INJECTORS FOR HIGH-INTENSITY LINEAR ACCELERATOR OF INR MOSCOW MESON FACTORY

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The presence of H^+, H^--ion injectors and injectors of polarized protons and negative hydrogen ions is one of the impotant peculiarities of high-intensity 600 Mev ion accelerator of Moscow Meson Factory.

The injector collection and low energy beam transport (LEBT) channel configuration permit to accelerate simultiniously two ion beams with opposite charges. The main high-intensity beam of accelerator (sum average current is 0.5 mA and pulse current is 50 mA) may be the beam either of protons or of H^--ions. Polarized proton beam current is one order magnitude less than the main beam current, and $\vec{H}^-$-beam current is two orders magnitude less.

Configuration of injector complex is schematically shown on Fig.1.

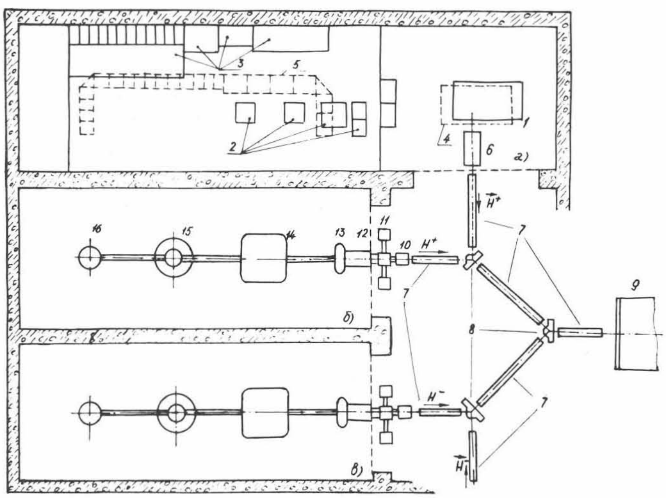

Fig.1.Linear accelerator injector complex:
a)polarized proton injector: 1 - ion source; 2 - RF-generator; 3 - modulator; 4 - vacuum system; 5 - ion source and injector supply/control panels; 6 - RFQ-accelerator; --- upper floor equipment; - - - down floor equipment;
b)linear accelerator and LEBT channel: 7 - LEBT channel equipment; 8 - bending magnets; 9 - linear accelerator (input);
c)proton injector: 10 - beam measuring chamber; 11 - vacuum chamber; 12 - accelerating column; 13 - ion source; 14 - high voltage dome with ion source supply system; 15 - impulse transformer; 16 - high-voltage pulse stabilizer;
d)negative hydrogen ion injector.

The H^+ and H^--injectors should provide to linac input beams with such transverse normalized emittance that in 0.15π cm·mrad region more than 70 mA of pulse current is to be contained. The energy of ions should be 750 keV ± 0.1%, pulse duration - 100 μs, repetition rate - 100 Hz.

The main equipment of proton injector has been designed by Efremov Institute of Electrophysical apparature (Leningrad). Other injectors are being designed and constructed by personal of INR.

The protons are accelerated up to 750 keV in open-type high-voltage accelerating column 12 (see Fig.1). The ion source of duoplasmatron type is inserted into column up to 72 cm; it produces beam currents up to 600 mA with phase density up to 2 A/cm mrad (2). Pulse modulator is used for arc current production. The hydrogen flow (by nikel leak), extraction and focusing voltages, magnet coil current and cathode heater current are supplied continiously. The ion source sinchronization pulses are transmitted by light-link control line from the ground-level equipment. The accelerating column has two gaps with a potential difference 300 kV on the first one, lengh of which equels 100 mm, and 400 kV on the second 350 mm gap. Accelerating voltage is produced by pulse transformer 15; the pulse plato is stabilized by 30-cascade capacity-diode amplitude stabilizer 16 (3). Ion source electronics placed inside the big electrode 14 under 750 kV potential is supplied by 400 Hz AC voltage; the last one is transmitted over pulse transformer high-voltage coil double wires. The injector exit beam parameters have been measured in box 10.

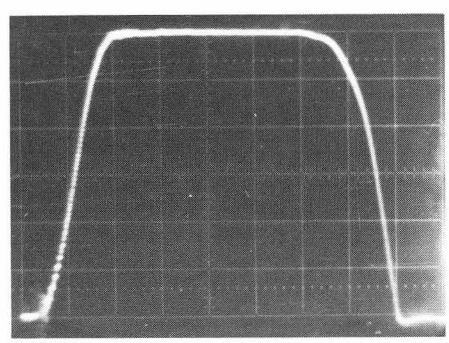

Fig.2. Accelerating voltage pulse. The vertical - 125 kV/div, the horizontal - 20μs/div.

High-voltage pulse up- and down-times (see Fig. 2) have 30μs duration with stability of pulse plato within ± 0.25%. The injector produces 750 keV proton beams with current up to 440 mA. From 1986 till now the proton injector has been used to supply 750 keV proton beam for the initial testing and preliminary operation of LEBT channel and of first Alvarez-type resonator.

of LEBT channel and of first Alvarez-type resonator. In the end of LEBT channel 115 mA current of focused beam was measured when injector exit beam current was 230 mA and 70 mA current having been contained in 0.15π cm·mrad normalized emittance. For exit current of 320 mA in above emittance about 120 mA current have been contained. Injector exit beam current oscillogram is shown on Fig. 3.

