Instrument Noise Testing

Albuquerque Seismological Laboratory

Noise

Instrument Noise

+

Site Noise

+

Instrument Sensitivity to installation

+

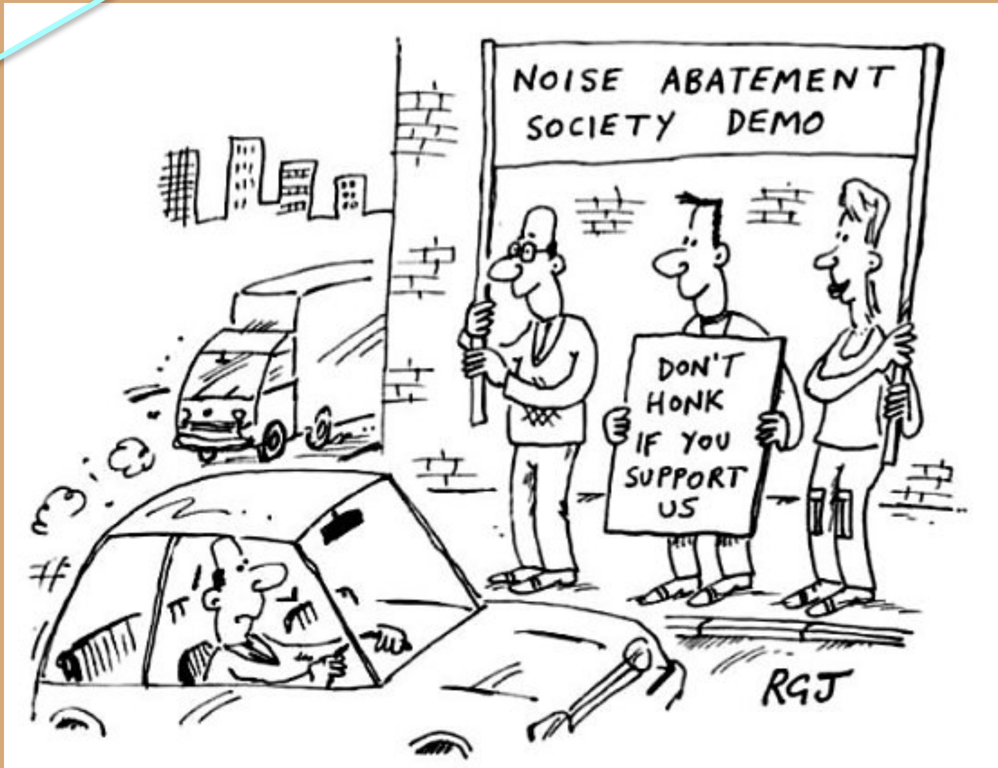
