HELMHOLTZ ASSOCIATION
Alliance for Astroparticle Physics

SPONSORED BY THE
Federal Ministry of Education and Research

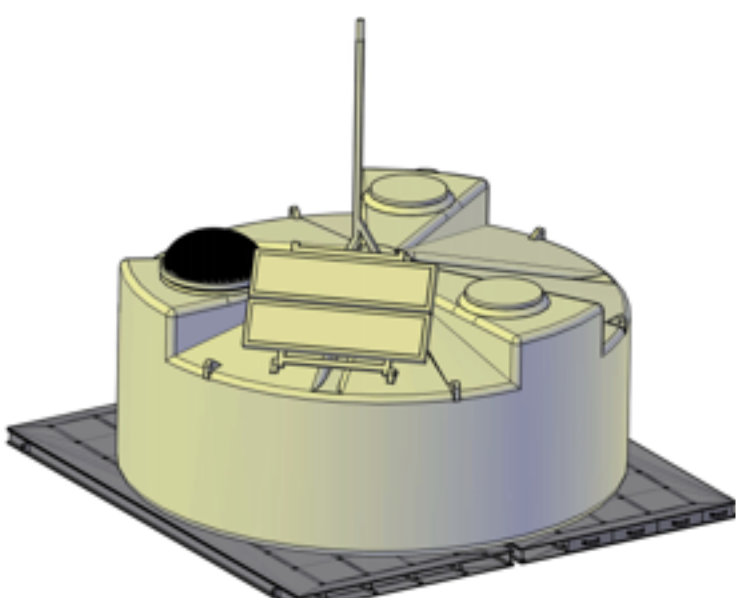
PIERRE AUGER OBSERVATORY

ASPERA

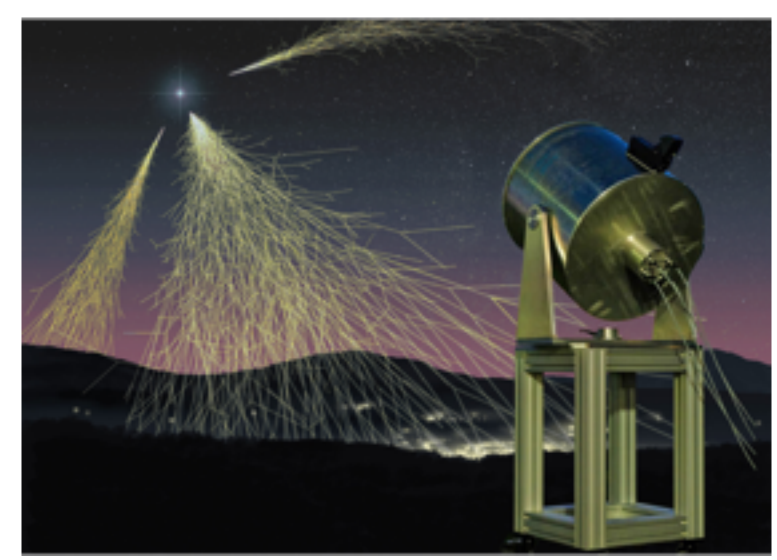
Prospects of silicon photomultipliers for ground-based cosmic ray experiments

Christine Peters,
Thomas Bretz, Thomas Hebbeker, Julian Kemp, Markus Lauscher, Lukas Middendorf, Tim Niggemann, Johannes Schumacher

III. Physikalisches Institut | RWTH AACHEN UNIVERSITY



UHECR 2016
Kyoto, Japan



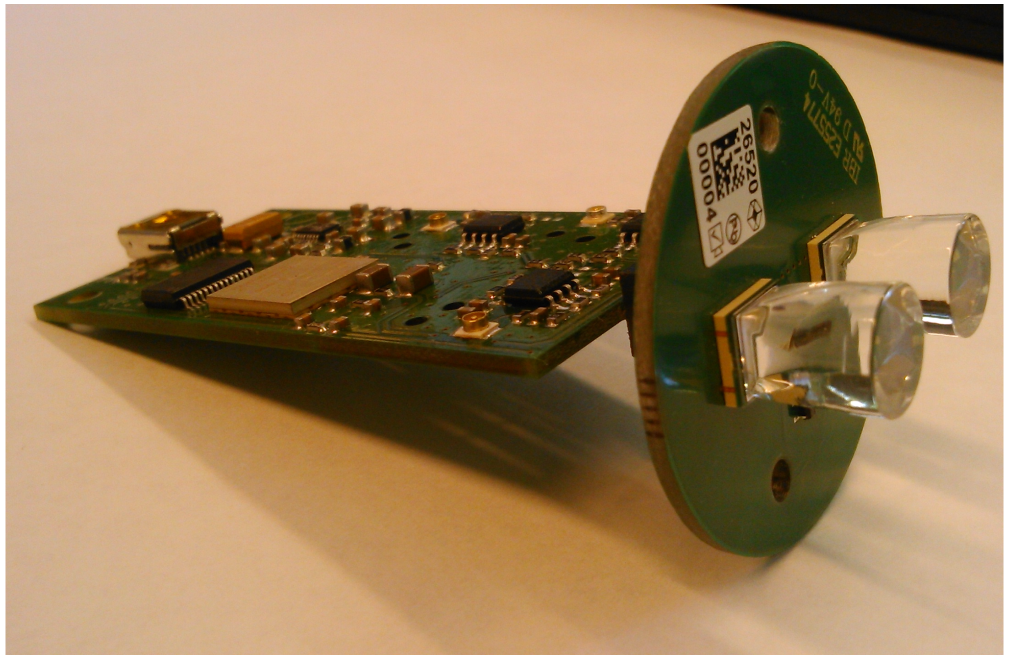
Outline

- Silicon photomultipliers - SiPMs
- The fluorescence telescope FAMOUS
- The muon detector upgrade SSD for AugerPrime
- The muon detector AMD

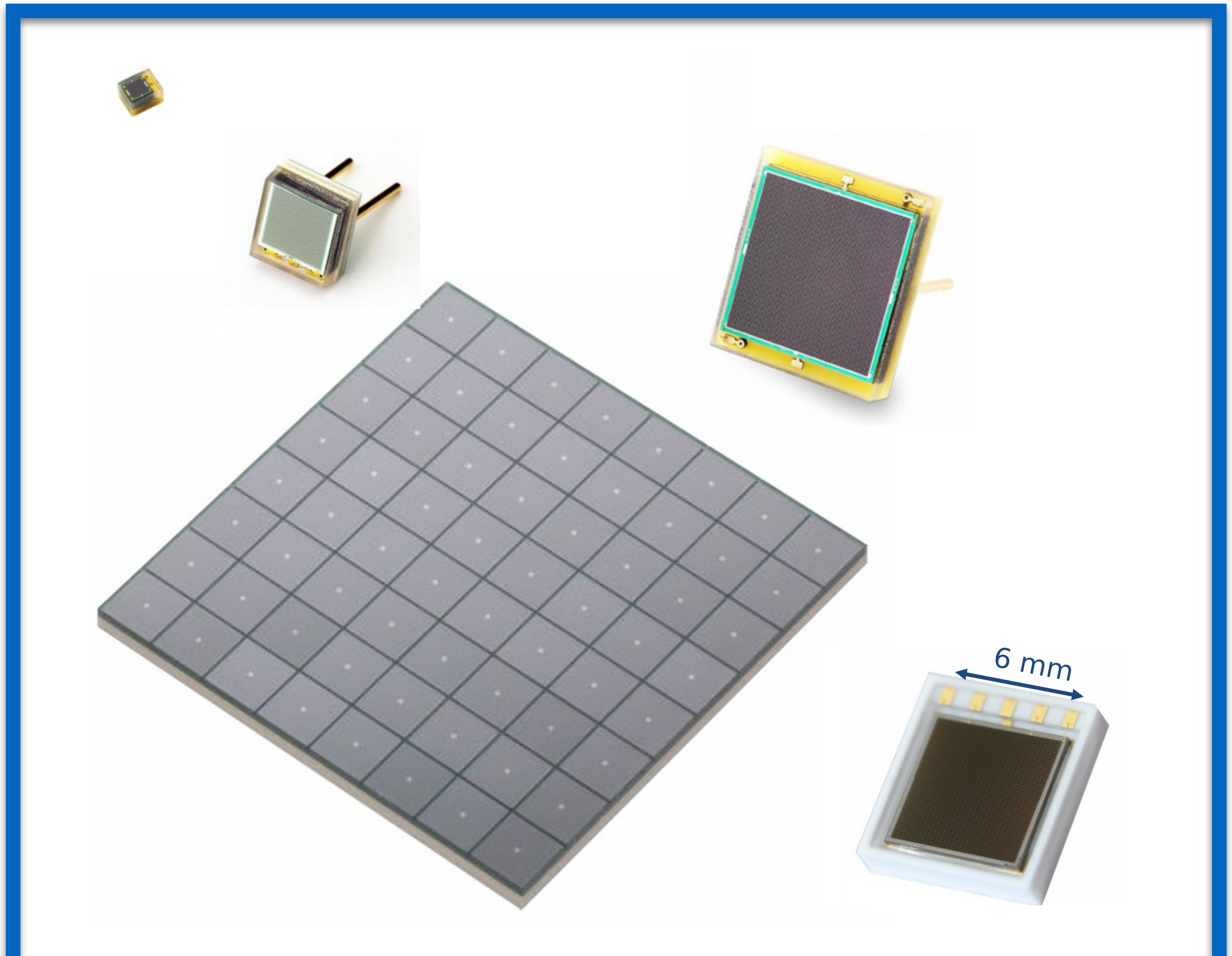
First **A**uger **M**PPC camera for the **O**bservation of **U**ltra-high-energy air **S**howers

