Change point detection in the time frequency plane

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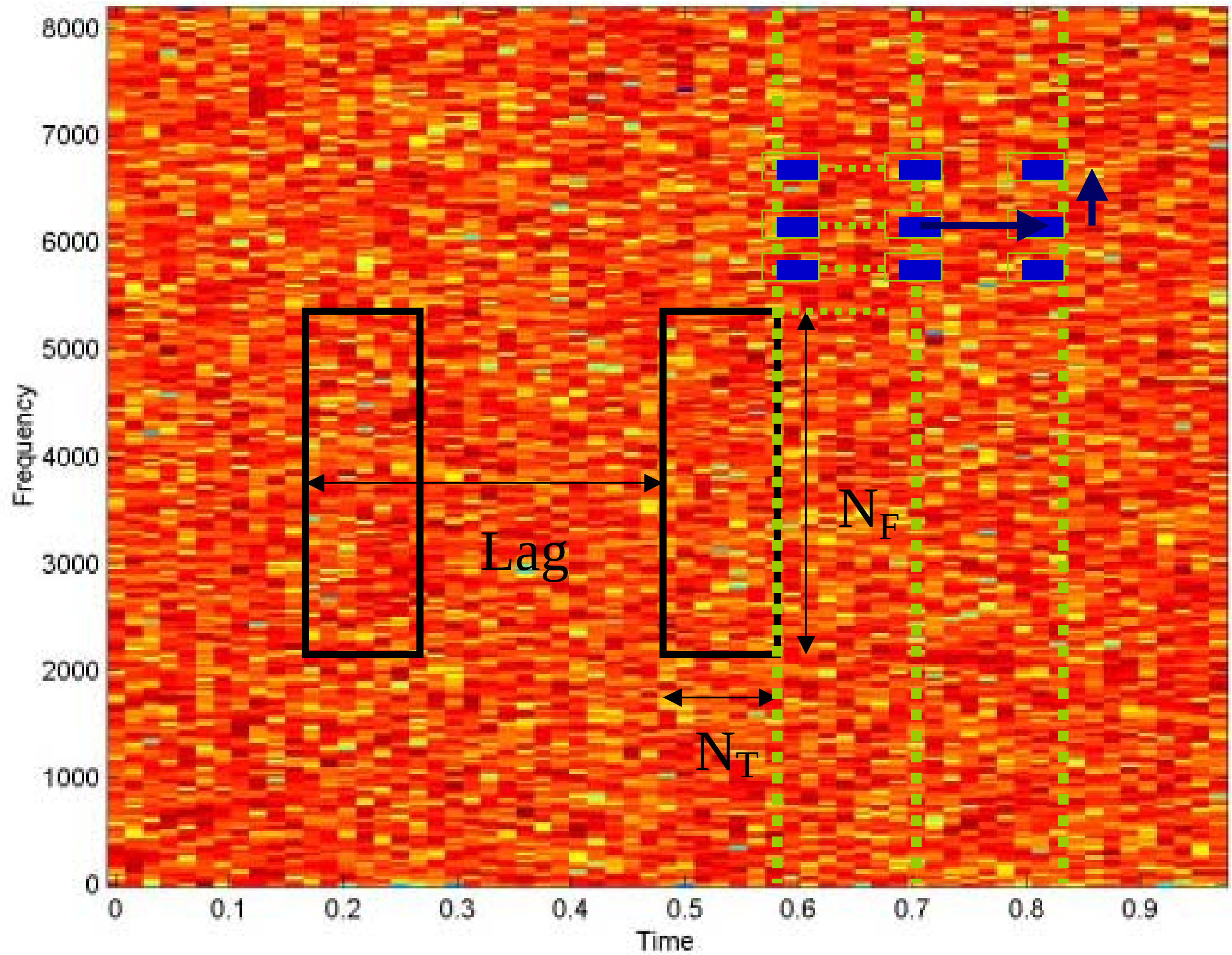
Time frequency plane

- Basic signature of a burst: changes the distribution of samples in some region of the time-frequency plane.
- Most Burst detection algorithms try to look for this effect in different ways
  - Excess power: thresholds the average (=band limited rms)
  - Tfclusters: thresholds cluster size
  - Waveburst: thresholds correlation in “cross-spectral density” TF plane
- PSDCD (Mohanty, PRD,’99): tests for difference in sample distributions of blocks in TF plane.
- PSDCD is a *change point* detector, others are *adaptive* detectors.

