Noise Transients and Veto Studies for Gravitational Wave Bursts in LIGO

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LIGO Scientific Collaboration

Talk Outline

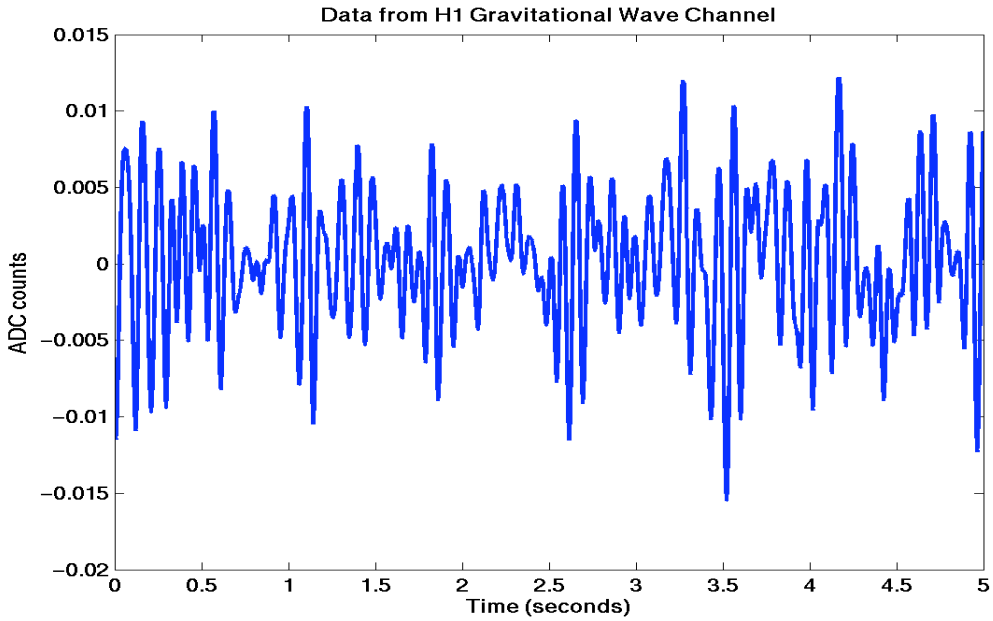
- Introduction to LIGO data and burst searches.
- Overview of tools used for studies of noise transients.
- Strategy used to veto events due to noise transients from burst searches.
- Some examples of detector malfunctions which masquerade as false "gravitational wave events".
- Conclusions.

List of Acronyms used in this talk :

- H1 - 4 km Hanford interferometer
- H2 - 2 km Hanford interferometer
- L1 - 4 km Livingston interferometer
- S5 - Fifth LIGO science run starting in Nov. 2005

