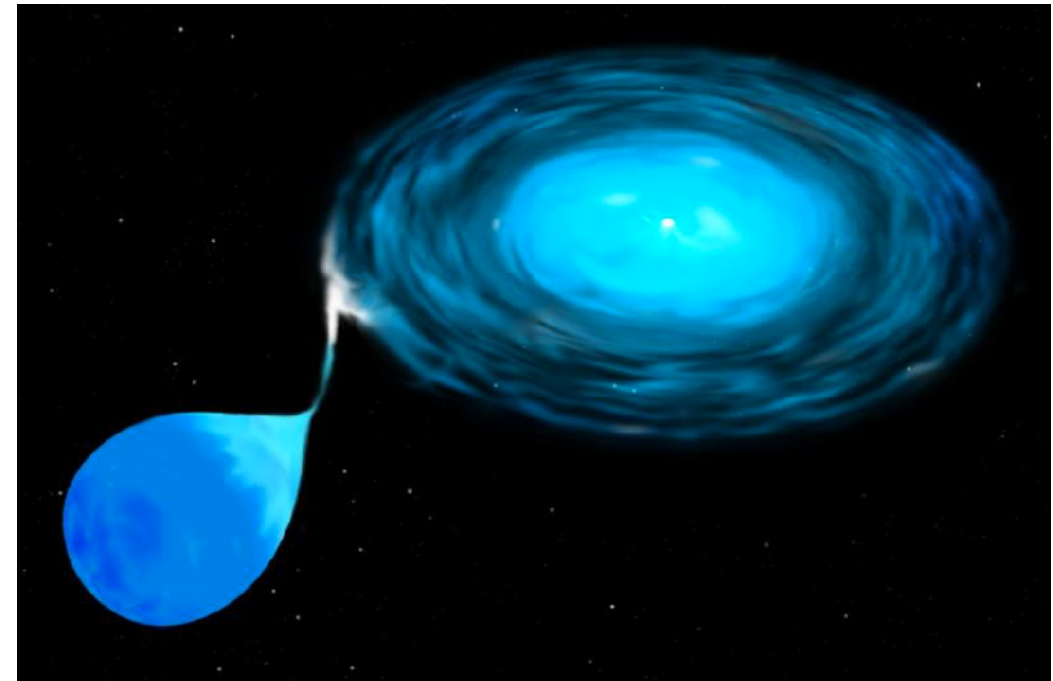
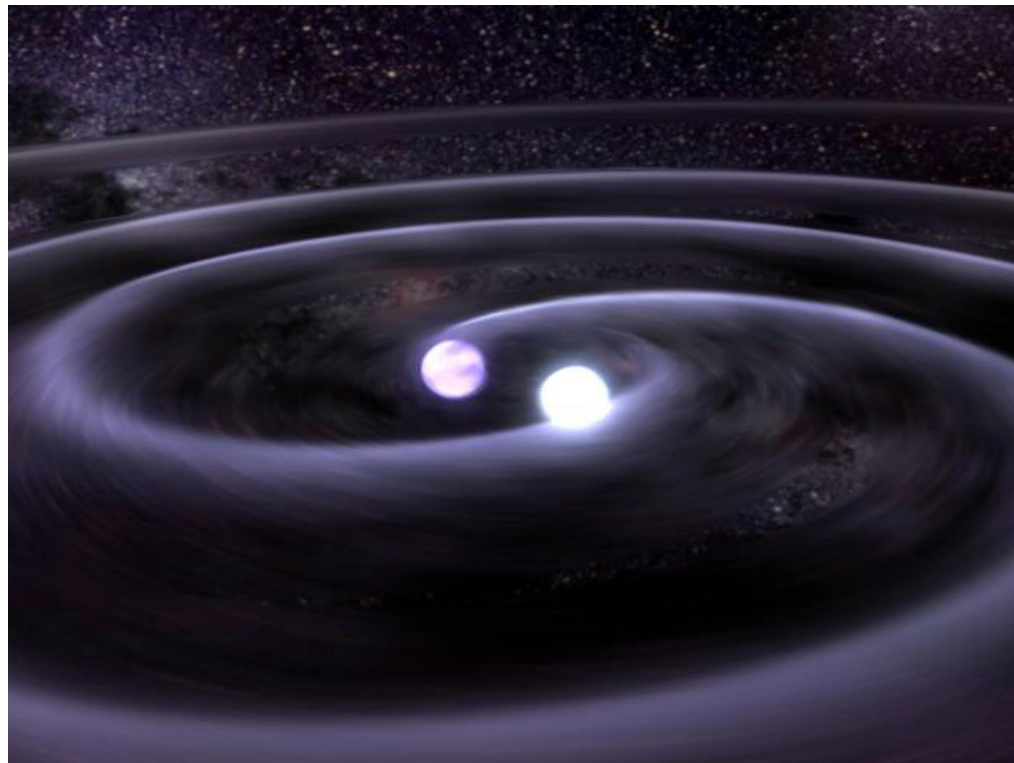
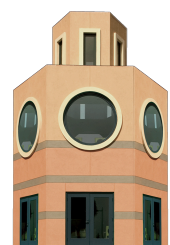


