Earth-Shaking Effects

Assessing EQ Mode Impacts on LLO DQ

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Overview

Context

- What is EQ Mode?
- Previous work at LHO
- Commissioner information on configuration tracking

Current Decisions

- Why glitch rates?
- 30-second averages and temporal trends

Next Steps

- Undesired noise sources

Understanding EQ Mode

- Earthquakes at observatory sites can cause laser cavities to lose lock.

Shaking ground ---> Shaking mirrors ---> Unstable resonance in IFO cavities

- Preventing lock loss helps to maximize useful observing time.

- Changing the behaviour of seismic isolation platforms during earthquakes can prevent lockloss due to EQs.

Previous Work

We are building on a report concerning the effects on BNS range and glitch rates of transitions to and from LHO EQ Mode: https://docs.google.com/document/d/1QRJjDHjEjjRVa_5cqBDLcwskDhnK2W

Document authors: Brennan Hughey, John Zweizig, Nicolas Arnaud, and Dripta Bhattacharjee

Glitch rate data they reported:

SNR(>=)	Tran - 8	Tran - 2	Trans	Tran + 8	Tran + 2
5	0.44061	0.43222	0.49538	0.49446	0.467307
6	0.01928	0.02827	0.04559	0.03022	0.02280
10	0.00697	0.00935	0.00951	0.00539	0.00494

Goals for LLO Extension

- Understand the uncertainties in DQ-related values for statistical comparison between configurations
- Intelligently select and sift for useful time segment categories
- Account for potential differences between IFO sites

Commissioner Info

aLog 51380 contains the information with which we started in searching for channels indicating observatory configuration. Information below is from there.

Definition 1 Summary:

Transition to EQ MODE: L1:GRD-SEI_CONFIG_STATE_N == 14 ("SWITCH_IFO_SENSCOR_TO_EQ_DM")

EQ MODE: L1:GRD-SEI_CONFIG_STATE_N == 15 ("EARTHQUAKE_ON")

Transition out of EQ MODE: L1:GRD-SEI_CONFIG_STATE_N == 9 ("SWITCH_IFO_SENSCOR_TO_NOMINAL")

EQ Mode Off: L1:GRD-SEI_CONFIG_STATE_N == 10 ("EARTHQUAKE_OFF ")

