HWR for PXIE: Proposed fabrication technology

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Physics Division

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- Recent activities of our Group
- Fabrication steps
  - Purchase of Nb sheets and bar stock
  - Nb forming
  - Brazed SS-Nb transition
  - Nb machining, wire EDM
  - BCP
  - EBW
  - SS vessel
  - Alignment fiducials
- HWR for PXIE specs

Development and construction of a new 162.5 MHz HWR

- EM Design - B. Mustapha
- Mechanical design and engineering analysis – Z. Conway
- Fabrication steps
  - Nb forming
  - Brazed SS-Nb transition
  - Nb machining, wire EDM
  - EBW
  - Frequency tuning
  - SS vessel – ASME pressure vessel code
- Cavity Sub-systems: RF coupler, slow and fast tuners – M. Kelly, G. Zinkann
- RF surface processing – M. Kelly
- Cryomodule: assembly, alignment – Z. Conway and M. Kelly
- Operational experience with SC ion linac – G. Zinkann

Recent Experience of ANL Linac Development Group

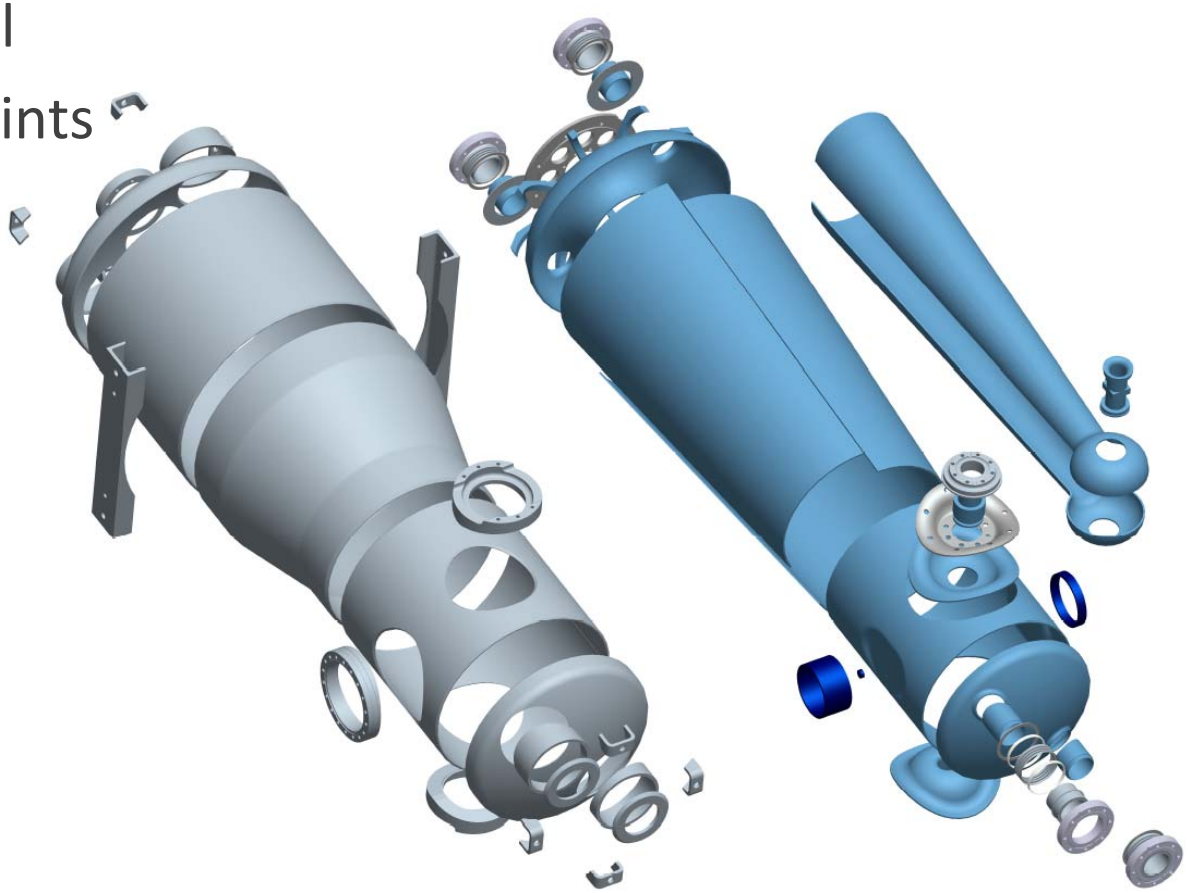
- In the past 26 months
  - Prototype 72.75 MHz QWR has been developed, built and tested
  - 6 production cavities have been built
  - Just finished construction of super-high gradient 72.75 MHz QW
    - Peak magnetic fields are expected to exceed 120 mT
  - New 322 MHz, β=0.285 HWR for the MSU/FRIB has been developed
    - Complete engineering and mechanical design
  - New super-high gradient 325 MHz HWR resonator has been developed
    - Being constructed, die forming of Nb parts is in progress
    - Will be completed in the summer of 2012
  - Optimized EM design of SC cavities for several other applications
    - 162.5 MHz HWR for FNAL
    - Low-β (0.085) and high-β (0.15) 176 MHz HWRs for SARAF
    - Low-β (0.085) and high-β (0.15) 109 MHz QWRs for SARAF

