



Oregon Proposal for LIGO Research

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MIT, PAC7
November 18, 1999

The emphasis of the Oregon research activities is sustained achievement of the ultimate performance of the LIGO interferometers needed for gravity wave physics, and a search for gravity waves associated with gamma ray bursts (GRBs).

LIGO-G990139-00-Z

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LIGO

Oregon Group working on LIGO

Faculty:

**Jim Brau
Ray Frey
David Strom**

Research associates:

**Evan Mauceli
Robert Schofield
Nikolai Sinev**

Graduate students:

**Masahiro Ito
Rauha Rahkola**



The Oregon group's effort includes the following goals:

**Understand the environmental influences on the IFO signal
Use this knowledge to produce reduced data sets
Search for gravitational radiation associated with GRBs**

Environmental Monitoring

**Weather monitoring
Magnetic field studies
Seismic characterization
Cosmic ray studies
Gravity-gradient noise**

Detector Characterization/ Data Analysis

**Data reduction
Transient analysis
Gamma Ray Burst studies**

**We have established a significant presence at the
Hanford site, and plan to work closely with the LIGO
Lab and the LSC in an effective effort on
detector characterization and data analysis**

LIGO



Environmental Monitoring

Weather monitoring

Magnetic field studies

Seismic characterization

Cosmic ray studies

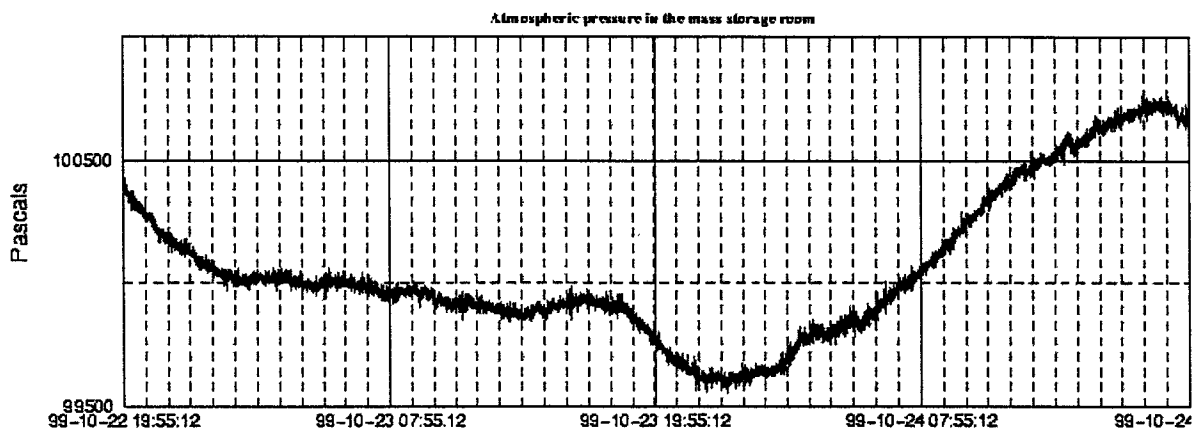
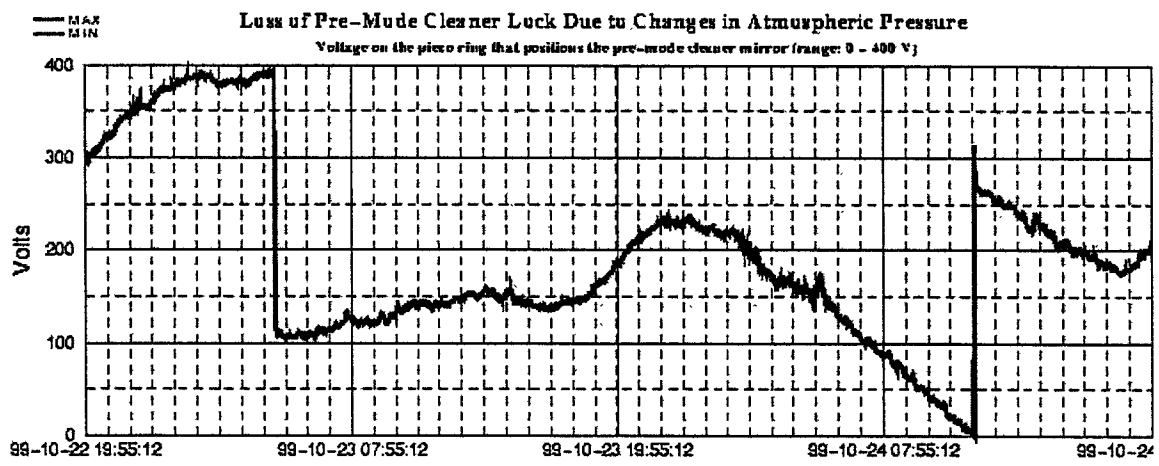
Gravity-gradient noise