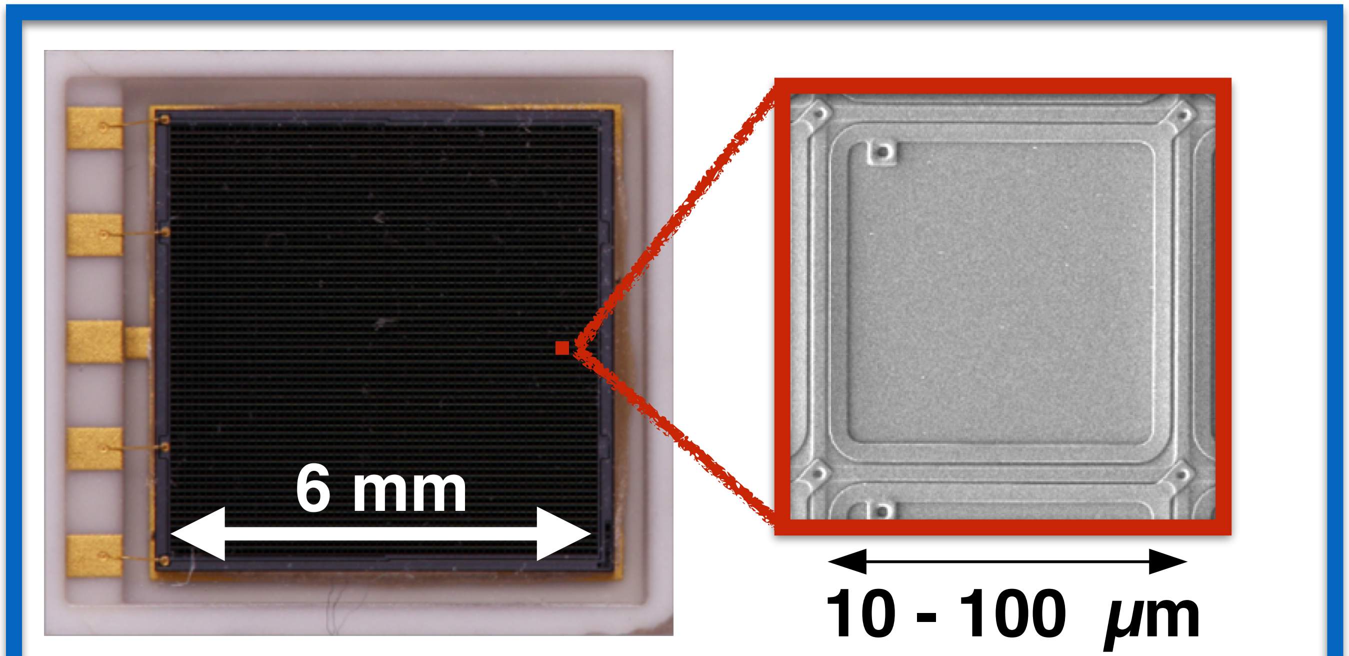
Aachen **M**uon **D**etector prototype

Surface **S**cintillator **D**etector



Silicon Photomultipliers

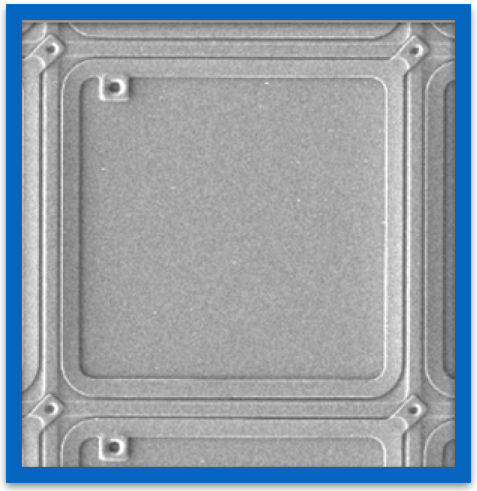


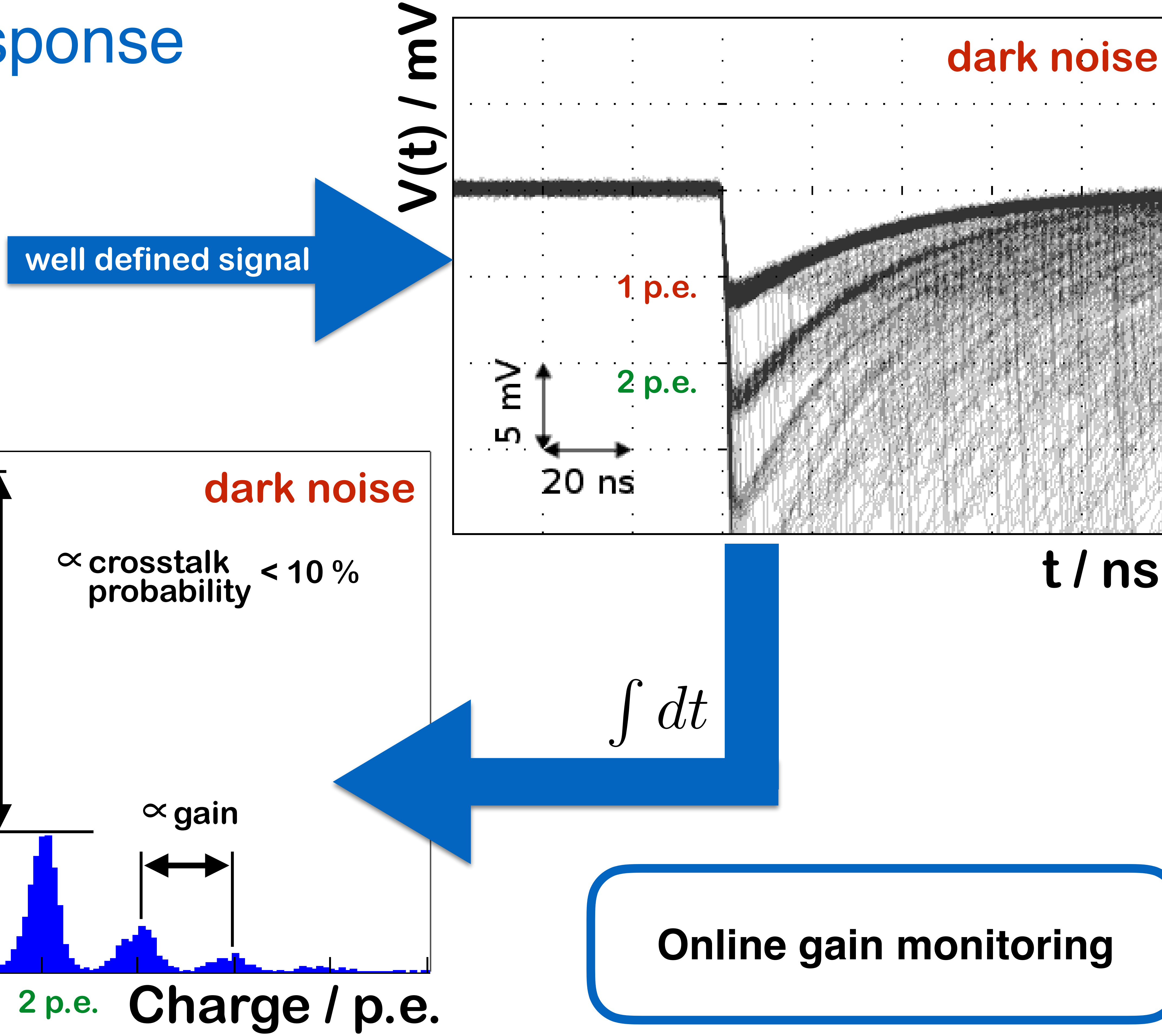


Cell-structured, photosensitive semiconductors based on G-APDs

- 😊 High photon detection efficiency
- 😊 Low supply voltage (< 100V)
- 😊 High robustness & reliability
- 😊 SiPMs are a mass product (0.50 $ / mm²)
- 😐 High noise rate (30 kHz / mm²)
- ☹ Temperature dependence
  - 😊 but can be corrected for

