COMISSIONING OF BNP INJECTION COMPLEX VEPP-5

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Abstract

The VEPP-5 Injection Complex [1] will supply BINP RAS colliders with electron and positron beams. Primary launch have been performed: electron and positron beams were obtained, injection to damping ring have been done, as well as storage of electrons and positrons. Now both transport channel to the electron/positron colliders VEPP-2000 and VEPP-4M are fully assembled and therefore test extractions of electron beam with energy of 360 MeV into beam lines to users are being performed. Main users require a reliable and trouble proof source of particles, thus reliability and stability of operation are a paramount tasks.

INTRODUCTION

VEPP-5 Injection Complex consists of 270 MeV driving electron linac, 510 MeV positron linac and dumping ring (See Fig.1). Both linear accelerators are based on four accelerating modules, each one feeds by one SLAC klystron (5045). Two first modules have three accelerating structures and second two — four structures. First accelerating structures of both linacs have an enhanced average acceleration gradient of 20 MeV/m and other regular sections up to 17–20 MeV/m. Both linacs can operate up to 50 Hz repetition rate. Dumping ring stores and cools down both electron and positron beams (See Figure 3). It is equipped by 50 Hz injection system.


Figure 2: Linear accelerators


Figure 3: Damping ring

Table 1: Designed Parameters of Injection Complex

Maximum Beam Energy (MeV)	510
Max. number of electrons in the beam	$2\cdot10^{10}$
Max. number of positrons in the beam	$2\cdot10^{10}$
Energy spread in the beam (%)	0.07
Longitudinal beam sigma (mm)	4
Vertical emittance (mm mrad)	0.005
Horizontal emittance (mm mrad)	0.023
Dumping times vert./horis. (ms)	17/11
Extraction rate (Hz)	1

Designed parameters of VEPP-5 Injection Complex are presented in Table 1. At the parameters listed above Injection Complex will be able to cover all needs of BINP e+ e- colliders for nearest future. This will greatly improve the VEPP-2000 and VEPP-4M performance, because of significant increase of positron production rate and will help to reach their maximum luminosity of these colliders.

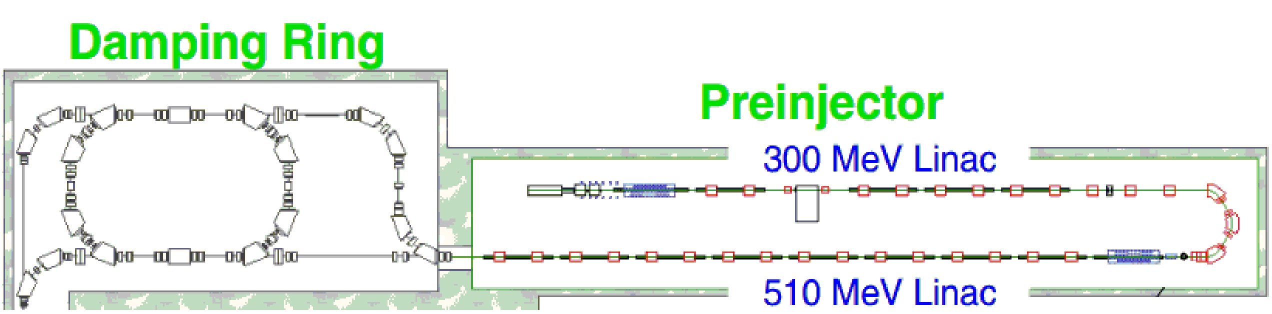

Figure 1: Injection complex

COMISSIONING PLANS AND TECHNIC

Commissioning Results

The VEPP-5 Injection Complex should be running with project parameters in the near future. Damping ring of the Complex stores the electron beams of 350 MeV today. Storage rate is $3{\bullet}10^9$ electrons per pulse and maximum store current is 160 mA, which exceeds design parameters. Beam transfer line to the BINP colliders is completely assembled and ready for beam accepting. The Damping ring optics were tuned to improve the Complex stability. Also new beam diagnostics were installed to ease beam injection in the Damping ring. The diagnostics methods and equipment are described below.

Cherenkov Beam Loss Monitor

The loss detection principle is based on the production of Cherenkov light in the optical fiber installed on the vacuum chamber through the electromagnetic shower generated when the beam hits the internal surface of vacuum chamber. Cherenkov beam loss monitor is successfully operating during the commissioning phase of Injection complex. It is very useful for accelerator tuning especially for first beam pass. The (BLM) consists a photomultiplier tube, three segments of optical fiber of 20 m in length attached to the vacuum chamber, ADC with 200 MHz bandwidth. Photoelectronic multipliers were connected with end of the fibers (See Figure 4). Then signal was transferred to ADC.

