

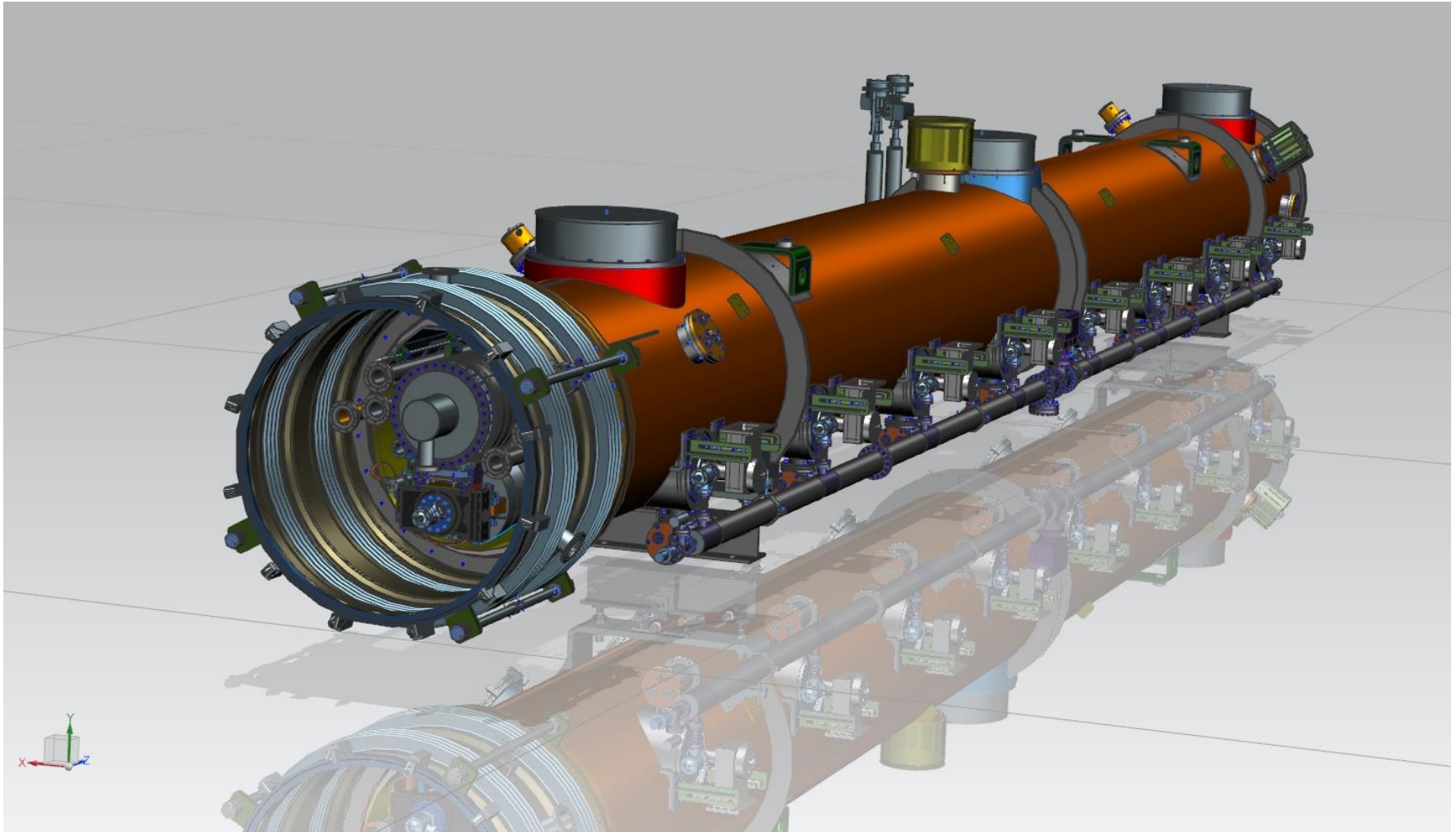


# Summary of “Lessons Learned” for the pCM

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## 1.3 GHz Prototype Cryomodule, F10009945 3D model



# Summary of Lessons Learned on pCM

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- Review Summary of Lessons Learned
  - WS2
    - Magnet
    - RF
    - Electrical
    - 2-Phase Welding
    - Magnetic Shielding
  - WS3
    - Cavity Tuners – Brief
    - Thermal Intercepts
  - WS5
    - JT Valve Welding
    - Electrical
    - Coupler Warm Ends