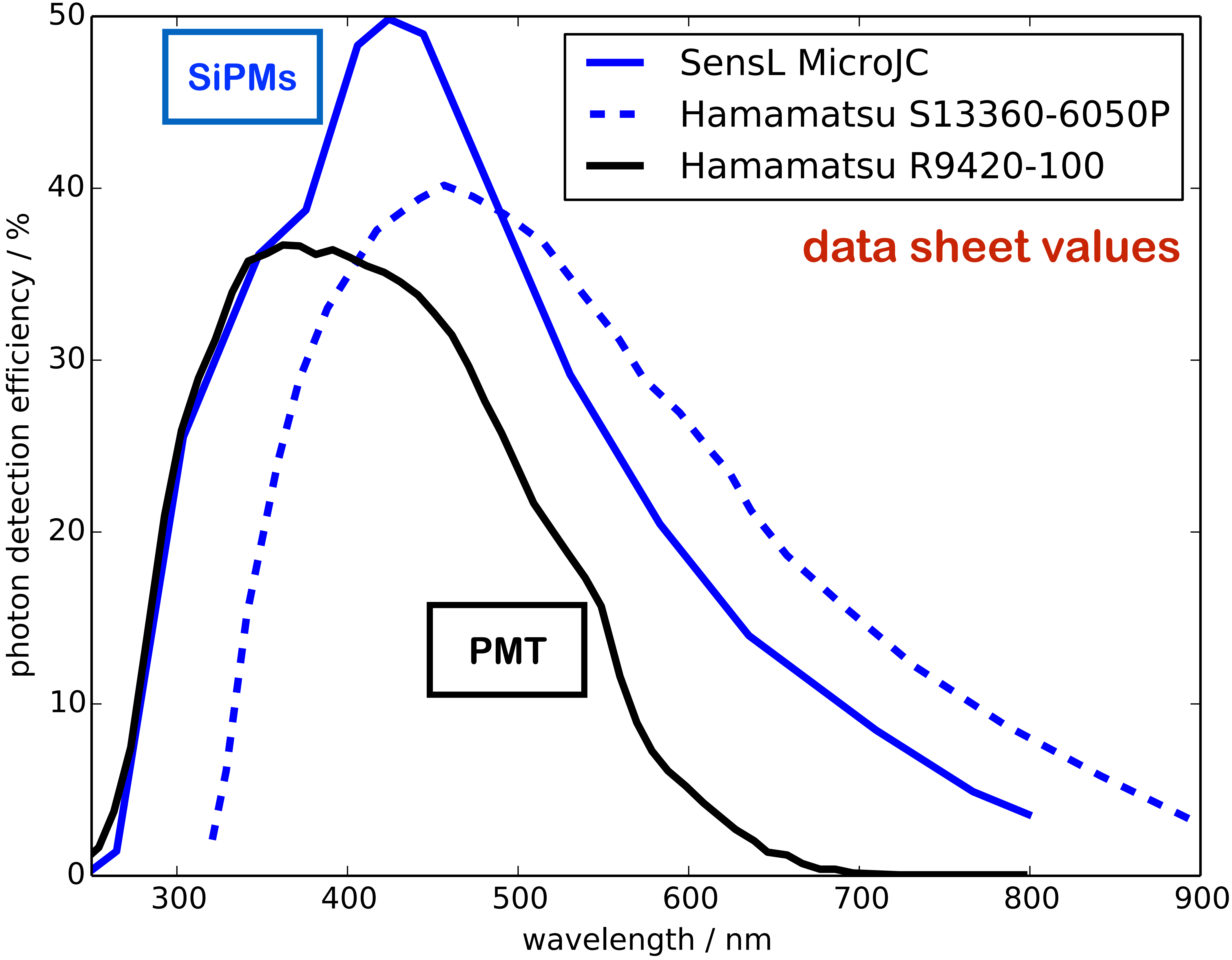
SiPM response



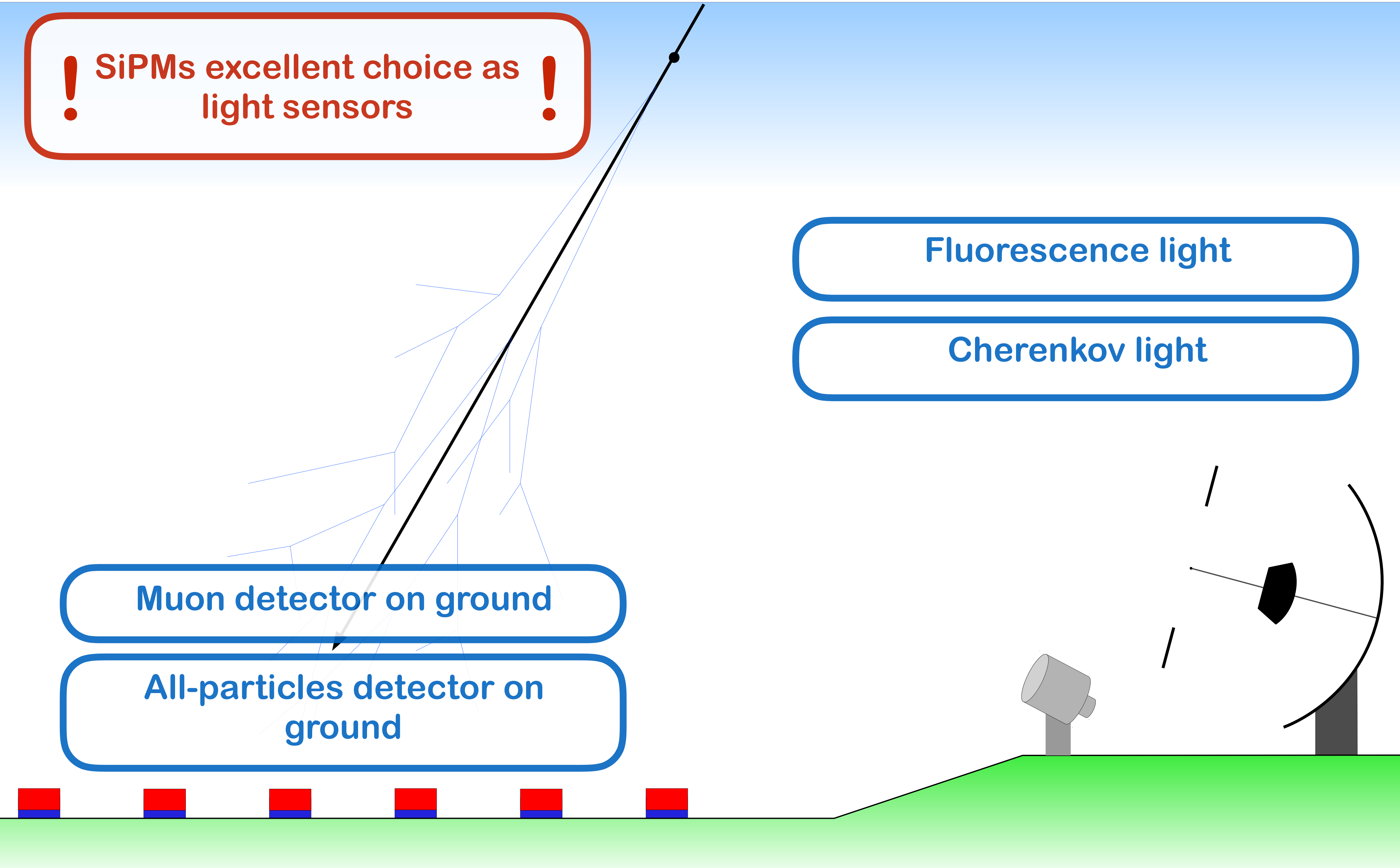


Online gain monitoring

Why SiPMs? - photon detection efficiency

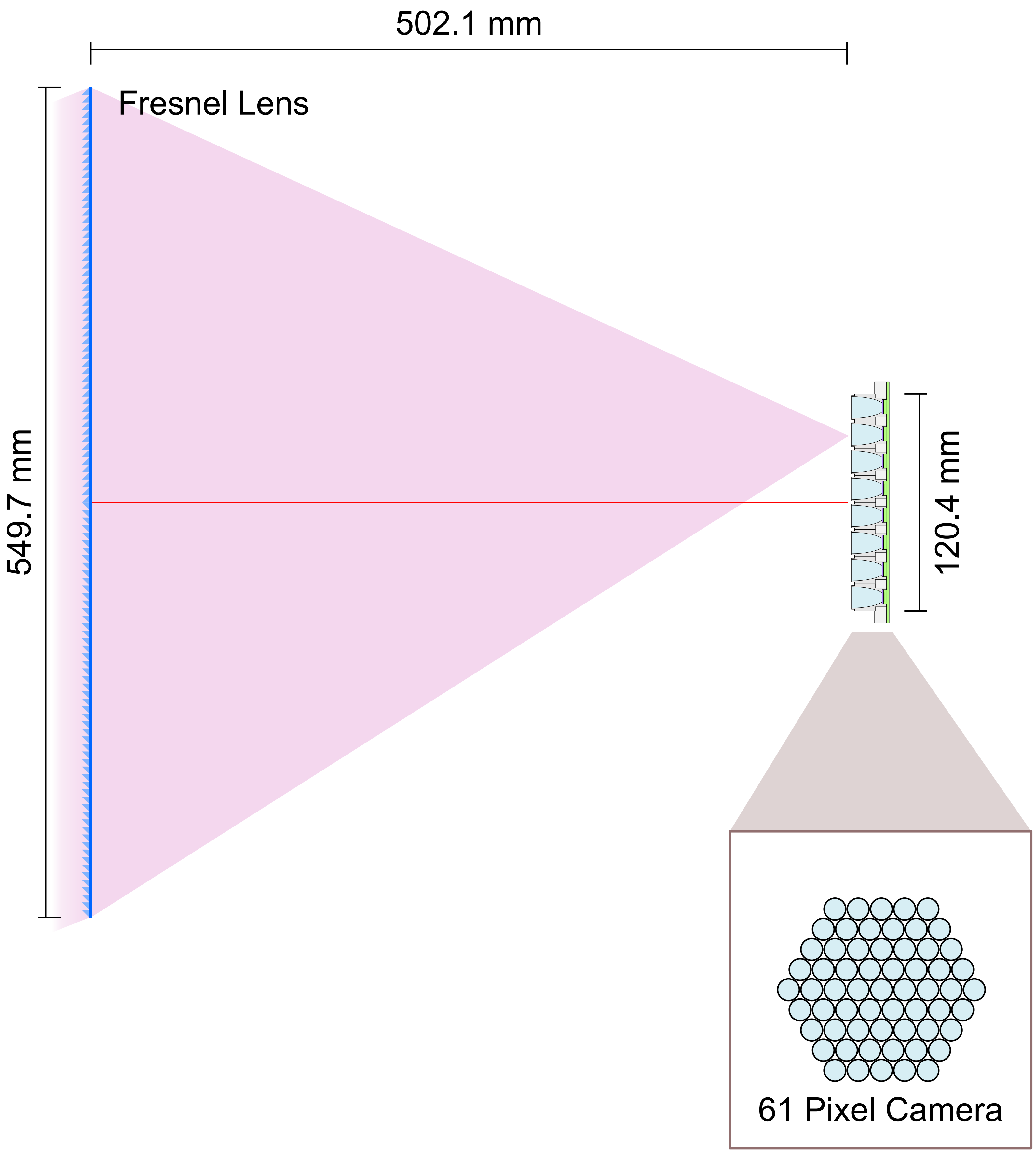


Extensive air showers - detection principles

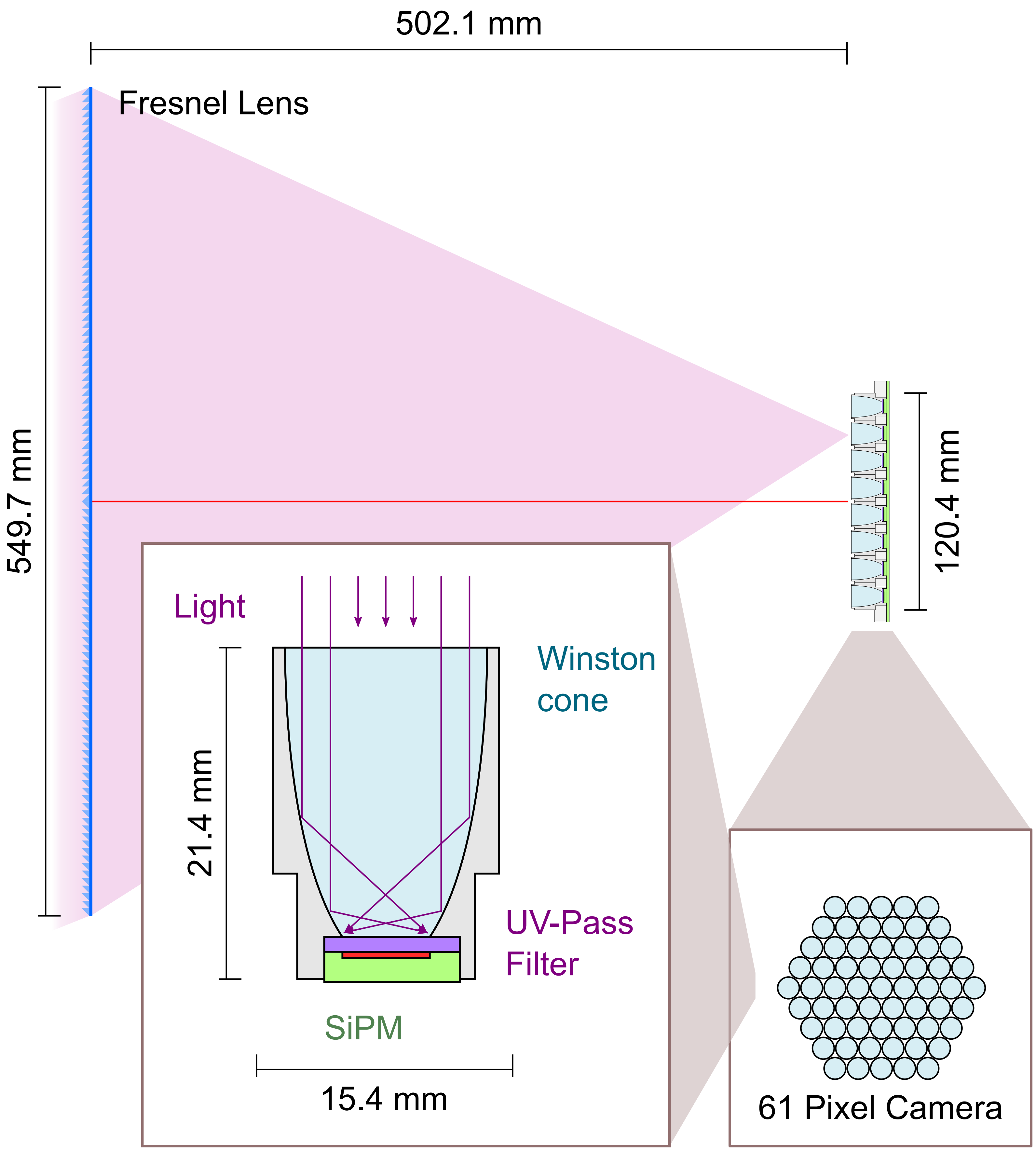



FAMOUS
courtesy: Michael Eichler

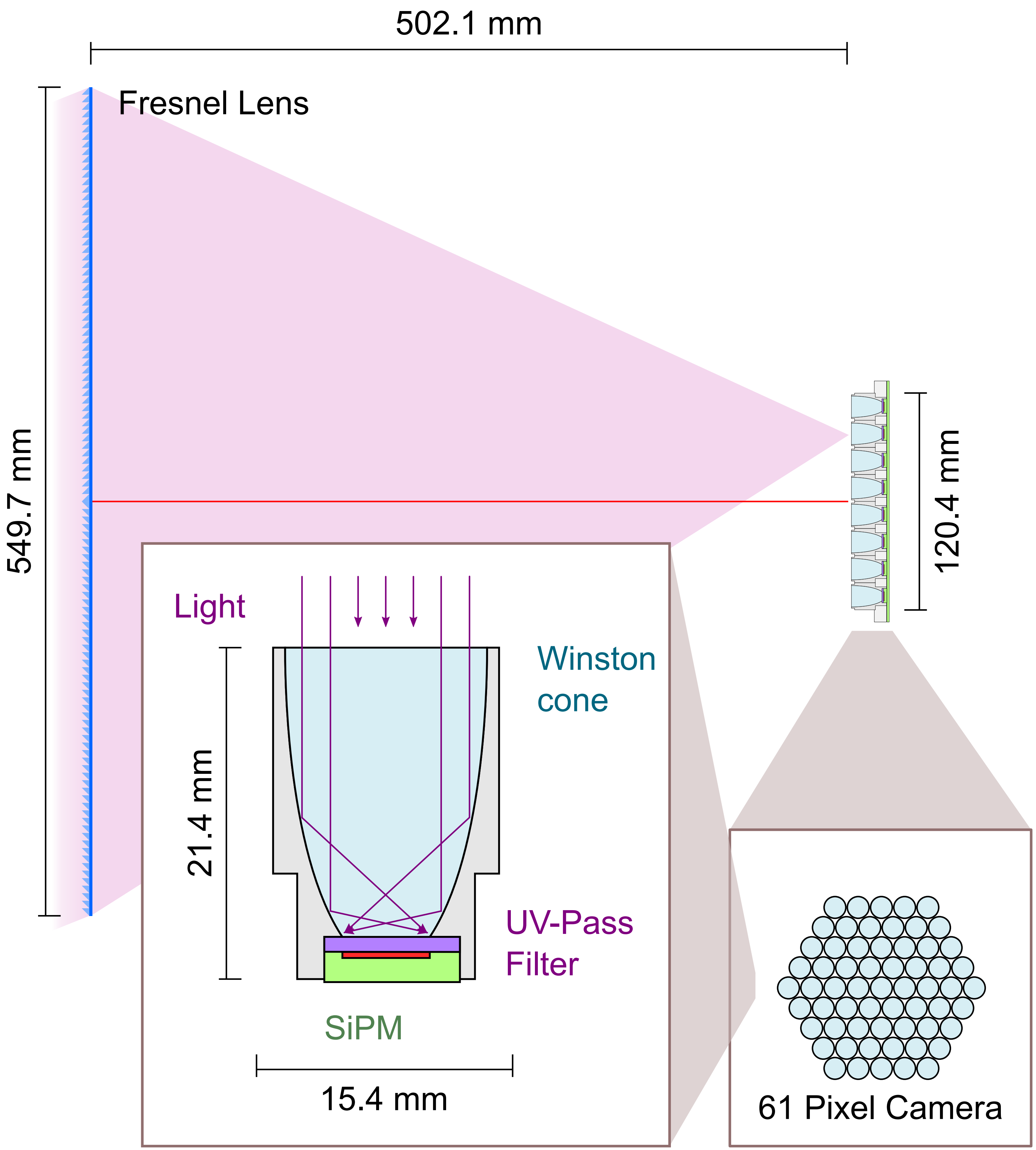
The fluorescence telescope FAMOUS



The fluorescence telescope FAMOUS



The fluorescence telescope FAMOUS



FAMOUS news

First test measurements

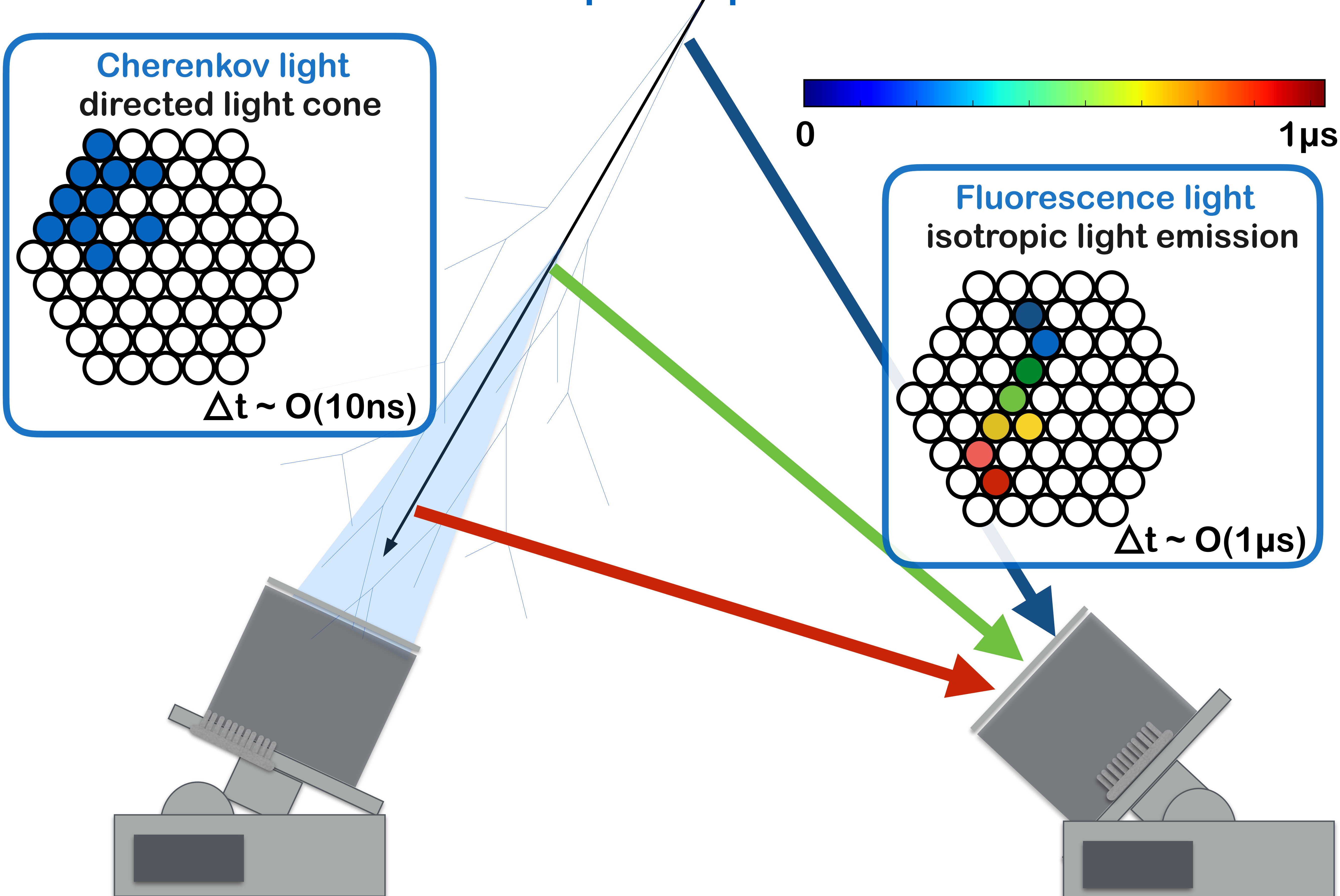
with 61 pixel telescope

Readout module based on TARGET7 (provided by FAU Erlangen)

