Gravitational-wave Posterior Post-processing with Normalizing Flows

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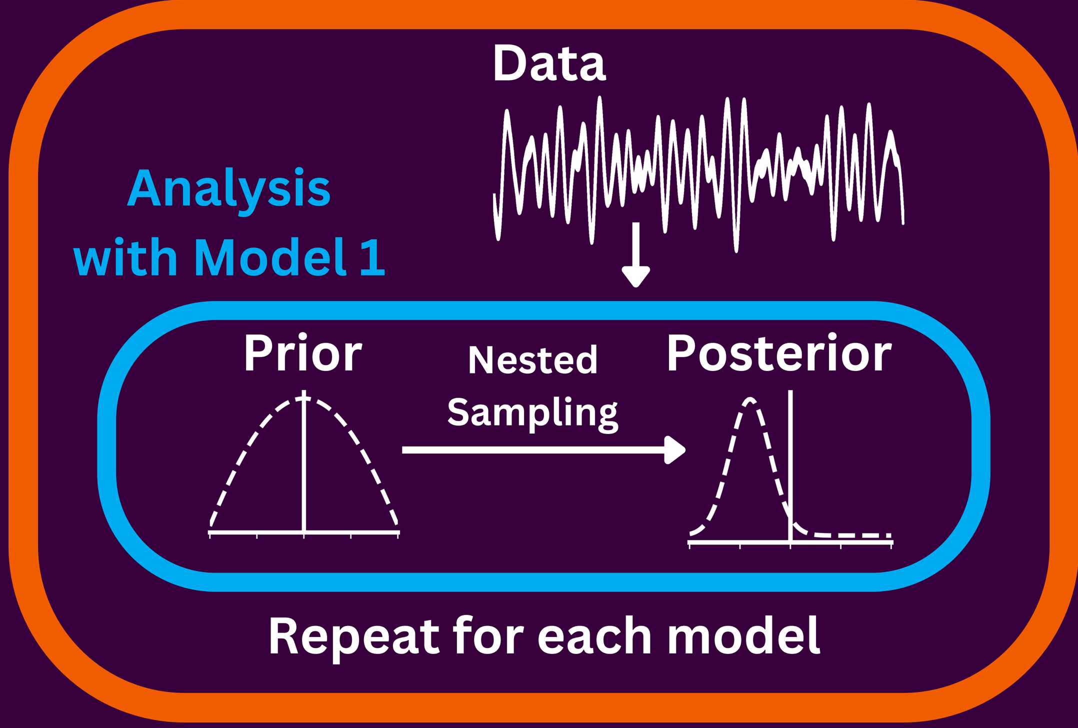
Introduction

- **Bayesian inference** is a key tool for gravitational-wave data analysis
- It enables us to infer the **properties of compact binaries** such as their masses and spins
- Standard analyses using Nested Sampling to **estimate the posterior distribution and evidence**

Problem

- There are many cases where we **re-analyze data** with e.g. a **new waveform model** that results in only slight changes to the posterior
- Standard analyses ignore existing results and rerun inference from the prior
- This is **computationally inefficient**

Standard analyses



AIM: To develop a framework to obtain results with new models by post-processing existing results

