STATUS OF THE VEPP-5 COMPLEX

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Abstract

The present paper describes the status of the VEPP-5 project. The VEPP-5 complex consists of colliding beam machines at energies of $2*510$ MeV and $2*2$ GeV. Both colliders are planned to be run with round beams for obtaining super high luminosities over $10^{33} cm^{-2} sec^{-1}$.

The paper gives also a brief description of the injection complex and the ϕ-factory. In more detail the paper describes a newly suggested version of the $c-\tau$-factory to be built in Novosibirsk.

1 INTRODUCTION

The VEPP-5 project developed at INP has undergone critical changes as a result of the Scientific Policy Committee recommendation to stop the work on building the B-factory and consider the option of building the c-τ-factory in the tunnel of the B-factory presently under construction. At present the VEPP-5 complex comprises: electron and positron linacs, a cooling storage ring, a ϕ-factory at a luminosity of $3*10^{33} cm^{-2} sec-1$ and a c-τ-factory at a luminosity of $10^{33} cm^{-2} sec^{-1}$.

2 INJECTION COMPLEX

The injector [1] will consist of two S-band linacs (fig.1) and a storage ring which should produce $2*10^{10}$ electrons (positrons) per second thus providing for simultaneous run of the ϕ- and c-τ-factories, as well as of the VEPP-4M collider. The 300 MeV electron linac is equipped with a 200 kV gun at a current of 10 A and a pulse duration of 2 ns with repetition rate 50 Hz. The accelerating sections have the SLAC type accelerating structure and are to be run at 2856 MHz at the travelling wave $2\pi/3$ mode. The sections are powered with four SLAC 5045 klystrons with a 3.5 μs pulse into the SLED power multiplying system. The first section following the gun, the subharmonic buncher and the convertor are placed in the focusing solenoids. Each section of the electron and positron linacs is embraced with two quadrupole lenses providing the transverse focusing of the beam. The damping ring stores and cools the electrons and positrons at an energy of 510 MeV. After that the beams are ejected from the damping ring and then injected in the ϕ- and c-τ-factories. At present all the elements of the injection complex are designed and put into production. The pre-injection part of the linac is manufactured and is under test. The first 5045 SLAC klystron and its modulator are mounted in the kystron gallery and are now under commissioning. The fabrication of the linacs magnetic elements are close to completion. The magnetic and vacuum systems of damping ring are to be completed and installed in 1995.

3 ϕ-FACTORY

The detailed description of the ϕ-factory is given in the Proceedings of the Workshop [2]. Its luminosity is planned to be $3*10^{33} cm^{-2} sec^{-1}$. The basic experiment will be the measuring on constants of CP violating interactions. In principle the design of the ϕ-factory has not changed. The main ideas employed in it are as follows. The colliding beams at the IP are round. The betatron frequencies ν_z, ν_r are similar and close to a integer. Equal transverse emittances are produced without the coupling of betatron mode oscillations. The round beams at IP are produced by two superconducting solenoids placed inside a detector symmetrically to the IP. The maximum longitudinal field should be 11 T. This focusing structure and shape of the collider ("Siberian butterfly") should provide for $\xi > 0.1$ and, thus, the required luminosity. The parameters of the ϕ-factory are listed in Table 1.

Table 1. Basic parameters of the ϕ-factory

Circumference, m	35.155
RF frequency, MHz	700
Emittances, cm*rad	$4.7*10^{-5}$
	$4.7*10^{-5}$
Energy loss, keV	32.1
Dimensionless decrements	$1.6*10^{-5}$
	$1.6*10^{-5}$
	$3.4*10^{-5}$
Momentum spread	$8.2*10^{-4}$
Betas at IP, cm	1.0
Betatron tunes	6.08
Number of ppb, e^+, e^-	$2*10^{11}$
Space charge parameters	0.1
Luminosity, $cm^{-2}s^{-1}$	$1*10^{33}$

The use of round beams together with integration of two interaction points into one yields a 4-fold increase in the luminosity under other similar conditions. The ϕ-factory stucture is optimized to compensate the betatron tune chromatism, the chromatic betatron and dispersion function by minimizing the possible effect of sextupole corrections on the dynamic aperture. In order to suppress the synchrobetatron nonlinear resonances at the IP the dispersion function at the IP is set to zero. In order to reduce the influence of different coherent instabilities, including weak nonlinear machine resonances, as well as noncoherent and coherent beam-beam effects it is necessary in our opinion to have rather large decrements of radiation damping. This is why in the first version of the ϕ-factory it was supposed to use superconducting bending magnets at a field of 6.5 T. In order to reduce the cost a lattice with resistive magnets was suggested with practically the same damping decrements.