Seismic Noise

=

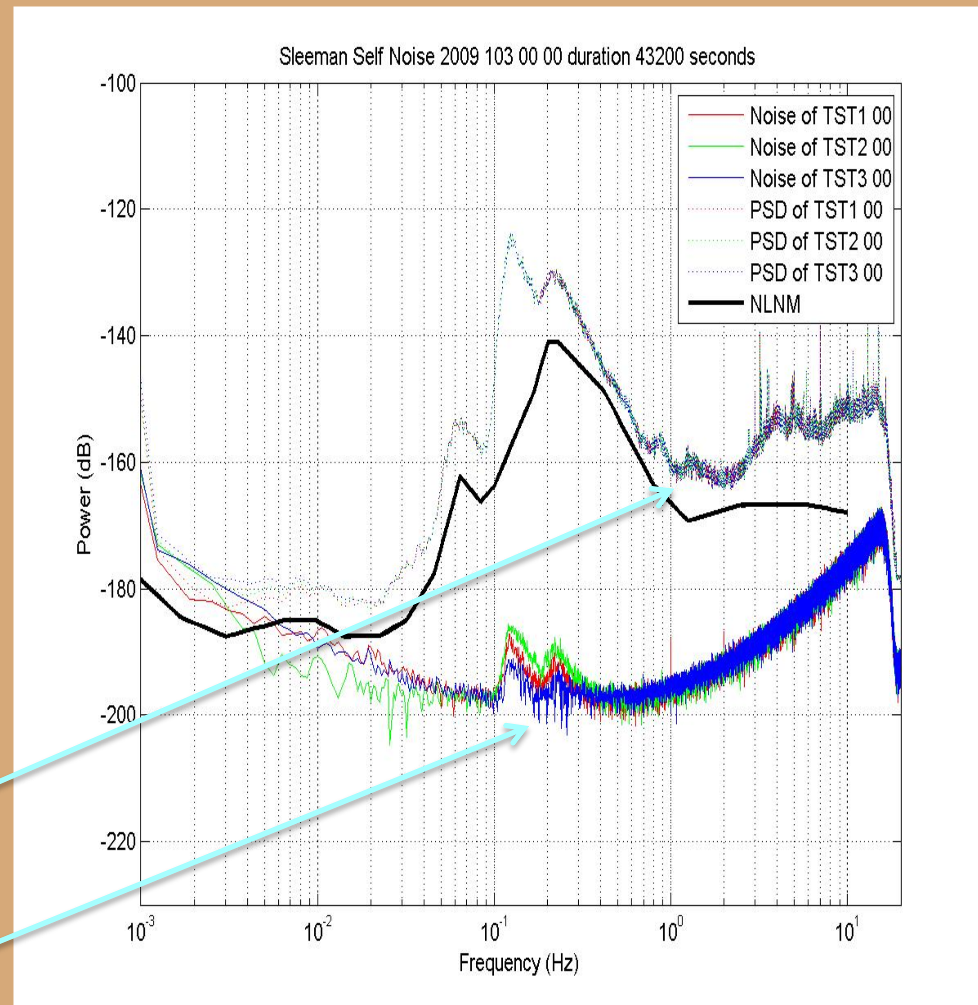
Noise

What we want to measure

Really hard problem



Coherence Analysis

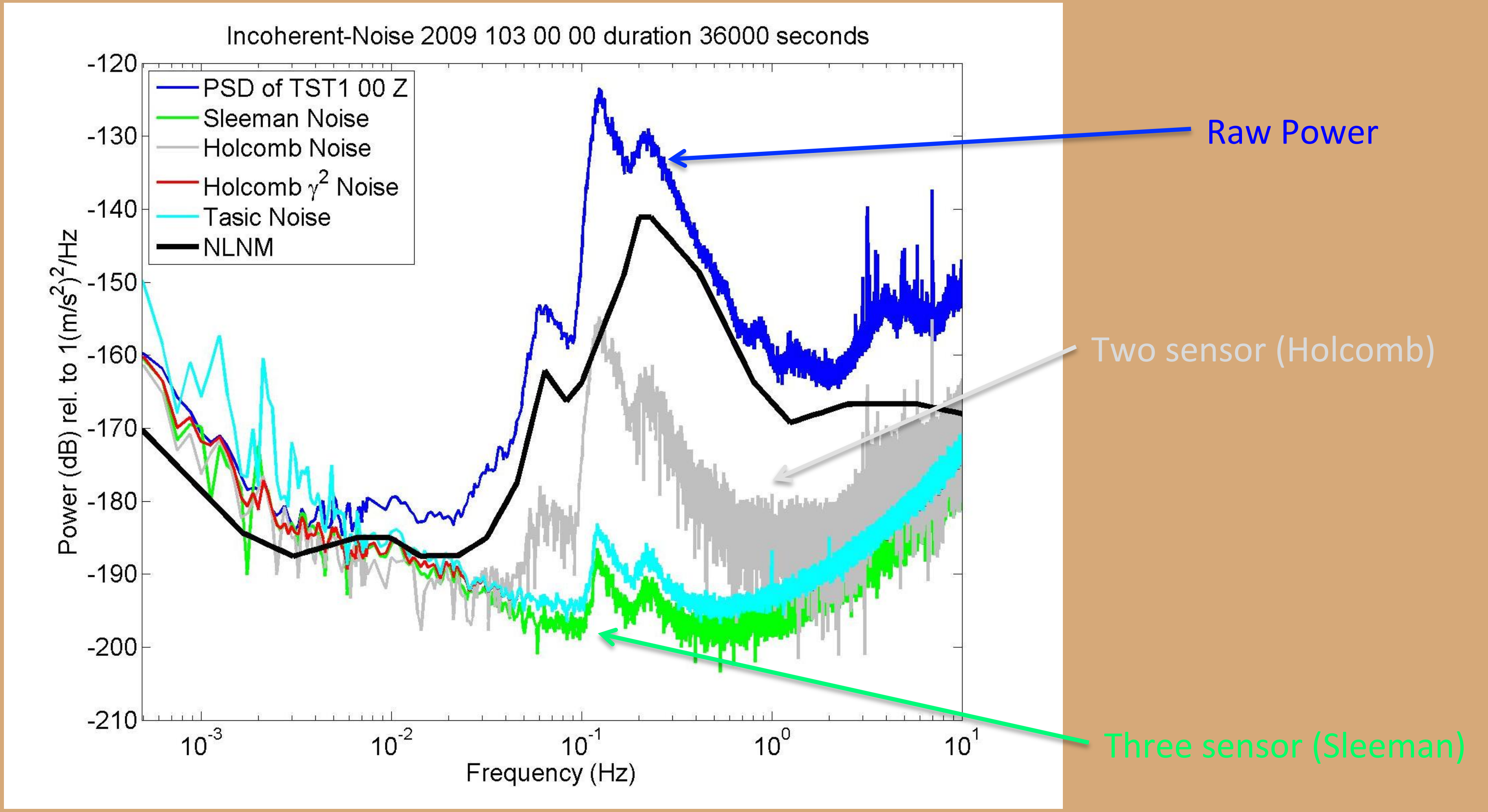


Install co-located sensors

Common signal

Incoherent noise

Different Methods



Sleeman

$$y_i = h_i * (x_i + n_i)$$

y = Seismometer Output
h = Transfer Function
x = Input to Seismometer
n = Seismometer Noise