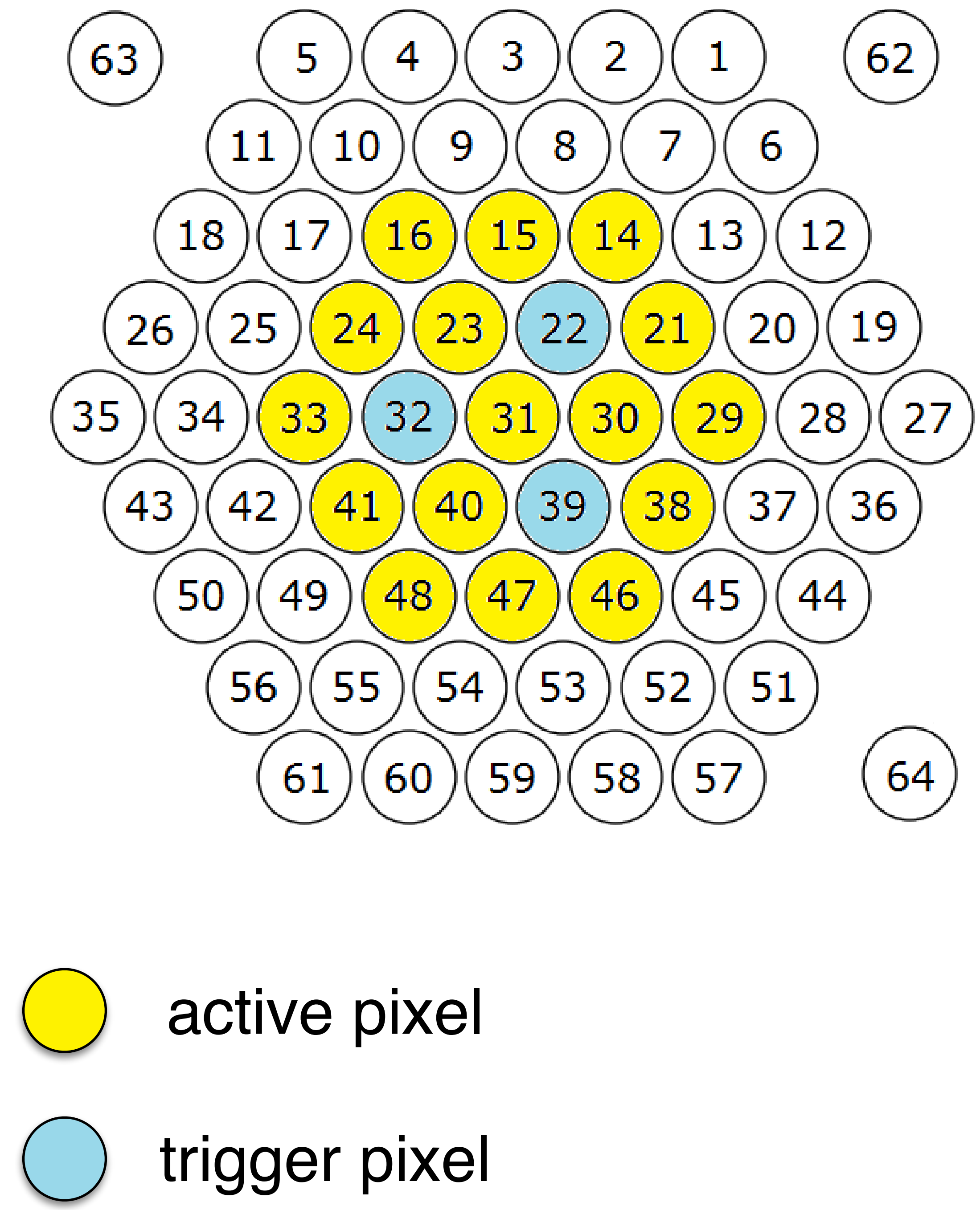
- to be implemented
- trigger threshold to be calibrated

