# CEBAF C100 Cryomodule Plasma Process Readiness Review

## Work Control Documents (WCD)

- WCD Register
- Beamline vacuum work
- Plasma processing

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Tuesday, February 28, 2023

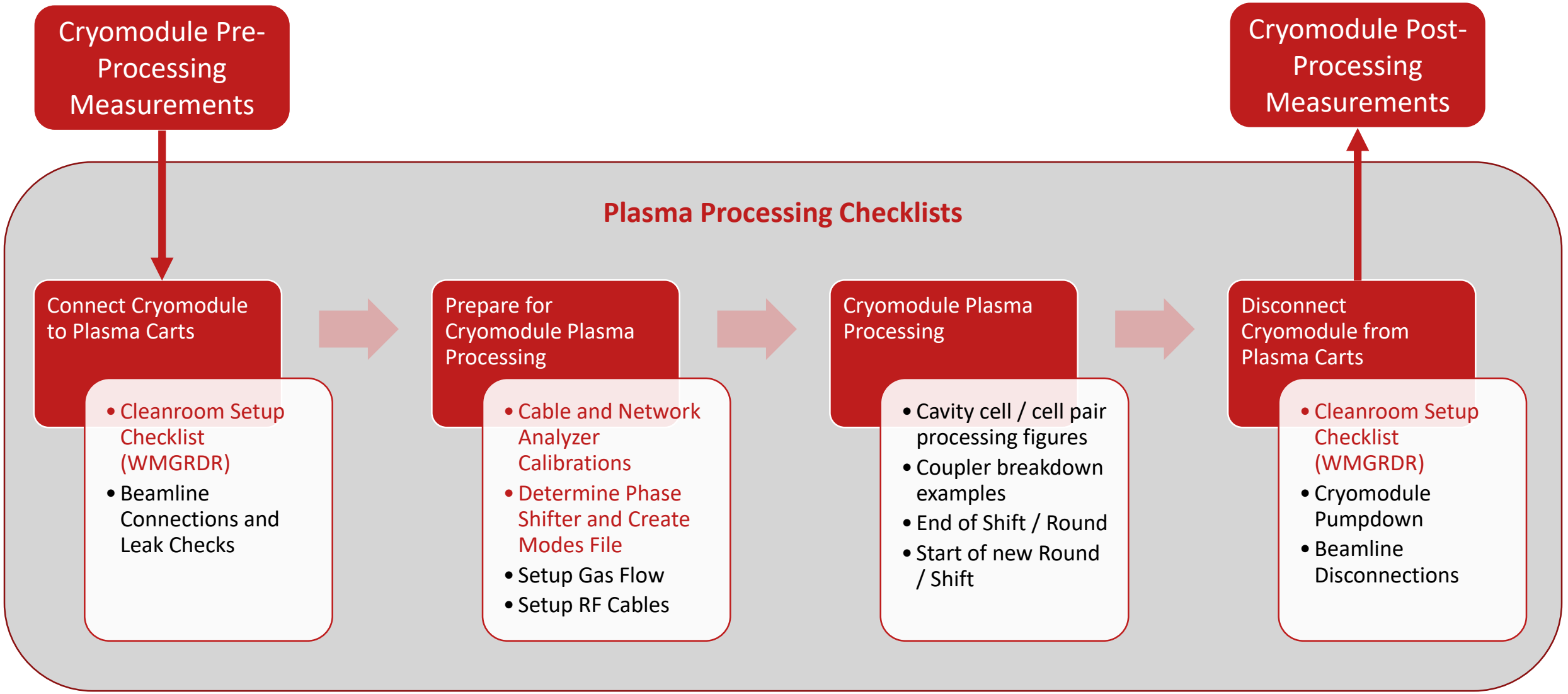
Procedures and Checklists are organized in the order in which work will be performed and with a primary technician type in mind (Beamline vacuum technician or Plasma processing technician).

Procedures and Checklists developed based on experience in the single cavity vertical plasma processing in the VSA and cryomodule plasma processing in the CMTF.

Relevant existing procedures and checklists were reviewed to ensure alignment to trained work practices and Beamline vacuum technicians provided input during the development of the plasma processing beamline work documents.

