BEAMS INJECTION SYSTEM FOR e^+e^- COLLIDER VEPP-2000

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Abstract

Electron-positron collider VEPP-2000 is under commissioning at the Budker Institute of Nuclear Physics. The paper presents the injection system of the collider delivering the beam from the booster storage ring BEP with maximum energy 900 MeV. A matching of the beam injection with the storage ring optics is done with a respect to nonlinear kicker field. Features of beam diagnostic and transfer line magnets including pulse septums (100 mksec; 30 kGs) and fast kickers (20 nsec; 70 kV) are described. Results of magnetic measurements and their comparison to calculated data are given.

VEPP-2000 PROJECT CONCEPT

Since the end of 1974 the e^+e^- collider VEPP-2M in Novosibirsk has been successfully running in the c.m. energy range from threshold of hadron production up to 1.4 GeV. The integrated luminosity of about 74pb^{-1} was collected with two modern detectors SND and CMD-2 allowing precise measurements of most of the hadronic channels of e^+e^- annihilation. VEPP-2000 project is a further development of the facility dedicated to improve the luminosity and in the same time increase the maximum attainable energy up to 2GeV, that will significantly broaden the potential of experiments performed at the collider. Moreover this ring will allow to check the concept of round colliding beams.

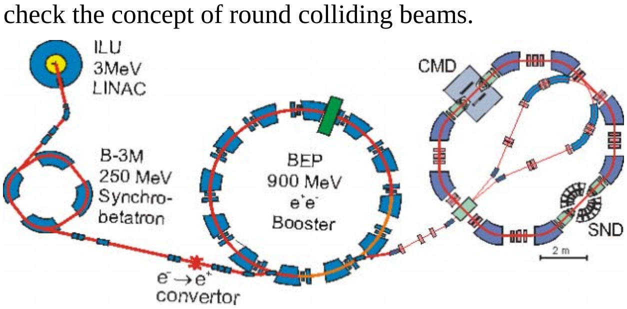

Figure 1: VEPP-2000 Complex layout.

Our approach to the new collider optics is determined by the requirements of the round beam concept that require equal horizontal and vertical b - functions at interaction point, together with equal emittances and tunes of betatron oscillations. It is implemented by placing two pairs of superconducting solenoids in the two interaction regions equipped with particle detectors, symmetrically with respect to the interaction points. Strong solenoidal focusing provides small and equal β-functions at IP and 90° rotation of betatron motion planes on each passage of particle over the interaction region. Symmetric focusing in the arcs and alternating orientation of the oscillation normal modes result in equal tunes and equal emittances.

As a consequence of these dynamical features an additional integral of motion will appear in this optics, leading to enhancement of dynamical stability, even with the account of nonlinear effects from beam-beam force. This novel approach to the collider optics substantiates expectations of higher luminosities attainable in the new machine. We expect to achieve the luminosity of $1\cdot10^{32}$ cm^{-2}c^{-1} at the energy of 1 GeV for both electrons and positrons.

Several steps of improvement to existing particle production system are proposed to gain the bunch population of 10^{11} particles. Injection of beams into the storage ring is planned to be done in the horizontal plane into the long straight opposite to the RF cavity at full working energy.

Constrained VEPP-2M complex area restricts the machine dimension leading to necessity of using strong dipole magnets. To achieve the beam energy of 1 GeV the guiding field of 2.4 T is required. Arc lattice includes 5 families of quadrupoles with the maximum gradient of 50T/m that can be varied independently. The chosen optics has an advantage of zero dispersion in IRs, RF cavity and injection straight sections.

Three families of sextupoles are installed in the fing the ring. The chromaticity correction is performed by the sextupole families Sx and Sz , placed near the quadrupole triplets, where the dispersion function is non-zero. Another set of sextupoles is placed in dispersion free regions and is used to improve the dynamical aperture.

Fine tuning of the machine optics is proposed to be made with 20 horizontal and 20 vertical dipole corrections combined with quadrupoles. For correction of the guiding field 8 additional horizontal dipole corrections are installed in the bends.

