# Comparison of h(t) and AS_Q on WaveBurst and CorrPower triggers

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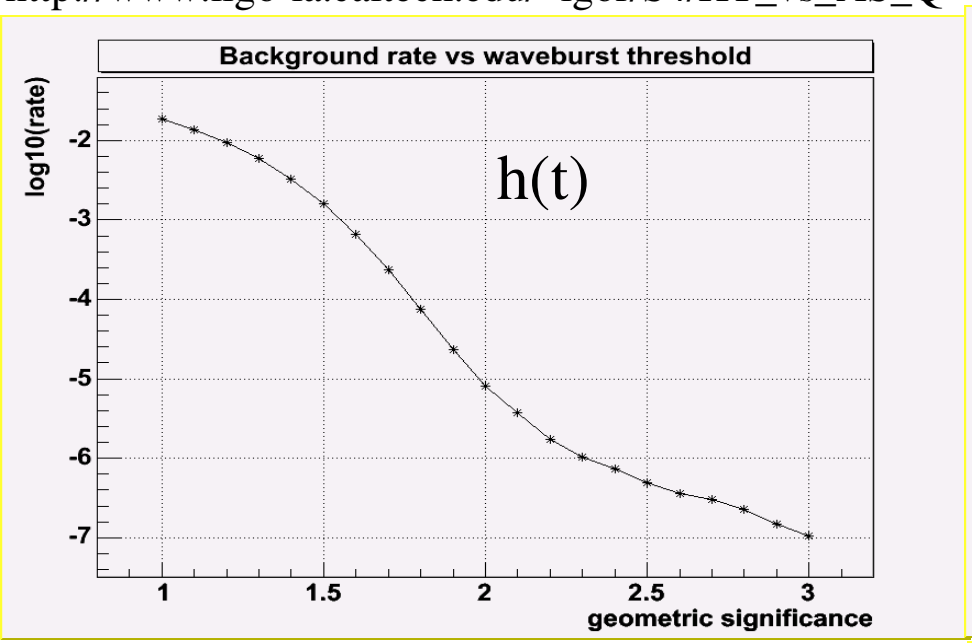
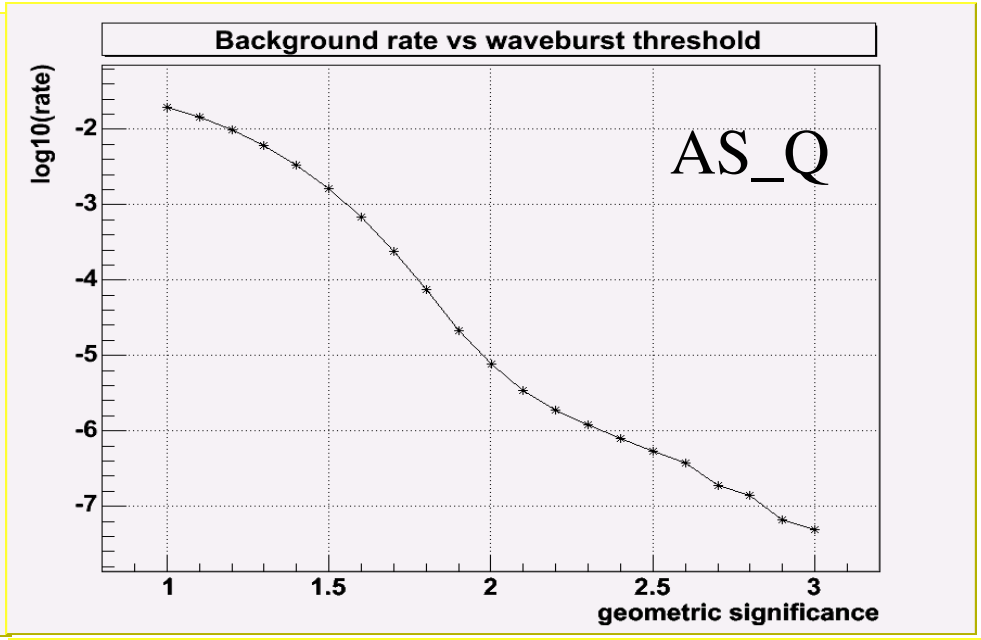
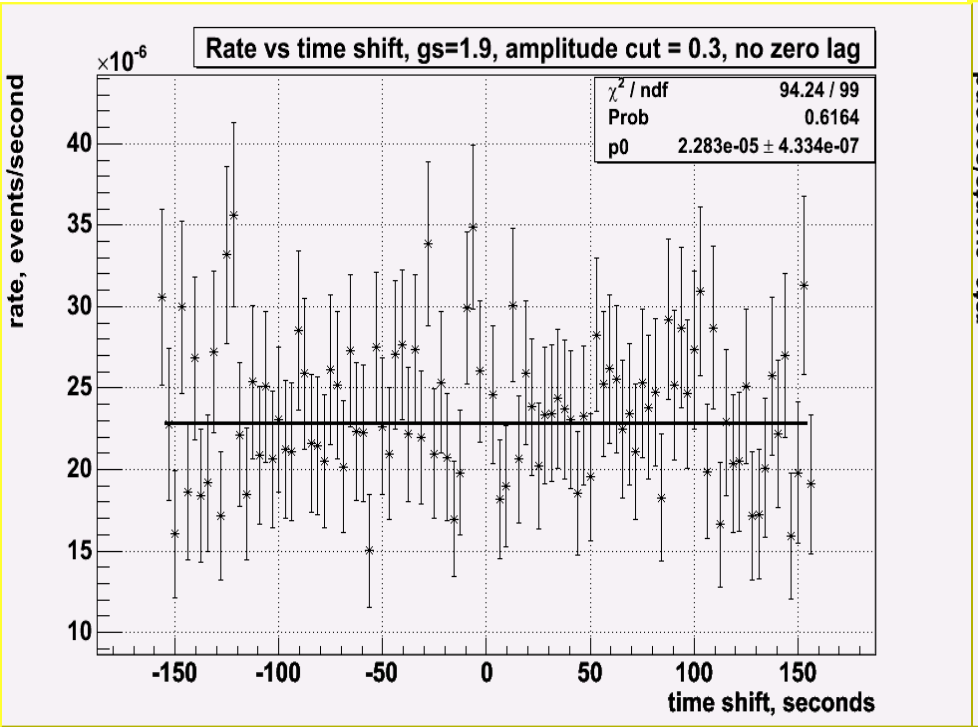
LIGO-G050407-00-Z

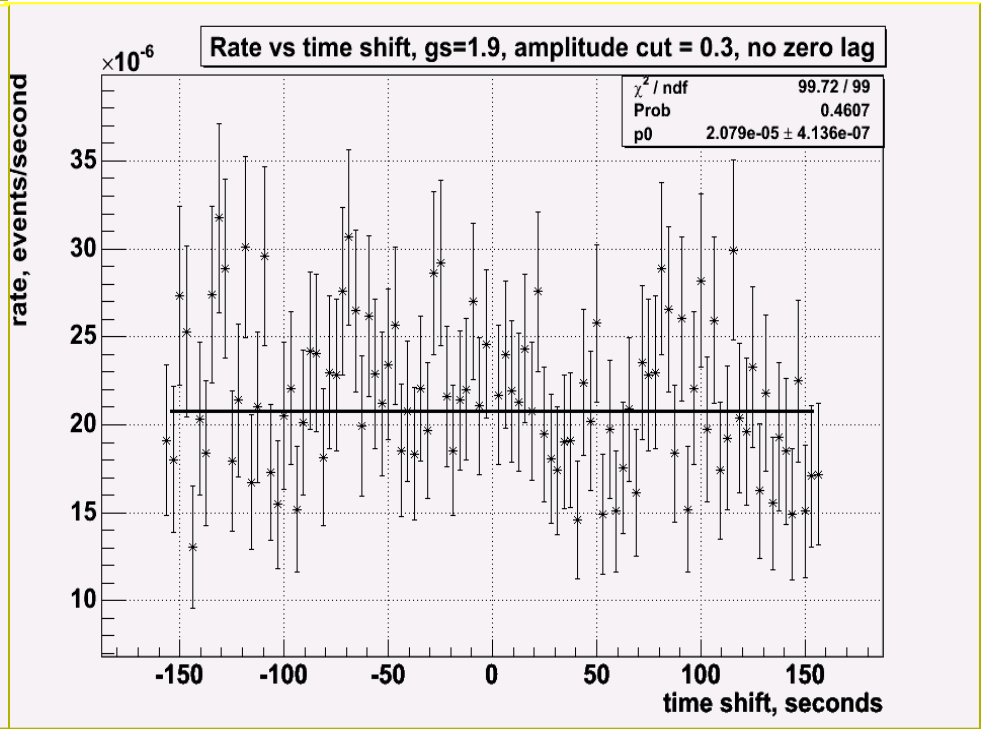
# Statistical properties of waveburst offtime triggers on h(t) and AS_Q

http://www.ligo-la.caltech.edu/~igor/S4/HT_vs_AS_Q



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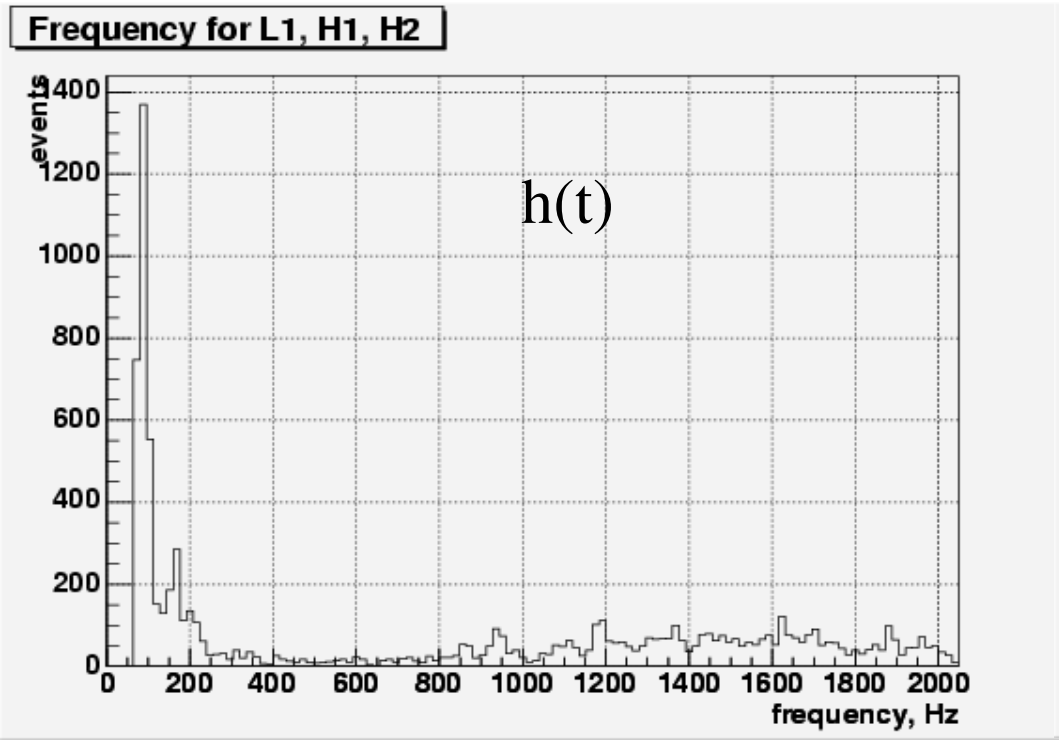


