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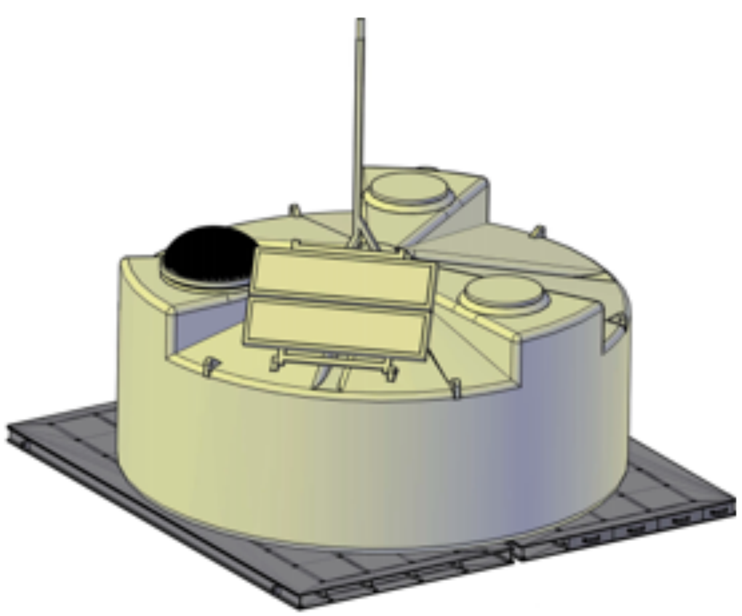
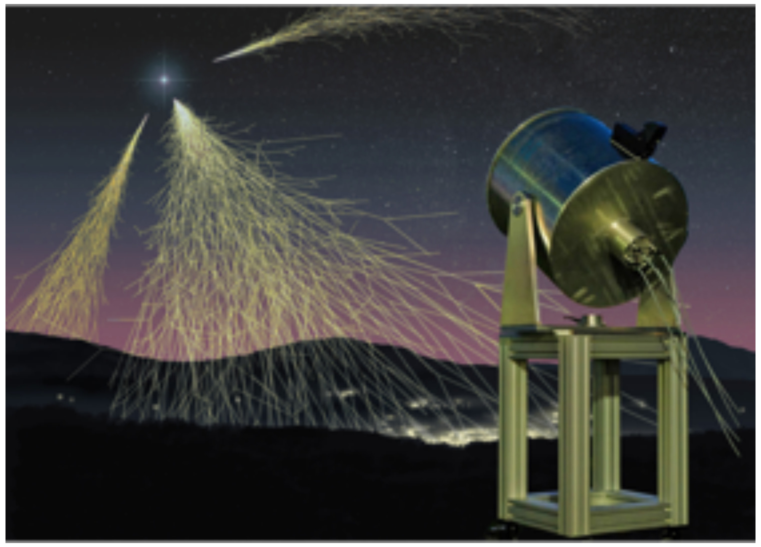
The Aachen Muon Detector and the FAMOUS telescope

Christine Peters

for the AMD and FAMOUS groups



HAP workshop
Non-thermal Universe
September 2016

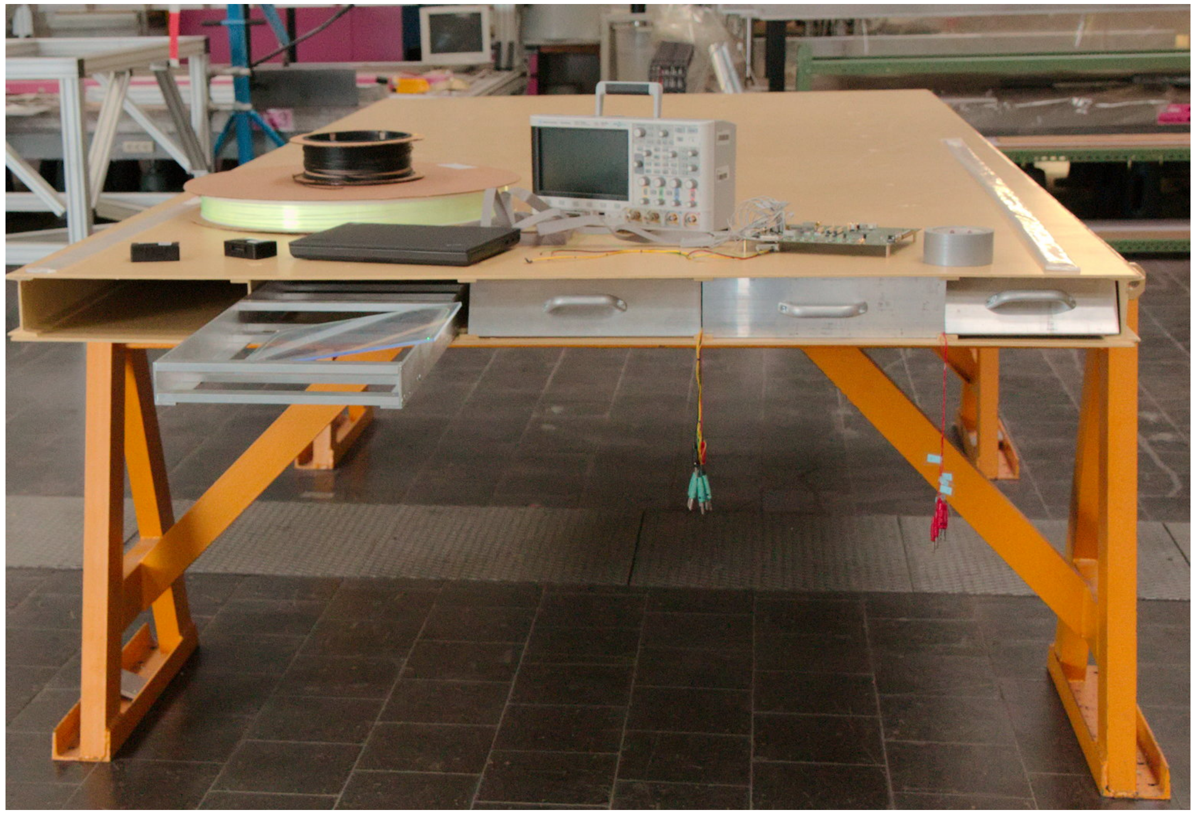


Outline

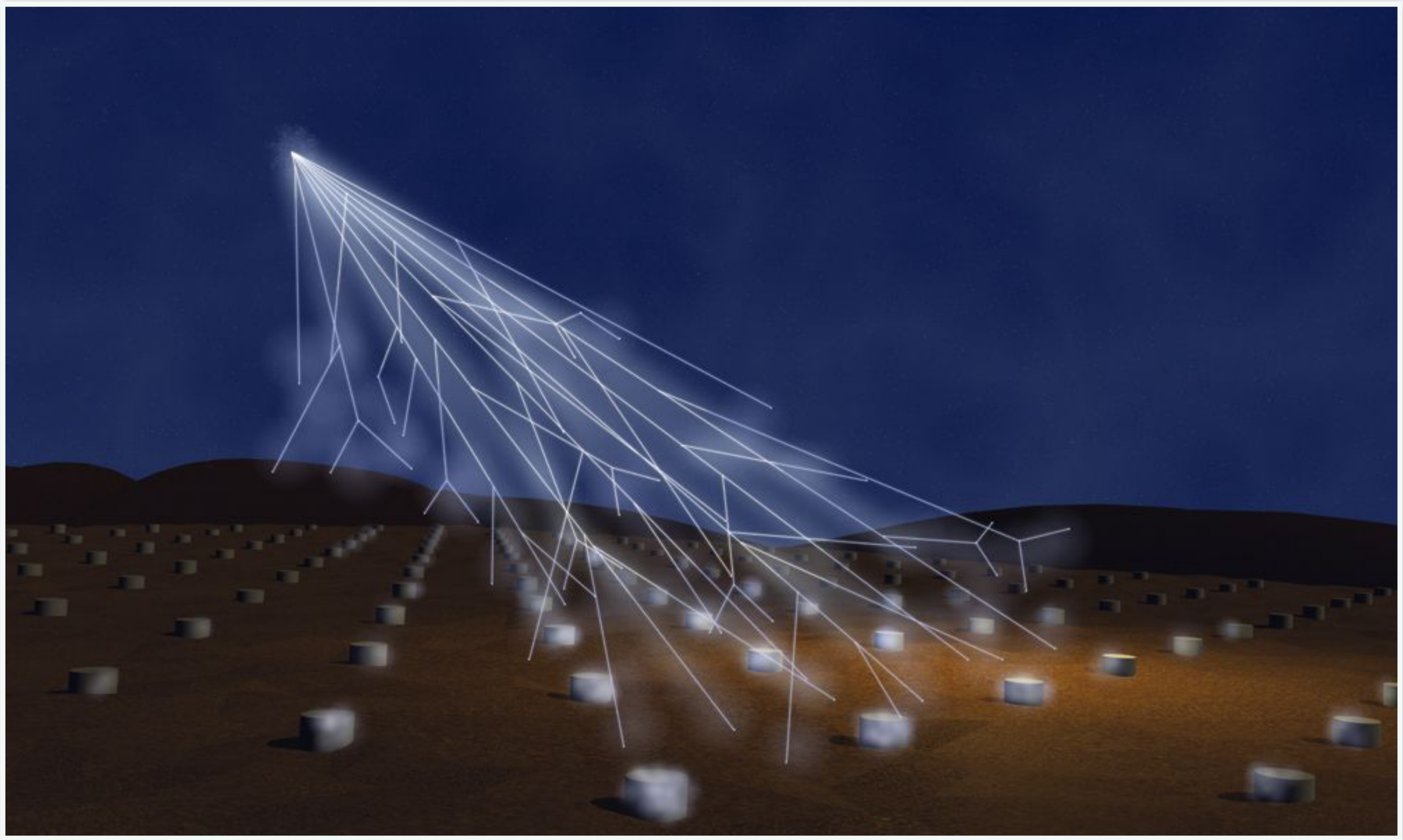
- Motivation
- The muon detector AMD
- The fluorescence telescope FAMOUS

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

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



Cosmic ray air showers components



Muonic component

- muons contain information about primary type
- separating electromagnetic & muonic component by hybrid detection
- separation of different primaries
  - → entangle hadronic interaction scenarios
  - → understand flux suppression
- anisotropy studies with protons
  - → searches for point sources

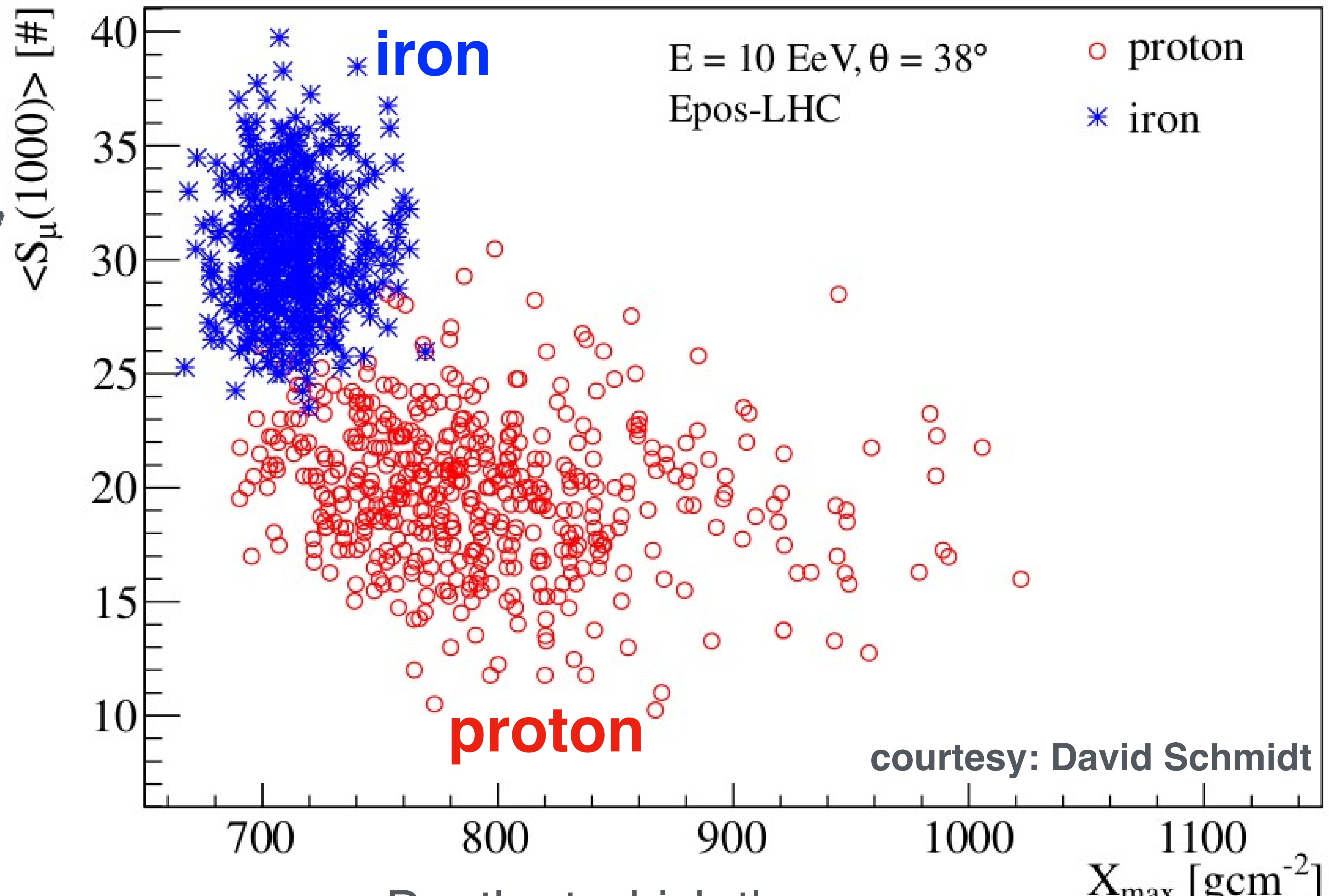
Fluorescence light

- measurement of energy
- measurement of depth of shower maximum
  - → observable sensitive to mass composition

