Are we missing the most interesting compact binary mergers?

Harry Ian

Based on:

IH et al. PRD89 024010 (2014)

Capano, IH et al. PRD93 124007 (2016)

IH et al. PRD94 024012 (2016)

Bustillo, IH et al. In preparation

Introduction

- Gravitational-wave observatories have observed 3 (2.9) BBH mergers to date
- However, we ignore many physical effects in these searches
  - Precession
  - Higher-order modes
  - Eccentricity
  - Neutron-star physics
- These are the most interesting systems! Are we just missing them?

Introduction

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  - **Higher-order modes**
  - ~~Eccentricity~~
  - ~~Neutron-star physics~~
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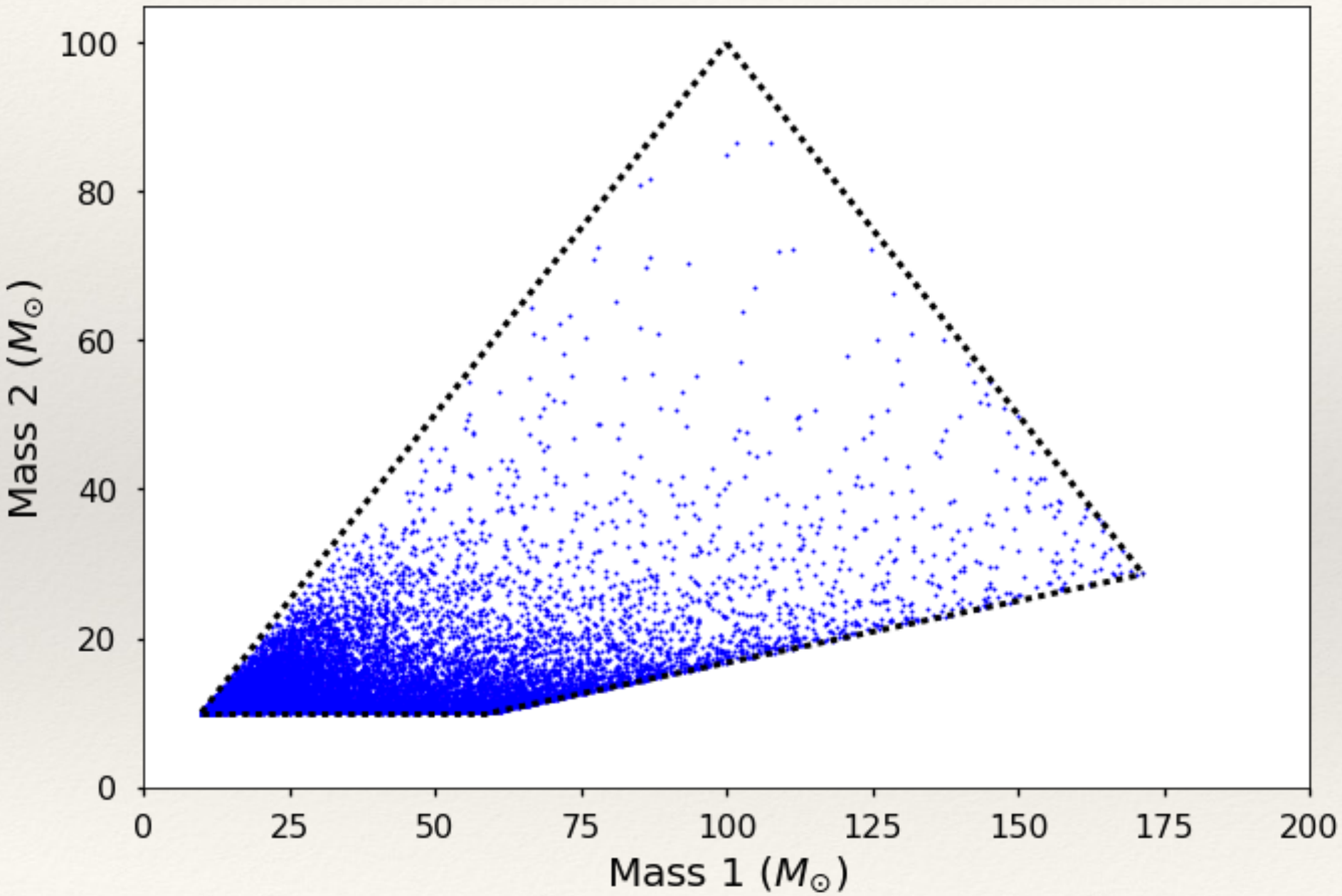
Investigating these effects

- Simulate signals with these real physical effects.
  - No waveform model includes all of these effects, so we have to investigate one at a time, with what we have.
- Measure what fraction of SNR is lost for each of these signals using the current search setup
- Not all signals are equally observable! Include the intrinsic GW luminosity of each signal to quote a “signal recovery fraction”.
  - Normally this is ~95% as the search uses a discrete set of waveform filters.

