OPERATION OF THE UPGRADED H⁻-INJECTION SYSTEM OF THE LINAC III AT DESY

C.-M. Kleffner, N. Holtkamp, M. Nagl, H. Poggensee, J. Peters
Deutsches Elektronensynchrotron DESY, D-22603 Hamburg, Germany
A. Schempp, IAP, University of Frankfurt, Germany

Abstract

During the winter shutdown 1997/98, the injection system of the H^--Linac III was upgraded. At present two different kinds of H^--sources are operated at DESY. The new cesium-free rf ion source is planned to operate parallel to the magnetron ion source.

In addition a new MEBT (Medium Energy Beam Transport line) between two distinct RFQ accelerators and the Alvarez accelerator of Linac III was installed to match the beam of each ion source to the Alvarez acceptance. This scheme makes it possible to operate either H^--source with the Alvarez linac with a miniumum of effort to switch from one to the other. The design of the transport line also facilitates the development and tests of newly proposed ion sources, for example deuterium and polarized proton sources.

After assembly of the RFQs and ion sources as well as the new components for the MEBT, a relatively easy commissioning could be demonstrated, although the ions have to be transported on a long distance from the RFQ to the Alvarez linac. First results of measurements will be presented.

1 INTRODUCTION

Linac III at DESY started operating as an H^--injector for the DESY III synchrotron in 1989 [1] and is part of the injector chain for the HERA collider. The negative charged ions are produced by a surface-plasma magnetron source at 18 keV and are accelerated with an RFQ to an energy of 750 keV. A conventional Alvarez linac is used to obtain the injection energy of 50 MeV into DESY III.

Further developments at the DESY cesium-free rf-volume source led to an operable and reliable design [2]. To integrate this volume source into the proton linac for standard operation it was desirable to find a technical solution to switch back to the magnetron source at any time. This improves the reliability of the proton injector chain to HERA. It was therefore decided to reconstruct the pre-accelerator of the linac to allow both ion sources to operate for the linac simultaneously.

The upgraded injection system in front of the Alvarez linac consists of the existing devices as well as of a new beamline with an additional RFQ and a rebuncher cavity. The assembly of the new MEBT beamline and the two ion sources also necessitated an extension of the accelerator tunnel. The shutdown period of the DESY accelerators

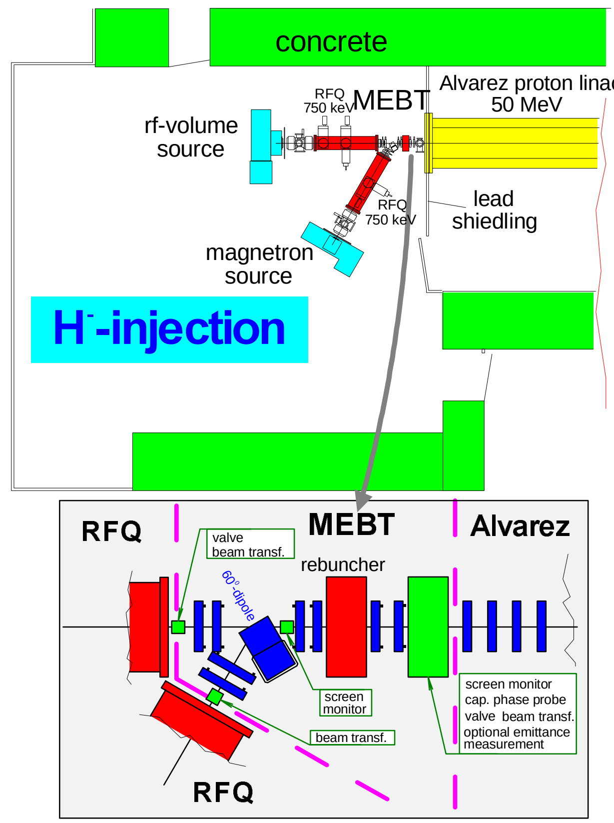

Figure 1: Floor plan of the injection system and a detailed view on the MEBT.

in winter 1997/98 was used for dismantlement of the pre-accelerator, the reconstruction of parts of the tunnel and related facilities and the assembly of the new components.