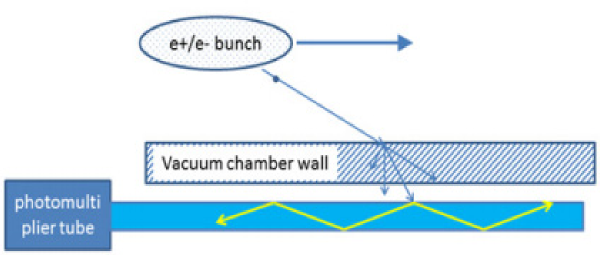

Figure 4: Concept of Cherenkov loss monitor

Test of the Monitor was done on beam transport lines between acceleration structures on linacs and on injection electron channel to the dumping ring (See Fig. 5, 6). Flashes of intensity emerge in locations of high beam losses. Spatial calibrating of the facility has being proceeded via artificial dropping of the beam against the vacuum chamber in known place (See Fig. 5). Due to short duration of the flash of Cherenkov light the monitor is sufficiently fast, which allows measuring energy losses in a dumping ring for each turn and continuously controlling and minimizing beam losses during the injection and collecting electron/positron beams.

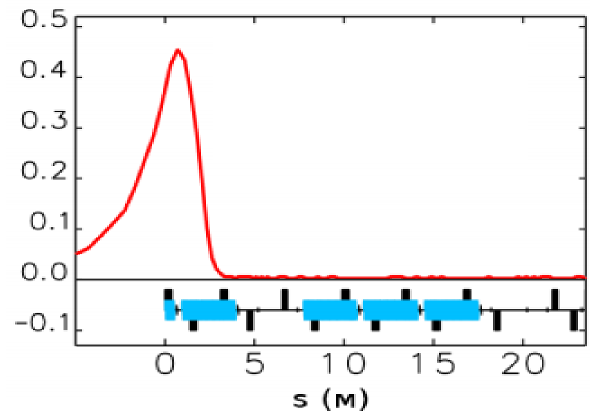

Figure 5: The beam of electrons with energy 125 MeV dropped into internal vacuum chamber after first accelerator structure. On ordinate axis – relative intensity of loses

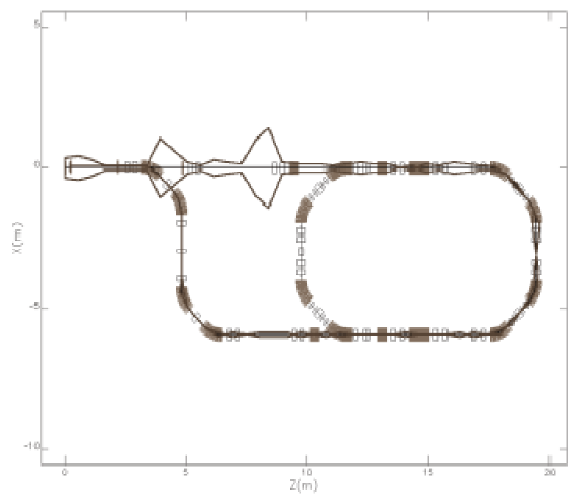

Figure 6: The beam of electrons with energy 350 MeV dropped into internal vacuum chamber on electron injection channel to the dumping ring

Carrying out the experiment was found that the measured position resolution is in a range 80 – 100 cm for optic fiber with length 20 m. However, it is possible to improve the spatial resolution by choosing of acceptable optic fiber cable: multimode with gradient index of refraction.

Dumping Ring Lattice and Closed Orbit Correction

One of the most crucial issues arising during launching the dumping ring is a presence of optical parameters in accuracies in a real structure. Thus, detection and removal of such inaccuracies are tasks of highest priority in achieving the stable functioning of the complex.

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First betatron tunes were set to the project values. After that software "sixdsimulation" developed for VEPP-2000 [2], was applied to correct linear lattice and closed orbit. It took 4 iterations to correct linear lattice by fitting the model to the experimental data composed of closed orbit responses to the all dipole correctors, dispersion, and betatron tunes. After last iteration, the fitted model didn't show significant variation from the ideal configuration (See Fig. 7).