Filter waveforms

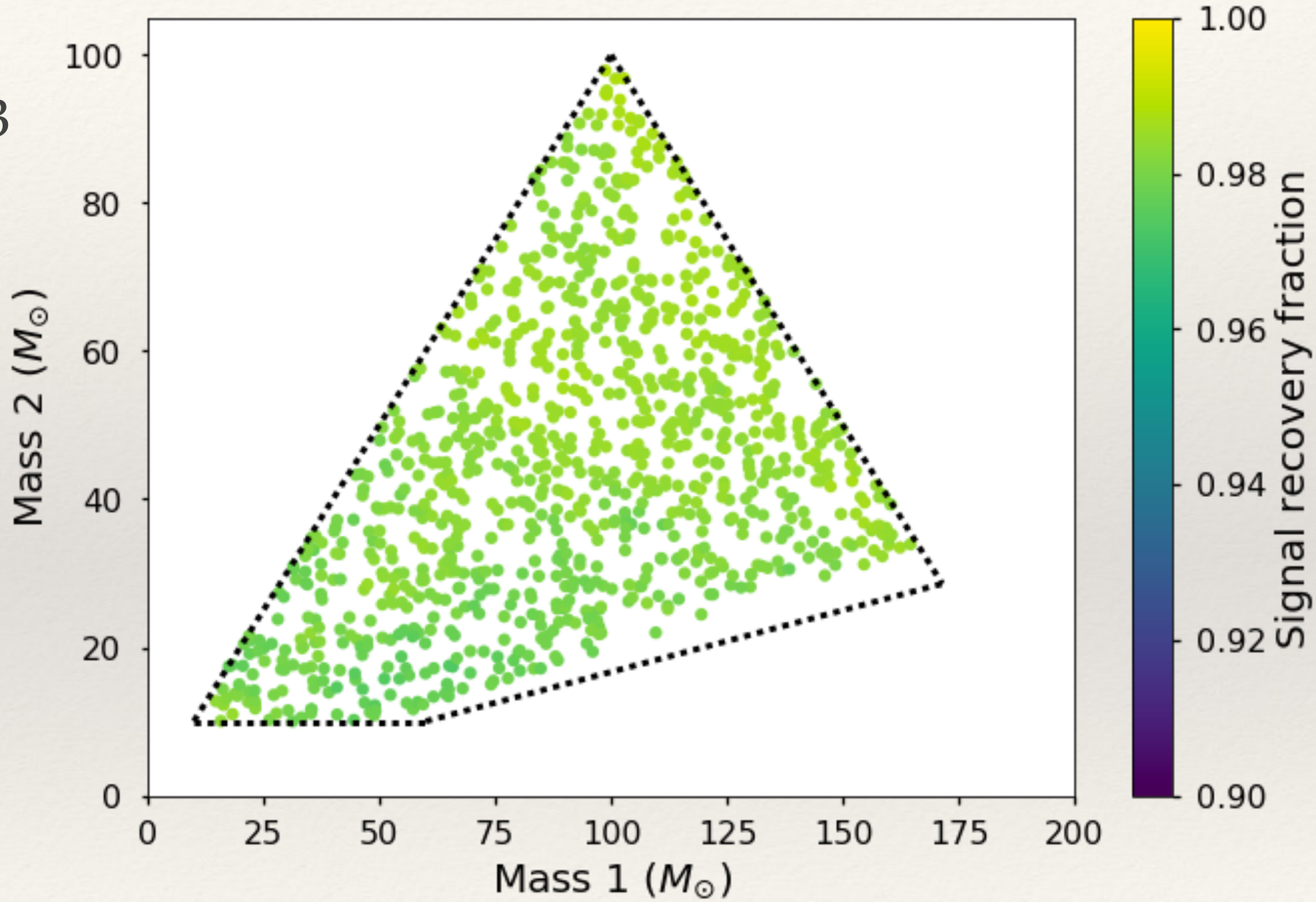


- ALIGO ZDHP noise curve
- Effective-one body (EOB) inspiral, merger and ringdown waveforms.
- Aligned-spins included
- No more than 3% SNR loss

Bohé, …. IH, …. et al. PRD95 044028 (2017)
Dal Canton and IH arXiv:1705.01845 (2017)

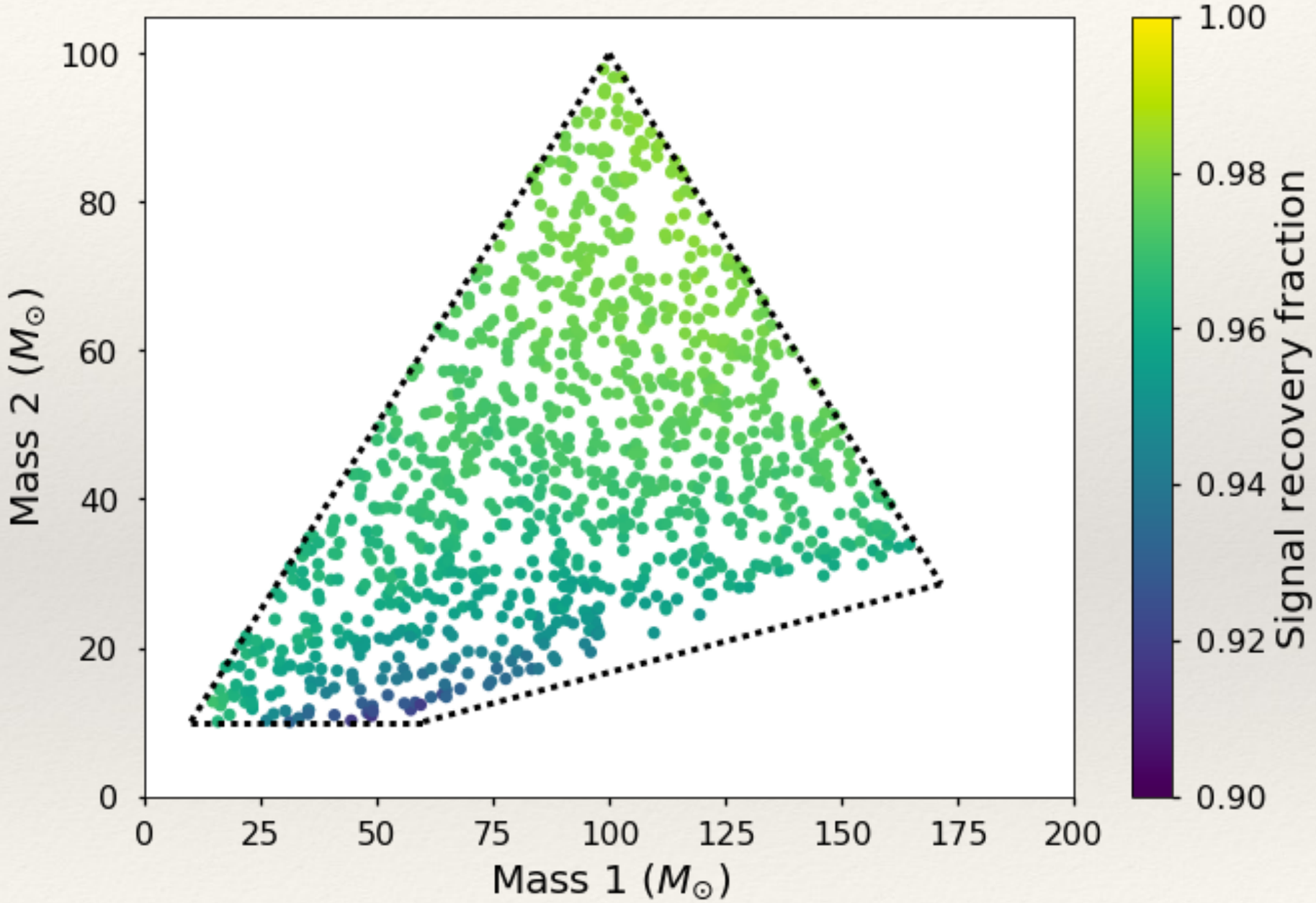
No interesting physics yet!

