LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

-LIGO-

CALIFORNIA INSTITUTE OF TECHNOLOGY

Characterization and Verification of PEM Channels:
Chirps in the PEM Data

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by

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Distribution:

all

This is a publication of the LIGO Project.

Characterization and Verification of PEM Channels

Chirps in the PEM Data

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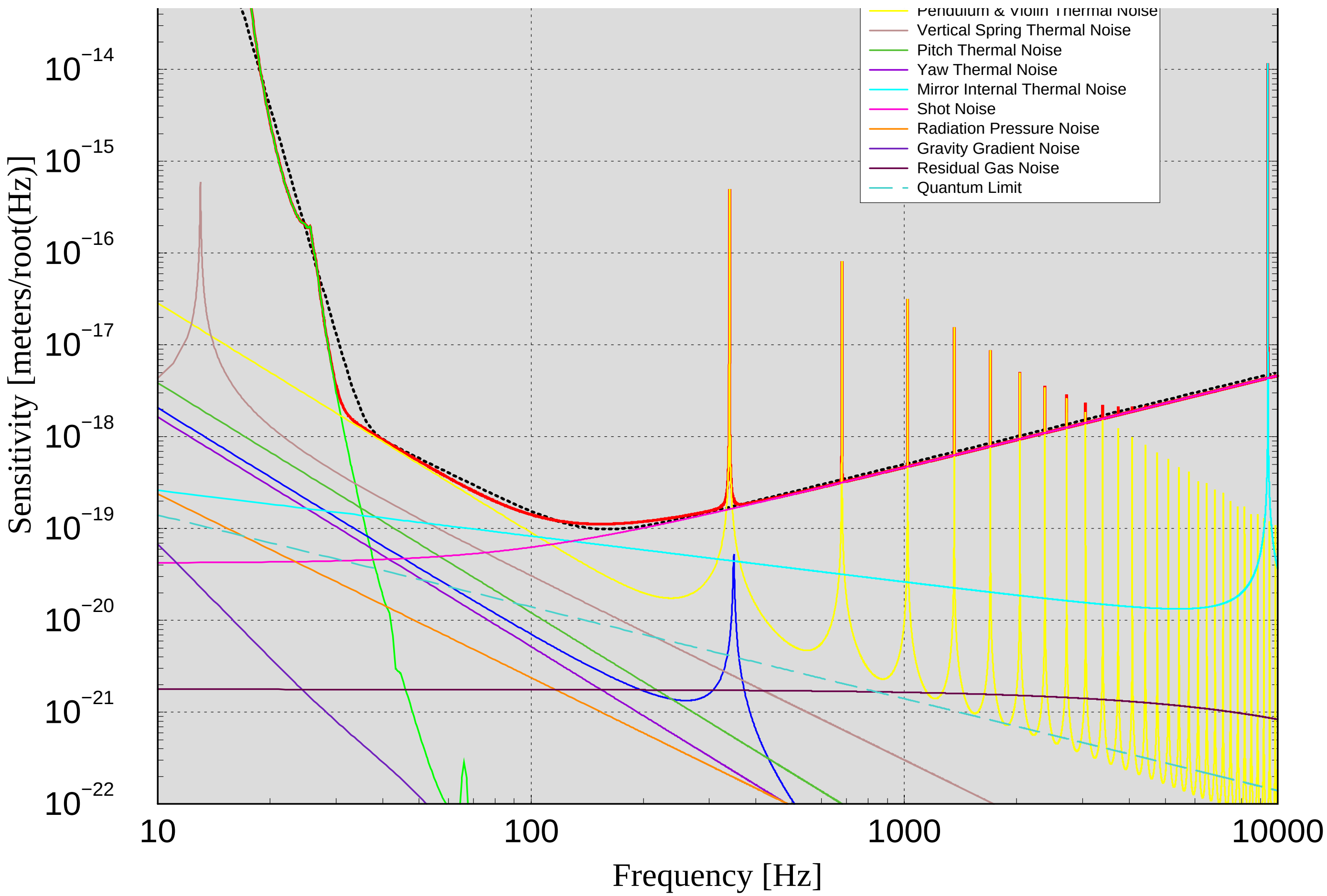
Goals

- 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

Accelerometers	C,Y,X= 8,1,1
Seismometers	1,1,1
Microphones	8,1,1
RF Receivers	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

IFO Noise Curves



James Kent Blackburn

Sat Apr 11 20:15:33 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.

