

# PEM Audit at LIGO Livingston

(Physical Environment Monitoring)

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## Motivation for study

- Verify proper operation of PEM system from PEM sensor through DAQ
- Understand a “typical” signal
- Involve UT Brownsville summer students

## Brief description of PEM

## Characterization

- Instrument analysis
- Statistical analysis of data

## Preliminary results for tiltmeters and accelerometers

- Produce a document for the PEM audit
- Eventually characterize all interferometer data channels

# Physical Environment Monitoring

(LIGO –T970112-00)

- ❑ Many channels (~100) of non-interferometer data monitoring
- ❑ Different sampling rates
- ❑ Provide veto
- ❑ Provide feedforward signal

	Detector	Sensitivity	Range	Nr WA LA	Cost (k\$)	
					Unit	Total
Seismic Noise	3 axis seismometer	$10^{-10}$ m @ 1Hz	1 - 10Hz	1/bldg: 5 + 3	14	112
	2 axis tiltmeter	$10^{-9}$ rad@1Hz	1 - 10Hz	1/bldg: 5 + 3	10	80
	1 axis accelerometer	$10^{-11}$ m @ 100Hz	10Hz-800 Hz	see 3.1.1.4.2.1 99+36	1.1	149
Acoustic Noise	B&K Microphone	$2 \times 10^{-9}$ atm. @ 100Hz	6.5 -8kHz	see 3.1.2.2.2.1 29+12	1.5	62
Magnetic Field	3 axis magnetometer	$10^{-11}$ T @ 100Hz	DC - 4.5kHz	see 3.1.3.2.2.1 7 + 1	6.5	52 with DAQ
Thunderstorm Monitor	Thunderstorm satellite service			1+0 RS232	28	first year 18/year
RF Interference	Broadband Receivers	0.01mV/m	10kHz to 1.3GHz	1/bldg 4 + 4	2.5	20
RF Interference TBD	Narrowband Receiver (CDS)	0.01mV/m	TBD 25-35MHz	1/dark port 2 + 1	2.5	8
Cosmic Muons	Scintillator Detector	$\frac{10^{-6} \cdot \mu}{s \cdot m^2}$	100Mev 1ms res.	1 / site 1 + 1	10	20
Power Line	Line Monitor	see 3.1.9.	up to 2kHz	2 + 1	6.	18
Residual Gas	RGA Head RGA controller	$P \leq 10^{-14}$ torr	1-100 amu	9 + 5	35	490
				6 + 4	25	250
Contamination TBD	Crystal Head controller	monolayer/ week	see 3.1.11.	8 + 5	4	52
				5 + 3	10	80
Weather Monitor	Weather Station T and T/RH	see 3.1.12.	see 3.1.12.	5+3 (RS232)	0.8	7
				25 + 12	0.24	9
Dust Monitor	Dust Part. Det.	see 3.1.13.1	see 3.1.13.1	21+13 (RS 232)	3.2	109
<b>TOTAL COST for full PEM (no carts)</b>					<b>1546</b>	
<b>Other costs: Mechanical: plates (\$140k) carts, etc (24k) (without CDS )</b>					<b>164</b>	
<b>TOTAL COST for full PEM with carts</b>					<b>2370</b>	

# Signal Characterization

## □ For every sensor

- Verify sensor eg. tap accelerometer
- Verify cabling
- Verify correct channel designation
- Verify A/D eg. put in known signal

## □ For every data channel

- Record a realtime series
- Record a power spectrum with a appropriate frequency span
- Record a long period time series where appropriate
- Make a histogram of time series with appropriate time span
- Make a histogram of filtered time series with appropriate frequency bands
- Also probability density plots for the histograms
- Check different periods eg. night/day, quiet/noisy