- Use the same EOB model as signals to set a baseline
- Aligned-spins
- No higher-order modes
- Perfect match to filter waveforms



Let's include precession

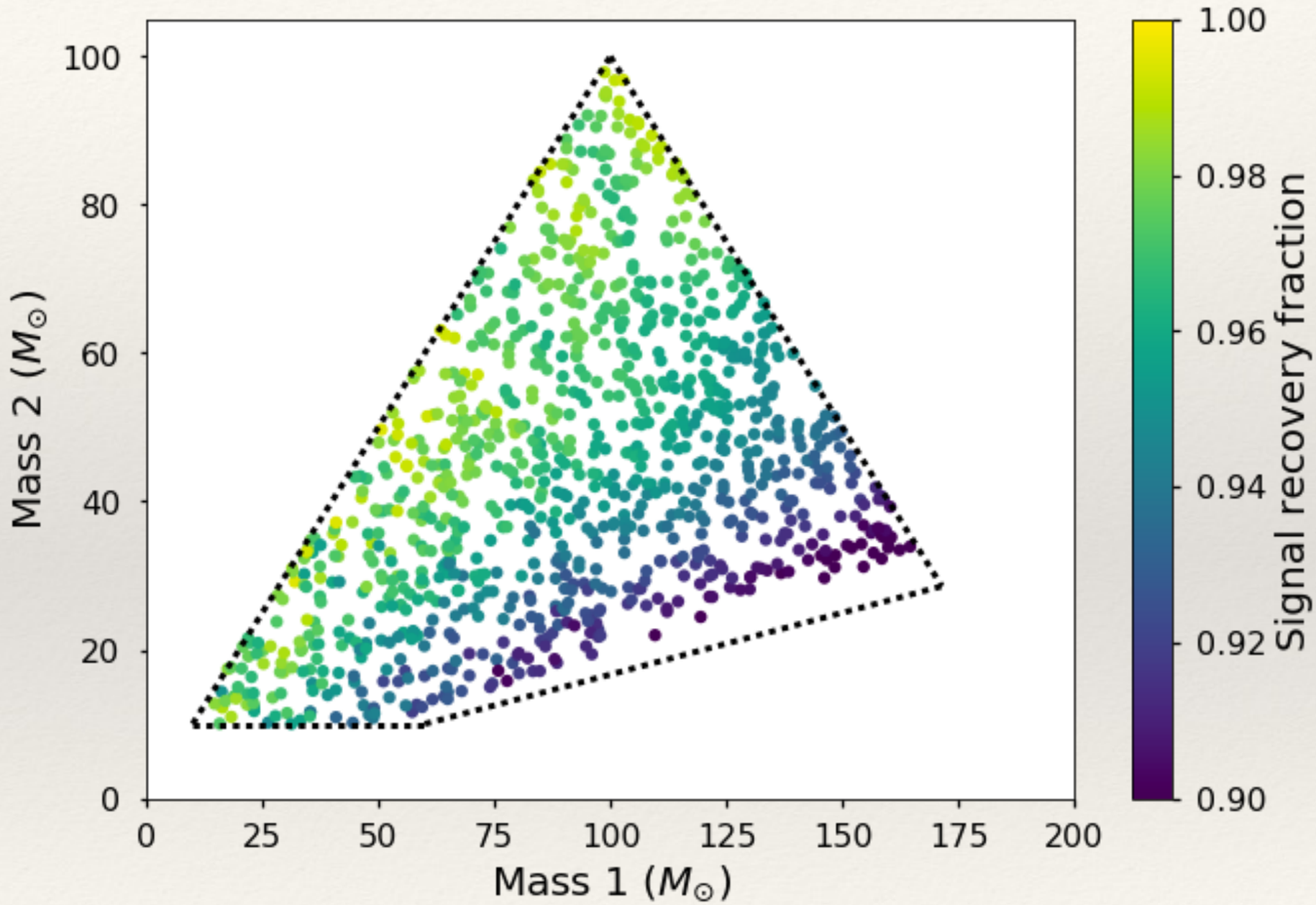
- Precessing EOB waveforms
- No higher-order modes



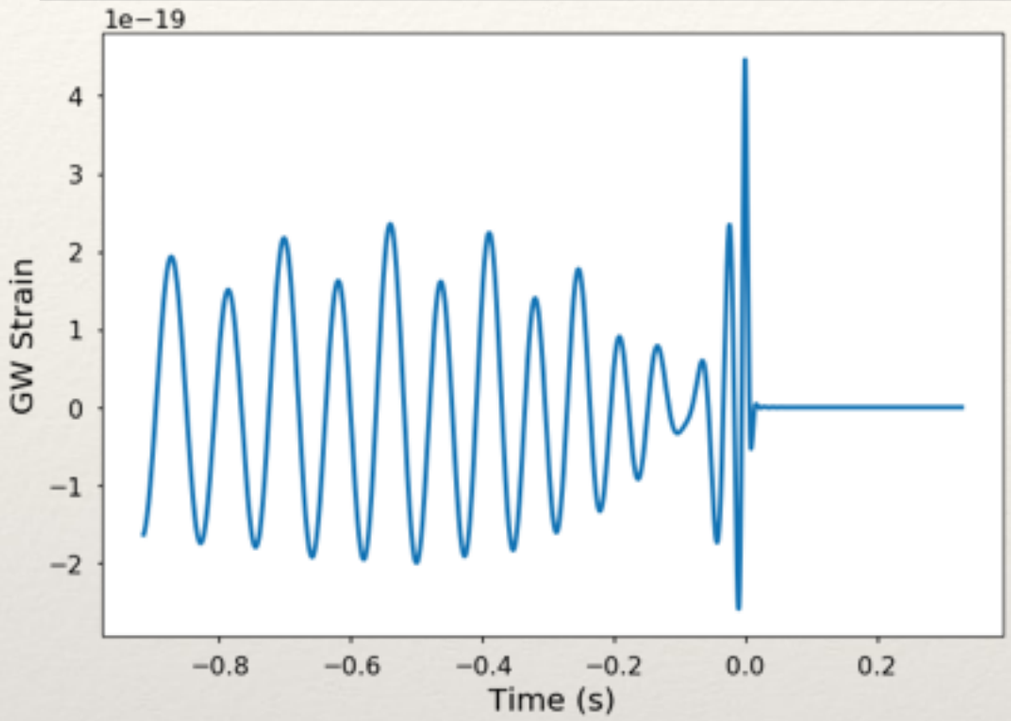
Taracchini et al. PRD89 061502 (2014)

