Muon detectors using SiPMs

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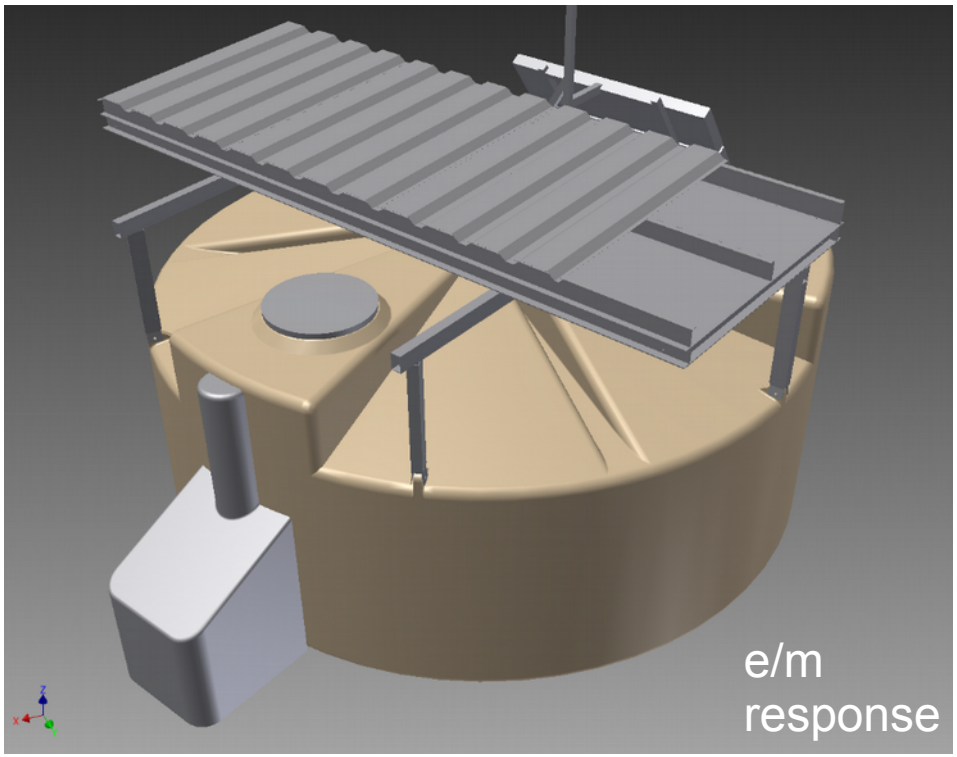
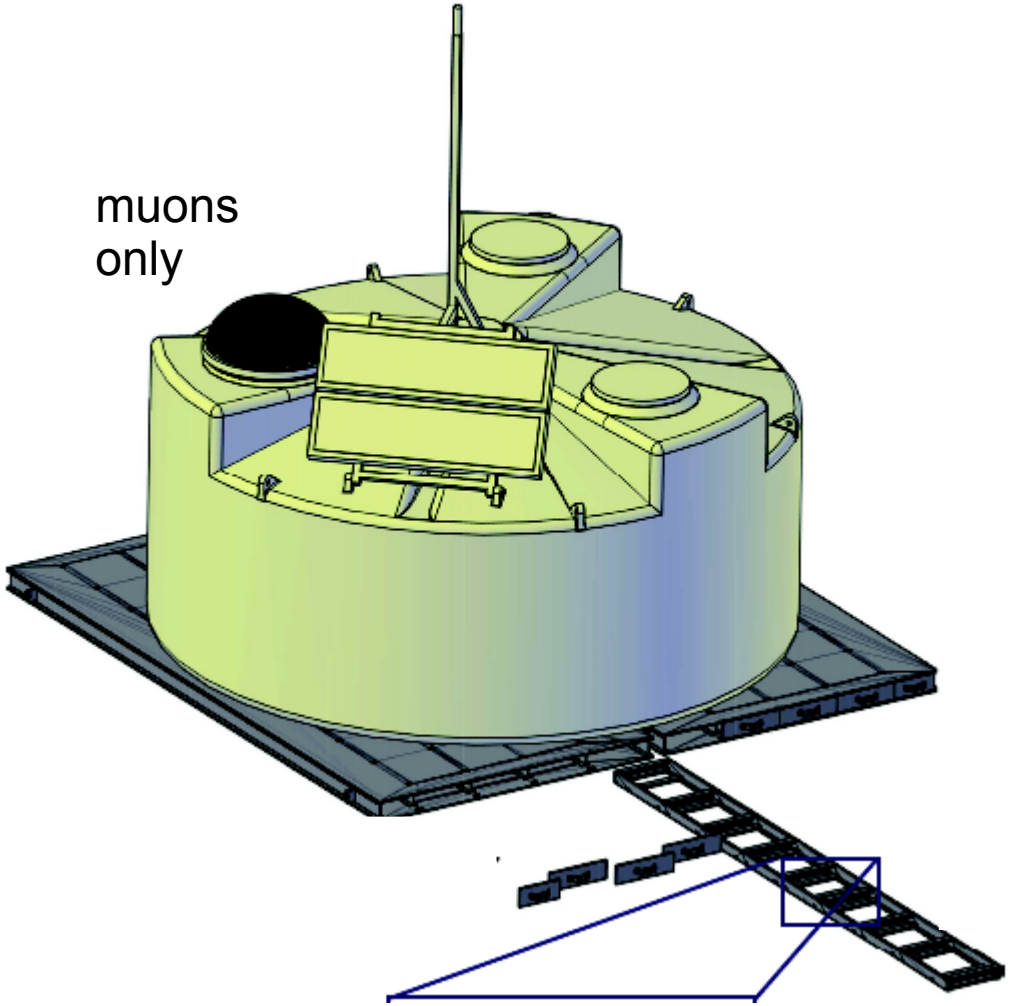




Two concepts

- **Auger SSD:**
  - Only few (one) light detectors (SiPMs)
  - No spatial resolution
  - Digitize signal amplitude/charge

- **Aachen Muon Detector [AMD]:**
  - Several light sensors
  - High spatial resolution
  - Just count, no ADC

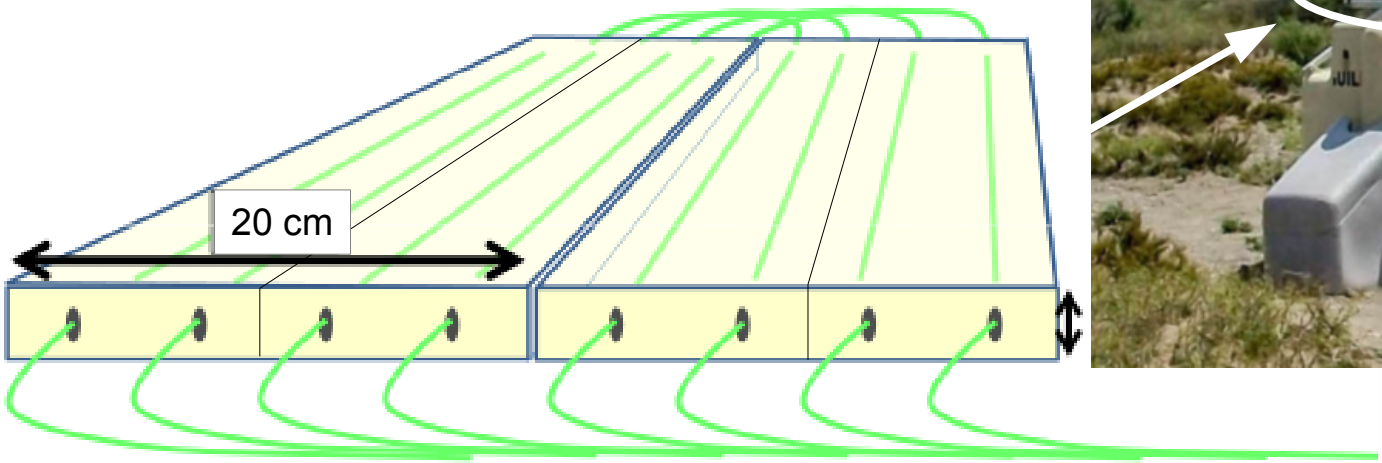
→ I am not talking about AugerPrime,
but about our experience with Muon Detector technology

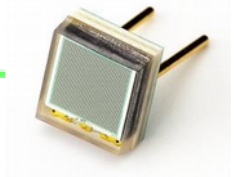

Pampa Amarilla, Argentina
?