Hopefully Initiate Conversations

## Workstation 2 pCM



View at CAF-MP9



# Workstation 2 pCM

- Magnet



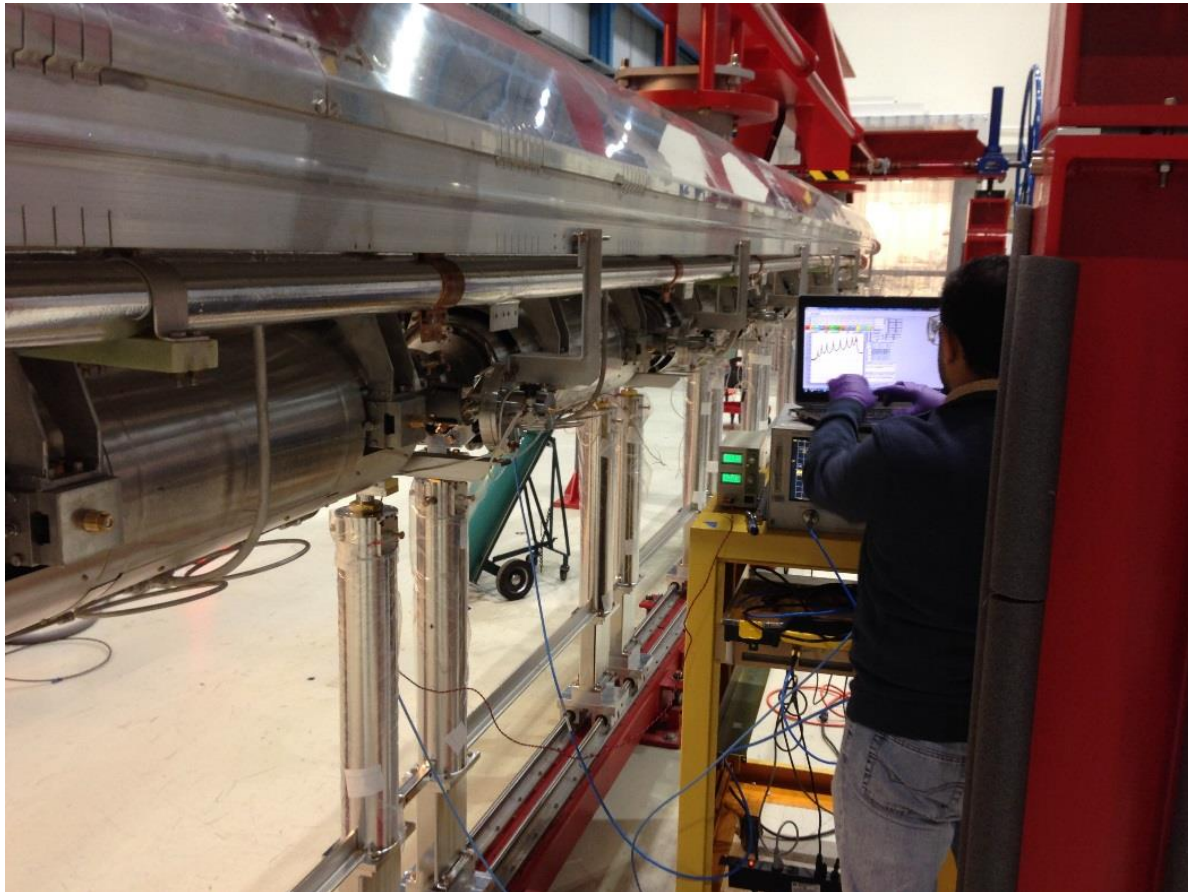
# Workstation 2 pCM

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- Magnet
  - Difficult to test magnet with long solid leads
    - Changed to softer leads
  - Magnet cores had slightly different lengths
    - Sasha: “end adjacent to BPM flange should be flattened against flange, other end “floats”, that’s ok.”
  - Soldering flags on thermal intercepts a lengthy process
    - Work moved to WS3
    - Wires were pre-tinned to speed up soldering process
    - 55K flags delivered to WS3 preassembled
    - 2 Tech trained to perform soldering work
    - Propose to have instrumentation group learn magnet soldering

