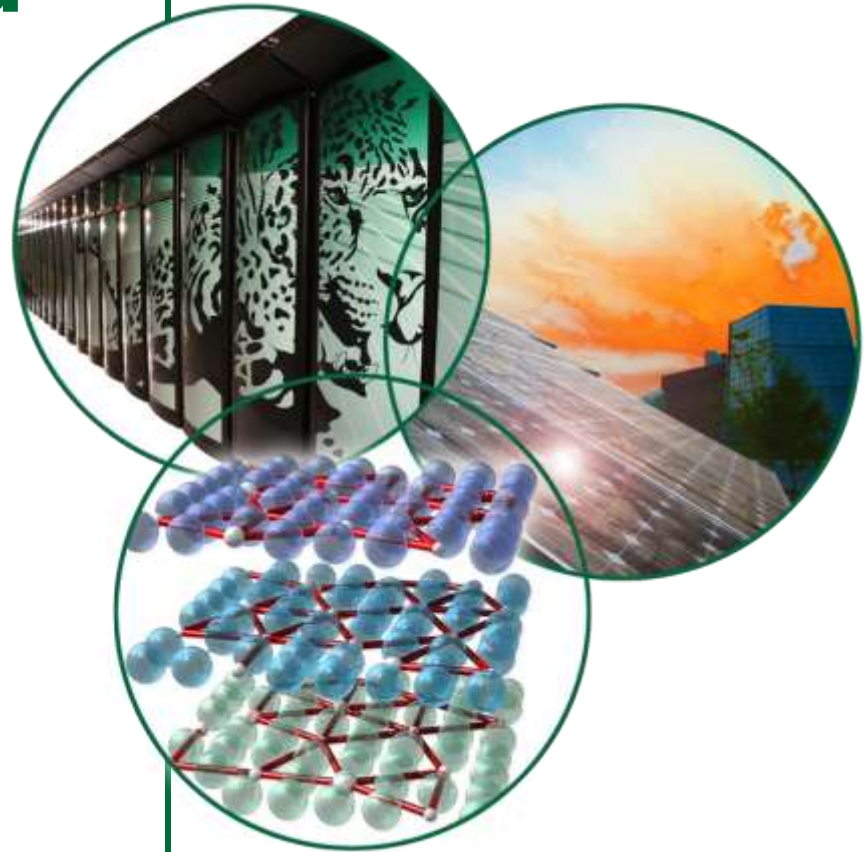


# Spare Cryomodule and Facilities Status

J. Mammosser



# Outline:

- **Status of Spare Cryomodules**
  - Qualification of cavities at Jefferson Lab
  - Understanding Performance Limitations
  - Design Status
    - Where we stand with the new design
    - Remaining Procurements
  - Building first HB Spare in the RFTF
- **Applying what was learned at Jlab to PUP**
- **Facilities Status and Plans**
  - Status of Plasma Cleaning Development
  - PUP Facilities Plans

# Qualification of cavities at Jefferson Lab

- **Since Last Review :**

- Helium vessels were added to 4 HB cavities (HB53,54,56,58)
- These cavities were then shipped to Jefferson Lab for qualification testing (6 month effort)
- Goal was to reduce field emission at the design operating gradient for all four cavities
  - Vertical test data has traditionally not been a good indicator of module performance due mainly to field emission limiting the collective gradients of all installed cavities
  - Since the original SNS production, Jlab has significantly improved their procedures and processes
  - Jlab results have significantly reduced and eliminated field emission for most beta =1 cavities
- **This was not the case for the four HB cavities !!**

# Understanding The Vertical Test Performance Limitations:

- **What We Found Was:**

- Pulse tests show clear evidence of multipacting to cavity limits in some cavities and not cleaning up
- Field emission during these tests was still unpredictable like the original production
- HB54 - showed repeatedly high levels of x-rays, additional process steps taken had little or no effect
  - Additional BCP chemistry
  - Additional degreasing and extended high pressure rinses
- HB53 - field emission onset reduced significantly in gradient and was not effected by additional cleaning steps
  - Additional degreasing and high pressure rinses
- Both cavities had extensive internal inspections after each test

