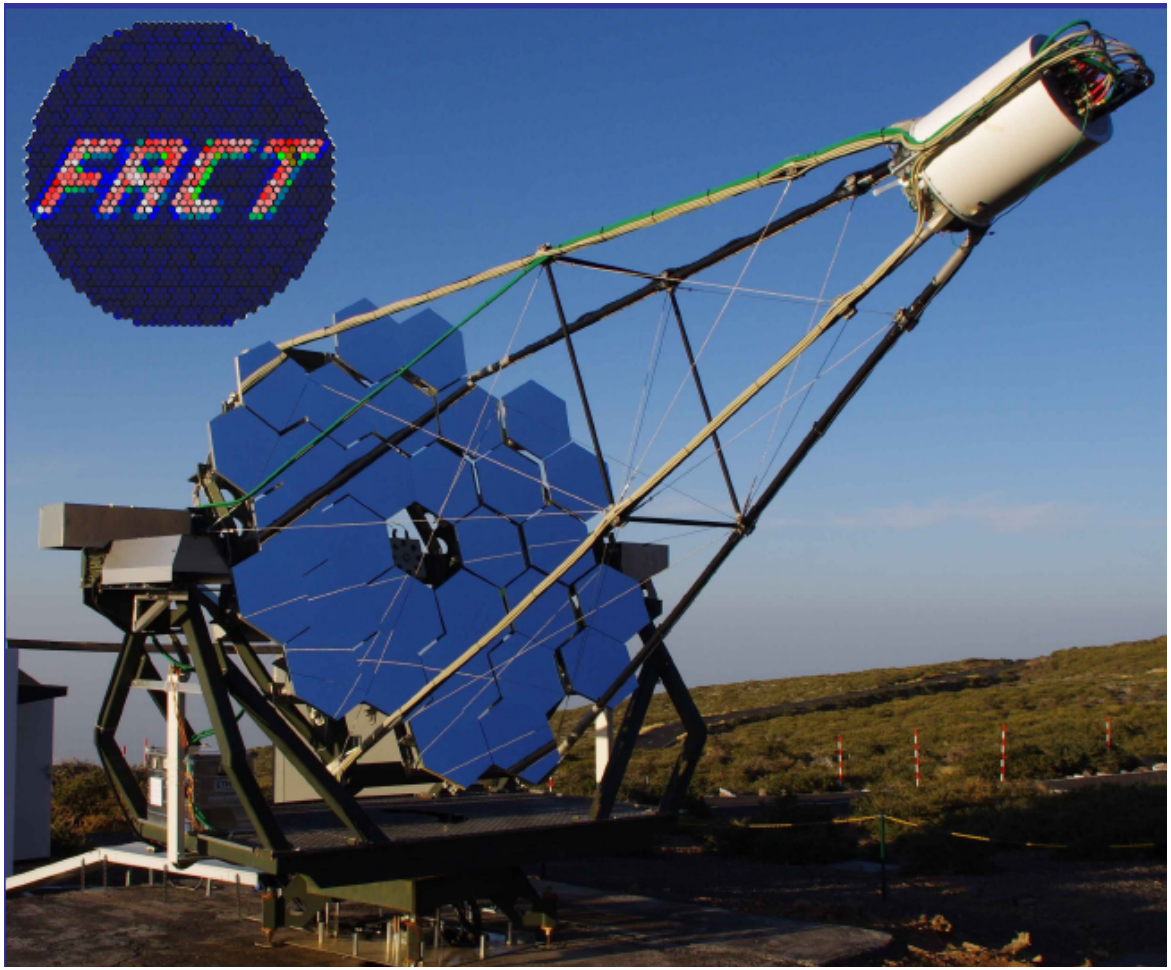
Measuring Atmospheric Condition with an Imaging Air Cherenkov Telescope



Dorothée Hildebrand, Adrian Biland
for the FACT Collaboration

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FACT

First G-APD Cherenkov Telescope:
using novel camera in refurbished HEGRA-CT3 telescope
(9.5m^2 mirror area, 1440 Pixel, 4.5deg FoV) at La Palma

FACT Design and construction: JINST 8 (2013) P06008 (open access)
FACT System performance: astro-ph/1403.5747, submitted to JINST

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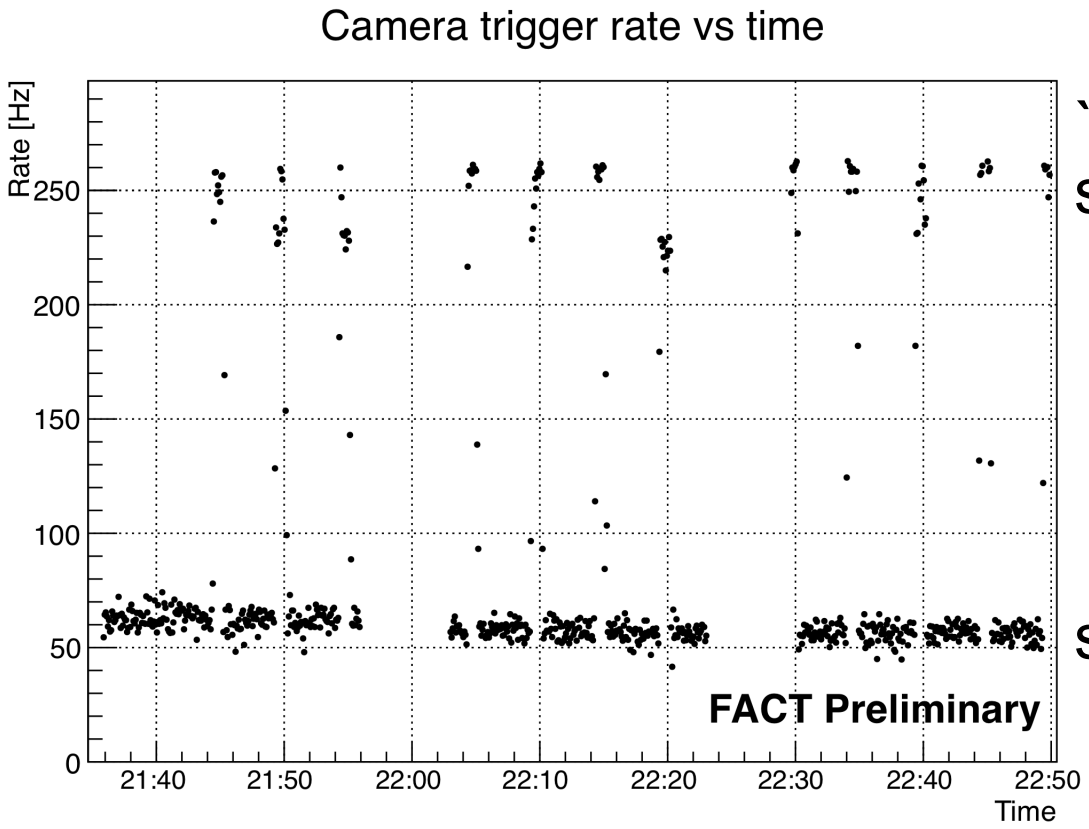
FACT and LIDAR

On a site with many telescopes and devices,
Laser shots of Lidars can affect instruments,



