ETH zürich

ETH Institute for Particle Physics

FACT
First G-APD Cherenkov Telescope

The First G-APD Cherenkov Telescope: Status and Results

Gareth Hughes for the **FACT** Collaboration
Annual Meeting of the SPS, 2014

Outline

- **FACT: F**irst G-**A**PD **C**herenkov **T**elescope
- Proof of concept for Geiger-mode Avalanche Photodiodes for Cherenkov astronomy
  > 2.5 years of operation
- How we calibrate and operate the telescope
- Atmospheric Monitoring
- Monitoring of Blazars

FACT Collaboration

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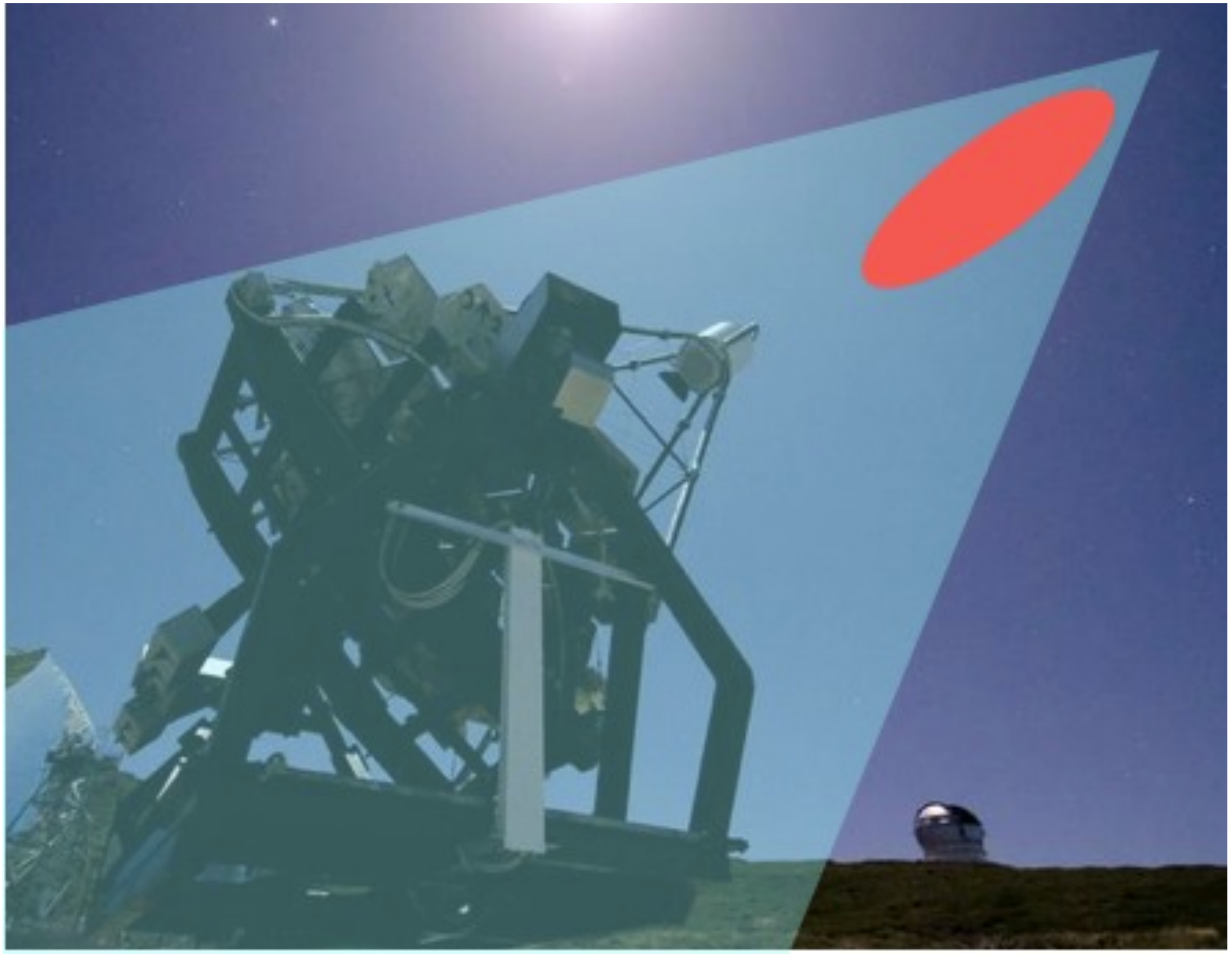
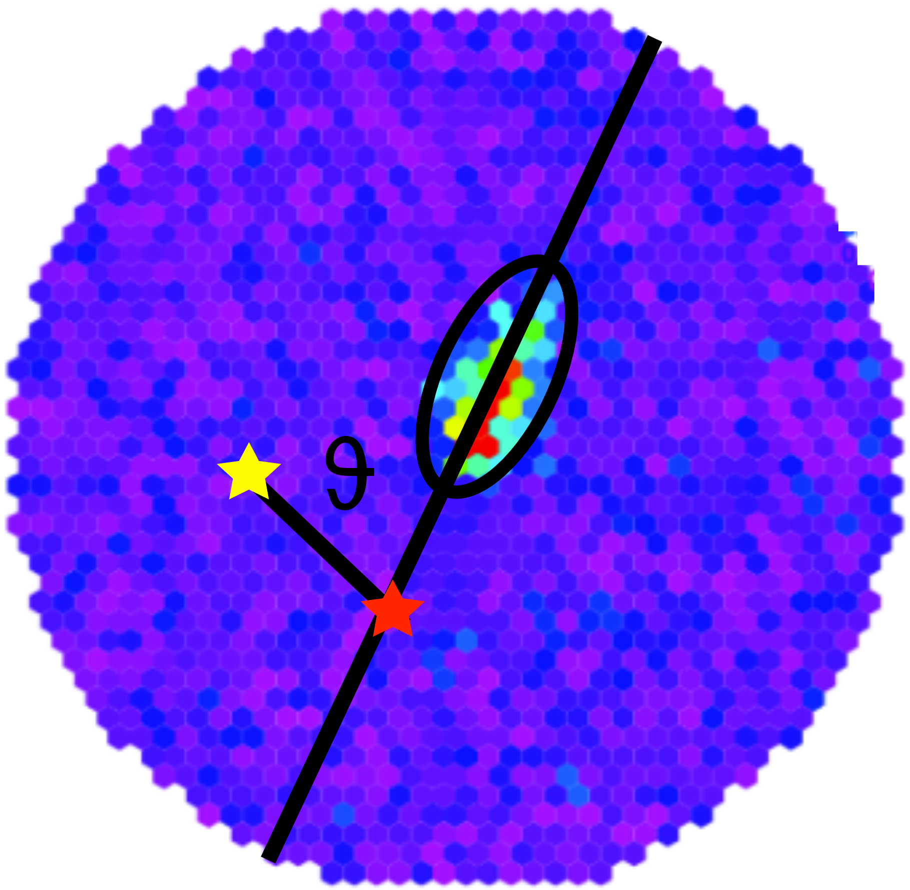
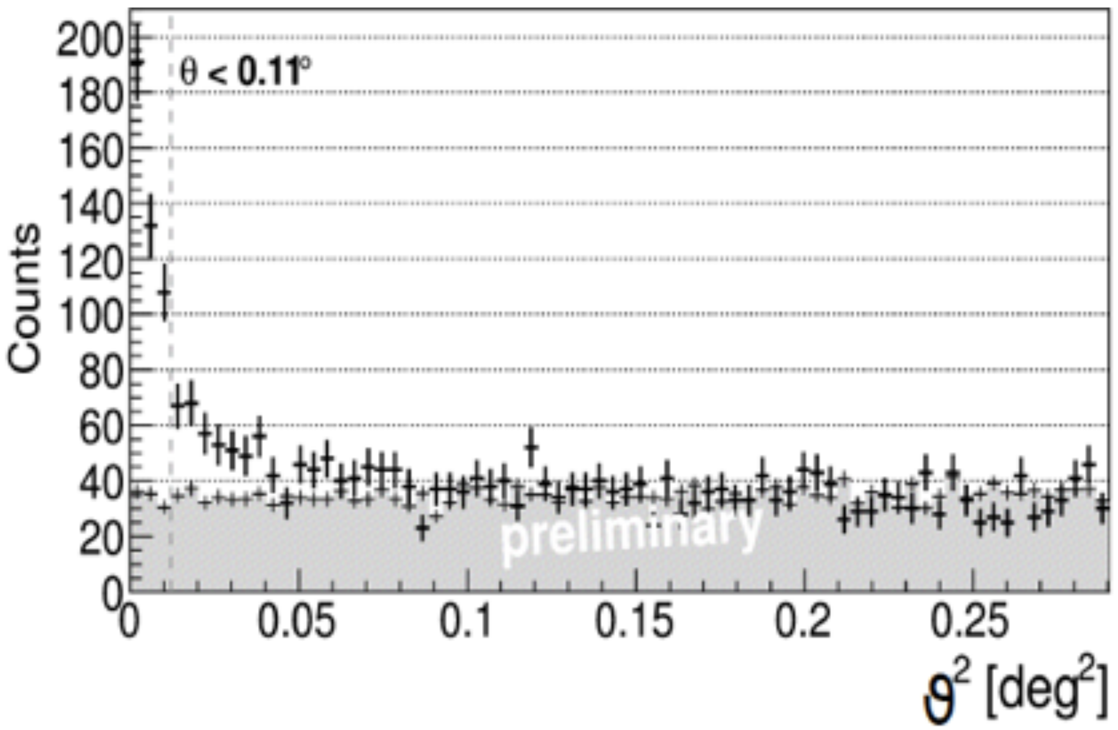
Cherenkov Technique



