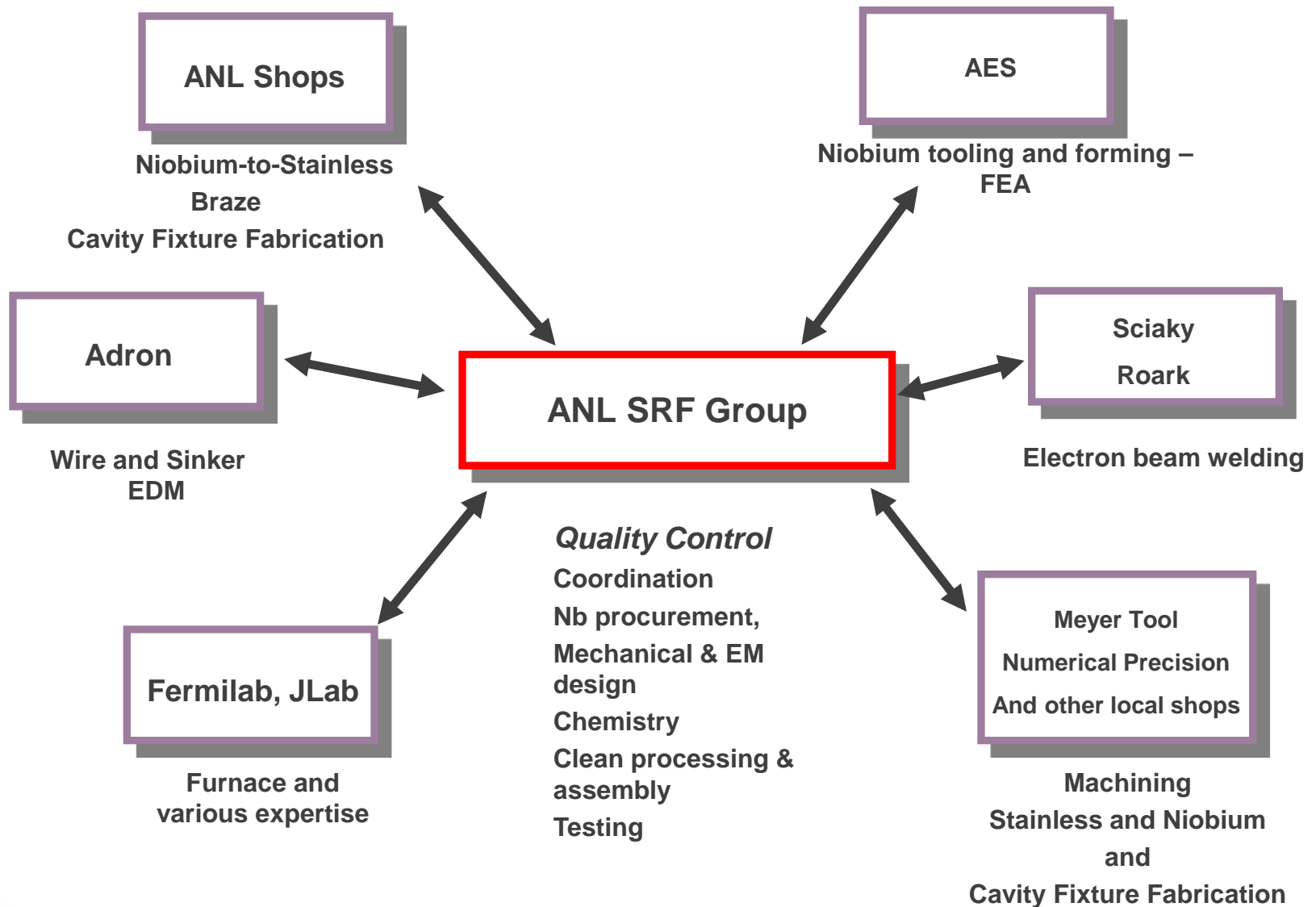


PXIE HWR FABRICATION TECHNOLOGY AND STATUS

Speaker: Mark Kedzie

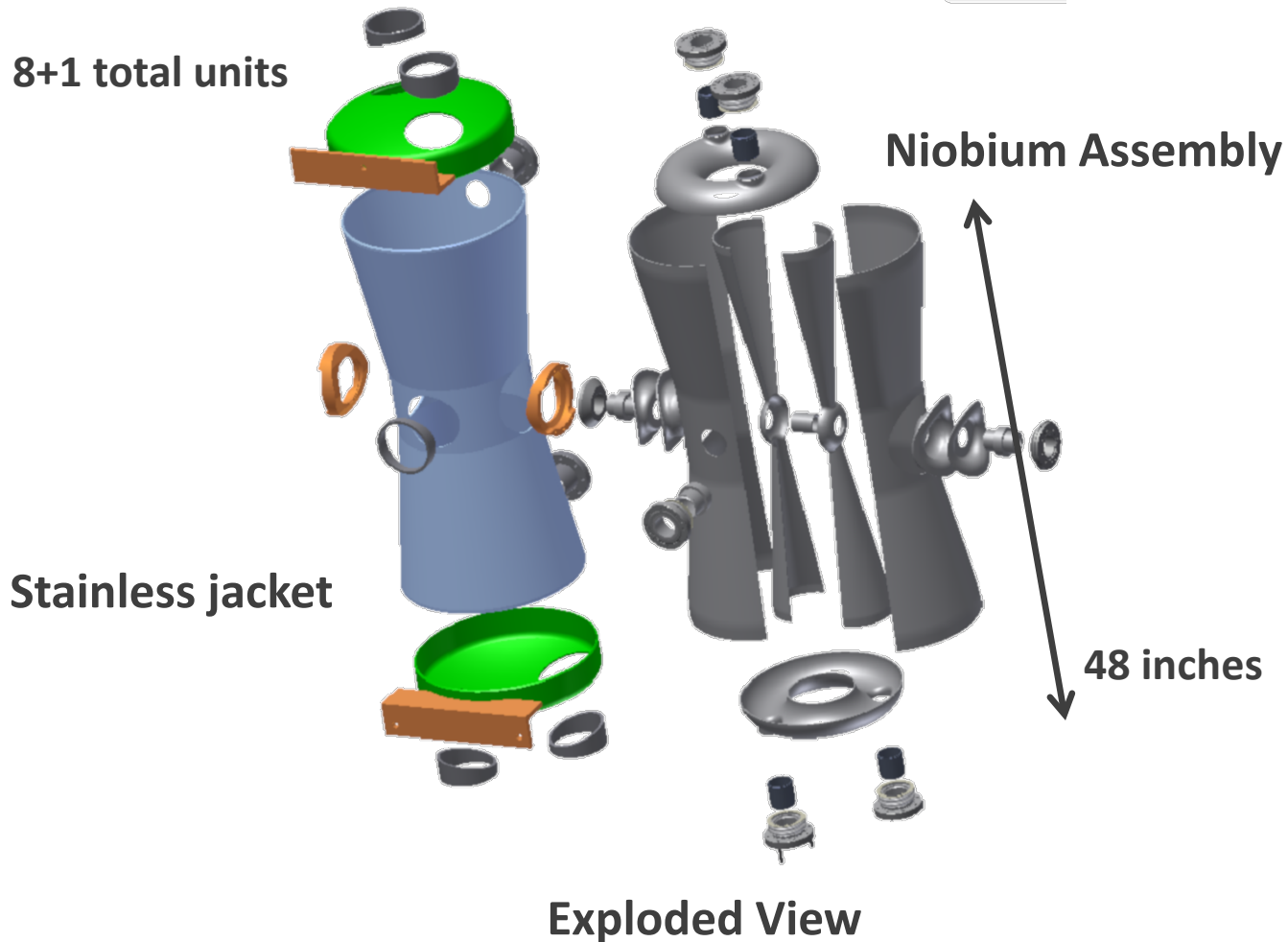
October 15, 2013

ANL Approach to Cavity Fabrication



162.5 MHz Half-wave Cavity

Starting point for cavities is EM model together with niobium parting/forming



FABRICATION PROCESS

- Fabrication starts with ordering of niobium sheet and bar stock.
- Niobium material is inspected giving a serial number and sent to vendors.
- Formed and machined parts are received back from vendors inspected and given serial number.
- Parts are machined in prep for EB welding.
- After all subassemblies are complete they are assembled for frequency tuning.
- Final EB welding of subassemblies is done to complete niobium cavity.
- Niobium cavity is sent to vendor to have stainless steel jacket assembled.
- Completed cavity is returned to ANL for Electro Polishing.
