LBNF/DUNE Far Site Detector Grounding System Requirements

- This document sets forth the LBNF infrastructure requirements necessary for the implementation of an isolated detector ground.
- This document does not address all the internal grounding rules of the detector. That scope will be covered in a separate document.

Revision History

9/29/2015 TMS Original Document

1/6/2016 TMS Document updated with drawings showing:

1. General construction placement of rebar (UFER ground), wire mesh and Ground Bars
2. General scheme of Detector Ground (not to scale and not all details are shown)

3/12/2018 TMS Update document

1. On point #6, require the detector be isolated from the concrete pad.
2. On point #15, note that double shielded “isolation” transformers are now planned to be located on the mezzanine.
3. Add point #23 to prevent moisture seepage to concrete.
4. Add points #24 and #25 to reflect the fact that the mid-chamber floor will shift lower than the 4850L due to the removal of the rock septum.

Grounding Committee Members

Theresa Shaw (FNAL) tshaw@fnal.gov

Linda Bagby (FNAL)

Paul Bauer (Sanford Lab)

Stephen Chappa (FNAL)

Marvin Johnson (Consultant)

Veljko Radeka (BNL)

Grounding Point Summary

At the SURF 4850 Level where the Neutrino Detectors will be located, the electrical conductivity of the various rock masses are unknown but expected to have extremely poor and inconsistent conductive properties. To insure adequate sensitivity of the detectors a special ground systems must be put in place that will isolate the detectors from all other electrical systems and equipment, and minimize the influence of inductive and capacitive coupling and ground loops. The objective of the following grounding system requirements is to reduce or eliminate ground currents through the detector which will affect detector sensitivity, maintain a low impedance current path for equipment short circuit and ground fault currents, and insure personnel safety by limiting equipment/equipment and equipment/ground touch potentials.

Basic Ground Structures

Cavern Ground consists of overlapping welded wire mesh supported by rock bolts and covered with shotcrete. The LBNF/DUNE **Cavern Ground** includes all walls and crown areas above the 4850 sill level in the North and South detector caverns and their associated central access drifts, plus tin plated copper bus bars specified to run the length of the detector vessels on each side along the cavern walls and mounted external to the shotcrete. The **Cavern Ground** structure:

- Spans the full length of the cavern from the West end access drift entrance through the mid-chamber to the East end access drift entrance.
- Spans the full width of the cavern from the 4850 sill (top of the detector vessels and mid-chamber floor) on both sides up and across the crown of the cavern.
- Includes the East and West end walls of the cavern, from the 4850 sill to the crown.

Detector Ground consists of the steel containment vessel enclosing the cryostat and all metal structures attached to or supported by the detector vessel.

UFER Ground consists of the metal rebar embedded in the concrete floors The LBNF/DUNE **UFER Ground** system includes the concrete floors in the cavern mid-chambers, center access drifts, and central utility cavern.

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High Level Requirements (apply to both North and South caverns and all detector chambers)

