BlockNormal Performance Studies

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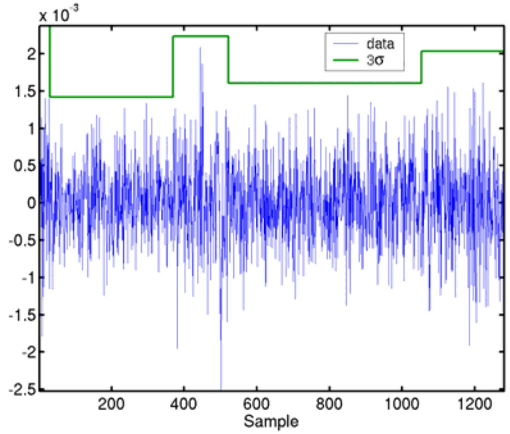
Outline

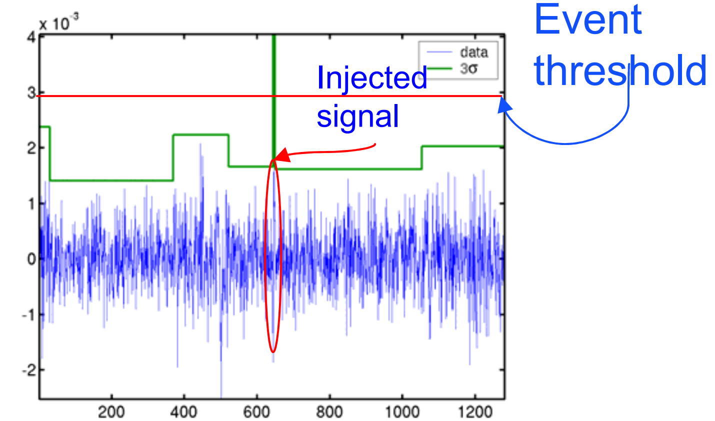
- What is BlockNormal
- Event Characterization and Coincidence
  - » Event Time
  - » Energy
- Detector Sensitivity Studies
  - » Efficiencies
  - » Sensitivity to thresholds

What is BlockNormal

Thresholds:

- Change-Points
  - » Where variance (σ^2) or mean (μ) changes
  - » Divides data into blocks of ~ constant mean & variance
- Events:
  - » Block becomes event when
    - – variance above threshold
    - – Mean differs from background by more than threshold
  - » Thresholds based on characteristics (μ_0,σ_0^2) of stationary epochs
- Cluster adjacent accepted blocks





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Event Characterization Study

- Coincidence cut requires accuracy & precision of reconstructed event properties
  - » BlockNormal output per IFO, frequency band:
    - – "Characteristic time"
    - – Energy
    - – Duration
- Reconstruction accuracy & precision studied with simulated signals

$$h(t) = h_0 \exp\left(-\frac{(t-t_0)^2}{2\tau^2}\right)\cos 2\pi f(t-t_0)$$

$$f = 576\,\text{Hz},\ \ \tau = 100\,\text{ms}$$

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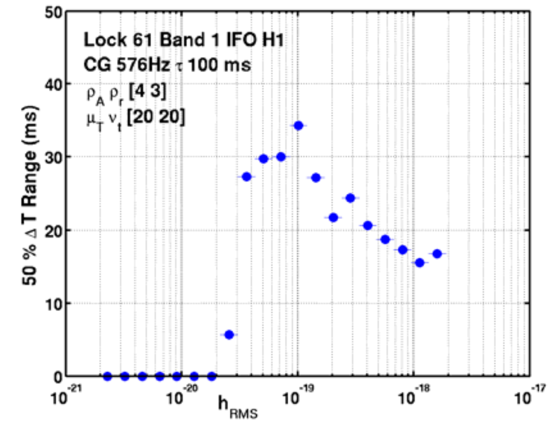
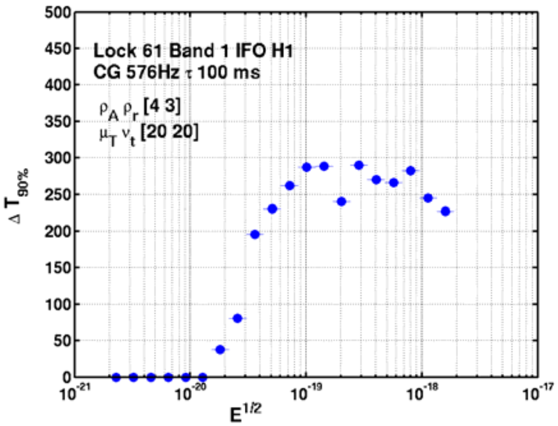
Event Time Reconstruction