`foreign` Lidar in field of view saturates data aquisition

standard trigger rate

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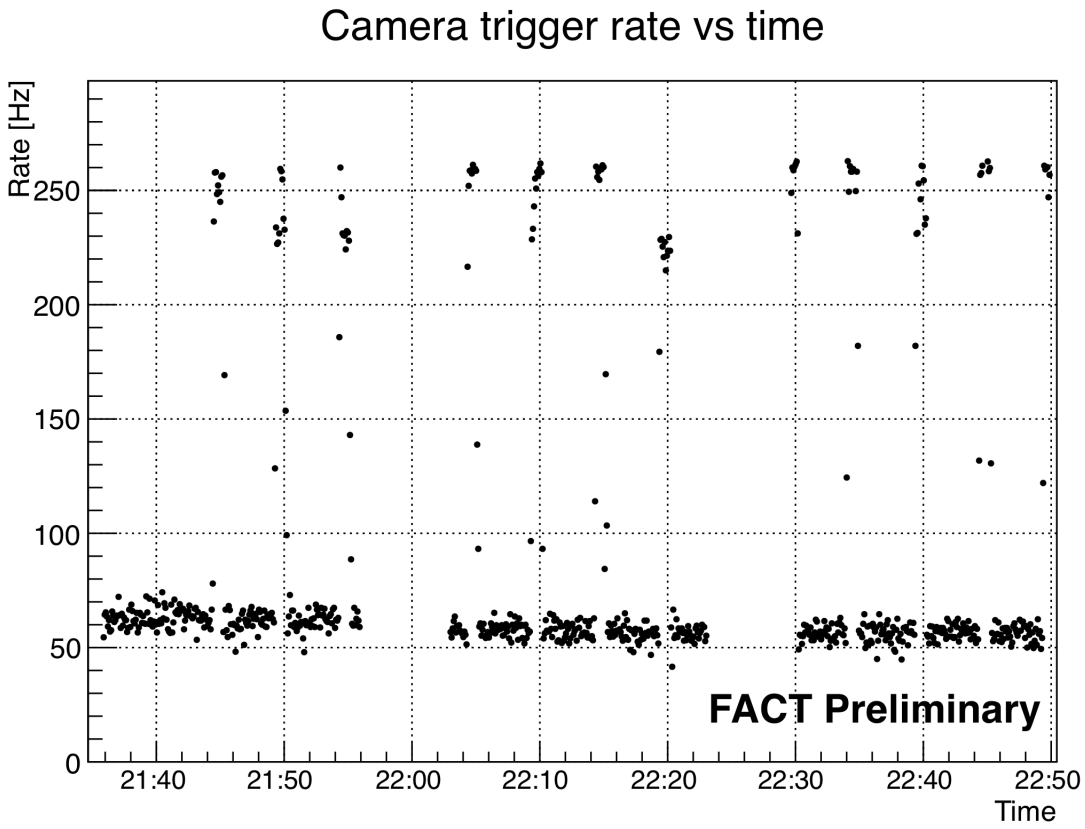

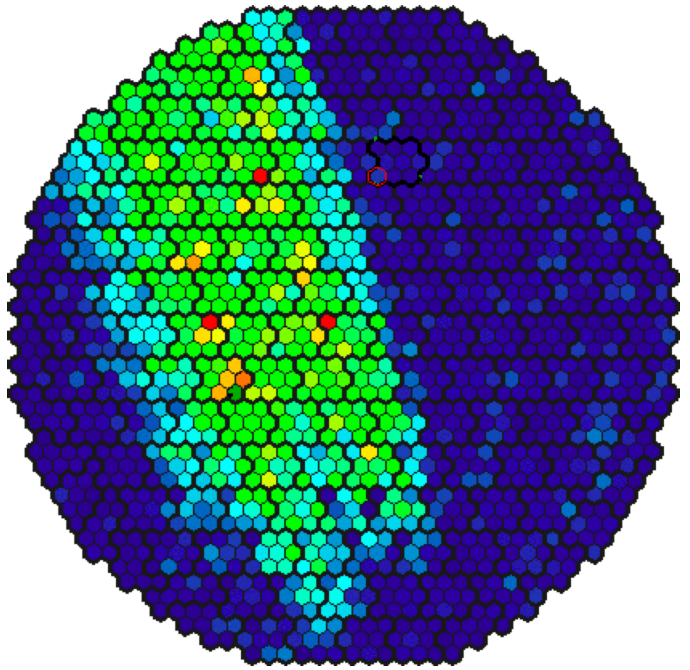

FACT image with Lidar

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Why not use the IACT itself to monitor the atmosphere?

Knowledge about the atmosphere is necessary since it affects the measurement of gamma-rays showers

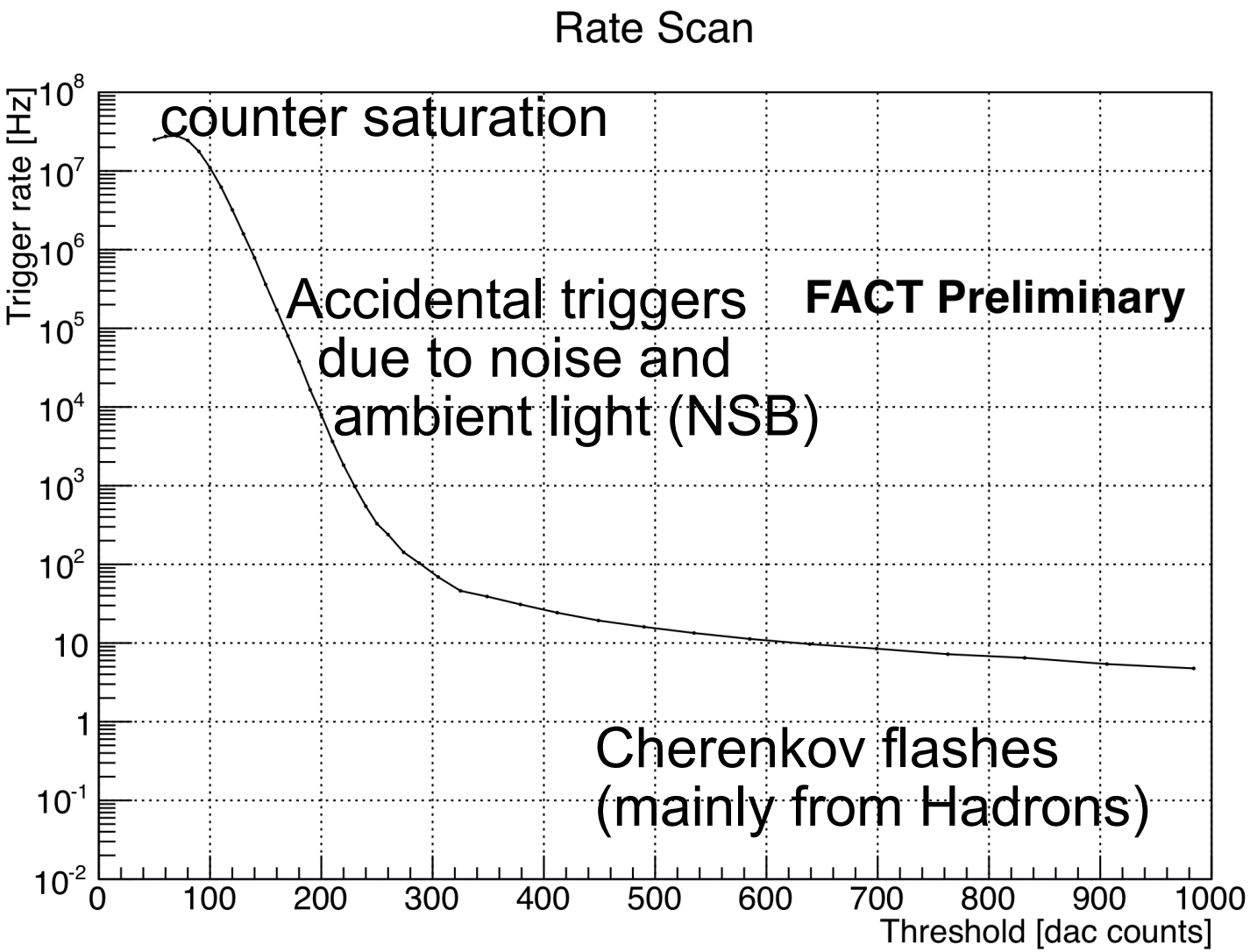
Hadronic showers are also affected by the atmosphere

The flux and spectrum of hadrons is constant

IACT measure hadronic as well as gamma-ray showers

Can hadrons be used as kind of concurrent testbeam ?

