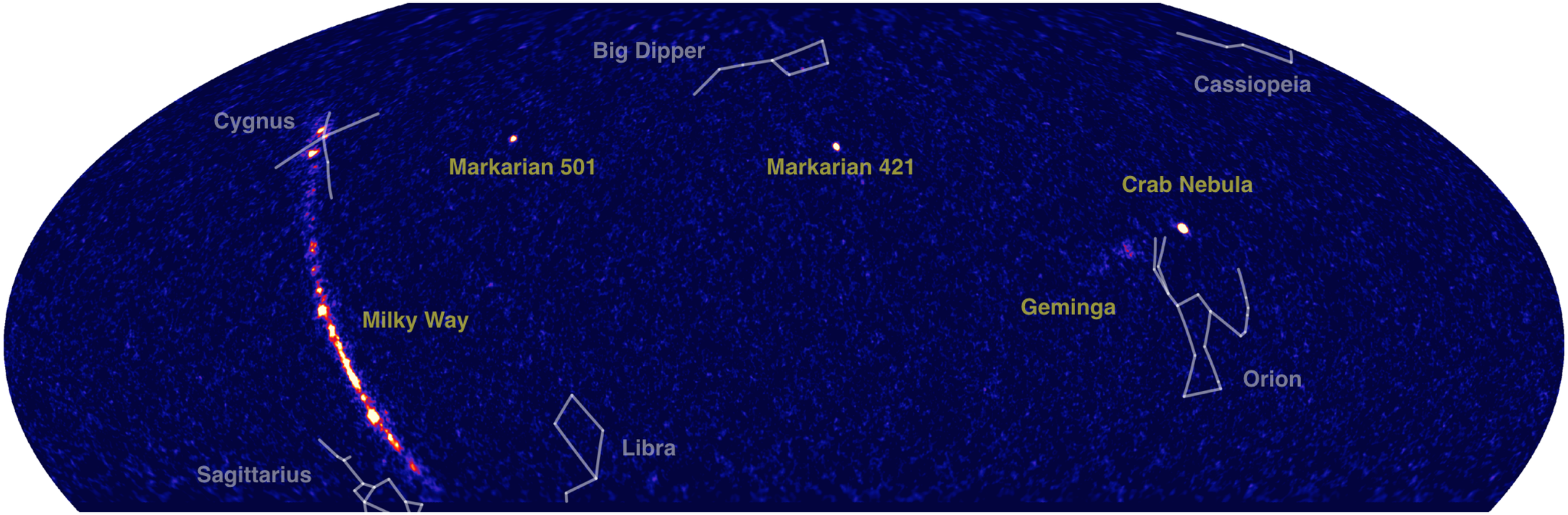
HAWC
4100 m a.s.l.

Google

R. Lauer (HAWC)

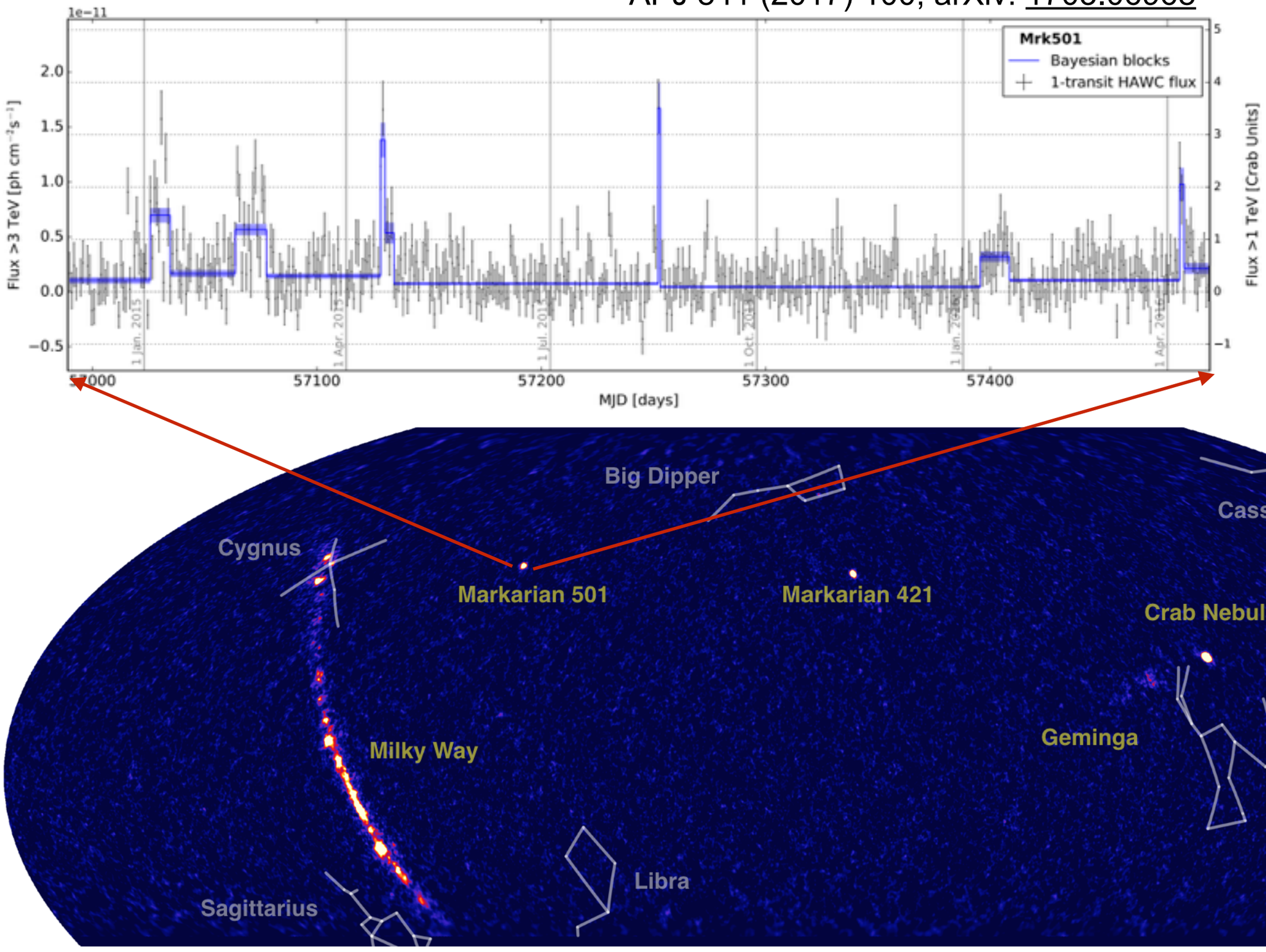
HAWC: monitoring the TeV sky

- first years of observations, 95% duty cycle
- Energy range: 0.5-100 TeV, angular resolution: 1deg - 0.2deg
- second source catalog available (arXiv: 1702.02992)
  - first confirmations (and non-confirmations) reported by VERITAS
  - comparison with HESS Galactic Plane Scan in progress



