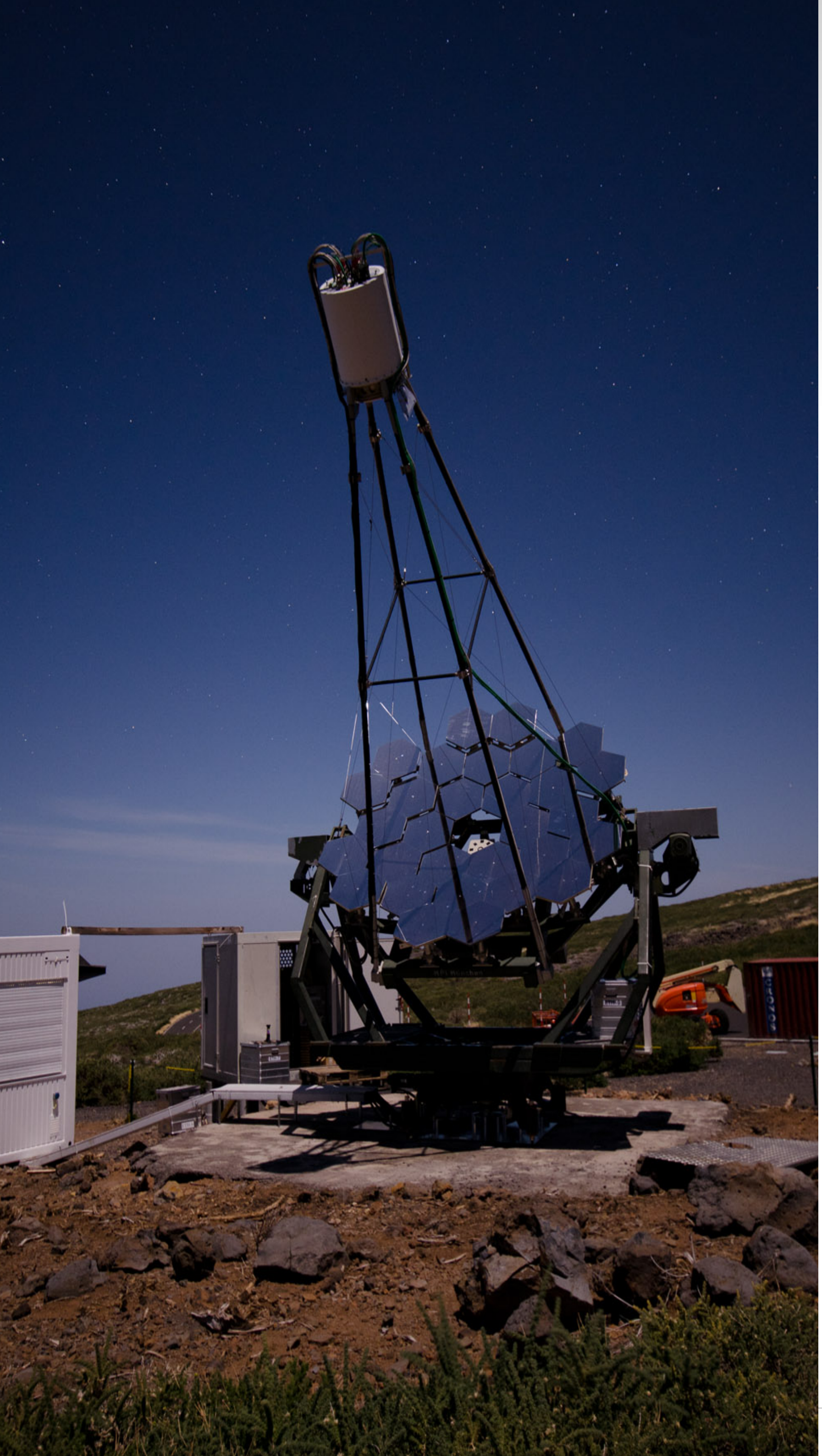


FACT
The future of Cherenkov astronomy?
(or: conclusions from FACT)

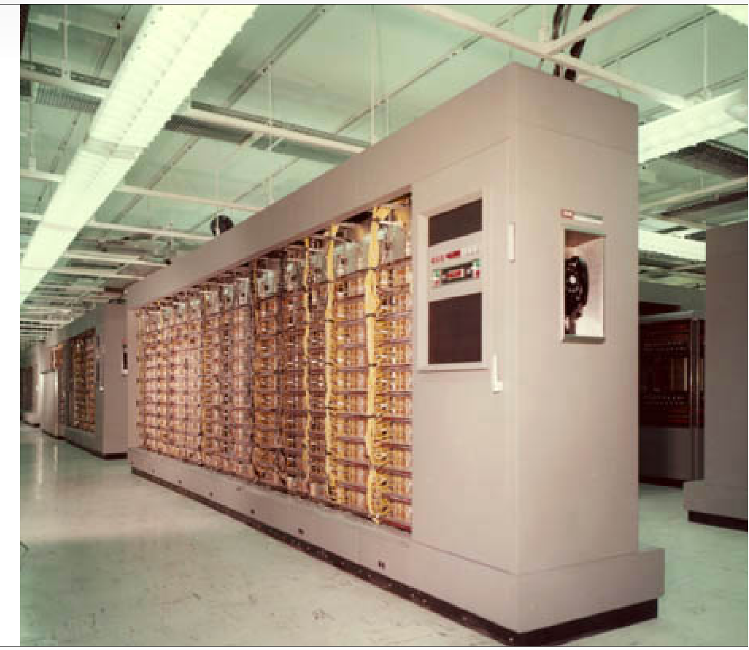
Thomas Bretz
(EPF Lausanne)

for the

FACT collaboration

FACT
First G-**A**PD **C**herenkov **T**elescope

tubes →



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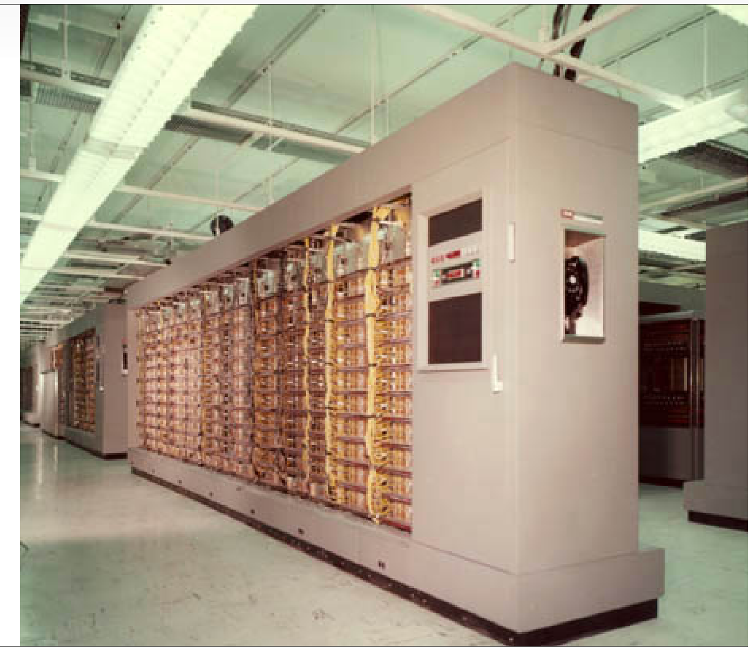

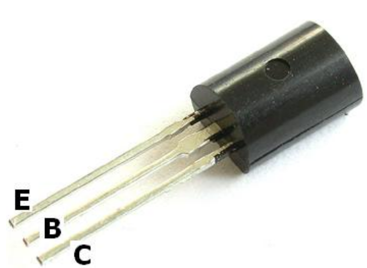

silicon devices →

FACT
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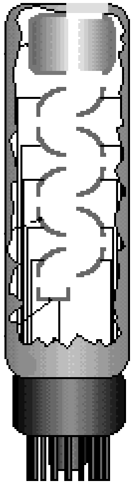

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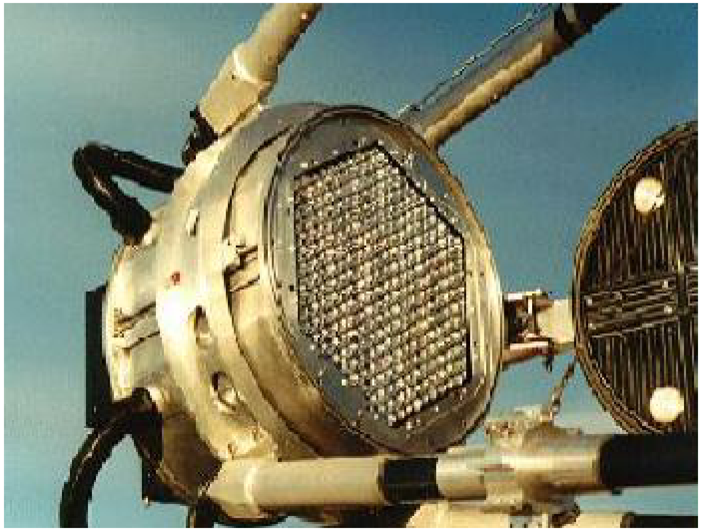
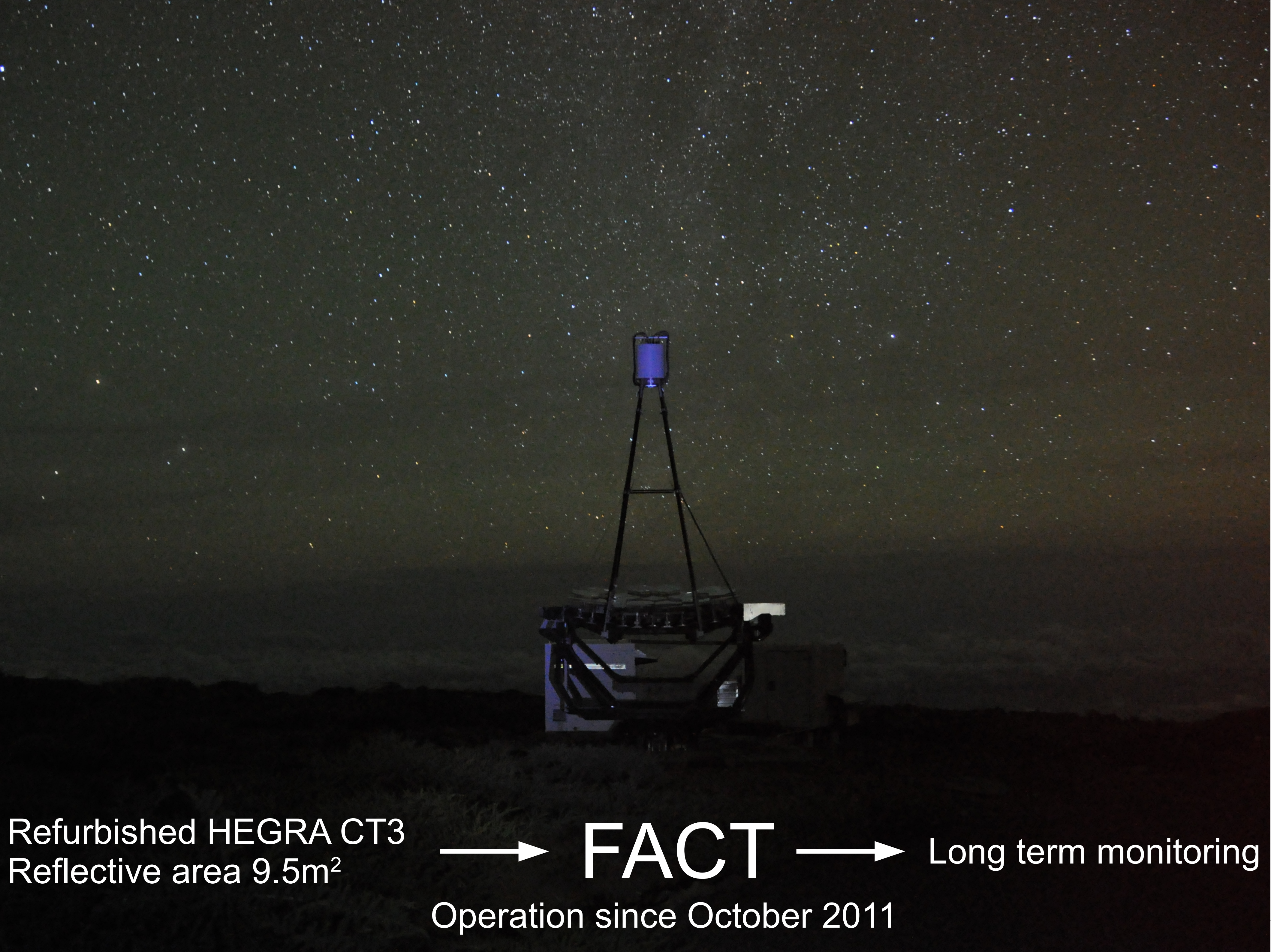


