TITLE

Re-alignment of the LLO 4K Interferometer Vertex Region

APPROVALS:	DATE	APPROVALS:	DATE
DRAWN: D. Coyne/M. Smith	5/22/01	CHECKED:--	--
CHECKED:		CHECKED:--	--
CHECKED:		DCN NO / APPROVED	DATE
CHECKED:			

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 LLO 4 km interferometer in the event that one or more optics require realignment (e.g. after a significant earthquake disturbance, or the replacement of the SUS sensor/actuator heads). 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	Isolatable Volume Pump Down

TITLE

Re-alignment of the LLO 4K Interferometer Vertex Region

E000121-A	Spool removal procedure
M980136-A	HAM Chamber Access Door Removal Procedure
E000120-A	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.)
M000178-A-L	Standard Operation Procedure (SOP): COS Infrared Alignment Laser Operation in the LLO LVEA
T000065-05	COS 4K IFO Alignment Procedure
E000065-04	Chamber Entry/Exit Checklist
T980072-01	COS alignment telescope/autocollimator/projector system
E000116-00	Procedure for Realignment of Large Suspended Optics
D970610-A	Interferometer Optomechanical Layout - Livingston Site
M990152-E	Procedure for Transition to the Laser Hazard Condition
M990153-E	Procedure for Transition to the Laser Safe Condition

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. <u>If, and only if, the vacuum system is not already open and therefore exposed:</u>
Clean the LVEA, particularly the floor adjacent to the spools which are to be removed (spool LBE-1A, near chamber LBSC3, and spool LBE-1B, near chamber LBSC1; Particulates and dust should be removed by mopping with clean water.

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 the spools to be removed (spools LBE-1A and LBE-1B)

q 4. Vent the vertex and beam manifold volumes per M980133

q 5. Remove spool LBE-1A
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 LBE-1B .
Cover the openings with clean rooms and ensure adequate purge air flow.
Reminder: cover open doors when access is not immediately required!

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 7. **Set up 1st total station** and support bench at LBE-1A spool position along the x-arm.

q 8. **Adjust the ITMx suspension PAM magnets** 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 autocolimator

q 9. **Place a target in front of MMT3** in LHAM1, 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 10. **Transition to a COS Laser Hazard Condition** per M990152-E and M000178-A.

q 11. **Mount the 4W COS laser autocollimator (LAC)** (940 nm wavelength) so that the optical axis is aligned with the X-beam centerline on the total station Sokia tripod mount in spool LBE-1A using the bayonet mount and post adapter. This may require changing the height of the total station first.

q 12. Align the COS LAC by autocollimating from the ITMx.

q 13. **Check MMT3 position** by projecting the 4W COS LAC reticle pattern onto the target in front of MMT3. The maximum allowed radial deviation from the MMT3 mirror center is 15 mm. Do not adjust MMT3. Measure and note the amount of decentering (mm) vertically and horizontally.

q 14. Place the ITMx on its stops and tilt its reflection out of the field of view of the COS LAC.

q 15. **Adjust RM PAM magnets** until the projected COS LAC reticle pattern retroreflects from the RM to within ~30 microradians.
Notes:
a) 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 ITMx in step 8)

q 16. Return ITMx to hanging free, by taking it off its stops.

Re-alignment of the LLO 4K Interferometer Vertex Region

q 17. **Set up 2nd total station** and support bench at LBE-1B spool position along the y-arm.

q 18. **Adjust the ITMy suspension PAM magnets** 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 autocolimator

q 19. **Mount the 500mW COS laser autocollimator (LAC)** (940 nm wavelength) so that the optical axis is aligned with the Y-beam centerline on the total station Sokia tripod mount in spool LBE-1B using the bayonet mount and post adapter. This may require changing the height of the total station first.

q 20. Align the COS LAC by autocollimating from the ITMy.