HAWC: monitoring the TeV sky

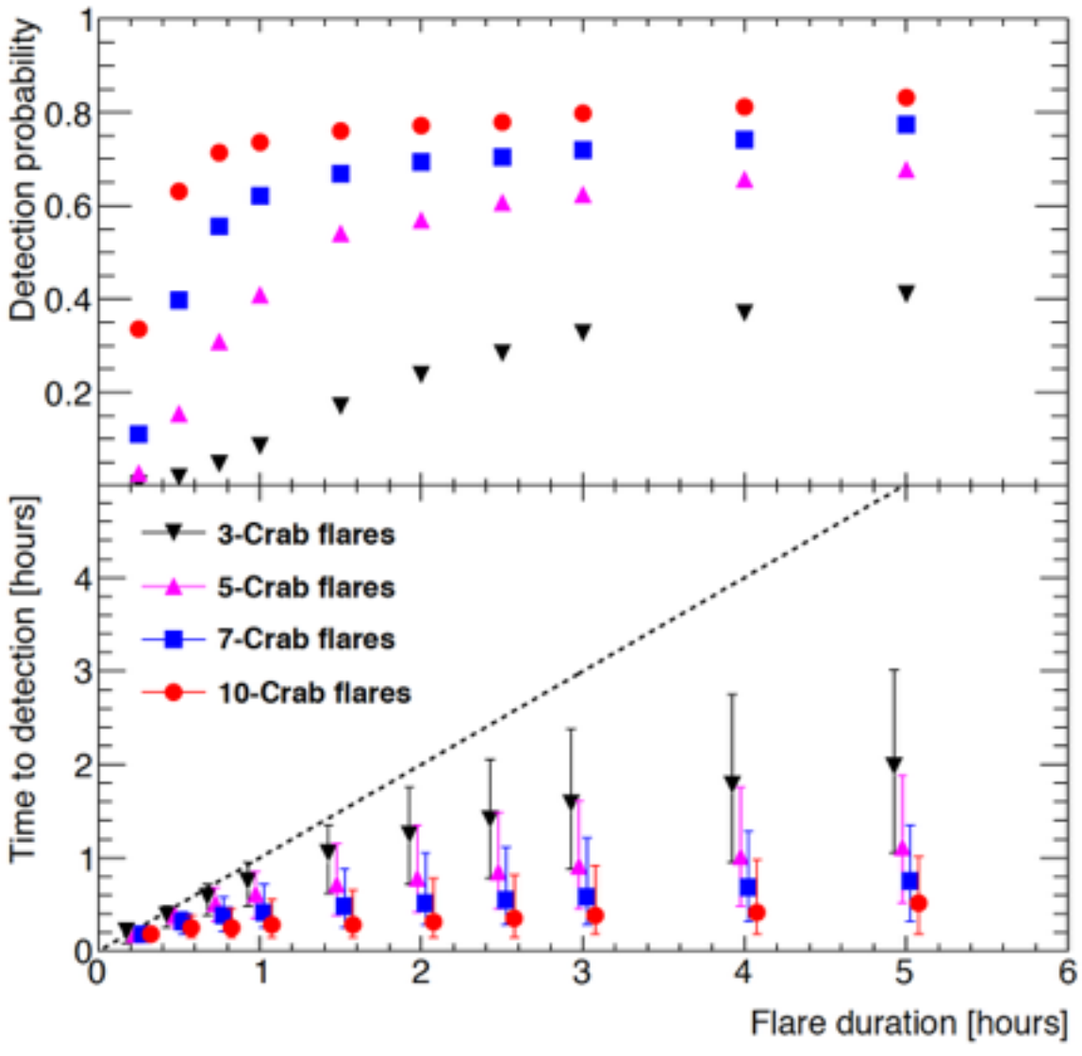
APJ 841 (2017) 100, arXiv: 1703.06968



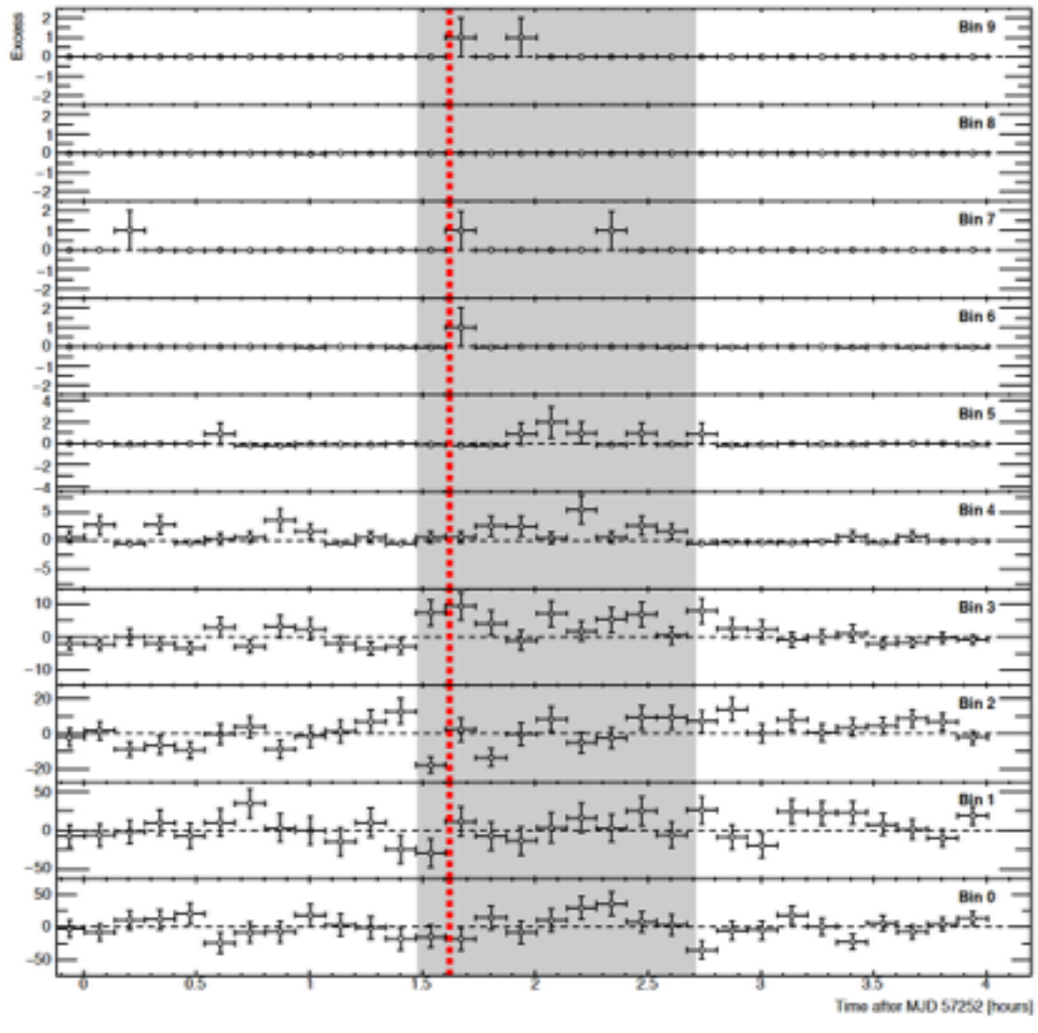
Online alert system
arXiv: 1704.07411

HAWC: online flare monitoring

- online monitoring of sources across the visible sky (~2sr instantaneous FoV)
- flares between 2min and 2days
- alert emission to MoU partners since 01/2017