Environmental Monitoring

- Weather

Pre-mode cleaner loses lock due to changes in atmospheric pressure.



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Environmental Monitoring - Weather

A summary of our contribution in weather monitoring follows.

- 1) helped set up the 5 weather stations**
- 2) designed, manufactured and installed a circuit to boost the relative humidity signals, compensating for the long cable lengths**
- 3) wrote the device driver code for the weather stations**
- 4) wrote code to transfer the data to the EPICS data collection system and developed MEDM screens to display the data in the control room (a simple tabulation of current data is available within the LIGO Laboratory at <http://ligo-www.caltech.edu/per/epics.pl>)**
- 5) have undertaken a calibration of the stations to improve on the factory calibration**



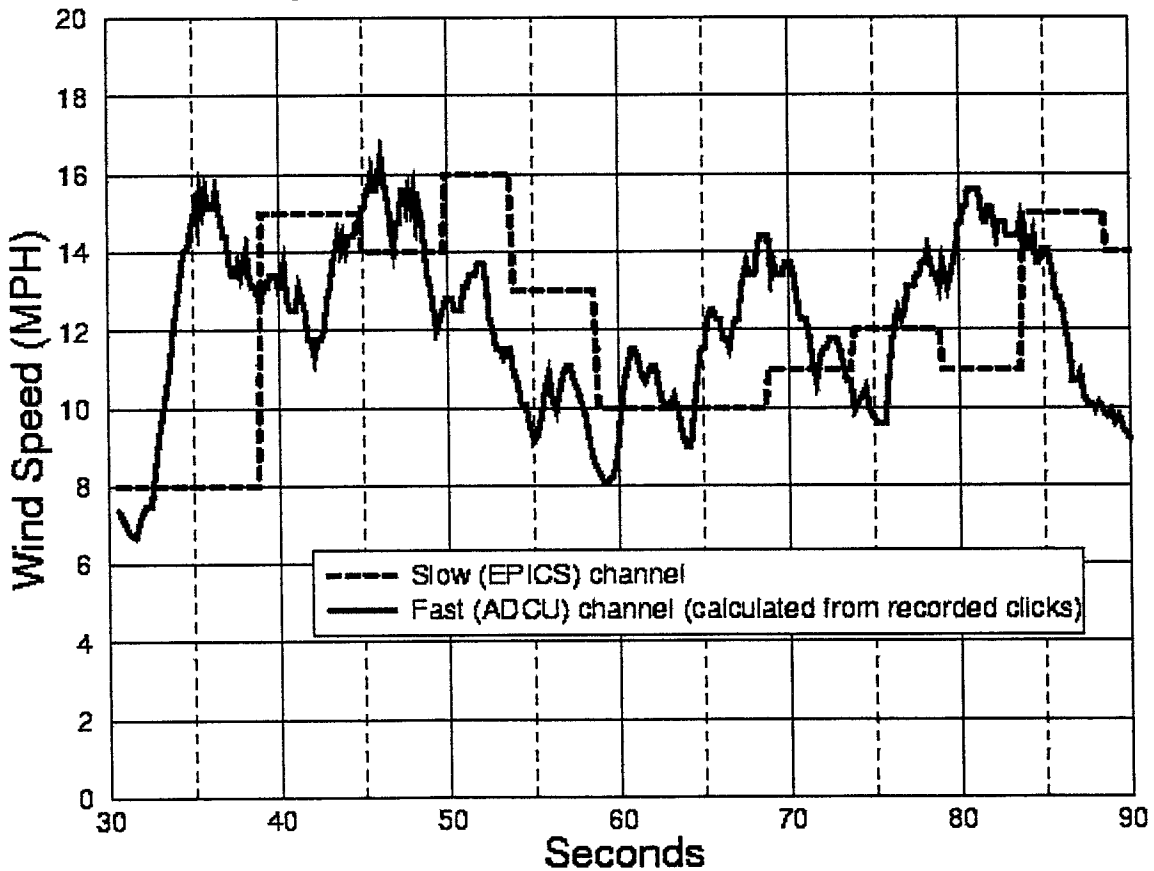
Environmental Monitoring - Weather

Wind Gust Monitoring

Perhaps more important than average wind speed
Modified anemometer read-out

Anemometer data – fast and slow channels

Slow is offset by a 2.25s integration delay and a 0.8 to 3s variable read out delay