Rudiments of LIGO Data

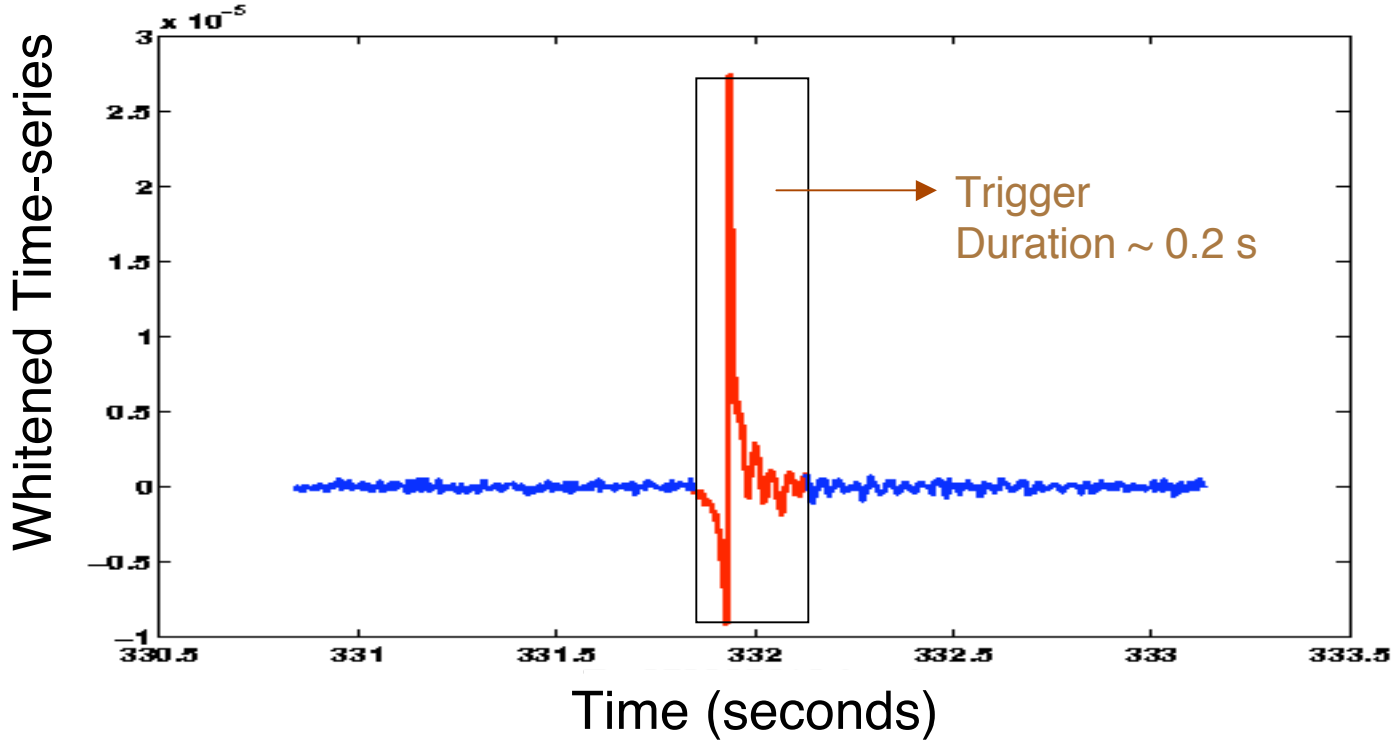
- Data containing possible signal of a gravitational wave is digitized and sampled at 16 KHz and saved in a data acquisition unit ("channel") called gravitational wave channel



- Data from auxiliary control channels and various environmental monitors (eg. seismometers, magnetometers) also stored in similar channels for various diagnostic purposes.

Basics of Burst Searches

- Various algorithms (time-domain, wavelets) are used to look for transients in the gravitational wave channel after whitening the data. Start and stop time of the transient is called a trigger



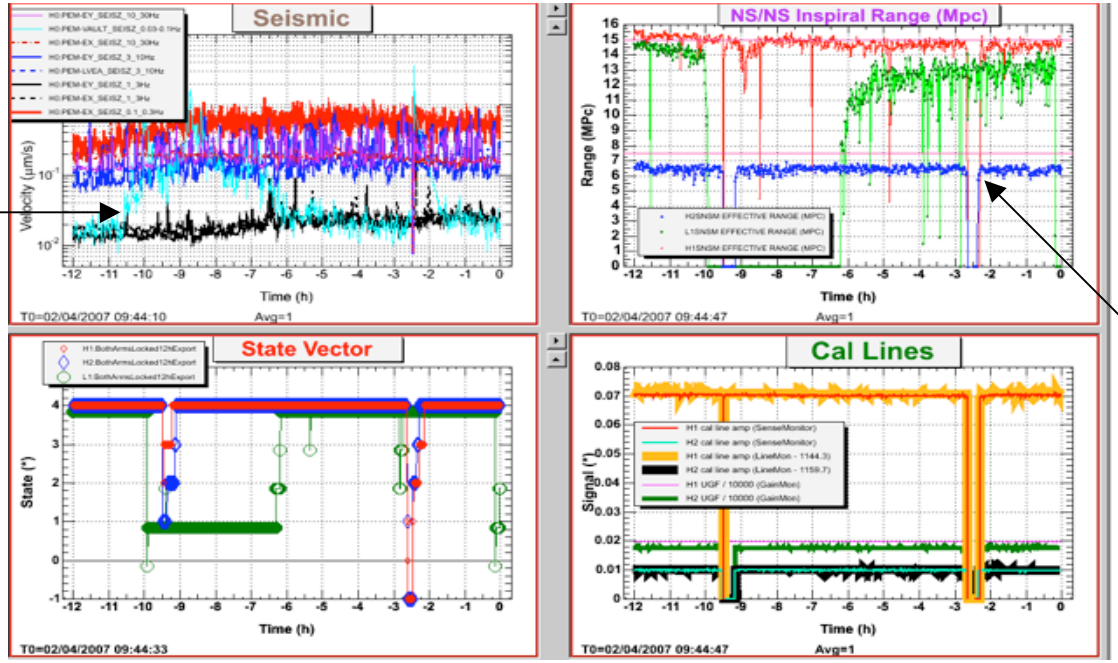
More details in following talks by L. Cadonati, I. Yakushin, K. Thorne

