THE INJECTOR OF NEGATIVE HYDROGEN IONS FOR INR LINAC*

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Abstract

The H^- injector has to provide a beam with the following parameters: mean current – up to 400uA; pulse duration – up to 200us; pulse repetition rate – 50Hz; energy of ions – 400keV. The surface-plasma H^- ion source developed in BINP, Novosibirsk is used. Pulsed accelerating voltage source of 400kV and pulsed high-voltage modulators for H^- ion source power supply with a discharge current up to 120A and extracting voltage up to 20kV have been fabricated and tested. Commissioning of the H^- injector is scheduled by the end of 2006.

The development of H^- injector is aimed at a solution of a fundamental problem of obtaining intensive accelerated beams of negative hydrogen ions in linear accelerators.

The experience of construction and maintenance of the proton injector has been taken into account while developing and fabricating the H^- injector equipment. The efforts for maximum unification of the equipment of both injectors have been applied. The general layout of the high-voltage equipment of the H^- injector and the proton injector is similar [1], except for the ion source (IS) high-voltage dome. The length of the dome has been increased up to 150cm to place inside it the IS vacuum chamber and the equipment for differential pumping. The injectors are located in the identical high-voltage side by side rooms [2] (see Fig.1).

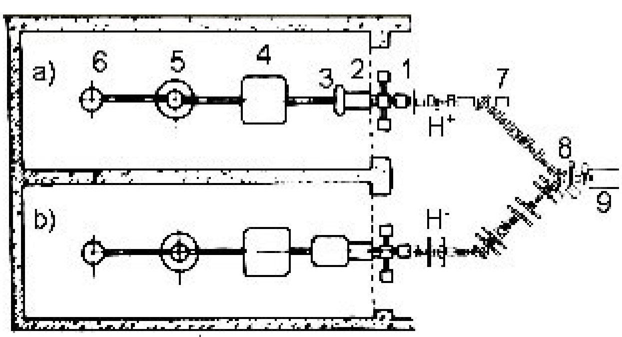

Figure 1: The H^+ (a) and H^- (b) injectors: 1 – vacuum equipment; 2 – accelerating tube; 3 – HV ion source dome; 4 – HV dome with ion source supply system; 5 – 400kV, 200us pulse transformer; 6 – HV diode stabilizer rack; 7 – LEBT; 8 – RFQ; 9 – Linac.

Photo of the injector HV equipment is shown on Fig.2.

Figure 2: View of HV devices: there is the ion source supply system dome on the white insulate column at the first plan, then 400kV pulse transformer is seen, the diode stabilizer rack has been placed after the latter.

The injector parameters are given in Table 1.

Table 1: The injector parameters

Energy of H^- ions	400 keV
Pulse beam current	40 mA
Average beam current	up to 400 uA
Pulse repetition rate (PRR)	2 – 50 Hz
Macro-pulse beam current duration	60 – 200 us
Normalized emittance	$\leq$0,35 π·cm·mrad

As a result of maintenance experience of the accelerating tube (AT) prototype its construction has undergone changes. AT input and output flanges are modified, and these efforts have allowed to avoid destroying loads originating because of difference in thermal coefficients of the extension of AT construction materials in all range of operation and storage (from -5°C up to +55°C). The number of AT both ceramic rings and metallic electrodes is reduced from 30 to 26. These changes have resulted in reducing of AT weight by 126kg and of AT construction fixing cantilever loads by 182kg·m. It also has allowed to reduce beam drift space, to upgrade the configuration of the electron-optical system (EOS) and to change rate of acceleration, to reduce mechanical loads in places of electrodes fixing and, thus, to increase stability of EOS geometry.

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Alignment device and referencing of the electrodes apertures to the AT geometrical axis with the help of the laser have provided accuracy of EOS installation within limits of 0.05mm for radius and 0.1mrad for angle of inclination (see Fig.3). The laser also is used when installation and referencing of the AT axis to an axis of LEBT is occurred.

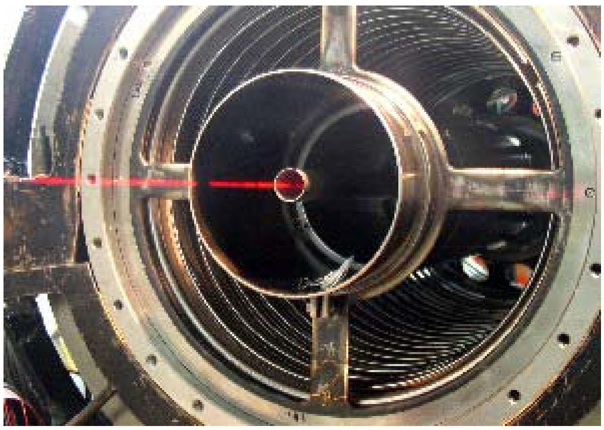

Figure 3: The accelerating tube EOS alignment.

The construction of the AT water divider is changed. The divider flow areas have been increased four-fold. This increasing has provided the best drain of heat and has allowed to eliminate a local water system and to supply the divider from the linac regular water system. AT with a water divider has been installed at the injector vacuum chamber (see Fig.4). Mechanical strains for the AT which is suspended as a console are reduced by the off-loading appliance.

