A CLYC and SiPM Based Detector for Neutron & Gamma Mixed Field Detection

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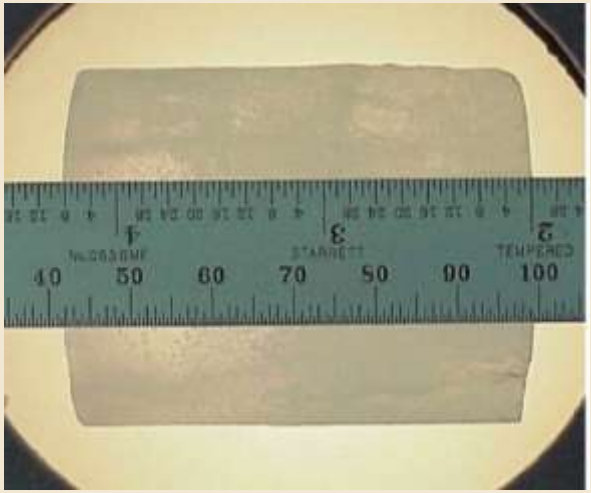
Outline

- Introduction
- Detector Setup
- Experiment Setup
- Results

Introduction - CLYC

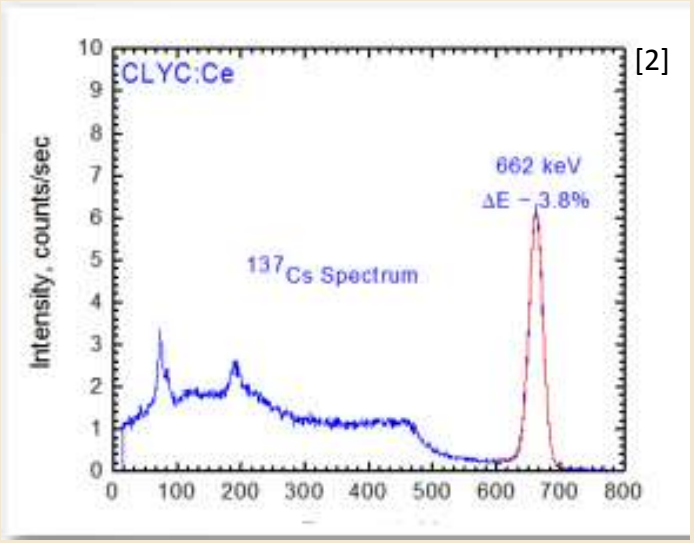


$Cs_2LiYCl_6:Ce^{3+}$ (CLYC) crystal was discovered at Delft University of Technology in 1999[1]

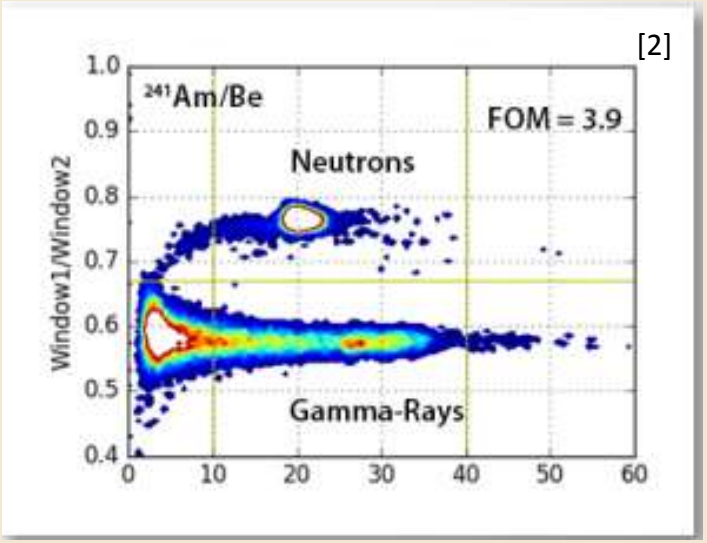
$n + {}^6Li = \alpha + {}^3T + 4.786MeV$

- Excellent Gamma ray detector
- Good n-γ PSD performance
- Efficient thermal neutron detector

The neutron cross-section of 95% ^{6}Li-enriched CLYC is 2.3 times that of ^{3}He (10 atmospheres) on same volume.



