# COMMISSIONING OF $e^+/e^-$ TRANSFER LINE FROM BINP INJECTION COMPLEX TO VEPP-2000 FACILITY*

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*Abstract*

VEPP-2000 $e^+/e^-$ collider [1] was constructed in 2006 at BINP. The design luminosity of $1\times10^{32}$ cm$^{-2}$s$^{-1}$ may be achieved at filling rate of $1\times10^8$ $e^+/e^-$ per second. Old VEPP-2M facility infrastructure provided only $1\times10^7$ $e^+/e^-$ per second. We decided to use Injection Complex [2, 3]. The transfer line [4] connects Injection Complex and VEPP-2000 facility. Commissioning of $e^+/e^-$ transfer line from Injection Complex to VEPP-2000 facility is done in 2016. Both electrons and positrons beams are injected to VEPP-2000 collider.

## GEOMETRY AND OPTICS

We simulated the optics with the RING program [5]. Detailed geometry and optics are shown in Figures 1-9.

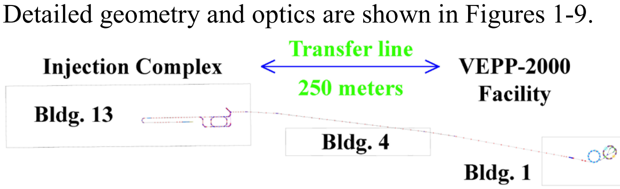


Figure 1: The transfer line location.

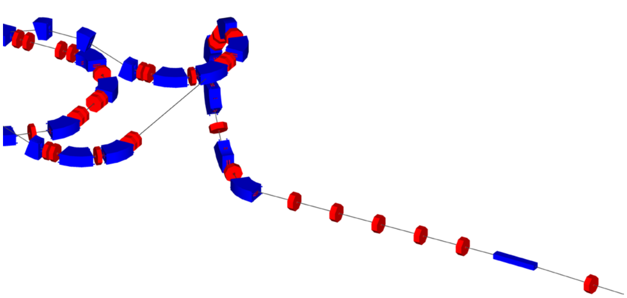

Figure 2: The descent from the storage ring.

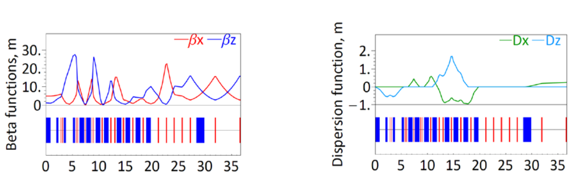


Figure 3: Lattice functions of the descent.

Figure 4: First horizontal bend.

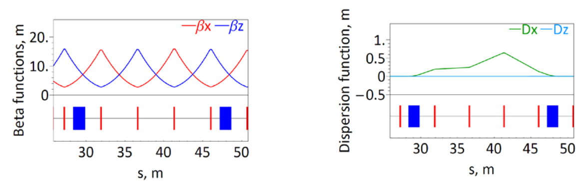


Figure 5: Lattice functions of first horizontal bend.

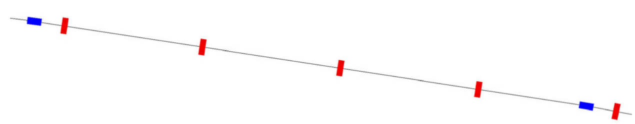

Figure 6: Second horizontal bend.

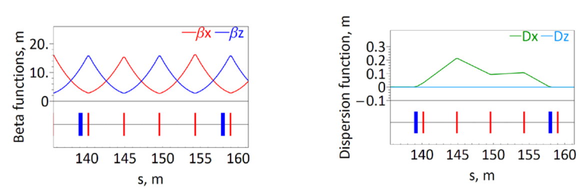


Figure 7: Lattice functions of second horizontal bend.

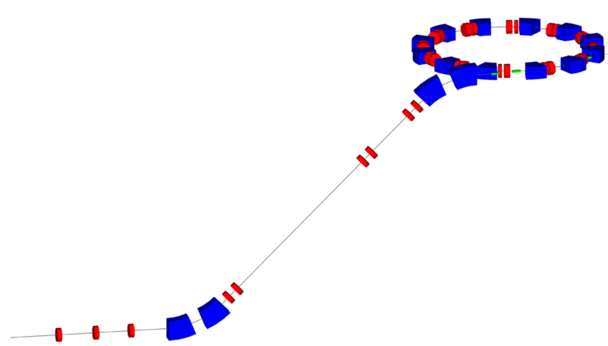

Figure 8: The ascent to booster BEP.