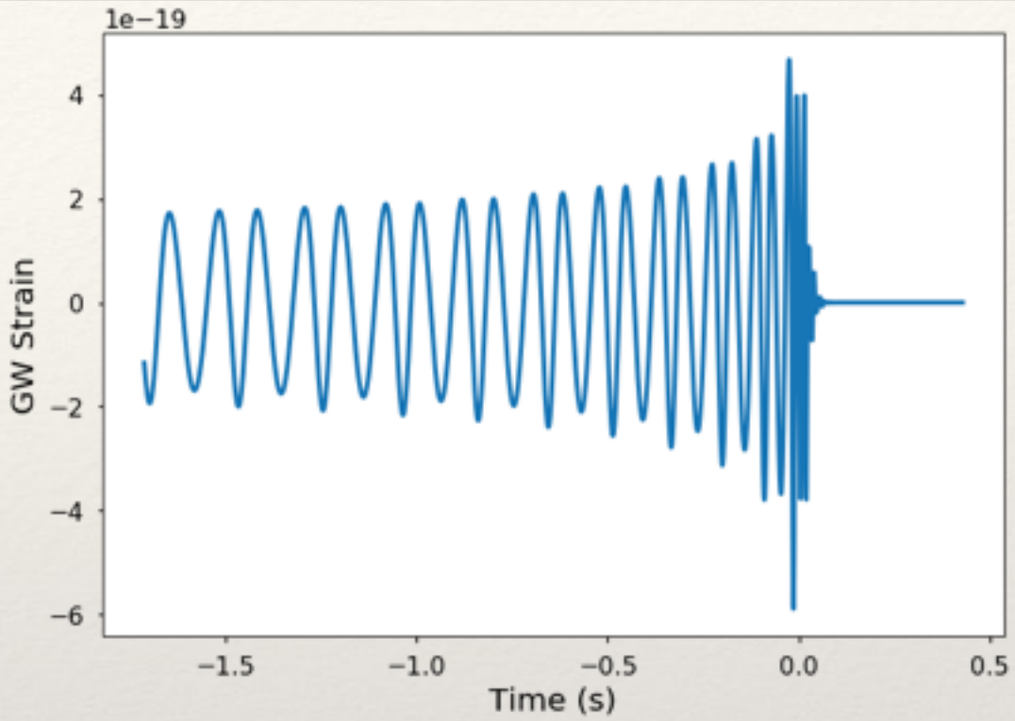
Or higher-order modes (no spin)

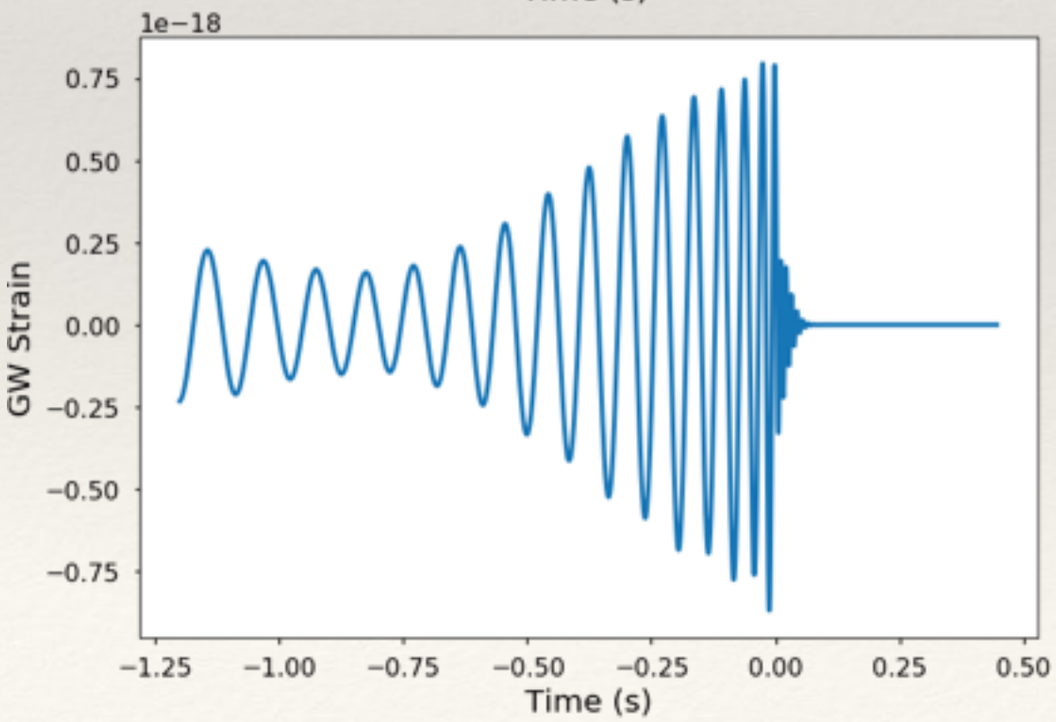
- Non-spinning EOB waveforms
- Includes higher-order modes