Environmental Monitoring - Magnetic Field Studies

Four studies of magnetic fields and effects:

- 1. Ambient fields inside and outside of BSC vacuum chambers**
- 2. Development of diagnostic system to generate forces on the optics using external coils**
- 3. Investigation of the transfer function from outside to inside of the chambers**
- 4. Experimental measurements of the gradients produced by optic support structures**

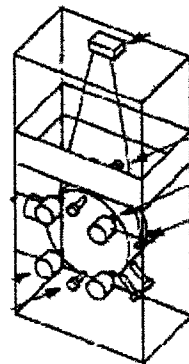
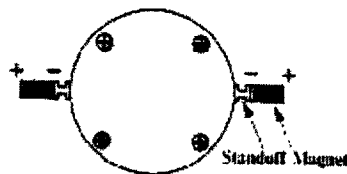


Environmental Monitoring - Magnetic Field Studies

1. Ambient fields inside and outside of BSC vacuum chambers

Why measurements of ambient fields ?

- Magnets on the optics may couple optic motion to time-varying ambient magnetic fields.



$$\tau = \mu \times \vec{B}$$

$$\vec{F} = (\vec{\mu} \cdot \nabla) \vec{B}$$

Why measurements of fields generated by external coils (diagnostic fields)?

- Obtain approximate transfer function from outside to inside of chamber.
- Map out field from standardized coil position for future shaking of optics.

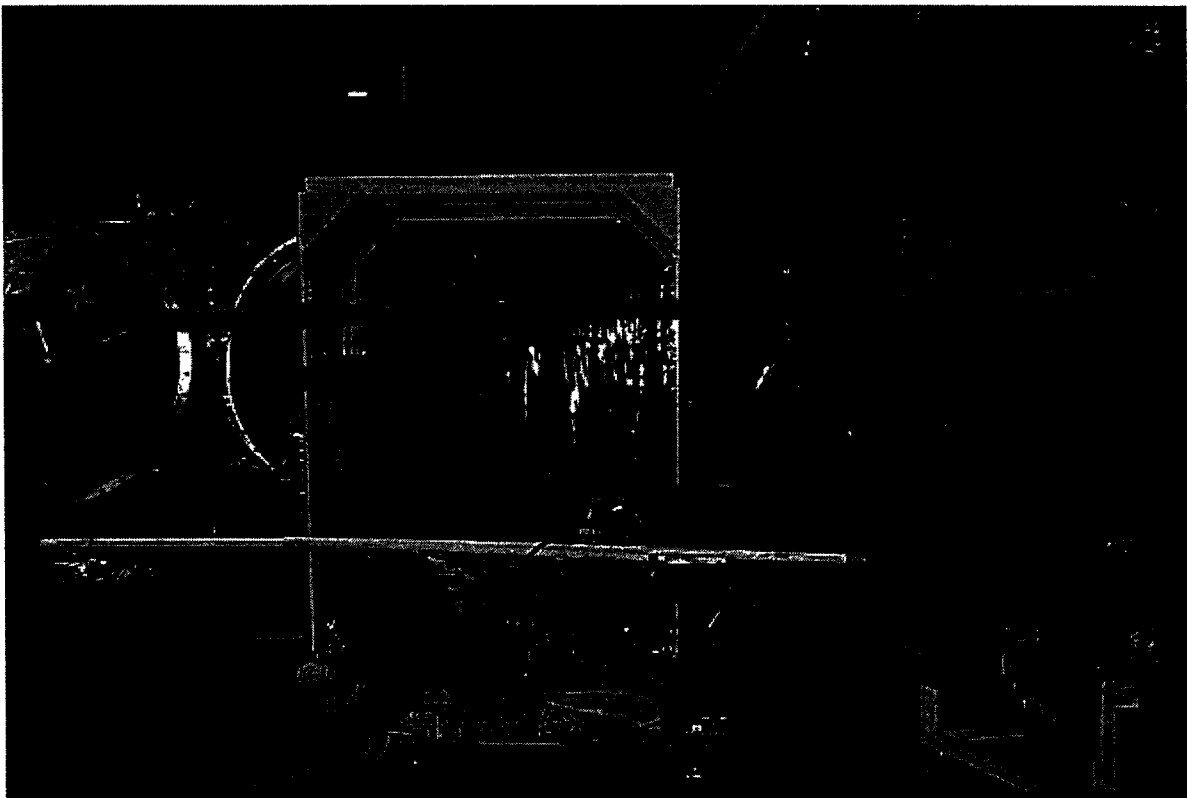
From Schofield, Stanford LSC meeting transparencies,
www.ligo.caltech.edu/LIGO_web/9907lsc/9907trans.html

