Cheap chi-squared tests for gravitational wave searches

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Gravitational wave searches have a higher background rate than expected for Gaussian noise due to the non-stationary noise of interferometric gravitational wave detectors. This presentation describes two computationally efficient chi-squared tests that are powerful at distinguishing real signals from non-stationary, non-Gaussian noise.

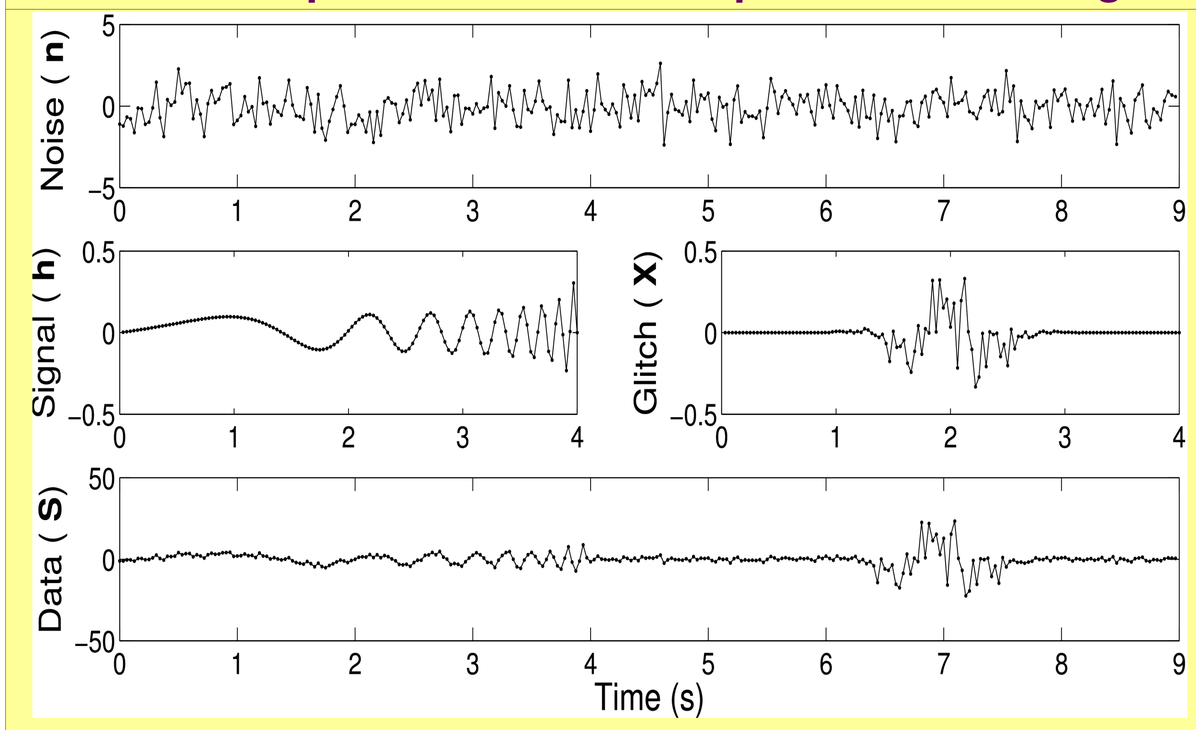

Fig 1. **Gaussian noise, non-stationary noise (transients) and a simulated gravitational wave signal.**

Action	Computations	% of filter time
Filtering	$5\mathcal{N}\,N\,\log_2[N]$	100%
χ^2_C	$5\,N\,\log_2[N]+\mathcal{O}(N)$	0.16%
χ^2_B	$\mathcal{N}\,N\,(p+1)/2$	16.0% (p=31)
χ^2_T	$5\mathcal{N}\,N\,(p/2)\,\log_2[N]$	1600% (p=32)

Comparison of computational cost relative to matched filtering for bank test, the conventional test and the test traditionally used in LIGO searches [1]. [$\mathcal{N}$ = 625, N = 1048576 in these examples 256s of data sampled at 4096Hz with 625 filters.]