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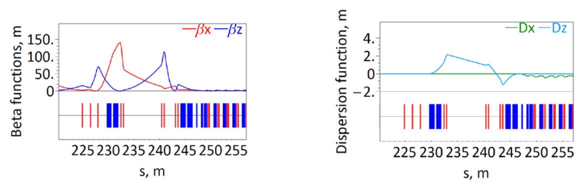


Figure 9: Lattice functions of the ascent.

## MAGNETS AND POWER SUPPLIES

We calculated magnets with the aid of the MERMAID code [6]. Parameters of magnets and power supplies [7] are listed in Table 1.

Table 1: Magnetic elements and power supplies for beam energy of 510 MeV.

| Element | Parameters | Power supply |
|---|---|---|
| 6 dipoles of the descent | H=1.52T<br>L=0.88m | 2 DC, IST<br>I=1.1kA |
| 2 horizontal dipoles of the first bend | H=0.08T<br>L=1.51m | 1 DC, UM-20,<br>I=20A |
| 2 horizontal dipoles of the second bend | H=0.1T<br>L=0.51m | 1 DC, UM-20,<br>I=20A |
| 4 vertical dipoles of the ascent to the booster BEP | H=0.67T<br>L=1m | 1 AC, GID-3000, W=3kJ |
| 1 horizontal dipole before the septum of BEP | H=1.74T<br>L=0.29m | 1 AC<br>W=2.4kJ |
| 1 septum of BEP | H=1.74T<br>L=0.43m | 1 AC<br>W=2.4kJ |
| 18 quadrupoles of the descent, the ascent and the matching part | G=1-16T/m<br>L=0.2m | 18 AC, GID-25, W=25J |
| 43 quadrupoles of the regular part | G=2.59T/m<br>L=0.2m | 8 AC, GID-25, W=25J |
| 6 dipole correctors in 6 dipoles of the descent | Hmax=0.02T<br>L=0.88m | 6 DC, PS-3A,<br>I=3A |
| 11 dipole correctors in 11 quadrupoles of the descent and the ascent | Hmax=0.1T<br>L=0.2m | 11 AC, GID-25, W=25J |
| 27 dipole correctors | Hmax=0.01T<br>L=0.1m | 27 DC, PS-3A, I=3A |

## VACUUM SYSTEM

The vacuum chambers are made of stainless steel. The inner aperture of quadrupoles is 23 mm. Inner regular part dipole's aperture is 24 mm, inner descent and ascend dipole's aperture is 21 mm. The required vacuum level of $1\times10^{-8}$ Torr was obtained by sputter ion pumps (quantity is 8 pcs) with pumping speed of 160 l/s (nitrogen equivalent). We located pumps at the distance of 25 meters each other.

## CONTROL SYSTEM

We based the automation system [8, 9] on several PC platforms under Linux operating system. The control of power supplies is based on VsDC2 integrators [10, 11].

Some fragments of control software are shown in Figure 10-14.

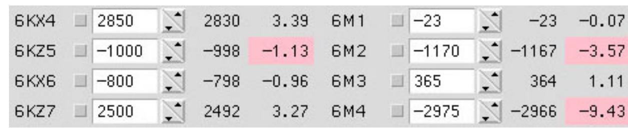


Figure 10: Control of some DC-elements.

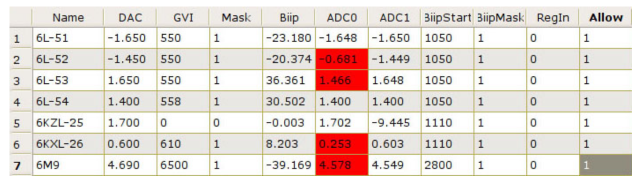


Figure 11: Control of some AC-elements.

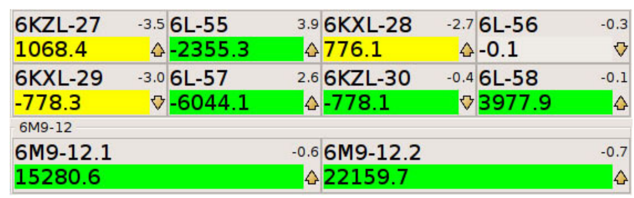


Figure12: Control of some power supplies.