  external trigger so far

FAMOUS - detection principles

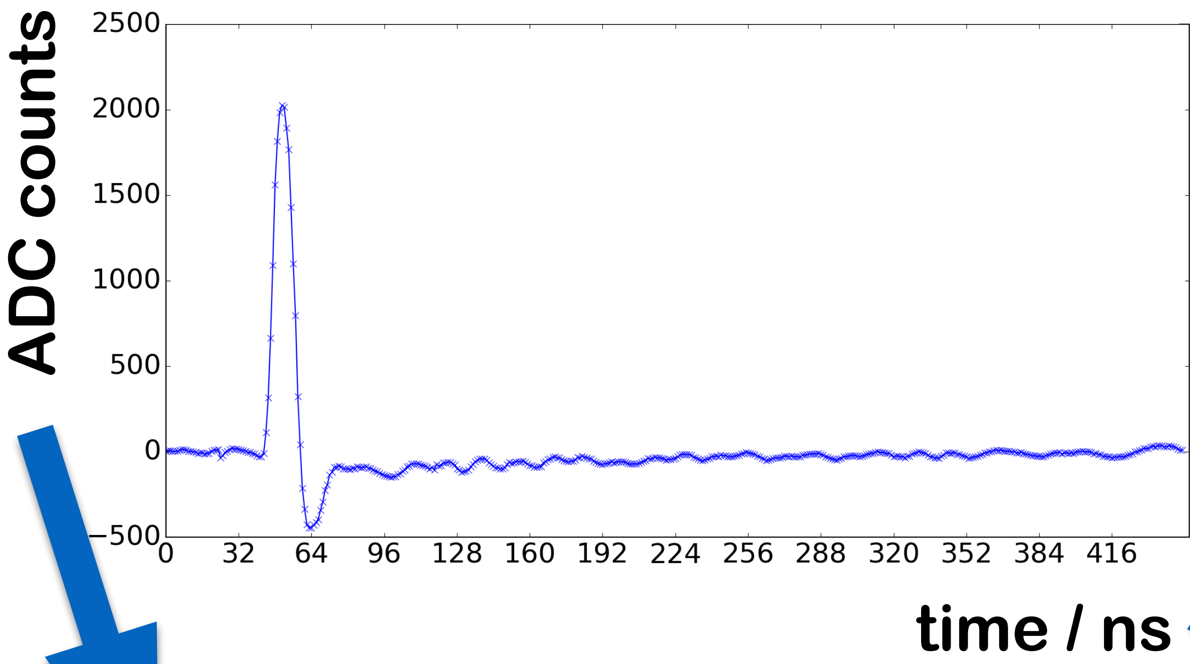


First measurement setup

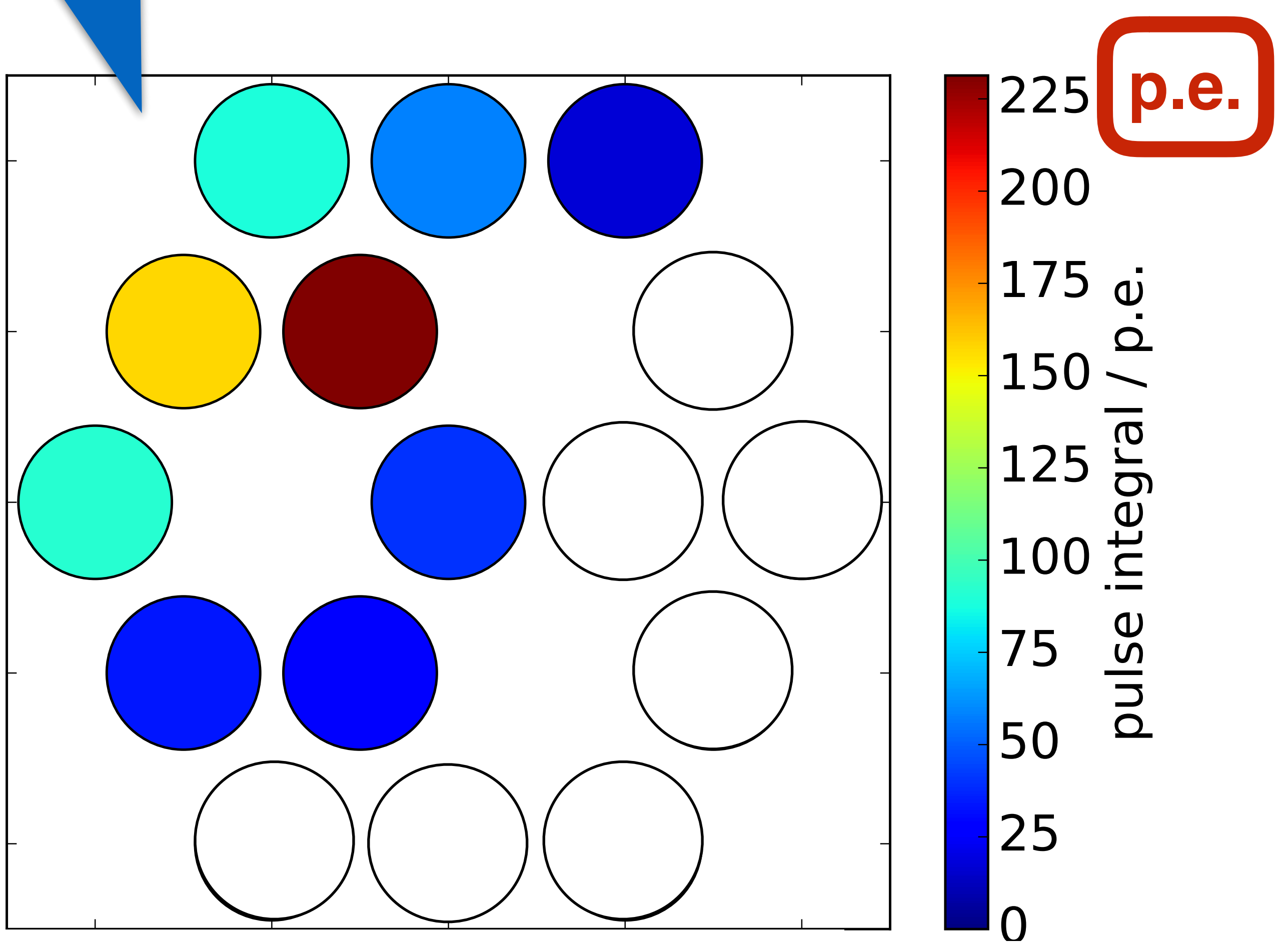


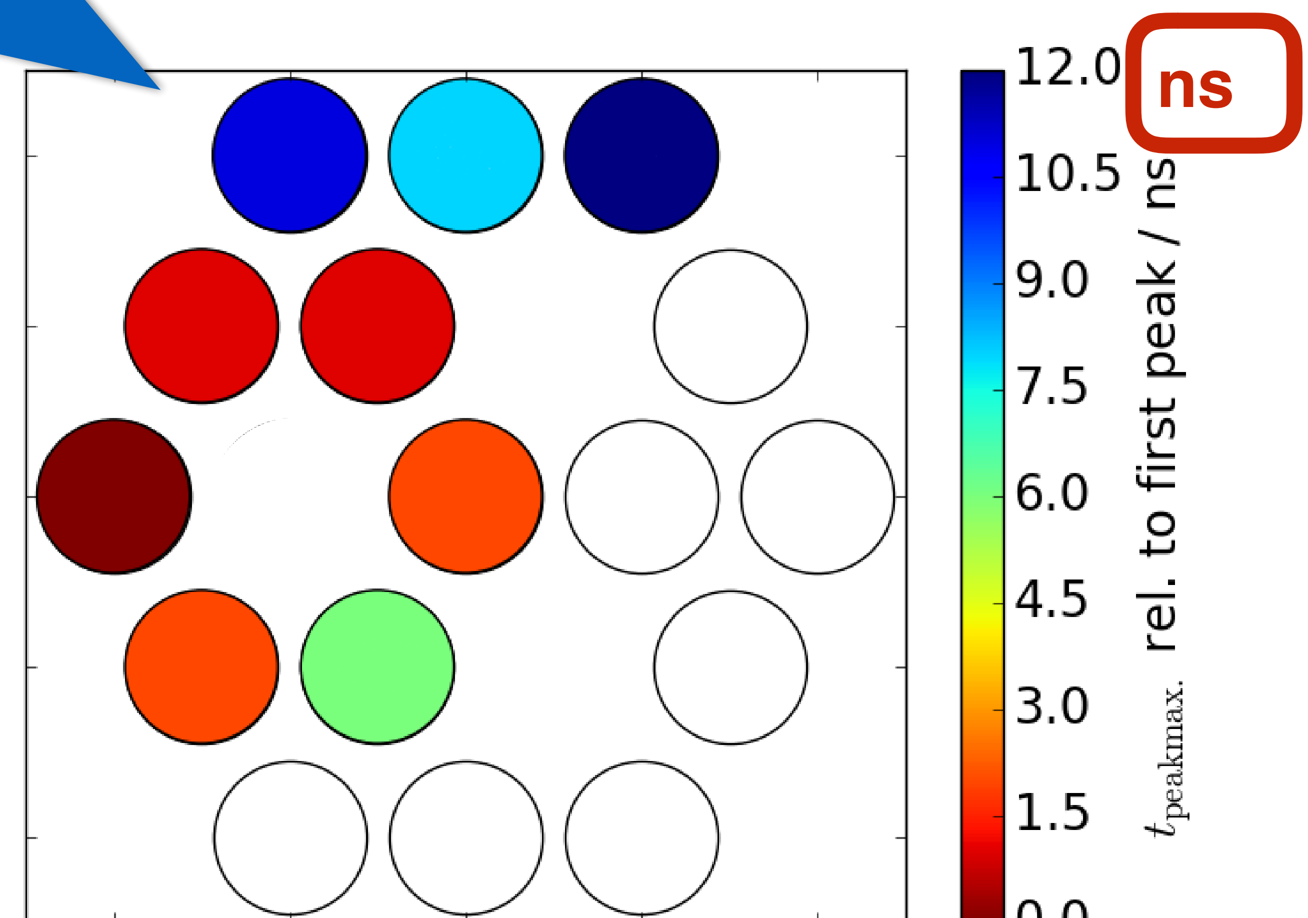
Search for coincidence events

Shower candidate

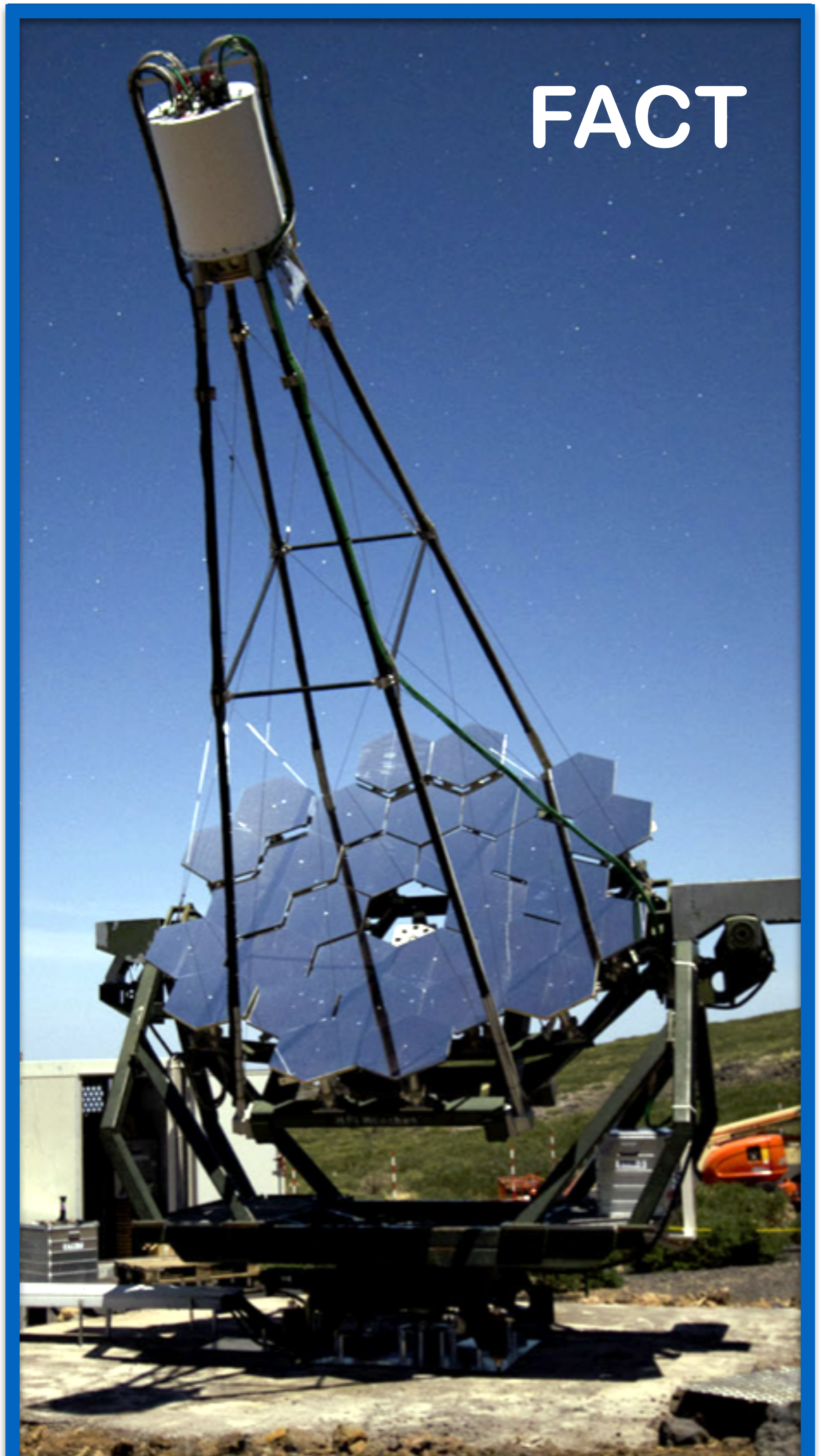


First Cherenkov-like candidates!





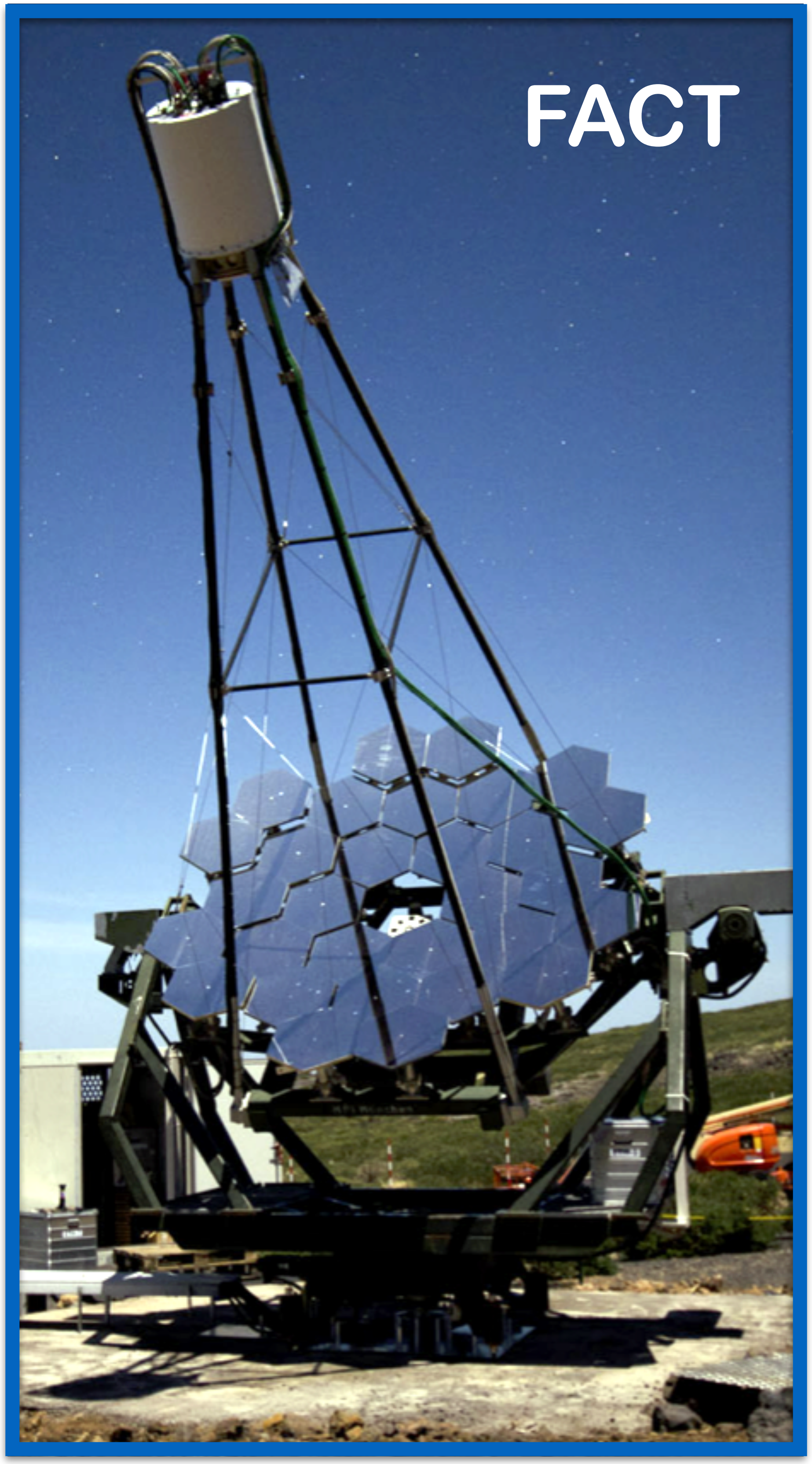
SiPM progress in astroparticle physics



First SiPM Cherenkov telescope running since 5 years!

