

K. Kawabe, C. Mueller, V. Frolov

1 References

1. G. Mueller et al., “Input Optics Installation Plan”, LIGO-T1000097
(<https://dcc.ligo.org/cgi-bin/private/DocDB/ShowDocument?docid=9466>)
2. J. Chavez and E. Sanchez, “HAM3-H1 Top Level Chamber Assembly”, LIGO-D0901094
(<https://dcc.ligo.org/cgi-bin/private/DocDB/ShowDocument?docid=2682>)
3. D. Cook et al., “Initial Alignment Procedure - WHAM3 and WHAM3”, LIGO-E1200470
(<https://dcc.ligo.org/cgi-bin/private/DocDB/ShowDocument?docid=91238>)
4. D. Jones, C. Gray and K. Kawabe, “H1 HAM3 Gouy Telescope Preparation”, LIGO-T1200433
(<https://dcc.ligo.org/cgi-bin/private/DocDB/ShowDocument?docid=96299>)

2 Tools and Hardwares

Tool	Number
OzOptics green laser (class 3R) and launcher	1
Platform for OzOptics launcher (e.g. a large metal block with a breadboard on top)	1
2” HR steering mirror for 532nm mounted on surrogate PRM holder from IO	1
Beam viewer card (wiped clean)	1
Assortment of class B Allen keys	1
Class A or B 1/4-20 bolt	Many

3 Procedure

See Figures 1 and 2 for the HAM1, HAM2 and HAM3 layout.