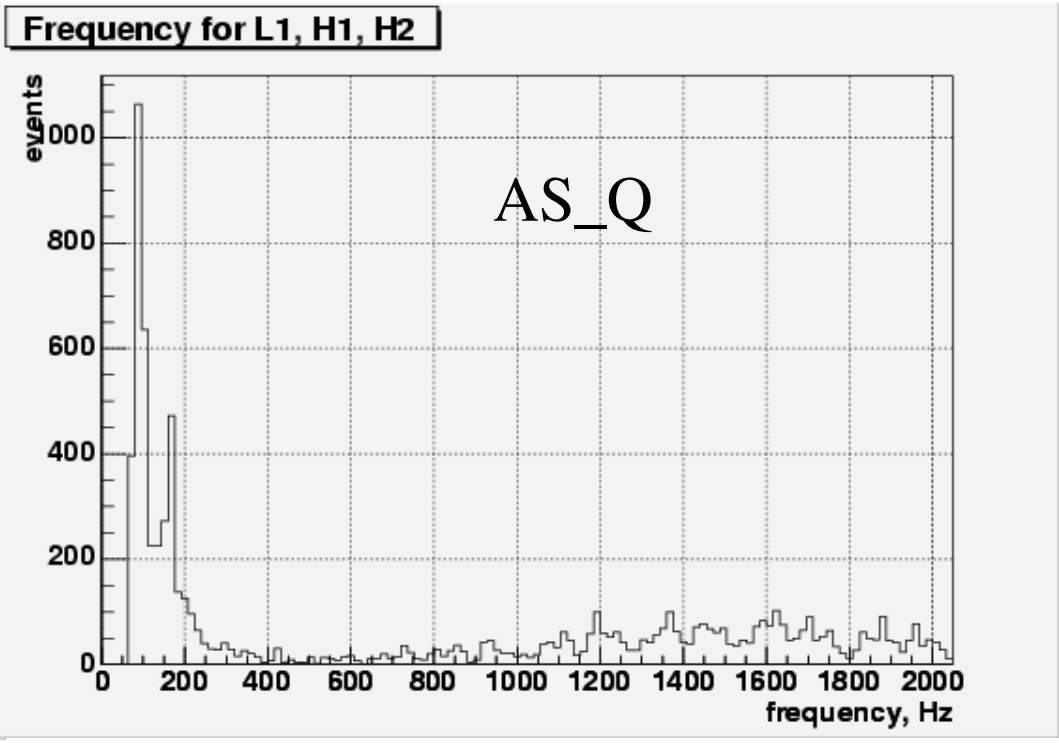


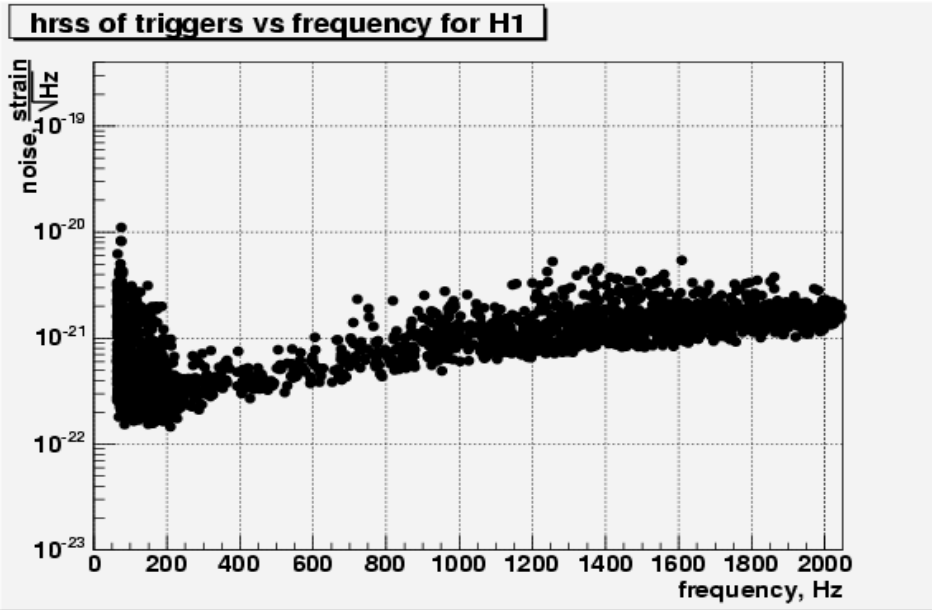


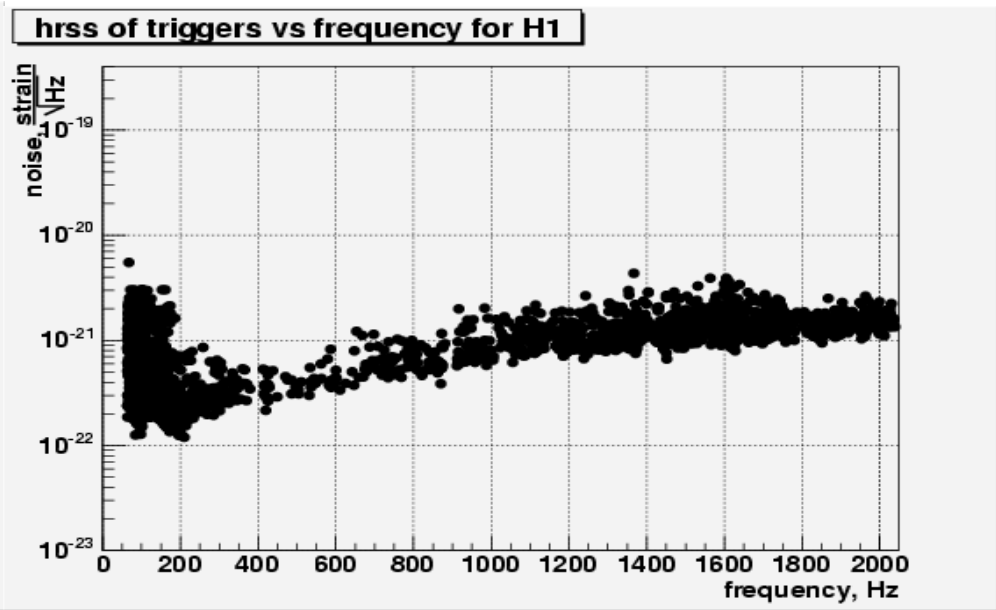

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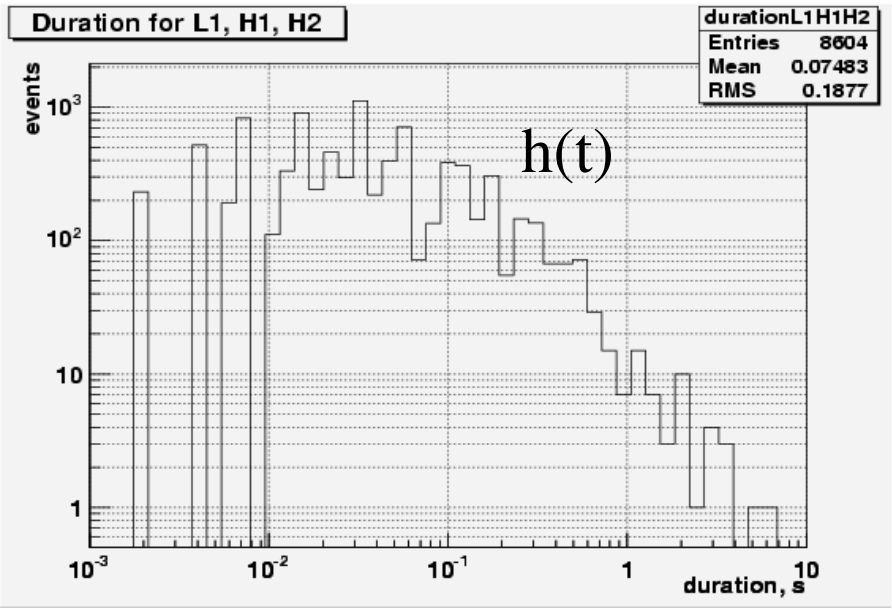


