Beam Emittance Studies at the Heavy Ion Linac UNILAC

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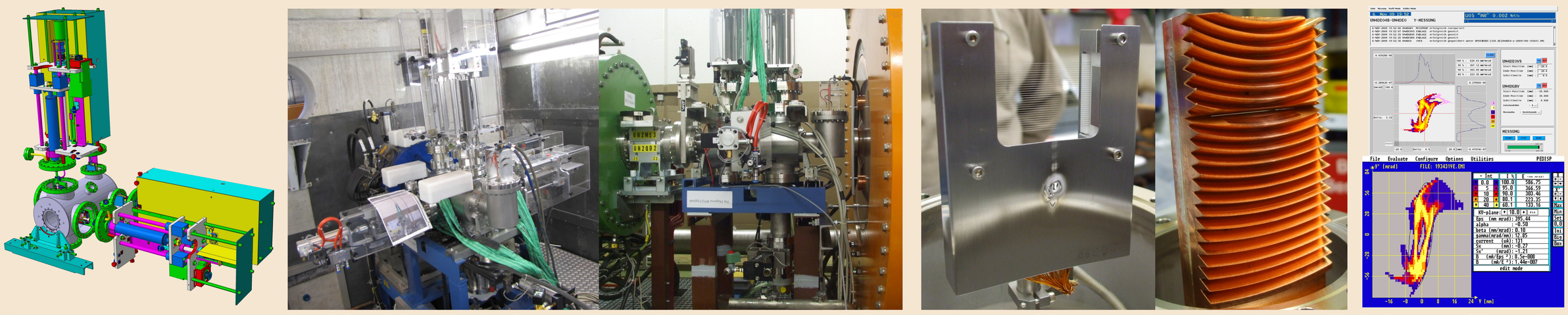
Abstract

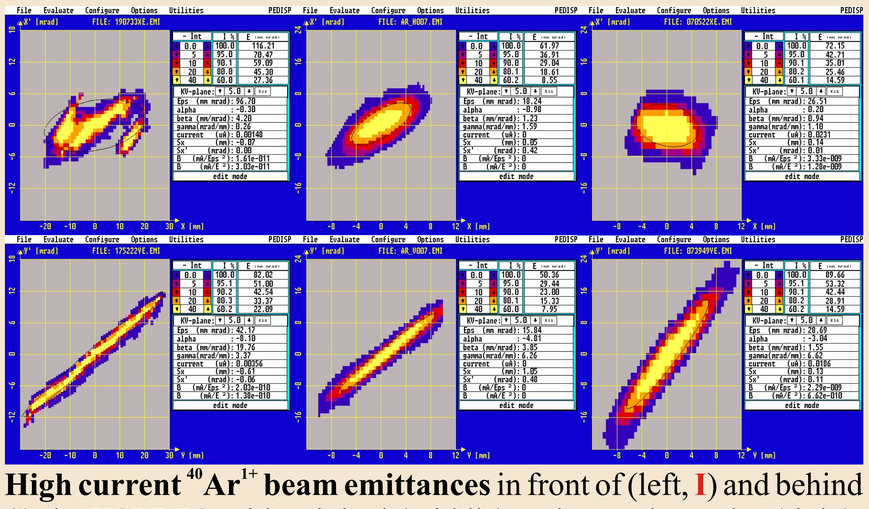
New accelerating structures for the UNILAC at GSI were commissioned in the last two years, and further machine upgrades are in preparation in order to meet the requirements for FAIR. Beam emittance is one of the key beam parameters that are essential for any beam dynamics calculation, for the design of new accelerators as well as verification or investigation of existing machines. Its measurement is intricate and often time consuming. Extensive emittance measurements went along with the commissionings and were conducted to provide a reliable basis for beam dynamics simulations. In addition to the 10 permanent transverse emittance measurement devices installed all over the UNILAC, two "mobile" devices had been built and mounted at four different sites in the UNILAC. This paper introduces the standard slit-grid device used for transverse beam emittance measurements and gives an overview of the activities and results. Amongst others, the following applications will be presented: Emittance growth of high current ion beams, stripping, and resonance effects in a DTL.