**Input from Detector Characterization welcome**

# Tiltmeters

## ❑ Model 520 Geodetic Platform 2 axis tiltmeter

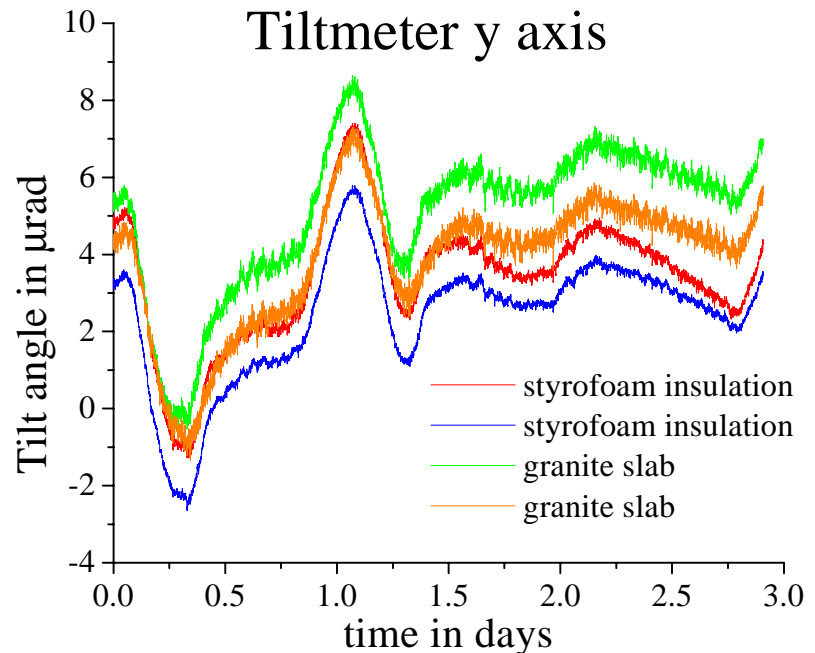
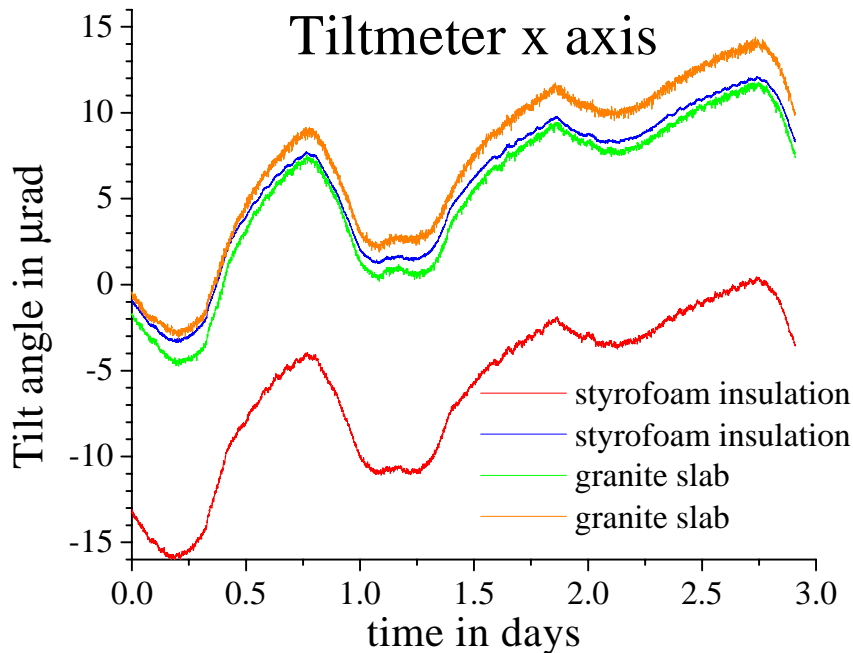
- electronic spirit level
- DC-30 Hz bandwidth

## ❑ Huddle test to compare data from 4 instruments simultaneously

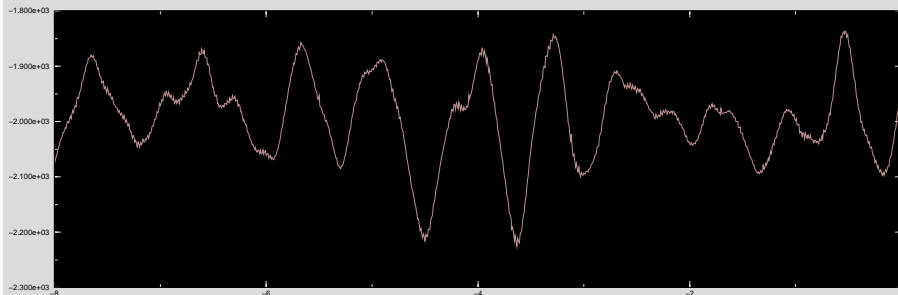
- Check for thermal effects
- Check for best mounting technique