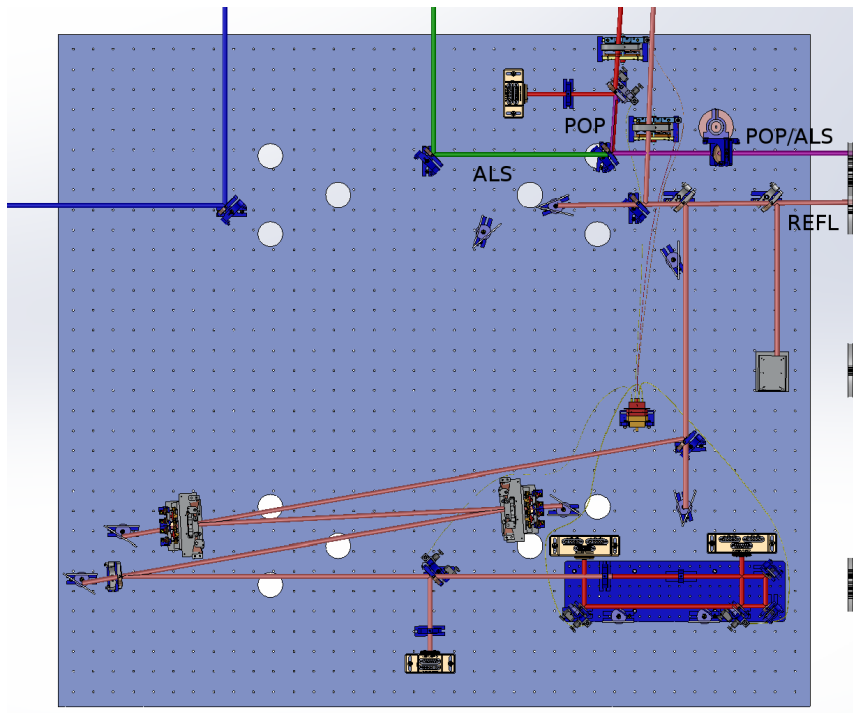


Figure 1: HAM1 layout

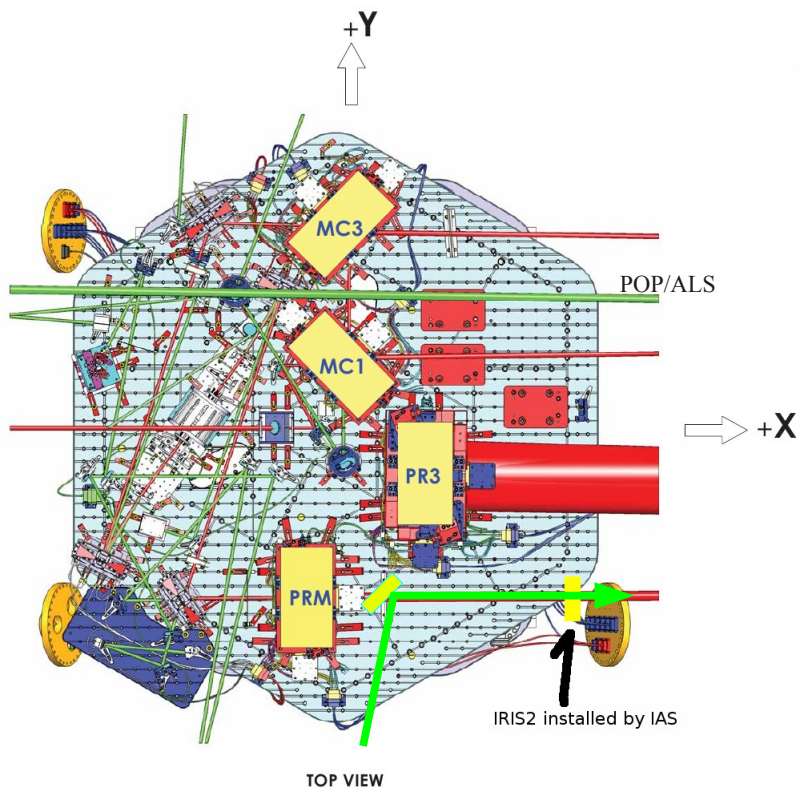


Figure 2: HAM2 layout. Green beam is injected from the East side for POP QPD sled alignment.

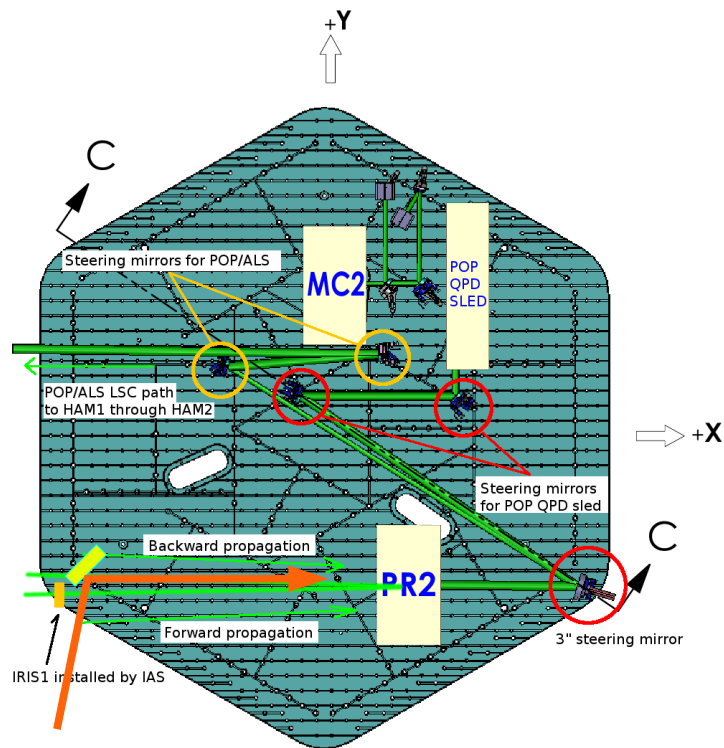


Figure 3: HAM3 layout. Green beam (drawn by an orange line) is injected from the East side for POP/ALS LSC path alignment, but not for POP QPD sled alignment. The angle of forward and backward propagation is exaggerated in this figure. Watch for any clipping by the mirror holder and IAS IRIS1.

