

Detector characterization

Lessons learned from O1 and preparing for O2

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for the DetChar group

LIGO DCC G1601646

Outline

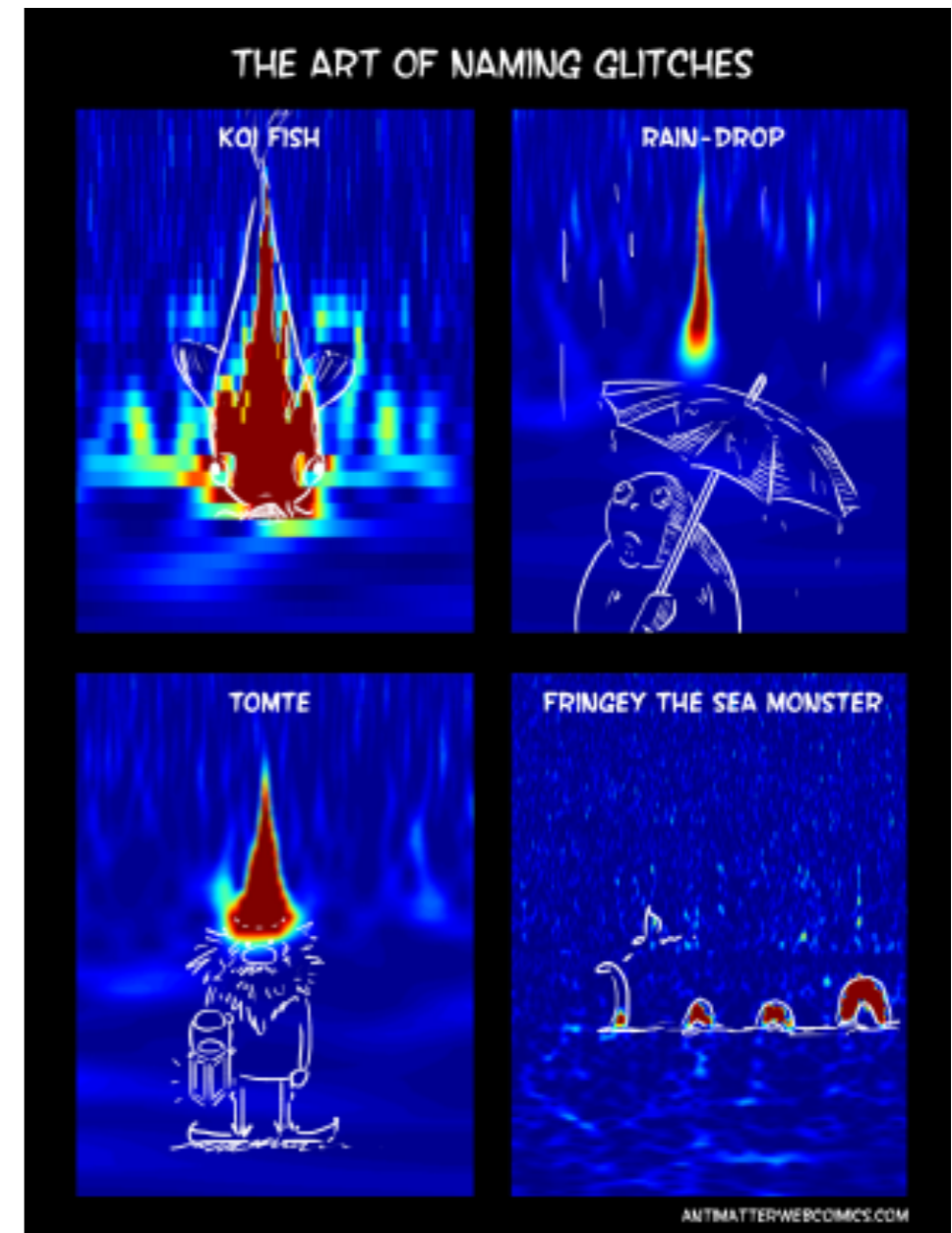
- Most problematic noise for the searches during O1
- Overview of DQ vetoes applied during O1
- Development towards O2

Most problematic noise for the searches during O1

- Glitches
- Combs
- Breathing noise
- Low-frequency noise

DetChar keeps track of this here:

<https://wiki.ligo.org/DetChar/WhiteBoard>



N. Kijbunchoo

Blip glitches

#1 Most wanted

Summary

- 10ms or less in duration
- 16-1024 Hz
- Appear in H1 and L1 $\sim 1x/hour$
- Similar glitches seen in S6

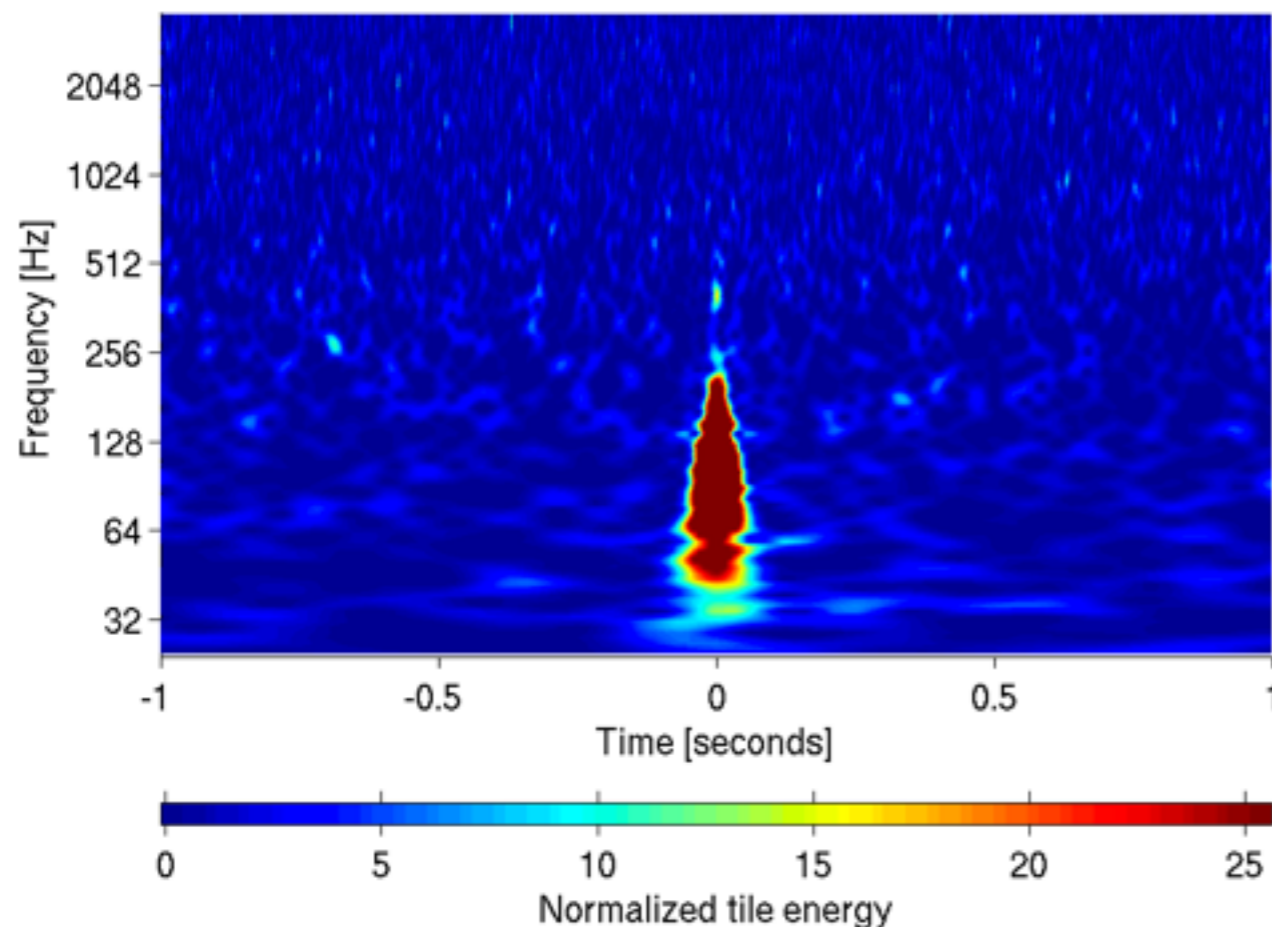
Impact

Biggest contributor to CBC and burst backgrounds

What do we know?