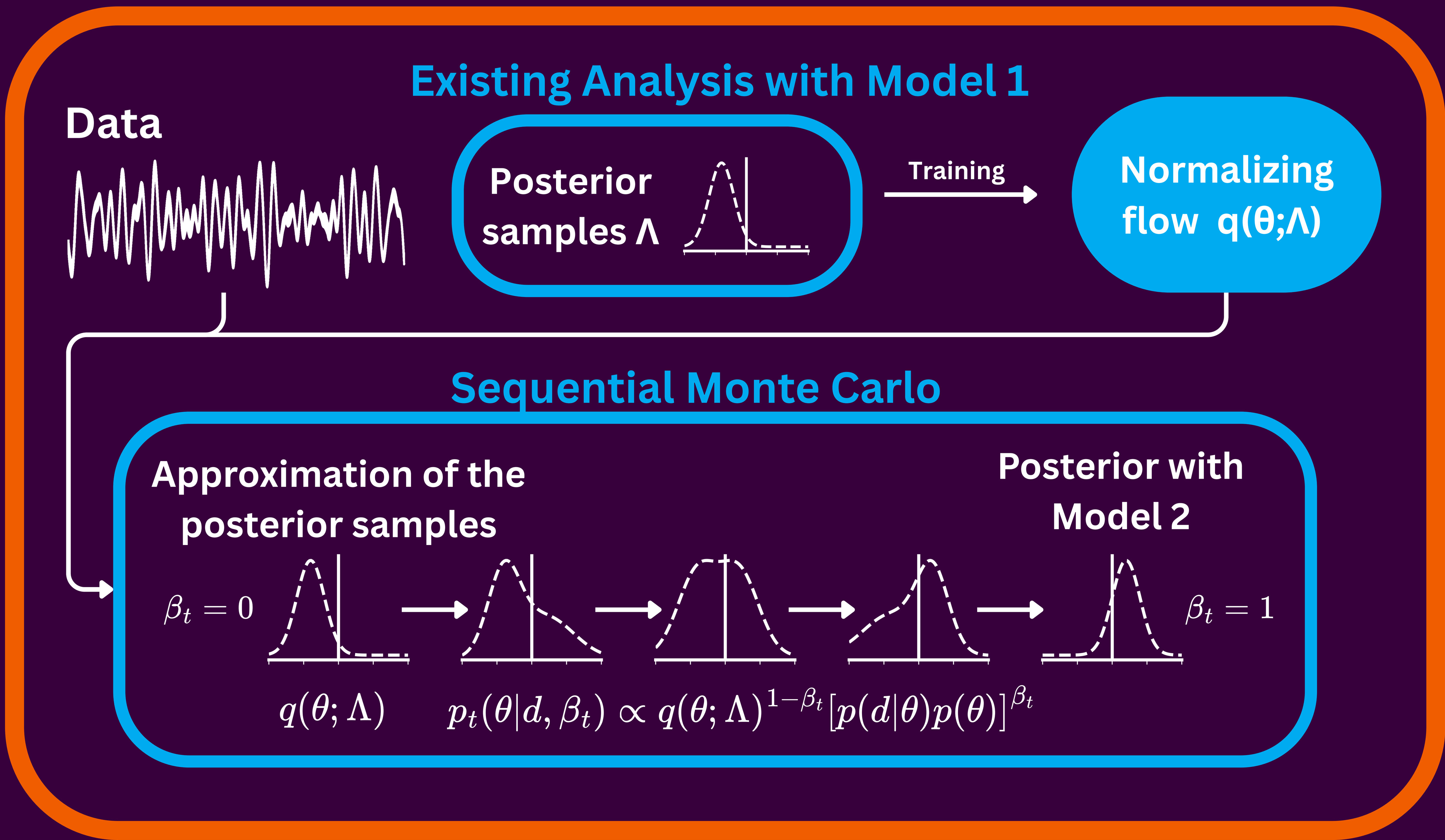
Method

We use a two step process:

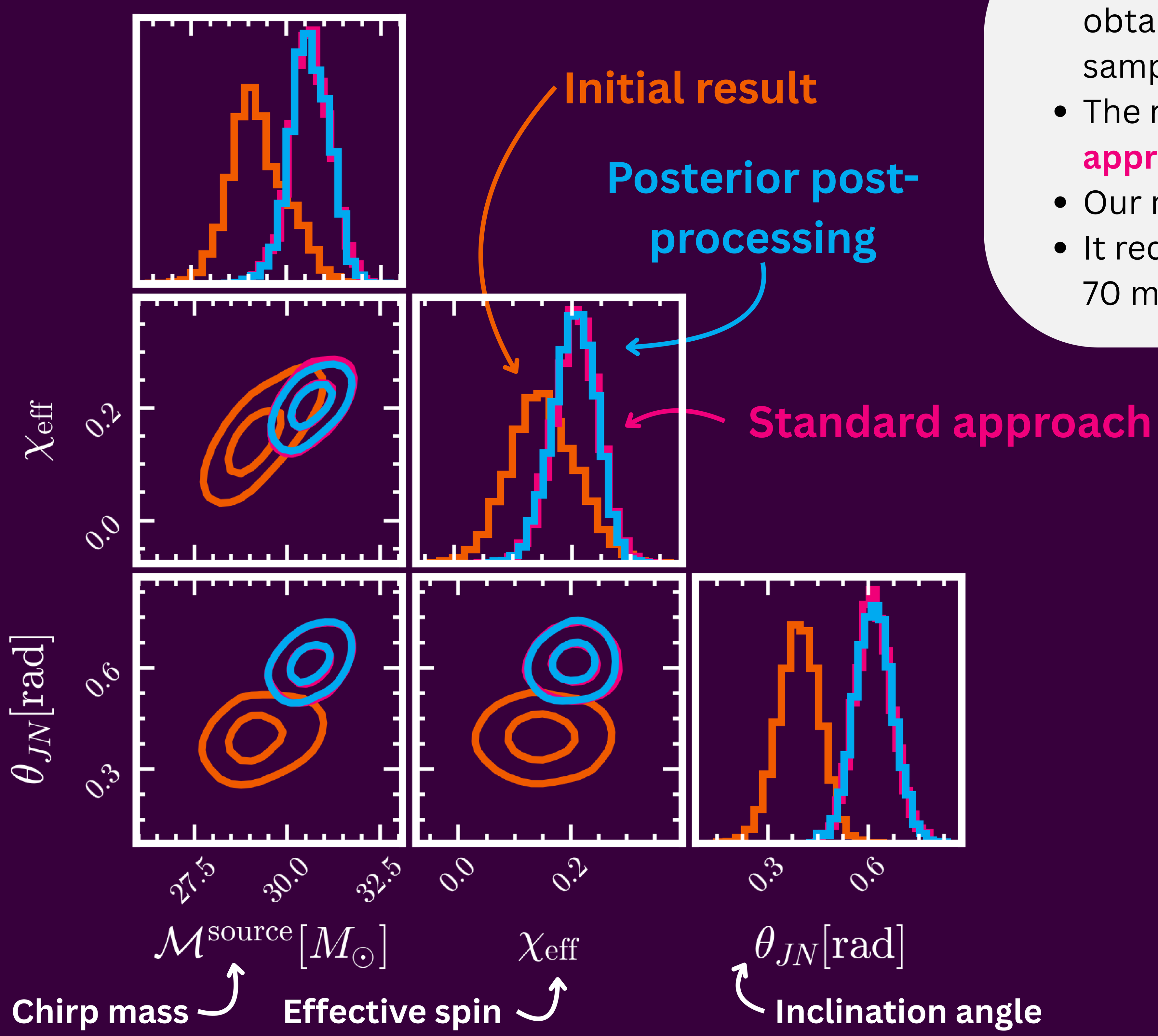
- **Approximate the initial posterior** using a **normalizing flow**
- **Sequential Monte Carlo (SMC):** Evolve particles from the approximate initial distribution to the new posterior

We refer to this framework as Posterior Post-Processing

Posterior post-processing



Equivalent results at a fraction of the cost



Results

- We demonstrate our method by post-processing posterior samples obtained with Model 1 (IMRPhenomXPHM) to obtain posterior samples for Model 2 (IMRPhenomXO4a).
- The results are consistent with those obtained using the standard approach.
- Our method took 3 hours, compared to 17 for the standard method.
- It required seven times fewer likelihood evaluations (10 million vs. 70 million), making it **seven times more efficient**.

Conclusions

- **Posterior post-processing** combines **normalizing flows** and **Sequential Monte Carlo** to provide a novel means of reanalyzing data.
- It enables us to obtain results with a new model **without repeating the full analysis**.
- The method is **consistent with the standard approach** but is significantly **more efficient**.

OUTLOOK: This work is a proof-of-principle and has many possible applications, including: **tests of General Relativity** or **gravitational-wave lensing analyses**.