# **Additional Cavities Showed Similar Behavior:**

- **After close inspection of additional cavity tests HB74 and HB57 showed similar behavior to HB53 and HB54 respectively**
  - **HB57 had very high field emission**
  - **HB74 showed identical behavior to HB53, reduced onset of field emission**
- **HB57 was modified prior to testing to remove HOM hooks**
  - **After BCP cavity suffered from high radiation during testing**
  - **After horizontal EP , radiation significantly reduced and gradient went to highest HB performance 23MV/m**

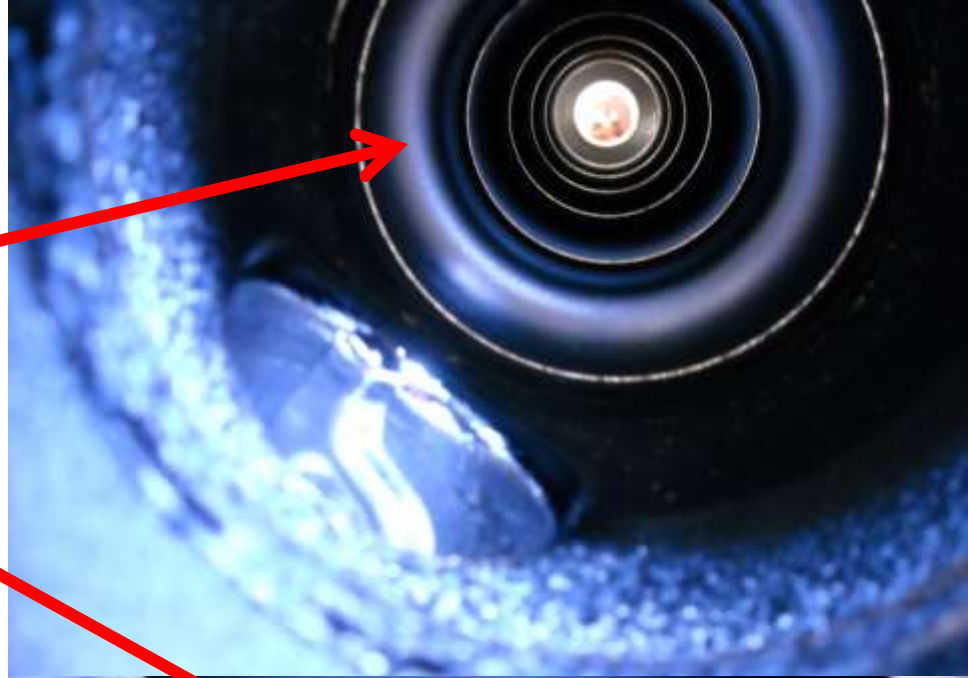
# Understanding The Vertical Test Performance Limitations:

- Internal inspections found that :
  - Cell surfaces were rather normal looking and no “smoking gun” defects were identified
  - Mode Analysis all pointed to end cells and end group
  - The end-groups were extremely rough in appearance and to the touch
    - End-group history – reactor grade material RRR40, was formed into their final shapes and then were heat treated at 1250C for 6 hours to improve the RRR
    - Visual inspection showed very sharp edges and features all the way up to the first iris
    - BCP was increasing the roughness of the end groups
    - Surface roughness increases the difficulty in cleaning end group surfaces (Including HOM coupler)
  - **This became the biggest suspect for why field emission and MP for these two cavities was not decreasing!!**