- No strong correlation with auxiliary channels
- Multiple different morphologies (different time-frequency content)
- These different classes potentially originate from different mechanisms
- Studies by Miriam Cabero: [G1600359](#), [G1600583](#)
- They are consistent with the step response of a high-pass filter
- Seen in both DCPDs simultaneously
- Correlation with humidity reported at LHO: [alog](#) (Paul S, Robert, Jordan)

L1:GDS-CALIB_STRAIN at 1124197089.188 with Q of 24.6



RF modulation

#2 Most wanted

Summary

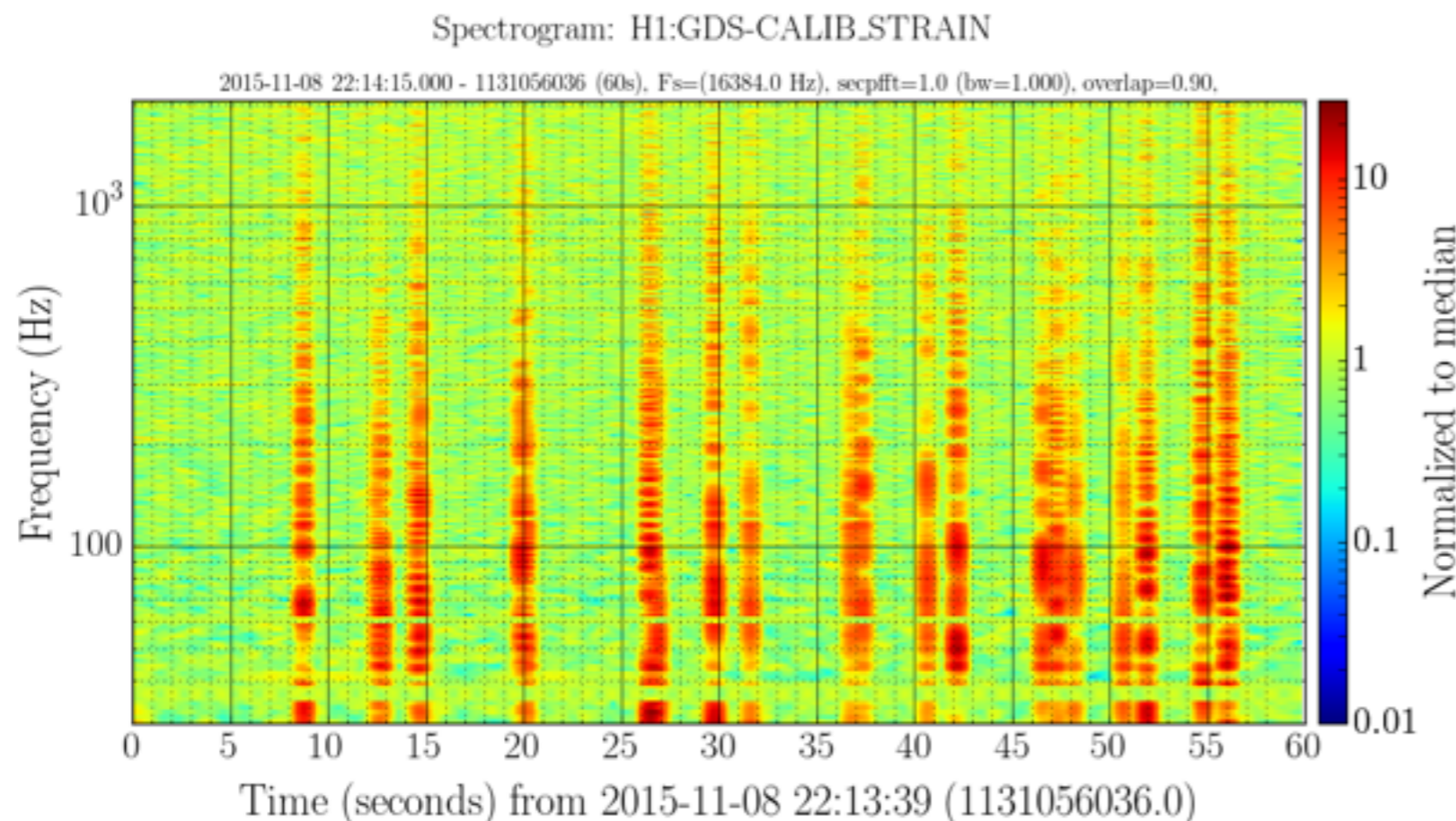
- Seen at LHO only
- Shows up in demodulated photodiodes (9, 36, 45 MHz)
- Seen in vertex DOFs (MICH, SRCL, PRCL)
- Broadband h(t) pollution; makes data unusable for the astrophysical searches

Impact

Easy to veto, but costs a significant amount of coincident lifetime.
Seen hours before GW151226.

What do we know?

- RF noise showed up in several demodulated photodiode signals throughout the run, but there was no consistent best witness channel: alog (TJ, Laura)
- Next step tests: now that a stabilization box is also installed for 9 MHz, compare photodiode witnesses for 9 MHz and 45 MHz during a period of RF modulation noise