3.1 Prerequisite

- At least three persons are present for the task.
- East door of HAM2 should be off.
- Both doors of HAM3 should be off.
- ISIs should be locked down.
- PR2 should be aligned by IAS.
- Two IAS irises should be present, one in HAM2 and one in HAM3, as per LIGO-E1200470 [3].

3.2 POP QPD sled alignment

- Put the launcher/platform for OzOptics laser on the work platform on the East side of HAM2.
- Place a steering mirror between PRM and the IAS iris on HAM2 (IRIS2).
- Hit the steering mirror using the laser launcher from outside.
- Adjust the laser and the steering mirror so that the green beam clears the center of both of IAS irises.

- Transmission from PR2 should be visible on a 3-inch steering mirror behind PR2 in HAM3. Position this steering mirror so the green beam is about a centimeter off from the center of the mirror, horizontally, in the direction of +Y (i.e. toward the EY).
 - This mirror receives both forward-propagating beam, which is aligned in this section, and back-propagating beam, which is aligned in the next section.
 - On PR2 HR surface, these beams forms an angle of about $0.48\text{m}/16\text{m} = 3\text{E-}2$ rad.
 - 3" steering mirror is about 60cm away from PR2 HR, so the two beams will be about $60\text{cm} * 0.03 = 1.8\text{cm}$ (about 0.7") separated from each other.
- There are two motorized steering mirrors for the QPD sled (yellow circles in Figure) downstream of the 3" optics. Once 3" optics is aligned so the next steering mirror is roughly centered, subsequent alignment should be done by adjusting the position and angle of motorized steering mirrors (and the position of QPD sled itself, if this makes things easier).
- Align motorized mirrors (either manually or using picomotors) until both of the QPDs are centered. Use QPD MEDM screen to see the centering.
 - NEVER MOVE/ADJUST THE MIRROR HOLDERS ON THE SLED.
- To confirm that everything is OK at this stage, find a MC flash with 200mW of input from PSL. At the position of QPDs the beam is very small and you can see the beam on a viewer card. You should also be able to see the flash QPD DC sum channel. It's OK even if the QPDs are not centered as long as both of the QPDs see the beam.

3.3 POP/ALS path alignment

- Move the green laser and the steering mirror to HAM3 as per Figure 3 and inject the green beam into PR2. You could inject from PR3 position but launching from HAM3 will make the beam size of the PR2 reflection 20% smaller (Figure 4).
 - Be careful about any clipping by the edge of the mirror holder and IAS IRIS1. There is only about 3cm of clearance between PR2-PR3 path and PR2-PRM path at IRIS1, and the beam diameter in PR2-PR3 path would be about 5mm while that of the PR2-PRM path is about 1cm at the IRIS1 position.
- Adjust the launcher and the steering mirror so that the reflection from PR2 curved surface is centered on both IAS IRIS1 and 2.
 - There should be about 6% reflection from PR2 curved surface and about 0.2% from PR2 AR. The reflection from AR should also be physically much smaller in diameter.
 - Beam diameter on IRIS2 is about 4cm, it doesn't fit the iris. Center it on a best effort basis. An error of 5mm on IRIS2 is not a problem in that the transmission through PR2 will still hit all of the steering mirrors and the beam will come out of the septum window.
 - A 5mm error on IRIS1 is fatal in that the beam would not come out of the septum window without moving the picomotor mirror. See Figure 5.
- Transmission from PR2 should be already on 3" steering mirror behind PR2. It should be off by about a centimeter from the center of the mirror in -Y direction.

- Don't touch 3" mirror unless something is grossly wrong.
- Move two steering mirrors for POP/ALS LSC path so the beam goes through HAM2 between MC1 and MC2, then through the POP/ALS septum window between HAM1 and HAM2.
 - The beam position on the window is mainly dictated by the fact that the beam should stay clear from any of the structures on HAM2.
 - There are more than one windows, but viewed from inside HAM2, POP/ALS window is to the right, high.
- Align POP/ALS periscope and downstream optics in HAM1.

