The bunch monitoring system of the HITRAP decelerator

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The HITRAP decelerator receives a 3 μs bunch of cooled, highly-charged ions from the experimental storage ring (ESR) and consists of two rebunchers, BB1 and BB2, followed by a drift-tube linac (IH-DTL) and a radio-frequency quadrupole (RFQ). The monitoring system is based on capacitive ring pickups and works for currents above 0.5 μA [1]. In 2014 new purpose-built main amplifiers were installed and extensive tests marked the end of the system development.

Monitoring of Bunched Primary Beam

Rebuncher BB1 generates a longitudinal particle focus at the IH-DTL entrance which decelerates the 4 MeV/u primary beam to ∼500 keV/u. Two pickups monitor the mean bunch energy of each extraction by a time-of-flight (TOF) measurement in front of the IH-DTL [2]. A resolution of σ_E=0.7 keV/u was achieved when the energy was changed during a phase scan of rebuncher BB2 [3]. During regular operation BB2 is switched off because it fails to improve the deceleration efficiency. Due to its simplicity, the TOF measurement has been established as reference and the ESR electron cooler voltage is adjusted to a target energy of 4024 keV/u. The TOF energy is 15 keV/u higher than the more accurate ESR energies based on Schottky (4008±3) keV/u or electron cooler voltage (4013±4) keV/u. Despite the small offset, relative changes are correctly detected.

Monitoring of IH-DTL and Buncher BB3

The ideal secondary IH-DTL beam is characterised by a small bunched fraction of accelerated primary ions and the larger, decelerated 500 keV/u design component. A pickup (DP6) monitors amplitude, i.e. deceleration efficiency, and the relative energy of bunches behind rebuncher BB3, which matches the beam to the RFQ acceptance. Fig. 1A presents bunch signals for three BB3 phases. BB3 affects only the decelerated ions, but its field is too weak to influence the remaining primary beam. Using the zero-crossing point of the decelerated bunch signal as reference, a variation in arrival time at the pickup can be converted to an energy shift. Results are shown for a full phase scan in Fig. 1B (dots) together with the data of the Energy Analyzer EA (triangles), a calibrated dipole spectrometer with position-sensitive optical MCP readout [4]. Both data sets are in excellent agreement and follow the expected sine function. The data have not been corrected for occasional glitches in the trigger which produce spurious offsets, most evident at 30° or 50°.

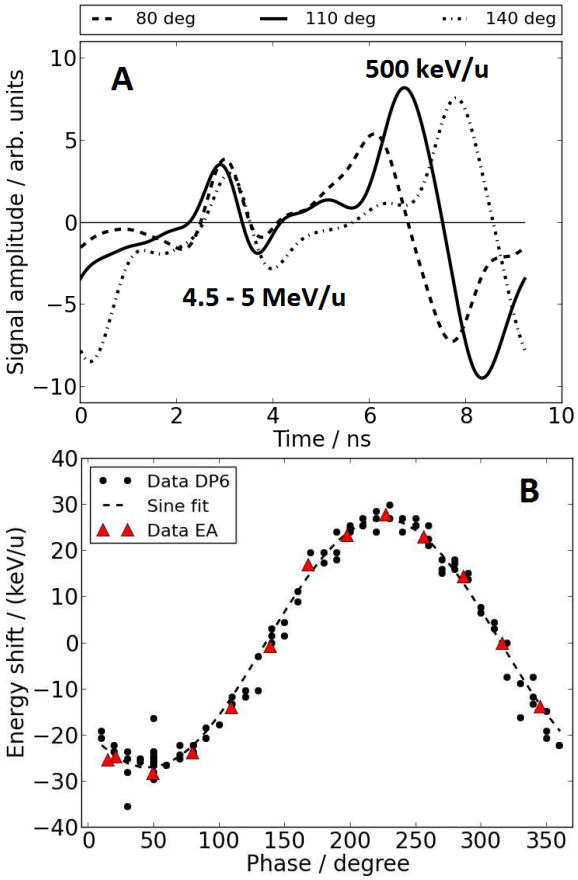

Figure 1: Signals of pickup DP6 for three BB3 phase settings (A). Energy shifts observed by pickup DP6 and Energy Analyzer EA during BB3 phase scan (B).

The HITRAP bunch monitoring system has been completed. Recent tests confirm previous findings and underline the systems' practical potential. The online monitoring system is now part of the standard beam instrumentation.

References

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