Pampa Amarilla, Argentina

Muon detector – in general

- Plastic scintillator produces light
- WLS fiber to collects the light

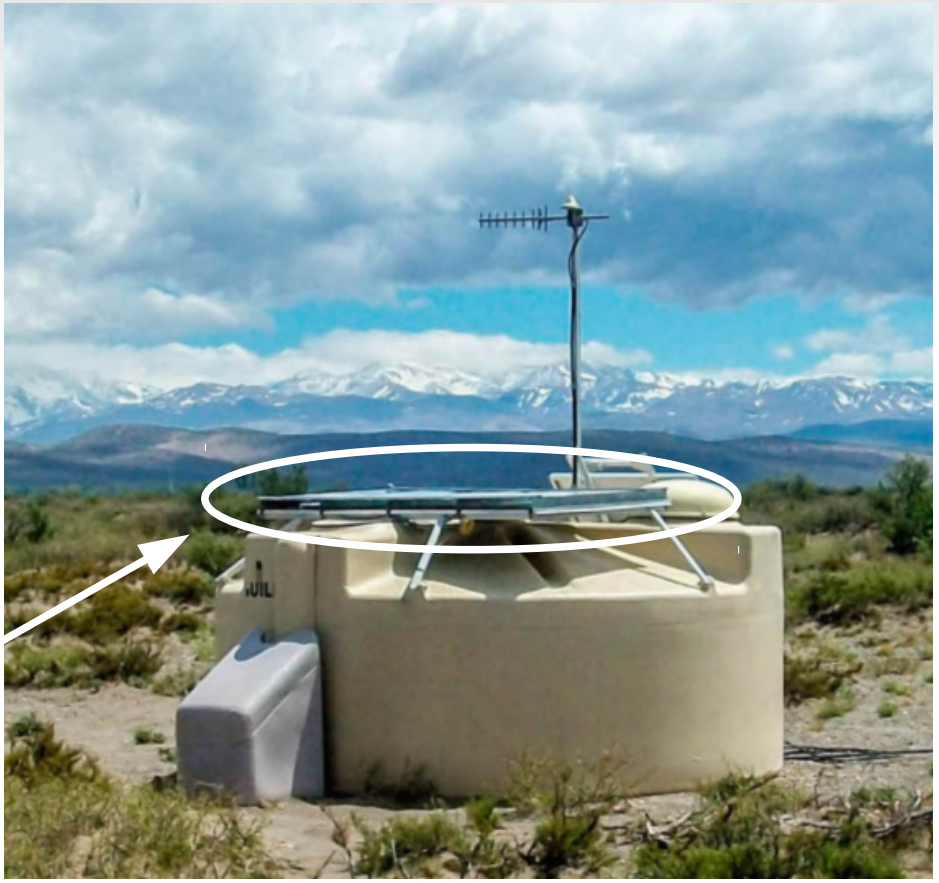


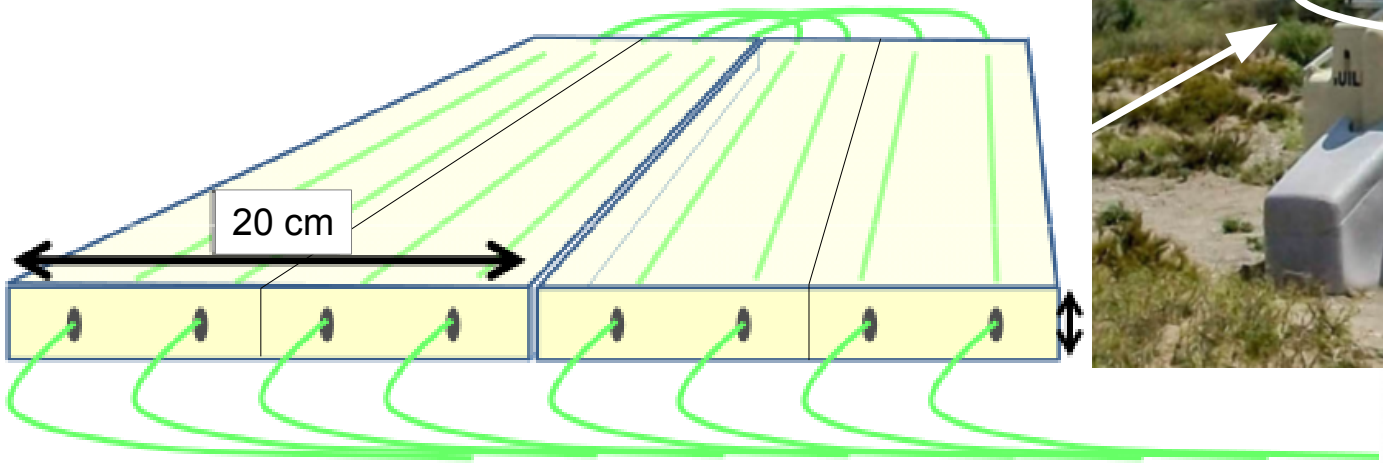


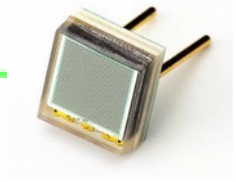
- WLS or optical fiber (less losses) transmits the light
- PMT/SiPM detects the light