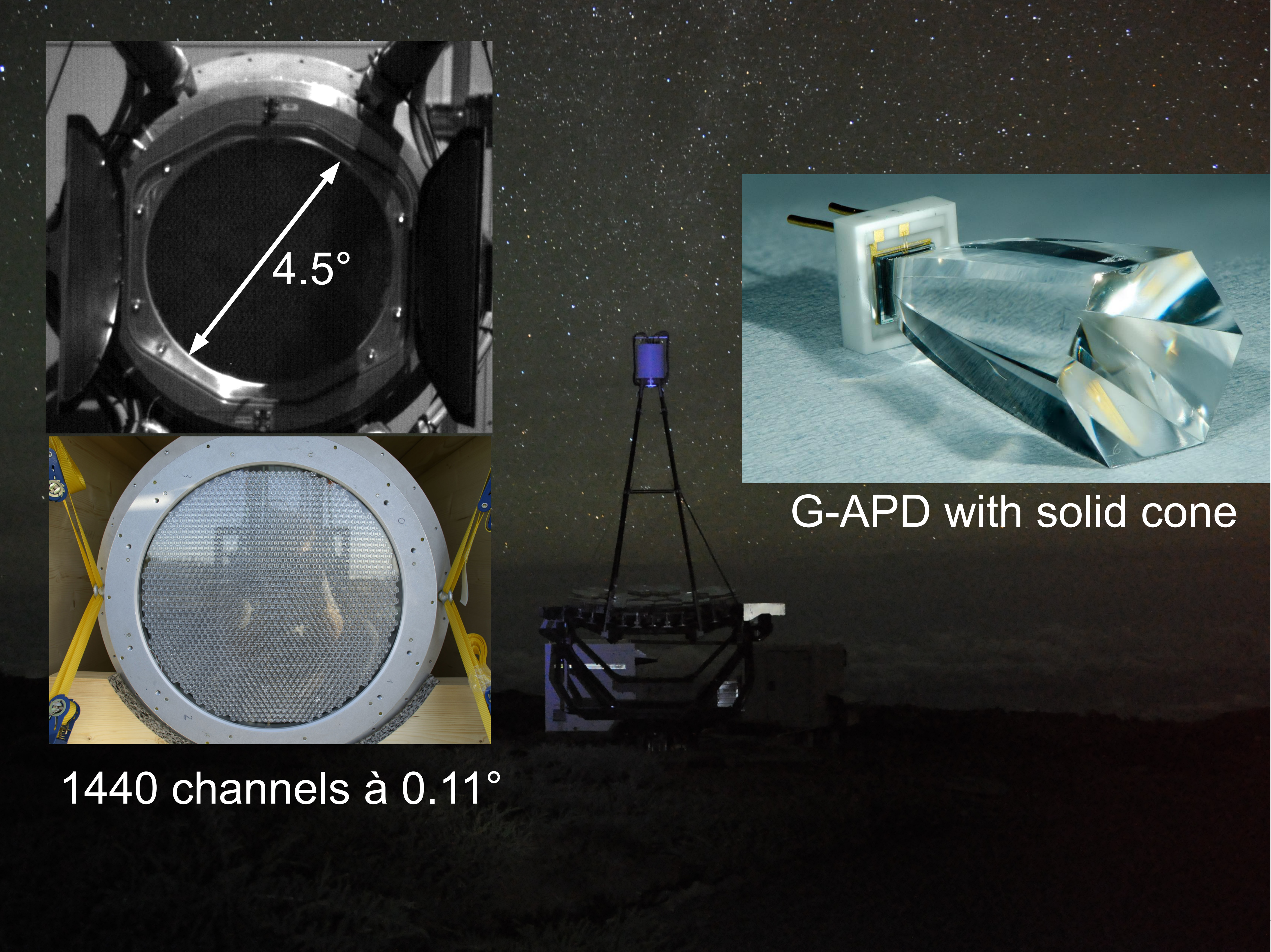
silicon devices →

?


only about
10 active FTE
working on the
commissioning
and analysis
TU Dortmund
Uni Würzburg
ETH (+Uni) Zürich
EPF Lausanne
Uni Geneve (ISDC)
FACT
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2010 Tele Atlas
US Dept of State Geographer
© 2010 Europa Technologies

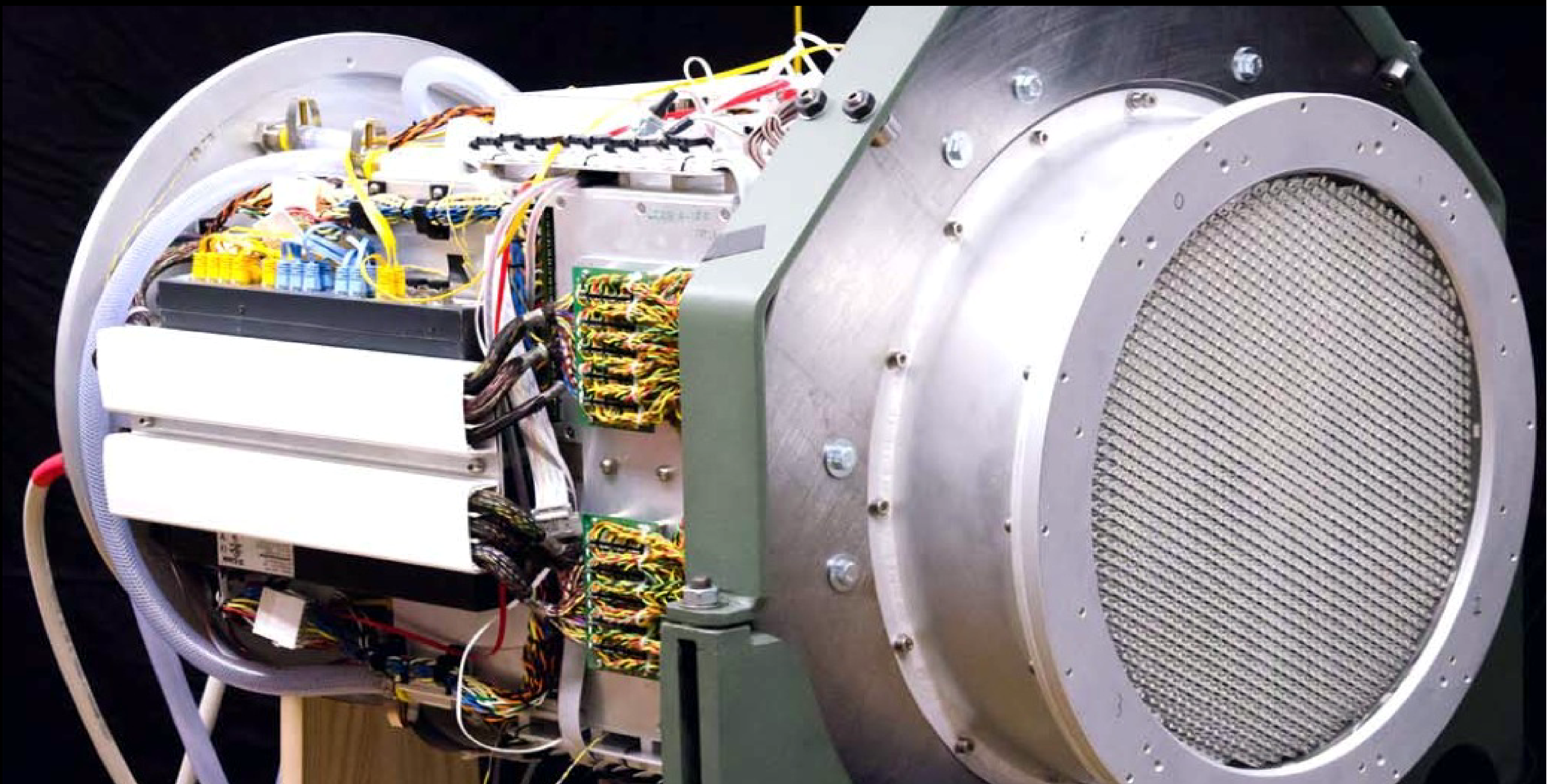

Refurbished HEGRA CT3
Reflective area 9.5m²
FACT
Long term monitoring
Operation since October 2011


4.5°
1440 channels à 0.11°


4.5°
G-APD with solid cone
1440 channels à 0.11°

Integrated electronics
DRS4 readout

320 bias voltage channels
(1 per 4/5 G-APDs)



Power consumption ≤500W
Readout via Ethernet

160 trigger patches
(sum of 9 channels)

Light pulser

- temperature stabilized
  - gain measurement

G-APDs

- Performance comparable to best available PMTs
- Cheaper than PMTs
- Future potential (PDE~70%)
- Very good timing
- Very easy to handle (U<100V)

- Afterpulses, crosstalk and darkcounts are **no problem** for Cherenkov telescopes

- Gain depends on
  - temperature
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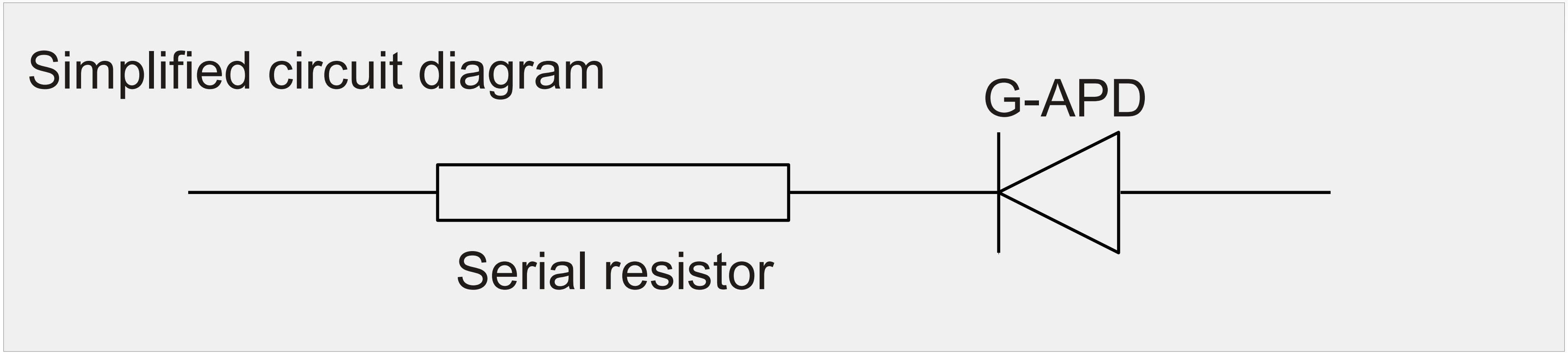
  - applied voltage

can be corrected by adapting the voltage (50mV/K)

Voltage correction

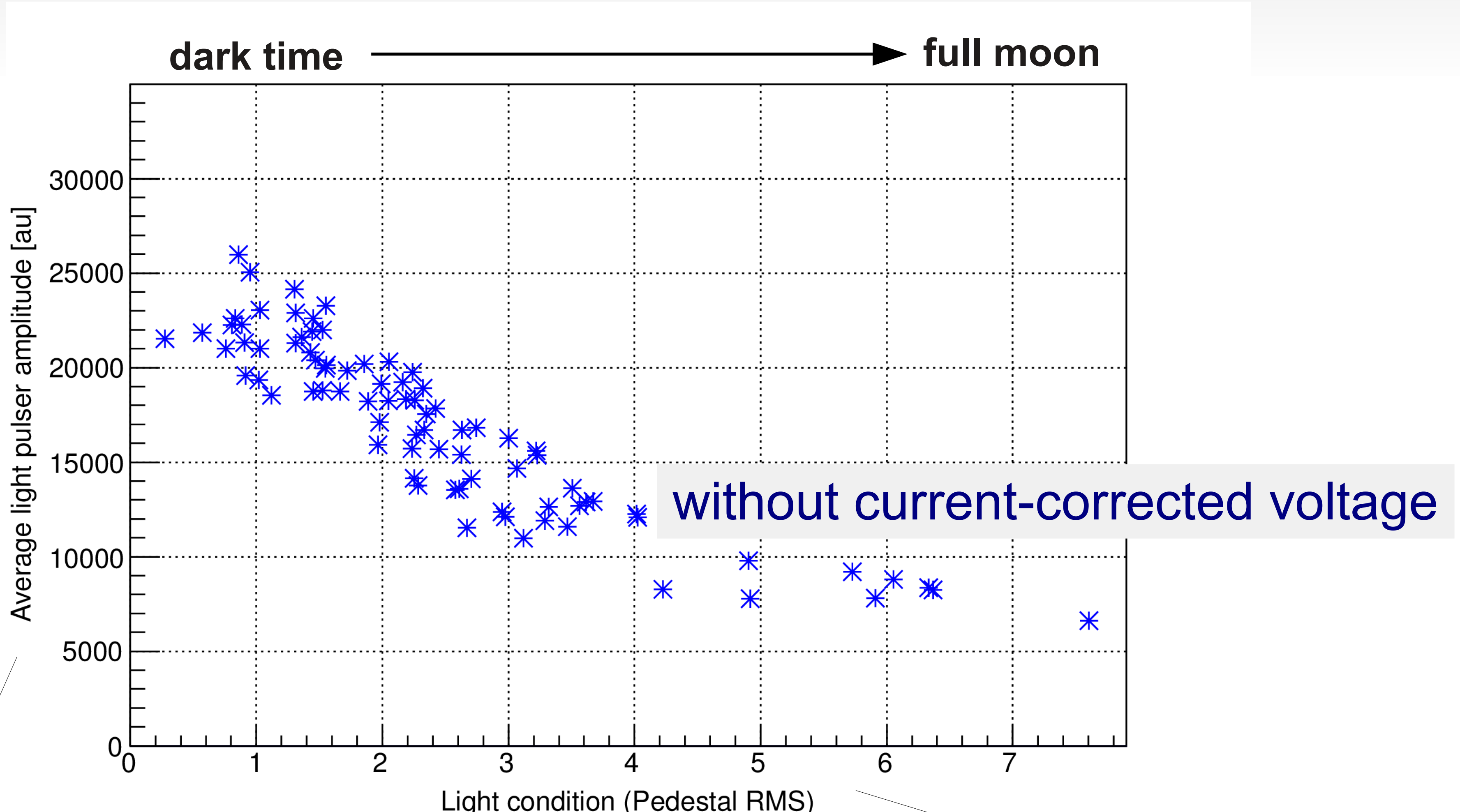


- Night-sky background induces continuous current

  → voltage drop at the resistor

  → to correct for that the current is measured and the voltage adapted accordingly

