# Progress towards a semi-coherent search for EMRI signals

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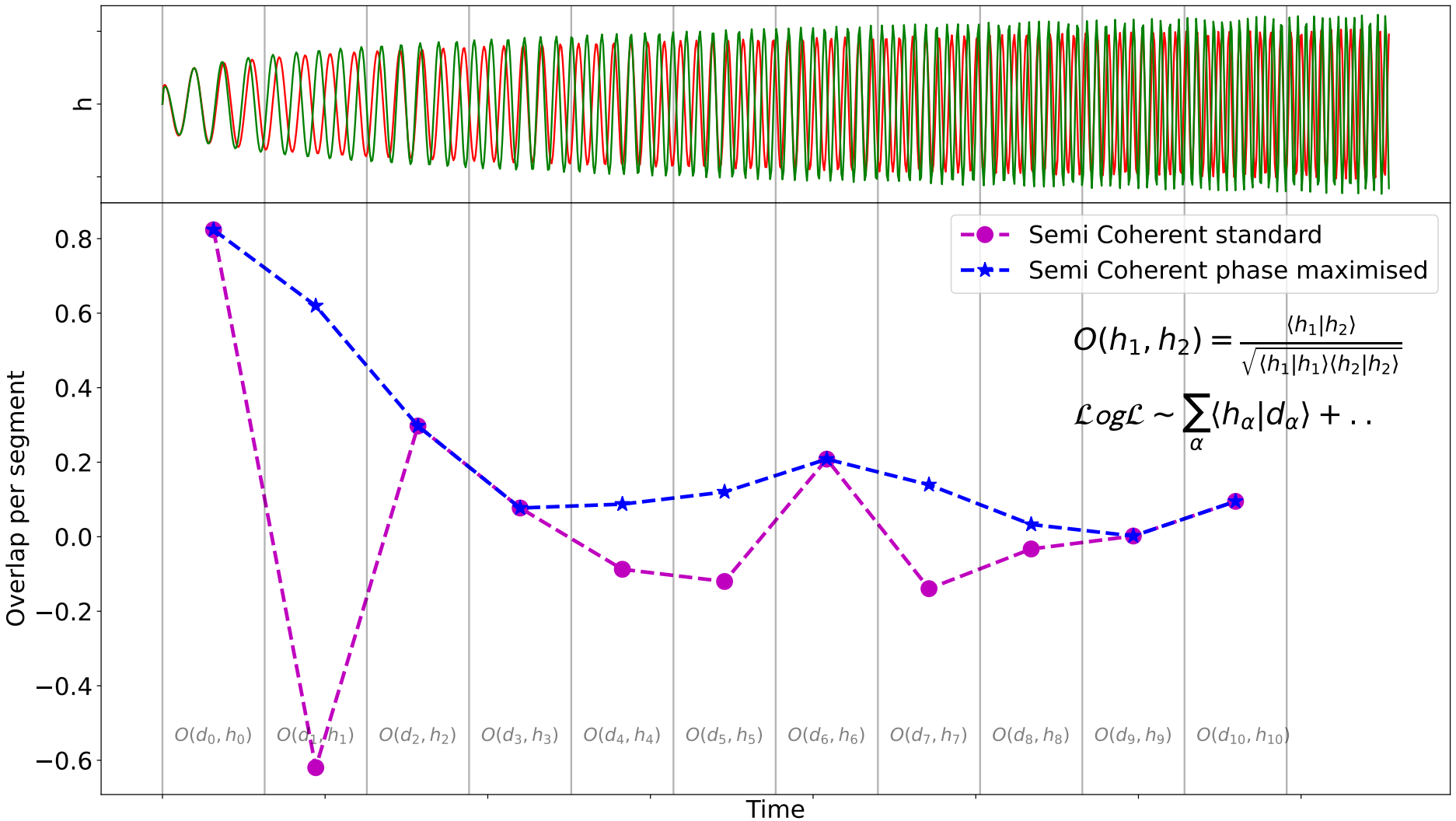
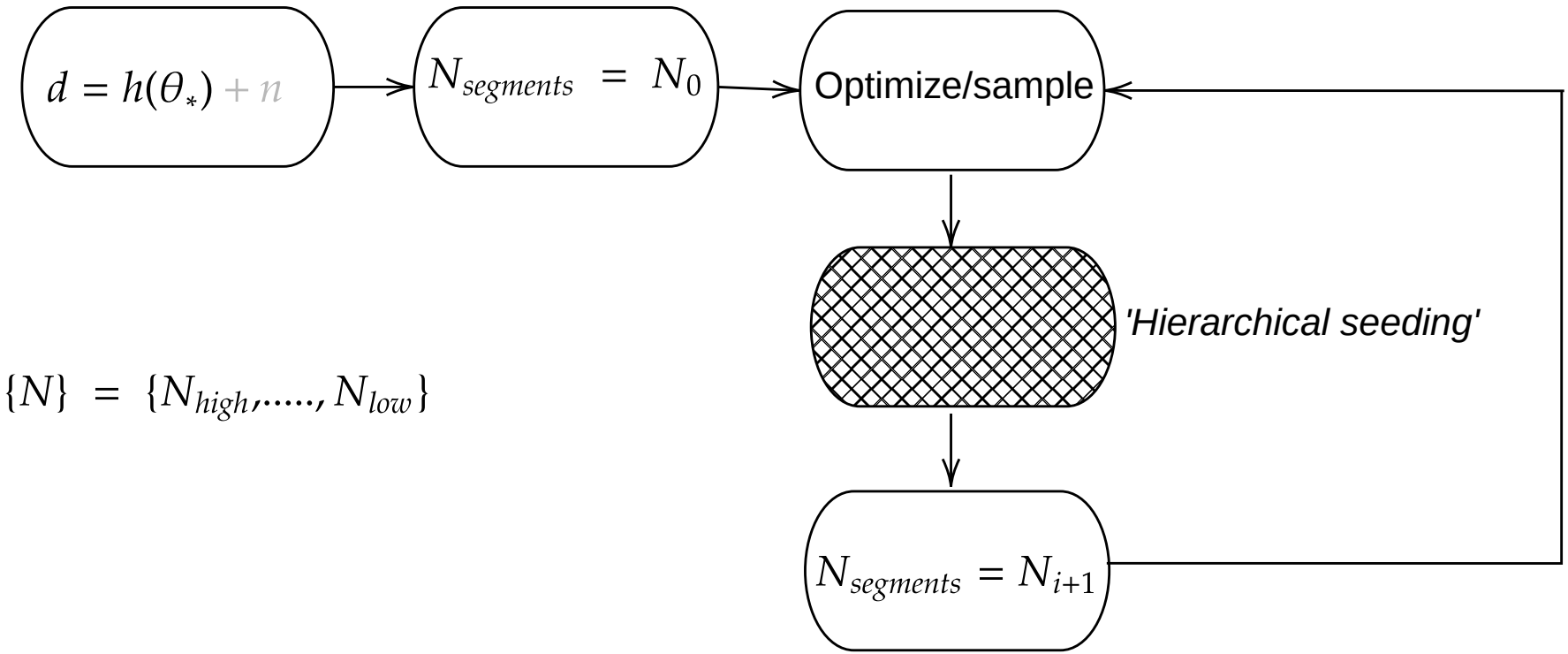
# Introduction

