

# Gravitational-wave parameter estimation with relative binning: Inclusion of higher-order modes and precession, and applications to lensing and third-generation detectors

H. Narola, J. Janquart, Q. Meijer,  
K. Haris, C. V. D. Broeck

[arXiv:2308.12140](https://arxiv.org/abs/2308.12140)



Universiteit  
Utrecht



Nikhef

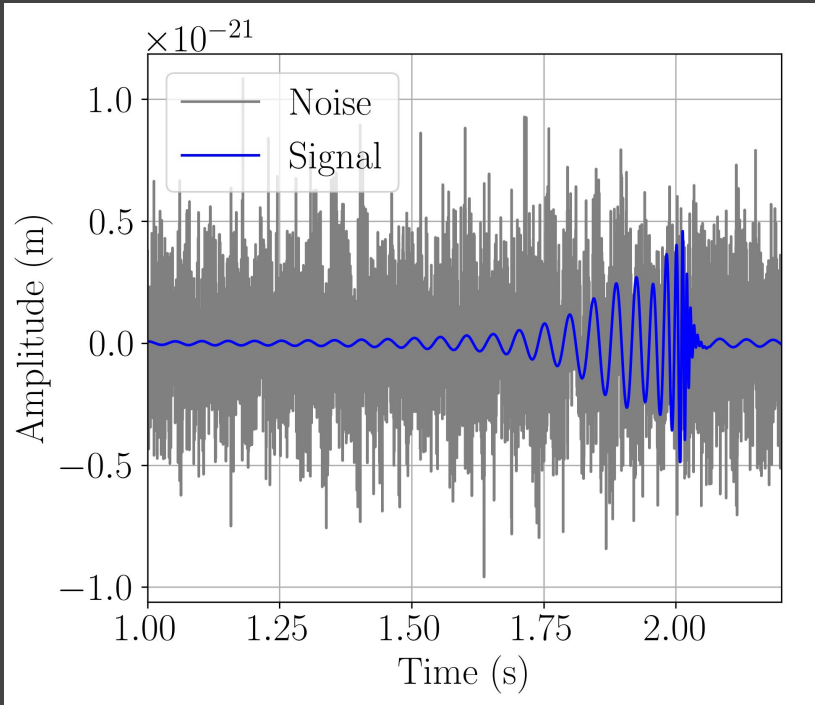
# Gravitational-wave parameter estimation with relative binning



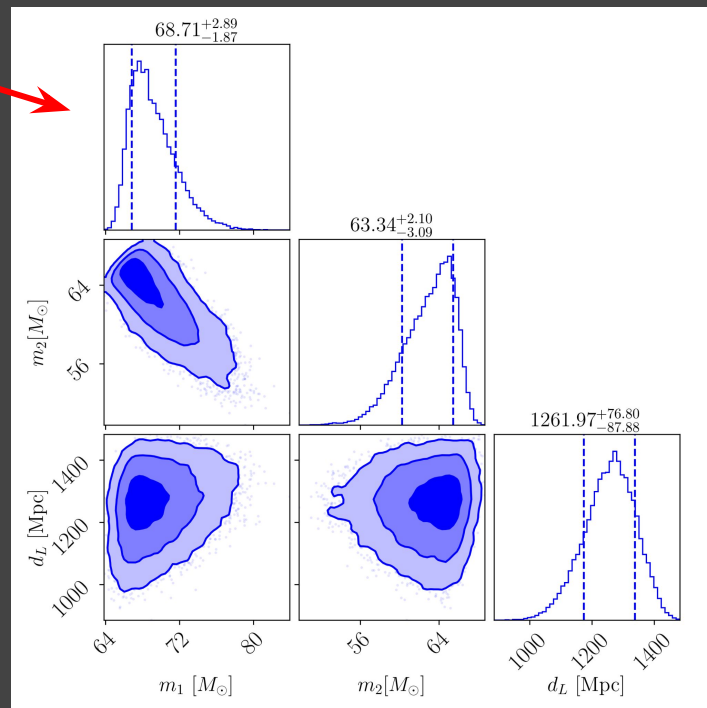
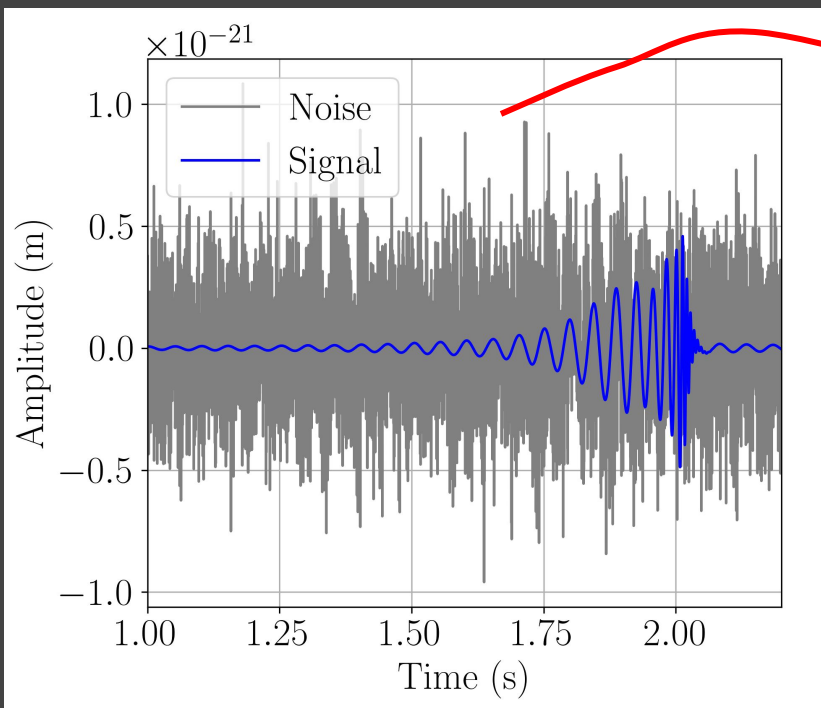
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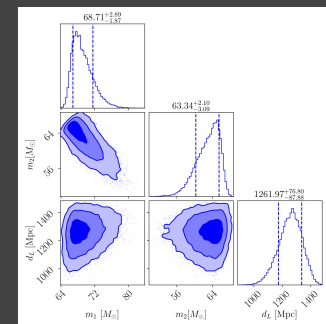
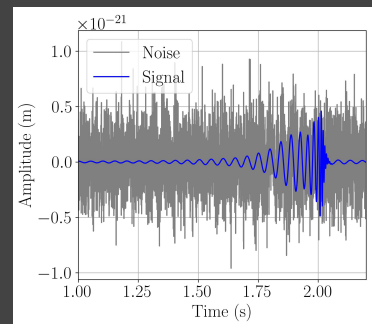
# What is parameter estimation?