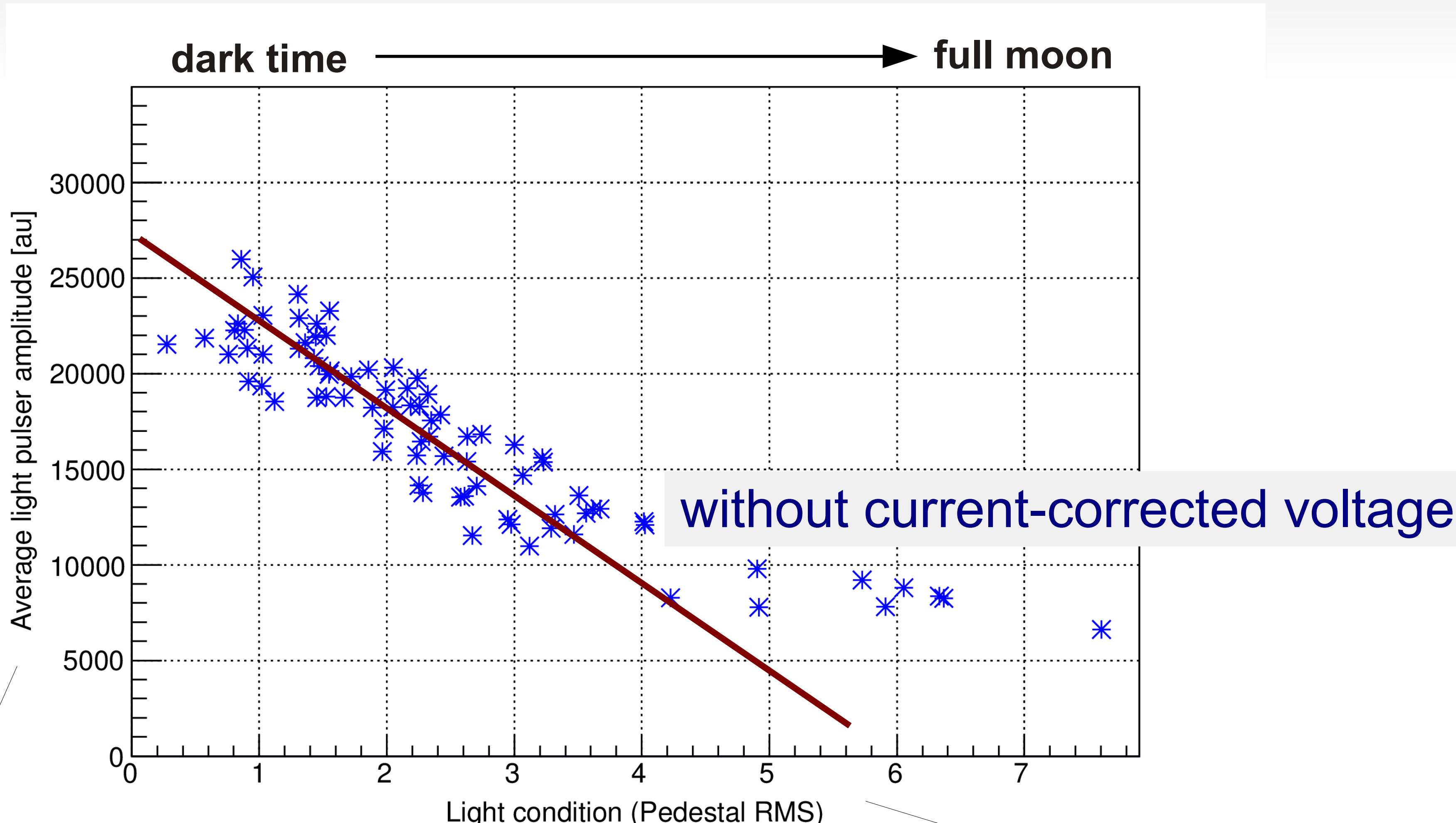
Light-pulser amplitude vs. light condition



Indirect measurement of the gain

The noise of the data is a measure for the brightness

Light-pulser amplitude vs. light condition



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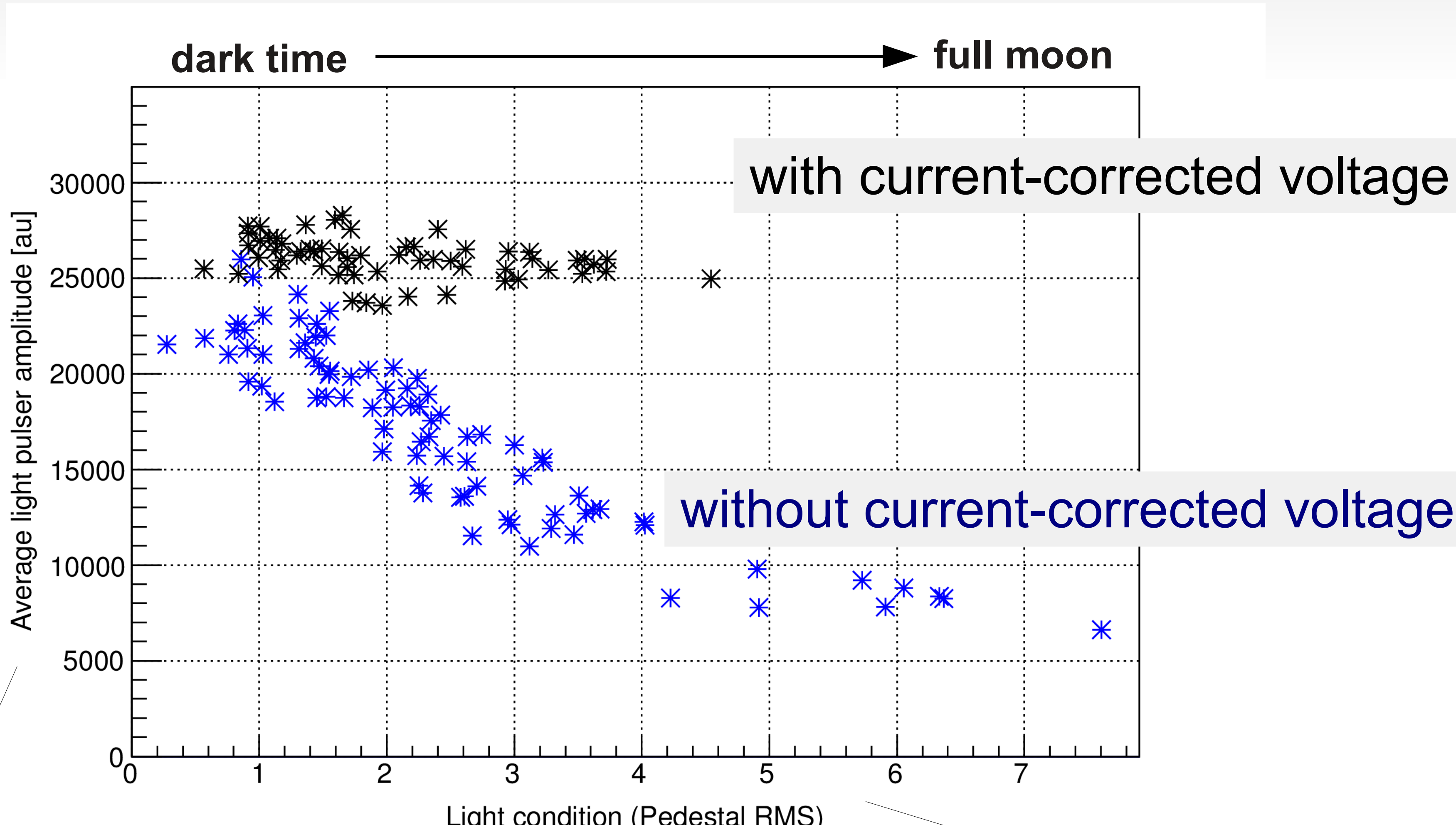

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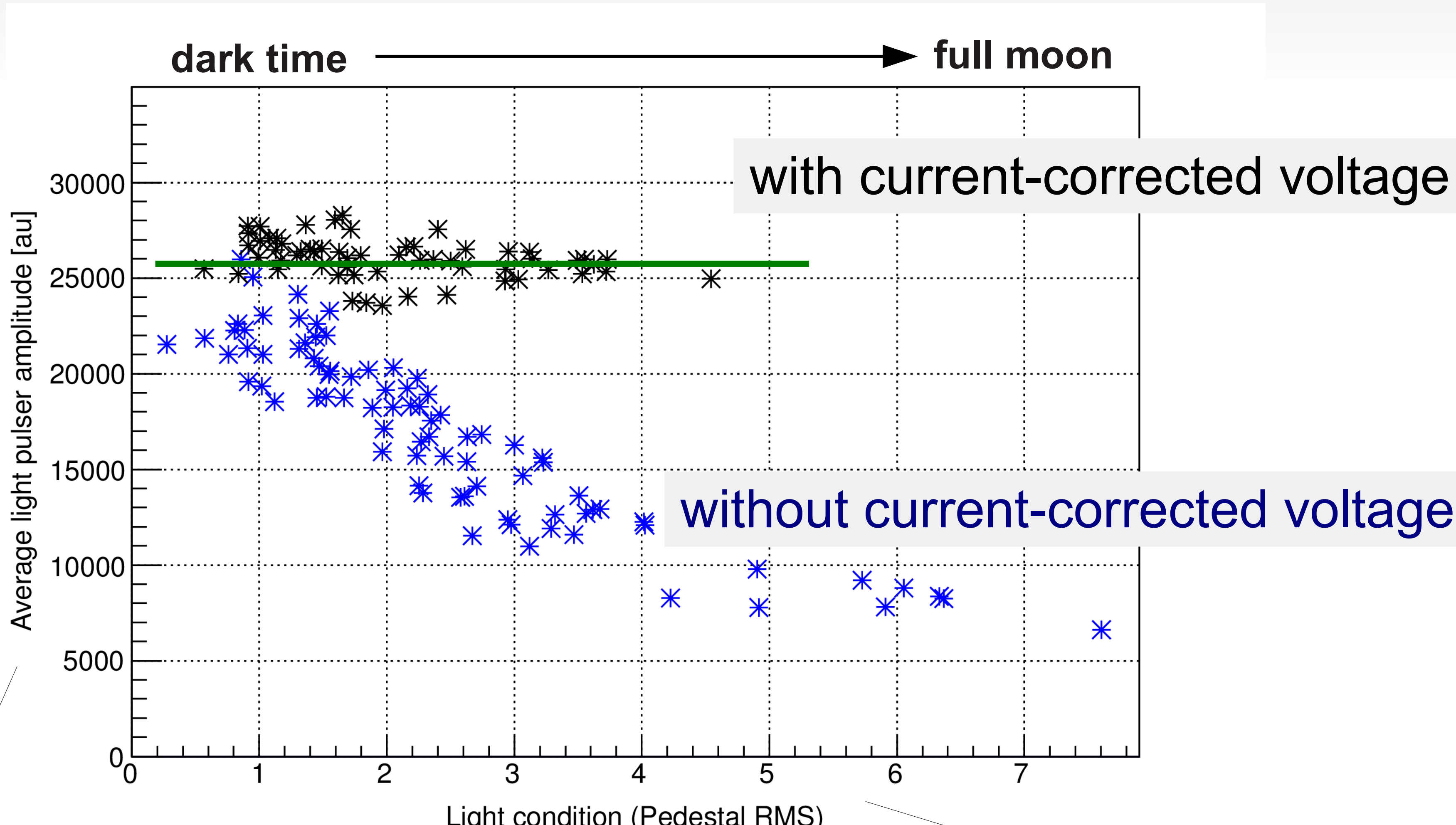
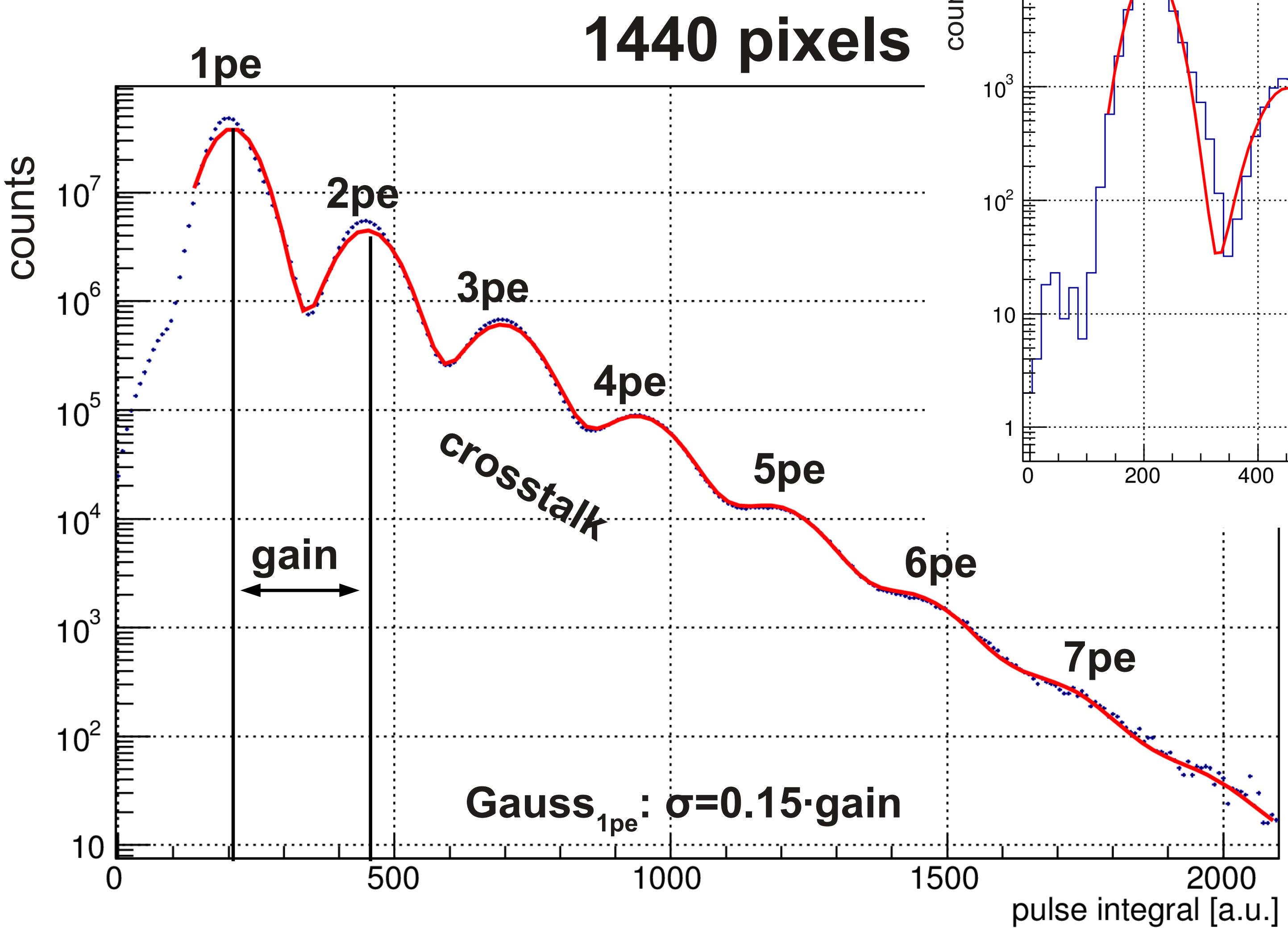


