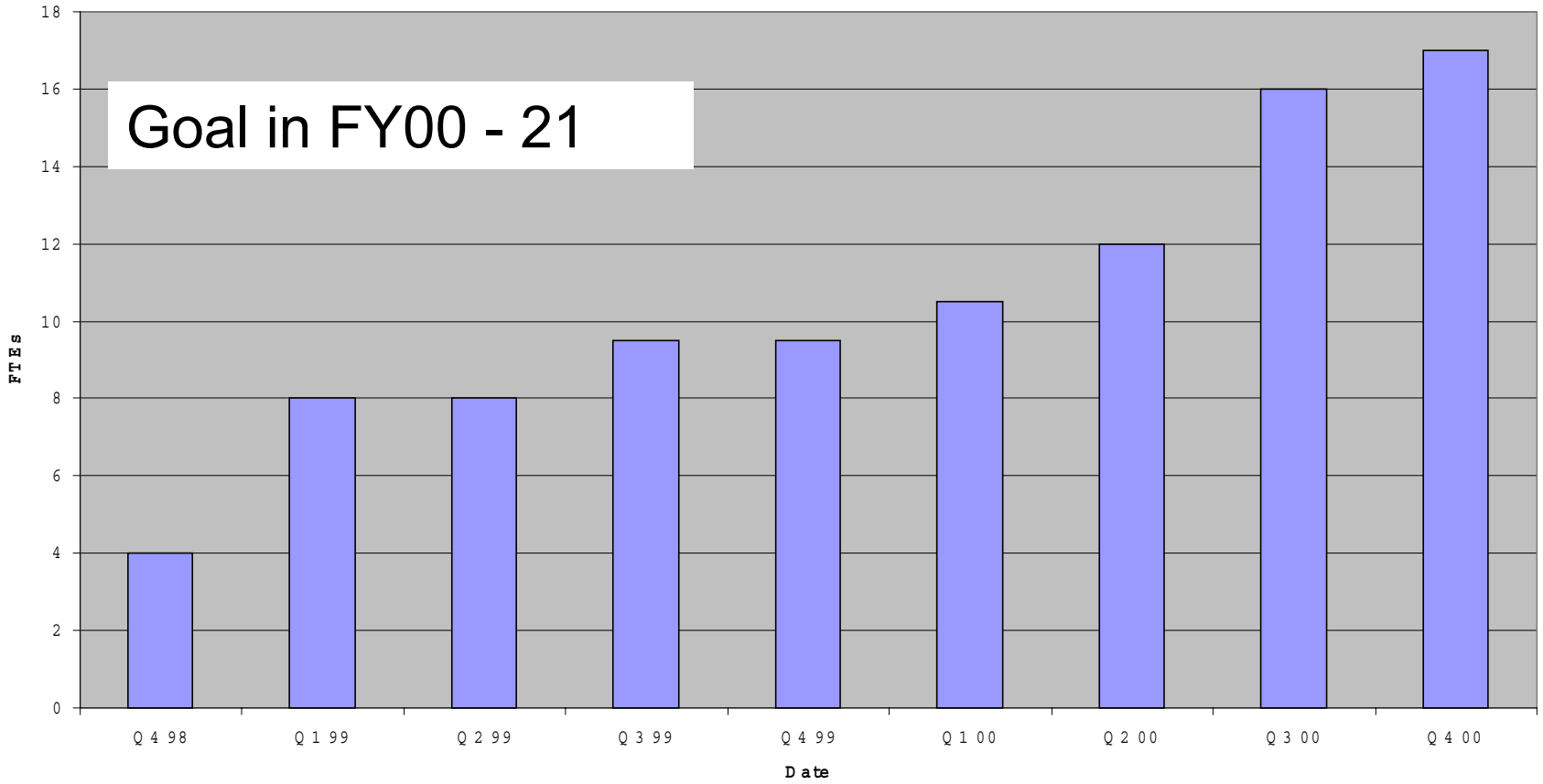
LIGO at Livingston

Mark Coles

Topics Covered

- Staff Development
- Facility Development
- Outreach

Staff Development (ctd)



Technical Staffing Functions

- Scientific staff
  - Support installation and commissioning activities
  - Lead detailed studies of interferometer and subsystem performance
- Engineering support staff
  - Electronics, software, vacuum, optics, facilities
  - Installation and commissioning
  - Maintain operation of installed system
- Operations Specialists
  - Mix of junior scientific staff, technicians, engineers
  - Support installation and commissioning activities
  - Provide operations support during commissioning

Staff Development

- **Present regular staff structure**

	Allocated	presently filled
–	6 resident scientific staff	3.5
–	1 LDAS scientist	0
–	6 engineering staff	5 (control software engineer open)
–	9 operations specialists	7
–	1 site administrator	1

- **Scientific staffing philosophy**
  - Plan to stagger 3 yr term appointments for 3 staff members, replace one per year
  - At present all but one scientific appointments are term positions, possibility to promote staff into long term positions
  - Look for opportunities to “leverage” scientific staff positions:
    - Agreements on joint appointments with SLU (one position filled beginning January ’01), adverstisement and search for second position fall ’01
    - Agreement with U Florida to share cost of basing to UF staff at LLO
  - LDAS scientist position will be initially a 3 yr term position with possibility of promotion

Staff Development (ctd)

- Augmentation of staff planned as LLO begins full-time scientific operation:
  - Data management
  - Repairs and rework of electronics and support eqpt
  - Additional operations personnel to cover shift work

  (discussed in more detail in budget presentation on Wednesday)
- Some difficulties encountered recruiting software professionals and technical people generally.
- Have developed a network of about 30 university departments regionally to find young people and have interviewed and hired as a result of this.
- Still look for ways to have strong candidates referred or directed to LIGO

