

Characterization and Verification of PEM Channels

Chirps in the PEM Data

Anthony Rizzi
Staff Scientist, LIGO

LIGO-G000044-00-D

Goals



- Push installation of PEM
- Verify PEM chain: installation and design
 - From instrument through data collection and analysis
- Characterize PEM and other “noise” channels

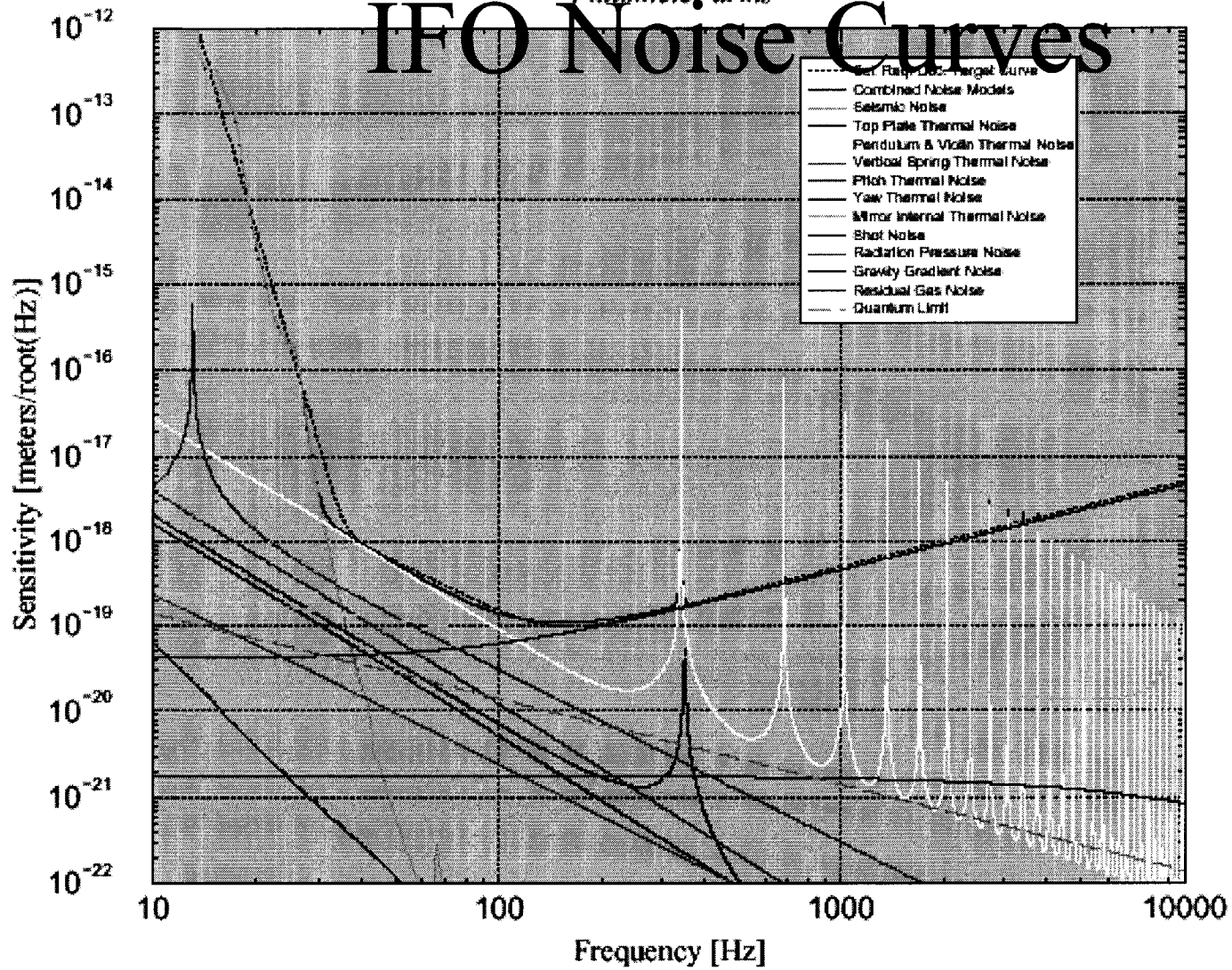
PEM Channels

	C,Y,X= 8,1,1
	1,1,1
	8,1,1
	1,0,0
Temp. Sensors	4,4,4
Residual Gas Analyzers	1,1,1
Weather Station	1,1,1
Tiltmeters	1,1,1
Dust Monitors	10,2,2
Muon Detector	1,0,0

Initial LIGO Noise Curves

4 kilometer arms

IFO Noise Curves



James Kent Blackburn

Sat Apr 11 20:15:23 1998

How to Interpret PEM Channels

- Displacement spectral density.
- What do we care about?
 - What interference does Non-gravitational wave source impinging on detector cause?
 - Include data analysis method.
 - Benchmark: #false GW/time interval:
E.G., 1 false GW/year.