- Cavity sent to FNAL for heat treatment.
- Cavity is returned to ANL for post bake chemistry.
- Cavity is cold tested at ANL.



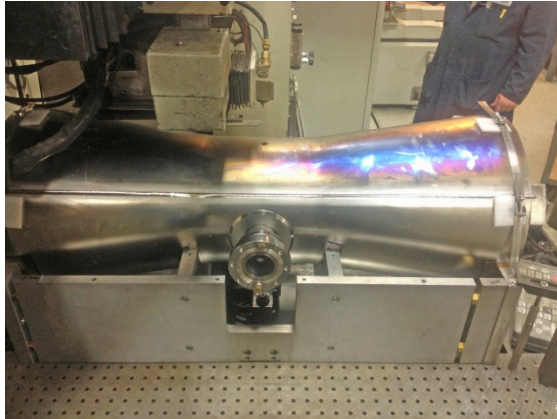
WIRE EDM

- We choose wire EDM because it is a noncontact form of machining.
- When parts are received from EDM vendor they etched prior to welding, to remove recast layer.
- About 70% of our machining steps are EDM.
- Since starting to use wire EDM we have not had one blowout during welding resulting in a hole of EB welded surfaces.



PXIE WIRE EDM FIXTURING

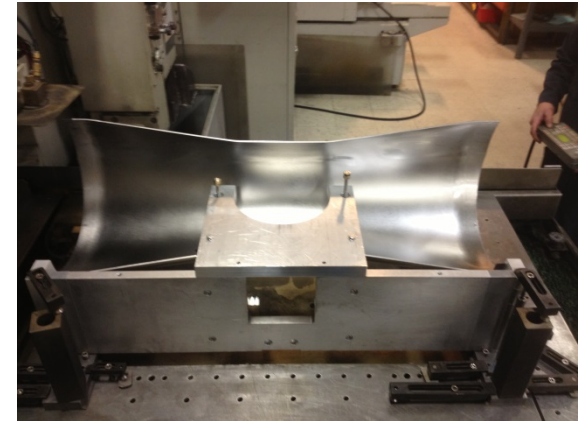
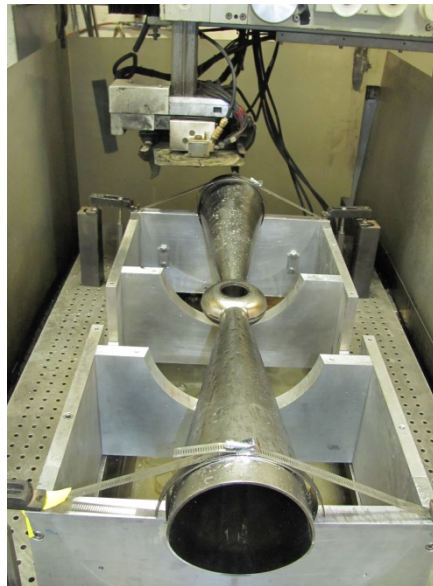
Shown here is a multipurpose EDM fixture for all Center Conductor and Housing cut.



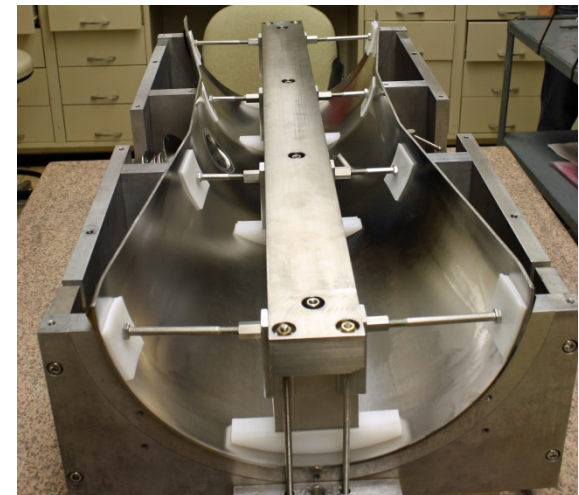
Setup for ReEntrant
Nose cuts



Fixture is used for all
Center Conductor cuts
Diameter length and
beam spool bore

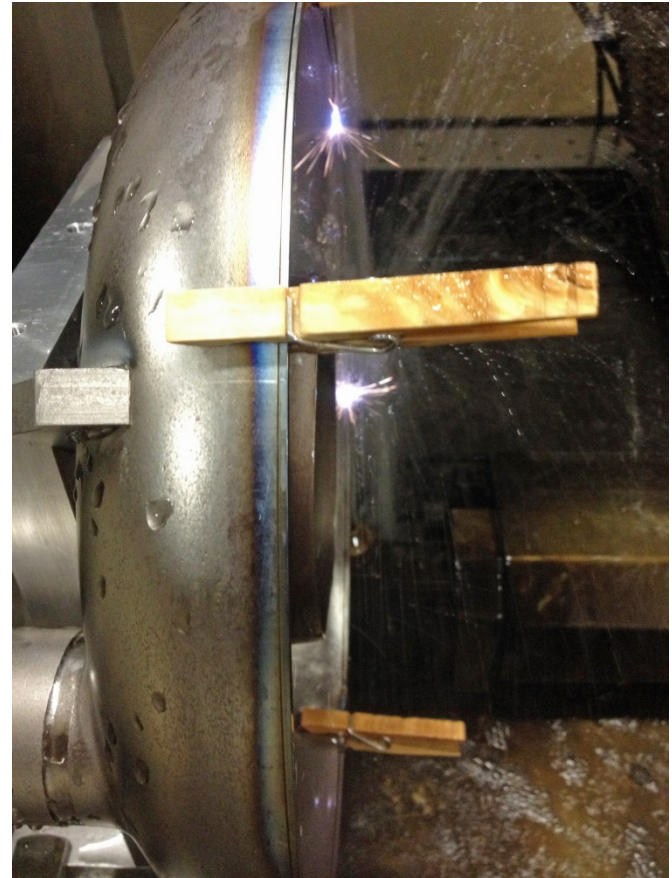
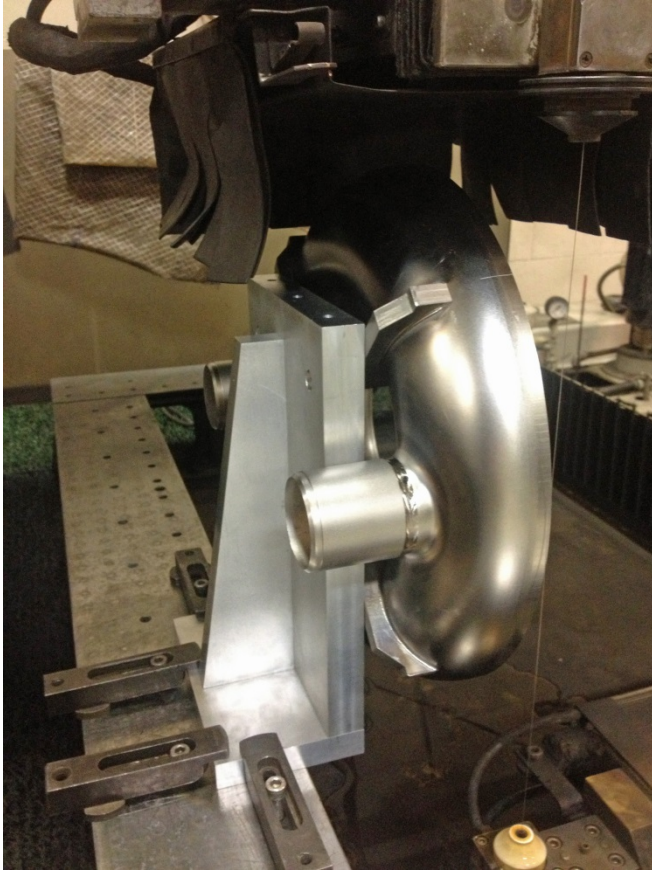


