Multiband Gravitational Wave With LISA

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The Gravitational Wave Spectrum

Sources

Primordial gravitational wave background

Supermassive black holes binary inspiral

Supermassive black holes binary merger
Galactic binaries inspiral

Stellar origin black holes binary

Period

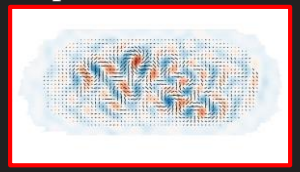
Age of Universe | Years | Hours | Seconds

Frequency (Hz)

10^{-16} 10^{-14} 10^{-12} 10^{-10} 10^{-8} 10^{-6} 10^{-4} 10^{-2} 1 10^{2}

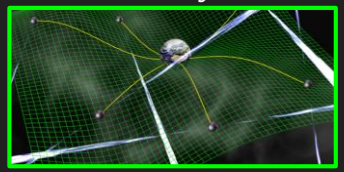
Probes

CMB polarization



Credit : BICEP

Pulsar Timing Array



Credit : David Champion

Space based detector

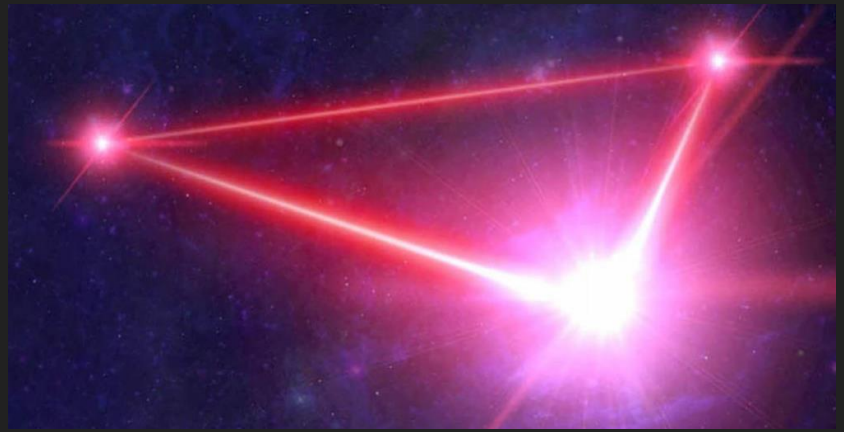
Credit : LISA

Ground based detector

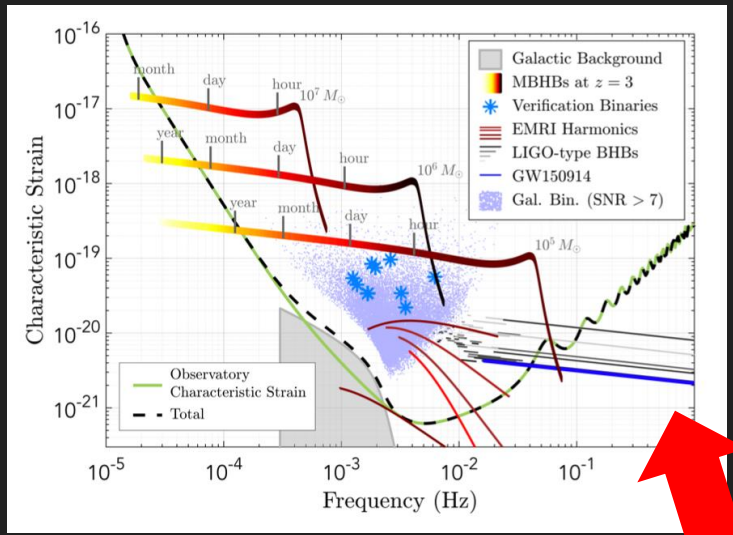
Credit : LIGO

LISA - Laser interferometer Space Antenna

Arm length 2.5×10^6 km
Orbit $50\text{-}65 \times 10^6$ km behind Earth
4 years mission



