
Stack-a-flare SGR burst search review readiness
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Photo: Joe Becker
LIGO-G080591-00-Z

Project Science Goals

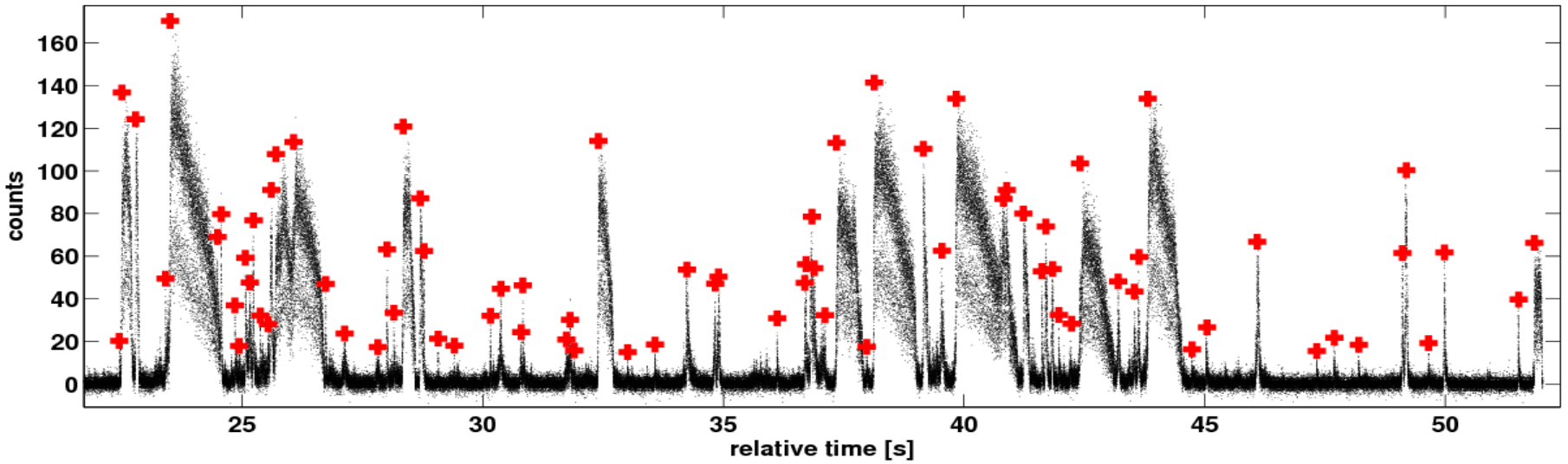
Astrophysical target: SGR 1900+14 storm (March 29 2006)

Use assumption of SGR burst similarity to improve SGR GW search

Detection statement

Improved upper limits

Probe new astrophysics with different stacking scenarios



Other Project Goals

Keep it simple

- **Stack-a-flare**: Flare pipeline does heavy lifting
- Review will be significantly quicker than for S5y1 SGR search

Publication target: ApJL

- We expect significant sensitivity gains over S5y1
- We are probing new astrophysics via stacking model scenarios

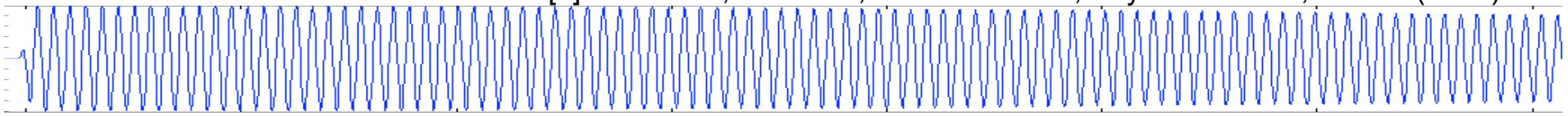
Search Parameter Space

Presentation of the search will be the same as for S5y1 SGR

Ringdowns 1– 3 kHz

Simulation frequencies: 1090, 1590, 2090, 2590 Hz
3 kHz upper bound: strange quark stars
1.5 kHz lower bound: lightweight star with stiff EOS [1]
Simulation tau: 200 ms
predicted range is 140-380 ms

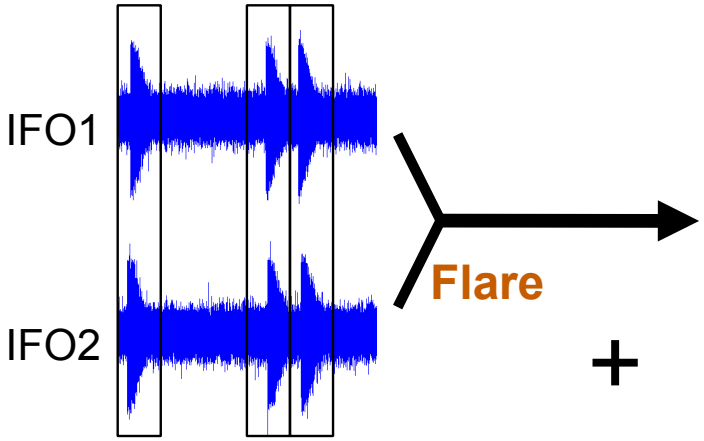
[1] O. Benhar, V. Ferrari, and L. Gualtieri, Phys. Rev. D 70,124015 (2004)