Housing diameter cut
EDM of Power Coupler
bore



TOROID

Setup to remove flash left from forming

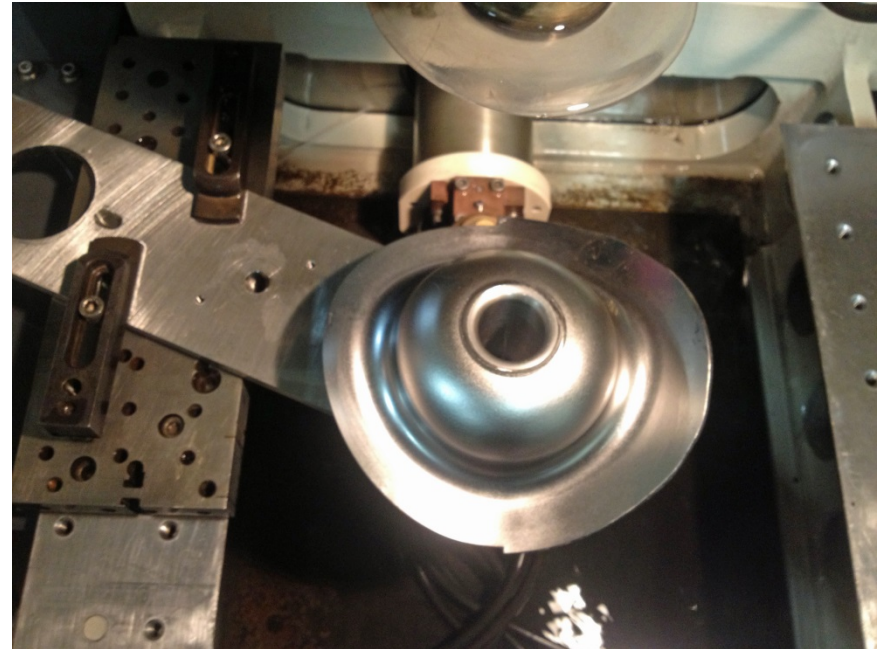


ReEntrant Nose



Trimming ReEntrant Nose OD to
fit Housing bore

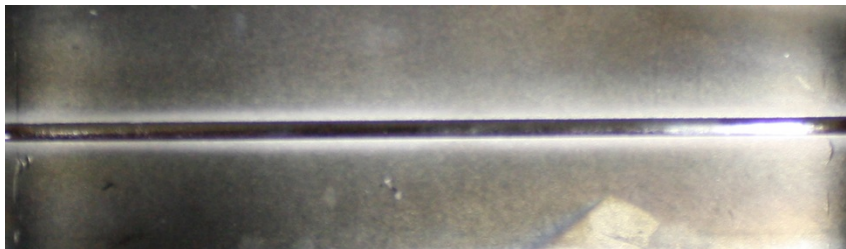
Two setups are required to
complete OD cut



PIXIE ELECTRON BEAM WELDING

- Two types of welds are used in cavity fabrication thru welds and keyhole welds.
- Thru welds are typically used in low field areas when there is no access to RF surface.
- Keyhole welds are used in high field areas where the RF surface is accessible.
- Keyhole welds have less heat input, smaller heat affected zone and less weld distortion than thru welds.

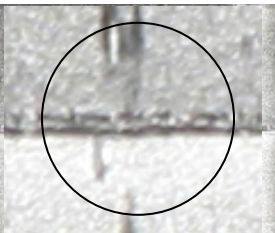
Keyhole weld with cosmetic pass RF surface



Keyhole weld root side cavity exterior



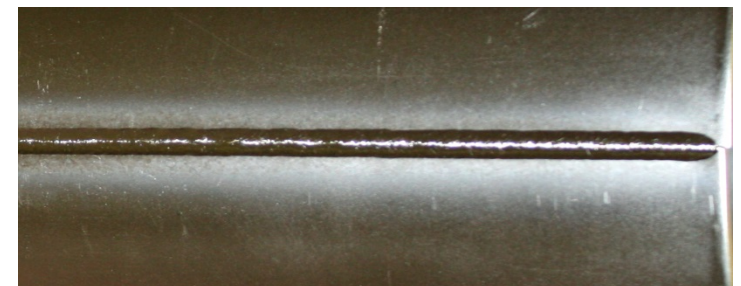
Rough surface



Thru weld RF surface



Thru weld exterior



WELD PREP

- All welds and there heat affected zones are etch with BCP within 24 hours of welding.
- All parts and weld seams are high pressured rinsed in clean room.
- Weld fixturing is also cleaned and High pressure rinsed.
- Parts and fixturing are dried in clean room assembled and bagged for transport.
- Parts or fixturing that can not be assembled at ANL are assembled in ANL cleanroom at Sciaky.