- Some of these algorithms are also applied to find transients in auxiliary interferometric or environmental channels.

Detector Characterization Tools

- Online Data Monitoring Tools *(available in real time)*

Band-Limited Seismic Noise Monitor

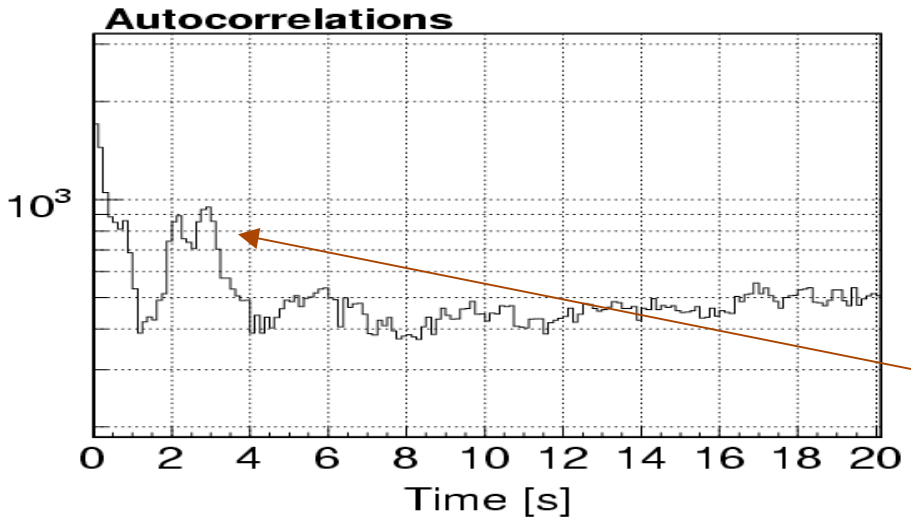


Snapshot of online "figures of merit" in Hanford control room on April 2nd 2007

Inspiral range sensitivity

- Offline Studies *(few hours to 1 day latency)*
  - Single-detector outliers found by burst and inspiral searches
  - Double and triple coincidence triggers (higher threshold)
  - Explore autocorrelation of transients
  - Study potential vetoes for astrophysical searches
- Event Visualization Tools

