LIGO-T010049-00-W: A Report on Interferometer and Mode Cleaner Transients During the E2 Engineering Run

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The Task

The Detector Characterization group encouraged involvement in the Engineering Run of November 2000 (E2) at the LIGO Hanford Observatory by forming task groups responsible for various aspects of monitoring the interferometer. Our task group was charged with looking for impulses and transients in the interferometer (IFO) and mode cleaner (MC) error signals. To clarify this responsibility, we identified the following goals:

- Monitor large deviations in the pre-stabilized laser (PSL), MC, and associated physical environment (PEM) data channels throughout the E2 run
- Distinguish some transients in the above-mentioned data
- Identify & track within the data channels a specific glitch observed directly from the PSL instruments in July 2000 (hereafter referred to as "PSL frequency glitches")
- Attempt to identify sources for any of the above transients

In addition, we wished to perform a majority of our analysis while on site during E2. We planned to achieve these goals using the analysis tools that were currently available, including J. Zweizig's DMT monitor, called PSLmon, DataViewer, D. Sigg's Diagnostic Test Tool (DTT), and P. Shawhan's Guild.

Before the Run

We prepared for E2 by configuring PSLmon to detect and mark glitches in the PSL, MC, and associated PEM data channels. We also configured DataViewer and DTT to look at these same channels in real time. Our hope was that during the E2 run we could periodically check the output from PSLmon using J. Zweizig's DMTViewer application, which could be used to view the latest stored spectra from the channels and the most recent glitches detected.

During the Run

Our analysis during E2 was minimal until the parameter studies regarding the supply current to the laser pump diode began, when we attempted to visually identify the PSL frequency glitches in real time. Our reasoning was based on our observation from July 2000 that the rate of the PSL frequency glitches was dependent on this supply current. Our attempts were unsuccessful, however. With a visual resolution of ~.1sec, we could see nothing in the PSL channels that was identifiable as a transient.

Our next period of analysis took place with the single-arm configuration, during which a number of transients in the IFO error channel, H2:LSC-AS_I, were correlated to transients in the MC control signal, H2:IOO-MC_F. When we plotted trends of these channels with the associated PEM data, we noted that some transients were associated

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with seismic transients while some were not. Those associated with seismic transients were observed later (by R. Schofield & D. Chin) to be imitated by stomping around the control room and/or driving around the corner station. No obvious correlation was made with the non-seismically-correlated transients, although data from microphone, magnetometer, accelerometer, and optical lever channels was compared visually with that of the MC and IFO error channels.

After the Run

Since we were unable to visually locate an example PSL frequency glitch in the data, we depended on PSLmon output to note when deviations had occurred. Based on the characteristics observed in oscilloscope traces from July 2000, the glitches were expected to best be seen in the pre-mode cleaner error signal (H2:PSL-PMC_ERR_F). The glitches were also expected to be somewhat visible in the PSL fast frequency servo signal (H2:PSL-FSS_FAST_F) as well, although the data acquisition rate was expected to limit the transient shape to a small DC shift for the duration of the glitch.

PSLmon output was non-discriminatory, in that it merely recognized large fluctuations in each channel, and marked the largest fluctuation for each second. Consequently, it marked over 17,000 glitches in H2:PSL-PMC_ERR_F during the E2 run. Time would not have allowed us to examine each of those glitches after the run, so we took a more statistical approach and plotted the number of glitches per minute throughout the run. We identified a number of stretches with similar glitch rates and investigated a few of these. We determined that the majority of the glitches which were marked by PSLmon were not actually PSL frequency glitches. However, PSLmon did mark a number of glitches which we could categorize consistently. These categories are described below.

