LIGO-T2500292-v1: Calibration statements on out of observing mode requests for GW240925n and GW250207bg

Contents

I. PURPOSE

This document serves as a record of checks by the calibration group on the requests for out of observing mode (OOOM) LIGO Hanford Observatory (LHO) data associated with GW240925n and GW250207bg. For reference, in both cases, LIGO Livingston observatory was in its normal observation mode and there was no issue with the calibration. LLO uncertainty budgets are available in the usual locations, specifically https://ldas-jobs.ligo.caltech.edu/ cal/archive/L1/uncertainty/v1/1411/261218/ is closest to 1411261107 (GW240925n) and https://ldas-jobs.ligo-la.caltech.edu/ ling.sun/O4c.1/v1/1422/964818/ is closest to 1422964623 (GW250207bg).

The original original OOOM request document is M2500113.

II. GW240925N

The event happened at GPS time 1411261107.98. The request is for LHO data from GPS time 1411261077 to 1411261110. The issue is the AR frames had cut data from 1411261077 to 1411261087.

The AR frames exclude GPS time 1411261006 to 1411261087. This is because the interferometer had put into a non-observing mode to allow for a change to a configuration setting that is used only during lock acquisition, not during low noise observation mode. Specifically, the H1:ALS-REFL_SERVO_COMOFS value was changed. This part of the control system is related to the arm length stabilization system (ALS) which is not used and has no impact on the interferometer during low noise observing, and thus the change would not have impacted the calibration of the detector or the gravitational wave data.

This was noted in an alog entry at the time, specifically LHO 80282. The alog does not include the exact time of the change, but the data can be gotten from the raw frames. Specifically, H1:GRD-IFO_OK, which is the guardian channel representing the readiness and observation intent of the IFO, was zero for these 81 seconds.
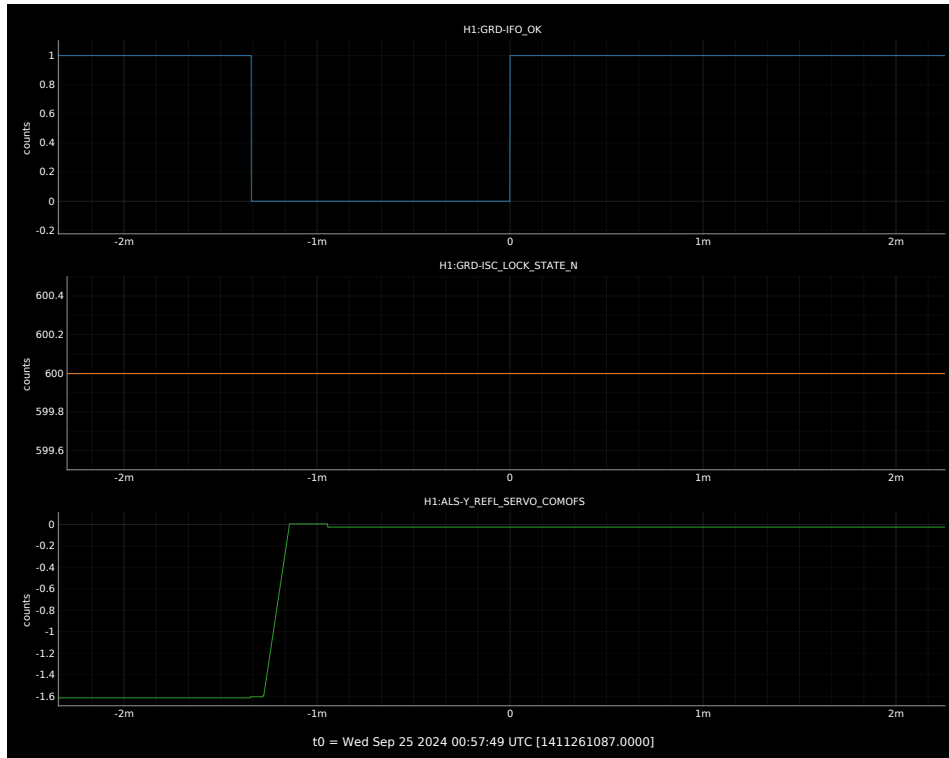
FIG. 1: Trends of the interferometer guardian channels, where H1:GRD-IFO_OK is telling us about observing intent, H1:GRD-ISC_LOCK_STATE_N is telling us the interferometer is in low noise observing state (600 is low noise operation), and the H1:ALS-REFL_SERVO_COMOFS channel is in fact shown to be changing at this time