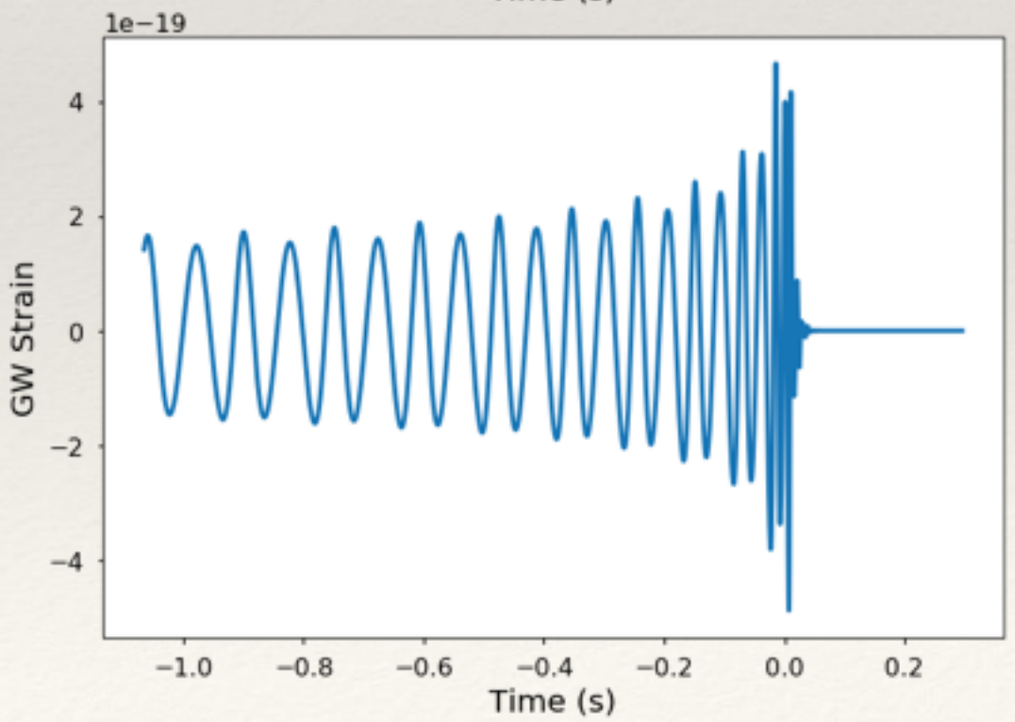


Some of the worst systems









What can we do?

Include these effects in search - requires waveform models, but's that's only half the problem!

- Two schools of thought for doing precessing/HOM searches
- ONE: Include extra parameters in template bank; keep maximisation simple
  - Capano et al. PRD89 102003 (2014), IH et al. PRD94 024012 (2016), Bustillo, IH et al. In preparation
- TWO: Don't include so many parameters in template bank; maximisation becomes complicated
  - Pan et al. PRD69 104017 (2004), McKechan Thesis (2011), IH and Fairhurst CQG 134008 (2011), Willis et al. In prep.

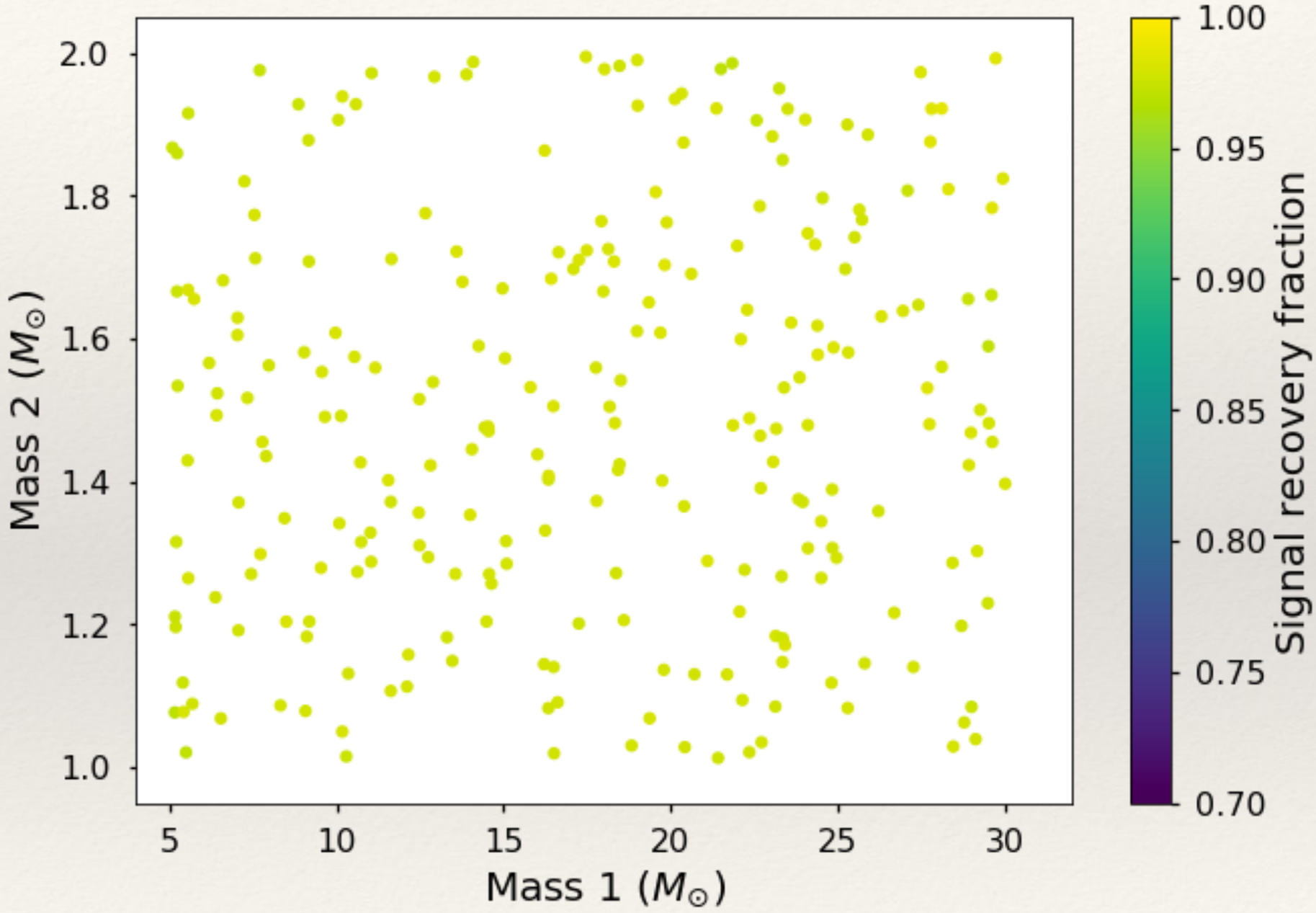
Conclusion

- In terms of overall detection count, aligned-spin searches will do pretty well
- Not considering waveform systematics here. Not perfect today, but this is improving with time.
- Our sensitivity to high mass-ratio and/or edge-on and/or highly precessing systems is sub-optimal
- Are such systems worth more than another [ten?] GW150914s?
  - Work underway to try to fill this hole.

