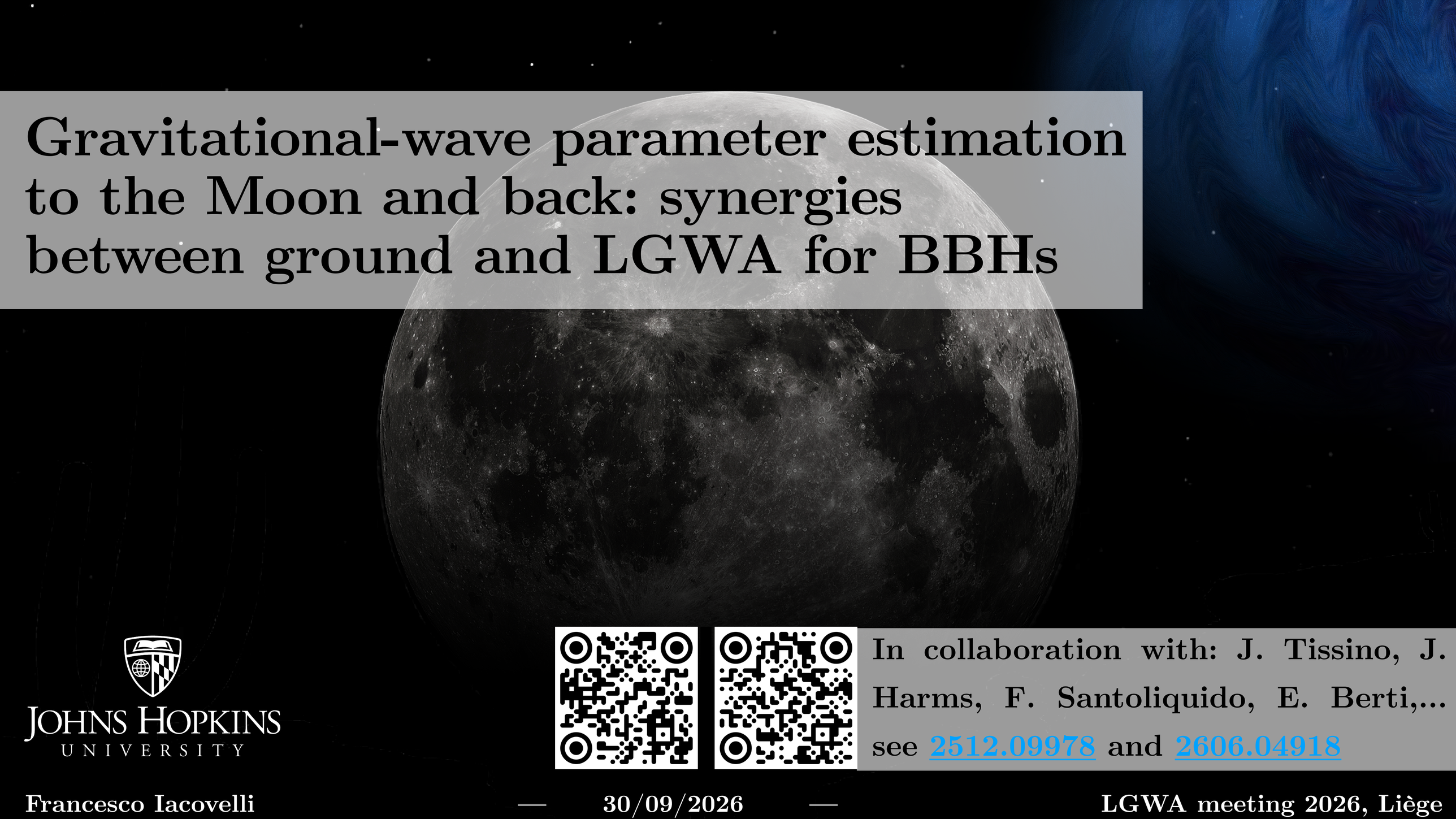
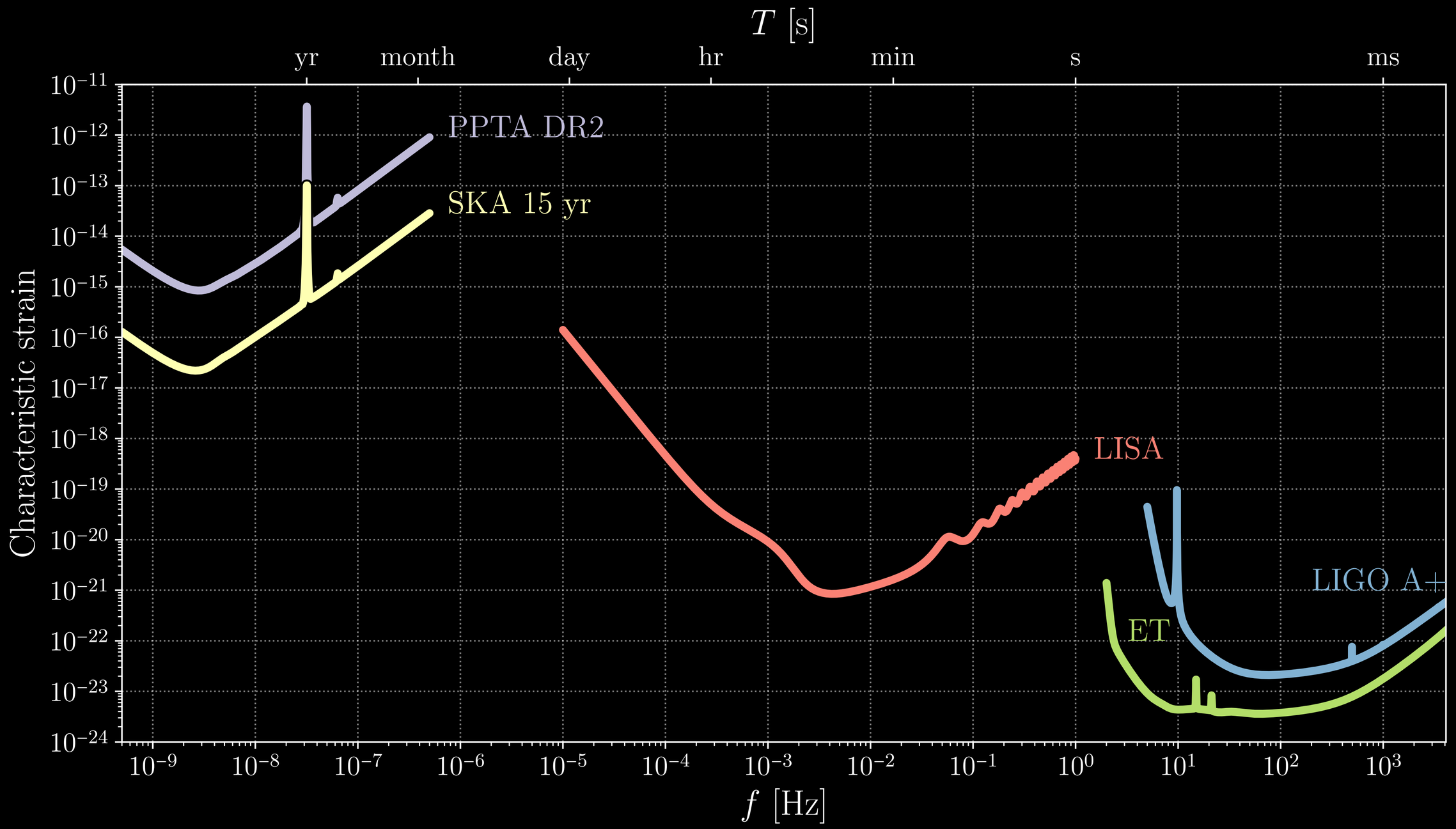
Gravitational-wave parameter estimation to the Moon and back: synergies between ground and LGWA for BBHs



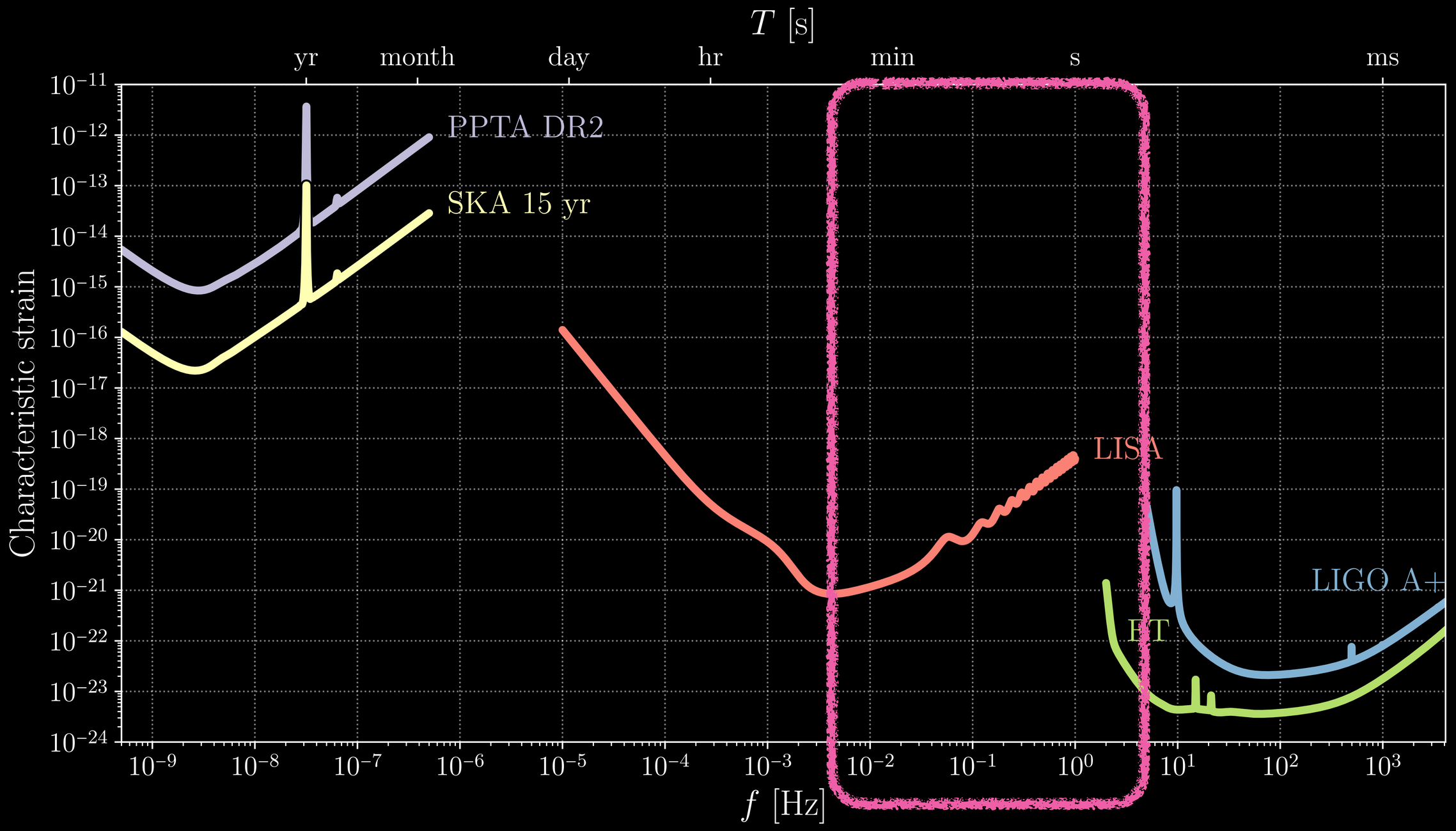
JOHNS HOPKINS
UNIVERSITY

In collaboration with: J. Tissino, J. Harms, F. Santoliquido, E. Berti,... see 2512.09978 and 2606.04918

