



Report on E3/E4 Lock Losses

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E3 & E4 Overview

- **E3 -- Single arm of Livingston 4K**
- **E4 - Recombined arms of Livingston 4K**
-> Focus on this run here
- **Tables of locked stretches posted on web**
(Go to E3 & E4 main pages on blue, then to Results link)

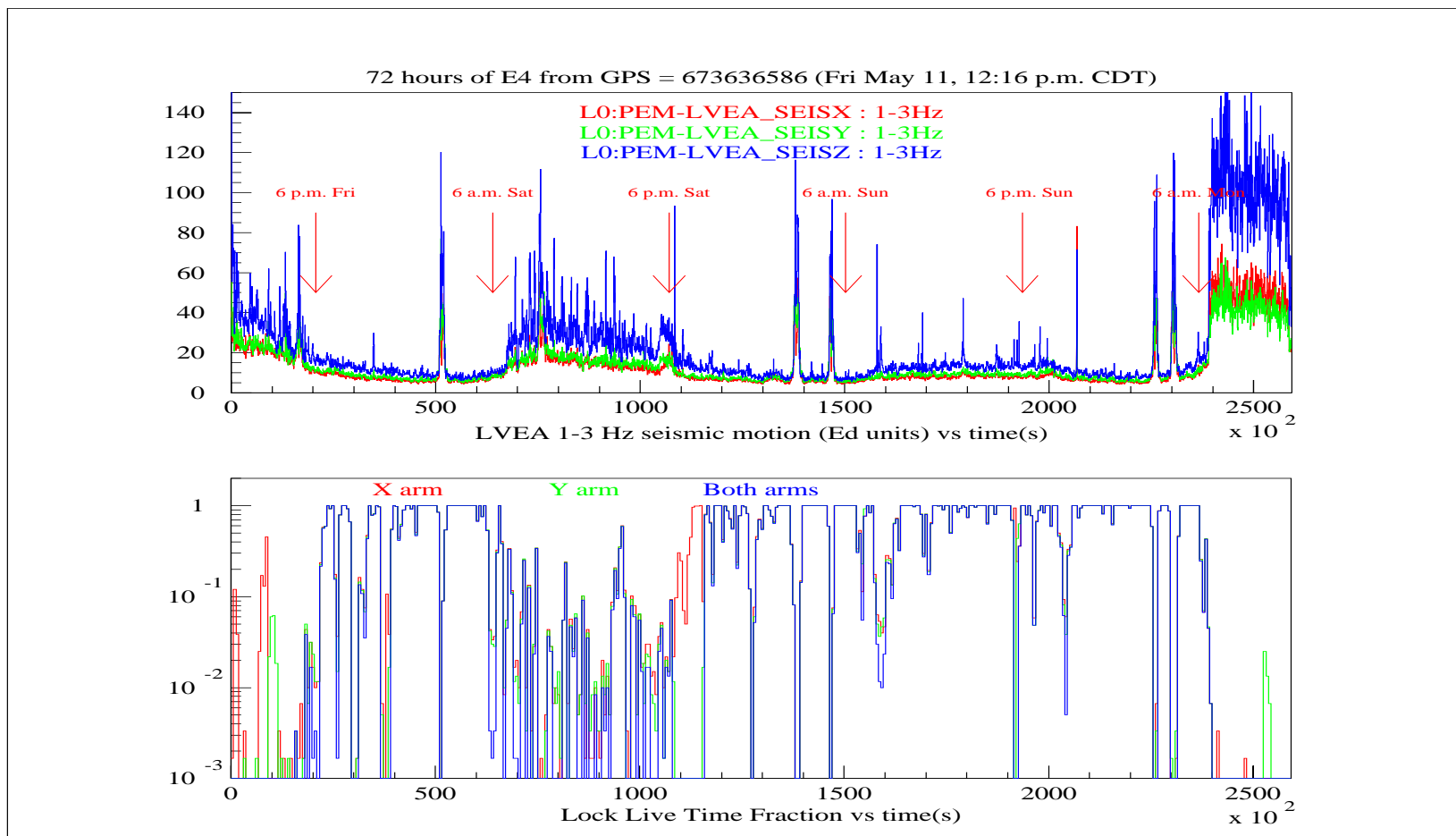
E3 Lock Losses (summary)

- **1-Arm Livetime ~90%**
(when not fiddling with things)
- **Many losses correlated to seismic motion**
(some due to high winds)
- **Some losses correlated to tidal drift**
(exceeding dynamic range of actuation)

E4 Lock Losses

- **2-Arm Livetime = 48%**
- **Correlation with 1-3 Hz seismic noise:**
 - » **Strong correlation between lock acquisition / retention trouble and high seismic noise in 1-3 Hz band recorded by Ed Daw's blrms DMT monitor (see 72-hour plot)**
 - » **Lock consistently lost during train passages in early a.m.**
 - > **Sharply increased power at stack resonances in APD and SPD before lock loss**
 - > **But no smoking gun of coil saturation (study hampered by AC coupling on most coil readouts)**
 - » **See talks by Weiss, Coles, Greenwood Thursday morning**