The low beam energy of 750 keV, small beam losses and a new arrangement of lead- and concrete-shielding permits access to the injection system during linac operating time.

2 CHARACTERISTICS OF THE MEBT

Beam transport of ions under space charge conditions at low energies reduces the variety of possible transport line designs. The goal was to control the longitudinal bunch shape with only one rebuncher cavity between the RFQs and the Alvarez linac. Therefore it was essential to keep the overall length of the transport line below 1 m. The mechanical components had to be composed in a very compact manner. Details of the MEBT have been given previously

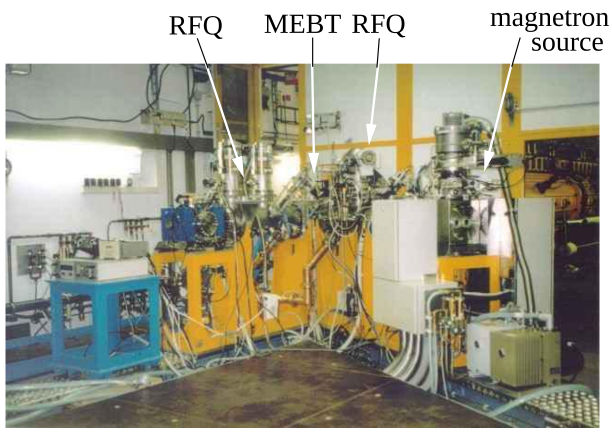

Figure 2: View of the rebuilt injection system in the Linac III tunnel.

[3], briefly the design is as follows:

The new rf-volume source is installed on the axis of the Alvarez linac, whereas the beam coming out from the magnetron source is bent by a 60°-dipole to this axis. Fig. 1 shows a survey of the injection system.

The main components including ion sources, RFQs and the MEBT are mounted independently on frames made of aluminium. These frames are put onto a rail system and are thus retracktable along the beam axis. It is therefore easy to install additional beam diagnostic elements for further investigation of beam properties at any place in one of the paths. Fig. 2 and Fig. 3 show the arrangement of the injection system and details of the MEBT transport line.

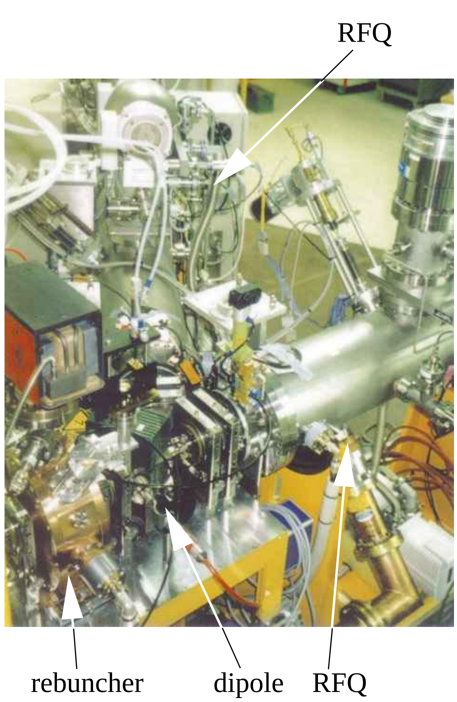

Figure 3: Side view of the MEBT beam transport line.

Table 1: Basic parameters of the new cavities for the injection system.

	RFQ	rebuncher
f_0	202 MHz	202 MHz
$U_{\rm rod}$ / $U_{\rm eff}$	80 kV	58 kV
P	80 kW	4 kW
L	120 cm	12 cm

The 4-rod RFQ and the rebuncher cavity were delivered by the University of Frankfurt [3]. A parameter list is given in Table 1. The rf-amplifier for the rebuncher was designed and constructed at DESY. The design is based on the rf-preamplifier of the existing rf-amplifiers for Linac III.