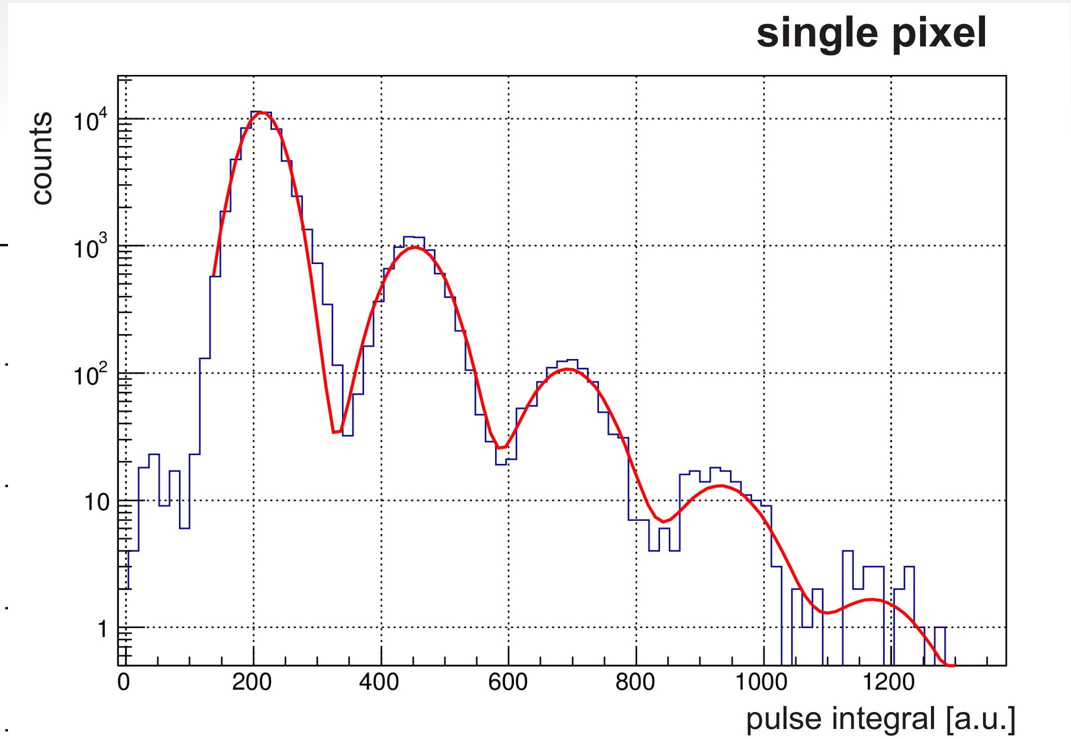
Indirect measurement of the gain

The noise of the data is a measure for the brightness

Single pe spectrum (closed lid)

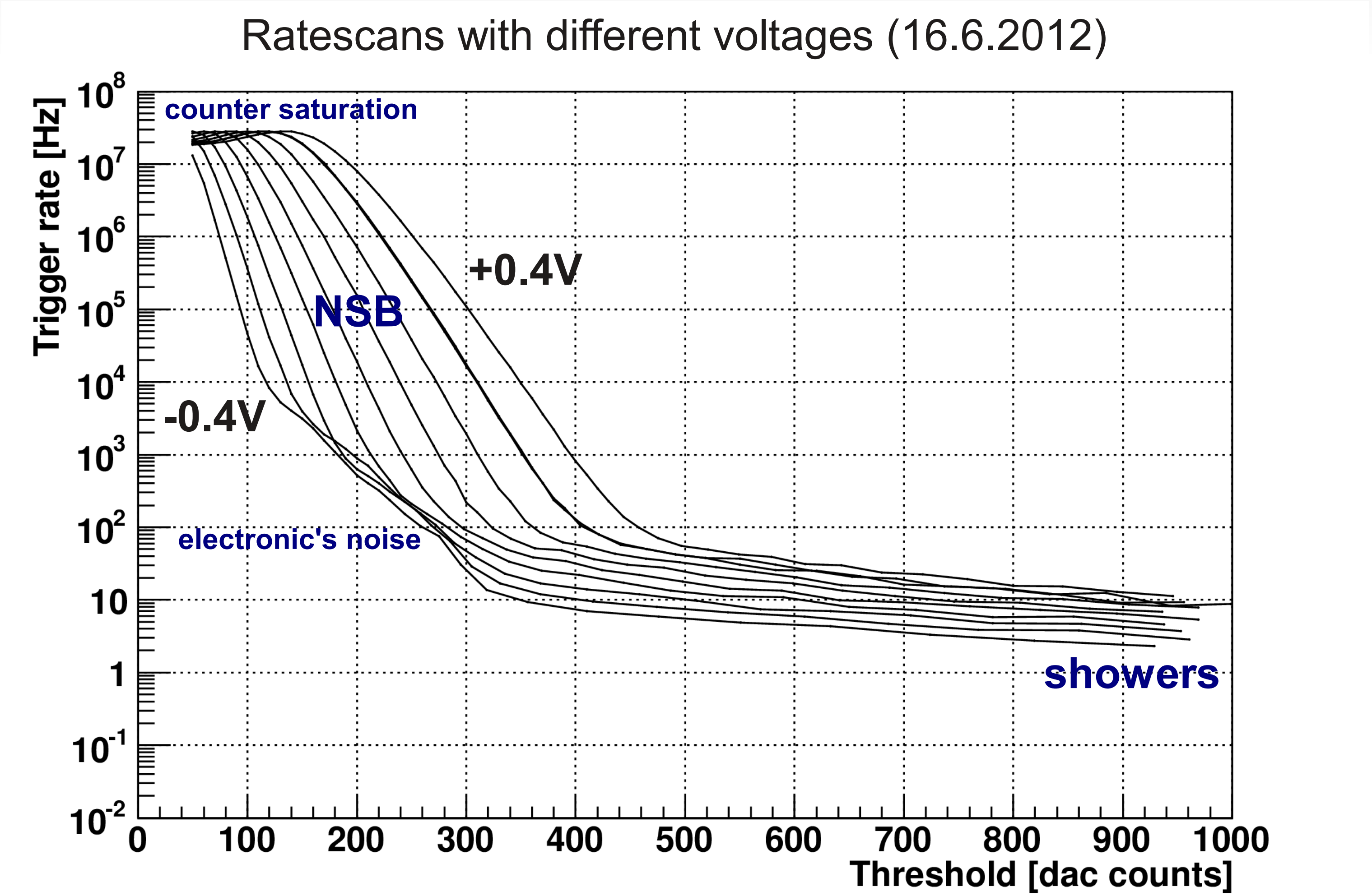
(180k events ~ 2h)