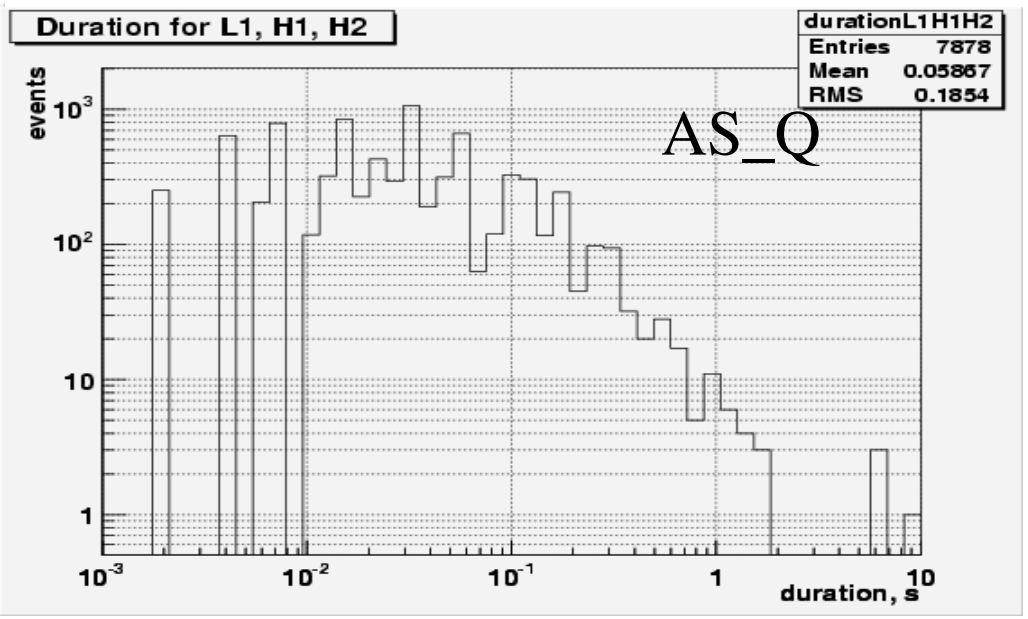


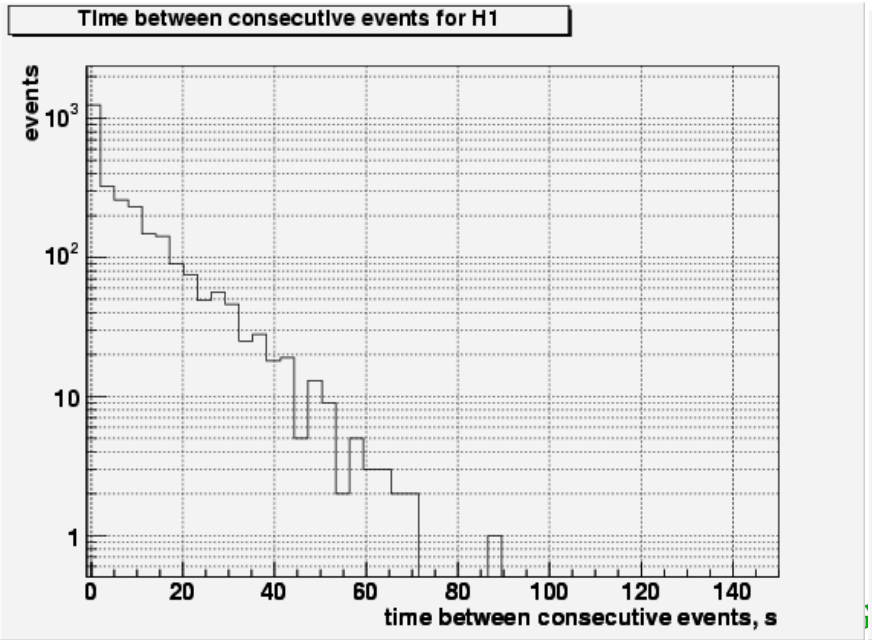


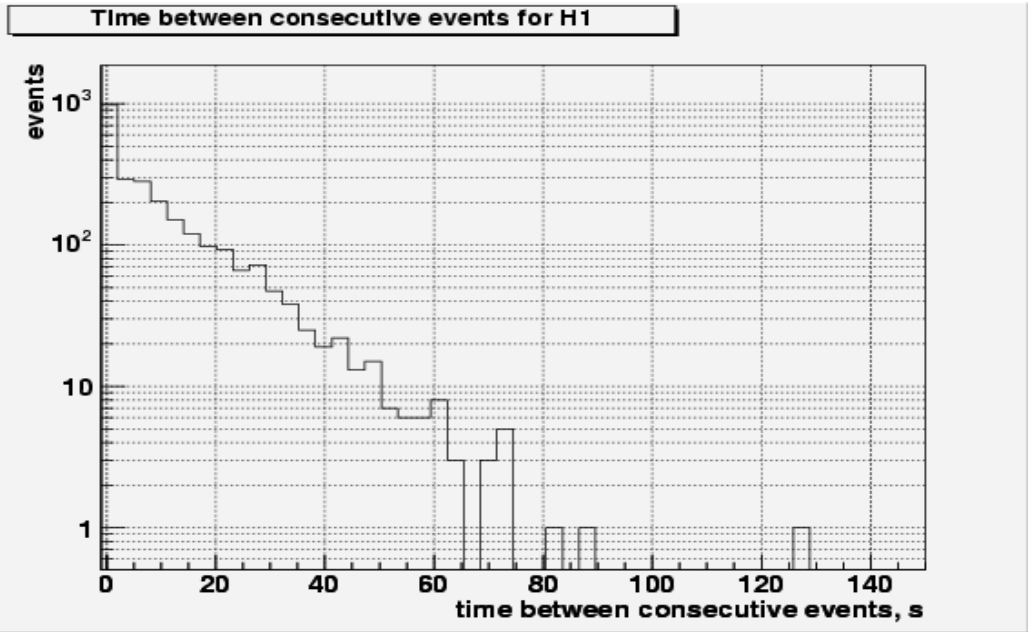

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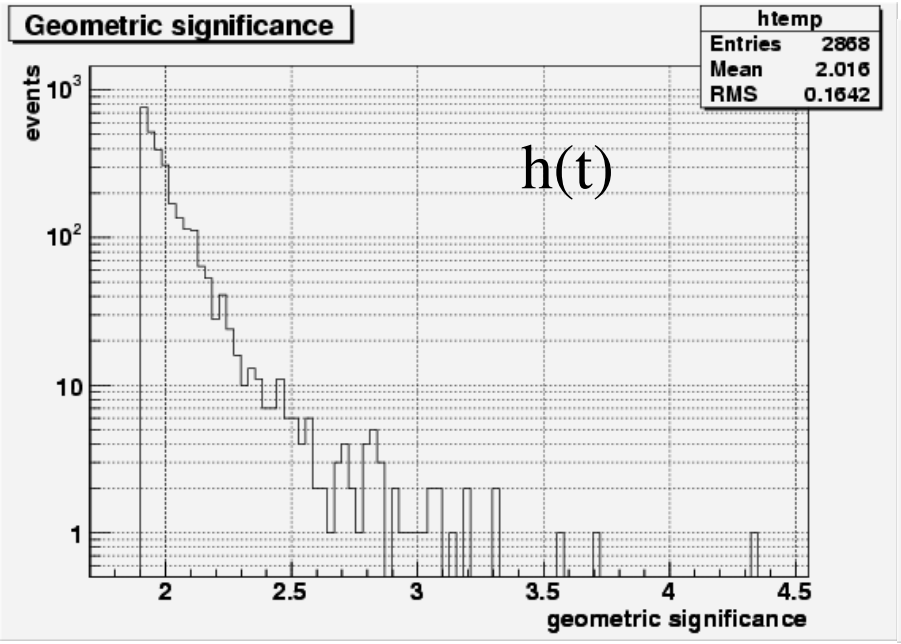
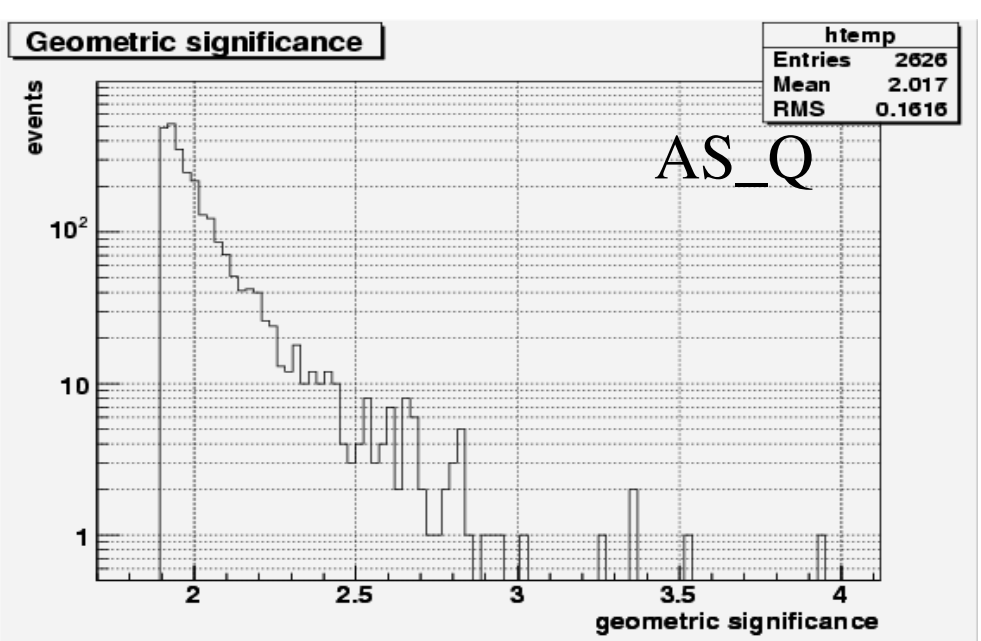
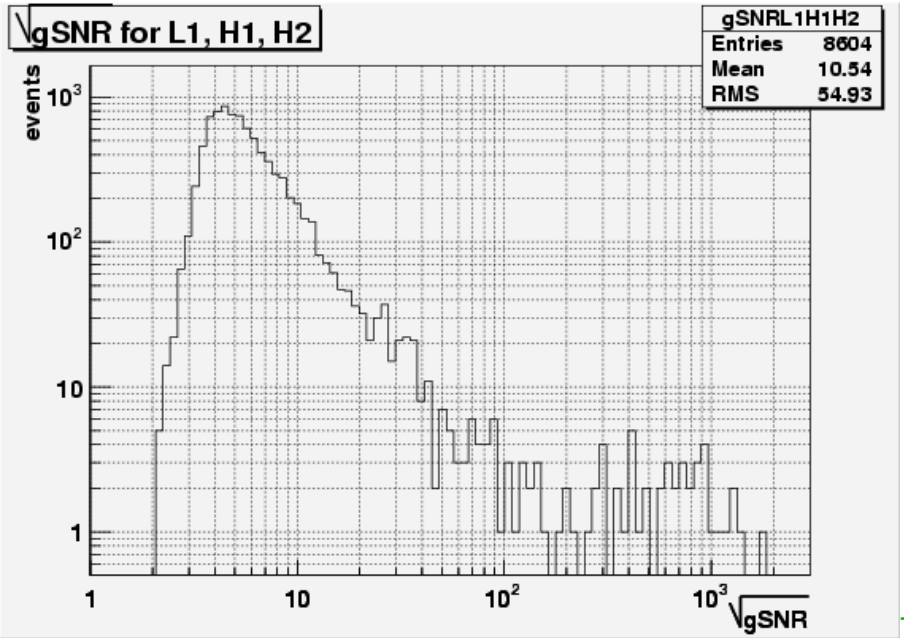
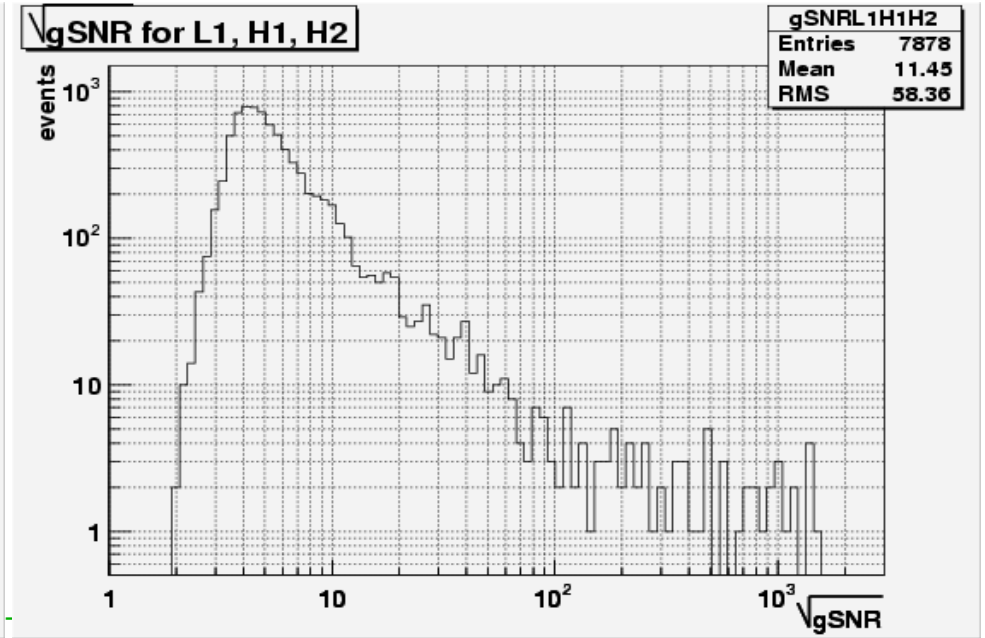
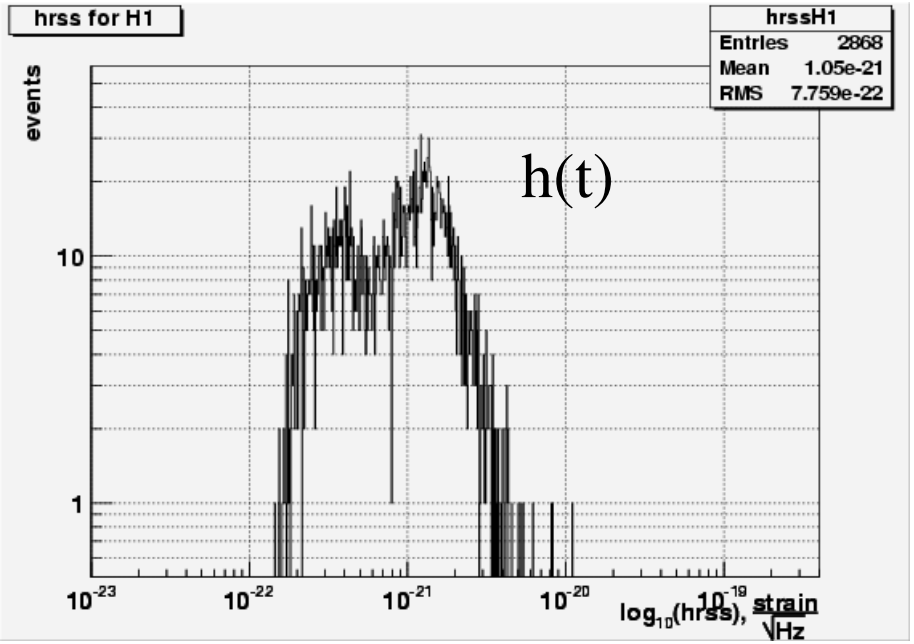