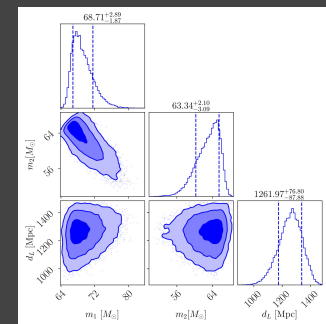
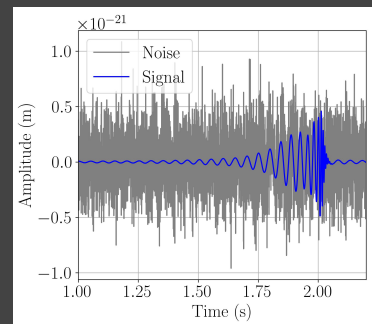
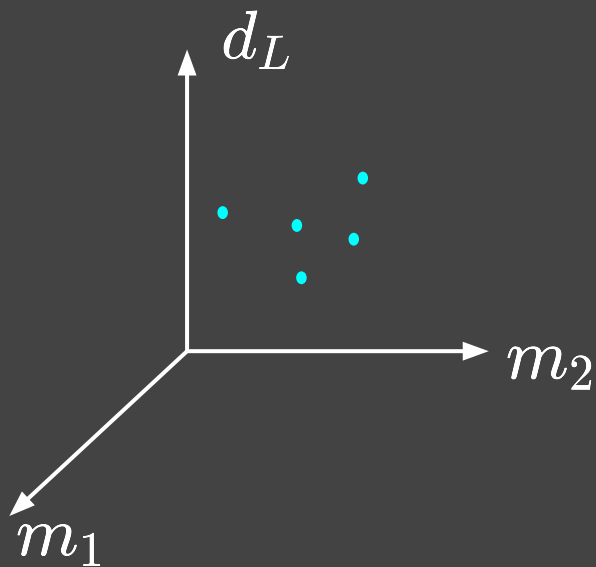
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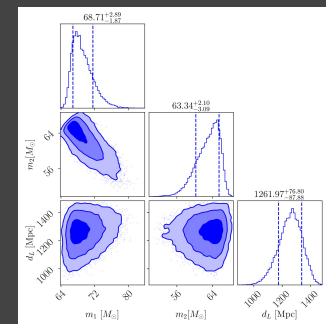
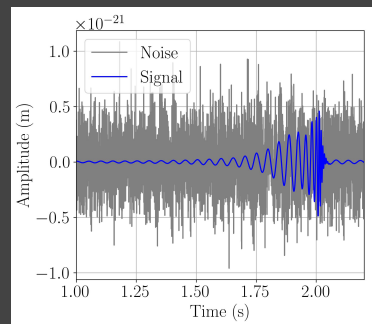
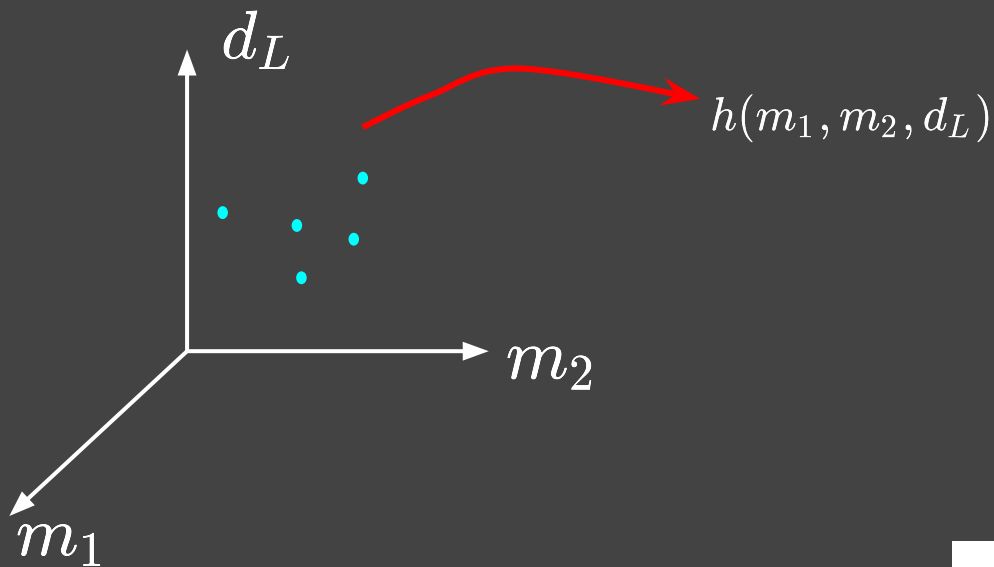
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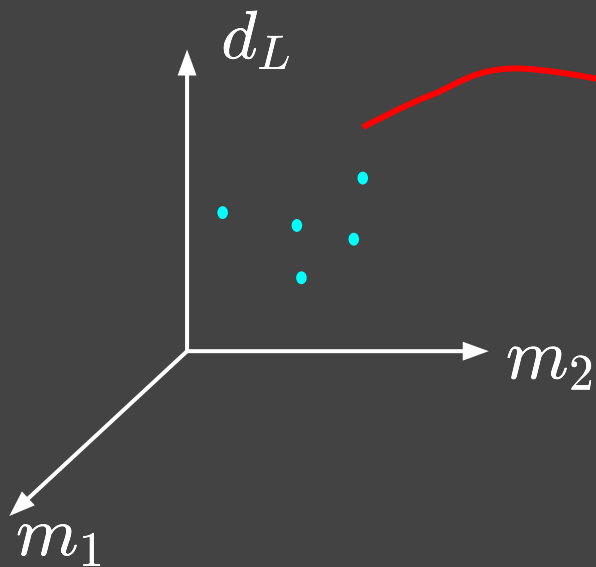


