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| **L2HE Cavity String to UCM Alignment Procedure****SRF Cryomodule Assembly** |
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# Purpose and Scope

The purpose of this document is to describe the Alignment Procedure when assembling the L2HE Cryomodules. The work begins after the Cavity String has been attached to the UCM and reviewed by the CMA Technical Staff. The Alignment data is captured in the Alignment Spread Sheet and uploaded into the appropriate Assembly Traveler for record.

# Terms, Definitions, and Reference Docs

Cold Mass-partial assembly the includes the upper cold mass and cavities

[F10127855\_A\_CM Top Assy Dwg](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-261916/F10127855_A_DWG1.pdf)

[F10127864-A-Cold Mass Dwg](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-261917/F10127864-A-DWG1.pdf)

# Roles and Responsibilities

The following actions are to be performed by knowledgeable, authorized Technicians only. Consult the Group Lead for details.

# Procedure

Steps in alignment of LCLS2 UCM and string

1. Since the cavity must not twist while it is moving, two technicians must work together on either side of the string to provide pure translations, x, y and z.
2. Loosen jam nuts on z locking screws on all cavities
	1. Verify all z locking screws are finger tight.
3. Loosen the clamps on the invar rods to allow the cavities to move in Z
4. Course set Z direction
	1. Work from cavity 4 out to the ends, starting with the flange next to the helium pipe on cavity 4.
	2. After the S&A technician tells you which direction the cavity needs to go,
		1. Loosen the screws on the z locking plates on the upstream end of the cavity
		2. Loosen the z locking plate screw on the downstream end on the side the cavity needs to move; i.e. if it needs to move north, loosen the screw on the north side of the downstream bearing block.
		3. Use the appropriate screw in the downstream bearing block to drive the cavity in the direction alignment says it needs to go. North screw to go south, south screw to go north.
		4. Both technicians must adjust their screws by the same amount at the same time.
	3. S&A will verify that the cavity is at the correct position at Z.
	4. Hand tighten all the Z locking screws.
* Not too tight since the blocks must slide by them while adjusting X and Y.
* Not too loose since they hold against the vacuum load while the Invar clamps are loose.
	1. Move to cavity 3 and repeat. Continue to the next southerly cavity.
	2. For cavity 1, the bearing blocks which holds the valve with the ion pump must be loosened also since the flange is bolted directly to the cavity.
		1. To move in the Z direction the valve bearing block just needs to be loose.
	3. Repeat steps 4.2 to 4.4. for cavities 6 through 8.
	4. When you reach the quad, loosen the z axis locking nuts and screws on the bearing blocks on the gate valve and quad until they are hand tight. Loosen the lock screws to allow the quad to move in the direction of the adjustment and then use the screw on both sides of the quad simultaneously to drive the magnet to within 50 microns of the final coordinates.
1. Course set X direction
	1. Work from cavity 4 out to the ends, starting with the flange next to the helium pipe on cavity 4.
	2. Check the fiducials to determine which way the cavity end needs to move
	3. If the top and bottom fiducials call out different values, split the difference
	4. Loosen the locking screws or spring loaded brass hardware on the X axis in the direction the cavity needs to travel
	5. Tighten the hardware on the side of the bearing block to drive the cavity in the correct direction.
	6. When the cavity is in the correct position at one end, repeat the process at the other. The cavity will pivot as the upstream and downstream bearing blocks are adjusted. And all four screws (right, left, upstream downstream) will require adjustment to square the cavity up.
	7. When both ends of the cavity are in the correct X position, hand tighten all the X alignment screws and locking nuts.
	8. Recheck the alignment in X and hand adjust the screws and locking nuts to get within 50 microns. Tighten locking screws to hand tight. Tight spring loaded brass crews with torque wrench, not to exceed 70 inch-lb.
	9. Move to cavity 3 and repeat. Continue to the next southerly cavity.
	10. For cavity 1, the bearing blocks which holds the valve with the ion pump must be loosened also since the flange is bolted directly to the cavity.
		1. To move in the X direction the valve bearing block just needs to be loose.
	11. Repeat steps 5.2 to 5.8. for cavities 6 through 8.
