Optimization of the KONUS beam dynamics for the HE-Linac

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Introduction

A new high energy heavy-ion injector (HE-Linac) for the FAIR project was proposed as replacement for the existing post-stripper linac at the GSI UNILAC [1]. Six 108 MHz IH-type drift-tube linac cavities within a total length of about 17 m accelerate the ions (up to U28+) from 1.4 MeV/u up to 11.4 MeV/u (Fig.1). The previous beam dynamics of the entire HE-Linac is based on the KONUS concept [2], with an external magnetic quadrupole triplet lens behind each cavity. Particle tracking was performed with the LORASR code, developed at the IAP, Frankfurt [3]. The optimization of the particle tracking through the HE-Linac [4] with respect to the emittance growth reduction is investigated.

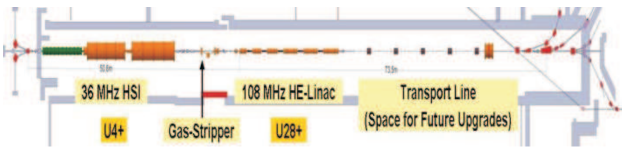

Figure 1: The scheme of the HE-Linac concept.

The Improved Design of HE-Linac

As the first step the influence of the input Twiss parameters on the emittance growth was investigated separately for each of the six cavities. The transverse emittances before the IH1 are 14 mm·mrad and 21 mm·mrad. The assumed longitudinal distribution was generated using the results of measurements for the HIPPI project [5]. The beam current is 20 mA.

The optimum $\alpha_{x,y}$(n) at the beginning of n-th cavity are found in the interval [2.0, 4.0]. The correspondent $\beta_{x,y}$(n) (in mm/mrad) depends on $\alpha_{x,y}$(n) by following rules:

β(1)=0.5α(1), β(2)=0.7α(2), β(3)=0.9α(3),
β(4)=1.3α(4), β(5)=1.6α(5), β(6)=1.9α(6).

These values can be changed by 20%. Then the additional emittance growth is less than 1% for each IH-cavity. For the beam current of 15mA the emittance growth is by 1-2% lower for each tank than for the current of 20mA.

The improved design of the HE-Linac (Fig.2) aims at defined Twiss parameters before each cavity, keeping the KONUS beam dynamics. The triplet gradients and the position of triplets are varied for this matching. The total length of the HE-Linac is increased by 1.4 m. The larger distance between the cavities allows integration of diagnostics devices.

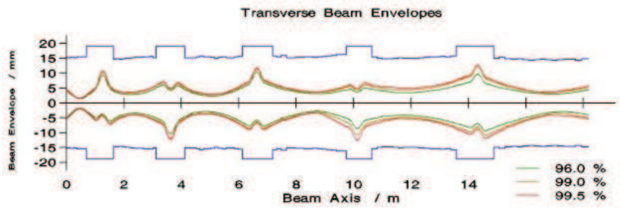

Figure 2: The transverse envelopes through the HE-Linac for the improved design.

The improved design increases transmission from 88% to 92%. By artificial decrease of the longitudinal input emittance from 20 keV/u·ns to 15 keV/u·ns the transmission can be increased up to 100% . The transversal emittance growth along the line is about 35% (instead of 50%). The beam brilliance behind the HE-Linac is about 1.5 times higher for the improved design.

Periodic Solution

The solution is called periodic, if α_x, α_y are the same at the beginning of each period (entrance to the IH-tank) and β_x, β_y change correspondently to the energy growth: $(\beta(n)/\beta(n\text{-}1))^2 = \beta\gamma(n)/\beta\gamma(n\text{-}1)$. Any α from the interval [2.0, 4.0] satisfy the conditions for the smallest emittance growth in each period and can be fixed for the periodic solution. The energy growth is known from the cavities design. Taking into account, that β defined above can be changed by 20% without significant emittance growth, the periodic solution, corresponding to the energy changes and being inside this 20% corridor, is found as:

β(1)=0.57α(1), β(2)=0.72α(2), β(3)=0.93α(3),
β(4)=1.15α(4), β(5)=1.35α(5), β(6)=1.53α(6).

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