# How can it be done?

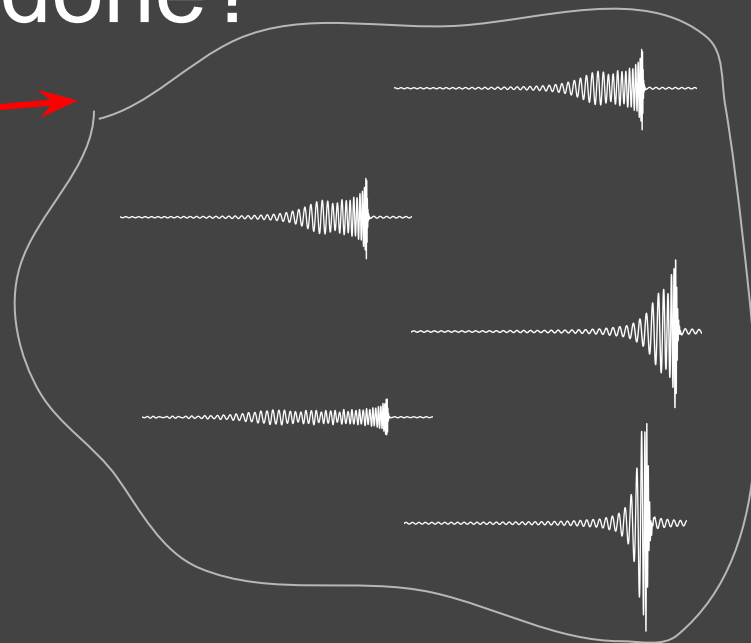




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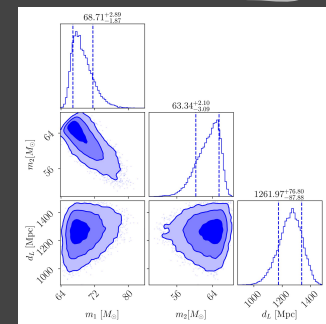
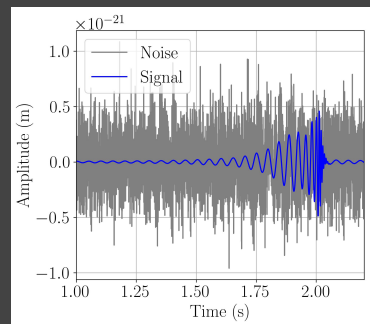


$$h(m_1, m_2, d_L)$$




If the noise is Gaussian and stationary...

