The Science Case for OzGrav HF

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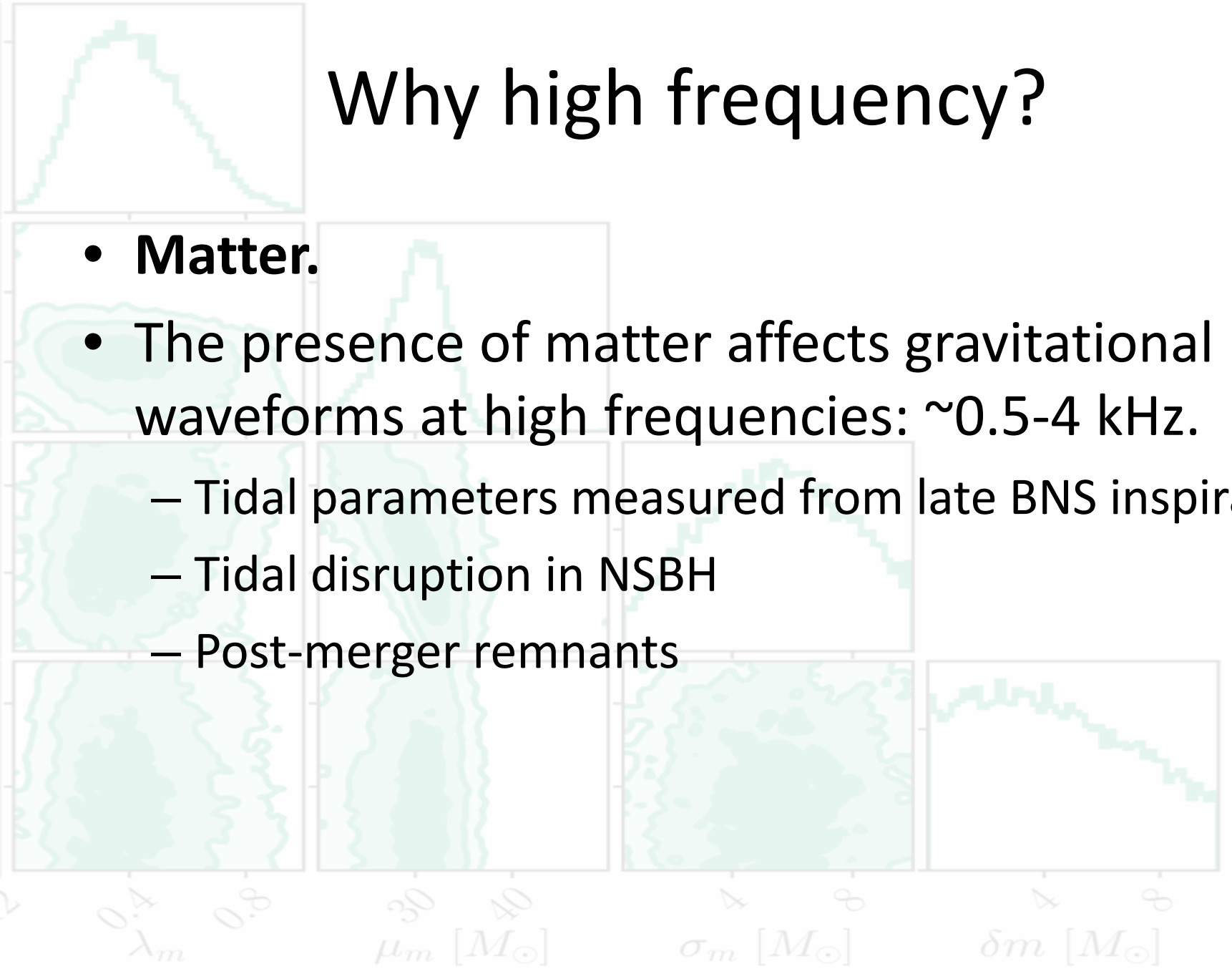
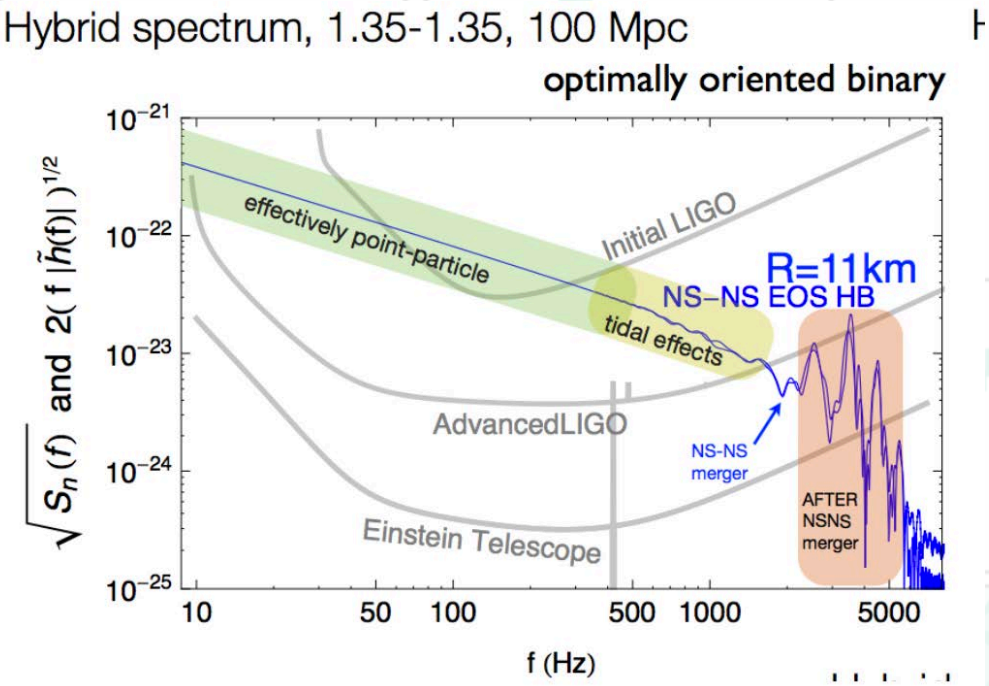
Why high frequency?

