



Procedure Title	LCLSII Warm FPC Assembly to Cryomodule	
Procedure ID	CP- L2PRO-FPCW-AC	
Procedure Description	This procedure specifies the assemble of the LCLSII Warm FPC to the cryomodule.	
Revision	R1	
Author	Sign:	Date:
	Name: Mircea Stirbet	
Reviewer	Sign:	Date:
	Name: John Fisher	
Reviewer	Sign:	Date:
	Name: Edward Daly	
Revision Notes	<i>Describe any changes between revisions here.</i>	
	R1: Initial Release	
References	<i>List and Hyperlink all documents related to this procedure.</i>	
Drawings	BOM	CP-LCLSII-FPC-EVACUATION

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LCLSII Warm FPC Assembly to Cryomodule

1.0 General notes

- 1.1 This procedure specifies and documents the LCLSII warm FPC assembly to the cryomodule. The procedure is to be followed for each of the 8 couplers to be installed. The procedure is the same for all of the couplers.
- 1.2 It also includes FPC motorized actuator installation procedure, for the FPC actuators to be used (during CMTF cryo-module qualification tests).
- 1.3 The following steps will be considered for all couplers
 - 1.3.1 Warm FPC installation
 - 1.3.2 Warm FPC vacuum leak check
 - 1.3.3 FPC waveguide installation
 - 1.3.4 FPC motorized actuator installation
- 1.4 The following pertinent information will be captured in cryomodule assembly traveler:
 - a) LCLSII cryomodule ID number
 - b) Cavity ID number
 - c) Cold FPC ID number
 - d) Warm FPC ID number
 - e) Vacuum leak check data for each coupler
 - f) Torque on value for inner conductor connection

2.0 Tooling, Tools and supplies

2.1. Tooling and equipment required:

- 2.1.1 Portable laminar flow hood
- 2.1.2 Clean room wire carts
- 2.1.3 Strain relief tool and hardware
- 2.1.4 T-handle M5 hex driver (for warm end to cold end inner conductor connection)
- 2.1.5 Torque wrench for T-handle
- 2.1.6 Survey tool MB-458941 (center location bar)
- 2.1.7 Warm FPC installation tooling with shims and hardware for connecting to vacuum vessel flange
- 2.1.8 Coupler support straps and hardware
- 2.1.9 Coupler support hook and mounting hardware
- 2.1.10 Berry bots extraction tool
- 2.1.11 Warm FPC ceramic restrain tools
- 2.1.12 Plastic containers for hardware
- 2.1.13 Plastic support for push-rod
- 2.1.14 Nitrogen manifold
- 2.1.15 Nitrogen ionized gun
- 2.1.16 Pumping system with RGA for vacuum leak check
- 2.1.17 Metallic protection cup for Warm window
- 2.1.18 Laptop for vacuum leak check and documentation support during warm FPC assembly

2.2. Tools required:

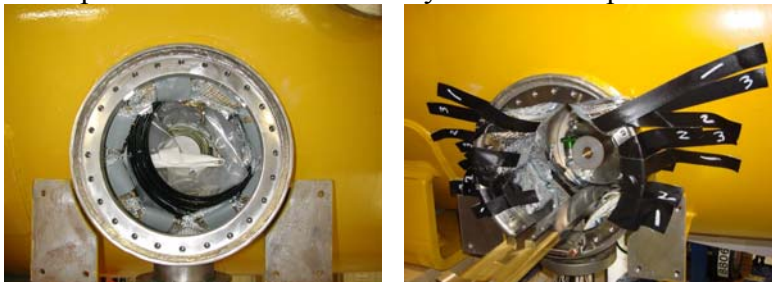
- 2.2.1 Metric Allen L-key sets
- 2.2.2 Socket driver with 12" extensions, universal and 13 mm sockets
- 2.2.3 Wrench sets (ASTM and metric)
- 2.2.4 Philips head screwdriver
- 2.2.5 Torque wrench
- 2.2.6 Inspection mirrors
- 2.2.7 Working lamps
- 2.2.8 Scissors
- 2.2.9 Long neck surgical pliers
- 2.2.10 Square and depth micrometer
- 2.2.11 Level
- 2.2.12 Caliper
- 2.2.13 Measurement tape
- 2.2.14 Multimeter with SMA cable connector
- 2.2.15 Camera

2.3. Supplies

- 2.3.1 Alcohol wipes
- 2.3.2 Tapes: Kapton, metalized plastic, clean room tape
- 2.3.3 Plastic cups for mini conflat ports
- 2.3.4 Plastic cups for 2 3/4" pumping port
- 2.3.5 Plastic cups for 2 1/8" push-rod ports
- 2.3.6 Plastic tie-ups
- 2.3.7 Clean room garments, gloves, hair nets
- 2.3.8 CF100, CF 2 3/4" CF 2 1/8" OFE gaskets
- 2.3.9 VITON o-rings for insulating vacuum
- 2.3.10 O-ring grease
- 2.3.11 Anti-seize grease
- 2.3.12 Dry, filtered, particulate free nitrogen supply
- 2.3.13 Helium gas for vacuum leak check

3 Warm FPC preparation for installation

- 3.1 Check and record string beam line vacuum
- 3.2 Cut superinsulation at cold FPC position
- 3.3 Fix superinsulation out of the way at FPC cold position with adhesive tape.