1 Hz combs

#3 Most wanted

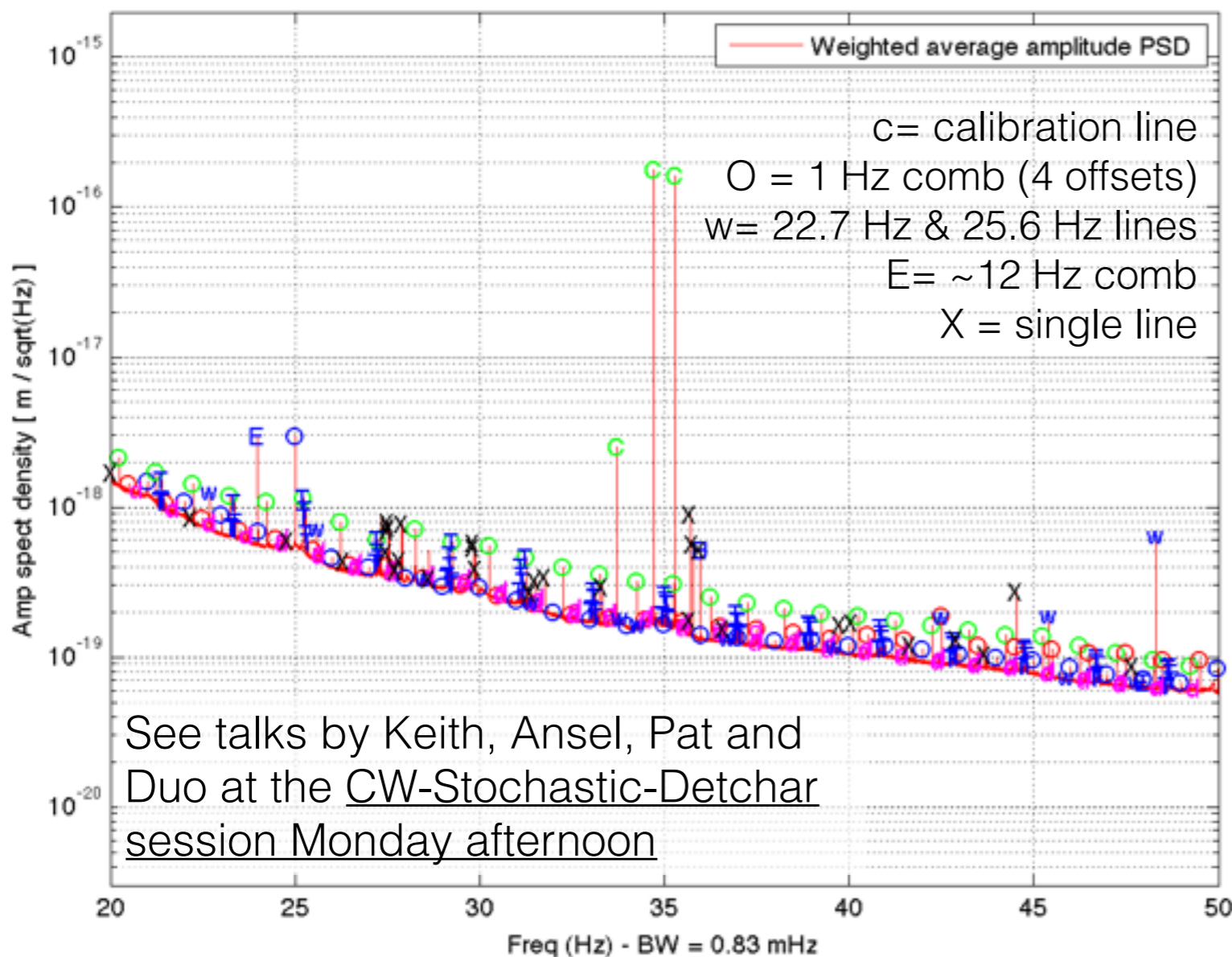
Impact

- Biggest contributor to CW and stochastic backgrounds; many frequencies need to be excised from the data.

Summary

- Appear in intervals of ~ 1 Hz at both L1 and H1 before, during, and after O1.
- Line character has changed between iLIGO and aLIGO.

O1 Average L1-CAL-DELTAL-EXT Spectra (20-50 Hz)



What do we know?

- Summary of blinking LED interventions: [alog](#) (Keith R)
- During O1 ~ 1 Hz combs were observed in L1 h(t) up to 113 Hz, with various offsets in rough multiples of 0.25 Hz: [alog](#) (Keith R)
- ~ 1 Hz combs also seen in H1 during O1, and new 1 and 2 Hz combs seen up to ~ 200 Hz during ER9: [alog](#) (Keith R)

60-200 Hz non-stationary noise

#4 Most wanted

Summary

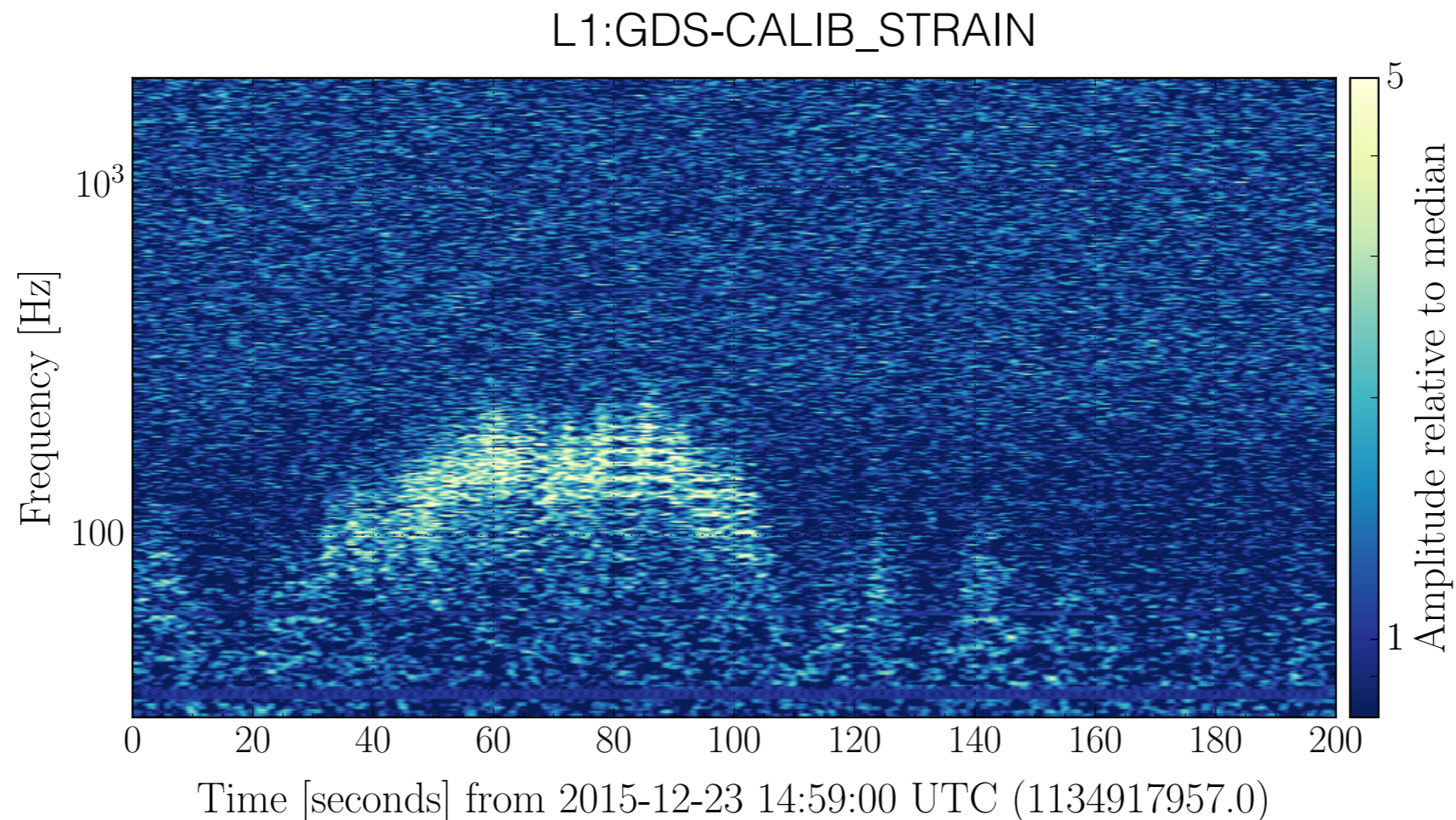
- Observed in LLO data
- Affects 60-200 Hz on the scale of minutes

Impact

Pollutes LLO data in a critical frequency range.
Contributor to CBC and burst backgrounds.

What do we know?

- It is actually composed of discrete glitches with a repeating structure of $n \times 14\text{Hz}$ lines: G1601301
- Shows up in bursts ~2 minutes long on the order of 1 per tens of minutes