$$p[\mathbf{n}] \propto e^{-\frac{1}{2} \langle \mathbf{n} | \mathbf{n} \rangle}$$



# Relative binning method to speed-up gravitational-wave parameter estimation

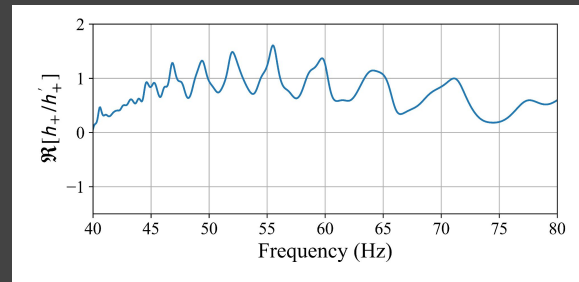
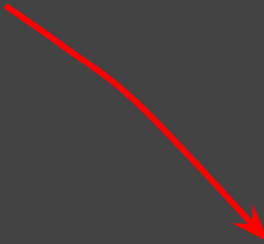
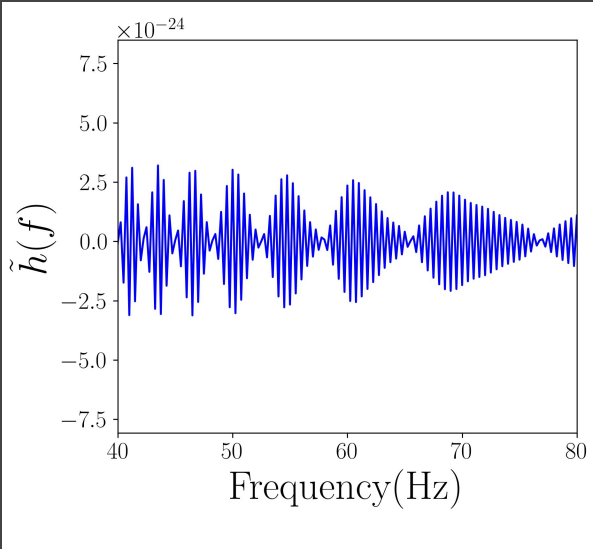


The diagram consists of two white curved arrows originating from the bottom of the main title. The left arrow points to the text 'Relative binning', and the right arrow points to the text 'Parameter estimation'. This indicates that the binning method is a component or technique used within the parameter estimation process.

