CEPC PARTIAL DOUBLE RING LATTICE DESIGN*

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Abstract

In this paper, we introduced the layout and lattice design of Circular-Electron-Positron-Collider (CEPC) partial double ring (PDR) scheme. The baseline design of CEPC is a single beam-pipe electron positron collider, which has to adopt pretzel orbit scheme. And it is not suitable to serve as a high luminosity Z factory. If we choose partial double ring scheme, we can get a higher luminosity with lower power and be suitable to serve as a high luminosity Z factory. In this paper, we discussed the details of CEPC partial double ring lattice design and showed the dynamic aperture study and optimization.

INTRODUCTION

In March 2015, we finished and published the Preliminary Conceptual Design Report(Pre-CDR) of CEPC-SPPC [1]. In this report, we choose the single ring scheme for CEPC. The synchrotron radiation power of CEPC is as high as 50 MW and its goal is to deliver a peak luminosity greater than $1 \times 10^{34} cm^{-2} s^{-1}$ per IP [2, 3]. The e^+e^- beams are in the same pipe, which has to adopt pretzel orbit. And it is not suitable to serve as a high luminosity Z factory. To solve the problems above, we raised a partial double ring scheme [4,5]. We can get a higher luminosity with lower power and be suitable to serve as a high luminosity Z factory though there are many challenges we should overcome. Figure 1 shows the advantages comparing with the single beam-pipe scheme and the challenges we should overcome. In this paper, we will discuss and show the lattice design of CEPC partial double ring.

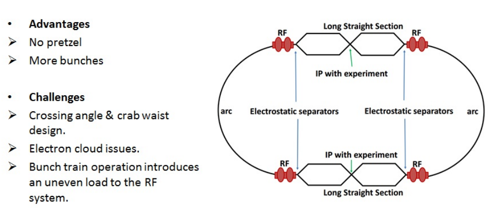

Figure 1: Advantages and challenges of CEPC partial double ring scheme.

CEPC PDR LATTICE DESIGN

CEPC PDR Lattice Layout

We choose double ring scheme for e^+e^- at IP1 and IP3. The total length of this part is about $3Km$. The arcs of both side of IP1 and IP3 are kept the same as the Pre-CDR single ring scheme designed by Huiping Geng. The other straight sections' length also keeps the same. Figure 2 is the whole layout of CEPC PDR part and arc part. Figure 3 is the detail of PDR part of CEPC.

The full crossing angle for CEPC partial double ring scheme is $30mrad$. We assume the final focus system (FFS) length is about $500m$, then the largest distance at the end of FFS is about $7.5m$ and between the two separated pipes is about $15m$. At the start of the double ring, we need to use electrostatic separator to separate the electron and positron beams. We choose the parameter of electrostatic separator according to the experience on LEP. The maximum operating field strength is $2MV/m$. The length of electrostatic separator is $4.5m$ [6]. For the beam energy $E0 = 120GeV$, the maximum deflection per separator is about $66urad$. We choose 12 electrostatic separators work together to obtain a deflection $0.75mrad$, each separator deflect $62.5urad$. After those separators, we use a pair of septum dipoles to obtain $4.25mrad$ and a group of dipole (B1) to acquire the other $10mrad$ and suppress the dispersion to zero. But the simulation of separators in MAD has a problem when we use SURVEY command, so we use dipoles stand for the separators, whose length and deflect angle are both same as the separators. The scheme is showed in Fig. 3. Then we use a group of dipoles to bend the beam, which is schemed in Fig. 3 as B2. B3, B4 are the symmetrical elements according to B2 and B1. Each group (for example B2) has 16 dipoles in 8 FODO cell and 8 half-strength dipoles in 2 dispersion suppressor section, and each dipole bend the beam by $1.5mrad$ and half-strength dipole bend the beam by $0.75mrad$. This scheme can keep the dispersion 0 at the two side of this bend part [7]. At beginning, we use straight FODO instead of final focus system optics. The total length of this scheme is about $3.2km$.

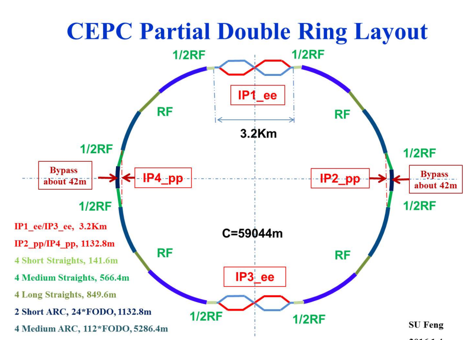

Figure 2: CEPC partial double ring layout (whole ring).