What Rate Scans are about



Cherenkov flashes only from within field of view of the IACT

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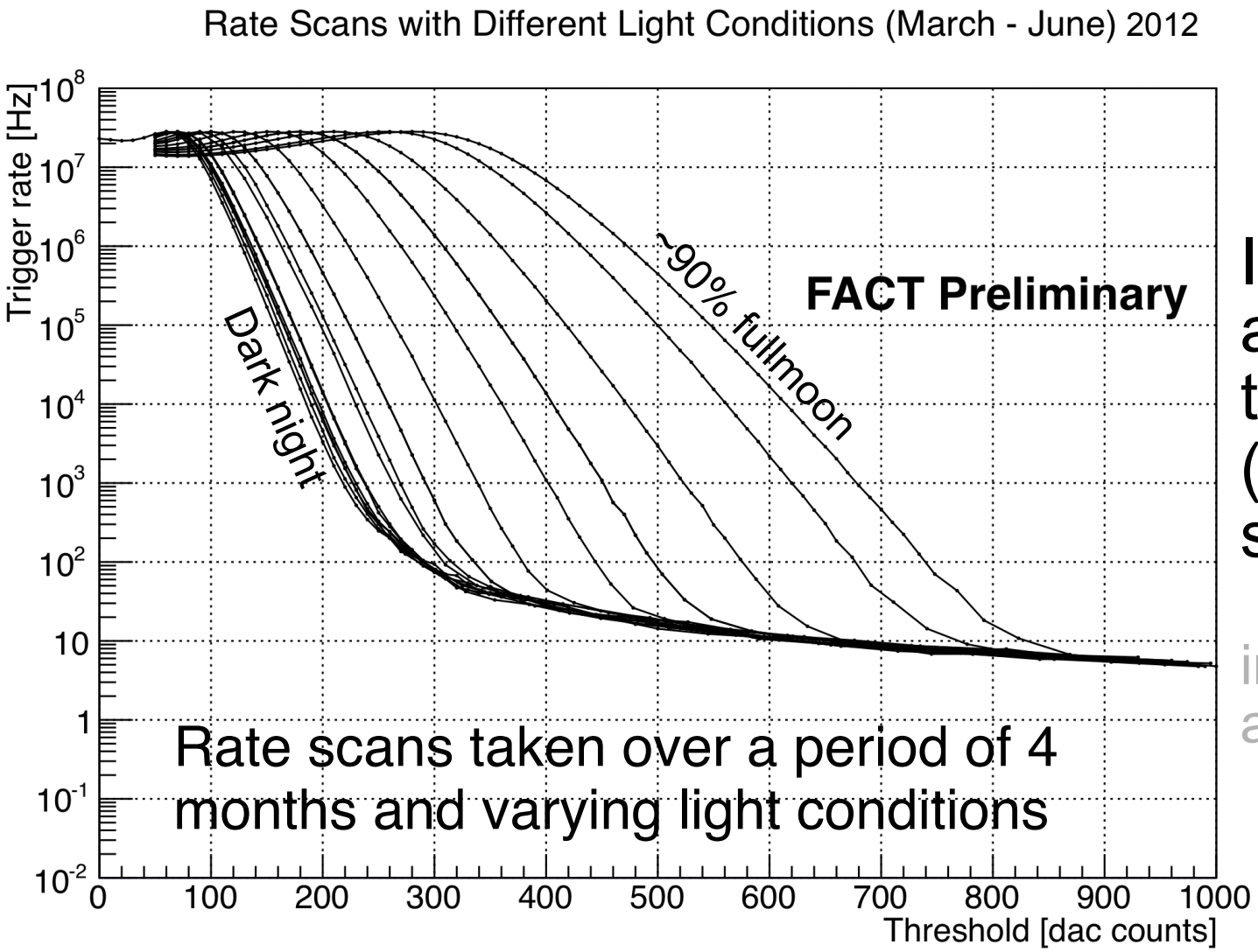
Rate Scans during different light conditions



In case of `good` atmosphere, the trigger rates from (hadronic) flashes stay constant

independent of ambient light

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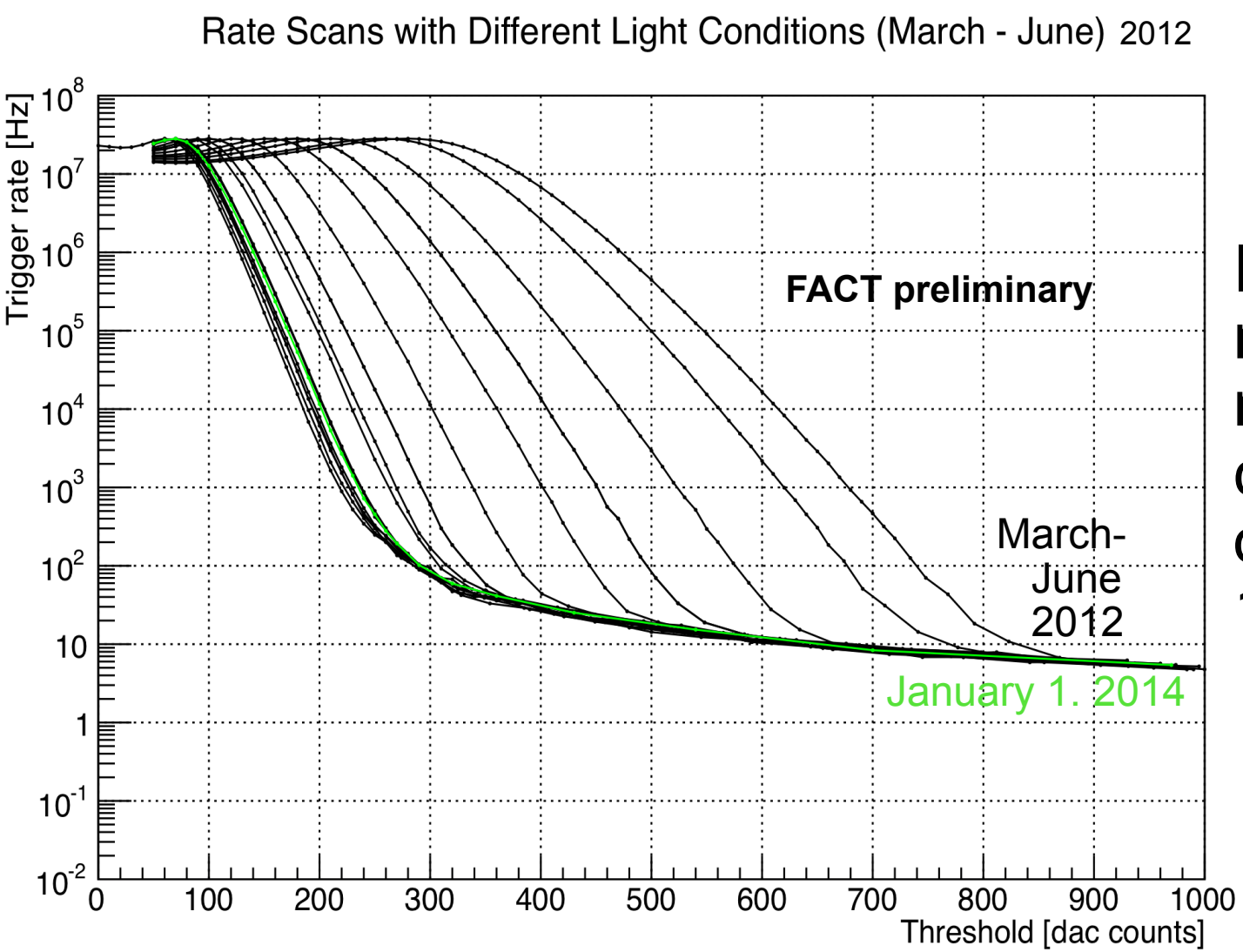
Rate Scans & system stability



In FACT the measured trigger rates are consistant over at least 1.5 years.

