THE MMF LINAC H- INJECTOR DEVELOPMENT*

V.P. Yakushev, S.K. Esin, A.V. Feschenko, O.T. Frolov, E.S. Nikulin#, INR RAS, Moscow, Russia

Abstract

In addition to the existing proton injector the new H^- injector with parameters as follows is under construction: energy of negative ions – 400keV; beam pulse duration – 200µs; pulse repetition rate – 50Hz; average beam current – 500µA The results of beam forming system synthesis and ion source power system automation control development are given. The television application for the beam parameters monitoring proposed.

INTRODUCTION

During long time the proton injector [1] provides the beam for the Moscow Meson Factory high-current Linac (MMFL) [2]. Now the new H^- injector with parameters as follows is under construction: energy of negative ions – 400keV; beam pulse duration – 200µs; pulse repetition rate – 50Hz; average beam current – 500µA.

Injector optics development was supported by simulation of accelerator tube (AT) beam transmission matching with linac Low Energy Beam Transport (LEBT) channel. AT beam forming simulation results obtained with "large particles" method and Kapchinskij-Vladimirskij microcanonical beam (MCB) model [3, 4, 5] are practically agree.

The accelerating voltage shapes and beam current parameters at the injector exit, measurements, processing and visual representation of results are planned on basis of the LabVIEW software packages [6]. The data will be operationally routed into the linac local network.

In a framework of H^- injector creation the project of the Computer Control System (CCS) [7] is developed using the National Instruments Corp. modules.

For non-destructive monitoring of the beam the two-coordinate ionization detector combined with TV is applied [8].

INJECTOR DESIGN

The basic purpose of the H^- injector development is an improvement of qualitative performance and increasing of average beam current. A possibility of the pulse current increase with the emittance growth being limited is studied. Some of calculation predictions have been checked experimentally using the H^+ injector beam.

Designed for proton injector computer models, control and diagnostics systems and the handling of measurement results are used in process of H^- injector creation.

The H^-injector has to provide a beam at the input of LEBT channel (hereinafter "target"). The ion source (IS) output is located approximately by 270cm upstream from the "target".

The version of the AT focusing electrodes, meeting these requirements, is shown in Fig.1. The beam focusing is provided by changing the focusing electrode voltage U_f and the intermediate electrode voltage U_1.

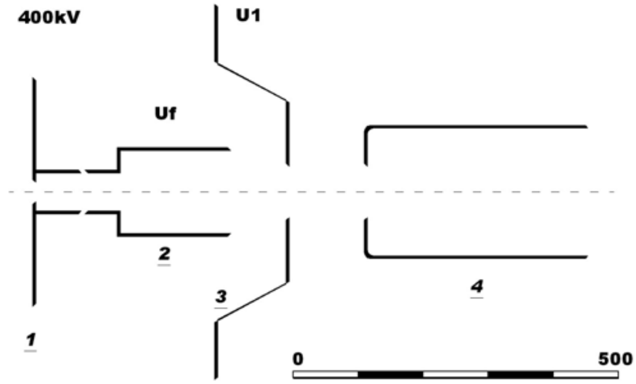

Figure 1: The forming electrodes drawing

1 – high-voltage AT flange, 2 – focusing electrode, 3 – intermediate electrode, 4 – grounded electrode

SIMULATIONS

Calculated with the help of MCB models opportunities of injector forming system are shown in Fig.2a. For a comparison, the characteristic of the system differed from the primary one only by 50mm longer focusing electrode, is given in Fig.2b. There are admissible areas of U_f and U_1 parameters, where the beam envelope is fitted into the apertures of forming electrodes and does not exceed radius of the "target" for fixed parameters of the AT input beam.

Depending on IS conditioning and tuning [9], one can obtain both an ordinary beam with fluctuations of a current during the impulse, and an optimum beam when the fluctuations are overwhelmed. For an ordinary beam the model with the following parameters at the AT input is taken: radius of the envelope – 15mm, divergence of an envelope – 15mrad, emittance – 2π·mm·mrad. The corresponding parameters for an optimum beam are: 10mm, 10mrad and 0,2π·mm·mrad. The ions energy – 20keV.

For the selected H^- injector electrode system there is an essential range of admissible parameters (see Fig.2a). The U_1 voltage in 90÷120kV range can be easily obtained with the existing AT design. The U_f with regulation in 20÷30кV range is also suitable for a beam control.

