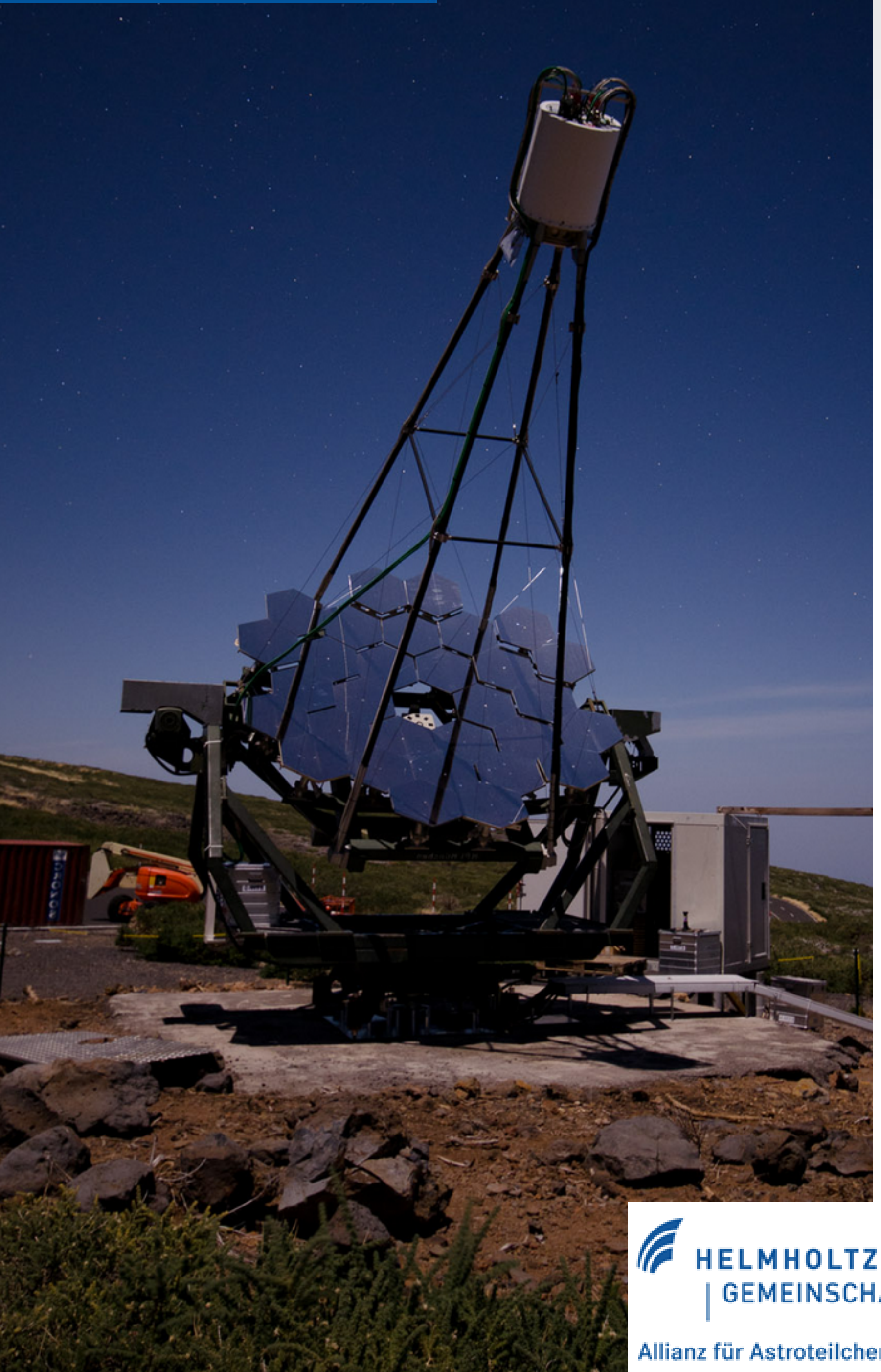
RWTH AACHEN UNIVERSITY

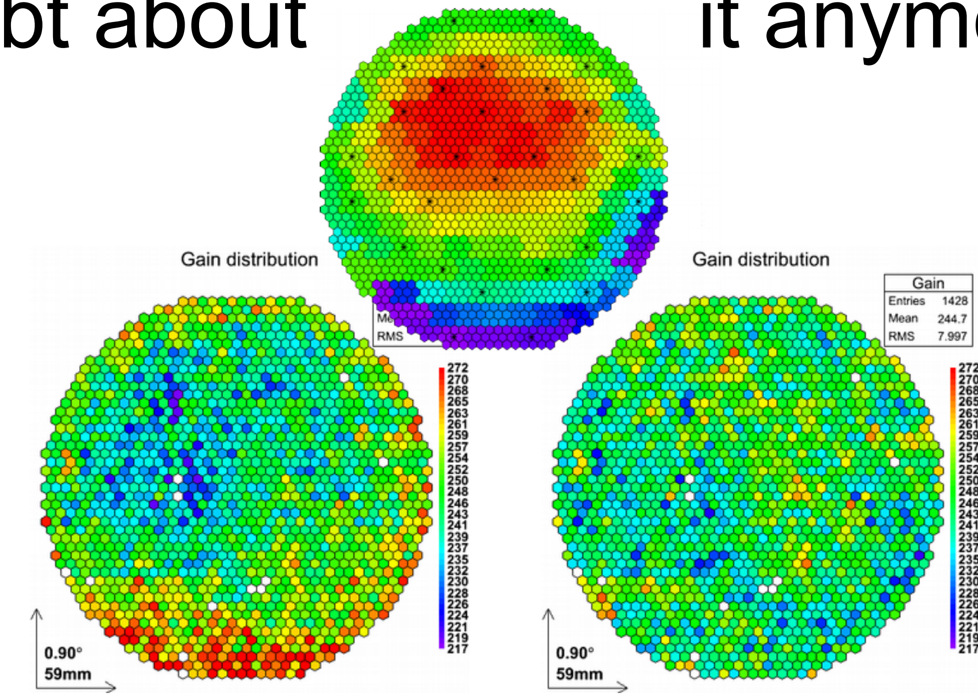


A low-cost wide FoV Cherenkov Telescope

Thomas Bretz
(RWTH Aachen)

HELMHOLTZ GEMEINSCHAFT
Allianz für Astroteilchenphysik

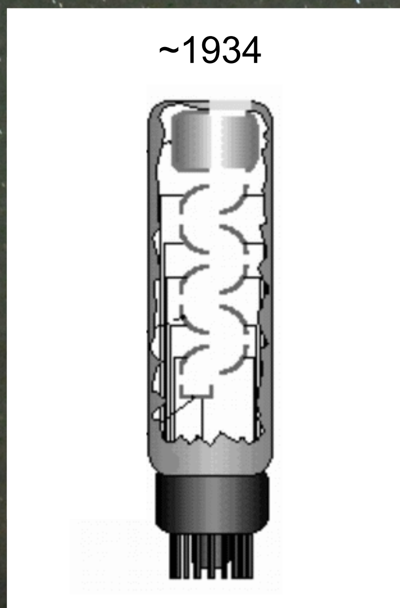
3 years ago, I was trying to convince you that SiPMs work... today there is no doubt about it anymore!



