5 - 16 Simulation of Neutron Efficiency for Liquid Scintillator Detector

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In a field mixed of neutron (n) and γ rays, one of the most widely used detectors for neutron spectroscopic studies is the organic liquid scintillator (EJ301, BC501A, NE213). Nevertheless, the efficiency calibration of liquid scintillator, studied for many years and well known in detail for neutrons below 20 MeV, is stillan essential to study for neutron at high energy[1].

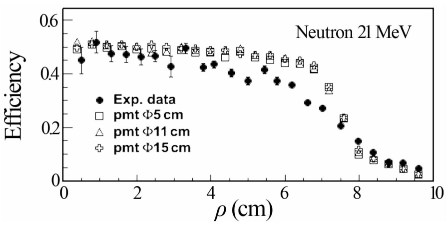

Fig. 1 Comparison between neutron efficiencies at 21 MeV vs radius of scintillator with different PMT diameters and experimental data.

The efficiency of liquid scintillator with 16cm in diameter and 20 cm in length, covered by 2 cm Aluminum in the surface, had been done with Monte Carlo simulation software GEANT. In order to let the simulation more close to a real detector, the transmission process of optical photon was taken intoaccount in the simulation. The scintillation yields of different particles werepicked up from Ref. [2]. A photomultiplier tube (PMT) was attached to the scintillator along the center axis to collect the photons.

A neutron source was positioned 1 m in front of the scintillator. The threshold for the scintillator was determined by γ rays with 661.661 keV. Fig. 1 shows the comparison between neutron efficiencies at 21 MeV versus radius of scintillator with different PMT diameters and experimental data[3]. One can see that there are slightly different in neutron efficiencies between the scintillator with different PMT diameters. Compared with experimental data, the simulations give higher values at radius larger than 4 cm. This may because the edge effect that was not taken into account in the simulation.

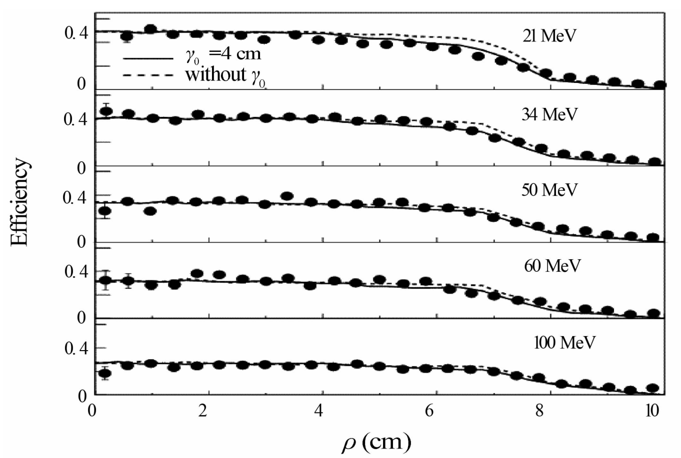

Fig. 2 Neutron efficiencies as a function of radius. • the experimental data, — and --- with r_0 and without r_0 correction.

A parameter $r_0 = 4$ cm was introduced to take into account the edge effect in the simulation. The number of photons produced in a radius larger than r_0 was modified by:

$$N = N_0 \times \left(\frac{r_0}{r}\right)^2 \tag{1}$$

where N_0 is the number of photons without any corrections. Fig. 2 shows the neutron efficiencies as a function of radius. The solid and dashed lines are with and without r_0 corrections, respectively. Compared with the experimental data at neutron energy from 21 to 100 MeV, one can get that the efficiencies with r_0 corrections matched the experimental data much better.

References

[1] M. Sasaki, et al., Nucl. Instr. and Meth., A480(2002)440.
[2] http://www.eljentechnology.com/index.php/joomla-overview/this-is-newest/71-ej-301.
[3] J. Thun, et al., Nucl. Instr. and Meth., A478(2002)559.

5 - 17 Study of CsI(Tl) Scintillation Detector's Properties for Gamma-ray Measurement

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Spallation reaction produced numerous light charged particles. Light charged particles were detected by using light charged particle flight time spectrometer, which is a complete set of system from different angle d*E*-*E* telescope system structure and a beam counter. The energy loss d*E* of charged particles was measured by a plastic scintillator detector. The total energy *E* of charged particles was measured by stopping the particles in a CsI(Tl) scintillation detector.

In this study, we systematically tested CsI(Tl) scintillation detector that consists of a CsI(Tl) crystal (diameter of 5 cm, length of 15 cm) coupling a Hamamatsu H7195 PMT. Other electronics conditions(the Gain is 20, the Threshold is 20 mV) being equal, we measured pulse height spectrum of CsI(Tl) detector at the different bias voltage and shaping time(1, 2, 3, 6 μs), respectively. Gamma-ray spectrum measurements were performed by using ^{137}Cs and ^{60}Co radio isotopes.

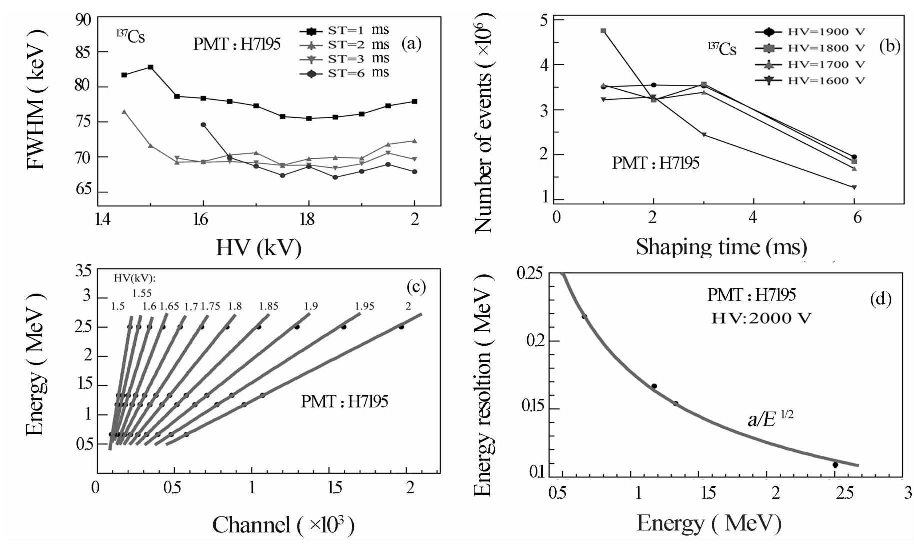

Fig. 1 (a) Energy resolution as a function of bias voltage. (b) Data acquisition count rate as a function of the shaping time. (c) Energy calibration curve in different bias voltage. (d) Energy resolution as a function of source energy.

Fig. 1(a) shows the energy resolution of CsI(Tl) detector as a function of bias voltage at different shaping time. The result shows that energy resolution tends to be stable with the increase of the bias voltage. And in the same bias voltage, the energy resolution tends to be better with the increase of the shaping time. Data acquisition count rate of CsI(Tl) detector at different bias voltage as a function of the shaping time is plotted in Fig. 1(b). With the increase of shaping time, data acquisition count rate gradually drops. Especially, it has the fastest decline as shaping time from 3 to 6 μs. To take into account the energy resolution and data acquisition count rate, 3 μs of shaping time is the best measurement condition for CsI(Tl) detector. Fig. 1(c) shows energy calibration curve of CsI(Tl) detector at the different bias voltage by using ^{137}Cs and ^{60}Co. We can found that energy calibration curves are linear at different bias voltage. Meanwhile,