Coincidence-based LIGO GW Burst Searches and Astrophysical Interpretation

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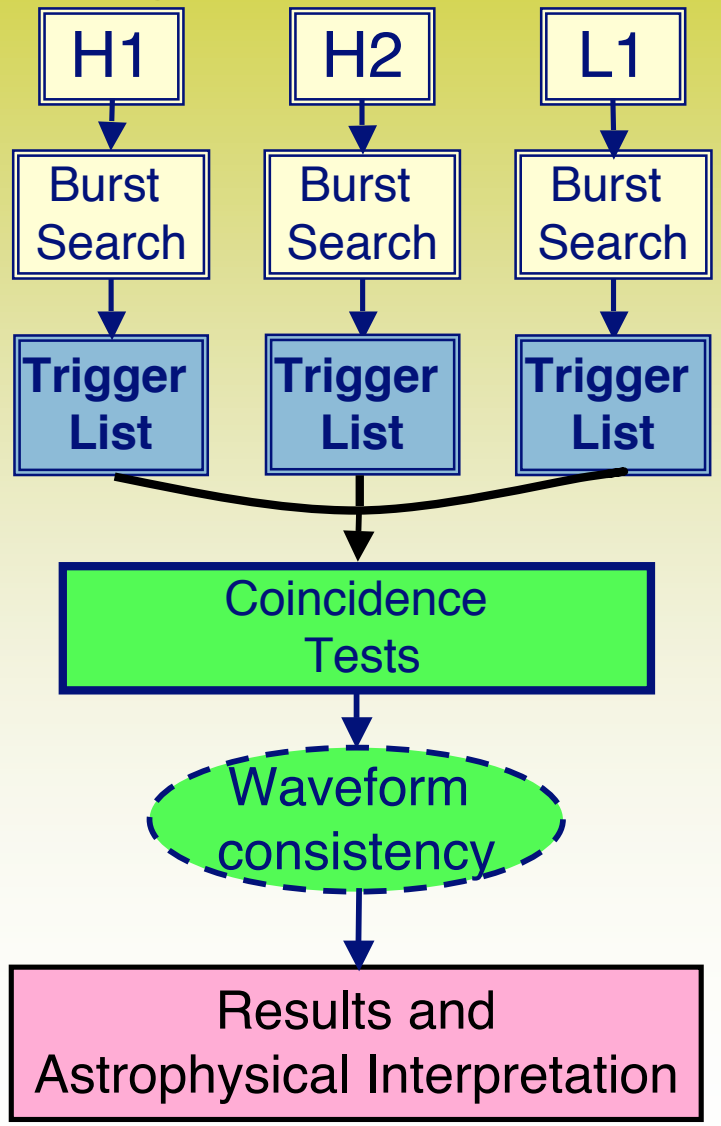
LIGO Coincidence-Based GW Burst Searches

- Used for LIGO all-sky gravitational-wave (GW) burst searches
- Search each detector's time-series data for burst triggers
- Apply time, frequency coincidence tests
- Follow with waveform consistency tests
- Results (upper limit or detection) are basis for astrophysical interpretation of rates