# Workstation 2 pCM

- RF



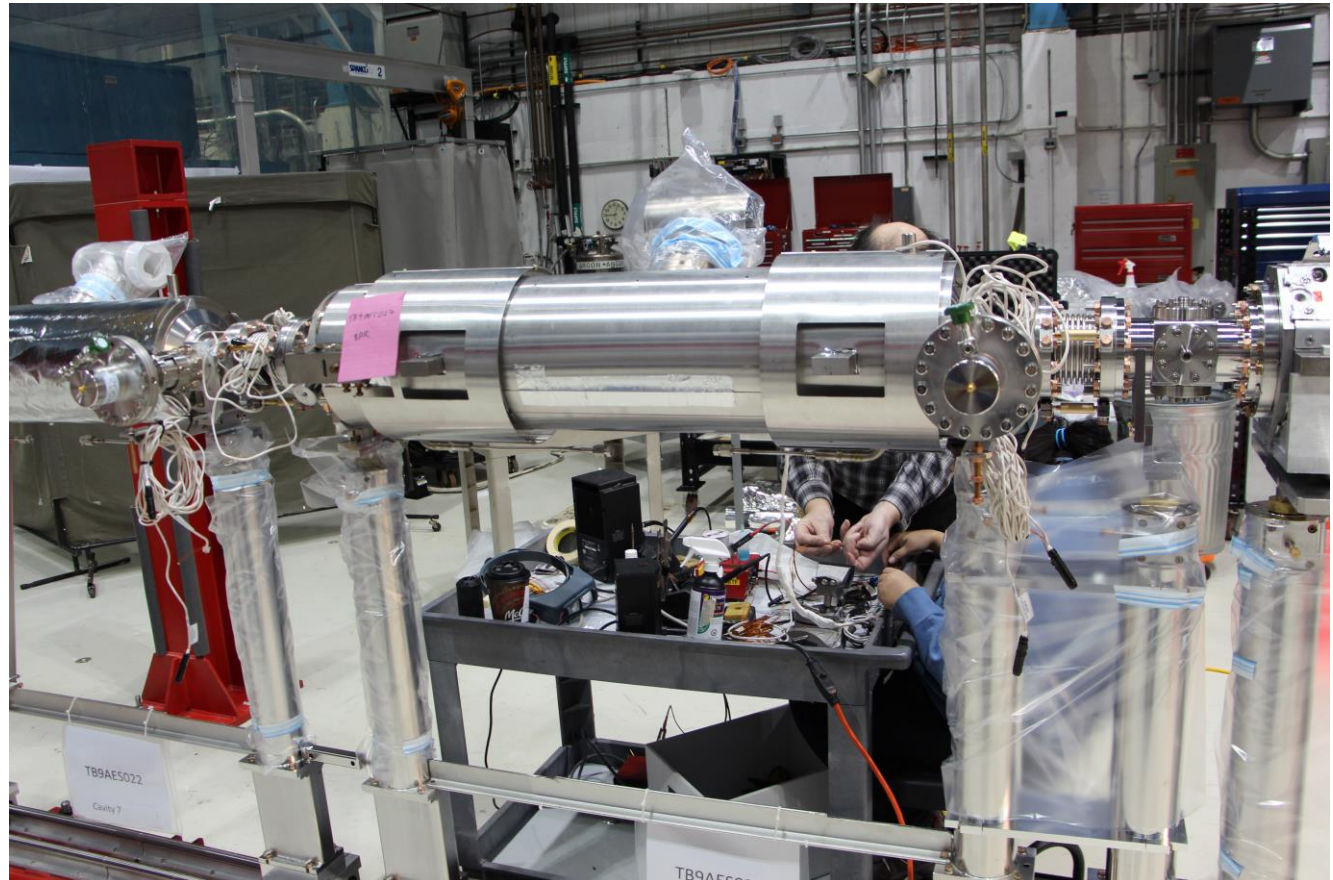
# Workstation 2 pCM

- RF
  - RF measurements should be taken as soon as the string is rolled out of the cleanroom
    - Frequency last checked at VTS and no known issues after
    - Frequency needs to be checked and possibly retuned after HTS test
    - Frequency and field flatness can be inadvertently modified when the tuner or the bellow restraints are removed/installed
  - Equipment ID's should be recorded in RF travelers
  - The HOM notch frequency measurements
    - Tool was modified due to the crowded nature of the tuner "short" endgroups
    - Notch tuner tool increased to 3 sets
  - More network analyzers would help to keep production on schedule
    - However cost prohibitive
    - Analyzers will be moved wherever needed to prevent bottlenecks