- Searching for an Extreme Mass Ratio Inspiral (EMRI) signal is a problem analogous to looking for a *needle in a haystack*.
- Needle: The bulk of the posterior occupies very little space in parameter space, primarily due to the observation of a large number of orbital cycles, resulting in a precise estimate of the chirp mass.
- Haystack: Numerous secondary peaks in the likelihood surface (which can be significantly far from the true intrinsic parameters) caused by phase matching of harmonic modes at a different locations in parameter space.
- Stellar mass black hole signals have a similar needle-like posterior peak.

# Semi-Coherent likelihood - Widening the needle

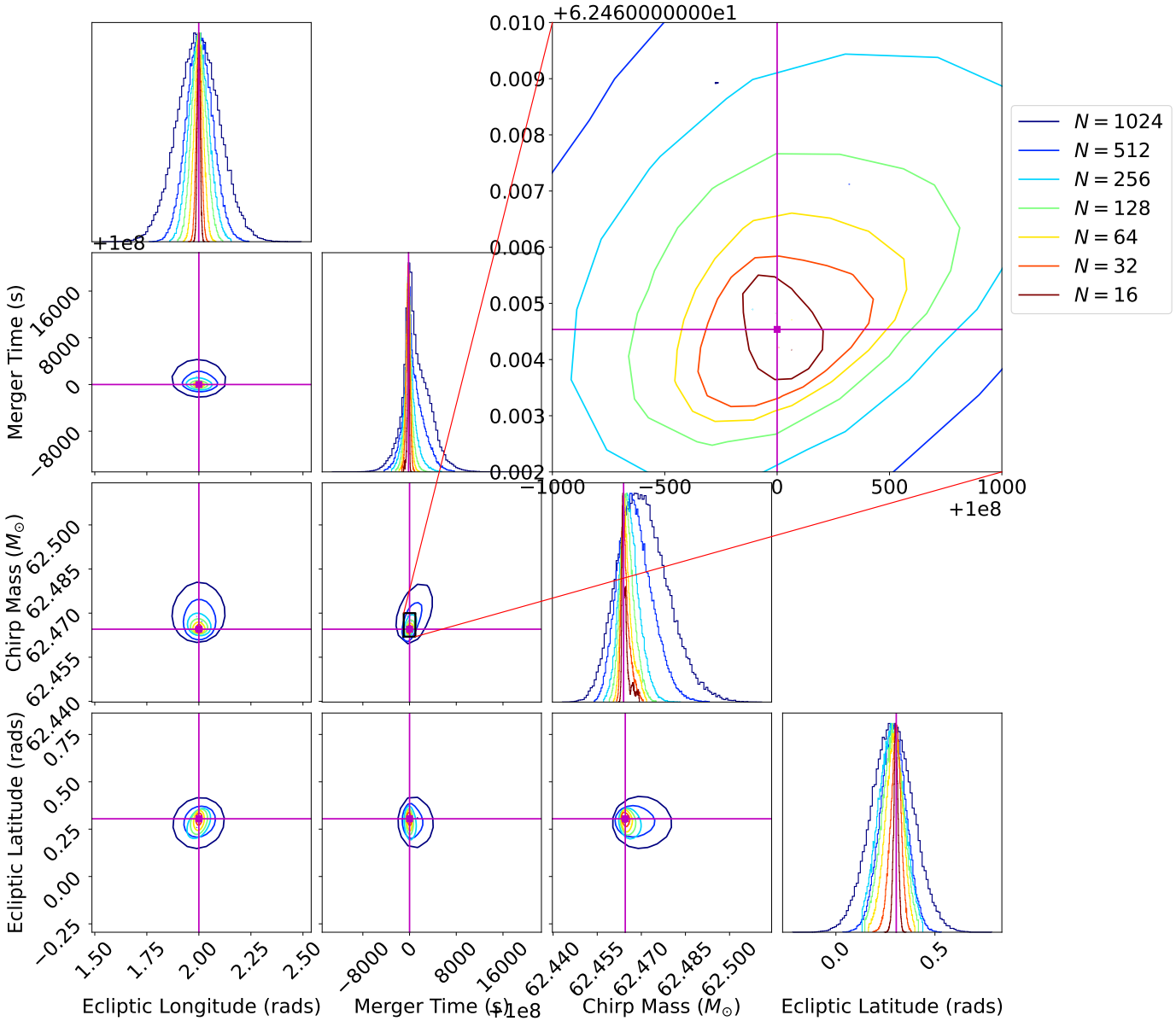


# Semi-Coherent schematic



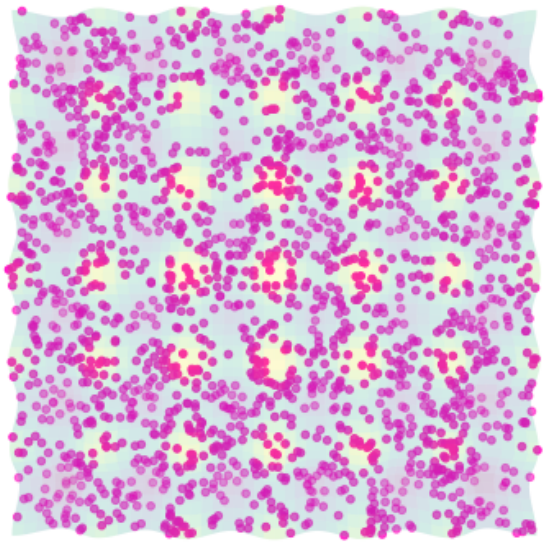

$\{N\} = \{N_{high}, ....., N_{low}\}$

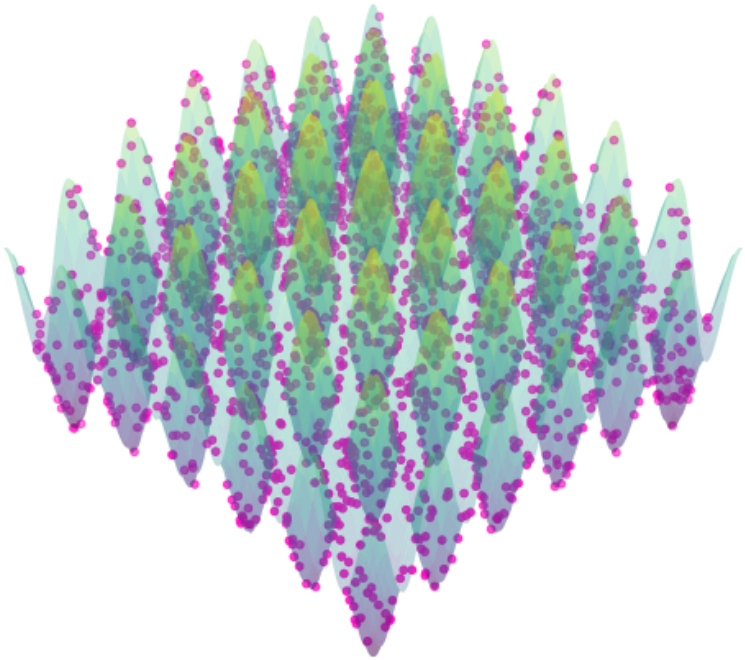
# Hierarchical sampling/search




- Chirp mass: 62.46 $M_\odot$
- Time to merger: 3.17 years.
- SNR $\sim$ 11.5.
- Spin aligned, (2,2) mode waveform.
- **Initial prior ranges cover whole sky, 15 $M_\odot$ in chirp mass and 2 months in time to merger.**

# PySO - Sorting through the haystack





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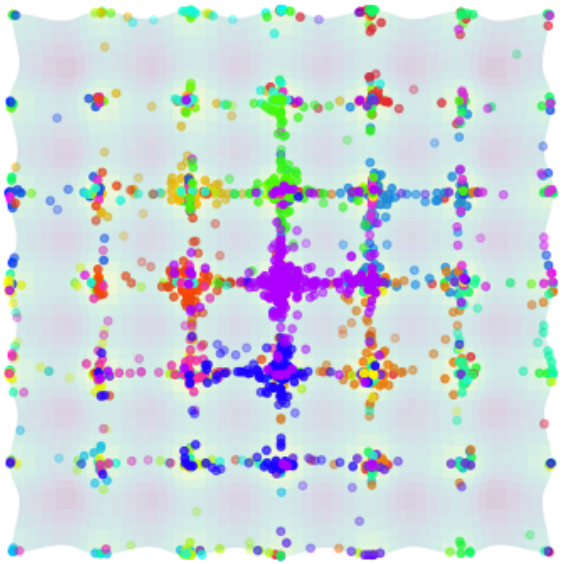

