LBNF/DUNE

Introduction to the Absorber

M. Kiburg, CAM for Absorber and Decay Pipe complex

Hadron Absorber Final Design Review

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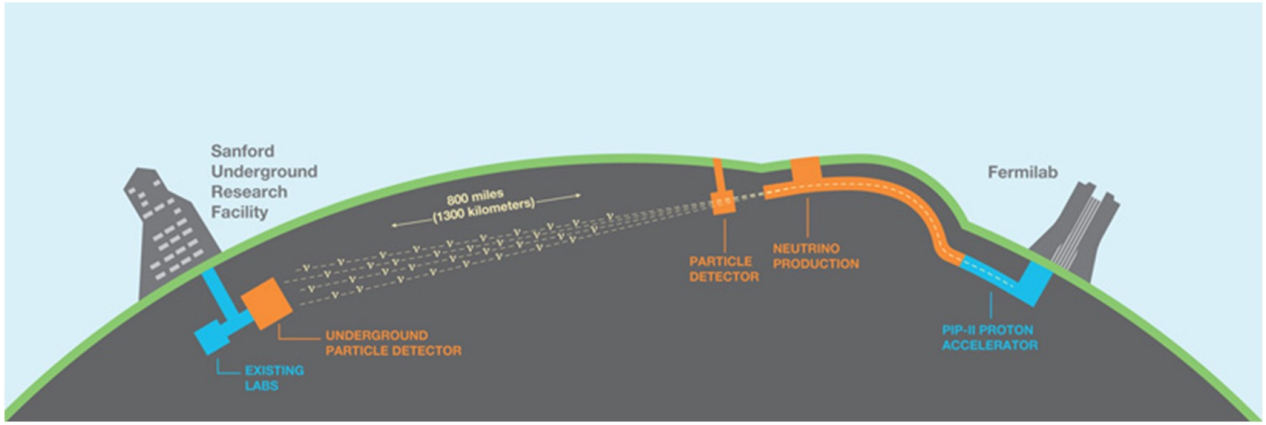
Fermilab CERN SANFORD UNDERGROUND RESEARCH FACILITY U.S. Department of ENERGY | Office of Science