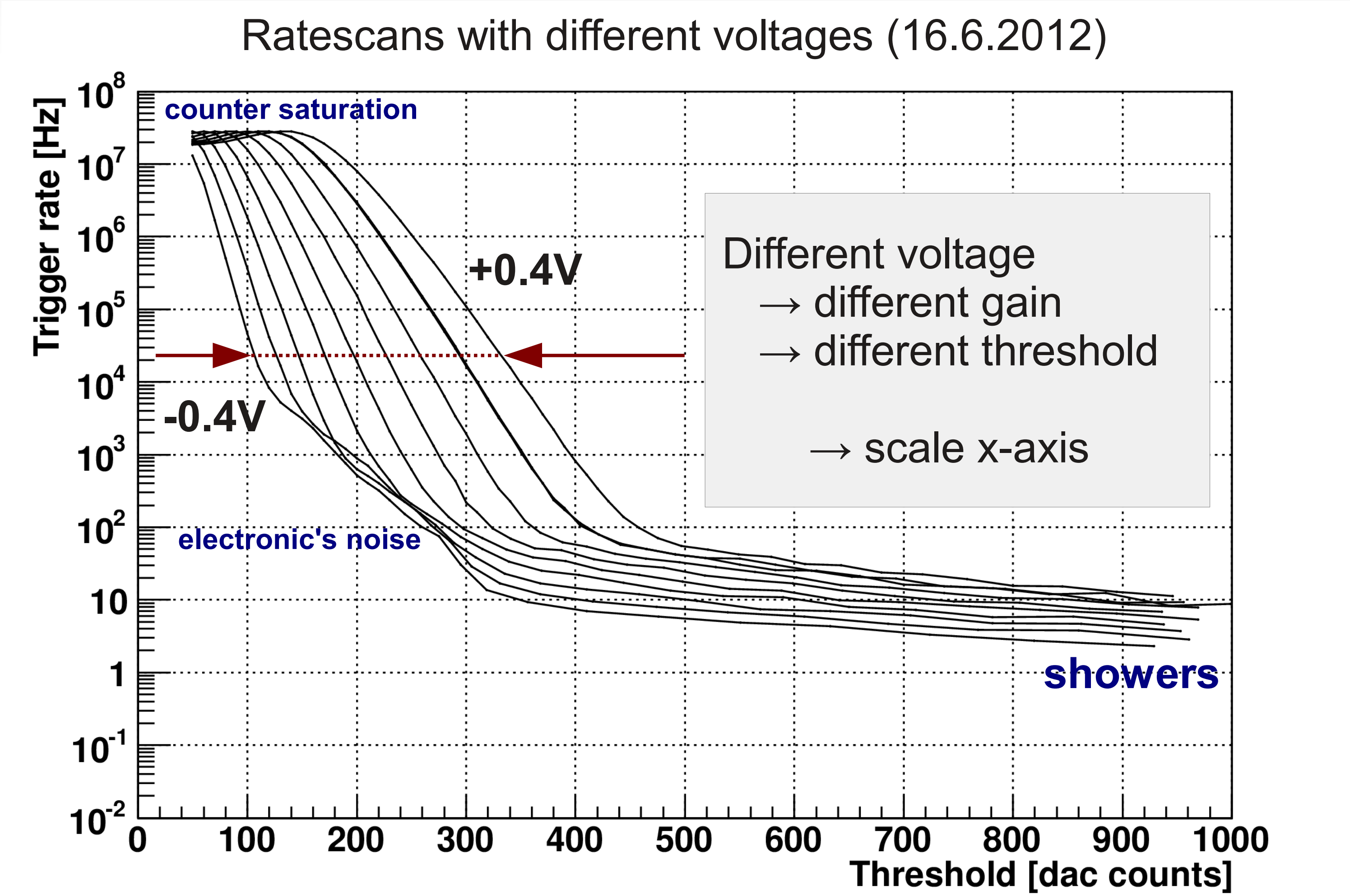


Changes over time and in between pixels must be small compared to **15%**

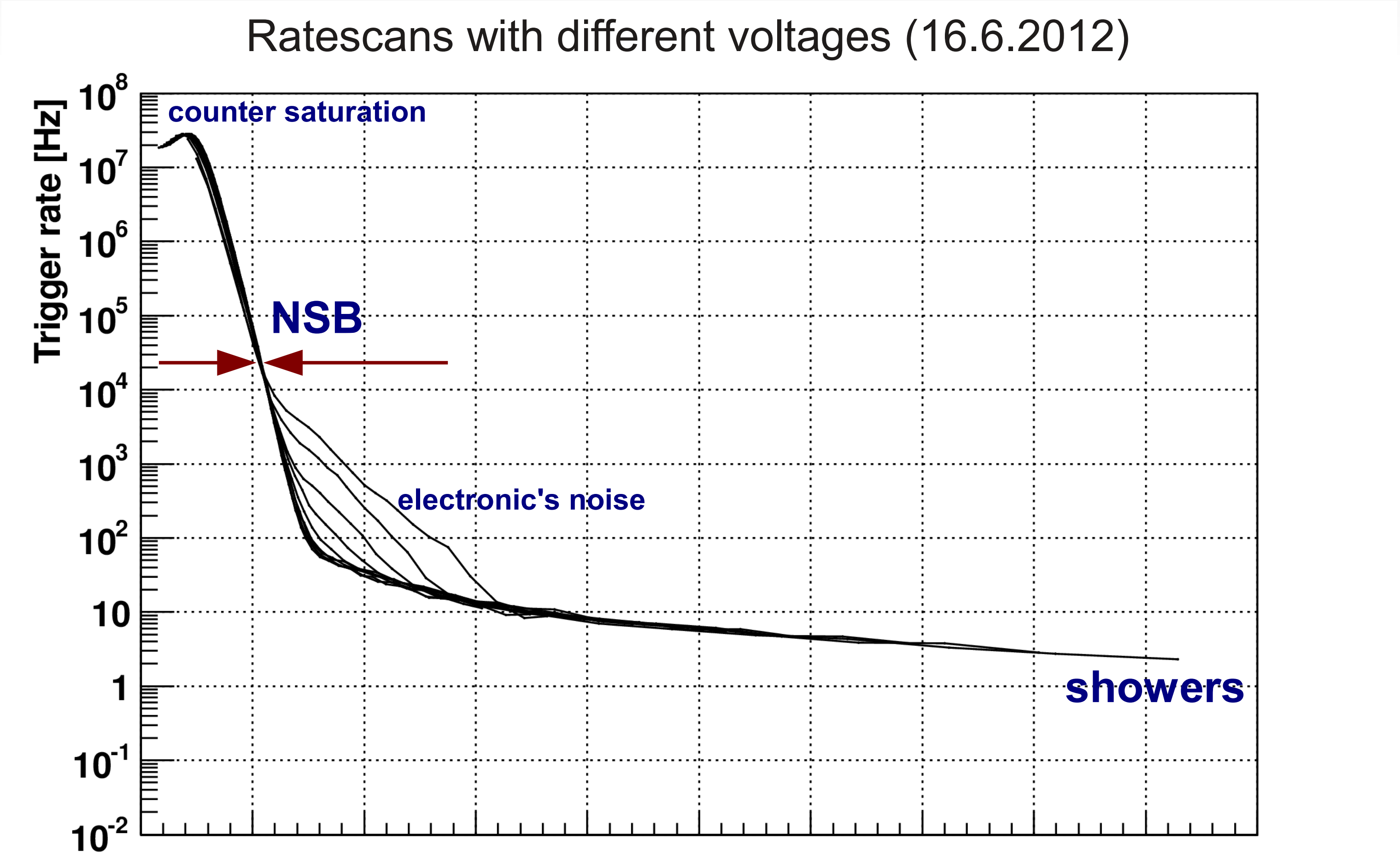
Ratescans with changing applied voltage (gain)



Ratescans with changing applied voltage (gain)



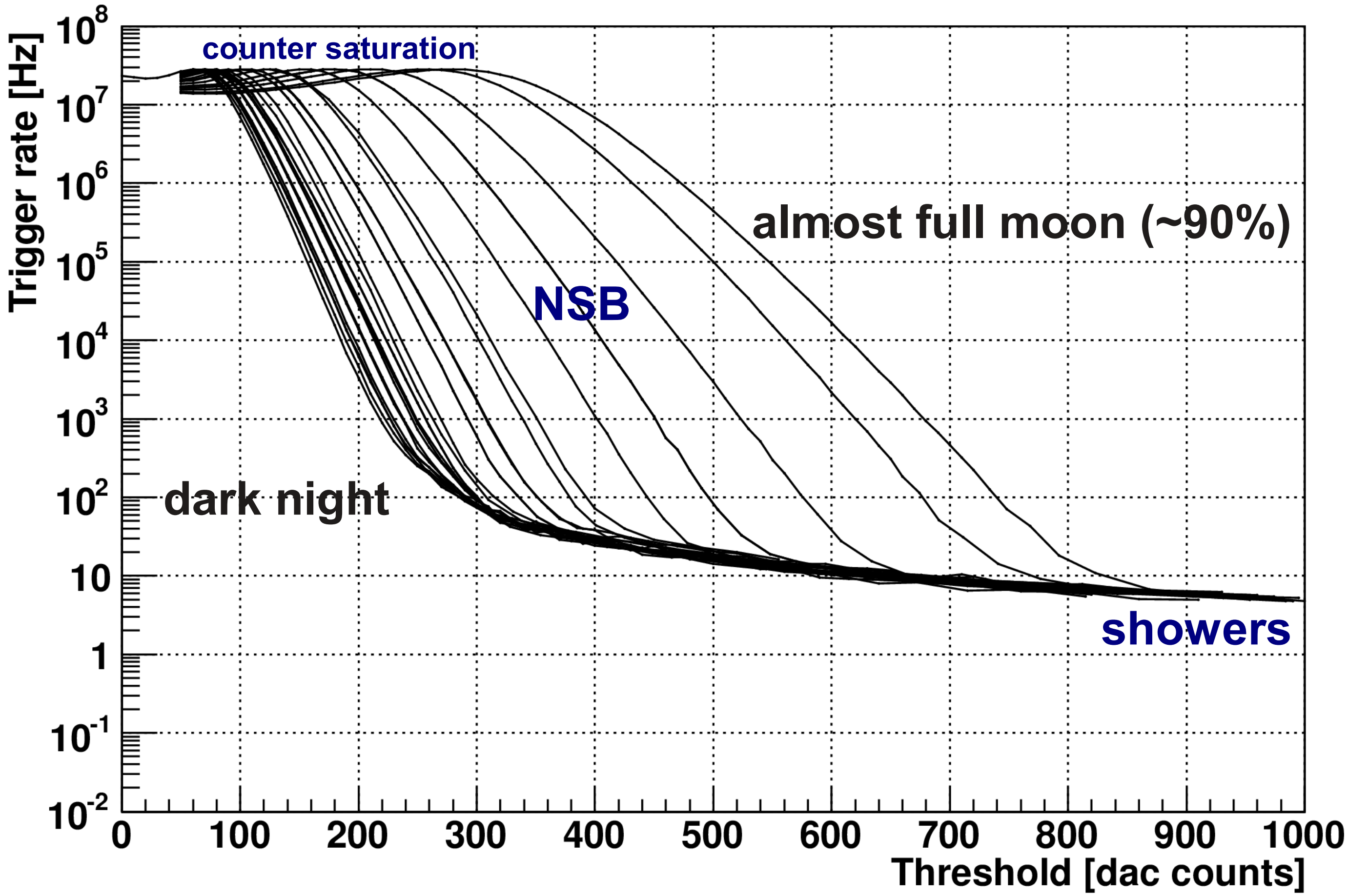
Ratescans with changing applied voltage (gain)



→ If the gain is stable only the NSB-shoulder should shift with changing light conditions

Ratescans with changing light conditions

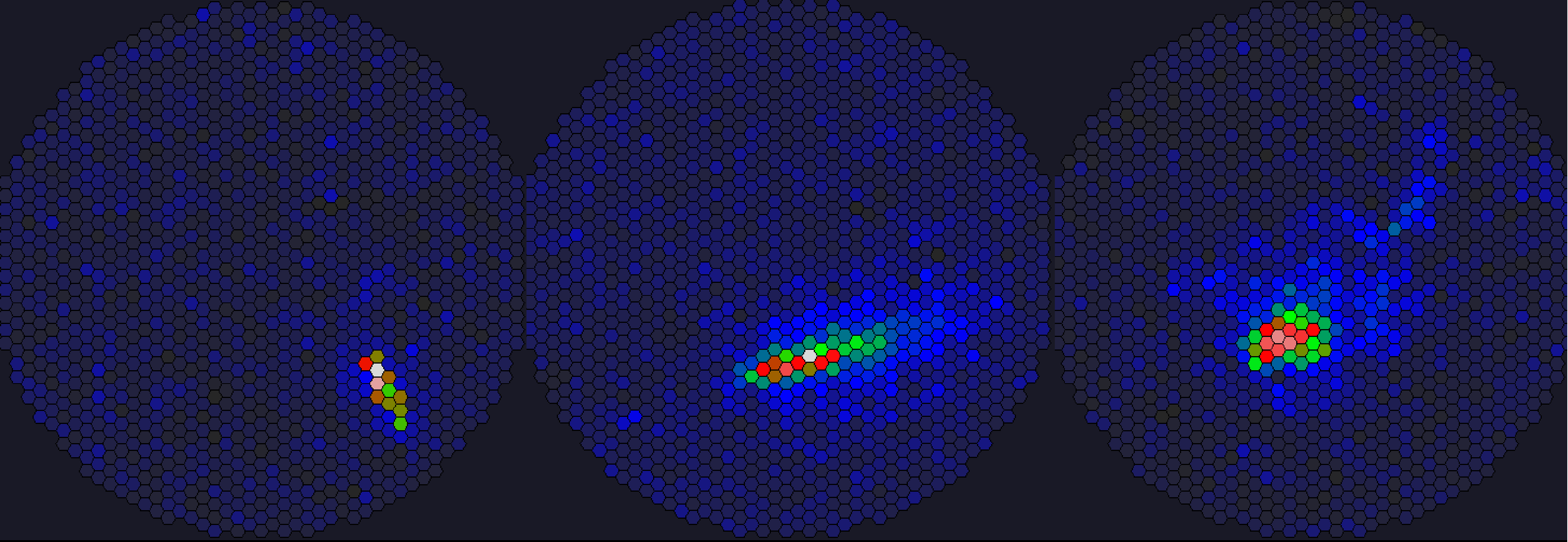
26 ratescans with different light conditions (March – July)



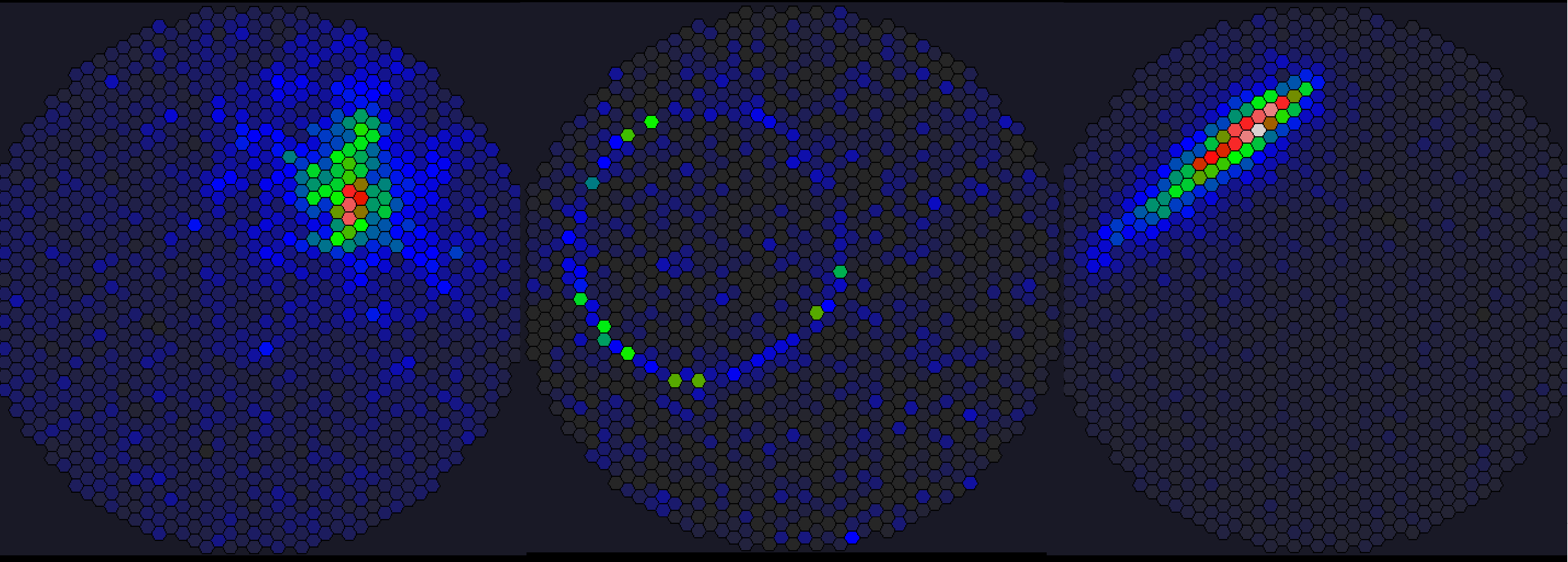
→ Gain independent of light conditions
→ Observations at full moon possible (large gain in observation time)