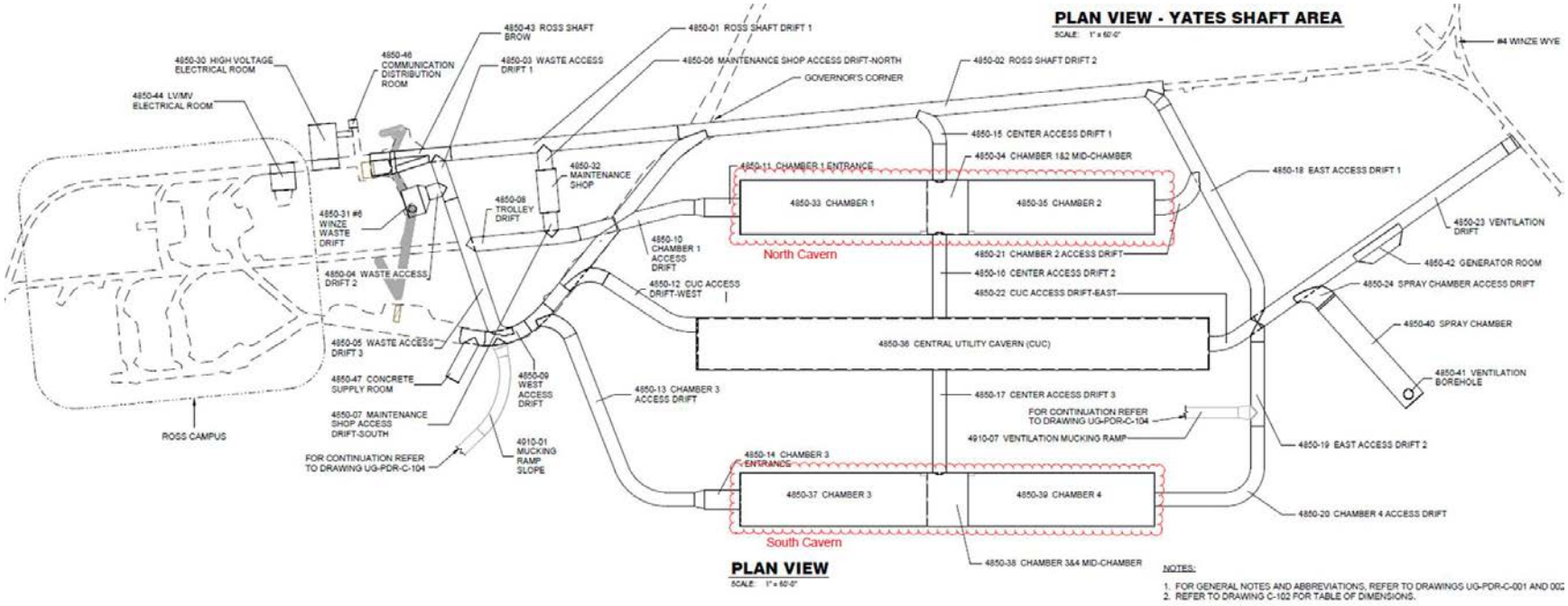
1. Require a solid electrical bond between all welded wire mesh panels that make up the **Cavern Ground**.
2. Require that copper buss bars be installed on each side of the cavern parallel to the detector vessels, and across the width of the detector chambers, for grounding electrical equipment located within the caverns. The buss bars must be made of flat copper bar to provide sufficient surface area and ground conductor properties. They must be tin plated to resist copper oxidation. Splice connections must be made with overlapping buss bar plates to maintain a minimum cross sectional area.
3. Require that the buss bars be tied to the **Cavern Ground** wire mesh at 5 foot intervals along the entire length of the ground buss.
4. Require that the **Cavern Ground** wire mesh be tied to the **UFER Ground** rebar in the mid-chamber and central access drifts, to create a single, solid, and continuous low inductive grounding system.
5. Require that the concrete floor rebar in the mid-chamber, center access drifts, and central utility cavern all be tied together to form a single, continuous **UFER Ground** system that originates at the electrical substation transformers.
6. Require that the **Detector Ground** be electrically isolated from everything including the concrete chamber floor. The only allowable conductive connections to the detector vessels are through saturable inductors.
7. Require the concrete detector cavern floor to have non-conducting fiber reinforcement.
8. Require that **NO** welded wire mesh be installed on the chamber walls from the 4850 sill down to the chamber floor, except for the chamber wall existing in the mid-chamber as described below. (This assumes that there is no electrical equipment installed between the vessel and the other chamber walls.)
9. Require welded wire mesh and shotcrete on the chamber wall only at the mid-chamber between detector caverns where cryogen piping, valves, pumps, fans, and other electrical equipment are located. The wire mesh on these chamber walls must be tied to both the mid-chamber **UFER Ground** rebar and the central access drift **UFER Ground**.
10. Require a minimum 2 foot high, moisture resistant **exclusion zone** between the chamber floor and the bottom of the shotcrete on all four chamber walls to isolate the Detector from the **Cavern ground**.
11. Require that ground monitoring instrumentation be installed to insure that the **Detector ground** remains electrically isolated from all other grounding systems.