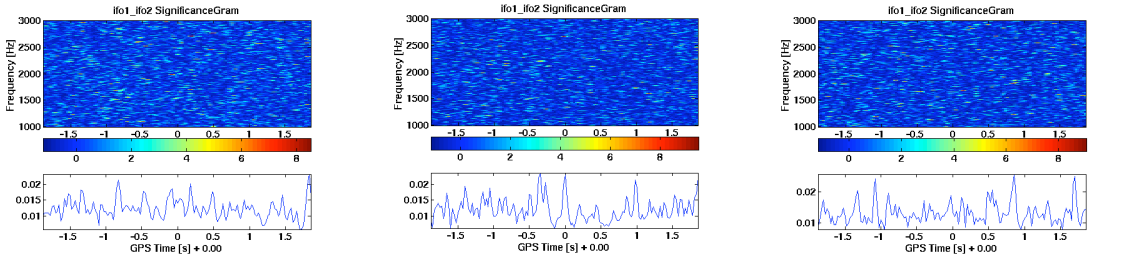


WNB below 1 kHz

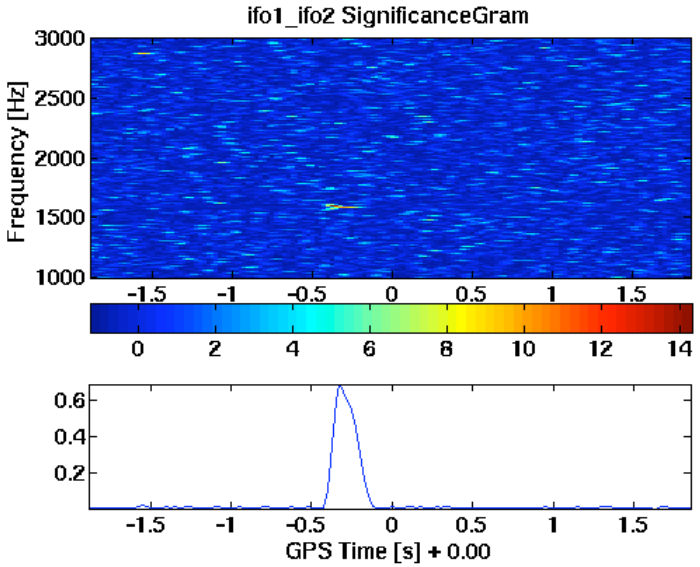
WNB injections to estimate upper limits; 11 ms and 100 ms durations
Band-limited to detector's sensitive regions:
100 – 200 Hz (small band)
100 – 1000 Hz (large band)

P-Stack Method





1. Apply Flare N times at EM burst times
2. Add up resulting **P**ower matrices



We have chosen parameters
We have obtained closed box results

Pros:

Suited for stochastic (WNB) SGR search

Less timing precision needed

$N^{1/4}$ amplitude sensitivity dependence in WN

Cons:

Less sensitive than coherent method (T-Stack)