Signal Saturation: PSLmon would consistently glitch when H2:PSL-PMC_ERR_F was saturated because of the calculation process involved. PSLmon determines the standard deviation for a series of data by implementing the formula: $s^2 = \langle x^2 \rangle - \langle x \rangle^2$. When calculating the value $\langle x^2 \rangle$ for a second of saturated signal, the maximum value, or ceiling, is reached. Thus PSLmon checks against a possible negative value for s^2 and sets the result to 0.0 if true. Consequently any fluctuations in the saturated signal will cause a trigger from PSLmon. Thus when the signal was saturated, a high rate of glitches/min would occur.

Mode Cleaner loss of lock: When the mode cleaner lost lock, the resulting signal in H2:PSL-PMC_ERR_F was consistently an increase in noise level combined with an overall DC shift. PSLmon would mark any fluctuations following the DC shift as glitches as well. This would cause an intermittent high rate of glitches as the mode cleaner regained lock.

Unidentified sources: There were many other glitches caught by PSLmon which did not exemplify characteristics of an expected PSL frequency glitch. These glitches may have occurred over much longer time scales than were expected, or may have had too many oscillations occur than were expected for a PSL frequency glitch.

In the end, PSLmon noted a few candidate PSL frequency glitches. These candidates appeared to have the expected waveform for a PSL frequency glitch in the H2:PSL-PMC_ERR_F data, but no significant observations could be made in H2:PSL-FSS_FAST_F. We were thus unable to conclude that these glitches were, in fact, PSL frequency glitches.

Results

To remedy the efficiency at distinguishing between glitches, we suggest that the following steps be taken:

- Remove the DC-coupling from the pre-mode cleaner piezo control channel, H2:PSL-PMC_PZT_F. This action should make this channel more accurate for detecting glitches than H2:PSL-PMC_ERR_F. As of 2/26/2001, H2:PSL-PMC_PZT_F is now AC-coupled.
- Monitor the PSL channels again with an oscilloscope to see if the tuning for the 2km 10-W laser (December 2000) has eliminated the PSL frequency glitches. As of 3/2/2001, the channels were monitored, and no PSL frequency glitches were seen.
- Modify the PSL monitor to suppress triggers when the MC has lost lock and when the signals are saturated.
- Modify the PSL monitor to further reduce the trigger rate to times when events in two or more channels are correlated.

The last two items are being implemented in a new monitor written by R. Rahkola, called PSLtrans. This monitor was not ready for the E3 run but should be available for limited use soon thereafter.

Interferometer and modecleaner transients during the E2 run

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LIGO Scientific Collaboration Meeting
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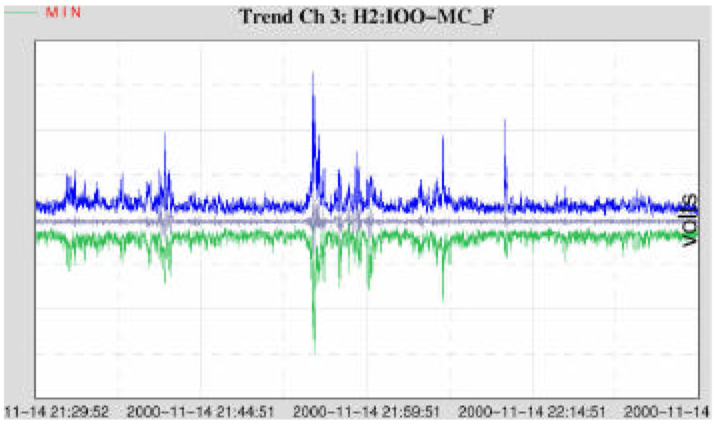
Investigations

- Modecleaner/IOO Transients – R. Frey
  - » Characterize transient behavior using Data Viewer in real time.
  - » Study in more detail off-line.