- FACT and its Performance
- FAMOUS
- Estimate FAMOUS Performance

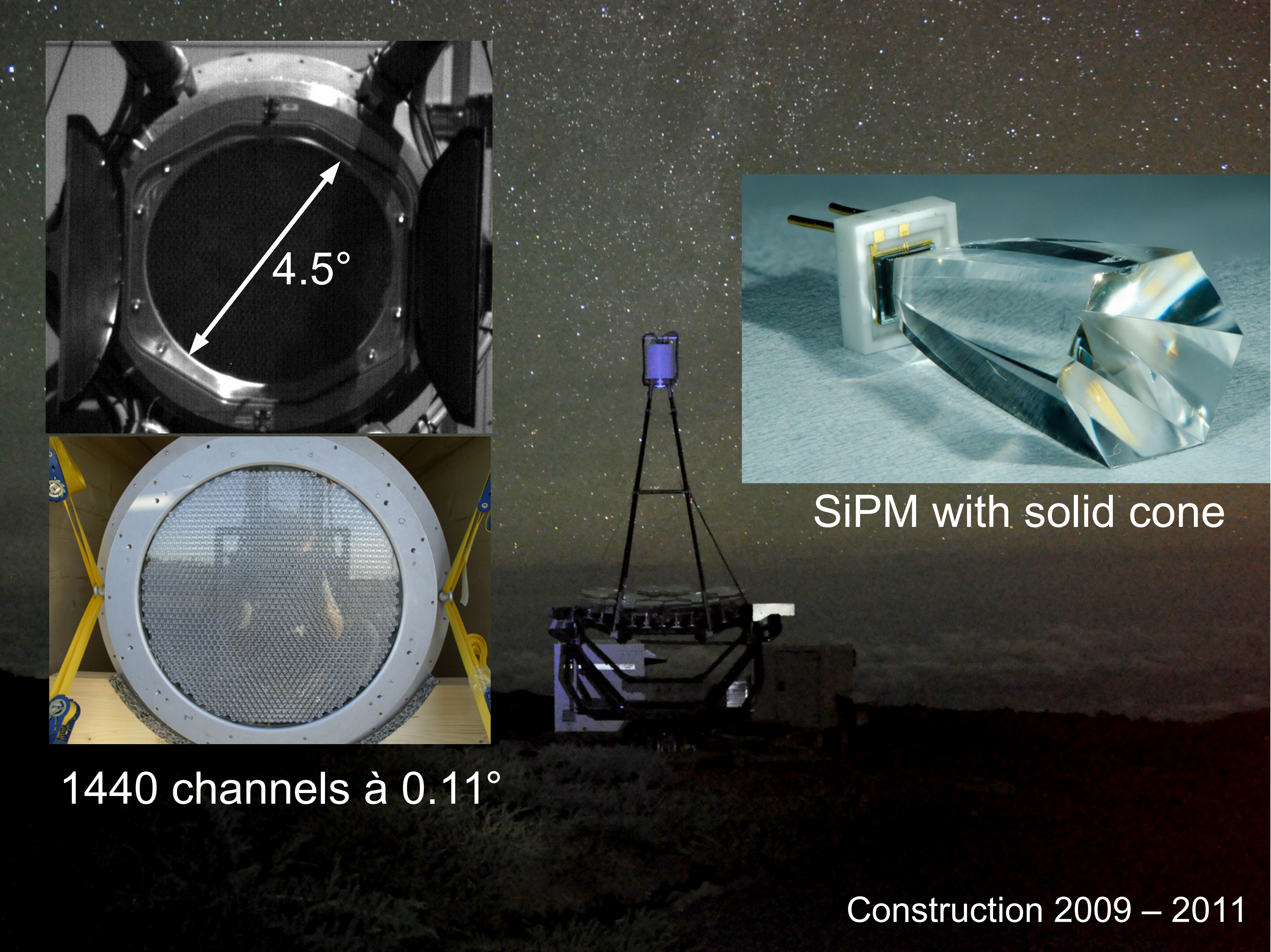
FACT

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

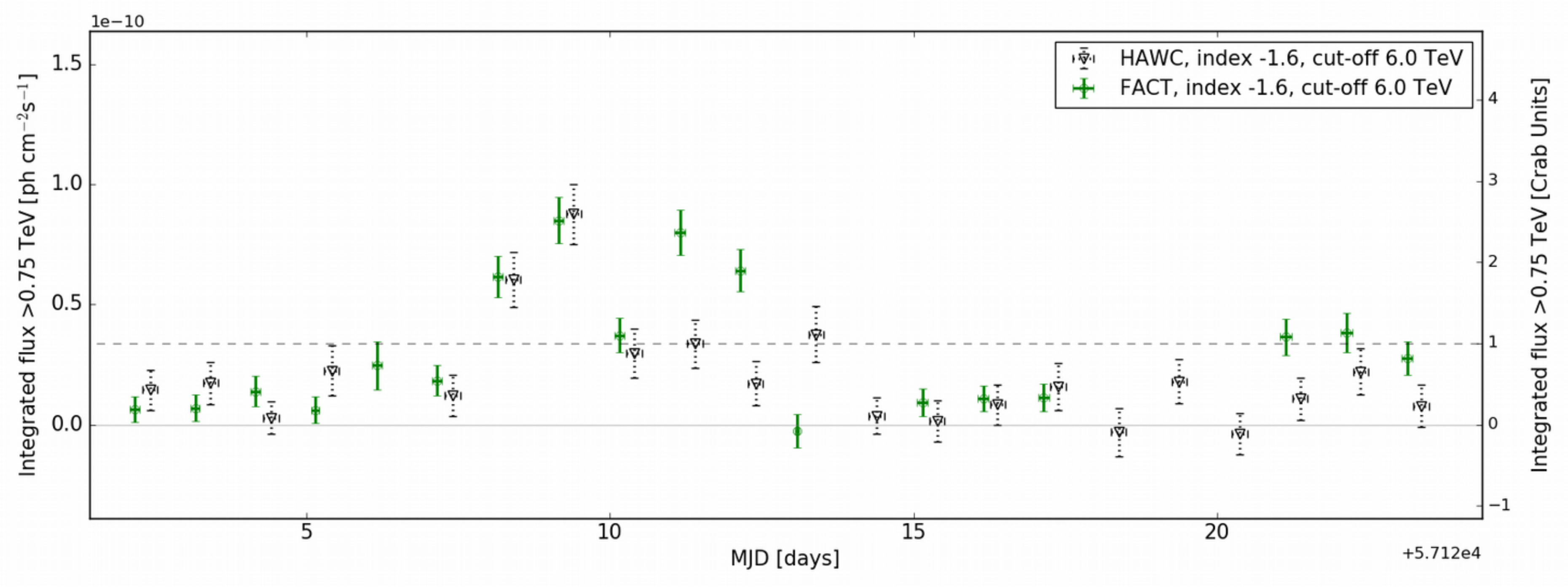


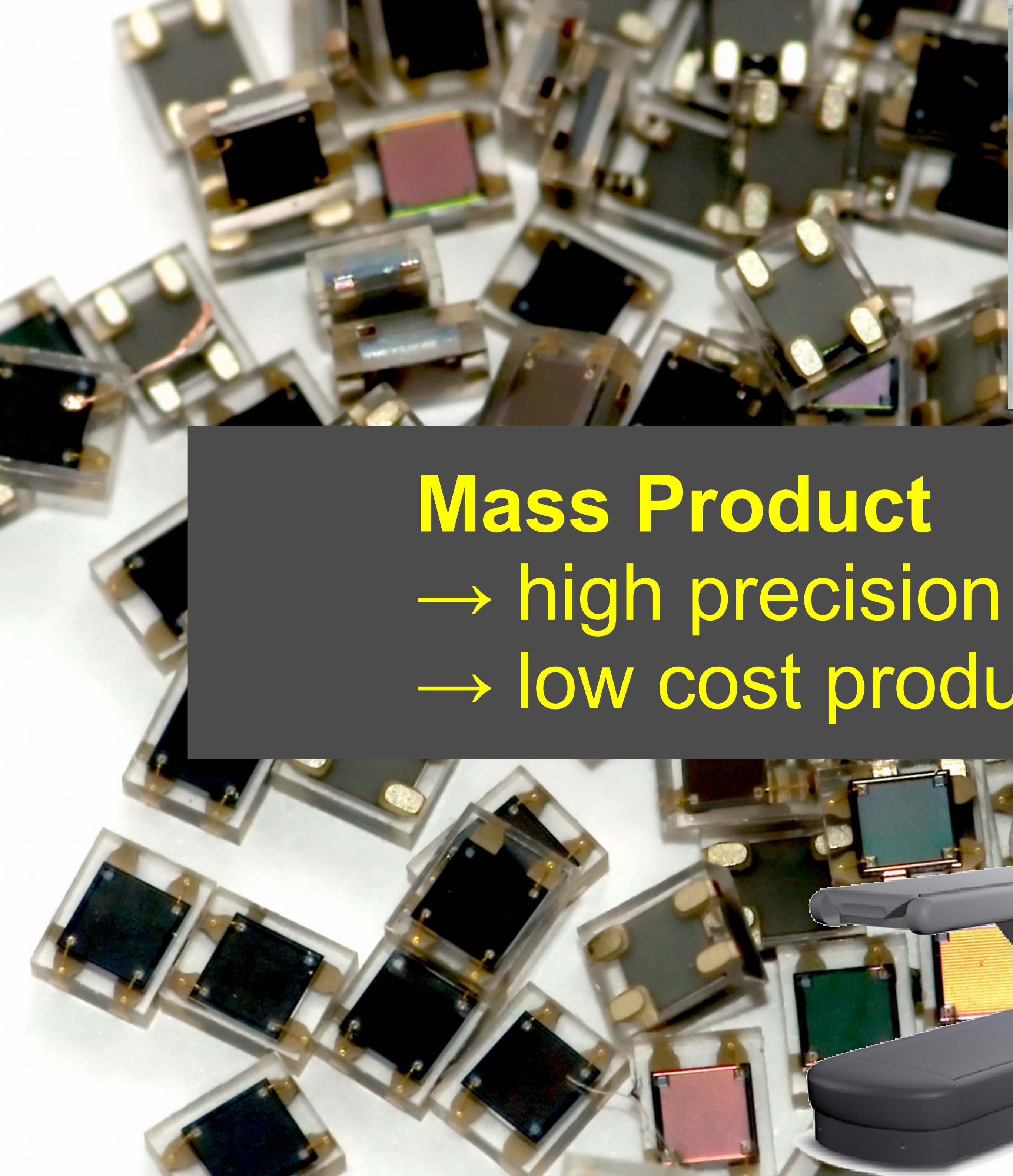
~ 2008

Dedicated monitoring telescope
with the possibility to observe during strong moon light


