
FEL Startup Procedure

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Estimated Time to Perform: 30 minutes

Procedure Overview

This procedure restores RF, magnets and Gun Voltage and machine energy to the point that the machine can be configured to the specific Operational Settings required.

This procedure is divided into sections as follows:



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Prerequisites

1. Machine is in Beam Permit.
2. Drive laser is ready or warming up.

Procedure Steps

1.0 Restore Magnet Box Supplies for the Desired Configuration

1. Open box supply medm screen from *Box Supply Controls* screen. This is found under **FEL Main Menu**⇒**Magnets**⇒**Magnet Commander**⇒**Box Supplies**⇒**Box Supply Summary**.

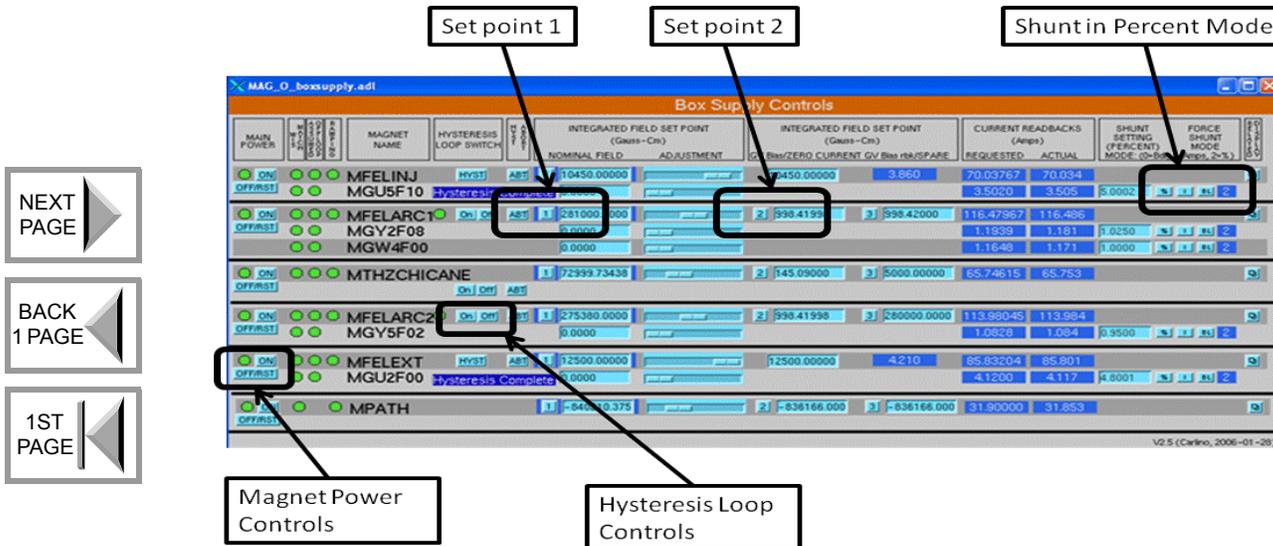


Figure 1-1: Box Supply Summary Screen

2. Ensure magnets **FELINJ** and **FELEXT** are **ON** and on their hysteresis loops. If not, refer to the following steps. Typically only the **FELARC1**, **FELARC2** and **THZCHICANE** magnets will need to be turned on and cycled thru their hysteresis loops.
3. Ensure **MPATH** magnet is on. This magnet is used for pathlength adjustment and has no hysteresis cycle control.
4. Check all shunts are in % mode by checking a series of 2's along the right hand side of this screen. If not push the % button under the Shunt Setting of any shunt not already in the % mode.
5. For any magnets to be turned on:
 - a. Push the 2 button under **Zero Current** setpoint for the power supplies that are to be turned on.

- b. Push the **OFF/RST** and the **ON** buttons to reset and turn on these power supplies.
- c. After the mismatch fault lights turn off and the strings are at zero current setpoint, click the **1** button under the Nominal Field setpoint. This will ramp the current to the operating setpoint.
- d. When the power supply **Actual** current reaches the **Requested** current, push the **Hysteresis Loop Switch Off** and then back **On**. Monitor the power supplies while they are cycling to verify they reach their nominal setpoints, with no yellow or red fault lights, and the requested current readbacks match the actual current readbacks.
- e. Repeat the hysteresis loop a second time by pushing the **Hysteresis Loop Switch Off** and then back **On** again.

2.0 Open the Gun Valve

1. Ensure Valve **VBV0F01** is open by ensuring the valve flag is green.
2. Is the valve flag green?
 - YES** **NO** → **A.** Open the valve by selecting the *SRF VAC Controls for FEL*. This is found under **FEL Main Menu**⇒**Vacuum**⇒**Vacuum Overview**.
 - a. Click the **Valves** for the Injector and 10 MeV Dump and select **VBV0F01**.
 - b. Is the Gun is at 0 kV?

