STATUS OF VEPP-5 INJECTION COMPLEX

M.S.Avilov, A.V.Akimov, A.V.Antoshin, P.A.Bak, Yu.M.Boimelshtein, D.Yu.Bolkhovityanov, A.R.Frolov, R.Kh.Galimov, R.G.Gromov, K.V.Gubin, S.M.Gurov, E.A.Gusev, N.S.Dikansky, I.V.Kazarezov, V.D.Khambikov, S.N.Klyuschev, E.S.Konstantinov, N.Kh.Kot, V.I.Kokoulin, A.A.Korepanov, R.M.Lapik, N.N.Lebedev, P.V.Logatchev, A.I.Lobas, P.V.Martyshkin, L.A.Mironenko, V.M.Pavlov, I.L.Pivovarov, O.V.Pirogov, V.V.Podlevskikh, S.L.Samoylov, Yu.I.Semenov, B.A.Skarbo, A.N.Skrinsky, A.A.Starostenko, S.V.Shiyankov, A.S.Tsyganov, O.Yu.Tokarev, A.G.Chupyra

BINP RAS, Novosibirsk, Russia.

Abstract

VEPP-5 injection complex is an intensive source of electron and positron bunches with energy of 510MeV (see Table 1), which will fulfill all the needs of existing and building colliders in BINP RAS. The complex consists of a 285MeV electron linac, 510MeV positron linac, and a damping ring with transport channels (see Fig.1). During last two years an intensive work on production, assembling and tuning of positron system was carried out. As a result, in May 2004 it was put into operation. This allowed to accelerate a single bunch of $2*10^8$ positrons to 75MeV. Results of preliminary tests of VEPP-5's regular positron system are presented in this article.

Table 1: Beam parameters at the output of injection complex

Energy	510 MeV
Maximum number of electrons in a bunch	$2.0\ 10^{10}$
Maximum number of positrons in a bunch	$2.0\ 10^{10}$
Repetition rate	1 Hz
Energy spread of the bunch	0.07 %
Longitudinal size of the bunch (FWHM)	0.4 cm
Vertical emittance	0.005 mm·mrad
Horizontal emittance	0.023 mm·mrad

