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BEAM BACKGROUNDS AT THE CEPC*

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Abstract

Circular Electron-Positron Collider (CEPC) is a 100 km circumference double-ring Collider, the corresponding lattice has small beta function at the interaction point. The machine-detector interface (MDI) issues are one of the most complicated and challenging topics at the Circular Electron Positron Collider(CEPC). Comprehensive understandings of the MDI issues are decisive for achieving the optimal overall performance of the accelerator and detector. The CEPC machine will operate at different beam energies, from 45.5 GeV up to 180 GeV. A flexible interaction region design will be plausible to allow for the large beam energy range. However, the design has to provide high luminosity that is desirable for physics studies but keep the radiation backgrounds tolerable to the detectors. In this poster, the latest design of the CEPC MDI based on the TDR draft will be presented, and the preliminary beam backgrounds estimation will be discussed.

INTRODUCTION

Circular Electron Position Collider(CEPC) is a Higgs factory proposed by the Chinese high energy physics community and aimed to measure the properties of the Higgs boson and electroweak parameters with unprece-dented precision. It will be a double ring machine with a circumstance of about 100km and a crossing angle of 33mrad. Its main design machine parameters at the Tech-nical Design Phase(TDR in progress) are listed in Table 1. To achieve optimal performance of the machine and detectors and ultimately to realize the precision physics program, it is critical to understand thoroughly the complex beam backgrounds originating from different sources, including the two main types, photons and off energy beam particles.The latest layout of the CEPC interaction region is shown in Fig. 1.

The designing goal of the CEPC IR and MDI is to achieve a so-called "flexible" design, which means using a common layout for all operation modes. On the one hand, a high-luminosity, low background impact, and low error design is demanded. On the other hand, all components in the IR must be easy to install, easy to replace and easy to repair. In this paper, we report our new design of the key component in the IR — the IR beam pipe with respect to these goals and principles.

In this paper, we report the preliminary results of the beam background study based on the latest design and parameters.

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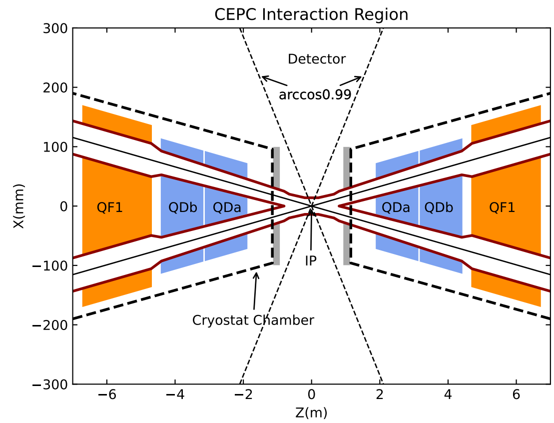

Figure 1: The layout of the latest design of the CEPC Interaction Region

Table 1: CEPC Main Machine Parameters (30 MW SR Power)

Operation Mode	Higgs (240 GeV)	Z (91 GeV)
Particles/bunch N_e [10^{10}]	14	14
Bunch Number	249	11951
Horizontal beam size σ_x [μm]	15	6
Vertical beam size σ_y [μm]	0.036	0.035
Energy spread[%]	0.17	0.13
$\mathscr{L}$ [10^{34} cm^{-2}s^{-1}]	5	115

LATEST IR BEAM PIPE DESIGN

Adopting to the design and parameter changes from CDR to TDR, the design of the IR beam pipe have been changed. The optimized IR beam pipe has a 20 mm inner diameter at the IP, which would result in a roughly 21% improvement on the performance of the vertex detector.

The parameters of the new IR beam pipe are listed in Table 2, covers the detail design of each slice of the IR beam pipe, including the position/length, the material of the pipe and the shape of the cross-section. The sample diagram of the detector beam pipe is shown in Fig. 2 and Fig 3. Figure 2 presents the physical design, and Fig. 3 presents the mechanical design.

SOURCE ITEMS AND SIMULATION TOOLS

There are three categories of beam induced background(BIB) at the CEPC: Photon Backgrounds, Off-Energy Particles, and also injection backgrounds. Photon backgrounds include SR and Pair Production, while beam loss particle backgrounds include beam-gas scattering(BGB), beam thermal photon scattering(BTH) and radiative-bhabha

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Table 2: The Detail Design of the New IR Pipe

Index	Range/mm	Material	Cross-Section Shape
1	±0-120	Be	Circle
2	±120-205	Al	Circle
3	±205-655	Al	Racetrack
4	±655-700	Al	Racetrack
5	±700-780	SS/Cu	Racetrack
6	±780-805	Al	Racetrack
7	±805-7000	Cu	Dual-Circle

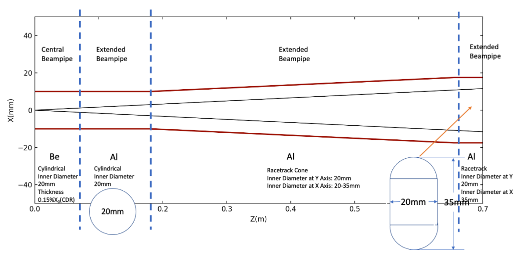

Figure 2: Half detector beam pipe

scattering(RBB). The beamstrahlung background itself would be effectively shielded by collimators. Table3 shows all the sources of beam backgrounds we've studied, and also the generation tools we used. For tracking in the ring, we use BDSIM [1] for photons and SAD [2] for beam paticles. For detector simulation, Geant4 [3] and FLUKA [4] has been used. Currently, we don't have enough knowledge about injection background, therefore we are mainly concentrate on first two.

