A consistency test of GR using different multipoles of gravitational radiation from binary black holes

S. Dhanpal, Abhirup Ghosh, P. Ajith, B.S. Sathyaprakash

Testing GR Telecon, December 18, 2017

Method

- **Gravitational waveform can be decomposed into the two independent polarisations:**

$$\mathrm{h}(t) := \mathrm{h}_+(t) - i\mathrm{h}_\times(t)$$

- **Alternatively, expand in a basis of spin -2 weighted spherical harmonics:**

$$\mathrm{h}(t; \iota, \phi_0, \lambda) = \sum_{l=2}^{\infty} \sum_{m=-l}^{l} \mathcal{Y}_{lm}^{-2}(\iota, \phi_0)\mathrm{h}_{lm}(t, \lambda)$$

$$\lambda = \{M_c, q, t_0, d_L\}$$

- **Split contributions from dominant (2, \pm2) modes, and the subdominant higher-order multipole moments:**

$$\mathrm{h}(t; \iota, \phi_0, \lambda) = \mathcal{Y}_{2,\pm2}^{-2}(\iota, \phi_0)\mathrm{h}_{2,\pm2}(t, \lambda) + \sum_{\mathrm{H.O.M}} \mathcal{Y}_{lm}^{-2}(\iota, \phi_0)\mathrm{h}_{lm}(t, \lambda)$$

Method

- **The Test: Check for consistency between estimates of λ, independently measured using the dominant and the sub-dominant modes of the gravitational waveform respectively:**

$$h(t; \iota, \phi_0, \lambda, \lambda') = \mathcal{Y}_{2,\pm 2}^{-2}(\iota, \phi_0)h_{2,\pm 2}(t, \lambda) + \sum_{\mathrm{H.O.M}} \mathcal{Y}_{lm}^{-2}(\iota, \phi_0)h_{lm}(t, \lambda')$$

