Position sensitive scintillation detector for gamma spectroscopy

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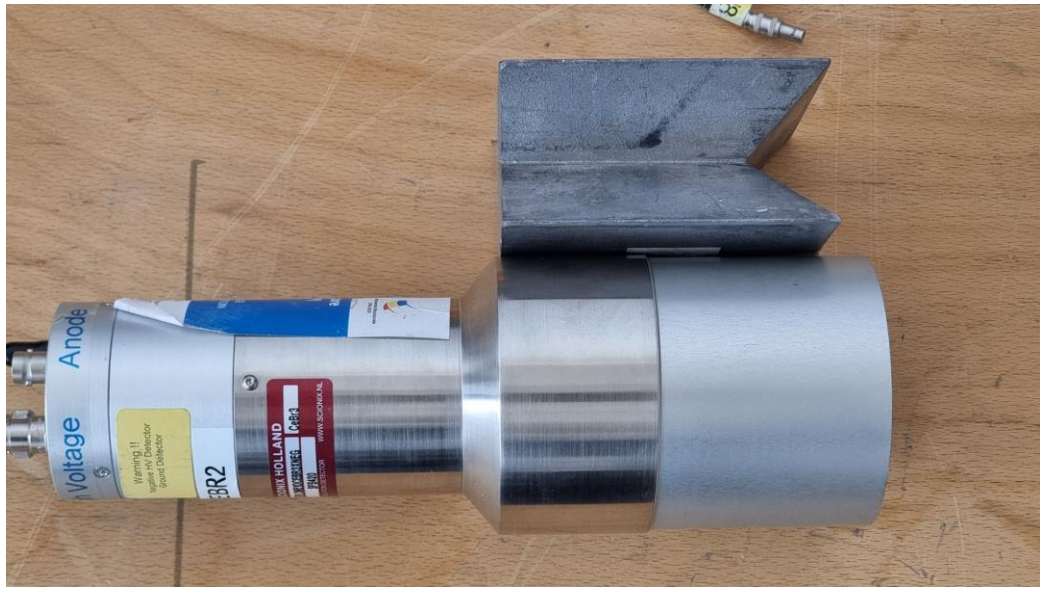
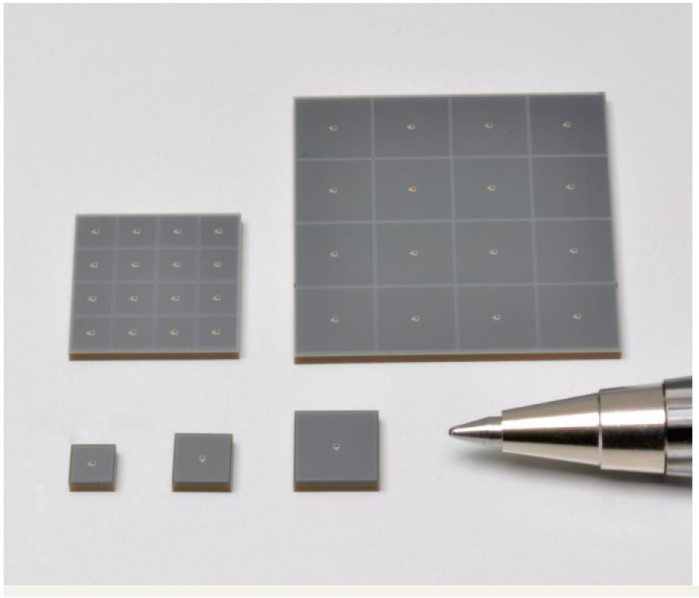
Gamma spectroscopy using scintillation detectors

- Scintillation detectors - scintillation crystal paired with a photomultiplier
- Information about gamma counts, energy and timing.
- No information about interaction location

- Too large setups for positioning with regular photomultiplier tubes
- Use of Silicon Photomultipliers (SiPM) to reduce scale of setups



