Laser Interferometer Gravitational Wave Observatory

Monitoring LIGO Data During the S2 Science Run

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on behalf of the LIGO Scientific Collaboration (LSC)

Detector Characterization Working Group

http://www.ligo.org

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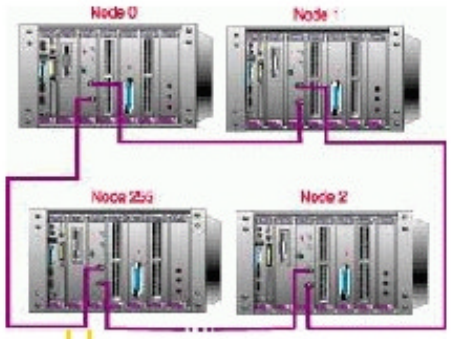
Science run monitoring of data

- Require rapid and accurate diagnostic information on interferometer and environmental channels
- Data Monitoring Tool (DMT)
  - DMT defines the environment and the tools necessary to support continuous data monitoring of the LIGO interferometers
  - Programs (monitors) provide foreground and background monitoring
  - Output: reports, triggers, trends, data objects (e.g. spectra), alarms
- What this talk is not: a report on online astrophysical search algorithms (LDAS DSOs)
- The DMT has many contributors (architecture, DMT authors, users/testers/contributors)
  - D. Barker, D. Chin, E. Daw, S. Finn, R. Frey, G. Gonzalez, M. Ito, S. Klimenko, M. Landry, S. Marka, B. Mours, T. Olson, A. Ottewill, C. Parameswariah, S. Penn, R. Rahkola, K. Riles, P. Saulson, K. Schlaufman, R. Schofield, D. Sigg, P. Sutton, J. Sylvestre, N. Zotov, and J. Zweizig

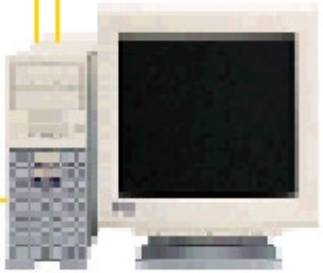
DMT architecture



LIGO DAQ System
Consists of a reflective memory ring linking VME-based instrumentation crates.

Reflective Memory Loop

CDS Frame Builder
Collects raw data into frames for archival



Frame Broadcaster
Builds frames with raw data and GDS test-point data, and broadcasts them to DMT machines.

Gigabit Ethernet Hub
Routes data multicasts to all connected hosts

DMT Machines
18 Ultra-Sparc CPUs at LHO and 8 processors at LLO run monitors and support processes

Analysis Sandbox Machines
fortress at LHO and decatur at LLO provide scientists with online data access and designer data set creation and copying platform

Hardware:

- Framebroadcaster serves up 5Mb/IFO/s of data, including testpoints (temporary channels)
- DMT machines have 16s of current data in a ring buffer (make analysis, trends, spectra)
- All data made rapidly available

Software:

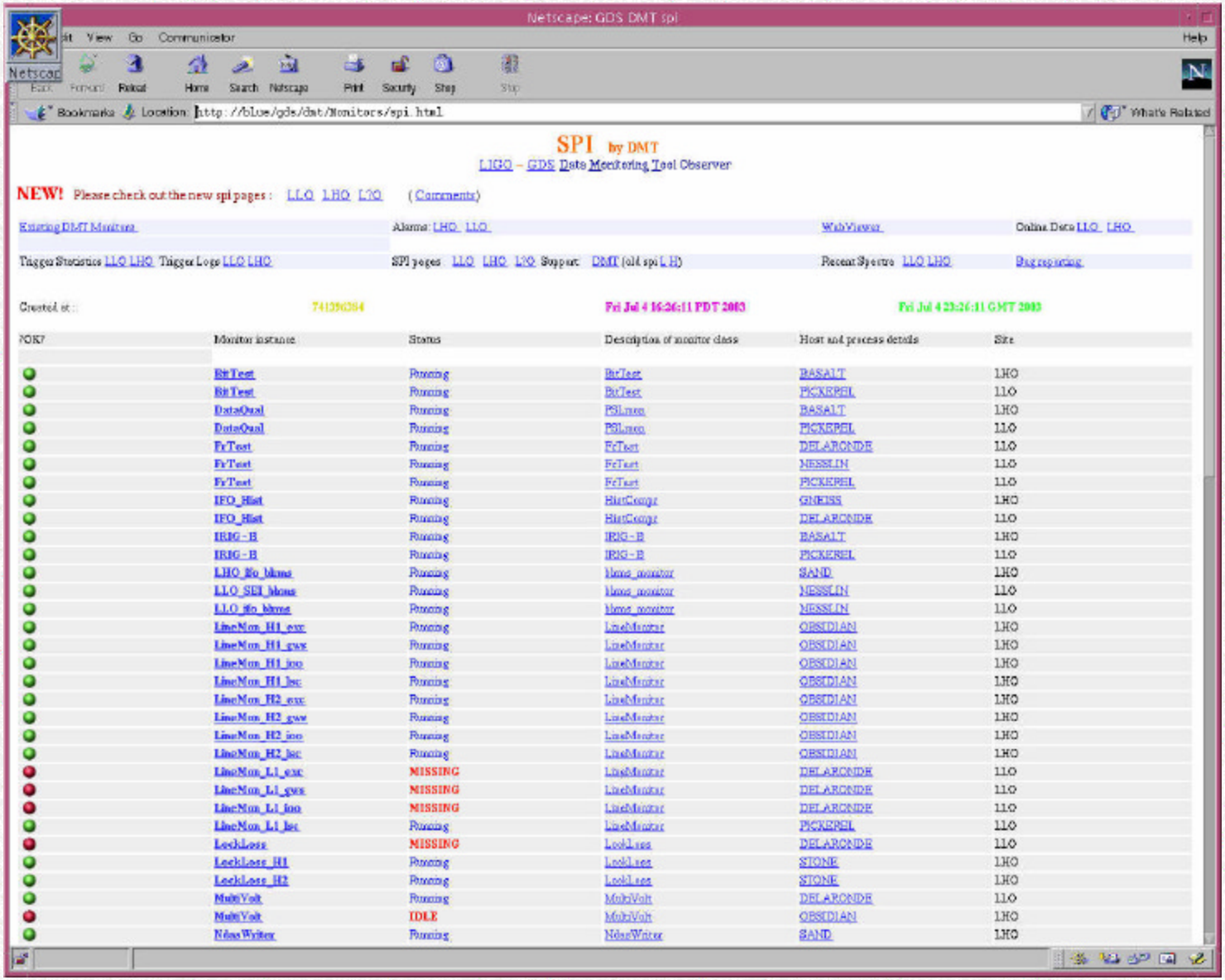
- DMT infrastructure provides data containers, I/0 classes, signal processing algorithms
- C++ code
- Root employed for graphics and interactive environment

