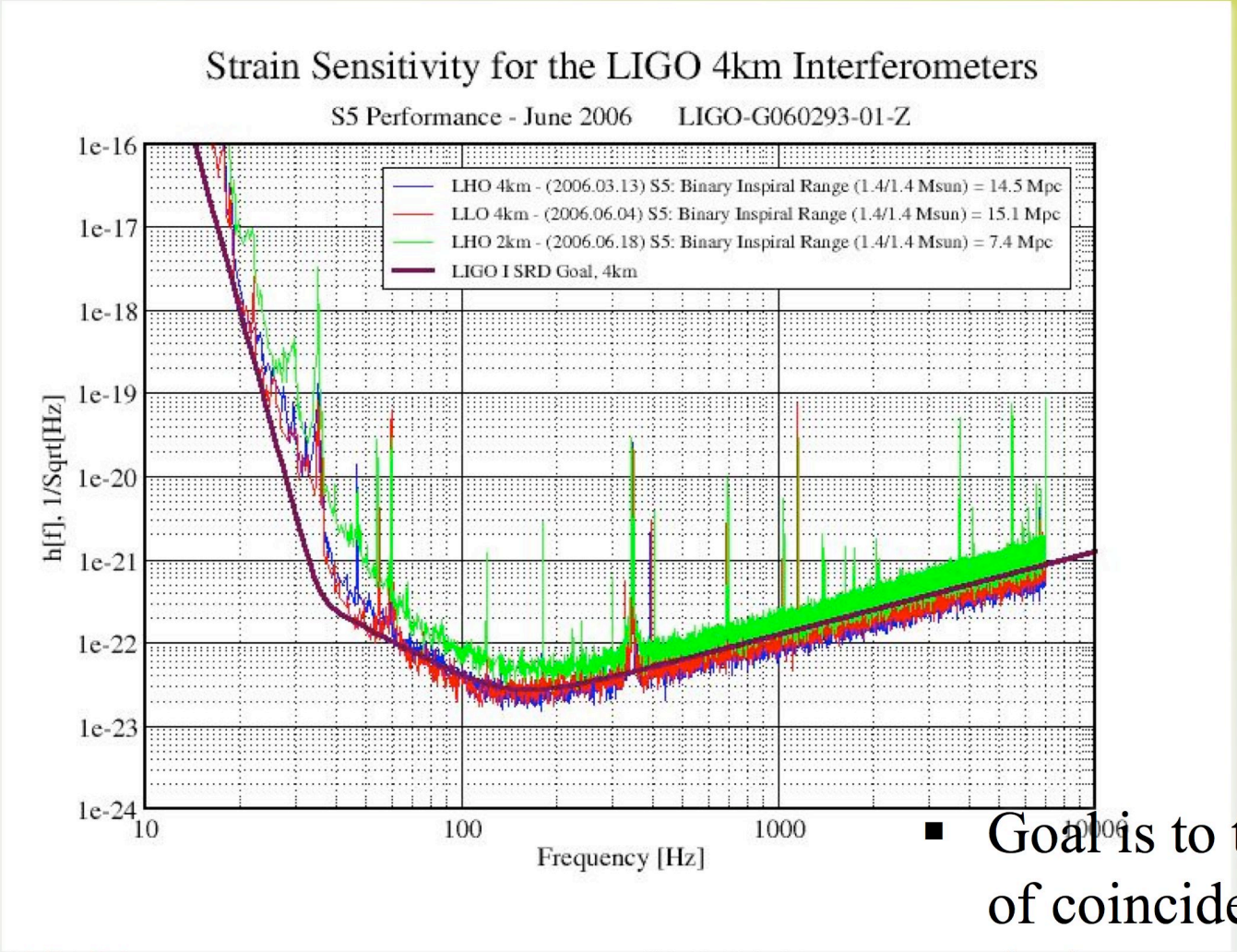
All-Sky Search for Gravitational Wave Bursts during the 5th LIGO Science Run

Brian O'Reilly (LIGO-Caltech)

for the LIGO Scientific Collaboration

11th Gravitational Wave Data Analysis Workshop

S5: The Fifth LIGO Science Run



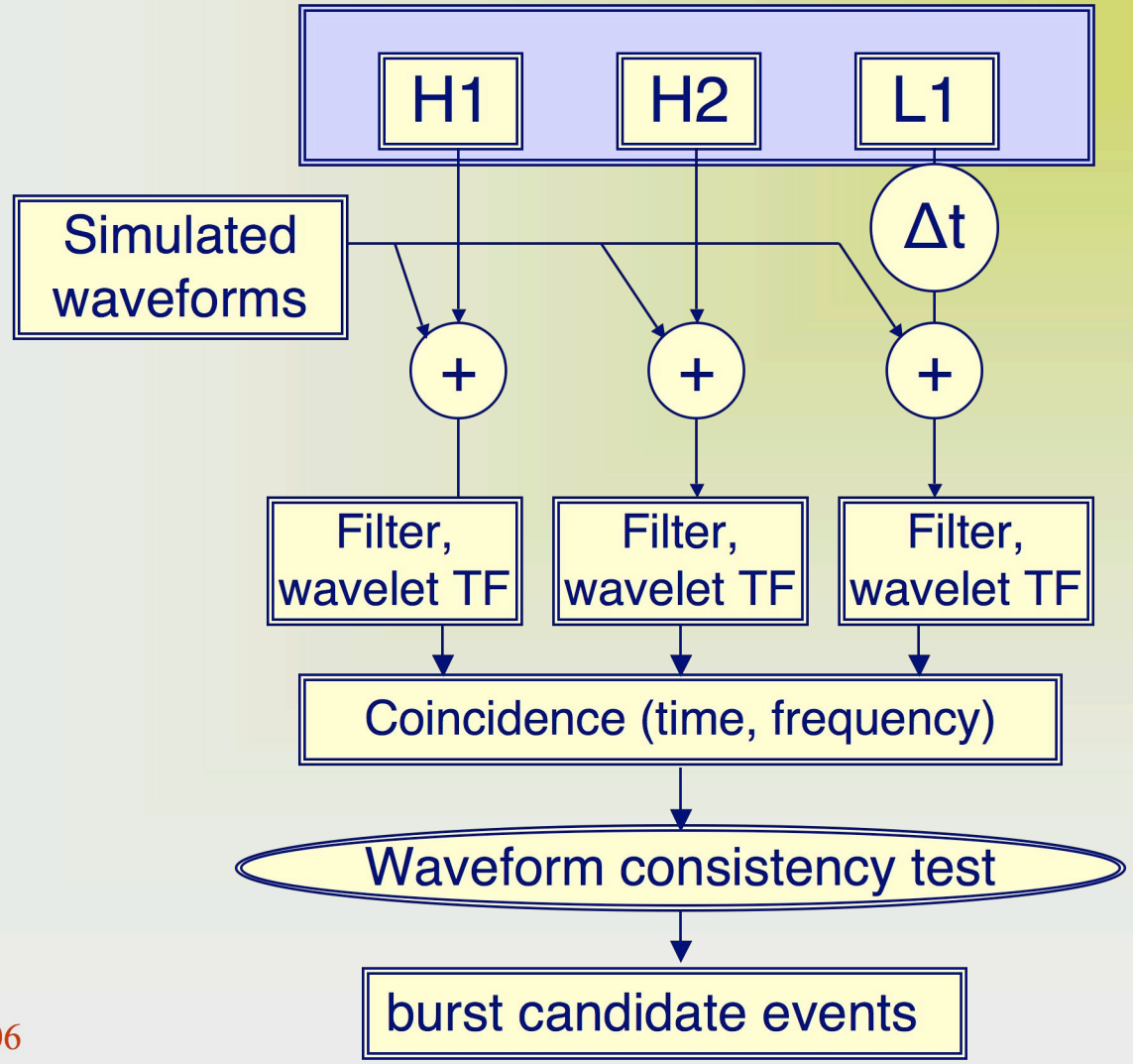
- Goal is to take one year of coincident data at design sensitivity.

Data analysis pipeline

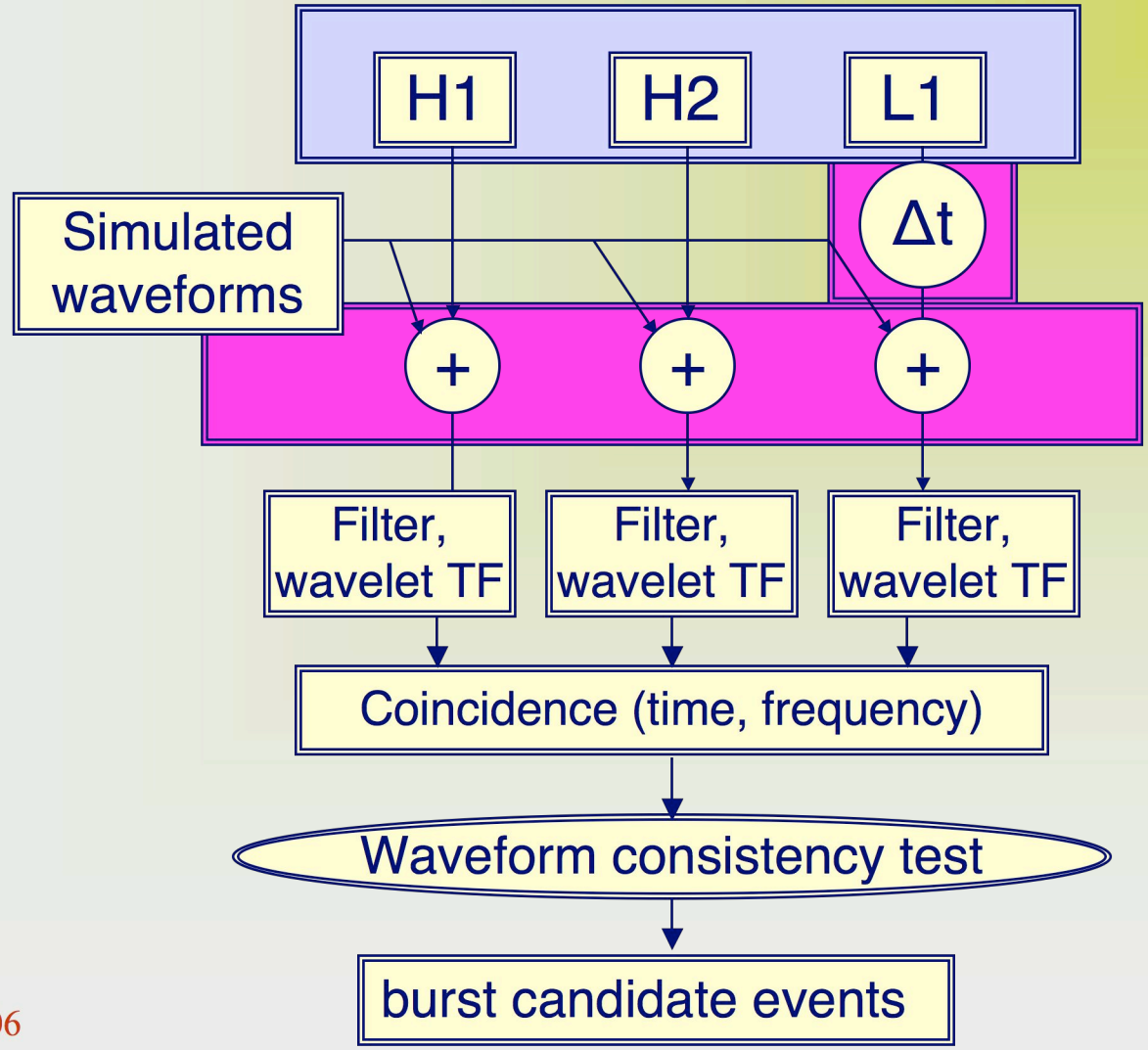
- Almost the same burst search pipeline as was used for S4.
  - Meyer wavelets
  - data-conditioning - linear predictor error filter for line removal
  - New analysis cuts in the post processing of candidates.

- We have an online high threshold analysis (HTA) and an offline final low threshold analysis (LTA):
  - HTA:
    - Quickly learn about obvious loud events;
    - Detector characterization, helps identify and correct problems.
    - Minimal post-processing.
  - LTA:
    - Once all the data quality (DQ) cuts and vetoes are defined (months after data is collected), we do the final LTA.

