# Parameter Estimation for Low-Mass Eccentric Binary Black Holes

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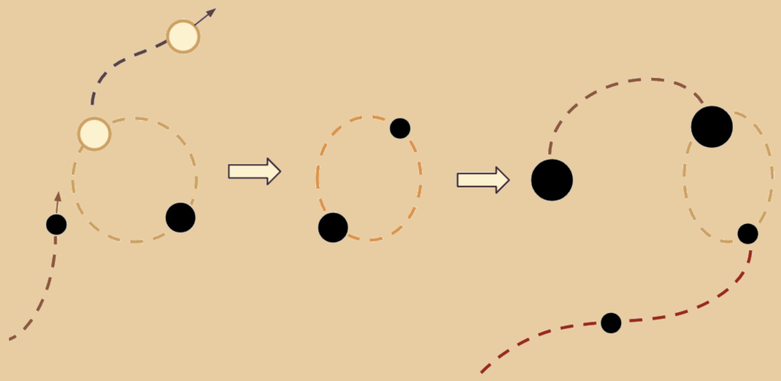
## CASE FILE

We examine the possibility of **dynamically formed compact binaries** by scrutinizing modulations encoded in gravitational wave signals. Leveraging currently available tools, our investigation focuses on eccentricity as key evidence for this alternate formation channel. In order to succeed, we must examine our ability to decode the distinctive signatures left behind by these binaries.



## SUSPECT

### Low-Mass Binary Black Holes

- More waveform cycles in LIGO band
- RIFT suited to higher computational expense
- parameter ranges:

| Parameter | Symbol | Prior | Injected Range |
|---|---|---|---|
| Chirp Mass | $\mathcal{M}_{\rm ch}$ | uniform in $m_i$ | $[10-20]M_\odot$ |
| Distance | $d$ | $\propto d_L^2$ | $[500-1000]$ Mpc |
| Eccentricity | $e_0$ | uniform | $[0.01, 0.1]$ |
| Spin | $\chi_{\rm eff}$ | uniform | $[-0.5, 0.5]$ |
| Inclination | $i$ | uniform | $[0.0, \pi]$ |