A sampling of LIGO monitors

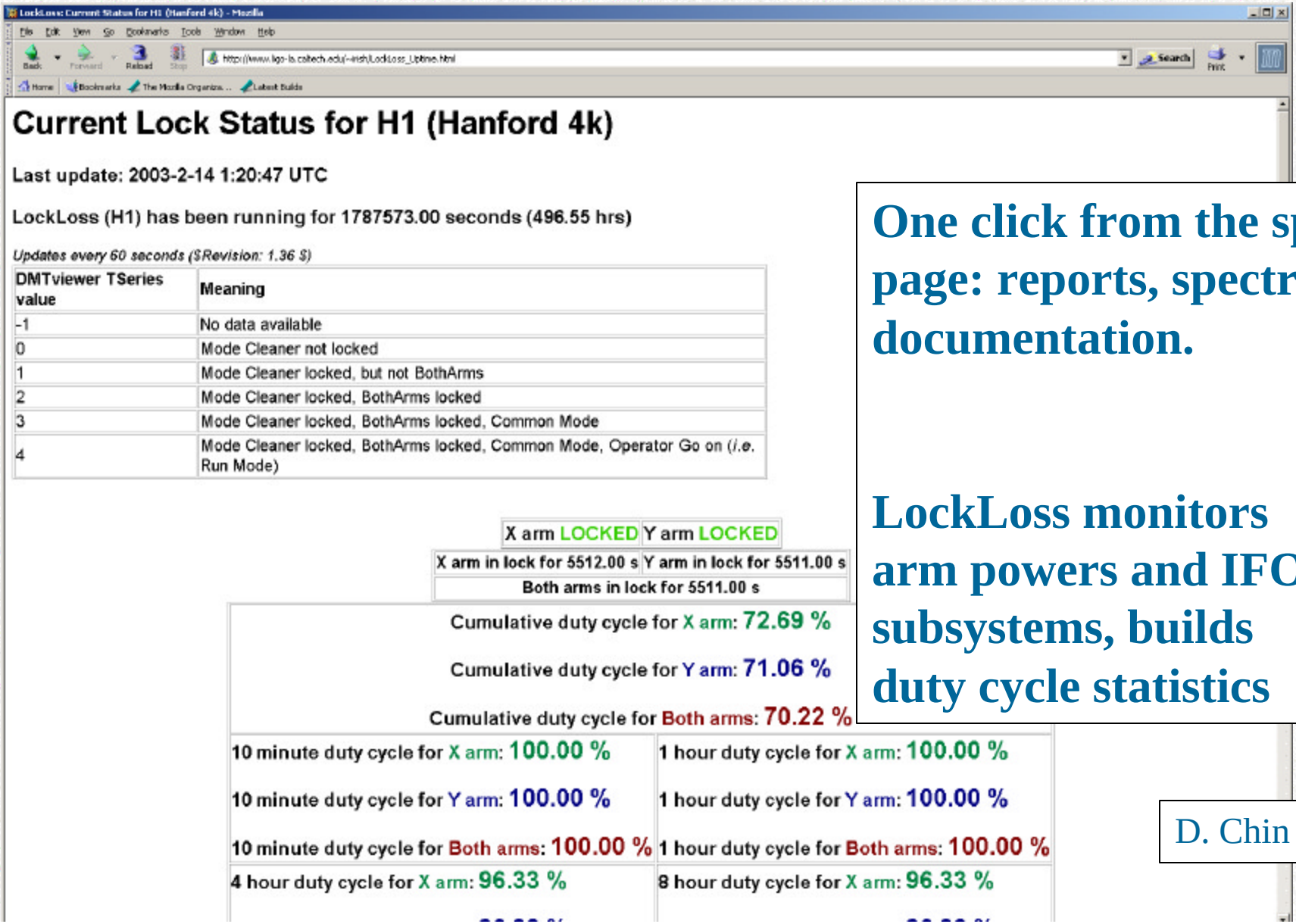
Background

- Performance Characterization (steady-state monitoring):
  - Blrms (E. Daw) - Displays and records band-limited RMS (New_Seis_Blrms looks only at seismic channels; LXO_ifo_blrms looks at AS_Q).
  - LineMonitor (S. Klimenko) - Tracks specified lines in several IFO channels, also reports detected lines above threshold SNR.
- Data Acquisition / Timing Validation
  - BitTest (J. Zweizig) - Looks for stuck ADC bits and saturations.
  - TimeMon (S. Marka) - Checks relative timing with fine resolution
- Transient Phenomena (glitches, state transitions)
  - GlitchMon (M. Ito) - Looks for sudden glitches in hundreds of channels (now allows for both adaptive and absolute thresholds).
  - LockLoss (D. Chin) - Displays and records all lock transitions, displays IFO state vector in abbreviated form.
- Foreground Monitors
  - SpectrumArchiver (T. Olson) - A once-per-hour background program that stores spectra for about 200 data channels
  - RayleighMonitor (P. Sutton) - Time-frequency display of spectral power and "rayleighness" - standard deviation of power over mean power -measures non-Gaussianity.