Low frequency glitching

#5 Most wanted

Summary

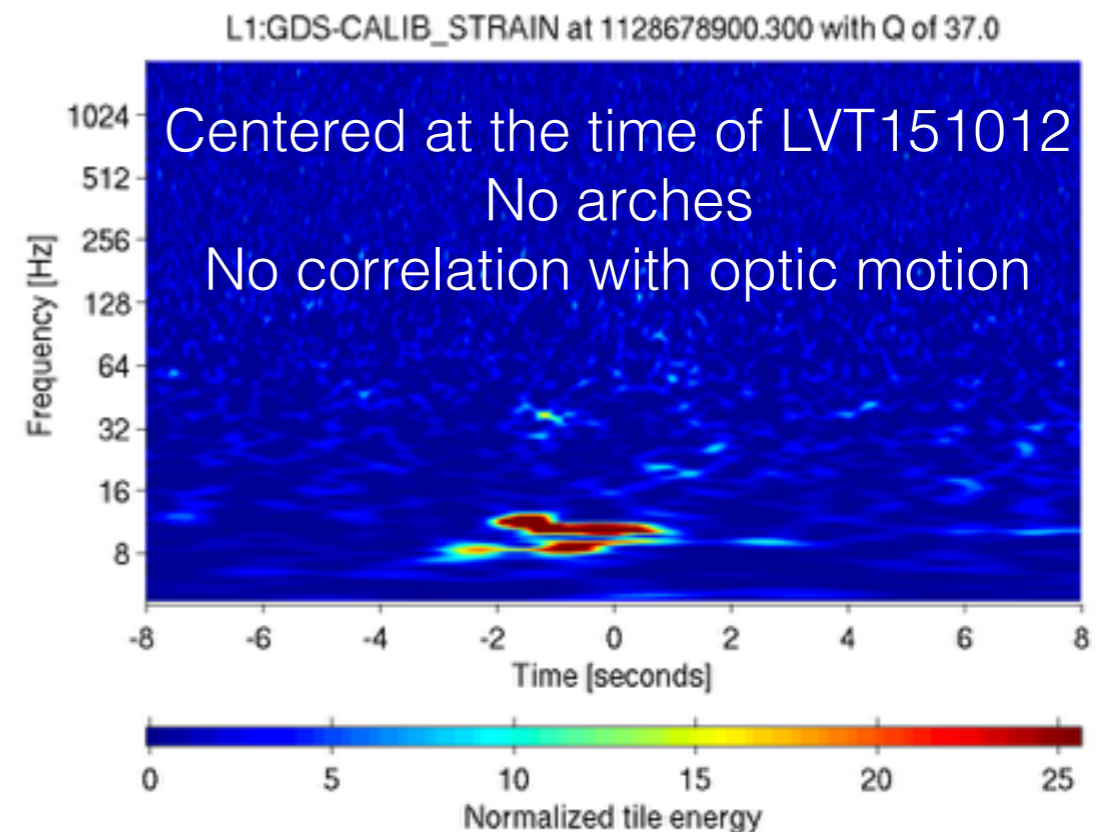
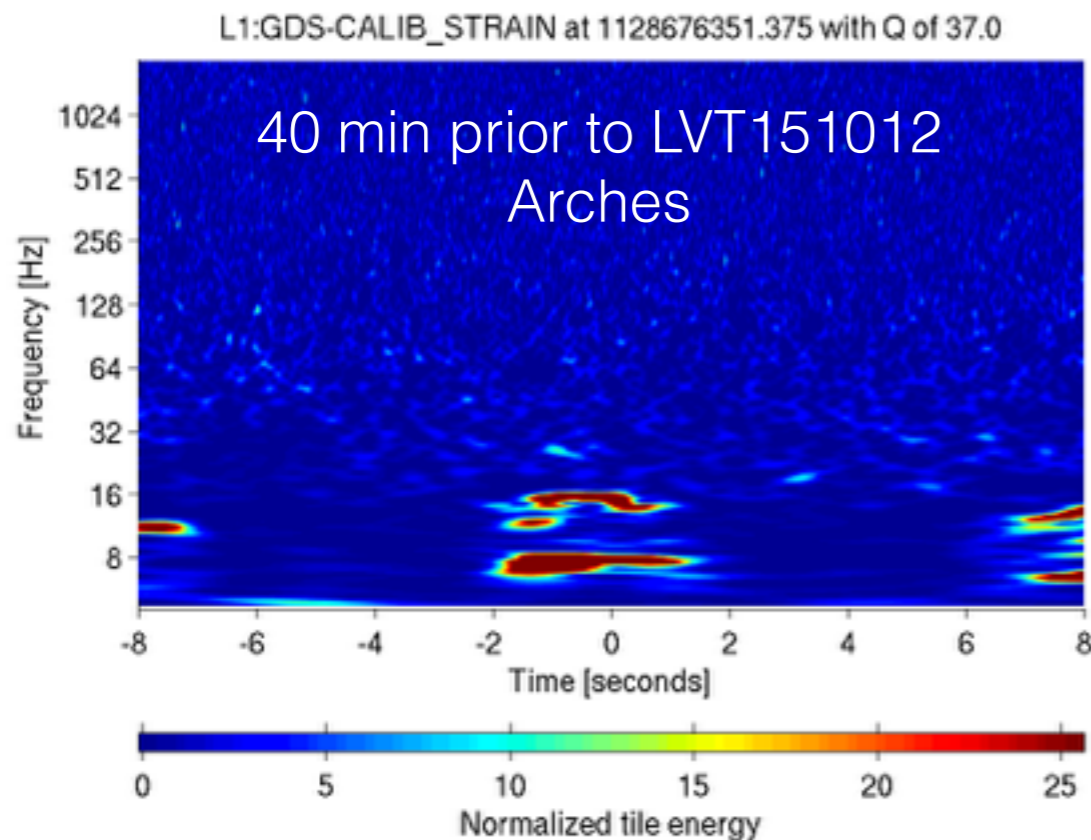
- Observed below ~ 30 Hz at LLO starting in mid-October 2015
- Two major morphologies: scattering and short duration 'scratchy' glitches

Impact

- Pollutes the data at important frequency range for BBH parameter estimation.
- CBC and burst searches will extend below 30 Hz.

What do we know?

- Some correlation between rate of low frequency glitching and elevated ground motion, particularly the microseism band
- The scattering below 30 Hz is sometimes well predicted by monitoring the motion of the major suspended optics. ([Summary pages scattering monitor](#) developed by Fullerton)
- Will look for improvement now that new Faraday isolator is installed



Breathing 55-90 Hz noise

#6 Most wanted

Summary

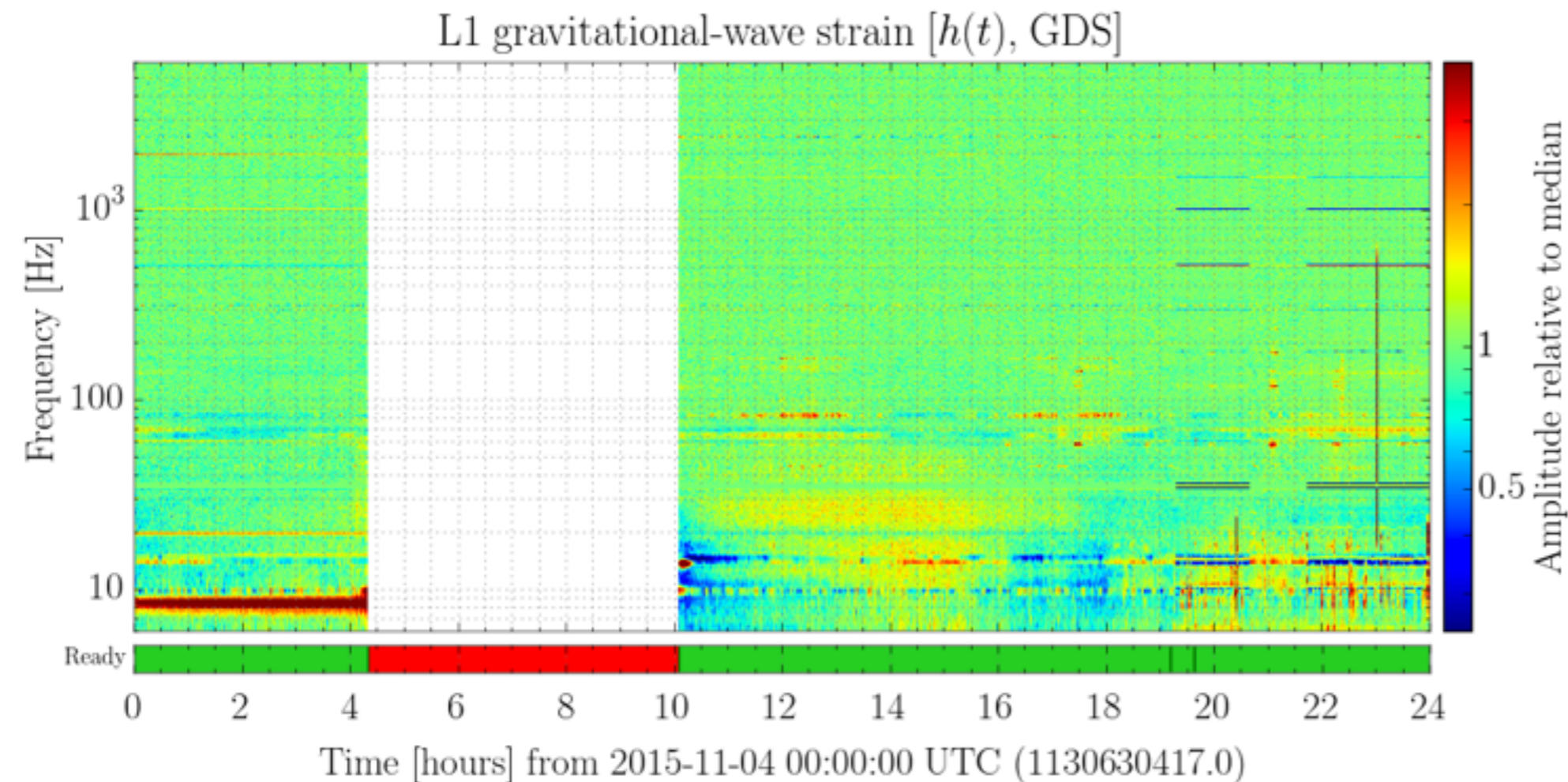
Seen in L1 data during O1.