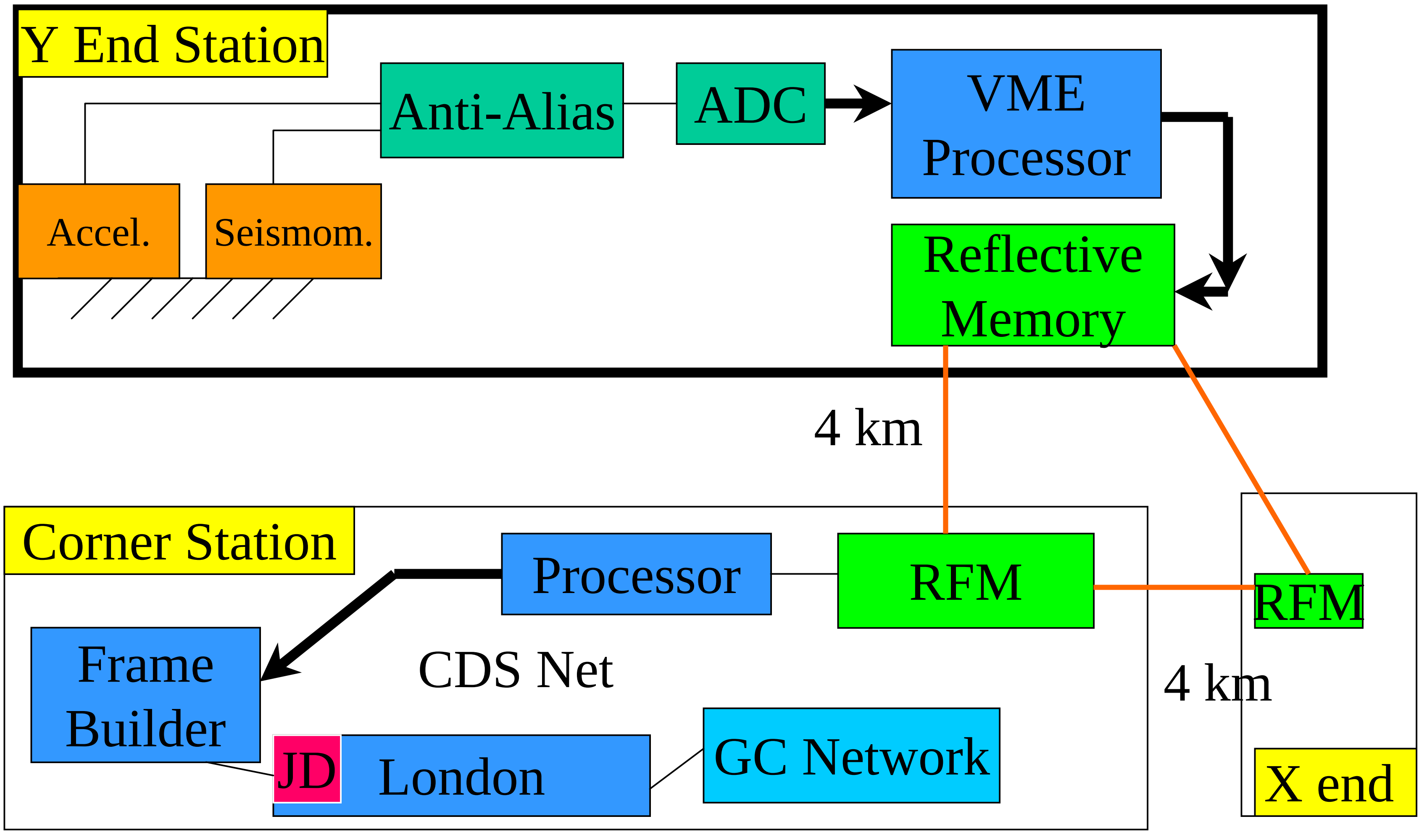
Optimal Filtering:
Each Channel Introduces Chirps

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

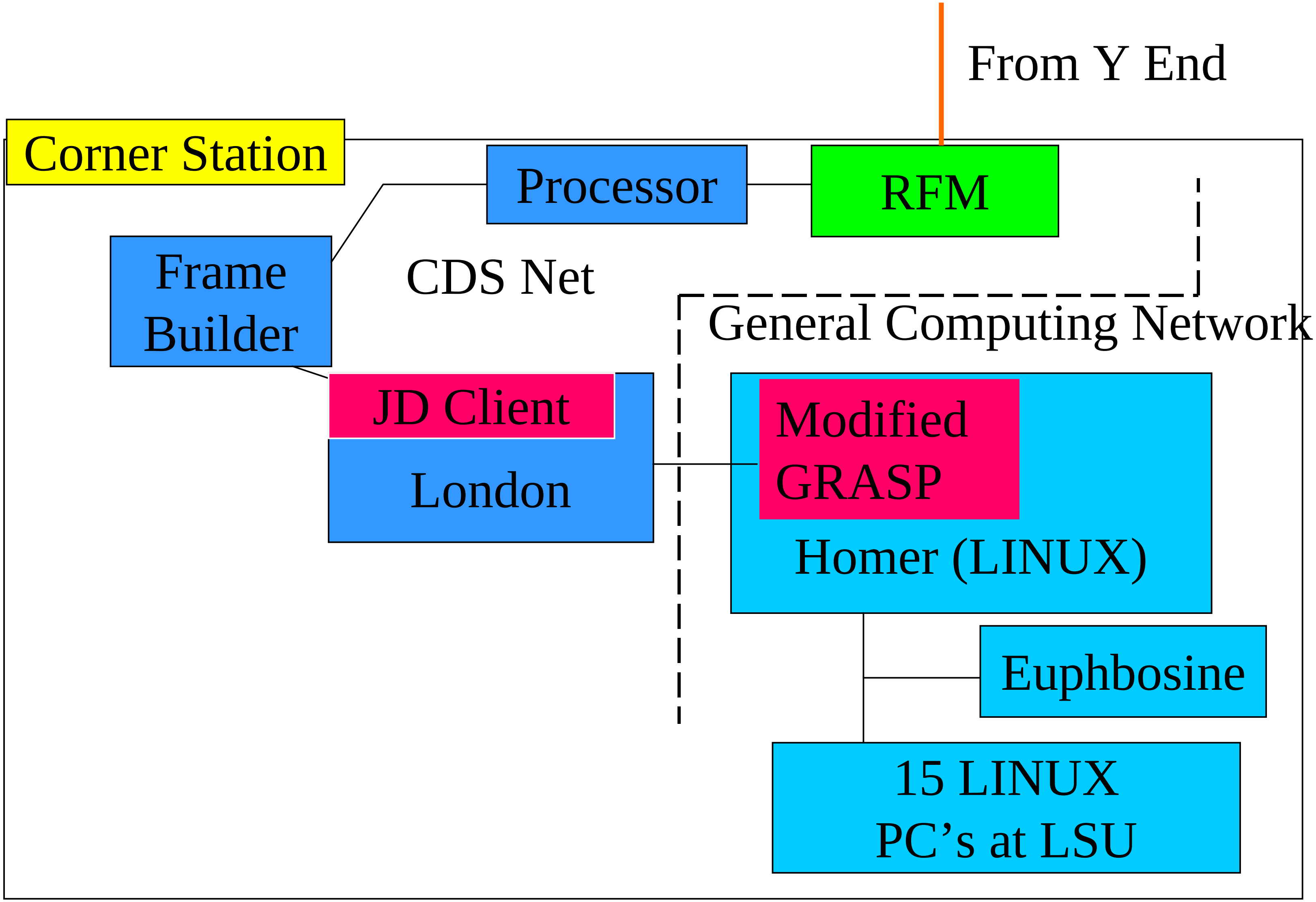
$$S_i = 2\int_{-f_{Nyquist}}^{f_{Nyquist}} df \, \frac{\tilde{h}_i(f)\hat{T}_i^*(f)}{S_{h_i}(f)} e^{-2\pi i f t_0}$$

