UPGRADE OF THE H^--INJECTION SYSTEM AT THE DESY PROTON LINAC III

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Abstract

In the near future the injection system of the proton linac at DESY will be upgraded. Two different types of H^--sources are operated at DESY. The new rf-driven volume source is free of cesium. On a long-term basis this source is planned to replace the present operating magnetron source.

For reasons of reliability of the proton linac and for further developments of ion sources a parallel operation of two sources should be possible at the Alvarez linac. Each source has a separate RFQ to accelerate the ions to an energy of 750 keV. A new transport line with one dipole, 8 quadrupoles and one intermediate buncher was designed to match the beam between both RFQs and the Alvarez linac.

The codes COPPOC and TRANSPORT were used to determine the length of the transport line and the parameters of the dipole and the buncher. Because of the high current of 20 mA and above the estimation of the space charge forces is of special interest. The macro-particle-code PARMTRA takes into account the particle-to-particle electric forces among all particles. The properties of the beam line have been studied in connection with the effects on the final beam quality after acceleration with the 50 MeV Alvarez linac.

1 INTRODUCTION

At present the H^--ion accelerator facility LINAC III at DESY consists of a magnetron ion source followed by a RFQ (Radio-Frequency-Quadrupole)-accelerator in front of a 50 MeV Alvarez linac [1].

The H^--injection system upgrade program which is under development at present will enable parallel operation of two ion sources at the Alvarez linac. The proposed MEBT (Medium Energy Beam Transfer) between the two RFQs and the Alvarez linac has a twofold goal: i) it is designed to match the beam of both ion sources to the acceptance of the Alvarez linac. ii) the mechanical construction of the upgrade will facilitate further developments of ion sources and tests at the Alvarez linac.

Concerning the reliability of the H^--injector for HERA operation in the near future, it is essential that the time necessary to switch from the new volume source to the magnetron ion source will become as short as possible. The MEBT between the two ion sources and RFQs and the Alvarez was therefore designed to operate in two modes without the need of altering the mechanical structure.

The new volume source will be installed on the axis of the Alvarez linac, whereas the beam coming from the magnetron source will be bent by a 60°-magnet to this axis. A rebuncher is needed for the longitudinal dynamics in the MEBT.

The optical design of the MEBT is important insofar as the beam quality in the low energy part determines the characteristic of the beam in the high energy part of the linac.

2 DESIGN OF THE MEBT

The design procedure for determing the parameters of the MEBT is as follows:

The space charge force at the high current of 20 mA at the energy of 750 keV finally limit the overall length of the MEBT due to the strong debunching of the ion beam.

As part of the design calculations for the new MEBT a number of options were investigated. Various combinations of one or two dipole magnets with 30°, 45° or 60° and different edge angles were tested in simulations. It was found that the effect of the dispersion generated by a 60° sector magnet on the beam quality can be minimized. A MEBT with only one short dipole gives the possibility to reduce the distance between both RFQs and the rebuncher to less than 60 cm.

The number of quadrupoles was kept small to save space. Since there is no space to install steering magnets the quadrupoles can be displaced transversally in order to align the beam in horizontal and vertical direction.

Eight quadrupoles – 6 for each transport line – arranged in doublets are used to focus the beam transversally. The parameters of the rebuncher cavity have been estimated by calculating the phase and energy spread at its position and the optimized drift length from rebuncher to the first Alvarez tank. A sketch of the layout of the MEBT is shown in figure 1.

3 PARAMETERS OF THE MEBT COMPONENTS

3.1 Magnets

For the beam focusing only one standard Alvarez type of quadrupole is employed. Steering angles of up to 10 mrad will be realized by transverse displacements of the quadrupoles of up to 1 mm. The 60°-bending magnet is a pulsed sector dipole magnet. The manufacturing of the magnets was given to industry. All magnets will be powered with the same type of DESY-developed pulsed power