AugerPrime – SSD

Not really a *muon* detector
Simple and inexpensive

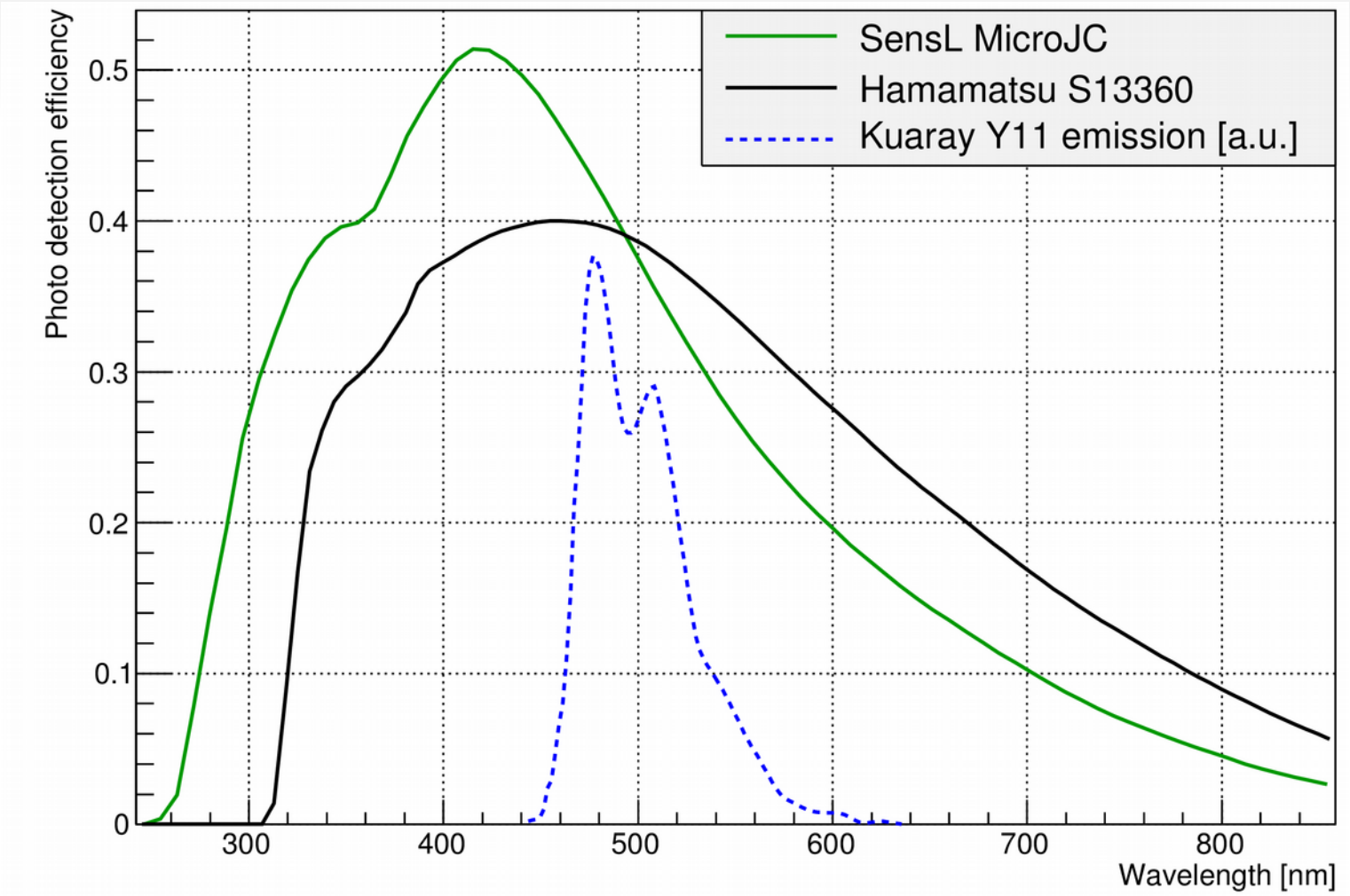


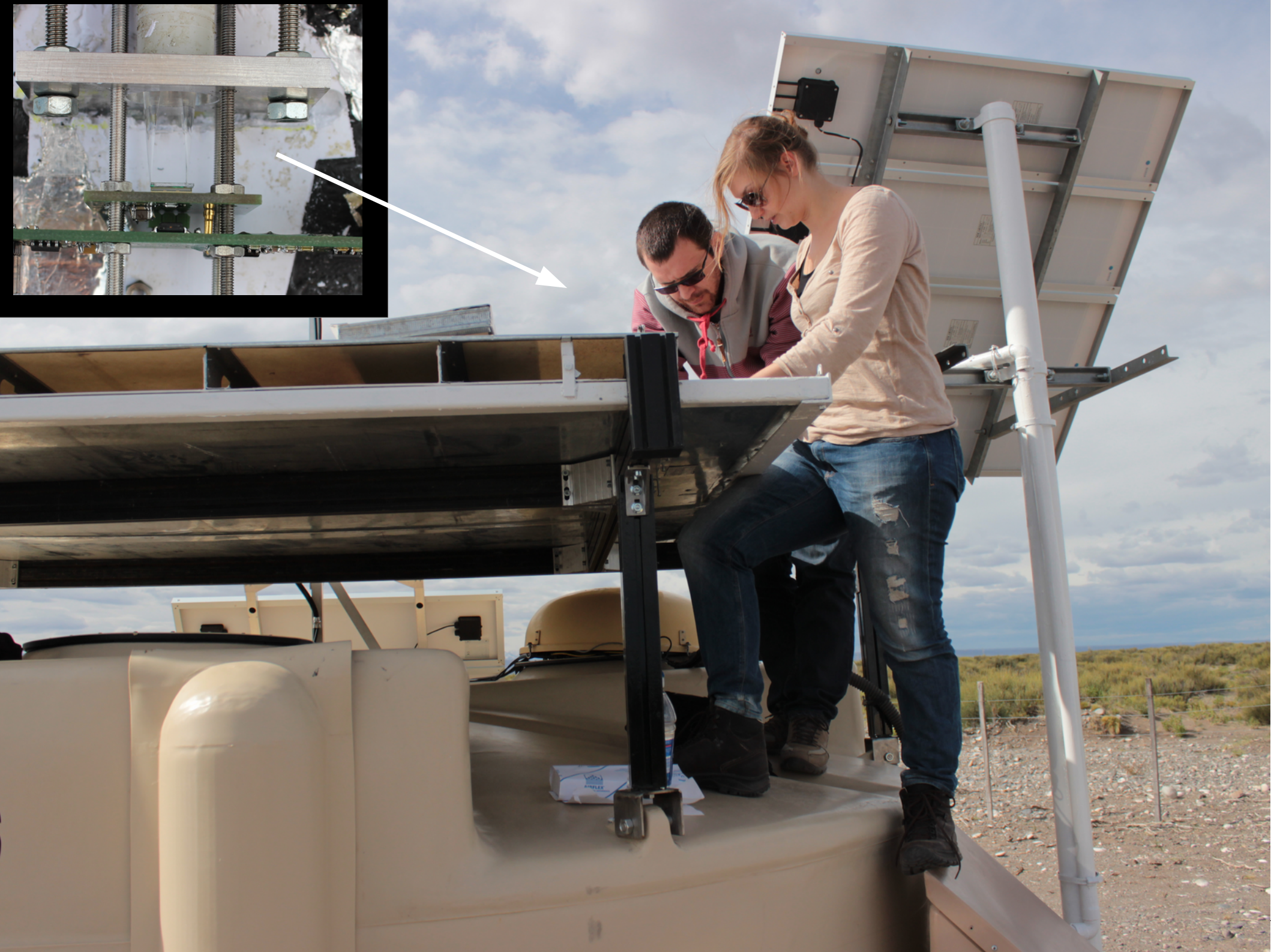


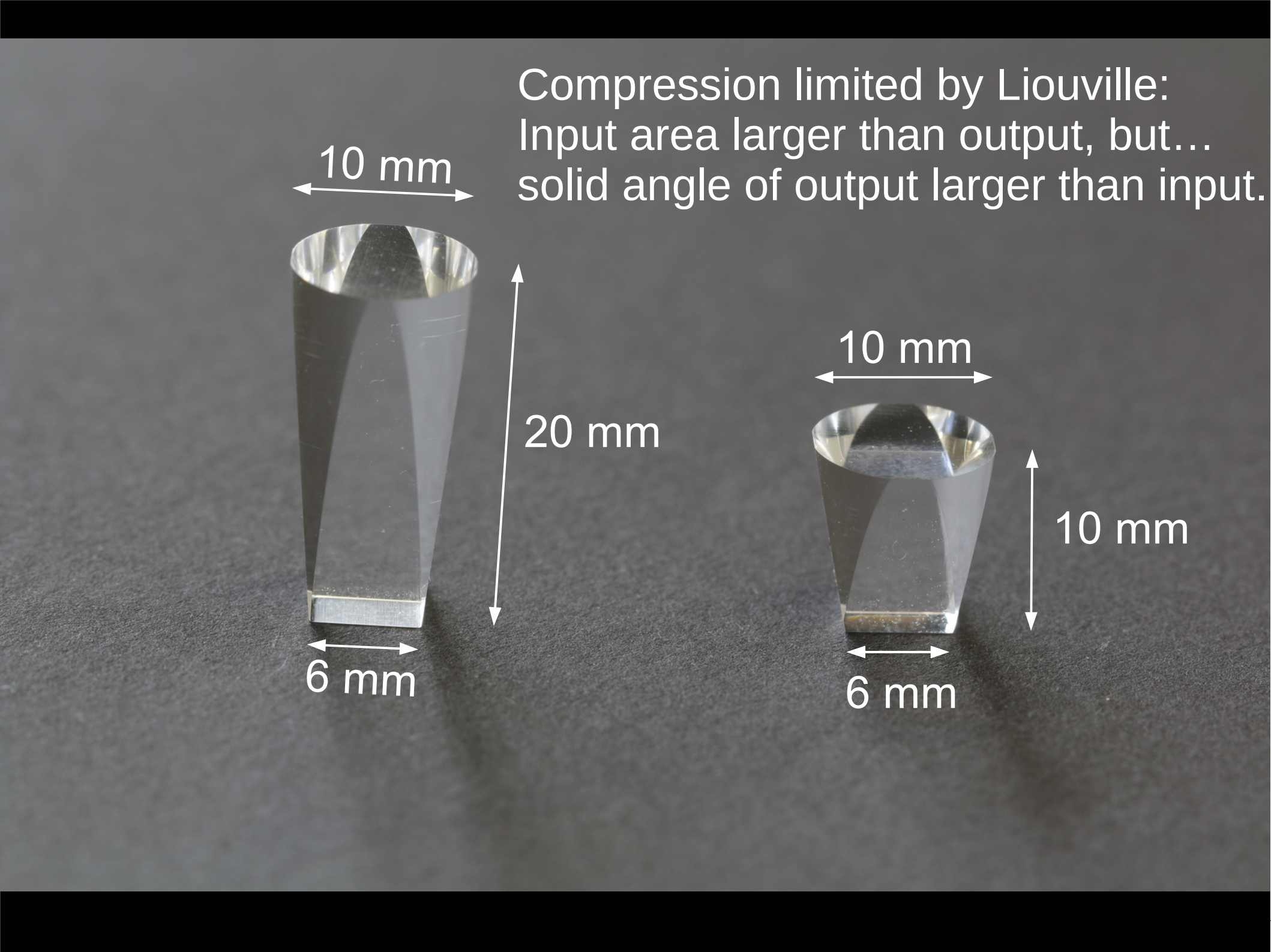


- no gluing of fibers
- no coupling of fibers
- most complicated piece: coupling to sensor

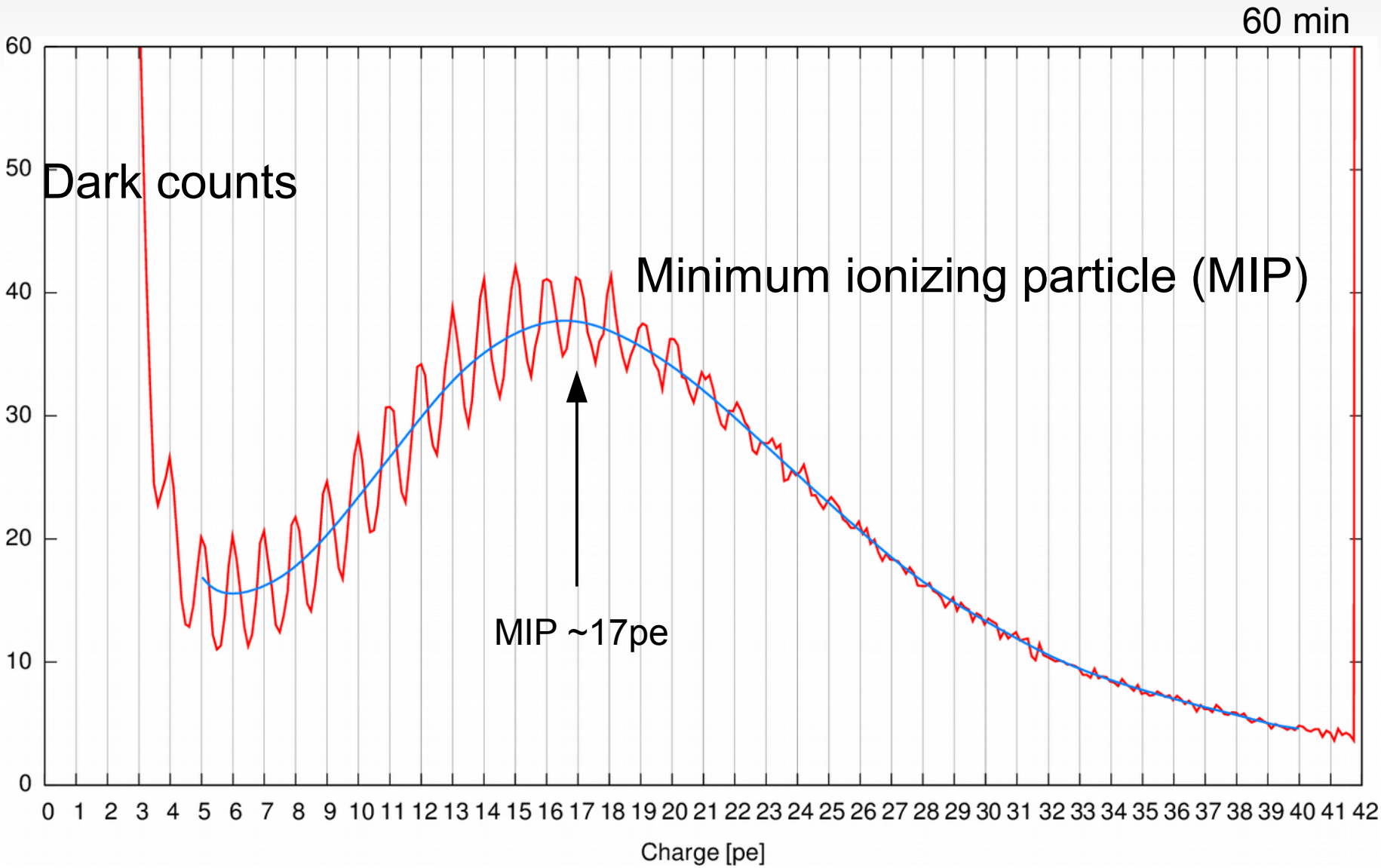
Spectral response






Compression limited by Liouville:
Input area larger than output, but…
solid angle of output larger than input.
10 mm
20 mm
6 mm
10 mm
10 mm
6 mm

Charge spectrum (calibrated)

