CEPC Detectors Letter of Intent

The Circular Electron Positron Collider (CEPC) is a large international scientific facility proposed [1,2] to probe the Standard Model (SM) and potentially uncover new physics beyond the SM (BSM). The CEPC program spans a wide range of center-of-mass energies and beam luminosities to achieve the highest yields of Higgs, W, and Z bosons produced in the exceptionally clean environment of an e^+e^- collider. The vast amount of bottom quarks, charm quarks and τ-leptons produced in the decays of the Z bosons also makes the CEPC an effective B-factory and τ-charm factory. Hence, the CEPC offers an unmatched opportunity for precision measurements and searches for BSM physics. The CEPC physics program, accelerator and detectors are presented in the CEPC Conceptual Design Report (CDR) [3, 4].

The current CEPC design accommodates two Interaction Points (IPs), each housing one large international detector. To deliver the physics program outlined above, the CEPC detector concepts must meet the stringent performance requirements. The detector designs are guided by the principles of large and precisely defined solid angle coverage, good particle identification, precise particle energy/momentum measurement, efficient vertex reconstruction, and excellet jet reconstruction and measurement as well as the flavor tagging. Two primary detector concepts have been introduced in the CDR [4]. One detector concept, used as the basis for the physics performance studies, incorporates the particle flow principle with a precision vertex detector, a Time Projection Chamber (TPC) and a silicon tracker, a high granularity calorimetry system, a three Tesla superconducting solenoid followed by a muon detector embedded in a flux return yoke. A variant of this detector incorporates a full silicon tracker without the TPC. A second concept is based on a precision vertex detector, a drift chamber tracker with a silicon wrapper, a dual readout calorimeter, a two Tesla solenoid, and a muon detector. Both options are considered to be valid solutions for the CEPC detectors, but the final two CEPC detectors are still to be defined although it is likely they will be composed of the detector technologies included in these concepts and possibly beyond.

Questions

To maximize the CEPC physics output, global optimizations of the detector design and operation scenarios are indispensable. In addition, to develop the detector concepts into full-scale technical designs for the planned two detectors, a set of critical R&D tasks has been identified. Prototypes of key detector components will be built and tested. Mechanical integration, thermal control and data acquisition schemes must be developed. Industrialization of the detector component fabrication will be pursued. International collaborations will need to be formed before the detector designs can be finalized and the technical design reports can be developed. Some of the key challenges to be addressed in the near future are:

Physics Requirements Quantify the detector performance requirement towards the inclusive CEPC physics program (Higgs, EW, Flavor, QCD, and BSM researches) via benchmark physics measurements and analyses.

Software, reconstruction and computing Fast and efficient simulation tools, common software frameworks and computing systems providing efficient analysis and resources sharing that will allow a worldwide community to participate. Development of reliable digitization to validate sub-detectors. Advanced reconstruction algorithms optimized for different detectors, including taking advantage of Machine Learning techniques.

Fast Integrated Sensors Tracking solid state sensors suitable for extremely low-material tracking devices. Typically, these would integrate both sensing and readout units, have low power consumption, and good robustness against radiation. Examples, monolithic CMOS sensors, SOI.

Low-mass solid state tracking detectors Tracking devices based on solid state sensors, with low-material budget. Typically such detectors will be air cooled or depend on innovative low-mass cooling systems.

Gas Detectors Large volume gas detectors that can sustain large particle rates. New readout schemes, novel materials and techniques that can ease industrialization and lower cost.

Calorimetry High-granularity calorimetery requiring novel techniques such as Silicon-based calorimetry, and scintillators+SiPM-based detectors. Dual Readout calorimetry based on fibers or crystals.

Particle Identification Some particle identification (PID) capability is available in some of the detector concepts solutions, for instance in the TPC and Drift Chamber. Study the requirements for PID, and alternative solutions, including high-precision timing detectors capable of delivering single-track resolution better than 30 ps (e.g. based on LGAD sensors or crystals).

Detector Magnet Low-mass and high-field magnet design. Reinforced superconductors and high-temperature superconductors cables. Design of a ultra-light cryostat system.

Electronics ASICS using mainstream CMOS technologies (28/16 nm), and high throughput data links, high performance FPGAs, and optoelectronics.

Machine Detector Interface The MDI represents one of the most challenging tasks for the CEPC project. Topics to study include the interaction region layout and integration, the final focusing magnets, the beam pipe, the detector radiation backgrounds and the luminosity instrumentation.

Detector integration Overall design of the Data Acquisition System, high-performance cooling and detector mechanics, including low-mass mechanical structures.

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Low-mass solid state tracking detectors ....

Time Projection Chamber ......

Drift Chamber ......

Silicon Tracker ......

Calorimetry ....

Detector Magnet ....

References

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[2] The CEPC-SPPC Study Group, *CEPC-SPPC Preliminary Conceptual Design Report, Volume II - Accelerator*, 2015. http://cepc.ihep.ac.cn/preCDR/volume.html. IHEP-CEPC-DR-2015-01, IHEP-AC-2015-01. 1

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