Coincidence-Based Searches in LIGO S5 Run

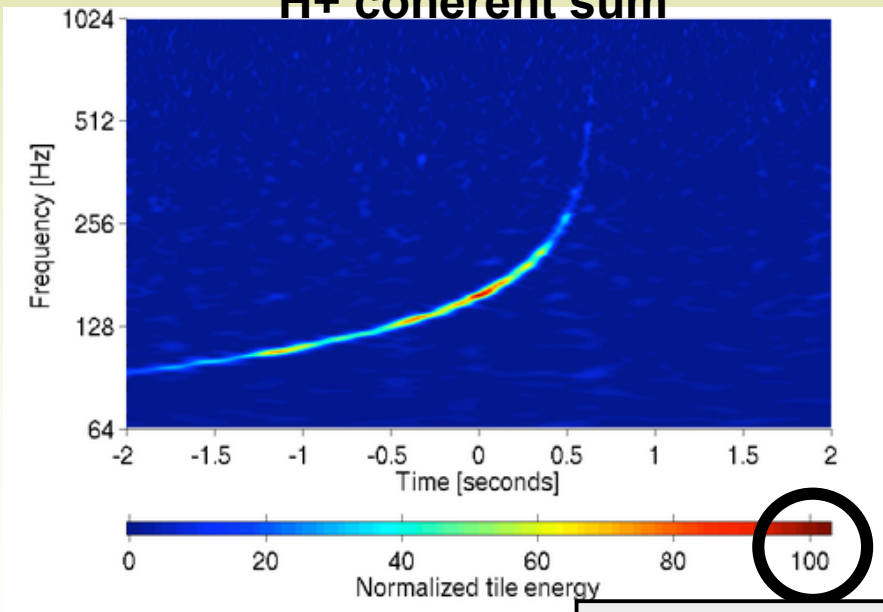
- "WaveBurst" + "CorrPower"
  - Similar pipeline as used in LIGO S4 result (online and offline)
  - Completed through first part of S5 (See L. Cadonati's talk)
- "Q" Pipeline
  - Main search is lower frequency (64 - 1 kHz)
  - Additional high frequency search up to 6 kHz
- "BlockNormal" + "CorrPower"
  - Online pipeline running since beginning of S5
  - Offline pipeline now run on first part of S5
- Excess Power
  - Online search pipeline during S5
- Cosmic String
  - Plan to repeat existing search for cusps of cosmic strings

"Q" Pipeline Search

- Multi-resolution time-frequency search for GW bursts
- Looks for statistically-significant excess signal energy
- Takes advantage of co-located Hanford detectors (H1, H2)
  - Power-weighted "coherent sum" (H+) maximizes signal from GW bursts
  - Differential "null stream" (H-) should be consistent with detector noise
- Search for Livingston (L1) events coincident with H+ events

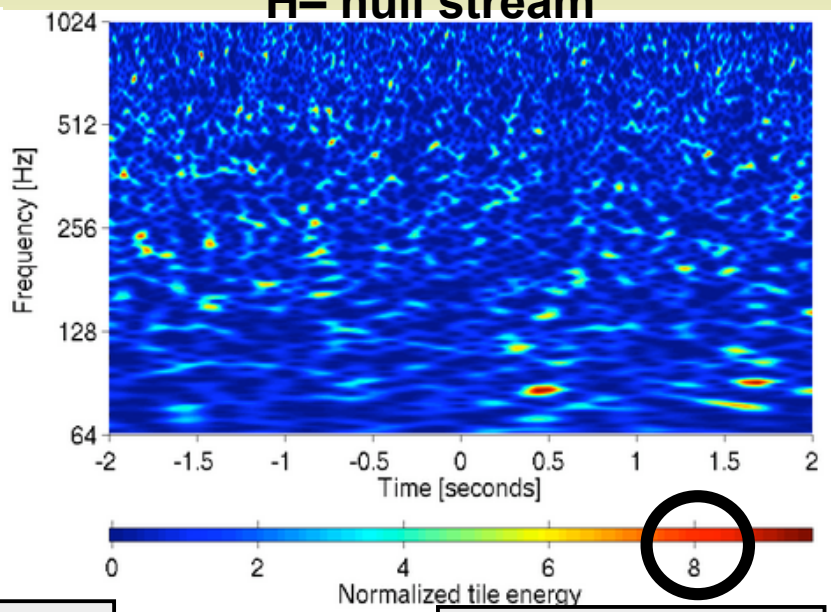
Simulated 1.4/1.4 $M_\odot$ inspiral injected at 5Mpc