Frequency Domain

$$Y_i = H_i \cdot (X_i + N_i),$$

$$P_{ij} = H_i X_i \overline{H_j X_j}$$

Cross-Power

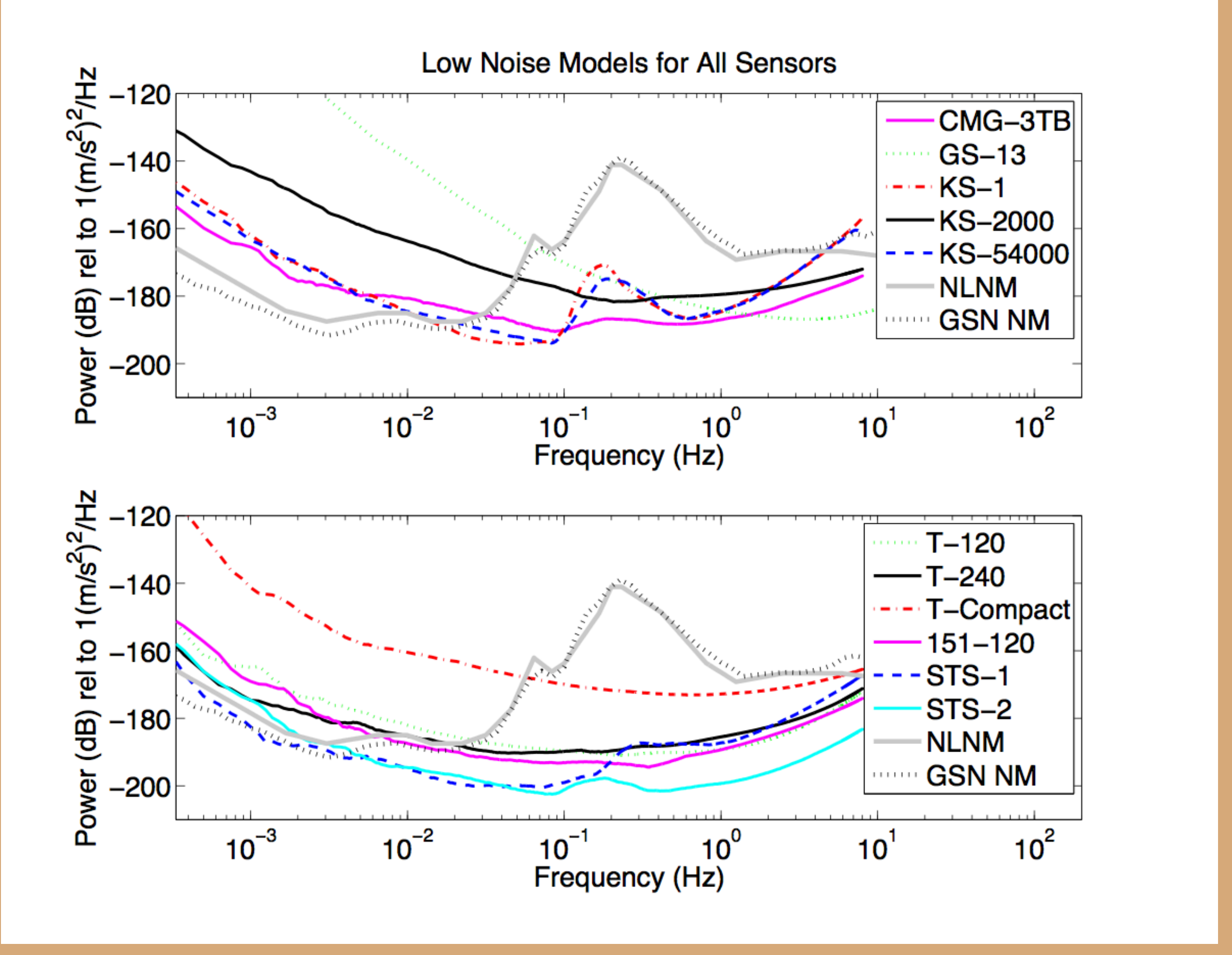
Sleeman Noise

A little bit of math and you can solve for the noise

$$N_{ii} = \left(P_{ii} - P_{ij}\frac{P_{ik}}{P_{jk}}\right) / (H_i \overline{H_j})$$

