INJECTOR OF THE LINAC LU-20

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The principal goal of our work is development, design, construction and subsequent appropriate research on a high power electron linear accelerator (beam energy up to 30 MeV, beam power more than 20 kW) for production of Technetium-99m [1].

An injector is the important part of a power high current accelerator because it determines beam characteristics as well as stability and reliability of a whole linac. The injector of the LU-20 accelerator includes the next elements for beam forming and for control beam parameters:

The 80-120 keV *electron gun* energy with LaB_6 cathode. The cathode is heated with electron beam from the additional gun with HV 3-4 kV.

The HV modulator of the gun. The gun is powered by a high voltage pulse modulator with full discharge forming line. The load of modulator is 12 kΩ. This allows to decrease the average power of modulator by decreasing the power that is lost on the ballast resistor. The modulator consists of next parts: line filter, voltage controller RTM-220V-12kW, high voltage transformer-rectifier VTM-12-40, filter capacitor IM-13-50, charging reactor with charging diode, pulse forming line, tiratron TGI-1-2500/35, pulse transformer, ballast resistor (15 kΩ), clipping diode with voltage dropping resistor. The forming line with impedance of about 100Ω includes 10 capacitors (3500 pF). The six cells are M-coupling with using variometers, and second, third and tenth cells are common inductive-coupling. To decrease the capacitance and inductance loss in the pulse transformer the ribbon type of wires is used in the primary (w=8) winding and the secondary (w=74) winding is applied to conical core.

The test of modulator was performed both at the test bench and at the LU-20 accelerator. Parameters of the HV pulse: max. voltage – 120 kV, pulse length at the level 0.5–7,3 μs, pulse flatness at the top (4.8 μs) – 1.2%.

The Electrostatic Deflector used for forming sharp fronts of current pulse by deflection of low energy electrons and its absorption in collimator.

The Collimator of beam is a copper cooling drum with internal hole 10 mm in diameter.

The Beam Current Monitor is of induction type. It represents the beam current transformer and has the following basic parameters: beam current sensitivity 1 V/A; an error of sensitivity calibration ±3%; pulse top tilt for the pulse length t_p = 4μs ≤ 2%; pulse rise time ≤ 0.1 μs. Dimensions of the monitor: body diameter – 90 mm, length – 40 mm, aperture for beam passing – 28 mm. As the core the ferrite ring 4000NM-A type is applied. The monitor is placed in the vacuum box, which is connected to beam pipe by metallic seals. The signal is taken out by the tight radiation hardness connector. It is going to the signal processing apparatus by RF-cable with length ~ 40 m. For this monitor the shielded twisted pair 100 Ω cable is applied. It has allowed essentially to reduce a noise level from high-power pulse generators. The possibility of operating calibration of a monitor sensitivity by one-turn coil and precision pulse current generator is provided.

The short magnetic lens for beam forming is used.

The Corrector of the beam position for deflecting the beam by the magnetic field of a strength $0.8 \cdot 10^3$ A/m is used.

The grouping resonator used for forming the short bunch of electrons operates with a work frequency of accelerator 2797MHz and a RF field amplitude 6 kV/sm.

The Magnetic Shield gives a geometry of magnetic field at the solenoid entrance.

The accelerating structure with a variable phase velocity. The length of waveguide is 3,05 m.

The Vacuum Beam pipe for passing electrons from the injector to the accelerating section with vacuum pressure 10^{-5} Pa is used.

The Vacuum System consists from the vacuum pump of 2HBP-5D type and NMD-0.16 pump.

These elements are connected by metallic tubes with an internal diameter 25 mm, and then fixed by soldering and welding.

The elements of injector assembled on nonmagnetic support and insert with accuracy 0.1 mm. The vacuum pressure is about 5.10^{-5} Pa.

The calculation on the beam pass from anode of a gun to the entrance in the accelerating section and component placement of injector were performed by the program PARMELA.

The calculation results for the 120 keV electron energy and 3 A beam current are present in Fig.1.

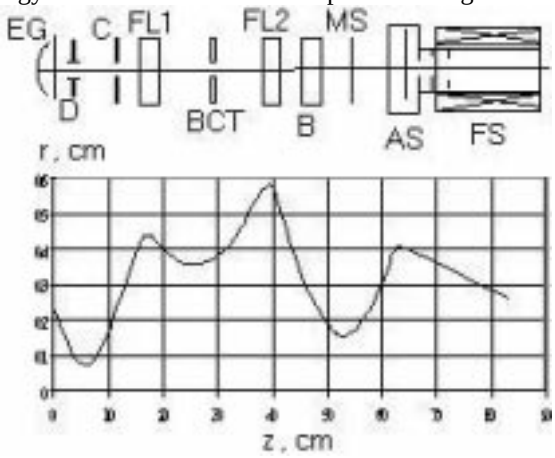

Fig.1. The arrangement of elements and beam trajectory overview.
EG – electron gun, D – deflector, FL – focus lens, BCT – induction beam current monitor, C - collimator, B – buncher, MS – magnetic shield, AS – accelerating structure, FS – focusing solenoid.

Fig.2. shows dependencies of the capture coefficient (ratio between the current at the injector section exit and the current at the gun exit) when electrostatic deflector was switched on and was

switched off versus the gun high voltage (current at the injector section was 0.7 A).

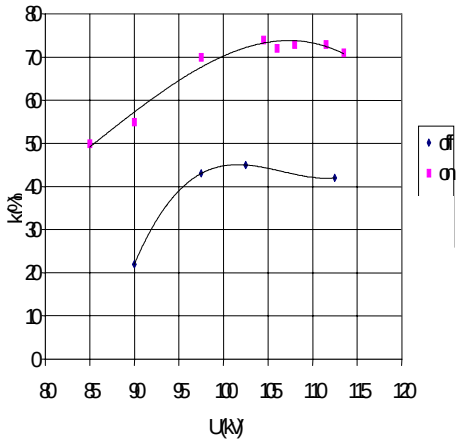

Fig.2. Dependens capture coefficient into acceleration vs.of gun high voltage.

Fig.3 shows the pulses of high voltage and beam current in cases: deflector off or deflector on.

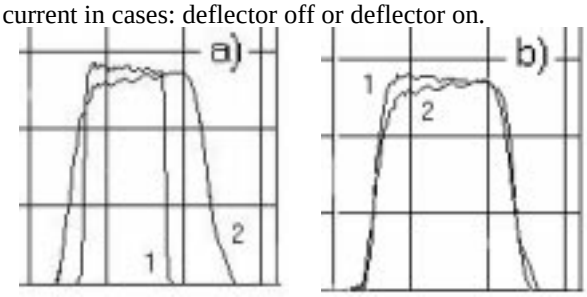

Fig.3. OscIllograms of the high voltage pulses (curve2; 40 kV/div) and beam current (curve 1; 0,4 A/div) in cases: deflector on (a) and deflector off (b). Time: 4 μs/div.

SUMMARY

The investigation have shown that the HV diode guns in combination with the forming system (collimator, deflector, buncher) are the most suitable for the use in injector accelerating structures with a high-power beam. The injector has been assembled with the linac and has been tested. In 1999 the injector had 1400 hours of operating time without accidents. The main parameters of the gun were 110 keV and 1.1 A.

REFERENCES

1. A.N.Dovbnya, E.P. Medvedeva, Yu.Tur, et al. Electron Accelerator's Production of Technetium-99m for Nuclear Medicine. // Proceedings of the 1997 Particle Accelerator Conference, Vancouver, B.C., Canada, 12-16 May 1997, p. 777-780.