

Six Month Report
LIGO Scientific Collaboration Activities
University of Oregon
February 16, 2002 – August 15, 2002

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The Oregon group activities during the period of February 16, 2002 – August 15, 2002, continued to concentrate on various aspects of the environmental monitoring, particularly at the Hanford site, development of software infrastructure, such as the Event Analysis Tool and reduced data sets, general aspects of commissioning and engineering runs, and preparation for the science investigations of the burst upper limits group. The following describes many of these activities. We take this opportunity to compile our activities over the last few years.

Outline:

- Reports on Progress (including activities of last few years)
- Review of Milestones of past six months

Reports on Progress

(including activities of last few years)

Where possible we cite an applicable LIGO internal document where more information on an item can be found. These may be documents which are referred to by their LIGO DCC number, or by an electronic log (elog) entry. Both of these types of documents can be retrieved via the LIGO web page, <http://www.ligo.caltech.edu/>.

- I. Assisted in setting up the Physical Environment Monitoring system (PEM).
 - A. Helped install and calibrate PEM sensors at LHO.
 - B. Wrote driving software where required (weather stations and dust monitors).
 - C. Designed interface "fixes" where required (magnetometer filters and weather sensor boosters).
 - D. Closely involved in trouble shooting the PEM system.

- E. Studied response of anemometer, proposed gust meter.
- F. Designed and are implementing cosmic ray detection system.

II. Identified, studied and helped reduce sources of environmental coupling to the interferometers.

A. Magnetic fields

- a. Designed and manufactured a system for generating large, relatively uniform magnetic fields or field gradients for studying magnetic coupling (T990092-00-H).
- b. Measured the transfer function of generated magnetic fields from outside to inside in-situ vacuum chambers (G990079-29-M).
- c. Measured the gradients produced by eddy currents in optic support structures.
- d. Measured ambient magnetic fields outside and inside of vacuum chambers (G990079-29-M).
- e. Using generated fields, found that the magnetic coupling to the gravitational wave channel is orders of magnitude higher than expected and should limit interferometer sensitivity; working on reducing this.

B. Seismic signals

- a. Measured frequencies of major pieces of on-site equipment (G010395-00-Z).
- b. Attributed the largest seismic peak in the corner station to the office air handler and helped redesign its seismic isolation to greatly reduce the signal.
- c. Attributed largest nearly continuous signal (0-50 Hz) at Hanford to truck traffic and showed that the frequency could be predicted from axel spacing and velocity (G000262-00-D).
- d. Discovered source of many other seismic signals appearing on gravitational wave channels or causing interferometer to lose lock, including tank and mortar fire (G010159-00-Z), earthquakes (G000088-00-D), wind gusts (G000088-00-D, lhoelog 01/12/02, G020253-00-Z), bumps and stomps (G010159-00-Z), compressors and pumps (G010159-00-Z etc.), hood fans (G020396-00-Z), nuclear power plant fans (G020396-00-Z), and vitrification plant construction (G020252-00-Z).
- e. Completed a statistical study of earthquake induced motion (G010017-00-1).
- f. Produced earthquake alarm for control room (<http://www.ligo.caltech.edu/~jzweizig/Monitors>).
- g. Studied "Otto's jumps" to aid in placing new building far enough away.
- h. Helped design isolation system of new building air handlers to avoid interferometer resonances.
- i. Measured signals from various facilities on the Hanford Nuclear Reservation.
- j. Measured level and propagation of signal from Stateline wind farm to predict signal level from the Maiden wind farm proposed near LIGO (T020104-00-Z).
- j. Measured dispersion relation and Q for ground around LHO (G000262-00-D, T010074-03-D).
- k. Updated estimates of newtonian or gravitational gradient noise (T010074-03-D).

I. Showed that GW band (>30 Hz) seismic signals such as compressors can appear on the GW channel at a level consistent with doppler shift due to PSL table motion relative to the inertial interferometer (G010395-00-Z).

C. Acoustic

a. Investigated acoustic coupling to interferometer signals and identified sources of coupling such as certain mirror mounts, periscopes, and the pre-mode cleaner (LHO elog 6/8/2000).

b. Calculated that sound induced index of refraction variation in the pre-mode cleaner could produce measured levels of frequency noise (LHO elog 6/8/2000).

c. Helped with PSL redesign to reduce acoustic coupling and design of acoustic insulation for the PSL. Obtained a bid for an acoustic isolation room around the PSL, which, in our opinion, will eventually be needed.

d. Developed a scheme to determine general location of coupling based on acoustic propagation delays (G010395-00-Z, LHO elog 8/23/02).

D. Radio Frequency

a. Have recently set up wide and narrow band receivers (LHO elog 8/23/2002) and have measured RF coupling to the LHO GW channels.