Operations Staff Training

- Need to broadly train staff in interferometer operation
  - Hands on installation and commissioning activities
  - Some formal lectures
  - Evolving and expanding list of daily shift duties:
    - Monitoring DCU operations
    - Inspecting laser beam spots
    - PSL and mode cleaner locking
    - PEM data monitoring – do things look OK
    - Checking configurations and values of servos
    - Vacuum system monitoring
  - Trouble-shooting with expert staff when faults occur
- Presently staff operate control room 8 am – 9 pm weekdays

Additional Facilities and Activities On-site

- Staging building addition
- High power laser test facility
- Seismic array
- Optical telescope

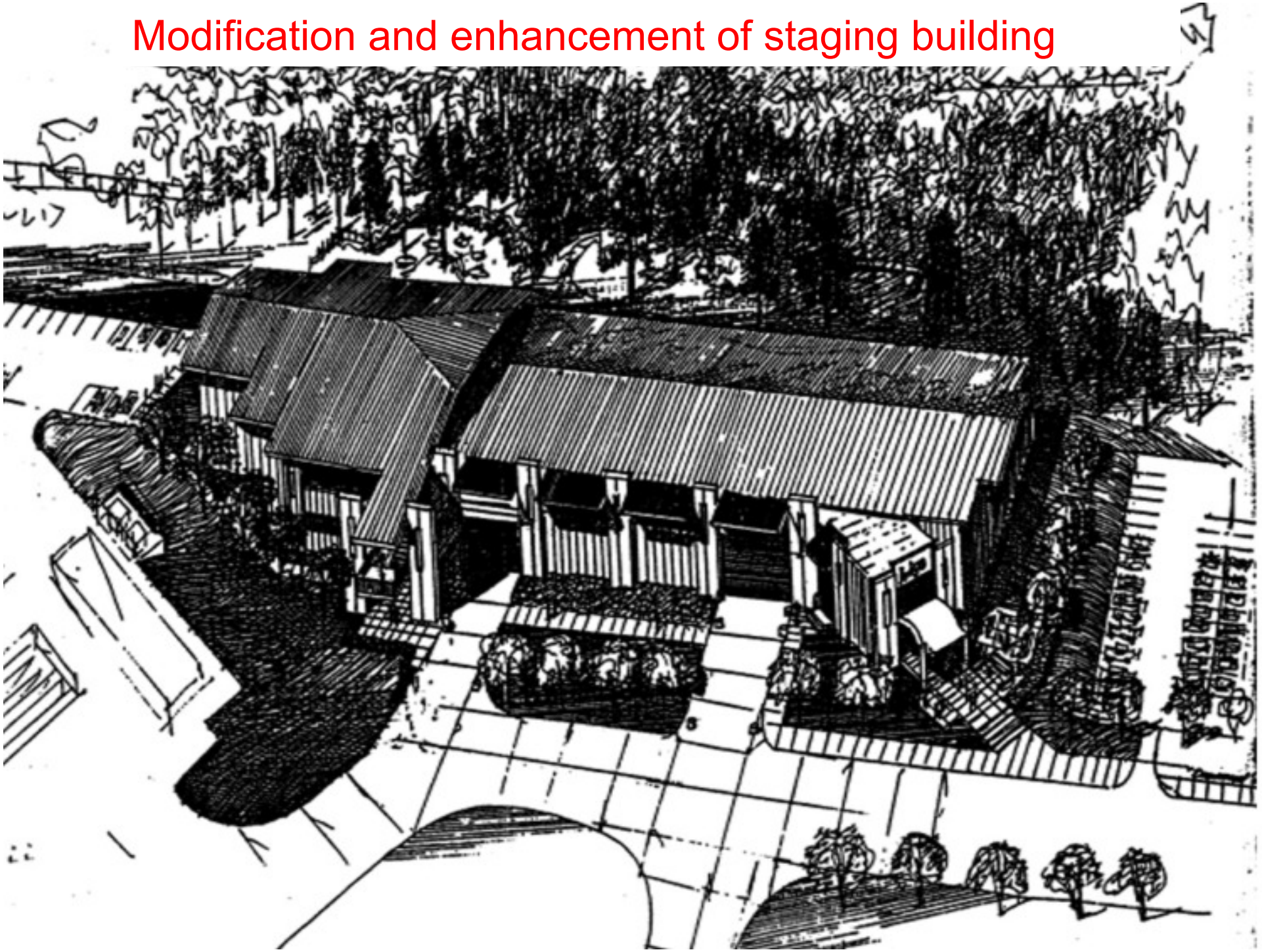
LLO BUILDING UPGRADE

- COMPLETE ORIGINAL PLANNED LAB SPACE
  - UPGRADE THE EXISTING STORAGE BUILDING
  - ADD A NEW BUILDING TO THE STORAGE BUILDING
- RENOVATED STORAGE BUILDING
  - SMALL AUDITORIUM FOR MEETINGS
  - SECOND FLOOR LABORATORY AND OFFICE AREA
  - MACHINE SHOP AND FUTURE LAB SPACE ON FIRST FLOOR
- NEW BUILDING ADDITION
  - HIGHBAY AREA FOR STAGING AND ASSEMBLY OF FUTURE DETECTOR UPGRADES
  - CLEAN LABORATORY SPACE

SCHEDULE

- DESIGN
  - ARCHITECTURAL DESIGN AND SPECIFICATION ARE COMPLETE
- CONTRACT
  - BIDS HAVE BEEN RECEIVED AND CONTRACTOR SELECTED
  - CONTRACT IS BEING REVIEWED AT NSF
- CONSTRUCTION
  - ANTICIPATED TO START IN JANUARY 2001
  - SCHEDULED TO BE COMPLETED BY END OF 2001