Overall design philosophy of SC cavities

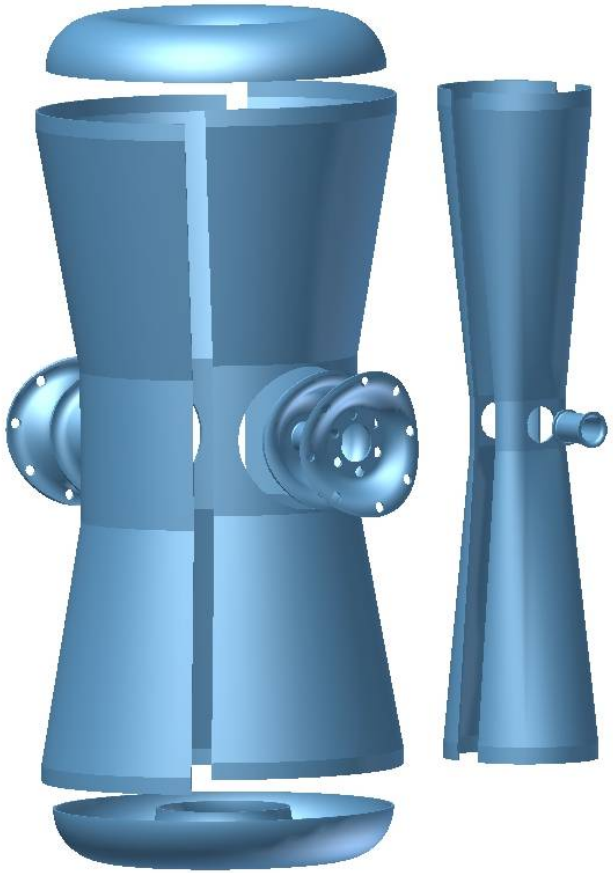
- Incorporate into the cavity design the following features and sub-systems
  - RF coupler
  - Slow tuner
  - Fast tuner
  - RF surface processing
  - Facilitate integration into the cryomodule
    - Cavity alignment
- Fabrication is being done under close supervision of ANL experts
  - EBW by an ANL engineer
  - Wire EDM set up by an ANL engineer
  - Helium vessel work - under ANL engineer guidance
- RF surface processing, assembly, testing
  - ANL experts

Example: 72.75 MHz QWR

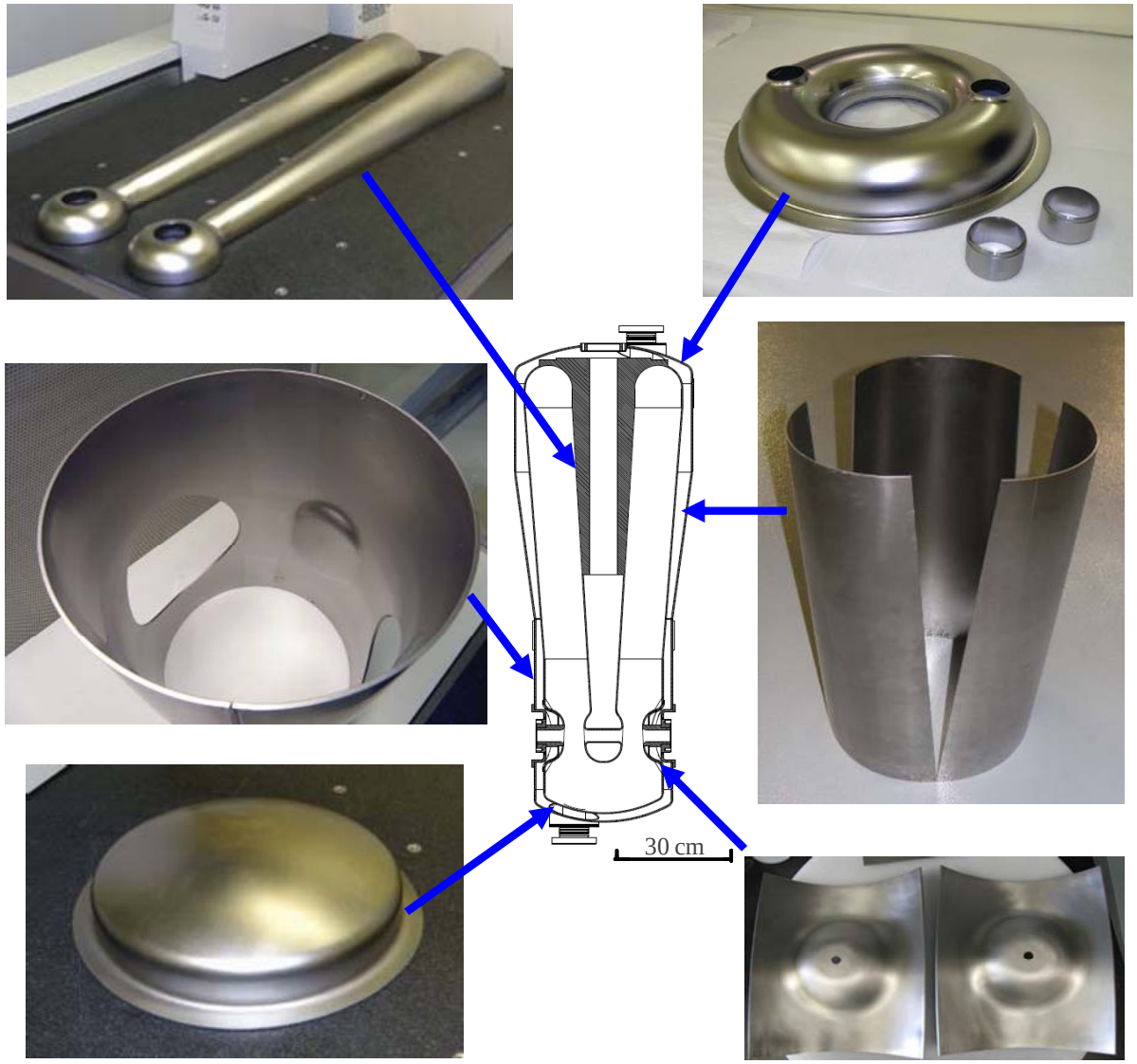
- Exploded view of Nb and SS parts
- Nb purchase: 1/8” sheets and bar stocks
- SS helium vessel
- Nb-SS brazed joints