$CeBr_3$ scintillation detector



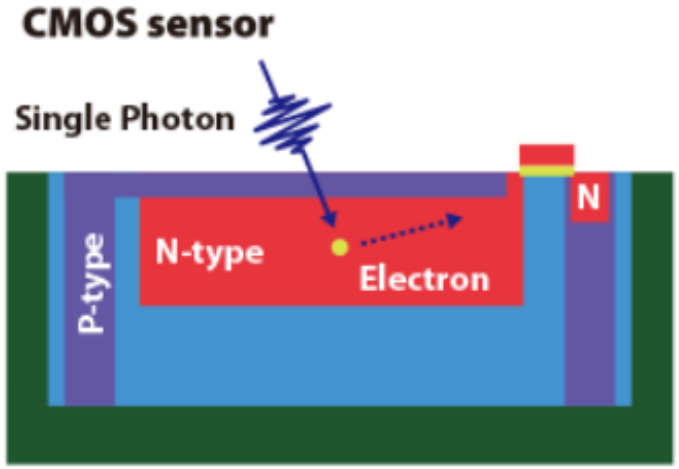
Multiple size SiPMs

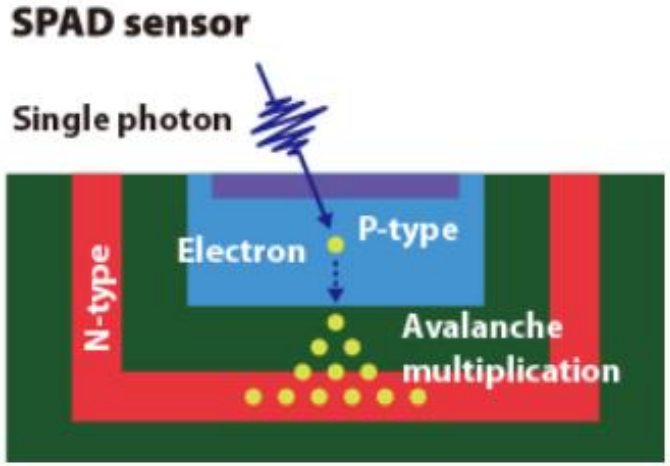
- SiPMs more suitable for determining particle interaction location

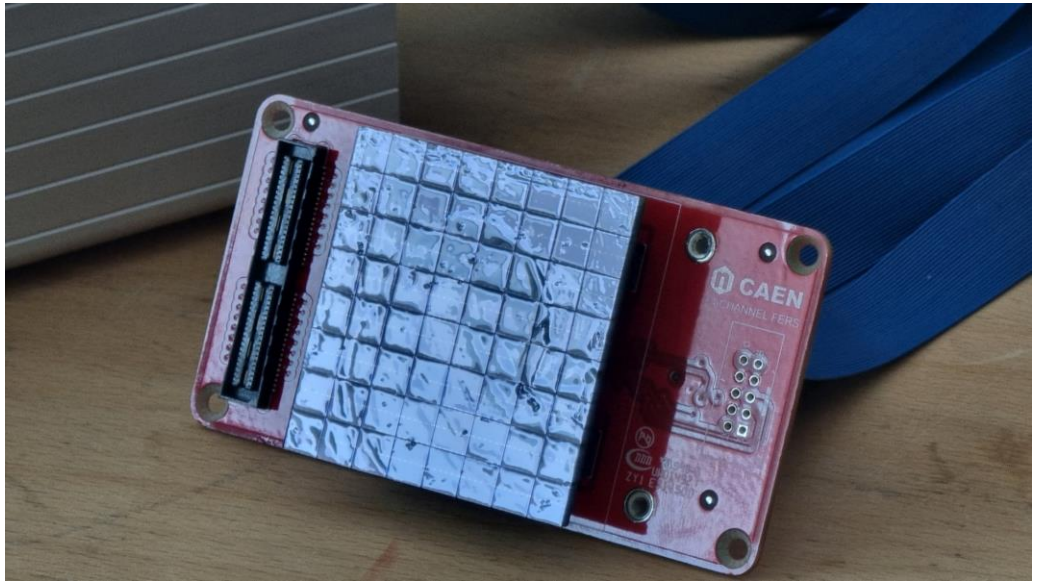
Construct and characterize a position-sensitive detector using an 8x8 SiPM array and a thin, flat CsI crystal

How do SiPMs work?

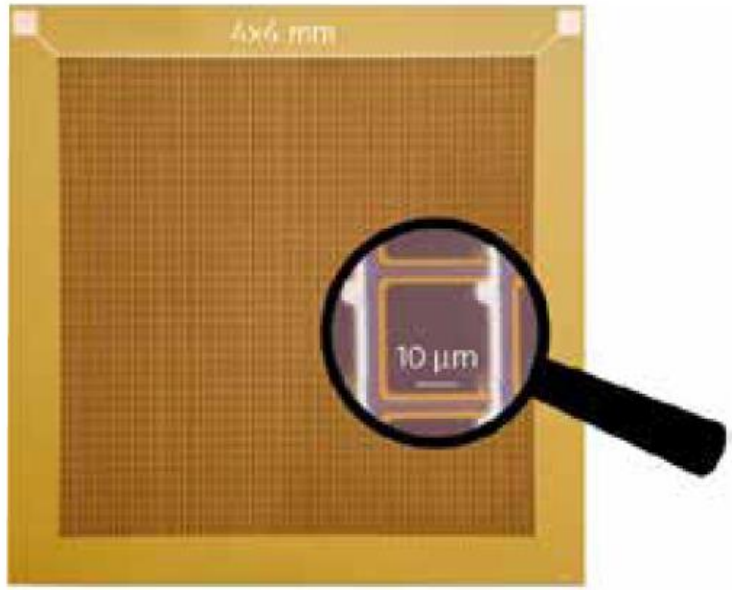
- Made of many SPADs (Single-Photon Avalanche Diodes).
- SPADs allow photon counting
- Similar to a normal photography camera







