

### 3 - 1 $\alpha$ Decay of the New Isotope $^{204}\text{Ac}$

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Proton- and  $\alpha$ -decay spectroscopy can provide valuable information on the nuclear structure and masses of neutron-deficient isotopes. In 1994, the proton drip line of Ac was reached by the detection of  $^{207}\text{Ac}$  which was

identified via the  $\alpha$ -decay spectroscopy. Four years later, the neighboring proton-unbound nucleus  $^{206}\text{Ac}$  was discovered. In our previous work,  $^{205}\text{Ac}$  was discovered, which is the third Ac isotope beyond the proton-drip line.

In this work, a new proton-unbound isotope  $^{204}\text{Ac}$  was produced in the fusion-evaporation reaction  $^{169}\text{Tm}(^{40}\text{Ca}, 5n)^{204}\text{Ac}$  and identified via the recoil- $\alpha$  correlation at the gas-filled recoiled separators SHANS2 and SHANS. The excitation function for producing  $^{204}\text{Ac}$  was measured and the optimal beam energy was evaluated to be 212 MeV. The  $^{204}\text{Ac}$  nuclei were produced via the 5n-evaporation channel of the fusion reaction of  $^{40}\text{Ca}$  ions with  $^{169}\text{Tm}$  targets in two experiments. In the first experiment, the 200 MeV  $^{40}\text{Ca}$  beam was delivered by a linear accelerator, namely the China Accelerator Facility for superheavy Elements (CAFE2). In the second experiment, the 210 ~ 214 MeV  $^{40}\text{Ca}$  beam was supplied by the Sector Focusing Cyclotron of the Heavy Ion Research Facility in Lanzhou (HIRFL). Eleven and eight ER -  $\alpha_1$  -  $\alpha_2$  -  $\alpha_3$  decay chains were observed for this isotope(Fig. 1), respectively.

Based on these chains, the  $\alpha$ -particle energy and half-life of  $^{204}\text{Ac}$  were determined to be 7948(15) keV and  $7.4^{+2.2}_{-1.4}$  ms, respectively(Fig. 2). The reduced  $\alpha$ -decay width was deduced to be  $49^{+15}_{-10}$  keV, which indicates a favored  $\alpha$  decay for  $^{204}\text{Ac}$ . In addition, more precise decay properties of  $E_\alpha = 7883(15)$  keV and

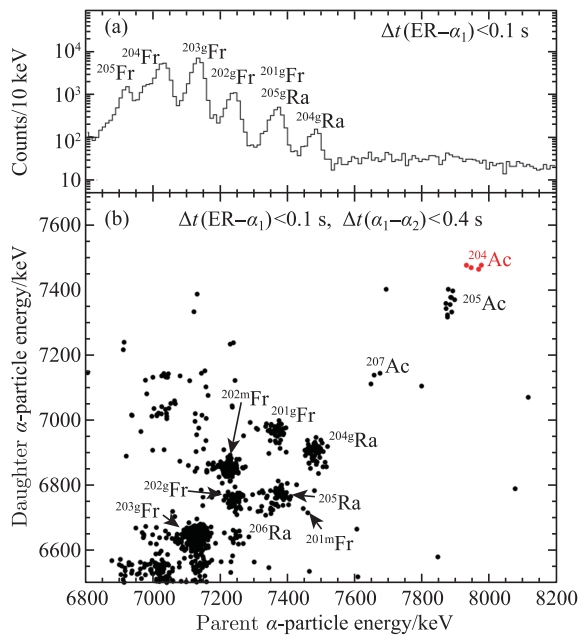


Fig. 1 (color online) Energy spectrum of  $\alpha$  particles within 0.1 s after an ER implantation at the beam energy of 200 MeV, (b) Parent and daughter  $\alpha$ -particle energies for ER- $\alpha_1$ - $\alpha_2$  correlation events.  $\alpha_2$  decays were detected within 0.4 s after the  $\alpha_1$  decays from (a). Only the  $\alpha$  particles detected by DSSD with full energy are shown.

$T_{1/2} = 7.7^{+2.7}_{-1.6}$  ms were obtained for  $^{205}\text{Ac}$ .

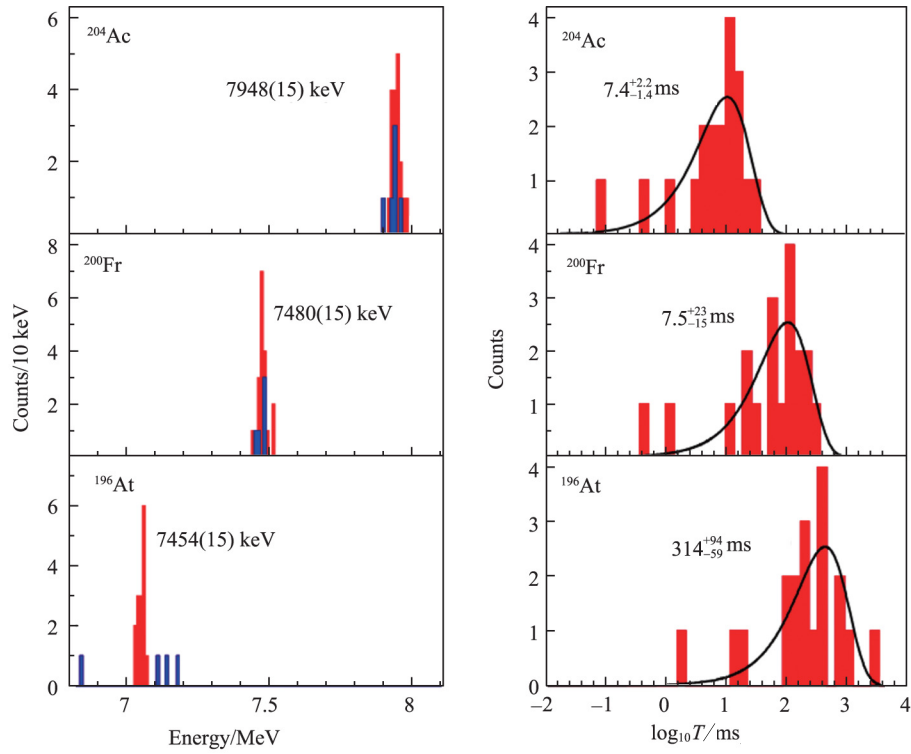


Fig. 2 (color online) Stacked histograms of  $\alpha$ -particle energy (left panel) and decay time distributions (right panel) for  $^{204}\text{Ac}$  and descendant nuclei. The average  $\alpha$ -particle energies were deduced without considering the escaped  $\alpha$  particles shown in blue color. Black curves correspond to the deduced half-lives.

## References

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\* Foundation item: Strategic Priority Research Program of Chinese Academy of Sciences (XDB34010000), Guangdong Major Project of Basic and Applied Basic Research (2021B0301030006), National Key R&D Program of China (2018YFA0404402), National Natural Science Foundation of China (U1932139, 12105328, 12035011, U2032135, 11975279), Youth Innovation Promotion Association CAS (2020409), CAS Project for Young Scientists in Basic Research (YSBR-002) and Special Research Assistant Project of Chinese Academy of Sciences