VEPP-5 INJECTION COMPLEX: TWO COLLIDERS OPERATION EXPERIENCE

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Abstract

Two BINP colliders VEPP-4M and VEPP-2000 e+e- colliders are under operation with the beams feeding from VEPP-5 Injection Complex via newly constructed K-500 beam transfer line. Upgraded injection chain demonstrated ability to provide designed luminosity both to VEPP-4M and VEPP-2000 and techniques of reliable operation are under development now. The design and operation experience of Injection Complex and transfer lines are presented.

INTRODUCTION

Two electron-positron colliders at Budker Institute of Nuclear Physics (Novosibirsk, Russia) are under operation: VEPP-2000 [1, 2, and 3] and VEPP-4M [4]. Both colliders are fed with the electron and positron beams from VEPP-5 Injection Complex [5, 6]. The infrastructure of BINP accelerator facilities are presented in Fig. 1. VEPP-5 Injection Complex and collider facilities are connected with the Beam Transportation Channels (K-500 Channels) [7].

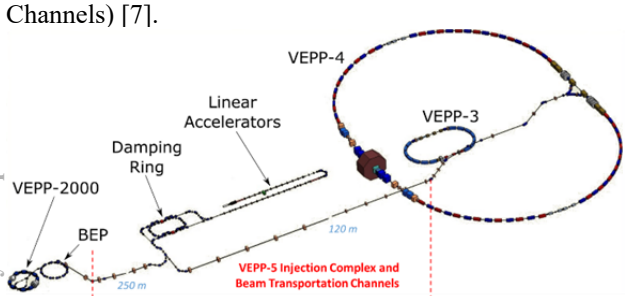

Figure 1: BINP Accelerator Facility layout.

INJECTION COMPLEX VEPP-5

VEPP-5 Injection Complex consists of electron gun, 270 MeV driving electron Linac, 510 MeV positron Linac and dumping ring. Damping ring stores and cools down both electron and positron beams for the next extraction to K-500 beam transfer line (see Fig. 2).

Repetition rate is decided to be kept under 12.5 Hz due to VEPP-5 operation experience: some subsystems, like injection/extraction system, require more powerful cooling and some radiation aspects should be reconsidered before planned repetition rate increasing.

Nevertheless, $1.2 \cdot 10^{11}$ of the particles corresponds to 200 mA circulating beam in the Damping Ring – it exceeds VEPP-5 project parameters more than twice [6, 8].

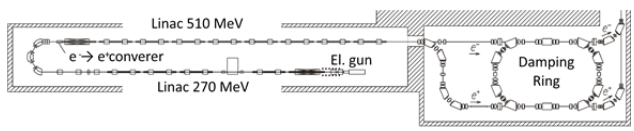

Figure 2: VEPP-5 Injection Complex layout.

Table 1: VEPP-5 Beam Production

Parameter	Value
Energy (2016/17 runs)	385 – 420 MeV
Electrons storage rate	$2 \cdot 10^{10}$/s
Positrons storage rate	$2 \cdot 10^{9}$/s
Repetition rate	up to 12.5 Hz
Maximum e^- extraction:	up to $1.2 \cdot 10^{11}$
Maximum e^+ extraction:	up to $1.2 \cdot 10^{11}$

K-500 BEAM TRANSFER LINE

The K-500 beam transfer line was turned into operation at BINP in the end of 2015 [7, 8]. This beamline to VEPP-2000 facility was designed to the energy of 510 MeV, it has the length of approximately 250 meters to VEPP-2000 side and 120 meters to VEPP-4M side. K-500 and consists of five sections: descent from Damping Ring to K-500 tunnel, regular FODO structure in the tunnel both to VEPP-2000 and VEPP-4M, and two lifting to the both collider facilities. The fragment of the transfer line are shown in Fig. 3.

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Figure 3: VEPP-5 – VEPP-2000 beam transfer line (right down corner – view of the beam at the phosphor screen at the end of transfer line).