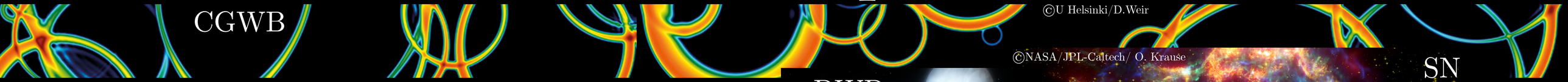
Gravitational-wave landscape



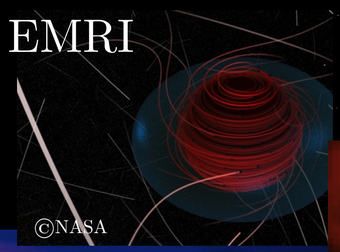
Gravitational-wave landscape



Gravitational-wave landscape



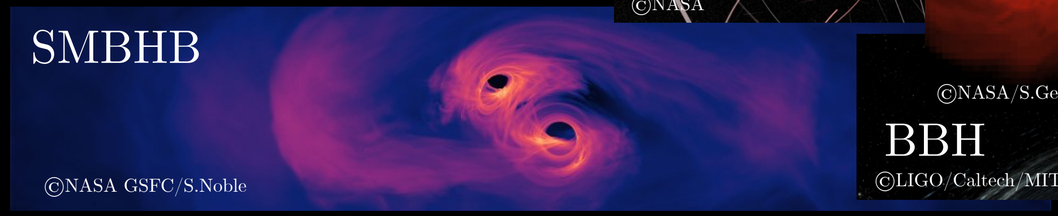


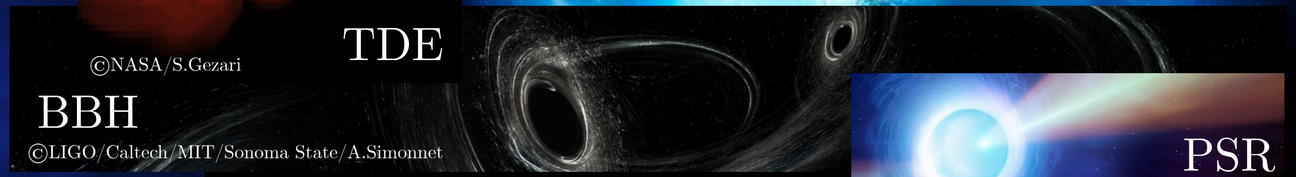


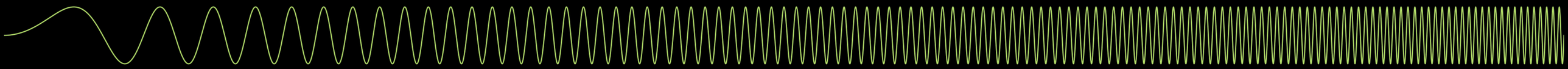








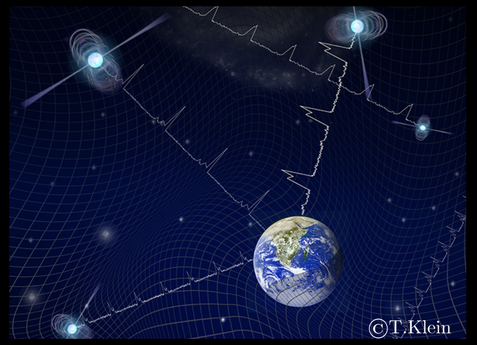


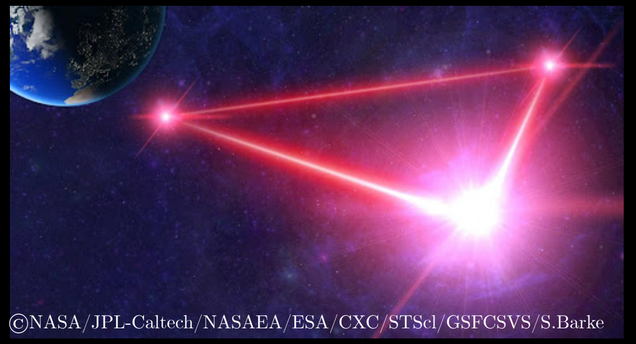


10^{-9} Hz 10^{-3} Hz 10^{-1} Hz 10^{3} Hz

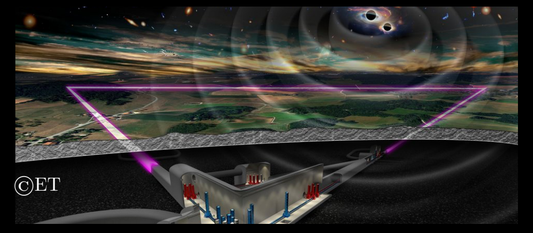
PTA Space Terrestrial

deci-Hz

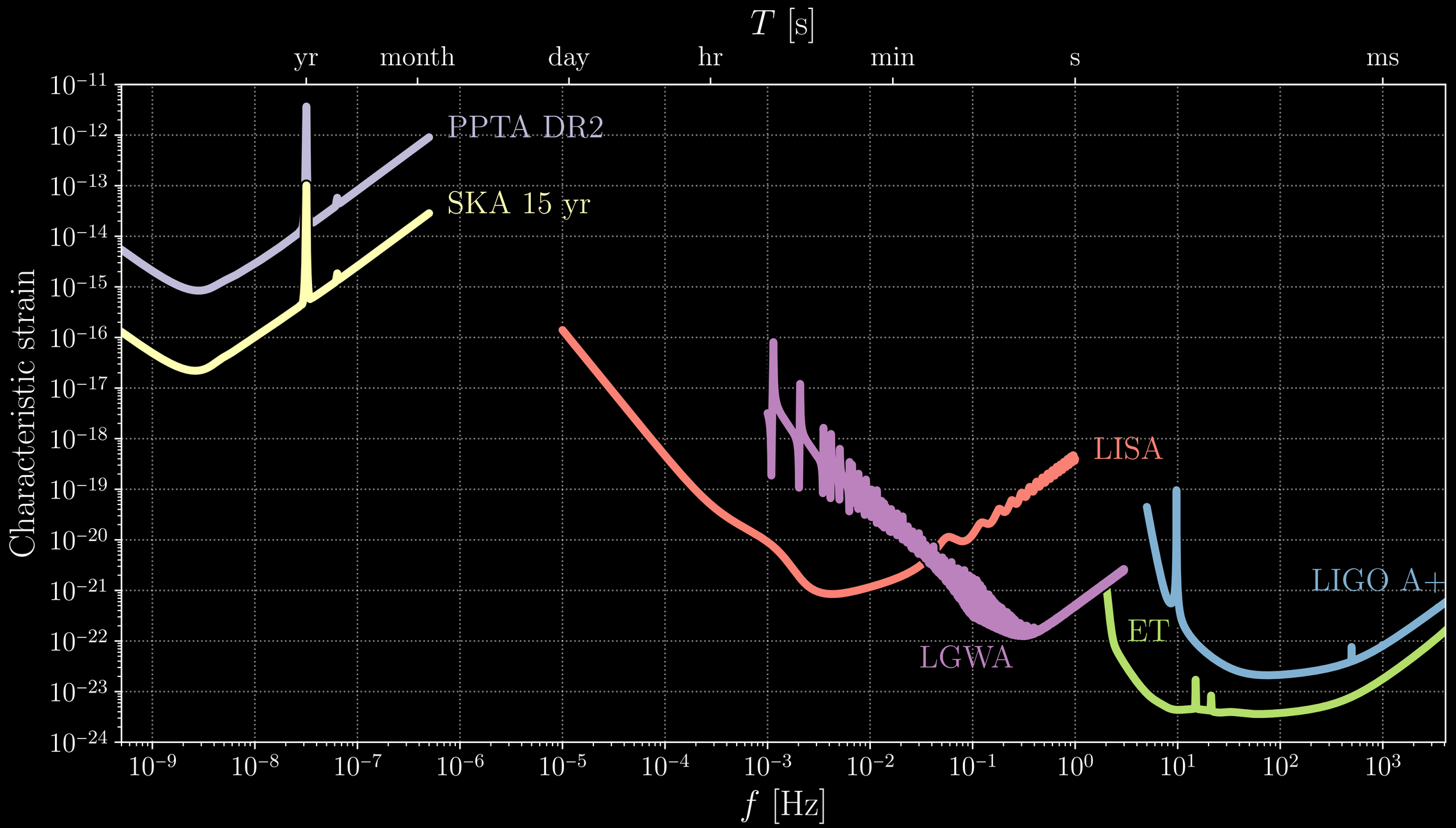