## ❑ Installed on ground in “stay clear zone”

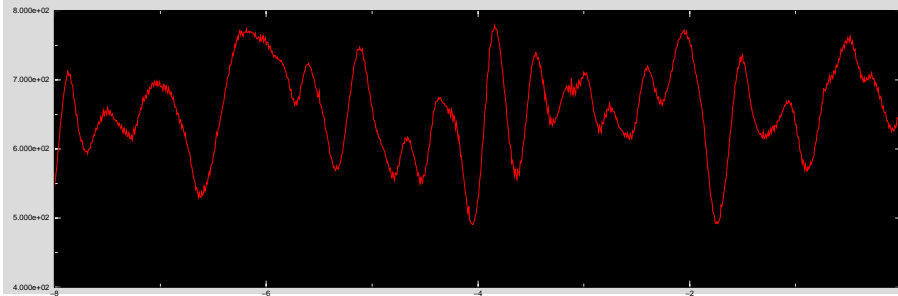
- one in each end station and one in corner station



DAQS Data Display 2 Channels at 00-8-4-20-58-36  
Ch 2: L0:PEM-EX\_TILTY

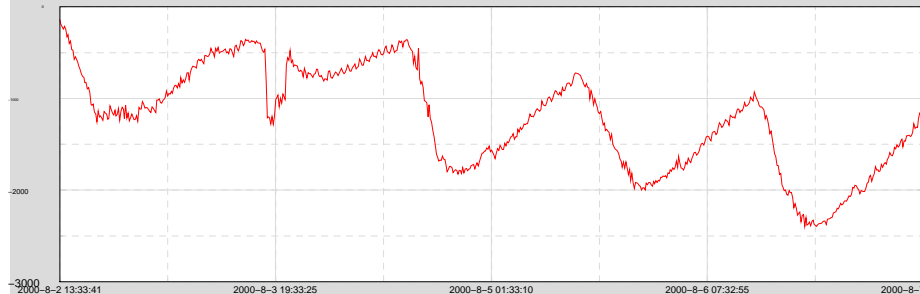


Ch 1: L0:PEM-EX\_TILTX

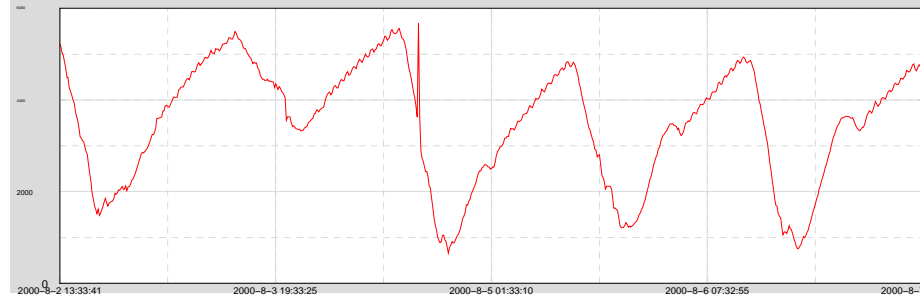


realtime "oscilloscope" output

Trend Data from 00-8-2-13-33-41 to 00-8-7-13-32-41  
Trend Ch 2: L0:PEM-EX\_TILTY



