STATUS OF THE LINEAR ACCELERATOR OF TNK FACILITY

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Abstract

TNK facility (F.V. Lukin Institute, Zelenograd) was designed and manufactured at Budker INP. It includes 80 MeV electron linear accelerator-injector and two electron storage rings: the main ring for energy of 2.0 GeV and booster ring for energy of 450 MeV. The paper presents the functional layout of the linear accelerator. Results of the accelerator startup is presented. In December, 2005, accelerated electron current of ∼50 mA with energy of ∼50–60 MeV was obtained; the beam was captured into the booster ring.

INTRODUCTION

The industrial storage facility (TNK) includes the 80–100 MeV electron linear accelerator-injector and two electron storage rings: 450 MeV lesser booster ring and main 2 GeV storage ring. The linear accelerator of TNK facility was commissioned in 2002 with obtaining the electron current at the accelerator's output.

The Table 1 contains the electron beam design parameters at the accelerator's output.

Table 1:

Beam energy	80 MeV
Energy spread	1%
Beam pulsed current	∼80 mA
Pulse duration	18 ns
Transverse emittance	0.1 mrad·cm
Repetition rate	1 Hz

Such parameters were reached early on the identical accelerator at RSC Kurchatov Institute [1, 2].

LINEAR ACCELERATOR SCHEME

Scheme of the linear accelerator-injector are shown in Fig.3. The injector includes disk-and-washers (DAW) accelerating structure [3], pulsed 20 MW RF power source, waveguide section, and electron-optic channel EOC-1. The pulsed linear accelerator operates in standing wave, storage power mode. The 6 meters long accelerating structure consists of 6 regular sections with the power input at the center. It is excited by "Olivin" klystron station via 90×45 mm^2 waveguide. The electron beam (4A/40 kV/×18 ns) from the diode gun enters the accelerating structure with no prebunching. During acceleration in the linear accelerator, it is divided into successive microbunches with a frequency of 2.8 GHz. The beam is transported to Siberia-1 booster ring via the electron-optic channel. Figure 1 presents the linear accelerator at the building berth; EOC-1 channel with the lesser ring are shown in Fig.2.

Figure 1: General view of the linear accelerator at the building berth.

Figure 2: EOC-1 channel and booster ring.

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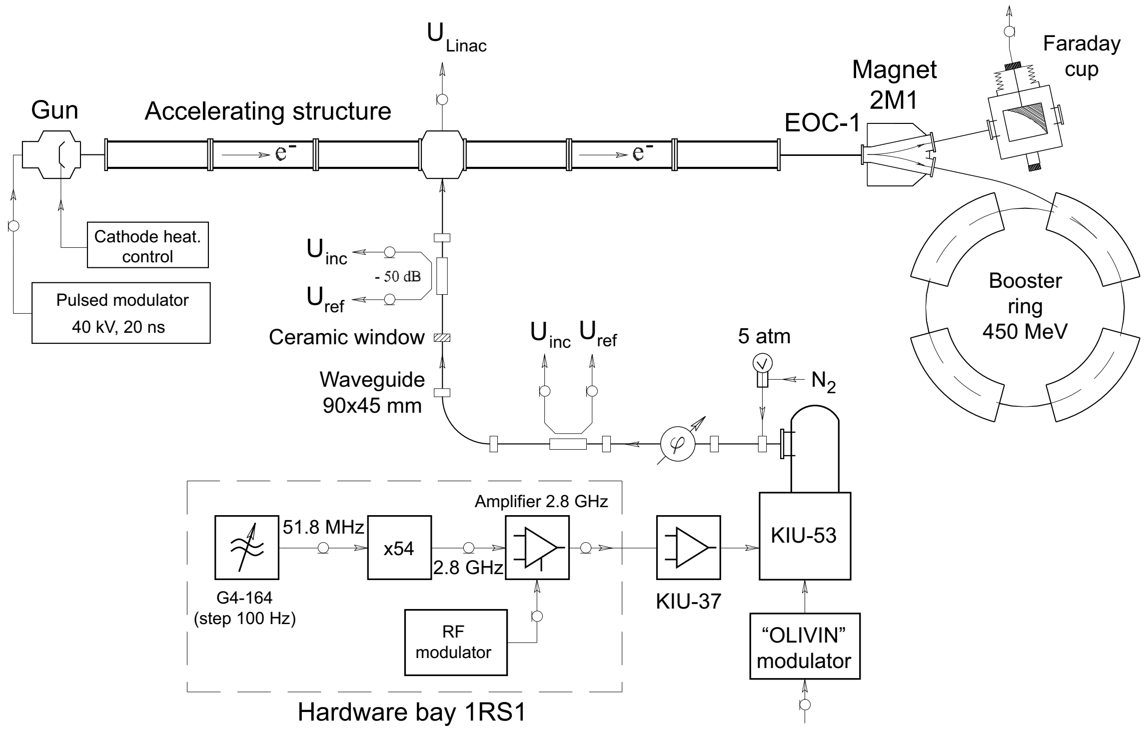

