



INSTALLATION SPECIFICATION

TITLE

Re-alignment of the 2 km Interferometer Vertex Region

APPROVALS:		DATE	APPROVALS:		DATE
DRAWN:	Dennis Coyne	3/26/01	CHECKED:--		--
CHECKED:	Hugh Radkins	3/26/01	CHECKED:--		--
CHECKED:			DCN NO	APPROVED	DATE
CHECKED:			E010060-00-D	Dennis Coyne	3/26/01

Instructions on the use of this document:

- 1) Laminate this procedure (or place it in a plastic sleeve) and have it available at all times during the installation. Check off items as the installation proceeds. (Clean the plastic with isopropyl alcohol and handle it as a class B tool per M990034). Also laminate the LOS installation procedure for BSC chambers (E000062) and have it available during the installation to follow along.
- 2) Use this installation procedure as a check list for preparation and during the installation. Note any discrepancies or deviations and augment with any missing definition. File any significant notes or data from the completed procedure in the electronic logbook (such as any deviations); as a minimum note in the electronic logbook that the installation was completed in accordance with this procedure (cite document number and revision).

1 SCOPE

This installation specification covers the angular re-alignment of the 2 km interferometer in the event that one or more optics require realignment (e.g. after a significant earthquake disturbance). It is assumed that the optics have already been positioned and initially aligned based on the Initial Alignment System (IAS) procedures (T970151) and Core Optics Support (COS) initial alignment procedures (T990088); It is assumed that the angular adjustments required are generally within the range of the Pitch and yaw Adjustment Magnets (PAMs), that the optics are properly positioned and that the COS optical elements are in adequate alignment. The scope of this document is limited to angular alignment of the core optics and alignment of the Mode Matching Telescope (MMT) to the Recycling Cavity (RC), i.e. alignment of the Mode Cleaner (MC) and associated optics (steering mirrors, Faraday isolators, etc.) are not part of this procedure.

2 APPLICABLE DOCUMENTS

Listed below are all of the applicable and referenced documents for this installation procedure. This list gives the latest revisions of the documents; Within the installation steps, only the document number (and not the revision) is quoted.

M990034-B	Contamination Control Plan
M980133-B	Vent Isolatable Volumes
M980101-B	Procedure for Isolatable Volume Pump Down
E000118-A	Hanford Checklist - Isolatable Volume Pump Down
E000121-A	Hanford Checklist - Spool removal procedure



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M980136-A	HAM Chamber Access Door Removal Procedure
E000120-A	Hanford Checklist - BSC Door Removal
M980132-B	O-Ring Installation and Flange Assembly Procedure for HAM and BSC Doors
T970151-C	Initial Alignment Procedures (Reference only: The alignment procedures defined within this procedure supersede the initial alignment procedures defined in T970151.)
M990316-00	Standard Operation Procedure (SOP): COS Infrared Alignment Laser Operation in the LHO LVEA
T990088-01	COS 2km IFO Alignment Procedure Note: Figure 10 in this document shows the alignment layout schematically for chamber WBSC6, but is missing the chamber, optics table, etc.
E000065-04	Chamber Entry/Exit Checklist
T980072-01	COS alignment telescope/autocollimator/projector system
E000116-00	Procedure for Realignment of Large Suspended Optics
D970308-B	Interferometer Optomechanical Layout - Hanford Site
M980047-E	Transition to Laser Hazard
M980048-E	Transition to Laser Safe



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3 PRE-REQUISITES

- q 1. The optics should have already been positioned and aligned via T970151; This is a remedial alignment procedure.
- q 2. All optics tables should be verified to be level and counterweights adjusted if/as required.
- q 3. Follow all contamination control procedures. In particular cleanrooms must be placed over the open spool sections and open chamber doors and the purge air must be flowing into all separate vented vacuum volumes.
- q 4. The Suspension assemblies and control electronics should be confirmed to be operating correctly (per E970154) prior to initiating this procedure.

4 PREPARATION

All preparation must be in accordance with the Contamination Control Plan (M990034).

- q 1. If, and only if, the vacuum system is not already open and therefore exposed:
Clean the LVEA, particularly the floor adjacent to the spools which are to be removed (spool WBE-3A1, between chambers WHAM3 and WBSC2, and spool WBE-2B, between chambers WBSC1 and WBSC2) and adjacent to the south door of WBSC8 and the east door of WBSC7 one or both of which will be removed; Particulates and dust should be removed by mopping with clean water.
Clean the BSC chamber (wipe or mop with clean water) from the stiffening ring above the door down, as well as the floor in the vicinity of the chamber well in advance of the opening of the vacuum system.
- q 2. Insure that there are no large openings to the exterior or the beam tube enclosure where insects or dust can get into the VEA.
- q 3. Arrange for clean room coverage over either, or both, chambers WBSC7 and WBSC8 and over the spools to be removed (spools WBE-3A1 and WBE-2B)
- q 4. Vent the diagonal, vertex and beam manifold volumes per M980133
- q 5. Remove spool WBE-3A1 from between BSC 2 and HAM 3 using 'C' bar on crane hook and per E000121-A (supports the MMT3, RM and ITMx alignments)
Cover the openings with clean rooms and ensure adequate purge air flow.
Reminder: cover open doors when access is not immediately required!
- q 6. Remove spool WBE-2B from between BSCs 1 & 2.
Cover the openings with clean rooms and ensure adequate purge air flow.
Reminder: cover open doors when access is not immediately required!