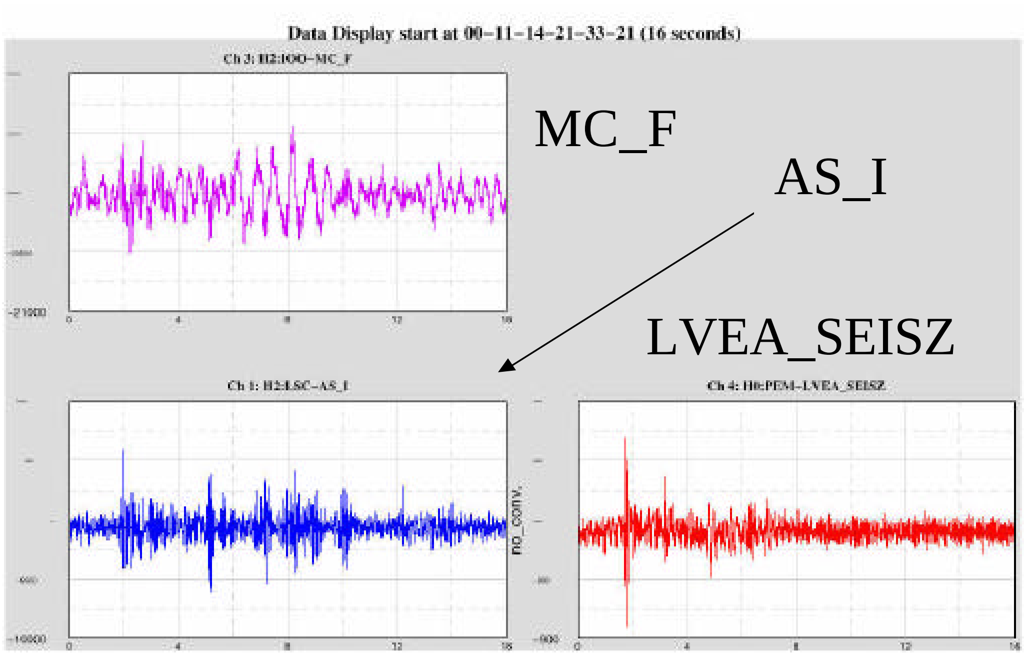


H2:IOO-MC_F

- PSL Frequency Glitches – R. Rahkola, R. Savage
  - » Use J. Zweizig's PSLmon monitor in effort to identify PSL frequency glitches previously observed using oscilloscope in the laboratory.
  - » Determine if previously observed PSL frequency glitches can be seen in the data channels.

MC/IOO Transients

- Some MC_F and AS_I transients induced by ground motion.

