Testing gravity with gravitational waves

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on behalf of the LVC

Testing Gravity, Simon Fraser University
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Three binary black hole events

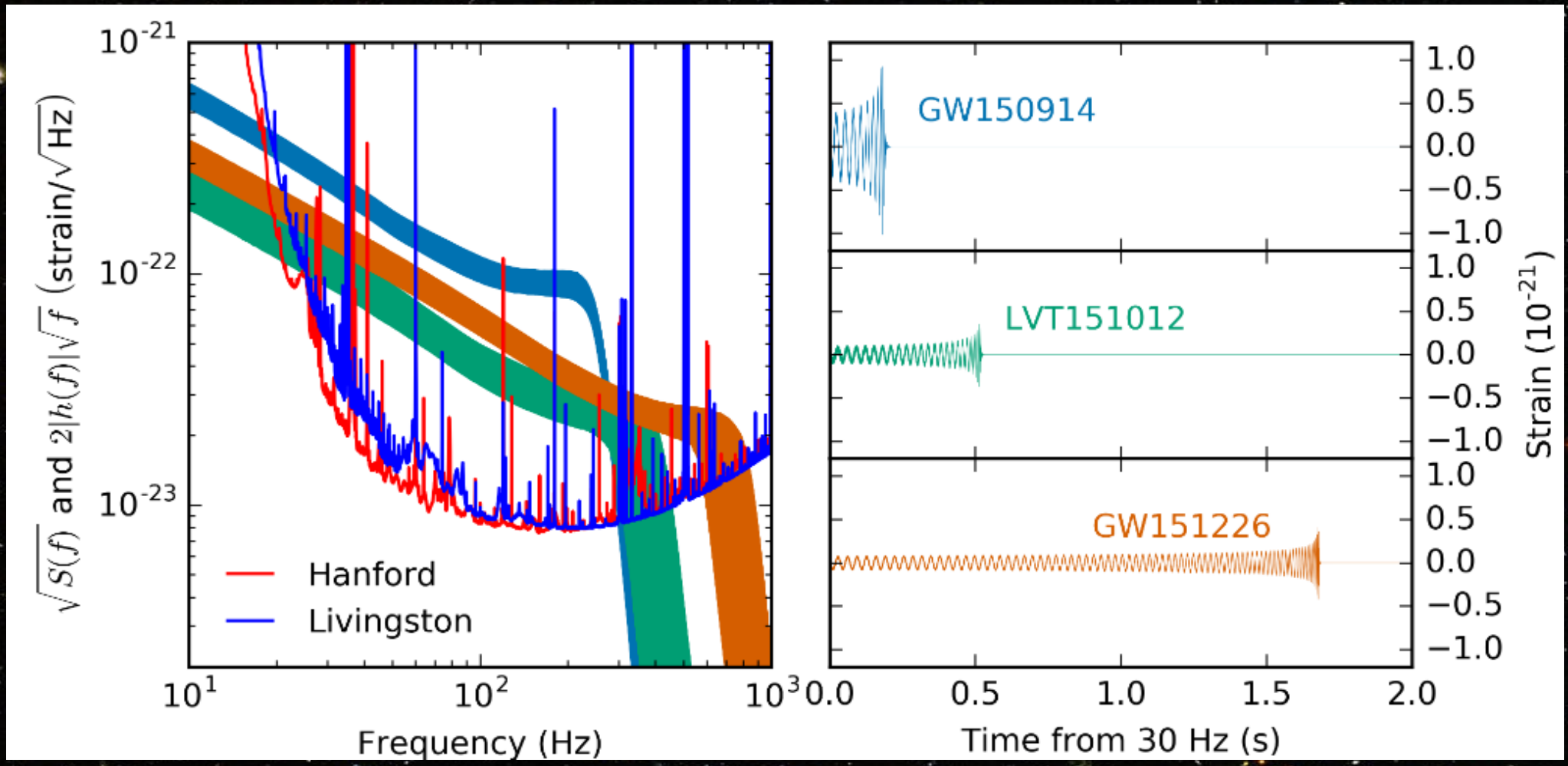


Fig 1 of LVC 1606.04856, PRX6 041015

Binary inspiral

- Quadrupole formula

$$\frac{dE_{GW}}{dt} = \frac{1}{5}\frac{G}{c^5}\frac{d^3Q_{ij}}{dt^3}\frac{d^3Q_{ij}}{dt^3}$$