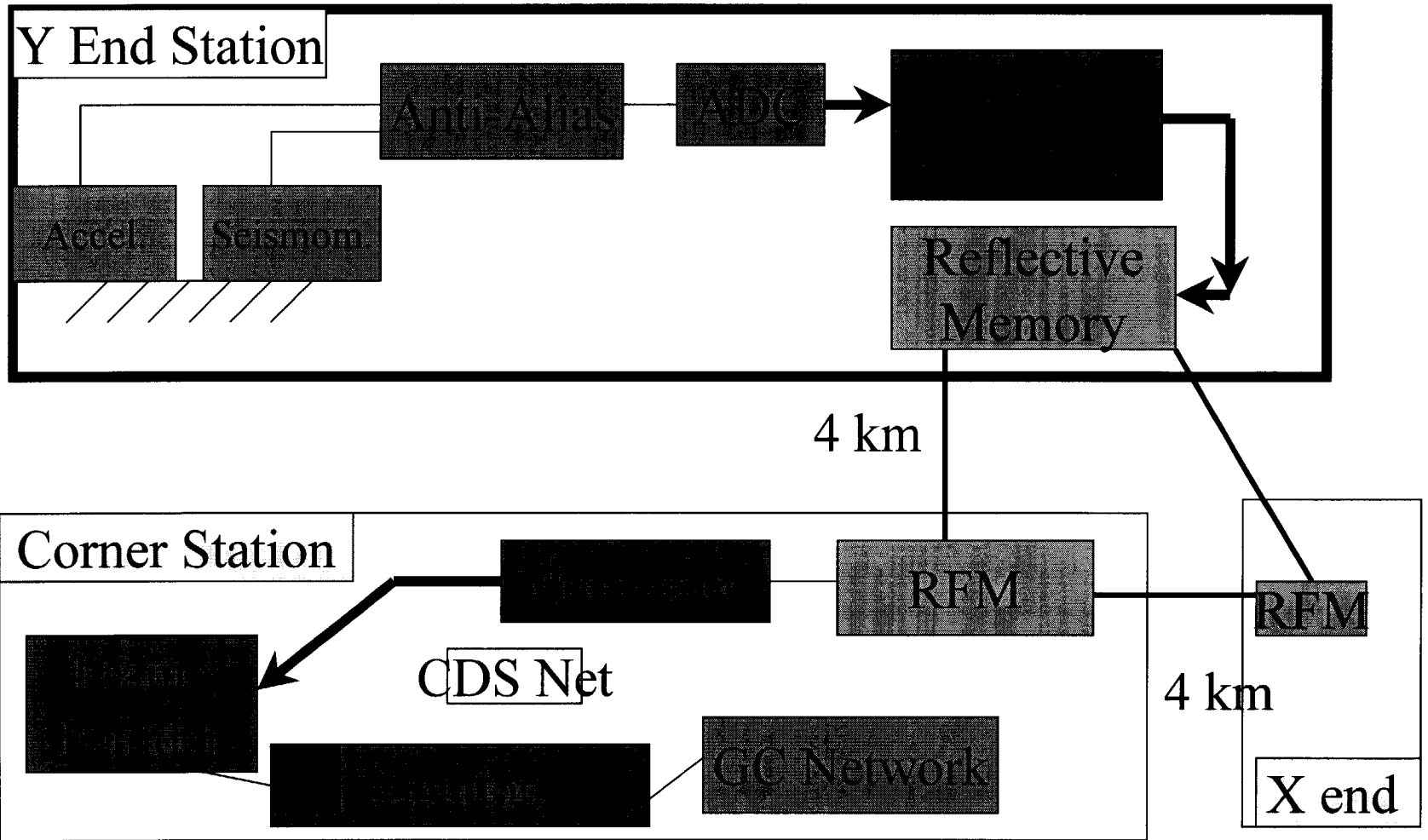
Optimal Filtering: Each Channel Introduces Chirps

