# Response Function for Neutron of Stilbene Scintillator using Simulation Codes

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## 1. Introduction

Organic scintillators are widely used in neutron detection because these are composed of light atoms, which are interacted with neutron easily, such as hydrogen and carbon. Stilbene scintillator is a representative one of organic scintillators using for measuring fast neutrons.

Currently, various methods are used in neutron measurements using scintillator detector. Typical methods among these are time of flight and digital charge comparison method [1]. The time of flight method is using flight time differences according to energies and particles in same flight distance, and the digital charge comparison method is a pulse shape discrimination method using signal differences depending on incident particles in scintillator. Use of the digital charge comparison method is increased because processing speed of an analog to digital converter (ADC) is growth.

For evaluating neutron energies, in case of the time of flight method, start time measurement is necessary for calculation of flight time duration from start point to stop point, in which stop time is a signal detection time by detector. In case of the digital charge comparison method, light output analysis is required as incident particle energies.

In this study, response function of stilbene scintillator for neutron is simulated by MCNPX and GEANT4 for applying the stilbene scintillator and digital charge comparison method.

## 2. Methods and Results

Response function of stilbene scintillator was obtained by simulation using MCNPX code version 2.5 and GEANT4 code version 4.9.6.p01. And simulation results by MCNPX and GEANT4 codes were compared and analyzed.

### *2.1 Stilbene Detector Modeling*

In this study, stilbene diagnostic system used in detection experiments of neutrons produced in nuclear fusion reactor was applied to simulation model. This is composed with a stilbene scintillator with a diameter of 25 mm and height of 20 mm and H6152-70 photomultiplier tube (PMT) manufactured by Hamamatsu in Japan. And PMT was covered by soft iron with thickness of 1 cm for shielding magnetic effects occurred in nuclear fusion reactor, and polyethylene and lead were used to shield neutrons and gamma-rays incoming on side of scintillator.

Figure 1 shows the simulation model for response function of stilbene scintillator, and PMT was excepted from this simulation model.

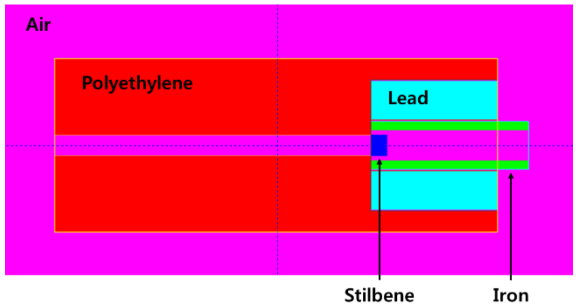



Fig. 1. Simulation model for response function of stilbene scintillator.

### *2.2 Simulation of Response Function*

Response simulation of stilbene scintillator was performed for neutron energies from 0.5 MeV to 20 MeV at intervals of 0.5 MeV.

The organic scintillators, such as stilbene scintillator, show nonlinear response as neutron energies unlike gamma-rays because a production process of light output for neutron and gamma-ray is different in scintillator. In case of neutrons, recoil protons are produced in the organic scintillator, and light outputs are occurred by the recoil protons. In case of gamma-ray, compton electrons are generated and produce light outputs.

Because of these characteristics of the organic scintillators, many researchers defined a related theory between incident neutron energies and light outputs and performed experiments [2-4].

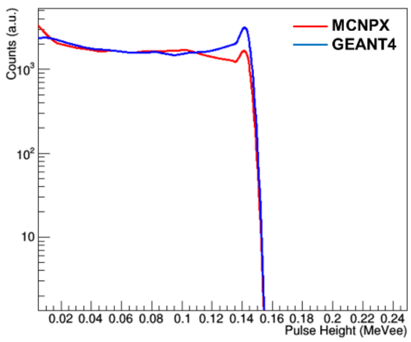
In this study, for obtaining the response function of stilbene scintillator, following equation [4] was applied to simulations.

$$L = 0.693E_p - 3\left[1 - e^{-0.2E_p^{0.965}}\right]$$

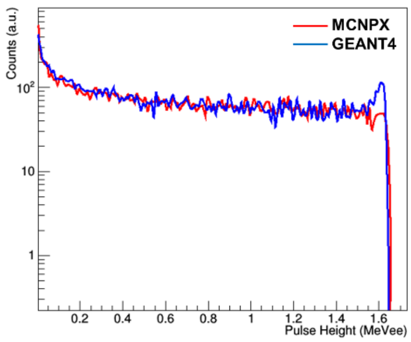
Where L is the light output of electrons in unit of MeVee, and Ep is proton energy in unit of MeV.

### *2.3 Simulation Results*

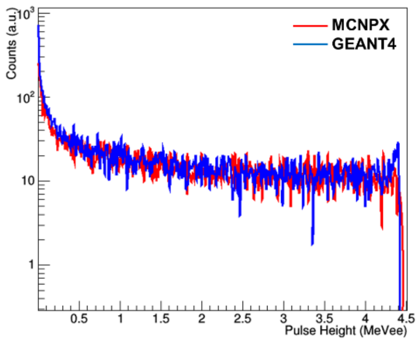
Figure 2 (a), (b), (c) and (d) show the simulation results of response of stilbene scintillator as incident neutron energy of 1 MeV, 5 MeV, 10 MeV and 20 MeV, respectively.



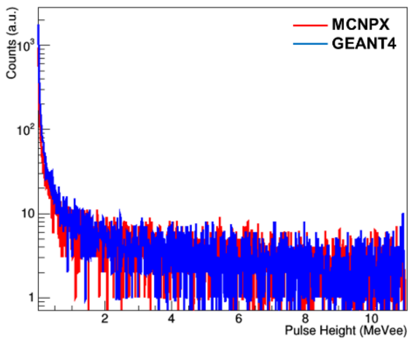

(a) 1 MeV neutron




(b) 5 MeV neutron




(c) 10 MeV neutron




(d) 20 MeV neutron

Fig. 2. Simulation results of response of stilbene scintillator as incident neutron energies.

As shown in Figure 2, some differences between MCNPX and GEANT4 simulation results are confirmed. In GEANT4 simulation, counts are more than MCNPX simulation in edge range of pulse height. It is determined to be due to differences in a physical model of MCNPX and GEANT4 simulations.

But edge energies of the pulse height is well matched in MCNPX and GEANT4 simulations. If a neutron has monoenergy, neutron energy estimation will be possible preliminarily by the edge energy of pulse height since the edge energy means the maximum ADC channels corresponding to the neutron energy measured by scintillation detector.

## 3. Conclusions

The simulations of response function of stilbene scintillator were carried out using MCNPX and GEANT4 codes. The simulation results show some differences of counts in edge range of pulse height, but the edge energies of pulse height are well matched.

In case of monoenergetic neutron, the neutron energy evaluation can be temporarily done. For energy estimation of neutrons without information, however, an unfolding method will should be applied. The response function of stilbene scintillator depending on neutron energies is required for applying the unfolding method to the measurement of neutrons by scintillator.

To supplement the response function of stilbene scintillator obtained by simulations, additional experiments about the response function is necessary. In the future, experiments using stilbene scintillator and neutron source will be performed.

It will be possible to acquire a precise neutron spectrum if the response function is improved.

## REFERENCES

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