Cosmic ray air showers observables

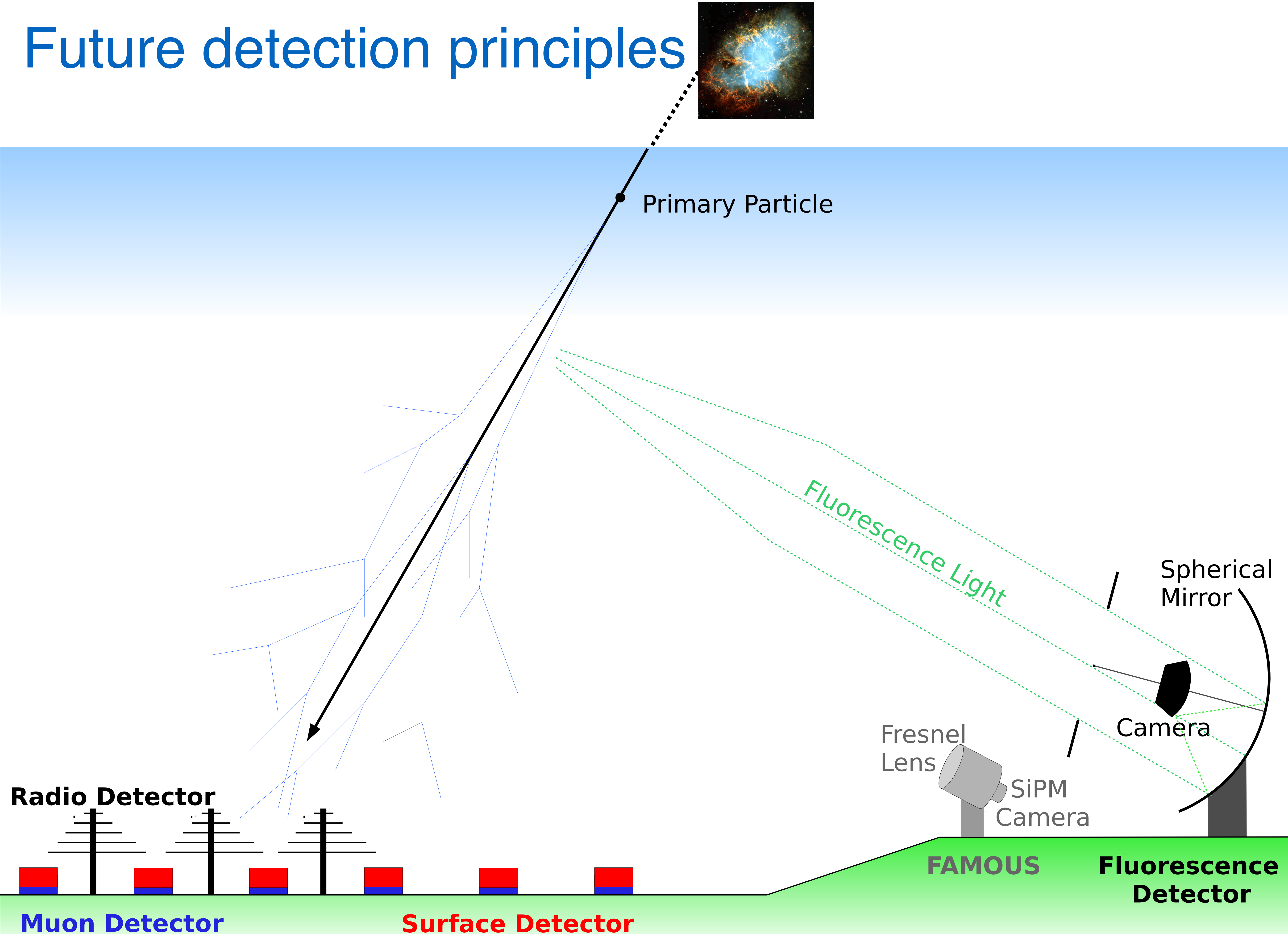
Combination of mass sensitive observables allows for an improved determination of the chemical composition of cosmic rays

Number of muons at a given reference distance at ground



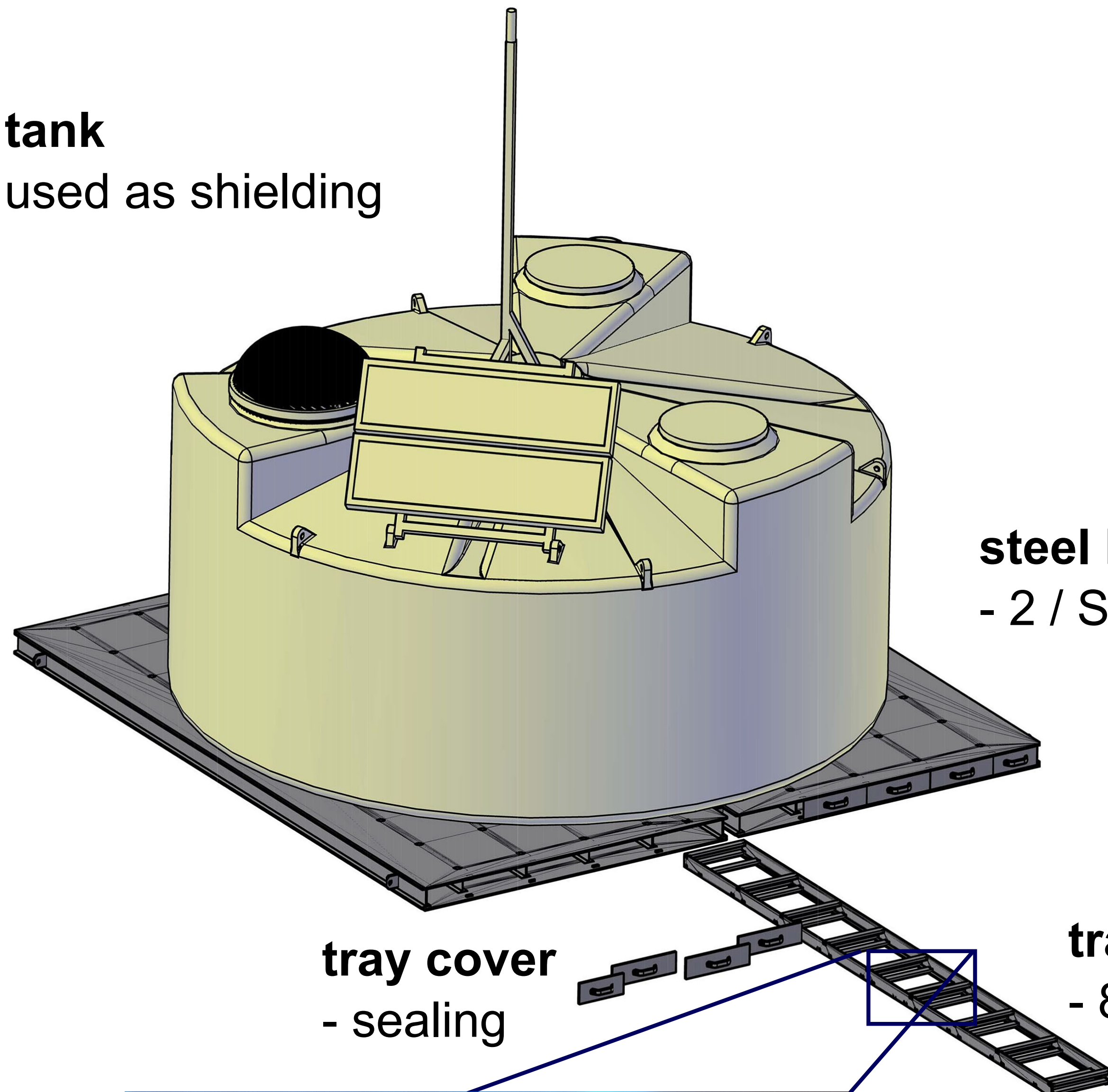
Depth at which the maximum of shower development occurs

Future detection principles



Aachen Muon Detector

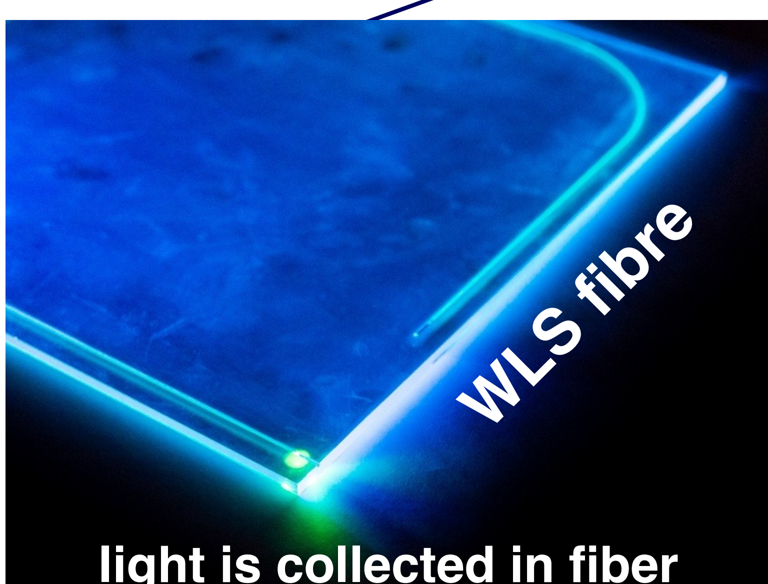
tank
used as shielding



steel housing
- 2 / SD station

tray cover
- sealing

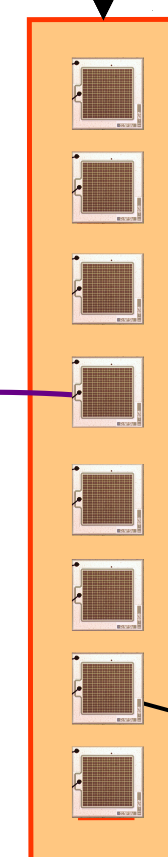
tray
- 8 tiles / tray



scintillator tile
- 64 tiles / detector

clear waveguide

Voltage Supply → 1 EASIROC SiPM ASIC

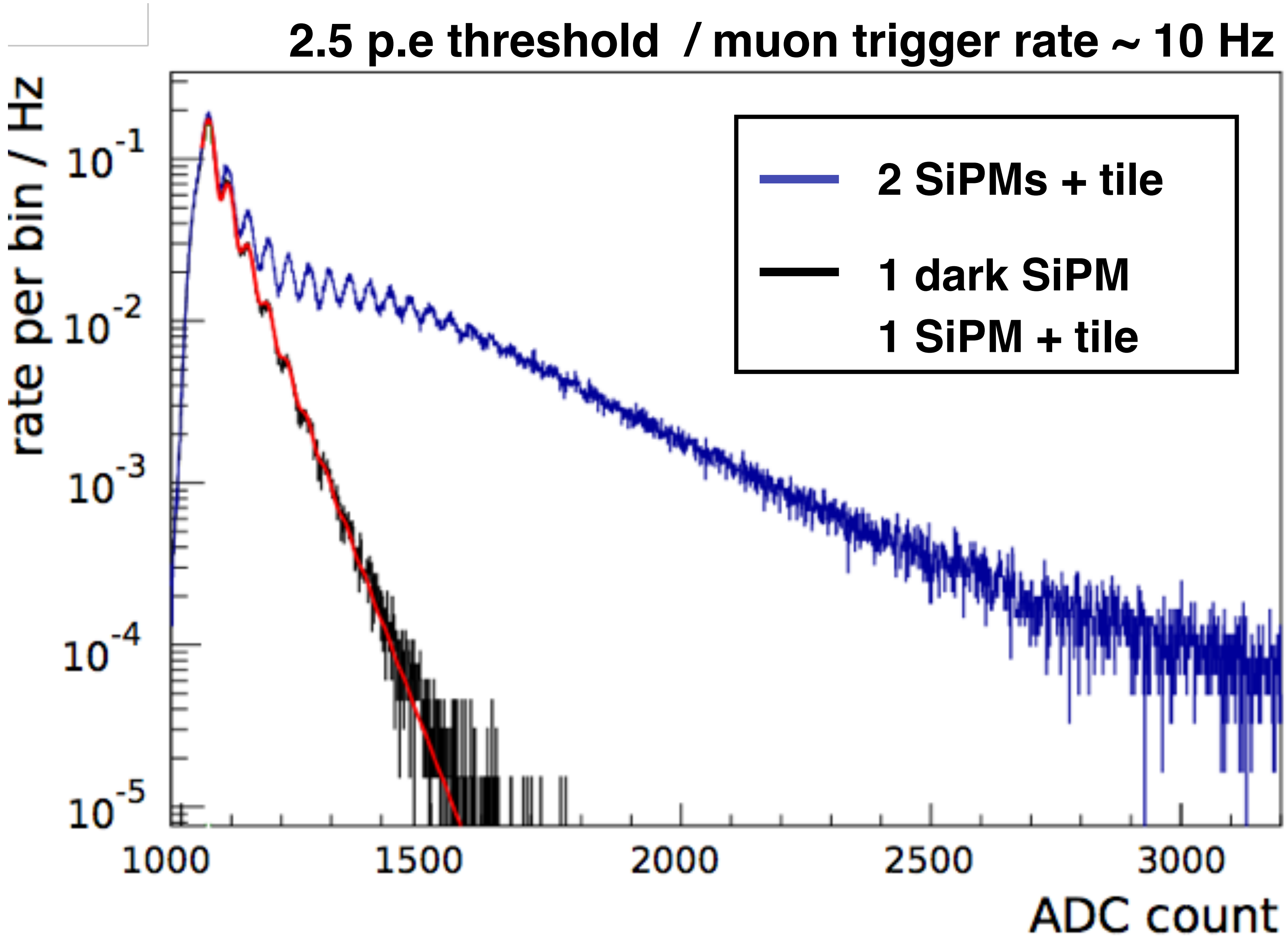


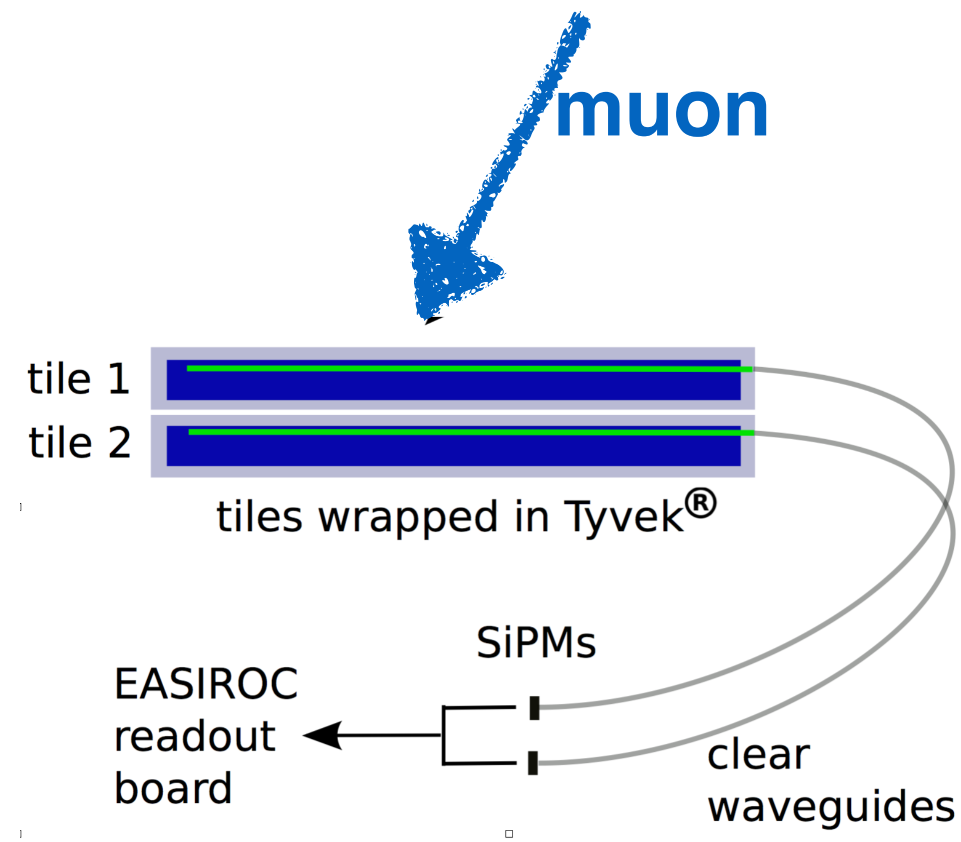
SiPM Carrier Board
- 1 board / tray
- located at the end of tray

