STATUS OF INJECTION COMPLEX VEPP-5

P. Logatchev, A. Petrenko, D. Bolkhovityanov, D. Nikiforov, A.Levichev, A.Barnyakov, A.Novikov, V. Gambaryan, K. Astrelina, Budker INP, Novosibirsk, Russia
A.Starostenko, F.Emanov, Budker INP, Novosibirsk; NSU, Novosibirsk, Russia

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 damping 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 with 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	$2 \cdot 10^{10}$
Max. number of positrons in the beam	$2 \cdot 10^{10}$
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.

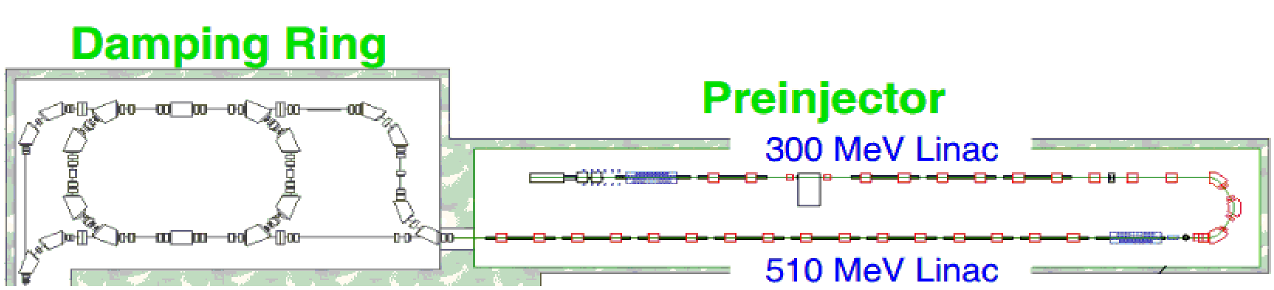

Figure 1: Injection complex.

ISBN 978-3-95450-170-0

COMMISSIONING 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.

Measurement of Injection Angle

To improve the parameters of storage rate it is necessary to perform matching of the injection system and damping ring. Injection scheme use vertical DC Lambertson type septum magnet biased from an equilibrium orbit in the radial direction and kicker. Septum magnet directs the beam to the median plate and then by means of kicker beam is shifted to closed orbit. In this system injection angle must tend to zero. To determine the transverse coordinate of the beam in the septum and injection angle we can measure the beam position as a function of some quadruple lens strength after septum magnet (See Figure 4). In this experiment, transverse coordinate x of the injected beam recorded by means of phosphor screen LK4, furthermore 3D2 lens and kicker plate were switched off (See Figure 5). Beam displacement on the phosphor screen is performed via a current variation in the 3F3 lens (See Figure 6). Coordinate value and angle on the phosphor screen (x, x') and in the septum magnet (x_0, x_0') is associated via transport matrix R :

$$\begin{pmatrix} x \\ x' \end{pmatrix} = \begin{pmatrix} R_{11} & R_{12} \\ R_{21} & R_{22} \end{pmatrix} \begin{pmatrix} x_0 \\ x_0' \end{pmatrix}$$

Thus by means of known coordinates for two values of current in a lens it is possible to obtain system of the equations for (x_0, x_0'):

$$\begin{cases} R_{11}(I_1)x_0 + R_{12}(I_2)x_0' = x_1 \\ R_{11}(I_2)x_0 + R_{12}(I_2)x_0' = x_2 \end{cases}$$

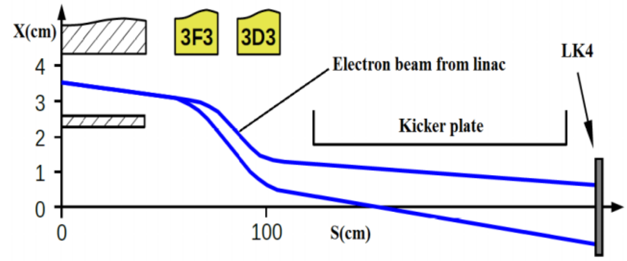

Figure 5: Scheme of angle measurement experiment.

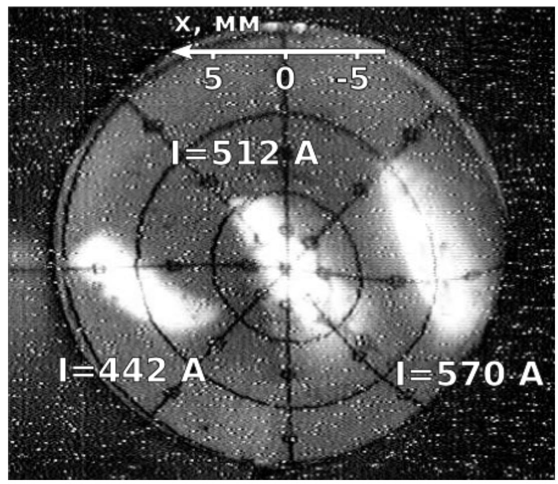

Figure 6: Beam shifting depends on the 3F3 current.

For measurement on the Figure 7 following values for x coordinate and x' angle were obtained: $x \approx 3cm$, $x' \approx -3mrad$. After precision geodetic installation of septum magnet and after repeated measurements the next values were obtained: $x \approx 3.5cm$, $x' \approx -0.08mrad$.