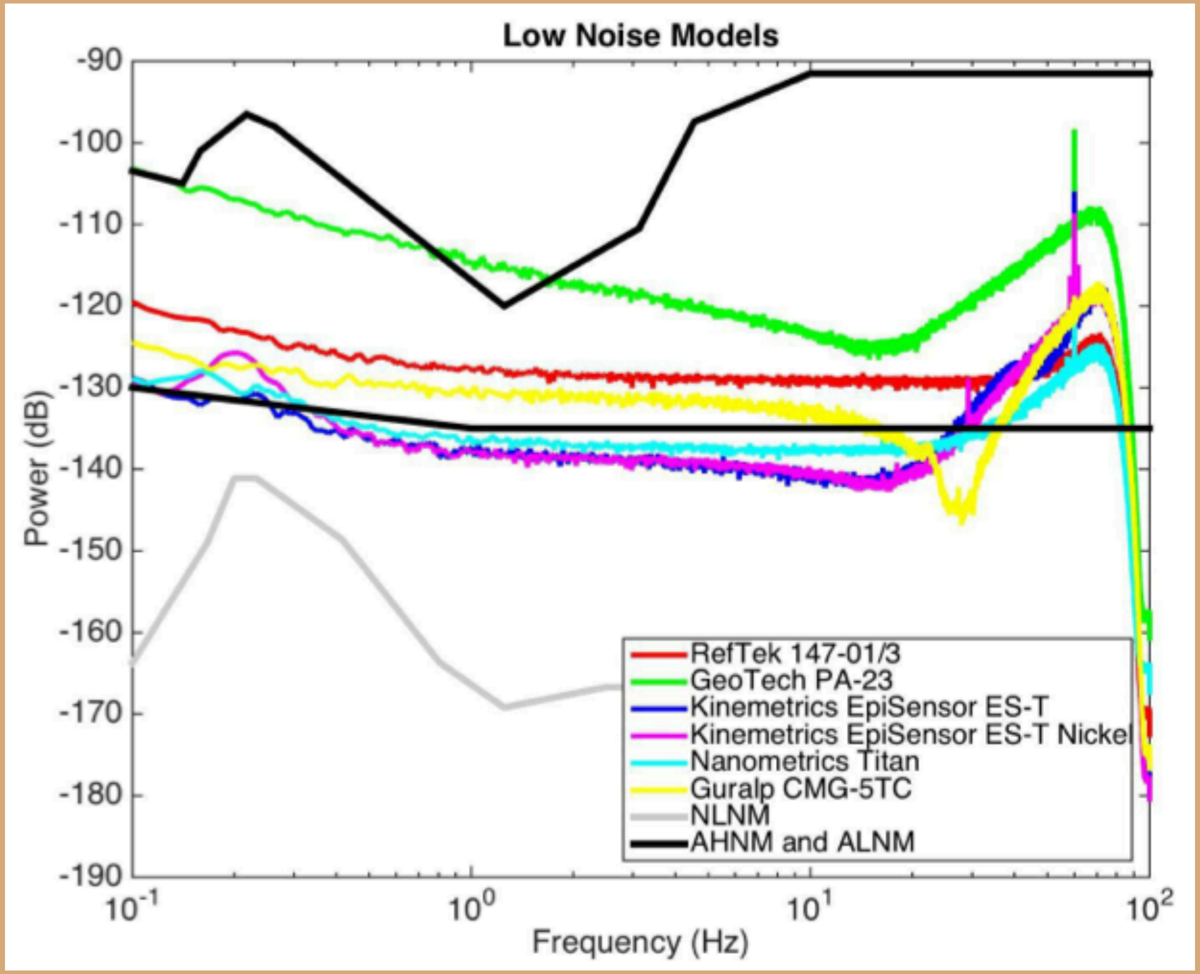
Velocity Sensors

Using multiple sensors over multiple tests we can make a point-wise low-noise model for a sensor



Accelerometers (New)