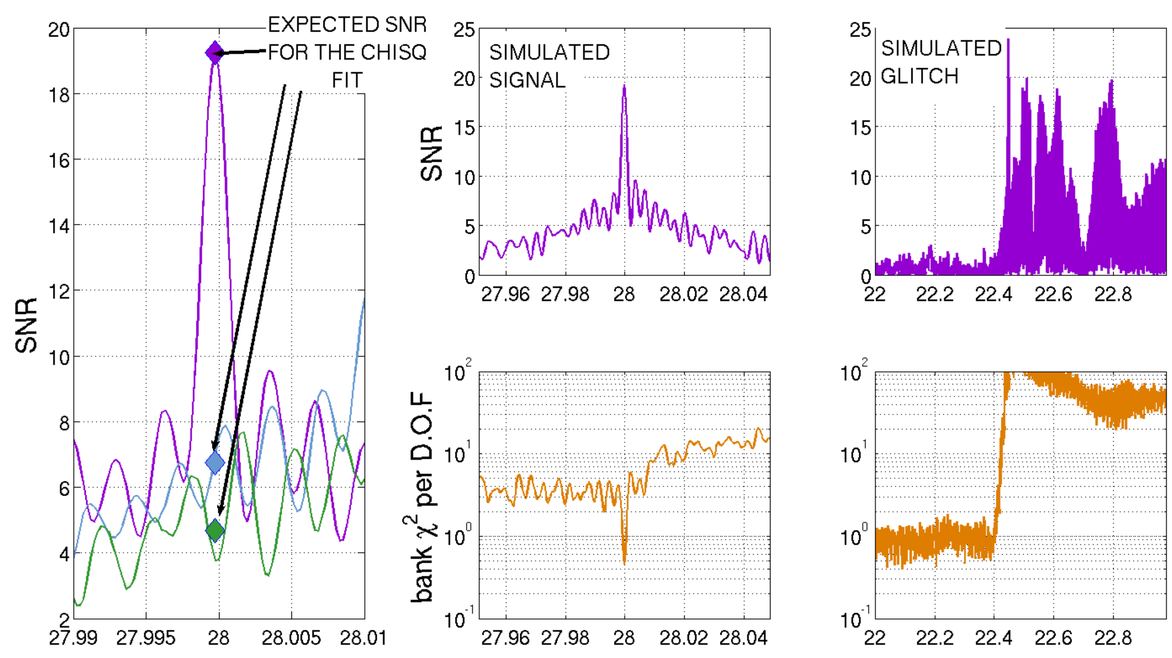

Fig 2. The bank chi-squared test examines the output of multiple matched filters and does a chi-squared test between the expected and measured SNR.

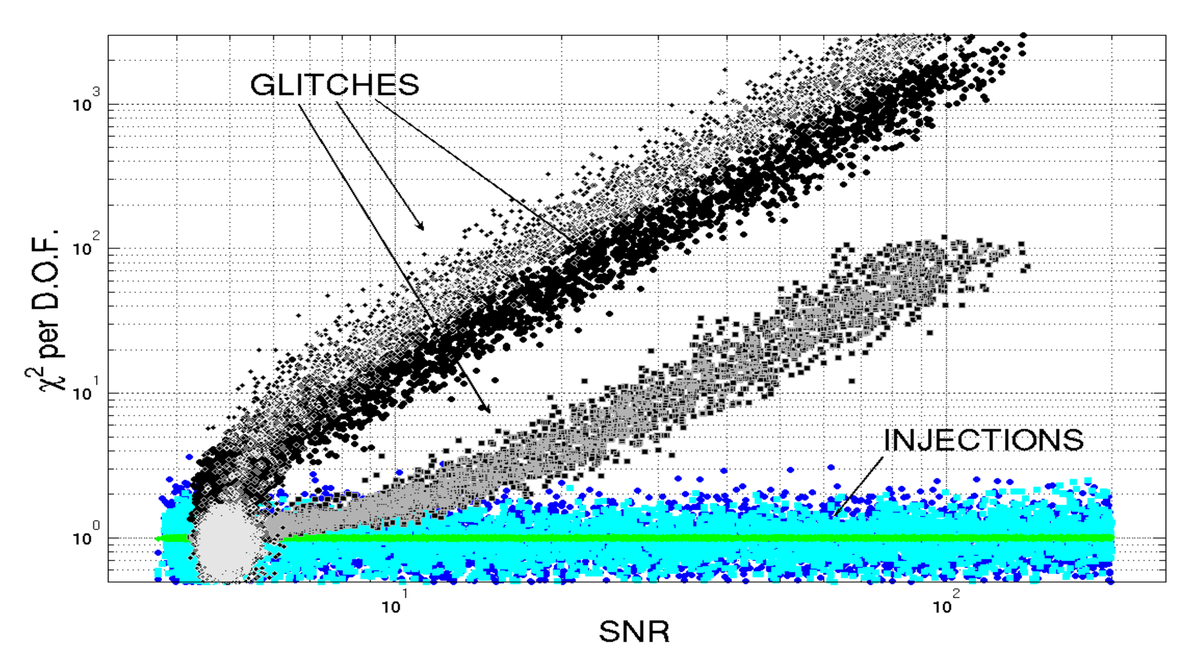

Fig 4. Scatter plot of injections and noise transients (glitches) in simulated data.[2]