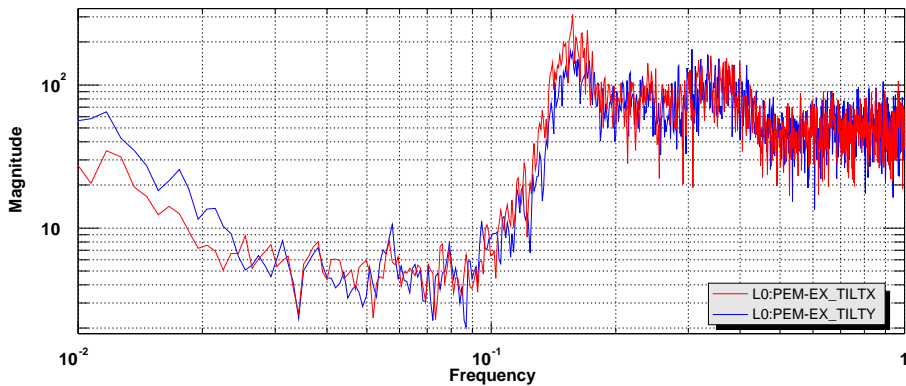
Trend Ch 1: L0:PEM-EX\_TILTX



5 day "long playback" output

# Tiltmeter Data

Power spectrum

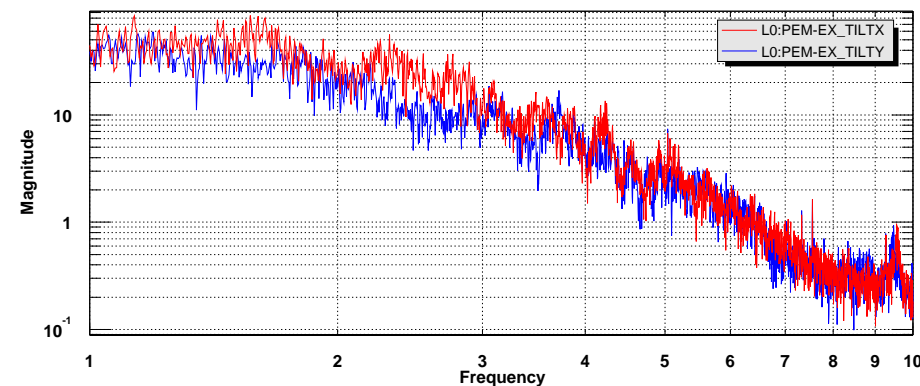


T0=08/08/2000 10:49:03

Avg=3

BW=0.00146484

Power spectrum



T0=08/08/2000 10:43:41

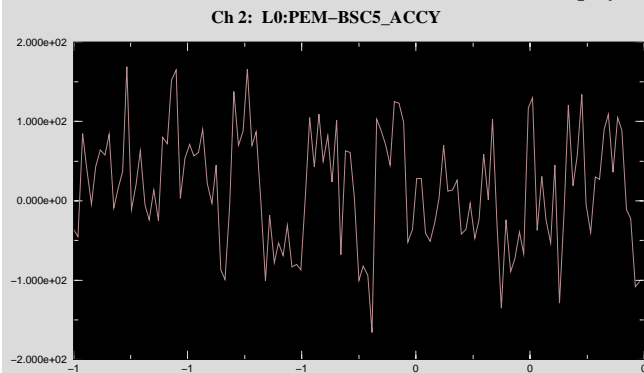
Avg=4

BW=0.00585937

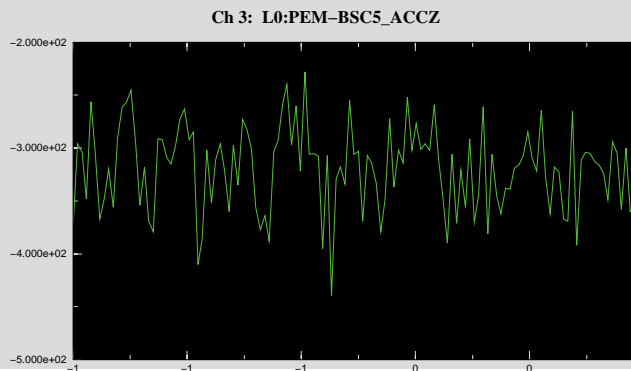
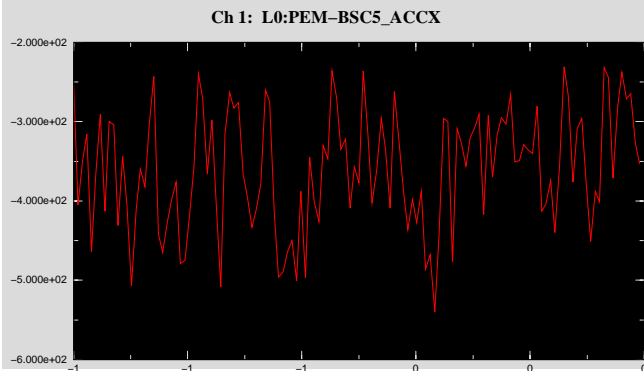
# Accelerometers

- ❑ Wilcoxon Research Model 731-207 single axis accelerometers
  - Piezoelectric
  - 1Hz-1kHz bandwidth
- ❑ Installed on support piers (both BSC's and HAM's)
  - 36 (12 X 3 axis clusters) total at LLO
- ❑ Tap test to study mechanical modes in power spectrum

