

# PROGRESS AND TDR PLANS OF THE MECHANICAL SYSTEM OF CEPC\*

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## Abstract

The TDR of CEPC is aimed at the key science and technology problems and makes preparations for the real project. This paper will describe the progress of mechanical system including the regular supports and transport vehicle design, the mockup plan, the installation scenario of machine detector interface (MDI) and the movable collimator, as well as the TDR plans of mechanical system.

## INTRODUCTION

The Circular Electron Positron Collider (CEPC) is a 100 km ring collider which has published its Conceptual Design Report (CDR) in November, 2018 [1]. Now CEPC has run into the Technical Design Report (TDR) stage, which aims at the key science and technology problems and makes preparation for the real project.

The mechanical system is responsible for the magnet supports, the installation scenario and some important devices at machine detector interface (MDI) and movable collimators. Particularly, the magnet supports include the supports for regular magnets and superconducting magnets at MDI. For the installation of the magnets, transport vehicles with three degrees of freedom and certain precision are also under consideration. This paper will describe the progress of mechanical system as well as the TDR plans.

## REGULAR SUPPORTS AND TRANSPORT VEHICLES

The CEPC is composed by the double ring Collider, the Booster, the Linac and Transport Lines as shown in Fig. 1. Over 75% of the length is covered by magnets of about 140 types, each magnet needs to be supported. Besides, the accelerating tubes, vacuum tubes, instruments also need supports. The aims of the support design are as follows:

- Simple and flexible structure.
- Small deformation and good stability.
- Low cost.

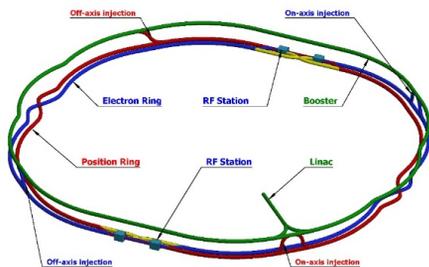


Figure 1: Schematic diagram of CEPC.

Manually adjusting has been chosen for the regular supports owing to its simple structure and low cost, using bolts for vertical adjusting and push-pull bolts for horizontal adjusting. The adjusting ranges are shown in Table 1.

Table 1: Adjusting Range and Resolution of Regular Supports

	Range of adjustment	Resolution
X	$\geq \pm 20\text{mm}$	$\leq \pm 0.02\text{mm}$
Y	$\geq \pm 30\text{mm}$	$\leq \pm 0.02\text{mm}$
Z	$\geq \pm 20\text{mm}$	$\leq \pm 0.02\text{mm}$
$\Delta\theta_x$	$\geq \pm 10\text{mrad}$	$\leq \pm 0.05\text{mrad}$
$\Delta\theta_y$	$\geq \pm 10\text{mrad}$	$\leq \pm 0.05\text{mrad}$
$\Delta\theta_z$	$\geq \pm 10\text{mrad}$	$\leq \pm 0.05\text{mrad}$

In Collider and Linac (including Damping Ring), the magnets are supported to the ground by concrete. In Booster, the magnets are hanged on the wall of the tunnel by steel frames. While in Transport Lines, the magnets are either supported like the Collider ring or like the Booster ring, due to the location of magnets.

In order to minimize the deformation of magnets, especially for the dipoles which length is over 5 meters, and to enhance the rigidity of the magnet supports in Booster, optimizations has been done in our previous work [2]. Figure 2 to Fig. 3 show some typical support structures.

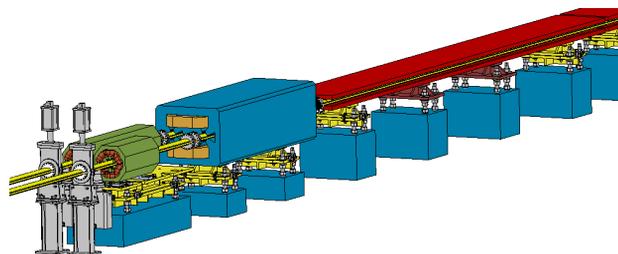


Figure 2: Supports for dipole, quadrupole and sextupole in collider.

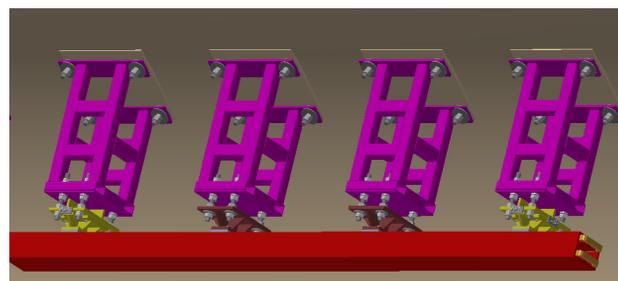


Figure 3: Support for dipole in booster.

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All the devices and their supports should be transported to their certain locations for installation. Two types of vehicles are under consideration, one for the long devices like dipoles and one for short devices like sextupoles. Figure 4 shows the schematic of the vehicle for long devices. The vehicles are designed for transportation as well as adjustment in three directions to roughly reach the installation location. Uneven ground has also been considered.