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

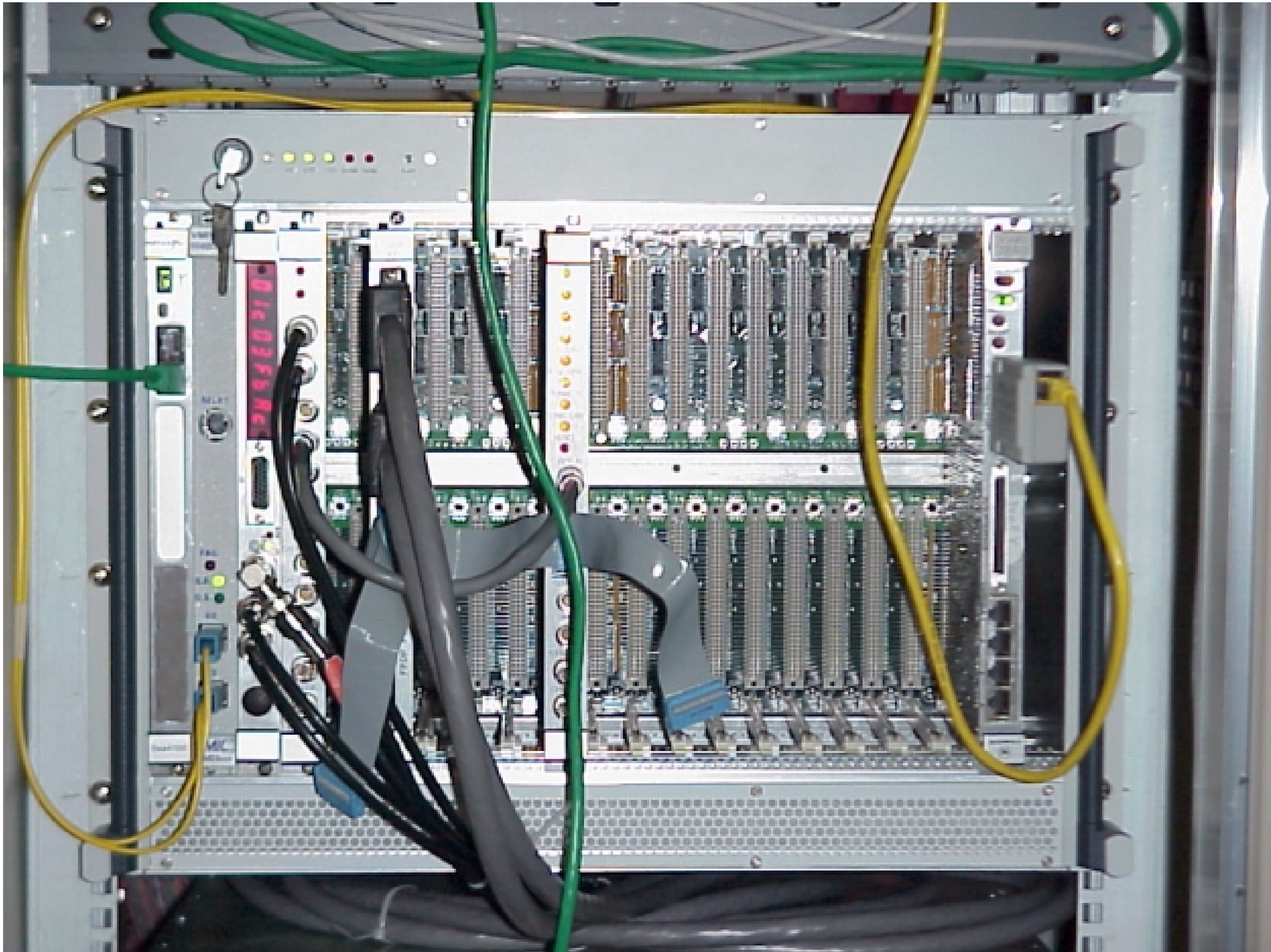
Data Flow


Y End Station
Anti-Alias
ADC
VME Processor
Accel.
Seismom.
Reflective Memory
4 km
Corner Station
Processor
RFM
RFM
Frame Builder
CDS Net
4 km
JD
London
GC Network
X end

Data Flow II



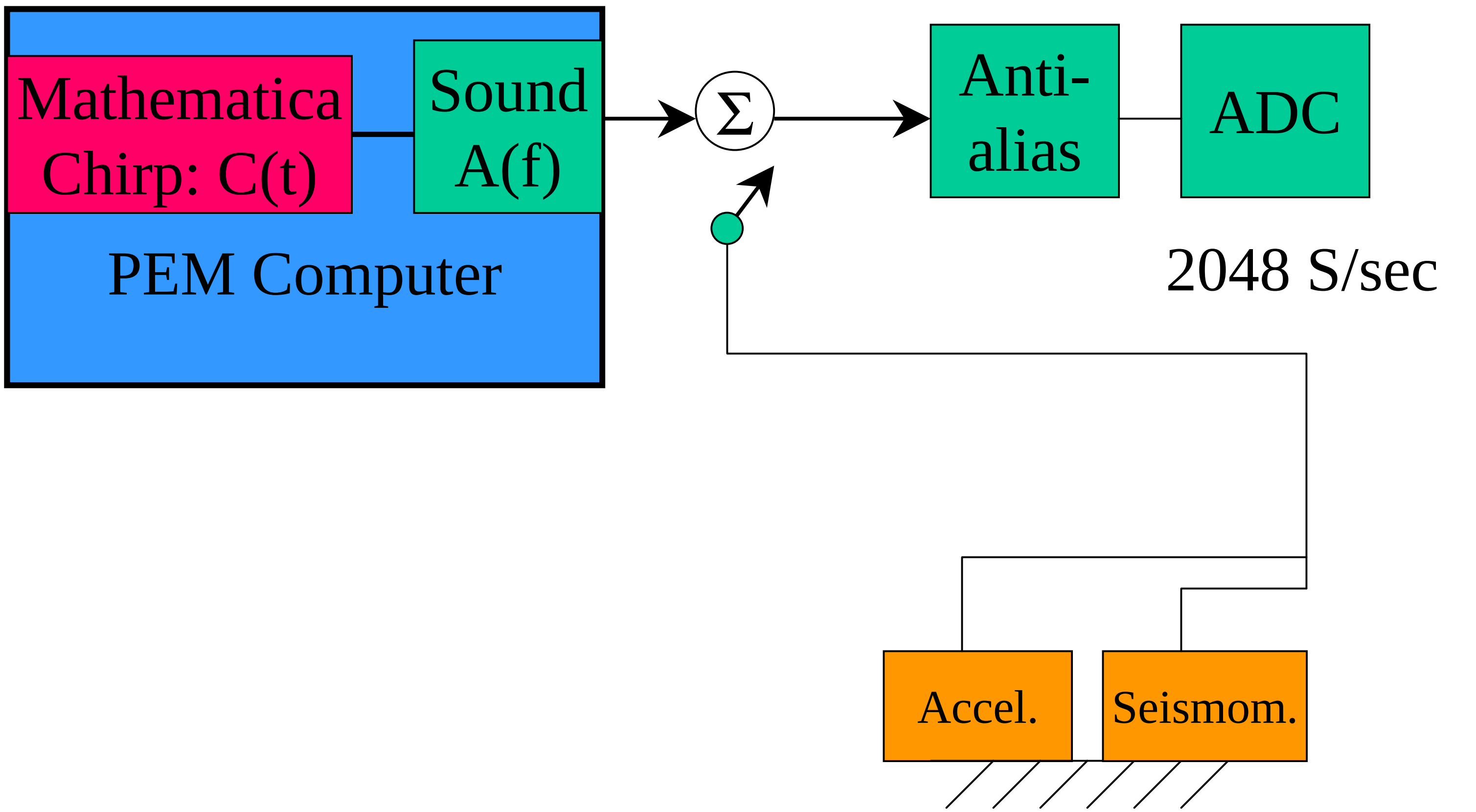
From Y End
Corner Station
Processor
RFM
Frame Builder
CDS Net
General Computing Network
JD Client
London
Modified GRASP
Homer (LINUX)
Euphbosine
15 LINUX PC's at LSU



