CEPC Detector TDR Meeting

Date/Time: Feb. 6, 2024; 09:00 - 12:50 (Beijing Time)

Meeting agenda and minutes

- indico page: https://indico.ihep.ac.cn/event/21572/
- Participants:
  - Present in the meeting room:
    - Yifang Wang, Zhaoru Zhao, Jianchun Wang, Yong Liu, Wei Wei, Zheng Wang, Gang Li, Mingyi Dong, Meng Wang, Manqi Ruan, Jingbo Ye, Jinyu Fu, Ling Zhao, Guang Zhao, Huaqiao Zhang, Shanzhen Chen, Fei Li, Feipeng Ning, Haoyu Shi, Huirong Qi, Yiming Li, Lianyou Shan, Quan Ji
  - Online
    - Shaojing Hou, Shengsen Sun, Yunpeng Lu, Xinchou Lou, Haijun Yang, Tao Lin, Lei Zhang, Jinfei Wu, Yubin Zhao, Hongyu Zhang, Miao He, Hideki Okawa, Yuekun Heng, Wei Wei, Ying Zhang, Fangyi Guo, Linghui Wu, Zijun Xu, Weiguo Lu, Mingshui Chen, Xuai Zhuang, Zhen-An Liu, Weiren Zhou, Zhonghua Qin, Xin Shi
- Minutes: Yong Liu, Zhaoru Zhang

Management and timeline for TDR: Jianchun Wang

- Slides by Jianchun
- The table of L2/L3 managers is updated, and personnel information of sub-system is integrated
- Considerations for some sub-detectors (e.g. tracker+TOF)
- Timeline as a reminder

Physics benchmarks planning for TDR: Manqi Ruan

- Slides by Manqi
  - A list of physics benchmarks, with different levels of priority and important
  - Resources needed
- Decisions
  - **Choose ~5 benchmarks** (max. 7) which have importance in physics and links to sub-detector systems
  - Physics benchmarks have a relatively lower priority than software developments before the software and detector options are finalized.
  - **Workable software (CEPCSW) in June 2024**

Software for TDR planning: Shengsen Sun

- Slides by Shengsen
  - Geometry status for sub-detectors (Chengdong Fu)
  - Key performance for vertex, tracker, calorimeters
  - A requirement list for software
  - Other focuses: detector layout, material budget, background/noise, mechanics, cost
- Decisions

    - Software developments: the highest priority
    - Also consider the relatively short timeline of option converging -> not necessarily need to develop software for all sub-detector options
    - Main/important decisions should be made by the L1 leader group (Jianchun, Joao, Miao, Mingshui)
- Important topics
    - **R/Z ratio: needs to be determined soon**
        - cos(theta) ~0.85
    - **Tracker inner/outer radius: fixed at 0.6m/1.8m respectively** as the current baseline for performance comparisons
    - Criteria: **the highest priority for Higgs**, requirements from Z-pole only for reference
- Arrangements for Weekly TDR Meetings every Tuesday
    - Routine agenda: **always firstly discuss software and mechanics progress/status**
    - **All L2 leaders** should report the status and planning
    - **All sub-system teams** should arrange weekly meetings -> indico pages and minutes should be well prepared and notified to L1/L2 managers

Detector mechanics: Quan Ji

- Slides on general considerations and planning by Quan Ji
    - First focus on structure designs, then consider assembly
    - Experimental Hall: a tentative design
        - Yifang: space must be included for electronics cabinets
    - Assembly has less priority than mechanic design
    - Key technical specs and validation
        - 3D simulation -> verify design
        - Key technical questions and parameters -> investigation
        - Feasibility and costs
- Planning and arrangements
    - **Deadline for a first version of mechanics design (机械总图): April, 2024**
    - **New person power**: responsible persons for sub-detector systems
        - Jinyu Fu: vertex and tracker
        - Shaojing Hou: HCAL and ECAL
    - **Yifang: mechanics people should attend all related sub-system weekly meetings; Quan Ji should also organise mechanics weekly meeting**s
    - Yoke design progress: to be presented in the next CEPC Day

Yoke design: Feipeng Ning

- Slides by Feipeng
    - Dramatic difference in two yoke designs: 40k ton (high cost) vs 1k ton (stability/feasibility issues)
    - A table of stray field from BES3 and Belle2
- Discussions
    - Yifang: suggest Feipeng and Ling consider stray field of 50 Gs and 5m (maybe ->10m)
    - Cost estimates
        - Steel: 6k CNY/ton raw materials; a factor of two for further processing

        - 3k ton yoke: probably a good estimate
    - Stray Field
        - Good references from BES3 and Belle2 (e+e- colliders) rather than ATLAS/CMS (pp collider)
- Planning
    - **Yifang: critical decision to be made on HCAL inside or outside magnet**
        - **Cost assessments and technical feasibility and risks -> an action item for Feipeng**
        - First to decide the magnet location, and later yoke design
        - First priority: to address critical issues
        - **Prepare schedules in a granularity of weeks**

