LAr Anti-Compton veto for HPGe's with SiPM

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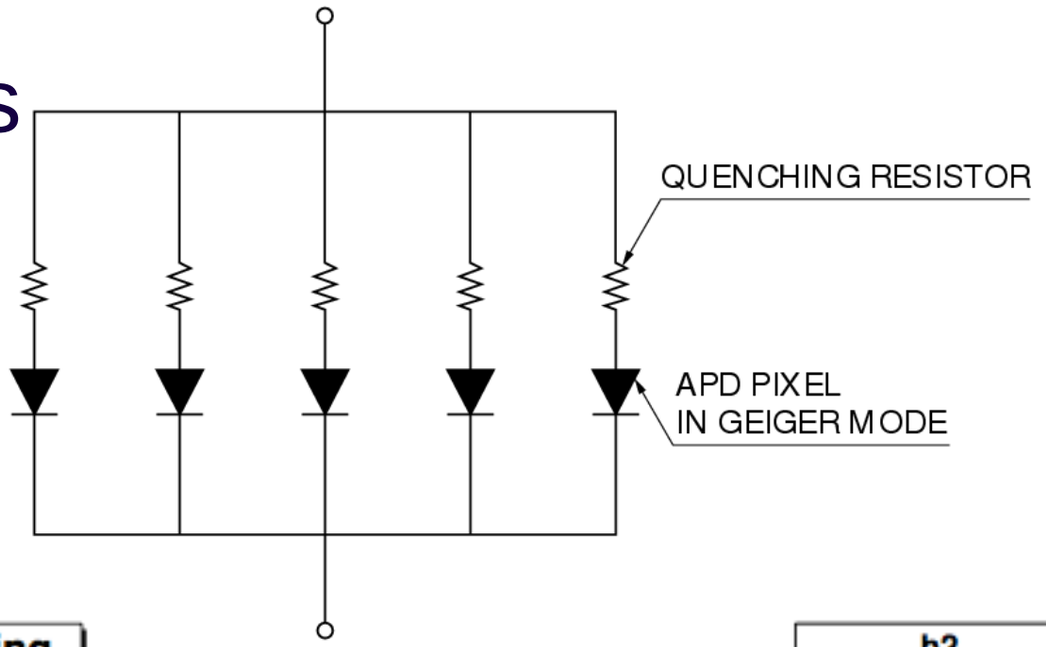
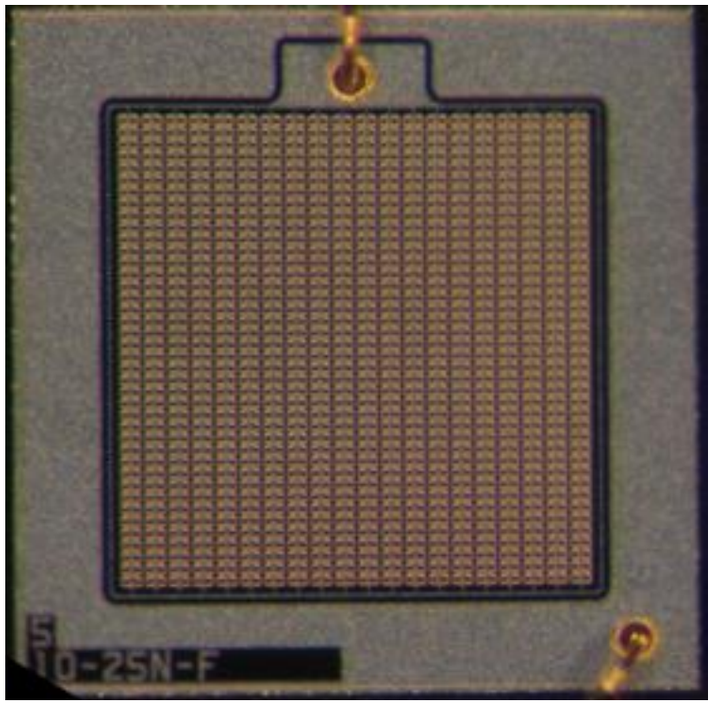
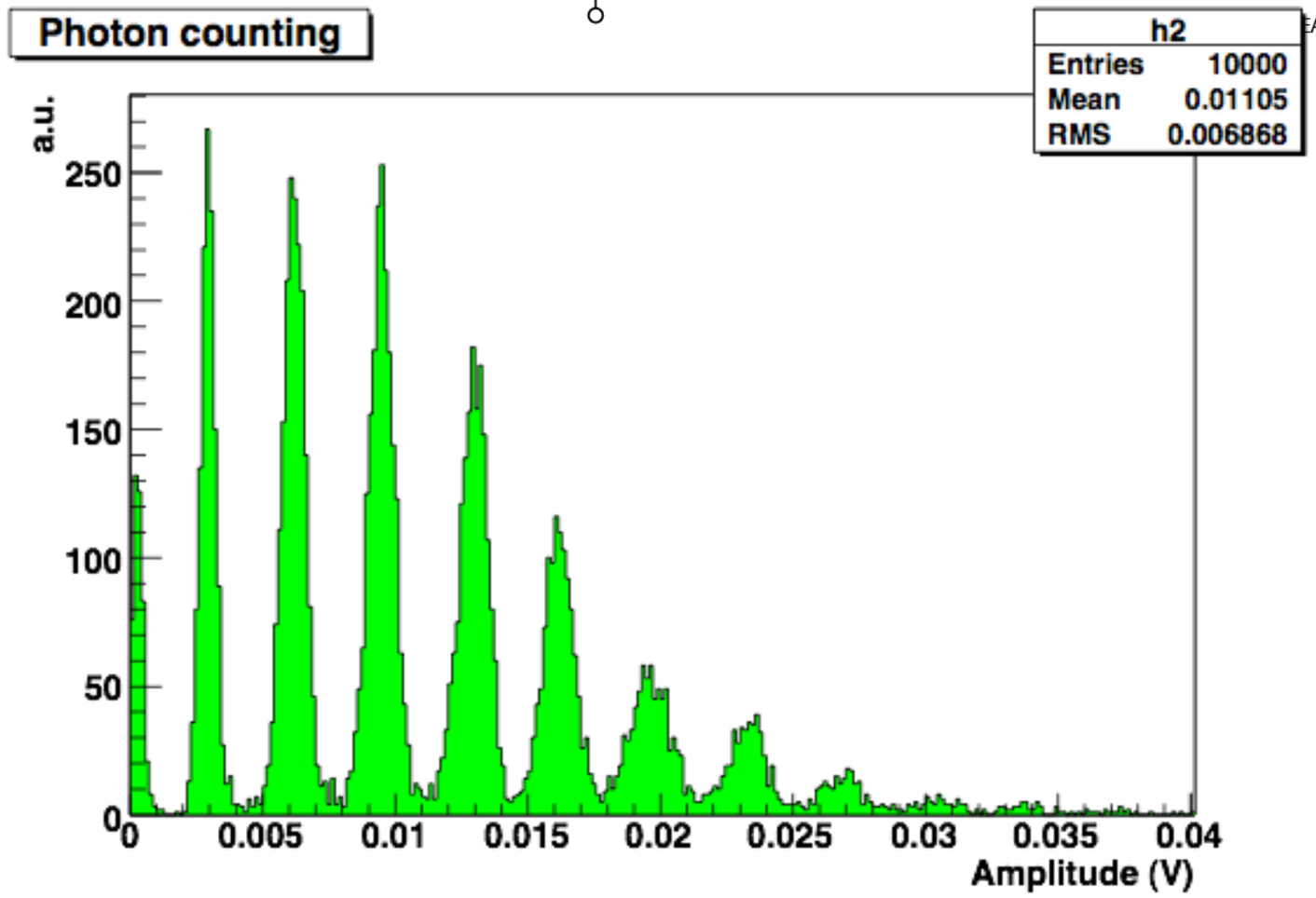
Introduction to SiPMs

- 100 - 1600 Geiger-mode APD cells
- Passive quenching
- Single Photon resolution
- Several commercial producers