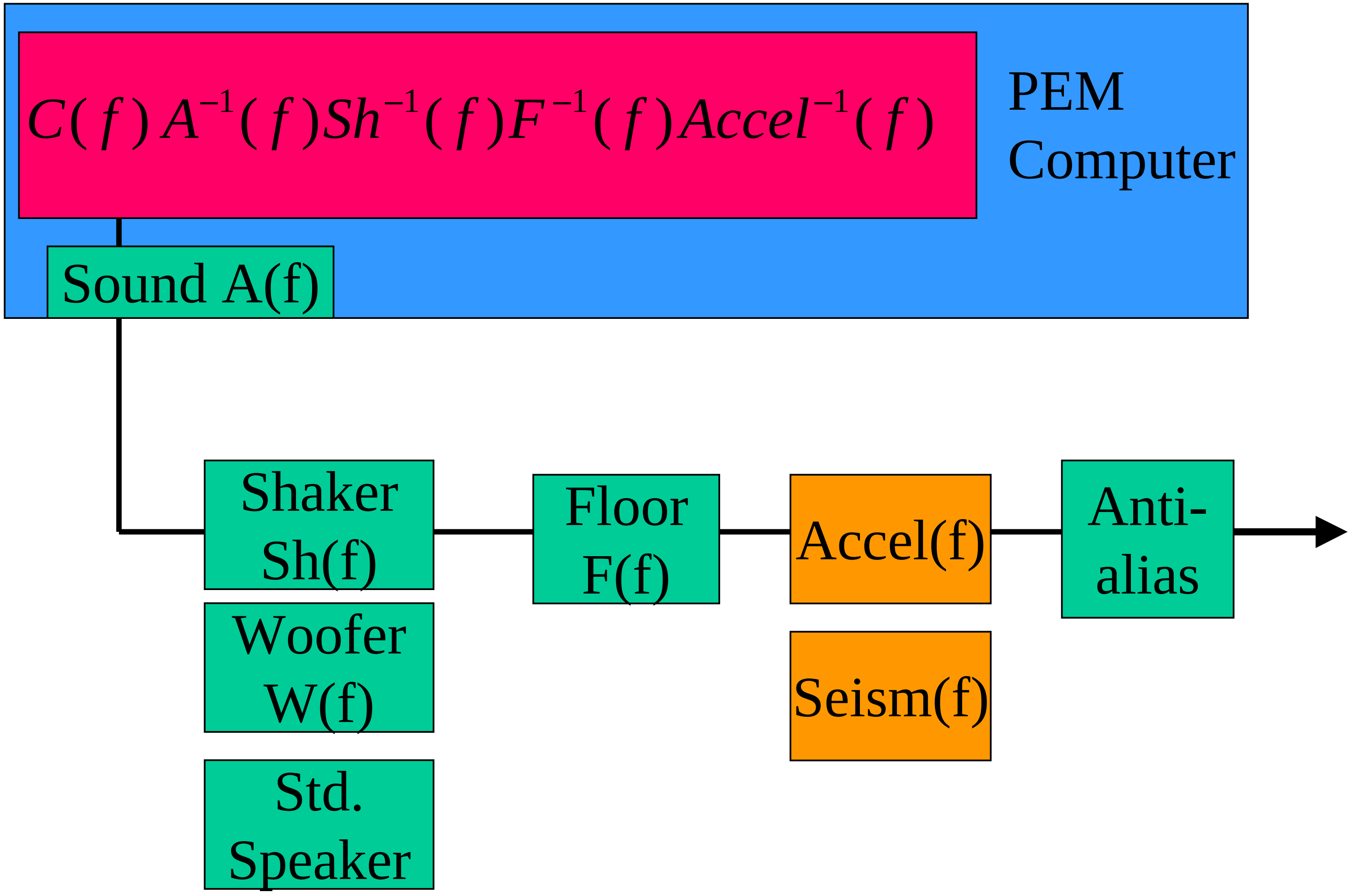
Verification of Seismic Chain

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

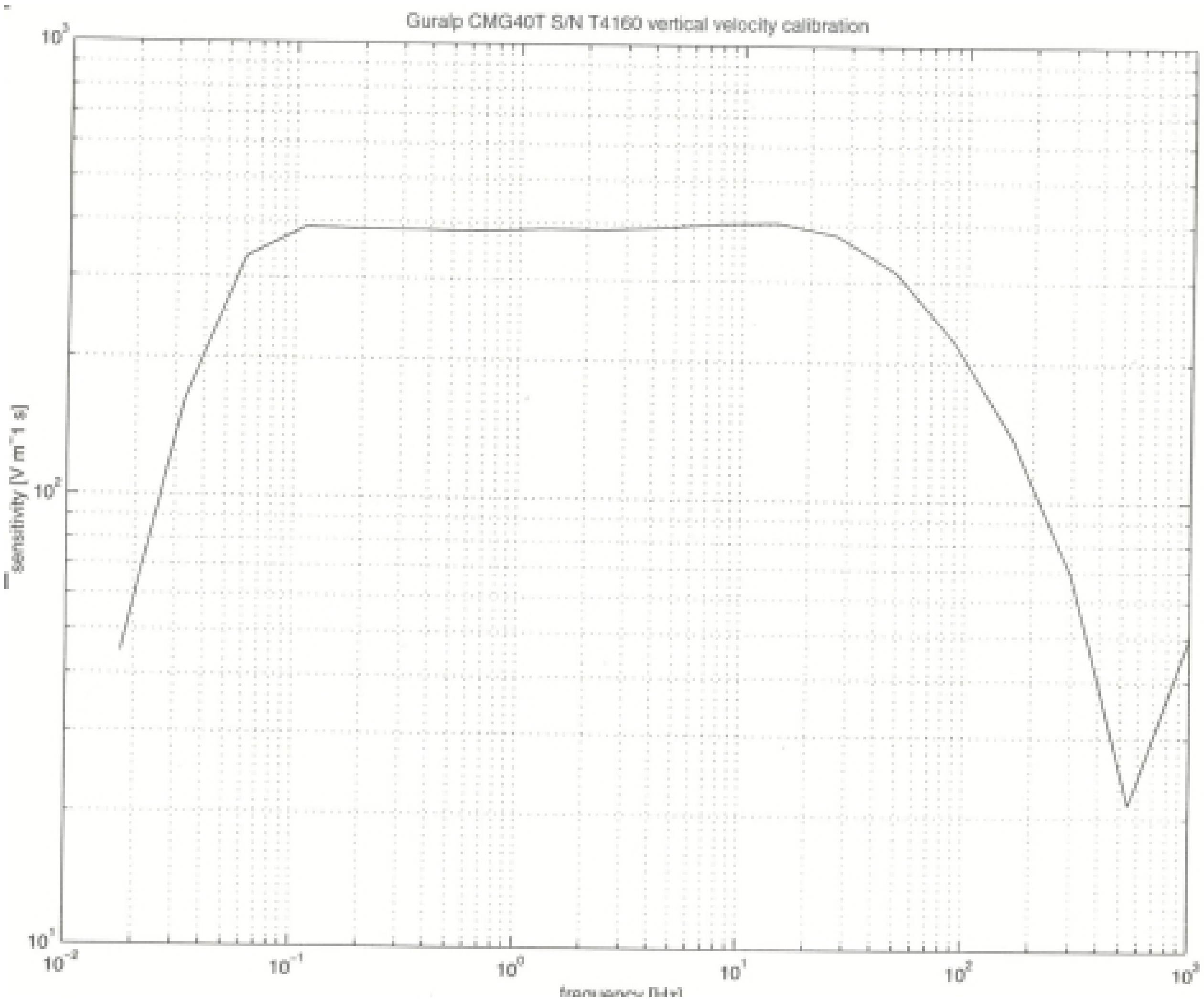
Direct and Summed Injection



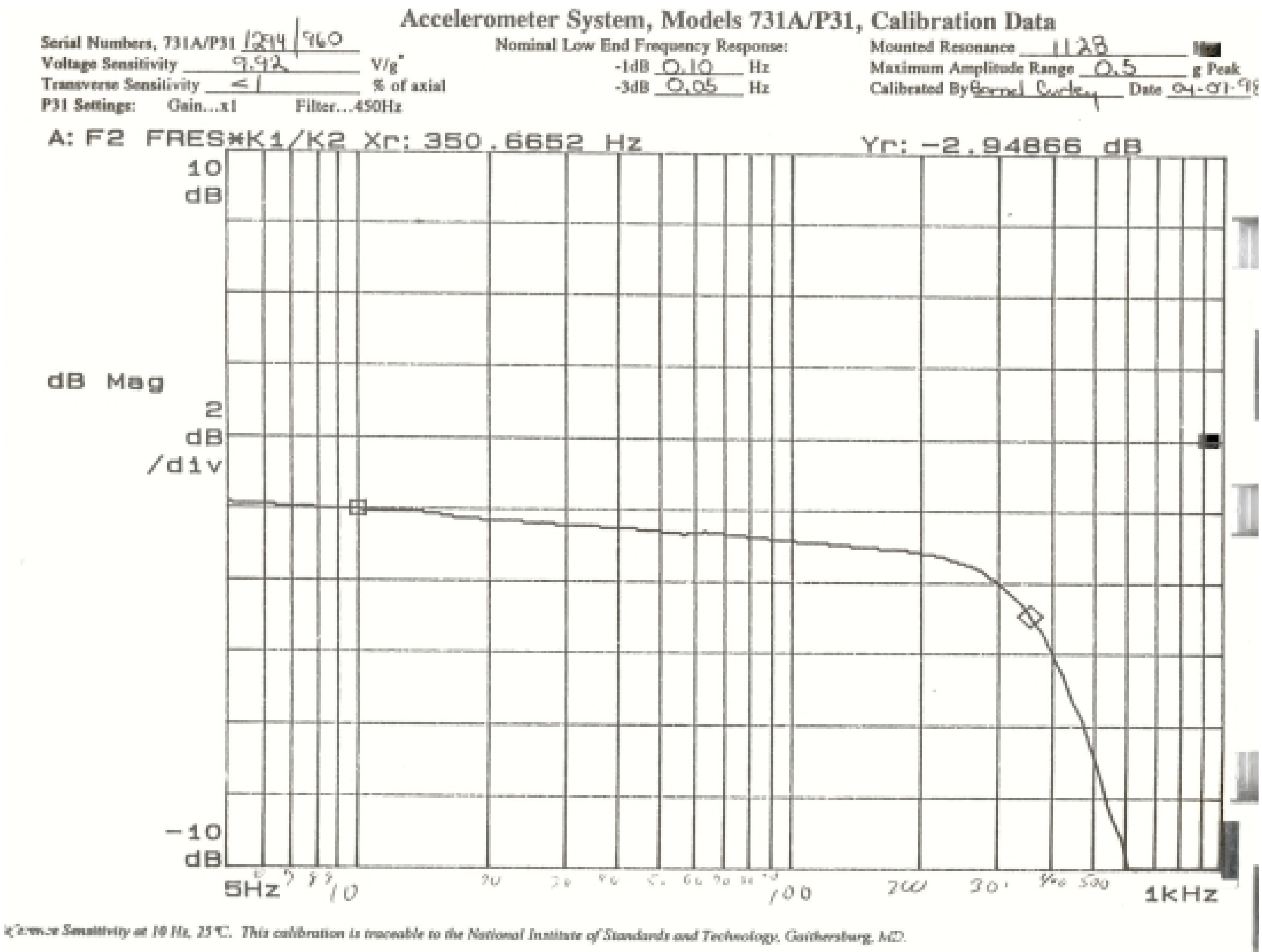
Ground Injection