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Environmental Monitoring - Magnetic Field Studies

1. Ambient fields inside and outside of BSC vacuum chambers





Environmental Monitoring - Magnetic Field Studies

1. Ambient fields inside and outside of BSC vacuum chambers

Ambient magnetic fields in WBSC-7 & 8

Location	(nT)rms at 60 Hz	noise (pT/sqrt Hz)rms at 50 Hz	n	instrument noise (pT/sqrt Hz) at 50 Hz
7 locations in WBSC-7; 5/30/99	3.73 ± 0.22	9.6 ± 1.4	7	≤ 2.6
3 locations in WBSC-8; 3/2/99	1.64 ± 0.21	10^{\sim}	4	≤ 2.6

Ambient B field gradients in WBSC-7

Location	(nT/m)rms at 60 Hz	noise (pT/m sqrt Hz)rms at 50 Hz	n	instrument noise (pT/m sqrt Hz) at 50 Hz
7 locations in WBSC-7; 5/29/99	2.31 ± 0.92	$\geq 9 \pm 2$ ≤ 20	7	≤ 11

From Schofield, Stanford LSC meeting transparencies,
www.ligo.caltech.edu/LIGO_web/9907lsc/9907trans.html

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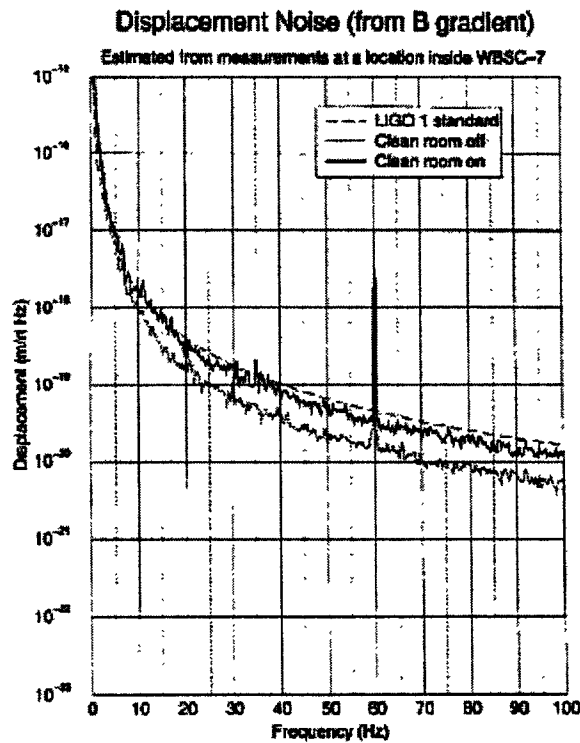