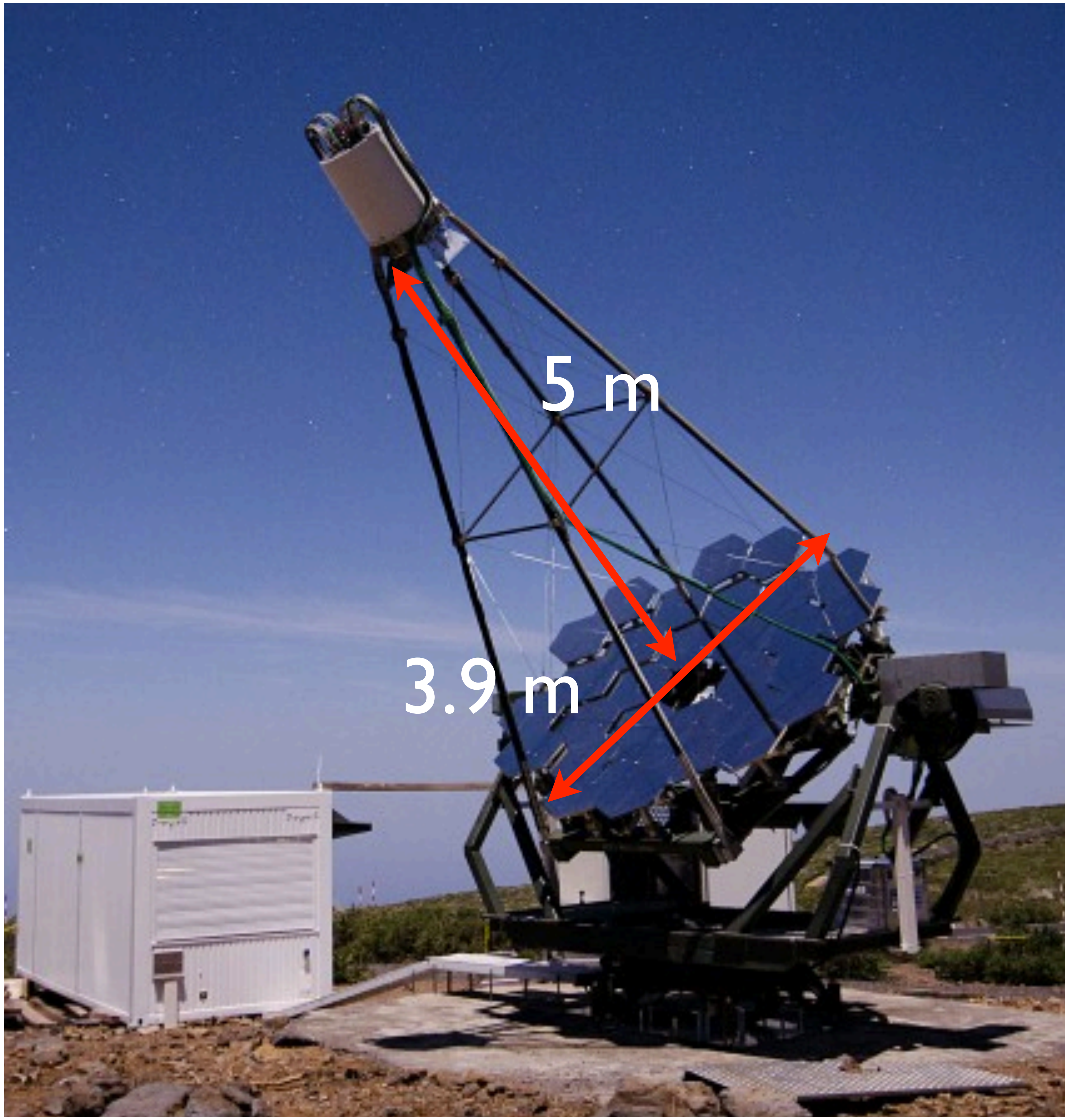




- Signal is fast O(~ns)
- Number of photons few →few 1000
- Peaked in the UV range

First G-APD Cherenkov Telescope

- 2km a.s.l La Palma
- Old HEGRA Mount
- Mirror Area 9.51 m^2
- 30 reconditioned facets
- Davies-Cotton Optics



G-APDs (SiPM)

- Hamamatsu MPPC S10362-33-50C
- Comparison with Photo-Multiplier Tubes:
  - Cheaper than PMTs
  - Similar detection efficiencies
  - Do not suffer significant aging (Moonlight)
  - Can be read out quickly
  - Voltages can be much lower
    (100V compare to 1000V for PMTs)
- Astroparticle community knows how to handle cross-talk and after pulsing

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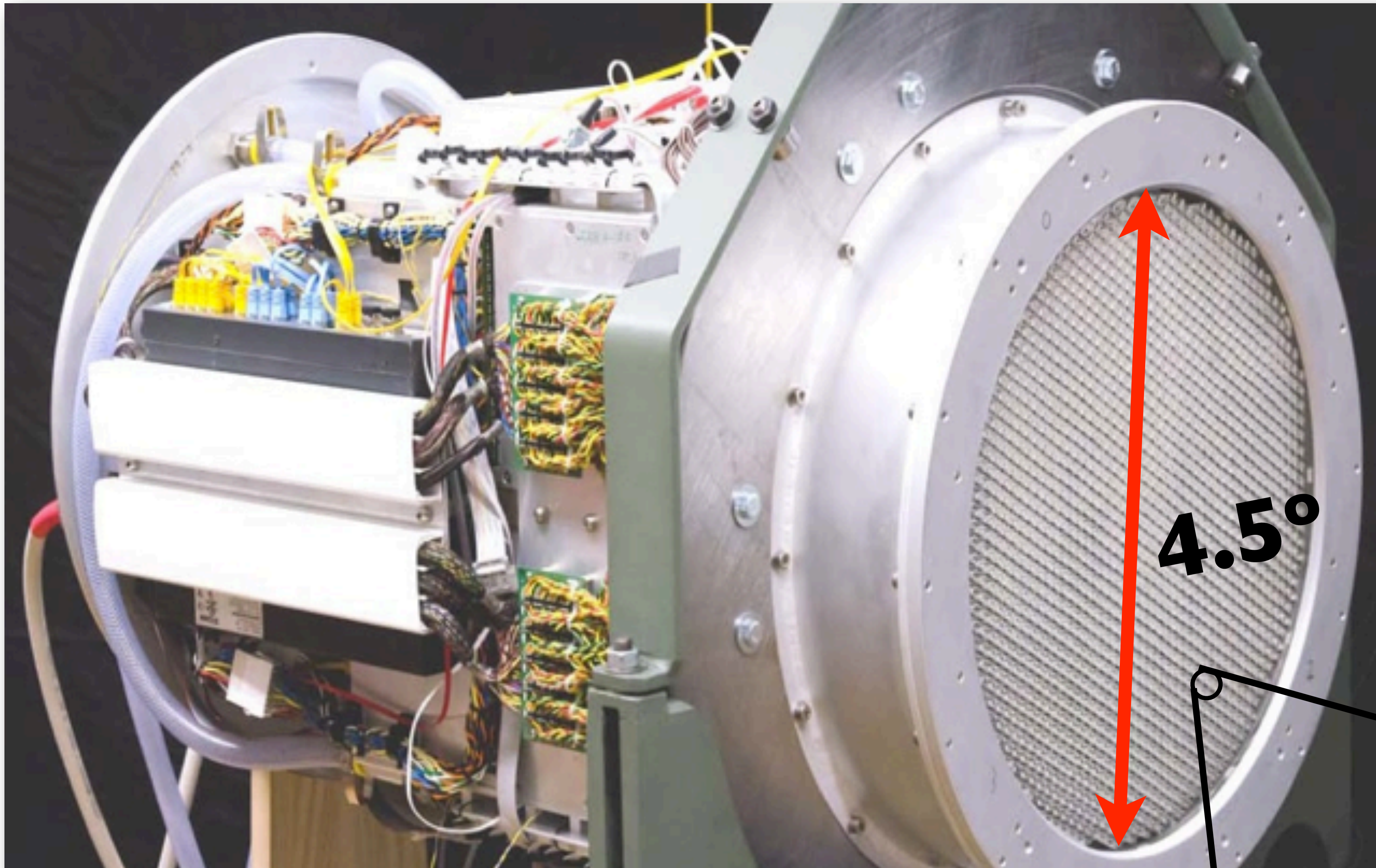
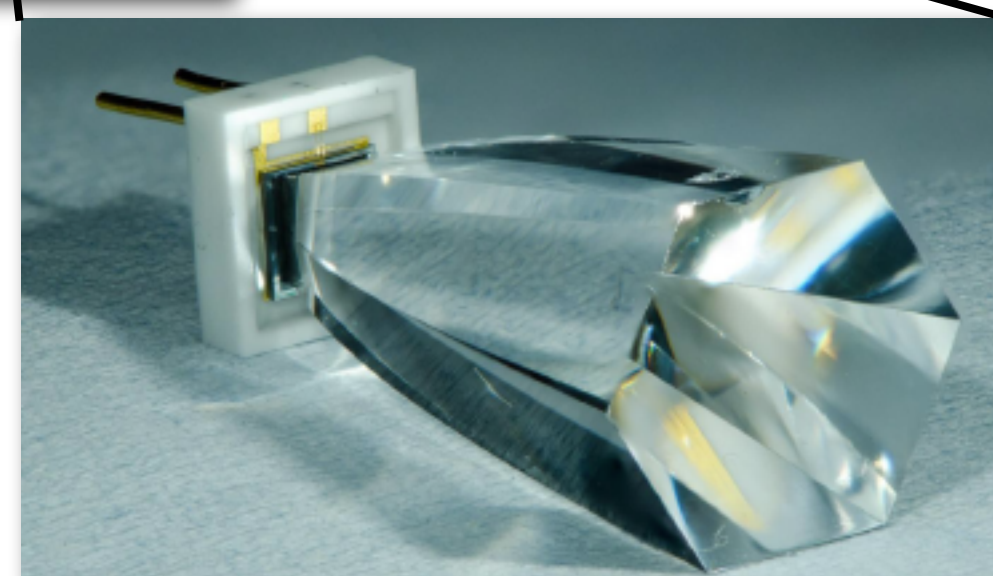
- However the gain is **temperature dependent** and **ambient light** will result in voltage drop (due to serial resistors)
  ⇒ **Feedback system required**

