

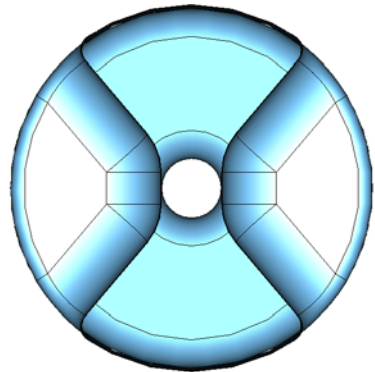
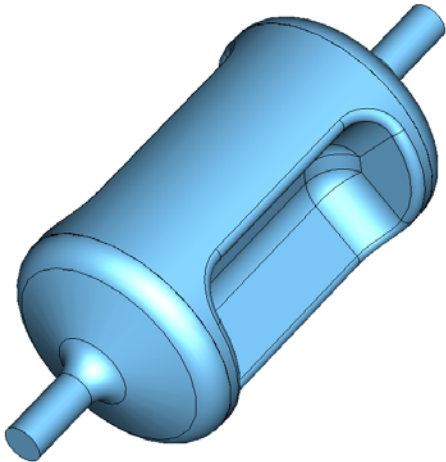
# PARALLEL-BAR PROTOTYPING STATUS

**Jean Delayen**

**Center for Accelerator Science  
Old Dominion University  
and**

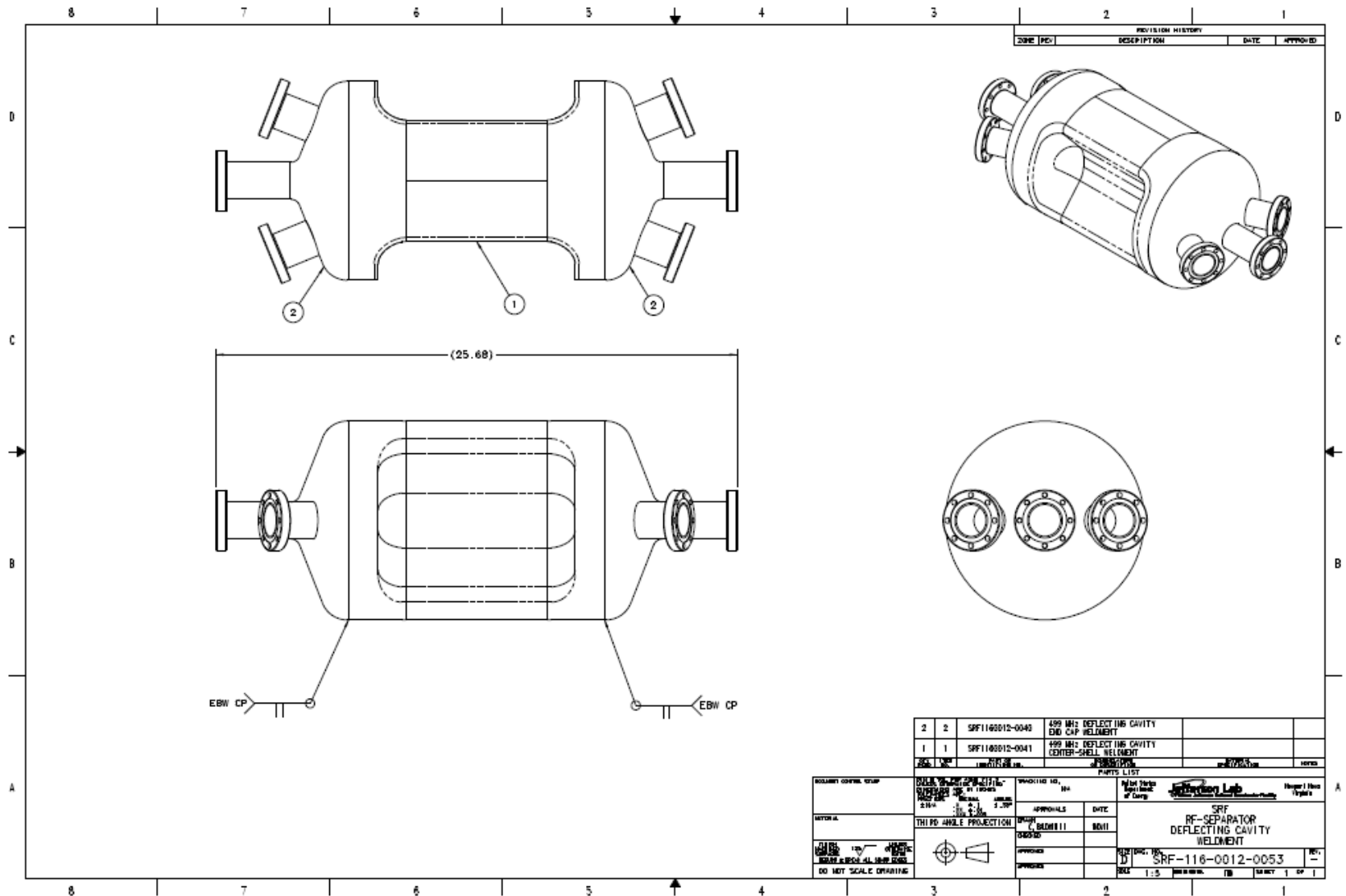
**Thomas Jefferson National Accelerator Facility**