Extra slides

Neutron-star–black hole systems

- Aligned-spin
- No higher-order modes
- Perfect match to filter waveforms



Neutron-star–black hole systems

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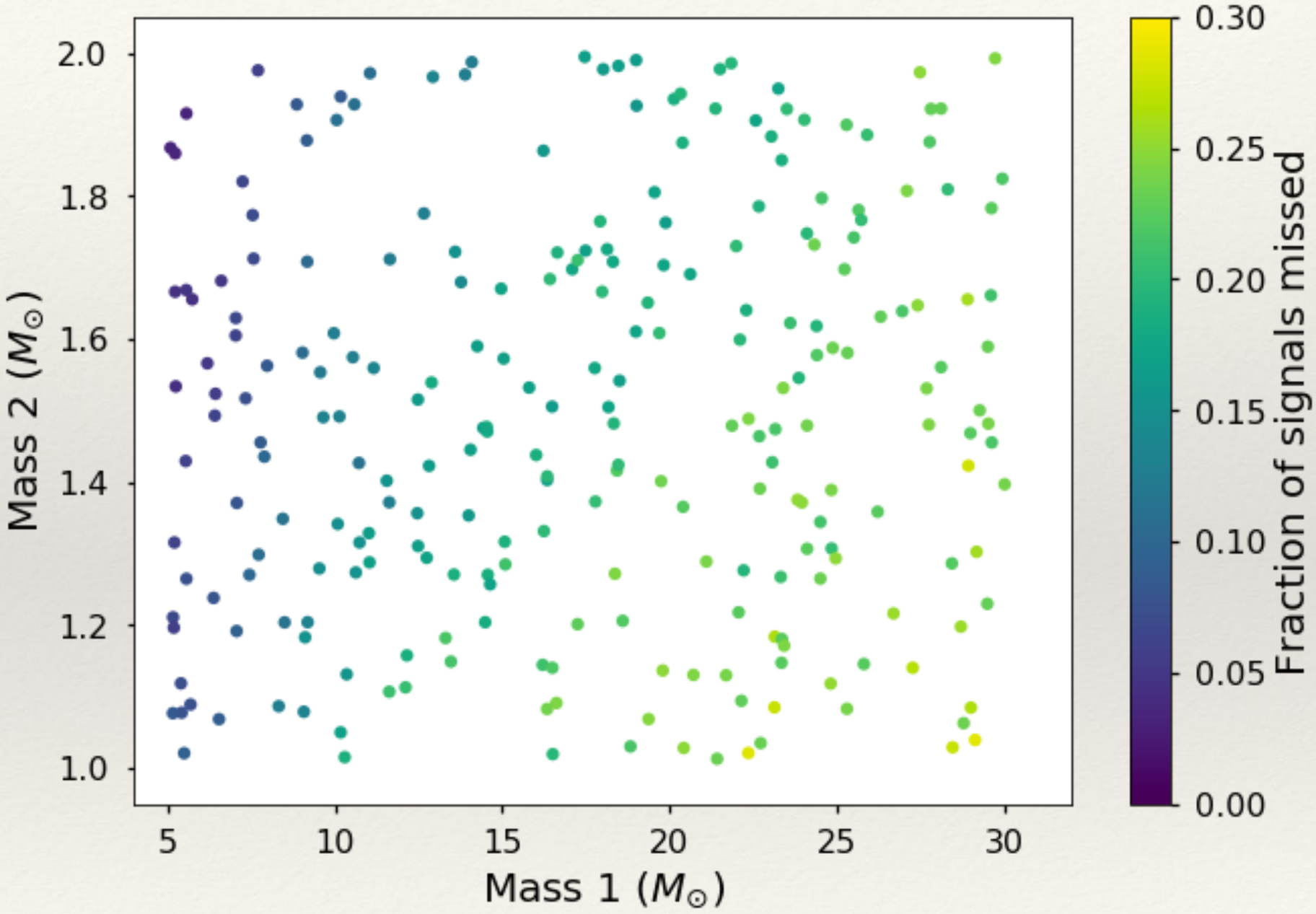
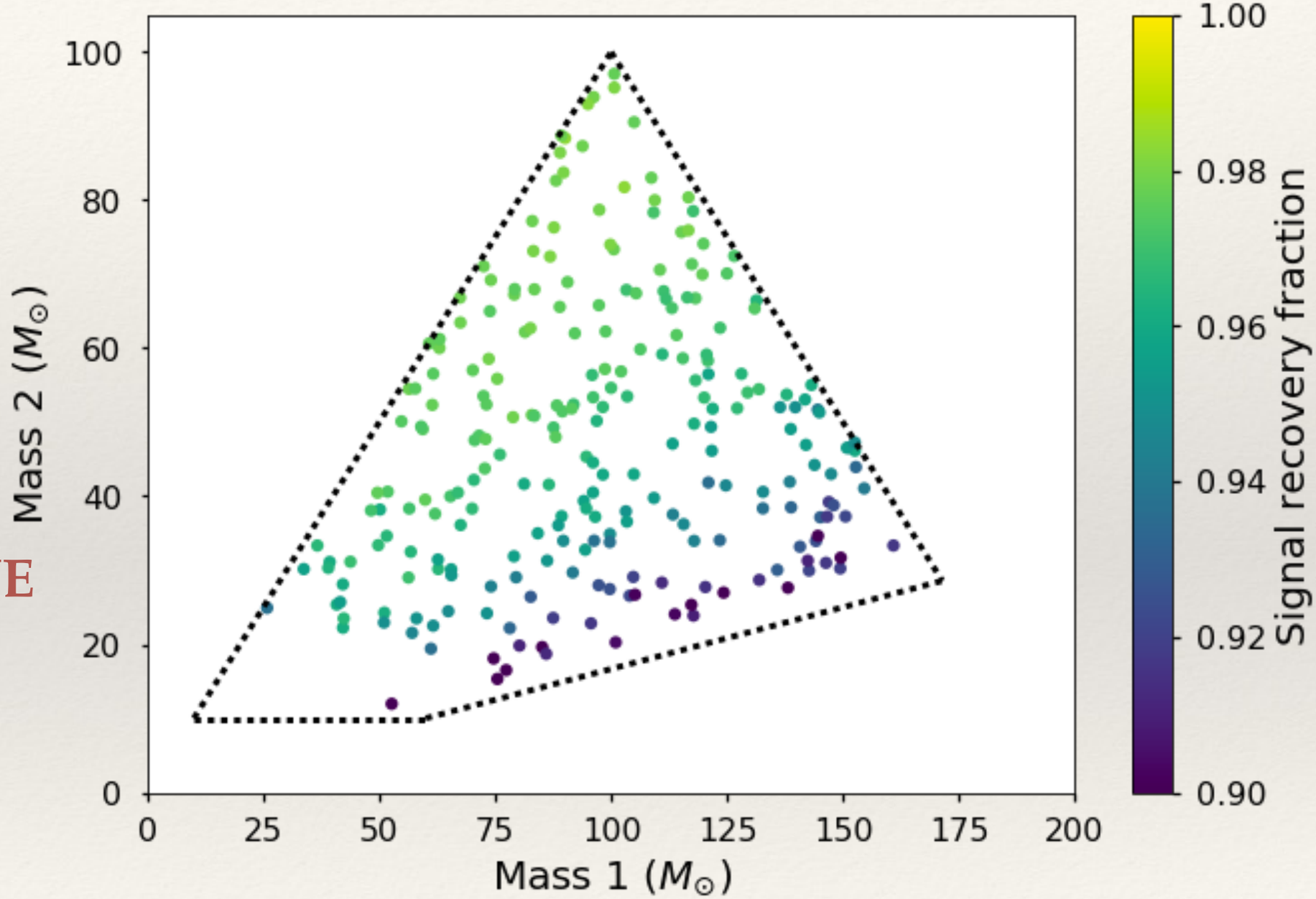