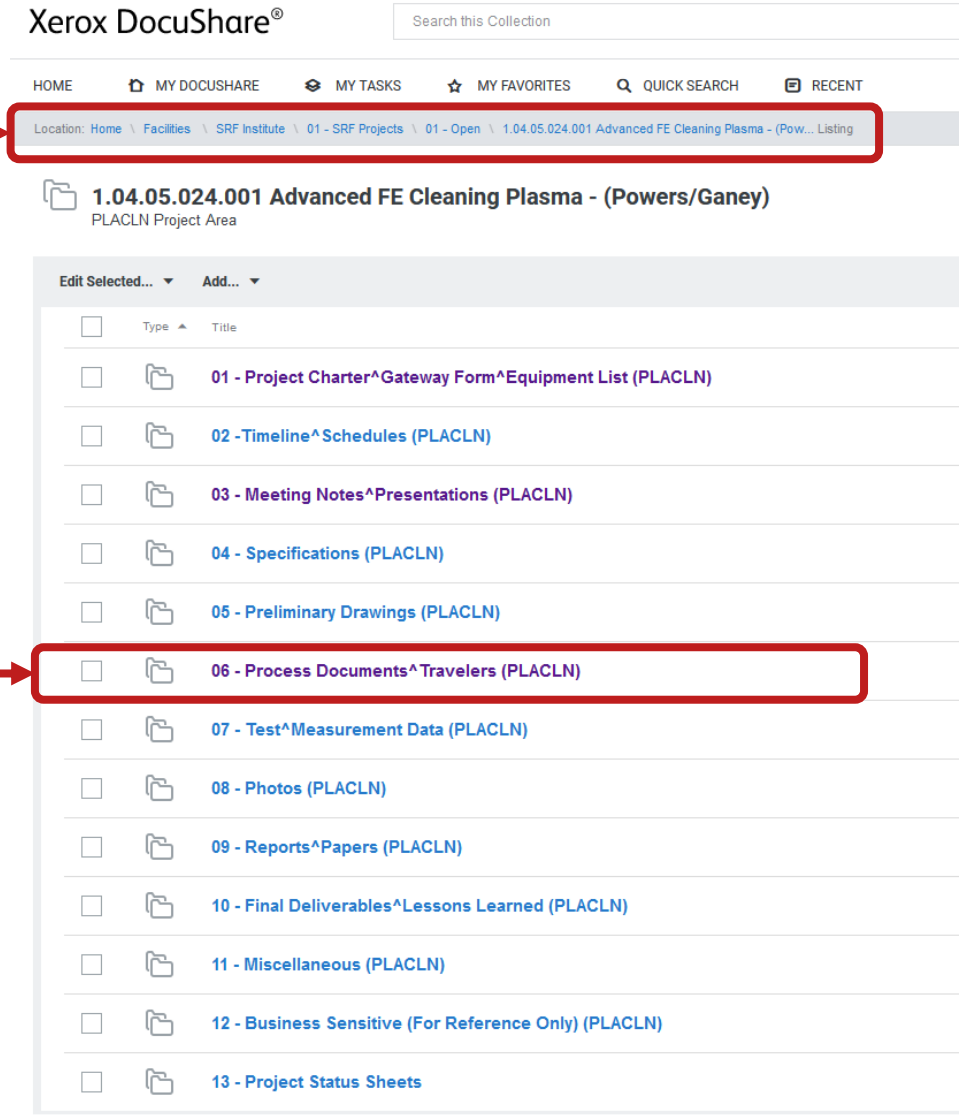
All documents are currently in review status.

# Work Control Document Sequence Overview



# JLab DocuShare – PLACLN Project Folders

- DocuShare is a web-accessible centralized file storage database (Lab-wide & SRF)
- Stores files for common access to the latest approved document versions.
- Revision control is maintained for history and records.
- The Plasma Processing Project (PLACLN) has a file directory in DocuShare to manage documents
- All Procedures and Checklist are available in the 06 – Process Documents and Travelers folder



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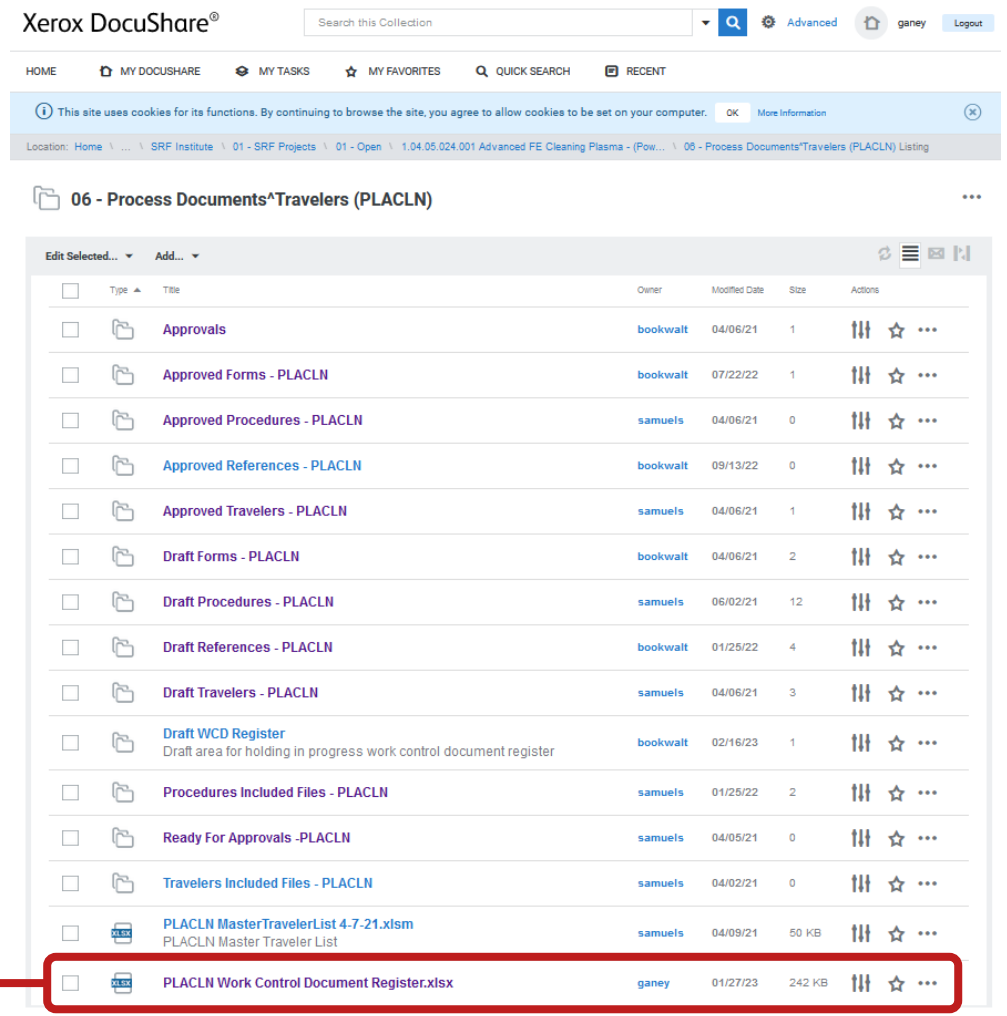
# Work Control Document (WCD) Register

- Available in the Project's DocuShare folder for Process Documents and Travelers
- Lists all documents needed to perform work, including beamline vacuum, setup, and plasma processing.