HWR: exploded view (preliminary)



Fabrication Steps: QWR Nb parts



Niobium parts for production cavities, formed from flat sheets and machined from bar stocks

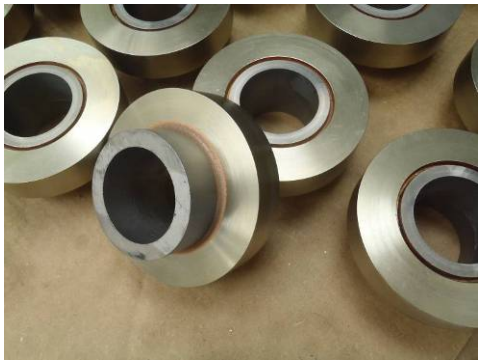
Central conductor halves

Toroids with gussets and extension tubes

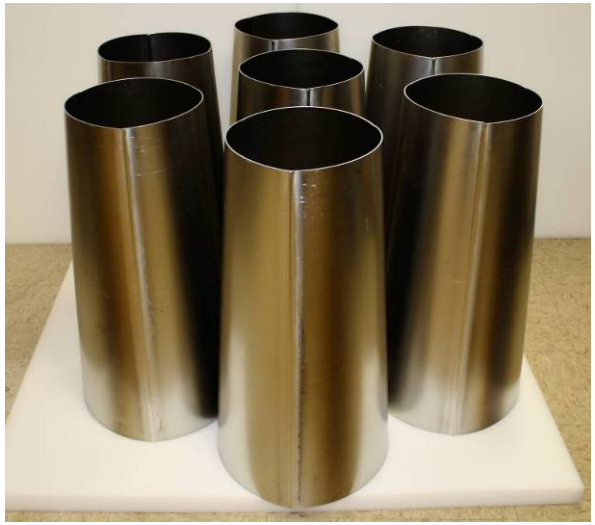
Bottom domes

Cylinder housing

Brazed Nb-SS transitions (coupling ports, beam ports)