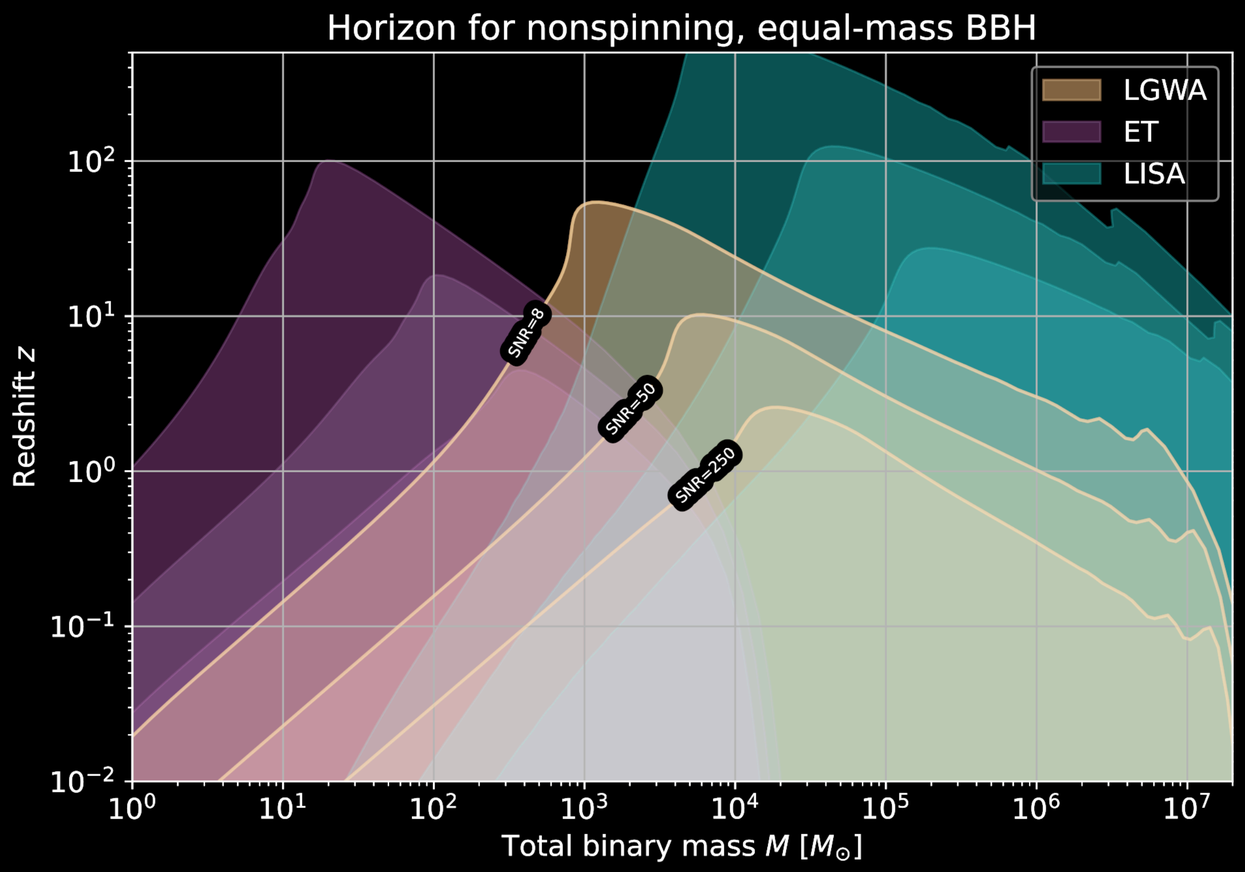


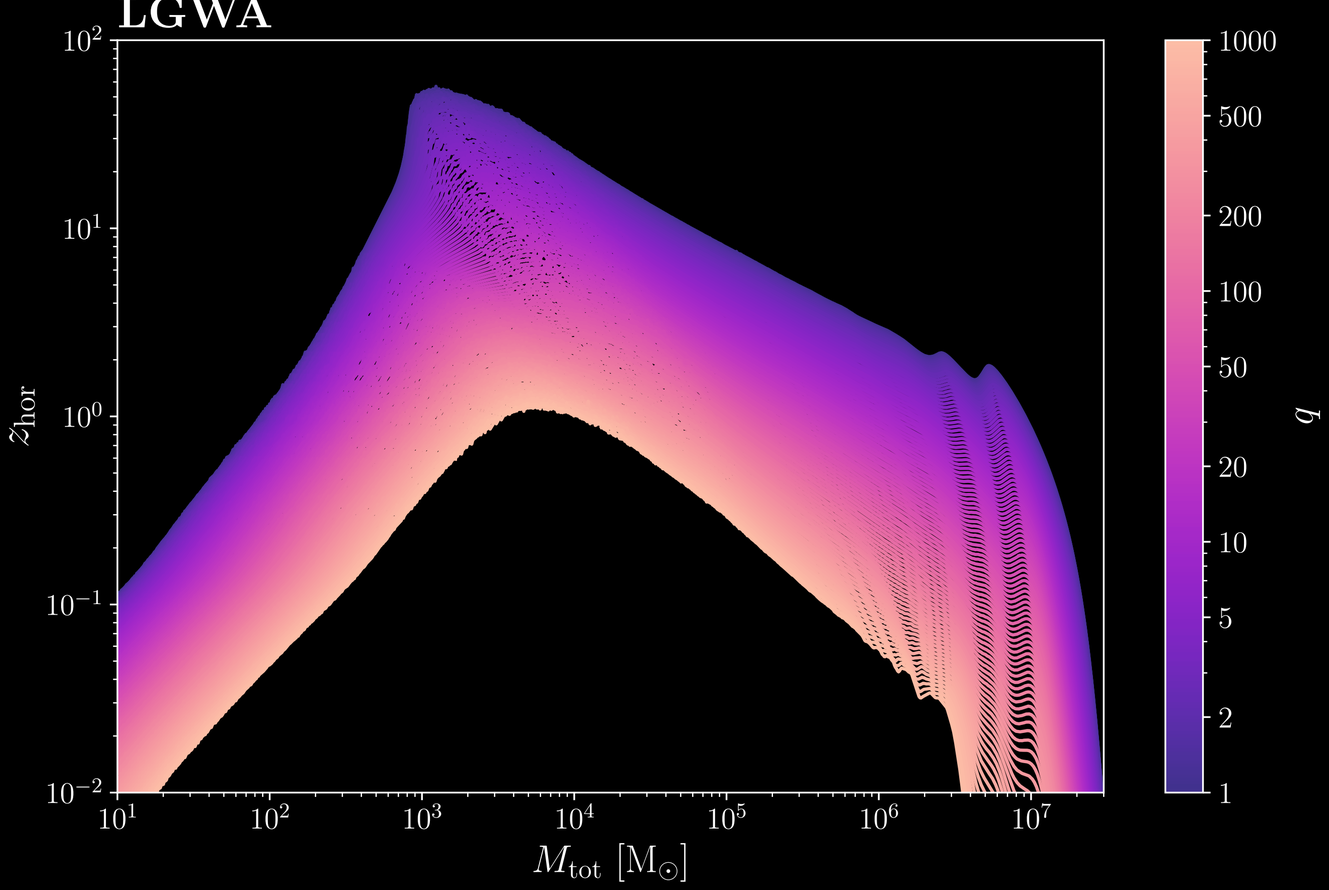
LGWA in the GW landscape



LGWA horizon

2404.09181

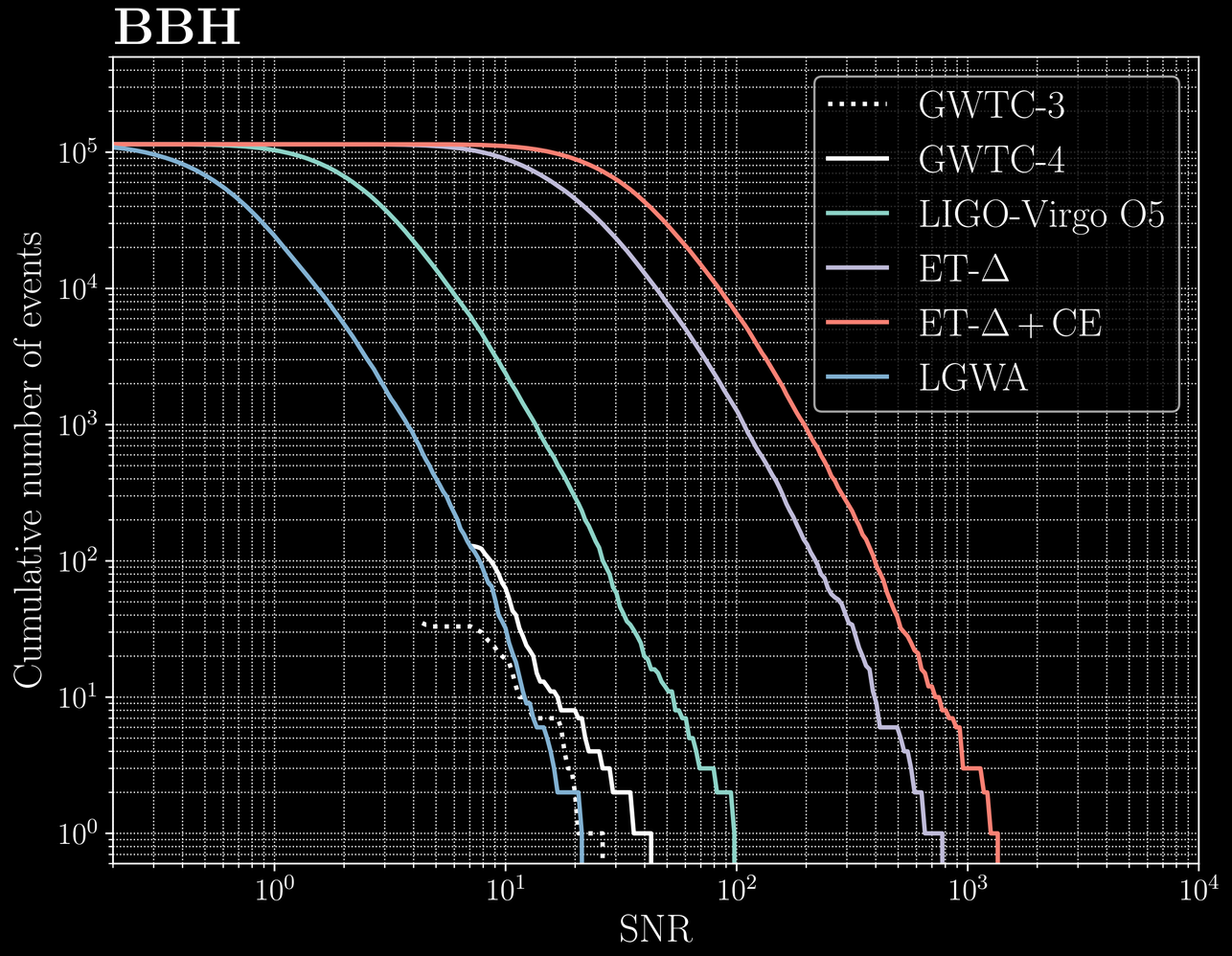




BBHs can be detected out to very high redshift, complementing both LISA and ground-based detectors

Detection of BBHs at LGWA

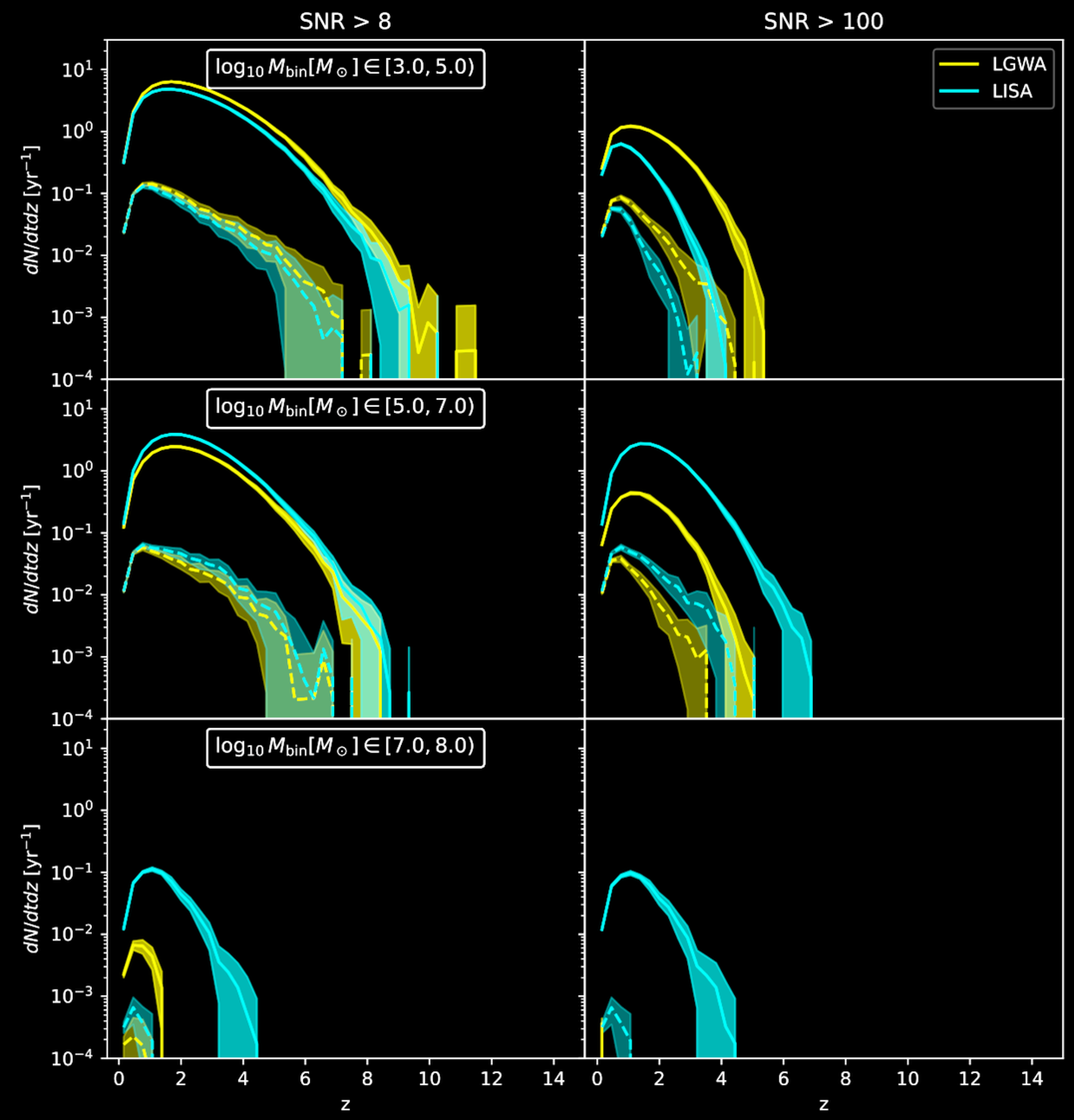
2512.06094



A detection rate of BBHs in the ground-based mass window compatible with LIGO in O4

2512.09978

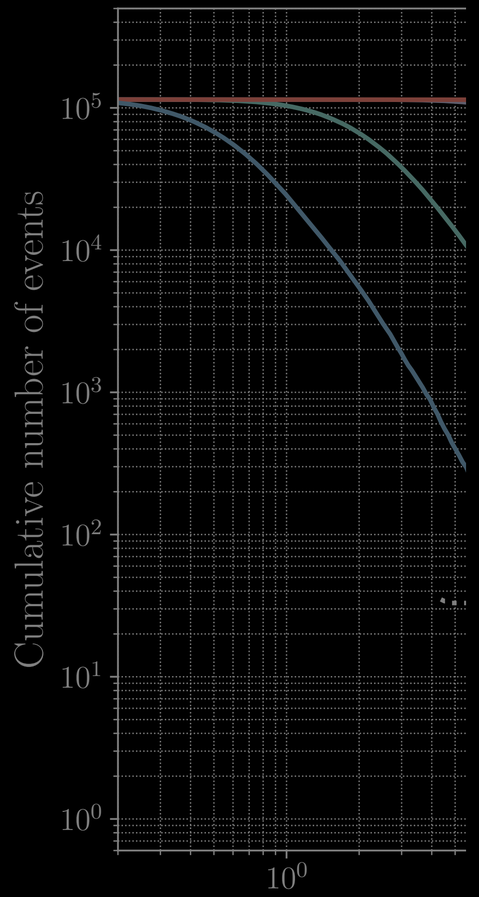
$\mathcal{O}(100)$ to a few detections of massive binary BHs in the mission lifetime