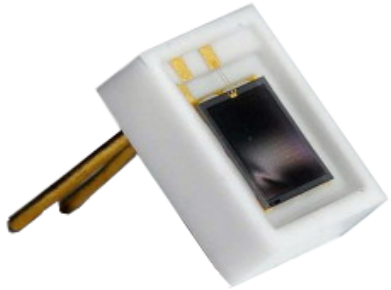


Feedback system

simplified sketch

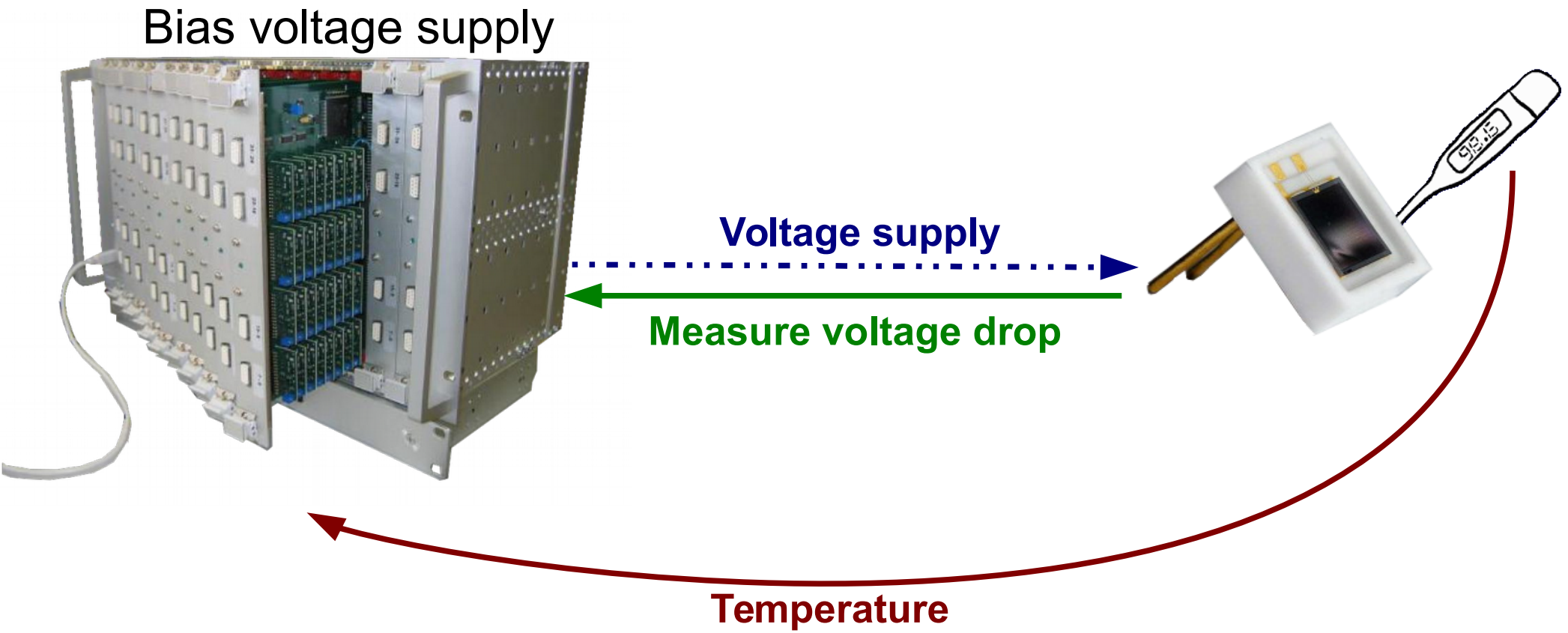
Bias voltage supply

Voltage supply



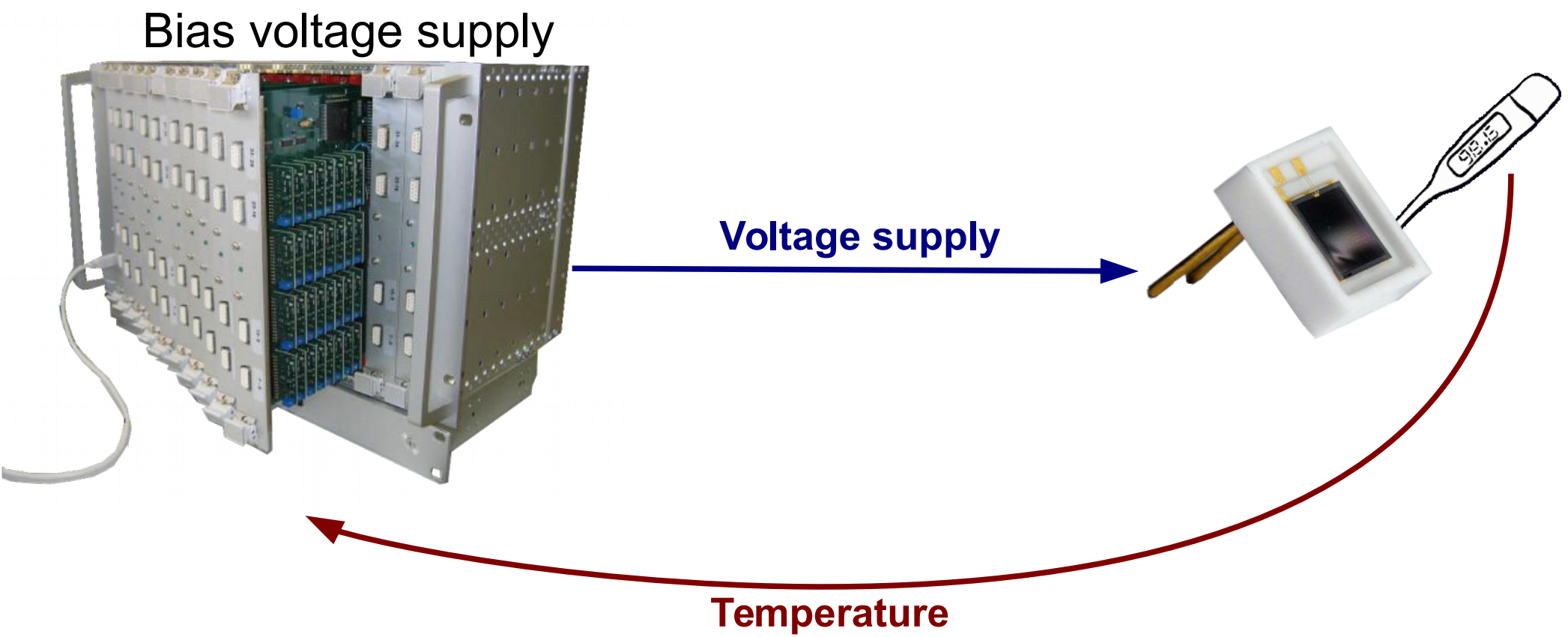
Feedback system

simplified sketch



Feedback system

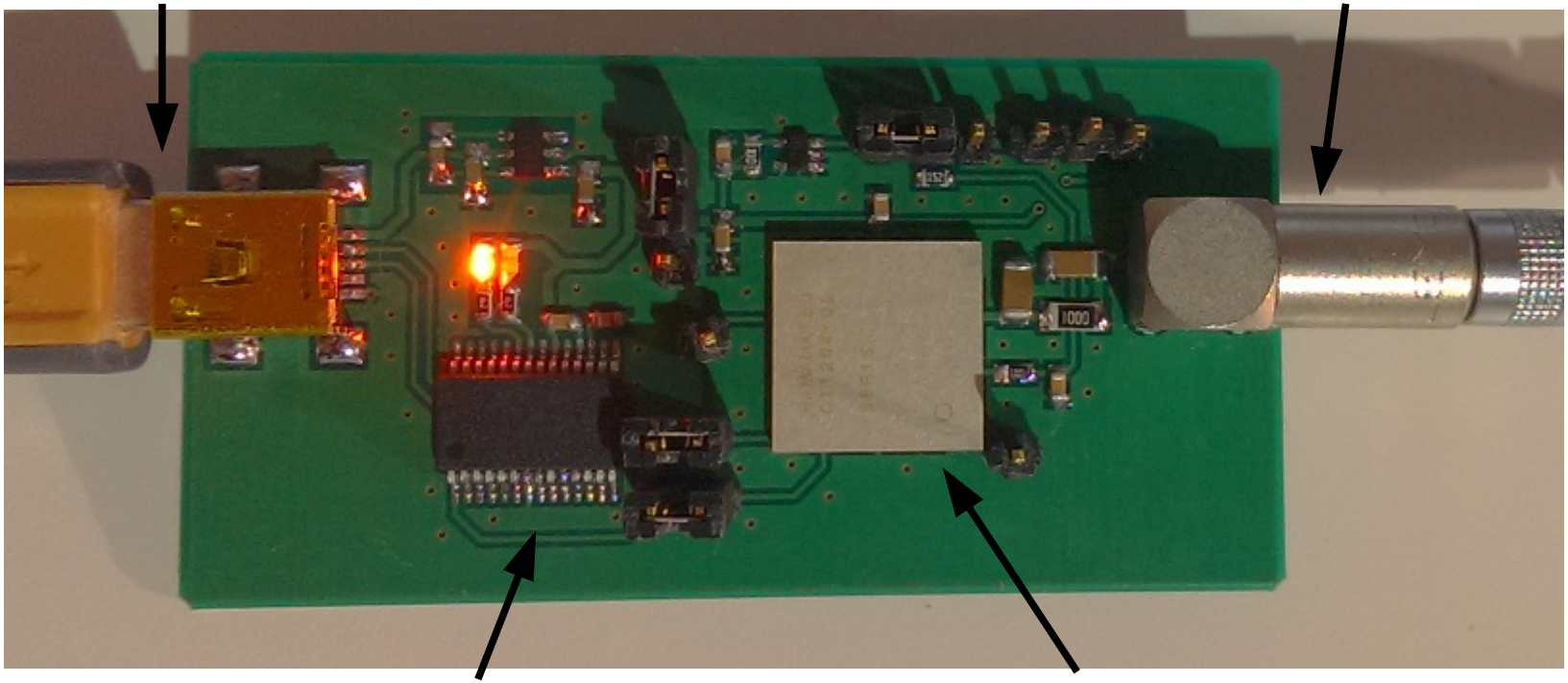
simplified sketch



Integrated circuits

IN:
USB for Communication and power

OUT:
Temp. compensated SiPM voltage



FTDI (USB driver)