Table 1: Main Parameters of VEPP-2000

Parameter	Value
Circumference	24.388 m
Synchrotron tune	0.003
Beam emittances, ε_x,ε_y	$1.29\bullet10^{-7}$ m•rad $1.29\bullet10^{-7}$ m•rad
B-functions at IP	10 cm
Betatron tunes, ν_x ,ν_y	4.1, 2.1
Beam-beam parameter ξx,ξy	0.75, 0.75
Luminosity per IP at 1GeV	$1\bullet10^{32}$cm$^{-2}\bullet$s^{-1}

INJECTION INTO VEPP-2000

Beam injection in VEPP-2000 collider occurs in horizontal plane in straight section opposite RF cavity. Injection system assumes single-turn injection with pre-kick of a stored beam. Two travelling wave kickers are arranged into vacuum chamber inside two bend magnets on both sides of injection region.

Passage of the injecting beam through nonlinear kicker field was modelled with combination of multipoles, and then injecting beam was checked on stability in VEPP-2000 structure with tracking procedure. The result of such procedure is Acceptance of the collider in the injection point, which appeared to be 5.5 cm•mrad.

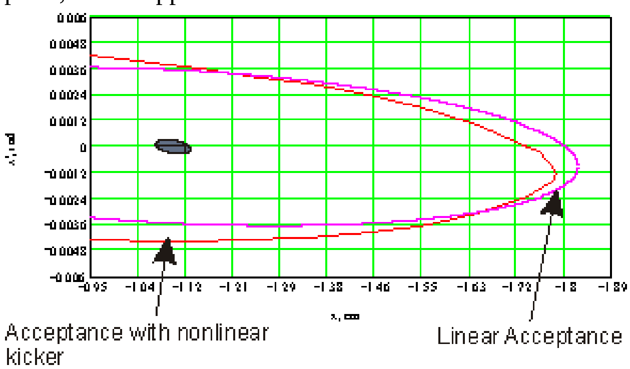

Figure 2 Acceptance VEPP-2000.

Due to lack of space injection region is separated on two magnets - low field (2T) septum and high field (3T) additional magnet. Both magnets are designed on coaxial-like scheme with laminated yoke.

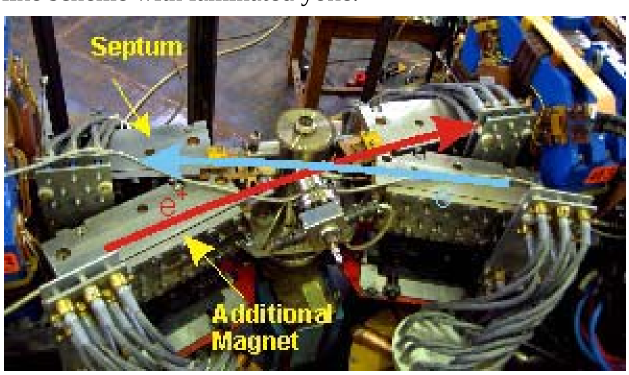

Figure 3: Injection region

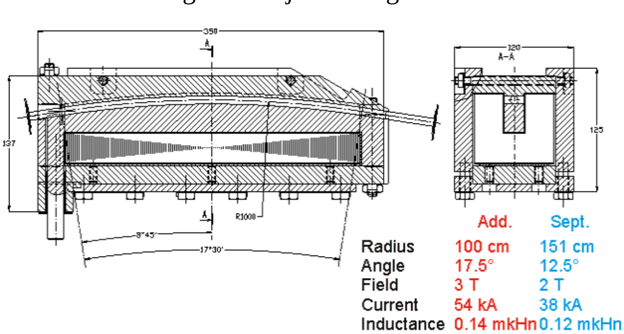

Figure 4: Additional magnet.

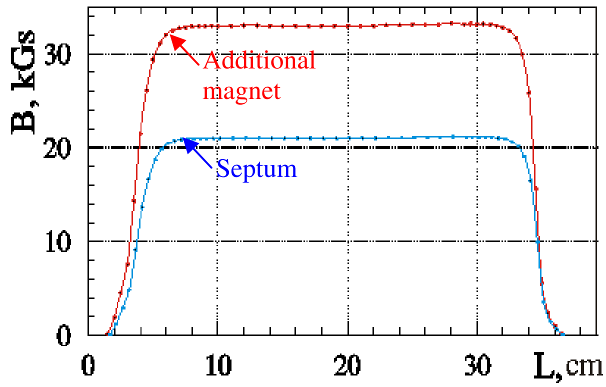

Figure 5: Fields of additional and septum magnets.

