



*LIGO Laboratory / LIGO Scientific Collaboration*

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**LLO, LHO site status for GW150914**

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## 1 Scope

The document [M1500042](#) describes the process for claiming a first detection. Step 1 of this process includes:

- *The Observatory heads activate the process for capturing the complete state of the observatories at the time of the event (assuming a transient event).*

The Observatory heads have delegated this process to the authors of this document. In the following we describe how we have answered this charge for GW150914.

This document includes external links to password-protected document repositories and electronic logbooks, intended for LIGO and Virgo collaboration use. If researchers who are not members of either collaboration require linked information, they can contact the authors.

## 2 Site Status

GW150914 occurred at 09:50:45 UTC on Monday September 14th 2015. The timing of the event was fortuitous in that only respective control room operators were on-site at LLO and LHO at this time. Landry and O'Reilly initiated a poll via email of all personnel at each site in order to confirm this. The results of this survey are in the LIGO Document Control Center at <https://dcc.ligo.org/LIGO-L1500134> (LHO) and <https://dcc.ligo.org/LIGO-L1600016> (LLO).

To summarize: Only the control room operators were on-site at the time of the event. A commissioner left the Hanford site approximately 30 minutes prior to the event. The Physical Environment Monitor (PEM) team (2 people) measuring environmental couplings left the Livingston site approximately 20 minutes prior to the event.

In addition to site staff, our checks include all people who were visitors to the site at the time of the event as well as all contractors who regularly work on-site. Maintenance activities at both sites are constrained to Tuesday mornings from 08:00 to 12:00 local time. With this, and the results of our polling, we are confident that we can account for everyone on site in the early morning hours of Sep 14, 2015.

## 3 Other Checks

We have ensured that all card access logs (LHO and LLO) and video records (LLO only, from the gate at Livingston) be archived. This archive runs from before the time of the event and covers the entire data set analyzed for the GW150914 event. It includes our first re-entry to the experimental areas.

At LHO, M. Landry and electrical engineers confirmed on Oct 14, 2015 that all end station access points such as main door, emergency door and roll-up doors produce an entry in the card reader database. This means that card access logs are a reliable gauge of access to end stations and thus obviate the need for seismometer and microphone investigations for endstation VEA access near the time of the event. Note that this is not the case for the cornerstation LVEA: cardreader access beyond the two main access points is not uniform and most emergency exits currently are not wired to create an electronic record in the card access log. This will be modified post-O1, with a revamping of LHO card access.

At LLO it is possible to access both the end stations and corner stations by using a key to non-alarmed doors. However any normal visit to an end station clearly registers on PEM channels (see <https://alog.ligo-la.caltech.edu/EVNT/index.php?callRep=11432>). Even with stealth the low frequency microphone or tiltmeters would record any entries to the experimental areas. The PEM channels at LHO have similar sensitivity.

Subsequent to the event candidate's discovery the maintenance activities, which had been scheduled for September 15th, were postponed. This included a cancellation of LN2 deliveries at both observatory sites. We restricted entry at both LHO and LLO to the Vacuum Equipment Areas (VEAs) at the corner and end stations. This included the Electronics bays at the corner and the end stations.

There is one recorded entry to the electronics bay at the Livingston corner station on September 15<sup>th</sup> by an electronics expert (cf. <https://alog.ligo-la.caltech.edu/aLOG/index.php?callRep=20570>). This entry was recorded in the general aLOG. The purpose was retrieval of a part from the spares' storage (<https://alog.ligo-la.caltech.edu/aLOG/index.php?callRep=20579>). Given that entry to the electronics' bays is not controlled by card access (LLO only) it is possible that there were other incursions. However, such entries are usually made in order to do some troubleshooting and should appear in both the operator's shift log and in a log entry related to the activity. People can (and have), entered these areas without informing the operator(s).

On September 22<sup>nd</sup> we interrupted observations for needed maintenance, in particular deliveries of LN2. We made controlled entries to the experimental areas and electronics' bays and documented the state of the instrument as we found it. We are confident that this constitutes an accurate picture of the physical state of both observatory halls and instruments at the time of GW150914.

At LLO we have photographs, video, and written documentation. The latter can be found at: <https://alog.ligo-la.caltech.edu/EVNT/index.php?callRep=11317>, and in the DCC at <https://dcc.ligo.org/LIGO-L1600020>. The photographs and video are stored locally, with multiple backups including hardcopy. They have also been uploaded to resource space (<https://ligoimages.mit.edu/pages/search.php?search=!collection1632>). Many of the items found are of a banal "house-keeping" variety and can be attributed to the fact that the clean up that normally occurs at the beginning of an observation run was postponed. Local detector and electronics experts examined the photographs. They saw nothing of concern. Some minor questions were followed up with the relevant people.

Similarly at LHO, the cornerstation LVEA and end and midstation VEAs were toured on maintenance Tuesdays Sep 22 and Sep 29, yielding written documentation on the state of the experimental halls, and photographic assays of i) all electronics racks, and ii) status and housekeeping. These sweeps, and links to photographs of the halls and electronics are given in the DCC document <https://dcc.ligo.org/LIGO-L1500139>. 536 photos were taken of the electronics racks and VEAs. All of these photos have been reviewed in detail and reports given in the L1500139 doc, above. No noteworthy activity was found and any installations that were initially not understood were followed up upon and found to be acceptable.

## 4 Potential for unexpected injection

Part of the site status assessment is to address the possibility that GW150914 was an unexpected injection, either made in hardware as an analog injection, or via software. Several different studies have been made to assess this possibility. We summarize them here for completeness:

- A technical doc <https://dcc.ligo.org/LIGO-T1500536> considers the signal morphology around the DARM loop, showing GW150914 cannot be a signal added to the control stream.
- The Control and Data Systems (CDS) group made a detailed audit of CDS computers, <https://dcc.ligo.org/LIGO-T1500541>. This document showed that there was no unusual activity on the CDS network in the days leading up to and after GW150914. Furthermore this study suggested additional ways to modify the CDS network, to close some loopholes in logins and file handling, etc. These mechanisms were implemented in Oct 2015.
- The EVNT log <https://alog.ligo-la.caltech.edu/EVNT/index.php?callRep=11382> describes inspections of electro-static drive and output photodiode electronics at LLO. We applied ad-hoc seals to the relevant chassis in lieu of taking any risk in opening them. After the run these seals were inspected and found to be intact. The internal electronics were inspected, photographed and compared to the as-built schematics. No problems with the integrity of the electronics were found (<https://alog.ligo-la.caltech.edu/EVNT/index.php?callRep=11561> and <https://alog.ligo-la.caltech.edu/EVNT/index.php?callRep=11563>).
- The EVNT log <https://alog.ligo-la.caltech.edu/EVNT/index.php?callRep=11566> describes similar efforts at LHO to seal electronics, and later inspect them, photographing and comparing to as-built schematics, for evidence of unexpected injection. None was found. The inspected electronics were later re-sealed.

## 5 Conclusion

The timing of the event candidate GW150914 made it relatively straightforward to assess the state of the instrument and the site. We are confident that we understand what was happening on each site at the time of the event and that we have good documentation of the physical state of the instrument at this time. We conclude that there were no unusual persons or activity at either site during the time of GW150914. We see nothing that would impede advancing this candidate to the next step or steps of the Detection Committee checklist.