    λ: PE estimates using dominant (2, \pm 2) modes
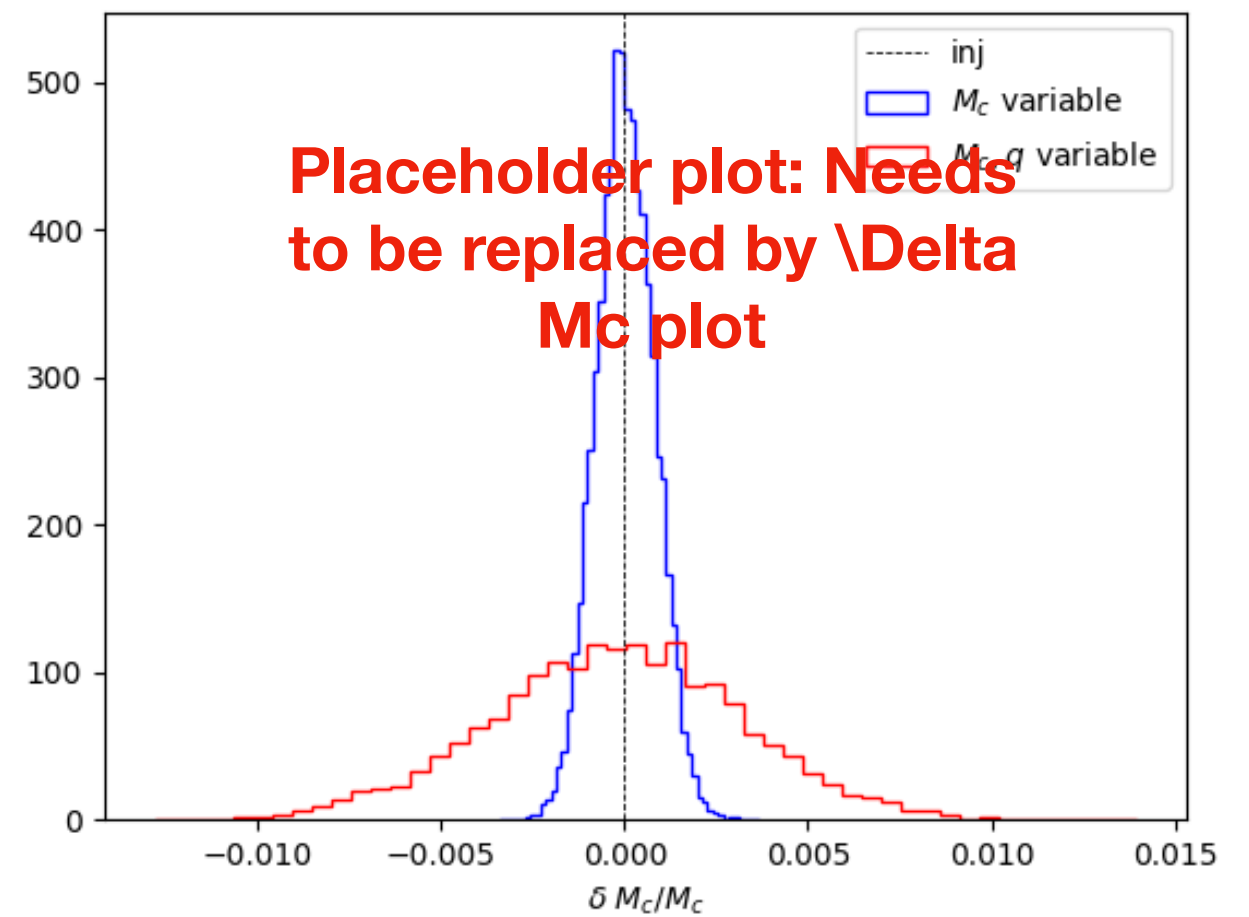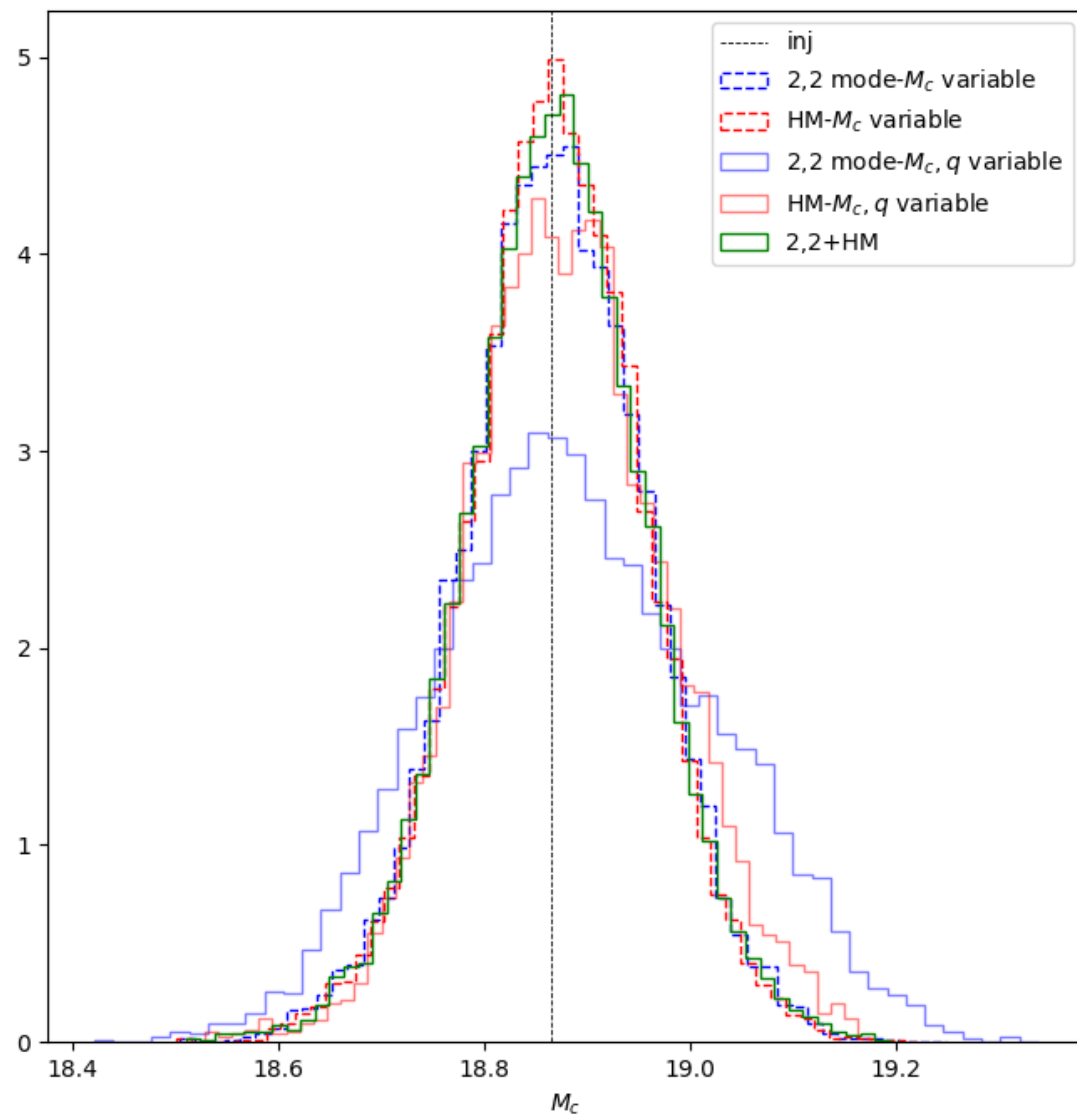   **λ': PE estimates using subdominant higher-order modes**