Multi-messenger potential for Galactic binaries



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Theoretical Physics

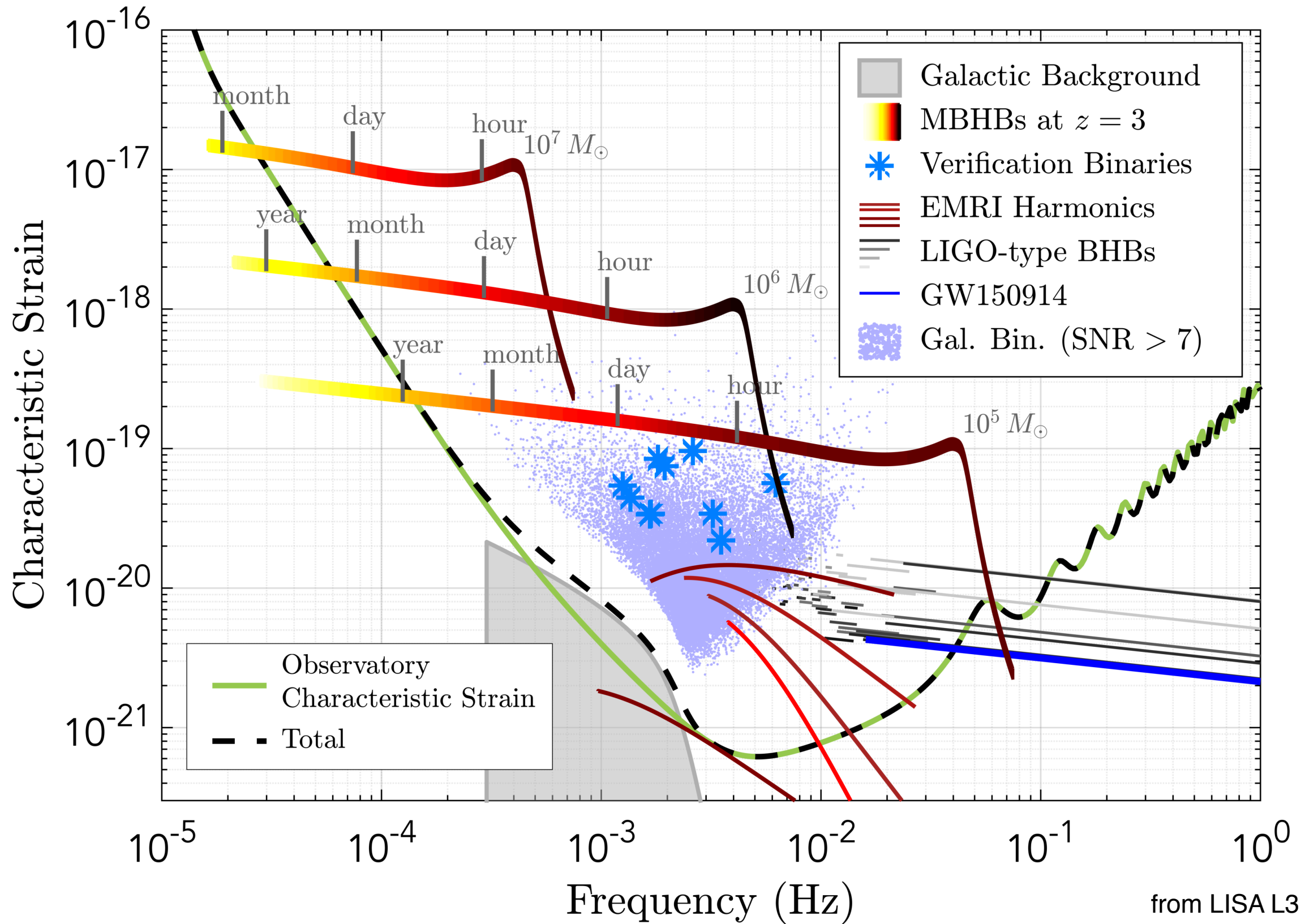
University of California, Santa Barbara



ZWICKY TRANSIENT FACILITY

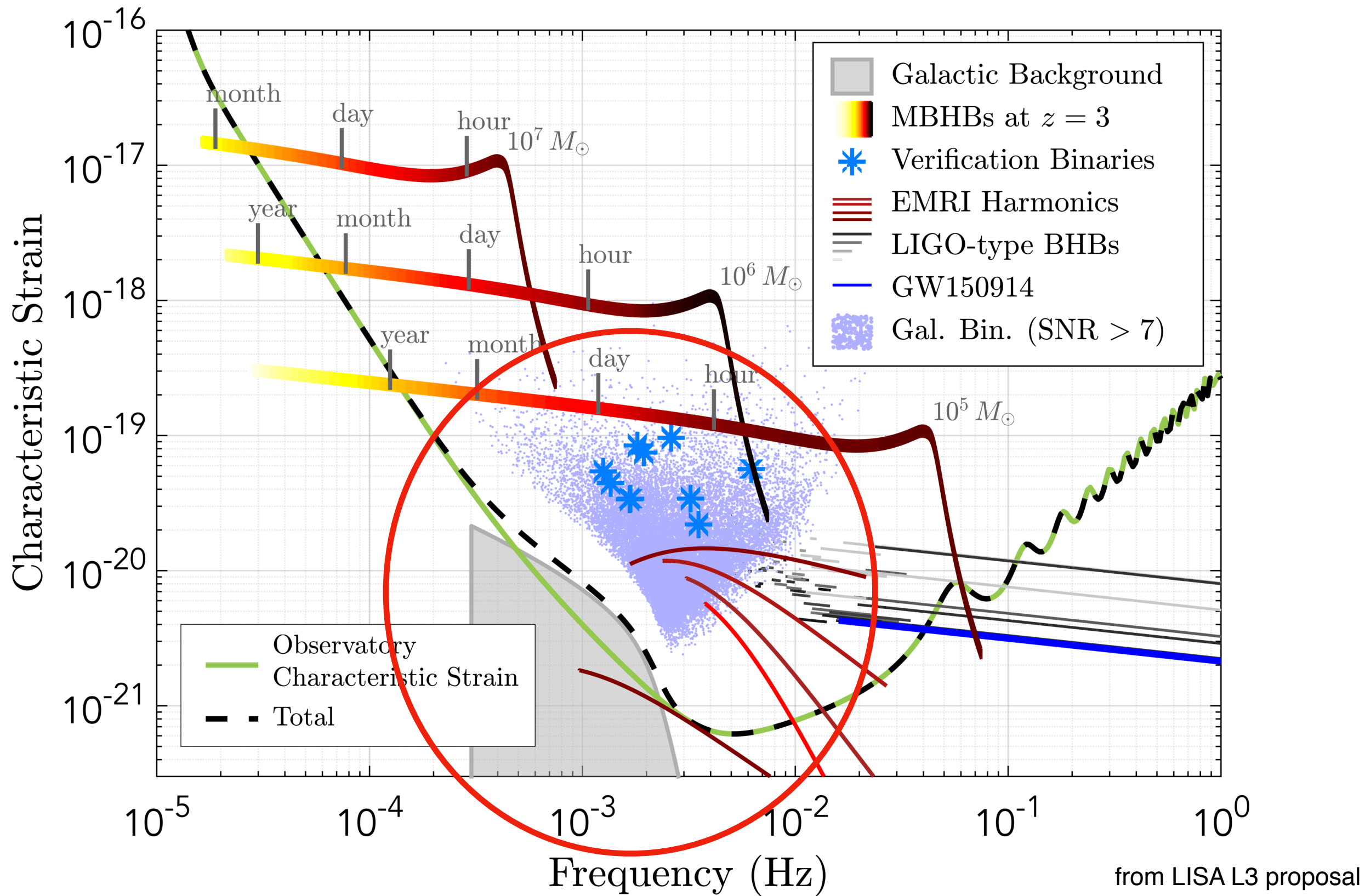


LISA sources

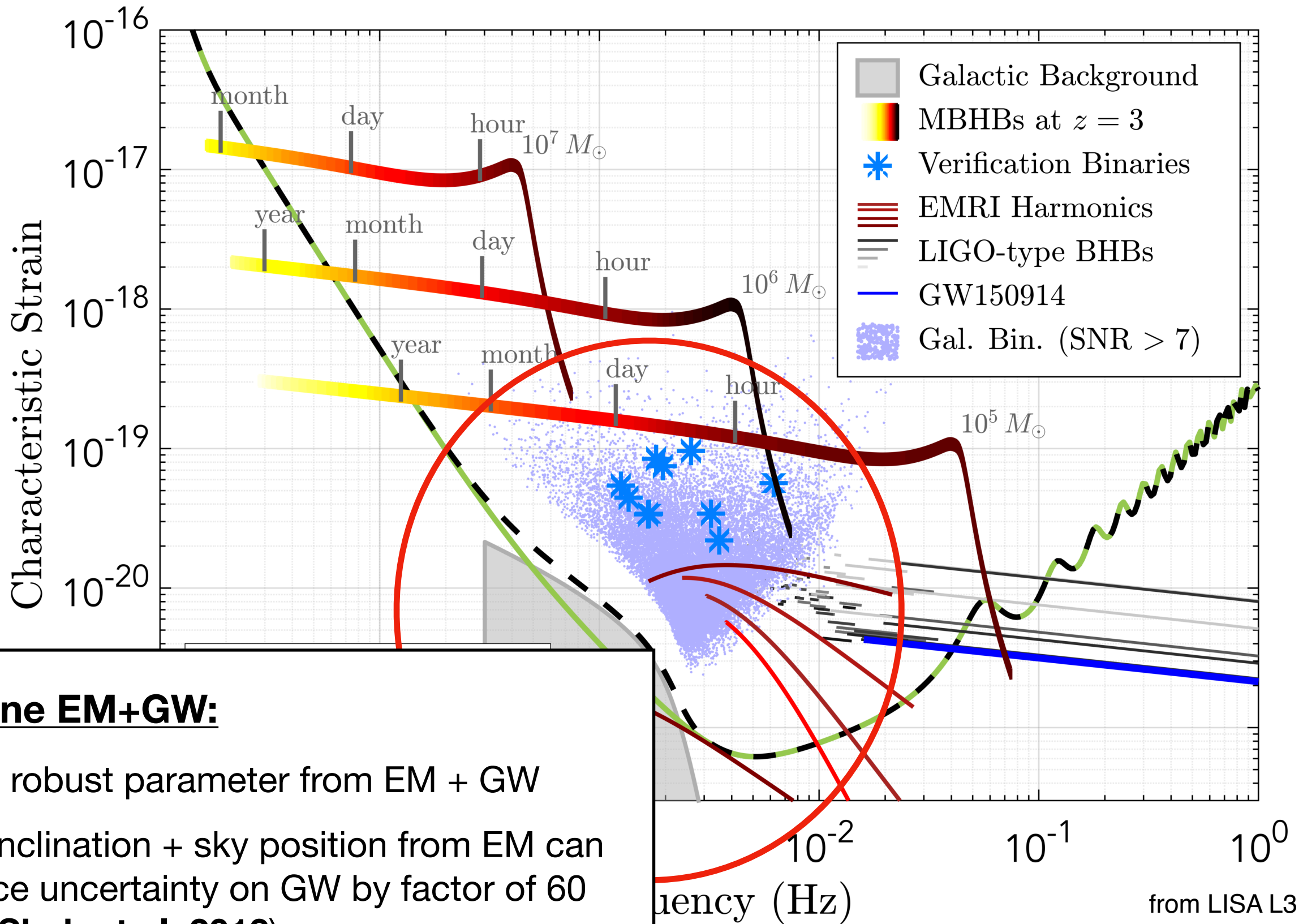


from LISA L3 proposal

LISA sources



LISA sources

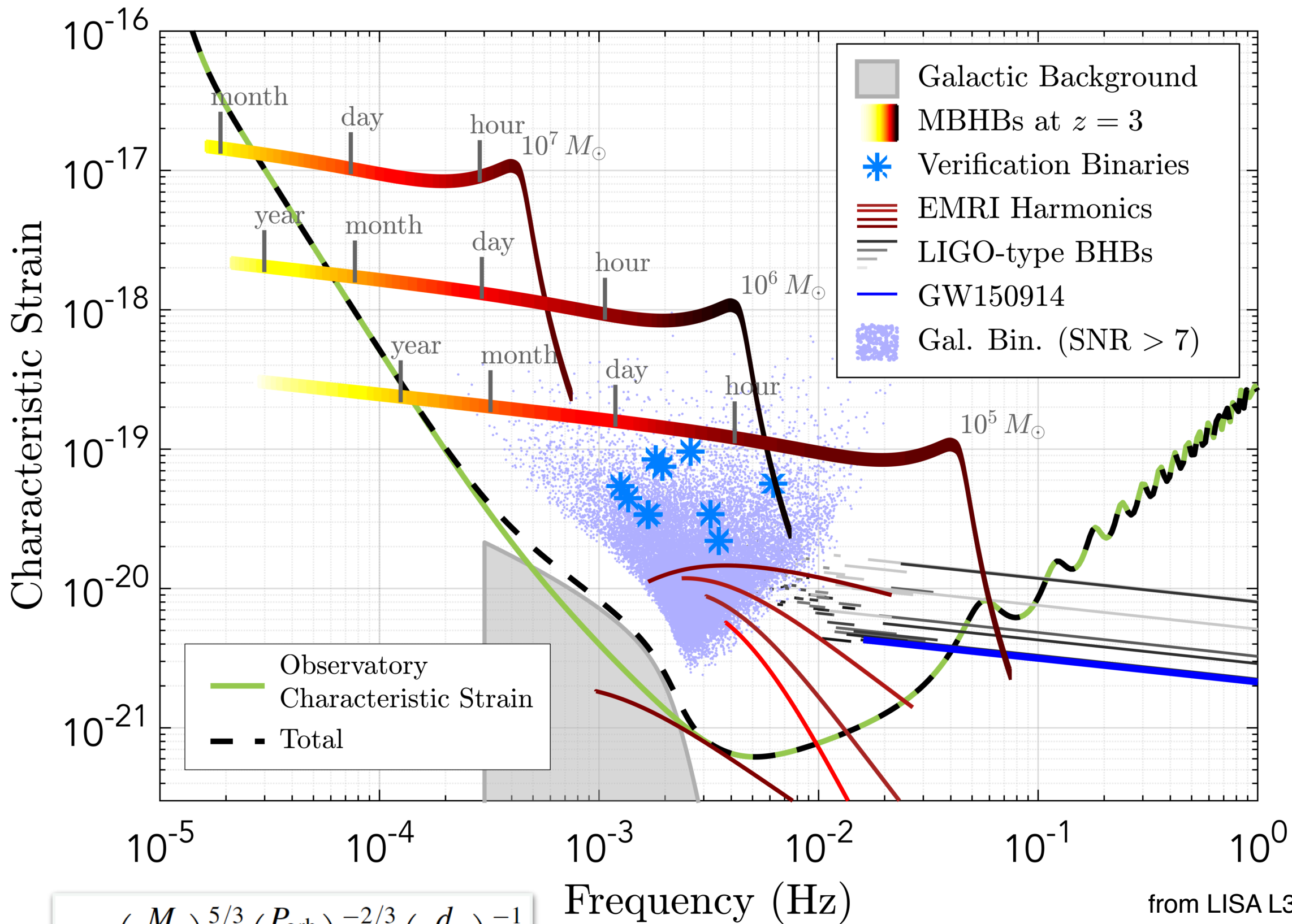


Combine EM+GW:

- more robust parameter from EM + GW
- e.g. inclination + sky position from EM can reduce uncertainty on GW by factor of 60 (e.g. **Shah et al. 2013**)