- Newtonian order, chirp mass

$$f(t) = \frac{5^{3/8}}{8\pi}\left(\frac{c^3}{GM_c}\right)^{5/8}(t_0 - t)^{-3/8}$$

- Increase of frequency determined by “chirp mass”

$$M_c = \frac{(m_1 m_2)^{(3/5)}}{(m_1 + m_2)^{(1/5)}}$$

Post-Newtonian expansion (2-2 phase)

PN order	Includes (amongst other things)
0PN	Kepler Newtonian Gravity
0.5PN	Zero in GR
1PN	Pericenter advance (cf zero) PPN parameters γ, β, ξ
1.5PN	Spin-orbit couplings Gravitational tails (backscatter)
2PN	Spin-spin couplings (Newtonian) quadrupole-monopole (GR BH) (Newtonian) magnetic dipole-dipole (cf zero)
3PN	Tails of tails
5PN	(Newtonian) Adiabatic tidal deformations

Bounds on PN coefficients from GW150914 and GW151226

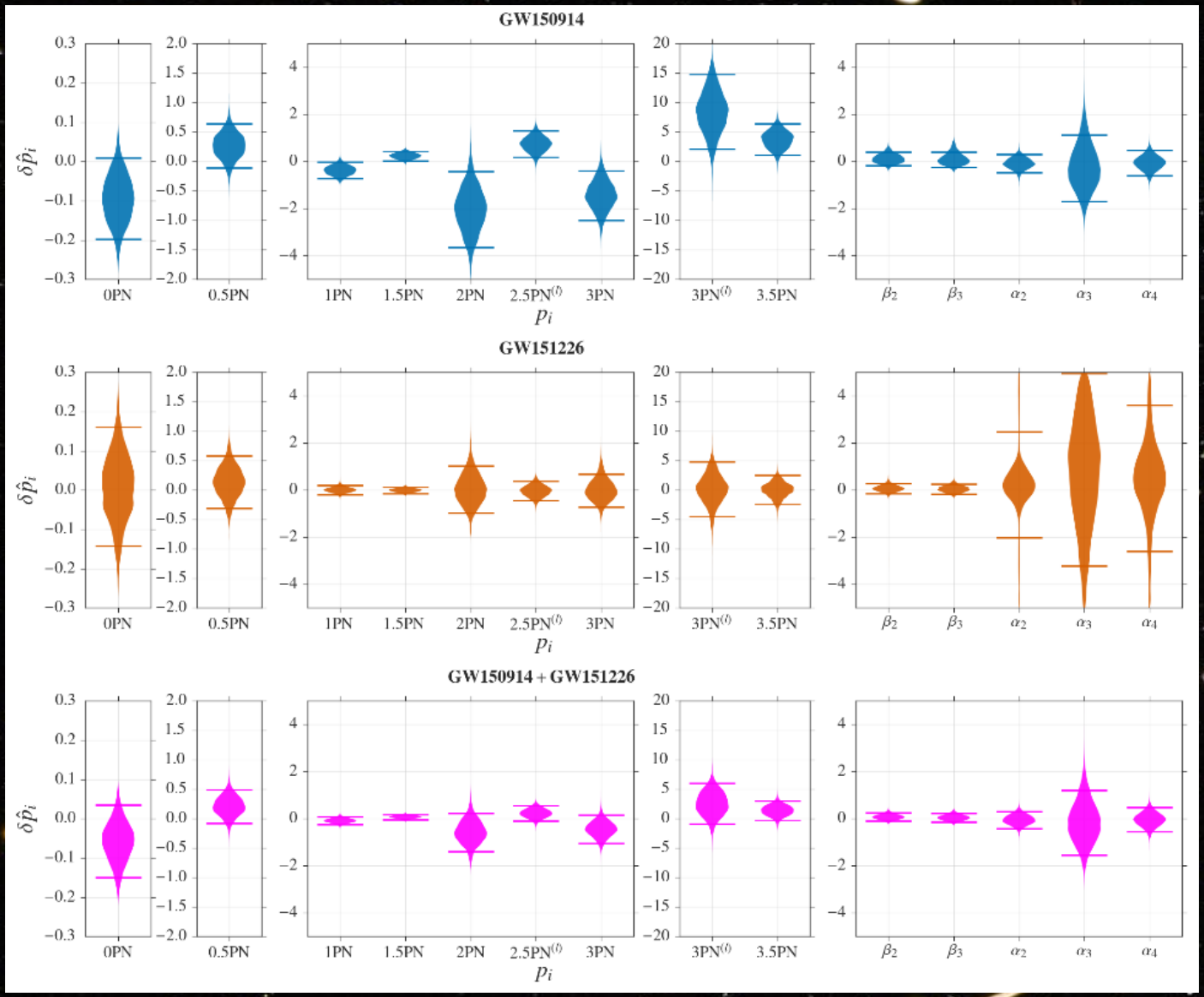