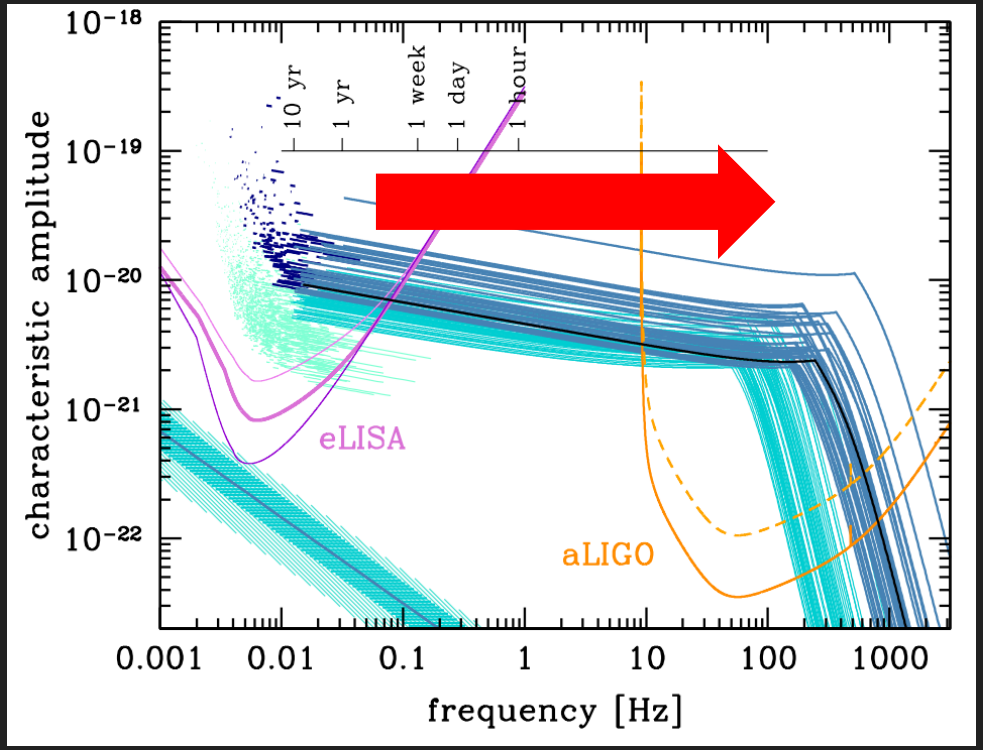
Credit : LISA consortium



Credit : LISA L3 proposoal

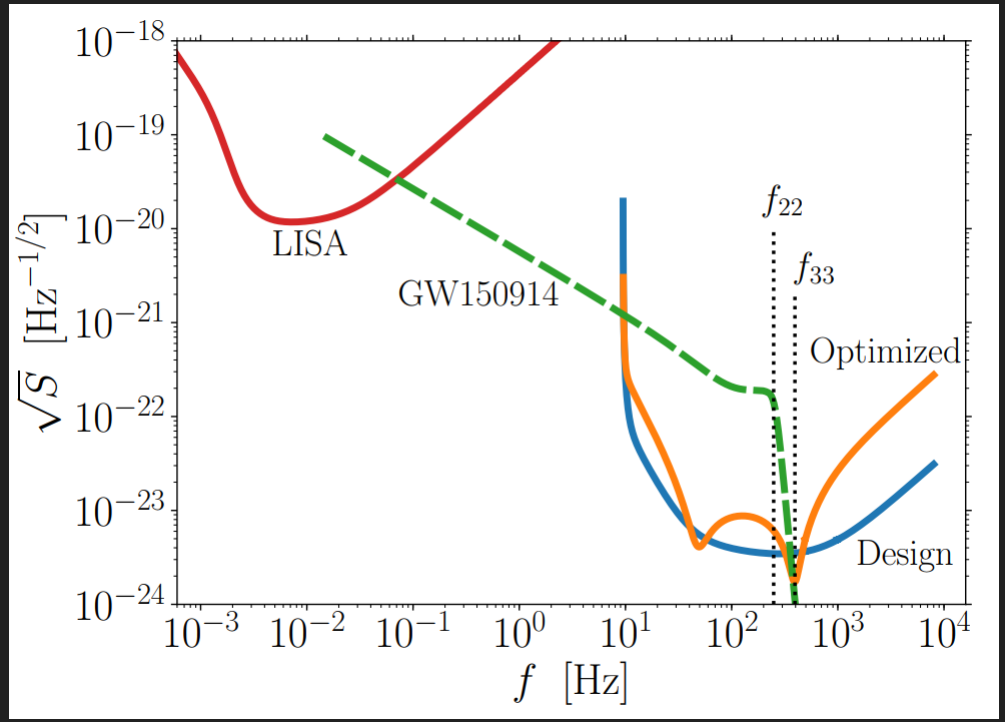
Multiband!!!