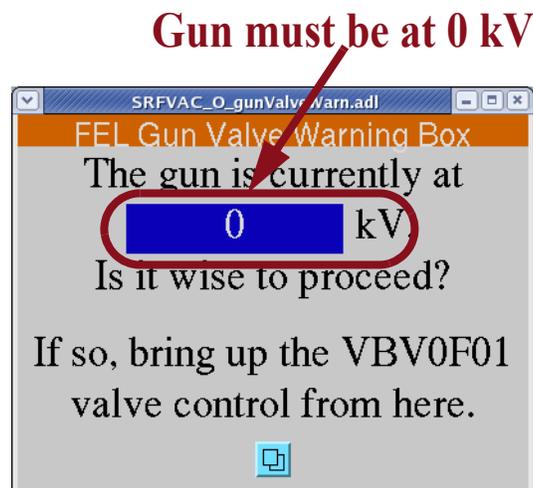


Figure 2-1: Gun Valve Warning Box

- YES** **NO** → **A.** Stop and reduce Gun Voltage to 0 kV or contact expert assistance.
- c. Click the light blue button at the bottom of the screen. On the **VBV0F01** screen that opens, click **O/C** and then **CONFIRM**. Observe the valve flag goes from red to green. This indicates the valve is open.
- d. Does the valve indicate it is open?
 - YES** **NO** → **A.** Stop and contact expert assistance.



3.0 Start the Gun Strip Tool

1. With the 3rd mouse button, select **Ops Tools Menu** and open **Strip Tool (Channel Access)**. Under the Strip Tool menu, select **Load** and load the file called **NUG with UHV**. This file has the Gun's high voltage and set point, the Gun current and 2 ranges of the Gun's vacuum. Monitor these parameters as the Gun is being turned on.

4.0 Turn On and Ramp up the Gun Voltage

1. Open the *FEL Gun Power Supply* screen from **FEL Main Menu**⇒**High Voltage**⇒**High Voltage Power Supply Control**.



Figure 4-1: FEL Gun Power Supply Screen

2. Check the following parameters:
 - Voltage **Ramp Set Point** is 0.0 kV.
 - **Ramp Rate Up** is 100 kV/min.
 - **SF₆ Press** is greater than 5.0 psi
3. Check the following interlocks are clear:
 - HV interlocks
 - MPS_Ready
 - HV_Ready
 - a. Are all interlocks clear?
 - A.** If the HV_Ready interlock is red, try clearing by clicking the **HV RESET** button to clear the interlock
 - B.** If any interlocks are still not clear, contact expert assistance.
4. When the interlocks are clear, push the **HV ON** button and check the Gun Current.



5. Is the Gun Current close to 0 (± 0.05 mA typically)?
 - YES** **NO** → **A.** Cycle the **HV OFF** and **ON** buttons until it is close to 0.
 - B.** Stop and contact expert assistance if unable to get the Gun Voltage to 0 ± 0.05 mA.
6. Enter a Voltage **Ramp Set Point** of 150 kV and then click the **HV Go** button. The **HVPS Volts Out** and **Readback** should ramp up to the Voltage **Ramp Set Point**.

NOTE: Turning on the Gun HV will cause the MPS_Ready interlock to be red. This interlock is green only when the Gun HVPS is off or when the Gun is at its operating voltage.
7. Monitor the striptool while the Gun is ramping to the voltage set point. There should be no vacuum activity and the current should ramp smoothly with the voltage (See Figure 5-1).

