Update on the Detector Characterization Working Group

Keith Riles & Daniel Sigg

University of Michigan & LIGO Hanford Observatory

LIGO Scientific Collaboration Meeting

LIGO Livingston Observatory

March 16, 2000

Overview

Aspects of Detector Characterization

- Commissioning*
- Online Diagnostics*
- Environmental Monitoring (installation & commissioning)
- Offline Data Monitoring
  - Performance Characterization:
  - Transient Analysis (subgroup chair: Fred Raab)
- Data Set Reduction (subgroup chair: Jim Brau)
- Data Set Simulation:
  - Parametrized Simulation (subgroup chair: Sam Finn)
  - End-To-End Model*

Working Group Web Site:

`http://www-mhp.physics.lsa.umich.edu/~keithr/lscdc/tasktables.html`

*Areas where LIGO Lab has main responsibility,
but where other LSC groups assist

Interferometer Commissioning:

- See parallel session talks by
  - Peter Fritschel (LIGO-MIT)
  - Steve Penn (Syracuse)
- Non-Lab LSC groups contributing:

  Florida, LSU, Michigan, PSU, Syracuse

Online Diagnostics:

- See parallel session talk by
  - Daniel Sigg (LIGO-LHO)
- Non-Lab LSC groups contributing:

  LSU, Oregon

Environmental Monitoring: (installation & commissioning)

- See parallel session talks by
  - Ed Daw (LIGO-MIT)
  - Dick Greenwood (La Tech)
  - Warren Johnson (LSU)
  - Evan Mauceli (Oregon)
  - Fred Raab (LIGO-LHO)
  - Anthony Rizzi (LIGO-LLO) (in ASIS session)
  - Robert Schofield (Oregon)
- Non-Lab LSC groups contributing:

  La Tech, LSU, Oregon, PSU

Data Monitoring Tool

Offline monitoring via the Data Monitor Tool (DMT)

$\Longrightarrow$ See talk in parallel session by John Zweizig

DMT provides (considerable) infrastructure for passive offline monitoring on dedicated on-site SUN workstations

- Records periodic characterization info in meta-database
- Generates triggers (& control room alarms)
- Allows for first level of data reduction
- Provides convenient data types & filters (Finn)

Support provided for

- Background monitoring
- Foreground monitoring + graphics display (root-based)
- Operator communication with background processes using diagnostics test tool (Sigg) (under development)

Data Monitoring Tool

Software can be run on "any" unix system with
Gnu egcs/gcc compiler installed

- Full root version demonstrated on Sun, Linux so far
  (non-trivial compiler incompatibilities on other platforms)
- Downloadable from the Web
- Supports C procedures, but C++ more convenient
  for exploiting existing infrastructure

Compatibility with other LIGO software:

- DMT had to be ready in a hurry
  $\Longrightarrow$ John forged ahead
- Will provide "wrapper" for LDAS data conditioning API
  (Finn, Romano, Charlton) now under development
- DMT Interface to Meta-Database (Shawhan) in progress
- DMT code ported to Matlab for Frame writing (Daw)

Data Monitoring Tool

Summary:

- DMT infrastructure up and running with powerful features (and more on the way)
- Many thanks to John!
- Our monitoring / characterization work is cut out for us...

Task Tables

At Stanford LSC meeting (July 1999) settled upon task assignments and priorities $\Longrightarrow$ White Paper

Original scheme

Priority 1 Needed at start of 2-km commissioning
$\Longrightarrow$ Due 10/99

Priority 2 Needed during 2-km commissioning
$\Longrightarrow$ Due 5/00

Priority 3 Needed 6 months before science run
$\Longrightarrow$ Due 6/01

Priority R Research area for advanced LIGO

Summary table from White Paper:

Task Category	Priority	Institutions
Online Diagnostics & Measurements	1, 3	CIT LSU MIT Mich
Offline Monitoring Infrastr.	1	CIT
Environ. Monitoring (hardware)	1, 2, R	CIT LSU MIT LaTech Oreg PSU
Line Noise Identification	1	AEI ANU Dublin Flor LSU Mich PSU Wisc
Instrumental Correlations	1	Dublin PSU Wisc
Enviromental Correlations	1, R	LSU LaTech Oreg PSU Syr
IFO State Summaries	1, 2, 3	ANU CIT LSU Flor Mich PSU Wisc
IFO–IFO Correlations	3	PSU
Transient ID / Analysis (instr.)	1, 2, 3	AEI IUCAA MIT Mich PSU
Transient ID / Analysis (instr.)	2, 3	CIT Oreg
Time / Frequency Analysis	2, 3	CIT Flor
Data Set Reduction	1, 2	Flor Oreg
Phenomenological Modelling	2	MIT PSU
End-To-End Modelling	1, 2	CIT Flor PSU Pisa

Only institutions with firm task commitments shown in summary table

Details at

http://www-mhp.physics.lsa.umich.edu/~keithr/lscdc/tasktables.html

Task Tables

On the bright side...

- Online diagnostics in good shape
- Offline monitoring infrastructure in good shape
- Much LSC activity in environmental monitoring
  (but more help needed!)

Problems:

- Almost no priority 1 offline software deadlines met (10/99)
- Some disagreements as to what tasks should be priority 1
- Some tasks not well defined (unclear "deliverable")
- DMT software threshold too high or learning time constant too long for some LSC groups with relevant hardware or analysis experience
- Other demands on time...

Task Tables

On the other hand...

- Some groups have now delivered (or very soon will deliver) first versions of DMT code
  (Even code that wasn't promised! – Oregon)

To discuss in parallel session:

- Most pressing needs
  $\Longrightarrow$ Revised (realistic) milestones?
- Consolidation of groups signed up for common tasks
  $\Longrightarrow$ Assignment of Lead Group for each deliverable?
- Better definition of DMT deliverable
  $\Longrightarrow$ Two stages?

Will report back on Saturday with revised task tables
(detailed version with names)

Offline Monitoring

Performance Characterization (ordered by priority)

- Line noise sources (priority 1)
  - See parallel session talks by
    - Bob Coldwell (Florida)
    - Sergey Klimenko (Florida)
    - Adrian Ottewill (Dublin)
    - Bernard Whiting (Florida)
- Seismic noise (priority 1)
  - See parallel session talks by
    - Ed Daw (LIGO-MIT)
    - Dick Greenwood (La Tech)
    - Warren Johnson (LSU)
    - Evan Mauceli (Oregon)
    - Fred Raab (LIGO-LHO)
    - Robert Schofield (Oregon)
- Stack Vibrations (priority 1)
- Inter-channel correlations (priority 1)
  - See parallel session talks by
    - Adrian Ottewill (Dublin)
    - Julien Sylvestre (LIGO-MIT)

*Presentation on DMT software

Offline Monitoring

Performance Characterization (cont.)

- Bilinear Cross-Couplings (priority 1)
- Operational State (priority 1)
  - See parallel session talk by
    - Keith Riles (Michigan)
- Band-limited RMS (priority 2)
- Time/Frequency plots (priority 2)
- Non-Gaussian noise (priority 2)
  - See parallel session talk by
    - Albert Lazzarini (LIGO-CIT)
- Time-domain system ID (priority 3)
- 2km-4km WA correlations (priority 3)
- Inter-site correlated noise (priority 3)
- Summary (astrophysical metrics) (priority 3)
- Gravitational gradients (priority R)

*Presentation on DMT software

Offline Monitoring

Transient Analysis (ordered by priority)

(Subgroup leader: Fred Raab)

- Frequency band transients (priority 1)
  - See parallel session talk by
    - Julien Sylvestre (LIGO-MIT)
- Servo instability (priority 1)
  - See parallel session talk by
    - Keith Riles (Michigan)
- Event catalog (priority 1)
- Flickering optical modes (priority 2)
- Impulse recognition (priority 2)
  - See parallel session talk by
    - Eric Chassande-Mottin (AEI)
- Magnetic field transients (priority 2)
  - See parallel session talk by
    - Robert Schofield (Oregon)
- Wind gusts / lightning (priority 3)
  - See parallel session talk by
    - Robert Schofield (Oregon)

*Presentation on DMT software

Offline Monitoring

Transient Analysis (cont.)

