Benefits of the trees around the LIGO Livingston Buildings.

Controlling the detectors against ground motion is one of the primary challenges of the Laser Interferometer Gravitational wave Observatory (LIGO). Operation in windy times is particularly difficult: the wind rocks the buildings in which the detector is housed, and the tilt of the foundation compromises the detectors' control systems. Wind speeds faster than 5 mph impacted the up-time of the Livingston, Louisiana detector during LIGO's first observing run [1]. Significant efforts are now underway to improve that detector's operation, including improvements to control systems, and investments in new sensors to measure the building tilts caused by wind. We are extremely concerned these efforts will be compromised by the planned harvesting of lumber, a forest, which protects the buildings at the Livingston.

The effect of wind, and the protection from it, can be understood by comparing the same respective buildings at each site. The corner station buildings are roughly 4 times wider than the end-station buildings. At the Hanford Observatory, all buildings are directly exposed to the wind. There, the measured ground motion at its end-station buildings are typically 3 to 10 times more noisy than the corner station during windy times.

In contrast, at the LIGO Livingston Observatory, the detector is surrounded by a person-made forest that is periodically harvested for its lumber. Livingston's measured ground motion at the X-End, the only building that has not had its lumber harvested recently, is the most quiet of the three main detector buildings [2]. We believe the forest is providing a natural wind break. In addition, the periodic harvesting results in a large increase of ground motion (factors of hundred [3]), beyond the range of the interferometer's control system. In November 2016, during our last observing run, the harvesting resulted in a downtime of roughly 50%.

Preserving the trees at the Livingston Observatory is a priority for LIGO. The forest provides natural protection for the building. As we move into the next observation run, we are working to achieve stable, high performance operation so we can measure many more gravitational waves. Keeping the buildings stable is a key part of achieving this goal.

[1] G1700246, Jim Warner, "Commissioning F2F Environment and Duty Cycle", and T1600586, Chris Billman, "LLO's Lock Losses and STS Response to Wind in O1"

[2] See page 6 of Billman's report T16000586. The wind rose for the X-end station, interferometer direction

[3] Night vs Day motion comparison during logging activities :
https://alog.ligo-la.caltech.edu/aLOG/index.php?callRep=29563

B. Lantz, J. Kissel, A. Pele. May 2018, LIGO technical note T1900321

Info for the public on why the trees are useful. This is a discussion to “catch them up” quickly.
Basic plots that show the problem:

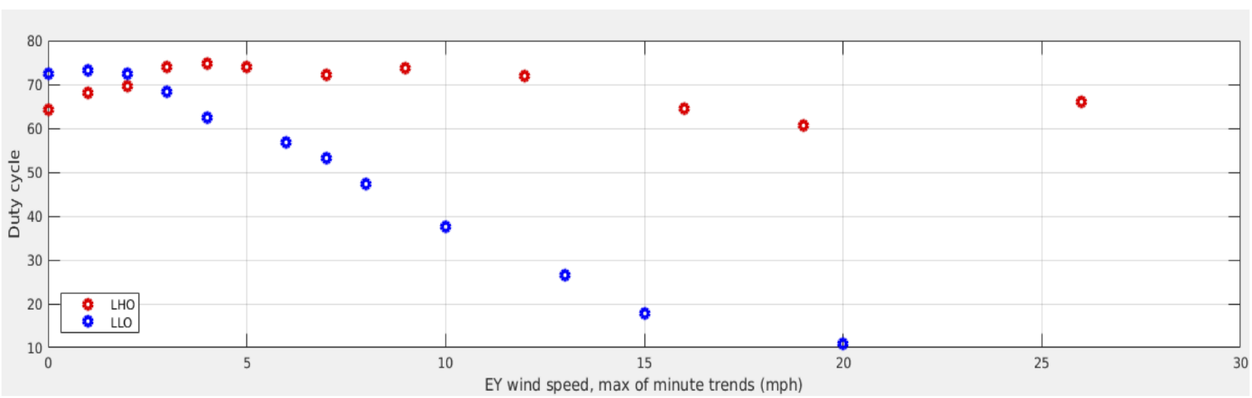
How tilt impacts an horizontal seismometer, e.g. pg 33 of
<https://dcc.ligo.org/LIGO-G1701922>
Or p4 of
T16000586

