Searching for Excess Noise in Suspensions

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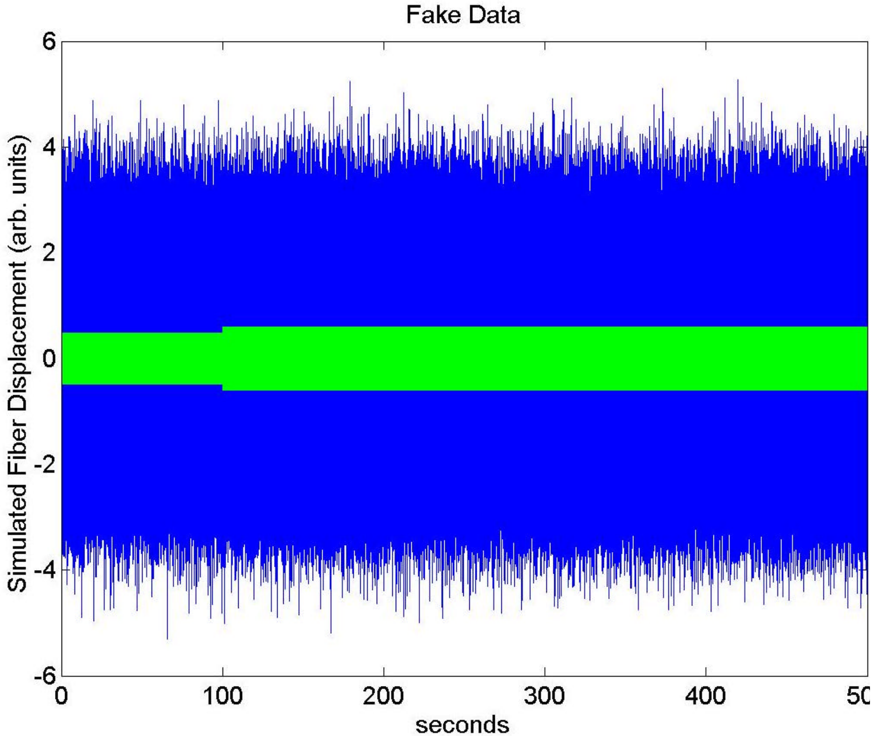
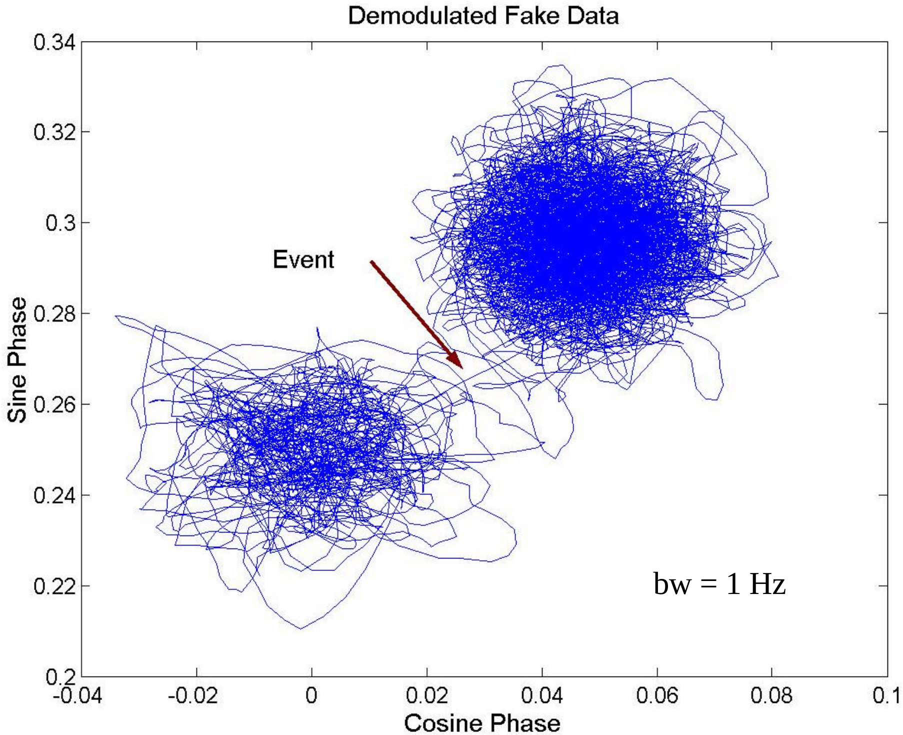
How are resonances useful?

