Poster ID 46: Study of Synchrotron Background in the CEPC

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Introduction

The Circular Electron Positron Collider (CEPC) offers a significant opportunity to advance high-energy physics study. However, its operation also presents challenges related to synchrotron background radiation. Besides, the synchrotron radiation simulation software used during the CDR phase of the CEPC is no longer supported. Therefore, it is urgently necessary to develop a new synchrotron framework within this study. This study focuses on the characterization and mitigation of synchrotron background radiation within the CEPC accelerator environment. The results of this study aim to enhance the understanding of synchrotron radiation behavior within the CEPC and contribute to the development of effective mitigation strategies, thereby ensuring the optimal performance and longevity of the accelerator and its detectors.

Method

In this study, we utilized GEANT4, developed by CERN, to generate and track synchrotron radiation. The tracking results were then imported into CEPCSW, developed by IHEP, for detector simulations to quantify the impact of synchrotron radiation on various detectors within the MDI region. However, if the only purpose is to generate synchrotron radiation using GEANT4, constructing the complete CEPC lattice within a short period is both challenging and unnecessary. Therefore, this study is based on the design parameters of the CEPC—specifically, the deflection angle, the arc length of the deflection in the final dipole magnet upstream of the MDI region, and the electron energy—to calculate the absolute position and momentum direction of the incident electron as shown in Figure 1. These calculations will ensure that the incident electron, after being deflected by the final dipole magnet, reaches the beam pipe and continues its trajectory toward the MDI region. The synchrotron radiation generated under these deflection conditions is precisely the radiation required for this study.

In the subsequent work, we will use CEPCSW to simulate the distribution of synchrotron radiation photons in each detector to estimate the background level caused by synchrotron radiation.