FACT Camera

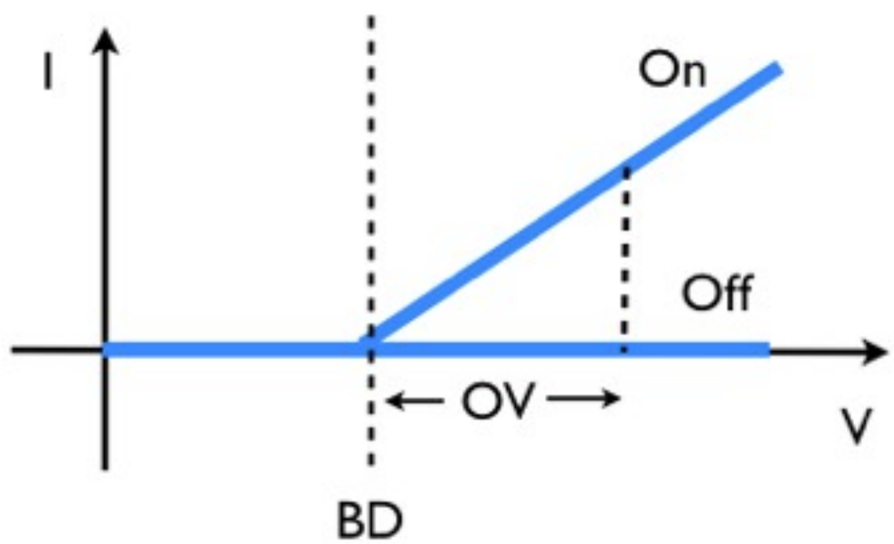


- 1440 G-APDs (SiPM) and readout channels
  Hamamatsu MPPC S10362-33-50C
- Active area of 3×3 mm^2

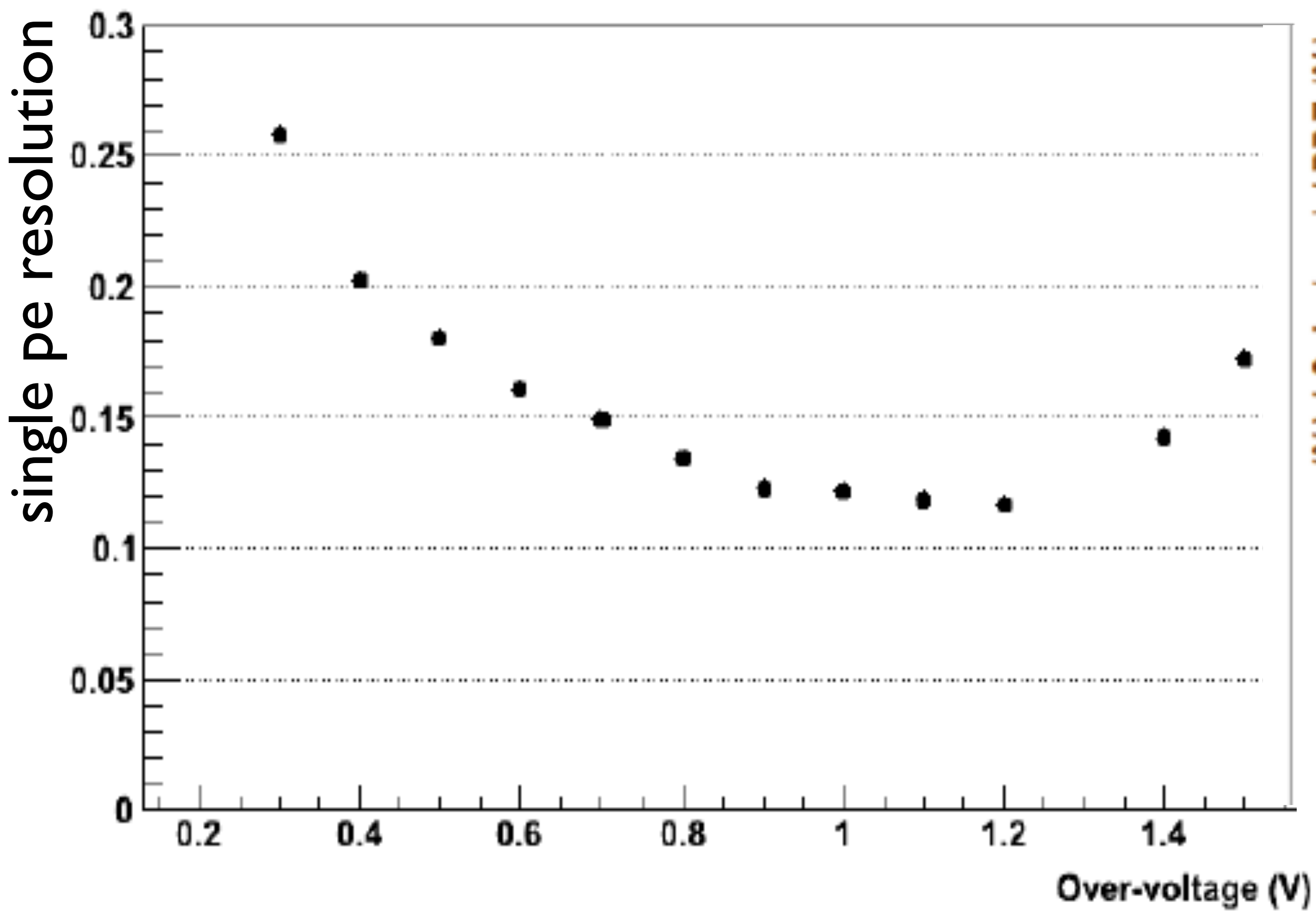
- 40 DAQ readout boards (DRS4)
- 320 bias voltage channels
- ~500 Watt power consumption
  Water Cooled