Modification and enhancement of staging building



ADVANCED SEISMIC ISOLATION DEVELOPMENT

- REQUIREMENT
  - REDUCE THE GROUND MOTION BY 3-4 ORDERS OF MAGNITUDE AT 10 HZ
- APPROACH
  - UTILIZE A TWO STAGE ACTIVE SEISMIC ISOLATION PLATFORM ON HYDRAULIC ACTUATORS
  - THE TWO STAGES ARE SUSPENDED ON STIFF BLADE SPRINGS AND MECHANICAL LINKAGES
  - VIBRATION IN EACH STAGE IS REDUCED BY SENSING ITS MOTION AND APPLYING FORCES THROUGH ACTUATORS VIA FEEDBACK LOOPS

LLO ROLE

- FACILITIES
  - PROVIDE THE LABORATORY AND OFFICE SPACE FOR ADVANCED DETECTOR TECHNOLOGY DEVELOPMENT (6700 SQ. FT)
  - PROVIDE CLEAN HIGH BAY AND STAGING AREA TO ASSEMBLE, TEST AND EVALUATE FULL SIZE SEISMIC ISOLATION SYSTEMS (6300 SQ. FT)
- PERSONNEL
  - PROVIDE THE MECHANICAL AND ELECTRICAL ENGINEERING SUPPORT AND THE PROJECT MANAGEMENT NEEDED TO DEVELOP THE NEXT GENERATION SEISMIC ISOLATION SYSTEM (3-4 FTEs)

Status

- PRE-PROTOTYPE
  - A PRE-PROTOTYPE TWO STAGE SYSTEM HAS BEEN FABRICATED, INSTALLED (AT MIT) AND TESTED
  - INITIAL TEST RESULTS DEMONSTRATED THAT STABLE AND ROBUST OPERATION CAN BE ACHIEVED
- PROTOTYPE
  - THE CONCEPTUAL DESIGN HAS BEEN COMPLETED
  - A DESIGN/FABRICATION CONTRACT WILL BE LET IN JANUARY 2001
  - TESTING OF THE SYSTEM (LESS HYDRAULIC) IN VACUUM IS SCHEDULED IN SUMMER OF 2001 AT THE STANFORD TEST FACILITY

High Power Laser Test Facility – Partnership with U of Florida

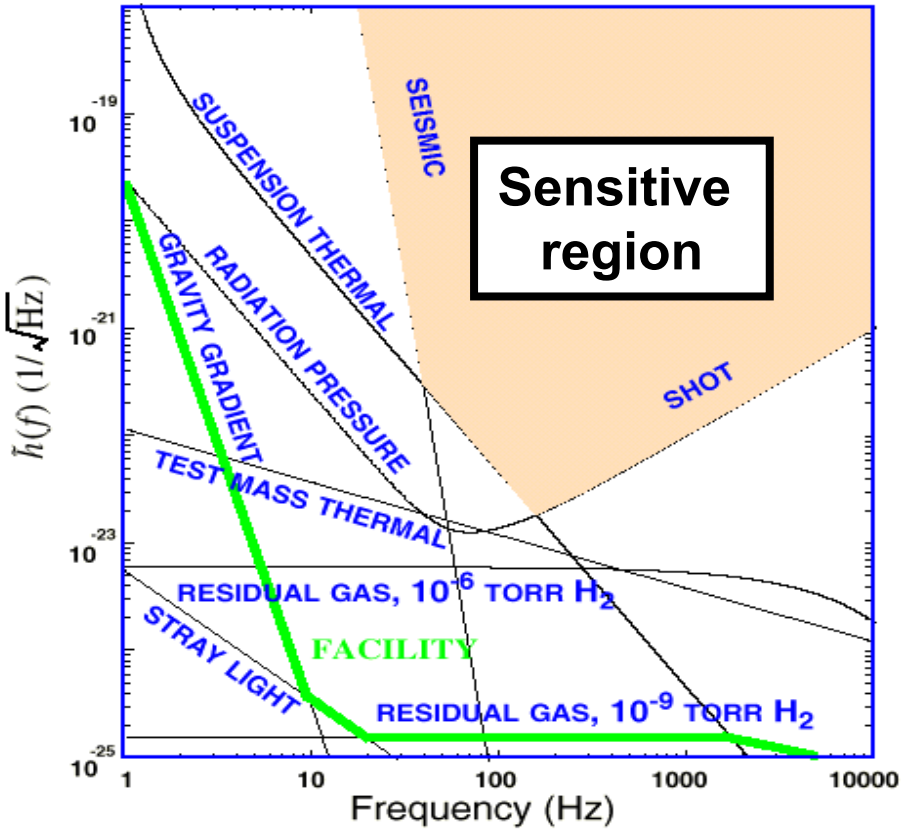
- Mission
  - Measure thermal lensing, thermally induced bi-refringence, component selection, at

    > 100 W for candidate LIGO transmissive optics
  - Use data to look at correlations of optical performance with other material properties
- LLO Staff involvement
  - Facility will be jointly utilized by LLO, UF, Southern Univ., and SLU staff to make these measurements
  - Utilization by other LSC members?
- temporary location in west end station, move to lab in staging building after renovation completed
- UF to provide optical table, basic test equipment, optics and opto-mechanical components, Shack-Hartmann sensor with PC
- LLO to provide lab space, laser