Multiband sources



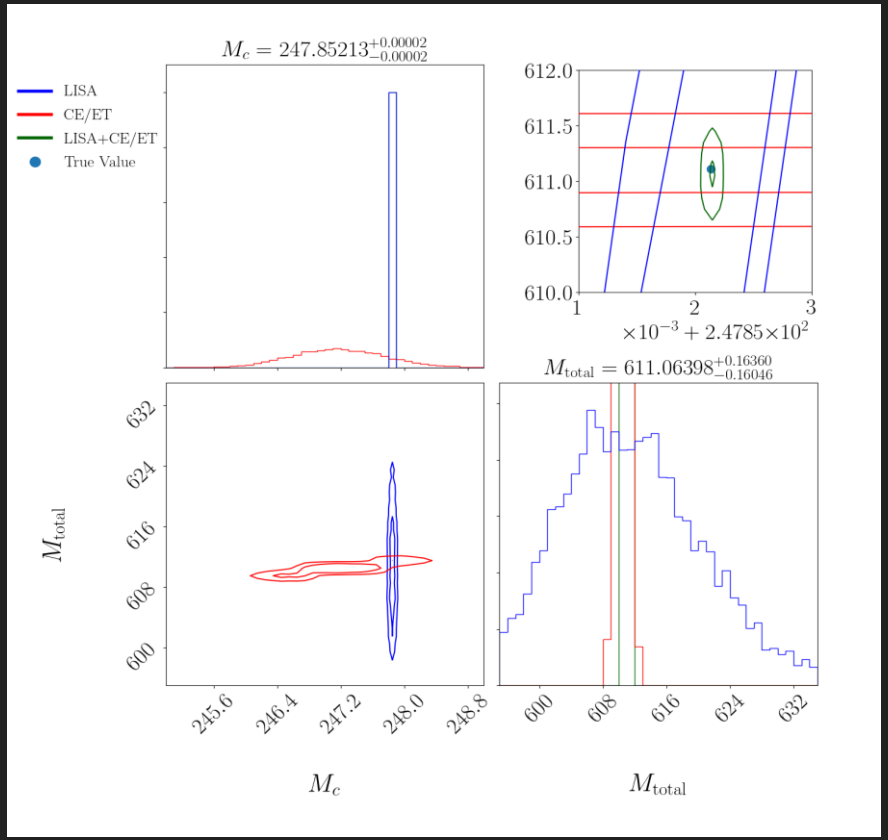
Credit : Sesana 2016

Multiband sciences - Forewarning

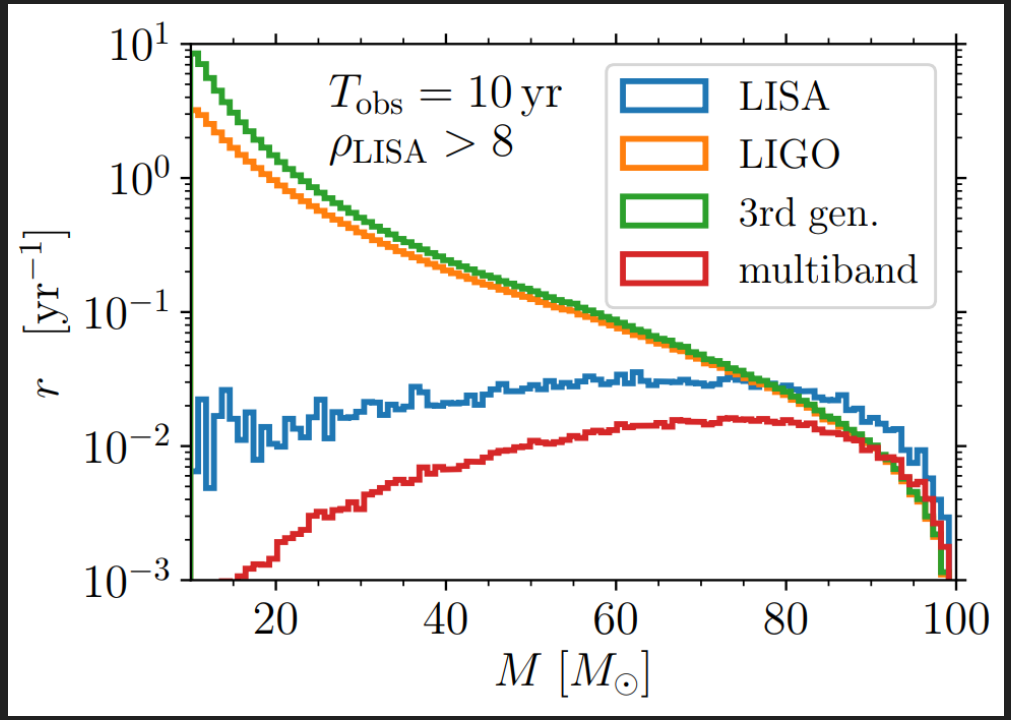


Credit : Tso et. al 2018