| 1 | Document Title | Document Type | Document ID |
|---|---|---|---|
| 2 | **General Use** | | |
| 3 | Plasma Processing Cable Calibrations | Procedure | PLACLN-PR-CAV-CCAL |
| 4 | Create HOM Modes File for Plasma Processing | Procedure | PLACLN-PR-CAV-MODE |
| 5 | Phase Shift for Plasma Processing C100 Cavities | Procedure | PLACLN-PR-CAV-PHASE |
| 6 | Calibrating the Network Analyzer | Procedure | PLACLN-PR-NA-CAL |
| 7 | Replacing a Tank in the Gas Cart | Procedure | PLACLN-PR-CART-TANK |
| 21 | **Cryomodule Plasma Processing** | | |
| 22 | **Cryomodule Test Facility (CMTF) or CEBAF** | | |
| 23 | Cryomodule Plasma Processing Checklists | Form | PLACLN-FM-CM-LIST |
| 24 | Connect Cryomodule to Plasma Carts | Procedure | PLACLN-PR-CM-CONN |
| 25 | Prepare for Cryomodule Plasma Processing | Procedure | PLACLN-PR-CM-PREP |
| 26 | Cryomodule Plasma Processing | Procedure | PLACLN-PR-CM-PROC |
| 27 | Disconnect Cryomodule from Plasma Carts | Procedure | PLACLN-PR-CM-DISC |
| 28 | C100 Cryomodule Plasma Processing | Traveler | PLACLN-CMTF-CM-PLSM |
| 29 | **Applicable WMGRDR Documents** | | |
| 33 | **Reference WMGRDR Documents** | | |



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# Beamline Vacuum Work Checklist

- Checklist provides an overview of primary actions required and points to the procedures
- Procedure provides detailed step-by-step instructions
  - Connect Plasma Processing Carts to Closed Volume
  - Disconnect Plasma Processing Carts from Closed Volume
- Intended to be performed by trained beamline vacuum technicians
- Reference existing WMGRDR documents when appropriate
- Plasma processing staff will provide oversite and assistance for operating the plasma processing carts

| Vacuum work. | | |
|---|---|---|
| 1 | Assemble a portable clean hood covering the area around the upstream and down stream girders. | FM-WMGRDR-CLNRM-SETUP |
| 2 | Using appropriate clean hood and clean assembly techniques connect the cavity to the pumping cart to the valve located on the ion pump just upstream of the cryomodule. | PLACLN-PR-CM-CONN |
| 3 | Pump out the line to UHV and open the valve between the pump cart and the ion pump. | |
| 4 | Insure that the “B” beam line valve just upstream of the cryomodule is closed and unplugged* from the control system. *Unplugging it makes it such that no one from operations can open the valve while we have the cryomodule beam line up to 0.3 Torr. | |
| 5 | Using appropriate clean hood and clean assembly techniques, connect the supply line manifold to the closed valve located on the downstream ion pump {downstream beam line valve}. | |
| 6 | Pump out the supply manifold {for CMTF do this with the right-angle valve attached to the beam line open}. | |
| 7 | Using a local* valve control box, open the valve connected to the downstream ion pump {for the CMTF open the downstream beam line valve. *Using a local box insures that no one from ops can close the valve when we are flowing gas through the cryomodule. | |
| 8 | Turn off the two ion pumps that one just upstream of the cryomodule and one just down stream of the cryomodule and unplug them from their respective power supplies. | |
| 9 | Using established procedures establish gas flow to the cavity and process the cavity and adjust the oxygen percentage. | PLACLN-PR-CM-PREP |
| 10 | After processing stop the flow of gas to the cavity using the MFC. | PLACLN-PR-CM-PROC |
| 11 | Close the valve between the gas supply cart and the gas supply manifold. | |
| 12 | When the gas supply and pump out manifolds are below 10 mTorr, open the main valve to turbo pump B. | PLACLN-PR-CM-DISC |
| 13 | When the system is at UHV close the valve between the downstream ion pump and the gas supply manifold {in the CMTF close the downstream beam line gate valve.} | |
| 14 | Turn on the two ion pumps {CMTF turn on the ion pump} | |
| 15 | Close the valve on the upstream ion pump. | |
| 16 | Using a flow of less than 70 SCCM backfill the supply manifold to slightly over 1 ATM. {CMTF While someone is watching the ion pump pressure backfill the supply manifold with 70 SCCM of inert gas.} If the pressure on the ion pump increases stop and evaluate the situation. | |
| 17 | Turn off the RGA. | |
| 18 | Turn off the turbo pumps and let them spin down for 20 minutes. | |
| 19 | Turn off the backing pumps on the turbo cart. | |
| 20 | Backfill pump out manifold with nitrogen via valve VB5 or VA5. | |
| 21 | Using appropriate clean hood and clean assembly techniques disconnect the pumping manifold and gas supply manifold from the beam line {cryomodule} and apply blank conflat flanges to all open ports. | |

# Beamline Vacuum Work Procedures

## Connect Plasma Processing Carts to Closed Volume

| | | | |
|---|---|---|---|
| Document Number: | PLACLN-PR-CM-CONN | Approval Date: | Mmm DD, YYYY |
| Revision Number: | 1 | Periodic Review Date: | N/A |
| Process Owner: | Ganey, Tiffany | Department Owner: | SRF Ops |

### 1 Purpose and Scope

This procedure provides instructions for a particle-free connection of the vacuum and gas carts for plasma processing of a C100 cryomodule in either the Cryomodule Test Facility (CMTF) or in CEBAF.
At the start of this procedure:

- The cryomodule and any applicable adjacent girders shall be under vacuum.
- The plasma gas cart and vacuum cart hoses shall be at atmosphere pressure.
- Cryomodule gate valves shall be leak tight. If needed, cryomodule gate valves shall be replace prior to the start of this procedure.
- The gate valves of the cryomodule being worked and the upstream gate valve of the downstream cryomodule shall be closed at the start of this procedure. All gate valves shall be under local box control only.