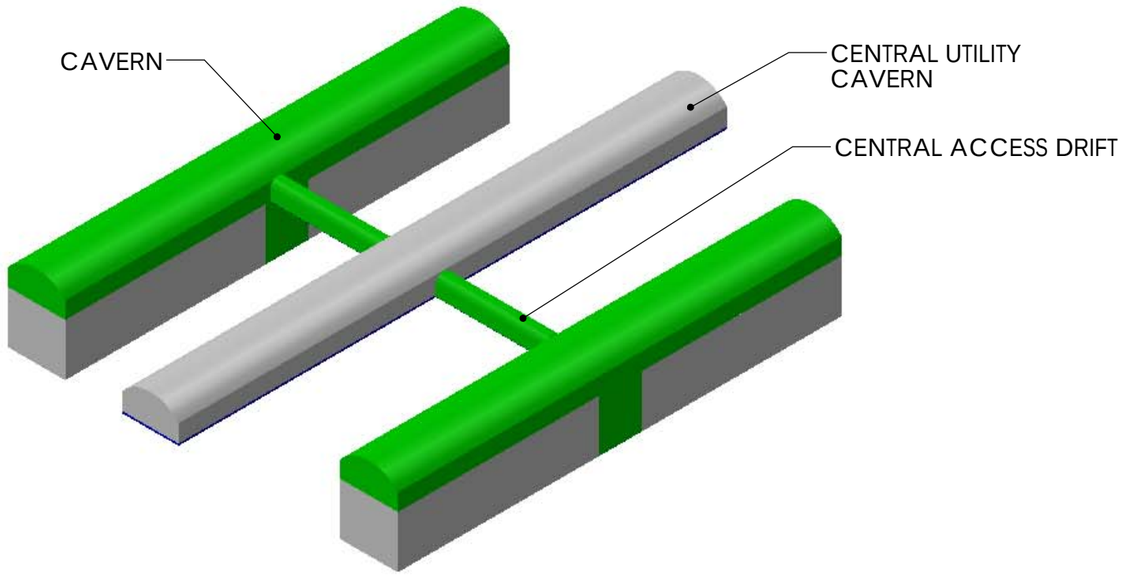
Other Detailed Requirements

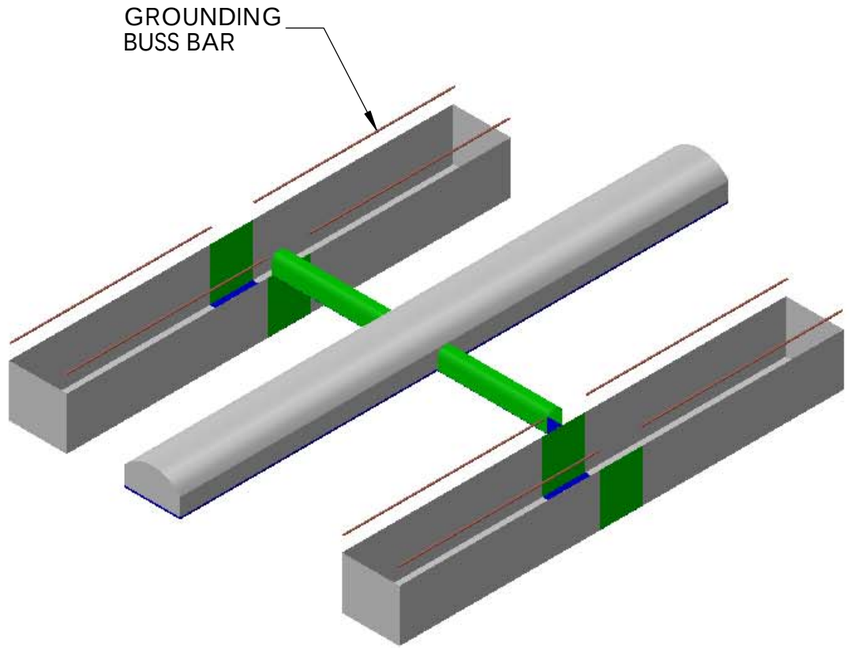
12. Require all shotcrete areas, which do not contain wire mesh, to use non-metallic containing shotcrete.
13. Require that tin plated copper bus bars shall be ~6" wide and a minimum of 3/8" thick.
14. Require all conductive piping and conduit entering/exiting the cavern must be bonded to local **Cavern Ground**. This can be accomplished with copper cable ties to the shotcrete mesh or through the creation of a local bus bar.
15. Require that the only AC distribution transformer(s) located inside a detector cavern are the detector double-shielded isolation transformers.
    a. The location of this transformer will be on the detector mezzanine structure.
    b. Galvanized Rigid Conduit (GRC) for 480 VAC circuits must be isolated from the **Detector Ground**.
16. Require a minimum of two saturable inductors to be located near the detector double shielded transformer with some separation >6 feet between the pair.