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5 RE-ALIGNMENT STEPS

All work must be in accordance with the Contamination Control Plan (M990034).

Sequence: The following steps are in a logical and workable sequence. However some of the steps can be done in parallel and some steps can be done at other points in the sequence.

- q 1. **Position the PLX** (Lateral Transfer Hollow Retroreflector) on a clean, stable mount in the chamber WBSC8 in front of ITMy,2k oriented vertically, with it's upper aperture approximately centered laterally and vertically with respect to the IMTy,2k optic.
- q 2. **Position the Sokkia total station** (with the LDS-1000 laser autocollimator mounted on top) over IAS monument IAM51 in the area where spool WBE-2B normally resides along the Y-arm. The local coordinates of IAM51 are {200.6, 2362.2} mm
Set the height so that the center of the LDS-1000 aperture is at -498.2 mm in local coordinates. Adjust the Sokkia so that it is pointing as follows:
 - Yaw = 0 (pointing +Y direction)
 - Pitch = 89 deg, 59', 57" (pointing 3" up)
- q 3. **Adjust the PLX** if/as required so that the LDS-1000 beam is centered in both apertures.
- q 4. **Adjust the PAM magnets of the ITMy,2k suspension** assembly until the LDS-1000 beam is autocollimated to within 10 microradians.
If a large yaw adjustment is required (greater than ~1 mrad), then first perform a coarse yaw alignment by shifting the suspension structure on the optics table as follows:
 - a) clamp the suspended optics on the table
 - b) position stops on two sides of the structure as a reference to the position, preferably with pusher screws to help rotate the structure
 - c) loosen the dog clamps which secure the structure to the table
 - d) rotate the suspension structure slightly, reclamp
 - e) unclamp the optic and recheck the yaw error with the LDS-1000 autocollimator
- q 5. **Place a target in front of MMT3** in WHAM7, with a reference mark indicating the center of MMT3. This target should have a positional accuracy of +/- 2 mm and can be positioned by reference to the MMT3 structure (i.e. does not need to be positioned optically).
- q 6. **Transition to a Laser Hazard Condition** per the COS Alignment SOP, M000011.
- q 7. **Mount the COS laser autocollimator (LAC)** (940 nm wavelength) onto the total station mount at a height so that the center of the COS LAC aperture is on the Y-beam centerline. This will require changing the height of the total station first.
- q 8. Autocollimate off of the ITMy,2k with the COS LAC.



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- q 9. **Adjust FMy PAM magnets** until the projected COS LAC reticle pattern is centered on the target in front of MMT3. A centering accuracy of +/- 2 mm is sufficient.
Notes:
a) ITMy,2k and FMy must be off of their stops (freely hanging) during this step.
b) If a large yaw adjustment is required (greater than ~1 mrad), then first perform a coarse yaw alignment by shifting the suspension structure on the optics table (in the same manner indicated for ITMy,2k in step 4)
- q 10. **Adjust RM,2k PAM magnets** until the projected COS LAC reticle pattern retroreflects from the RM,2k to within ~30 microradians.
Notes:
a) ITMy,2k, FMy and RM,2k must all be off of their stops (freely hanging) during this step.
b) If a large yaw adjustment is required (greater than ~1 mrad), then first perform a coarse yaw alignment by shifting the suspension structure on the optics table (in the same manner indicated for ITMy,2k in step 4)
- q 11. **Check the ITMy,2k Pick-Off beam alignment** with an infrared sensitive camera looking directly into the PO viewport on WHAM10. The COS LAC projected reticle pattern should be centered in the aperture to within ~100 microradians.
- q 12. **Transition to a Laser Safe Condition** per the COS Alignment SOP, M000011.
- q 13. **Position the PLX** (Lateral Transfer Hollow Retroreflector) on a clean, stable mount in the chamber WBSC7 in front of ITMx,2k oriented vertically, with its upper aperture approximately centered laterally and vertically with respect to the IMTx,2k optic.
- q 14. **Position the Sokkia total station** (with the LDS-1000 laser autocollimator mounted on top) over IAS monument IAM54 in the area where spool WBE-3A1 normally resides along the X-arm. The local coordinates of IAM54 are {-2133.6, -200.5} mm
Set the height so that the center of the LDS-1000 aperture is at -499.0 mm in local coordinates. Adjust the Sokkia so that it is pointing as follows:
Yaw = 0 (pointing +X direction)
Pitch = 90 deg, 2', 8" (pointing 2' 8" down)
- q 15. **Adjust the PLX** if/as required so that the LDS-1000 beam is centered in both apertures.
- q 16. **Adjust the PAM magnets of the ITMx,2k suspension** assembly until the LDS-1000 beam is autocollimated to within 10 microradians.
Note: Since ITMx,2k did not need repair following the 2/28/01 earthquake, a coarse yaw alignment of the suspension structure should not be necessary.