### 2 Safety

Individuals must keep safety as the first priority in the process; before beginning any job, the user must assure they have the correct PPE for the individual job. Maintaining the level of safety and secure nature of the work area is paramount.
The work area may be a Radiologically Controlled Area (RCA), and dosimetry must be worn at all times while in an RCA.
Refer to the plasma processing and work-center OSPs for specifics.

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## Disconnect Plasma Processing Carts from Closed Volume

| | | | |
|---|---|---|---|
| Document Number: | PLACLN-PR-CM-DISC | Approval Date: | Mmm DD, YYYY |
| Revision Number: | 1 | Periodic Review Date: | N/A |
| Process Owner: | Ganey, Tiffany | Department Owner: | SRF Ops |

### 1 Purpose and Scope

This procedure provides instructions for disconnecting the vacuum and gas supply carts for plasma processing of a C100 cryomodule in either the Cryomodule Test Facility (CMTF) or in CEBAF.

This procedure begin once plasma processing is completed, the gas flow from the plasma gas supply cart has been stopped, and the cryomodule is pumping through the plasma vacuum cart.



Contents

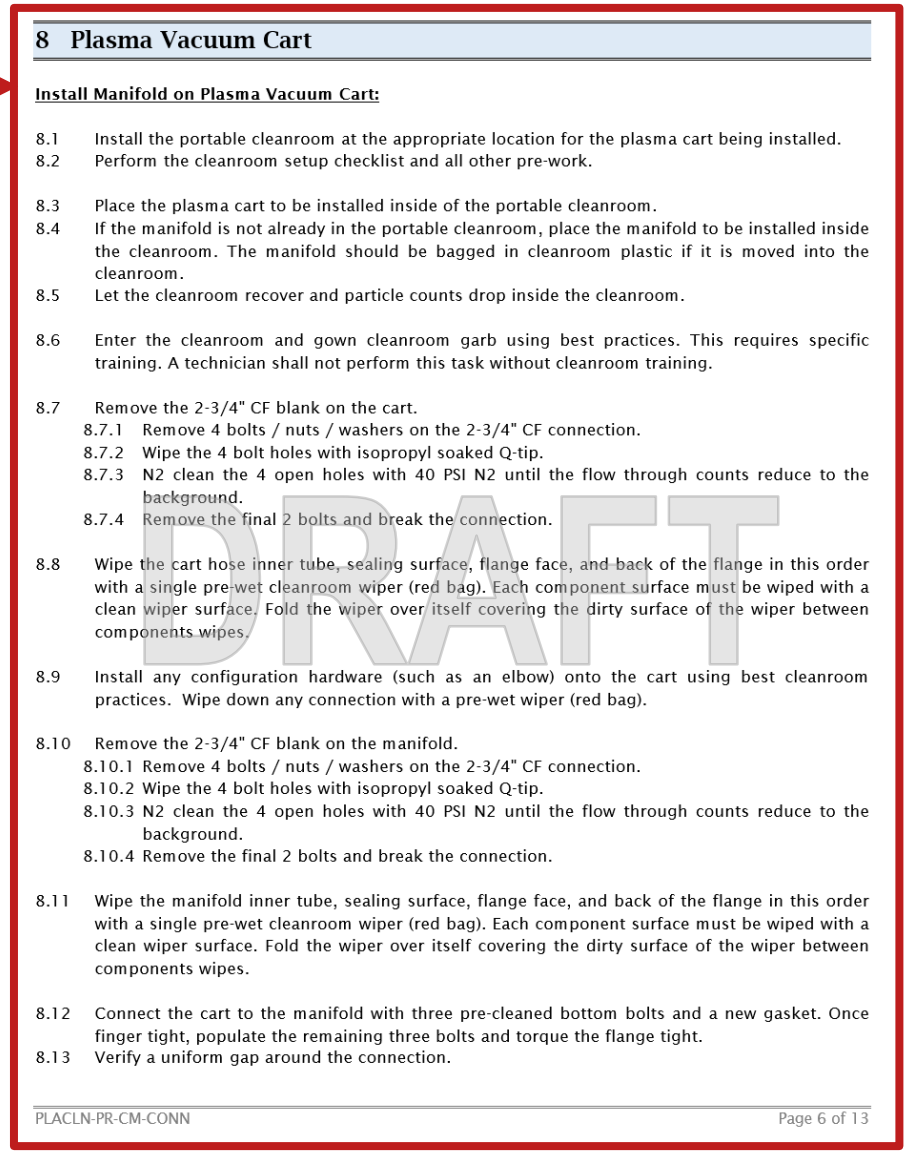
# Beamline Vacuum- Connect Plasma Processing Carts to Closed Volume Procedure

## Section 8

- Install Manifold on Plasma Vacuum Cart
- Leak Check Plasma Vacuum Cart and Manifold
- Install Plasma Vacuum Cart to Cryomodule
- Leak Check Plasma Vacuum Cart Connection to Cryomodule
- Open Cryomodule to Plasma Vacuum Cart

## Section 9

- Install Manifold on Plasma Gas Supply Cart
- Install Plasma Gas Supply Cart to Cryomodule
- Leak Check Plasma Gas Supply Cart Connection to Girder
- Open Girder to Plasma Gas Supply Cart



8 Plasma Vacuum Cart

**Install Manifold on Plasma Vacuum Cart:**

8.1 Install the portable cleanroom at the appropriate location for the plasma cart being installed.
8.2 Perform the cleanroom setup checklist and all other pre-work.