The RF system should provide the required accelerating voltage (up to 1 MV) without excitation of coherent instabilities and bunch lengthening. The coaxial power input with capacitive coupling is placed close to the cavity body. Three waveguides are located on the opposite side of the cavity placed at an angle of 120^o to one another to provide the HOM power extraction.

The ϕ-factory lattice is specially optimized to reduce the background in the detector region due to particle losses. Besides, the storage ring admittance in the bending arcs will be adjusted with the help of controlled scrapers. It will help to confine the losses of particles in scattering "tails" at designed spots.

Today the prototypes are under design and fabrication. The hall for the ϕ-factory is now presently under construction. The completion of the ϕ-factory construction is anticipated in 1997.

4 C-TAU-FACTORY

The main conception of the C-TAU-factory under development is to provide high luminosity in the energy range from 700 MeV up to 3000 MeV. To attain this it is planned to build a rather long storage ring with a strong focusing system. The radial and vertical emittances are to be controlled with dedicated magnetic systems. This storage ring provides for a rather easy switch to the operation mode with monochromatization of energy of colliding beams by introducing vertical dispersion and producing the vertical dimension mainly due to the momentum spread at a small betatron vertical dimension.

4.1 *MAGNETIC SYSTEM*

The regular section of the storage ring consists of a simple FODO system. One 4.2 m long cell comprises: a dipole magnet, 1.5 m long, with a magnetic field of 957 G, and a quadrupole lense, 40 cm long, and a gradient of 1.43 kG/cm. The beam bending angle by one cell makes 0.048 rad. The beam dimension (the beam emittance is $2 * 10^{-6}$ cm) is equal to 0.36 mm, while the aperture size for condition 27 σ is equal to 1 cm, which corresponds to the 3 cm gap in the magnet, with the necessary allowance for the gap for the magnetic chamber. The natural quantum radial emittance for such a magnetic structure makes only $1.26 * 10^{-8}$ cm, which is 130 times less than that required for the beam-beam effects.

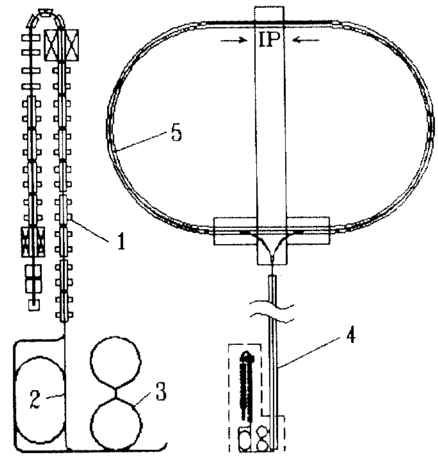

Figure 1: Injection complex and c-τ factory project,1-injection linac, 2-damping ring,3-ϕ-factory,4-injection tunnel,5-c-τ-factory.

4.2 *EMITTANCE CONTROL SECTION*

For emittance control special sections of the magnetic system sould be used which are able to change their magnetic field. For example, let us consider a section with a standard FODO structure, but with magnetic dipoles which have specially chosen values of magnetic field for exciting the ψ-function. At the system output the value of the ψ-function is matched with that in the regular cell of the storage ring. It should be noted, that with such a system a considerable distortion of the equilibrium orbit takes place and one can use quadrupoles with large aperture or have the small-aperture lenses automatically positioned with the help of step motors to match the beam position. Fig. 1 shows the values of the ψ-function at such a section. At amplitudes of the magnetic fields of 1 and 2 kH this section contributes losses of 1.68 and 6.74 keV, respectively. The values of the integrals $K^3\psi * HF * ds$ (in cm) make $4.4 * 10^{-8}, 1.4 * 10^{-6}$ as compared to those contributed by the integral of the rest part of the storage ring $(1.6 * 10^{-8})$. This fact makes it possible to increase several hundred times the values of emittances within such a system without contributing very much to the energy loss.