$$h_i(t) = \alpha T_i(t - t_0) + n_i(t)$$

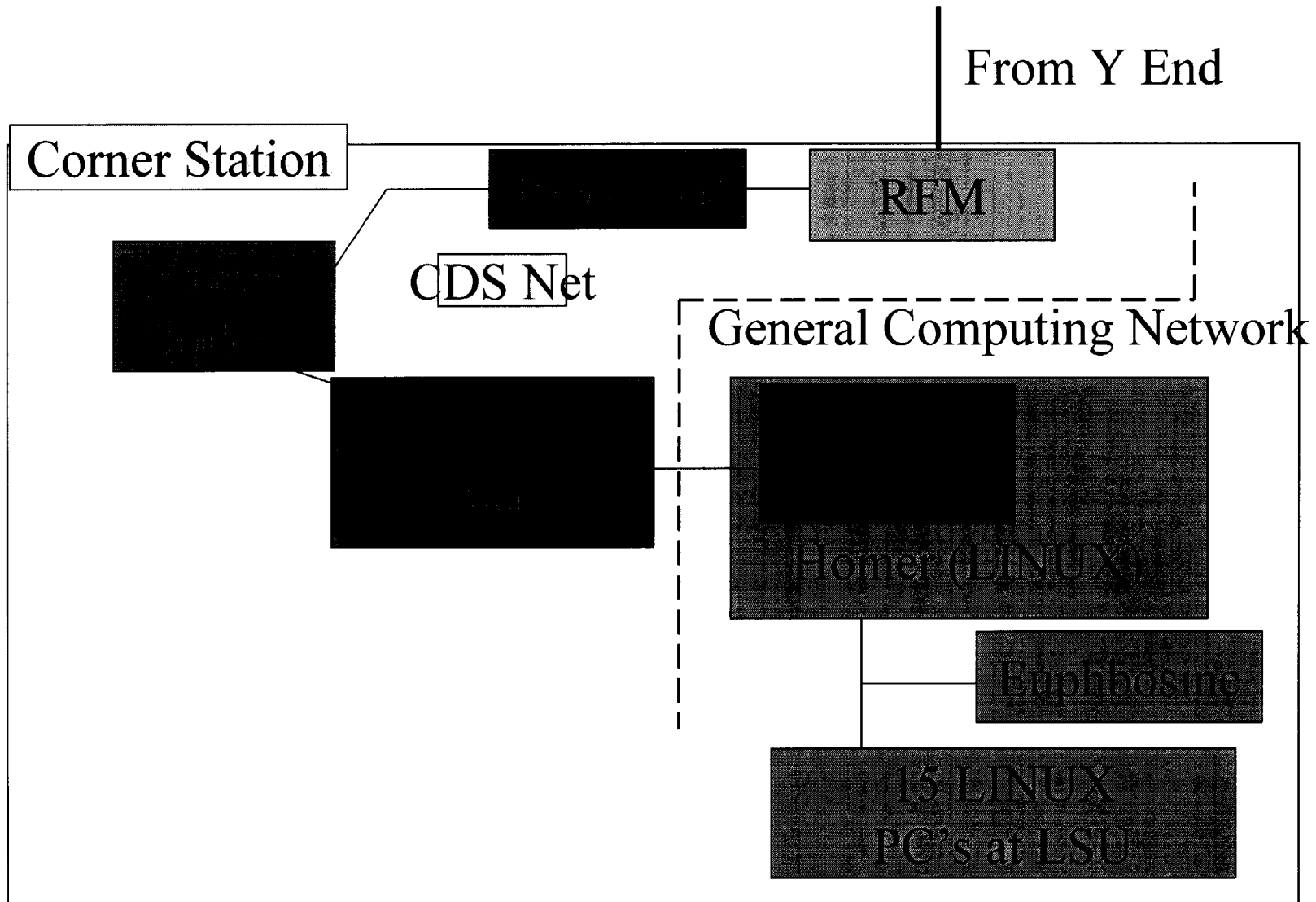
$$S_i = 2 \int_{f_{Nyquist}}^{f_{Nyquist}} df \frac{\tilde{h}_i(f) \hat{T}_i^*(f)}{S_{h_i}(f)} e^{-2\pi i f t_0}$$