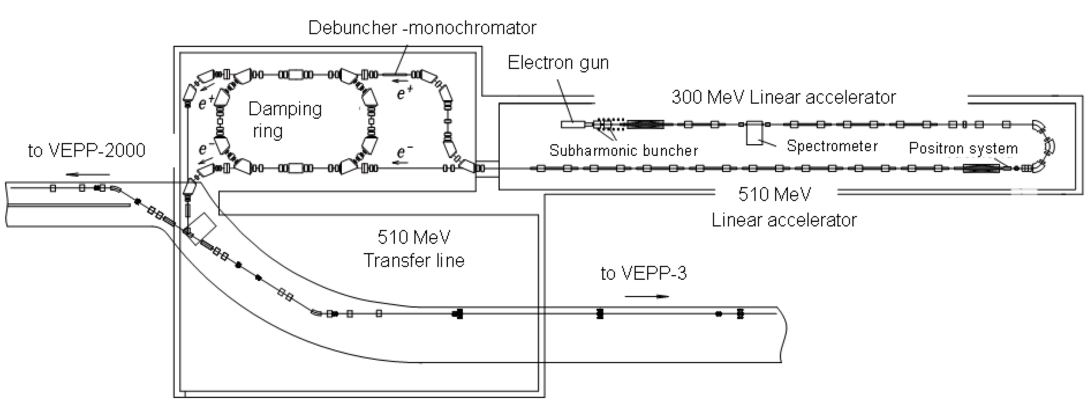

Fig.1: VEPP-5 layout

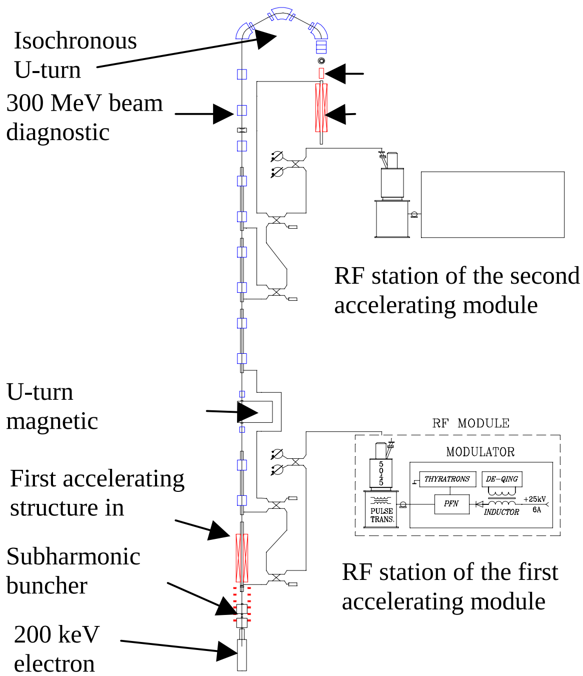

Fig.2: Currently operating part of injection complex

DESCRIPTION OF CURRENTLY OPERATING PART OF THE FACILITY.

Accelerator consists of two equally RF-fed accelerating modules. Each one includes a klystron (5045, SLAC), SLED-type power compression system, and three accelerating structures with a constant impedance incursion of 2π/3 per cell, operating on a running wave. System operating frequency is 2856Hz. Accelerating structure has a length of 3m and is a round diaphragmatic waveguide, at ends coordinated with a rectangular waveguide of 72×34mm. Through this rectangular waveguide the structure is fed with impulse RF-power of 60–120MW and length of 0.5µs. Duration of input impulse is equal to a wave propagation time in a 3m accelerating structure. RF power, passed through the structure, is completely absorbed by a matched load.

Acceleration of the beam is performed at the moment when RF power reaches the load, accelerating structure is filled, and absorption of the energy by the beam is maximal. Forming of the feeding RF impulse occurs in power compression system, which works as a storage of RF energy, collected during the main part of klystron impulse (3µs duration), and sends all the energy, collected during last 0.5µs of RF impulse, to accelerating structures. Energy sending process is initiated by a quick (in several nanoseconds) 180° change in phase of a wave from klystron. As a result, at the output of the power compression system a 5µs, 240MW RF impulse is formed, which is than divided between module's three accelerating structures in a 2:1:1 ratio. Acceleration structures are identical. One such module at klystron power of 60MW accelerates the beam to 180MeV. Each module also includes a magnetic focusing system, a beam diagnostic system and a thermostabilization system.

285MeV electron linac includes electron source, grouping system, the whole 1st accelerating module and two lowered-rate acceleration structures from the second module. Pulse-fed electron gun forms a beam of 2.2ns duration, with a current of 2.5A at 200kEV energy. For effective seize of a beam by linac the duration must be reduced from 2200ps to 20ps. It is achieved via longitudinal compression of the bunch by two RF cavities, operating at 178MHz (16th harmonic of main frequency), and by a buncher at a main frequency. In order to preserve transverse beam size the bunching process is performed in increasing magnetic field.

Layout of linac's two first modules is presented on Fig.2. The 3rd structure of the 2nd module is located after isochronous turn and is used to accelerate positrons. A temporary diagnostic channel is located after this structure and is being used for positron beam parameters measurement. Directly after the isochronous achromatic turn a tripled is located, which focuses the beam onto tantalum conversion target.

Beam transverse profile monitors, located in the turn, provide measurement of energy and energy spread in the beam. Secondary-emission wire sensors of beam's transverse profile located before and after the turn, control loss of particles in the turn. Single-bunch mode (see Table 2) is primary for injection complex's linacs. It provides accumulation of intensive electron and positron bunches in a damping ring with subsequent transport into VEPP-4M and VEPP-2000 colliders.

Table 2: Main parameters of injection complex's linacs

Energy	510 MeV
Maximum number of electrons in a bunch	1011
Maximum number of positrons in a bunch	109
Repetition rate	50 Hz
Energy spread of the electrons bunch	1 %
Energy spread of the positrons bunch	3 %
Emittance	15 mm·mrad
Longitudinal bunch size (FWHM)	0.4 cm
Acceleration structure operational frequency	2856 MHz
Klystron output power	63 MW
Number of klystrons	4

OPERATION OF POSITRON SYSTEM.