# Workstation 2 pCM

- Electrical

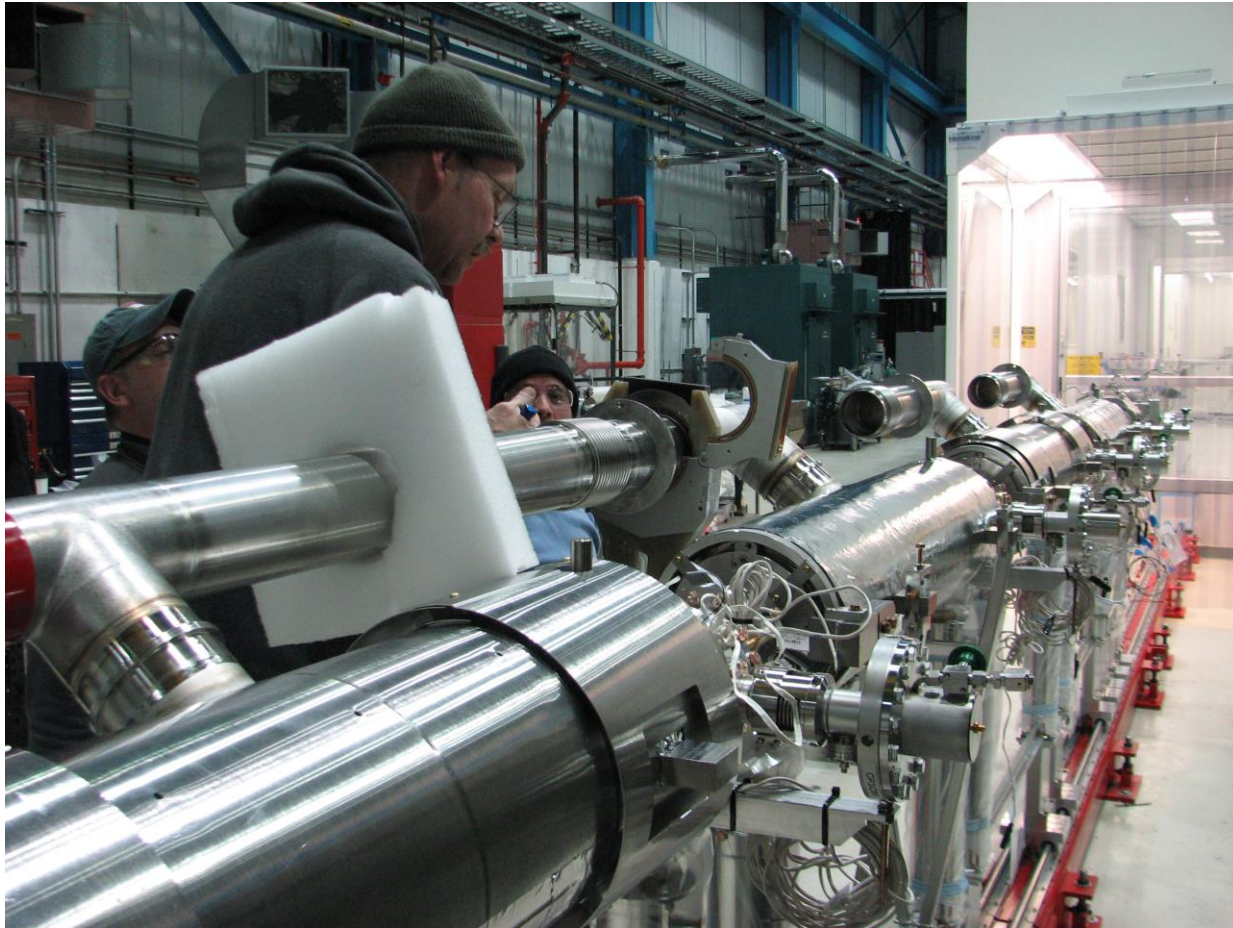


# Workstation 2 pCM

- Electrical
  - Part kit lists needed to be finalized, parts should be handled like all other parts (i.e. inventoried, kit lists, etc.)
  - Instrumentation group to generate spreadsheets for all work
    - These will be uploaded into the traveler
  - Storage of equipment and tools
    - Require space at MP9 and ICB for cart equipment and cabinets for storing parts
  - All leads, sensors, and cables need to be capped, grounded, or shorted after installation
    - Required before any welding can be performed
    - Communication between welding and instrumentation groups essential
  - Steps were added to travelers to assure flux is cleaned from soldered wire connections