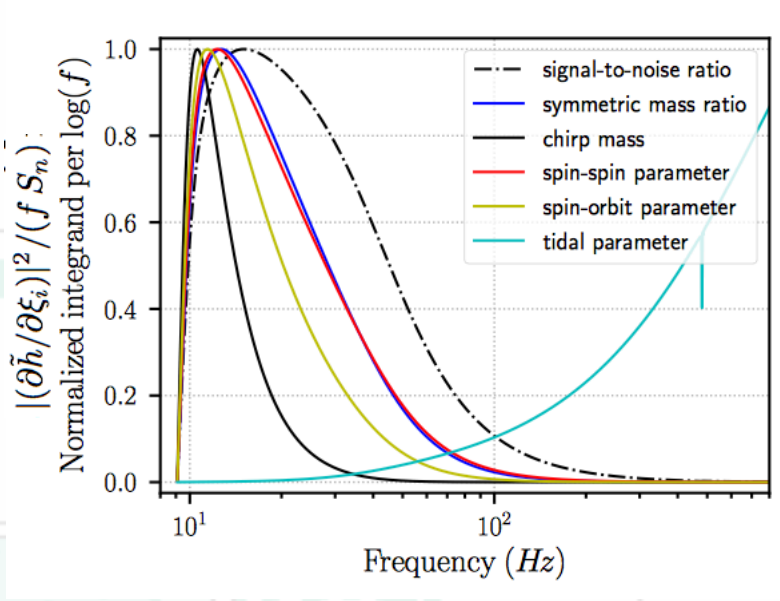
- **Matter.**
- The presence of matter affects gravitational waveforms at high frequencies: ~0.5-4 kHz.
  - Tidal parameters measured from late BNS inspiral
  - Tidal disruption in NSBH
  - Post-merger remnants