# JLab 11 GeV Deflector

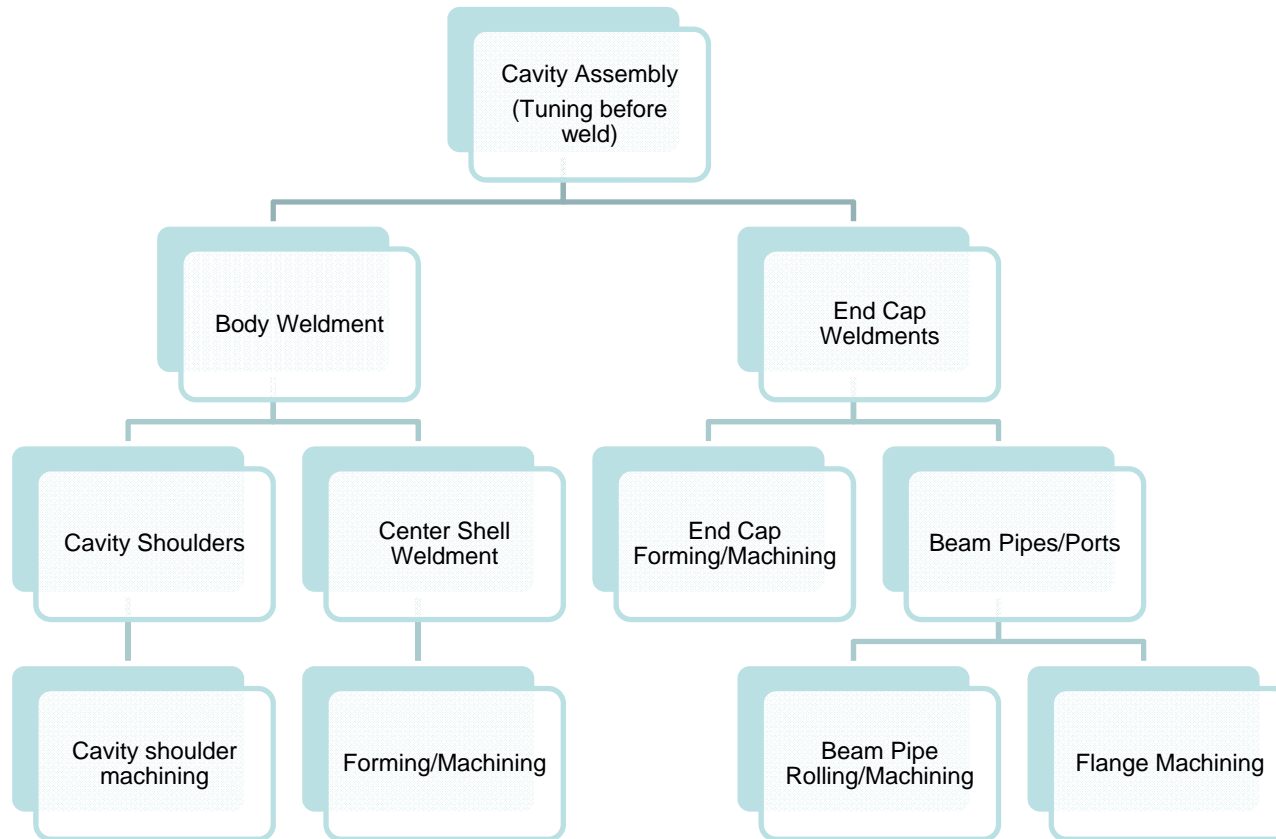


| Parameter                        | 499 MHz            | 400 MHz           | 750 MHz           | 365.6 MHz         | Units      |
|----------------------------------|--------------------|-------------------|-------------------|-------------------|------------|
| Frequency of $\pi$ mode          | 499.0              | 400.0             | 750.0             | 365.625           | MHz        |
| $\lambda/2$ of $\pi$ mode        | 300.4              | 375.0             | 199.9             | 410.0             | mm         |
| Frequency of 0 mode              | 1035.9             | 729.5             | 1314.4            | 659.7             | MHz        |
| Frequency of near neighbour mode | 771.2              | 593.4             | 1143.1            | 571.9             | MHz        |
| Cavity length                    | 440.0              | 520.0             | 300.0             | 530.0             | mm         |
| Cavity diameter                  | 241.9              | 339.8             | 193.0             | 388.4             | mm         |
| Bars length                      | 260.0              | 345.0             | 185.0             | 350.0             | mm         |
| Bars inner height                | 50.0               | 80.0              | 57.5              | 85.0              | mm         |
| Angle                            | 50.0               | 50.0              | 36.2              | 55.0              | deg        |
| Aperture diameter                | 40.0               | 84.0              | 60.0              | 84.0              | mm         |
| Deflecting voltage ( $V_T^*$ )   | 0.3                | 0.375             | 0.2               | 0.41              | MV         |
| Peak electric field ( $E_P^*$ )  | 2.96               | 3.82              | 4.95              | 3.61              | MV/m       |
| Peak magnetic field ( $B_P^*$ )  | 4.49               | 7.09              | 8.74              | 6.41              | mT         |
| $B_P^* / E_P^*$                  | 1.52               | 1.86              | 1.77              | 1.77              | mT/(MV/m)  |
| Energy content ( $U^*$ )         | 0.029              | 0.19              | 0.056             | 0.19              | J          |
| Geometrical factor               | 105.6              | 119.7             | 136.9             | 115.9             | $\Omega$   |
| $[R/Q]_T$                        | 982.2              | 312.2             | 152.9             | 378.5             | $\Omega$   |
| $R_T R_S$<br>At $E_T^* = 1$ MV/m | $1.04 \times 10^5$ | $3.7 \times 10^4$ | $2.1 \times 10^4$ | $4.4 \times 10^4$ | $\Omega^2$ |

