Study on detector response to spontaneous fission events of heavy nuclides using the $^{206}Pb+^{48}Ca$ reaction

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Detector response to spontaneous fission (SF) of products by the $^{206}Pb+^{48}Ca$ reaction was studied using a new focal plane detector that has a Si-Ge array[1)] installed at a focal plane of the gas-filled recoil ion separator GARIS.

By using GARIS and GARIS-II, we plan to study the production and decay properties of the superheavy element (SHE) produced via actinide-based fusion reaction (hot fusion). It is reported that SHE nuclides produced by the hot fusion are radioactive and decay by α-particles emission or SF, and all decay chains are terminated in SF[2)], which emit γ-rays. Therefore, it is important to measure the γ-rays of the SF of heavy nuclides. In 2013, we newly installed the Si-Ge detector array[3)] for studying the production and decay properties of reaction products by including $^{248}Cm+^{48}Ca$[4)]. Thus far, we have searched for SF using Si detectors, however, the Si-Ge array can carry out a more accurate identification than the Si detector because the Si-Ge array is expected as a probe for the detection of prompt γ-ray coincided with SF. Before the experiment, the Si-Ge array was caliblated using a well-known $^{206}Pb(^{48}Ca,2n)^{252}No$ reaction. The ^{252}No decays by 73.1% α-particle emission and 26.9% SF[5)]. We assigned this reaction based on its branching and half-life.

A $^{48}Ca^{11+}$ beam was extracted from the 18-GHz ECR ion source and accelerated up to 218.5 MeV by the RILAC. The typical beam intensity was 1.0×10^{12} particle/s (0.17 pμA). The metallic ^{206}Pb (enrichment of 99.3%) target was prepared by vacuum evaporation on a backing of 60 $\mu g/cm^2$ carbon foil. The target thicknesses had a mean value of 353 $\mu g/cm^2$. Sixteen frames of the sector targets were mounted on a ϕ30 cm rotating wheel, which was rotated at 3300 rpm. The reaction products were separated in flight from projectiles and other by-products by GARIS, which was filled with helium gas at a pressure of 73 Pa, and then the products were transported into the focal plane detection system after passing through the time-of-flight (TOF) detectors. The detector system comprised two TOF detectors, a PSD box[1–3)], which is composed of a position-sensitive detector (PSD) and four solid state detectors (SSDs), and a planer typed Ge-detector for counting low-energy photon (CANBERRA, BE6530). The Ge-detector was separated from the other detector vacuum by a 1-mm thick aluminum window. Magnetic rigidity was set to 2.064 T·m for ^{252}No. Gamma rays emitted in coincidence with SF events registered by the PSD box were measured by the Ge-detector.

Figure 1 (A) shows a two-dimensional plot of energy measure between PSD and SSD. SF fragment energy is measured by SSD based on the implantation depth in PSD. When the recoil energy of evaporation residues is low, recoil ions are stopped at the surface of the detector. Then, SF fragments are detected in both PSD and SSD (region a). Conversely, both SF fragments are either stopped in the detector or one of fragment escapes in the backward direction if the recoil energy is high, the implantation depth is deep (region b).

Figure 1 (B) shows a two-dimensional energy plot of SF- and γ-rays observed in prompt coincidence. The probability of coincidence is 52.6% because an SF event emits some γ-rays. From this probability, the Si-Ge array is considered to be useful for the identification of SF fragments.

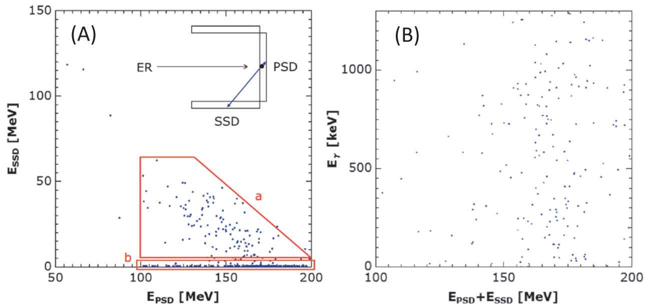

Fig. 1. (A) Two-dimensional plot of energy measure between PSD and SSD. (B) Two-dimensional plot of SF-γ coincidence.

References
1) D. Kaji et al., Contribution in this report.
2) Yu. Ts. Oganessian et al., J. Phys. G: Nucl. Part. Phys. **34**, p.R165 (2007).
3) D. Kaji et al., Contribution in this report.
4) K. Morita et al., Contribution in this report.
5) Table of isotope 8th ed. (John Wiley & Sons, New York, 1998 update).

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