Search of S5's First Calendar Year for Coincident Saturation Events

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Introduction

It's been suggested that a strong gravity wave could actually saturate IFO's, leading to data quality flags or even lock-loss. As a first attempt to search for such events, we conjecture that if a gravity wave is indeed at hand, saturation should occur in 2 or more IFO's. This note outlines a search of the first calendar year of the S5 run for "coincident saturation events."

Methods and Results

We consider the possibility that segments of data usually thought of as unusable might actually be indications of gravitational waves. Specifically, we look at 2 lists of times: lock-losses (represented by science mode end times) and overflows in the length sensing control (LSC) channel. We consider a "coincident saturation event" any time when 2 or 3 IFO's concurrently experience lock-loss or the start of an LSC overflow flag.

Using Segwizard, we assemble lists of lock-loss times for each detector (the end times of science mode segments) and lists of LSC overflow times (the start times for the MASTER_OVERFLOW_LSC data quality flags). Hardware injections are associated with data quality flags, so we omit overflow flags that start during a hardware injection. The lists from all 3 detectors are compared, seeking coincident times. We impose the condition that times must agree to 1 second to be considered "coincident." In addition, we time shift the data to see if our results are within the typical statistics of such a search.

Double event counts (coincident saturation in two detectors) appear below. Here, we take time shifts in 3 second intervals. A positive time shift means that the time is subtracted from H1 and added to L1.

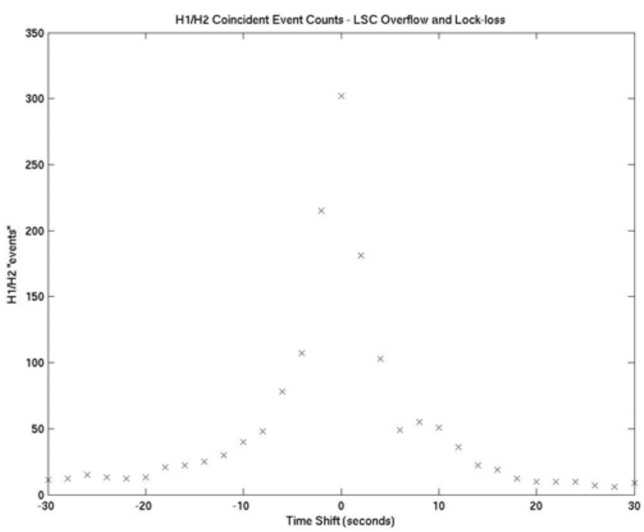

Figure 1

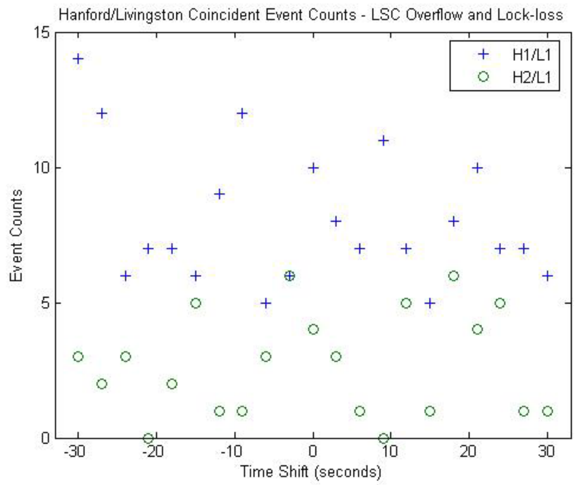

Figure 2

H1 and H2 (Figure 1) share many events near 0 time-shift. Partially, this reflects the shared environment of these two detectors. Additionally, the list of lock-loss times is really the end times of science mode segments, so some of these H1/H2 coincident times may be times when the Hanford IFO's are intentionally taken out of science mode.

Comparison between Hanford and Livingston (Figure 2) reveals that the 0 time-shift double events are not statistically exceptional. However, we plan to further pursue the H1/L1 and H2/L2 double events by comparing these times to trigger lists. If any of these double events are the result of a GW, we expect to see a coincident trigger in the third detector. Particularly, there are 10 coincident saturations of the two 4 km IFO's. A strong trigger in the H2 detector at one of these times is an interesting possibility.

Triple Coincidence Event

We find only one occurrence of a 0 time-shift saturation triple coincidence. This occurs at Jan 4, 2006, 08:36:58 UTC. The event is a triple lock-loss event, and seems to be consistent with an earthquake that the US Geological Survey reports as originating in the Gulf of California at 8:32 UTC. The reported epicenter is equidistant from the Hanford and Livingston sites to within 3%, making coincident lock-loss as a result of the earthquake plausible.

Follow-Up with Loud Triggers

To follow-up the double coincident events between Hanford and Livingston, we postulate that if a gravitational wave passes through with magnitude sufficient to cause a veto and/or lock-loss in 2 detectors, then the third detector should – at a minimum – experience a large trigger.

To put this idea to practice, we download loud KW triggers (significance greater than 200) from the darm-err channel for the first calendar year of S5. We now call a "triple coincidence" an event when 3 detectors experience end of science mode, the start of an LSC_overflow flag, or a loud darm-err trigger within a 1 second window. We exclude the case where all three detectors experience only a loud trigger, with the idea that these events will be carefully studied in "typical" burst group analysis. The triple coincidence results, with time shifts, are shown in Figure 3.

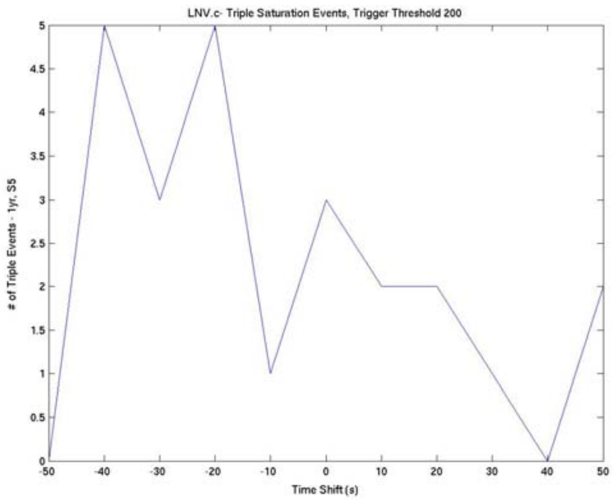

Figure 3

At zero time shift, we discover 3 "triple coincident" saturation/loud trigger events. One of these events is the earthquake induced, triple lock-loss event discussed above. The other two events are times when H1 and H2 register loud triggers during a hardware injection, coincident with a lock-loss in L1. The times of the three events are shown below:

820399032 – triple lock loss - earthquake
825691758 - hardware injection
826593393 - hardware injection

A follow-up showed that both hardware injection events were associated with highest amplitude, 3kHz injections which are known to be problematic.

In addition, Erik Katsavounidis has performed a study of lock loss times as well as science mode start times. His search confirms the single occurrence of a triple lock loss event. He also provides many interesting plots and statistics. In particular, he makes a study of time between lock losses, and finds in H1 *and* H2 a strange preference for 2500 seconds between consecutive lock losses. His results may be viewed here: http://lancelot.mit.edu/~kats/s5/kw2/815155200_849715200_day1_to_day400_locks/

Implications

In the first year of S5, we find no evidence for a saturating gravitational wave. While such a powerful GW event seems unlikely, searches of this nature are simple and easy to implement. They could be run occasionally to rule out this possibility.