4.5°
SiPM with solid cone
1440 channels à 0.11°
Construction 2009 – 2011

5yr monitoring / combined monitoring





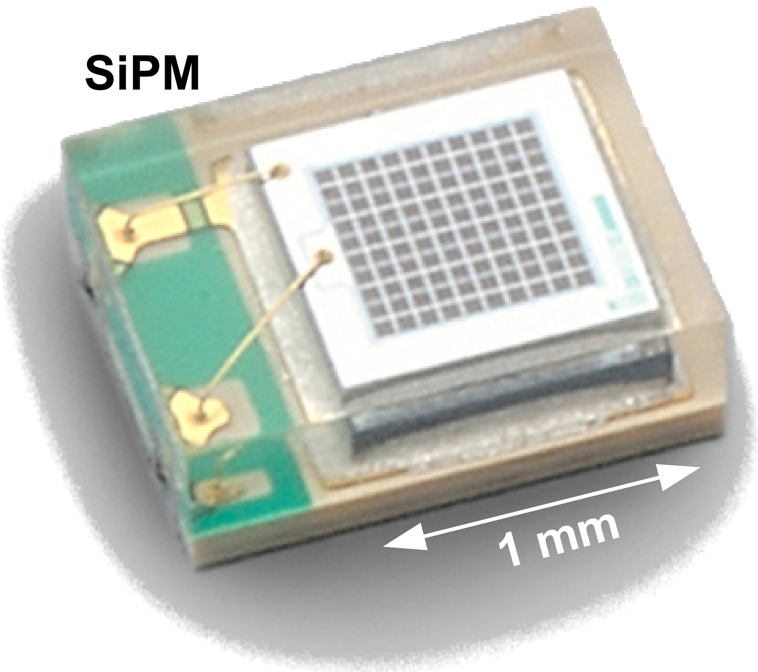
Mass Product

→ high precision

→ low cost product

What is a SiPM?

Silicon based photo sensors



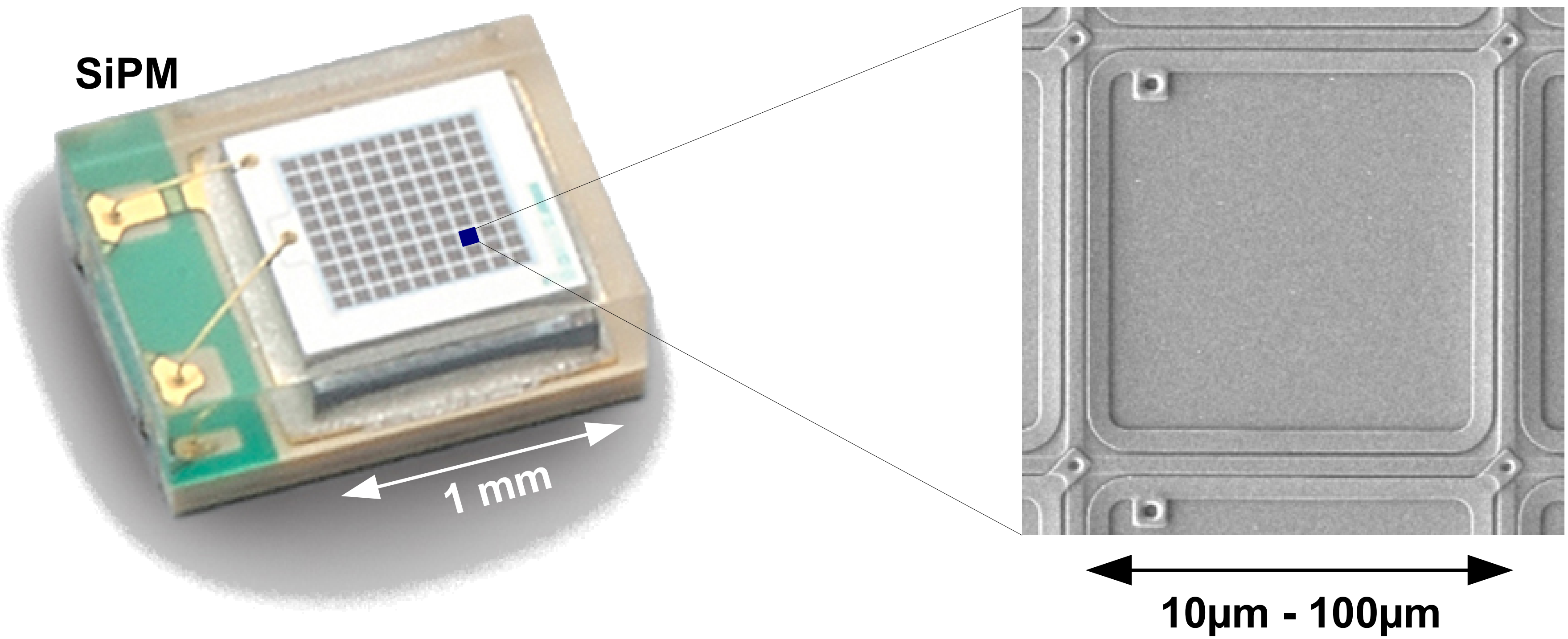
Example: Hamamatsu 1mm²

Credits: Hamamatsu

What is a G-APD?

Silicon based photo sensors

Geiger-mode
avalanche photo diode



Example: Hamamatsu 1mm²

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What is a G-APD?

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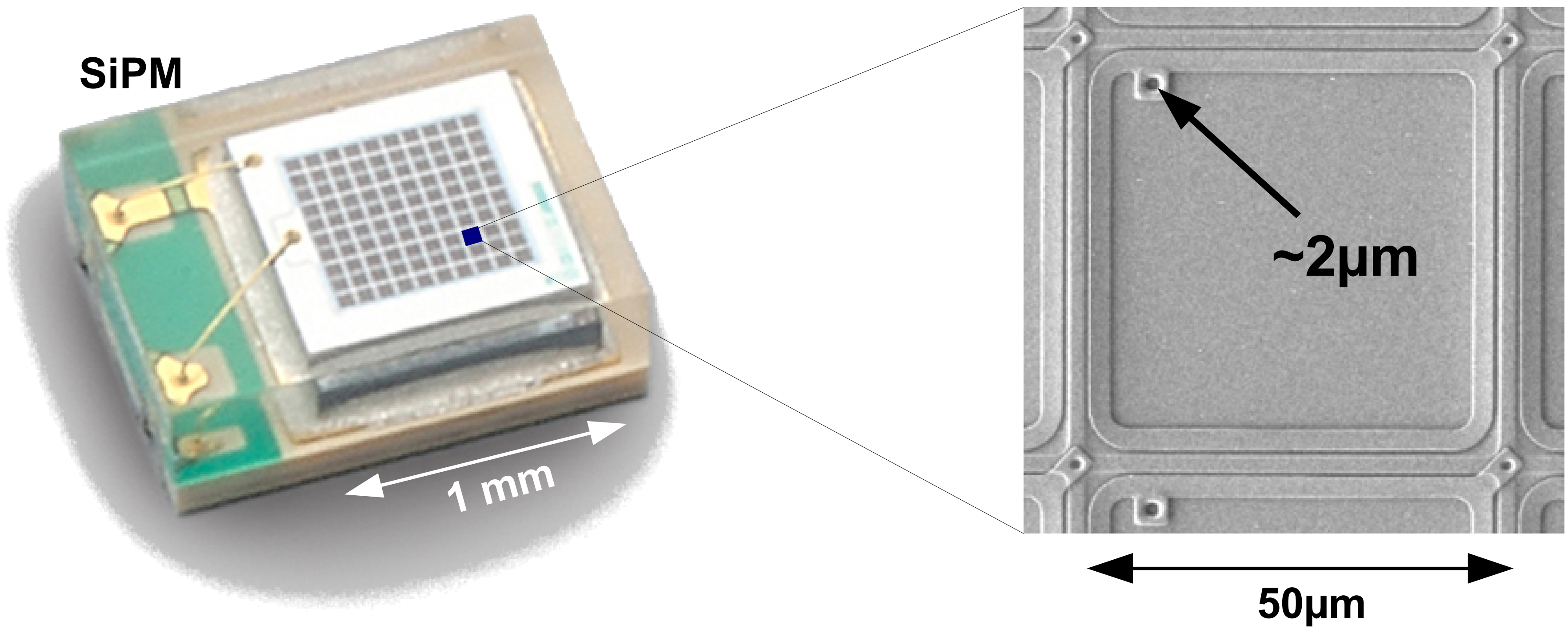