3 FIRST OPERATION WITH THE MEBT

After the assembly and adjustment of the new injection system first acceleration tests with the magnetron source were performed. The rf-volume source is already assembled in position but not in operation yet. It is expected, that first beam tests with the new source can be performed in autumn.

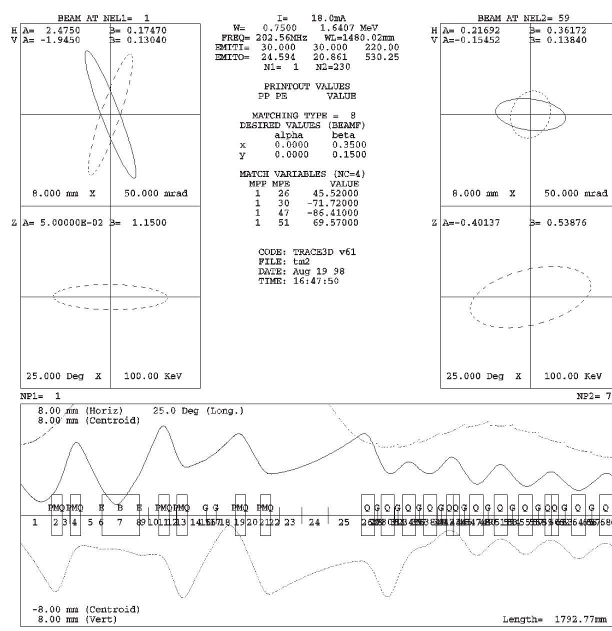

Figure 4: Matched beam envelopes (5σ) calculated by TRACE3D.

Once the beam delivered by the magnetron coasted through the MEBT line, only little empirical tuning of the MEBT quadrupole focusing strength was necessary. The numerical simulations (s. Fig. 4) led to a solution with good transmission through MEBT and the Alvarez linac. Only one quadrupole was displaced by 0.7 mm for beam steering reasons. Whereas the transmission of the solenoid focusing channel in front of the RFQ is found to be limited under space-charge conditions to 50 % [4], the transmission from the RFQ up to the end of the high energy transport line after the Alvarez linac under typical conditions reaches 75 %. At the injection point to DESY III currents of 10 to 15 mA are obtained, depending on the current of the magnetron source of typically 30 to 65 mA.

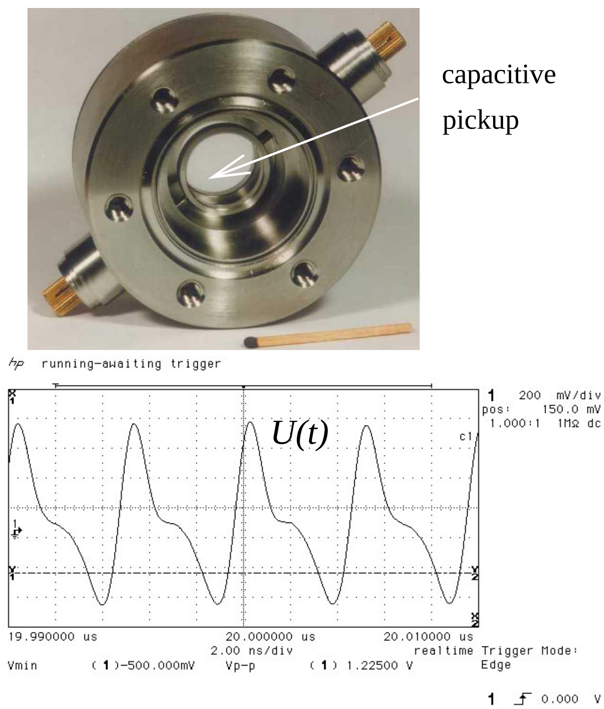

Figure 5: Signal of a bunched beam with $\Delta\varphi\,(2\sigma) = \pm 30°$ measured with the capacitive probe above.