H+ coherent sum



~10% increase in SNR

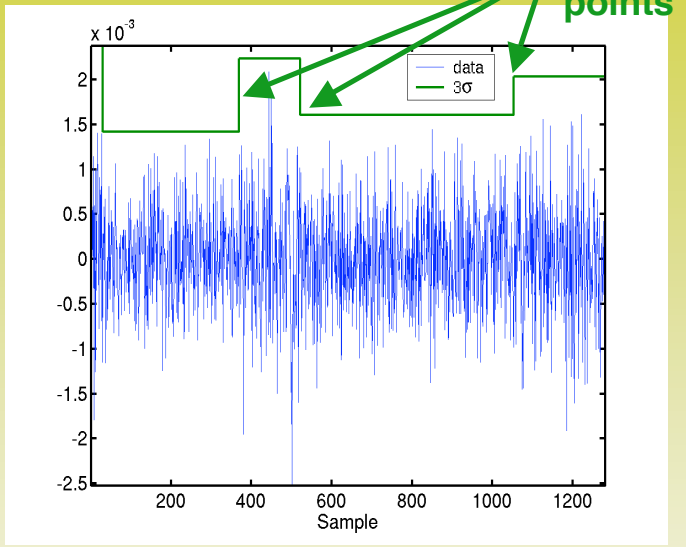
H– null stream

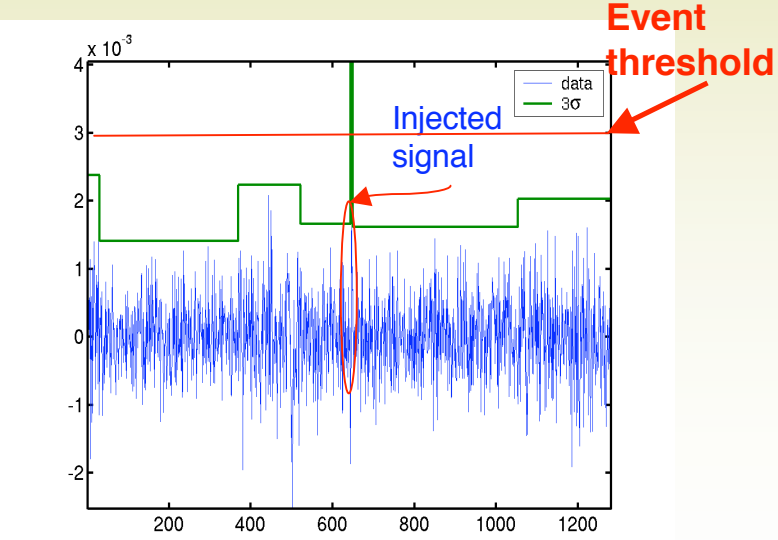


consistent with noise

"BlockNormal" Pipeline

- Identify change-points in mean, variance of time-series data in each detector
- Threshold on excess power in blocks between change-points
- Use multiple frequency bands to provide coarse frequency resolution
- Select coincident triggers with timing, combined power criteria on H1,H2,L1
- Waveform consistency test (CorrPower) then applied to all coincident triggers

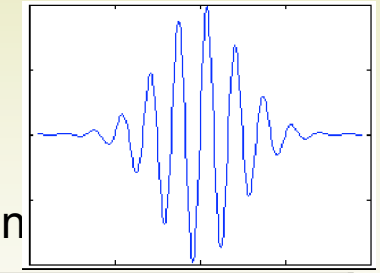




S5A Burst Sensitivity

- Use standard sets of ad hoc waveforms (Sine-Gaussian, etc.)
- WaveBurst search has frequency range 64-1,600 Hz
  - BlockNormal search restricted to >96 Hz
- In S5A, BlockNormal+CorrPower sensitivity approaches that of existing LIGO all-sky burst search (WaveBurst+CorrPower)
- Sensitivity during first five months (Period A) of LIGO S5 run