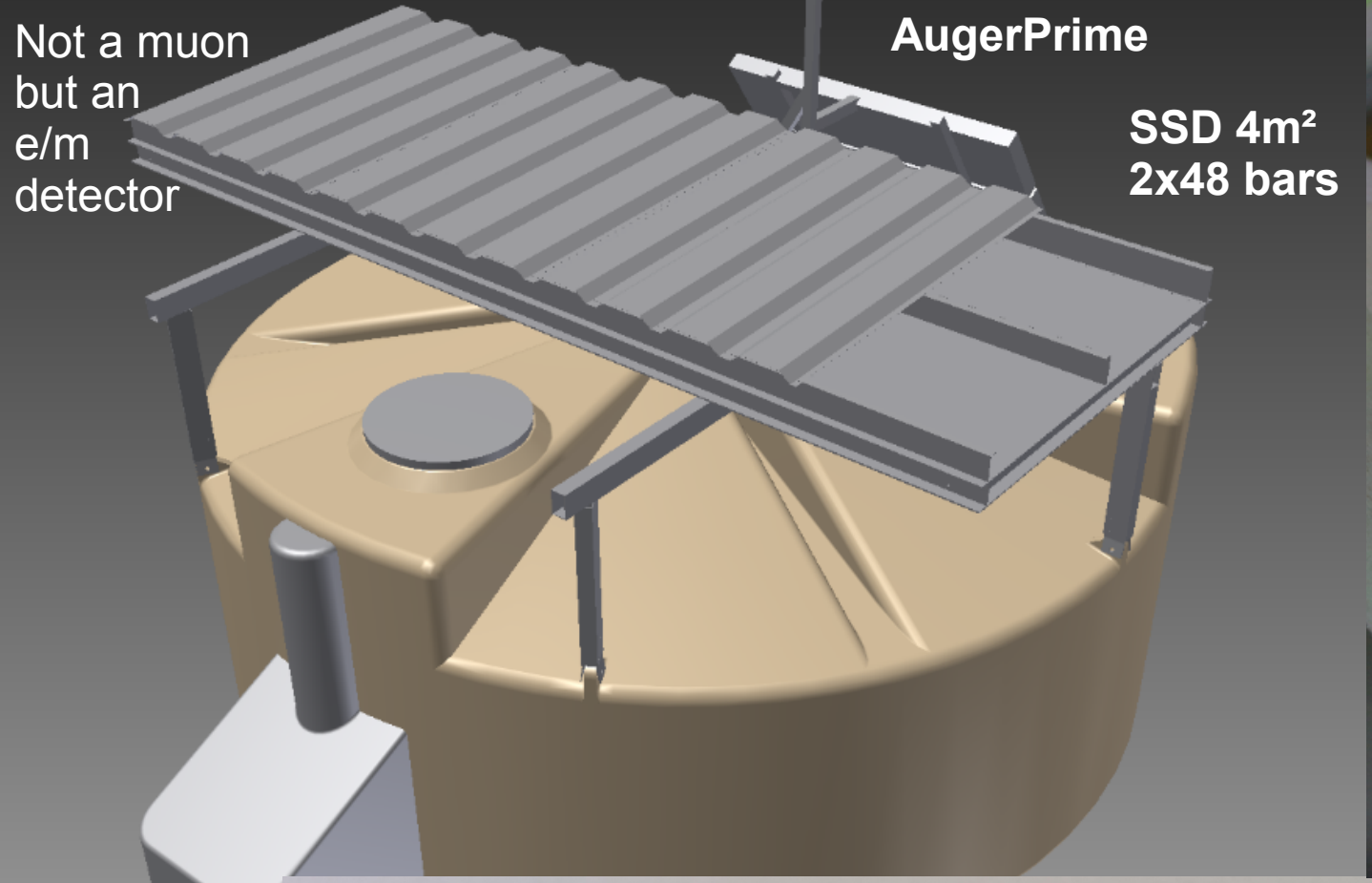
Hamamatsu C11204-02

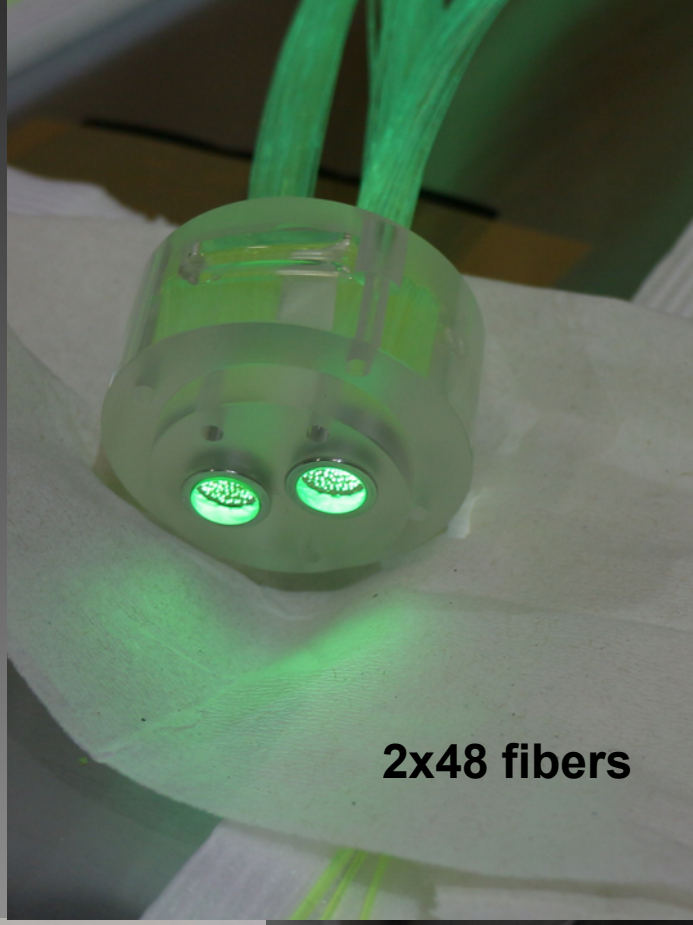
→ More example applications

Not a muon but an e/m detector

AugerPrime

SSD 4m²
2x48 bars





2x48 fibers

SiPM-PMT ;)