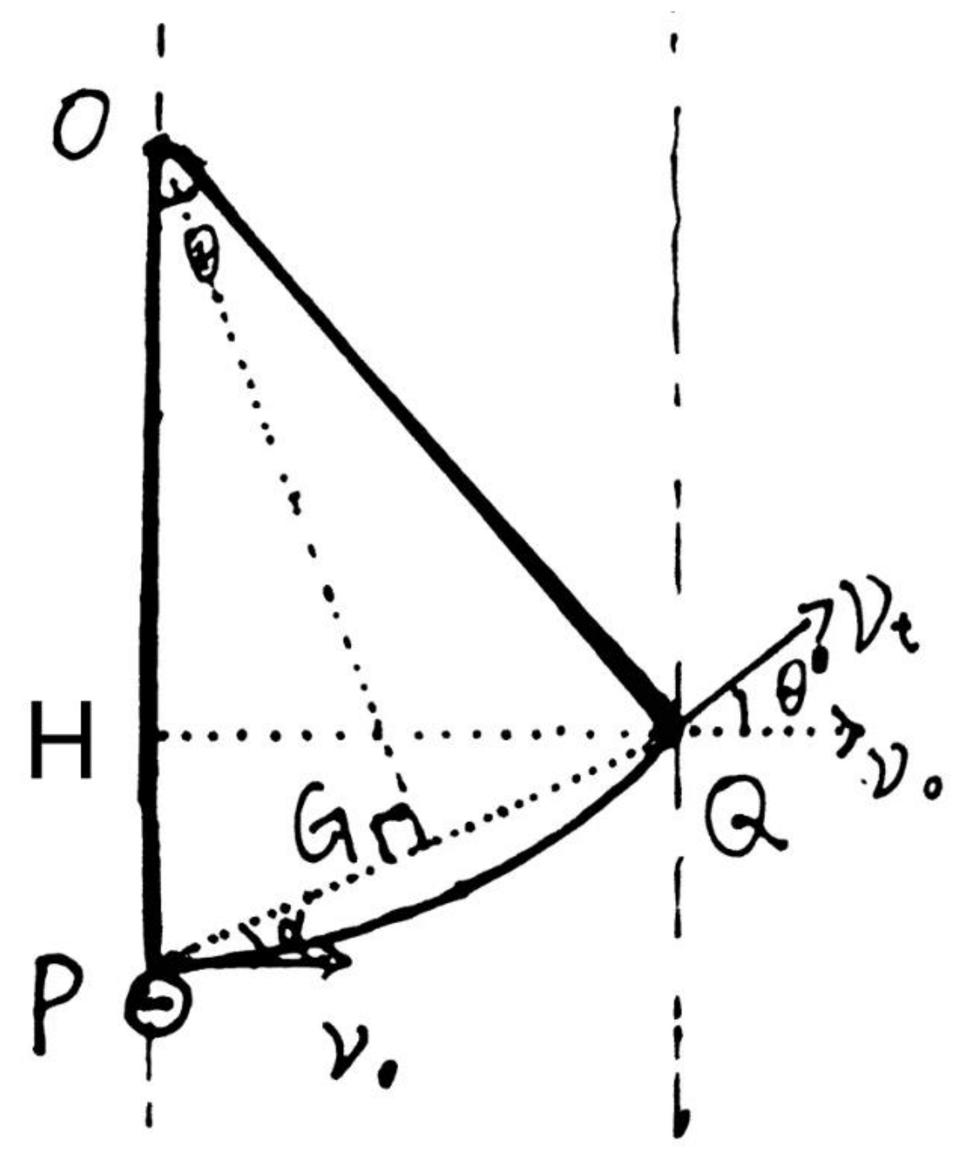

Figure 1. The theoretical sketch of the calculation of the electron source's incident parameters.