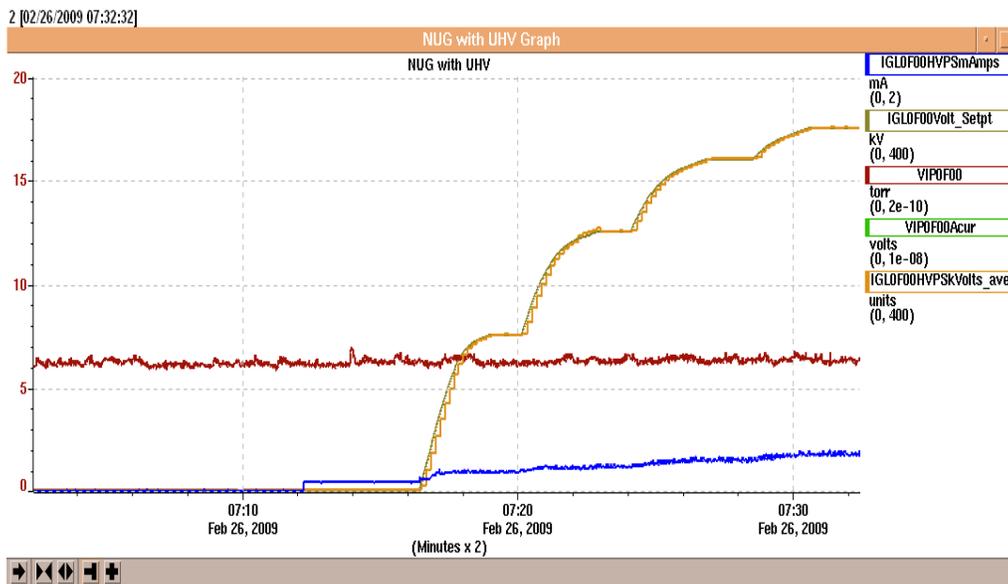


Figure 4-2: Gun HVPS Ramp Up to 350 kV.

8. If there is any vacuum or current activity, reduce the Gun's high voltage immediately until the activity stops and call the Operations Coordinator for instructions.
9. If there has been no vacuum or less than $20 \mu\text{A}$ current activity after one minute, enter the next higher Gun Voltage in the Voltage **Ramp Set Point** box and click the **HV Go** button. Monitor vacuum and current as before. The steps for the Gun Voltage are 150, 250, 320 and 350 kV (357 with the Conditioning Resistor inserted).

5.0 Open All Valves to the Selected Dump.

1. Open the *SRF VAC Controls for FEL* screen from **FEL Main Menu** ⇒ **Vacuum** ⇒ **Vacuum Overview**. Press the **All Valve Controls** button and select the *Open *ALL* Valves - Except VBV0F01 and VBV2F00A* screen. Press the **Open** button followed

by the **Confirm** button. Ensure the valves are open to the selected dump by noting the flags are green on the *SRF VAC Controls for FEL* screen.

a. Did all valves open to the selected dump?

YES NO → **A.** Open the individual valve screen from the *SRF VAC Controls for FEL* screen and attempt to open the valve.

a. Are all valves open now?

YES NO → **B.** Stop and contact expert assistance.

6.0 Turn on RF for the Buncher

1. Open the *Ops 4 Seater* screen from **FEL Main Menu** ⇒ **RF** ⇒ **RF FEL Main Menu** ⇒ **Ops** ⇒ **Ops 4 Seater** (Figure 6-1).

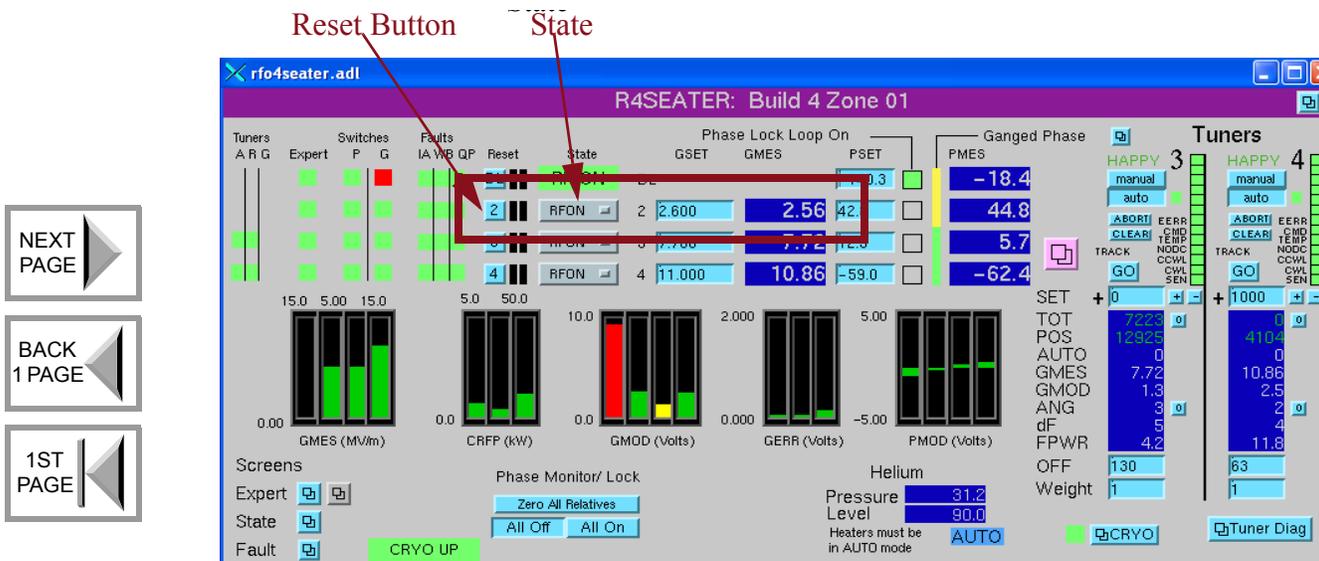


Figure 6-1: RF 4-Seater screen

2. Is the Buncher in Filaments?

YES NO → **A.** Bring to Filaments and allow to time out (600 seconds).