# Endgroup Roughness

Cells have normal  
surface finish

Rough Surface  
to the First IRIS



# Understanding The Vertical Test Performance Limitations:

- **The only option at this point was to try electropolish due to (helium vessel) processing limitations**
  - Additional BCP did not improve performance
  - Grinding was not an option due to Q-disease risk
- **The JLab horizontal EP setup was unavailable for these cavities due to Helium Vessel**
- **Vertical EP was only option**
  - Inexpensive setup was built to perform the processing
  - Helium jacket was utilized to provide cell cooling



# Vertical EP Results:

- **What was learned:**
  - **First attempts with full (traditional style) cathode showed that the hydrogen gas bubbles were filling the end-group and causing excessive etching not polishing in the upper end-group**
  - **HB54**
    - **Oscillations were small during processing**
    - **Results : HB54 had reduced gradients and showed field mission**
    - **Cavity limited to 12 MV/m**
    - **A second manual cleaning of the end groups +HPR improved the gradient and field emission (13MV/m)**

# Vertical EP Results:

- **Partial cavity polishing was performed next to reduce hydrogen gas, moving cathode two cell at a time**
  - **HB53**
    - Oscillations were large during processing (what is expected)
    - Results: HB53 recovered to 17.5MV/m low field emission (what we wanted)
- **Processing stopped at this point to proceed with the first spare cryomodule**
  - **Cryomodule assembly team is in place!!!**
  - **3 of 4 cavities low field emission and good gradients, HB54 about average of installed HB gradients**
  - **String assembly is underway!**

# HB53 Recovery With VEP

| Test Number | Process        | Max Gradient (MV/m) | Max Rad at Emax (mR/hr) |
|-------------|----------------|---------------------|-------------------------|
| HB53        | 50um BCP+HPR   | 18.0                | 2.0                     |
| HB53a       | 20um BCP+HPR   | 11.0                | 8150                    |
| HB53b       | US+HPR         | 9.5                 | 902                     |
| HB53c       | 30umVEP+US+HPR | 17.6                | 1.5                     |

- Cavity showed reduced performance after additional BCP
- Reduced radiation after additional HPR
- Full recovery of original performance after vertical EP

# HB54 Reduction of Field Emission with VEP

| Test Number | Process        | Max Gradient (MV/m) | Max Rad at Emax (mR/hr) |
|-------------|----------------|---------------------|-------------------------|
| HB54        | 50umBCP+HPR    | 19.4                | 2166                    |
| HB54a       | 40umBCP+HPR    | 19.0                | 15166                   |
| HB54b       | 50umBCP+HPR    | 12.6                | 4633                    |
| HB54c       | US+HPR 27hrs   | 15.9                | 49000                   |
| HB54d       | 30umVEP+US+HPR | 12.0                | 850                     |

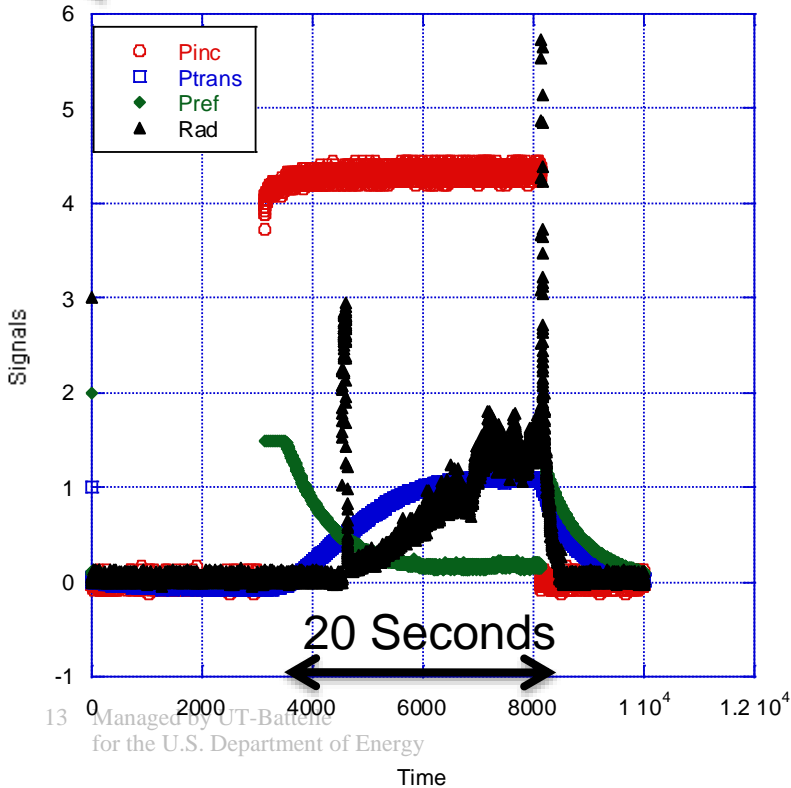
- Additional BCP increased radiation significantly
- Additional BCP gradient reduced significantly
- Extended HPR significantly increased radiation
- Vertical EP reduced radiation , gradient not fully recovered