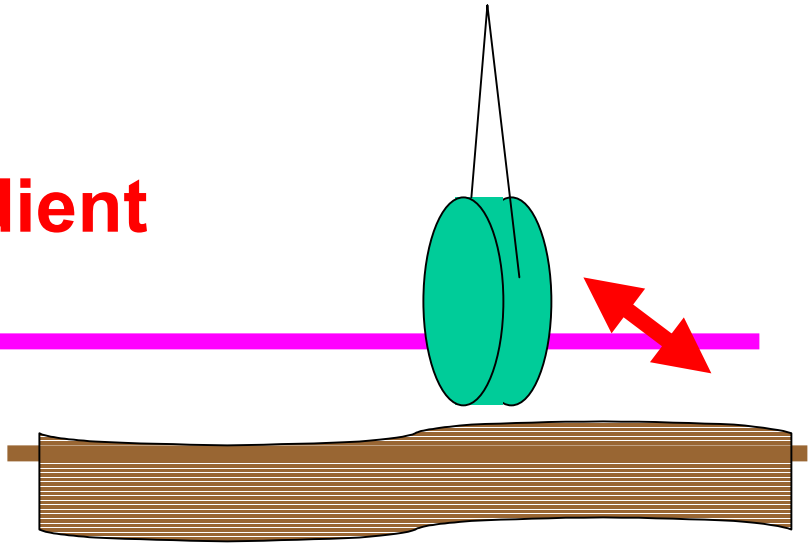
Seismic array

- Gravity gradient noise is a fundamental, site dependent noise limit on ultimate interferometer performance

- Also want to understand how correlation lengths of ground motions



Gravity Gradient



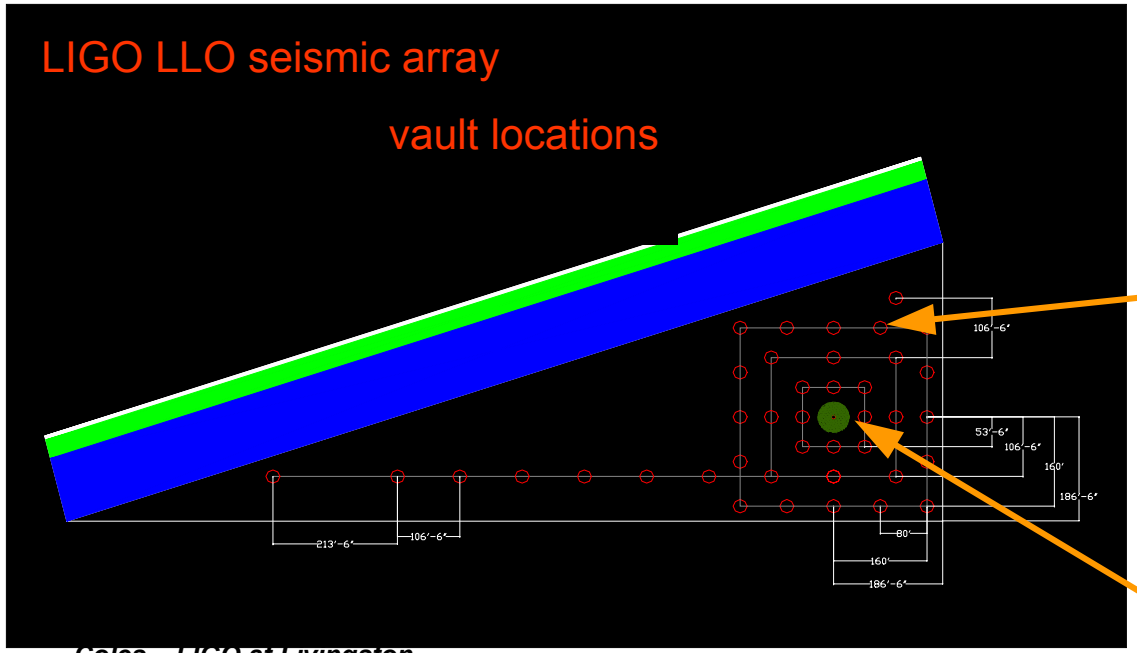
- Motivation/theory
  - Fluctuations in mass distribution surrounding suspended test masses directly couples LIGO to external environment
  - Need to sort out which oscillatons redistribute mass:
    - » Rayleigh modes: S waves with vertical displacements and P waves
    - » Love modes (S waves with horizontal displacement) do NOT contribute since they don't produce fluctuations in density
    - » Measurements of earth motion need to distinguish between these modes.

Areas of interest for LIGO

- How big is the effect?
  - This is a fundamental limit on the best possible earth-based detectors
- Are the modes that produce gravity gradients coherent?
  - Coherence may allow subtraction or compensation. Preliminary measurements don't look very coherent
- What are the sub-surface depth considerations needed to infer gravity gradient from surface measurements?

LLO Seismic Array

Location and instrumentation



Guralp CMG-40T

"Broad Band"