- Provide information about suspension-induced broadband signals (“creaks”).
- May report on unexpected high frequency coil activity.
- In prototype suspensions, look for excess mechanical noise at the level of the thermal noise.

Detecting creaks – First step: Heterodyne!

this page: Fake data set with no thermal noise





Energy Innovation

Mode amplitude and phase drift:

$$q(t) = r(t)\sin(\omega_0 t + \theta(t)) = x(t)\cos(\omega_0 t) + y(t)\sin(\omega_0 t)$$

For random driving:

$x(t)$ and $y(t)$ are Gaussian distributed.

Define the Energy Innovation, η^2:

$$\eta^2(t,\Delta t) = [\bar{x}_{\Delta t}(t+\Delta t) - \bar{x}_{\Delta t}(t)]^2 + [\bar{y}_{\Delta t}(t+\Delta t) - \bar{y}_{\Delta t}(t)]^2$$

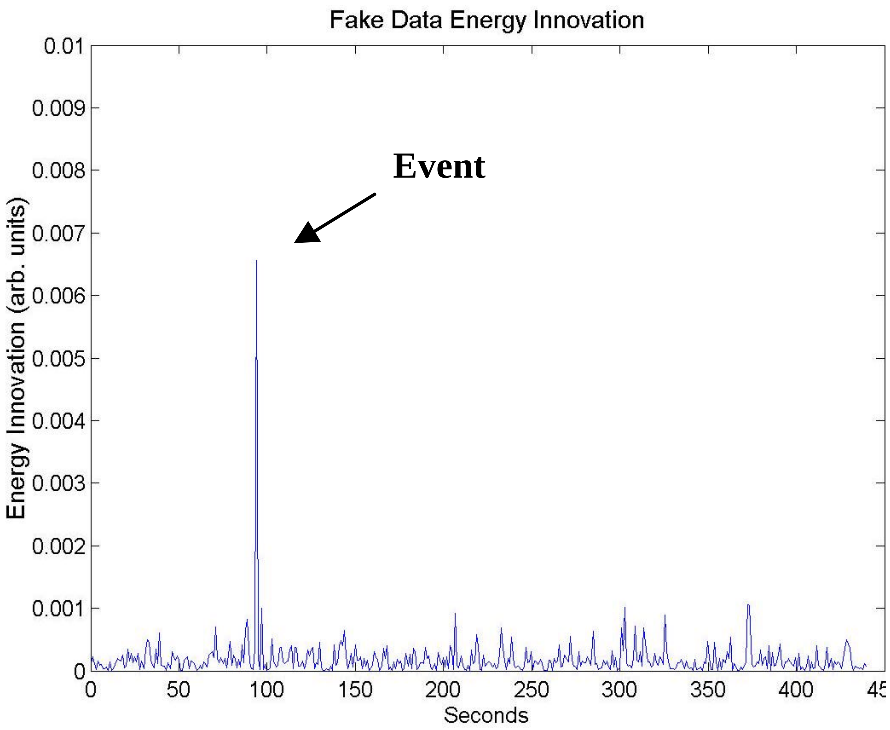
$\eta^2(t,\Delta t)$ is:

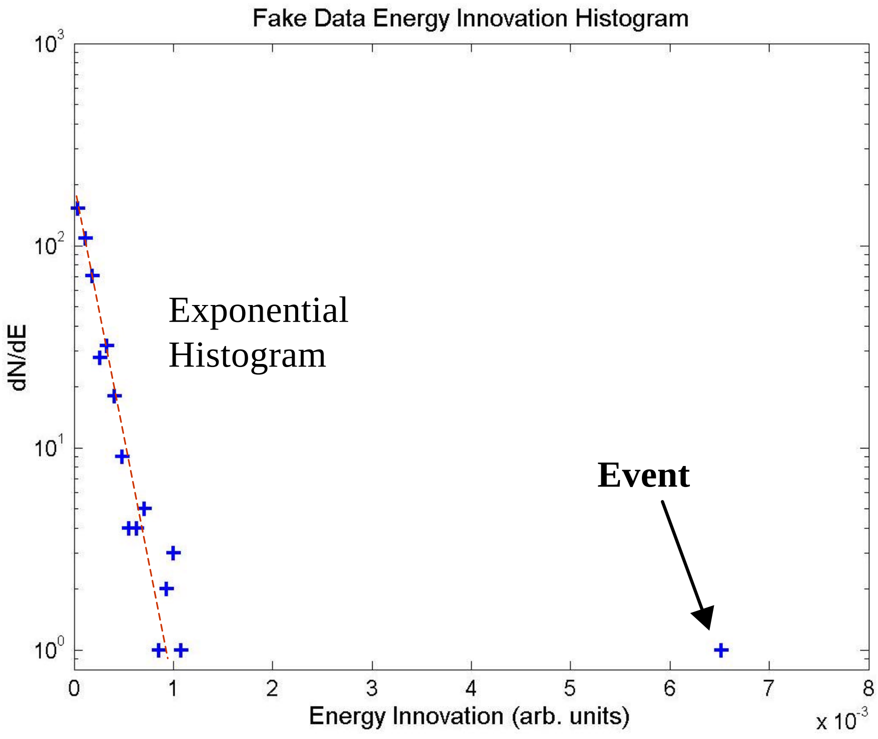
1. *Exponential* distributed.