4.3 *INTERACTION POINT*

To attain the highest luminosity one of the most interesting options is to arrange the IP with a small β-function with the help of a strong longitudinal field. Symmetrical focusing over both degrees of freedom well conforms with the idea of operation with round beams and may provide for attaining $\xi > 0.1$. Fig. 3 shows $\beta-$ and ψ-functions in the presence of a 2 m long solenoid at a field of 10 T. In order to obtain a small value of the β_0 function one should

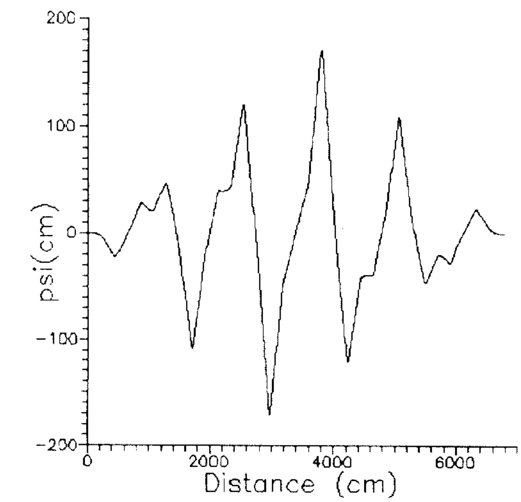

Figure 2: Value of ψ-function along the section of the transverse emittance excitation.

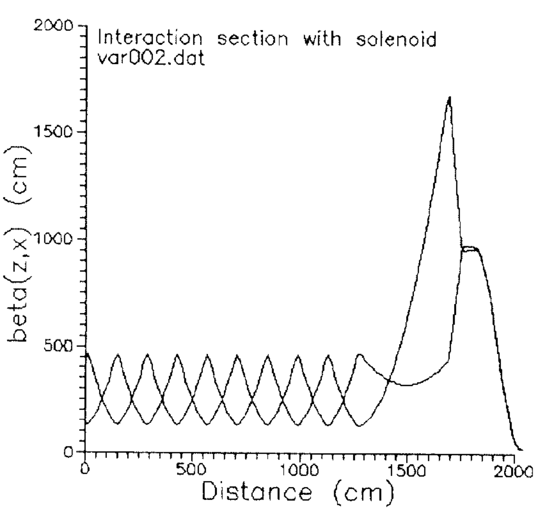

Figure 3: Values of β and ψ-functions along the interaction region.

have a very high magnitude of β_{max} at the solenoid input

$$\beta_0 = \frac{4F^2}{\beta_{max}}$$

In order to get β_0 = 2 cm and F = 100 cm it is necessary to attain β_{max} = 200 m. Fig. 3 gives an example of a structure approaching these parameters, but in reality the interaction point requires more accurate calculations taking into account the chromaticity correction and beam separation. The parameters of colliding bunches required for attaining the necessary luminosity are listed in Table 2.

Table 2. Basic parameters of the C-TAU-factory.

Energy (GeV)	2.0
N/bunch	$3.0 * 10^{10}$
β_0(cm)	2
$\sigma(\mu m)$	18
ξ_{max}	0.1
$\gamma\beta\varepsilon(cm)$	6.6810^{-3}
Curent (A)	0.336
Lum.$(cm^{-2}s^{-1})$	1.510^{33}
Vert.ψ-function (cm)	1-10
dp/p	$2 * 10^{-4} - 2 * 10^{-3}$

In the mode of energy monochromatization the beams remain round with the radius dispersion of 17μm. The value of monochromatization is determined here by the ratio of the vertical betatron dimension to the vertical energy one.

5 REFERENCES

[1] N.S.Dikansky et al. "Novosibirsk B-Factory: Status and perspectives". Proc. XVth International Conference on High Energy Accelerators. Hamburg, Germany, 1992, v.1, p. 452.

[2] L.M.Barkov et al. "Novosibirsk Project of Phi-Meson Factory". Proc. of Workshop on Phyiscs and Detectors for DAFNE. The Frascati Phi-Factory. 1991, p. 67.