from LISA L3 proposal

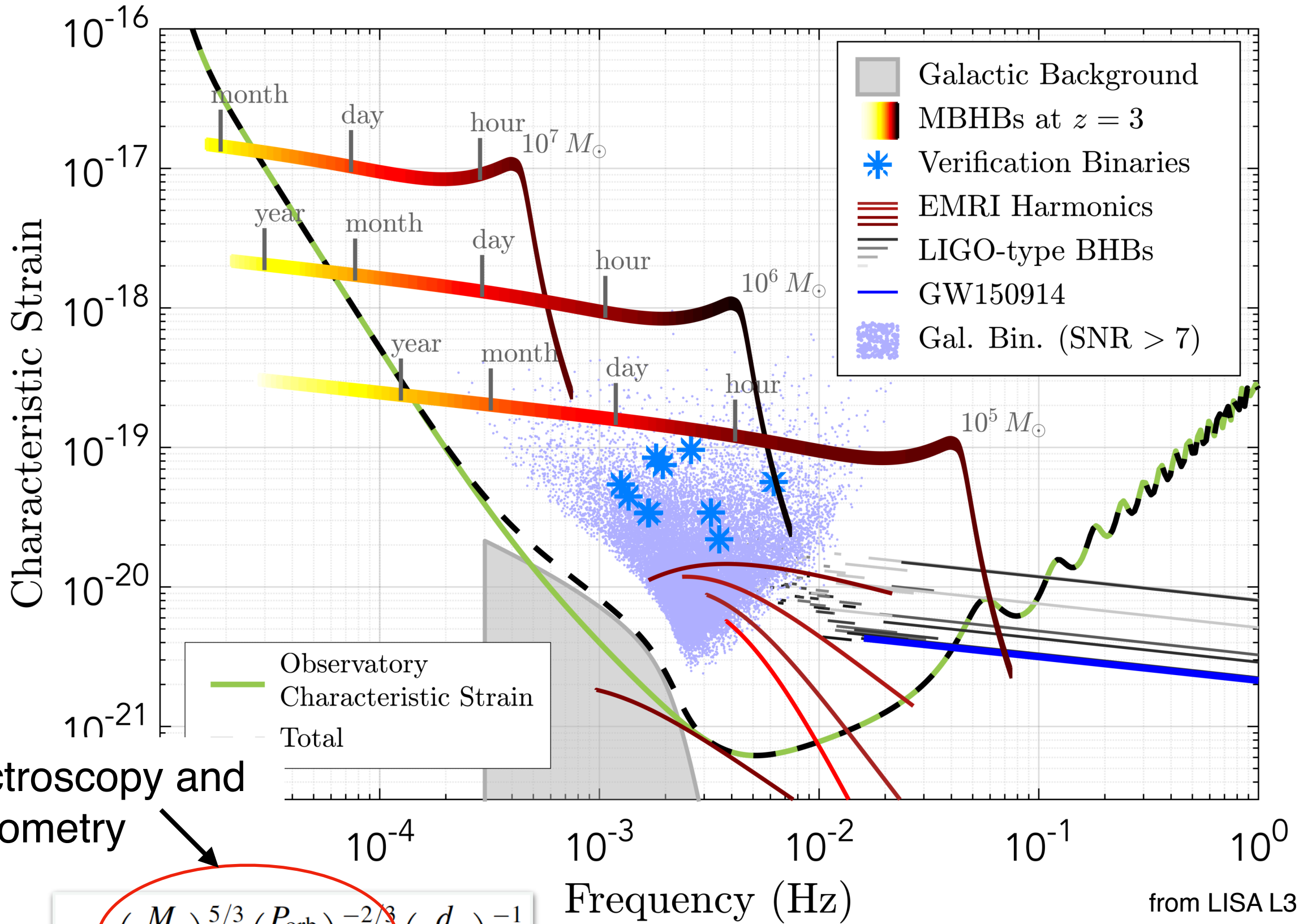
LISA sources



strain:
$$h \propto \left(\frac{M}{M_{\odot}}\right)^{5/3} \left(\frac{P_{\text{orb}}}{1\text{hr}}\right)^{-2/3} \left(\frac{d}{\text{kpc}}\right)^{-1}$$

from LISA L3 proposal

LISA sources

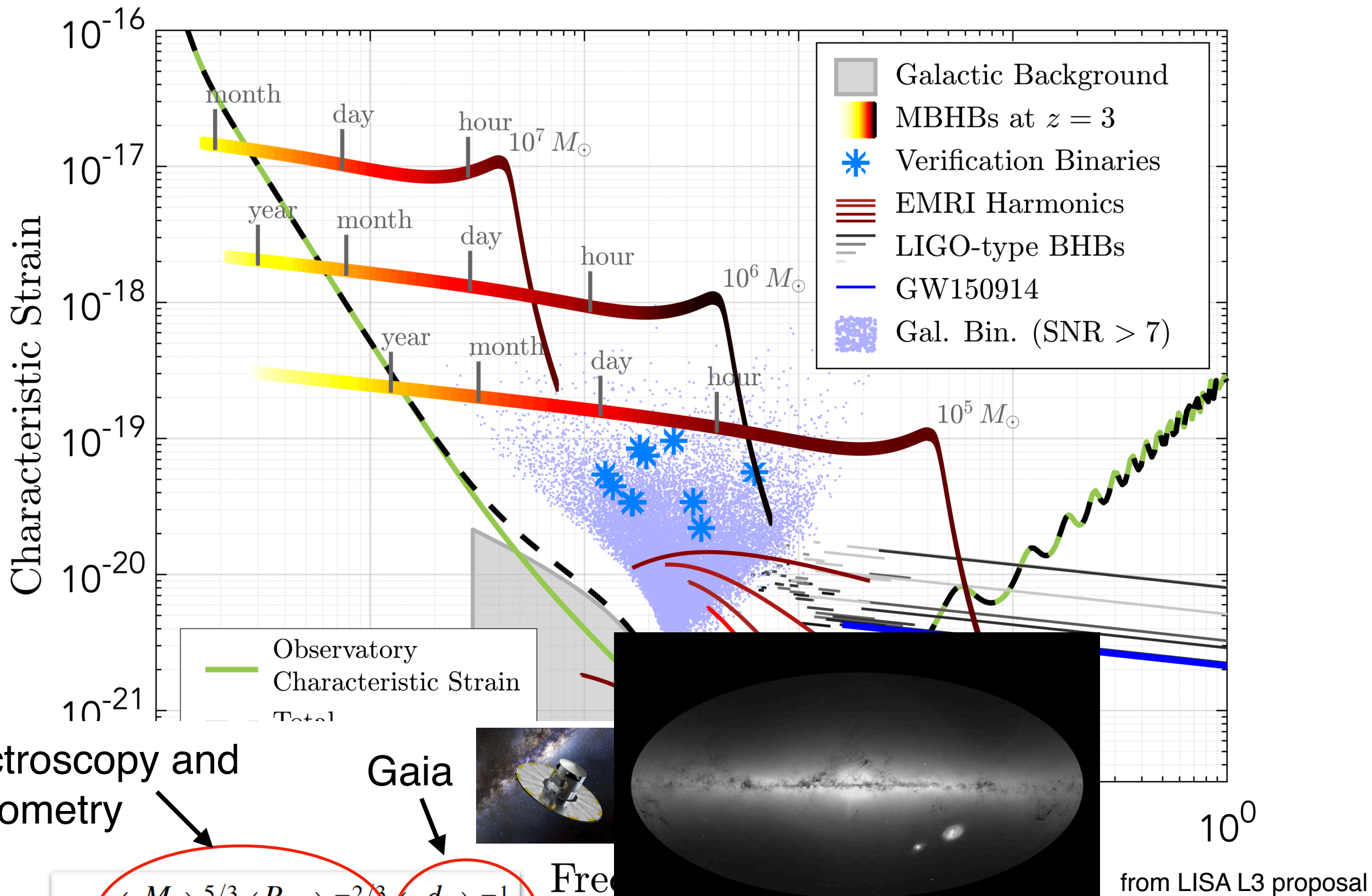


spectroscopy and photometry

$$\text{strain: } h \propto \left(\frac{M}{M_{\odot}}\right)^{5/3} \left(\frac{P_{\text{orb}}}{1\text{hr}}\right)^{-2/3} \left(\frac{d}{\text{kpc}}\right)^{-1}$$

