CEPC Detector TDR Meeting (Mar. 19, 2024)

09:00 - (Beijing Time)

Meeting agenda and minutes

- indico page: https://indico.ihep.ac.cn/event/21975/ (https://indico.ihep.ac.cn/event/21975/)

- Participants

    - Present in the meeting room (M.B. 112)
        - Zheng Wang, Jingbo Ye, Zhijun Liang, Manqi Ruan, Huaqiao Zhang, Mingshui Chen, Jianchun Wang, Zhaoru Zhang, Weidong Li, Yong Liu, Feipeng Ning, Yiming Li, Gang Li, Shengsen Sun, Quan Ji, Huirong Qi, Yunyun Fan, Wei Wei, Jinyu Fu, Shanzhen Chen, Guang Zhao
    - Online
        - Fangyi Guo, Fei Li, Chengdong Fu, Haijun Yang, Haoyu Shi, Hengne Li, Hongyu Zhang, Suen Hou, Huirong Qi, Jingzhou Zhao, Jun Hu, Miao He, Mingyi Dong, Tao Lin, Meng Wang, Shang Xia, Xiaolong Wang, Xin Shi, Xinchou Lou, Xiongbo Yan, Yao Zhang, Ying Zhang, Yunpeng Lu, Yunyun Fan, Zhan Li, Ling Zhao, Ye Chen, Shaojing Hou, Junsong Zhang
    - Minutes: Yong Liu, Zhaoru Zhang

Software: Weidong Li

- Oral updates by Weidong
    - Geometry implementation: double-layer silicon tracker
    - Progress on ACTS (discussions with CERN colleagues)
- Oral updates by Shengsen
    - Progress on jet performance with long-crystal bar configuration -> ongoing validation to the BMR
- Discussions
    - Zhijun: 2mm distance between one double layer -> should be treated as two separate layers in tracking
        - Weidong: yes
    - Zhijun: software release timeline (tracker related)?

- ■ Weidong: the end of next month

Electronics: Wei Wei

- Status report by Wei (slides (https://indico.ihep.ac.cn/event/21975/contributions/152955/attachments/76644/94896/elec_0319.pptx))
  - ○ TOF and silicon strip: preliminary readout strategy and rough cost estimation
  - ○ Silicon pixel tracker: data rate
  - ○ Crystal ECAL: requirements on readout electronics (accuracy needs further discussions
  - ○ Plan
    - ■ To determine preliminary readout scheme of calorimeters
    - ■ To summarise
- Discussions
  - ○ Meng: considerations on mechanics of electronics
    - ■ Jianchun: to use the supporting structure of gas-based tracker
  - ○ Suen: fast electronics to address the pile-up issue (23ns bunch spacing)
    - ■ Jianchun: occupancy and backgrounds expected lower than LumiCal
    - ■ Jianchun: 5% dead time in LHCb (peak time+25ns bunch spacing), not seriallised readout -> negligible

Mechanics: Quan Ji

- Status report by Quan (slides (https://indico.ihep.ac.cn/event/21975/contributions/152956/attachments/76655/94913/20240319CEPC%E6%8E%A2%E6%B5%8B%E5%99%A8TDR%E6%9C%BA%E6%A2%B0%E8%AE%BE%E8%AE%A1%E5%B7%A5%E4%BD%9C%E8%BF%9B%E5%B1%95.pdf))
  - ○ Global design: updates from sub-detector dimensions
  - ○ Gap between sub-detectors: 15mm
  - ○ Beampipe and LumiCal: integration and positioning alignment precision
  - ○ Vertex detectors
    - ■ Deformation due to self-weight
    - ■ Air-cooling design and simulation with various air-flow speeds
    - ■ Air cooling may not work with vertex endcaps
  - ○ TPC: endcap design difined
  - ○ Silicon tracker: 1.1mm deformation of 3rd-layer (3200mm long)
  - ○ Calorimeters: boundary definition needs more discussion

- o Magnet: dimensions update accordingly to calorimeters
- o Iron yoke: > 5000 ton
- o Assembly of sub-detectors
- Discussions
  - o Detector explosion plots
    - ▪ Jianchun: try to fix the colour scheme
    - ▪ Meng: to add a scale (e.g. a person)

Magnet: Feipeng Ning

- Status report by Feipeng: slides
  (https://indico.ihep.ac.cn/event/21975/contributions/152957/attachments/76643/94905/CEPC%20Detector%20M
  agnet%20ref%20TDR%20Physical%20Design%20RT_V1.1.pptx)
  - o Yoke: 3kton -> 5kton
  - o Magnetic field: non-uniformity: 19.2%
  - o Yoke and stray field
    - ▪ Add pole head; extend coil and add compensation coils
    - ▪ Optimisation objective: peak-peak non-uniformity < 10%
- Discussions
  - o Manqi, Jianchun, Meng: **gradient** of B-field would have more impacts to tracking prevision, rather than peak-peak non-uniformity like an integrated variable
  - o Weidong: measurement precision from B-field?
    - ▪ Weidong: e.g. in Drift Chamber, non-uniformity may not corrected due to strong B-field distortions
  - o Jianchun: provide inputs of B-field by comparing a few scenarios to tracker group
    - ▪ Step size to be determined: tentatively 10cm? can be iterated
  - o Huirong: within certain regions of sub-detectors
  - o Yao Zhang:
    - ▪ Studies on low-momentum particles: a factor of 10 from measurement precision to tracking precision
    - ▪ B-field distortion -> spacial resolution -> tracking precision

MDI: Haoyu Shi

- Status report by Haoyu
  - o Beam-induced backgrounds
    - ▪ Results in ROOT files: hit density, TID, neutron flux
    - ▪ More reliable results from "pairs", less reliable in beam loss