2. Especially sensitive to *sudden* changes in the resonant mode amplitude or phase.

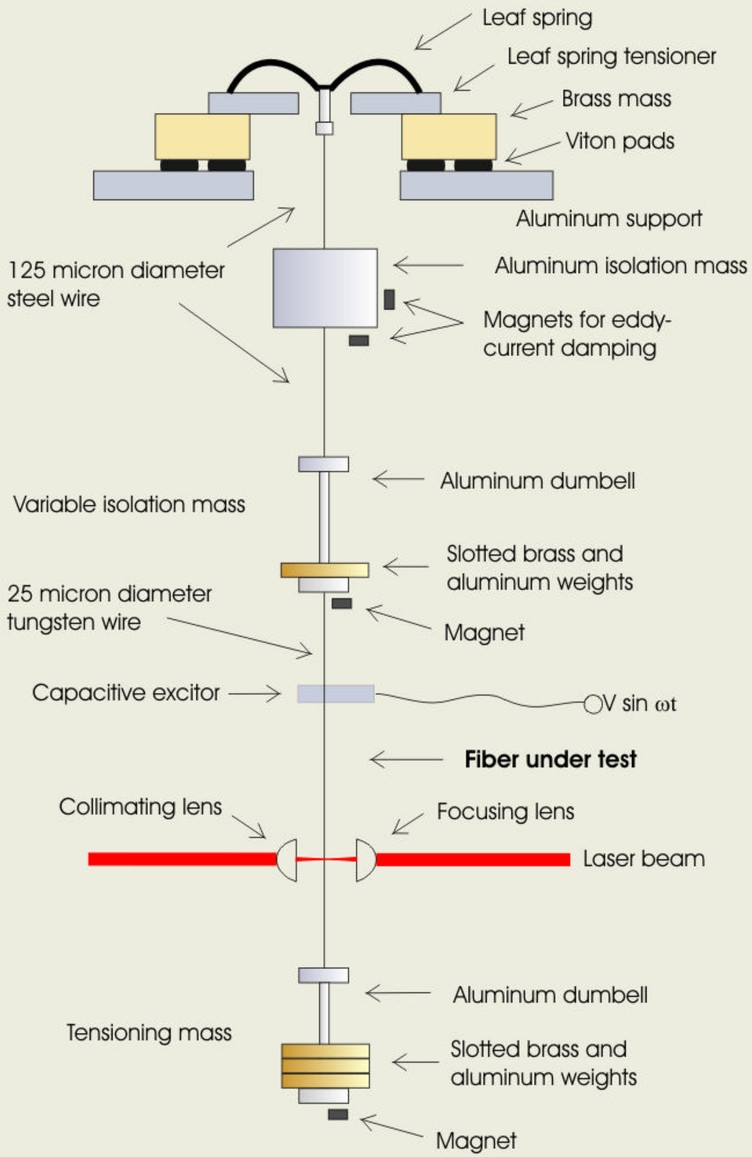
Creaks show up as outliers in η^2

this page: Fake data set with no thermal noise.

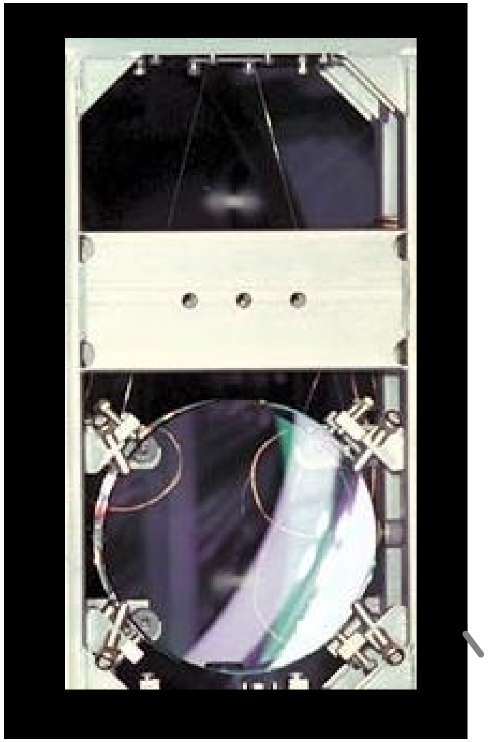


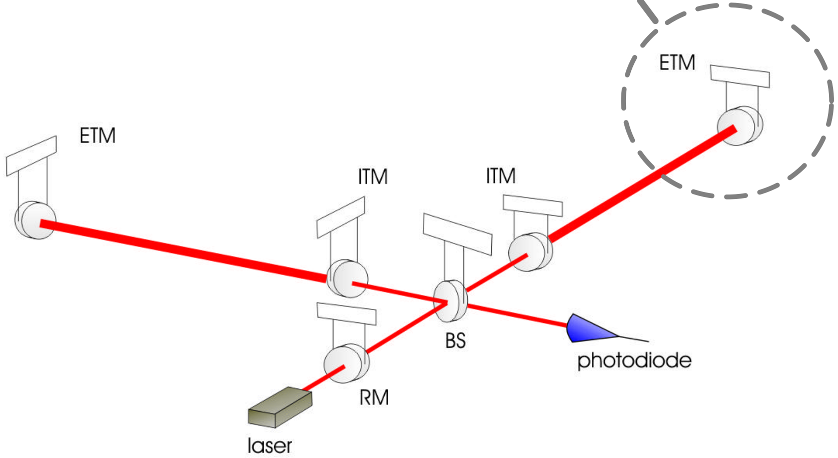


Compare



Leaf spring
Leaf spring tensioner
Brass mass
Viton pads
Aluminum support
125 micron diameter steel wire
Aluminum isolation mass
Magnets for eddy-current damping
Aluminum dumbell
Variable isolation mass
Slotted brass and aluminum weights
25 micron diameter tungsten wire
Magnet
Capacitive excitor
V sin ωt
Fiber under test
Collimating lens
Focusing lens
Laser beam
Aluminum dumbell
Tensioning mass
Slotted brass and aluminum weights
Magnet