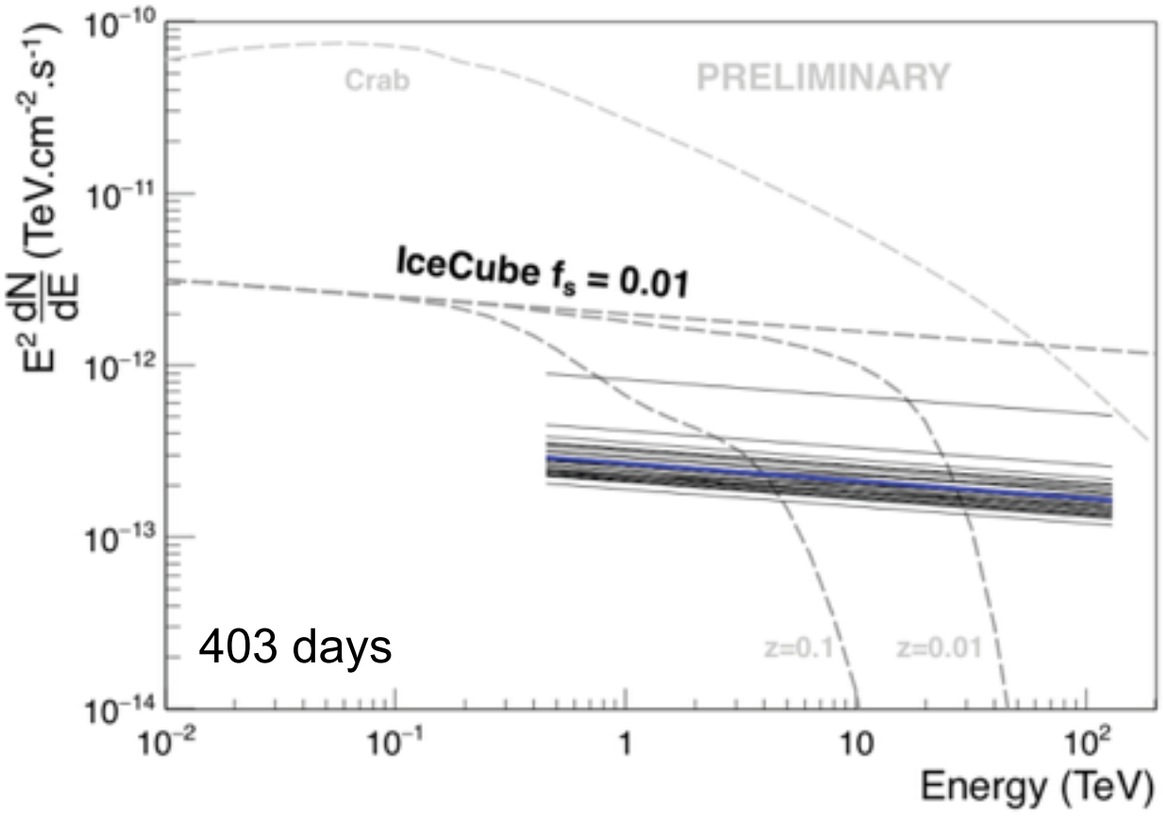
Mrk 501 (August 18, 2015)

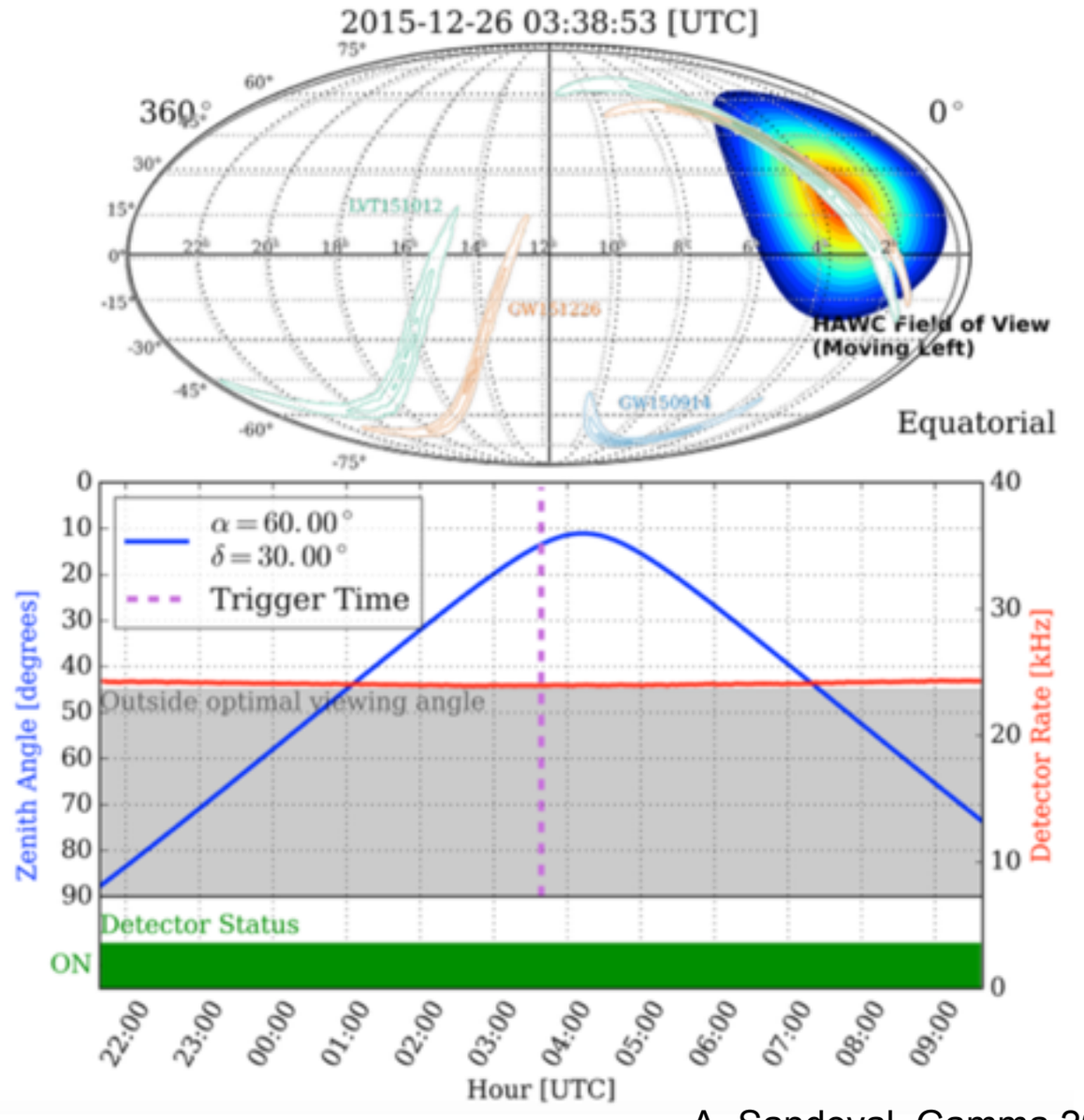


T. Weisgarber (HAWC), arXiv: 1704.07411

HAWC: multi-messenger transients

- full-sky monitoring allows for efficient multi-messenger searches
  - high-energy neutrinos, e.g. IC-HESE tracks (~1deg^2) + cascades ~200deg^2)
  - gravitational waves (~1000deg^2)

