BlockNormal Near-Online S4 Burst Analysis

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https://gravity.psu.edu/~s4

Why Near-Online Analysis for S4?

- BlockNormal pipeline (started for S2) now mature, reviewed
  - ⇒ Review helped identify some data-conditioning issues
- LSC Grid computers would have access to RDS frames within a few hours of acquisition (even on Tier2)
- New utilities (LSCsegFind, LSCdataFind, etc.) improved ability to automate pipelines
  - ⇒ Could set up daily processing pipeline
- Need to prepare now for long-duration science runs (S5, etc.)
  - ⇒ Physics results can't wait for the end of the run

⇒Implement near-online burst analysis for S4

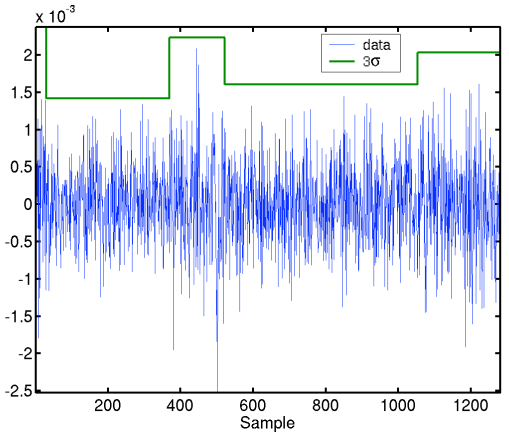
BlockNormal ETG

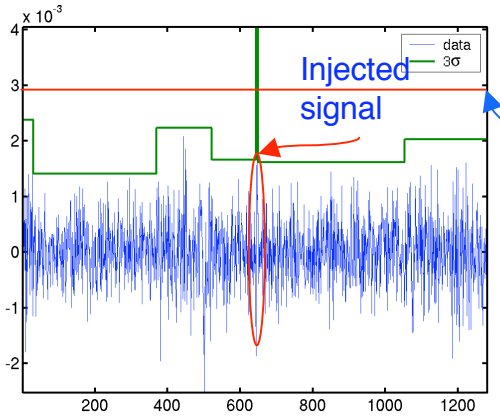
Thresholds:

- Change-Points (ρ_2)
  - » Where variance (σ^2) or mean (μ) changes
  - » Divides data into blocks of ~constant mean & variance
- Events (P_E)
  - » Use relative excess power to select exceptional blocks as events
  - » Threshold relative to characteristics (μ_0,σ_0^2) of stationary epochs

Cluster adjacent events

Use 30ms Coincidence Windows





Changes for S4 Analysis

- Data-Conditioning (Thorne, Summerscales)
  - » Automated band-filter tuning, narrow (Kalman) line-finding
- Vetos (Desai)
  - » Developed Figure-of-Merit to optimize veto selection
  - » Integrated vetos into analysis
- ETG (Stuver)
  - » Found excess power threshold better than event mean/variance
- Distributional Analysis(McNabb, Lin)
  - » Test for statistical difference in amplitude distribution of signal and background distributions
  - » Integrated waveform matching (r-statistics) into analysis

Bayesian Rate Statistic

- Given

# of zero-lag (N)

background rate (b)

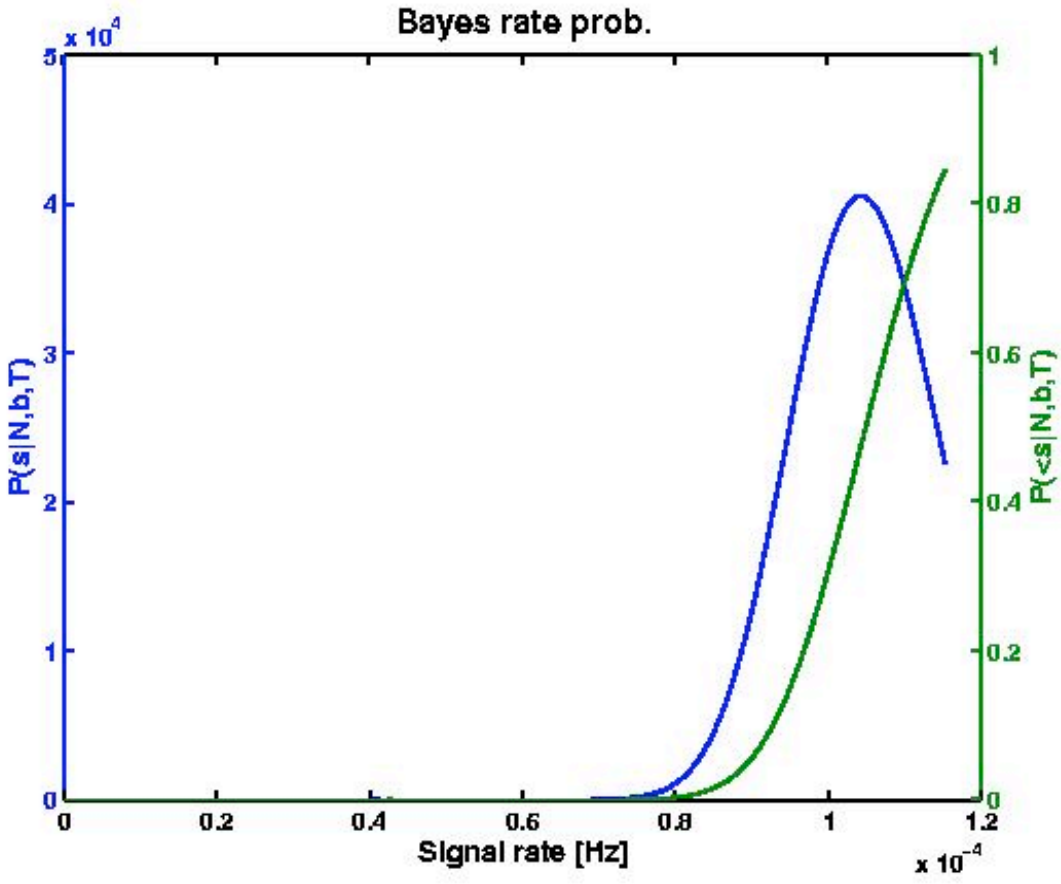
Livetime (T)