## Workstation 2 pCM

- 2-Phase Welding



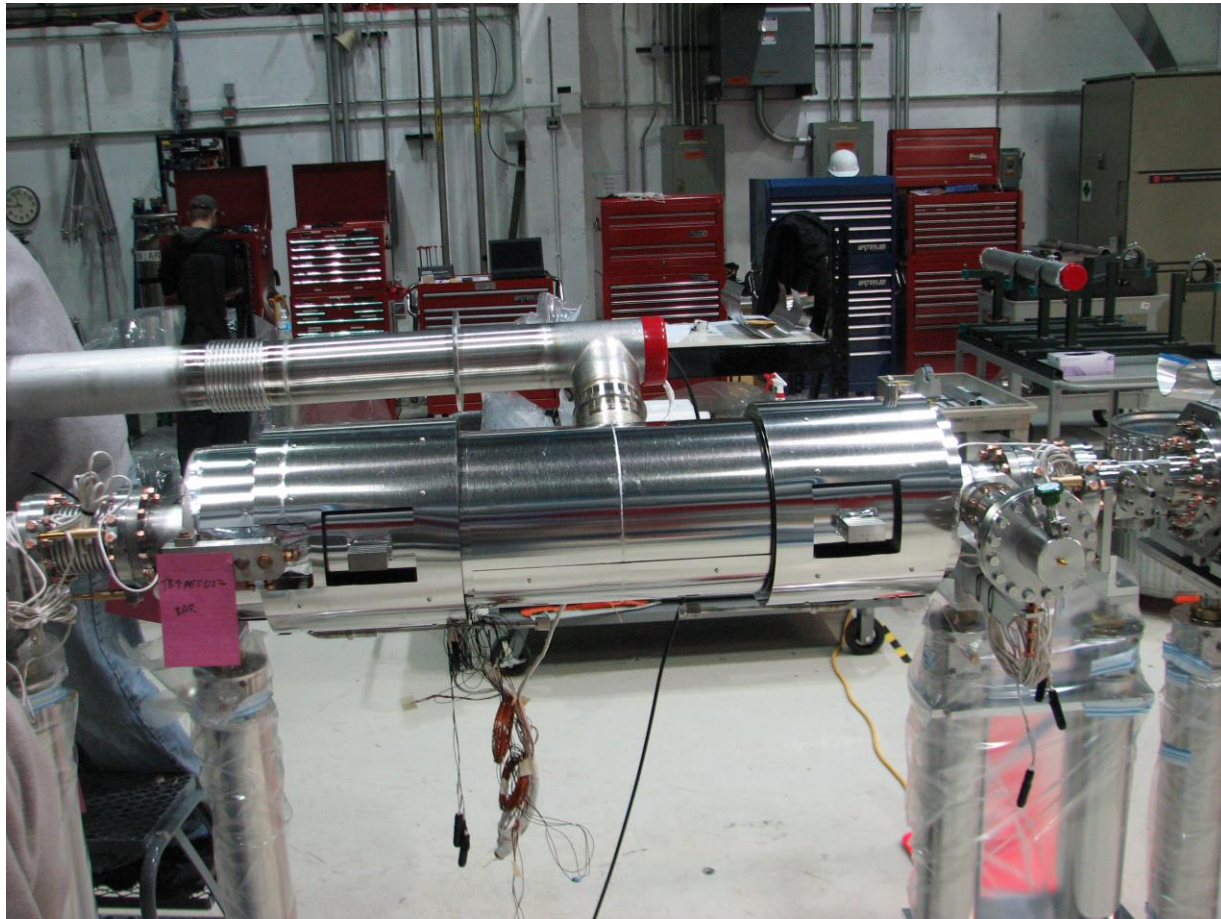
# Workstation 2 pCM

- 2-Phase circuit welding
  - Second orbital head was purchased
    - Commissioned prior to use on the pCM and currently being used
    - Older head stored as “back-up”
  - Warm-up/cool-down lines changed from butt weld to weld sockets
    - Reduces the chances of closure of small line or reducing inner diameter
  - Capillary lines from liquid level manifold to warm-up/cool-down lines removed from production assembly as separate parts
    - Interference with lollipop stands and magnet tooling, cut from pCM UCM and re-welded after UCM mating to cavity string and raised from lollipops
  - There are 8 common sub-assemblies for 2-phase line construction
    - Parts were welded on the bench ahead of time
    - Sub-assemblies kit made for all CM’s and added to part inventory
    - Significantly decreases 2-phase line construction
  - Welders are qualified for 2-phase pipe welding either with the orbital welder or manually
  - Cavity vertical alignment in the cleanroom needs to be improved to minimize steps between adjacent cavities



## Workstation 2 pCM

- Magnetic Shielding



## Workstation 2 pCM

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- Magnetic shielding
  - Many design changes have been implemented
    - Virtually all were due to interference issues
  - All dual layer He tank shields added except for 2<sup>nd</sup> layer center section opposite the 2-phase line
    - Extra space made available for warm-up/cool-down line welding
  - Clearance holes for shield screws changed to slots for easier assembly

