Stack-a-flare SGR burst search development

Peter Kalmus
Caltech

Photo: Joe Becker

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Project Goals

Use assumption of SGR burst similarity to improve search

Detection statement (as before)

Improved upper limits

Improved astrophysical context
- S5y1 SGR individual search should stimulate theorist interest

Perform the search with **Stack-a-flare**
- Initial Flare pipeline does heavy lifting
- Review should be quick

Search Parameter Space

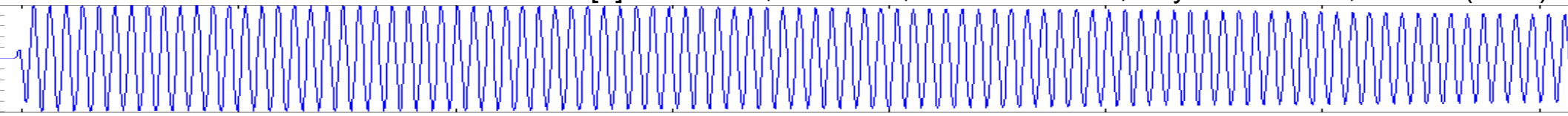
Parameter space choices for S5y1 SGR still apply

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)

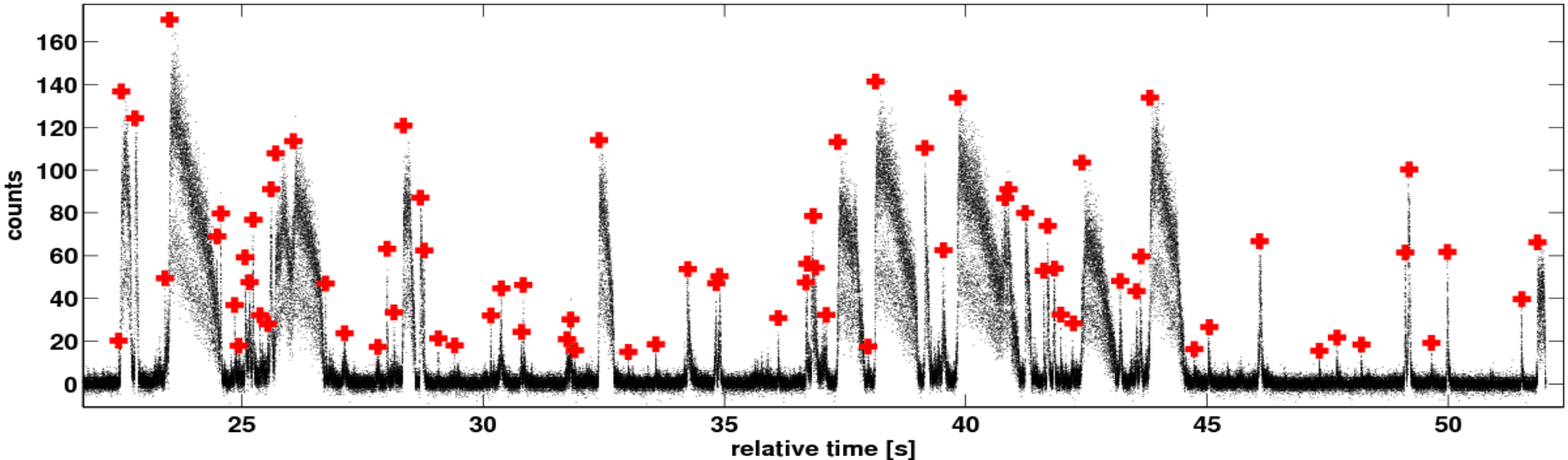
SGR 1900+14 storm

BAT light curve with 100 us bins

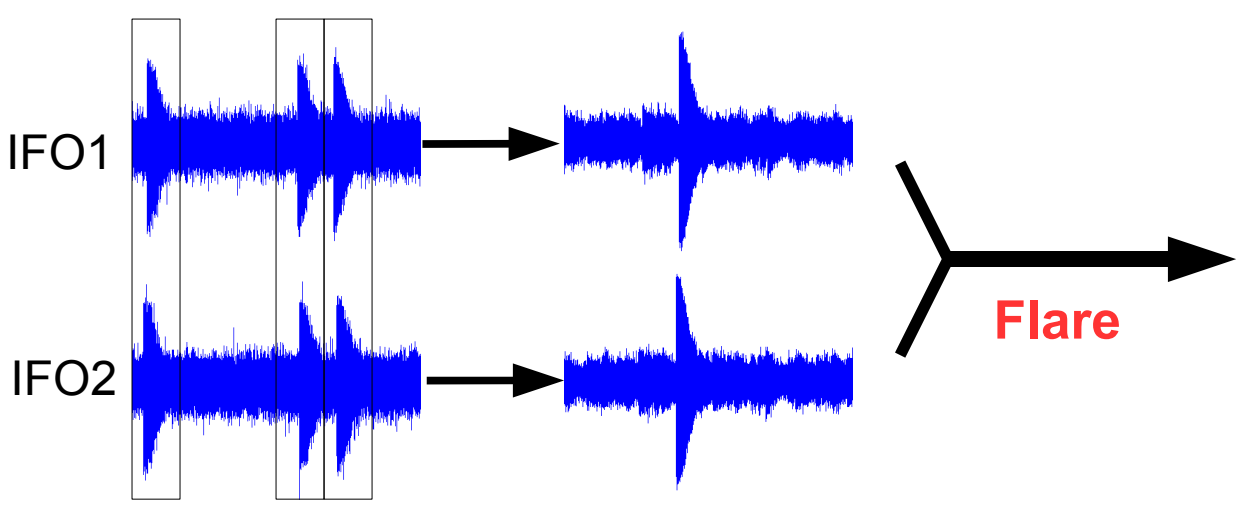
Method for matching rising edge of bursts may be helpful

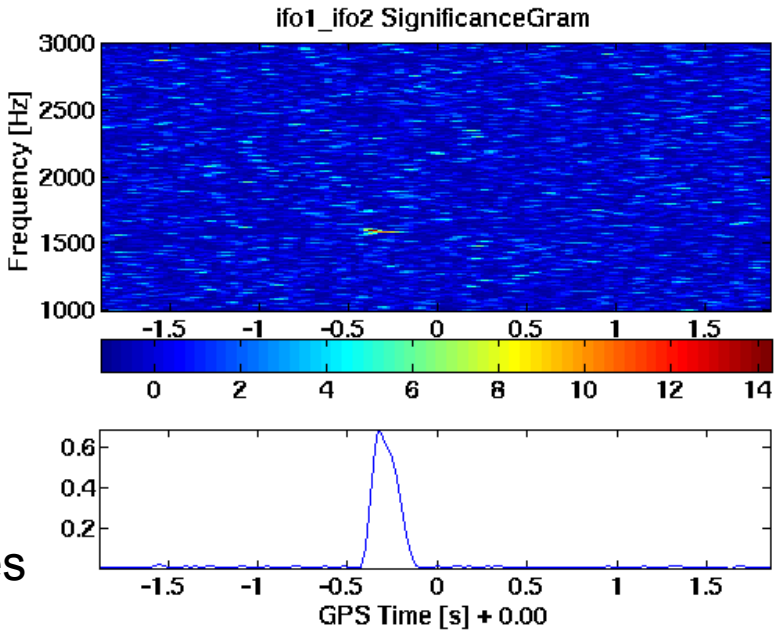
N = number of bursts to include

- How to pick burst set to stack?
- How to weight each burst?
- How to align bursts?
- Are there 2 distinct burst types here?
- Theorist involvement could help



Method 1: T-Stack





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

Pros:

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

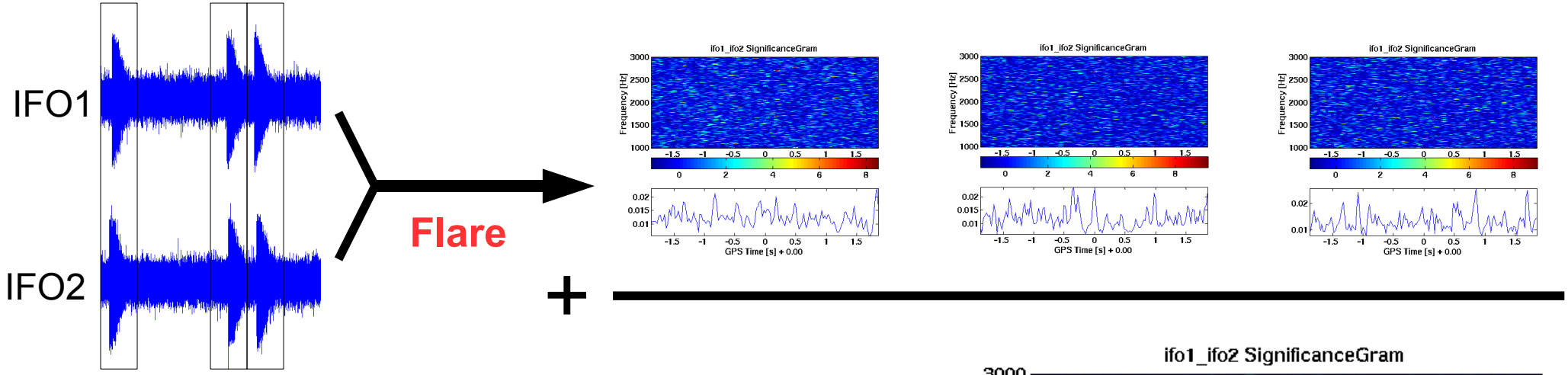
expect ~N^1/2 amplitude sensitivity dependence in WN

Cons:

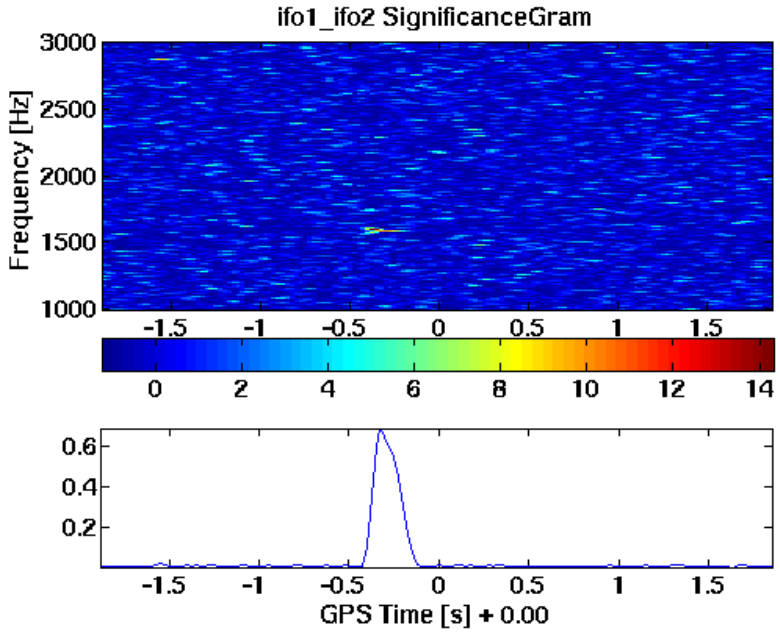
Either precise timing, or expensive time shift combinatorics, is needed

Sensitive to relative sign between detectors

Method 2: P-Stack



1. Time-align to signals & apply Flare N times
2. Add up resulting **P**ower matrices



Pros:

- Suited for stochastic (WNB) SGR search
- Less timing precision needed

Cons:

- Less sensitive. Stacking ***power***
- expect ~N^1/4 amplitude sensitivity dependence in WN

Prototype Characterization

Characterize:

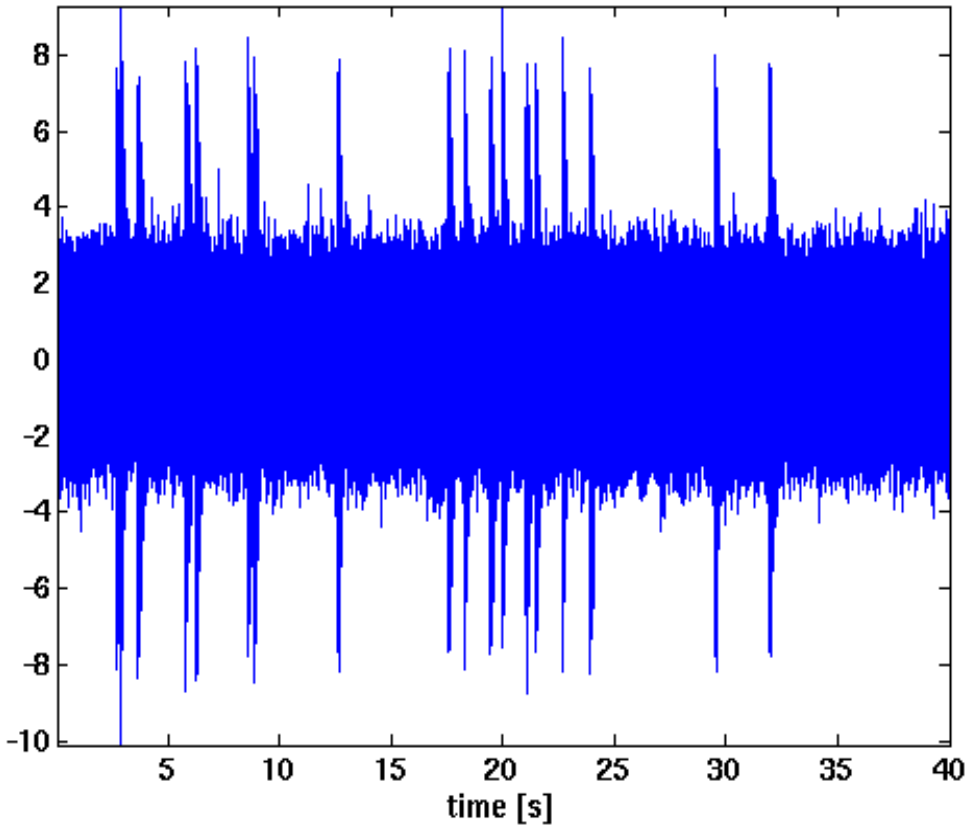
- sensitivity dependence on **N**
- sensitivity dependence on $\boldsymbol{\sigma_{\Delta T}}$

Shift component injections by small times **ΔT**

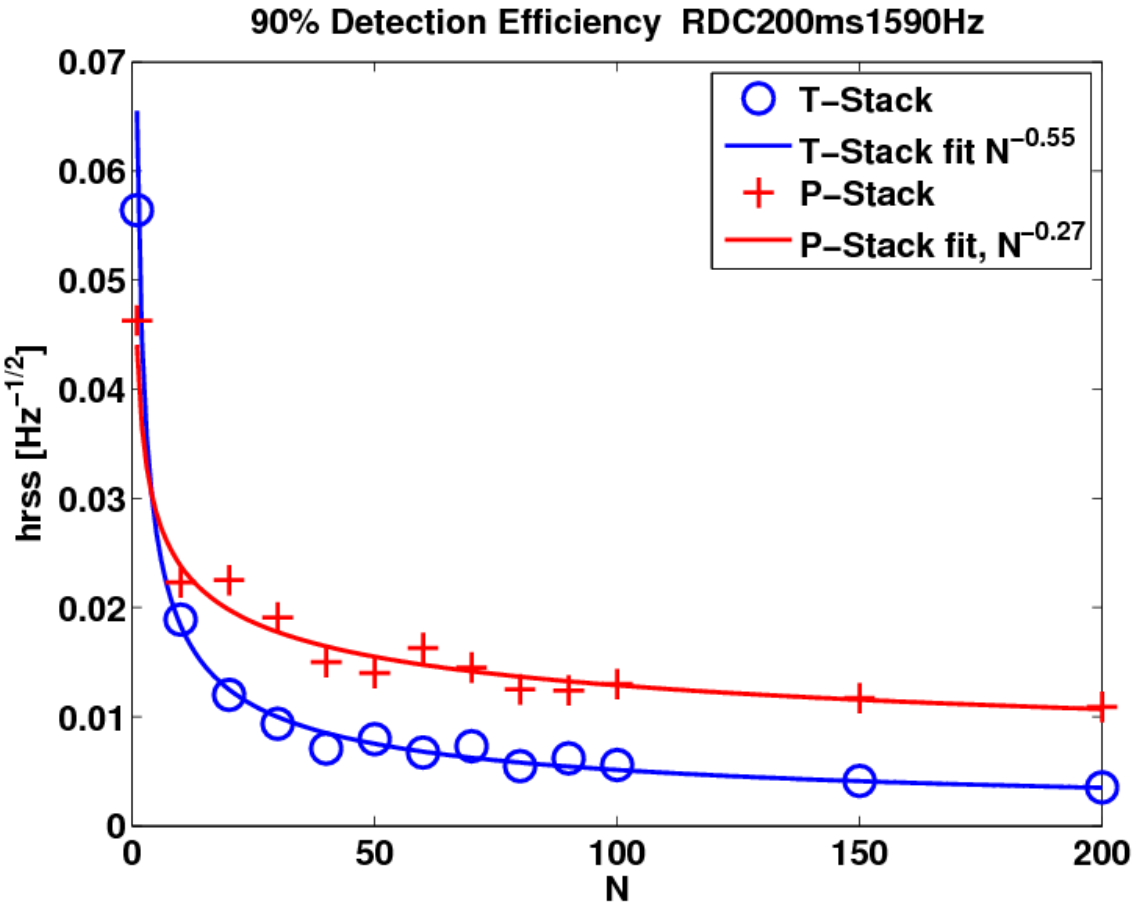
- simulates timing imprecision
- subsample shifting

