

# Evidence for eccentricity in the population of binary black holes observed by LIGO-Virgo-KAGRA

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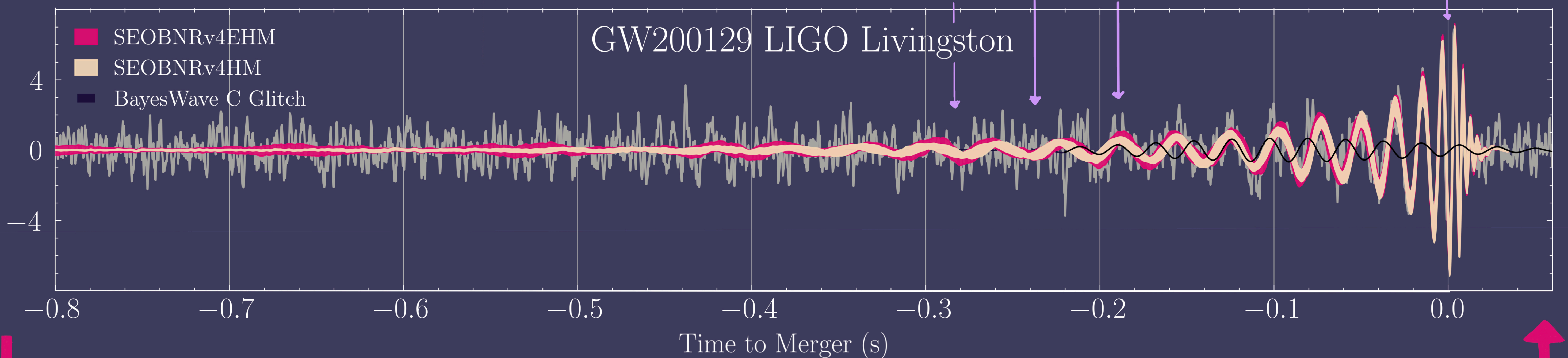
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Motivation: how does eccentricity look?

We use the “effective-one-body”, SEOBNRv4EHM, waveform model which includes aligned (anti aligned) spins, higher modes, eccentricity and the relativistic anomaly.<sup>7,8</sup>

The amplitude modulations are due to periastron passages.