Noise models for accelerometers



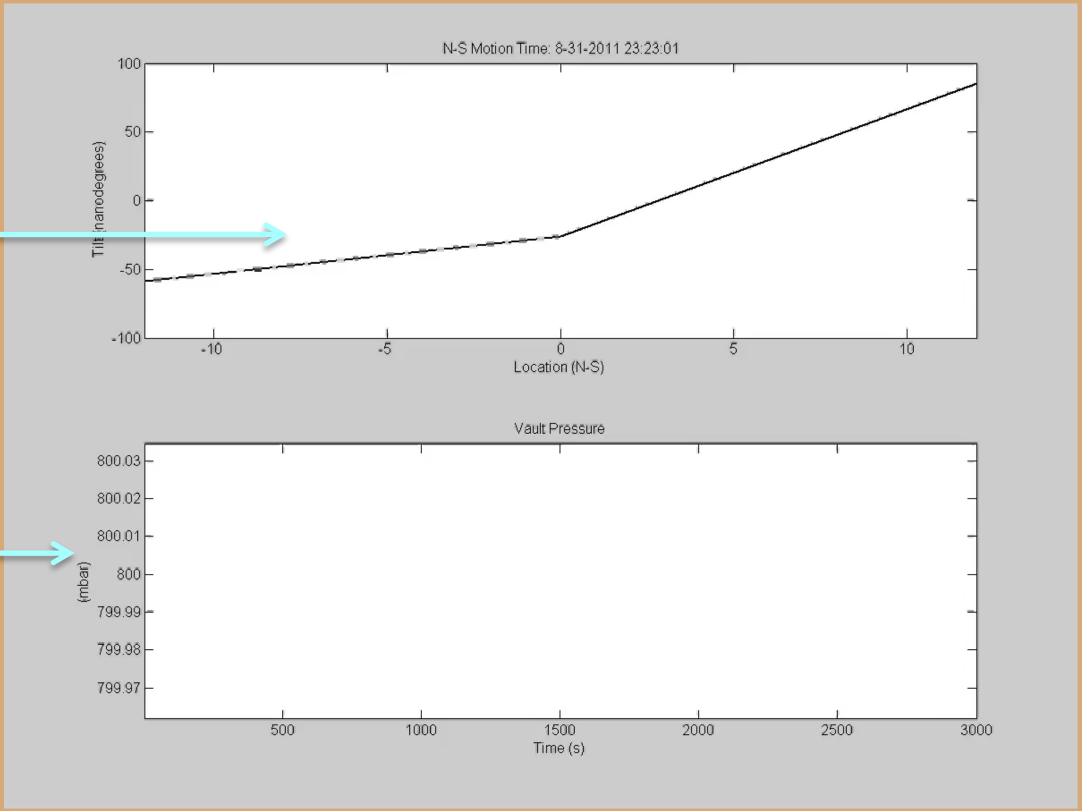
Not using coherence since site noise is below sensor noise

Horizontal Problem

Atmospherically induced tilt makes it difficult to estimate horizontal self-noise

Tilt across ASL vault

Pressure



Estimated using 9 STS-2s across the vault

The Missing Definition

Given tilt and instrument sensitivity to non-seismic noise sources what is "Instrument self-noise"?

Is an instrument that pulses, but is quiet between pulses a quiet instrument?

Is an instrument that is noisy in field conditions, but quiet when tested a noisy instrument?

How long should be allowed for an instrument to settle before we call it the instrument's self-noise?