$$i \in \{\text{PEM Channels}\} \quad \sum_i$$

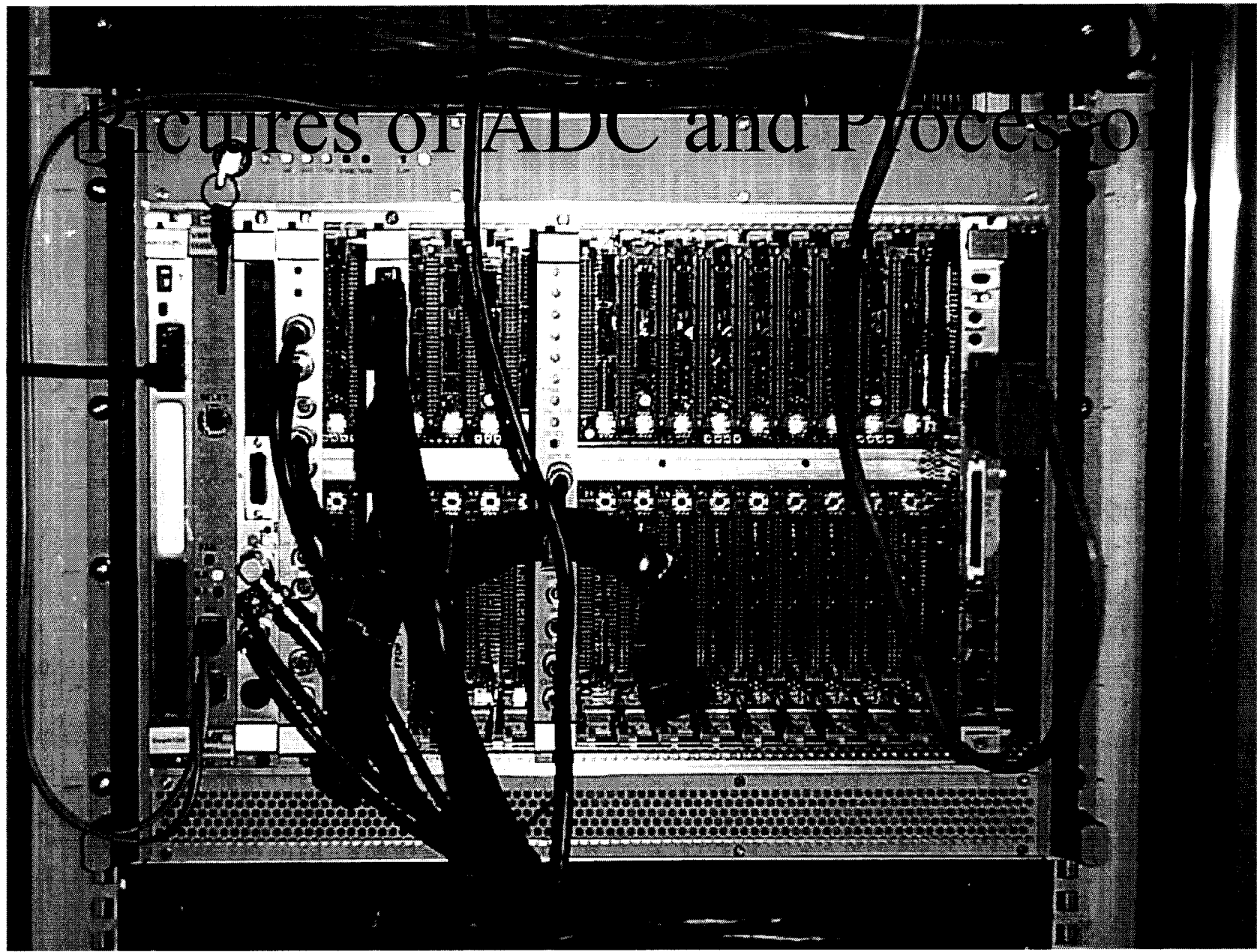
Data Flow



Data Flow II



Pictures of ADC and Processo

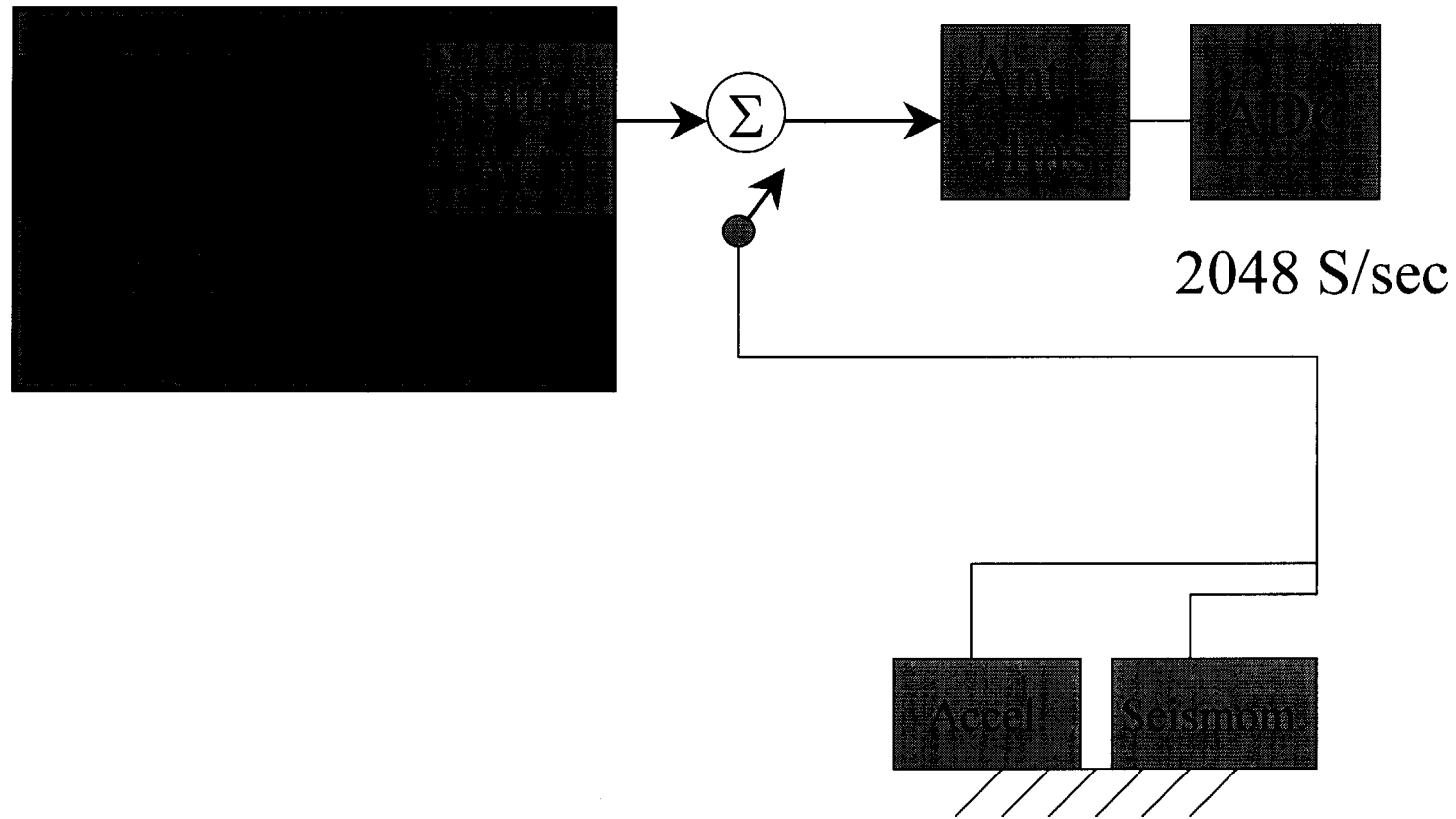




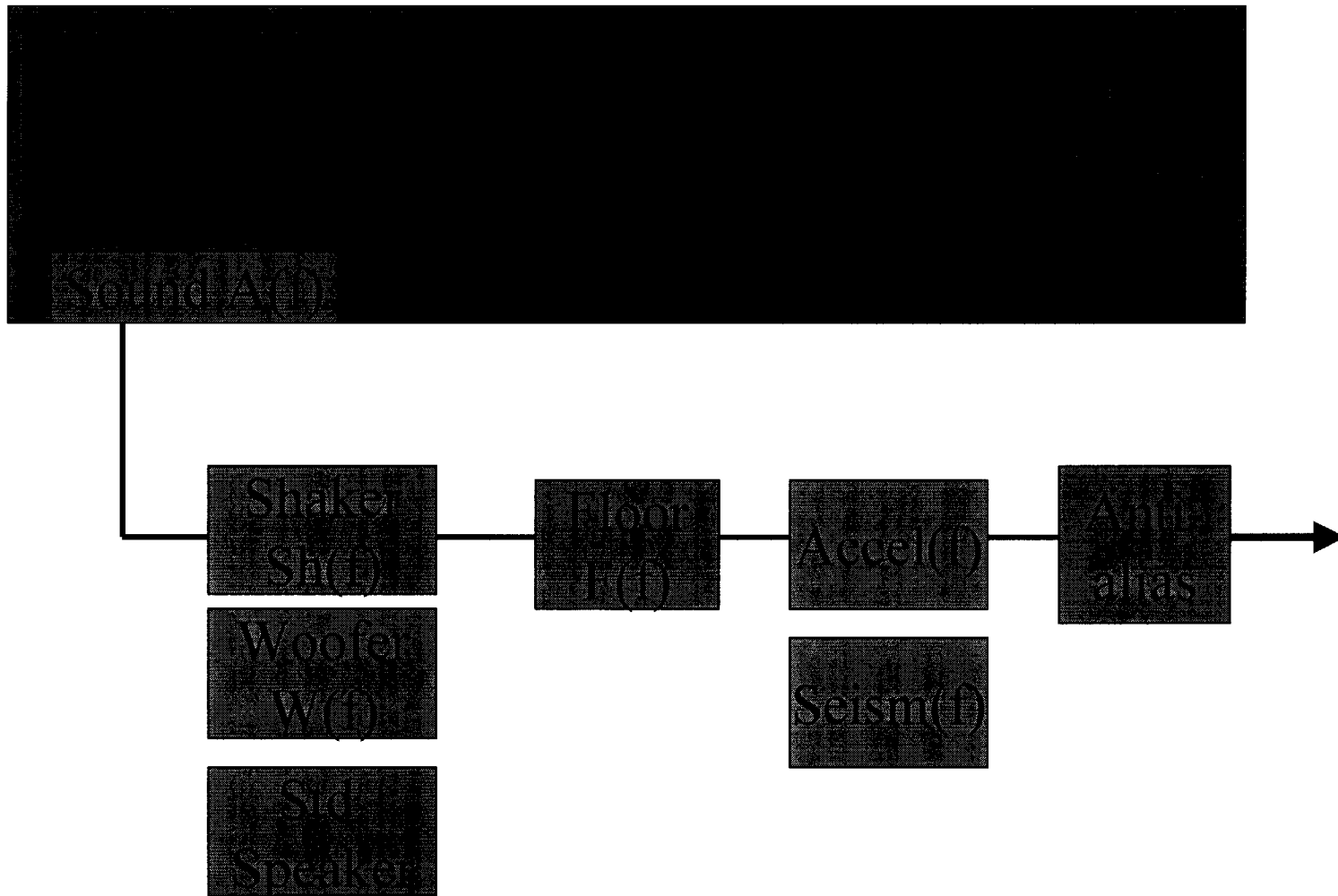
Verification of Seismic Chain

- Inject signal directly into anti-aliasing filter
- Inject signal summed with seismic signal
- Inject signal into ground near seismometer:
 - Shaker
 - Large woofer
 - Standard speakers

