Commissioning of a continuous broadband data acquisition for Schottky signals in storage ring experiments at GSI and FAIR*

C. Trageser[1,2], *C. Brandau*[1,2], *C. Kozhuharov*[2], *Yu.A. Litvinov*[2,3], *A. Müller*[1], *F. Nolden*[2], *S. Sanjari*[2], *and Th. Stöhlker*[2,4,5]

[1]Justus-Liebig-Universität, Gießen, Germany; [2]GSI-Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany; [3]Ruprecht-Karls-Universität, Heidelberg, Germany; [4]Friedrich-Schiller-Universität, Jena, Germany; [5]Helmholtz-Institut, Jena, Germany

During 2013 and 2014 a modular New Time-Capture (NTCAP) data acquisition system for Schottky signals was set-up, tested off-line and finally commissioned with beam at the ESR [1, 2]. The main purpose of this device is to uninterruptedly record the RF-signals of storage ring's Schottky probes with high bandwidth for the typical duration of experimental runs at storage rings (1 - 4 weeks). Presently, the DAQ is optimized with respect to the new Schottky resonator with high quality factor that was installed 2010 at the ESR [3]. The core unit of the NTCAP-DAQ is a vector signal analyzer (VSA, NI PXIe-5663E) that internally shifts the RF signal by a carrier frequency down to frequencies around 0 and decomposes the signal into its in-phase (I) and quadrature (Q) components. With a maximum sample rate of 150 MSamples/s, the VSA is capable to deliver rates up to $7.5 \cdot 10^7$ IQ-Samples/s. The data is recorded as IQ raw-data in the time-domain for further offline processing and analysis. The VSA is supplemented by two latchable fast counter cards (100 kHz readout), a high precision oscillator, a synchronization module that can use network or GPS signals, and second digitizer. The details are described in [2].

The applications of such a versatile DAQ are manifold. The Schottky DAQ can run either stand-alone, or synchronized and seamlessly integrated into other experimental setups: in the latter mode it serves as a "beam-logbook" in support of the main experiment and records essential beam parameters such as the composition of stored species down to a single stored ion, the cooling process, frequency, intensity or stability of the beam. As a main DAQ it can be used for experiments on (time-resolved) Schottky mass spectrometry (SMS) and β-decay studies of highly charged ions, e.g., [4, 5]. It is proposed by our collaboration to also utilize the improved time-resolution that is achieved with the new Schottky resonator [3] for particle detection in atomic and nuclear reaction studies at the internal target or the electron cooler.

Already in the very first tests with a 400 MeV/u C^{6+} beam at the ESR the high performance of the NTCAP-DAQ could be shown. IQ rates of up to $3.5 \cdot 10^7$ IQ-Samples/s corresponding to a data rate of 140MByte/s could be sustained over hours. At the same time the recorded signal showed a high dynamic range, low noise and a low level of spurious distortions [2]. By oversampling of the signal further improve on dynamic range and noise level can be achieved offline using decimation or averaging algorithms before the Fourier transform into the frequency domain. In addition to these initial tests, two main experiments and several smaller measurements at the ESR were supported with our NTCAP-DAQ: in a beamtime on laser spectroscopy of Li-like $^{209}Bi^{80+}$ the DAQ was used to monitor the stability of the ion beam energy during the measurement and thus to help to improve significance and precision of this strong-field QED study. The second major experiment was a two-body β-decay study with single stored ions of $^{142}Pm^{60+}$ aiming at a clarification of the puzzling observation of a modulated non-exponential decay [6]. Figure 1 shows an example of such a decay demonstrating the capability of our DAQ to also work with weak signals on a single particle level.

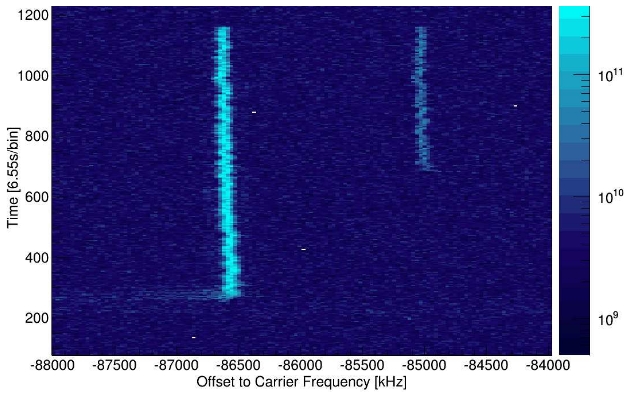

Figure 1: Single EC-decay of $^{142}Pm^{60+}$ (appearance of second trace) recorded with the NTCAP DAQ.

* Work is supported by BMBF (contracts 06GI911I and 06GI7127/05P12R6FAN), by the Helmholtz-CAS Joint Research Group HGJRG-108 and by HIC for FAIR.

References

[1] C. Brandau et al., GSI Scientific Report 2013, p. 160.

[2] C. Trageser et al., Phys. Scr. T, submitted.

[3] F. Nolden et al., Nucl. Instrum. Meth. A **659** (2011), 69.

[4] Yu.A. Litvinov and F. Bosch, Rep. Prog. Phys. **74** (2011), 016301.

[5] F. Bosch et al., Progr. Part. Nucl. Phys. **73** (2013), 84.

[6] P. Kienle et al., Phys. Lett. B **726** (2013) 638.

 DOI:10.15120/GR-2015-1-APPA-MML-AP-06