2x SiPM

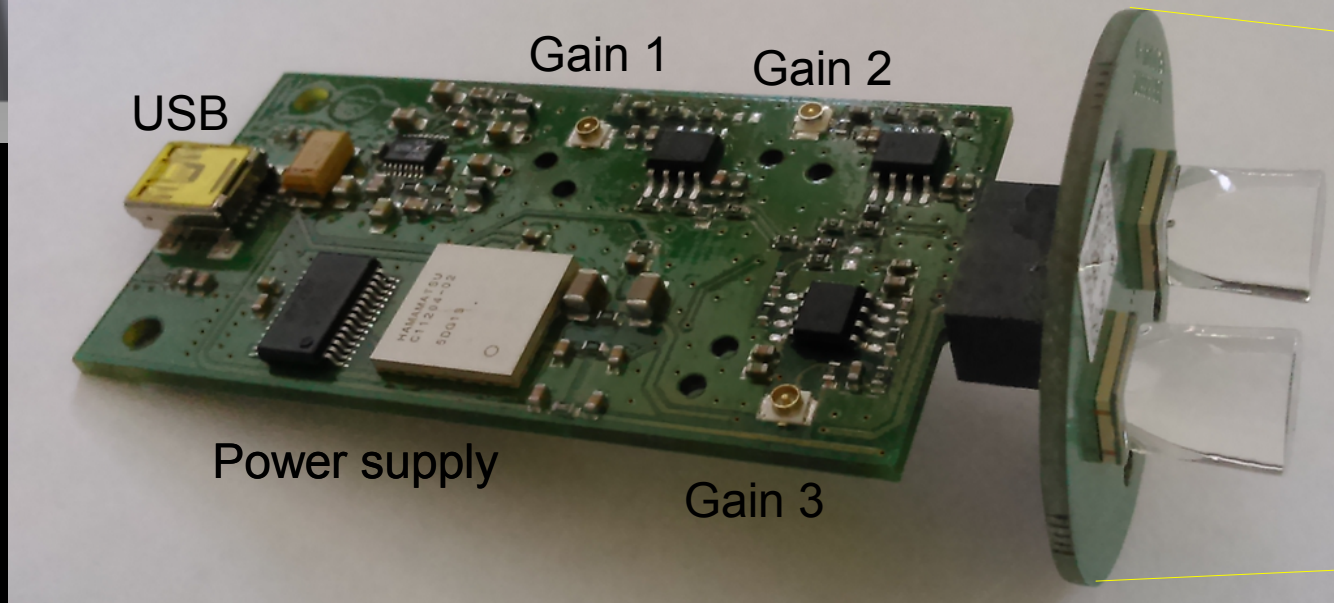
USB

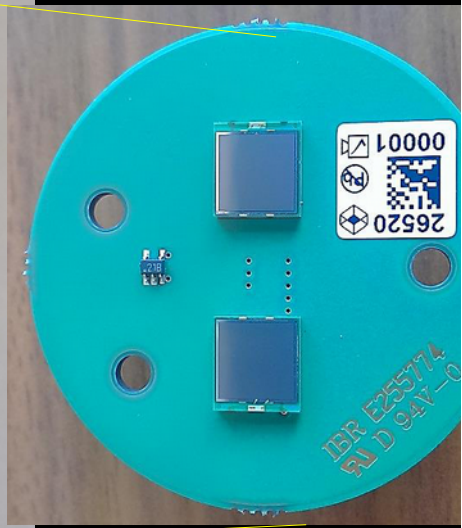
Gain 1

Gain 2

Gain 3

Power supply

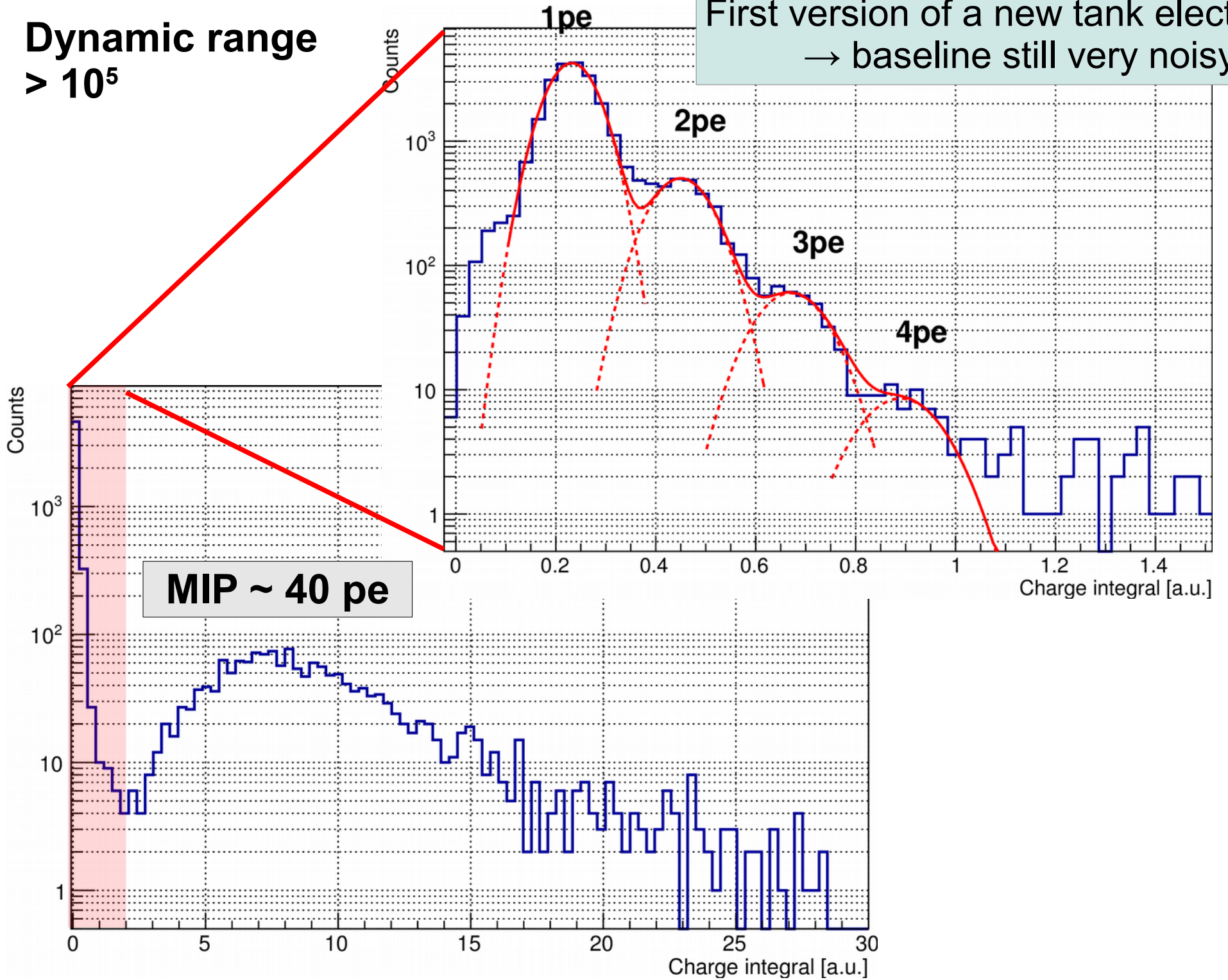




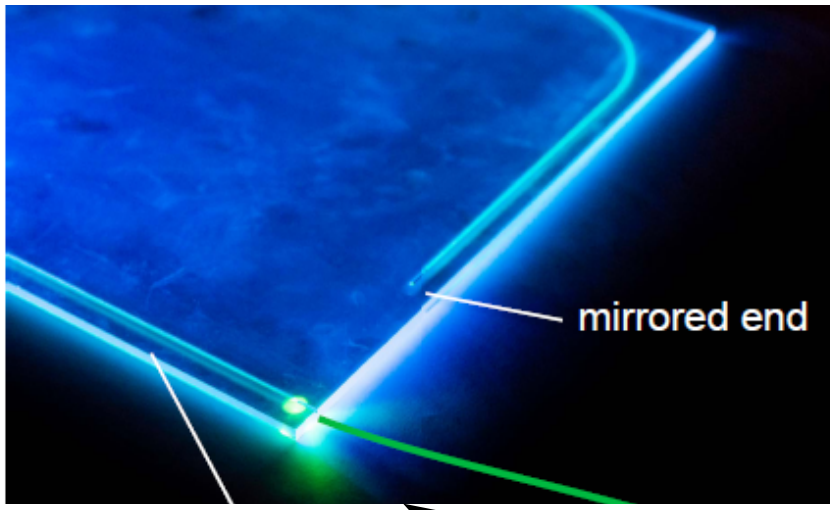
< 250mW

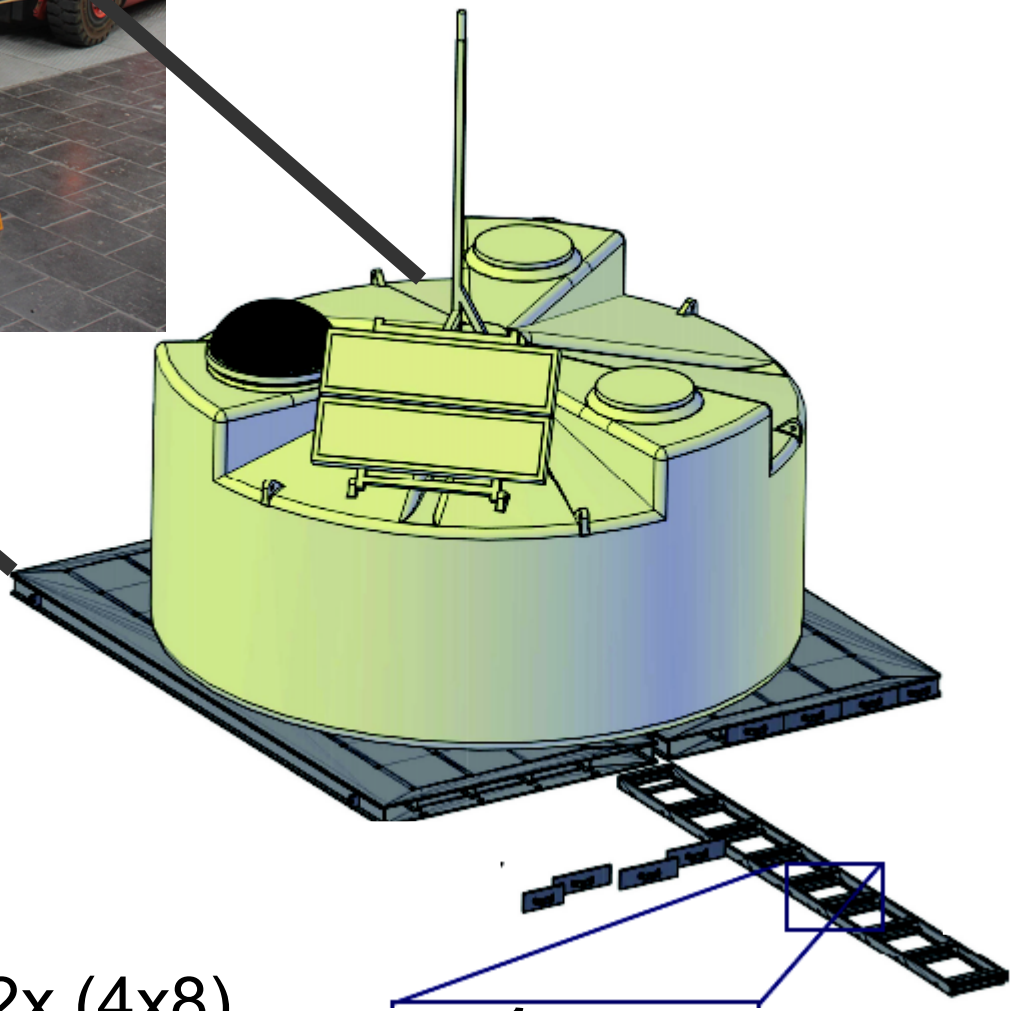
Dynamic range
> 10^5

First version of a new tank electronics
→ baseline still very noisy



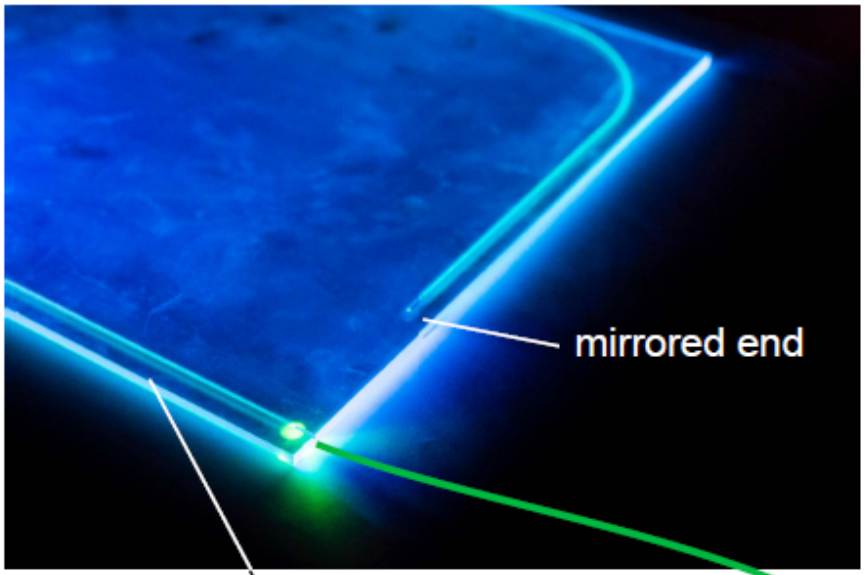
Real Muon Detector

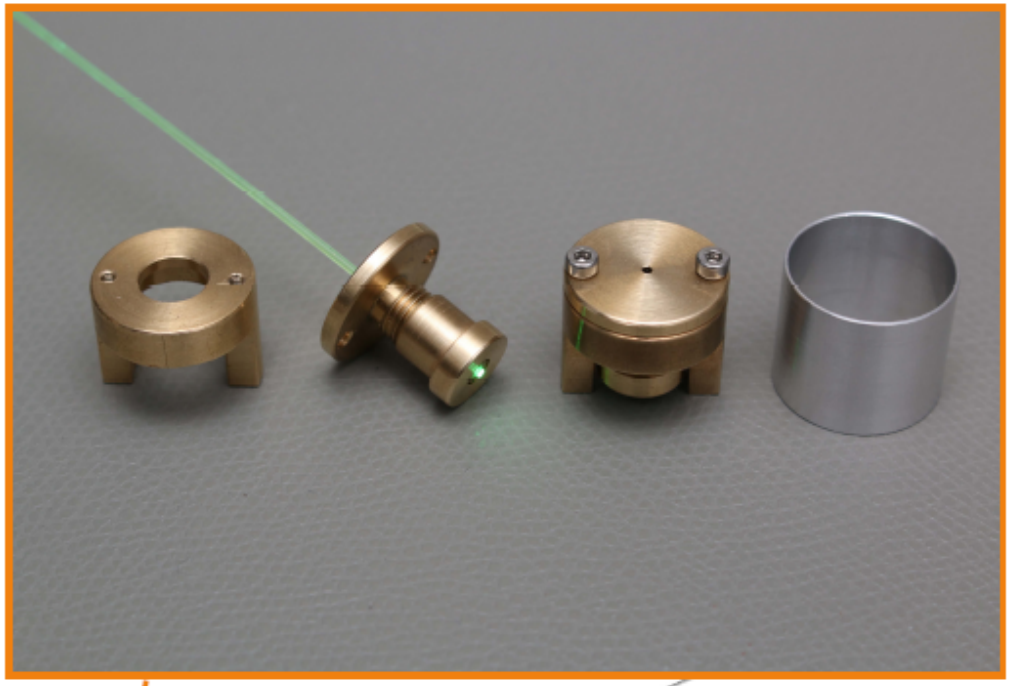




2x (4x8)

Scintilating Tile
(30x30 cm²)