# Summary of Cavity VTA Performance:

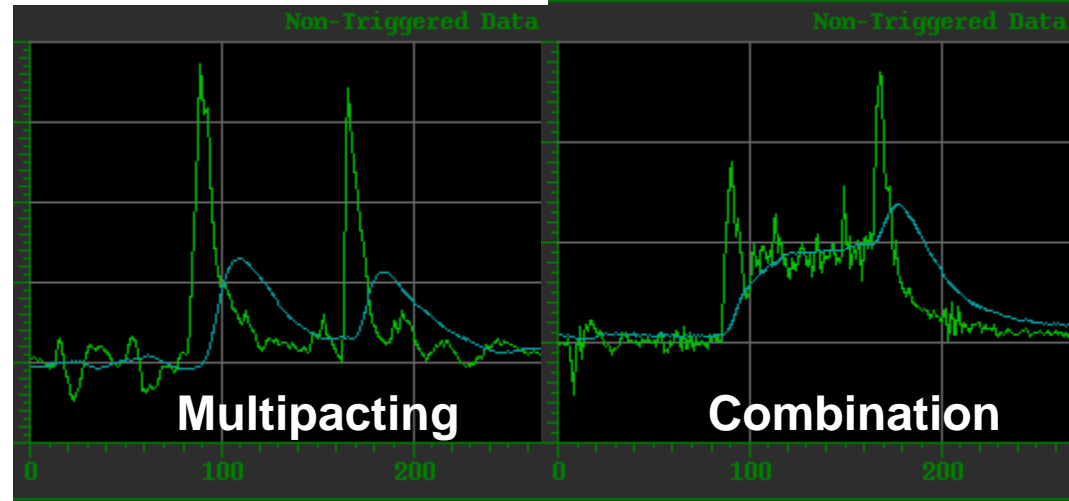
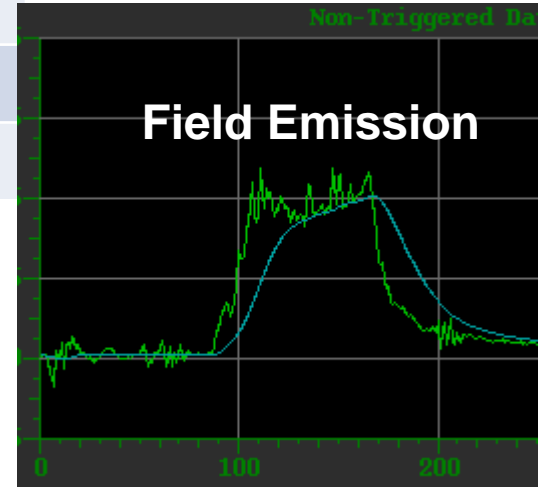
| Cavity Number | E <sub>max</sub> (MV/m) | Rad at E <sub>max</sub> (mR/hr) |
|---------------|-------------------------|---------------------------------|
| HB53          | 17.6                    | 2.0                             |
| HB58          | 17.2                    | 0.0                             |
| HB56          | 17.5                    | 408                             |
| HB54          | 13.0                    | 850                             |