17. Require all metal structures to be bonded to a ground structure – No floating metal. (Note: This rule does not apply to isolated rock bolts.)
18. Require that no VFDs or motor controllers shall be used in the detector caverns unless reviewed by and approved by DUNE Grounding Committee.
19. Require galvanized rigid metal conduit (GRC) to be used for all electrical circuits.
20. Require that cavern light fixtures must be non-arcing or non-sparking.
21. Require dielectric isolators on piping between **Cavern** and **Detector Ground** structures. The Cryogenics team should work with DUNE Grounding Committee so that capacitive coupling can be minimized.
22. Require a local bus bar tied to **Cavern Ground** and **UFER Ground** mesh in the mid-chamber area to provide a reference for any cryogenic equipment located in that area.
23. The concrete of the slab under each cryostat warm structure shall be kept dry from naturally occurring water.

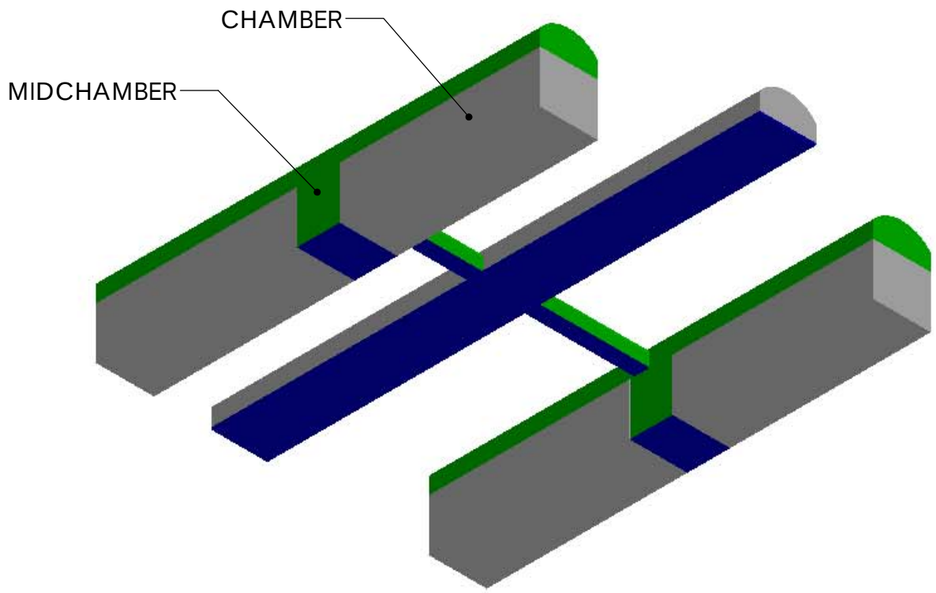
If the rock septum is to be removed either partially or entirely, the mid-chamber floors will now be at lower level(s). The following additional requirements are to be added.