SiPM
- 1x1 mm²
- 1 SiPM / tile

First measurements - light yield of scintillator tiles

Coincidence measurements of two stacked prototype tiles read out by SiPMs





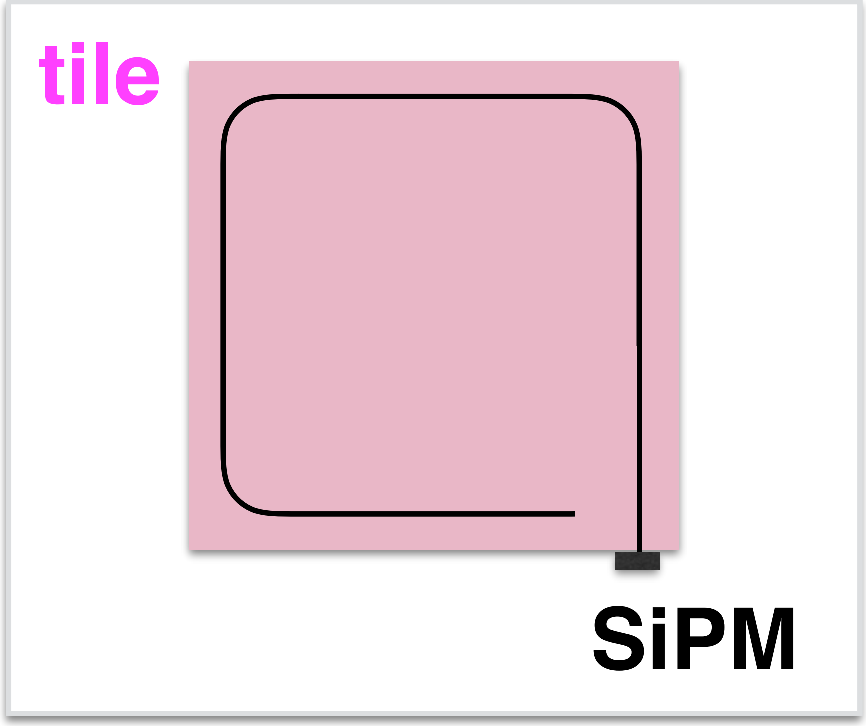
We measure muons!

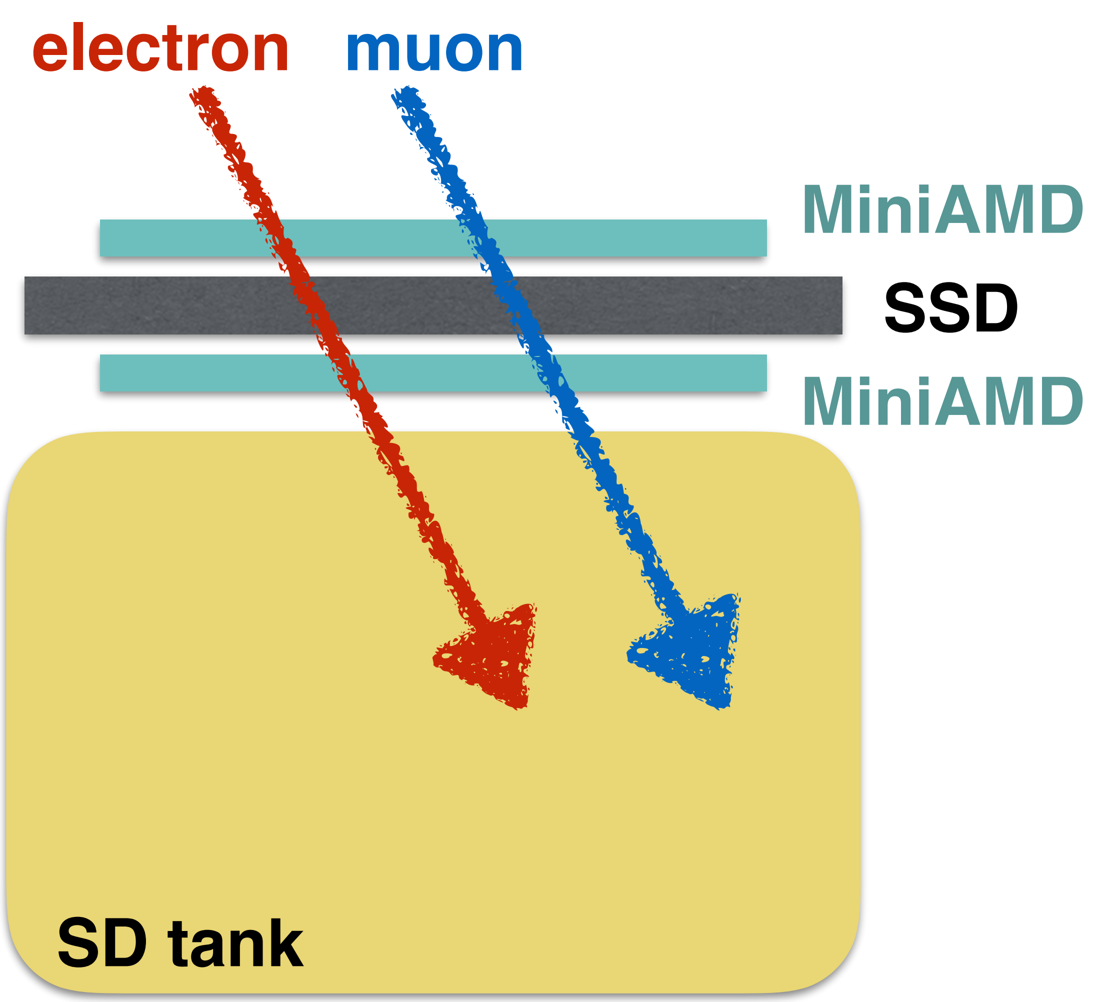
SiPMs excellent choice for the detection of muons due to single p.e. resolution!!

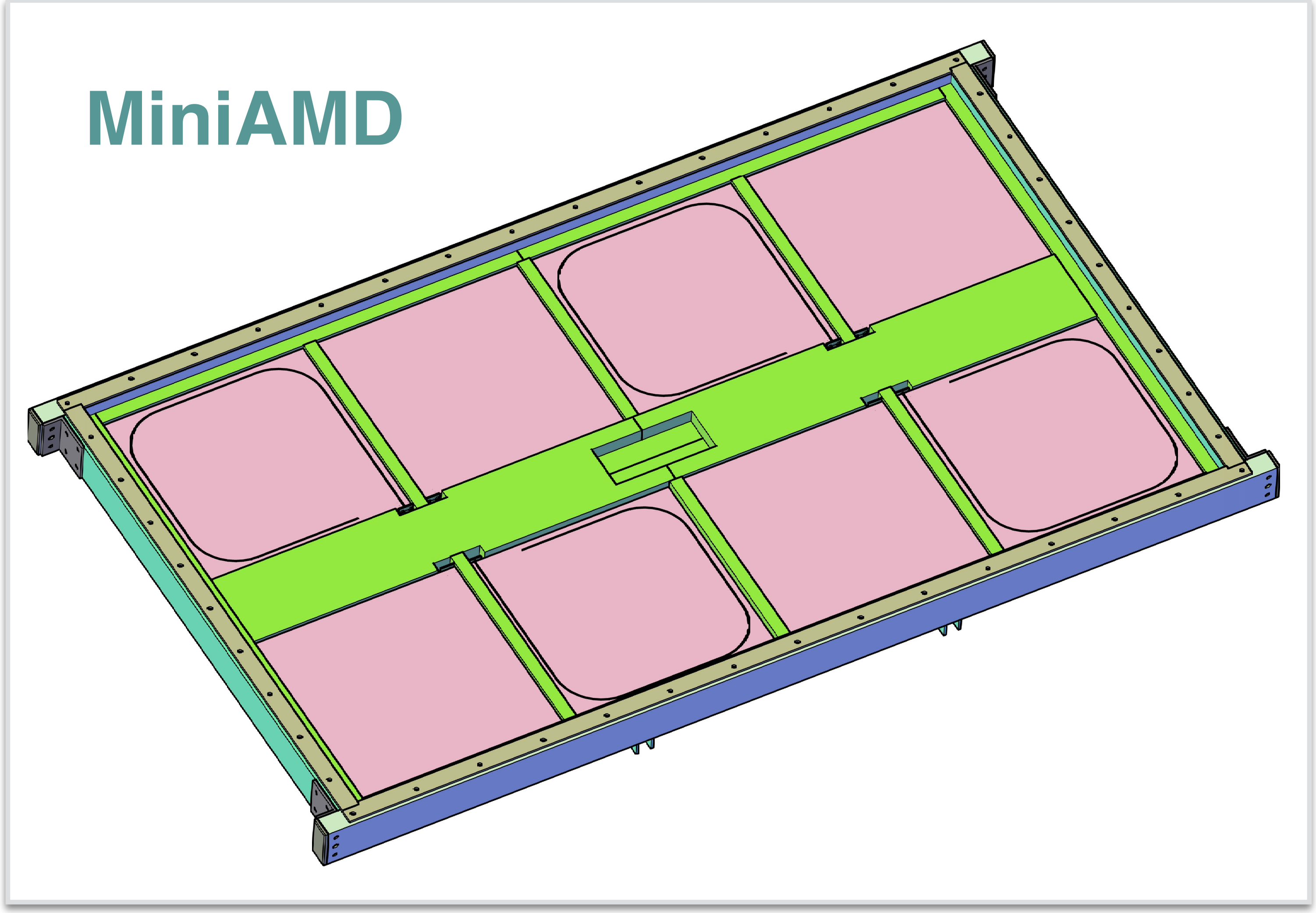
Impact of knowledge - MiniAMD

Calibration device for SSD?

- Number of tiles + SiPMs: 8 each
- Size SiPM: 1.3 mm x 1.3 mm
- SiPMs directly connected to tile
- Weight: ~ 40 kg

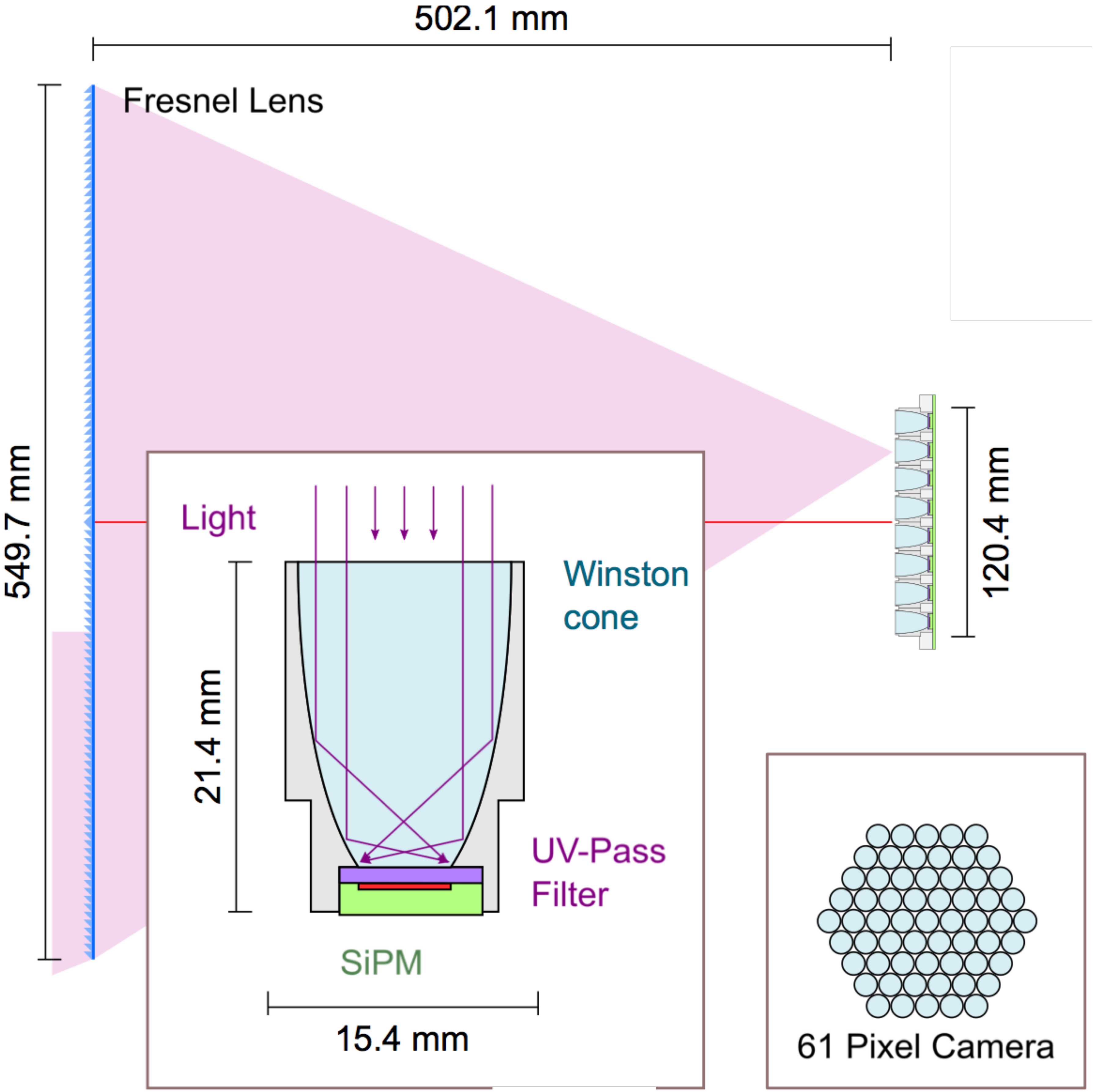







FAMOUS
courtesy: Michael Eichler

The fluorescence telescope FAMOUS



FAMOUS news

First test measurements

with 61 pixel telescope

TARGET readout chip

successfully

implemented

but calibration still needed

First test measurements in Aachen

First field test with full 61 pixel camera

- Measurement of star trails
- Check of the pixel to channel assignment
- Measurement of the mean current over 1 h
- One measurement each 5 sec