MITIGATION METHODS

Masks and collimators can be inserted into the beam line to reduce the number of particles lost in the IR. Masks are designed to absorb the SR photons and collimators are intended to shield the beam loss particles. The aperture size of the collimators should be as small as possible to block the off energy beam particles but still large enough not to disturb the beam. Adopting to TDR phase of the CEPC, 9 sets of collimators are introduced in each ring, as listed in Table 4. The collimators are design with respect to some principles, including the requirements of the beam stay clear region and the requirements of the impendance. Currently in the simulation, the collimators are considered to be ideally,

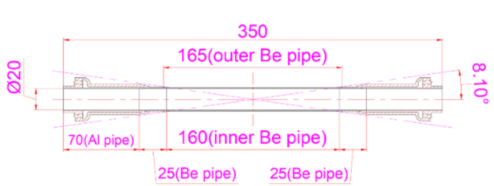

Figure 3: Mechanical design of the central beam pipe

Table 3: The Sources and Tools in CEPC Beam Background Study

Background	Generation
Synchrotron Radiation	BDSIM [1]
Beamstrahlung/Pair Production	Guinea-Pig++ [5]
Beam-Thermal Photon	Py-BTH [6, 8]
Beam-Gas Breamsstrahlung	Py-BGB [8]
Radiative Bhabha	BBBREM [7]

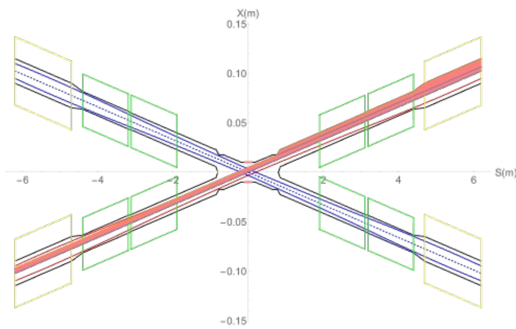

Figure 4: Synchrotron radiation fans

which means they would totally absorbed all the energies carried by the particles hitting the collimators.

Table 4: Design Parameters of the Collimators

Name	Distance to IP	Range of Half width allowed (mm)
APTX1	44611 m	1-6
APTX2	44680 m	1-6
APTY1	44745 m	0.156-3.6
APTY2	44817 m	0.156-3.6
APTX3	1729.66	1-6
APTX4	1798.24	1-6
APTY3	1932.52	0.156-3.6
APTY4	1901.1	0.156-3.6
APTX5	56.3	2.9-11.78

SIMULATION RESULTS

Some preliminary simulation has been performed, including the tracking of all the source items in the accelerator using SAD and BDSIM. The SR fans in the IR are presented in Fig. 4. The Pair Production distribution is presented in Fig. 5. The loss rate and loss power distribution of beam induced backgrounds in the IR is shown in Fig. 6 and Fig. 7, respectively. The loss particles has very high energy, and their orbits are very close to the beam. Comparing with our previous results in CDR [9], the backgrounds level sightly increased due to the shrinking of the diameter of central beam pipe. All the results here would be used as the input of detector simulation to study their impact on the detector in our future work.

SUMMARY AND OUTLOOK

CEPC has been proposed as a Higgs factory, aimed to measure the properties of the Higgs boson with unprecedented

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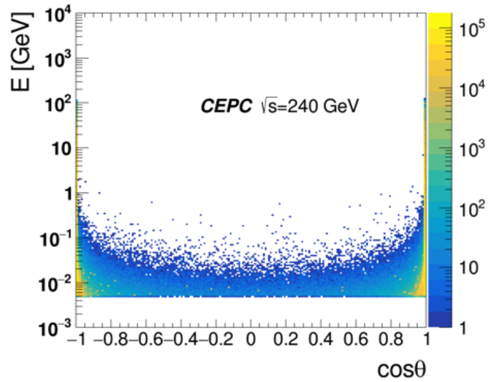

Figure 5: Pair production

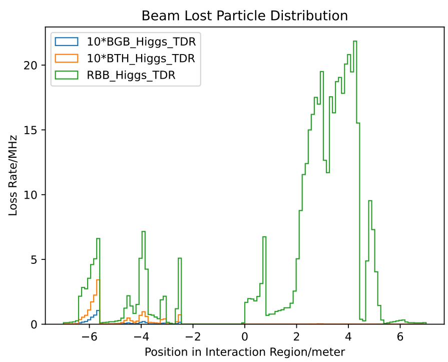

Figure 6: Loss rate of BIB

precision. The design of the interaction region, especially the IR beam pipe, is critical for the CEPC. The new physical and mechanical design of the IR beam pipe have been carried out, the heat deposition and thermal analysis were conducted based on the new design. The loss map of the beam backgrounds in the IR has also been updated, and future studies will be performed to compute the backgrounds levels in the detector and other components in the IR, and optimize the whole IR design at the same time.

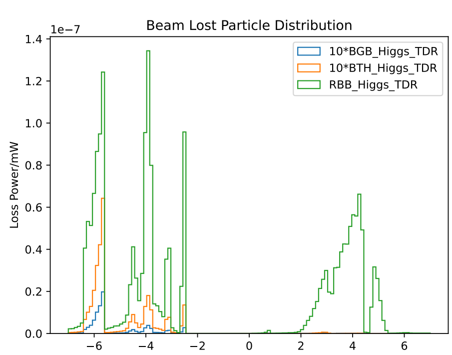

Figure 7: Loss power of BIB

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