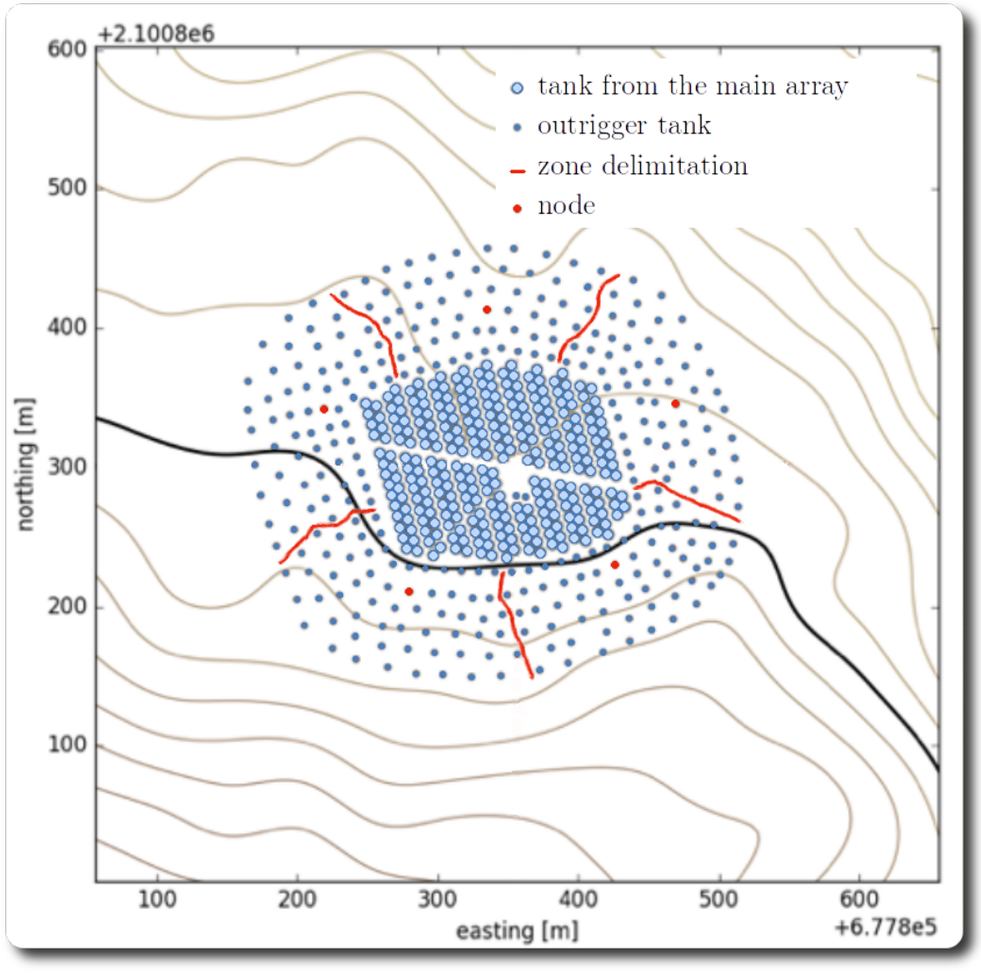




A. Sandoval, Gamma 2016

HAWC: upgrade

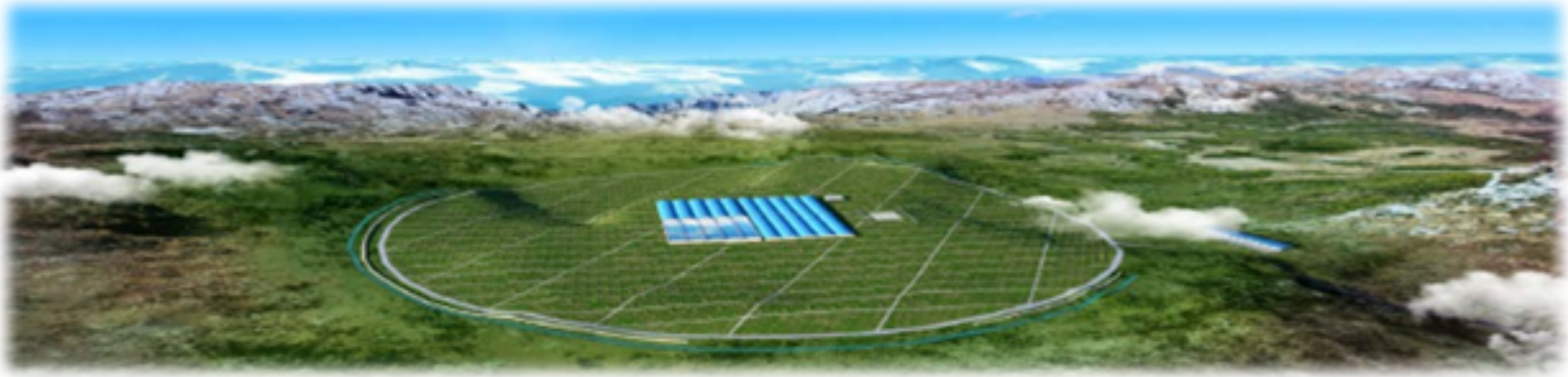
- installation of 300 outrigger stations around the main detector
- improved angular resolution + gamma/hadron separation
  - factor 3-4 increased sensitivity above 10TeV
  - important improvements also at lower energies
- use of CTA electronics (FlashCam@MPIK/Germany)



arXiv: 1509.04269

LHAASO

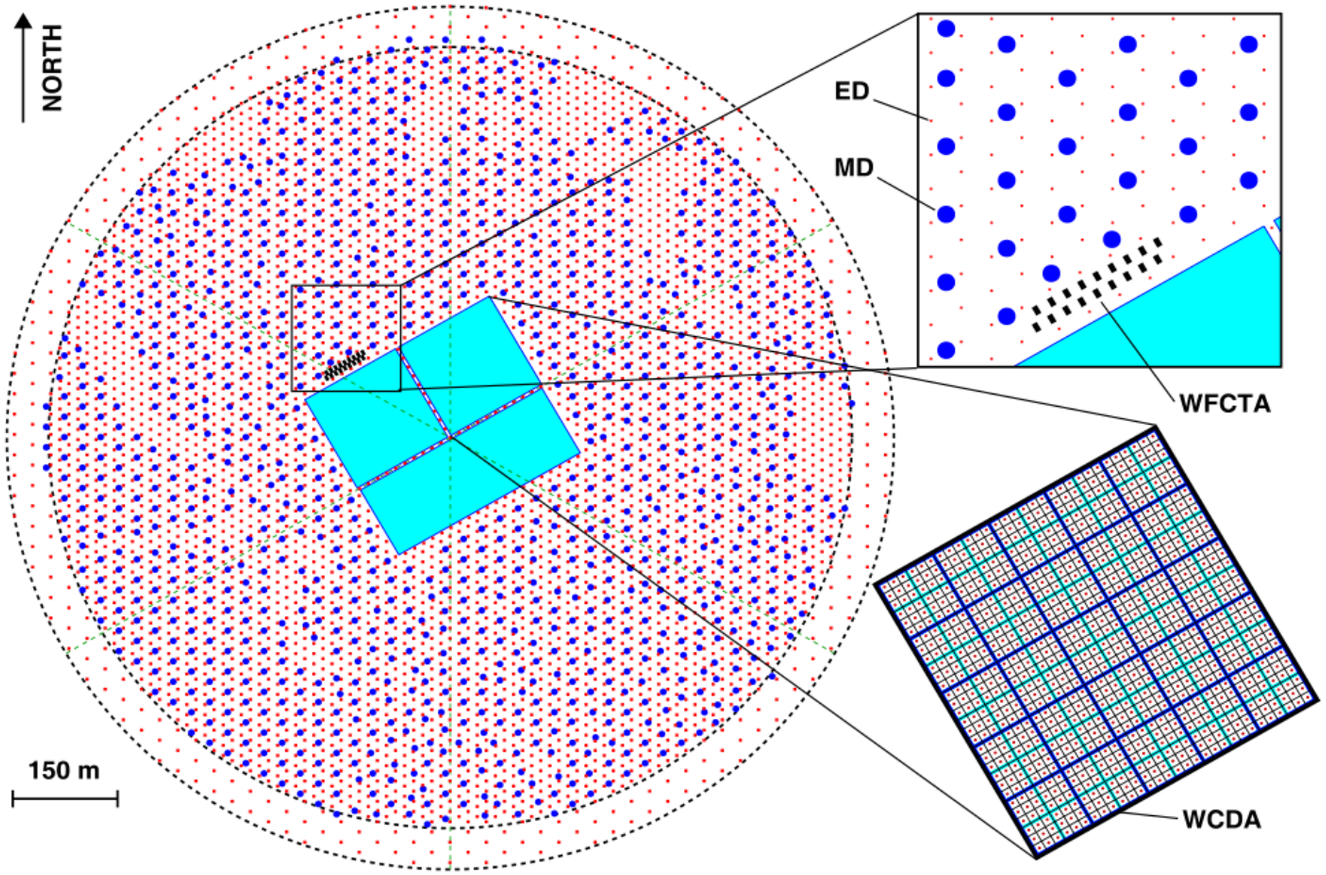
LHAASO site, Sichuan province China, 4410m a.s.l.