Figure 3: Linear accelerator scheme.

ACCELERATING STRUCTURE CONDITIONING

The first start-up of the linear accelerator and obtaining of the accelerated beam took place in December, 2005. Then the accelerator was temporarily closed down due to lack of financing; forevacuum was maintained. In December, 2005, the second start-up of the linear accelerator was carried out for the purpose of injection of the electron beam into the booster ring and caption of the beam into accumulation mode.

It should be noted, that in spite of the long break (two years) in the accelerator operation the vacuum in the accelerating structure and waveguide ($\sim 10^{-6}$ Torr) was restored for several working shifts. After RF discharge conditioning of the structure and waveguide, the regime for beam acceleration at the linear accelerator was established, so the accelerating field strength at the axis exceeded 200 kV/cm. ∼50 MeV accelerated beam was obtained at the accelerator's output. The further axis field strength increasing up to 300 kV/cm would allow us to obtain ∼80 MeV accelerated beam but it required prolonged additional RF conditioning of the accelerating structure cells surface.

In the presence of RF discharge and multipactor, accelerating structure conditioning was carried out at RF pulse repetition rate of 1 Hz. During conditioning, RF power level of the incident wave in the waveguide was adjusted and the master oscillator frequency was tuned to be equal to the linear accelerator resonant frequency. Oscillograms of the accelerating structure voltage and incident and reflected wave voltage shapes in the waveguide during conditioning are shown in Figs.4,5. Electron energy of ∼50 MeV and electron current of 50 mA were obtained at the linear accelerator's output within the energy range of ∼1%.

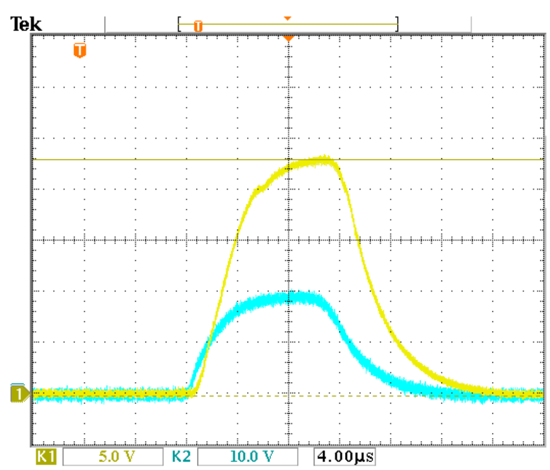

Figure 4: Accelerating structure and incident wave voltage oscillograms. Upper beam — U_{LinAcc}, lower beam — U_{inc}. Signals are attenuated by 10 dB. Anode voltage at KIU-53 is about 195 kV.

