Answers to IAC Recommendation in 2017 from CEPC Accelerator point of view

3. Detector

R13: Concerning the MDI, the IAC recommends close interaction with superKEKB and Belle-II.

Action in 2018 (responsible for arranging the visit to KEK from IHEP, ***Jie GAO****):*

1) Dr. Haoyu SHI at KEK, started to visit from Oct. 2018 for three months under IHEP-KEK MoU with Hiroyuki Nakayama and Shuji Tanaka, on MDI detector part.

2) Dr. Sha Bai visited KEK in May, 2018 for one month on MDI from accelerator part on RVC.

3) Ohuchi-san visited IHEP for one week and review on CEPC.

4) Zhanguo Zong (KEK super B MDI, SC magnets) visited IHEP from Nov 12-14, 2018, cepc–sppc.

4. Accelerator

Recommendations:

The present design contains several limitations to reach the maximum luminosity. The IAC

therefore recommends studying the possibilities on:

R14: At the Higgs energy:

• *Increase the arc quadrupole length from about 2 m to about 3 m because short and thus stronger quadrupoles make the associated synchrotron radiation stronger and reduce the dynamic aperture. High fields may also preclude the machine upgradability toward future running beyond the tt-bar threshold. A longer quadrupole also reduces the power consumption.*

(***Yiwei Wang****: For CEPC at Higgs, the synchrotron radiation due to quadrupoles is mainly from the final doublet but not arc quadrupoles.*

*We checked the pole-tip fields of arc quadrupoles at tt-bar energy. It is still in the limit of normal conducting.*If we required a high performance at tt-bar, a longer arc quadrupoles are needed)

• *Reduce the strength of QD0 in the IR because it can be a limitation of the vertical dynamic aperture due to synchrotron radiation.(****Yiwei Wang****: In the dynamic aperture study, we explored a longer QD0. The result shows that when the length of QD0 increased from 1.73 m to 3.46 m, the vertical dynamic aperture can be increased around 30 percent.*

However, the long cryo-module may suffer distortion due to massive weight, thus we just increase the length of QD0 from 1.73 m to 2.0 m. A even longer QD0 is preferred for dynamic aperture and the effort to solve the mechanism problem is undergoing.)

R15: At the Z energy:

*• Try to squeeze β*y down to 1 mm. The CEPC dynamic aperture with β*y at 2 mm seems larger than the necessary requirement. Dividing the QD0/QF1 into several magnet sections can help with the design (**YiweiWang**: Now in CDR beta_y=1.5mm, 3Tesla detector dipole case; beta_y=1mm for 2Tesla case).*

*• The limitation on the required high bunch intensity can be mitigated by increasing the height of the beam pipe by ~ 20%, as well as using a thinner NEG coating. This possibility should be evaluated, as the resulting gain in the luminosity will likely be enormous compared to the small increase in the cost.(**Haiyi Dongoing**： It is not a problem for the increase of the height of the beam pipes, but the cost of the magnet fabrication will rise. A thinner NEG coating provide a short lifetime of pumping gases, minimum effective thickness of NEG films (such as 1 um to 200 nm) or part of NEG coating inside the inner surface of a vacuum chamber need to be studied for decreasing the resistive wall impedance).*

R16: At all energies:

*• Please consider a design of an arc beam pipe with concentrated (localized) photon stops, which can eliminate the lead shielding in the magnets except around the photon stops. It may also ease the cooling of the beam pipe needed for pumping with a thinner NEG coating (**Zhongjian Ma**: The reason why we not considering the concentrated photon stops had been discussed with Weiren CHOU and other colleagues. I can't explain the exact reason but something related to beam physics or beam characteristics. **Haiyi Dong**: The linear synchrotron radiation power of the CEPC collider is about 450 w/m, a conventional elliptical vacuum chamber with a cooling channel is enough to dissipate the SR heat, and the manufacture cost is low. While the beam pipes with the antechamber and the photon stops need much more fabrication cost. According to the simulation, a copper stop is difficult to intercept the SR because of a very large photon critical energy for CEPC).*

*• The estimation of single-bunch instabilities should always take into account the bunch length that is increased by beamstrahlung at all energies. The committee's opinion is that a closer collaboration with the CERN FCC-ee team in the field of high-current operation (impedances, wakes, electron clouds, etc.) is highly desirable to arrive at a more rapid convergence for CEPC (done in CDR, **Jie Gao**).*

R17: Design the pp interaction region for the highest possible imagined proton energies and incorporate any length changes into the CDR.