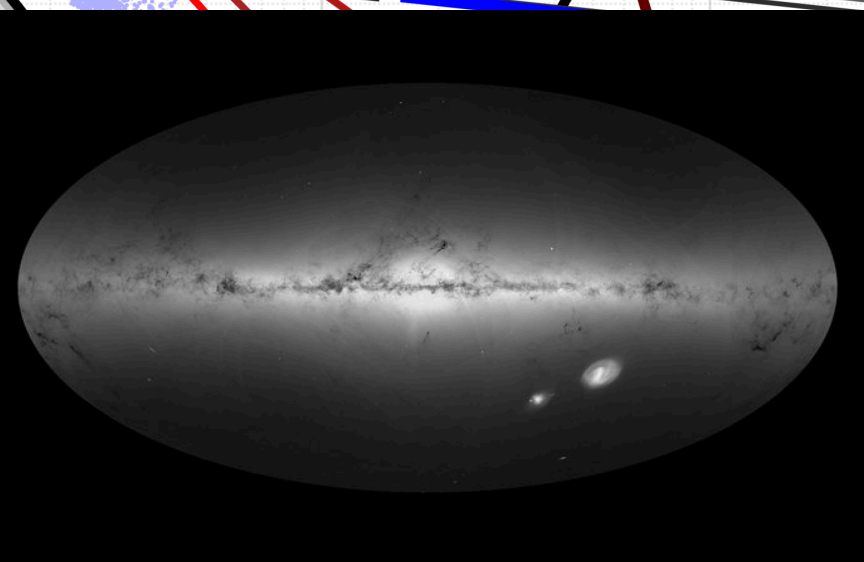
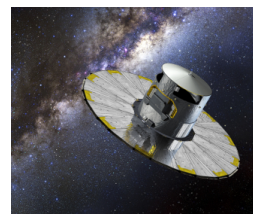
from LISA L3 proposal

LISA sources



spectroscopy and photometry

Gaia

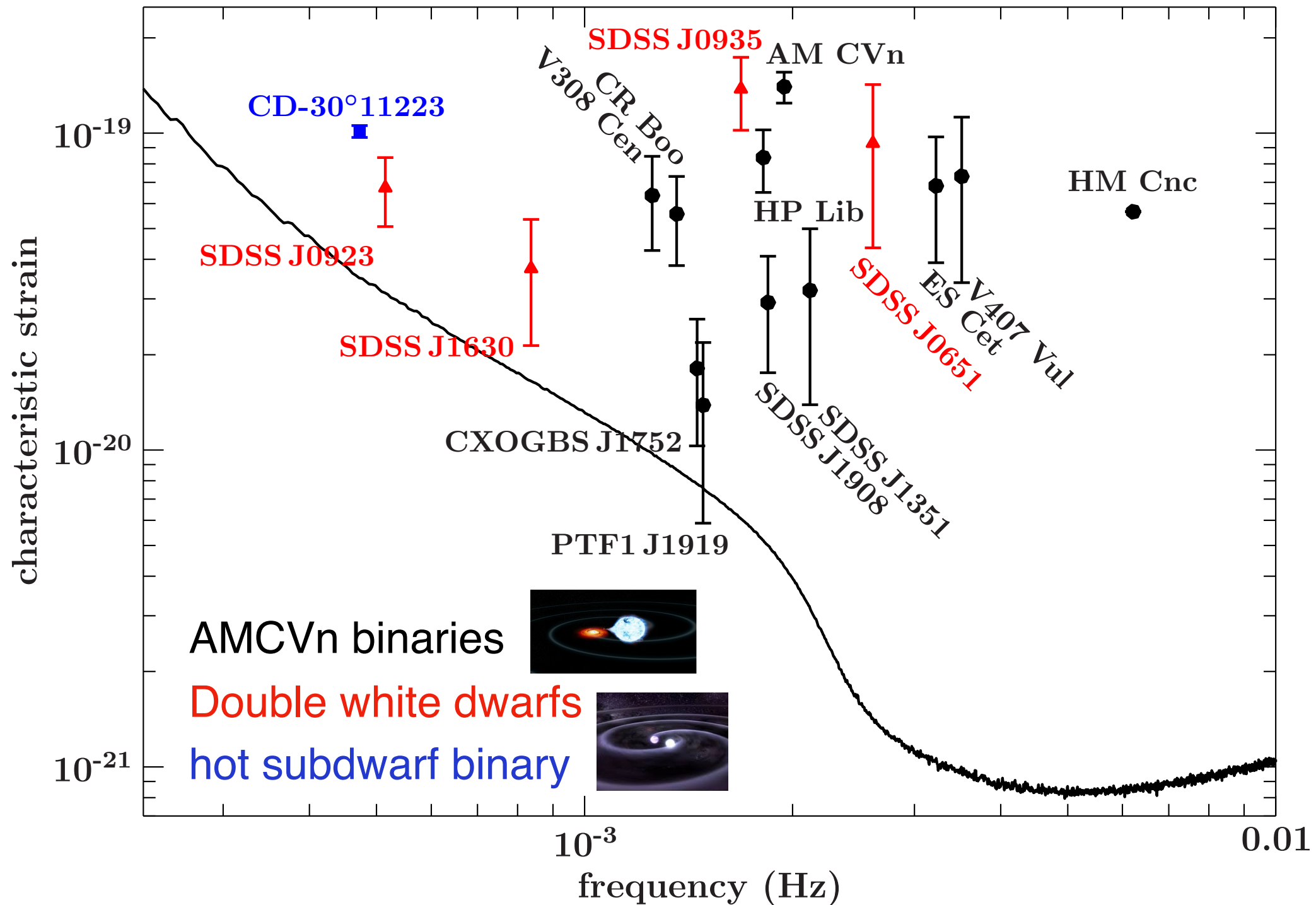


strain:

$$h \propto \left(\frac{M}{M_\odot}\right)^{5/3} \left(\frac{P_{\text{orb}}}{1\text{hr}}\right)^{-2/3} \left(\frac{d}{\text{kpc}}\right)^{-1}$$