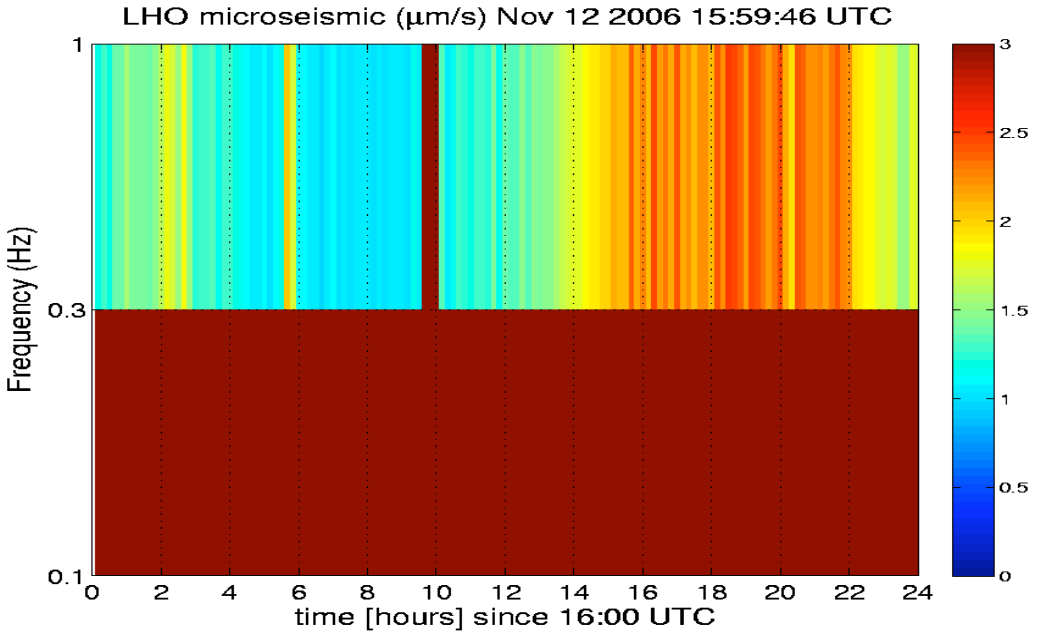
Autocorrelation Studies



Autocorrelogram of H1 triggers

(obtained from one of the burst search algorithms: Kleine-welle)

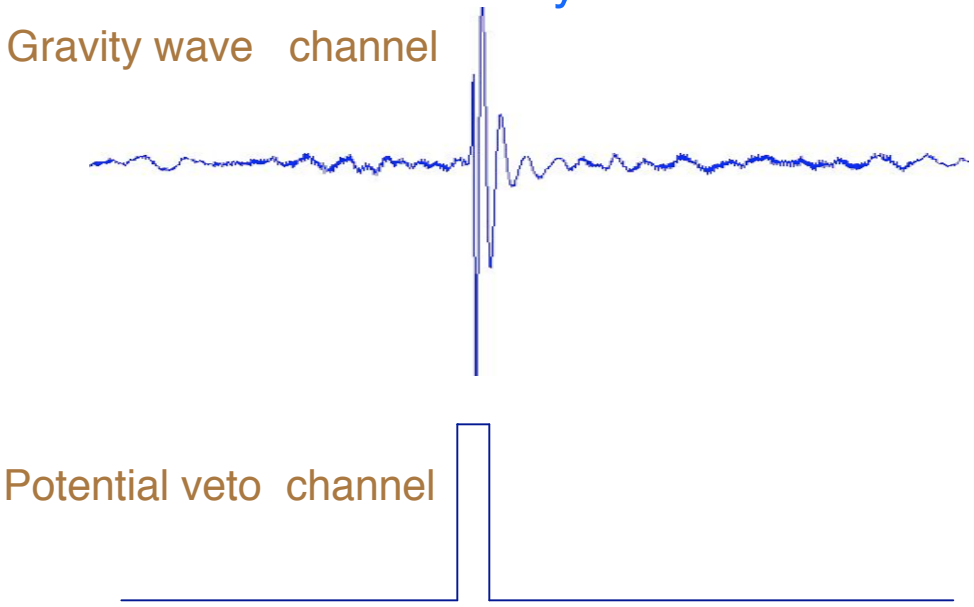
Peaks at 3 sec. due to elevated microseismic noise (0.1 - 0.3 Hz)



Strategy for Veto Identification

- Generate Data quality flags for bad intervals with different severity levels.
  - Category 1 - Do not analyze
  - Category 2 - Used in post-processing
  - Category 3 - Advisory for detection confidence and used in upper limit, if no detection
  - Category 4 - Advisory flag used to exert caution in case of a detection candidate

