In-HAM Procedures for the eLIGO IO Faraday Isolator Swap / Mode Matching Adjustment / Mode Cleaner Cleaning

APPROVALS	DATE	REV	DCN NO.	BY	CHECK	DCC	DATE
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APPROVED:							
DCC RELEASE							

SCOPE

As part of the upgrade for eLIGO a new Faraday isolator (equivalent to the Advanced LIGO Faraday isolator) will be installed in L1 and H1. The mode cleaner mirrors in H1 and L1 will be cleaned. The mode matching of L1 will be fixed. This document covers the procedures carrying out the HAM table work for the upgrade.

The procedure for assembling the Faraday assembly on its breadboard is in a separate document, “eLIGO IO Faraday Isolator Assembly” E070291.

The procedure for drag wiping the mode cleaner mirrors after removal from HAM1 and HAM2 is in a separate document, E07xxxx.

The calculations supporting the movements of MMT1 and MMT2 to improve the mode matching are in a separate document, T07xxxx.

Both the EAST and WEST doors of HAM1 and HAM2 will be removed during this vent.

Estimated total vent duration (from vent to pump down): 15 days

APPLICABLE DOCUMENTS

M980133-B	Vent Isolatable Volumes
M980101-B	Procedure for Isolatable Volumes
M980136-A	HAM Chamber Access Door Removal Procedure
M990034-B	Contamination Control Plan
E000065-04	Chamber Entry/Exit Checklist

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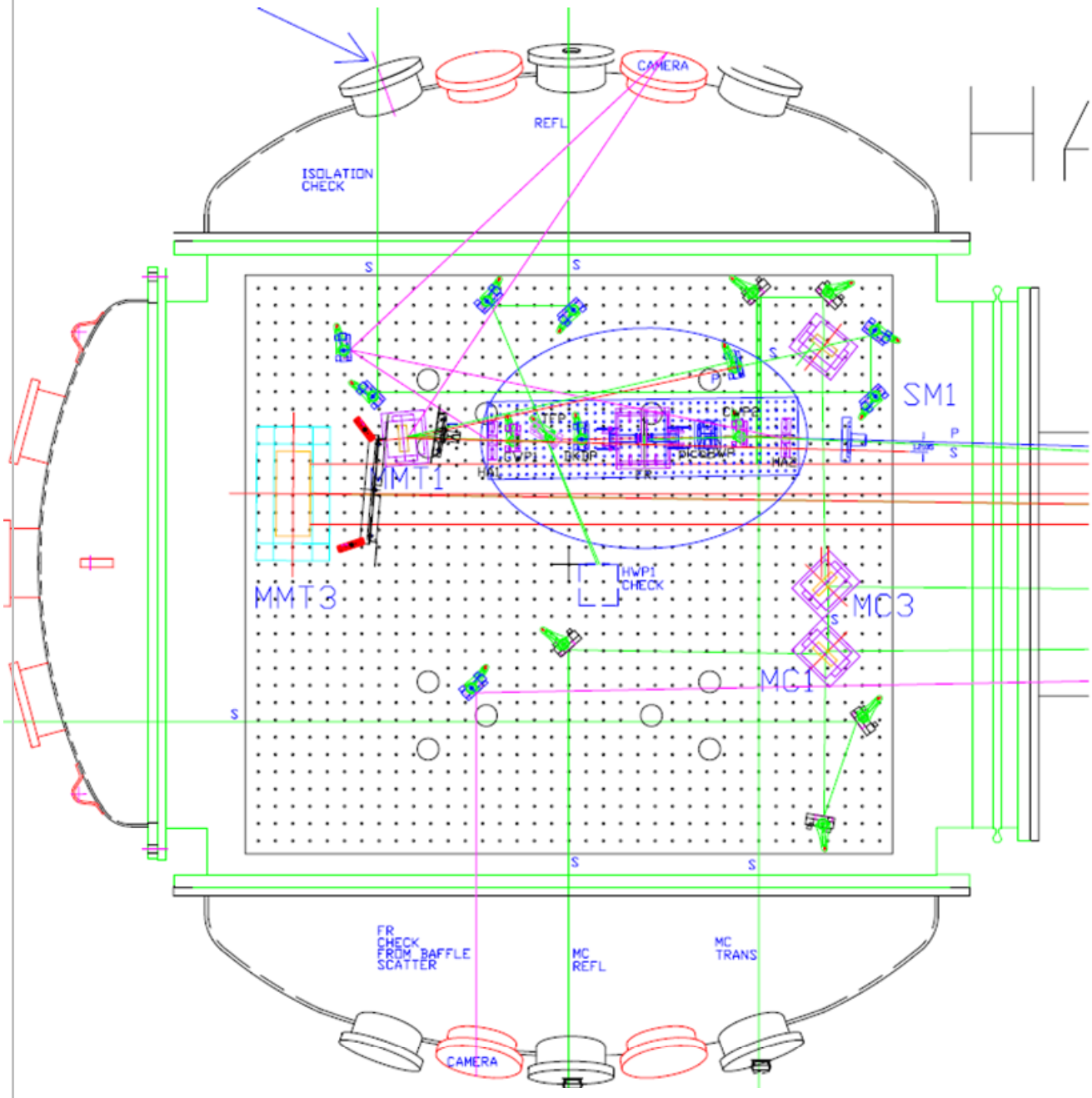

