LIGO

TFClusters Tuning for the LIGO-TAMA Search

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LIGO-G040032-00-Z

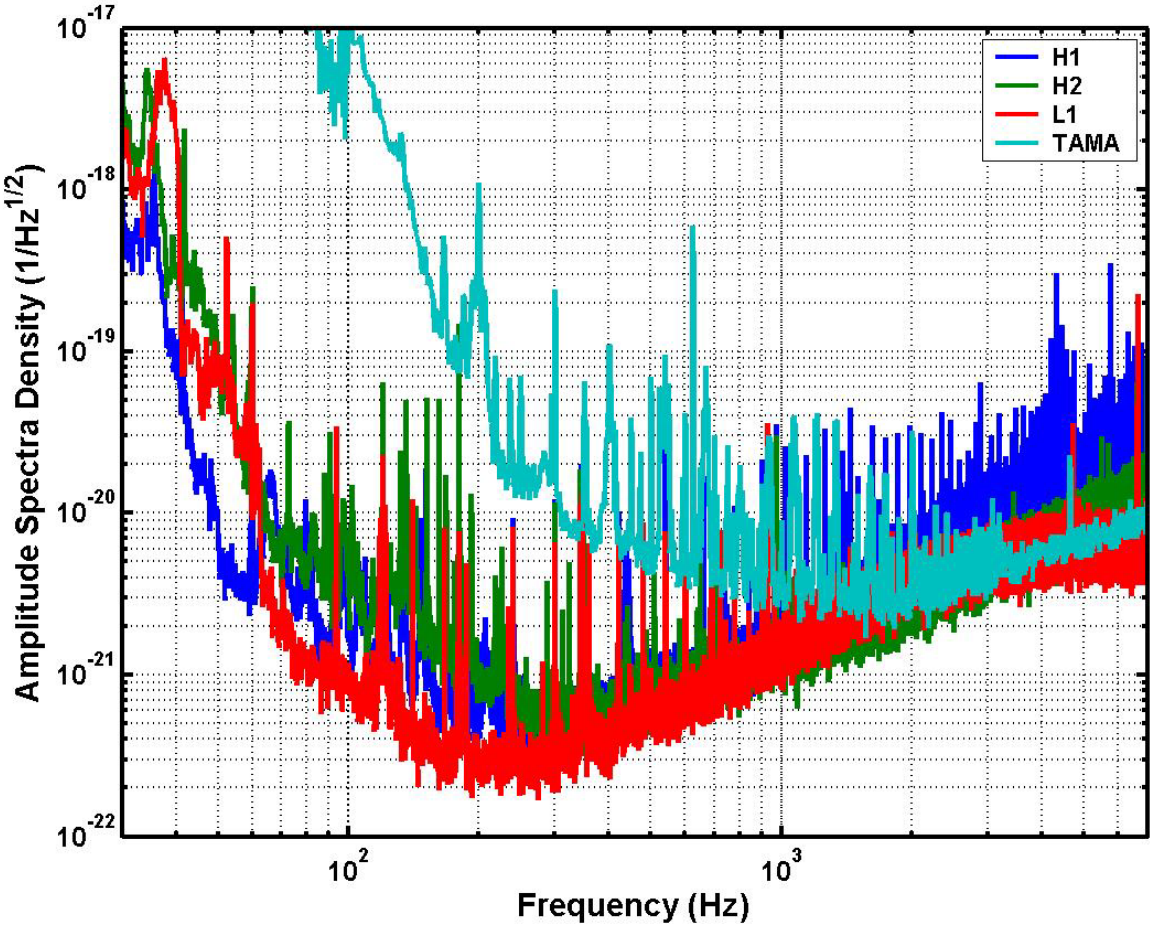
Overview

- Goal: determine parameters for the production running of TFClusters over the three LIGO IFOs for the LIGO-TAMA coincidence analysis.
  - » TAMA: fixed low rate (<0.01Hz), estimated sensitivity at h_{rss} > 15 x noise floor.