Detection of BBHs at LGWA

2512.06094

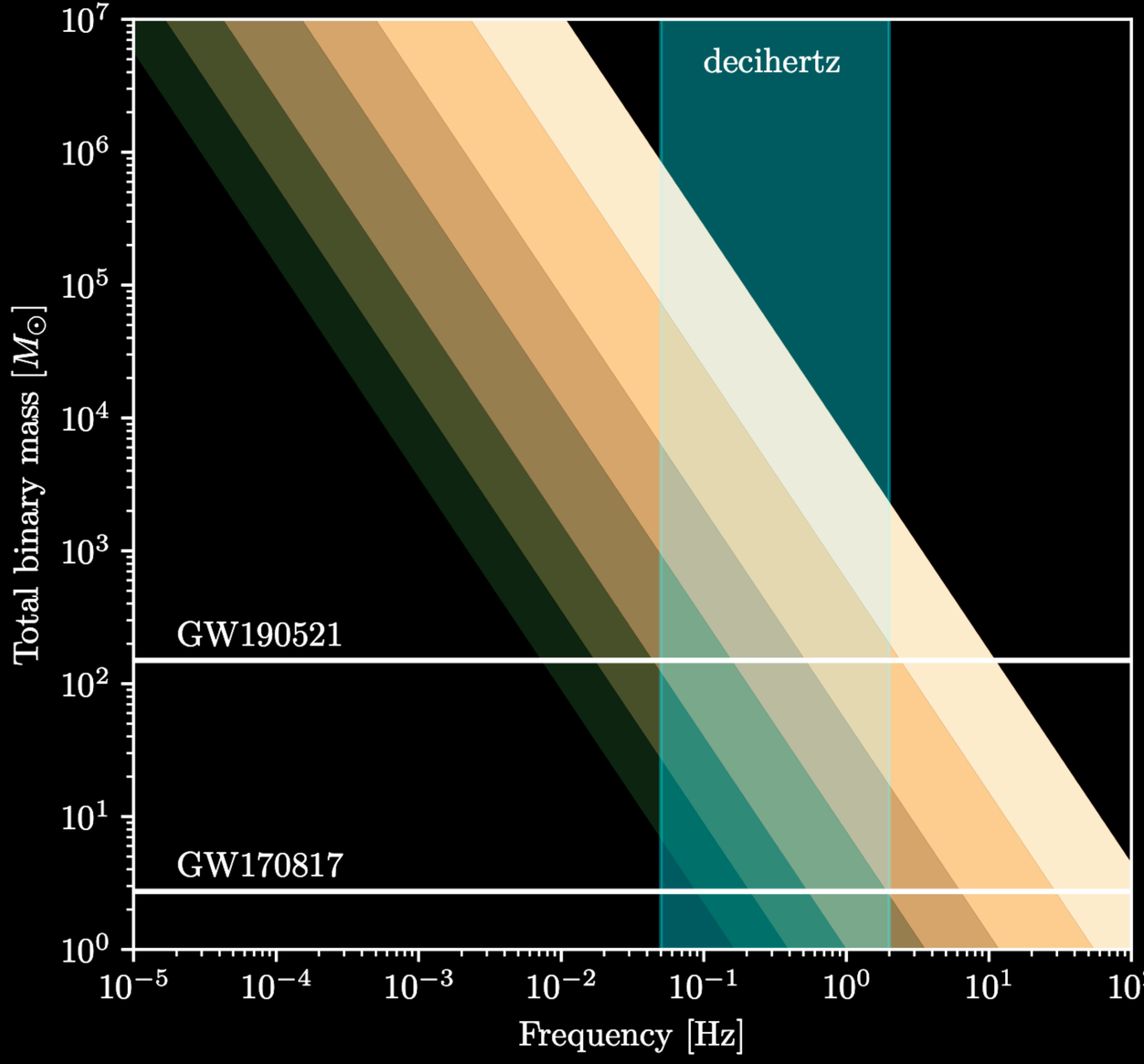
BBH

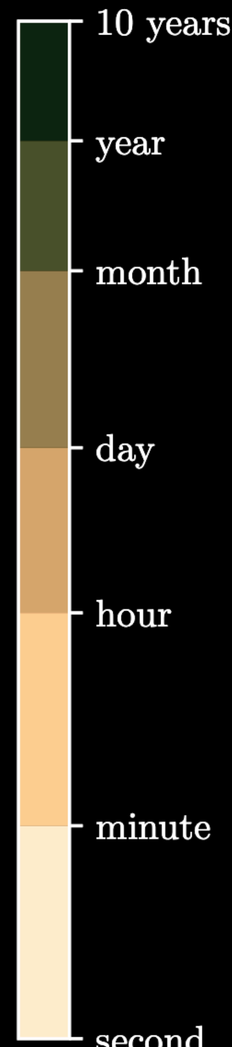


A detection ra
based mass win

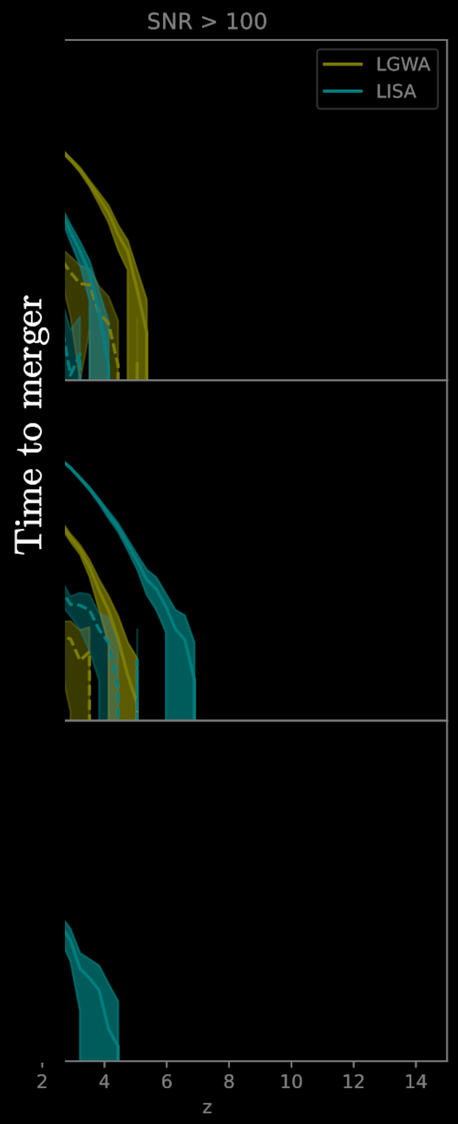
2512.09978

@(100) to a few detections of massive
ssion lifetime





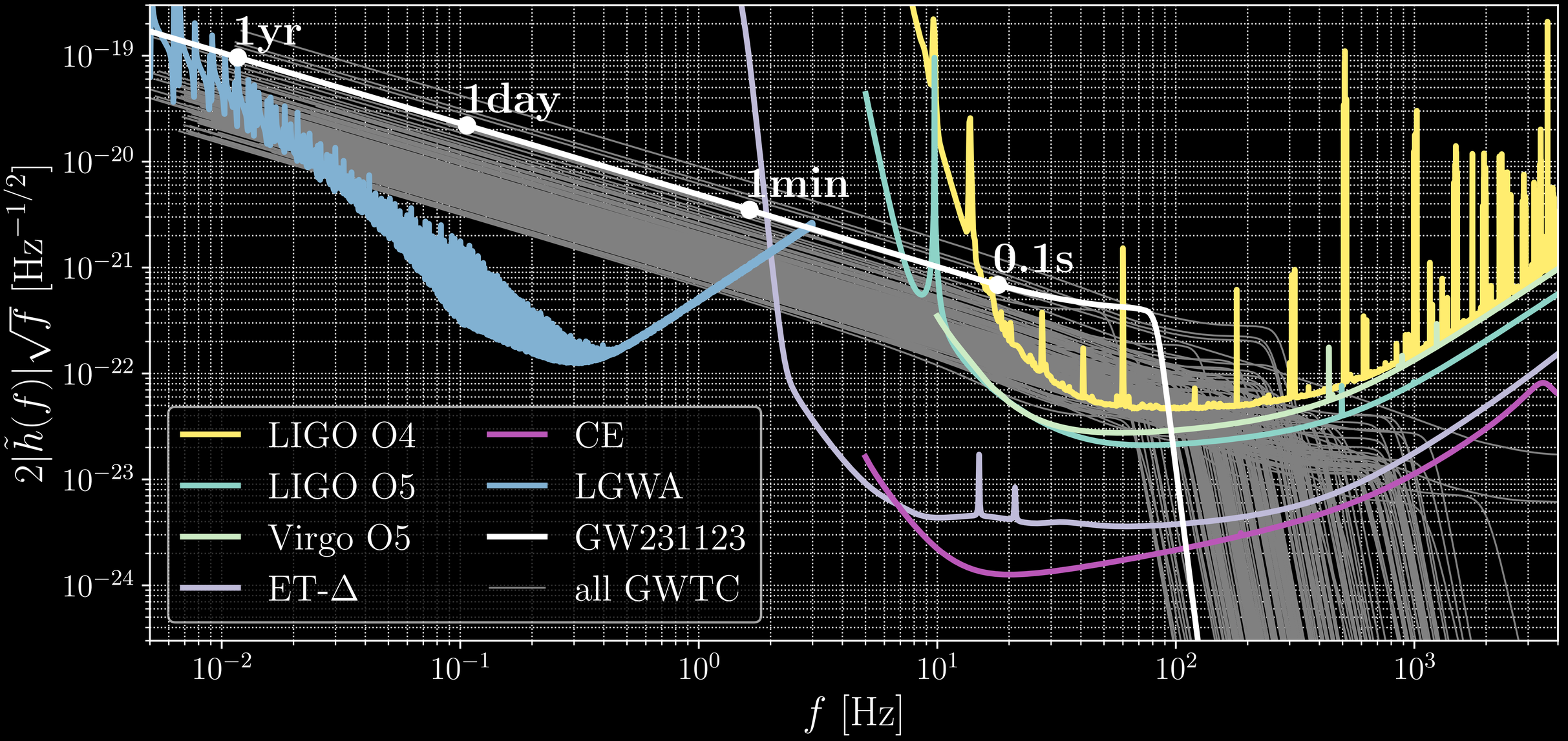
2309.15160



Detection of BBHs at LGWA

2512.09978

Short events at LVK now can be observed for a very long time with LGWA



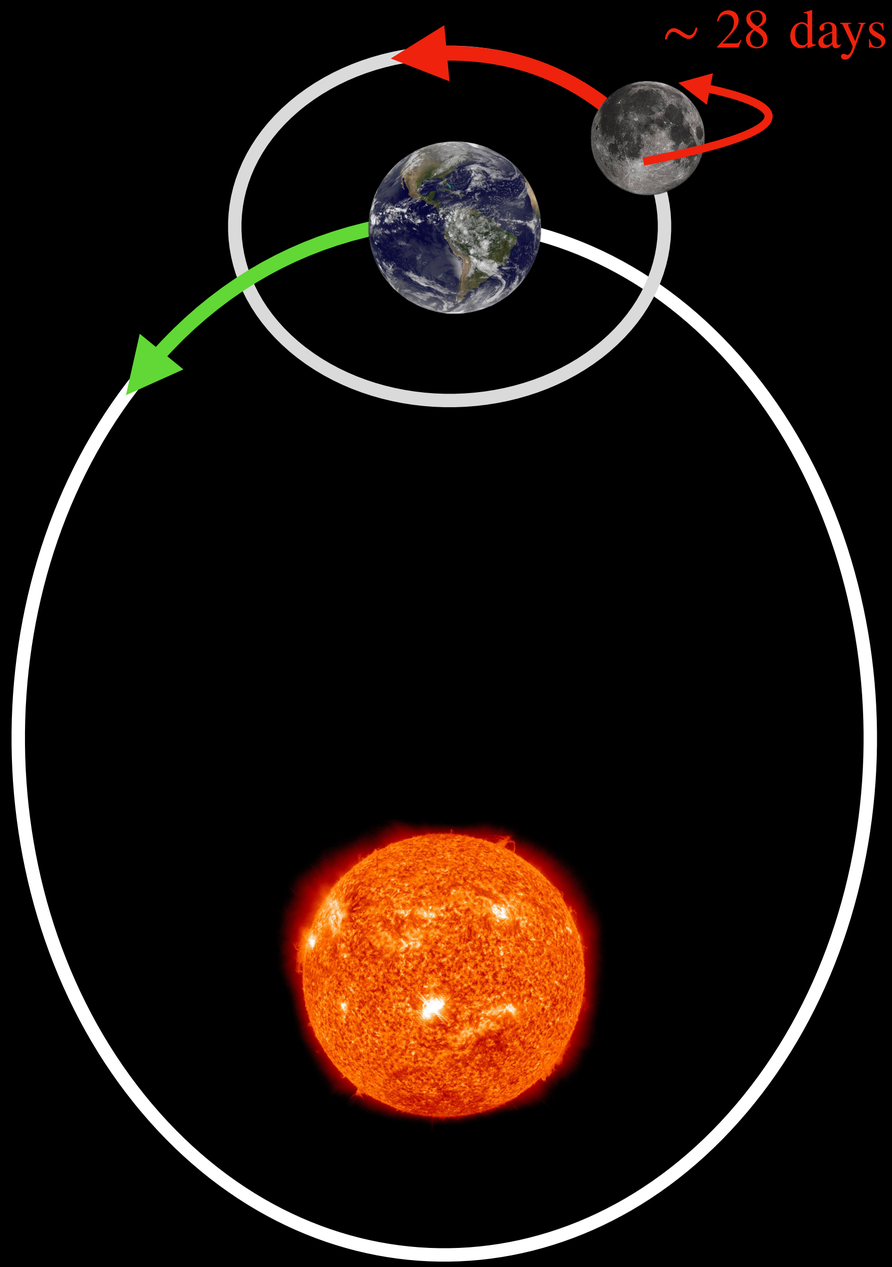
Lunar response

Modeling the response of a lunar detector for a long period of time has its subtleties and differences with respect to a ground-based interferometer:

We need to model three motions: the Earth-Moon system around the Sun, the Moon around the Earth, and the Moon on its axis.

It is tricky, but can be done, e.g., by interpolating the ephemeris.

With all those modulations, with appropriate modeling, the localization can be exquisite

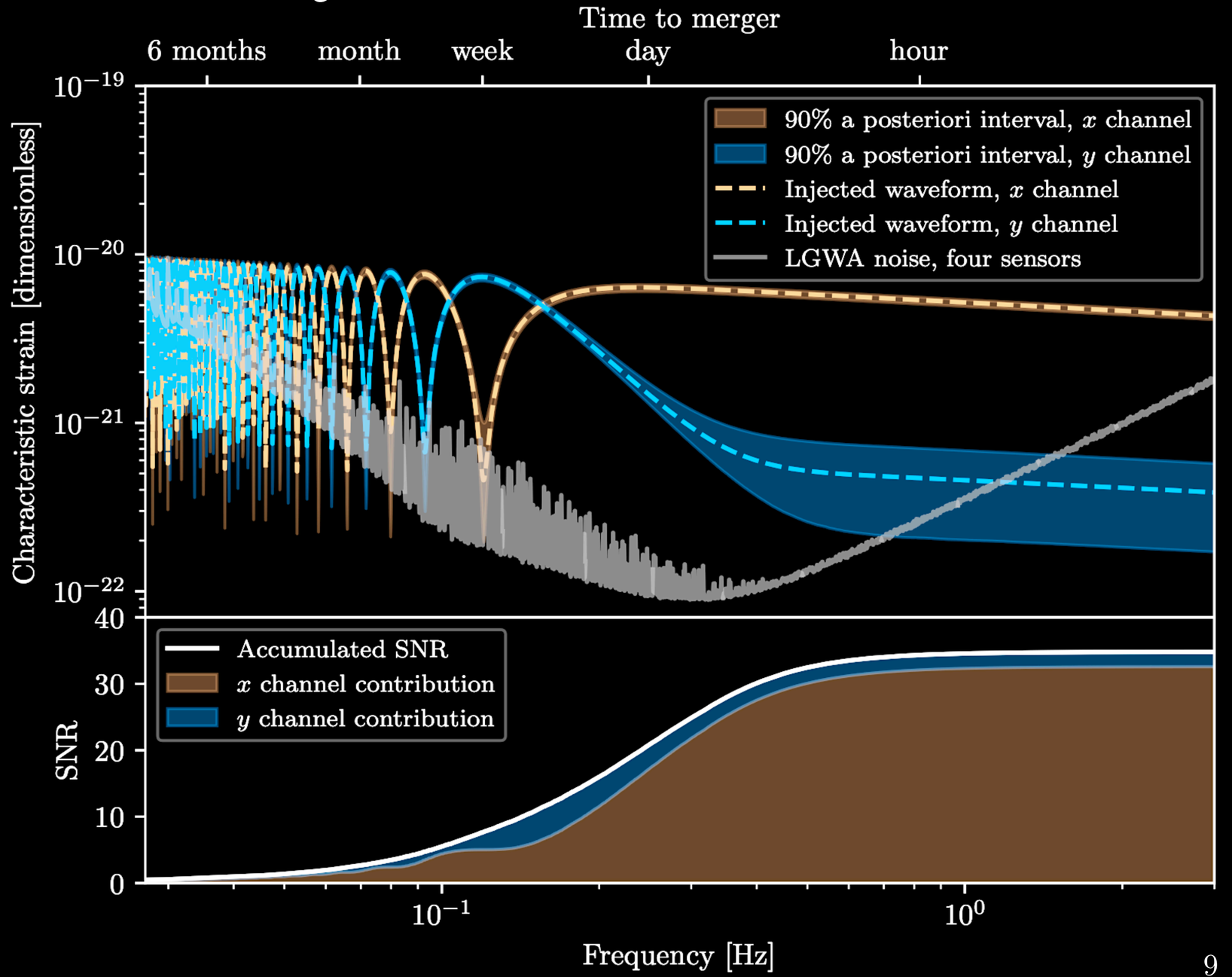


CBC signal as observed by LGWA

2606.04918

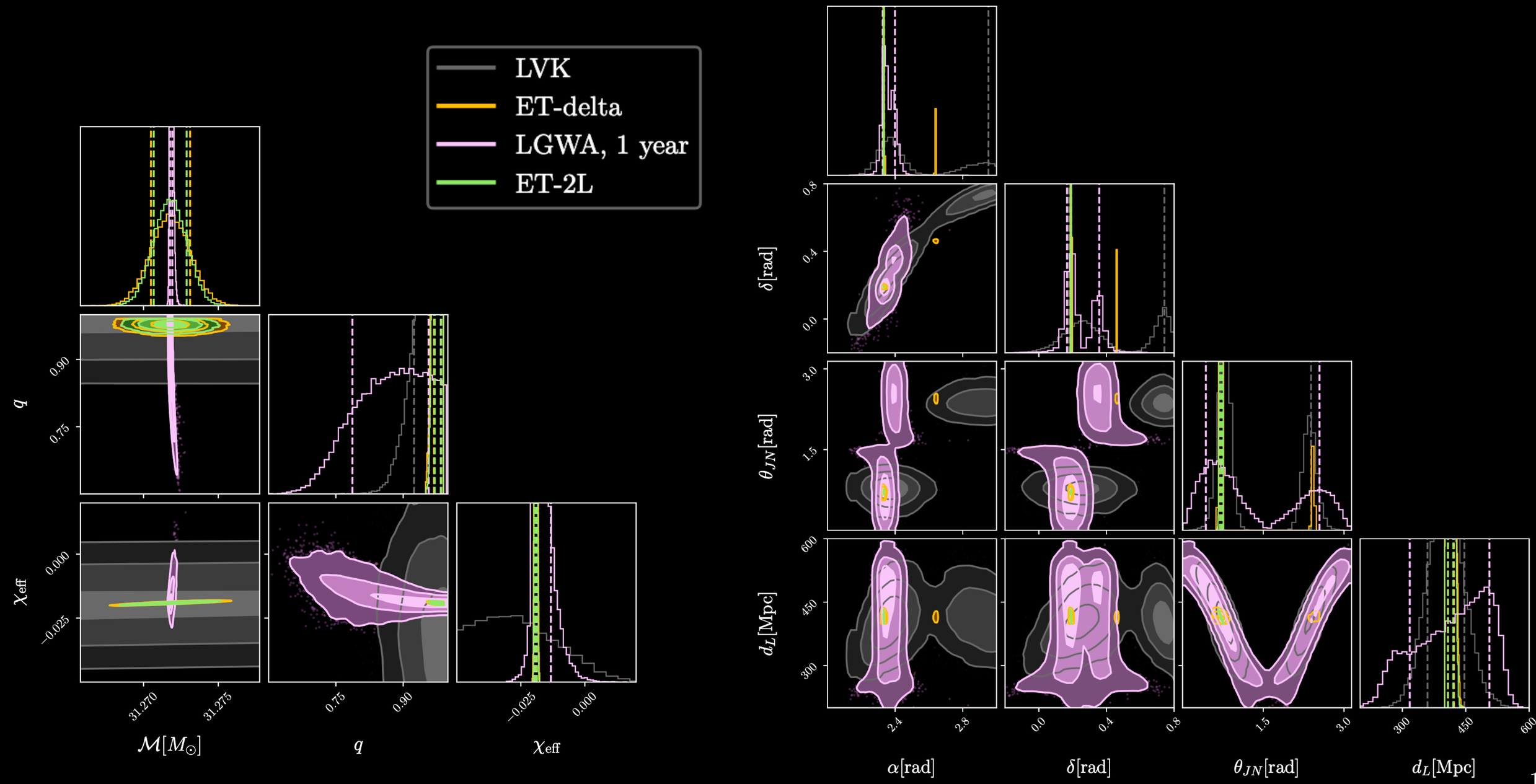
We can visualise the impact of the orbital modulations on the amplitude by looking at the projection of a signal onto the channels of the detector.