TDS\_082809\_140540 17MV/m



Tunnel Data RF Only



# HB54 PROCESSING SETUP



# Hydrogen Gas Bubbles During Processing

With power off acid level and flow shown here



With power on top beam-pipe completely filled with gas and no flow , temperature on cavity end-group was >35C and rising



# Summary of Cavity Processing Effort:

- **We demonstrated direct correlation between VTA and operational data in the machine**
- **We suspect that the end-groups are the cause of many of the cavity performance issues**
  - **Multipacting**
  - **Field Emission**
- **Electropolishing is the best option for the spare cavities and should give new cavities additional gradient margin**
  - **Reduces field emission consistently**
  - **However we can not ensure end-group performance statistically with the spare cavities**



# Design Status:

- **Much progress has been made on the new cryomodule design!**
  - Design was informally reviewed by Jlab engineering group in December 09
  - Next step is a external design review (Feb 11-12) before procurement of vacuum vessel and end cans
  
- **Design Strategy:**
  - Pressure Boundary Set to Vacuum Vessel and End-Cans
  - This will allow for fabrication, testing and procurement of pressure stamped subcomponents
  - Some minor improvements were implemented in the design
  - **2 Additional pressure reliefs will be added**

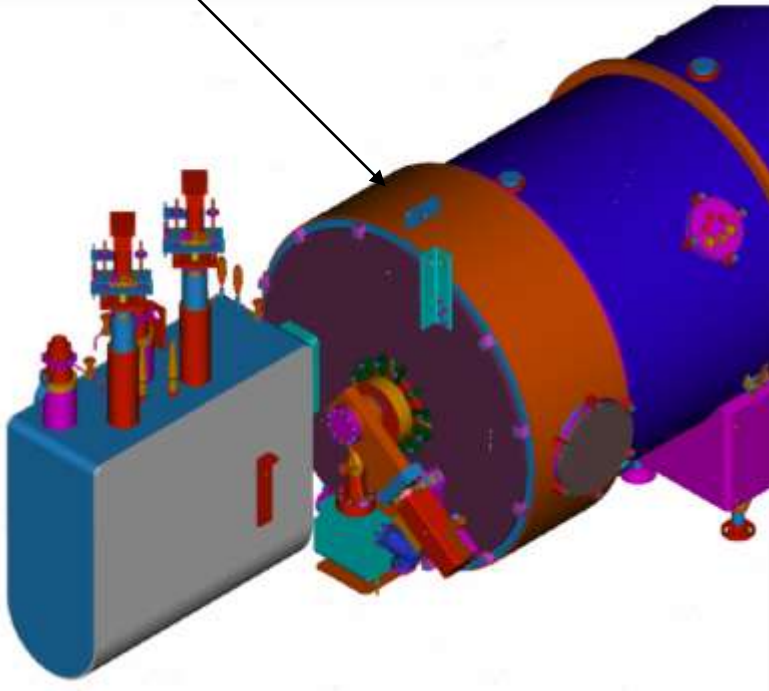
# Remaining Procurements:

- **Supply and Return End Cans**
  - These will be produced in industry, pressure tested and code stamped
  
- **Vacuum Vessel**
  - This will be produced in industry, pressure tested and code stamped