Result

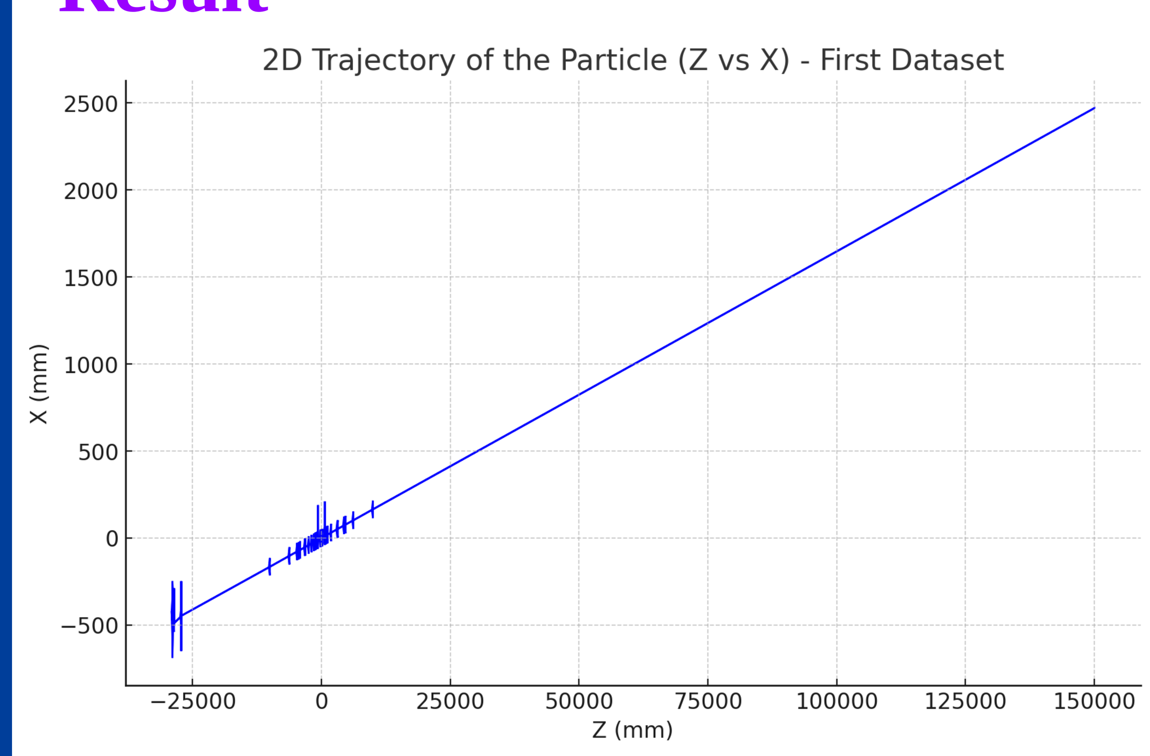

Figure 2. electron trajectories without dipole magnet

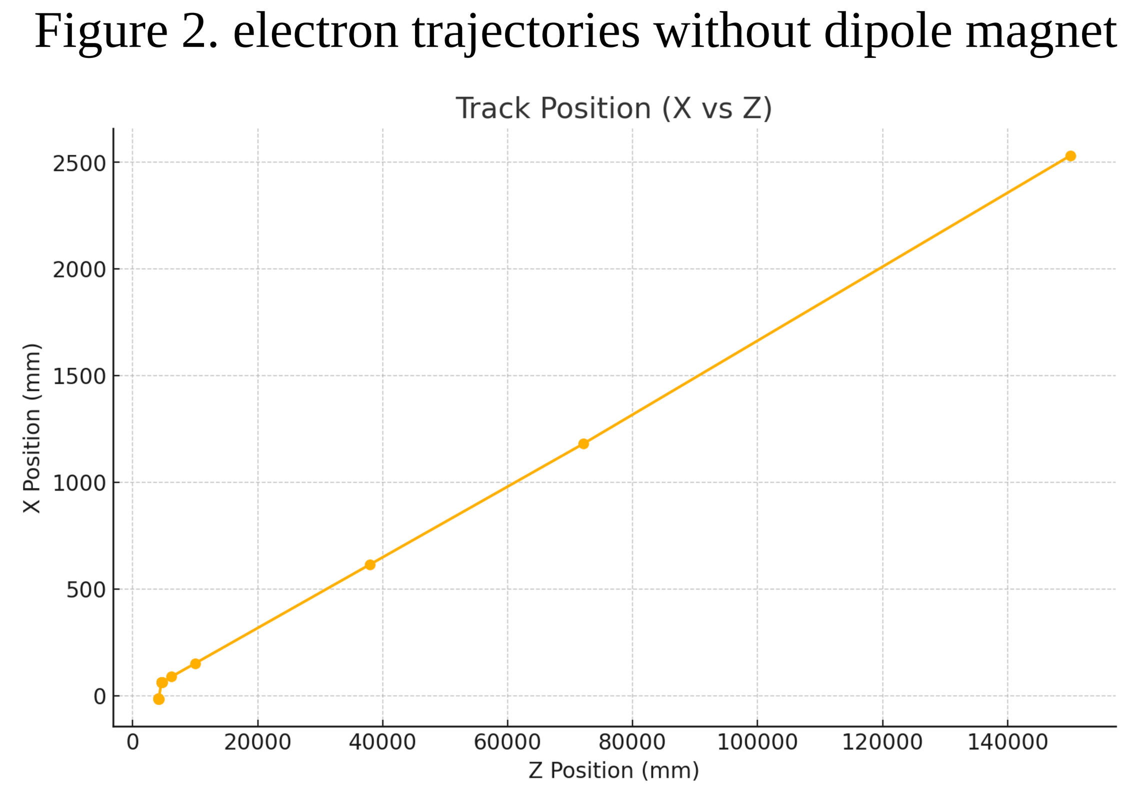

Figure 3. electron trajectories with dipole magnet

The above two figures show the electron trajectories without and with the dipole magnet, respectively. The fitted slope values of the curves are close to the crossing angle designed for the CEPC, and the recorded synchrotron radiation photons are also in the keV order of magnitude, which verifies the correctness of our synchrotron radiation generate method.