8.3 Place the plasma cart to be installed inside of the portable cleanroom.
8.4 If the manifold is not already in the portable cleanroom, place the manifold to be installed inside the cleanroom. The manifold should be bagged in cleanroom plastic if it is moved into the cleanroom.
8.5 Let the cleanroom recover and particle counts drop inside the cleanroom.

8.6 Enter the cleanroom and gown cleanroom garb using best practices. This requires specific training. A technician shall not perform this task without cleanroom training.

8.7 Remove the 2-3/4" CF blank on the cart.
8.7.1 Remove 4 bolts / nuts / washers on the 2-3/4" CF connection.
8.7.2 Wipe the 4 bolt holes with isopropyl soaked Q-tip.
8.7.3 N2 clean the 4 open holes with 40 PSI N2 until the flow through counts reduce to the background.
8.7.4 Remove the final 2 bolts and break the connection.

8.8 Wipe the cart hose inner tube, sealing surface, flange face, and back of the flange in this order with a single pre-wet cleanroom wiper (red bag). Each component surface must be wiped with a clean wiper surface. Fold the wiper over itself covering the dirty surface of the wiper between components wipes.

8.9 Install any configuration hardware (such as an elbow) onto the cart using best cleanroom practices. Wipe down any connection with a pre-wet wiper (red bag).

8.10 Remove the 2-3/4" CF blank on the manifold.
8.10.1 Remove 4 bolts / nuts / washers on the 2-3/4" CF connection.
8.10.2 Wipe the 4 bolt holes with isopropyl soaked Q-tip.
8.10.3 N2 clean the 4 open holes with 40 PSI N2 until the flow through counts reduce to the background.
8.10.4 Remove the final 2 bolts and break the connection.

8.11 Wipe the manifold inner tube, sealing surface, flange face, and back of the flange in this order with a single pre-wet cleanroom wiper (red bag). Each component surface must be wiped with a clean wiper surface. Fold the wiper over itself covering the dirty surface of the wiper between components wipes.

8.12 Connect the cart to the manifold with three pre-cleaned bottom bolts and a new gasket. Once finger tight, populate the remaining three bolts and torque the flange tight.
8.13 Verify a uniform gap around the connection.

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# Plasma Processing Checklist

- Checklists provides an overview of primary actions required
  - Initial setup
  - Beginning of each day
  - End of each day
- Procedure provides detailed step-by-step instructions
  - *Cable Calibrations*
  - Network Analyzer Calibration
  - Create Modes File
  - *Determine Phase Shift*
  - *Prepare Carts, System, Software*
  - *Plasma Process*
- Intended to be performed by trained plasma processing technicians

| **RF work for plasma processing a cryomodule accelerator tunnel {and CMTF}** | |
|---|---|
| 1 | Using appropriate LOTO procedures remove a section of waveguide upstream of the one-half to full-height waveguide transition. Place a metal blank on the upstream waveguide and a waveguide to type-N transition on the downstream waveguide. (EES-RF {SRF cryomodule assembly} group task) |
| 2 | Using established procedures calibrate the RF cables. |
| 3 | Using a calibrated network analyzer S1 port connected to the HOM coupler being used to drive the cavity and connect the motorized phase shifter to the second HOM port use the established procedure to measure S11 and S21 as a function of phase shifter position for all 8 cavities. The phase shifter position shall be varied between 0 and 360 degrees of two-way phase shift in 5 degree increments. |
| 4 | Using established procedures determine the optimal phase shift position for processing each cavity. |
| 5 | Connect the output of the RF system to the selected HOM and the input to the RF system to the waveguide top-hat. |
| 6 | Using established procedures, process each cell or combination of two cells for one hour. Up to four cavities can be processed at the simultaneously. One may not process adjacent cavities simultaneously. |
| 7 | The RF controls must be attended at all times when the coupler interlock is not engaged. |
| 8 | Process all of the cavities twice with at least a 24-hour break between processing cycles on individual cavities. |

# Plasma Processing Checklists Continued

| Plasma Processing a cryomodule Beginning of Day Checklist | |
|---|---|
| 1 | Verify the cryomodule's upstream gate valve (near the plasma vacuum cart) is closed and the cryomodule's downstream gate valve (near the plasma gas cart) is open. |
| 2 | Verify the cryomodule's ion pumps are off. |
| 3 | Verify the PlasmaMain software is running and reading all sensors, meters, gauges, etc. correctly. Verify the RGA is running and the filament is on. |
| 4 | Verify the cryomodule's pressure is in the E-5 Torr or lower range and the plasma gas cart is reading 0.1 Torr (bottom of scale). |
| 5 | Verify the MFC is closed. |
| 6 | Close the plasma gas cart valves to the scroll pump (Pump Main and VN2). Open the gas tanks, VA1, VA2, VM1, and VM2. |
| 7 | Slowly open the valve on the gas cart manifold between the plasma gas cart and the girder isolation valve. Verify the cryomodule's pressure remains steady. If any significant change in the cryomodule's pressure is observed, close the gas cart manifold valve and seek assistance to troubleshoot. |
| 8 | Using the PlasmaMain software, set the MFC setpoint to the value used on the previous plasma processing day. Verify the pressure setpoint is correct. Start gas flow with the PlasmaMain software. |
| 9 | Once the gas flow is regulating at the correct pressure, check the O2%. Adjust the gas cart slowly as needed to ensure the O2% is in the target range. |
| 10 | Move the RF input and phase shifter cables to the cavities to be processed. |
| 11 | Load the correct mode files to the PlasmaMain software and set the phase shifter position for each cavity. |
| 12 | Turn on the amplifier(s). |
| 13 | In the PlasmaMain software, set the network analyzer S21 baseline trace and modes for frequency shift calculation. |
| 14 | Verify the RGA is reading good baseline partial pressures. Begin plasma processing in accordance with the procedure. |

