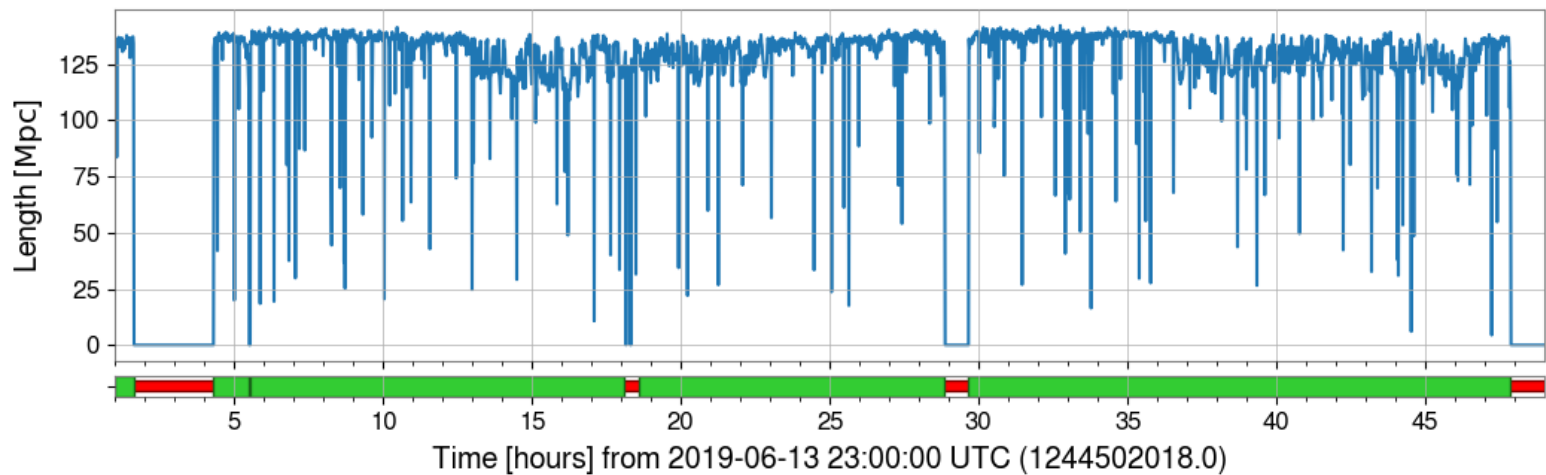


Correlation of Environmental Noise to Signals in LIGO Detectors via Clustering

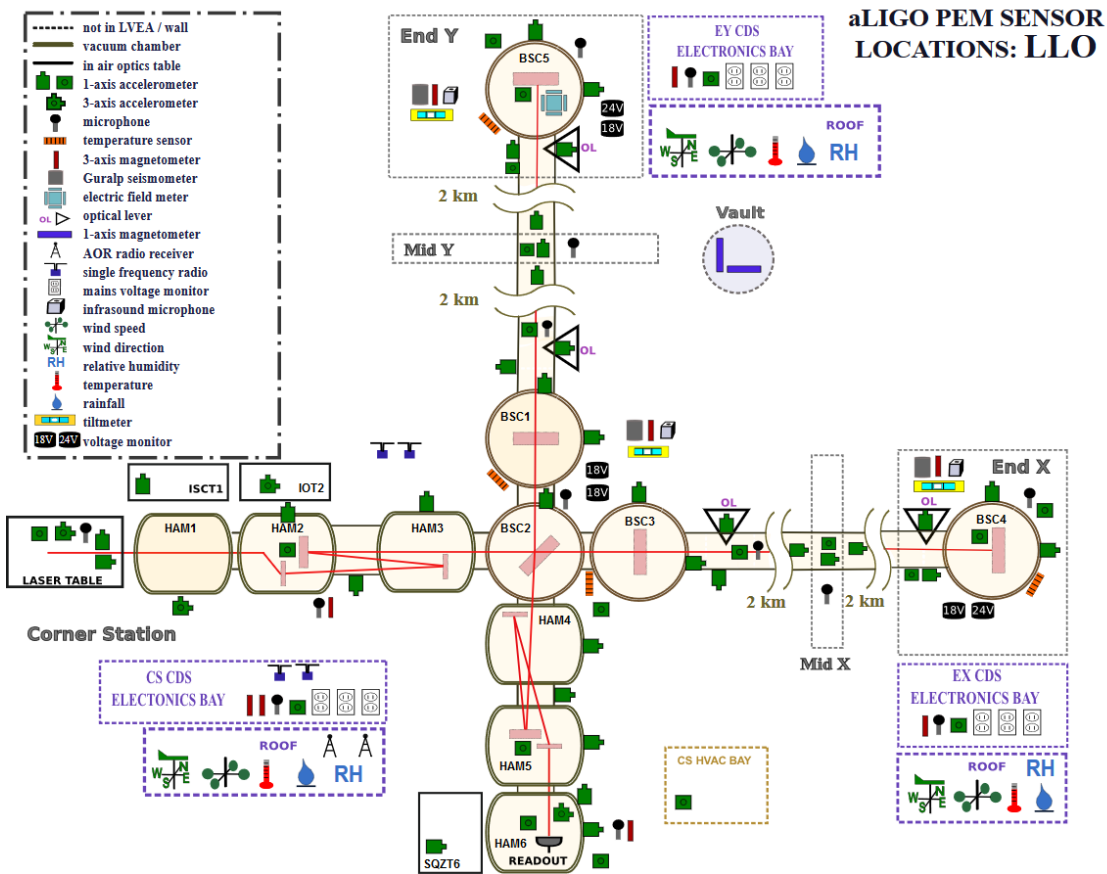
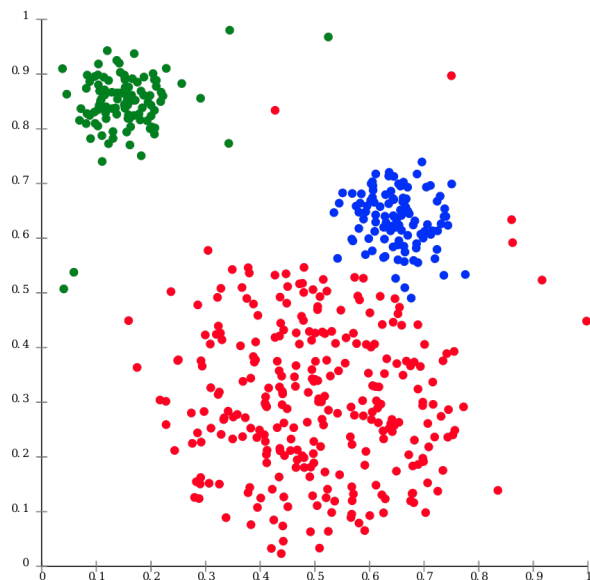
Jacob Bernhardt

Clustering

L1:DMT-SNSH_EFFECTIVE_RANGE_MPC.mean