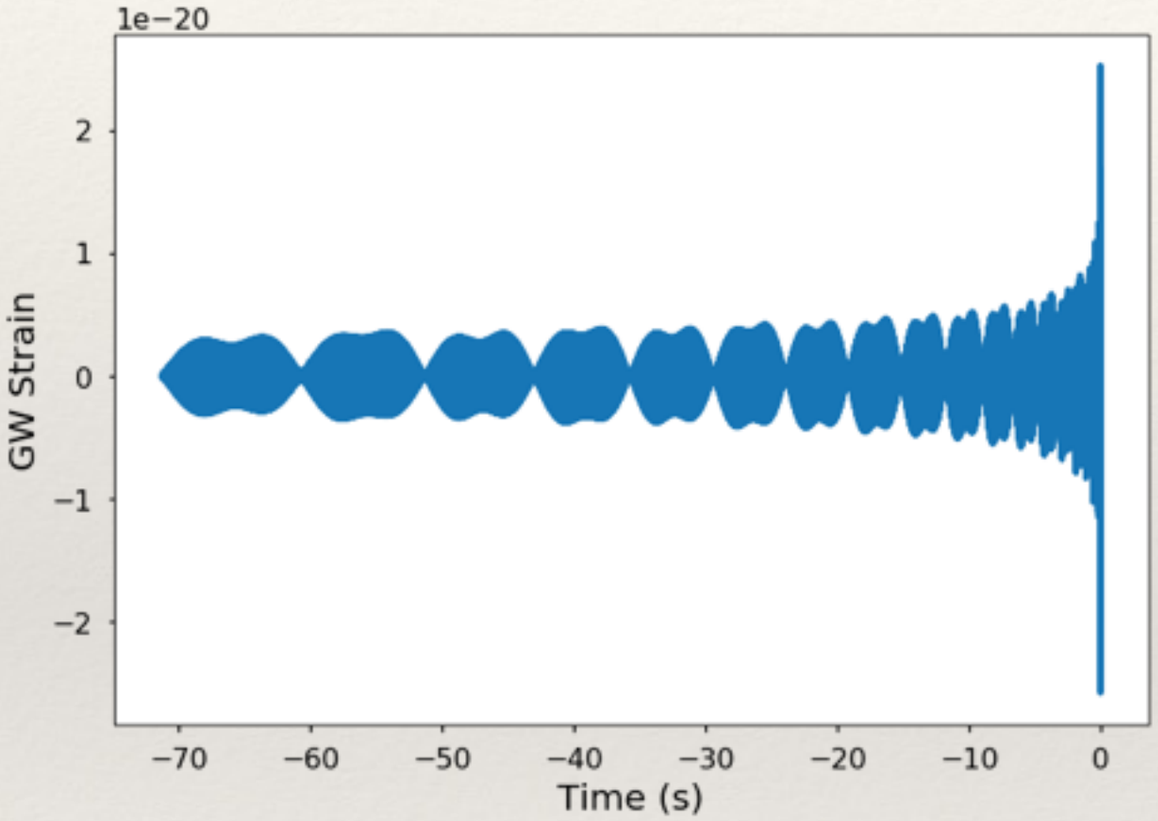
Let's include precession

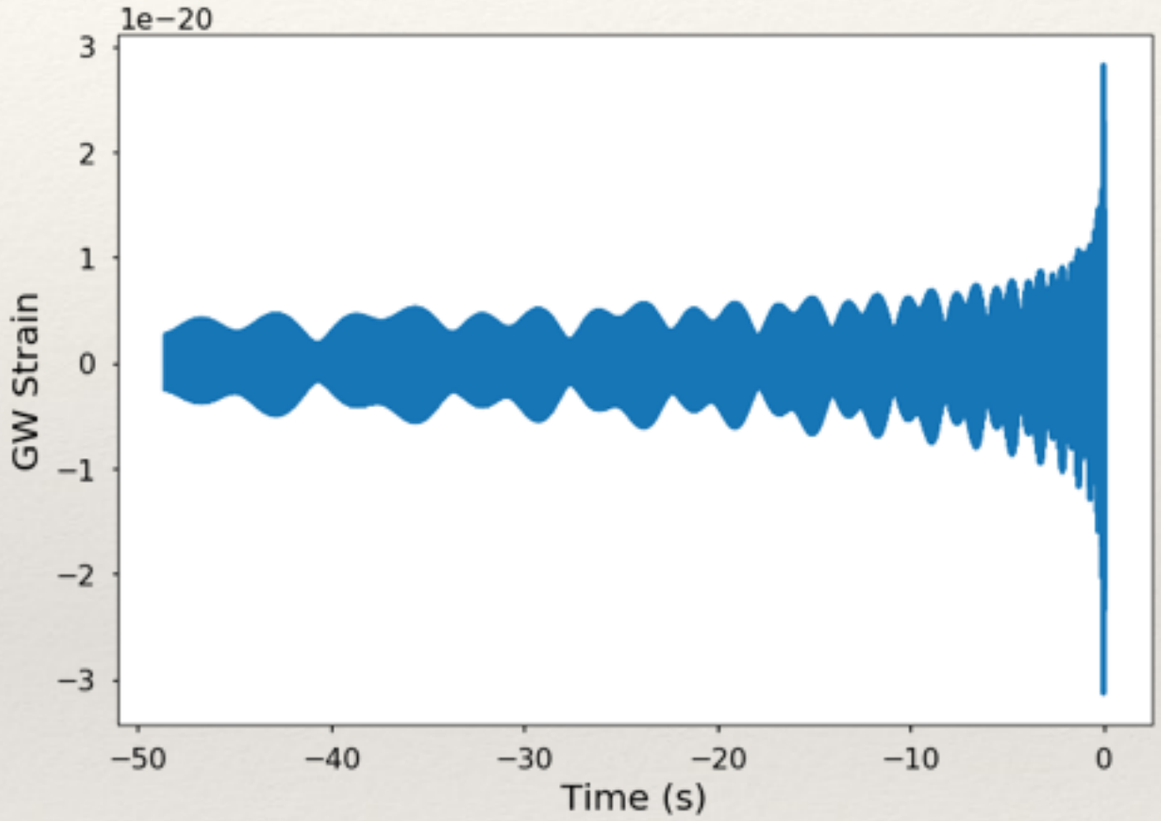
- Precessing EOB waveforms
- No higher-order modes
- **ET NOISE CURVE**
- Systematic effects not investigated