The 8x8 matrix of SiPMs used

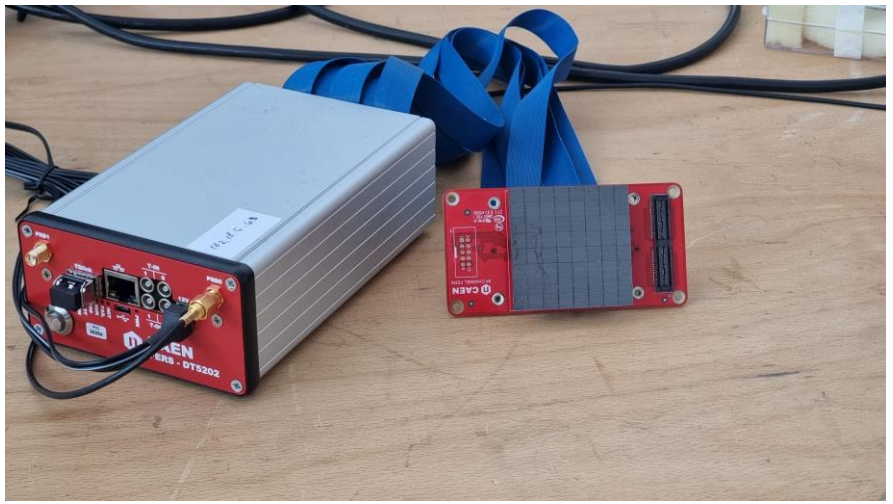


4x4mm SiPM made of many 10µm SPADs

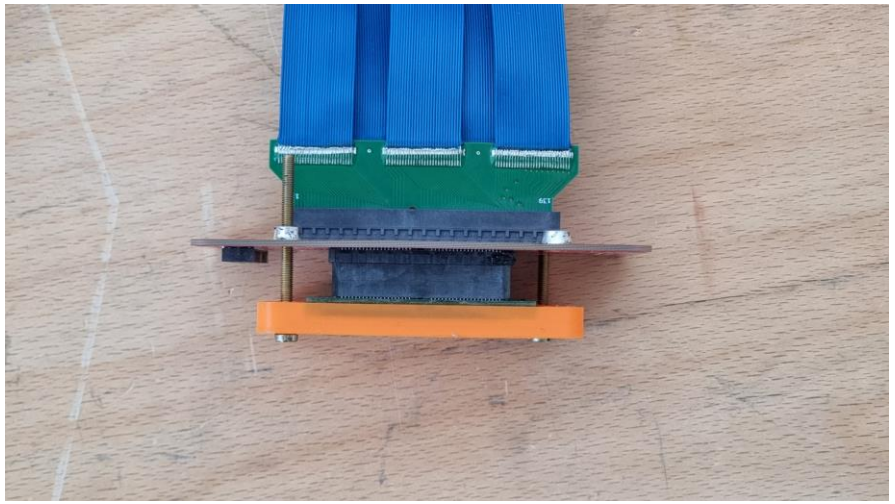
Detector construction

- CsI scintillator paired with an 8x8 SiPM array
- Encasing for stray photon prevention
- Electronic module to collect data from each SiPM

Cylindrical and flat scintillation crystals



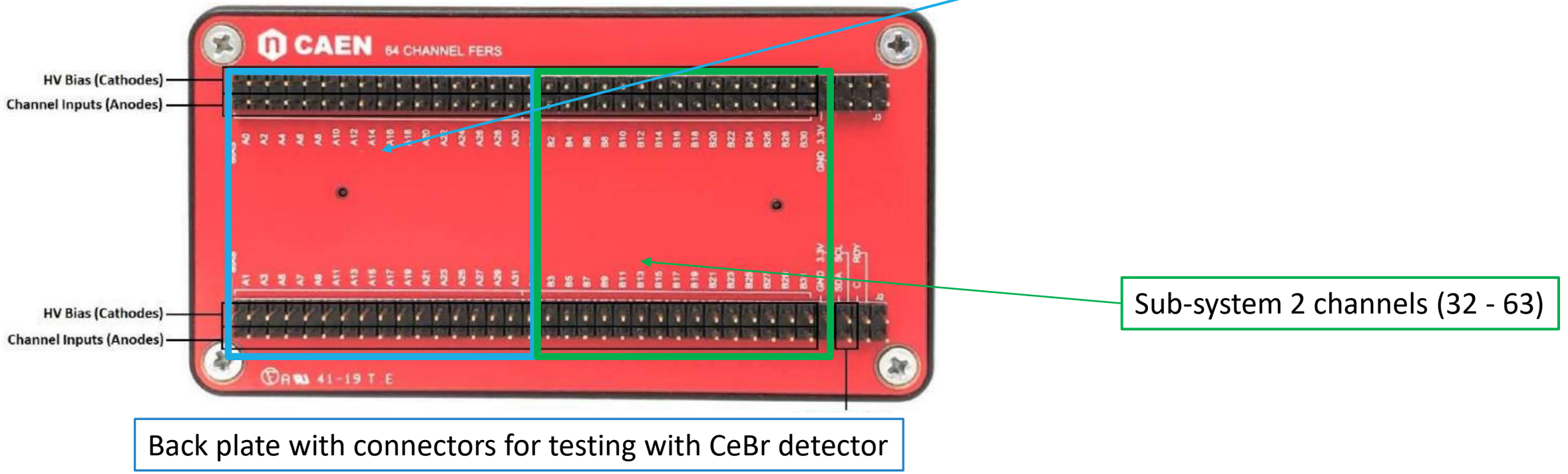
Connected 8x8 SiPM array



The flat scintillator installed

Detection assembly used

- Electronic module with two sub-systems, each handling 32 channels
- Control the voltage applied to each channel (SiPM)
- Read and process signal from each channel