DAMPING RING INJECTION AND EXTRACTION

The cycle of injection/extraction in/from Damping Ring consists from several cycles of beam injection and one extraction action. Extraction channels are presented in Fig. 4. They consist from extraction "bridges" and 900 turns: DC powered solid yoke dipole and quadrupole magnets (green and grey correspondingly in Fig. 6), and descending beam line with VEPP-2000/VEPP-4M separation: DC powered dipoles and pulsed quads. Such a mixture of techniques appeared during long (the project started in 1993) and staged construction and commissioning of the VEPP-5 IC.

EXTRACTION AND TRANSFER MODES

VEPP-5 IC has four modes of operation: electrons and positrons to two directions.

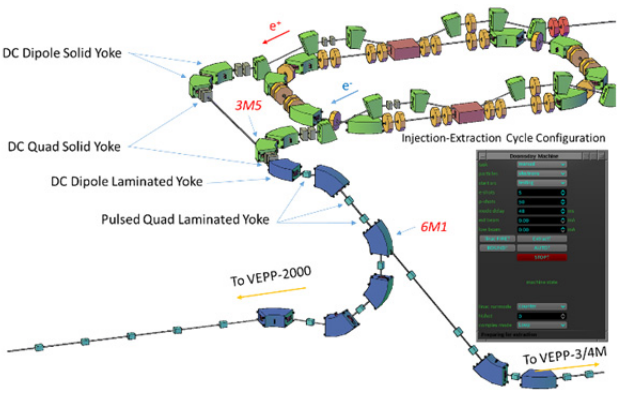
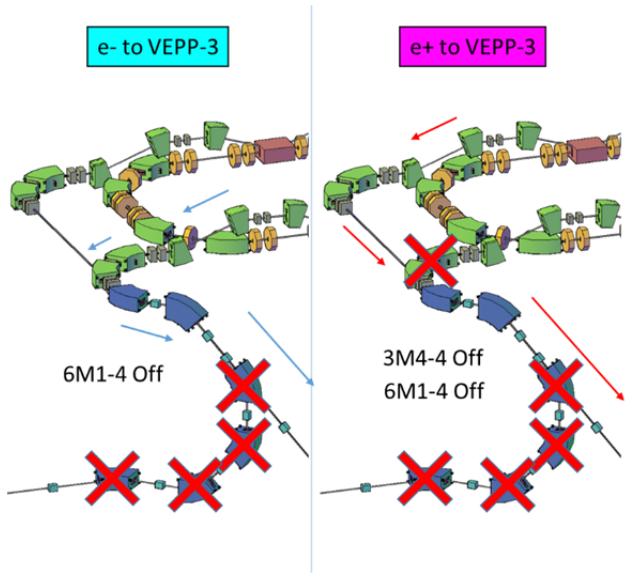


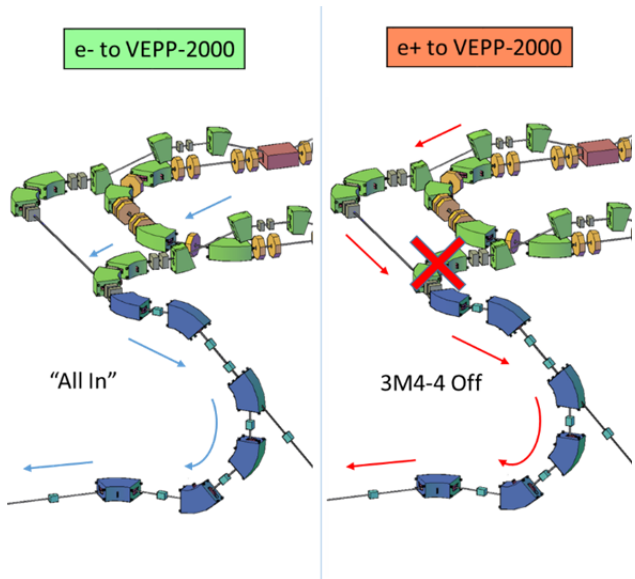
Figure 4: Extraction lines from Damping Ring.

Thus, one need to configure 12 different switch processes (see Fig. 6). In the simplest cases, only type of particles is changing. For the other cases one need to magnetize ex-traction magnet system using the opposite type of particles first. Nevertheless, the last rule has the exception: for the transfer of the particles to VEPP-4M direction mag-nets 6M1-4 has to be turned off (see Fig. 5a). So it is very important the state before zero current setup. In our case, positron mode to VEPP-2000 was chosen for both transitions from VEPP-2000 to VEPP-4M directions for stable operation.