[2]



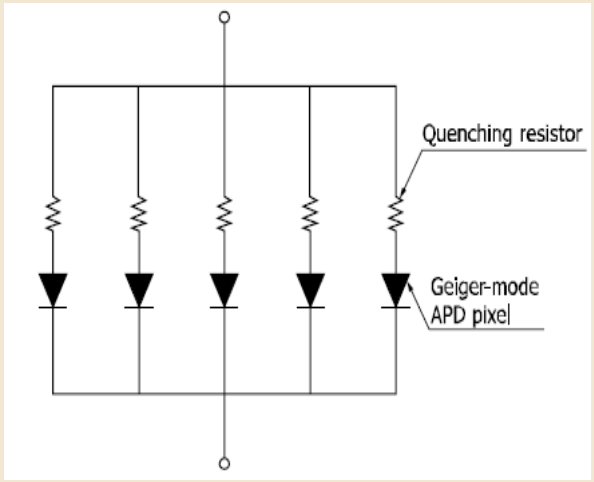
[2]

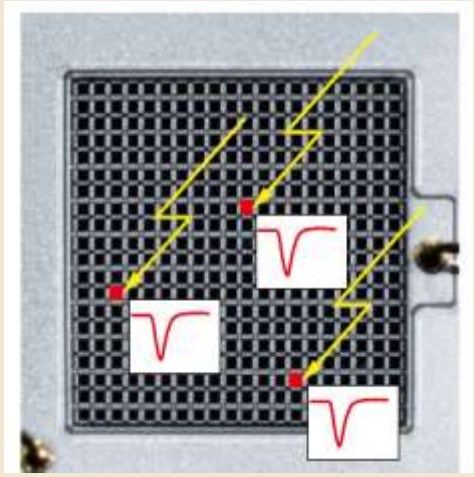
[1] Combes, C. M., et al. *Journal of Luminescence* 82.4(1999):299-305.

[2] http://rmdinc.com/wp-content/uploads/2016/06/CLYC-Properties-5-10-16.pdf

Introduction - SiPM

Silicon Photomultiplier (SiPM, MPPC)

