Results of searches for gravitational waves in O3 LIGO-Virgo data

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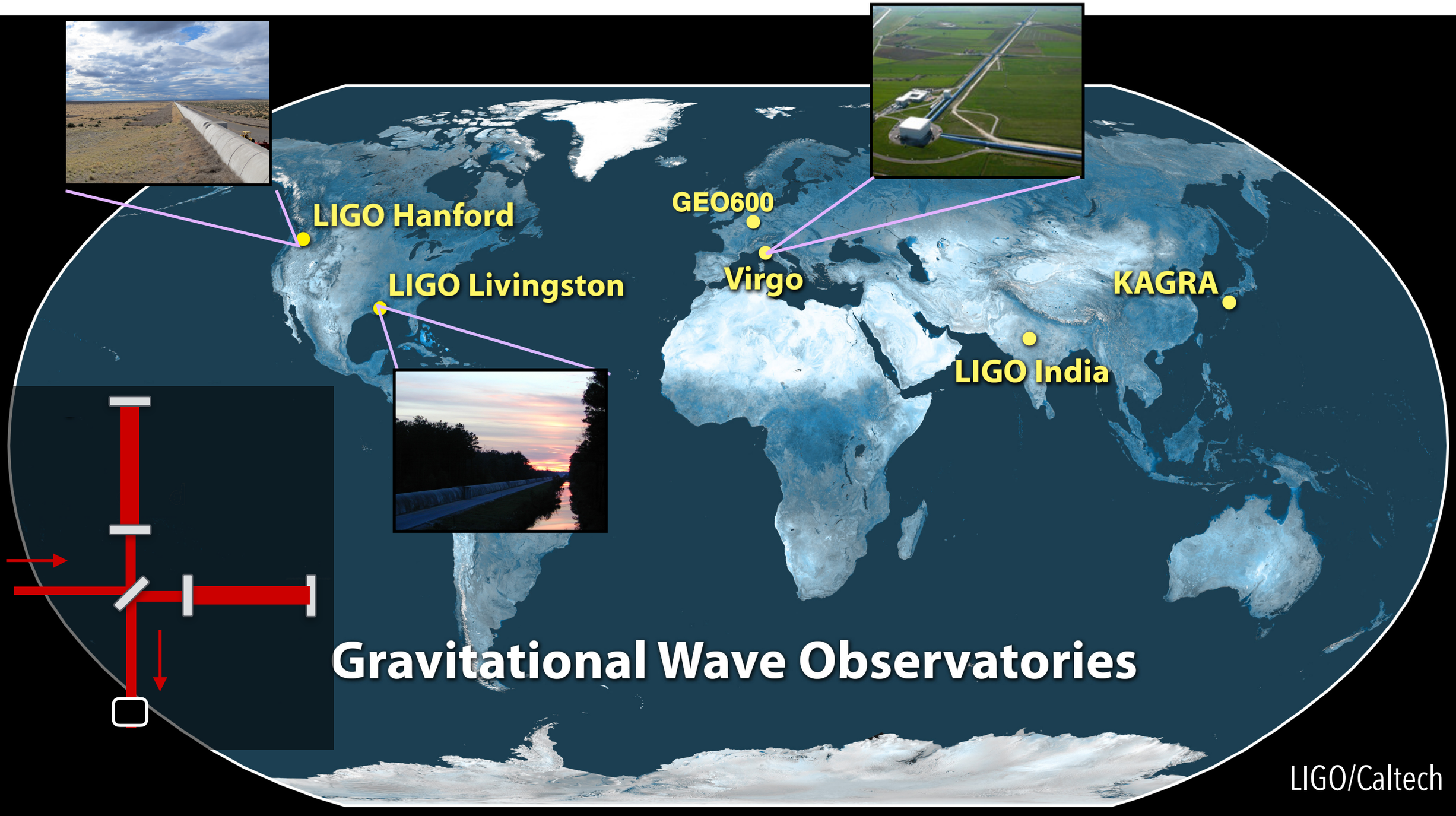
Outline

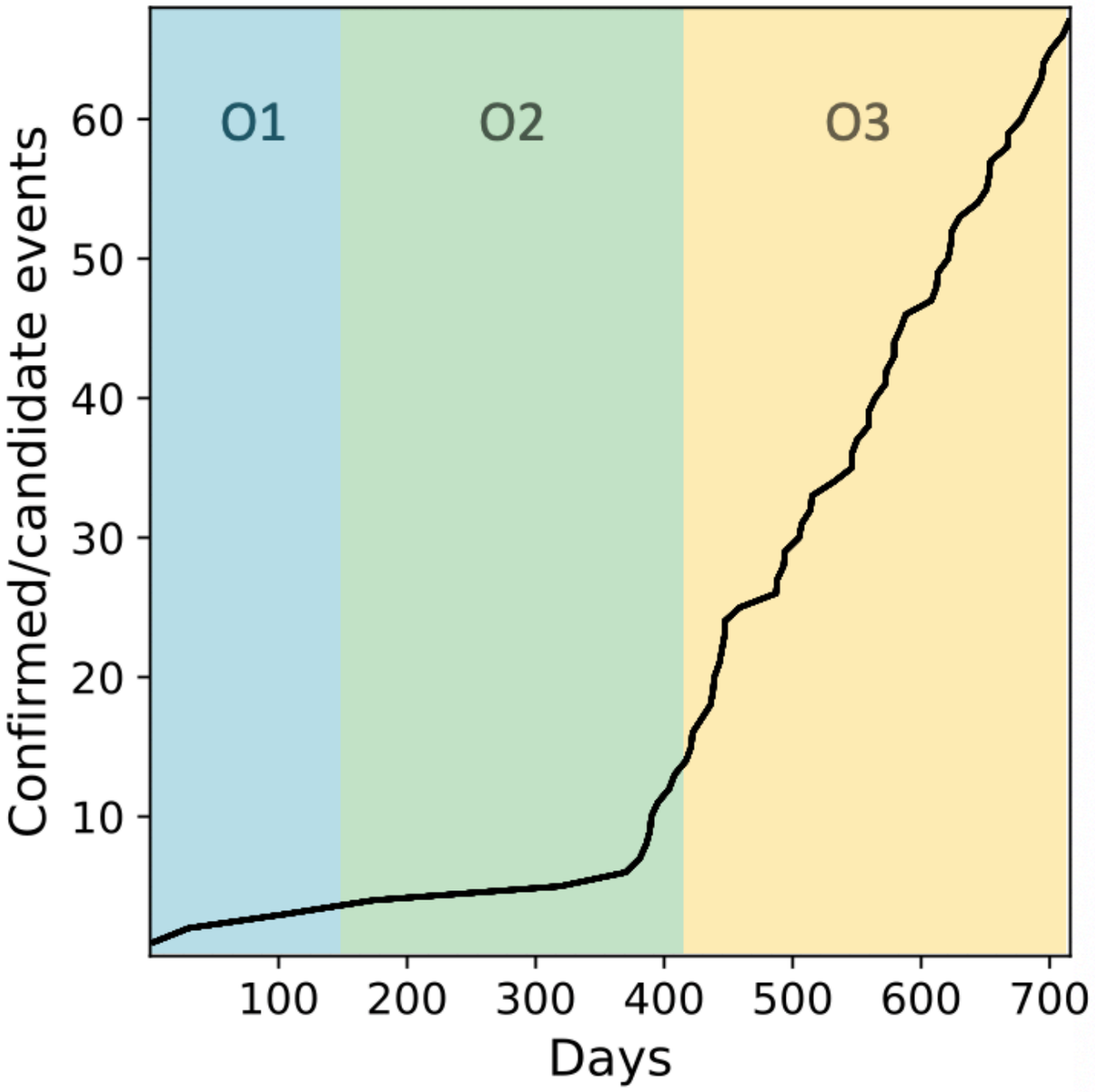
- LIGO-Virgo gravitational wave detectors
- Third observing run
- Detections and astrophysical result highlights
- New frontiers - searches for continuous gravitational waves