The beam at the entrance of AT is almost parallel. It has large diameter and may be sufficiently well focused when passing through AT

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#nikulin@inr.ru

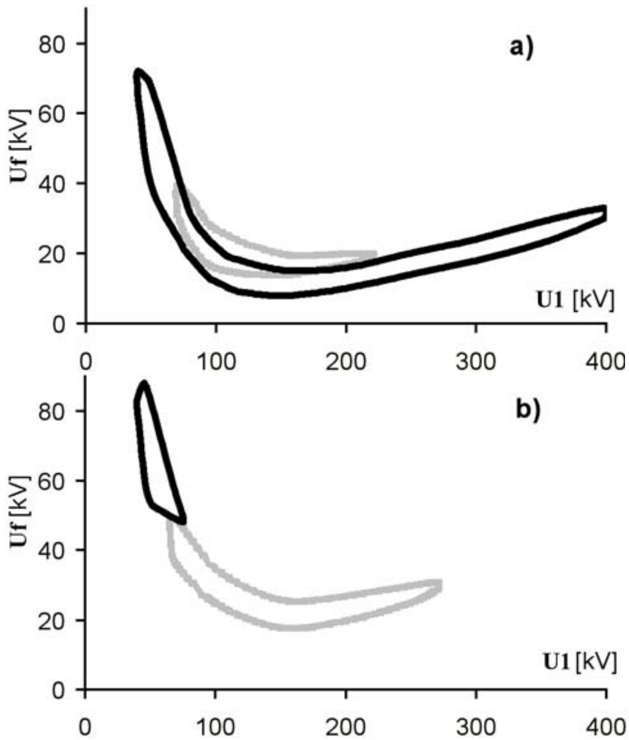

Figure 2: Admissible areas of focusing and intermediate electrodes voltages

. Beam with current fluctuations

Beam without fluctuations

a) Forming system of the H^- injector, Fig.1

b)Focusing electrode is 50mm longer, other – the same

CONTROL, DATA ACQUISITION AND PROCESSING

At the present time the measuring system of the HV-modulator parameters and the proton injector beam characteristics is put into operation. The similar soft and hardware for H^- injector is prepared. The base of systems is the LabVIEW software. Injector operator workstation provides the control (up to 73 channels) of the 400kV pulse generator with pulse repetition rate up to 100Hz. The control of ion sources which are under high potential (104 channels for H^-) is carried out with the help of fiber line. The analog channels transmission band has a width 0-1,6MHz. Fig.3 represents the H^- injector CCS flowchart.

The operator workstation has an opportunity of data exchange with other linac control workstations by the Ethernet protocol through 100Mb/s local network. The workstation built-in PCI-1200 and PCI-MIO-16E1 multifunctional input/output modules provide the HV-modulator and auxiliary systems data acquisition and processing. These modules have 4 DAC and 24 ADC 12-bit programmable amplification channels with (0,01÷10)V input signals range and the accuracy of digitizing ±0,025 %. Also there are 40 TTL-input/output channels, 5 counter/timer channels with 10ns precision.