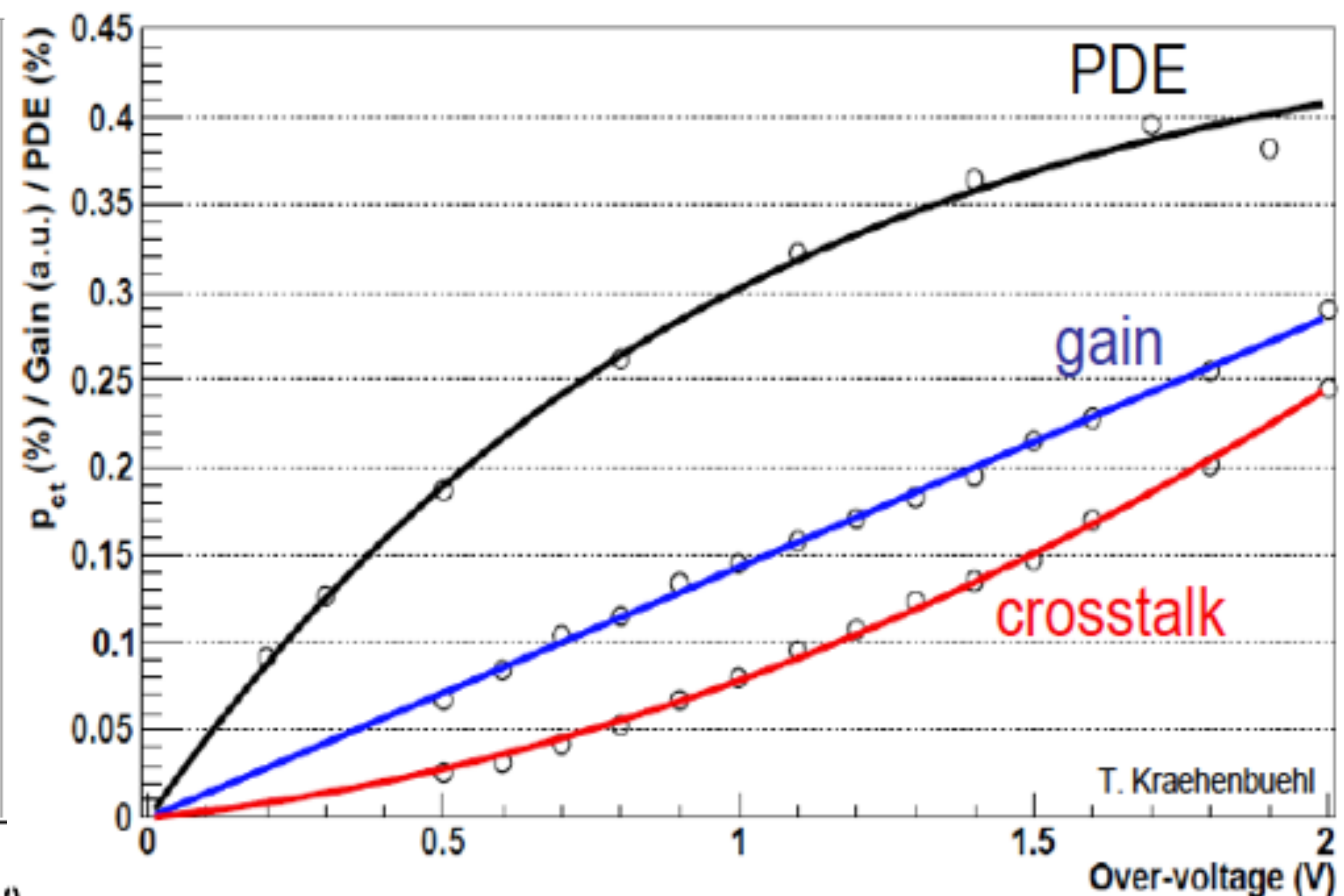


Over-Voltage

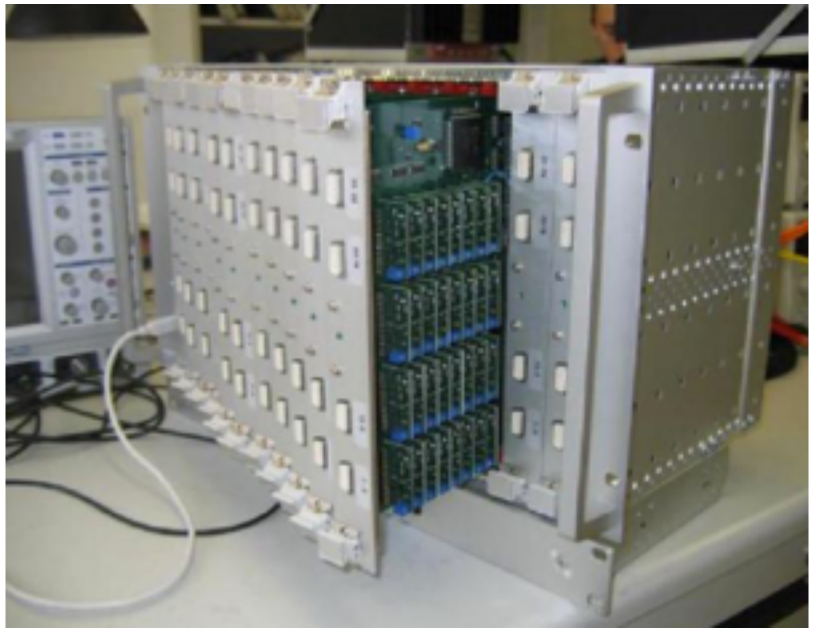


- V_{BD} depends linearly on Temperature
- Cross talk vs PDE: Both depend on Over-Voltage
- As well as Single PE resolution
- Best Over-Voltage found to be just above 1 V



