

Neutrino Beamline Horns B and C Preliminary Design Review

Horns B & C Fabrication Plans

Meredith Lee

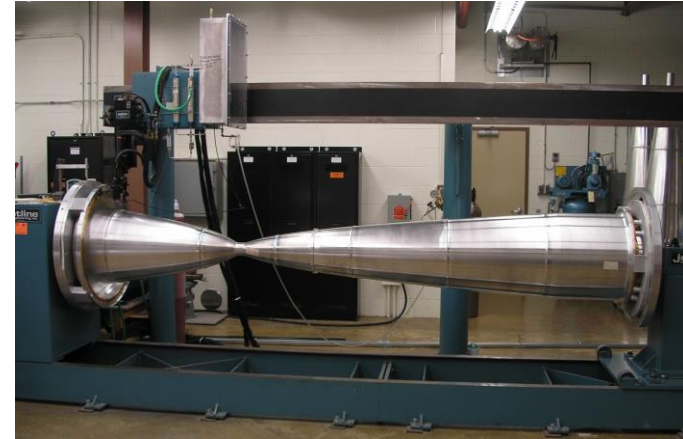
3 December 2021

Agenda

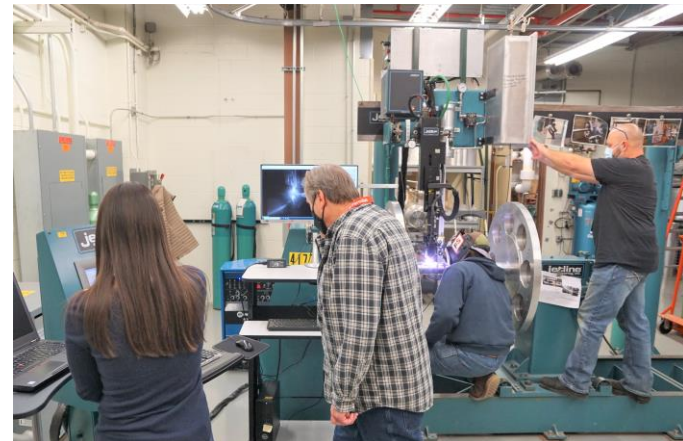
- Weld Progress and Plans
- Welding Machine Expansion
- Inner Conductor Nickel Plating Fixture
- Outer Conductor Anodizing Fixture
- Horn Flipping Fixture Configurations
- TSIB Layout and Lift Plan
- Fabrication Procedures
- Summary

Weld Progress and Plans – Overview

- Jetline CNC circumferential welding machine
- Used to weld NuMI horn inner conductors
- Welding inner conductor sample parts since August 2021
 - Refine weld routines prior to welding LBNF horn inner conductors
 - Achieve clean welds with 100% penetration
 - X-ray and certify to NAS 1514 Class 1



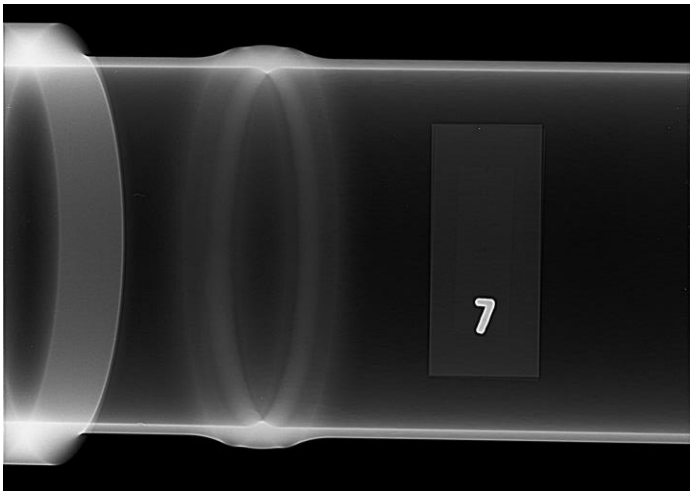
NuMI horn 2 inner conductor on welding machine



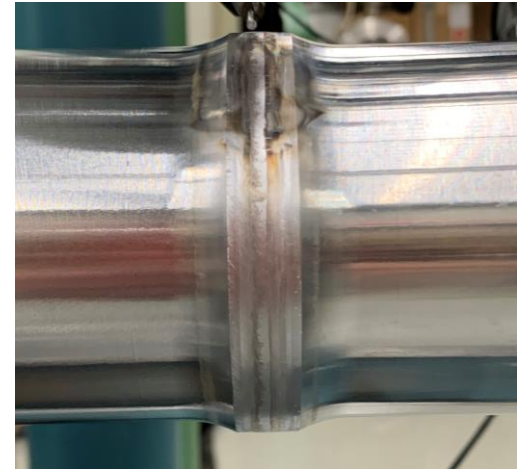
Welding Team: Meredith Lee, Kris Anderson, Austin Fletcher, Jaime Sanchez, and Cory Crowley

Weld Progress and Plans – Results

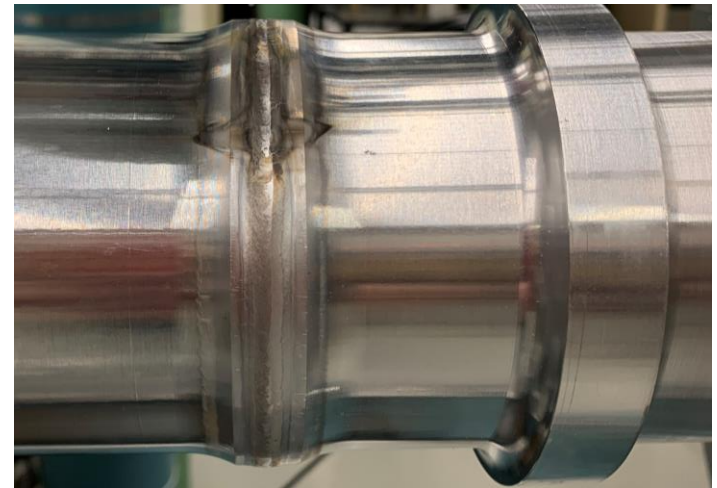
- Finalized routine parameters for Horn A welds
- Clean, 100% penetration welds with crown
- Final samples X-rayed and certified to NAS 1514 Class 1



Horn A 3.780" Diameter Sample X-ray



Horn A 3.380" Diameter Sample



Horn A 3.780" Diameter Sample

Weld Progress and Plans – QA Documentation

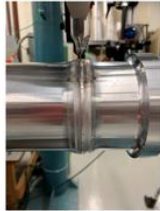
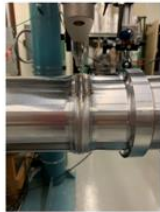
- Xiris monochrome weld camera installed to capture videos
- Positioned to allow monitoring of weld puddle, tungsten, and wire
- Videos conducive to troubleshooting and routine modifications



Weld Progress and Plans – QA Documentation

- Dedicated [SharePoint page](#) contains information for each sample run:

- Routine used
- Run date
- Comments
- Plots
- Image(s)
- Video

Sample/Routine	Run Date	Comments	Plot	Image(s)	Video
Sample: HA_3780-1 Routine: 3780-1	10/21/2021	<ul style="list-style-type: none"> Stopped routine on first attempt because wire was jammed in rollers within first 10 degrees of weld <ul style="list-style-type: none"> Removed and replaced with new spool of wire New start/stop located 180 degrees from original start/stop and marked with "x" Second attempt routine ran smoothly <ul style="list-style-type: none"> Wire tracked closer to weld seam than previously Weld was flat from 0-55 degrees, while 55-360 had a more defined crown that was colder after 145 degrees <ul style="list-style-type: none"> Underbead was wider from 0-55 degrees and narrower after 55 degrees 	HA_3780-1 (second attempt)		HA_3780-1 first attempt HA_3780-1 second attempt
Sample: HA_3780-2 Routine: 3780-2	10/21/2021	<ul style="list-style-type: none"> Reduced current from 0-55 by 1 A, kept same current from 55-145, and increased current by 1 A for 145-410 degrees Full penetration with uniform underbead. Perfect X-rayed and certified to NAS 1514 Class 1 	HA_3780-2		HA_3780-2

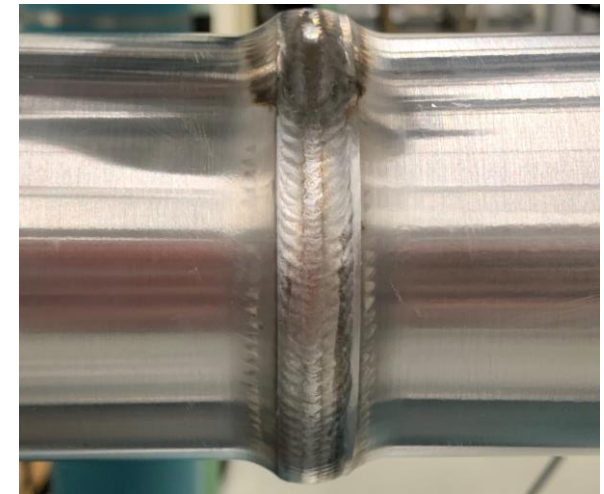
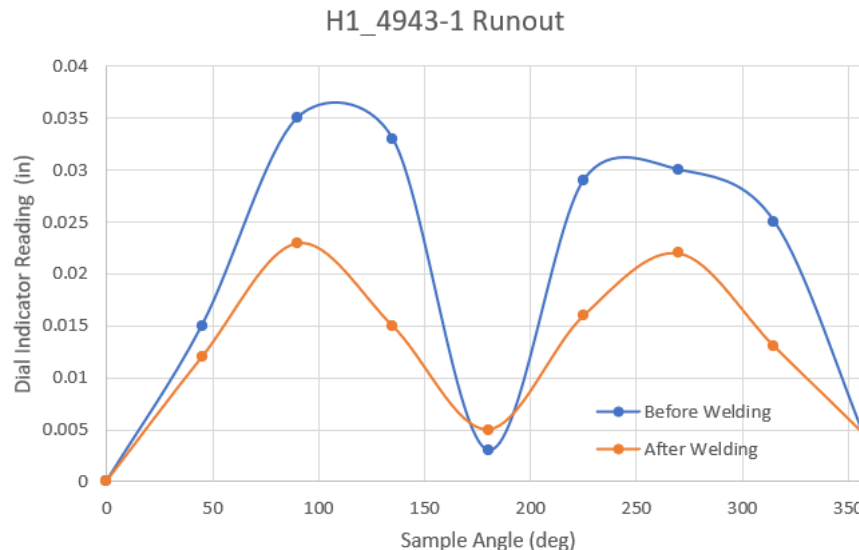
X-rays

Weld Progress and Plans – Other Capabilities

- Routines for missed underbead
- Cosmetic overpass routines using mag arc oscillator
- Straightening routines to correct runout



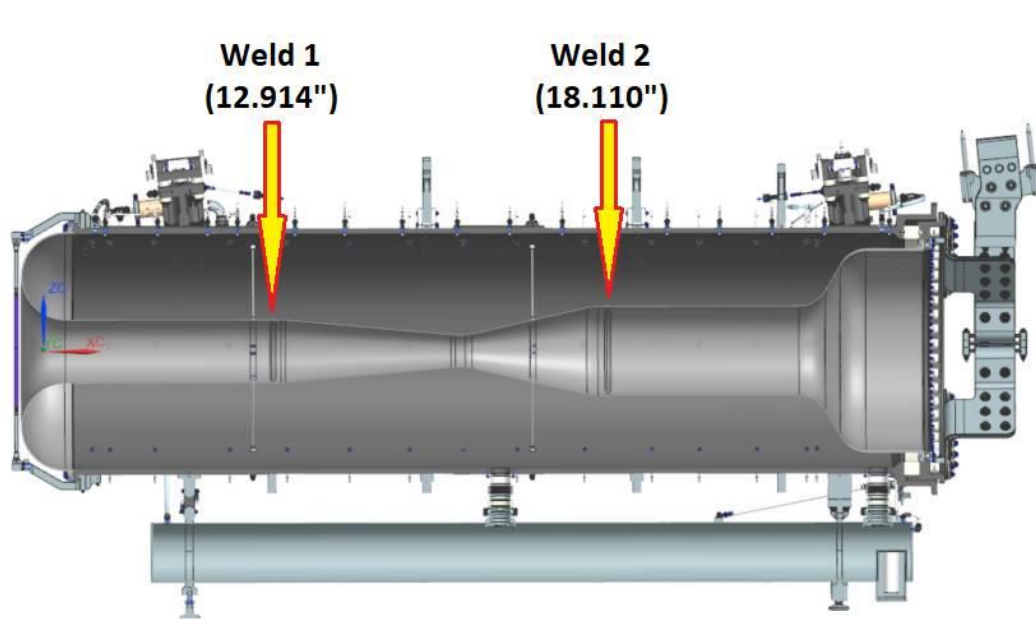
DC Cosmetic Overpass Routine – NuMI sample



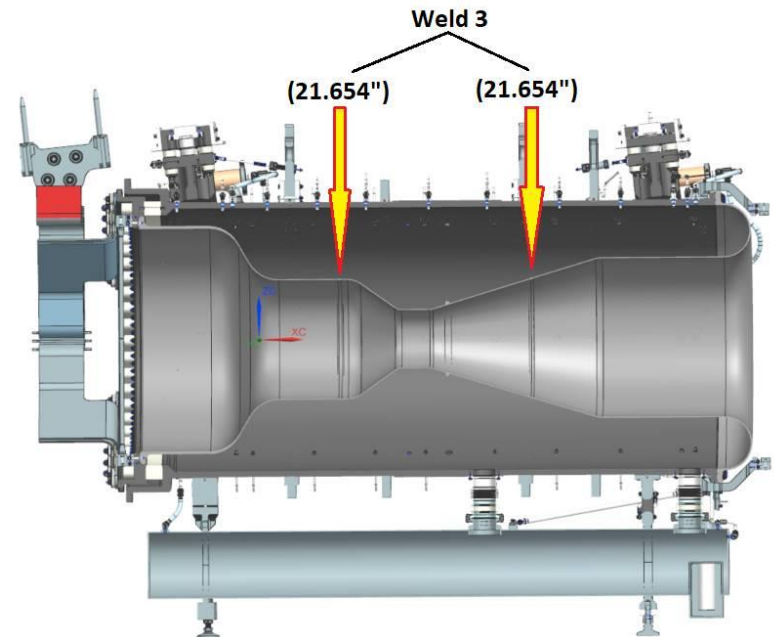
DC Cosmetic Overpass – NuMI sample

Weld Progress and Plans

- Horn B and Horn C inner conductors both consist of 2 welds
- Requires weld samples for 3 different diameters