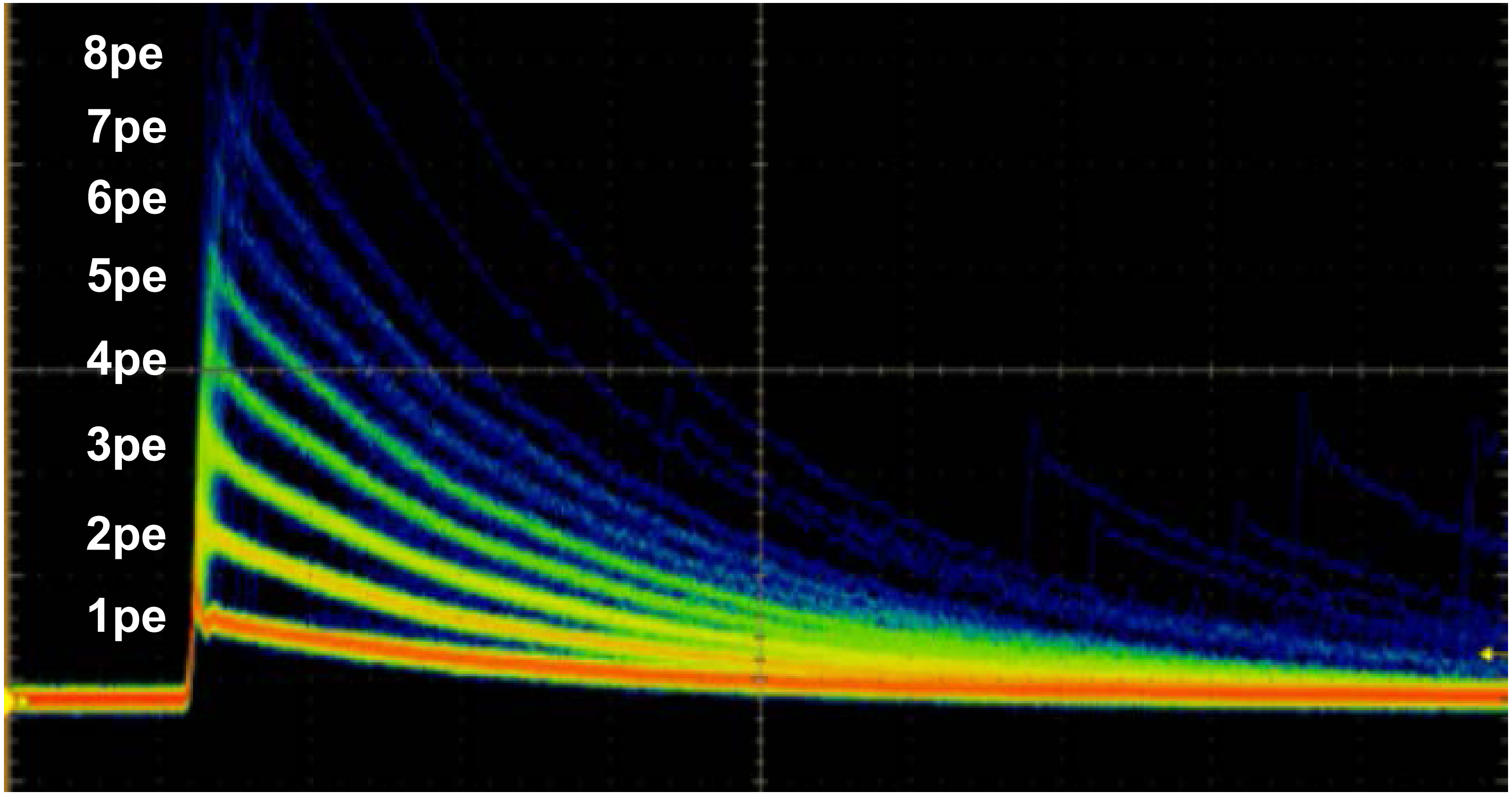
Example: Hamamatsu 1mm²

Transistor in 2015: ~20nm(!)

Credits: Hamamatsu

Photon counting

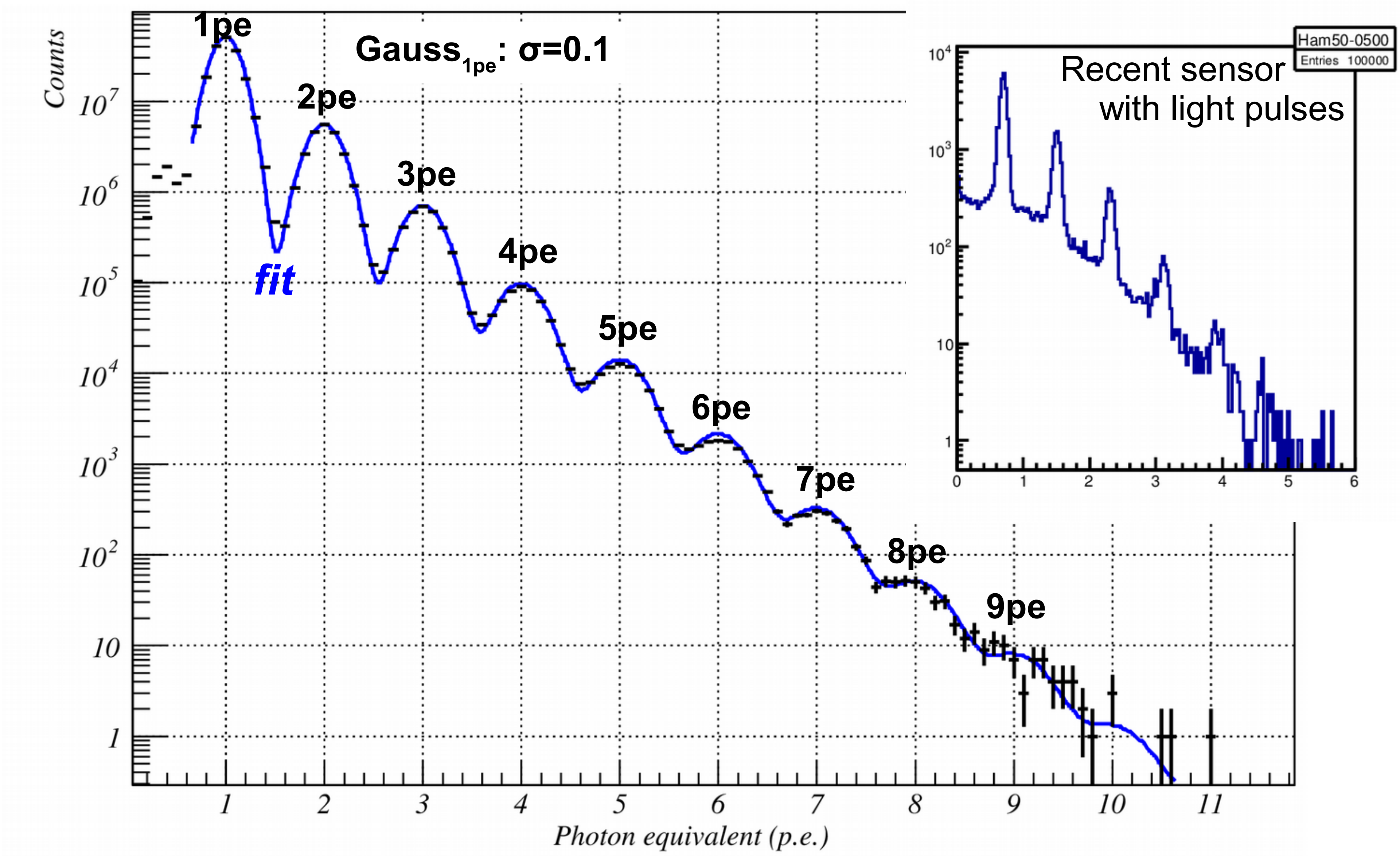
High precision → every avalanche (cell) releases similar charge



