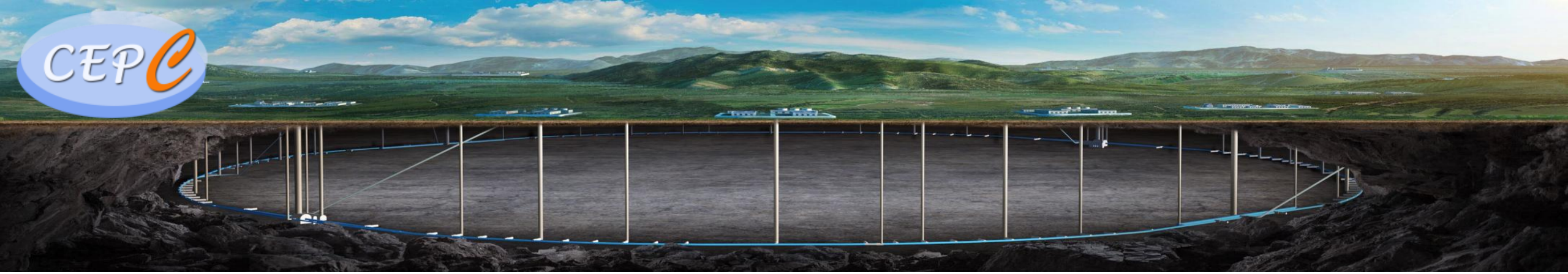

Discussion of the Second IDRC Meeting Report:
Overall Construction Cost and Timeline

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Findings

- The cost estimation is provided as an ancillary table outside the Ref-TDR, following a standard Work Breakdown Structure (WBS). Only summary tables for the baseline detector option are included within the TDR text itself. Costs are primarily based on raw material prices (by volume, weight, or area), projected over the next 5 to 10 years, and multiplied by a fabrication factor.
- Currently, only a very rough timeline for detector construction is presented in Chapter 16 of the TDR.

Comments (1)

- For future, more informed cost reviews, it would be beneficial to provide the full WBS information, with a breakdown of:
  - Raw material costs
  - Production costs (including fabrication losses)
  - Labour costs
  - Integration costs
- Additionally, for each item, the following should be clearly specified:
  - Unit description (clearly linked to the detector design)
  - Unit cost (in original currency)
  - Basis of the estimate (e.g., vendor quote, internal prototype, previous projects, catalogue pricing)
  - Quantity required for the detector
  - Quantity including yield loss
  - Total quantity and total cost
- It should be explicitly stated whether the current costs include allowances for yield loss.
- A structured, consistent table format for each major cost item would greatly improve clarity and traceability.
- We plan for an internal cost review for each system in the second half of this year, with all above suggestions included. An international cost review is under consideration.

Comments (2)

- Concerning computing costs: while the extrapolations appear reasonable, the model could be further refined by considering data size, number of re-processing, number of data copies, and data accumulation schedules. Even a small additional effort to refine or document these factors would be valuable.
- The projections for hardware performance and price evolution over 10 years seem somewhat optimistic, as they combine assumptions of improved CPU performance per core with reductions in cost per core.
- The physics group and the offline group will work together to improve the estimation of data size and requirement of data processing. The extrapolation model will be further refined by analyzing price trends.

- Regarding the detector construction timeline, the information currently provided is too limited to allow for a meaningful assessment.
- A detailed timeline will be worked out in the detector EDR stage.

ECAL BGO Crystals

- The cost of BGO crystals significantly impacts the overall budget. The table presented dates back to 2019. We recommend engaging with multiple vendors to ensure the required quality, production rate (given the enormous volume), and lowest possible price.
- Before and after the review, we visited three suppliers of BGO.
  - SIC can produce BGO crystals of 1.5x1.5x40 (up to a meter) cm^3 by modified Bridgman method.
  - Xiamen Tungsten can produce BGO crystals of 8" x 3" by Kyropoulos method with possible significant reduction of cost compared with Bridgman method. They are working on longer (40 cm) crystals.
  - Boya can produce BGO crystals of 3" x 8" by Czochralski method while the cost is similar to Bridgman. They also plan to try Kyropoulos method.
  - **Action: collaborate with Xiamen Tungsten and Boya developing new methods**
- We also visited the research institute of the Aluminum Corporation of China (Chinalco) and its subsidiary, Yunnan Chihong Germanium International Co., Ltd.
  - Production capacity fully meets CEPC's requirement (~50 ton GeO_2)
  - **GeO_2 price increased by a factor of two since 2023, hard to predict the future trend**
  - **Action: potential collaboration with Chinalco through a high-level channel.**