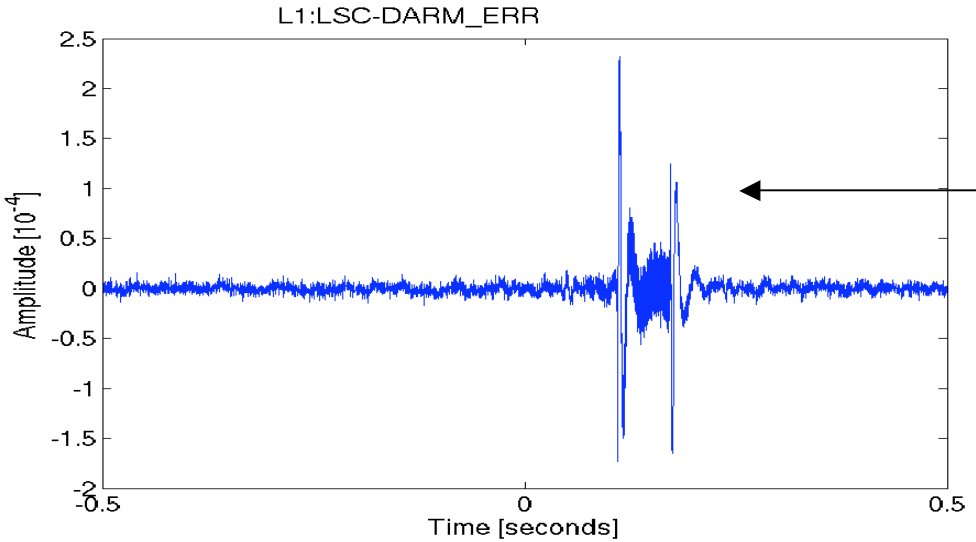
- Use vetoes from auxiliary channel on an event-by-event basis.



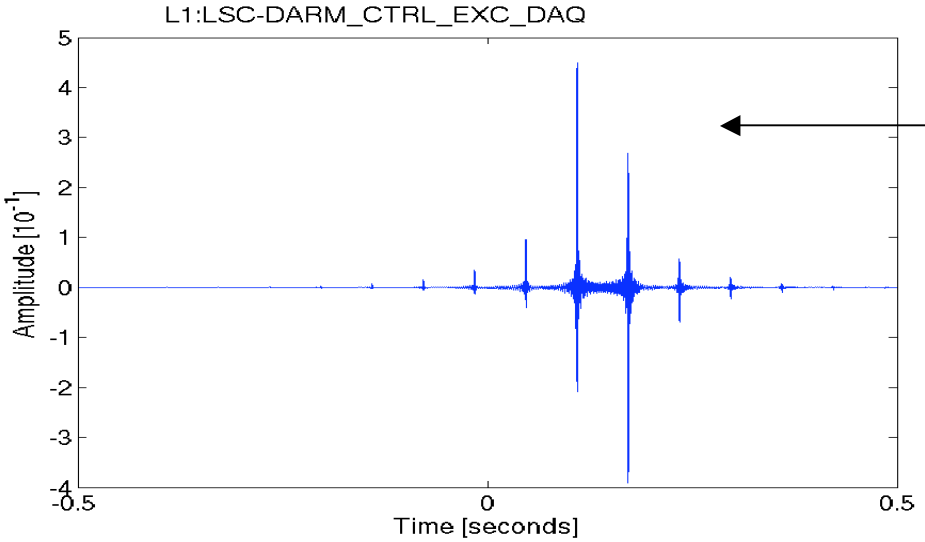
Tuning done on single interferometer triggers.
Veto Yield ~ 10 % for interferometric channels and 1 % for environment channels
Dead-times ~ 0.5 %

- Check a real gravitational wave would not couple to veto channels.

Example : Calibration malfunction



Gravity wave channel



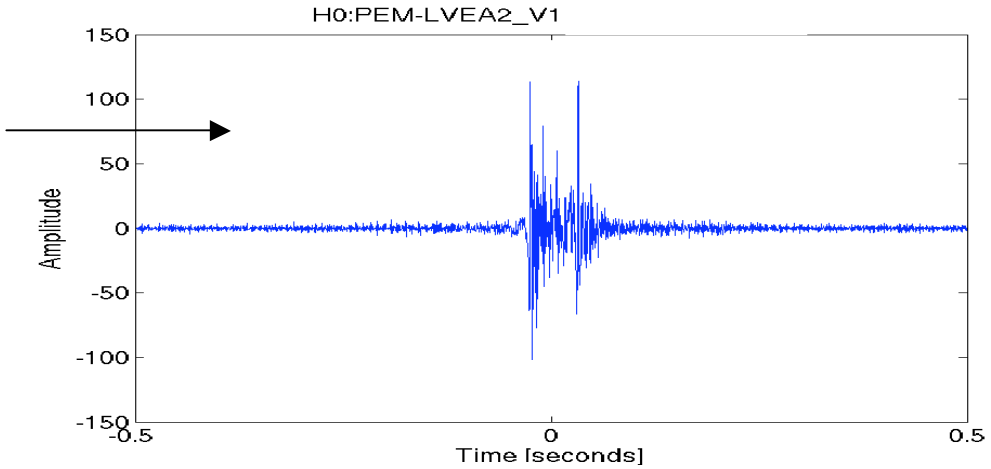
Channel which contains injected calibration line