24. The mid-chamber floor will remain part of the **UFER Ground** and the newly created mid-chamber wall, which shall contain wire mesh and is part of the **Cavern Ground**, shall provide a well bonded path between the central access drift floor **UFER Ground** and the mid-chamber floor **UFER Ground** .
25. Concrete pours between the cryostat/chamber pad areas and the mid-chamber area between the cryostat pads shall be isolated from each other. Use of a rubber barrier, or equivalent, is required.


PLAN VIEW - YATES SHAFT AREA
SCALE: 1" = 60'-0"
4850-30 HIGH VOLTAGE ELECTRICAL ROOM
4850-44 LV/MV ELECTRICAL ROOM
4850-46 COMMUNICATION DISTRIBUTION ROOM
4850-43 ROSS SHAFT BROW
4850-03 WASTE ACCESS DRIFT 1
4850-01 ROSS SHAFT DRIFT 1
4850-06 MAINTENANCE SHOP ACCESS DRIFT-NORTH
GOVERNOR'S CORNER
4850-02 ROSS SHAFT DRIFT 2
#4 WINZE WYE
4850-15 CENTER ACCESS DRIFT 1
4850-34 CHAMBER 1&2 MID-CHAMBER
4850-18 EAST ACCESS DRIFT 1
4850-32 MAINTENANCE SHOP
4850-08 TROLLEY DRIFT
4850-31 #6 WINZE WASTE DRIFT
4850-11 CHAMBER 1 ENTRANCE
4850-33 CHAMBER 1
4850-35 CHAMBER 2
North Cavern
4850-23 VENTILATION DRIFT
4850-42 GENERATOR ROOM
4850-10 CHAMBER 1 ACCESS DRIFT
4850-21 CHAMBER 2 ACCESS DRIFT
4850-16 CENTER ACCESS DRIFT 2
4850-04 WASTE ACCESS DRIFT 2
4850-12 CUC ACCESS DRIFT-WEST
4850-22 CUC ACCESS DRIFT-EAST
4850-24 SPRAY CHAMBER ACCESS DRIFT
4850-40 SPRAY CHAMBER
4850-36 CENTRAL UTILITY CAVERN (CUC)
4850-05 WASTE ACCESS DRIFT 3
4850-41 VENTILATION BOREHOLE
4850-47 CONCRETE SUPPLY ROOM
4850-09 WEST ACCESS DRIFT
4850-13 CHAMBER 3 ACCESS DRIFT
4850-17 CENTER ACCESS DRIFT 3
FOR CONTINUATION REFER TO DRAWING UG-PDR-C-104
4850-07 MAINTENANCE SHOP ACCESS DRIFT-SOUTH
4910-07 VENTILATION MUCKING RAMP
4850-19 EAST ACCESS DRIFT 2
ROSS CAMPUS
FOR CONTINUATION REFER TO DRAWING UG-PDR-C-104
4910-01 MUCKING RAMP SLOPE
4850-14 CHAMBER 3 ENTRANCE
4850-37 CHAMBER 3
4850-39 CHAMBER 4
4850-20 CHAMBER 4 ACCESS DRIFT
South Cavern
4850-38 CHAMBER 3&4 MID-CHAMBER
PLAN VIEW
SCALE: 1" = 60'-0"
NOTES:
1. FOR GENERAL NOTES AND ABBREVIATIONS, REFER TO DRAWINGS UG-PDR-C-001 AND 002
2. REFER TO DRAWING C-102 FOR TABLE OF DIMENSIONS.