See L. Cadonati Talk



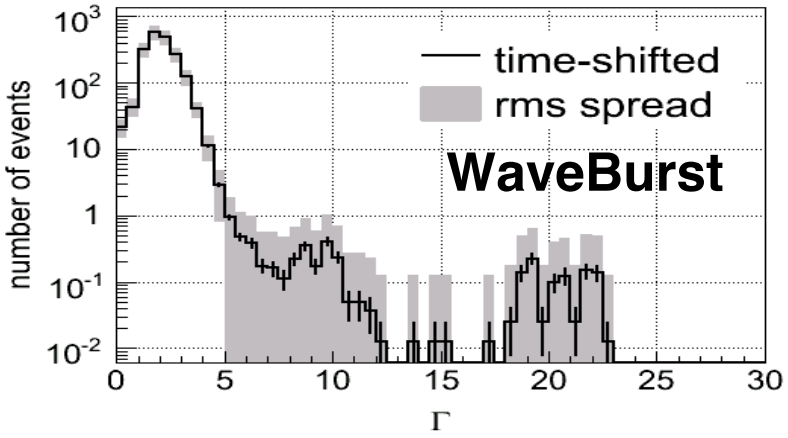
h_{rss} (x 10^{-22}strain/$\sqrt{Hz}$) for 50% detection efficiency of Q=9 Sine-Gaussian

LIGO Burst Search	70Hz	100Hz	153Hz	235Hz	361Hz	553Hz	849Hz	1053Hz
WaveBurst + CorrPower	40	12	6	7	11	12	19	24