Data analysis

- **Data selection:**
  - Only dark-night data and data with zenith distance < 25°
- **Analysis:**
  - θ^2 analysis
    (Disp coefficients taken from MAGIC I Monte Carlo!)
  - Very simple dynamical cuts
- **Note:**
  - Systems are still in commissioning (e.g. ratecontrol, bias feedback)

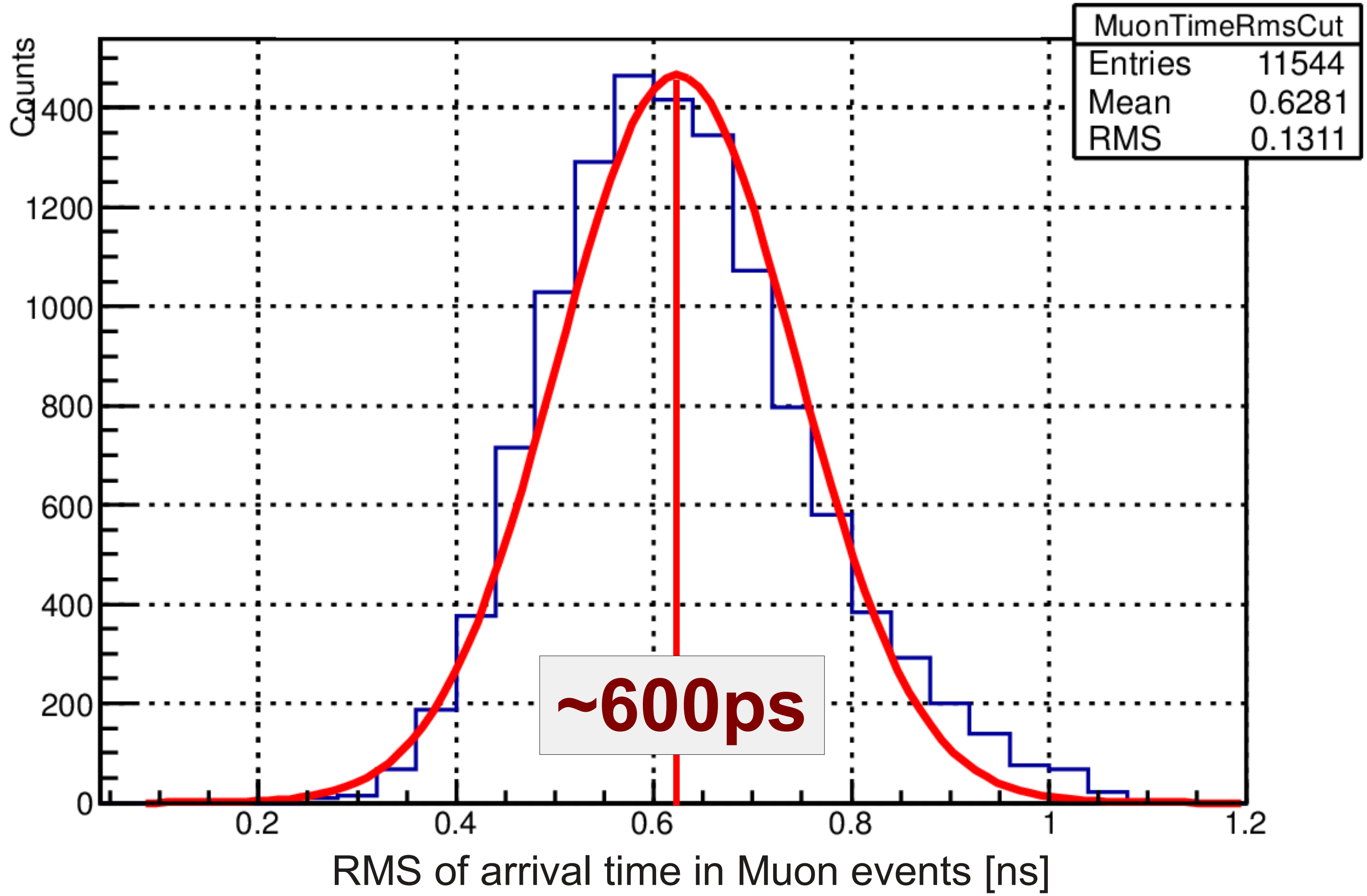


FACT – Selected events of the first nights of data-taking (October 2011)

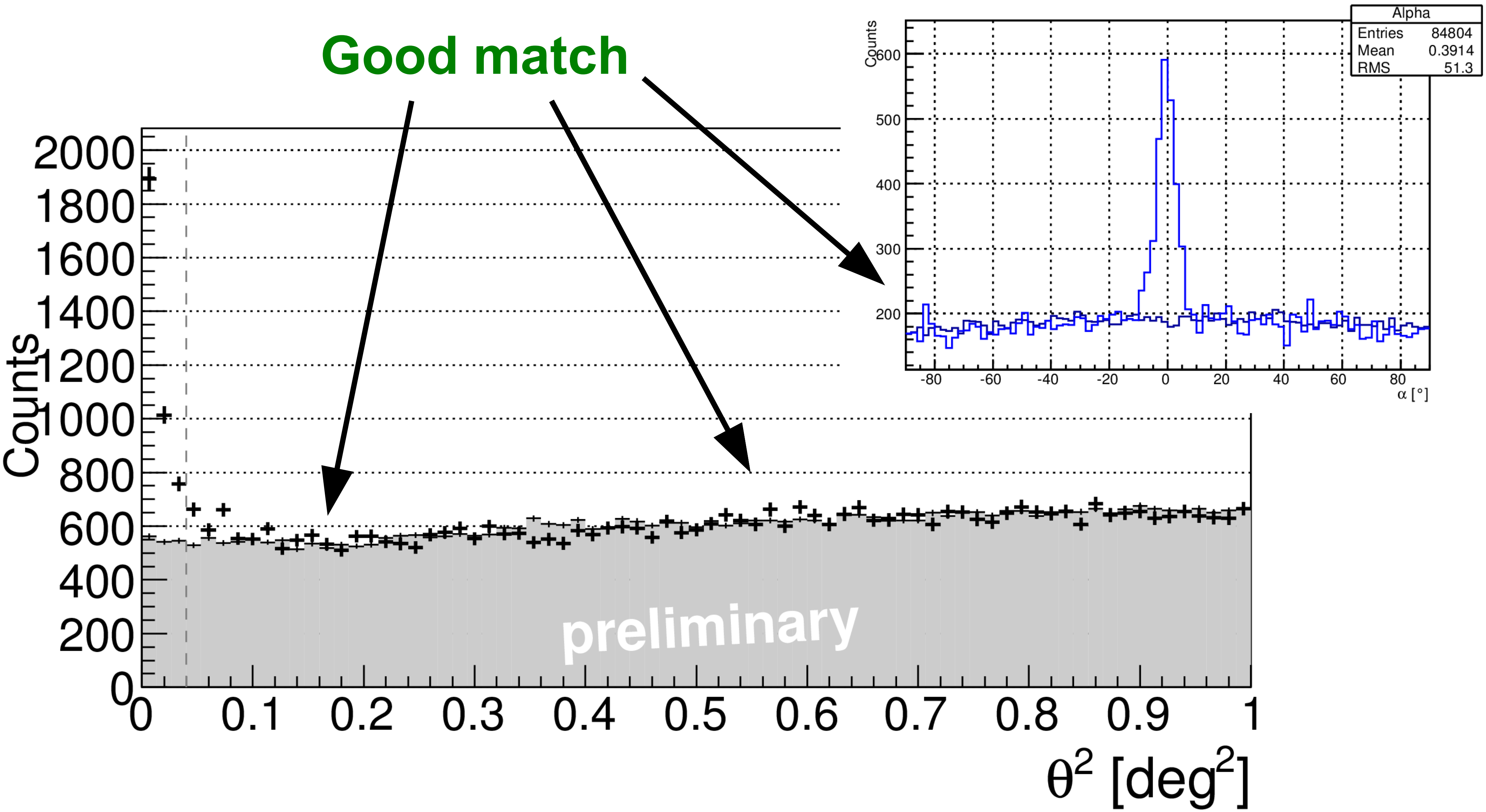


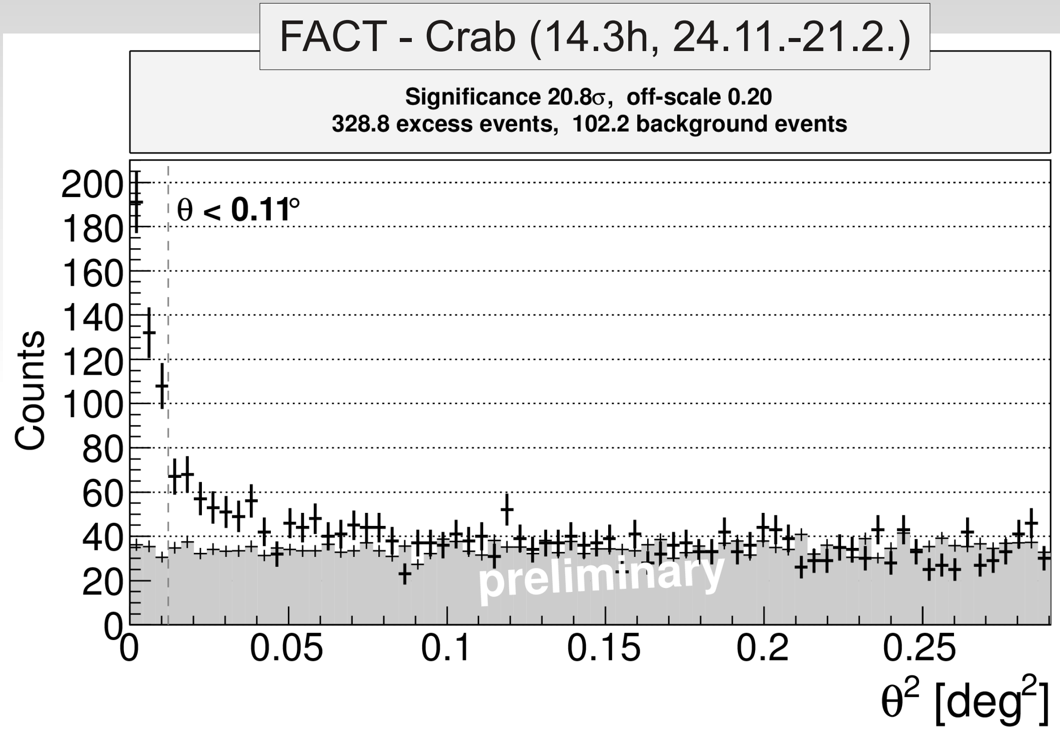
Time resolution

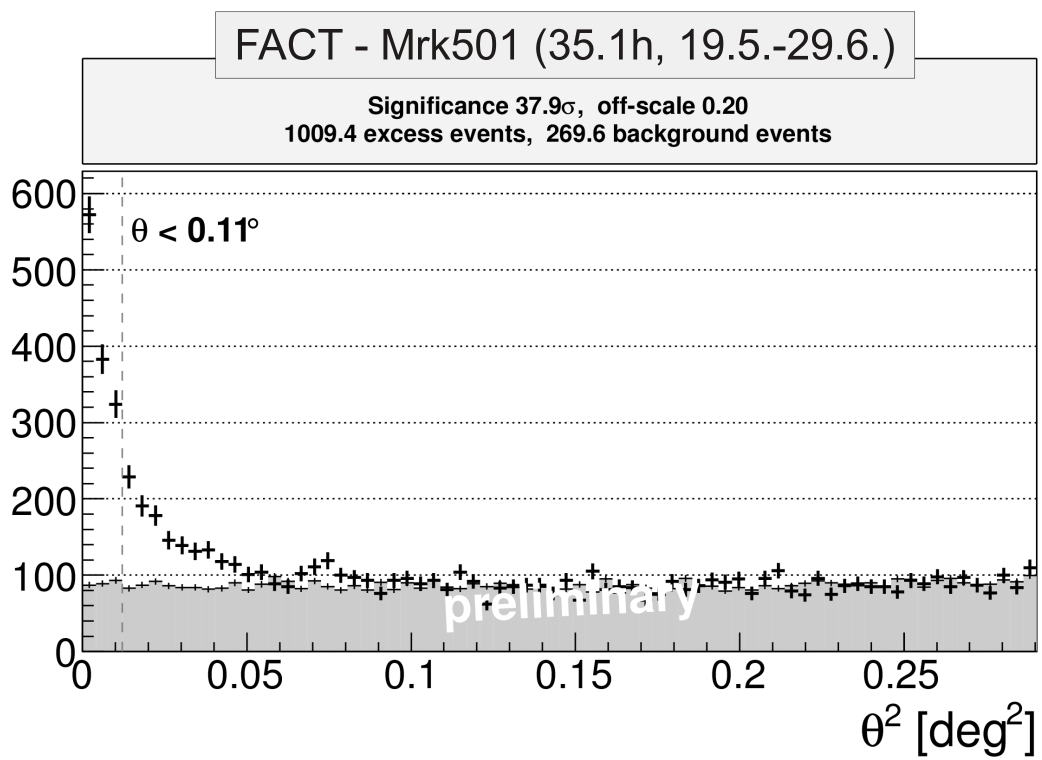
→ Time resolution of the **whole system better than 600ps**
(typical signal per pixel in muon rings in FACT: **<10pe**)