Impact

Pollutes LLO data in a critical frequency range.

What do we know?

- This appears as a long-duration effect (breathing in and out on the scale of minutes)



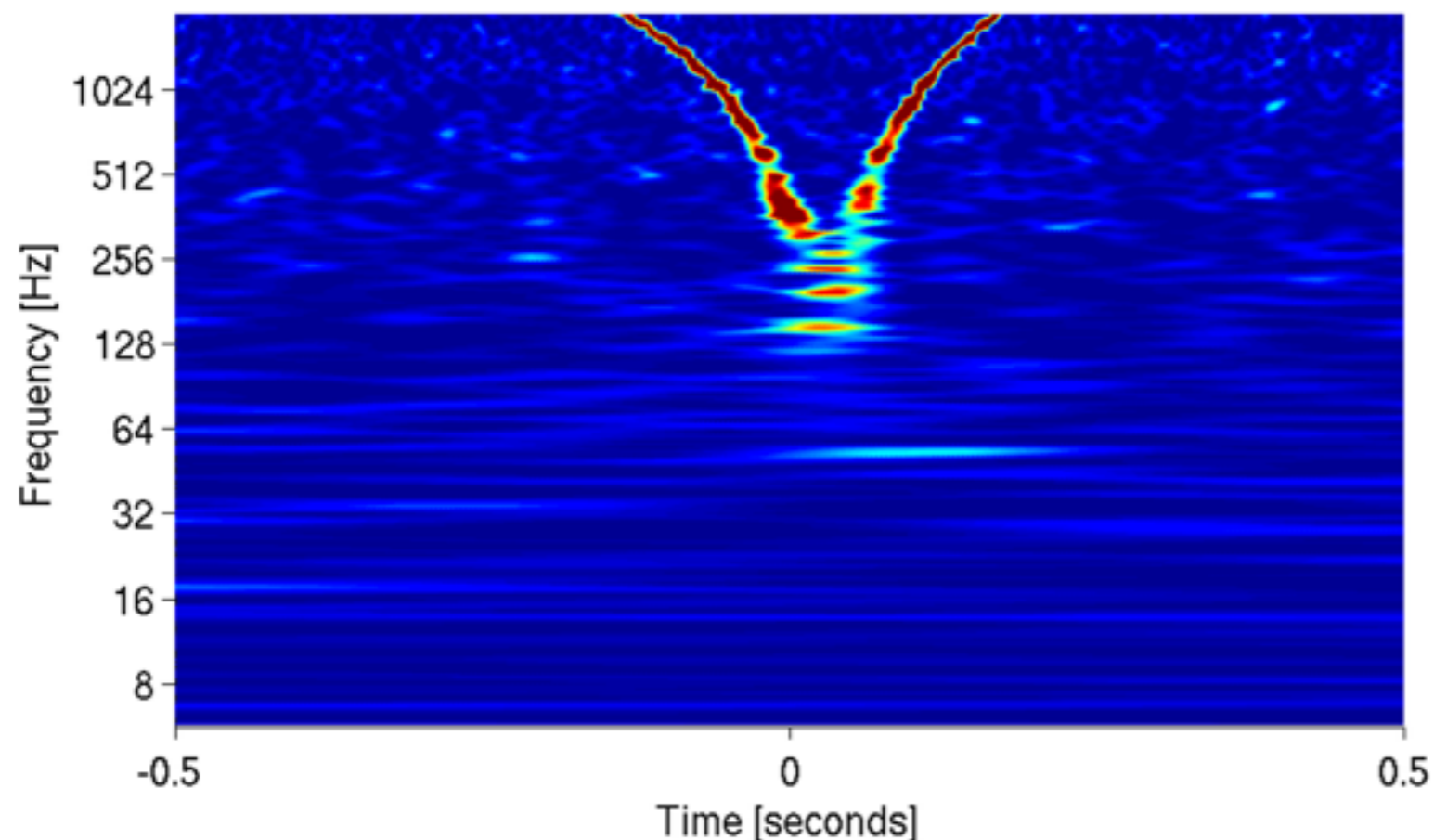
- Given the timescale, some correlation with environmental effects is suspected
- Slow-correlation tracker in development at Fullerton should help target this. (See slide 12)

RF beatnotes

#7 Most wanted

Summary

- Occur at both L1 and H1
- Associated with RF beatnote between PSL VCO and stationary RF fields inside the PSL enclosure
- Appear as a sweep down and up in frequency as the two beating frequencies cross



Impact

- Occasionally pollute $h(t)$ in the bucket
- Pollute $h(t)$ above 2 kHz at LLO
- Constantly pollute auxiliary channels at both sites, hindering searches for other correlations

What do we know?

- Recipe for mitigation of radiated RF fields at LLO: [alog](#) (Rich Abbott et al)
 - Replace connections on phase frequency discriminator chassis
 - Remove BALUN transformers for PSL, ALS DIFF, and ALS COM VCOs and ISS AOM
 - Clip-on common mode choke on PSL VCO output

Overview of the DQ vetoes applied to the astrophysical searches during O1

“Category 1” vetoes

- Indicate some egregious issue with the data; this data is not analyzed.
- Applied to all searches (CBC, burst, CW, stochastic)
- **Consequences:** search pipelines require some minimum amount of continuous data for analysis.
 - For PyCBC, this is more than 2000 seconds.
 - One second of cat 1 veto could cost the better part of an hour.
- **Examples from O1:**
 - LHO Y-end Beckhoff failure (1.5% deadtime)
 - LHO RF modulations (~3% deadtime)
 - Both sites: data just before lock-losses
 - LLO PCal DC power fluctuations

