Deep searches for long duration transient sources

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KAGRA f2f 2016
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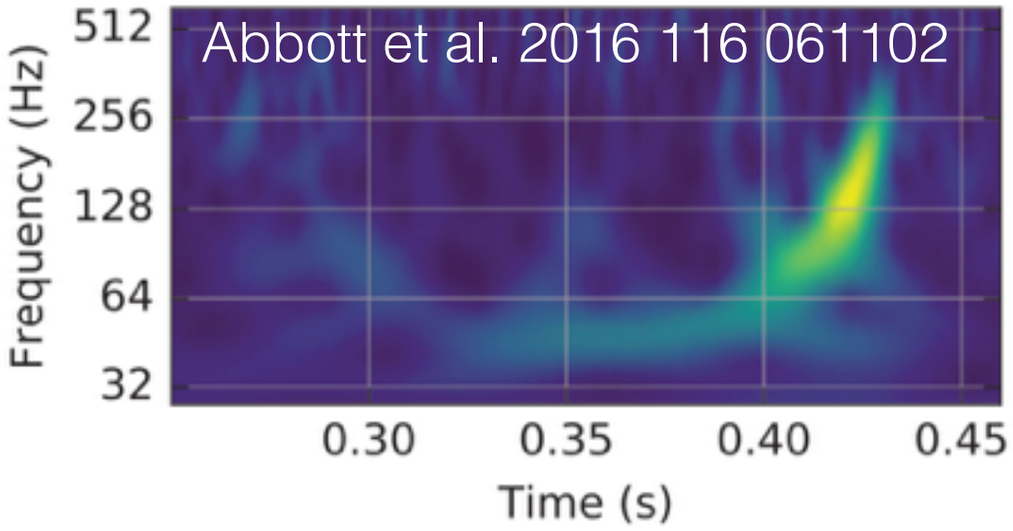
Transient sources

Binary coalescence GWB150914

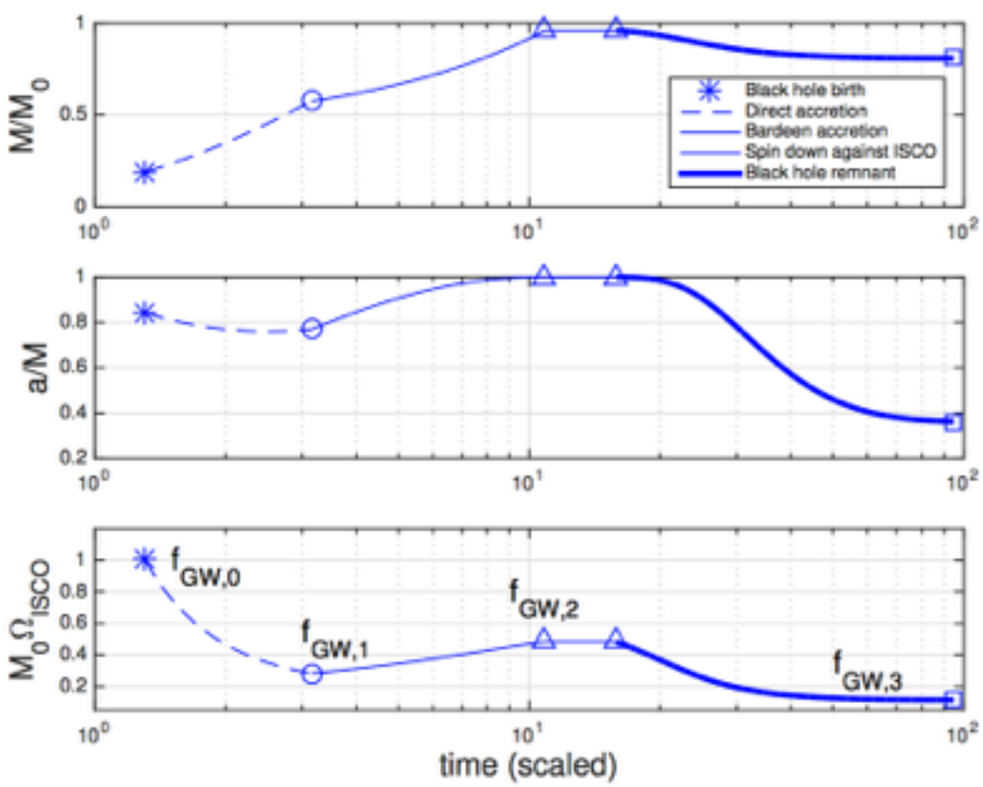
slowly rotating progenitors a/M~0.3



Core-collapse supernovae

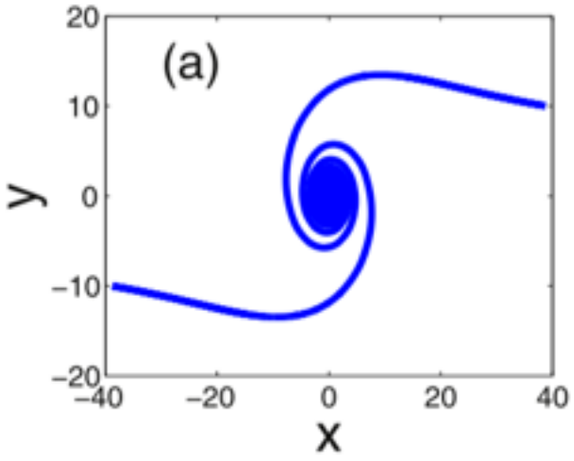
factories of NS and Kerr BH

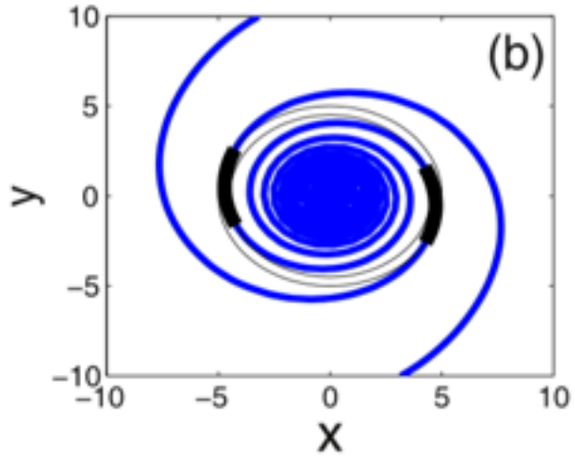
type Ibc:
parent population LGRBs
slowly rotating remnants a/M~0.3