- Event “when” necessary to for inter-detector coincidence
  - » Mid-point of block with greatest variance will be independent of event amplitude
- Time resolution improves with amplitude
- ΔT < 8 samples (32 ms) for 50% of events
  - » Clusters at very low amplitude are short-duration ΔT ~ 0
- ΔT < 80 samples (320 ms) for 90% of events
- Why long tail?
  - » One playground segment in H1 Lock 61 has several “odd”, long events
  - » Under investigation; suspect need for veto





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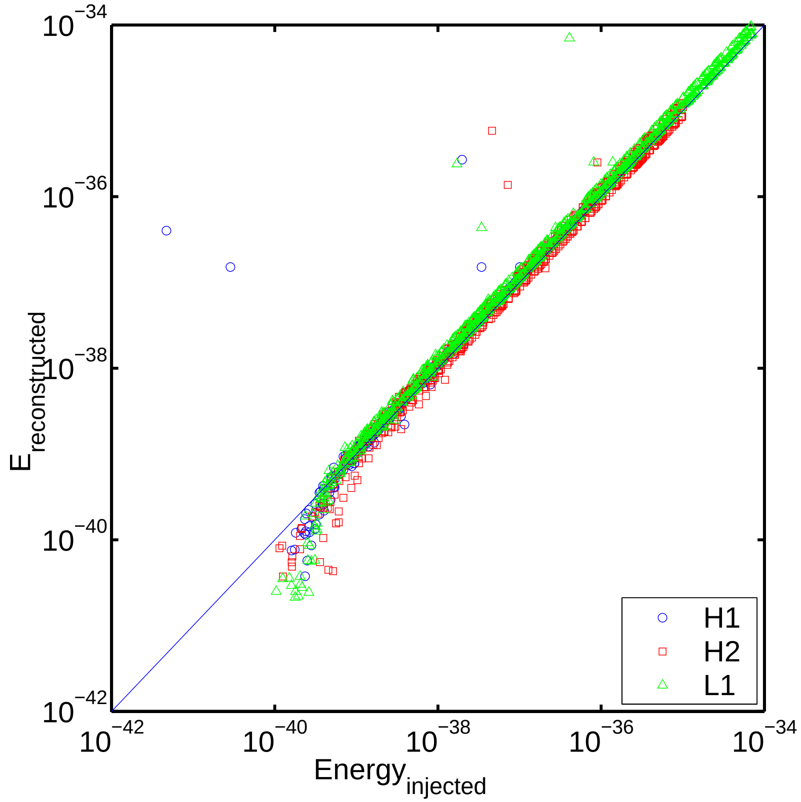
Energy Reconstruction

$$E_R = \frac{\Delta t}{\left|R_{eff}\right|^2} \sum_k \left(N\mu_k^2 + (N-1)\sigma_k^2 \right)$$

