STATUS OF VEPP-5 PREINJECTOR

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Abstract

During 2001 all activities in design, manufacturing, assembling, tuning and testing of the VEPP-5 preinjector elements were continued. As a result, 285 MeV S-band linear accelerator with electron gun, subharmonic pre-buncher, RF buncher, and other standard subsystems was put in operation. The achromatic isochronous U-turn as well as the positron production target assembled with first accelerating structure for positrons is also put in operation, so we can work now with positron beam at the energy up to 75 MeV. The results of preliminary accelerator tests are presented.

1 INTRODUCTION

The test of the preinjector was carried out on the basis of two equal (from RF point of view) accelerator assemblies. Each one consists of 5045 SLAC klystron with SLED type power compression system and three constant impedance travelling wave accelerating structures. One structure utilises a half of the total power and each of two others - a quarter. Structures are identical and have the length of 3 m. The energy gain of one assembly at nominal klystron power is 180 MeV. These assemblies comprise also focusing magnetic systems and systems of beam diagnostics. 285 MeV electron linac includes first accelerating assembly and two quarter-powered structures of the second assembly. Third structure of the second assembly is placed after isochronous U-turn and used to accelerate positrons. Temporal positron beam diagnostic line follows the first positron structure and is used for experiments with prototype of NLC positron production target made in BINP for SLAC. The isochronous achromatic U-turn precedes the quadrupole triplet, which focus an electron beam on the positron production target. The beam profile monitors along the U-turn provided the beam energy and energy spread measurements. In order to measure the beam energy spectrum and the total charge at the output of the second accelerating structure of electron linac, a 180° spectrometer with sectional Faraday cup of full beam absorption was used. This device enables to measure the energy spectrum and the bunch charge with 2% accuracy.

The VEPP-5 preinjector electron accelerator can work both at the single bunch and the multibunch modes. A multibunch mode, though not previously planned, was used to study the ultimate possibilities for the accelerator subsystems when the long (up to 250 ns) current pulses were accelerated. In 2001, the possibility of operation at the nominal parameters was demonstrated for the electron linear accelerator of the Intense resonant neutron source (IREN), which is under manufacturing at BINP in the framework of the collaboration with JINR, Dubna [1].

A single bunch mode is a basic one for the injector complex operation with electron-positron colliders in BINP (VEPP-4 and VEPP-2000). In fact, the electron beam of 200 kV energy, 4 A current, and 2.5 ns width produced in the electron source should be almost 100 times compressed in the longitudinal direction. So that the pike current in the bunch and the bunch length should be 400 A and 6 mm, respectively. The compression occurs in two cavities which operate at the 16^{th} RF subharmonic (178.5 MHz) of the accelerator main operation frequency (2856 MHz). The maintenance of the transverse beam size within a given range is ensured by the increasing value of a magnetic field in the longitudinal direction. The stable operation of accelerator in a single bunch mode requires steady amplitudes and phases for all elements of RF system. To control the bunch structure and bunching efficiency an electron beam probe [2] was developed and installed on the electron linac. The operation of this non-destructive beam diagnostic tool is based on scanning of a thin low energy electron beam in the electromagnetic fields of a short relativistic bunch. This device allows measuring the accelerated charge in each bunch of the train as well as to control relative transverse bunch positions and sizes. The scheme of all the installation is shown in Fig. 1.

2 THE RESULTS OF OPERATION IN MULTIBUNCH REGIME

The test with a long bunch train proves the possibility of linac operation at high current load for the production of high power beams, as determined in the project of LUE-200 accelerator for the Intense resonant neutron source (IREN) at JINR, Dubna. Beam parameters after the gun for the multibunch operation:

pulse repetition rate 2 Hz,
electron gun voltage 200 kV,
gun pulsed current 1.6 - 3.5 A,
current pulse width 130 ns (FWHM).

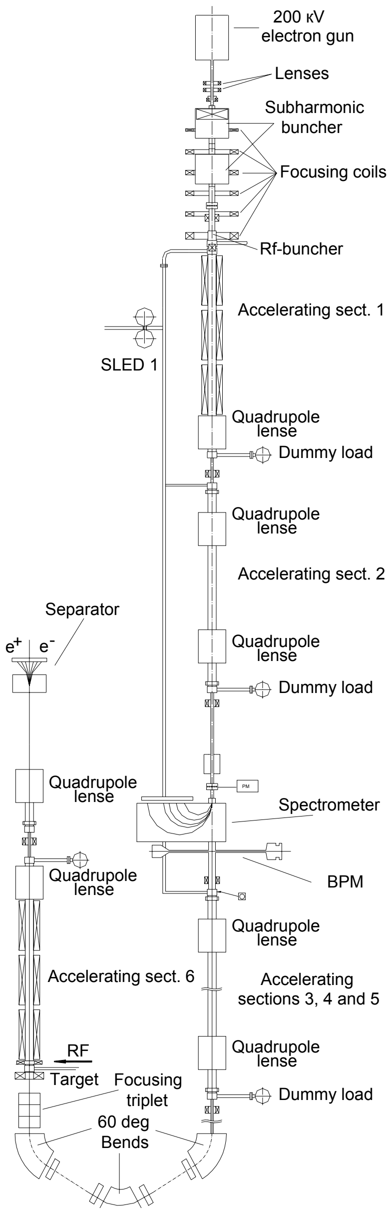

Figure 1. The layout of installation.