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- q 17. **Adjust the PAM magnets of FMx until the optical lever beam** gives the same reading as prior to the alignment disturbance event. An alignment resolution of +/- 0.01 non-dimensional digital units is sufficient. Note the reference pitch and yaw optical lever values used.
Notes:
a) This step can be skipped if desired as the next step is a more accurate means to align the FMx. However, at a minimum the optical lever centration should be checked.
b) ITMx,2k must be off of its stops (freely hanging) during this step.
c) Since FMx did not need repair following the 2/28/01 earthquake, a coarse yaw alignment should not be necessary.
- q 18. **Transition to a Laser Hazard Condition** per the COS Alignment SOP, M000011.
- q 19. **Mount the COS laser autocollimator (LAC)** (940 nm wavelength) onto the total station mount at a height so that the center of the COS LAC aperture is on the X-beam centerline. This will require changing the height of the total station first.
- q 20. **Autocollimate off of the ITMx,2k with the COS LAC.**
- q 21. **Adjust the PAM magnets of FMx until the COS LAC reticle is centered** in the APS port as viewed with an infrared sensitive camera looking directly into the APS viewport on WHAM10. The COS LAC projected reticle pattern should be centered in the aperture to within ~100 microradians. Confirm that the optical lever for the FMx is reasonably well centered (see step 17).
Notes:
a) ITMx,2k and the FMx must be off of their stops (freely hanging) during this step.
b) Since FMx did not need repair following the 2/28/01 earthquake, a coarse yaw alignment should not be necessary.
- q 22. **Adjust the BS,2k PAM magnets** to retroreflect the COS LAC reticle pattern from the RM,2k to within ~30 microradians
Notes:
a) Since BS,2k did not need repair following the 2/28/01 earthquake, a coarse yaw alignment of the suspension structure should not be necessary.
b) This requires ITMx,2k, FMx, BS,2k and RM,2k to all be freely hanging.
- q 23. **Check the ITMx,2k Pick-Off beam alignment** with an infrared sensitive camera looking directly into the PO viewport on WHAM9. The COS LAC projected reticle pattern should be centered in the aperture to within ~100 microradians.
- q 24. **Check the BS,2k Pick-Off beam alignment** with an infrared sensitive camera looking directly into the PO viewport on WHAM10. The COS LAC projected reticle pattern should be centered in the aperture to within ~100 microradians.
- q 25. **Mount the COS laser autocollimator (LAC)** (940 nm wavelength) onto the total station mount at a height so that the center of the COS LAC aperture is on the Y-beam centerline. This may require changing the height of the total station first.



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- q 26. **Autocollimate off of the ITMy,2k with the COS LAC.**
- q 27. **Recheck alignments:**
- a) Recheck the autocollimation of the RM,2k and adjust the RM,2k PAMs if the error is > 30 microradians
 - b) Check the Michelson arm co-alignment on the APS port of WHAM10. The Michelson beams should be co-aligned to within 30 microradians. If necessary, adjust the FMy to align the Y Michelson beam to the X Michelson beam.
Note: It may be necessary to mount a COS laser autocollimator/projector on both the Y- and X-arms in order to allow chopping each arm and verifying relative alignment. If this is possible, then also use each COS laser autocollimator/projector as a receiver to verify good alignment to one another (< 30 microradians).
 - c) Recheck centering of the projected COS LAC reticle pattern at MMT3. Do not adjust. Measure and note the amount of decentering (mm) vertically and horizontally.
- q 28. **Align the MMT to the Recycling Cavity (RC)**
- a) Adjust MMT3 bias controls to center the COS LAC reticle pattern on the center of a target in front of MMT2
 - b) Adjust MMT1 bias controls to center the PSL beam on the center of a target in front of MMT2
 - c) Adjust MMT2 bias controls to center the PSL beam to the same position that the COS LAC reticle pattern hits the target in front of MMT3
- q 29. **Transition to a Laser Safe Condition** per the COS Alignment SOP, M000011.