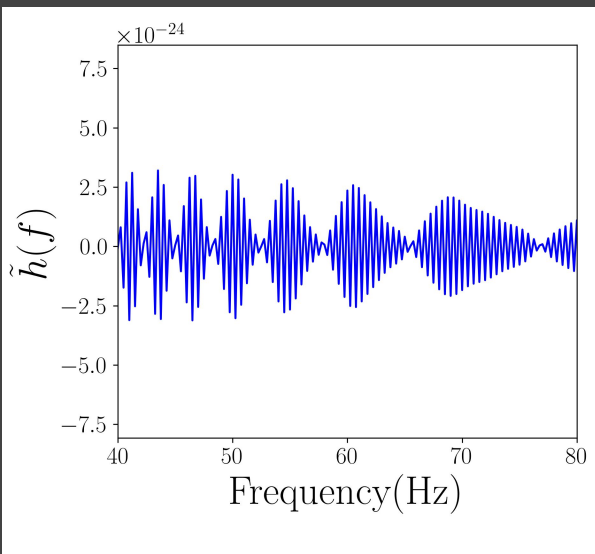
**Relative  
binning**

Parameter  
estimation

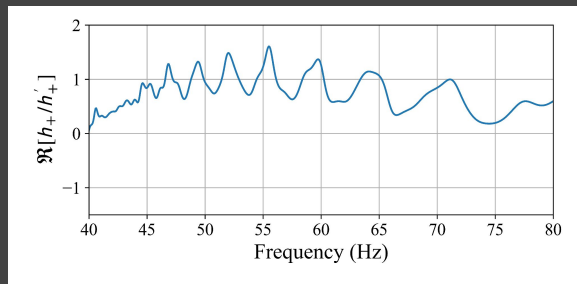
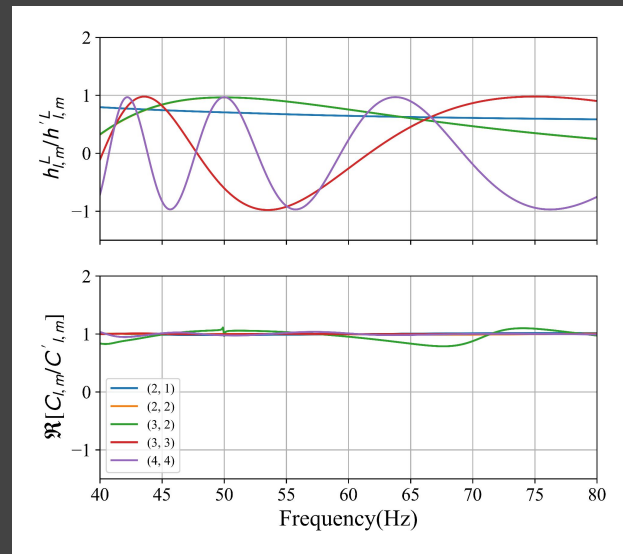
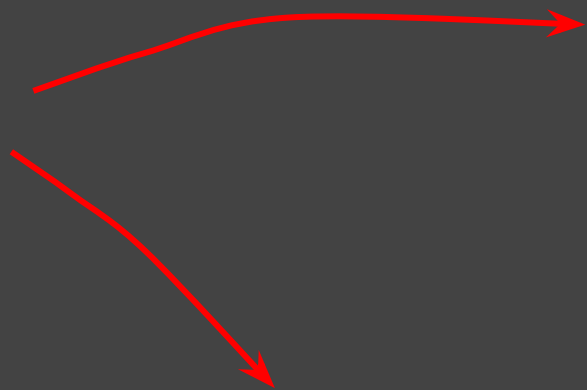
# What does relative binning do?



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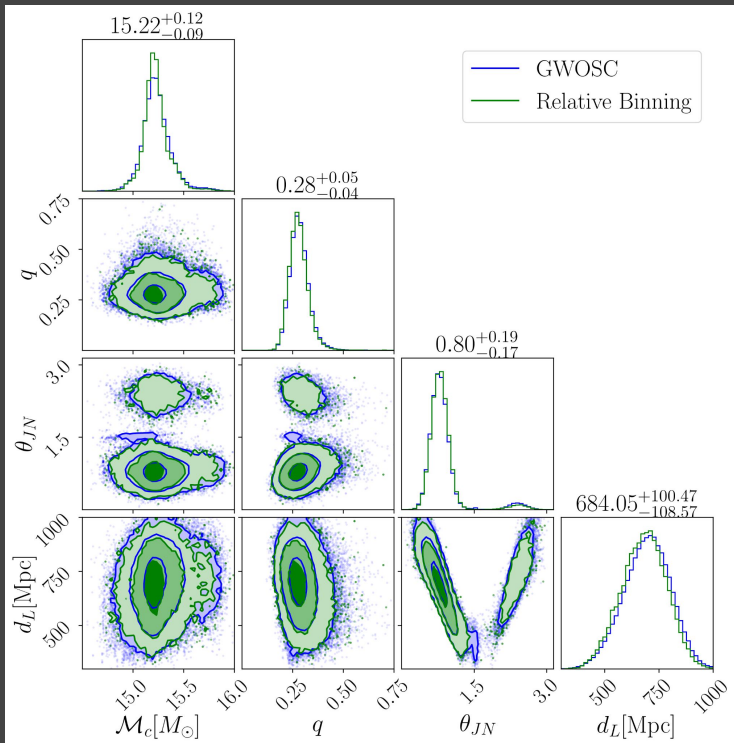