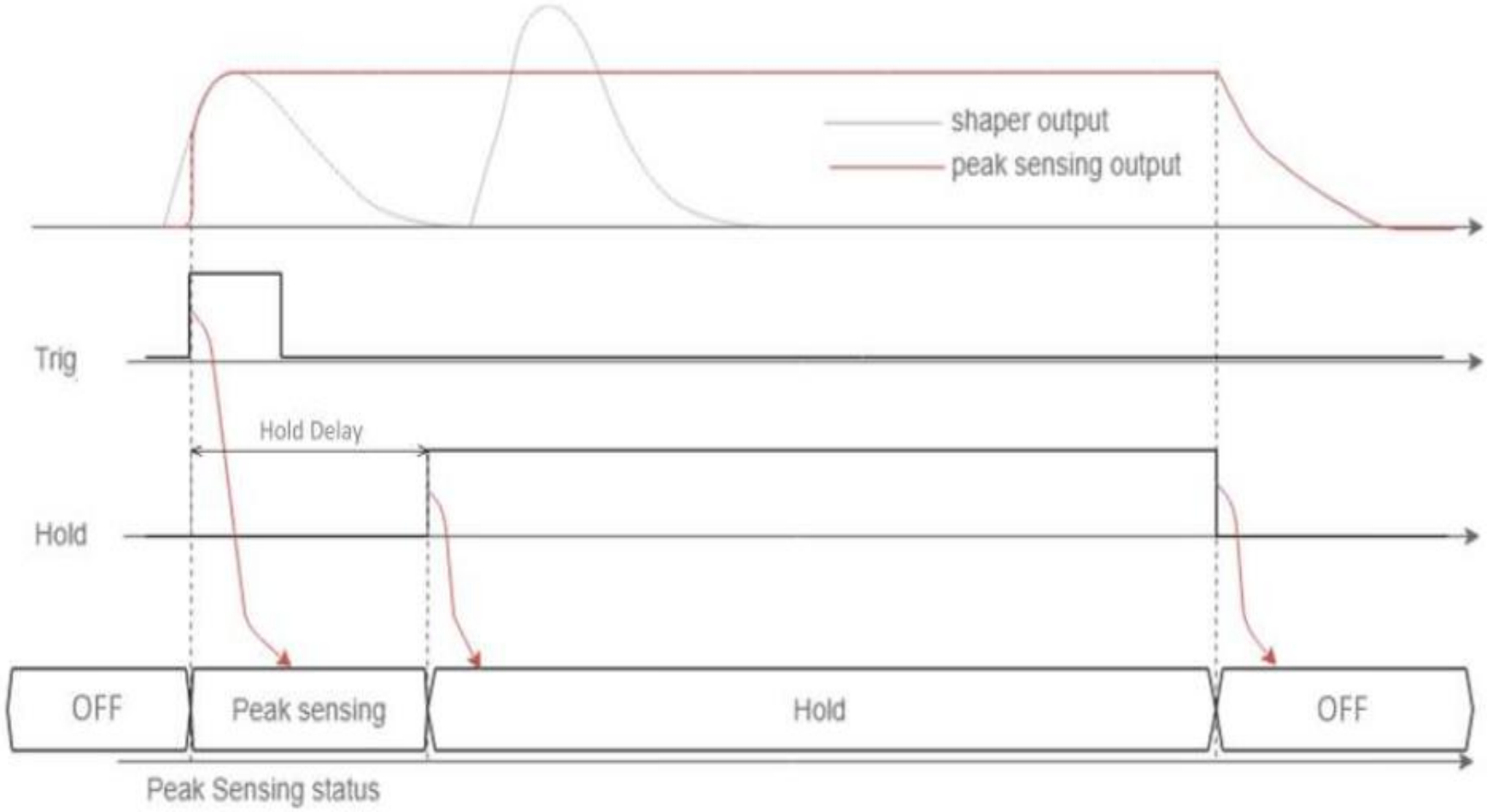
- Use of algorithms to reconstruct X and Y coordinates of interaction location

Peak sensing

Two parameters control the processing of signals from SiPMs:

- Shaping time: controls time constant of peak shaper
- Hold delay: time interval between the trigger start and hold signal

