Wavegraph clustering for coherent Waveburst

Principles, applications and improvements.

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Wavegraph : principles (1/3)

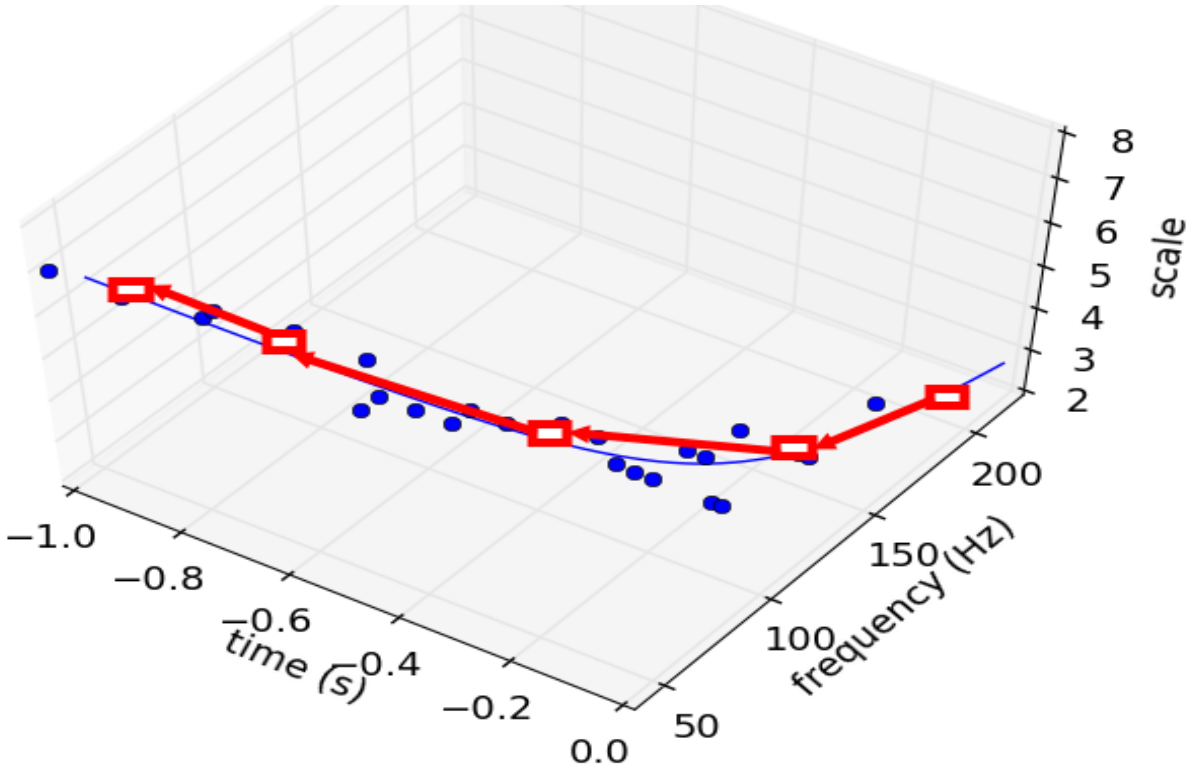
Wavegraph :

- is a new clustering scheme dedicated to cWB.
- Goal : Incorporate astrophysical informations in coherent GW burst searches at clustering step.
- improves performances of coherent searches for ¨chirp¨-like signals
- has potential applications : BBH (considered here), eBBH, long bursts (could be connected to GRBs)

$\rightarrow$ Sensitivity study of Wavegraph compared to cWB (standard configuration) for BBH waveforms.

Wavegraph : principles (2/3)