Get probability of true signal rate

P(s | N,b,T)

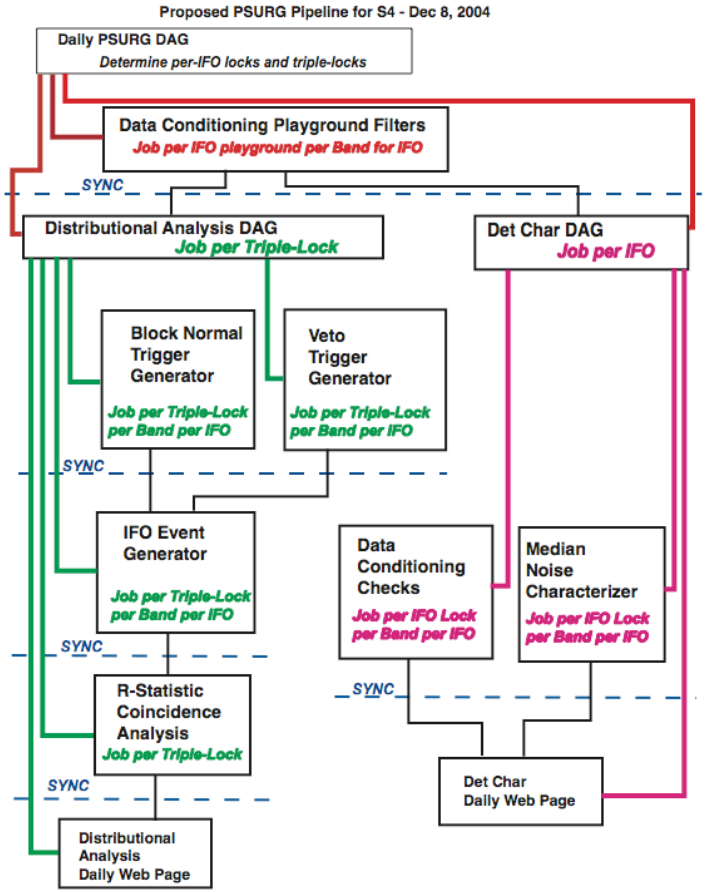
Rate limit probability

P(< s | N,b,T)



S4 Daily Pipeline Design

- Starts about 2 AM each day, is done by ~ 9 AM
- Implemented as condor DAGman pipeline
  - » **Used DAGiT templates (John McNabb) to organizes loops**
- Each step is a shell (csh) script
  - » Calls MATLAB executable as needed
- Could run on any grid with frames from all IFOs
  - » PSU chosen due to MATLAB problem with FedoraCore3



"Original" S4 Run Plan

- First Week - Tune, set thresholds
  - » Data-Conditioning: Decide on filters, do over-all tuning
  - » Vetoes: Decide on veto channels, set thresholds
  - » ETG: Decide on rates, tune, set thresholds
- Remaining Weeks - Analyze data on daily basis
  - » Run pipeline automatically each day
  - » Post automated web-page summaries
  - » Staff 'analysis' shifts to monitor daily processing
- At end of run - Finalize, report initial result
  - » Adding DQ cuts on segments could test for systematic errors

