# Proton and α capture studies for nuclear astrophysics at GSI storage rings

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**Synopsis** The $^{124}$Xe(p,γ) reaction has been measured for the first time at energies around the Gamow window by using stored ions at the ESR facility. The desired beam energies below 10 MeV/u introduce new experimental challenges like windowless ions detection under UHV conditions, extremely short beam lifetimes and efficient beam deceleration and cooling, all of which have been successfully met.

In the nucleosynthesis of the so-called *p* nuclei radiative capture reactions like (p,γ) or (α,γ) play an important role to model the reaction network and to explain the stellar production yields in different explosive scenarios [1]. Most of the key reactions involve radioactive nuclei [2] and can be studied solely in inverse kinematics. The GSI facility offers the unique possibility to produce such exotic ions and to store them in the experimental storage ring, ESR, and eventually in the CRYRING. This setting allows one to use the limited intensities available for radioactive ions with maximum efficiency.

In a first step, fully-stripped ions are stored at beam energies below 10 MeV/u. Subsequently, nuclear reactions are introduced by colliding the stored ions with the internal jet target that consists of either hydrogen or helium gas for (p,γ) or (α,γ) reactions, respectively. Ions, which capture a proton or an α particle at the target, are separated from the stored beam in the next dipole magnet and are detected by UHV compatible double-sided silicon-strip detectors (DSSSD) with a 100% efficiency. Due to atomic interactions the lifetime of the highly charged beam is on the order of seconds. However, the dominant mechanism reflected by this is the well-known radiative electron capture (REC), which can be used for normalization by employing high resolution x-ray spectroscopy around the target.

The very first measurement in the ESR was performed with a beam of stable $^{124}$Xe$^{54+}$ ions decelerated to and stored at energies between 5.5 MeV/u and 8 MeV/u to study the reaction $^{124}$Xe(p,γ)$^{125}$Cs. The spacial resolution of the employed DSSSD allowed a clear identification of the (p,γ) signal sitting on a background of elastically scattered ions, as shown in Fig. 1. Similar signals could be identified for five different beam energies in the aforementioned energy range. The analysis of the data set is ongoing and preliminary results will be presented.

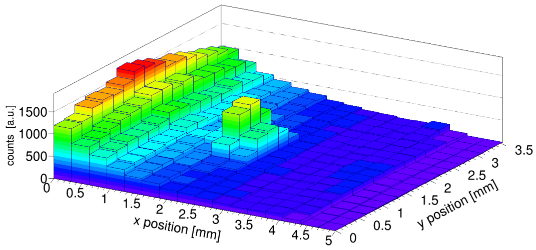


**Figure 1.** 2D map of the DSSSD data taken at 7 MeV/u. The peak contains the (p,γ) products sitting on a distribution of elastically scattered ions.

In the future, first reaction studies on radioactive nuclei are planned and will be carried out using the ESR setup described above. For energies below 4 MeV/u the newly installed CRYRING facility [3] is ideally suited to serve as a low-energy extension of the ESR. Corresponding experimental equipment is already being designed and will be ready for first experiments in 2018.

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## References

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