Letter of Interest for Snowmass 2021

Jingyu Tang for the SPPC Study Group
Institute of High Energy Physics, CAS, Beijing 100049, China
tangjy@ihep.ac.cn

The discovery of the Higgs boson at CERN's Large Hadron Collider (LHC) in July 2012 triggered world discussions for large-scale accelerators to succeed LHC. In September 2012, Chinese scientists proposed a two-stage project with the first being 240-GeV *Circular Electron Positron Collider* (CEPC), and the second being 75-TeV *Super Proton-Proton Collider* (SPPC). CEPC is considered as a Higgs factory, though it will conduct research on Z-physics, while SPPC will be a discovery machine aiming at searching on new physics beyond Standard Model [1-3]. The two colliders share the same tunnel of about 100 km in circumference.

As the SPPC study aims at the construction of a far future machine around 2040, it focuses on the layout compatibility with the CEPC, main accelerator physics problems and some key technologies requiring long-term R&D efforts [4]. For the latter, it is particularly important to develop high-field superconducting magnets. The main R&D efforts on high-temperature superconductors, with a particular focus on the iron-based superconducting wires have been chosen. This will allow us to reach 75 TeV in center-of-mass energy with about a dipole magnet field of 12 T in an early phase, but ultimately increase the energy to 125-150 TeV with a magnetic field of 20-24 T. With the nominal luminosity of 1×10^{35} $cm^{-2}s^{-1}$, the physics run is expected to collect 30 ab^{-1} in 10-15 years.

The ongoing accelerator physics study includes: general layout and lattice design in coordinating with the CEPC study, luminosity optimization and leveling method, beam collimation, beam-beam effects, longitudinal beam dynamics and instabilities, and injector chain. Preliminary study results are outlined as follows:

1) The layout compatibility design between CEPC and SPPC is generally feasible but very challenging, especially if one tries to keep the whole CEPC collider when SPPC will be added in a later phase in the same tunnel, and thus the e-p collision would be another option in the future.

2) One may manage to deal with the huge stored energy in beams of 9 GJ per beam. A novel collimation method of five-stage collimation and combined betatron and momentum collimation system is being studied [5]. By arranging the momentum collimation in the same long straight section with the betatron collimation, it allows the former to clean the single diffractive particles produced in the latter. Special superconducting magnets with protection measures in the betatron collimation section can enhance the phase advance in order to increase the collimation efficiency.

3) Different luminosity and leveling methods have the potential to reach a higher averaged luminosity and avoid event pile-up.

4) Beam-beam effects play a key role in reaching high luminosity [6]. It is found that long-range interactions are even more crucial than head-on interactions, but the compensation method by current wires seems to be effective.

5) Bunch gymnastics in the whole accelerator chain plays a key role in the bunch filling pattern and the instability suppression in the colliding rings.

6) The injector composed of powerful accelerators can contribute to reduce the turnaround time thus increase the averaged luminosity. It is possible to produce a minimum turnaround time of 0.8

hours. The powerful beams from the injector accelerators can be exploited for other application programs like what are going on at LHC.

References:

[1] CEPC-SPPC Pre-CDR, http://cepc.ihep.ac.cn/preCDR/volume.html, 2015.

[2] CEPC-SPPC Progress Report, http://cepc.ihep.ac.cn/Progress%20Report.pdf, 2017.

[3] The CEPC Conceptual Design Report, Vol I: Accelerator, arXiv: 1809.00285, http://cepc.ihep.ac.cn/CDR_v6_201808.pdf, 2018.

[4] Jingyu Tang et al., Concept for a Future Super Proton-Proton Collider, arXiv: 1507.03224, 2015

[5] Jian-Quan Yang, Ye Zou, Jing-Yu Tang, Collimation method studies for next-generation hadron colliders, Phys. Rev. Acc. and Beams, 22, 023002 (2019)

[6] Lijiao Wang, Jingyu Tang, Kazuhito Ohmi, Beam-beam Studies for Super Proton-Proton Collider, Proc. of IPAC2018, Vancouver (2018) ID:3021