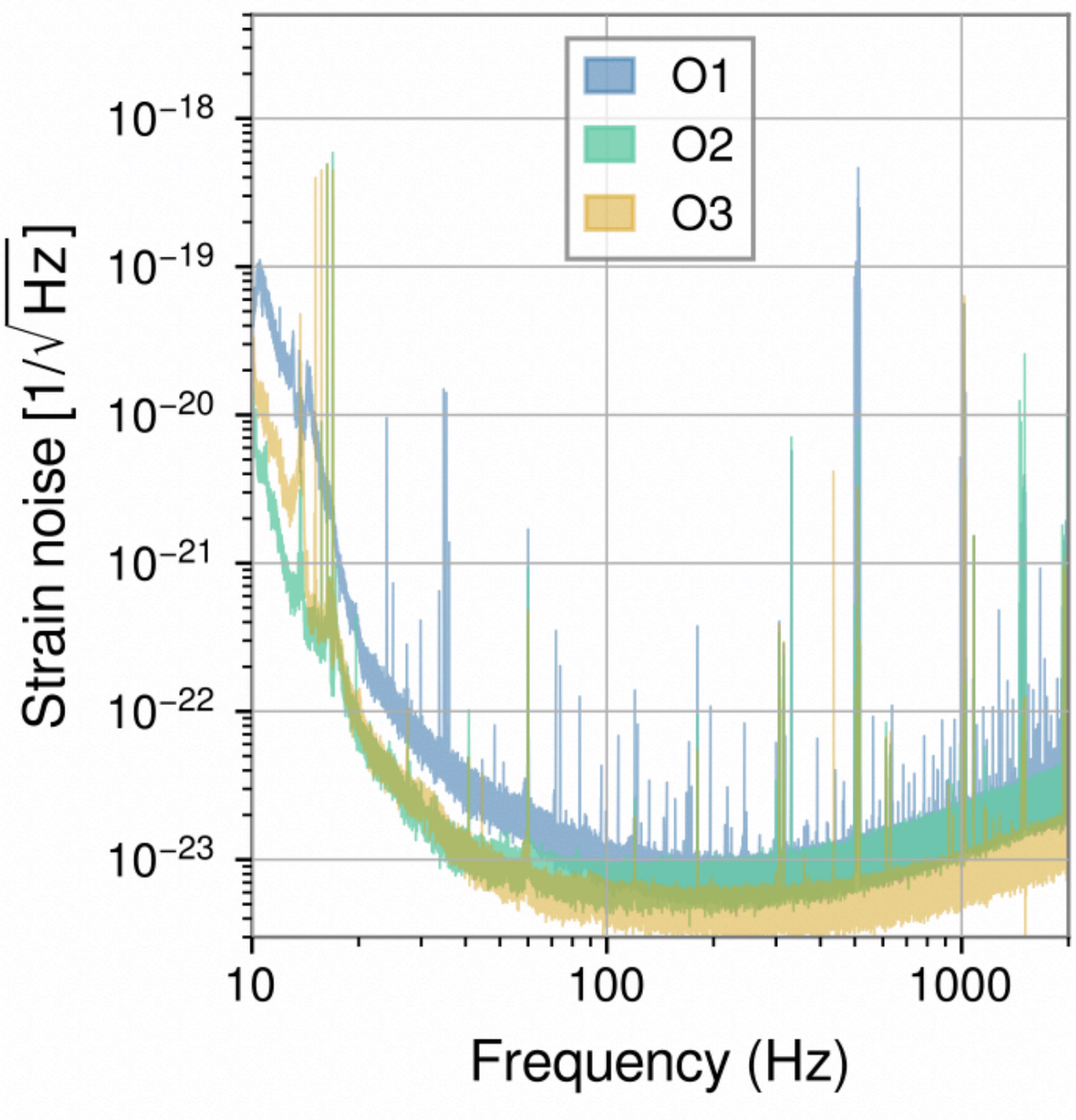
Gravitational wave detector network



LIGO-Virgo candidate events over time

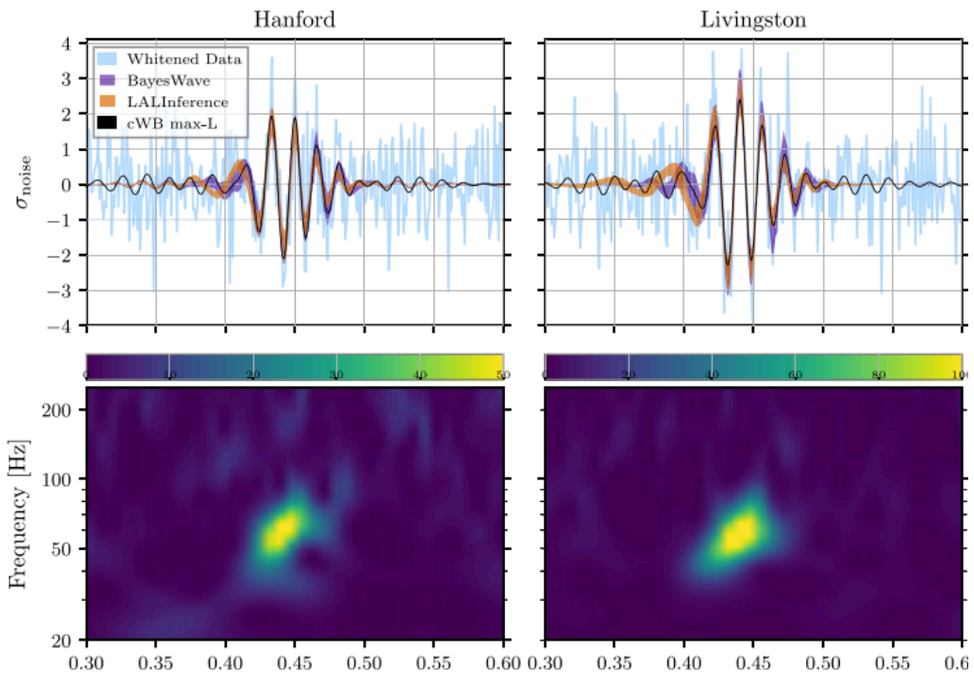
O3: 1 April 2019 — 27 March 2020

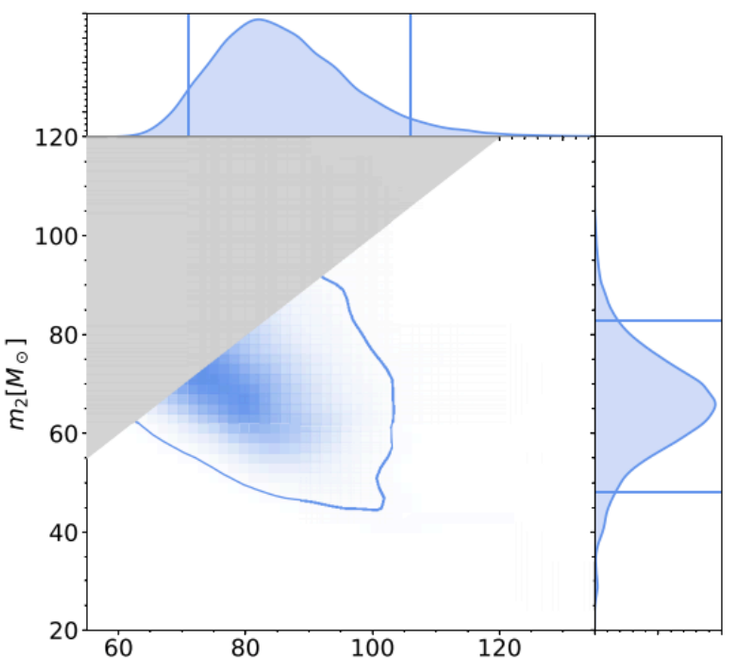




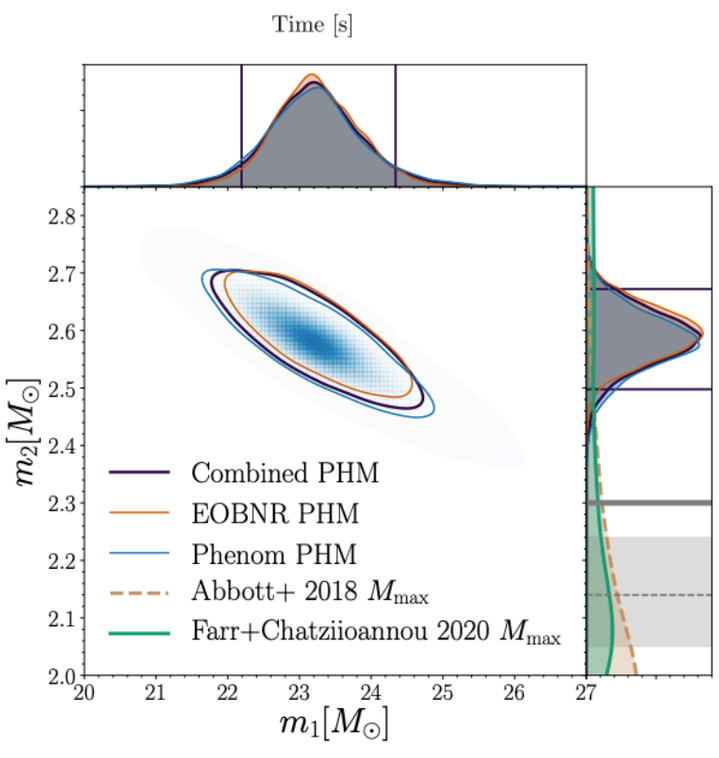
McIver & Shoemaker, in prep.