| Plasma Processing a cryomodule End of Day Checklist | |
|---|---|
| 1 | Stop gas flow by closing the MFC. Note the MFC setpoint on the PlasmaMain program. Close the gas tanks and the valves on the gas cart. Continue pumping the cryomodule with the plasma vacuum cart. |
| 2 | Close the valve on the plasma manifold between the gas cart and the girder isolation valve. Leave the isolation valve open. |
| 3 | Using the scroll pump on the gas cart, pump out the gas line from VA2, VM2 through to the closed gas cart manifold valve. |
| 4 | Once the capacitive manometer on the plasma vacuum cart manifold reads in the E-5 Torr range, fully open the V21 valve on the vacuum cart. |
| 5 | Turn off the amplifier(s). |
| 6 | Back up files. |
| 7 | Create Elog entry noting which cavities and cells were processed, the gas pressure, gas flow, and O2% used. |
| 8 | Complete fields in the traveler PLACLN-CMTF-CM-PLSM for work performed. |

# Cable Calibration Procedure

## Plasma Processing Cable Calibrations

| | | | |
|---|---|---|---|
| Document Number: | PLACLN-PR-CAV-CCAL | Approval Date: | MMM DD YYYY |
| Revision Number: | 1 | Periodic Review Date: | N/A |
| Process Owner: | Ganey, Tiffany | Department Owner: | SRF Ops |

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## 1 Purpose and Scope

This procedure provides instructions for performing cable calibrations for plasma processing of a C100 cavity. The cable calibration process consists of calibrating the forward, reflected, and transmitted power cables; forward power to a detuned cavity, and RF power. This procedure may be used for either single cavity or cryomodule plasma processing.

Instructions for calibrating the network analyzer are provided in the procedure PLACLN-PR-NA-CAL.

For Cryomodule Plasma Processing, the HOM on the BOTTOM will be used. The HOMs connectors are labeled on the outside of the cryomodule. For cavities 1-4 (near the Supply End Can), HOM A shall be used. For cavities 5-8 (near the Return End Can), HOM B shall be used.

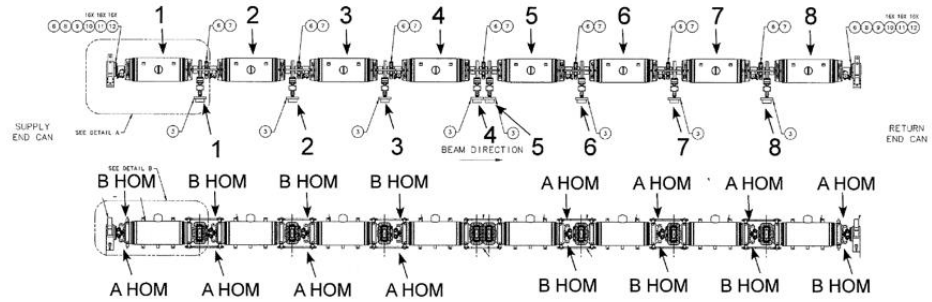


*Figure 5-b: C100 Cryomodule Cavity Order and HOM Positions*

## 7 PFwd to Cable End

7.1 Press the "PFwd to Cable End" button.
7.2 Connect the RF source 1 cable (Signal Generator Freq 1) to the input of the circulator. See the dash line on Figure 7-a.
7.3 Connect the PTrans power meter to the cable that is normally connected to the cavity HOM port. See the dash-dot line on Figure 7-a.

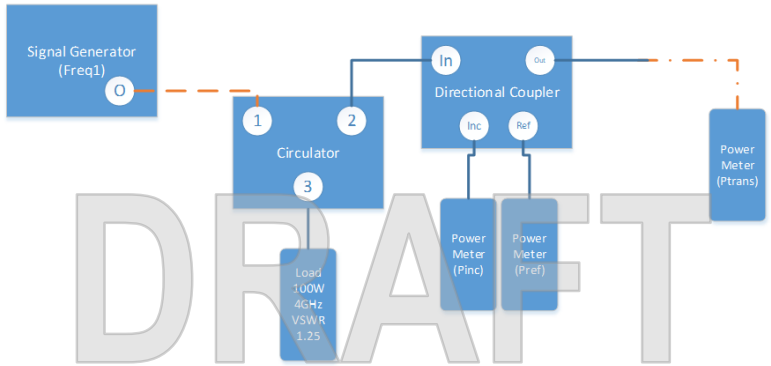




*Figure 7-a: PFwd to Cable End Connections*

7.4 Verify that the directivity is about -20 dB and that the calibration factor is about 35 dB.

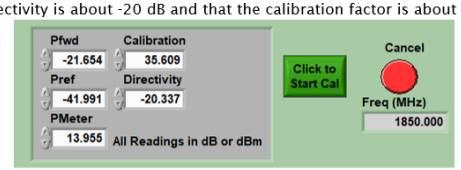


*Figure 7-b: Example data for PFwd calibration*

7.5 Click the green Start Calibration Button.

7.6 In the blue popup window, verify that the Change column values are within a few tenths of a dB as a function of frequency and click Done.