In this case, we use a signal with the characteristics of GW250114



PE of GW250114 at LGWA

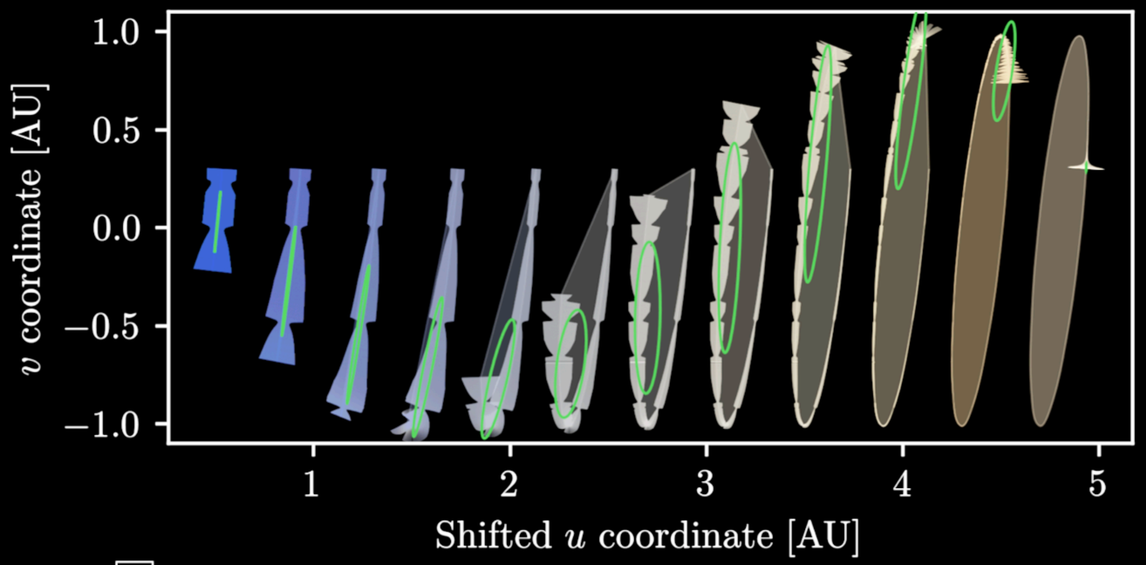
2606.04918

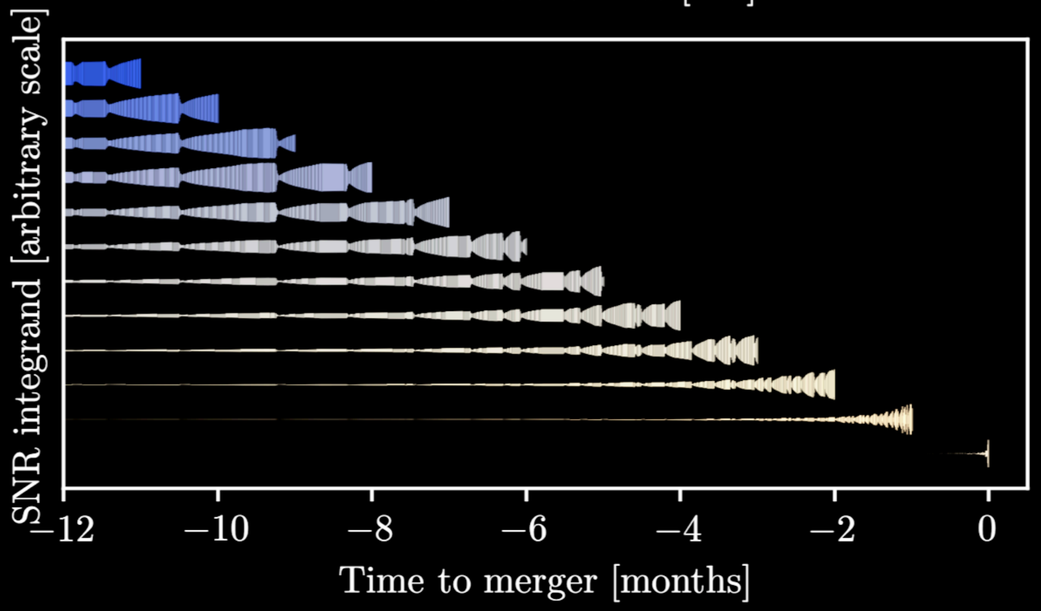


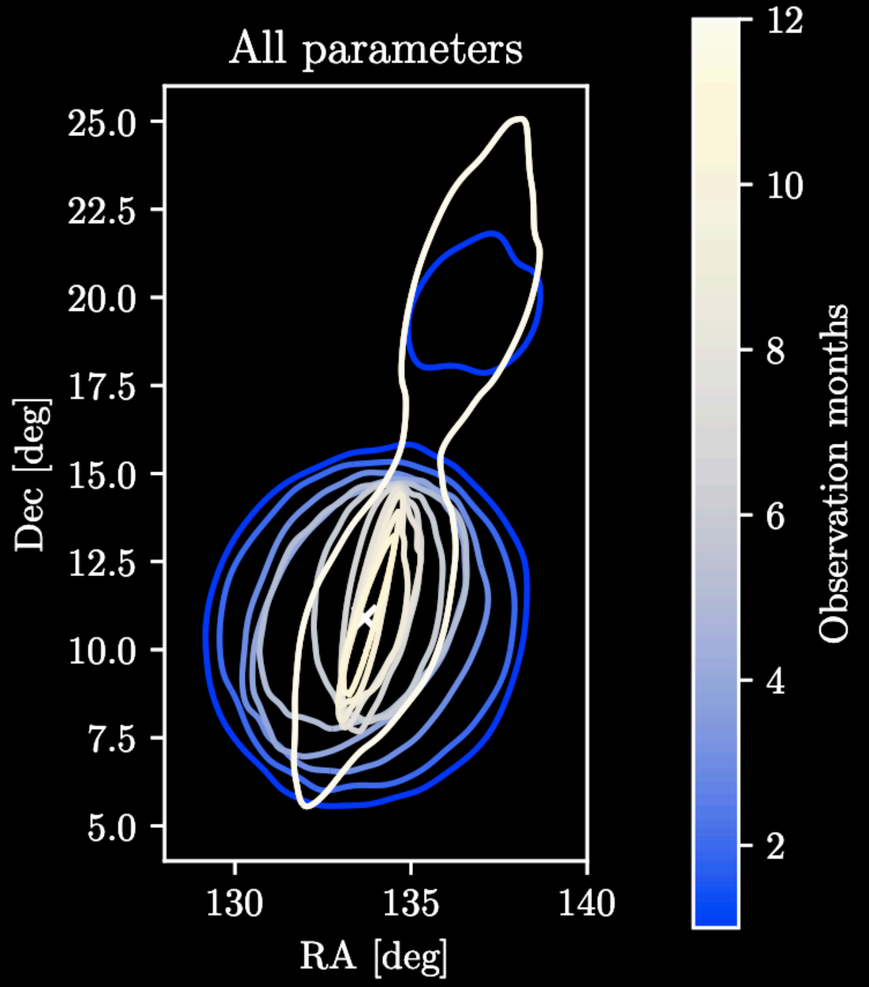
How localization depends on duration

2606.04918

Where you accumulate SNR matters in localization, it is not only a matter of duration!

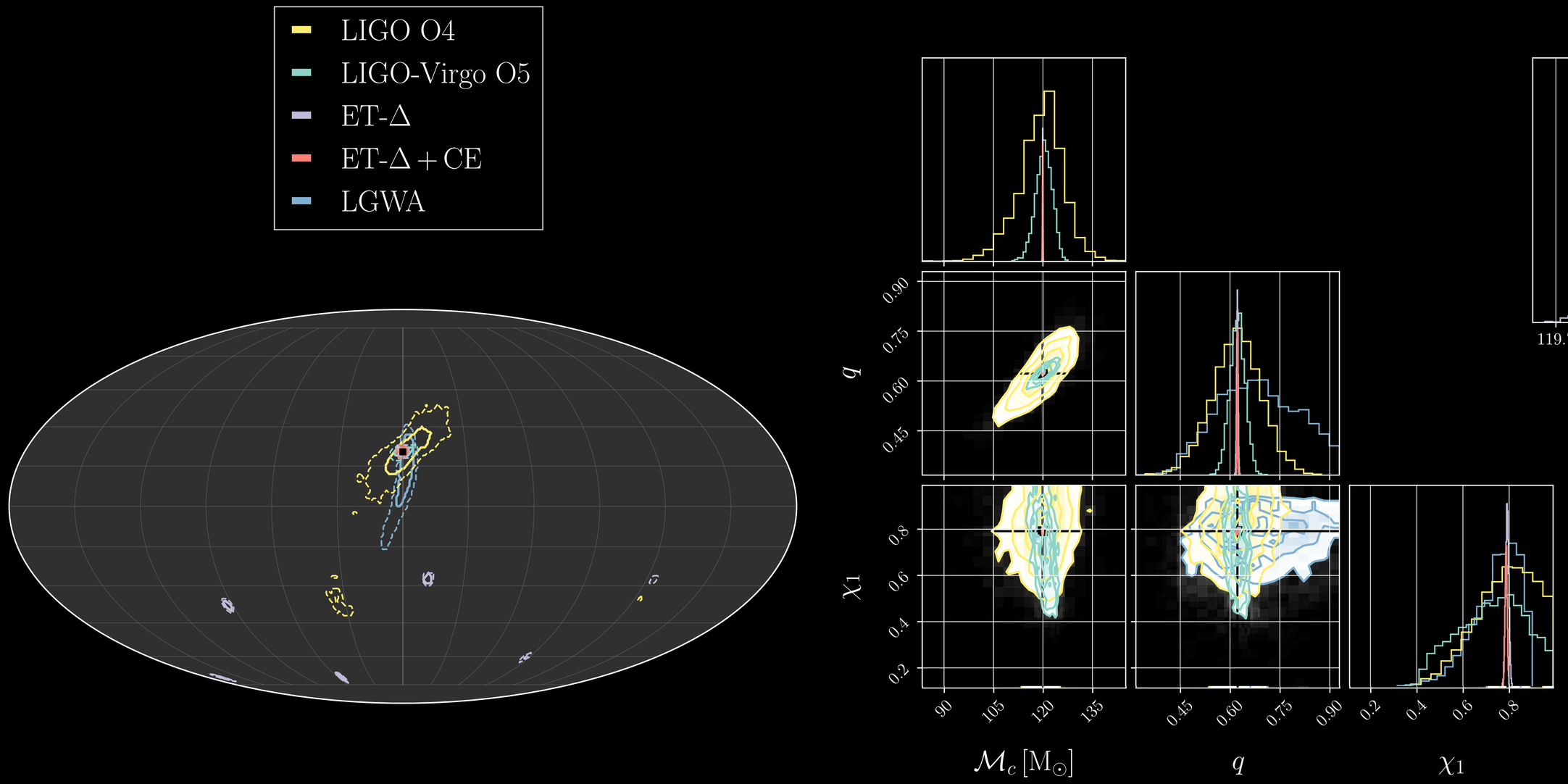






PE of GW231123 at LGWA

2512.09978



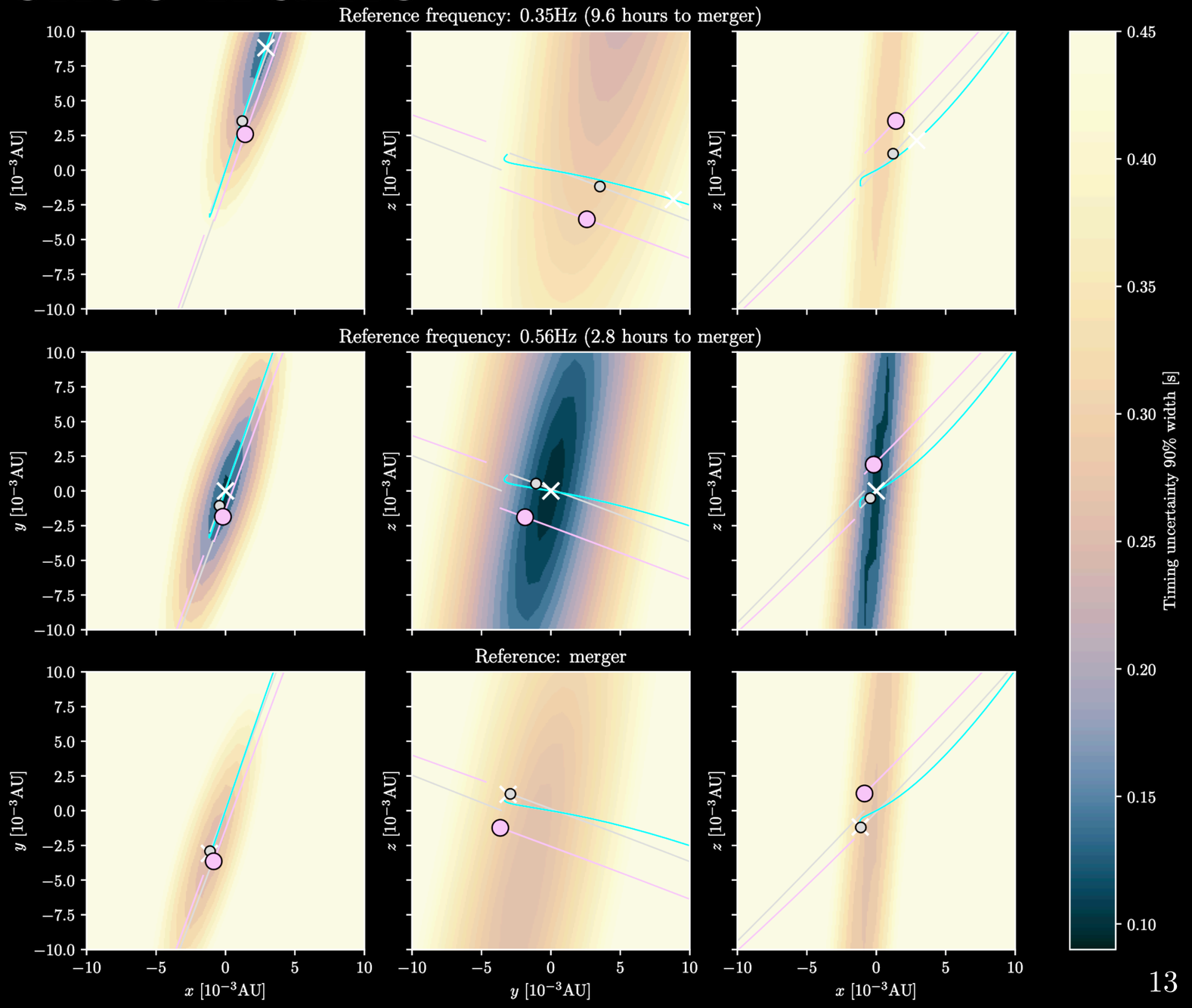
$\mathrm{SNR}_{\mathrm{O4}} \sim 23,\ \mathrm{SNR}_{\mathrm{O5}} \sim 76,\ \mathrm{SNR}_{\mathrm{ET}} \sim 580,\ \mathrm{SNR}_{\mathrm{ET+CE}} \sim 1250,\ \mathrm{SNR}_{\mathrm{LGWA}} \sim 12$