Burst All-Sky Pipeline



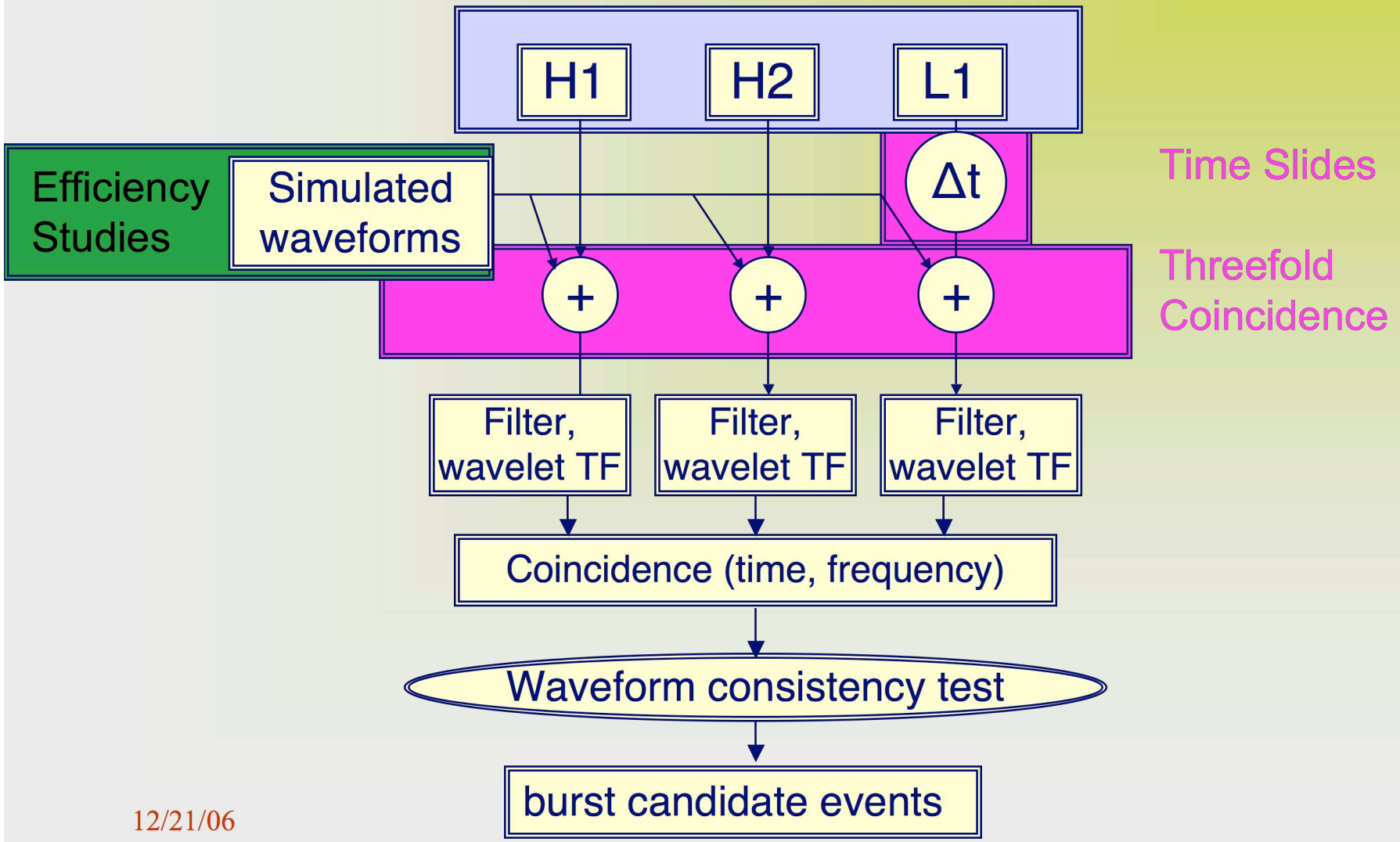
Burst All-Sky Pipeline



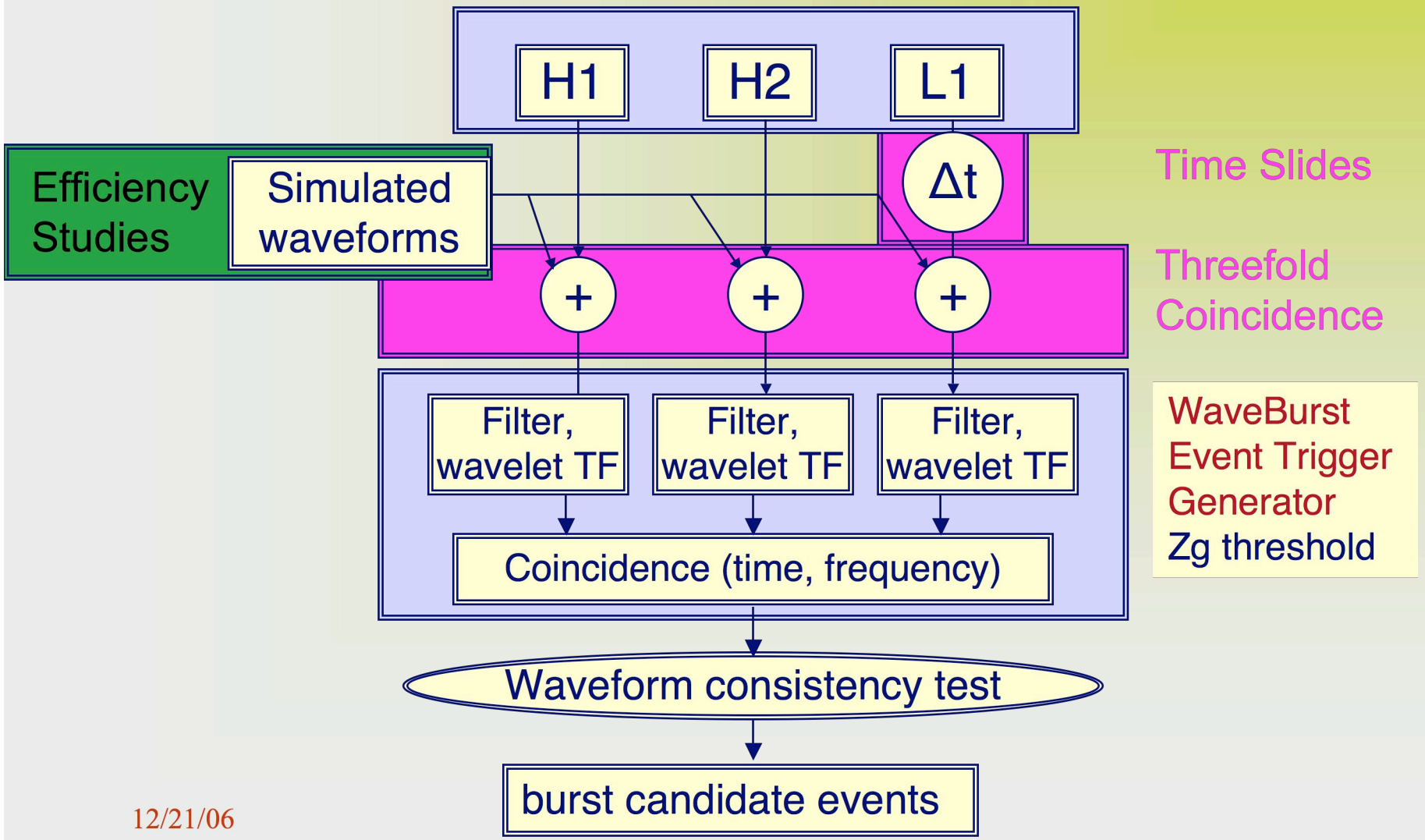
Time Slides

Threefold Coincidence

Burst All-Sky Pipeline



Burst All-Sky Pipeline

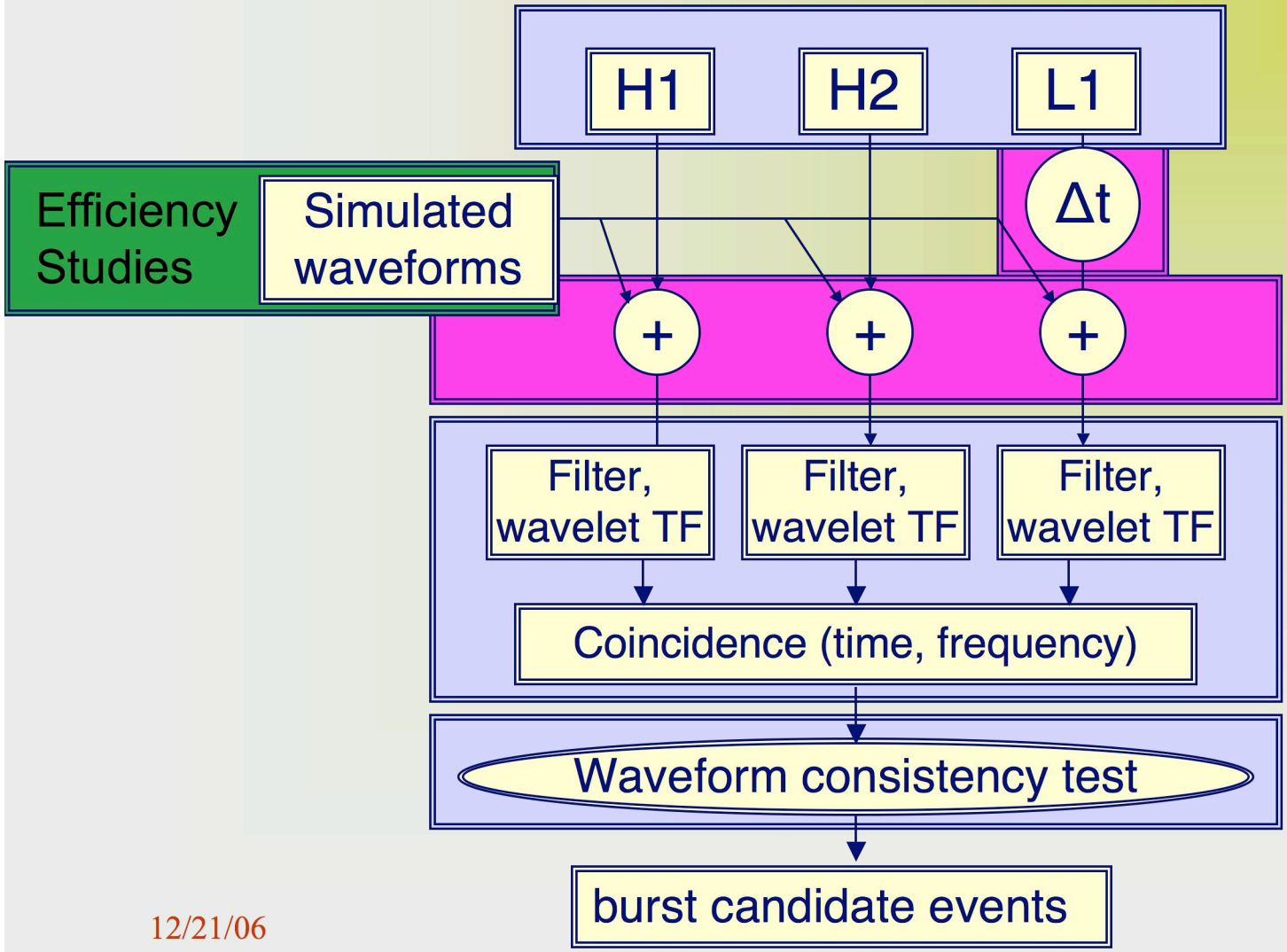


Time Slides

Threefold Coincidence

WaveBurst Event Trigger Generator
Zg threshold

Burst All-Sky Pipeline



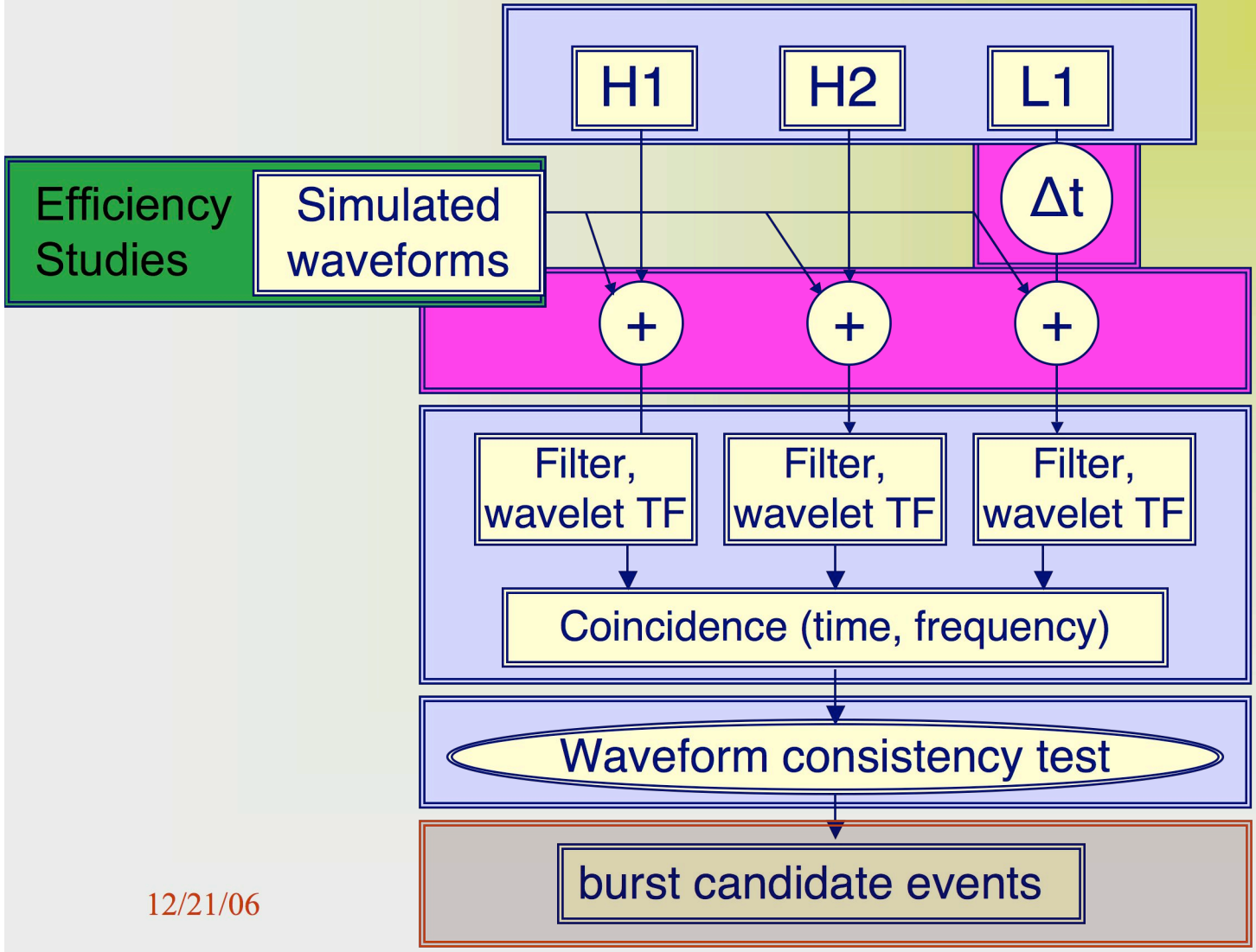
Time Slides

Threefold Coincidence

WaveBurst Event Trigger Generator
Zg threshold

CorrPower r-statistic test
Γ threshold

Burst All-Sky Pipeline



Time Slides

Threefold Coincidence

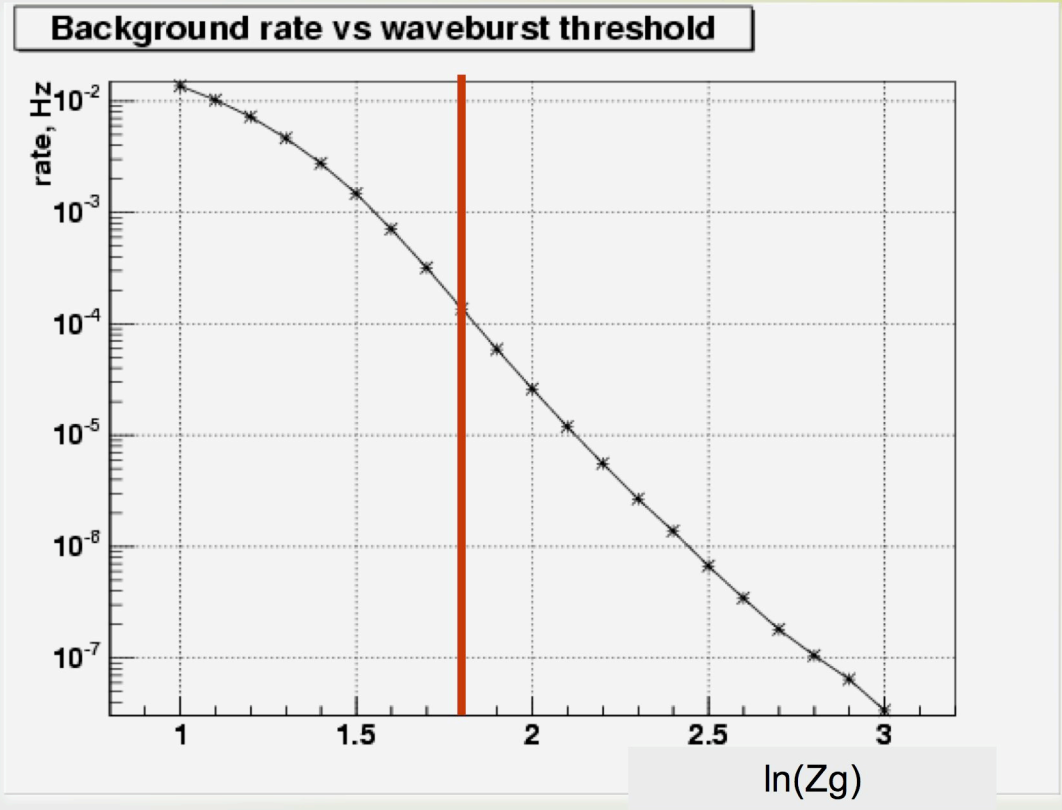
WaveBurst Event Trigger Generator
Zg threshold

CorrPower r-statistic test
Γ threshold

Low Threshold Analysis

- Performed on data obtained between Nov-17-2005 and Apr-3-2006.
- Uses preliminary calibrated strain, h(t)
- A minimal set of Data Quality flags was used for initial data selection.
- r-statistic test: Data cross-correlated using CorrPower at the time of WaveBurst triggers.

WaveBurst Triggers



- Reject triggers that are not in the range 64-1600 Hz
- Cluster triggers that lie within 0.2 second of each other.
- Require Zg ≥ 6.0

Data Quality Cuts

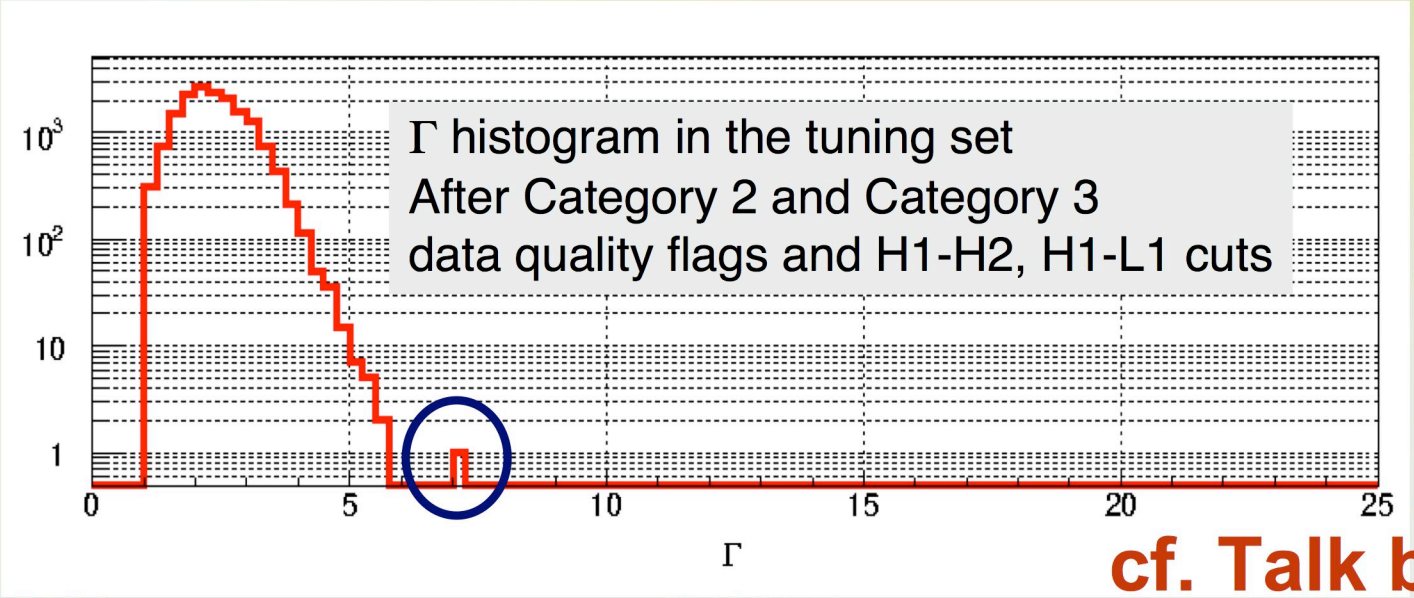
Category 1	Minimal Data Quality flags, for the selection of data segments to be analyzed
Category 2	Unconditional Post Processing flags: data is unreliable at these times and there is an established correlation with loud glitches. These flags are to be used both for upper limits and candidate detections (although we should always look at anything we reject)