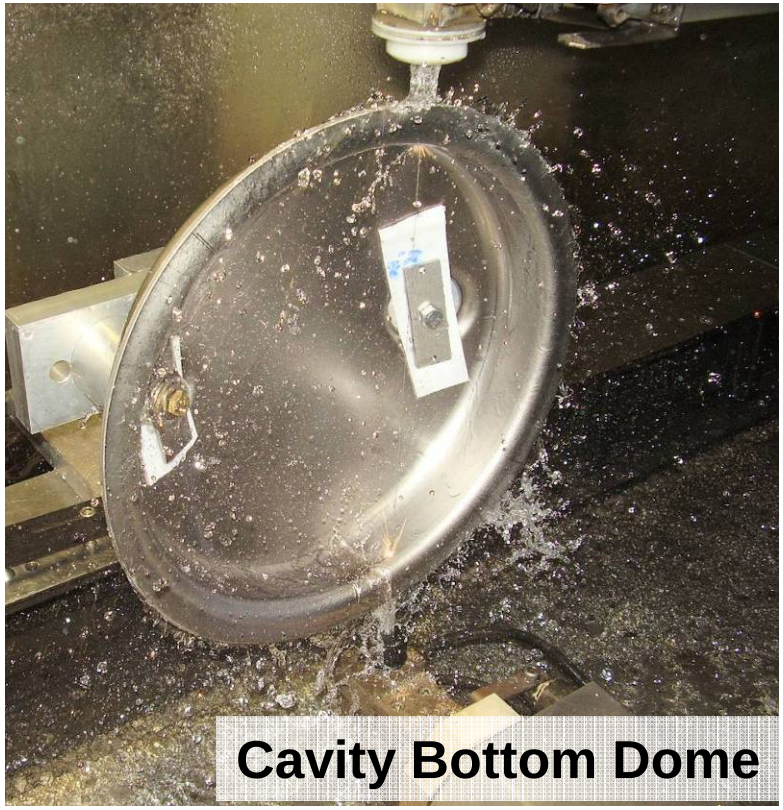


Tapered sections

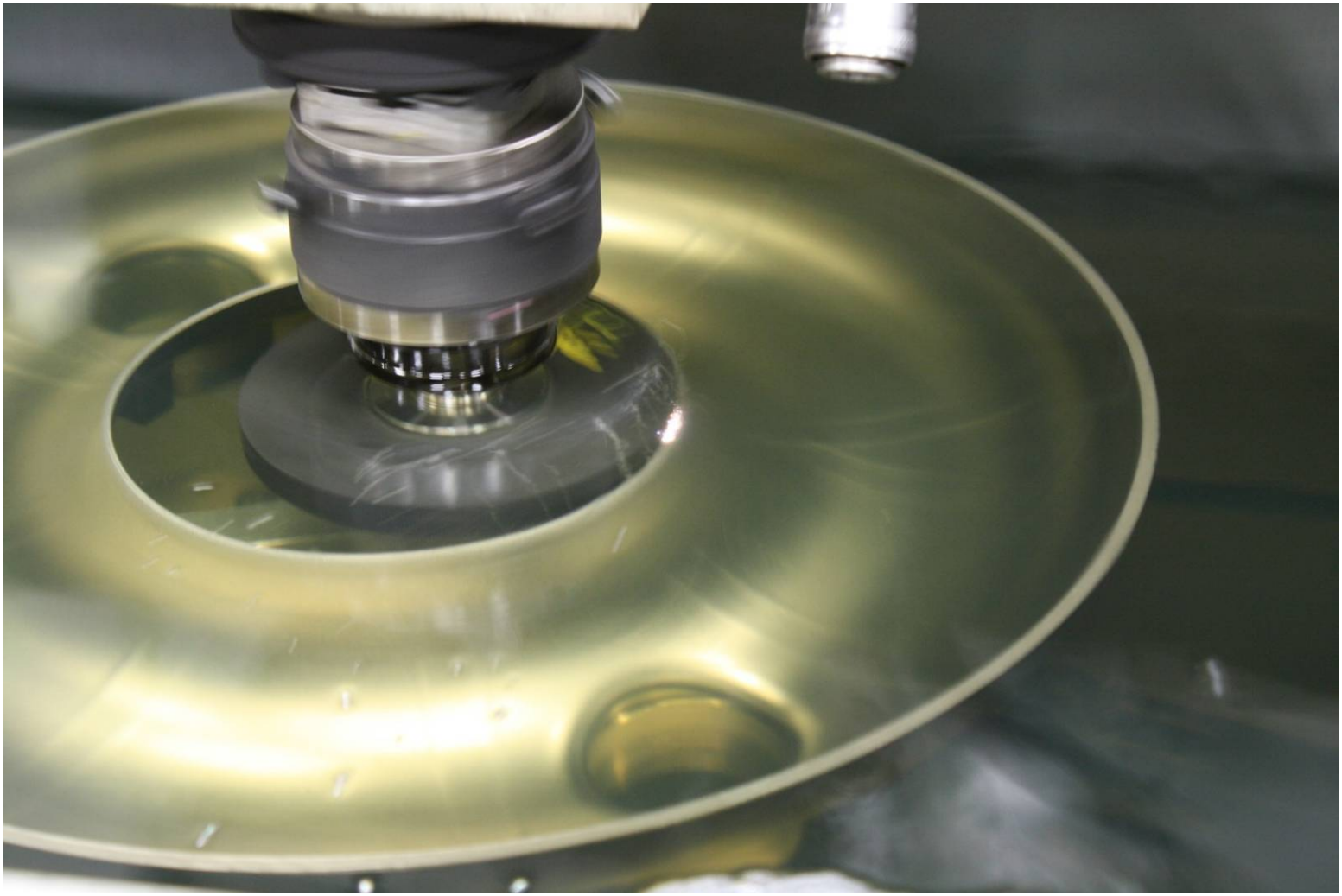


Cavity Fabrication by Wire EDM

- Essentially no possibility for inclusions

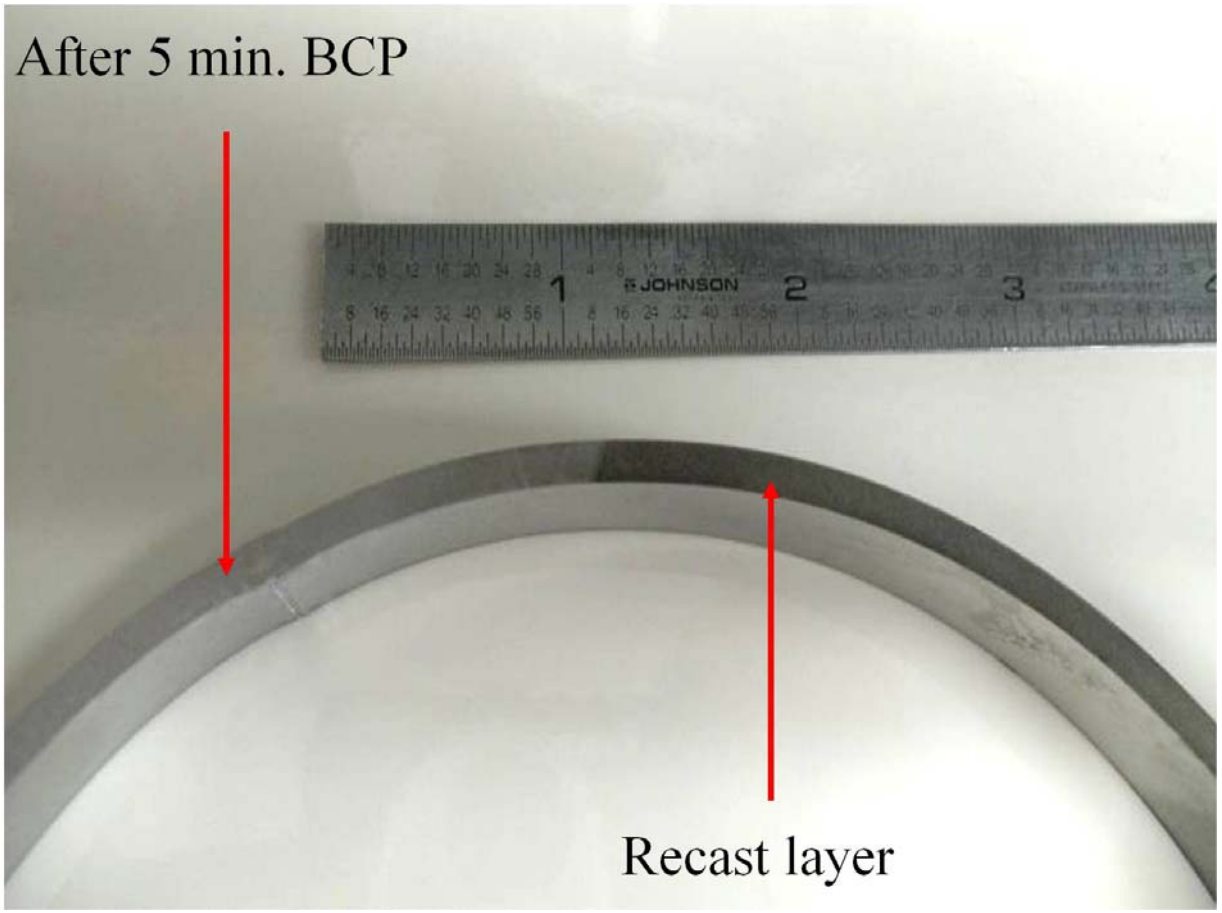


Sinker EDM of the Toroid center conductor mating surface



Wire EDM

- Recast layer only 5 microns thick
  - Oxide of brass and niobium
