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Neutron Detector Based on SiPM and CLYC

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1. Introduction

- In order to accurately measure the space environment, a neutron detector based on SiPM and CLYC was developped. In this detector, CLYC is an inorganic scintillator, the size of which is 5cm × 5cm. It contains ^{6}Li and ^{35}Cl, respectively, which have large cross section with thermal neutron and fast neutron, and have high neutron detection efficiency, and have waveform discrimination ability to neutron and γ-ray. The SiPM consists of arrays of multiple pixels working in the Geiger mode in parallel with each other, each of which consists of a series of avalanche photodiodes and quenching resistors. SiPM has the advantages of high photon detection efficiency, fast time response, and is insensitive to magnetic field, low operating voltage and small volume. The detector uses 97 pieces of 3 mm × 3 mm SiPM. The charged particles produced by the neutron reaction with the CLYC excite the CLYC's luminescence, and SiPM converts the detected photon signal into a pulse waveform signal, which is dealed with by the waveform discrimination technique. The neutron detector has the characteristics of high neutron detection efficiency, small volume and low power consumption.

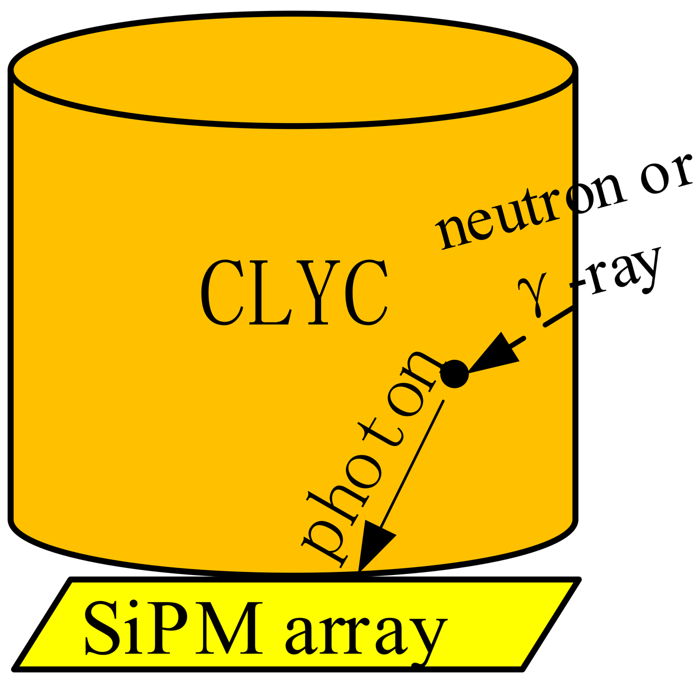

Fig.1 The structure of the detector

2. Detector Characteristic

- The reaction between neutron and CLYC scintillator is complicated, including ^{6}Li (n, ν) ^{3}H, ^{35}Cl (n, p) ^{35}S, ^{35}Cl (n, p) ^{32}P. Energy deposition and generation efficiency of charged particles produced by neutron interaction with CLYC scintillator are simulated by Monte Carlo method. The results are shown in Figure 2 and Figure 3.The light yield of CLYC to thermal neutrons is about 70000 ph/ thermal neutrons, and the energy produced by the reaction of each thermal neutron with ^{6}Li is 4.786 MeV, so the light yield of CLYC is about 14600 ph/ MeV by energy deposition. The average photon yield of different energy neutrons in the scintillator can then be obtained, as shown in Figure 4.