- 3.4 Fix instrumentation cables on the instrumentation port, plastic tie-ups.
- 3.5 Clean the working area



- 3.6 Move the laminar flow tent in assembly working area
- 3.7 Move cart with cleaned working tools under the laminar flow tent.
- 3.8 Wipe down external surface of the vacuum vessel, vessel flange.
- 3.9 Using a plastic cone, isolate cold FPC area.

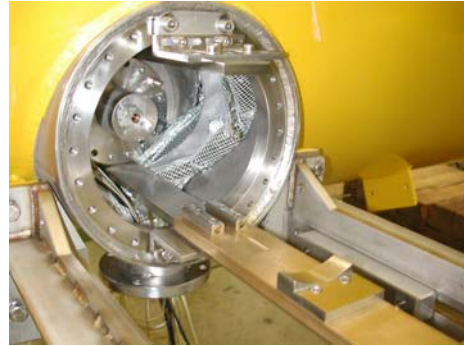


- 3.10 Position the laminar flow tent and tape the plastic curtains to the vacuum vessel to seal as best as possible.
- 3.11 Check cold PFC alignments using survey tool MB-458941 and a square. The SMA connector on the cold ceramic protection cup should be with aligned ± 2 mm to the FPC vessel port. Record measured deviations of the SMA connector on the cold ceramic protection cup, relative to the center of the FPC cryo-stat port, both on vertical and horizontal positions.

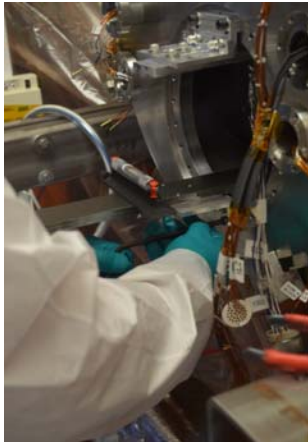


- 3.12 Use the survey tool and a precision ruler to check distance from vessel flange to the cold FPC protection cup. This distance should measure between 210 mm to 214 mm (8.27 in to 8.34 in). Measure in four locations, i.e. 12 o'clock, 3 o'clock, 6 o'clock and 9 o'clock.

- 3.13 Check and compensate flange support alignments with concentricity measurements done at pct. 3.5 and 3.6.
- 3.14 Install warm FPC bottom tooling (at 6 o'clock position) using M8x20 SS SHCS bolts, taking care not to load the cavity through the coupler. Use level to ensure installation tooling is level and perpendicular to flange. If not, use bottom tooling adjustment to compensate for cold coupler non-concentricity.



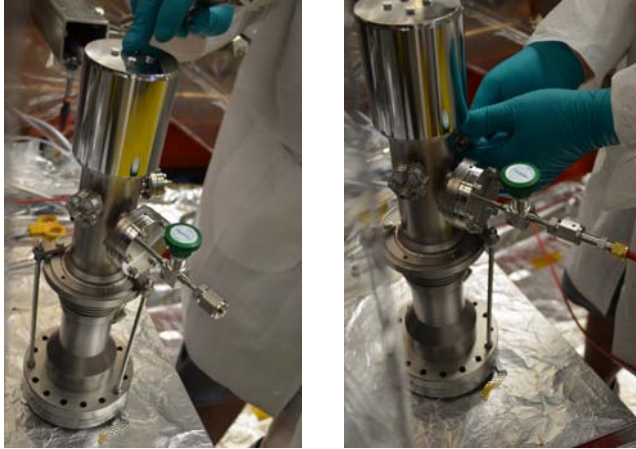
- 3.15 Install brass sled tool and assure that it moves freely on the tooling and that the end pins engage the open bolt holes on the cold FPC window protection cup.
- 3.16 Check alignment (parallelism) between the upper and lower tools, using a level and a square.