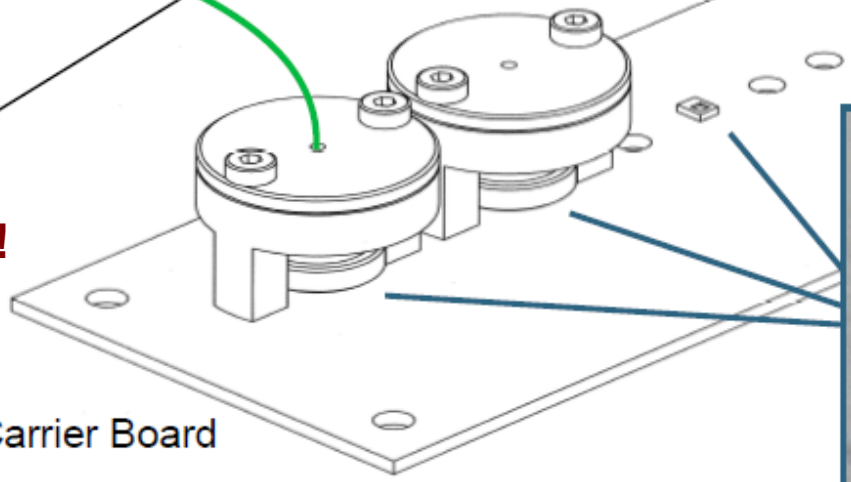


mechanical couplings

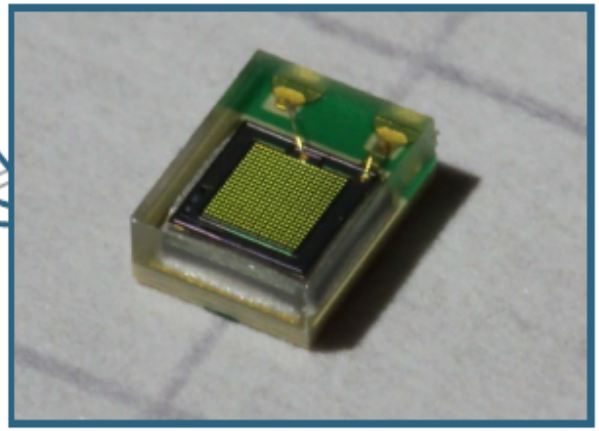
WLS fibre (1mm)

optical fibre (1mm)

coupling is very difficult!

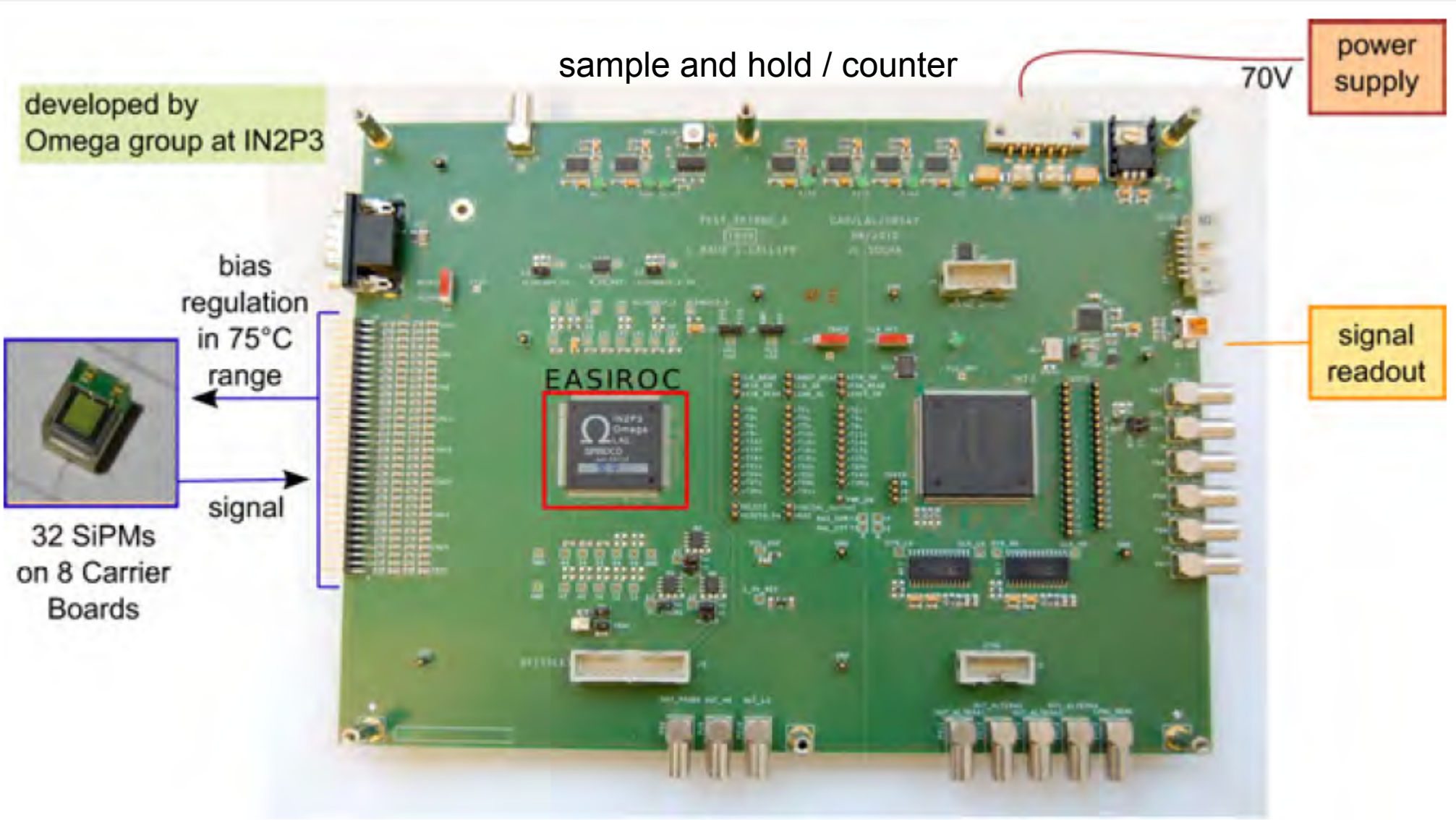


SiPM (1x1 mm²)



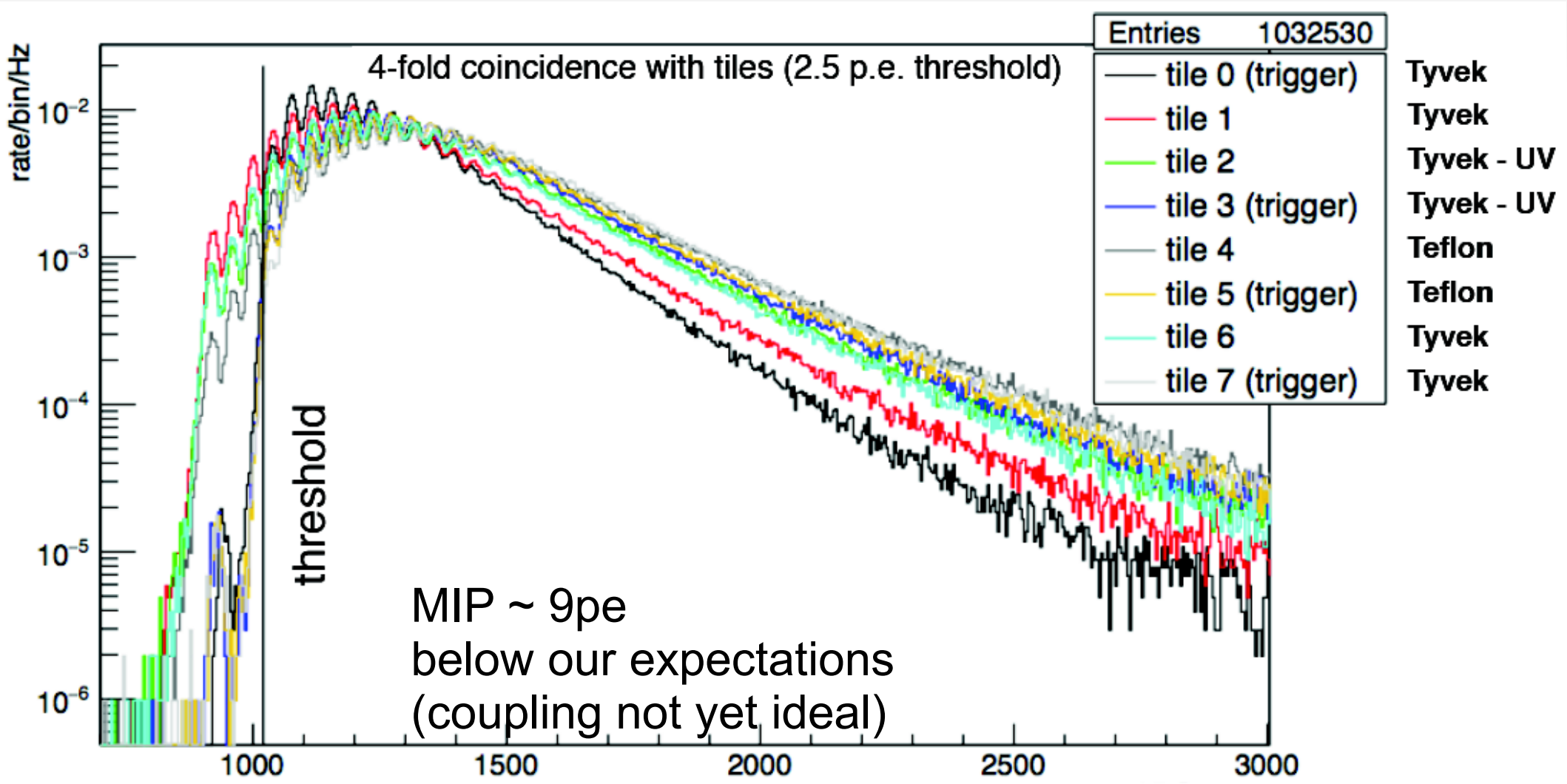
→ another solution: SiPM coupled to the WLS fiber