DMT spy page


Netscape: GDS DMT spi
Bookmarks Location: http://blue/gds/dmt/Monitors/spi.html
SPI by DMT
LIGO - GDS Data Monitoring Tool Observer
NEW! Please check out the new spi pages : LLO LHO L1O (Comments)
Existing DMT Monitors
Alarms: LHO LLO
WebViewer
Online Data LLO LHO
Trigger Statistics LLO LHO Trigger Logs LLO LHO
SPI pages LLO LHO L1O Support: DMT (old spi LHO)
Recent Spectra LLO LHO
Data reporting
Created at : 741356384
Fri Jul 4 16:26:11 PDT 2003
Fri Jul 4 23:26:11 GMT 2003
OK? Monitor instance Status Description of monitor class Host and process details Site
BitTest Running BitTest BASALT LHO
BitTest Running BitTest PICKEREL LLO
DataQual Running PSLmon BASALT LHO
DataQual Running PSLmon PICKEREL LLO
FrTest Running FrTest DELARONDE LLO
FrTest Running FrTest NESSLIN LLO
FrTest Running FrTest PICKEREL LLO
IFO_Hist Running HistCreator GNEISS LHO
IFO_Hist Running HistCreator DELARONDE LLO
IRIG-B Running IRIG-B BASALT LHO
IRIG-B Running IRIG-B PICKEREL LLO
LHO_ifo_hbms Running hbms_monitor SAND LHO
LLO_SEI_hbms Running hbms_monitor NESSLIN LLO
LLO_ifo_hbms Running hbms_monitor NESSLIN LLO
LineMon_H1_exc Running LineMonitor OBSIDIAN LHO
LineMon_H1_gnx Running LineMonitor OBSIDIAN LHO
LineMon_H1_ioo Running LineMonitor OBSIDIAN LHO
LineMon_H1_lsc Running LineMonitor OBSIDIAN LHO
LineMon_H2_exc Running LineMonitor OBSIDIAN LHO
LineMon_H2_gnx Running LineMonitor OBSIDIAN LHO
LineMon_H2_ioo Running LineMonitor OBSIDIAN LHO
LineMon_H2_lsc Running LineMonitor OBSIDIAN LHO
LineMon_L1_exc MISSING LineMonitor DELARONDE LLO
LineMon_L1_gnx MISSING LineMonitor DELARONDE LLO
LineMon_L1_ioo MISSING LineMonitor DELARONDE LLO
LineMon_L1_lsc Running LineMonitor PICKEREL LLO
LockLoss MISSING LockLoss DELARONDE LLO
LockLoss_H1 Running LockLoss STONE LHO
LockLoss_H2 Running LockLoss STONE LHO
MultiVolt Running MultiVolt DELARONDE LLO
MultiVolt IDLE MultiVolt OBSIDIAN LHO
NdasWriter Running NdasWriter SAND LHO

LockLoss report



Current Lock Status for H1 (Hanford 4k)

Last update: 2003-2-14 1:20:47 UTC

LockLoss (H1) has been running for 1787573.00 seconds (496.55 hrs)

Updates every 60 seconds ($Revision: 1.36 $)

DMTviewer TSeries value	Meaning
-1	No data available
0	Mode Cleaner not locked
1	Mode Cleaner locked, but not BothArms
2	Mode Cleaner locked, BothArms locked
3	Mode Cleaner locked, BothArms locked, Common Mode
4	Mode Cleaner locked, BothArms locked, Common Mode, Operator Go on (*i.e.* Run Mode)

X arm LOCKED | Y arm LOCKED

X arm in lock for 5512.00 s | Y arm in lock for 5511.00 s

Both arms in lock for 5511.00 s

Cumulative duty cycle for X arm: 72.69 %

Cumulative duty cycle for Y arm: 71.06 %

Cumulative duty cycle for Both arms: 70.22 %

10 minute duty cycle for X arm: 100.00 %	1 hour duty cycle for X arm: 100.00 %
10 minute duty cycle for Y arm: 100.00 %	1 hour duty cycle for Y arm: 100.00 %
10 minute duty cycle for Both arms: 100.00 %	1 hour duty cycle for Both arms: 100.00 %
4 hour duty cycle for X arm: 96.33 %	8 hour duty cycle for X arm: 96.33 %

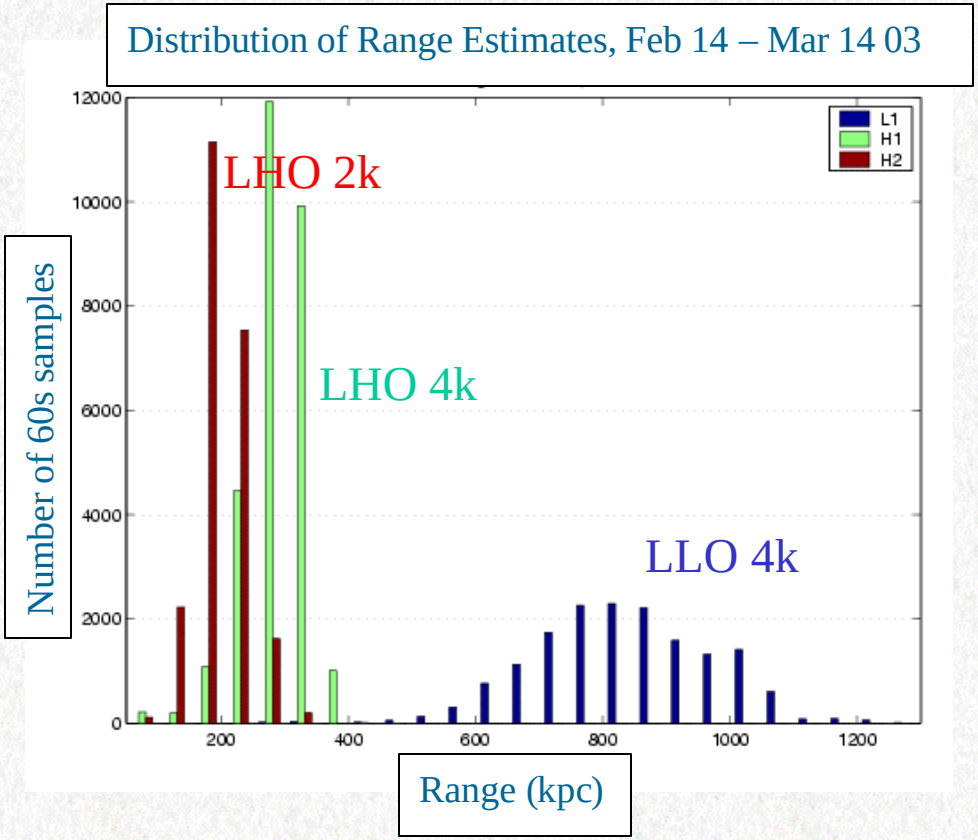
One click from the spy page: reports, spectra, documentation.