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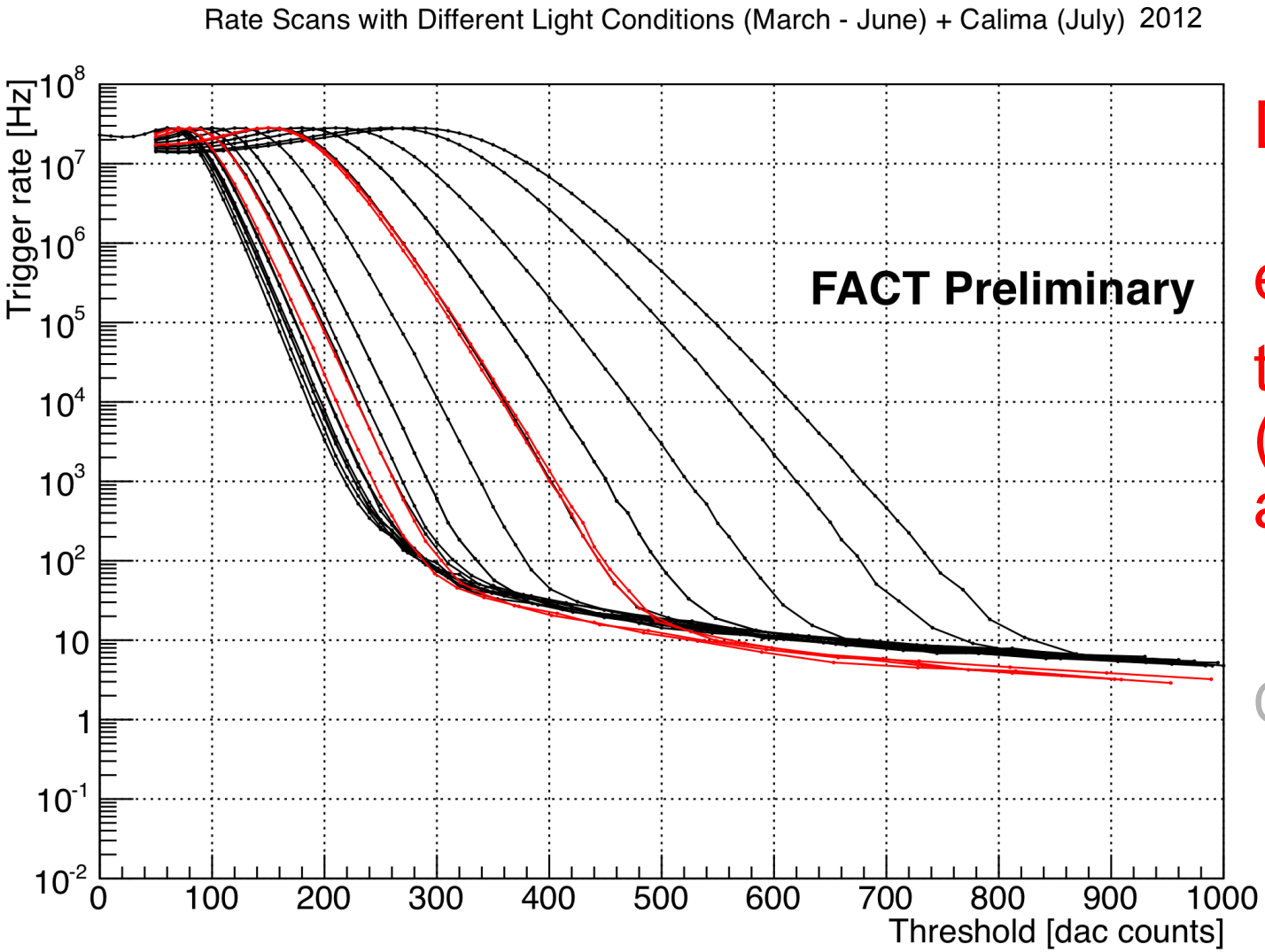
Rate Scans with Calima



Disturbed atmosphere e.g. Calima:

trigger rates from (hadronic) flashes are reduced

Calima is a weather situation with a lot of sahara-sand in the atmosphere

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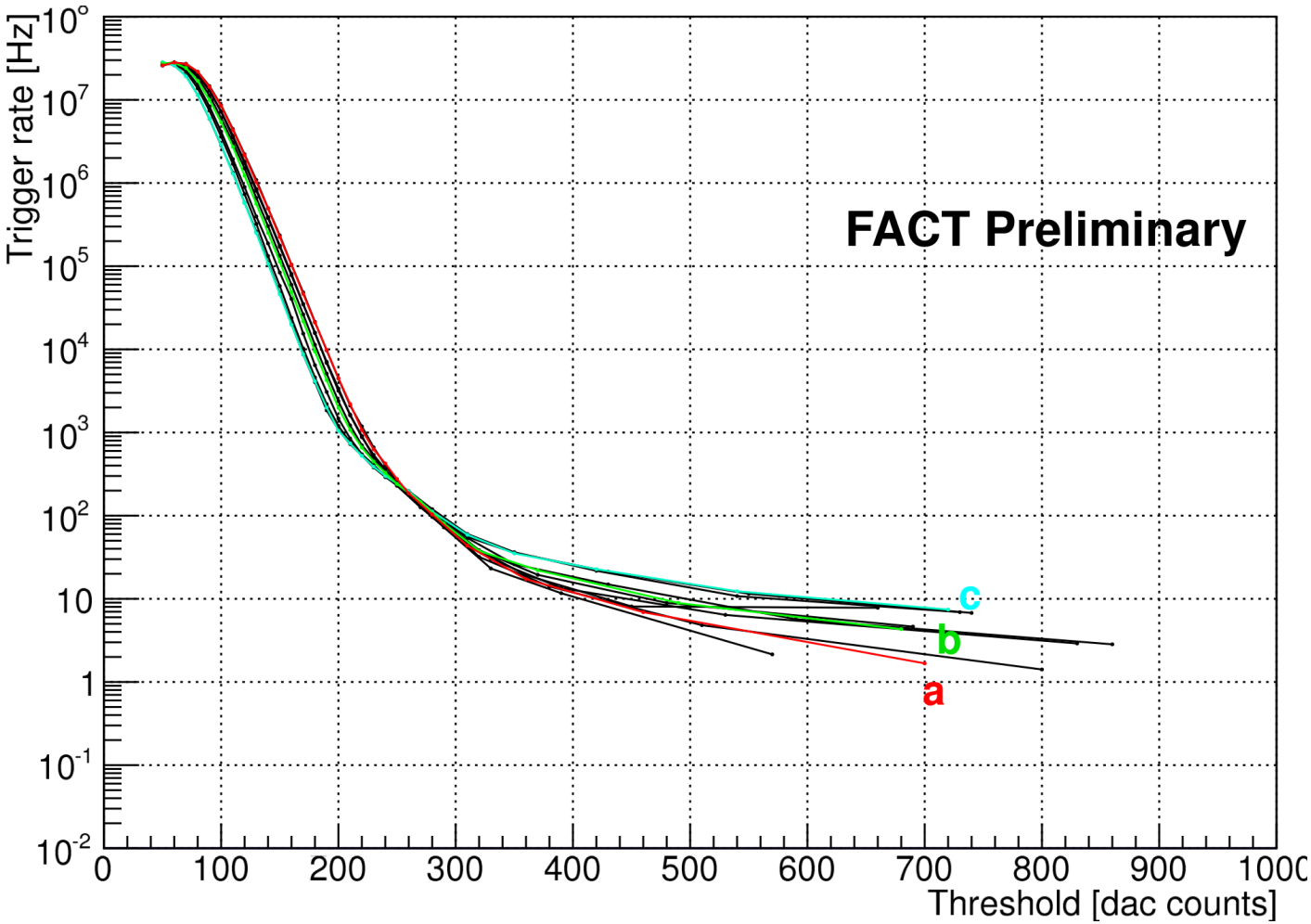
Rate Scans with different cloudiness



Disturbed atmosphere e.g. Clouds:

trigger rates from (hadronic) flashes change

Rate scans taken during two hours showing various atmospheric conditions.