Maximum and minimum energies of electrons in the accelerated beam were 117 MeV and 60 MeV, respectively. The total beam charge was 327 nC (total number of particles was $2.04{\cdot}10^{12}$). Beam energy capacitance was 28 J. The measured pulsed current of the electron gun was 2.84 A, that is the equivalent to a current of a beam ≈ 1.3 A at the design pulse duration 250 ns [3].

3 AN EXAMPLE OF OPERATION IN SINGLE BUNCH REGIME

Electron beam parameters just after the gun for the single bunch operation:

pulse repetition rate 5 Hz,
electron gun voltage 200 kV,
gun pulsed current 2.5 A,
current pulse width 5.2 ns (FWHM).

For single bunch operation the long-range wakefield doesn't influence essentially on the acceleration process of the main bunch, and the accelerating field for this bunch is determined by incoming power from RF assembly. It is not true for the following low intensity bunches which form a low energy tail of the beam energy spectrum.

As much as $1.6{\cdot}10^{10}$ electrons in the main bunch are detected after the first pair of accelerating sections at the energy of 125 MeV (75 MeV after first high-gradient section plus 50 MeV in one low-gradient section of the first RF module). The energy gain in the next three low-

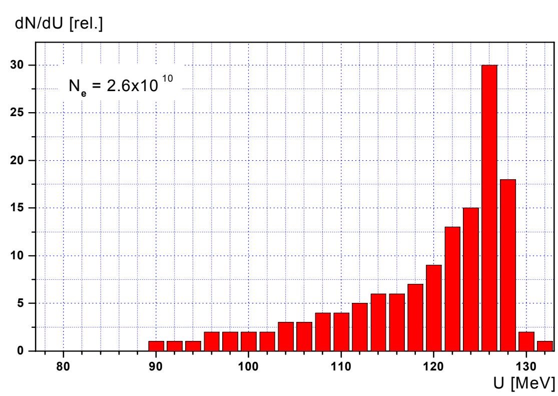

Figure 2. The electron beam spectrum after second accelerating structure (single bunch regime).

gradient sections before the isochronous turn is 160 MeV (54 MeV in the last section of first RF module plus 106 MeV in two sections of the second RF module). So the total energy of driving electron linac is 285 MeV. The beam energy spectrum after the second accelerating structure of electron linac is presented on Fig. 2.

Temporal structure of the bunch train can be seen on the monitor of electron beam probe (Fig. 3). This device is placed just after the spectrometer, before the third accelerating structure. Each loop corresponds to each bunch and the vertical size of the loop is directly proportional to the corresponding bunch charge. For this particular case the major bunch contains 63 % of the total train charge. The second electron beam probe is placed between the focusing triplet and positron production target, after isochronous U-turn of driving electron beam. Secondary emission wire beam profile monitors before and after U-turn together with electron beam probes control the particle loses in the turn due to energy spread in the beam. In the regime described above $1.0 \cdot 10^{10}$ electrons in the most intense bunch are focused on the positron production target with the spot diameter of 1 mm.

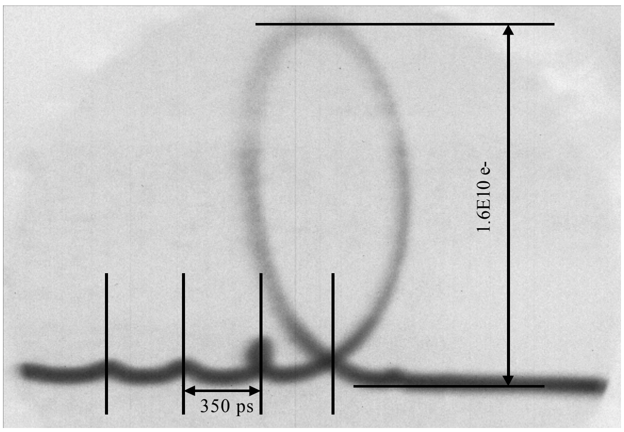

Figure 3. The picture from photo-camera of the first electron beam probe.

Now the prototype of NLC positron production target assembly together with 10 T pulsed flux concentrator magnet has integrated to the facility. The experimental study of the positron production process has already started. As an example Fig. 4 shows the spectrum of electrons and positrons accelerated in the 6-th structure measured at the exit aperture of separating magnet (flux concentrator is off). The spectrum was measured by sectional Faraday cup (FC) of full beam stop. Two central sections of FC indicate the adsorption of high-energy photons. This measurement was done for $1.0 \cdot 10^{10}$ electrons striking the lead target, so for this particular case the electrons to positrons conversion coefficient is about $5.0 \cdot 10^{-4}$.

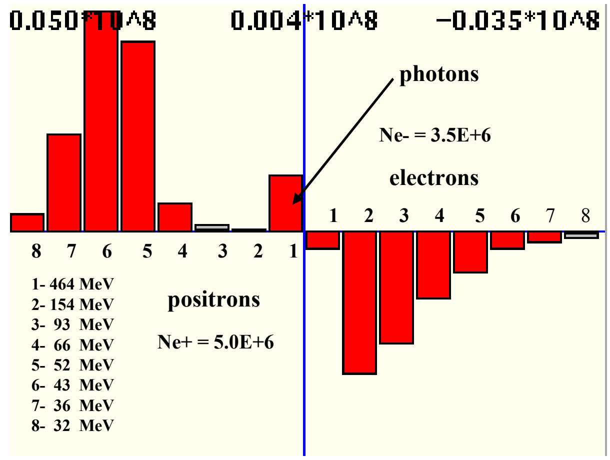

Figure 4. The energy spectrum of electrons and positrons after the first accelerating structure of positron linac (flux concentrator magnet is off).

4 REFERENCES

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