# Cavity Drawing



# FABRICATION OVERVIEW



# Fabrication Procedure

**OFC copper unit will be fabricated before Niobium cavity.**

- **Components forming and machining**

Each components will have longitudinal margin for tuning and welding

- **Sub-assembly e-beam welding**

All weld seams are full thickness butt weld, weld parameter study done

- **Warm tuning**

Initial measurement of frequency before welding

- **Sub-assembly BCP**

Currently BCP is preferred. JLAB BCP supports 80-100 mT gradient

- **Assembly welding**

- **Frequency measurements before and after vacuum load**

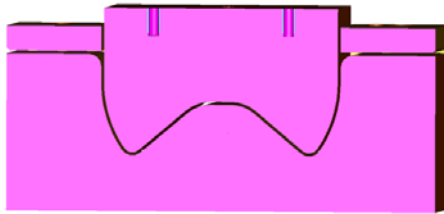
- **Stiffener welding**

- **Frequency measurements before and after vacuum load**

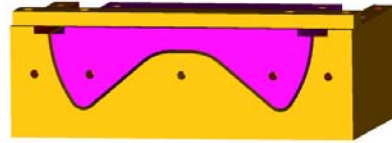
- **Final BCP and high pressure rinse**

- **Electro polish is also considered**

# Body Weldment



**Center shell forming  
(Die cross section)**



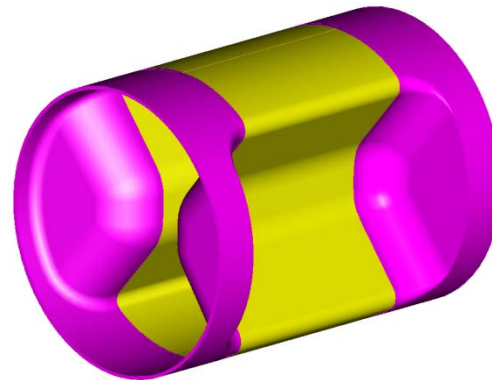
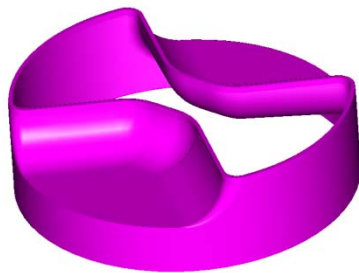
**Center shell machining  
Weld margin included**



**Machined cavity shoulder**



**EBW seams: 40% pre-pass, 50kV  
48mAmp 6 in/min beam speed  
Welding will be both sides to  
ensure the smooth surface inside**



**Welding cavity shoulder and center shell**

# Transition block

## Aluminum trial part shown

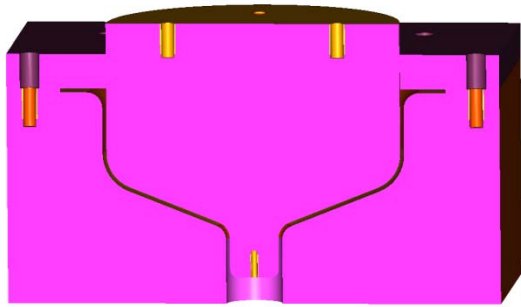


End cap side

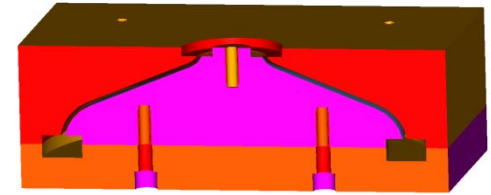
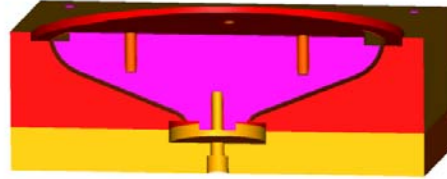


Center shell side

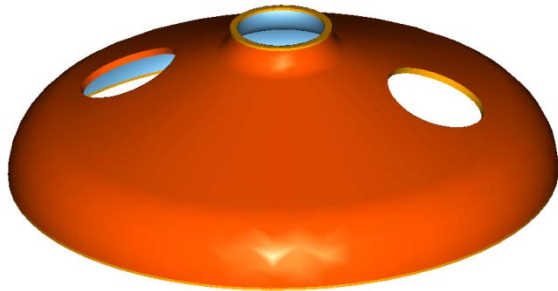
# End Cap Weldment



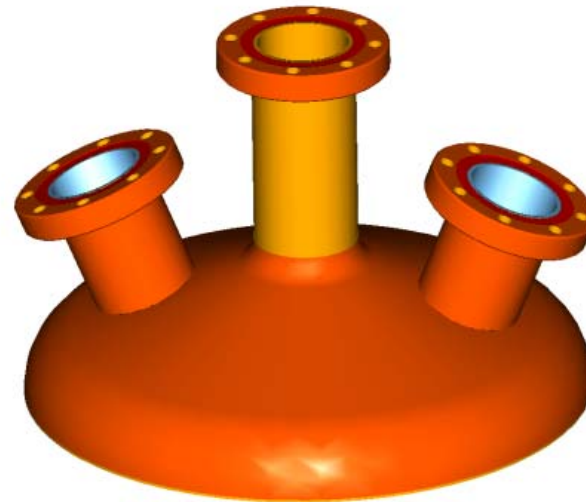
End cap forming



Machining  
(Weld and tuning margin included)