- Strategy: determine the efficiency and false rate as functions of TFClusters parameters, then select parameters to give lowest false rate while maintaining sensitivity to events detectable by TAMA.
  - » Combine antenna patterns and single-IFO efficiencies to select a sensible target rate for each LIGO detector.

Tuning Preliminaries

- Restrict to triggers overlapping TAMA frequency range: [700-2000]Hz ("soft cut").
- Tune for best efficiency versus false rate to Q~9 sine-Gaussians centered at f_0 = 1200Hz (minimum of the LIGO and TAMA S2 noise curves).



Procedure

- Preliminary parameter sweep: Follow method of Sylvestre (see http://www.ligo.caltech.edu/~jsylvest/). Examine how different parameters affect false rate.
- Fix alpha=1 (no secondary threshold on clusters).

```
set TFCThr "(\\\\\\[1e-3,3e-2,16,l\\\\\\])"
set TFCWin "1"
set TFCThrMethod "0"
set TFCdata "0"
set TFCTRez "(7.8125e-3,0.015625,0.03125,0.0625)"
set TFCFmin "-700.0"
set TFCFmax "-2000.0"
set TFCalpha "(1.0)"
set TFCsigma "(2,3,4,5,6)"
set TFCdelta "0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0"
```

black pixel prob (bpp)

time resolution (sec)

min cluster size (pixels)

Procedure

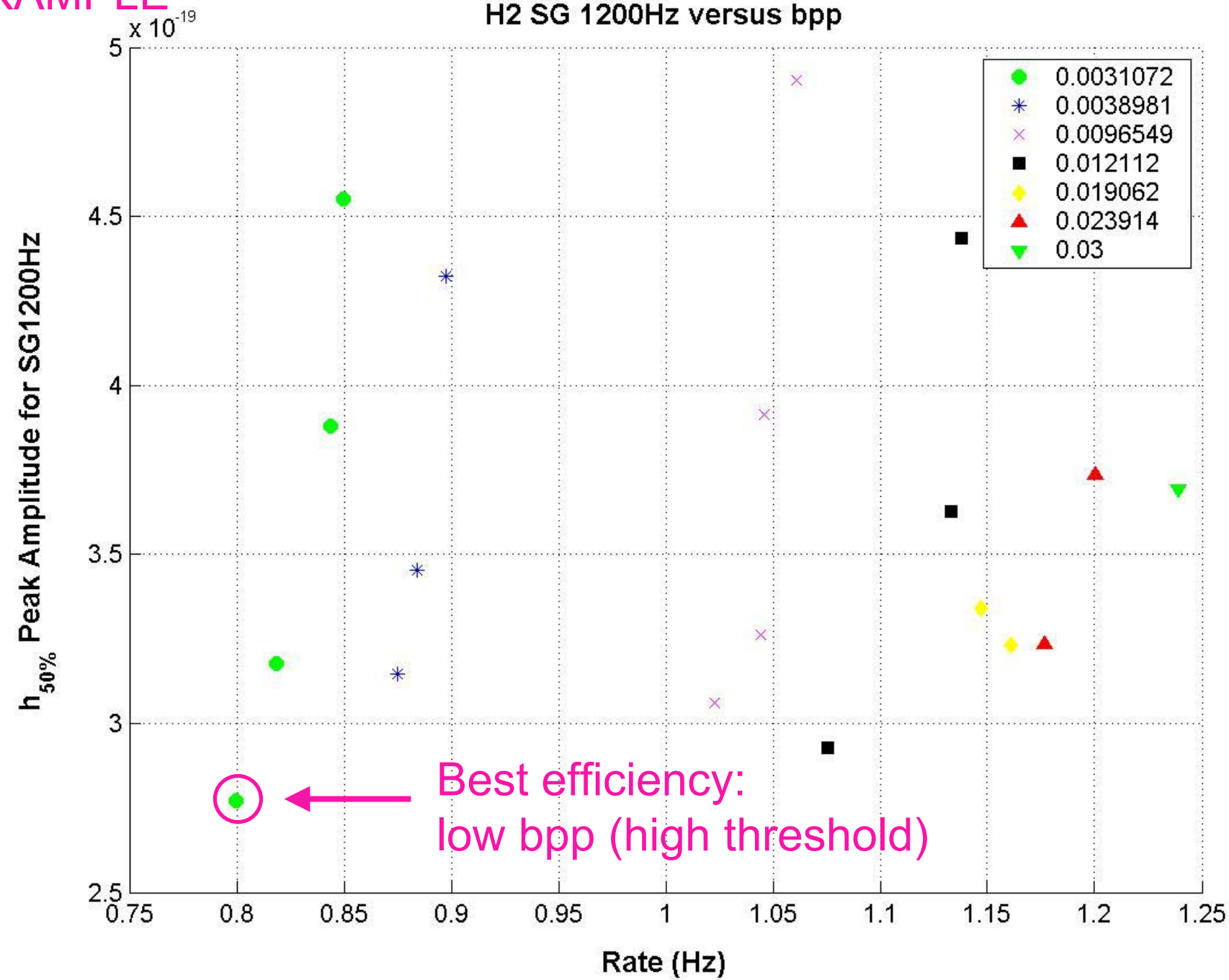
- Target rate: Select parameter sets for each IFO that give event rates (unclustered) in the ranges $[10^{-0.6}, 10^{-0.4}]$Hz ~ 0.3Hz and $[10^{-0.1}, 10^{+0.1}]$ Hz ~ 1Hz.
- Simulations: Re-run with these parameter sets, but including injected sine-Gaussians at 1200Hz.

```
set waveforms "SG1200"
set injAmp "(\\\\\[3e-20,3e-18,21,l\\\\\])"
```