# New Design:

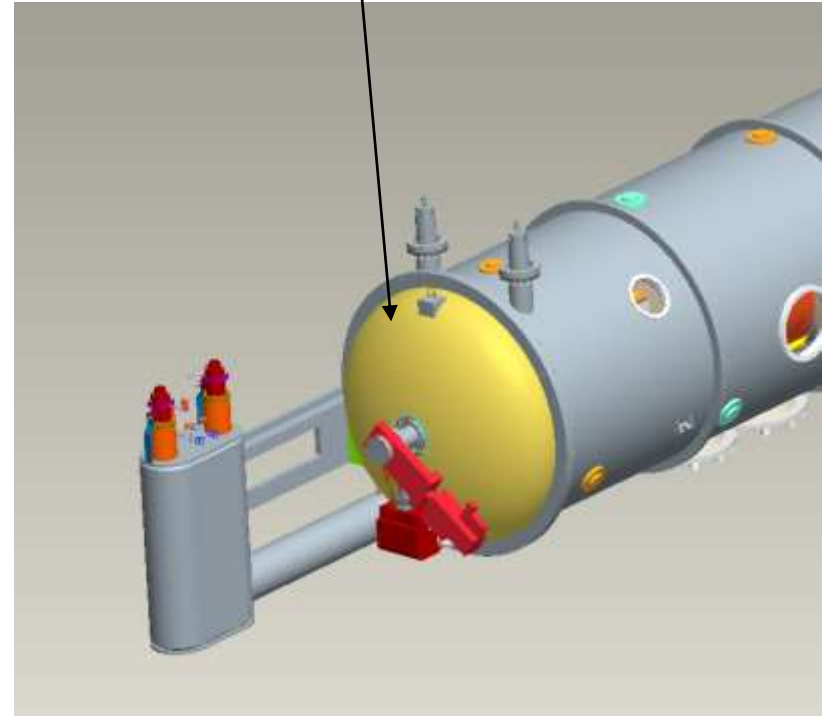
- Removed Bridging Ring and Added an Elliptical Head