E4 Lock Losses

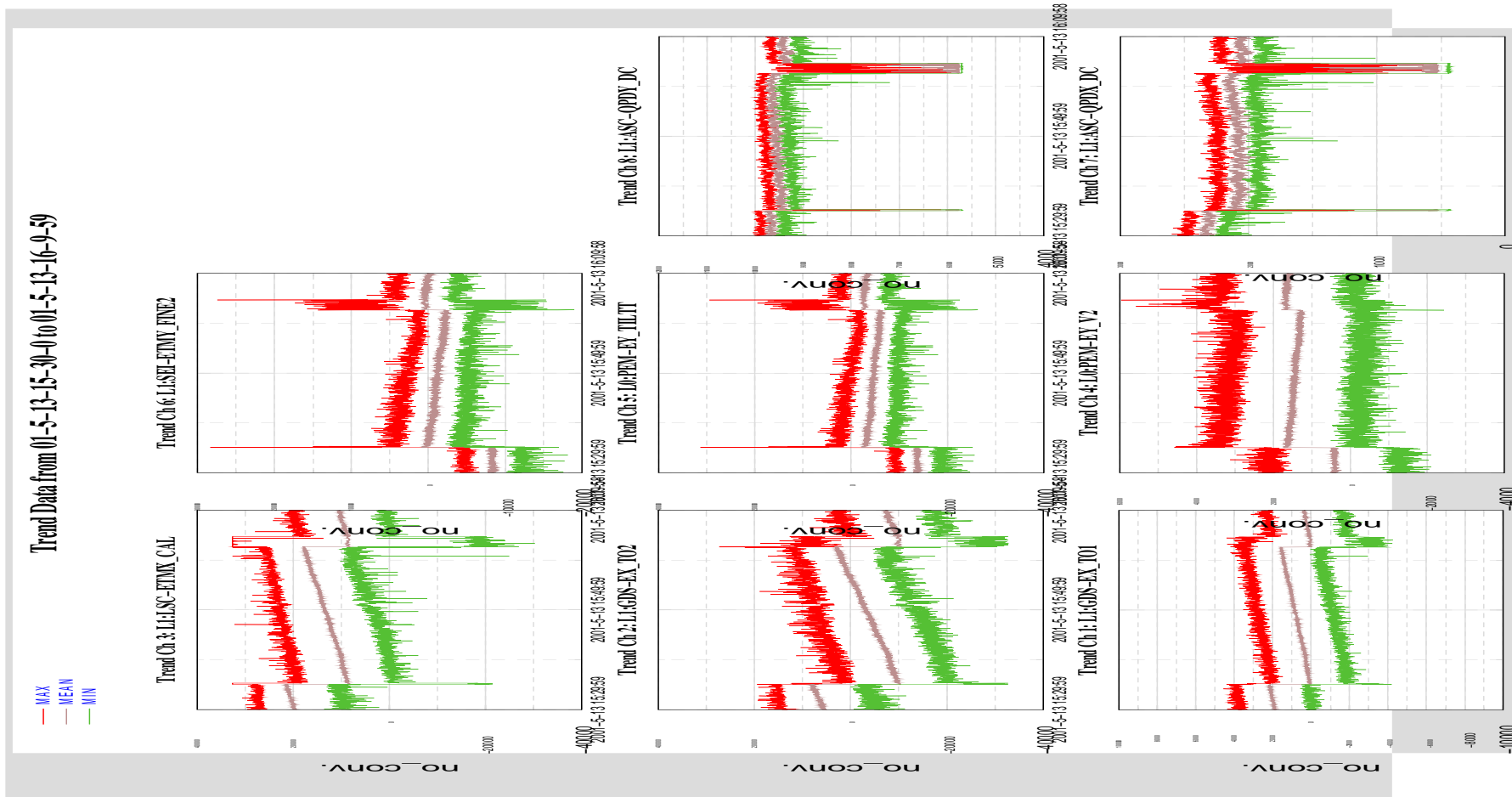


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E4 Lock Losses

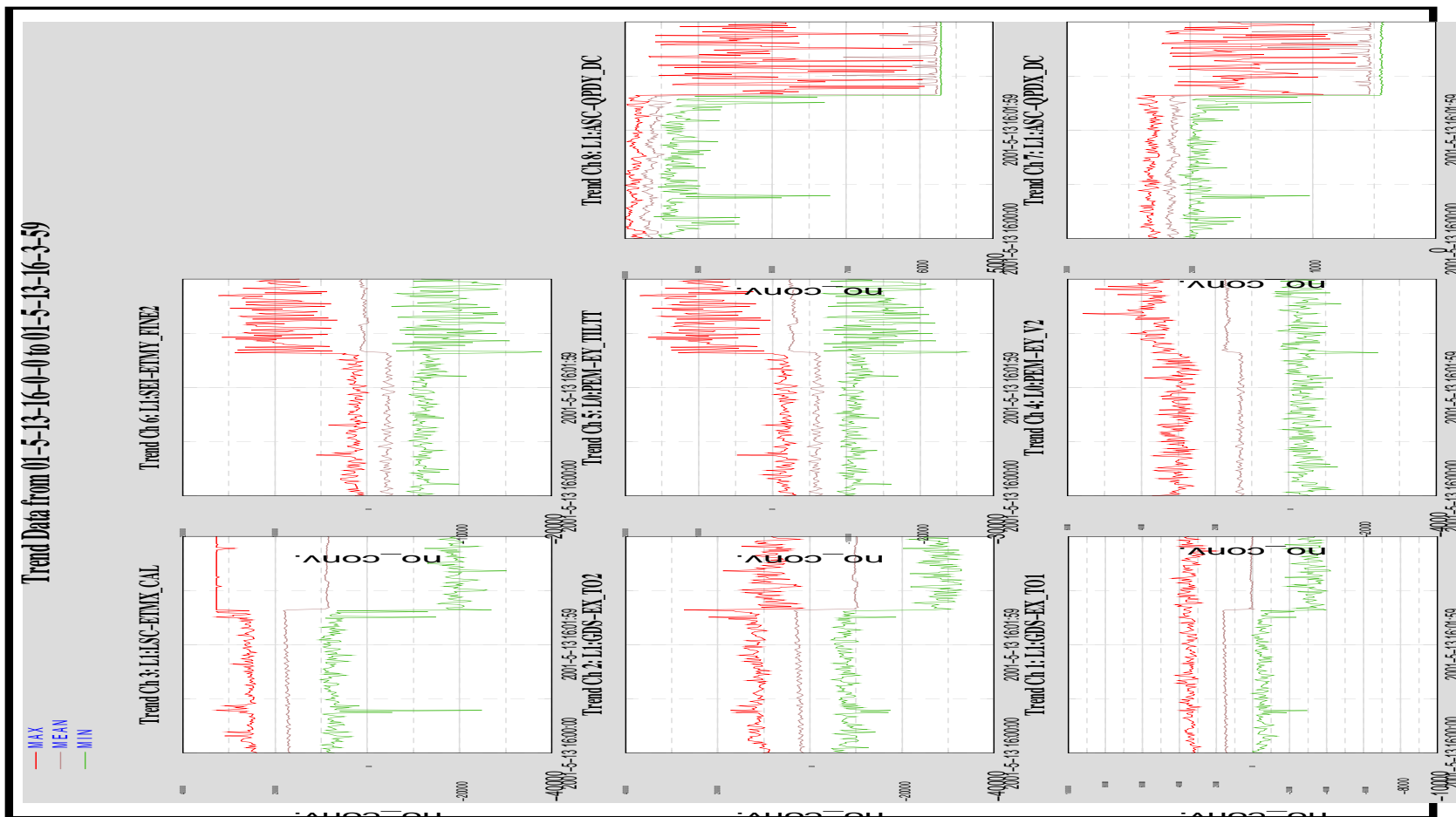
- **Coil saturation after tidal drift:**
 - » Because of frequent losses from other effects, tidal drift was **not** a common cause of lock loss, but a few clean examples were seen (see 40-minute and 4-minute second-trends of coil currents & transmitted light)
 - » Saturating coil in example is ETMX_LR, mapped to temporary, DC-coupled DAQ channel L1:LSC-ETMX_CAL
 - » Should not be a problem after feed-forward tidal actuation!