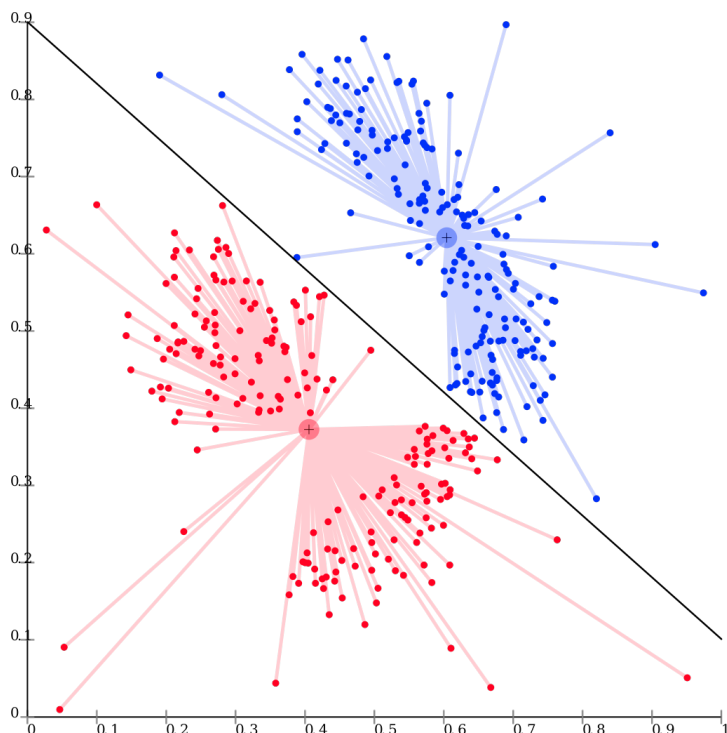
Clustering



k-means with Histories

$$\{s(t_0), s(t_{-1}), s(t_{-2}), \dots, s(t_{-n})\}$$

Coordinates of a point in the clustering subspace for a channel, with $s(t)$ the channel amplitude time t .