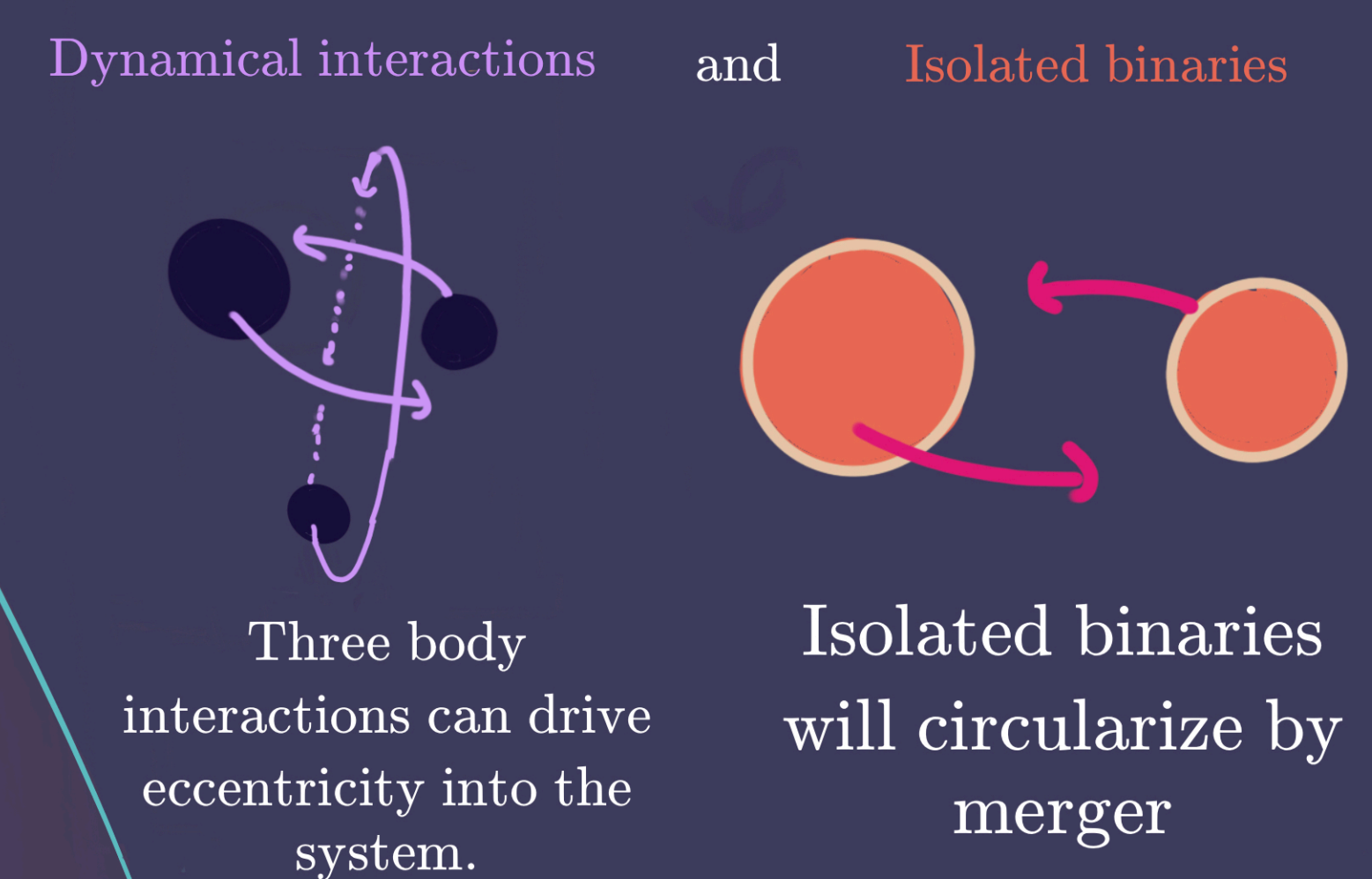
## Methods: DINGO

We analyze 57 events with the machine-learning code DINGO. This offers a 2-3 order of magnitude speed-up making this large scale analysis possible.<sup>1</sup>