The LHAASO project is currently under construction.
Infrastructures will be finished in 2017.
One fourth of the Observatory will be finished in the year of **2018**.
The whole observatory will be completed by the end of **2021**.

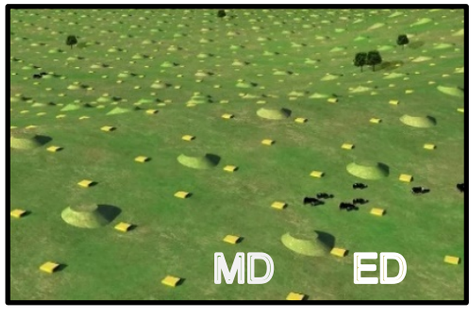
Zizhao Zong (LHAASO)

LHAASO implementations



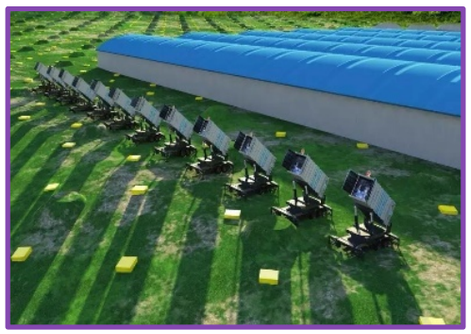
Y. Liu, et al. The Astrophysical Journal (2016)

KM2A



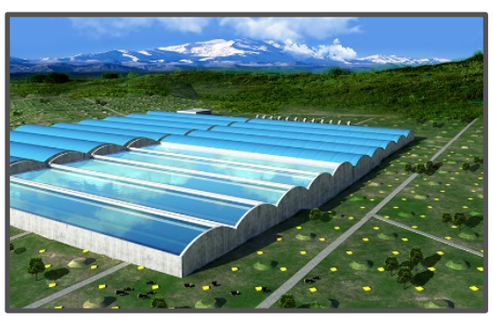
1 km² array
5195 electromagnetic particle detectors (ED)
1171 muon detectors (MD)

WFCTA



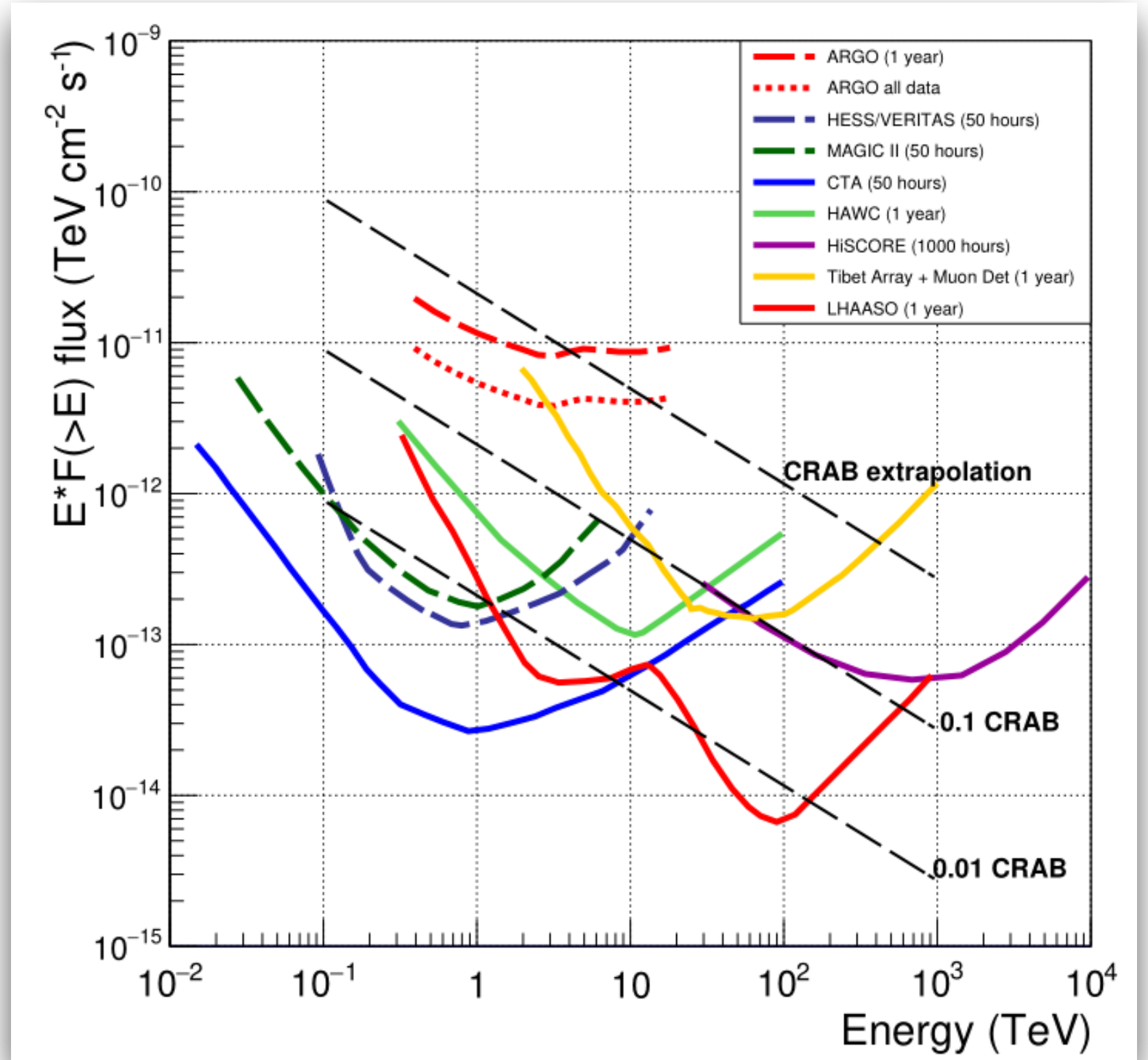
Wide field-of-view (FoV) Cherenkov Telescope Array 12 telescopes
16×14° FoV
1024 pixels in each camera

WCDA



Water Cherenkov Detector Array
3000 detector units
5×5 m² for each unit
Total effective area of 78000 m²