* Supported by National Natural Science Foundation of China (NSFC 11575218) and (NSFC 11505198).
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ISBN 978-3-95450-147-2

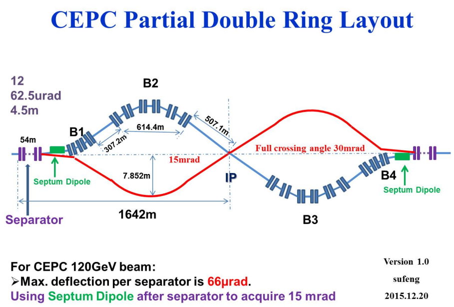

Figure 3: CEPC partial double ring layout (PDR part).

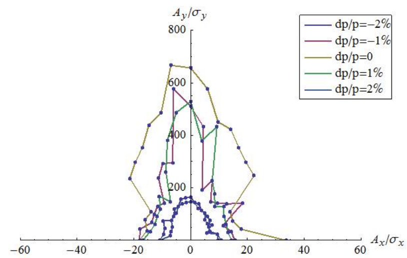

Figure 6: Dynamic aperture of CEPC PDR without FFS.

CEPC PDR Lattice without FFS

Orbit and Optics without FFS We design the lattice of CEPC partial double ring by MAD. Following is the optics and orbit. Figure 4 shows the beta function of CEPC PDR part without FFS. Figure 5 shows the orbit of CEPC PDR part without FFS.

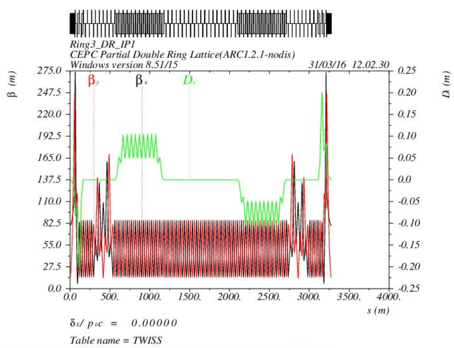

Figure 4: Beta function of CEPC partial double ring part without FFS.

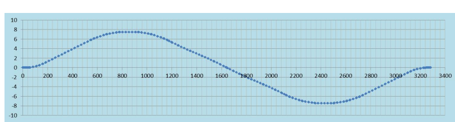

Figure 5: Orbit of CEPC partial double ring part without FFS.

Dynamic Aperture without FFS Figure 6 is the dynamic aperture of CEPC partial double ring lattice without FFS. The on-momentum dynamic aperture is about $20\sigma_x$ in horizontal and $650\sigma_y$ in vertical. But the off momentum particles dynamic aperture is only about $18\sigma_x$ in horizontal and $550\sigma_y$ in vertical for $dp/p = \pm1\%$ and $13\sigma_x$ in horizontal and $160\sigma_y$ in vertical for $dp/p = \pm2\%$.

Comparation of Dynamic Aperture with Single Ring Lattice In this part, we compare the dynamic aperture of CEPC partial double ring lattice (without FFS) with the dynamic aperture of CEPC single ring lattice (the so called CEPC main ring lattice designed by Huiping Geng 2014.9). The results are showed in Fig. 7. We can see the decrease of dynamic aperture is obviously. This is reasonable and indicates that we should optimize the lattice design to acquire a larger dynamic aperture.

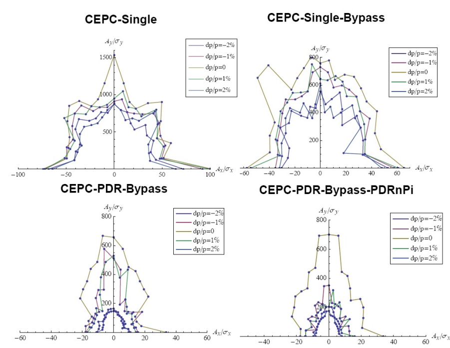

Figure 7: Dynamic aperture compare with CEPC single ring.

CEPC PDR Lattice with FFS

Orbit and Optics with FFS In this part, we insert the FFS lattice designed by Dou Wang into the partial double ring lattice. Figure 8 is the beta function of CEPC PDR lattice with FFS. Figure 9 is the orbit of CEPC PDR lattice with FFS.