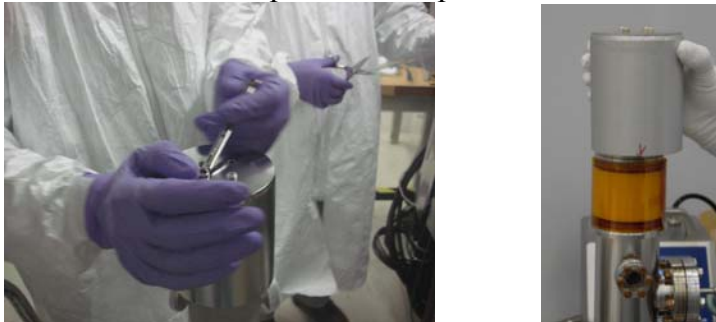
- 3.17 Bring the warm coupler to be installed, wipe clean the first plastic bag, then push the coupler inside the laminar flow tent
- 3.18 Cut and discard the first plastic bag



- 3.19 Wipe clean the second plastic bag, cut it and remove the coupler
- 3.20 Place the warm FPC on a clean room cart, sitting on the CF100 flange.



- 3.21 Record warm part Serial Number – found on CF100 flange.
- 3.22 Check warm coupler bellow integrity
- 3.23 Connect the filtered, particulate free nitrogen line to the Swagelok valve on 2 3/4” flange. The nitrogen purge will be used for almost all duration for warm FPC part installation.
- 3.24 Keep in place upper e-pick up and the sapphire optical view port (near to the warm ceramic). These parts will be removed after vacuum leak check done on CF100 flange.
- 3.25 Remove warm ceramic protection cup



- 3.26 Warm FPC ceramic should be protected with a Mylar (Kapton, plastic) sleeve. If not, make sure you have a Mylar sleeve (or equivalent) to protect the ceramic.
- 3.27 Install the strain relief tool on the waveguide end of the coupler. Loosen push-rod retaining bolts (four bolts), using the tool to counter any torque applied to the warm ceramic window.



- 3.28 Remove the strain relief tool, then the push-rod retaining bolts.

3.29 Remove the push-rod by turning 90deg and then slowly extracting it. Take care not to distort bellows or damage the RF springs retained by machined dents in the push-rod axel.



3.30 Install the tooling warm ceramic protection cup (has a central hole, allowing for later insertion of the long T screw driver).

3.31 Install the warm bellows horizontal holder. Support coupler to avoid bellows stress.



3.32 Loosen the bolts on CF100 flange and remove bellows transport protection fixtures (stiffening rods or bars).

3.33 Remove the CF100 bolts, then CF100 flange. Remark, one vendor supplies the warm FPC with inner conductor restrained by a bolt inserted in the middle of CF100 flange. In this situation, position the coupler packaging base, to gain access to the center bolt and remove this central bolt.



3.34 Properly store the hardware used for warm coupler transport. These parts will be sent back to the vendor to keep LCLSII coupler production going on.

3.35 Visually inspect: copper plating inside the warm part of the coupler, copper plating on the CF 100 flange, CF100 conflat knife status, RF contact area of the inner conductor. Report any discrepancies: oxidized copper plating, copper plating flakes, damaged conflat knife.

3.36 Two persons are requested for this step: One person should reposition the warm coupler with ceramic down, the other person, using the T-handled drive, should

insert the inner conductor socket head screw from underneath ceramic and thread it in the inner conductor until it is fully through the inner conductor hole.



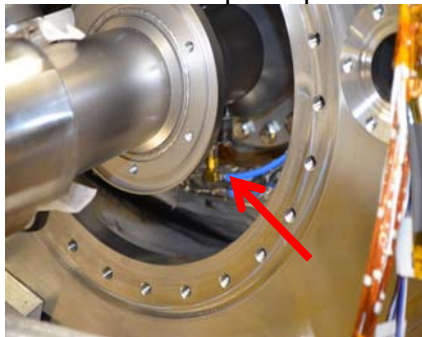
3.37 Once the inner conductor screw is inserted, carefully place coupler on the slide tool, in a manner that prevents excessive bending, taking care that the 2 3/4" pumping port (with nitrogen supply attached) point out to the left.



3.38 Strike the CF100 gasket, on an edge, to develop a slight out-of-round shape. If the gasket becomes non-flat, discard and try again.

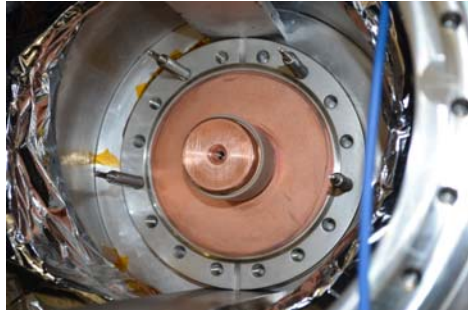
3.39 Place the slightly deformed CF100 gasket on the CF100 flange. Make sure it will not fall down.