LockLoss monitors arm powers and IFO subsystems, builds duty cycle statistics

D. Chin

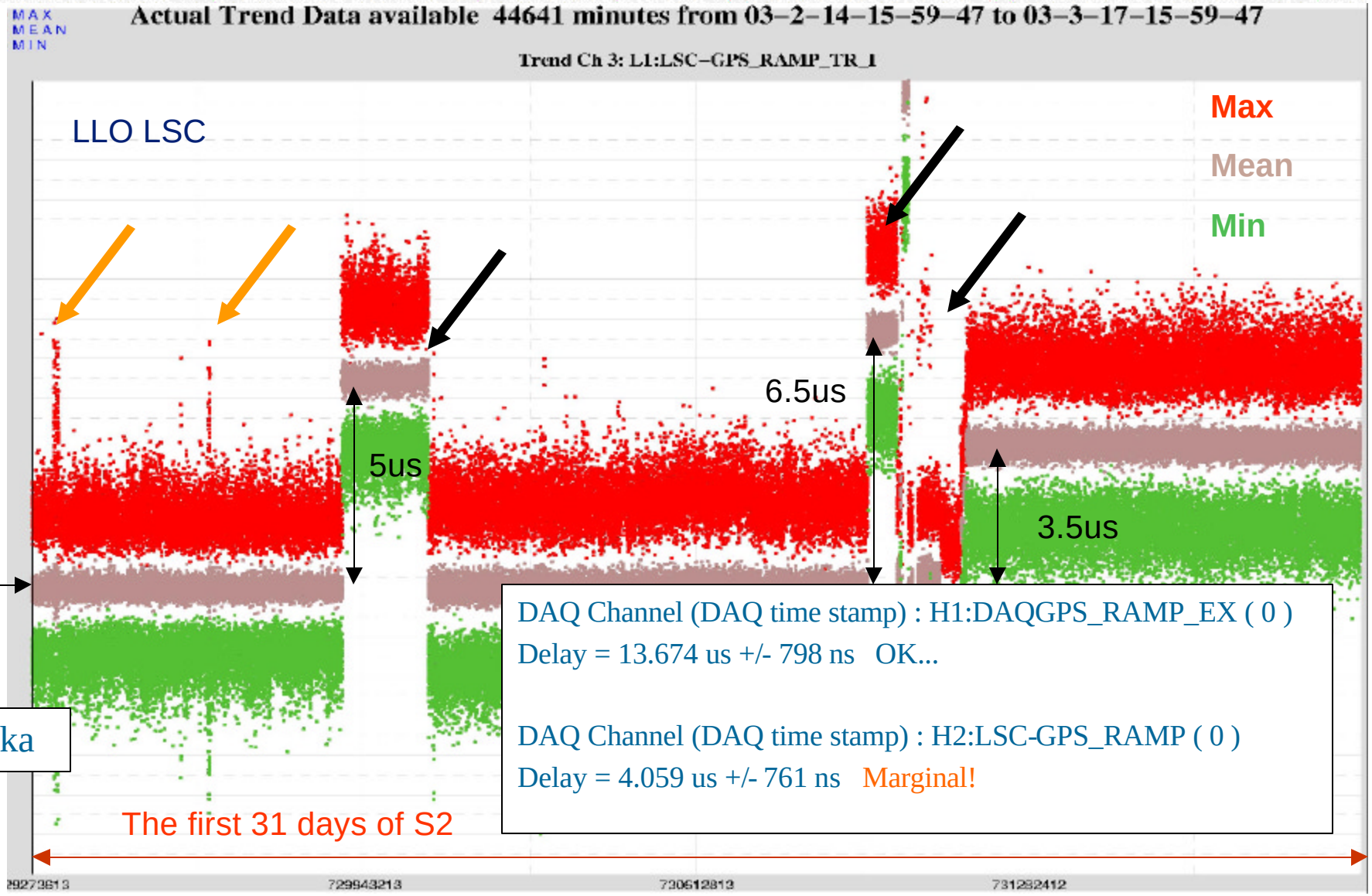
Inspiral monitor (with preliminary ranges)

- **"Inspiral Range"** [to see 1.4M_{sun}-1.4 M_{sun} NS-NS Coalescence with SNR=8, average orientation/direction]
- Histogram of distributions of inspiral range for the three interferometers (first month of S2)