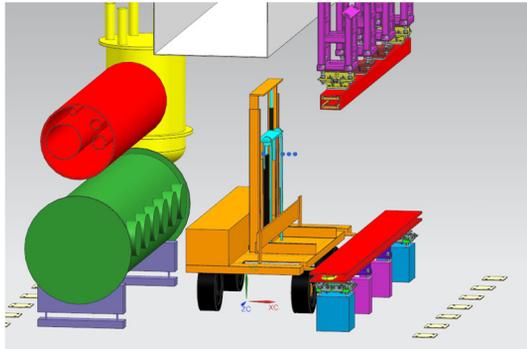


Figure 4: Schematic of vehicle for long devices.

### TUNNEL MOCKUP PLAN

In TDR stage, a mockup of the ring tunnel will be built on basis of the design above, which is used for checking of the equipment interface, installation, alignment and transportation. It is composed by part of arc section including two dipole cores, one quadrupole, one sextupole and one BPM in Collider ring and Booster ring separately (shown in Fig. 5), and part of RF section including one cryomodule in each ring.

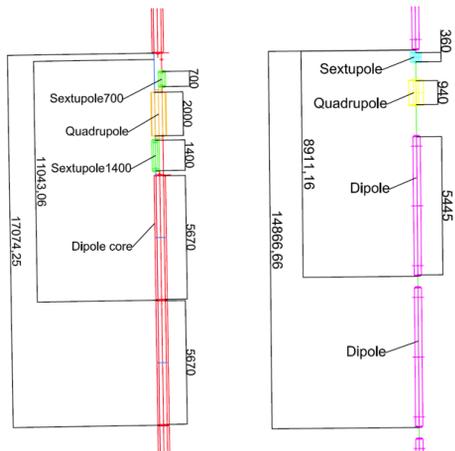


Figure 5: Elements of the mockup arc section.

The relative positions of the magnets and BPM in each ring are determined by the lattice design of CEPC. The total length is between thirty and fifty meters. All the supports will use the real design and the other elements such as magnets will use the roughly designed model with the same size and weight. The detailed design is ongoing.

### INSTALLATION SCENARIO OF MDI

The 3D layout and the cross section near the interaction point is shown as Fig.6 and Fig. 7. There are IP chamber,

detectors such as vertex detector (VTX), silicon inner tracker (SIT), forward tracking detector (FTD) and Lumical, accelerator components such as vacuum tubes, remote vacuum connector, high-order mode (HOM) absorber, BPM, SC magnets and their support system. The detector part and accelerator part will connect at the end of IP chamber, which is about 700 mm distance from the interaction point. Due to tight installation space, it is impossible to connect the flanges by hands at their installation locations.

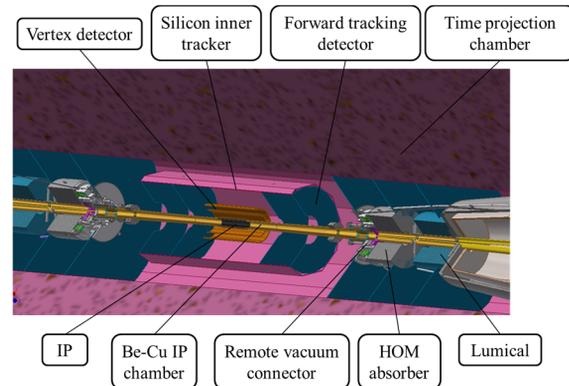


Figure 6: 3D layout near the interaction point.

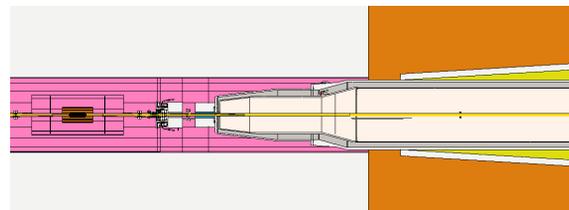


Figure 7: Cross section near the interaction point

Some basic conditions are made for the MDI installation, which are listed below:

- Both sides of IP chamber are fixed to VTX transversally and are free longitudinally.
- The IP chamber and the detectors near interaction point can be considered as one assembly.
- The assembly above can be supported by TPC and be aligned transversally.
- The high precision part of Lumical is with the detector part and the main body is with the accelerator part.
- Remote vacuum connection will be used.

Based on the basic conditions, the primary installation scenario is as follows:

- The inner layer of the VTX is mounted to the IP chamber, then the other two VTX layer are mounted to a frame support. Using the similar method, the IP chamber, VTX and other detectors near the interaction point can be considered as one assembly, which is shown in Fig. 8.
- The assembly above is installed to the TPC. The support, fix and alignment method are not clear now.
- Pre-alignment of SC magnets when the cryomodule is in working condition.