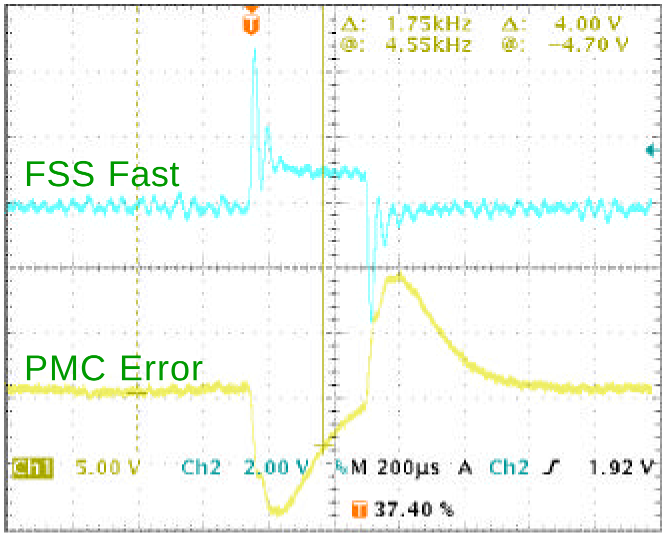


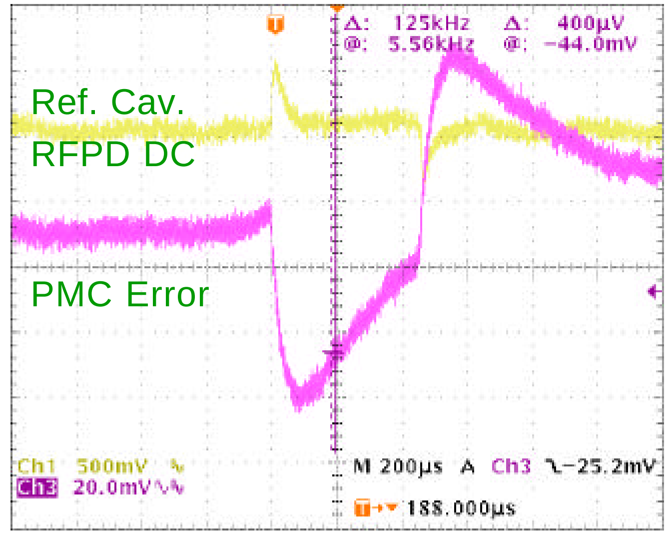
SEISZ transient preceedes MC_F and AS_I transients by ~ 0.2 sec.

MC_F transient peaks ~6 sec. after initial SEISZ Impulse.

- R. Schofield and D. Chin were able to induce similar transients by stomping on LVEA floor, driving over a bump, etc.

PSL Frequency glitches



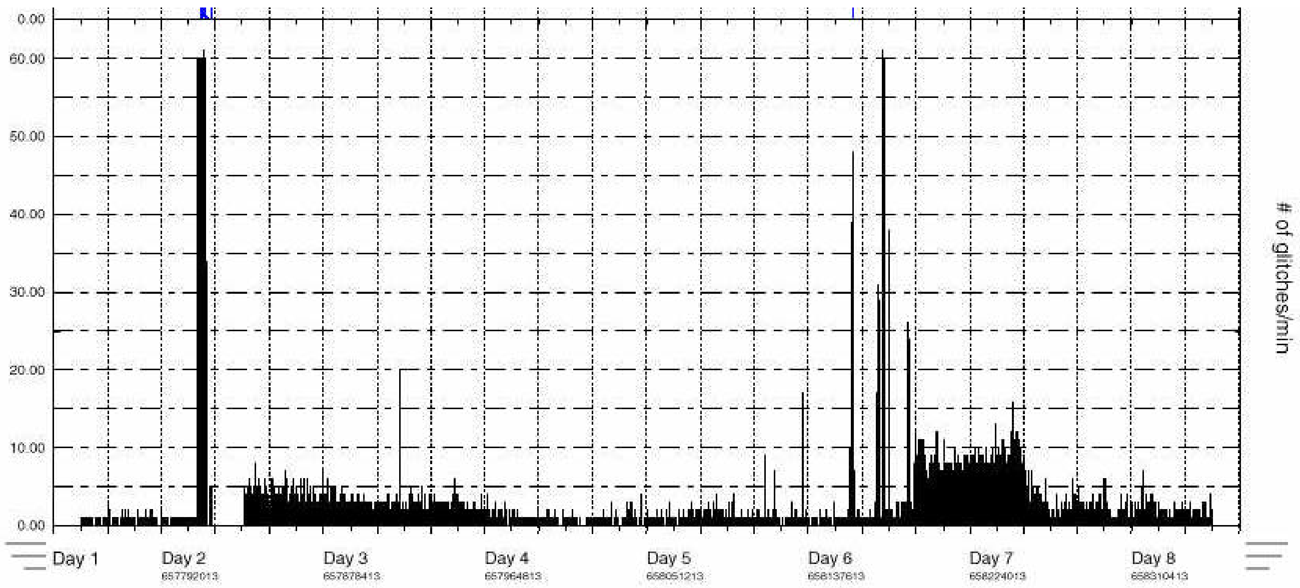


200 usec/div. (~3 counts/div)

-Observed 6/00 in lab at rate of 10's per second
- Eliminated (?) by adjusting NPRO pump diode current by 0.02 amps