## Workstation 3 pCM

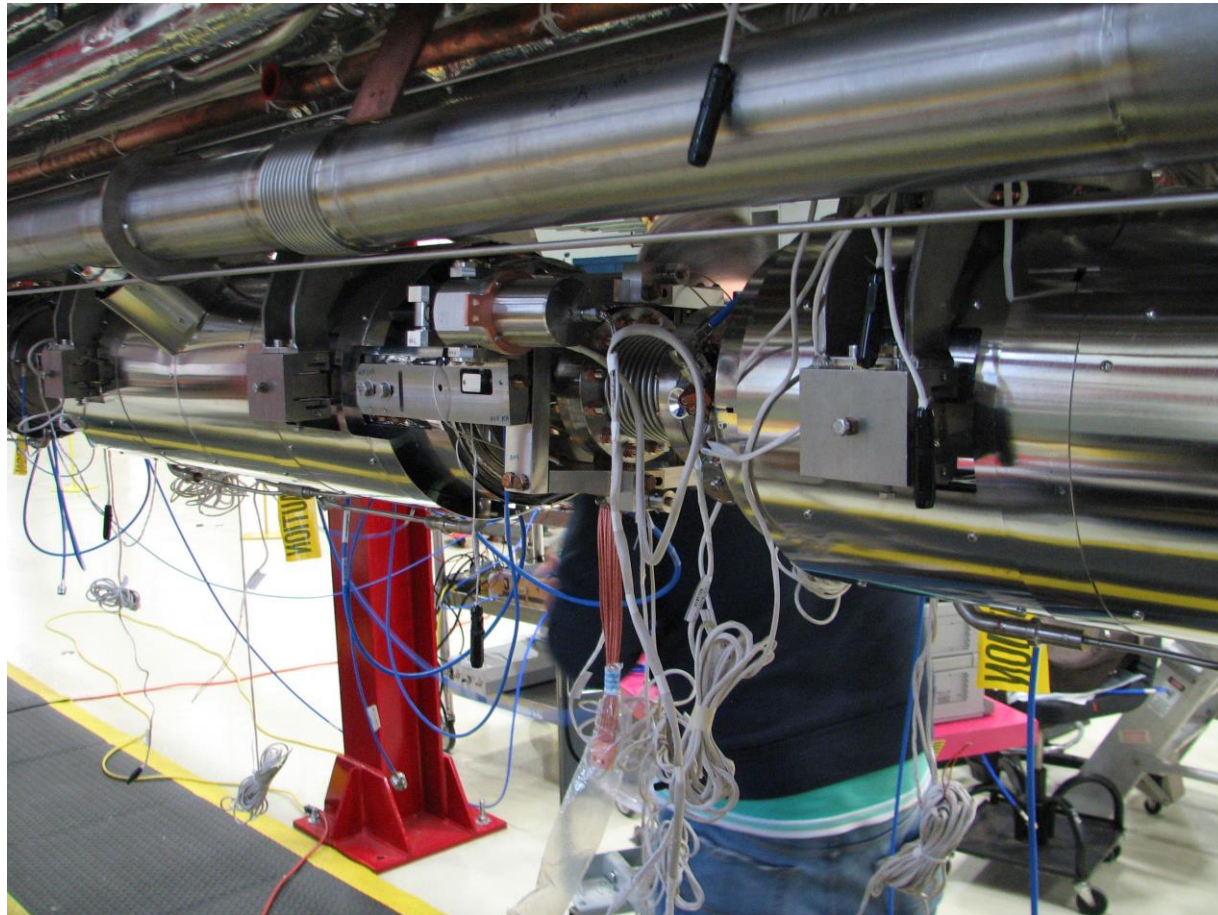


View at CAF-ICB



# Workstation 3 pCM

- Cavity Tuners





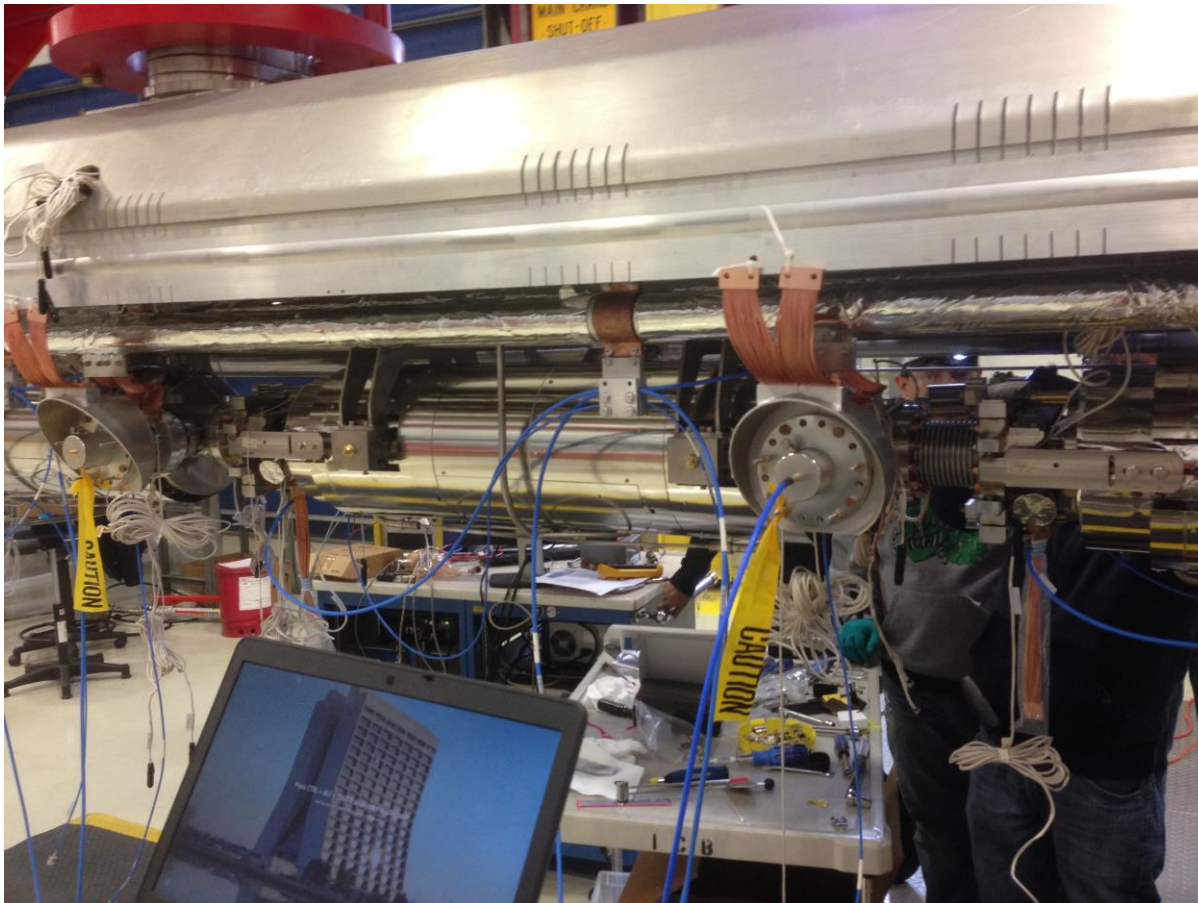
# Workstation 3 pCM

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- Cavity Tuners
  - Tuner motor tests
    - Bench tested after being pulled from stock
    - Motors are shipped sealed and do not want to open until use protecting from reduced shelf life
  - Magnetic hygiene performed on tuners
    - Demagnetization for tuner being set up
  - No DR's were written on the prototype tuners
    - Notes were taken and design changes were made