used in array

stations

Streckeisen STS-2

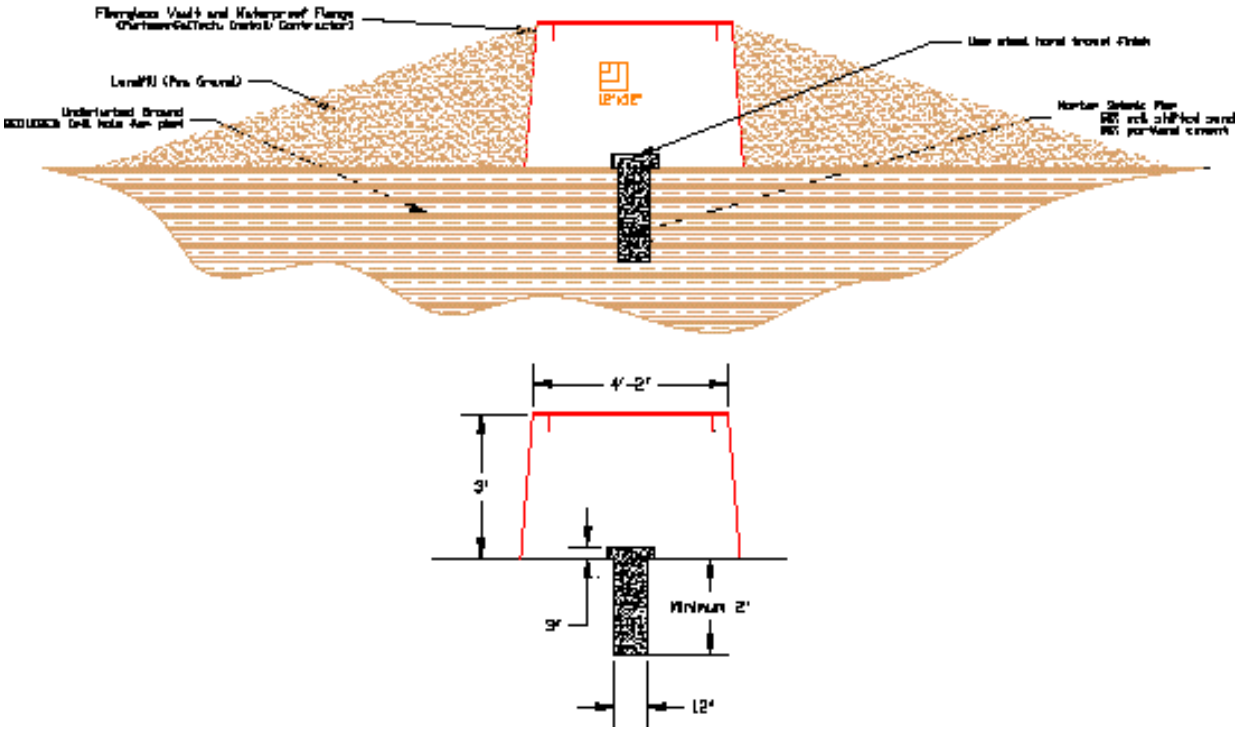
"Very Broad Band"

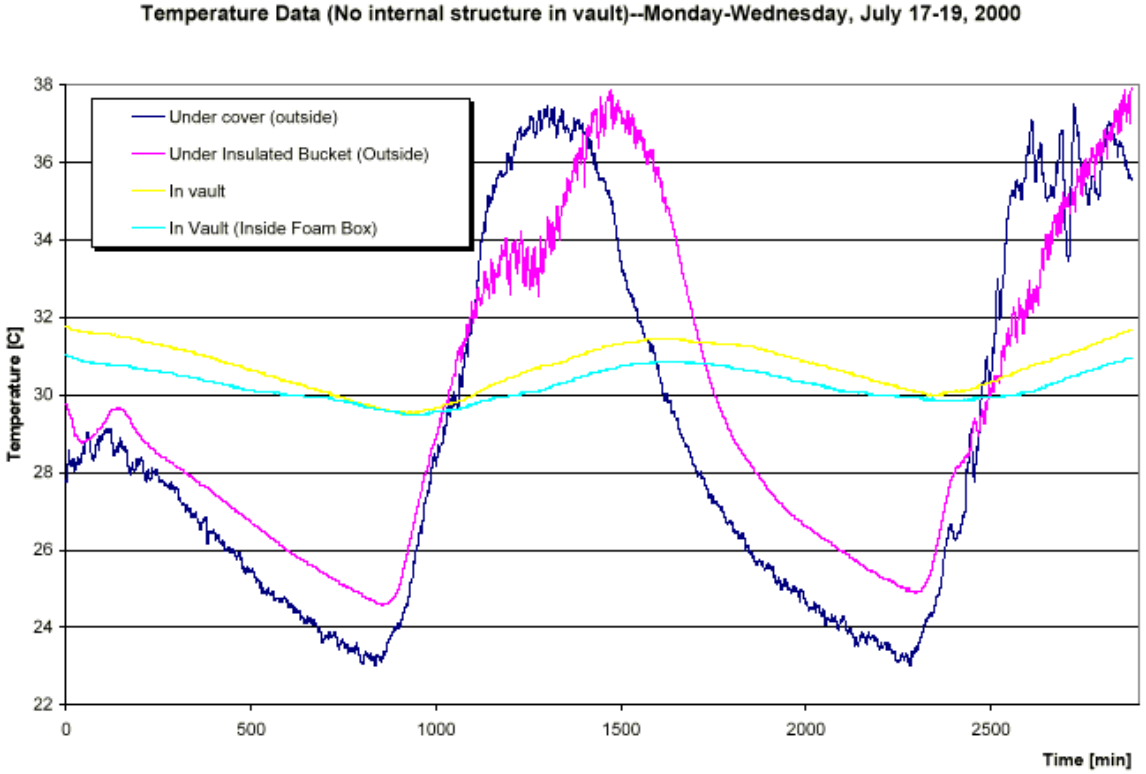
used in central

TriNet station

Detail of Seismometer Vault

LIGO Livingston Pascal Array Vault





Data from Szabi Marka and Keisha Williams

Plans

- Begin measurements with 9 Guralp CG-40T 3 axis seismometers this winter.
- Instrumentation loaned by:
  - **IRIS PASSCAL Instrument Center (NSF supported center)**
  - **New Mexico Tech**
    Socorro, New Mexico
  - http://www.passcal.nmt.edu/passcal.shtml
- Louisiana Tech (Greenwood + students), Coles, and 2 Southern Univ students to analyze data for first measurement during Q1 - 2001
- Requested 32 additional seismometers and data loggers from PASSCAL for more detailed investigations

Measurement Strategy

Use 3 axis seismometers to measure x,y,z displacements

Fit motion to lossy plane wave field with compressional, vertical shear and horizontal shear polarizations.