For completeness, I note that the online data (C00) produced by the calibration group had known defects at the time, with frequency dependent errors as large as 20% in magnitude and 20 degrees in phase. A full accounting of issues can be found in LHO alog 86547.
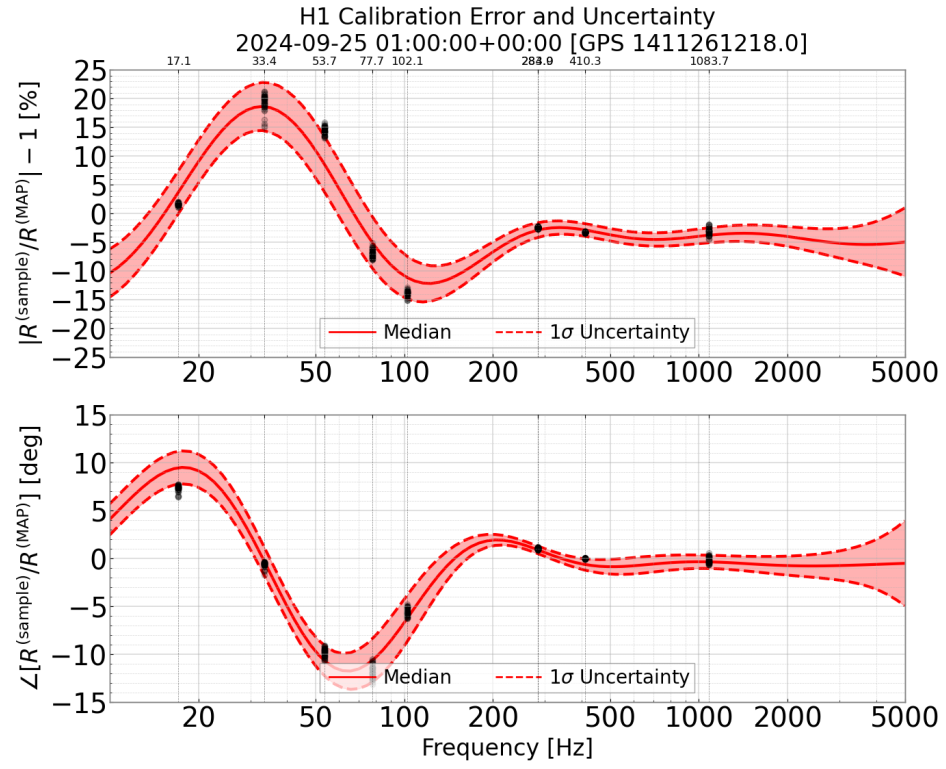
FIG. 2: Online (C00) GW240925 calibration uncertainty budget with monitoring line data overlaid

This bad calibration was one of the reasons a second version of the calibration (called C01) was regenerated.
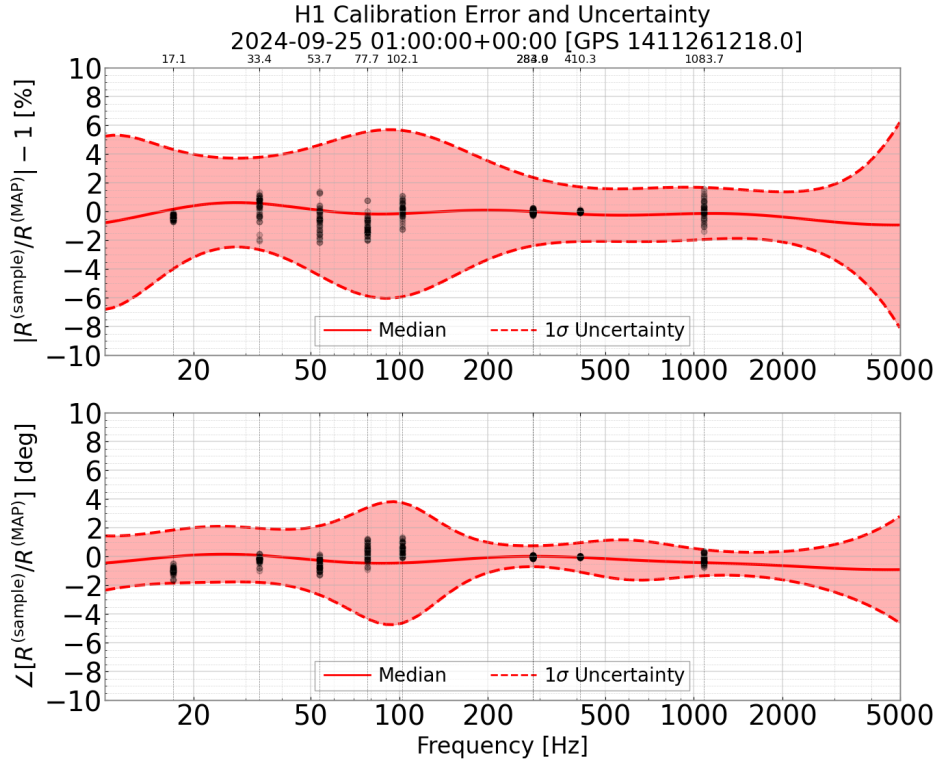
FIG. 3: Regenerated (C01) GW240925 calibration uncertainty budget with monitoring line data overlaid