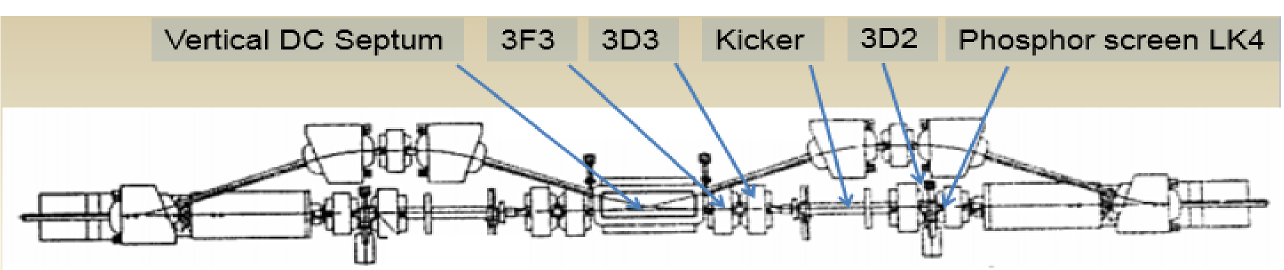

Figure 4: Injection transport line. 3F3, 3D3, 3D2 – quadruple lenses after septum magnet.

ISBN 978-3-95450-170-0

Damping 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.

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).

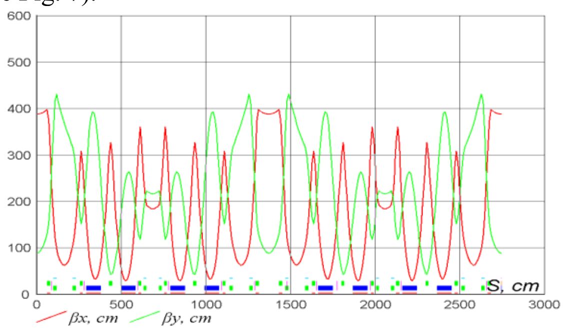

Figure 7: Beta functions for project optics in VEPP-5 dumping ring.

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].

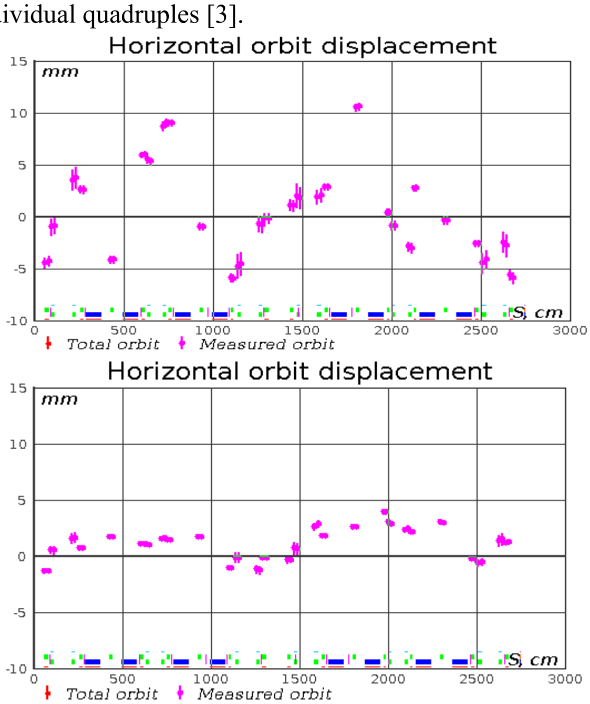

Figure 8. Closed orbit correction. Top – befor correction, bottom – after.

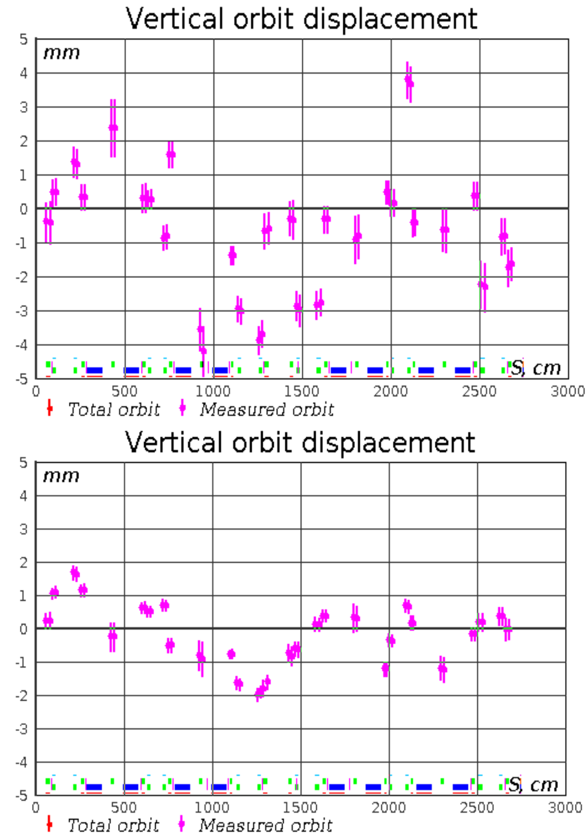

Figure 9: Closed orbit correction. Top – befor correction, bottom – after.

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.

REFERENCES

[1] P.V.Logatchev et al, "Status of VEPP-5 Injection Complex",Proc. RuPAC-2006

[2] A. Romanov et al., Round Beam Lattice Correction using Response Matrix at VEPP-2000, Conf. Proc. IPAC-2010, THPE014 (2010).

[3] *J. Safranek*. Experimental Determination of Storage Ring Optics Using Orbit Response Measurements, Nucl. Instr. And Meth. A388, (1997) p. 27.

ISBN 978-3-95450-170-0