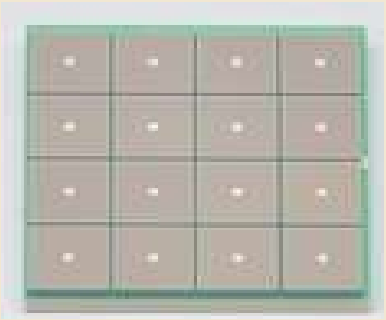




R6233-01 PMT Φ76×127mm

1×1mm

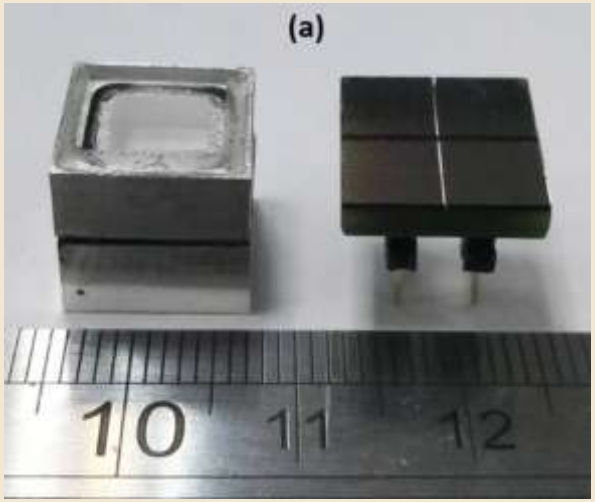
3×3mm

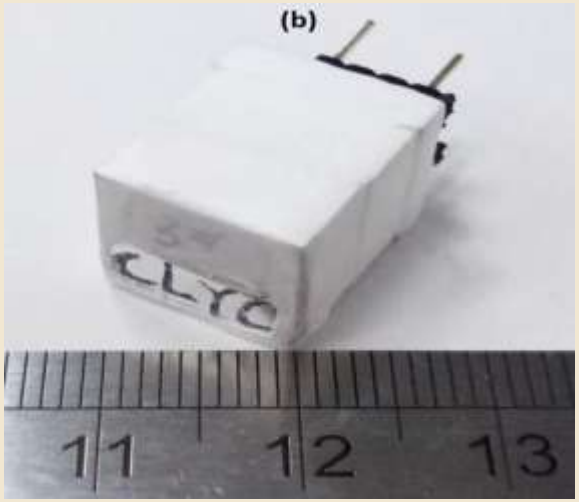


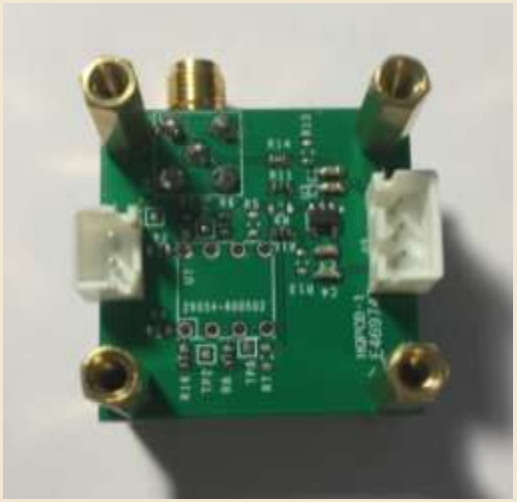
3×3mm (4×4 array)

- Much smaller size (~mm)
- Much lower Vop (20~70V)
- Insensitivity to magnetic
- Much cheaper
- Similar gain (~10^6)
- Much higher noise
- Temperature sensitive

Detector Setup







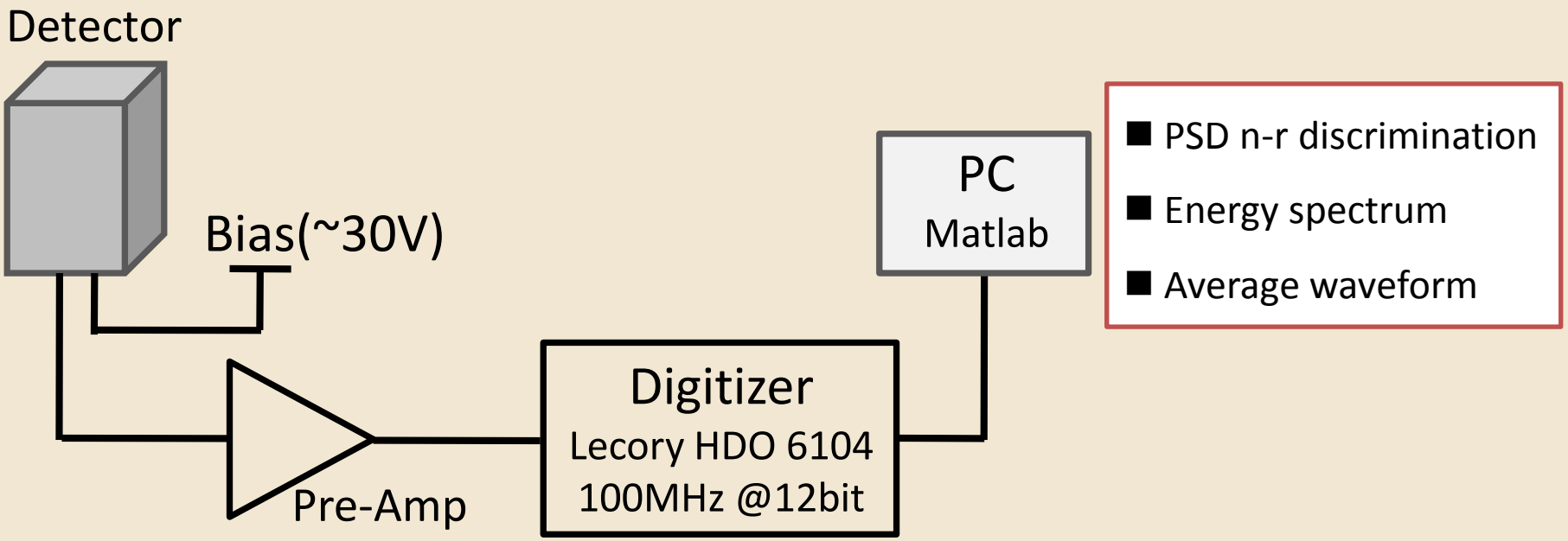
CLYC:

- Size is 8×8mm
- Enriched 95% ^{6}Li
- made by BGRI

SiPM:

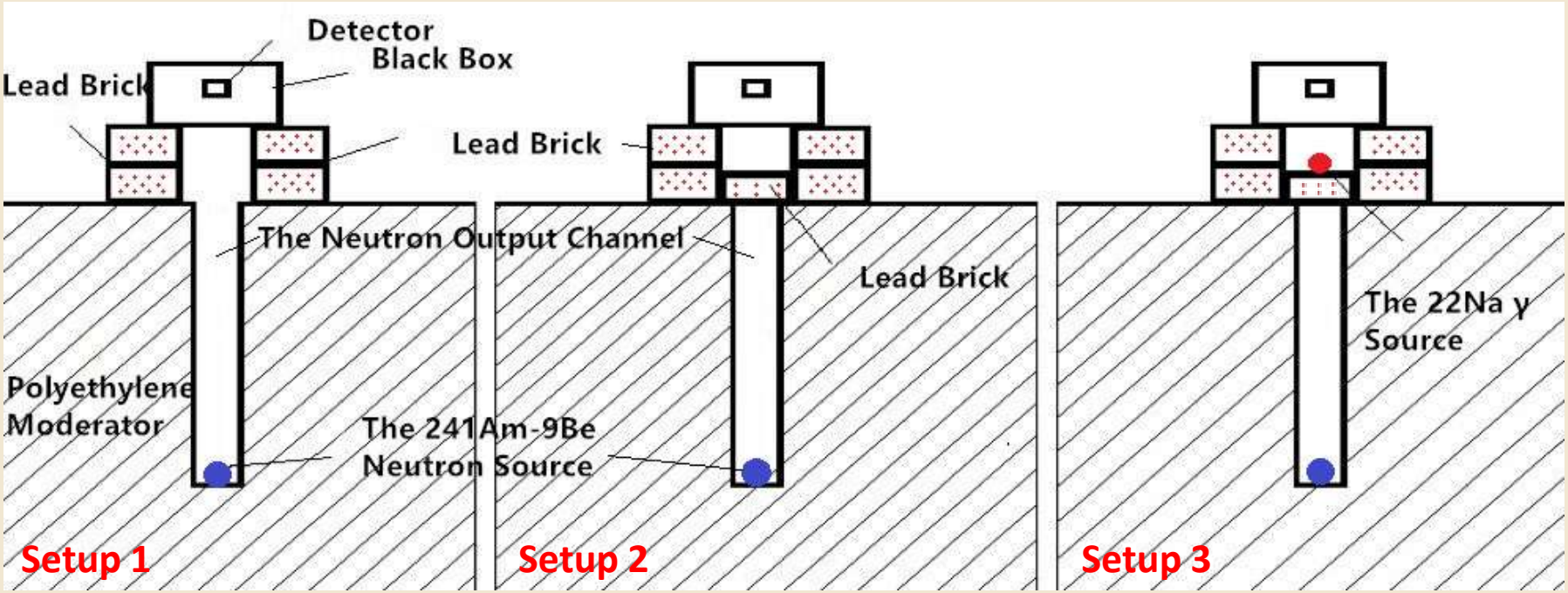
- Array-J-60035-4P-BGA
- ~9×10^{4} APDs(microcell
- Wavelength 300~800nm