CAVERN GROUND (WIRE MESH)

UFER GROUND (REBAR)

GROUNDING BUSS BAR

Sanford Underground Research Facility

MATERIAL:	DRAWN BY: BC	CHECKED BY: PB	APPROVED BY: PB	DATE: 3/13/2018	SCALE:
UNLESS OTHERWISE SPECIFIED	DRAWING TITLE: LBNF/DUNE GROUNDING			SHEET: 1	OF: 1
UNITS: INCHES					
TOLERANCES: ANGULAR ± 1.0° 2 PLACES .XX ± .06 3 PLACES .XXX ± .010	DRAWING NUMBER: **LBNF GROUNDING**			REVISION: **1**	SIZE: **B**

Rev G: Added mezzanine platform will cover part of or all of the detector top surface.

Mezzanine will be supported by cross-cavern horizontal support beams, not vertical columns going to the detector top surface. These beams are connected to cavern ground.

Four detector power isolation transformers will be placed on the mezzanine platform.

The middle septum, separating the two detector caverns, may not be used and thus one large cavern will house two detectors separated by a multi-level metal platform.

Concrete base for detectors are separated by insulating barriers from the concrete base for the middle utilities section.

Shotcrete with Wire Mesh for Wall and Ceiling (Cavern SRG)

Cryogen Equipment Located Above the Detector on Mezzanine Platform

Shotcrete with Wire Mesh Extends Through to the Mid-chamber Wall and Ceiling

Cavern Utilities Tied to Wire Mesh (Cavern SRG) via Mesh Tie-points or Ground Bus Bar

AC Power Circuit(s) for Cavern Utilities

Pipe Entering Cavern Connected to Cavern SRG

AC Power Circuit(s) for Mezzanine Utilities

480/208 VAC Isolation Transformer(s) for Detector Power (Mounted on Mezzanine)

480 VAC Circuit for Detector Power Transformer(s)

Tinned Copper Ground Bus Bar Connected to Wire Mesh Tie-points

Cavern Ground Tinned Copper Grounding Bus Bar

Saturable Inductor(s) (Mounted near Transformer)

Mezzanine Platform

Mezzanine Platform Cross-cavern Support

Piping Dielectric Couplings

208/120 VAC Panel

AC Panel(s) for Detector Electronics

Detector Ground Structure

Cavern Ground Structure

AC Power Circuit(s) for Service Utilities and Equipment on middle platform section

Detector SRG Copper Grid

Piping to Detector Connected to SRG

Multi-level support metal platform structure

Inner SS Membrane and the Steel Structure and the Top SRG Copper Connected Together (Grounded) through the Electronics Feed-Through Ports

Electrical Isolation between Detector Service Platform and the Detector Shell Metal

Shotcrete with Wire Mesh for Mid-chamber wall's SRG

Break (at the detector top level) Between the Metallic and Non-metallic Reinforced Shotcrete

Shotcrete Without Wire Mesh

Separation between shotcrete with wire mesh and the shotcrete without wire mesh

Shotcrete with Nonmetallic Reinforcement

Lower Level Utilities Tied to Wire Mesh (Mid-chamber SRG) via Mesh Tie-points or Ground Bus Bar

Detector Inner Membrane Structure

Dielectric Coupling

Detector Outer Metal Structure

Crogen Equipment (column, pump, etc.) Located in the Middle Utilities Section (Electrical Isolation from Concrete Not Required)

Detector Concrete Base for 2nd Detector

Detector Resting Directly on Chamber Floor Using Isolation Pads (G10 or Epoxy/Grout)

Chamber Rock Base

Chamber Concrete Floor with Non-conductive Reinforcement Separated from the Chamber Rock Using an Insulating Vapor Barrier

Equipment Isolation Pads in Pit

Insulating Barrier Placed Between the Detector Base Concrete and the Middle Utilities Section Concrete

Concrete Base, with Ufer Grounded Rebar, for Middle Utilities Section

Two-foot Isolation Gap (Be it some moisture-resistant material or simply an air gap between the shotcrete and concrete floor)

Title: **DUNE Far Detector Conceptual Grounding Diagram (1 of 2 Detector Sections)**

Project:	Drawn:	Date:	Sheet:	Rev:
LBNF/DUNE	Steve Chappa	03-05-2018	1 of 1	G