Post etch HPR



Sciaky clean room



Parts and fixturing ready for assembly



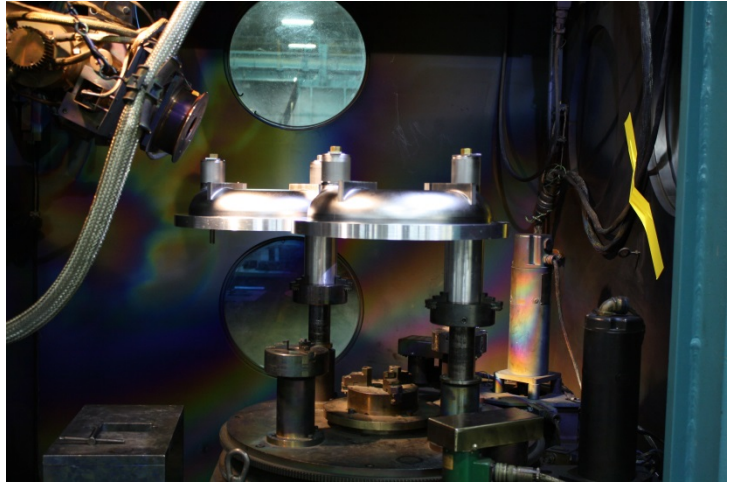
TOROIDS

One fixture accommodates three different weld setups

When ever possible multiple parts are placed in chamber to reduce welding cost

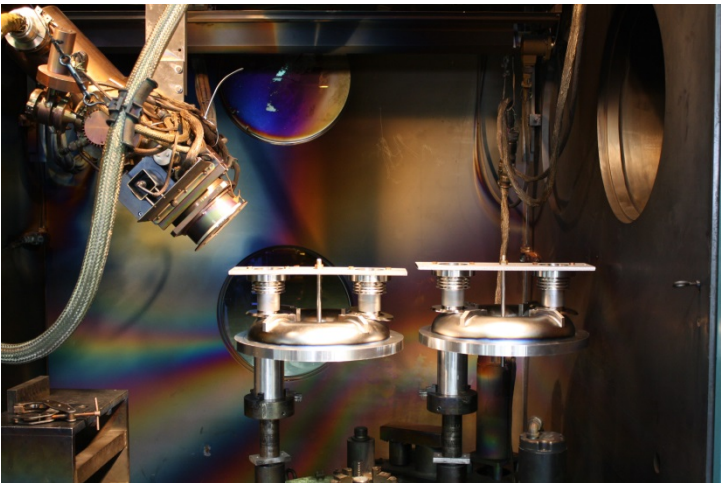


Setup for welding gussets



Setup for coupling port braze transitions

Setup for welding port extension tubes



CENTER CONDUCTOR



Center Conductor seam weld setup

Note: Fixture holds four parts and is also used for welding beam spool

Center Conductor weld with cosmetic pass



REENTRANT NOSE

Able to setup four parts at a time in EB chamber

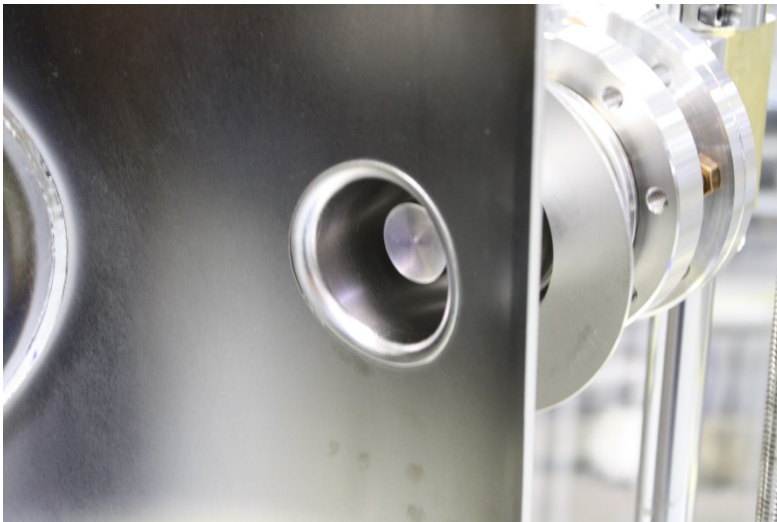
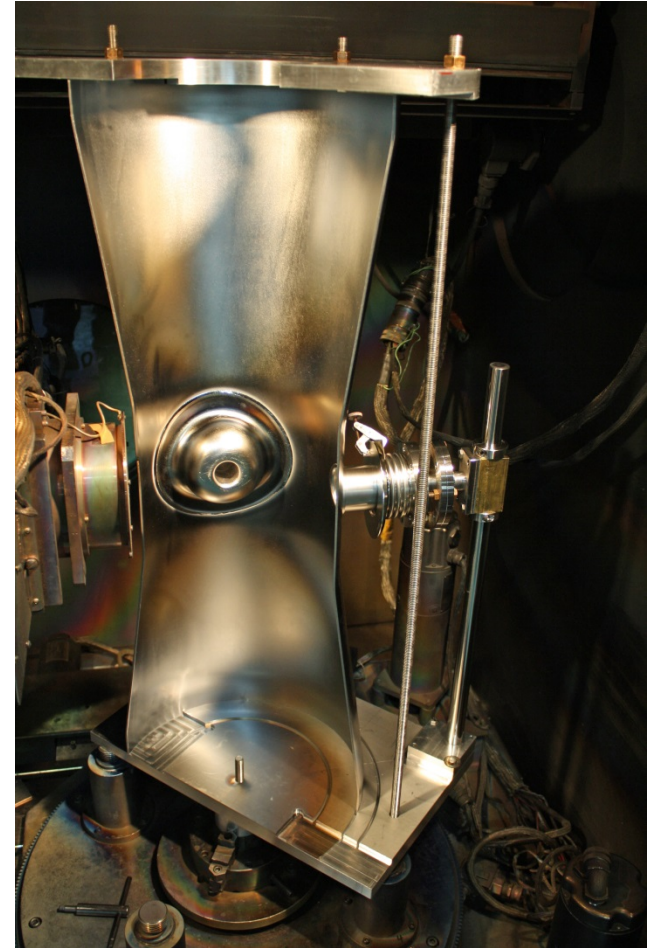