Expand displacements as Fourier-Bessel series ~$J_m(kr)\sin m\phi$.

Gravity gradient term is J_1 amplitude, since it adds mass on one side of a suspended test mass and subtracts on the other side.

$X(\omega) \sim F_{grav}/2m\omega^2$

where $X(\omega)$ is the displacement spectral density well above the suspension resonance frequency and F_{grav} is the gravitational force due to the rearrangement of the matter distribution surrounding the suspended test mass.

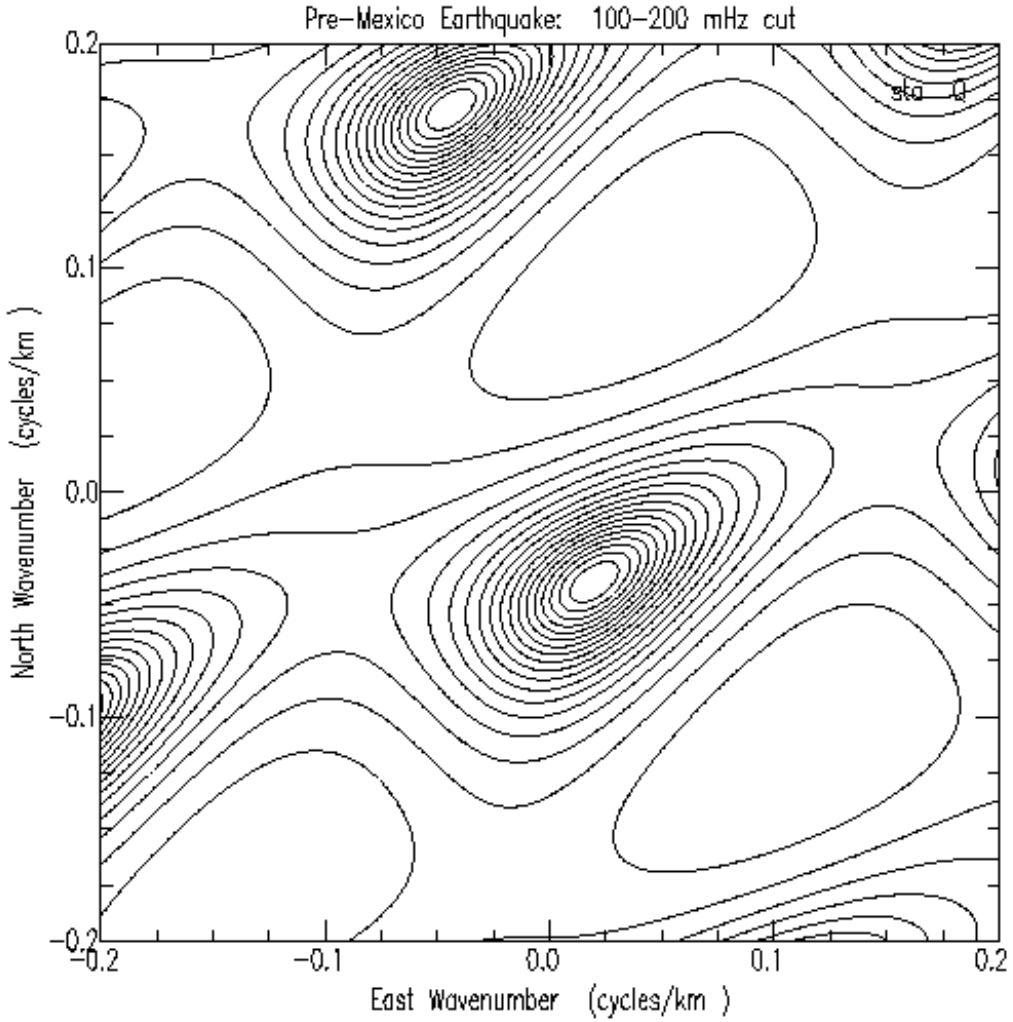
Correlated Microseismic Motion

- Initial measurements made by Alan Rohay, PNNL. Further measurents made at LLO by D. Greenwood and C. Westbrook (Louisiana Tech U) and M. Coles (LIGO)

Measurement Instrumentation

- 3 element array of 3 axis Guralp ESP seismometers at corner and ends of “L”, Reftek data loggers sampling at 50 Hz, with GPS antennae to synchronize data acquisition
- 4 km separation