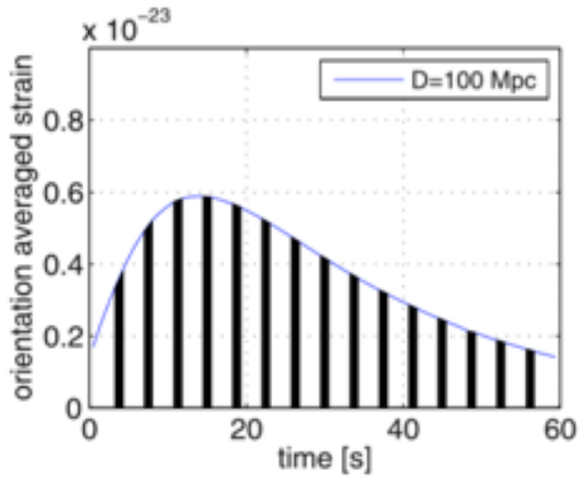


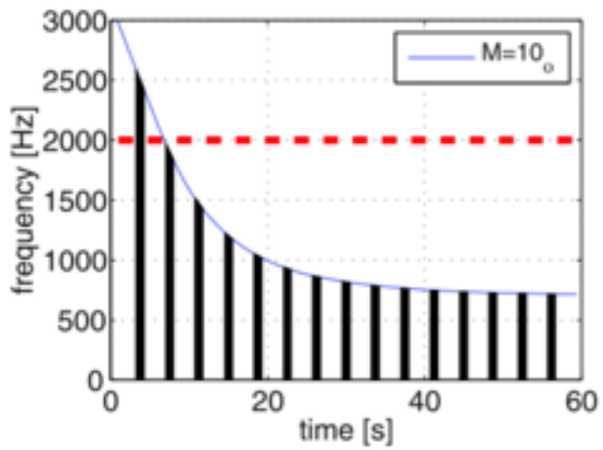
van Putten & Della Valle, 2016, subm.