Tidal Effects



Usman, et al., DCC P1500105



Harry & Hinderer (arxiv/1801.09972)

normalized quantity characterizing the accumulation of information about the binary parameters per logarithmic frequency interval

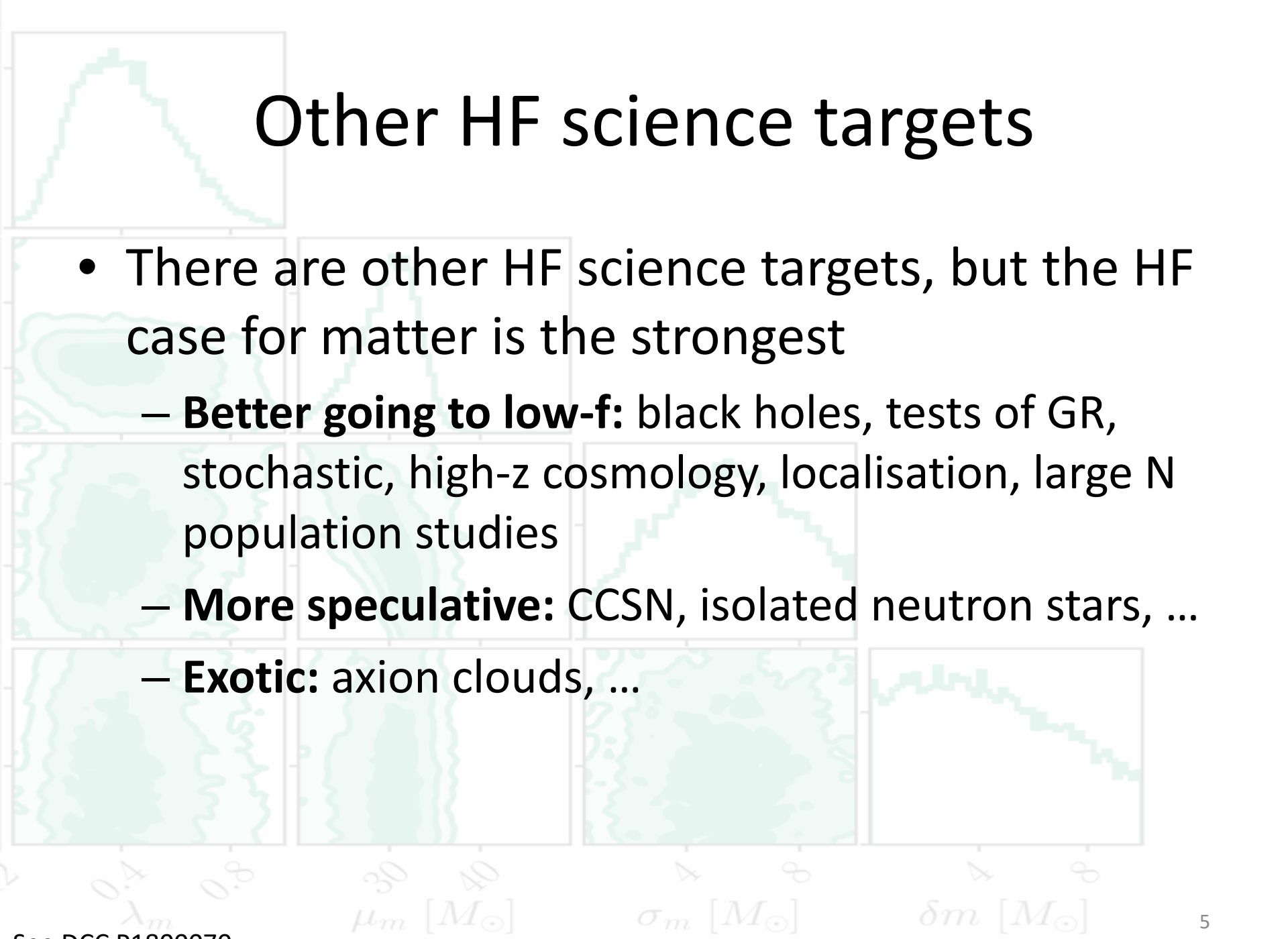
Why matter?

