Research in support of LIGO Binary Inspiral Search and Detector Characterization

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Overview of Planned Research

Inspiral Analysis Group

- Running Binary Neutron Star code
- Work with graduate student on another section of binary parameter space
- Run near-real-time inspiral analysis code at LIGO Livingston
- Chi-squared test – removing symmetric glitches
- Fast veto analysis
  - New and more flexible script needed
  - Tracking glitches through interferometer
  - Determining physical causes of glitches

Detector Characterization

- DMTViewer and Dataviewer code in glitch monitor PTmon
- Maintaining and improving PTmon

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Inspiral Projects

Running binary neutron star code

Many runs over playground data needed to establish cuts, parameters

Full data sets – extra runs needed for new data quality flags, etc.

Graduate student – opportunity to learn grid computing, Inspiral pipeline, DAG construction, interpretation of output

Cover more of inspiral parameter space

Much of parameter space associated with binary searches still unexplored

Carving out new section benefits Inspiral Analysis Group, and graduate student, who needs original, identifiable project

Each search restricted, e.g. to comparable masses, to limit number of templates and triggers. Many new searches needed.

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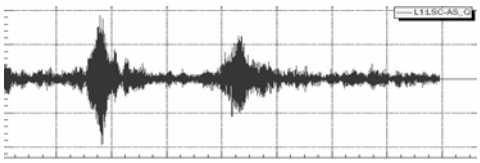
Inspiral Projects

'Online' inspiral analysis at LIGO Livingston

Procedures for running the inspiral pipeline in near-real time, using science data without data quality flags and preliminary calibration data, being worked out at Hanford.

Group needs member with easy access to Livingston and not already heavily committed to implement the analysis at Livingston.

Chi-squared test still needs to be improved to remove inspiral candidates that are time symmetric. Problem for BBH search as well as BNS. Using frequency analysis within existing inspiral code desired.



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Inspiral Group

Fast veto analysis is also desired.

Group has a list of 'usual suspect' channels. Scripts need to be written, tested, and agreed on to take advantage of all of them and allow for variations in conditions. (No single channel is going to be appropriate, especially throughout a long run.)

Group also wants to know physical causes of typical glitches and patterns. Nontrivial amount of work. Students invaluable!

Run glitch monitors under Condor when reruns needed.
WaveMon experience – 5 months' work -> 3 days
PTmon – S3 to be rerun – grid software just updated

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Currently inspiral and veto triggers are plotted using Matlab, time windows and thresholds tweaked, web pages with thumbnails prepared …

No final agreement on most effective channels, and these may vary during a long run.

More than one run of veto scripts needed as inspiral triggers refined

- long time windows needed until chi-squared value and amplitudes used to select optimal trigger from each cluster

Pairs of example plots show (i) inspiral triggers, red if vetoed, and (ii) PTmon triggers, red if used to veto.

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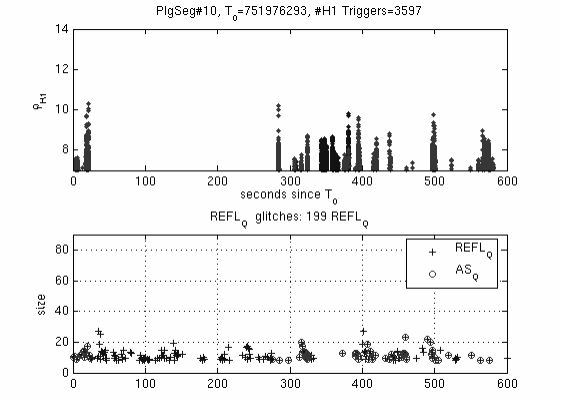

The long gap in inspiral triggers is due to veto from data quality flags

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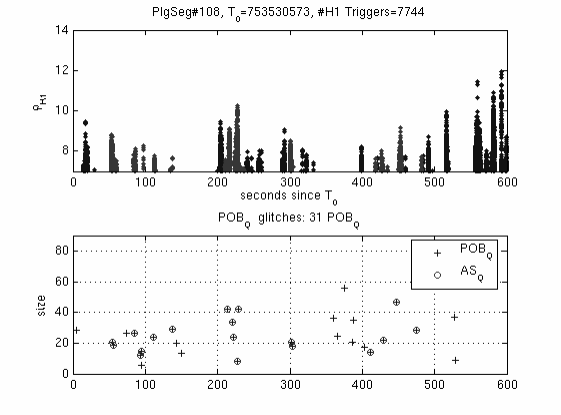

Interval 350-400 s vetoed by data quality flags

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Veto Analysis - Tracking experiments

More needed, as part of veto studies, and tracking physical causes.

Illustration from E11:

All H1 AS_Q glitches in 20 minute interval accompanied by glitches on usual LSC channels within one second.