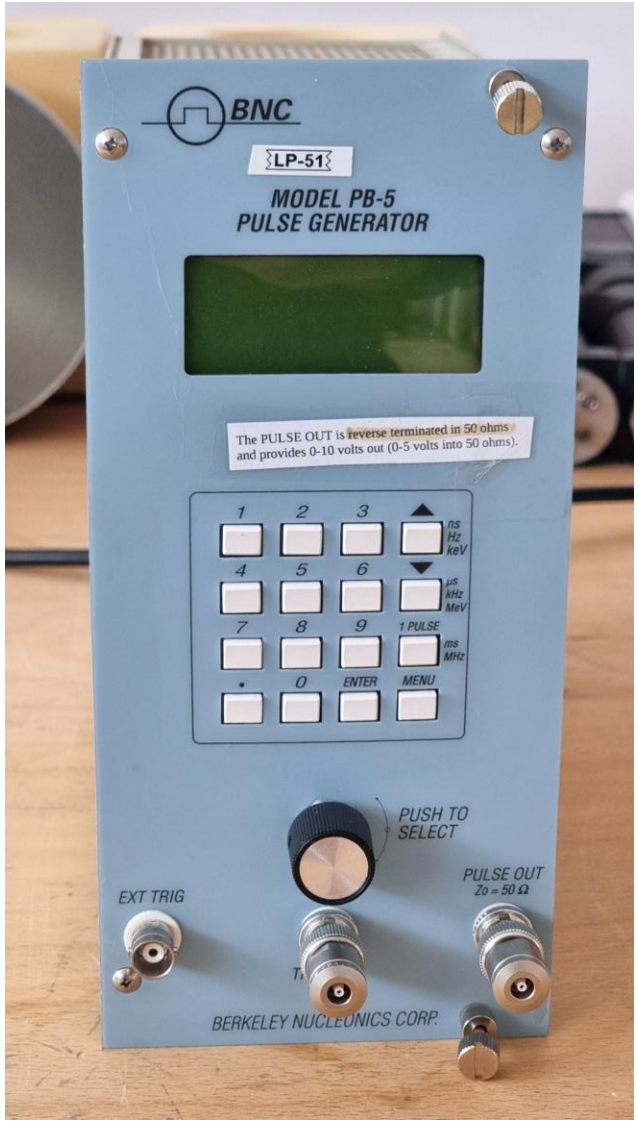
- Off phase: peak detector is off
- Peak sensing phase: when the trigger arrives, the peak detector holds the amplitude
- Hold phase: no other input signal is detected, the peak detector is disconnected from the shaper output

