Figs. 1(a) and 1(b) show the experimental[2] and simulated revolution time spectra, respectively. The horizontal axis is the revolution time, T. The details for extracting T can be found in Ref.[2]. Fig. 1(c) is the comparison of the experimental (red open circles) and simulated (black solid circles) standard deviation of revolution time, σ_T. It is striking that the agreement between the simulated results and the experimental data is so good although only the linear component of magnetic elements is considered.

The SimCSR has been used to investigate the key contributing sources to the σ_T of stored ions. We found that there are three ways to reduce the σ_T. First, one can tune the slope of the dependence of transition point (γ_t) on the momentum difference (dp/p) to reduce the phase slip factor (η). However, this method can only be applied to the specific ions fulfilling the condition $\gamma=\gamma_t$. Second, one may take a measure to reduce width of momentum difference ($\sigma_{dp/p}$). However, a small $\sigma_{dp/p}$ could lead to low statistics. This method can't be applied to the measurement of ions with low yields. Finally, one can measure the velocity of ions. This method has been tested at the HIRLF-CSR. The data analysis is currently in progress.

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2 - 9 Half-life Measurement of $^{94m}Ru^{44+}$ at CSRe*

Zeng Qi, Zhang Yuhu, Wang Meng, Xu Hushan, Tu Xiaolin, Zhou Xiaohong, Yan Xinliang, Chen Ruijiu, Huang Wenjia, Ge Zhuang, Liu Dawei, Fu Chaoyi, Sun Mingze, Mei Bo, Xu Xing, Xing Yuanming, Shuai Peng, Zang Yongdong, Zhang Wei, Xiao Guoqing, Yu. A. Litvinov and Isao. Tanihata

A radioactive nucleus is characterized with an intrinsic half-life. However, for a nuclear species, the half-lives in neutral atoms could be very different from that in highly charged ions. The half-lives of some highly charged ions have been directly measured at GSI for multiple motivations[1]. In the same case, the nuclear state(*i.e* the isomer) may be in the range of several tens of microseconds and their half-live can be measured using isochronous mass spectrometry. The $J^{\pi}=8^{+}$ isomeric state in ^{94}Ru was chosen to test this method. The half-life of this isomer is 71 μs [2] in neutral atoms, and the excitation energy is 2.64 MeV. The internal conversion coefficient of this decay in neutral atom is 0.335. So its half-life in the bare nucleus would be modified to be 94.78 μs when the internal conversion channel is blocked.

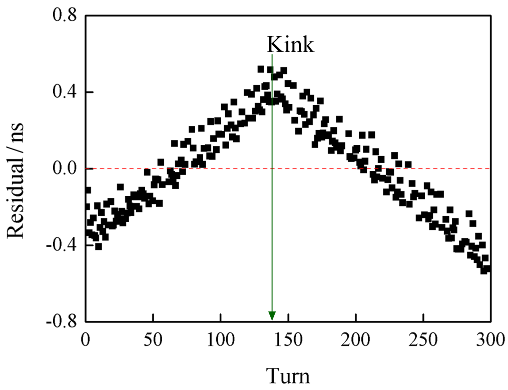

Fig. 1 (color online) Podala Palace, Tibet

The procedure of the experiment is the same as our typical IMS experiments[3]. The $^{94m}Ru^{44+}$ are produced by fragmentation of the primary $^{112}Sn^{34+}$ beam and then stored in the CSRe. The signal of the ions from the time-of-flight detector are recorded with a digital oscilloscope Tektronix DPO 71254. The recording time was set to 200 μs for each injection corresponding to ≈300 revolutions. The CSRe was tuned to be isochronous for $^{94}Ru^{44+}$, so its revolution time directly depends on its mass-to-charge ratio. If a $^{94m}Ru^{44+}$ decays during the storage in the CSRe, then the revolution time will change markedly because of the different mass. Then, by linear fitting the time stamps as a function of the turn numbers, the residual of the fitting have been obtained and shown in Fig. 1. In this figure, one can see a kink which corresponds to the decay time of the isomer. In this way, 39 decay cases were observed and their decay times were extracted. In addition, another 36 $^{94m}Ru^{44+}$ that didn't decay within the recording time were identified from their characteristic revolution times. So in total 75 $^{94m}Ru^{44+}$ were recorded.

We can extract the half-life and its error based on the exponential and binomial distribution function:

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

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

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

Tang Xiaodong, Ren Jie[1], Chen Han, Chen Zhijun, Chen Xiongjun[1], Huang Hanxiong[1], Jiang Liyang[1], Li Kuoang, Ruan Xuchao[1], Wang Shuo[2], Zhang Ningtao and the JUNA collaboration

([1]China Institute of Atomic Energy, Beijing 102413, China
[2]Department of Physics, Shandong University, Weihai, Shandong, China)

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.