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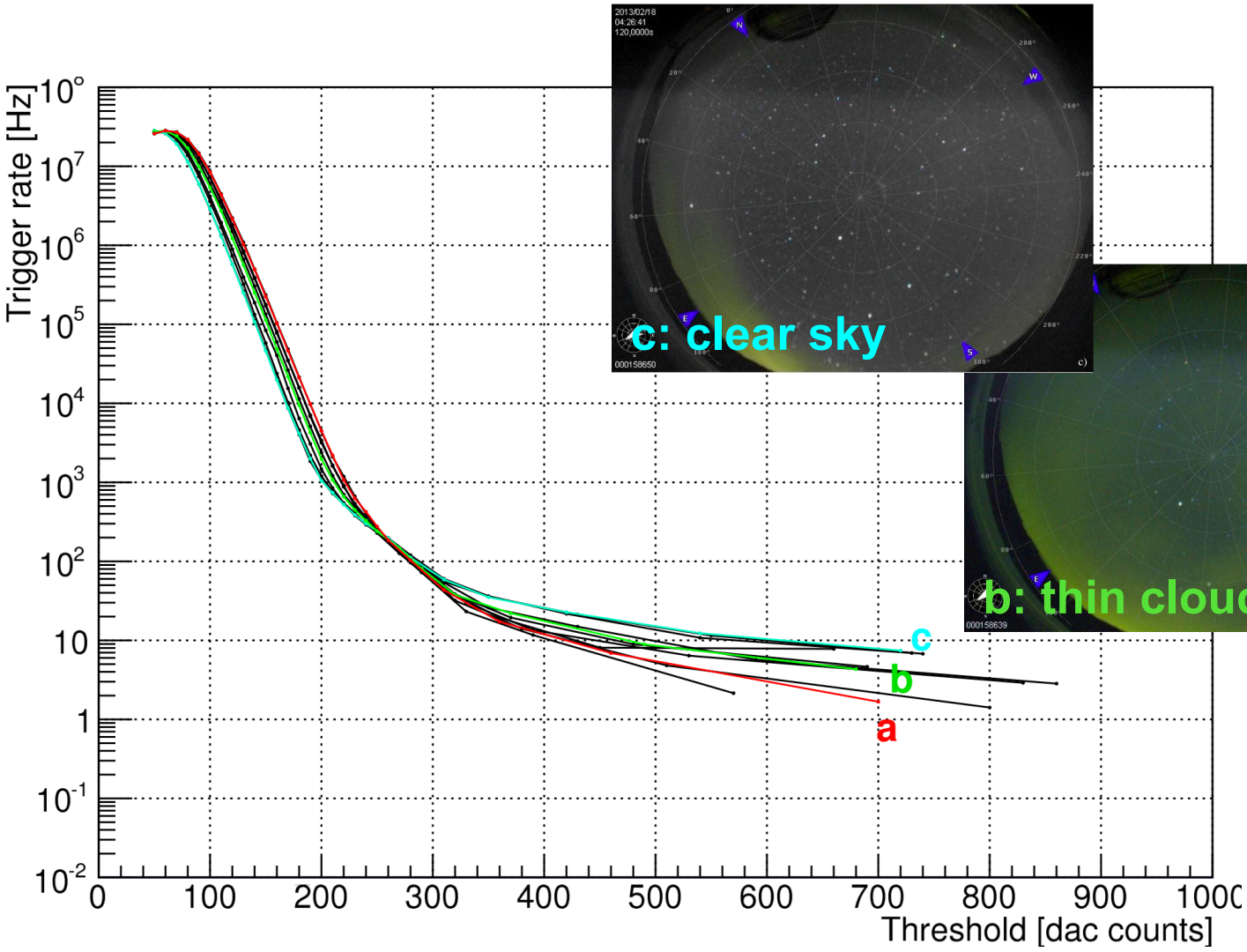
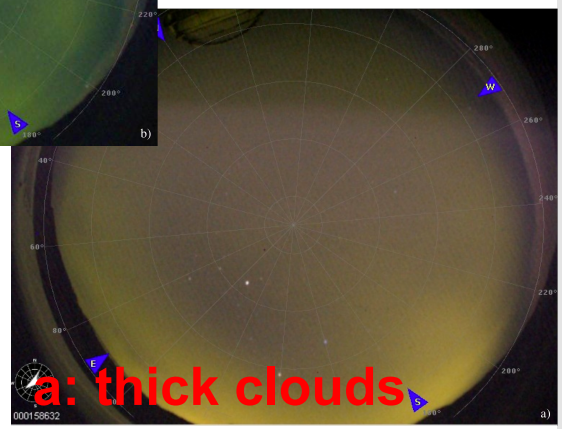
Rate Scans with different cloudiness





GTC allsky camera

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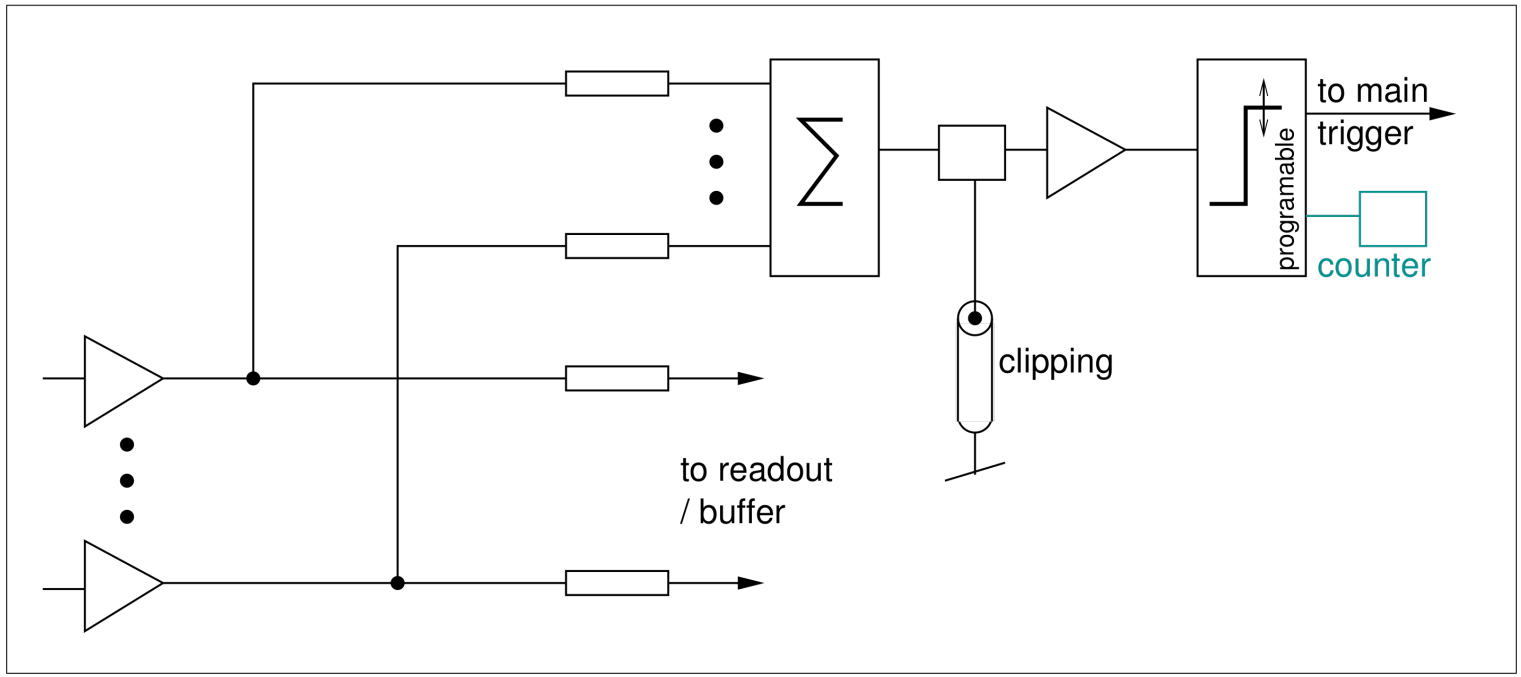
FACT Trigger

programmable threshold with a counter;
necessary to interrupt data-taking to take a ratescan