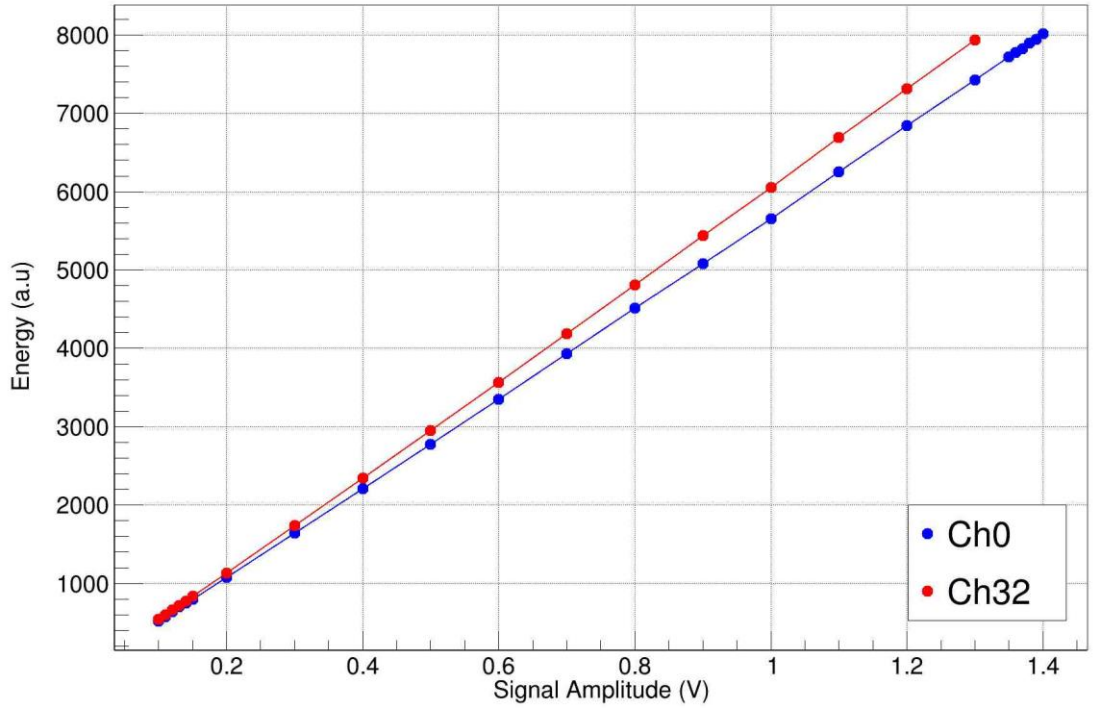


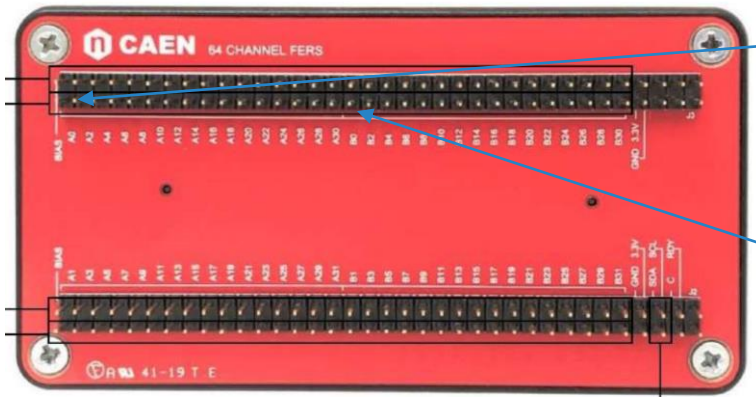
Measurements so far

- Linearity of channels
- Hold delay optimization
- Addback optimization

- Linearity test
- Pulse generator for signals with varying amplitudes (0.1V to 1.5V)