In the mode reviewed below, $2{\cdot}10^{10}$ electrons in one bunch with energy of 270MeV are focused on tantalum conversion target into a spot with 1mm diameter. Target's thickness is 2.5 radiation lengths, which provides maximum positron output at a given beam energy. Besides the target itself, positron system includes a pulse concentrator magnet of the flow, a system of solenoids which form constant magnetic field, and the first positrons' accelerating structure. Pulse magnet coordinates phase volume of a positron bunch, emitted from the target, with acceptance of the accelerating structure. Measured and calculated dependencies of number of accelerated positrons from magnetic field value are presented on Fig.3. Energy spectrums of positrons and electrons, passing through the 1st positron structure with pulse magnet turned on and off, are presented on Fig.4.

Spectrums were measured with a sectioned Faraday cup, located at the output of a separating magnet, at the end of diagnostic positron channel. Two central sections of Faraday cup are positively charged due to secondary electron emission, caused by high energy photons, emitted from conversion target at low angles. These measurements were performed for $2{\cdot}10^{10}$ electrons, falling onto tantalum target in one bunch, with flow concentrator magnet turned on. The conversion ratio of electrons into positrons, accelerated and delivered to Faraday cup, was 0.01.

Now, in parallel with testing of positron system, production of missing components of positron linac is being done. Currently a 510MeV transport channel to VEPP-2000 collider is being constructed.

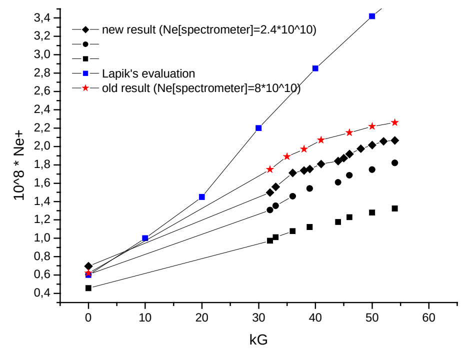

Fig.3: Dependency of accelerated positrons on a maximum field in a concentrating magnet

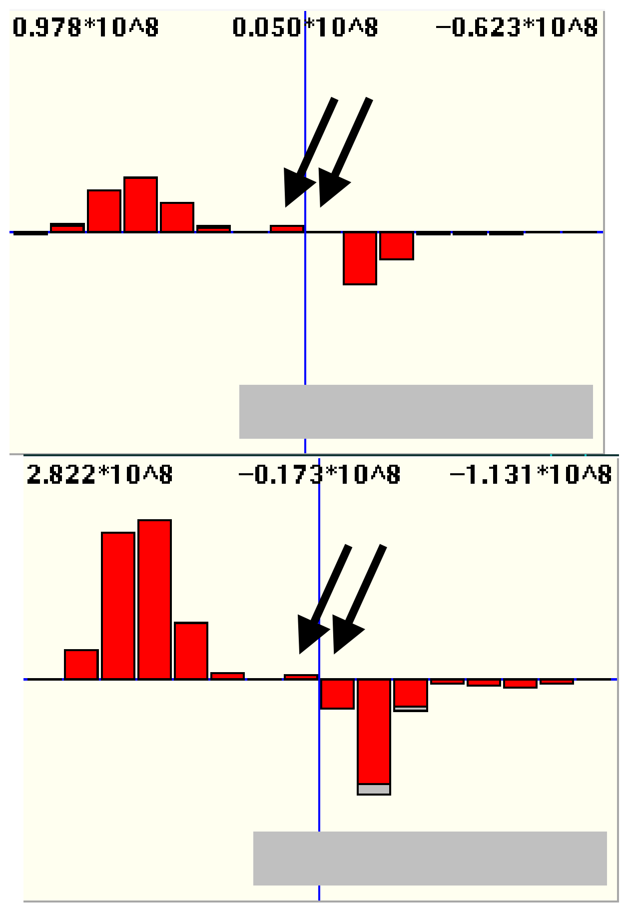

Fig.4: Energy spectrum of electrons and positrons at the output of the 1st accelerating structure