- Background code: ongoing migration to CEPCSW
  - LumiCal
    - Positioning precision requirements
    - Crystal part and SiW part -> geometry in CEPCSW
    - Luminosity measurements with other sub-detectors
  - Optimisation of Interaction Region
- Discussions
  - Jianchun: High energy hardon will be considered later
  - Meng: hit definition in the "hit density"
    - Haoyu: a step in Geant4 by charged particles
    - Meng: Care more about particle density, which can distinguish charge/nutral particle
  - Jianchun: take care of daughter particles of primary charged particles

Vertex: Zhijun Liang

- Status report by Zhijun: slides
  (https://indico.ihep.ac.cn/event/21975/contributions/152958/attachments/76657/94919/Vertex-20240319v2.pptx)
  - MDI background plot
  - Geometry update for CEPCSW release
    - Chip and ladder dimensions
    - To finalise the 1st draft of layout design in the end of March
  - Long barrel cabling
    - Optoelectronics module: radiation hardness, space
  - Beampipe cooling: water vs oil
- Discussions
  - Gang: endcap in long barrel configuration
  - Jianchun: great caution of water near Beryllium beampipe at LHC
  - Yiming: planning different Taichu chip dimensions?
    - Zhijun: yes, wider/longer Taichu chips in outer layers
  - Wei: longer chips lead to worse timing, but less concerns to 10-year Higgs run
  - Suen: suggest consider optoelectronics readout in all sub-detectors to minimise cabling

Tracker: Meng Wang

- Status report by Meng: slides
  (https://indico.ihep.ac.cn/event/21975/contributions/152959/attachments/76653/94910/20240319_wm_tracker.pptx)
  - Silicon inner tracker: layer optimisation with fast simualtion
  - TPC: readout module optimisation, dN/dX, hit density
  - Silicon pixel tracker: data rate wo beam background, timing requirements (TBD)
  - Silicon strip tracker: beam background study, layout
  - LGAD and TOF: number of modules and channels; readout scheme, cost estimation
  - Performance: TPC vs DC
- TPC status by Huirong: slides
  (https://indico.ihep.ac.cn/event/21975/contributions/152959/attachments/76653/94912/CEPC_TDR_TPC_IHEP_Huirong_20240319.pdf)
  - Finalised tracker geometry -> optimisation of modules at endcap
    - Improvement: 92% -> 96% in sensitive detection area coverage
    - Table of performance parameters at Higgs and Z
  - Performance in simulation
    - Simulation framework: Garfield++ and Geant4
    - PID performance: 3σ separation of π/K at 20 GeV with dN/dX; 3.2% with dE/dX only
    - Maximum distortion: with updated geometry
    - Hit density at inner radius at 2T (Z-pole): 0.05Gbps data with 25ns bunch spacing
  - Validation
    - Power consumption requirements: 10kW in total, <100mW/cm^2 (2nd prototype to validate)
  - Cost estimate: <180M CNY
    - Update from back-end electronics: lower cost
- Discussions
  - Jingbo: 1Mbps/chip, why 3 orders of magnitude less than vertex detector (48-bit)
    - Wei: 30Mbps in the first inner tracker, based on projection from vertex detectors
  - Manqi: TPC endcap material budget (<0.5X0?)
    - Huirong: 17%X0 in total, including 10% cooling, 7% cabling and other services

Calorimeters: Jianbei Liu

- Status report by Jianbei: slides
  (https://indico.ihep.ac.cn/event/21975/contributions/152960/attachments/76658/94925/updates.pdf)
  - HCAL thickness enlarged to 1470 mm to cover 6λ (48 layers) for ttbar running
  - Detector boundaries are determined
    - dR=300mm for ECAL; dR=1550mm for HCAL
  - Cost estimate:
    - Identified crucial parameters
    - CMS HGCAL is used as an important source
    - First version presented for different options -> more iterations
  - All options: refining layout within the fixed boundaries
    - Including dead materials
  - Readout electronics and cooling designs: to be reinforced
  - Need input from beam backgrounds -> ECAL/HCAL performance and data rate estimation
  - Started considerations of endcap layout design
    - Yong collected and shared references on CMS-HGCAL and ILD-AHCAL endcap designs
- Discussions
  - Jianchun: barrel crystal ECAL layout

Muon detector: Xiaolong Wang

- Status report by Xiaolong: slides
  (https://indico.ihep.ac.cn/event/21975/contributions/152961/attachments/76659/94920/Muon_20240319.pdf)
  - Updated comparison table: scintillator vs. RPC
    - $5.6\mathrm{kCNY/m^2}$ (scintillator) vs $7.5\mathrm{kCNY/m^2}$ (RPC at Daya Bay)
    - RPC activities discontinued at GNKD
  - Muon detector Geant4 simulation
    - WLS fiber diameter: 2mm in consideration (previouly 1.2mm)
- Discussions
  - Jianchun
    - Peak luminosity: the quoted number for RPC is for proton collider and also depends on the distance of muon detector to IP -> need a more appropriate number
    - Need to refine the parameters/naming for comparison
  - Zheng: 4-layer RPC (3 RPC modules) at Daya Bay

- Jianchu: Zheng Wang can help provide more inputs on Daya Bay RPC

Physics: Manqi Ruan

- Oral updates
  - Physics studies in CEPCsoft
    - Pending on CEPCSW updates
  - International colleagues
  - Samples of beam-induced background -> further validation
- Discussion
  - Weidong: suggest to use new CEPCSW to analyse old data for existing physics benchmarks