

Cold Electronics – Mechanical Parts Cost and Schedule

Marco Verzocchi

Fermilab

Cold Electronics Mechanical Review

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When are the various parts needed

- Production parts
 - CE boxes
 - As soon as possible, will want to test APAs with “new” / “final” FEMBs
 - Assume Fall 2021
 - Cable trays
 - When we start integration of the detector in the clean room outside the Cryostat at SURF (official date August 2024)
 - Cryostat penetrations
 - Needed sometimes between completion of the cryostat steel structure and readiness for detector installation
 - Required to seal the cryostat (leave only manholes / TCO open, reopen individual cryostat penetrations for cable routing)
 - Schedule not completely clear, assume October 2023

There is ample time

- CE boxes
 - Make new prototypes when design of ASICs/FEMBs/cable plant complete, assume this is in Fall 2020
 - Use prototypes for integration tests with DUNE APA at CERN in late 2020, test of initial APA production
 - Bulk order in early 2022 (order for O(6000) pieces, production can be spread over 2-3 years)
- Cable trays
 - Prototypes required for test stand at BNL and later at Ash River
 - Production needed for Fall 2024
 - All commercial parts, minimal machining (cutting trays / supports to length)
 - Bulk order in 2023

There is ample time

- Cryostat penetrations
 - Prototype needed later this year for equipping test stand at BNL
 - Eventual second prototype in 2020, to be moved to Ash River
 - 150 cryostat penetrations plus spares needed at the end of 2023
 - Launch production at the beginning of 2022
 - Do we need a mockup with actual parts from the cryostat (i.e. cryostat crossing tube and relevant flange) ?
 - Yes, and do it as soon as the cryostat design is complete (now ?)
 - Define the quality control procedures for the cryostat penetrations
 - Pressure test'
 - Helium leak test after installation / after cable routing
 - Do we need to perform X-ray inspections on the welds ?

When can we complete the design ?

- Significant progress made in design
- Clearly need to implement the documentation
- Main engineer is Manhong Zhao with support from other personnel at BNL for generating drawings
- Next steps are
 - Completing / Improving documentation
 - Perform FEA of gas flow, understand temperature gradients (cryostat penetrations)
 - Mockups
 - Improve understanding of interfaces with DSS/APA/cryostat
 - Improve the design if needed

When can we complete the design ?

- It seems reasonable to have another check-point (Engineering Design Review) roughly 1 year from now, we will have much more information, including results from mock-ups
- Production readiness review at the beginning of 2021 (needed for the CE boxes, for other components it could be delayed until later)

Costs (i)

- Cost of CE boxes is not going to be much different from that of ProtoDUNE (\$126.18 per box, plus \$15.21 for custom mailers, expect some cost reduction for very larger order)
 - Fabricated in industry
 - Documented in DocDB-10165 (access restricted)
- Cost of DUNE cryostat penetration estimated at \$8,552, based on extrapolation of ProtoDUNE penetration (inflate cost of spool piece by 50% to account for additional port)
 - Fabricated in industry
 - Documented in DocDB-10359 (access restricted)
 - Will soon have quote for fabrication of prototype
 - CE flanges: additional \$432.16/flange + \$1,164.00 (NRE) plus labor for testing (1h per flange, equipment exists, need He gas refill), documented in DocDB-10356

Costs (ii)

- Cable trays
 - Initial estimate was \$35k for cable trays corresponding to 1.5 times the length probably required, will have to re-estimate now that the design has been updated, clearer scheme for cable trays support
 - Documented in DocDB-10353 (access restricted)
 - Currently cable trays may be double counted (both under APA and under CE, original design had both cable trays supported by APA and cable trays supported by DSS for which CE was responsible)
 - Now single design, support shifts after installation
 - Will address in APA/CE interface document
 - Small item
- Overall CE boxes (\$425k) + cryostat penetrations (\$707k) + cable trays (\$50k) are ~\$1.3M total for one SP detector, including reasonable amount of spares