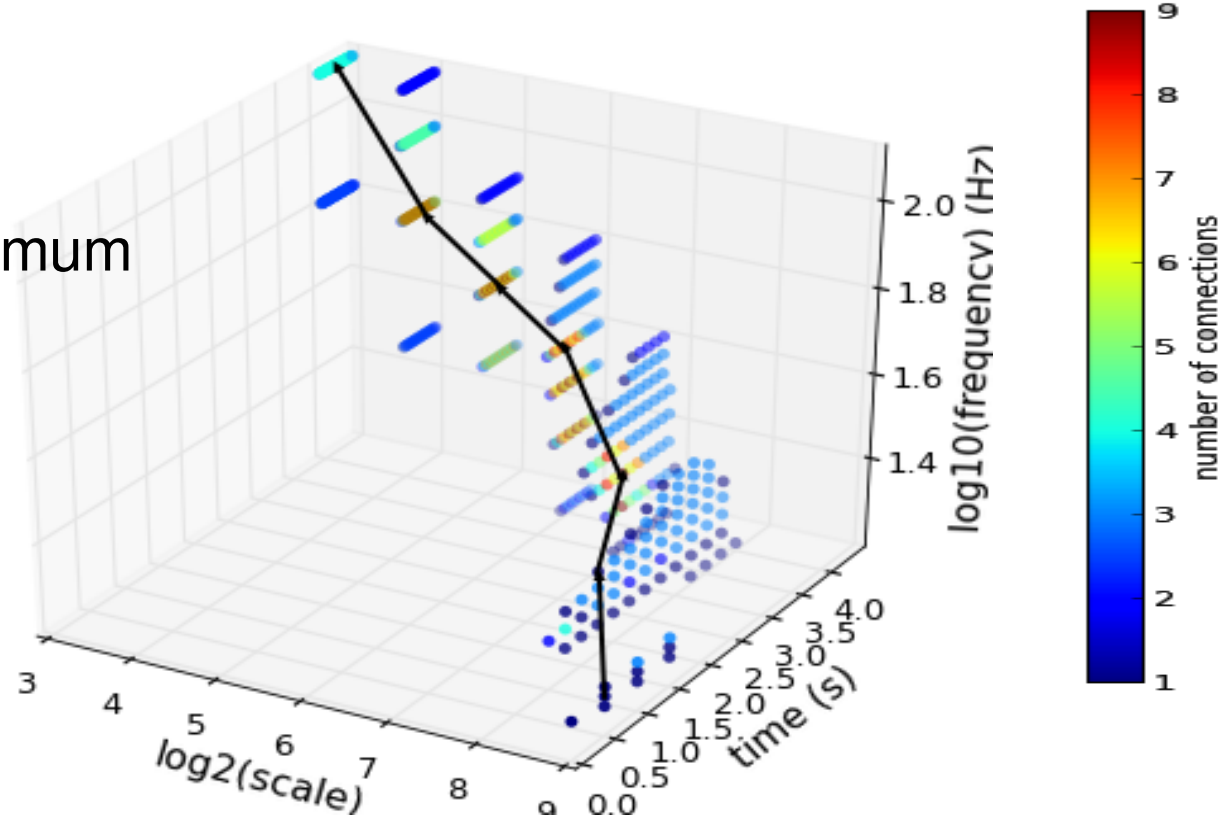
- cWB represents data in a 3D space (time t, frequency f, timescale a) $\rightarrow$ WDM transform
- Chirp signals in this space are 1D paths : set of linked pixels.



Wavegraph : principles (3/3)

- Exploring parameter space, one gathers many chirps
- Wavegraph apply a clustering algorithm on this graph.

It will extract the maximum SNR value over the possible paths in the graph...