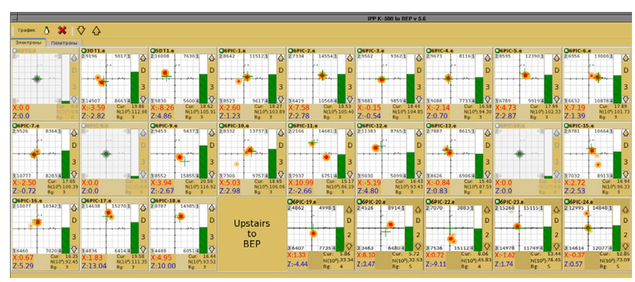


Figure 13: Image current monitors over the transfer line.

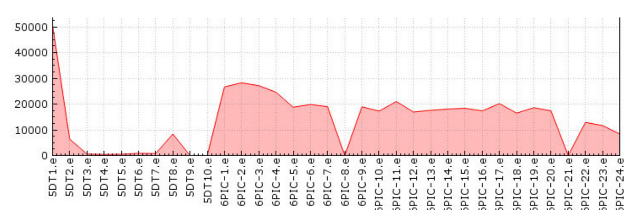


Figure 14: Current distribution over the transfer line.

## BEAM DIAGNOSTICS

We used three types of sensors for beam diagnostics: 12 luminophor probes, 24 image current monitors and 1 Faraday cup. They are presented in Figures 15-17.



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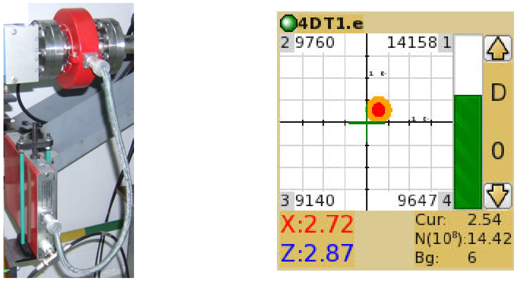


Figure 15: We used image current monitors in real time beam pass.

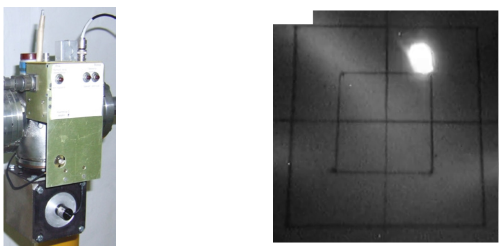

Figure 16: Luminophor probes are used for first beam-pass. Beam-picture's size is about 20 mm.

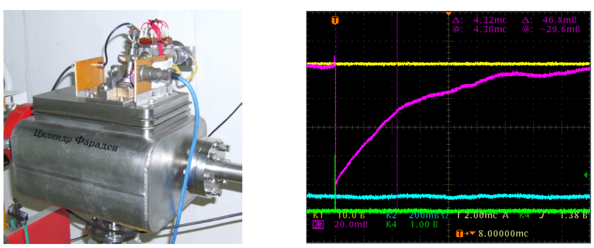

Figure 17: We use Faraday cup to determine the number of particles in the beam before the ascent. The graph shows the beam discharge.

## CONCLUSION

During creation of the transfer line, a number of tasks has been solved. We created the optical scheme of the transfer line connecting Injection Complex and VEPP-2000 facility. Simulation of the acceptance of BEP [12] in the admission place for determination of optimum coordinates and inclinations of bunches is carried out. We simulated magnetic calculations of all magnetic elements, beginning from the descent. We made the analysis of possible deviations of the bunch trajectory from a design trajectory, for the reasons of instability of power supplies and possible errors of a geodetic exhibition. For correction of a trajectory, installation sites of dipole correctors are optimized. Considering an arrangement of magnetic elements and dipole correctors, we defined locations of the diagnostic equipment. Losses of positrons and electrons at design luminosity of a collider of VEPP-2000 are estimated. Proceeding from the necessary speed of replenishment of particles, we developed the working mode of the transfer line and we defined additional requirements to designs of magnetic elements and power supplies.

Transfer of bunches from Injection Complex to BEP was a lot of work. We synchronized RF systems of Injection Complex and VEPP-2000 facility. The control of power supplies and beam diagnostics are debagged. We written software applications. The bunch is transported through all turns.

The transfer line will allow us to obtain new data on detectors SND [13] and CMD-3 [14].

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