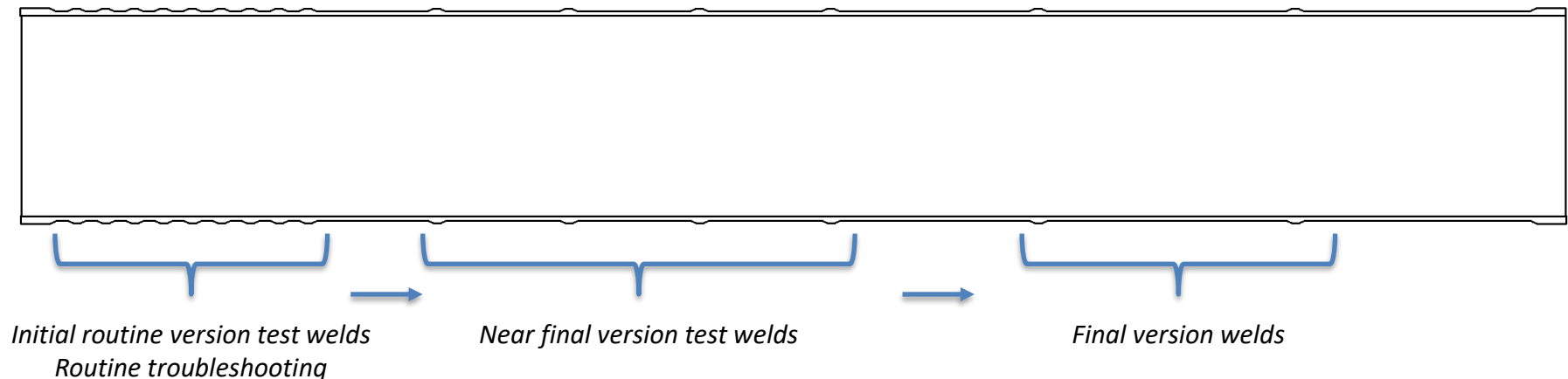
Horn B Weld Diameters and Locations



Horn C Weld Diameters and Locations

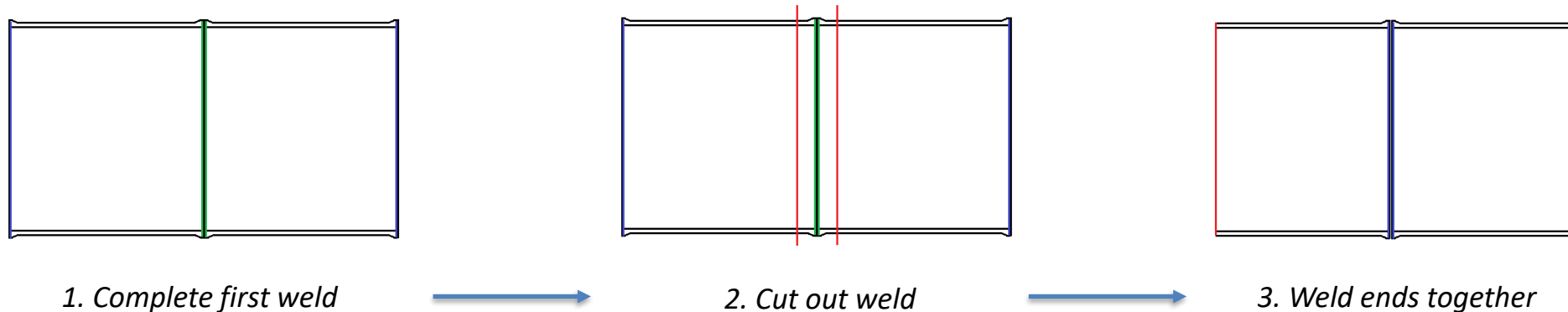
Weld Progress and Plans

- Program testing and troubleshooting will use a multi-ring sample
 - Either forged or machined from Al round stock
- Multi-ring sample for each weld diameter
 - Rings spaced closely together: initial routine tests and modifications
 - Rings spaced moderately apart: near final-stage routine version
 - Rings spaced far apart: final routine version



Weld Progress and Plans

- Sample sets will be used for final welds prior to horn welds
- Two sets of samples for each diameter
 - Each sample half contains step in and step out
 - Allows each sample set to be used for two welds
 - Four total sample welds



Welding Machine Expansion

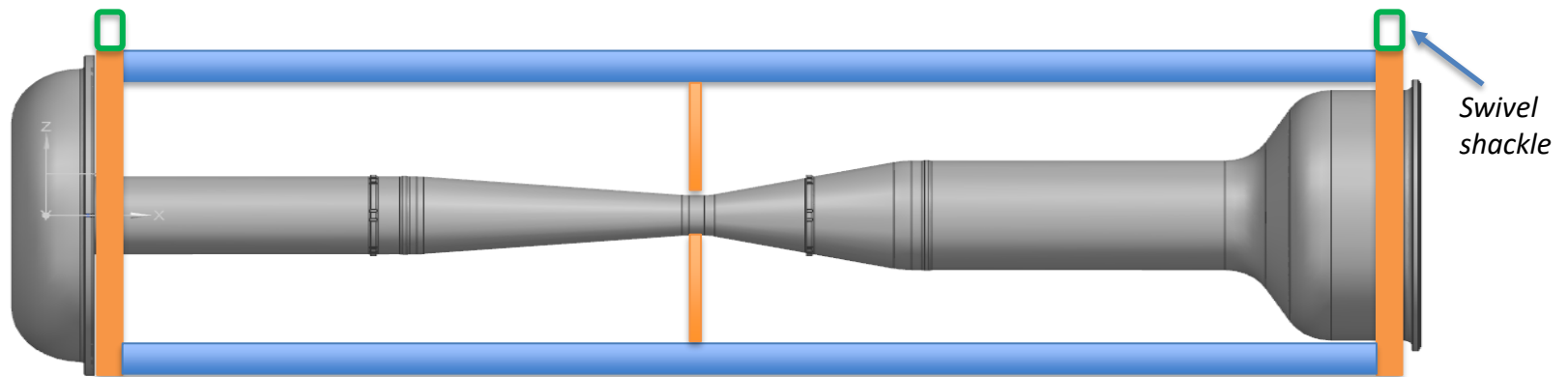
- Floor rails need to be extended to allow tailstock to accommodate Horn B length
- New section will be fabricated and attached to existing rail
- Upper rail will not need extension