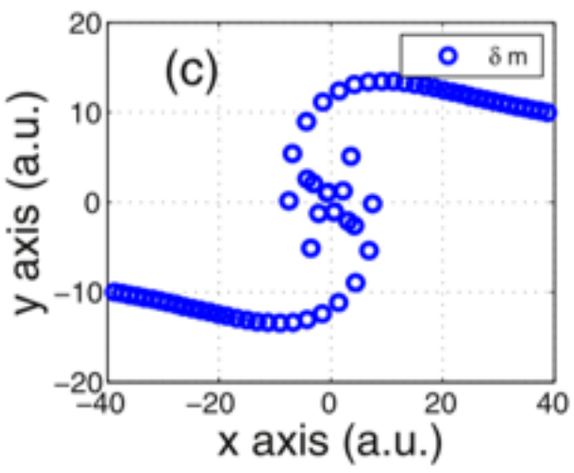
Broadband GW emission from CC-SNe

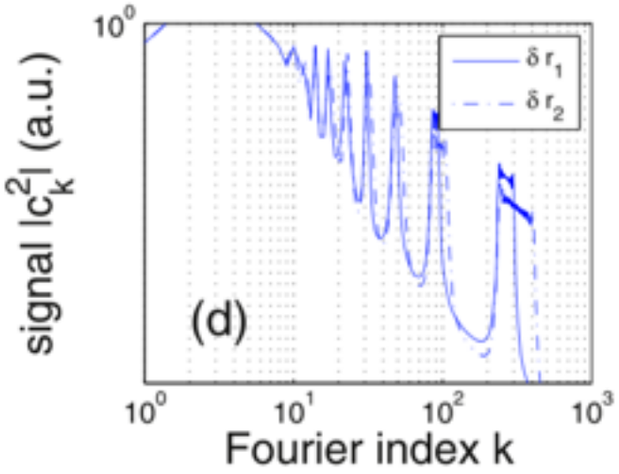


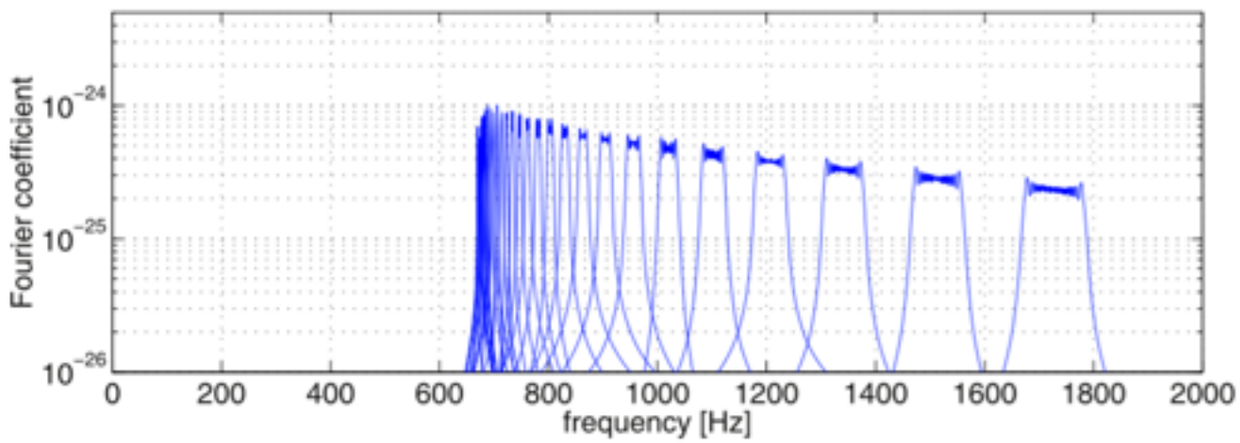






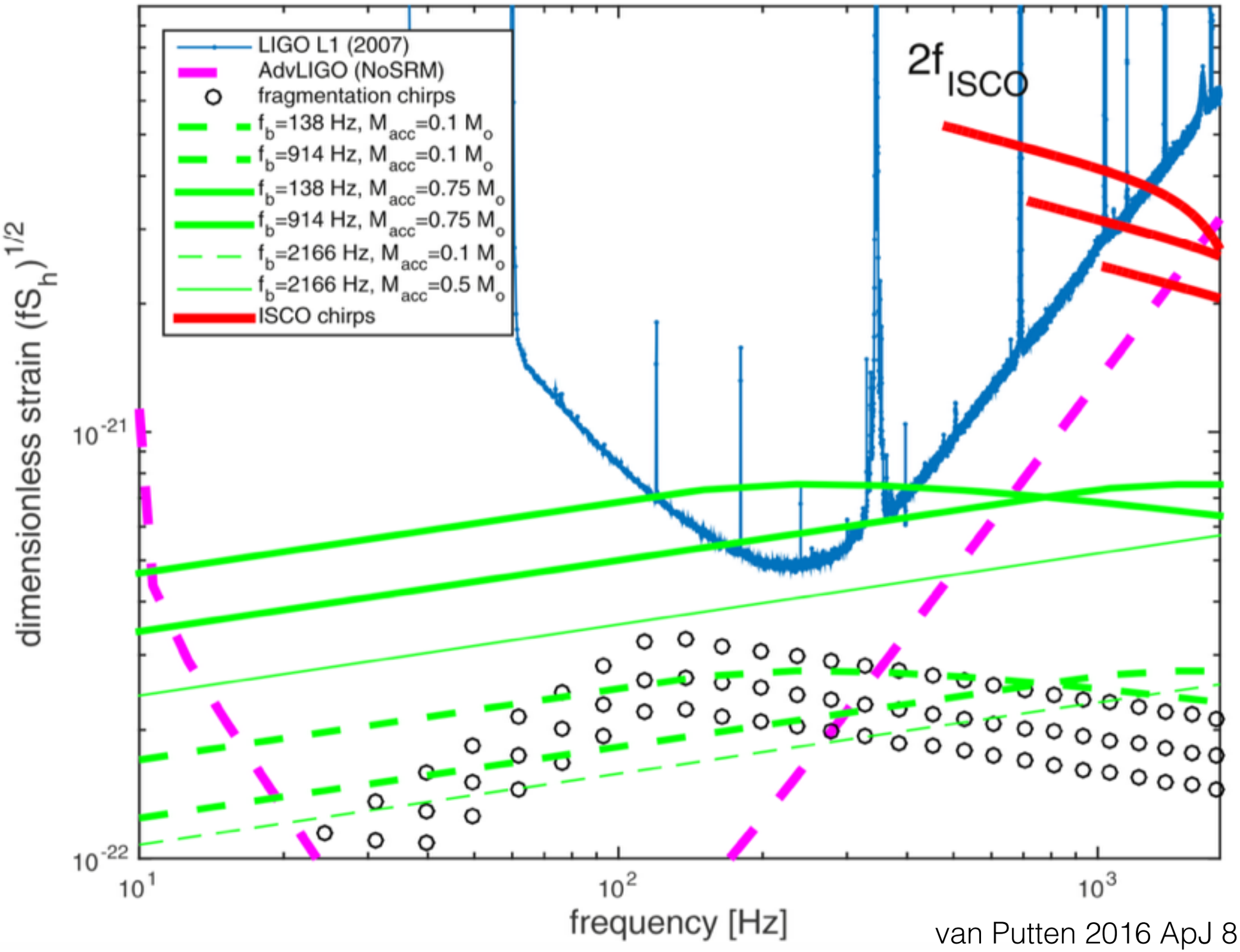






Levinson, van Putten & Pick 2015 ApJ 812 124, van Putten 2016 ApJ 819 169

Broadband GW emission from CC-SNe



van Putten 2016 ApJ 819 169

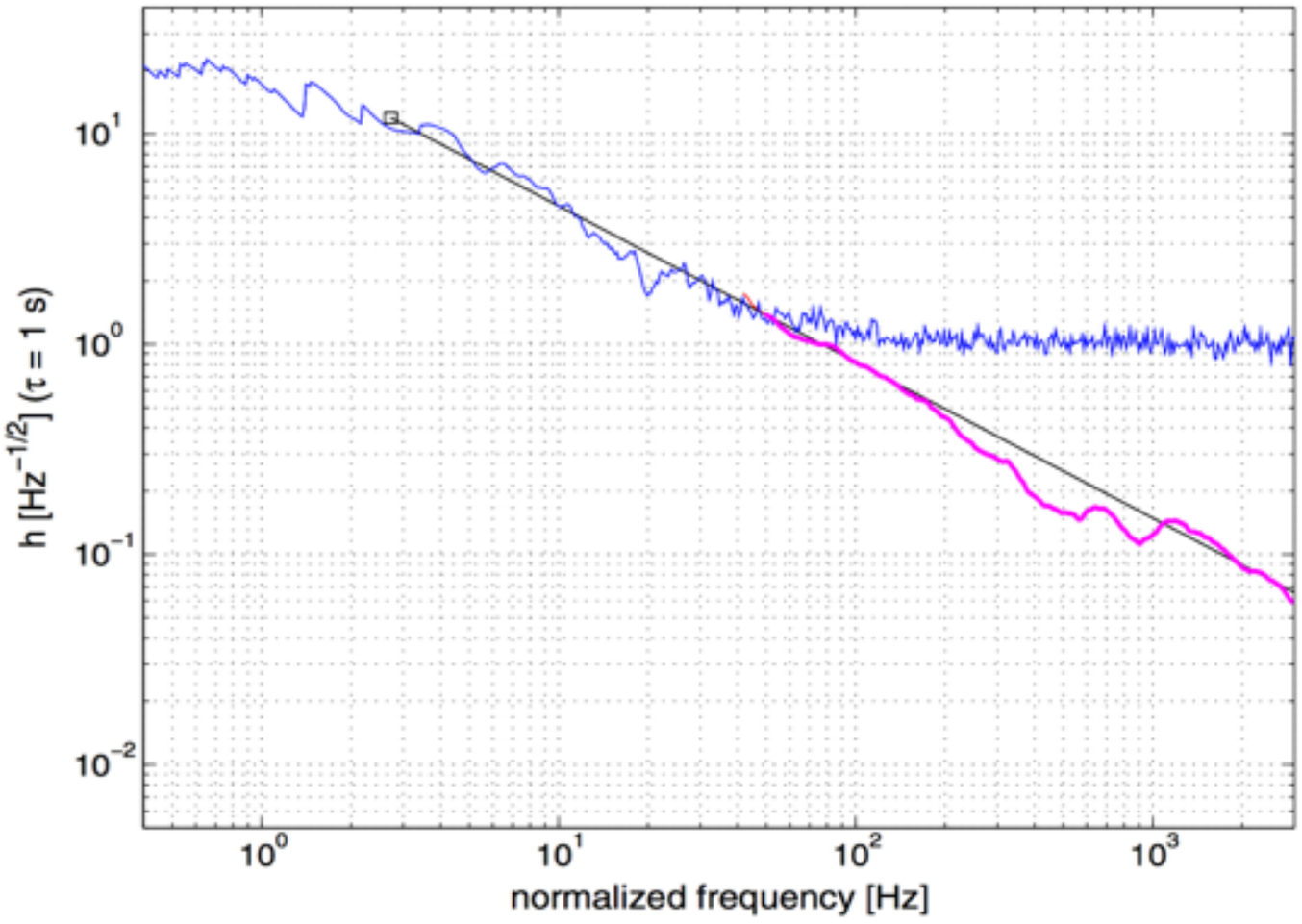
Levinson, van Putten & Pick 2015 ApJ 812 124