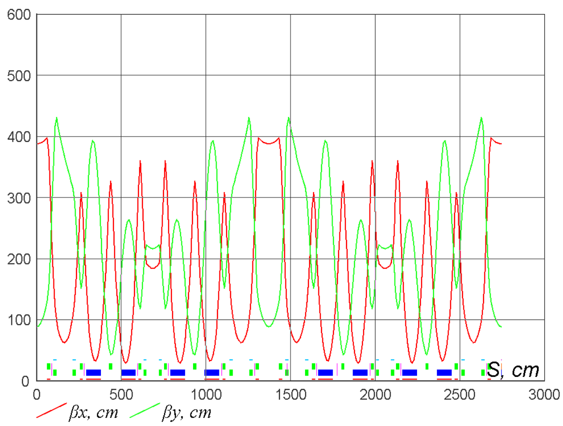

Figure 7: Beta functions for project optics in VEPP-5 dumping ring

Closed orbit correction was done with respect to the quadruple magnetic centers (See Fig. 8-9). To do so closed orbit responses to the gradient variations of the individual quadruples [3].

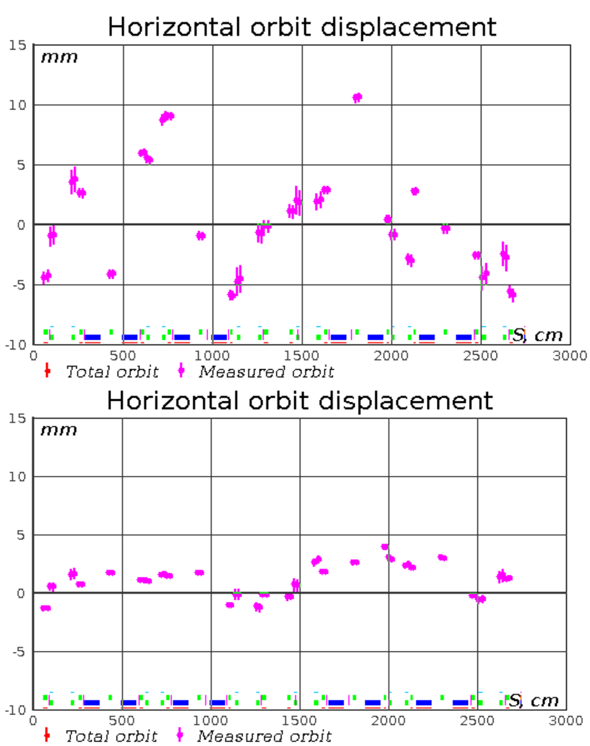

Figure 8. Closed orbit correction. Top – before correction, bottom – after.

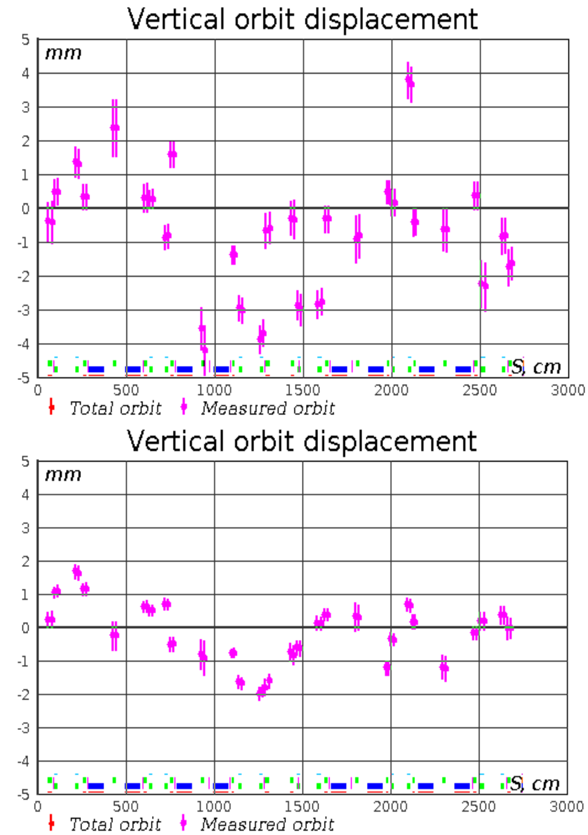

Figure 9. Closed orbit correction. Top – before correction, bottom – after.

CONCLUSION

During the season 2013/2014 following results were achieved: number of e^- on conversion target - $1.5 \bullet 10^{10}$ per pulse, energy of e^- on conversion target- 275Me, energy of e^+ at the end of linac – 420 MeV, number of e^+ at the end of linac - $6 \bullet 10^{+}$ per pulse, maximum current of e^+ in dumping ring - 70 mA (number - $4 \bullet 10^{10}$), maximum current of e^- in dumping ring -160 mA (number - $9 \bullet 10^{10}$), injection rate - 12.5 Hz. Maximum storage rate of electron is $9.3 \bullet 10^{9}$ per pulse. Maximum storage rate of electron is $5 \bullet 10^{8}$ per pulse.

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