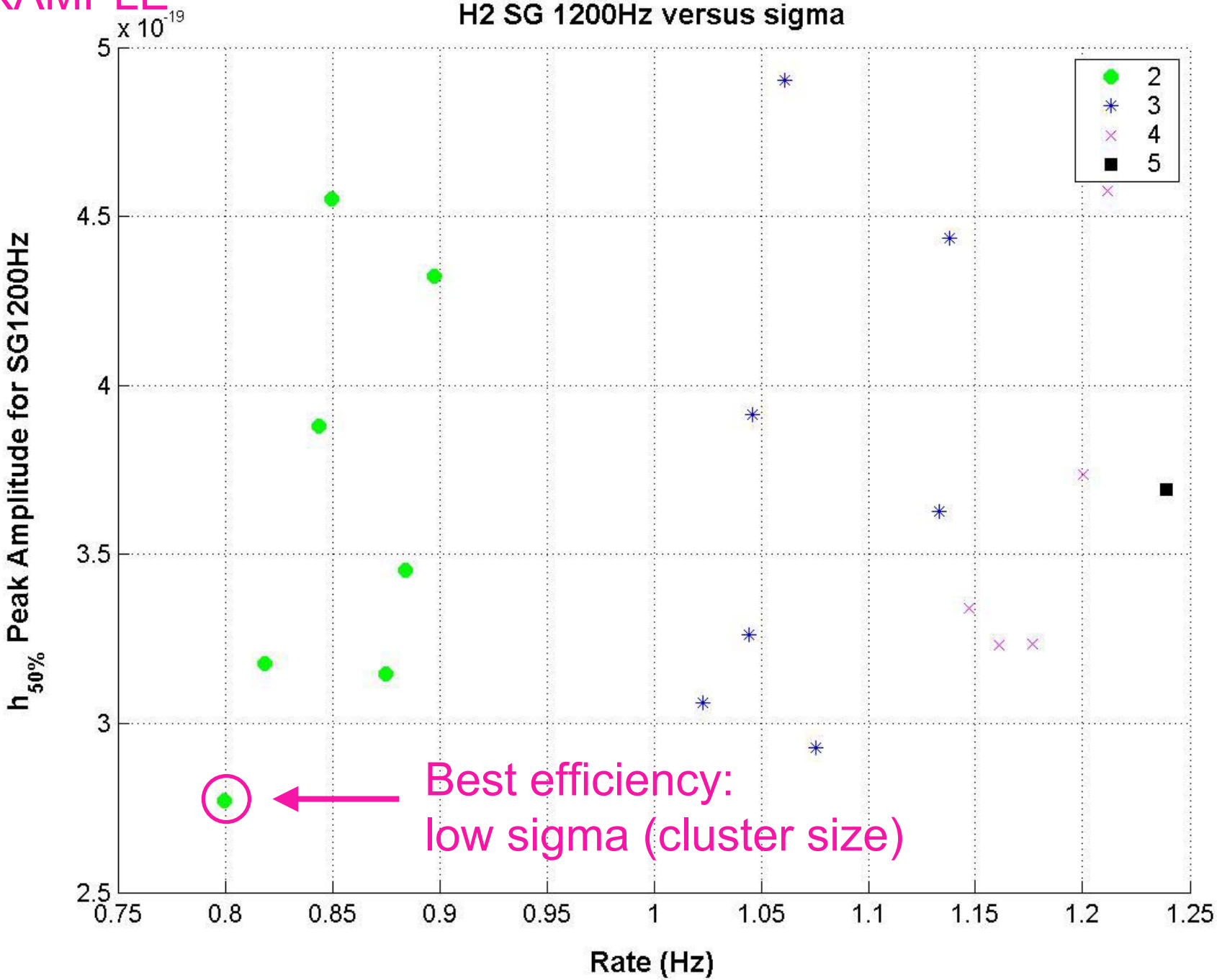
peak amplitude

- Plot: $h_{50\%}$ versus rate for each IFO, sorted by bpp, sigma, and time resolution.
- Results: Best efficiencies at given rate were for the smallest cluster sizes (sigma = 2) and time resolution (1/128sec), and the lowest black pixel probability.