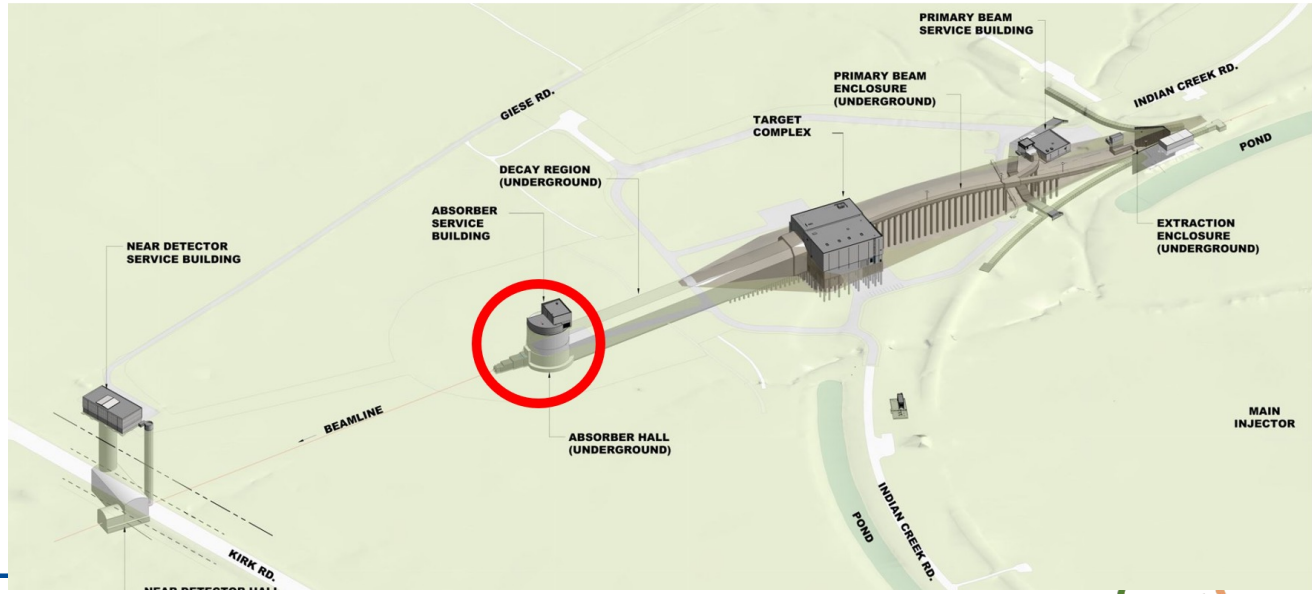
Outline

- Intro to LBNF/DUNE
- Requirements
- Intro to Absorber
  - Broad outline of design
  - Design philosophy
- History of reviews
  - Brief discussion of responses
- Current review
  - Charge questions
  - Scope (what is NOT included)
- ESH will be discussed in later talk
  - This is meant to be overview, details will be provided in following talks.

Intro to LBNF/DUNE

- Flagship Neutrino Experiment
- Beamline based at Fermilab
- Sending neutrinos to Far Detector at SURF 4850 ft underground
- Near Detector complex at Fermilab





CHARGE QUESTION 1

Beamline requirements for Absorber

- The LBNF Beamline shall have an uptime (including the uptime of the accelerator complex) of at least 55%.
- The LBNF Beamline shall be designed for a beam power of 1.2 MW, with the exception of a few subsystems.
- The LBNF Beamline shall be upgradeable to 2.4 MW primary proton beam power without modifications to the main elements of civil construction and shielding, assuming an uptime of 90% for a given year.
- The beam absorber shall be designed to absorb the remaining flux of hadrons at the end of the decay pipe. The design shall include consideration of the muon flux measurements
- The Beamline running lifetime is assumed to be 20 years. 5 years running at 1.2 MW and 15 years running at 2.4 MW.

CHARGE QUESTION 1

Absorber Requirements

- The absorber shall provide radiation protection to people, in compliance with the FRCM.
- The absorber shall absorb the energy of the particles exiting the decay pipe and transfer this energy away using an active cooling system.
- The absorber shall sustain the beam energy deposition under all accident situations that may occur with some reasonable probability.
- The absorber shall sustain at least 2 successive accident beam pulses without damage to components or loss of functional ability.
- The absorber shall include an Interlock system that limits the accident pulses to 2.
- The actively cooled absorber core blocks shall have the ability to be repairable and/or replaceable during the lifetime of the experiment.