  - Completely removed with a 5 minute BCP; not removed easily by EP

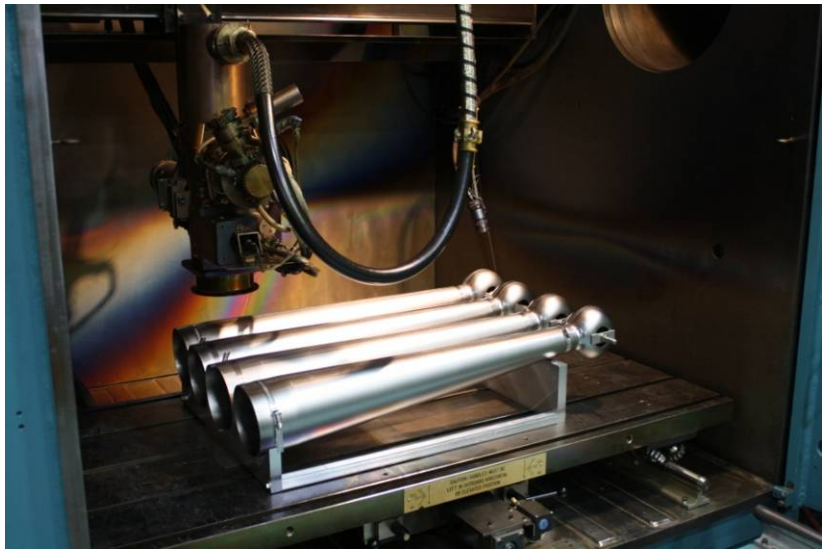


BCP etch after Machining, EDM, 24 hours prior EBW

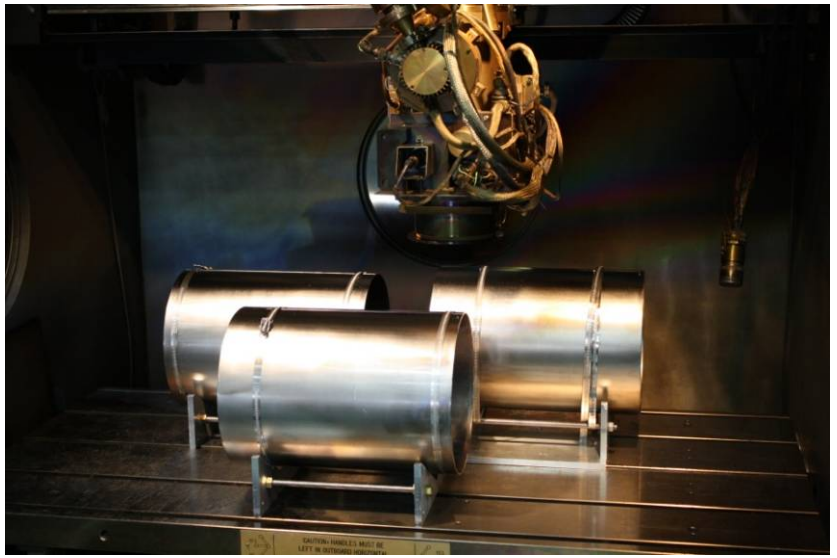
Electron Beam Welding

AFTER THE PARTS WELD SEAMS ARE EDMed OR MACHINED TO SIZE THEY RECEIVE A 5 MICRON BCP ETCH AND WITHIN 24 HOURS OF ETCH ARE WELDED.