Bridging Ring



Old Design

Elliptical Head

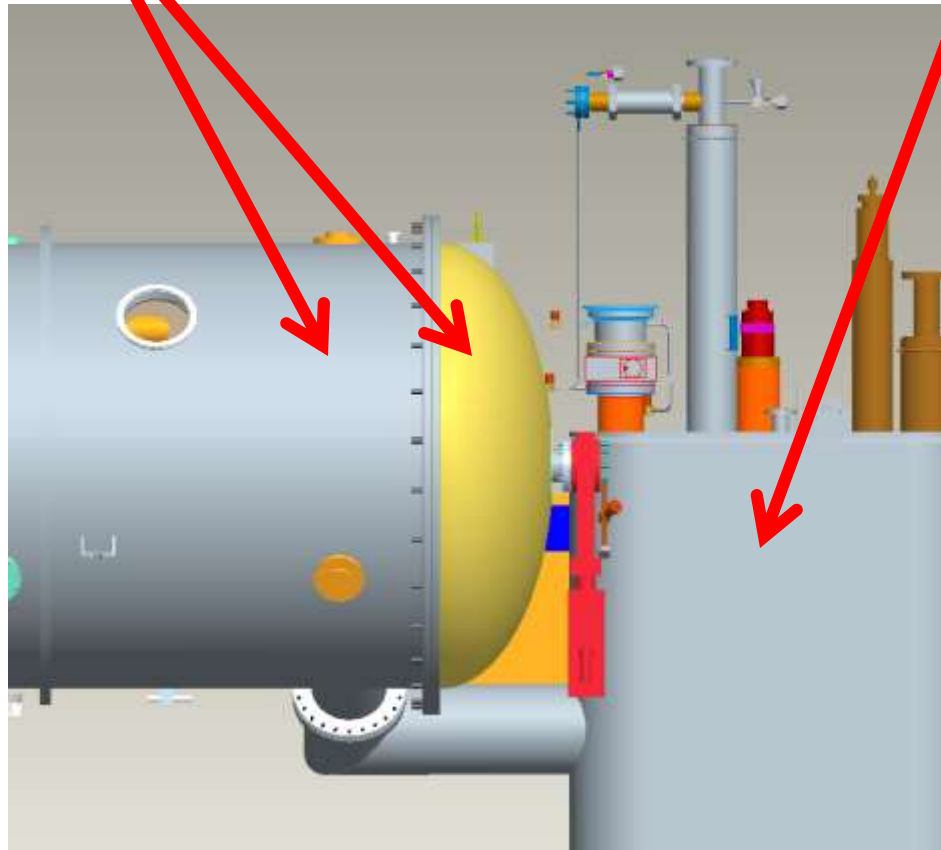


New Design

# Pressure Stamped Subcomponents for Industrialization:

Vacuum Vessel and Dish Head Fabricated as a Set

Supply and Return End Can Fabricated as a Set

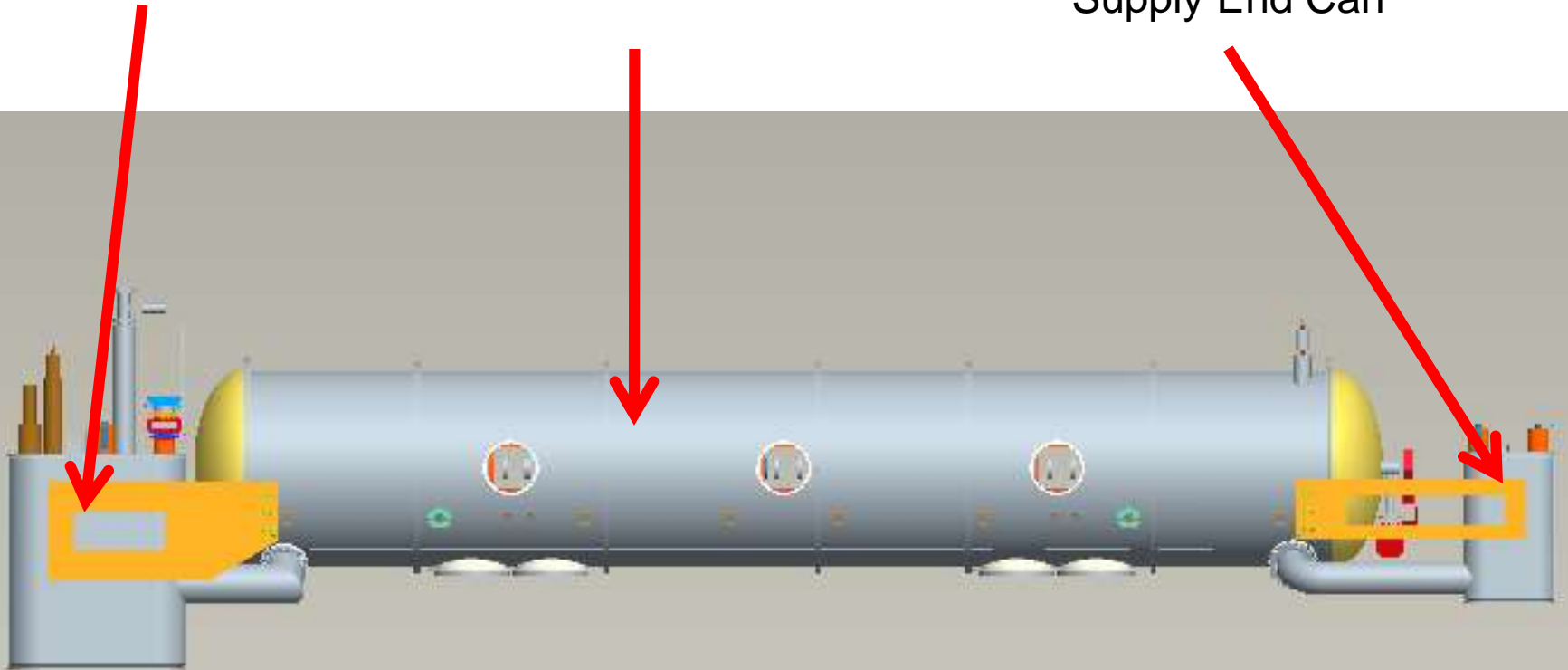


# Side View of New Design:

Return End Can

Vacuum Vessel

Supply End Can



# Building The First Spare In the RFTF:

- **Team is excited and ready to go!!**
  - **Personnel Identified for**
    - **Instrumentation**
    - **Cleanroom Assembly**
    - **Alignment**
    - **RF Measurements**
    - **Module Assembly**
    - **QA**
    - **RF Testing**
- **Facility Preparation for String Assembly Underway**