Impact of the reference frame

2606.04918

A crucial aspect when dealing with such long signals and many modulations is the choice of the reference frame.

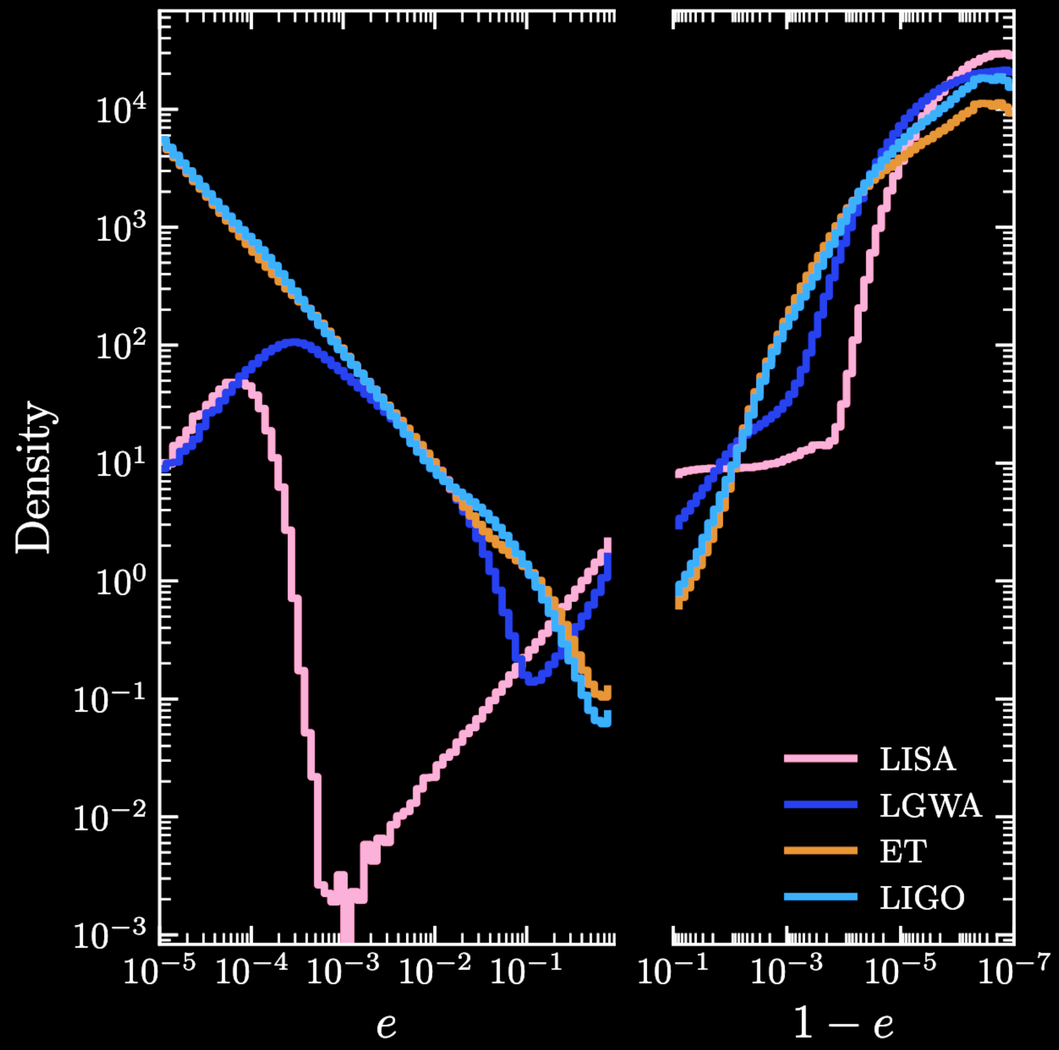
By choosing a frame coming with the SSB but entered elsewhere, we can reduce the timing uncertainty and its correlation with intrinsic parameters

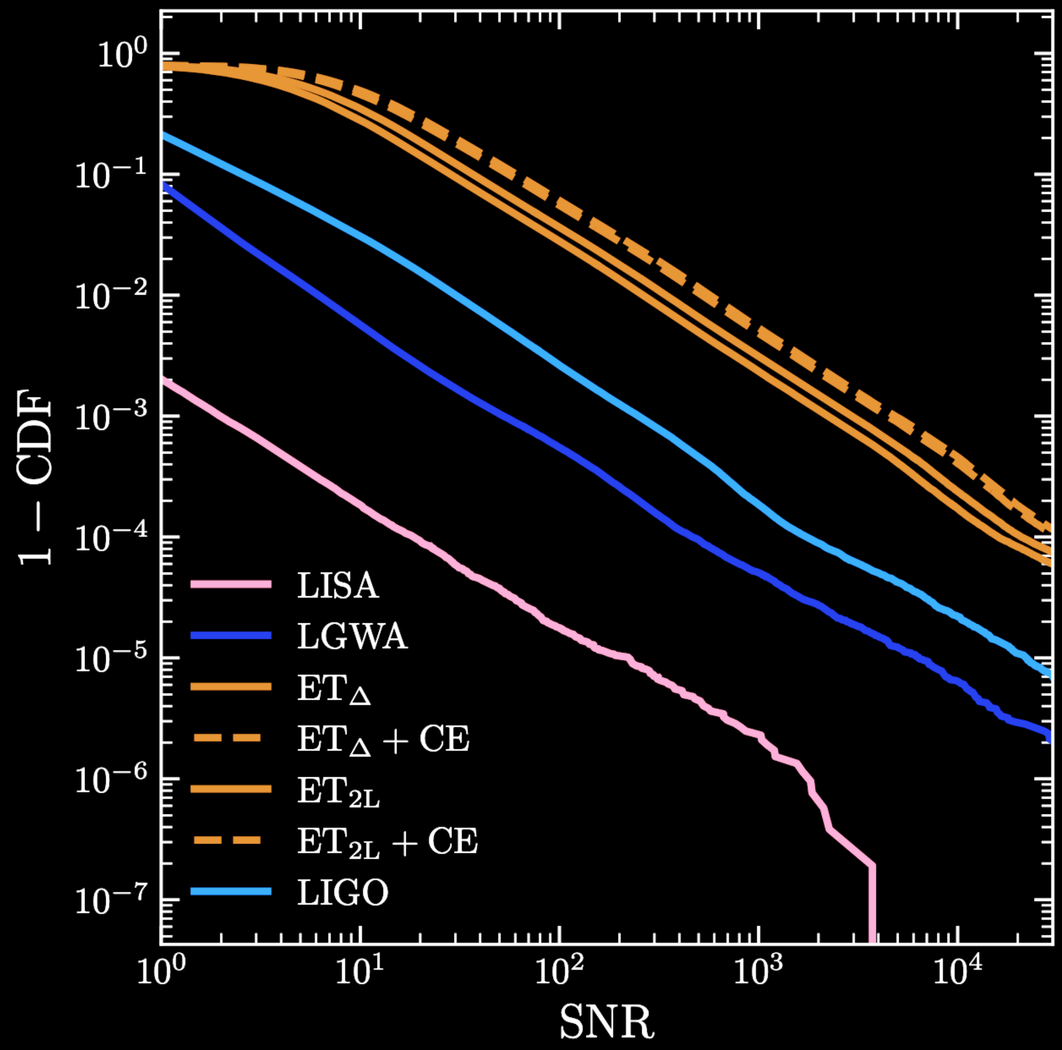


Eccentricity constraints at LGWA

2609.26878

LGWA's sensitivity in the deci-Hz could be a game-changer to identify eccentricity and distinguish dynamical binary formation channels