Category 3	Conditional Post Processing flags: to be used in upper limit, because there is proven correlation. We should look for detection candidates in these periods though, and if we find any, include the fact there is a Cat 3 veto in our confidence level.
Category 4	Advisory flags: we do not use them in the upper limit, because they are too expensive or because the correlation with single-ifo glitch or triple accidentals is consistent with random. We will look for detection candidates in these periods as well, and if we find any, include the fact there is a Cat 4 veto in our confidence level.

Category 1	H1,H2,L1 OUT_OF_LOCK L1 AS_TRIGGER H1,H2,L1 INJECTION *using the union (OR) of version V0 and V1* H1,H2,L1 CALIB_DROPOUT_1SAMPLE H1,H2,L1 CALIB_DROPOUT_1SEC L1 CALIB_DROPOUT_BN H1,H2,L1 CALIB_DROPOUT_AWG_STUCK H1,H2,L1 CALIB_GLITCH_ZG H1,H2,L1 PD_Overflow H1,H2,L1 MASTER_OVERFLOW_LSC
Category 2	MASTER_OVERFLOW_ASC, ASI_CORR_OVERFLOW, MASTER_OVERFLOW_SUS_RM, CALIB_BAD_COEFFS_60,H2:OSEM_GLITCH,H2:MMT3_OPTLEVER,POWMAG
Category 3	All seismic flags (available now: L1:TRAIN_LIKELY and H1:SEISMIC_EY_99PCTL_3_10HZ), LIGHTDIP, PRELOCKLOSS_60
Category 4	L1:BAD_SENSING, H1H2:CHECKSUM_MISMATCH, L1:MASTER_OVERFLOW_SUS_MC2. H1H2:WIND_OVER_30MPH

cf. Talk by L. Cadonati

Event-By-Event AuxChan Veto

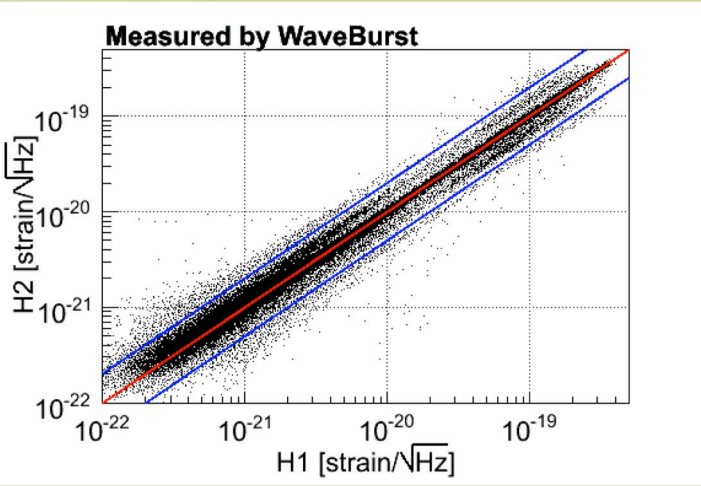
- Decided *a priori*, based on efficiency at vetoing loud single-interferometer triggers.
  - LLO: 60 environmental and 45 interferometric
  - LHO: 29 environmental and 44 (H1) / 44 (H2) interferometric
  - Deadtime 1.6%
- The event at highest Γ after Category2+Category3 is vetoed