3. Press the **2** button under Reset to clear any faults.
4. Select **HV** from the State control button and wait for acknowledgement.
5. Press the **2** button under Reset to clear any faults.
6. Select **RF On** from the State control button.
7. Does the Buncher turn on?

YES NO → **A.** Press the **State** button and select **Buncher**.

B. Use the fault(s) displayed for diagnosis and correction.

C. Contact system experts if unable to restore.

NOTE: The Buncher gradient will ramp up in Heater mode and will switch to Phase mode when it is ready and at temperature.

7.0 Turn on RF for Quarter Cavity 4

1. Open the *Ops 4 Seater* screen from **FEL Main Menu**⇒**RF**⇒**RF FEL Main Menu**⇒**Ops**⇒**Ops 4 Seater** (Figure 7-1).

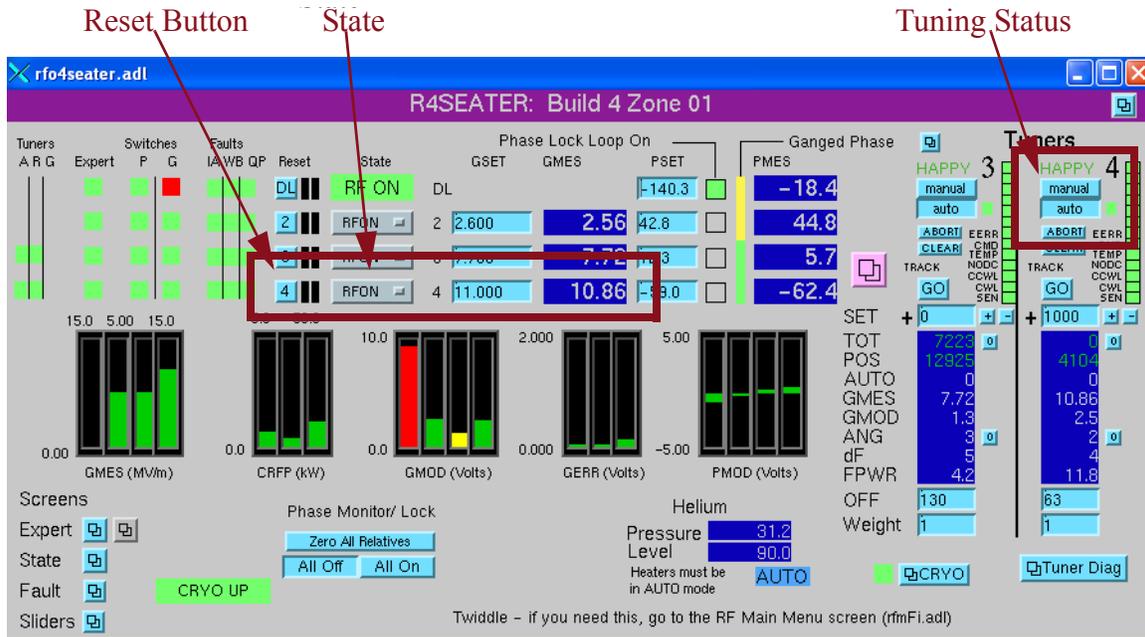


Figure 7-1: RF 4-Seater screen

2. Is Quarter Cavity 4 in Filaments?

YES NO →

A. Bring to Filaments and allow to time out (600 seconds).

NOTE: A thyatron crowbar will take a few minutes longer warming up.

3. Press the **4** button under Reset to clear any faults.
4. Select **HV** from the State control button and wait for acknowledgement.
5. Press the **4** button under Reset to clear any faults.
6. Set the **GSET** to 5.0 MV/m.
7. Select **RF On** from the State control button.
8. Does Quarter Cavity 4 turn on?

YES NO →

A. Press the **State** button and select **Quarter Cavity 4**.

B. Use the fault(s) displayed for diagnosis and correction.

C. Contact system experts if unable to restore.

9. Ensure the cavity is in **auto** tune mode and tuning.
10. Gradually increase the gradient to the operating level as the cavity tunes.
11. Is the cavity at operating gradient and **Happy**?

YES NO →

A. Contact expert assistance for help.



8.0 Turn on RF for Quarter Cavity 3.

1. Open the *Ops 4 Seater* screen from **FEL Main Menu**⇒**RF**⇒**RF FEL Main Menu**⇒**Ops**⇒**Ops 4 Seater** (Figure 8-1).