# RFTF Facilities

- **New DI Water System**
  - Commissioned and operational
  - Cavity Degreasing Operational
- **HPR**
  - Niowave completed cabinet fabrication
  - Instrumentation design complete
  - HPR pump installed
- **Vertical Test**
  - Overhead Crane installed
  - Reevaluating location of vertical Pit
  - Radiation analysis completed
- **Separate Refrigerator and Distribution Box in Progress**
  - Supporting Vertical and Horizontal Testing

# Plasma Cleaning Facility Progress:

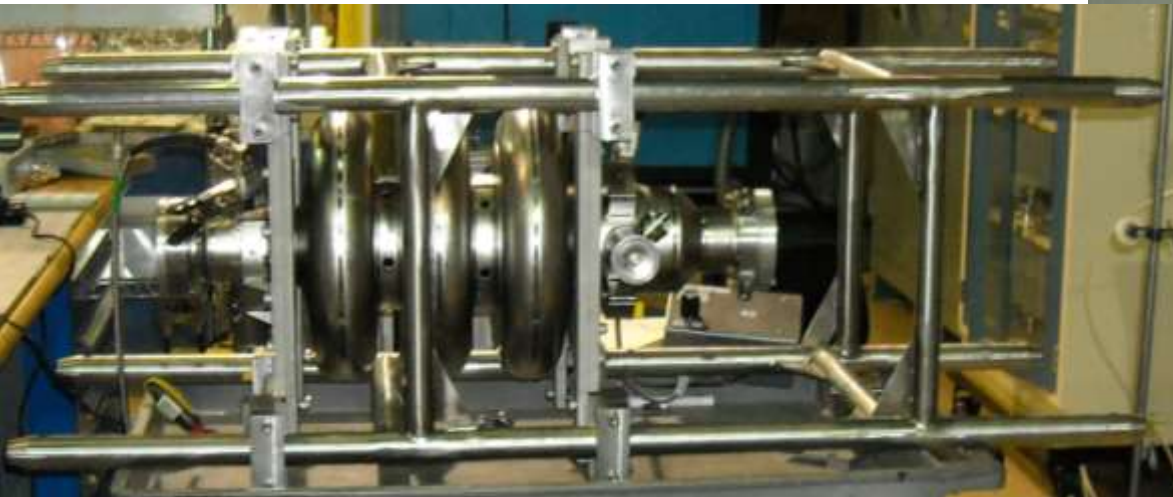
- **Plans are to develop plasma cleaning with four new research tools**
  - Plasma oven for small sample evaluation
  - TM020 cavity for witness plate RF testing
  - 3-Cell MB Cavity (MB3C)
  - 6 Cell HB Cavity
- **TM020 Cavity**
  - Subcomponents Fabricated
  - Needs EB welding to complete cavity
- **Need Minimum Capability for Chemistry**



# Plasma Cleaning Facility Progress:

- MB3C

- Cavity modified to remove HOM flanges
- Cavity Processed by Vertical EP
- Currently undergoing baseline testing at JLab



# Conclusion:

- **Cryomodule Preparation and String Assembly is Underway**
  - Staffing and roles identified
  - Processing Completed for the first spare cavities
- **Cryomodule Design Completed**
  - External Review Next Week
- **Facility Preparation in Progress**
- **Preparations for Plasma Processing Development Underway**