E. Weather

a. Identified barometric pressure as source of pre-mode cleaner lock losses and helped investigate range needed to accommodate pressure fluctuations (G000088-00-D).

b. Studied relation of beam jitter to high frequency pressure fluctuations.

c. Began a study of the mechanism by which wind gusts cause lock losses (G000088-00-D, lhoelog 01/12/02, G020253-00-Z), have purchased a gust meter for this purpose.

d. Showed that steady winds correlated with low frequency (below 0.03 Hz) building tilts that will affect microseismic feed-forward systems (LHO elog 4/14/01).

F. Led environmental disturbances investigations groups for E2 through S1.

III. Investigated between-site environmental correlations.

A. Co-led investigations groups.

B. Developed code to search for between-site coincidences (30 ms window) of low amplitude bursts (G010286-00-H, G020253-00-Z).

C. Found coincidences in coil magnetometer signals at each site that can be explained by lightning. Greater than chance levels of coincidences have not been seen on other environmental channels (G020253-00-Z).

D. Studied east-west power grid connections and possible mechanisms of coherence between sites (G010286-00-H, G020253-00-Z, T010101-01-E, T010101-00-E).

IV. Developed data analysis, monitoring and distribution software.

- A. Contributed to development of reduced data sets (RDS)
 - a. Performed tests of the RDS software and provided feedback to the LDAS group.
 - b. Developed lists of channels for the RDS.
 - c. Produced Level 2 reduced data sets for the E7, E8, and S1 LIGO data runs.
- B. Developed glitchMon to monitor bursts and glitches on large numbers of interferometer and auxiliary channels (<http://www.ligo.caltech.edu/~jzweizig/Monitors>).
- C. Developed absGlitch, the tool used by the Burst and Inspiral groups to produce vetoes of gravitational channel data (G020047-00-Z).
- D. Developed eqMon earthquake monitor (<http://www.ligo.caltech.edu/~jzweizig/Monitors>).
- E. Quickly developed the histogramming tool at the request of the Detector Characterization group leader (<http://www.ligo.caltech.edu/~jzweizig/Sand/DataContainers.html>) for the LIGO Data Monitoring Tool (DMT).
 - a. Wrote the DMT histogram library for 1-D and 2-D histograms.
 - b. Wrote code to implement histograms in the DMT viewer.
 - c. Wrote code so that the histograms could be stored in LIGO format.
- F. Developed a transient reference catalog (G020046-00-Z).
- G. Developed software to allow DMT tools to save data in LIGO format.
- H. Helped code the Event Analysis Tool, the primary tool for identifying astrophysical events from coincidences between sites (G020237-00-D).
- I. Developed a programmer's interface for handling common DMT tasks (G020349-00-Z).
- J. Co-wrote the DMT digital filter library.
- K. Developed data analysis code (DSO) to look for GWs associated with gamma ray bursts (G020045-00-Z).

V. Veto production

- A. Have "injected" environmental signals before each run to determine coupling to the gravitational wave channel. Most recently these have included seismic, acoustic, magnetic and RF injections.
- B. Have set veto thresholds for environmental channels based on this measured coupling (G020254-00-Z).
- C. Demonstrated that proposed IFO veto channels had stronger than expected coupling to the GW channel, which could result in vetoes of GWs. Proposed and are helping implement a system for measuring this coupling using injected simulated astrophysical signals.
- D. Participated in astrophysical injections for S1 run at Hanford.

VII. Additional contributions to Advanced LIGO

- A. Showed that Newtonian noise may limit the sensitivity of Advanced LIGO below 10 Hz (T010074-03-D).
- B. Measured statistics of earthquake motion for planning of Advanced LIGO control system (G010017-00-1).
- C. Contributed extensively to the environmental assessment for Advanced LIGO (T010074-03-D).

D. Measured ambient magnetic fields, transfer functions to vacuum chambers, and coupling to the interferometer (G990079-29-M).

VIII. Other commissioning activities

- A. Helped install seismic isolation systems and optics in several vacuum chambers at LHO during 1999.
- B. Discovered that PSL table leg resonances produced large frequency noise peaks (LHO elog 10/06/00, 10/14/00) and were active in testing both piezo and pneumatic active isolation table leg systems.
- C. Identified the main source of frequency noise above about 30 Hz as being the PSL periscope (LHO elog 2/17/01) and showed that it could be dramatically reduced (LHO elog 6/09/01).
- D. Developed a system for reducing the effect of polarization drift (LHO elog 2/15/ 02).
- E. Identified power supply ripple produced by test mass controller-fans as being the source of a forest of peaks on GW channel spectra.
- F. Studied the failure of the MMT2 suspension. Suggested slider limits and watchdogs (even though slow) for a number of optics (G020396-00-Z).
- G. Many other collaborative activities.

