

# LBNF Horn A Prototype Final Design Review and Long- Lead Item Production Readiness Review Closeout



**E. D. Zimmerman (Chair)**  
**University of Colorado and CERN**  
**29 January 2021**

# Review Panel

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- Kris Anderson, Fermilab
- Alessandro Dallocchio, CERN
- Yun He, Fermilab
- Tetsuro Sekiguchi, KEK
- Eric D. Zimmerman, Univ. of Colorado and CERN  
(chair)

# Review

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- Combined Final Design Review (FDR) of Horn A Prototype and Production Readiness Review (PRR) of long-leadtime items
- Nine long-lead items were identified
- Review sessions took place January 26-29 via Zoom

# General impressions

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- The panel was highly impressed with the quality and completeness of the work.
- Interaction with the project team has been excellent and all questions have been answered quickly and completely

# Draft answers to charge questions

1. Does the final design meet the requirements of LBNF/DUNE?
  - a. Are the requirements clearly stated, documented and approved? **Yes.**
  - b. Have design choices been fully identified and documented and do they meet LBNF/DUNE beamline requirements? **Yes.**
  - c. Specifically, is the horn design lifetime sufficient to meet the beamline uptime requirement of 55% (including the annual summer shutdown) which assumes a projected efficiency for component changeout at 93%? **Yes, for the fatigue lifetime. Other known failure modes of horns have been considered and addressed.**
  - d. Does the design meet electrical design requirements? **Yes.**
2. Has the safety of the design been adequately assessed? Have design and analysis efforts been thoroughly addressed and validated?
  - a. Have the relevant safety and engineering standards been correctly identified? Have design efforts been conducted using appropriate engineering standards and best practices (e.g., Fermilab Engineering Manual, ASME B31.3)? **Yes.**
  - b. Has the FEA and structural analysis been completed – including the impact of both beam heat loading at 1.2 MW and thermal-mechanical loads under full current? **Yes, pending analysis of beam heating over 10  $\mu$ sec vs. 0.8 msec as currently studied.**
  - c. Have appropriate safety factors been specified? **Yes.**
  - d. Have both the FEA and structural analysis been independently reviewed? Does the independent review report demonstrate that the design complies with all applicable safety and engineering standards? **Internal peer reviews have been done, but not yet documented to the panel.**



# Draft answers to charge questions

3. Have interfaces with other systems been addressed, agreed and documented?
  - a. Have all interfaces with the LBNF/DUNE target been properly identified and the specifications finalized and documented? **Yes.**
  - b. Does the design accommodate any forseen changes to the final LBNF/DUNE target design, in particular length variations within the range of 1.5 m – 1.8 m? **Yes, in the case where target remains cantilevered from upstream. Provisions for alternate target designs can be accommodated as well.**
  - c. Have all interfaces with Near Site Conventional Facilities (NSCF) been adequately identified and documented? **The horn only has interfaces with the support module, so no interface with the conventional facility is expected other than insertion/extraction paths.**
4. Is the plan for tests sufficient to validate the design? **Yes, pending resolution of the recommendation to complete the field mapping probe and assure it is compatible with the port design.**
5. Are all 3D CAD models available and do they demonstrate that there are no interferences with the NSCF? Are all 2D drawings complete and appropriate for final design? **Yes- it was presented that the drawings are complete pending the outcome of this review (i.e., review results indicate they require no revisions). Drawings still need to go thru the formal TeamCenter approval process prior to procurement of the long-lead items.**
6. Have the relevant lessons learned from operational experience at other neutrino beamline facilities (i.e. NuMI, BNB, T2K) been appropriately documented and incorporated in the design? **Yes, the design takes into account lessons learned from previous horn systems.**
7. Have all relevant previous review recommendations been satisfactorily addressed? **Yes.**

# Draft answers to charge questions

Production Readiness Review for the long lead items charge questions:

8. Are the procurement specifications or manufacturing plans appropriate?
  - a. Have appropriate manufacturing and procurement methods been identified? **Yes.**
  - b. Are the plans for procurement and fabrication oversight documented? **Yes, pending completion of some fabrication oversight documentation**
  - c. Are all 2D drawings at a level sufficient to proceed to production? **Yes, pending TeamCenter approval**
9. Are the fabrication and assembly procedures complete and documented? **Yes, for the purpose of this review.**
10. Have Bill of Materials been developed for the equipment being fabricated? **Yes.**
11. Is the final QA/QC plan sufficient and documented? **Yes, for the long-lead items.**
12. Is the cost and schedule reasonable? **Yes, for the long-lead items.**
13. Have the handling, storage and shipping procedures/plans been documented? **Yes.**
14. Have all resources (facilities, infrastructure, and workforce) been identified and availability of personnel assured to progress according to project schedule requirements? **Yes, for the procurement of the long-lead items. Further resources will have to be identified for prototype assembly prior to the full prototype PRR.**
15. Has the Facility Safety Program been evaluated and implemented for the scope of work to be performed? **Fermilab has a safety program in place for horn and target production facilities. The long-lead items have been designed to the appropriate safety standards and compliance has been checked by peer reviews.**

# Draft technical recommendations

## 1.3– Recommendations

- The design of the field mapping probe should be advanced to determine if it will be compatible with the ½" outer conductor ports and will be capable of operating within the horn voltage requirements.
- Consider conducting additional electromagnetic and thermal-structural analysis of the stripline transition region where the configuration transitions from 9 layers to 8 layers to identify potential geometry enhancements (e.g., larger radius in select areas). This analysis should also include the effects of +/- 0.25" vertical offset for alignment. To investigate the actual displacement, vibration measurements should be conducted using prototype Horn A.
- It is recommended to perform a transient analysis with finer time steps compared to the beam spill and to take into account the realistic beam spill structure (bunch width and bunch spacing) in the analysis in order to estimate dynamic thermal stress due to beam correctly.



# Closeout

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- Panel report draft is in progress; will complete in the coming days
- During this closeout session, we will discuss the status of each long-lead item
- Yun will discuss/demonstrate the Sharepoint site for the project

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- Thanks to the project team and the management for a successful review of a well-advanced project!