P. Sutton

Timing monitor example



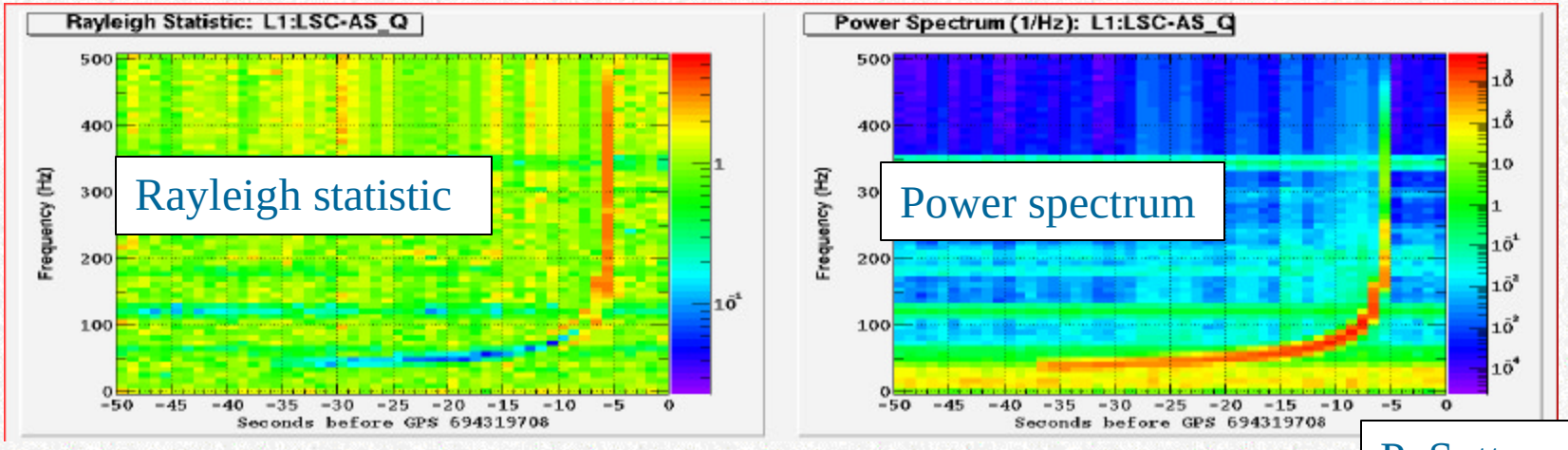
DAQ Channel (DAQ time stamp) : H1:DAQGPS_RAMP_EX (0)
Delay = 13.674 us +/- 798 ns OK...

DAQ Channel (DAQ time stamp) : H2:LSC-GPS_RAMP (0)
Delay = 4.059 us +/- 761 ns Marginal!

S. Marka

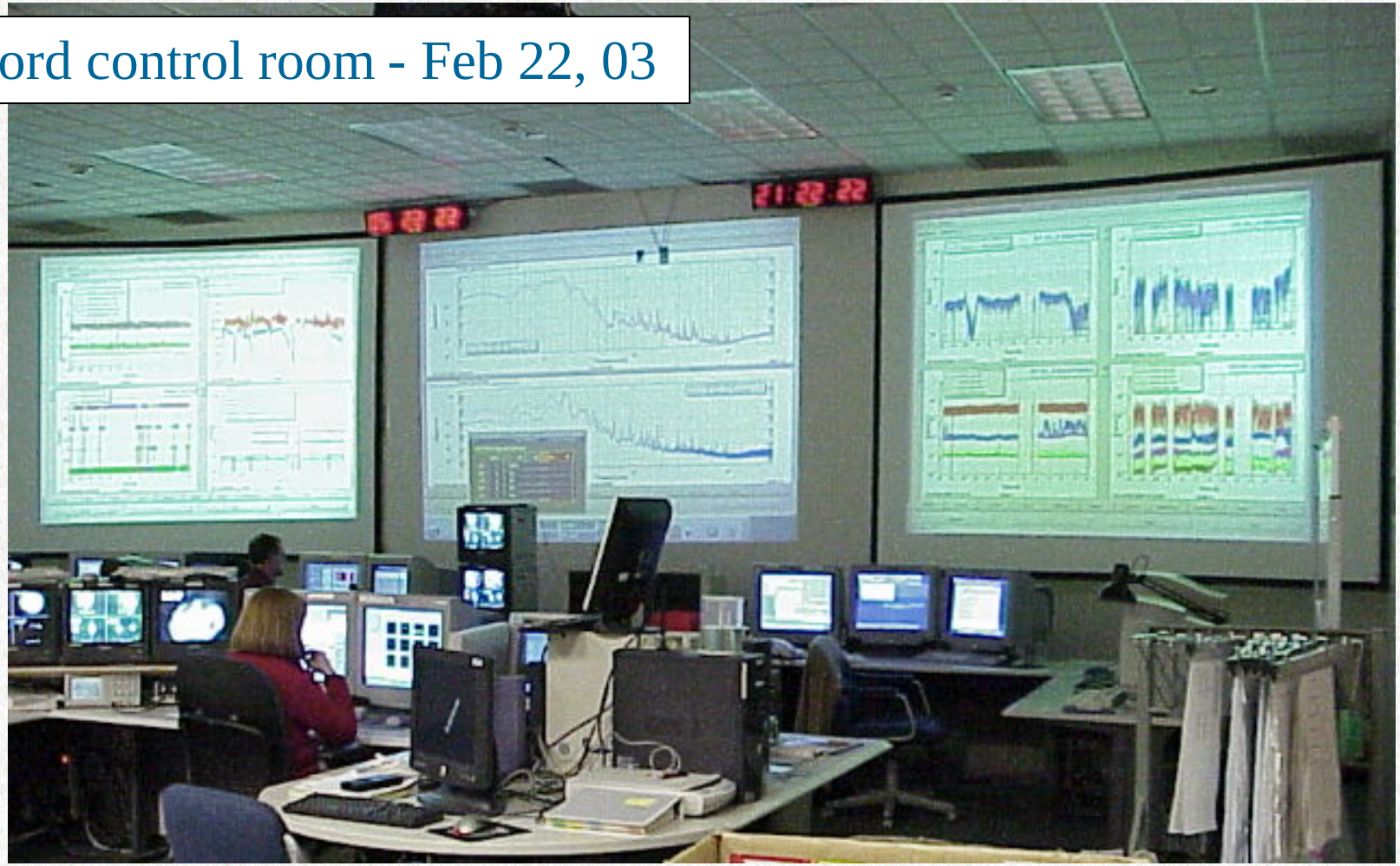
Foreground example: Rayleigh monitor

- Each PSD used 1 second of data divided into 8 pieces
- Rayleigh statistic (left) and power spectrum (right) for Livingston antisymmetric port output showing injected chirp.
  - R << 1 (blue) shows power is coherent on 1/8-1 sec scale at low frequencies, where chirp spends many cycles.
  - R >> 1 (red) shows power is incoherent on 1/8-1 sec scale at high frequencies, where chirp spends few cycles.