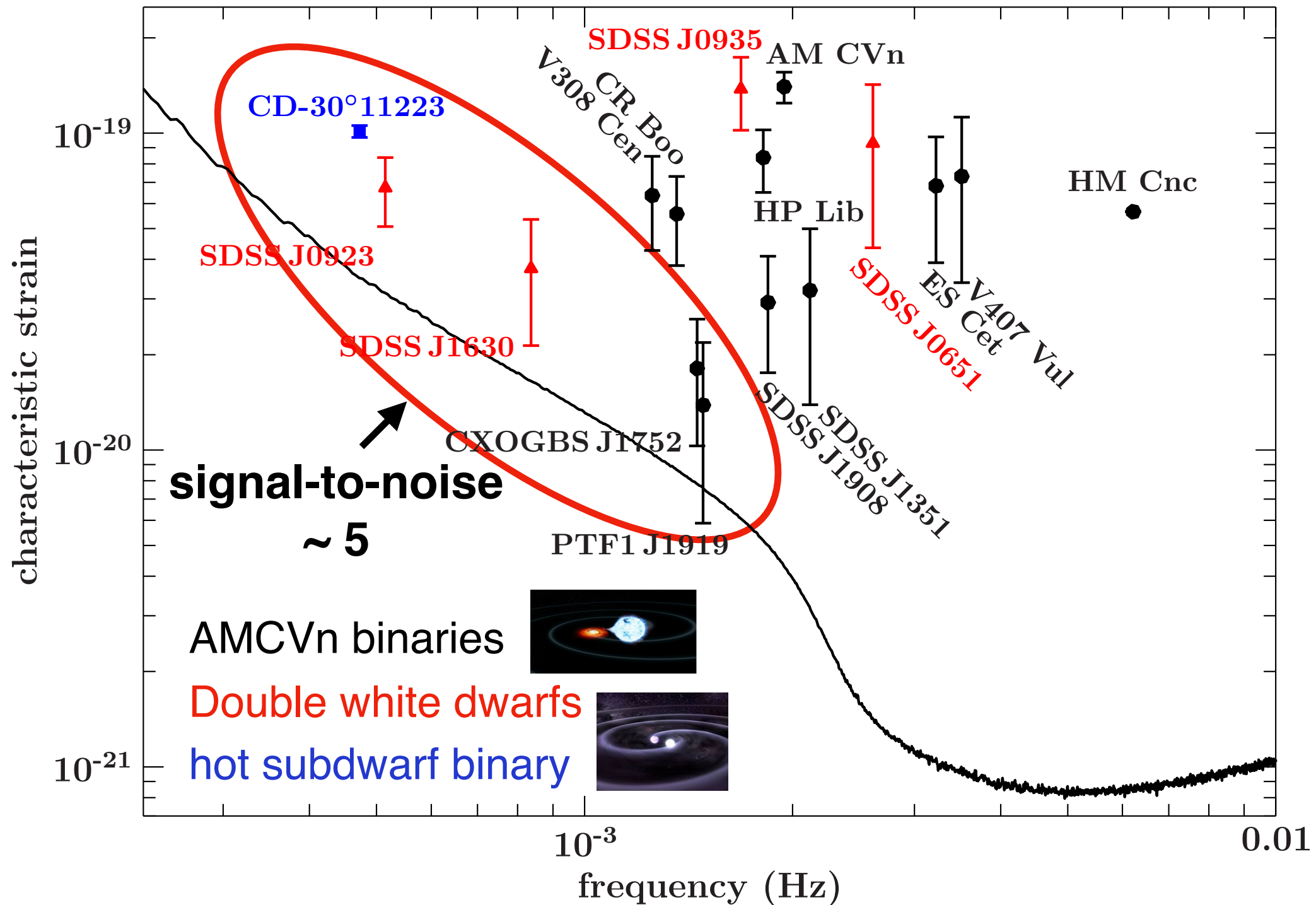
Freq

Known verification binaries



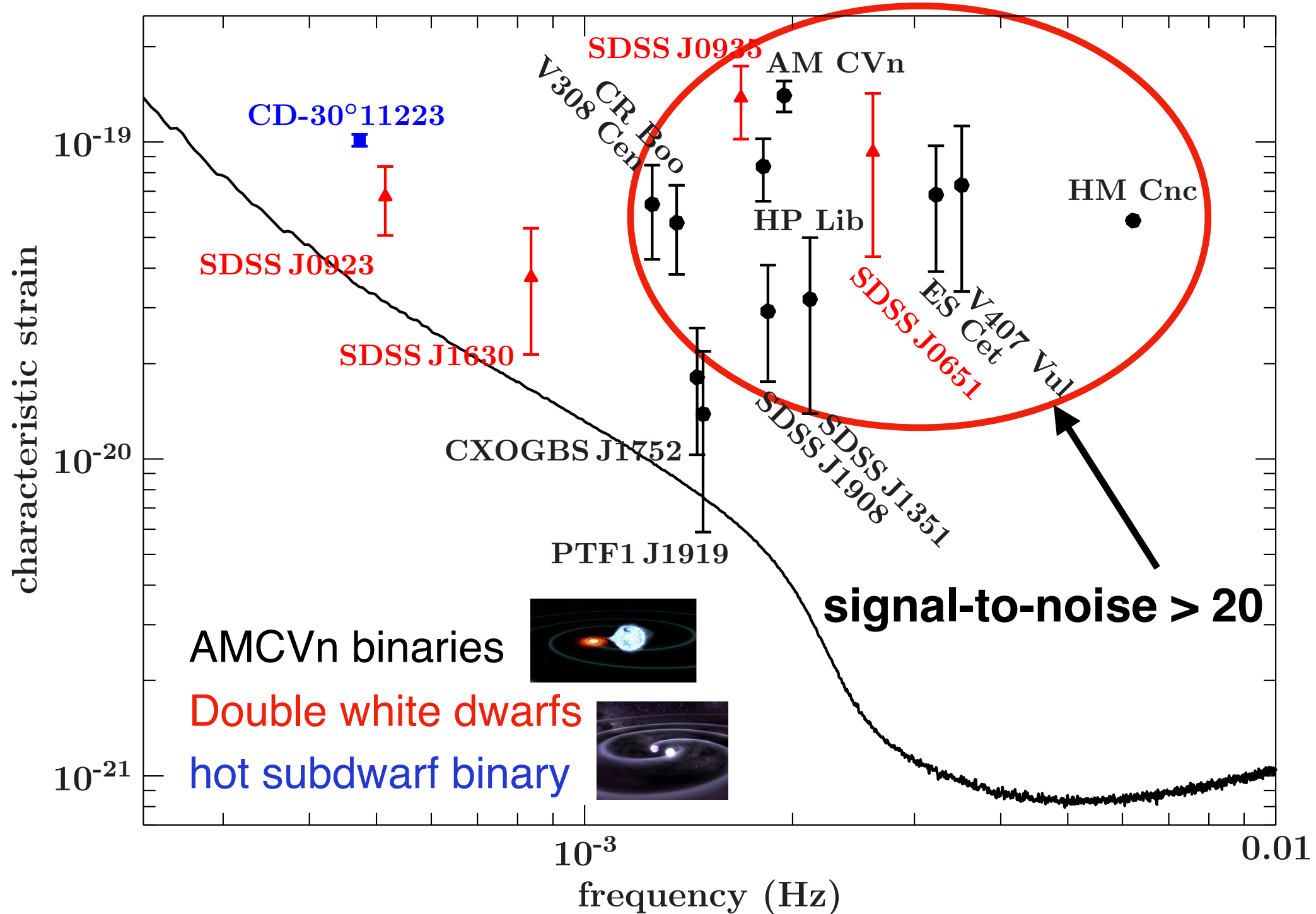
- We calculated strain/SNR for ~50 systems
- 16 systems expected to have signal to noise around 5 or larger

Known verification binaries



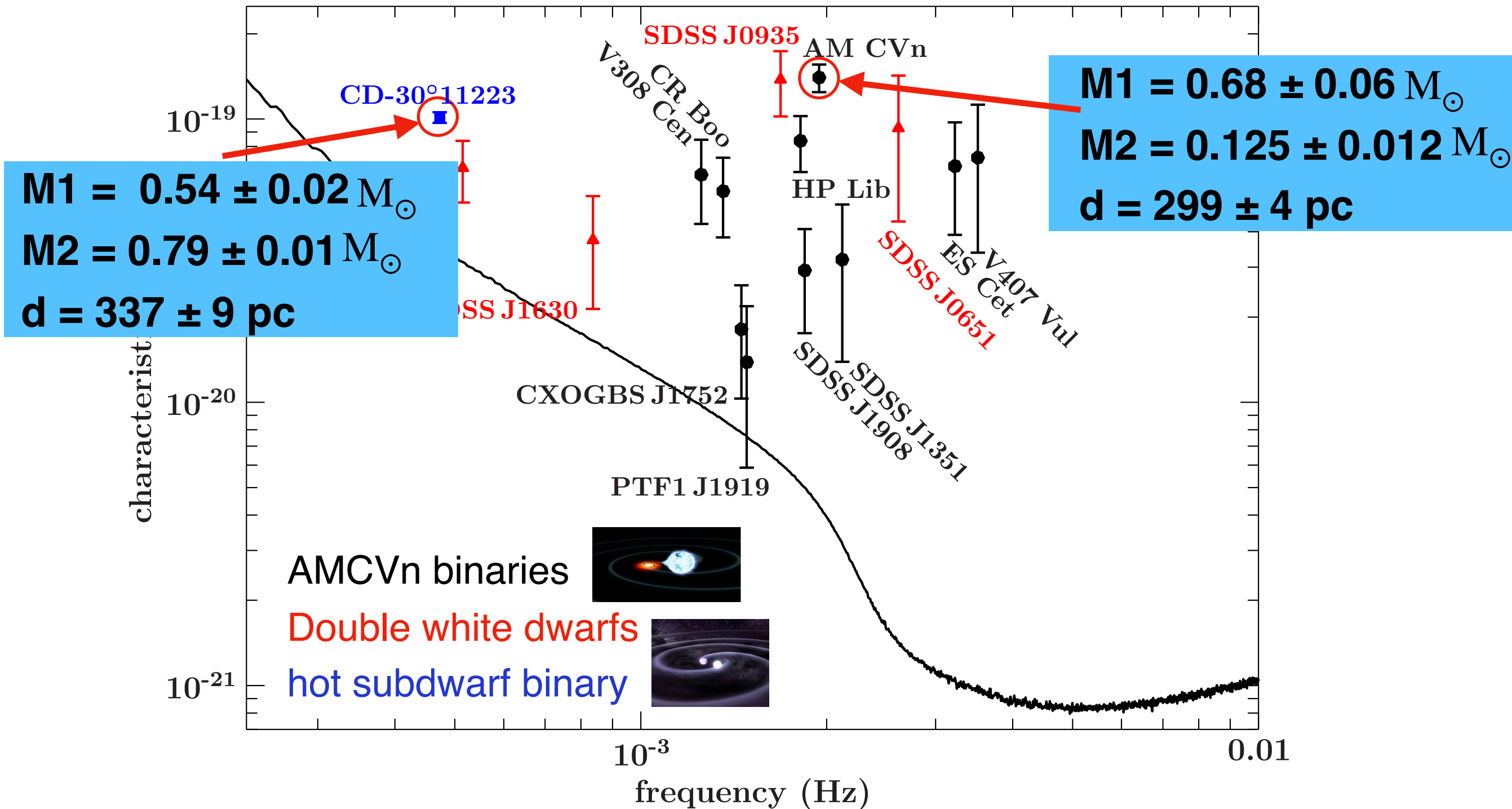
- We calculated strain/SNR for ~50 systems
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Known verification binaries