Machining port openings



Welding beam port and coupler ports



# Niobium beam ports with Nb-Ti flanges



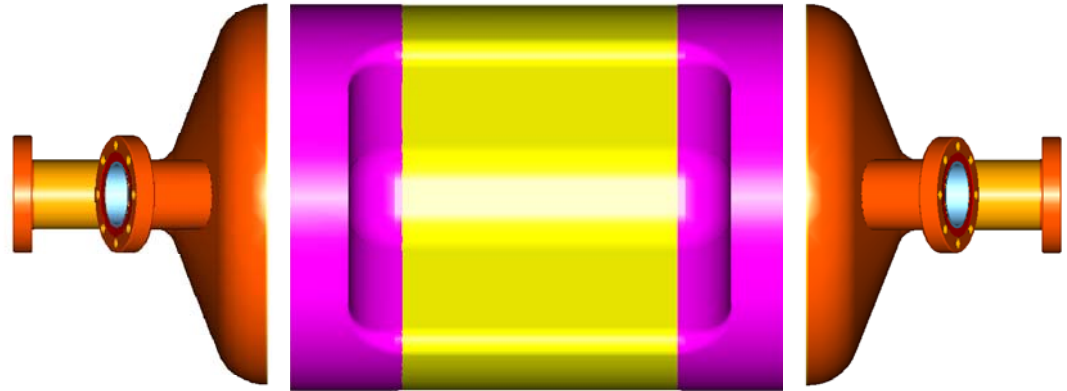
**Al-Mg gaskets for final assembly.  
For tunings and measurements  
Indium seal will be used.**

**Beam pipes and coupler ports are made.  
Blank flanges are not shown.  
Pipe ends need to be machined before welding.**

# Frequency Measurements

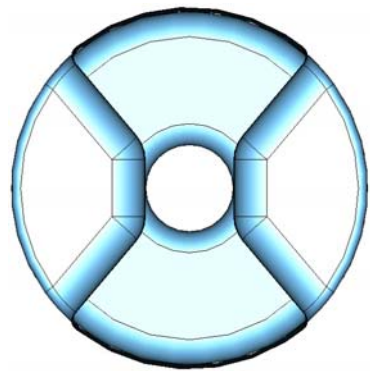
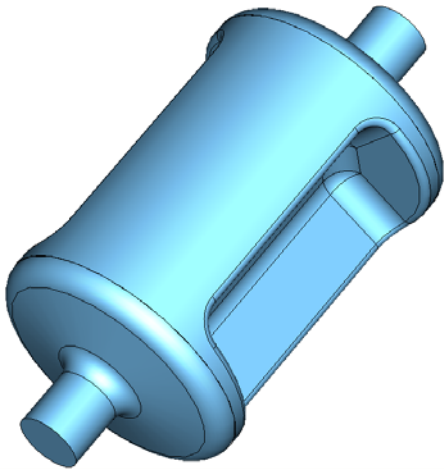
**Multi step frequency measurements to compare with the analyses**

**1. Warm Tuning before Final Weld**



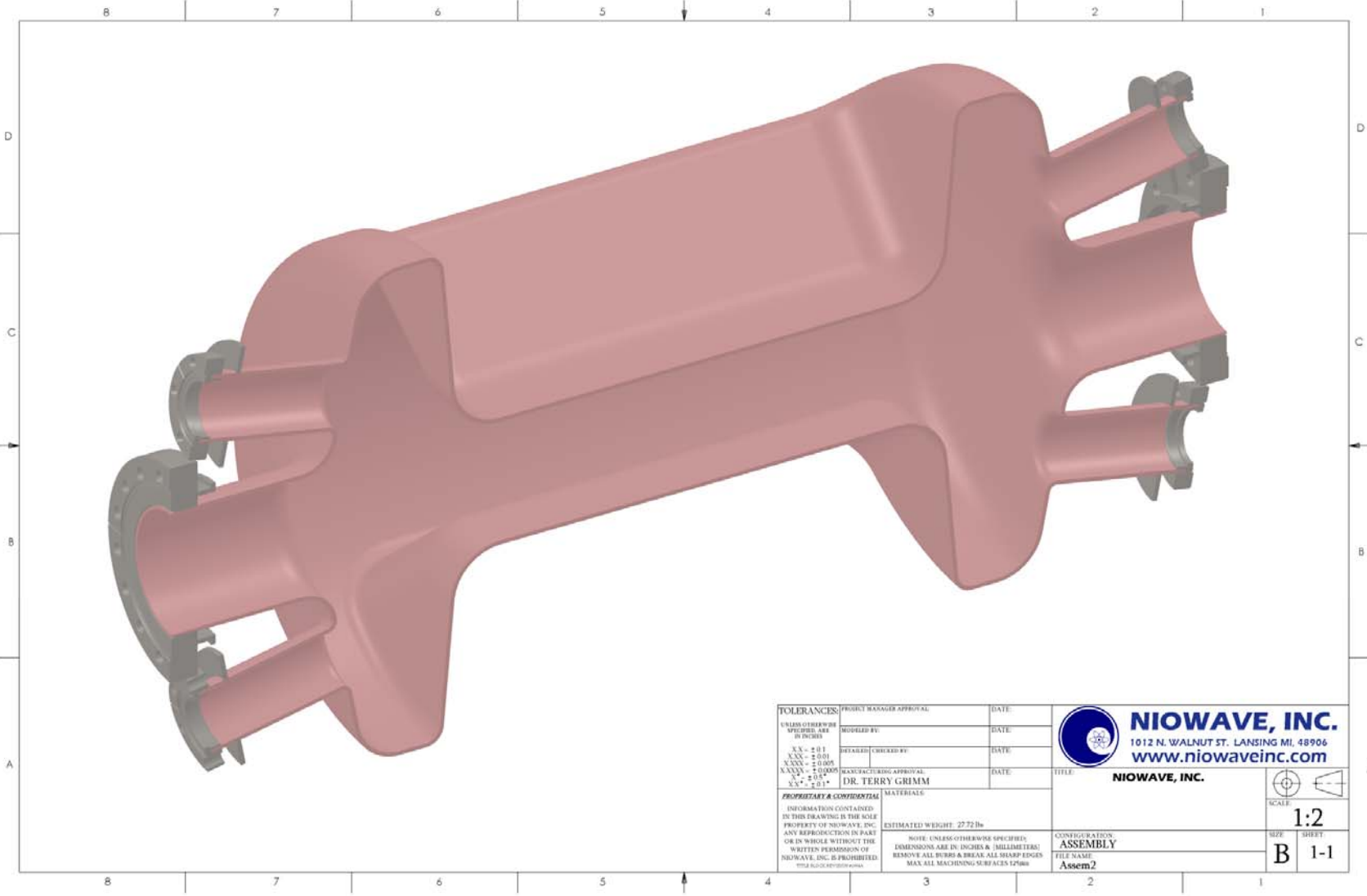
- 2. Frequency measurement after final weld**
- 3. Evacuate and measure frequency**
- 4. Weld stiffeners**
- 5. Evacuate and measure frequency**
- 6. Final BCP and high pressure rinse**