E4 Lock Losses



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E4 Lock Losses

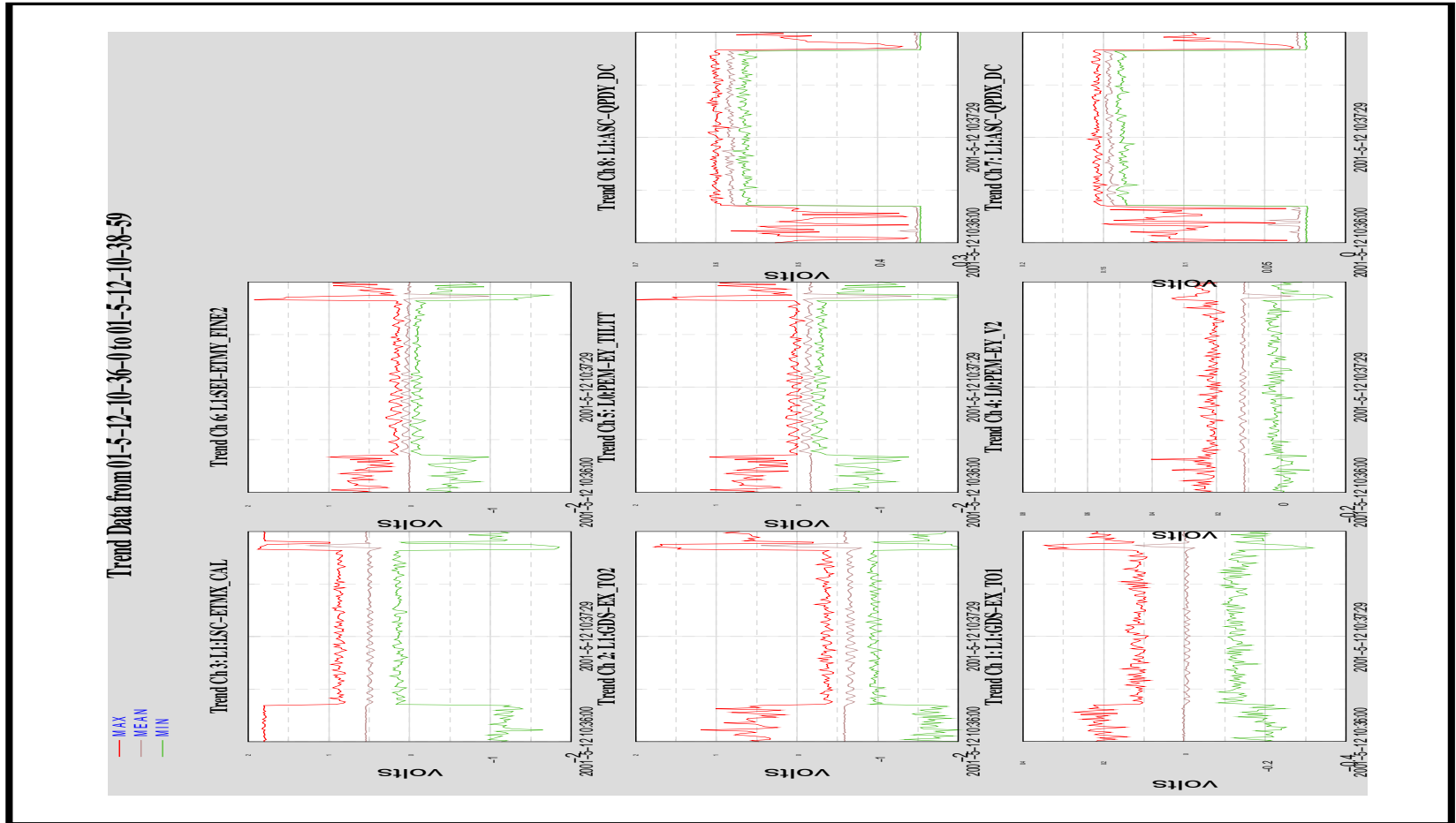


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E4 Lock Losses

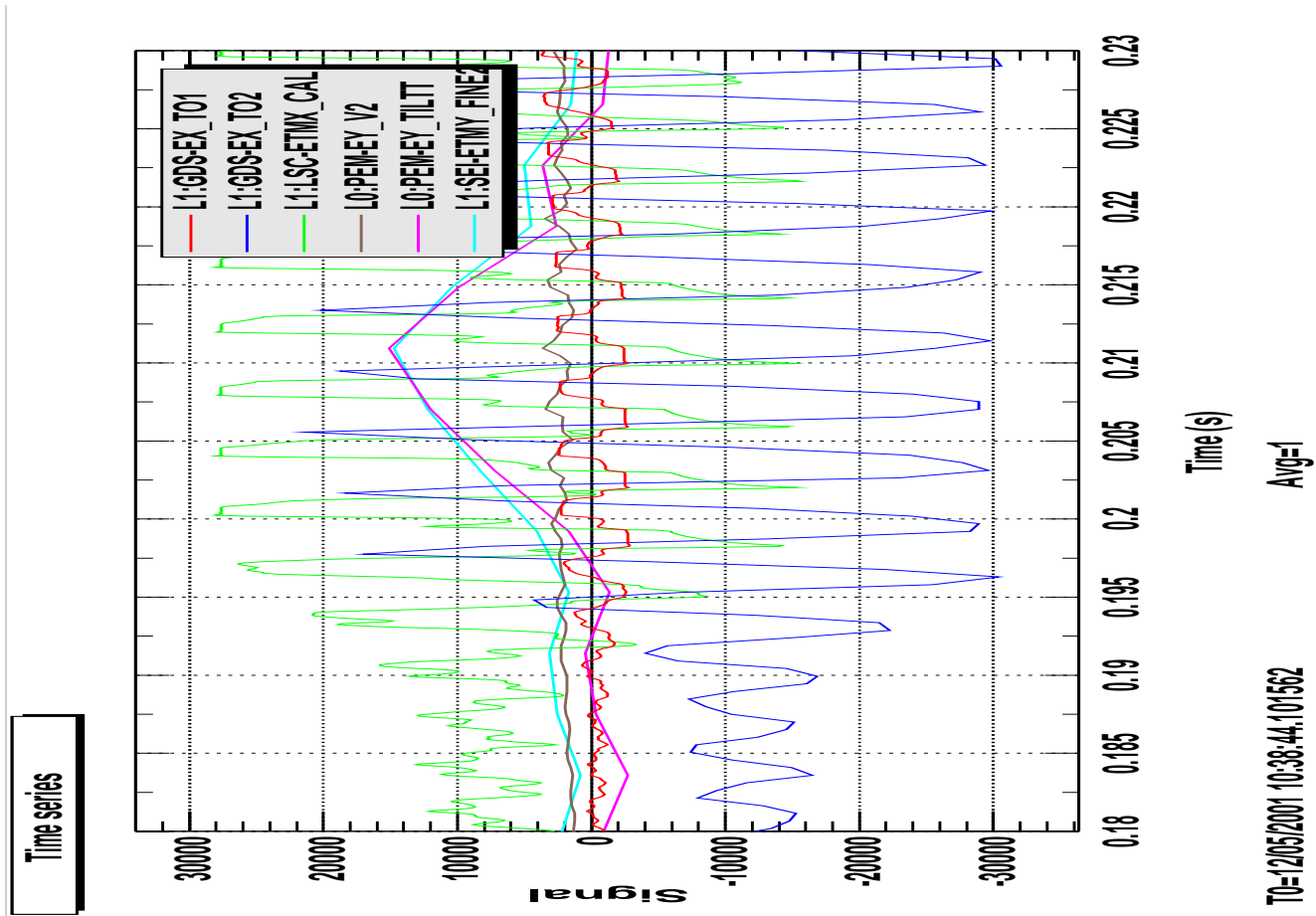
- **Apparent servo instability:**
 - » Observed class of lock losses preceded by all three active ETMX coils undergoing unstable oscillation buildup (see 3-minute second-trend and 0.05-second, 1-second full-BW plots)
 - » Typically, ETMX_LR saturates first. In this example, lock loss develops about 0.3 second after first saturation
 - » Side note - Masahiro Ito's glitch monitor picked up two transients coincident with this example (and with others)
 - Microphone oscillation in ETMX end-station that tracks coils (acoustic pick-up from coil controller power supply?)
 - Glitch in beam splitter OSEM LR sensor (LR sensor apparently picking up scattered laser light)