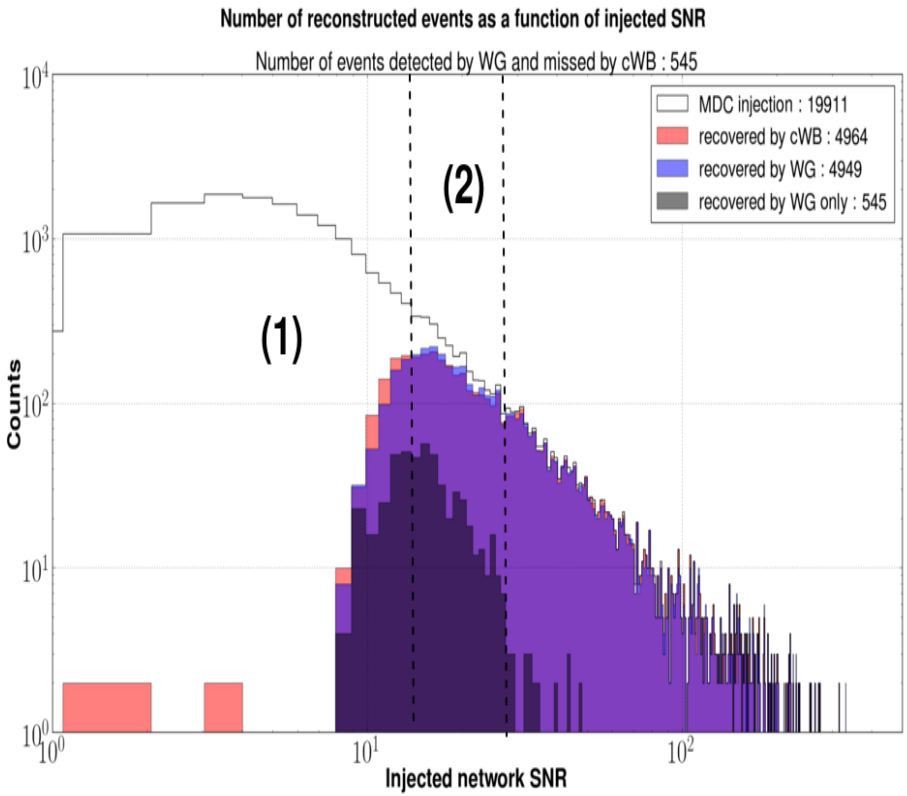


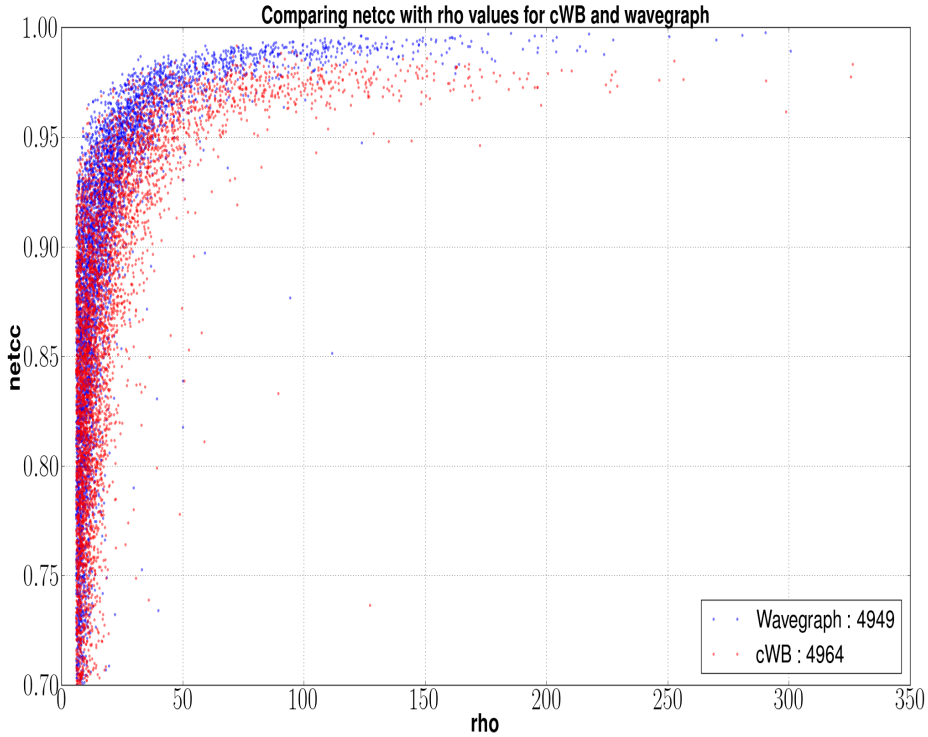
- ...so that a single cluster containing the observation is produced !

Wavegraph : application to MDC

1. Mock Data Challenge description on O1 data :
   Sept 12 to Jan 19 $\rightarrow$ 49 days of effective live time
   - SEOBNR non-spinning BBH waveforms
   - Total mass range : 30 -150 $M_{\odot}$
   - 20,000 injections
   - Isotropic (α, δ) distribution
2. Cuts : Minimal cWB cuts : $c_c > 0.7$ and $\rho > 6$
3. Graph used for WG searches :
   - same mass range as MDC
   - timescales : 3 to 9
   - 563 nodes in graph

Application : reconstructed events vs. injected SNR / rho vs. netcc





(1) : SNR < 14 : cWB is more efficient ($\sim$ 10 – 20%)

(2) : 14 < SNR < 30 : WG is more efficient (few % on few bins)

Recovered WG AND missed cWB : 545 events : **complementarity**

WG identifies pixels for which correlation is the largest between detectors.