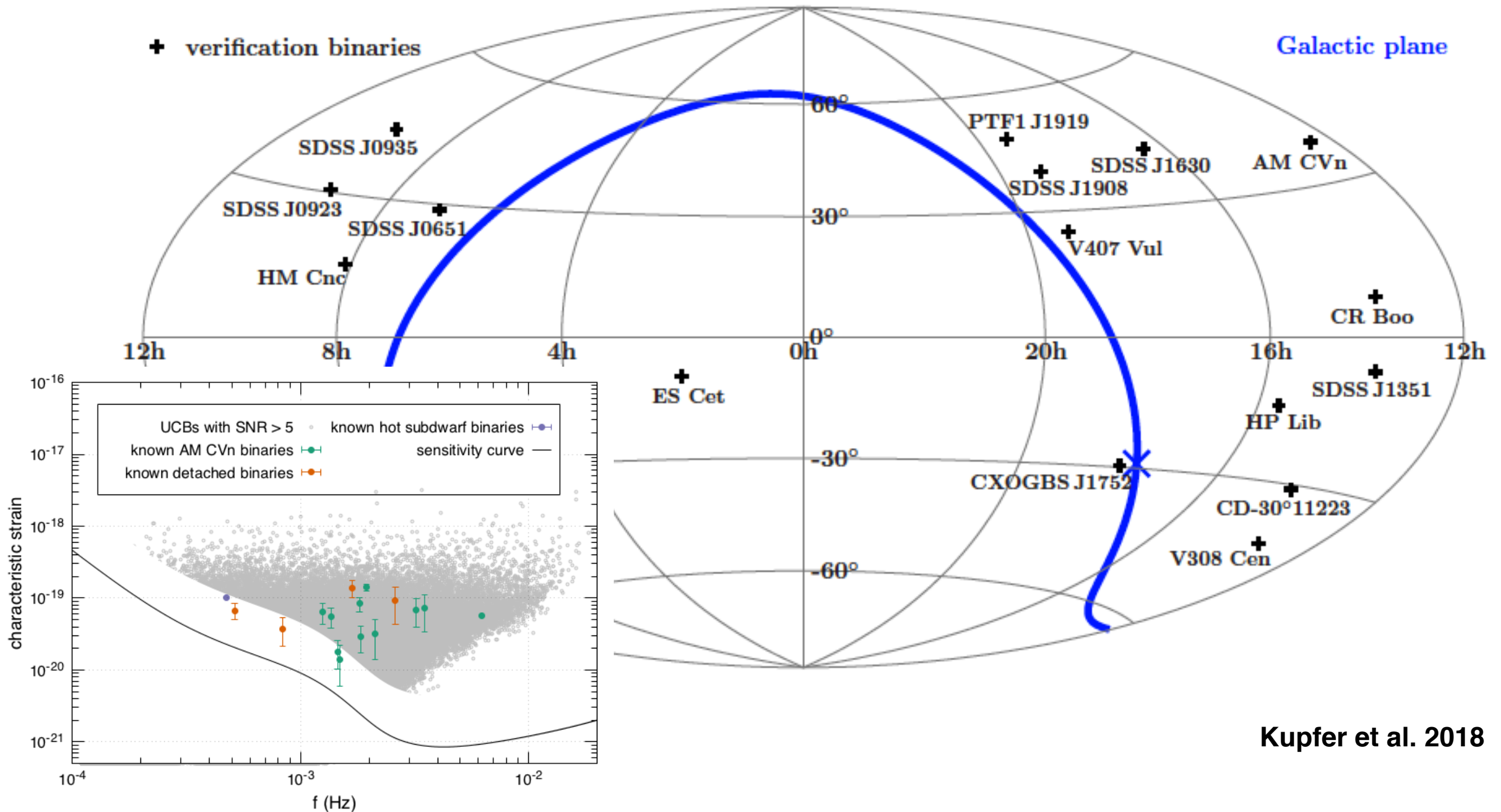
- We calculated strain/SNR for ~50 systems
- 16 systems expected to have signal to noise around 5 or larger

Known verification binaries



- Some systems have a precision in the strain better than 5-10%
 - Ideal for LISA performance validation tests

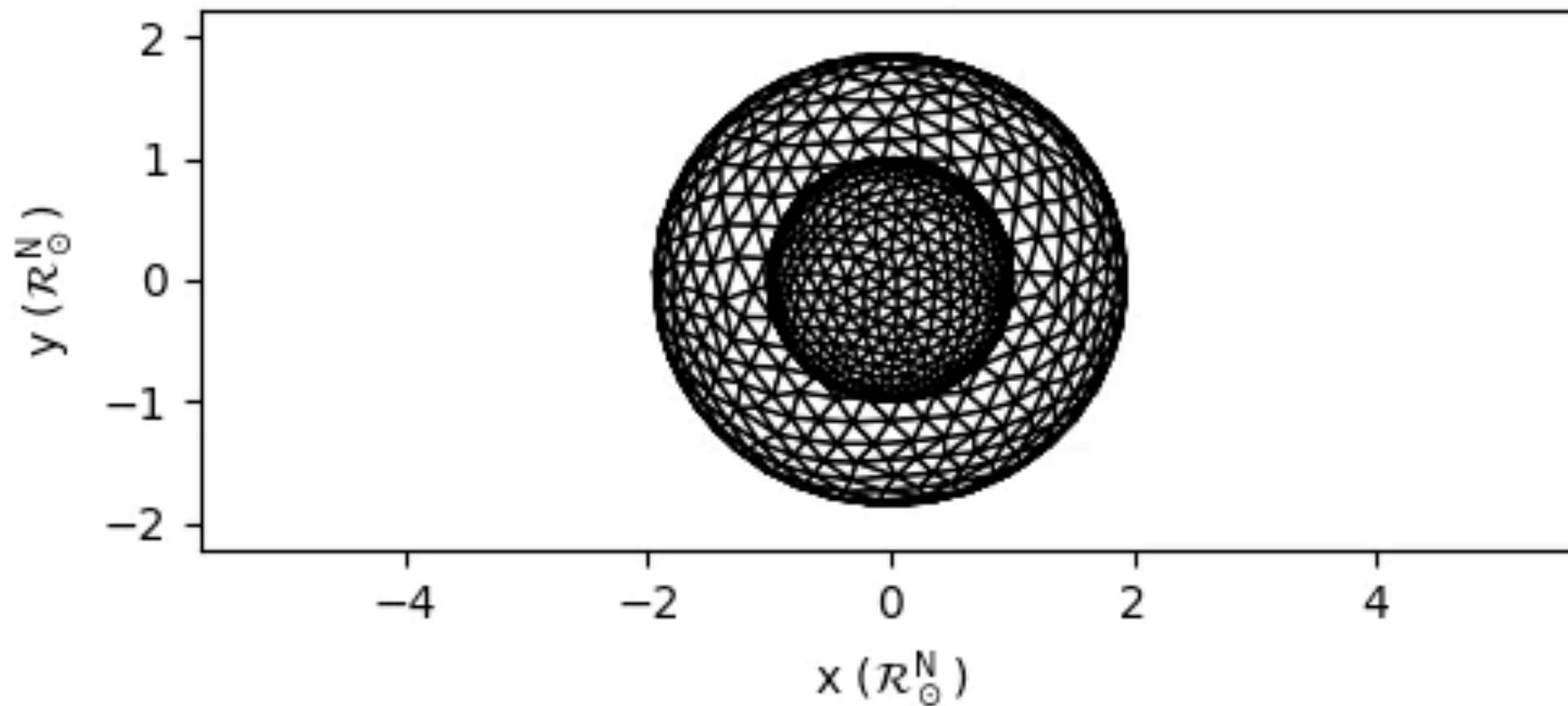
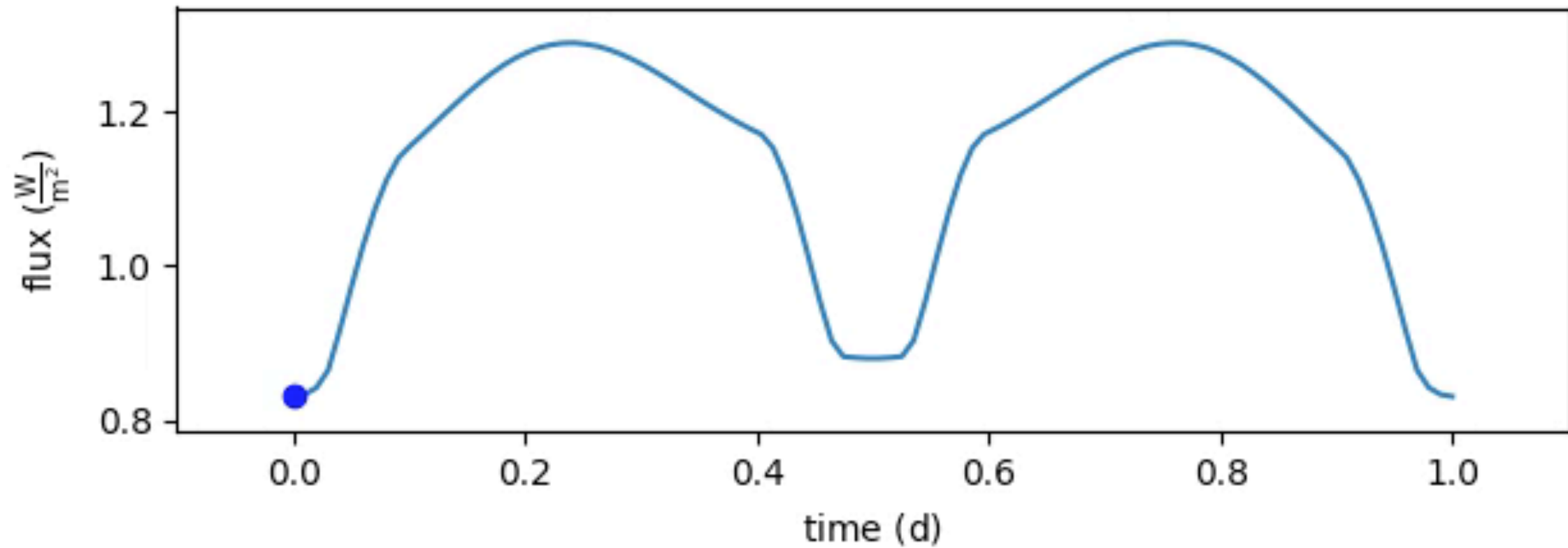
Sky position of the verification systems



Kupfer et al. 2018

- Systems are expected to follow Galactic population
- Known sample located mostly in the Northern hemisphere and at high Galactic latitudes → sample is biased and incomplete