One H2 AS_Q glitch not accompanied by H2 LSC glitches, but very strong glitches on seismic and accelerometer channels coincided with this H2 glitch and set of H1 glitches.

Most likely, these were the direct cause.

Other causes suspected, e.g. optical lever glitches, but not yet tracked through interferometer.

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Veto analysis – Example of tracking experiment

Foot stamps in control room tracked through seismometers, PSL accelerometer, and through interferometer channels to AS_Q. Major changes in amplitude and frequency noted.

Wavelet decomposition of signal detected by accelerometer on PSL table showed slow signal 2-4 Hz arriving at the table, PSL periscope resonating at > 512 Hz, followed by resonances building in table legs, etc.

Plot in next slide shows frequency bands with boundary frequencies increasing by powers of 2 from $2^0 - 2^{10}$.

Glitches spread, and decreased in amplitude and frequency to ~90 Hz on arrival at AS_Q.

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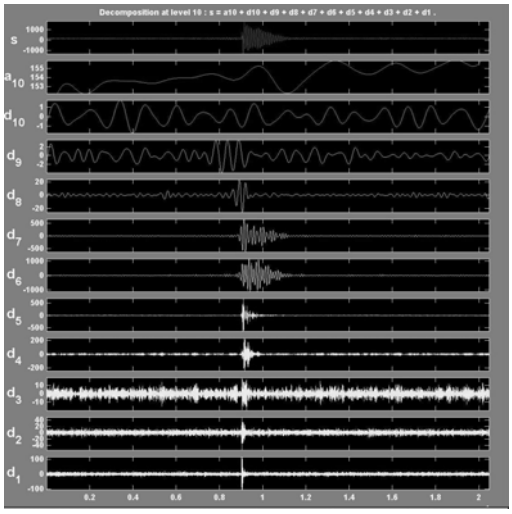
Wavelet decomposition of one glitch arriving at PSL table, and periscope ringing.



d9: 2 – 4 Hz

d8: 4 – 8 Hz

d7: 8 – 16 Hz

d6: 16 – 32 Hz

d5: 32 – 64 Hz

d4: 64 – 128 Hz

d3: 128 – 256 Hz

d2: 256 – 512 Hz

d1: 512 – 1024 Hz

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Inspiral Projects – Veto analysis

Other known or possible sources of glitches in ‘gravity wave ‘ channel

include **accoustic** glitches

- one has been tracked through the Livingston interferometer

glitches on **optical levers**

- cause or chance coincidence an open question currently

glitches due to **misalignment**

Details of tracking, couplings, and transfer functions time-consuming

- would increase confidence in veto scripts

- suitable projects for undergraduates

- web pages needed, to be copied to Group’s e-notebook

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DMTGen

Simulation software for testing DMT monitors

Three waveforms available
- Gaussian, sine Gaussian, and damped sine

Testing PTmon

All three wave forms used

White noise at 16K Hz produces triggers with snr < 6
Testing accuracy - need injections with snr > 5

Injections in very close pairs, separation < 0.1 s could be separated, but monitor would be killed for high trigger rate. Separation irrelevant for setting vetoes.

Results: 293 injections, 95 Gaussian bursts, 88 sine Gaussian, 110 damped sine.
All Gaussian bursts found, one from each of the other types missed. No false alarms above six sigma.

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DMTViewer code has been added to PTmon

Monitor intended primarily as analysis too,
but code will allow it to show glitch trend rates on any desired channels in control rooms

So far, output produced, but archived data will be needed to check and debug

(LHO output not visible in LLO control room – only one of three Lousiana authors lucky during M5 - and LLO is being re-commissioned)

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Resources

LONI: Louisiana Optical Network Initiative

Latech to be primary tie-in point between Dallas, TX and Jacksonville, FL
for southern link of national LambdaRail (Route change I-10 -> I-20)
Current plans: 40 Gbps link to LSU, then 10 Gbps to New Orleans
and 1 GPS to Livingston and Southeastern U.

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Resources

Grid Cluster at LSU

40-node cluster will run under Pegasus

Any other desired software can be installed (e.g. LSCDataGrid)

LSU hopes to have cluster used by LIGO Livingston and LaTech
for analysis of Livingston data
- possibilities: rerunning monitors and inspiral code

Doctoral II Status for LaTech?

Expected in 2005. Would mean

- much higher level of state funding
- reduced teaching loads for research faculty

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Resources Requested

Summer salary for PI

Stipend for graduate student

Wages for one undergraduate (academic year)

Travel for PI to Livingston and to meetings

Computers – probably change to Linux PCs
(needed for LSC Data Grid software)

Undergraduates (three strong candidates are seriously interested) will apply separately for summer funding from LIGO Undergraduate Research Program

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