Detecting broadband signals by MF

Ascending and descending chirps of long duration (tens of s)

Phase-coherence on intermediate time scale

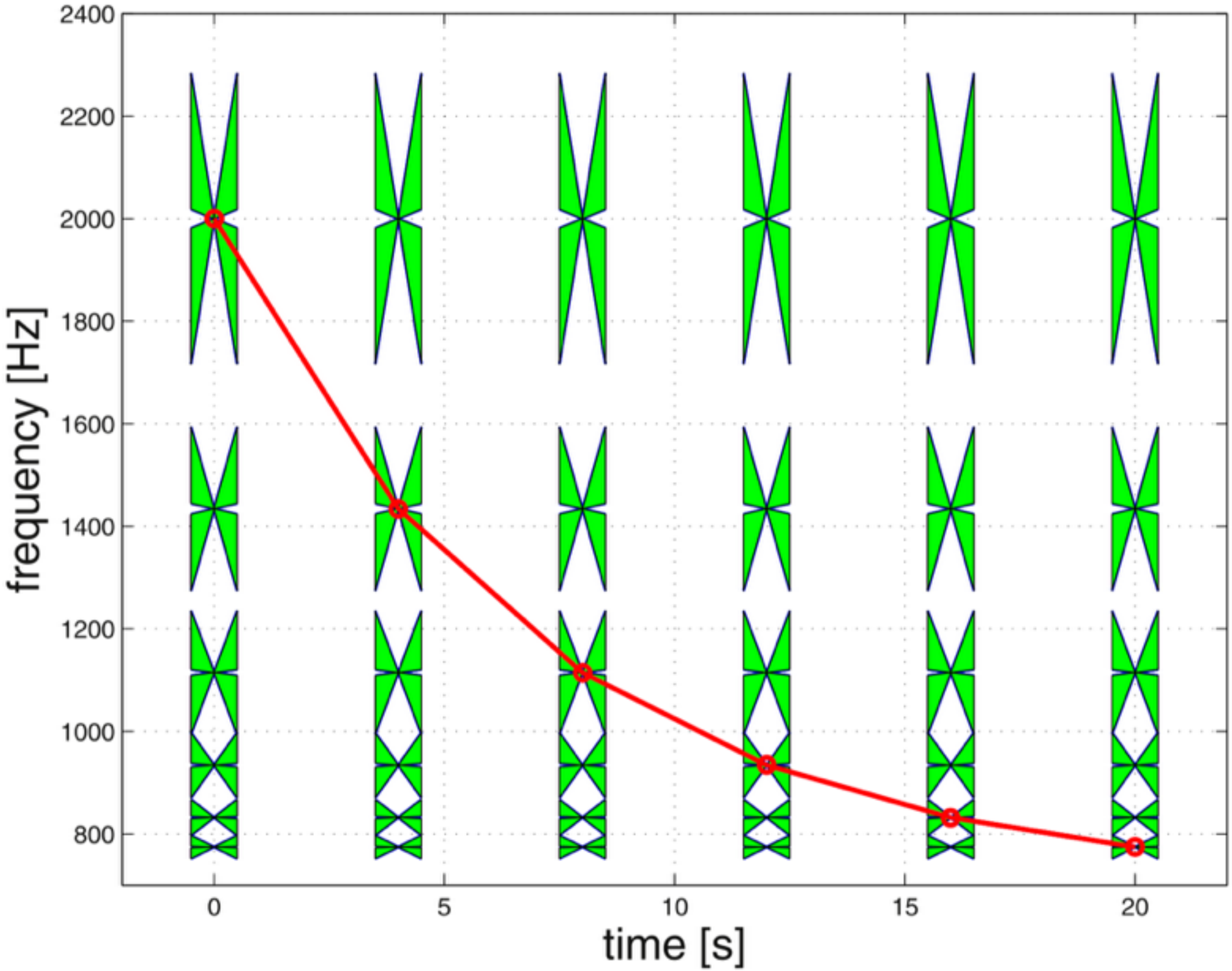
Apply matched filtering with large bank of chirp templates