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# Determine Phase Shift Procedure

## Phase Shift for Plasma Processing C100 Cavities

| | | | |
|---|---|---|---|
| Document Number: | PLACLN-PR-CAV-PHASE | Approval Date: | MMM DD YYYY |
| Revision Number: | 1 | Periodic Review Date: | N/A |
| Process Owner: | Ganey, Tiffany | Department Owner: | SRF Ops |

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## 5 Capture Phase Shift Data for a Cavity

5.1 Perform a network analyzer cable calibration in accordance with the procedure PLACLN-PR-NA-CAL.
5.2 Place the Phase Shifter near the HOM ports.
5.3 Connect an Ethernet cable from the Plasma computer to the Phase Shifter.
5.4 Connect a cable between the HOM port to be phase shifted and the Phase Shifter.
5.4.1 For C100 cryomodules:
5.4.1.1 Cavities 1-4: the phase shifter is typically installed on HOM B. HOM A is on the bottom side and is typically used for RF power input for plasma processing.
5.4.1.2 Cavities 5-8: the phase shifter is typically installed on HOM A. HOM B is on the bottom side and is typically used for RF power input for plasma processing.
5.5 Connect the other HOM to the Plasma Processing RF input cable.
5.6 Connect the FPC Tophat to the Plasma Processing transmitted power cable.
5.7 Turn on the Amplifier.
5.8 Open and run the 'E5080 Network Analyzer S11_S21.vi' LabVIEW program.
5.8.1 If this is the first time the E5080 Network Analyzer S21 program has been launched for plasma processing the current cavity, in the popup window select "Set up Network Analyzer". Else, select "Network Analyzer OK".
5.8.2 If error messages are displayed, click Continue.
5.9 Open the 'Sweep Phase Shifter with E5080.vi' LabVIEW program.

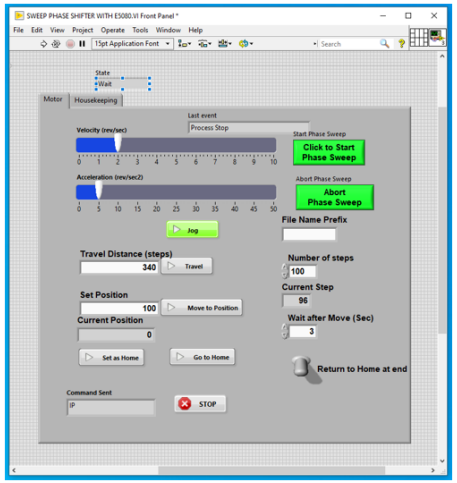


*Figure 5-a: Sweep Phase Shifter LabVIEW Program*

In Development





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# Prepare for Plasma Processing Procedure

## Prepare for Cryomodule Plasma Processing

| | | | |
|---|---|---|---|
| Document Number: | PLACLN-PR-CM-PREP | Approval Date: | Mmm DD, YYYY |
| Revision Number: | 1 | Periodic Review Date: | N/A |
| Process Owner: | Ganey, Tiffany | Department Owner: | SRF Ops |

### 1 Purpose and Scope

This procedure provides instructions for preparing for plasma processing of a C100 cryomodule in either the Cryomodule Test Facility (CMTF) or in CEBAF. It references other procedures that provide detailed instructions on specific portions of the process. Connecting and disconnecting the plasma vacuum and gas supply carts will be performed by technicians specifically trained for beamline work within a portable cleanroom. Cable calibrations and RF equipment setup will be performed by the plasma processing technicians. At the end of this procedure, the cryomodule will be ready to begin plasma processing.

### 2 Safety

Individuals must keep safety as the first priority in the process; before beginning any job, the user must assure they have the correct PPE for the individual job. Maintaining the level of safety and secure nature of the work area is paramount.
The work area may be a Radiologically Controlled Area (RCA), and dosimetry must be worn at all times while in an RCA.
Refer to the plasma processing and work-center OSPs for specifics.



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### 8 Establish Gas Flow

8.1 Verify:
- The cryomodule isolation valve(s) to the vacuum cart are open and the vacuum cart is pumping the cryomodule.
- Vacuum cart V17 is open and the RGA filament is warmed up.
- The Gas supply cart is pumping on the space up to the closed cryomodule / girder isolation valve.
- The Gas supply cart MFC valve is closed and that the gauge PGX is reading 0.1 Torr.
- The cryomodule and girder ion pumps are turned off.
- The cryomodule gate valve near the vacuum cart is closed and the gate valve near the gas supply cart is open.
- The gate valves are disconnected from EPICS and are controllable only locally.

8.2 Set up the PlasmaMain graphs to monitor mass flow (MF), cavity pressure (PCav (Torr)), and $\%O_2$.
8.3 Close the gas supply cart Main Pump valve and VN2.
8.4 Slowly open the cryomodule /girder valve to the gas supply cart. **Opening the cryomodule / girder valve shall be performed by personnel trained to perform valve operations in accordance with CEBAF procedures and standard work practices.**
8.5 Monitor the pressure reading on the Capacitive Manometer(s) and vacuum cart B controller.
- The pressure readings may increase slightly on the capacitive manometer and on pump B.
- If a large increase in the pressure is observed, stop and regroup.

8.6 Fully open V22 while leaving V23 in its nominal operating position and close V21.
8.7 Fully open V13 while leaving V12 in its nominal operating position and close V11.
8.8 If not done, verify the tank regulators are set to 5 psi and open the processing gas tanks.
8.9 Open the gas supply cart valves VA1, VA2, VM1, and VM2.
8.10 In accordance with the following substeps, slowly open the MFC Valve and begin the process of purging gas while keeping the mass flow below 35 SCCM and the pressure at or below the setpoint pressure.
- The setpoint pressure is the pressure that the plasma processing will be done. This is typically between 50 – 300 mTorr. Contact the SME for guidance on the setpoint pressure if needed.
- The Mass Flow Setpoint cannot be set to a value lower than 6 SCCM, other than 0 SCCM.

8.10.1 On the PlasmaMain yellow screen, set the Pressure Setpoint to the setpoint pressure that will be maintained for plasma processing.
8.10.2 On PlasmaMain, select the Vac Cntl tab. Verify the Gain on the Vac Cntl tab is set to 5.
8.10.3 Set the Mass Flow Setpoint to 10 and the Mass Flow Max to 25 SCCM or lower.
8.10.4 Set the Mass Flow mode to "False" (MF Setpoint). The toggle button light will be dark when the Mass Flow mode is set to False.
8.10.5 Click the Pressure Loop button to turn on the PlasmaMain pressure control loop. The button will turn green when the pressure control loop has been turned on.
8.10.6 Monitor the Cavity Pressure. The cavity pressure should slowly start to rise and reach a steady state.
- If the cavity pressure is leveling out below the pressure setpoint, increase the Mass Flow Setpoint by 0.5 - 1 SCCM.
- If the cavity pressure is increasing too quickly and could exceed the pressure setpoint, decrease the Mass Flow Setpoint by 1 -2 SCCM.