POWER COUPLER

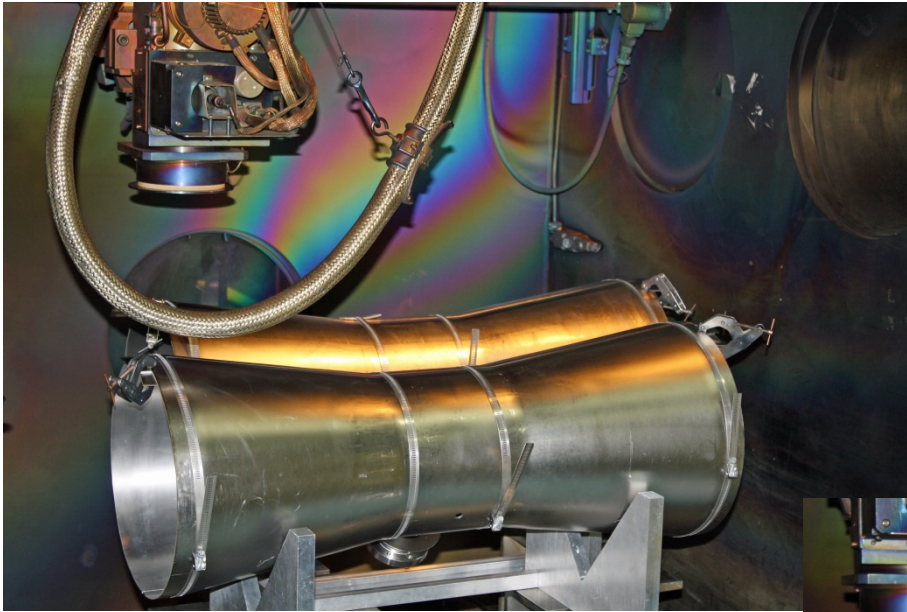
Able to setup four parts at a time



Power coupler welded into housing half



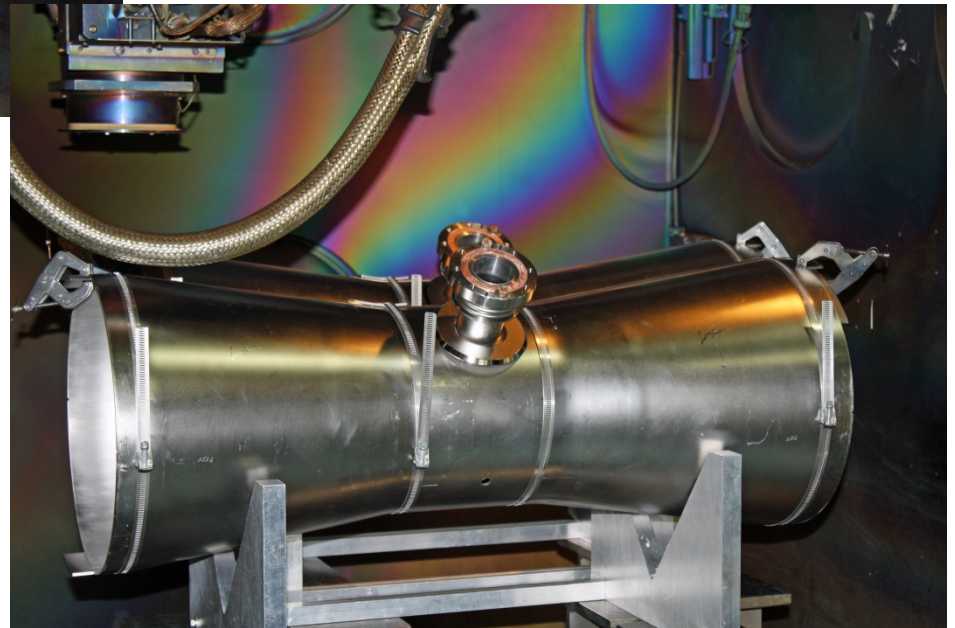
HOUSING



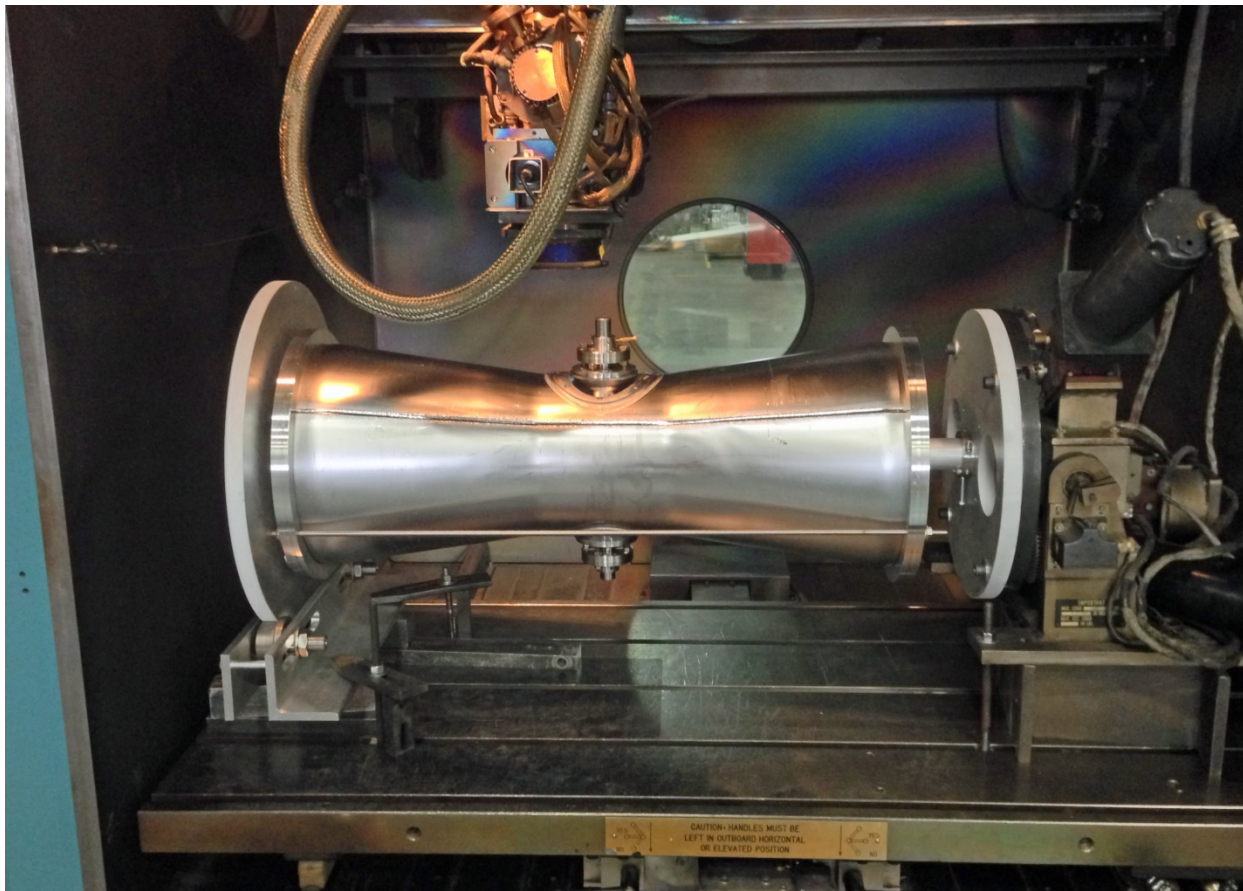
Setup for seam tack weld two parts per pump down

After tacking first seam parts are rotated to Tack second seam.

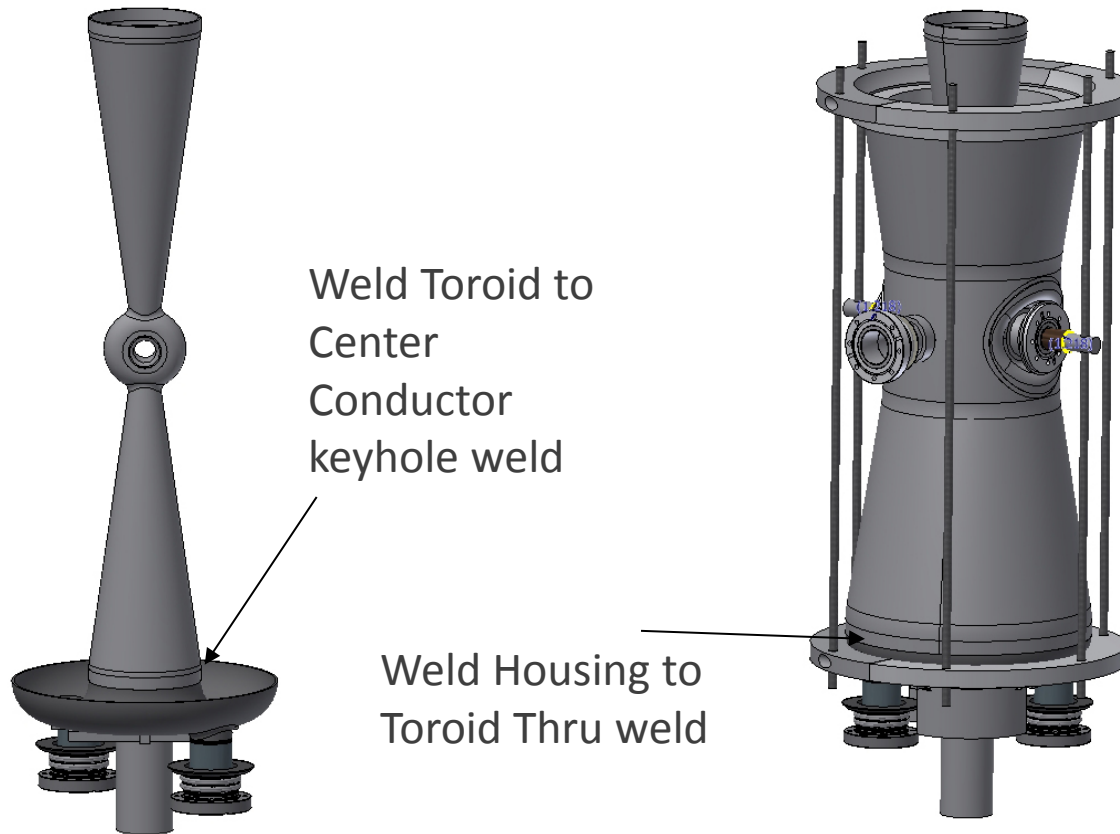
Tacking clamps are removed and seams are welded using Thru weld procedures