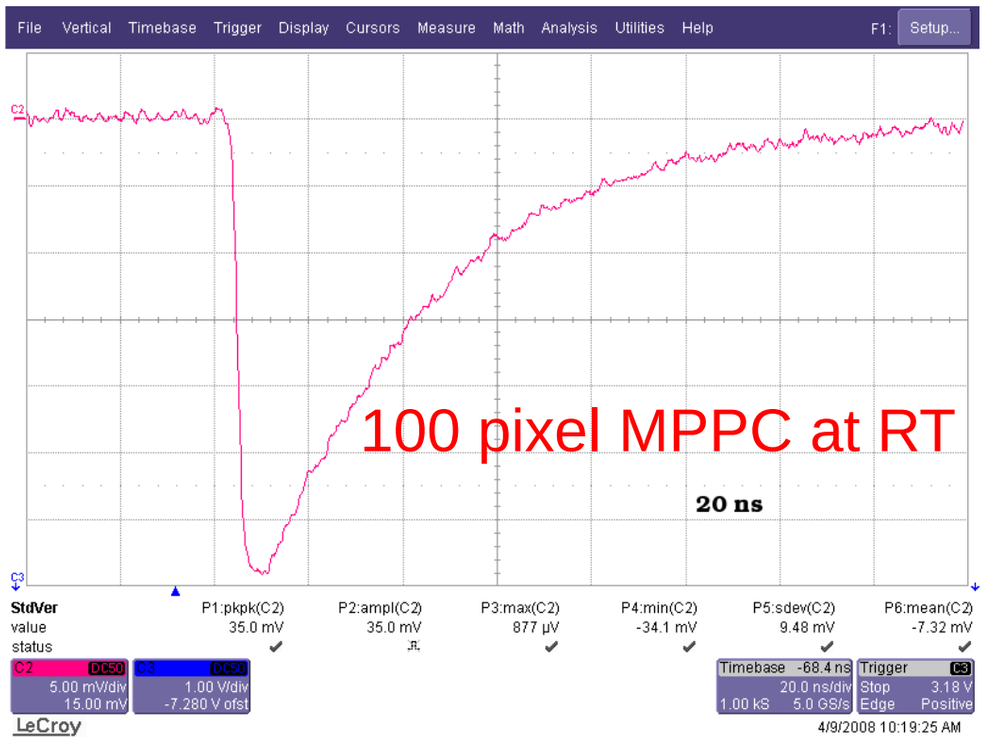


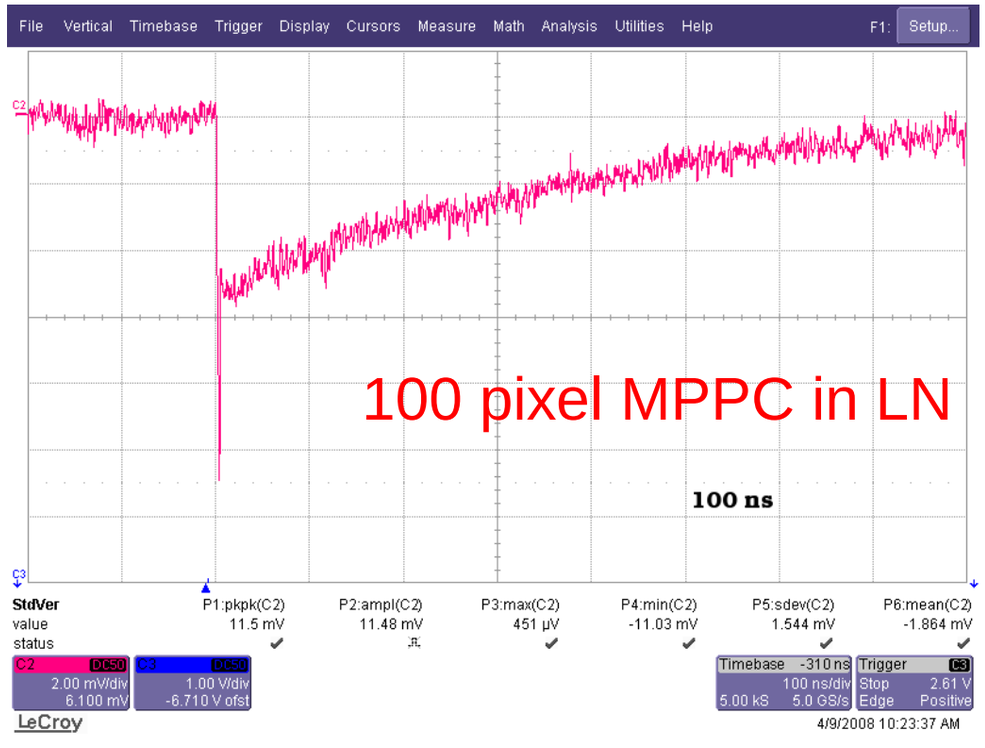


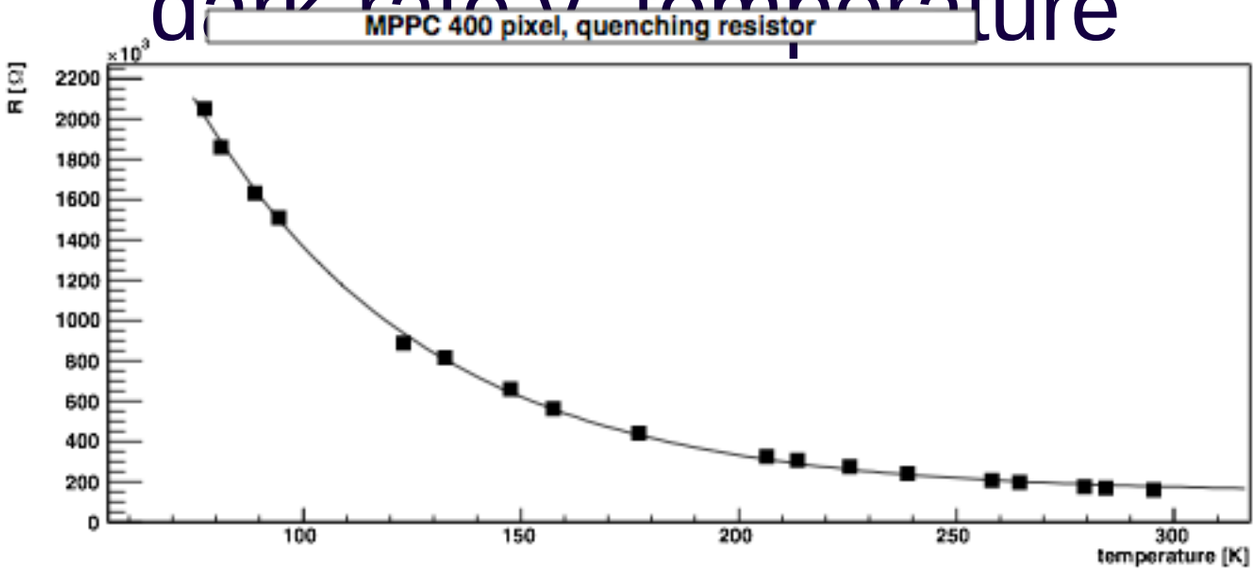


SiPMs in LN

- Tested: Hamamatsu MPPC S10362-11-025C/050C/100C in liquid nitrogen (LN)
- It works at 77 K
- Pulse shape changes - temperature dependent quenching resistor
- Measured , break-down voltage, dark rate v. temperature