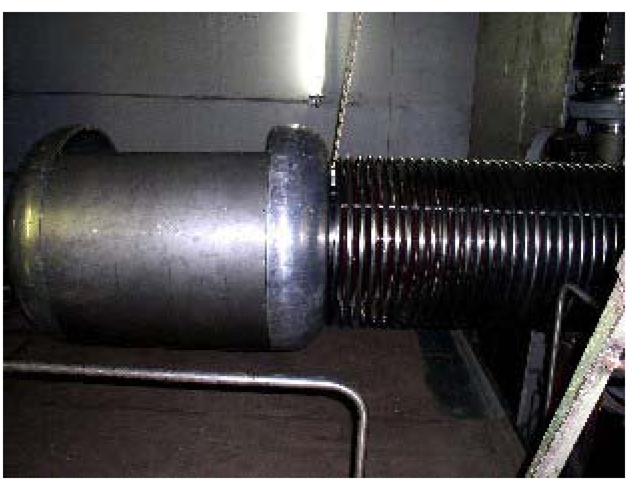

Figure 4: The accelerating tube with the IS high-voltage dome.

The IS assembly has a weight about 300kg. For reducing of mechanical loads caused by additional equipment the one more off-loading device is made.

The accelerating pulse voltage generator providing pulses with amplitude of -400kV, duration of 210us and PRR of up to 50Hz have been developed, fabricated and mounted [3]. Form of the HV pulse is presented on Fig.5. Amplitude slope is caused by absence of voltage from the system of compensation of the pulse plateau inclination.

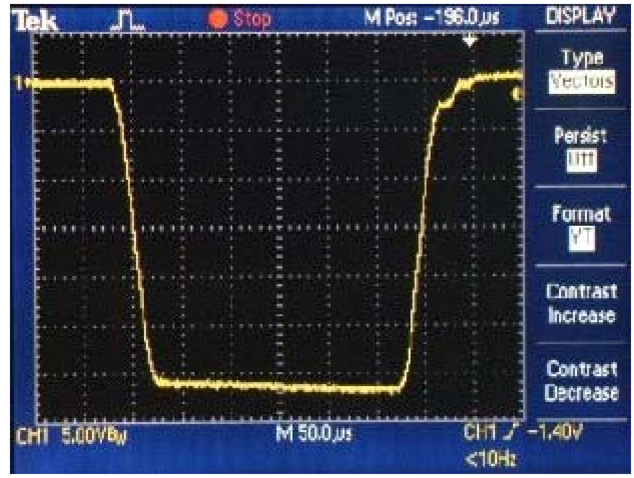

Figure 5: HV -400kV pulse.

The devices of the IS power supply have been developed, fabricated and tested. They have been installed into three standard racks located at the high-voltage dome (see Fig.1, 6).

Figure 6: The devices of the IS power supply inside the high-voltage dome.

The parameters of all power supply devices are stabilized and can be changed in accordance with reference signals.

The discharge current generator (DCG) consists of the charger, thyristor switch unit and artificial line (AL). DCG forms stable pulse of ion source discharge current. The DCG parameters are given in Table 2.

Table 2: The DCG parameters

Short circuit current	up to 130A
Wave resistance of 10-section AL	11,6 Ohm
Charge voltage stability	±0,2 %
Idling voltage	0 – 1800 V
Pulse current duration	60 - 200 us
PRR	up to 50 Hz
The accuracy of the voltage setting	±1 %

DCG charger is a transformer-free regulated and stabilized converter of voltage. It consists of the inverter, controller, step-up transformer and high-voltage rectifier. DCG has been tested using 12 Ohm load equivalent; the current of 100A has been obtained for the pulse current duration of 200us and PRR of 50Hz as well as the short circuit current of 130A has been obtained.

The extracting voltage generator (EVG) forms negative polarity pulses of high voltage. The parameters are given in Table 3.

Table 3: The EVG parameters

Pulse amplitude	up to 20kV
Stability of voltage along pulse	±0,5 %
Pulse current	up to 1A
PRR	up to 50Hz
Pulse duration (plateau)	200us

EVG scheme is identical to those of the accelerating pulse voltage generators that we use in both injectors: a modulator with a pulse transformer and a capacity-diode amplitude discriminator (each of 5 cascade contain 4uF/5kV capacity and 10H/5kV choke) at exit. The advantage of such an approach is a possibility to avoid using of a high-voltage lamp. The EVG charger is the 6kV 250mA ВИВН 6/250 device (firm: ВИВН, Obninsk, Russia). Pulse amplitude of 20kV is achieved at the 20kOhm load when current in primary winding of the HV transformer is 7.5A, see Fig.7.

The magnet power supply unit, the power supply unit of the hydrogen pulsed feed valve and the unit of cesium heater are developed with the following controlled parameters:

Table 4: Parameters of the power supply units

Magnet current	Up to 6 A
Pulse current of a gas feed valve	Up to 30 A
Cesium heater current	up to 6 A

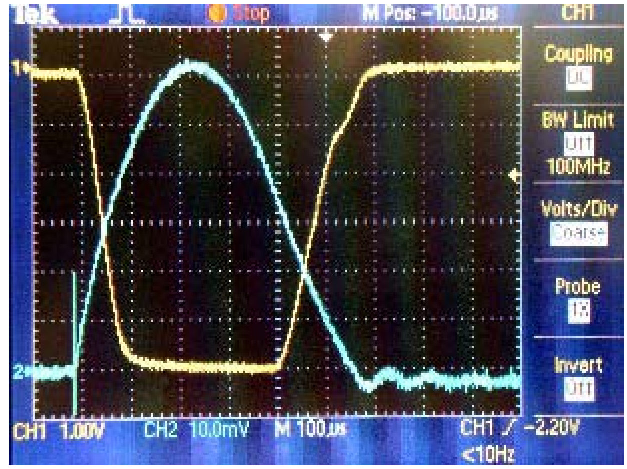

Figure 7: EVG output voltage and HV transformer input current 4kV/div; 2A/div.

Commissioning of the H^- injector is scheduled by the end of 2006.

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