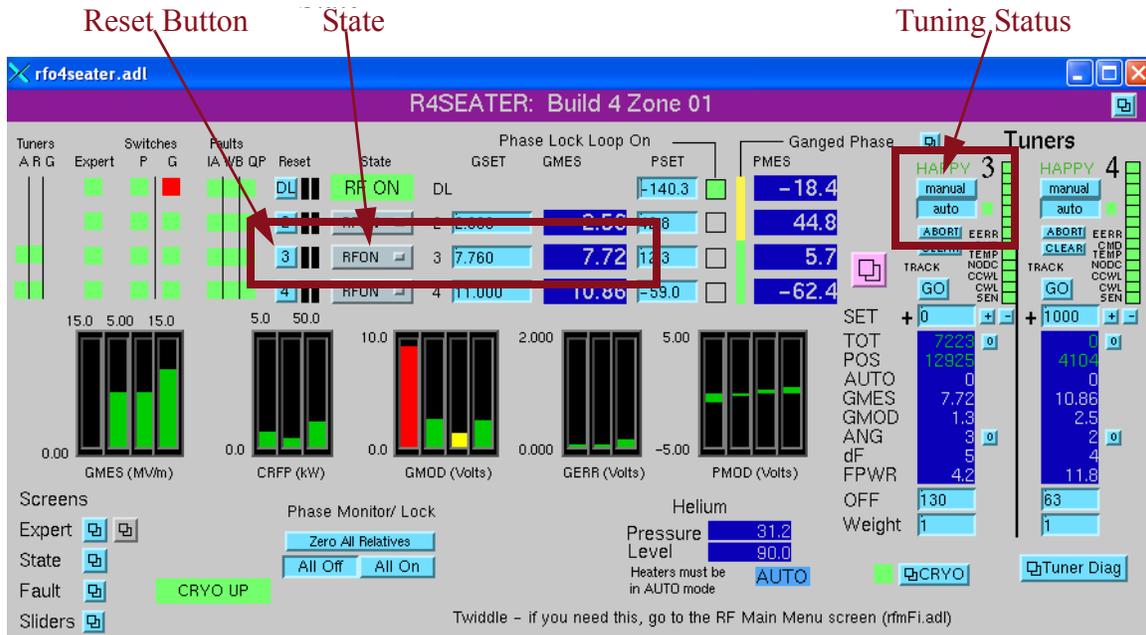


Figure 8-1: RF 4-Seater screen

2. Is Quarter Cavity 3 in Filaments?

YES NO →

A. Bring to Filaments and allow to time out (600 seconds).

NOTE: A thyatron crowbar will take a few minutes longer warming up.

3. Press the **3** button under Reset to clear any faults.
4. Select **HV** from the State control button and wait for acknowledgement.
5. Press the **3** button under Reset to clear any faults.
6. Set the **GSET** to 5.0 MV/m.
7. Select **RF On** from the State control button.
8. Does Quarter Cavity 3 turn on?

YES NO →

A. Press the **State** button and select **Quarter Cavity 3**.

B. Use the fault(s) displayed for diagnosis and correction.

C. Contact system experts if unable to restore.

9. Ensure the cavity is in **auto** tune mode and tuning.
10. Gradually increase the gradient to the operating level as the cavity tunes.
11. Is the cavity at operating gradient and **Happy**?

YES NO →

A. Contact expert assistance for help.



9.0 Turn on RF for Zone 2

1. Open the *RF Combo 4L02* screen from **FEL Main Menu**⇒**RF**⇒**RF FEL Main Menu**⇒**Zone 2 Misc**⇒2nd blue button (Figure 9-1).

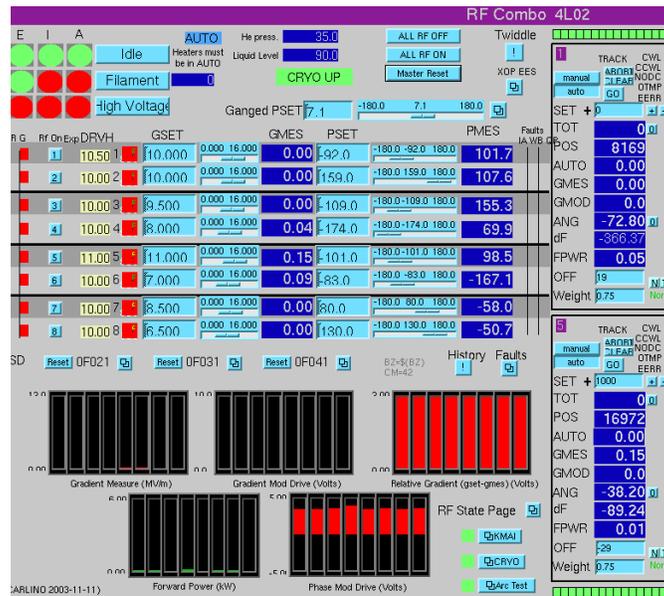


Figure 9-1: RF Zone 2

2. Is Zone 2 in Filaments?

YES NO → **A.** Press the **Master Reset** and then the **Filament** buttons to bring to Filaments and allow to time out (600 seconds).