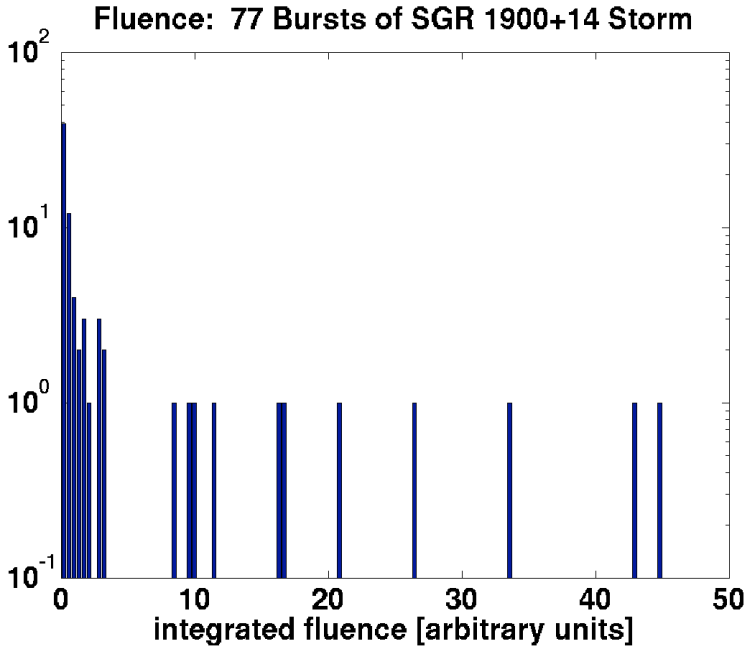
SGR 1900+14 storm

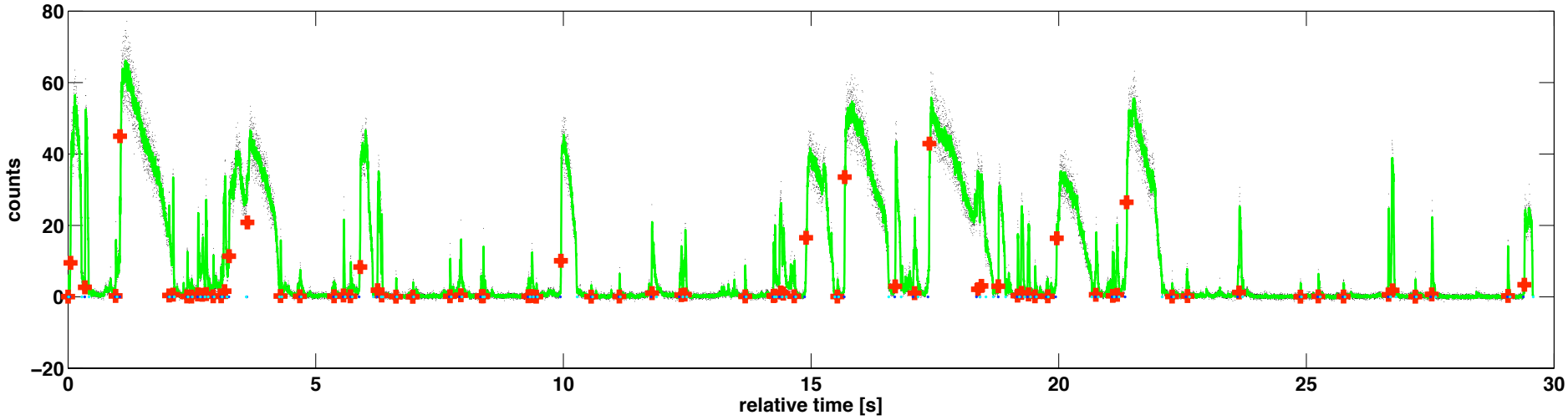
Proposed stacking scenarios (preliminary)
- Flat (N=11) – most energetic bursts
- Integrated fluence weighting (N=77)