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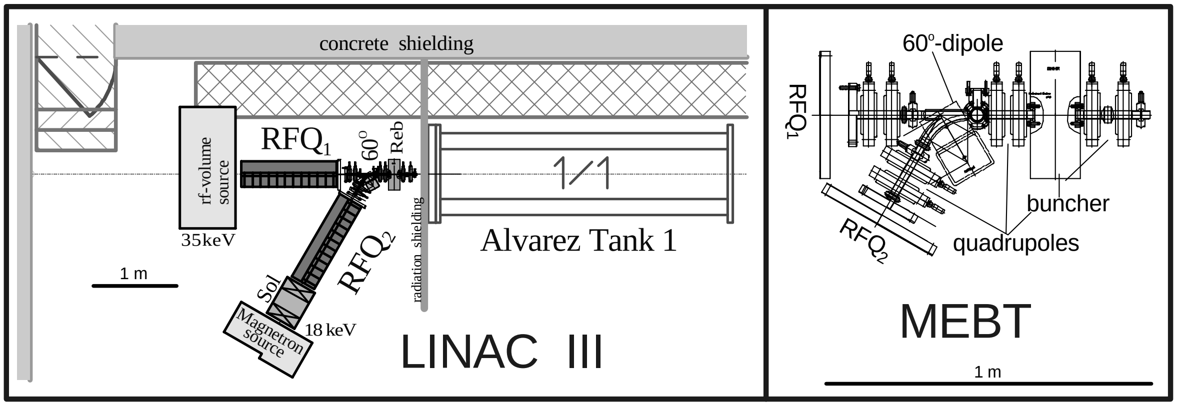

Figure 1: Layout of the MEBT.

supplies. Due to the small duty factor of the proton linac of 1:4000 at a repetition rate of 0.25 Hz air-cooling is sufficient.

3.2 RFQ accelerator

The new RFQ accelerator is based on the design of the operating 4-ROD RFQ [2] at LINAC III and was delivered by the IAP Frankfurt. The design input energy has been increased from 18 keV to 35 keV in order to permit the operation of the volume source with higher extraction voltage.

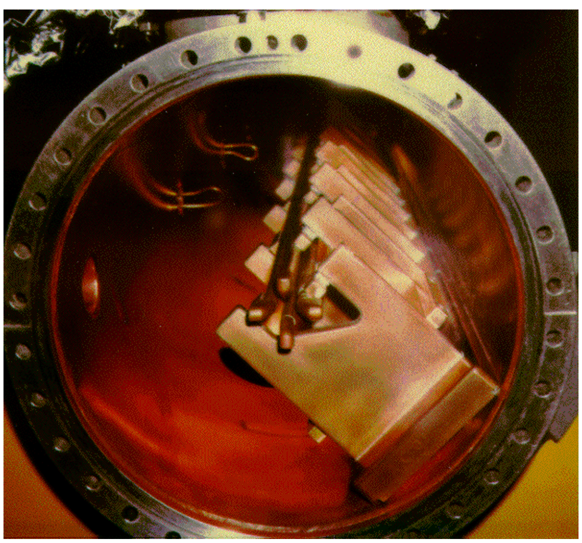

Figure 2: View of the RFQ accelerator.

Figure 2 shows the low energy part of the RFQ. Both RFQs will be powered by the same rf-amplifier.

3.3 Rebuncher cavity

A new rebuncher cavity is under construction at the IAP Frankfurt. It is a two gap spiral loaded resonator operating at 202 MHz. The design values are as follows:

f_0	202 MHz
U_{eff}	58 kV
U_{gap}	45 kV
P	5 kW
length	12 cm

Table 1: Main parameters of the rebuncher cavity for the MEBT.

A rf-amplifier for the rebuncher cavity is under construction at DESY.

3.4 The Ion Sources

Currently a 18 keV magnetron source is operating as the H^--ion source for LINAC III. To reduce the work functions for the electrons the magnetron source must be operated with cesium. The rf-driven volume source [3] at DESY makes a cesium-free operation possible with high currents and smaller emittances compared to the magnetron source.

3.5 Beam diagnostic

The measurement of the beam parameters will be performed by DESY standard devices. At the exit of the RFQs and in front of the Alvarez tank the current will be measured by commercially available current transformers. Screen monitors at two different places in the MEBT will be used to optimize the beam alignment and the focusing strengths of the quadrupoles. The bunch length at the entrance of the Alvarez tank will be derived from signals of a capacitive pick-up and of the new BSM monitors inside the Alvarez linac [4]. As an alternative an additional BSM [5] can be installed between MEBT and the Alvarez linac.

4 BEAM DYNAMICS CALCULATIONS

The beam optic was developed using the codes COPPOC [6] and PARMTRA [7]. The first order code COPPOC was used because of its powerful optimizer and the intuitive interface. PARMTRA is a particle tracking code for ions that takes into account the space charge forces and the rf-defocusing in the rebuncher cavity.