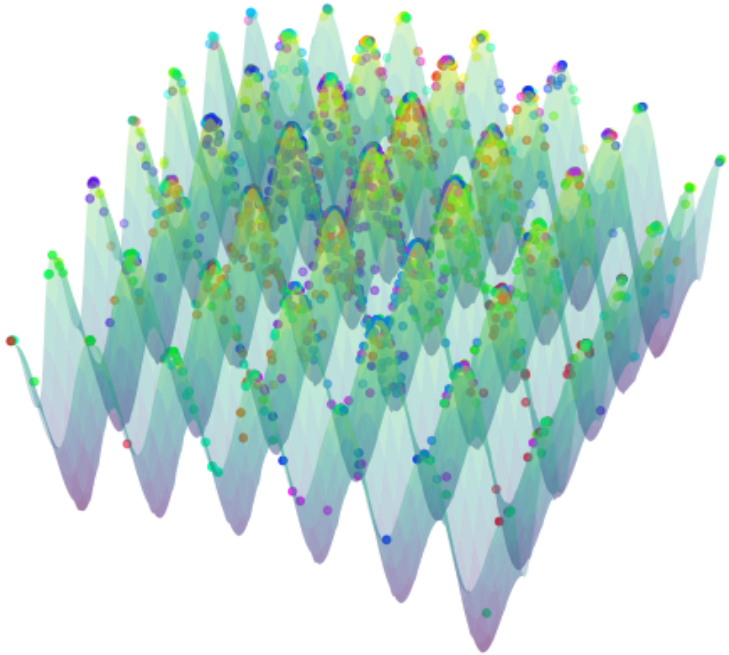

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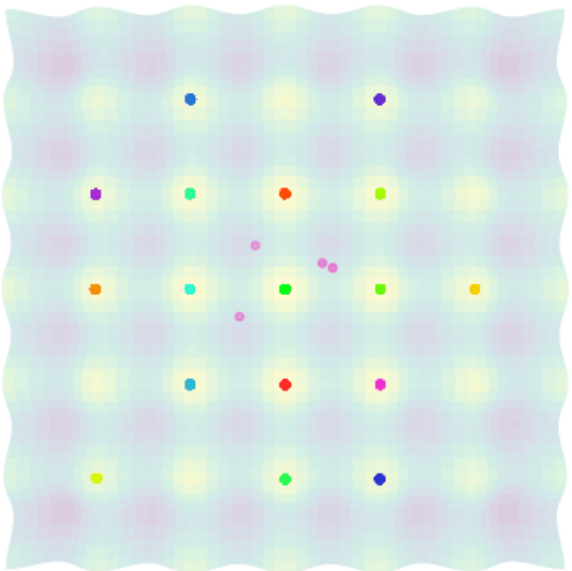
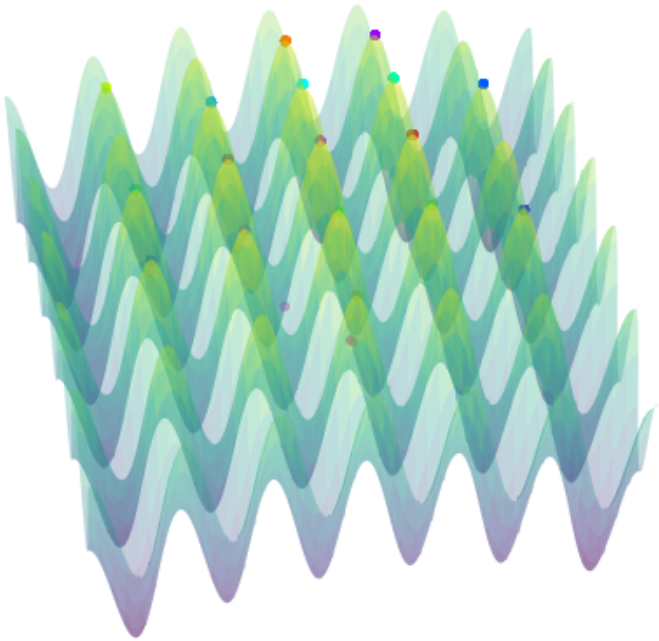
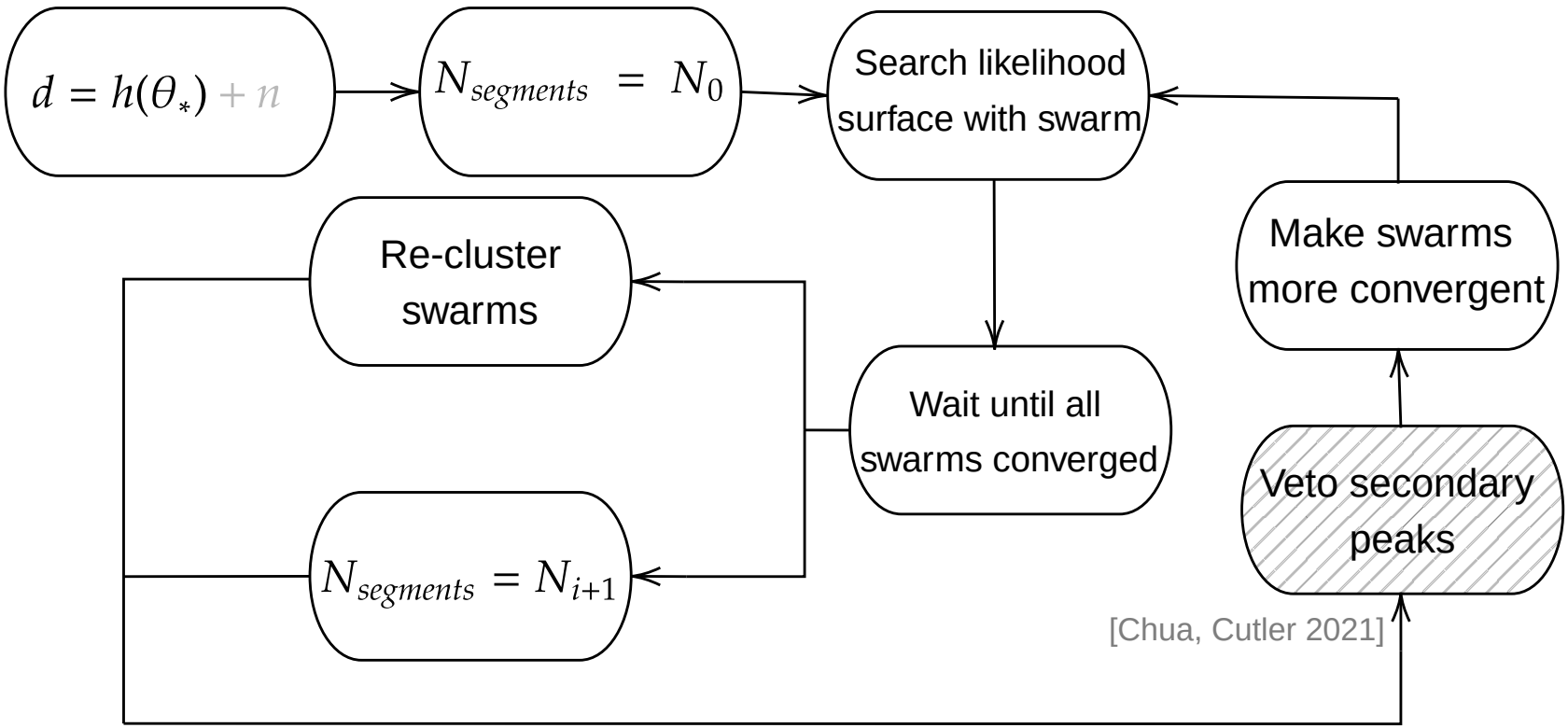




# Searching for the needle in the haystack




[Chua, Cutler 2021]

# Conclusions

- Semi-Coherent hierarchical search methods seem promising for the search of broadband and long lived sources such as stellar mass black hole binaries and hopefully EMRIs!
- Particle swarm optimisation may be well-suited for the task of exploring the extremely multi-modal likelihood distribution expected for EMRI signals.
- The interaction of the semi-coherent approach to the likelihood with detector noise is yet to be investigated, how does the posterior shift under realistic detector noise?