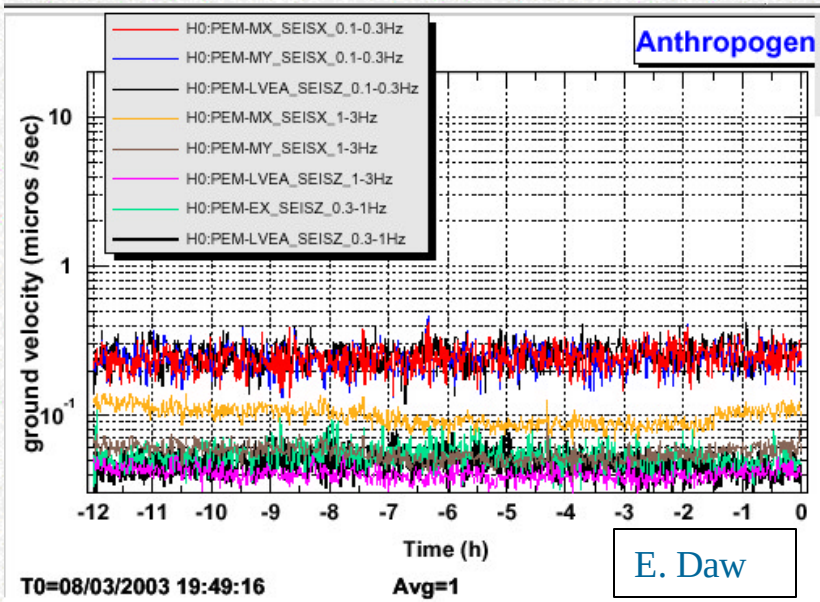


DMT and DTT Figures of Merit

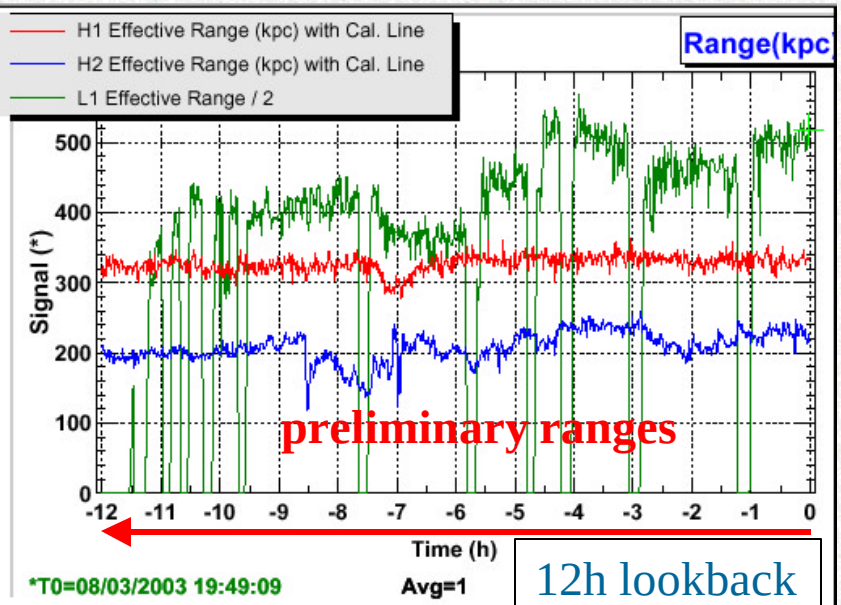
Hanford control room - Feb 22, 03



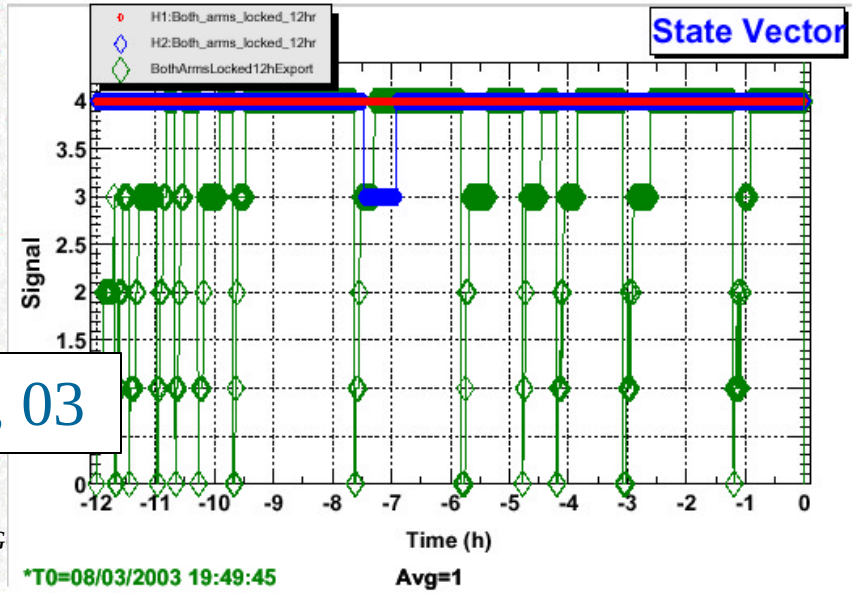
Sample 12-hour “Figure of Merit 1” at Hanford

