Response of stacked GSO detector to deuteron

F. Saiho,[a] T. Kin,[a] S. Hohara,[a] K. Ikeda,[a] K. Ichikawa,[a] G. Wakabayashi,[a] N. Ikeda,[a] Y. Uozumi,[a] M. Matoba,[a] and N. Koori[b]

[a]*Department of Applied Quantum Physics amd Nuclear Engineering, Kyushu University, 6-10-1 Hakozaki, Higashi-ku, Fukuoka 812-8581, Japan*
[b]*Faculty of integrated Arts and Sciences, University of Tokushima, Tokushima 770-8502, Japan*

We developed stacked spectrometers which used GSO(Ce) scintillators as the main detector and measured DDX's of (p,p′x) reactions at 300 and 392.[1, 2] In order to obtain the DDX's of (p,p′x) reactions, the performances of spectrometers for proton energy measurements were investigated.[3, 4] In recent years, we measured DDX's of (p,dx) reactions at 300 and 392 MeV using the stacked spectrometers. The investigations of the performances of the spectrometer, however, were insufficient to determine the absolute DDX's of (p,dx) reactions. So, we decided to measure the performances of spectrometers for deuteron energy measurements, i.e. the light output response of GSO(Ce) scintillators and the absolute efficiency of the stacked spectrometer.

The measurements were performed in the ES course of the Research Center for Nuclear Physics (RCNP), Osaka University. The ^{4}He beam of 400 MeV bombarded a target of 50 mg/cm^2 thick CD_2 plate. The response of the stacked GSO(Ce) spectrometer was investigated with monoenergetic deuterons of up to 256 MeV from elastic αd scattering. There were two types of spectrometers.[2] One consisted of three plastic scintillators, two cubic GSO(Ce) crystals of 43 × 43 × 43 mm^3 and a cylinderistical GSO(Ce) crystal of 62 mm diameter by 120 mm length. Another consisted of three plastics and three cubic GSO(Ce) crystals of 43 × 43 × 43 mm^3. One of the plastics in each spectrometer had an aperture of 15 mm diameter and acted as an active slit to determine the solid angle of the spectrometer. A photomultiplier tube (PMT) was attached to one facet of each scintillator and other facets were covered with aluminum tape.

Figure 1 shows the measured light output of GSO(Ce) to deuterons, in arbitrary units, as a function of energy. The error bars of the present data correspond to the standard deviation of the peaks in measured energy spectra. The curves are the results of the calculations proposed by Birks[7] for organic scintillators. The light output per unit length, dL/dx, is

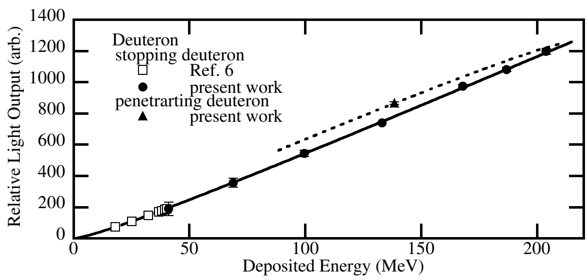

Figure 1: Light output of the GSO(Ce) to penetrating deuterons as well as stopping deuterons. The lines show the results of calculations by Eq. (1) for stopping and penetrating particles.

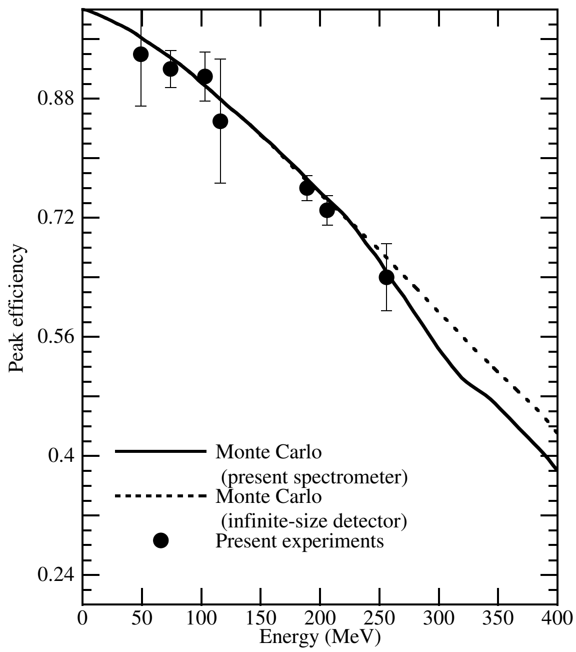

Figure 2: Absolute efficiency of the stacked GSO(Ce) spectrometer for deuterons as a function of the energy.

defined by

$$\frac{dL}{dx} = \frac{S(dE/dx)}{1 + kB(dE/dx)}, \tag{1}$$

where S the absolute scintillation factor, kB the Birks parameter that depends deeply on the light quenching of scintillator. The parameters, S and kB, are determined by a best fit to the experimental data. In the present study, S and kB were found to be 6.6 (arbitrary units) and 1.70×10^{-5} $(\mathrm{MeV/m})^{-1}$, respectively. The calculation provides a good description of the light output to deuterons in Fig. 1.

The absolute efficiencies of the stacked GSO(Ce) spectrometer for deuterons are shown in Fig. 2 as a function of the energy. The solid line in Fig. 2 represents the efficiency calculated by the use of a Monte Carlo calculation code[4]. The Monte Carlo calculation for present spectrometer was in good agreement with the measured efficiencies.

References

[1] Y. Uozumi, J. Tanaka, F. Saiho, et al., *Phys. Rev.*, **C64**, 011601 (2001).

[2] Y. Uozumi, F. Saiho, T. Kin, et al., *J. Nucl. Sci. Technol. : Proc. Int. Conf. on Nuclear Data for Science and Technology*, Tsukuba, Oct. 7-12, 2001, **Suppl.2**[1], 385 (2002).

[3] K. Anami, H. Yoshida, D. Konishi, et al., *Nucl. Instrum. Method*, **A404**, 327 (1998).

[4] H. Yoshida, D. Konishi, K. Anami, et al., *Nucl. Instrum. Method*, **A411**, 46 (1998).

[5] V. V. Avdeichikov, L. Bergholt, M. Guttormsen, et al., *Nucl. Instrum. Method*, **A336**, 381 (1993).

[6] V. V. Avdeichikov, L. Bergholt, M. Guttormsen, et al., *Nucl. Instrum. Method*, **A349**, 216 (1994).

[7] J. B. Birks, *The Theory and Practice of Scintillation Counting*, New York, 187(1964)..