KSCD

- Power Spectral Density Change Detector [DMT Monitor]
- Kolmogorov-Smirnov test based Change Detector (KSCD)
- KSCD: improvement in detection efficiency and implementation
- PSDCD used Student's t-test to test for difference in mean
- KSCD uses the Kolomogorov-Smirnov test to look for any possible deviation between the sample distributions
- t-test performance is degraded by long tailed distributions. Not so much for the KS test
- PSDCD regions were 1 frequency bin wide. KSCD regions are rectangles (also other implementation improvements).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Time
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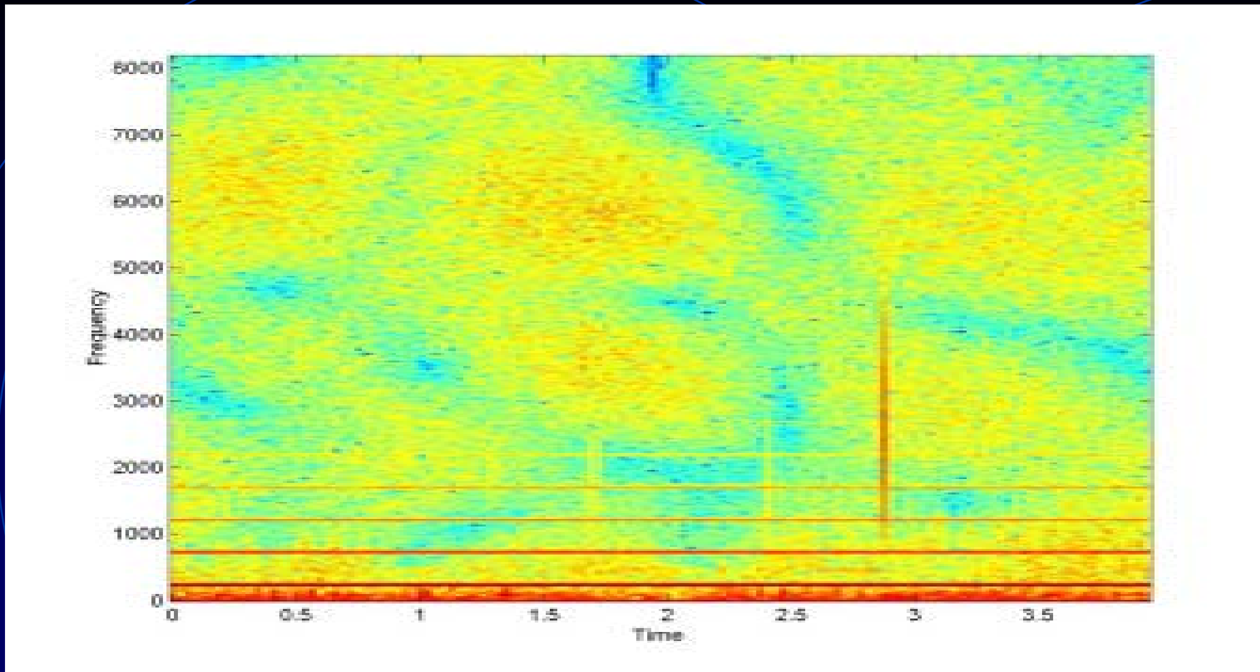
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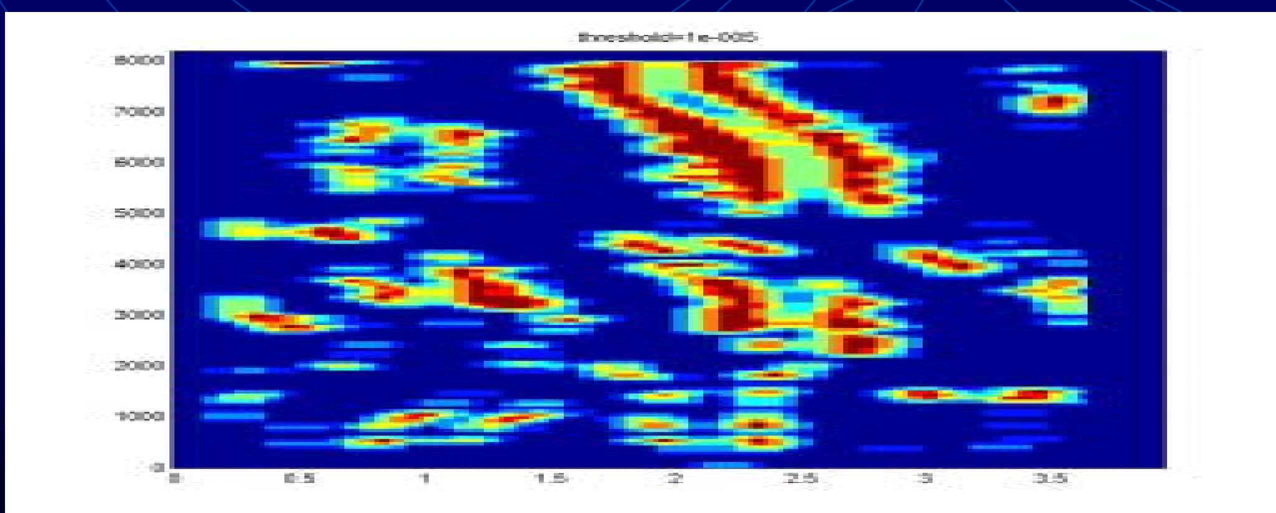
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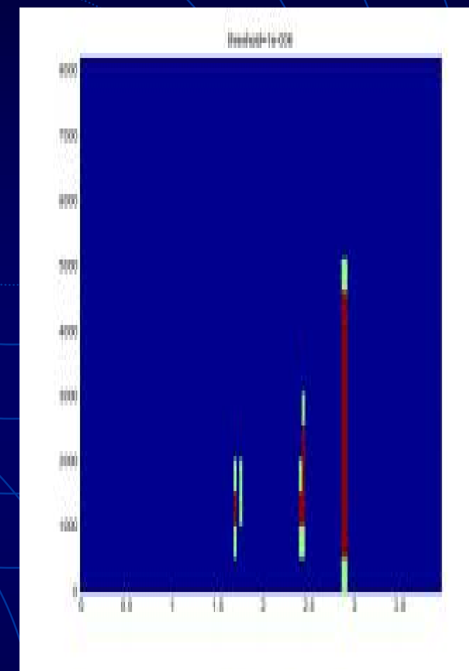