Experiment Setup



Experiment setup diagram

Experiment Setup



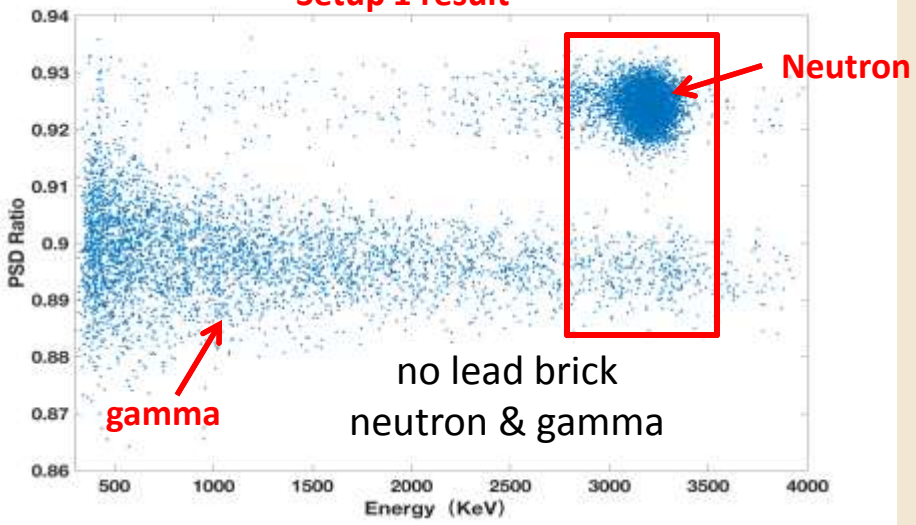
1. The detector was placed ahead on the ^{241}Am-^{9}Be source.
   (Neutron and gamma are both from the ^{241}Am-^{9}Be source)

2. A 5mm thick lead brick was placed between source and detector to block gamma rays.
   (Neutron is from the ^{241}Am-^{9}Be source. Most gamma is blocked by lead brick.)

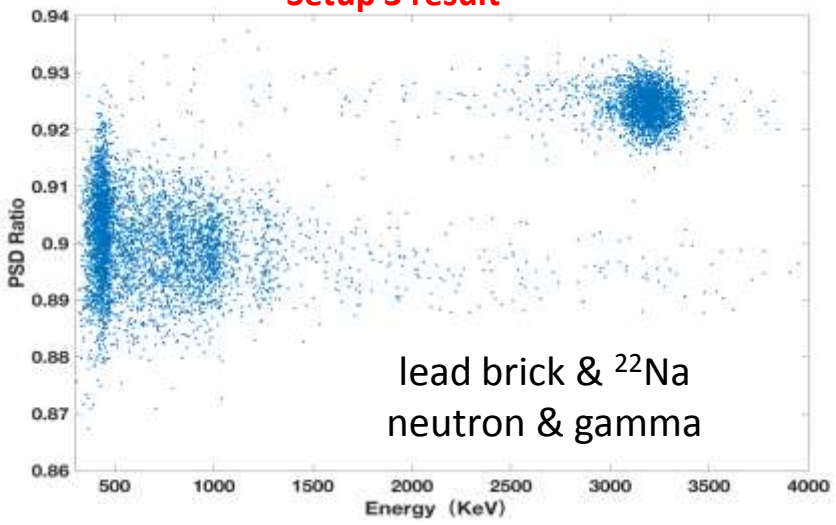
3. A ^{22}Na gamma source was placed on the lead brick.
   (Neutron is from the ^{241}Am-^{9}Be source. Gamma is from ^{22}Na source.)