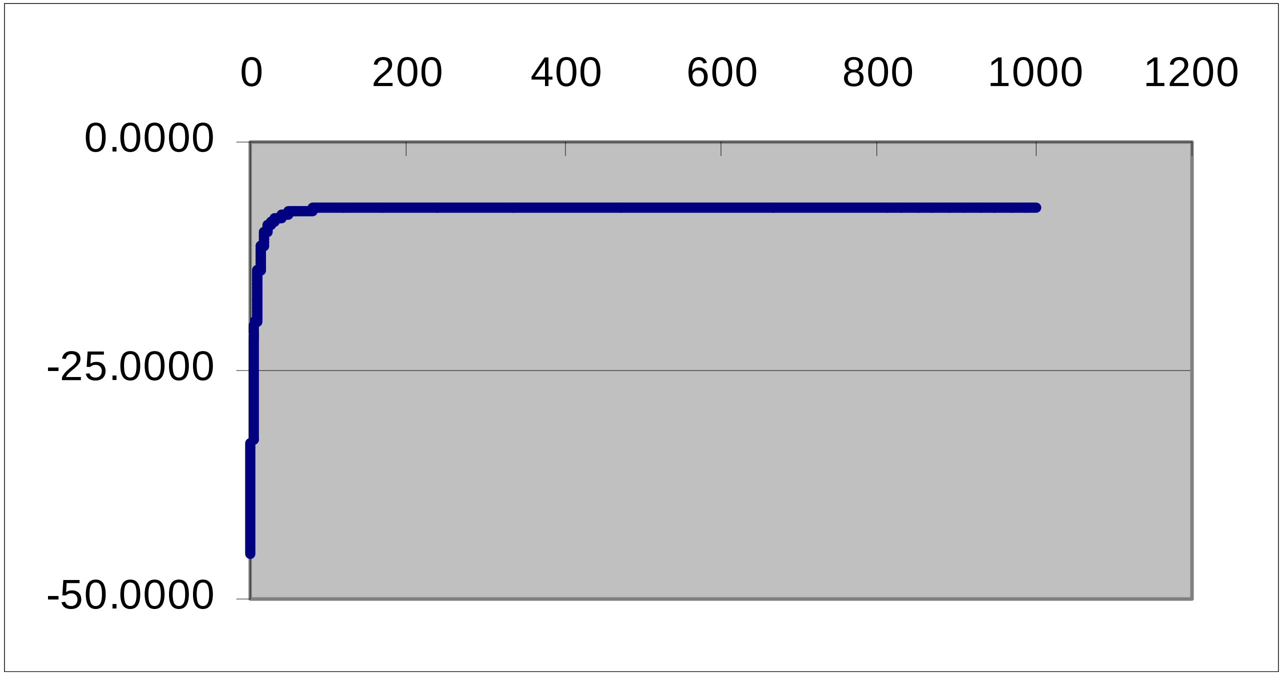
Transfer Function of Seismometer



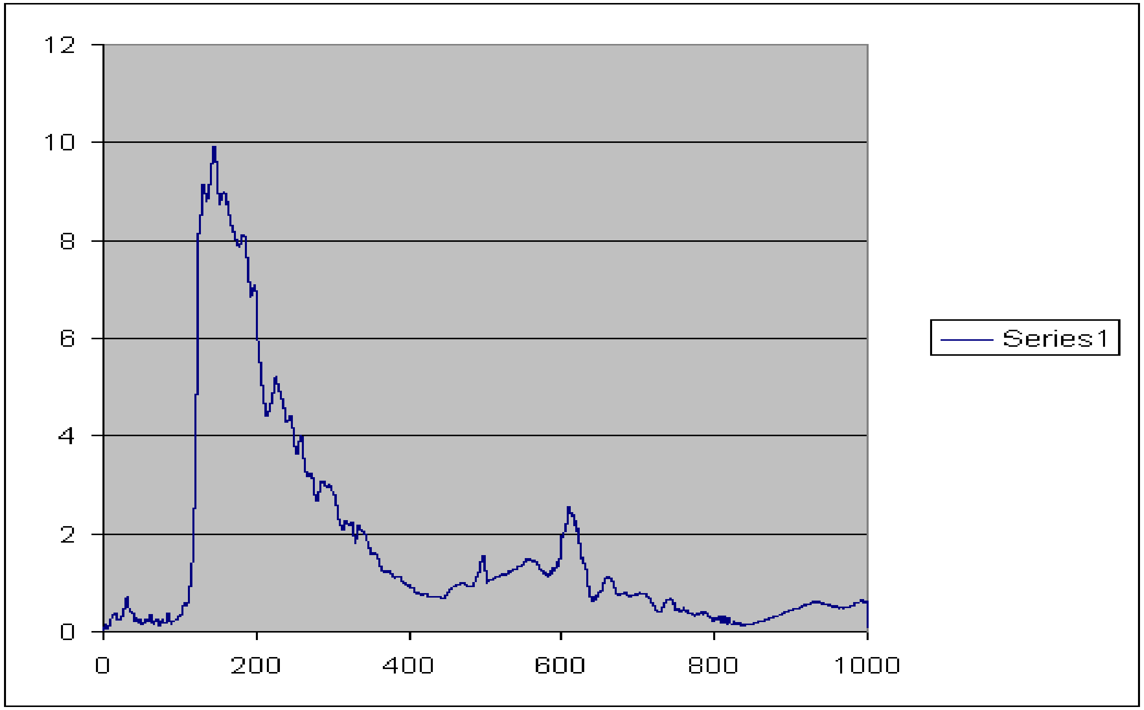
Transfer Function of Accelerometer



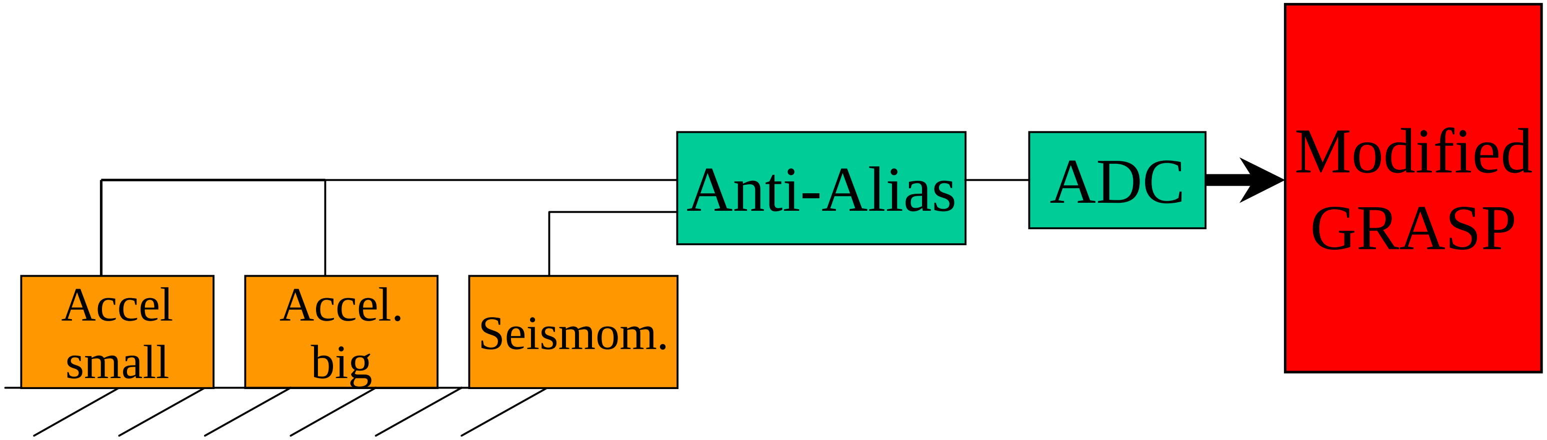
Transfer function of Audio Card



Transfer function of Shaker & Audio