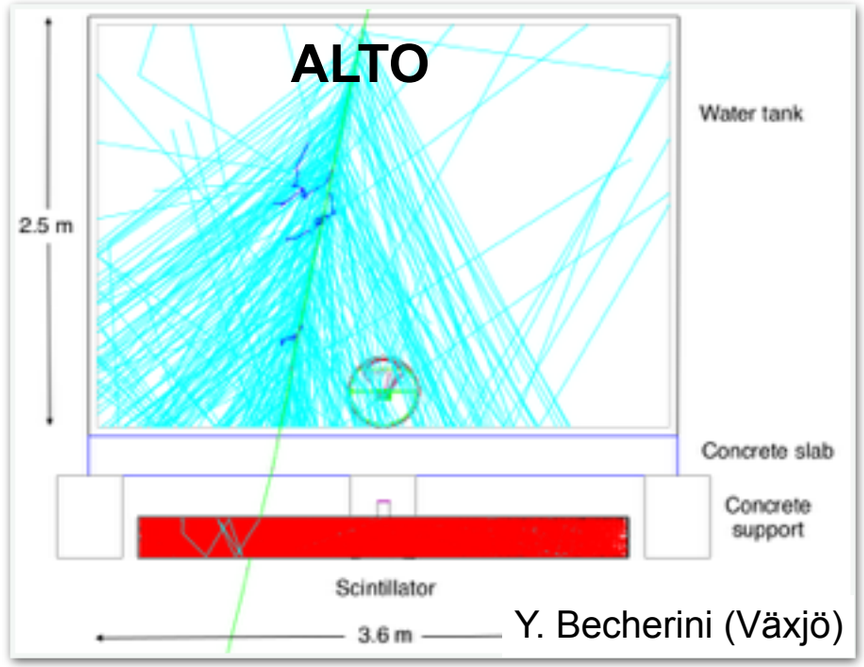
Overview



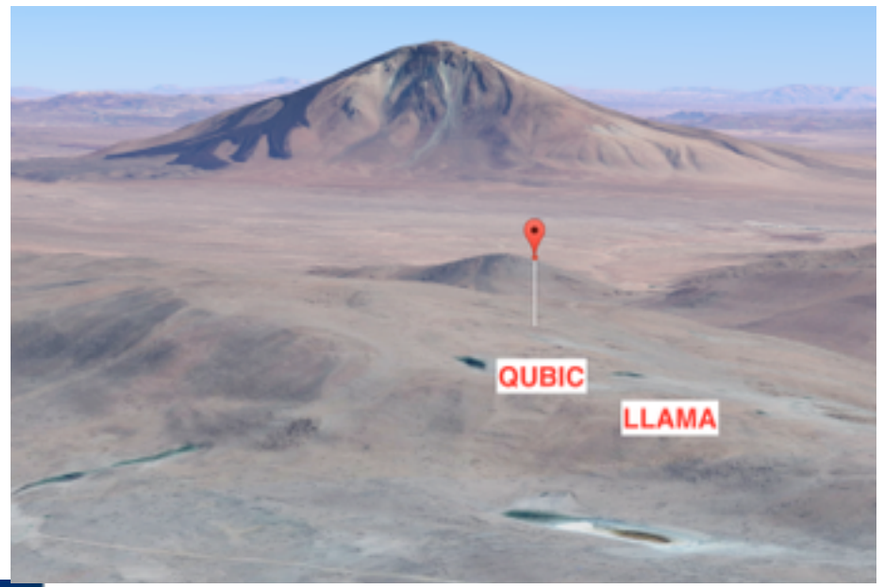
Zizhao Zong (LHAASO)

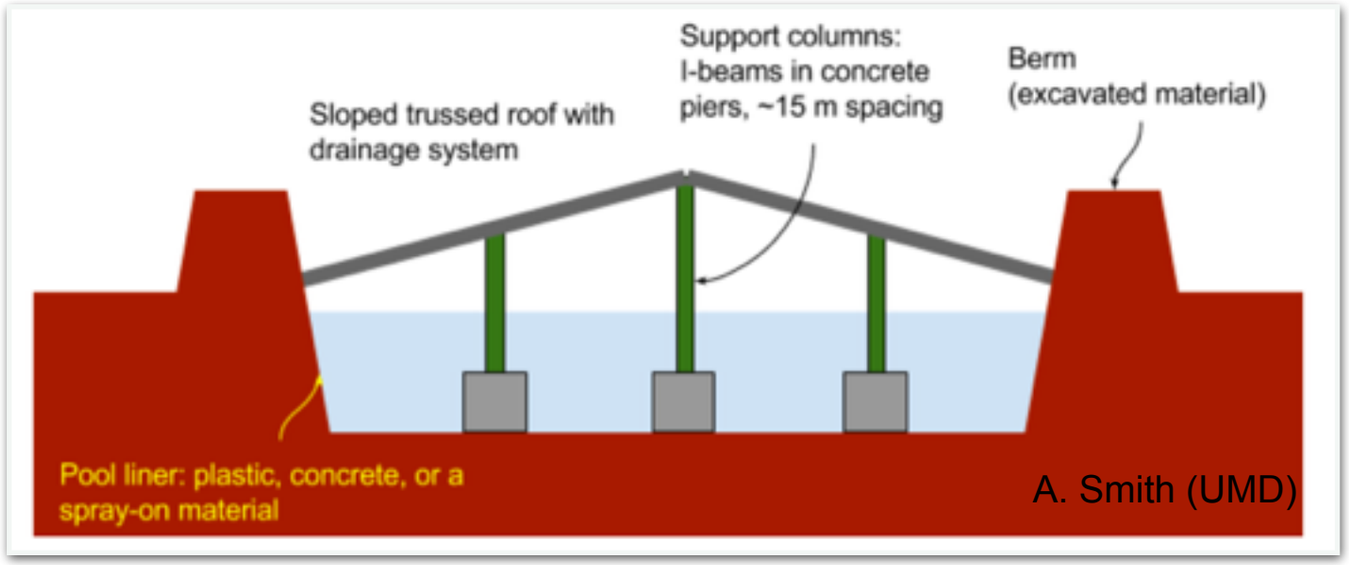
A next generation instrument in the Southern Hemisphere (?)

- community starting to form
  - first workshop 11/2016 (Puebla, Mexico) + second workshop in 06/2017 (Rochester/NY)
- White paper on Science Case in preparation
  - “Studying Galactic Particle Accelerators”
  - *“Monitoring the Transient Sky”*
  - “Probing Physics Beyond the Standard Model”
- various design proposals discussed in parallel
- various sites under consideration