Central Conductors

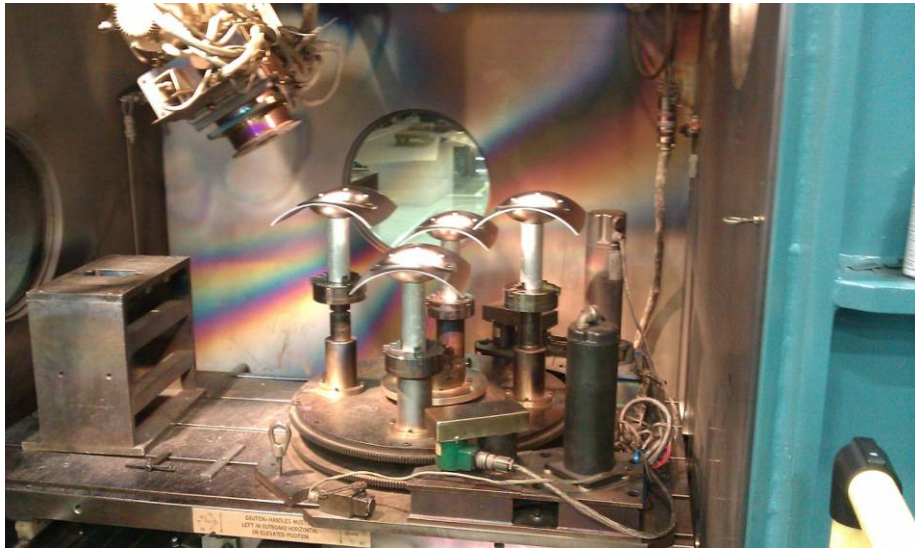


Cylindrical Housing

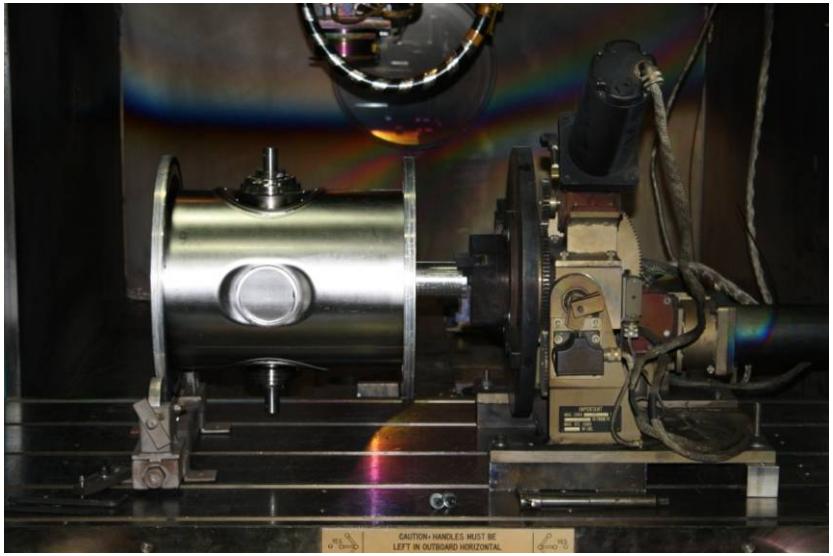


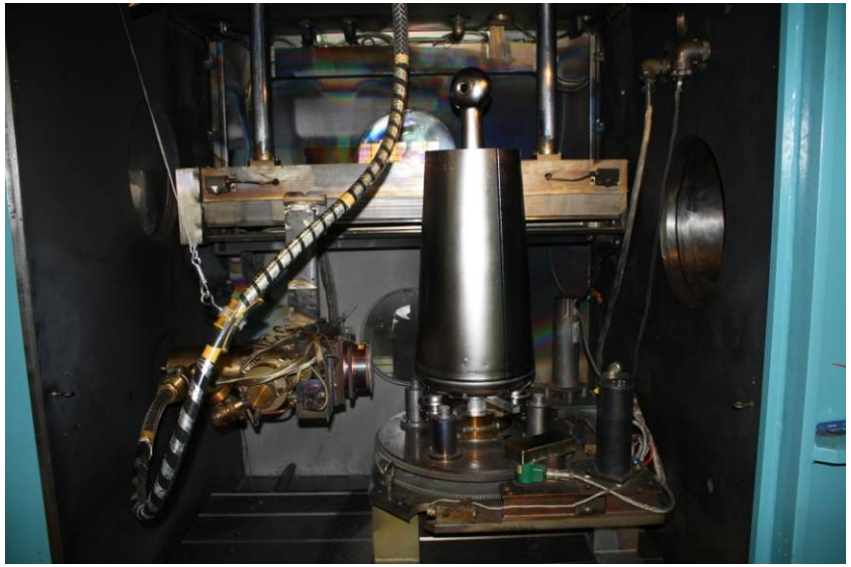
Electron Beam Welding of multiple parts

Tapered sections

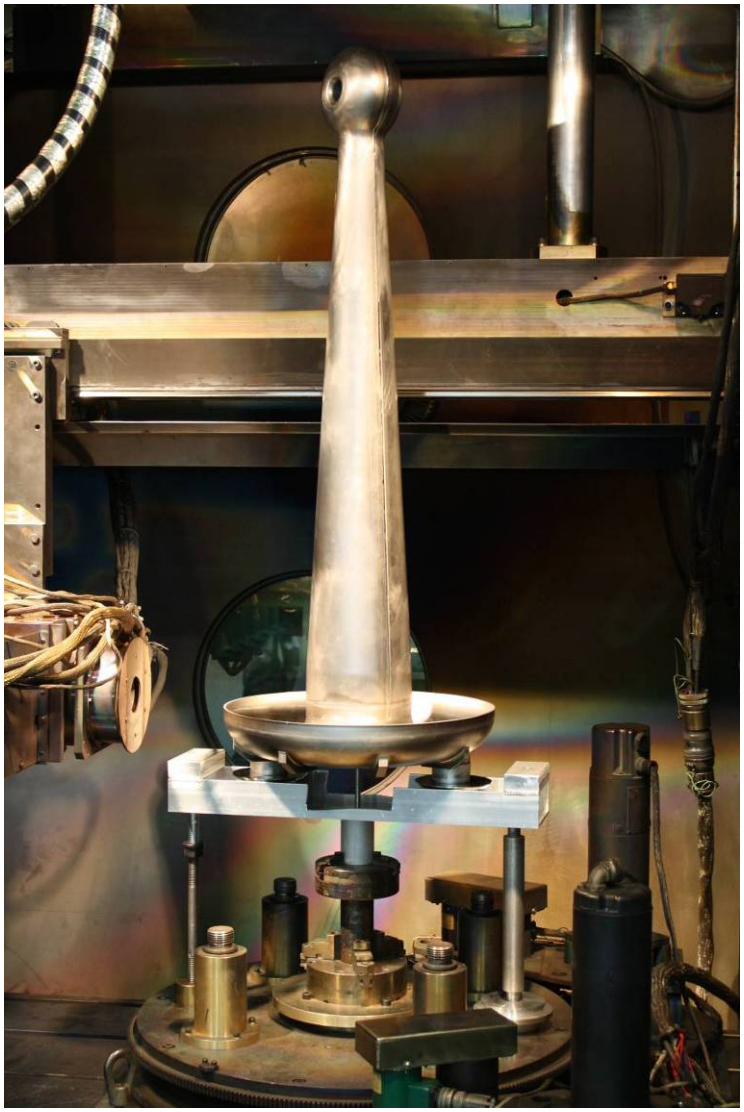


Welding of each part requires well-designed support fixturing





Electron Beam Welding

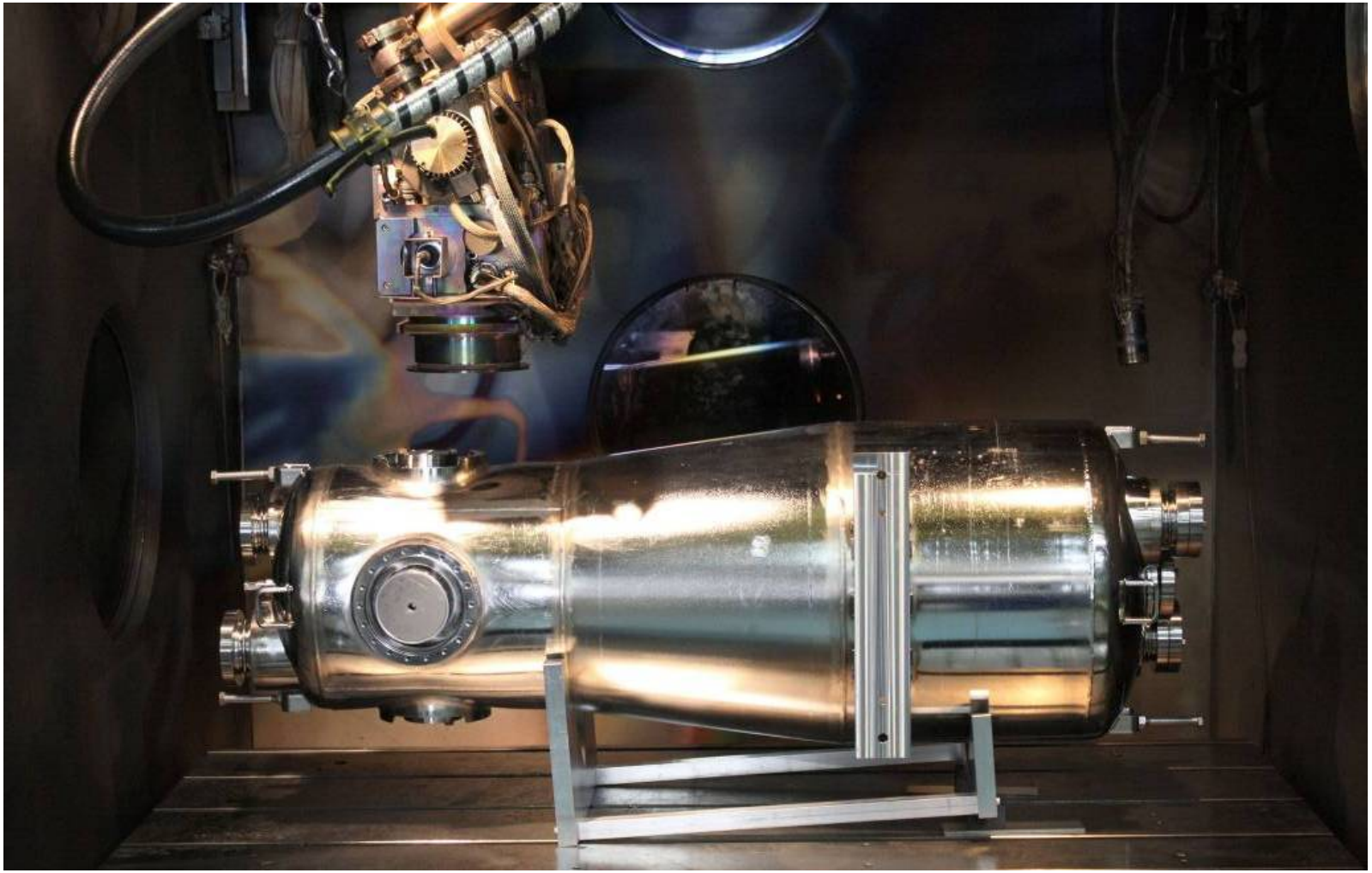