Welding machine rail extension

Inner Conductor Nickel Plating Fixture

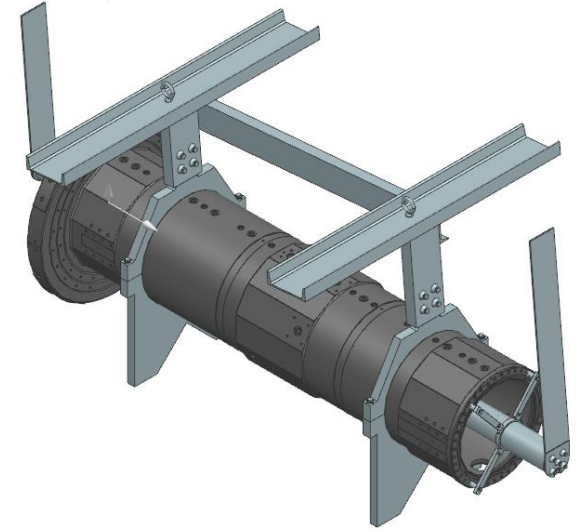
- Nickel plating fixture for Horns B & C constrained by process tank size
 - Cannot exceed length of Horn B
 - Cannot exceed 58" width
- Structure will use 6061-T6 Al
 - 316 SS hardware
- Fixture design to occur following Horns B&C Final Design Review



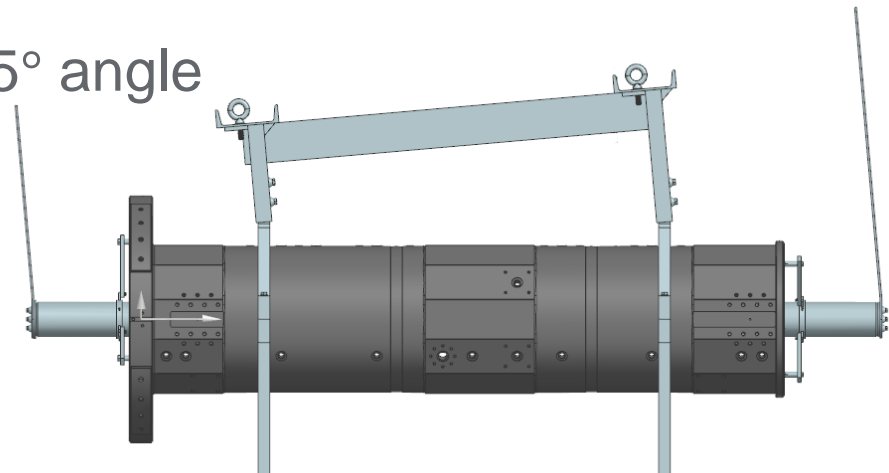
Horn B Nickel Plating Fixture Concept

Outer Conductor Anodizing Fixture

- Anodizing fixture nearly identical to NuMI design
 - Design for Horns B & C will be scaled version of Horn A design
- Clamps and support channels to hold and lift conductor
- Cathode tube assembly inside conductor
- Processed in chemical baths at 5° angle
- Process tank size is 5' x 5' x 16'
 - Vendor will fabricate tank

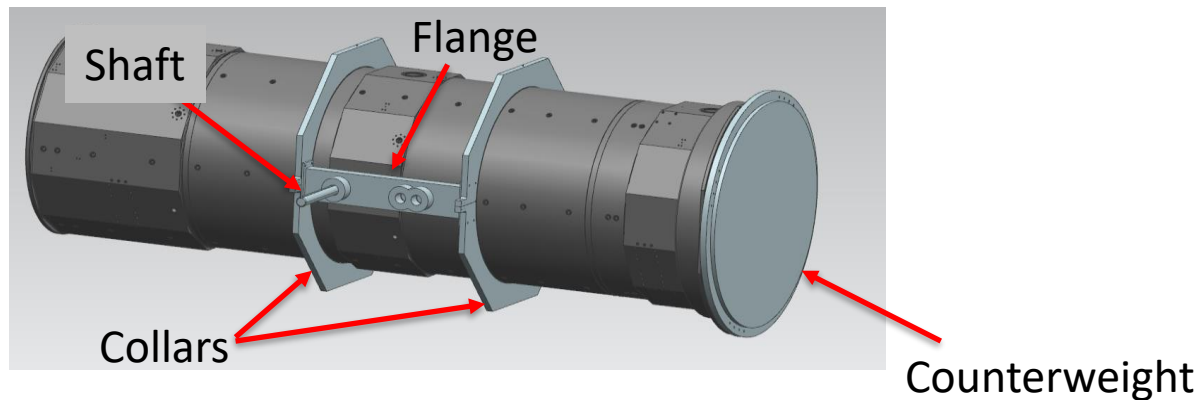
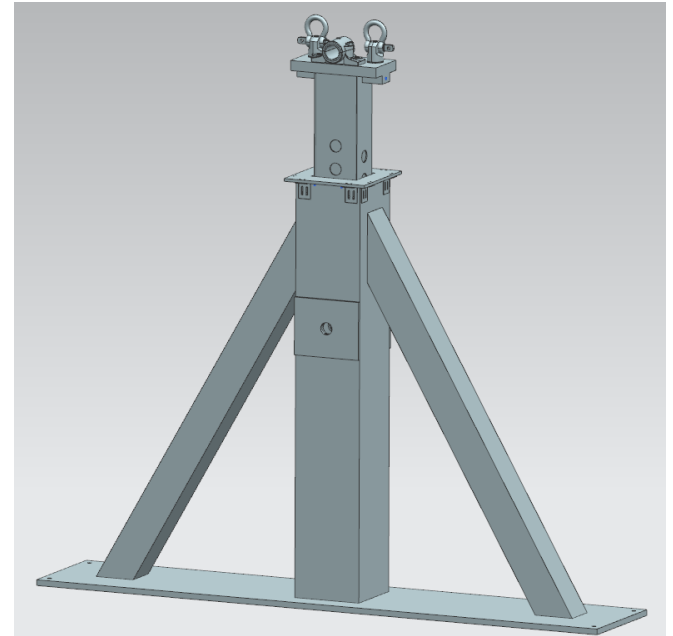