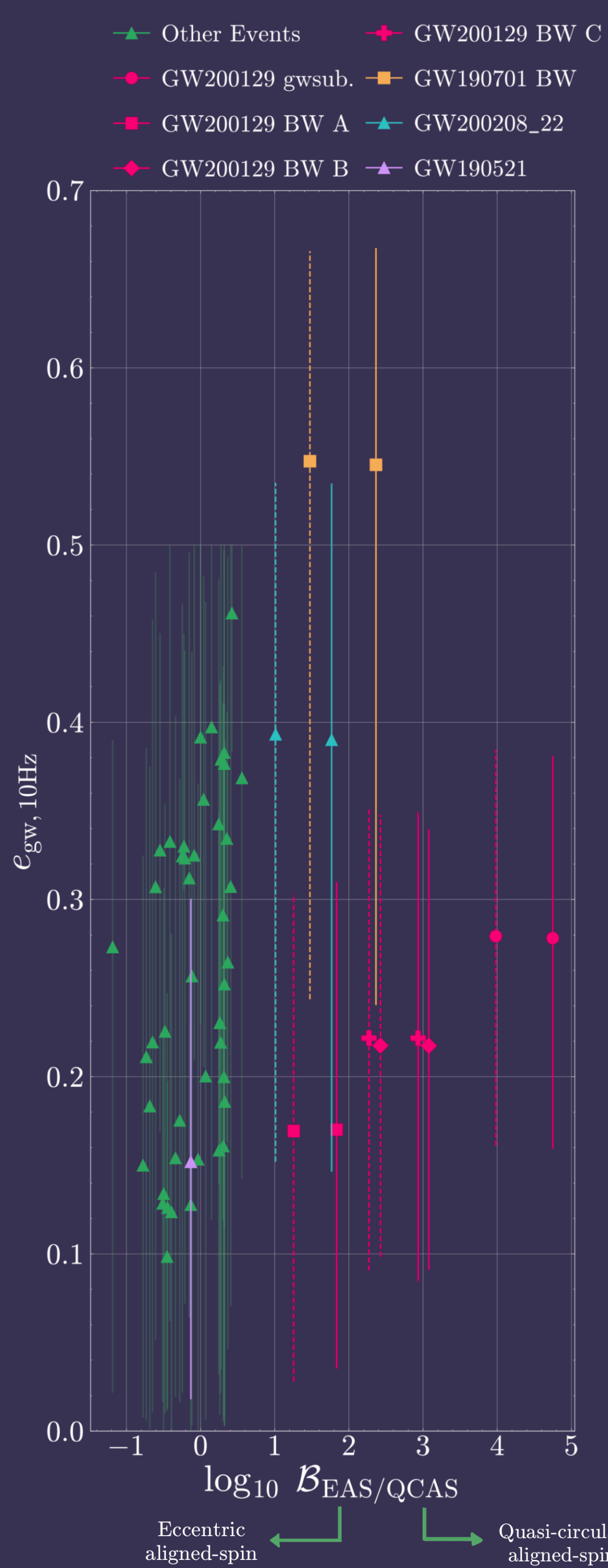


## Motivation: why eccentricity?

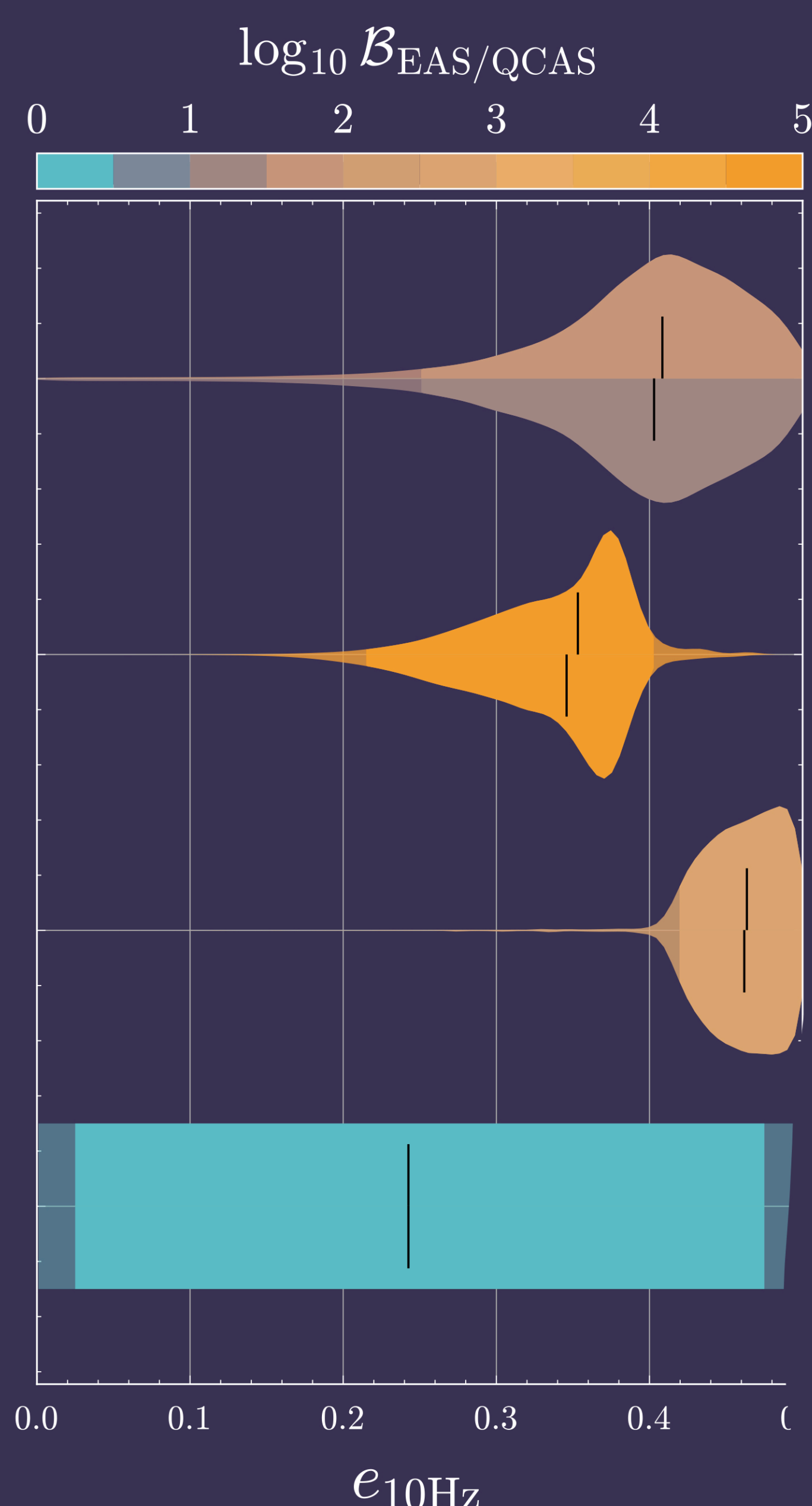
If we measure eccentricity in BBHs, we can determine the fraction of BBHs originating from:



## Results: Bayes factors

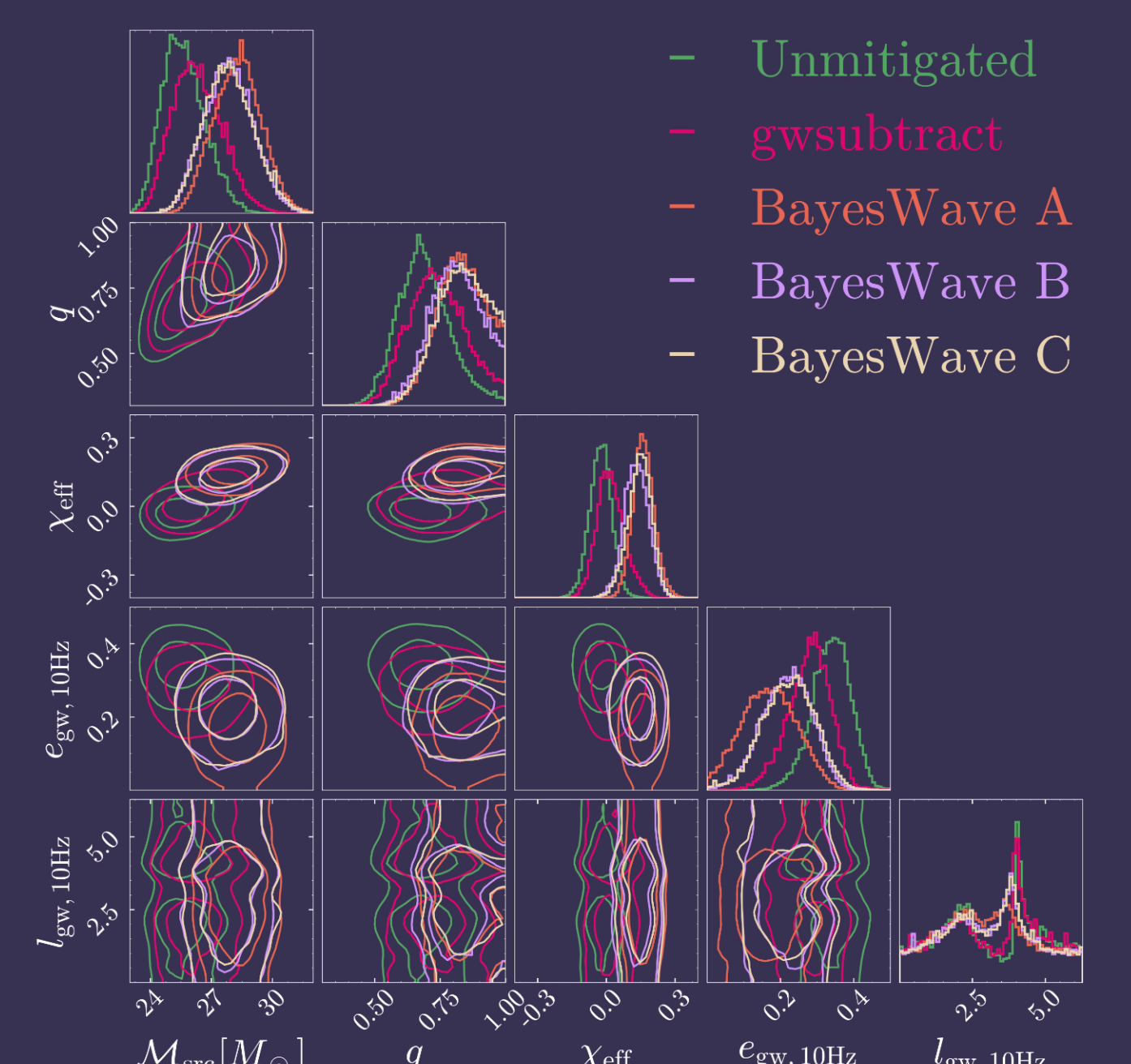


Highest density intervals vs log 10 Bayes factors for the 57 analyzed events. The dashed lines are when using a log-uniform prior in eccentricity. The shapes correspond to different glitch mitigation techniques.



Posterior distributions for BBHs with signs of eccentricity. They are colored by the log 10 Bayes factor between the eccentric aligned-spin and quasi-circular aligned-spin hypotheses.