EASIROC readout board



Two fully calibrated boards available

Comparison of different wrappings

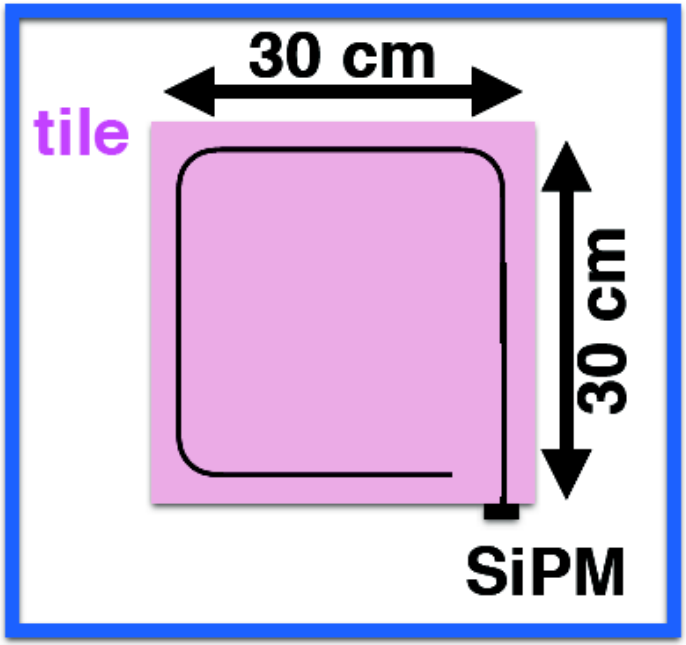


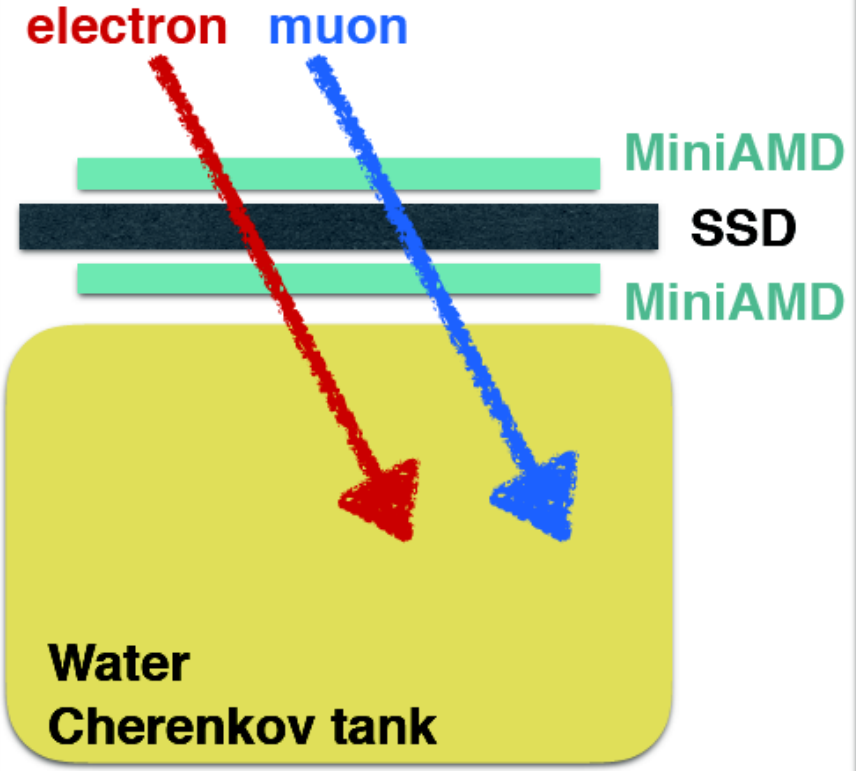
Still loosing about 50% light due to non ideal coupling of optical fiber and fiber-end mirror

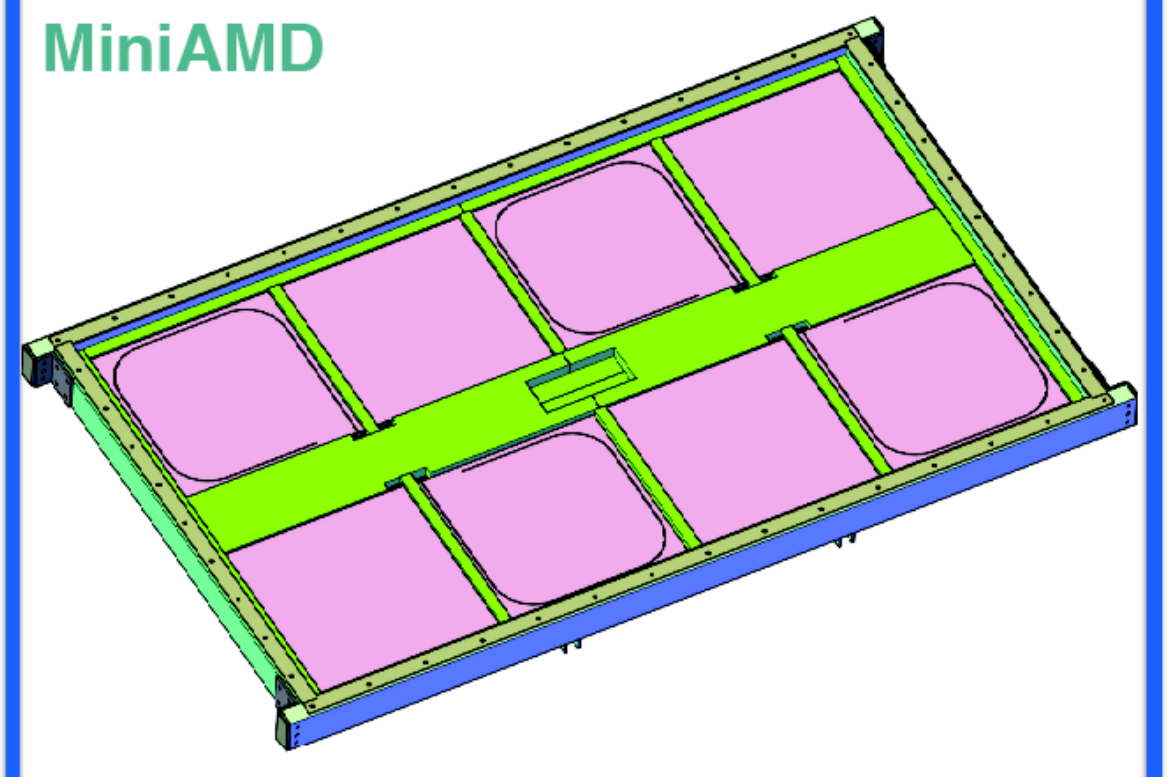
Proof of concept - MiniAMD

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







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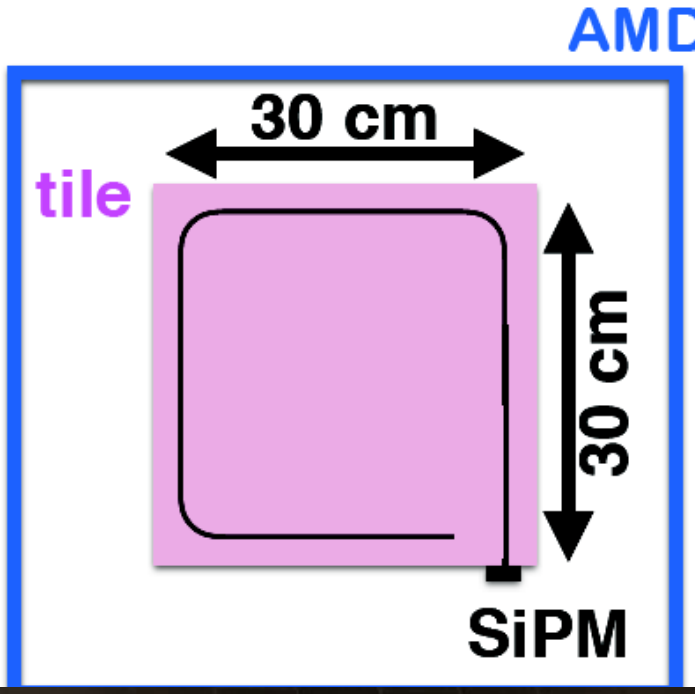

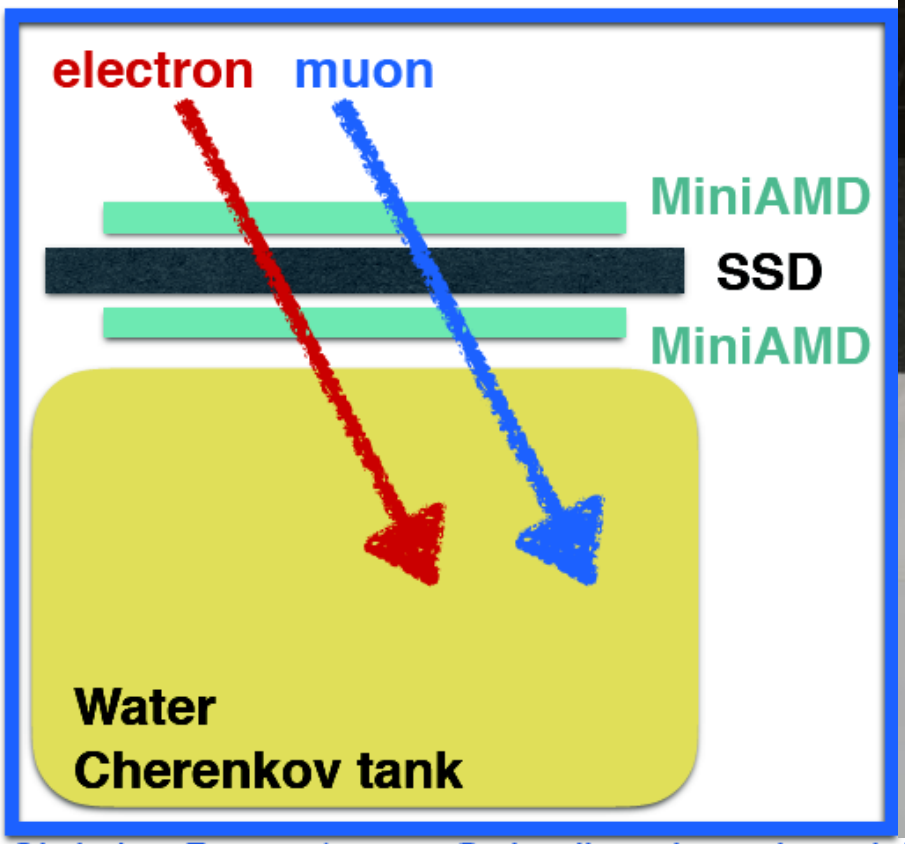

Summary (Mini-)AMD

- Advantage:
  - high spatial resolution
  - goal: avoid ADCs → just counting
  - More complex then AugerPrime-SSD
- Optimized:
  - gluing process
  - mirror at the end of the fiber
  - coupling
- Not yet optimized:
  - size and thickness of scintillator

Conclusions

- Technology of any kind is available
  → for low costs detectors
  → for detectors with spatial resolution
  → for single muon counters
  → …
- SiPMs can make them very robust and stable