HAM 1 for eLIGO

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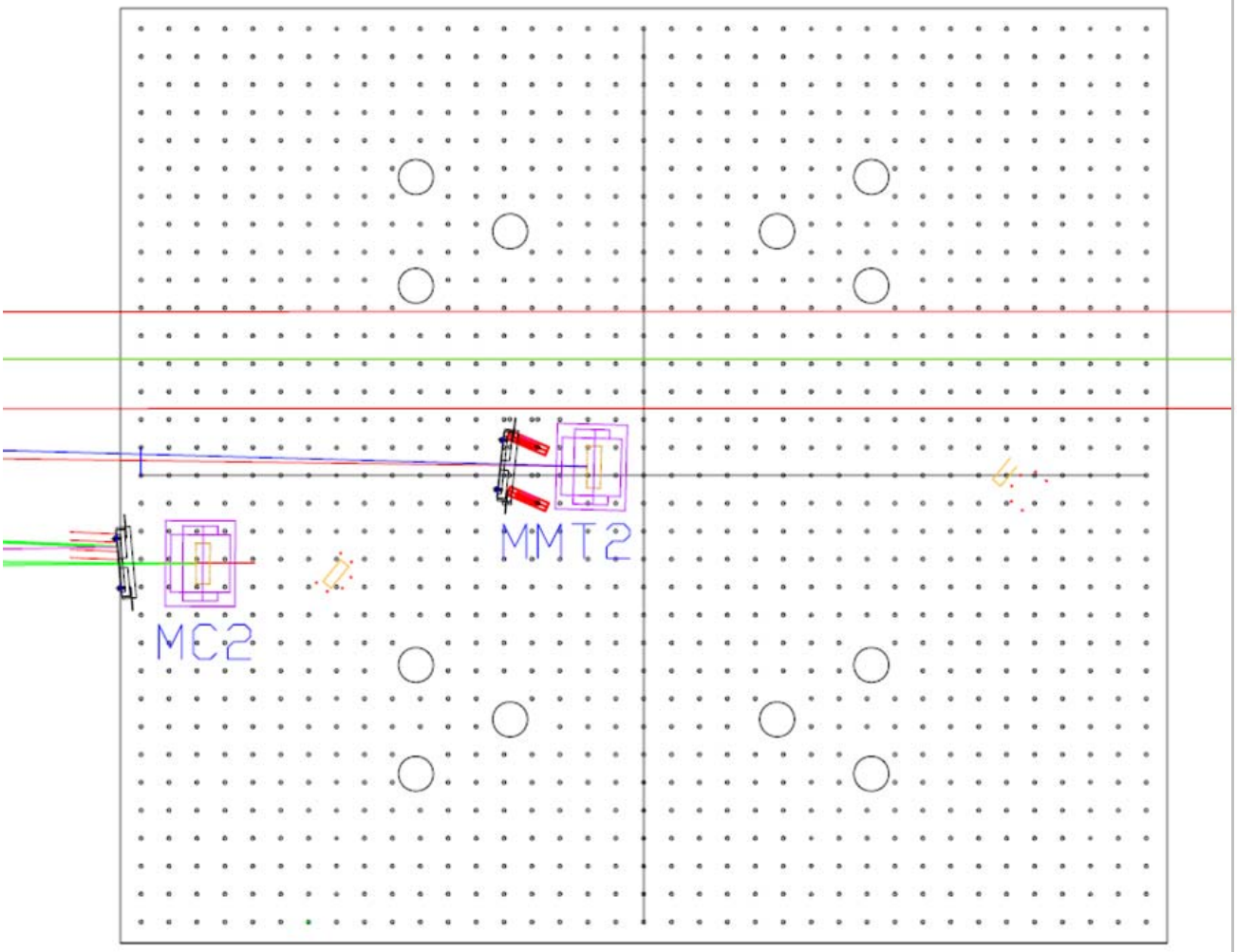