Category 1 Data quality flag
Dead-Time ~ 0.02 %

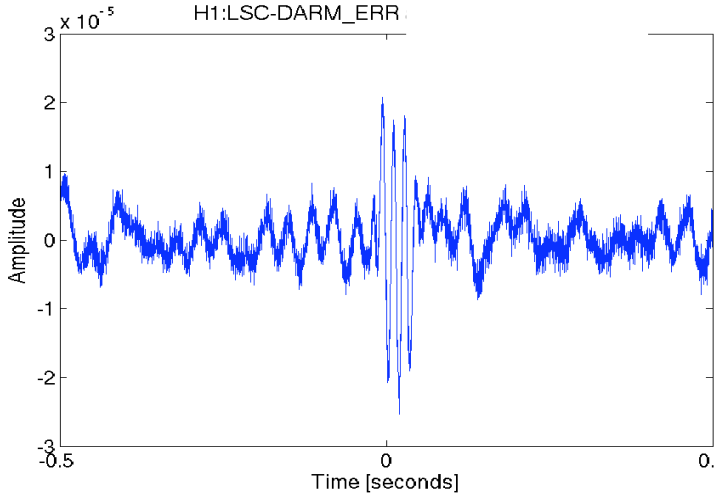
LIGO Example:Power line fluctuations

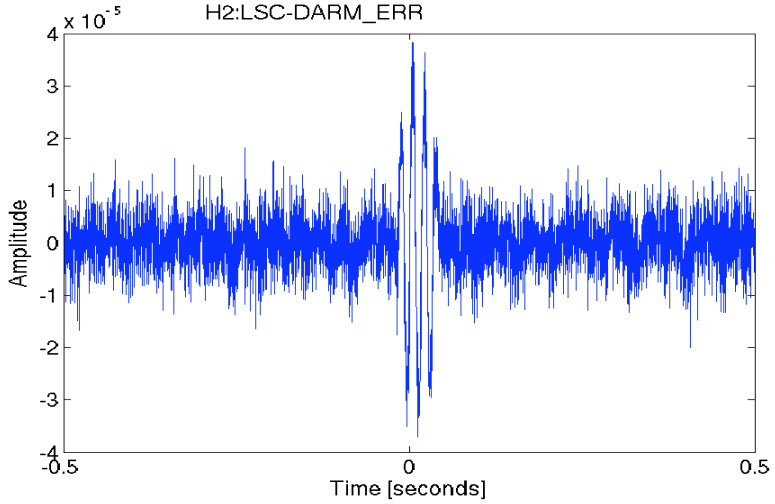
- Disturbances on power mains :
  These cause simultaneous coherent noise transients in H1 and H2.