Some references (w pictures) :
https://alog.ligo-la.caltech.edu/aLOG/index.php?callRep=28757
https://alog.ligo-la.caltech.edu/SEI/index.php?callRep=1131

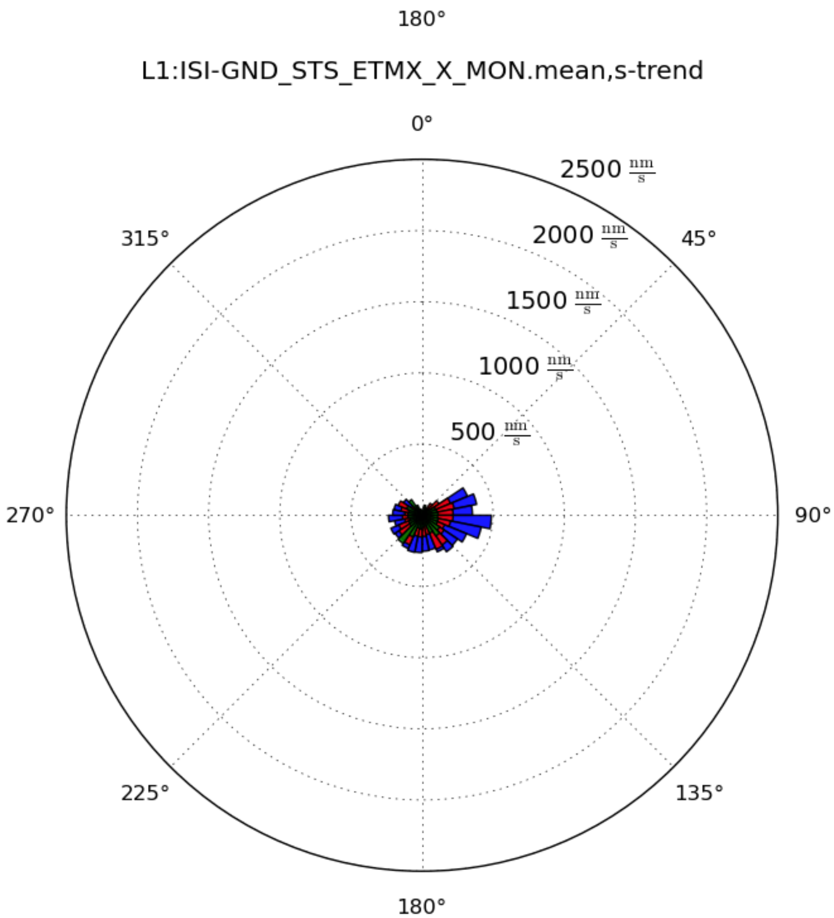
Study showing NO effect before / after tree logging from Dipongkar, but not clear since seismometer was moved between before / after.
https://alog.ligo-la.caltech.edu/aLOG/index.php?callRep=32892

Brian's presentation on wind / wind fence (MIT F2F ?) :
https://dcc.ligo.org/G1501371

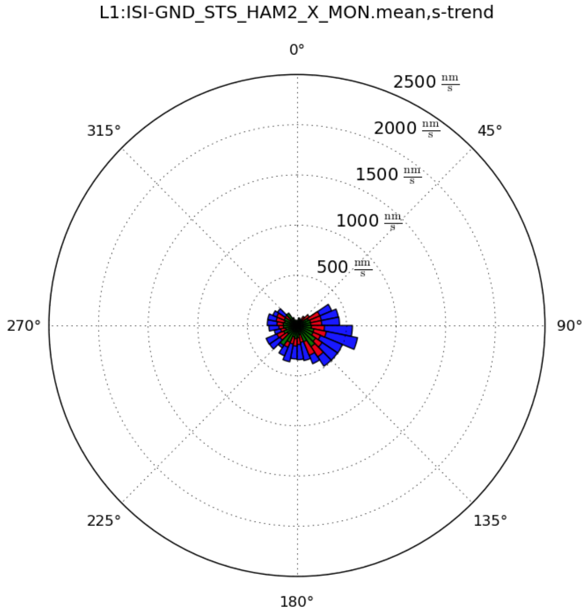
Jim Warner, G1700246, “Commissioning F2F - Environment and Duty Cycle”
https://dcc.ligo.org/G1700246