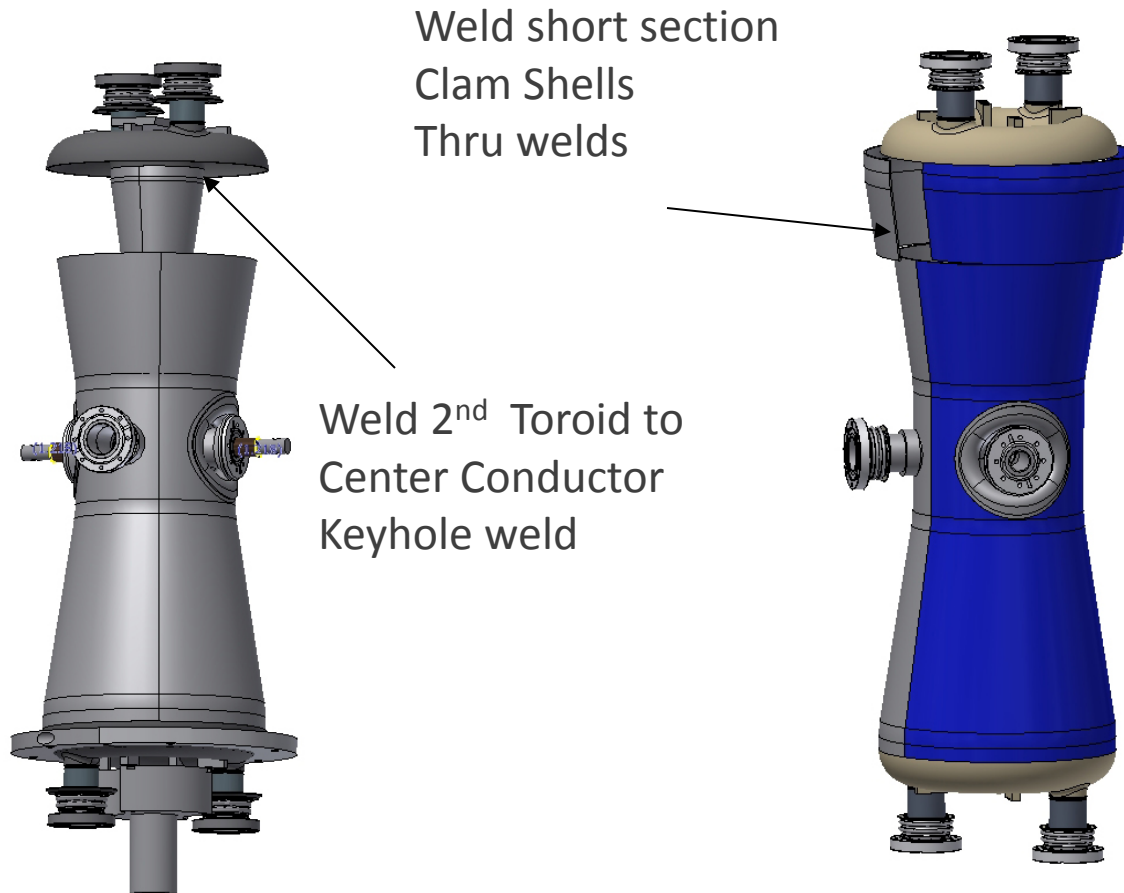
REENTRANT NOSE TO HOUSING WELD



REMAINING WELDS AFTER TUNNING

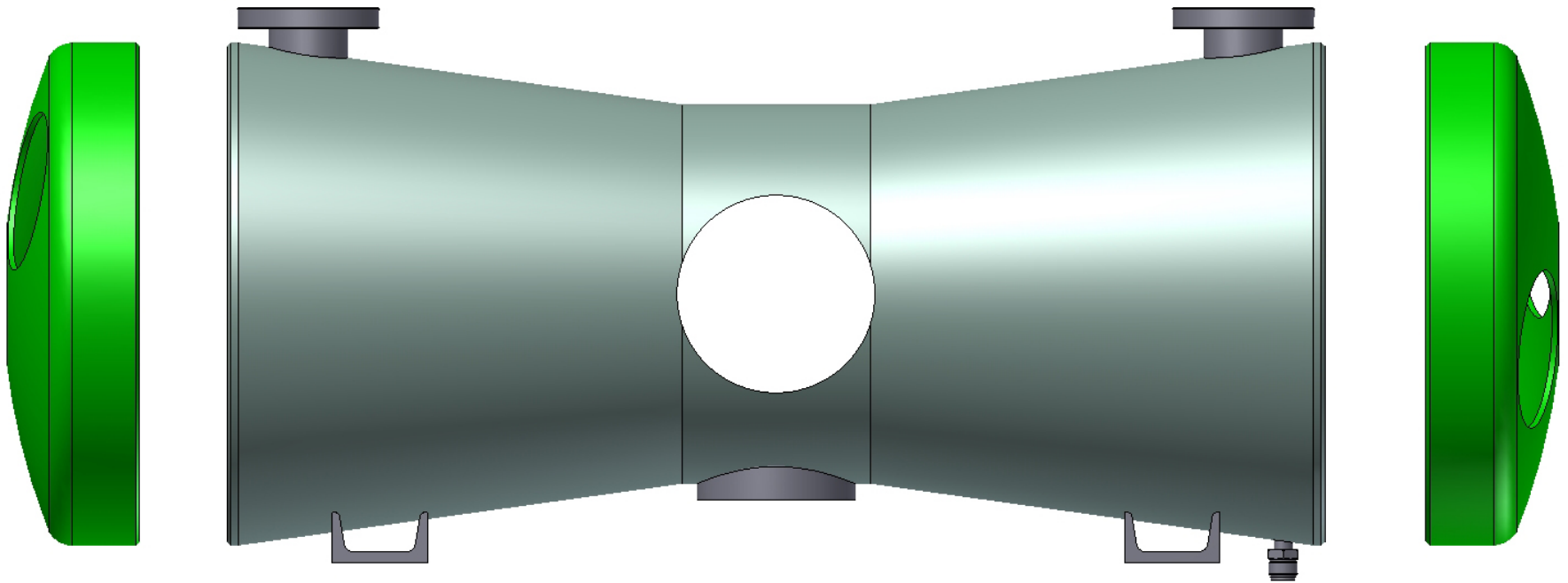


REMAINING WELDS AFTER TUNNING



STAINLES STEEL JACKET

FINAL STEP IS TO ADD SS JACKET TO CAVITIES



PROTOTYPE STATUS

- Two prototype cavities are being fabricated.
- One cavity is being fabricated out of FNAL supplied material from Cabot.(Cabot Cavity)
- The second cavity materiel comes from vetted suppliers (PXIE Cavity)
- All subassemblies are completed on PXIE cavity and is ready for tuning.
- Cabot cavity needs ReEntrant noses welded in and it will be ready for tuning.