- The main things we learn
  - **The equation of state for matter at nuclear densities**
  - Phase transitions in nuclear matter (maybe) [1]
- Other things we learn
  - **Hubble**. Matter effects break redshift-mass degeneracy, allowing us to measure H_0 without EM counterparts [2].
  - Everything else…

[1] Bauswein et al., arxiv/1809.01116
[2] Messenger & Read, PhysRevLett.108.091101 (arxiv/1107.5725)

Other HF science targets

- There are other HF science targets, but the HF case for matter is the strongest
  - **Better going to low-f:** black holes, tests of GR, stochastic, high-z cosmology, localisation, large N population studies
  - **More speculative:** CCSN, isolated neutron stars, …
  - **Exotic:** axion clouds, …



See DCC P1800070

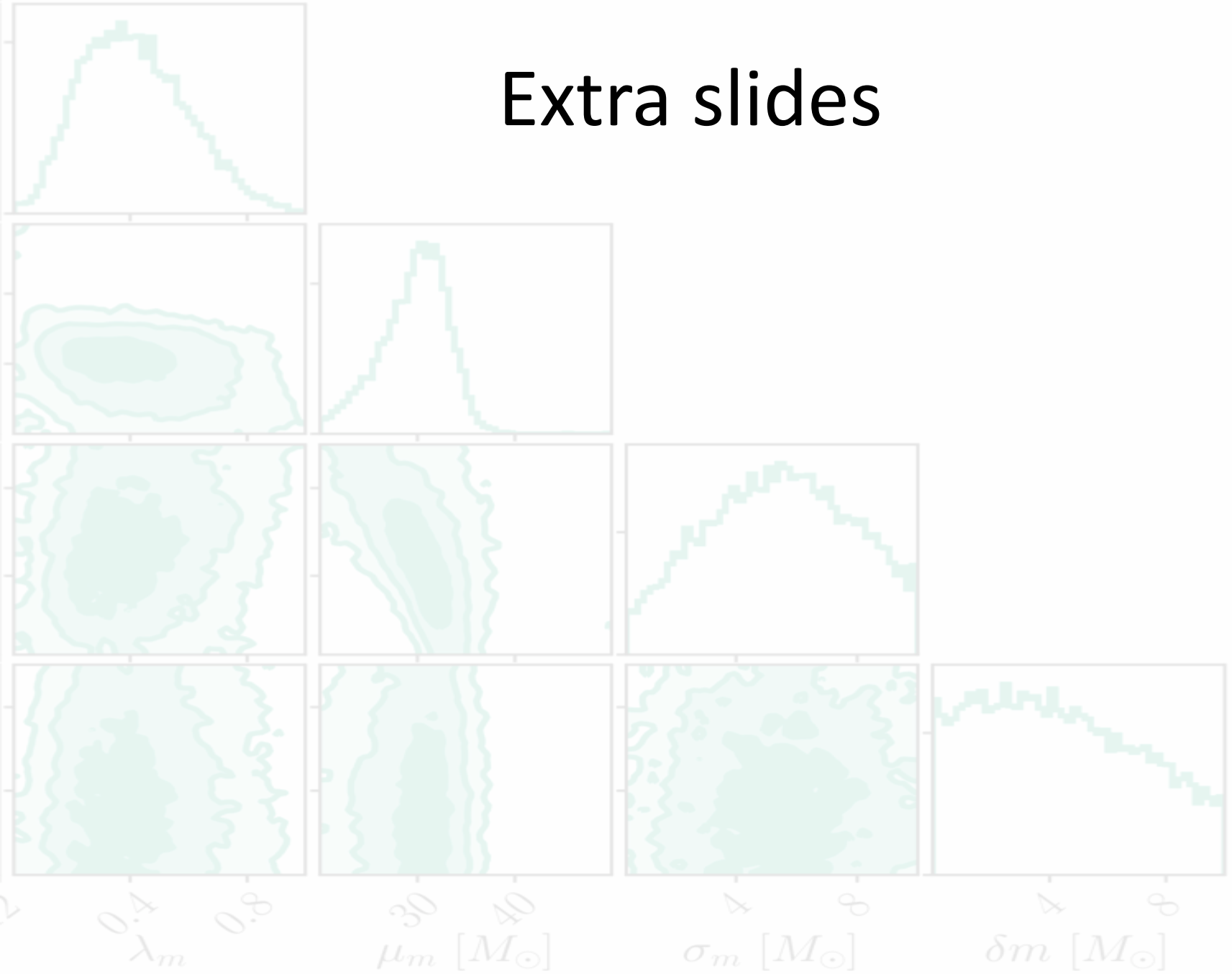
Network

- We should envision OzGrav HF as the specialised high-frequency component of a global network.
  - The network detects and localises sources.
  - OzGrav HF measures matter effects.
- Perhaps OzGrav HF will be a springboard to a full 3G detector, but there's no reason it has to be: ~$50M versus ~$1B.