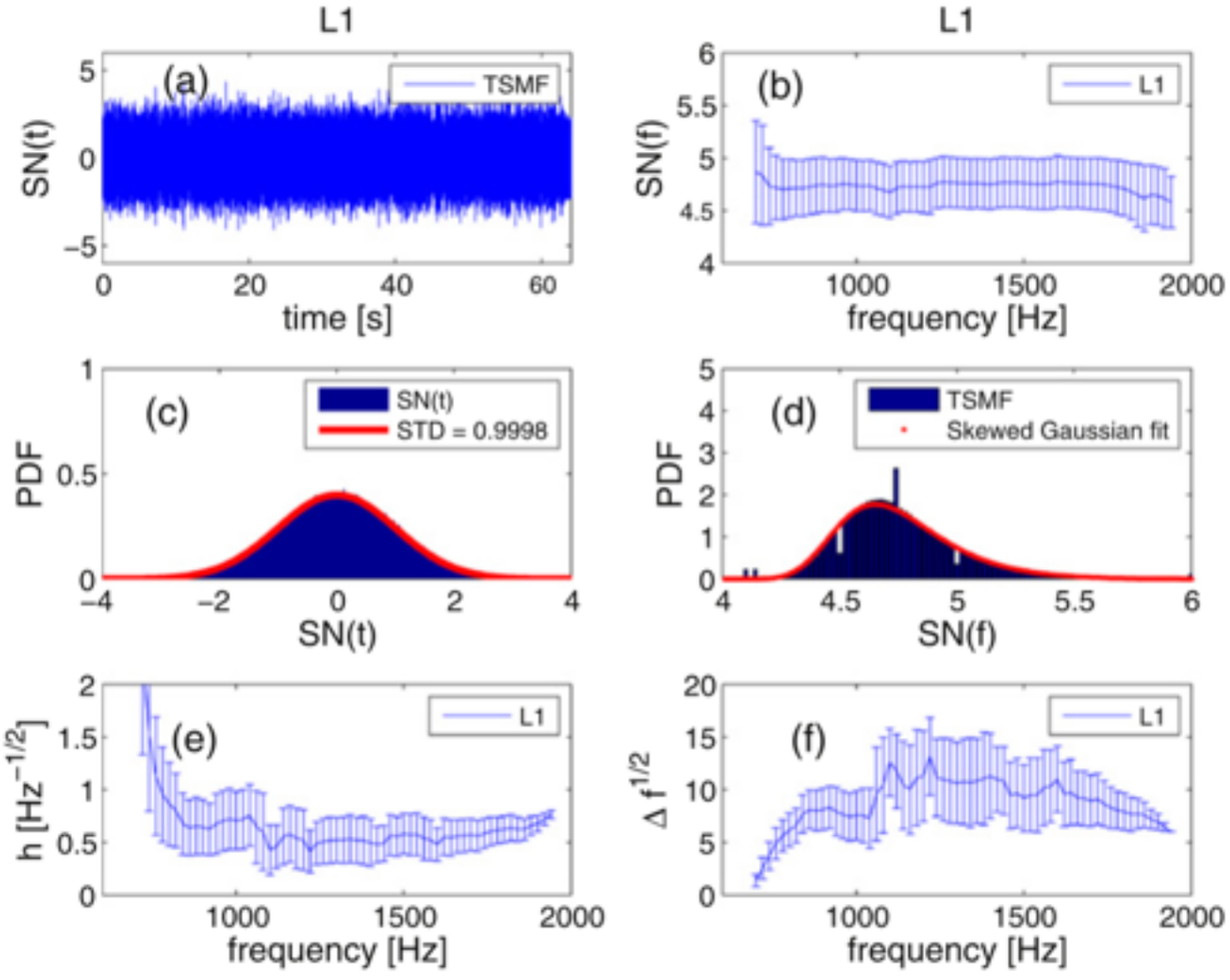
Identification of broadband Kolmogorov spectrum at 1.26 photons/0.5ms with 8.64 million chirp templates

van Putten, Guidorzi & Frontera, 2014, ApJ, 786, 146

Butterfly filter in (f,df/dt)