CHARGE QUESTION 1

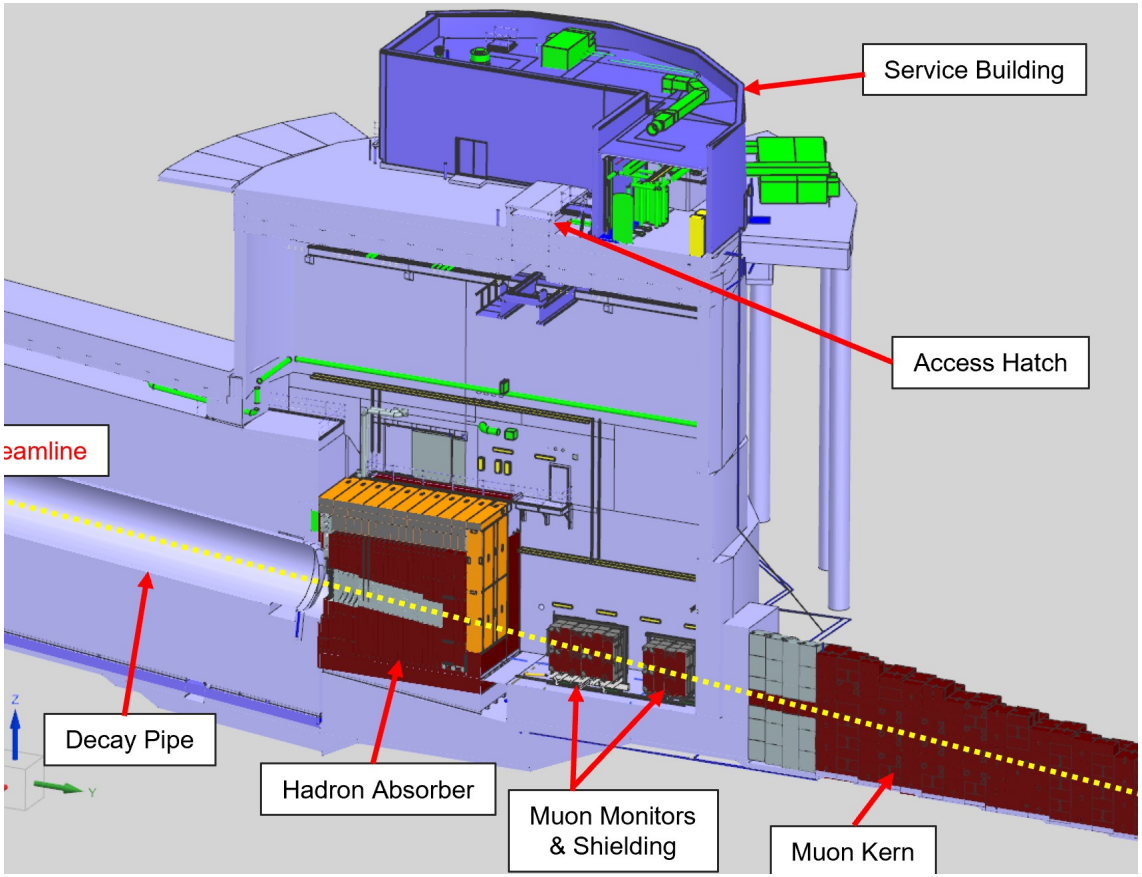
Beam Operational Modes

- Normal beam operations (beam permit inputs enabled, cooling water flowing, HVAC at operational levels)
- Beam based alignment scans at low beam power (targeting bpm beam permit inputs disabled, cooling water flowing HVAC at operation levels)
- The following non-beam operational modes require the disabling of the electrical safety system and LOTO of the critical devices upstream as access to the absorber is required; the beam permit is down
  - HADES replacement (normal cooling water flow, HVAC at access levels)
  - Maintenance or repair situations of various kinds (cooling water flow may be on or off, HVAC at access levels)
  - Maintenance or repair of HVAC may require special conditions