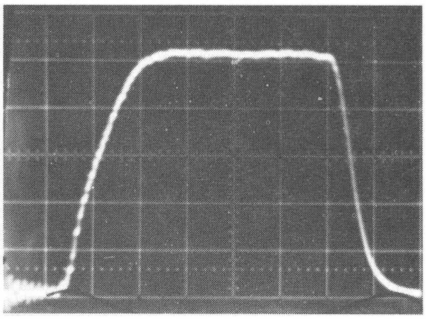

Fig.3. Proton injector exit beam current. The vertical - 40 mA/div, the horizontal - 20μs/div.

In the process of H^--injector constructing the modified equipment of proton injector has been used (4). In future this helps without significant difficulties to reequip the operating proton injector inthe second H^--injector.

The polarity of high-voltage pulse generator was changed to the opposite one. The accelerating column is of the same type. The focusing needed is provided by properly formed ion source exit electrode.

Penning-type surface-plasma ion source of H^--ions has been used (5,6). It produces beam currents up to 130 mA and in modified so-called "noiseless" operation mode - up to 80 mA (see Fig. 4); for 50 mA part of beam current the emittance has been measured at $(0.07\ 0.04)\pi^2 cm^2\ mrad^2$.

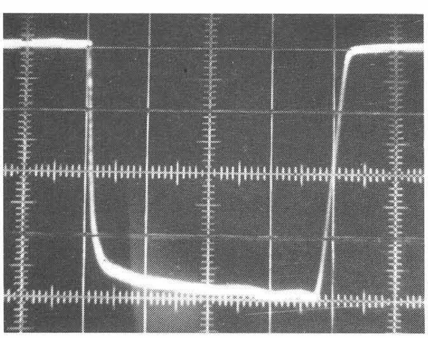

Fig.4. H^--ion source exit beam current. The vertical - 20 mA/div, the horizontal - 20μs/div.

100 A arc discharge current, 20 kV extraction voltage and gas valve turning on voltage have pulse form; DC supply has been used for magnet coil and for Cs--heater. The supply parameters have been stabilized and regulated with accuracy$\pm$0.2%. The ion source equipment is operated at -750 kV level by light-link control from ground level equipment. H^--injector was mounted in the regular hall of accelerator; in December of 1986 the injector began its operation. On the exit of accelerating column 20 mA beam current of 750 keV H^--ions without Cs vapors in a discharge ion source chamber was measured (see Fig.5).

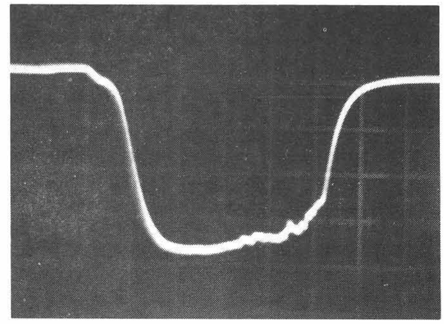

Fig.5. H^--injector exit beam current. The vertical - 5 mA/div, the horizontal - 20μs/div.

We suppose to accelerate polarized hydrogen ions to an energy of 750 keV in RFQ-accelerator (8); this provides an opportunity to place complicated equipment of ion source and vacuum system at ground potential level (see Fig. 1a).

Atomic beam type polarized proton source has been developed in INR (9). Hydrogen atomic beam is produced by pulsed rf discharge in pyrex dissociator tube and then flows through two sextupole magnets where the electron polarization of atomic beam is occured. The magnetic field produced by sextupole magnets reaches 9 kG. Then in a weak-field rf transition unit the protons are polarized. A new type of ionizer was developed where polarized protons are formed via charge exchange between polarized hydrogen atoms and deuterium plasma ions in a strong magnetic field.

The source produces a beam of polarized 20 keV protons with a peak current up to 10 mA and polarization of 0.76. The normalized emittance ofthe beam is $(0.16\ 0.22)\pi^2 cm^2\ mrad^2$ in horizontal and vertical planes accordingly. Polarization depends on intensity, increasing up to 0.9 with current decreasing up to 3 mA.

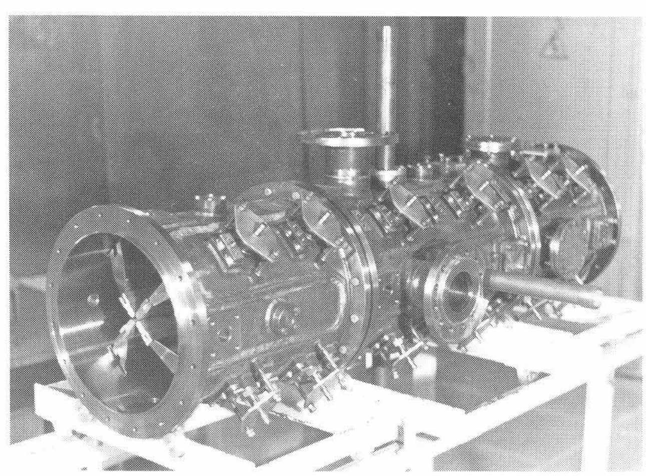

Fig.6. RFQ-cavity.

Four-chamber RFQ-accelerator is now under construction. It should accelerate polarized protons up to 750 keV with energy dispersion $\pm 2\%$. Cavity diameter is 306 mm; length is 1340 mm; average aperture radius is 5 mm; regular frequency is 198.2 mHz. Pole tips material is copper, other details are made from stainless steel with further coppering. Pulse power of losses in copper is 100 kW. RFQ-cavity and blades are being cooled by water.

We suppose to construct the injector of negative hydrogen polarized ions by analogy with polarized proton injector, but with using of ion source with optical pumping (10), which produces $\vec{H}^-$-beams with currents about hundreds μA.

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