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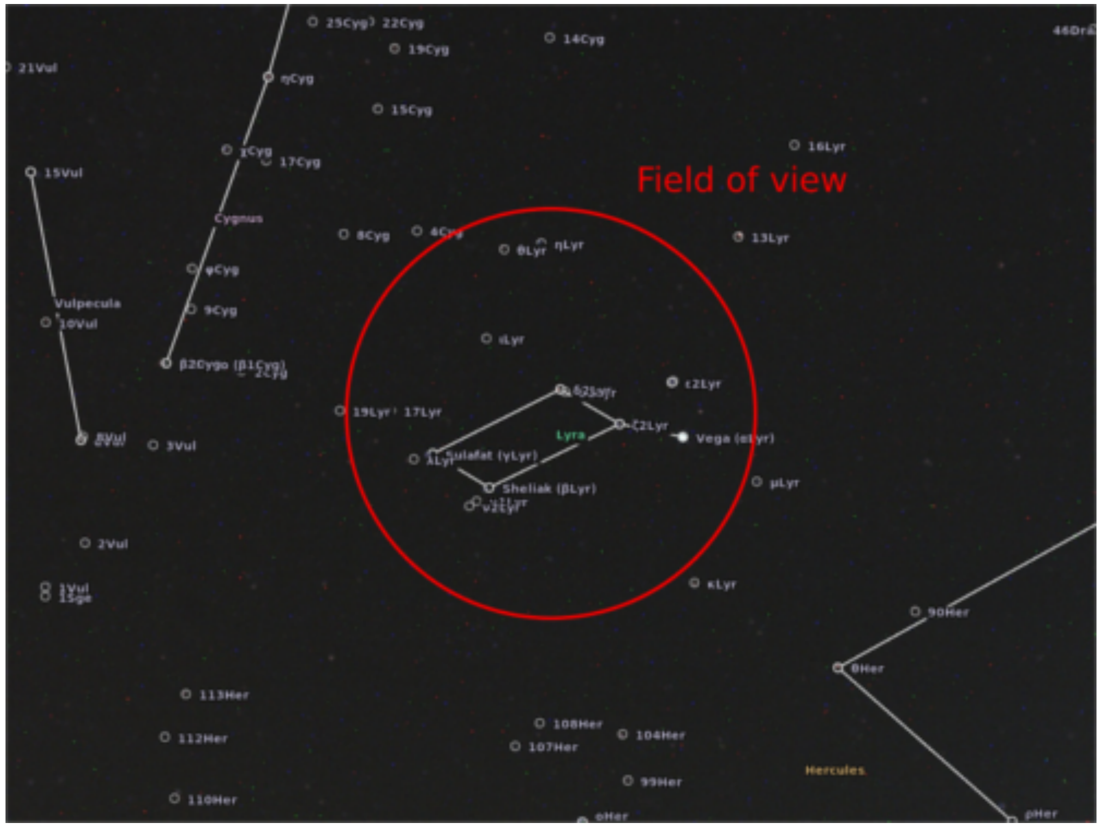

- Photograph taken with CMOS camera
- Automatic image analysis for star detection

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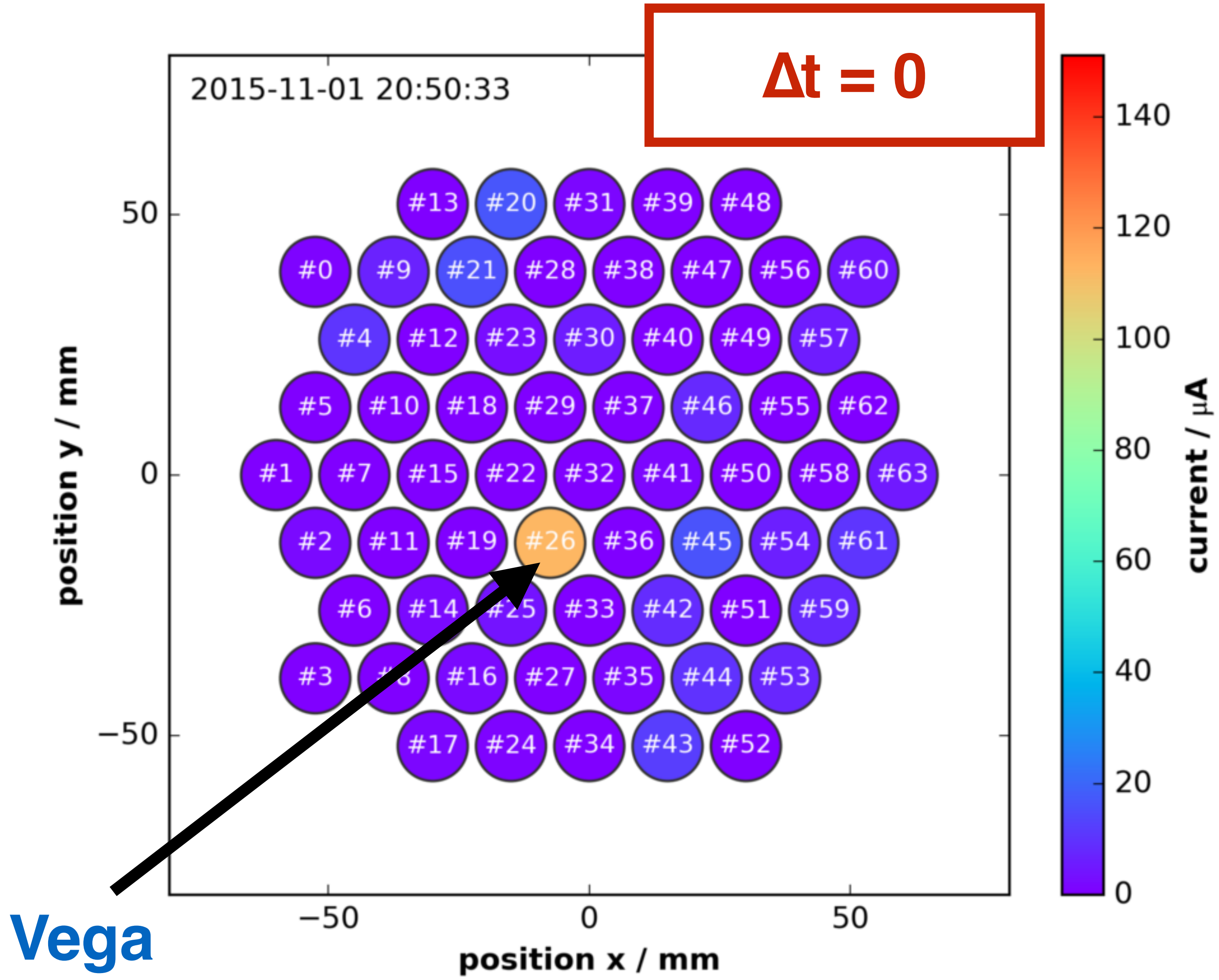

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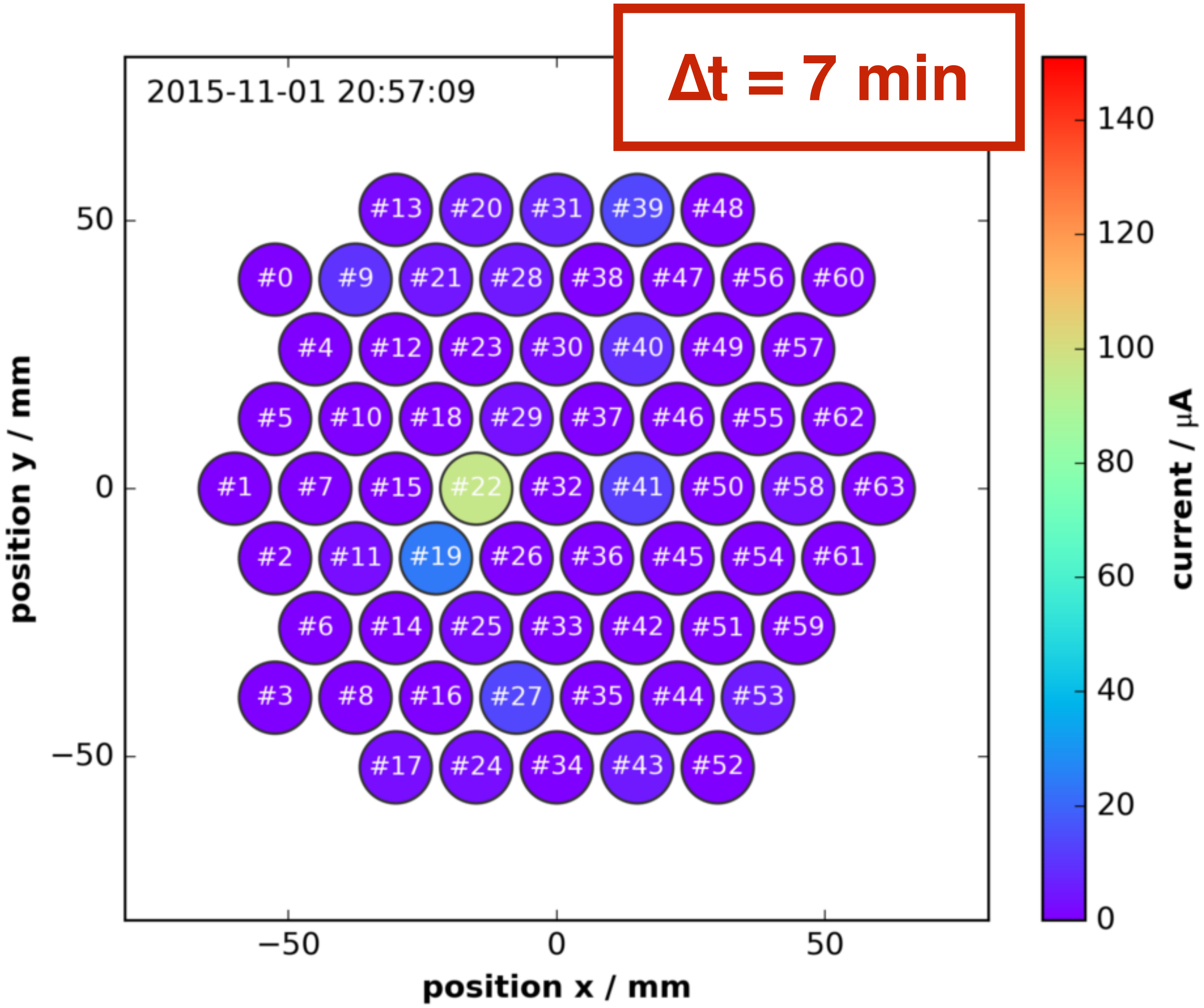

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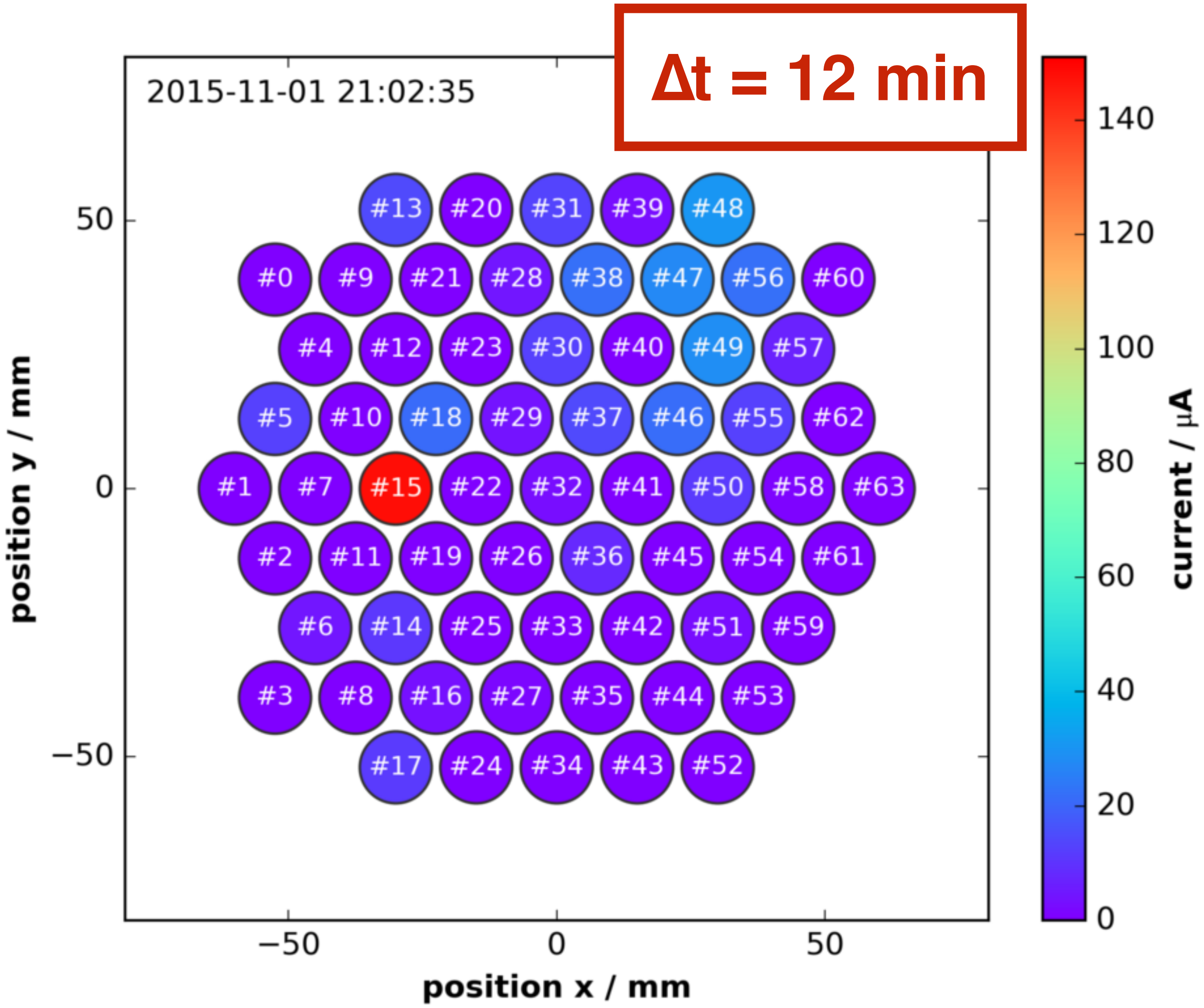