$$h(m_1, m_2, d_L)$$



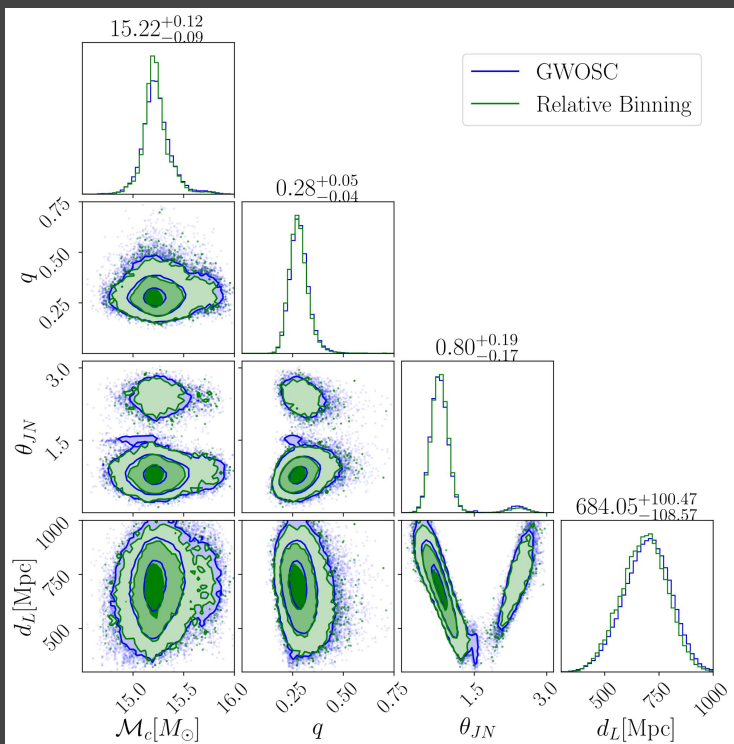
# Results

## GW190412

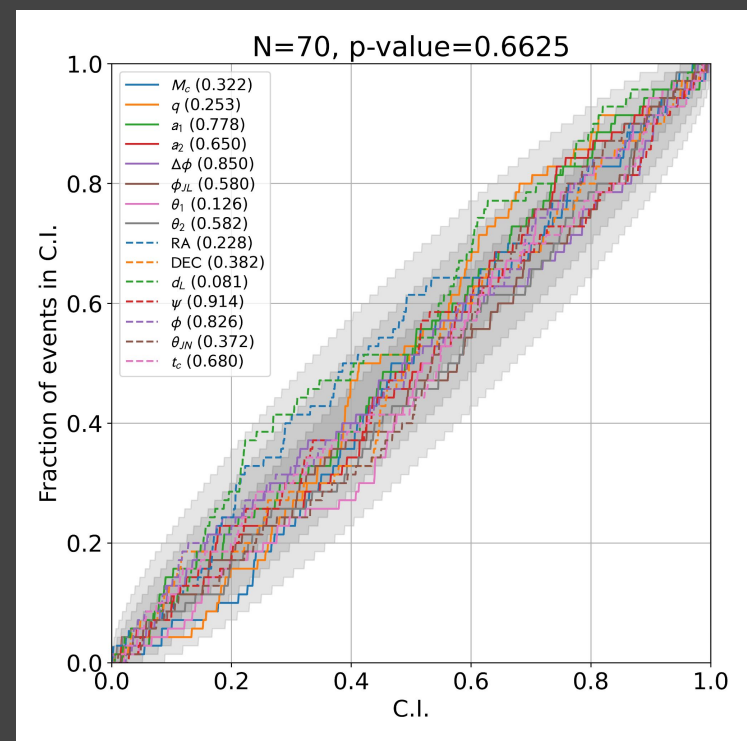


# Results

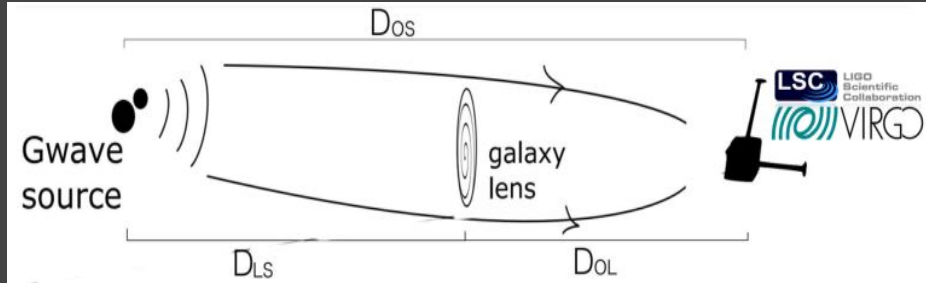
## GW190412



## Injections

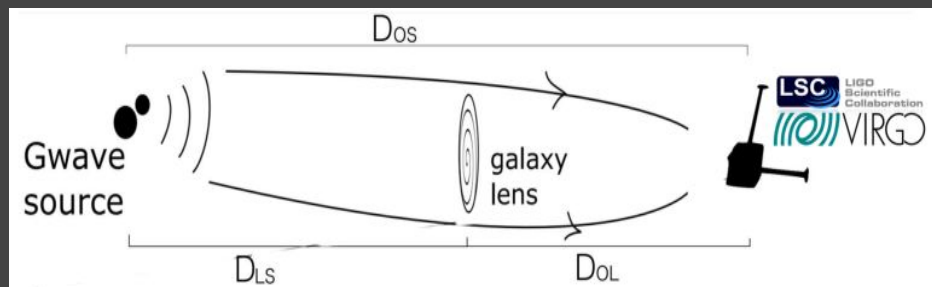