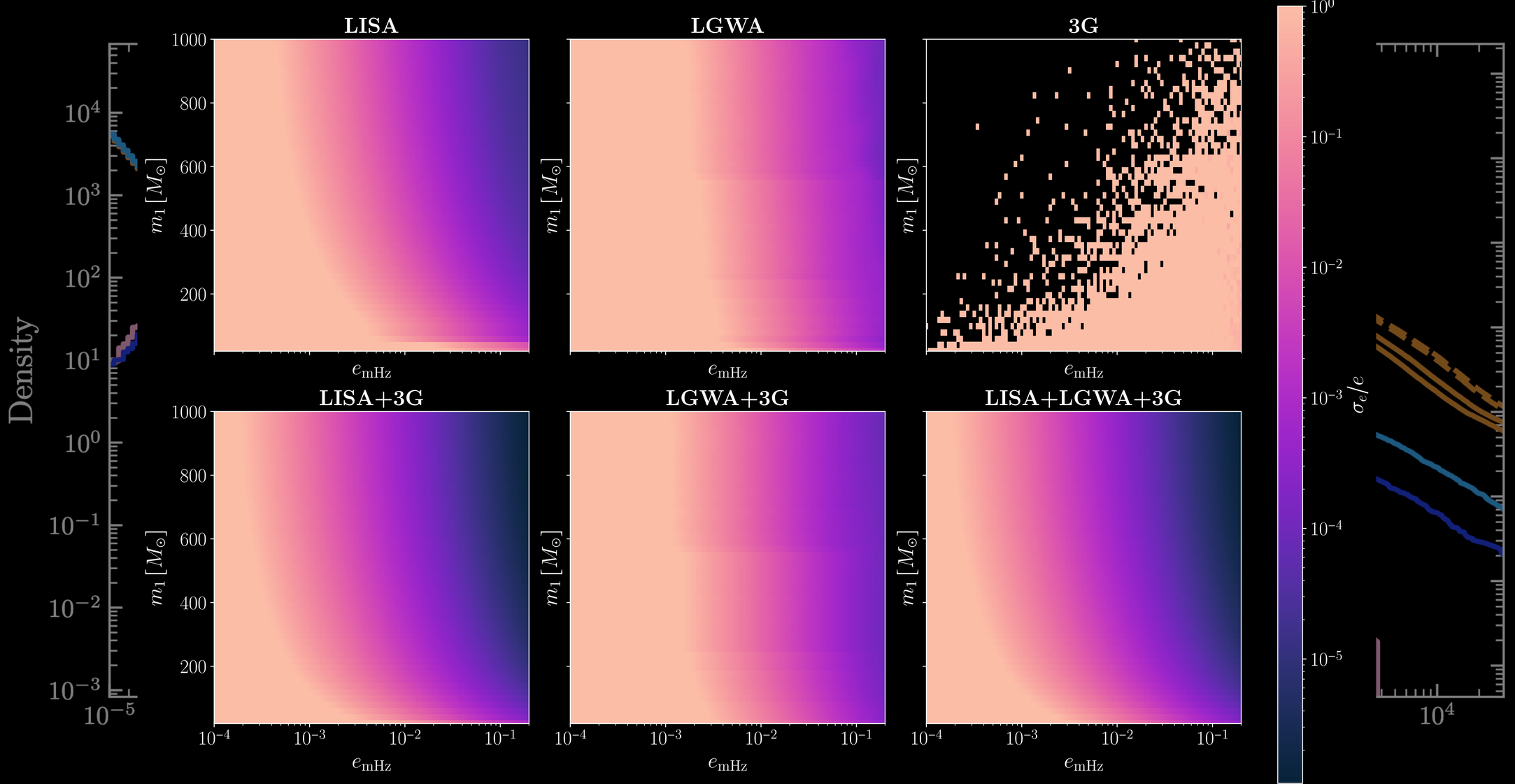




Eccentricity constraints at LGWA

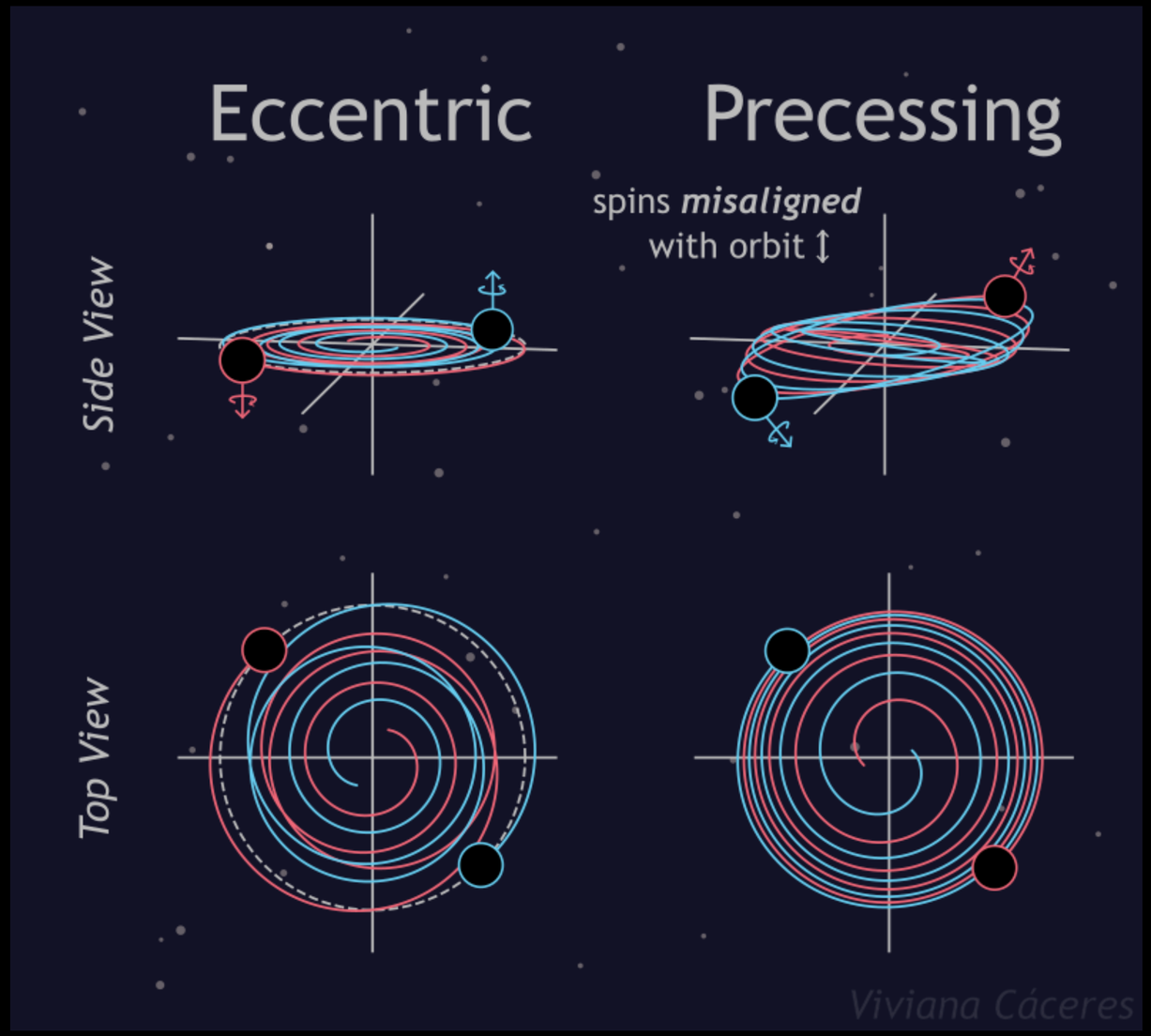
2609.26878

LGWA's sensitivity in the deci-Hz could be a game-changer to identify eccentricity and distinguish dynamical binary formation channels

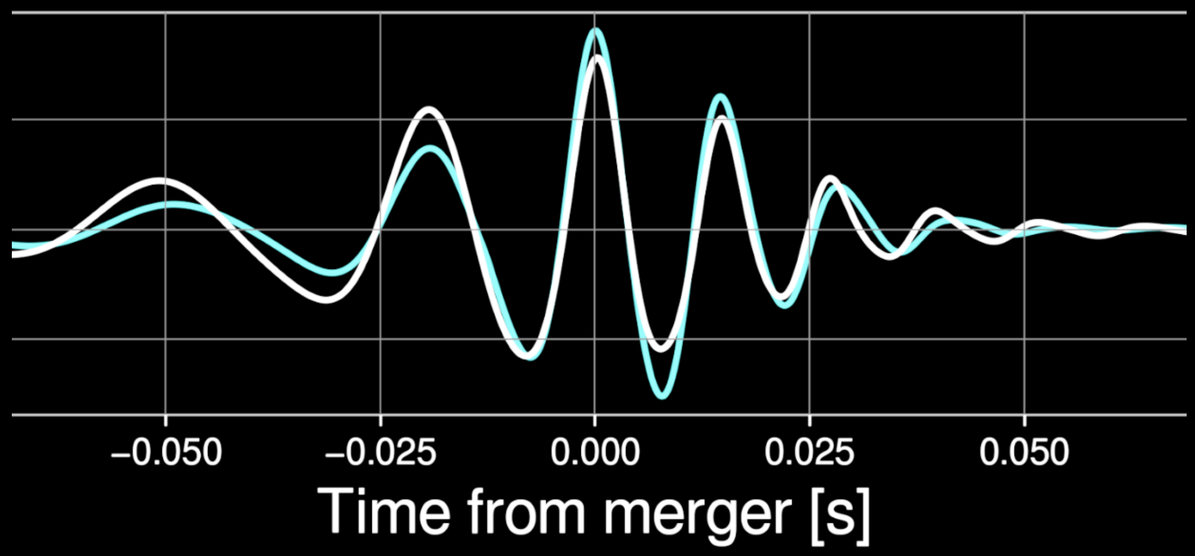


Eccentricity constraints at LGWA

2601.02260

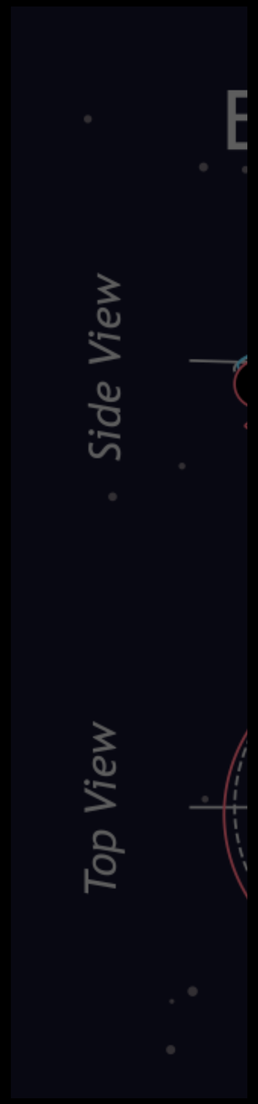


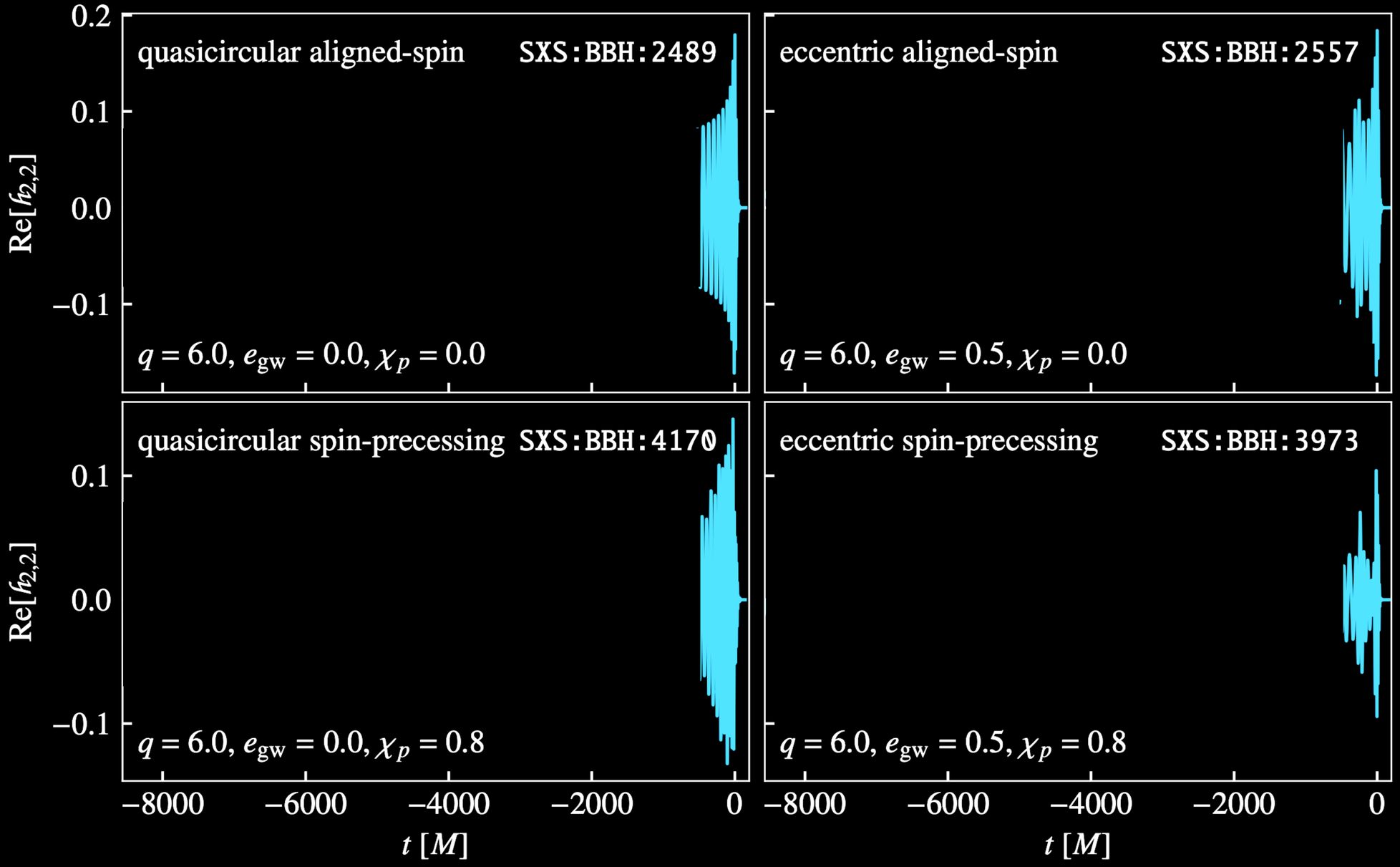
Eccentricity and precession are difficult to tell apart with few cycles



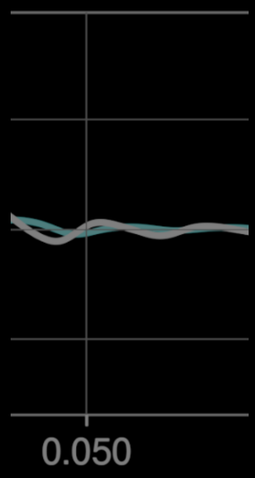
Eccentricity constraints at LGWA

2507.08345



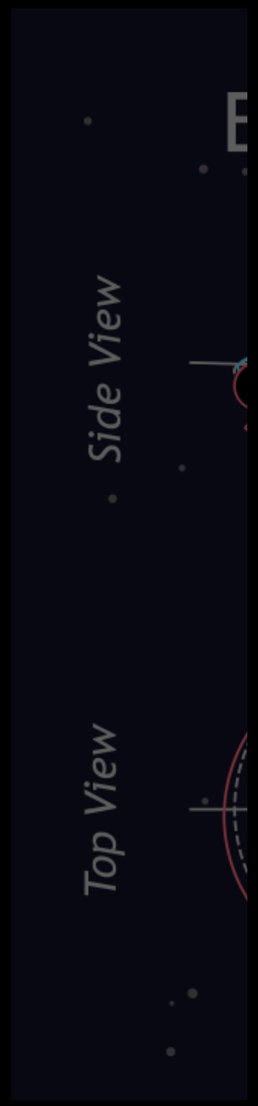


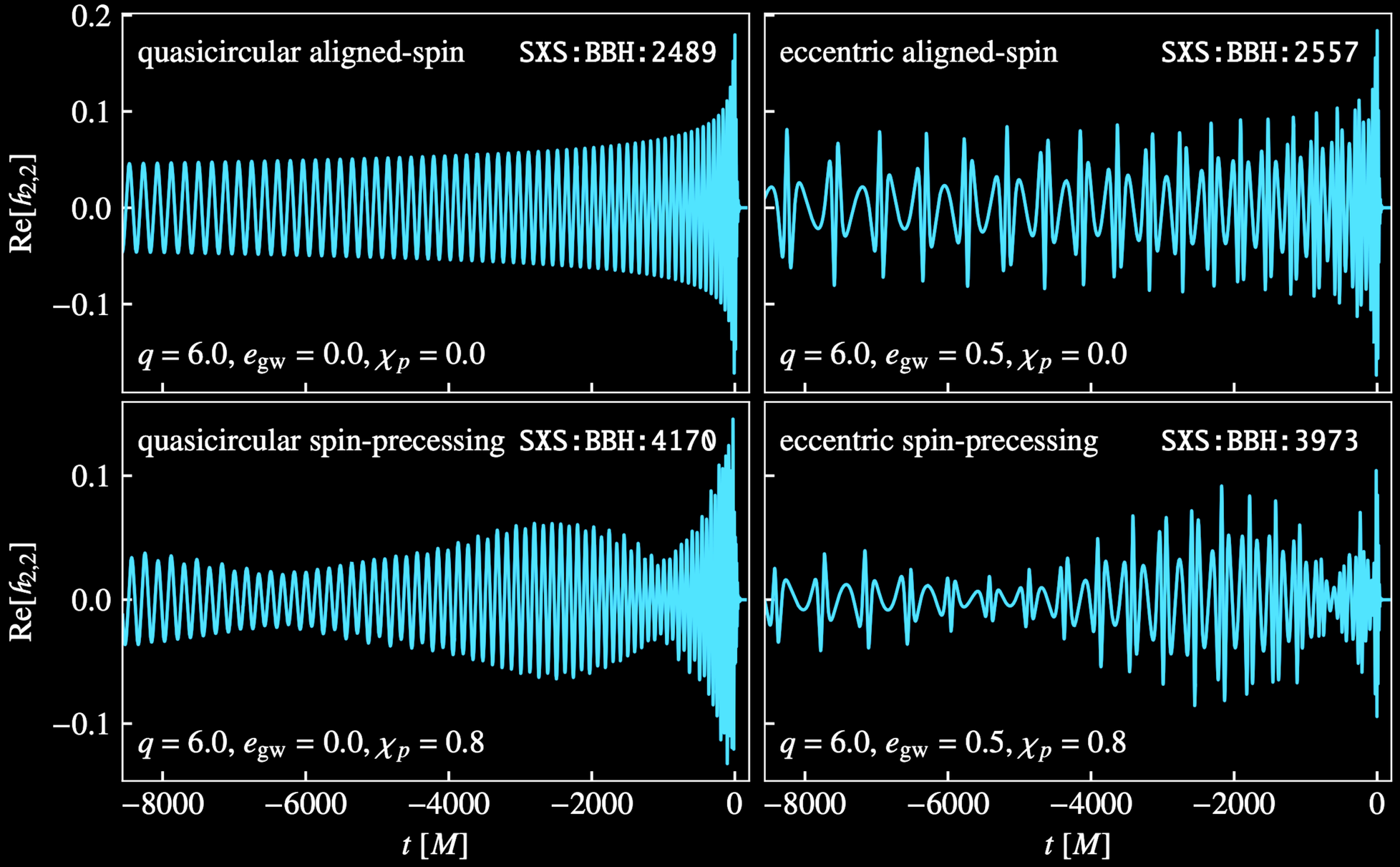
difficult
es



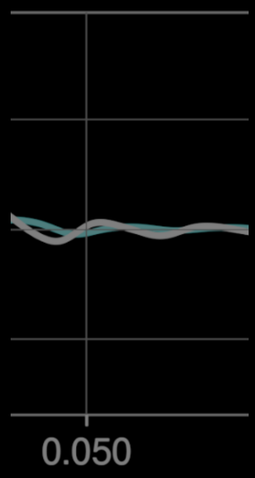
Eccentricity constraints at LGWA

2507.08345





difficult
es



Summary

- The deci-Hz band bridging the gap between ground-based experiments and space-based ones has an extremely rich science case