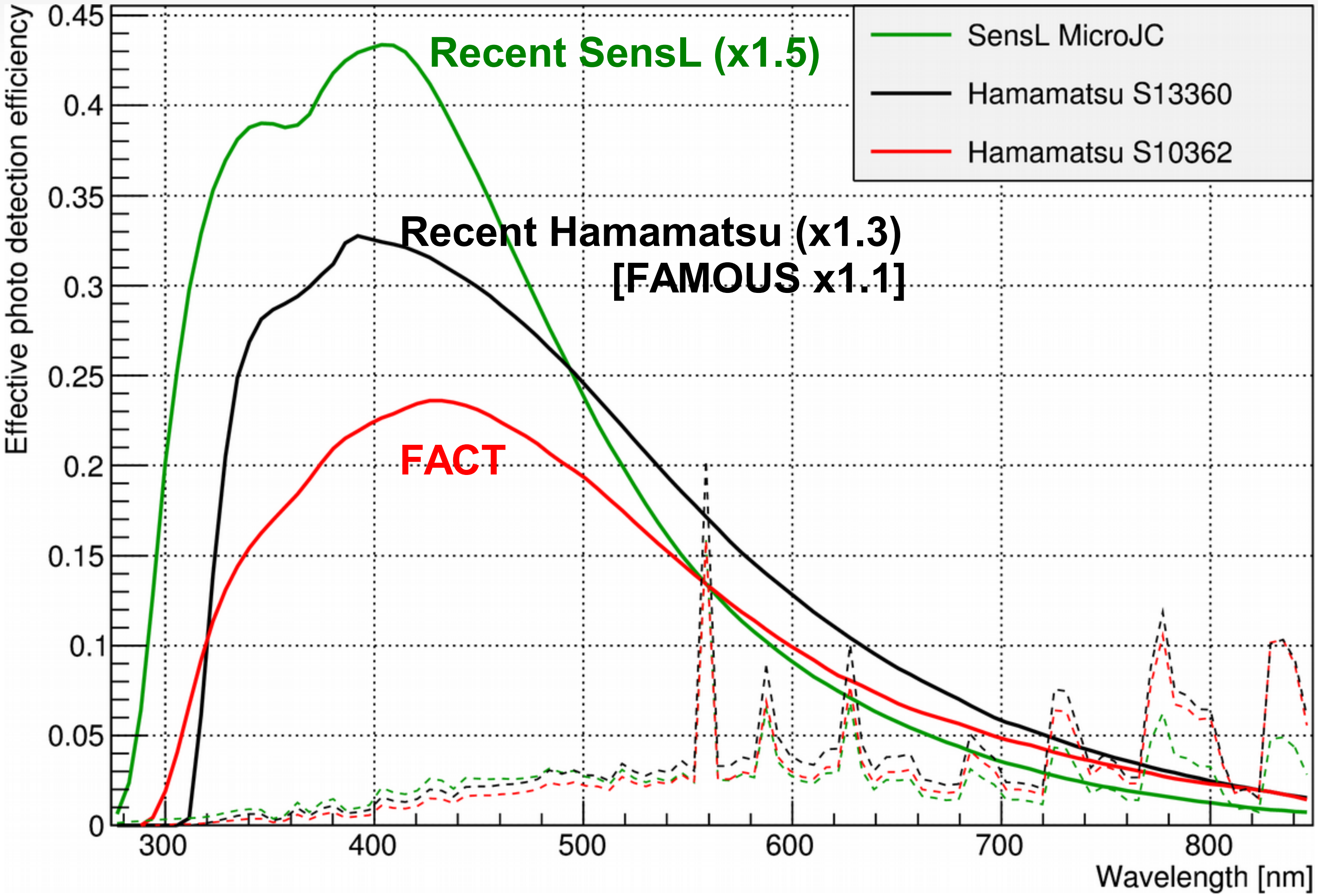
Credits: Hamamatsu

Self calibrating / Stability

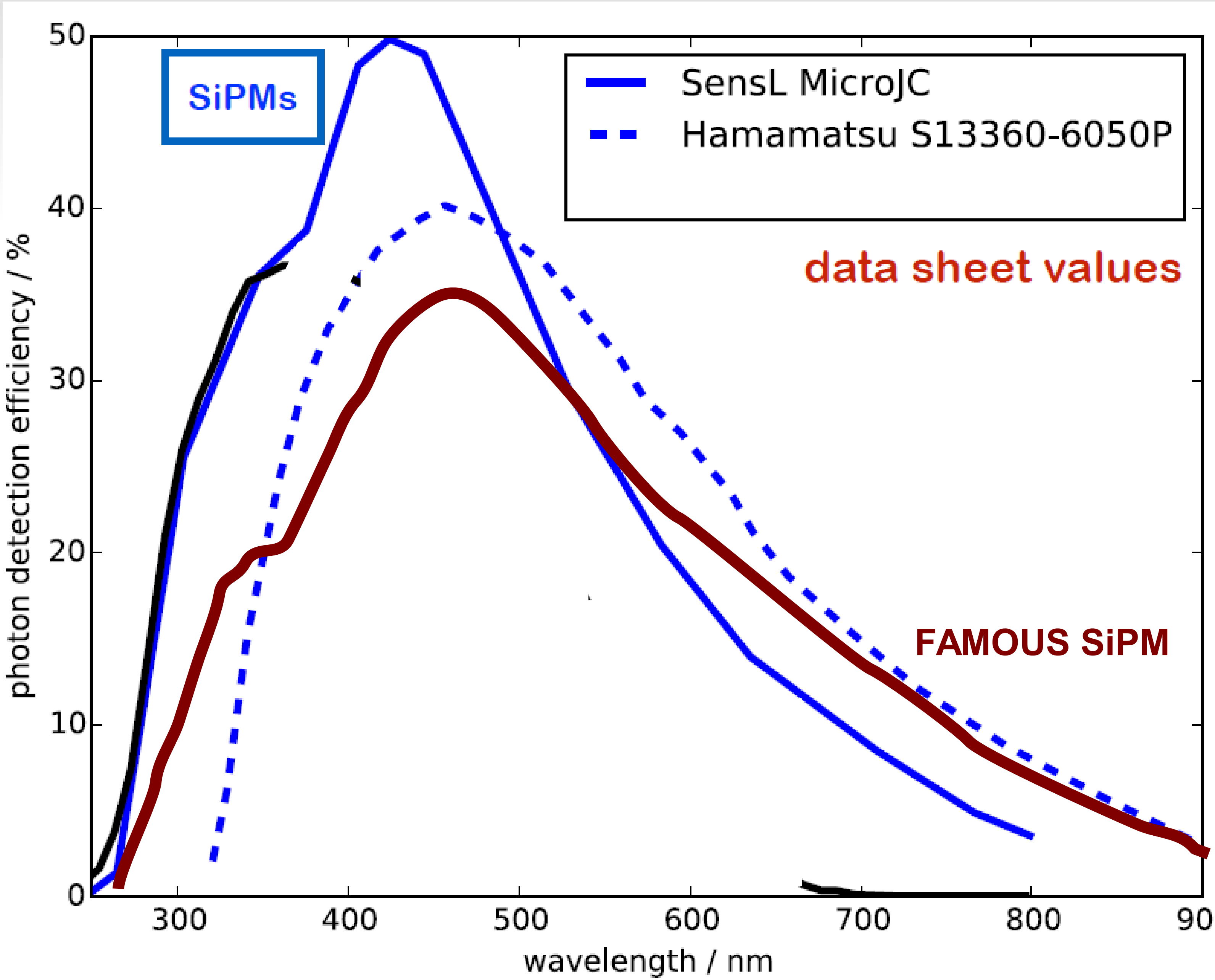
all pixels; **one year**; temp: ~0°C – 25°C