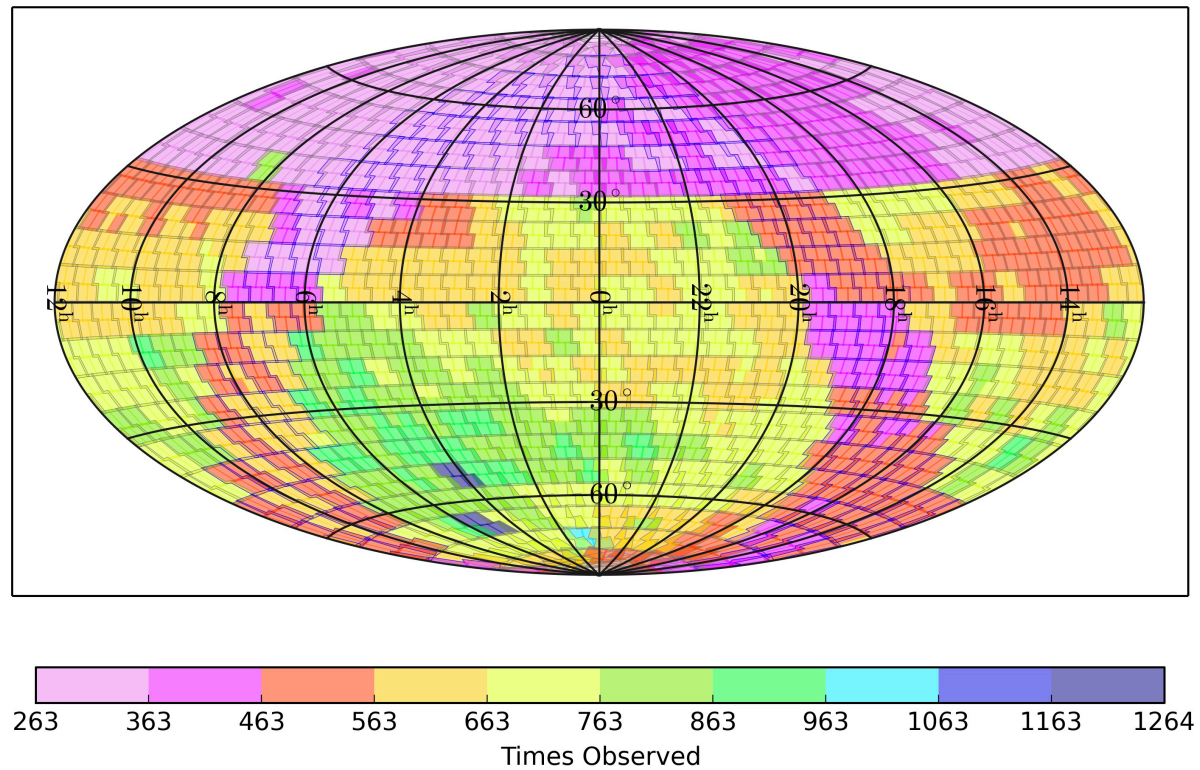
Lightcurve variability of binary stars



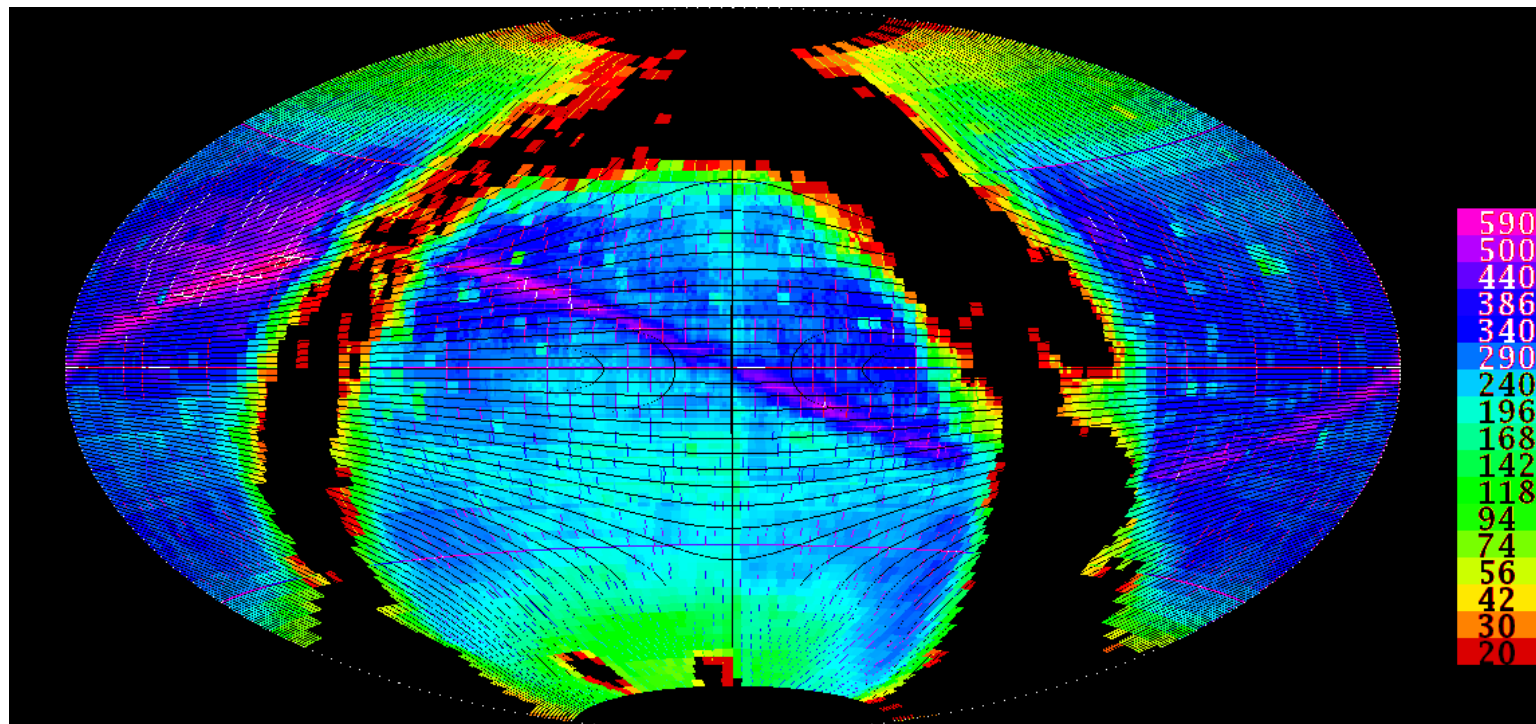
Large-scale time-domain surveys

ASASS-SN

Fri Mar 15 06:21:43 2019

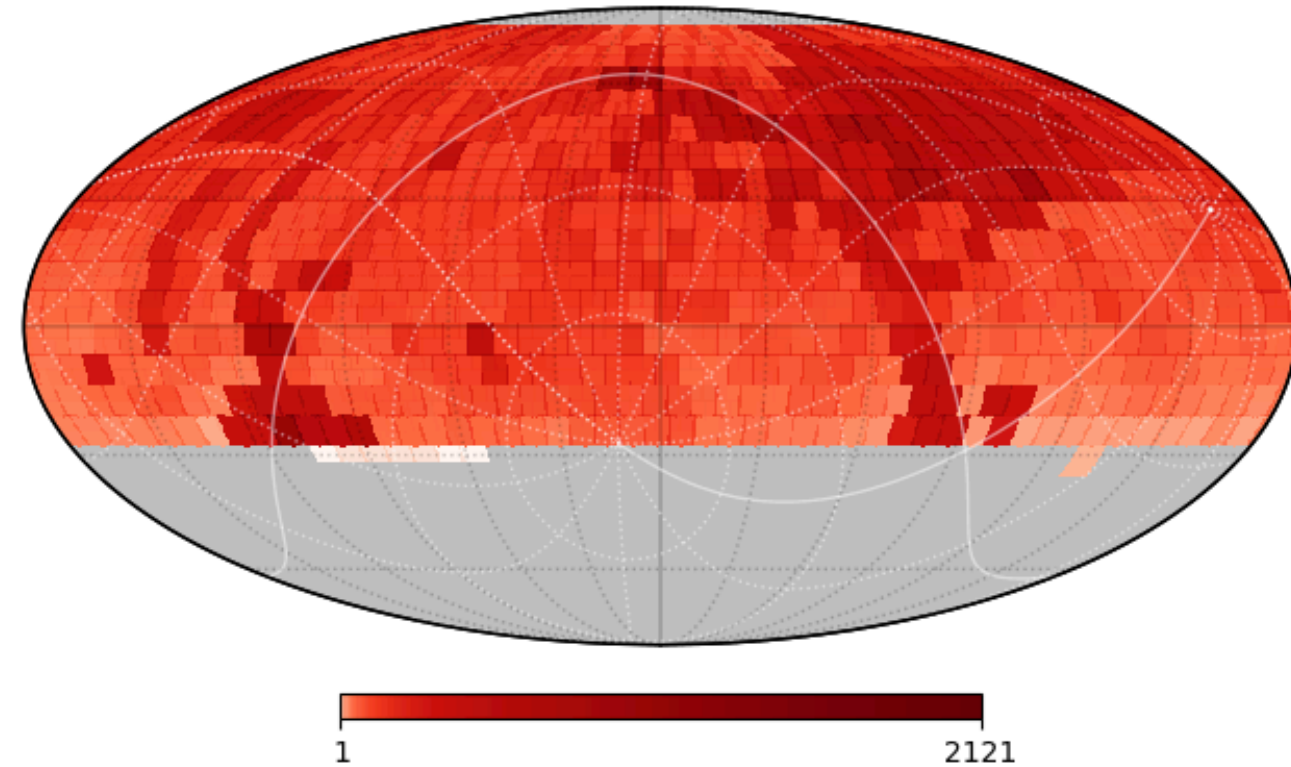


CRTS



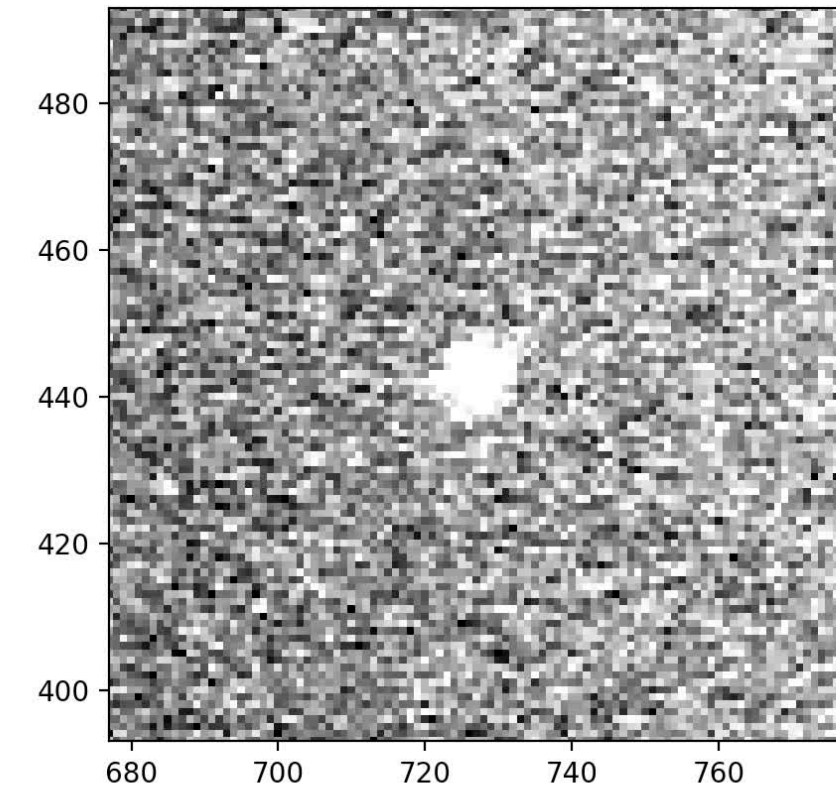
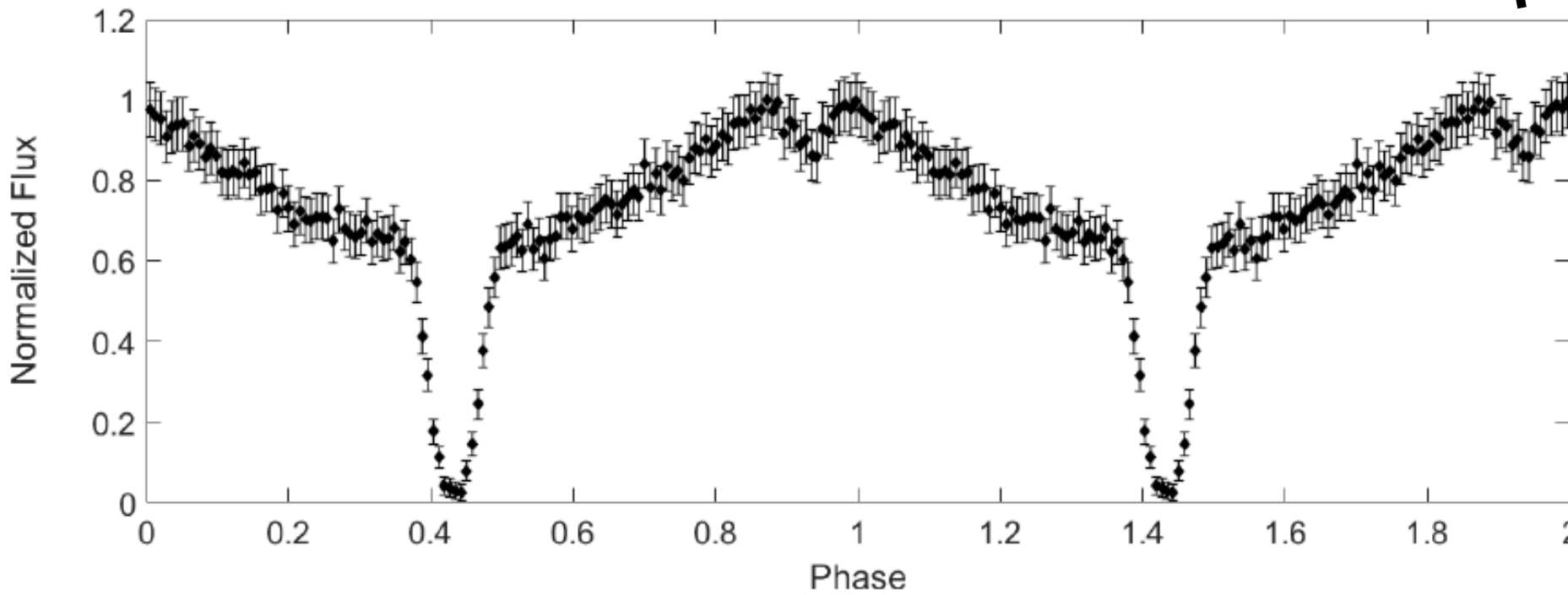