NOTE: Zones 2,3, and 4 can be brought to Filaments at the same time to save on machine turn on time.

3. Press the **Master Reset** button to clear any faults.
4. Press **High Voltage** button and wait for acknowledgement.
5. Set all **GSETs** to 2.5 MV/m.
6. Press **All RF ON**.
7. Press **Master Reset** and then **ALL RF ON** to reset any faults and attempt to turn on any faulted cavities.
8. Are any cavities repeatedly faulting or require more than 5 kW of **FPWR**?

NO YES → **A.** Press the **On** button for the affected cavities to turn off.

B. Go to the [RF Manual Tuning Procedure](#).

C. Contact system experts if unable to restore.

9. Ensure the cavity is in **auto** tune mode and tuning.
10. Gradually increase the gradient to the operating level as the cavity tunes.
11. Is the cavity at operating gradient and **Happy**?

YES NO → **A.** Contact expert assistance for help.



10.0 Turn on RF for Zone 3

1. Open the *RF Combo 4L03* screen from **FEL Main Menu**⇒**RF**⇒**RF FEL Main Menu**⇒**Zone 3 Misc**⇒ 2nd blue button (Figure 10-1).

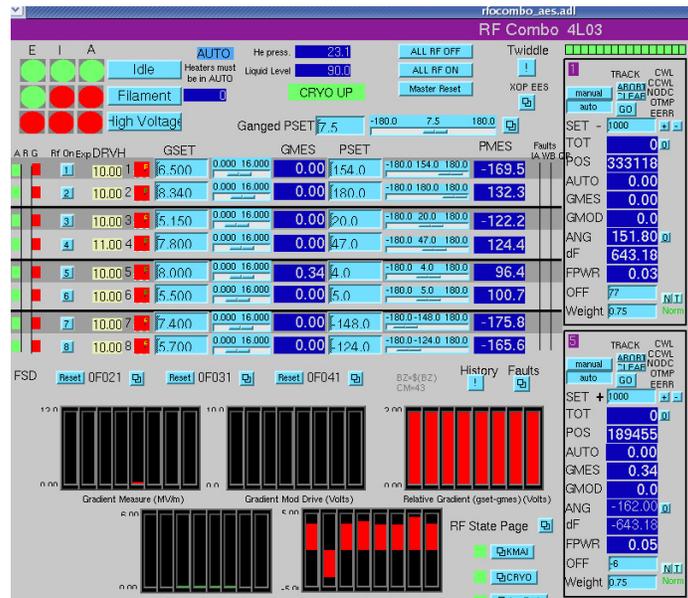


Figure 10-1: RF Zone 3

2. Is Zone 3 in Filaments?

YES **NO** → **A.** Press the **Master Reset** and then the **Filament** buttons to bring to Filaments and allow to time out (600 seconds).

NOTE: Zones 2,3, and 4 can be brought to Filaments at the same time to save on machine turn on time.

3. Press the **Master Reset** button to clear any faults.
4. Press **High Voltage** button and wait for acknowledgement.
5. Set all **GSETs** to 2.5 MV/m.
6. Press **All RF ON**.
7. Press **Master Reset** and then **ALL RF ON** to reset any faults and attempt to turn on any faulted cavities.
8. Are any cavities repeatedly faulting or require more than 5 kW of **FPWR**?

NO **YES** → **A.** Press the **On** button for the affected cavities to turn off.

B. Go to the [RF Manual Tuning Procedure](#).

C. Contact system experts if unable to restore.

9. Ensure the cavity is in **auto** tune mode and tuning.
10. Gradually increase the gradient to the operating level as the cavity tunes.
11. Is the cavity at operating gradient and **Happy**?

YES **NO** → **A.** Contact expert assistance for help.



11.0 Turn on RF for Zone 4

1. Open the *RF Combo 4L04* screen from **FEL Main Menu**⇒**RF**⇒**RF FEL Main Menu**⇒**Zone 4 Misc**⇒ 2nd blue button (Figure 11-1).