# LHC Crab Cavity (ODU/Niowave)



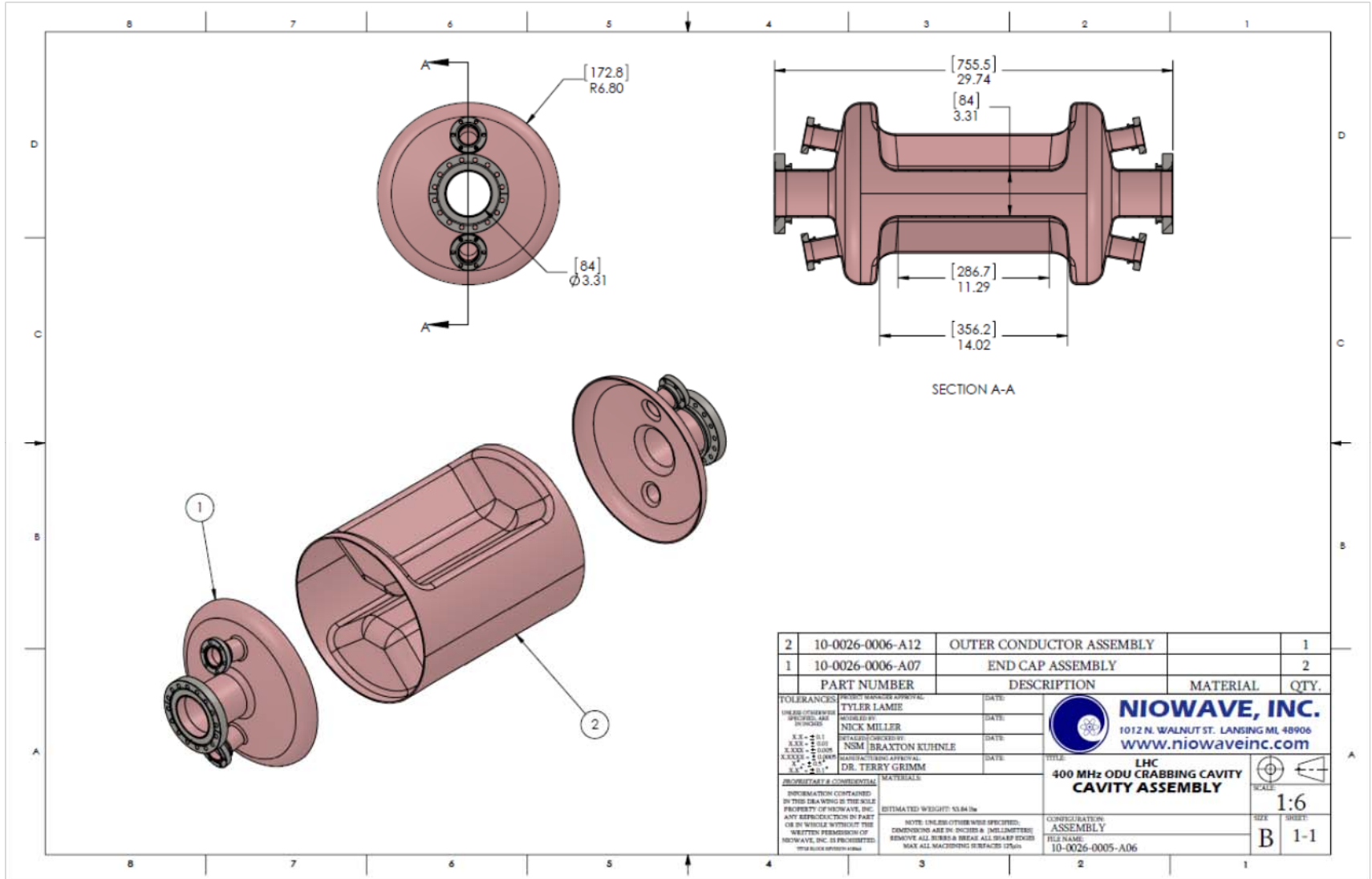
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| At $E_T^* = 1$ MV/m              |                    |                   |                   |                   |            |