- Dust in beam (priority 3)
- Quake recognition (priority 3)
  - See parallel session talks by
    - Ed Daw (LIGO-MIT)
    - Dick Greenwood (La Tech)
    - Warren Johnson (LSU)
    - Evan Mauceli (Oregon)
    - Robert Schofield (Oregon)
- Wavelet analysis (priority 3)
  - See parallel session talk by
    - Sergey Klimenko (Florida)
- Automated transient ID (priority 3)

*Presentation on DMT software

Data Set Reduction

(Subgroup leader: Jim Brau)

- See parallel session talk by
  - David Strom (Oregon)
- Basic infrastructure for designer / customized data sets in place at LHO
  - Can save compressed to disk for long-term storage
  - Can write to tapes
- Need to discuss formal mechanism for distributing engineering data to LSC groups conveniently (tape format agreed upon at Stanford meeting)
- Oregon group has circulated proposed content (outline form) of default reduced data set ($\approx$300 kB/s)
- Need to decide soon on default and implement / test

Data Set Simulation

Two lines of attack:

- Parametrized modelling (Subgroup leader: Sam Finn)
  $\Longrightarrow$ See parallel session status report
- End-to-End (E2E) Model (Team leader: Hiro Yamamoto)
  $\Longrightarrow$ See parallel session talk:
  "Applications of the End-To-End Model
  to the LHO 2-km IFO"

Brief status of parametrized modelling:

- MATLAB program written to simulate (on the fly, in time domain) superposed sources of interferometer noise (Finn)
- First version released November 1, 1999 (as promised!)
- Contains shot noise, radiation pressure noise, suspension thermal noise, internal test mass thermal noise
- Second version in preparation (Finn/Daw)
- Will contain seismic noise, violin modes, better internal thermal noise, and Frame output
- Will be handed over to E2E team
  for algorithm incorporation

Fall 1999 40-Meter Data

With (much appreciated) support from the Caltech group, Dick Gustafson (Michigan) & Steve Vass (Caltech) made two several-day data runs in fall 1999 with the 40 Meter prototype, following a summer of shaking down the instrument.

- First run: Sept. 17-21 (in coincidence with TAMA!)
  $\Longrightarrow \sigma_{\delta L} \approx 2 \times 10^{-17}$ m/$\sqrt{\text{Hz}}$ 1 kHz
- Followed by more interferometer tweaking & tuning
- Second run: Sept. 30 - Oct. 4
  $\Longrightarrow \sigma_{\delta L} \approx 4 \times 10^{-18}$ m/$\sqrt{\text{Hz}}$ 1 kHz
  $\Longrightarrow \sigma_h \approx 1 \times 10^{-19}$
  (nearly unattended running!)

Remarks:

- Noise dominated by electronics
- Data's astrophysics potential probably miniscule

But!

- Data from a fully recycled LIGO-like interferometer
- ≈100 data channels recorded, many at 16 kHz sampling
- Opportunity for real-world detector characterization
  (under combat conditions!)

Fall 1999 40-Meter Data

Coincidence analysis with TAMA in the works

- Walid Majid (Caltech) coordinating the LIGO side of the analysis effort
  $\Longrightarrow$ See talk in parallel session
- Formal analysis proposal to LSC in preparation
- One goal of analysis is development / testing of detector characterization algorithms
  $\Longrightarrow$ See talk by Julien Sylvestre (LIGO-MIT)
- Analysis effort open to additional LSC participants

Web page for analysis effort:

`http://www.ligo.caltech.edu/~wmajid/40m+tama/docs.html`

Note 1, Linda Turner, 05/09/00 09:32:23 AM
LIGO-G000062-00-D