q 21. **Adjust the APSy output beam alignment:**
a) check the alignment of the APSy output beam by looking at the APSy COS LAC reticle pattern with an infrared-sensitive camera from the outside through the APS viewport on LHAM4. The reticle pattern should be centered in the illuminated aperture to within ~100 microradians.
b) Move the table weights, and/or tilt the steering mirror entering the Faraday isolator on LHAM4, if necessary, so that the center of the reticle pattern passes through the Faraday aperture without being vignetted.
Note: It may be necessary to remove LHAM5 door and gain access to the LHAM4 optical table in order to make these adjustments.

q 22. **Adjust the BS PAM magnets:**
a) Turn on the COS LACs in both arms.
b) check the BS alignment by looking at the APSx COS LAC reticle pattern with an infrared-sensitive camera from the outside through the APS viewport on LHAM4. The APSx COS LAC reticle pattern should be superimposed on top of the APSy COS LAC reticle pattern to within ~30 microradians
b) Adjust the BS PAM magnets so that the APSx reticle pattern is superimposed with the APSy reticle pattern.
Note: The APSx and APSy beams can be independently blocked with an opaque card at the BS chamber location.

TITLE

Re-alignment of the LLO 4K Interferometer Vertex Region

q 23. **Adjust the BS Pick-Off beam alignment:**
a) check the alignment by viewing the projected reticle pattern with an infrared sensitive camera looking from the outside into the BS PO viewport on LHAM4.
b) center the alignment through the output optical train, if necessary, by adjusting the BS2 PO mirror in LBSC2. The COS LAC projected reticle pattern should be centered in the aperture to within ~100 microradians.

q 24. **Adjust the ITMx Pick-Off beam alignment:**
a) check the alignment by viewing the projected reticle pattern with an infrared-sensitive camera that looks from the outside into the ITMx PO viewport on LHAM4.
b) center the alignment through the output optical train, if necessary, by adjusting the ITMx PO mirror in LBSC2. The COS LAC projected reticle pattern should be centered in the aperture to within ~100 microradians.

q 25. **Adjust the ITMy Pick-Off beam alignment:**
a) check the alignment by viewing the projected reticle pattern with an infrared sensitive camera looking from the outside into the ITMy PO viewport on LHAM3.
b) center the alignment through the output optical train, if necessary, by adjusting the ITMy PO mirror in LBSC2. The COS LAC projected reticle pattern should be centered in the aperture to within ~100 microradians.

q 26. **Align the MMT3, MMT2, and MMT1 to the Recycling Cavity (RC)**
a) Remove the target on MMT3 and adjust MMT3 PAM magnets (or bias controls if they are within range) to center the COS LAC reticle pattern on the center of a target in front of the center of MMT2
b) Transition to a 10W PSL Laser Hazard Condition per M990151-B-L, M990152-E-L
c) Turn on the PSL 1064 nm laser.
d) Adjust MMT1 bias controls to center the PSL beam on the center of a target in front of the center of MMT2
e) Replace the target on MMT3 and adjust MMT2 bias controls to center the PSL beam to the same position that the COS LAC reticle pattern hit the target in front of MMT3

q 27. **Final Adjust the MMT3:**
a) Turn on the COS LAC in the x-arm.
b) check the alignment of the symmetric port output beam (SPS) through the input Faraday isolator by looking at the SPS COS LAC reticle pattern with an infrared-sensitive camera from the outside through the SPS viewport on LHAM1 in front of ISCT-1. The projected reticle pattern should be centered in the aperture to within ~100 microradians.
b) Adjust the MMT3 OSEM bias voltage so that the reticle pattern is centered.

TITLE

Re-alignment of the LLO 4K Interferometer Vertex Region

q 28. **Final Adjust the MMT2:**
a) Turn on the PSL beam.
b) check the alignment of the symmetric port output beam (SPS) through the input Faraday isolator by looking at the PSL beam with an infrared-sensitive camera from the outside through the SPS viewport on LHAM1 in front of ISCT-1. The PSL beam should be centered in the aperture to within ~100 microradians.
b) Adjust the MMT2 OSEM bias voltage so that the PSL beam is centered.

q 29. Re-check the alignment in steps 27 and 28 and re-adjust MMT3 and MMT2 if necessary.

q 30. **Transition to a Laser Safe Condition** per M990153-E