OPERATION OF THE MOSCOW MESON FACTORY LINAC PROTON INJECTOR WITH THE PULSE DURATION OF THE BEAM CURRENT UP TO 150 μS

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In the autumn of 1998 the RFQ - resonator was installed [1] at the MMF Linac input. This installation allowed to reduce the energy of the high-voltage injector protons from 750 down to 400keV and to increase the pulse duration of the beam current from 85 up to 150μs without saturation of the core of high-voltage pulse transformer [2]. A new 50kV artificial line (AL) was built in the pulse high-voltage generator (PHVG). It consists of 9 coils with inductance of 1x264mH + 8x132mH and 9 cells of 0.05μF capacitance each. Actuation of a part of the line (1x264mH + 5x132mH and 6 cells of capacities) provides the operational mode at U=750kV and τ_{imp}=85 μs, and actuation of the whole line provides the mode of 400kV and 150μs. The parameters of the proton injector at 50Hz repetition rate are given in Table 1.

To increase the duration of sawtooth voltage which compensates the sloping rise of accelerating pulse [3], the 300Ohm resistor that was used to connect the high-voltage capacity-diode stabilizer with "ground" was changed for the 600Ohm resistor.

Table 1

Parameter	Unit	Acceleration Voltage (kV) 750	400
PHVG			
The AL rectifier voltage	kV	22	12
1-st modulator rectifier voltage	kV	12	6.5
Average current of rectifiers	A	0.75	0.95
Delay time of the AL thyratron (2-nd modulator)	μs	55	55
Delay time of the short-circuit thyratron (3-rd modulator)	μs	140	215
Ion source (IS)			
Arc-drop voltage	V	120	125
Discharge current	A	24	36
Current in the magnet	A	0.40	0.62
Extraction voltage	kV	14.5	9
Focusing voltage	kV	32	26
Injector output beam current	mA	135	120

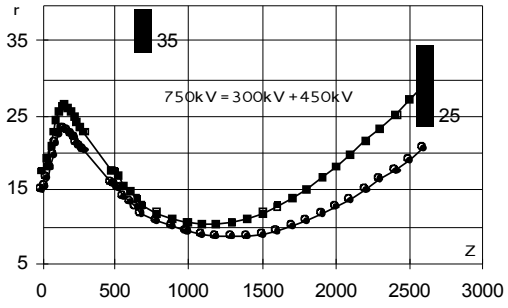
In the IS discharge modulator the AL was modified to increase the pulse duration of the injector beam current up to 150μs.

At 400kV voltage the beam from the accelerating tube (AT) with the electrode geometry for 750 keV proton energy has a greater size, thus, current transmission is worse. For this reason it is necessary to use a more intensive IS operation mode with values of the magnet current and discharge current increased by 30%.

The particles from a beam halo with oversize, falling upon the walls of the AT, disturb more strongly the distribution of accelerating voltage along the AT, which is made with the help of the water divider. In the long beam session at 400kV with the large resistance AT divider the poor stability of the beam forming caused by above-stated circumstance was marked [4]. Thus the resistance of the water divider at one "flat electrode – isolator - flat electrode " gap was 200kOhm, and at the last 18 gaps, which control voltage on the second accelerating interval of the AT, it was 3600kOhm. The instability means that "the negative resistance of the beam" become comparable with this value. For example, 10-kV reduction of voltage at the second interval invokes the increase of the current on the electrode by 10^4V /3,6x10^6Ohm = 3мА (because of the hit of particles from the beam halo on the electrode and much greater current, caused by secondary electrons). The 2.5 times reduction of the water divider resistance made the beam forming more stable when regulating IS extraction and focusing voltages. But for this purpose it was necessary to make the off-line system of water supply for the AT divider.

Besides, 8 of 30 "flat electrode - isolator - flat electrode " gaps were shorted at the grounded end of the AT in order to have a greater size of the beam crossover before the low energy beam transport (LEBT) channel input and, accordingly, the smaller divergence.

In Fig. 1 the beam envelopes in the AT and in the drift space up to the first solenoid of the LEBT channel are compared for acceleration modes with energies of protons 750 and 400keV and initial value of a slope angle of an envelope r_0'=0.2rad. The calculations are based on the Kapchinskij-Vladimirskij "microcanonical" beam model [5,7]. It is obvious that the particles from the beam halo with the energy of 400keV fall more often on the AT electrodes.