Horn A Anodizing Fixture



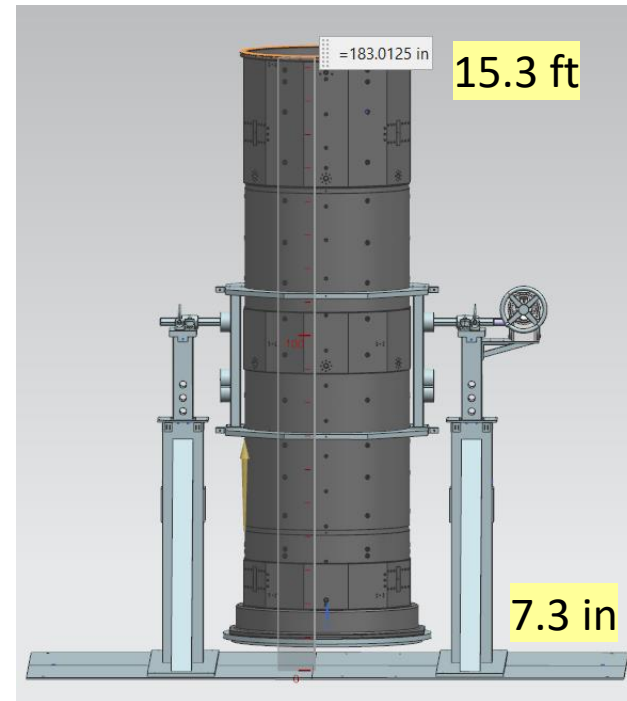
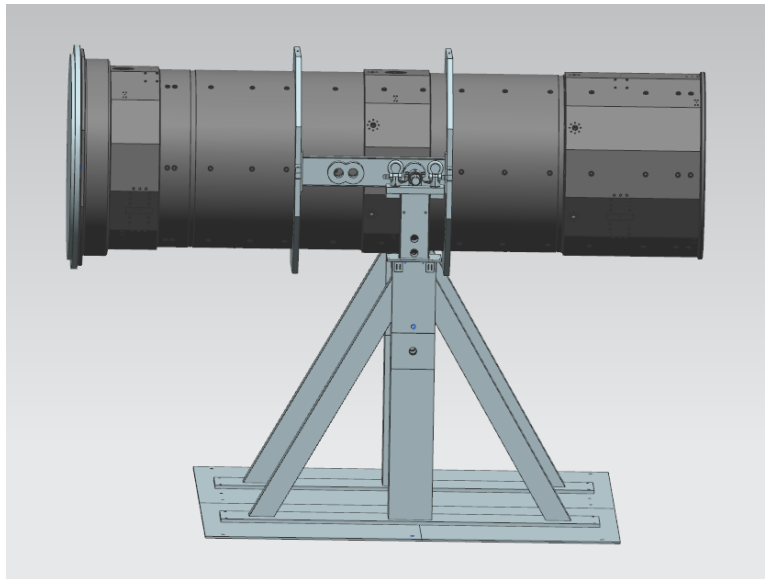
Horn B Assembly in Flipping Fixture

- Assemble collars, flanges and shafts on the outer conductor
- Bolt counterweight to upstream end of outer conductor
 - Use plastic washers
- Set stand height to Horn C position for Horn B initially



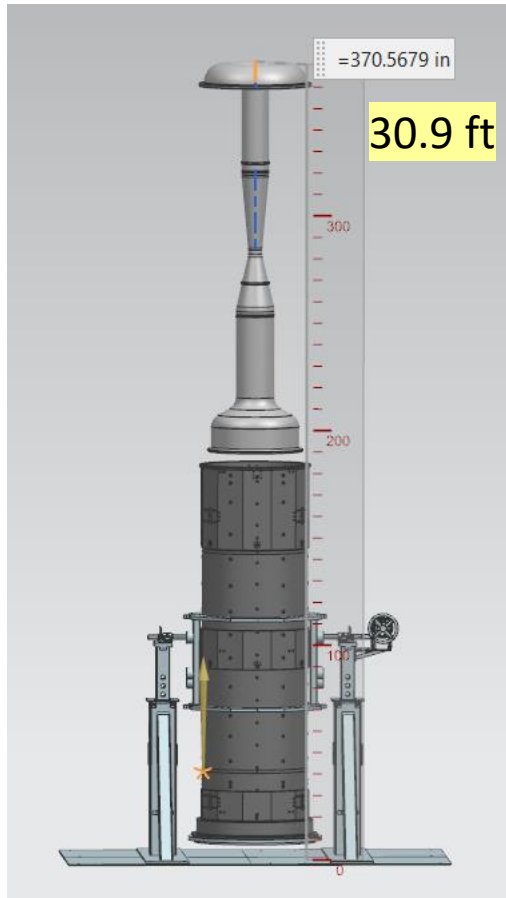
Horn B Assembly in Flipping Fixture

- Lift outer conductor and position in stands
 - Attach shafts to pillow block bearings
- Rotate horn to vertical position with counterweight end closest to floor



