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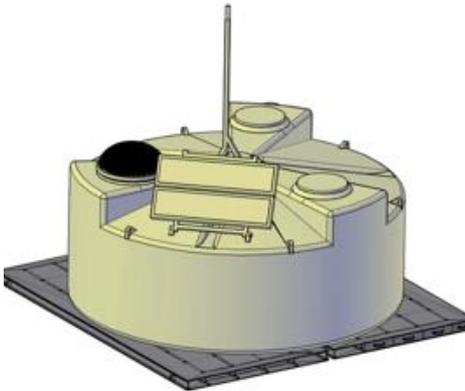
RWTHAACHEN
UNIVERSITY

AMD & SSSD

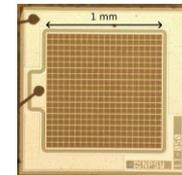
Two SiPM-based scintillation detectors for Auger

Johannes Schumacher

for the Pierre Auger Collaboration

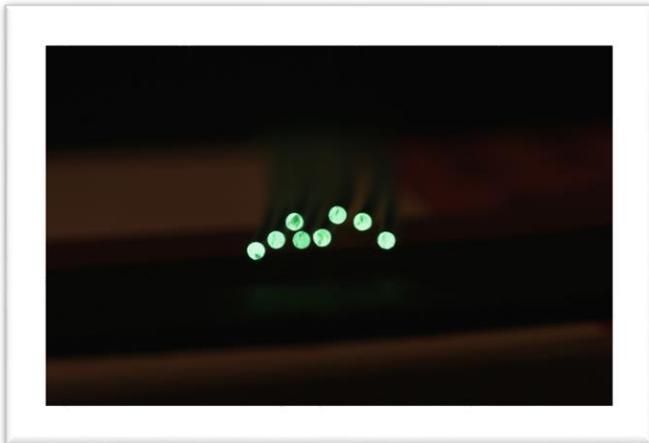


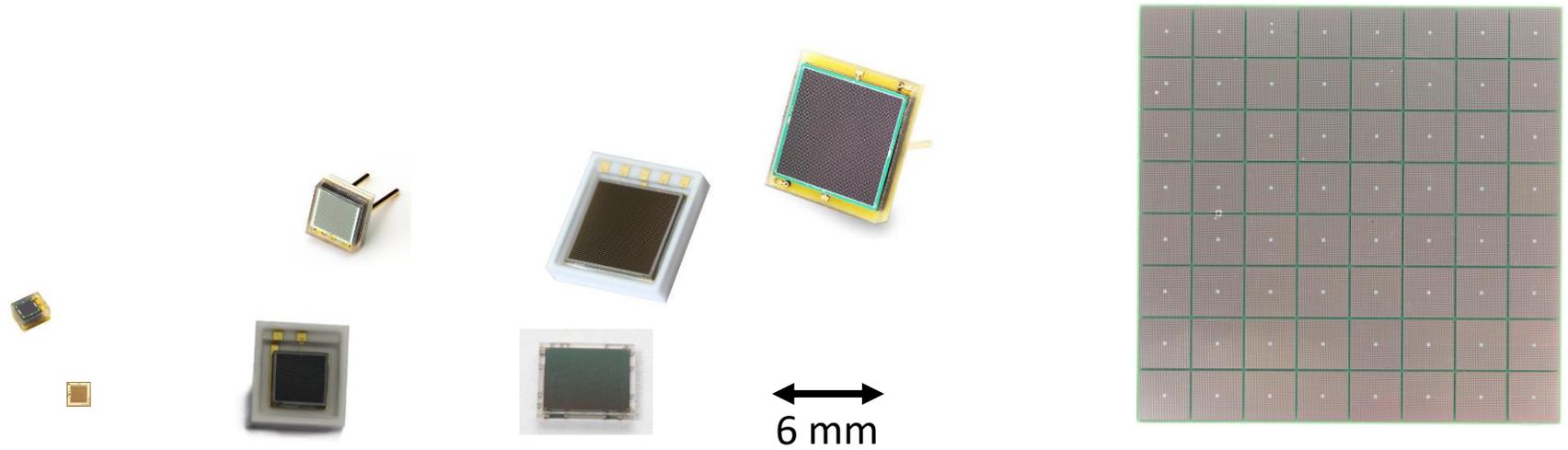
HAP workshop Feb. 2016



Outline

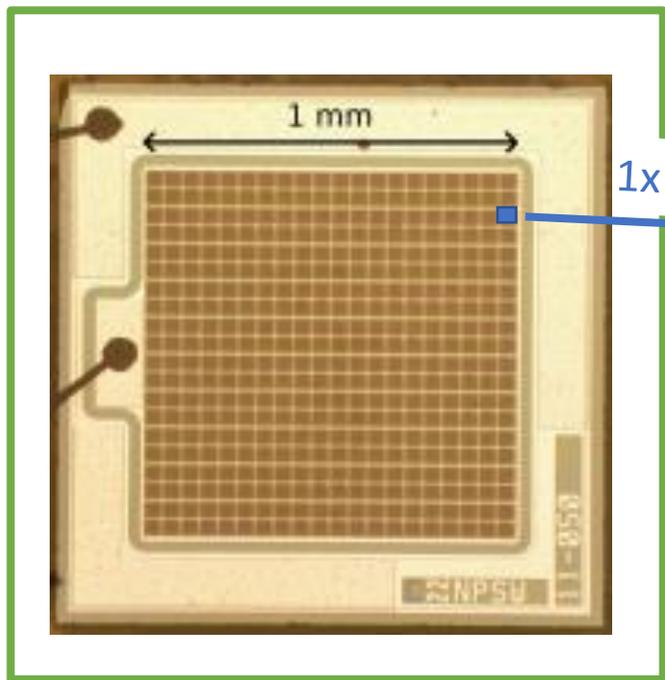
- Motivation for SiPMs
- Part 1: AMD – Aachen Muon Detector
- Part 2: SSSD – SiPMs for the Scintillation Surface Detector in the scope of AugerPrime



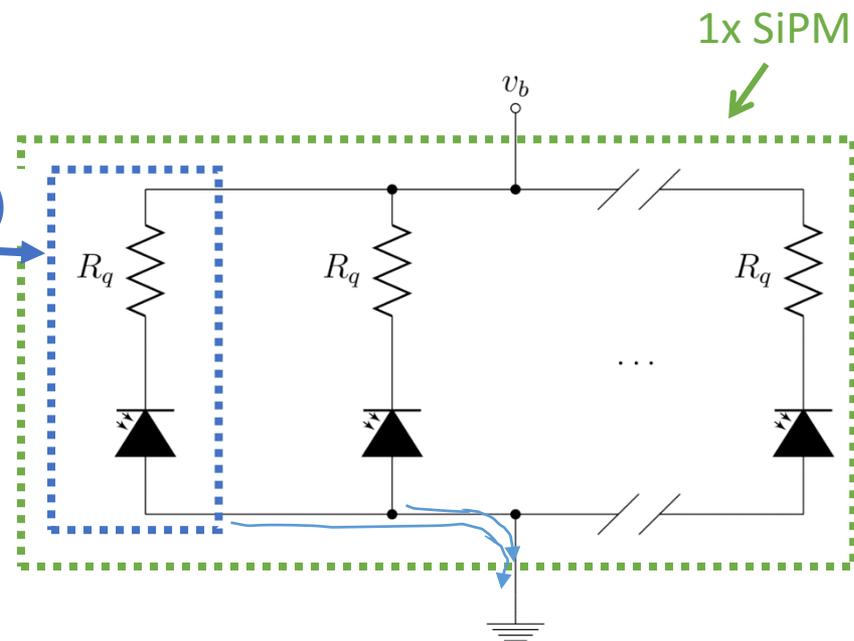


Silicon Photomultipliers

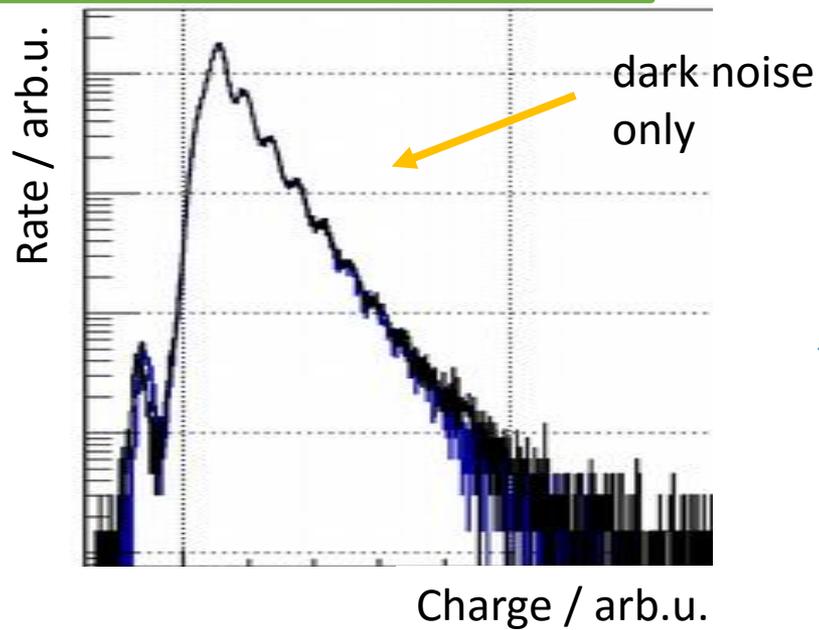
aka SiPMs, MPPCs, G-APDs, ...



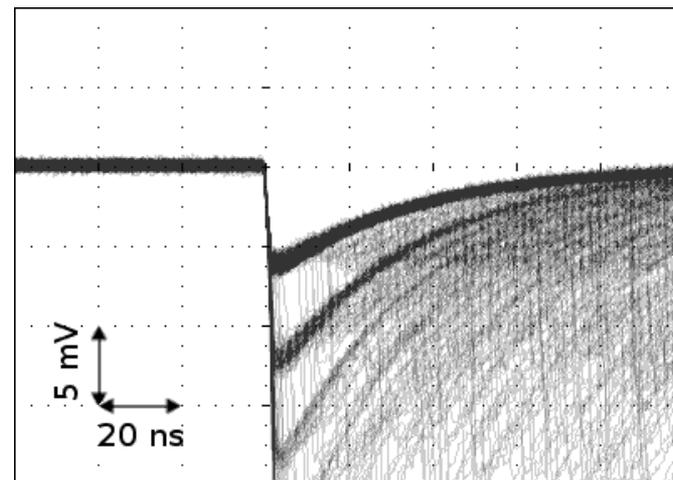
eq. circuit

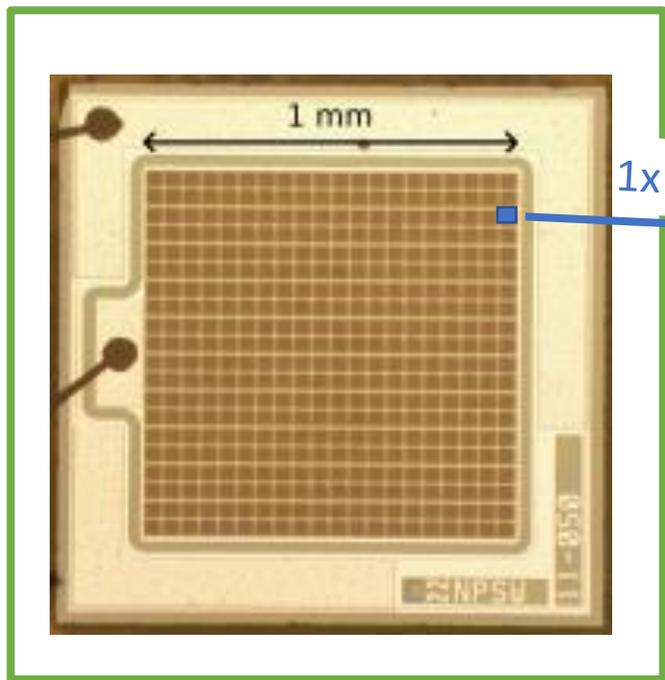


Σ

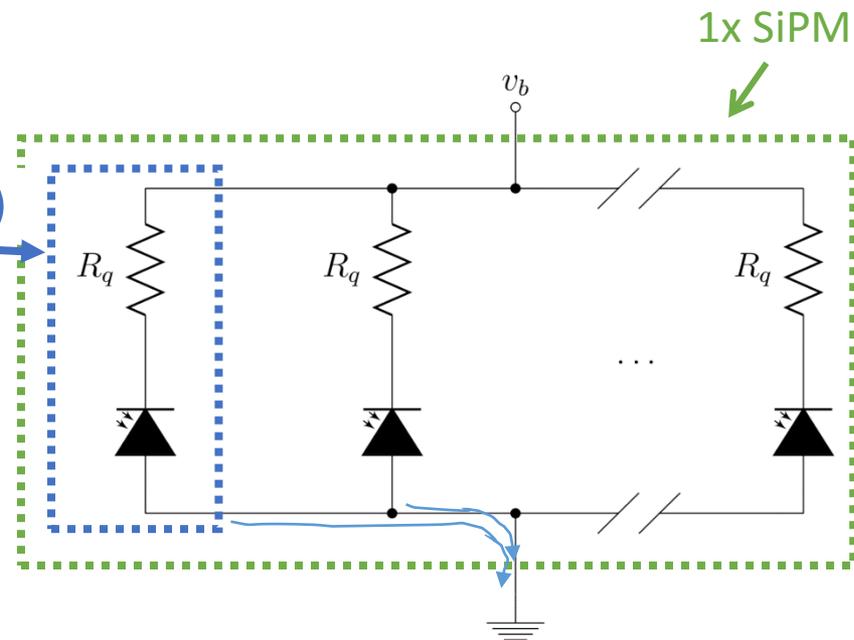


$\int dt$

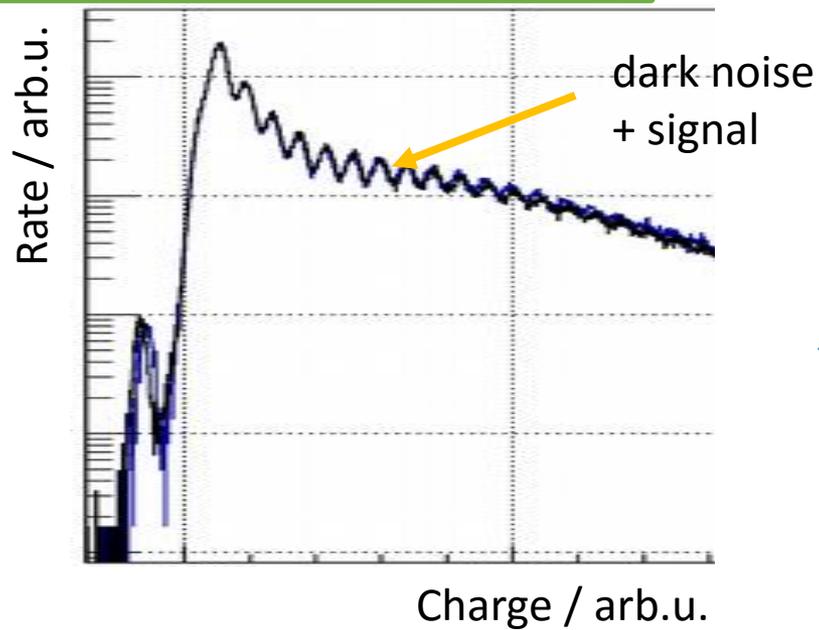




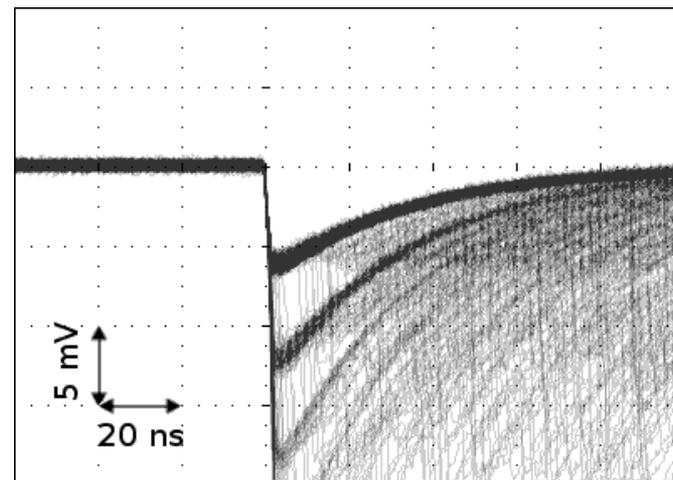
eq. circuit



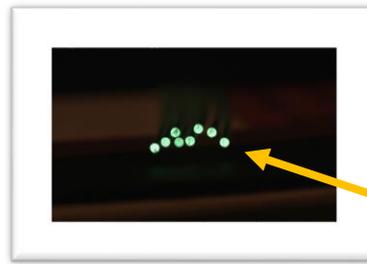
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$\int dt$