Environmental Monitoring - Magnetic Field Studies

1. Ambient fields inside and outside of BSC vacuum chambers

Conclusion: Simplified model of coupling between ambient fields and optic motion

$$\text{noise} < 2 \times 10^{-20} \text{ m} / \sqrt{\text{Hz}} @ 50 \text{ Hz}$$



This is a factor 3 down from the LIGO I requirement

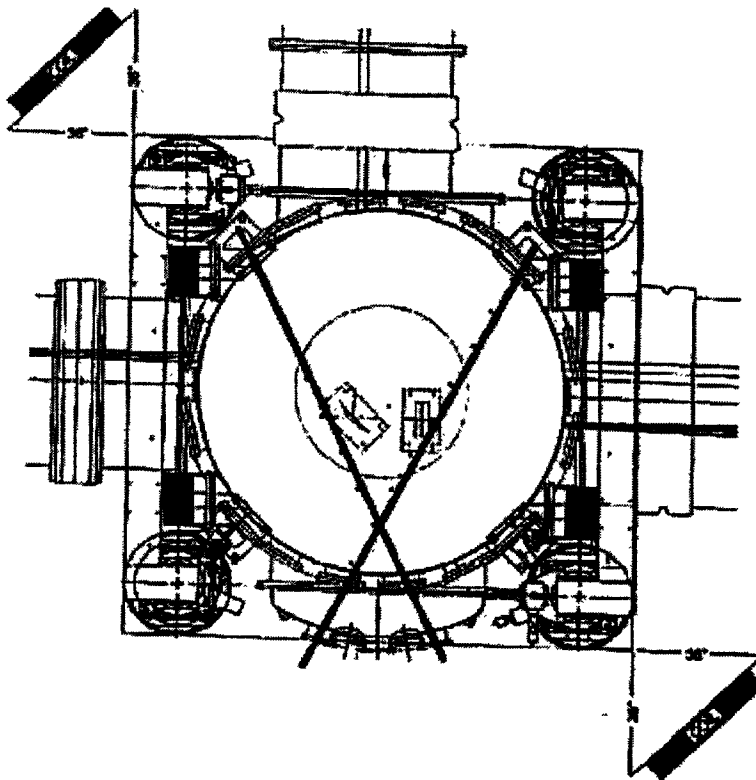
Continued investigations are warranted



Environmental Monitoring - Magnetic Field Studies

2. Development of diagnostic system to generate forces on the optics using external coils

Built two (2) 1 m diameter coils of 12 gauge varnished copper wire wound on plywood spools. Select 10, 30, 60, or 100 turns.



From Schofield, Stanford LSC meeting transparencies,
www.ligo.caltech.edu/LIGO_web/9907lsc/9907trans.html

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Environmental Monitoring - Magnetic Field Studies

- 2. Development of diagnostic system to generate forces on the optics using external coils**





Environmental Monitoring - Magnetic Field Studies

2. Development of diagnostic system to generate forces on the optics using external coils

Fairly uniform field, or uniform gradient, can be produced in the central region of the vacuum chamber.

Model of expected field from Frey and Rahkola (LIGO-T990092-00-H)

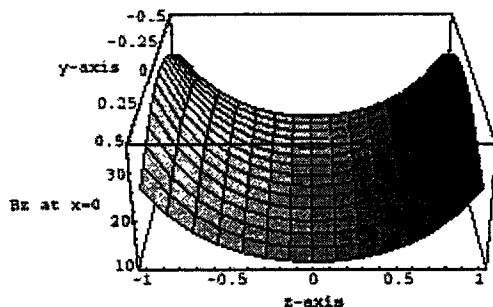


Figure 1: The axial field B_z as a function of (y, z) at $x = 0$ for the Helmholtz configuration with $N = 10^4$, $I = 3$ A. The coils are placed at $z = \pm 2$ m. The field is in units of 10^{-4} T.