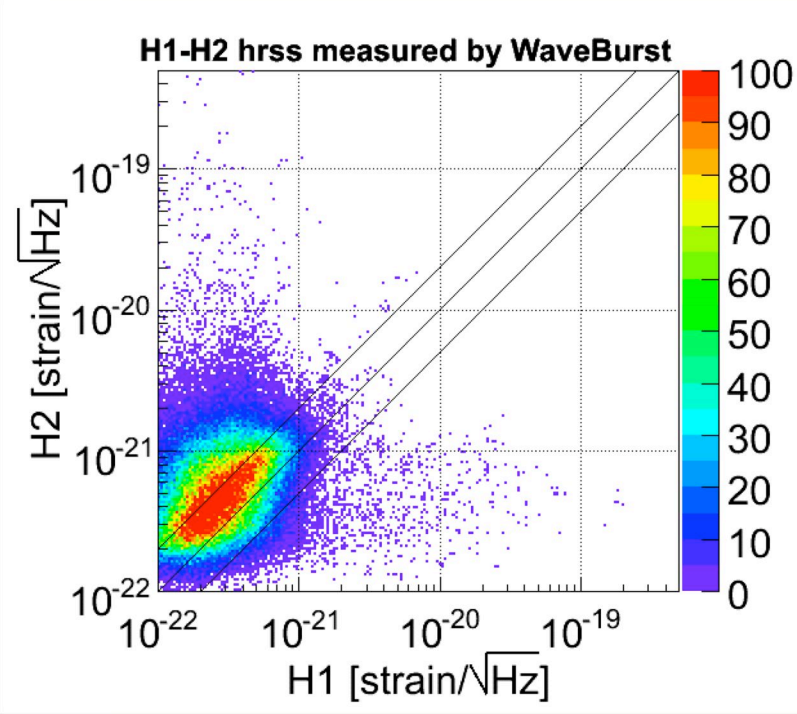


cf. Talk by E. Katsavounidi

H1-H2 Consistency Checks

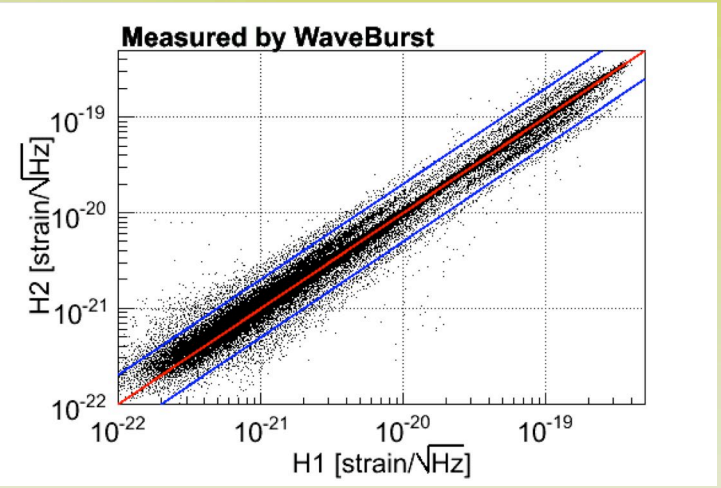
Simulations: SG Q=8.9,3

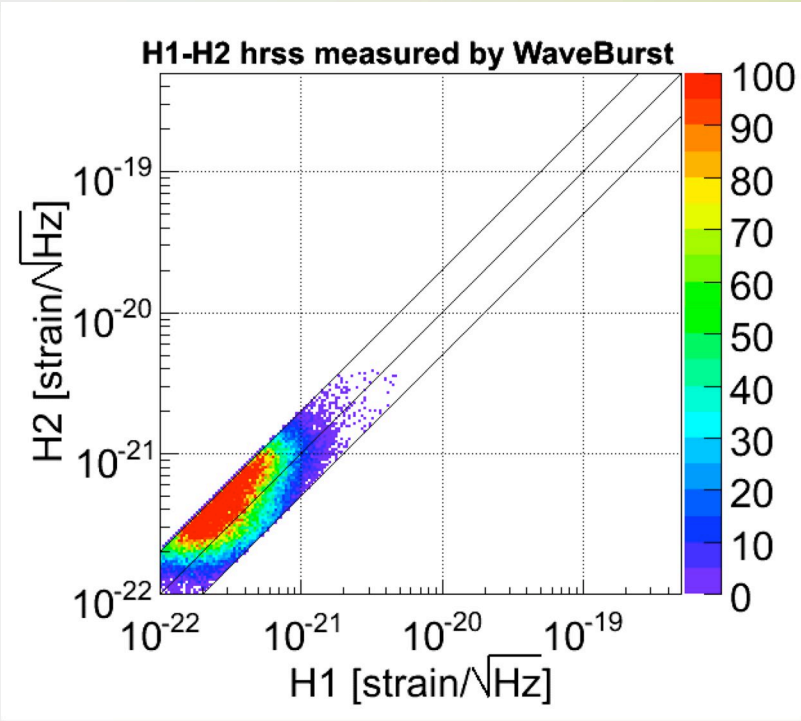




H1-H2 Consistency Checks

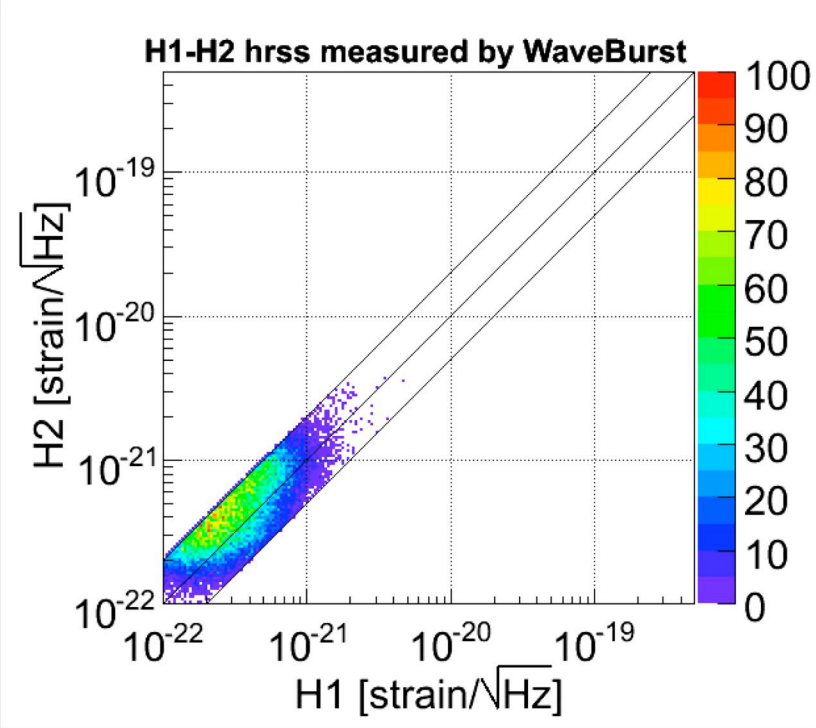
Simulations: SG Q=8.9,3



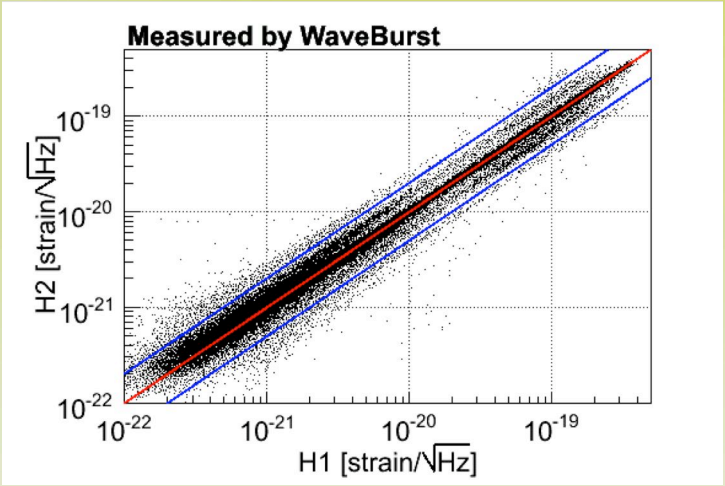


- Estimated amplitudes must agree within a factor of two.

H1-H2 Consistency Checks



Simulations: SG Q=8.9,3

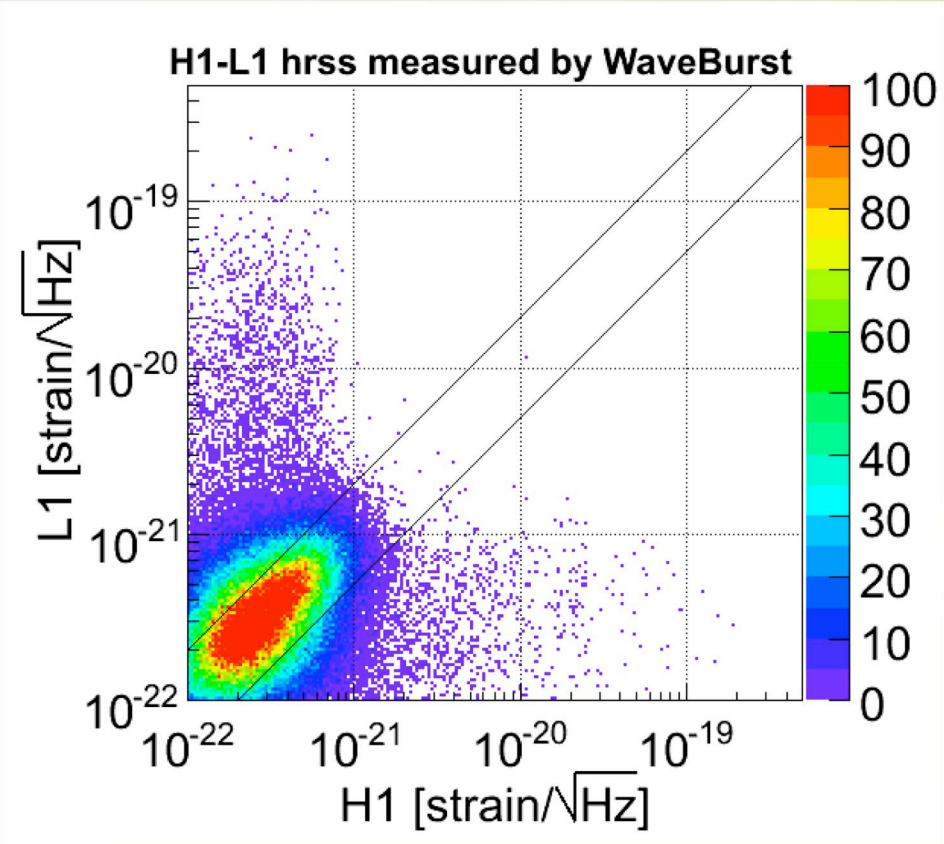


- Estimated amplitudes must agree within a factor of two.

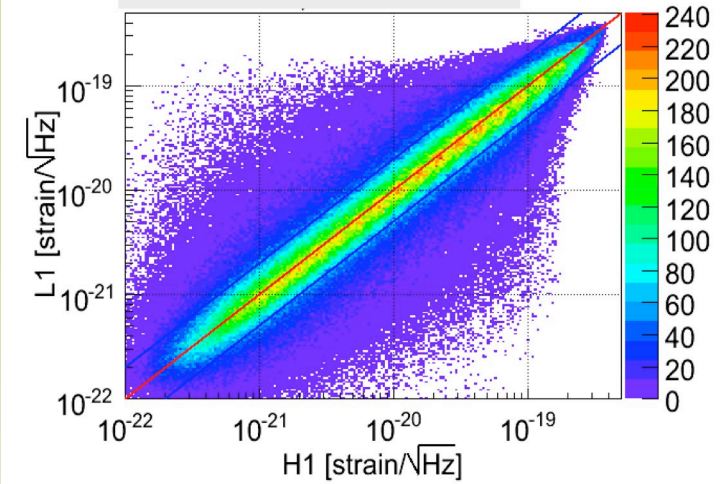
AND

- Signals must be positively correlated.

