LIGO-I Detector Characterization

Keith Riles
University of Michigan
Chair, LSC D.C. Working Group

LIGO-G000117-00-E

Detector Characterization

- Commissioning
- Online Diagnostics
- Environmental Monitoring (hardware)
- 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

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Goals

- Quantify “Steady-State” Behavior of IFO’s
  - Monitor instrumental & environmental noise
  - Measure channel-to-channel correlations
  - Quantify IFO sensitivity to standard-candle GW sources
  - Characterization includes both description & correction
- Identify transients due to instrument or environment
  - Avoid confusion with astrophysical sources
  - Identify & correct contamination in data stream
  - Diagnose and fix recurring disturbances

Examples of Ambient Noise

- Seismic
- Violin modes
- Internal mirror resonances
- Laser frequency noise
- Electrical mains (60 Hz & harmonics)
- Coupling of orientation fluctuations into GW channel
- Electronics noise (RF pickup, amplifiers, ADC/DAC)

Examples of Transients

- Earthquakes, Trains, Wind Gusts
- Machinery vibration
- Magnetic field disturbances
- Wire slippage
- Violin mode ringdown
- Flickering optical modes
- Electronic saturation (analog / digital)
- Servo instability
- Dust in beam

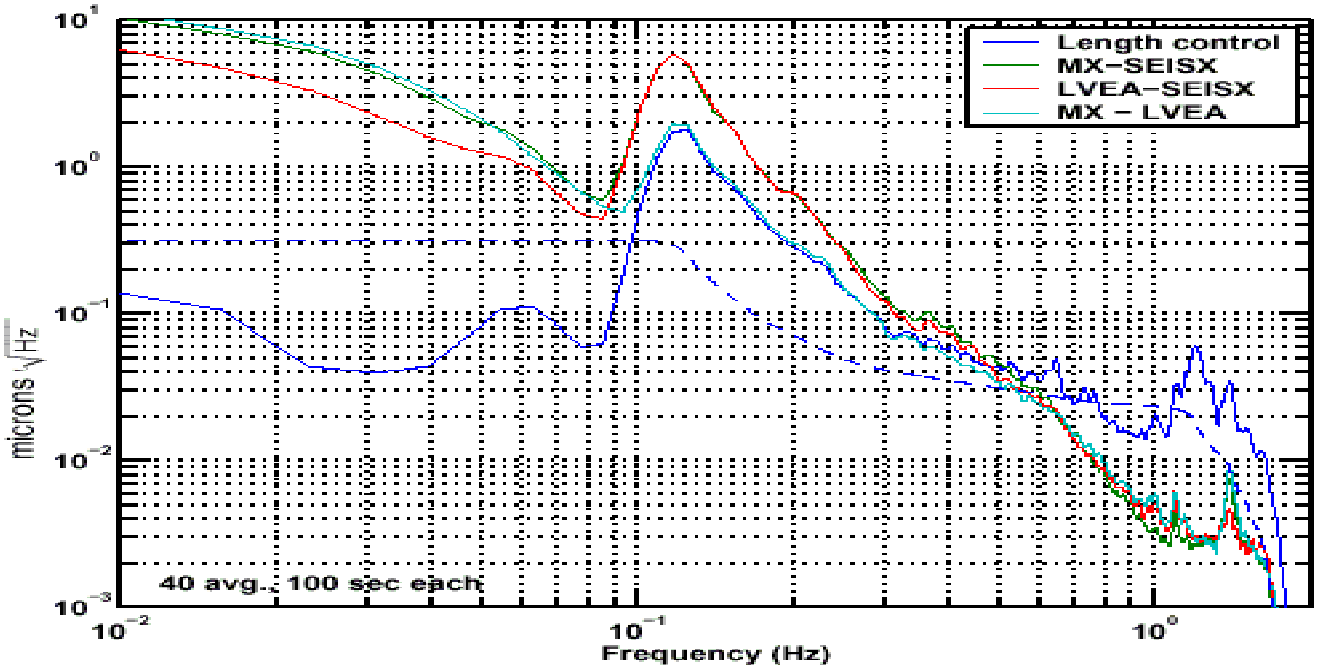
Characterization Methods

- Measured optical, RF, geometrical parameters
- Calibration curve
- Statistical trends & analysis (outliers, likelihood)
- Power spectra
- Time-frequency analysis
  - » Band-limited RMS
  - » Wavelets
- Principal value decomposition
- Non-linear couplings measurement
- Matched filters

Microseismic Peak

Comparing seismometers to length servo signal:

(plot from Fritschel talk at LSC meeting)



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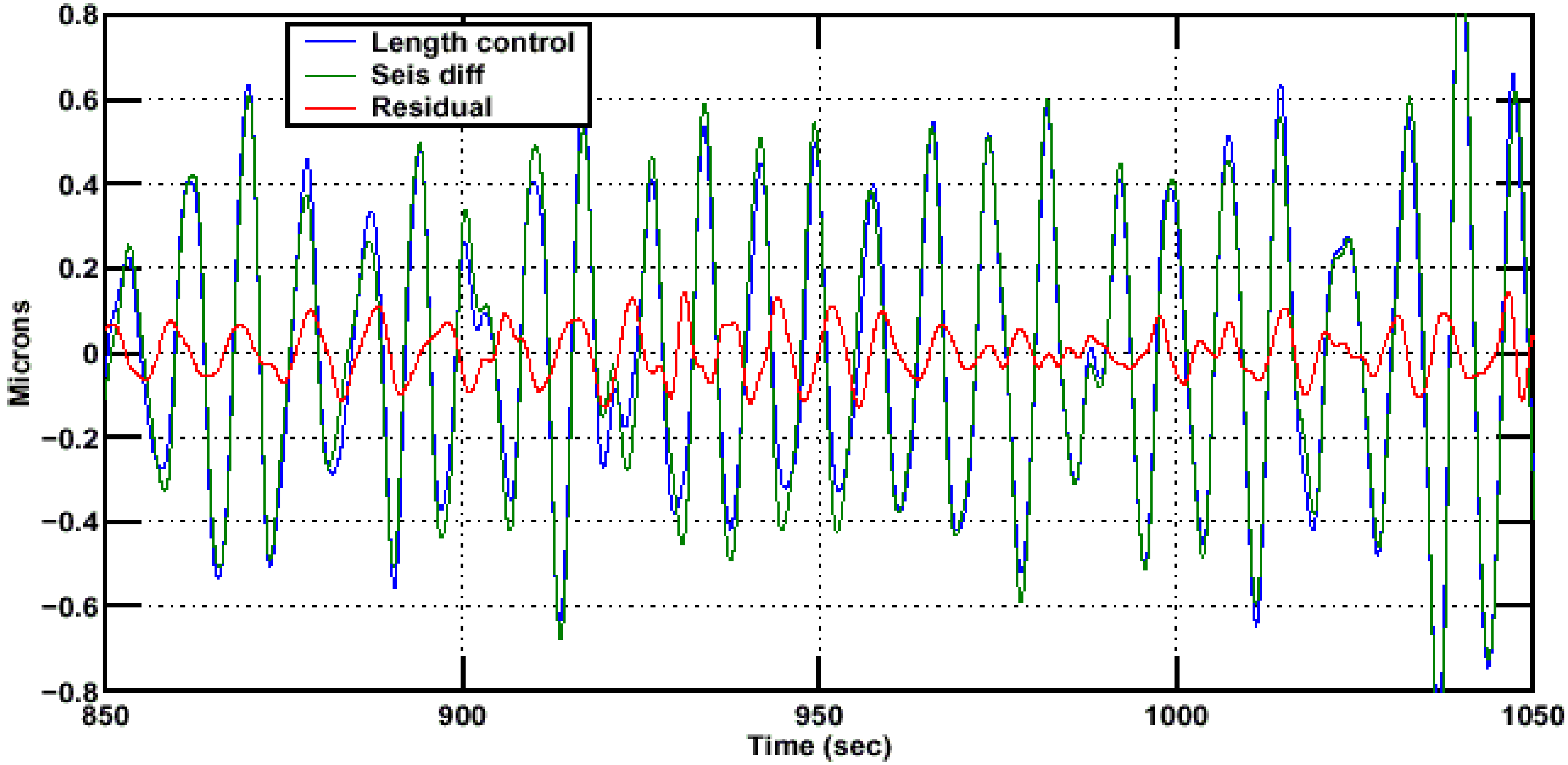
Microseismic Peak