Known States: Seismic BLRMS

Identified with “2-hour history” *k*-means over 30 days:

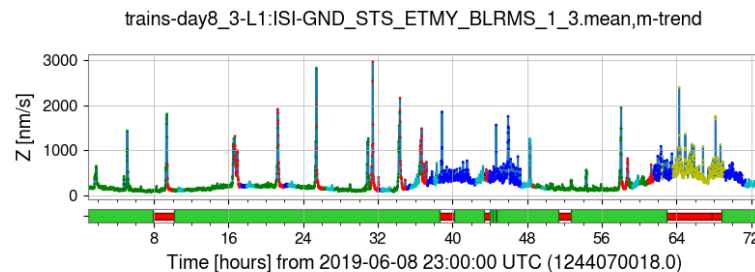
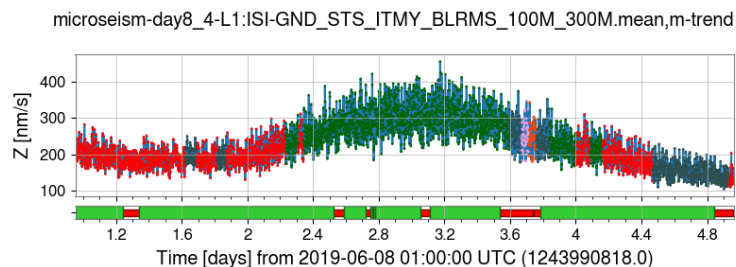
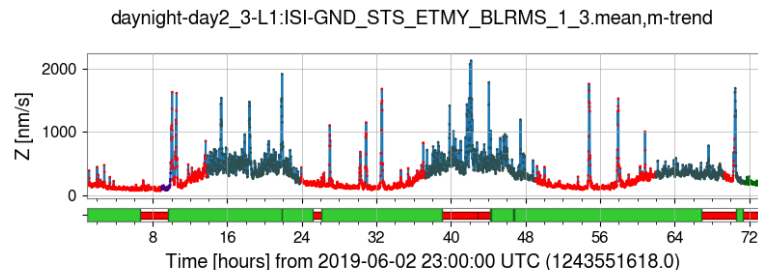
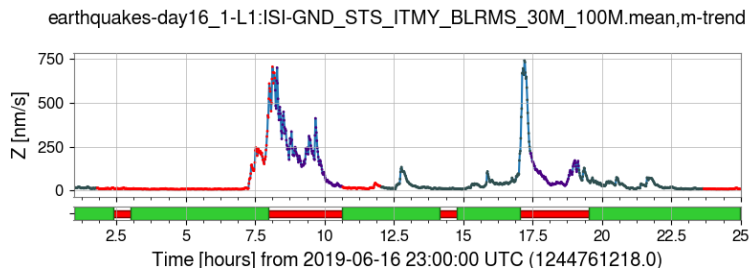
- Earthquakes (0.01 to 0.1 Hz)
- Microseisms (0.1 to 1 Hz)
- Anthropogenic noise (1 to 10 Hz)

Optimized:

- length of history / number of clusters
- size of clustering space

Known States: Seismic BLRMS

Hz	0.01-0.1	0.1-1	1-10
E.Q.	~100x	~10%	~0%
μSeism	~50%	~250%	~10%
Anthro	~80%	~10%	~200%



Acoustic States

BLRMS:

10-28

28-32 (HVAC)