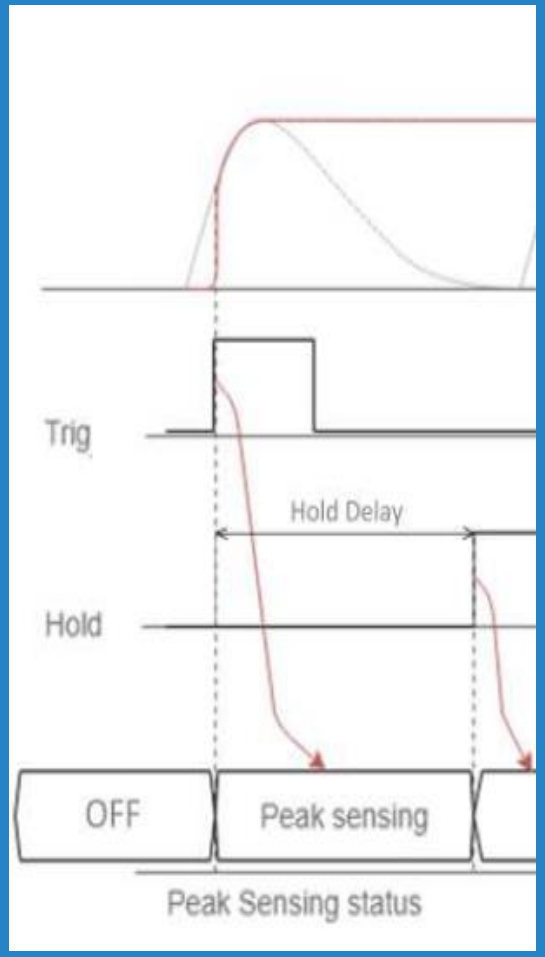


Channel 0

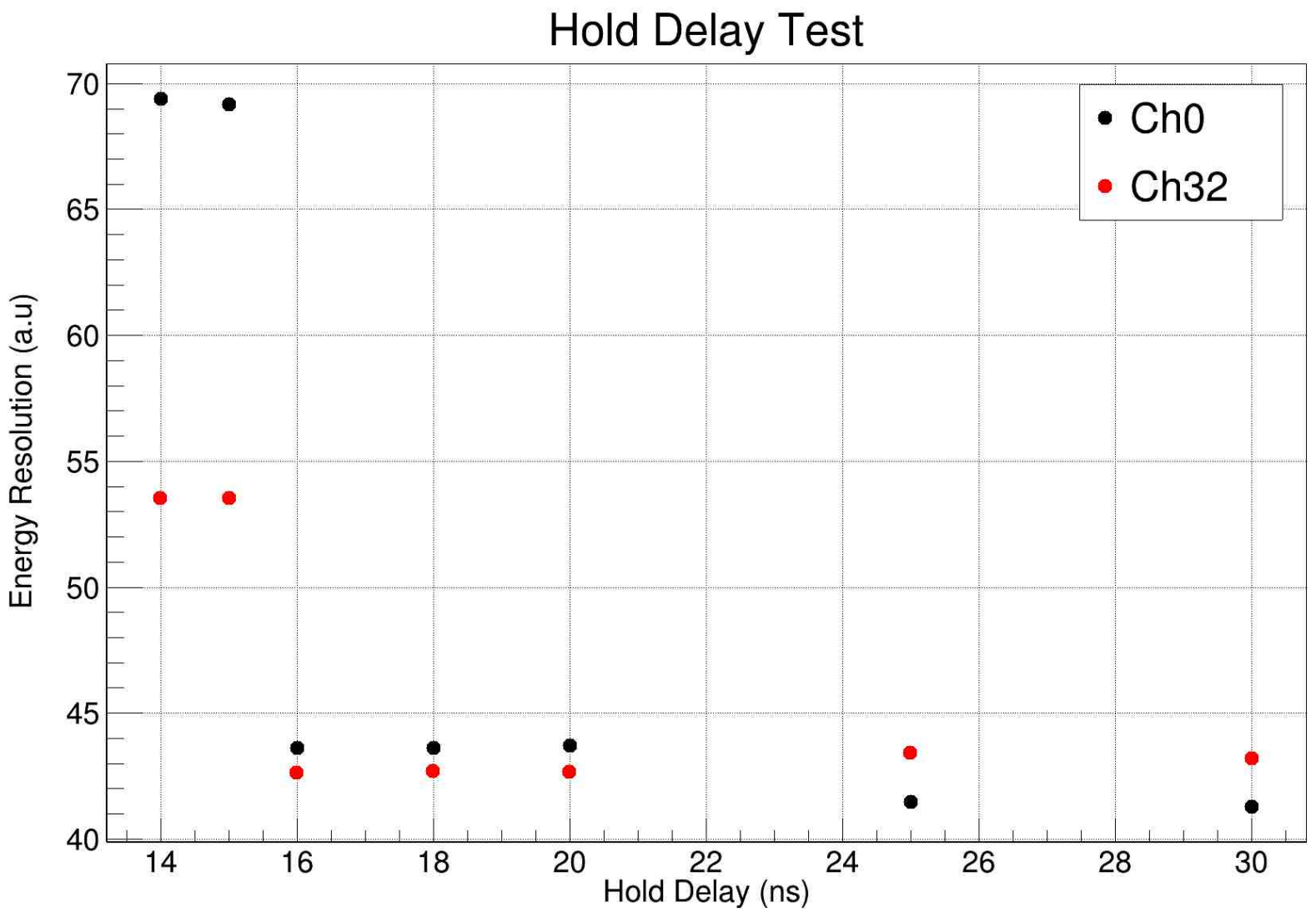
Channel 32

Measurements so far

- Linearity of channels
- Hold delay optimization
- Addback optimization



- Hold Delay influence on energy resolution for each sub-system

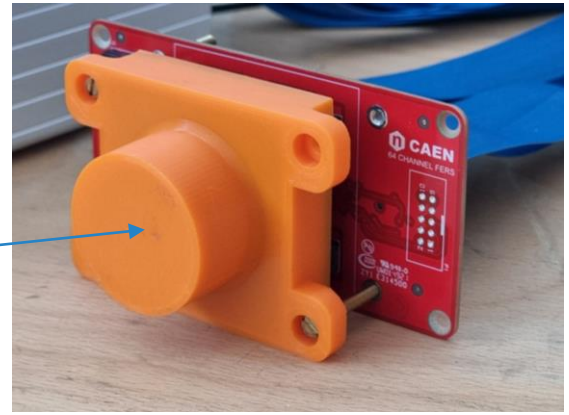


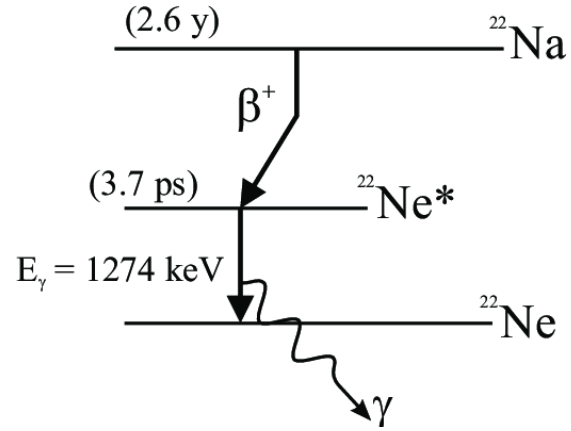
Measurements so far

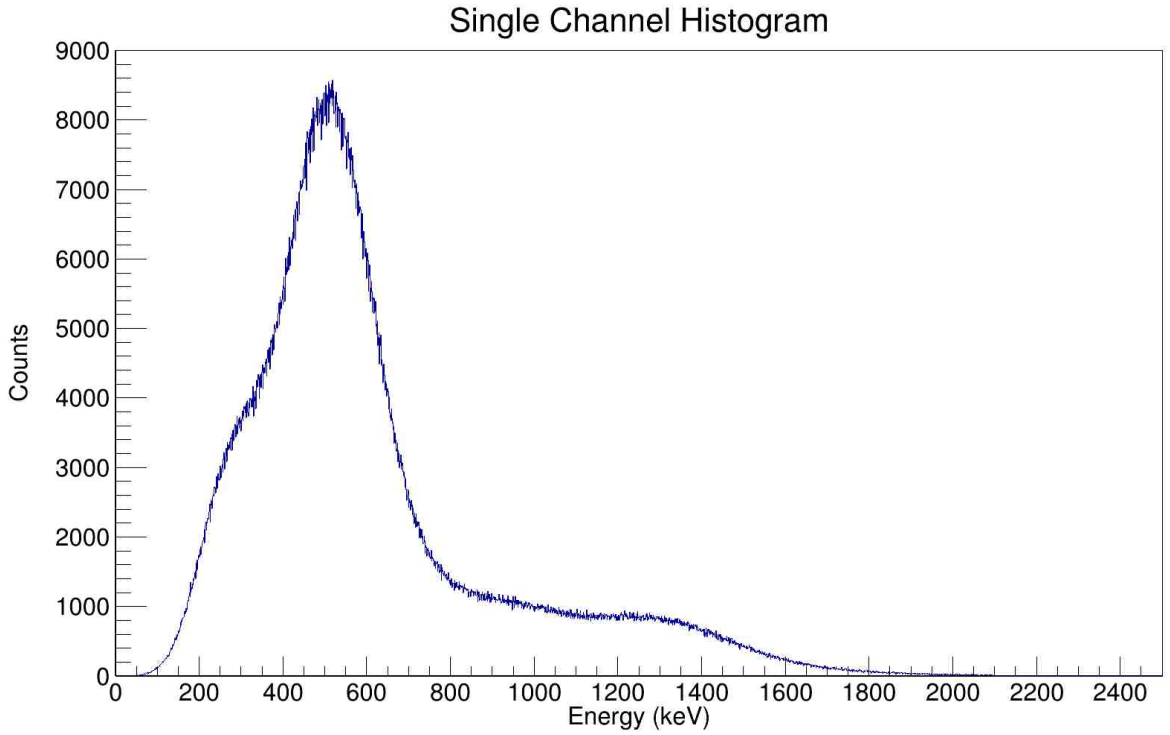
- Linearity of channels
- Hold delay optimization
- Addback optimization

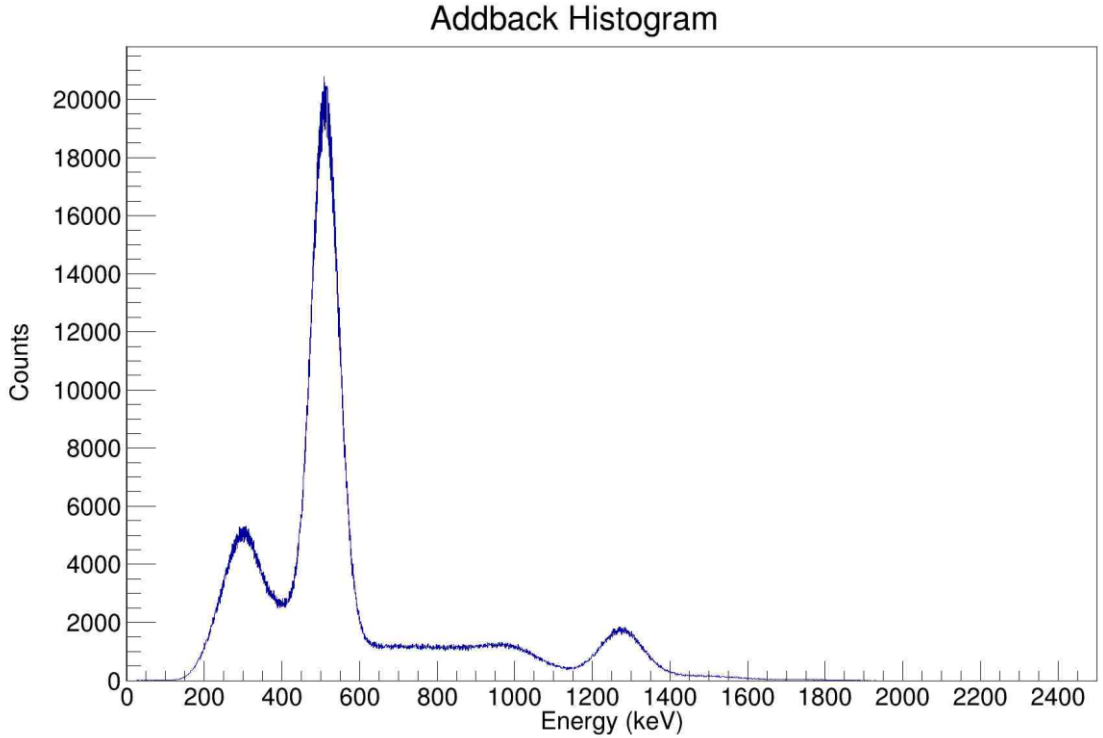
- Addback – sum data from multiple channels
- $^{54}Mn(834\ keV), {}^{22}Na(511\ keV)\ and\ {}^{137}Cs(661\ keV)$, for calibration
- Addback on ^{22}Na to reveal 1.275MeV gamma peak

Scintillator covers 16 channels









Conclusions and Next Steps

- Tested linearity of channels
- Hold Delay parameters optimization
- Tested addback performance
- Next steps:
  - Finalize the construction of the detector
  - Implement and test an algorithm that outputs the X and Y coordinates of the striking photon
  - Further testing and optimization

Thank you for your attention!