Each single changing of the magnets fields lasts 30 seconds due to parameters of DC power converters and the inductance of their loads. Therefore, the maximum time of mode change is 60 seconds.



a) operation with VEPP-4M facility.



b) operation with VEPP-2000 facility.

Figures 5 a) and 5 b): IC VEPP-5 Operation Modes.

All mode switching as a mode saving and restoring are provided with the special designed infrastructure [9] based on CX modular accelerators modular control system [10].

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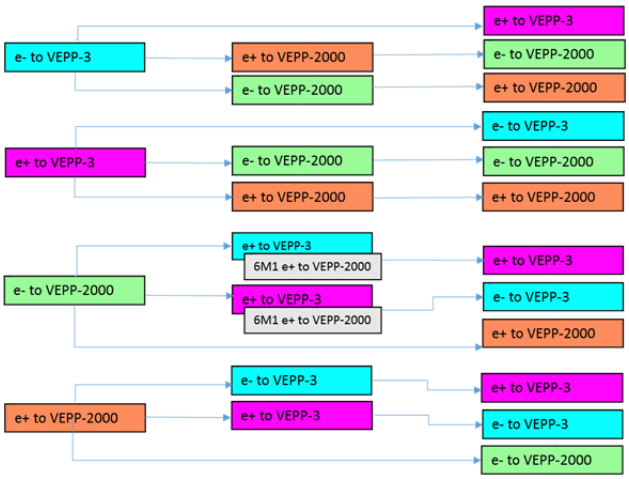

Figure 6: IC VEPP-5 extraction matrix of modes.

TWO COLLIDERS OPERATION

Common cycle based on the current operation experience starts from the positrons to VEPP-4M mode. Ten minutes are enough to fill the facility booster with 60-90 mA of circulating currents (see the Table 2 for BINP accelerator rings parameters comparison). Than VEPP-4M performs own cycle of boosting and injection to the collider. For this time, IC VEPP-5 is switched to VEPP-2000 direction and provides the required particles for another collider. Own VEPP-4M cycle lasts about 15 minutes, then, IC VEPP-5 is turned back to VEPP-4M direction but in the electron mode. Than the common cycle repeats. Typical IC VEPP-5 switching modes are presented in Fig. 7.

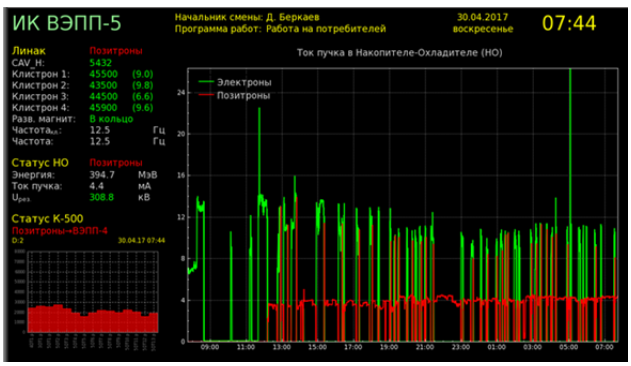

Figure 7: Status page of IC VEPP-5 [11].

Table 2: Comparison of the Number of Particles and Beam Currents for Different BINP Accelerator Rings

	VEPP-5 DR	BEP	VEPP-2000	VEPP-3	VEPP-4M
N/P,m	27.40	22.35	24.18	74.39	366.1
$1 \cdot 10^9$	1.75	2.15	1.99	0.65	0.13
$5 \cdot 10^9$	8.76	10.74	9.93	3.23	0.66
$1 \cdot 10^{10}$	17.52	21.48	19.85	6.45	1.31
$5 \cdot 10^{10}$	87.59	107.38	99.26	32.26	6.56
$1 \cdot 10^{11}$	175.18	214.77	198.51	64.52	13.11

CONCLUSION

At the present, Injection Complex VEPP-5 are routinely provide both types of particles to both BINP Colliders with the efficiency up to 80% VEPP-2000 and VEPP-4 colliders are under operation for the experiments according to their scientific programs.

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