Introduction

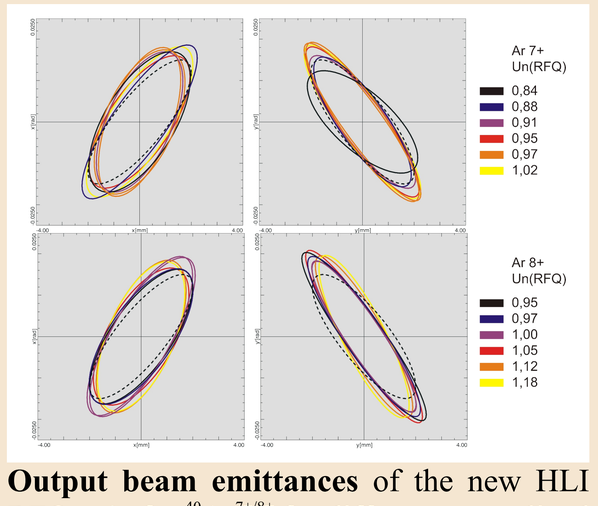
The UNIversal Linear ACcelerator (UNILAC) at GSI is a heavy ion linac, comprising the high current injector (HSI), a gas stripper section, the high charge injector (HLI), a drift tube linac (DTL) of Alvarez-type (Poststripper), and the transfer channel (TK) to the synchrotron (SIS 18) with a foil stripper. The experimental hall for coulomb barrier experiments like SHIP or TASCA is served by the UNILAC directly. The first complete commissioning took place in 1975. Since then the UNILAC underwent major upgrades like the extension of the Alvarez DTL by two additional tanks and the replacement of the Wideroe injector by today's radio frequency quadrupole (RFQ) and interdigital H-structure (IH) accelerator at the HSI. Beam brilliance has risen several magnitudes. The original design of course could not anticipate this development. With FAIR (Facility for Antiproton and Ion Research) the requirements on beam parameters, especially intensity and emittance, became even more challenging, making further machine upgrades necessary. Optimizing the existing accelerator and the design of new accelerator components requires a profound knowledge and understanding of the machine behavior. Beam emittance measurements are an inevitable basis for this.



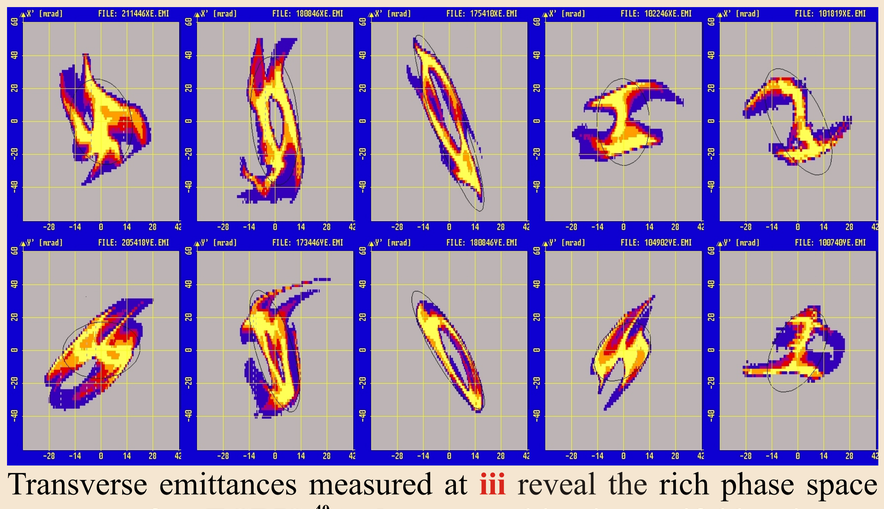
The emittance measurement device (left to right): Sketch of the "mobile" emittance measurement device (MEMD), comprising one emittance slit and one multiwire beam profile monitor (BPM) mounted on linear feedthroughs for each transverse plane, and one x/y-BPM for general operation and coarse emittance measurements; the MEMD mounted at **iii** and **i**; BPM and water cooled high current slit, both showing beam traces; screenshots of the data acquisition (top) and analysis software (bottom) DE and ProEmi.



High current $^{40}Ar^{1+}$ beam emittances in front of (left, **I**) and behind (**i**) the HSI RFQ with original (middle) and new electrodes (right). The emittances reflect the larger acceptance of the new electrodes.