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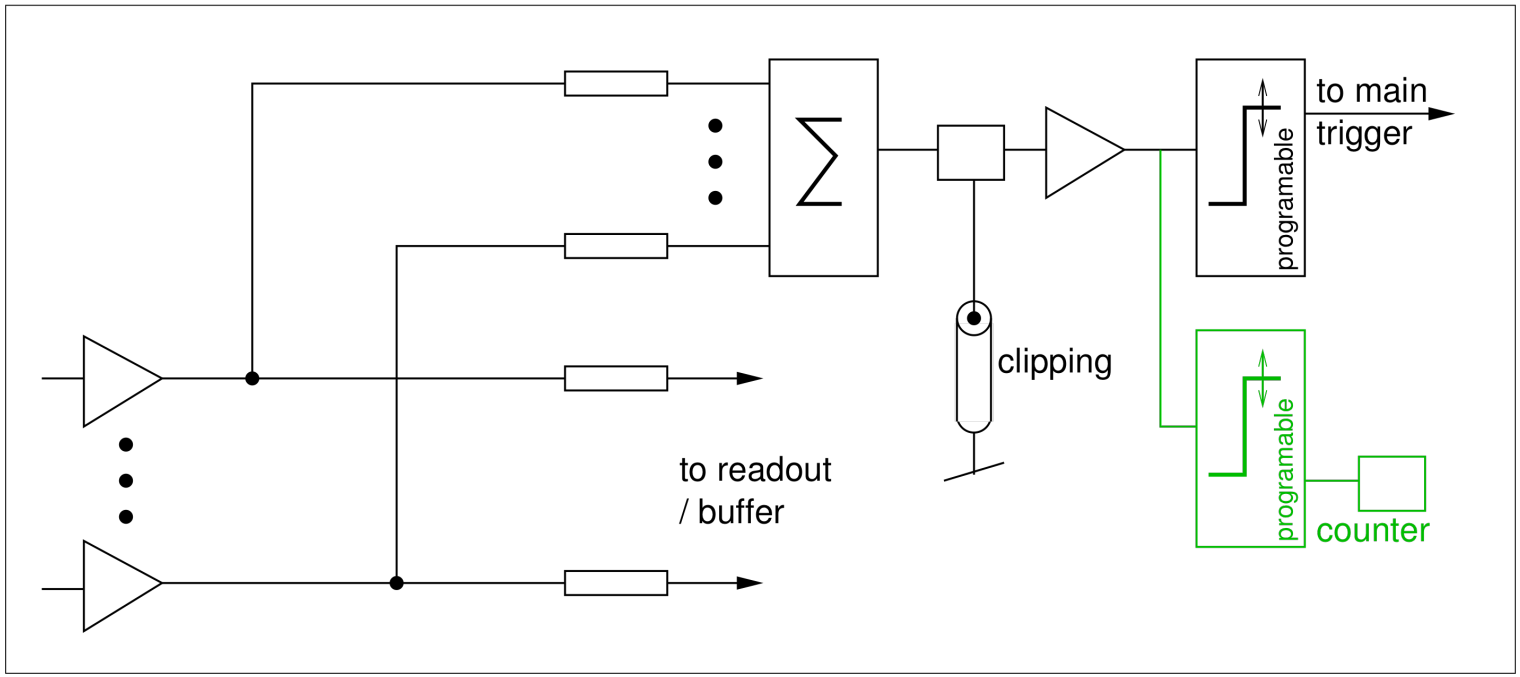
Possible Trigger Improvements

Use a 2nd programmable threshold for the counter
=> can take serial ratescans concurrent to data-taking



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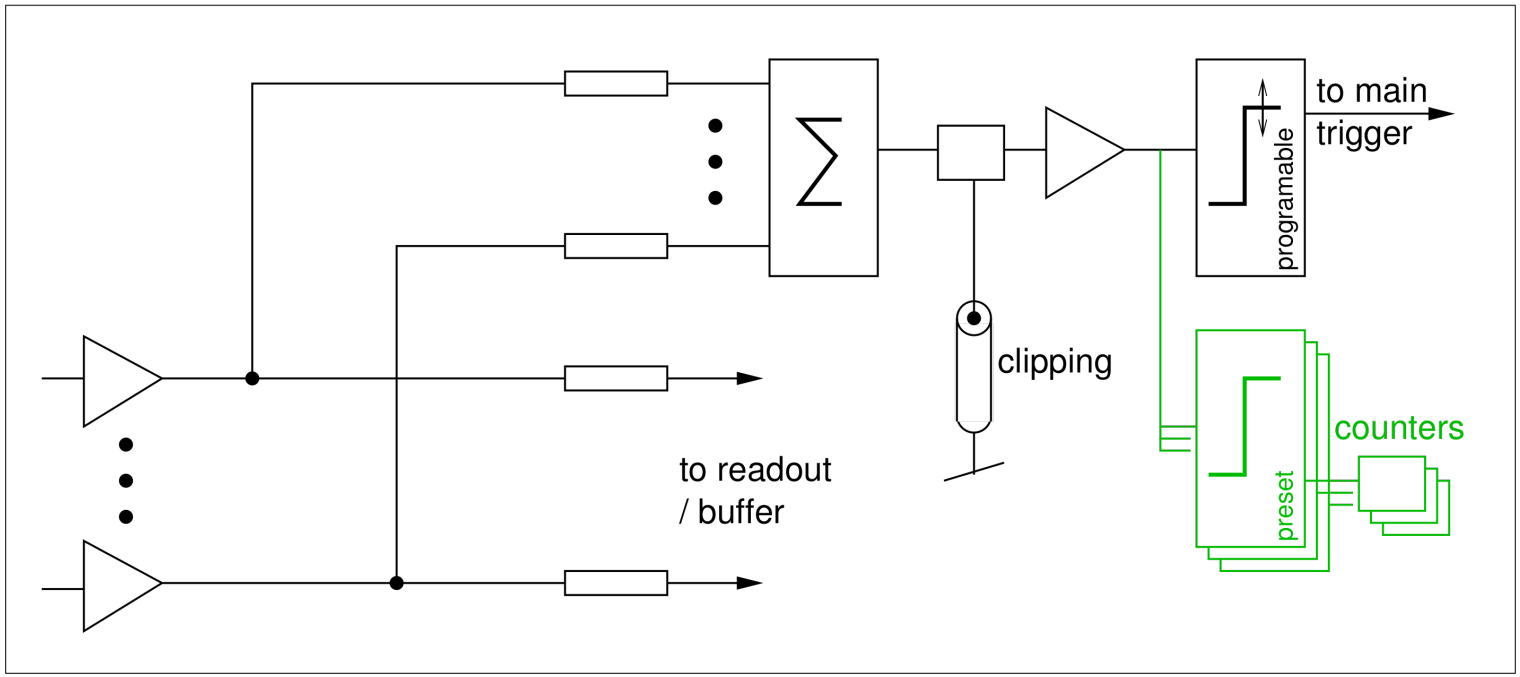
Possible Trigger Improvements

Use several preset thresholds
=> do parallel ratescans concurrent to data-taking



Or use a fully digital trigger like in `Flashcam`

Conclusion

Cherenkov telescopes can
monitor the atmospheric condition within their field of view concurrent to data taking without auxiliary devices

Absolutely no disturbance of neighbouring systems
=> no problem if CTA operated as many subarrays