- LGWA could detect several CBC signals per year coming from different channels, offering promising multi-band opportunities in conjunction with other experiments

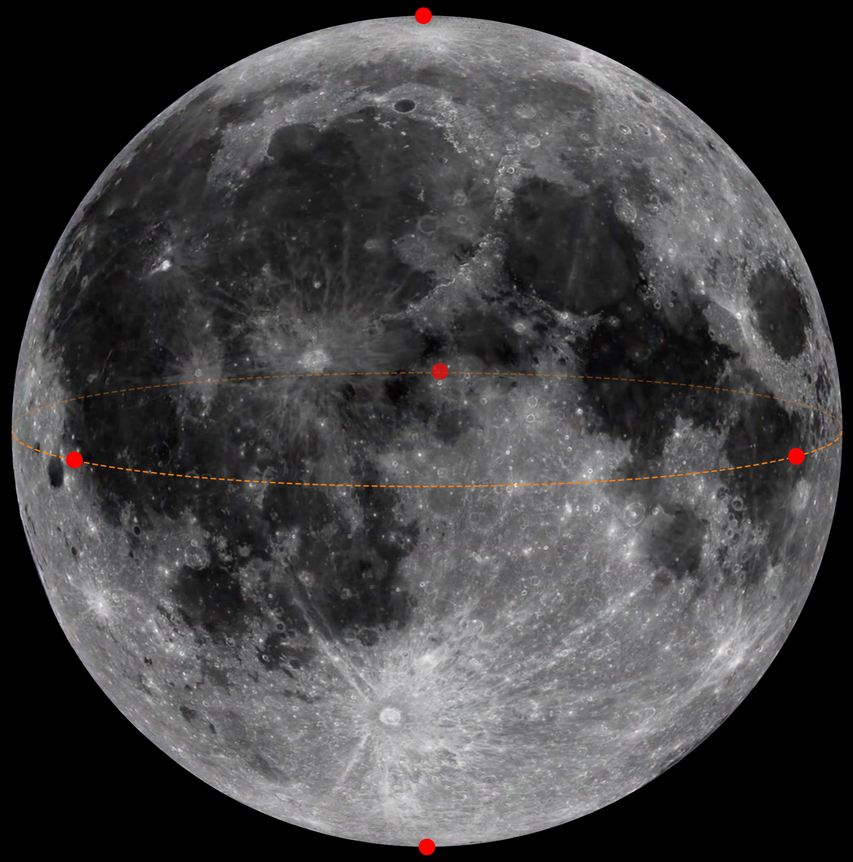
- LGWA offers interesting opportunities and complementarity to other experiments for CBS parameter estimation, both for intrinsic and extrinsic parameter reconstruction

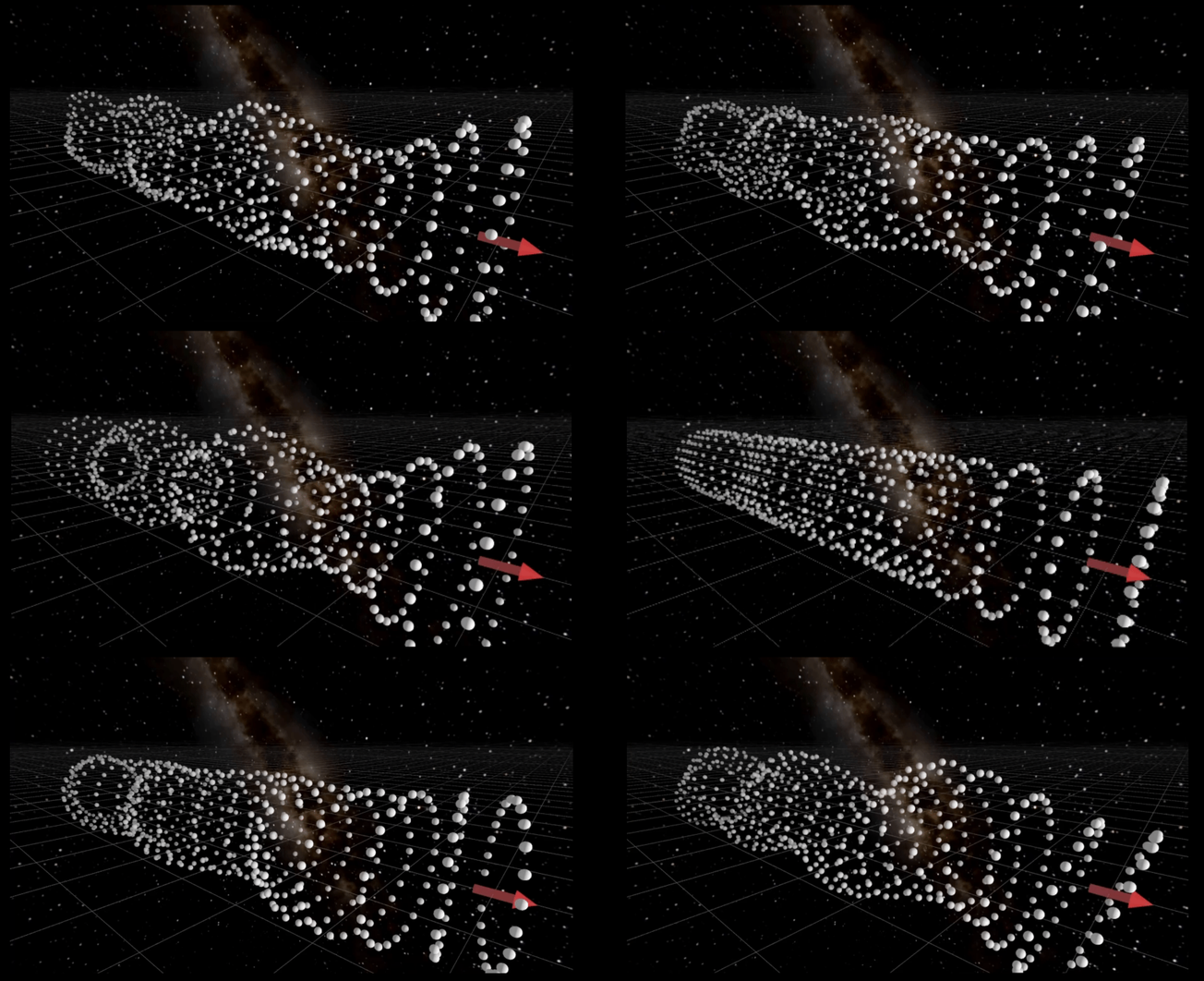


You can also contact me at
fiacovelli@jhu.edu

GW polarizations with LGWA

With a global deployment LGWA can provide measurements of different GW polarizations, hence testing GR

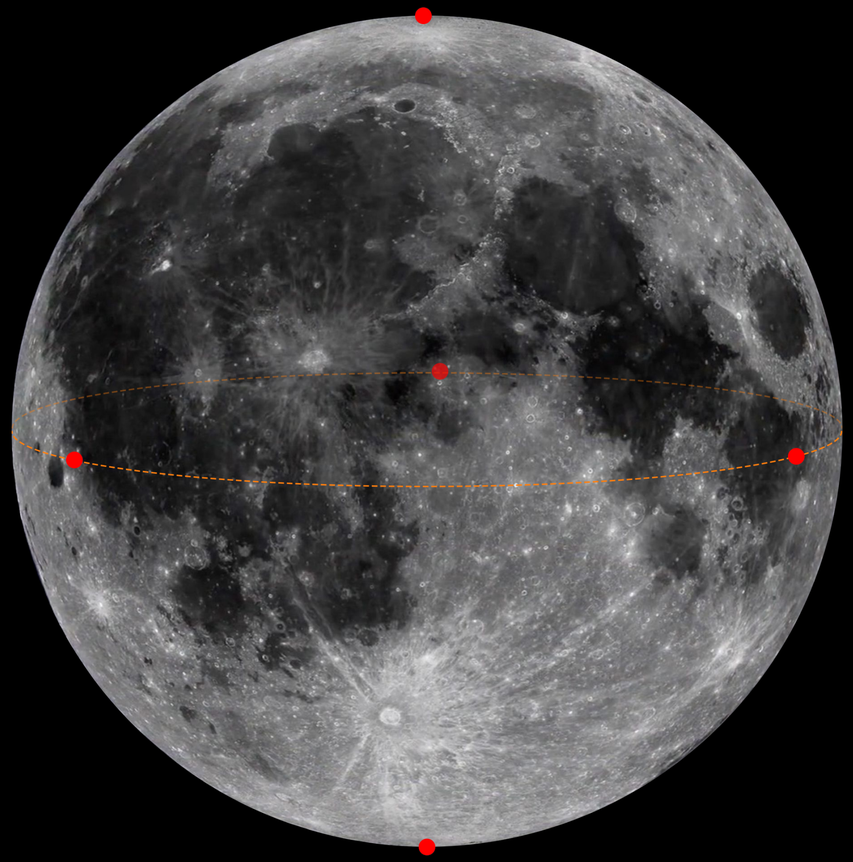


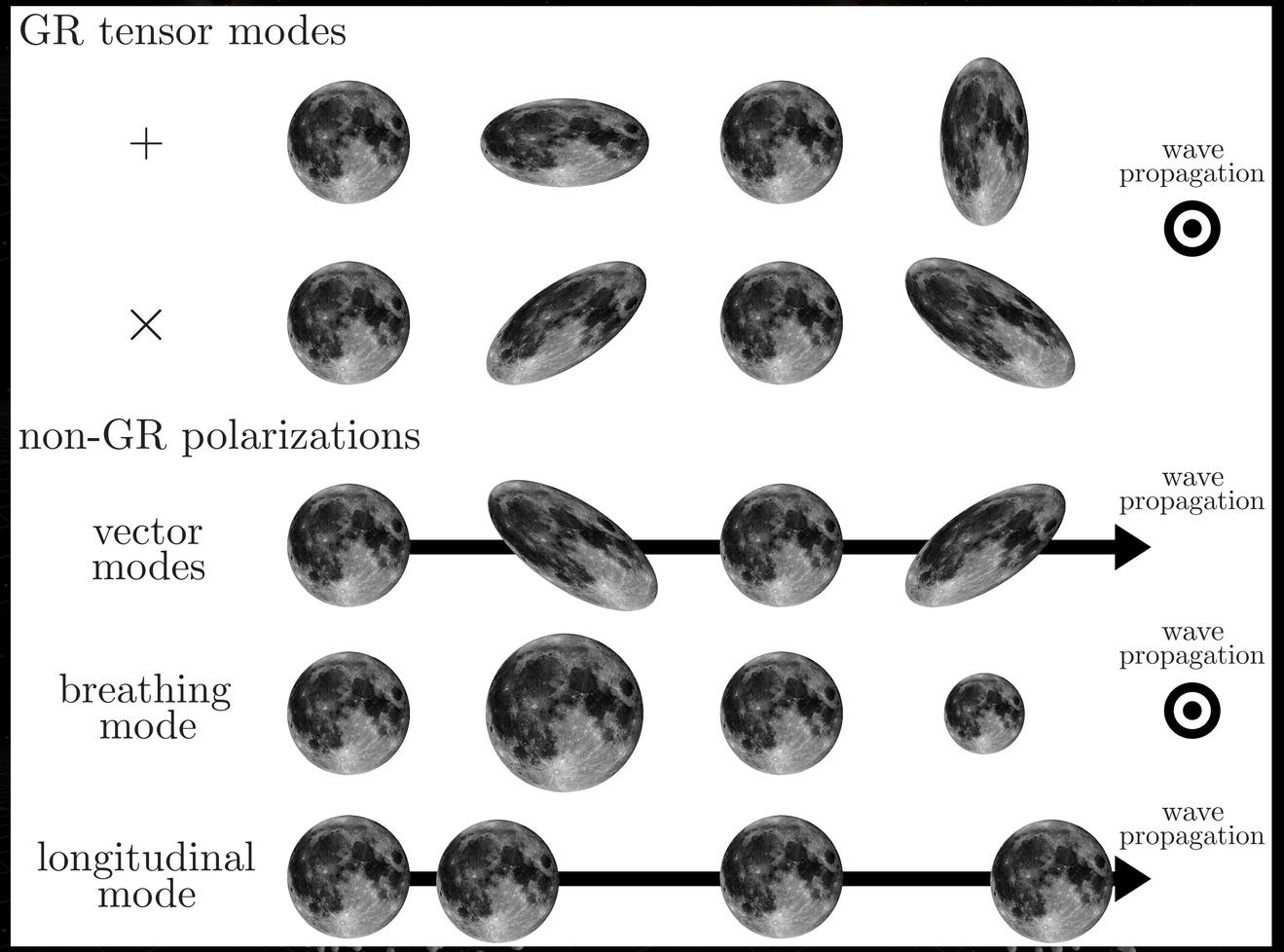


Schumacher, K+ (2025)

GW polarizations with LGWA

With a global deployment LGWA can provide measurements of different GW polarizations, hence testing GR





Schumacher, K+ (2025)