As may be seen from oscillograms on Figs 4,5, the microdischarge lasts till the signals' peaks, where particle acceleration takes place, what decreases the accelerating field and shunt impedance of the accelerating structure. The reflected wave signal shape also still has no typical zero dip which usually appears when a generator operates at the high-Q matched load with low VSWR.

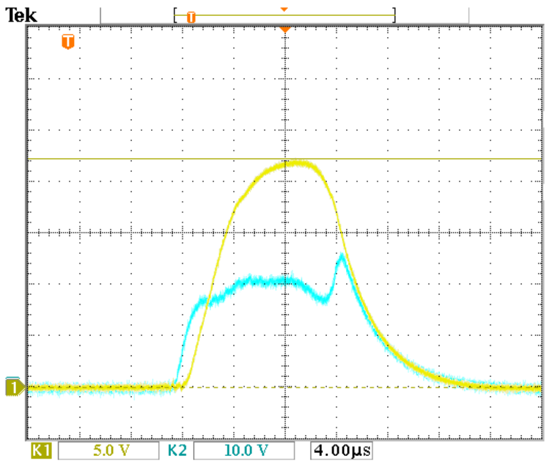

Figure 5: Accelerating structure and reflected wave voltage oscillograms. Upper beam — U_{LinAcc}, signal is attenuated by 10 dB, lower beam — U_{ref}, with no attenuation. Anode voltage at KIU-53 is about 195 kV.

Figure 6 presents signals from linear accelerator accelerating field probe and voltage from the Faraday cup at the accelerated beam charge passing through.

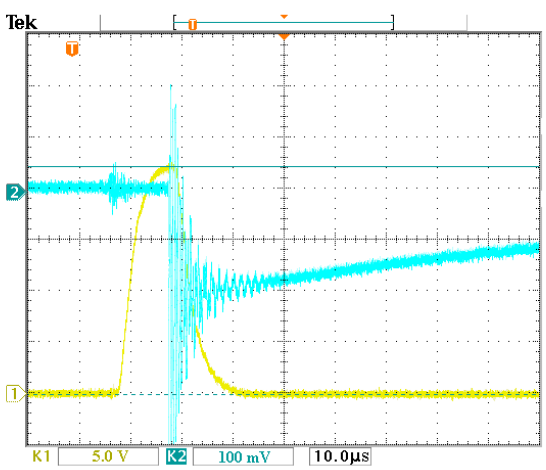

Figure 6: Accelerating field and Faraday cup voltage oscillograms. Anode voltage at KIU-53 is about 190–195 kV. Anode voltage at KIU-37 is about 11.6 kV. External driving. Conditioning mode. Yellow — U_{LinAcc} (attenuation of 10 dB), Blue — U_{FC}. Faraday cup capacitance is 3246 pF. Deflecting magnet 2M1 current is 8 A.

Figure 7 presents experimental curve of the accelerated beam current at the faraday cup placed in EOC-1 channel in the booster entrance plane obtained when varying the deflecting magnet 2M1 current.

CONCLUSION

In December, 2005, the electron beam from the linear accelerator was captured in the booster ring, and current of 2 mA was stored. The further accelerating structure conditioning in order to output beam energy increasing was planned at the end of 2006 together with the linear accelerator, gun, and lesser ring electron equipment modernization.

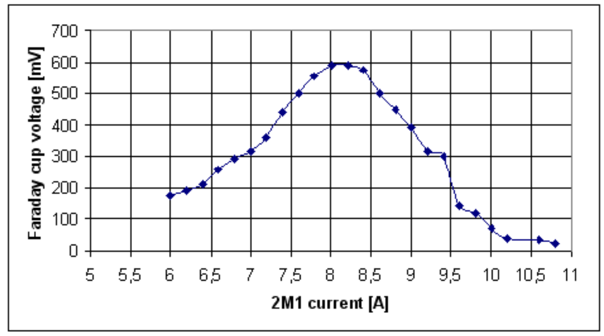

Figure 7: Faraday cup voltage versus deflecting magnet 2M1 current.

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