With the caveat that the online C00 data has errors at the level of 20% and 20 degrees, while the re-calibrated C01 data has better than 6% and 5 degree errors in the 20 to 2000 Hz frequency range, the calibration group sees no problem with using the out of observing mode data requested from GPS time 1411261077 to 1411261110. The calibration group further notes the entire 81 second period that was cut out from the AR frames is usable for parameter estimation or any other use. The C00 best estimate of the uncertainty can be found at https://ldas-jobs.ligo.caltech.edu/ cal/archive/H1/uncertainty/GW240925C00/. The C01 uncertainty budget can be found in the usual place: https://ldas-jobs.ligo.caltech.edu/ cal/archive/H1/uncertainty/v2/1411/261218/.

III.   GW250207B

The event happened at GPS time 1422964623.26. In this case, LHO had just reached its low noise operational state. Specifically, the requested data GPS time is 1422964617 to 1422964626. LHO had achieved its nominal low noise state at GPS time 1422964561, 56 seconds earlier than the requested time.

The gstlal calibration pipeline's longest FIR filters need 10 seconds of data, which was satisfied by this point, but the calibration time dependent correction factors (often called kappas) need several minutes of data to settle. In addition, any line subtraction applied to the H1:GDS-CALIB_STRAIN_NOLINES subtraction channel would also be updating with new data transfer functions and possibly changing over this time.

At the time of interest, the time dependent correction factors values were held constant from the prior lock since the algorithm lacked sufficient good data to update them. Using data from 15 minutes later, when those calculations had clearly settled, the calibration group was able to make a very rough estimate of the error in the calibration in a frequency dependent way. This is not accounting for thermalization effects one would expect to be happening as the mirrors warm up from the full power state. However, as the out of observing mode request is not asking for a calibration error budget, the group feels this check indicates that the calibration is likely to be good enough for analysis. This information is also available in LHO alog 86502
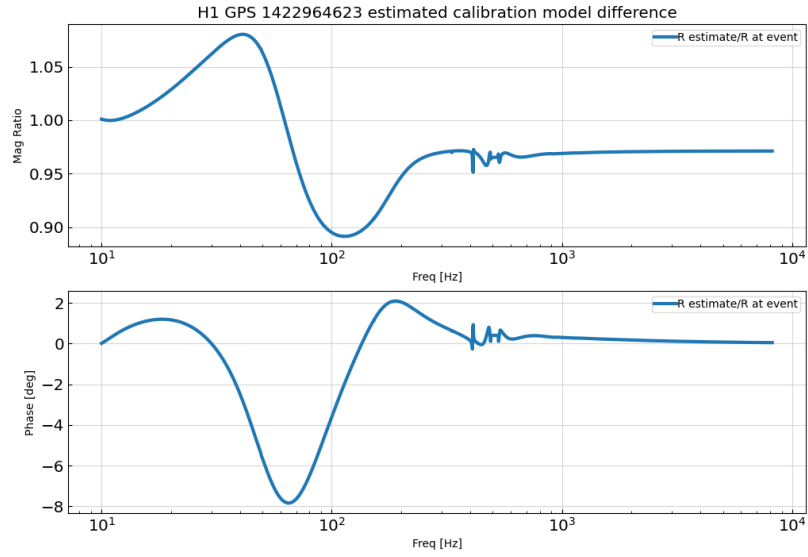
FIG. 4: Ratio of inteferometer response estimated from data 15 minutes later over the interferometer response model applied to online data at GPS 1422964617, the time of the event

Since this investigation suggests the additional multiplicative estimated error is only an additional 12% and 8 degrees on top of the normal calibration error, the calibration group is comfortable with a rough 20% and 20 degree statement during the requested time.