Many noteworthy transient GW signals discovered in O3

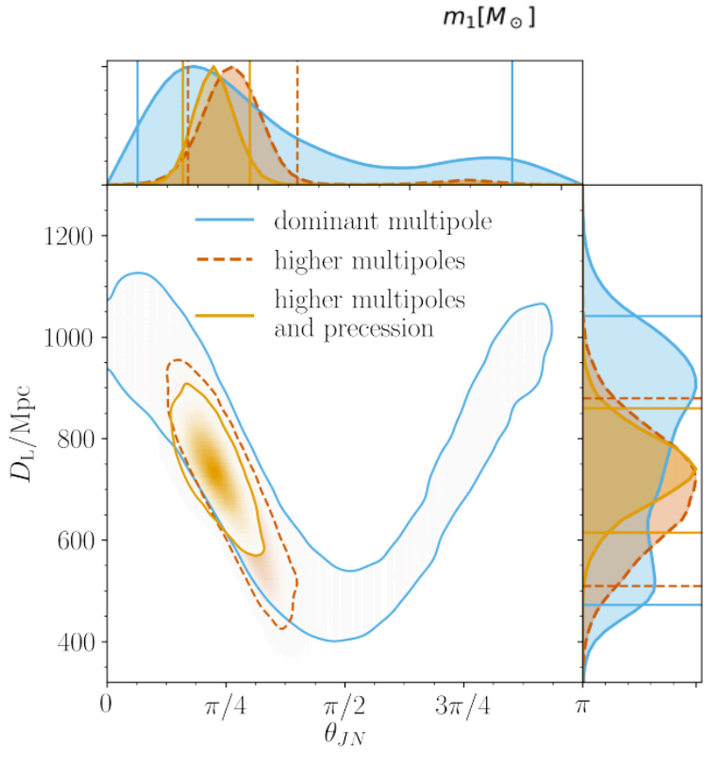




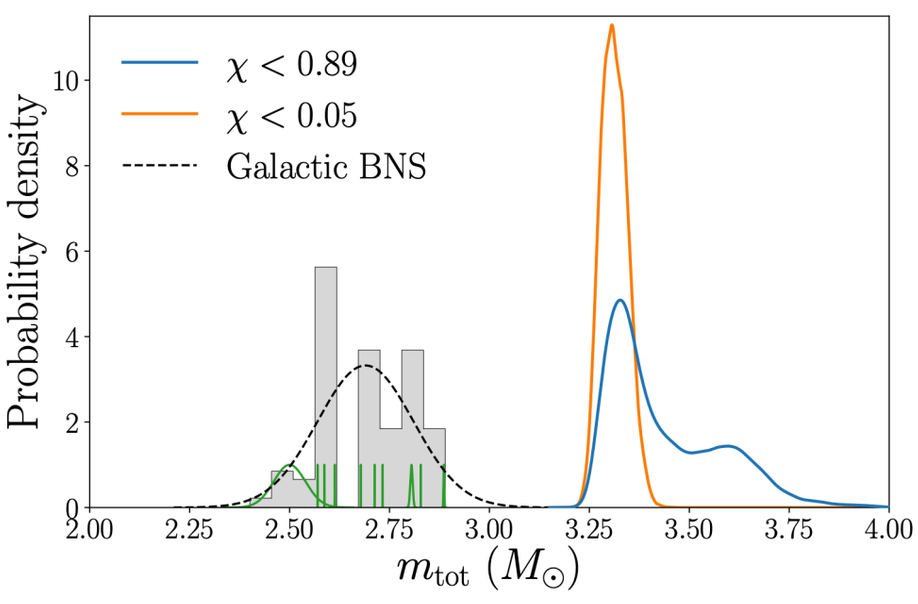
GW190521: 85, 66 $M_\odot$ system ==> 150 $M_\odot$
PISN mass gap: ~65-120 $M_\odot$
Abbott, et al., PRL **125** 101102



GW190814: 23, 2.6 $M_\odot$ system
Uncertain nature of companion
Abbott, et al., ApJL **896** L44



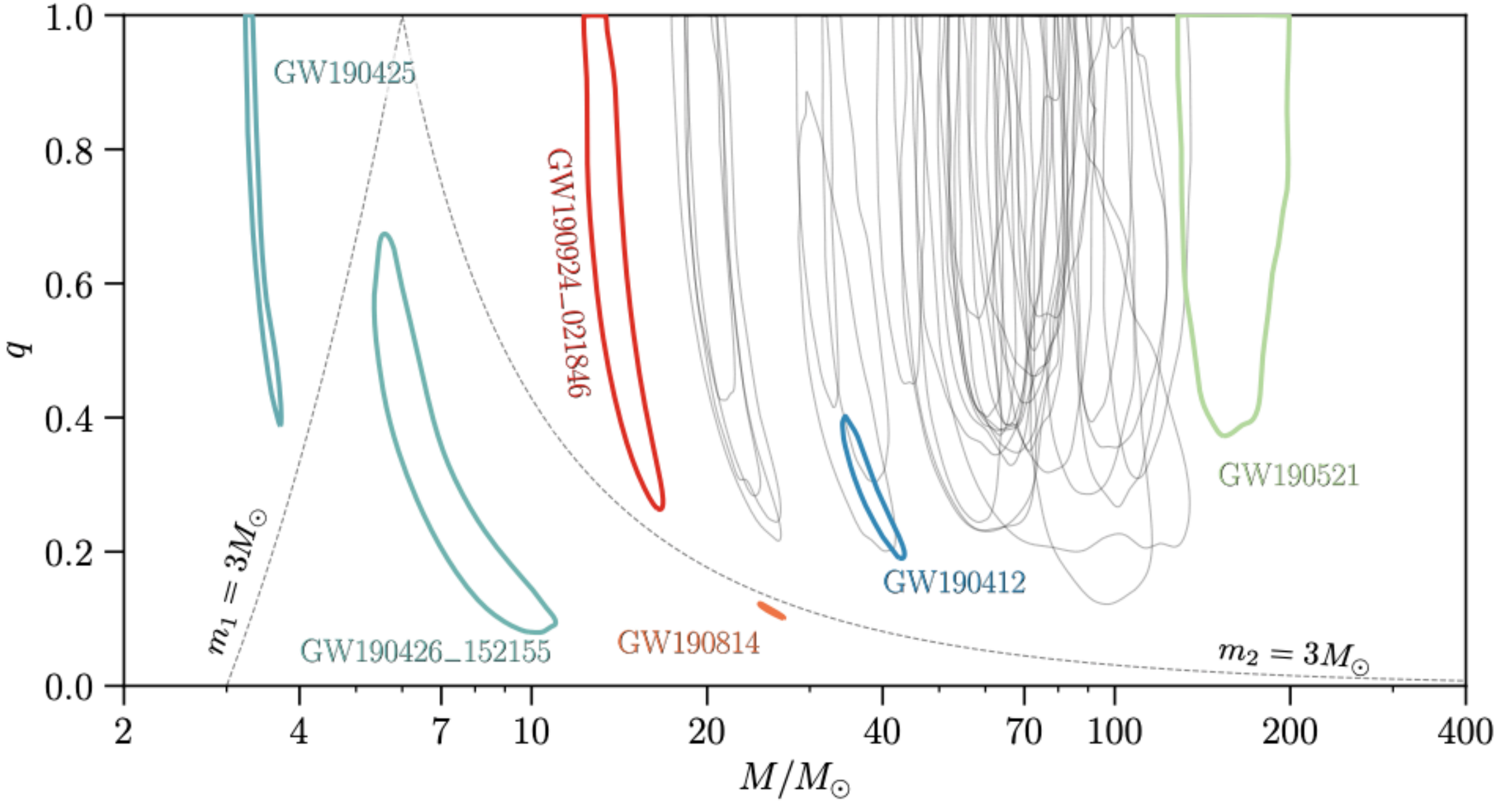
GW190421: 30, 8 $M_\odot$ system
Higher order modes
Abbott, et al., PRD **102** 043015



GW190425: second BNS detection
Total mass inconsistent with other galactic binary NSs
Abbott, et al., ApJL **892** L3