Effective radius : cWB vs. Wavegraph

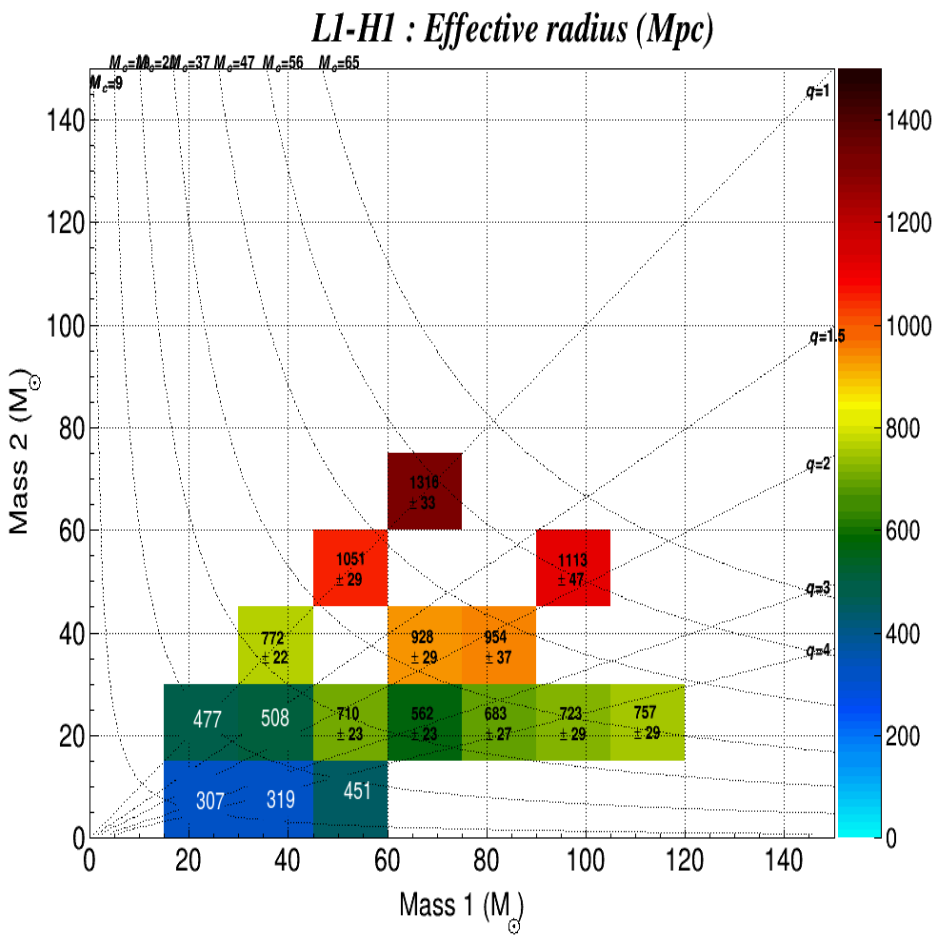


Figure: cWB

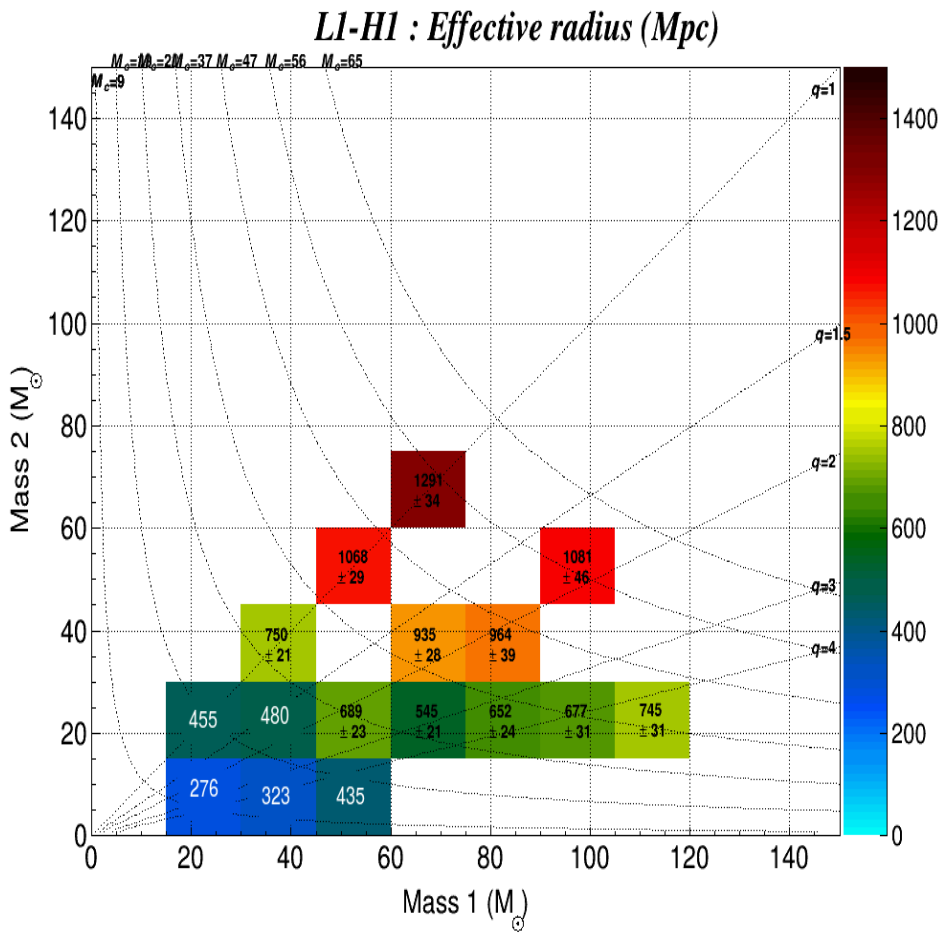
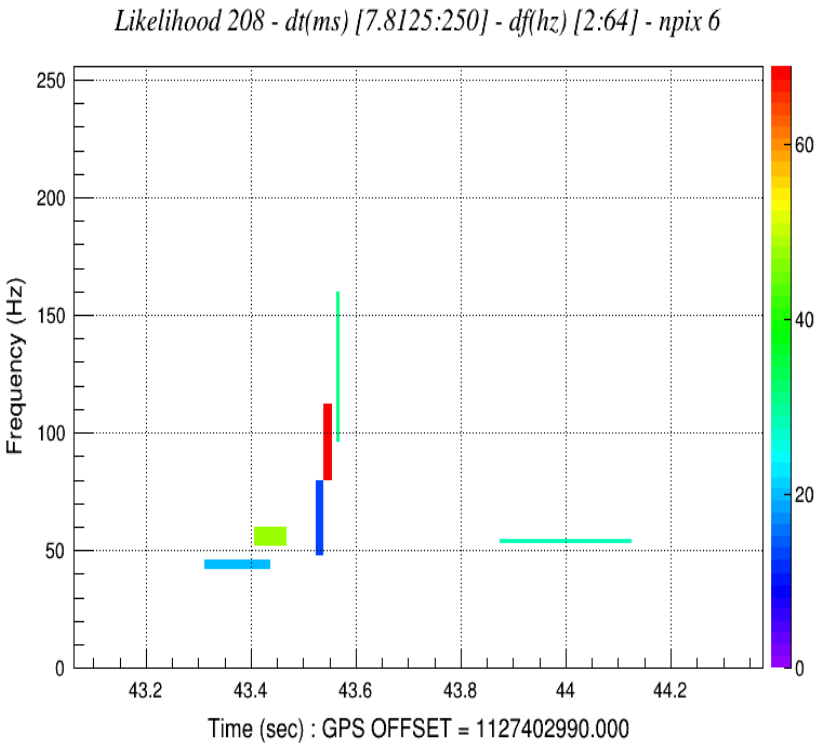


Figure: cWB + Wavegraph

Slightly lower effective radius for wavegraph due to missed low-SNR injection – to be investigating

Comparable in the high-mass range.