Absorber Design Philosophy

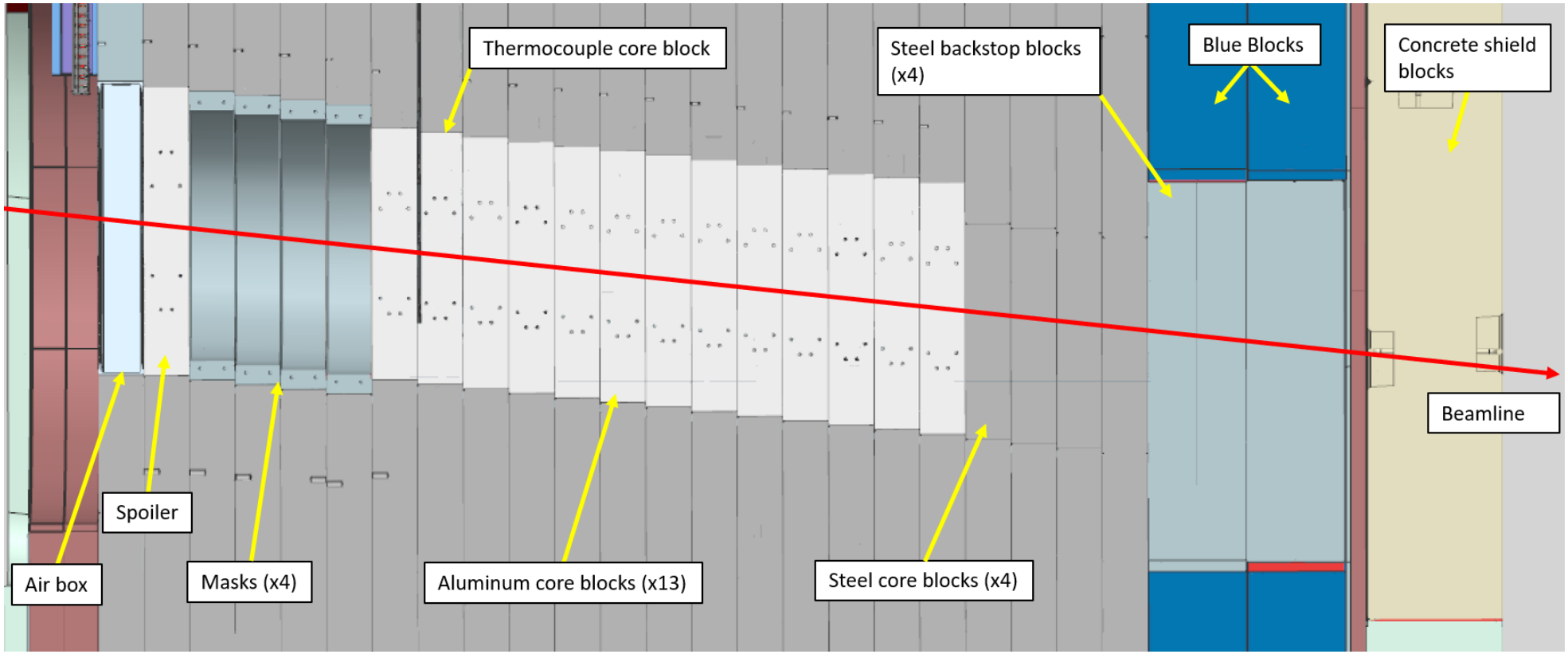
- The Absorber is designed to last for the life of the facility
  - It must be robust against potential failures in the water cooling loops in the core
  - The core is broken up into a segmented design to allow replacement if needed
- Expected failure rate of core elements is zero, but the unexpected failure rate is unknown
  - Use industry piping and pressure vessel codes (ASME BPVC, B31.3) and tight control of welding process (plus previous weld tests and inspections) to avoid systematic flaws
  - We mechanically and procedurally allow for the ability to recover from a failure
    - RAW pan and sump to contain water spills
    - Morgue for failed components
    - Retain assembly fixturing to reinstall a module
    - Water connections can be reattached
    - Remotely-operable 30-ton crane (with power rotating hook) in Absorber Hall
- Significant experience at Fermilab building and operating such a system, and this has informed the LBNF Absorber design:
  - NuMI absorber was similarly constructed and has operated for over 20 years without issue
  - Absorber core block design and remote handling is based on the NuMI shield pile T-Blocks
  - Bulk shielding design and construction is similar to the MiniBooNE and NuMI Target Shield Piles

Absorber Overview



- The Absorber sits in a circular building at the end of the decay pipe
- The Absorber hall includes the Absorber, neutrino beam instrumentation, RAW systems

Absorber Details



CHARGE QUESTION 11

Previous Reviews

- Hadron Absorber Core Advanced Conceptual Design Review (2015)
  - Settled on design and material choice
  - No showstoppers identified
  - Details in Docdb 324
- Preliminary Design Review (2020)
  - Design 60% complete.
  - Recommendations focused on welding of components
  - Details Docdb 19734
- Director's Review (2021)
  - Affirmation of design choices
  - Recommendations focused on reliability and accident cases
  - Details in Docdb 24016
- Response to recommendations are addressed throughout the next talks
  - Responses recorded in Docdb 30121