E4 Lock Losses



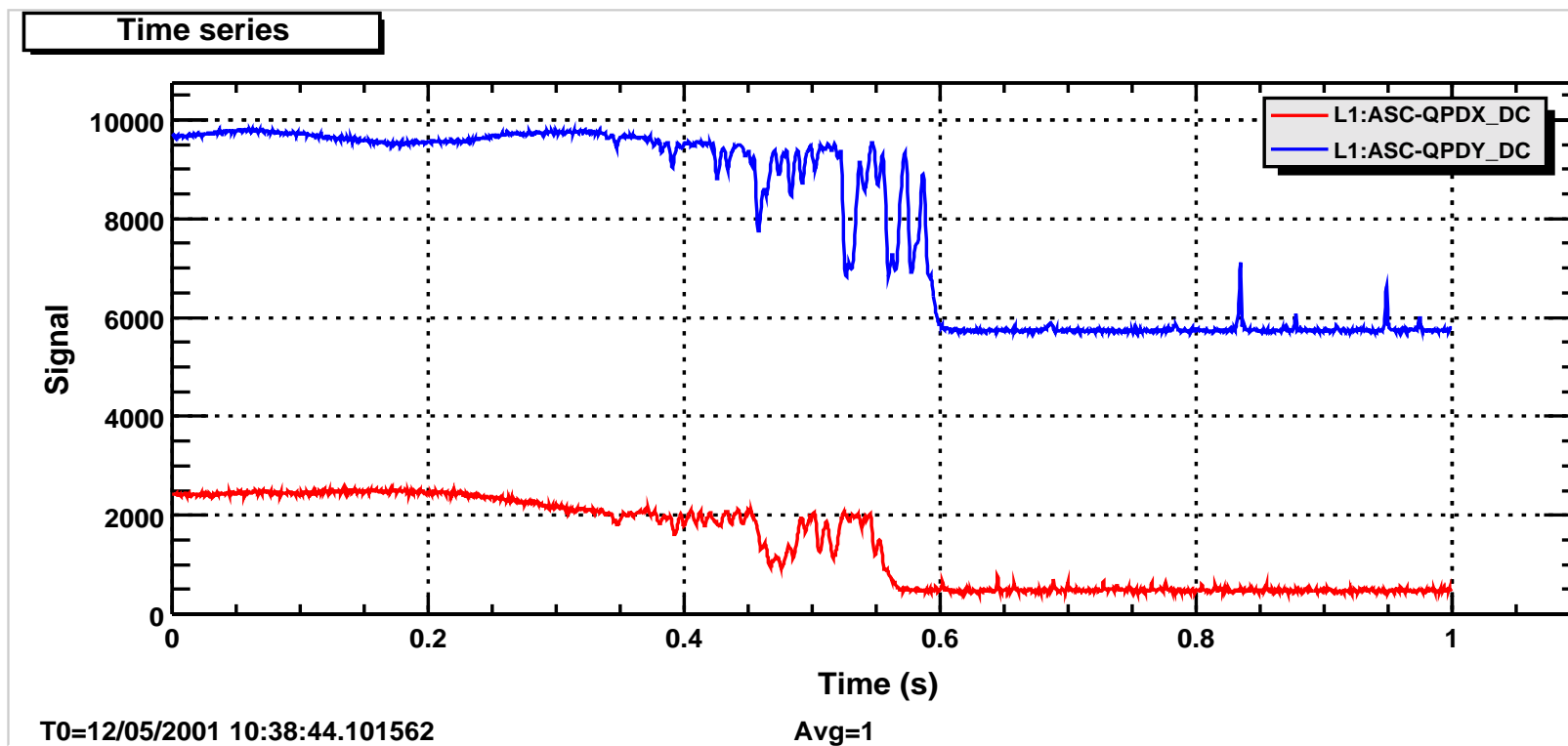
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E4 Lock Losses