Vertex detector: Zhijun Liang

- Slides by Zhijun
- Discussions
    - **Xinchou: prepare documentation and minutes on the justifications of the option selection process and decision**
- Critical decisions
    - **"CMOS pixel" selected as the baseline option for vertex**
    - **For those sub-detector options not selected in the TDR, L3 leaders will be removed accordingly**

Tracking detector: Meng Wang

- Slides
    - A developing schedule
    - Criteria for deciding a detector technology
        - Performance, cost, readiness (strongly depends on timeline (3-5 years))
- Important topics
    - **Jianchun: Z-positioning precision requirements -> to be determined**
    - **Two major tracker options: TPC vs Drift Chamber**
        - Yifang: critical decision based on thorough comparisons
    - **Endcap material budget**
        - Manqi: endcap material budget <1X0 (hard limit)
- Decisions
    - **Yifang: barrel-endcap boundary - cos(theta) around 0.85**
    - **Tracker Radius range: 0.6 m - 1.8 m**
    - Yifang: the same person for the mechanics design and its validation for each sub-system

Calorimetry

- Slides and status by Yong
    - Yong reported the option selection criteria (while Jianbei is absent)
        - Down-select criteria for calorimetry options: summarised after collective discussions, which could be used a template for other sub-systems
    - Oral report on status by Yong: had first meetings with electronics and mechanics teams

- Important topics and planning
    - **HCAL geometry (barrel design) in Phi direction**
        - Yifang: need to decide 8 or 16 phi-segments before end of Feb, so that software and mechanics teams can move on based on the design; **can start with 16 phi-segments as the baseline**
    - Endcap region
        - Yifang: need to design
        - Yong: radiation issues on BGO crystals (and SiPMs) in the endcap/forward regions
    - Haijun and Manqi
        - **HCAL total depth: fixed 6 lambda to cover the ttbar**
    - Yifang: HCAL
        - Further HCAL optimisation studies of layer thickness and transverse granularity to balance between performance and cost saving
    - Yifang: PFA
        - First develop reconstruction for crystal ECAL, and combine with HCAL using Arbor; the critical decision can be made slightly later than June 2024

Muon detector: Xiaolong Wang

- Slides by Xiaolong
    - SiPM-scintillator R&D status and planning
    - Plastic scintillator R&D
- Important topics and planing
    - Yifang
        - **Comparison of costs and performance: SiPM-Scintillator vs RPC**
        - **Optimisation studies: layer thickness and number of layers**
        - **Necessary to include energy measurements, espe. (high-speed) waveform sampling in muon detector?**
    - Jingbo:
        - **Considerations for the general-purpose design in electronics, e.g. for SiPM-readout**
    - Muon ID and Long-live particle (LLP)
        - **Manqi: major contributions of muon ID to BMR from HCAL; low-energy muons difficult for detection**
    - Yifang
        - **LLP searches: should be considered in the trigger schemes**
        - **Large potentials in cost saving from electronics**
        - **Will be a dedicated SiPM-ASIC developed for HCAL, which can be used for the muon detector**

Electronics: Wei Wei

- Slides by Wei
    - Summary of last week progress based on separate discussions
        - Vertex (Zhijun), calorimeter (Yong), Silicon Pixel Detector (Yiming), LGAD TOF (Zhijun)
        - Strong requirements on clock synchronisation
- Discussions

    - TOF time resolution
        - Time resolution requirement ~50 ps
            - Major the 1GeV kink in the K/pi separation curve; could be compromised if necessary
    - Yong: critical question for the crystal calorimeter design
        - **Critical decision on the possible degraded performance due to the mechanics, cooling and electronics (data+power)**
- Planning
    - **Yifang: wireless data transfer using mm-microwave technology**
    - **Wei: propose Jun Hu to report the WDT progress in next CEPC Day meeting**

MDI and LumiCal: Haoyu Shi

- Slides by Haoyu: beam-induced backgrounds
    - Estimate of impacts and radiation at 50MW
    - Background samples -> detector optimisation
    - Current status: planning towards a first version
- Decision
    - Yifang: on the safety factor
        - **A safety factor of 10 should not be set as a default setting**
        - **Should report the only uncertainty without any safety factor**
        - In special cases, the safety factor should be clearly specified
        - **The same criteria shall also apply on cost estimate**

Magnet: Feipeng Ning

- Heat leakage
    - Action item: Feipeng will talk to Rui Ge soon

AOB

- **Suggestions by Xinchou: general MC productions** for
    - Event samples for physics benchmark studies
    - Fast simulation: detector optimisation and option selection (not necessarily DELPHES, but focus more on the sub-detectors)
- Follow-up action items
    - Manqi will arrange further discussions and task assignments
    - Gang: full simulation and DELPHES for fast simulation