STATUS OF THE GSI POSTSTRIPPER - HE-LINAC

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Abstract

The High-Energy (HE) Linac is proposed to substitute the existing UNILAC post-stripper section. The post-stripper is an Alvarez DTL, which is in operation over four decades successfully. A quasi Front-to-End simulation along the UNILAC shows that by taking future upgrade options into account already, with the existing Alvarez section the FAIR requirements are not reached. Even by substituting the Alvarez section by the HE Linac the aim is not reached per se regarding the existing boundary conditions. Currently workpackages are defined together with the Institute of Applied Physics at Frankfurt University. Starting from the ion sources to the SIS18 transfer channel every section is reinvestigated for improvements in beam quality and intensity.

REVIEW OF FAIR URANIUM ACCELERATOR CHAIN

The design ion for the future Facility for Antiproton and Ion Research (FAIR) is uranium. The present GSI-accelerator complex, i.e. the linear accelerator UNILAC and the heavy ion synchrotron SIS18, are foreseen to serve as an U28+ injector for FAIR.

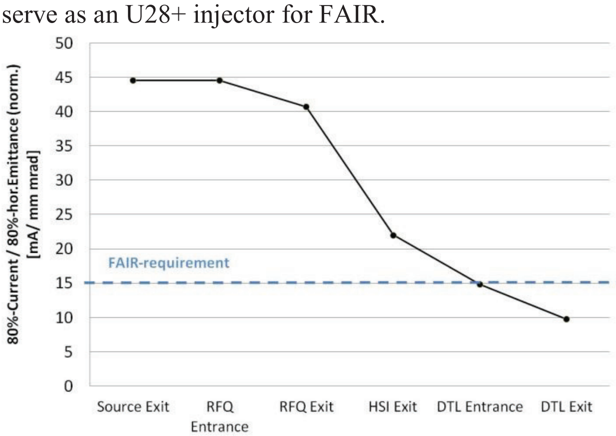

Figure 1: Beam quality along the UNILAC including future upgrade options like the Compact LEBT already with the existing Alvarez DTL [2].

In November 2013 this accelerator chain was reviewed by five external accelerator experts. The two main results are pointed:

- The input beam parameter window for the SIS18 is defined. For providing $2x10^{11}$ U28+ particles a beam current of 15 mA at a pulse length of 80 µs within a total horizontal emittance of 5 mm mrad is required [1].
- A quasi Front-to-End simulation along the UNILAC shows that by taking future upgrade options into account already, with the existing Alvarez section the FAIR requirements are not reached. Even by substituting the Alvarez section by the HE Linac the aim is not reached per se regarding the existing boundary conditions [Fig. 1].

In its report the review committee recommends the following measures [3]:

- Privilege the maintenance of beam quality instead of rf efficiency
- Establish the 3 Hz operation of uranium source
- Redesign the LEBT
- Substitute/redesign the consumed RFQ electrodes
- Optimize/redesign the matching line from RFQ to HSI IH – the MEBT

LEBT

A dedicated high current uranium ion source and LEBT is planned to fulfil the intensity requirements for FAIR [4]. This new injection line is integrated in between the two existing branches as a straight injection line without a dipole magnet (Fig. 2).

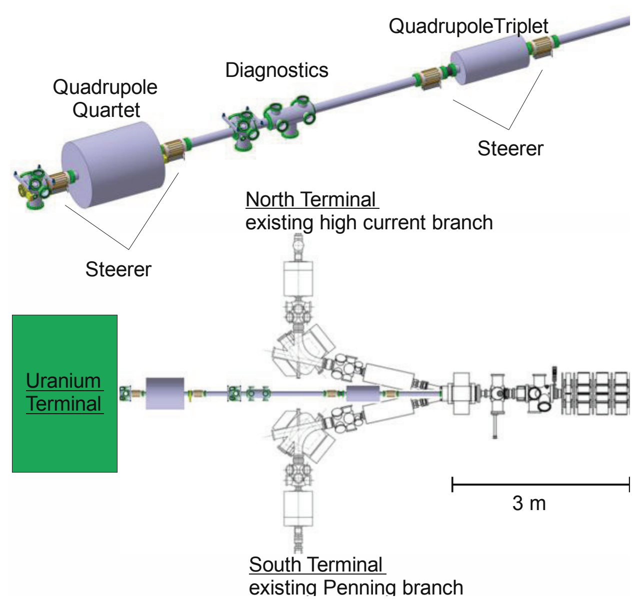

Figure 2: The existing HSI-LEBT branches together with the planned straightforward injection.

All uranium charge states, coming from the ion source, are injected into the HSI-RFQ. Only the design charge state U^{4+} is accelerated through the RFQ, while the other charge states are lost inside the RFQ mainly.