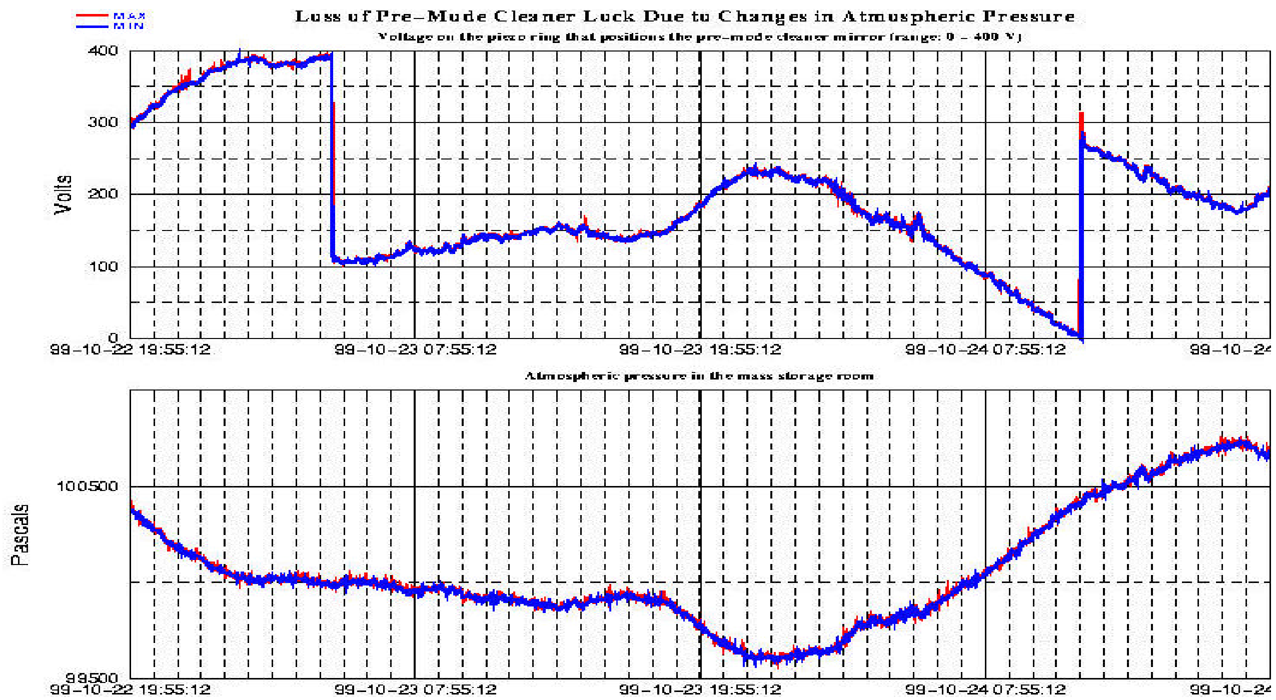
Correcting GW signal for largest μ–seismic component:



Atmospheric Pressure

Pre-Mode Cleaner losing lock from barometric changes:

(plot from Schofield talk at LSC meeting)