# Workstation 3 pCM

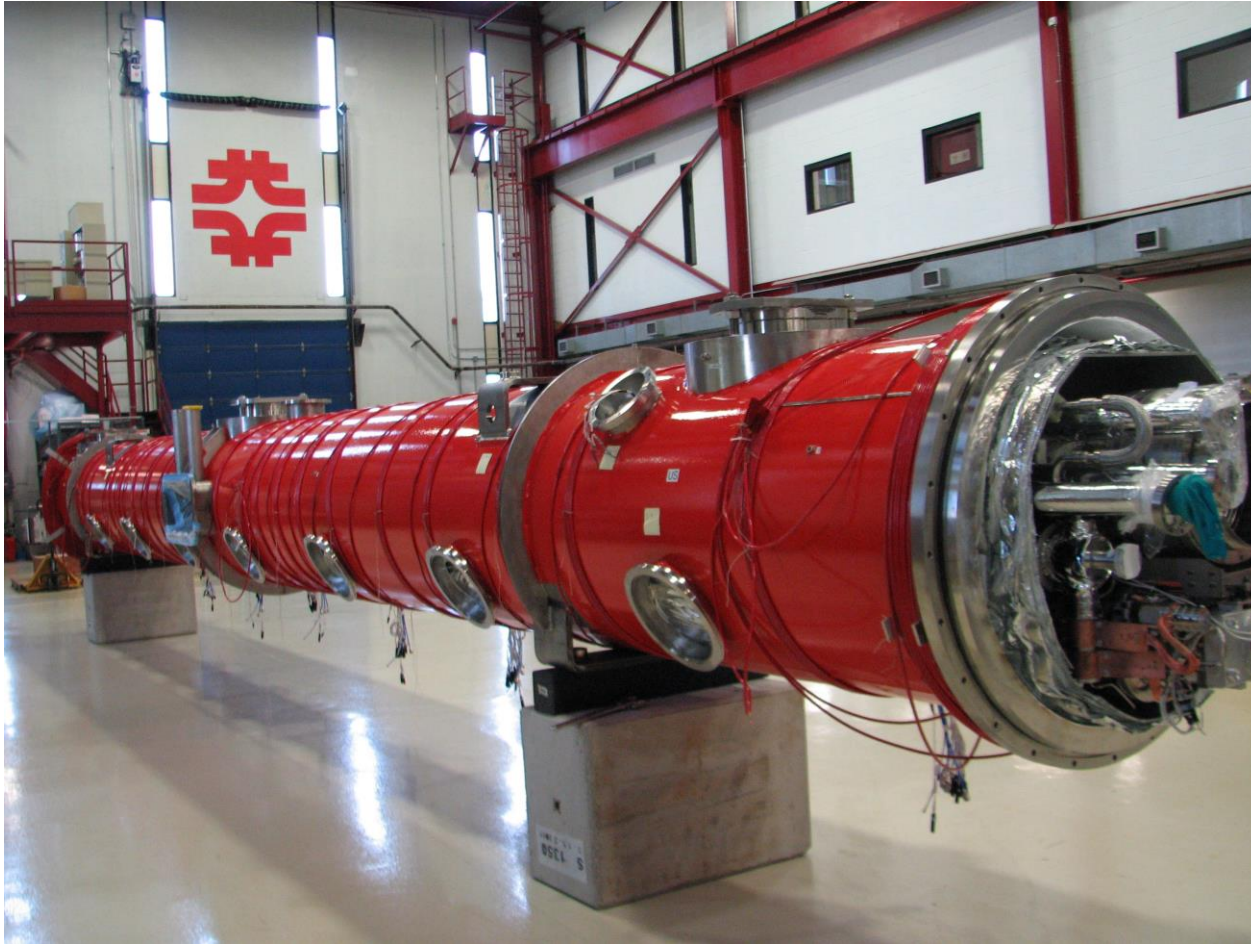
- Thermal Intercepts



# Workstation 3 pCM

- Thermal Intercepts
  - Pipe clamp problems
    - Clamp issue resolved - radii were machined vs. “bump” formed
    - Belleville washers for thermal connections will be used
  - Indium used on all hard connections for thermal intercepts
    - Indium creep – clamps to be retightened as part of the procedure
    - Torque values for all thermal connections added to travelers
    - Torque verification prior to traveler “sign-off”
    - Revive the calibration program for torque wrenches
  - 55K intercept mount for the coupler changed to a copper block mounted directly to the 55K pipe
  - Mylar shrink tube added to coupler and HOM straps
  - 2-phase pipe end clamps shoulder screws added to improve sliding function