- Installation of Lumical main body, BPM, HOM absorber, remote vacuum connector and relative support mechanism, as shown in Fig. 9.
- Move the SC magnet to working location using the moving mechanism of support system. Connect the flanges using remote vacuum connector and do the alignment. This step is shown as Fig. 10.
- Finish the connection and alignment for both sides and install the yoke walls.

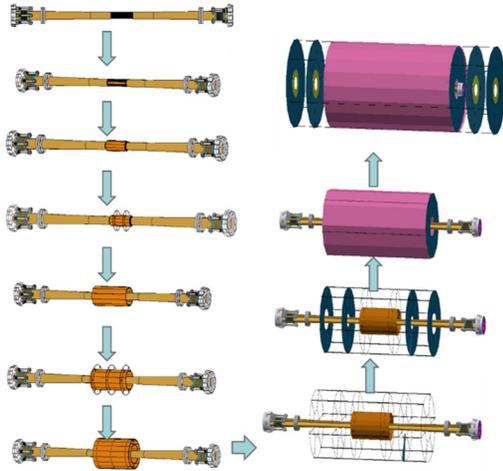


Figure 8: Assembling of IP chamber and relative detectors.

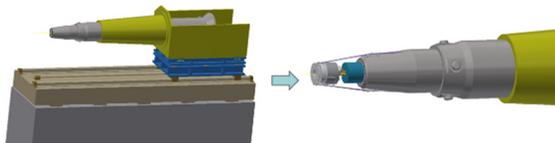


Figure 9: Pre-alignment of SC magnets and installation of accelerator components.

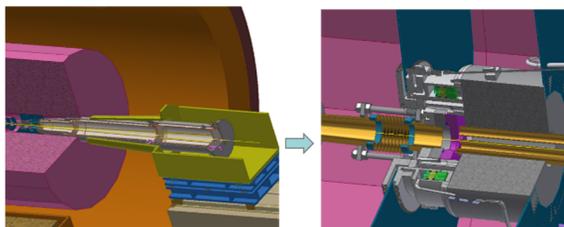


Figure 10: The connection and alignment of one side.

For the remote vacuum connection, the RVC structure similar the SuperKEKB is considered as the baseline [3], as shown in Fig. 10. Meanwhile, we are searching for alternative designs to decrease the connector size and material budget.

The requirement on alignment of the SC magnet is better than  $30\ \mu\text{m}$ , which has no clear solution by now. Now we are focusing on the rigidity improvement of the support system as shown in Fig. 11. The adjusting mechanism are all wedge jacks in three direction. The movement mechanism is high precision track & rack. The optimization is ongoing to improve the rigidity in limited space. Sensors will be used for deformation monitoring. Meanwhile, we are trying our best to search special structure and method to fulfil the alignment requirement.

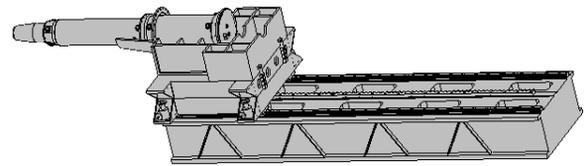


Figure 11: Support system of SC magnet

In TDR stage, the installation scenario of MDI will be determined, and the remote vacuum connect method will be tested and chosen. The support system of SC magnet will be designed in detail as well.

## MOVABLE COLLIMATORS

There are two types of collimator, the movable and fixed. In TDR stage, we mainly focus on movable collimators.

The sketch of the movable collimator is similar to SuperKEKB [4] and PEP-II [5], which is shown in Fig. 12.

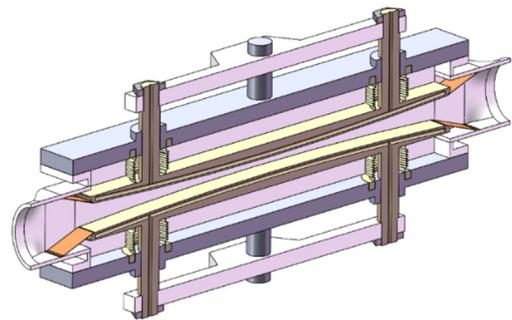


Figure 12: Sketch of movable collimators.

The collimator is located in the straight section between two dipoles. Primary impedance estimation has been done which shows the maximum thermal load from impedance is 166 W when the facility operates as a Z factory. The main thermal load is from synchrotron radiation which is estimated about 7 kW. The cooling method is under design.

In the TDR stage, the prototype of movable collimator will be developed based on the optimization of impedance, thermal load and cooling method.

## CONCLUSION

The preliminary design of supports for regular magnets and their transport vehicles has been done, based on which a mockup of part of ring tunnel will be developed for the interface checking, the test of alignment, adjustment and transportation. The rough installation scenario of MDI has been done, and the development and test of the remote vacuum connection will be finished in the TDR stage, as well as the detailed design of support system of SC magnets. The sketch of movable collimator and roughly thermal load and impedance estimation has been finished, the prototype will be developed in TDR stage to verify to design.

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