GWTC-2: 39 new confident detections

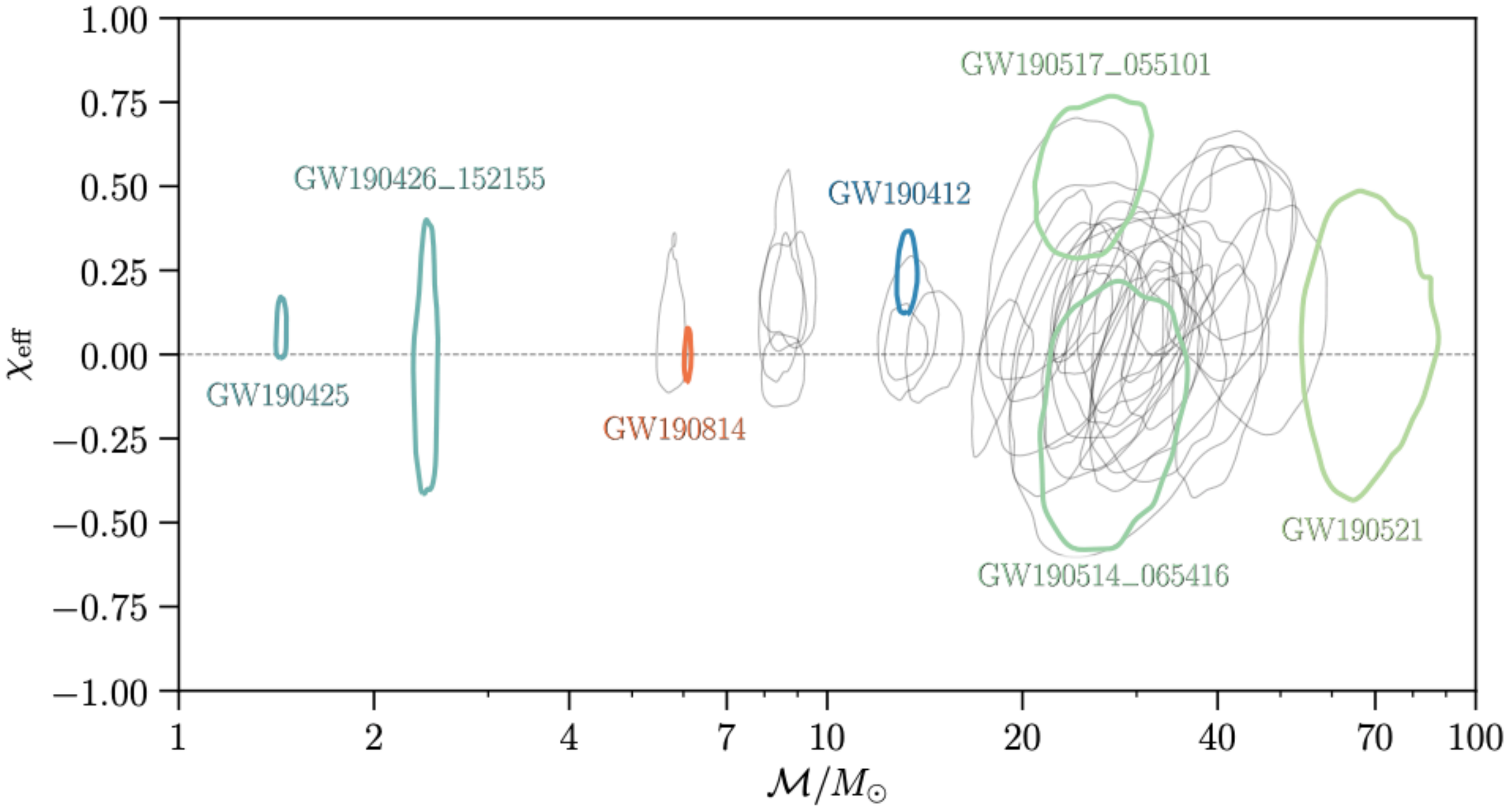
Mass ratio vs. total mass



Abbott, et al., arXiv:2010.14527 [gr-qc]