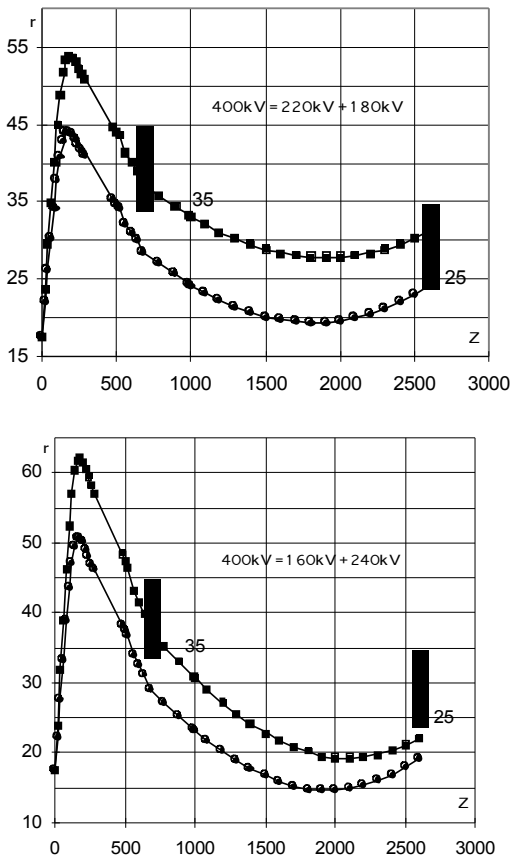


Fig.1

- the main body of the beam, I_b=120mA, E_n=0.25π·cm·mrad;
- the beam with a halo, I_b=150mA, E_n=0.5π·cm·mrad

The oscillograms of the beam current, accelerating voltage and its upper part are shown in Fig. 2. The stability of accelerating voltage from pulse to pulse in 400kV mode is better than in 750kV mode because of the greater stability towards high-voltage sparks and breakdowns in the AT and other high-voltage equipment [3]. The value of voltage instability from pulse to pulse is less than ±0.018%, instability of voltage during the pulse is up to ±0.31%.

The pulse beam current at the injector output is 120-125мА, normalized emittance measured at the end of the second (out of the three) segment of the LEBT channel [6] has the value of 0,35π·cm·mrad for 90% of 65-70mA beam current with 85μs duration.

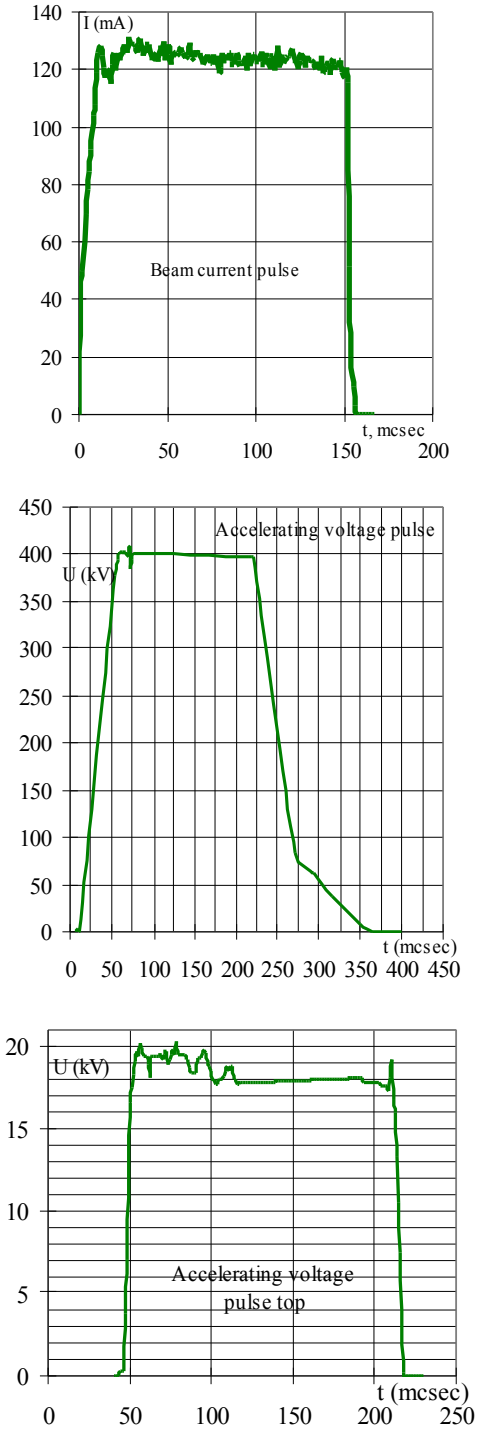


Fig. 2

In 1999 the injector in two long beam sessions operated for approximately 1100 hours. The breakdowns connected with high voltage problems were not observed.

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