Direct and Summed Injection



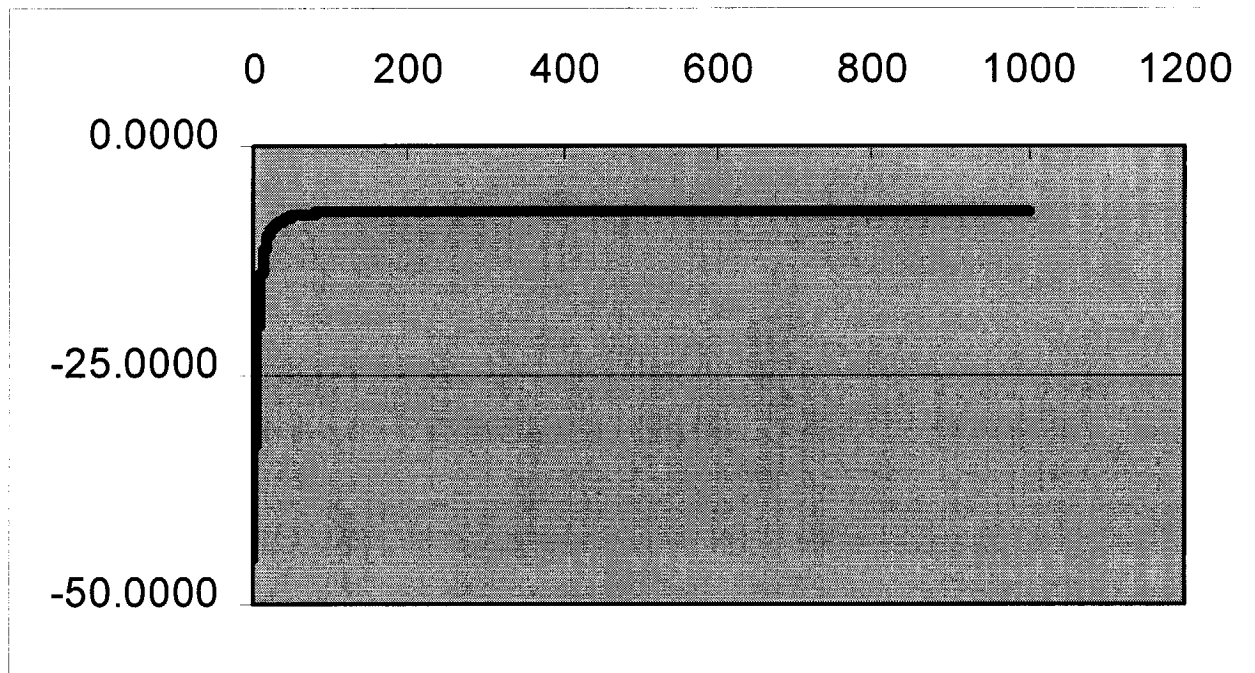
Ground Injection



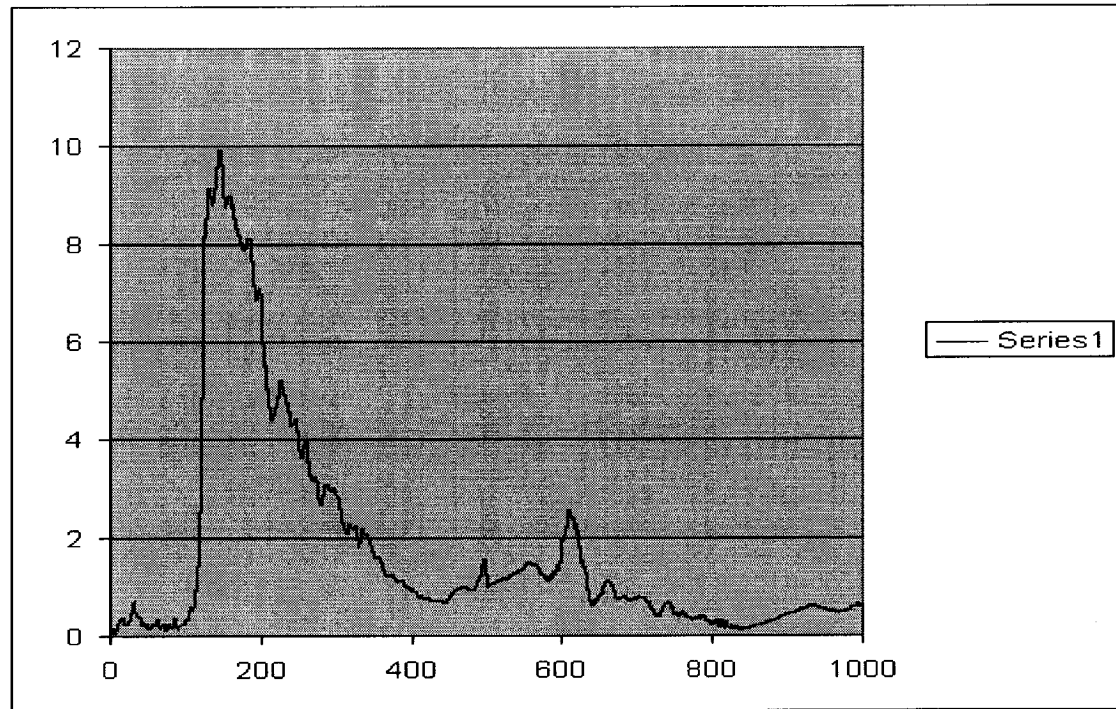
Transfer Function of Seismometer

Transfer Function of Accelerometer

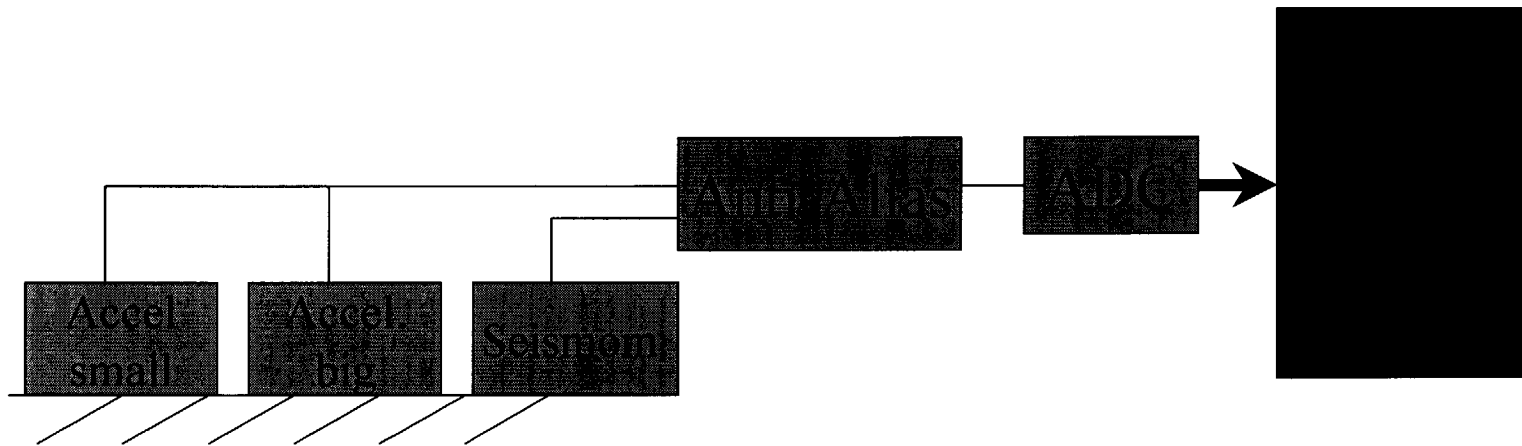
Transfer function of Audio Card



Transfer function of Shaker & Audio