Examples : recovered injections



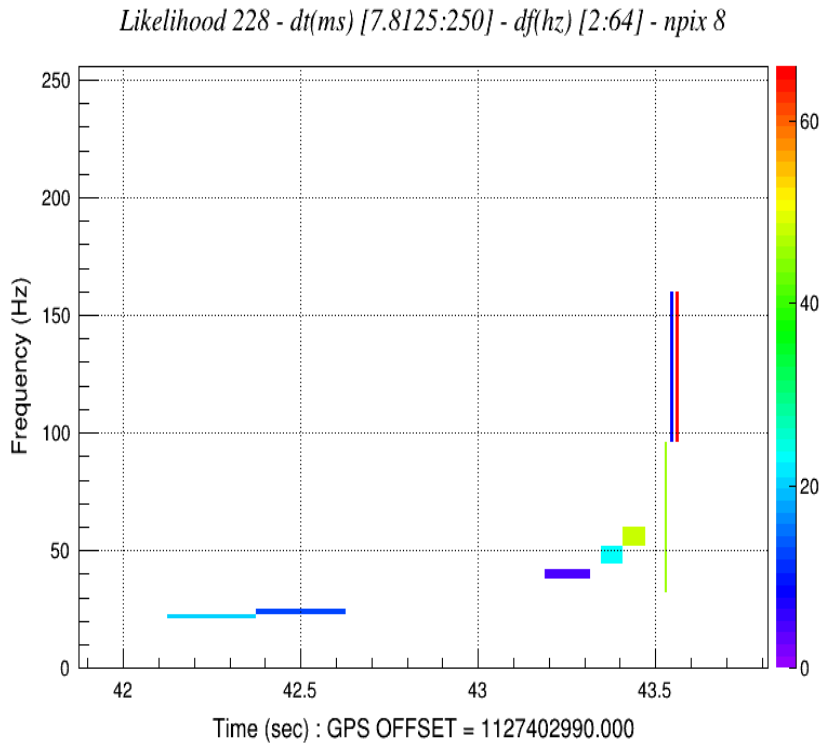


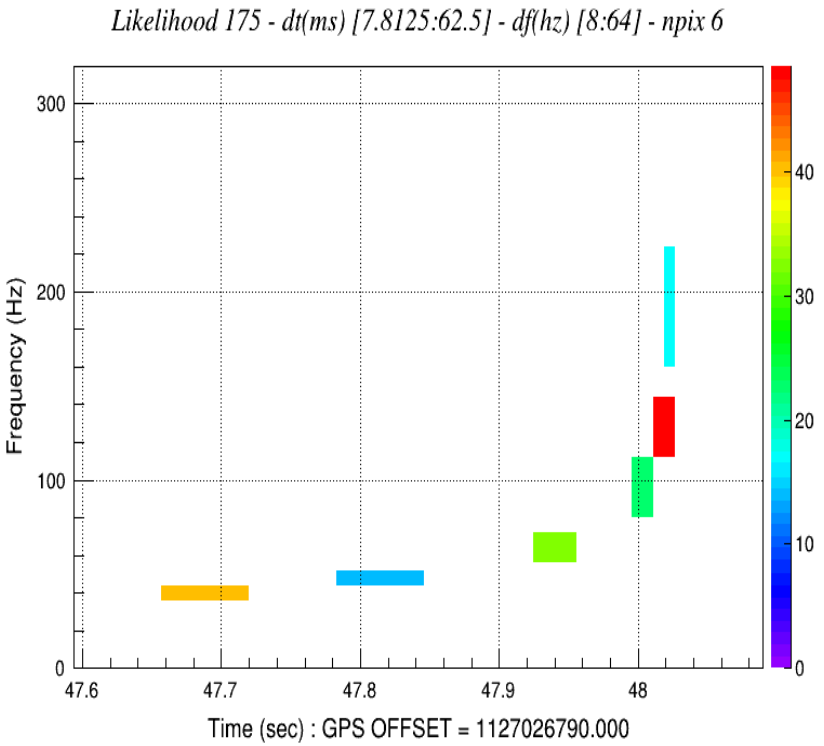
Figure: Recovered injection by cWB.

Figure: Recovered injection by cWB+WG.

Wavegraph recovers more pixels from the chirp signal,

and does not reconstruct non physical pixels.

