Commissioning the BRIKEN array in parasitic mode using exotic Ni-Ga secondary beam

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Very neutron-rich nuclei can emit neutrons after β^--decay when the decay Q-value is larger than the (one/two/three…) neutron separation energy of the daughter nucleus ($Q_\beta > S_{xn}$). For neutron-rich nuclei away from the valley of stability, β-delayed one/two/three-… neutron emission is the dominant decay process. These β-delayed neutrons play a key role in the formation of heavy elements in the so-called astrophysical r process[1,2]. Furthermore, the emission probability (P_n) provides information about the distribution of the nuclear levels above the separation energy populated in the β^--decay. A common approach to measure P_n values is to implant the isotope of interest into a silicon detector, register its β-decay and count the delayed neutrons using a neutron detector in coincidence with the β^--decay events.

In the last year, the largest and most efficient neutron counter has been built at the RIKEN Nishina Center[3]. The neutron detector, surrounding the AIDA silicon implantation array[4], has a flexible design. The so-called compact BRIKEN array consists of 166 ^{3}He gas-filled proportional counters, embedded into a 90 cm x 90 cm x 75 cm high density polyethylene neutron moderator. The hybrid BRIKEN detector configuration contains 148 proportional counters and two Eurisol-type clover HPGe detectors. Figure 1 shows the schematic view of the experimental setup.

The detection system was commissioned in November 2016 in parasitic mode during the NP1412-RIBF123R1 main experiment. A high intensity ^{238}U beam was accelerated up to an energy of 345 MeV/nucleon at the RIKEN cyclotron accelerator complex before hitting a 5000 micron thick beryllium target to produce secondary beams by in-flight fission.

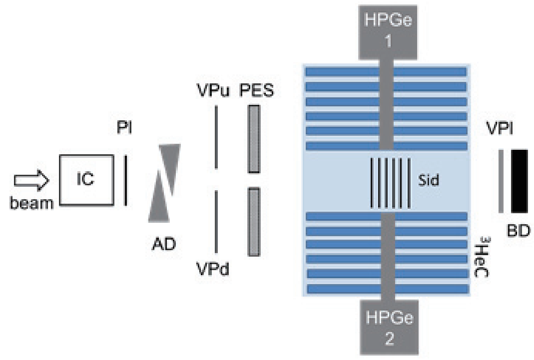

Fig. 1.: Schematic view of the experimental setup. Particle identification was carried out using the ionization chamber (IC) and the plastic scintillator (Pl) located at F11. The energy of the isotopes of interest was reduced using the adjustable degrader (AD) and then they were implanted into the silicon detectors (Sid) and their decay was measured using 166 ^{3}He counters (^{3}HeC) and the clover type HPGe detectors (HPGe1 and 2). In order to reduce the neutron background the BRIKEN array is shielded by a polyethylene wall (PES) equipped with active veto detectors (VPu and VPd). Furthermore, at the rear side of the array, a veto detector (VPl) and a beamdump (BD) are located.

The secondary radioactive beam was filtered through the BigRIPS and ZeroDregree spectrometer and implanted in the AIDA array containing 6 layers of highly segmented silicon detectors. The emitted neutrons and γ-rays following the β-decay were recorded by the BRIKEN array configured in hybrid geometry. Some of the implanted isotopes are identified as β-delayed neutron emitters with well-known P_n values, which allowed us to determine the efficiency of the array and compare it with the results of the Monte-Carlo simulations[3] and a good agreement was found. In the latter phase of the analysis, new P_n values will be obtained for isotopes with scarce or uncertain from previous experiments.

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