3.40 Attach the electron pick up cable to the port near to CF100 flange.



4 Cold FPC preparation for installation

- 4.1 Wipe down the cold ceramic protection cup (particularly the outer diameter) and dry out by blowing filtered deionized nitrogen.
- 4.2 Remove M8 bolts on cold CF100 flange. Be sure to hold the metallic cup with one hand while removing the last bolt, so the cup does not tilt onto ceramic.
- 4.3 Using the brass sled as a guide, slowly withdraw the protection cup straight toward you, to clear the cold ceramic.



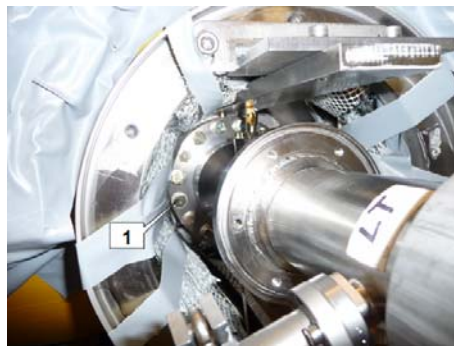
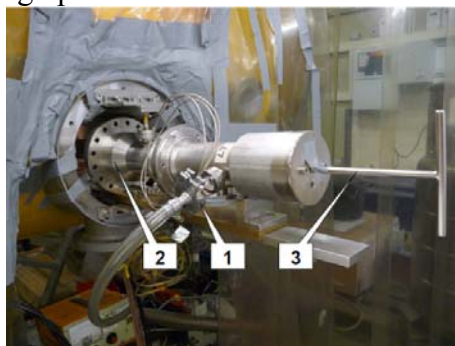
- 4.4 Check cold ceramic integrity status, copper plating on the cold CF100 flange, cold CF100 knife status.
- 4.5 By hand, unscrew the spring loaded RF connector from the cold antenna end.
- 4.6 Store the cold ceramic protection cup and the RF spring loaded screw. These parts will be sent back to vendor, to keep coupler production going on.

5 Install the warm FPC

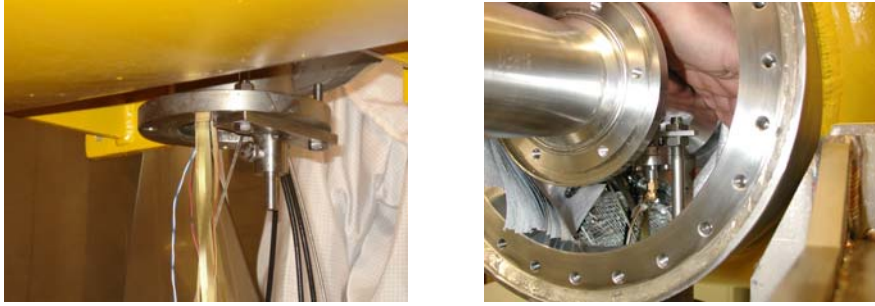
- 5.1 Place the warm FPC and the brass sliding rail on the FPC bottom tooling.
- 5.2 Gently slide the warm FPC part into position towards CF100 cold flange.



- 5.3 With the T-handle held, feel for the center conductor screw and the threaded hole.
- 5.4 Slowly turn the T-handle to join the warm inner conductor extension to the cold antenna. **Later, this screw should be torqued, and a second person will have to check the torque value.**
- 5.5 Install 2 M8 x35 Nitronic 60 HHCS with washers at the 3 and 9 o'clock positions. These bolts must go easily into the threaded holes, if everything is properly aligned. Tighten them finger tight. Reach with your hands and wiggle the warm CF100 flange to make sure both flanges are engaged with the CF100 gasket.
- 5.6 Visually inspect the CF100 flange interface to assure proper fit.
- 5.7 Snug up fasteners.

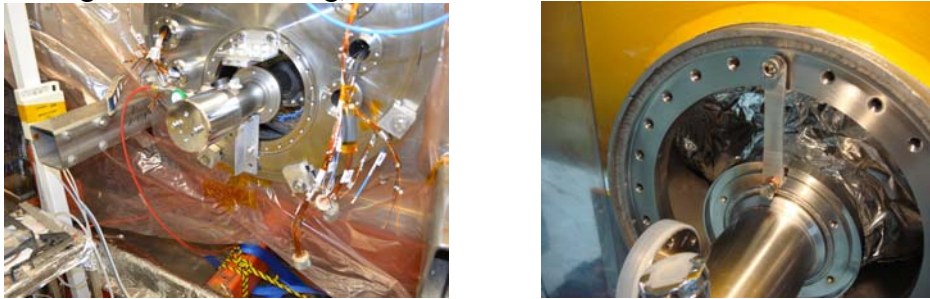


5.8 Install hook support through instrumentation port to support the warm FPC part. Be careful not to crash instrumentation cables, or electron probe.