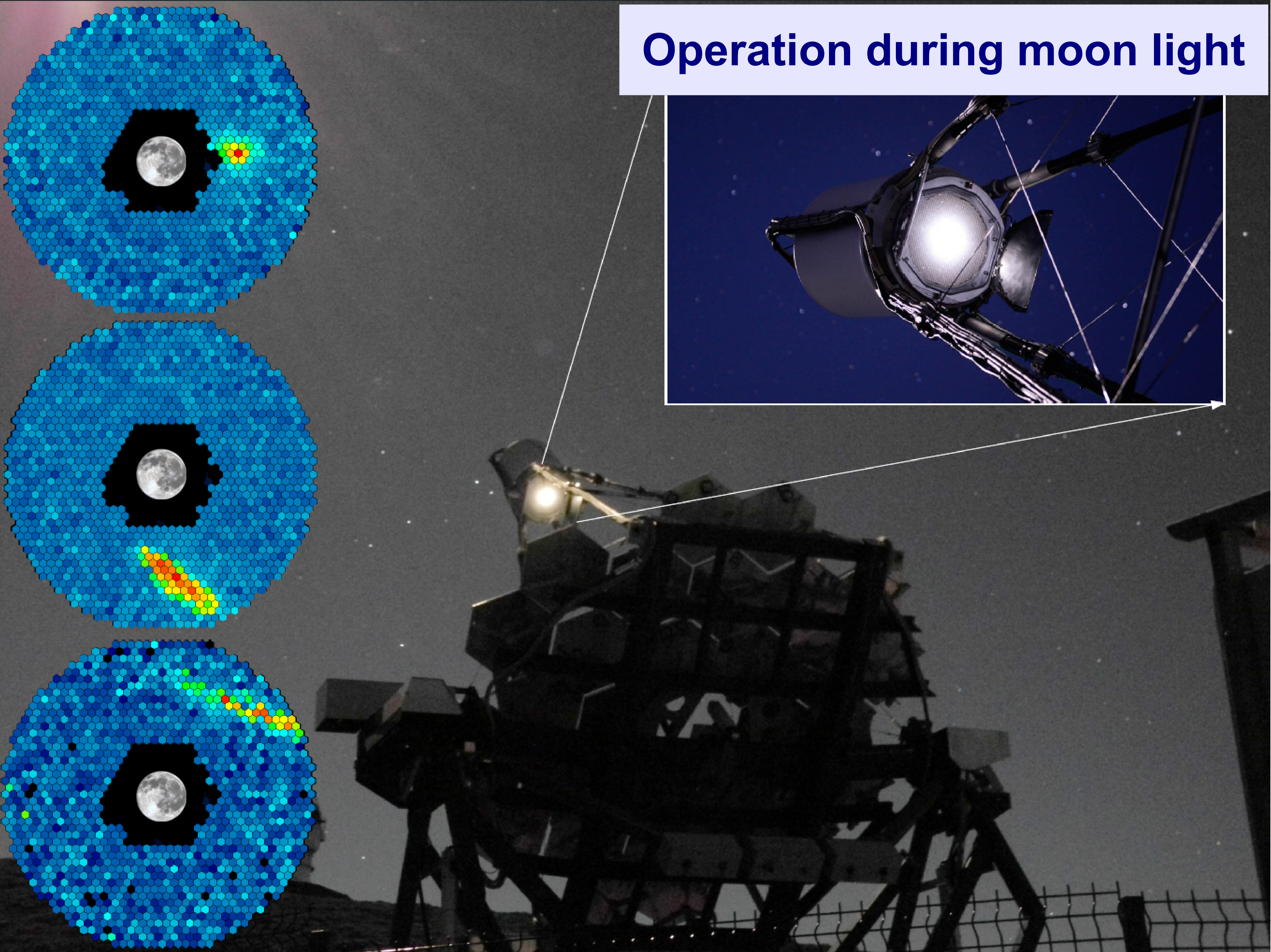
Spectral response for C-Spectrum



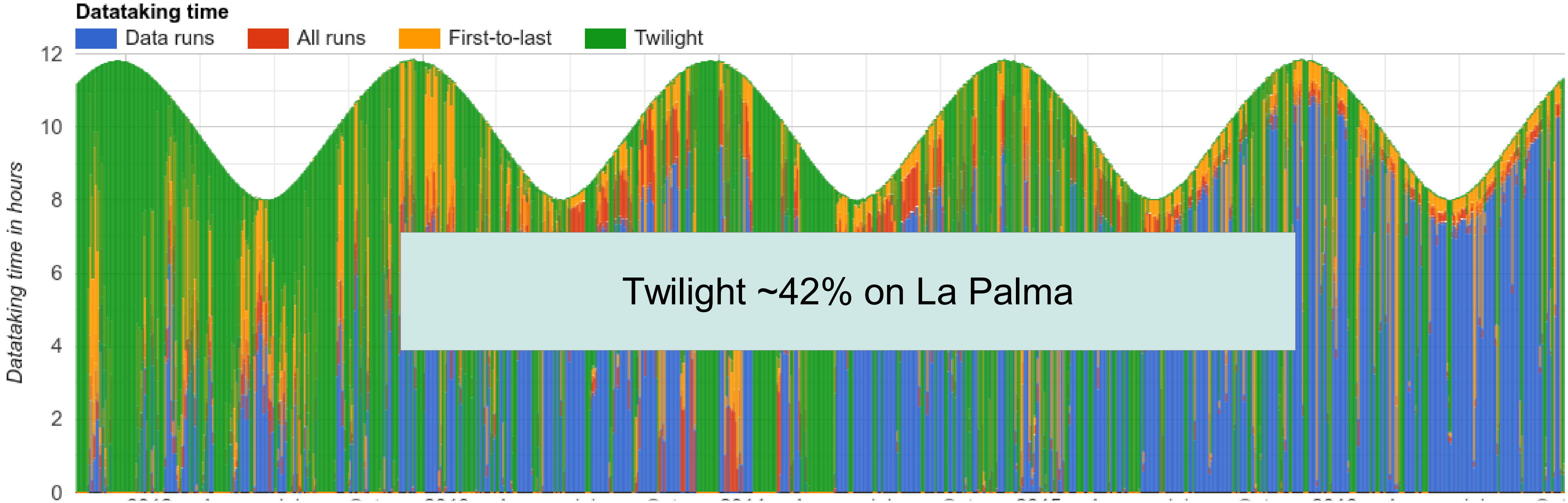
(x ~1)


SiPMs
SensL MicroJC
Hamamatsu S13360-6050P
data sheet values
FAMOUS SiPM
photon detection efficiency / %
wavelength / nm
0
10
20
30
40
50
300
400
500
600
700
800
900

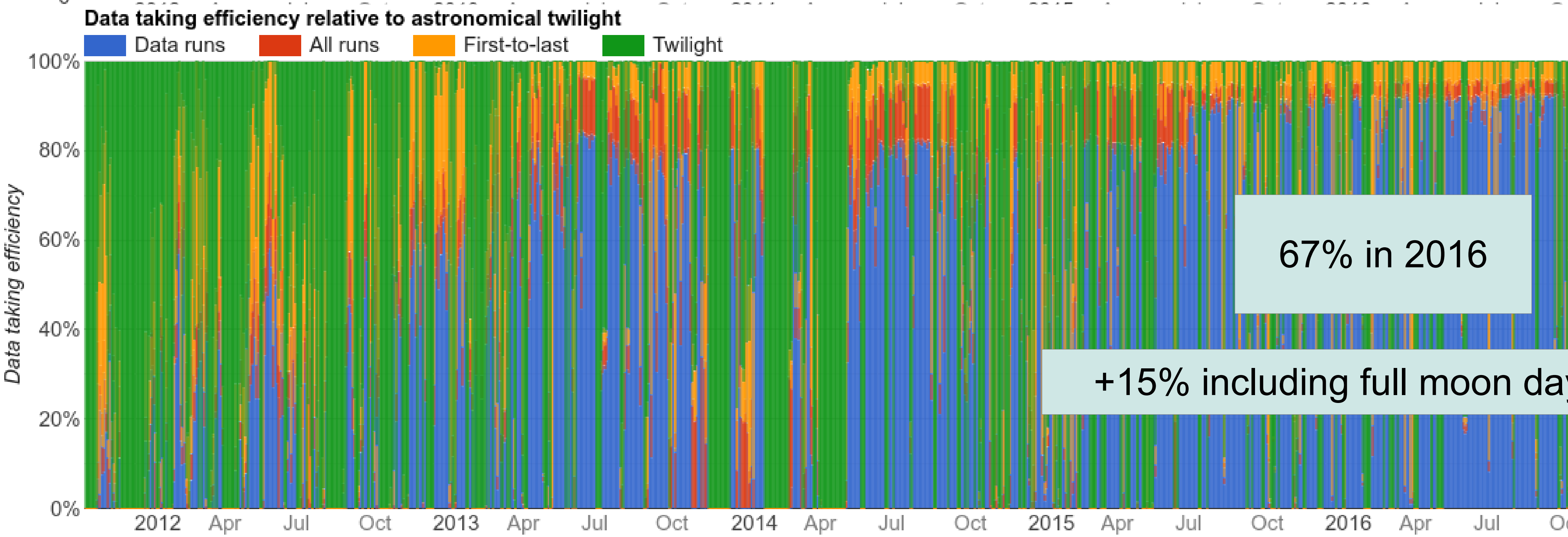
Operation during moon light



Duty cycle



Twilight ~42% on La Palma



67% in 2016

+15% including full moon days

Total duty cycle $1.15 \cdot 0.67 \cdot 0.42 = 0.32$

FACT – Selected events of the first nights of data-taking (11 Oct. 2011)