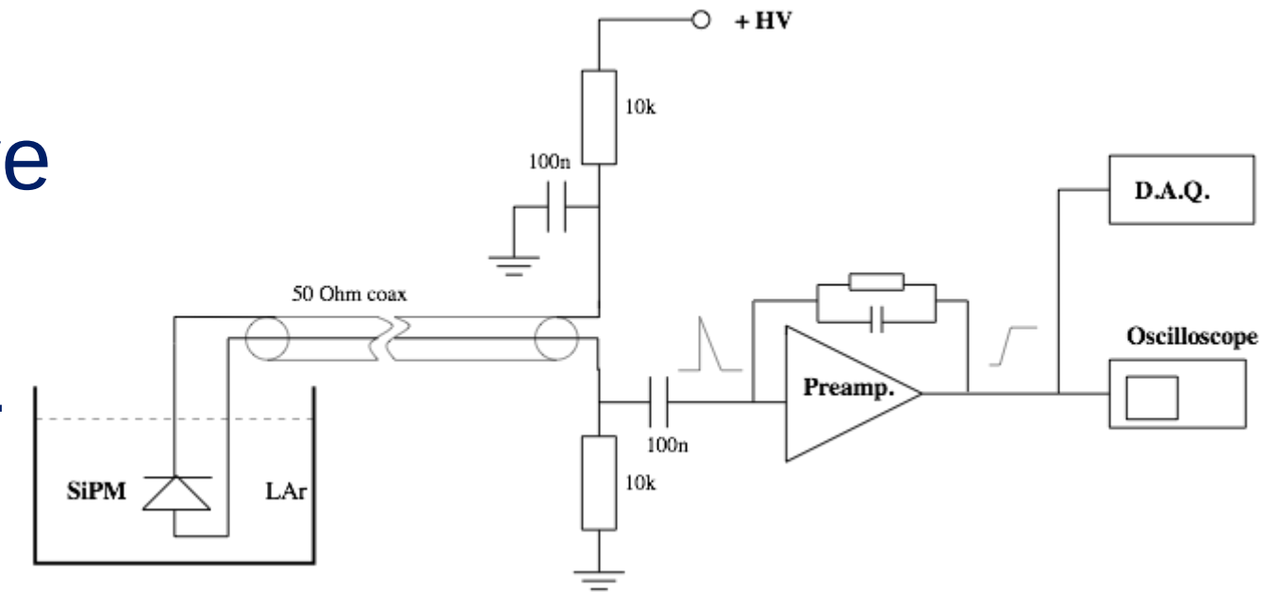


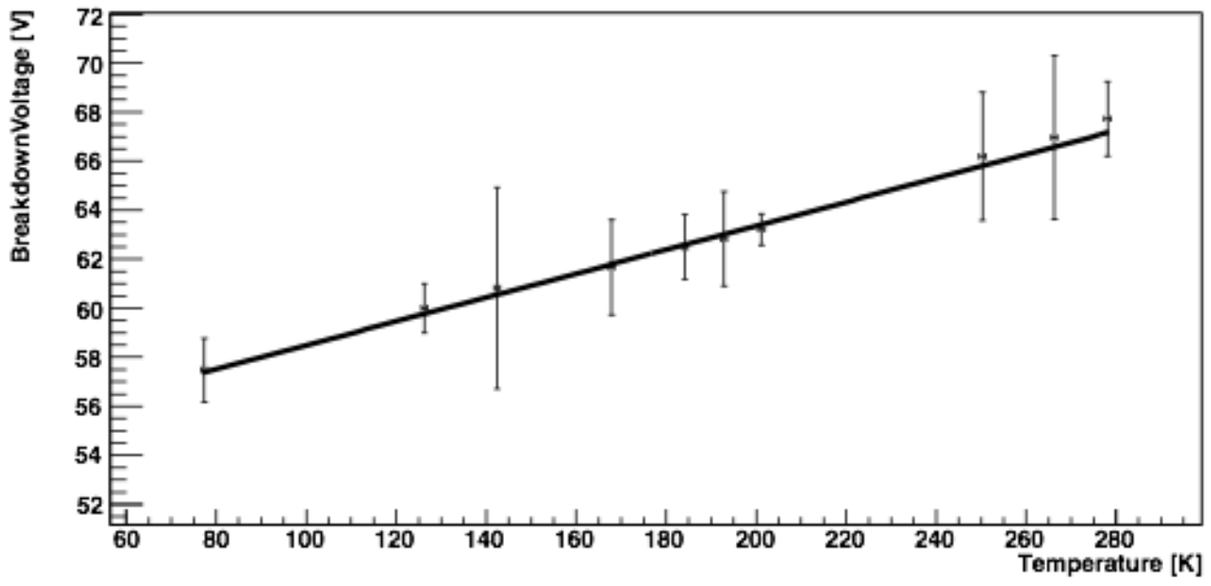




SiPMs in LN

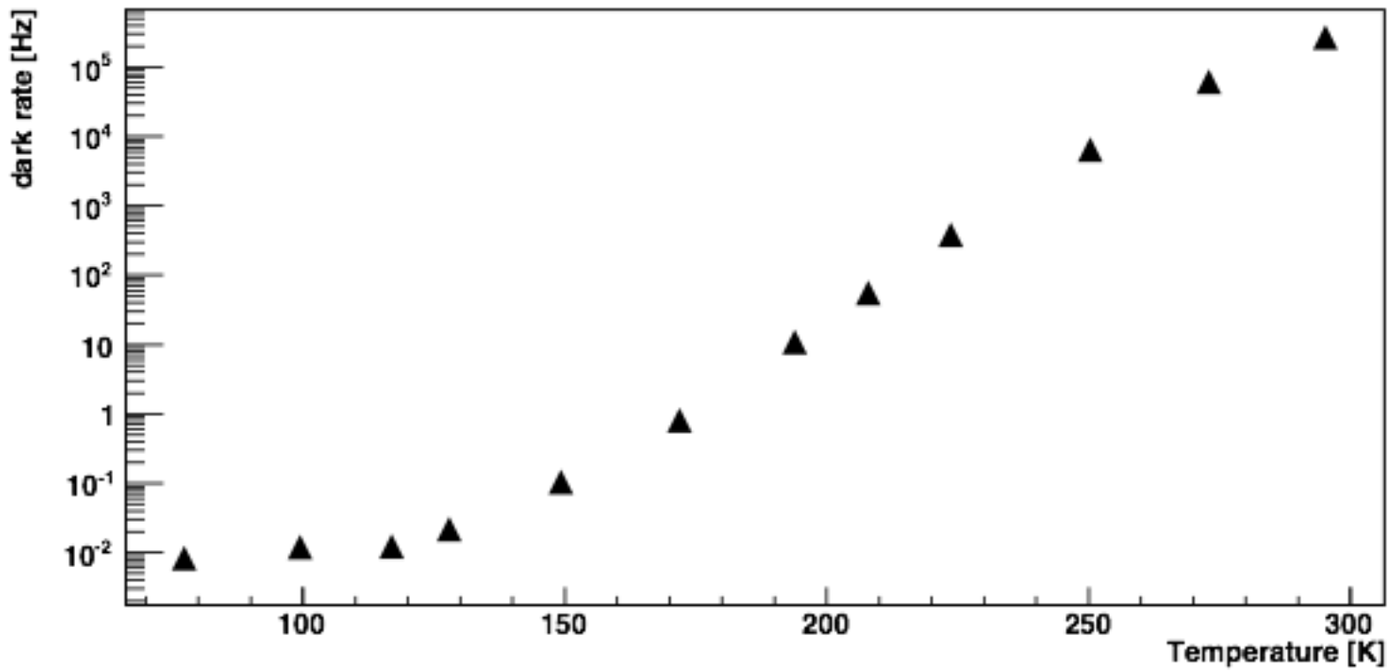
- Long integration time (μs) to recover single photon resolution = Charge Sensitive Amplifiers
- Long cables: preamps at RT
- Long acquisition time to measure dark-rate below 1 Hz = DAQ (XIA Pixie4)
- Same over-voltage over a wide temperature range = we need to know the break-down voltage as a function of temperature