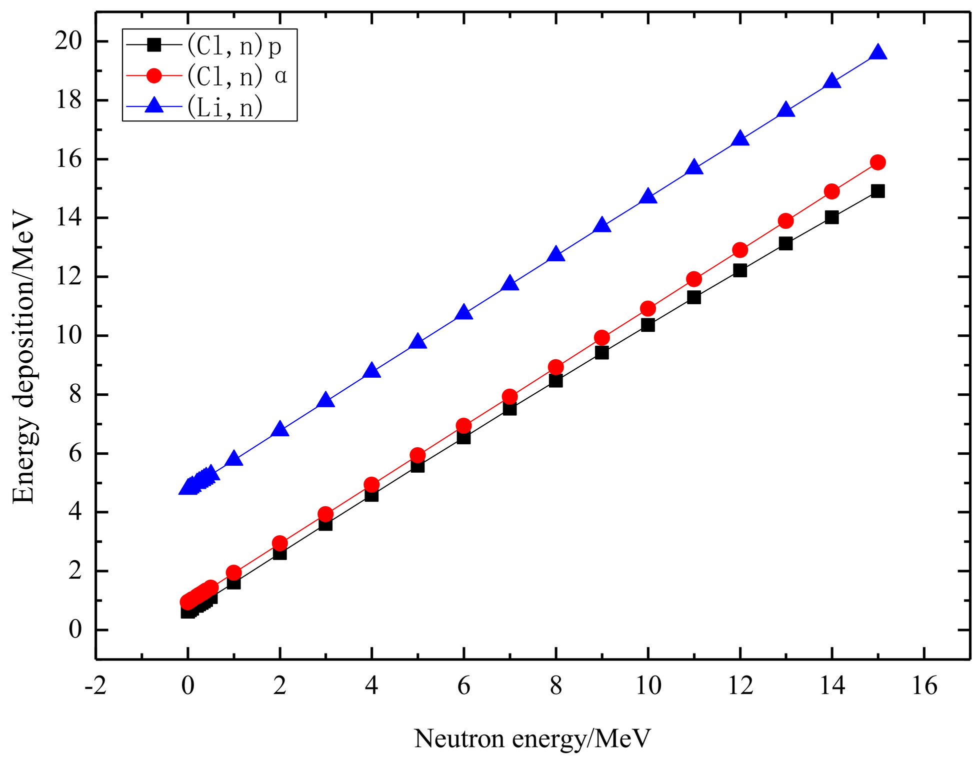

Fig.2 Energy deposition of neutrons in CLYC

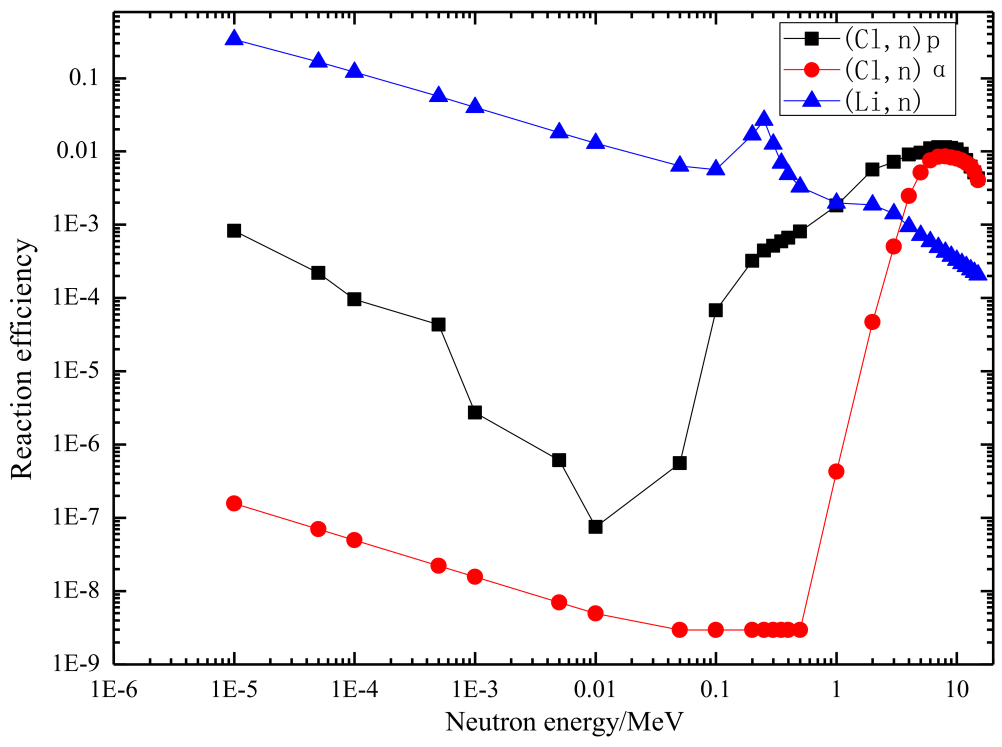

Fig.3 Efficiency of neutrons producing particles in CLYC

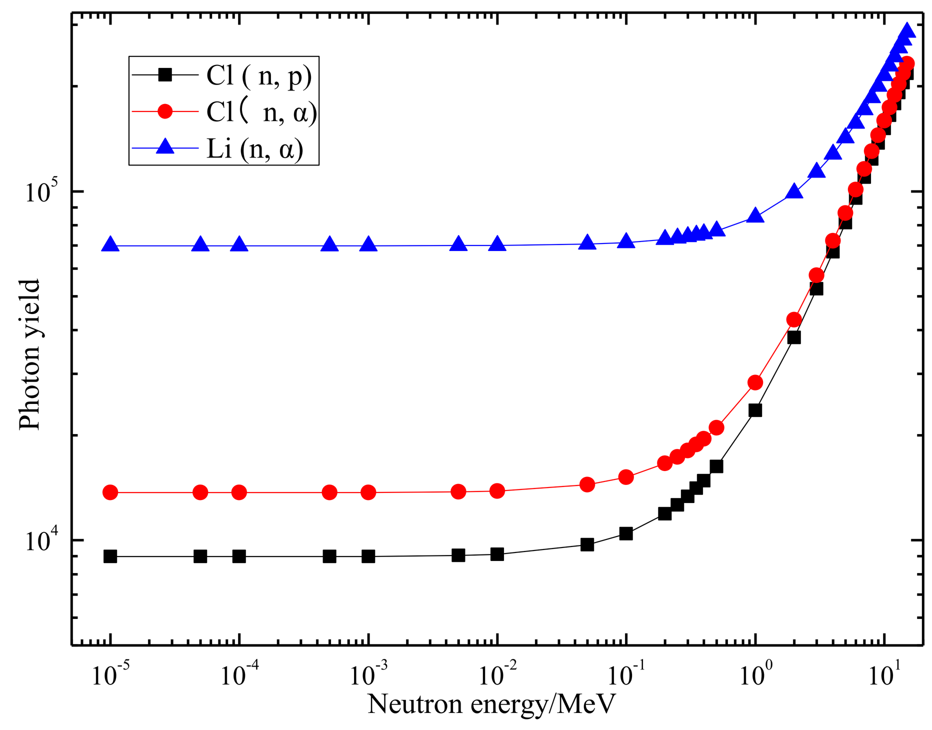

Fig.4 Photon yield produced by neutrons in CLYC

- The light yield of CLYC to electron is about 20000 ph/ MeV and the gain of SiPM is about 2.7×10^{6}.The average signal amplitude of different energy neutrons in CLYC, the neutron sensitivity of detector and the average signal amplitude of the ray in CLYC can be obtained by the theoretical calculation. The results are shown in Figure 5, Figure 6 and Figure 7 respectively.

