$$(T_{1/2})_i = \frac{(t_i - t_1)\ln 2}{\ln N_1 - \ln N(t_i)}, \tag{1}$$

$$(\sigma_{T_{1/2}})_i = \frac{(t_i - t_1)\ln 2}{(\ln N_1 - \ln N(t_i))^2}\sqrt{\frac{1}{N(t_i)} - \frac{1}{N_1}}, \tag{2}$$

where $T_{1/2}$ is the half-life of $^{94m}Ru^{44+}$. N_1=75 is total number. t_1 is first observed decay time. t_i is observed decay time. i is decay number from 2 to 39. $N(t_i)$ is the number of remain ions at the decay time of t_i.

Applying Eqs. (1) and (2), and correcting the relativistic effect γ=1.302, we get a preliminary result that the half-life of $^{94m}Ru^{44+}$ in the ion rest frame is (89.55±19.49) μs. The result agrees with the expected value 94.78 μs, proving that half-life in tens of microseconds has been measured successfully. The detailed analysis of half-life of $^{94m}Ru^{44+}$ is in progress.

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2 - 10 Direct Measurement of the Main s-process Neutron Source Reaction, $^{13}C(\alpha, n)^{16}O$, at Stellar Energies

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The $^{13}C(\alpha, n)^{16}O$ reaction is the key neutron source reaction for the main s-process nucleosynthesis[1]. The important energy range (Gamow window) for the $^{13}C(\alpha, n)^{16}O$ reaction during the s-process spans from 140 to 230 keV in the center of mass frame. Because of the Coulomb barrier, the cross sections drop exponentially as measurement approaches the Gamow window energies. Limited by cosmic ray background and the available beam intensity, the ground-based measurements are limited to energies above 280 keV. Therefore, the extrapolation based on R-matrix calculation and/or in-direct measurement is the current method to estimate the cross sections for astrophysical interest with limited precision. Moreover, due to the existence of sub-threshold resonances, there are rather large uncertainties associated with the extrapolated cross sections which limit the precision of the current reaction rate and thus prevent us from a complete understanding of the nucleosynthesis of heavy elements.

China JinPing underground Lab (CJPL) is currently the deepest underground lab in the world, with an over-burden of 6720 m.w.e[1]. By comparing with Gran Sasso National Laboratory in Italy, the muon flux in CJPL is about 1/100, the U/Th backgrounds and neutron background are also significantly lower. With its supreme low background condition, CJPL is listed as one of the most ideal underground laboratories for particle physics and nuclear astrophysics. By now, two dark matter experiments, CDEX[2] and PandaX[3], are being carried out in CPJL. Meanwhile, new experimental caves are being built to host more underground experiments, such as underground nuclear astrophysics JUNA[4].

"The underground experimental study of the key problems in nuclear astrophysics", is initiated in 2015 by the JUNA collaboration consisting of China Institute of Atomic Energy, Institute of Modern Physics, Tsinghua University, Shanghai Jiaotong University and Sichuan University. This project is funded jointly by NSFC, CAS and CNNC. The goal of the project is to take the advantage of the ultralow background in Jinping underground lab, the first underground high current accelerator based on an ECR source and high sensitive detection systems to study directly the crucial nuclear reactions for the first time within their relevant stellar energy range.

The $^{13}C(\alpha,n)^{16}O$ project is one of the first four physics programs. Our high current accelerator driven by a powerful ECR source will be the first of its kind in underground laboratories. It will provide 10 mA He^+ in the energy range of 50 ∼ 400 keV (Fig. 1(a)). The detection system consists of a liquid scintillator and 20 ^3He detectors

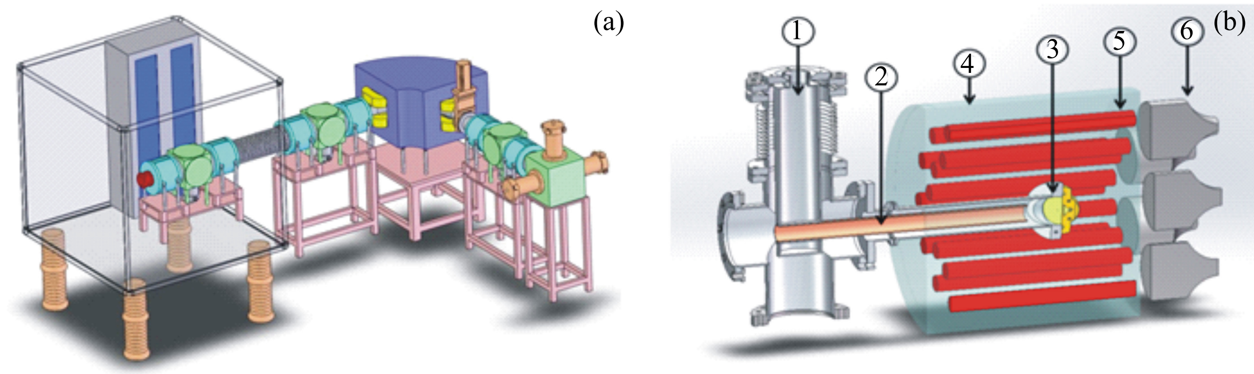

Fig. 1 (color online) (a)400 kV High current accelerator driven by ECR source. (b) Schematic drawing of low background highly sensitive fast neutron detector. 1) LN_2 cold trap; 2) Copper tube; 3) high power ^{13}C target; 4) Liquid scintillator; 5) ^3He detectors; 6) PMTs. The neutron shielding is not shown in this figure.

(Fig. 1(b)). The neutrons produced by $^{13}C(\alpha, n)^{16}O$ has energies between 2 ∼ 3 MeV. These neutrons will be firstly slowed down by the scintillator. Some of the thermalized neutrons will be captured by the ^3He detectors. The fast neutron signal will be identified with the coincidence between the liquid scintillator and the ^3He detectors. With the high current beam, ultralow natural background and highly sensitive fast neutron detector, we shall be able to extend our measurement down to $E_{\rm cm}$=0.2 MeV, the middle of the Gamow window. The accelerator will be installed in CJPL by the end of 2017. The physics experiments will be started in 2018. Our result will be crucially important for testing and calibrating the predictive power of extrapolating model, providing a reliable astrophysical reaction rate, and eliminating one important uncertainty in AGB stellar model.

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