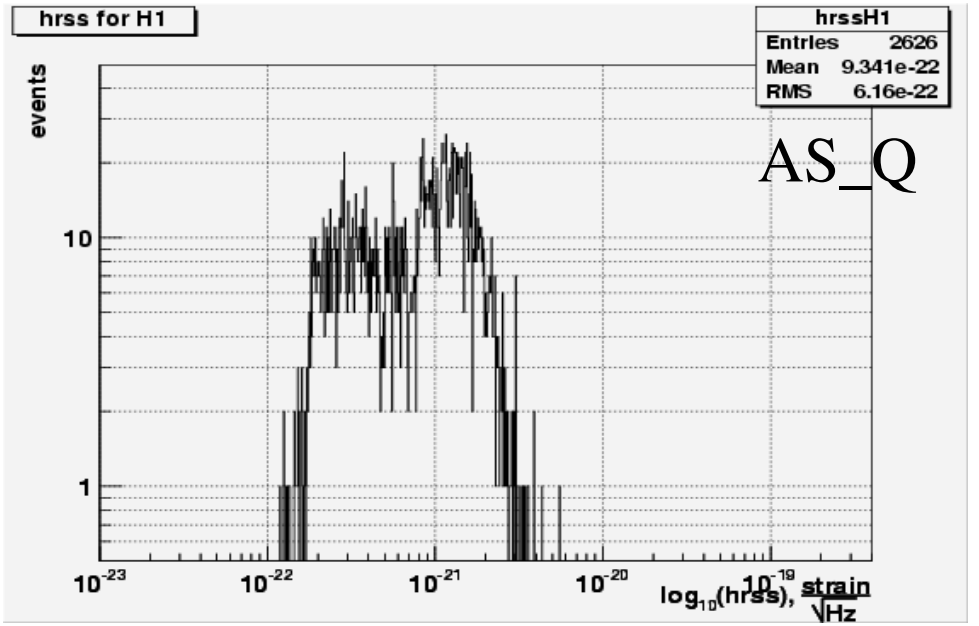



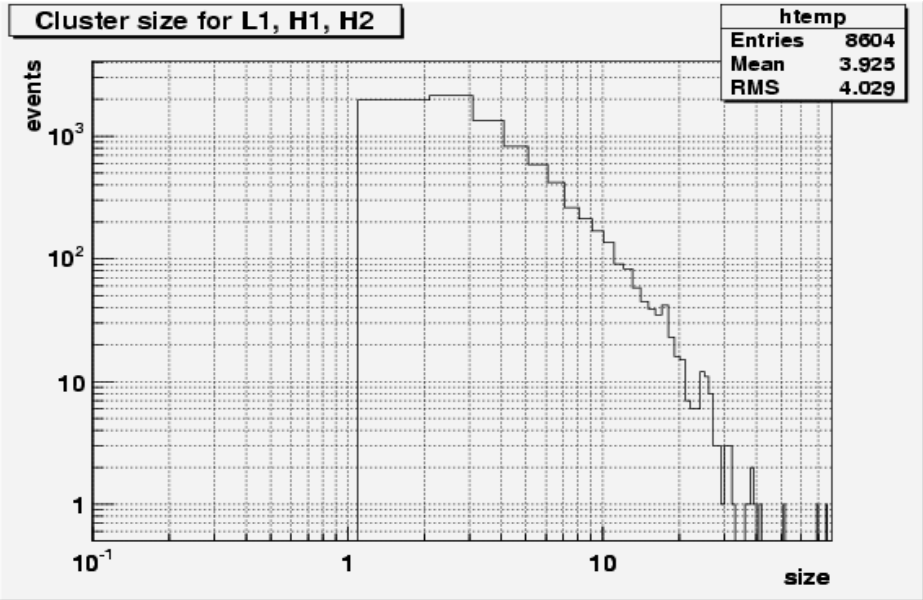



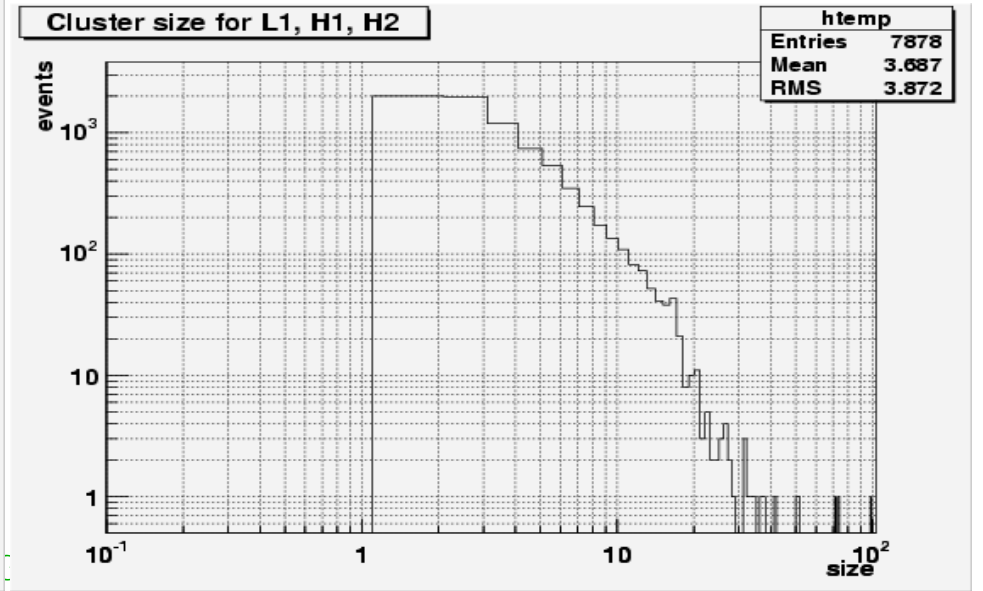



# Statistical properties of waveburst offtime triggers on h(t) and AS_Q



# Statistical properties of waveburst offtime triggers on h(t) and AS_Q

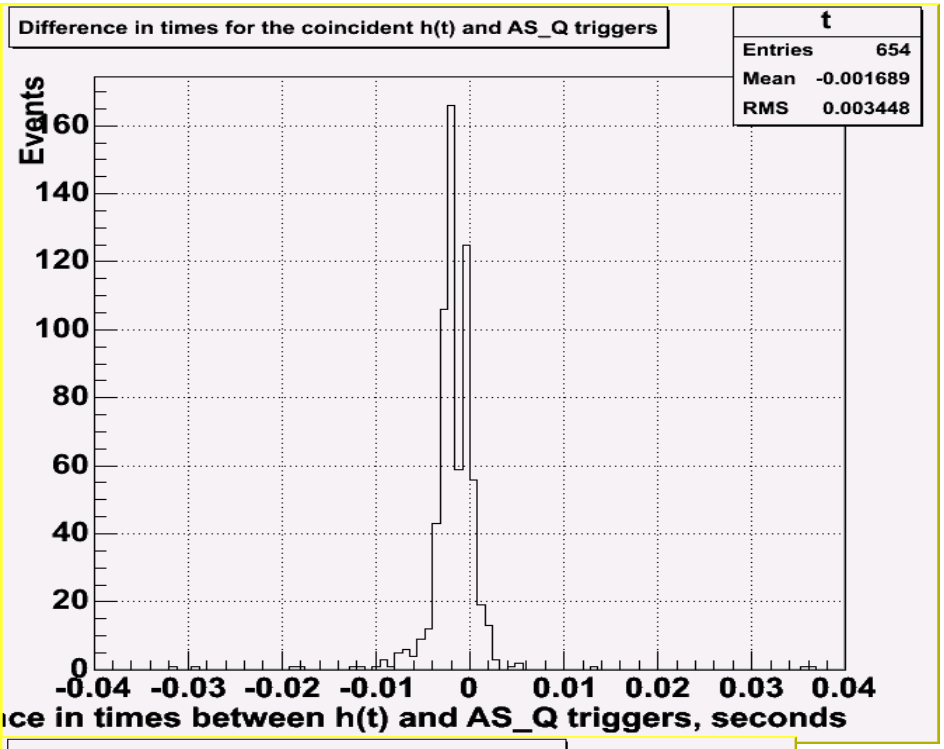
- Both on h(t) and AS_Q WaveBurst used gs=1.9 and standard H1-H2 amplitude cut.

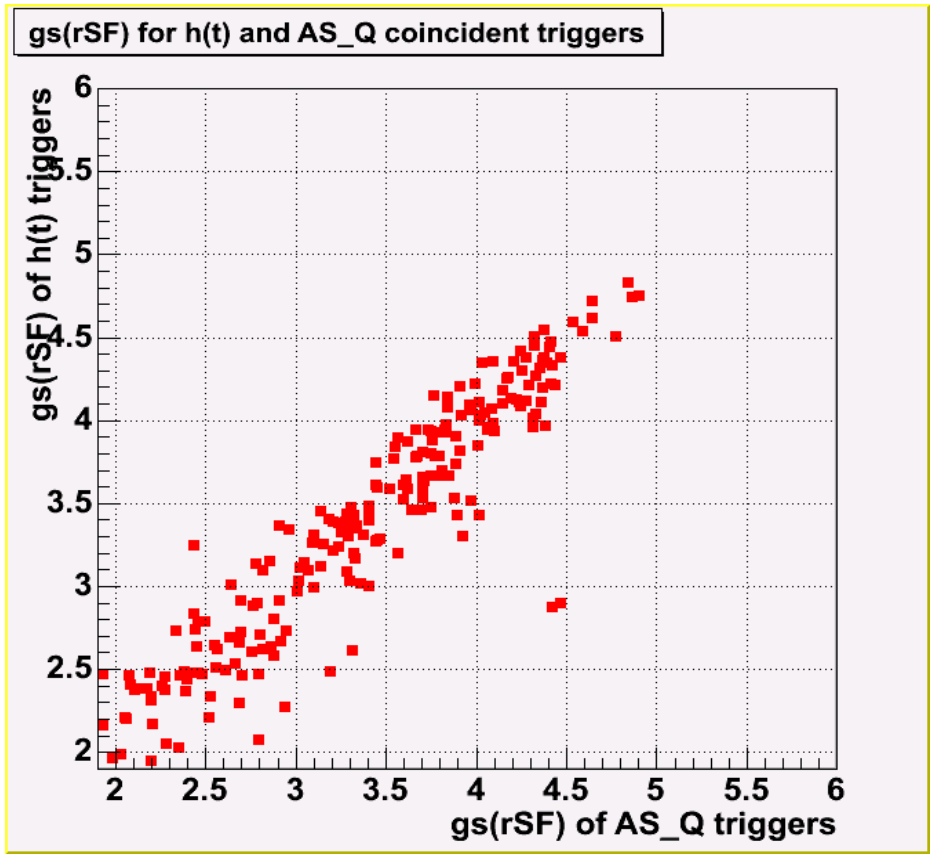
| | | h(t) | | AS_Q |
|---|---|---|---|---|
| | mean | RMS | mean | RMS |
| rate, $\mu$Hz | 22.8 | 0.4 | 20.8 | 0.4 |
| duration, ms | 75 | 178 | 59 | 175 |
| bandwidth, Hz | 173.3 | 213.6 | 167.9 | 189.9 |
| SNR | 10.5 | 54.9 | 11.5 | 58.4 |
| size | 3.9 | 4 | 3.7 | 3.9 |
| hrss, strain/sqrt(Hz), H1 | 1.05E-021 | 7.80E-022 | 9.30E-022 | 6.20E-022 |
| gs | 2.02 | 0.16 | 2.02 | 0.16 |