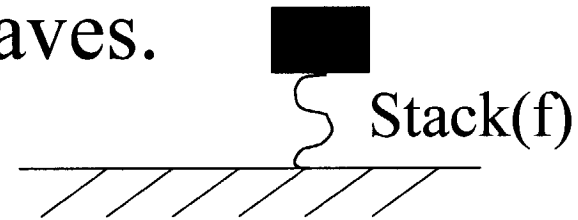


Experimental Setup



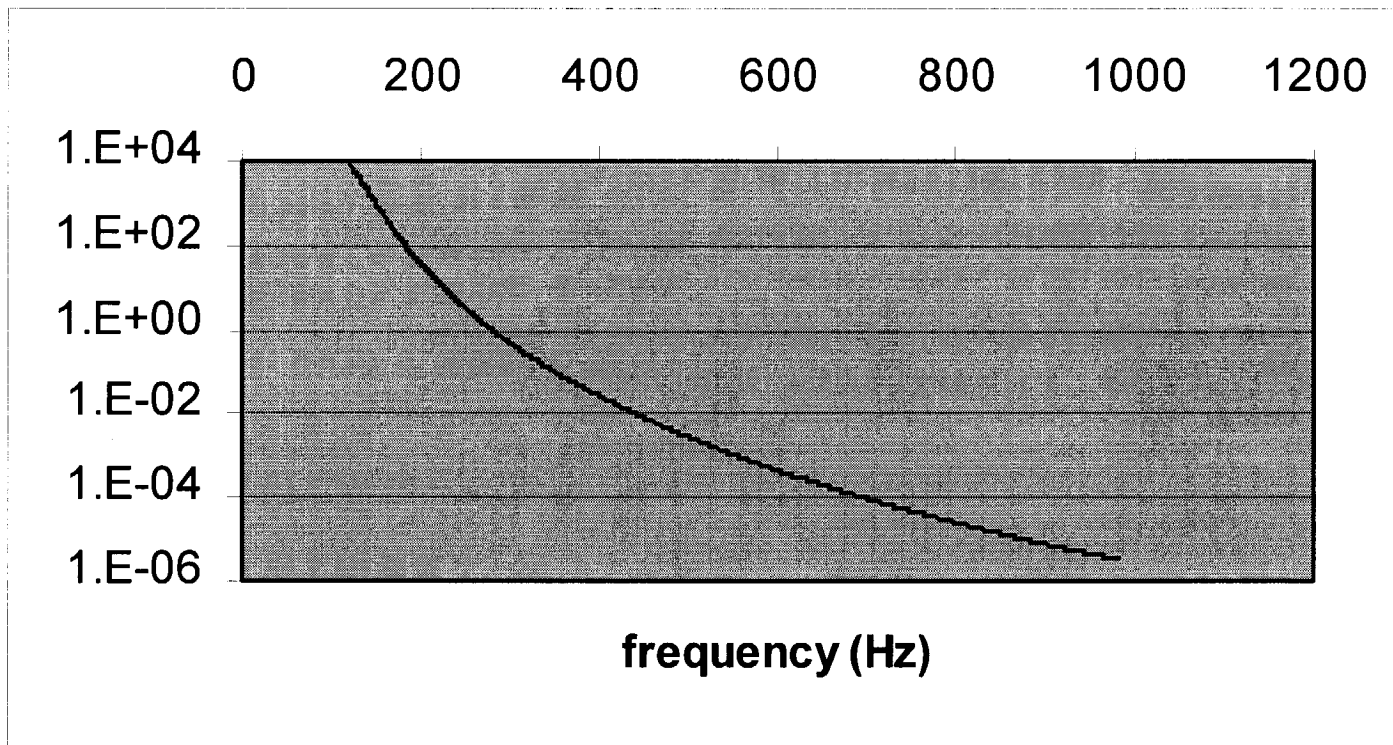
Looking for Chirps

- Ground Motion will cause test mass motion that can mimic gravity waves.



- Transfer ground motion to test mass using stack transfer function and pendulum transfer function.
 - Get Stack Model, use Mathematica to generate table.