	12. When you reach the quad, loosen the X axis locking nuts and screws on the bearing blocks on the gate valve and quad until they are hand tight. Loosen the lock screws to allow the quad to move in the direction of the adjustment and then use the screw on the other side (right) of the quad to drive the magnet to within 50 microns of the final coordinates.
	13. Hand tighten the locking screws and brass spring loaded screws for the quad.
2. Course set Y direction
	1. Work from cavity 4 out to the ends, starting with the flange next to the helium pipe on cavity 4.
	2. Check the fiducials to determine which way the cavity end needs to move
	3. If the top and bottom fiducials call out different values, split the difference
	4. Loosen the locking screws or spring loaded brass hardware on the Y axis in the direction the cavity needs to travel
	5. TWO PEOPLE REQUIRED. One person on each bearing block. Simultaneously tighten the hardware on the bearing block to drive the cavity in the correct direction.
	6. When the cavity is in the correct position at one end, repeat the process at the other. The cavity will pivot as the upstream and downstream bearing blocks are adjusted. And all four screws (right, left, upstream downstream) will require adjustment to square the cavity up. Remember to move the screws on the right and left bearing blocks simultaneously.
	7. When both ends of the cavity are in the correct Y position, hand tighten all the Y alignment screws and locking nuts.
	8. Recheck the alignment in Y and hand adjust the screws and locking nuts to get within 50 microns. Tighten locking screws to hand tight. Tight spring loaded brass crews to 10 inch-lb.
	9. Move to cavity 3 and repeat. Continue to the next southerly cavity.
	10. For cavity 1, the bearing blocks which holds the valve with the ion pump must be loosened also since the flange is bolted directly to the cavity.
		1. To move in the Y direction the valve bearing block just needs to be loose.
	11. Repeat steps 6.2 to 6.8. for cavities 6 through 8.
	12. When you reach the quad, loosen the Y axis locking nuts and screws on the bearing blocks on the gate valve and quad until they are hand tight. Loosen the lock screws to allow the quad to move in the direction of the adjustment. Simultaneously tighten the adjustment hardware on the right and left sides of the quad to drive the Quad to within 50 microns of the final coordinates. Repeat for the northern pair of bearing blocks on the quad.
	13. Tighten the screws and lock nuts. Tighten the brass, spring loaded, screws to 6 N-m.
3. Final Align Z of cavity 8 by adjusting the locking screws to move the fiducial within 50 microns. When the fiducial is within 50 microns, tighten the clamp on the Invar rod to 70 in-lb. Adjust the clamp so it resists the motion that the vacuum loads try to move the cavity.
	1. Loosen the locking screws while watching the Z position. It will likely change as the invar clamp relaxes by 50 – 100 microns, when it does,
		1. Loosen the Invar clamp and re set the locking screws to compensate for the slip
		2. Re tighten the Invar clamp and repeat until final position is within 50 microns.
	2. Remove the Z locking screws and plates except on the northern end of cavity 4.
4. Final align X of cavity 8
	1. Adjust the locking screws to move the fiducial within 50 microns. When the fiducial is within 50 microns, tighten the screws and lock nuts.
	2. Tighten the brass, spring loaded, screws to 6 N-m.
5. Final align Y of cavity 8
	1. Check the fiducials to determine which way the cavity end needs to move
	2. If the top and bottom fiducials call out different values, split the difference
	3. Loosen the locking screws or spring loaded brass hardware on the Y axis in the direction the cavity needs to travel
	4. TWO PEOPLE REQUIRED. One person on each right /left bearing block. Simultaneously tighten the hardware on the bearing blocks to drive the cavity in the correct direction.
	5. When the cavity is in the correct position at one end, repeat the process at the other. The cavity will pivot as the upstream and downstream bearing blocks are adjusted. And all four screws (right, left, upstream downstream) will require adjustment to square the cavity up. Remember to move the screws on the right and left bearing blocks simultaneously.
	6. Recheck the alignment in Y and hand adjust the screws and locking nuts to get within 50 microns. Tighten screws and locking nuts to hand tight. Tight spring loaded brass crews to 6 N-m.
6. Repeat steps 7-9 for cavities 7 through 1 moving in a southern direction.
7. Back off all the spring loaded brass screws by one quarter turn.
8. Perform a final survey of the string.

# **Release and Revision History**

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| Rev # | Revision or update: | Effective: |
| A | Initial version | 11/8/2023 |
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# **Approvals**

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