Multiband sciences - Cross-checking

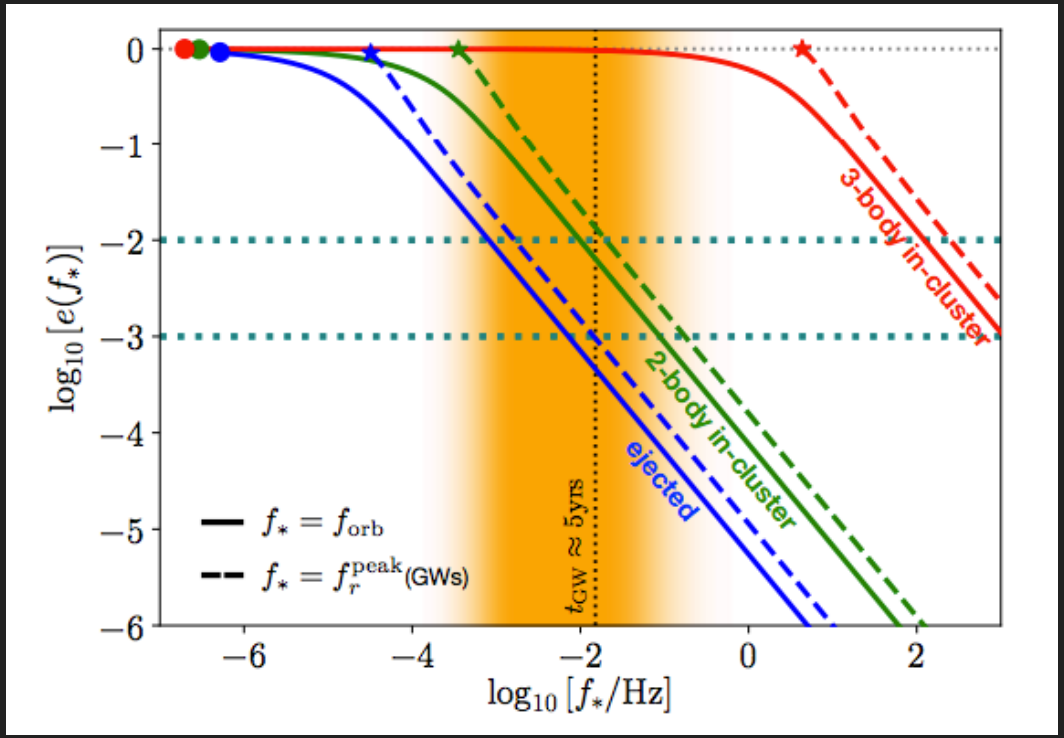


Multiband sciences - Population science



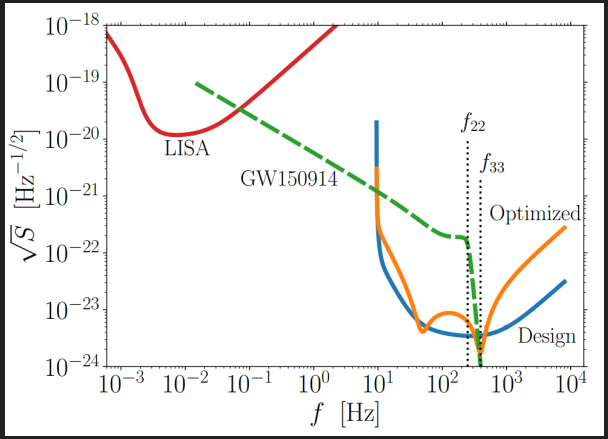
Credit : Gerosa et. al 2019