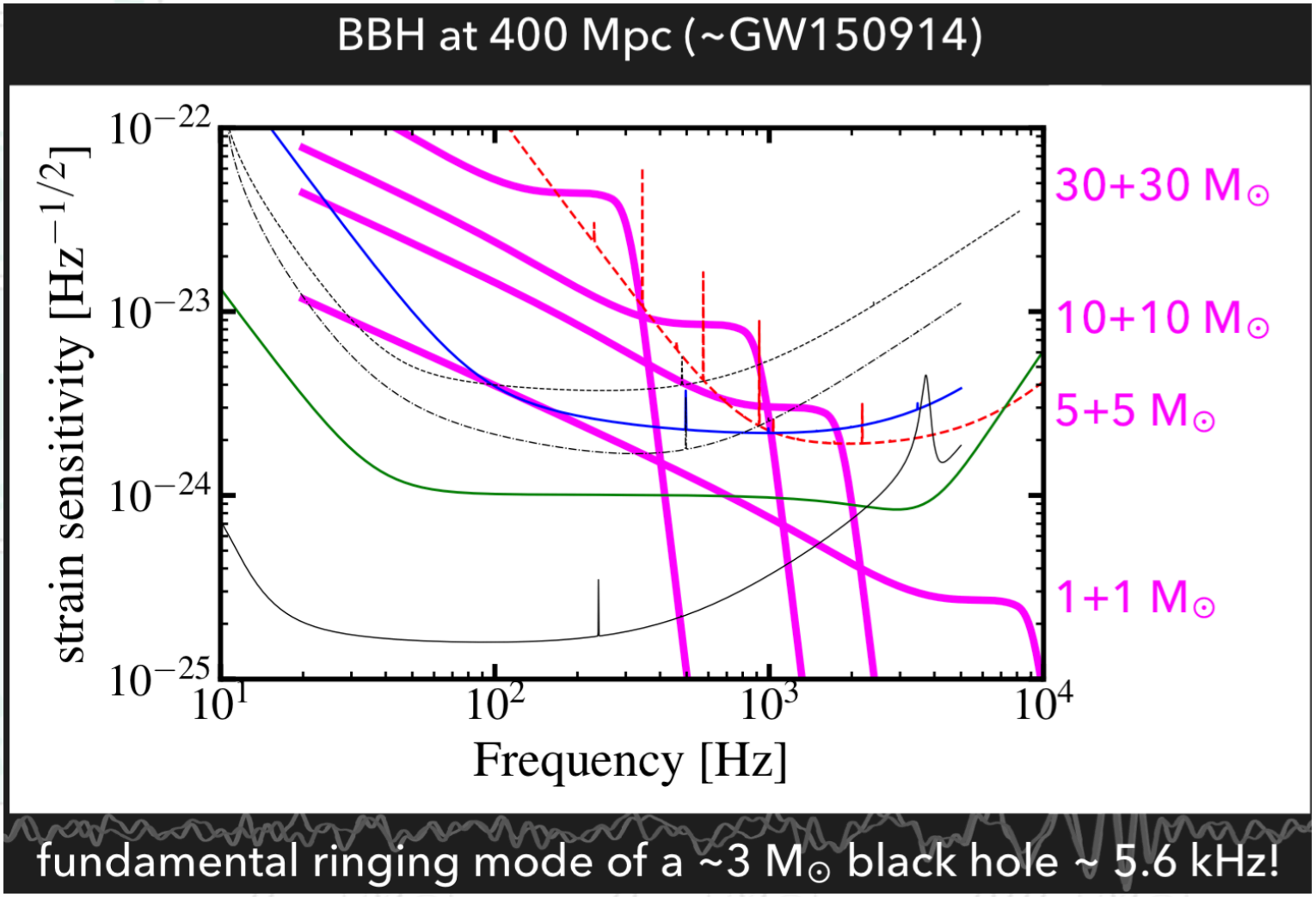
Summary

- High-frequency detectors are matter machines.
- Need one detector
- Not a big geographical advantage for Oz
- Sacrifice performance if it saves money or improves HF performance.
- For a modest budget, and building on our instrumental strengths, we can lead the worldwide effort above 500 Hz.