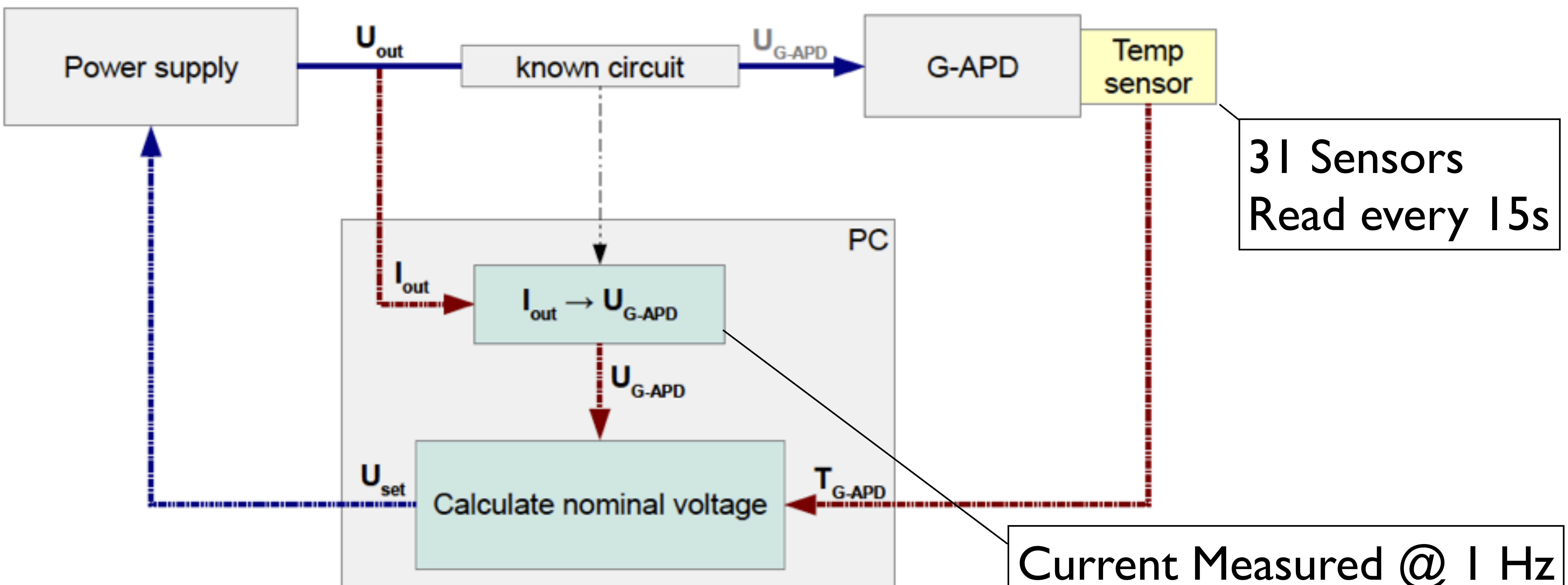


Feedback: Temperature



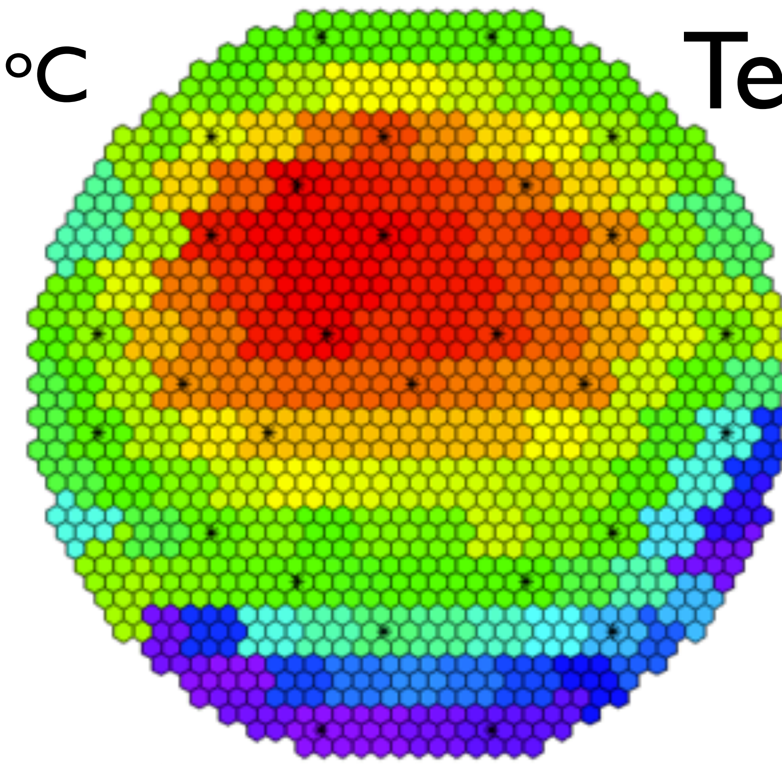
- 320 bias voltage channels

Max Voltage 90 V
Max Current 4 mA
ΔV ~ 22 mV
ΔI ~ 1.2 μA



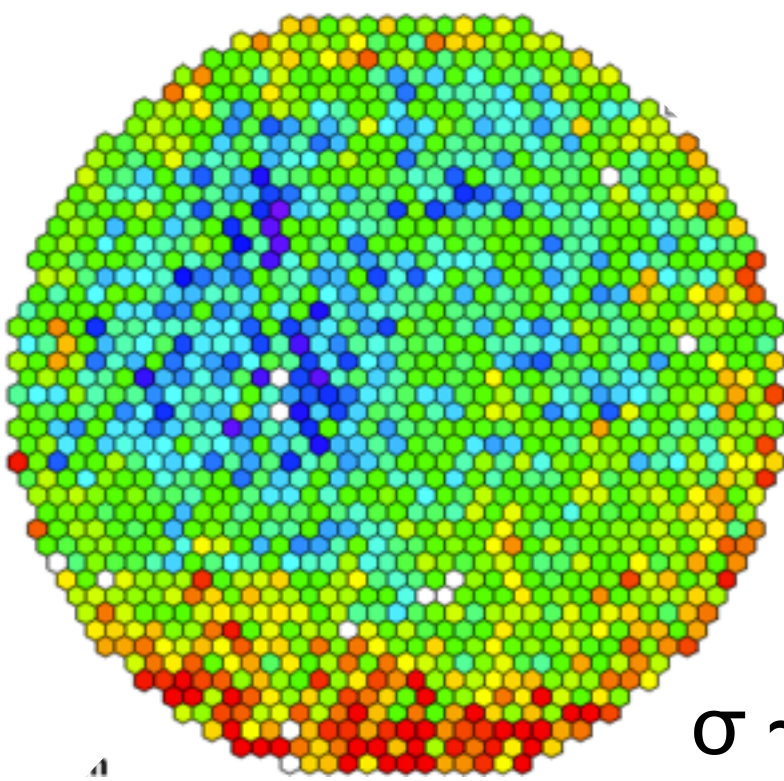
Feedback: Temperature

ΔT ~ 3.5°C



Temperature

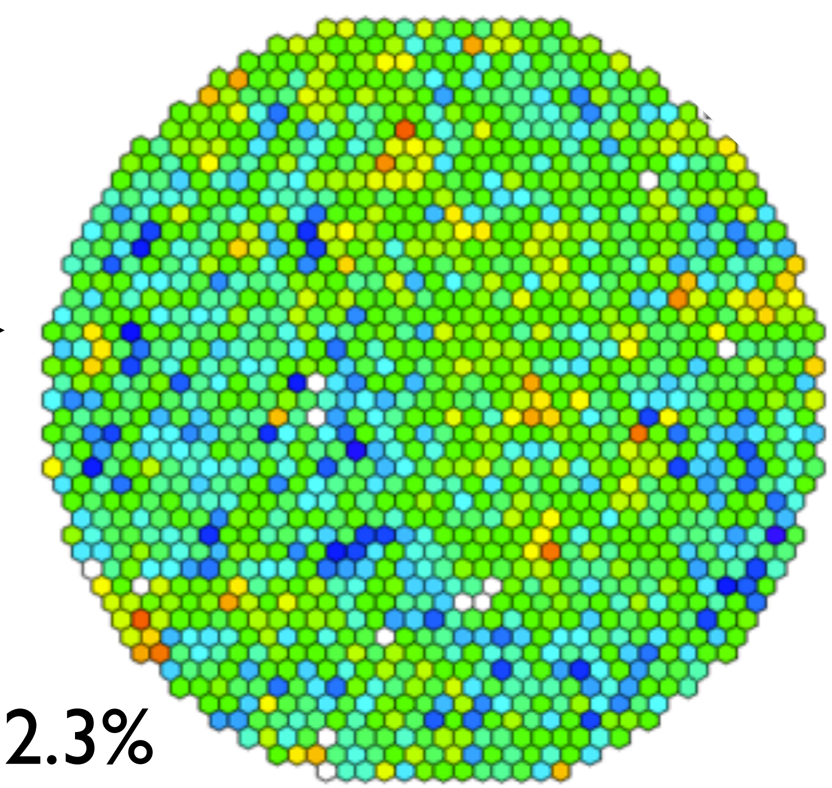
Gain



σ ~ 4%

Voltage Correction

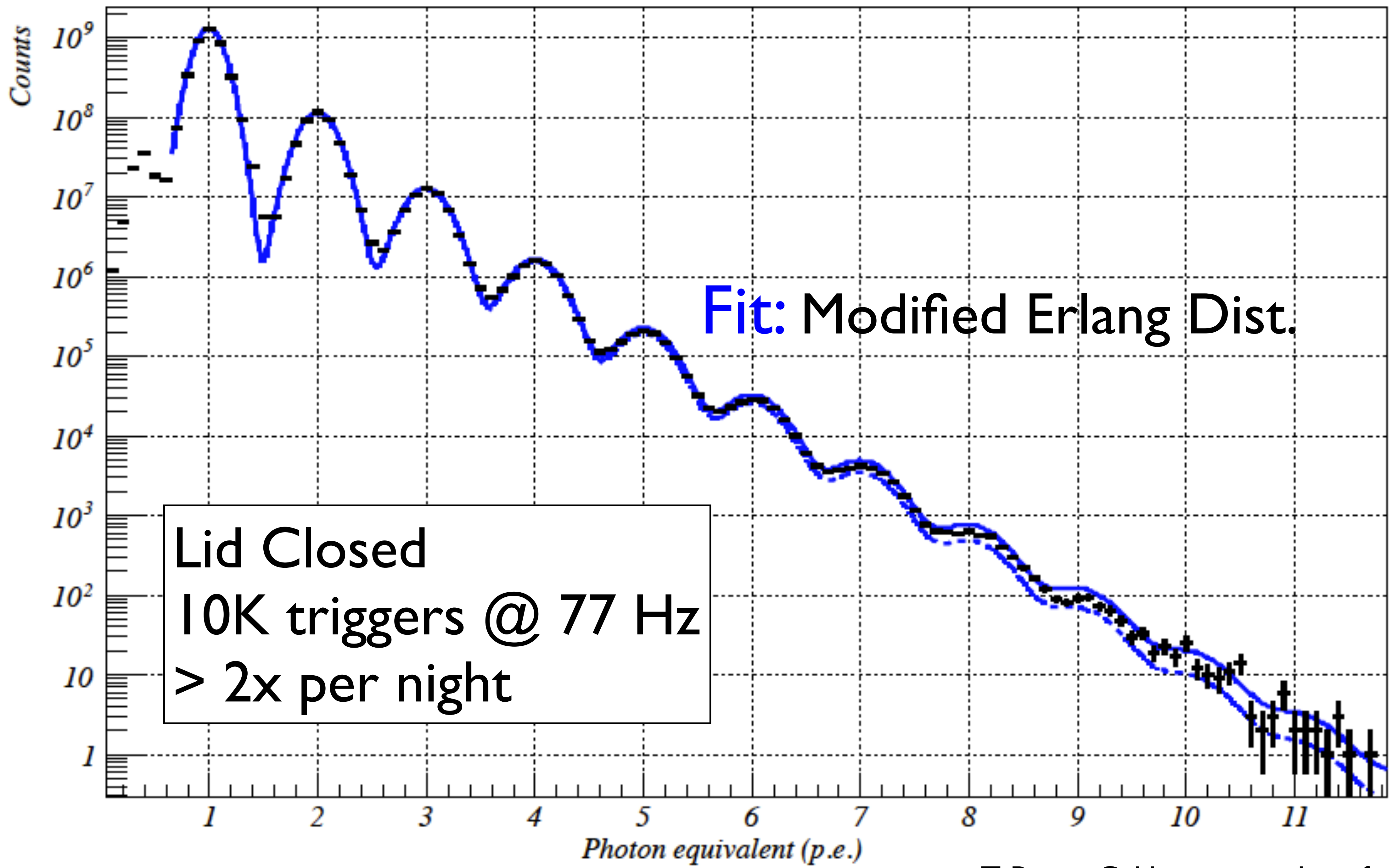
Gain



σ ~ 2.3%

Feedback: Dark Count Spectra