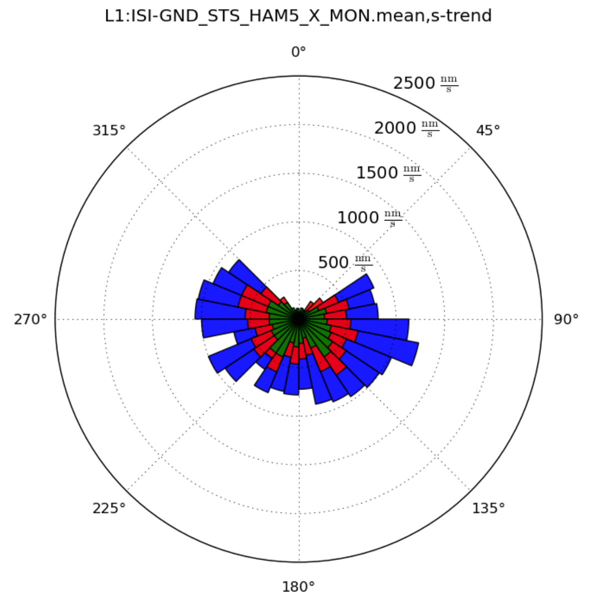


from G1700246 - Duty cycle vs. wind speed for O2 prior to L2A control update



Histogram of ground motion at LLO X-end X direction from T1600586. The roses show the ground motion as a function of wind speed and direction. Each plot (the one above, and the two following) is for the 10-30 mHz BLRMS in a particular directions for each seismometer. 32 angular bins are created, and an average STS velocity is calculated by using the data points with wind direction within the angular bin. This process is also repeated for subsets of data points with wind above some threshold. Blue is for wind > 8 mph, red is for wind speed between 4 and 8 mph, and green is for wind speed less that 4 mph.





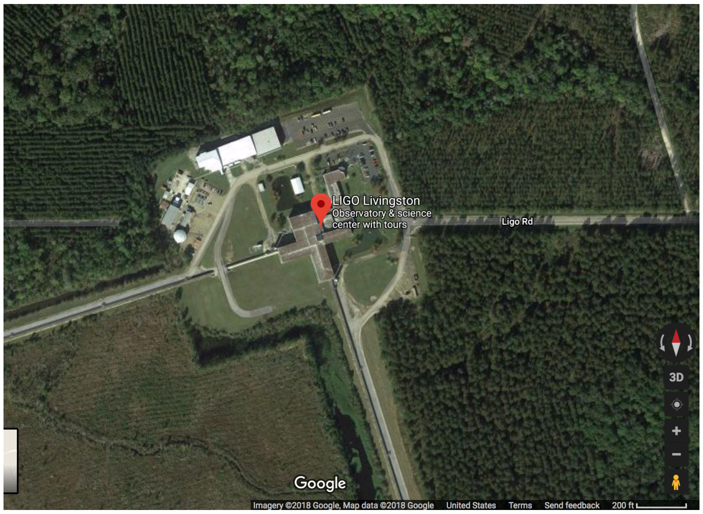
These two roses are for the X-direction in the Corner station. On the left is the quietest X location (by HAM2) and on the right is the loudest X direction (HAM5).

Wind modelling effect on building pressure :

Google timelapse of LIGO interferometer :
https://earthengine.google.com/timelapse/ , type LIGO road

https://earthengine.google.com/timelapse/#v=30.54724,-90.77847,12.273,latLng&t=0.00

Gmaps pictures of the corner vs end station at the same scale:



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Pictures of the trees at the X end Station from ~ March 2017. The trees are taller than the building.

Warehauser’s 2015 schedule
<https://alog.ligo-la.caltech.edu/aLOG/index.php?callRep=19427>