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E4 Lock Losses

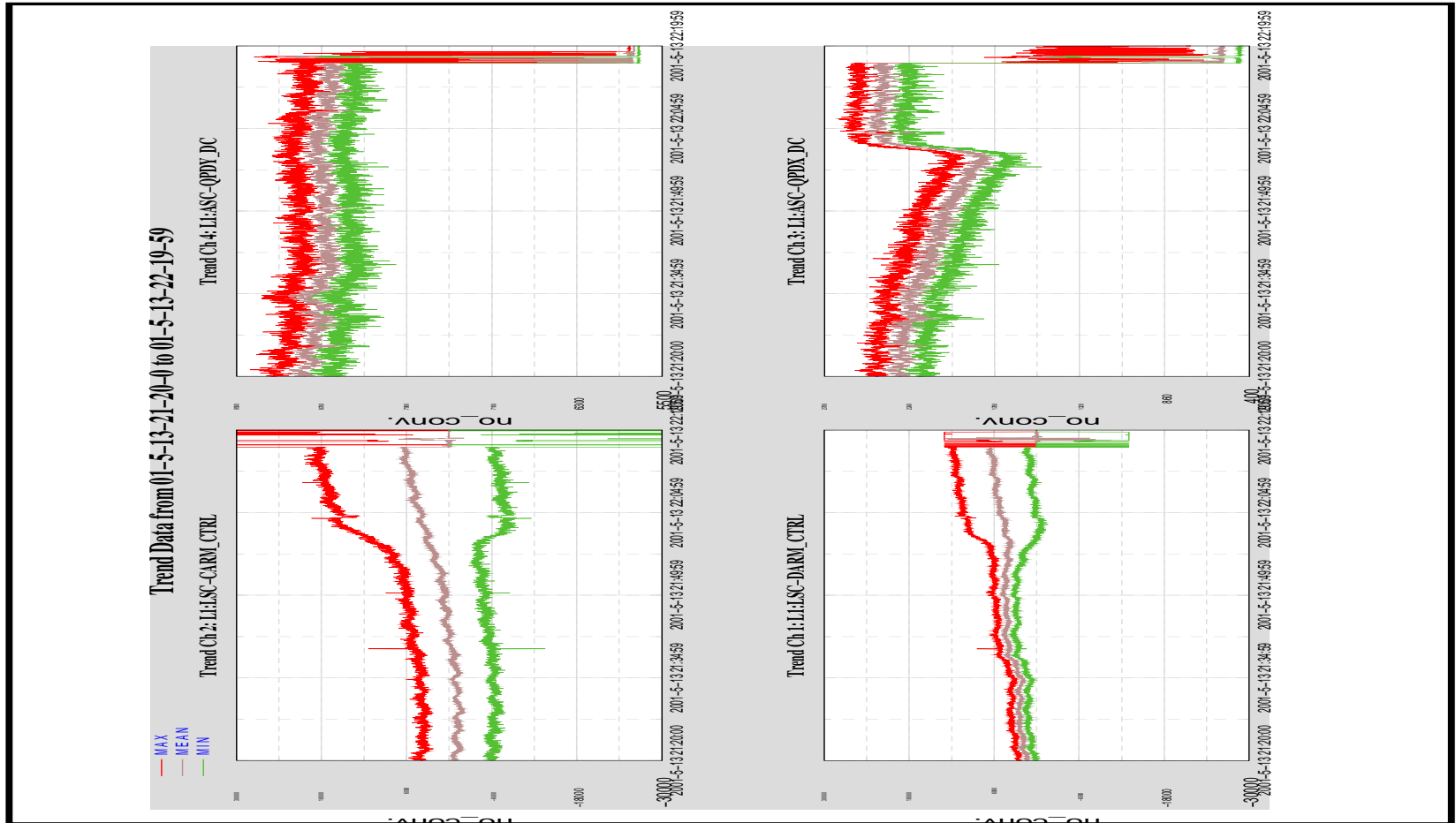


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E4 Lock Losses

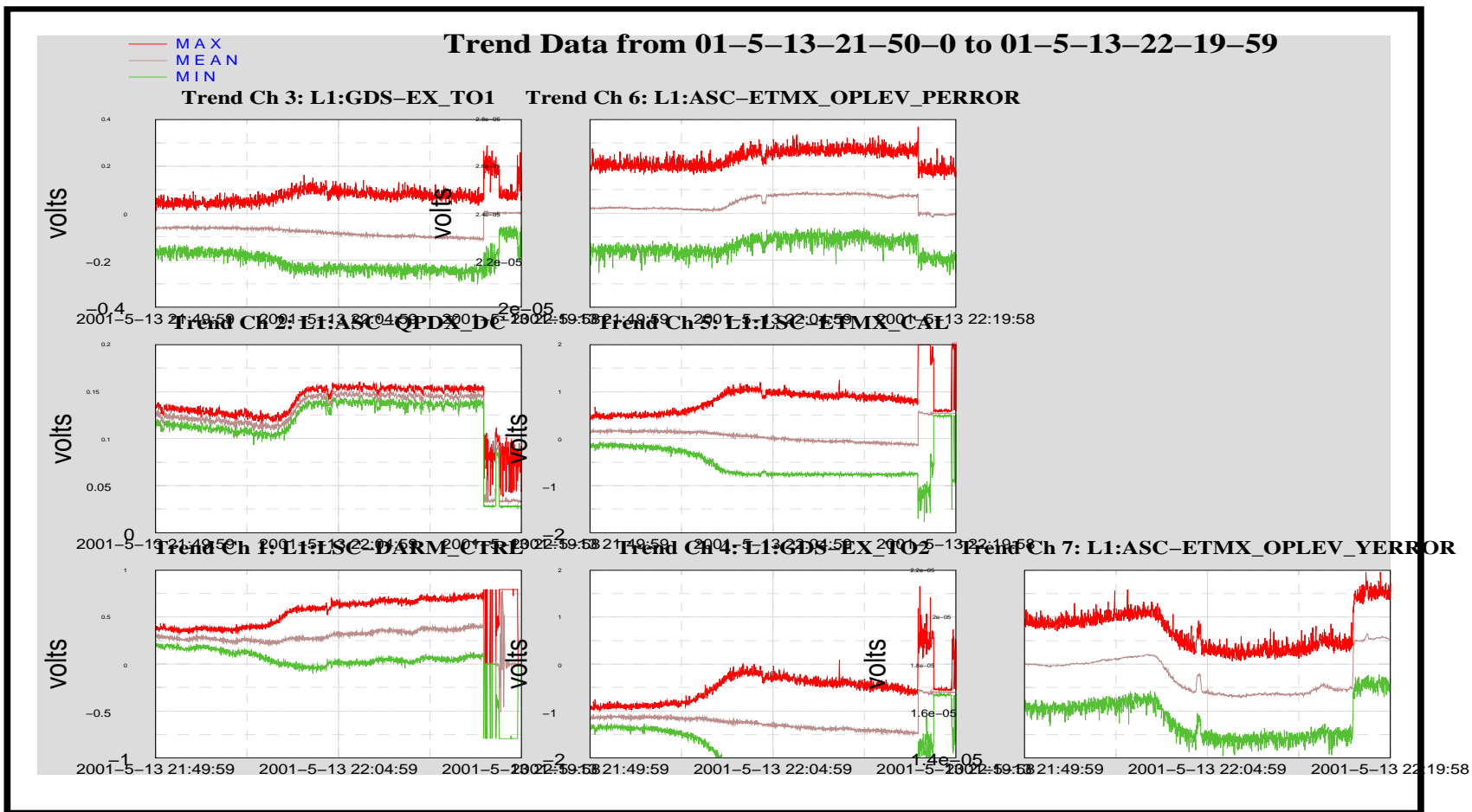
- **Driven violin mode harmonic (apparently)**
 - » Plot 1 shows growing envelope of arm length servo control signals
 - » Plot 2 shows envelope growth stopping when ETMX_UL saturates and X arm transmitted light increases(!)
 - » Apparently long tidal drift in alignment due to actuation matrix mistuning is “fixed” rapidly (and coincidentally) by railing of one coil.
 - » Plot 3 shows power spectra of two arm and mode cleaner control signals during envelope growth
 - » -> Sharp peak at 686 Hz with upconversion shoulders
 - » Plot 4 shows power spectrum of differential arm control signal at 20-minute intervals from oscillation absence to full strength.
 - » Interpretation: 1st harmonic of large-optic violin mode being excited by servo.
 - » **Similar oscillation (Hanford 2k) seen at times in E5 at 687 Hz!**