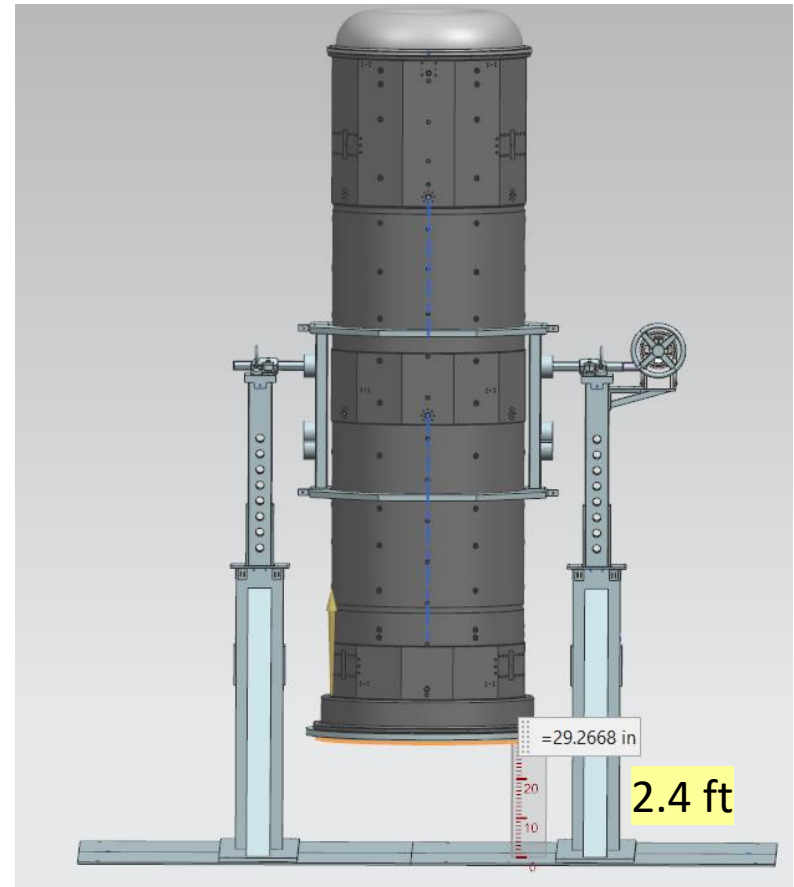
Horn B Assembly in Flipping Fixture

- Lower inner conductor and fasten to the outer conductor



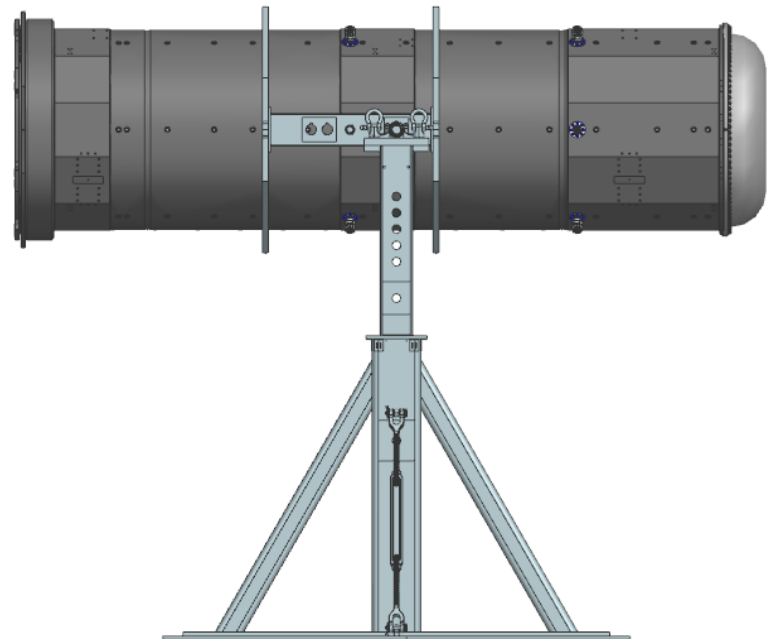
Horn B Assembly in Flipping Fixture

- Raise stands to Horn B pin position
- Support the counterweight using a hydraulic cart and remove
- Place connecting flange and ceramic ring together on hydraulic cart and bolt to the horn



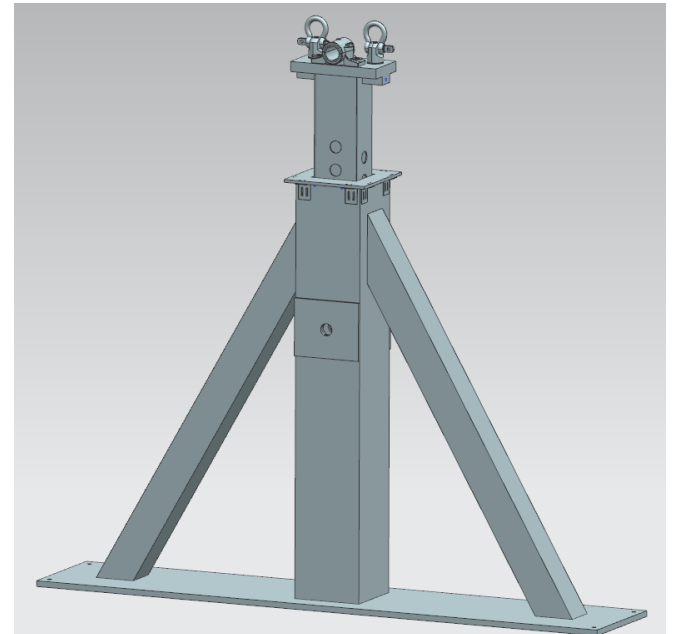
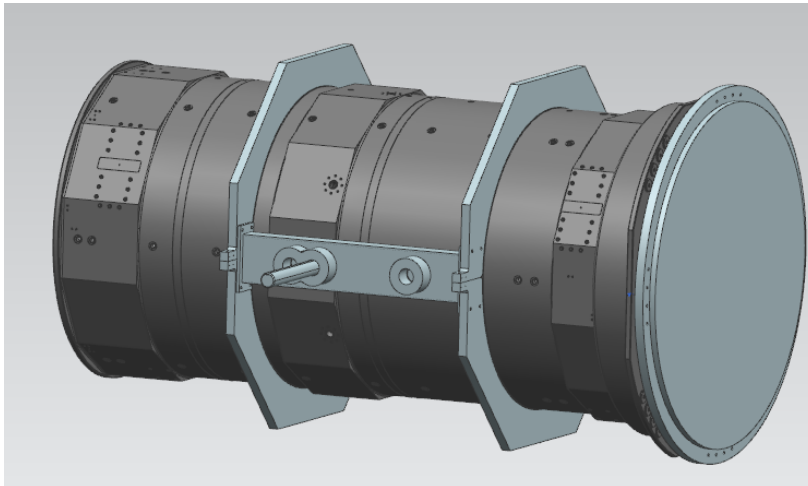
Horn B Assembly in Flipping Fixture

- Rotate horn to horizontal position and remove from fixture



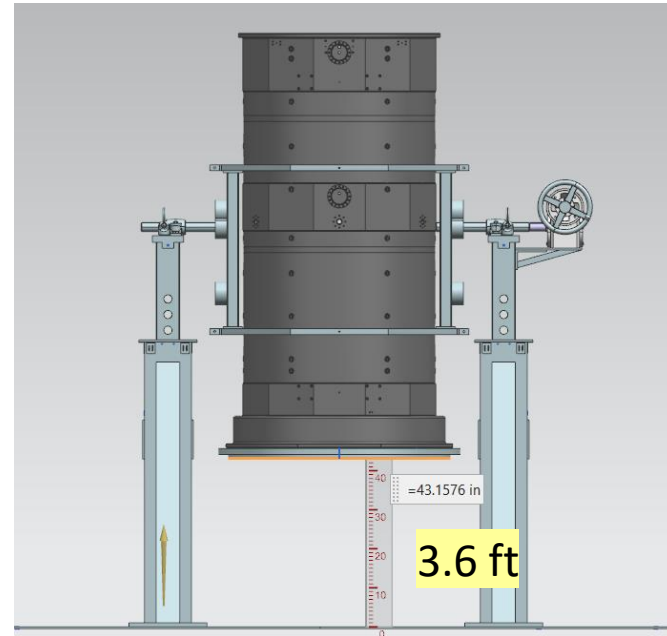
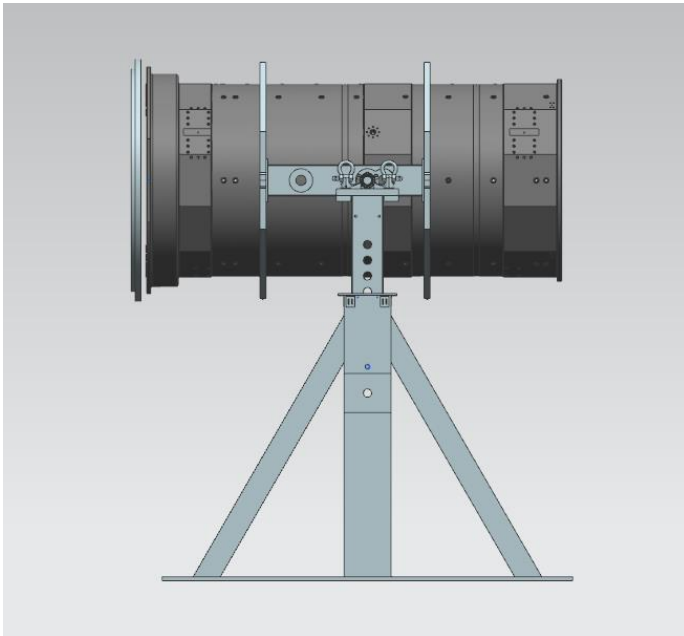
Horn C Assembly

- Assemble collar, flange and shafts on the outer conductor
- Bolt counterweight to upstream end outer conductor
- Use plastic washers
- Set stand height to Horn C position



