

# The investigation of deuteron production double differential cross section induced by 392 MeV protons.

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There are many protons that have intermediate energy in space as a cosmic ray. We have to control the expose dose of human and also determine the cosmic ray affection to apparatus like single event upset of memory. And intermediate energy protons will be used in accelerator driven system (ADS). We should estimate the radiation damage of beam window, beam duct materials and so on.

To realize these technique there are high request of high accuracy evaluated nuclear data. However, around intermediate energy region, nuclear data are still-inadequate.

We have investigated the deuteron productions from 392 MeV proton induced reaction for target nuclei of <sup>12</sup>C, <sup>27</sup>Al and <sup>93</sup>Nb as data of the energy region. The detectors were stacked GSO(Ce) scintillators detectors<sup>1)</sup> Fig.1. Deuteron production double differential cross sections were determined over a broad energy range and scattered angles from 20 to 105 degrees in laboratory system. Those spectra were compared with two theoretical models; quantum molecular dynamics (QMD) model<sup>2)</sup> and intra nuclear cascade (INC) model.<sup>3,4)</sup> For QMD model, we used the JQMD code that was developed by JAERI.<sup>5)</sup> Although the calculated (p,p'*x*) double differential cross section spectra had certain degree of accuracy,<sup>6)</sup> the spectra of (p,d) double differential cross section spectra didn't have good reproducibility. We developed the code of INC model and we've got good results to reproduce the experimental data.

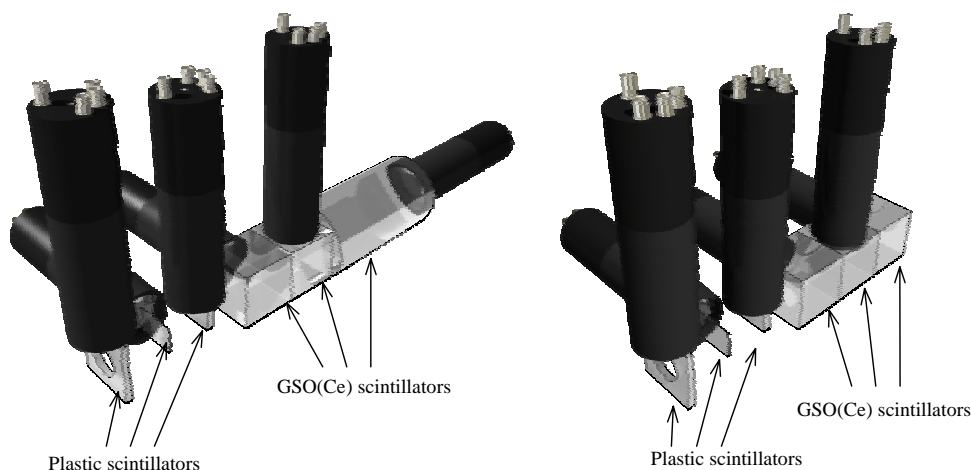


Fig. 1 Stacked GSO(Ce) spectrometers. The long one (left) and the short one (right).

## References

- 1) H. Yoshida, D. Konishi, K. Anami. *et.al.*, *Nuc. Ins.* **A 411**, 46 (1998).
- 2) J. Aichelin, *Phys. Rep.* **202**, 233 (1991).
- 3) H. W. Bertini *et al.*, *Phys. Rev.* **131**, 1801 (1963).
- 4) J. Cugnon, *ibid.* **22**, 1885 (1980).
- 5) K. Niita, S. Chiba, T. Maruyama, H. Takada, T. Fukahori, Y. Nakahara, and A.Iwamoto *Phys. Rev.* **C 52**, 2620 (1995).
- 6) T. Kin, F. Saiho, S. Hohara, K. Ikeda, K. Ichikawa, Y. Yamashita, M. Imamura, G. Wakabayashi, N. Ikeda, Y. Uozumi, and M. Matabo *Phys. Rev.* **C 72**, 014606 (2005).