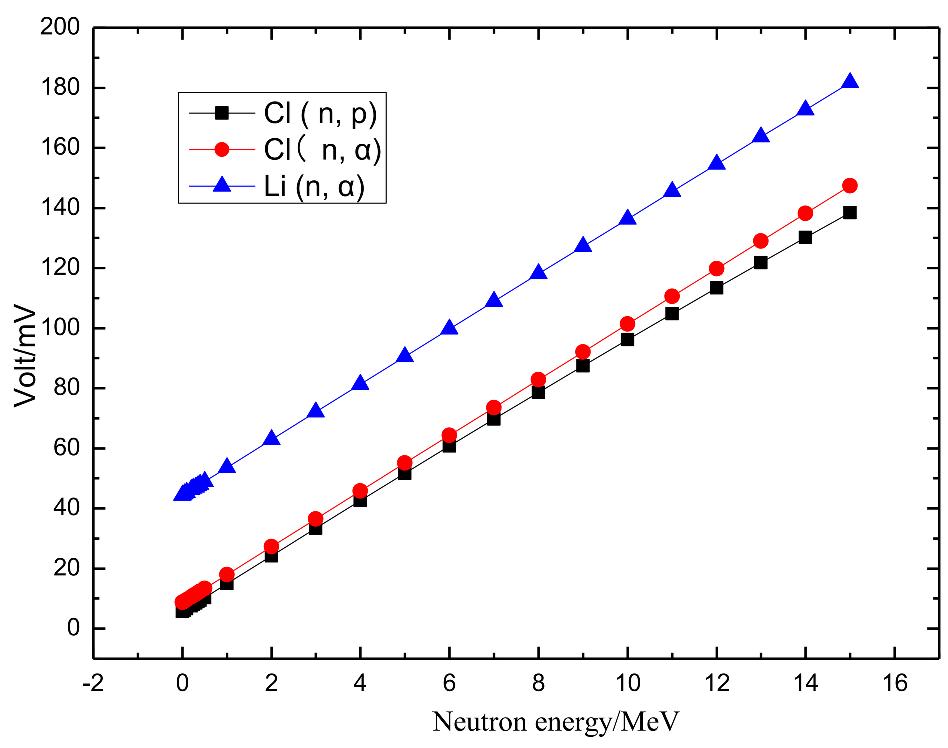

Fig.5 Average signal amplitude of neutron in CLYC

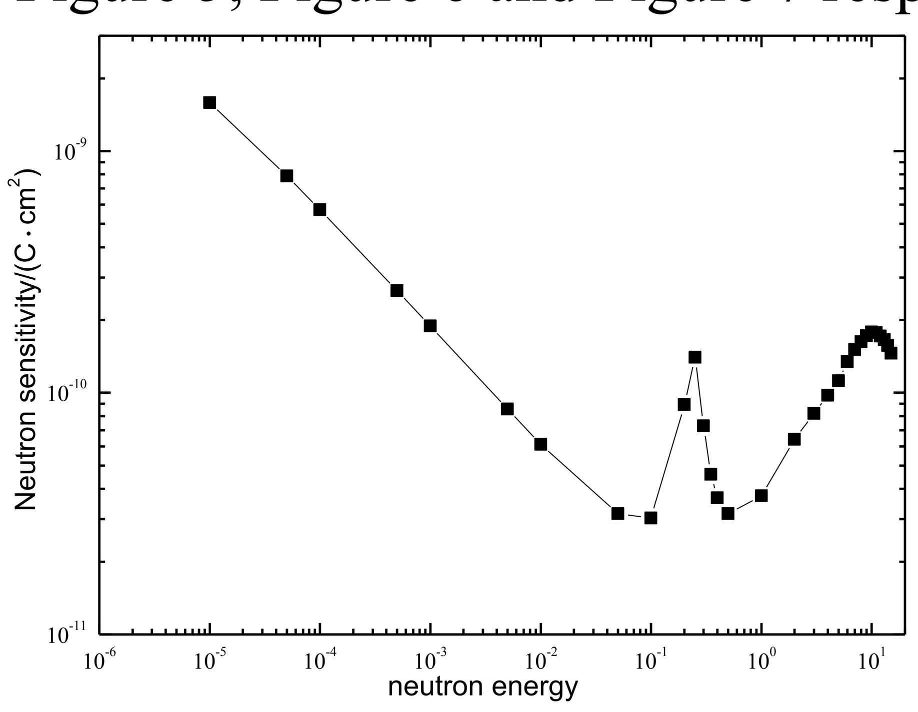

Fig.6 Neutron sensitivity of detector

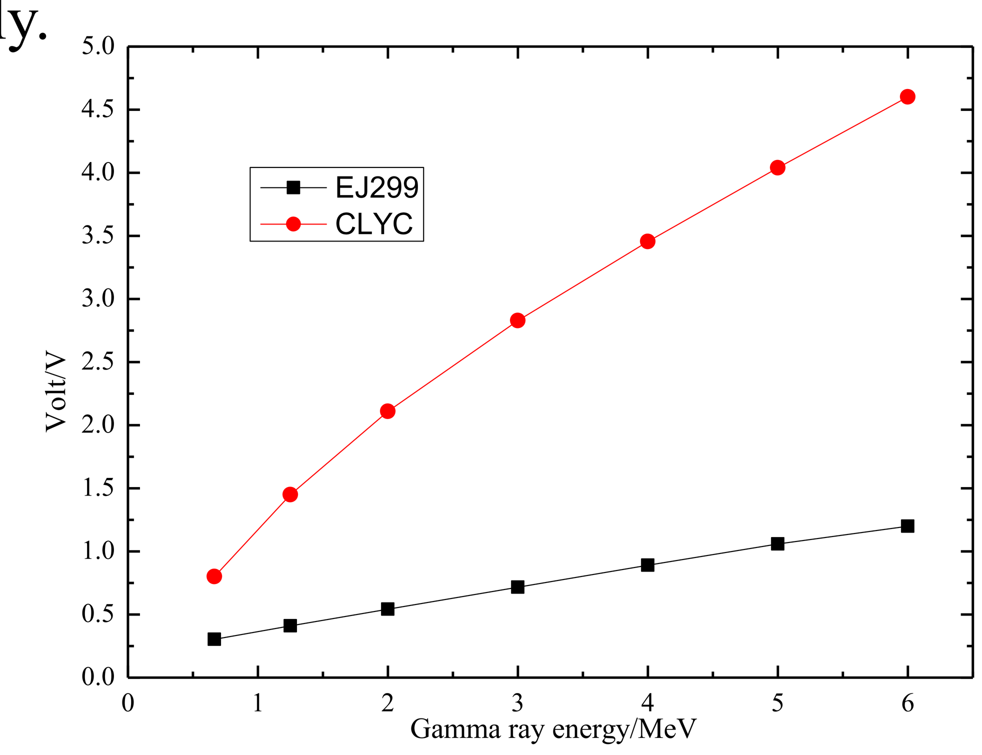

Fig.7 Average signal amplitudes generated by γ-ray in scintillator

3. Experiment

- An experimental study was carried out on the Am-Be neutron source in the Northwest Institute of Nuclear Technology, and the typical waveform generated by neutrons in the detector was obtained, which is shown in Figure 8. detectors