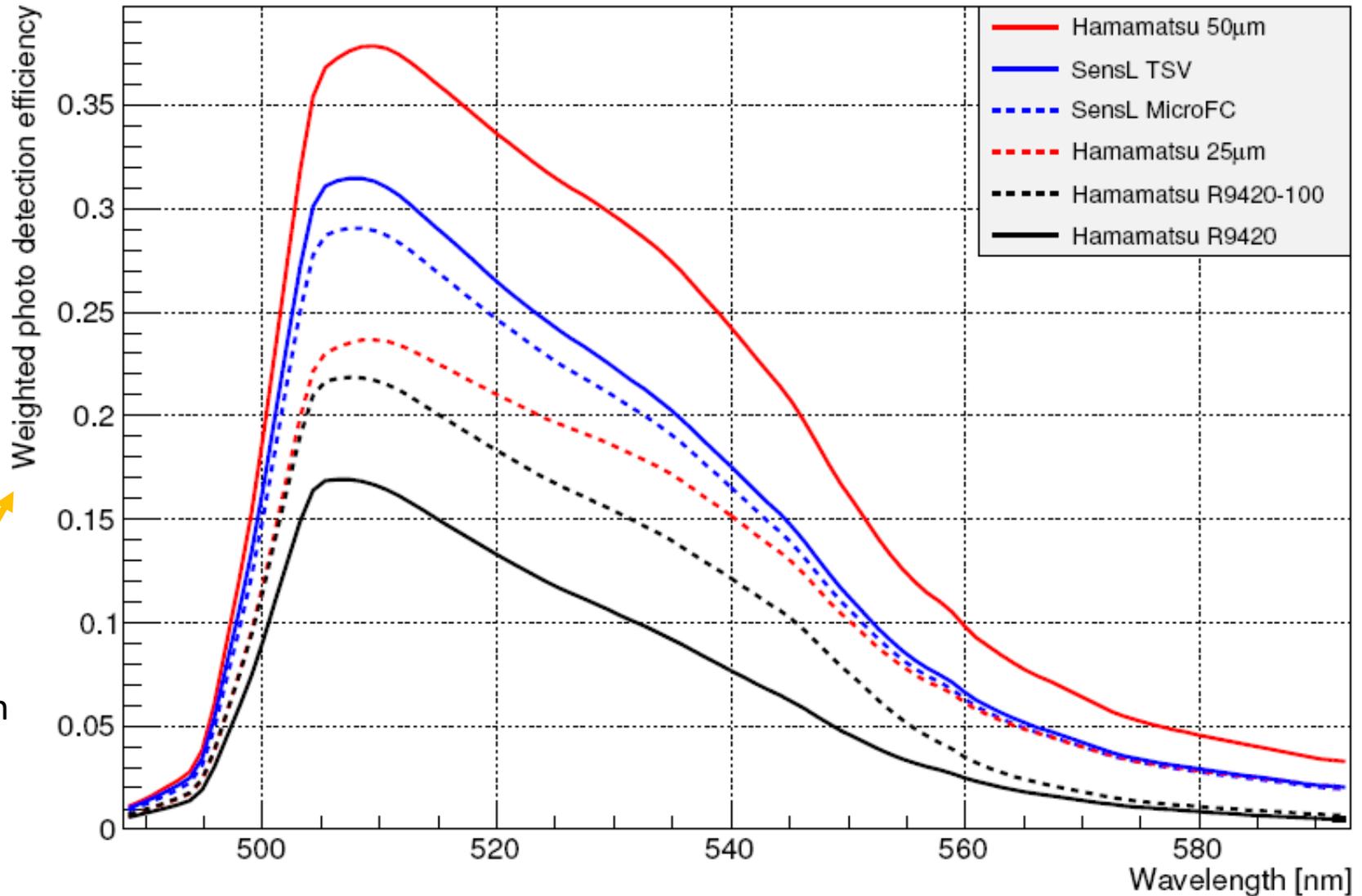


Why SiPMs?

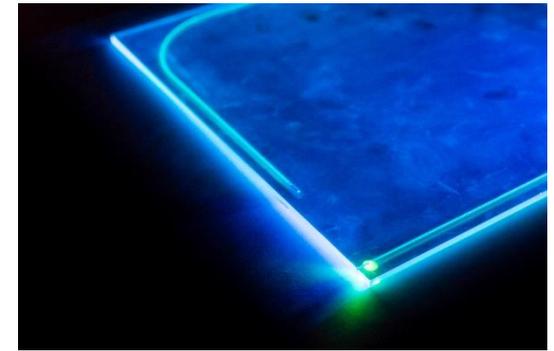
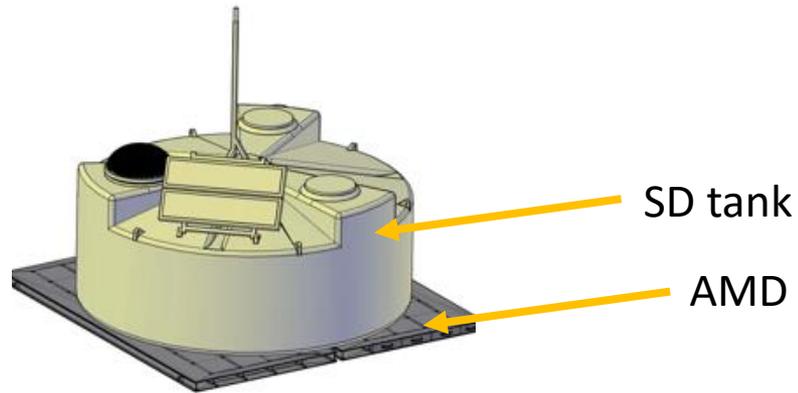


Based on datasheet values

WLS fibres



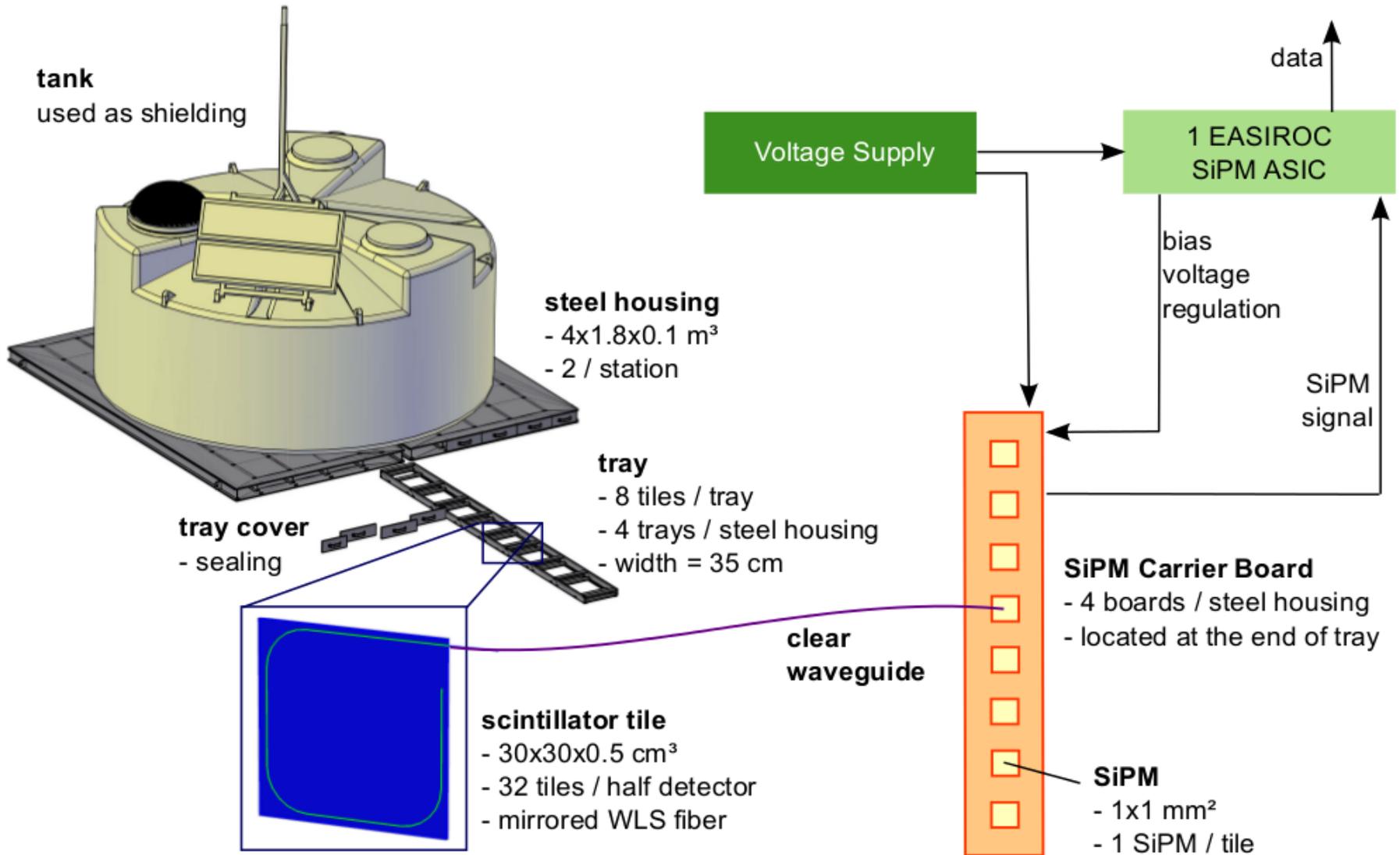
... with fibre emission



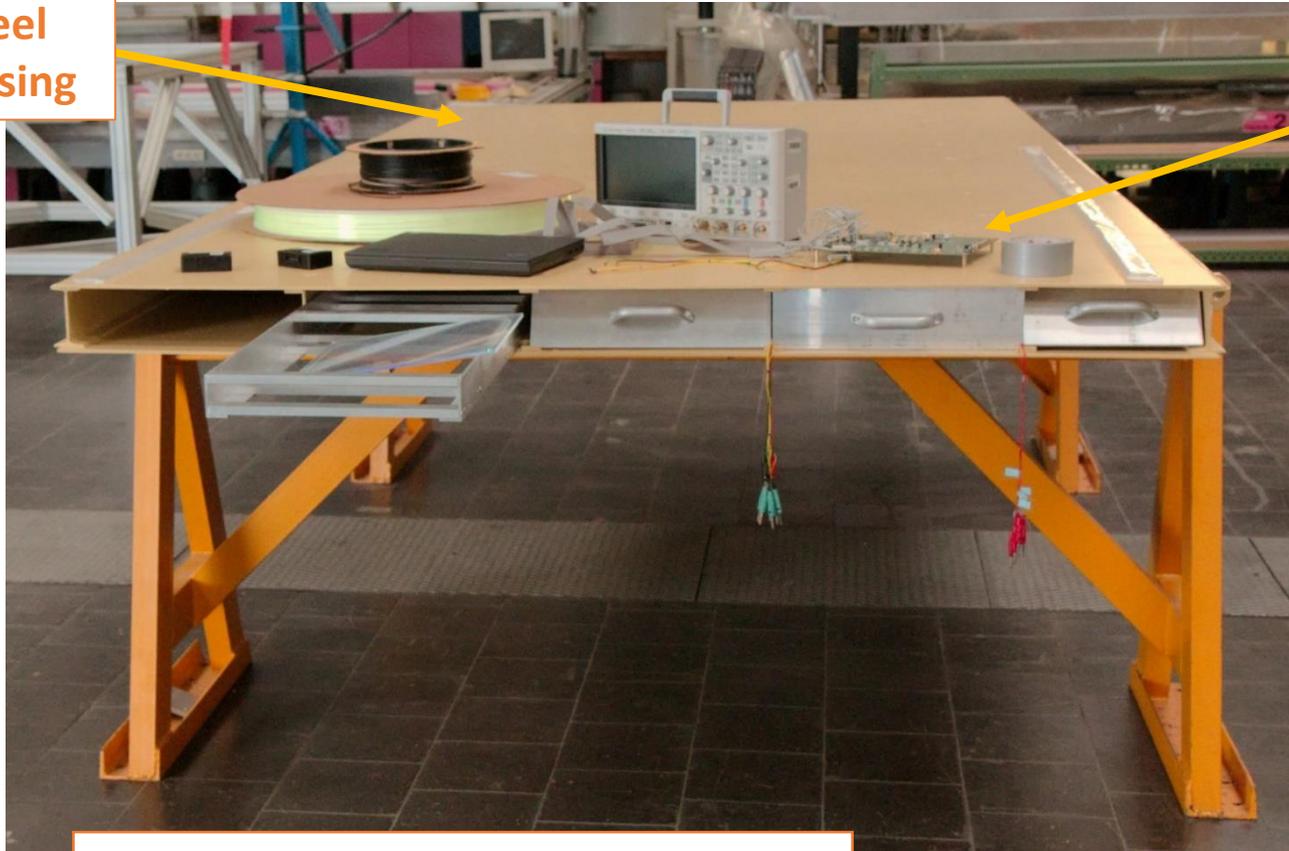
The Aachen Muon Detector (AMD)

Seed-funded project: a SiPM-based prototype muon detector

Hamamatsu S12571-50P SiPM

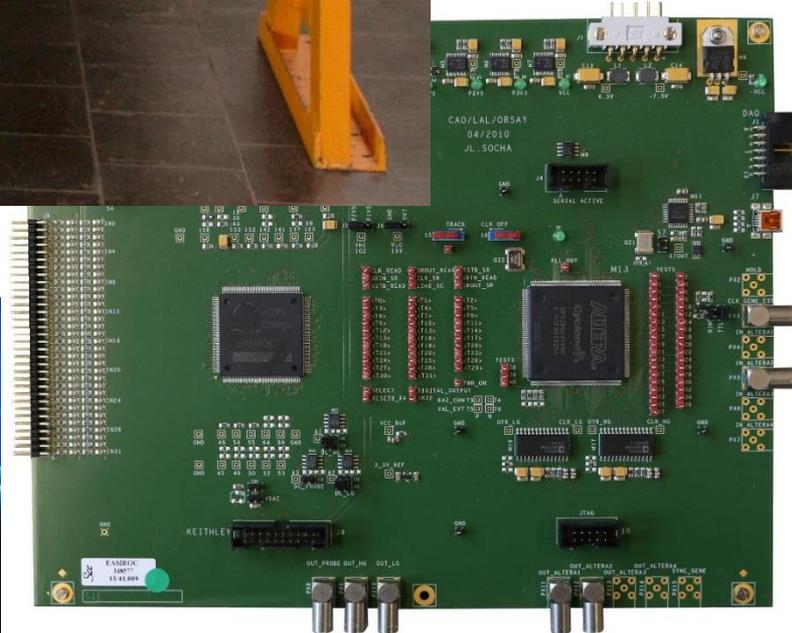
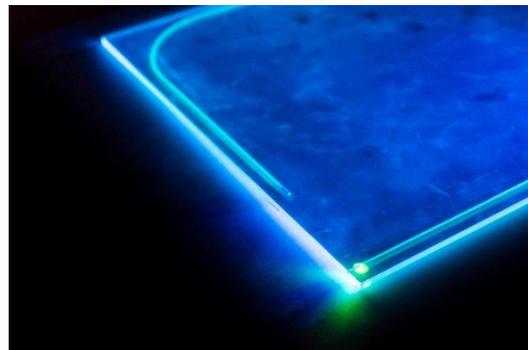
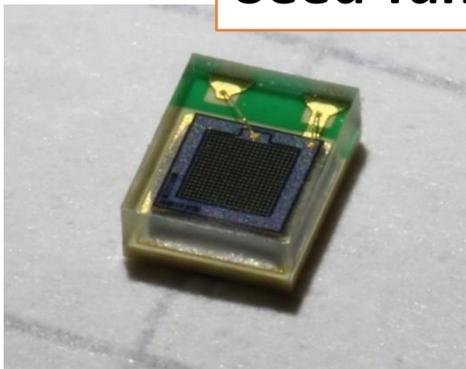