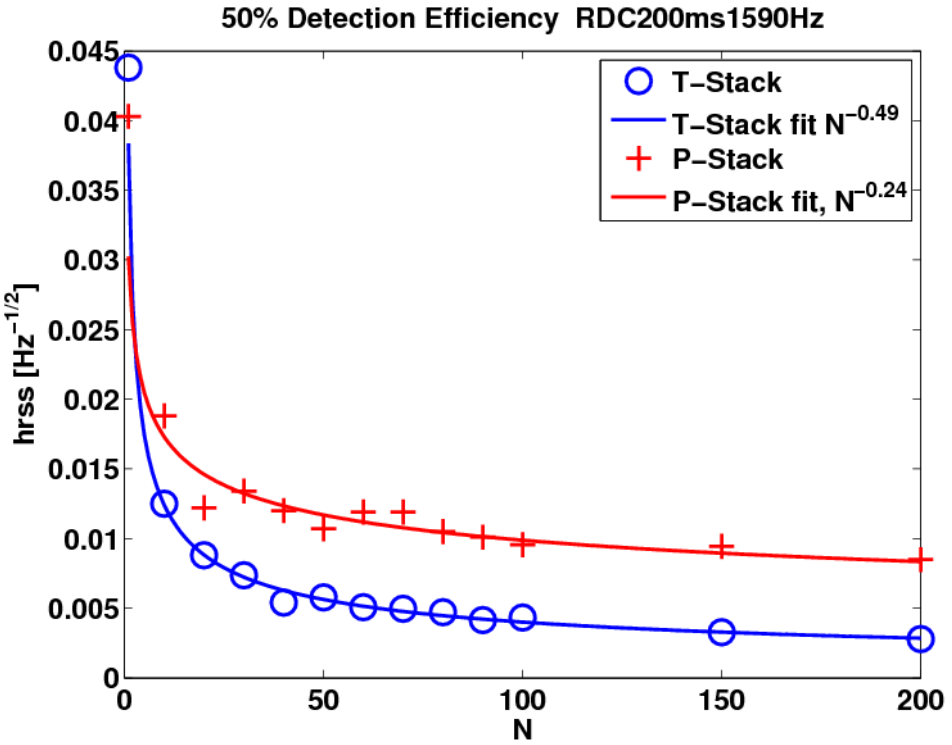
Two simulation designs tell consistent story

- Rough simulated SGR 1900+14 storm
- 18 identical ringdowns into **σ=1** WN
- **N** evenly spaced injections (RDs or WNBs)