Taracchini et al. PRD89 061502 (2014)

Some of the worst systems





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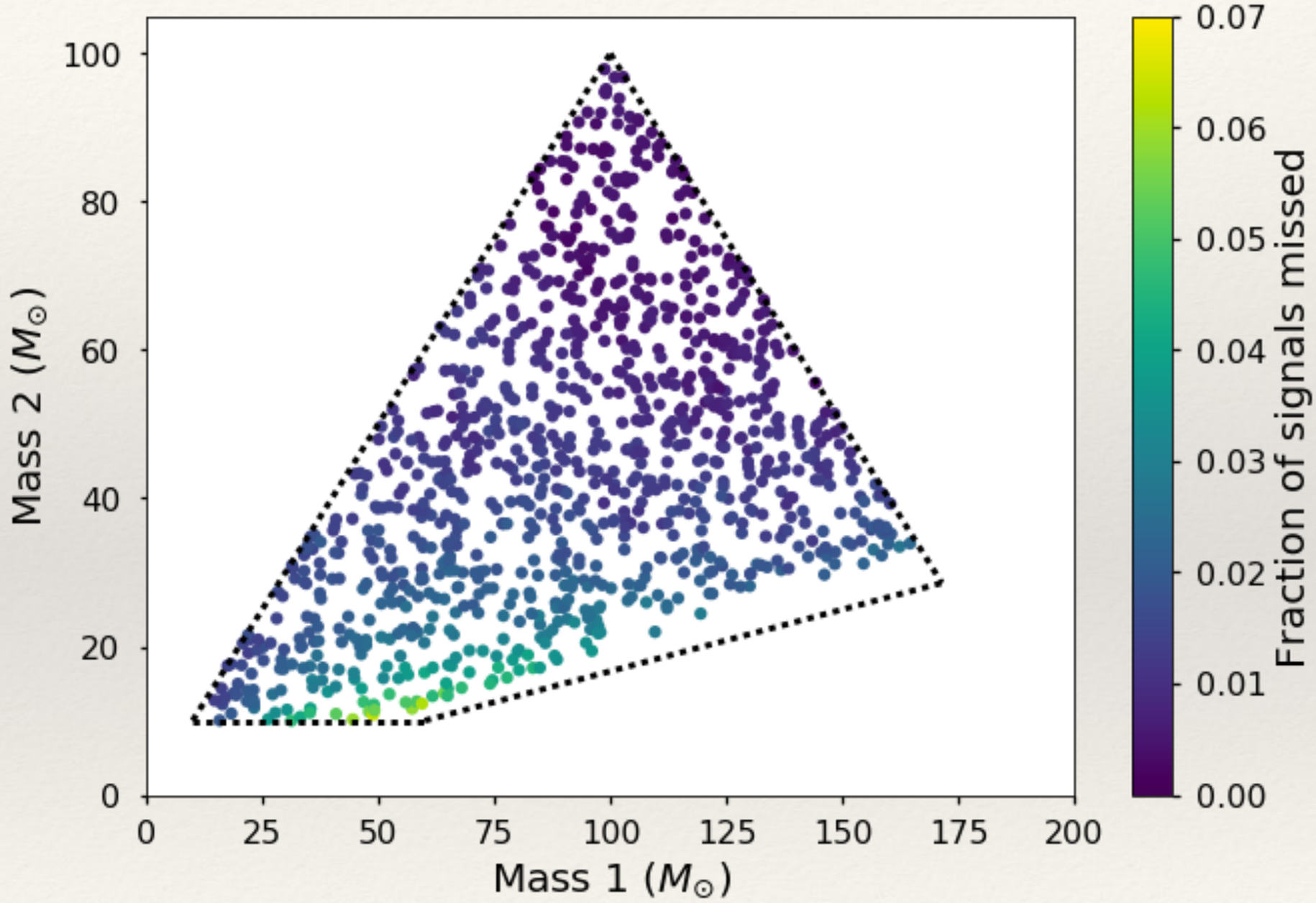

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