Steel housing



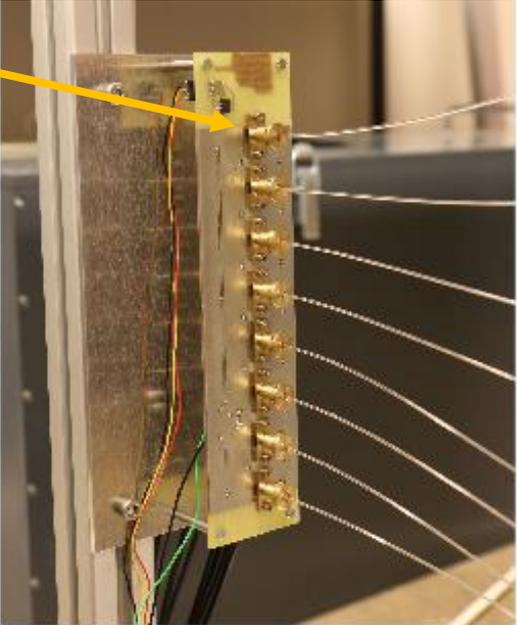
Easiroc

Seed-funded for 1/2 detector



Scintillator efficiency test stand

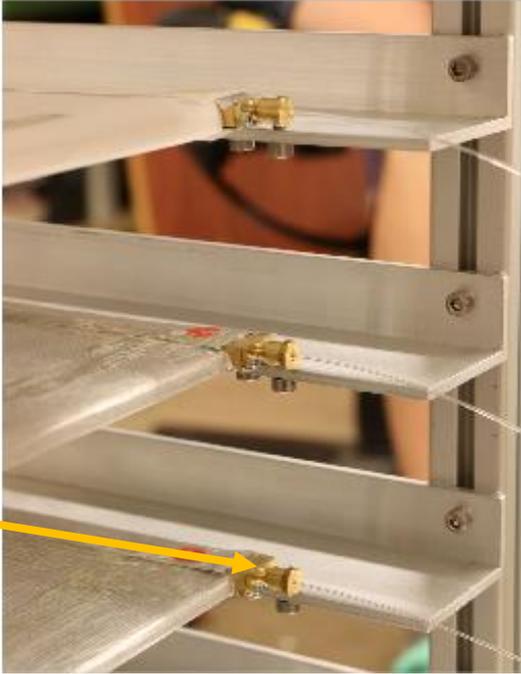
Optical coupling (SiPM side)



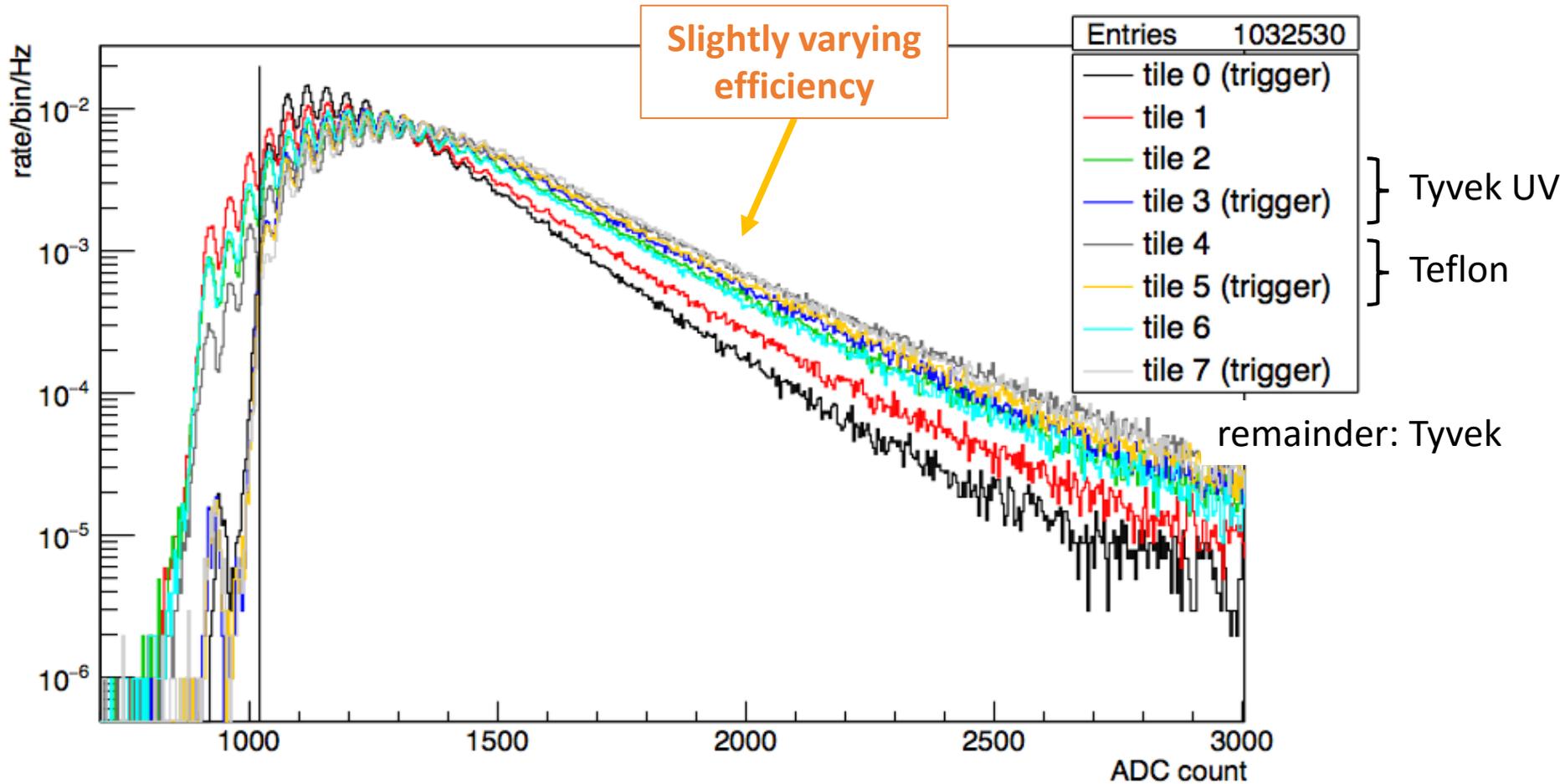
μ

- measure impacts of different ...
- ... scintillator wrapping techniques
 - ... fibre conditioning techniques

Optical coupling (scint. side)



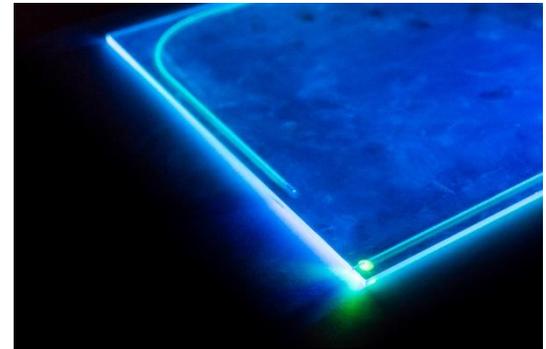
Example: different wrapping techniques



Efficiency not matter of wrapping technique,
but more likely a matter of wrapping
experiance!

To do list

- test of water/light tightness of steel housing next months
- wrapping of remaining 24 naked scintillator tiles by hand
- test measurements of scintillator tile efficiency vs. impact position

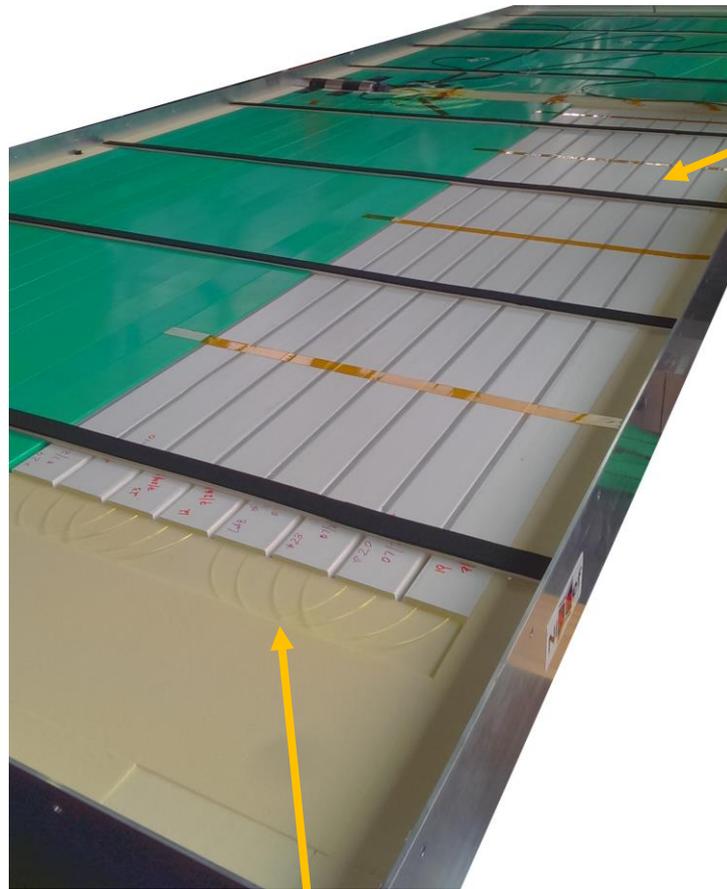


SiPMs for the Scintillation Surface Detector (SSD)

In the scope of AugerPrime

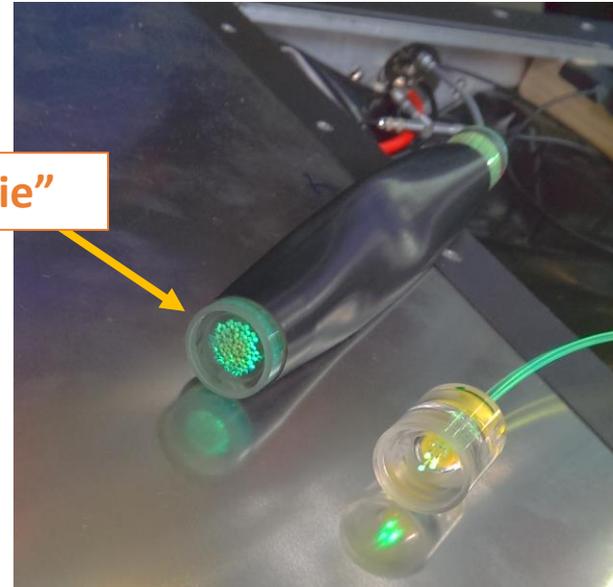


SSD - overview



Scintillator bars

"Cookie"



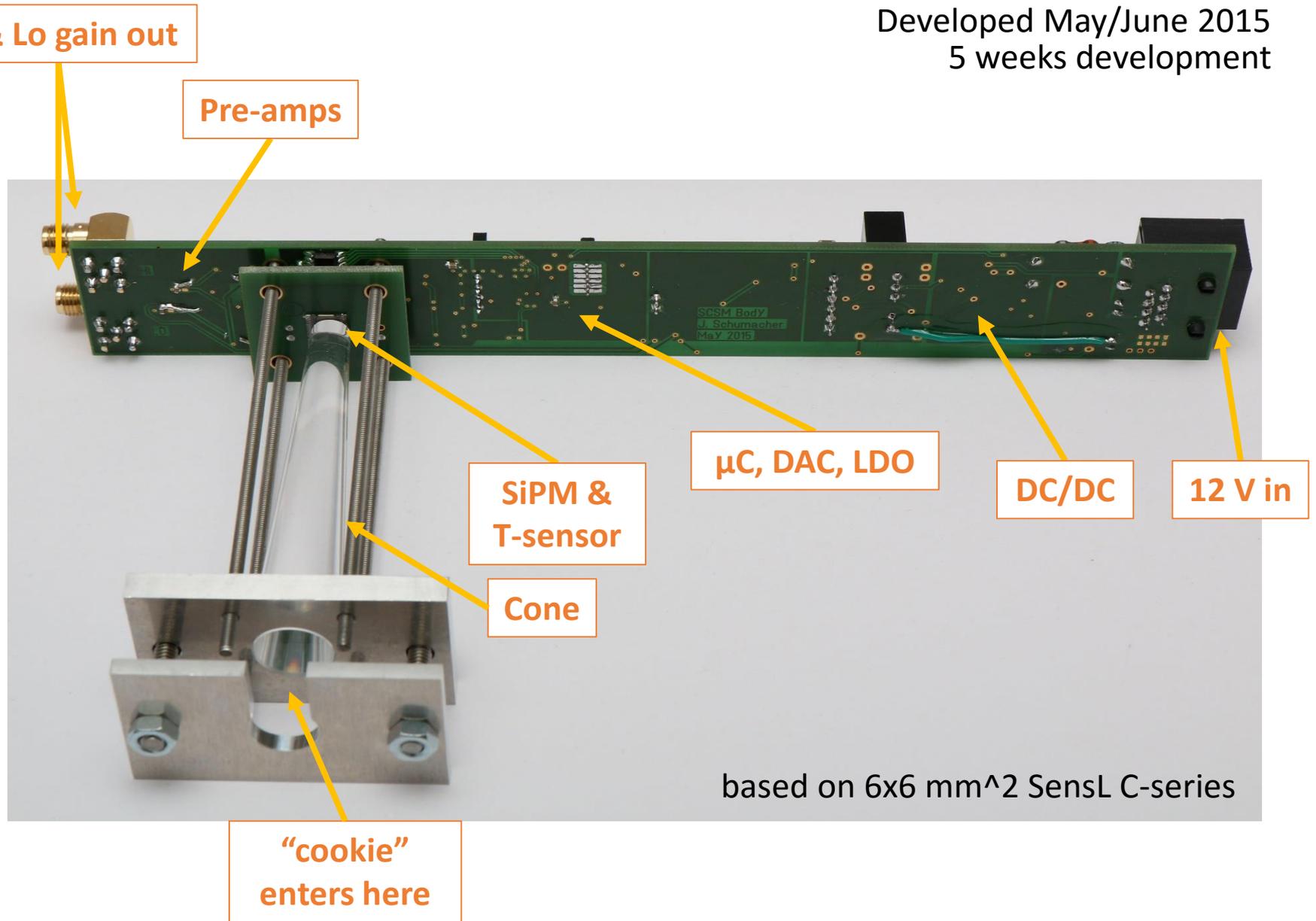
WLS fibres

WLS fibres coupled to a single optical coupling ("cookie")