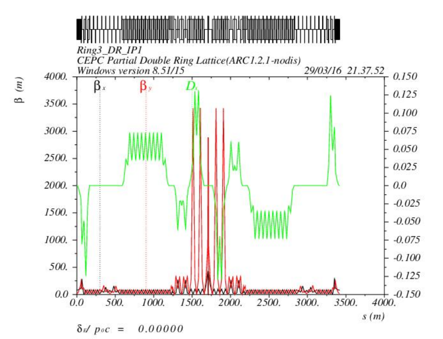

Figure 8: Optics of CEPC partial double ring with FFS.

Dynamic Aperture with FFS Figure 10 is the dynamic aperture of CEPC PDR lattice with FFS. The on-momentum dynamic aperture is about $13\sigma_x$ in horizontal and $55\sigma_y$ in

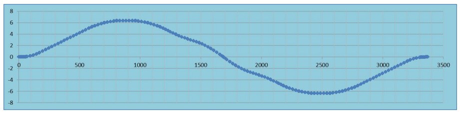

Figure 9: Orbit of CEPC partial double ring with FFS.

vertical. But the off momentum particles dynamic aperture is only about $1\sigma_x$ in horizontal and in vertical for $dp/p = \pm 1\%$ and 0 in both horizontal and vertical for $dp/p = \pm 2\%$.

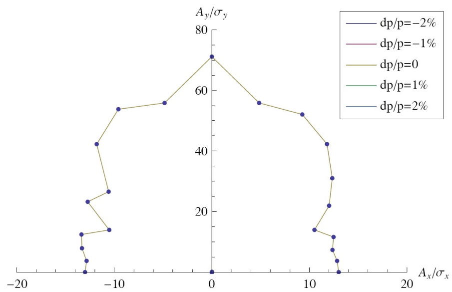

Figure 10: Dynamic aperture of CEPC PDR with FFS.

New FODO Cell Design for CEPC PDR Lattice

The above results are based on the phase advance of ARC FODO cell as 60 degree. According to the new parameter of CEPC partial double ring, we need to design a smaller emittance lattice. So we design a 90 degree phase advance FODO cell and divided the sextupoles into 12 groups. We choose non-interleaved arrangement and the sextupoles arrangement is showed in Fig. 11. Figure 12 shows the dynamic aperture of this new design without FFS and Fig. 13 shows the dynamic aperture with FFS. We can see that the dynamic aperture of on-momentum particles become larger but the off-momentum particles' aperture is still very small. All of this is still under studying and optimization.

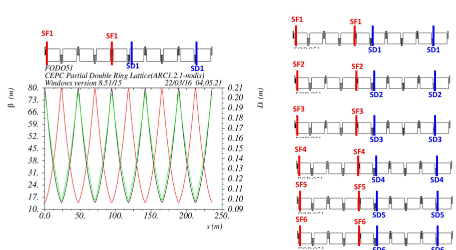

Figure 11: 90 degree phase advance FODO cell and sextupole arrangement.

SUMMARY

In this paper, we discussed the details of CEPC partial double ring lattice design and showed the dynamic aperture study and optimization. The first version of CEPC partial double ring lattice has been done and the dynamic aperture need to be optimized. Now the DA of CEPC with PDR and Bypass(at IP2/4) and without FFS is better than before,

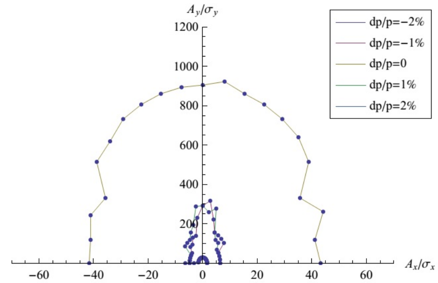

Figure 12: Dynamic aperture of CEPC PDR without FFS(new FODO).

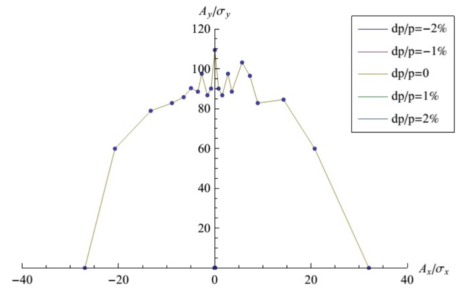

Figure 13: Dynamic aperture of CEPC PDR with FFS(new FODO).

but the DA with FFS is not good enough. All the above results and figures indicate that we have lots of work to do to optimize the design.

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ISBN 978-3-95450-147-2