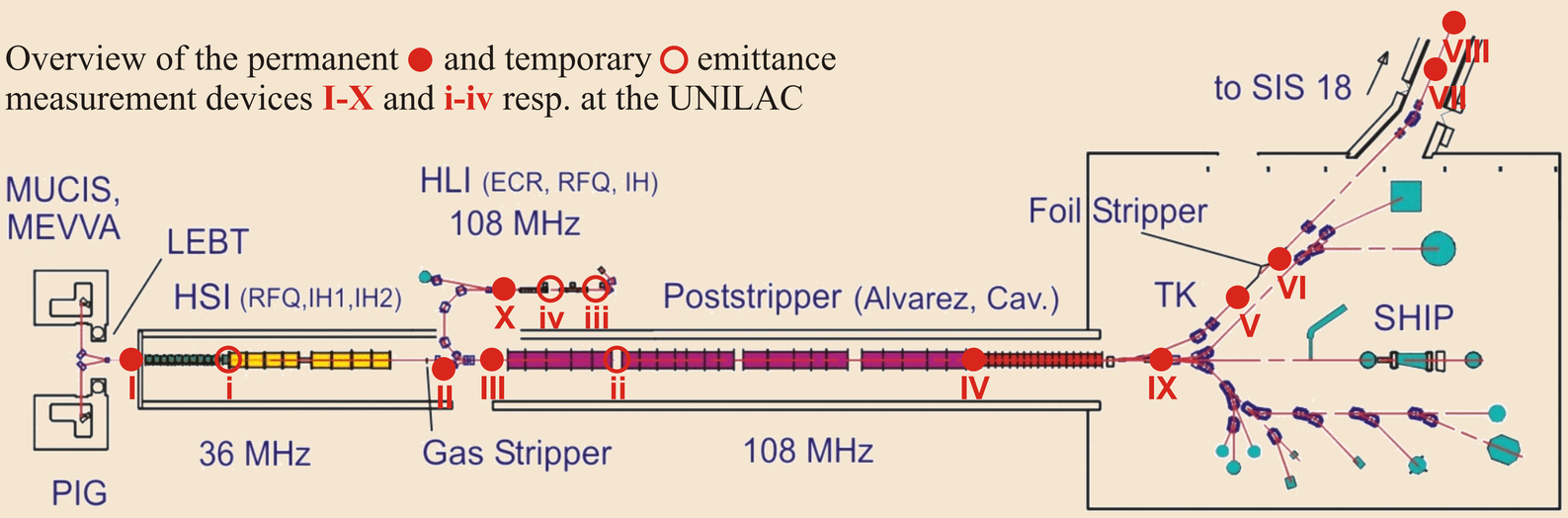


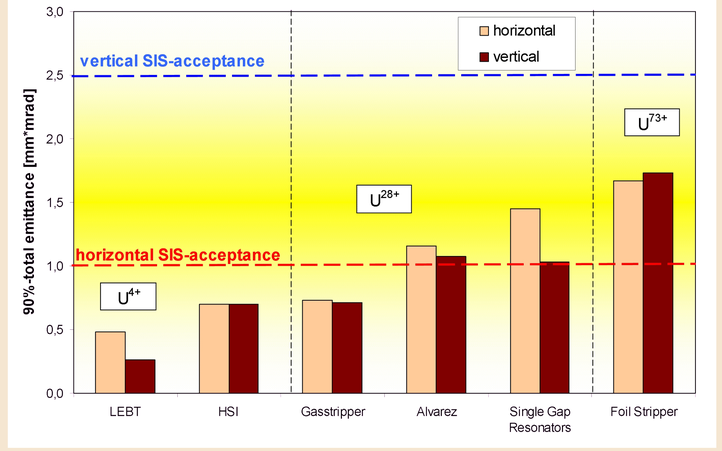
Output beam emittances of the new HLI RFQ at **iv** for $^{40}Ar^{7+/8+}$ for different normalized rf amplitudes; dashed: original design .