→ single large area photosensor needed

SiPM solution for prototype detector

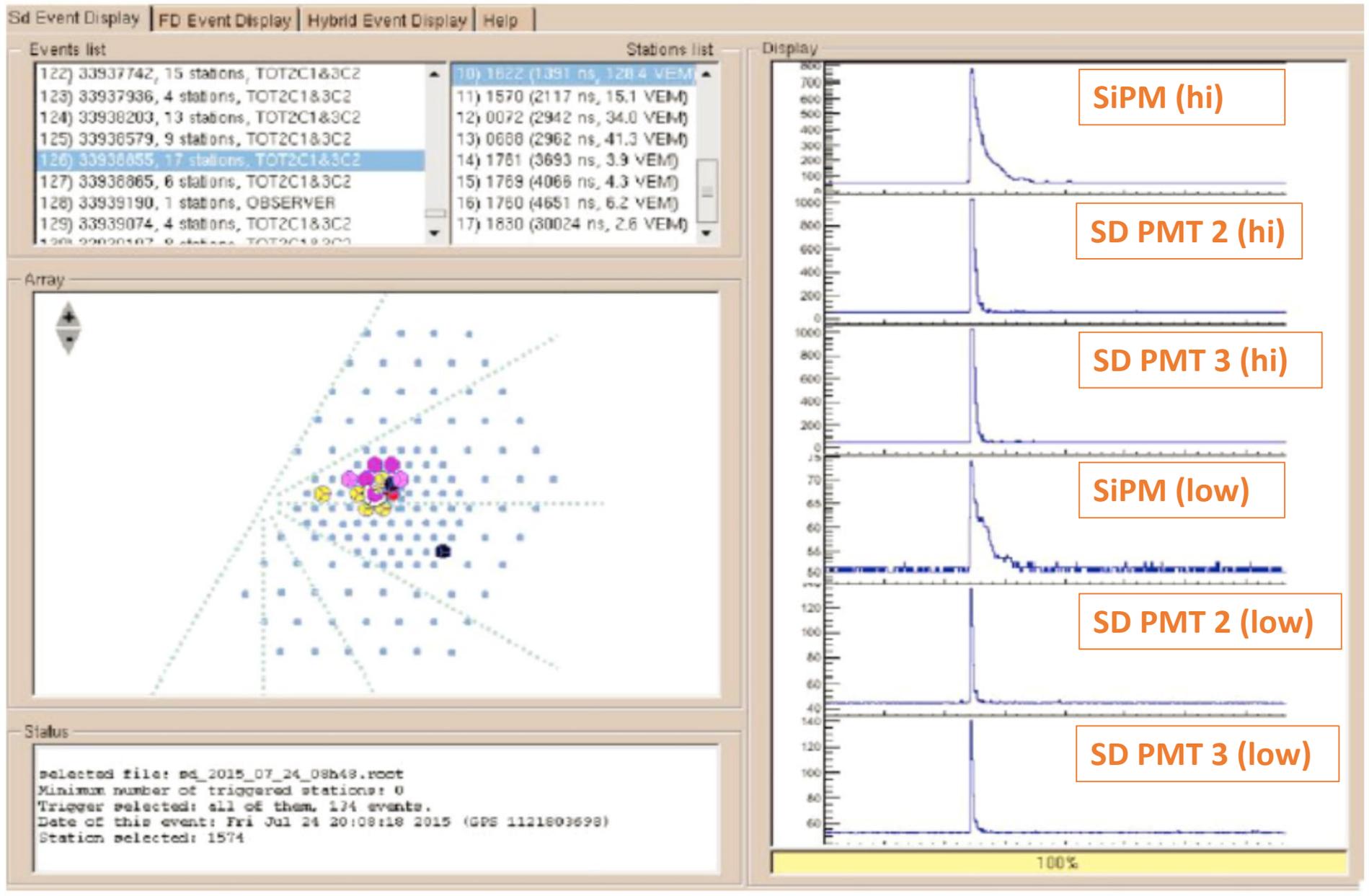
Developed May/June 2015
5 weeks development



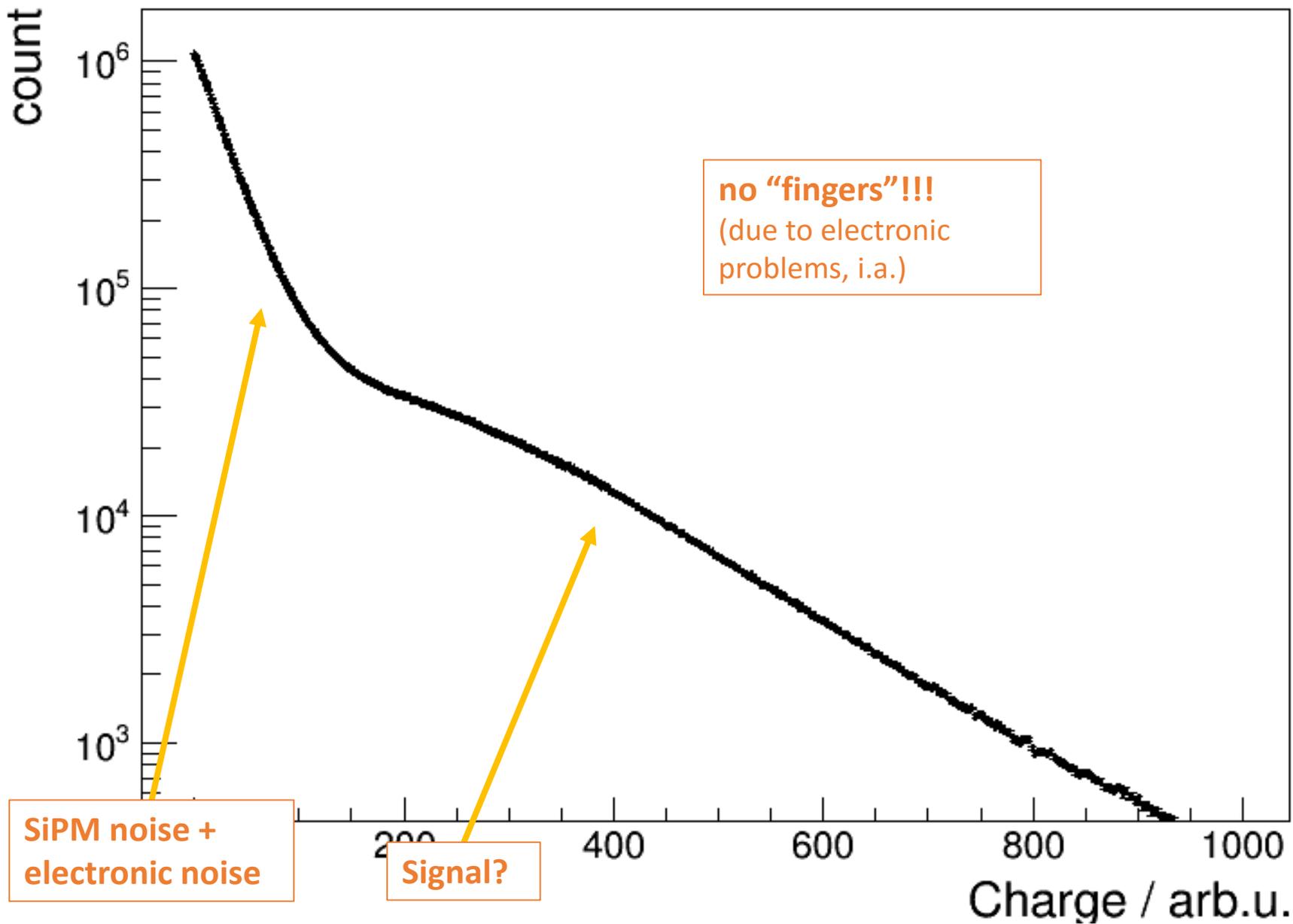
SiPM solution installed in Argentina



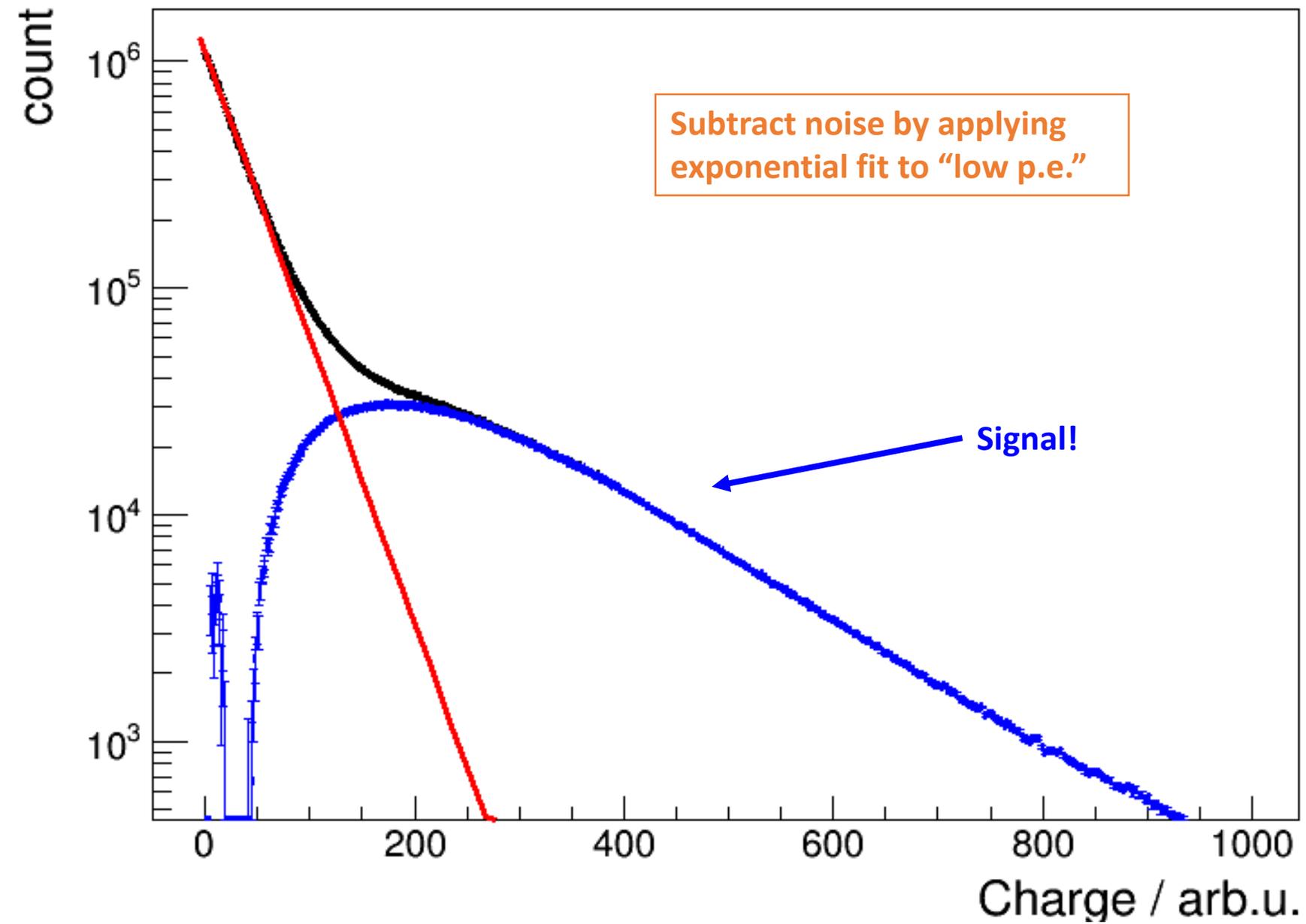
SD event display



Charge histogram

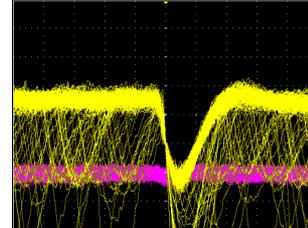
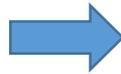
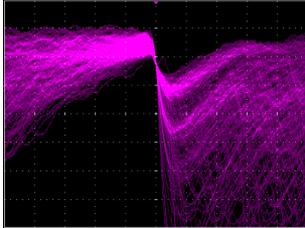


Charge histogram

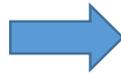


Changes

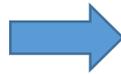
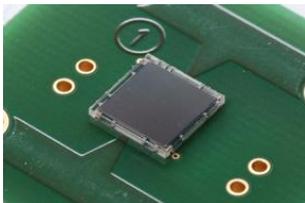
- Improved electronics
→ less electronic noise