# LHC Crab Cavity



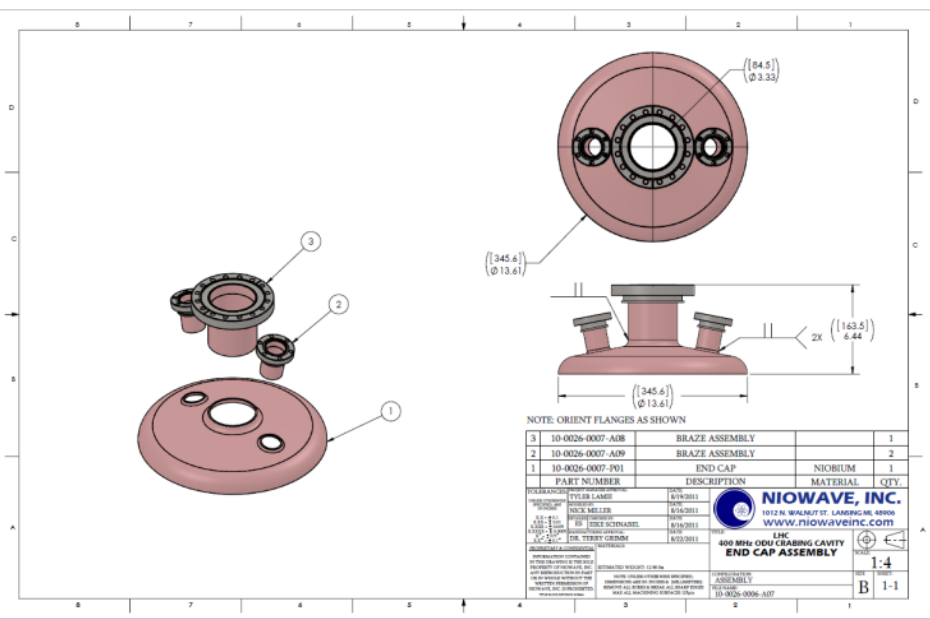
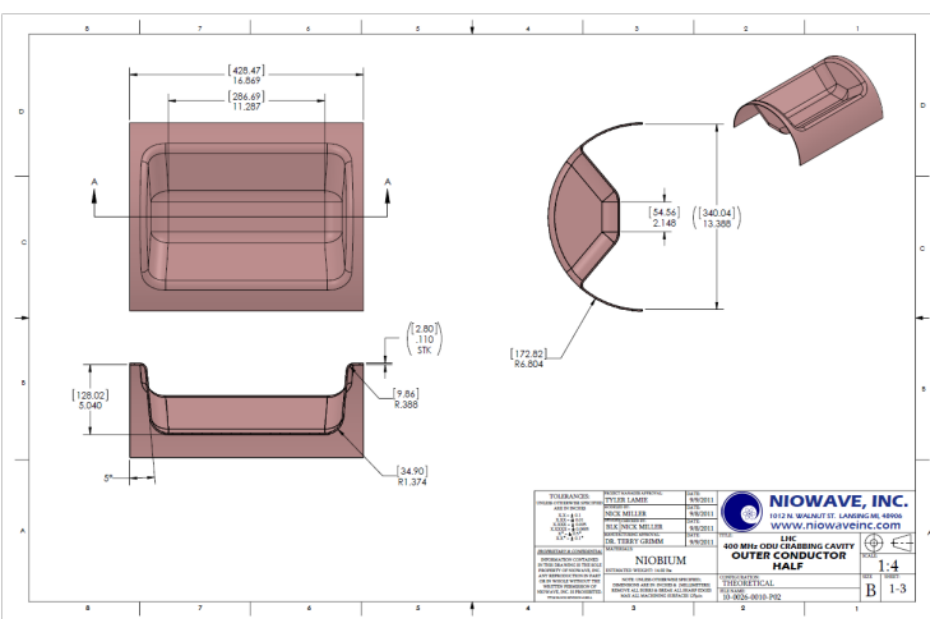
|   |  |  |   |
|---|--|--|---|
| <b>TOLERANCES:</b><br>UNLESS OTHERWISE SPECIFIED ARE IN DECIMALS<br>XX = ± 0.1<br>XXX = ± 0.05<br>XXXX = ± 0.005<br>XXXX* = ± 0.0005<br>X.X = ± 0.1"<br>X.XX = ± 0.1" | PRODUCT MANAGER APPROVAL<br>_____<br>DATE: _____   |  <b>NIOWAVE, INC.</b><br>1012 N. WALNUT ST. LANSING MI, 48906<br><a href="http://www.niowaveinc.com">www.niowaveinc.com</a> | <br>SCALE:<br><b>1:2</b> |
|   | MODELED BY: _____<br>DATE: _____<br>DRAWING CHECKED BY: _____<br>DATE: _____<br>MANUFACTURING APPROVAL: _____<br><b>DR. TERRY GRIMM</b><br>DATE: _____ |  |   |

# Cavity Assembly



|   |                  |   |          |  |
|---|------------------|---|----------|--|
| 2   | 10-0026-0006-A12 | OUTER CONDUCTOR ASSEMBLY  |          | 1  |
| 1   | 10-0026-0006-A07 | END CAP ASSEMBLY  |          | 2  |
|   | PART NUMBER      | DESCRIPTION   | MATERIAL | QTY.   |
| <b>TOLERANCES</b><br>UNLESS OTHERWISE SPECIFIED, ARE IN INCHES<br>X.XX - ± 0.1<br>X.XXX - ± 0.01<br>X.XXXX - ± 0.005<br>X.XXXX - ± 0.0025<br>X.X - ± 0.1                        |                  | PREPARED BY:<br>TYLER LAMIE<br>CHECKED BY:<br>NICK MILLER<br>DATE:                                | DATE:    | NIOWAVE, INC.<br>1012 N. WALNUT ST. LANSING MI 48906<br>www.niowaveinc.com |
| INFORMATION CONTAINED BY THIS DRAWING IS THE SOLE PROPERTY OF NIOWAVE, INC. ANY REPRODUCTION IN PART OR IN WHOLE WITHOUT THE WRITTEN PERMISSION OF NIOWAVE, INC. IS PROHIBITED. |                  | DETAILED/CHECKED BY:<br>NSM BRAXTON KUHNLE<br>MANUFACTURING APPROVAL:<br>DR. TERRY GRIMM<br>DATE: | DATE:    |  |
| MATERIALS:  |                  | ESTIMATED WEIGHT: 43.84 lbs   |          | TITLE:<br>LHC<br>400 MHz ODU CRABBING CAVITY ASSEMBLY                      |
| NOTE: UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES & DECIMALS. REMOVE ALL BEARS & BREAK ALL SHARP EDGES. MAKE ALL MACHINING SURFACES 12.5µm.                            |                  | CONFIGURATION:<br>ASSEMBLY<br>FILE NAME:<br>10-0026-0005-A06                                      |          | SCALE:<br>1:6<br>SIZE:<br>B<br>SHEET:<br>1-1                               |