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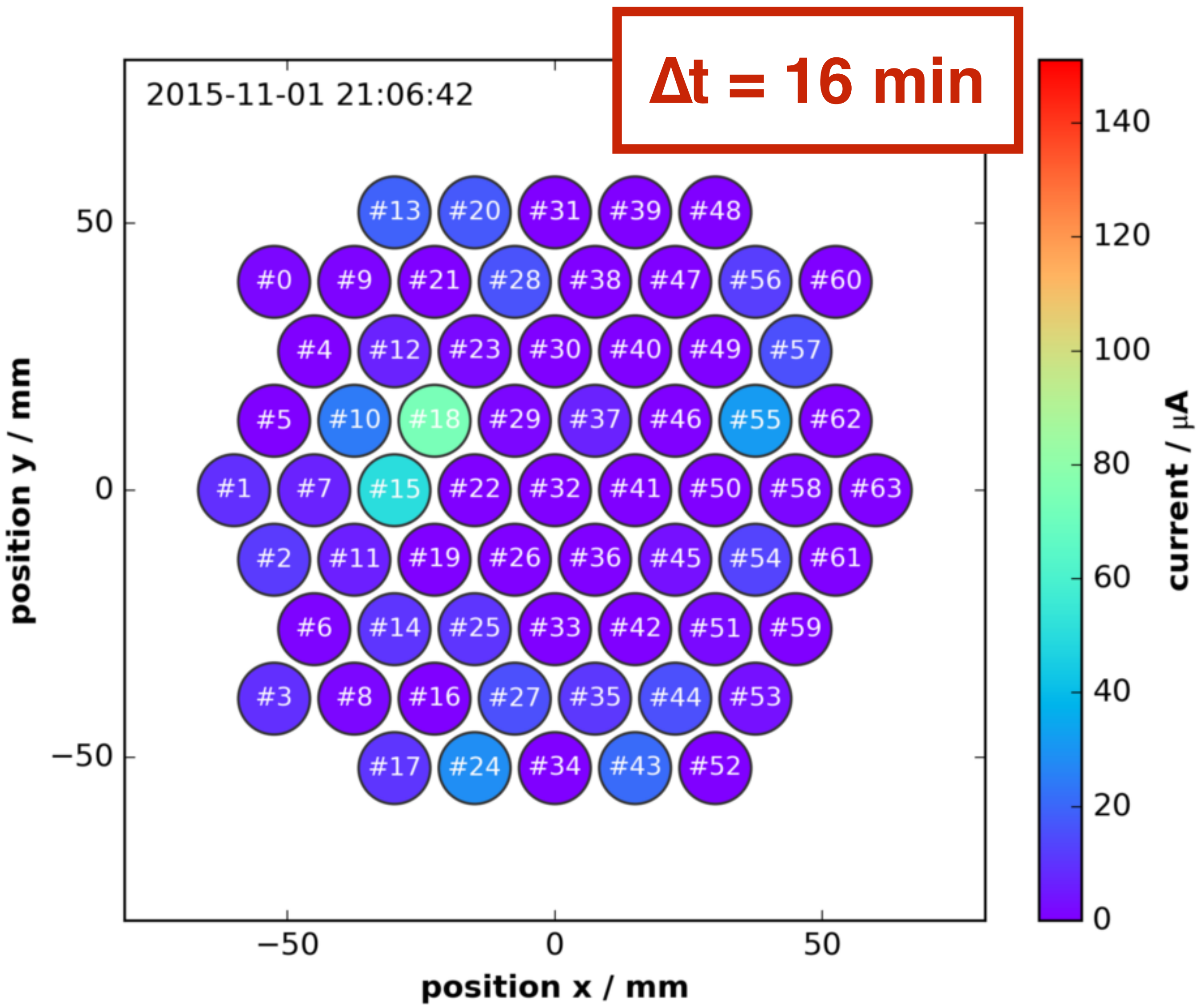

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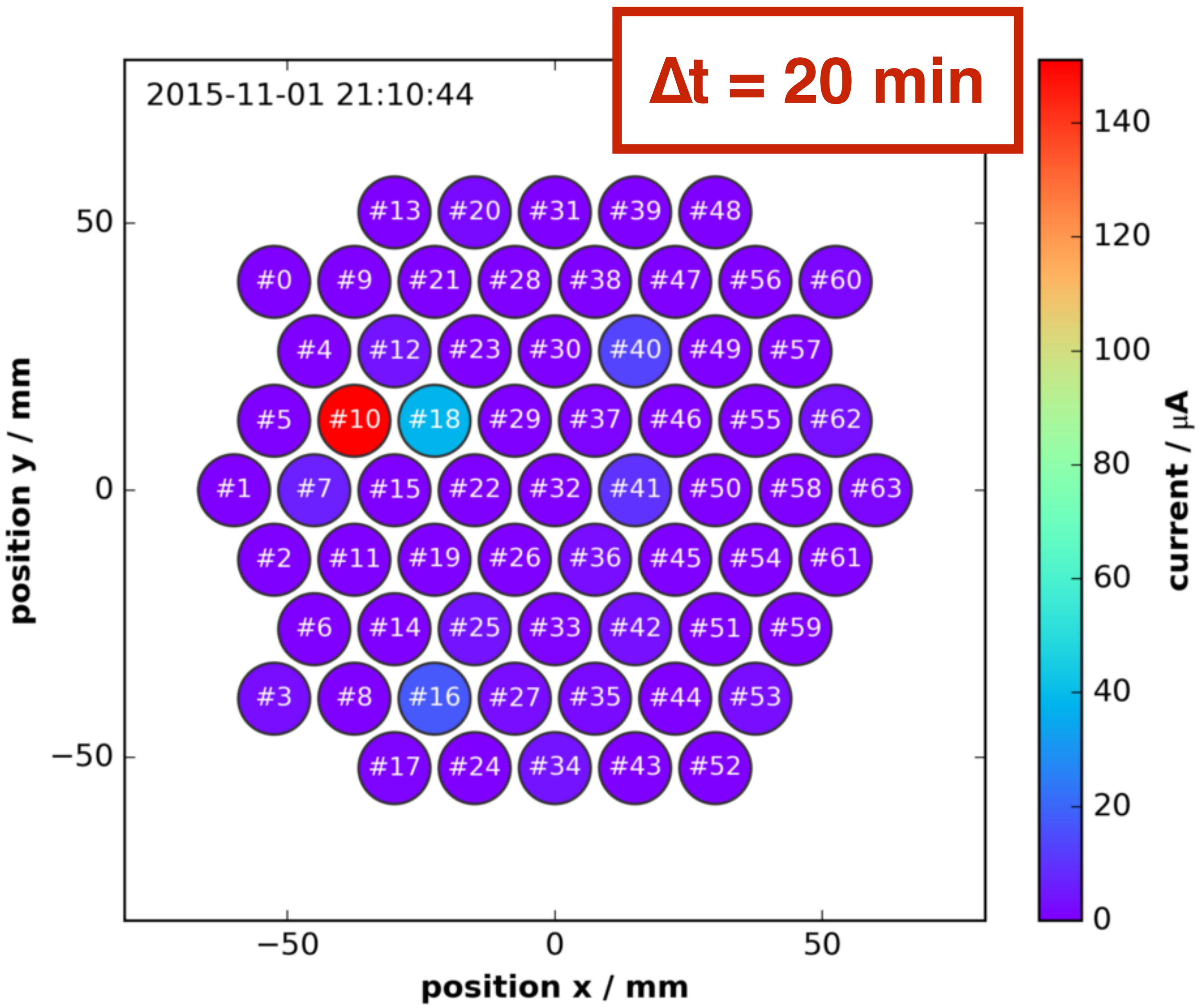

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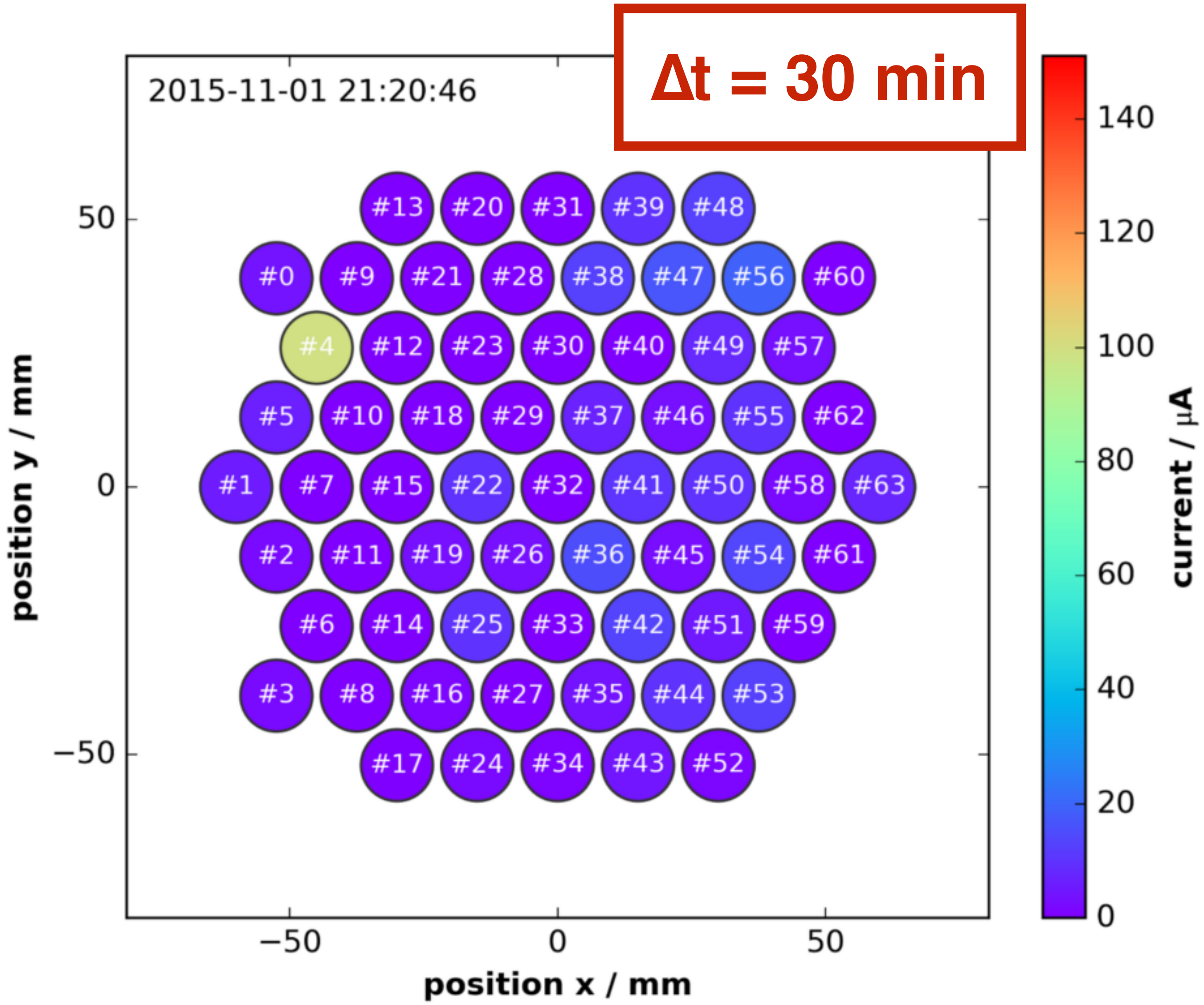