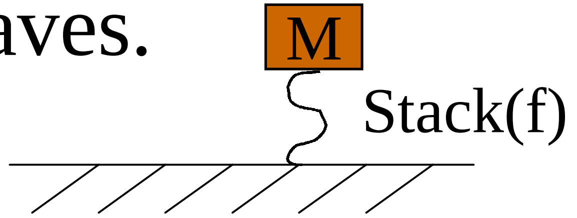


Experimental Setup



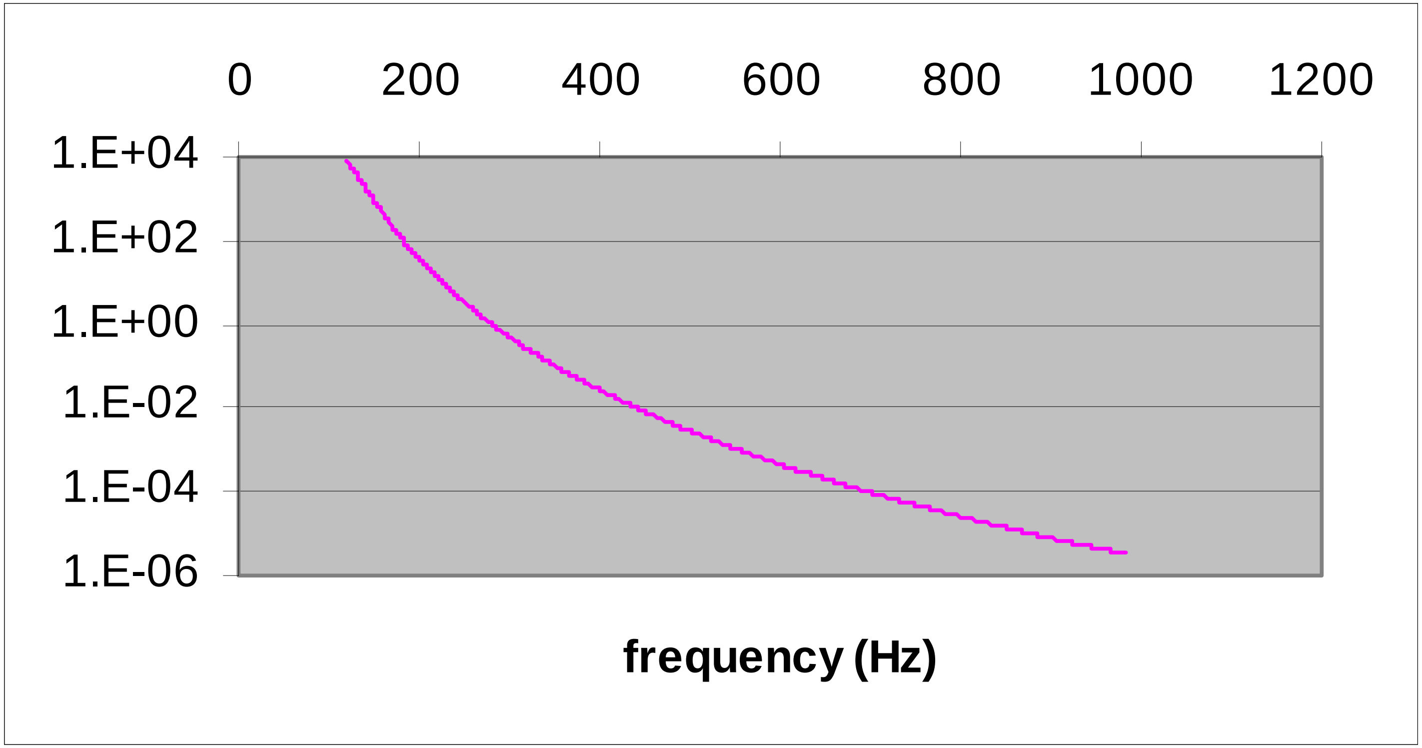
Looking for Chirps

- 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



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

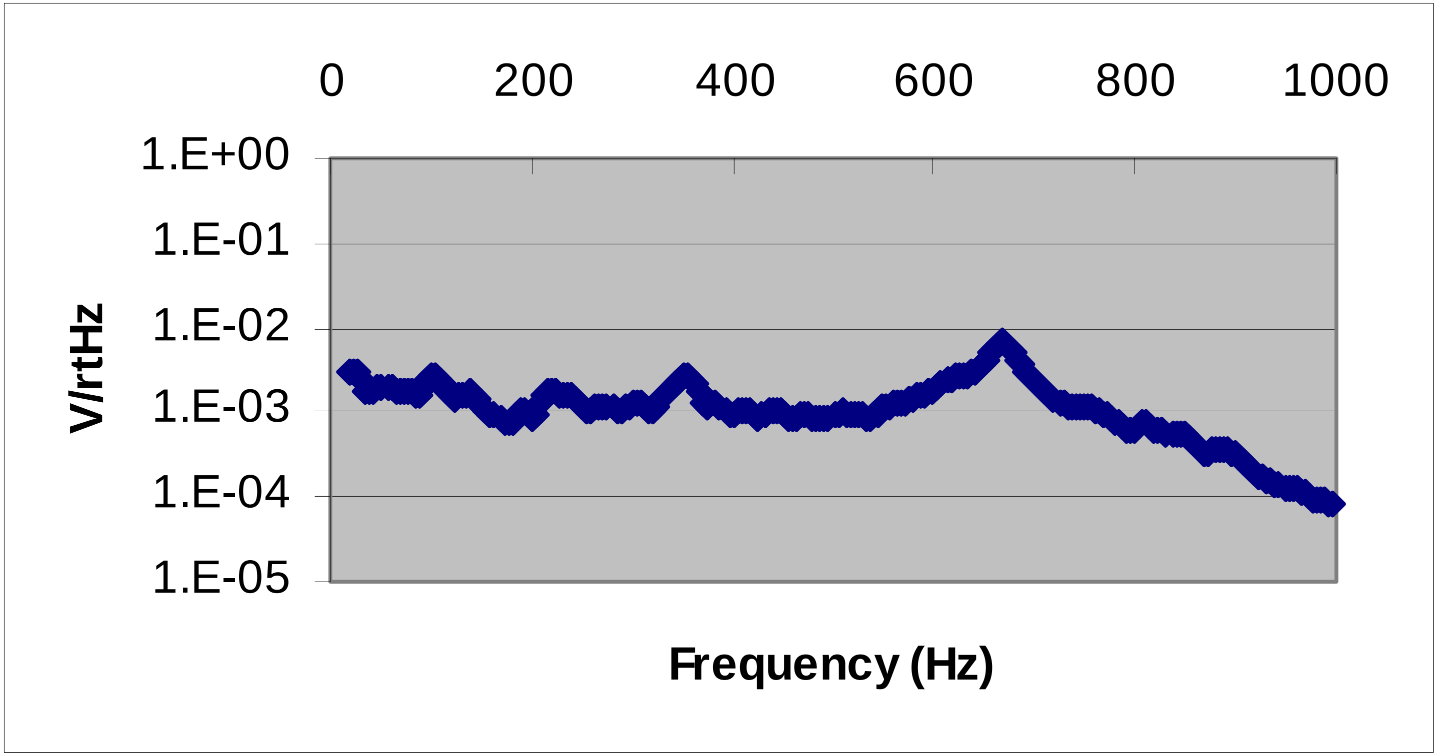