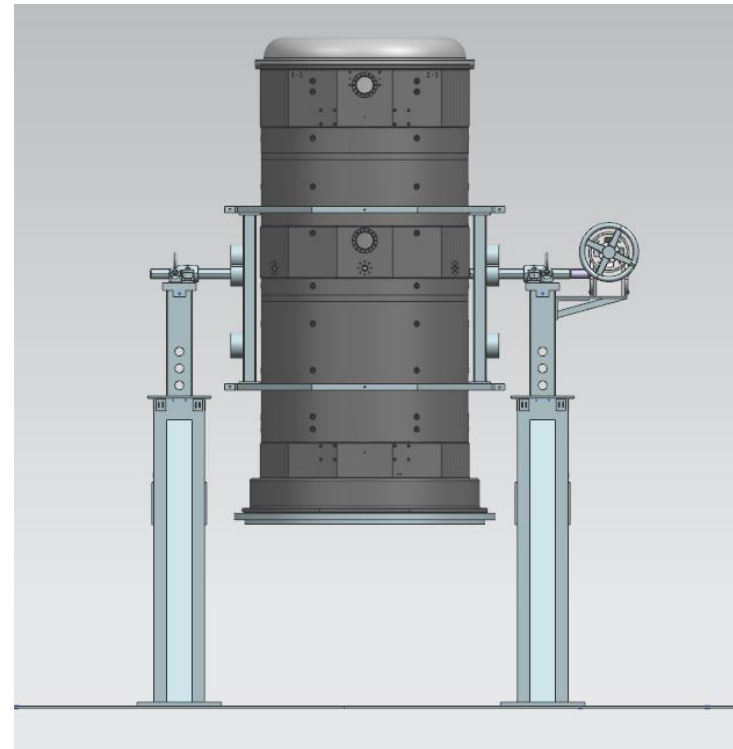
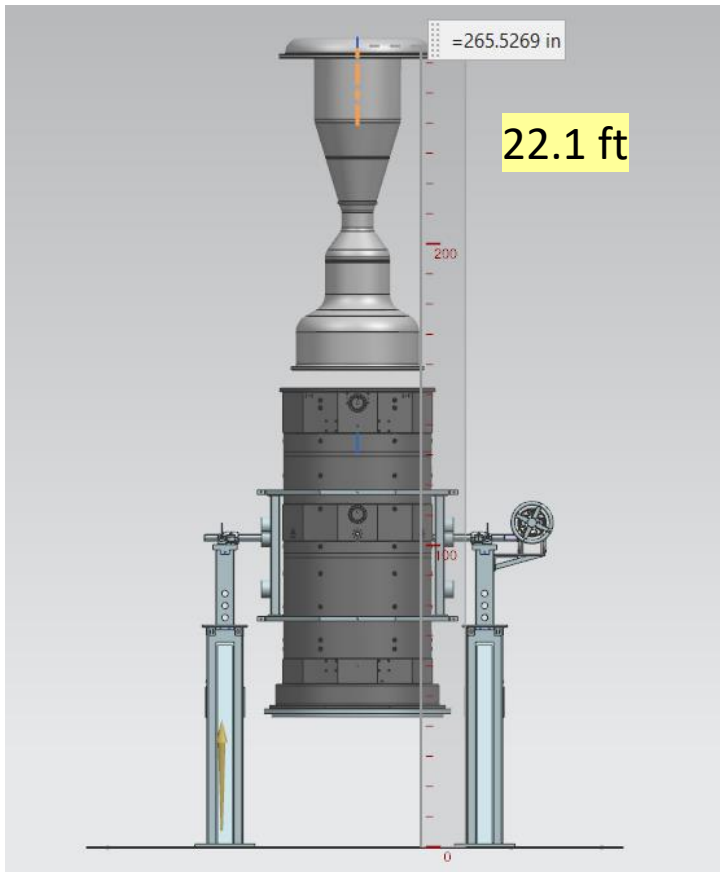
Horn C Assembly

- Lift outer conductor and position in stands
 - Attach shafts to pillow block bearings
- Rotate horn to vertical position with counterweight end closest to floor



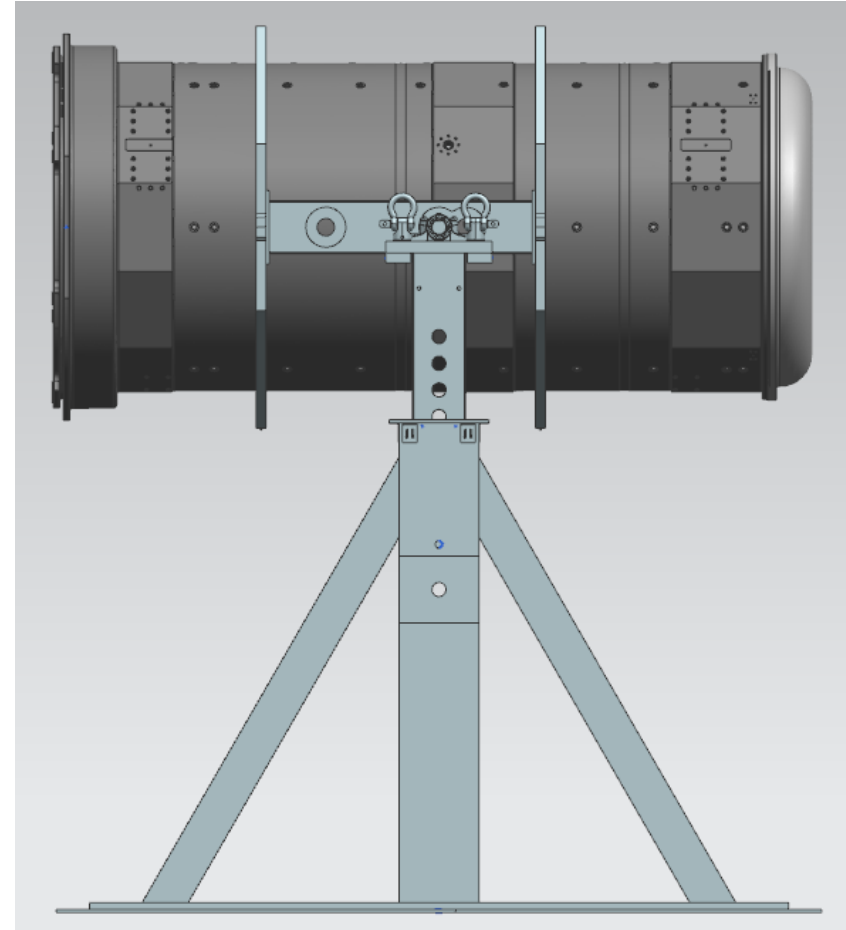
Horn C Assembly

- Lower inner conductor and fasten to the outer conductor



Horn C Assembly

- Remove counterweight, using hydraulic cart to support
- Place connecting flange and ceramic ring together on hydraulic cart and bolt to the horn
- Rotate horn to horizontal position and remove from fixture



TSIB Layout and Lift Plan

- Lowering of inner conductor into outer conductor confirmed to fit within hook height