L1-H1 Checks

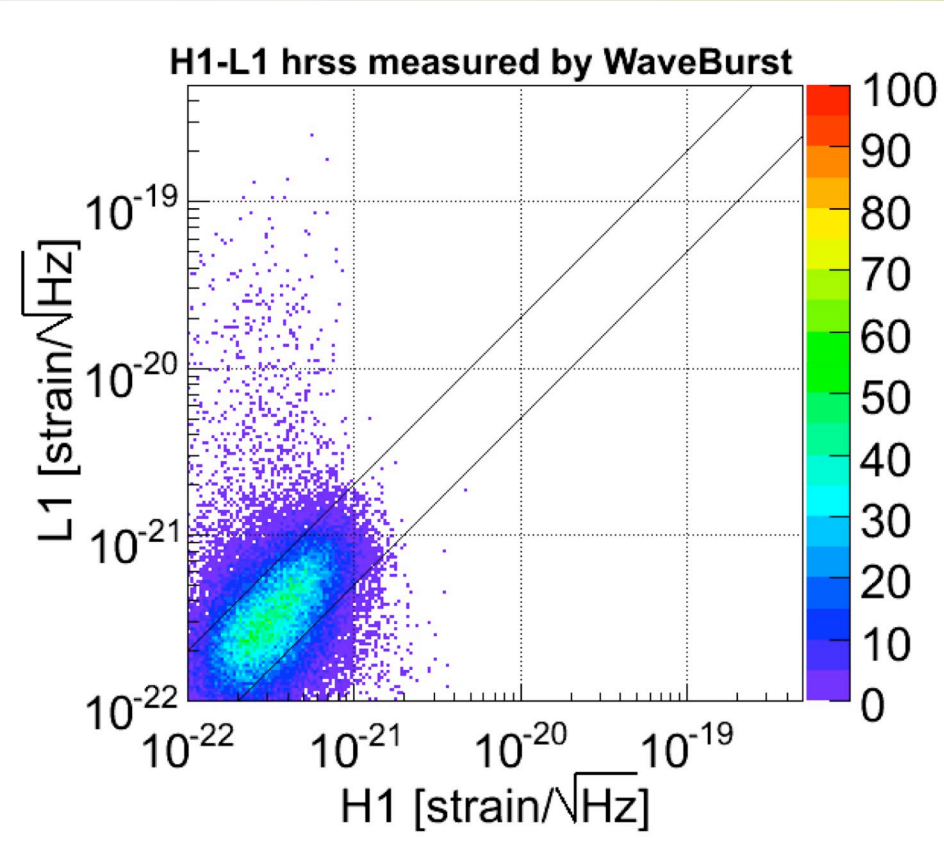


Simulations: SG Q=8.9,3

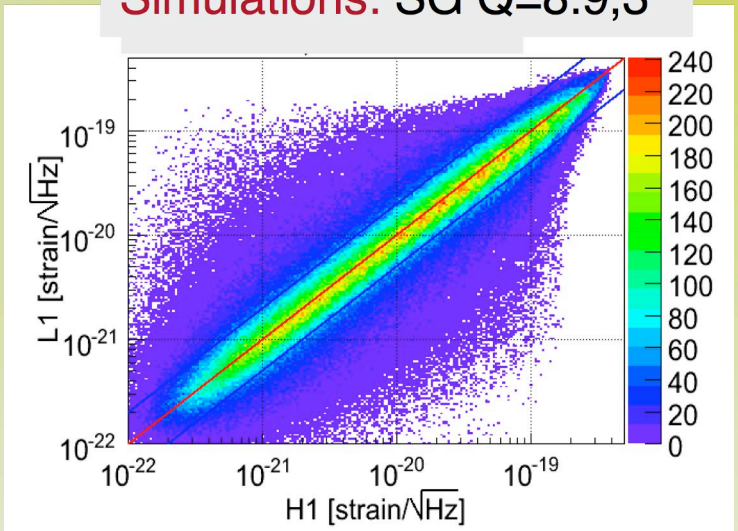


- Require $\Gamma_{H1L1} > 3$ (less than 0.1% probability to get the measured linear cross-correlation from uncorrelated noise at L1 and H1)

L1-H1 Checks

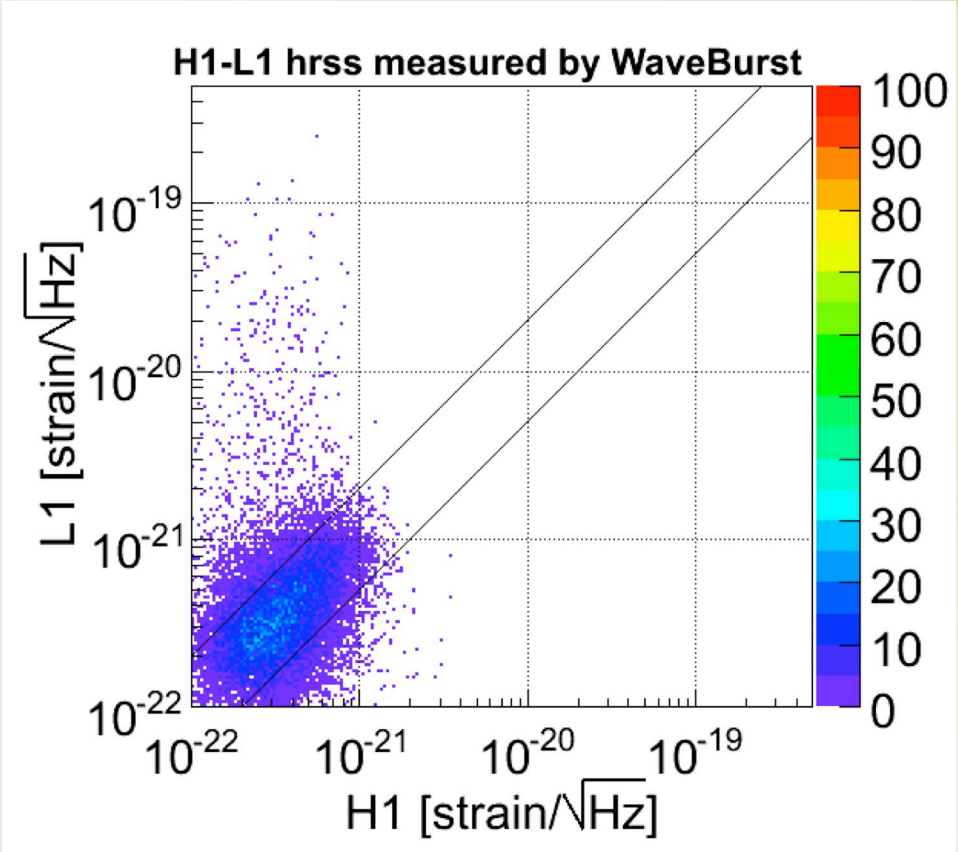


Simulations: SG Q=8.9,3

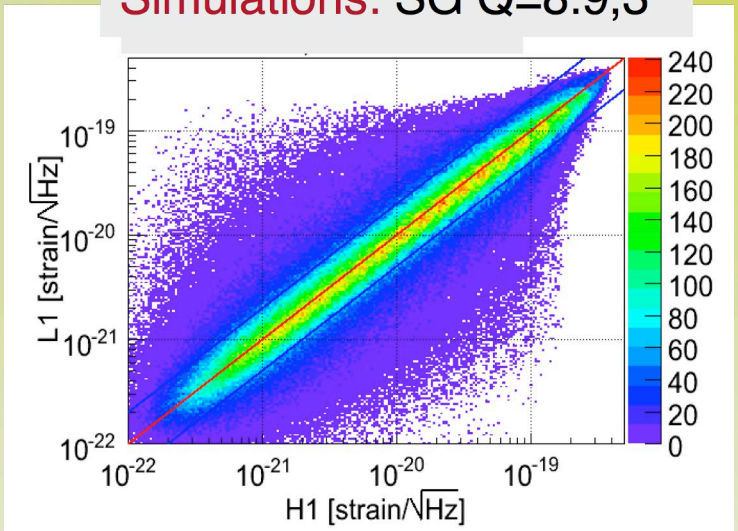


- Require $\Gamma_{H1L1} > 3$ (less than 0.1% probability to get the measured linear cross-correlation from uncorrelated noise at L1 and H1)

L1-H1 Checks



Simulations: SG Q=8.9,3

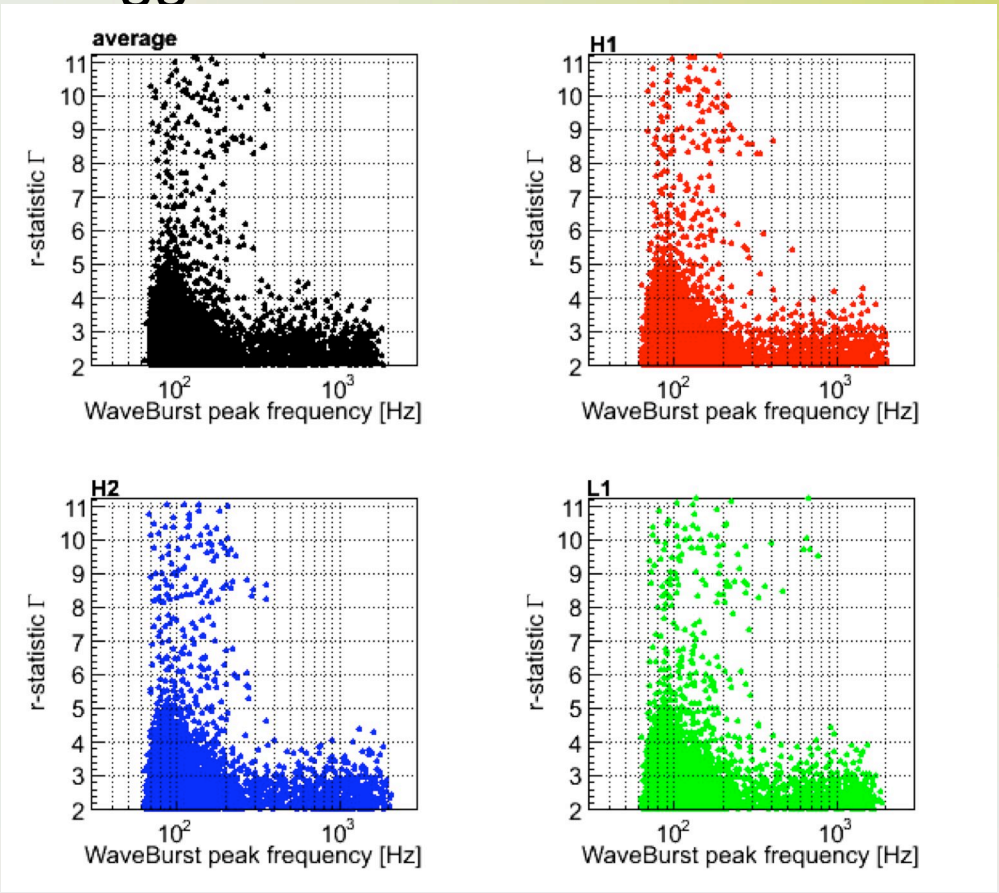


- Require $\Gamma_{H1L1} > 3$ (less than 0.1% probability to get the measured linear cross-correlation from uncorrelated noise at L1 and H1)

