Gravitational-wave Inference with Marginalization over Waveform Uncertainty

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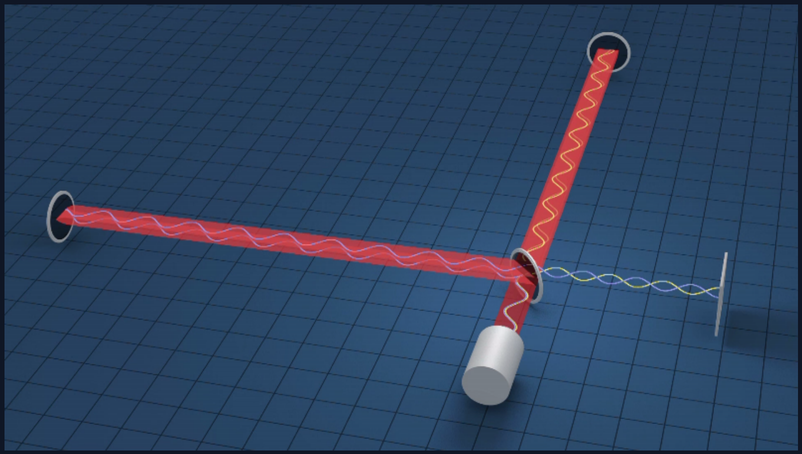
Introduction

- Gravitational wave predicted by Einstein’s General Theory of Relativity
- Astrophysical sources
  - Compact binary mergers: BBH, BNS, BHNS etc
  - Continuous wave



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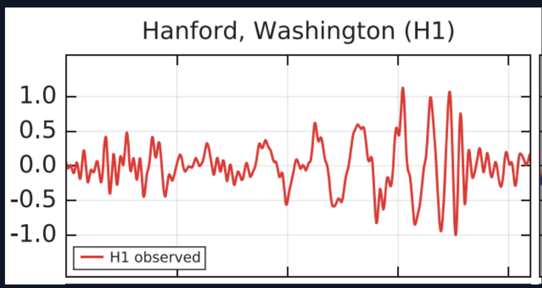
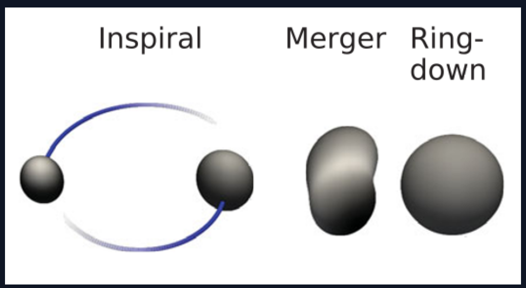
Parameter Estimation



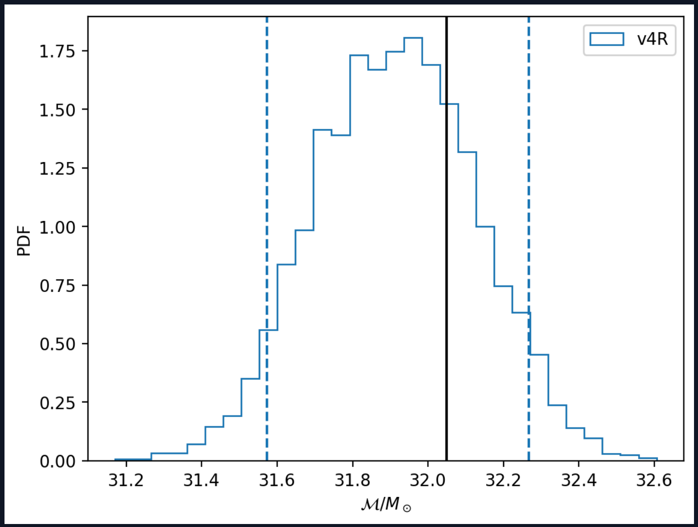
Bayesian

Inference



$$p(\vec{\theta}\,|\,d) = \frac{\mathscr{L}(d\,|\,\vec{\theta})\,p(\vec{\theta})}{p(d)}$$

BBH Parameters θ



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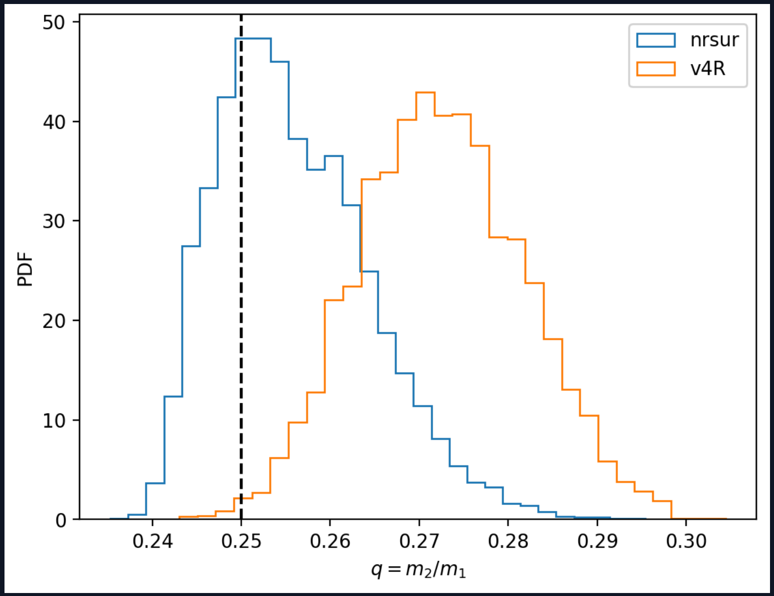
Uncertainty in PE