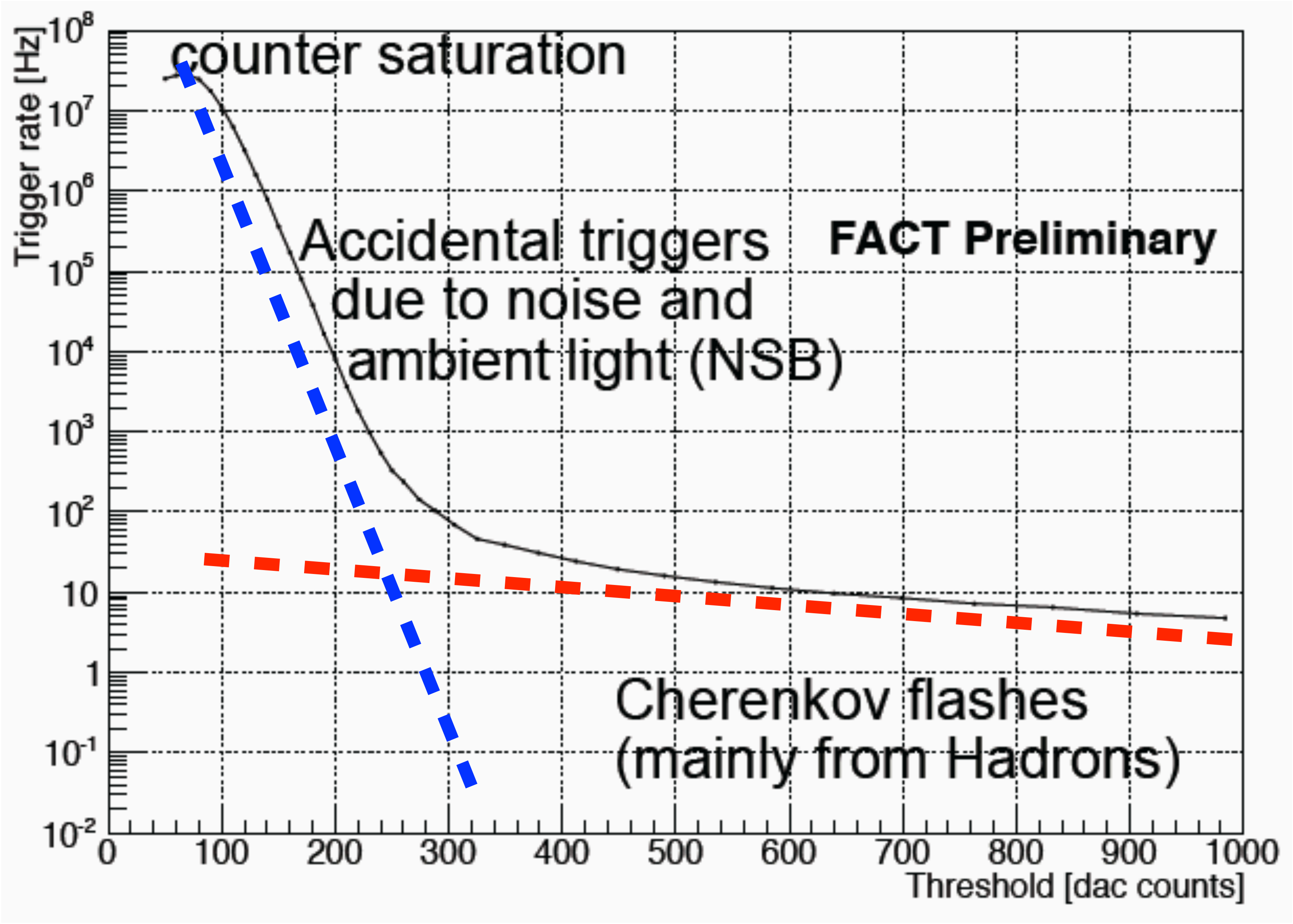
1428 Pixels, 1 year data, ΔT ~ 25°C



T. Bretz, Calibration and performance of the photon sensor response of FACT, JINST

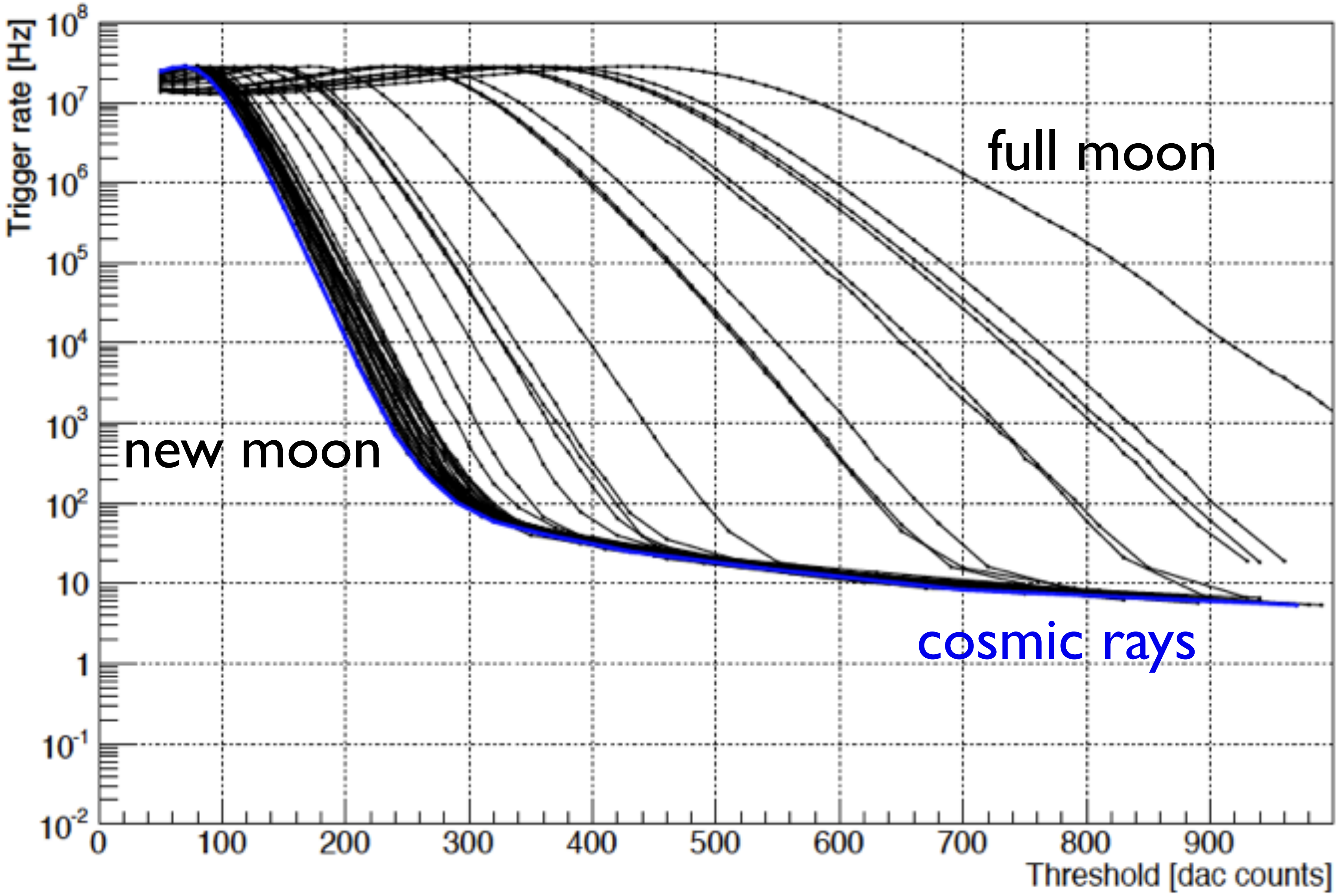
Feedback: Rate Scan

- Rate Scans measure both CR background and NSB



Feedback: Dark Current

- Rate scans prove that cosmic ray trigger rate is constant despite changing NSB

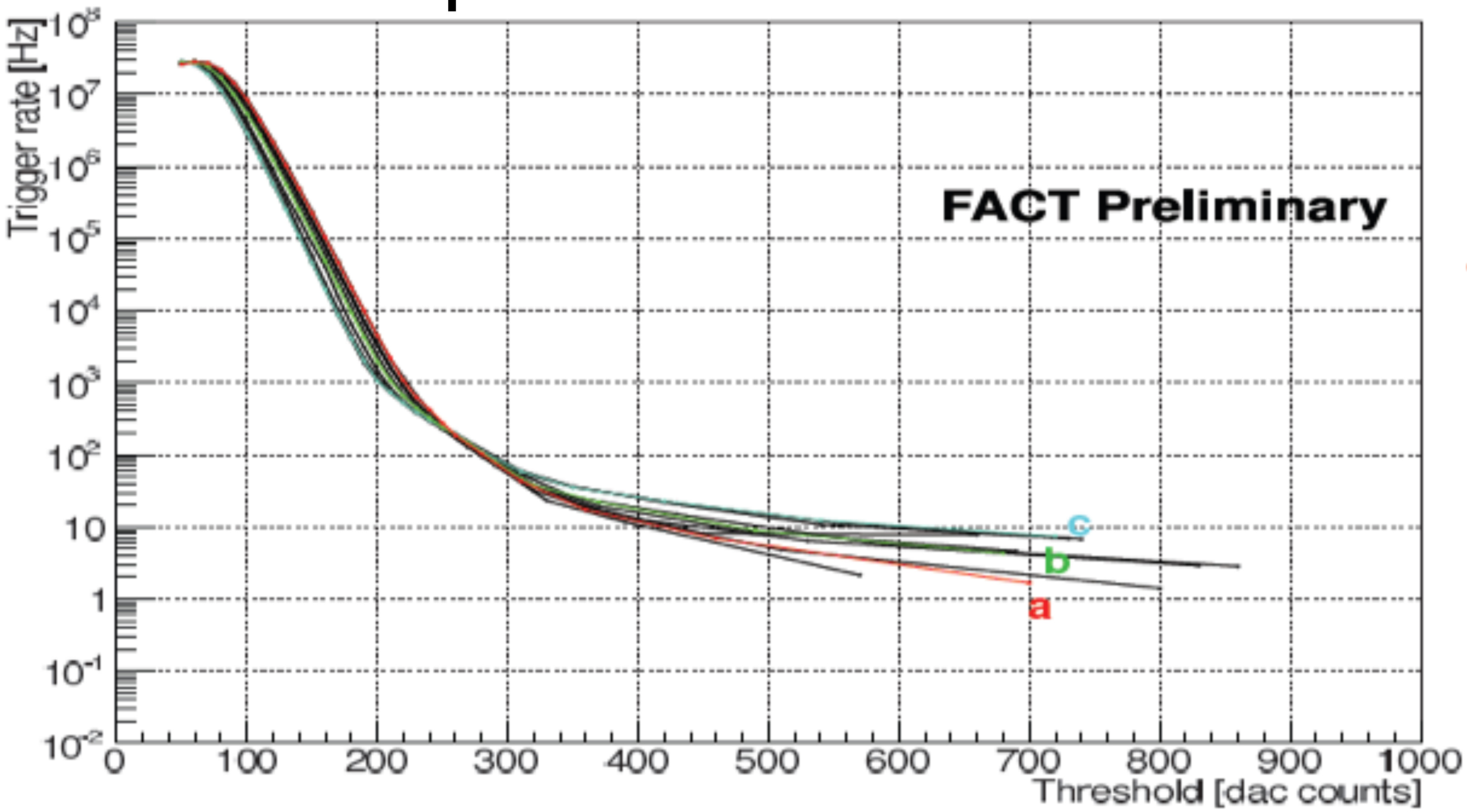


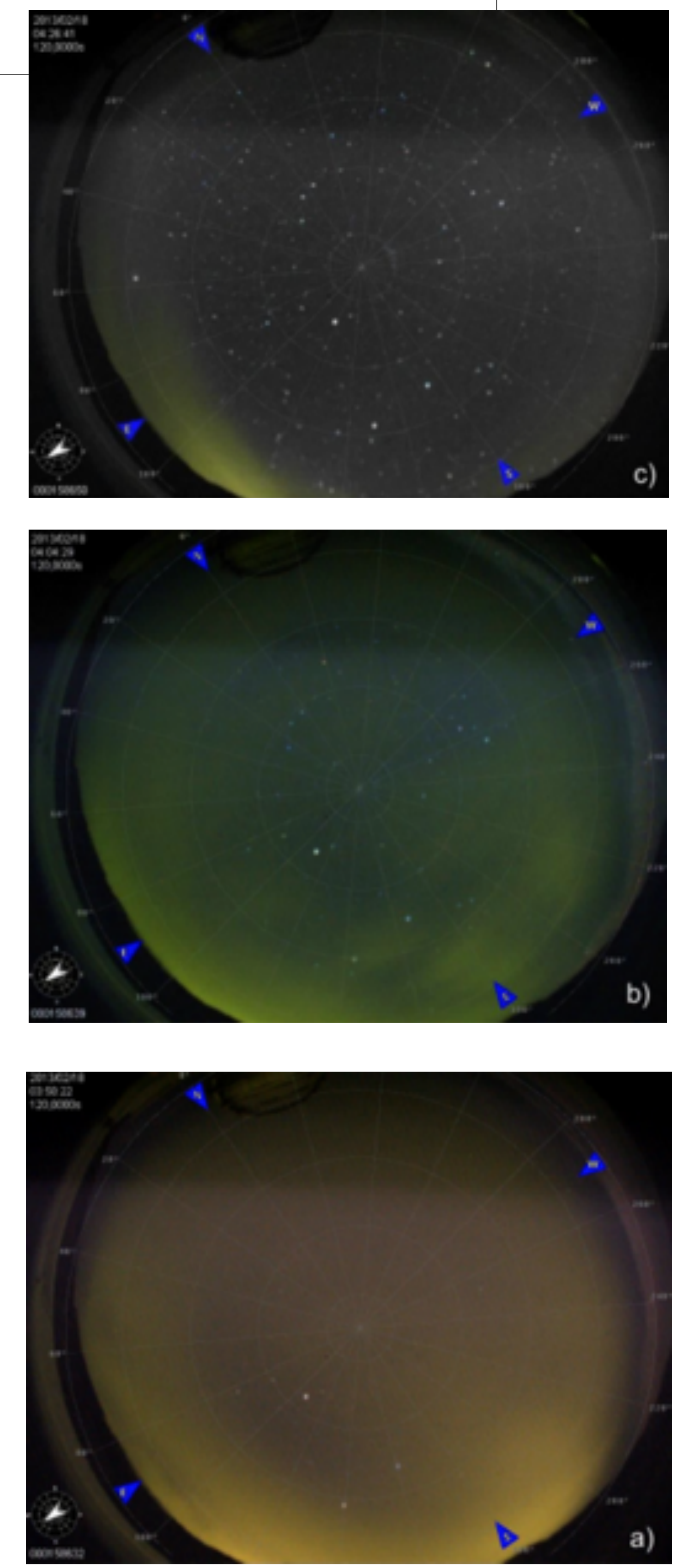
Atmosphere