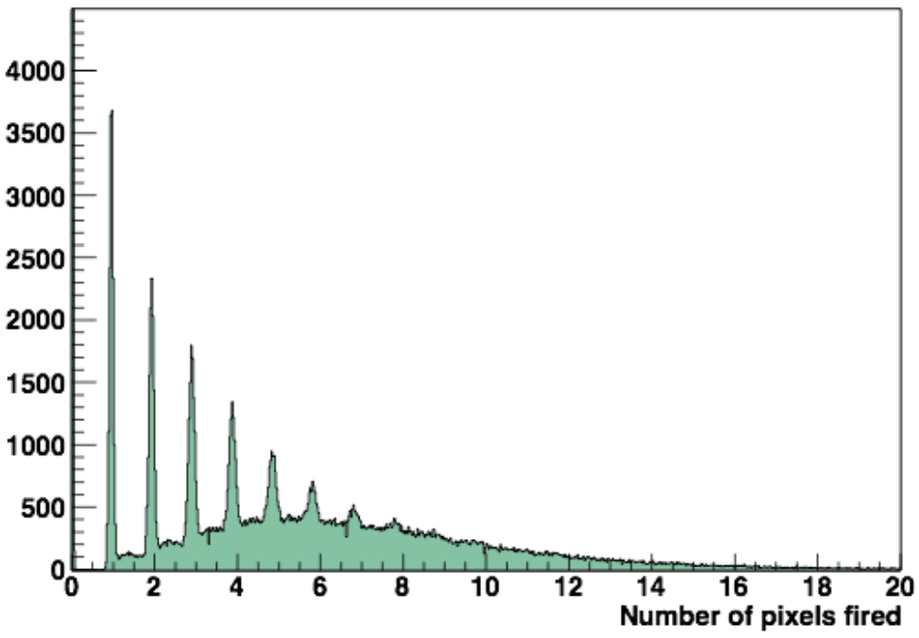


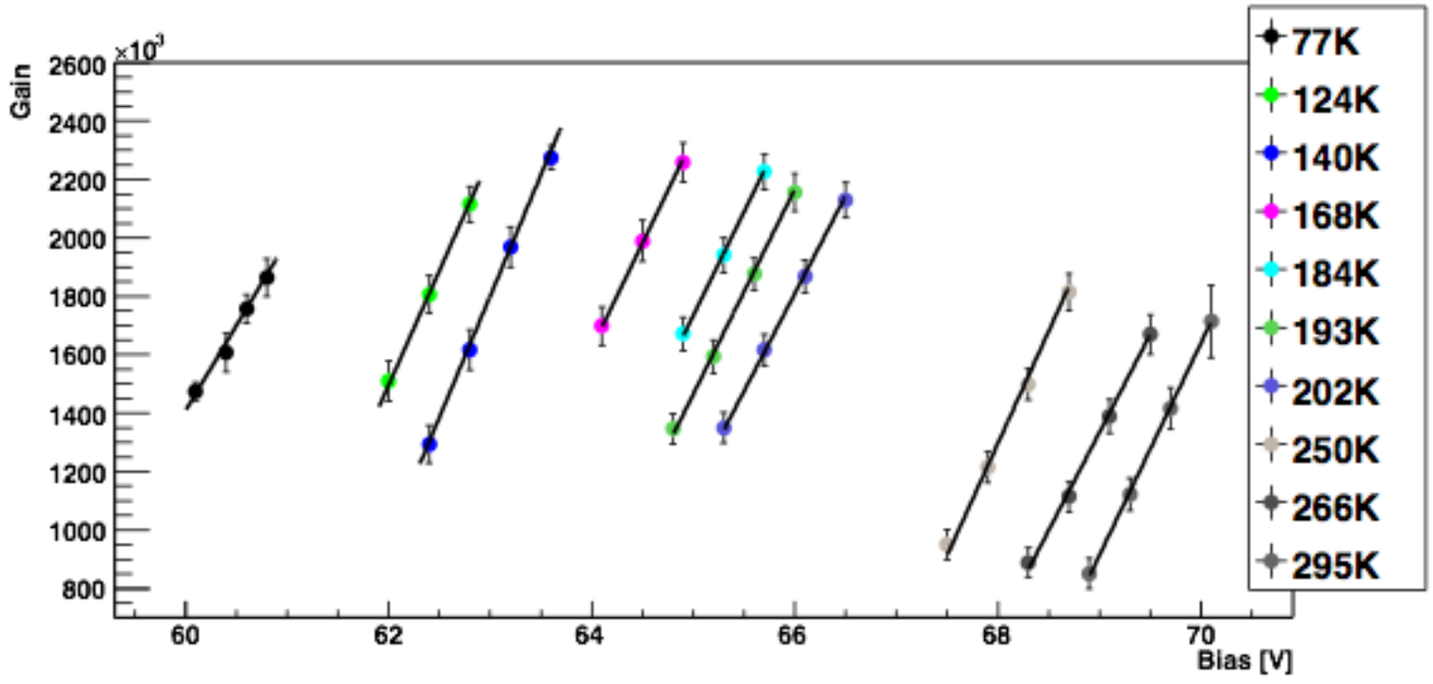
SiPMs in LN

- Dark-rate below 1 Hz in LN
- Gain is about 10^6 , the same as at RT
- BDV 10 V smaller