Niobium welds completed

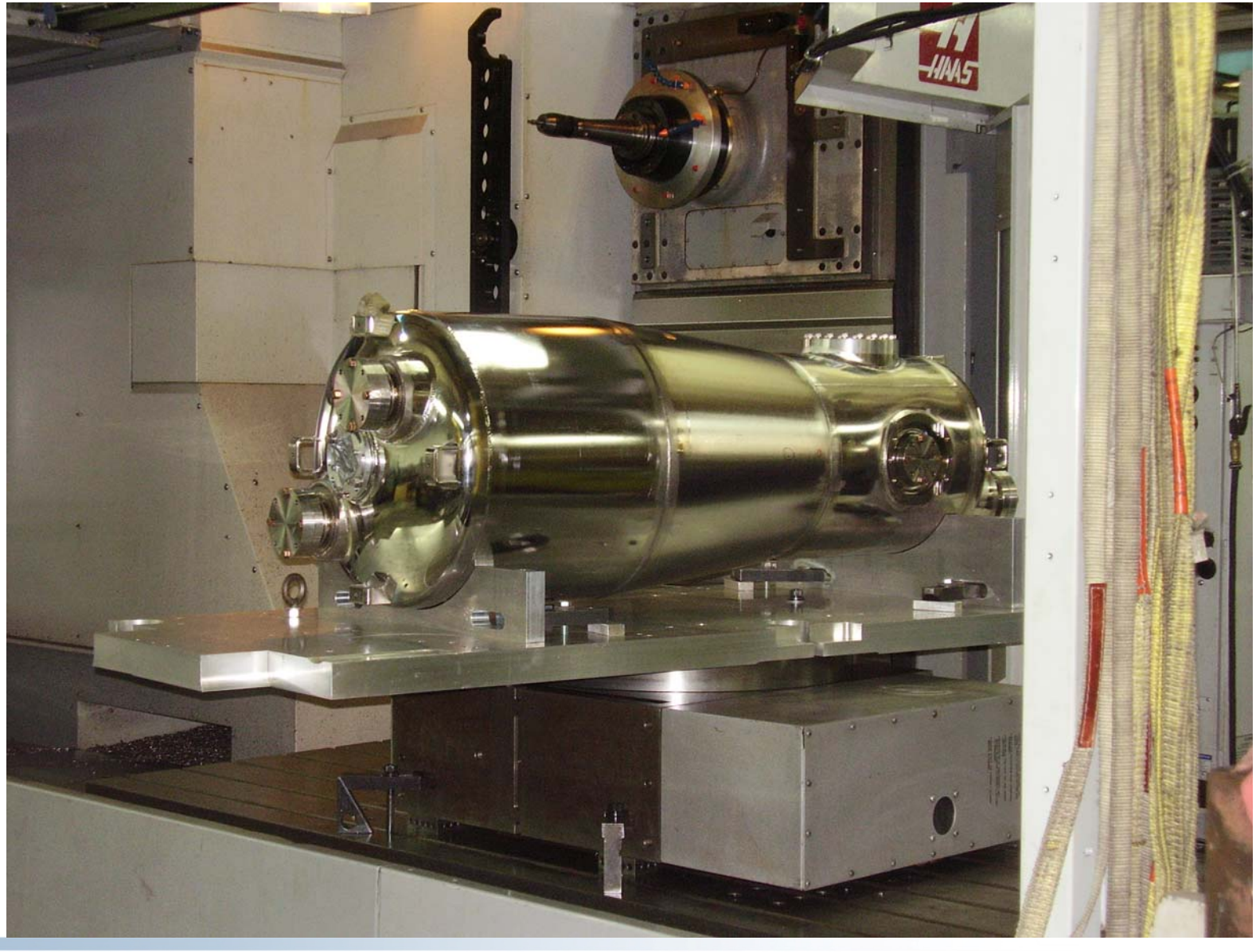
Stainless steel jacket is assembled to complete cavity fabrication

Stainless Steel LHe Vessel, TIG welding

Final Step: connect beam ports to the SS helium vessel using Electron Beam Welding



Fiducials for the cavity alignment



Current status of the 162.5 MHz, β=0.11 HWR

- EM design is nearly complete
- Detailed procedures for the mechanical design and engineering analysis have been developed
  - is being started as I speak
- Detailed fabrication procedure exists
- Beam aperture – 33 mm
- RF coupler will be capable either to transmit 10 kW RF power to the beam or withstand full reflection
- Will be built in compliance with the ASME pressure vessel code

First “Cold Test” of the new ATLAS Superconducting Quarter Wave Resonator, December 14, 2010