Examples : missed injection



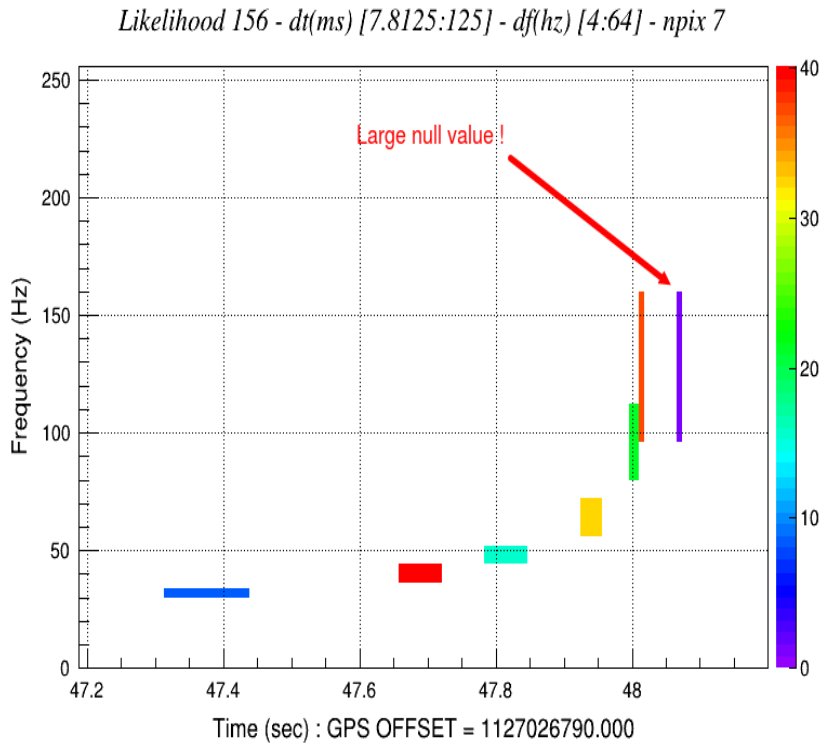


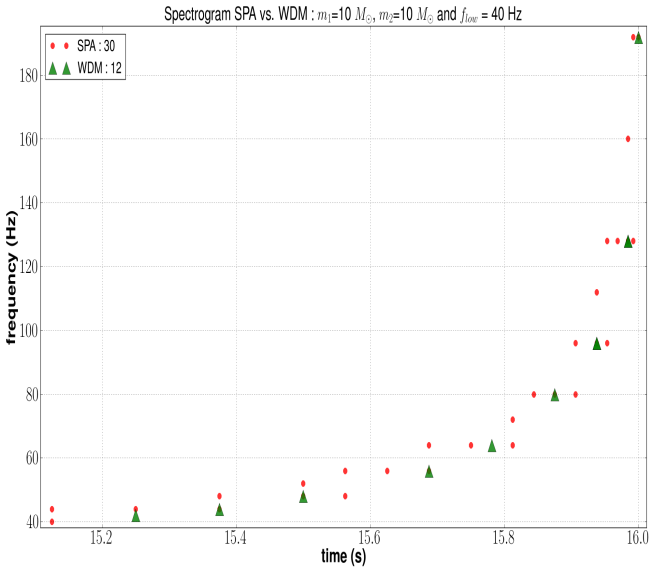
Figure: Recovered injection by cWB.

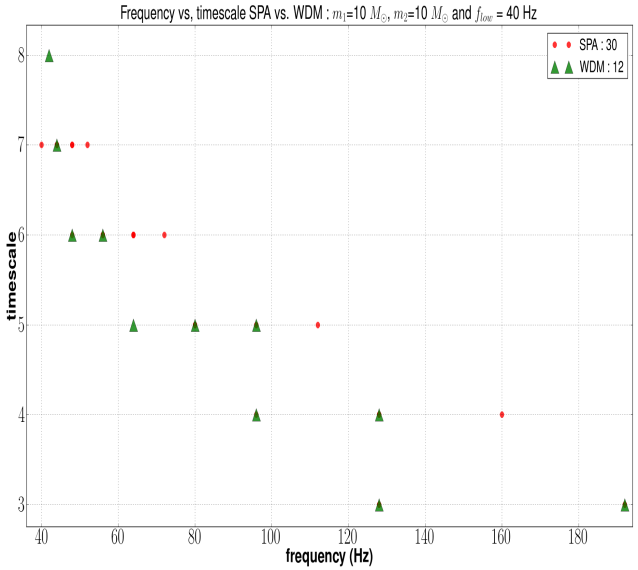
Figure: Missed injection by cWB+WG.

Large null value $\rightarrow$ low c_c $\rightarrow$ event does not pass internal cWB cuts.

$\Rightarrow$ Same margin for improvement.