Mains power voltage monitor



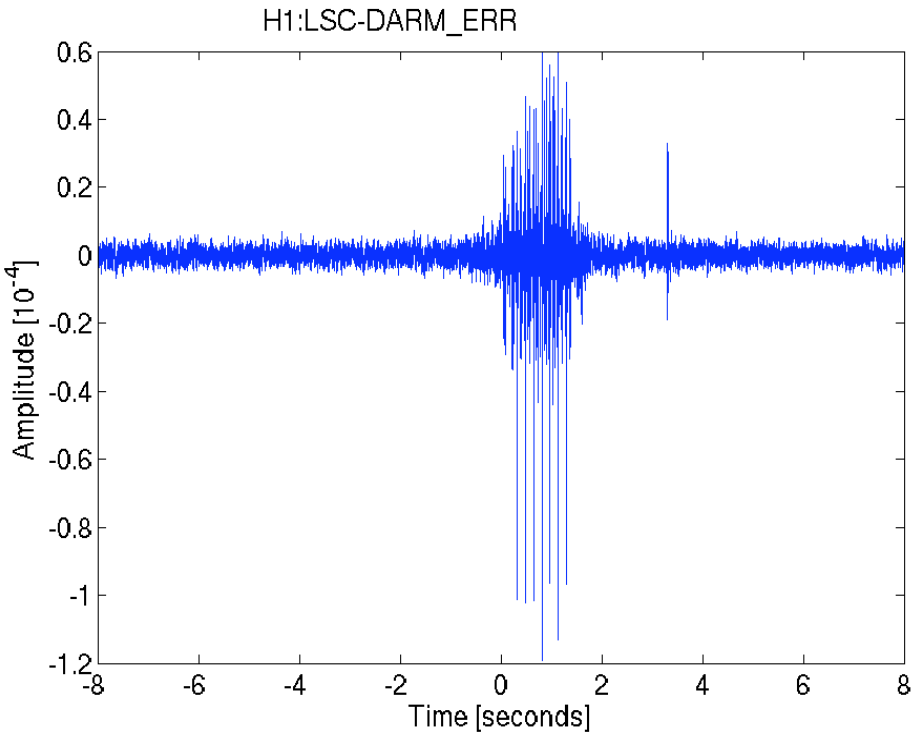
Category 2 Data quality flag
Dead-Time ~ 0.003 %