SiPM Packaging Costs

- The cost of packaging could be as high as 50% or more. It should be clarified whether packaging costs are included in the quoted SiPM price, and this should be explicitly reflected in the WBS. The current estimate of 1.25 CHF per channel may be optimistic.
  - TAO uses SiPM 6×12 mm^2, 8 times larger than CEPC SiPM 3×3 mm^2
  - Assuming the cost packaging for CEPC is 50%, and for TAO is 25%, the new estimation is 20 RMB/piece, twice of our expectation.
  - Plan to ask Hamamatsu to give a new quote. Looking for new vendors. Further decrease is expected in the next 5 years.

	TAO	Extrapolated to CEPC
Material	10 RMB	10 RMB
Packaging	3 RMB	10 RMB

Price of SiPM per 3×3 mm^2 based on TAO's experience

HCAL Cost Estimates

- Currently, the lowest informal offer is used for the cost of glass plates. Until it is confirmed that the lowest bidder meets the required specifications, it would be more prudent to use the average of the three quotes.
- The average price is 0.8 CHF/cc, 40% higher than our expectation (~0.5 CHF/cc). We will continue working with the three suppliers, to investigate their difference and to verify if the lowest price is reasonable.
- Additionally, the cost estimate assumes one SiPM per glass plate, whereas the detector design currently requires four SiPMs per plate for viability.
- In the new version of the TDR, the baseline design has been changed to one SiPM per glass plate.
- Some cost uncertainty reflecting the outcome of ongoing R&D should be included.
- If taking the difference between suppliers, the cost uncertainty is 40%, mainly coming from raw materials, the estimated yield and manufacturing procedure since it is a new material.

Muon Detector Electronics

- The cost book reports 43,000 ASICs, 43,000 FEE units, and 43,000 Readout FEE units. However, the readout architecture has recently been updated to a three-stage system, and the number of FEE boards (uFEBs) should be significantly lower than the number of SiPM channels. The cost estimate should be updated to reflect this new architecture.
- Additionally, the TDR mentions the need for 72 Management Boards for slow control and DAQ interfacing—these boards are currently missing from the cost book and should be added.
- The cost estimation including has already converted the total cost into the cost per single channel. Management boards are part of the on-detector FEE. The recent updates of the readout architecture, e.g. number of management boards from 72 to 80 are being incorporated into TDR and with be used to reevaluate the cost.

Magnet Cost Comparison

- The TDR quotes a magnet cost of about 22 MCHF, compared to around 130 MCHF for the more complex ILD system (which includes the yoke). A cross-check should be performed to understand and justify the difference between these two estimates.
- An internal review of the magnet design was organized on May 16. A detailed comparison with ILD will be done afterwards and a dedicated internal cost review is foreseen.

TPC Cost Comparison

- Similarly, the TPC cost is estimated at 5 MCHF, whereas the ILD TPC estimate was 36 MCHF. This discrepancy should be investigated and explained.

  - TPC cost (kCHF) in CEPC : 5223 + 1094 = 6317 (6.3 MCHF)
    - Electronics / Cost_total = 47.5%
  - TPC cost (kCHF) in ILD : 15360 (15.4 MCHF) using Micromegas
    - Electronics / Cost_total =57.2%
  - TPC cost (kCHF) in ILD : 19070 (19.1 MCHF) using GEM
    - Electronics / Cost_total = 46.5%@GEM

TPC Cost Comparison

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Items	Pixelated reaout TPC @CEPC kCHF	Micromega TPC @ILD KCHF	Comments
Fieldcage: Hanging, damping and shipping	0	468	230kCHF should be added refer to mechanical
mesh and DLC	0	524	350kCHF should be added refer to USTC/KEK
Laser system	0	505	325kCHF should be added refer to IHEP R&D
Assembly on site	0	2023	Labor cost (w.o.)
Management	0	56	Labor cost (w.o.)

TPC Cost Comparison

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System	Cost (kCHF)
Gaseous tracker	5,223
Common Mechanics	1,997
MPGD Readout	518
Electronics (FEE)	2,149
HV /Gas system /Calibration	407
Installation (3%)	152
Extra cost for back-end electronics	1,094

+905