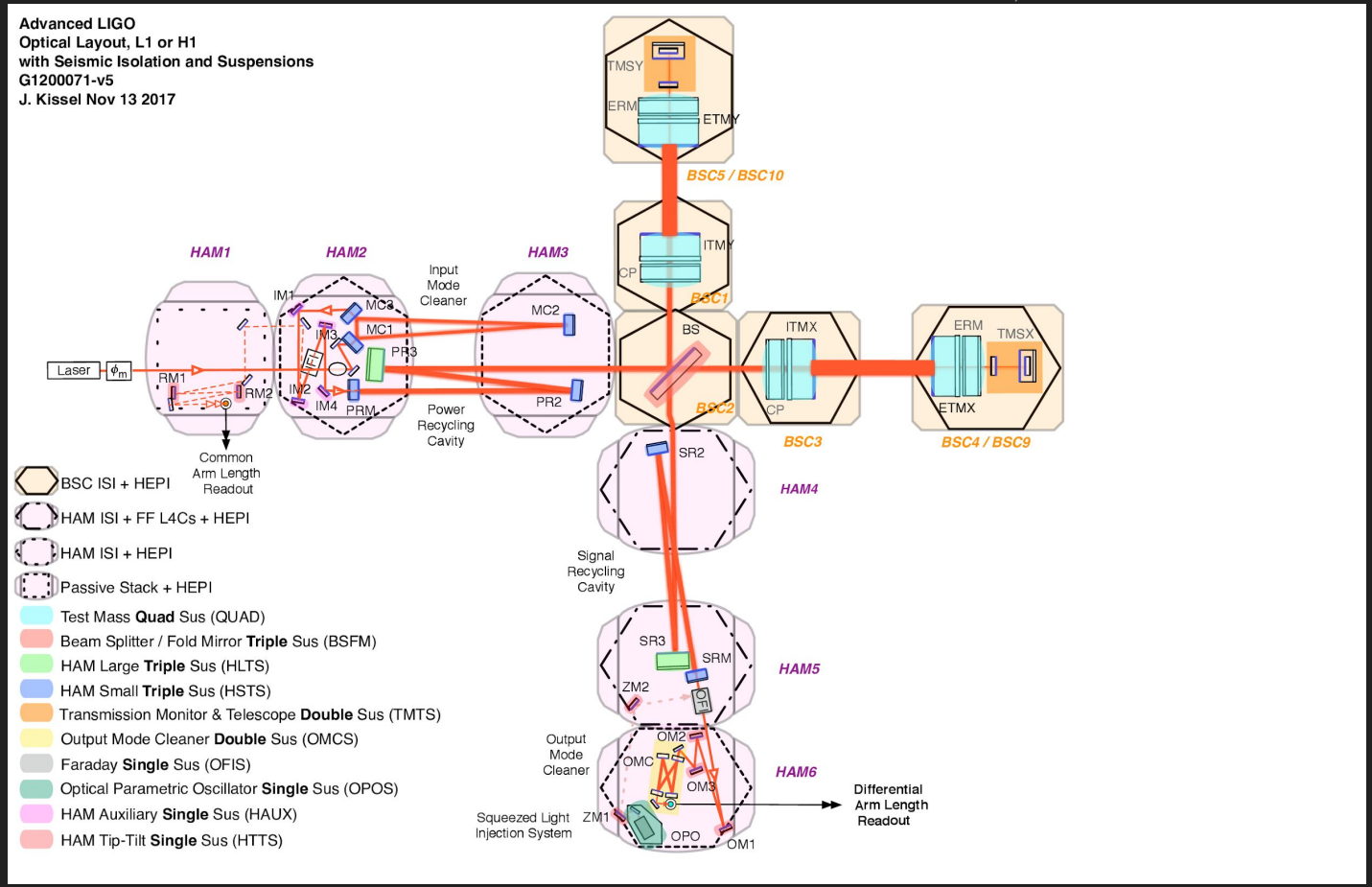
Definition 2 Summary:

If any of the channels L1:ISI-{BSC_ST1 or HAM}_SENSCOR_{X or Y or Z}_FADE_CUR_CHAN_MON == 5, 6 or 7 this means the earthquake mode is engaged (Currently using FM5)

The transition timing can be monitored by this countdown channel : L1:ISI-{BSC_ST1 or HAM}_SENSCOR_{X or Y or Z}_FADE_TIME_LEFT_MON