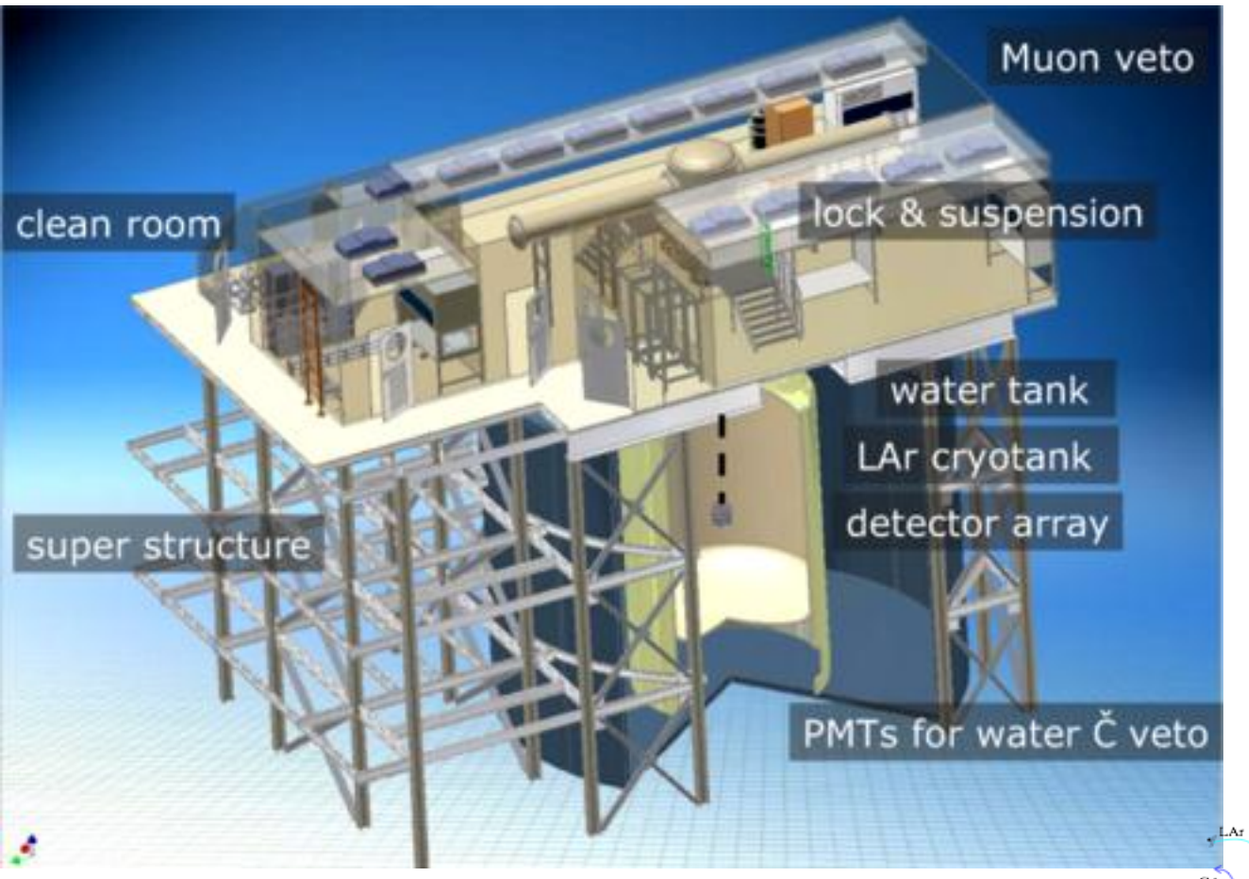


- Single photon resolution preserved



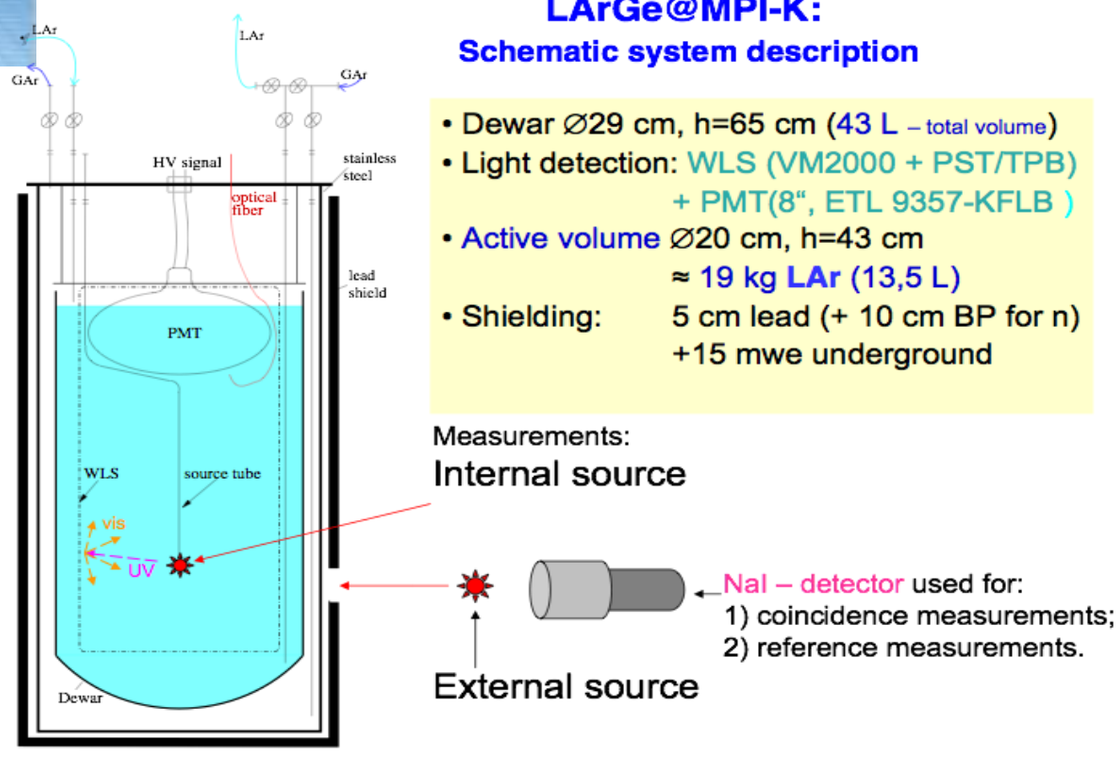


GERDA and related R&D



- The GERDA experiment is being commissioned now
- Bare HPGe are operated directly in Liquid Argon

- LAr instrumentation R&D started at MPIK
- PMTs are too radioactive, bulky, expensive, etc.

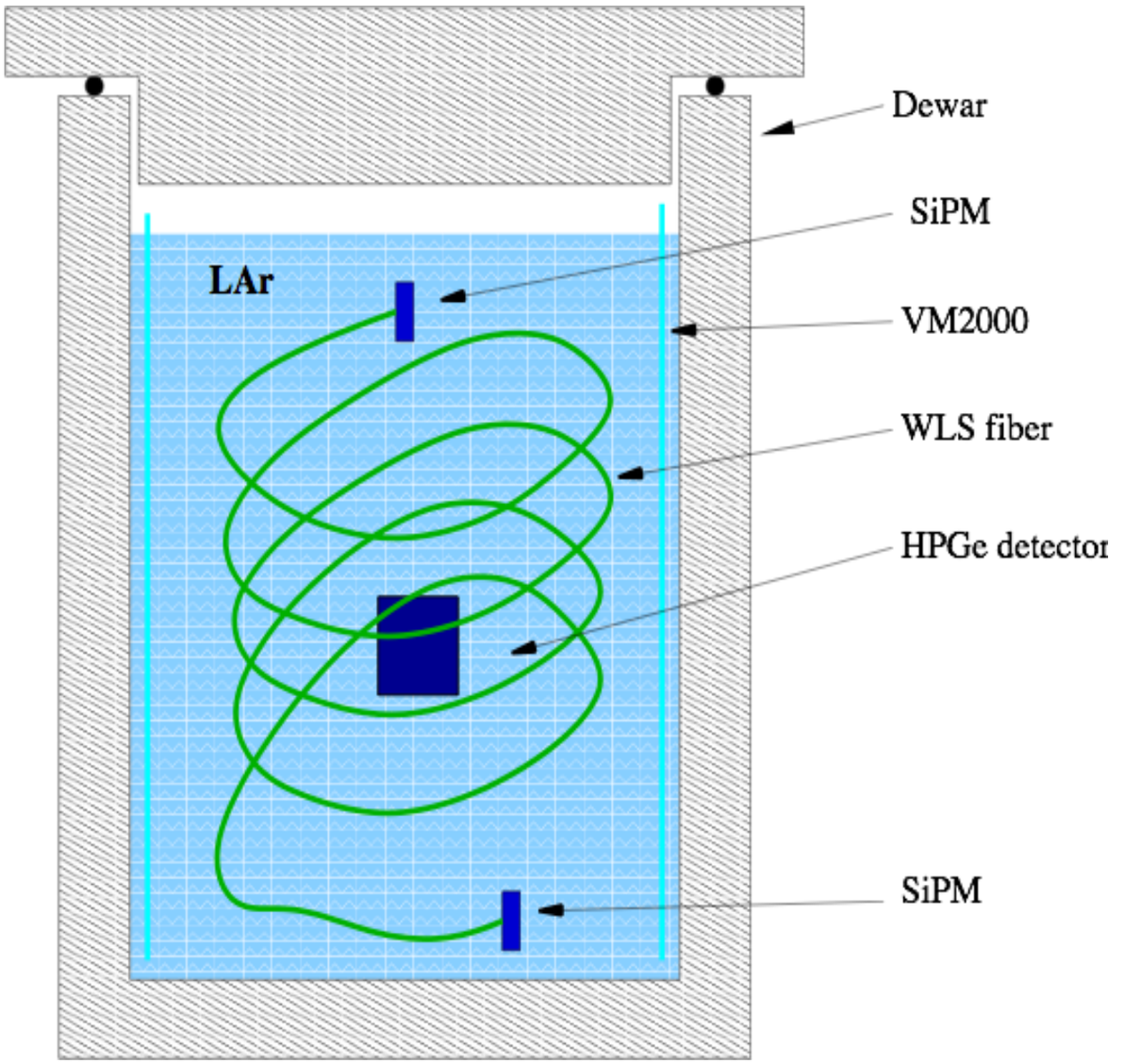


Setup at MPI München

- SiPM are attached to wavelength shifting fibers (WLS)
- Primary wavelength shifter: VM2000 + TPB
- 12 SiPM with 6 - 2.5 m WLS fibers

Major limitations:

- Attenuation length (>3.5 m)
- Low trapping efficiency (7.3%)
- Two step wavelength shifting:
- Spectral efficiency ~ 50%