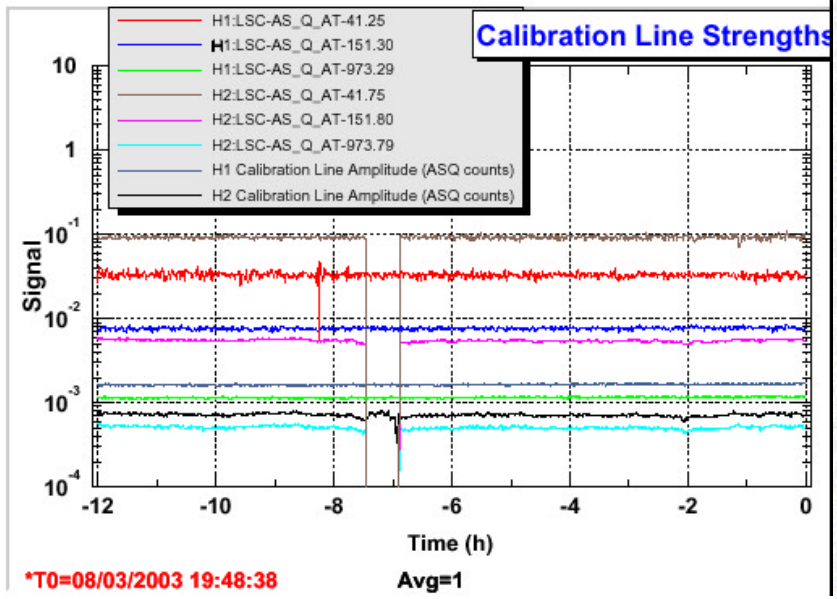


E. Daw



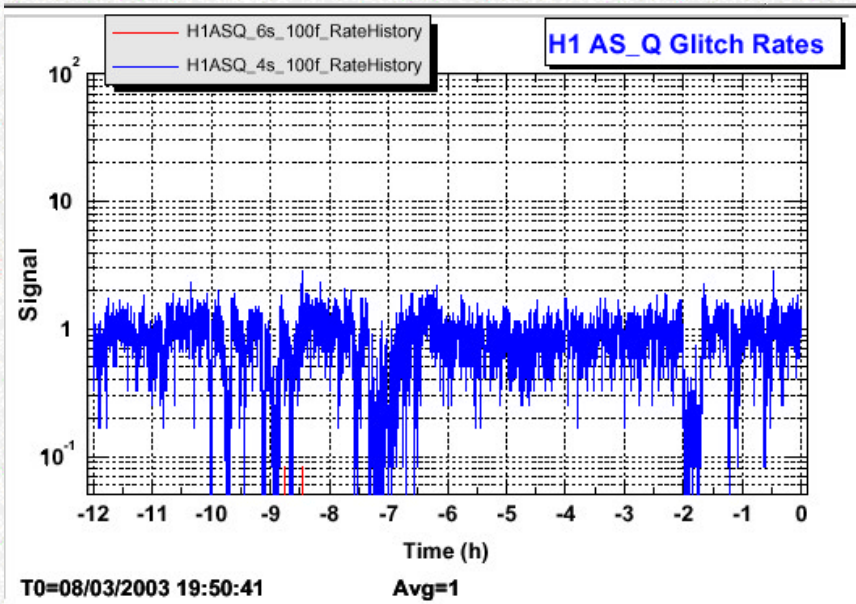
12h lookback

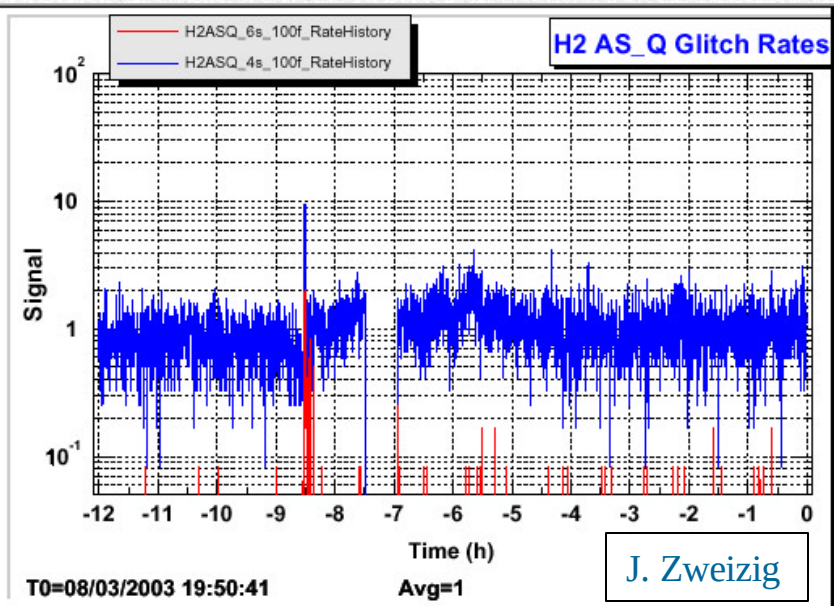




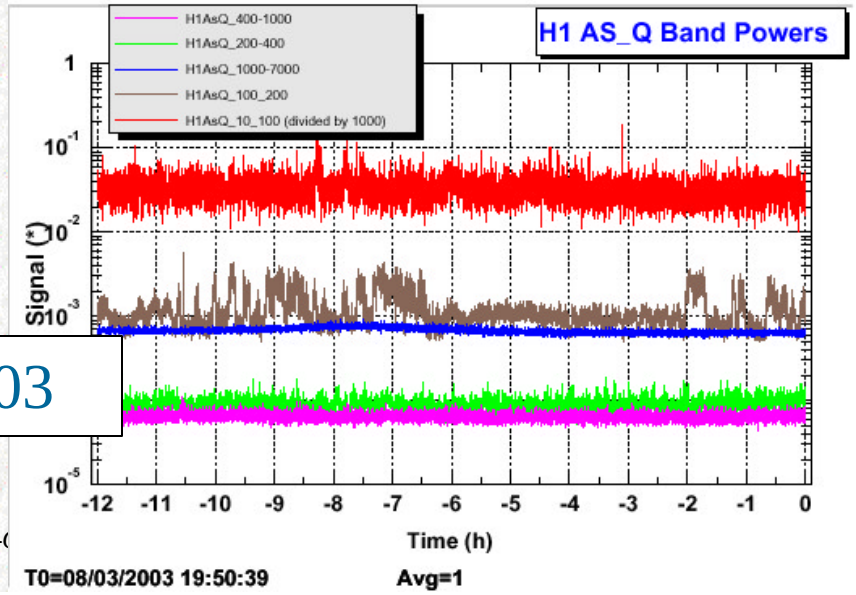
Mar 8, 03

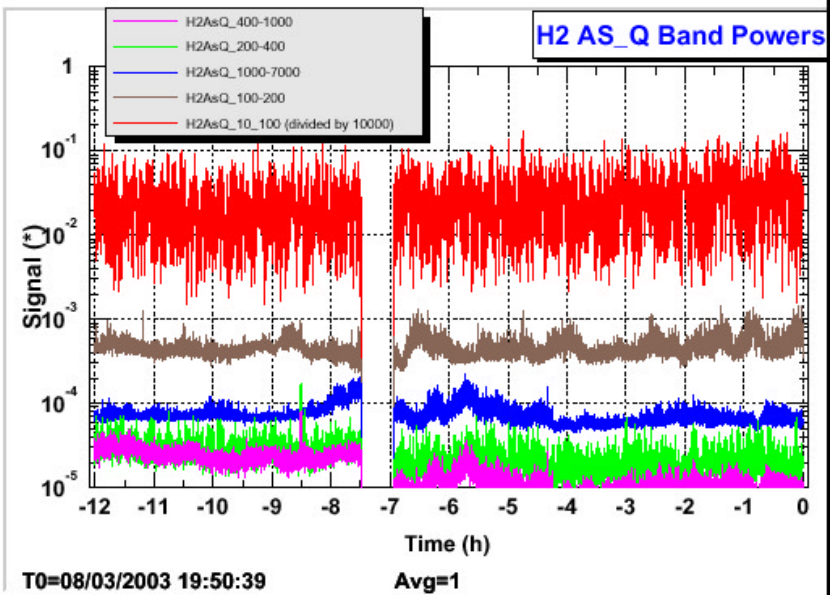
Sample 12-hour "Figure of Merit 2" at Hanford





J. Zweizig





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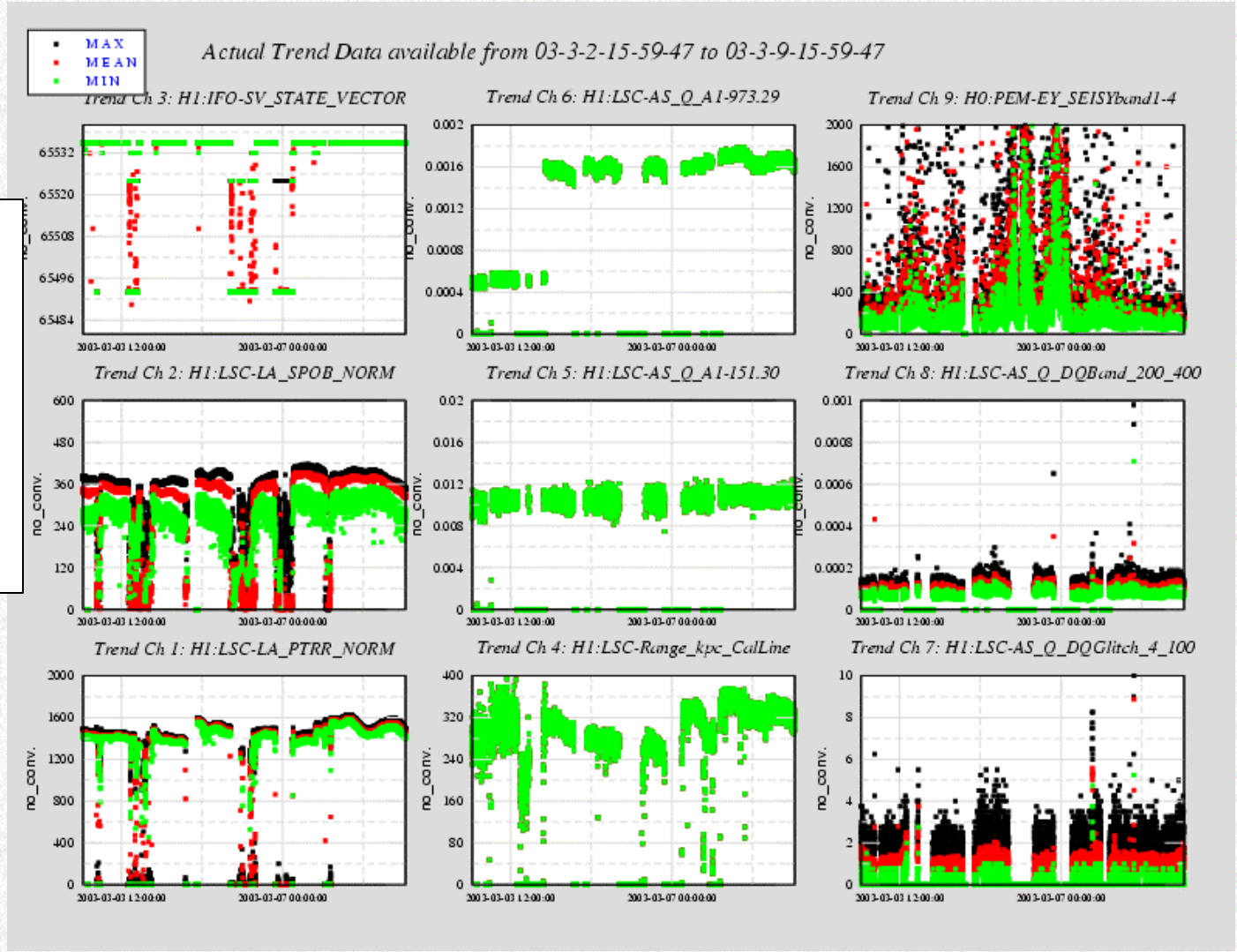
Daily & Weekly Summary Plots

One week of Hanford 4k performance

(includes part of 66-hour lock)



Concluding remarks

- Data Monitoring Tool employed in a wide variety of science run tasks (online reporting, data monitoring, writing triggers to relational database, trends, alarms)
- DMT reaching maturity and now standard set of windows into data during science run
- Want to better utilize the DMT during commissioning
- Next window into the data: make better use of online astrophysical searches