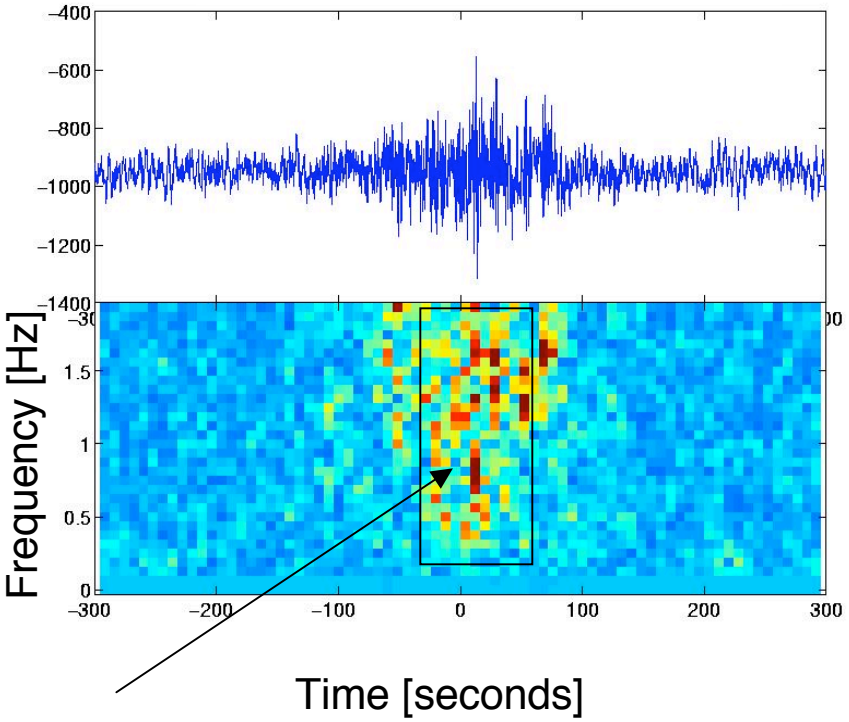


Example: Seismic Noise

- Transient seismic noise < 10Hz getting up-converted into LIGO band



Hanford Y-end seismometer

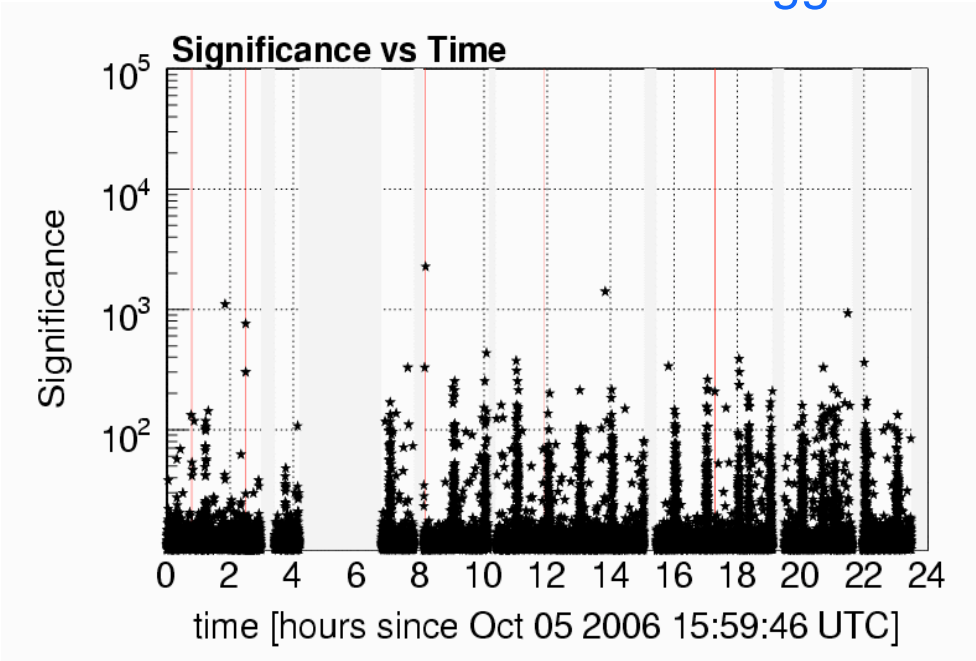


Category-3 Data quality flag
Dead-Time ~ 0.6 %

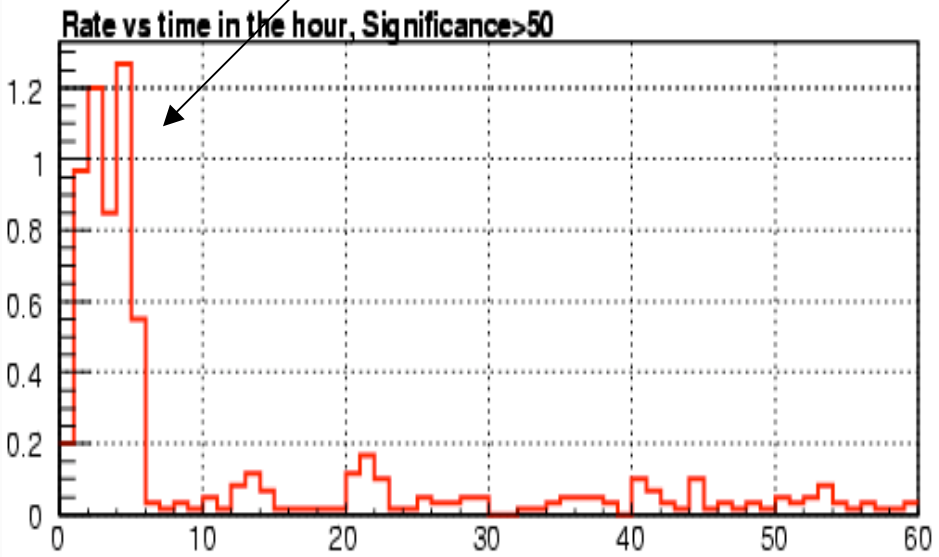
Excess Seismic noise

Periodic L1 transient events

Kleine-welle L1 triggers



Peak when time (in minutes) ~ 0



- Hourly noise transients first appeared on October 3rd 2006.
- Attributed to snapshot processes performed by the detector DAQ on a periodic basis (every hour in Oct. 2006). This has been addressed now.
- Use and classification as a Data quality flag under study.

Conclusions

- During the S5 run, the LSC made significant progress in the identification of bad data and eliminate transient noise events with various offline/online monitors and event-visualization tools.
- Several data quality flags with different levels of severity have been identified.
- Prompt feedback of analysis findings is provided to detector commissioners.
- More work still in progress to track down unknown transient noise events

Aim is to bring lot of this effort to real-time in the future so as to support online astrophysical searches.