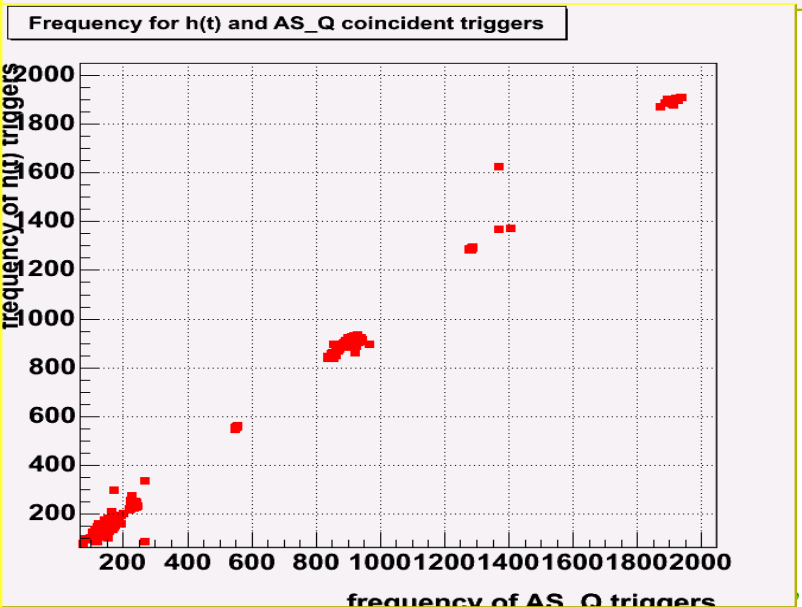
- 2864 h(t) triggers, 2613 AS_Q triggers, only 262 common triggers!

# Zero-lag waveburst triggers around hardware injections

- 221 h(t) triggers, 229 AS_Q triggers, 218 common triggers.



# Comparison between S4 events produced by Waveburst + r-statistics on AS_Q and h(t)

http://emvogil-3.mit.edu/~cadonati/S4/waveb-offline/events/waveb-outliers.html

Only events with Γ≥5 that passed H1-H2 consistency cuts are listed.

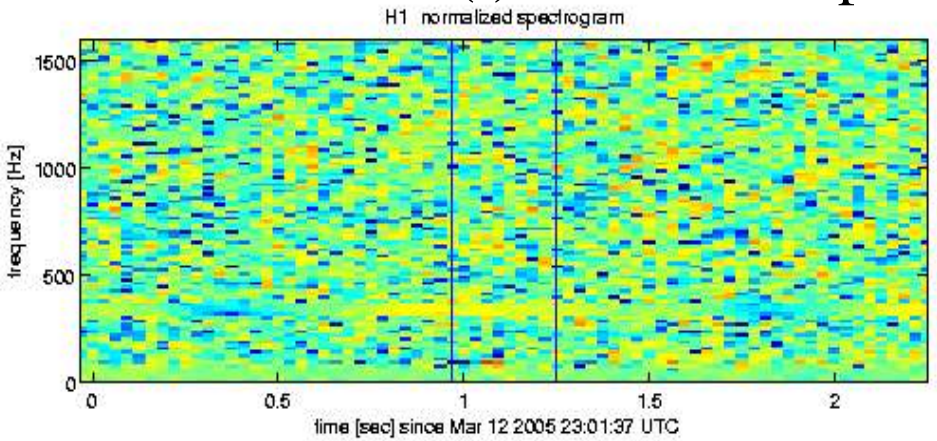
Color legend:

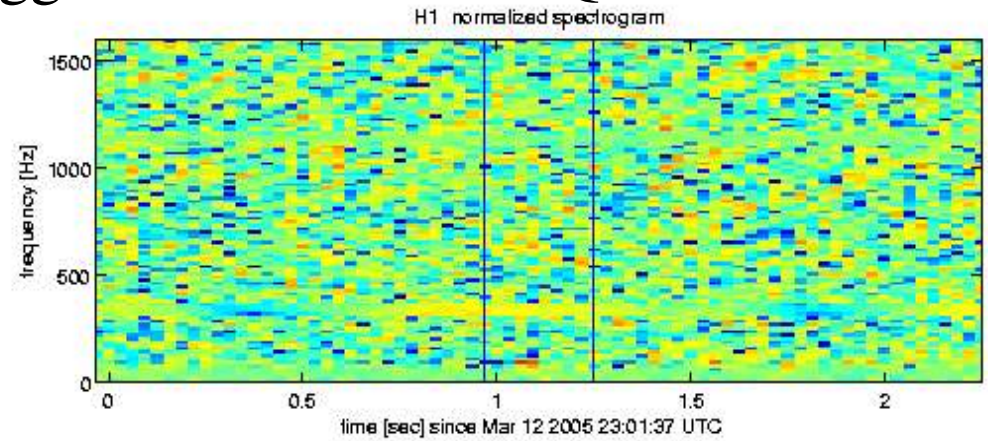
| |
|---|
| events seen in both searches |
| glitches in AS_Q/DARM_ERR that do not appear in h(t) data – typically, calibration line drop-outs -1 sec or 1 sample |
| events associated with violin mode breathing |
| not obvious why these events were missed in one of the searches |

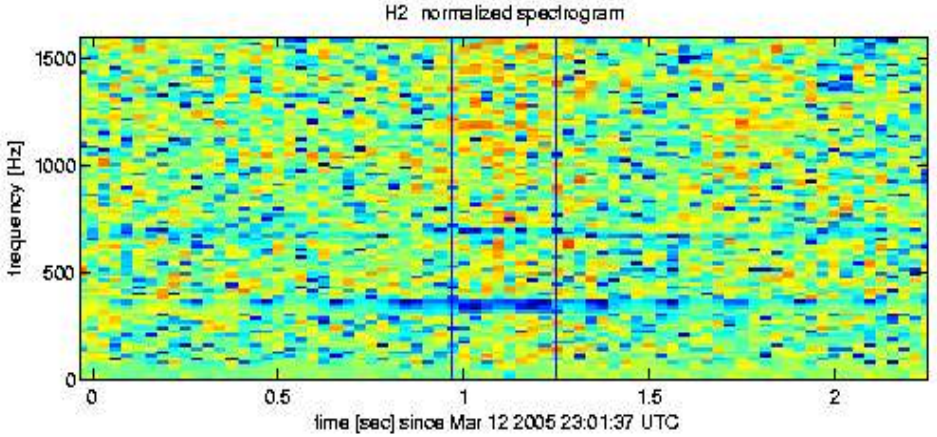
## Waveburst + r-statistics on h(t)

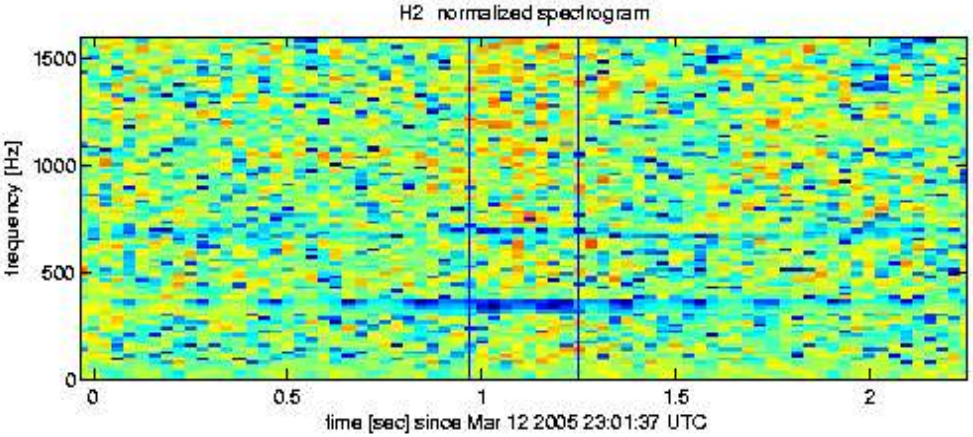
| gps: LHO-LLO | Γ | WB on AS_Q | Comment |
|---|---|---|---|
| 794703710-794703607 | 30.1 | NO | Noise at or below 100 Hz in all 3, violin mode at L1, |
| 794962839-794962720 | 5.7 | YES | H1-H2 glitch |
| 795129055-795128917 | 5.6 | YES | glitchy noise below 100 Hz in all 3 |
| 793940093-793940046 | 5.3 | YES | H1 0-300Hz glitch, L1 ~100 Hz glitch |