Microseismic peak preceding earthquake

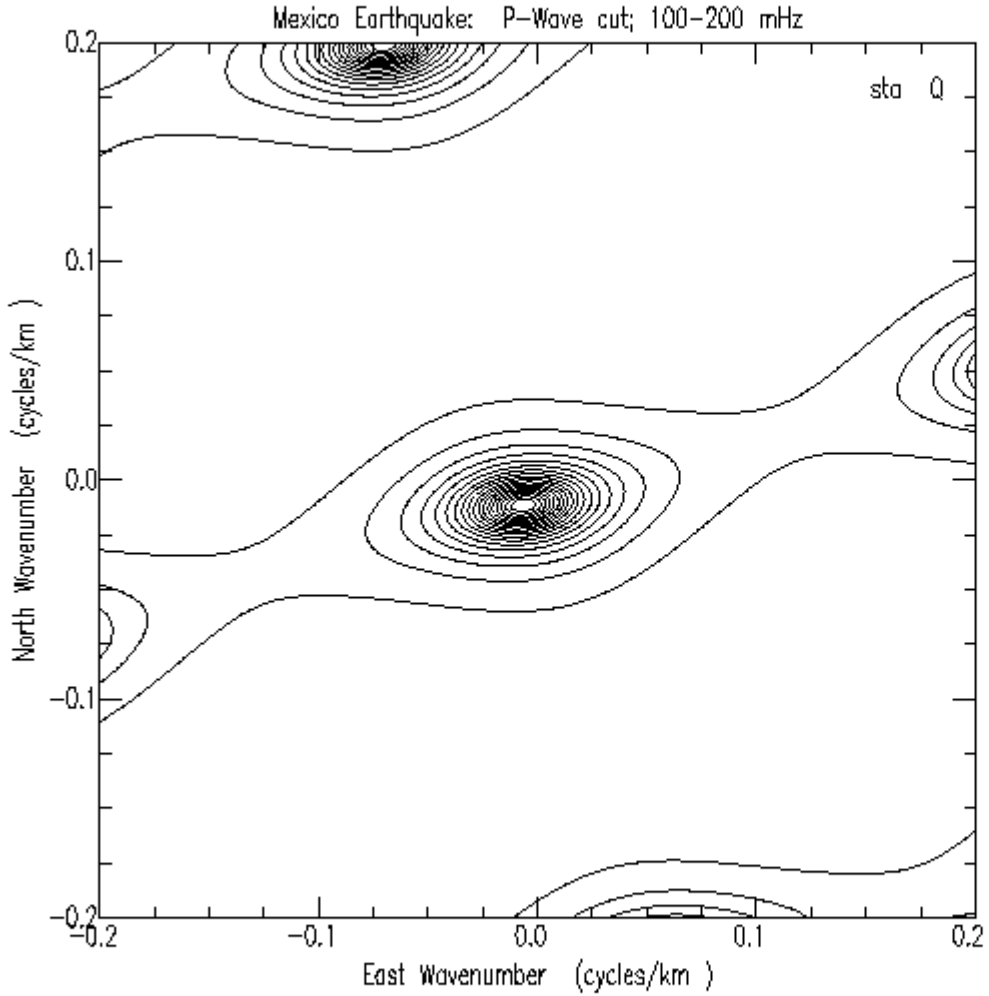


C=f/wavenumber

= 0.15Hz/0.05cycles/km

= 3 km/sec

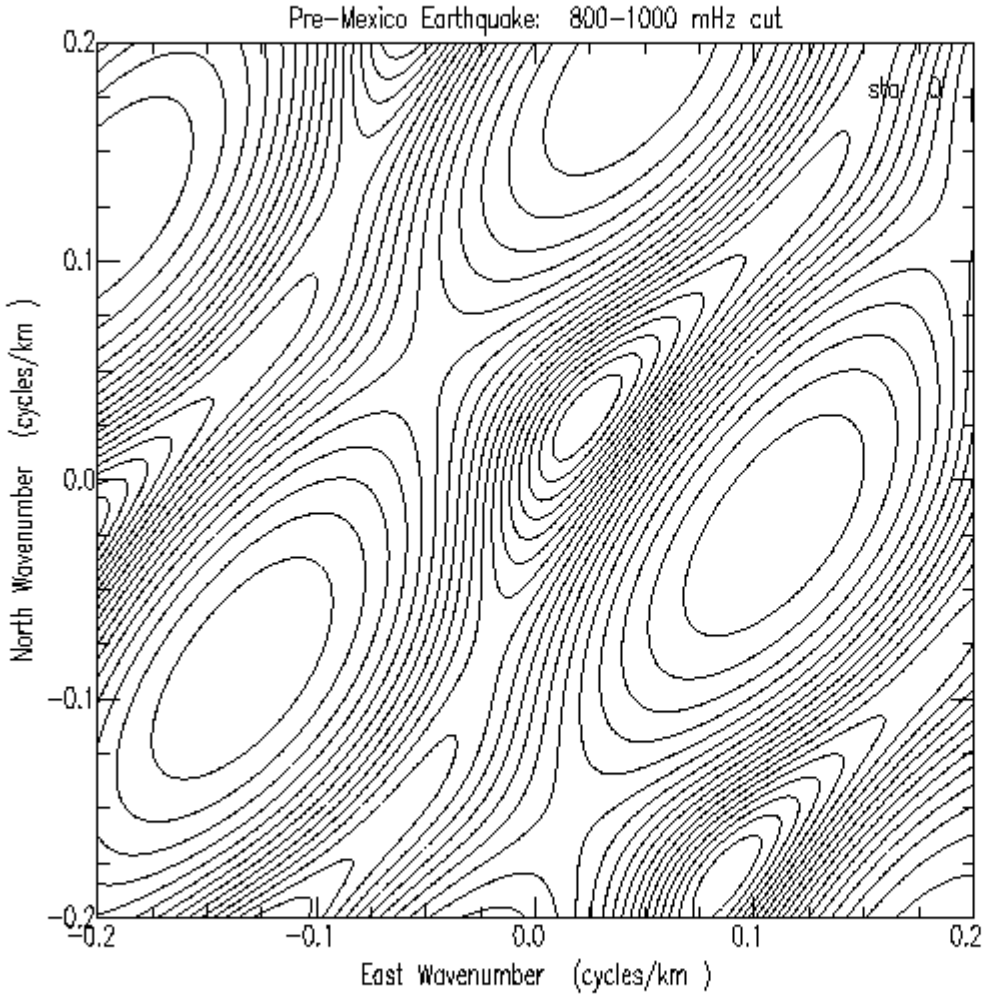
Microseismic Peak during earthquake



C =0.15 Hz/0.015 cycles/km

=10 Km/sec

Preceding Earthquake

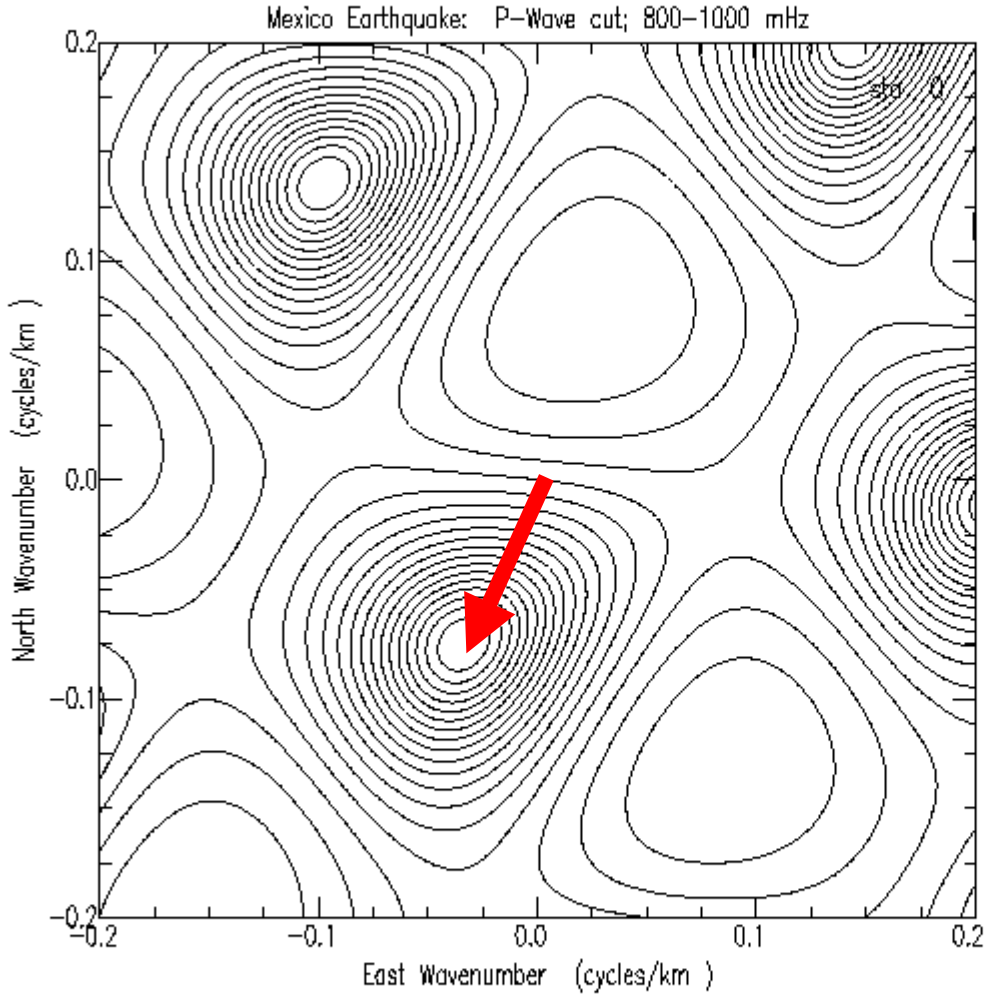


$C=0.9\ Hz/0.1km^{-1}$

$=9\ km/sec$

Closer to crustal velocities, expected 5-15 km/sec

During Earthquake



C= 0.9Hz/ 0.09km^{-1}

= 10 km/sec

Note direction

Community outreach

- Continuing to strengthen community outreach ties
  - ***No more shooting***!
  - More than 3000 visitors in last year (mostly school classes), 750 during public open house
  - teacher open houses in summer and winter, approximately 100 middle and high school science teachers in Livingston Parish have toured LIGO as part of teacher in-service
  - class field trips
  - hands-on activities
- Begin to plan for formally budgeted outreach activities as part of future operations
  - Possible extension of LIGO-SST (Scientist – Student – Teacher) program now underway at LHO?
  - Partnership with Educators – Northwestern State University Space Science Education Program

Optical Telescope

- Funded through Greg Guzik at LSU via Louisiana Technical Innovation Fund and Louisiana Board of Higher Education (only state employees are eligible to apply)
- Endorsed by LIGO and to be located at LLO site
- $98K for 16 inch robotic telescope, dome, controls
- Web accessible for remote use by classrooms
- LLO to provide:
  - Site, internet connection, staffing for use for community outreach
- Issues:
  - Opportunities to pursue complementary science?
    - Monitoring variable stars, supernovae searches, etc.
    - Opportunity to attract staff with formal backgrounds in astronomy and interests in LIGO science
  - **LIGO has endorsed, and the state has approved, the 16 inch telescope. Concern about scope changes by LSU**

Outreach Center

- Local Congressman – Richard Baker – has supported establishment of an outreach center along the lines of centers at Arecibo, Lowell Observatory, MacDonald Observatory
- Center mission
  - Host site visitors with hands-on exhibits and science classes (like Lederman Center at FNAL)
  - Teacher in-service training and support for classroom enrichment (also like Lederman Center)
  - Host a modest school-to-work program for vocational training
- Baker sought federal support this year for center construction - unsuccessful
- NSF policy is not to pay for infrastructure such as building, parking lots, etc., but OK to pay for program content, start-up labor costs.
- Possibility of private fund raising?