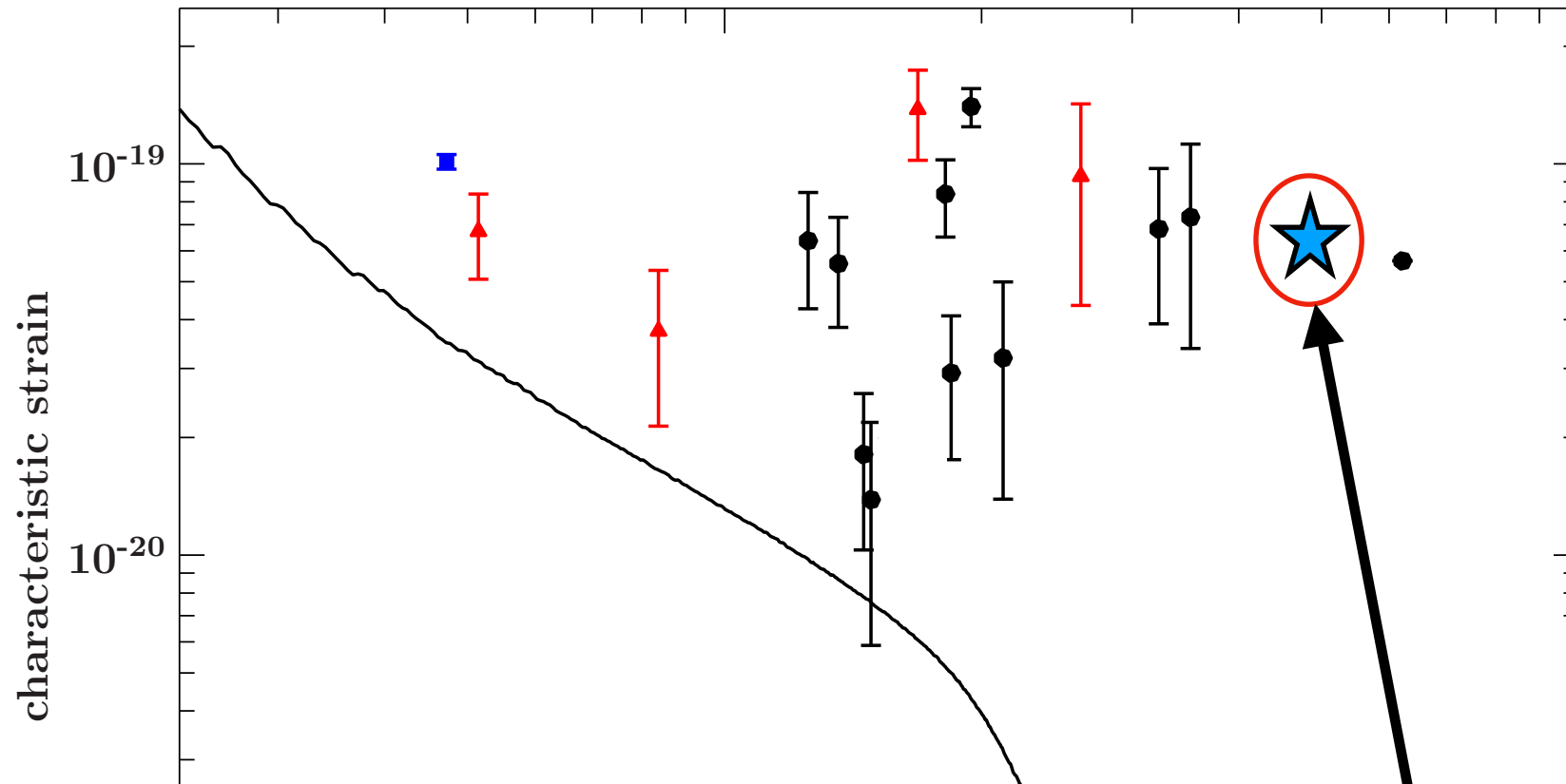
ZTF

ZTF : R : Equatorial : All Programs : Thru 2019-03-05 (252/310 Nights)



- Current time-domain surveys provide hundreds of epochs
- LSST will increase the detectable volume even more

A new verification binary from ZTF



A double white dwarf with a period of 7min

Burdge et al. submitted