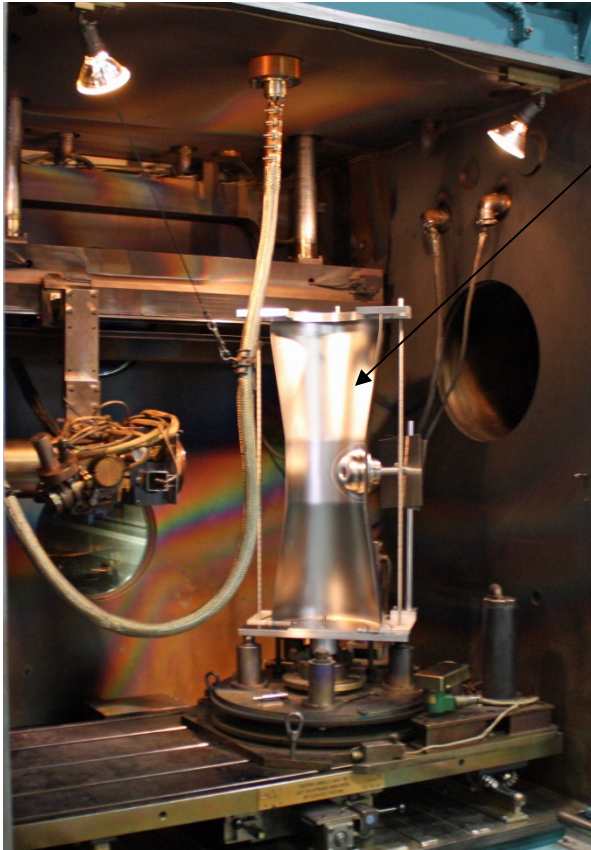
FABRICATION ISSUES

- Original fabrication plane called for ReEntrant nose to be welded into housing halves. This step caused unexpected warping in housing halves which would cause beam port and housing seam misalignment.
- It was then decided to weld housing halves together then weld ReEntrant noses into housing cylinder while maintaining beam port alignment.
- New housing halves were fabricated and ReEntrant noses were wire cut from old housing halves and reused.

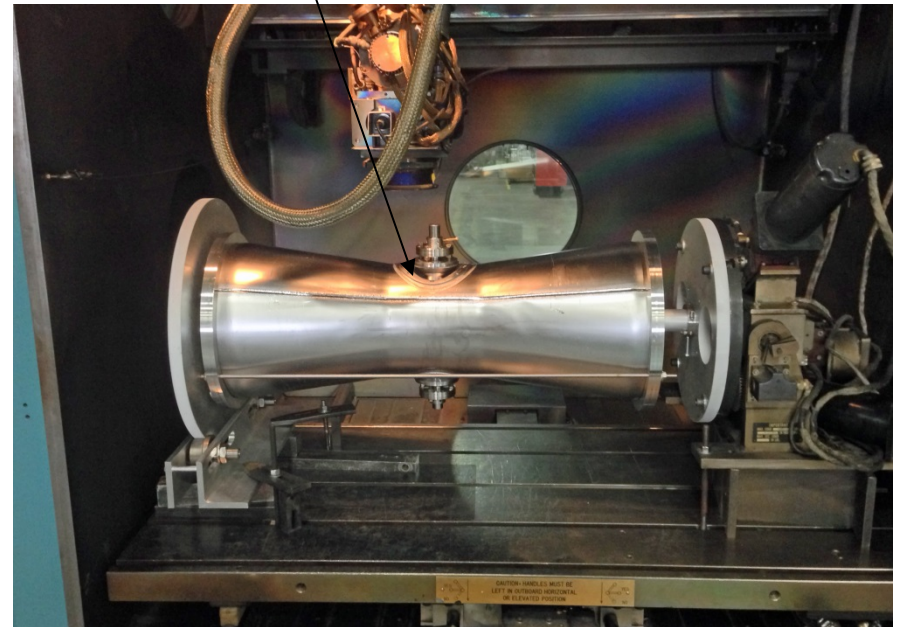


FABRICATION ISSUES

Welding Nose into housing half



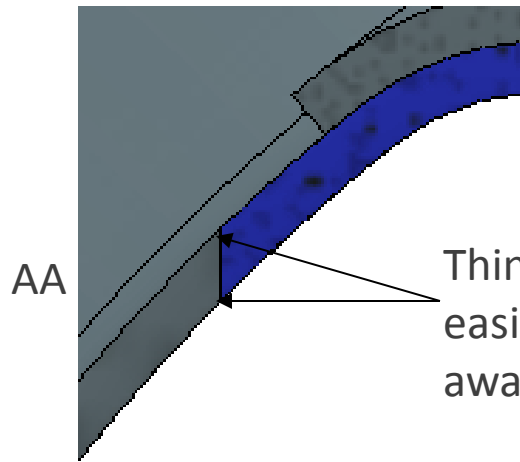
Welding Nose into whole housing



FABRICATION ISSUES

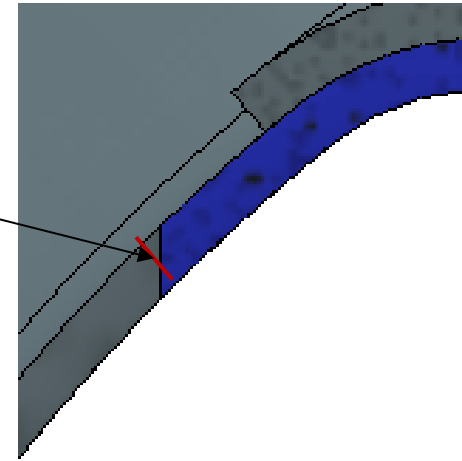
- A second welding issue developed with the Nose welds.
- Reusing the old noses made fit up of parts for welding difficult.
- Noses were also warped from all of the fabrication welding.
- Wire boring a circle into the housing and wire cutting of noses to match gives you an over lapping weld joint. This joint design cause the niobium to have a very thin edge which can melt away leaving a non weld area on the inside of cavity.
- This has happened on the PXIE cavity which required a re-melt of non welded area.
- Cabot cavity will have same problem we will work on getting a better joint fit up to hopefully resolve the issue. If not re-melt will also be required.
- **Solution for production cavities is to keep joint perpendicular to surface. This will make a standard butt weld which allows more tolerance for seam mismatch.**