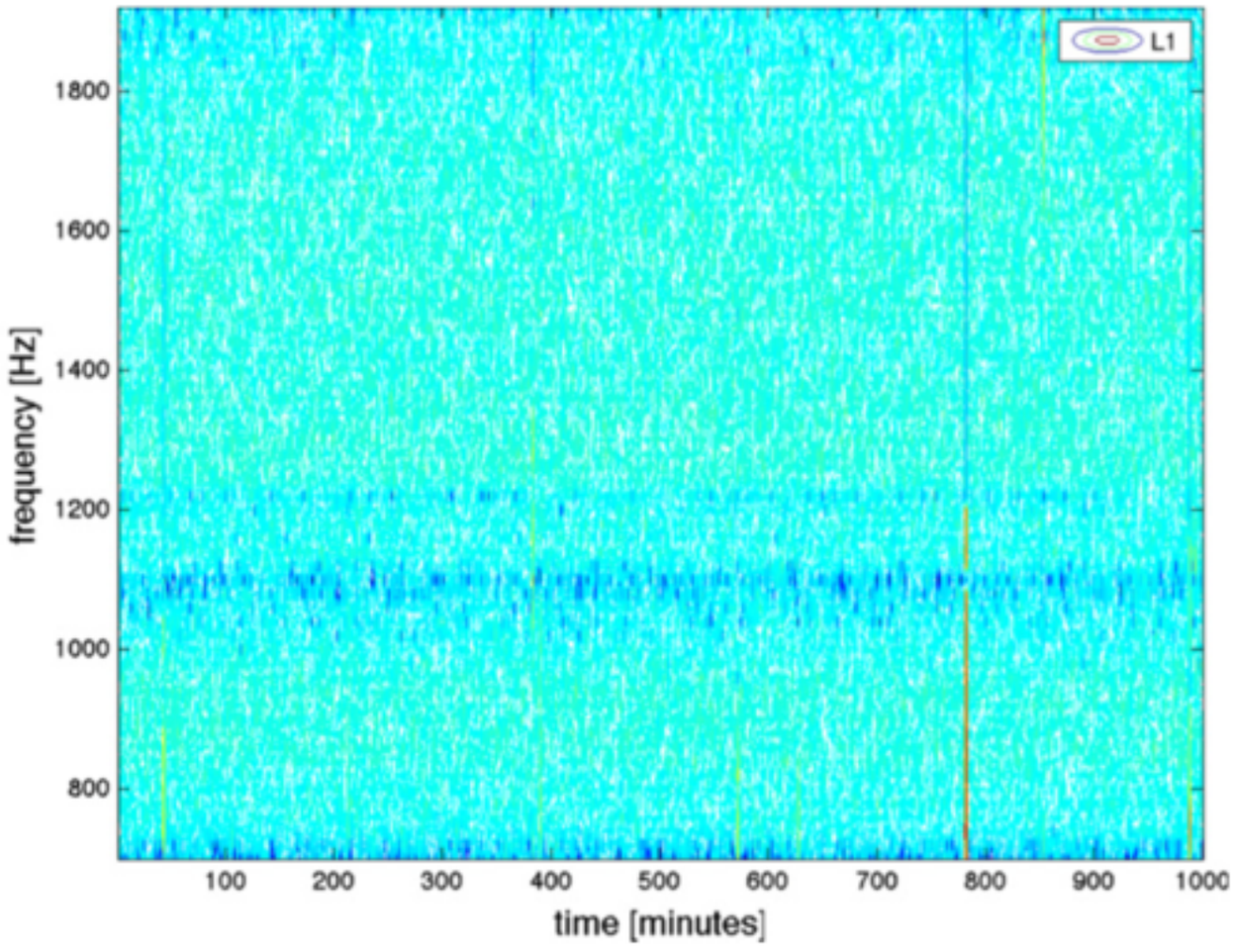


LIGO S6



(low frequencies filtered out)

Butterfly filtered



van Putten 2016 ApJ 819 169

Butterfly filtering

$$\rho(t) = \int z(s)c(s+t)\,dt$$

$$\rho = ifft\left\{\tilde{z}\tilde{c}^{*}\right\}$$

#z (16 seconds)= 1.6 million
#c = 8 million

$$N \sim 10^{20} \text{ flops}$$

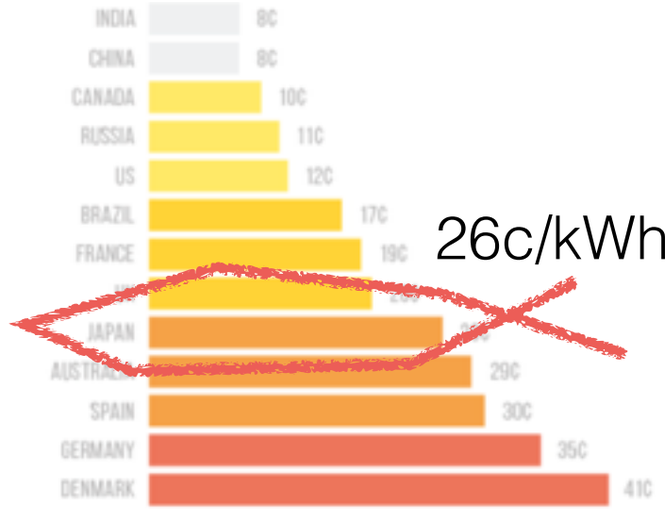
CPU or GPU?