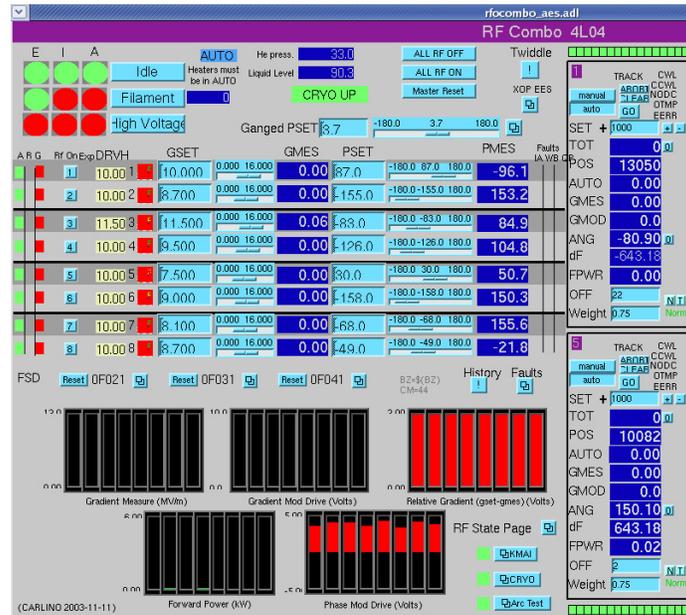


Figure 11-1: RF Zone 4

2. Is Zone 4 in Filaments?

YES NO → **A.** Press the **Master Reset** and then the **Filament** buttons to bring to Filaments and allow to time out (600 seconds).

NOTE: Zones 2,3, and 4 can be brought to Filaments at the same time to save on machine turn on time.

3. Press the **Master Reset** button to clear any faults.
4. Press **High Voltage** button and wait for acknowledgement.
5. Set all **GSETs** to 2.5 MV/m.
6. Press **All RF ON**.
7. Press **Master Reset** and then **ALL RF ON** to reset any faults and attempt to turn on any faulted cavities.
8. Are any cavities repeatedly faulting or require more than 5 kW of **FPWR**?

NO YES → **A.** Press the **On** button for the affected cavities to turn off.

B. Go to the [RF Manual Tuning Procedure](#).

C. Contact system experts if unable to restore.

9. Ensure the cavity is in **auto** tune mode and tuning.
10. Gradually increase the gradient to the operating level as the cavity tunes.
11. Is the cavity at operating gradient and **Happy**?

YES NO → **A.** Contact expert assistance for help.



12.0 BURT Restore and Comparison of Machine Parameters.

1. Load an appropriate allsave as follows to verify proper Magnet Bdl and RF phase and gradient settings. Unless specifically instructed otherwise (FLOG or FEL Shift Plans), this should be either:
 - The “morning miniphase” (if setting up from the previous day), or
 - The current running setup or what should have been running for access recovery or performance recovery.
 2. Using the 3rd mouse button, select **Ops Tools Menu**⇒**BURT - FEL Save/Restore**.
 3. Under **Area-Selection**, select **ALL Parameters**.
 4. Under **Execute**, select **Perform A Restore of Selected Area** from an ALL save file.
 5. A window then opens with a selection of files. From this file:
 - a. Left mouse click on the file that describes the desired restore setup.
 - b. Push the **Filter/View/Compare** button. This will open a new window with a list of signal names and values.
 6. Push the **View Current Values** button in the window that opens. This will highlight differences between the current machine setup and the desired setup. Push the **PRINT** button to print a listing of these differences.
- NOTE: Before restoring any parameters, be aware that there are RF settings saved which should only be restored with some consideration.**
7. If a blanket restore is desired, filter on Bdl, GSET, and PSET prior to restoring.



13.0 Setup the Drive Laser for Pulsed Operation

1. Open the *Advanced Drive Laser Master* screen from **FEL Main Menu**⇒**Drive Laser** ⇒**DriveMaster** (See Figure 13-1).