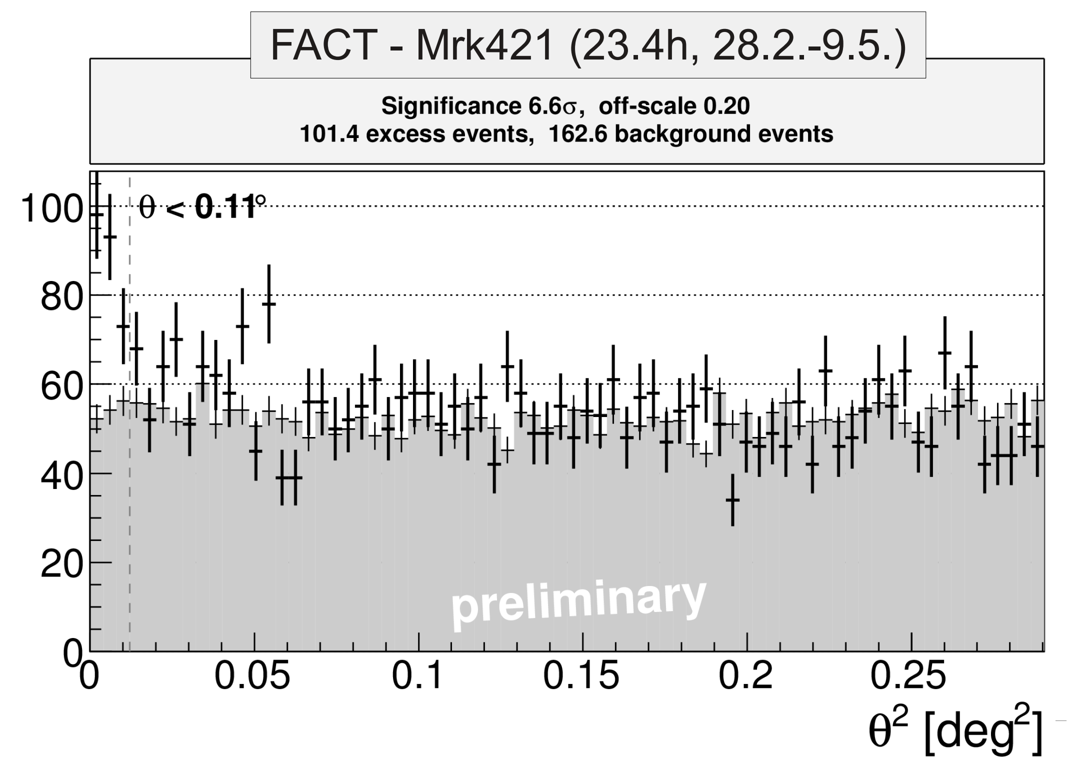


Background match




FACT - Crab (14.3h, 24.11.-21.2.)
Significance 20.8σ, off-scale 0.20
328.8 excess events, 102.2 background events
θ < 0.11°
Counts
preliminary
θ² [deg²]


FACT - Mrk501 (35.1h, 19.5.-29.6.)
Significance 37.9σ, off-scale 0.20
1009.4 excess events, 269.6 background events
θ < 0.11°
preliminary
θ² [deg²]


FACT - Mrk421 (23.4h, 28.2.-9.5.)
Significance 6.6σ, off-scale 0.20
101.4 excess events, 162.6 background events
θ < 0.11°
preliminary
θ² [deg²]

Energy threshold

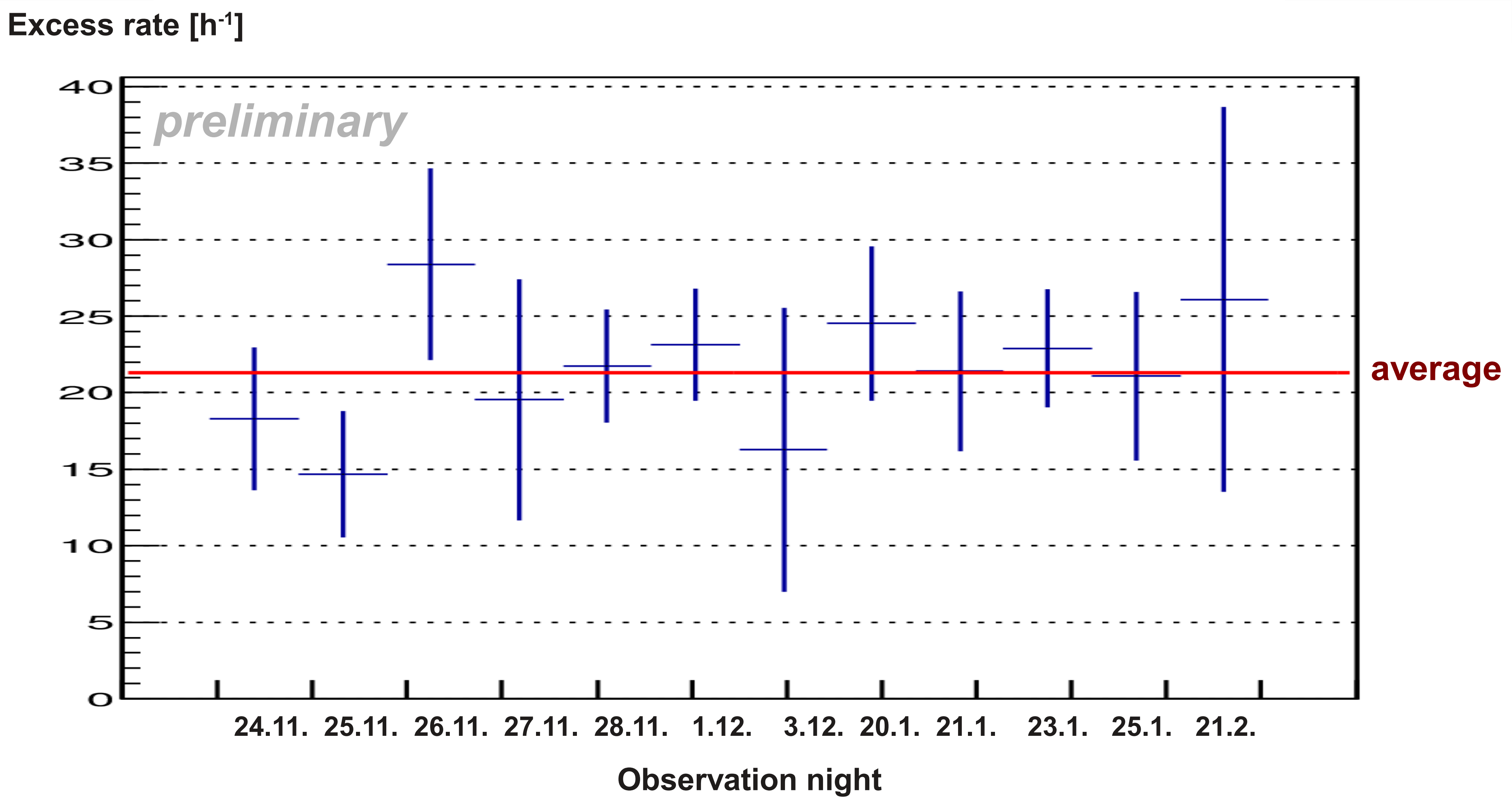
- ***<u>Very simple analysis:</u>***
  - Sensitivity cuts (optimized for best integral sensitivity):
    (very similar excess rate than CT1)
    → **~700 GeV**
  - Open cuts
    (excess rate extrapolated with Crab spectrum)
    → **~400 GeV**

Sensitivity (Crab in 50h)

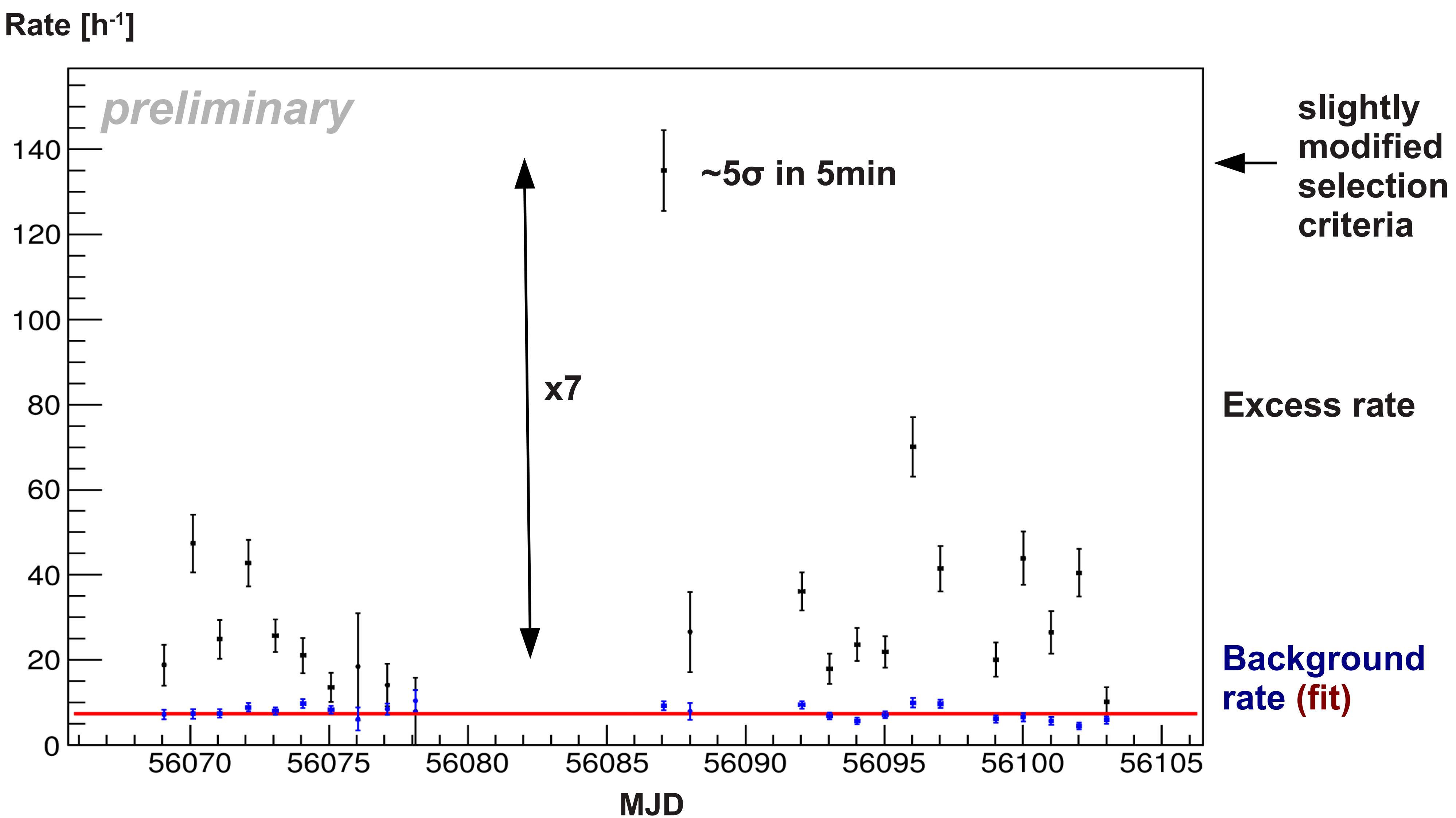
- ***Very simple analysis:*** $$5 \cdot \sqrt{\frac{T_{obs}}{50\mathrm{h}}} \cdot \frac{\sqrt{background}}{excess}$$

  - HEGRA CT1 (Eckart Lorenz, priv. com.) ~15%
    (3.7 σ / √h)
  - HEGRA System (astro-ph/9901094) ~10%
  - HEGRA System (astro-ph/0306123) ~6%
  - **FACT:** **~8%**
    (5.5 σ / √h)

Crab "Light curve"