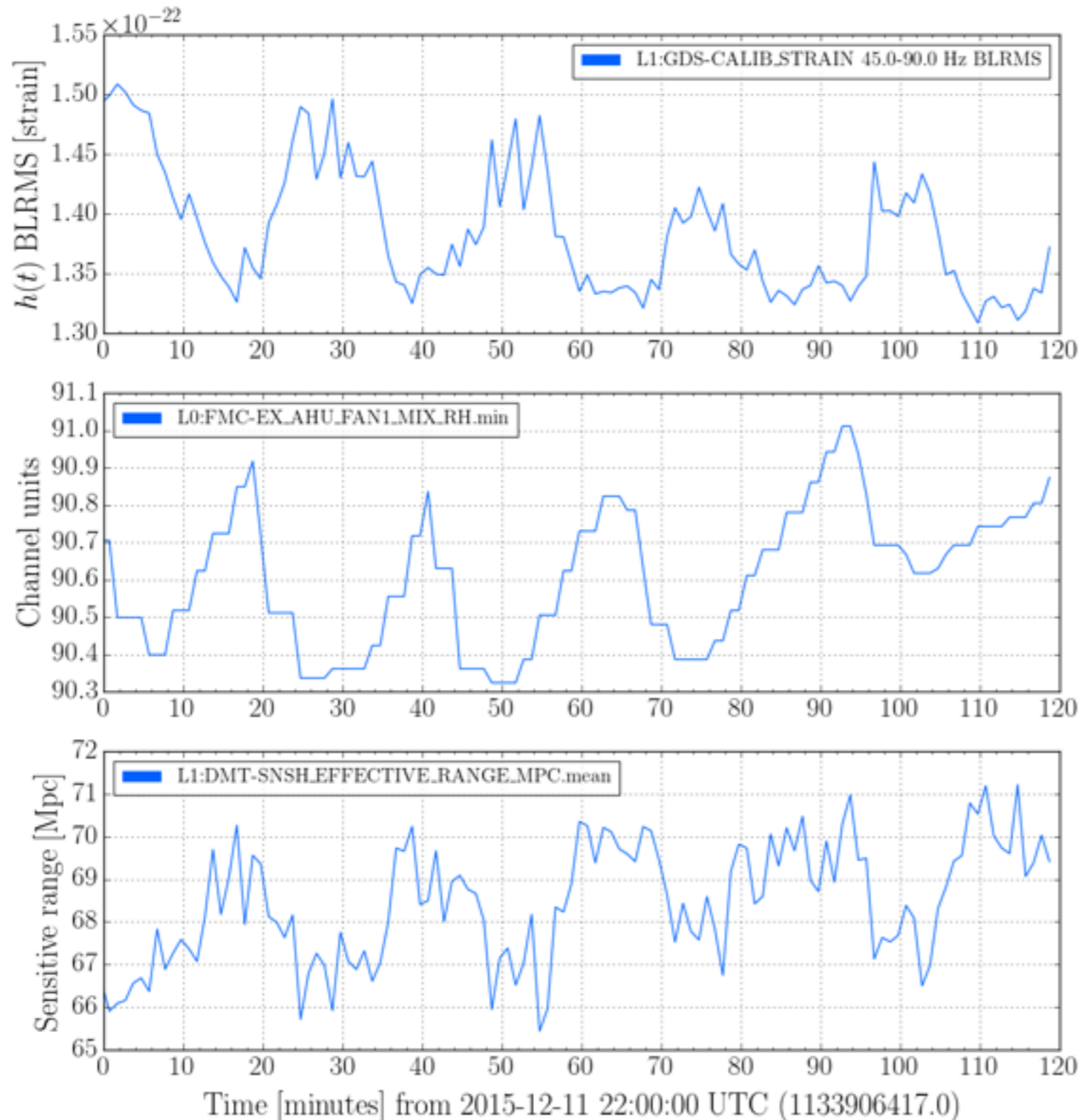
“Category 2” vetoes

- Indicate some known instrumental problem that impacts the search backgrounds.
- Different searches use different category 2 vetoes
- **Consequences:** This data is still analyzed; any candidate signals found during these times would be rejected.
- **Examples from O1:**
 - Both sites: ETMY SUS ESD saturations
 - Both sites: OMC PD ADC overflows
 - Hanford 10-30 Hz seismic noise (~0.4% downtime)

Development towards O2

Slow correlation tracker

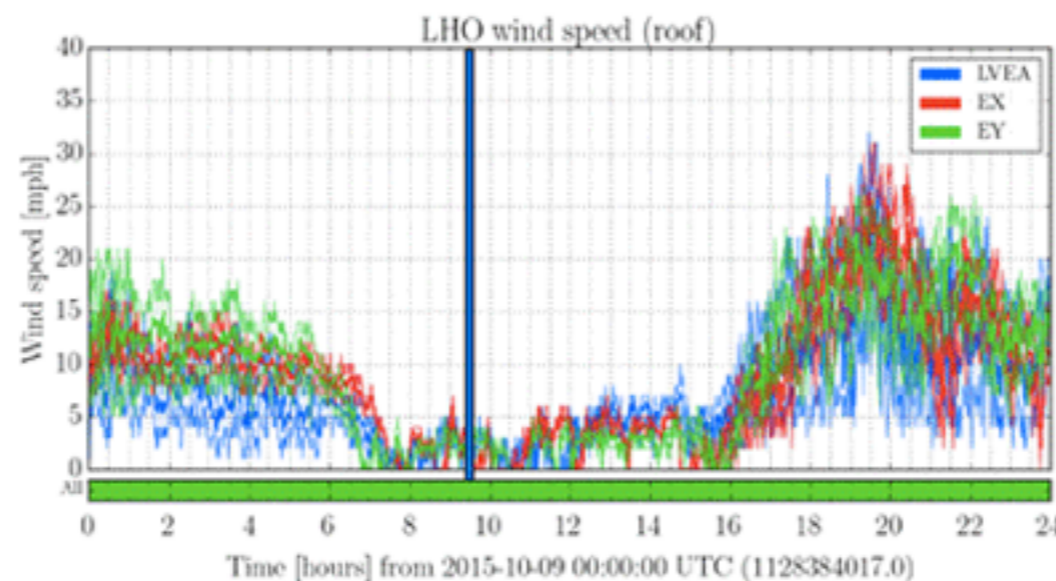
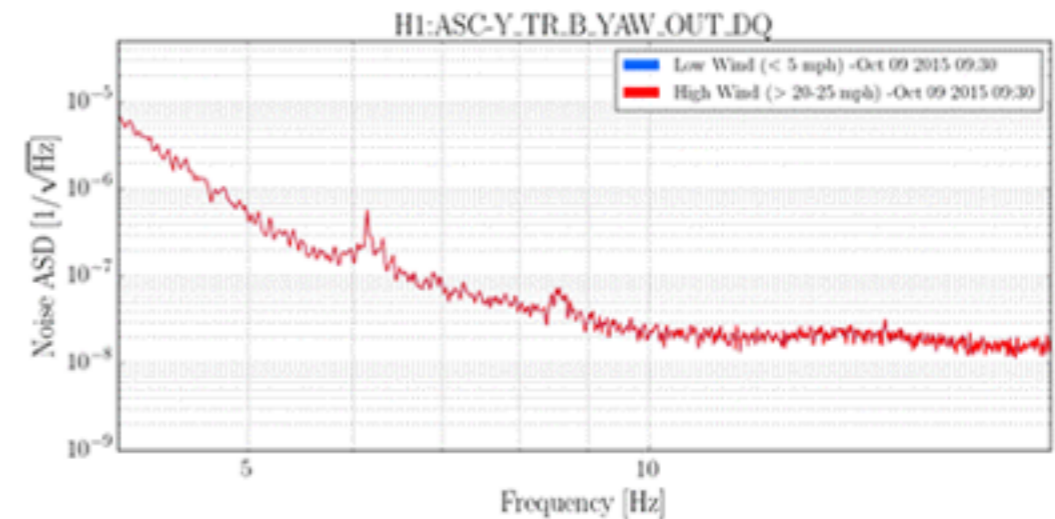
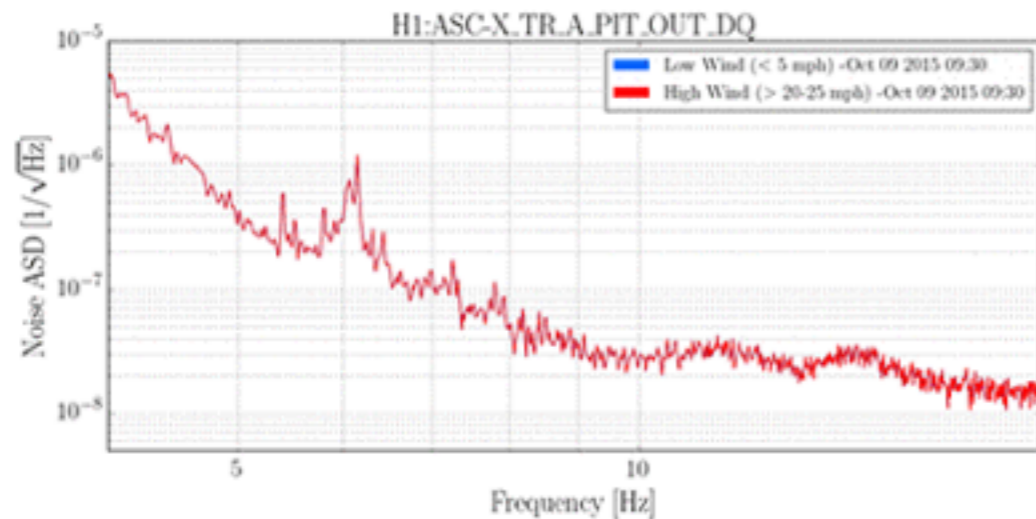
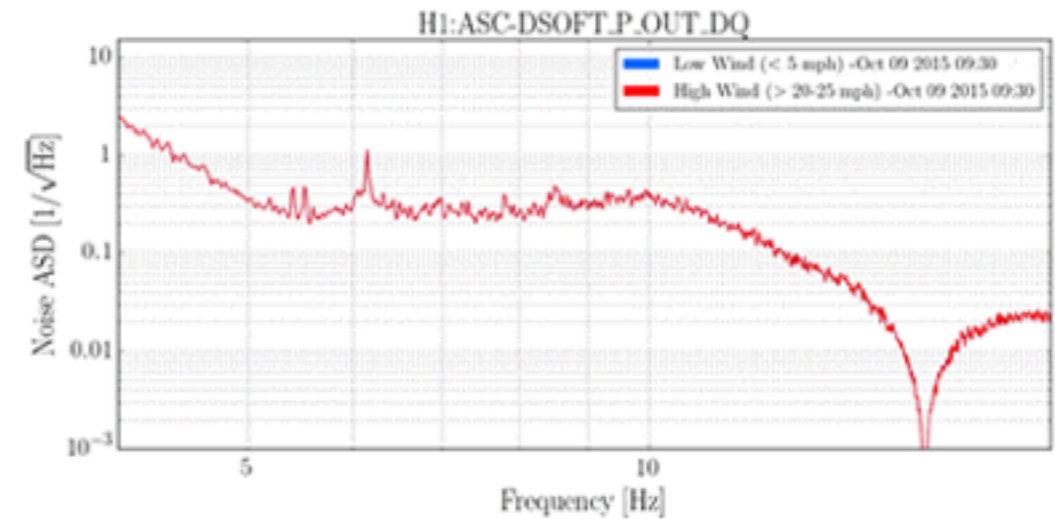
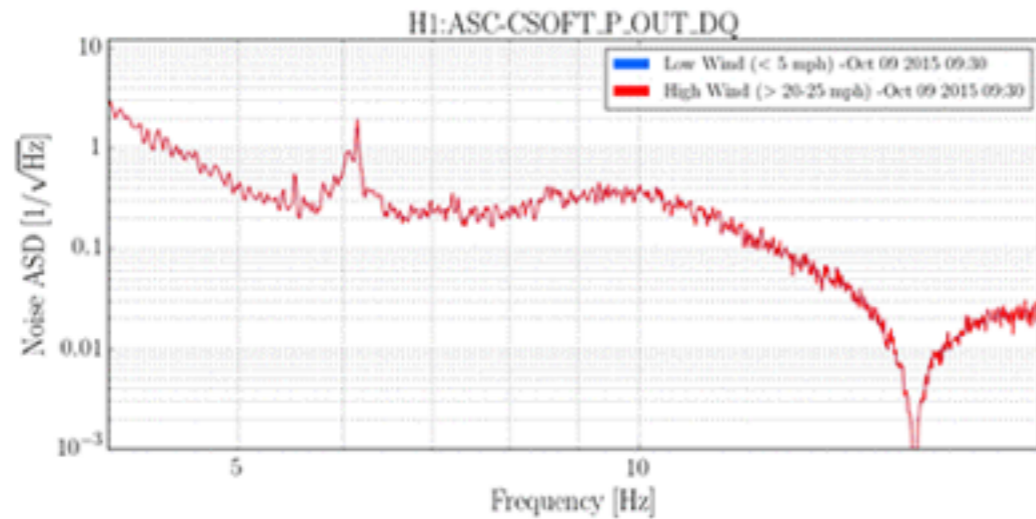
Isa Patane, Michelle Aleman, Josh Smith, CSU Fullerton