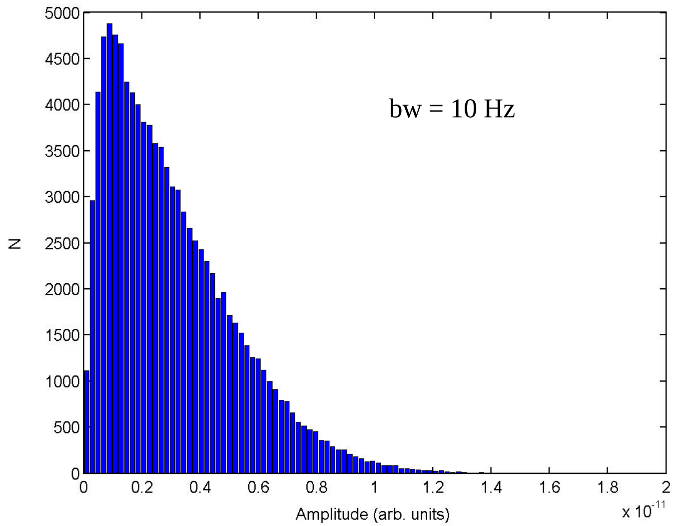




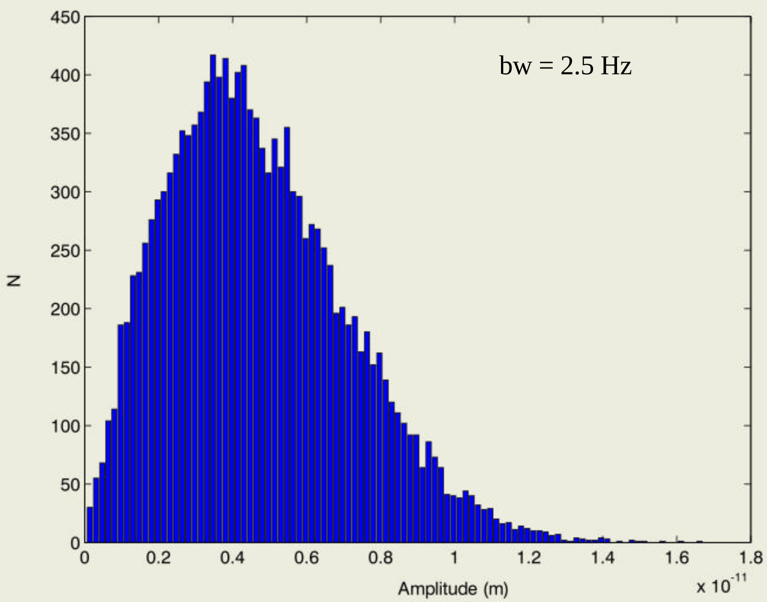
ETM
ETM
ITM
ITM
BS
photodiode
RM
laser

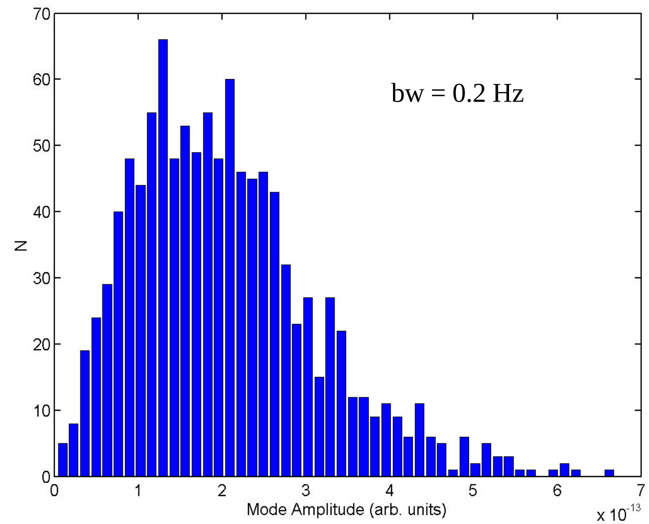
Mode Amplitude

LLO violin mode