Timing error can be simulated
- 5 ms preliminary timing error

Swift BAT light curve, 100 us bins

G. L. Israel et al., ArXiv e-prints 805 (2008), 0805.3919

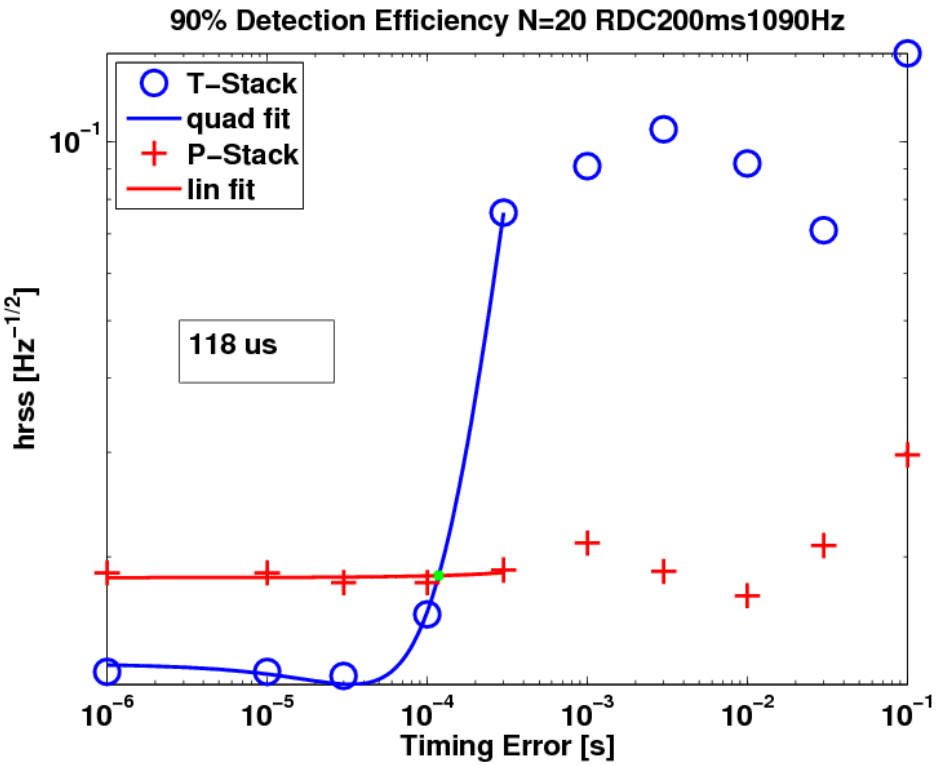


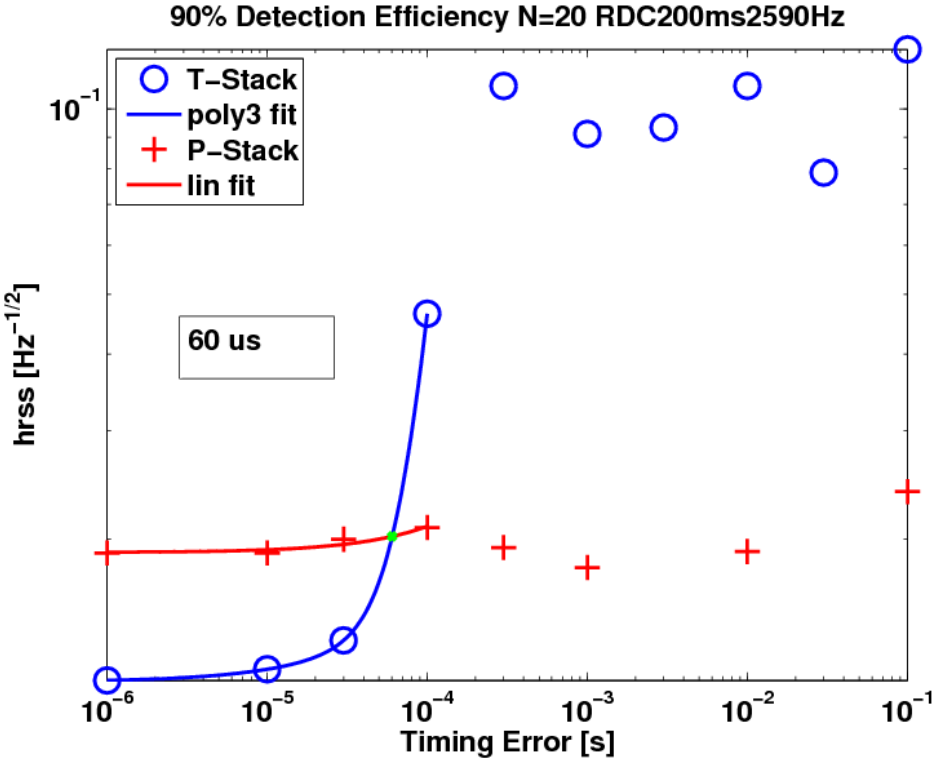


Stack-of-$\sigma_{\Delta T}$

Timing Error is σ of distribution used in Monte Carlo
P-Stack (red) is insensitive to time shifts (so long as signal TF pixels overlap)
T-Stack is sensitive. Crossover points are given

hrss50 plots look very similar





Storm search strategy

On-source choice ±2 s as before

BAT timing precision: < 100 usec (after propagation to geocenter)

GW emission delay: probably less than 100 ms (S5y1 SGR paper)

Empirical test: ±1 s hrss90 limits are 2.4% lower than ±2 s (24 trials)

[-1000,1000] second background region as before

estimate $\mu(f)$, $\sigma(f)$ used by Flare pipeline

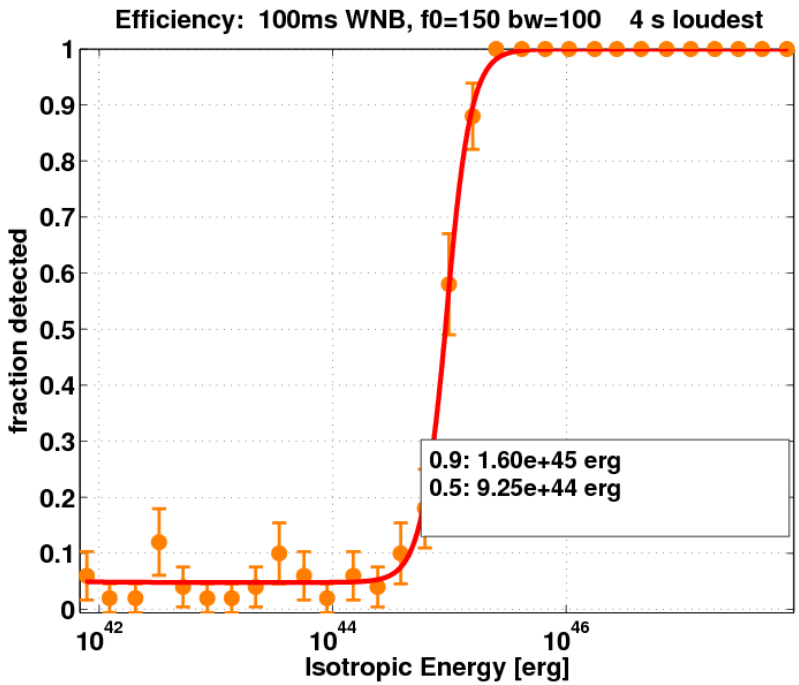
estimate local false alarm rate (FAR)

background data treated identically (i.e. stacked)

same bg region; choose time slide (new to stack)