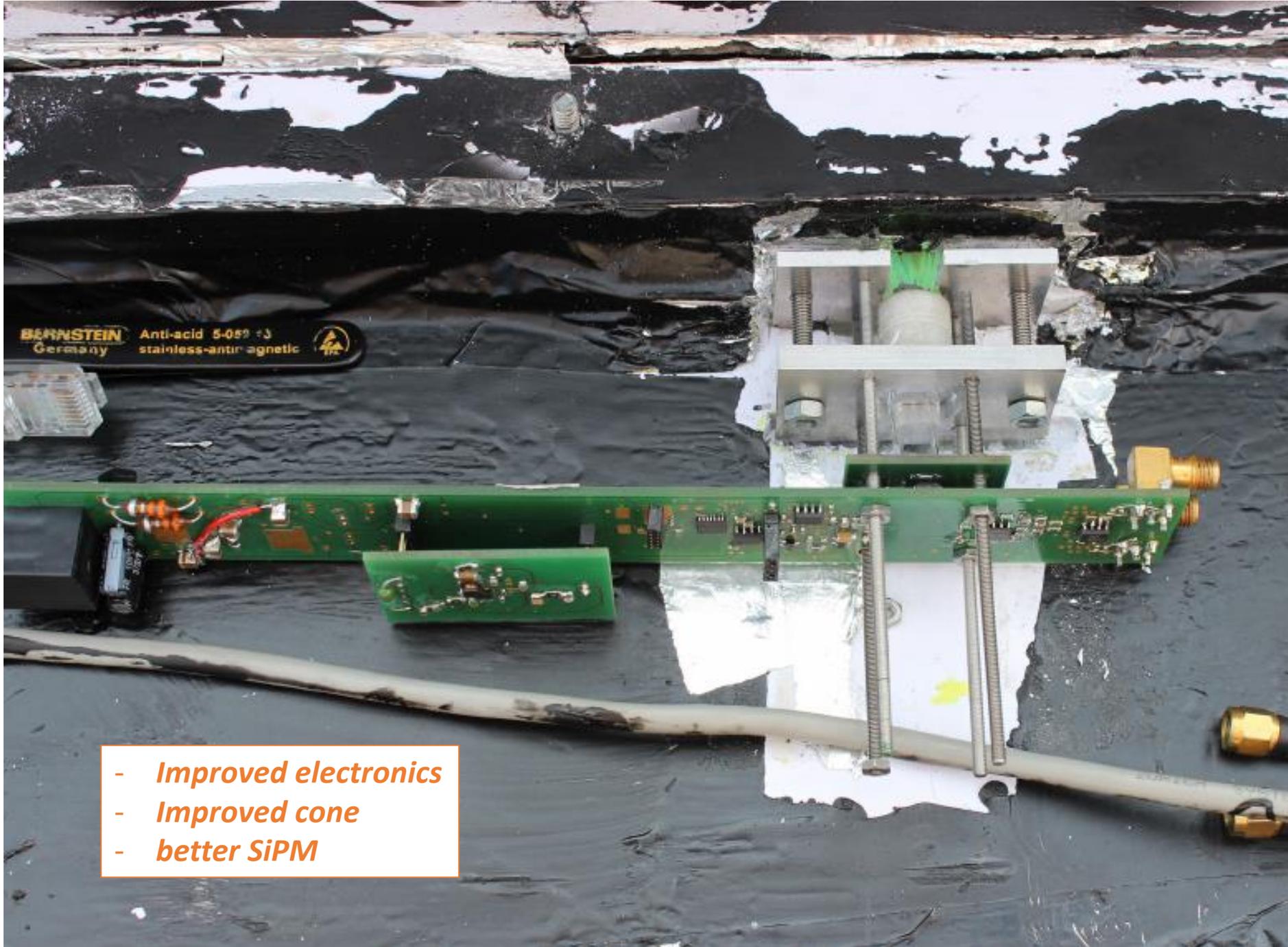


- Improved cone
→ higher efficiency

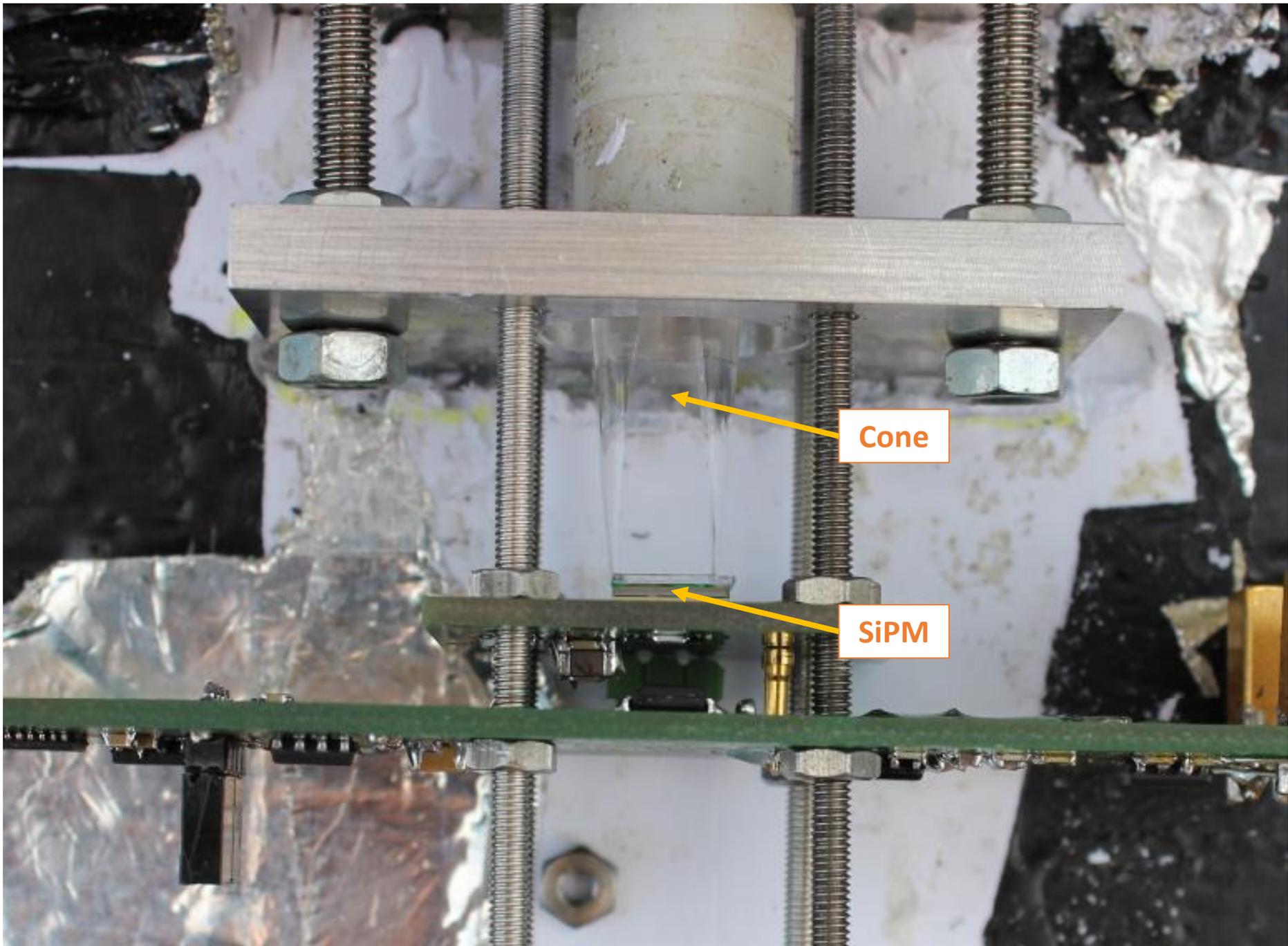


- “better” SiPM
→ less dark noise, less crosstalk, higher efficiency





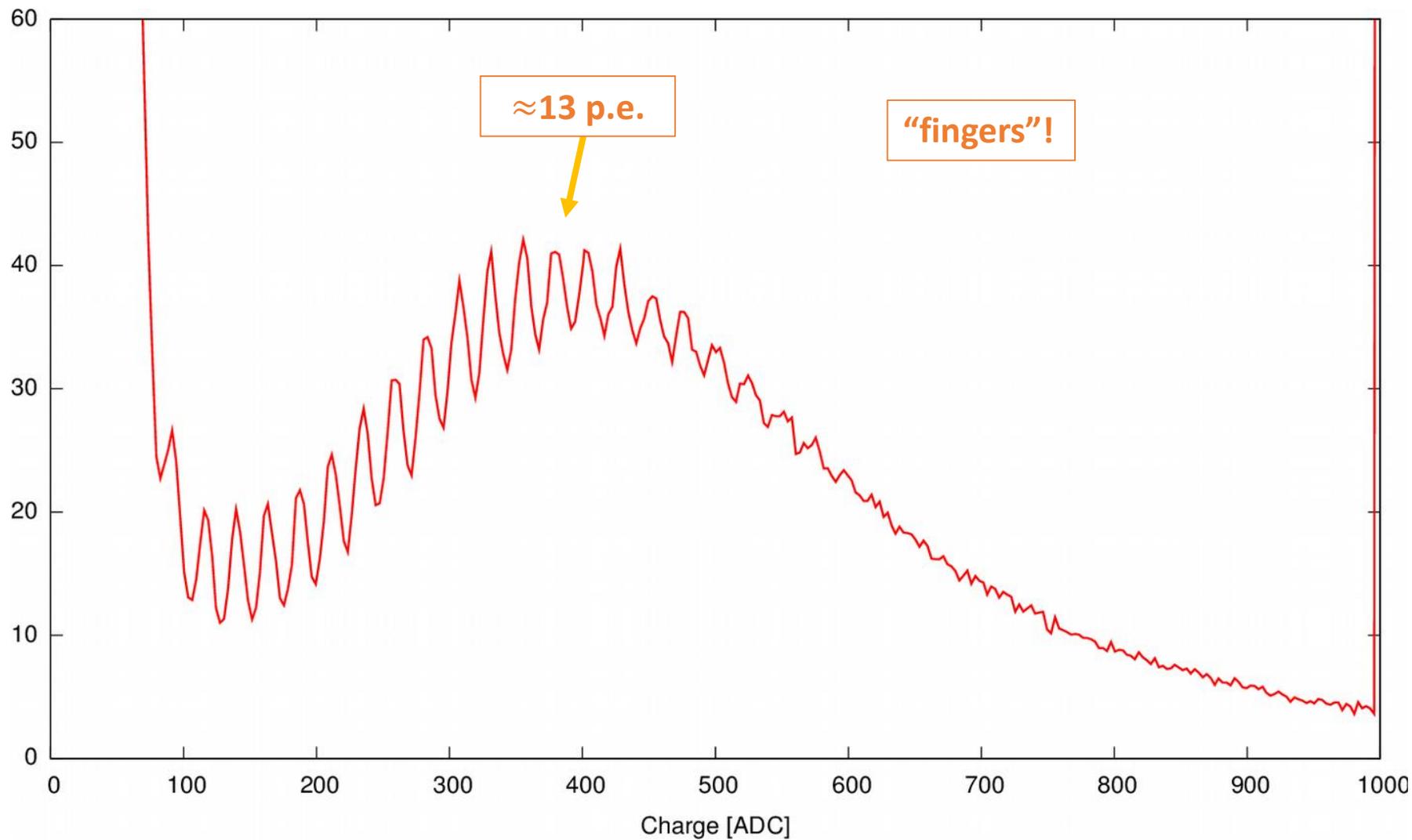
- *Improved electronics*
- *Improved cone*
- *better SiPM*



Cone

SiPM

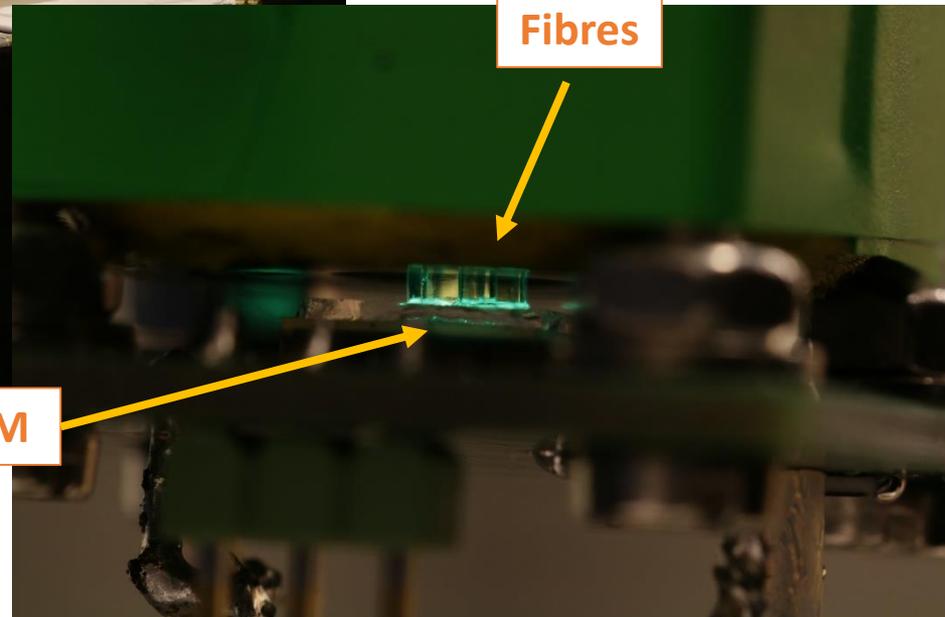
Hamamatsu S13360-6050PE, low crosstalk version



Measurement in Aachen

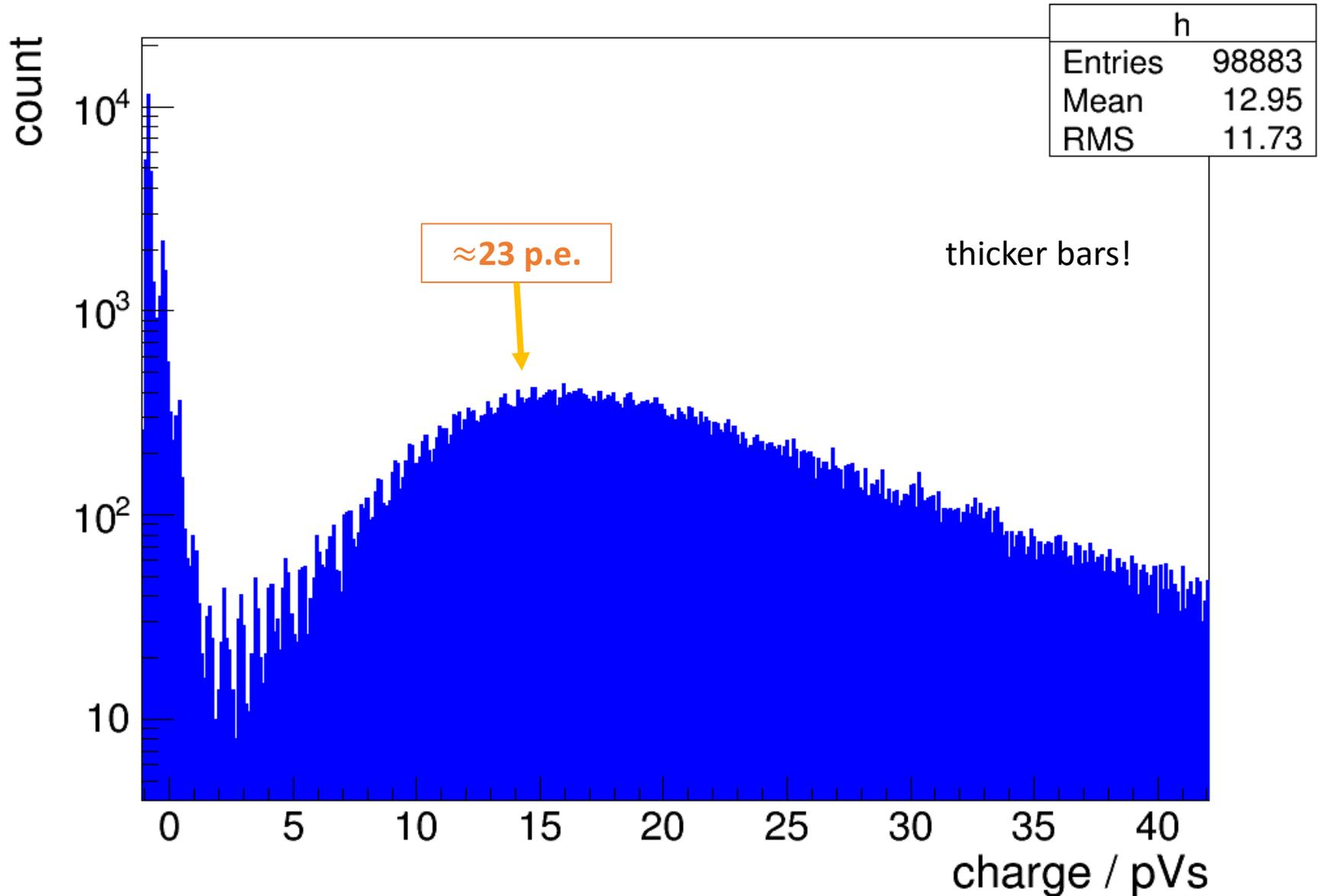


SSD scintillator bars
triggered by AMD sc. tiles



No cone! (Expect increased efficiency)

Hamamatsu S13360-6050PE charge histogram

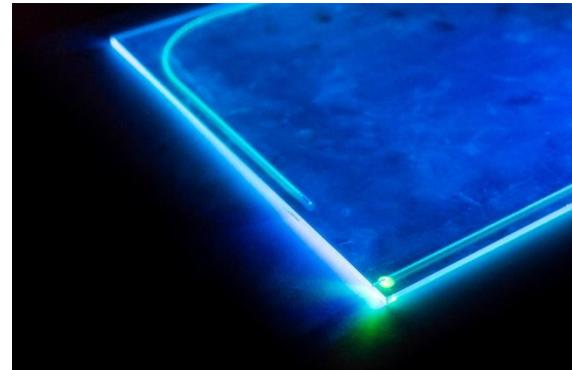
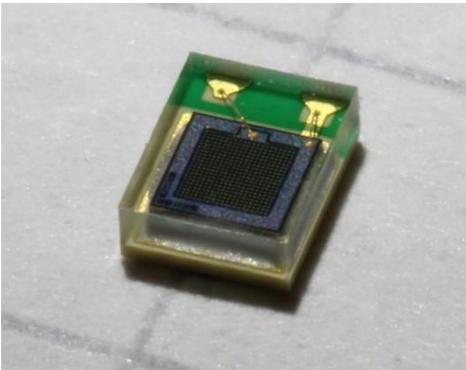


Summary/outlook

- Currently working on a two-channel SiPM solution for AugerPrime
 - electronics will be finished in March
 - shipping in mid-April together with aluminium housing from KIT to Argentina or in summer
 - tests (optical coupling, efficiency, reliability, noise, ...) will be done until mid-April