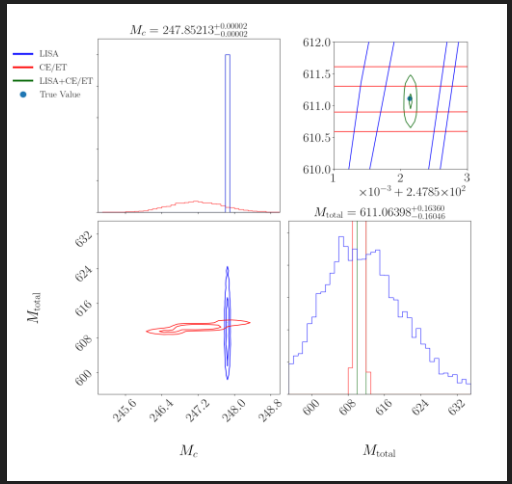
Multiband sciences - Eccentricity

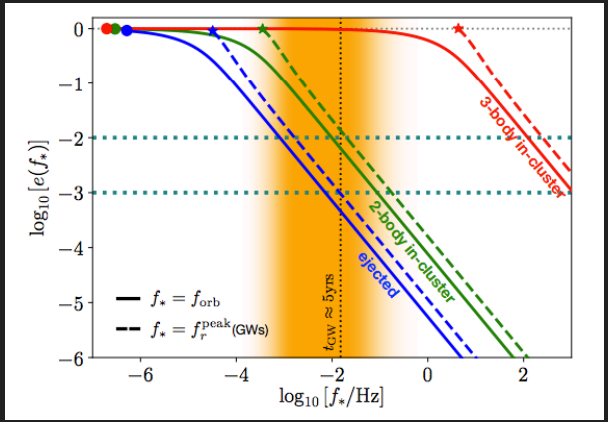


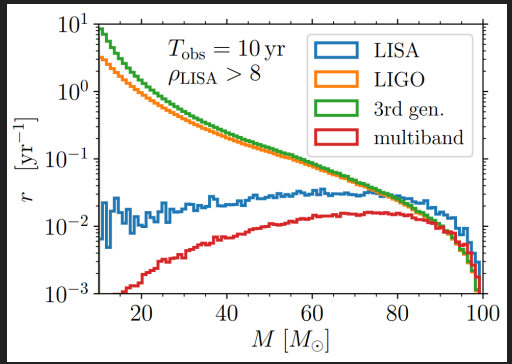
Credit : D'Orazio 2018

Look at all these cool stuffs!

