LIFE TIME AND INJECTION CONSIDERATIONS FOR CEPC

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Abstract

To make a precise study on the Higgs bosons, CEPC ,a circular storage ring collider is being proposed in China. The beam lifetime calculation results in CEPC are shown in this paper. Due to the fact of short lifetime, a top-up injection scheme is needed and some considerations on the injection design is presented.

INTRODUCTION

After the discovery of Higgs bosons at LHC, e+e- collider working as a Higgs factory for further studies has been in consideration throughout the world. CEPC is such a circular e+e- collider proposed in China. The electron and positron energy are chosen to be 120 GeV, which is optimized for a Higgs research. This Collider has a circumference of 50 km, which is about twice the size of LHC, the existing world largest circular collider. Synchrotron radiation energy loss power is 50 MW, and the budget should be more than 20B CNY. The main parameters are listed below in Table 1.

Table 1: Main Parameters of CEPC

Beam Energy	**120 GeV**
Circumference	54.75 km
Luminosity	2.0E34 cm-2s-1
SR power/beam	50 MW
Number of IPs	2
Number of Bunches/beam	50
Momentum compaction factor	3.39E-5
Energy acceptance	0.01
Beam current	16.6 mA
Horizontal emittance	6.12E-9 m.rad
Bunch length	0.00253 m
Beam-Beam parameters(x/y)	0.116/0.082
Emittance coupling	0.003

BEAM LIFETIME

Beam lifetime in a storage ring is a parameter to describe the losing rate of particles, it is defined to be [1]:

$$\frac{1}{\tau} = -\frac{1}{N}\frac{dN}{dt}. \qquad (1)$$

In storage rings many effects could reduce the beam intensity, so that the beam life time should include many parts, the total lifetime and the lifetime due to a single beam loss mechanism have a relation as:

$$\frac{1}{\tau_{total}} = \sum \frac{1}{\tau_i} \qquad (2)$$

For the CEPC lifetime study lifetime from these effects are taken into account [2]:

(i) Beam-Gas scattering
(ii) Quantum fluctuation of radiation
(iii) Touschek effects
(iv) Radiative BaBar
(v) Beamstrahlung effect

The beam lifetime of CEPC is shown in Table 2, in the calculation a gas consists of 80% H2 and 20% CO with a vacuum pressure of 1E-8 Torr, and a 1.5 cm vacuum chamber radius is assumed.

Table 2: Lifetime of CEPC Due to Different Effects

	Lifetime	**Unit**
Elastic H2 scattering	189	Hours
Elastic CO scattering	15	Hours
Inelastic H2 scattering	149	Hours
Inelastic CO scattering	14	Hours
Transverse quantum	2218	Hours
Longitudinal quantum	Infinity	Hours
Touschek	530	Hours
Radiative BhaBha	51	Min
Beamstrahlung	80	Min
Total lifetime	30	Min

INJECTION DESIGN

The current baseline design of CEPC injection is chosen to use a ramping booster as the main injector. The system consists of one Linac which accelerates the electrons and positrons to 6 GeV, a booster ring which ramps from 6GeV up to high energy of 120 GeV. A sketch of the system is shown in Figure 1.

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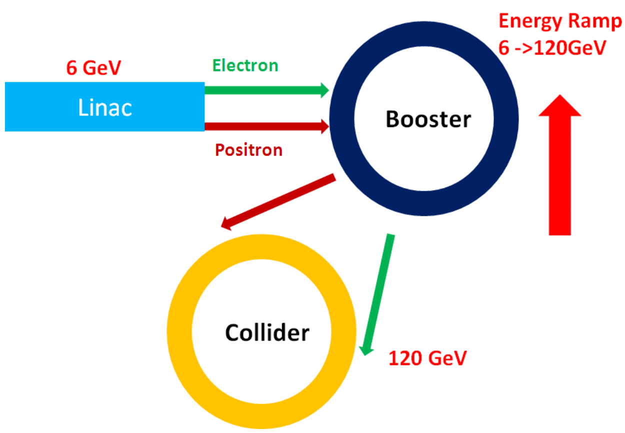

Figure 1: A schematic diagram of CEPC system configuration.

