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A continuous, broadband data acquisition for Schottky signals in atomic and nuclear physics experiments at heavy-ion storage rings

C. Trageser[*,†] [1], C. Brandau[*,†,‡] [2], C. Kozhuharov[†], Yu.A. Litvinov[†,◇], A. Müller[*], F. Nolden[†], S. Sanjari[†], Th. Stöhlker[†,○,•]

[*] Justus-Liebig-Universität, 35392 Gießen, Germany
[†] GSI-Helmholtzzentrum für Schwerionenforschung, 64291 Darmstadt, Germany
[‡] ExtreMe Matter Institute, EMMI, and GSI Research Division, 64291 Darmstadt, Germany
[◇] Ruprecht-Karls-Universität, 69120 Heidelberg, Germany
[○] Friedrich-Schiller-Universität, 07743 Jena, Germany
[•] Helmholtz-Institut, 07743 Jena, Germany

Synopsis At heavy-ion storage rings Schottky noise techniques belong to the established non-destructive diagnostics methods. In addition, Schottky mass spectrometry is used to observe atomic masses and nuclear decays down to the level of a single stored ion without destruction of the circulating ion beam. In this contribution a new broadband, continuous data acquisition for Schottky signals and first experimental results obtained with this system during several commissioning runs at the storage ring ESR, Darmstadt are presented. Special emphasis will be given to present and future applications in atomic and nuclear physics experiments at storage rings.

Schottky probes are a common non-destructive tool at synchrotrons and storage rings to record the noise spectrum of ions in the ring. From the frequency spectrum of this Schottky noise a large variety of parameters of the ion-beam can be deduced, e.g., revolution frequency, beam intensity and momentum spread [1]. Besides application in beam-diagnostics this method is also exploited for experiments in atomic and nuclear physics in storage rings: the so-called (time-resolved) Schottky mass spectrometry (SMS) allows for a determination of atomic masses and for the investigation of decay processes with long half-lives [2–4]. The sensitivity of SMS reaches down to a single stored ion. The Schottky technique is also an indispensable tool in atomic physics experiments such as dielectronic-recombination measurements with artificially synthesized radioisotopes. This has been demonstrated and further developed at the Experimental Storage Ring (ESR) at the GSI-Helmholtzzentrum für Schwerionenforschung in Darmstadt, Germany [5, 6].

A decisive improvement has been obtained at the ESR in 2011 with the installation of a new resonant Schottky probe with high a quality factor, increased sensitivity and with a time resolution on the level of 10 ms [7]. The resonator typically operates at frequencies around 245 MHz, corresponding to about the 125th harmonic of the circulating ions. In order to fully exploit this new Schottky probe a new data acquisition system (DAQ) was developed and commissioned at the ESR which allows for a continuous and broadband recording of the radio frequency (RF) Schottky-signals of the stored ions [8]. The new DAQ is capable of persistently recording up to $3.5 \cdot 10^7$ pairs of inphase and quadrature samples per second (data rate: 140 MByte/s), thus allowing more than 10 harmonics of the ion beam to be recorded simultaneously.

In this contribution we report on the commissioning and first experimental results using this new advanced Schottky DAQ. In addition, we will discuss potential applications of this next generation Schottky set-up with emphasis on atomic physics experiments at the storage rings of GSI and of the upcoming Facility for Antiproton and Ion Research (FAIR) [9].

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[1] E-mail: c.trageser@gsi.de [2] E-mail: c.brandau@gsi.de