2 - 20 Attempt to Synthesize a New Neutron-deficient Isotope ^{224}Np

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Nuclei in the light actinide region with $Z\sim92$，$N\sim134$ are predicted to be candidates for shape coexistence[1], some nuclei in this region are also predicted to have stable octupole deformation[2]. Actinide nuclei with N=134 have been produced up to plutonium (^{228}Pu), and the lightest plutonium isotope and neptunium isotope discovered so far are ^{228}Pu and ^{225}Np respectively. A campaign has been started to investigate the nuclei in this region. The reaction ^{20}Ne + ^{209}Bi was used to produce ^{224}Np (N=131) in fusion-evaporation reaction as the first step.

In this measurement, the ^{209}Bi (^{20}Ne, 5n)^{224}Np reaction was employed. Rotating ^{209}Bi targets were bombarded for 55 h by a 122.6 MeV ^{20}Ne^{7+}beam delivered by the SFC cyclotron at HIRFL, with average beam current of around 400 particle nA. The targets consisted of ^{209}Bi layer of 400 μg/cm^2 with carbon backing of 40 μg/cm^2. A 10 μg/cm^2 thick carbon was covered on the downstream side of the target to protect the target from sputtering. The gas-filled recoil separator SHANS was used to collect evaporation residues (ERs) and to separate them from the ^{20}Ne beam and other reaction products. The separated recoils were implanted in a position-sensitive Si strip detector (PSD) after passing through a multiwire proportional chamber (MWPC) used to distinguish α-decay from recoil implantation in PSD.

The isotopes implanted in the PSDs were identified using the temporal and position correlations the recoil implantation and subsequent α-decay chain. An $\alpha-\alpha$ correlation spectrum is presented in Fig. 1. For ^{222}Pa (α3n) 217 events were observed and a cross section of (141 ± 71) nb was deduced, consistent with the HIVAP calculations.

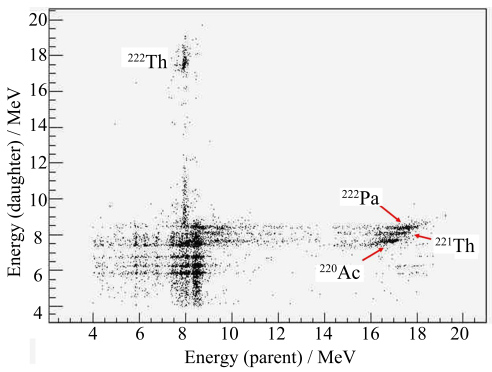

Fig. 1 (color online) Two dimensional spectrum of $\alpha-\alpha$ correlation. The time difference between implanted ERs and the α-decay of the parent nuclei and between the α-decays of the parent and daughter nuclei was set to 125 ms and 1.5 s, respectively. These events were measured within the horizontal position of the same strip (∼3.1 mm width) and the vertical window of ±2.5 mm in the PSD. The energy of the implanted ERs was between 0.8 and 10 MeV.

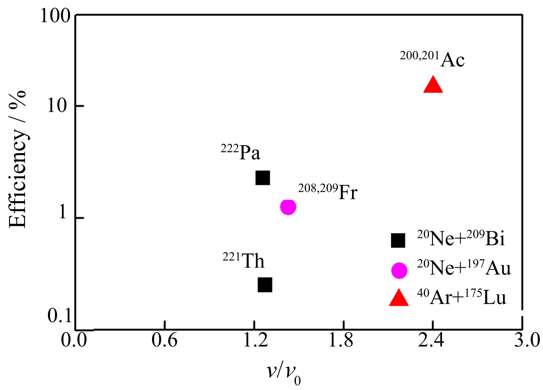

Fig. 2 Efficiency of the SHANS as a function of the recoil velocity expressed in Bohr velocity units ($v_0 = c/137$, where c denotes the speed of light). The data for ^{222}Pa, ^{221}Th, and ^{208,209}Fr are obtained from this experiment, while the data for ^{200,201}Ac was from Ref. [3].

The magnetic rigidity acceptance of the SHANS decreases with the recoil velocity due to the multiple scattering of the recoil ions in helium gas, leading to the decrease of transmission efficiency at low recoil velocity. The transport efficiencies at different recoil velocities measured on SHANS are compiled in Fig. 2.

The decay of ^{224}Np was not identified due to the very low transport efficiency of the ^{20}Ne+^{209}Bi reaction products and the implantation profile of ^{224}Np in the PSD detectors was found shifted away from the implantation detectors.

References

[1] Peter Möller, Arnold J Sierk, Ragnar Bengtsson, et al., Phys. Rev. Lett, 103(2009)212501.

[2] Peter Möller, R. Bengtsson, B. G. Carlsson, et al, Atomic Data and Nuclear Data Tables, 94(2008)758.

[3] Z. Y. Zhang, Z. G. Gan, et al., Atomic Energy Science and Technology, 10(2011)1262.