Actual S4 Experience

- External events impacted schedules
  - » Late Installation of LDR Upgrade prevented E12 studies
  - » Instability in segment-finding method
- Only simplest Data-Conditioning Implemented
  - » Band-pass filters, Low-order whitening filters
- Threshold Setting based mostly on background rates
  - » Target source is white-noise bursts 20-30ms duration
  - » Initial thresholds set to avoid any chance of event pile-up in IFO
- Limited bandwidth (6 bands from 96-1024Hz) due to large processing time on bands > 1kHz.
- Initial Veto Channels chosen from S3 studies
- Daily Summary pages not implemented until third week (but have been updated for all days)

Initial S4 Results

- Present thresholds ($\rho_2 > 6$, $P_E > 12$) give very low background at triple-coincidence (~ 3 events / 50 time lags without r-statistic).

  https://gravity.psu.edu/~s4/online/DailySummary.html

  ⇒ Need to back this off for distributional analysis (already have per-IFO event samples at range of thresholds)

- Despite this, high detection rate on hardware injections

  (i.e.< 1e-21 on 235Hz Sine-Gaussian)

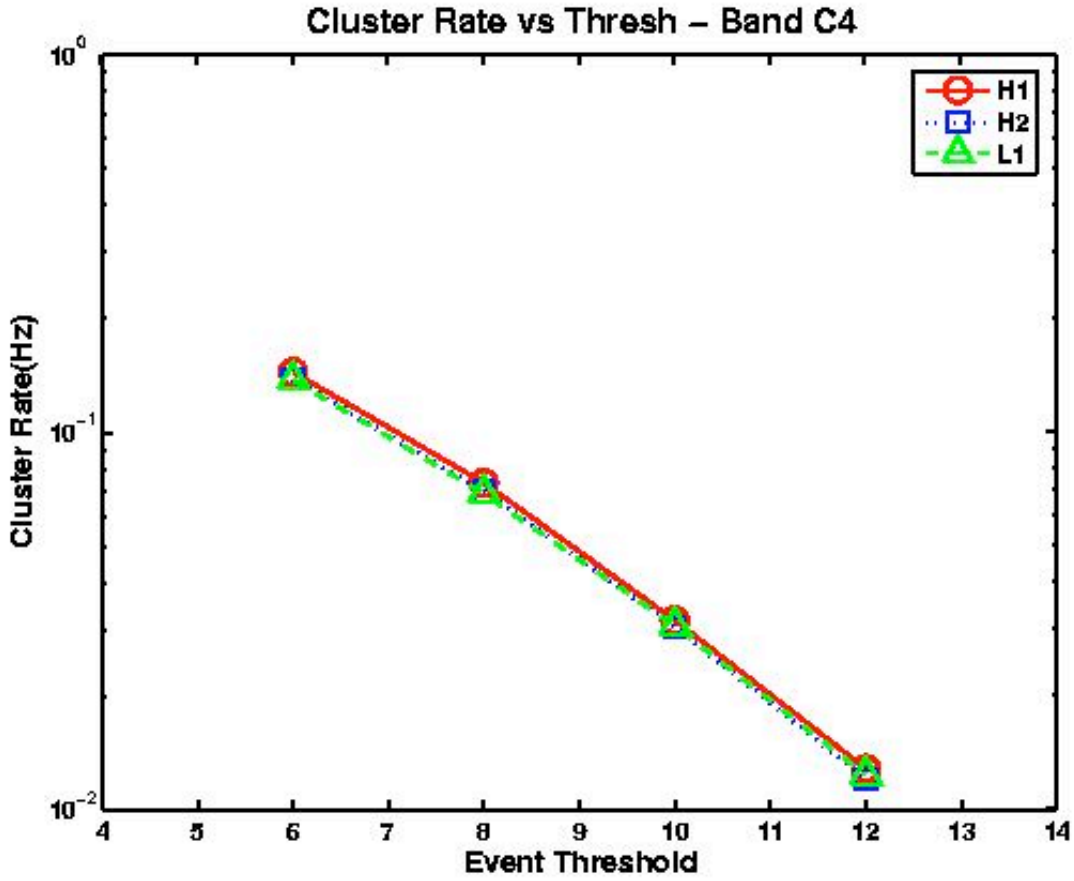
  https://gravity.psu.edu/~s4/online/HW_Injections_Matches.html

  ⇒Clearly a great improvement over S2/S3

Per-IFO Event Rates in S4

- Smooth falloff with threshold

P_E	Predicted Triple-Rate
6	5×10^{-6} Hz
8	2×10^{-6} Hz
10	2×10^{-7} Hz
12	**2×10^{-8} Hz**



Next Steps for S4 Analysis

- Do Software Injections to get detection yield
- Form lower-threshold coincidence sample for distributional analysis
- Check for GRB coincidence with much lower threshold

A Somewhat "Radical" Proposal:

Only add in changes (data-conditioning, DQ cuts) which actually affect detection yield on simulations, or lower background (non-zero-lag) rates.

--> would like to report physics well before S5