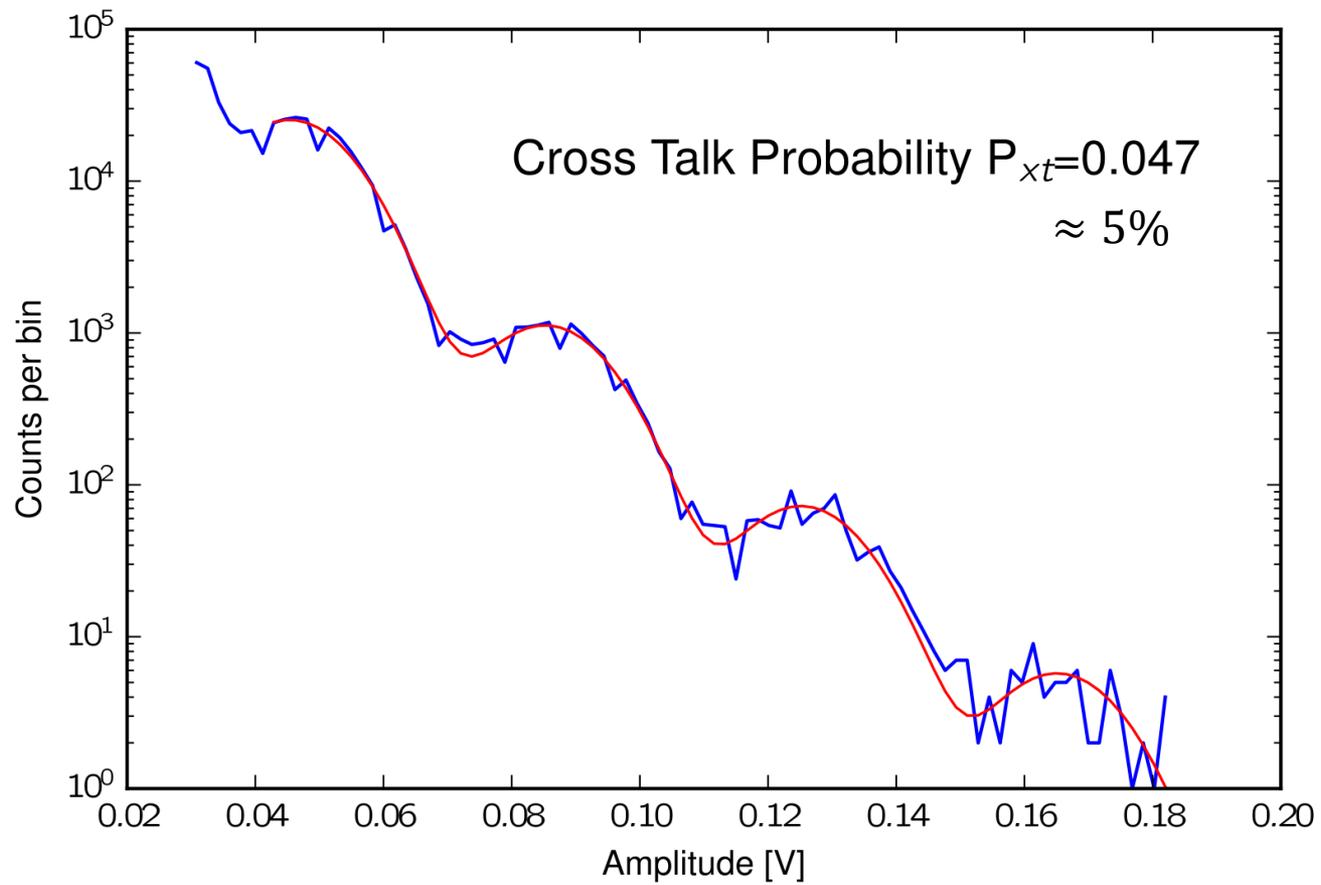
Conclusion

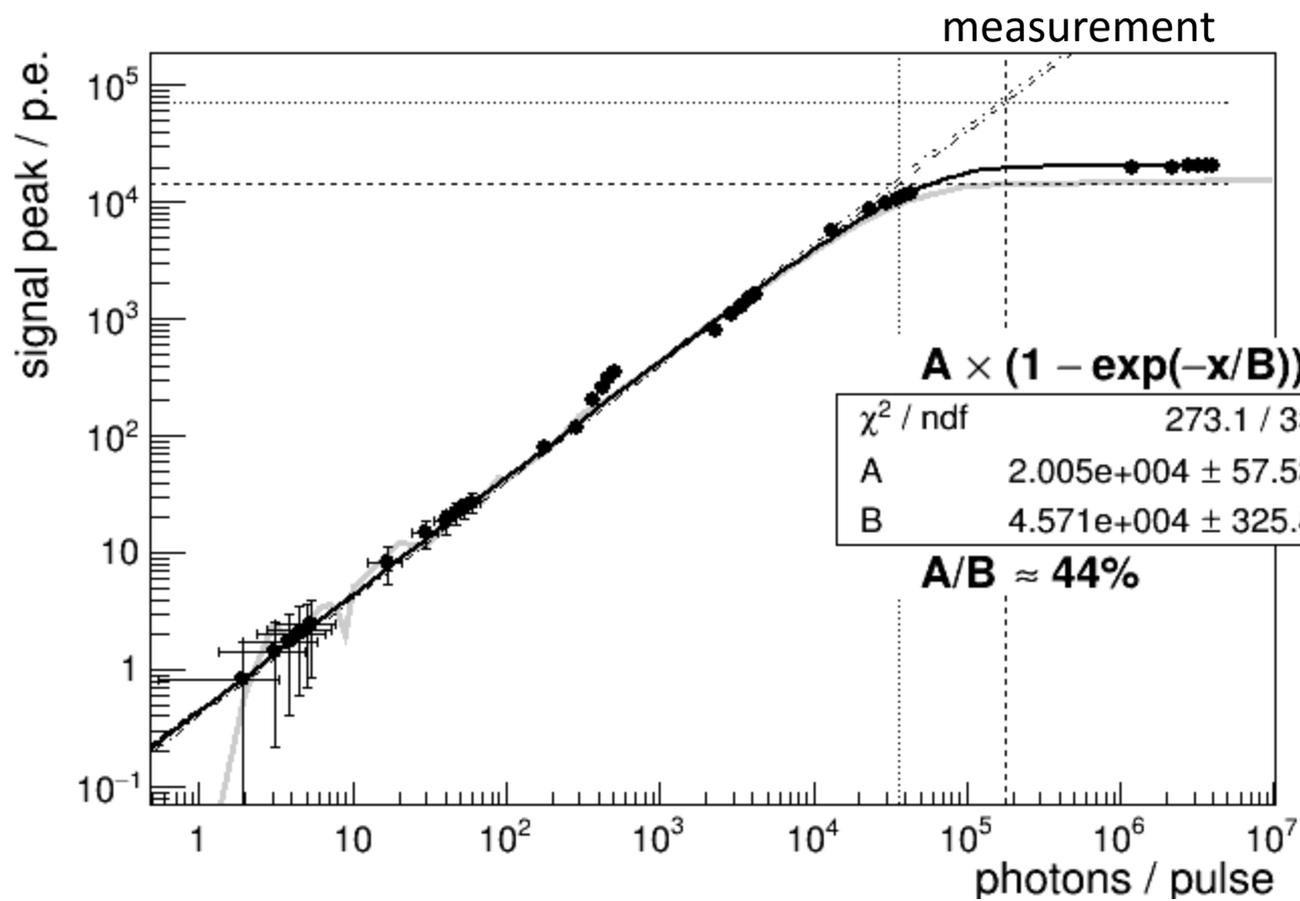
- SiPMs are an excellent choice for WLS-fibre read-out, due to high efficiency
- Low noise, high dynamic range SiPMs available!



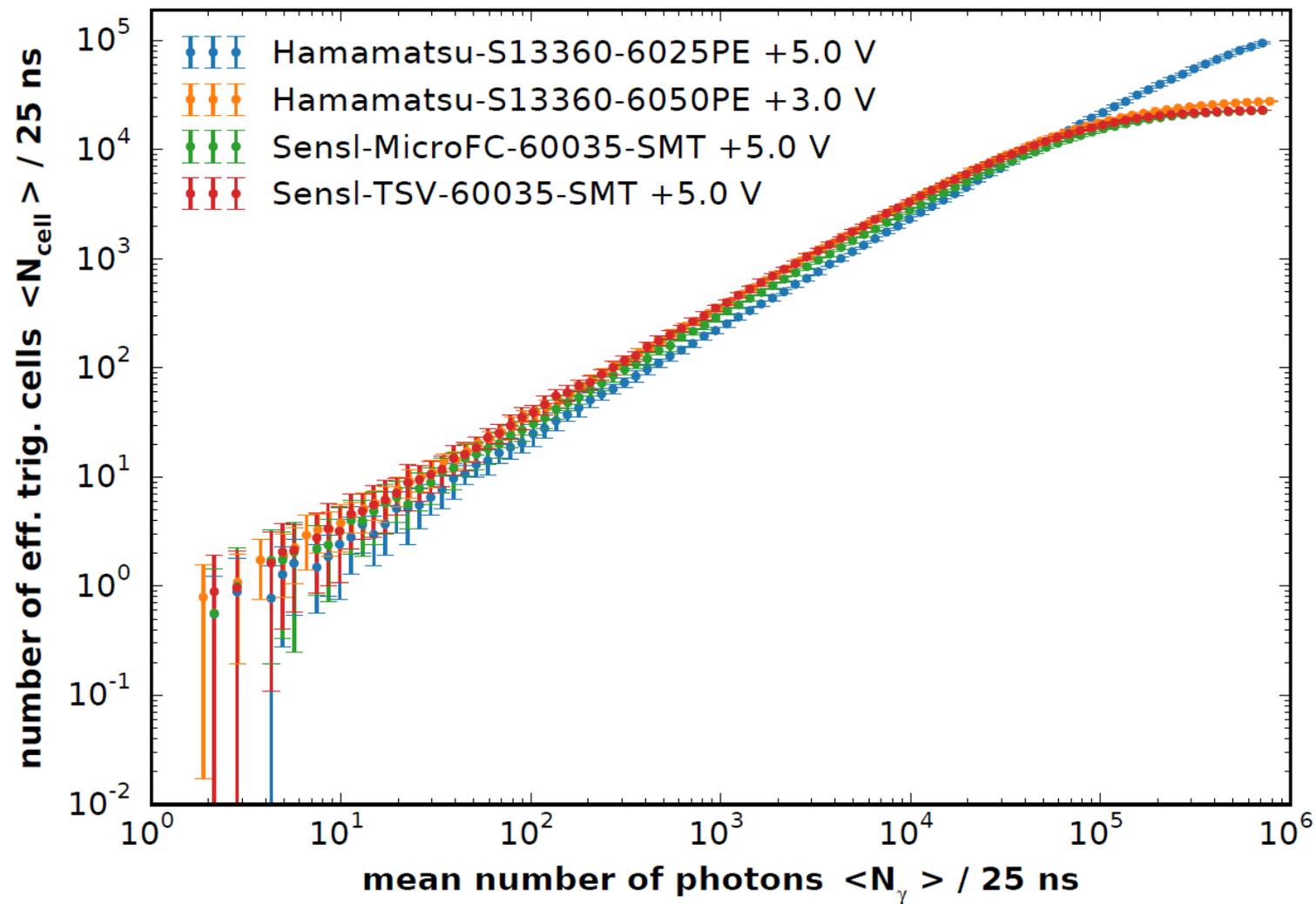
Appendix

some additional measurements



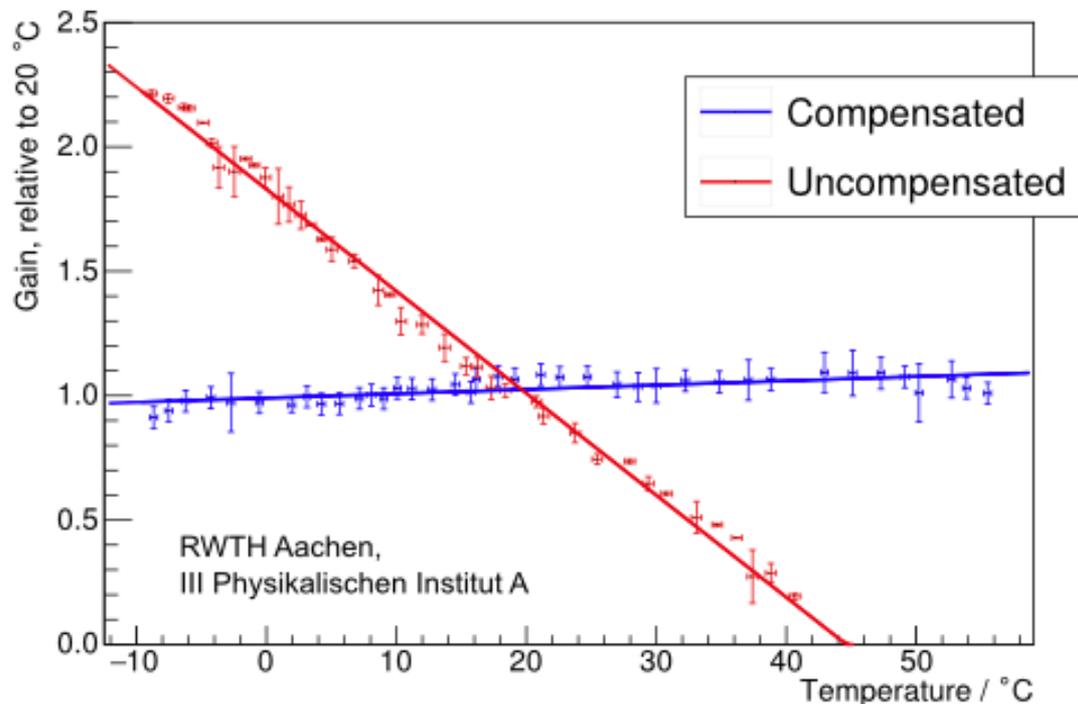


simulation

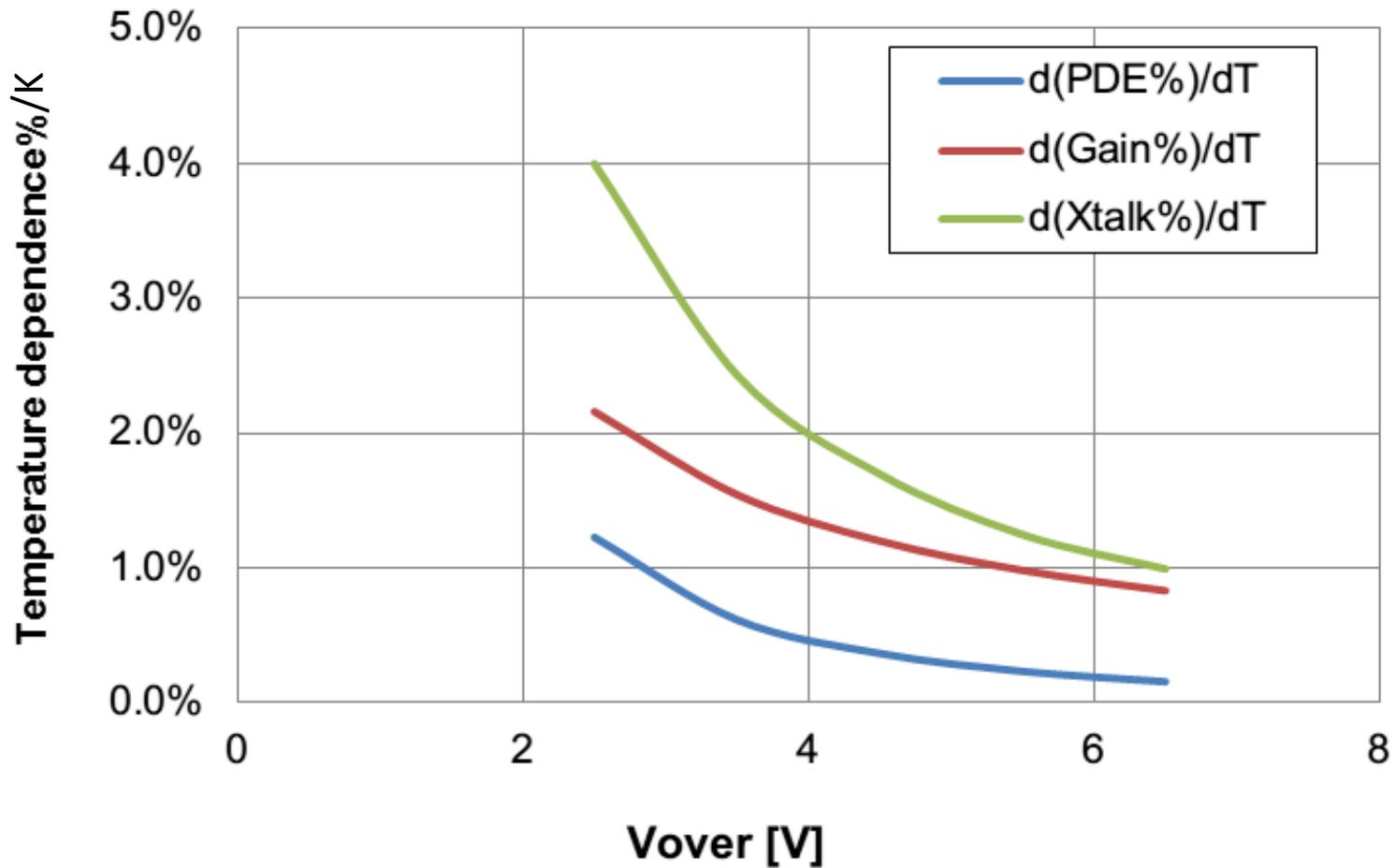


SiPM temperature dependence

- ▶ SiPM properties heavily depend on temperature
- ▶ dependence can be canceled by adjusting the bias voltage
 $V_{\text{bias}} = V_0 + 60 \text{ mV/K} \cdot (T - 25^\circ\text{C})$ (for Hamamatsu)
- ▶ method tested between -10°C and 40°C
- ▶ correction already implemented in electronics