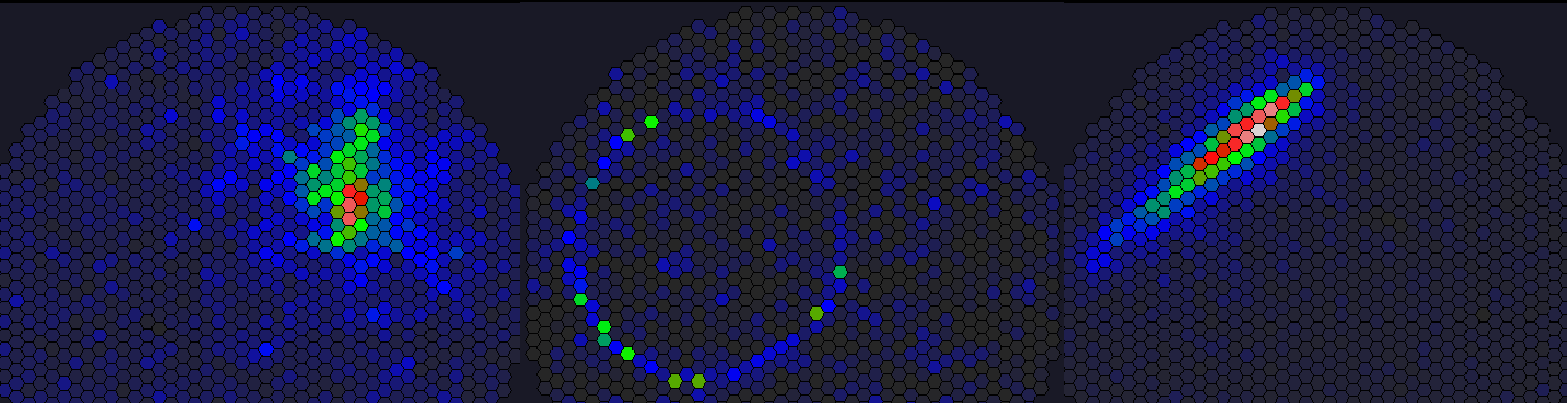
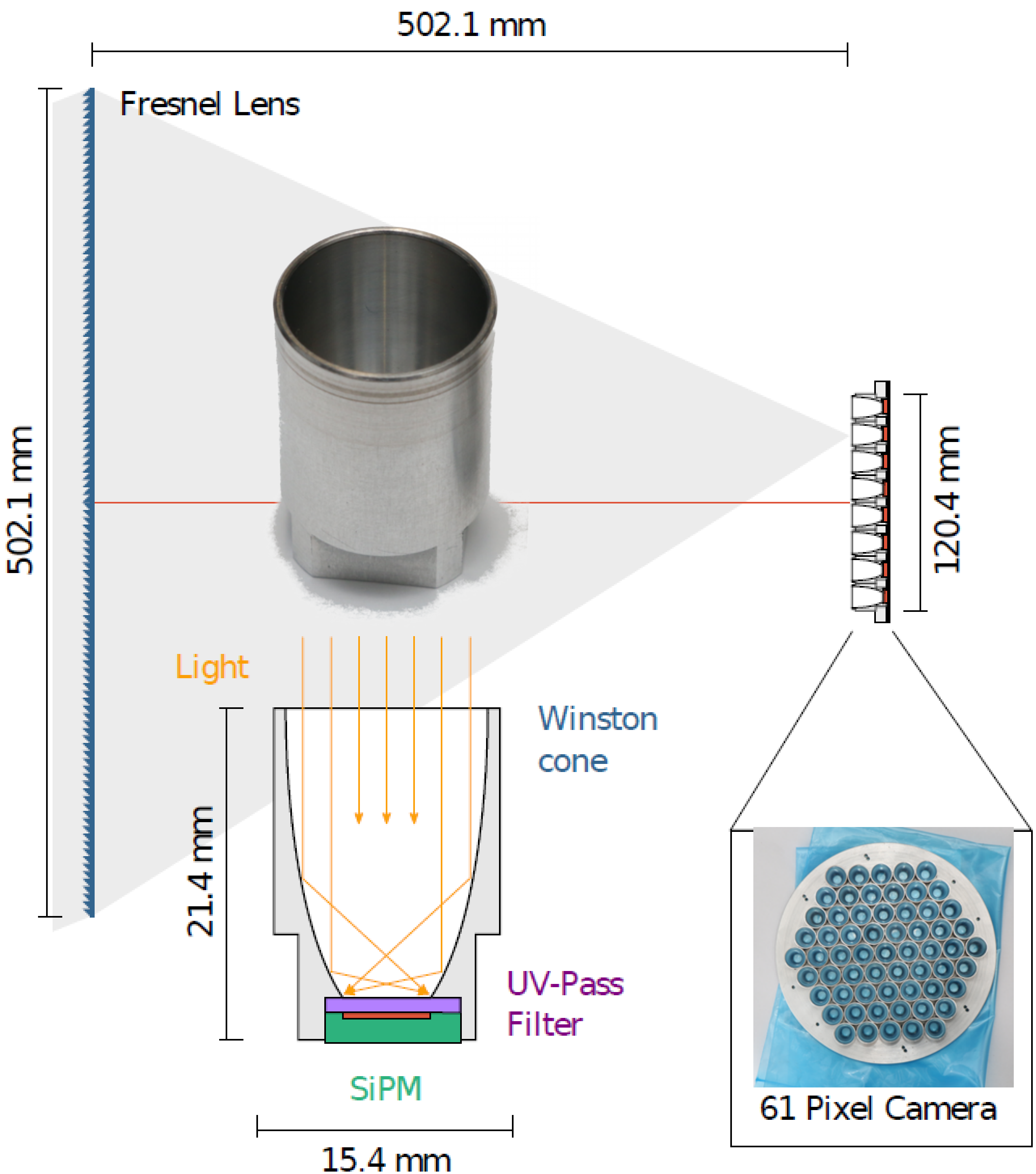
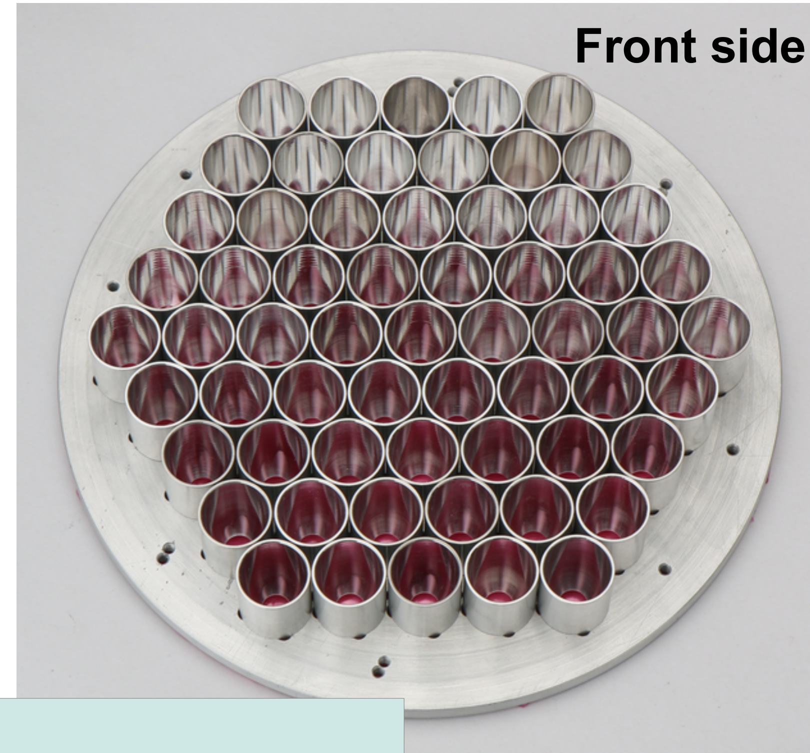


Image analysis required for IACTs
→ not required if geometry comes from WCD array
→ pixelization nevertheless needed to lower the S/R (NSB)