Follow up events with significant FAR as before

Loudest event upper limits as before



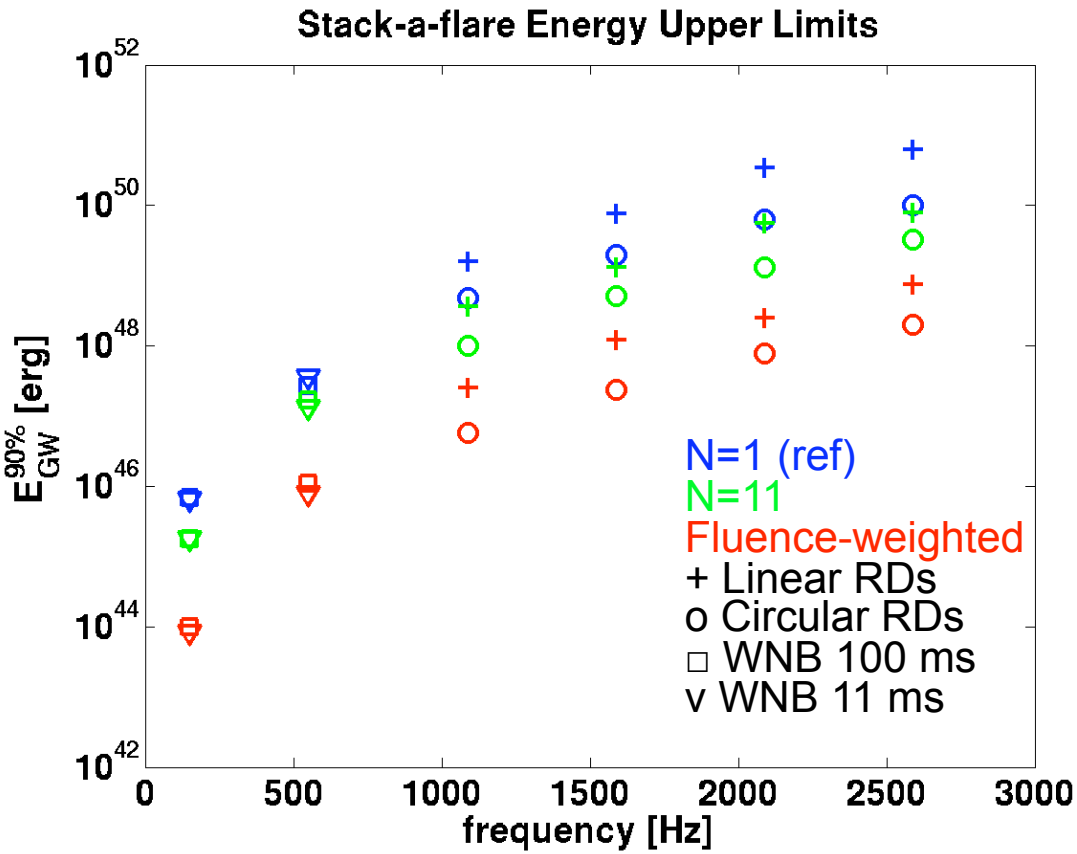
Closed Box Results
Energy Limits

SGR 1900+14 simulation
400 s after open box trigger
4 s on-source
50 trials per result
5 ms simulated time error

Flat N=11
$11^{1/2}$ = 3.3 (expected, over N=1)
Mean = 4.4 (observed)

Fluence-weighted
Simulation mean E_GW is presented

Isotropic GW energy at 10 kpc
90% detection efficiency



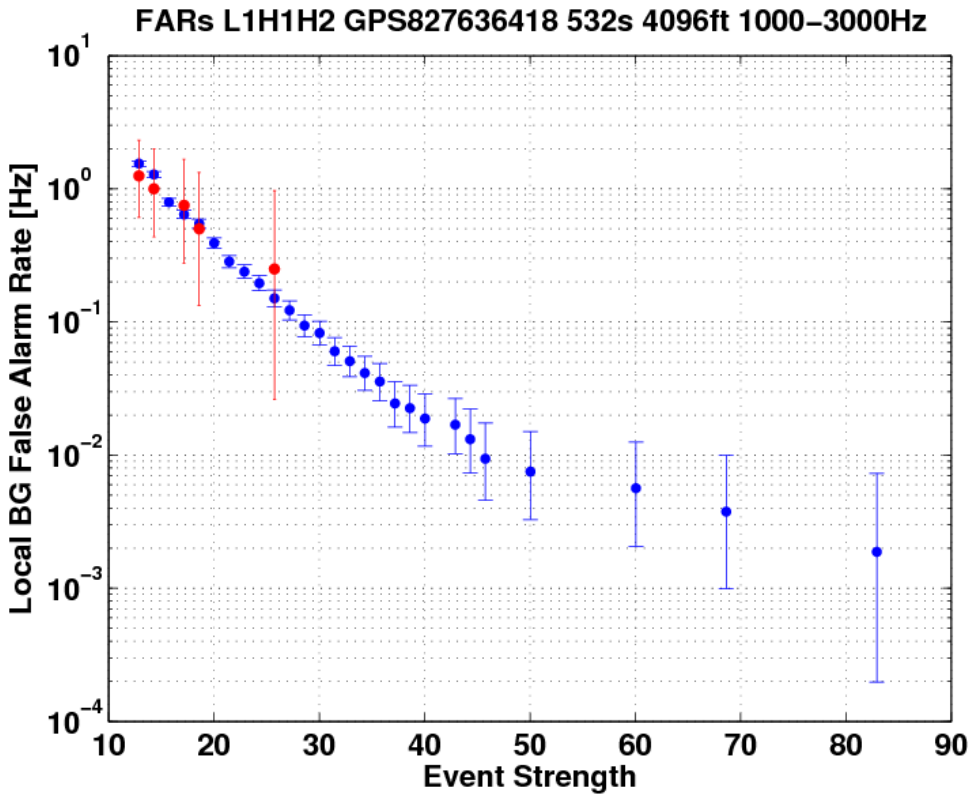
PRELIMINARY

Closed Box Results
Detection Statement

PRELIMINARY

Same procedure as before
Live time is stacked live time
T is time from stack center