Future improvements : WDM/SPA chirp paths



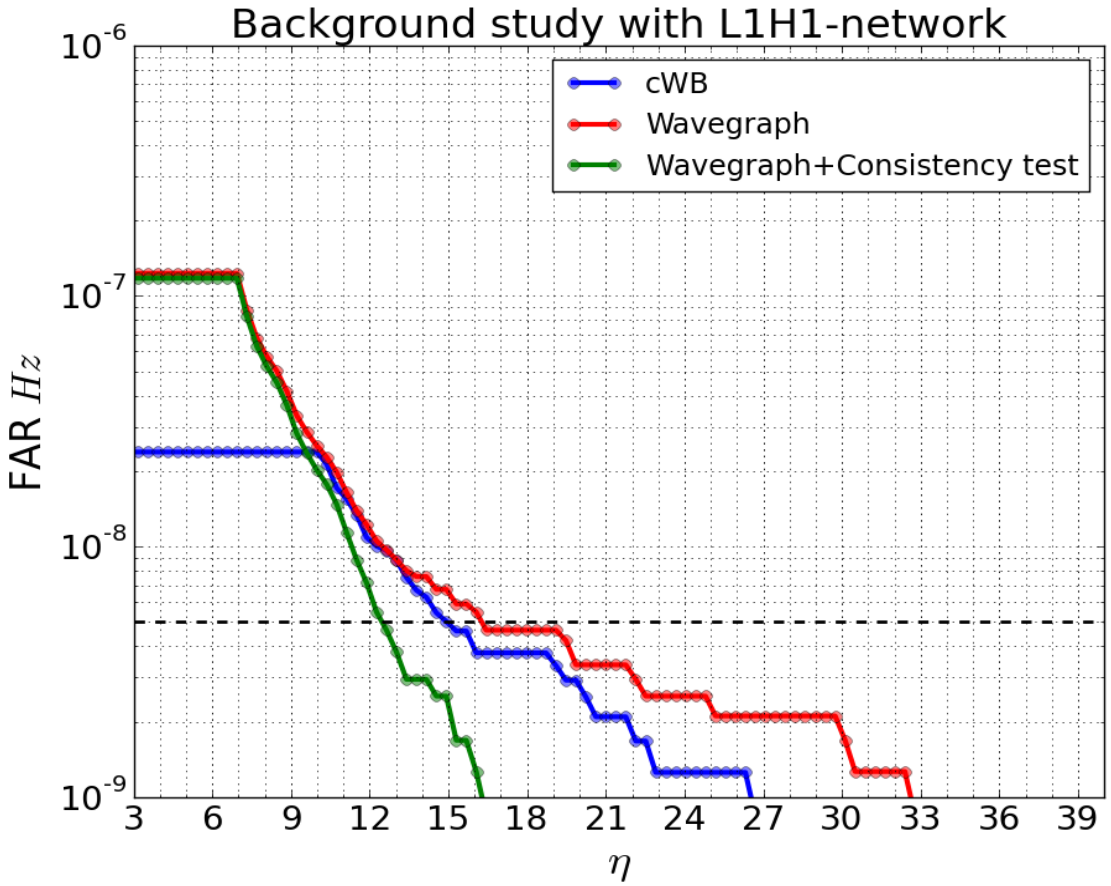


1. chirp path currently computed via stationary phase approximation :

$$t(f) = -\frac{1}{2\pi}\dot{\psi}(f) \qquad a(f) = \frac{f_s}{2\pi}\sqrt{\frac{\ddot{\psi}(f)}{2}}$$

2. Exact numerical calculation directly from Wilson Daubechies Meyer (WDM) transform.
   - Good agreement
   - With WDM : lower number of pixels in the path
   - Will build a full graph with this new algorithm.

Future improvements : consistency test



1. Wavegraph clustering uses phase information only
2. χ^2 test : Amplitude information can be used to reject transient noise

Lead to reduction of the background tail

(Gayathri V., A. Pai)

To conclude

1. Wavegraph is a new clustering algorithm for cWB
   $\rightarrow$ include astrophysical information.
2. For BBH waveforms, Wavegraph shows complementarity with cWB in the mid mass range.
3. Pixels selected by WG have a larger correlation between detectors on average (larger c_c).
4. Margin for improvement :

> Exact graph computed numerically directly from WDM.

> Rejection of glitches thanks to a consistency test.