Y. Becherini (Växjö)

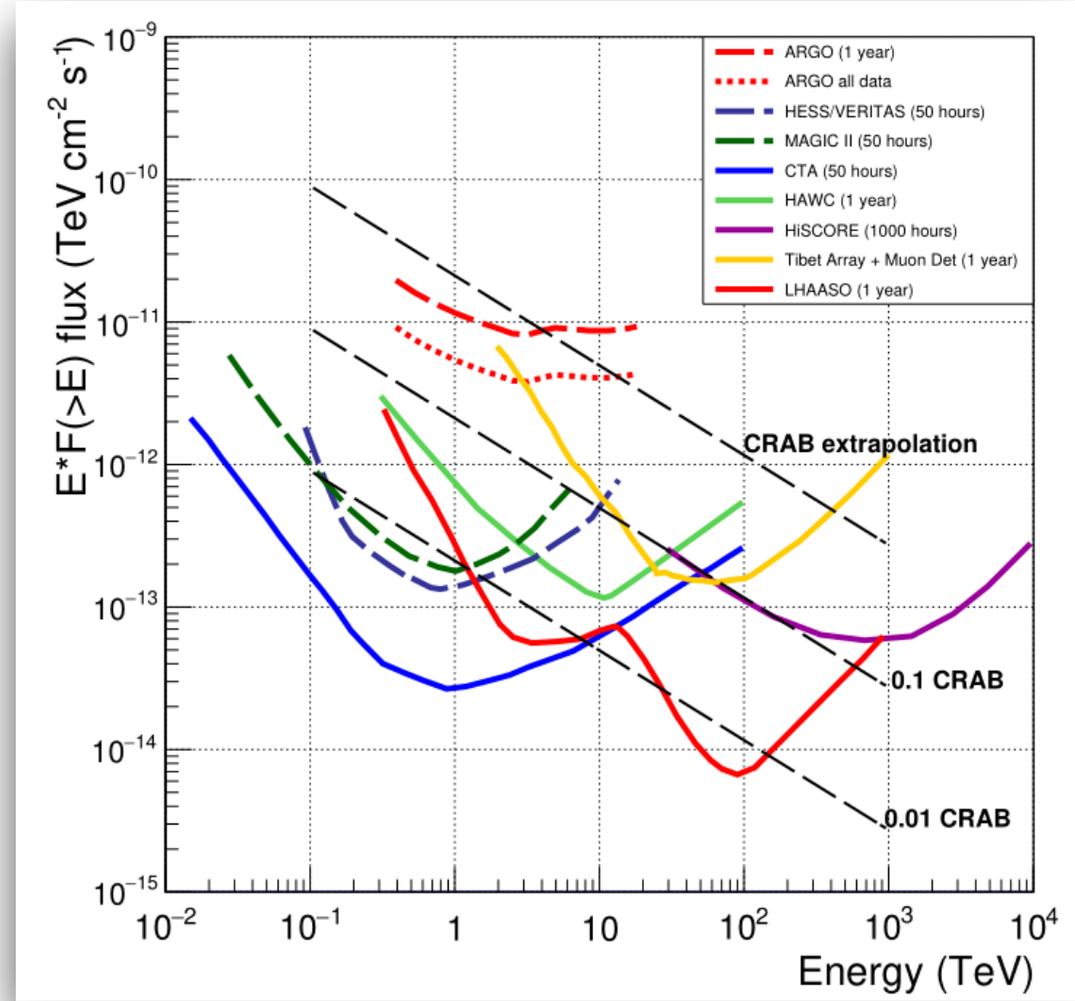




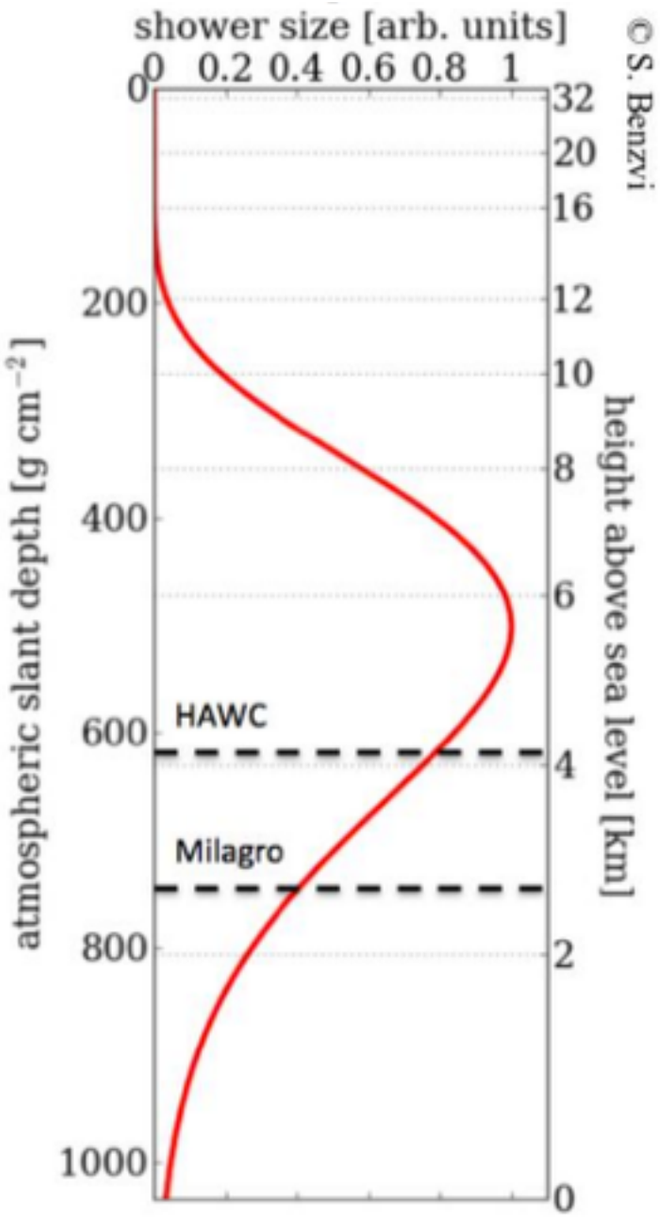
A. Smith (UMD)

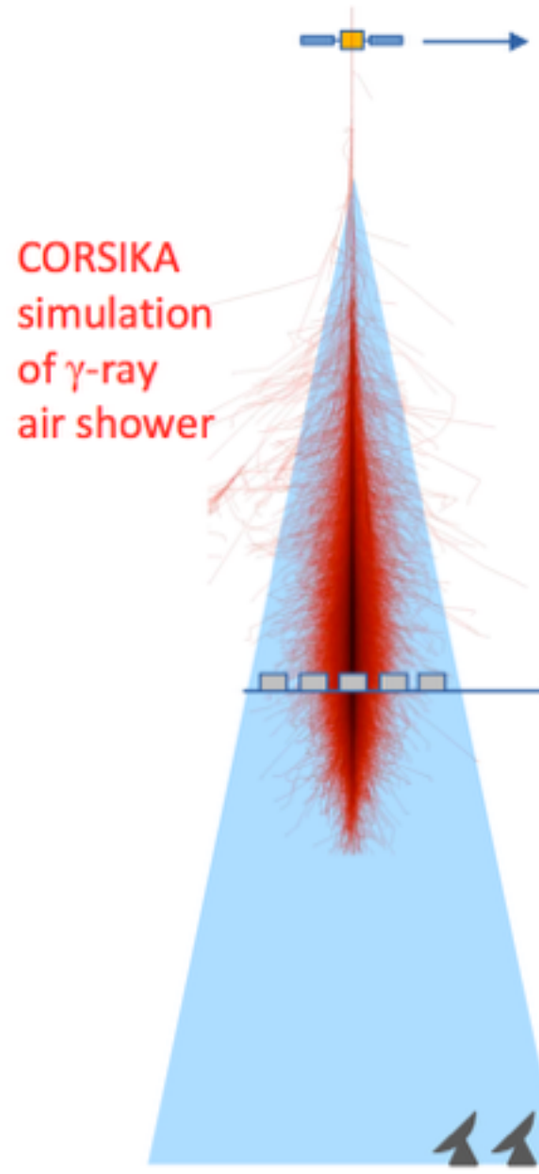
Summary

- currently a large variety of instruments are monitoring the HE+VHE sky
  - Fermi-LAT (+ Swift-BAT, etc.)
  - FACT
  - HAWC
- Transient Sky in 2020
  - Fermi-LAT (?)
  - FACT world-wide network (?)
  - HAWC + outriggers
  - LHAASO
  - Next generation observatory in the Southern Hemisphere (??, 2020++)



- HE + VHE monitoring crucial for a large range of transient searches
  - realtime alerts on a large variety of transient sources
  - long-term monitoring + light-curves
  - archival data (”go back in time and check for signal from a given direction”)
- Important synergies with CTA: ”finder scopes” triggering deep follow-up observations of transient events