5.9 Pull back the brass sled to get the last two Nitronic 60 bolts into 6 o'clock holes.

5.10 Remove the bottom FPC tooling. A slight rotation will eventually be needed when extracting the bottom tooling, due to the warm bellows holder interference.



5.11 Replace the bottom warm FPC tooling with a link between warm FPC vacuum insulation flange and FPC cryo-module port at 6 o'clock position.

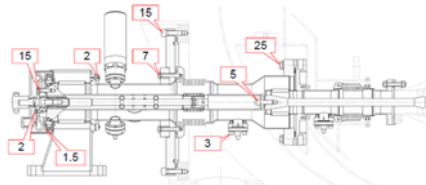
5.12 Remove the upper warm FPC tooling from 12 o'clock position and replace with a link between warm FPC vacuum insulation flange and FPC cryo-module port.

5.13 Remove Berry bolts: remove first the small M4 nut, then the Berry bolts sleeve, using eventually the two SiB nuts, then the long Berry bolt, using the Berry bolts removal too. Repeat for the other three Berry bolts.



5.14 Replace the Berry bolts with Nitronic 60 M8 bolts.

5.15 Torque all 16 Nitronic 60 M8 bolts on CF100 flange conform **Torque specification and procedure**



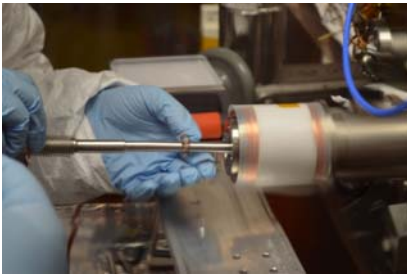
TTF-3 coupler screws torque [N.m].

Check 5 for 2014 new bolt dimension and torque value !!!

5.16 Torque M6 bolt connecting the inner conductor to the cold antenna. **Torque specification and procedure. Two person rule.**

5.17 Remove warm ceramic protection cup

5.18 Looking into the back of the warm ceramic with a flashlight to verify the orientation for the slit in the inner conductor. The push-rod bayonet will be inserted into this slit.



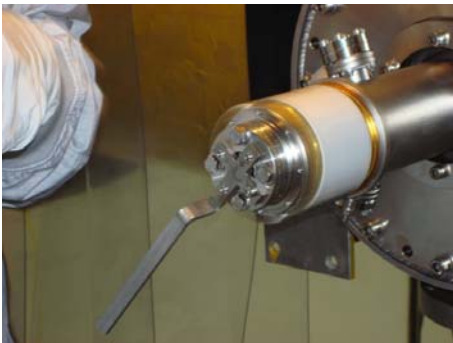
5.19 Locate the push-rod and verify that both RF springs are in place.

5.20 Check CF 2 1/8" knife, and place a new CF 2 1/8" gasket into push-rod.

5.21 Blow the push-rod with filtered ionized nitrogen gas.

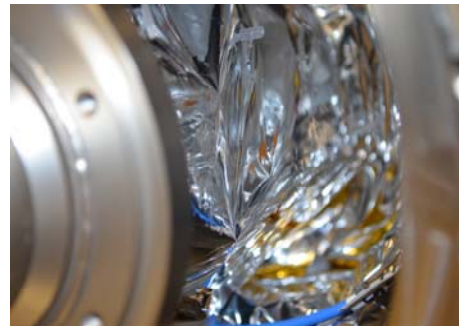
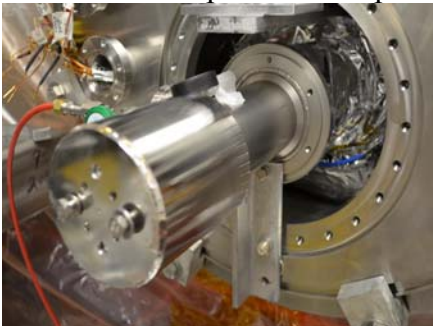
5.22 Install push-rod, with engagement pin and rod end oriented to match position of slot in inner conductor. Gently rotate tuning rod CW 90 deg. If rod will not rotate, use a small hex key or other blunt tool to push inward on inside of threaded portion of the push-rod to extend the bellows and then rotate it CW 90deg.