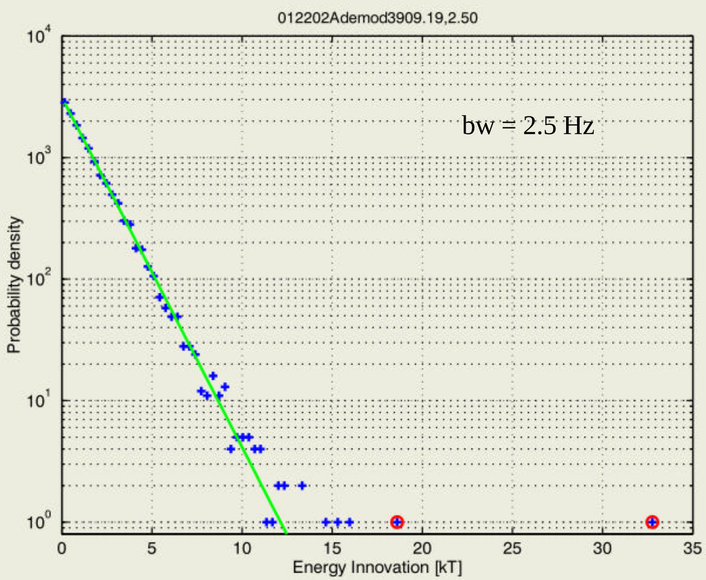
Syracuse tungsten fiber



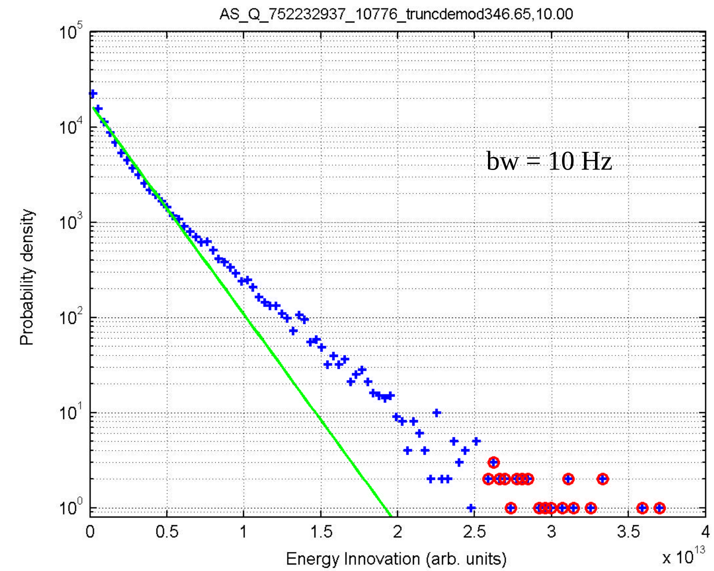


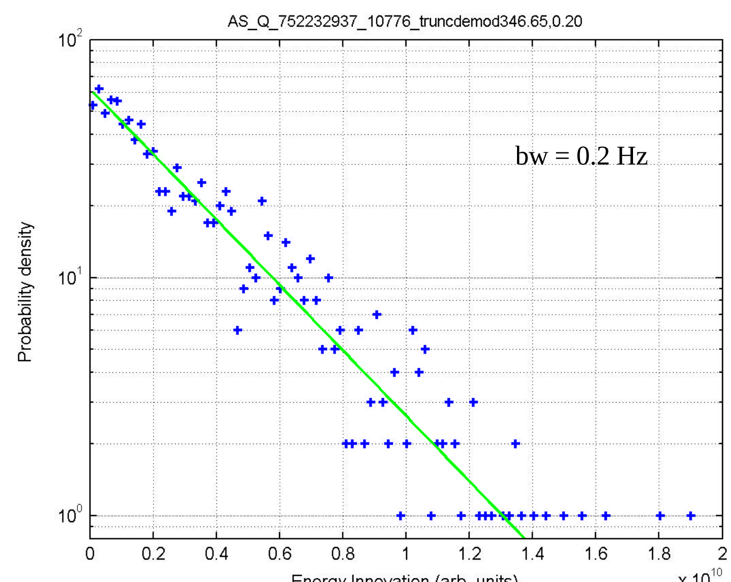
Energy Innovation

Syracuse tungsten fiber



LLO violin mode





