Highly Sensitive Detection System for High-Spin Isomer

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We have developed a highly sensitive method to investigate high-spin isomers. Essential is the use of (i) inverse kinematics in fusion reaction to focus the fusion products into forward direction, (ii) the EN-course [1] which separates the objective evaporation residues from the primary beam in order to eliminate prompt and background γ rays from the target as well as the primary beam dump, and (iii) a tagging counter for the residues event by event, prior to their implantation into a catcher foil surrounded by the γ-ray detectors.

Its practical application has been successfully made in searching for the high-spin ($I \geq 39/2$) shape isomers expected in nuclei with $N \sim 51$ (^{93}Nb and ^{93,94}Mo). The 7.4 MeV/u $^{86}Kr^{21+}$ beam from the AVF cyclotron bombarded a ^{13}C target (1.0 mg/cm^2 thick) and the fusion-evaporation residues recoiling out from the target were accepted with a high efficiency into the EN-course. This beam line consists of the first dipole magnet system delivering the ions to the momentum-dispersive focal plane and of the second dipole magnet system with the achromatic focus point at its exit. The prompt γ-rays in-flight were thoroughly extinguished during the long flight time of ~520 ns for the flight length of 16.3 m. Based on the detailed investigations on the charge state distributions of the primary beam ^{86}Kr and the objective ^{93}Mo, the $B\rho$ selection was optimized for $^{93}Mo^{35+}$ with a magnetic rigidity acceptance of $\Delta(B\rho)/B\rho = 5.8\%$. This setting prevented all fractions of the primary beam with various charge states from being transmitted after the first focus. It is worth noting that the observed charge state distributions were reproduced well only by the empirical formula by Winger *et al.* [2], but not by other several formulae. At the second focus the residues were focused into a spot size of ~5 mm in diameter on a Pb catcher foil (42 mg/cm^2 thick), which is placed in the East Experimental Hall well shielded both from the target and the primary beam dump. The energy loss signal of the residues from a thin Si detector (20 μm thick), which was installed just upstream of the catcher foil, triggered the data acquisition for γ-ray detection with a Ge-detector array surrounding the foil. The array consisted of 14 coaxial Ge detectors and its total efficiency was 1.8% at 1.3-MeV γ-ray. Such arrangement enabled a high S/N measurement for the high-spin isomer decays. Figure 1 shows the γ-γ total projection spectrum. It is to be noted that the γ-rays associated with the isomers in nuclei such as ^{92,93,94}Mo, ^{91,92}Nb, ^{90,91}Zr, ^{89,90}Y, ^{86}Sr were selectively observed.

Careful analyses have set the limit for the ^{93}Mo high-spin isomer production cross section as $\sigma \lesssim 1$ μb. The present method, even with a small Ge array, enabled very high sensitivity comparable to that with a large scale Ge-detector array.

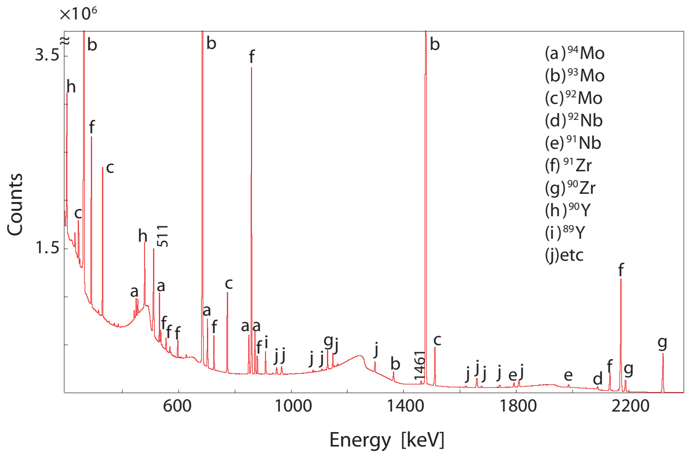

Figure 1: Gamma-gamma total projection spectrum.

References

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