5.23 Make sure CF 2 1/8" gasket is seated properly and secure flange with four M6x20 HHCS nuts and washers.



5.24 Install threaded tuning link (for manual adjustment of antenna penetration). **Without this link, the inner conductor will collapse during vacuum leak check.**

5.25 Install metallic protection cup over the warm ceramic.



6 Install electron probe

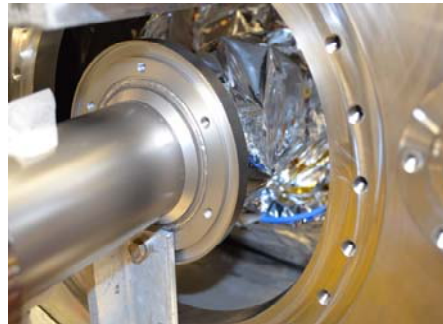
- 6.1 Install electron probe cable situated in insulating vacuum on the warm coupler, using the RF cable SMA torque wrench.
- 6.2 Check the RF cable connection using a multimeter with adequate adapter: multimeter reading should show Infinity.
- 6.3 Using a multimeter and touching with the two probes the copper rings on one side and another of the warm ceramic, check that the tip of the antenna is not in contact with the beam pipe.

7 Vacuum leak check CF100 flange

- 7.1 Disconnect nitrogen gas supply from the 2 3/4" pumping port and connect pumping system for vacuum leak check.
- 7.2 Pump down and perform vacuum leak check.
- 7.3 Record He trace and RGA spectra.
- 7.4 If vacuum leak check is OK, slow bleed up the warm coupler to normal atmosphere.
- 7.5 Disconnect pumping system.

8 Install super-insulation on 50K heat sink and warm coupler

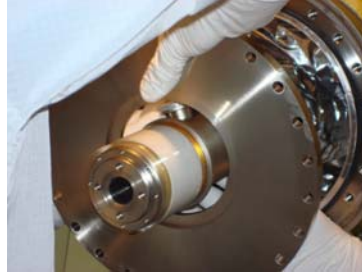
- 8.1 Fold down (10) layers of the 50K superinsulation. Tape in positions that follow the curve of the 50K shield.



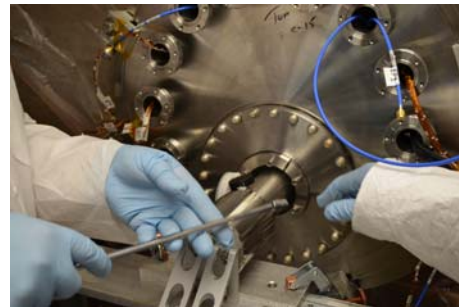
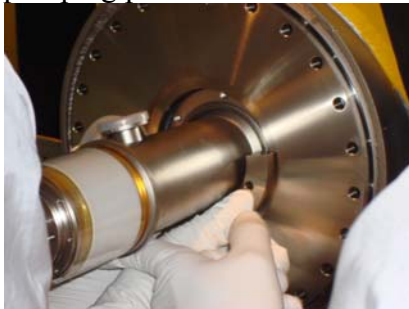
- 8.2 Install (10) layer super-insulation ring and secure it with metallized tape.
- 8.3 Repeat layering scheme two more times.
- 8.4 Install warm protection bellows support.

9 Install insulation vacuum flanges

- 9.1 Remove electron probe and sapphire optical window.
- 9.2 Place plastic protection cups on the two mini-conflat and 2 3/4" flanges
- 9.3 Install the two brackets for waveguide support
- 9.4 Apply a thin film of O-ring grease to bath seals used on the insulation port flange.
- 9.5 Install the smaller VITON seal on the warm coupler insulating vacuum flange



- 9.6 Pass over the warm ceramic the large diameter Viton gasket and the vacuum insulation flange. Be sure not to touch the ceramic metallic protection cup.
- 9.7 Secure vacuum insulation flange on the waveguide brackets.
- 9.8 Install tooling for restraining the warm ceramic (to keep the warm part in place during installation of the vacuum insulation flange).
- 9.9 Remove installation fixture (links) from 12 and 6 o'clock positions.
- 9.10 Install the large diameter insulating flange to vacuum vessel port using stainless steel M8x SHCS and washers, and then torque all M8 bolts.
- 9.11 Install the split rings into warm coupler insulating vacuum flange using M6x SHCS bolts and washers, then torque all M6 bolts. The split reams runs left and right.
Remark: expect some issues related with screw length interfering with 2 3/4" pumping port.

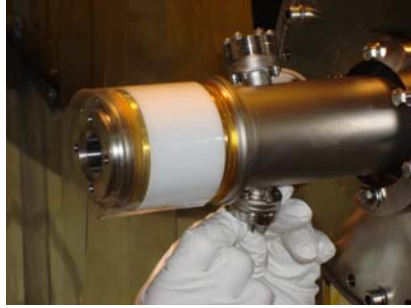


- 9.12 Remove tooling used to restrain the warm coupler.
- 9.13 Remove the metallic protection and using a multimeter set for resistor measurements, check the reading of Infinity across the warm ceramic.