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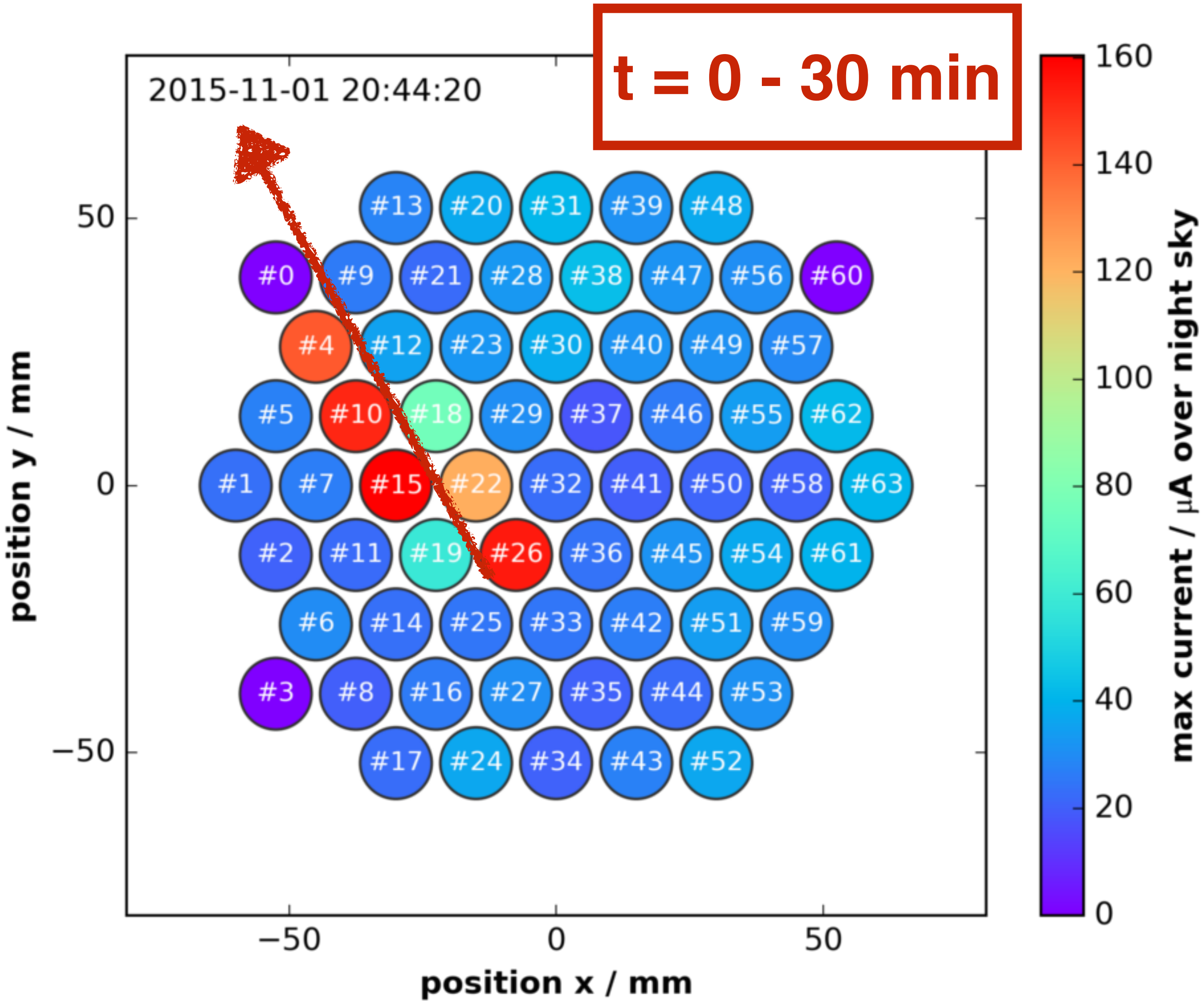

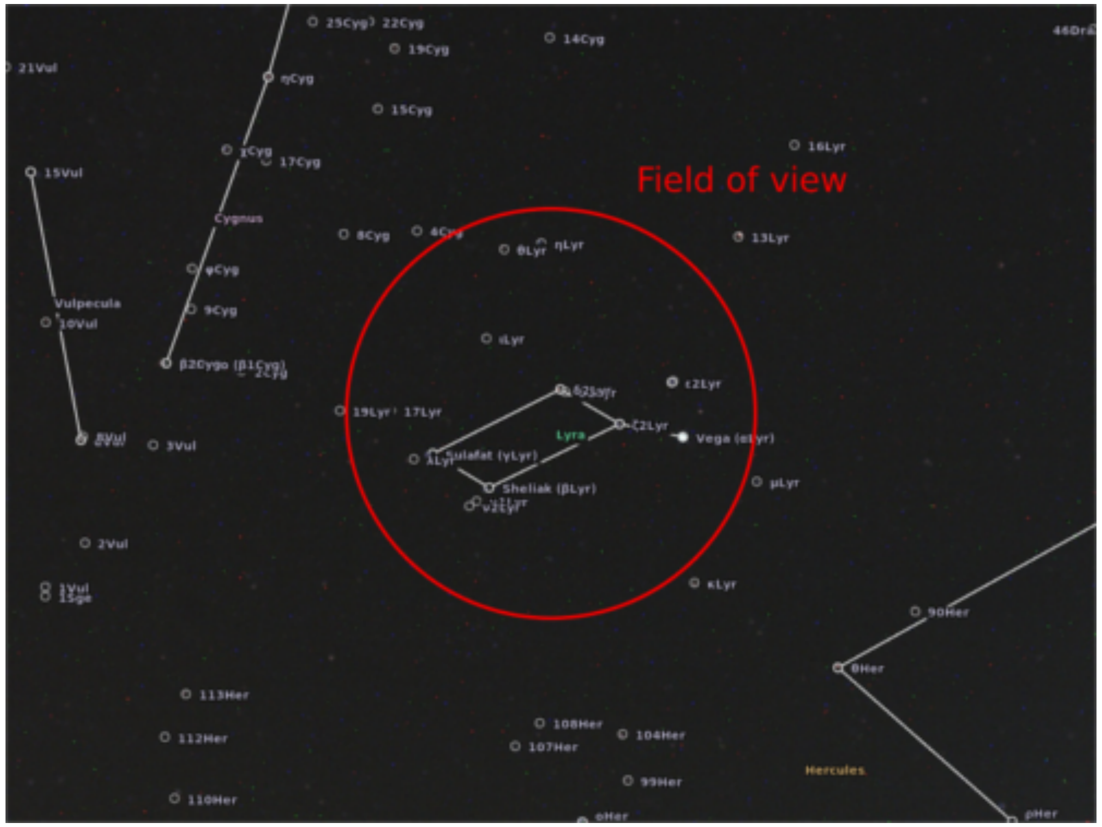

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AMD **PoS(ICRC2015)596**

- Steel support structure and first 16 scintillator tiles are built
- Electronics ready
- First measurements show: **Performance is promising**
  Use of SiPMs also option for SSD upgrade

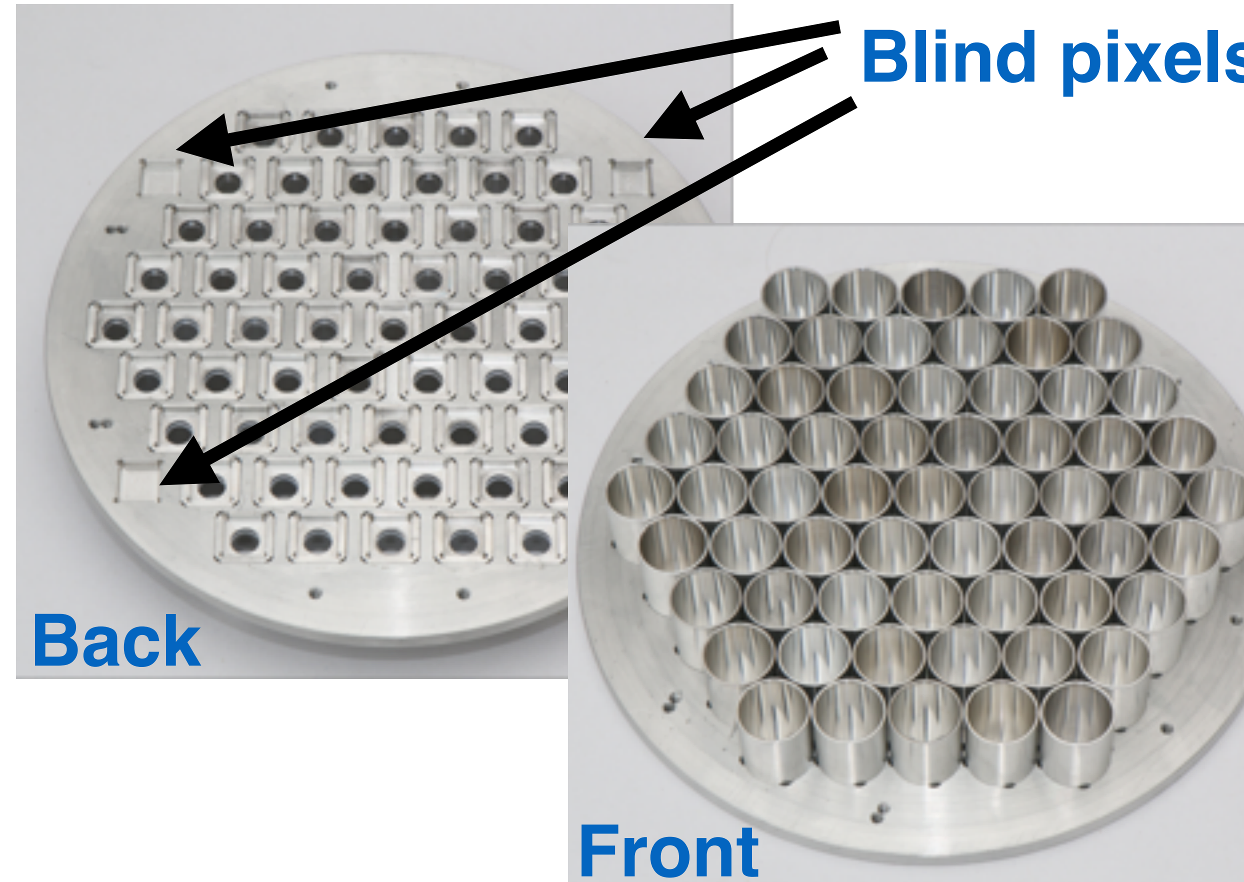
- Next step: **Deployment of MiniAMD at Auger site**

FAMOUS **PoS(ICRC2015)605 PoS(ICRC2015)649**

- Successful commissioning of the new 61 pixel focal plane
- Measurement of star trails
- **Deployment of IceAct Cherenkov telescope at South pole based on FAMOUS design**

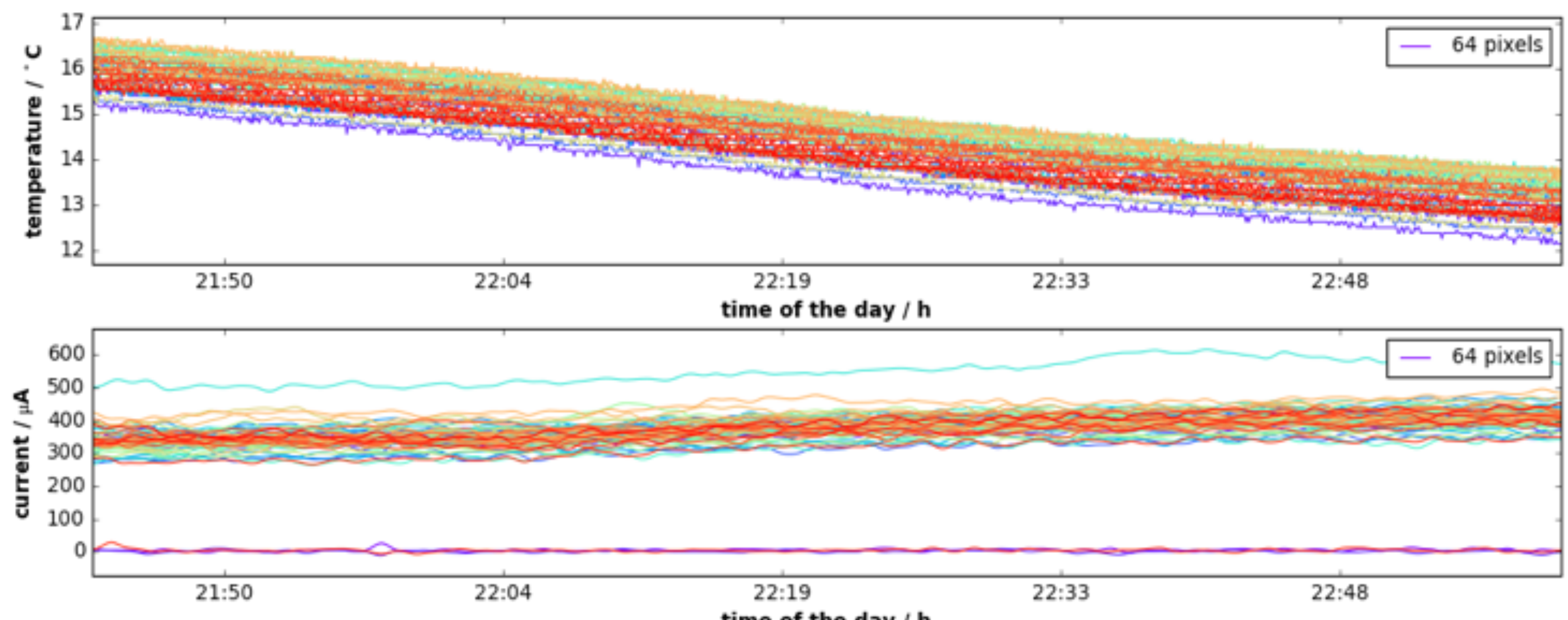
New 61 pixel focal plane and power supply unit