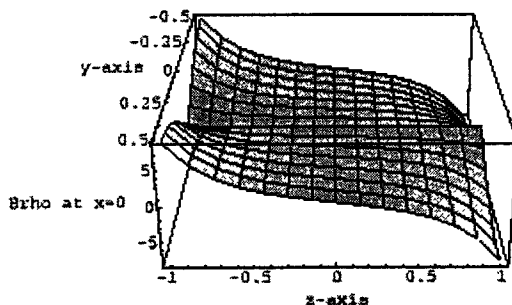


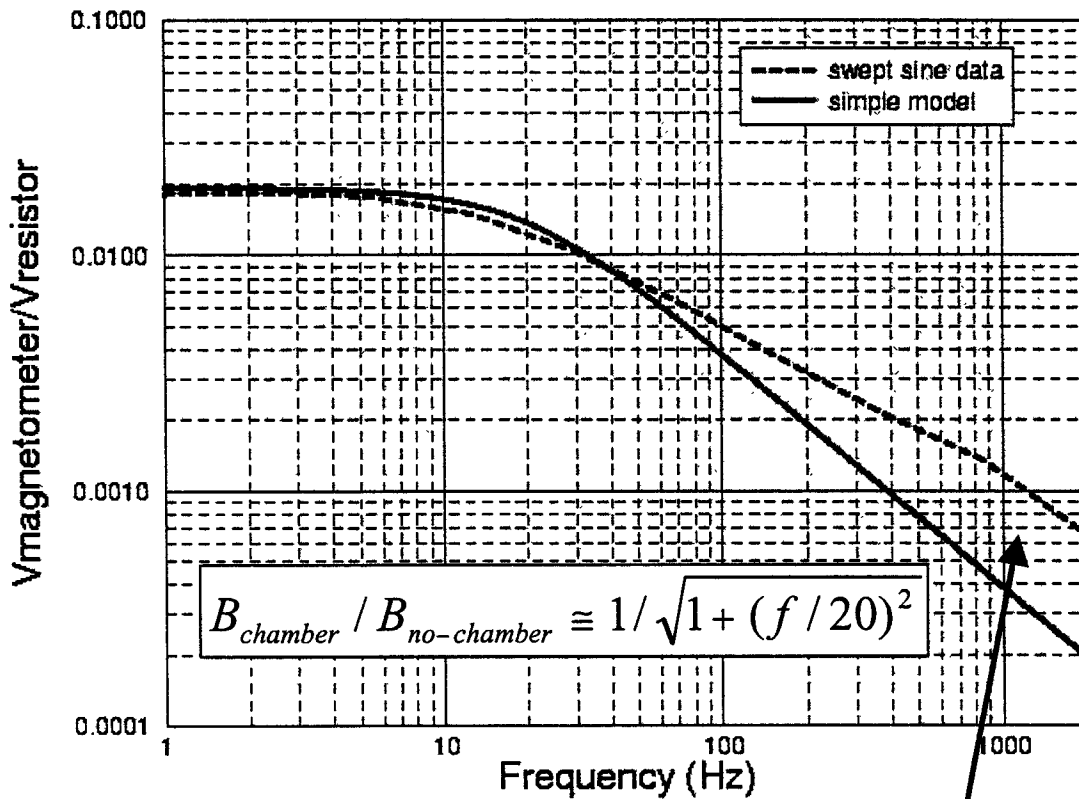
Figure 2: Same as previous figure but for the transverse field component, B_ρ .



Environmental Monitoring - Magnetic Field Studies

3. Investigation of the transfer function from outside to inside of the chambers

Frequency Response at position B8 in BSC-7



Eddy current effects will be investigated further.