Example here:
Flat N=11 1000-3000 Hz on-source events



no.	Z	FAR(local)	T	DT	F	DF	N
1	2.61e+01	1.43e-01	1.453	0.100	1044.0	0.0	5
2	1.86e+01	5.43e-01	-1.218	0.200	1549.0	4.0	4
3	1.76e+01	6.11e-01	-1.324	0.050	2280.0	0.0	3
4	1.45e+01	1.23e+00	0.811	0.025	1469.3	4.0	3
5	1.30e+01	1.52e+00	1.103	0.150	2713.3	12.0	3

Documentation

Project summary page:
https://www.lsc-group.phys.uwm.edu/cgi-bin/bag-enote.pl?nb=burs5trig&action=view&page=33
Includes links to config files
Includes instructions for installation and running

Method is described in a chapter of my thesis
Methods paper draft has been started
Results paper not started

Code is in DASWG CVS:
http://www.gravity.phys.uwm.edu/cgi-bin/cvs/viewcvs.cgi/matapps/src/searches/burst/Stac?cvsroot=lscsoft

This talk has addressed the burst group's review readiness requirements

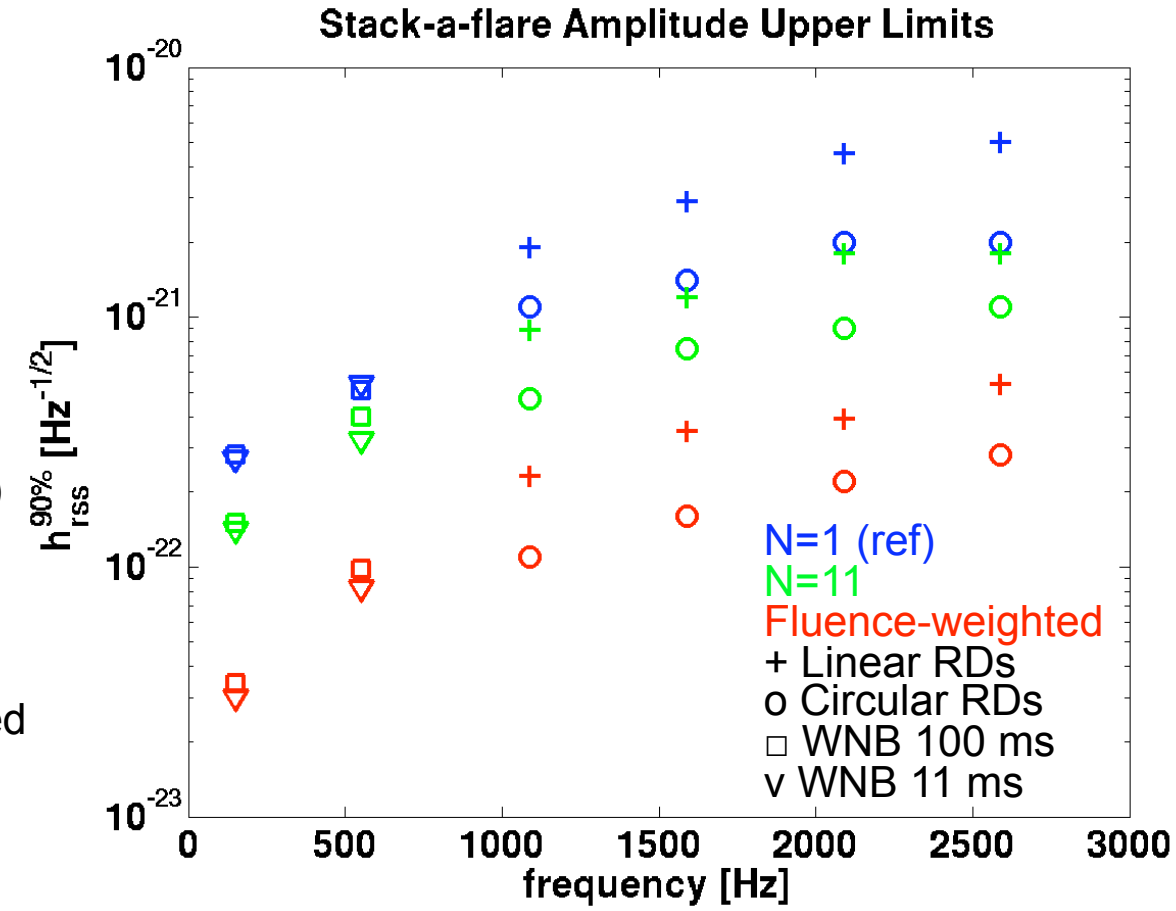
EXTRA SLIDES

Closed Box Results
Amplitude Limits

SGR 1900+14 simulation
400 s after open box trigger
4 s on-source
50 trials per result
5 ms simulated time error

Flat N=11
$11^{1/4}$ = 1.8 (expected, over N=1)
Mean = 2.1 (observed)

Fluence-weighted
Simulation mean hrss is presented



PRELIMINARY

Stacking Isolated Bursts

P-Stack timing:

- Propagation of light crossing times to detectors
- Light curve analysis for precise burst start times

Weight each burst according to antenna pattern before stacking

Combining bursts

- All bursts from all SGR sources?
- All bursts from particular SGR sources?
- Brightest N bursts from a given source?
- Weight each burst according to fluence?
- Theorist input required

