CEPC Detector R&D Project

4.1 Scintillator-based Muon Detector Prototype

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| Last saved by on | 12/18/19 11:15:00 AM |
| Revision number: | 1 |
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Change history

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| **Revision** | **When** | **What changed and why** |
| 1 | 12/17/2019 | First draft |
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|  |  | < Add further lines to table as required > |

Readme first

1. Please do not delete or modify this section or its structure.
2. Only change text enclosed by (and including) angled brackets “< … >”.
3. Don’t change field directly, instead modify the document options, under File🡪 Properties (or similar)
   * Enter name of person that wrote the document in Document:Summary: Author
   * The project ID number, should follow the rules provided to you earlier. The number should be changed in Document:Custom: PBS.
   * The project name should be changed in Document:Summary: Subject.
4. In Section [*Project Objectives*](#ProjectObjectives) provide a brief description of the project goals, i.e. why and what is being produced, for PBS item **1.1** **Vertex Prototype**. If this project includes identifiable sub-projects you can indicate them in the [*Sub-projects Description*](#SubprojectsDescription) Section, otherwise submit a separate document for each of them. The sub-project IDs are free for you to define.
5. Finally, remember to update the [*Change History*](#ChangeHistory).

4.1 : Project Objectives

A simple structure of Scintillator + WLS fiber + SiPM is proposed for CEPC muon detector. Organic scintillator can be produced massively according to the geometry of the detector, and the required spatial resolution can be achieved by changing the width of the scintillator strip. Multiple hits in the muon detector with a good spatial resolution is used for muon identification. High density of scintillator and the dE/dx offer large output of scintillation photons, some of which are captured by WLS fiber and then guided to SiPM. Similar to TOF, a good time resolution and a narrow time window is possible for muon hits.

The objectives of R&D can be divided in to (1) procurement and testing of Scintillator strips and SiPMS; (1) improvement on light output and collection with high signal-to-noise ratio; (2) time/spatial resolution measurement benchmark and improvement; (3) radiation hardness test; (4) prototype detector arrays for detecting muon tracks from cosmic rays.

4.1 Scintillator-based : Sub-projects Description

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| **Project ID** | **Title** | **Description** |
| 4.1 | SiPMs and Scintillator strips procurement | High Gain SiPMs and high light output and short decay time scintillator strips procurement and Q/C testing.  This can be studied with some MPPCs from HAMAMATSU and some scintillators purchased in China. The specific MPPC of interest is one kind SiPM used comprehensively in Belle II and T2K experiments. More studies with different kinds of SiPMs should be performed to find the best SiPM for CEPC. We also need to study SiPM performance and trying to improve the quality of the scintillator strips. |
| 4.2 | WLS fiber and optical couplings | Improve photon collection efficiency with WLS fiber and couplings to SiPM.  This is about how to improve the photon collections for a large muon hit signal. The type of WLS fiber, the couplings between fiber and scintillator, between fiber and SiPM should be studied carefully. |
| 4.3 | Time/spatial resolution measurements | Signal detection performance benchmark and improvement.  This is to do a complete test of experimental setup and perform the (injected) signal efficiency and time/spatial resolution measurements. Simple readout electronics for testing will also be studied. |
| 4.4 | Radiation Hardness of SiPM and scintillator | Study the performance of SiPM and scintillator after the projected radiation level for CEPC.  This should be performed by MC simulation and beam testing. The noises of SiPM and scintillator, and the gain reduce of SiPM should be studied. |
| 4.5 | Prototype construction: Multi-layer detectors | Several layers of scintillator modules constructed to build a detection array for cosmic rays test.  This is the prototype study. Sensitive detector channels of scintillator+fiber+SiPM setup will be constructed to build a single module, and several layer of modules will be then combined to build an array. DAQ system with the test stand will also be built and integrated with readout electronics. Studies with cosmic ray should be performed, especially reconstruction the cosmic ray tracks with high efficiency. |
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4.1 Scintillator-based : CEPC Relationship

The activities are a part of ongoing CEPC muon detector R&D. Scintillator-based muon detector is one of the highly considered CEPC muon detector options.

4.1 Scintillator-based Muon detector Prototype: Project Schedule

Project 4.1 can be completed soon after sufficient funding is secured, hopefully by end of 2020.

Project 4.2 can be completed after 4.1, hopefully also by end of 2020.

Project 4.3 can be completed after 4.1 and 4.2, hopefully by end of 2021.

Project 4.4 can be completed by end of 2022.

Project 4.5 can be completed by end of 2023 once sufficient funding is secured.

4.1 Scintillator-based : Funding Availability

We have limited funding support from Fudan University (mostly for Belle II experiment upgrade R&D, which can cover a small portion of 4.1 and 4.2) and Shanghai Jiao Tong University (mostly for CEPC Phase-I general software simulation and performance studies).

We are in short of R&D funding and we are requesting 600K CNY to complete 4.1-4.4 and prototype building (4.5).

4.1 Scintillator-based Muon detector Prototype: Leadership Arrangement

Leaders: Xiaolong Wang (Fudan University) and Liang Li (Shanghai Jiao Tong University).

Leading institute for this project will be Fudan University (led by Xiaolong Wang) with strong contributions from Shanghai Jiao Tong University (led by Liang Li) on all sub-projects. Significant participations are also expected to come from Institute of High Energy Physics at Beijing (led by Zhi Wu).

4.1 Scintillator-based Muon detector Prototype: Manpower Resources

< Briefly summarize the manpower resources available for the project, including type (student, faculty, engineer, etc) and FTEs for each type. >

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| **Type** | **Average FTE Expected** |
| 3 Faculty | 1 |
| TBA Postdoc | TBA |
| 5 Students | 2.1 |
| 1 Engineer | 0.2 |