Excess power trigger generator

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Excess power method:  
the basic idea

• The basic idea:
  » Pick a start time, a duration (dt), and a frequency band (df)
  » Fourier transform detector data with specified start time and duration
  » Sum the power in the frequency band
  » Calculate probability of obtaining the summed power from Gaussian noise using a \( \chi^2 \) distribution with \( (2 \times dt \times df) \) degrees of freedom
  » If the probability is small, record a trigger
  » Repeat procedure for all start times, frequency bands and durations

• For Gaussian noise, the method is optimal to detect bursts of specified duration and frequency bandwidth
  » Details are in Anderson, Brady, Creighton and Flanagan [PRD 63, 042003. (2001)]
Excess-power method: time-frequency decomposition

- Using $N$ data points corresponding to maximum duration of signal to be detected
- Construct time-frequency planes at multiple resolutions
- Each plane is constructed to have pixels of unit time-frequency volume
- Time resolution improves by factor of 2 from plane to plane
Excess-power method: Implementation

- Calculate time-frequency planes as described above
- Compute power in tiles defined by a start-time, duration, low-frequency, frequency band
- Output is sngl_burst trigger if probability of obtaining power from Gaussian noise is less than user supplied threshold
Tuning the search code

- **Parameters available for tuning**
  - Lowest frequency to search
  - Maximum and minimum time duration of signals
  - Maximum bandwidth
  - Confidence threshold
  - Number of events recorded for each 1 second of data

- **Tuning procedure**
  - Lowest frequency decided based on high glitch rate below 130 Hz
  - Max duration is 1 second; Min duration is 1/64 seconds
  - Max bandwidth of a tile 64Hz, but allows for broader band signals by clustering
  - Tuned confidence threshold and number of events recorded to allow trigger rate ~ 1 Hz
Running the search on large data sets

- Excess power runs standalone using Condor batch scheduler
  » Directed Acyclic Graph describes workflow
- Use LALdataFind to locate data
  » Interrogation of replica catalog maintained by LDR (S. Koranda)
- All search code in
  » LAL and LALApps (many contributors)
- Power code
  » Generates triggers from each interferometer
- Coincidence stage of the search is part of the jobs we run
  » Coincidence needs to be tuned within burst group (See talk by Cadonati)
Performance on interferometer data

600s: uncalibrated data

Same data with Sine-Gaussians at 250Hz, \( h_0 = 6e^{-20} \)
Frequency Dependence of Triggers

Hanford 4km: # of triggers in various freq. bands

Livingston 4km: # of triggers in various freq. bands

800 Triggers

Frequency

800 Triggers

Frequency
Measuring the efficiency of algorithm

- **Sine Gaussian waveform**
  - \( h_+(t) = h_0 \sin[2 \pi f_0 (t-t_0)] \exp[-(t-t_0)^2/\tau^2] \)
  - \( h_x(t) = 0 \)

- **Signal parameters used:**
  - Frequencies: 235, 319, 434, 590, 801
  - \( Q = \sqrt{2} \pi f_0 \tau = 8.89 \)
  - \( h_0 = [10^{-21}, 10^{-17}] \) uniform on log scale

- **Location on sky for single detector tests:**
  - Zenith of each detector
  - Linearly polarized w.r.t. that detector
  - That is \( F_+ = 1, F_x = 0 \)
Efficiencies to Q=9 Sine-Gaussians
4km Interferometers
Parameter accuracy: peak time and central frequency

Q=9 Sine-Gaussian at 235Hz

Peak time

Central frequency
Continuing work as part of LSC burst analysis group

• Tune the coincidence step to best utilize triggers from excess power
• Extend efficiency measurements to all sky for sine-Gaussians
• Extend efficiency measurements to include supernova waveforms
• Implement multi-detector extension of excess power discussed in Anderson, Brady, Creighton and Flanagan [PRD 63, 042003. (2001)]
• Test alternative statistic involving over-whitened data [See ABCF and/or Vicere PRD 66, 062002. (2002)]