## TOOLS

### RIFT

**R**apid parameter inference on gravitational wave sources via **I**terative **F**it**T**ing

**Initial Grid**

**Integrate Likelihood Extrinsic**

- compute marginalized likelihood
- dithering

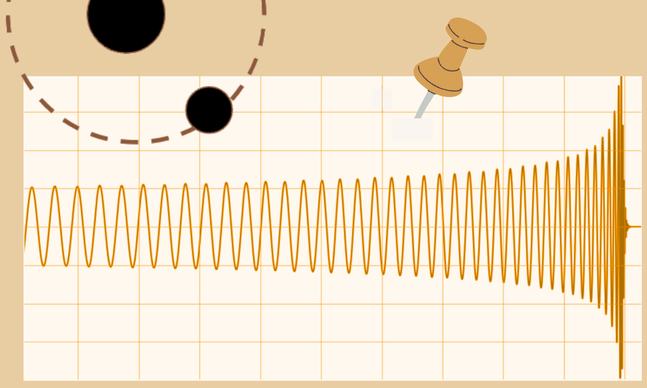
**Construct Intrinsic Posterior**

- fit marginalized likelihood
- construct posterior
- fairdraw samples

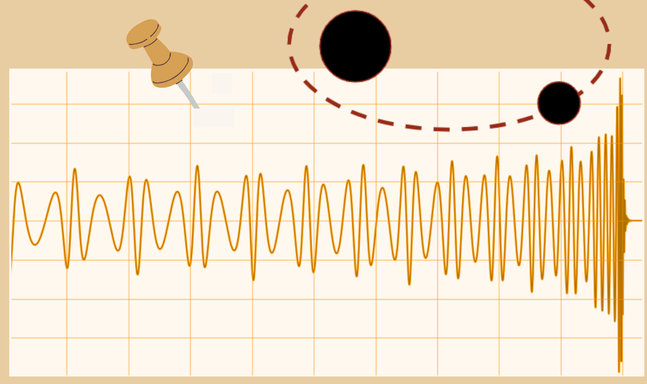
**Converged or Repeat**

## CLUES

Eccentricity creates a distinctive signature in gravitational waveforms



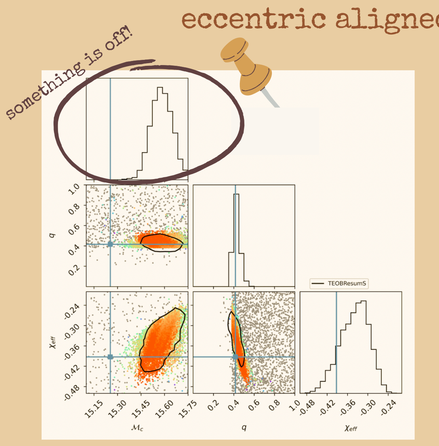
e = 0.0



e = 0.5

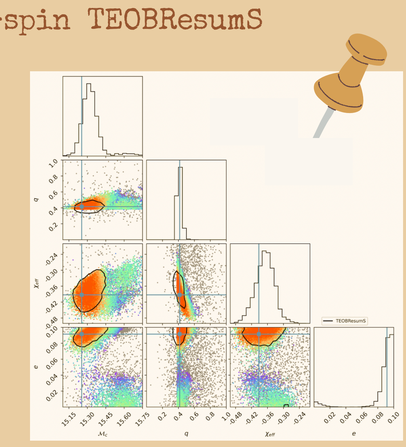
## TRIAL & EVIDENCE

### eccentric aligned-spin TEOBResumS



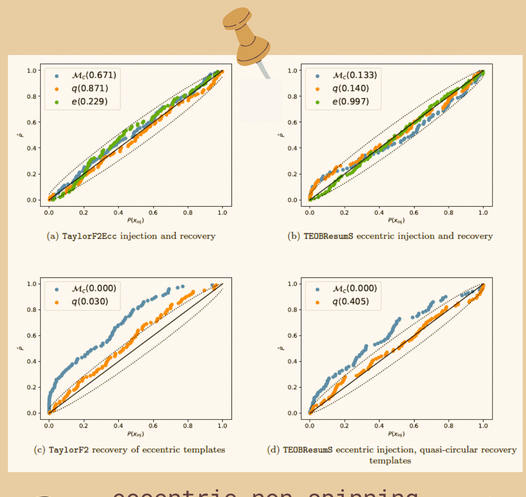

non-eccentric recovery

Note: blue crosshairs indicate true injected parameter values




eccentric recovery

Note: color scale indicates log-likelihood values, where gray points fall below cutoff




(a) TaylorF2Ecc injection and recovery
(b) TEOBResumS eccentric injection and recovery
(c) TaylorF2 recovery of eccentric templates
(d) TEOBResumS eccentric injection, quasi-circular recovery templates

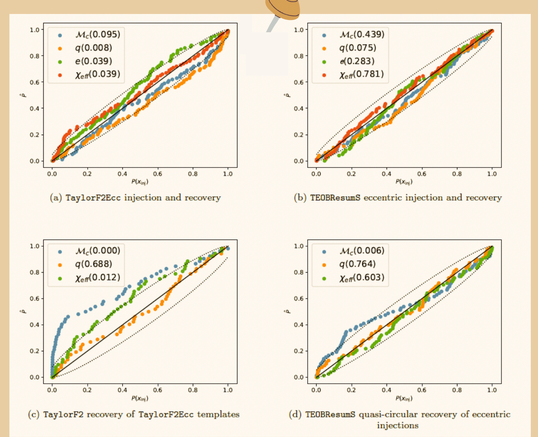
### eccentric non-spinning

Note: diagonal probability-probability plots indicate the injected and recovered distributions match.

### PP tests: injection & recovery

{sets of 100 signals}

waveform models: TaylorF2Ecc & TEOBResumS




(a) TaylorF2Ecc injection and recovery
(b) TEOBResumS eccentric injection and recovery
(c) TaylorF2 recovery of TaylorF2Ecc templates
(d) TEOBResumS quasi-circular recovery of eccentric injections

### eccentric aligned-spin

## VERDICT

1. eccentricity **must** be included in PE
2. RIFT can measure both the **presence** and the **value** of eccentricity

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