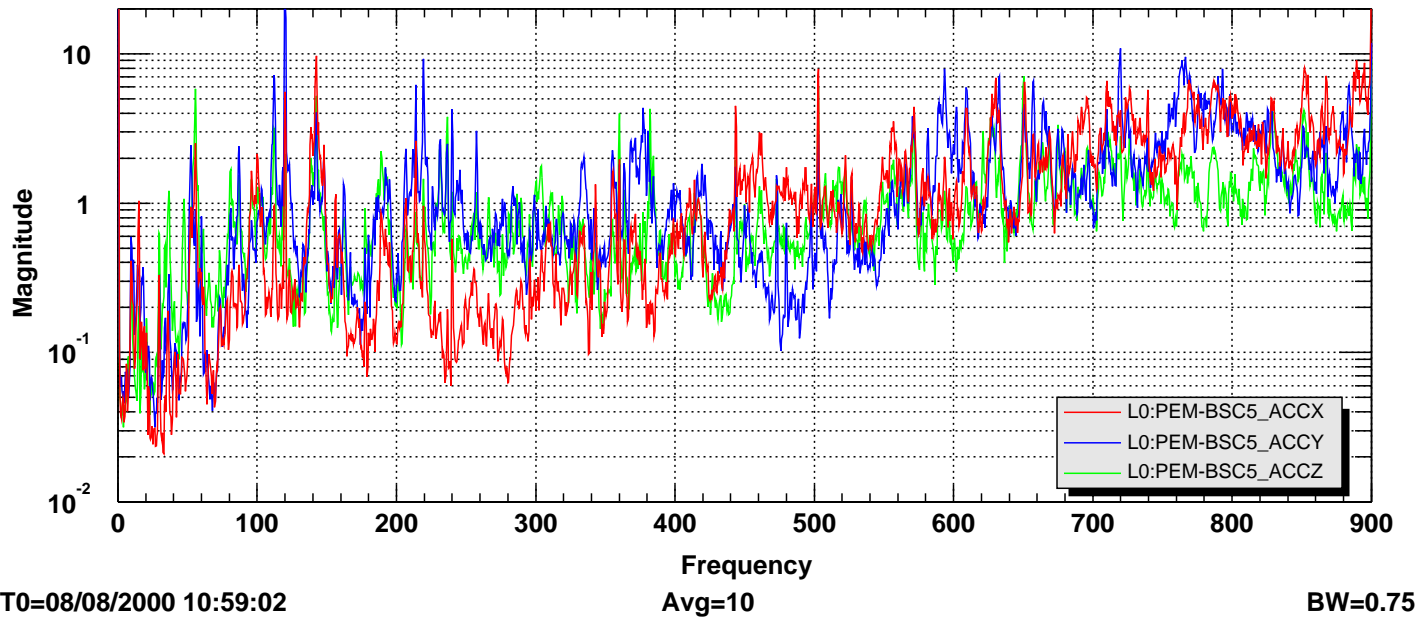
DAQS Data Display 3 Channels at 00-8-4-21-2-15



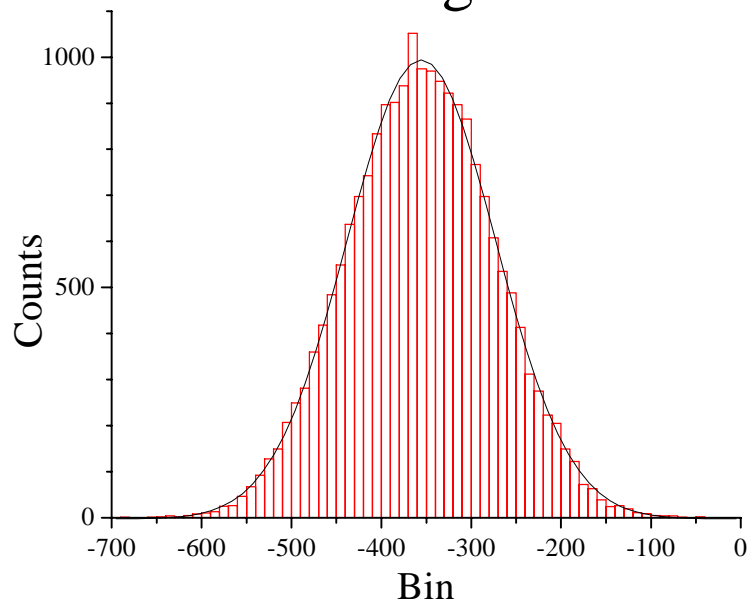
realtime “oscilloscope”  
time series



# Power spectrum



# Histogram



# Probability density plot