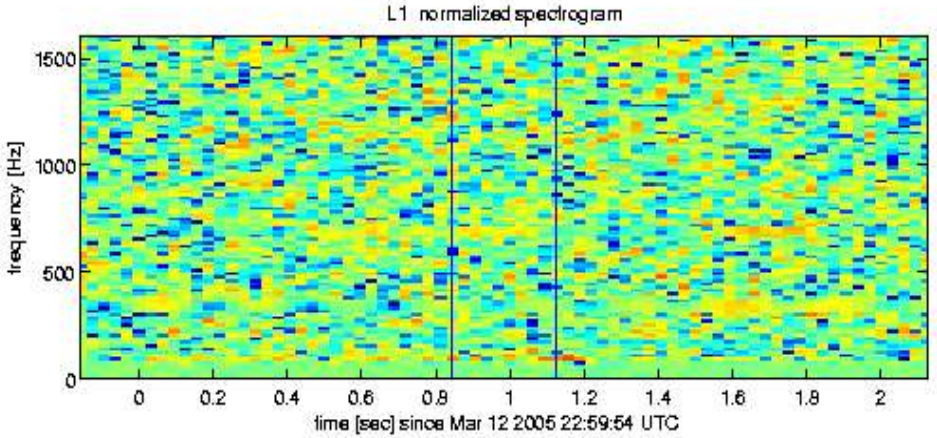
h(t) pink trigger AS_Q

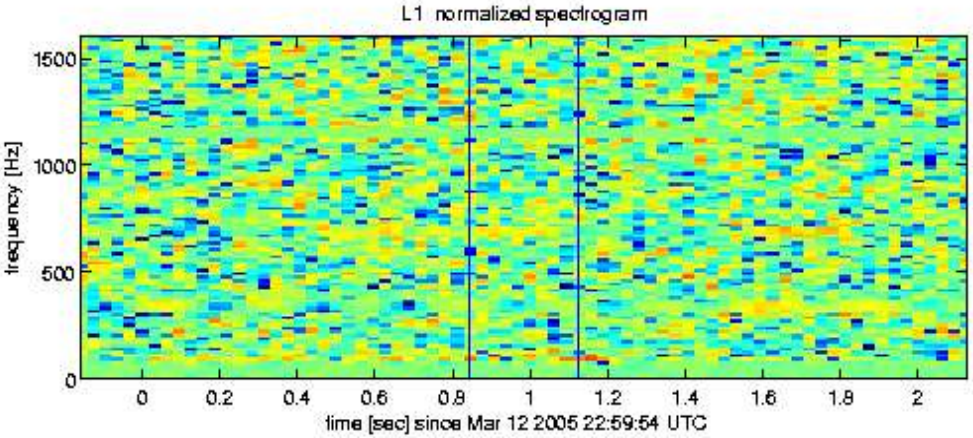


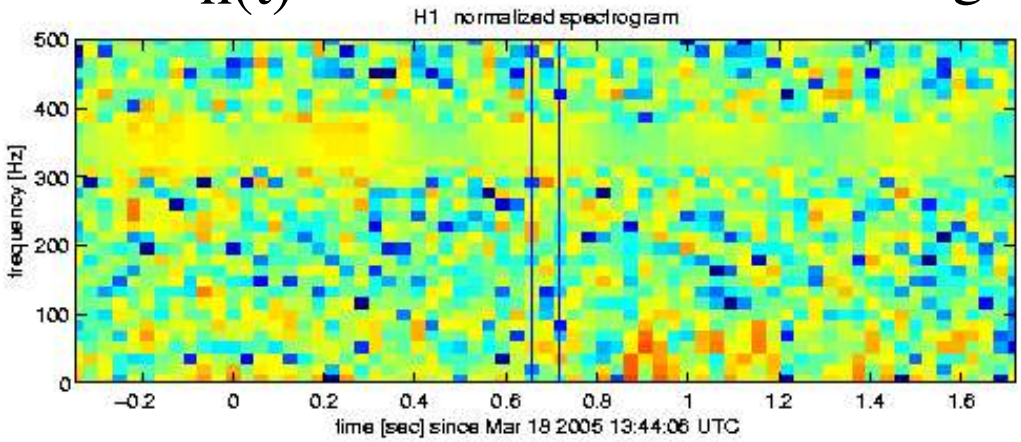



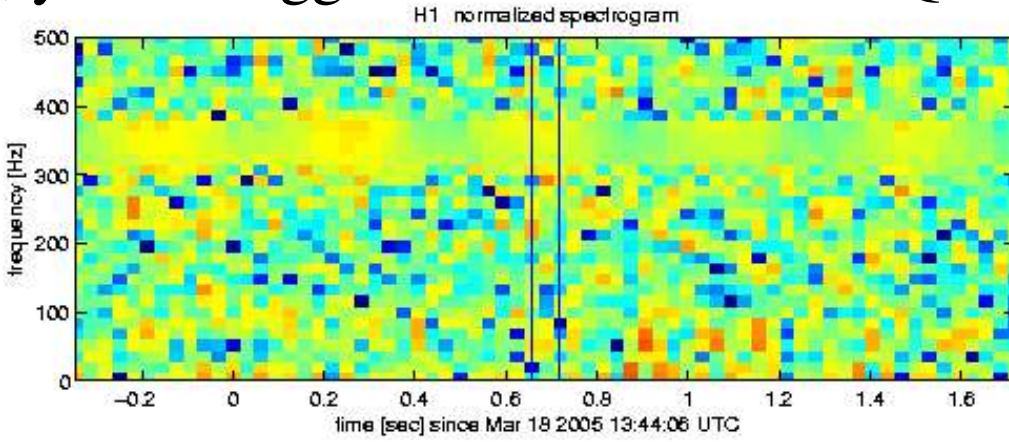



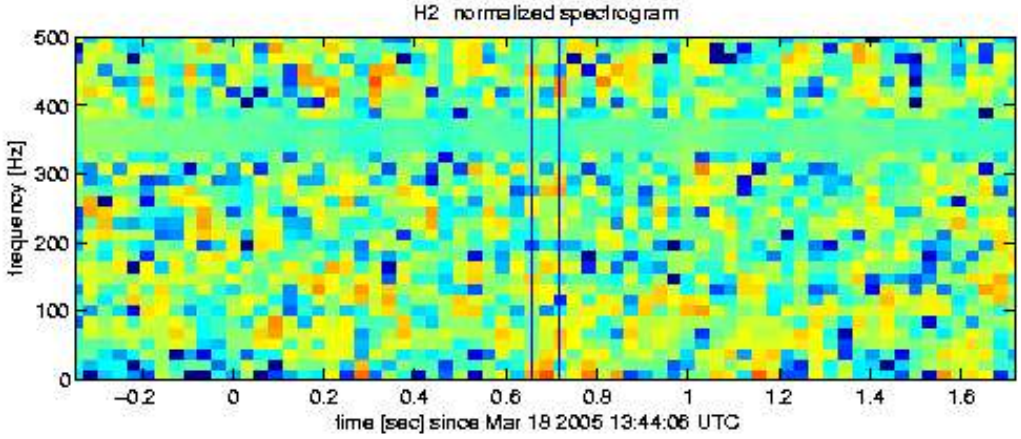
# WaveBurst + r-statistics on AS_Q

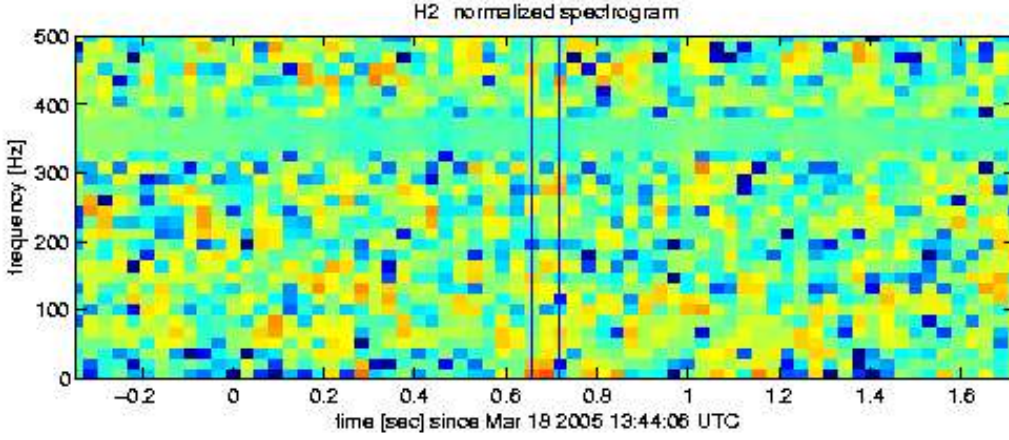
| gps: LHO-LLO | Γ | WB on h(t) | Comment |
|---|---|---|---|
| 795188659-795188775 | 21 | NO | violin mode breathing at H1, H2 |
| 793995059-793994941 | 9.4 | NO | H1-H2 glitch – absent in h(t), 1 sample calibration dropout H1, H2 |
| 794253084-794253175 | 9.3 | NO | H1-H2 glitch – absent in h(t), 1 sample calibration dropout H1, H2 |
| 795577404-795577339 | 8.7 | NO | H1-H2 glitch – absent in h(t), 1 sample calibration dropout H1, H2 |
| 793264474-793264515 | 7.5 | NO | H1-H2 glitch – absent in h(t), 1 sample calibration dropout H1, H2 |
| 793213800-793213722 | 7.3 | NO | H1-H2 glitch – absent in h(t) + weird stuff in L1, 1 sample calibration dropout H1, H2 |
| 794336254-794336242 | 7.2 | NO | H1-H2 glitch – absent in h(t), 1 sample calibration dropout H1, H2 |
| 795129055-795128917 | 5.8 | YES | glitchy noise below 100 Hz in all 3 ifo |
| 794827367-794827404 | 5.4 | N0 | violin mode breathing at L1, H2 |

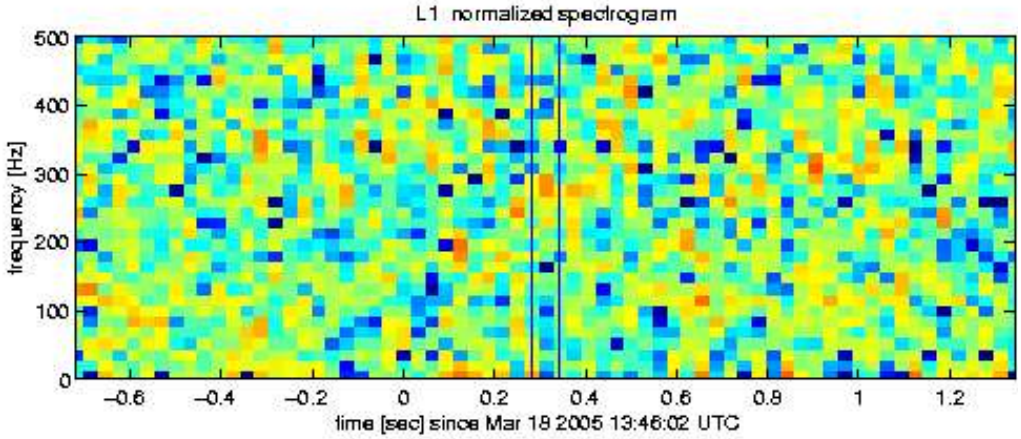
h(t) violin mode glitch, yellow trigger AS_Q