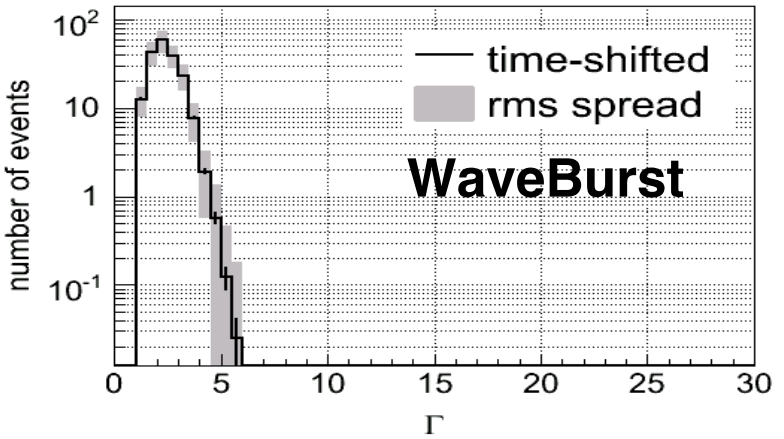
S5A Background Distributions

See L. Cadonati Talk

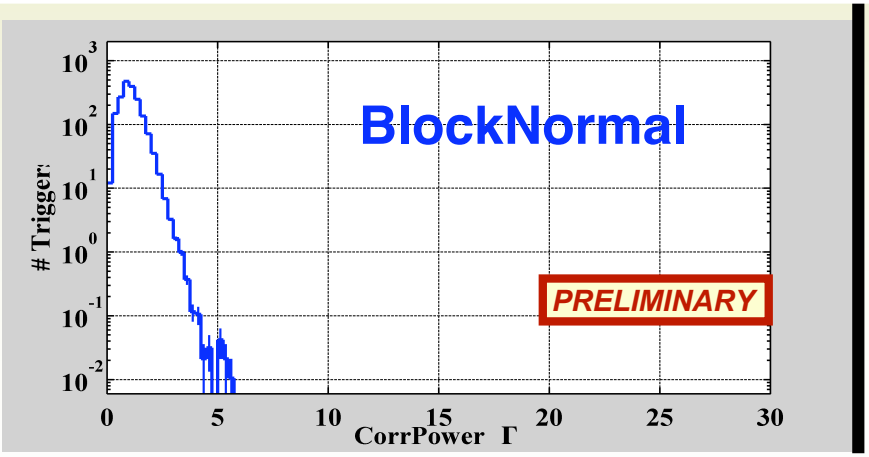
Before CorrPower, DQ Cuts

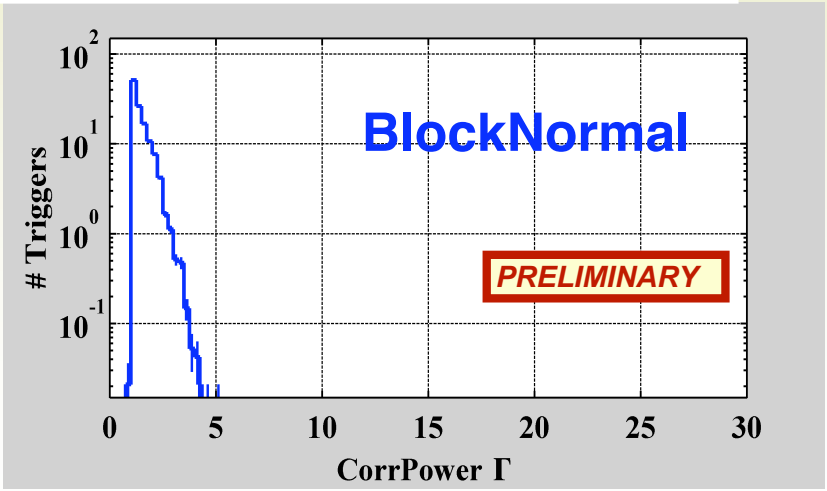


After CorrPower, DQ Cuts



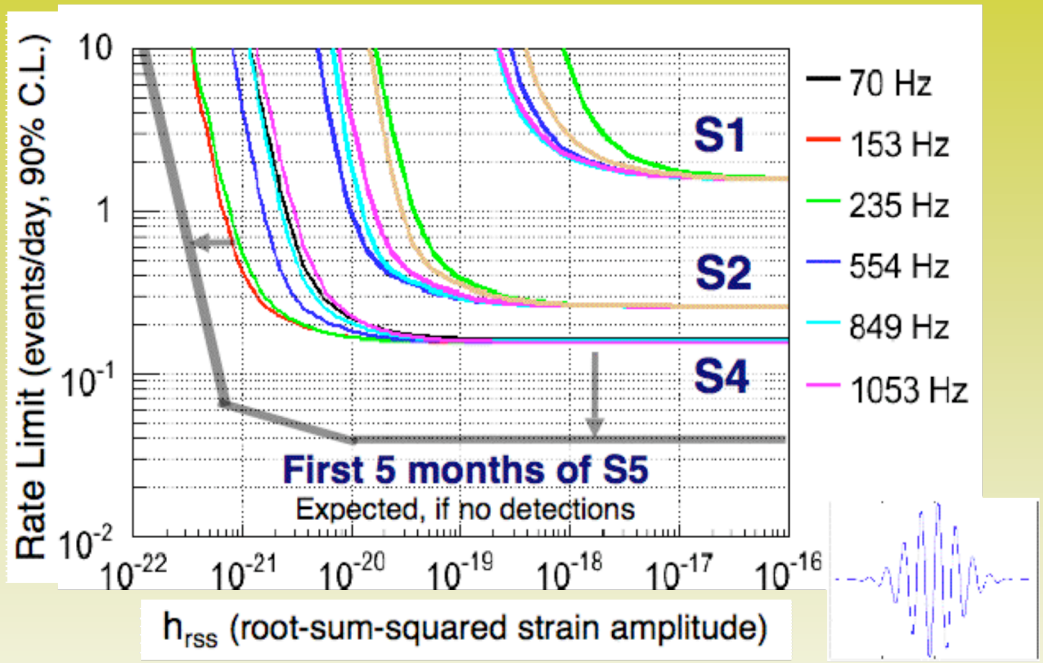
Target False Rate: A few events above CorrPower Γ threshold over the 100 time-lags