# Use case 1: Strong lensing searches



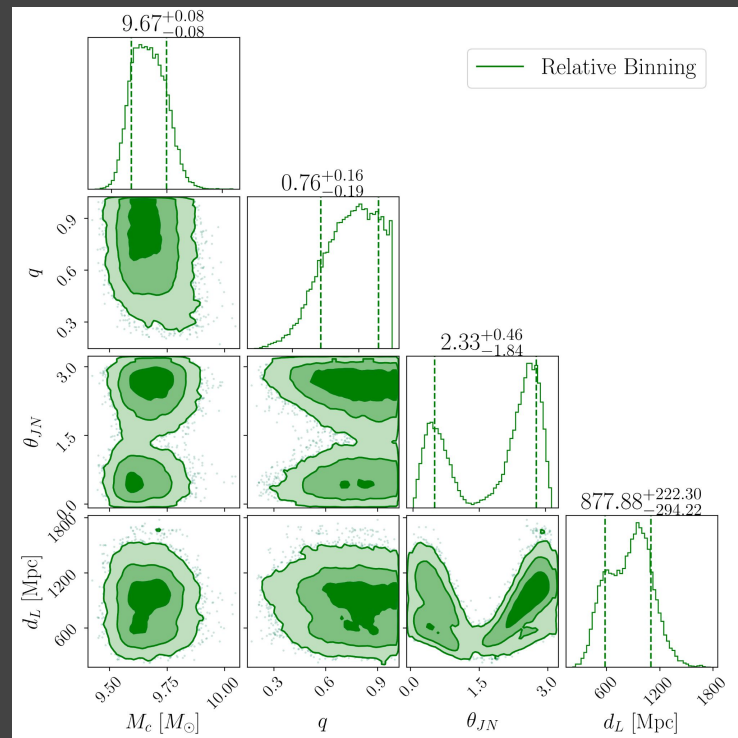
[\\*LVK lensing paper \(2023\)](#), [Janquart et al \(2023\)](#)

# Use case 1: Strong lensing searches



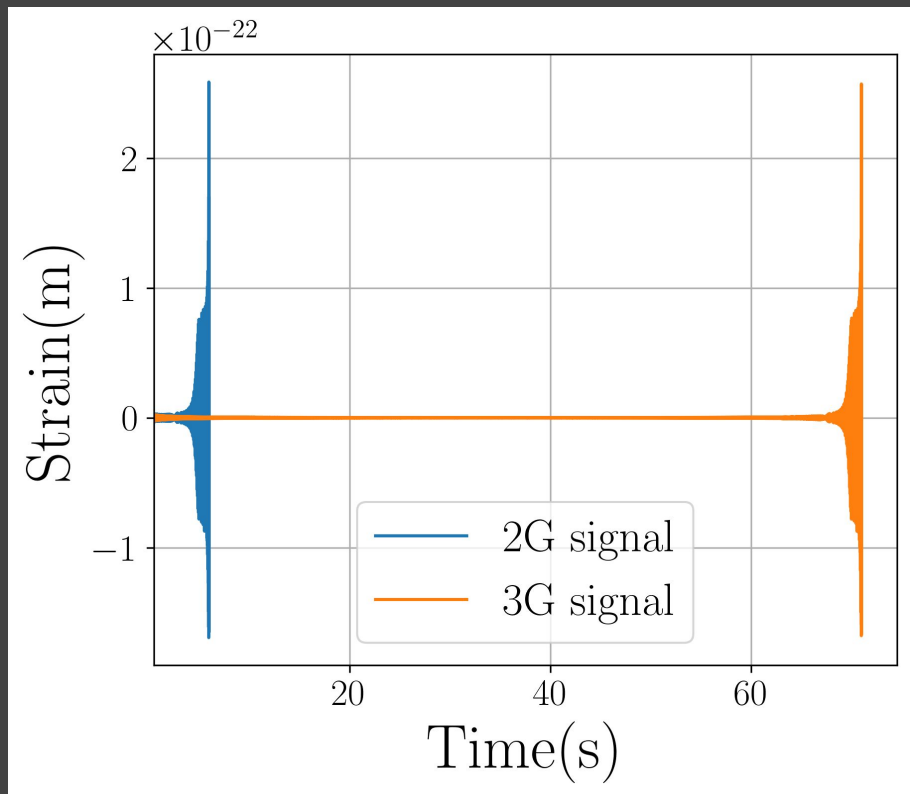
[\\*LVK lensing paper \(2023\)](#), [Janquart et al \(2023\)](#)

(GW191103\_GW191105)