The transversal and longitudinal envelopes in the MEBT are shown in figure 3 to figure 5. The parameters of the H^--beam behind the RFQs differ according to the different electrode design. Following parameters have been assumed in the calculation:

	MEBT 1: rf-source & RFQ_1 $\rightarrow$ Alvarez	MEBT 2: magnetron source & RFQ_2 $\rightarrow$ Alvarez
$\epsilon_{x,y}$	36 π mm mrad	36 π mm mrad
$\Delta\phi$	$\pm$ 19°	$\pm$ 29°
ΔW	$\pm$ 10 keV	$\pm$ 14 keV

Table 2: Beam properties (at 750 keV) at the exit of the RFQ.

The quadrupole strengths and the gap voltage of the buncher were optimized with the code PARMTRA. The equivalent defocusing force of the rebuncher amounts to 40% of that of the following quadrupole magnet. Thus, it cannot be neglected in finding the matching parameters of the beam line.

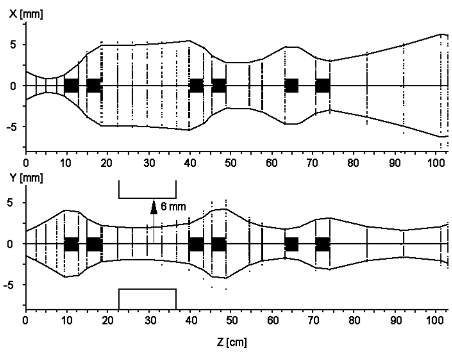

Figure 3: Transversal beam envelopes (2σ) for the MEBT 1 transport line with 20 mA.

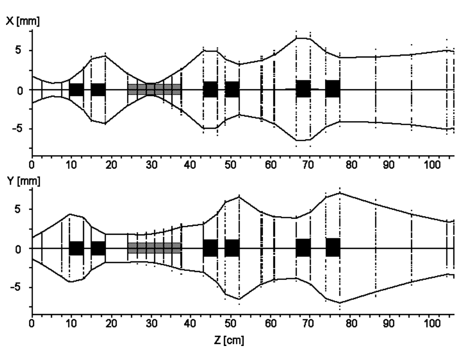

Figure 4: Transversal beam envelopes (2σ) for the MEBT 2 transport line with 20 mA.

There is some enlargement in the emittances (table 3). The rf-defocusing inside the buncher causes a transverse emittance growth due to the nonlinear forces. The dispersion induced by the bending magnet cannot be fully compensated but was minimized due to the small horizontal β-function inside the dipole magnet.

The calculated beam properties with currents of up to 30 mA are suitable for further acceleration with the Alvarez. Compared to the present situation the beam matching to the Alvarez linac can be improved and compensates

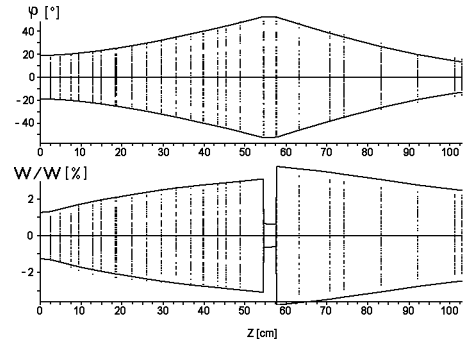

Figure 5: Longitudinal beam envelopes (2σ) for the MEBT 1 transport line with 20 mA.

I/[mA]	$\epsilon_x/\epsilon_{x,0}$	$\epsilon_y/\epsilon_{y,0}$	$\epsilon_z/\epsilon_{z,0}$
0	1.1	1.0	1.0
10	1.3	1.2	1.1
20	1.4	1.3	1.2
25	1.6	1.4	1.2
30	1.7	1.6	1.3

Table 3: Emittance growth factors at different currents in the MEBT 2 transport line.

the influence of emittance growth within the MEBT on the final beam quality. Tracking calculations of the Alvarez linac with and without the MEBT are still in progress and show that a reduction of the emittance at the high energy end should be possible with the usage of the MEBT.

5 SCHEDULE

The modifications of the accelerator system are planned to be made during the HERA shutdown in winter 1997/98. First tests are scheduled for March 1998.

6 ACKNOWLEDGMENTS

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