CURRENT JOINT DESIGN

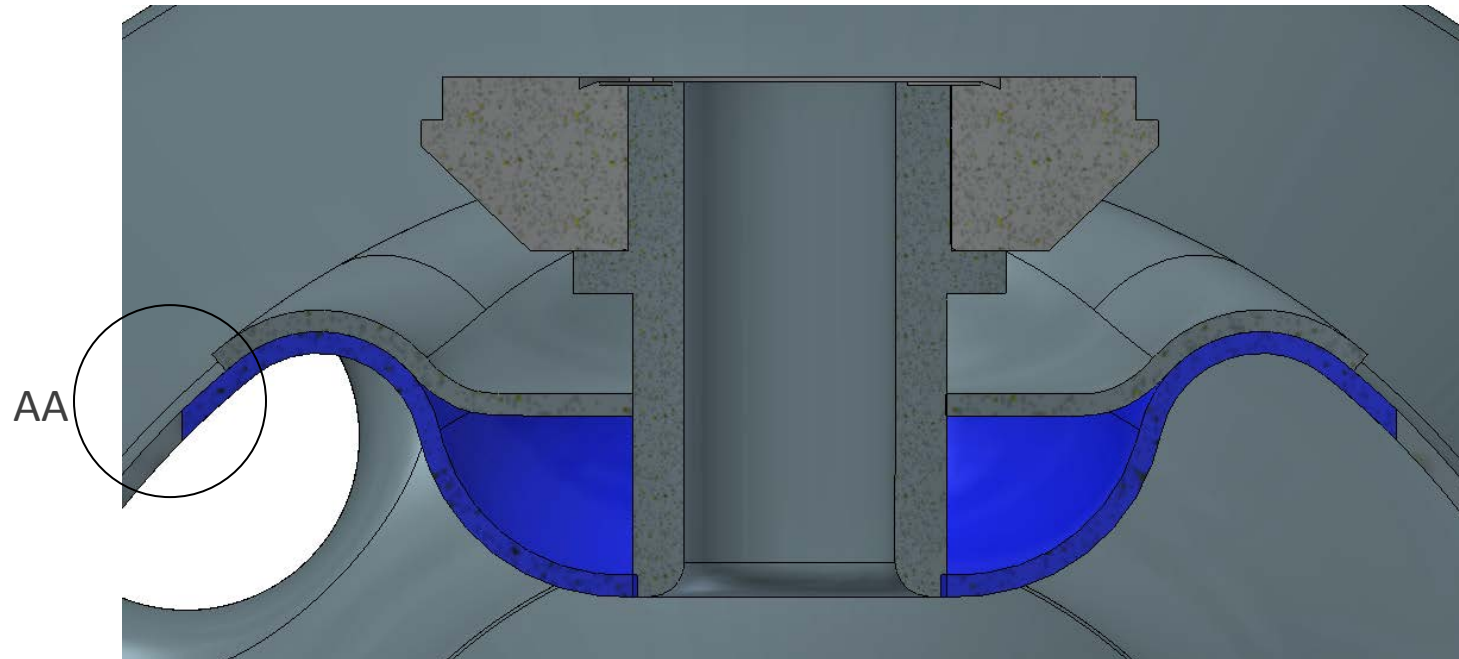


Solution keep joint perpendicular to surface

Thin sharp edges can easily overheat and melt away during welding



ReEntrant Nose section view



CAVITY FABRICATION QUALITY CONTROL



NIOBIUM SHEET INSPECTION

Sheet and bar stock is soaked for minimum of 8hrs.



Inclusions show up as rust spots



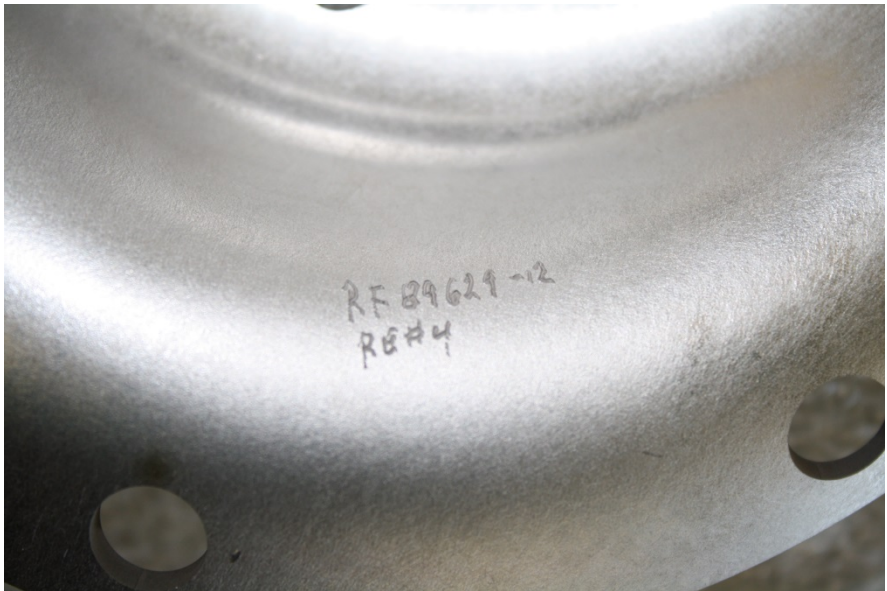
Spots are acid etch to remove inclusions and resoaked. Best sheet side is marked for interior surface



SHEET AND BAR STOCK IS INSPECTED AND GIVEN SERIAL NUMBER THAN SENT TO VENDORS FOR FABRICATION



PARTS ARE RECEIVED FROM VENDORS INSPECTED
AND GIVEN A SERIAL NUMBER



QUALITY CONTROL TRAVELER

All cavity fabrication steps are tracked and recorded in traveler

FNAL HWR CAVITY FABRICATION TRAVELER

By Mark Kedzie

HWR Serial No. _____

Responsible Engineer: _____ Date: _____

Comments: _____

Responsible QA Engineer: _____ Date: _____

Comments: _____



NIOBIUM STOCK

1. Visual Inspection

Receive all Niobium sheet, plate and bar stock from vendor inspect for nicks, scratches and other damage. Take pictures.

Inspected by: _____ Date: _____

Comments: _____

2. Soak Test

Place all Niobium stock in poly containers and fill containers with DI water above the Niobium. Soak for minimum of 8 hours. Look for inclusions and treat with acid. Take pictures of any inclusions.

Done by: _____ Date: _____

Comments: _____

3. OA Approval

Responsible QA Engineer: _____ Date: _____

Comments: _____

4. Transport Material

Ship Niobium material to vendors for fabrication.

Done by: _____ Date: _____

Comments: _____

QUALITY CONTROL TRAVELER (continued)

REENTRANT NOSE ASSEMBLY

ReEntrant Nose Serial No. _____
ReEntrant Nose Serial No. _____
Niobium Stock Serial No. _____

1. Visual Inspection

Receive parts from vendor inspect for nicks, scratches and other damage.

Inspected by: _____ Date: _____

Comments: _____

2. Soak Test

Place parts in poly container and fill container with DI above the parts. Soak for minimum of 8 hours. Look for inclusions and treat with acid.

Done by: _____ Date: _____

Comments: _____

DOUBLERS

Doubler Serial No. _____
Doubler Serial No. _____
Niobium Stock Serial No. _____

3. Visual Inspection

Receive parts from vendor inspect for nicks, scratches and other damage.

Inspected by: _____ Date: _____

Comments: _____

1. Soak Test

Place parts in poly container and fill container with DI water to a level above the parts. Soak for minimum of 8 hours. Look for inclusions and treat with acid.

Done by: _____ Date: _____

Comments: _____

2. Wire EDM

Transport parts to Adron for final EDM of doubler OD and cooling holes.

Done by: _____ Date: _____

Comments: _____

3. EBW Prep (Nose and Doubler)

Clean parts than etch with BCP and rinse with DI water. High pressure rinse with DI water while in clean room. Dry all parts in clean room and package for transport **Note: Etch both ReEntrant nose and doubler plates.**

Done by: _____ Date: _____

Comments: _____

4. Electron Beam Welding

Transport parts to EBW vendor and complete welding of Nose and doubler. Return parts to ANL.

Done by: _____ Date: _____

Comments: _____



PRODUCTION STATUS

ALL FORMED PARTS FROM AES ARE RECEIVED



PARTS HAVE BEEN INSPECTED
REENTRANT NOSE WELDDING WILL START WEEK OF 10/21/13