Approach

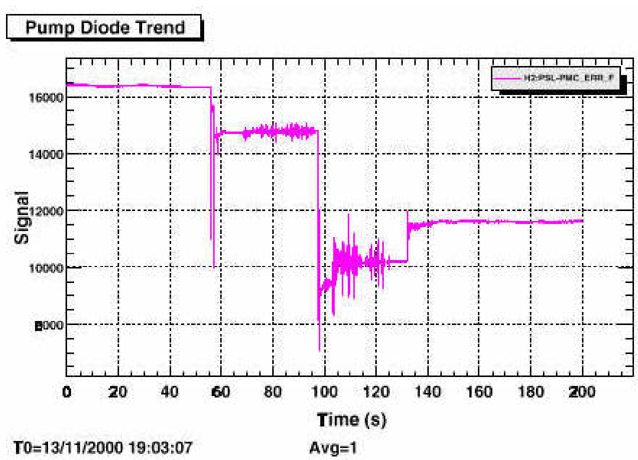
- Use PSLmon monitor (J. Zweizig) on several PSL channels
  - » Calculate standard deviation for each one second interval
  - » For each second that signal level exceeds a user-defined threshold, generate a trigger at the time of maximum deviation.
  - » Triggers recorded in the LDAS meta-database.
  - » Investigate triggers using GUILD interface (P. Shawhan).