GWTC-2: 39 new confident detections

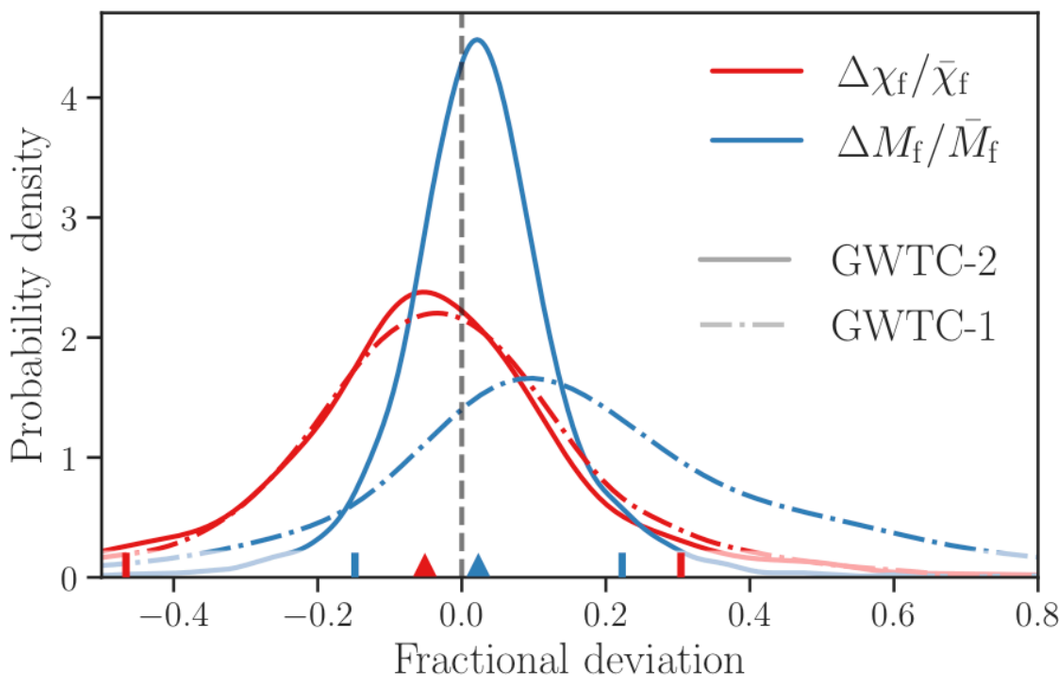
Effective spin vs. chirp mass



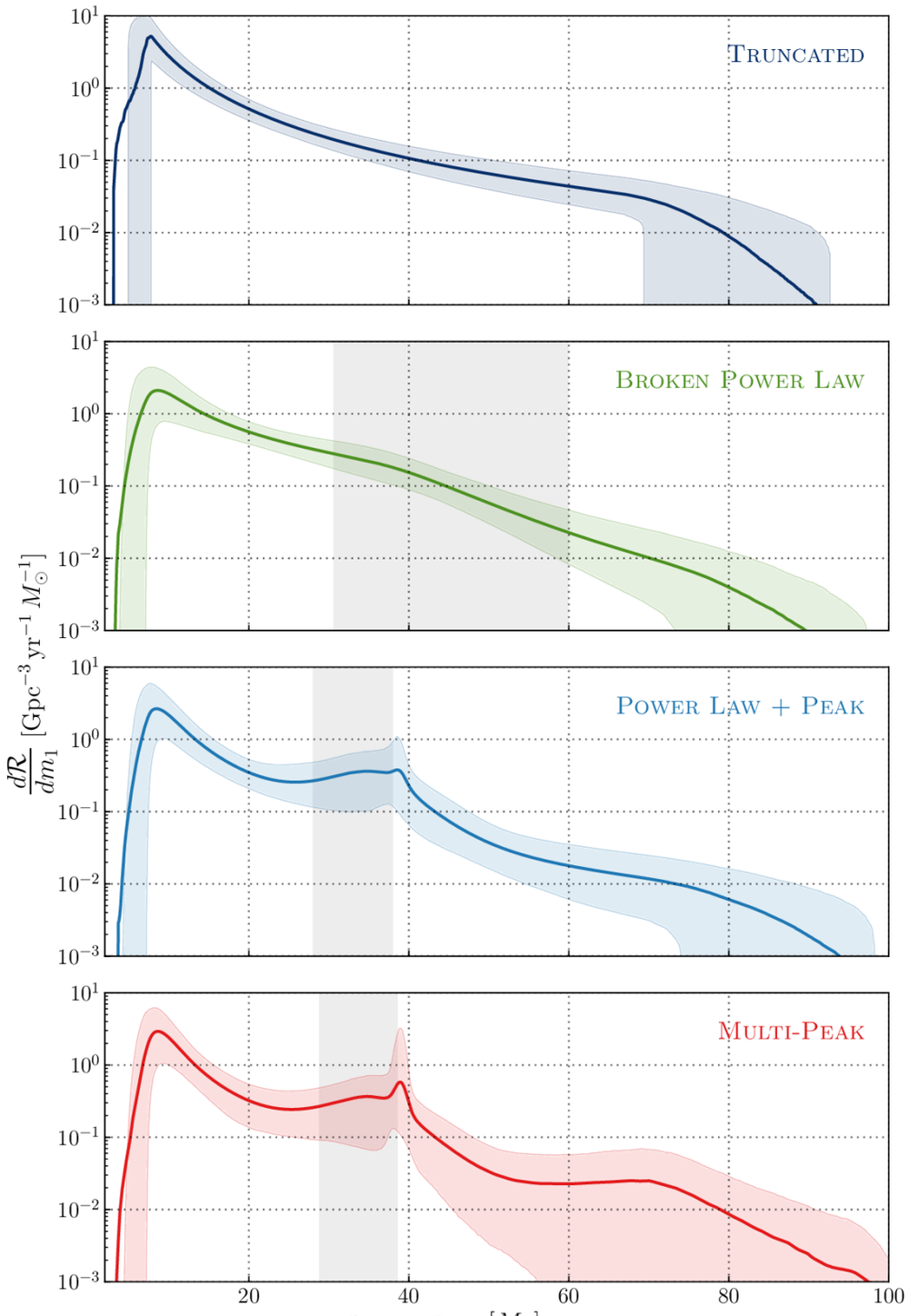
Abbott, et al., arXiv:2010.14527 [gr-qc]

Astrophysical implications

- Measuring deviations of GR
  - Comparing inspiral-measured PE with ringdown-measured PE
- Population properties
  - Mass, spin distributions, rate evolution