The new LEBT design is based on recent beam emittance and current measurements behind the existing ion source. The generated particle input distribution is used for detailed investigations including alternative concepts also (Fig. 3).

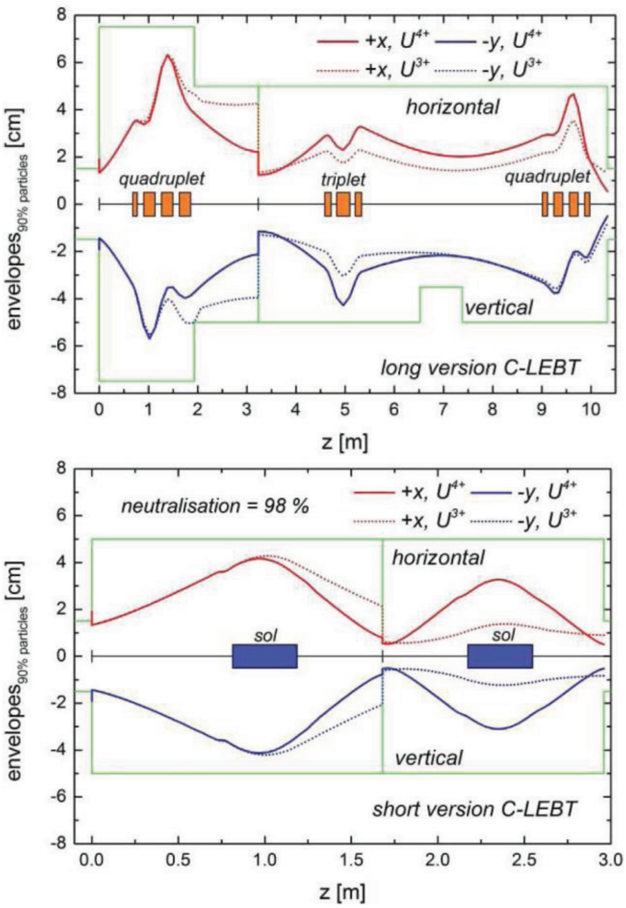

Figure 3: The preferred LEBT solution (top) in comparison with an alternative concept for the LEBT comprising two solenoids [4].

MEBT

After the HSI RFQ upgrade in 2009 the intertank section between the RFQ exit and the IH entrance became a bottleneck as it is confirmed by the Front-to-End simulations. The losses in front of the RFQ are transfered to the HSI IH entrance due to increasing the RFQ-acceptance.

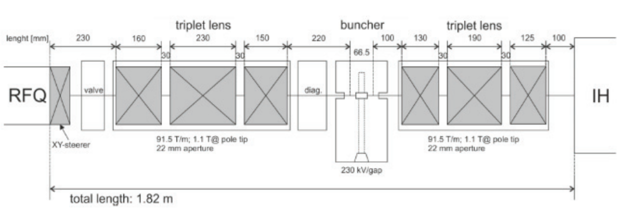

Figure 4: An alternative concept for the MEBT instead of the existing doublet-superlens combination [6].

Presently the beam matching to the IH-DTL is managed by a quadrupole doublet in combination with a superlense. Recent investigations propose at least an increase of the quadrupole doublet gradients for beam quality improvements at the IH exit [5].

An alternative MEBT concept is based on separation of longitudinal and transverse focusing (Fig. 4). First simulations show promising results [6].

GSI POST-STRIPPER

The GSI Poststripper is an Alvarez DTL, which accelerates the ions from 1.4 AMeV to energies up to 11.4 AMeV. The Alvarez DTL, which was designed for 25 years of operation, is now in operation over four decades successfully.

The status and the operational risk of the overaged Alavarez DTL were evaluated recently [7]. The effort of maintenance and the amount of service time is rising. In worst case scenarios due to a failure of a drift tube or the Alvarez rf-tanks itself the downtime is estimated to the range of several months, which does not fit the long term requirements of an adequate and reliable FAIR injector. The substitution of the existing Alvarez DTL is necessary. First considerations propose the substitution of the existing Alvarez DTL by an rf-efficient IH-DTL (Fig. 6). The longitudinal beam quality in an IH DTL applying the KONUS beam dynamics is more sensitive than in an Alvarez DTL applying the synchronous particle beam dynamics. The longitudinal IH DTL acceptance for input beam parameters is more strict. In this respect an Alvarez DTL with its higher periodicity is less sensitive. Its higher periodicity allows an analytical matching procedure for a broad window of input beam parameters. On the other hand an Alvarez is less rf efficient and its fabrication and assembling is more complex and costly.

R&D projects are triggered by the review with respect to the two DTL concepts.