- Uses a Pearson's correlation coefficient to quantify correlation between band-limited RMS $h(t)$ and many slow trend auxiliary channels
- O1 examples produced for correlations between L1 $h(t)$ and PEM channels and L1 $h(t)$ and FEC channels: <https://wiki.ligo.org/DetChar/O1NoiseBreathing>

Studying seismic-ASC loop coupling

Michael Anita, TJ Massinger, Jess McIver, Paul Altin

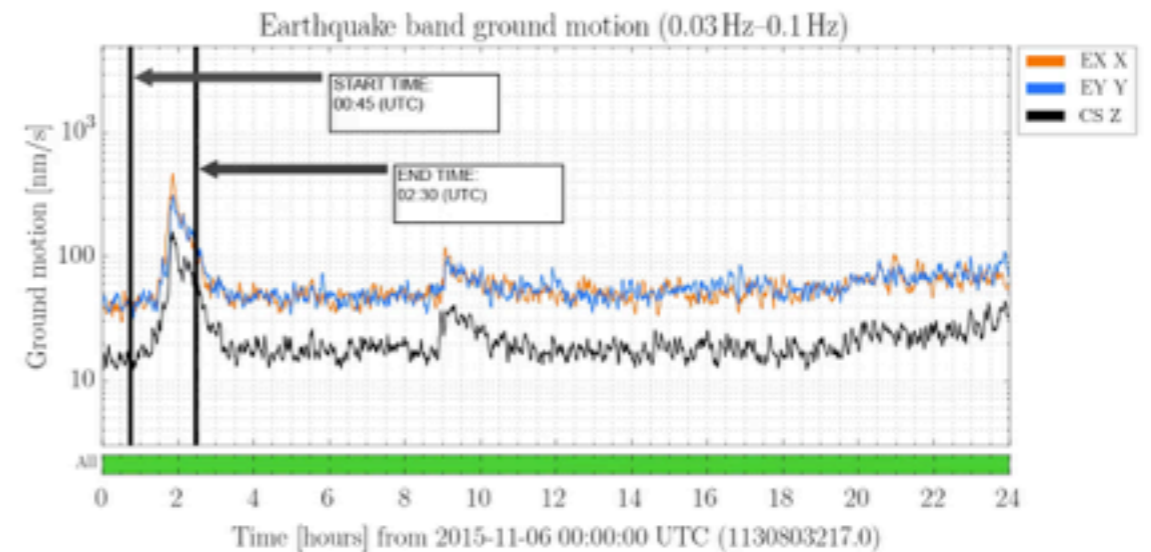
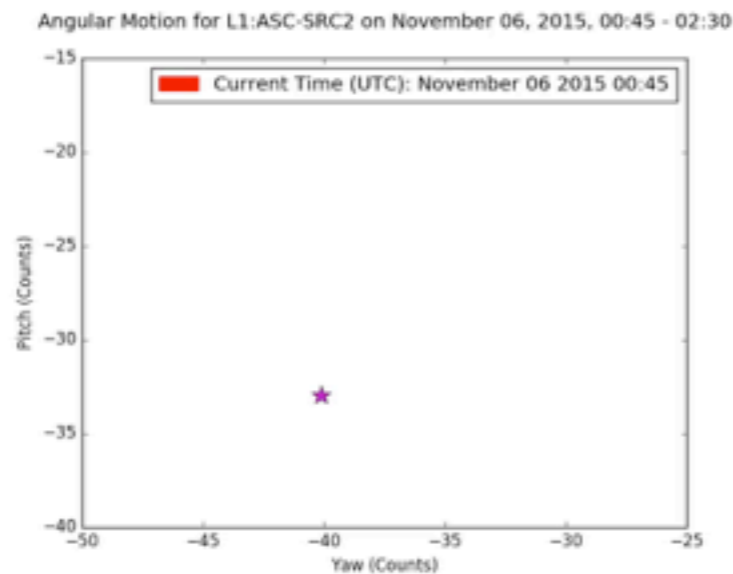
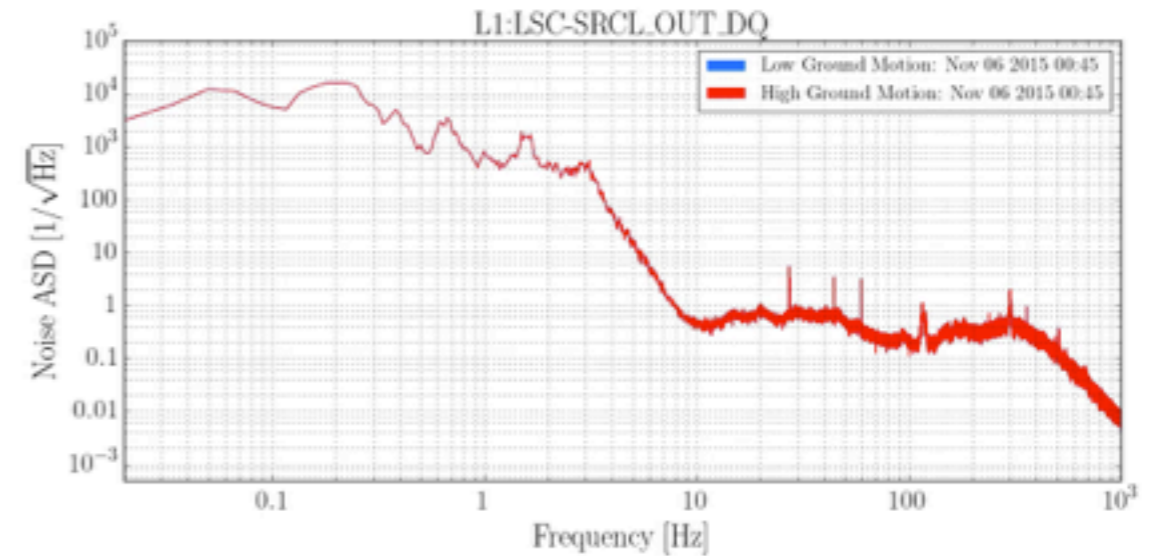
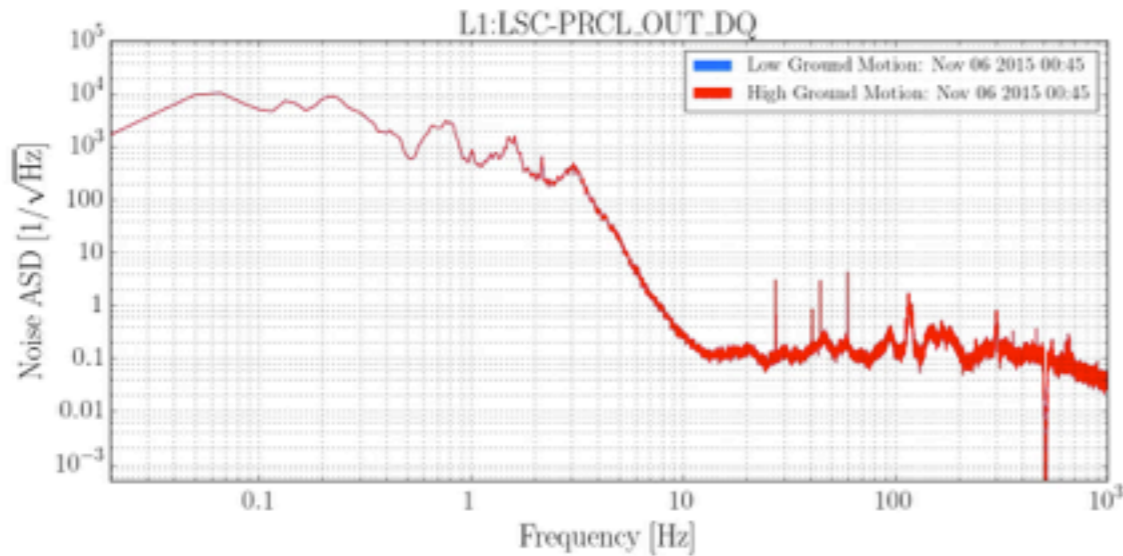