Effect of Cuts

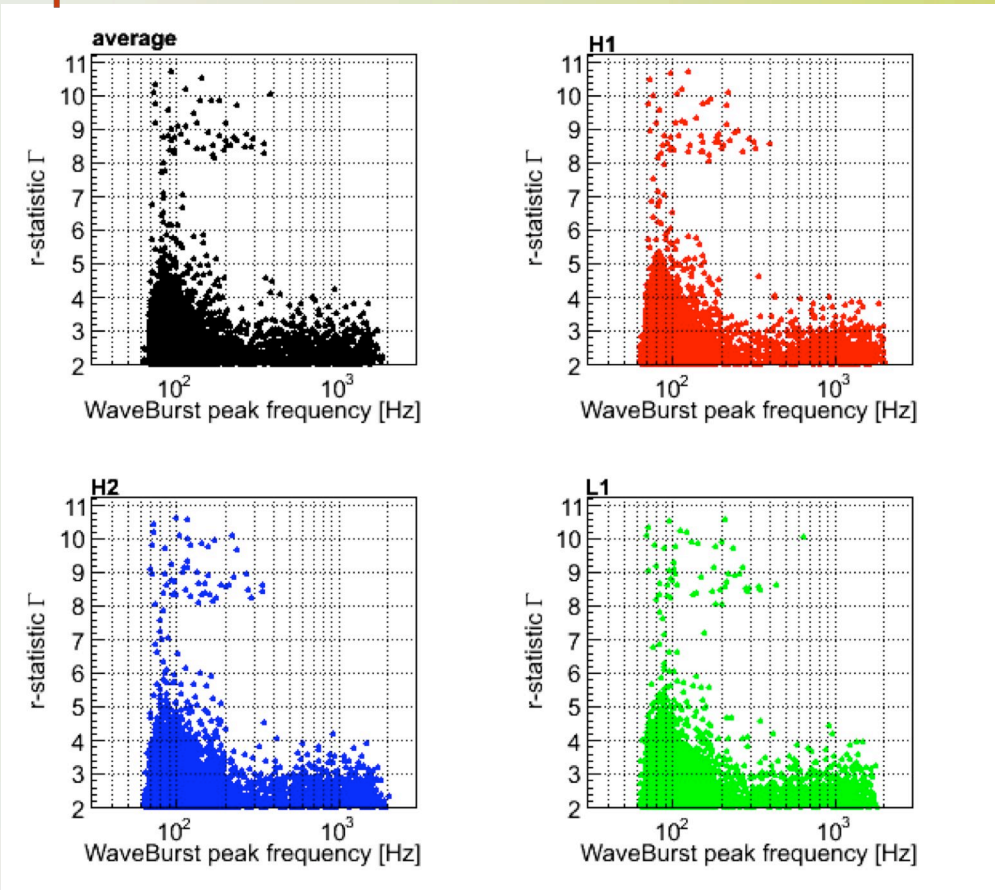
Effect of Cuts

All WB Triggers



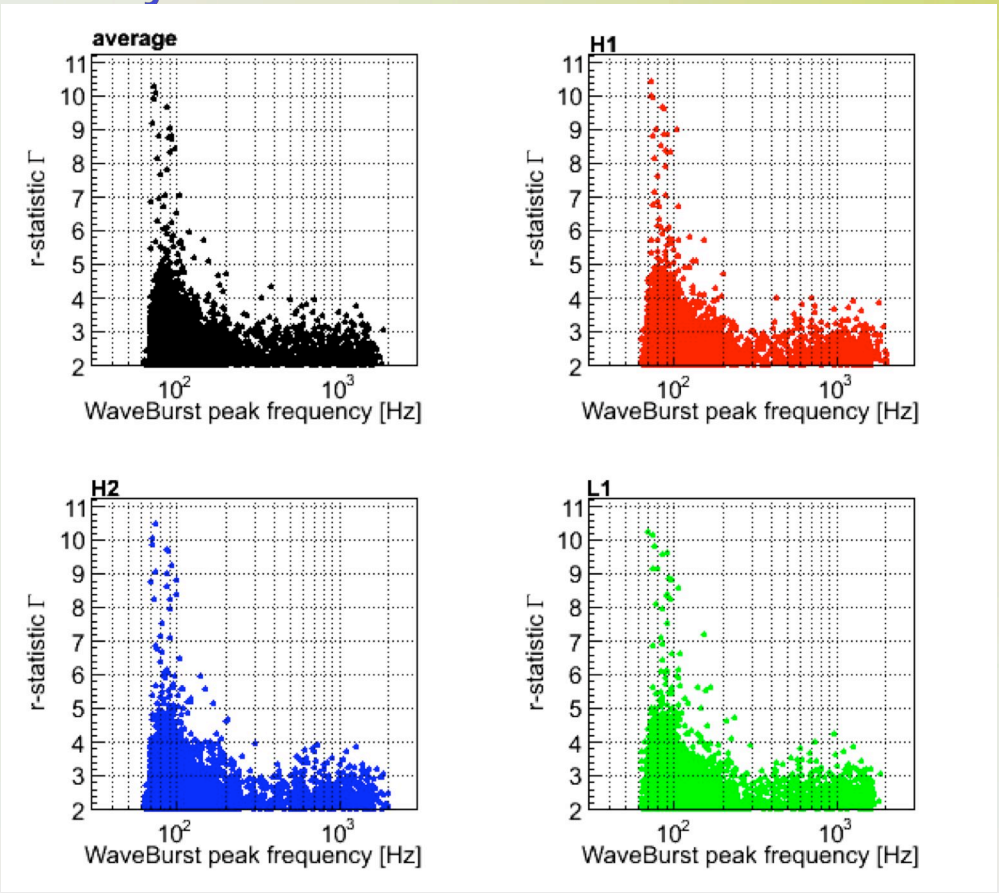
Effect of Cuts

H1-H2 Amplitude Cut



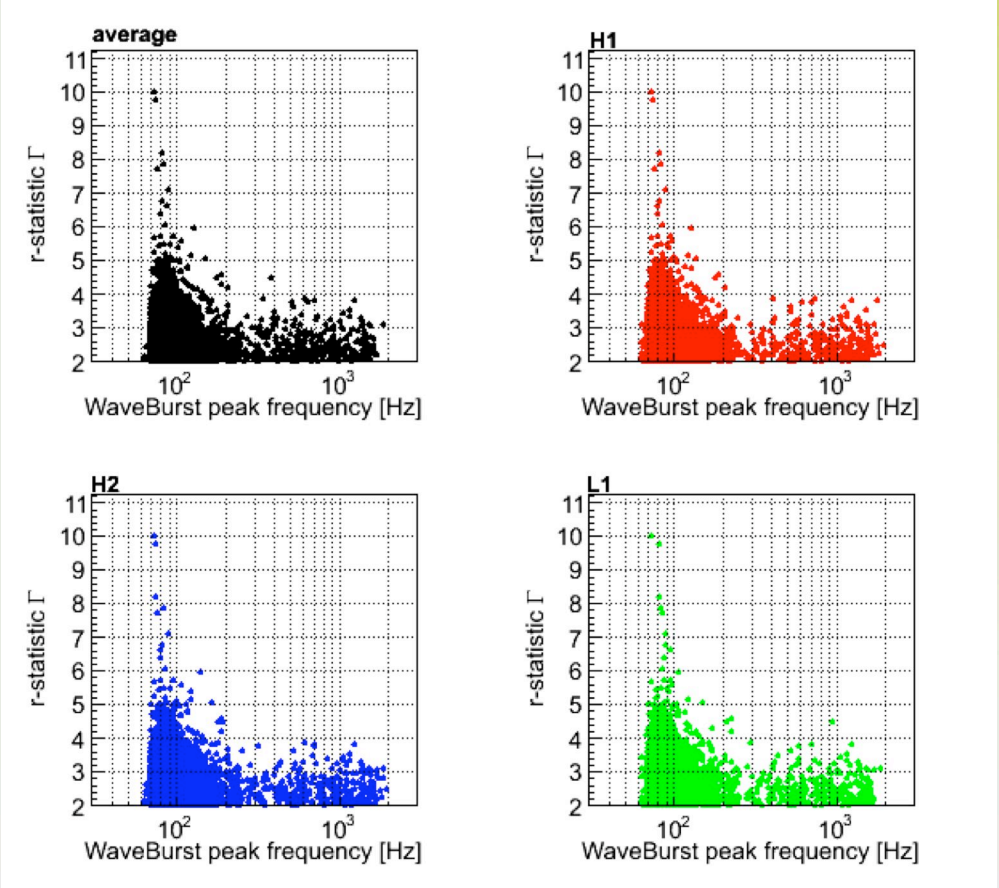
Effect of Cuts

H1-H2 Positively Correlated



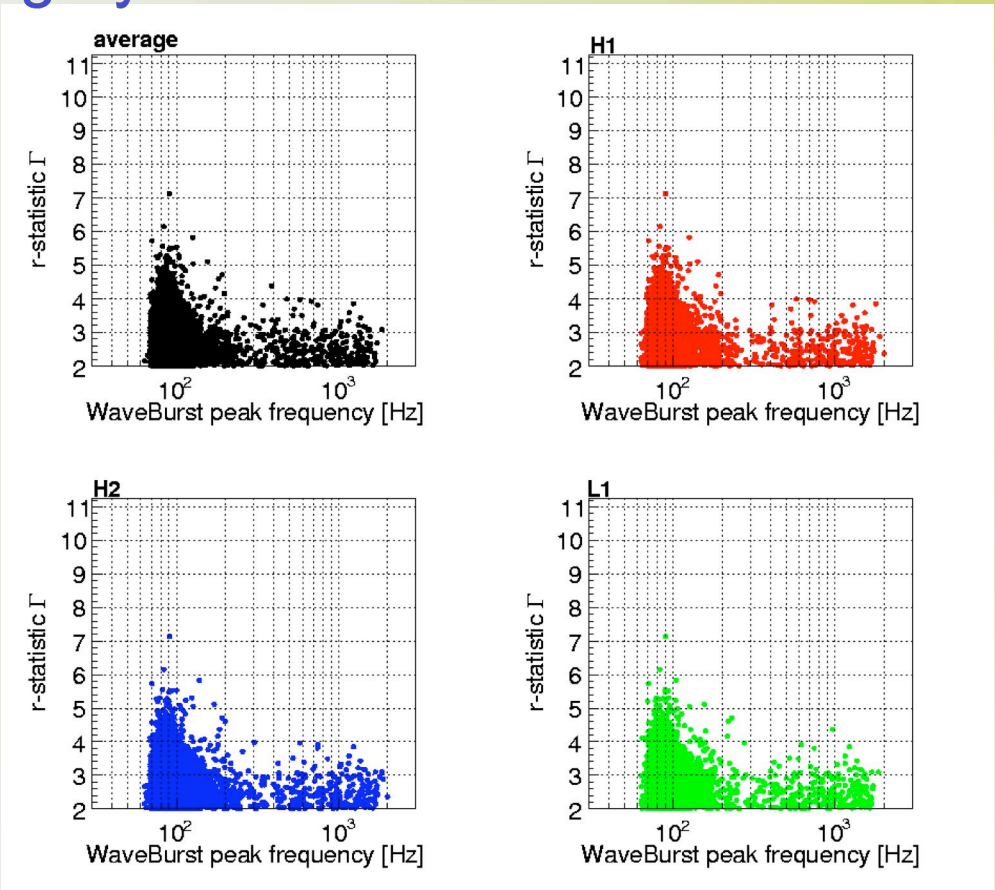
Effect of Cuts

H1-L1 Consistency



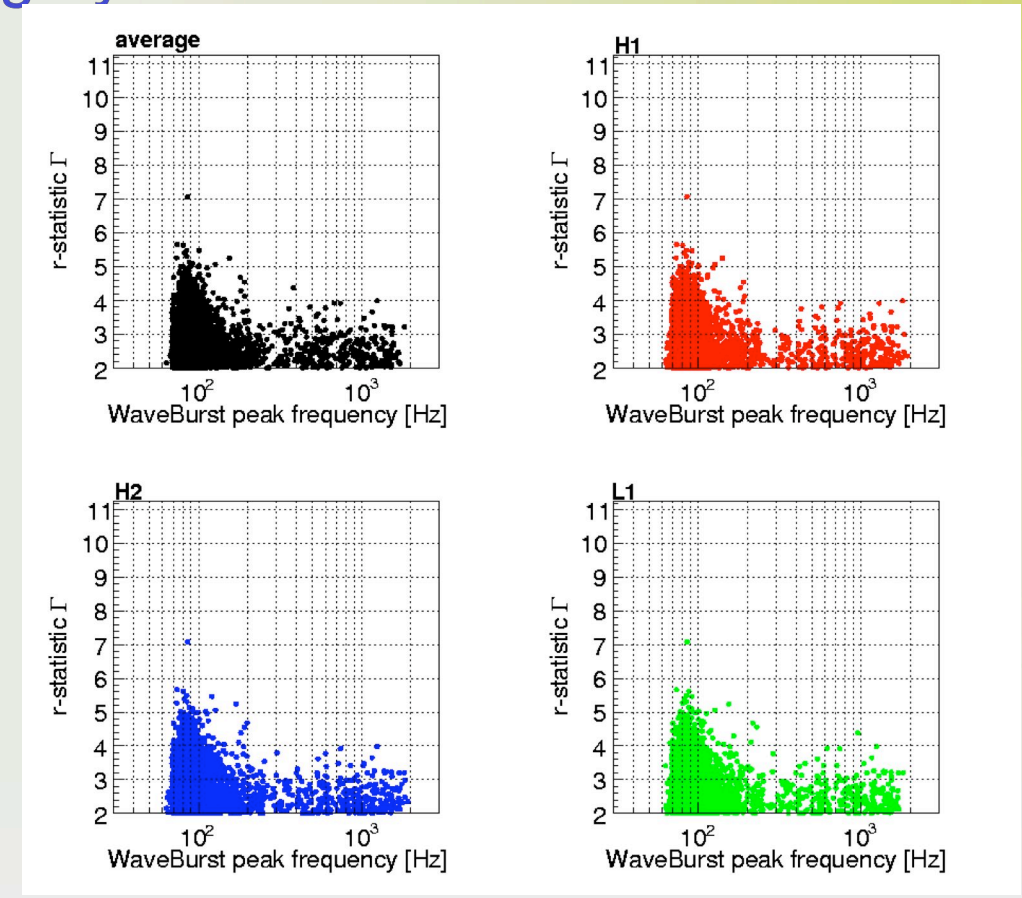
Effect of Cuts

After Category 2 Vetos



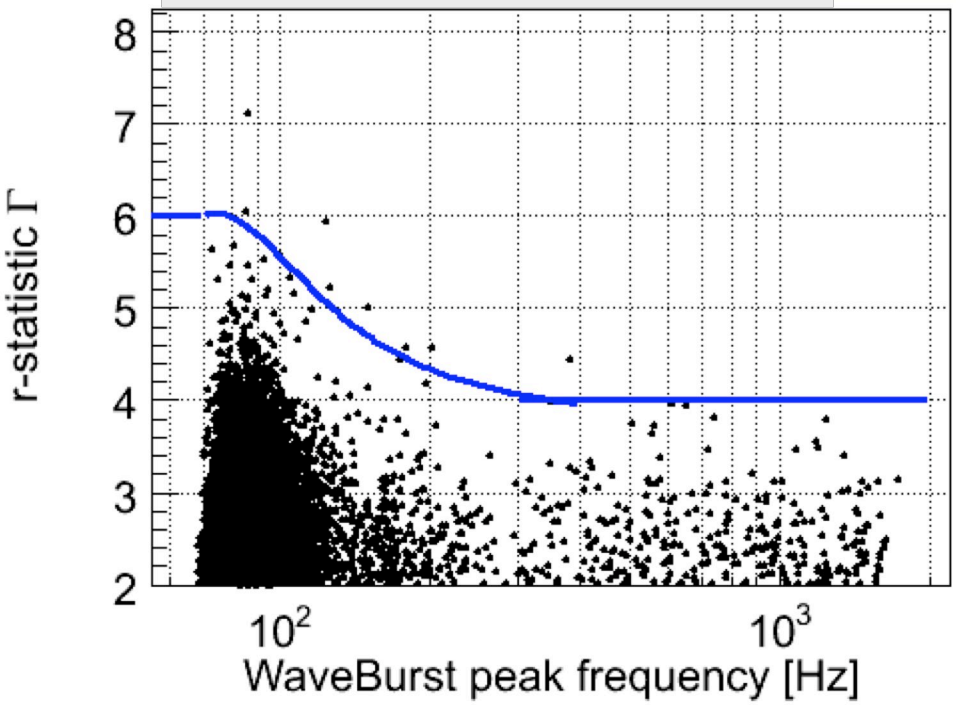
Effect of Cuts

After Category 2 and 3 Vetos

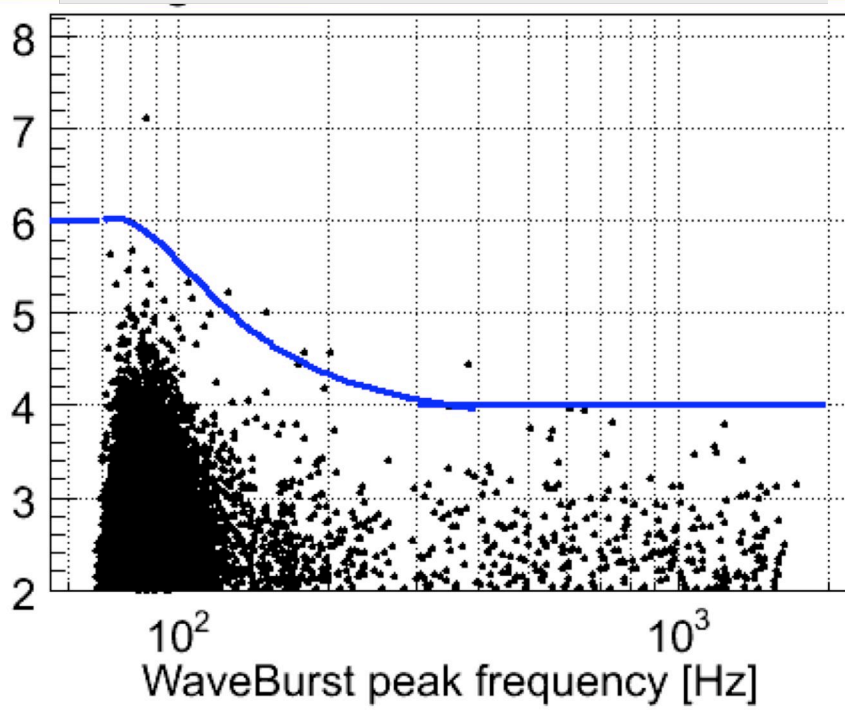


Frequency-Dependent Γ Threshold

After Category 2 DQ flags



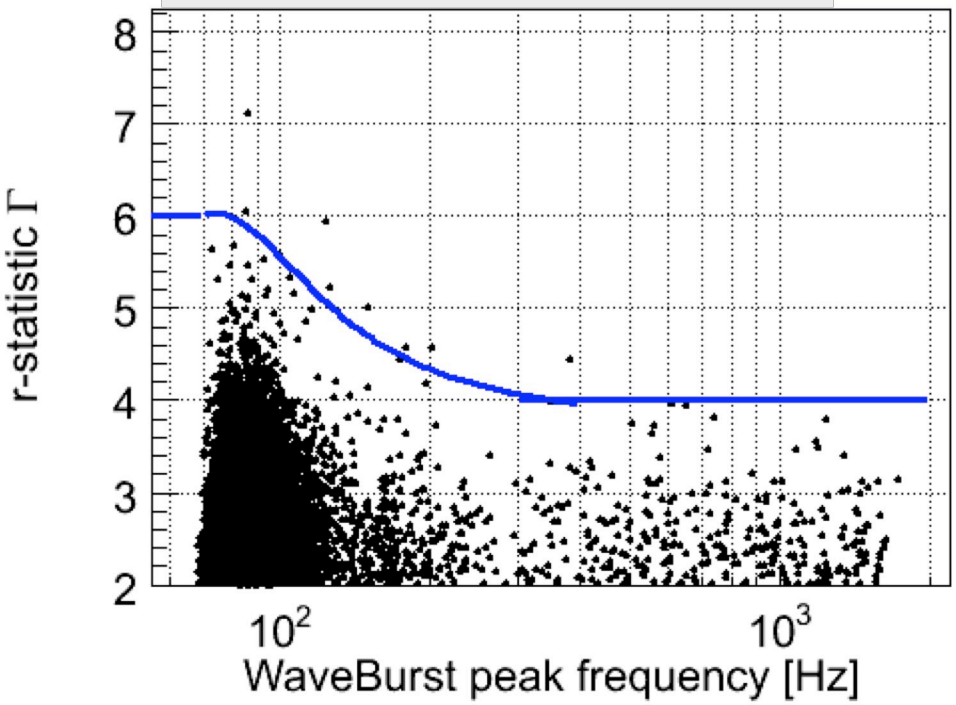
After Category 2 and 3 DQ flags