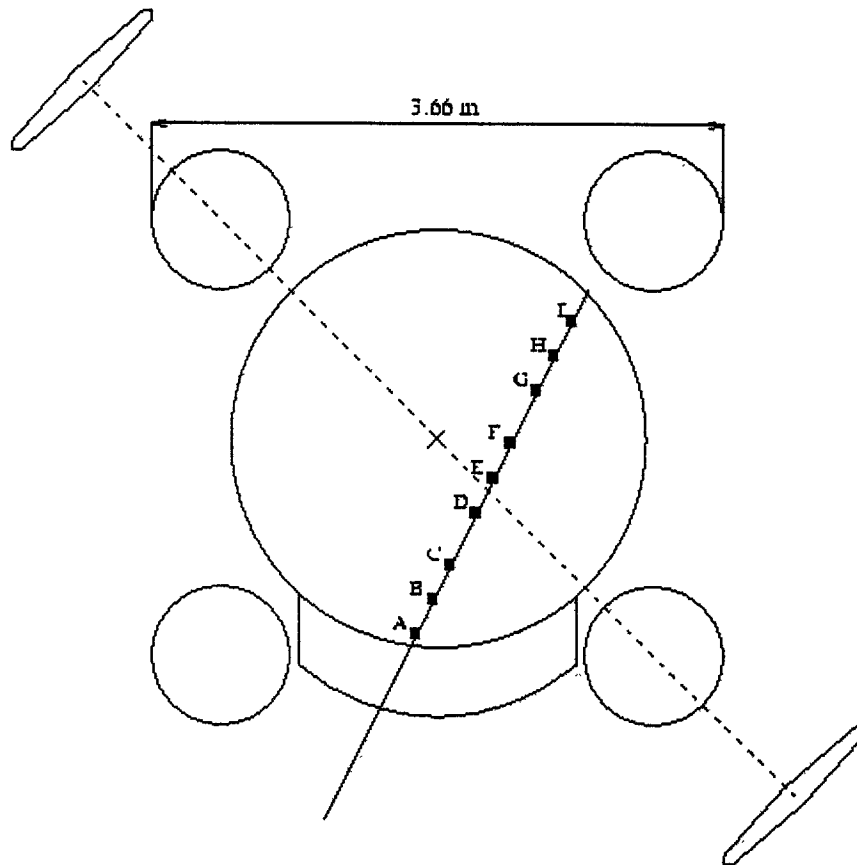


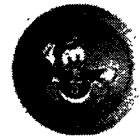
Environmental Monitoring - Magnetic Field Studies

3. Investigation of the transfer function from outside to inside of the chambers

Eddy current effects are being investigated with the data from several positions along the tube.