KSCD for GW Burst detection

- KSCD is a non-parametric detector. The *false alarm rate* is independent of noise distribution *by construction*. Sets it apart from other burst detectors.
- A non-stationary time series can be thought of as a sequence of transitions from one noise model to another (e.g. $1\sigma \rightarrow 10\sigma \rightarrow \ldots$)
- A non-parametric detector should maintain a *constant false alarm rate* even for non-stationary noise
- Change point detection also detects the transition points if the transition is fast. (Interesting in itself.)
- May be possible to classify such events for further study (under investigation; S. Mukherjee, LSC Mar'02)

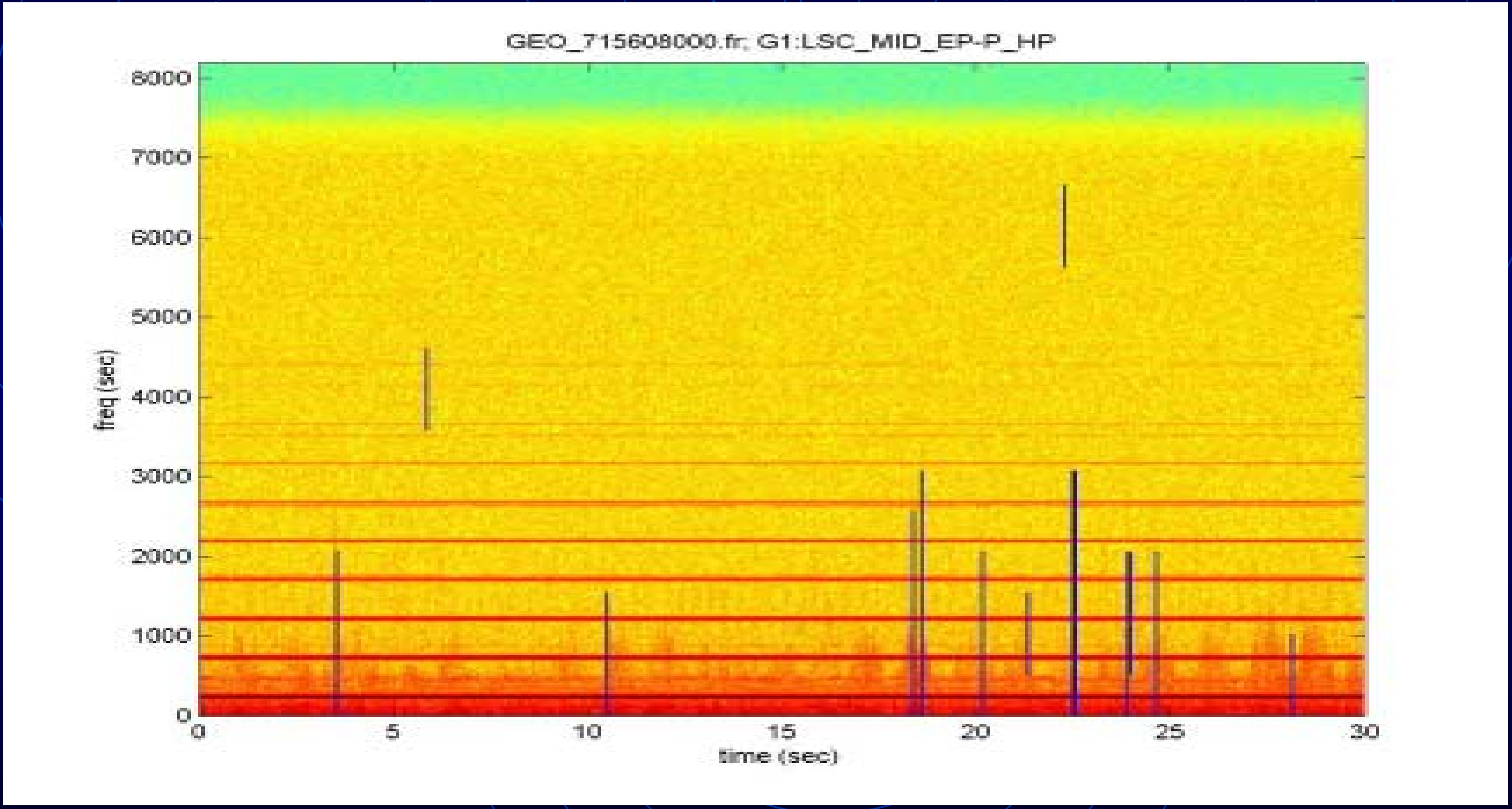
Trial run on GEO S1 data

- Uncalibrated h(t). 3.47 days (some breaks).
- Plagued by fast non-stationarity in the <1.5kHz band.
- 90% - 95% of MTFC triggers could be attributed to this fast non-stationarity. (R. Balasubramanian, this conference)
- These false triggers skew the interpretation of histograms such as the time interval between triggers.
- KSCD can be tuned to be insensitive to these features but still catch “genuine” glitches.
- Change point detection can be tuned to reject “common mode” noise.