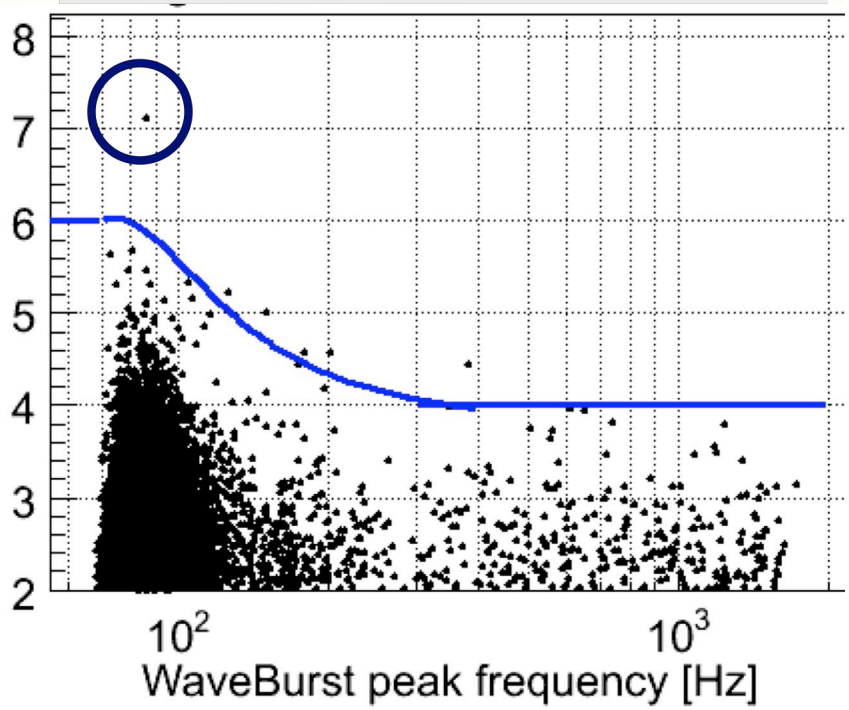
Empirically chosen, frequency-dependent threshold
~1/(f-64Hz) in 100-300Hz, 4 at high frequency, 6 at low frequency
Target rate of accidental coincidences: << 1 per analysis period
Expected: 0.06 in early S5, 0.4/year

Frequency-Dependent Γ Threshold

After Category 2 DQ flags

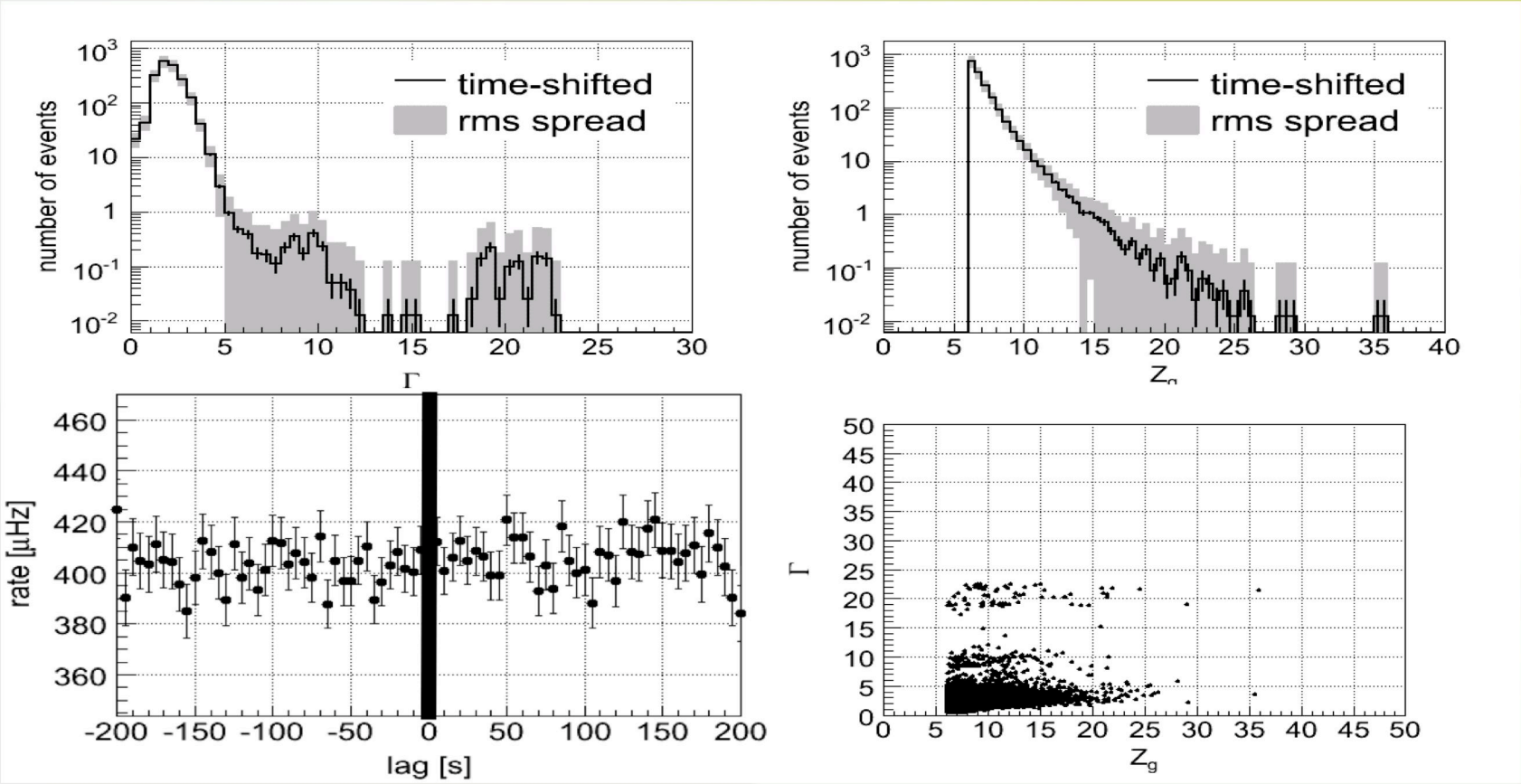


After Category 2 and 3 DQ flags

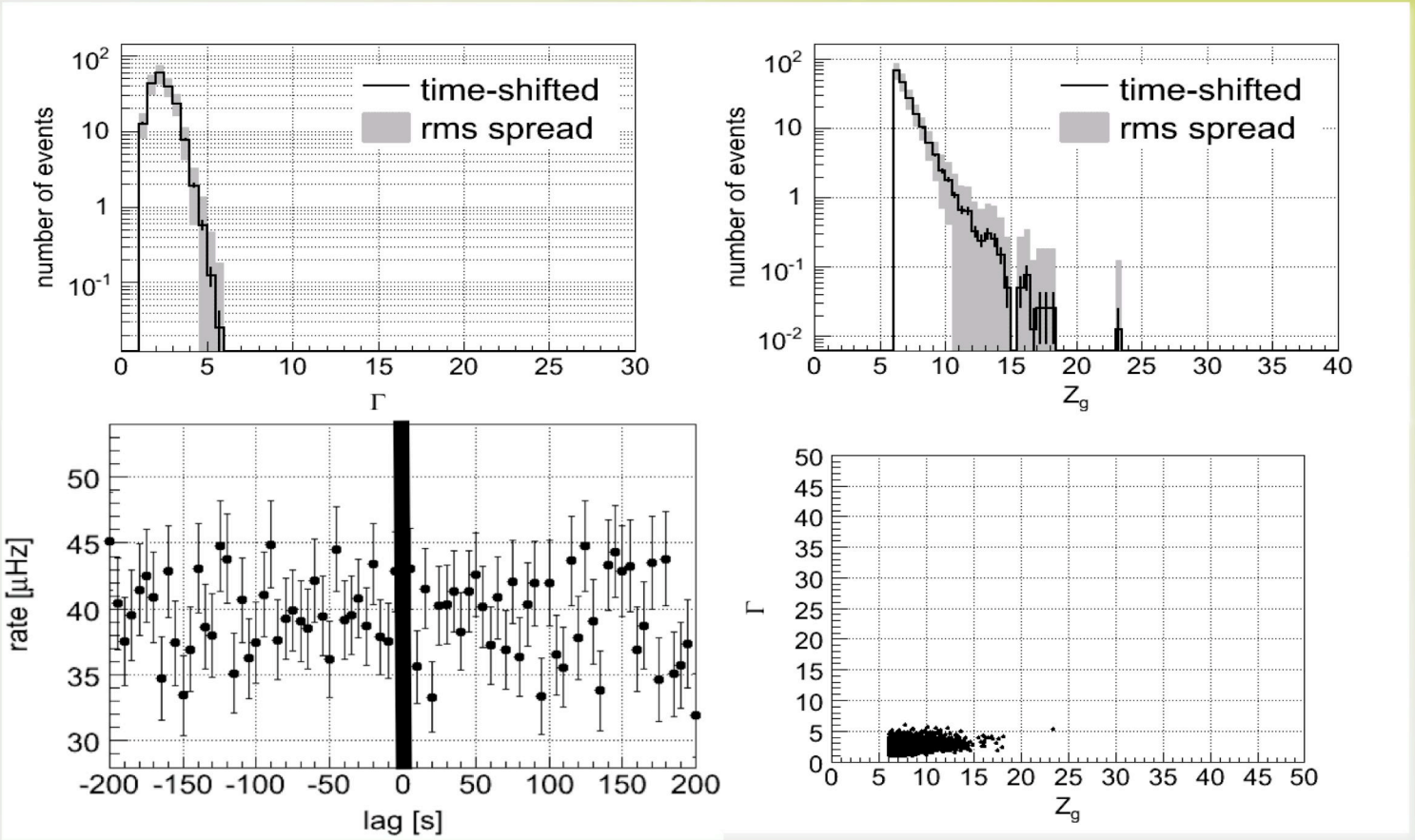


Empirically chosen, frequency-dependent threshold
~1/(f-64Hz) in 100-300Hz, 4 at high frequency, 6 at low frequency
Target rate of accidental coincidences: << 1 per analysis period
Expected: 0.06 in early S5, 0.4/year