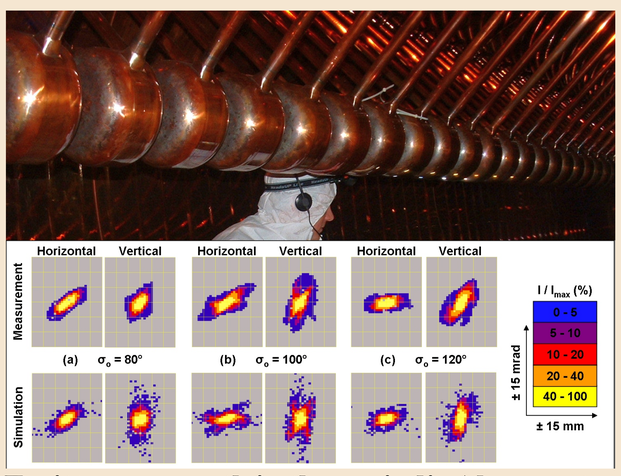
Transverse emittances measured at **iii** reveal the rich phase space structure of an **ECRIS ^{40}Ar beam**, resulting in manifold emittance figures for different beamline (matching to RFQ) and source settings.

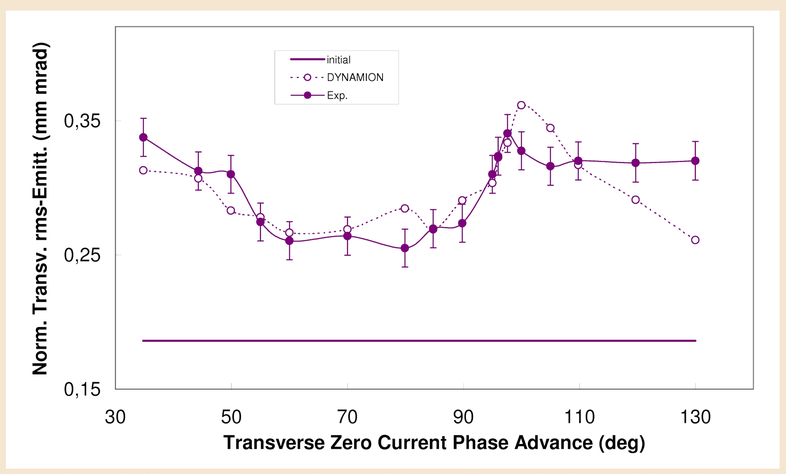
Overview of the permanent ● and temporary ○ emittance measurement devices **I-X** and **i-iv** resp. at the UNILAC

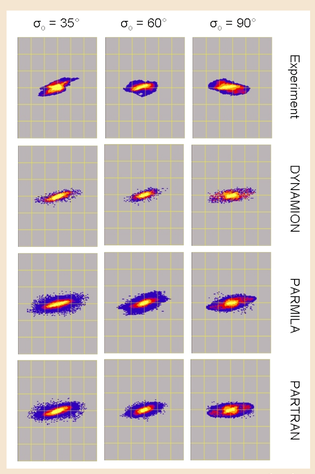


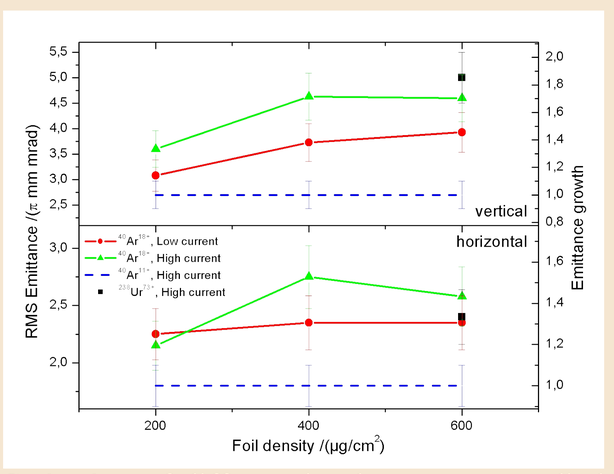


Emittance growth along the UNILAC can be monitored by the permanent devices **I-VIII**; matching the main DTL and foil stripping are the main sources.









Emittance growth in the periodic Alvarez structure (top left) was investigated (**III**, **IV** and **ii**). At high beam currents resonant growth is excited at transverse phase advance 90° (left bottom & middle). Simulation and experimental data were benchmarked (middle & left).

Stripping of different ion beams was studied for 3 foil densities at **IV**, **VI** and **VII**.

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