RD Stack-of-N

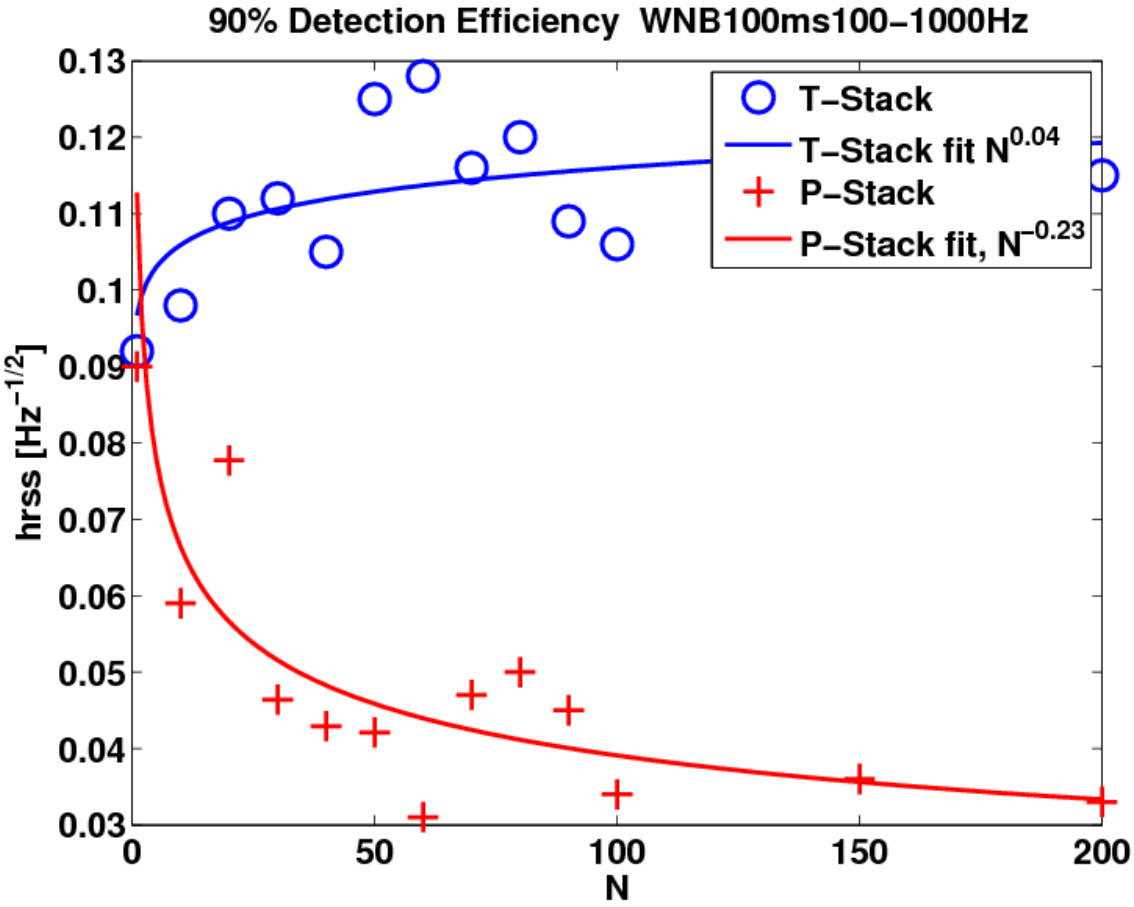


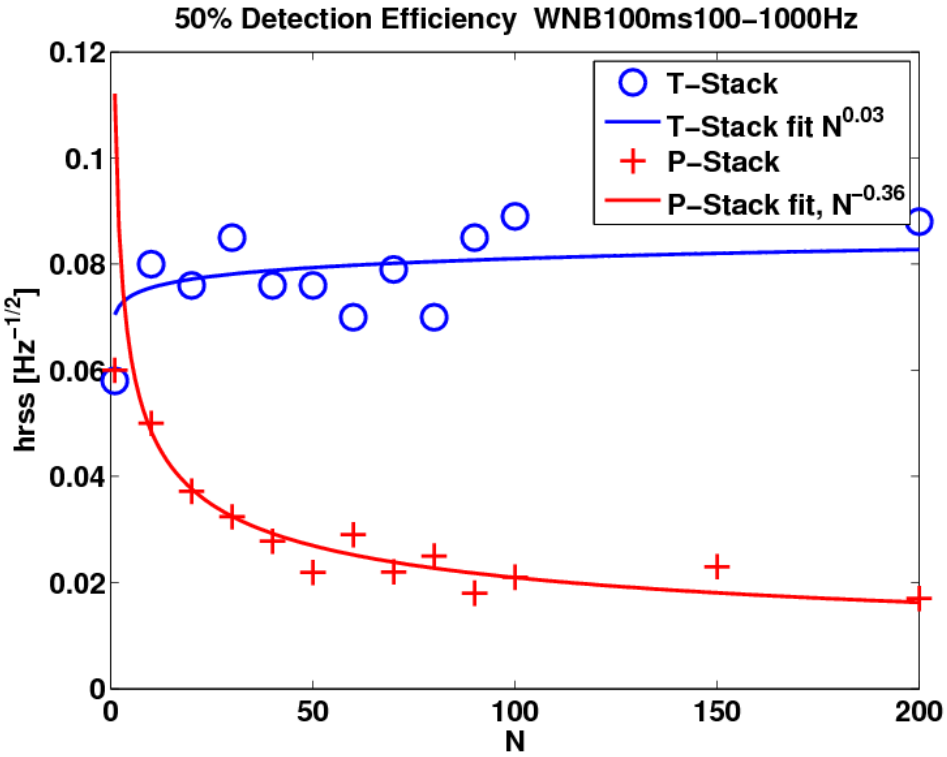


P-Stack goes as N^1/4

T-Stack goes as N^1/2

WNB Stack-of-N





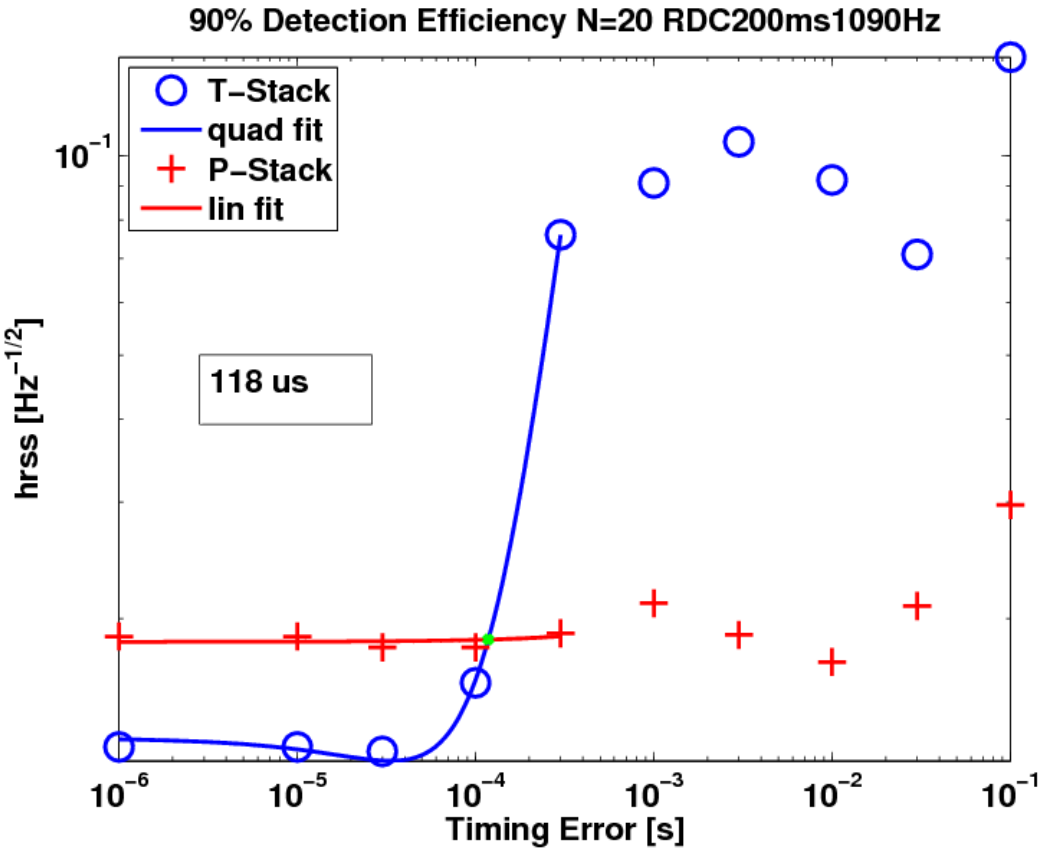
P-Stack goes as N^1/4

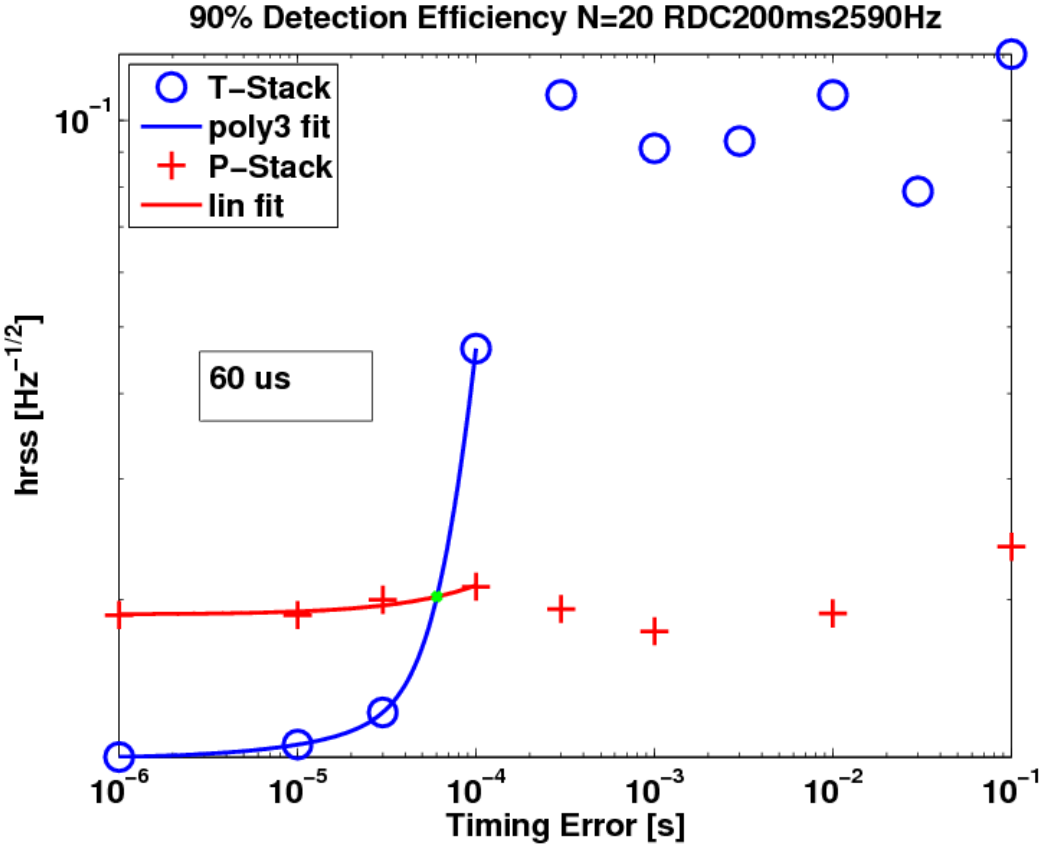
T-Stack is flat

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

Ringdowns: 1090 Hz (left) 2590 Hz (right)
P-Stack (red) is insensitive to time shifts (so long as signal TF pixels overlap)
T-Stack is sensitive. Crossover points are given

hrss50 story looks very similar





Storm search strategy

Precise trigger timing means smaller on-source region

[-1000,1000] second background region as before (cat2 DQ)

- estimate μ(f), σ(f) used by Flare pipeline
- estimate local false alarm rate (FAR)
- background data will need to be stacked

Follow up on-source analysis events with significant FAR as before

Loudest event upper limits as before

Stacking Isolated Bursts

Timing precision makes T-Stack unfeasible

P-Stack requires:

- Propagation of all light crossing times to detectors
- Light curves could yield precise burst times

Weight each burst according to antenna pattern before stacking

How to combine bursts

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

Future of Stack-a-flare

P-Stack

storm unmodeled search, isolated bursts

T-Stack

Requires timing precision of ~50 us or better to be worth it

RD search only

Concentrate first on storm

T-Stack *may* be possible

P-Stack S5 closed box results soon (stay tuned)

Time-to-publish should be small, thanks to Flare review

People:

S5y1 search reviewers (Kipp, Ben) have agreed to review

Max Factourovich, Columbia grad student

Experience from storm analysis will aid isolated bursts search