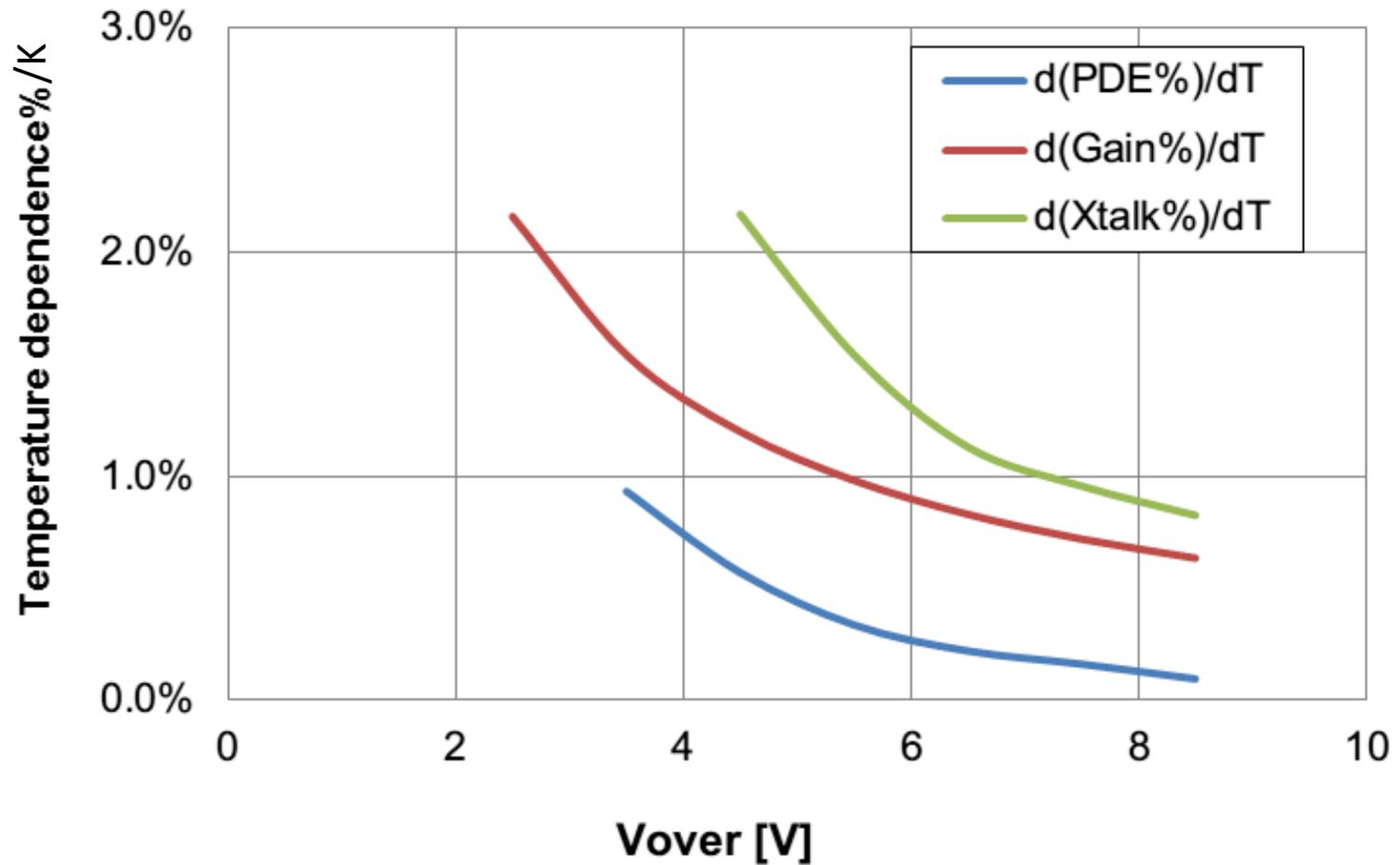


S13360 series 50um

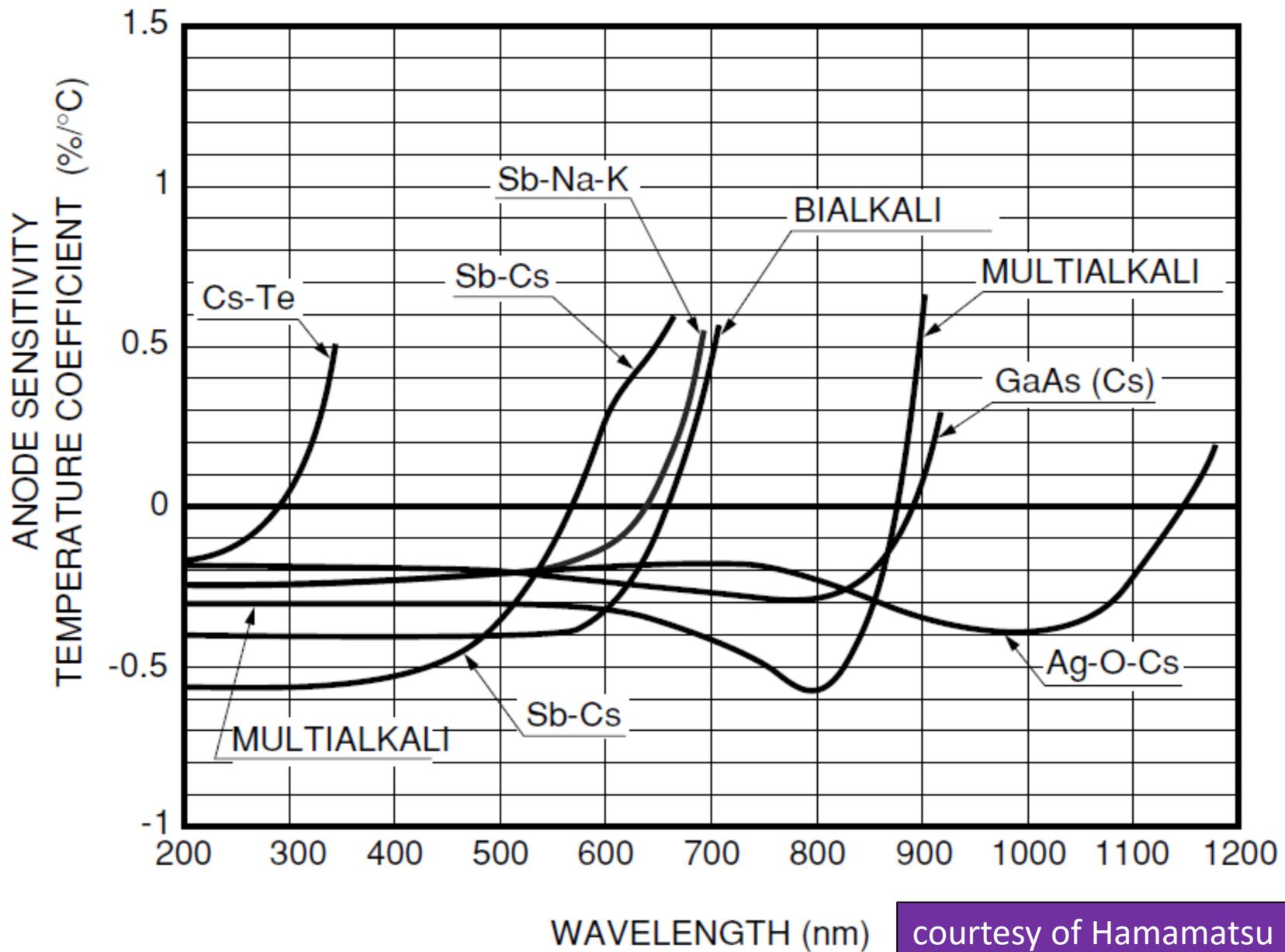


courtesy of Hamamatsu

S13360 series 25um



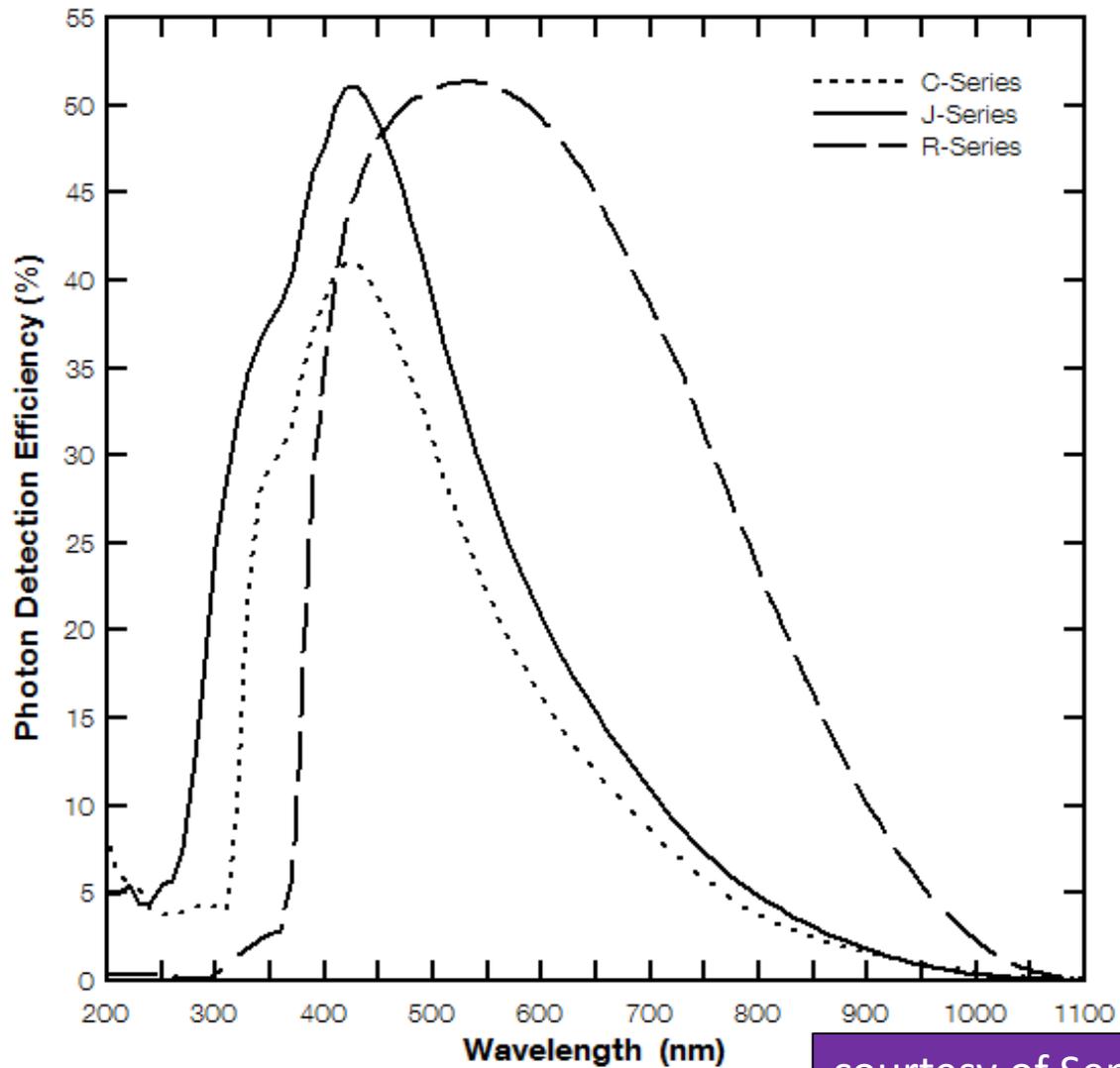
courtesy of Hamamatsu



courtesy of Hamamatsu

PDE versus Wavelength

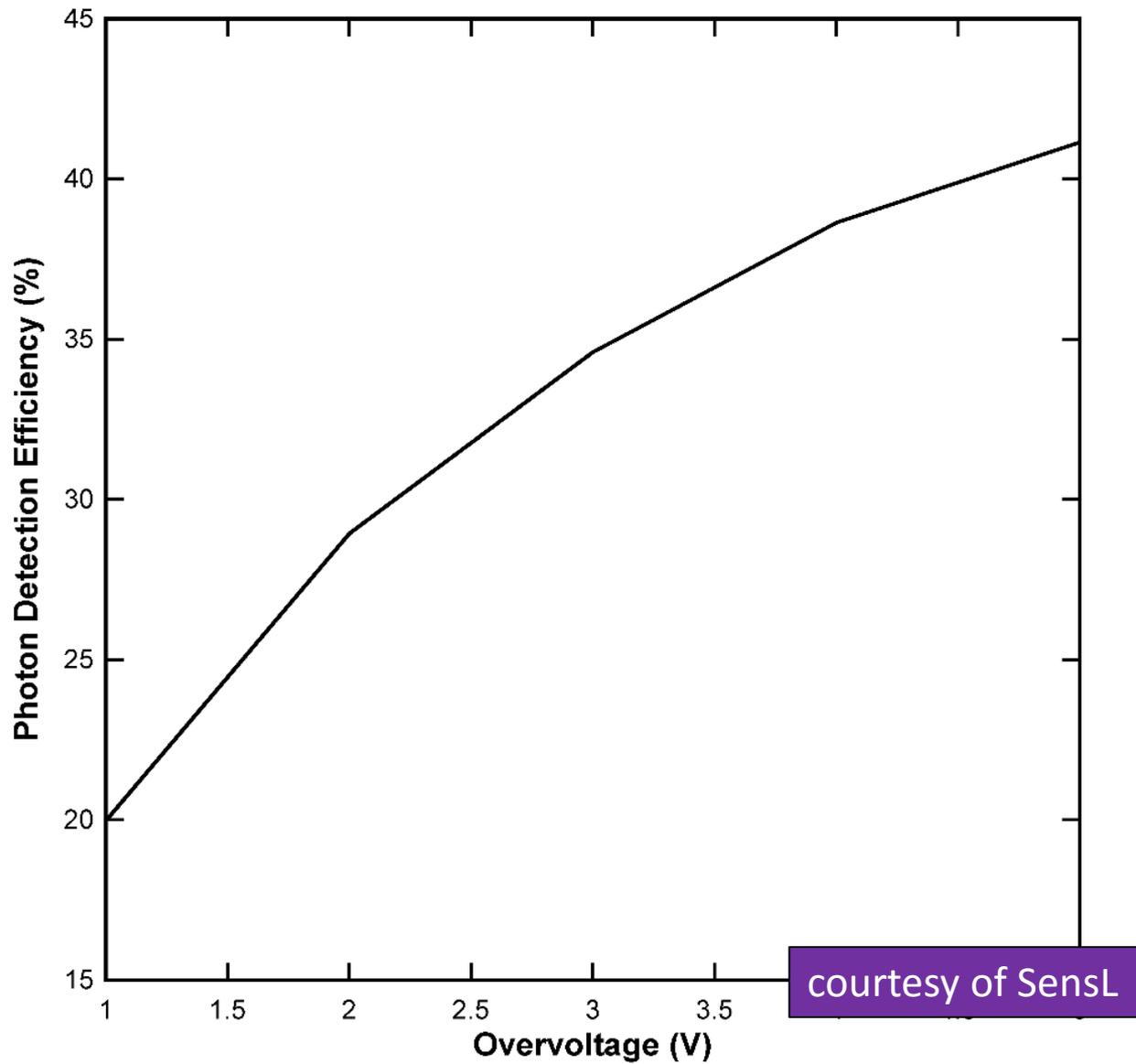
35 μ m Microcell Products



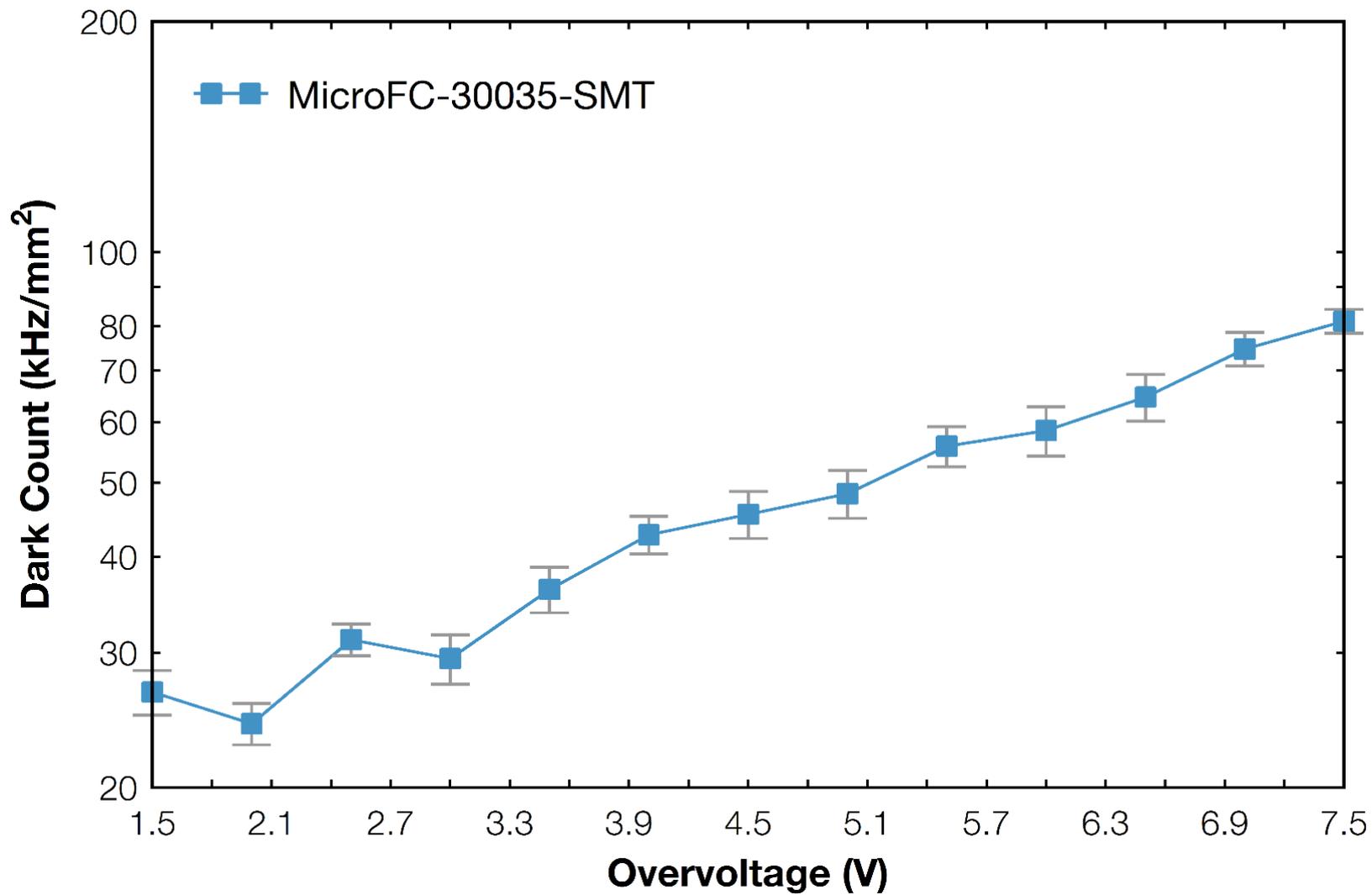
courtesy of SensL

PDE at 420nm versus Voltage