BSC7 Plan View

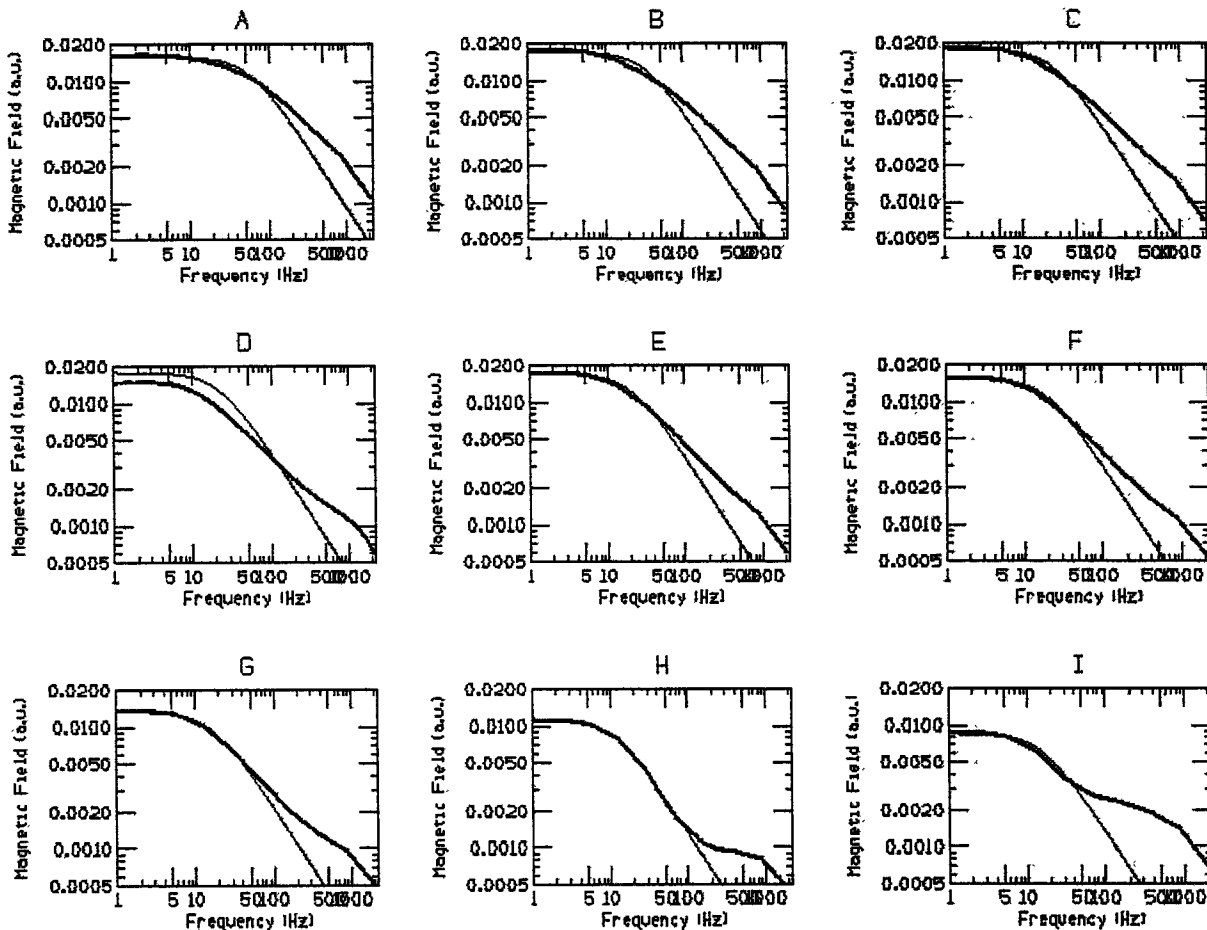




Environmental Monitoring - Magnetic Field Studies

3. Investigation of the transfer function from outside to inside of the chambers

Effect of eddy current depends significantly on distance to the wall





Environmental Monitoring - Magnetic Field Studies

4. Experimental measurements of the gradients produced by optic support structures

Optic support structures were not in place for our measurements

Will measure gradients produced by an isolated optic support structure

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Also ⇒ Sources of Ambient Fields

Move wall mounted emergency light away from BSC-8 transformer is a large source

**Seismic isolation piers are magnetized
this may be a negligible effect, but we will check it further**

Lightning strike noise

We plan to search for other sources



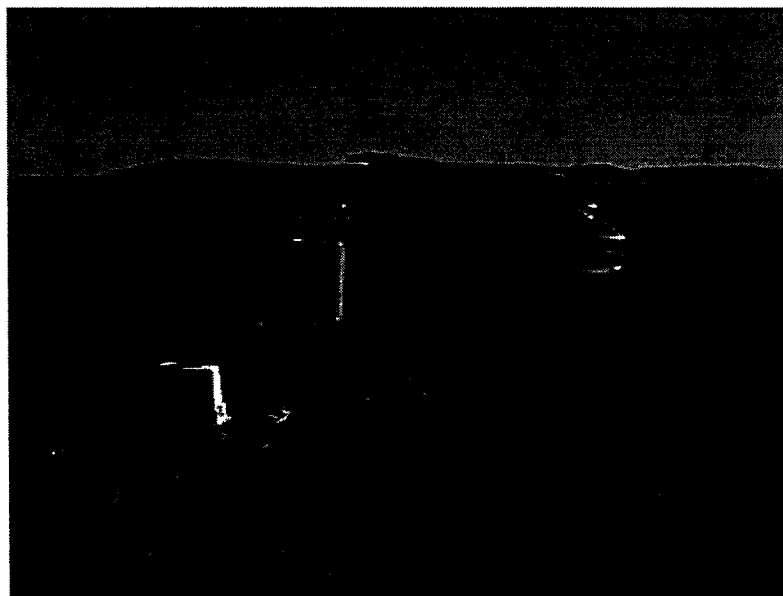
Environmental Monitoring - Seismic Characterization

**Placed accelerometers on major pieces of equipment
to identify characteristic frequencies
identified office area air handler as
the major source of noise**

Schofield and Ito, LIGO-T990091-00-W

Road Traffic

highway 240 traffic \Rightarrow nm/ $\sqrt{\text{Hz}}$ at end stations



Two seismometer cross-correlation measurements



Environmental Monitoring - Seismic Characterization

**Wannawish Dam (5 km from Y end-station)
comparable to road noise, but 5 km distance kills it**