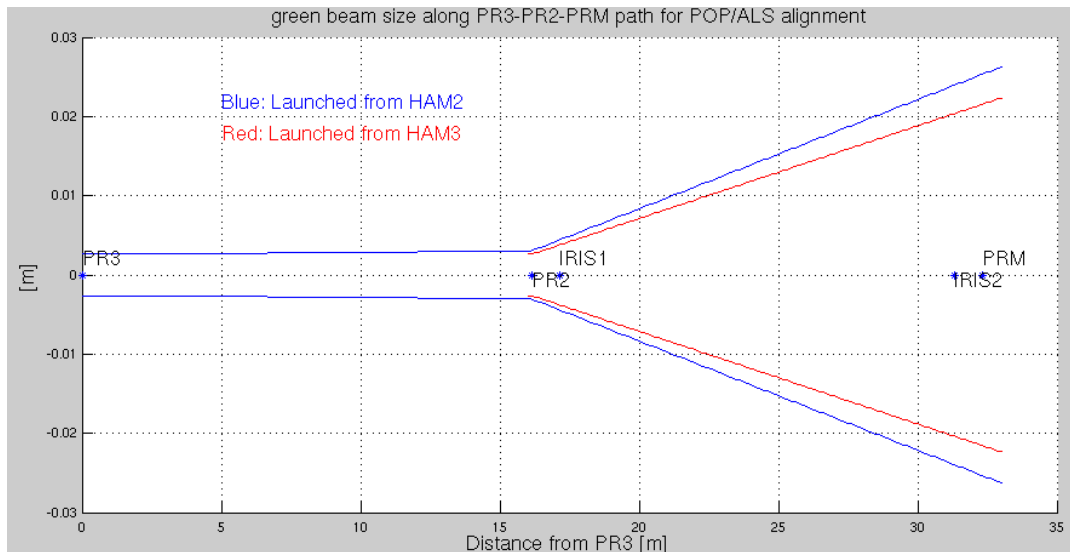


Figure 4: Green beam size along PR3-PR2-PRM path.

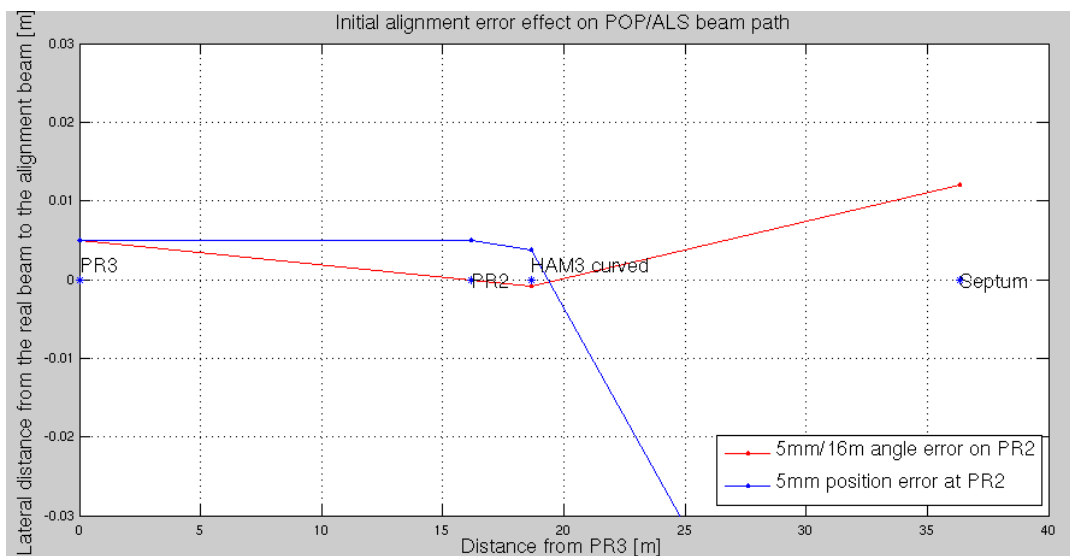


Figure 5: Distance between the real beam and the alignment beam.