Obligatory IFO Diagram

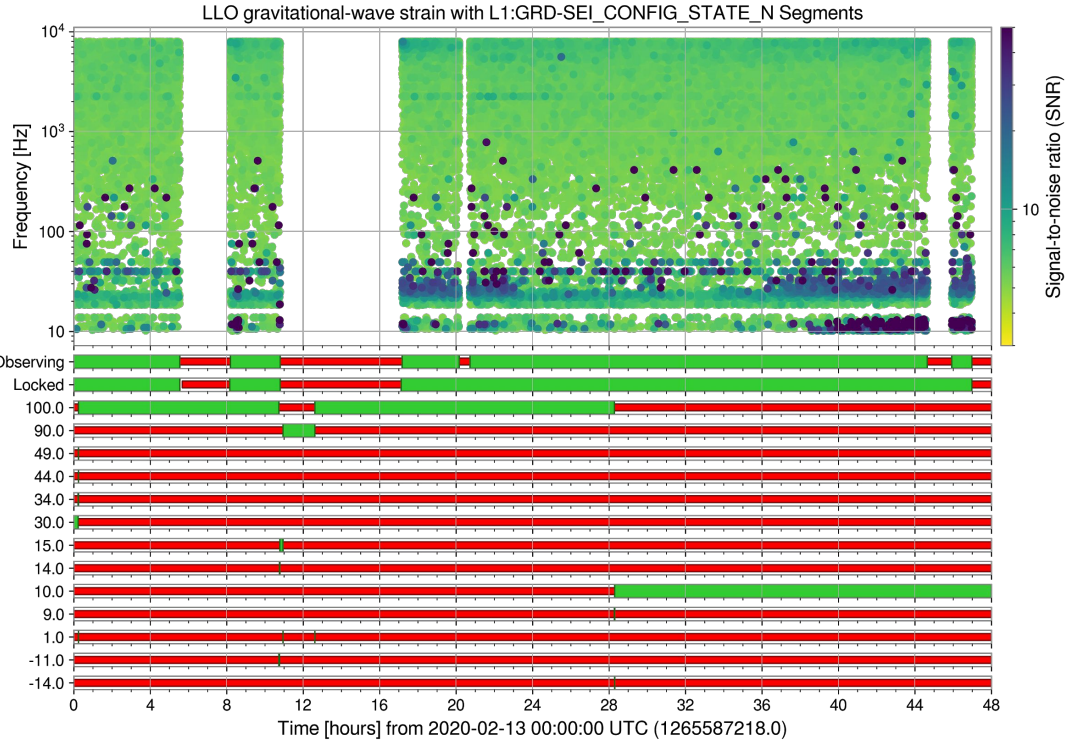
Credit: J. Kissel, DCC LIGO-G12000



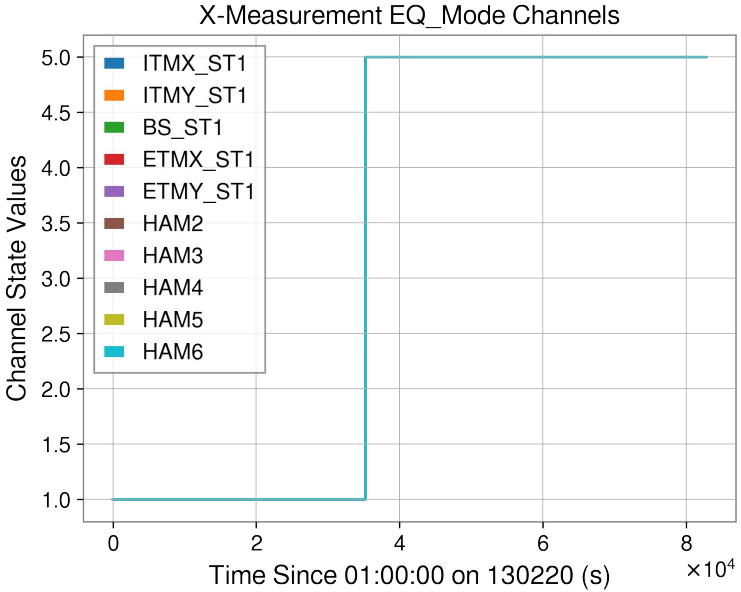
Comparing Definitions

Feb 13 - Raine Hasskew reports in aLog 51639 that LLO was in EQ Mode during 1047 UTC 2/13/20 through 0417 UTC 2/14/20