The main collider is designed to be 8-fold symmetric, it has 8 arc sections and 8 long straight sections, as shown in Figure 2. IP1 and IP2 are sections for the real IPs, IP3 and IP4 are preserved for the IPs of SPPC, so the injection of electrons and positrons are put in the straight sections right next to the IP1, separately. The booster is installed in the same tunnel with the main colliders, it is with the same circumference and stays right up-side with the collider. Due to the short beam lifetime, top-up injection is needed, and in a injection process the injection time length is mainly determined by the ramping time of the booster. To reduce the injection time, 50 bunches are injected from the booster in one ramping cycle. 50 bunches in the booster are designed to have the same time structure with that in the main collider, the kickers in the booster and collider are turned on before a bunch comes and turned off after, thus 50 bunches are injected into the main collider one by one.

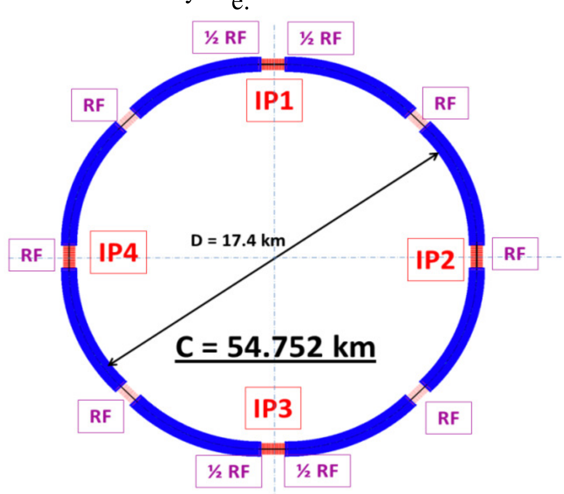

Figure 2: The layout of the CEPC main collider.

The top-up injection period is determined by the lifetime, the luminosity drop and the positron production rate. For a 30 min lifetime in CEPC, 10% luminosity drop needs to fill the bunch every 90 seconds, and the bunch charge in the booster need to be 2.8 nC. When the current in the main collider is dumped, we need to inject with a frequency higher than the top-up mode. Assuming the injection period is 60 seconds , 30 min is needed to reach the peak current.

For a baseline design of the injection mode, betatron injection is chosen , and three kickers are used to bump the circulating beam near the injected beam. The Twiss function at the injection section is shown in Figure 3.

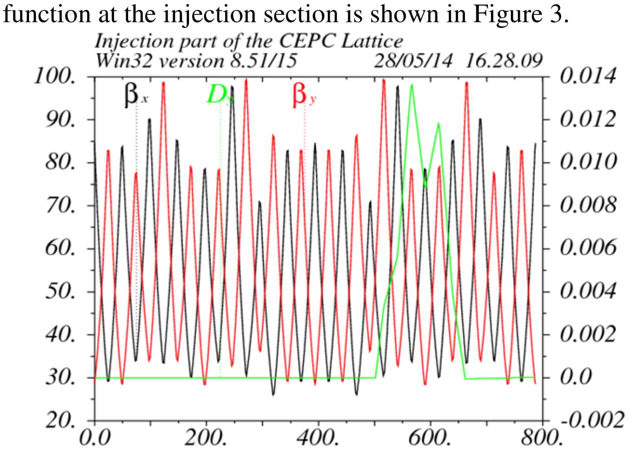

Figure 3: The Twiss functions in the injection straight section.

The bump height and the machine acceptance is determined from the injection phase space [3]:

$$\text{Acceptance length} > 5\sigma_c + 10\sigma_i + S \quad (3)$$

$$\text{Bump height} > 10\sigma_i + S \quad (4)$$

Where, σ_{xc} is the beam size of the circulating beam, σ_{xi} is the beam size of the injected beam, S is the thickness of the septum board. For our design, the kicker gives a 20 mm bump and the acceptance should be larger than 15mm.

CONCLUSION

In this paper, a primer baseline design of the injection system is given. Still, there are many works to be done. Detector protection should be considered in top-up injection, beam instabilities with pretzel orbit is a serious problem, and effects of imperfections should be included. These will be done in our future work.

ACKNOWLEDGEMENT

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