Abbott, et al., accepted by PRD, arXiv:2010.14529 [gr-qc]



Abbott, et al., arXiv:2010.14533 [astro-ph.HE]

Transient vs. continuous GW signals

- **Compact binary coalescence** gravitational wave signals are relatively strong but transient

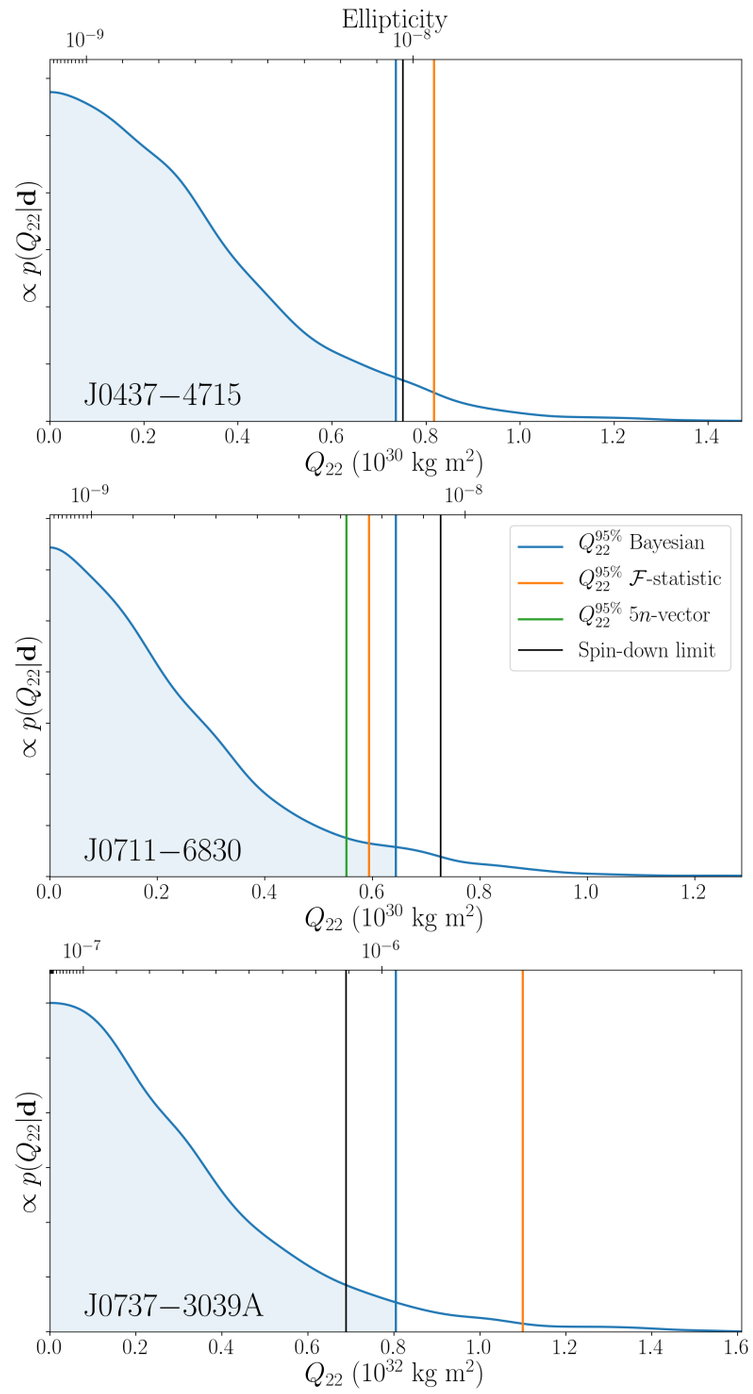
- For ground-based observations, cannot perform long duration studies of a particular source