E4 Lock Losses



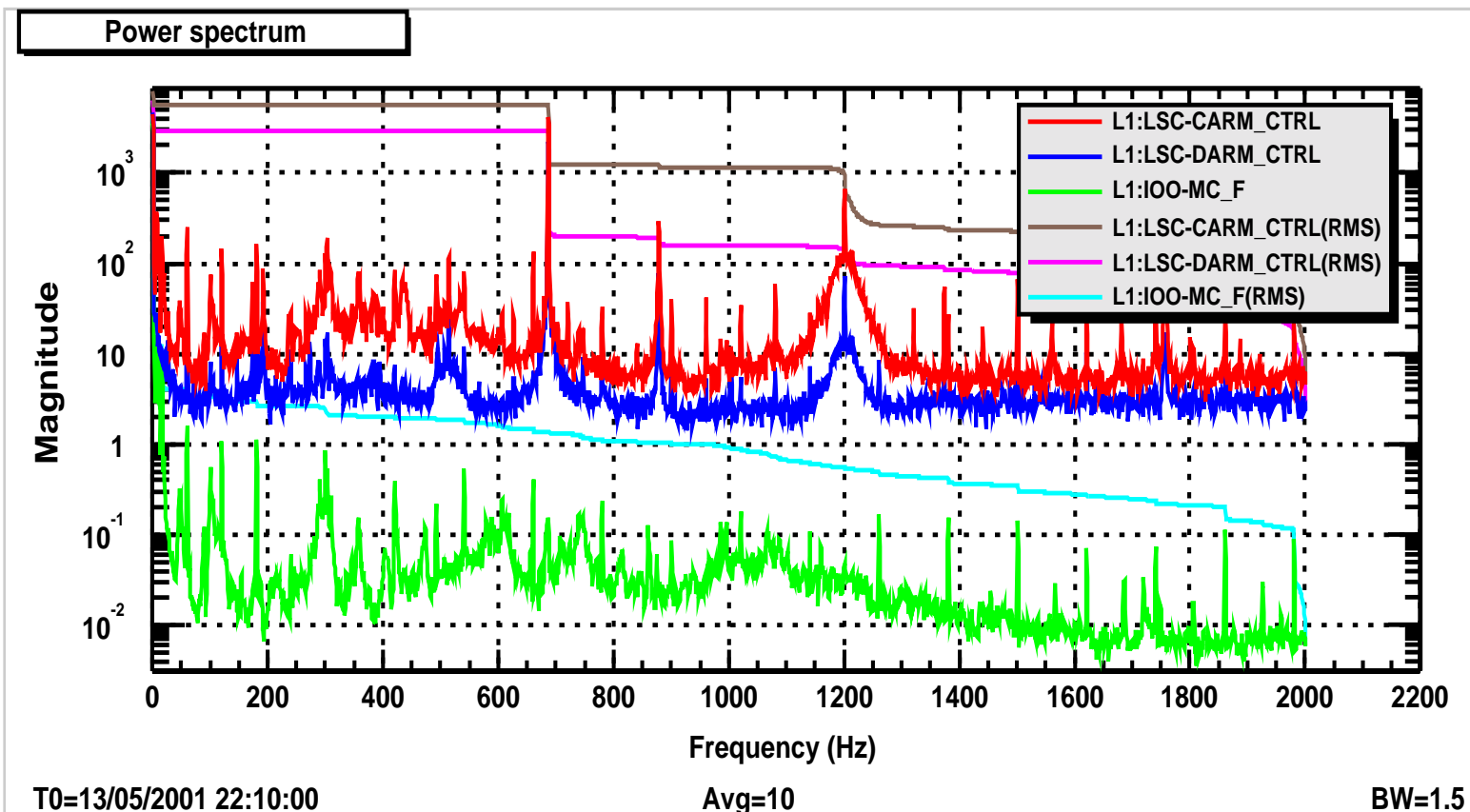
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E4 Lock Losses