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

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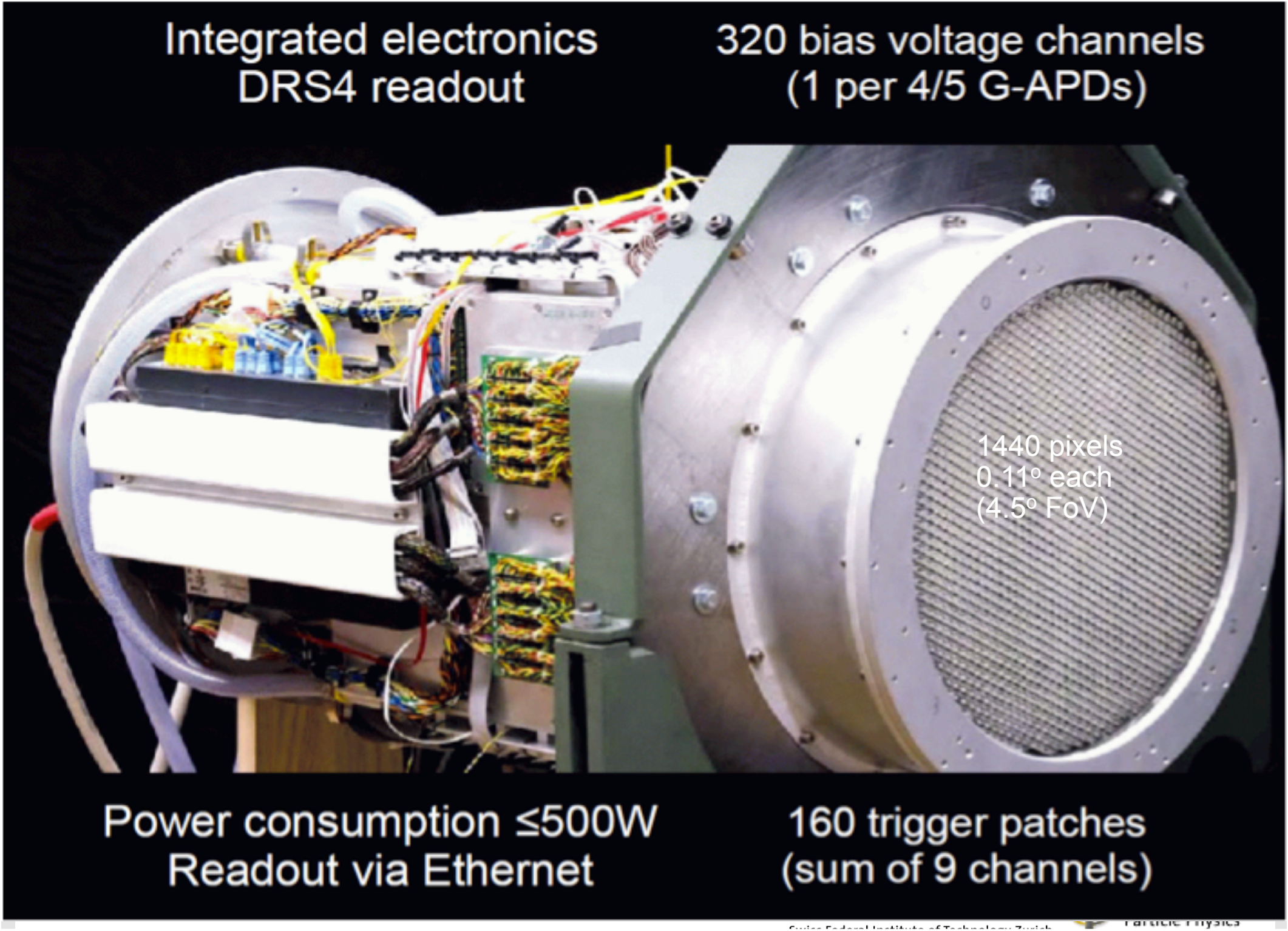
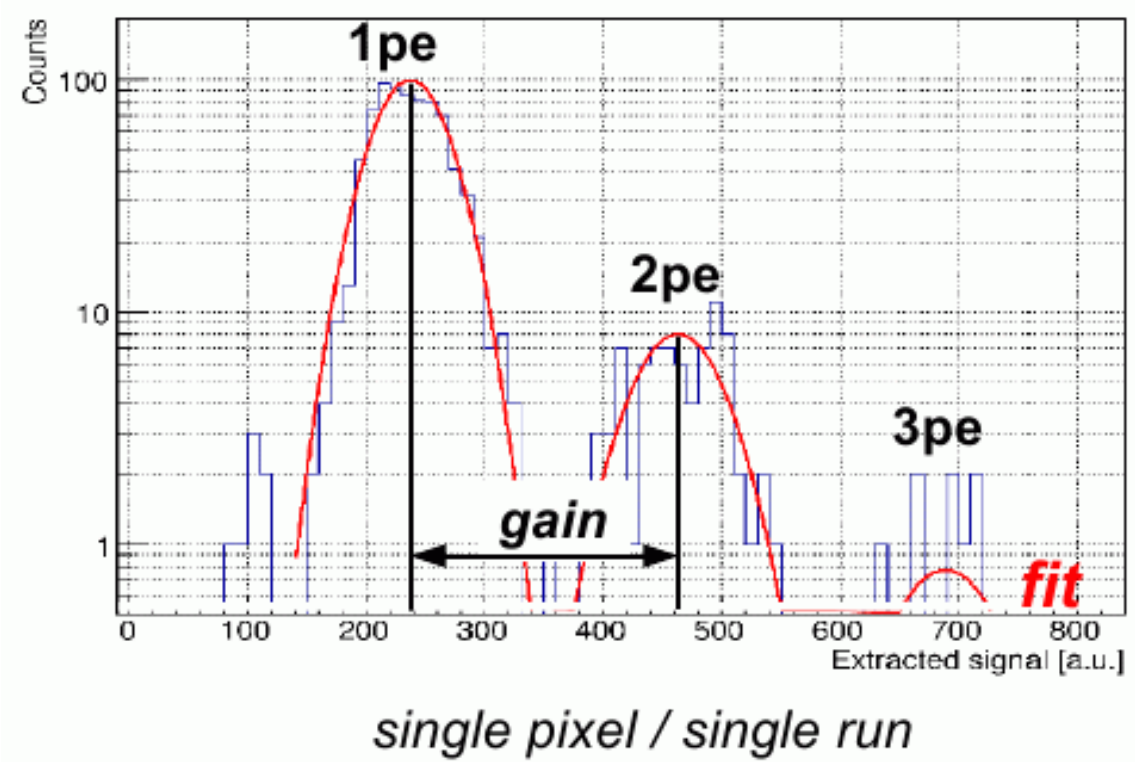
BACKUP


Integrated electronics
DRS4 readout
320 bias voltage channels
(1 per 4/5 G-APDs)
1440 pixels
0.11° each
(4.5° FoV)
Power consumption ≤500W
Readout via Ethernet
160 trigger patches
(sum of 9 channels)

BACKUP



single pixel / single run

Dark noise from a single pixel allows to measure gain
(>1pe from crosstalk intrinisc to G-APD)