HAM 2 for eLIGO

In-HAM Procedures for the eLIGO IO Faraday Isolator Swap / Mode Matching Adjustment / Mode Cleaner Cleaning

A. PRIOR TO VENT (Days before vent – tasks can be done simultaneously)

A0. OPTIONAL: Measure the MC length in air with the corner station vented (lock the MC in air, sweep the resonant sideband and measure the reflection dip or amplitude modulation on the transmitted light)

A1. Assemble and align FI assembly on bench in optics lab.

A2. A cleanroom must be placed over HAM1 and HAM 2 – all panels attached and turned on.

A3. A smaller clean room will be placed outside of the HAM 1 cleanroom to serve as a preparation/staging area, and as a place for drag wiping the mode cleaner mirrors. This room should not be rolled into place until after the HAM 1 East door has been removed.

A4. Clean the LVEA floor near HAM 1 and HAM 2 and clean the HAM 1 and 2 chambers (wipe or mop).

A5. Stage the following items near HAM 1, ready to be placed in the staging cleanroom once the doors are removed.

- Cleanroom garb, gloves, foil, Ameristat, isopropanol, methanol
- HAM cloth door covers (3)
- 3 Belly bars and clamps
- Fork lift plank
- 2 Flashlights
- Ionizing gun and N2 bottle
- Laser pointer and belly bar clamp assembly
- Oscilloscope and Octopus box with connecting cables to sat. boxes
- 2x Class B tool pans
    i. Ensure that tools are non-magnetic for FI installation
- Faraday Isolator assembly (in the Optics or Vacuum prep lab) and associated mirrors
- Template fixtures for FI breadboard, position mirrors
- Breadboard Indexing fixtures
- COS window target fixtures
- Dog Clamps
- ¼-20 fastener stock
- Retro-reflecting mirror assy.
- HWP-TEMP-H1 (optional - can use one already in ham1 between SM1 and MC3)
- HWP-TEMP-PSL
- Table leveling equipment/monitoring system
- Bubble Level
- SOS tower targets
- Ophir Power meter
- Temp MC Beam Block
- 5.5” Beam Height Target
- Adjustable height alignment irises
- CCD video cameras (3) and associated mounting hardware
- Laminated layout drawings, check sheets

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- IR Card and Viewer

A6. Ensure that the vacuum equipment purge air system is operable before starting the task.

A7. Mark the wall fiducials for the MC Refl and Trans beams. Be sure to time stamp and clearly identify the new marks as there are many old marks still on the wall.

A8. Set the 2 PSL irises to maintain PSL pointing into HAM1 (one at top of periscope, one at HAM1 viewport).

A9. Install PSL/MC temporary polarization monitoring and rotating components (this will break MC lock – disable IOO WFS system)

- Install a temporary polarizer (POL-TEM) into pick-off beam (RFAM monitor) on the PSL table. This will provide polarization references for the beam going into the MC.
- Adjust the roll angle of the polarizer such that it is aligned with the polarization of the pick-off beam and lock the roll angle adjustment.
- Install a halfwave plate (HWP-TEMP-PSL) on the PSL table downstream of the second Brewster polarizer in the EOM chain and upstream of the pick-off for the RFAM monitor beam. This will be needed later to rotate the polarization of the beam incident on the MC so that changes from vertical to horizontal which can be seen on the POL-TEMP.
- Adjust the roll angle of HWP-TEMP-PSL to align the polarization with POL-TEM as before.
- Recheck the MC REFL wall fiducial.
- Mark the footprint of ISCT1 and IOT1.

A9. Prep ISCT1 and IOT1 for moving – what equipment needs to be unplugged, etc…

A10. Move ISCT1 and IOT1 out of the way to facilitate door removal.

A11. Mark MC wall reflection fiducial again – without periscope mirrors. Be sure to time stamp and clearly identify the new marks.

A12. Setup particle counter in HAM1 cleanroom.