- Telescopes expend a lot of effort to characterize the atmosphere
- Large source of systematic errors
- LIDAR, Infra-rad cameras, LASERs and observers eyes
  - Inconsistent and/or can get in the way of taking data
- First step of any analysis is to identify good quality data

Atmosphere

Hadronic Trigger Rate does depend on atmospheric conditions

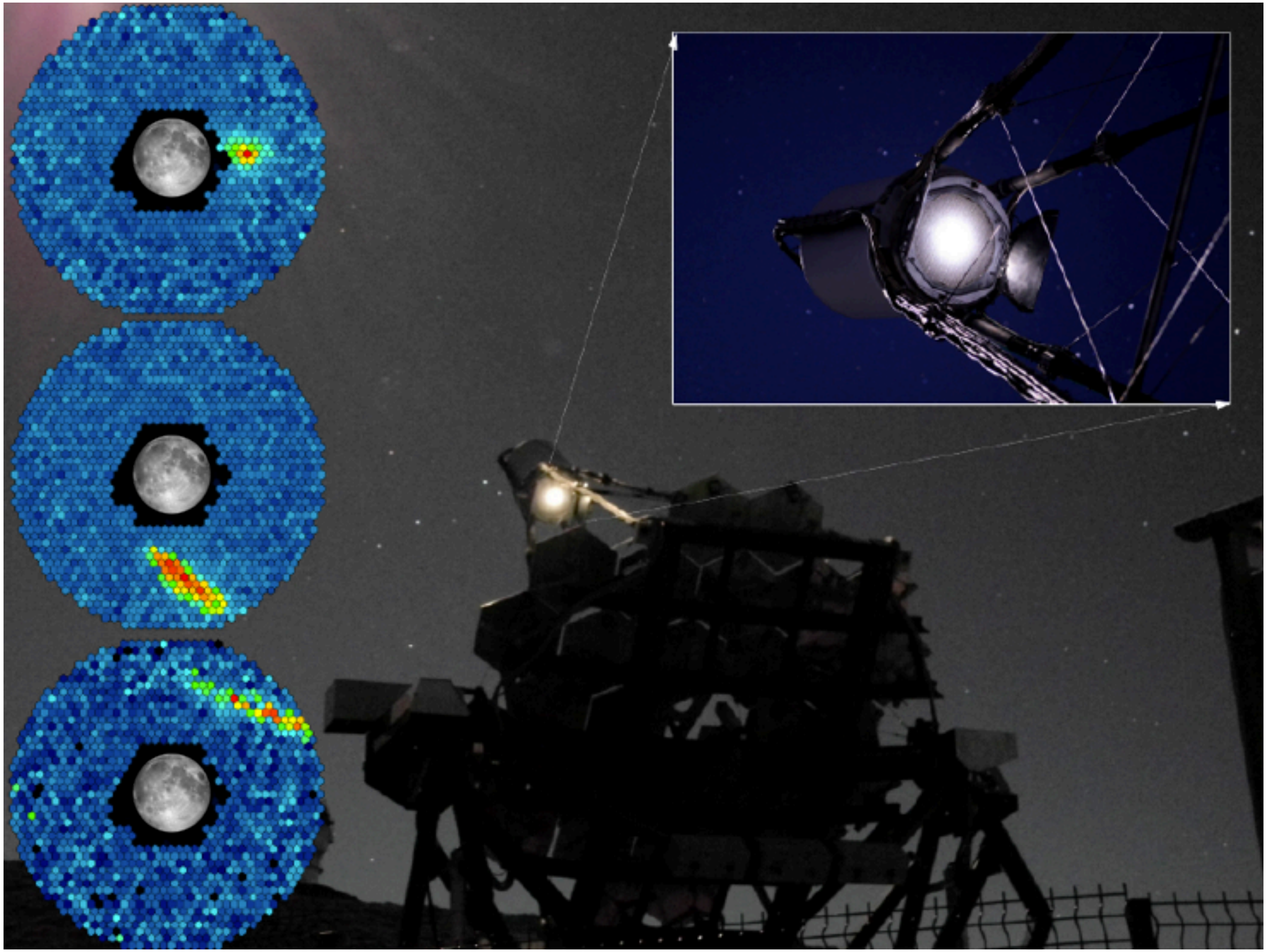




Work in progress: Can we split the signal to do Rate Scans on the fly?