$$E_0 = \frac{1}{\left|R_{eff}\right|^2} \int_{-\infty}^{\infty} h(t)^2 \, dt$$



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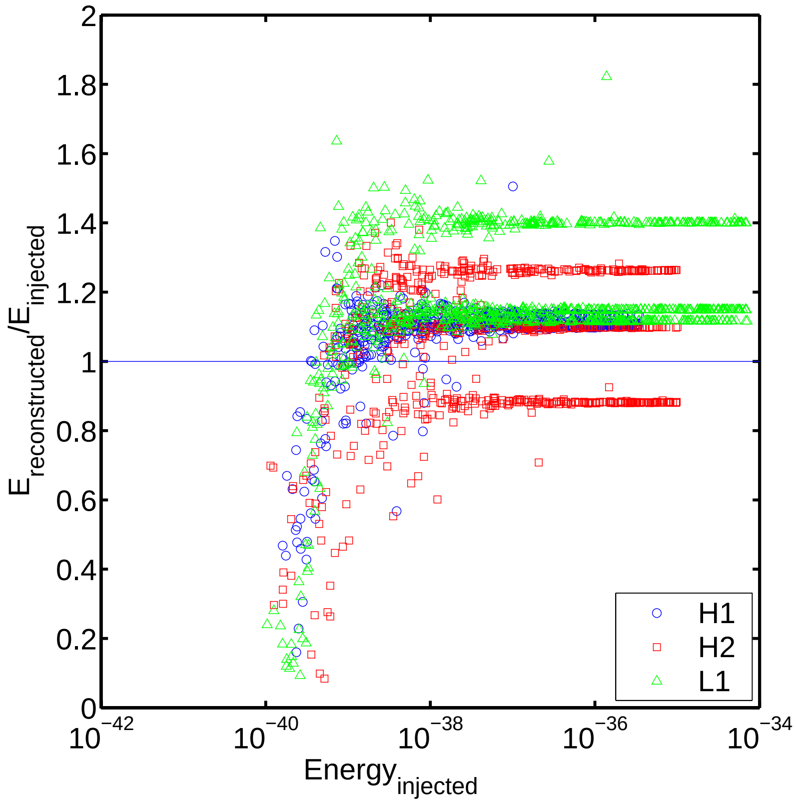
- Note different ratios
  - » Lock 61: Three different 10m playgrounds separated by 1h46m10s
  - » Differences owe to time dependent calibration
- Reconstruction: good precision, open questions on accuracy



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BNETG Sensitivity Study Goals

- Measure and characterize efficiency as function of amplitude
  - Amplitude at 50% efficiency?
  - How rapidly does efficiency climb with amplitude?
  - Maximum efficiency?
  - Residual false rate?

- Sensitivity of efficiency to BN thresholds
  - Change-point, event thresholds

Sensitivity Determination

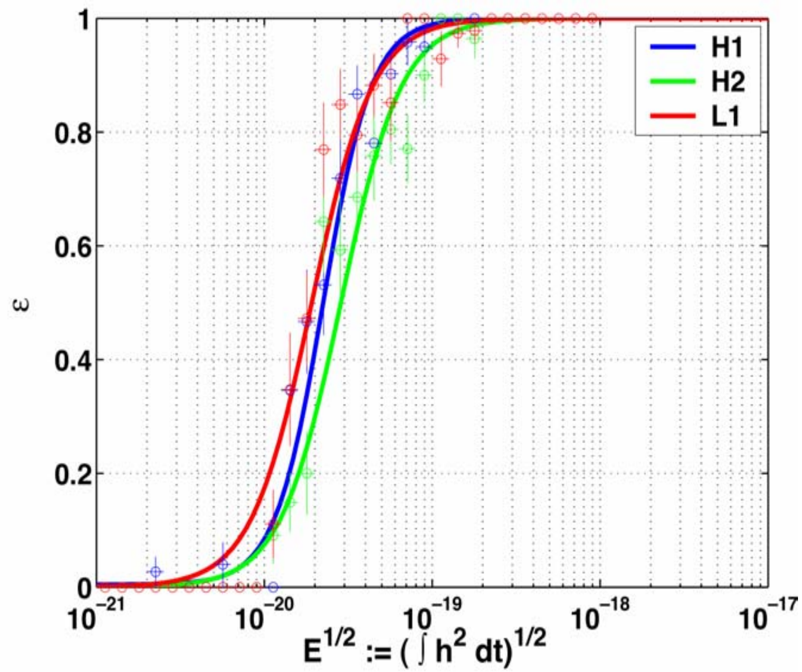
- Initial study lock 61 playground 512-640 Hz band
- In-band simulated signal

$$h(t) = h_0 \exp\left(-\frac{(t-t_0)^2}{2\tau^2}\right)\cos 2\pi f\,(t-t_0)$$

$$f = 576\,\mathrm{Hz},\ \ \tau = 100\,\mathrm{ms}$$

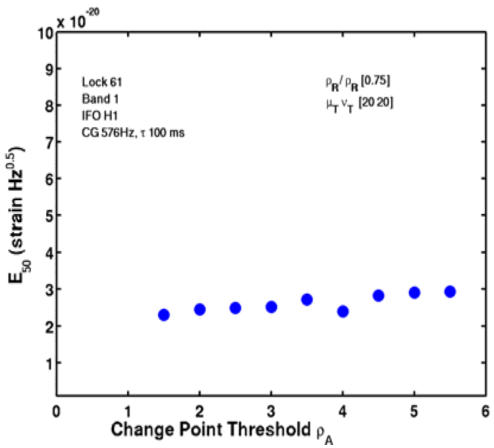
- Fit to sigmoid with parameters for efficiency, false alarm rate