# Cavity Parts



- Mechanical design of the end plates with flanges is finished and the parts of this subassembly are manufactured
- Outer conductor forming design is in progress

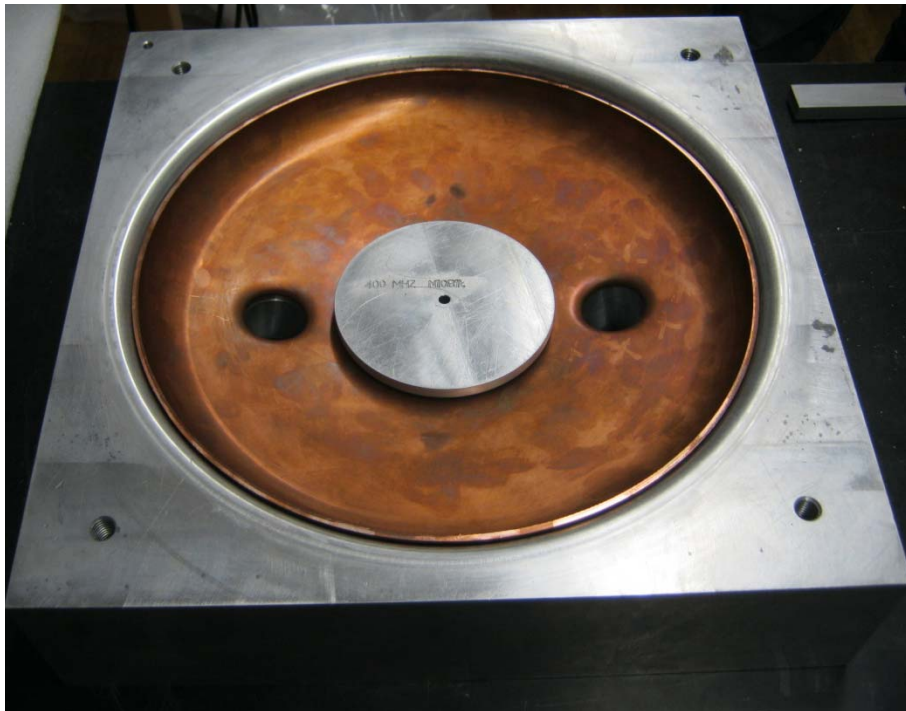
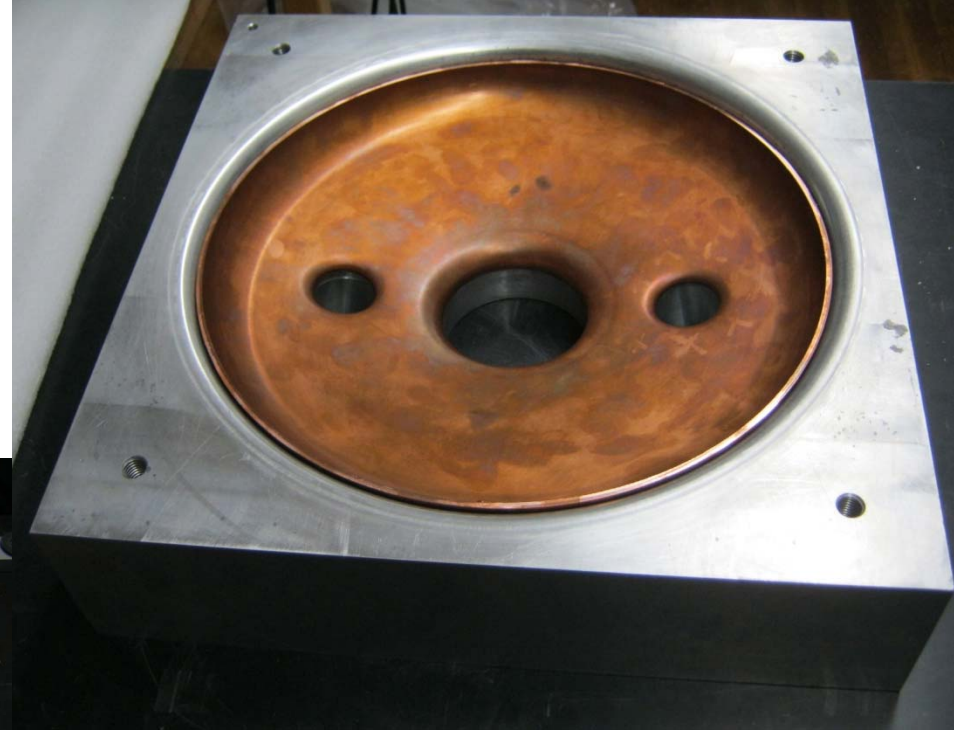




# 400 MHz LHC Crab Cavity Parts in Production (1)

**NIOWAVE**  
[www.niowaveinc.com](http://www.niowaveinc.com)

- Copper prototype of the end plates was stamped



- And the nipples were pulled



# 400 MHz LHC Crab Cavity

## Parts in Production (2)

**NIOWAVE**  
www.niowaveinc.com



- Beam and side port pipes are brazed with the stainless steel conflat flanges
- Both of the Nb end plates were stamped and nipples were pulled
- The preparation for the welding of the brazed beam pipes and side ports pipes is underway
- The OC parts and dies are in production





