

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
- LIGO -
CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Publication	LIGO-P010001-00 - D	1/15/01
Detector Characterization and Global Diagnostics System of the Laser Interferometer Gravitational-wave Observatory (LIGO)		
Daniel Sigg, Rolf Bork and John Zweizig <i>Conference Proceedings The Ninth Marcel Grossmann Meeting</i>		

Distribution of this draft:

all

This is a publication
of the LIGO Project.

LIGO Hanford Observatory
P.O. Box 1970 S9-02
Richland, WA 99352
Phone (509) 372-8106
FAX (509) 372-8137
E-mail: info@ligo.caltech.edu

LIGO Livingston Observatory
19100 LIGO Lane
Livingston, LA 70754
Phone (504) 686-3100
FAX (504) 686-7189
E-mail: info@ligo.caltech.edu

California Institute of Technology
LIGO Project - MS 51-33
Pasadena CA 91125
Phone (626) 395-2129
Fax (626) 304-9834
E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology
LIGO Project - MS NW17-161
Cambridge, MA 01239
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

WWW: <http://www.ligo.caltech.edu/>

DETECTOR CHARACTERIZATION AND GLOBAL DIAGNOSTICS SYSTEM OF THE LASER INTERFEROMETER GRAVITATIONAL-WAVE OBSERVATORY (LIGO)

DANIEL SIGG

LIGO Hanford Observatory, P.O. Box 1970 S9-02, Richland, WA 99352

ROLF BORK AND JOHN ZWEIZIG

LIGO Project, California Institute of Technology, Pasadena, CA 91125

Characterizing the instrumental performance and understanding environmental effects is essential for reaching the design sensitivity in LIGO. We show how the global diagnostics system in LIGO is used for performing stimulus-response tests and for constantly monitoring the status of the detector.

1 Overview

Traditionally, diagnosing the state of a prototype gravitational-wave detector involved a great deal of analog electronics experience and dedicated test equipment. With the introduction of digital feedback control systems the emphasis has shifted towards computer tools and software solutions.

*Detector Characterization Effort*¹ — The LIGO collaboration created a working group with the charter to investigate the behaviour of the instrument and to develop and implement solutions suited for on-line performance monitoring. Its main goal is to establish confidence in the understanding of the detector and the physical environment, so that machine artifacts and odd environmental behaviour are not mistaken for astrophysical events.

*Global Diagnostics System*² — A subsystem of LIGO with the task to assist the detector commissioning activity and to support operations by providing computer and software infrastructure to probe the status of the detector and the physical environment. It is used by the detector characterization effort to develop software algorithms for transient analysis, for performance characterization, for data set simulation and for reduced data set generation.

2 Global Diagnostics System

2.1 Data Viewing

LIGO has a data acquisition system³ with several thousand channels and a throughput of approximately 3 MB/s. The highest sampling rate is 16384 Hz. It includes digital feedback signals, analog output signal of laser, mode cleaner, suspensions and sensors of the physical environment monitor. All channels are available from disk for the last 24 hours before they are written to tape. The data viewer replaces the “old-fashioned” oscilloscope. Both on-line and off-line time series data can be displayed for user selected channels and times.

2.2 Stimulus Response Testing

The diagnostics test tool (DTT) allows active probing of the instrument by injecting a stimulus signal and observing the response of the system—both in time and frequency domain. Since the LIGO detectors heavily rely on active feedback systems to keep them in optimal operating conditions, stimulus response tests are important to determine noise suppression, frequency response and cross-coupling factors. DTT provides an arbitrary waveform generator for both analog and digital subsystems. It supports Fourier analysis (power spectral density, coherence, cross spectrum), swept sine response, multiple sine response (transfer matrices, two-tone intermodulation, harmonic analysis) and time averaging (step response). DTT runs on Sun workstations in the control room and connects to the data acquisition system and the arbitrary waveform generator through ethernet. Data and stimulus signals are synchronized by local GPS clocks.

2.3 Data Monitoring

The data monitoring tool (DMT) provides a platform for detecting transient events introduced by machine artifacts or the environment and for continuously monitoring the “health” of the apparatus to guarantee optimal performance. The DMT consists of multi-processor SUN workstations which receive the full data stream on-line and which make it available to user programs. At its core is a C++ class library implementing container objects for time and frequency series, signal processing routines such as FFT and linear filters, and output classes for generating triggers, alarms, trend data, web pages and log files. It utilizes the ROOT environment⁴ to provide both an interactive command line interface with plotting capabilities and a background processing environment.

3 Conclusions

The combination of a high performance data acquisition system which includes a 24 hour look back capability together with a set of new software and analysis tools has enabled a fast learning curve in commissioning the instrument. It allows the scientists to focus on analysis tasks to diagnose the detector status rather than the collection of measurement data.

This work is supported by National Science Foundation cooperative agreement PHY-9210038

References

1. Keith Riles, <http://www-mhp.physics.lsa.umich.edu/keithr/lscdc/home.html>.
2. Rolf Bork, David Shoemaker, Daniel Sigg, and John Zweizig, “*Global Diagnostics System: Final Design*”, <http://admdbsrv.ligo.caltech.edu/pubdcc>, T990018-A-D (1999); and <http://www.ligo-wa.caltech.edu/gds>.
3. David Barker, and Rolf Bork, “*Data Acquisition System: Final Design*”, <http://admdbsrv.ligo.caltech.edu/pubdcc>, T980026-00-C (1998).
4. Rene Brun, and Fons Rademakers, <http://root.cern.ch>.