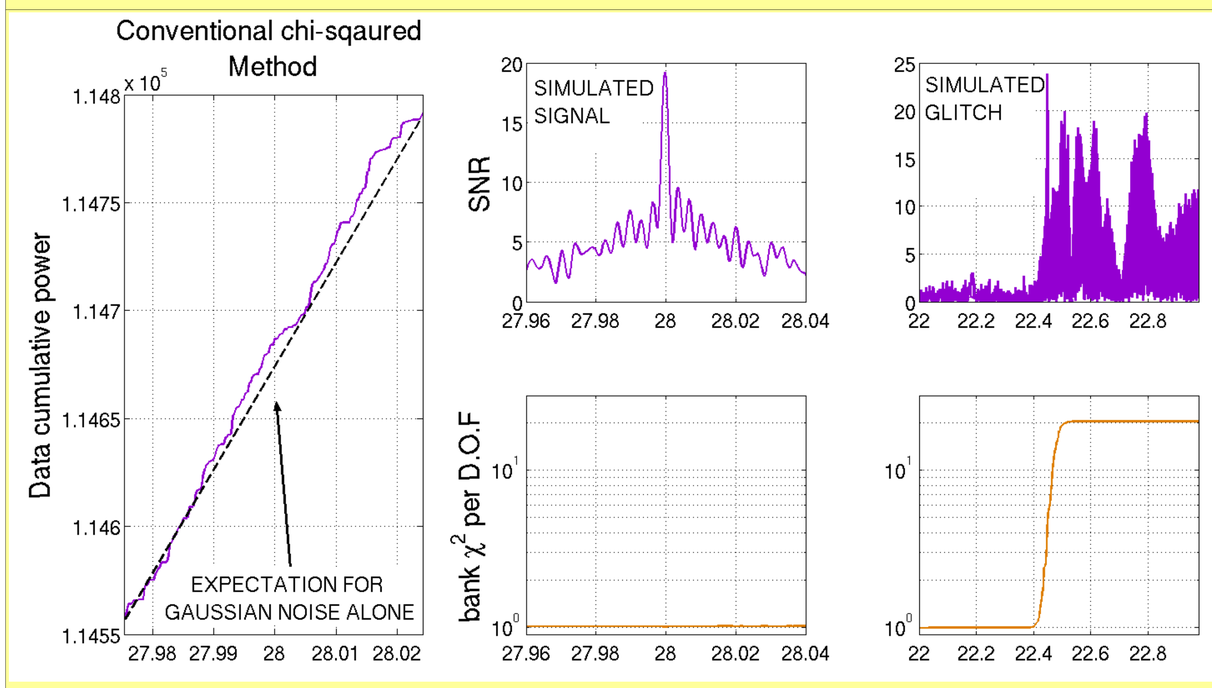

Fig 3. The conventional chi-squared test checks that the cumulative power in the data agrees with the measured SNR of a trigger.

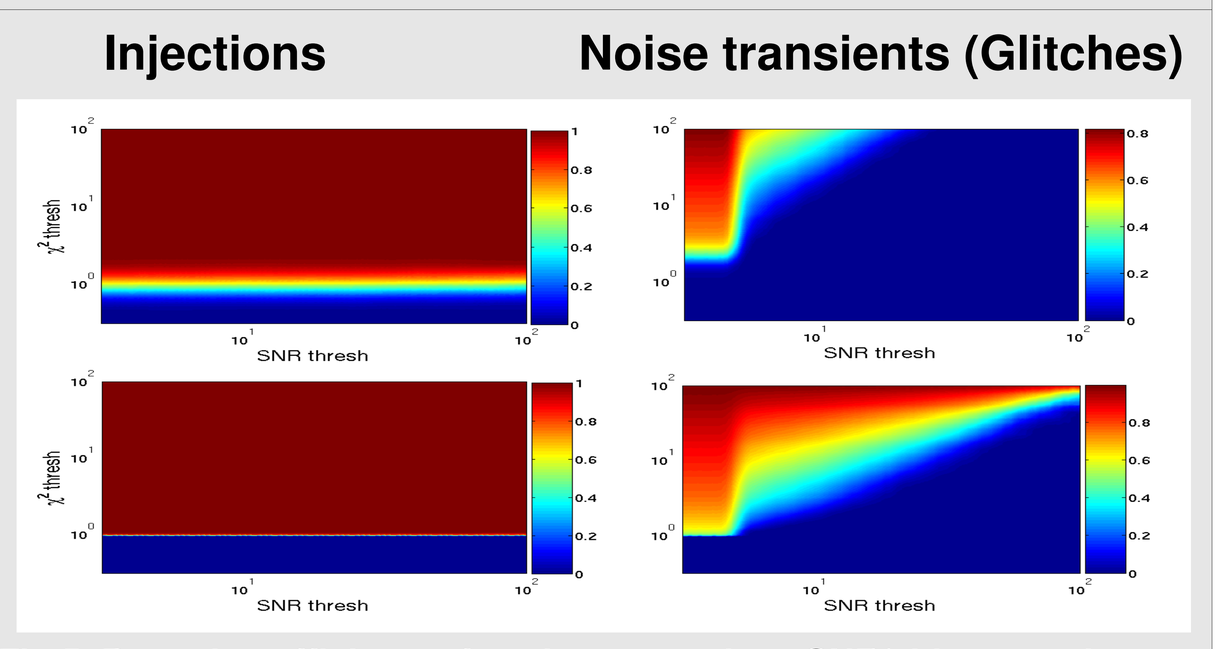

Fig 5. Detection efficiency for triggers at given SNR/chi-squared thresholds.

1. arxiv.org/abs/gr-qc/0405045 and also arxiv.org/abs/gr-qc/0509116
2. The plots above use MATLAB®, but versions are also in LAL http://www.lsc-group.phys.uwm.edu/daswg/projects/lal.html

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