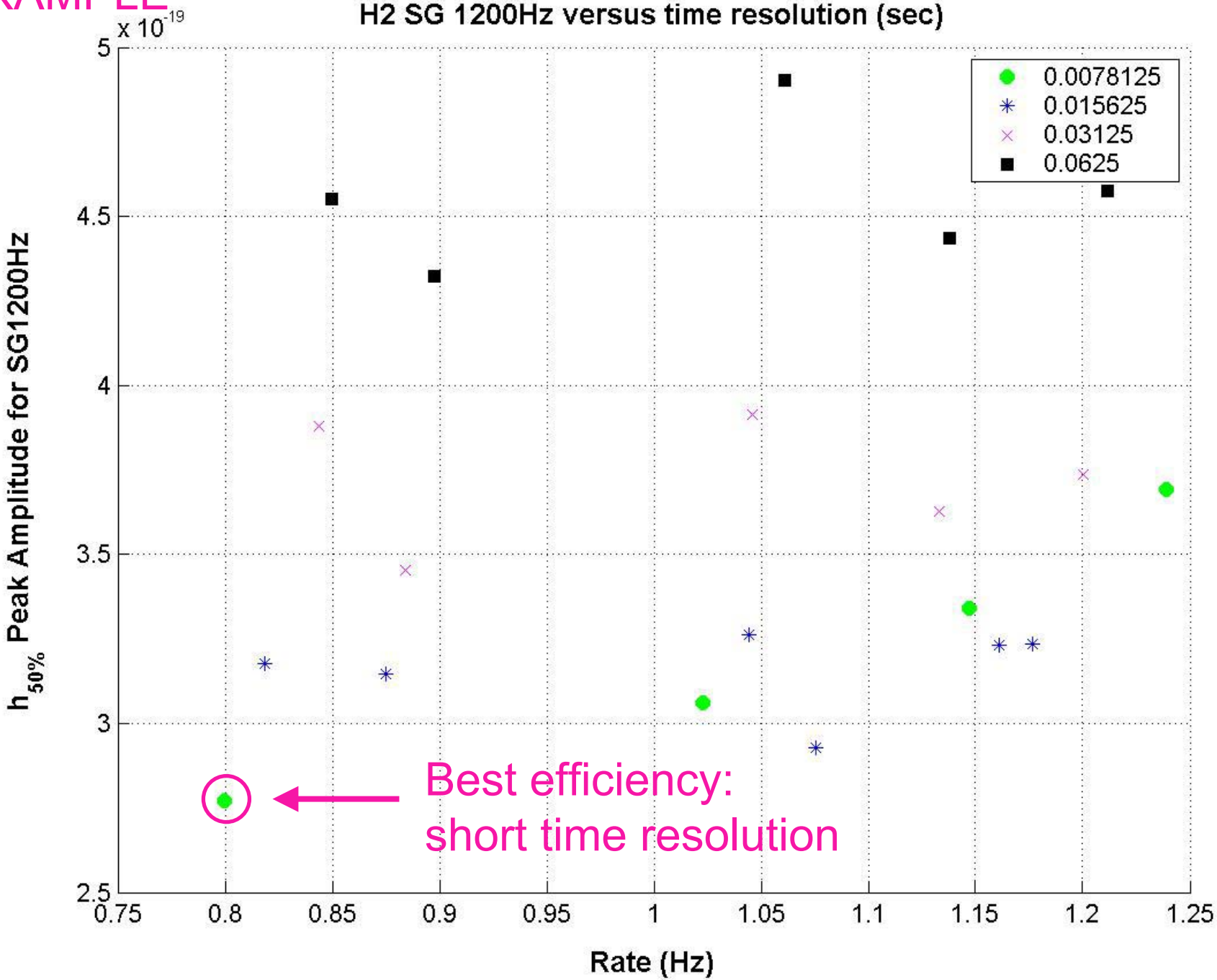
EXAMPLE


H2 SG 1200Hz versus bpp
x 10^-19
5
4.5
4
3.5
3
2.5
h50% Peak Amplitude for SG1200Hz
0.75
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15
1.2
1.25
Rate (Hz)
0.0031072
0.0038981
0.0096549
0.012112
0.019062
0.023914
0.03
Best efficiency:
low bpp (high threshold)

EXAMPLE


H2 SG 1200Hz versus sigma
x 10^-19
h50% Peak Amplitude for SG1200Hz
Rate (Hz)
2
3
4
5
5
4.5
4
3.5
3
2.5
0.75
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15
1.2
1.25
Best efficiency:
low sigma (cluster size)

EXAMPLE


H2 SG 1200Hz versus time resolution (sec)
x 10^-19
5
4.5
4
3.5
3
2.5
0.75
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15
1.2
1.25
h50% Peak Amplitude for SG1200Hz
Rate (Hz)
0.0078125
0.015625
0.03125
0.0625
Best efficiency:
short time resolution

Tuning Rules of Thumb

1. For alpha=1, use sigma=2, time resolution = 1/128sec (small clusters and short time resolution).
2. Adjust only the black pixel probability to achieve the desired false rate:

$$\log_{10}(\text{rate}) = m \log_{10}(\text{bpp}) + b$$

H1: m = 1.23 b = 3.12
H2: m = 1.24 b = 3.12
L1: m = 1.11 b = 2.95

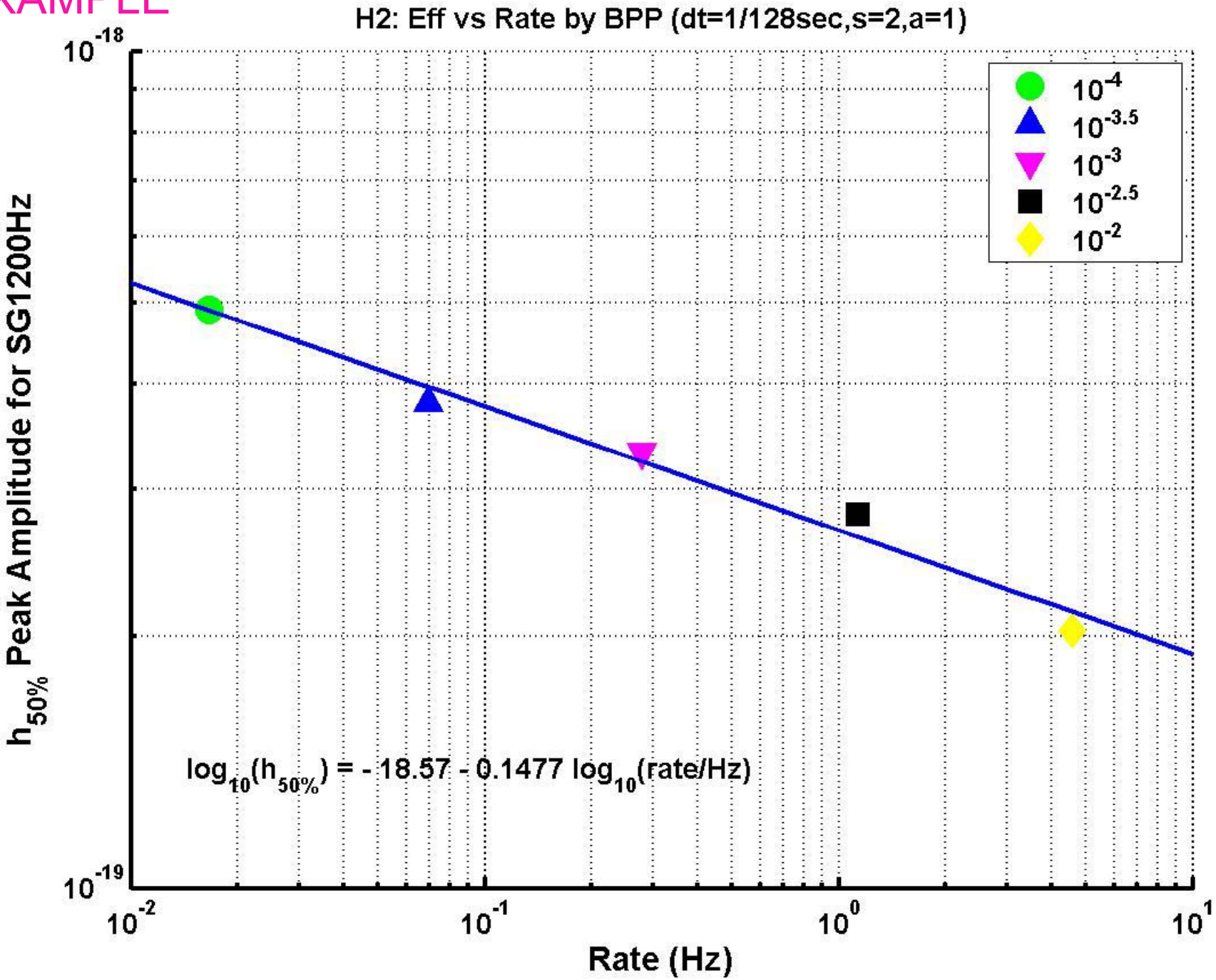
Efficiency vs. Rate

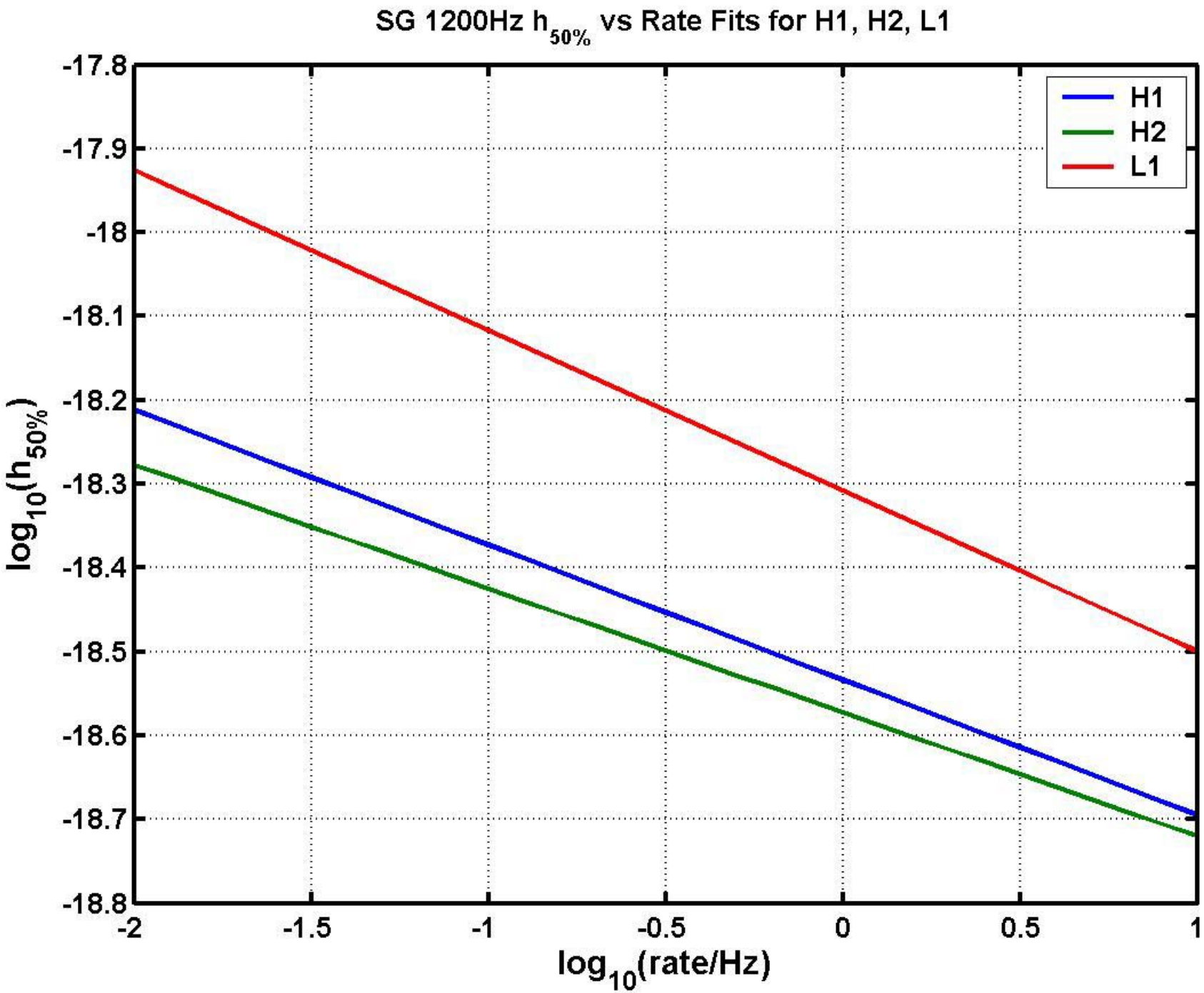
- Nail down the efficiency versus false rate curve for each detector over whole 4x playground using a few different bpps.
- Find power-law fit of $h_{50\%}$ vs rate is good to about 10% for each detector:

$$\log_{10}(h_{50\%}) = m \log_{10}(\text{rate}) + b$$

H1: m = -0.1610 b = -18.53
H2: m = -0.1477 b = -18.57
L1: m = -0.1915 b = -18.31

EXAMPLE


H2: Eff vs Rate by BPP (dt=1/128sec,s=2,a=1)
10^{-4}
$10^{-3.5}$
10^{-3}
$10^{-2.5}$
10^{-2}
$h_{50\%}$ Peak Amplitude for SG1200Hz
10^{-18}
10^{-19}
$\log_{10}(h_{50\%}) = -18.57 - 0.1477 \log_{10}(\text{rate/Hz})$
10^{-2}
10^{-1}
10^{0}
10^{1}
Rate (Hz)


SG 1200Hz h50% vs Rate Fits for H1, H2, L1
H1
H2
L1
-17.8
-17.9
-18
-18.1
-18.2
-18.3
-18.4
-18.5
-18.6
-18.7
-18.8
log10(h50%)
-2
-1.5
-1
-0.5
0
0.5
1
log10(rate/Hz)

LIGO

Next Steps

- Combine with TAMA efficiency to make final tuning choice (bpp).
  - » Use Monte Carlo to estimate effect of antenna patterns. Find safety margin to leave in the LIGO tuning to ensure detectability of signals seen by TAMA.
- Test efficiencies for other waveforms (sine-Gaussians, Gaussians, supernovae) to make sure this tuning is not pathological in some way.
- Generate trigger lists for each IFO and proceed to coincidence.