To simulate the actual operating conditions of the CEPC, where the number of particles per bunch (Num/bunch) can reach 10^{11}, parallel simulations for generator are performed by varying the random number seed. The results are subsequently combined into a single ROOT file for detector simulations using CEPCSW.

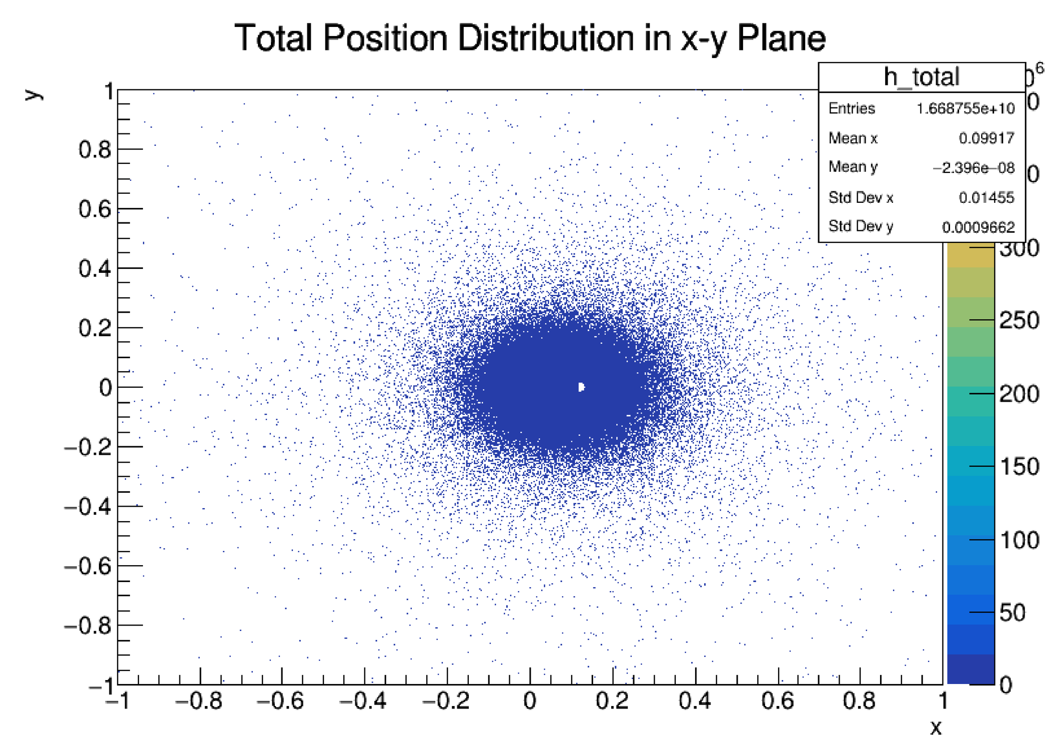

Figure 4. Distribution of synchrotron radiation

The above figure shows the distribution of synchrotron radiation photons at a distance of 7 meters upstream of IP. As seen in the figure, the photons are distributed over a large area, which could potentially cause irradiation and noise effects on various detectors in the MDI. Of course, this will depend on the final synchrotron radiation background results for each detector. If the impact is too significant, we will consider adding shielding walls to block synchrotron radiation photons from entering the detectors. The white spots in the figure are merely visual artifacts caused by the angle between the counting detector and the beam pipe in the software, and they do not affect the subsequent detector simulation results.

Summary and Outlook

This study successfully generated CEPC synchrotron radiation and tracked it through theoretical calculations and software simulations. The subsequent detector simulations are currently underway...

Reference List

[1] GEANT4 collaboration group.

[2] ROOT collaboration group.

[3] CDR of CEPC work group.

[4] CEPCSW work group.