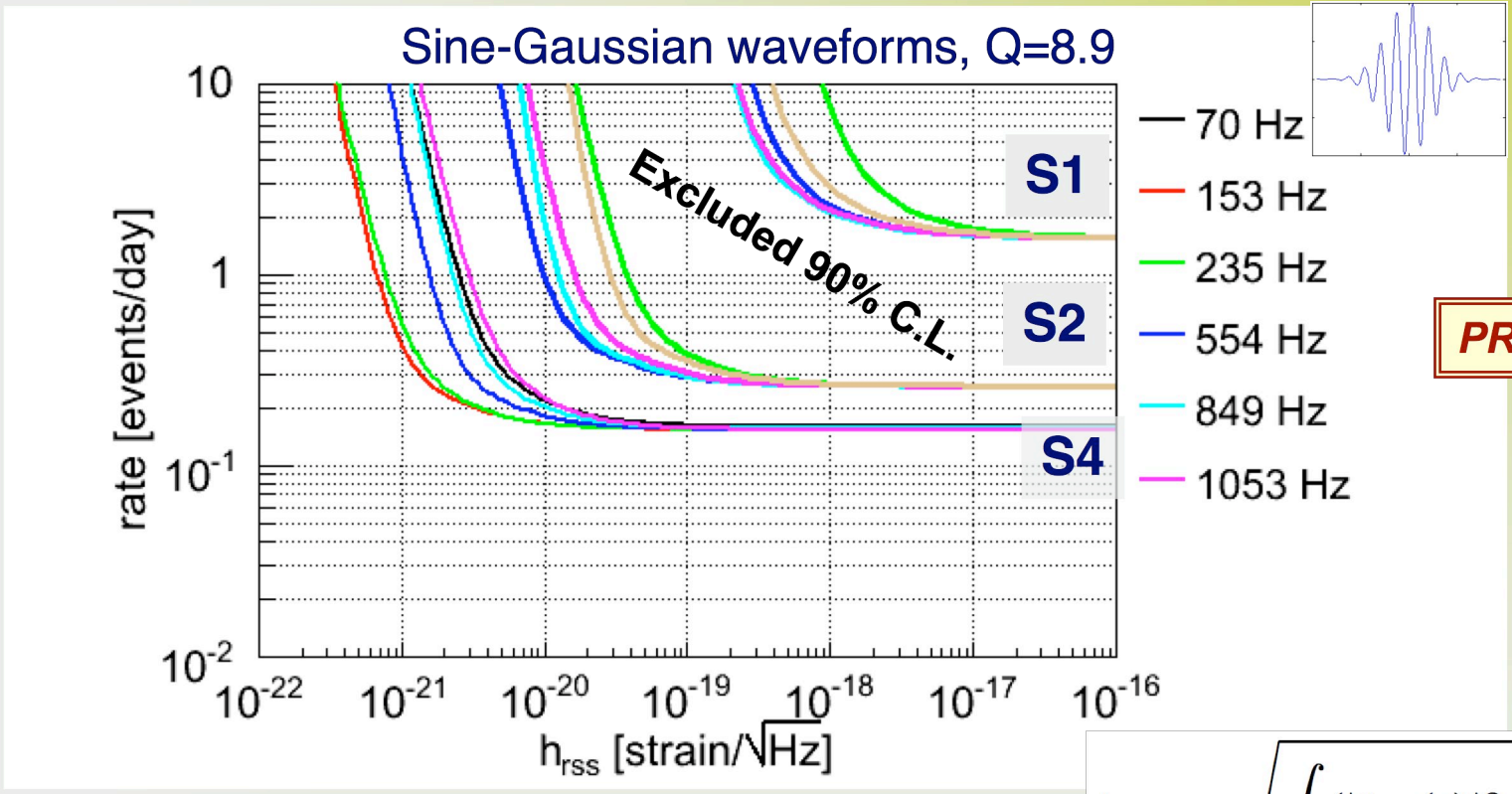
Before Analysis and DQ Cuts



After Analysis and DQ Cuts



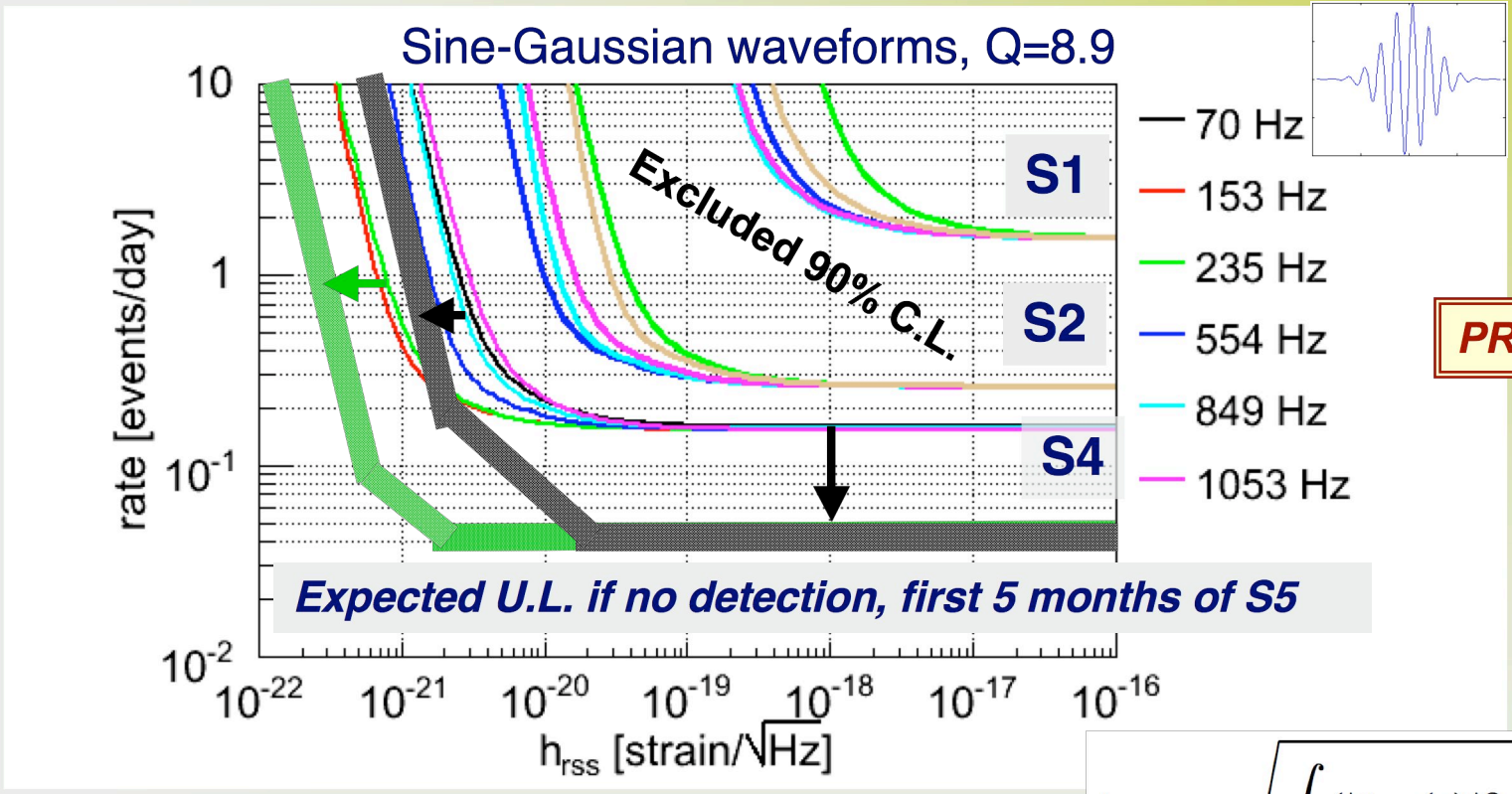
LSC Burst Search from S1 to S5



PRELIMINARY

$$h_{\rm rss} \equiv \sqrt{\int (|h_+(t)|^2 + |h_\times(t)|^2)\, d}$$

LSC Burst Search from S1 to S5

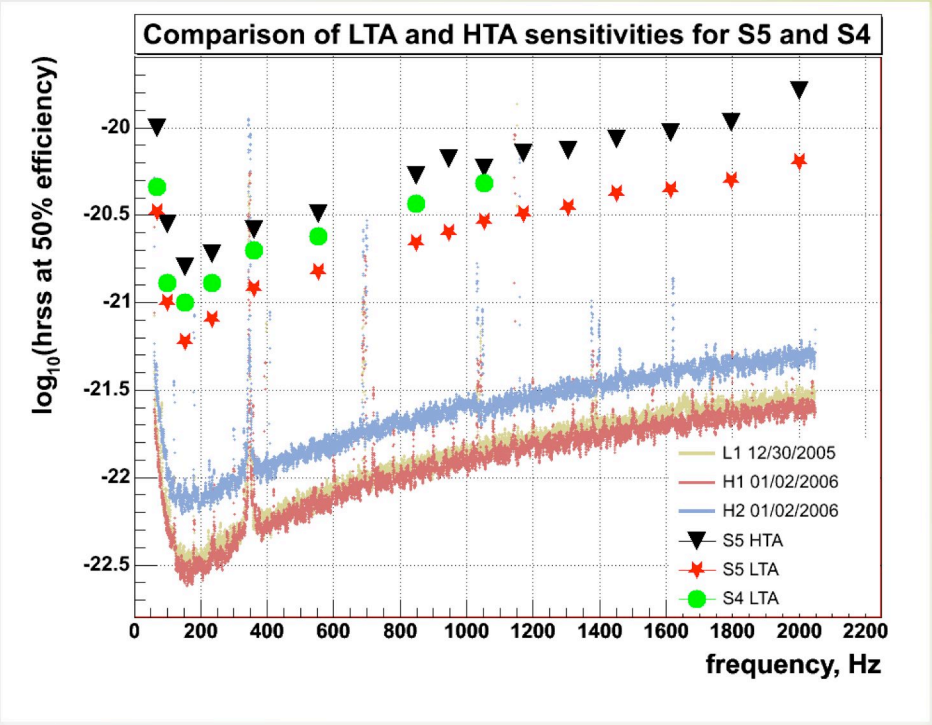


PRELIMINARY

$$h_{\rm rss} \equiv \sqrt{\int (|h_+(t)|^2 + |h_\times(t)|^2)\, d}$$

We are sensitive to $E_{GW} \sim 0.1\ M_\odot c^2$ at 20Mpc @153Hz

High Threshold Analysis



- High Z_g threshold ~21
- No Γ cut
- No data quality or veto cuts.
- About 2.5 times less sensitive than what is expected from LTA.
- 162+1 triggers found as of Oct-24-2006.
- Single zero-lag event fails H1-H2 Amplitude cut.

Summary

- We have almost completed tuning on the early S5, low threshold WaveBurst+CorrPower burst analysis.
- Period covered: November 17 to April 3
- Expect to open the box soon.
- High-Threshold analysis running online and searching for very loud events in real-time.
- Performance of the detectors has improved since early S5 so we anticipate greatly increased sensitivity compared to previous science runs.