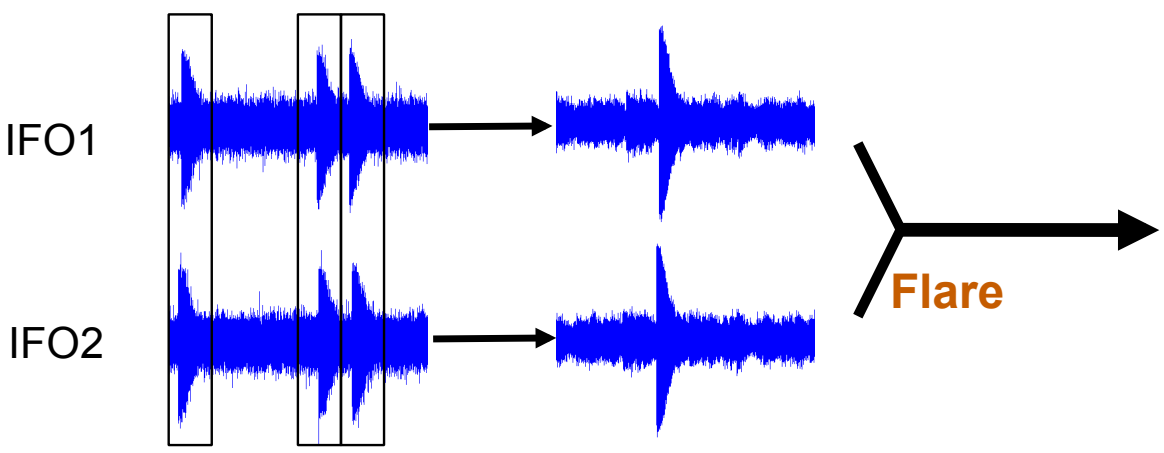
Future of Stack-a-flare

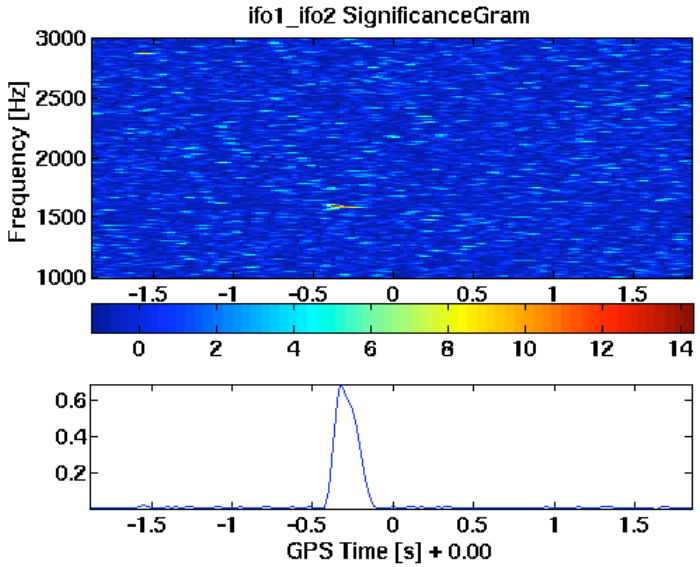
P-Stack is worth developing
storm unmodeled search, isolated bursts
T-Stack issues
Requires timing precision of ~50 us or better to be worth it
Cannot do WNB

Concentrate first on the storm
Relative timing between bursts **much** easier to get precisely
T-Stack *may* be possible; theorist input needed
Get P-Stack S5 closed box results
Time-to-publish should be small, thanks to Flare LSC review

Experience from storm work may help approach isolated bursts

T-Stack Method





1 + 2 + ... + N Time-align to signals & add Time series

Pros:

Greater potential sensitivity. Stacking ***amplitude***

expect ~N^1/2 amplitude sensitivity dependence in WN

Cons:

Either precise timing, or expensive time shift combinatorics, is needed

Sensitive to relative sign between detectors

T-Stack will NOT be used for initial search

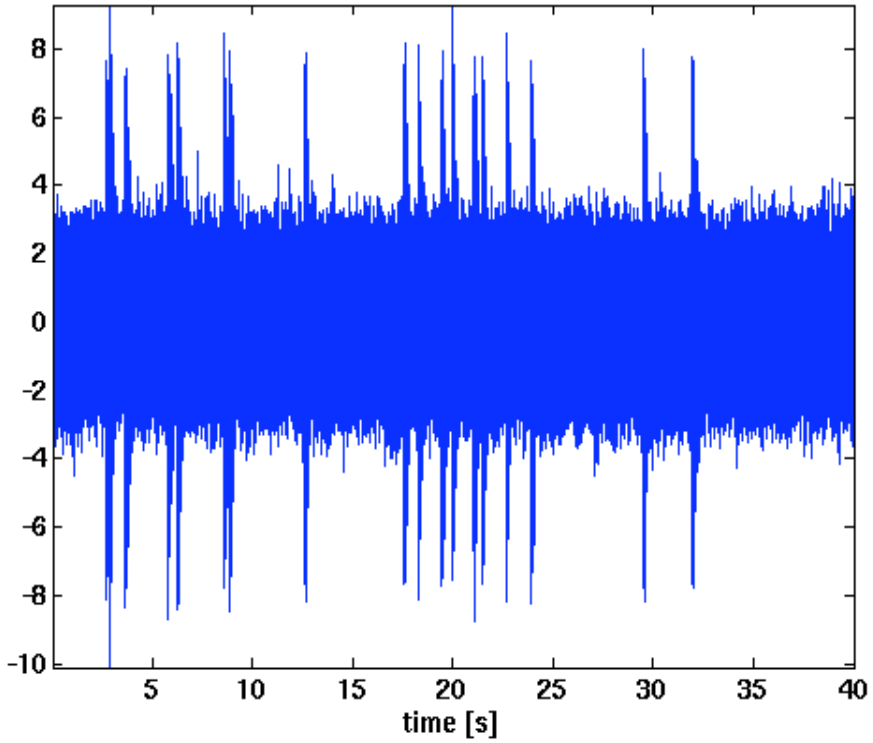
Prototype Characterization

Benchmark: individual burst simulations & vanilla Flare

Characterize:
sensitivity dependence on **N**
sensitivity dependence on $\boldsymbol{\sigma_{\Delta T}}$

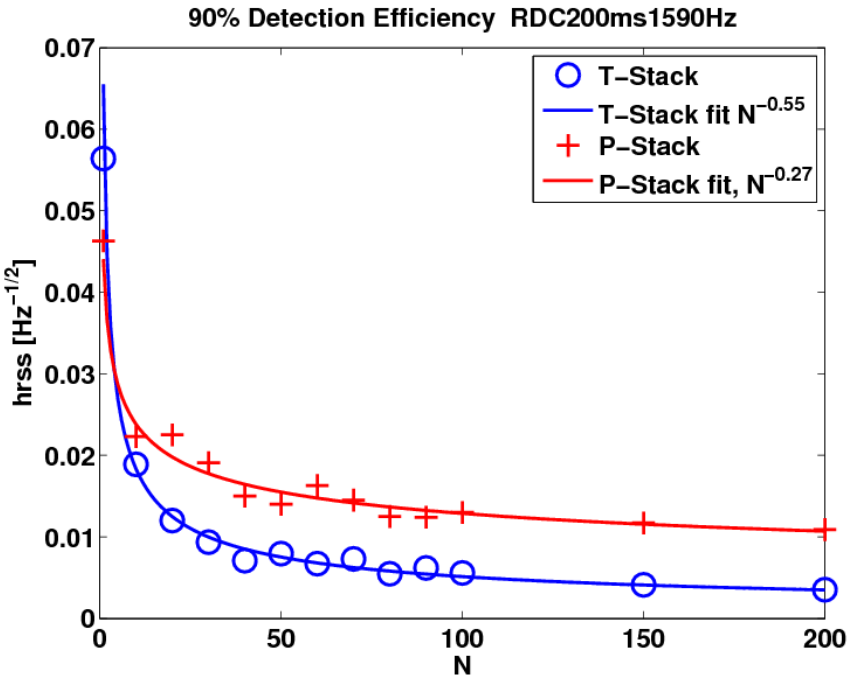
Shift component injections by small times **ΔT**
simulates timing imprecision
subsample shifting

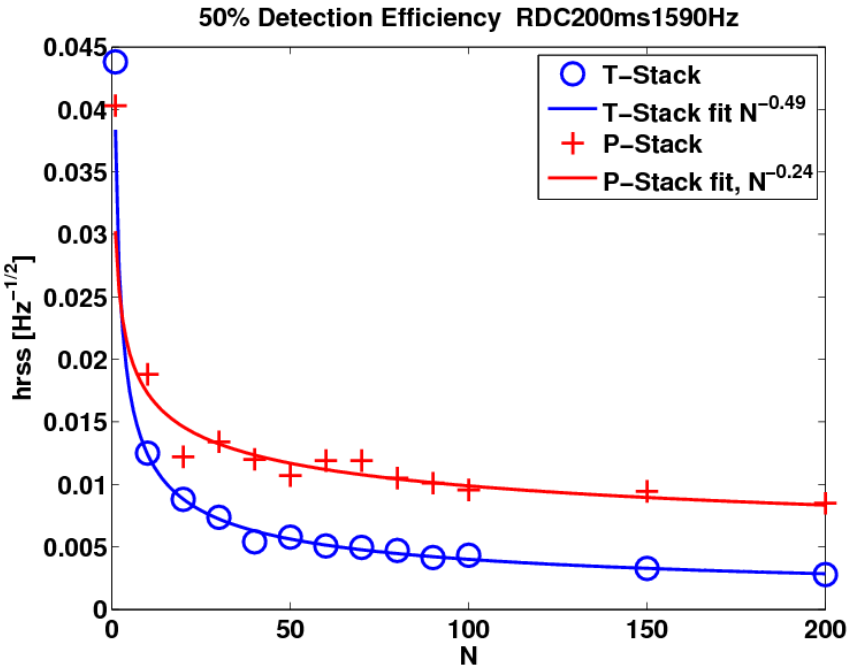
Two simulation designs tell consistent story
Rough simulated SGR 1900+14 storm
18 identical ringdowns into **σ=1** WN
N evenly spaced injections (RDs or WNBs)



RD Stack-of-N

P-Stack goes as N^1/4
T-Stack goes as N^1/2





WNB Stack-of-N

P-Stack goes as N^1/4
T-Stack is flat