A13. Block laser power at PSL/HAM1 shutter. Lock and tag.

A14. Bring FI assembly out to LVEA.

A15. Bring table, wipes, and solvents for drag wiping the MC mirrors into the LVEA.

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B. HAM2 Measurements in advance of FI installation

All tasks must be performed in accordance with Contamination Control Plan M990034.

** Close cloth covers on HAM doors at all times when access is not required.

B1. Vent the vertex volume (per procedure M980133).
B2. Remove HAM1, HAM2 NORTH and SOUTH doors (LLO); EAST and WEST doors (LHO).
B3. Turn up the purge air
B4. Mount belly bars and HAM bridge in HAM2.

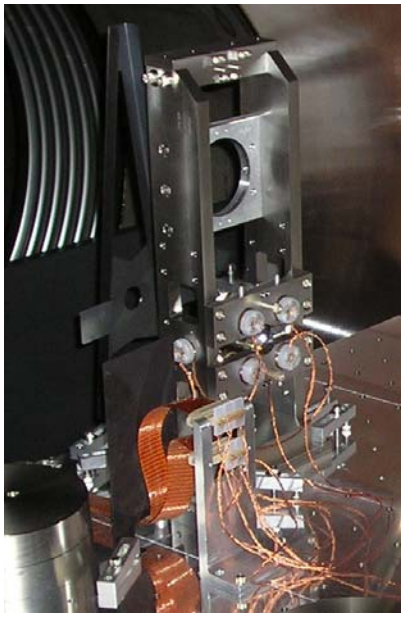
LHO only procedure (B4 through B7):

Beams on HAM table

B5. Unshutter PSL
B6. Install beam alignment target on MMT2. Caution: Optics are UNCLAMPED!!
B7. Record where beam hits targets: MMT2 _____
B8. Install an additional alignment iris in front of MMT2 to mark the beam path and for use in retroreflector installation.
B9. Shutter PSL.

Both:

B10. Clamp optics MMT2 and MC2.
B11. Check HAM2 table level, and record _____



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B12. Add reference iris upstream of MMT2 to establish initial beam line and for retro-reflection alignment

B13. Set a temporary retroreflector mirror on HAM2 to redirect light back through the iris to HAM1 (through HAM2 and HAM1 reference irises). Check that the alignment is good through all irises, and then place a temporary beam block between the retro-reflector and MMT2. Note that the beam is diverging as it comes to HAM2 and will continue to diverge as it goes back to HAM1.

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Beams on HAM table

C. HAM1 Measurements in advance of FI installation

C1. Setup the COS viewport alignment fixture to model the HAM1 east (LHO) or north (LLO) door. Lock all of the viewport targets down to maintain the relative location of the viewports. This fixture will be used when aligning additional steering mirrors on HAM1, while the door is removed.
C2. Check HAM1 table level, and record _____
C3. Remove PSL/HAM1 shutter lock and tag, letting beam into chamber.
C4. Mark MC wall Refl fiducial again – doors off.
C5. Install temporary MC beam block to prevent the MC from resonating.
C6. Install MC Refl beam dump (BD) on HAM1 West Belly Bar.
C7. Rotate the polarization of the beam incident on the MC by turning the HWP-TEMP-PSL on the PSL table by 90 degrees by observing the rejected beam in POL-TEMP. The beam in the IO chain in HAM chamber will now be in the wrong polarization and therefore will become visible after the MC.
C8. Temporarily remove the HWP in front of SM-1. This will provide the correct polarization for the FI when the PSL is outputting the wrong polarization. (NOTE: THIS WAS NOT DONE AT LLO. INSTEAD, THE HWP WAS ROTATED. THE ORIGINAL ANGLE WAS 204 DEG AS RECORDED ON THE CVI ROTATION STAGE. THE STAGE SHOULD BE RESET USING THE FARADAY TO SET THE PROPER POLARIZATION)
C9. Verify the beam path from MC3 → SM1 → MMT1 → FI
C10. Install a temporary alignment iris downstream of the FI (near the edge of HAM1 beyond all of the FI components). Along with the iris and MMT2 alignment target installed on HAM2 – these will serve as the reference beam line for the FI installation.
C11. Install alignment targets on SM1 and MMT1. Caution: Optics are UNCLAMPED!!
C12. Record where beam hits targets: SM1_____ MMT1 _____
C13. Clamp all optics (MC1, MC3, SM1, MMT1, and MMT3). Verify that the optics are clamped by gently pushing on the HAM table after clamping all of the optics and inspecting each optic to make sure it doesn't move.
C14. Adjust clamping of SM1 to maintain its original pointing onto the MMT1 target.
C15. Adjust clamping of MMT1 to maintain its original pointing through the irises and onto the MMT2 target on HAM 2.
C16. Shutter the PSL.