Fig 6 of LVC 1606.04856, PRX6 041015

End of PN inspiral phase

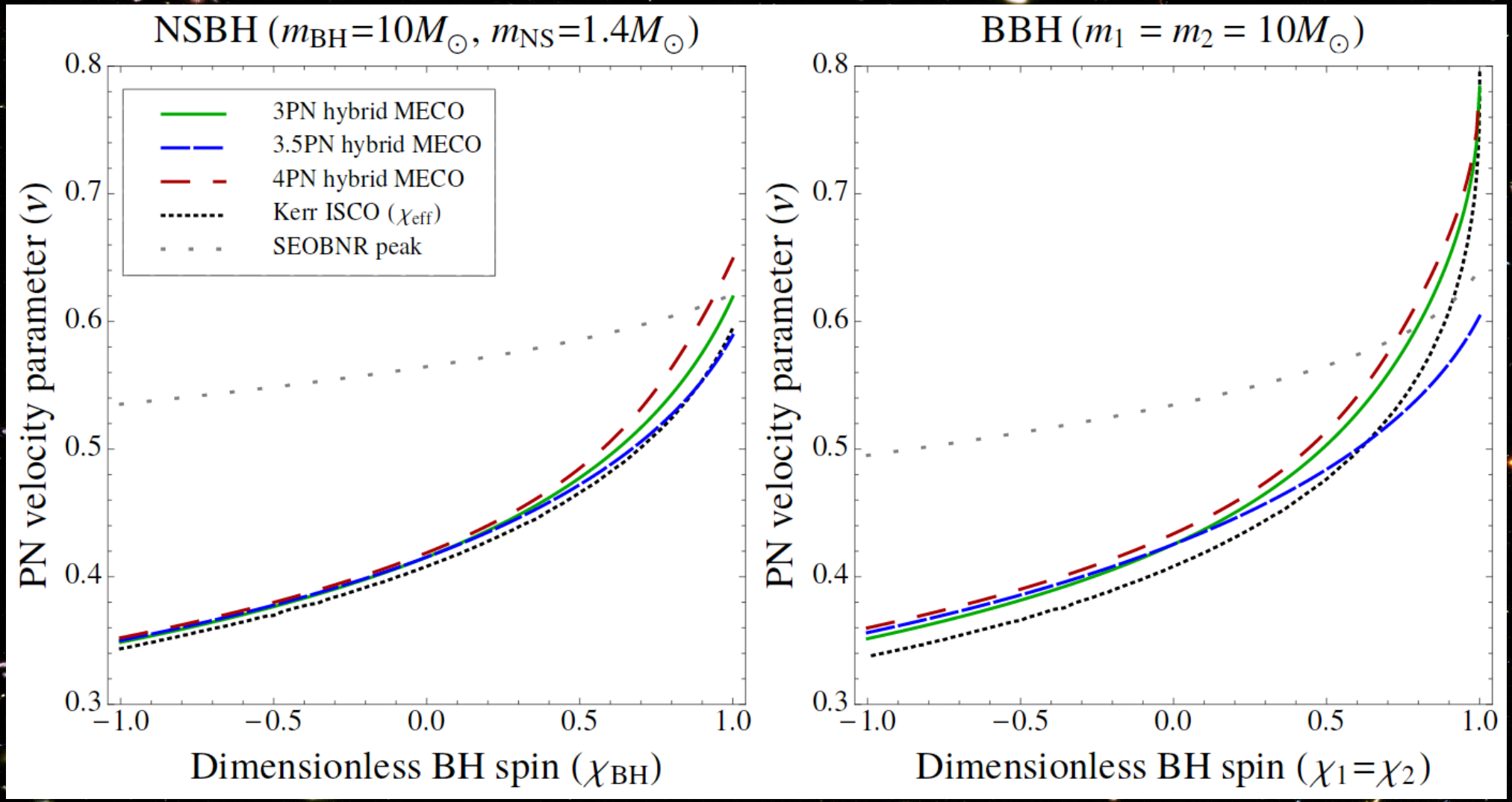


Fig 4 of Cabero et al. 1602.03134

Inspiral-merger-ringdown consistency

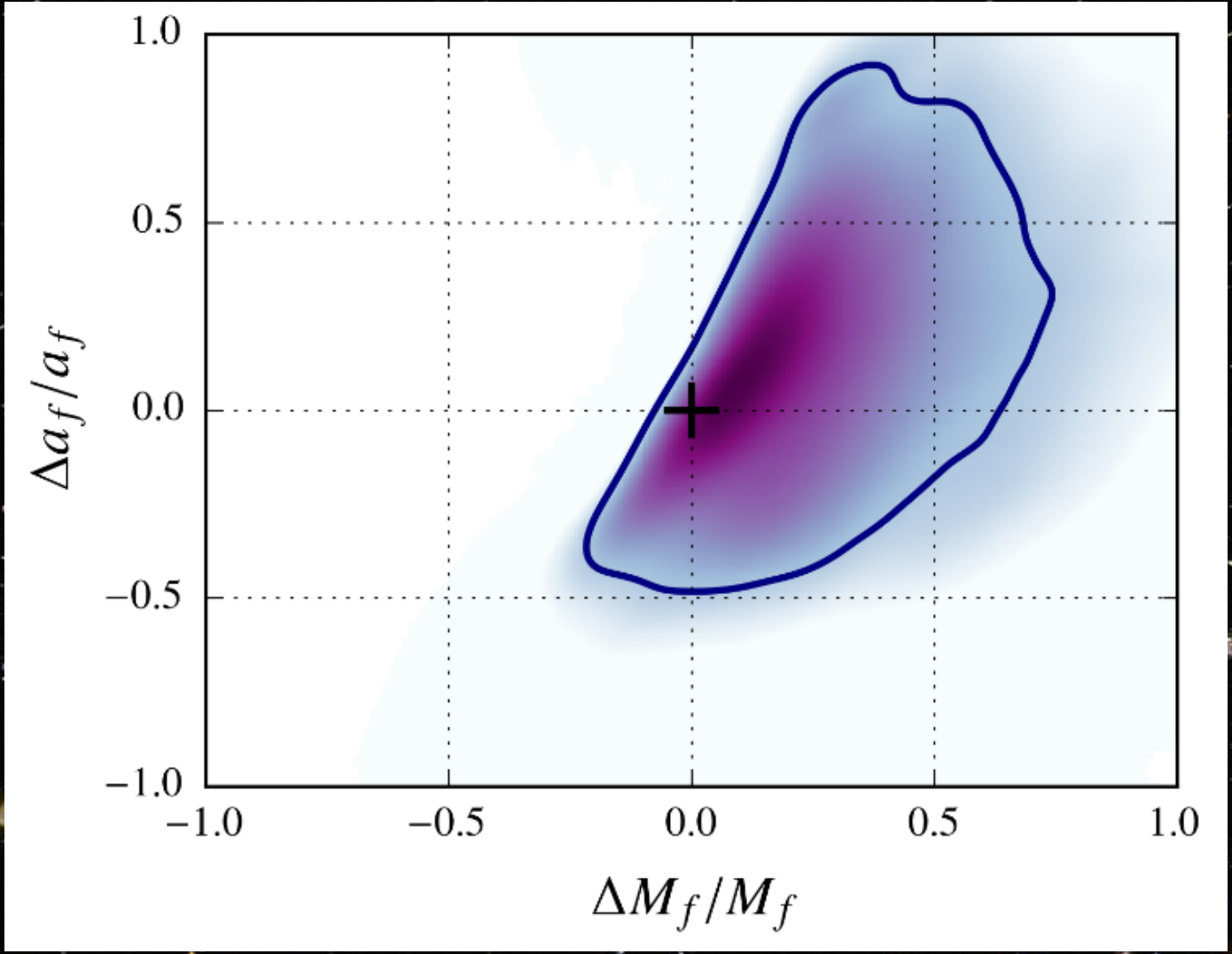
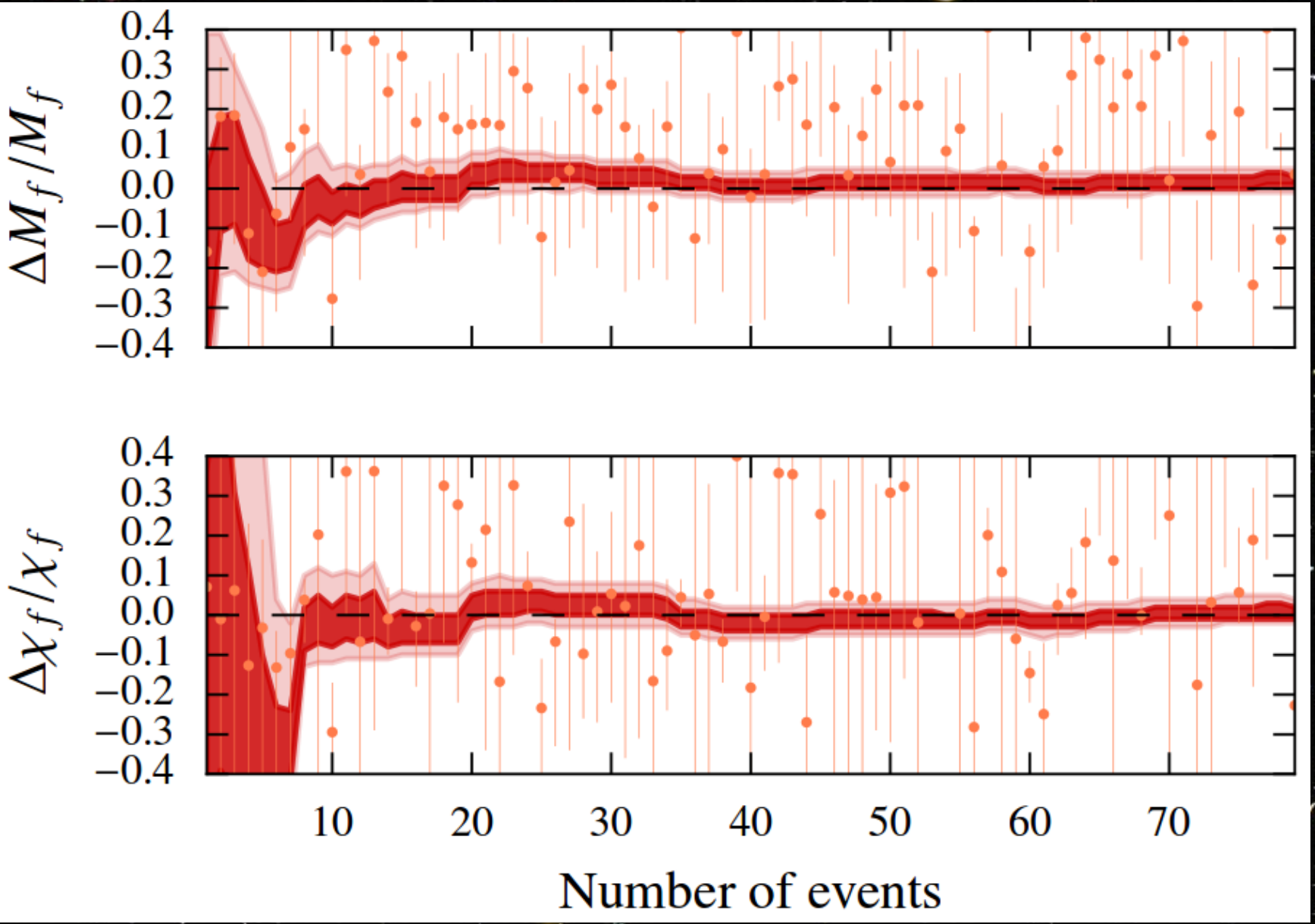


