Beam instrumentation for the RFQ injector at CRYRING

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In 2015 the CRYRING storage ring will resume operation after its installation in Cave B [1]. Commissioning begins with the compact injector, consisting of ion source branch and radio-frequency quadupole (RFQ) linac. It will provide beams of light charged particles for commissioning of the experimental storage ring.

The beam instrumentation of the injector consists of Faraday cups, scintillating screens, and capacitive pickups. All detector systems are compliant to the new FAIR standards and provide a front-end software architecture (FESA) interface to the accelerator control system. CRYRING will be the first machine to be equipped with the new White-Rabbit timing system.

Ion Source and Dipole Spectrometer

Beams of light, singly-charged ions of 10 keV/u, mainly D^+, will be extracted from a MINIS source. Directly behind the ion source and behind the 90° spectrometer dipole, intensity and distribution of the DC beam can be measured with a Faraday cup (FC) or a scintillating screen (SCR). The compact diagnostics chamber with a single motor drive for both detectors was originally designed by KVI Groningen for the HITRAP facility . The driver unit and the controller are a joint FAIR development of GSI and Slovenian in-kind contributor Cosylab.

Expected beam currents along the injector range from 100 μA after the source to 1 μA after the RFQ linac. For the multi-turn injection into CRYRING, the chopper behind the ion source cuts out a $25 - 100\,\mu$s macropulse from the DC beam. Each FC is equipped with a low-noise amplifier, suited for DC and AC operation, with switchable gains of $10^2 - 10^8$ V/A. The output is sampled by a 100 MSa/s ADC with 16 bit resolution in a VME system. Its embedded controller runs the "CryCup" acquisition software.

The SCRs are composed of 25 mm diameter multi-channel plates and P43 scintillators. Beam images are recorded with triggered 10 bit digital CMOS cameras. They are controlled by an industrial PC which hosts the "CUPID " acquisition software. The application takes care of all data handling (image rotation, region cuts, profile calculation) and acts as server to the control system clients [3].

A special camera system with 75 mm fixed-focus lens and optical x4 extender is mounted on the external 0° port of the dipole chamber and looks approx. 3 m upstream into the ion source. During operation it monitors the plasma around the filament, after ion source service or exchange the fixed camera is used to check the re-alignment. The system resolution was measured to be about 20 pixel/mm.

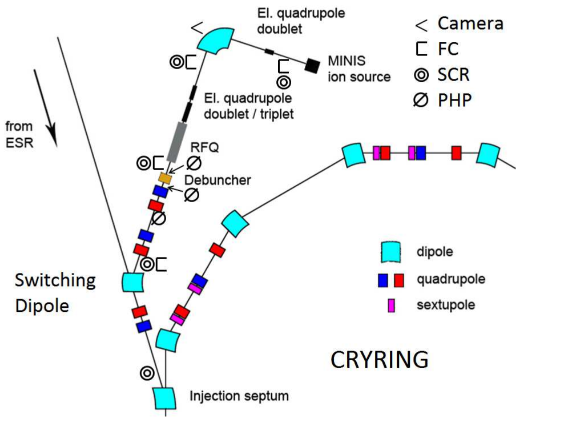

Figure 1: Schematic of RFQ injection for CRYRING; detector positions are indicated with symbols described in the legend. The distance between RFQ and injection is ~10 m.

RFQ linac and debuncher

The 108.4 MHz RFQ linac accelerates ions of q/A>0.36 from 10 to 300 keV/u. The following debuncher reduces the momentum spread $\Delta p/p$ to $\sim$ 1% and increases the injection efficiency. The new bunch monitoring system analyses pairs of signals selected from 3 pickups (PHP) or RFQ and debuncher tank. The derived information may be the beam energy via time-of-flight, phase relations between beam and rf tank power or the verification of the debuncher operation. Signals are amplified, in the case of PHPs, and routed via a remote-controlled switching matrix to a digital 5 GSa/s oscilloscope. A FESA application integrates amplifiers, switching matrix and data readout. The analysis procedure is identical to the one employed at the HITRAP decelerator and achieves a resolution of ~10 ps [2].

As in the source branch two FC/SCR pairs, one at the RFQ exit and one after the two quadrupole doublets, measure intensity and distribution of the 300 keV/u beam. In the bakeable area after the switching dipole, a robust, heat-resistant Cromox screen is mounted close to the injection septum on a pneumatic drive. The detectors are part of the readout systems described in the previous section.

References

[1] M. Lestinsky et al., "CRYRING@ESR: A study group report", June 2012

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[3] B. Walasek-Höhne et al., TUPD062, IBIC 2014, Stanford, USA

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