Method 1: Transition to 15 ('EQ_ON') inconsistent with aLog



Method 2: Transition to 5 consistent with aLog

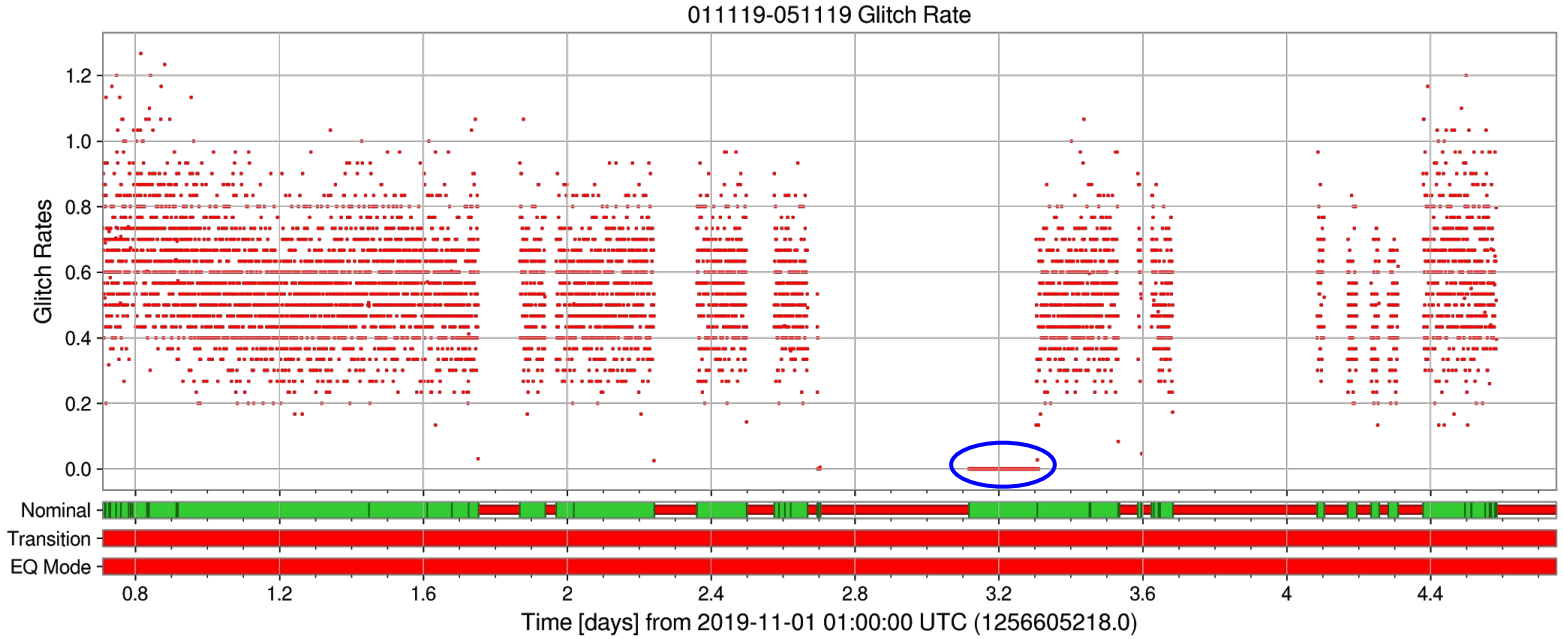


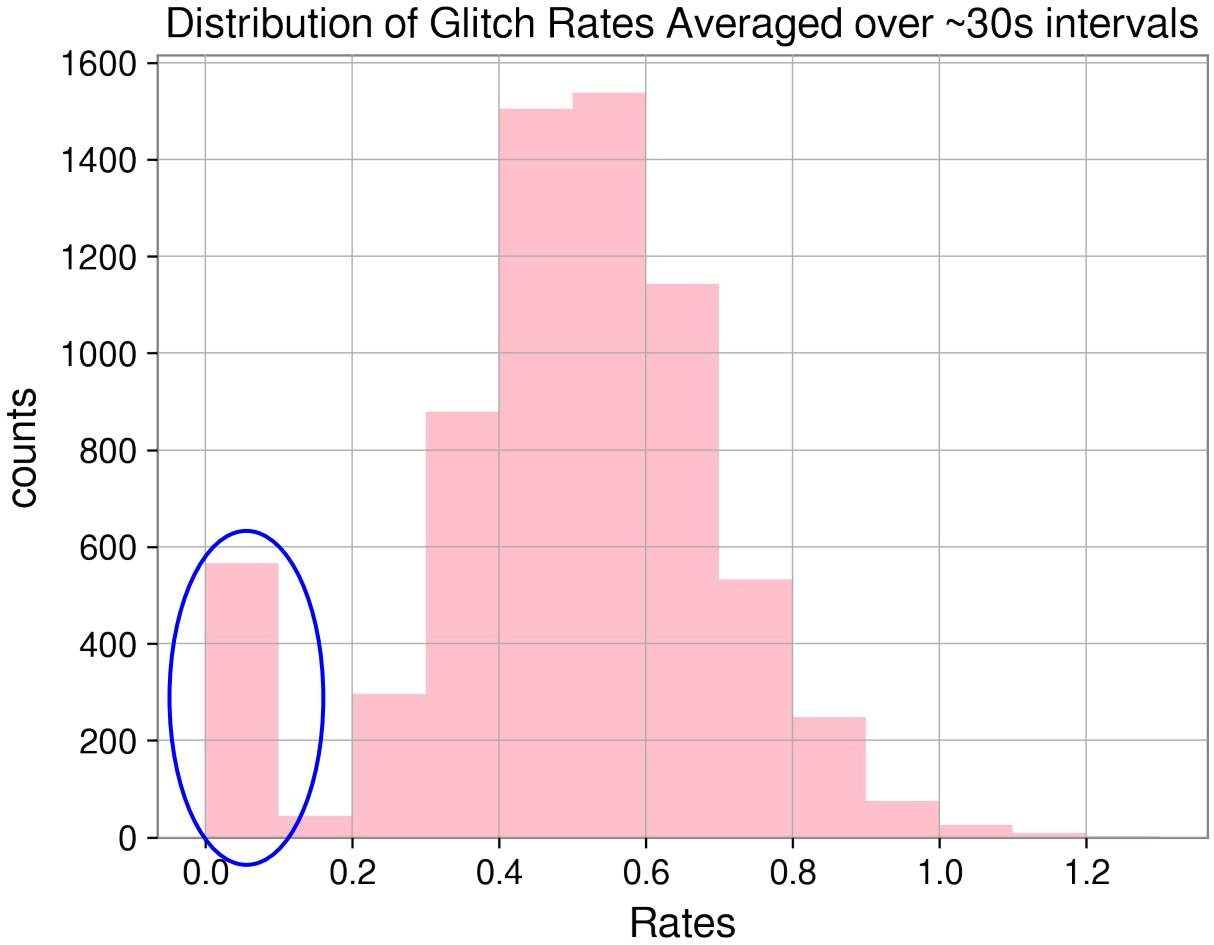
Why Glitch Rates?

“the systematic removal of noisy data from analysis time is shown to improve the sensitivity of searches for compact binary coalescences” (Abbot *et al*. 2018)

- Correlation between glitch rates and ‘search volume sensitivity’ (minimum discernible signal strength of an event).
- Qualitatively gaussian rate distributions indicate that statistical comparisons are possible.

An example, and a Mystery




Distribution of Glitch Rates Averaged over ~30s intervals
counts
1600
1400
1200
1000
800
600
400
200
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Rates

Unwelcome Noise

These noise sources also influence glitch rates, and thus should be removed to isolate for observatory configuration effects.

- Wind

Potential solutions include removing wind speeds >= 5m/s and applying a cutoff to tilt motion channels - caveat concerning ‘glitchy’ behavior inconsistent with other SEI information.

- Anthropogenic Sources

Potential solutions include BLRMS_3_10<=500 nm/s and cutting known high-noise times out from data examined

- Microseism

Potential solutions include the fixed threshold BLRMS_100M_300M<=1000nm/s

Conclusion

- Glitch rates are a useful metric for determining IFO data quality

- We can measure glitch rates during times coinciding with different detector states, and establish uncertainties for them. We are planning to do this for comparison between earthquake-related detector states.

- In order to examine potential state-DQ correlations, we need to compare times with different states, but similar environmental conditions

Noteworthy Contributions

- Project management: Jess McIver, Evan Goetz
- Seismic Expertise: Beverly Berger
- Coding Assistance: Arnaud Pele, Katie Rink

Works Cited

B P Abbot *et al*. (2018). Effects of data quality vetoes on a search for compact binary coalescences in Advanced LIGO's first observing run. *Classical and Quantum Gravity, 35.*(6). 10.1088/1361-6382/aaaafa