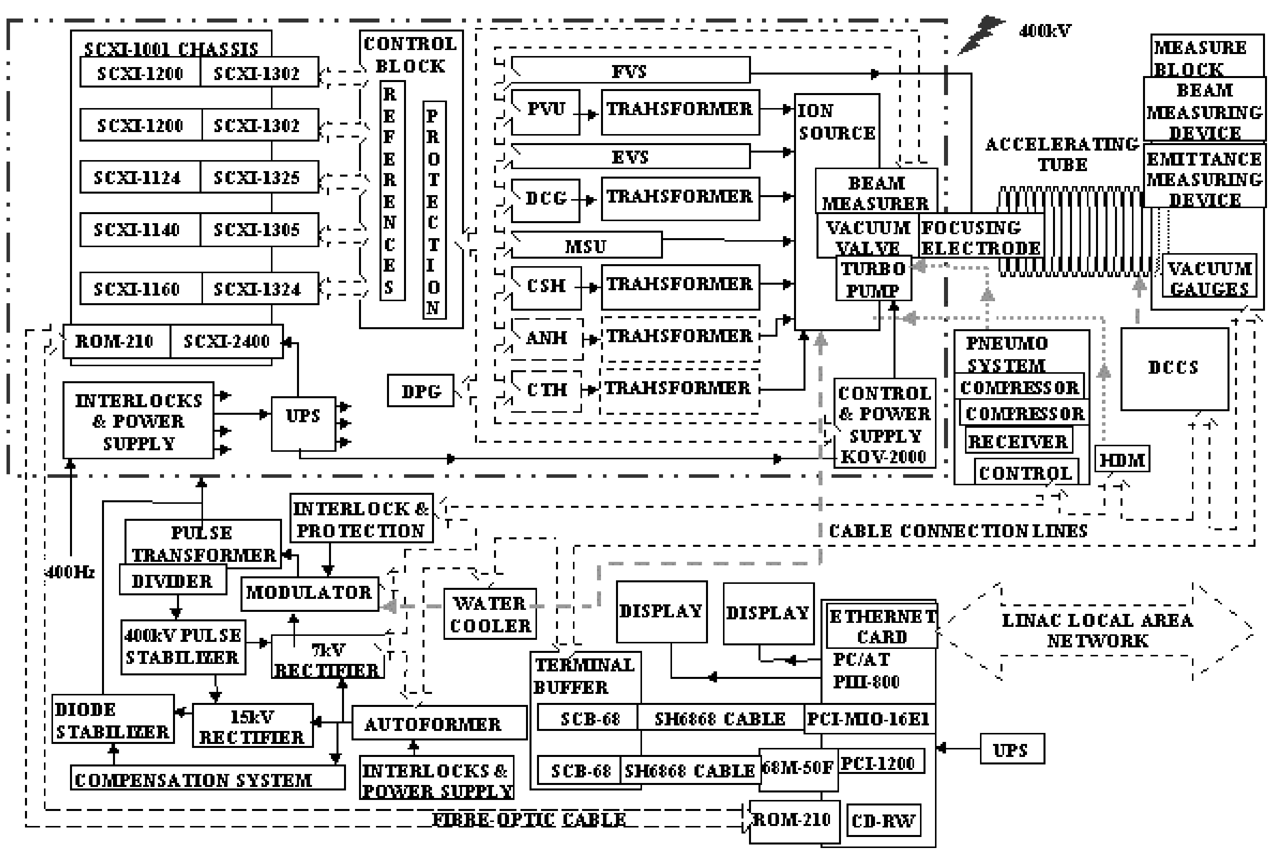

Figure 3: The H^- injector CCS flowchart

The IS control subsystem located inside the HV electrode is based on SCXI-1001 microprocessor chassis. The built-in modules namely ADC SCXI-1124, DAC SCXI-1140, relay SCXI-1160, and multifunctional SCXI-1200 use 34 analogue, 48 discrete, 6 counter/timer channels. Besides 16 relay channels are used for direct control of apparatus with switching currents up to 2A at a voltage up to 250$V_{\mathbf{rms}}$. The part of channels is reserved The SCXI system stores the information and dumps it to the operator workstation through the fibre line. The data is transferred in both directions through the SCXI-2400 connection module using RS232 ports.

The workstation 256Mb RAM stores a previous injector operation history for the subsequent analysis.

Beam diagnostics and data processing programs allow us to control the beam parameters [6, 10].

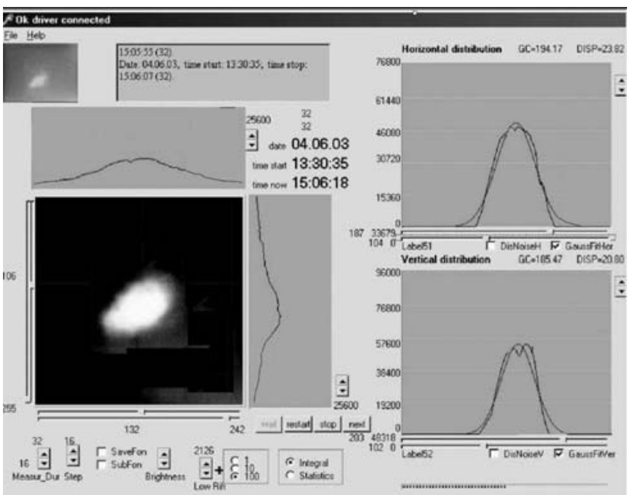

Figure 4: The proton injector beam cross-section characteristics at the control program's interactive display

The non-destructive ionization transverse dimensions detector is foreseen. The optical image of the beam cross-section is recorded from the screen by TV camera. The computer display provides the visual control of the beam cross-section, profiles and the beam centre-of-mass position (Fig.4). The frame resolution is 384*288 points with 64 brightness levels. The full amount of frames that can be saved in the RAM is up to 256.

The software provides on-line opportunity of:

- frame background discrimination;
- 128 point vertical and horizontal beam profiles presentation;
- averaged vertical and horizontal profiles presentation;
- accumulation up to 256 frames, that result in absolute sensitivity growth and signal to noise ratio increase more than order of magnitude;
- frame profile Gauss distribution fitting with least square method to find out beam position;
- beam position distribution dispersion and average beam position calculation derived from Gauss fitting procedure results.

CONCLUSIONS

It is important to minimize the ion beam losses and to match emittance with LEBT/RFQ acceptance.

The synthesis of linearized injecting path constructed from the simplest lenses has successfully demonstrated opportunity of obtaining of beam parameters acceptable for either proton or H^- acceleration. Our experimental results provide the base to check our simulations for proton and H^- beams.

Future studies are needed to decrease the value of the beams emittance and to include other effects to make the simulations more realistic.

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