Final Design Review Requirements from Review office

- Validate the final design (~90% level)
- Validate plan to complete detail and assembly drawings.
- Evaluate how the system under review fits into the larger system, e.g., via CAD models.
- Validate plan to start procurement and fabrication, including detailing and fabrication of fixtures, test equipment, and fabrication procedures

Final Design Review Requirements from Review office

- Validate the final design (~90% level)
  - The absorber components are completely designed
- Validate plan to complete detail and assembly drawings.
  - The drawings will be complete for the PRR, which is scheduled for 2028
- Evaluate how the system under review fits into the larger system, e.g., via CAD models.
  - CAD models and drawings exist
  - Interfaces are specified and signed off
- Validate plan to start procurement and fabrication, including detailing and fabrication of fixtures, test equipment, and fabrication procedures
  - Fabrication and installation plans are mature and will be presented here

FDR Charge Questions

1. Does the final design meet the requirements for LBNF/DUNE?
    a. Is the prototyping effort complete?
2. Have all engineering analyses been performed and documented, and reviewed/peer reviewed and approved, where applicable? The relevant analyses are for the normal operating conditions and viable accident conditions Do we need to be more prescriptive here, for example include details such as analyses for normal operation and all viable accident/off-normal conditions?
3. Have the relevant engineering codes and standards been adequately/appropriately identified and applied to the design?
4. Are all 2D/3D mechanical model drawings complete and documented?
5. Is there a centrally maintained, accessible to all, CAD assembly model with the appropriate level of detail needed for an integration model?
6. Have all interfaces been finalized and documented?
7. Have the following ES&H issues been identified and analyzed appropriately?
    a. Radiation safety
    b. Contamination mitigation (containment of cooling fluid)
    c. Mechanical safety while installing
    d. Confined spaces and ODH concerns
8. Does the draft documentation detailing plans for procurement, manufacturing, quality assurance/quality control, and part identifiers exist at a sufficient level of maturity for this stage of the design.
9. Are transportation, installation and testing plans in development?
    a. Have sufficient resources for installation and testing been identified?
10. Have all major risks been identified and have mitigation strategies been determined and documented?
11. Have all recommendations from previous reviews been adequately addressed and approved by the relevant authority?

What this Review includes

- Mechanical design of absorber
- Thermocouples instrumentation
- Preliminary assembly plans for the core modules
- Preliminary Installation plan for absorber
- Preliminary QA/QC plan
- Preliminary procurement plans
- Preliminary ESH Considerations and Risks

What this review does NOT include

- Systems outside the Absorber Bunker
  - Remote handling for HADeS (including movement system) and core blocks
  - RAW systems
  - Production drawings
  - Air handling systems
  - DAQ for instrumentation

CHARGE QUESTION 8, 10

Documentation Notes

- Relevant review documentation is included in (or linked from) DUNE-doc-30121
- Engineering Notes/Documents are generally hosted on Teamcenter
  - Notes have been included in the DocDB entries as dated copies for easier reference
- The CAD model for the Absorber (and integration model for the LBNF-30 Absorber Complex) are maintained on Teamcenter
  - F10156700 – Absorber model
  - F10151229 – LBNF-30 Integration model
- Document Guide included on Indico
  - Will be updated throughout the review and a copy will be uploaded to Docdb and EDMS once the review is finalized.

CHARGE QUESTION 6

Interfaces

- Conventional Facilities
  - CF interfaces are well defined and signed off
  - CF has a completed design and is out for bid
  - Documentation located 31203
- RAW
  - Very advanced design.
  - Interfaces have been examined and agreed upon
- HADeS/Remote Handling
  - Closely working with Vladimir
  - Interfaces defined and any changing will be on HADeS side
- Instrumentation
- Beamline ICDs are listed in DocDB 32539

Agenda

- Intro (This talk)
- Mechanical Design
- Installation
- Risks, QA/QC, ESH Considerations