Demo of Key Executables for Injection Testing

- AnimateF and SnapshotF
- OptimalF

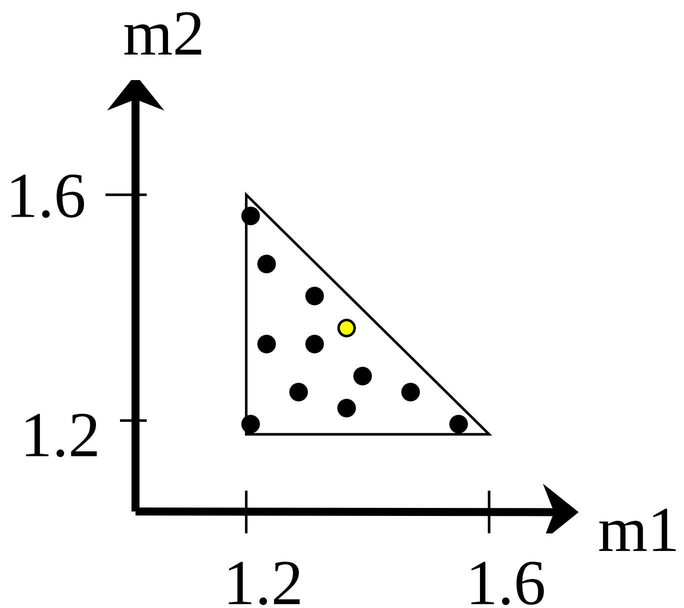
Demo of Key Executables for Experiment

- 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:

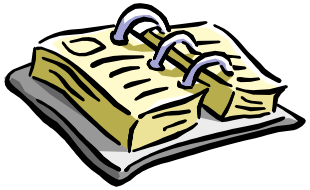
$$\mu = \max_{t_0} \frac{< a, b >_{t_0}}{\sqrt{< a, a >< b, b >}}$$

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

Intermediate Result using 24hrs of data

- >32 False Events/day (66 templates)
  - with prob. >.1 (all snr >= 5)
- > 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.