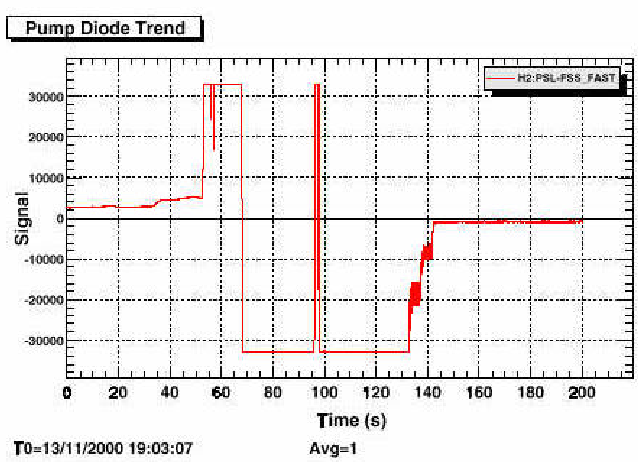


Glitches per minute for PMC_ERR_F

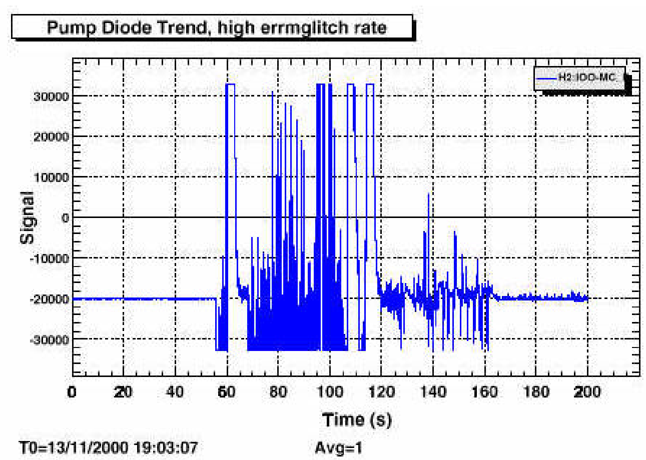
Transients that generated triggers …

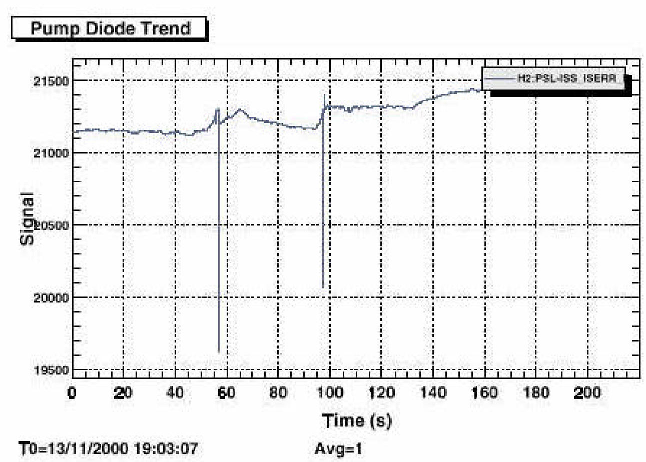
- Saturated signals





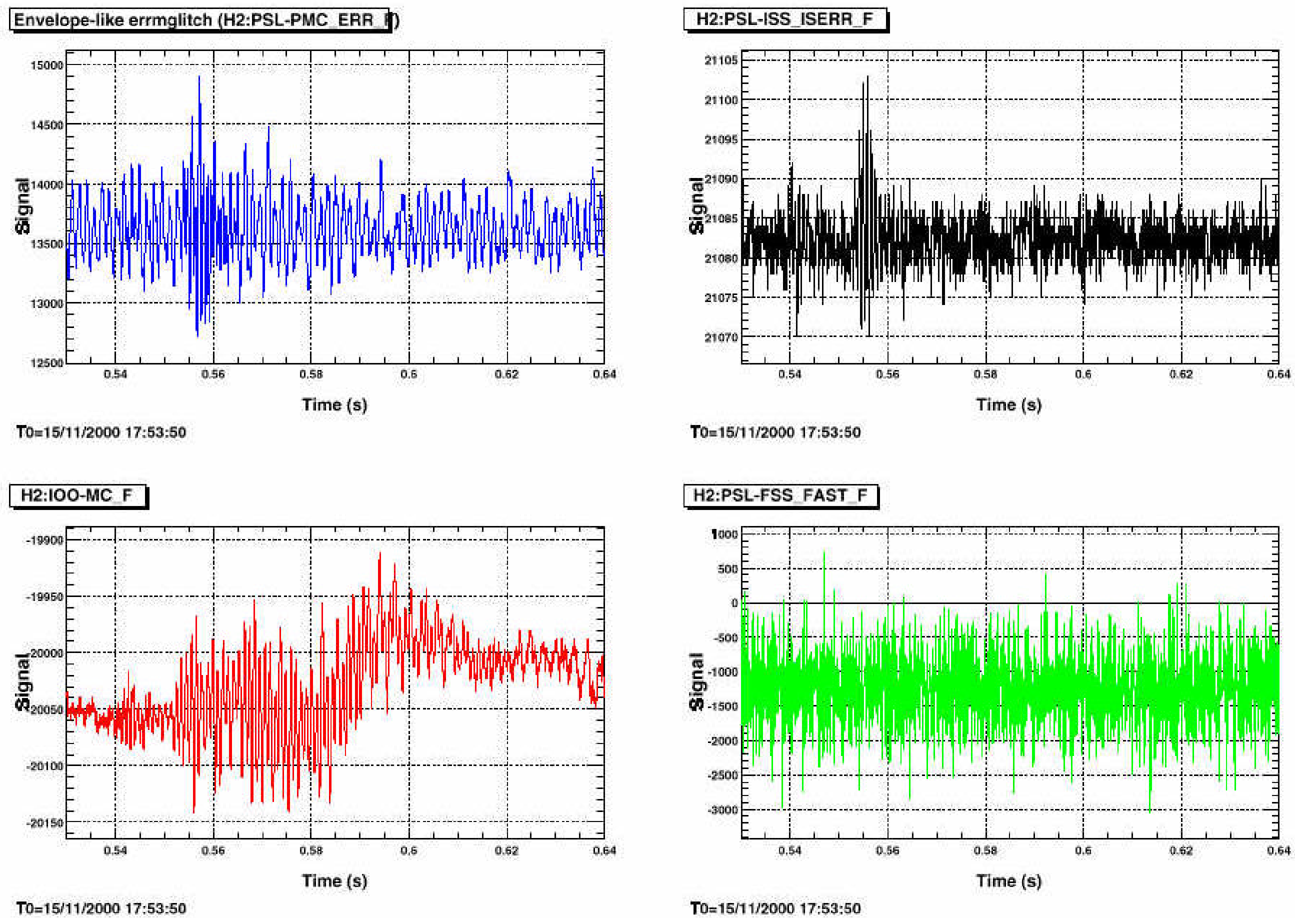
- Mode-cleaner loss of lock





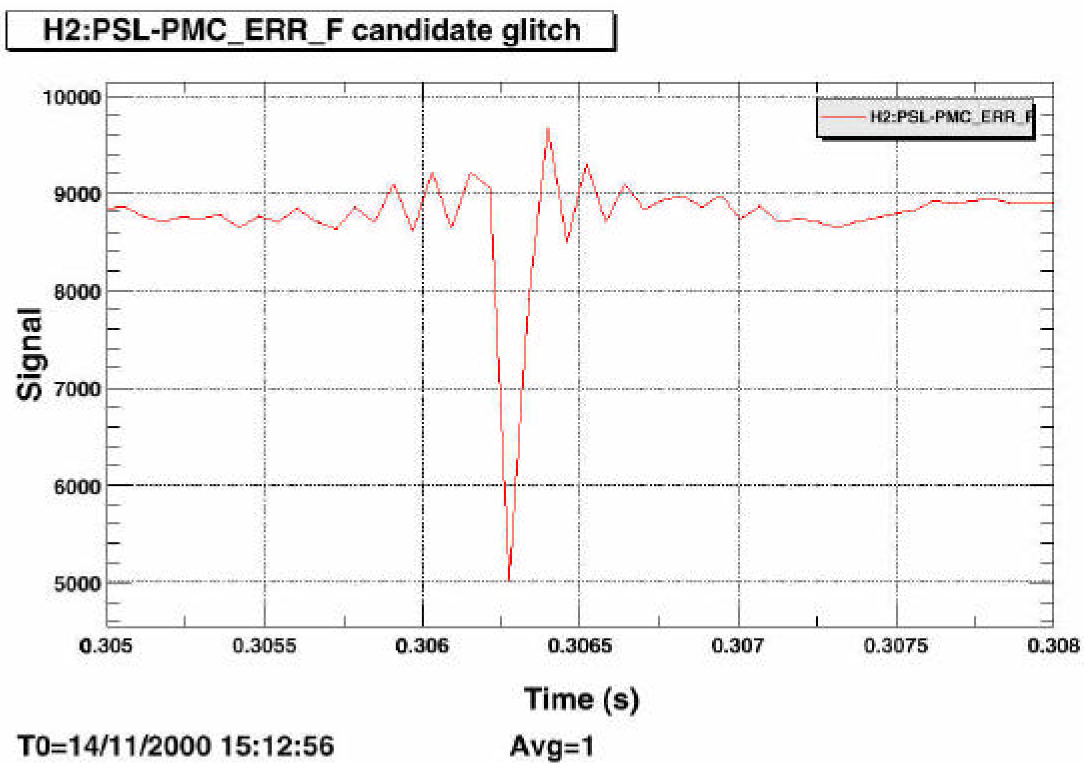
Transients that generated triggers …

- Unidentified sources



Transients that generated triggers …

- PSL frequency glitch?



* Not seen in H2:PSL-FSS_FAST_F as expected.

Upgrades to monitor/future plans

- AC couple H2:PSL-PMC_PZT_F channel. (Done)
- Monitor PSL channels with oscilloscope to see if recent tuning of 10-W laser has eliminated glitches. (No glitches observed on 4/2/01)
- Suppress triggers when MC is out of lock and when signals are saturated.
- Reduce trigger rate by triggering on correlated events in two or more channels.
- Run new monitor (written by R. Rahkola) – check event rate, sample glitches. (not quite ready for E3 run).