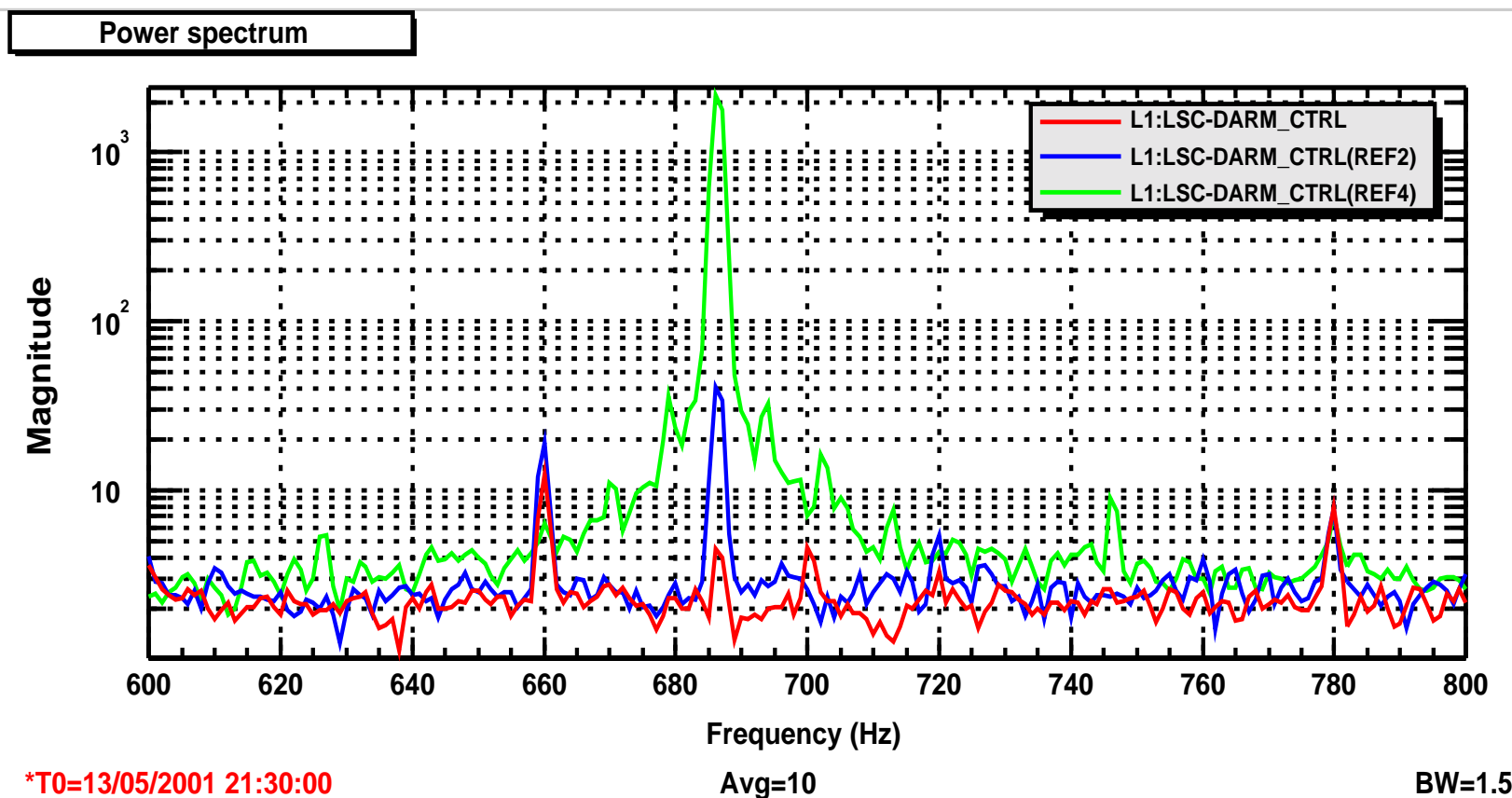


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E4 Lock Losses



E4 Lock Losses



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Early results from E5

Three main categories of lock losses seen:

- 13 Hz runaway oscillation in Michelson servo control signal (vertical bounce mode of large optics)
 - » Typically seen in first half of run
(improved with realignment of recycling mirror Saturday night)
 - » Likely bouncing optic: folding mirror for X arm
 - » Oscillation usually developed after some tidal drift
 - » 13-Hz resonant gain filter probably helped at start of each lock stretch, but aggravated problem after drift
 - » Result of drifting alignment in recycling cavity? (gain of Michelson / Recycling servos sensitive to SB recycling gain -- **not** proven!)

Early results from E5

- Saturation of error signal for recycling servo error signal after tidal drift
- “Deliberate” software railing in servo control signals (EPICS parameters set by MEDM control panel)

Also had one lock loss from earthquake in South Pacific (magnitude 6.5)

Acknowledgements

Aside from “official” lock loss team, many persons in the control room assisted in these studies

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- **E4:** R. Adhikari, S. Penn, P. Saulson
- **E5:** W. Kells, P. Shawhan, D. Sigg