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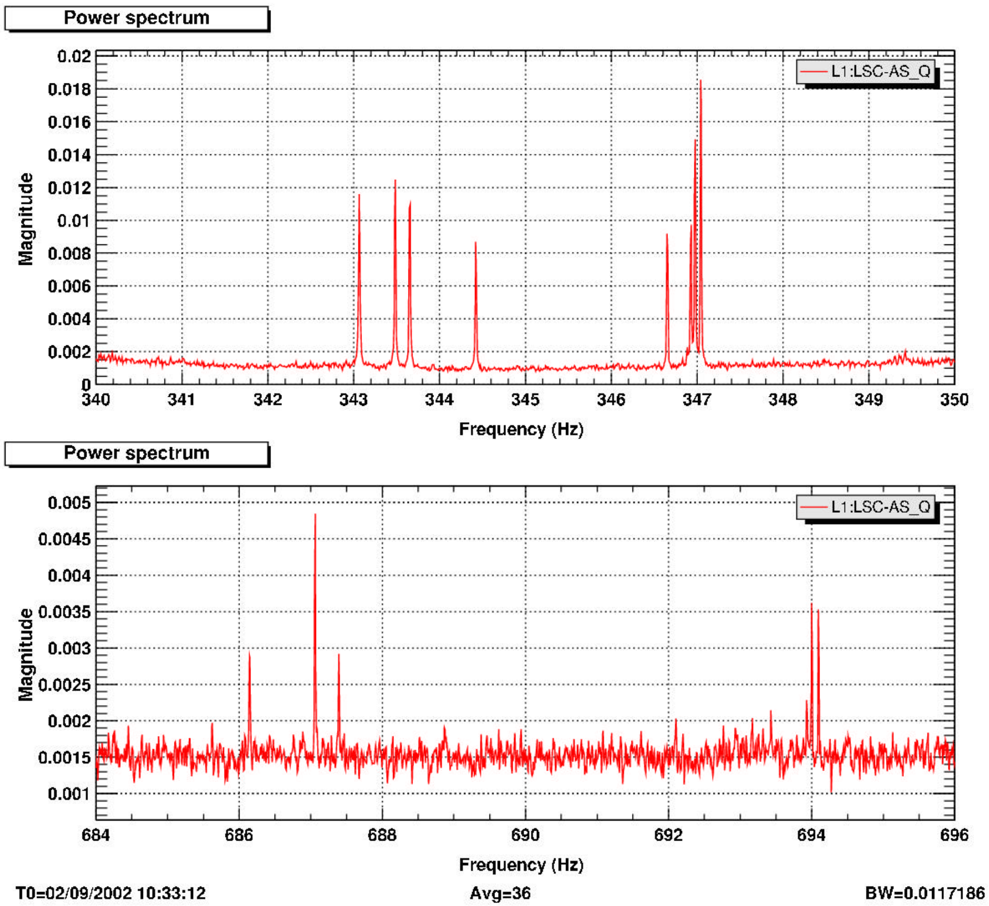
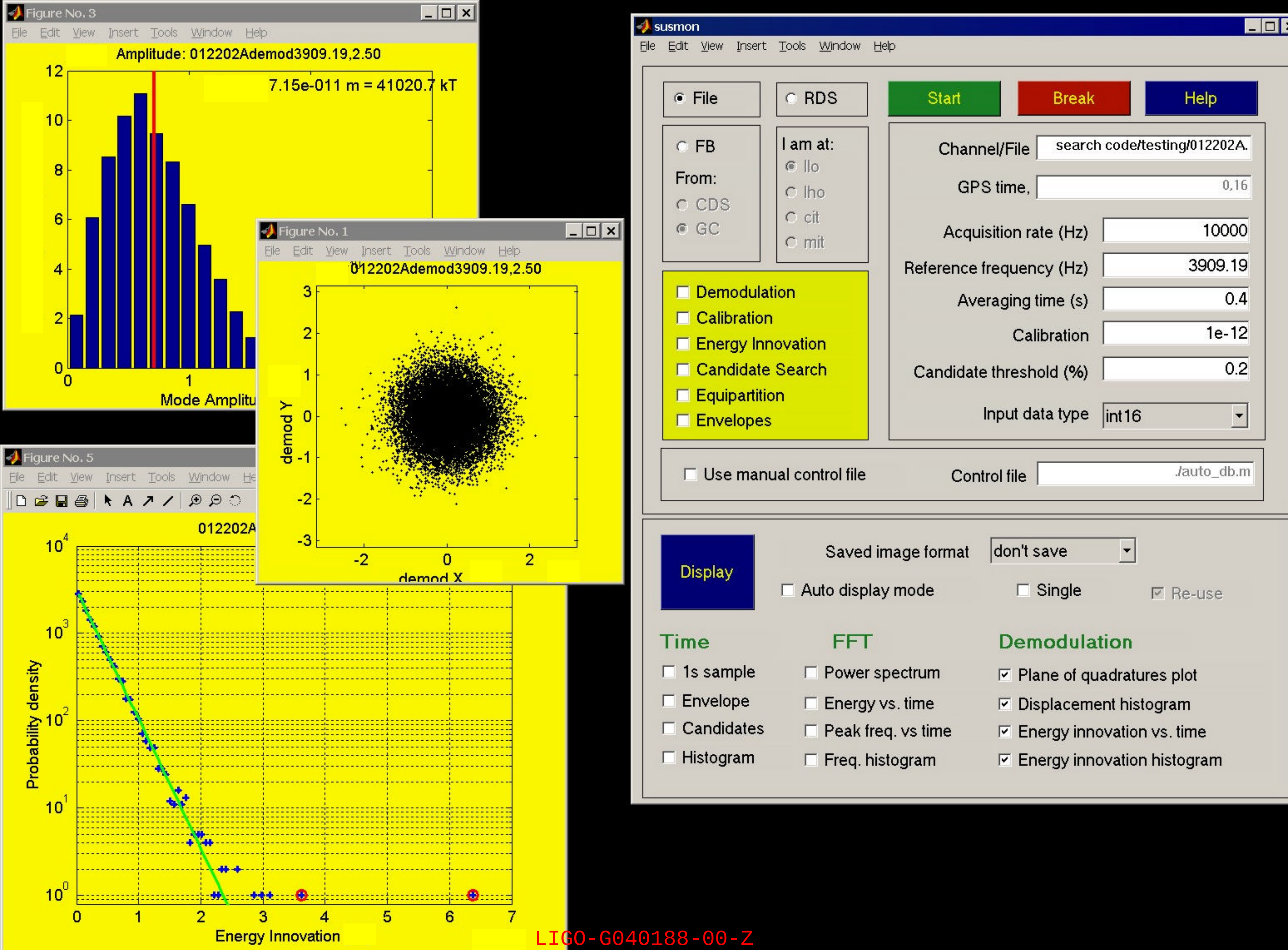
Correlations

Look for Correlations between events:

- Between modes of the same wire
- Between identical modes of wires attached to same test mass
- Between modes of wires attached to the different test masses
- Between modes and nearby non-resonant frequencies





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