Wavelength Shifter

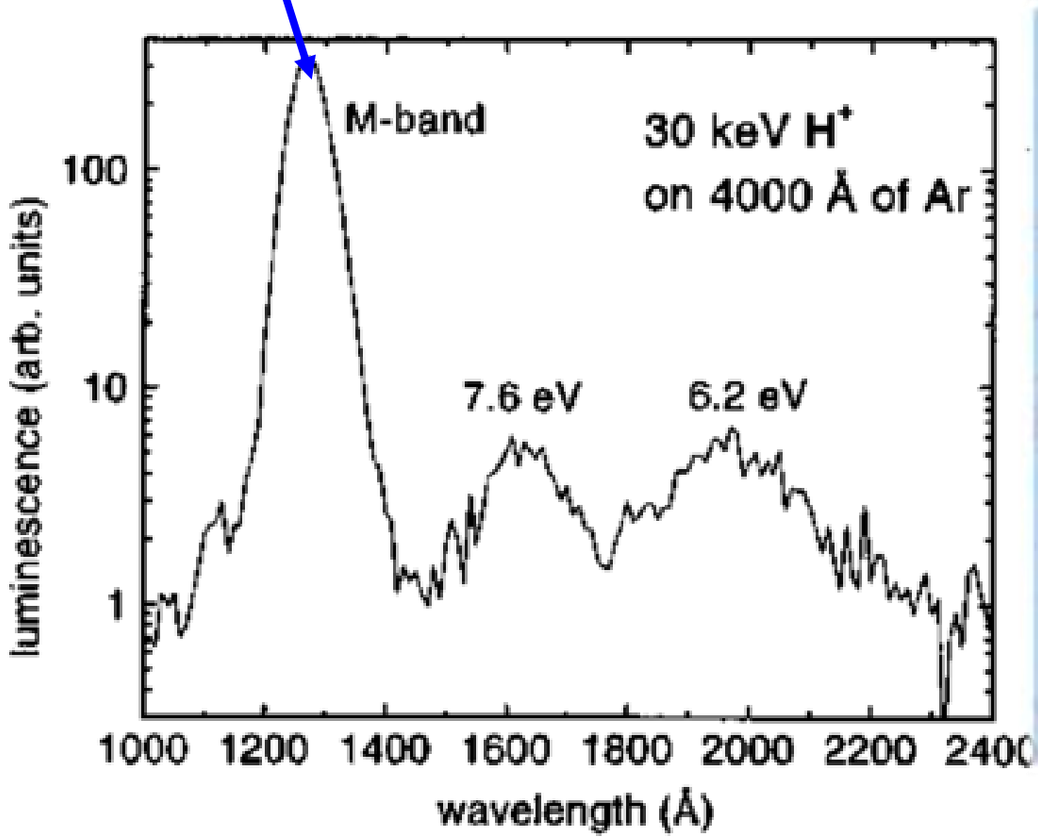
Emitted

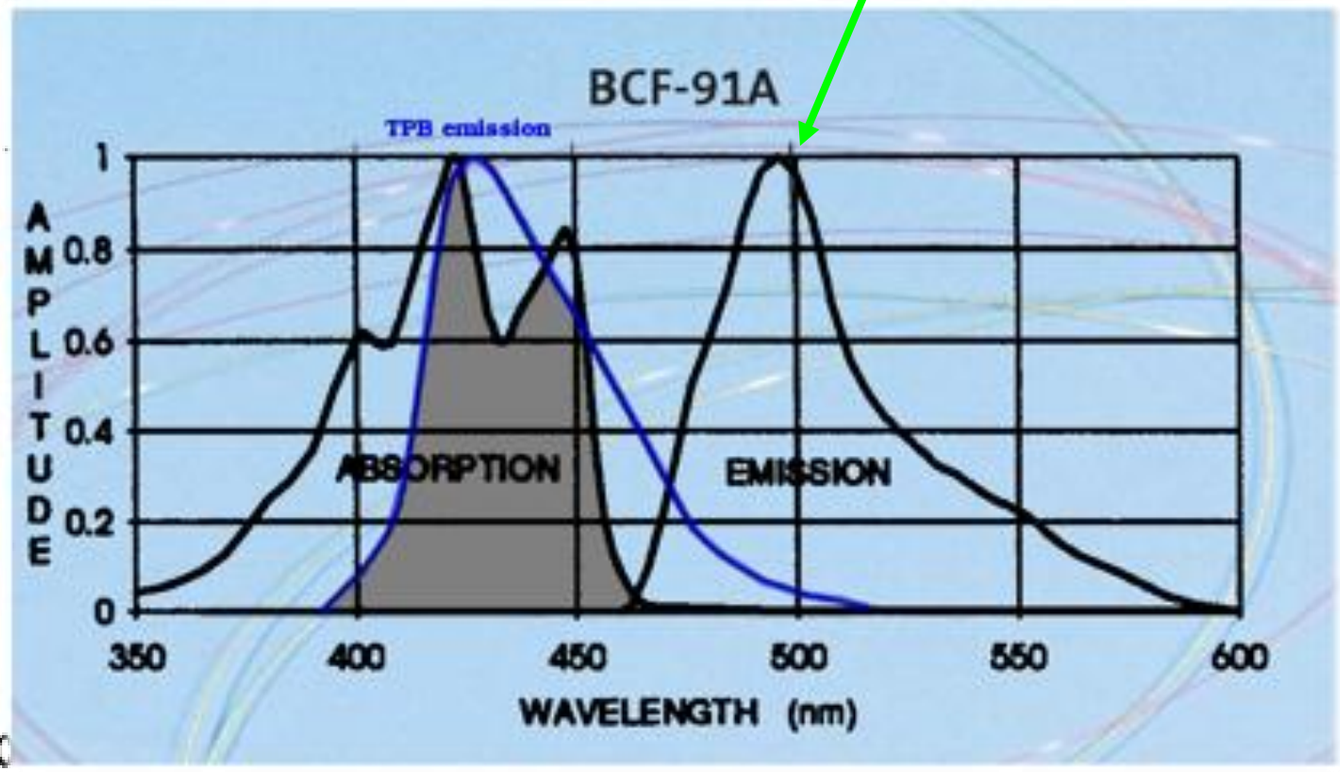
Detected

TPB

WLS fiber

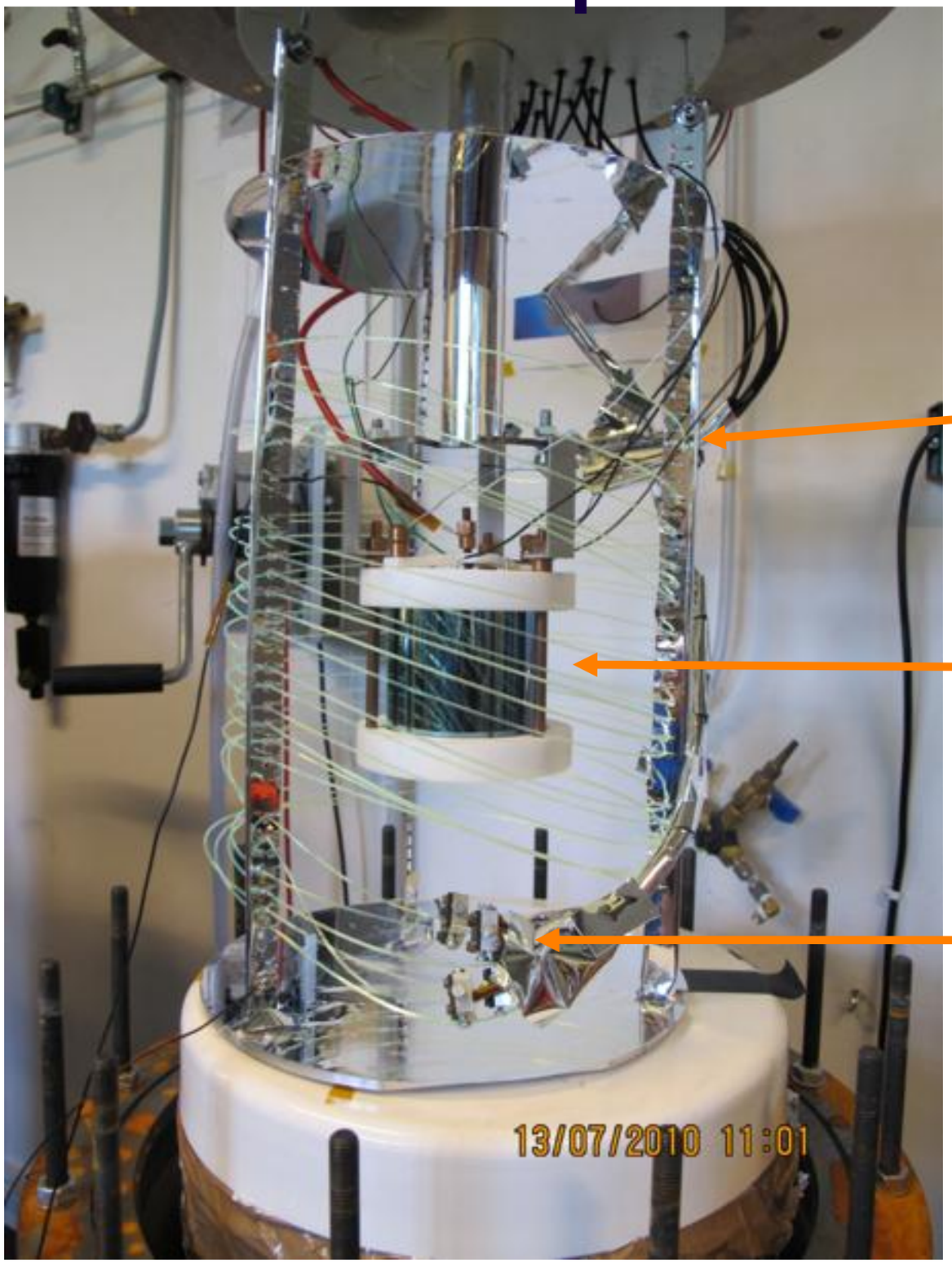
128 nm → 430 nm → 500 nm





Inefficient (~50%), but it works

Experimental Setup

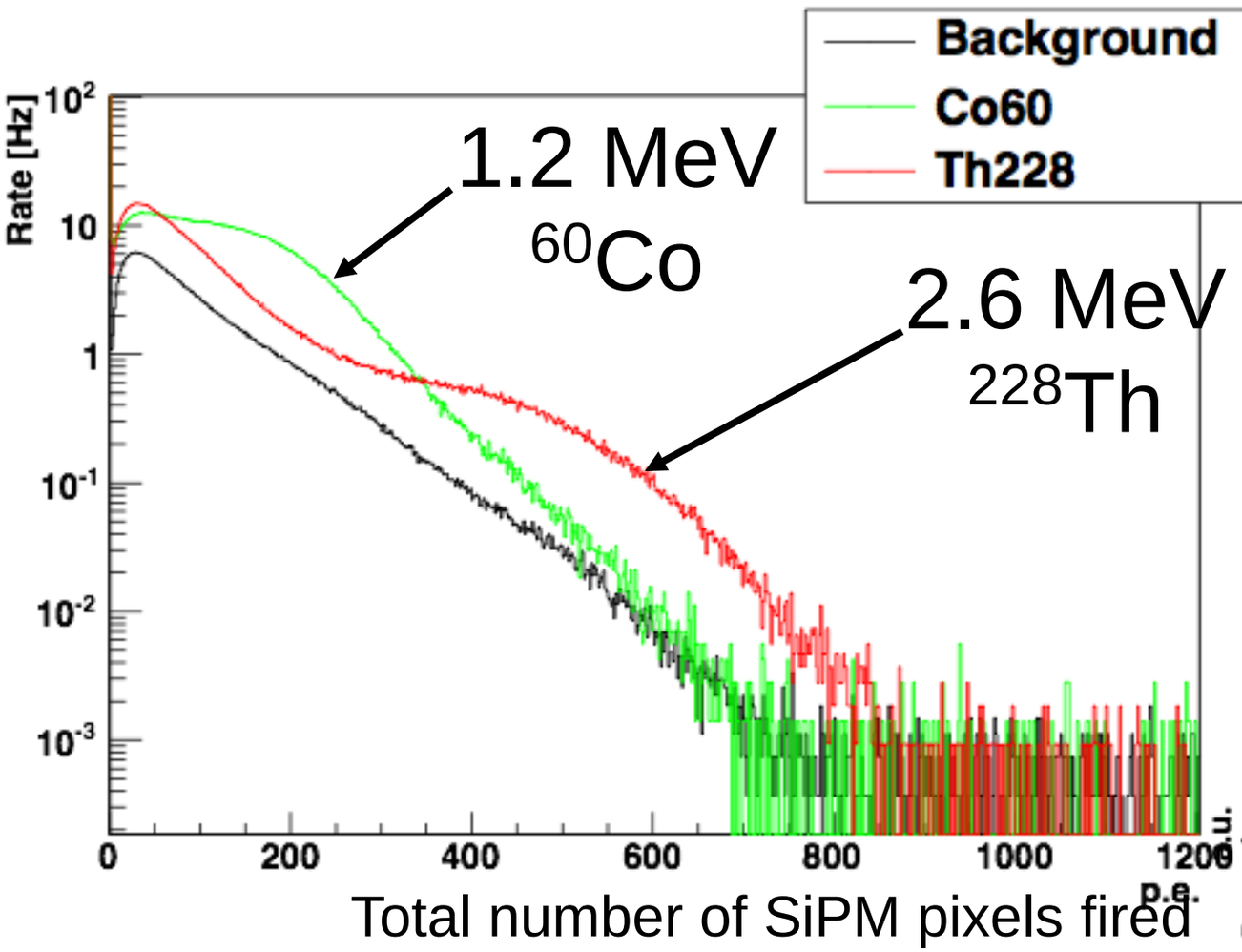


WLS fibers, 15 m in total