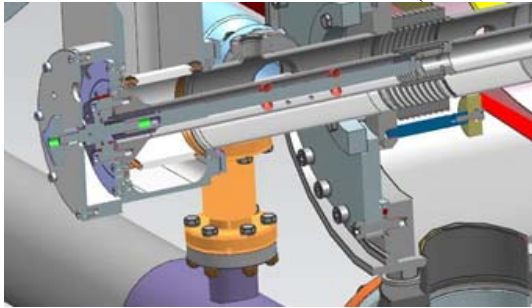
10 Re-install electron probe, sapphire window and all metal right angle valve

- 10.1 Change gloves and check for cleanliness near to the mini-conflat and 2 3/4" ports.
- 10.2 Attached the sapphire optical window to the top mini-port.
- 10.3 Attached the electron probe on the other mini conflat port.



10.4 Attach right angle all-metal valve using OFE seal and M6x35 SS HHCS, washers and silicone bronze nuts. Set valve port pointing to the floor.

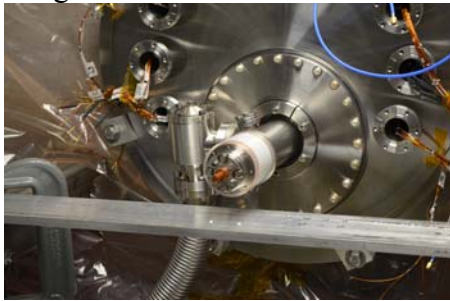
10.5 Connect the weldment bellows (FC0047475) on the all-metal valve



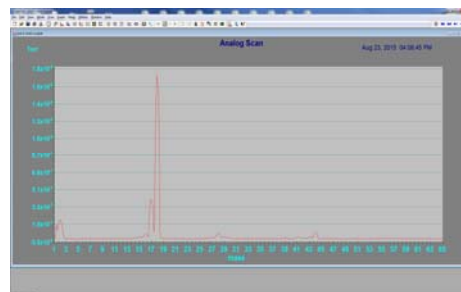
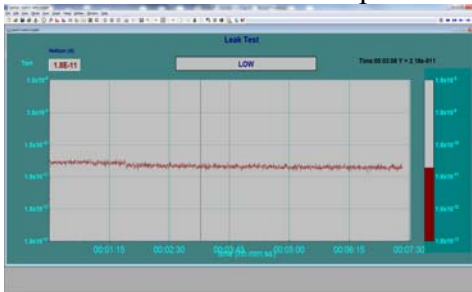
11 Vacuum leak check warm coupler instrumentation ports

11.1 Connect pumping system for vacuum leak check

11.2 Pump down and perform vacuum leak check of all new joints: 2 mini-conflat flanges, 2 3/4" pumping port, all metal right angle valve flanges, weldment bellows flanges.



11.3 Record He trace and RGA spectra.



11.4 If vacuum leak check OK, bleed-up warm coupler via pumping system

11.5 Close all-metal right angle valve.

11.6 Disconnect pumping system from weldment bellows.

11.7 Protect the weldment bellows port with a metallic 2 3/4 blank.

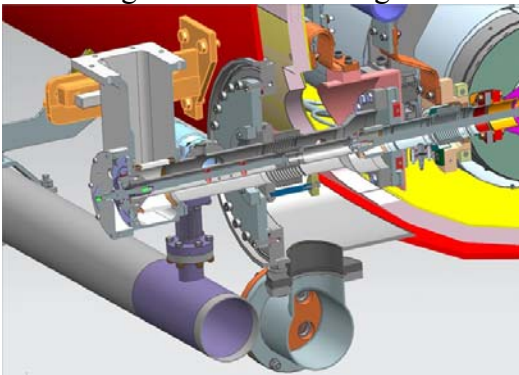
11.8 Check and record pCM beam line vacuum.



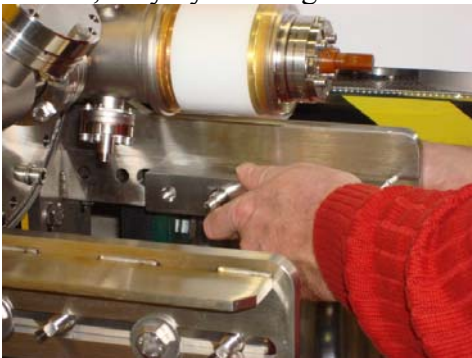
12 Install FPC waveguide

12.1 Make sure the metallic protection of the warm ceramic is in place.

12.2 Check alignment of the waveguide holders LH (F10010348) and RH (F10010348).



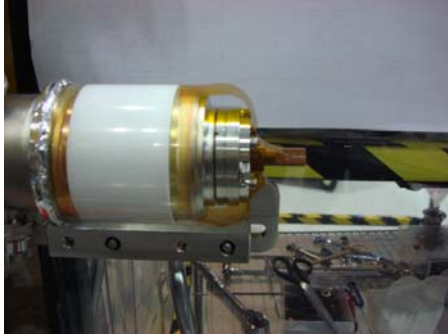
12.3 Install waveguide mounting support bars on side rails with 4 M10x30 bolts and large washer, only by hand tighten and coat threads with anti-seize.