Direct γ-detection

Shower particle interception

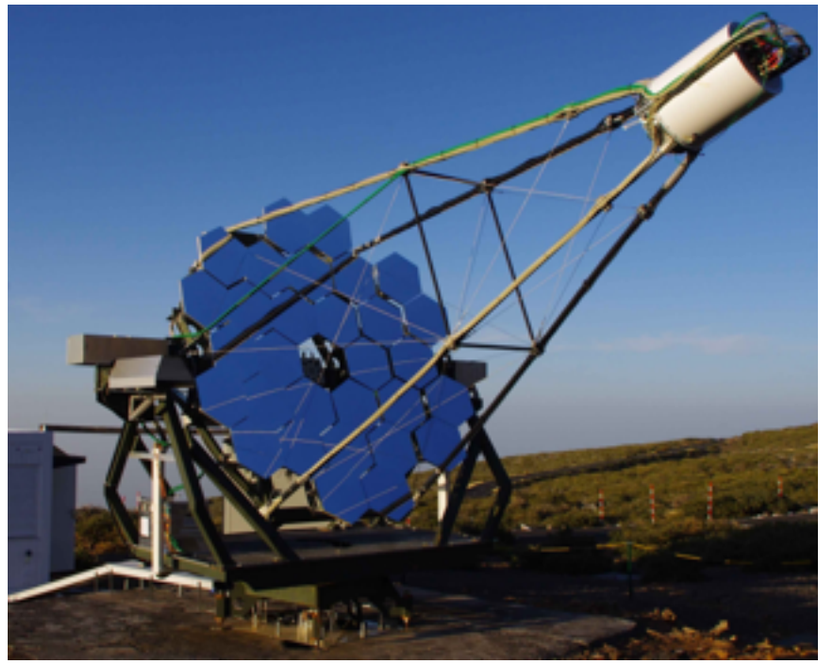
Shower imaging

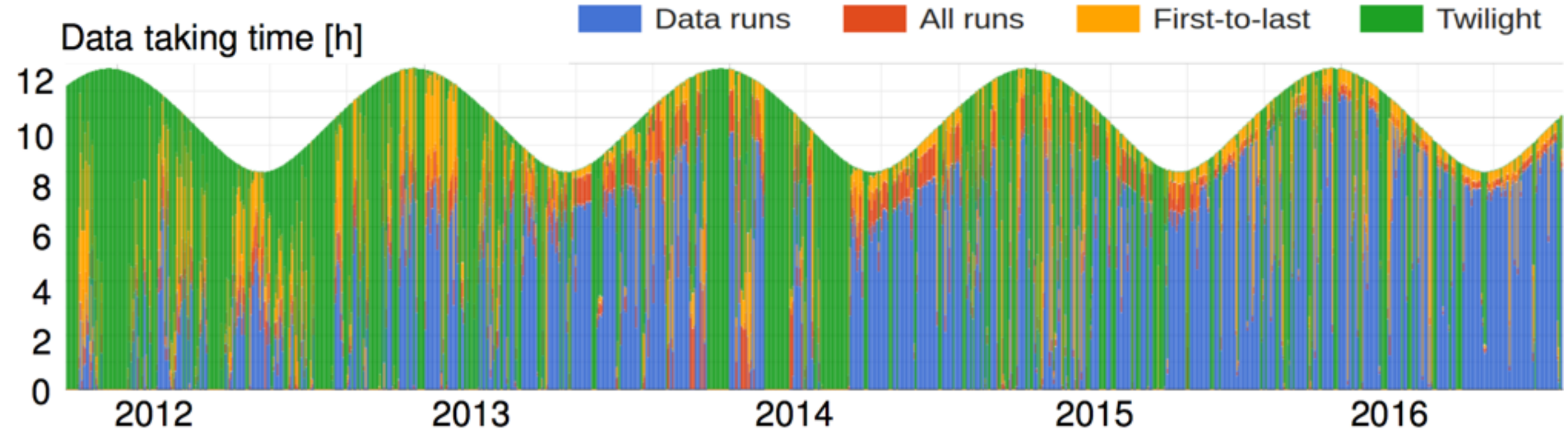
Wide Field of View, Continuous Operation, TeV Sensitivity

R. Lauer (HAWC)

FACT

- HEGRA telescope mount
- SiPM camera (operation during moon-light possible)
- largely automatized + remote monitoring

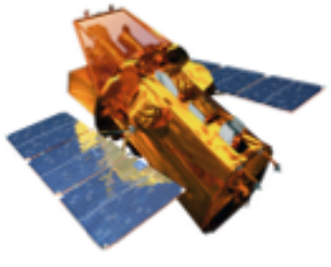


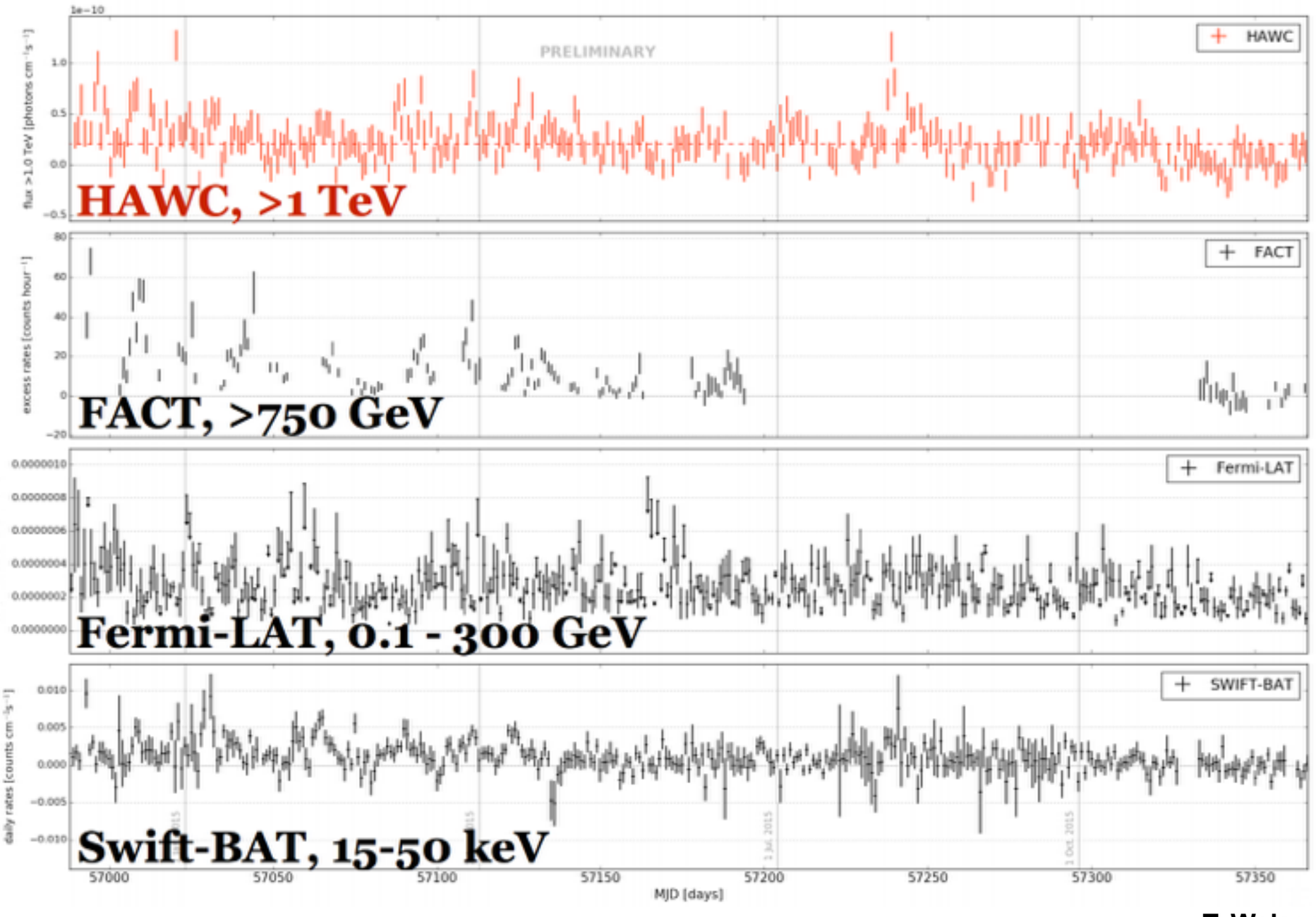


D. Dorner et al.

Long-term light-curves across the EM spectrum

- currently: various wide FoV instruments monitoring the sky
- extremely valuable for long-term MWL studies





T. Weisgarber (HAWC)