Magnetic measurements have shown good agreement with previously calculated values and even better results in some of parameters.

PULSE QUADRUPOLES

Rigid requirements of injection electrons and positrons at 900 MeV demands special design of injection channels. One of the channels elements is quadrupole pulse magnet. Maximum gradient is 7 kGs/cm.

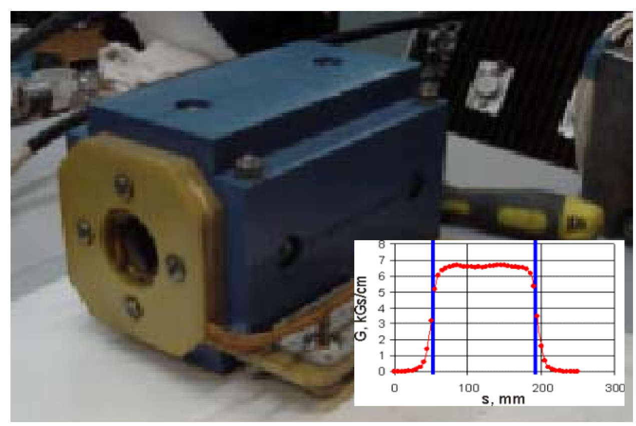

Figure 6: Pulse quadrupole

Table 2: Parameters of pulse quadrupole

Parameter	**Value**
Gradient	7 kGs/cm
Current	0.7 kA
Number of turns	5
Length	15 cm

BEAM DIAGNOSTICS

To measure beam position along injection channels used two types ob beam position monitors - secondary emission sensor and image current monitor.

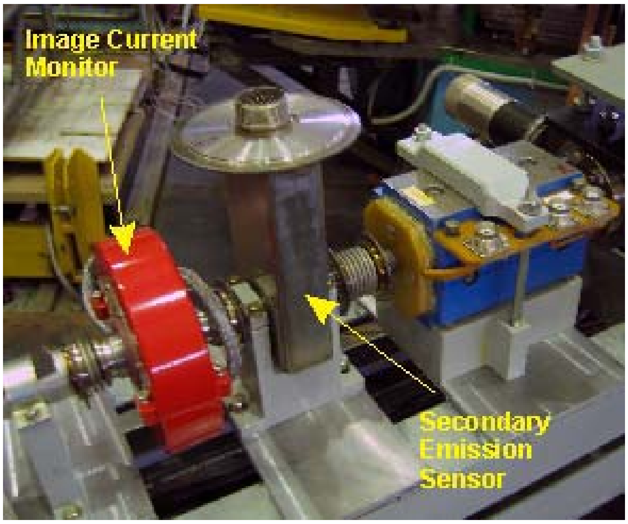

Figure 7: Beam position monitors installed on injection channel.

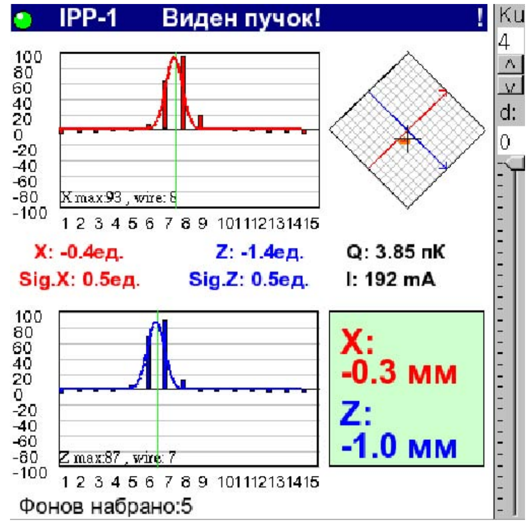

Figure 8: Data from secondary emission sensor (screenshot).

VEPP-2000 COMISSIONING

Acceleration complex VEPP-2000 is under commissioning in Novosibirsk now. All magnetic measurements are finished and they have shown good agreement with previously calculated values. At present time the beam from booster ring BEP is being transported by injection channels. Nearest plans assume first injection into VEPP-2000 collider ring.