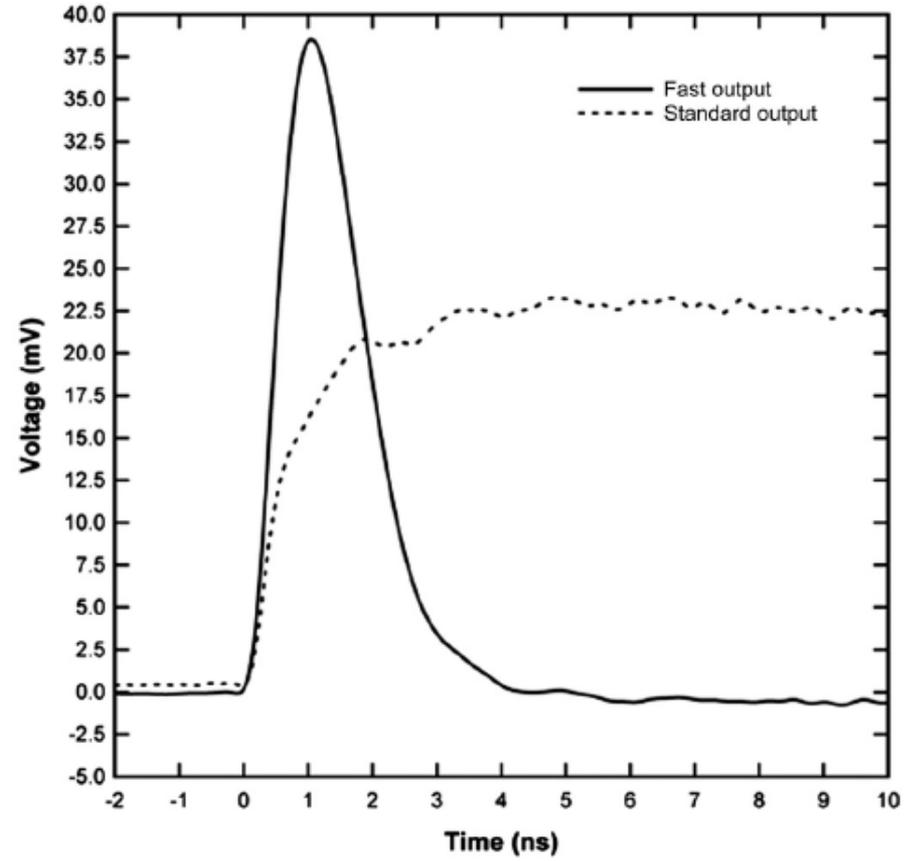
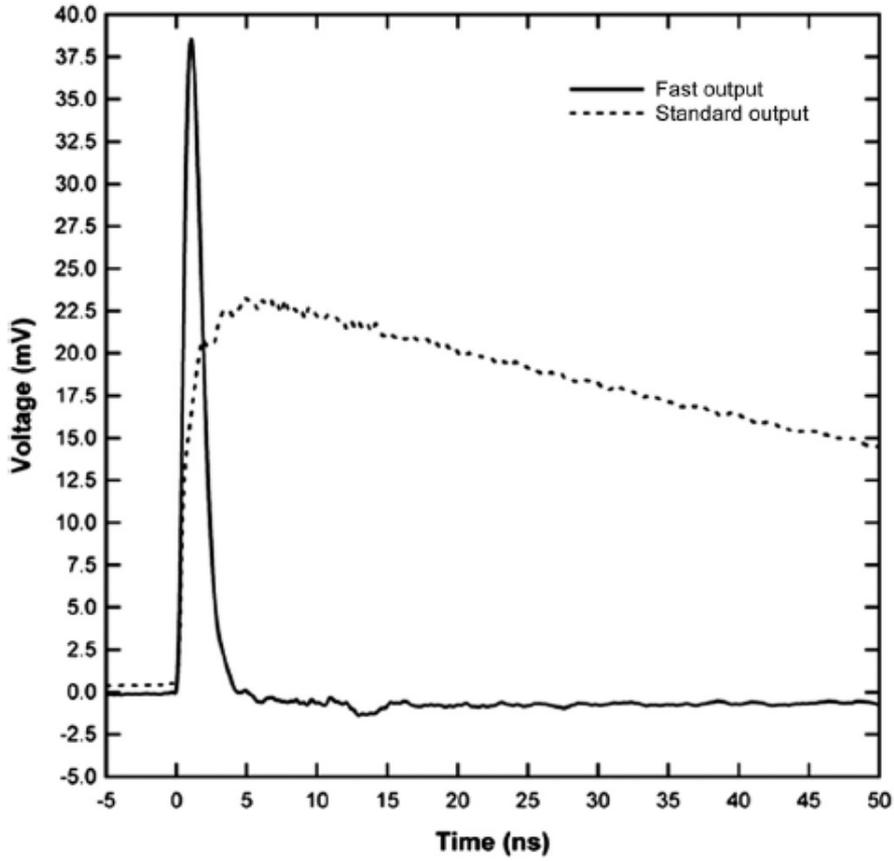
MicroFC-30035-SMT



courtesy of SensL



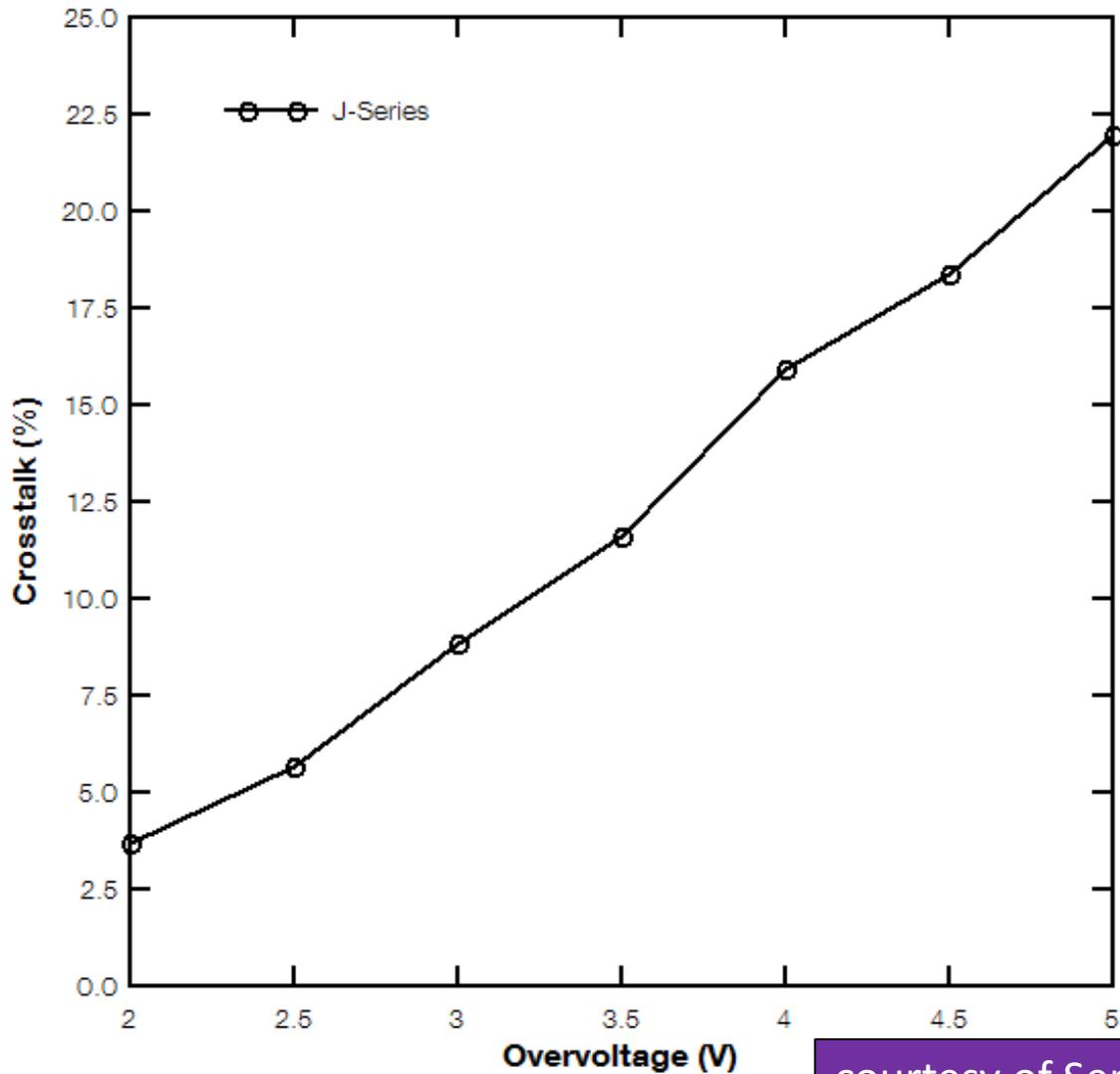
courtesy of SensL



courtesy of SensL

Crosstalk versus Overvoltage

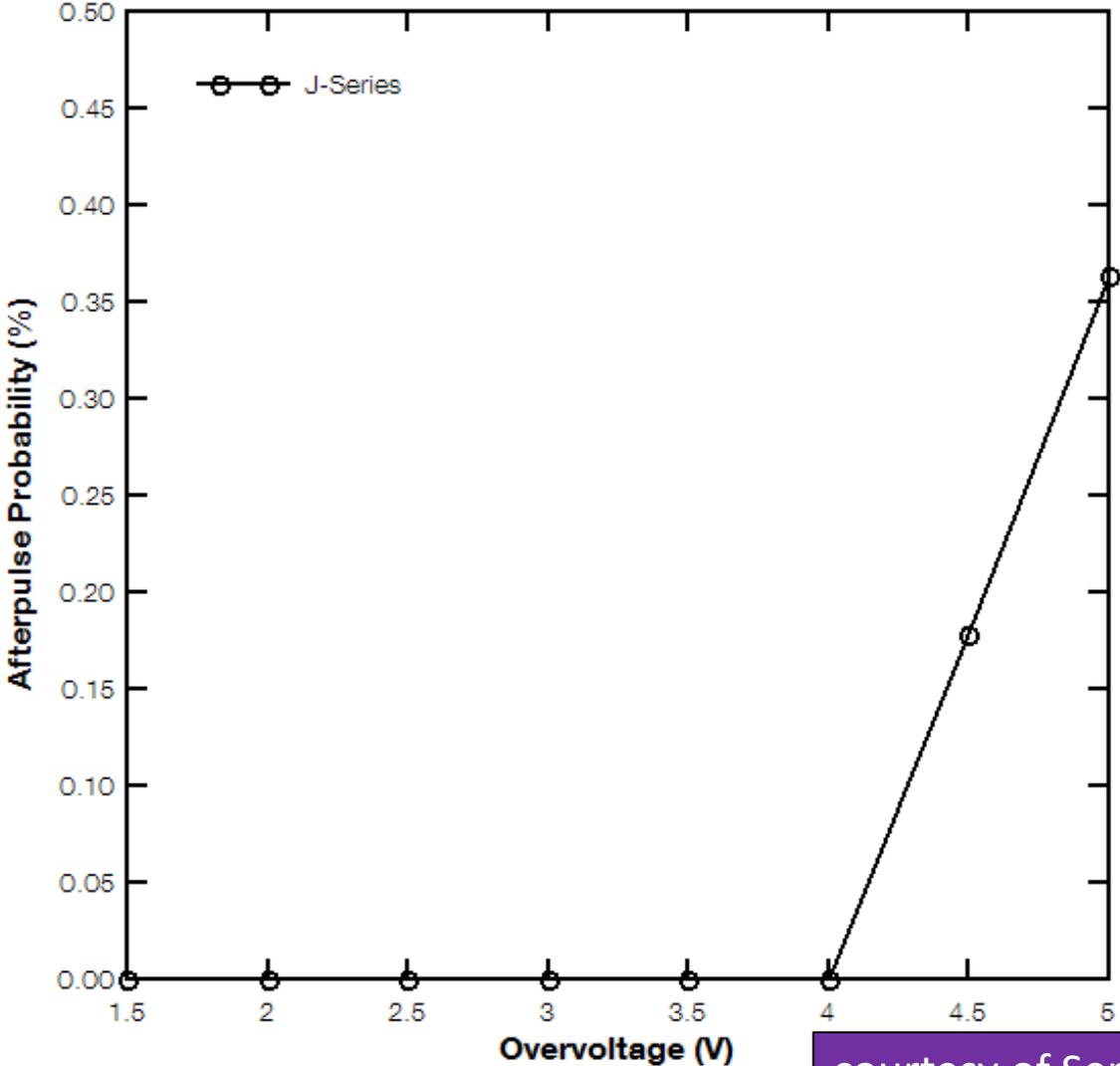
MicroFJ-60035-TSV



courtesy of SensL

Afterpulse Probability versus Overvoltage

MicroFJ-60035-TSV



courtesy of SensL