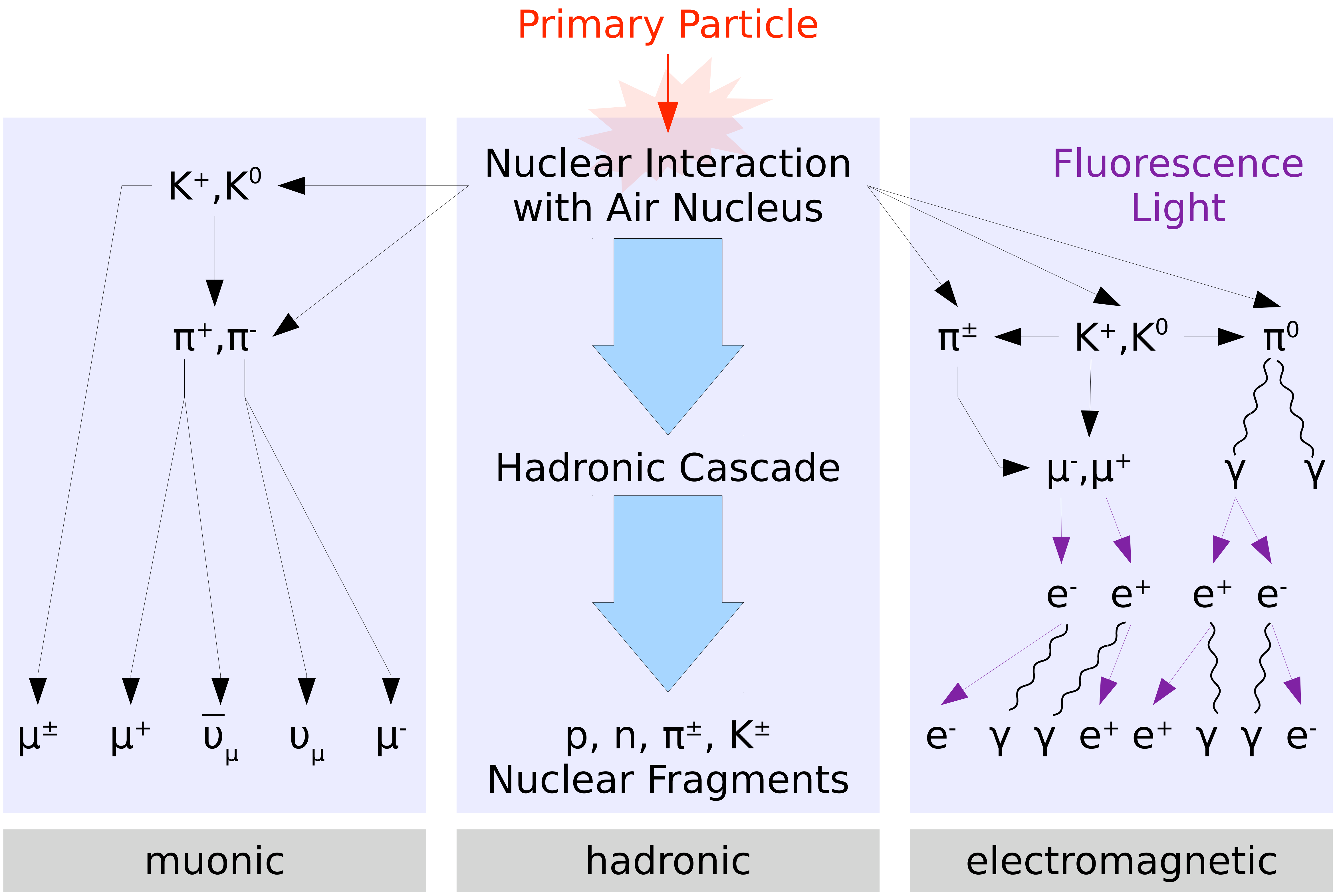
- 61 pixels
- 3 blind pixels for noise monitoring
- Winston cones polished by hand and glued into base plate



- PSU: stable power-supply individually for all pixels
- Automatical temperature compensation

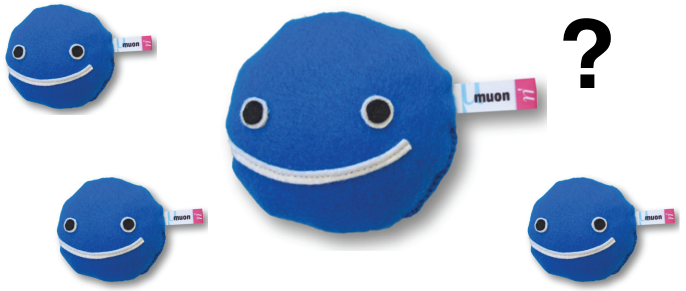
Live monitoring of all channels

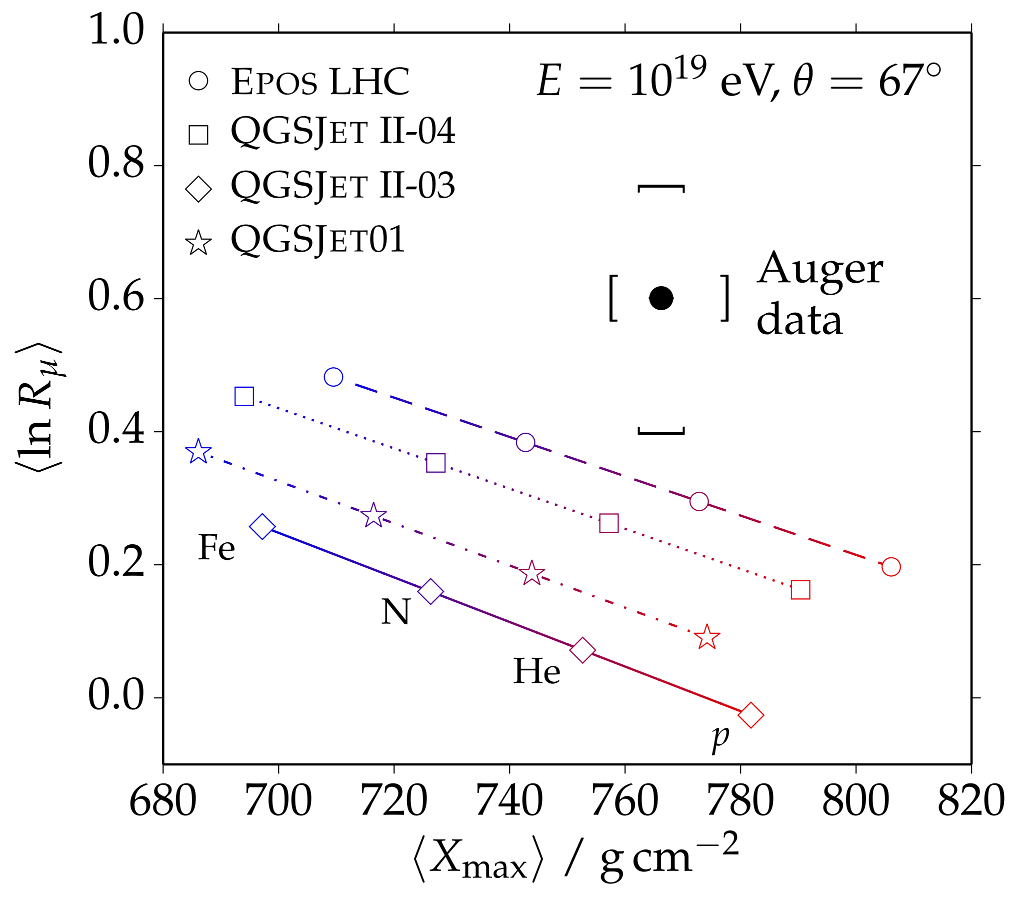


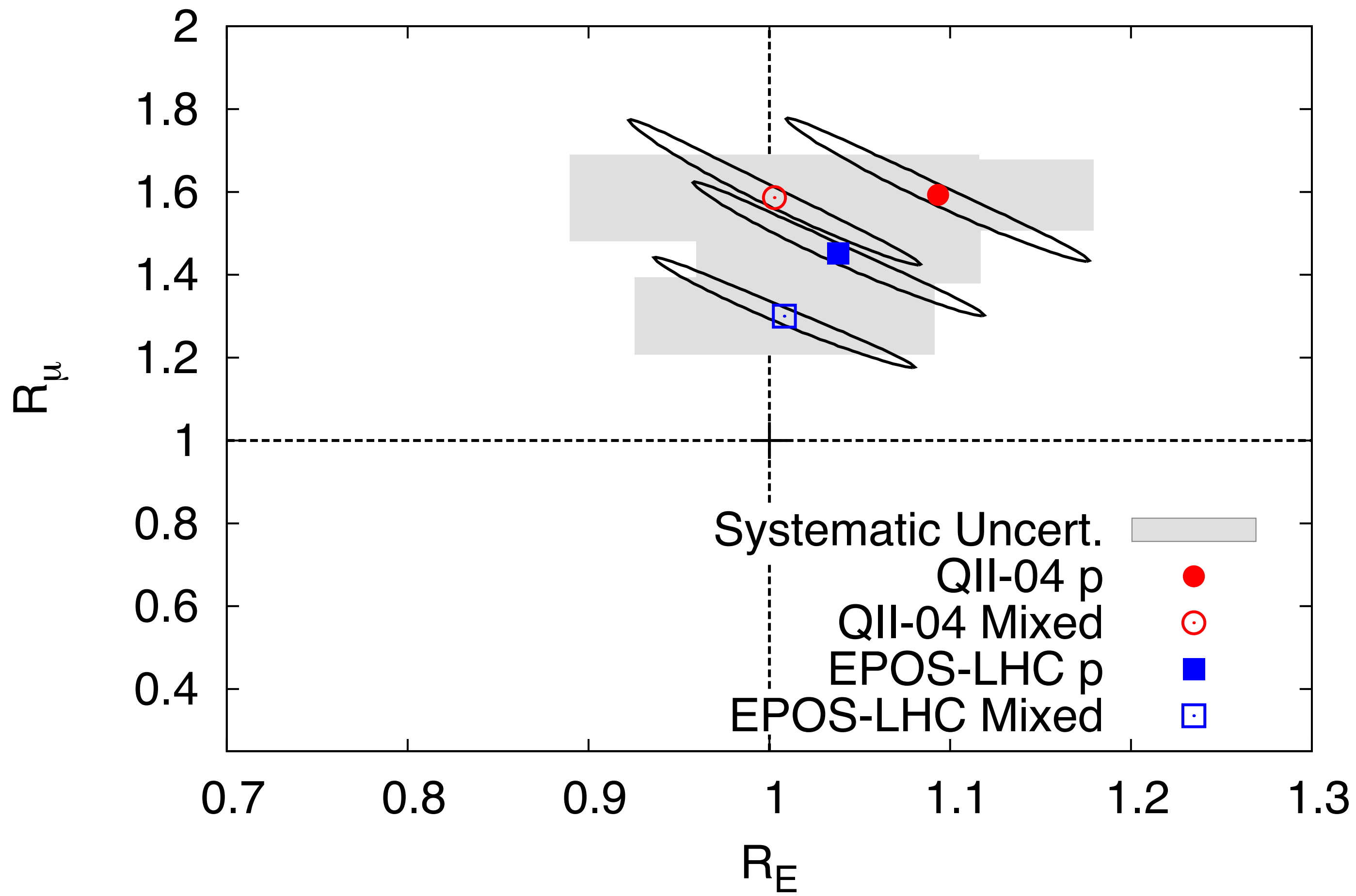

Primary Particle
Nuclear Interaction with Air Nucleus
Hadronic Cascade
p, n, π±, K±
Nuclear Fragments
K+,K0
π+,π-
μ±
μ+
$\bar{\upsilon}_\mu$
υ_μ
μ-
Fluorescence Light
π±
K+,K0
π0
μ-,μ+
γ
γ
e-
e+
e+
e-
e-
γ
γ
e+
e+
γ
γ
e-
muonic
hadronic
electromagnetic

Importance of muons

Hadronic interaction models





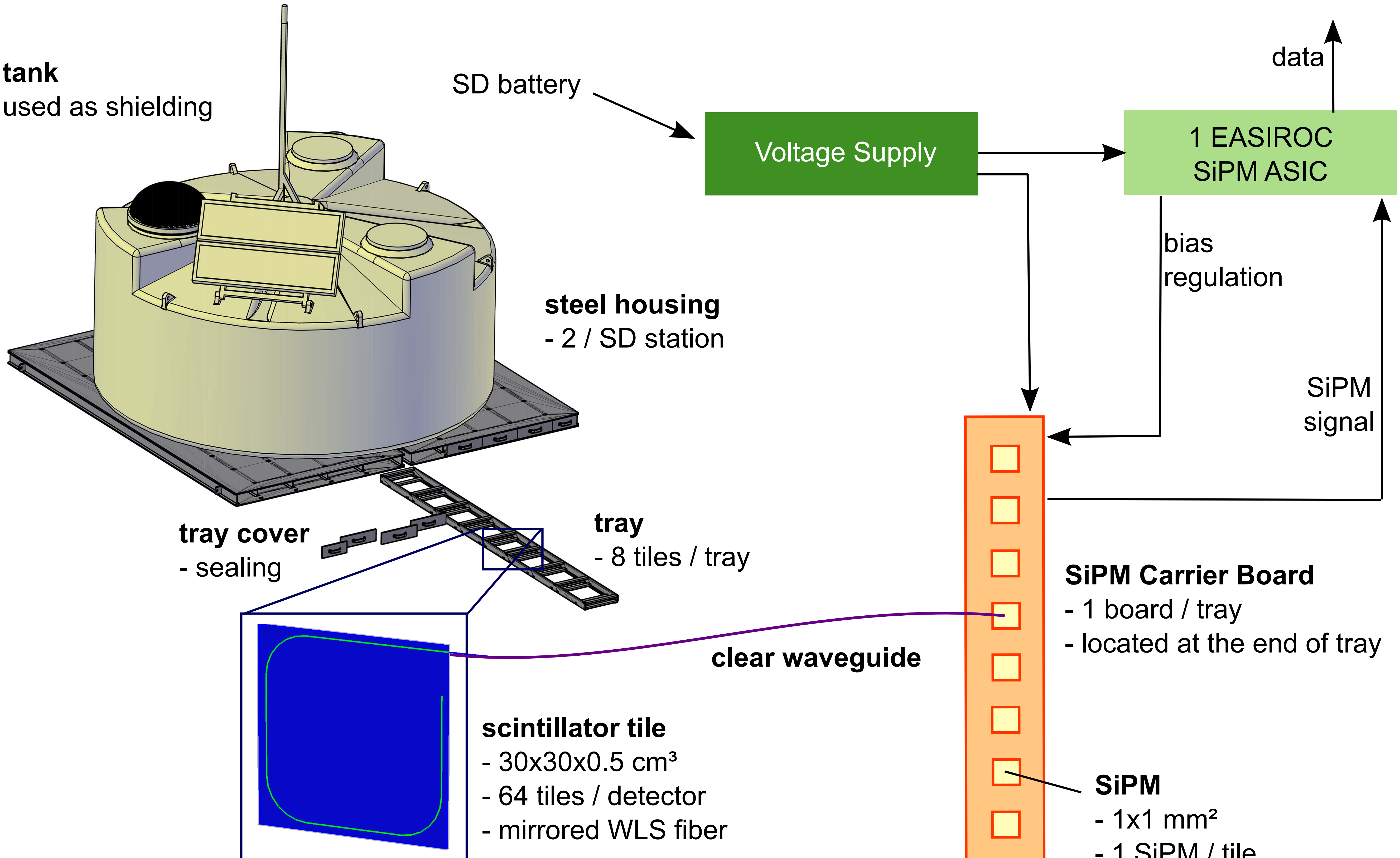


- Air showers have surprisingly high number of muons (not yet understood)

- study of extensive air showers and hadronic multiparticle production
  → exploration of fundamental particle physics at energies well beyond those accessible at terrestrial accelerators