D. Remove MC1, MC2, and MC3 drag wiping.

D1. On HAM2, unplug MC2 OSEMS.
D2. Set up video monitor to look at MMT2 remotely from HAM1.
D3. Place spare dog clamps against the base of MC2, adequate to define its position on the table. (Minimum of 3) (NOTE: MC2 is on a small riser block, and the spare dog clamps must define the base of the SOS tower and not the location of the riser.)

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D4. Record plugs of MC2 OSEMS on connector stand, with plugs on stand numbered from top left to bottom right: 1,2, 3, 5,6: UL ___ UR ____ LR____ LL____ S____
D5. Remove MC2 from the HAM. Take it to the place where the drag wiping will occur.
D6. On HAM1, remove any beam dumps and wire-protection A-frame assemblies (errant beam blocks) in front of all towers if they would affect tower removal.
D7. Place spare dog clamps against the base of MC1 and MC3, adequate to define their positions on the table. (Minimum of 3)
D8. Record plugs of MC1 OSEMS on connector stand, with plugs on stand numbered from top left to bottom right: 1,2, 3, 5,6: TL ___ TR ____ LR____ LL____ S____
D9. Record plugs of MC1 OSEMS on connector stand, with plugs on stand numbered from top left to bottom right: 1,2, 3, 5,6: TL ___ TR ____ LR____ LL____ S____
D10. Unplug MC1 and MC3 OSEMS.
D11. Remove dogs and take MC1 and MC3 to safe location for cleaning.

E. Reinstall MC1, MC2, and MC3, alignment check

E1. Reinstall MC1, MC2, and MC3. Dog down.

THE FOLLOWING STEPS CAN BE DONE WHEN CONVENIENT BEFORE THE CLOSE-OUT:

E2. Reinstall OSEM cables.
E3. Rebalance HAM1 table.
E4. Unlock suspended optics
E5. Unshutter PSL
E6. Check MC Ref, Tran reference beam positions in HAM 1
E7. Check HAM2 level and position of beam on MMT2.

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F. Removal of old FI and (LLO only) MMT1 adjustment in HAM1

F1. Remove the old Faraday Isolator components from HAM chamber.
F2. Add temporary counterweights to maintain table height, balance.
F3. Remove old DLC mounts that are associated with the Faraday. Remove MC mystery DLC mount. (Leave MC Refl DLC mounts!) Check the layout diagram before removing mounts.
F4. Remove or move out the way old beam blocks.
F5. Place the "SM1 present location" fixture against the base of SM1, after removing any interfering dog clamps. (Leave two in place!)
F6. Remove remaining SM1 dog clamps.
F7. Install "SM1 new location" fixture. Look at the diagram for proper locations and tapped holes to bolt the fixture down.
F8. CAREFULLY move SM1 into place against the "SM1 new location" fixture.
F9. Remove "SM1 present location" fixture and clamp SM1 to the table.
F10. Remove "SM1 new location" fixture and clamp the other side.
F11. Place the "MMT1 present location" fixture against the base of MMT1, after removing any interfering dog clamps. (Leave two in place!)
F12. Remove remaining MMT1 dog clamps.
F13. Install "MMT1 new location" fixture. Look at the diagram for proper locations and tapped holes to bolt the fixture down.
F14. CAREFULLY move MMT1 into place against the "MMT1 new location" fixture
F15. Remove "MMT1 present location" fixture and clamp MMT1 to the table.
F16. Remove "MMT1 new location" fixture and clamp the other side.
F17. Reposition the dummy weights to re-establish the table balance.
F18. Unshutter the PSL.
F19. Verify that the beam coming from the MC hits the center of SM1. If not, slightly adjust the position of the SM1 tower to properly center the beam.
F20. Verify that beam coming from SM1 hits the center of MMT1. If not, slightly adjust the rotation (yaw) of the SM1 tower to center the beam on MMT1.
F21. Verify that the beam coming from MMT1 hits MMT2. It does not have to be precisely centered on MMT2 yet, but should hit the mirror. The iris on HAM2 will need to be opened for the beam to get to MMT2. Slightly adjust the rotation (yaw) of the MMT1 tower as needed to get the beam on MMT2.