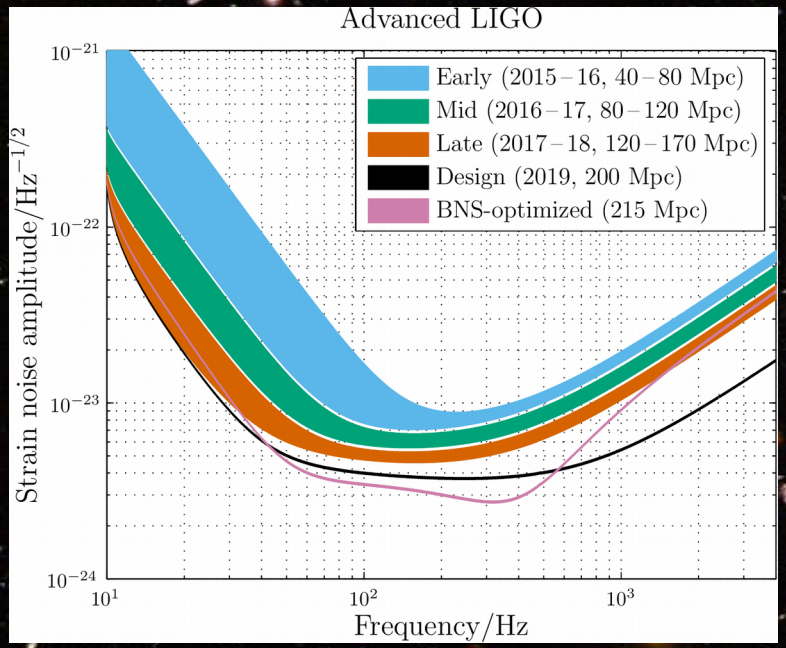
Fig. 3 (bot) of LVC 1602.03841, PRL 16 221101