LIGO S6: one-year of data (1.1 TB)
L1 & H1 duty cycle ~ 40%

Butterfly filtering with 8 million templates

Real-time analysis (1 hr/1 hr, slicing 16 s): 3 TFlop/s FFT

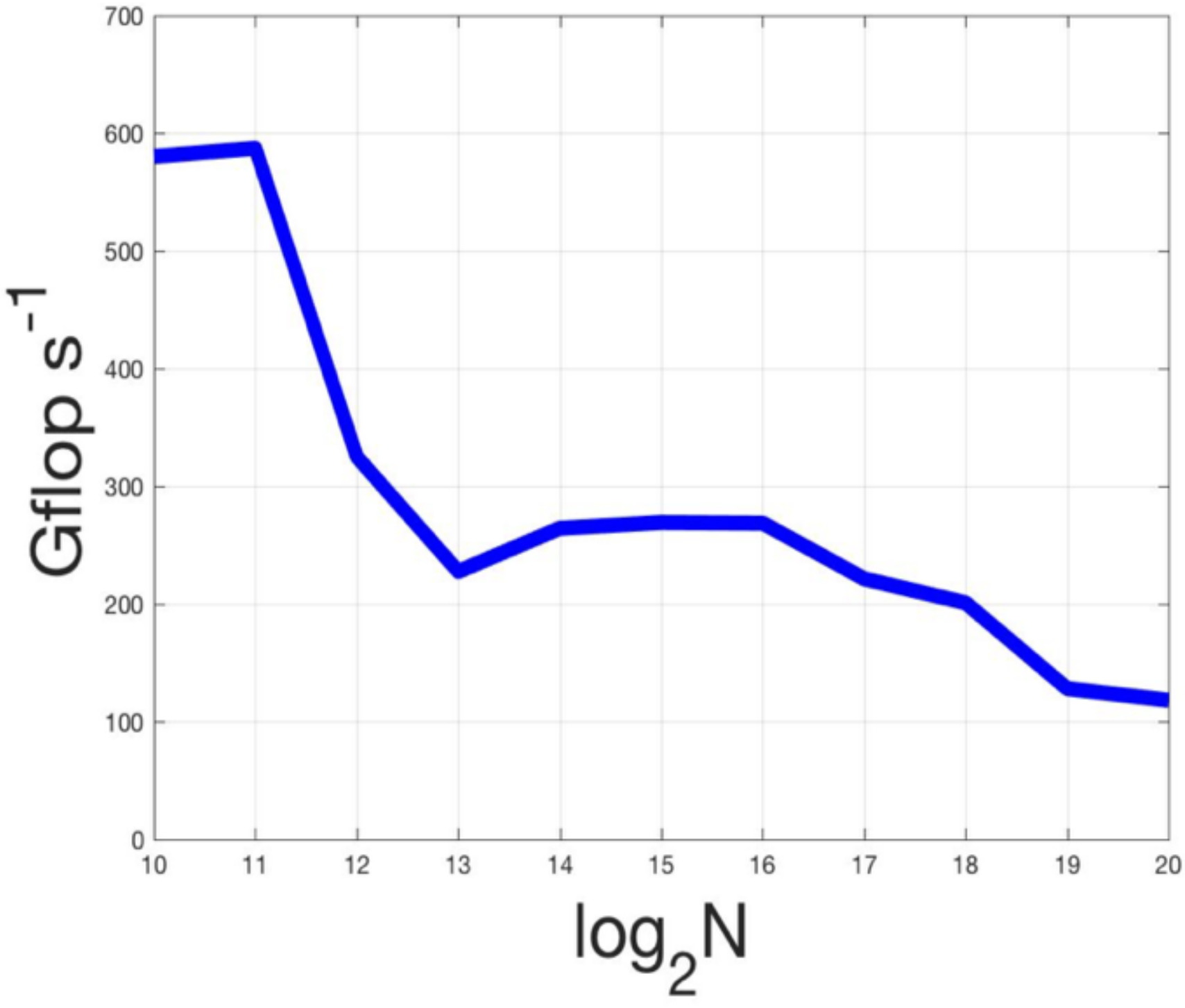
Moore's law continues to apply to GPUs



1000 CPU-cores
250 PCs ($125,000)
20 kW ($40,000/yr)

10 GPUs
5 Dual GPU systems ($20,000)
2 kW ($4,000/yr)

clFFT GPU performance (C2C, SP, AMD D700)



CPU-GPU butterfly

CPU

GPU

Create templates

$\tilde{C}_k = FFT\{C_k\}$

precallback

Z=(H1,L1)

$\tilde{Z} = FFT\{Z\}$

$\tilde{Z}\tilde{C}_k^*$

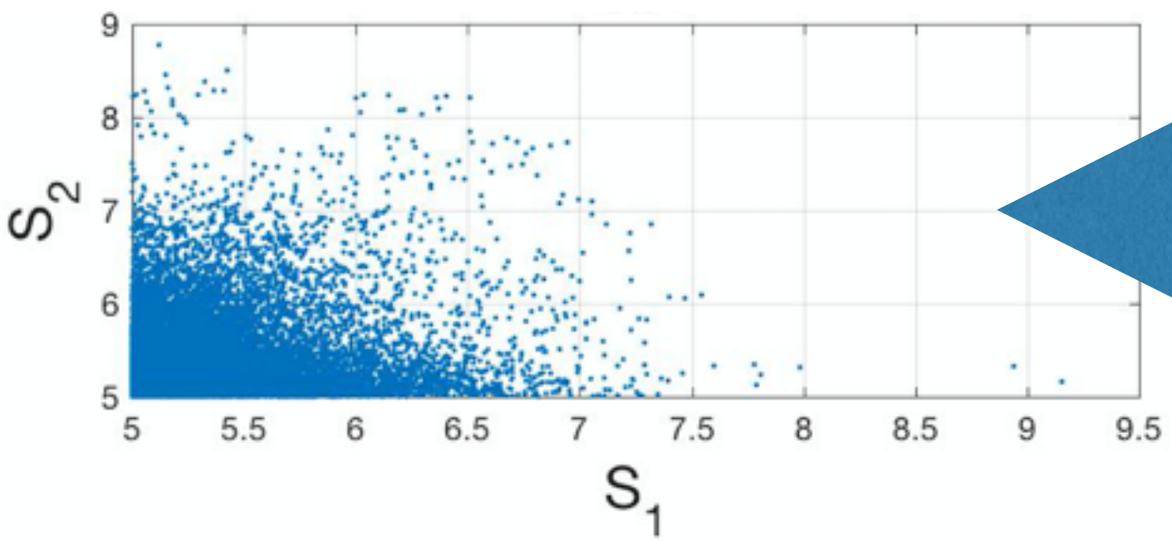
$S = IFFT$

Read data

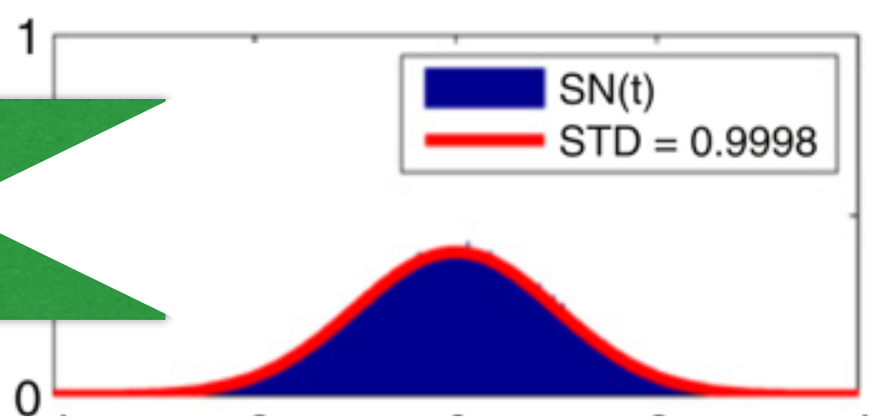
Parseval:

$\{\sigma_{H1},\sigma_{L1}\}$

postcallback



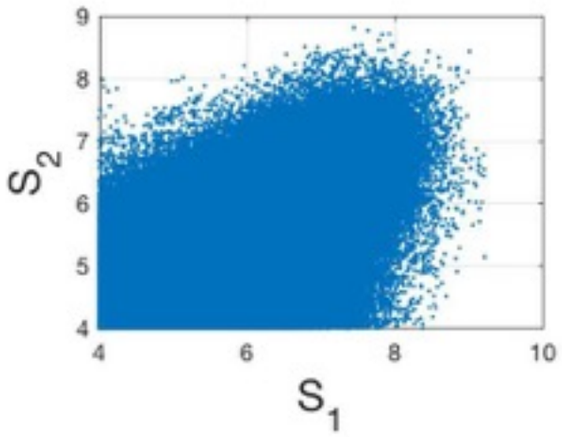
Normalised near-Gaussian PDF

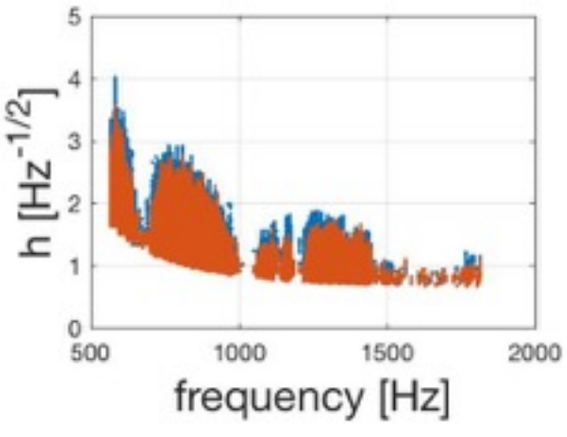


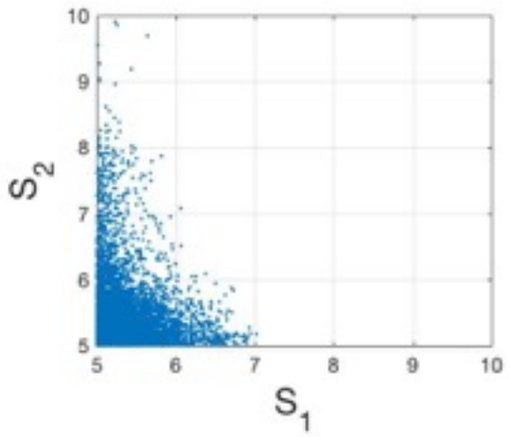
~ 15kB/s

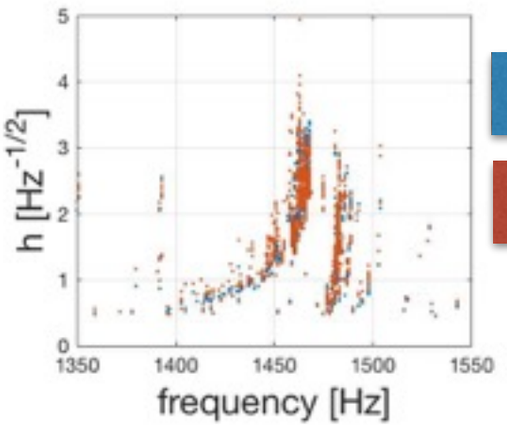
~ 25GB/s

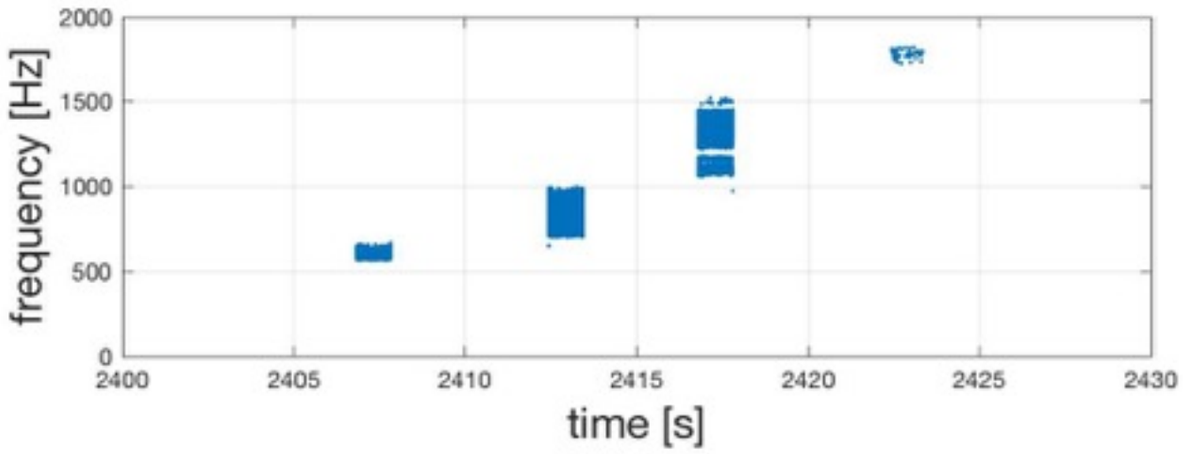
Examples

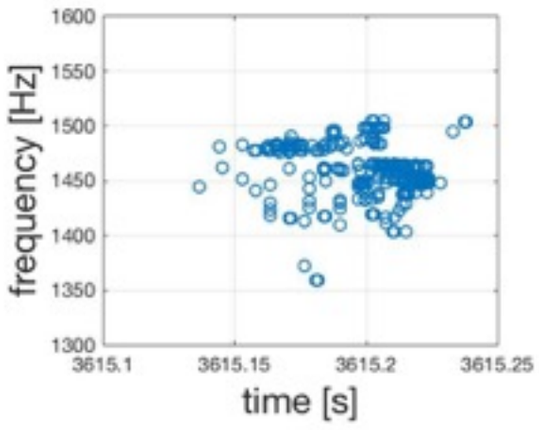


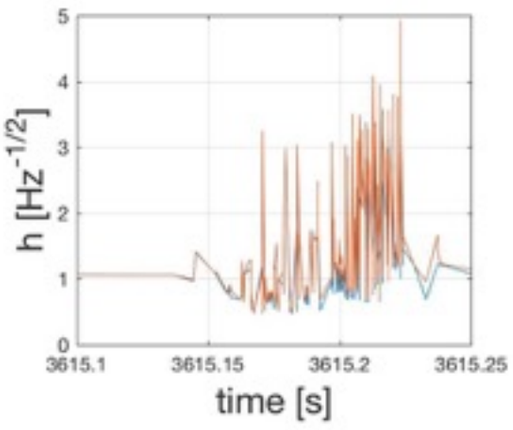












LIGO injection

“mysterious features”

Conclusions and outlook

Butterfly filtering by CPU-GPU enables deep searches

10x more efficient, green, etc. than CPU implementation

Preliminary application to LIGO S6:

Captures LIGO injections
Various features in (h,f)-diagram

- mostly spurious
- challenging to identify genuine features
- Further post-processing analysis is needed…