Beams on HAM table

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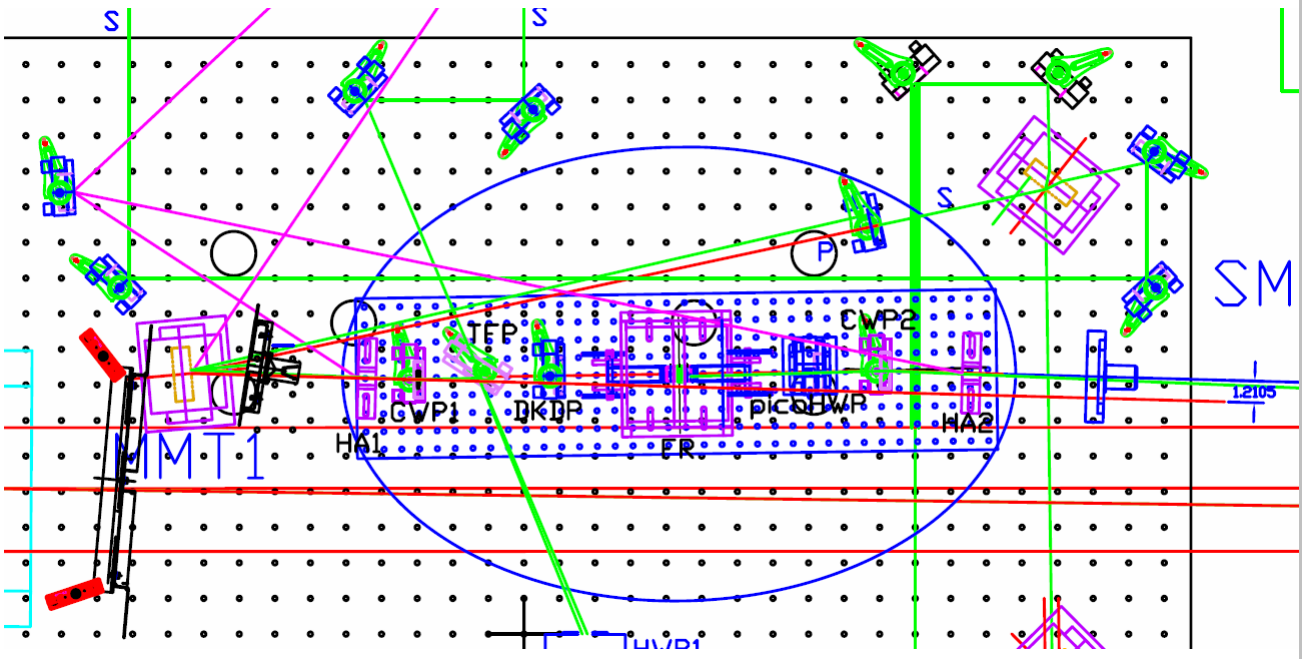

eLIGO Faraday detail

G. Installation and Alignment of FI in HAM1

G1. Check locations of ribbon cabling to see if any will interfere with FI installation. Temporarily unplug and move any that would interfere, noting it here:

_____

G2. Attach the FI breadboard indexing fixture to the HAM table as per the layout drawing.
G3. Remove temporary weights installed in step D3. The order of this and the last step is not important.
G4. Remove and relocate additional weights identified in weight/balance calculation.
G5. Install the FI assembly in the HAM chamber and locate it to the indexing fixture.
G6. Loosely install FI dog clamps.
G7. Install all of the auxiliary mirrors (M1 through M6). Loosely install their fork clamps.
G8. Remove FI template indexing fixtures.
G9. Re-check the level the HAM table and shift weights as needed. Note that the level will needed to be checked again later after all temporary optics and fixtures have been removed from HAM1
G10. Open PSL shutter to let beam back on table.
G11. Recheck the beam pointing on the SM1, MMT1.
G12. Position the FI breadboard so that the beam coming from MMT1 goes through the center of both irises (which are mounted on the Faraday magnet).