IMR consistency going forward



Source: Ghosh et al 1602.02453, PRD94 021101

Event rate estimates



Multiple detections by the end of observing run O3 is quite likely

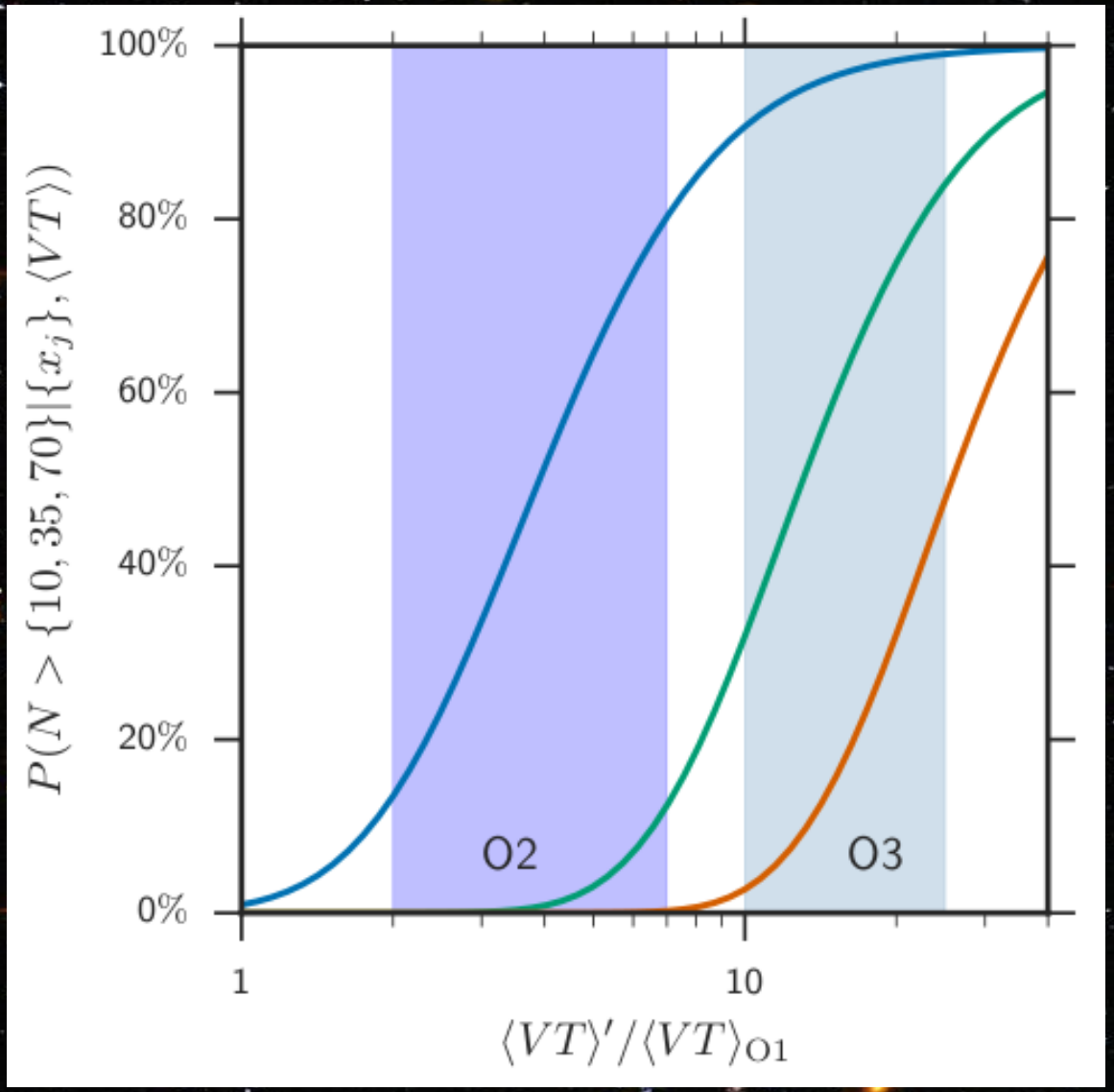