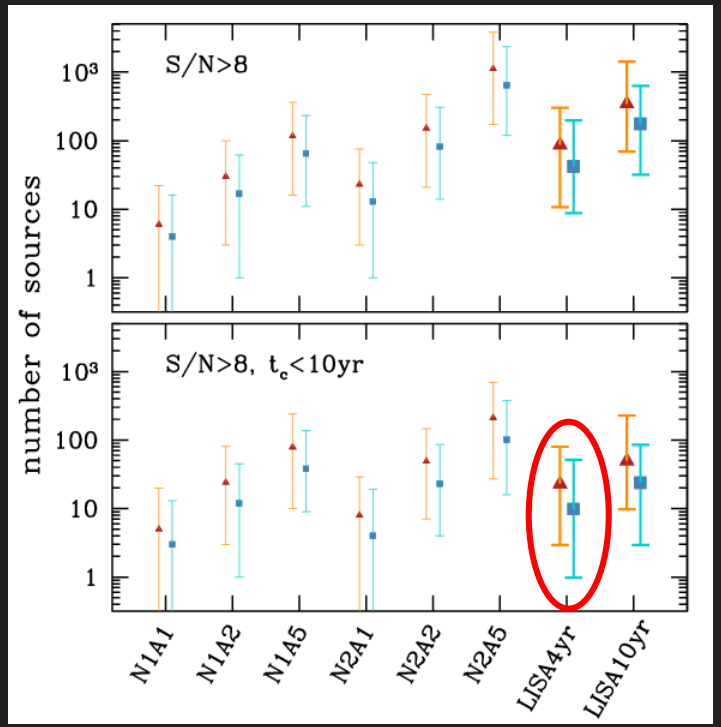




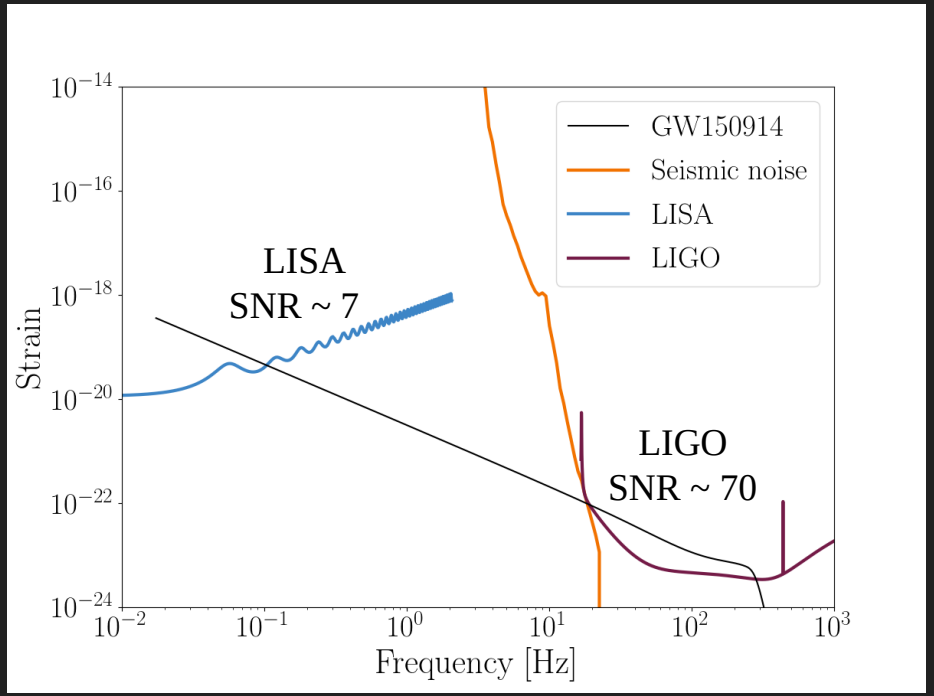




Sorry, we don’t have much sources to do the science



Credit : Sesana 2016

