Towards background-free studies of capture reactions in a heavy-ion storage ring

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Synopsis Stored and cooled highly-charged ions offer unprecedented capabilities for precision studies in realm of atomic-, nuclear-structure and astrophysics. In context of the latter, after the successful investigation of the cross section of ^{96}Ru(p,γ) in 2009, in 2016 the first measurement of the ^{124}Xe(p,γ)^{125}Cs reaction was performed at the Experimental Storage Ring (ESR) at GSI.

Highly-charged stable or radioactive ions can be stored and cooled in a heavy-ion storage ring. Their charge state and their momentum can precisely be chosen and controlled over extended periods of time [1]. We have employed the unique feature of the ESR facility at GSI to address astrophysically relevant reactions. In a first, proof-of-concept, experiment ^{96}Ru(p,γ) has been measured [2]. The new experiment has been performed with decelerated fully-ionized ^{124}Xe ions [3]. Using a Double Sided Silicon Strip Detector (DSSSD), introduced directly into the Ultra High Vacuum environment of the storage ring, the ^{125}Cs proton-capture reaction products of interest have been successfully detected. The cross sections are measured at 5 different energies between 5.5 AMeV and 8 AMeV, on the high energy tail of the Gamow-window for hot, explosive scenarios such as supernovae and X-ray binaries. The well-understood atomic REC cross section for ^{124}Xe+H_2 reaction is used for luminosity calibration.

Elastic scattering on the internal H_2 gas jet target is the major source of background. Monte Carlo simulations show that an additional slit system in the ESR in combination with the energy information of the Si detector will make background free measurements of the proton-capture products possible, see Figure 1. This improvement is about to be implemented and will increase the sensitivity of the method tremendously.

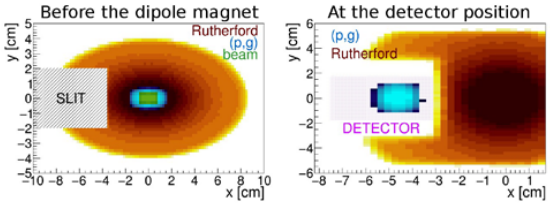

Figure 1. Simulated particle distributions before the dipole magnet (left) and at the detector position (right). Combining a scraping system with an offline energy separation of the measured ions can lead to background free measurement of the p-capture products.

In this contribution, the details of the ^{124}Xe(p,γ)^{125}Cs experiment and the data analysis will be introduced. As an outlook, future perspectives at ESR and CRYRING are discussed [4] focusing on precision (p,γ) reaction studies in the Gamow-window using stored and cooled, highly charged, radioactive ions.

References

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