Fig 12 of LVC 1606.04856, PRX6 041015

GW150914 ringdown only

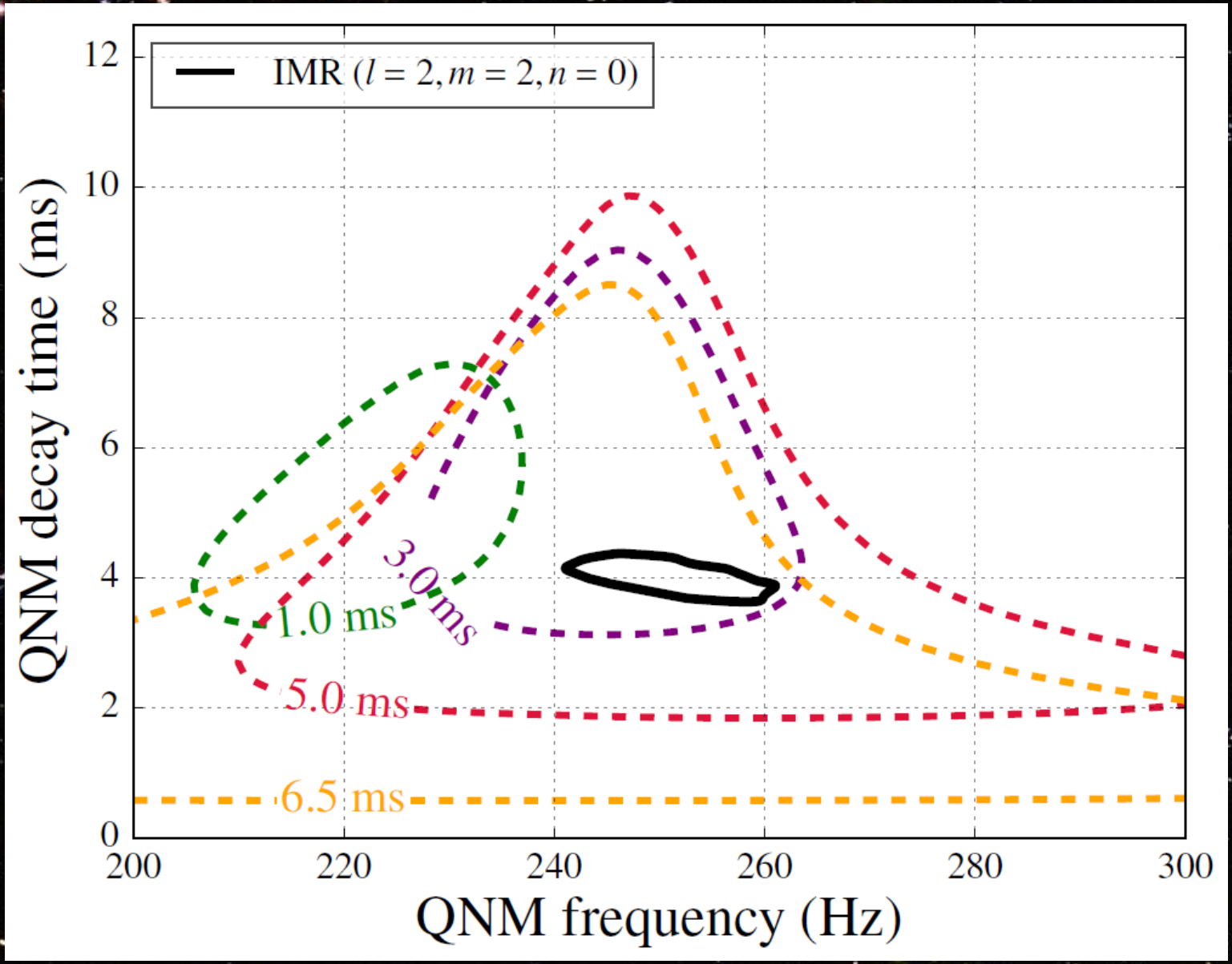
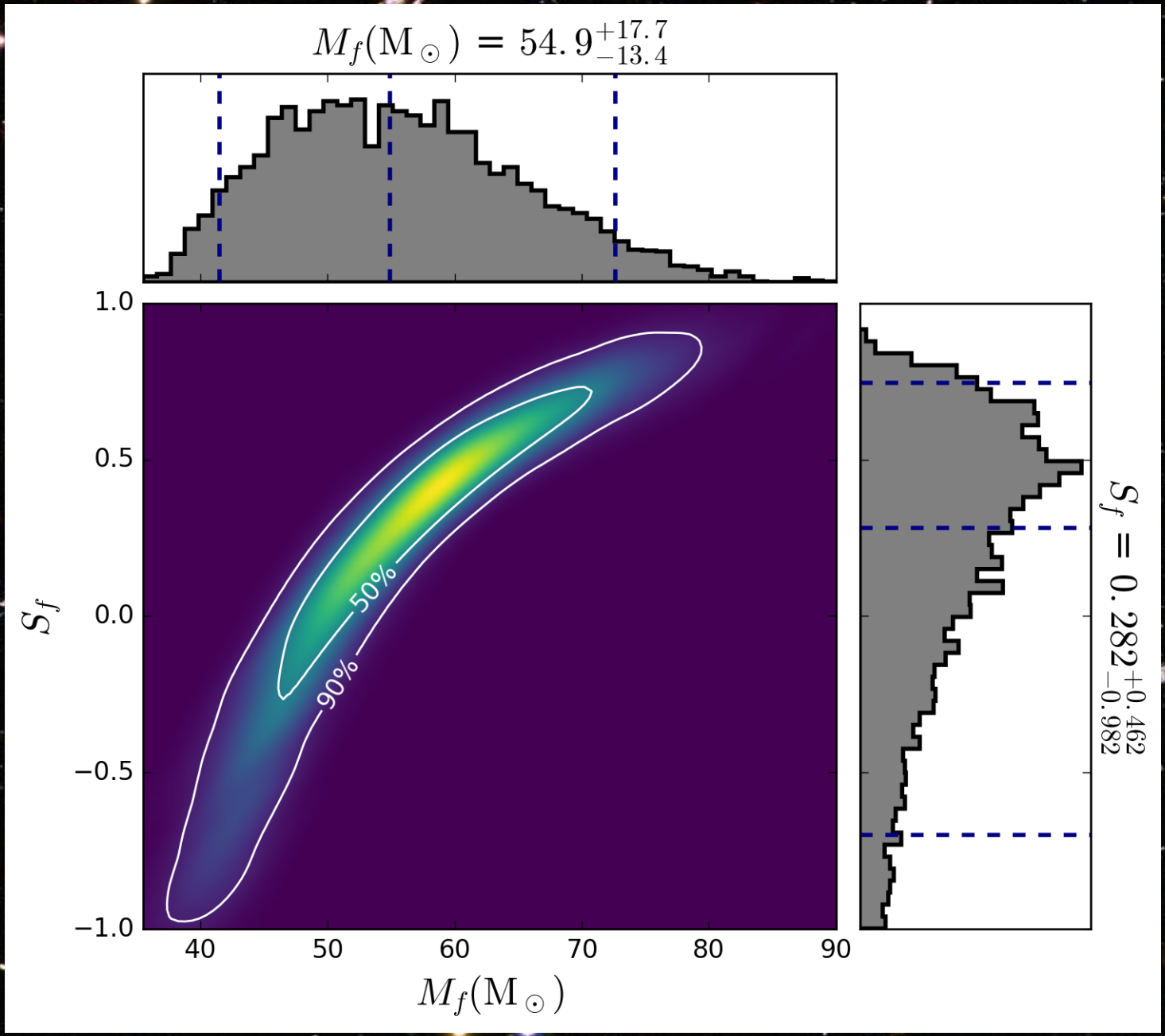


Fig 5, LVC 1602.03841, PRL116, 221101

GW150914 ringdown only




Thank you