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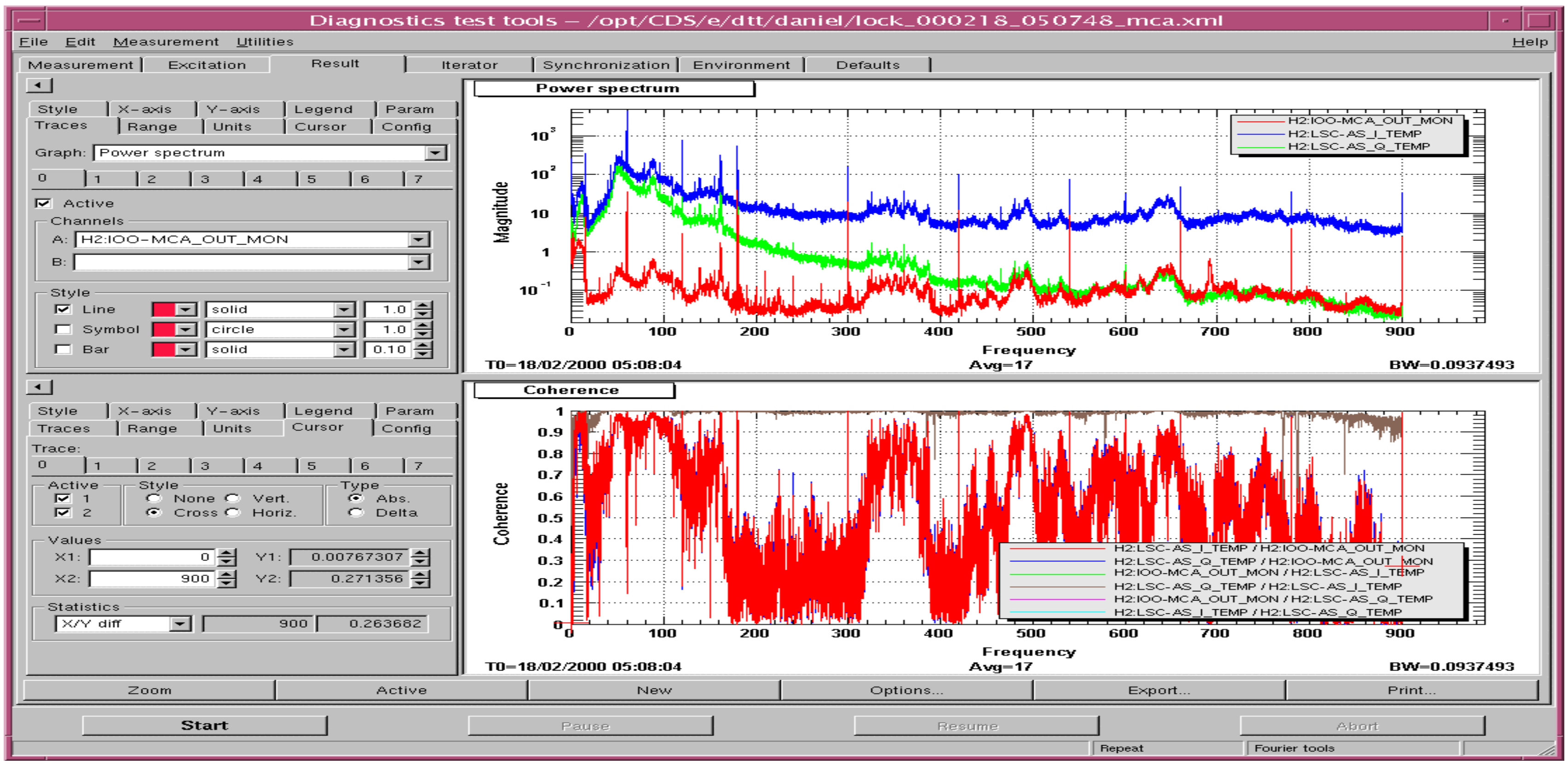
Online Diagnostic Test Tool

(slide from Sigg talk at LSC meeting)



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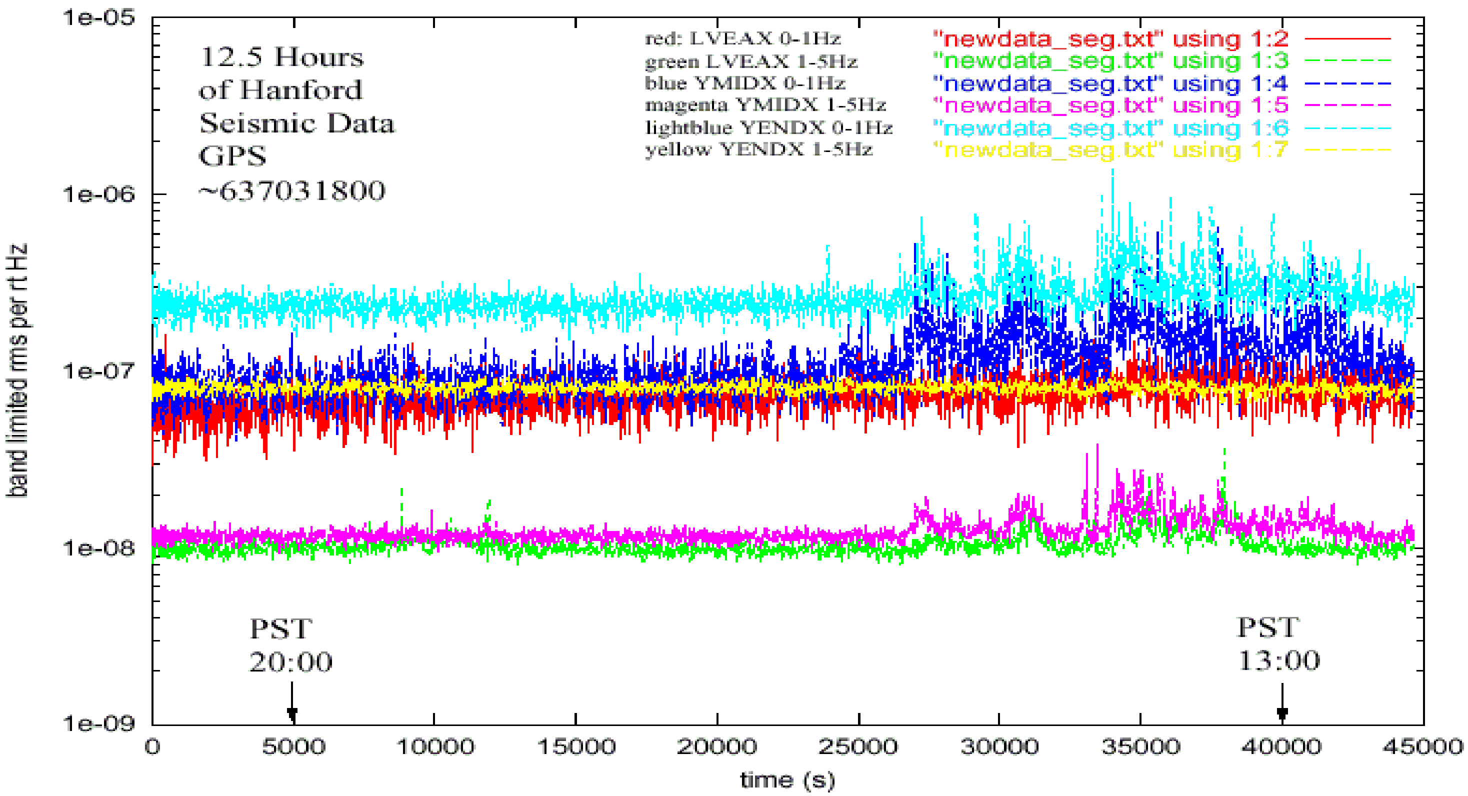
Offline Data Monitor Tool