[Link](#)

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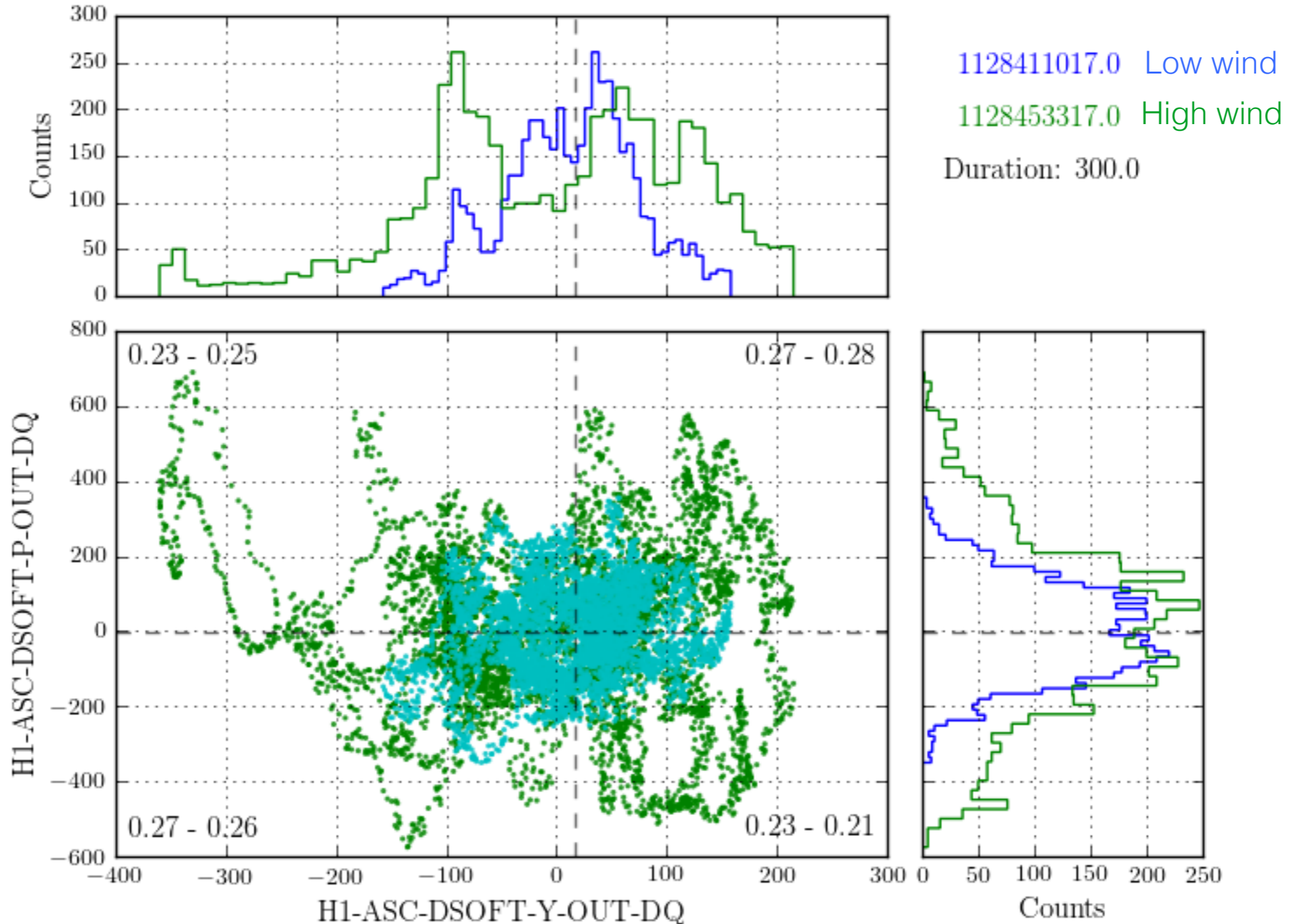
Big pushes in angular control generate glitches in vertex DOFs



Studying seismic-ASC loop coupling

Michael Anita, TJ Massinger, Jess McIver, Paul Altin

Plotting ASC phase space for times of varying seismic noise



Interacting with DetChar

Have a request for the summary pages?

Sure! Please send it to detchar@ligo.org or file an issue here: <https://git.ligo.org/detchar/ligo-summary-pages/issues>

DetChar intends to communicate with the commissioning teams primarily:

- via the alogs
- on the Friday commissioning call
- through the subsystem leads

Who are the DetChar subsystem leads?

<https://wiki.ligo.org/DetChar/AligoSubsystemMatrix>

Another link to the DetChar whiteboard:

<https://wiki.ligo.org/DetChar/WhiteBoard>