Results - n/γ discrimination

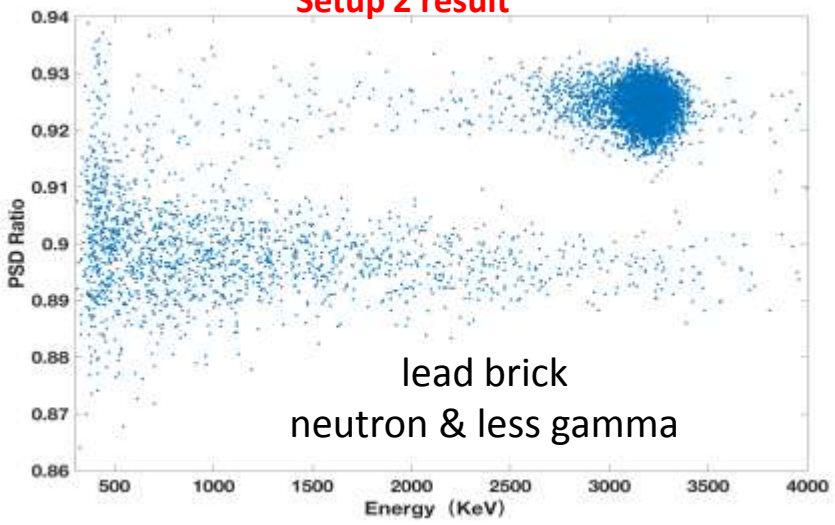
Setup 1 result

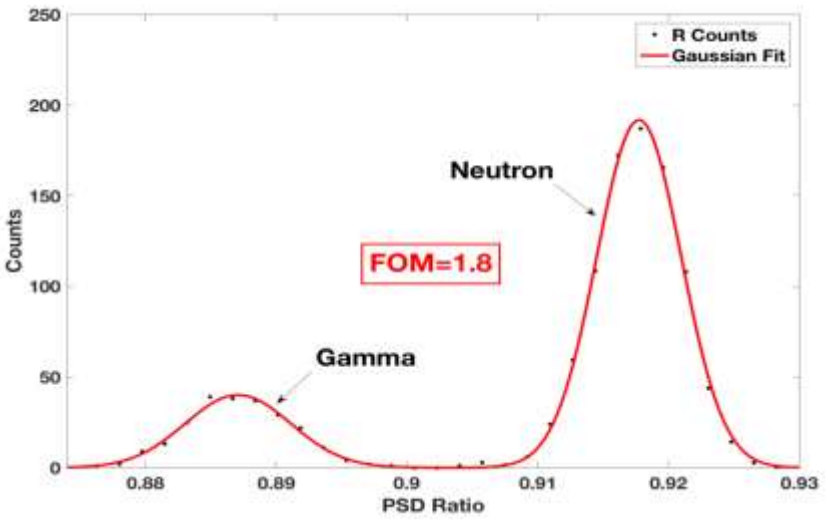


Setup 3 result

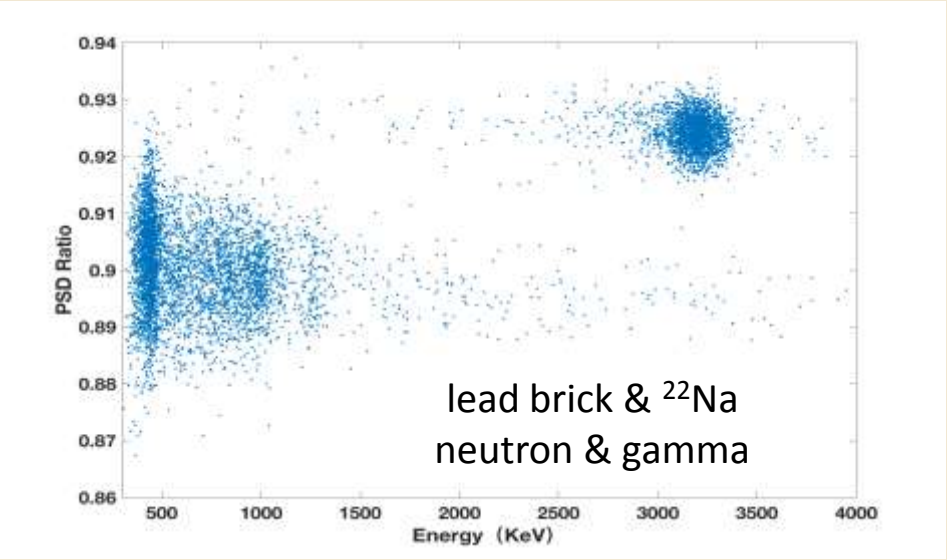


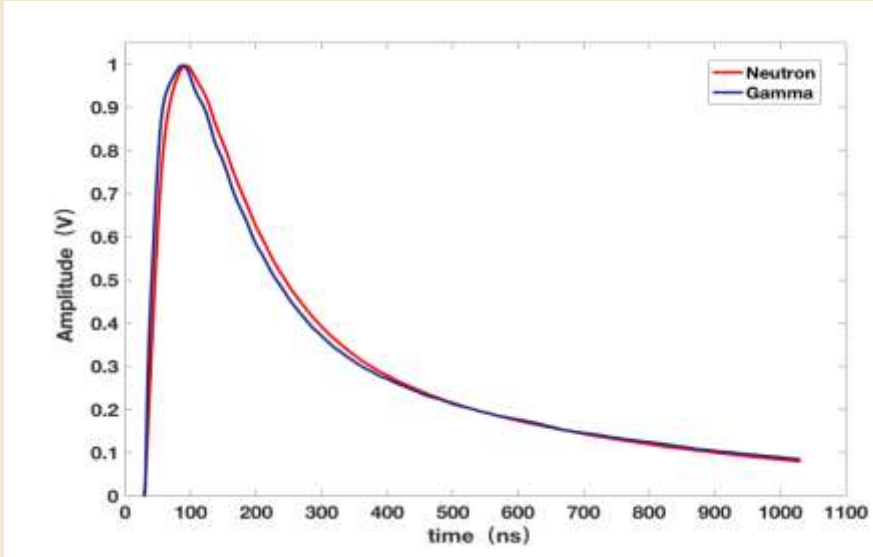
Setup 2 result

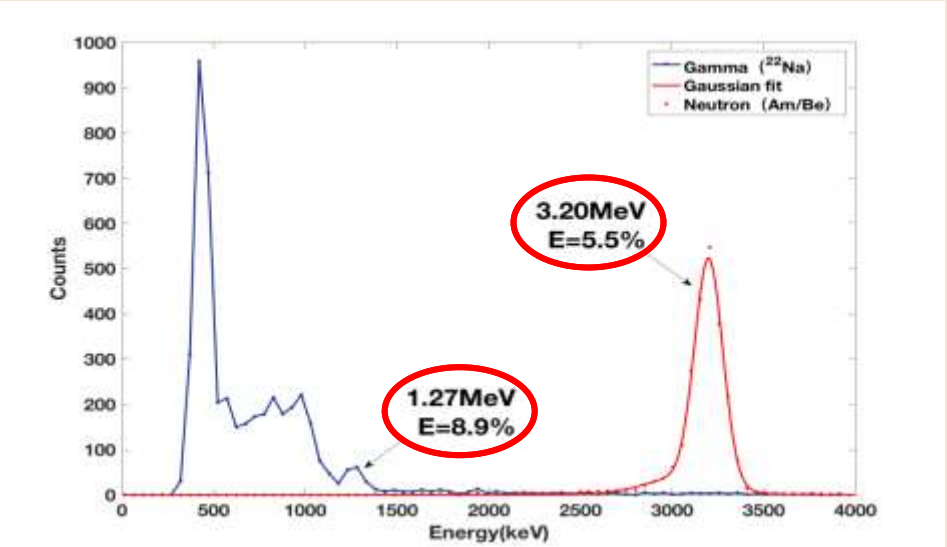




Results – Energy Spectrum & Average Waveforms







Average waveform parameters

Gamma:

Rise time (10%~90%)	26ns
Fall time constant	215ns

Neutron:

Rise time (10%~90%)	35ns
Fall time constant	224ns

Conclusion

- We assembled a detector with CLYC and SiPM for neutron and gamma detection.
- The detector has a very good n-γ discrimination performance. The FoM is 1.8.
- The detector's energy resolution for thermal neutron is 5.5%@3.2MeV.
- According to the average waveforms for neutron and gamma. The difference between the waveforms is mainly the rising edge.

Thanks for your attention!

Acknowledge:
Thanks for BGRI providing CLYC crystal for testing.