- **Continuous** gravitational wave signals are relatively weak but persistent enabling long term studies of a source

Recent results for continuous wave searches

Surpassing spindown limit of millisecond pulsars

- Spindown limit benchmark for GW emission amplitude from known NSs
- First time spindown limit surpassed for millisecond pulsars
- MSPs have significantly different evolutionary history than slowly rotating pulsars
- Implications for internal magnetic field strength

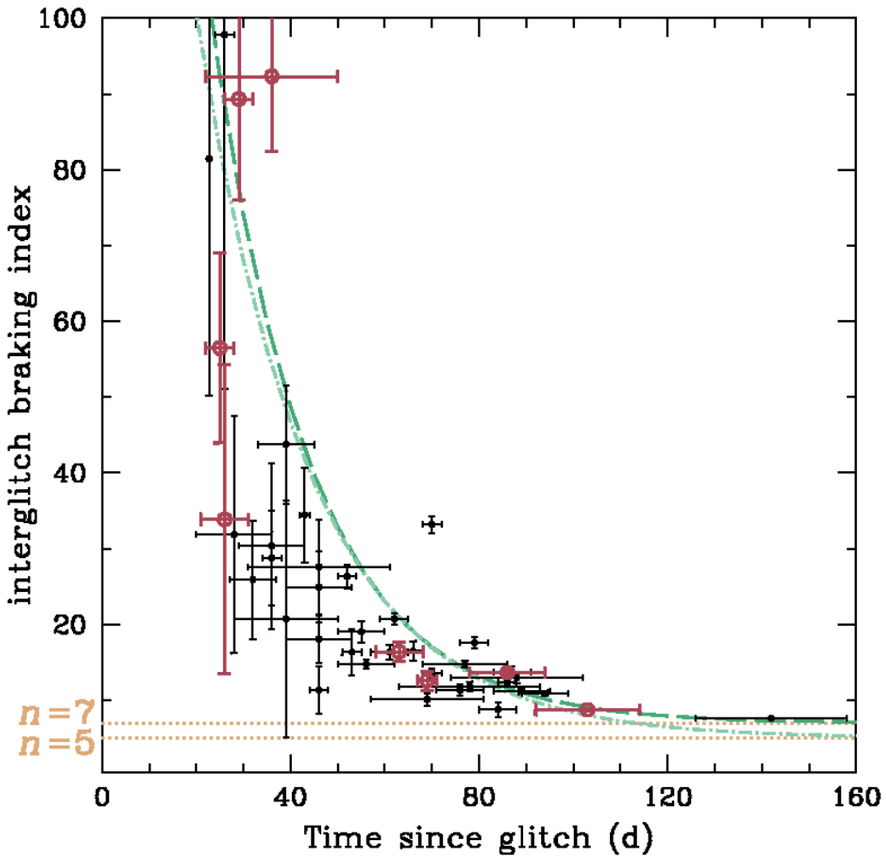


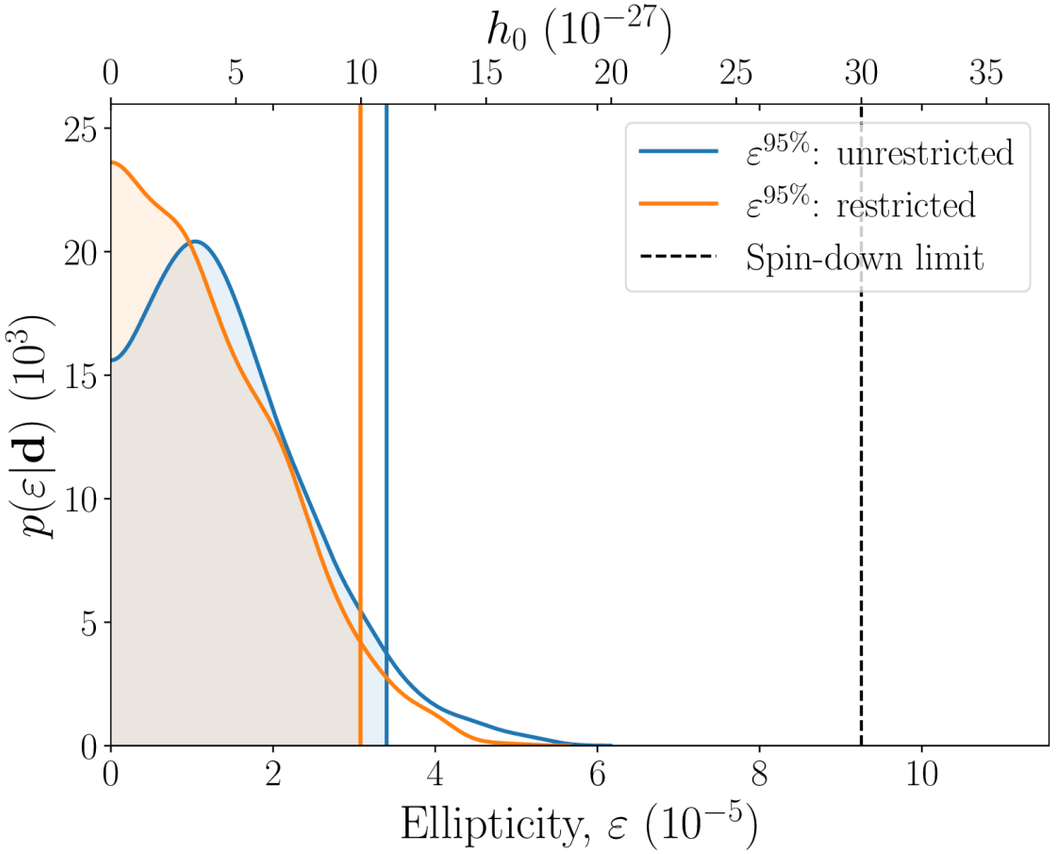
Abbott, et al., ApJL **902** L21

Recent results for continuous wave searches

Constraining continuous GW emission from J0537-6910

- Large spin down luminosity and frequent pulsar glitches observed
- NICER timing solution + LIGO/Virgo data ==> surpass spindown limit for first time