## Caveats: glitches and spin-precession



For GW200129, there is a glitch in Livingston. Depending on the glitch mitigation used, the level of eccentricity changes.<sup>5,6</sup>

Glitch Subtraction	SEOBNRv4PHM <sup>10</sup>	NRSur7dq4 <sup>9</sup>
	log <sub>10</sub> B <sup>†</sup>	log <sub>10</sub> B <sup>†</sup>
GW200129		
gsubtract	4.92	4.0
BayesWave A	2.20	1.53
BayesWave B	3.43	2.35
BayesWave C	2.63	1.43
GW190701		
BayesWave	2.61	-
GW200208_22		
Unmitigated Strain	1.23	-

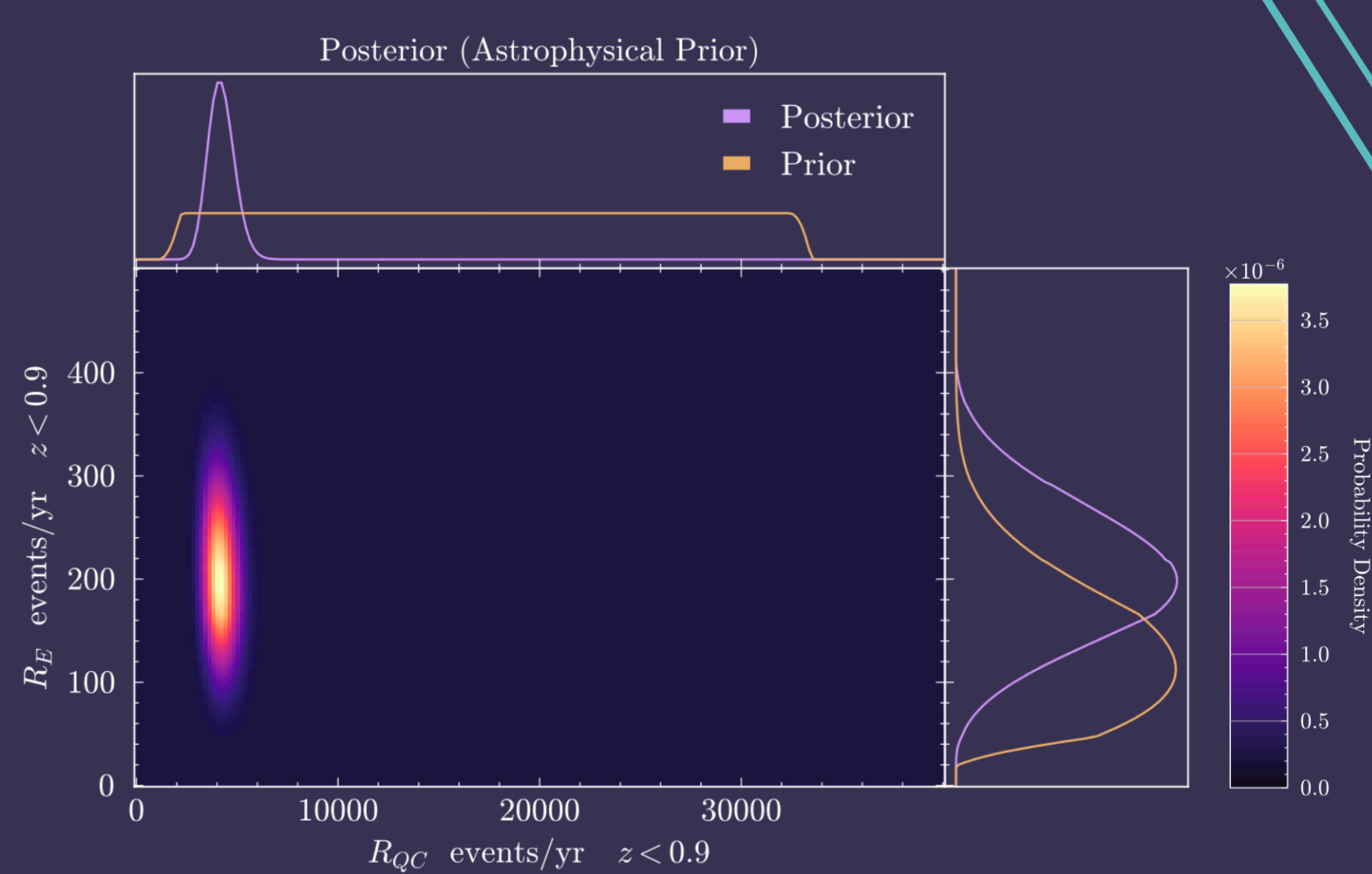
The eccentric aligned-spin hypothesis is also preferred over the quasi-circular precessing-spin hypothesis.

## Rates

We can combine the individual events with astrophysical knowledge to obtain the probability that at least one event is eccentric.<sup>12</sup>

The probability of eccentricity in the population is > 99.5% or 99.99916% (For this particular number, we neglect the effect of spin-precession)

Rate of eccentric and quasi-circular BBHs. This combines an astrophysical prior with GW data.



## References

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Link to paper