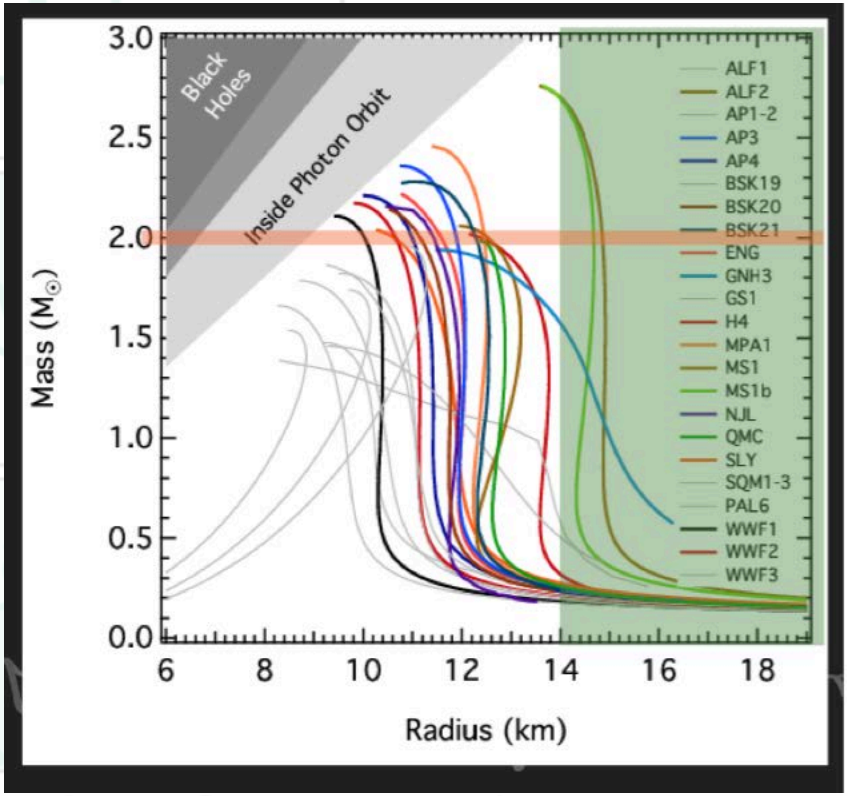
Extra slides



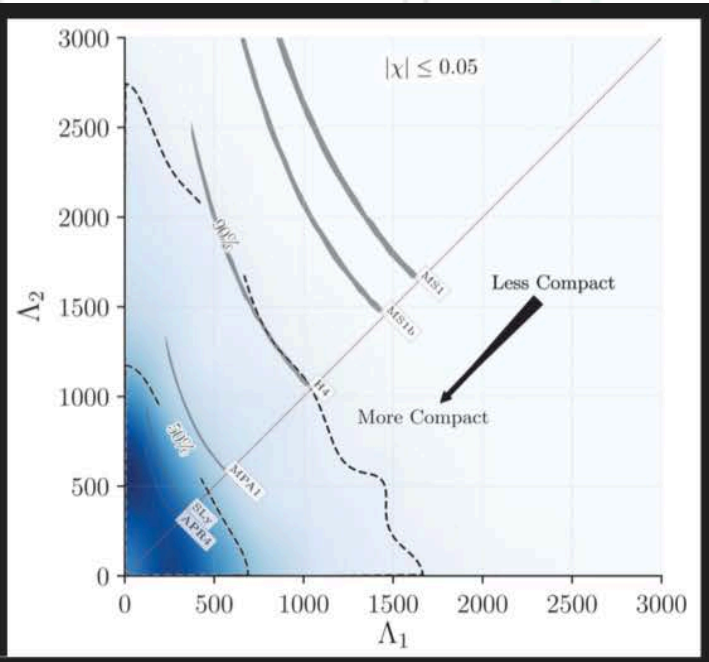
BBH


BBH at 400 Mpc (~GW150914)
strain sensitivity [Hz$^{-1/2}$]
10^{-22}
10^{-23}
10^{-24}
10^{-25}
10^{1}
10^{2}
10^{3}
10^{4}
Frequency [Hz]
30+30 M$_\odot$
10+10 M$_\odot$
5+5 M$_\odot$
1+1 M$_\odot$
fundamental ringing mode of a ~3 M$_\odot$ black hole ~ 5.6 kHz!