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

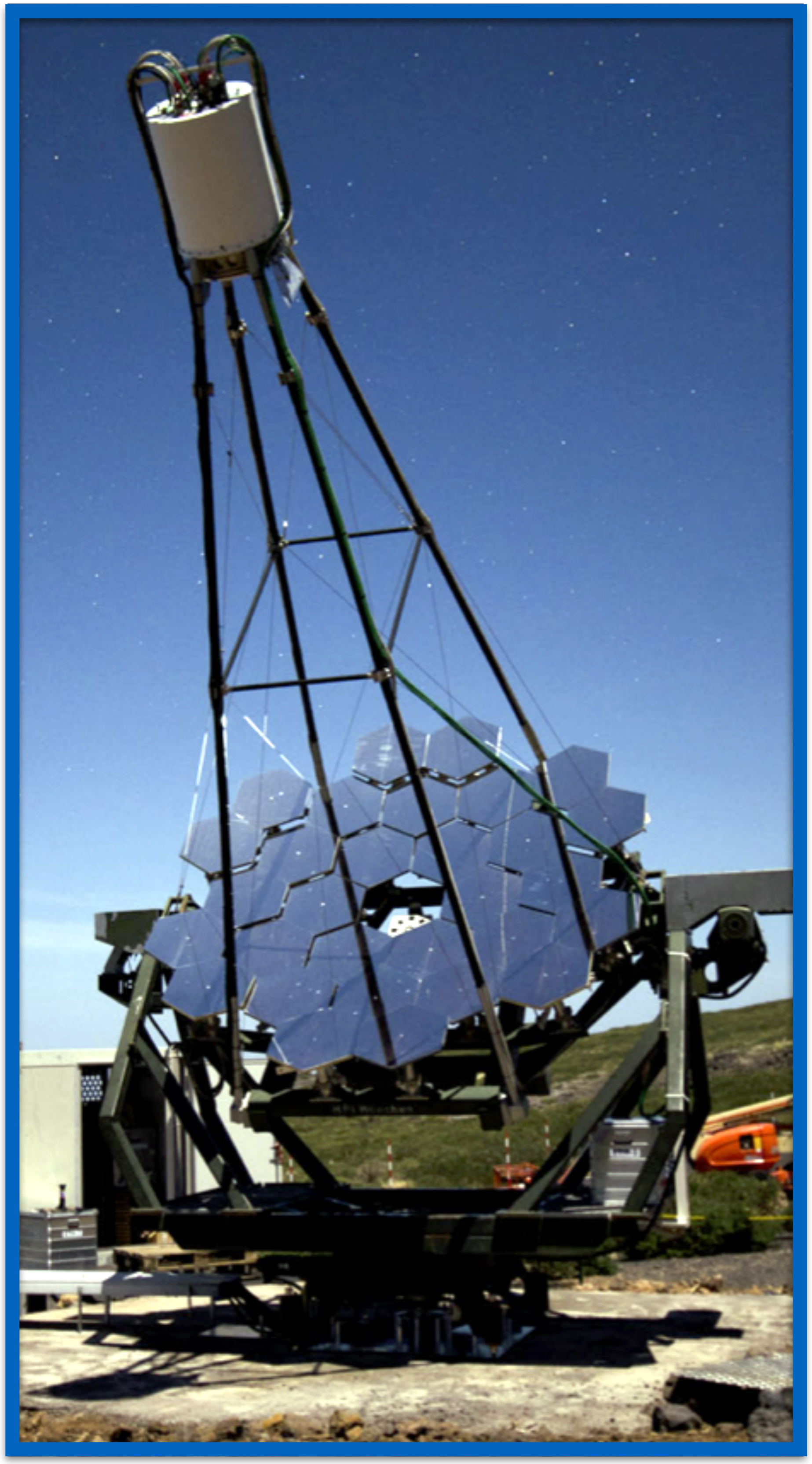
SiPM progress in astroparticle physics

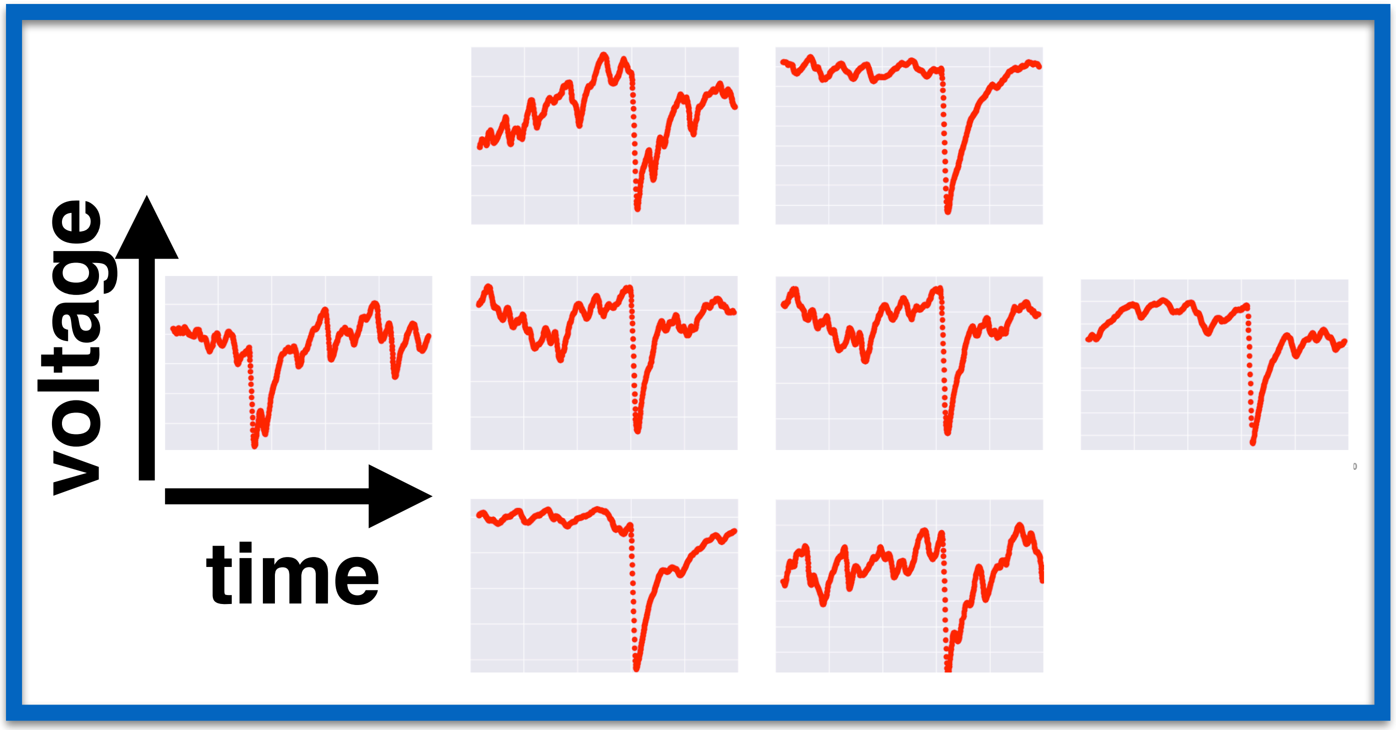


First SiPMs at South pole

Deployment of FAMOUS based design IceAct Cherenkov telescope at South pole

SiPM progress in astroparticle physics





SSD - scintillator detector for AugerPrime

Preliminary design report - arXiv:1509.03732

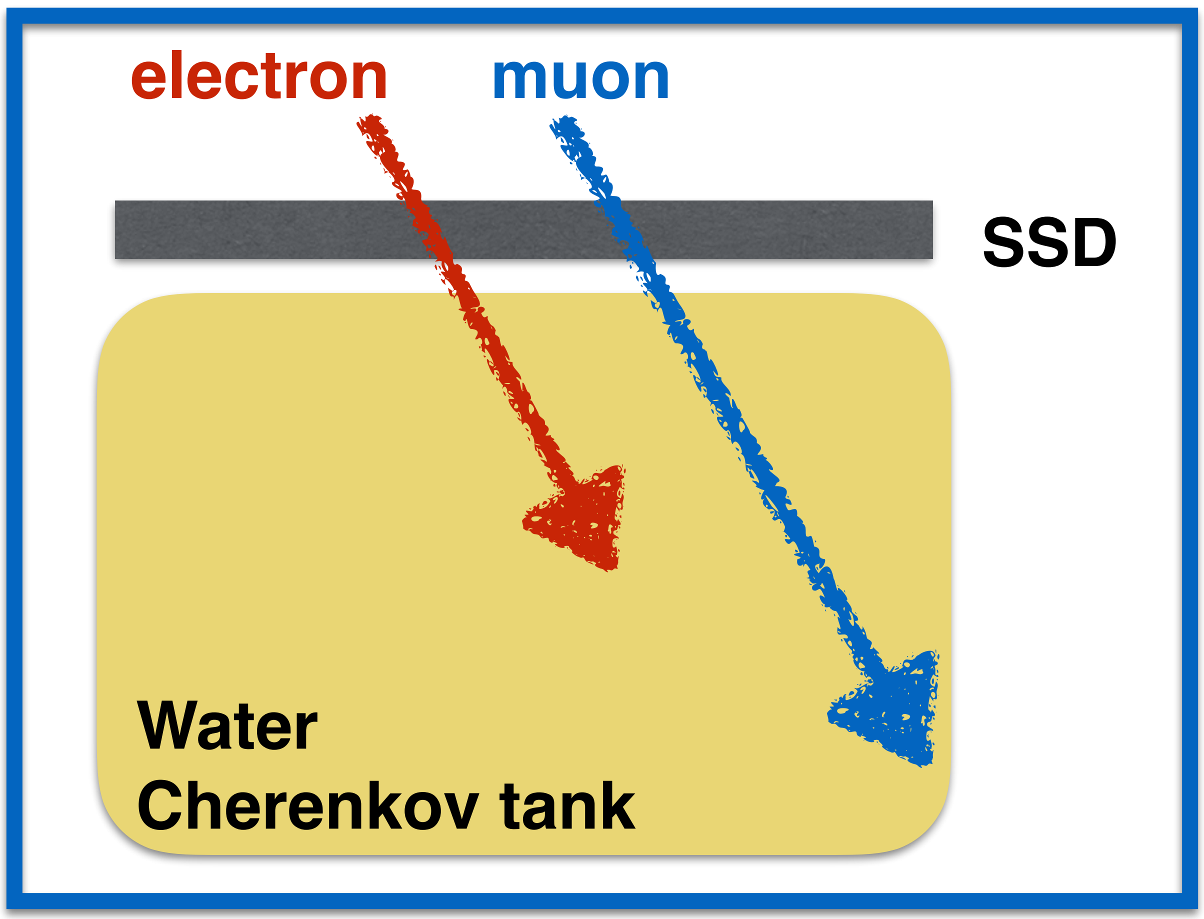
Different detector response of scintillator detector and water Cherenkov tank

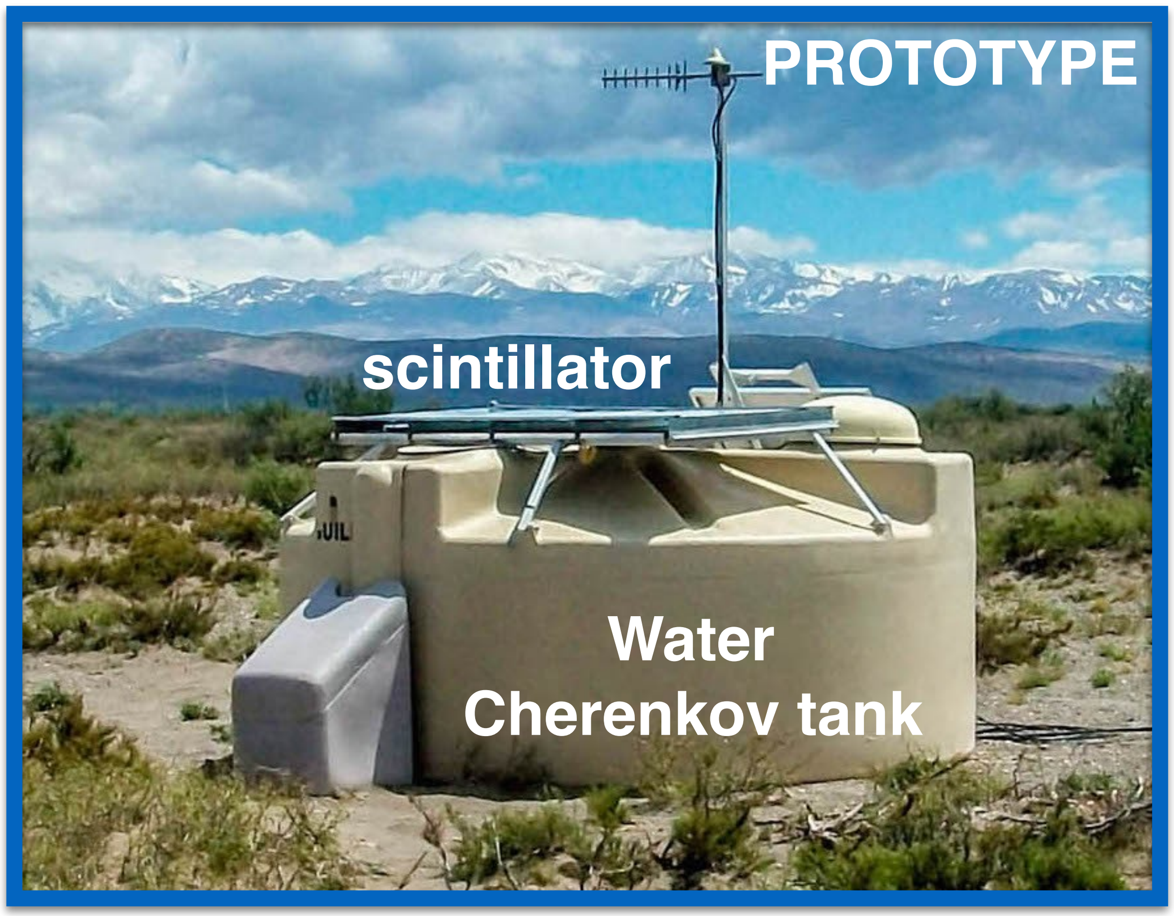
- One goal: Mass composition by number of muons

! Both detectors have ≈ 100% duty cycle !