Fabrication Procedures

- All procedures and specifications shown at Horn A reviews apply to Horns B and C
- Aluminum Welding Specification
- Electrical Isolator Assembly
- Electroless Nickel Plating Specification
- Friction Stir Welding Requirements for Conductor Buswork
- HI-POT Voltage Testing Procedure for LBNF Focusing Horns
- Instrumentation Line Assembly Procedure
- Horn A Spider Supports Installation Procedure
- LBNF Horn Assembly in Flipping Fixture
- LBNF Horn Inner Conductor Welding
- LBNF Horns Traveler
- Silver Brush-Plating Procedure for Focusing Horns
- Vendor Specification for LBNF Silver Plating

All procedures available at
[DUNE-doc-21618](#)

Fabrication Procedures - Traveler

- Document containing all QA checks and signoffs for every assembly and fabrication step
- Categorized by specific parts, assemblies and processes
- References in-depth procedures
- One traveler assigned and populated for each horn built



Procedural Document					
		Title:	LBNF Horns Traveler		
		Doc. #:	DUNE-doc-21618		
		Author(s):	Meredith Lee		
Rev.	Date:	Description:	Originated By:	Checked By:	Approved By:
R0	1/12/2020	Initial Release	Meredith Lee	Cory Crowley	Cory Crowley

LBNF Horns Traveler

Overview:

This traveler serves as a comprehensive list of quality assurance checks to perform during assembly of LBNF horns. It is categorized by specific segments, assemblies or processes to be completed during horn assembly. Each horn that is built should have an accompanying completed traveler document.

1. Inner Conductor Segments

U.S. Flange Inspection

Material Certification Available: ☐ Yes ☐ No

Drawing Number: Click or tap here to enter text.

Technician Name: Click or tap here to enter text.

Date of Inspection: Click or tap to enter a date.

Approved Variances: Click or tap here to enter text.

Conductor A Inspection

Material Certification Available: ☐ Yes ☐ No

Drawing Number: Click or tap here to enter text.

Technician Name: Click or tap here to enter text.

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LBNF Horns Traveler

Target Systems Department

Date of Inspection: Click or tap to enter a date.

Approved Variances: Click or tap here to enter text.

Transition Flange Inspection

Forging Certification Available: ☐ Yes ☐ No

Drawing Number: Click or tap here to enter text.

Technician Name: Click or tap here to enter text.

Date of Inspection: Click or tap to enter a date.

Approved Variances: Click or tap here to enter text.

2. Outer Conductor

Forging Inspection

Forging Certification Available: ☐ Yes ☐ No

Drawing Number: Click or tap here to enter text.

Technician Name: Click or tap here to enter text.

Date of Inspection: Click or tap to enter a date.

Approved Variances: Click or tap here to enter text.

Machining Inspection

Drawing Number: Click or tap here to enter text.

Technician Name: Click or tap here to enter text.

Date of Inspection: Click or tap to enter a date.

1. Wall Thickness (list to .001" precision): Click or tap here to enter text.

2. Ports in Correct Location: ☐ Yes ☐ No

3. Locating Holes in Correct Location: ☐ Yes ☐ No

Fermi National Accelerator Laboratory

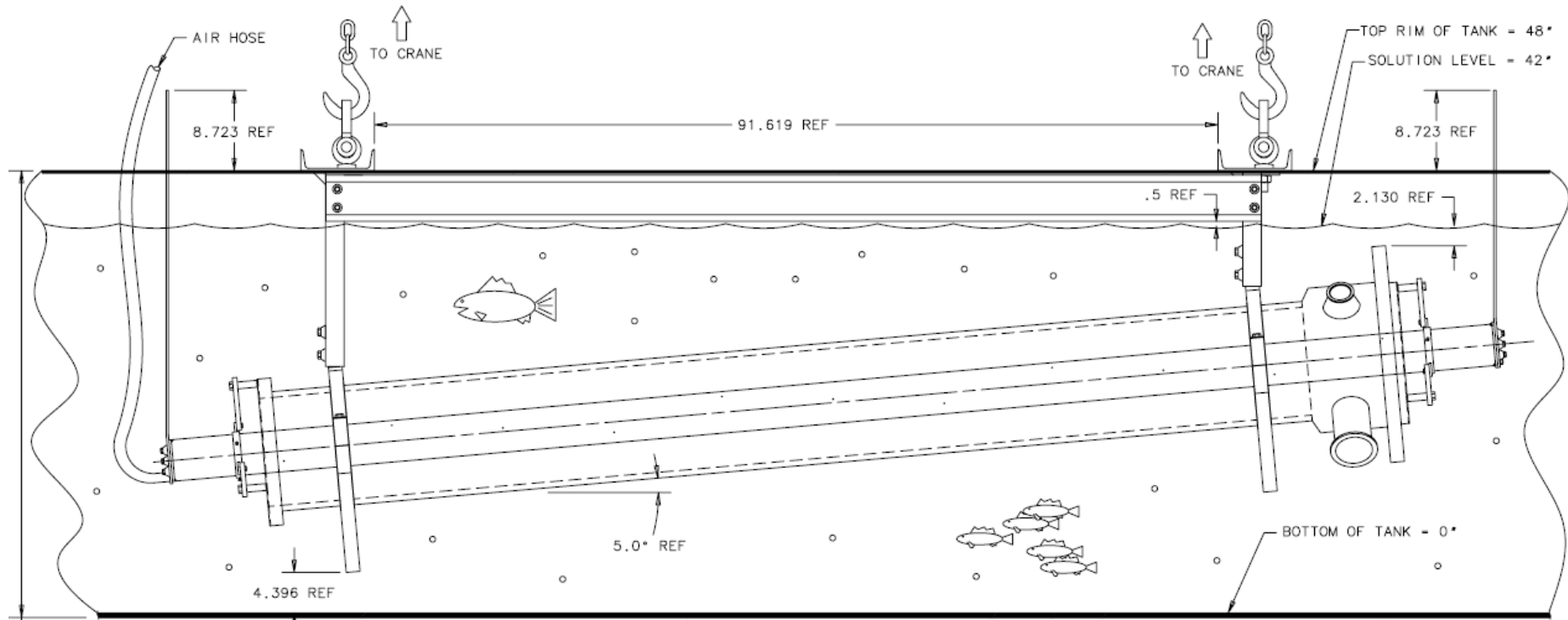
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Summary

- Fabrication planning occurred at same time as horn design to ensure feasibility
- Welding plan will follow proven process to date
 - Greater dependence on multi-ring sample due to high cost of individual sample parts
- Anodizing and nickel plating fixtures heavily influenced by NuMI design
 - Nickel plating fixture design requires slight differences in order to not exceed tank size
- All stages of flipping fixture assembly confirmed to fit in TSIB
- Fabrication procedures available for all critical assemblies and processes

Additional Slides

Anodizing Fixture in Tank



Horn B Assembly in Flipping Fixture

- Four ground steel plates form 178"x115"x0.75" (14.8'x9.6') base plate
 - Holes to anchor plate to the floor
 - Holes to anchor stands to plate
- Left stand is fixed
- Right stand has 1 position for Horn A and 1 position for B and C