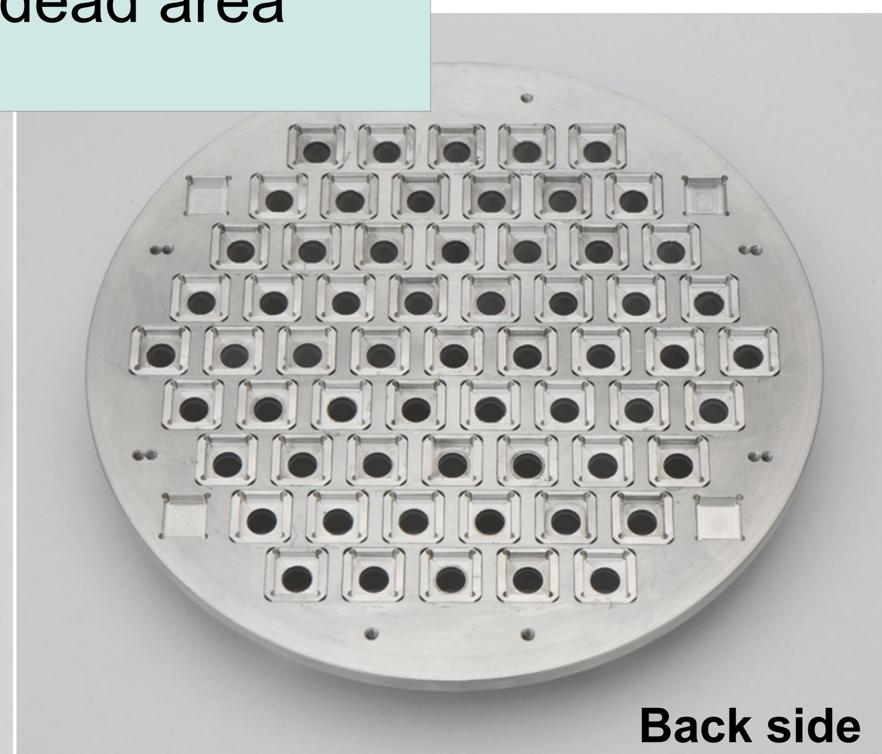


Coarse pixels
→ not ideal for IACT
→ can work with a
WCD array

transmission losses in the lens ~50%

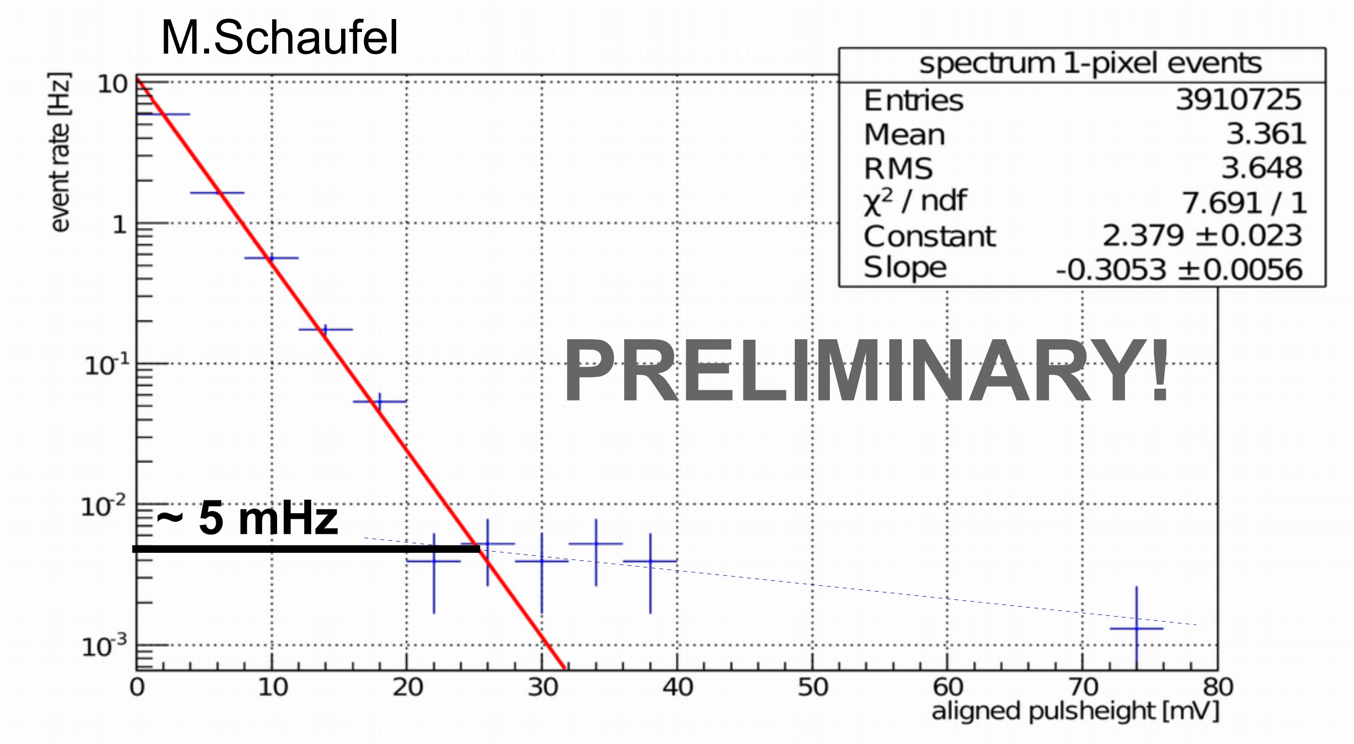


15% dead area



~0.2 m²
3° FoV

Performance: 7-pixel prototype



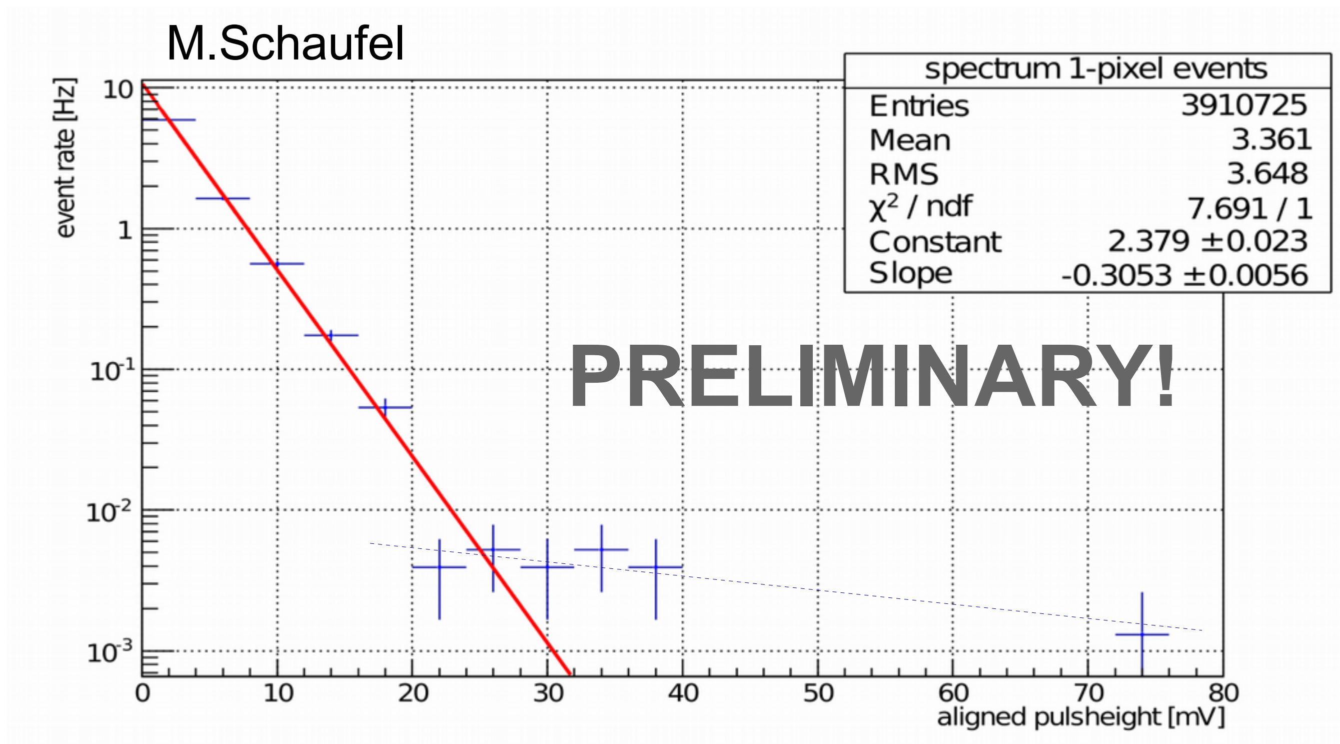
FACT Trigger Threshold ~ 400 GeV
~70 Hz @ 4.5° FoV → ~ 30 Hz @ 3° FoV

CR Spectrum $E^{-1.7}$	4 TeV	~ 0.6 Hz
	40 TeV	~ 12 mHz
	60 TeV	~ 5 mHz

non optimized system, especially trigger far from optimum

~0.2 m²
12° FoV

Improvements



Change from 0.2m² lense to 1m² mirror	x5
No transmission losses	x2
Better SiPMs	x1.25
No dead space between the cones	x1.15
No reflectivity loss of the cones	x1.10
Total	**x15**
Trigger threshold	**60 TeV → 4 TeV**

Crosscheck:

FACT
10m² 400 GeV
1m² 4 TeV
SiPM 3 TeV

→ consistent

Conclusions

- With optimizations (1m², less transmission losses, …), a (trigger) threshold of O(few TeV) could be achieved
- Sub threshold analysis possible with external trigger
- This does ***not*** replace the WCD array because spatial resolution is not enough to do an image analysis at TeV (e.g. no direction reconstruction, no background suppression)
- Background suppression could be improved by muon detector (see second talk)

Conclusions

- With a FoV of 12° (could be extended),
  ~13 telescopes are needed to see ±45° of the sky
- Current price ~ 6000 € → 1 m² telescope < 20 k€
- 45° coverage in stereo: 2·13·19 k€ = 500 k €
- With your help we could write a proposal to
  DFG (German Research Society)
  to research this solution and
  build a prototype
  (needs a strong physics case)