# 400 MHz LHC Crab Cavity

## Parts in Production (3)

**NIOWAVE**  
[www.niowaveinc.com](http://www.niowaveinc.com)





# LHC Crab Cavity Schedule

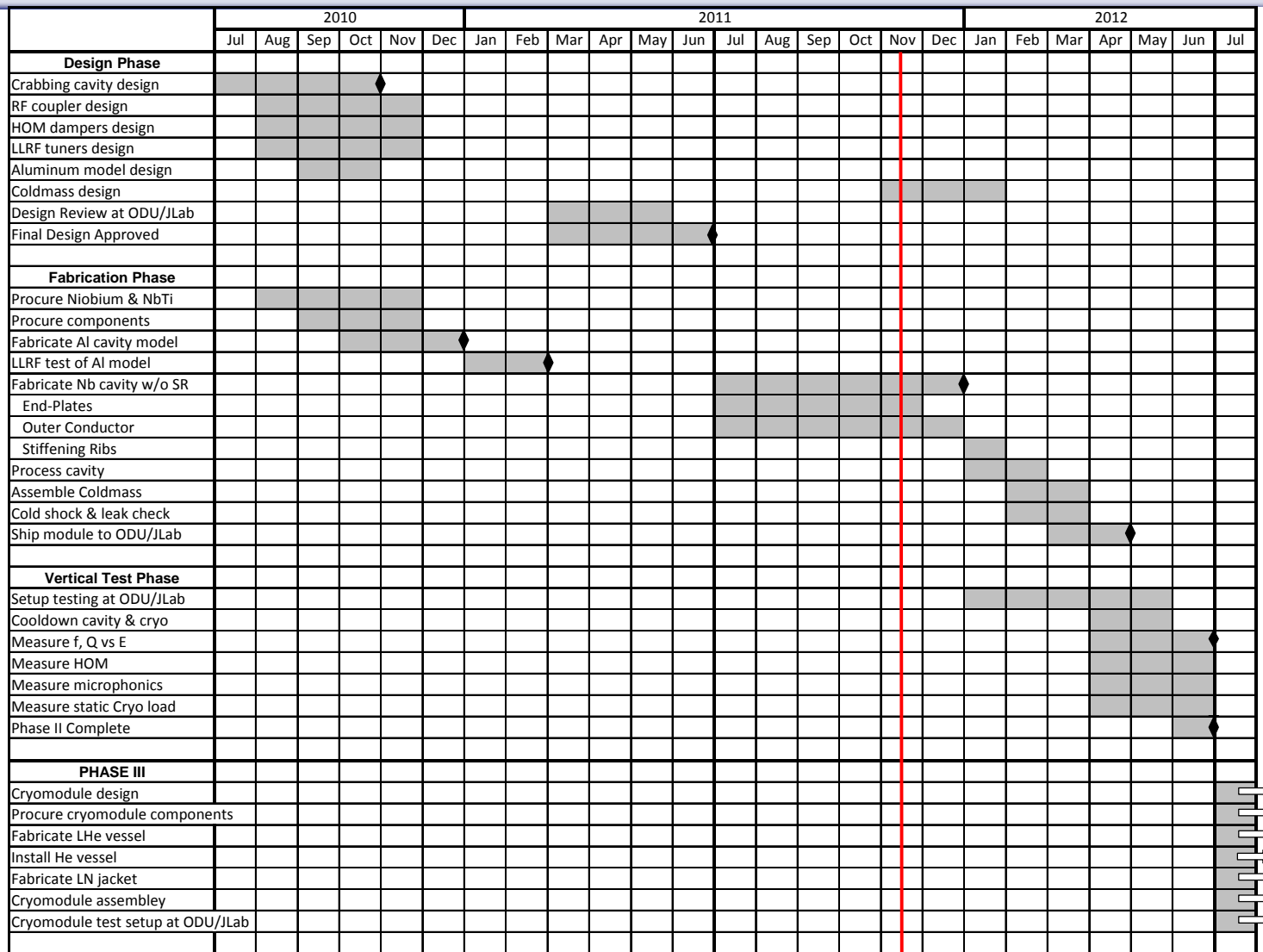
**NIOWAVE**  
[www.niowaveinc.com](http://www.niowaveinc.com)

- Complete EB Welding of End Caps with beam and side ports
  - November 8<sup>th</sup>, 2011
- Welding Fixture for the Outer Conductor manufacture
  - November 21<sup>st</sup>, 2011
- Complete OC fabrication
  - November 28<sup>th</sup>, 2011
- Complete Cavity Fabrication (Welding of End-plates with OC)
  - December 12<sup>th</sup>, 2011
- Welded Cavity leak checking and inspection
  - December 19<sup>th</sup>, 2011
- Flash Cavity Etch (~20  $\mu\text{m}$ )
  - December 21<sup>st</sup>, 2011
- Stiffening Ribs design and fabrication
  - January 31<sup>st</sup>, 2012



# LHC Crab Cavity Schedule

**NIOWAVE**  
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|                                 |                  |                                     |                  |
|---------------------------------|------------------|-------------------------------------|------------------|
| ◆ Milestones                    | Date to complete | ◆ Milestones                        | Date to complete |
| Crabbing Cavity Design Complete | 31-Oct-10        | Niobium Cavity Fabrication Complete | 31-Dec-11        |
| Aluminum Model Complete         | 31-Dec-10        | Complete assembly of Coldmass       | 30-Apr-12        |
| LLRF Test of Cu Model Complete  | 28-Feb-11        | Measure f, Q vs E                   | 30-Jun-12        |
| Final Design Approved           | 30-Jun-11        | Phase II Complete                   | 30-Jun-12        |