D. Hildebrand et al. (FACT Collaboration): Proceedings 33rd ICRC, Rio de Janeiro 2013

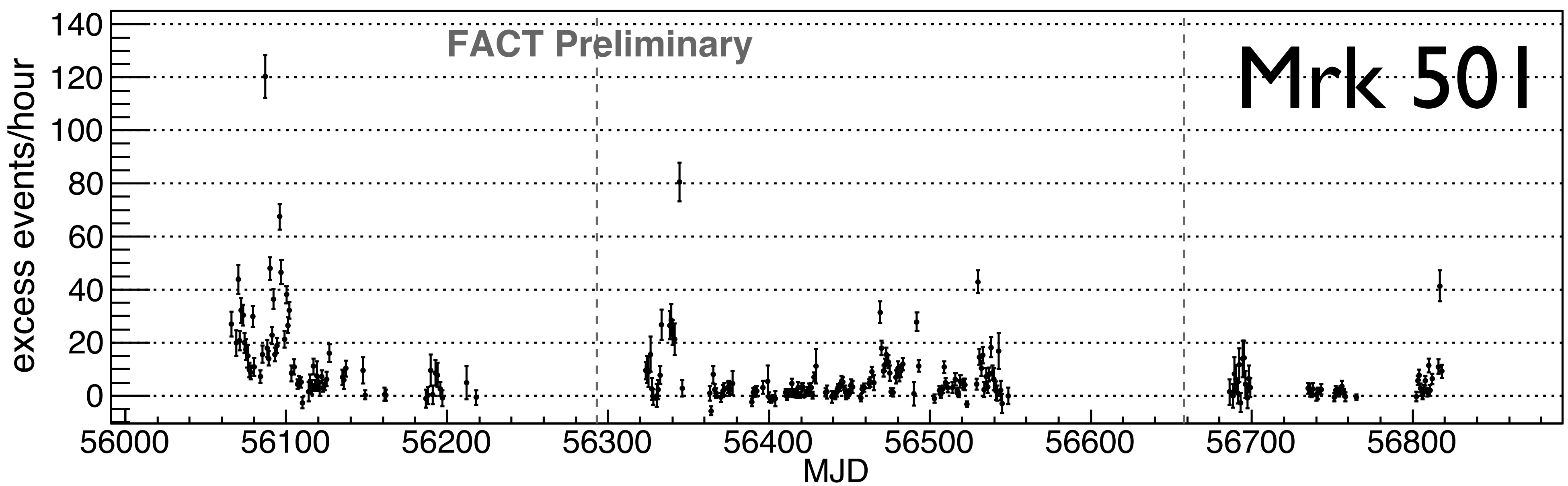
Moonlight Observations

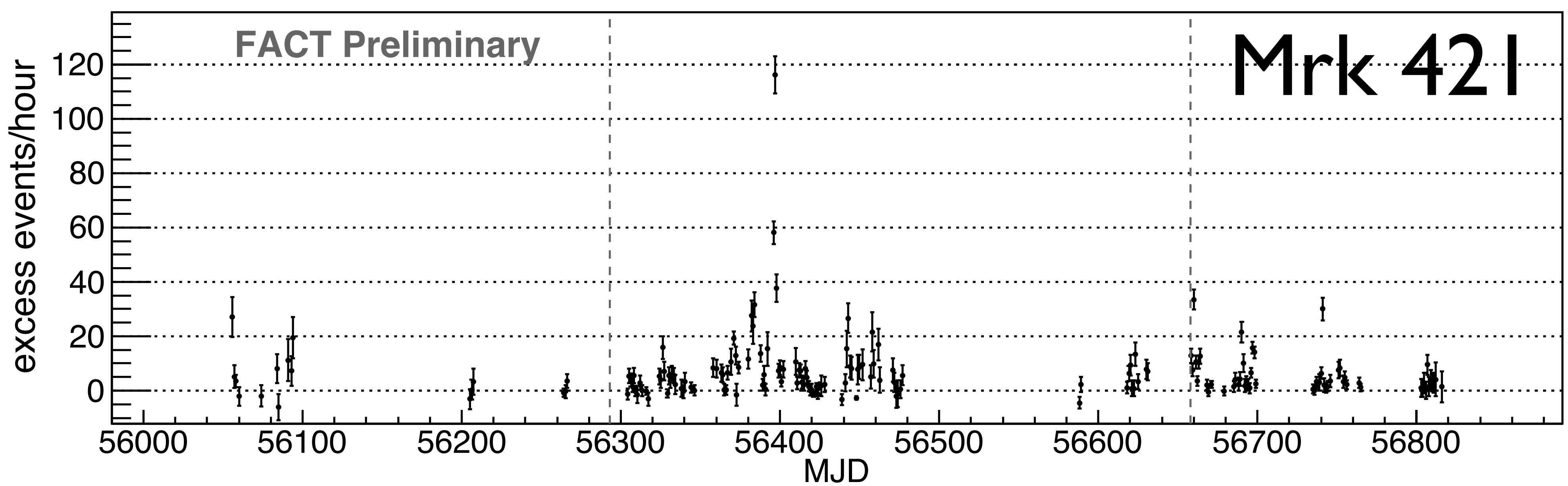


Quick Look Analysis

Real Time fast analysis publicly available almost instantly

www.fact-project.org/monitoring/



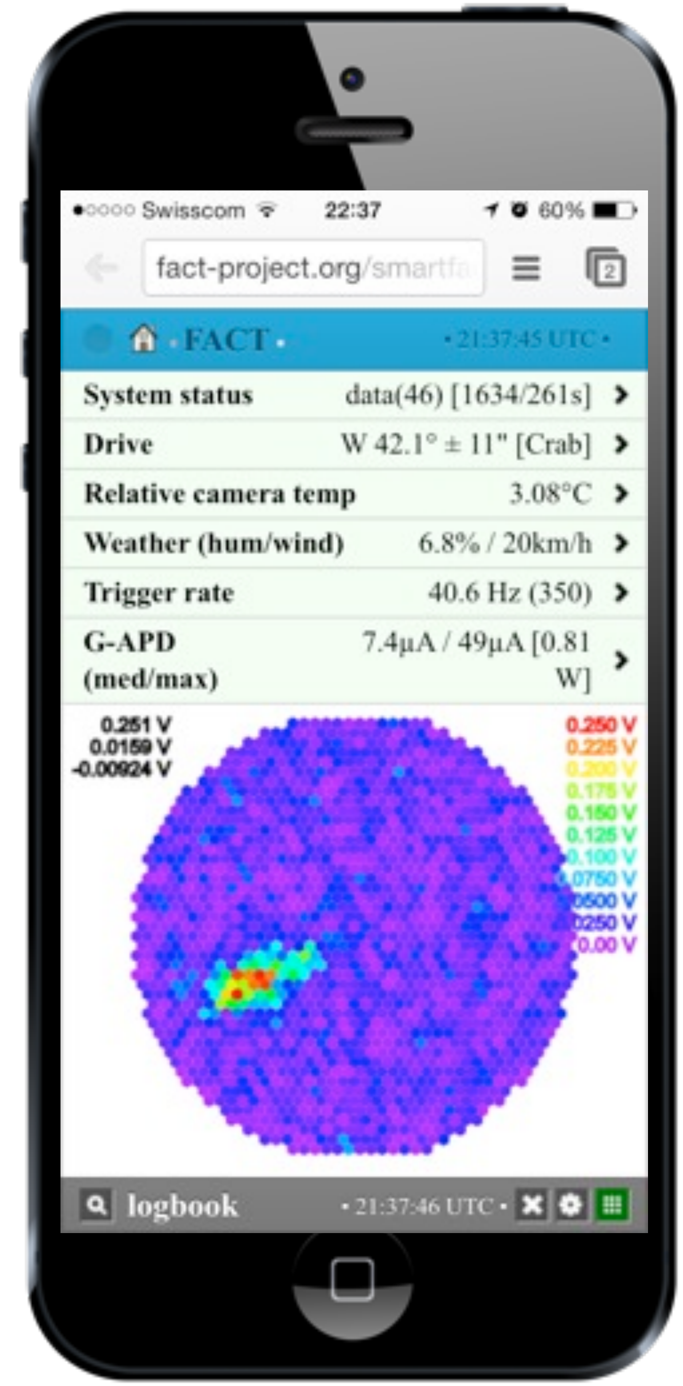


2 Flare Alerts sent to the community in the last few days

Conclusion

- **No Focal Plane Problems: In over 2.5 yrs**
- System is so stable we operate the telescope remotely
- Using a feedback system temperature and night sky gain dependence can be mastered
- The atmosphere could be monitored through the data stream
- Monitoring Blazars to provide alerts to the community

- **G-APDs are an excellent choice for Cherenkov Telescopes**



http://fact-project.org/smartfact