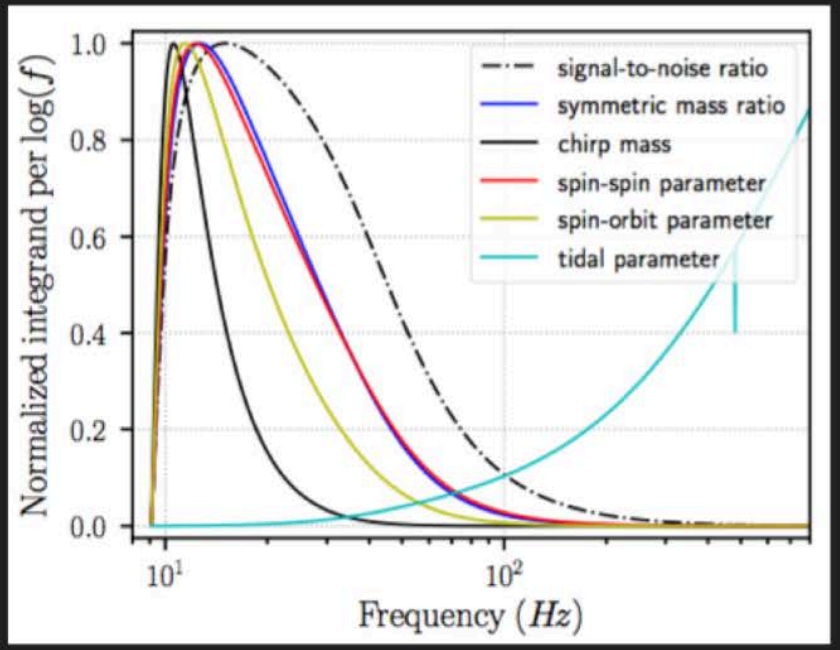
Equations of state



Tidal effects

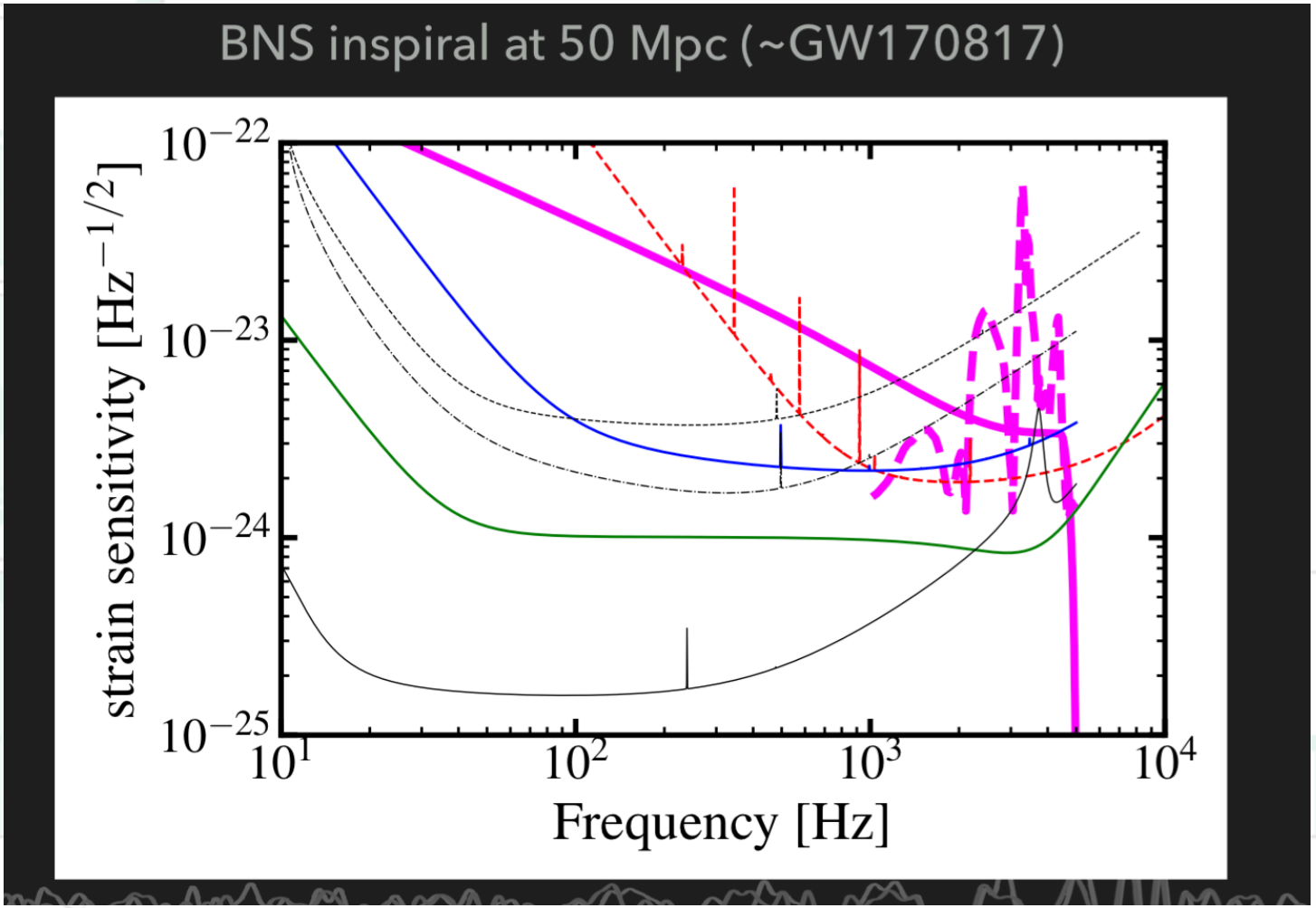


ABBOTT ET AL. (2017; BNS DISCOVERY)



HARRY & HINDERER (2018)

Post-merger


BNS inspiral at 50 Mpc (~GW170817)
strain sensitivity [Hz$^{-1/2}$]
10^{-22}
10^{-23}
10^{-24}
10^{-25}
10^{1}
10^{2}
10^{3}
10^{4}
Frequency [Hz]

Hubble with BNS