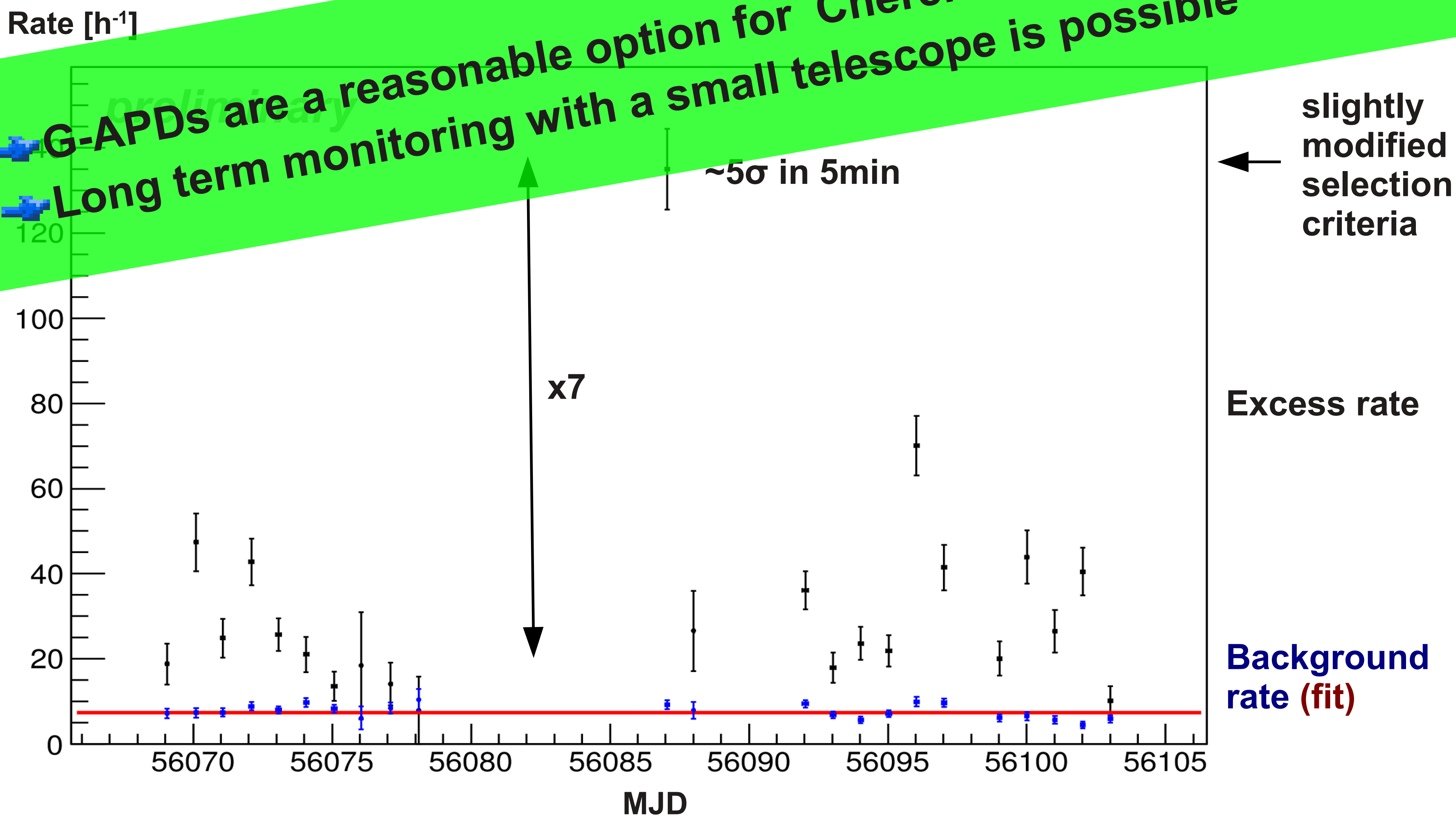


Mrk501 "light curve"

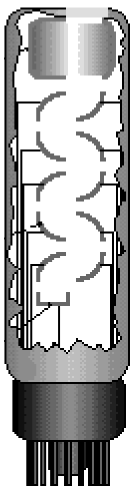


Conclusion

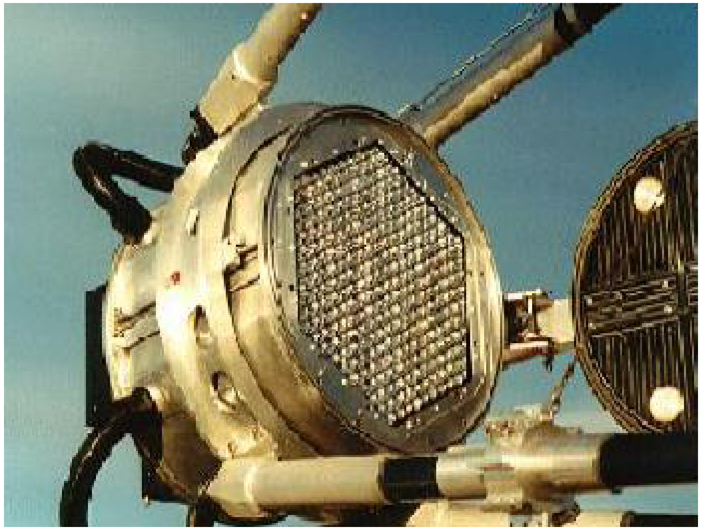
- G-APDs are a reasonable option for Cherenkov telescope
- Long term monitoring with a small telescope is possible



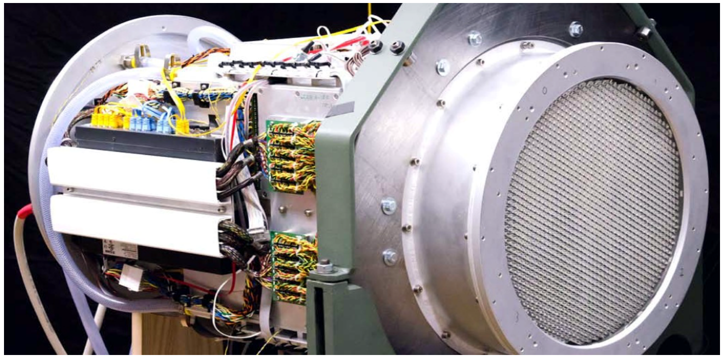
FACT
First G-**A**PD **C**herenkov **T**elescope



tubes →



silicon devices →



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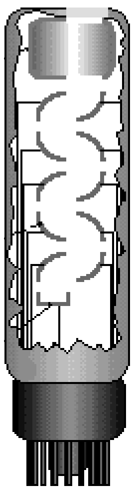

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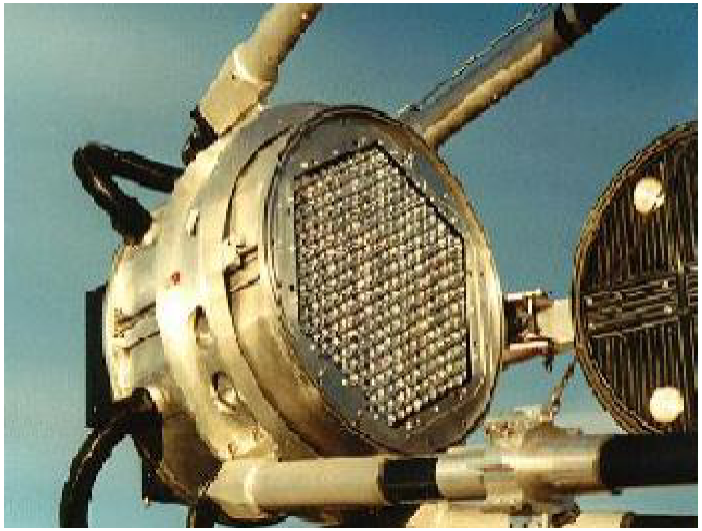

silicon → devices

?

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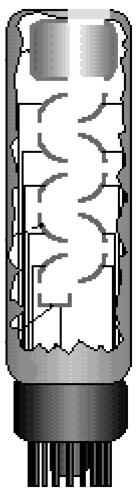

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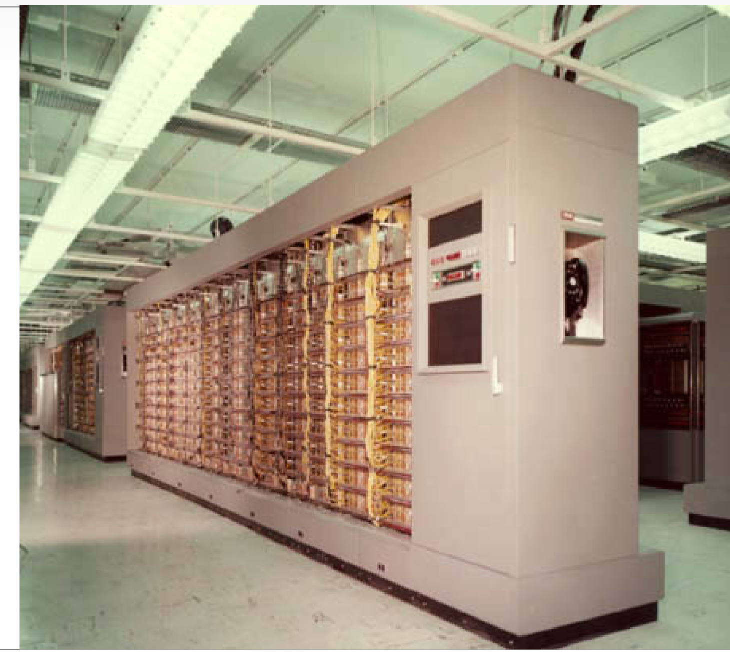
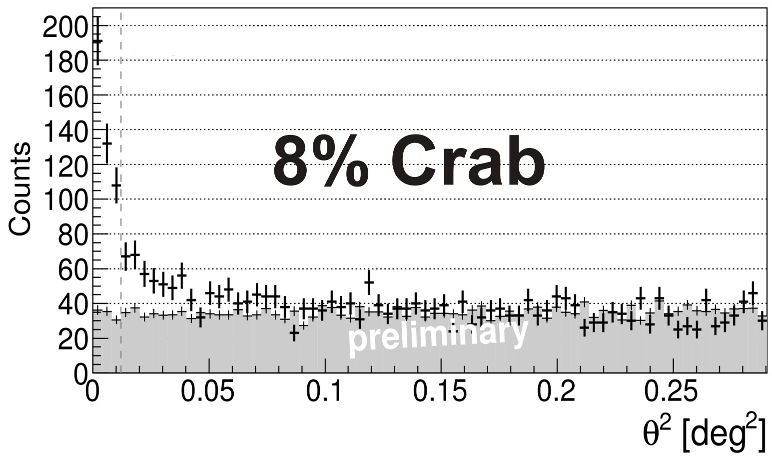
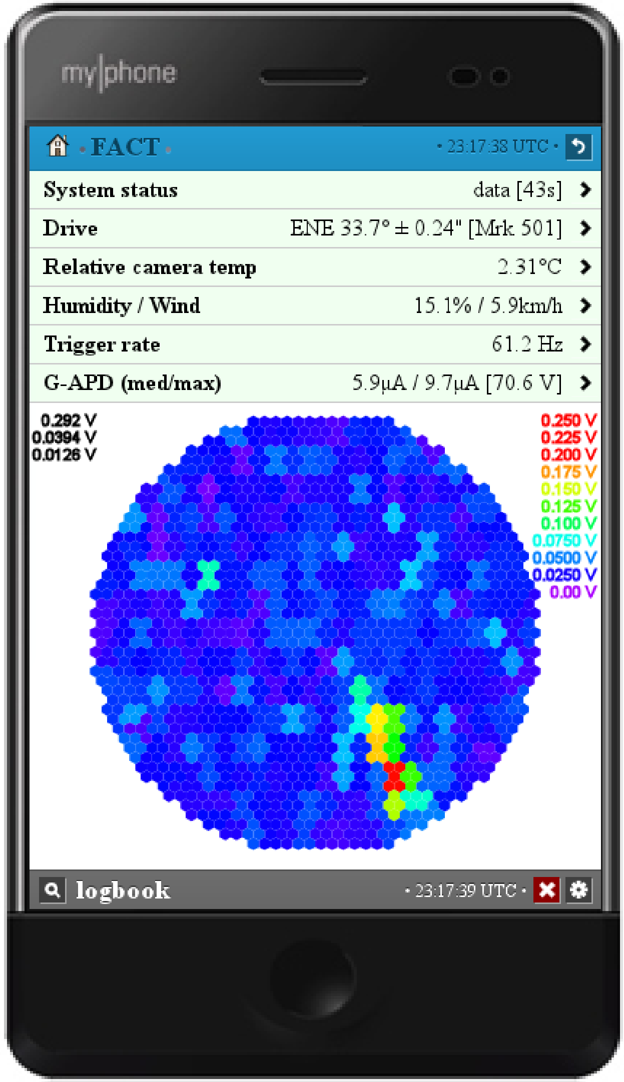


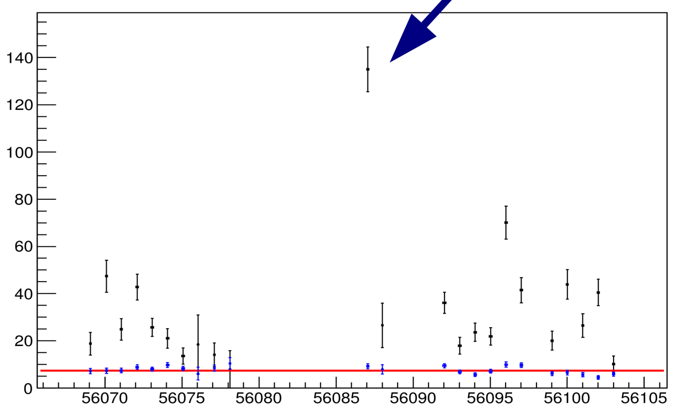
silicon devices →

www.fact-project.org/smartfact





~5σ in 5min



You are invited to join us during monitoring!