- **If GR is correct, these two independent estimates would be consistent with each other.**

- **Alternatively define: λ' = λ + Δλ**

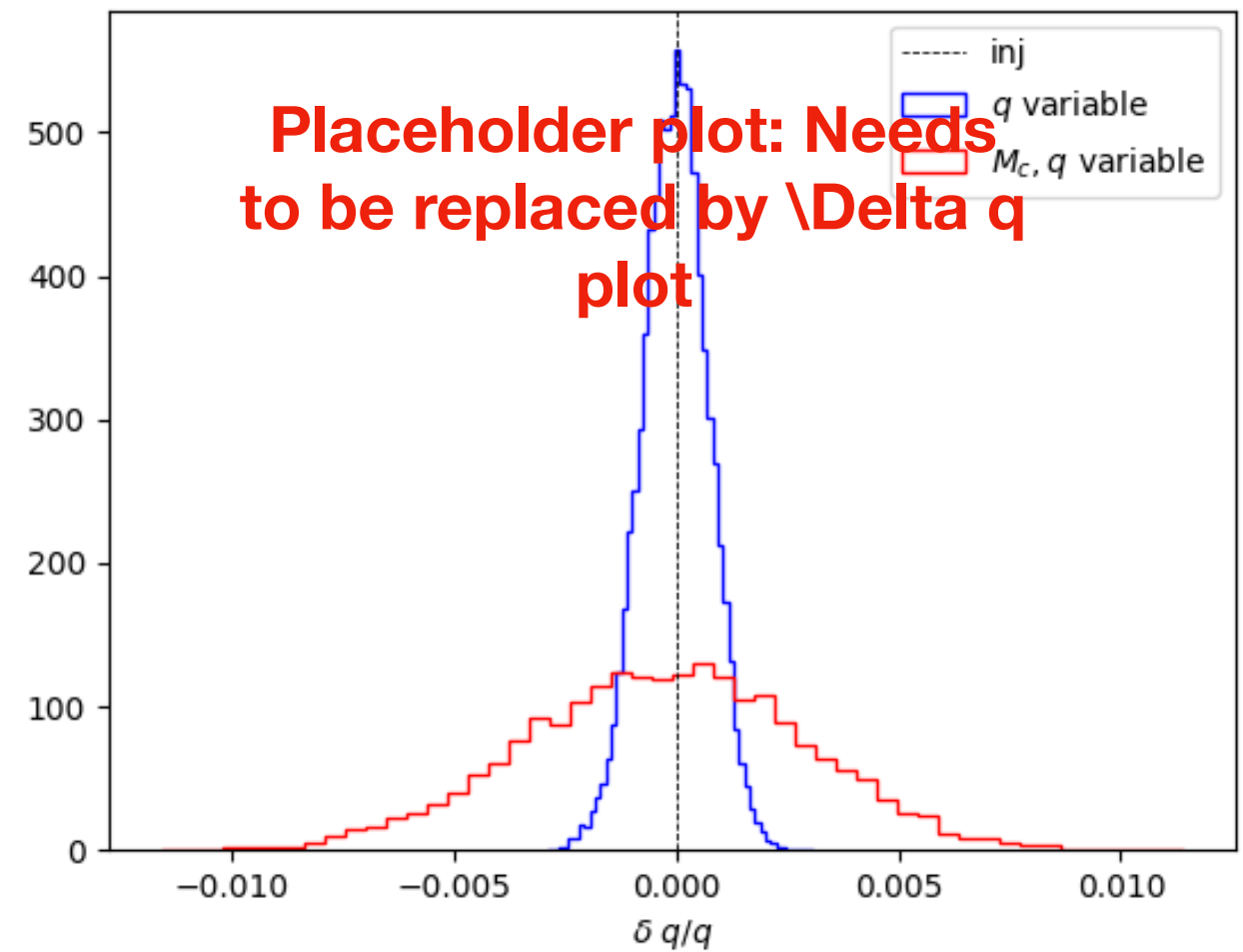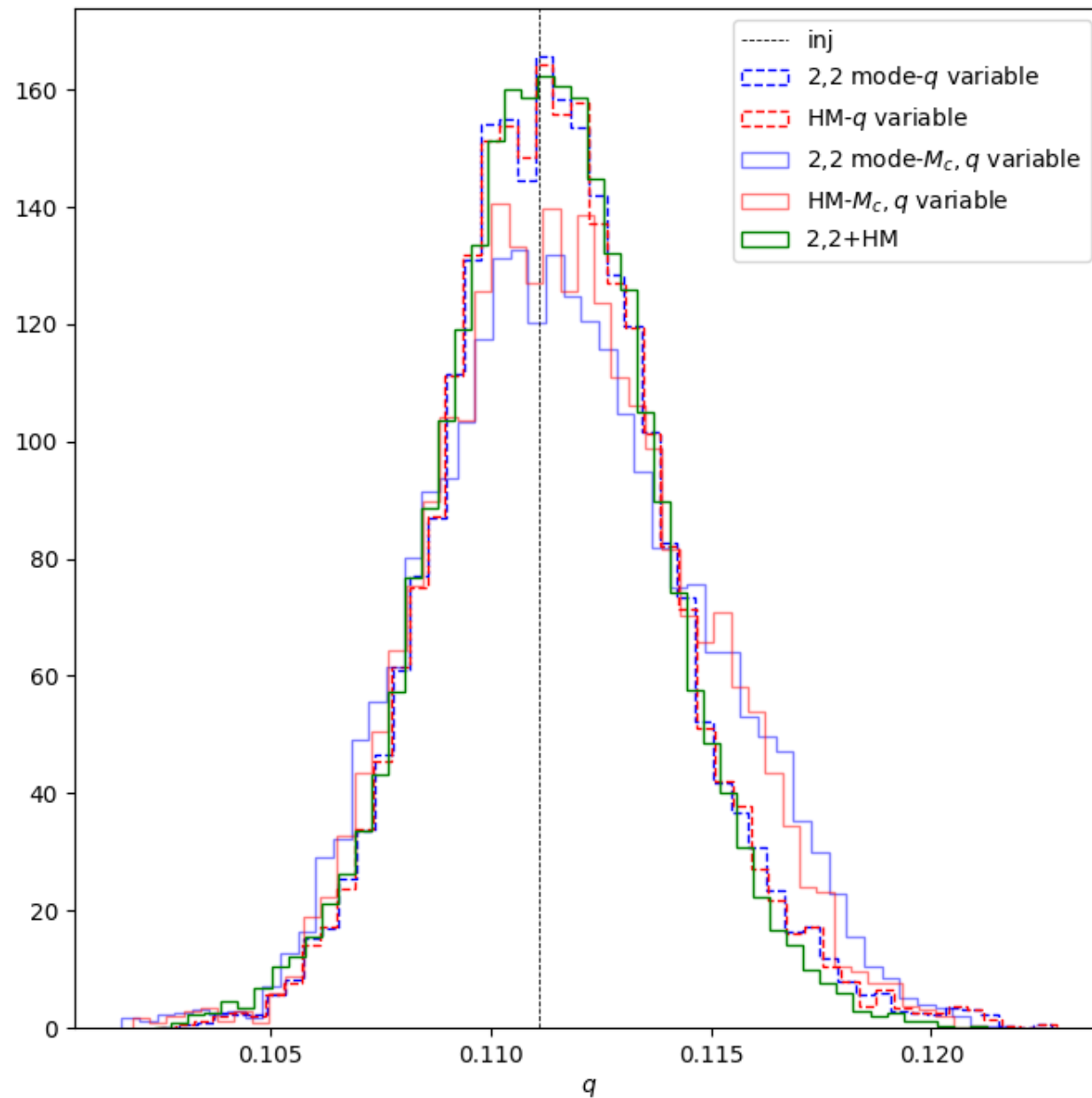- **If GR is correct p(Δλ) should be consistent with 0.**

3

Results

- Analysis:
  - Single IFO PE over $\lambda = \{Mc, q\}$
  - Fixed SNR = 25 (optimally oriented on the sky)
  - Waveform model: higher-order IMR model described in Mehta et al (arxiv:1708.03501, accepted in PRD)
  - Noise PSD: Advanced LIGO ZDHP noise

Results: Posteriors of Mc and ΔMc

Results: Posteriors of q and Δq

Results