Transfer function of Stack and Pendulum



$$\propto \frac{1}{f^8} * \frac{1}{f^2}$$

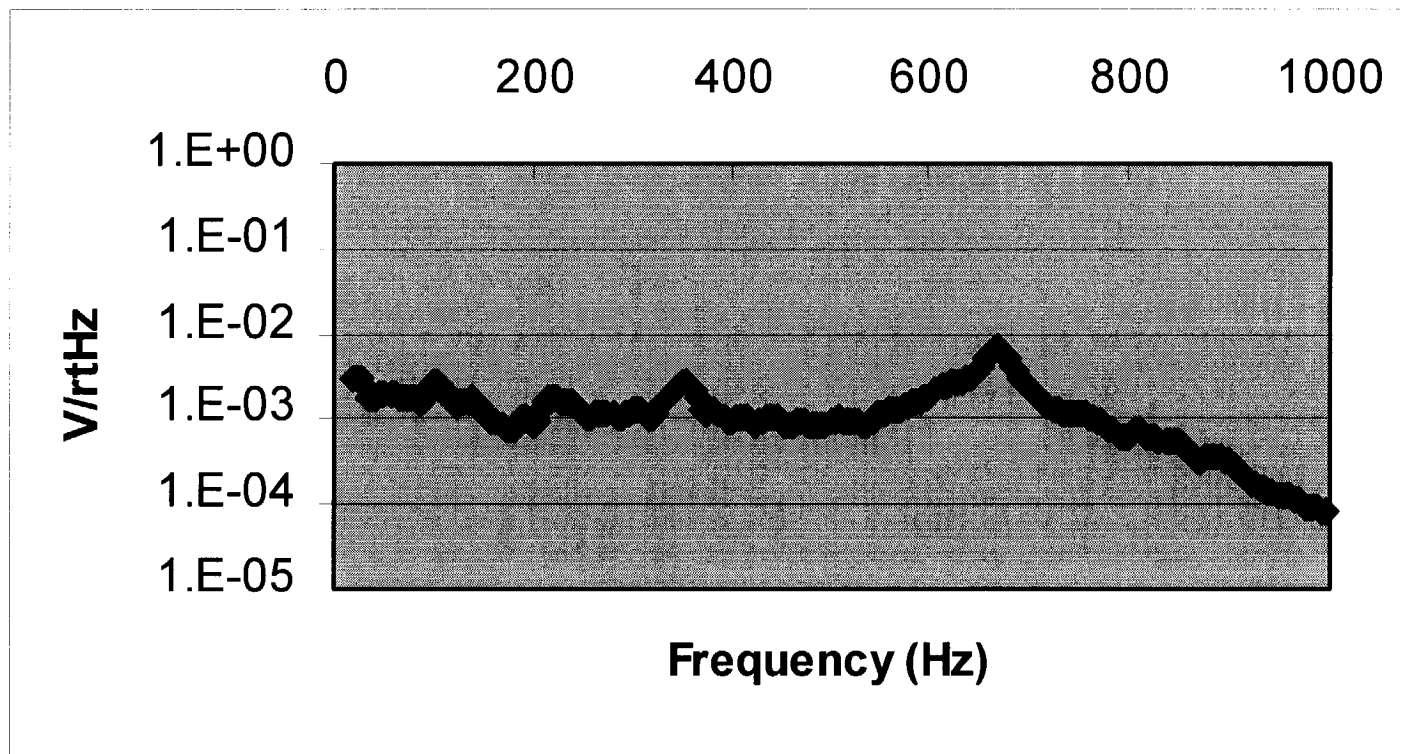
Demo of Key Executables for Injection Testing

- AnimateF and SnapshotF
- OptimalF

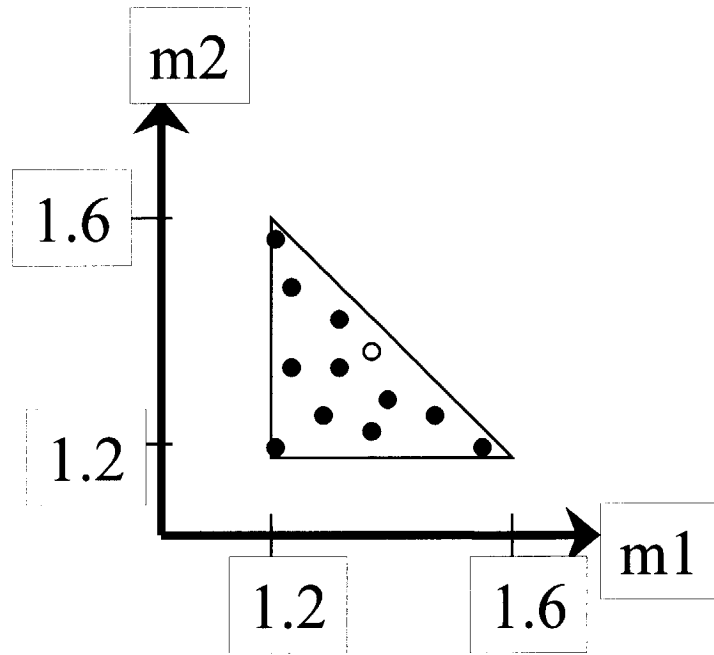
Demo of Key Executables for Experiment

- OptimalF needs transfer function file created by Mathematica.
- make_grid, make_mesh....seismic noise spectrum
- MultifilterF w/ transfer function file above

Background Seismic Spectrum (Accelerometer)



Mass Template



Match between a and b:

$$\mu = \max_{t_0} \frac{\langle a, b \rangle_{t_0}}{\sqrt{\langle a, a \rangle \langle b, b \rangle}}$$

$$\langle a, b \rangle_{t_0} \equiv \int_{-\infty}^{\infty} df \frac{A^*(f)B(f)}{S_h(f)} e^{-2\pi f t_0}$$

Intermediate Result using 24hrs of data

- >32 False Events/day (66 templates)
 - with prob. $>.1$
- > 97 False Events/day (66 templates)
 - with snr > 5
- > 5 False Events/day (66 templates)
 - with snr > 10

Future Direction



- Generate mass grid structure based on seismic noise.
- Run data with these mass templates and determine benchmark for Seismic noise for significant data base.
- Make experiment algorithmic so all nonGW signals can be characterized by the chirpiness benchmark. Incorporate non-PEM noises.
- Setup so chirp checking is continuous to allow long data stretch real time checking.
- Generalize to other types of GW's.