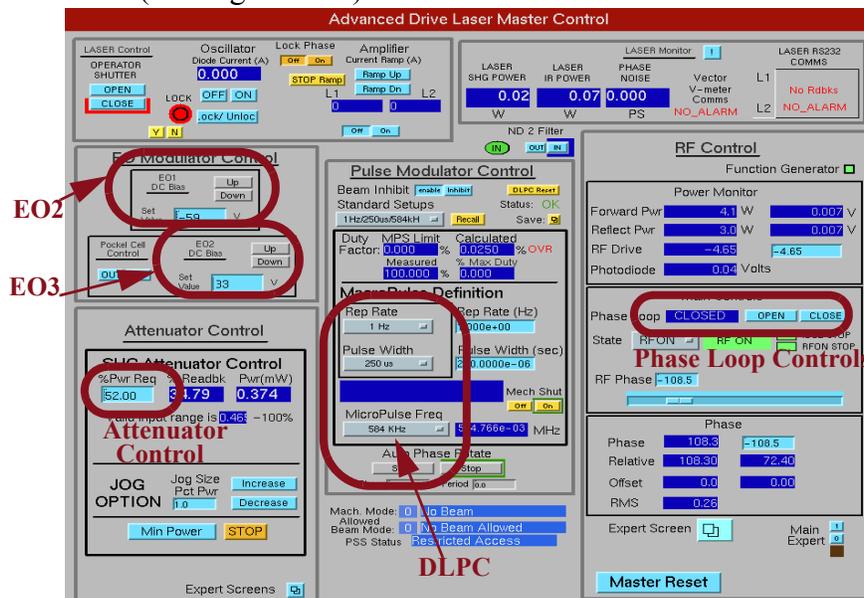


Figure 13-1: Drive Laser Master Control

2. Set the **DLPC** to **4.68 MHz**, **250 us**, and **2 Hz**.
3. Close the **Phase Loop** in the **RF Control** section by pushing the **CLOSE** button if not already closed.
4. Set the optical variable **Attenuator Control** to 10%.
5. Set **EO2** to 13 and **EO3** to -56. These values give good places to start at low duty factor.

NOTE: The Operator Shutter is not open at this point in the procedure.

14.0 Setup of TekScope B and Drive Laser Tek Scopes

1. TekScope B must be set to Monitor 15 and the Drive Laser TekScope must be set to Monitor 6
 - a. Are the two TekScopes set properly?

YES **NO** → **A.** Contact the Operations Coordinator and/or other expert assistance.
2. When set properly the channels for the TekScopes are:
 - a. TekScope B:
 - 1. Dump Current - Yellow
 - 2. Injector Beam Current Monitor (Linear) - Blue
 - 3. Injector Beam Current Monitor (Log) - Pink
 - 4. Unser Monitor - Green
 - b. Drive Laser TekScope:
 - 1. Drive Laser Macro-Pulse - Yellow
 - 2. Phase Error of Drive Laser - Blue



15.0 Check MPS and Mask BLMs

1. Open the *FEL MPS Control* screen from **FEL Main Menu**⇒**MPS**⇒**MPS Ops Screen**.
2. Push the **Master Reset** button to clear any faults.
3. Open the *FEL BLM/BLM_HV Control* screen from **FEL Main Menu**⇒**BLM**⇒**BLM High Voltage**.
4. Push the **MASK** button of **MegaMask** to mask all of the BLMs. Note the surrounding boxes change from green to red and that the BLM voltages are appropriate.

16.0 DLPC Reset, Check for Drive Laser Pulses, and EO Cell Adjustment

1. Check for a Drive Laser MacroPulse by checking on Monitor 6. Is there a MacroPulse?

YES **NO** → **A.** Push the **DLPC Reset** button (upper center of *Advanced Drive Laser Master Control* screen).
2. Adjust EO1 and EO2 on the *Advanced Drive Laser Master Control* screen while watching Monitor 6 to increase the extinction ratio and eliminate the

“ghost pulses”. Monitor the Drive Laser MacroPulse (yellow trace) and eliminate all but the main pulse.

17.0 Check Beam and refine EO Cell Settings

1. Open the Operator Shutter. The beam should appear on Monitor 15
2. Adjust the EO Cells to eliminate the “ghost pulses” while monitoring the Injector Beam Current log signal.

NOTE: The EO Cells will drift when the Duty Factor is changed and will need to be readjusted. Give several minutes to stabilize at a new setting.

18.0 Check Beam Position in the Injector, Linac, and Selected Dump

1. Using the Viewer Commander for a selected monitor, check the beam’s position at **ITV0F04**, **ITV1F01**, **ITV2F03**, and at the selected dump (**ITV1G03** for the energy recovery dump).
2. Are the beam spots correct?

YES NO → A. Stop and contact expert assistance.

B. If beam is not centered on the **ITV1F01** viewer, close the Operator Shutter and cycle the Injector dipole (**MFELINJ**) thru hysteresis.

C. Open the **Operator Shutter** and recheck position at **ITV1F01**. Is the beam centered on the viewer now?

YES NO → D. Stop and contact expert assistance.



19.0 Perform a MiniPhase of the Machine

1. Open the [MiniPhase Procedure](#) and perform a MiniPhase of the machine.

20.0 Check Orbit of the Machine

1. Remove all viewers.
2. Unmask and reset the BLM’s. The BLM’s should remain clear, if the beam is not hitting any place other than the selected dump.
3. Check the BPM spike screens.
4. Does the orbit look good with low losses?

YES NO → A. Stop and contact expert assistance.

21.0 Go to Operational Settings

1. Check the Operational Shift Plan for the shift and setup the machine accordingly.
2. PROCEDURE COMPLETE.