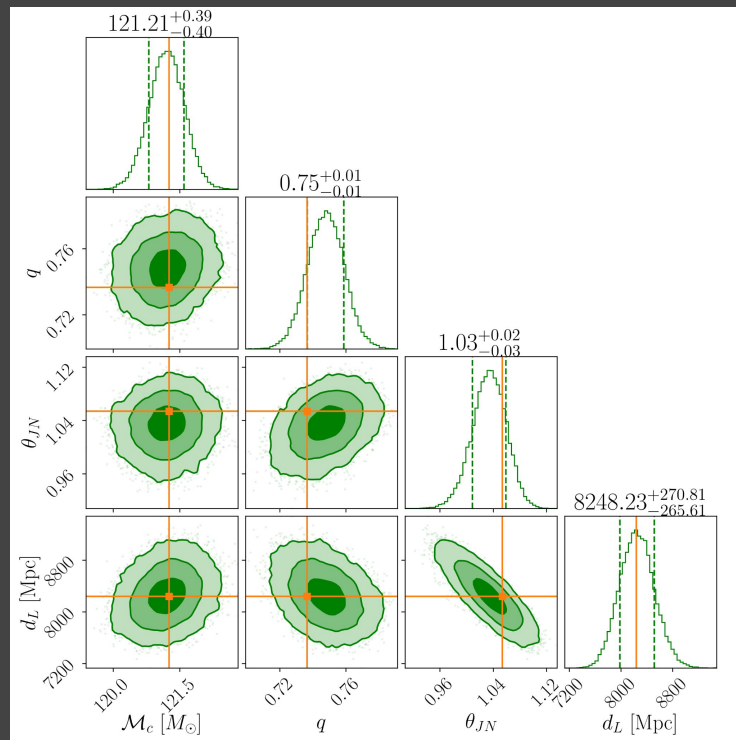




# Use case 2: 3G Detectors



## Einstein Telescope and Cosmic Explorer





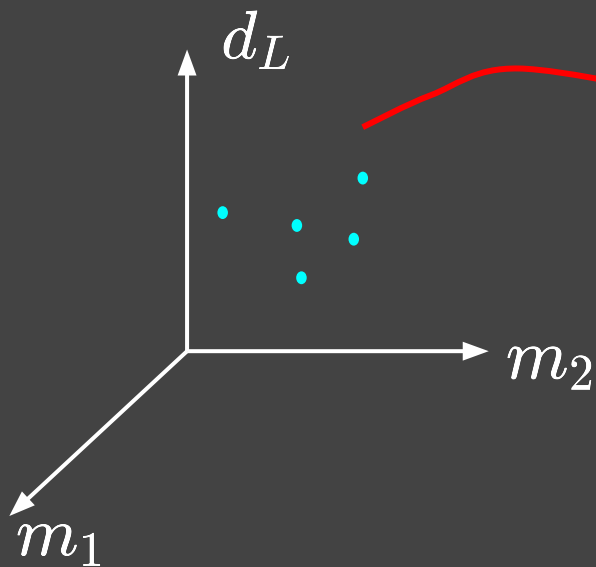
# Summary

- A large number of GW signals need to be simulated in order to perform parameter estimation.
- As the signal models become complex – strong lensing, higher harmonics, precession – or the duration of the signal increases – Einstein Telescope and Cosmic Explorer – the waveform simulation becomes more expensive.
- Relative binning can speed up the parameter estimation, at a desired accuracy, by simulating the waveform on a sparse frequency grid. Link to the codebase:  
<https://github.com/lemn12/relativebinning>
- Ongoing work on parameter estimation for 3G detectors. Several problems to be tackled...earth rotation, overlapping signals, PSD estimation, confusion background...

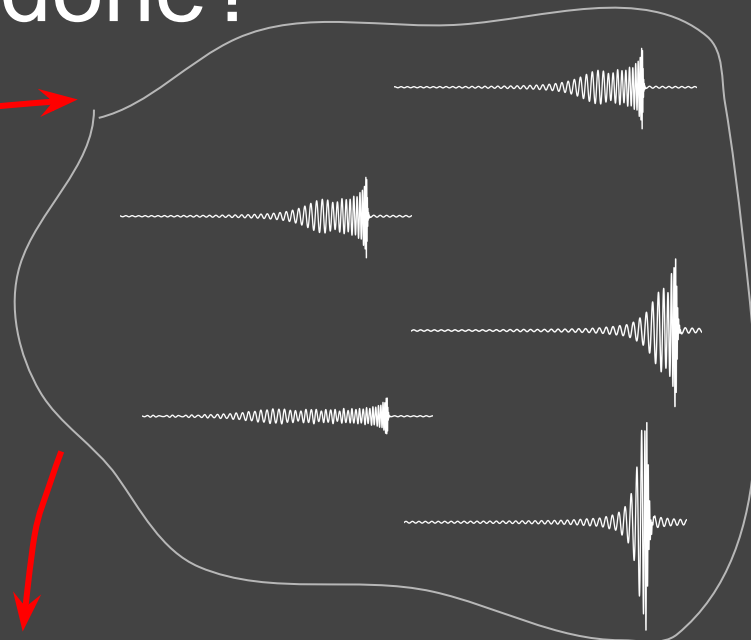
Thank you!

## Buffer slides

# How can it be done?



$$h(m_1, m_2, d_L)$$



If the noise is Gaussian and stationary...

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