The cavity phase and amplitude settings of the RFQ and rebuncher with respect to the Alvarez tanks was to be found more laborious. The phase settings of the cavities is based mainly on the measurements of energy and momentum spread after the Alvarez linac. A capacitive phase probe built at DESY (see Fig. 5) between rebuncher and the Alvarez was used to estimate the longitudinal bunchlength at the end of the MEBT.

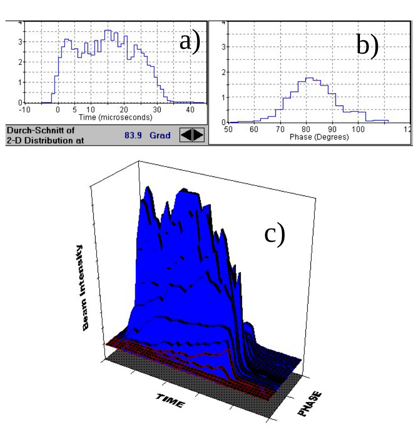

Figure 6: Current density along the bunch train **(a)**, phase spread **(b)** and a 3D-view **(c)** of the buch train measured with the bunch shape monitor at the Alvarez Tank 1.

The bunch shape monitor [5] in the Alvarez Tank 1 was used for fine tuning of the relative phase setting between the rebuncher cavity and the Tank 1 as well for the amplitude settings of these cavities. Fig. 6 shows a offline estimated 3D-view of the bunch train.

The phase tuning was to be found slightly depending on the beam current delivered by the ion source. Fig. 7 shows a typical devolution of momentum spread and energy during tuning of the cavity settings.

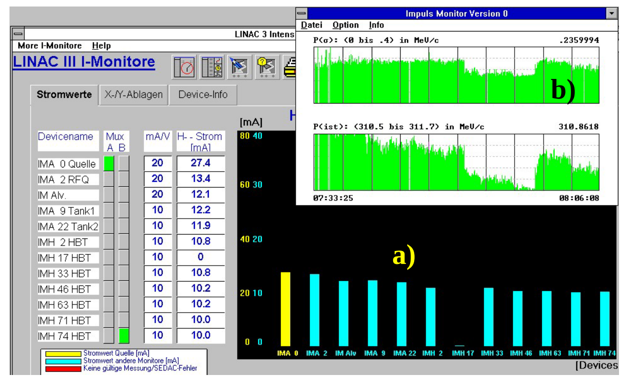

Figure 7: Transmission along the linac **(a)** and a history of evaluated beam properties **(b)** shown on a PC console station.

4 ACKNOWLEGMENT

The authors wish to thank all contributing colleagues and the collaborating institutes for their technical support and helpful discussions.

5 REFERENCES

[1] LINAC III collaboration, Rev. Sci. Instruments **62** (4), April 1991.

[2] J. Peters, Review of Negative Hydrogen Ion Sources High Brightness/High Current, this conference.

[3] C.-M. Kleffner, G. Jacobs, N. Holtkamp, M. Nagl, I. Peperkorn, J. Peters, Deutsches Elektronen Synchrotron DESY, Germany, A. Schempp, IAP, Universität Frankfurt, Germany, and V. Paramonov, INR Moscow, Russia, Upgrade of the H^--Injection System at the DESY Proton Linac III, Proc. of the 1997 PAC, Vancouver, Canada, 12-16 May 1997.

[4] A. Sauer, diploma thesis, IAP Frankfurt, 1998.

[5] A.V. Feschenko, A.V. Liiou, A.N. Mirzojan, A.A. Menshov, P.N. Ostroumov, N. Holtkamp, C.-M. Kleffner, M. Nagl, I. Peperkorn, Bunch Shape Monitors for the DESY H^--Linac, Proc. of the 1997 PAC, Vancouver, Canada, 12-16 May 1997.