(slide from Daw talk at LSC meeting)



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Detector Characterization Group

- Structure:
  - » Chair: KR LIGO Liaison: Daniel Sigg (GDS leader)
  - » Subgroups:
    - – Transient Analysis (Chair: Fred Raab - LHO Director)
    - – Data Set Reduction (Chair: Jim Brau - U. Oregon)
    - – Data Set Simulation (Chair: Sam Finn - Penn. State U.)
  - » Participating institutes:

    AEI-Potsdam, Austral. Natl. U., Dublin, Florida, La. Tech, IUCAA, LHO, LLO, LSU, Michigan, MIT, Oregon, Pisa, PSU, Syracuse, Wisconsin

- Web site:
  - » http://www-mhp.physics.lsa.umich.edu/~keithr/lscdc/home.html

Detector Characterization Group

- Meetings & teleconferences:
  - March 1998 - Hanford LSC meeting
  - August 1998 - JILA LSC meeting
  - March 1999 - Florida LSC meeting
  - June 1999 - Teleconference
  - July 1999 - Stanford LSC meeting
  - December 1999 - Teleconference
  - February 2000 - Teleconference
  - March 2000 - Livingston LSC meeting
  - May 2000 - Teleconference
- Minutes available on DC web page
- Transparencies available on DC / LSC web pages

Task Categories (summary)

Online Diagnostics & Measurements	CIT LSU MIT Mich
Offline Monitoring Infrastructure	CIT
Environmental Monitoring (hardware)	CIT LSU MIT LaTech Oreg PSU
Line Noise Identification	AEI ANU Dublin Florida LSU Mich PSU Wisc
Instrumental Correlations	Dublin PSU Wisc
Environmental Correlations	LSU LaTech Oreg PSU Syr
IFO State Summaries	ANU CIT LSU Flor Mich PSU Wisc
IFO-IFO Correlations	PSU
Transient ID / Analysis (instrumental)	AEI IUCAA MIT Mich PSU
Transient ID / Analysis (environmental)	CIT Oreg
Time / Frequency Analysis	CIT Flor
Data Set Reduction	Flor LaTech Oreg
Phenomenological Modelling	MIT PSU
End-to-End Modelling	CIT Flor PSU Pisa

(detailed tasks & milestones posted at DC web site)

Where does LDAS fit in?

- Detector characterization used online for diagnosis / warnings and offline for interpreting data
- Characterization conveyed downstream to LDAS via meta-database and frame-contained constants
- Meta-database entries (examples)
  - » Calibration constants and power spectra
  - » Environmental noise measures
  - » Cross-coupling coefficients (for regression)
  - » Line noise strength and phase
  - » Triggers (for veto or “handle with care”):
    - – Environmental disturbances
    - – Excess noise or unstable conditions

Where does LDAS fit in?

- First test of GDS/DMT $\Rightarrow$ LDAS analysis chain in summer 2000 Mock Data Challenge:
  - » Veto triggers
  - » Line tracking
  - » Regression constants