# Cryomodule Plasma Processing Procedure

## Cryomodule Plasma Processing

| | | | |
|---|---|---|---|
| **Document Number:** | PLACLN-PR-CM-PROC | **Approval Date:** | Mmm DD, YYYY |
| **Revision Number:** | 1 | **Periodic Review Date:** | N/A |
| **Process Owner:** | Ganey, Tiffany | **Department Owner:** | SRF Ops |

## 1 Purpose and Scope

This procedure provides instructions for performing vertical plasma processing of a C100 cryomodule in either the Cryomodule Test Facility (CMTF) or in CEBAF. Once all cavities in the cryomodule have been plasma processed an equal number of times, a round of plasma processing has been completed. Multiple rounds of plasma processing may be performed. Typically two rounds of plasma processing are performed with a 24 or more hour break between rounds.

Prior to initiating this procedure, the plasma processing vacuum and gas carts shall be set up in accordance with PLACLN-PR-CM-PROC.



## 2 Safety

Individuals must keep safety as the first priority in the process, before beginning any job, the user must assure they have the correct PPE for the individual job. Maintaining the level of safety and secure nature of the work area is paramount. Assure personal safety by using caution in movement and taking necessary steps to avoid unnecessary personnel in the immediate area.
The work area may be a Radiologically Controlled Area (RCA), and dosimetry must be work at all times while in an RCA.
Refer to the work-center OSP for specifics.

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## 7 Process Cells 4 and 3

**7.1 Adjust interlock if needed.**

**CAUTION: Do not adjust interlock to a value lower that its current setting as this will cause the RF to trip off.**

**CAUTION: Do not increase the interlock value unnecessarily or higher than needed to achieve plasma ignition in the target cell.**

**NOTE:**

**If the interlock trips off the RF when attempting to walk the plasma to a new cell but no sign of coupler breakdown is apparent on the network analyzer trace, the interlock value may need to be increased to allow changing the cell that contains the plasma.**

**NOTE:** Ignite plasma in cell 4 by either turning off all RF power and igniting cell 4 directly in accordance with step 7.2 or "walking" plasma from cell 5 in accordance with step 7.3.

**7.2 Optional: If able to directly ignite cell 4 (step 5.3 was used), turn off RF power and ignite cell 4.**

7.2.1 Click the RF off button to turn off the plasma in cells 5 and 6.

7.2.2 Set Freq 1 to the 2π/7 mode {1910.95 MHz on Freq 1}, turn on RF 1, and increase PWR 1 until cell 4 ignites.

7.2.3 Adjust PWR 1 as needed in cell 4 to approximately 2 W.

**7.3 If unable to directly ignite cell 4, walk plasma to cell 4 and from cell 5.**

7.3.1 Decrease PWR 1 in the 4π/7 mode {1970.5 MHz} until RF 1 can be turned off.

7.3.2 Decrease PWR 2 in the 3π/7 mode {1936.9 MHz} until power is approximately 2 W.

7.3.3 Set Freq 1 to the 2π/7 mode {1910.95 MHz} and turn on RF 1.

7.3.4 Increase PWR 1 until cell 4 ignites.

7.3.5 Reduce PWR 2 and turn off RF 2.

7.3.6 Adjust PWR 1 as needed in cell 4 to approximately 2 W.

**7.4 Ignite plasma in cell 3.**

7.4.1 Set Freq 2 is set to the 3π/7 mode {1936.9 MHz} and turn on RF 2.

7.4.2 Increase PWR 2 until cell 3 is ignited.

**7.5 Adjust power {PWR 1 and/or PWR 2} as needed to a total of approximately 10 W to the cavity.**

**4 MHz to increase the plasma density.**

**er and lower values.**



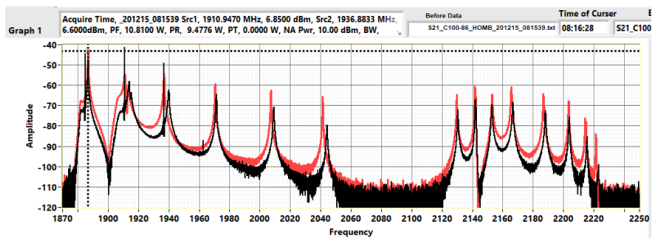


*Figure 7-a: Network Analyzer trace of Cell 4 and 3 ignited*

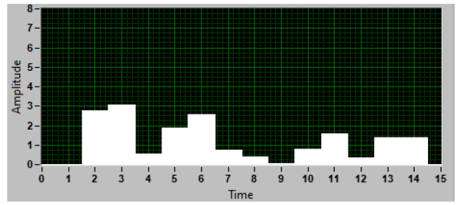


*Figure 7-b: Frequency Shifts for Cell 4 and 3 ignited*



Jefferson Lab

# Questions?

## CEBAF C100 Cryomodule Plasma Process Readiness Review

### Work Control Documents (WCD)

- All process documents saved to an accessible DocuShare location
- WCD Register provides a list of all documents
- Checklists and Procedures were developed for Beamline vacuum work and Plasma processing
  - Checklists provide control of the sequence of actions and verification for actions that need to be completed
  - Procedures provide the detailed instructions on how to perform each action
  - Existing WMGRDR documents were used as reference while developing the beamline vacuum work procedures
  - Plasma processing and beamline vacuum work documents were developed based on experience during the single cavity and cryomodule plasma processing cycles