6 fold segmented p-type HPGe detector

SiPMs, 12 in total

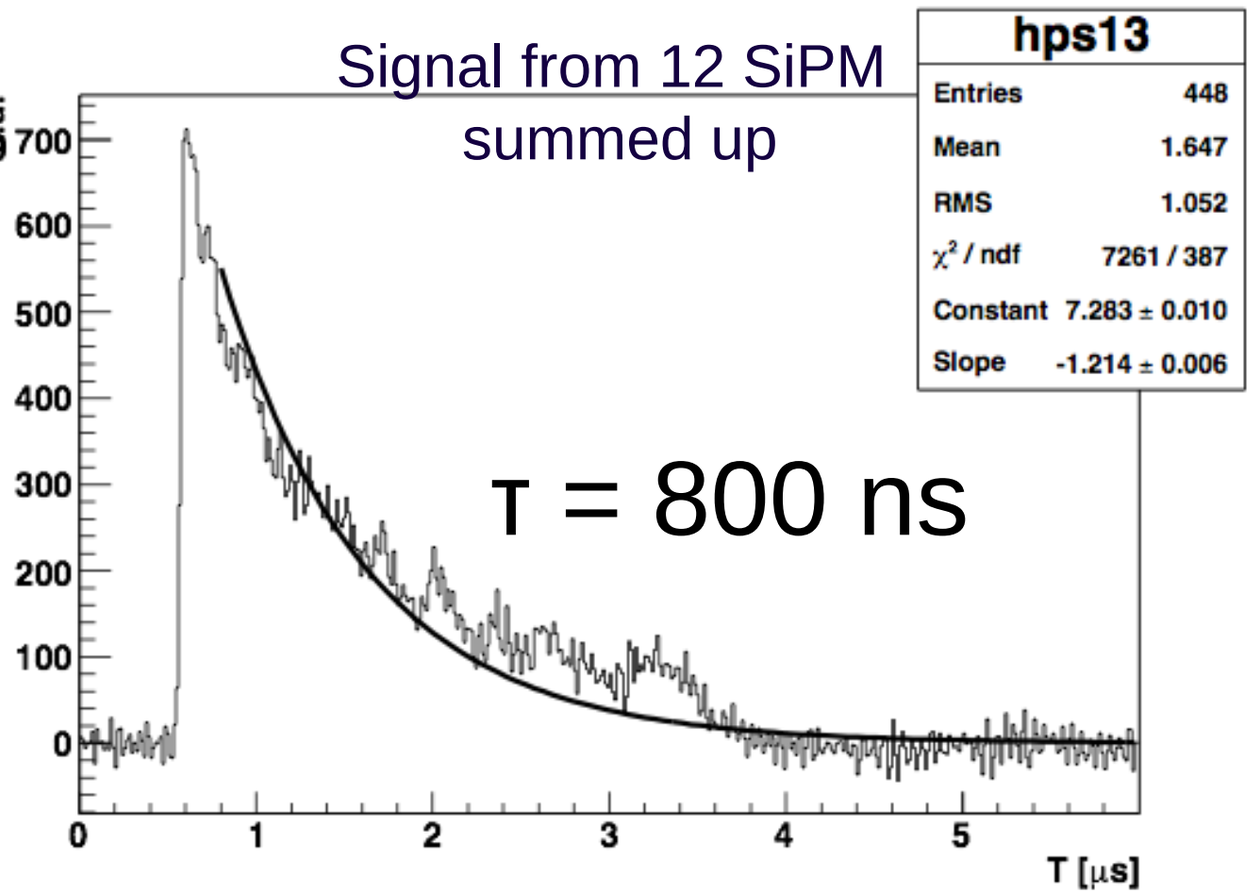
Light Yield (no HPGe)



- The setup reacts to the presence of radioactive sources
- Despite the reduced light yield, about 100 p.e./MeV was achieved

- Triplet decay time should be 1.6 μs (not 800 ns), only 60% of the expected light