IX. Shift participation for interferometer runs. The Oregon group has strongly supported the operation and scientific integrity of the engineering (E2-E8) and science runs (S1) at the Hanford observatory, as reflected in the table below, which shows the total number of scientific monitoring shifts for each run, and the number of these shifts taken by Oregon group members. (There was no data available for E1.) This information is available from the “Detector Characterization” link at the LSC home page: <http://www.ligo.org/> .

LIGO Run	LHO Expert Shifts		LHO Trainee Shifts	
	Total Shifts	Oregon	Total Shifts	Oregon
S1 (Aug-Sep 2002)	51	9	51	9
E8 (June 2002)	8	1	8	0
E7 (Dec-Jan 2002)	35	9	35	6
E6 (Nov 2001)	10	4	10	4
E5 (Aug 2001)	10	2	10	2
E4 (May 2001)	7	1	none	
E3 (Feb 2001)	10	1	10	1
E2 (Nov 2000)	22	3	44	10

Review of Milestones

Milestones for March 2002 – August 2002, from the previous six-month report are listed below, together with a brief review of the status of each milestone.

March 2002 Produce Level 2 reduced data set, without decimation, for the LSC.
Status: Completed. (G020051-00-Z)

Present work on RDS generation and list of future work and decisions to be made regarding LIGO reduced data sets at the LSC detector characterization session at the March 2002 LSC meeting.
Status: Completed. (G020051-00-Z)

Participate in the weekly LDAS data conditioning API user's group teleconference, mainly to facilitate the task of producing reduced data sets for future LIGO science runs using the LDAS system.
Status: Done.

Perform tests and investigations of the LDAS system's capability and readiness to produce reduced data sets, including the capability to do resampling.
Status: Done for E8 and S1.

Provide feedback to LDAS software engineers, from a user's point of view, regarding the performance of the LDAS system in producing reduced data sets, and regarding improvements which can be made in the future to better accomplish the said task of producing reduced data sets.
Status: Done for E8 and S1.

Write tcl script, which submits jobs to LDAS at LHO and LLO to continuously generate reduced data sets at the two sites.
Status: Done. (see below for further comments)

June 2002 Complete integration of particle detector as a complete system at LHO.
Status: Hardware integration complete. Software components complete in principle, But integration of the components (custom DAQ and DMT) to be completed Fall 2002.

In-situ measurement of transfer functions from magnetic fields to IFO control signals.
Status: Partially completed. To be completed by March 2003.

Major update of GlitchMon (for E8)

Status: Completed.

Generate Level 2 reduced data set for the eighth LIGO engineering run using the LDAS system.

Status: Done.

Generate Level 2 reduced data set for the first LIGO science run using the LDAS system.

Status: All of the goals listed in the previous 6-month report relating to reduced data sets have been accomplished. An interim Level 2 reduced data set (RDS) was generated for the S1 run, providing much-needed experience, lessons, and good momentum for future science runs. The tcl script used in generating this interim RDS has served as a template for the script used to generate the more permanent RDS which now resides at the LHO and LLO sites in lieu of the full raw data. Feedback from the end users of LIGO frame data have been received and will be used to improve reduced data sets for future runs.

Quantitative comparisons of original channels and resampled channels have been done and show the soundness of the LDAS resampling algorithm and the createRDS command used to generate the RDS. All of these are summarized in a report given at a Detector Characterization telecon and which can be found at:

<http://darkwing.uoregon.edu/~ileonor/ligo/s1/rds/s1rds.html>

The channel list for the S1 RDS can be found at:

http://blue.ligo-wa.caltech.edu/scirun/S1/RDS_Channels/rdstable_s1.pdf

Evaluate the performance of the LDAS system to produce reduced data sets and identify performance issues, if any, which should be addressed.

Status: Completed. (see above)

Perform quantitative comparisons of the original data channels in the original data set with the resampled data channels in the generated reduced data set to investigate the effects of data resampling.

Status: Completed. (see above)

July 2002 Use LIGO cosmic ray systems as part of an outreach program.

Status: LIGO cosmic ray detectors were used as a template for prototype detectors to be installed at Oregon high schools as part of NSF/DoE QuarkNet program. Participating HS teachers plan to visit LHO Summer 2003.

First tests using new gust meter for studying the coupling of gusts and optic motion.

Status: Incomplete.

August 2002 Determine the source of the 2.295 Hz signal, the 19.6 Hz signal and other

environmental contributors to large peaks in IFO signals.

Status: Completed. 2.295 Hz signal source identified as Nuclear Power Plant fan blades. 19.6 Hz signal source identified as hood fans in optics prep lab. Several other sources identified, including test mass controller fans.