Performance of a scintillator-based ion detector for CRYRING@ESR

E B Menz[1,2,3] *, C Hahn[1,2,3], P Pfäfflein[1,2,3], G Weber[1,2] and Th Stöhlker[1,2,3]

[1] Helmholtz Institute Jena, Jena, 07743, Germany
[2] GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, 64291, Germany
[3] Friedrich Schiller University Jena, Jena, 07743, Germany

Synopsis A detector based on the scintillator material YAP:Ce and capable of counting single ions is presented. The detector consists of a YAP:Ce crystal and a light guide operating in ultra high vacuum and a conventional photomultiplier outside the vauum. The crystal demonstrated the necessary radiation hardness against heavy ion irradiation. The detector has been commissioned at CRYRING@ESR and its detection capabilities have been confirmed with beam from the local source.

The novel FAIR accelerator and storage ring complex, currently under construction at the site of the GSI Helmholtz Center for Heavy Ion Research near Darmstadt, Germany, achieved a major milestone with the first stored beam at CRYRING in 2017. Since then both beam acceleration and electron cooling have been achieved and the first user experiments are planned for 2019. To fully exploit the multifaceted field of research thus made accessible, the availability of robust and reliable ion detectors is of fundamental importance [1]. These sensors will need to provide single-hit detection efficiency at MHz count rates of ions with energies ranging from sub-MeV/u to 15 MeV/u, while withstanding the radiation damage imparted by the energetic ions.

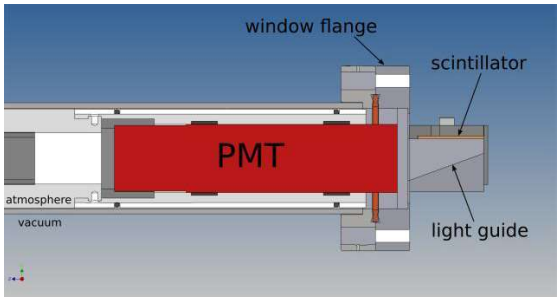

Figure 1. Schematic design of the detector with the scintillator crystal inside and the photomultiplier (PMT) outside the vacuum.

Given these restrictions, a detector system based on the YAP:Ce crystal scintillator provides an attractive approach, utilizing a material that is endowed with a significant degree of radiation hardness while remaining comparatively affordable [2]. A detector system was designed and constructed as part of the CRYRING@ESR instrumentation and has been installed at the ring.

The contribution details the detector design and outlines the results of characterization measurements before and after installation. A proof-of-concept measurement was conducted with various ion species at the 3 MV tandem accelerator JULIA operated by the University of Jena's Institute of Solid State Physics. This experiment confirmed the feasibility of the setup and found a destruction threshold fluence (50% signal amplitude loss) of approximately 10^{13} cm^{-2} across the range of ion species and energies investigated.

At CRYRING the detector is located downstream from the electron cooler and will be used for the observation of electron-ion recombination products. The system has already demonstrated its viability in commissioning measurements with H_2^+ and D^+ beams from the local ion source. These light ions could be detected even at the injection energy of 300 keV/u and from the measured count rate the lifetime of the H_2^+ beam was determined to be ~180 ms.

The setup will be used for e.g. dielectronic recombination and 1s Lamb shift measurements on slow, heavy, highly-charged ions of all species that the GSI accelerator complex is able to produce and transport through ESR.

References

[1] Lestinsky M *et al* 2016 *Eur. Phys. J. Special Topics* **225** 797
[2] Tokman M *et al* 2001 *Phys. Scripta* **2001** 406

* E-mail: e.menz@gsi.de