Signal from 12 SiPM summed up

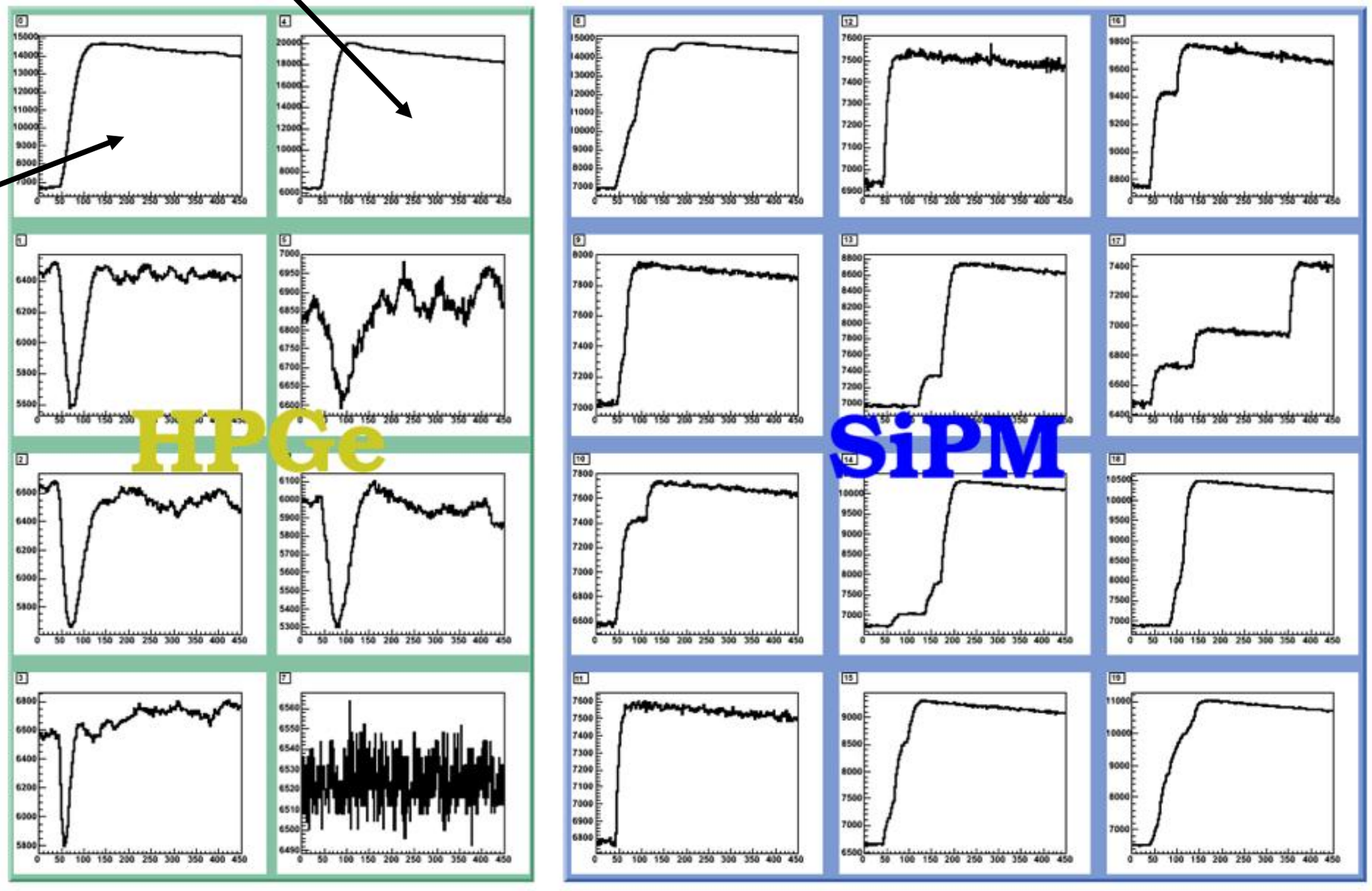


Segmented HPGe + 12 SiPM

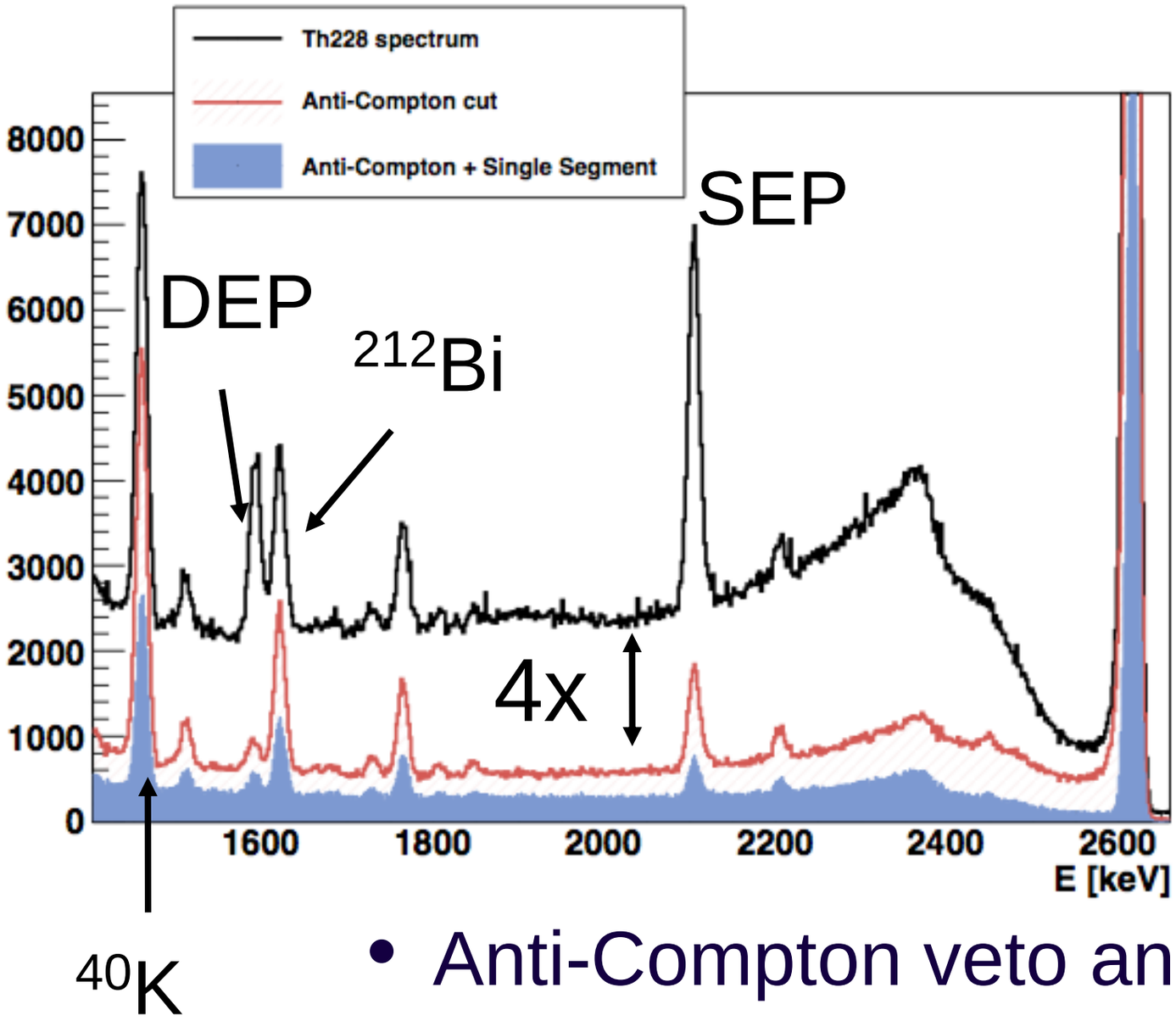
Single Segment Event

12 x veto

Core Channel



Anti-Compton Veto



- 4.2 fold suppression achieved around 2MeV
- factor 6.2 suppression of the DEP

- Anti-Compton veto and Single Segment cut

(and/or Pulse Shape Analysis) are complementary

Activity measurement

- The motivation for all this work is to find a light detection solution for low activity experiments
  - ✶ Activity of the WLS fibers was measured at LNGS with the GeMPI detector

	^{226}Ra mBq/kg	^{228}Th mBq/kg	^{40}K mBq/kg
BCF-91 WLS fiber	<16	<16	<150
PMT glass *	820±230	130±12	500±120

* Astroparticle Physics 18 (2002) 1-25

Conclusion

- SiPMs (Hamamatsu MPPCs) tested in LN
- Liquid Argon scintillation light detected with SiPMs and WLS fibers
- Anti-Compton veto for HPGe detectors was tested with success
- Suppression factors comparable with a PMT setup were achieved