Muons are important - Auger Upgrade needed

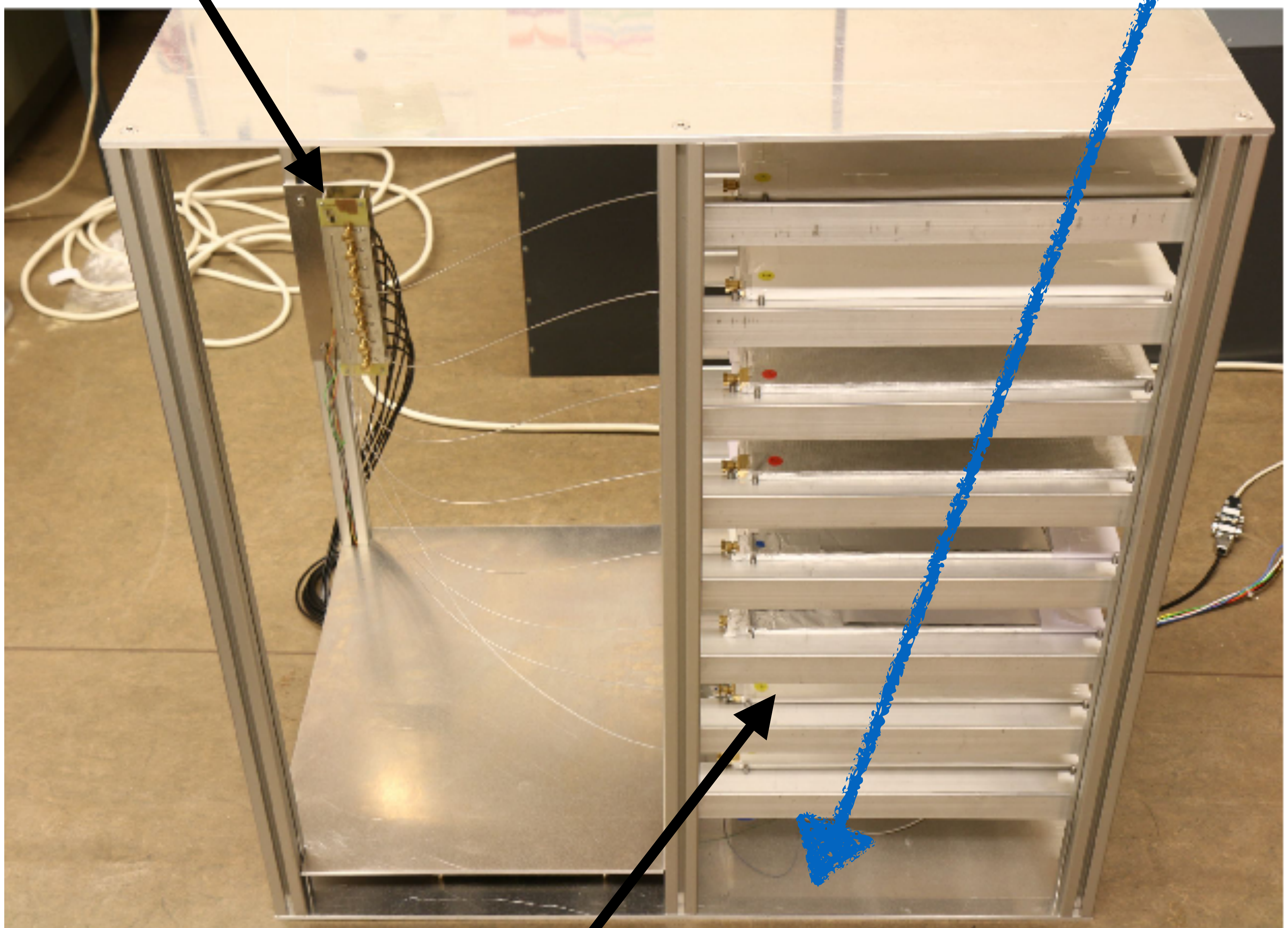
The Aachen Muon Detector



AMD tile test bench

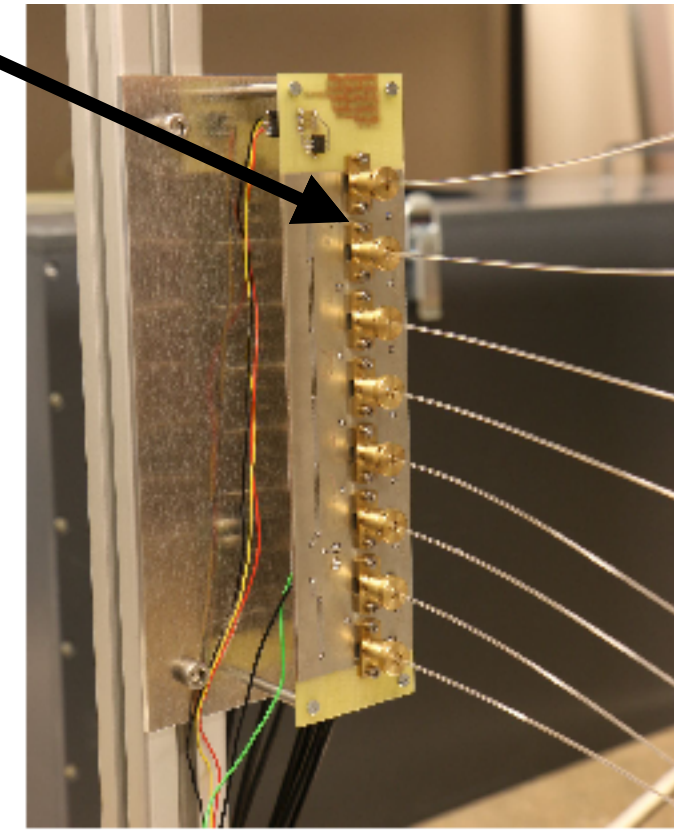
SiPMs

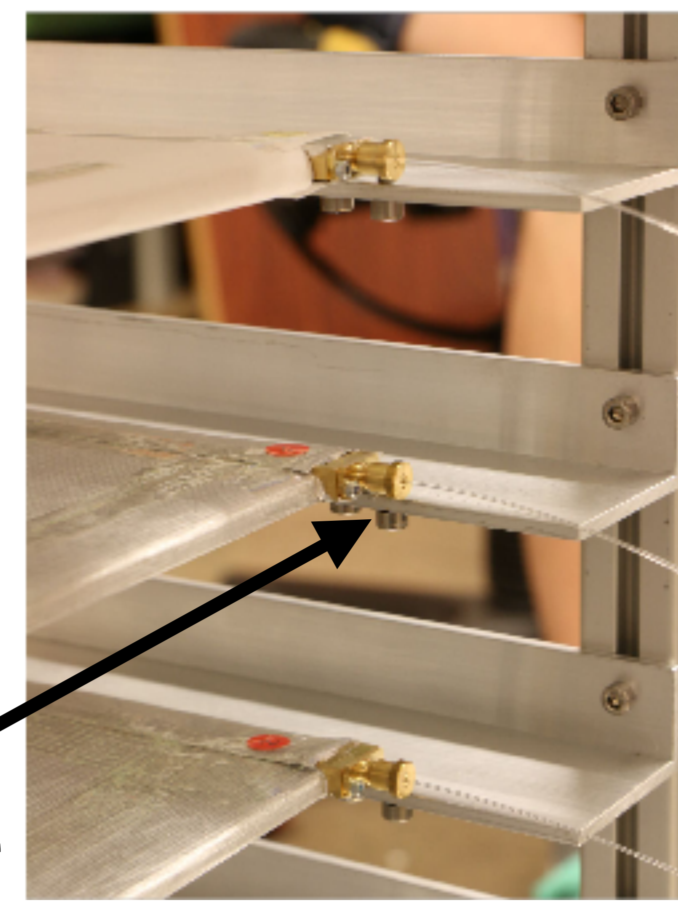
muon



wrapped tiles

coupling
waveguide - SiPM



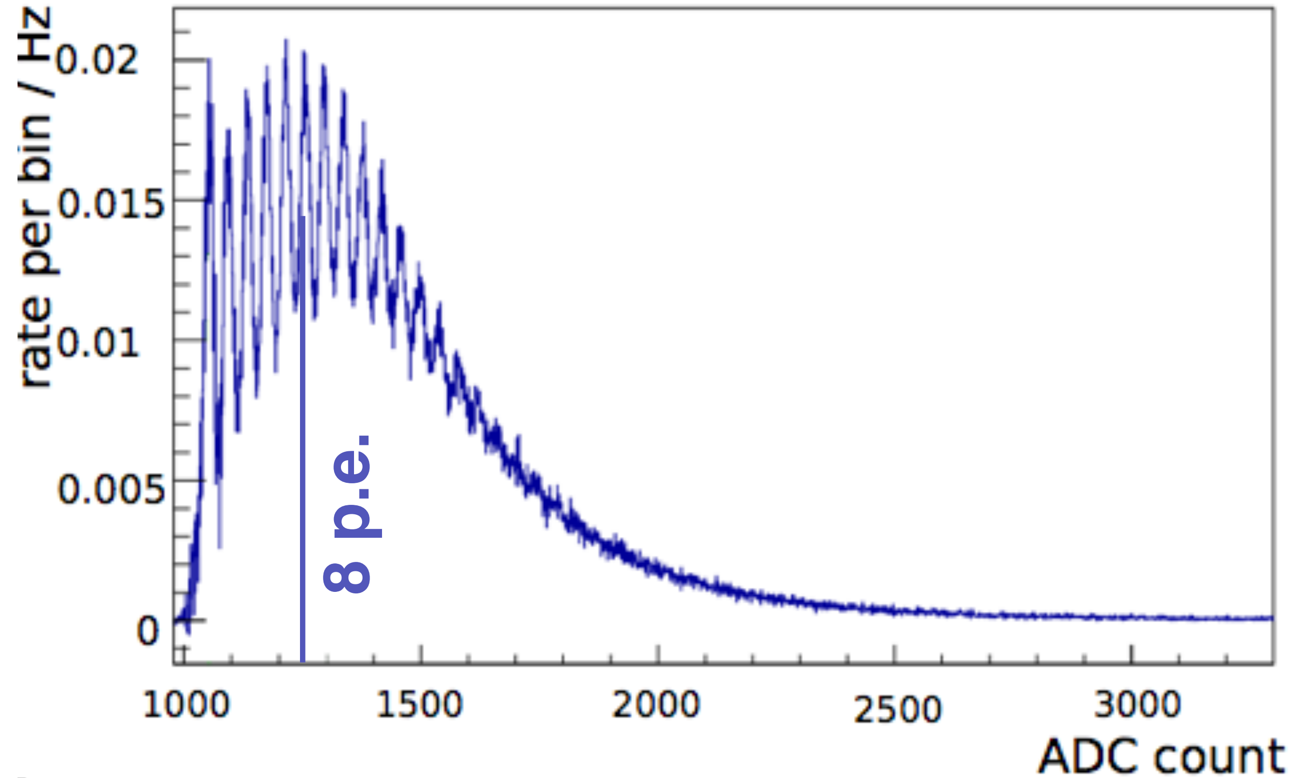


coupling
WLS fibre - waveguide

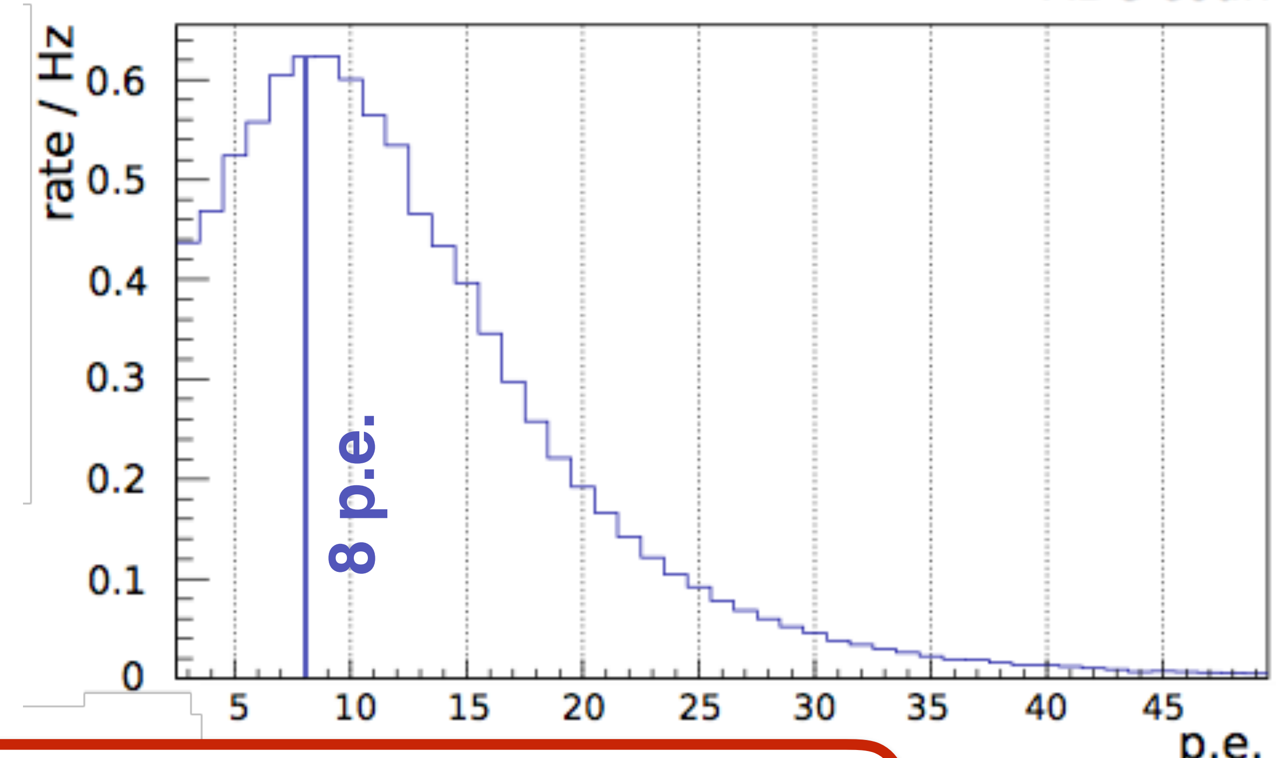
First measurements - light yield of scintillator tiles

Extract signal

Subtract dark noise spectrum, signal remains.



Each peak corresponds to a certain number of photon equivalents.



SiPMs excellent choice for the detection of muons due to single p.e. resolution!!