## Workstation 5 pCM

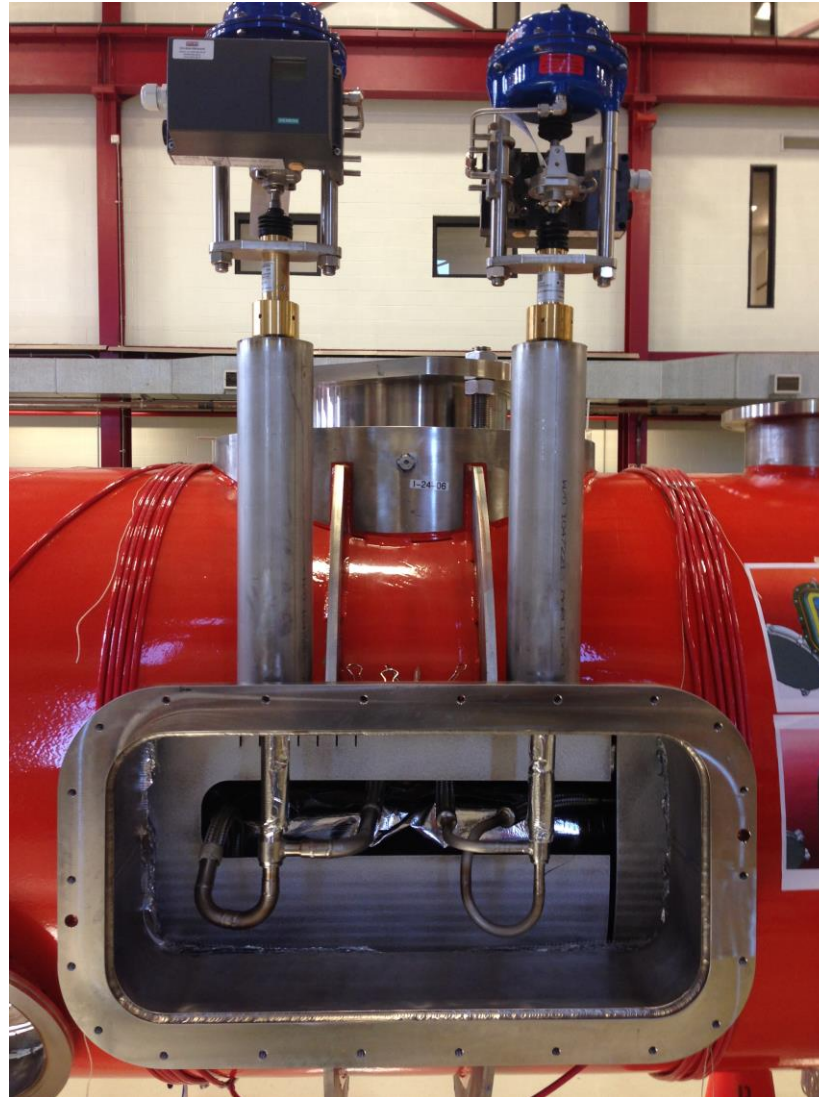


View at CAF-ICB



# Workstation 5 pCM

- JT Valve Welding



# Workstation 5 pCM

- JT Valve Welding – Thermal Intercepts
  - Three closure welds subjected to x-ray
    - Due to high pressure test (~20+ bar) lines cannot be pressure tested after welding due to lines common to cavity helium circuit
    - Reduced to 2 welds for future CM's
  - Potential issue with local magnetization during welding
    - Grounding line looked at as potential culprit
    - Improved grounding locations near welds should help this problem
    - Cryomodule demagnetization using coils fixed the problem on pCM
  - Thermal shields around valve stems not added
    - One possible reason for valve icing up during CM testing
    - Added at CMTF cave during CM warm-up cycle

# Workstation 5 pCM

- Electrical



# Workstation 5 pCM

- Electrical
  - Only soldering to be done at WS5 on Flange C for split quad
    - Adding voltage taps at Flange C will add time, but not much
  - All other flange assemblies will be bench built and pre-checked prior to use on cryomodules
  - Connector sub-assemblies
    - Connectors not leak checked, may save this step for assembled flanges
    - Fixture is needed for instrumentation leak checks to speed up process
  - Problem with leaking E1/L1 flange, O-ring is suspect
    - Changed at CMTF during recent warm-up – problem resolved
  - Problem with the wiring hole (location) for K Flange on 55K shield
    - Resolved on future shields



# Workstation 5 pCM

- Coupler Warm Ends



# Workstation 5 pCM

- Warm Coupler Ends
  - Tooling
    - Currently 2 sets of tooling for warm end installation
    - Two portable cleanrooms
    - Should be ok for production
  - Additional Technicians need to be trained for warm end installation
  - Goal is 2 coupler installations per day
    - Coupler and waveguide assembly work completed in 5 days
  - Storage of couplers (cold and warm ends) is major issue
    - Three desiccator cabinets have been ordered
    - Possible use of desiccators in IB4 RF cleanroom?
  - Bringing couplers into the inventory system
    - Warm end installation kits under development and added to traveler system
    - Two different coupler vendors, each needed slightly different hardware kits

## Summary of Lessons Learned on pCM

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Thank you!