12.4 Leave mounting rods pulled back so only 2 or 2 threads protrude so that the waveguide can be inserted,

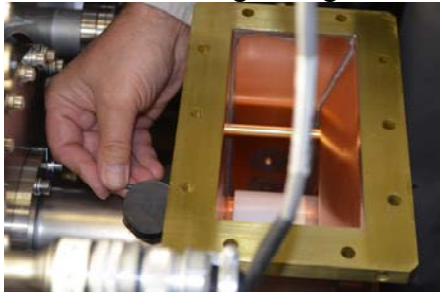
12.5 Locate the 2 half rings that secure the waveguide as well as all the other necessary parts and screw.

12.6 Remove the metallic cup protecting the warm ceramic and carefully place 2 pieces of Kapton tape on the Mylar sleeve at 12 and 6 o'clock, attach these to the adjuster, otherwise the sleeve may not be removed.



12.7 Install the waveguide, with WR650 flange pointing up, carefully sliding it over the ceramic and sleeve onto the lower part of the warm ceramic.

12.8 Install the half-rings using mounting screws at the back of the waveguide.



12.9 Check that WR650 flange is horizontal using a level.

12.10 Gasp the Kapton tapes and pull to remove Mylar sleeve.



12.11 Install copper ring replacing the capacitor.

12.12 Re-level the waveguide

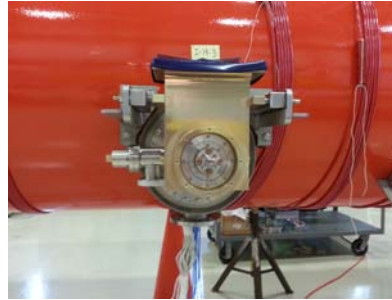
12.13 When the waveguide is leveled, tighten crosswise all bolts the waveguide for the copper ring

12.14 Install waveguide protection cover.

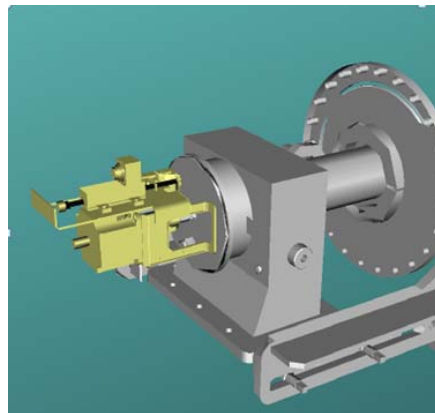
12.15 Tighten all screws on the back of the waveguide.

12.16 Push the mounting rods out till they touch the waveguide, then slide and move the LH and RH waveguide holder brackets and mounting rails till the rods can freely turn into the waveguide.

12.17 Tighten all mounting rods, support bar bolts and verify rods turn reasonable freely and then snug rods into waveguide by hand and fix then hand tighten.



13 Install FPC motorize actuator



- 13.1 If in place, remove existing cover from back of Waveguide.
- 13.2 If manual tuning link is in place, remove (4) M4 HHCS securing it. Unscrew tuning link CCW to remove.
- 13.3 Install automatic tuning link. Turn by hand to bottom of travel. Do not force.

- 13.4 Locate WG cover that includes (4) mounting holes for the tuner assembly. HV bias cable and connector should be installed onto it.
- 13.5 Install forked spade of HV cable onto backside of doorknob with (1) M4x8 HHCS into one of the (4) vacant tapped holes.
- 13.6 Stuff coiled HV cable into WG and secure cover in place with (8) M4x8 Phillips head screws.
- 13.7 With a calipers or scale, measure distance that plastic threaded link rod protrudes from backside of Waveguide. Length should be $\leq 25\text{mm}$. Do not include small boss/tang at end of rod in this measurement.
- 13.8 Locate tuner motor assembly. Measure distance from motor shaft face to mounting surfaces of brackets which fasten to WG. Length should be $\geq 25\text{mm}$.
- 13.9 Mount tuner assembly with LVDT up using (4) M5x10mm SHCS and washers. Watch that plastic tuning link and motor shaft end are properly mated/aligned. Do not jam the two shafts end to end.
- 13.10 Back out plastic tuning link from coupler to just close gap between rod ends. Do not end-load shafts.
- 13.11 Finger tighten coupling being careful not to damage plastic shaft.
- 13.12 Use M8 wrench on plastic tuning link and custom spanner wrench to tighten this coupling.
- 13.13 Adjust the position of the two limit switches so that they are centered about the limit switch activation arm mounted on the motor shaft.