- A few thousand signals were obtained by the detector from the measurement of Am-Be neutron source and ^{60}Co. The neutron and γ-ray peak signals were obtained through processing these waveforms. The results are shown in Figure 9, which indicates that the detector can distinguish between neutron and ray signal.

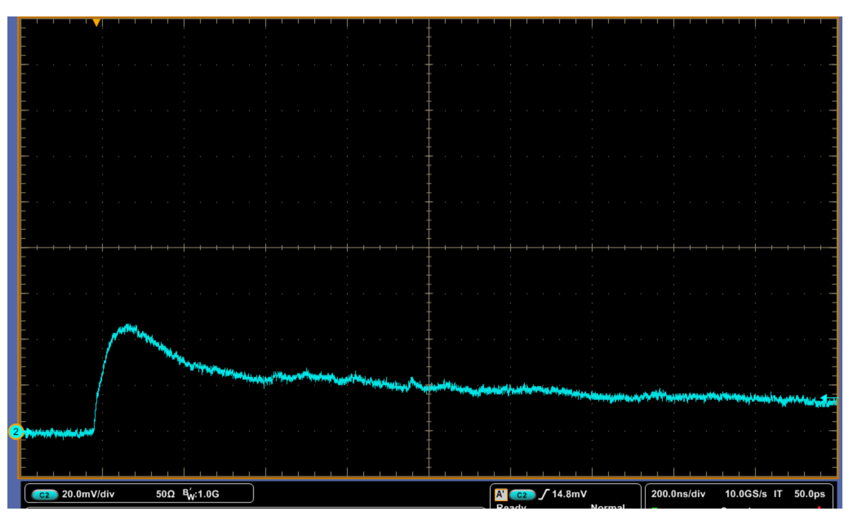

Fig.8 Typical waveform of neutron in CLYC

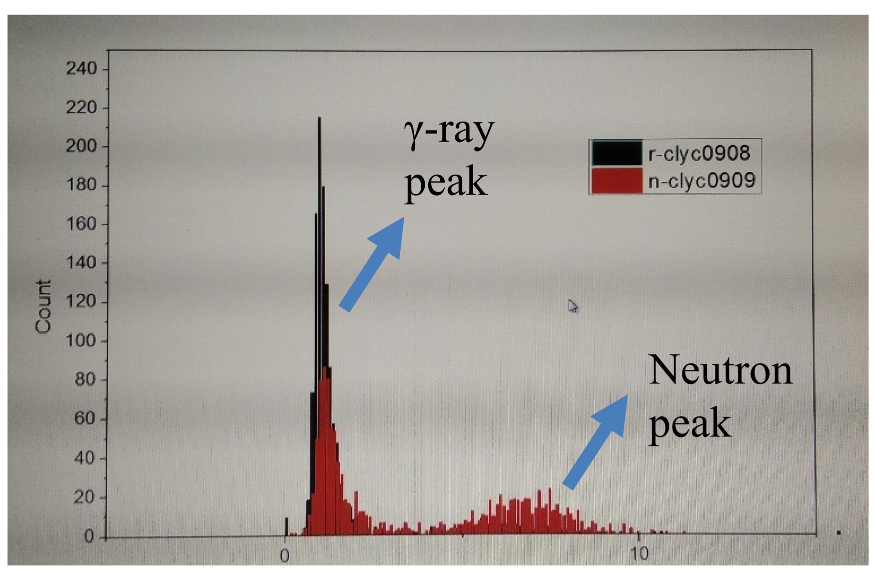

Fig.9 Signal processing results of Am-Be neutron source