Reporting GW Burst Results

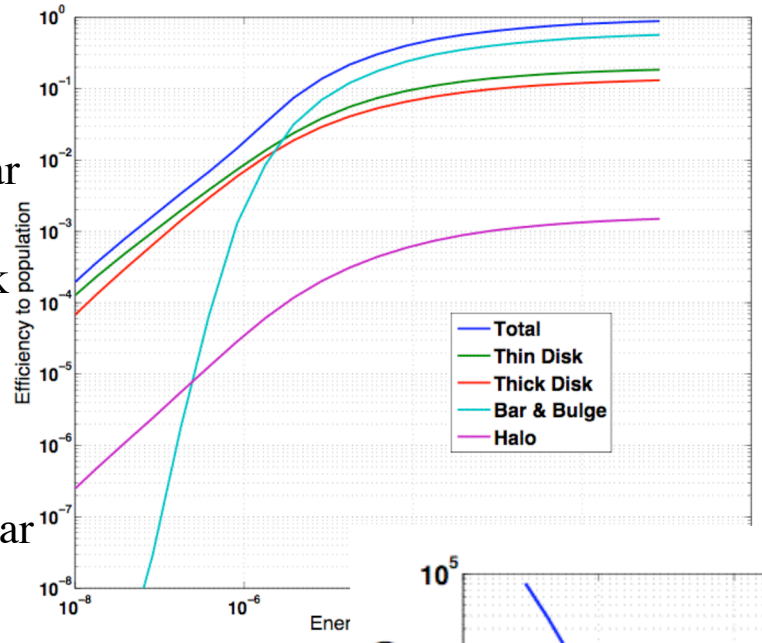
- Detector-centric "Rate vs. Strength" says nothing about sources, rate of source events
  - Rate? Event rate at detector
  - Strength? Measure of wave amplitude at detector
  - "Strength" reveals nothing about source luminosity

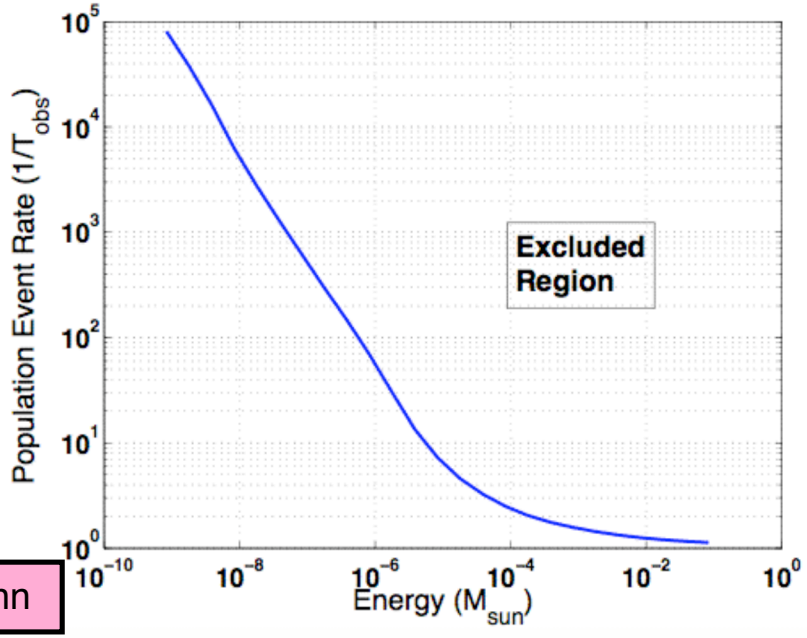


- Better: report rate in population vs. intrinsic energy radiated
- Interpretation (astrophysical or otherwise) is always in terms of a model
- Model components: population (e.g., galactic), source strain energy spectrum (appropriate for burst searches)

Astrophysical Interpretation

- Source population
  - Assume sources trace old stellar population
  - Galactic model (thin disk, thick disk, bulge, bar and halo)
  - Characteristic of white dwarfs
- Source model
  - Impulsive event involving stellar mass compact object (supernovae, AIC,etc.)
  - Axisymmetric source with "standard candle" amplitude
  - Burst has flat spectral density to 1kHz, 10ms duration
- Detectors in this example
  - Virgo, LIGO H1, H2(2Km), L1 with step-function efficiency at strain~10^{-20} $Hz^{-1/2}$ [LIGO S2]





Plots provided by L.S. Finn

Concluding Remarks

- Coincidence-Based Searches remain active at LIGO during S5
  - They will be part of S5 "Full-Year" results
  - Q Pipeline being extended to GEO, Virgo
  - BlockNormal Pipeline plans on adding Virgo for joint run
- These provide an alternative to "coherent network" methods
  - Diversity of approaches will ensure robust detection of GW Bursts
  - May simplify combining of LIGO and Virgo pipeline search results
- Astrophysical Interpretation of GW Burst Results will improve their relevance and accessibility to the astronomical community