Summary

Co-locate sensors and remove common signal to get *incoherent* noise

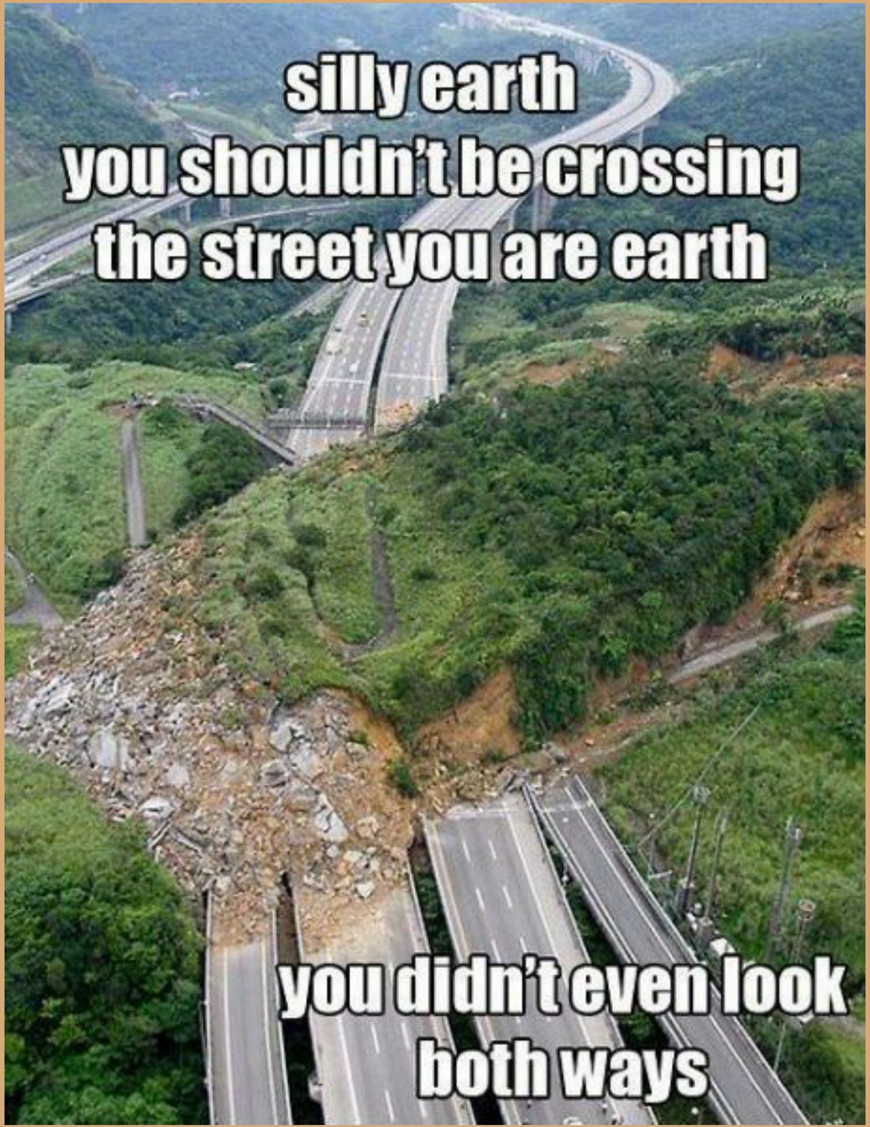
In ideal situation this is the "self-noise"

By doing multiple tests you can approx. the self-noise of a model of sensor

Horizontal noise is difficult to characterize because of tilt

No consistent definition of *INSTRUMENT* self-noise

Thanks


silly earth
you shouldn't be crossing
the street you are earth
you didn't even look
both ways

References

Cauzzi, C., & Clinton, J. (2013) A high- and low-noise model for high-quality strong-motion accelerometer stations. Earthquake Spectra, 29, 85-102.

Holcomb, L. G. (1989). A direct method for calculating instrument noise levels in side-by-side seismometer evaluations, U. S. Geological Survey Open File Report, 89-214, 34 pp.

Holcomb, L. G. (1990). A numerical study of some potential sources of error in side-by-side seismometer evaluations, U. S. Geological Survey Open File Report, 90-406, 41 pp.

Ringler, A. T., Evans, J. R., & Hutt, C. R. (2015). Self-noise models of five commercial strong motion accelerometers. Seismological Research Letters, in review.

Ringler, A. T., Sleeman, R., Hutt, C. R., Gee, L. S. (2014). Seismometer self-noise and measuring methods. Encyclopedia of Earthquake Engineering, doi: 10.1007/978-3-642-36197-5_175-1.

Ringler, A. T. & Hutt, C. R. (2010). Self-noise models of seismic instruments. Seismological Research Letters, 81, 972-983.

Ringler, A. T., Hutt, C. R., Evans, J. R., & Sandoval, L. D. (2011). A comparison of seismic instrument noise coherence analysis techniques, Bulletin of the Seismological Society of America, 101, 558-567.

Sleeman, R. & Melichar, P. (2012). A PDF representation of the STS-2 self-noise obtained from one year of data recorded in the Conrad Observatory, Austria, Bulletin of the Seismological Society of America, 102, 587-597.

Sleeman, R., van Wettum, A., & Trampert, J. (2006). Three-channel correlation analysis: A new technique to measure instrumental noise of digitizers and seismic sensors, Bulletin of the Seismological Society of America, 96, 258-271.

Tasič, I & Runovc, F. (2012). Seismometer self-noise estimation using a single reference instrument, Journal of Seismology, 16, 183-194.