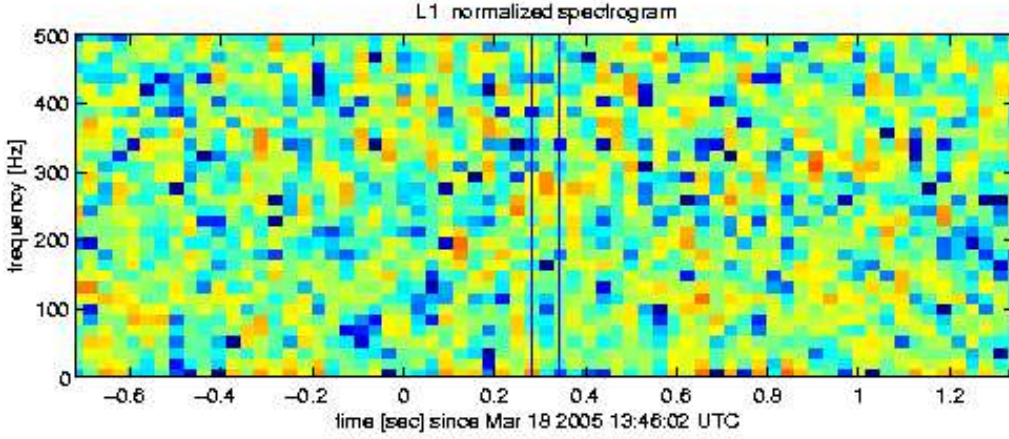


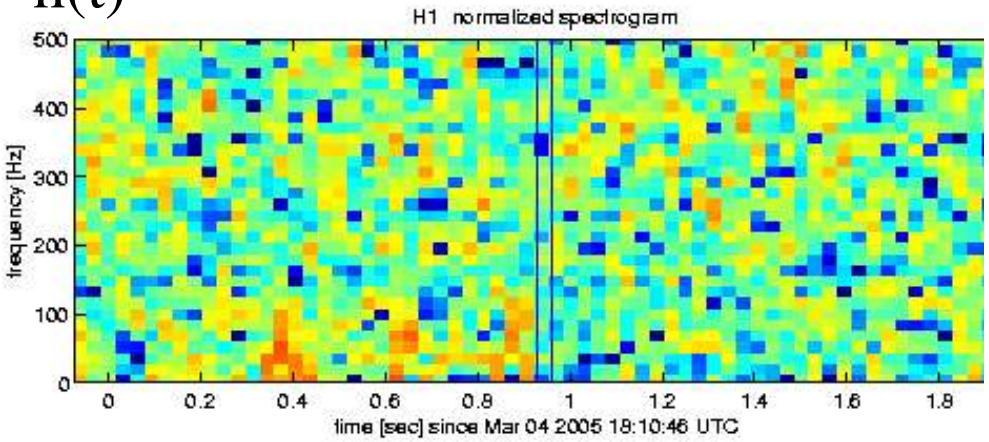



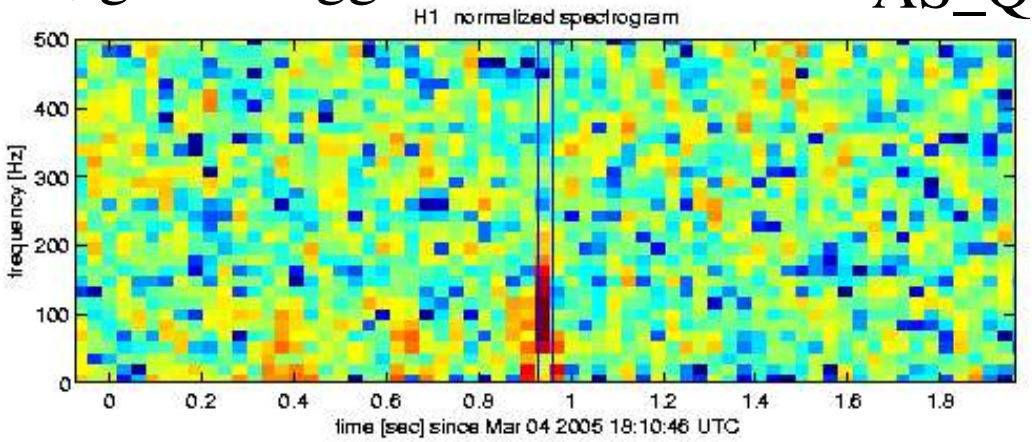



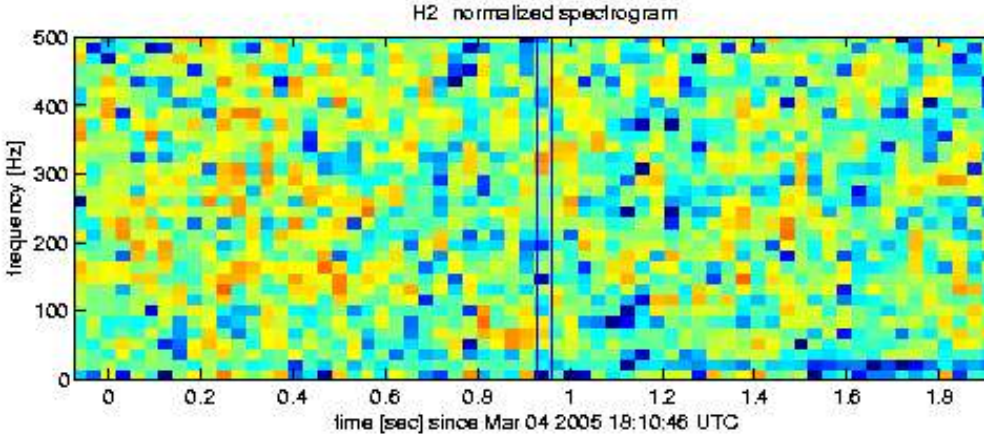



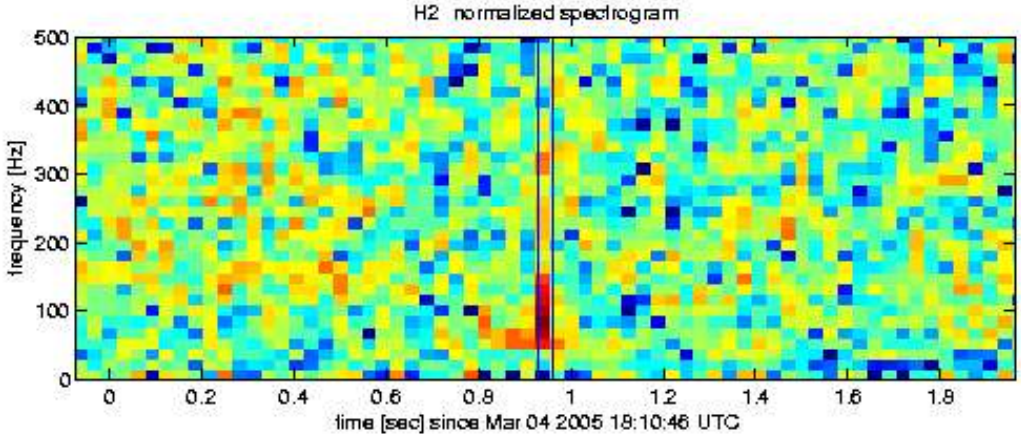



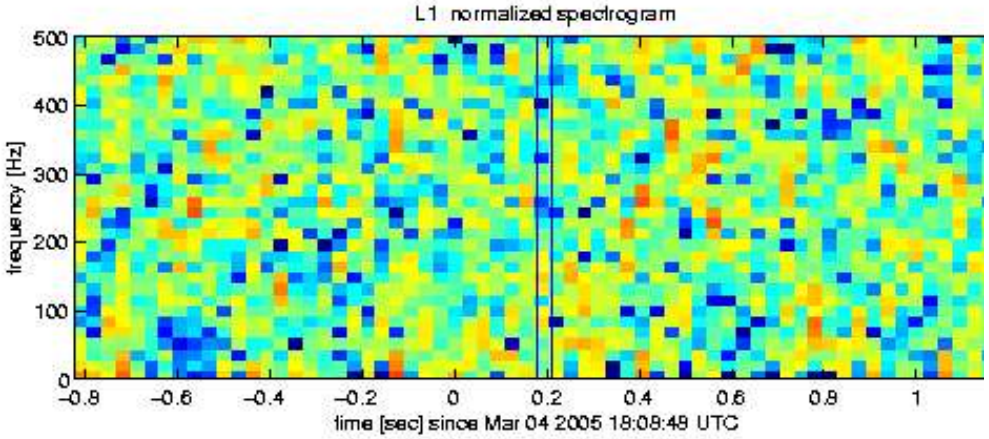
h(t) calibration line dropout, green trigger AS_Q