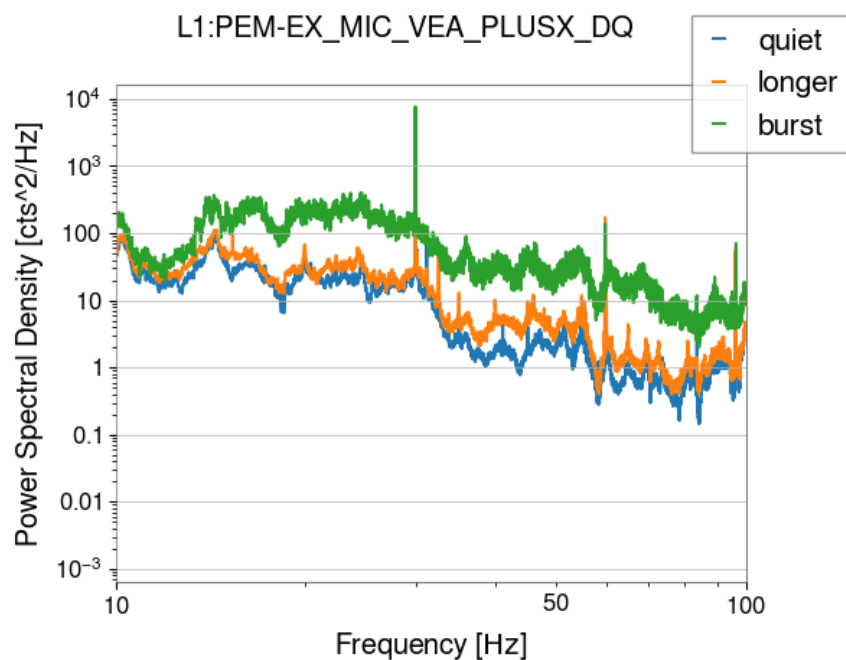
32-50

50-70

70-100

100-200

Hz	10-28	28-32	32-50
LVEA	109%	95%	176%
PLUSX	87%		89%
PLUSY	131%	83%	165%



Longer (hours) cluster, less loud, locked times

Quick loud burst cluster @ lock-losses

Hz	32-50	50-70
LVEA	1112%	890%
PLUSX	1183%	1034%
PLUSY	1100%	

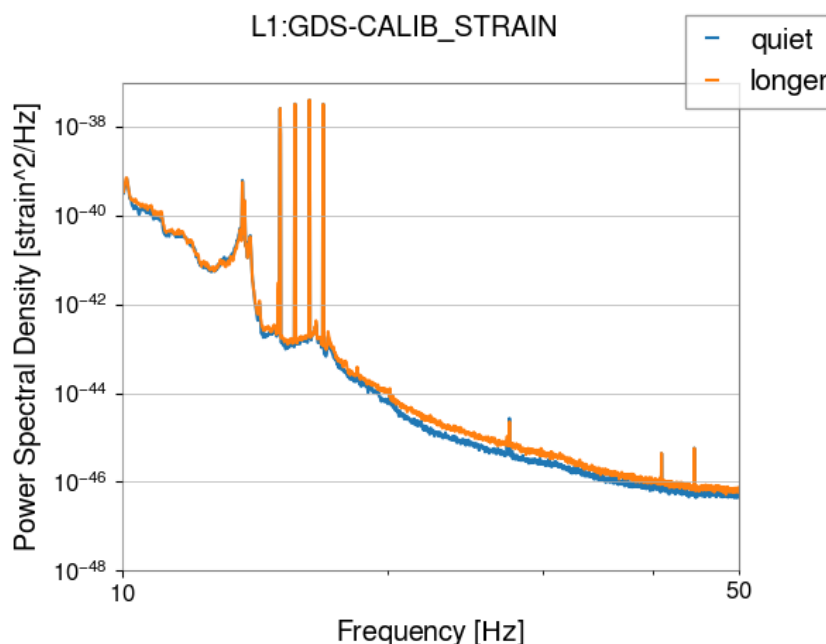
Clustering with DARM

DARM
BLRMS*:

10-13
18-22
22-27
27-29
29-40
40-54
54-65
65-76
75-115
115-190
190-210
210-290
290-480
526-590
590-650
650-885
885-970
1110-1430

Longer (hours) cluster, less loud,
locked times

Hz	22-27	27-29	29-40
GDS-CALIB_STRAIN	1%	3%	1%



*aLIGO LLO Logbook entry 45374 by Gabriele Vajente

Accelerometer States

BLRMS:

1-4
4-10
10-28
28-32
32-48
48-60
60-80
80-118
118-122
122-200

Infrequent
burst

~1/2
day

Hz	4-10
EX BSC4 X	427%
EX BSC4 Z	884%

BSC
focus

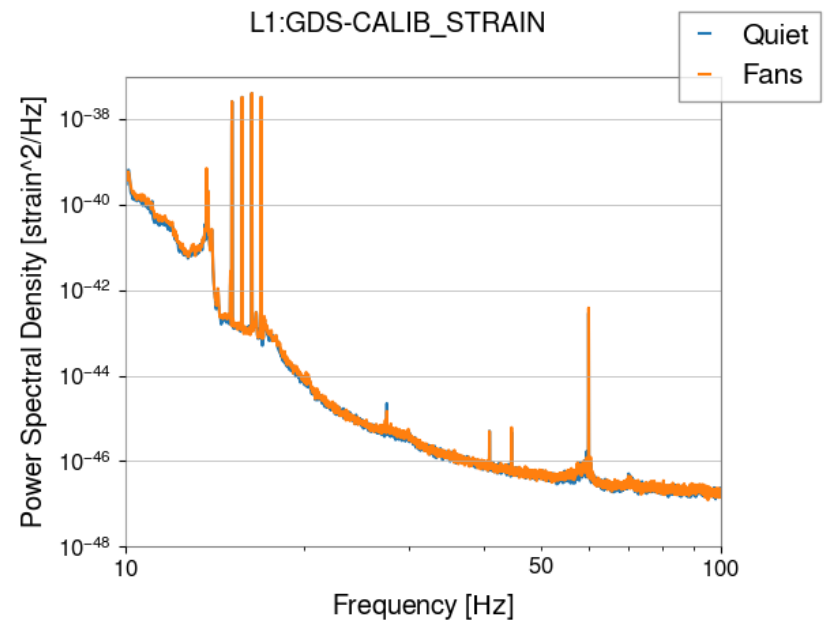
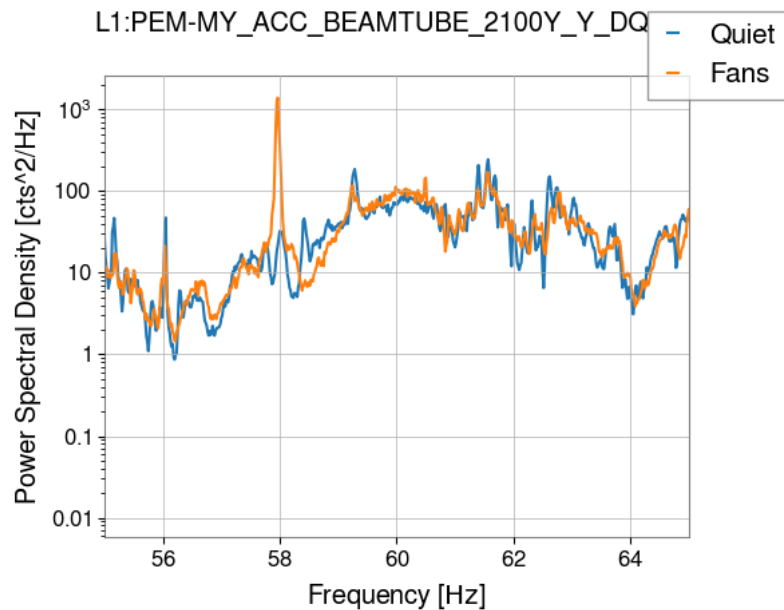
Hz	48-60	60-80	80-118
MY VEA BTUBE	256%	259%	123%
EY BSC5 Z	108%		

Hz	48-60
MY 2100Y BTUBE	618%

Beamtube
focus

Clustering with DARM

Hz	48-60	54-65
MY 2100Y BTUBE	618%	
GDS-CALIB_STRAIN		38%



Next Steps

- Focus on DARM
 - Try clustering only observing times
- More small PEM subsets
 - Many channels in few bands
 - Many bands in few channels
 - Target new sensors

Acknowledgments

Special thanks to:

Anamaria Effler

Rana Adhikari

All LLO Staff

Alan Weinstein & the coordinators of SURF



Appendix
