§42-8 R&D of Alpha Particle induced Gamma-ray Imaging System with Tandem Accelerator

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It is important to study plasma physics on the confinement of the energetic particles, which are produced by DT and/or DD reaction in a burning plasma. The diagnostics of the distribution of energetic particle loss site have been proposed. The fundamental principle is the detection of 4.44-MeV gamma rays produced by the interaction between the energetic particles come from the plasma and the first wall. To study the loss of the high energy alpha particles, it is need to obtain an image of the gamma-ray production points on the first wall. The aim of this study is a development of the imaging system for high energy gamma rays.

The HP-Ge detector was set at the end of beam line on the 1.7 MV tandem accelerator at Kobe University. Gamma rays can be produced by some reactions such as Be(α, nγ), Be(p, γ), Be(d, γ), C(d, γ) reactions. Be(α, nγ) reaction has been typically used for recent experiments and the incident ion is 4.5-MeV helium. The energy of the gamma ray is 4.44 MeV. Because the energy is higher than the energy of environmental gamma ray, a conventional gamma camera can't be applicable for this usage. To fabricate a high-energy-gamma-ray camera, some components should be developed, such as, a pinhole or a collimator, a scintillator and a detector array, and the electronics for reading signals. A high energy gamma ray can easily penetrate the edge of the pinhole or the collimator. From penetration of gamma ray in the edge causes bokeh (out of focus) on the output signals.

It is considered that Lead (Pb) can be used with a collimator material, because Pb is good absorption material for gamma ray. But, the mass attenuation coefficients for a several MeV gamma ray are almost same for all materials. Another materials, such as Fe, Cu, and so on, can be used for a collimator. The manufacturing is easy, but the length is larger than Pb case. Experiments have been conducted with Lead (Pb) block to obtain the dependence of the bokeh on the detector.

Fig. 1 shows typical experimental set up for a gamma ray detection. A slit with a taper is set on the rotatable table, and a field of sight on the Be target position changes by rotating the table. Three type of taper was prepared. The entrance widths are 1 mm and the exit widths are 1, 3, and 6 mm. Fig. 2 shows an example of the experimental results. It shows photo peak of 4.44 MeV gamma ray distribution produced on a Be target for some Pb taper slit. The beam spot on the target is 1 mm. The bokeh becomes smaller for narrow slit.

The experiment with Fe slit was conducted and the photo peak yield for Pb taper slit and Fe taper slit are compared. The results are shown in Fig. 3. Because these slit lengths are the same, the bokeh for Fe slit is larger than that of Pb slit.

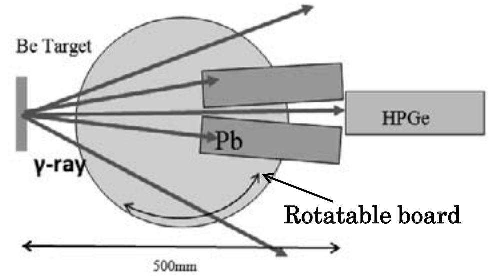

Fig. 1. Experimental set up for a slit geometry.

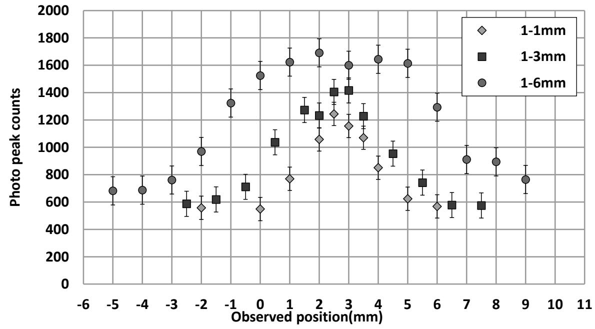

Fig. 2. Photo peak of 4.44 MeV gamma ray distribution produced on a Be target for some Pb taper slit.

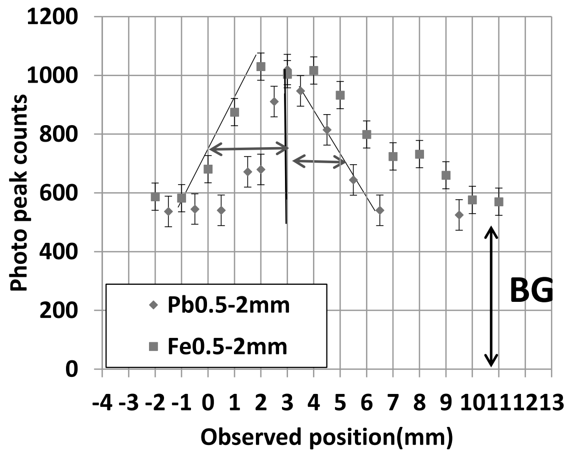

Fig. 3. Comparison of photo peak yield between Pb taper slit and Fe taper slit.

We have studied about the collimator of high energy gamma camera. The bokeh from the penetration of the gamma ray on the collimator edge was experimentally obtained with the slit of Pb block. Some simulation was conducted for some geometry of slit or collimator. The images on the detector array were calculated with the phits simulation code [1]. The results of this study is applicable for the collimator design for high energy gamma ray camera.

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1 Sato, T. et al., J. Nucl. Sci. Technol. 50:9, 913-923 (2013)