First prototypes in the field
Start of data taking: 2018

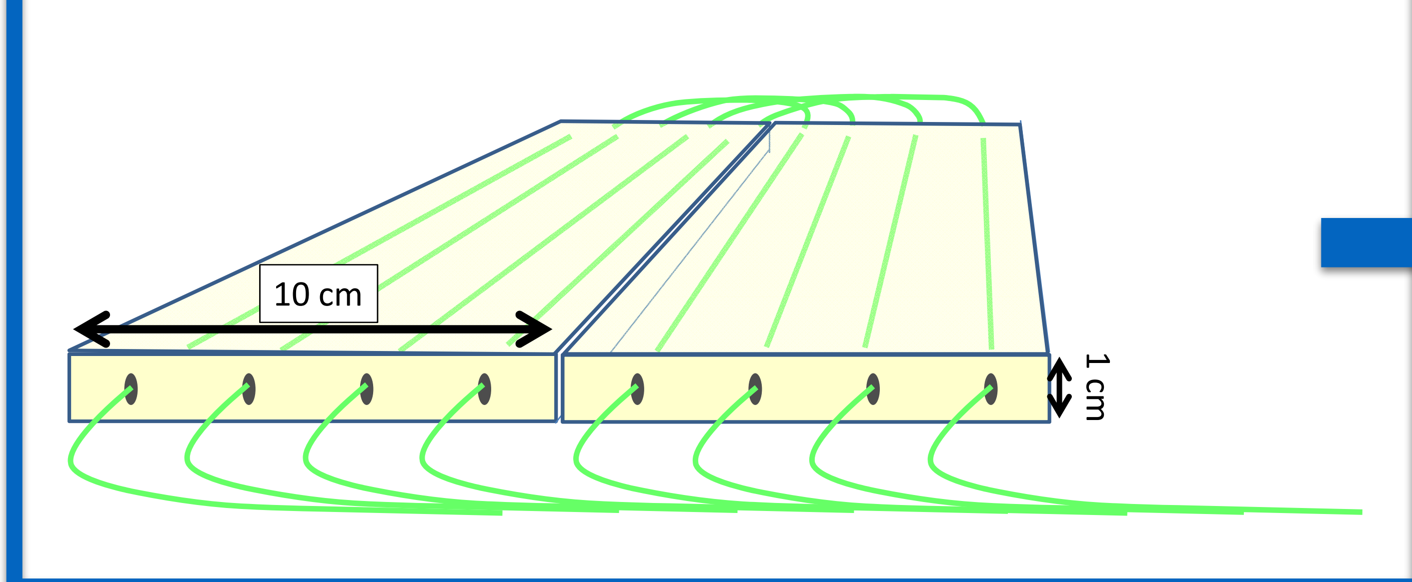
SiPMs excellent option for light sensor

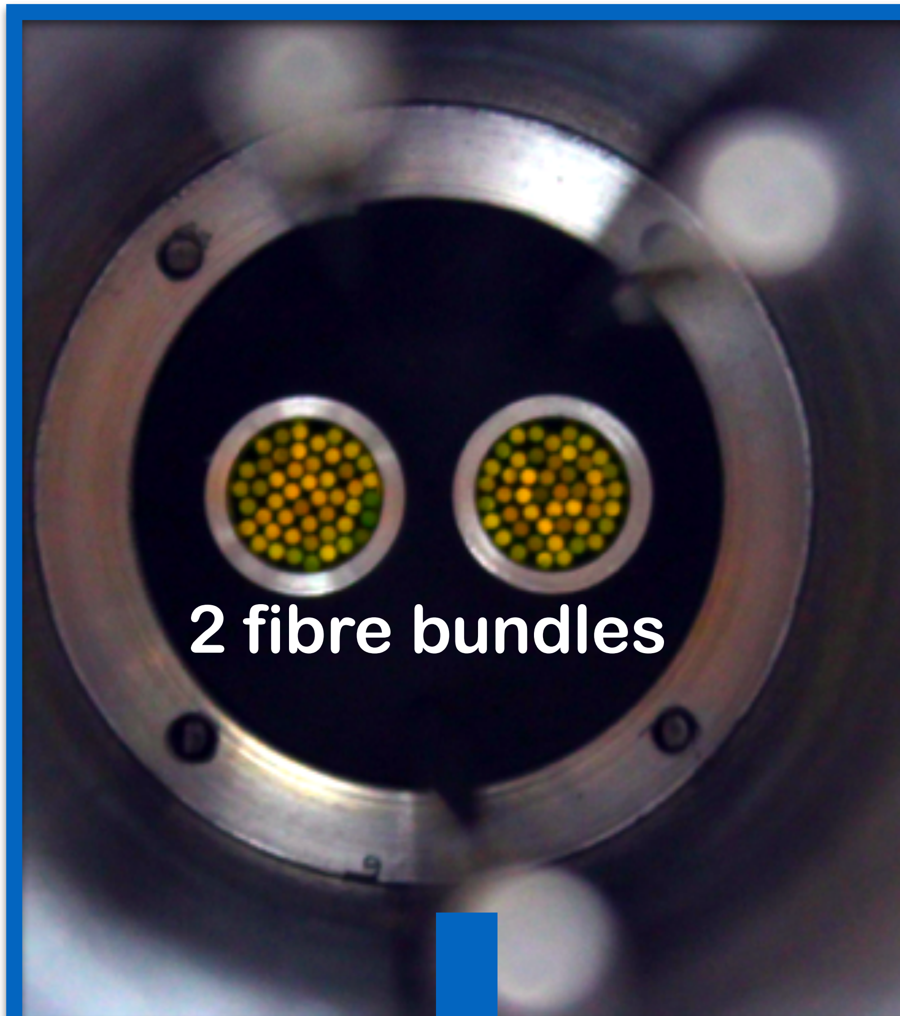


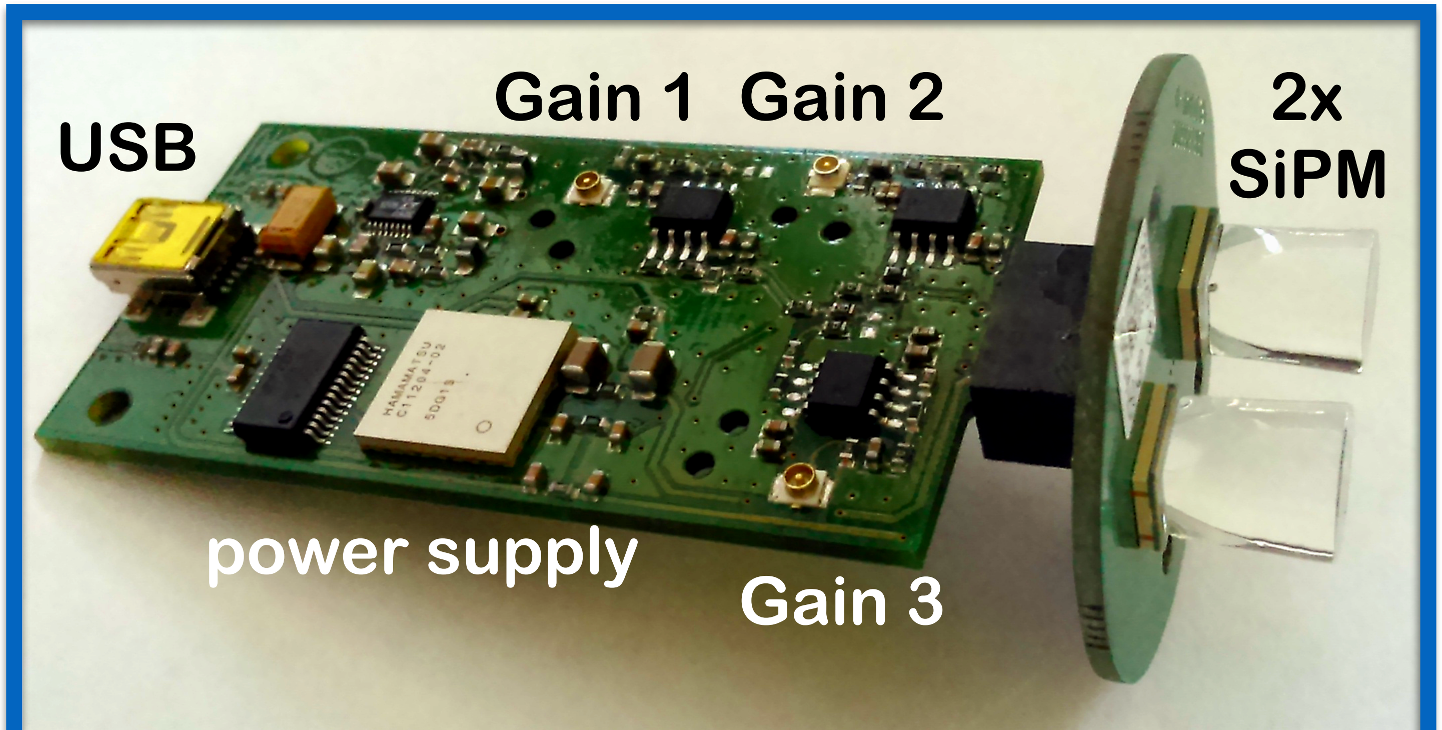


SSD with SiPMs?