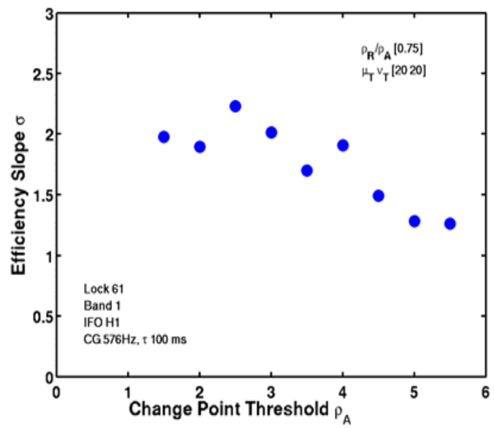
$$\varepsilon(h) = \frac{\varepsilon_0}{2}\left[1+\tanh\left(\sigma \ln\frac{h}{h_{50}}\right)\right](1-\alpha)+\alpha$$



Sensitivity to Change-Point Thresholds

- Use ρ_A trigger for adding change-points
- Use ρ_R trigger for removing change-points
  - » Creates “dead-band” to prevent thrashing
- Sensitivity (E_{50}) depends weakly on ρ_A
- Efficiency steepness (σ) falls with increasing ρ_A
- Sensitivity nearly independent of “dead-band” width $\Delta\rho$





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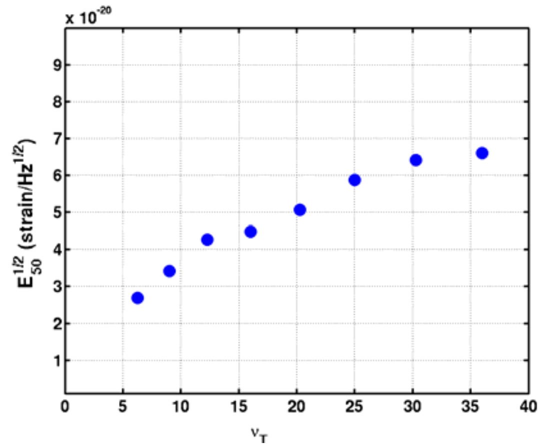
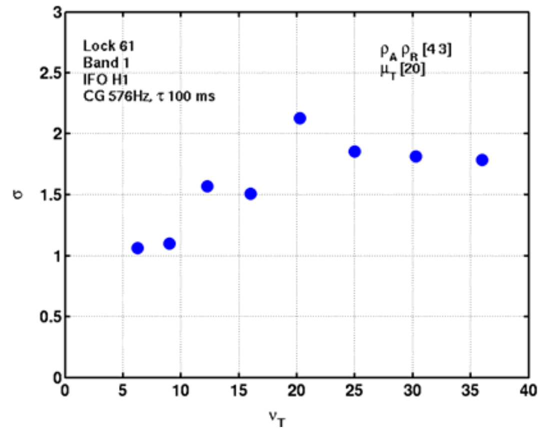
Sensitivity to Event Thresholds

- Blocks become events when
  - » $(\mu - \mu_0)^2 / \nu_0 > \mu_T$ or
  - » $\nu / \nu_0 > \nu_T$
- E_{50} more sensitive to ν_T than to ρ_A
- Steepness σ plateaus with large ν_T
- At thresholds investigated so-far most events from ν_T
  - » Should we balance ν_T, μ_T thresholds for equal # events? Under investigation





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Next Steps

- Complete pipeline implementation
  - » Coincidence, correlation, statistical inference
- Set operating parameters
  - » Tune on coincident/correlated event performance
  - » Characterize behavior over range of signal types
- Discover and understand anomalies on playground
  - » E.g., lock 61 H1 features
- Run over full S2 (and available S3) data for science results