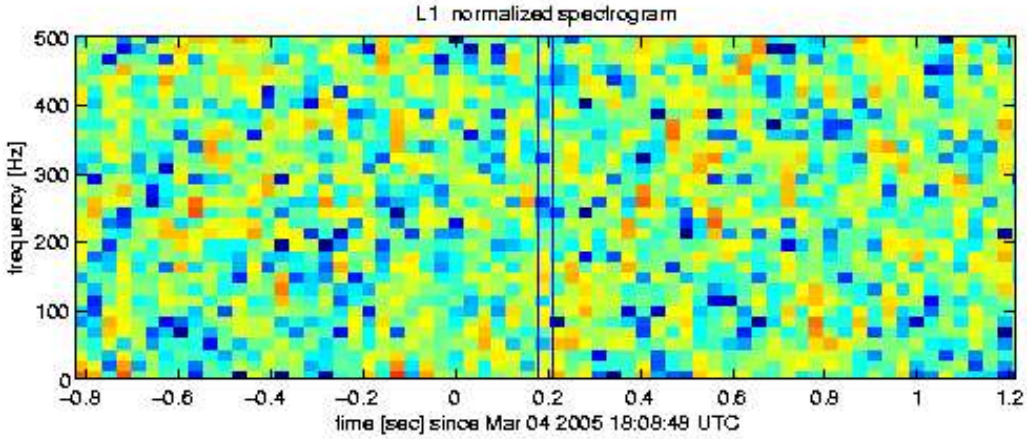


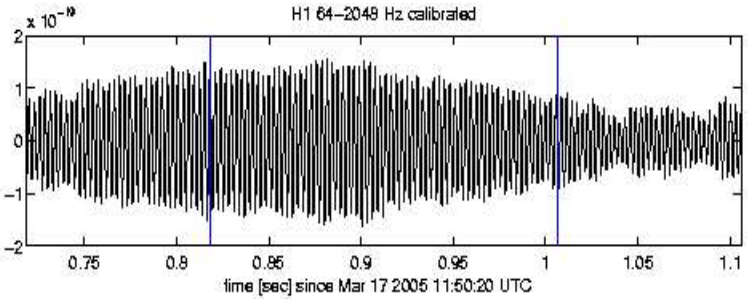



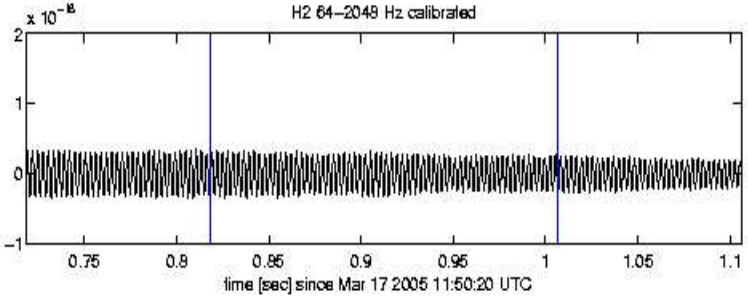



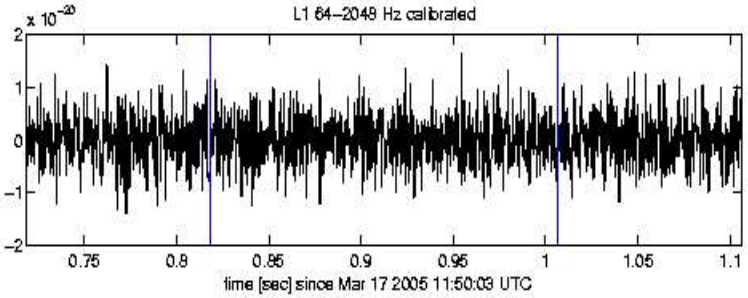



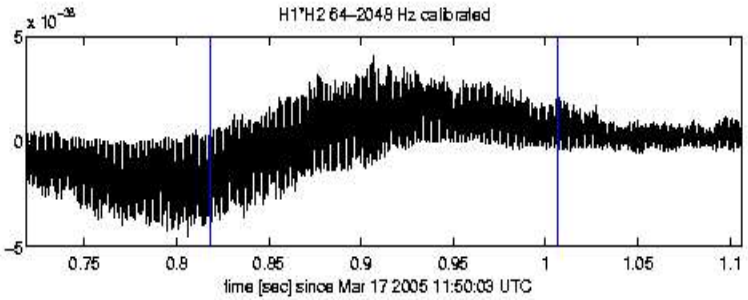



# violin mode glitch time series

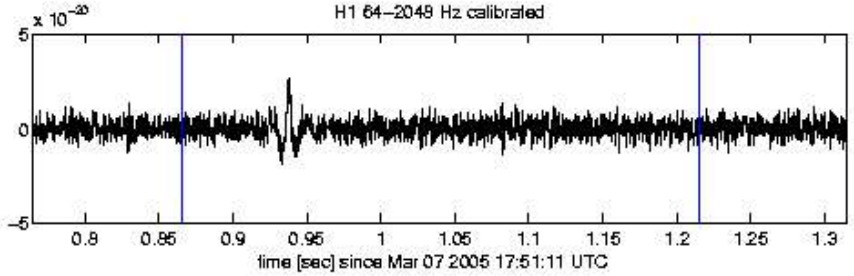


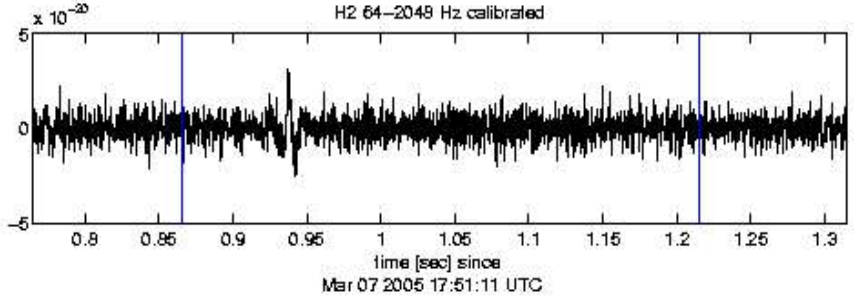



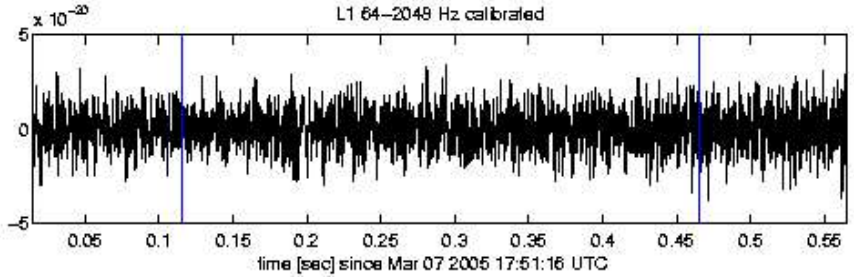



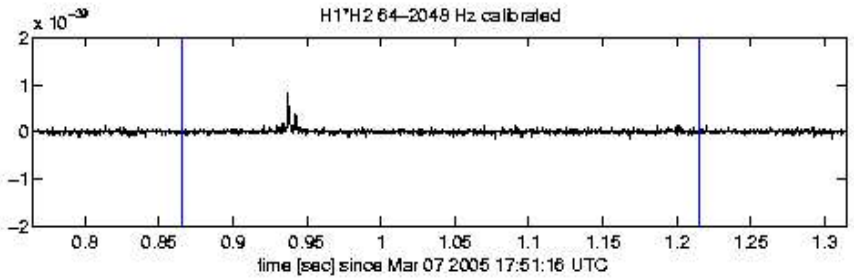




# calibration dropout time series



# CorrPower on h(t) and AS_Q

http://emvogil-3.mit.edu/~cadonati/S4/CorrPower/CorrPower-1.html

10 non-zero time lags vs 100 non-zero time lags in WaveBurst + r-statistics search, only events with Γ≥5 that pass H1-H2 consistency test are shown.

## h(t) triggers

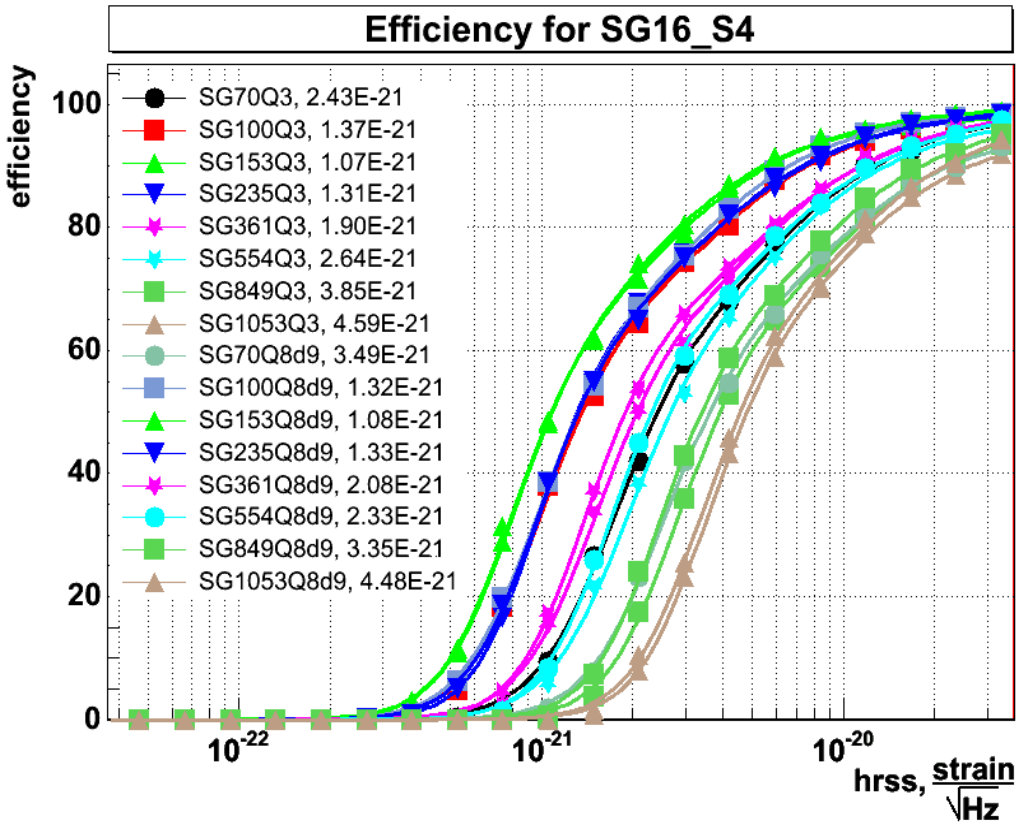
| gps: LHO-LLO | Γ | CP on AS_Q | WB on h(t) | WB on AS_Q | Comment |
|---|---|---|---|---|---|
| 794950231-794950222 | 9 | NO | NO | YES | H2 violin mode - L1 activity (~350Hz+low freq) |
| 794944075-794944062 | 6.5 | NO | YES | YES | H2 violin mode - L1 activity (~350Hz+low freq) |
| 794845015-794845011 | 5.2 | NO | NO | NO | H2 violin mode - L1 activity (~350Hz+low freq) |
| 794576936-794576915 | 5.2 | NO | NO | NO | H2 violin mode - L1 activity (~350Hz+low freq) |

## AS_Q triggers

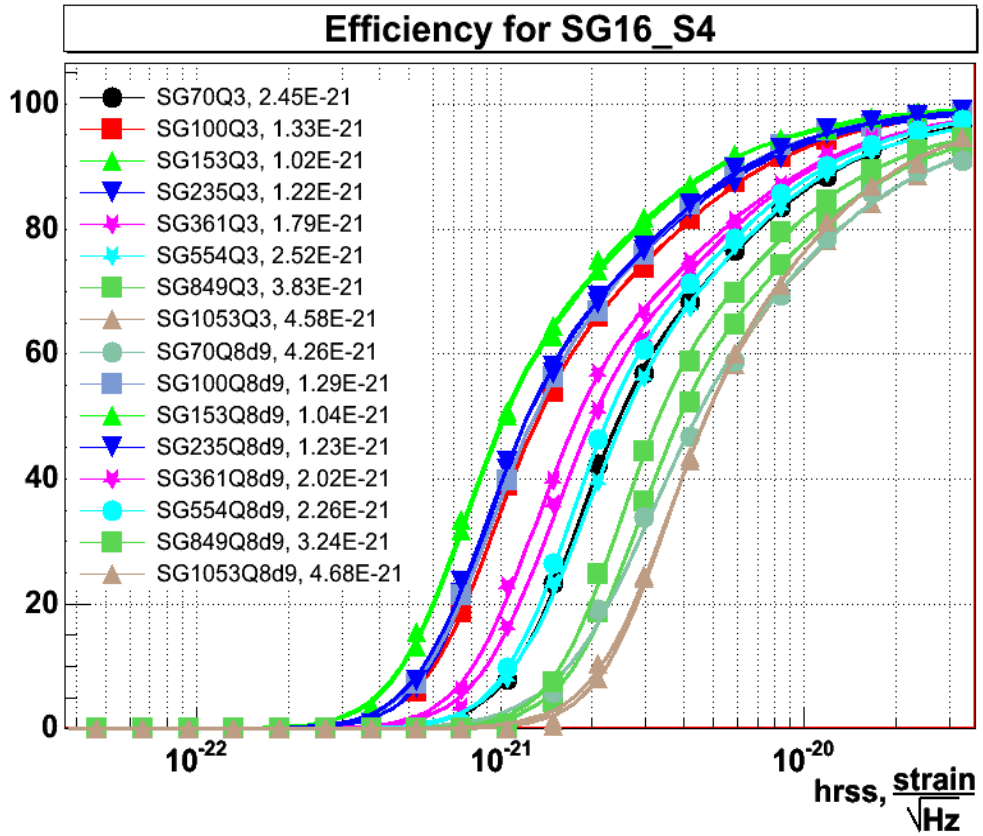
| gps: LHO-LLO | Γ | CP on h(t) | WB on h(t) | WB on AS_Q | Comment |
|---|---|---|---|---|---|
| 795038191-795038200 | 19.2 | NO | NO | NO | Violin mode breathing at H1,H2 |
| 793995059-793995051 | 8.3 | NO | NO | YES | H1-H2 glitch, absent in h(t) |
| 794253084-794253089 | 8 | NO | NO | YES | H1-H2 glitch, absent in h(t) |
| 794336254-794336242 | 7.1 | NO | NO | YES | H1-H2 glitch, absent in h(t) |
| 793264474-793264479 | 6.9 | NO | NO | YES | H1-H2 glitch, absent in h(t) |
| 795577404-795577417 | 6.2 | NO | NO | YES | H1-H2 glitch, absent in h(t) |

# How to do simulations on h(t)?

naïve h(t) simulations




DARM_ERR simulation




Is it correct to do simulations with h(t) in a naïve way: add strain signal without subjecting it to the same kind of filtering that is used to make h(t)?

# Summary

- Statistical properties of waveburst background offtime triggers (~20μHz) look very similar for h(t) and AS_Q, however, only about 10% of triggers actually overlap.
- 97% of waveburst h(t) and AS_Q triggers obtained in zero-time lag on hardware injections overlap and have similar detected properties (central frequency, gs, central time).
- After applying r-statistics and H1-H2 consistency cuts the rate is reduced to ~0.1μHz and the difference between h(t) and AS_Q triggers is reduced to two main cases:
  - violin mode breathing glitches (to be excluded by extra notch)
  - calibration dropout glitches (by construction this glitch does not make it into h(t))
- CorrPower triggers after H1-H2 consistency cuts show the same kind of difference on h(t) and AS_Q.
- It is an open question how to do the software injections accurately on h(t): should we just naively add strain signal to h(t) or should we calibrate it to adc, add to AS_Q and transform the result into h(t)?