scintillator bars with WLS fibre readout





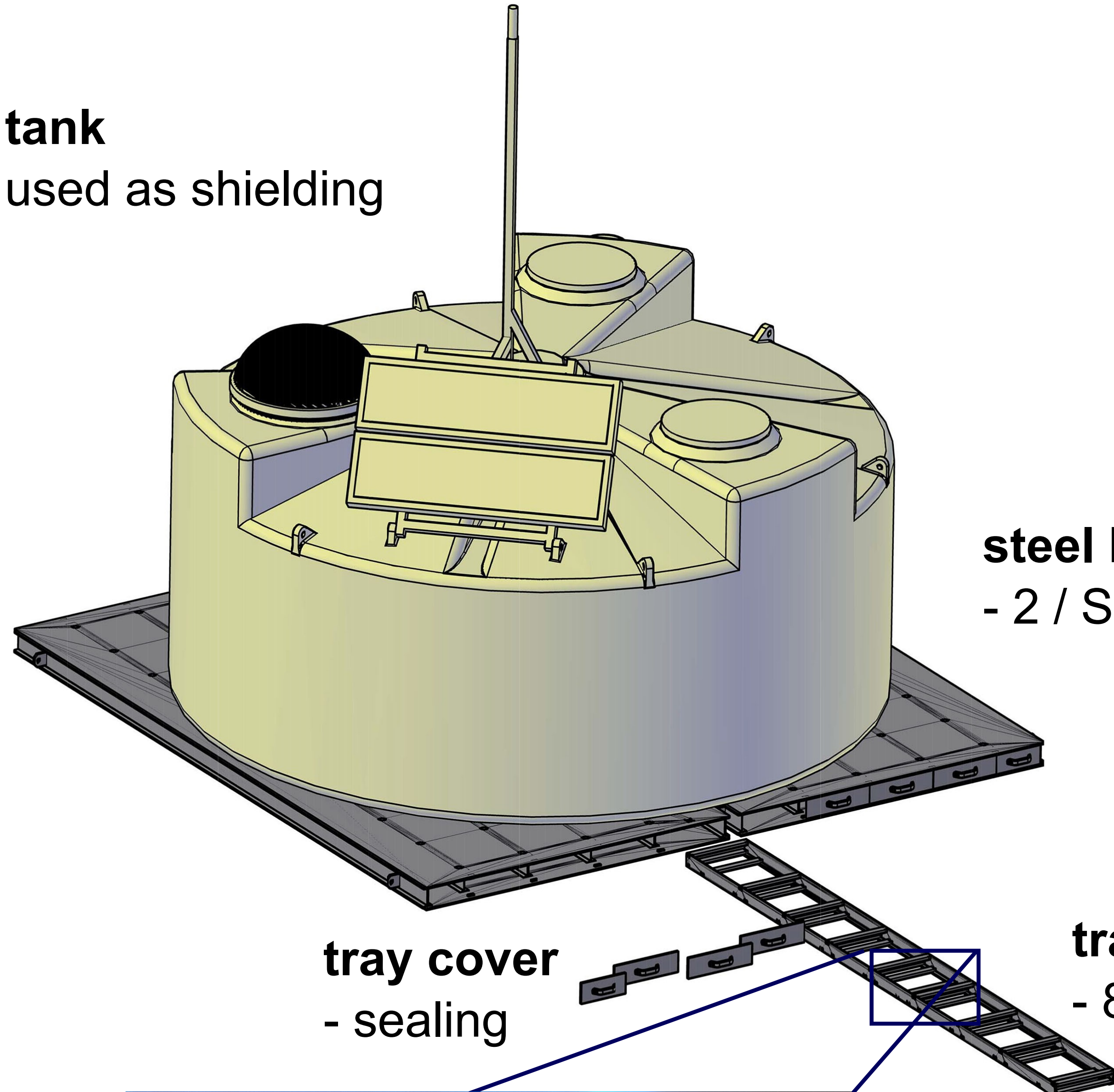


First modules in the field since September

Aachen Muon Detector

Alternative detector concept - many channels

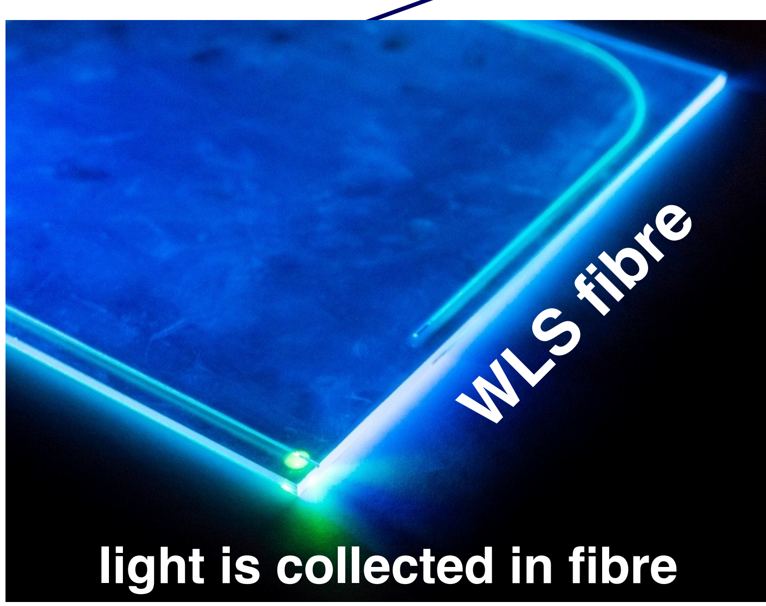
tank
used as shielding



steel housing
- 2 / SD station

tray cover
- sealing

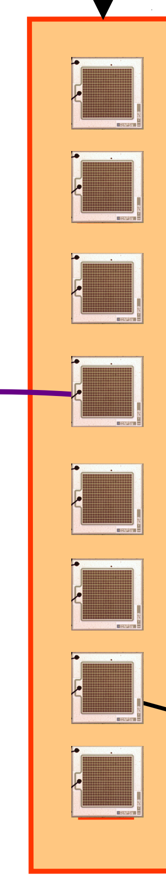
tray
- 8 tiles / tray



scintillator tile
- 30x30x0.5 cm³
- 64 tiles / detector

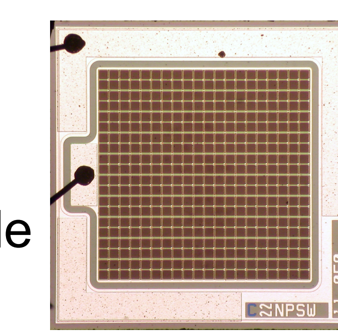
clear waveguide

Voltage Supply → 1 EASIROC SiPM ASIC



SiPM Carrier Board
- 1 board / tray
- located at the end of tray

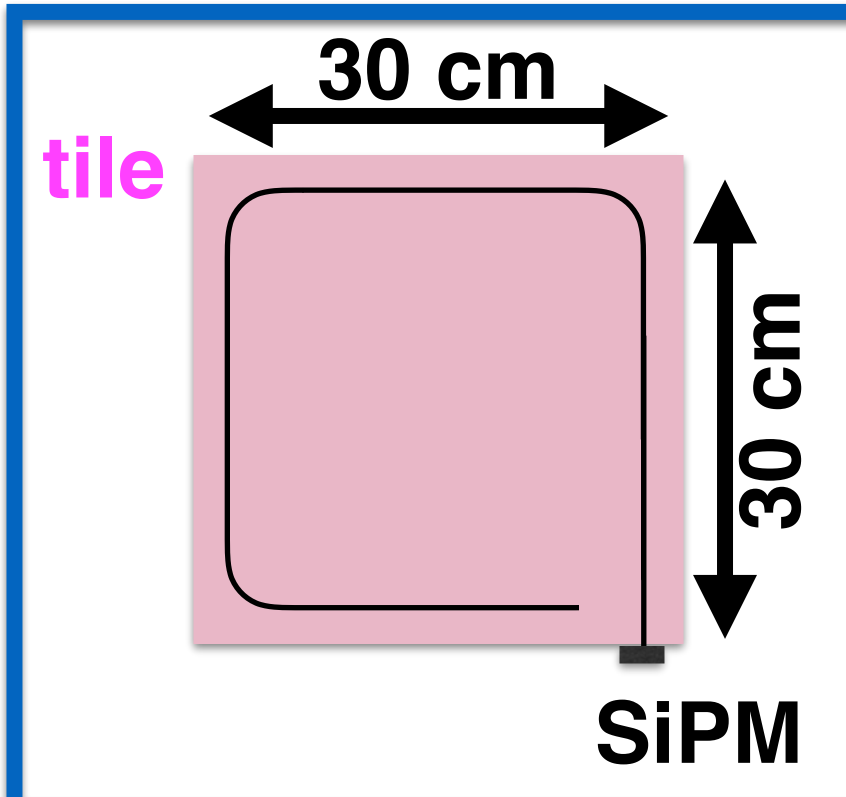
SiPM
- 1x1 mm²
- 1 SiPM / tile

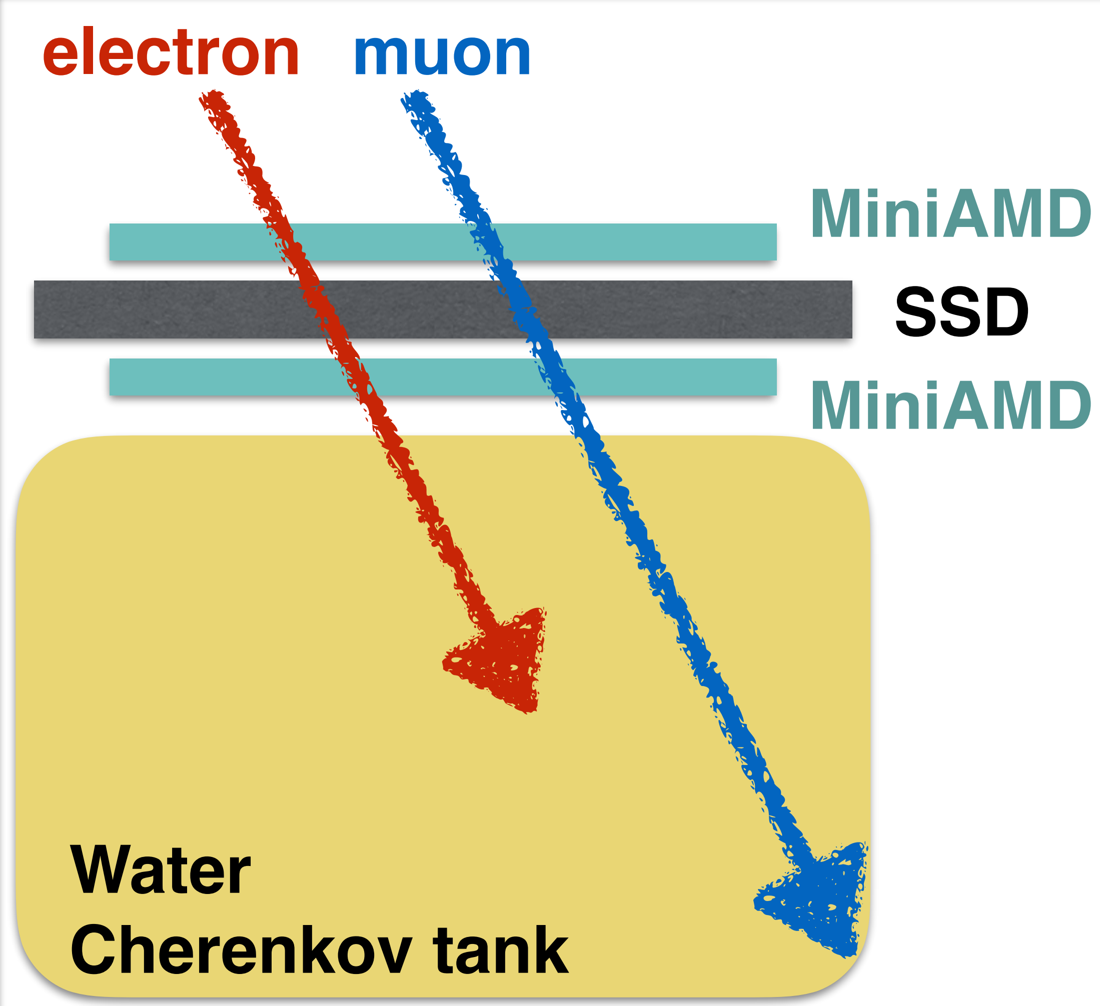


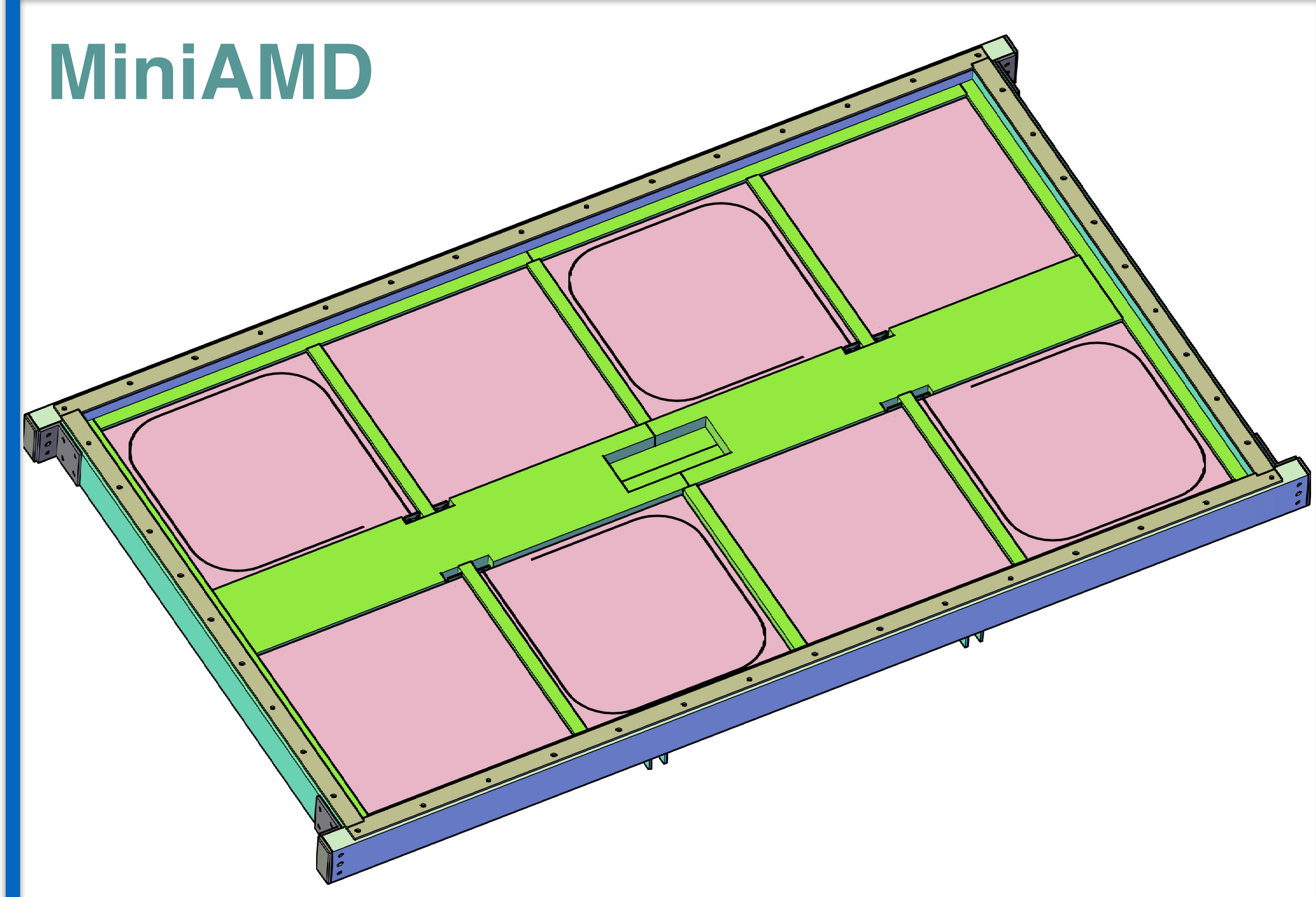
Proof of concept - MiniAMD

Potential calibration device for SSD

- 8 tiles and one SiPM each
- Size SiPM: 1.3 mm x 1.3 mm
- SiPMs directly connected to tile
- Weight: ~ 25 kg



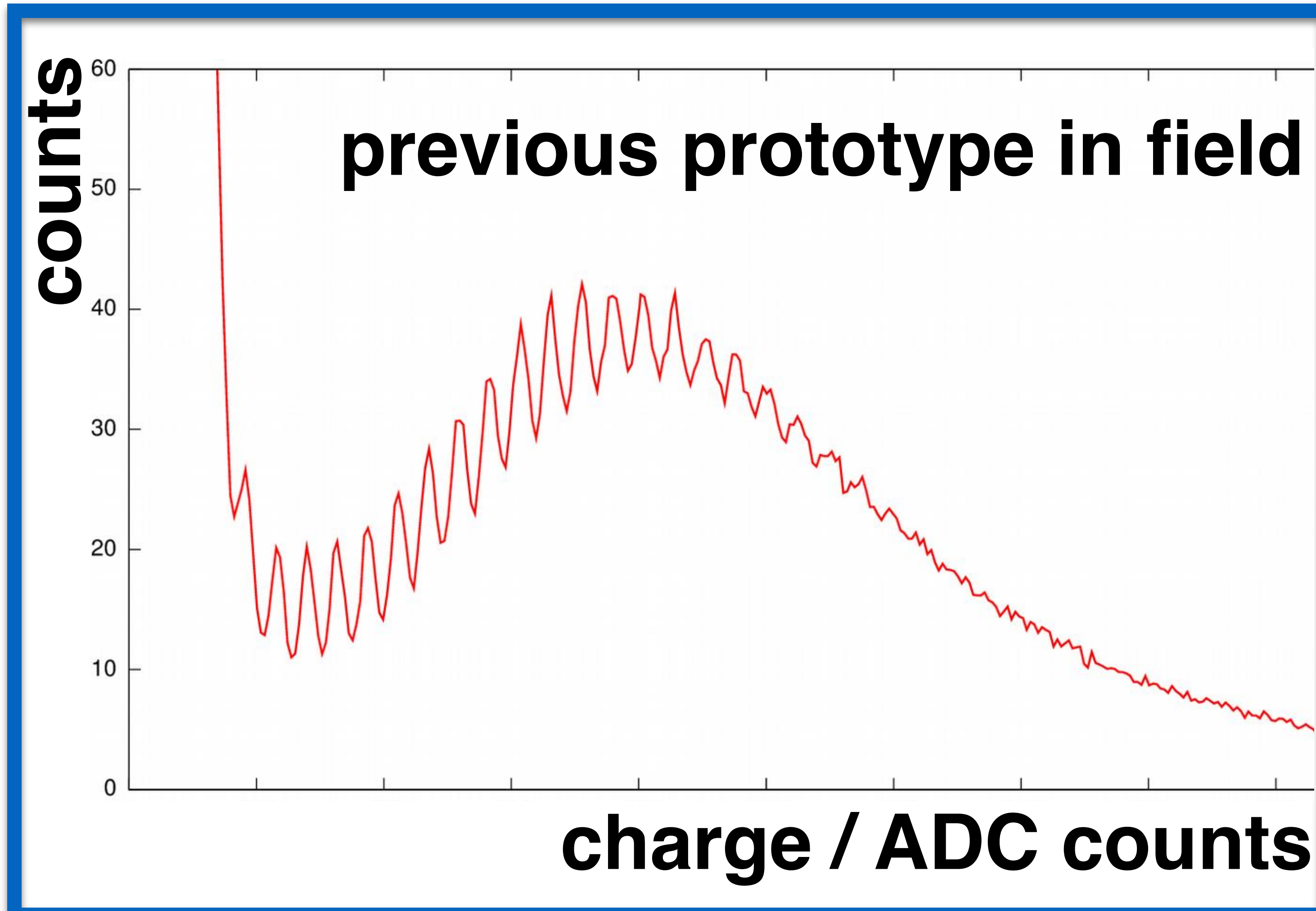




Summary

Determination of number of muons

- **SiPMs excellent option for detection of muons**
- SSD: **First modules in field, few equipped with SiPMs**
- AMD: **MiniAMD at Auger site next year**



FAMOUS

- Successful commissioning of the new 61 pixel focal plane
- Measurement of first shower candidates

The very near future

Exciting time ahead!