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G13. Establish the alignment from MMT1 to MMT2. At this point, you may have to move the yaw of MMT1 as well as the orientation of the Faraday isolator breadboard. This will be an iterative and possibly time consuming process, but at the end of it the beam should follow the original beamline (centered through the iris downstream of the FI breadboard, the HAM2 iris, and on the original location on the MMT2 target).
G14. Carefully, dog clamp breadboard down tightly.
G15. Adjust clamping of SM1 to maintain its original pointing onto the MMT1 target.
G16. Adjust clamping of MMT1 to maintain its original pointing onto the MMT2 target.
G17. Temporarily remove the MC Refl beam dump and double check the MC wall Refl fiducial. Replace the beam dump when finished.
G18. Re-position M1 through M6 so that beams are on center of mirrors.
G19. Align REFL beam and all FI ancillary beams through appropriate COS viewport aligners; align any viewing mirrors.

H. Measurement of Faraday Isolator Performance and SM-1 Transmission

H1. Replace the HWP that was originally between MC3 and SM1 in its new location after SM1 so that the polarization hitting MMT1 is horizontal, i.e., the one that will be used in operations. Since the input beam is in the orthogonal polarization with respect to normal operation, the light will not get through the Faraday but be dumped by the TFP on the Faraday breadboard. (LLO ONLY – reset the CVI stage to the appropriate angle)
H2. Measure the power incident on SM-1 and transmitted through SM-1 with the small OPHIR power meter.
H3. Record P_inc:_____ and P_trans:_____
H4. Measure the power incident before the first aperture of the Faraday isolator assembly and the power leaving the final aperture of the Faraday isolator assembly. (You may have measure the power leaving the Faraday in HAM2 if the aperture is near the edge of HAM1)
H5. Record FI_P_inc:_____ and FI_P_trans:_____
H6. Unblock the retroreflector on HAM2 to redirect light back to FI (through HAM2 and HAM1 reference irises).
H7. Measure the power coming out of the REFL port (from the TFP).
H8. Record FI_P_refl:_____ and compute the isolation ratio
H9. NOTE ALL THE POWER READINGS IN THE LLO I-LOG!!!
H10. Track down **all** ghost beams leaving the Faraday assembly and make sure that they are **all** dumped. In order to get sufficient light levels, the power may need to be turned up to 1 W. Make sure that the installed beam dumps do not interfere with the main beams. Make sure that the beam dumps are clear of the beams to/from MMT3!
H11. Install wire-protection A-frame assemblies (errant beam blocks) in front of all towers.
H12. Install parking beam dump on HAM1 right under the beam from the FI to MMT2. This can replace the iris that was placed there earlier.
H13. Remove all alignment irises, fixtures, etc. from HAM1.
H14. Re-secure all ribbon cabling to table in original locations.
H15. Remove all alignment irises, retroreflector, etc. from HAM2

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I. MMT2 Position Adjustment (LLO ONLY)

LLO only procedure (B10—B15):

I1. Place the "MMT2 present location" fixture against the base of MMT2, after removing any interfering dog clamps. (Leave two in place!) MMT2 is on a large riser. Leave the tower clamped to the riser, and treat riser/tower as a single unit.
I2. Remove remaining MMT2 dog clamps.
I3. Install "MMT2 new location" fixture.
I4. CAREFULLY move MMT2 into place against the "MMT2 new location" fixture
I5. Remove "MMT2 present location" fixture and dog MMT2 to the table.
I6. Remove "MMT2 new location" fixture and dog other side.

J. CLOSEOUT

J1. Close PSL/HAM1 light pipe shutter. Lock and tag.
J2. Remove all temporary equipment if it hasn't already been removed:
- HWP-TEMP-H1 (NOT DONE FOR LLO)
- SM1 and MMT1 targets
- Pushers
- Templates
- Retro-reflecting mirror assembly
- Temp Laser Safety Beam Blocks (MC refl beam)
- MC resonance Beam Block
- HWP-TEMP-PSL
- Cameras

J3. Check and final level HAM1 and HAM2 tables if necessary.
J4. Check Unclamp all optics. Check MMT3 for proper positioning of earthquake stops!
J5. Discharge and test for touching stops with HENE laser pointer tests.
J6. On PSL table, check that the polarization of the beam incident on the MC is back to normal (s-polarization, E vertical).
J7. Complete Exit Checklist tasks, final inspection, and photographs
J8. Replace HAM1 and HAM2 doors.
J9. Pump down.
J10. Check MC length in air and compare with the old numbers – the length should not differ by more than 50 microns. If it does, MC 2 must be repositioned on a subsequent vent.