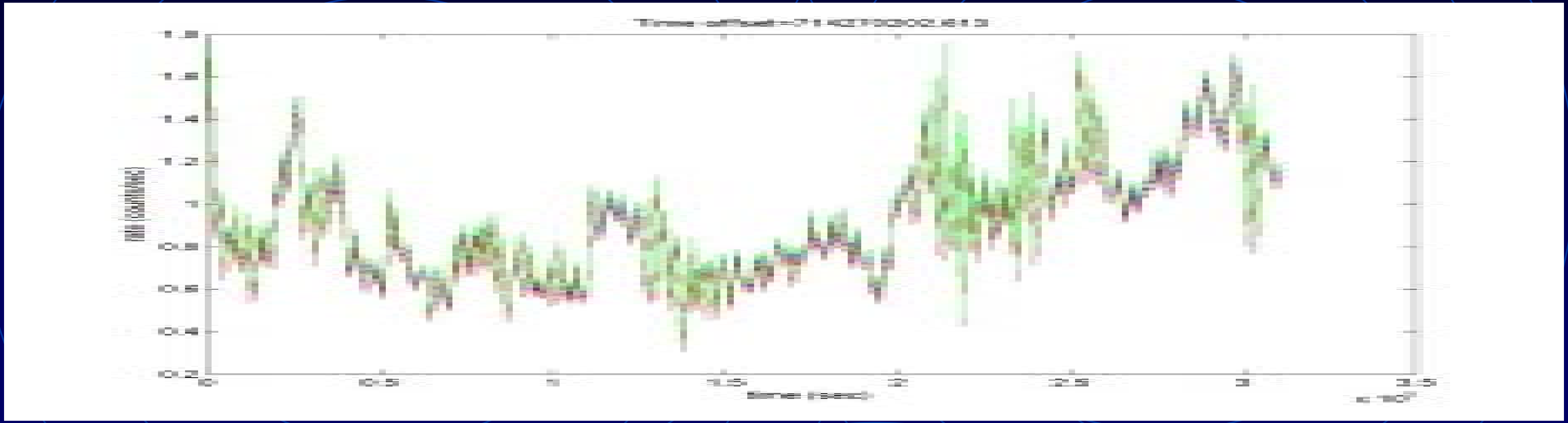
Analysis goals

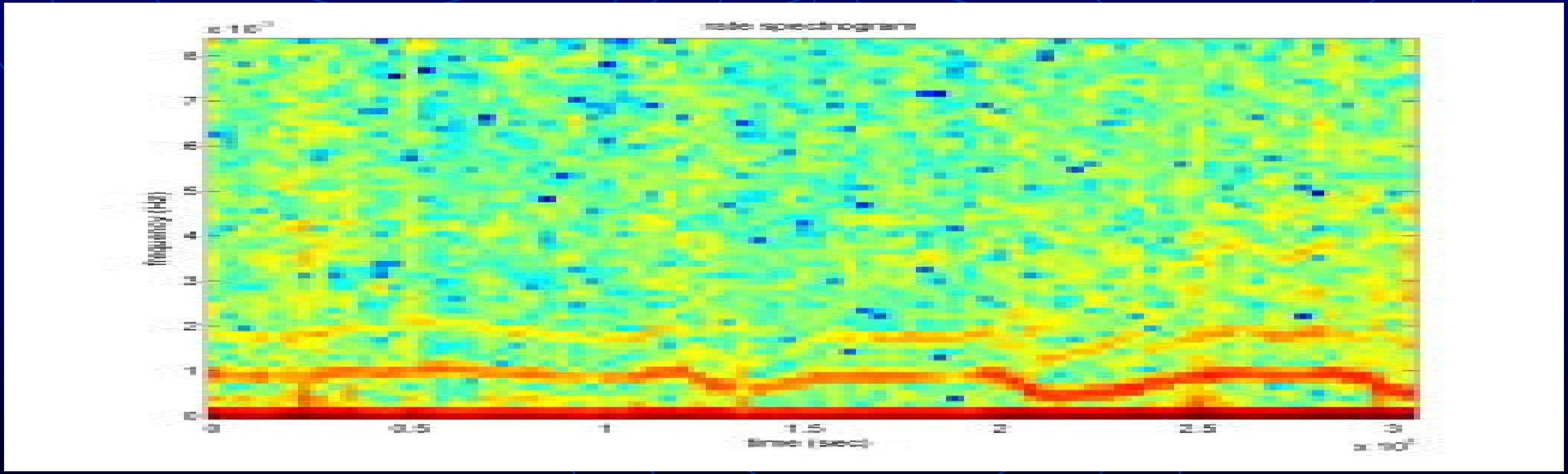
- Disentangle fast low frequency non-stationarity from “genuine” triggers.
- Study time dependent behavior of the triggers.
- Study trigger rate vis a vis band limited rms trend.
  - Does KSCD trigger rate track band limited rms?
- Tune KSCD to reject triggers but catch fast non-stationarity
  - Analyze the dependence of “genuine” trigger channel on fast non-stationarity channel.

Rejection of features in TF plane



Trigger rate





Summary

- Change point detection in the time-frequency plane has some attractive features
  - non-parametric change point detection can lead to more robust performance in non-stationary noise. This can improve the statistical reliability of background rate estimation etc.
  - Change point detection can be tuned to reject some features at the pre-trigger stage itself
- KSCD improves substantially upon PSDCD
- Various aspects of non-parametric change point detection being tested using real data (S1 GEO/LIGO)