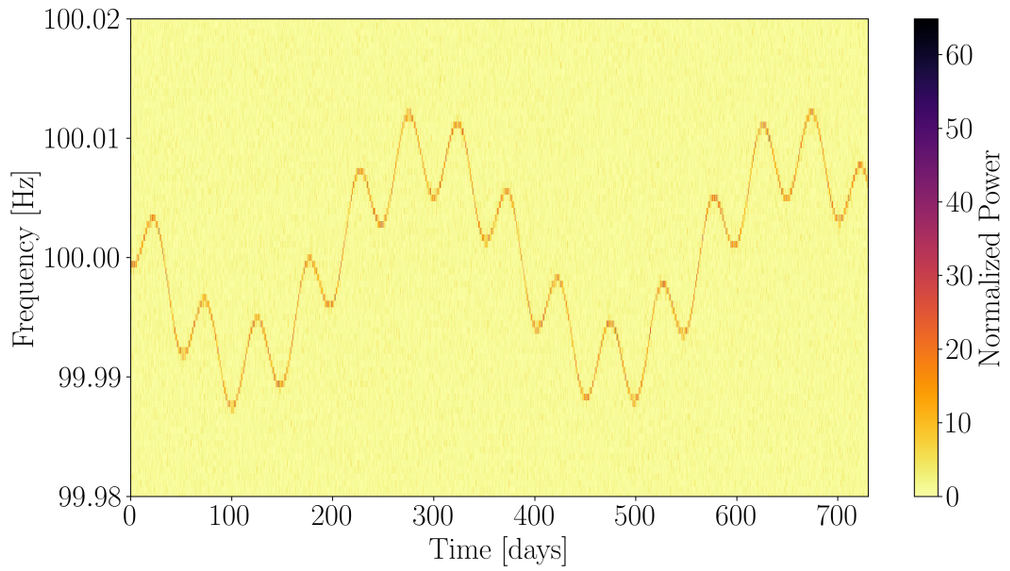


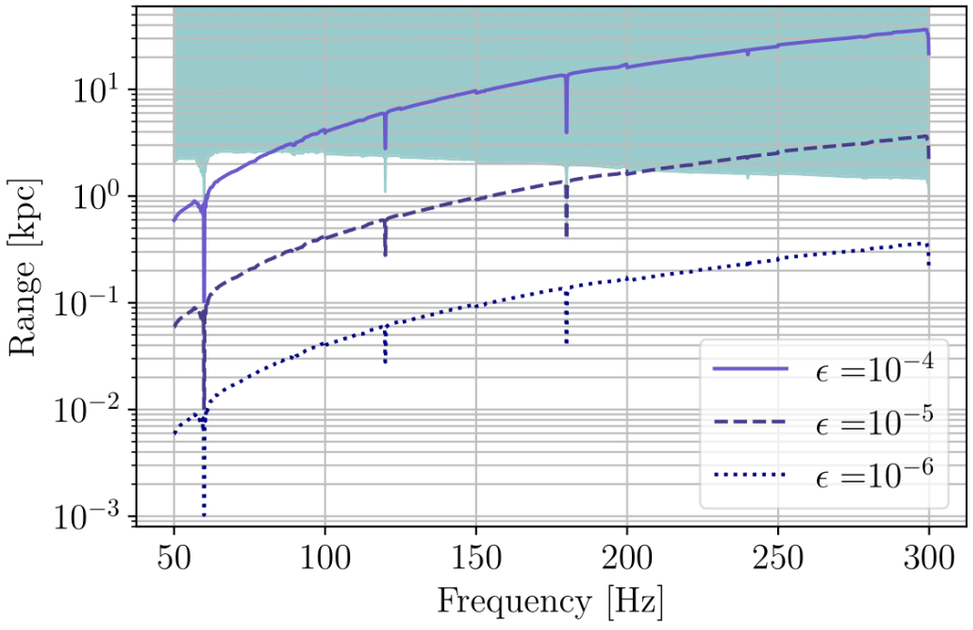
Abbott, et al. arXiv:2012.12926 [astro-ph.HE]

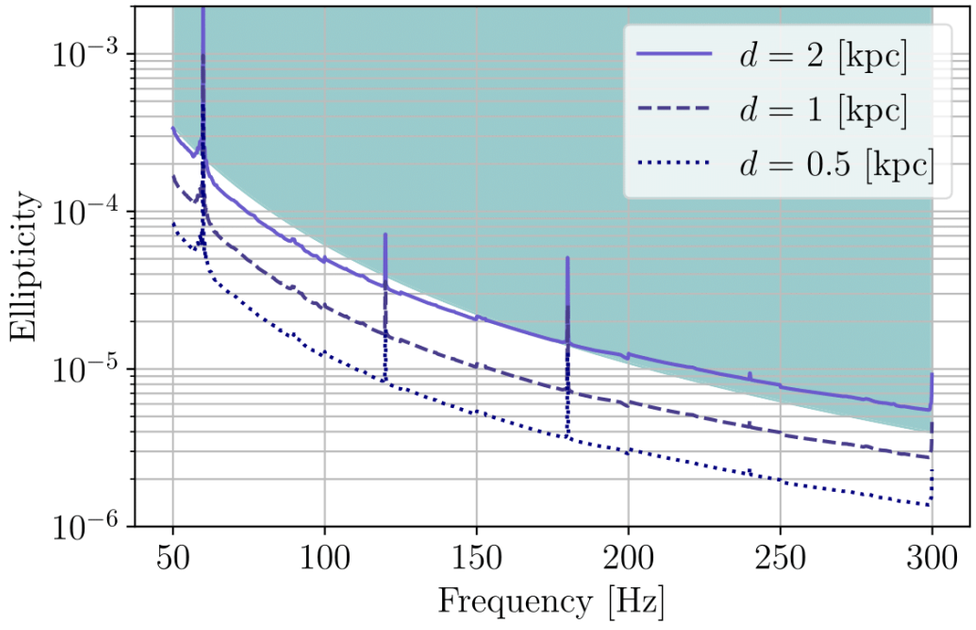
Recent results for continuous wave searches

All-sky search for unknown neutron stars in binary systems

- Notoriously computationally challenging search to include the additional unknown binary orbital parameters
- Most constraining results to date and probing sources in Galactic neighborhood







Abbott, et al., arXiv:2012.12128 [gr-qc]

Summary and outlook

- LIGO-Virgo and future GW detectors opening new windows for study of extreme astrophysical systems
- O3 provides new constraints on BBH population models, deviations from general relativity, masses of BHs, formation channels of massive BHs, and more
- Searches for continuous gravitational waves from non-axisymmetric neutron stars in full-swing
- Recent results place new constraints on neutron star energy loss, ellipticity for interesting sources; implications for neutron star properties