- Accurate waveform models based on numerical relativity simulation
- Approximate models - much faster but more generic than NR
- Statistical Error > Systematic Error
- Therefore systematic error may dominate over statistical errors for loud events



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Incorporating Uncertainty in WF model

- Goal: Incorporate uncertainty in waveform mode into parameter estimation
- Approximate model: SEOBNRv4_ROM
- Calibration Error (CE) model: SEOBNRv4CE and SEOBNRv4CE0

$$\tilde{h} = [1 + \delta A(f)]\, e^{i\delta\phi(f)} \times \tilde{h}_{\mathrm{SEOBNRv4}}$$

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PE with Synthetic BBH Signal

- Injection waveform using NRHybSur3dq8
- PE is done using bilby and dynesty
- Recovered with various model:
  - NRHybSur3dq8
  - SEOBNRv4_ROM
  - SEOBNRv4CE
  - SEOBNRv4CE0

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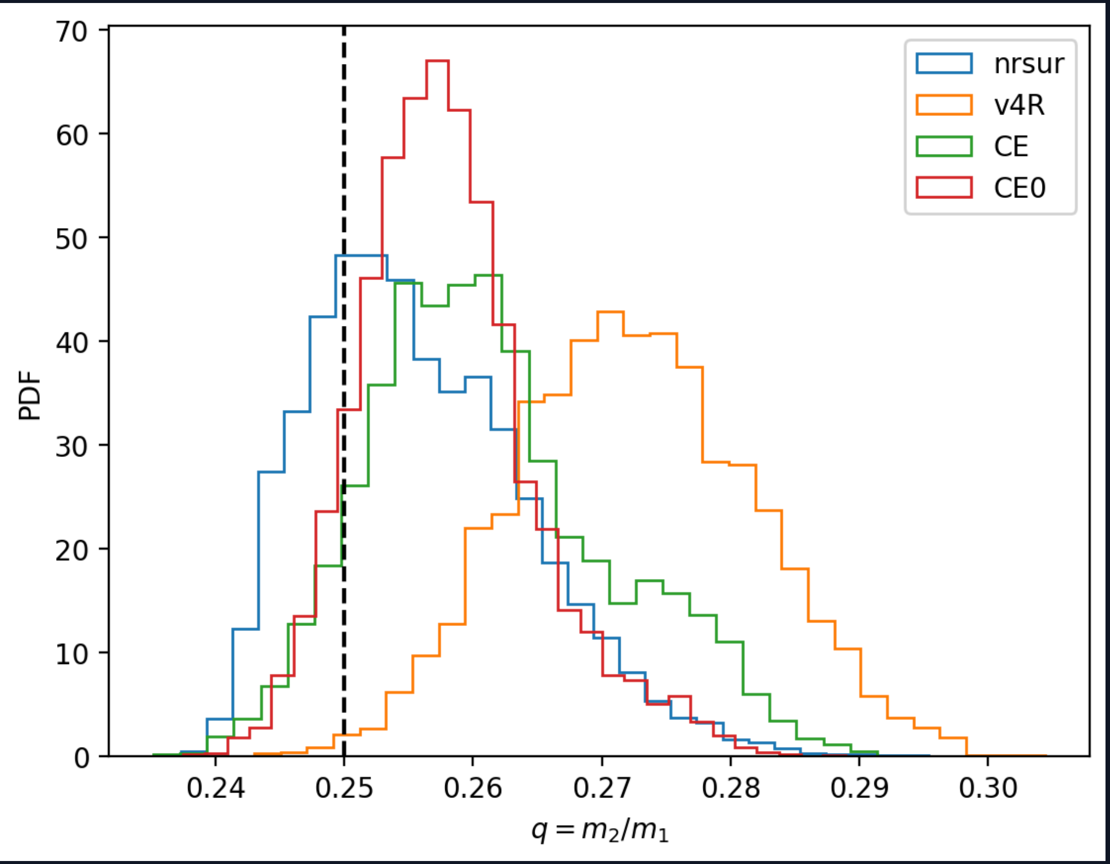
Posterior Distribution



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Topics Learned

- Bayesian inference tool: bilby
- Design shell script to submit job on HPC cluster
- Understand waveform uncertainty model develop the code further
    - Extended python script and added mode useful features
- Parameter estimation of gravitational wave events
- Analysis of posterior distribution in jupyter notebook

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Future Work

- Unexpected behavior of the model in few cases
- Perform PE for a range of signal-to-noise ratios
- Compliment bilby PE results with Dingo code

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Publications/Contributions

- We will discuss the result of the study and extension in upcoming publication
- Shell script and python code as a part of this project are committed to github repository which will be made available upon publication of the study

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