Six IH-cavity DTL

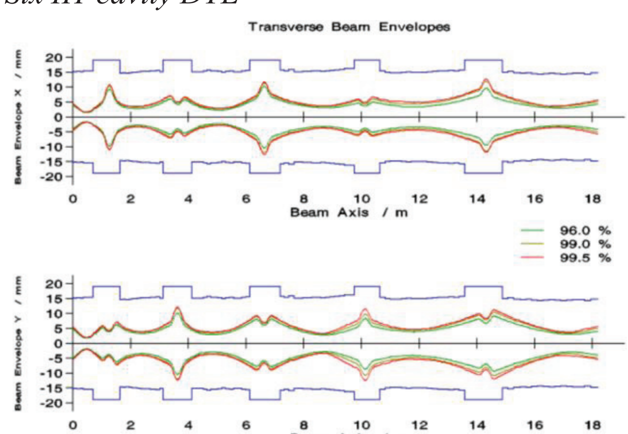

Figure 5: Transverse envelopes through the HE-Linac.

This post stripper option comprises six 108 MHz IH DTL cavities within a total length of about 24 m accelerating the ions up to 11.4 AMeV (A/Q=8.5)

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applying the KONUS beam dynamics concept [8]. External magnetic quadrupole triplet lenses are used for transverse focusing between the cavities (Fig. 5).

The effort of finding a periodical solution for this system was quit after the results showed no improvements. More promising was the investigation of a best set of input Twiss parameters in front of each cavity. A complex numerical approach leads to an improvement in brilliance behind the IH DTL by a factor of 1.5 [9].

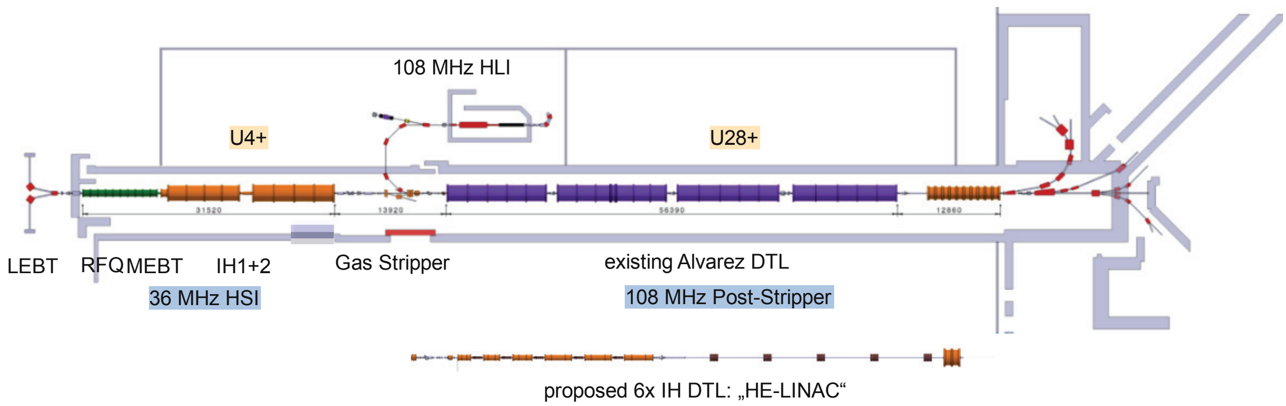

Figure 6: The existing GSI linear accelerator UNILAC with an Alvarez DTL behind the gas stripper. The Alvarez is proposed to be substituted by an IH DTL, the so-called HE-Linac [8].

Alvarez DTL

Parallel to the IH concept investigations towards a new Alvarez DTL are made. Starting from the existing Alvarez design the drift tube shape is optimised with respect to improve the field properties and to increase the shunt impedance. First results are promising. Optimising the drift tube geometry, especially smoothening the drift tube's cap, lower the surface peak fields. The shunt impedance could be increased by 10 percent (Fig. 7).

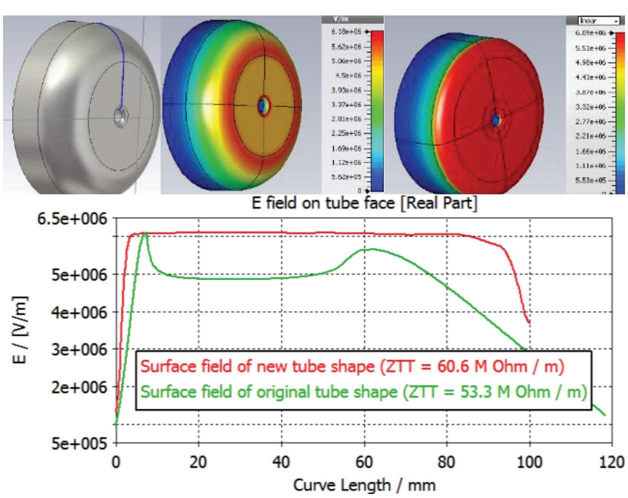

Figure 7: Comparison between existing and new drift tube design regarding the shunt impedance.

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