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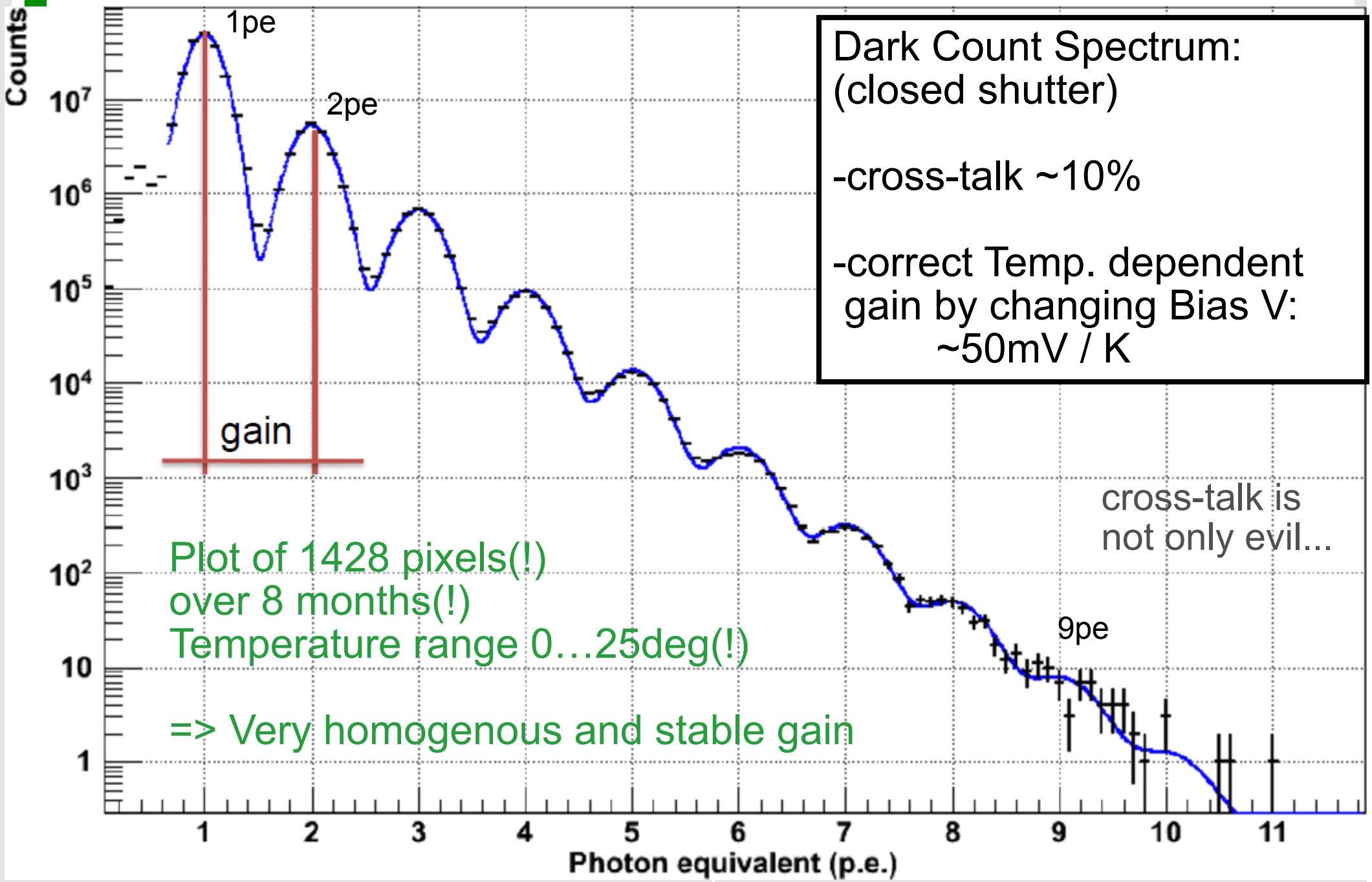
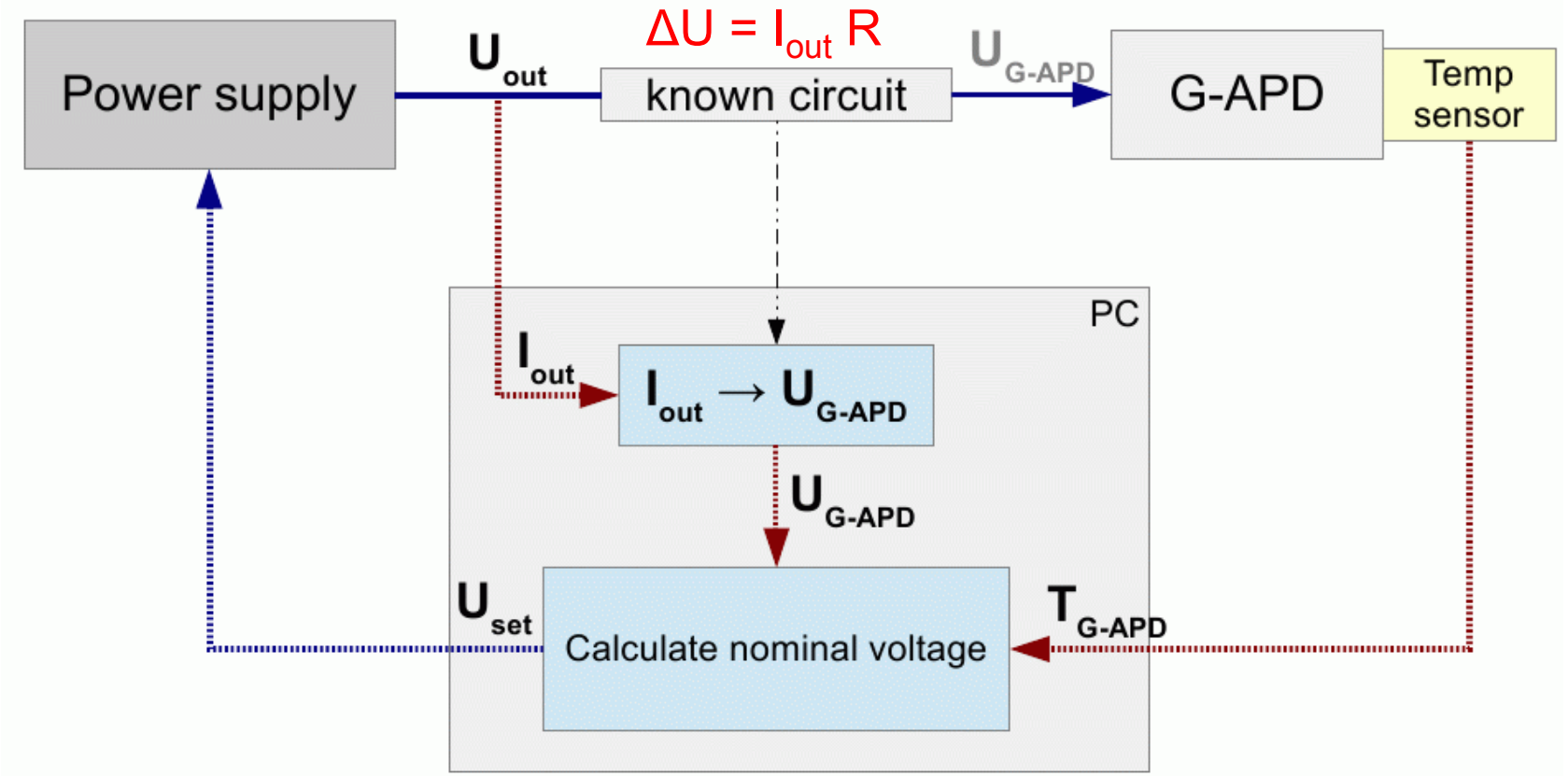

Counts
1pe
2pe
gain
9pe
Photon equivalent (p.e.)
Dark Count Spectrum:
(closed shutter)
-cross-talk ~10%
-correct Temp. dependent gain by changing Bias V:
~50mV / K
cross-talk is not only evil...
Plot of 1428 pixels(!)
over 8 months(!)
Temperature range 0…25deg(!)
=> Very homogenous and stable gain

BACKUP



- $U_{G\text{-}APD}$ must be corrected for Temperatur dependence of G-APD
- to apply correct $U_{G\text{-}APD}(T)$, must also correct for $\Delta U = I_{out} R$
- I_{out} (DC-current) is proportional to amount of ambient light (NSB)

No need for an external calibration system (light pulser etc.)

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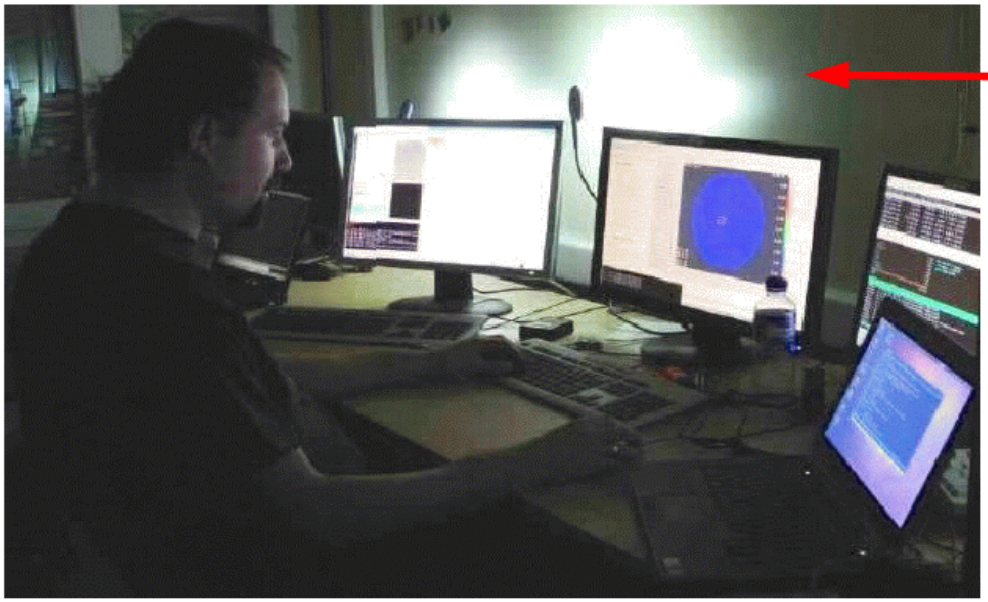
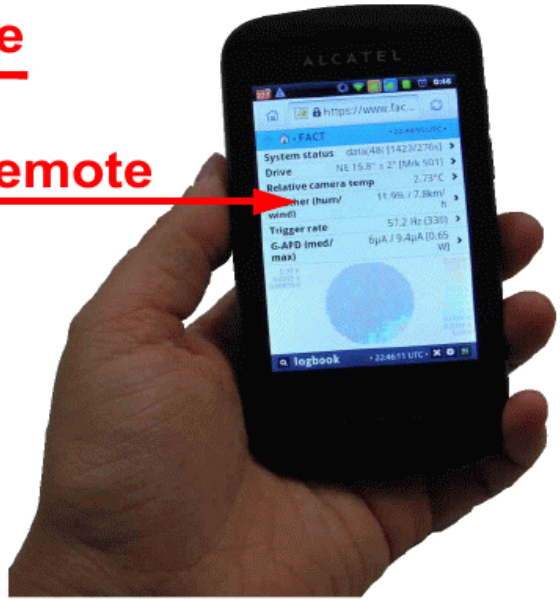
BACKUP

Since Oct 2011, FACT is operated almost every night



onsite

remote



Sitting in the container @ La Palma --- *or wherever you want*

Full system so stable and reliable that remote operation since summer 2012; working on minor improvements on auxiliary systems to allow robotic operation.