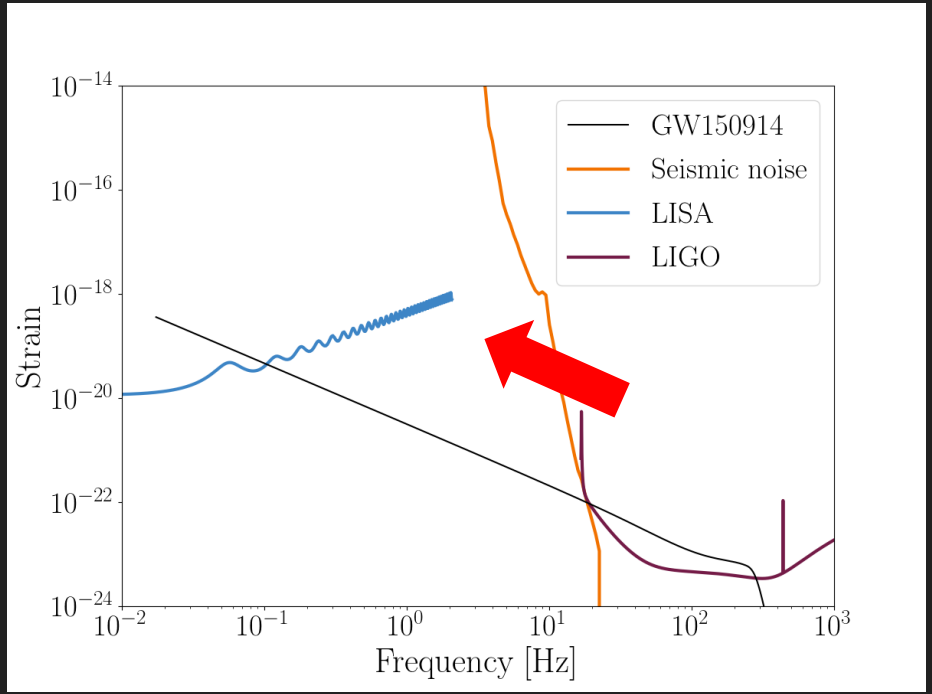


It is hard, unless you know the answer

Retrodicting from ground-based detection

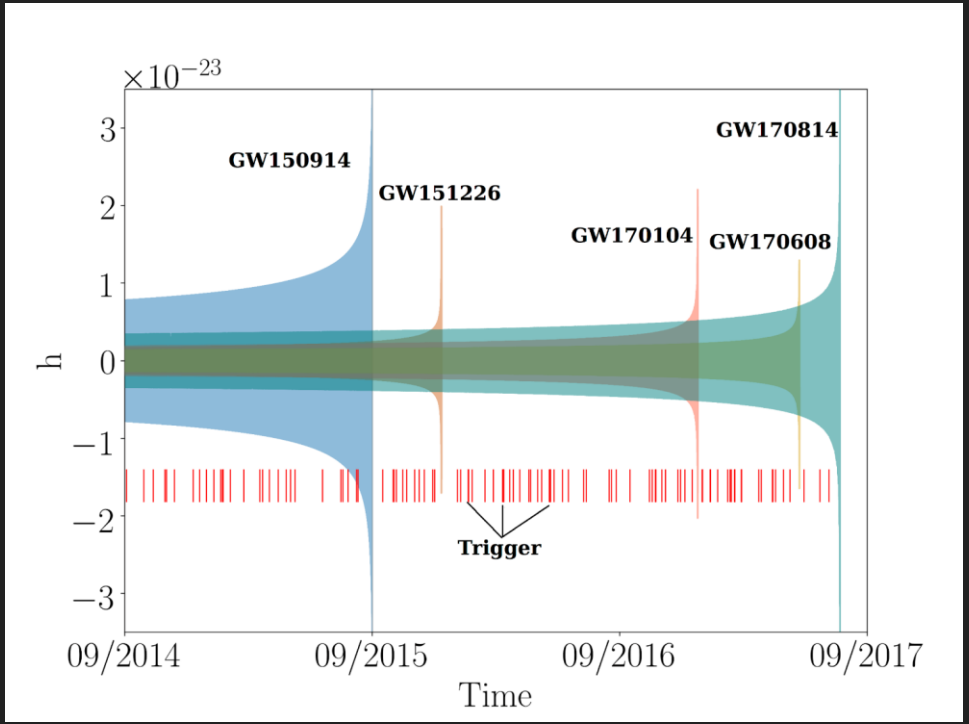
Assumption:

1. Astrophysical sources have same properties in both band.
2. Not necessary true for noise.

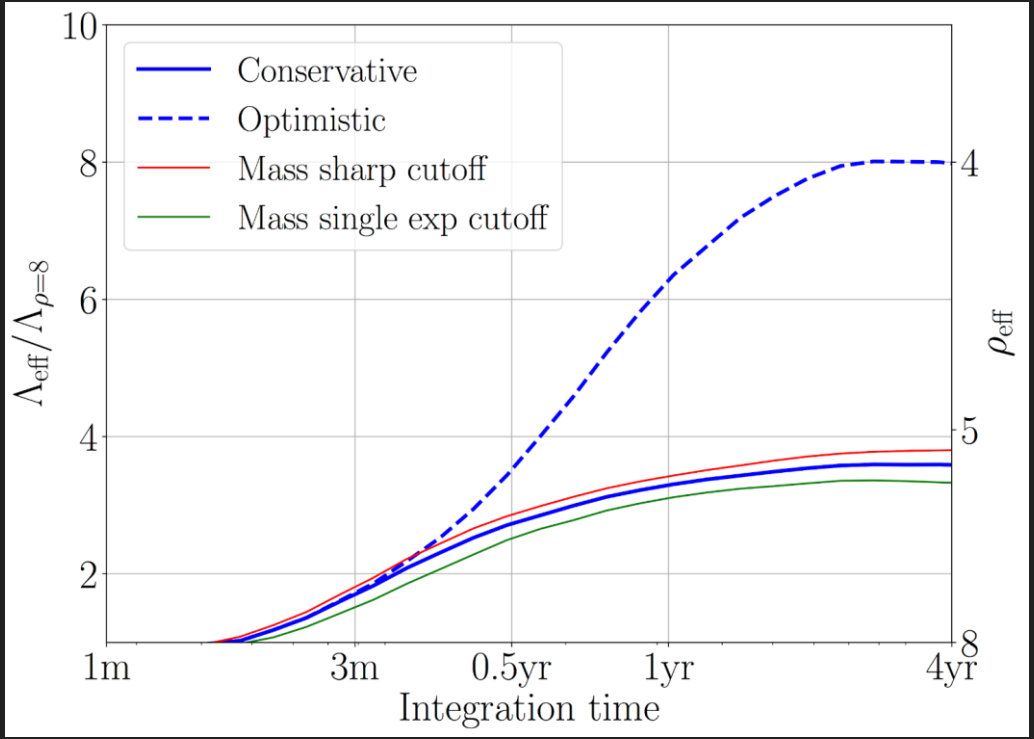


Example - Time of coalescence

1. Get yourself a LISA triggers list
2. Fetch the ground based catalog
3. Relegate the one which does not match the ground based catalog.
4. Do it again with lower SNR threshold, until FAP is too high.



Result


Conservative
Optimistic
Mass sharp cutoff
Mass single exp cutoff
$\Lambda_{\rm eff}/\Lambda_{\rho=8}$
$\rho_{\rm eff}$
10
8
6
4
2
4
5
8
1m
3m
0.5yr
1yr
4yr
Integration time

Summary

1. What multiband gravitational wave with LISA is about ?
    1. What is LISA ? A space based detector which probe earlier phase of SOBHs.
    2. Why do we care ? Distinguishing formation channels, test of systematics, test of GR ...
    3. Wait, we have a problem… We don't have enough multiband events.
2. Tackle the challenge
    1. The idea - consistency test
    2. Result - 4 - 8 times improvement
    3. Future development - Implementing on Mock data challenge

Multiband is new and cool, many things to be done.

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