*(**Jingyu Tang**: The SPPC design scope assumes at the maximum 150 TeV in Center of Mass energy in the energy upgrading phase. We have not studied the length requirement on the IP insertions at this energy. If we use a scaling of square root with energy ratio, the length of the two IP insertions should be increased from 1.25 km from the present design to 1.75 km. This should be possible but needs more careful balance among the long insertions, and more difficult to be compatible with the CEPC lattice.)*

R18: Evaluate whether the accelerator components should be constructed with sufficient

*margin to reach the tt-bar region, if the additional cost is minimal.(**Yiwei Wang**:*
The quadrupole power dominated in all the magnets. If the additional cost is minimal, it may be better to be used to increase the quadrupole length.This help to reduce the power at both Higgs and tt, and increase the dynamic aperture at tt thus the Luminosity. The additional RF cavities for tt bar is essential. *)*

*R19: The project should develop a mechanism for awarding R&D and construction tasks regarding the involvement of international industries as well as domestic industries (**Jie GAO**: CIPC has been established in Nov. 2017, and in July 2018 an assembly meeting was held in IHEP, and during CEPC-SppC international conference from Nov 12-14, there are 6 parallel sessions of CIPC on CEPC related talks, and a plenary summary talk was given also on Nov. 15, 2018. CIPC participated also to LCWS2018, Oct. 2018 in USA, and a talk from CIPC in industry session was given. In 2017, Chinese industries have deeply envolved in CEPC CDR and R&D towards TDR,* such as civil engineering, siting and implementation, MDI connection mechanics, MDI mass supporting system, SCRF system, cryoplant, RF power sources, instrumentation, SC magnets,..Two CEPC numerical Civil engineering design and implementation with components in the tunnels have been done jointly with IHEP CEPC accelerator group by **Yellow River Company** and by **Huadong Engineering Company**, **two 3~4 minutes videos** have been made available from these TDR R&D results. In the TDR phase, more industries will join and play a key role in TDR R&D, and also in construction phase. As for international industries, not yet.)

Appendix A: Charge

The CEPC International Advisory Committee shall advise on all related matters for the CEPC project, specifically on the following aspects related to the CDR, R&D and the international collaboration:

1. Given the limited time remaining, how can we produce a set of high quality CDR volumes? (**Jie Gao**: Completed and released online Sept. 2, 2018 for accelerator after passing international review in June 2018)
2. Is the current R&D plan on the right track? Can we complete the required critical R&D in the next 5 years? (**Jie Gao**: CEPC accelerator started to conduct and to collaborate actively in many key technology issues both within IHEP and with industries and with international collaboration (KEK for example), such as civil engineering, siting and implementation, MDI connection mechanics, MDI mass supporting system, SCRF system, cryoplant, RF power sources, instrumentation, SC magnets,...Collaboration with BINP on SC magnet of IR has planned. In Sept. 2018, the first EP in China is completed in IHEP which is a key step permitting Chinese scientists to perform home based R&D on SC cavities with high Q and high E.

Generally speaking, we think CEPC current R&D plan on the right tract with a new mechanism with scientists, engineers and industries, and we have confidence to finish TDR in 2022, with more international participants including international industries)

Additional information for international collaboration (Jie Gao):

Example:

In 2018, under the envelope of MoU between IHEP and KEK on Super KEK B and circular e+e- collider in general.

March 17, 2018 Jie Gao, Yiwei Wang(3) participated the first round Super KEK B commissioning and operation and collider ring collaboration for one week.

In May, Sha Bai visited Super KEK B on MDI, Kanazawa-san provided RVC design materials of Super KEK B MDI for reference.

In June, 2018, Yuan Zhang, visited Super KEK B on beam beam and dynamic apertures for one week.

In July 5, Jiyuan Zhai and Dianjun Gong visited Super KEK B on SCRF system of Super KEK B for one week.

From Oct. 2018, Dr. Haoyu SHI at KEK, started to visit for three months under IHEP-KEK MoU with Hiroyuki Nakayama and Shuji Tanaka, on MDI detector part.

From Nov. 2018, Jingru Zhang will visit KEK super B linac for one week.

From Nov. 2018 Dou Wang will visit KEK Super B on damping ring, booster and collider ring for one week.

In 2018 IHEP is working with BINP to form a new body of collaboration to be signed at the end of 2018, aiming at collaboration on key issues of e+e- colliders, such as lattice DA, polarization, SC magnets of MDI..

The question (Nov 15, 2018) from Michelangelo Mangano (CERN), about SppC collimation in relation with CEPC, the answer is: Current SPPC design uses an insertion length of 4.3 km, which is good enough for SPPC alone. However, when making these two long insertions in the presence of CEPC detectors, it becomes extremely challenging. Detouring schemes starting from the neighboring arcs to produce an orbit separation of about 30 m are under consideration (**Jingyu Tang**).