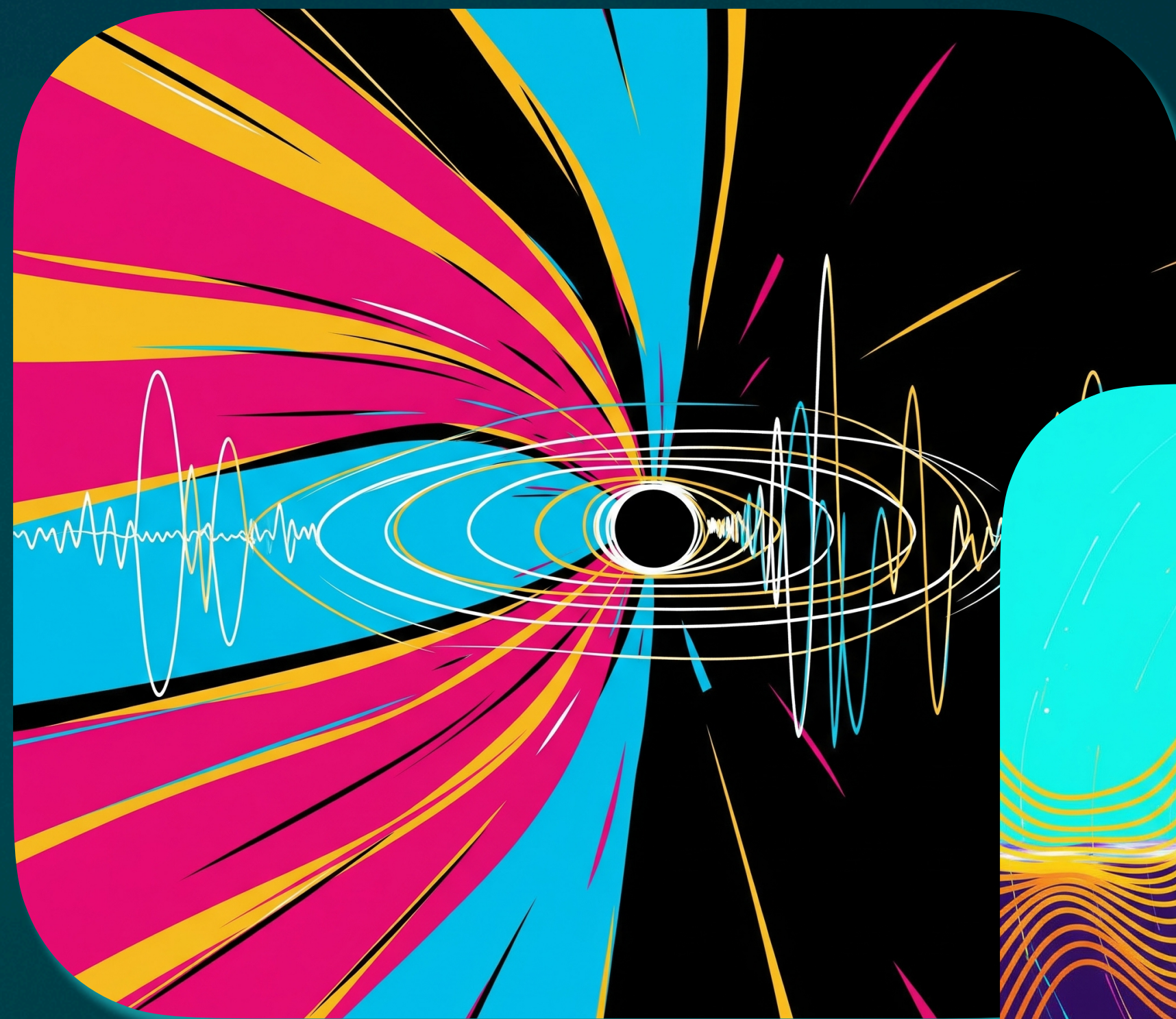




Can we unlock the LISA Global Fit with SBI?

Tools and Strategies



Google Gemini 2.5 ("Unlocking the
LISA global fit with SBI")

james **alvey**
Kavli Institute | University of Cambridge



Collaborators



Huifang Lyu
(see her poster!!)



Christoph
Weniger



Mauro
Pieroni



Noemi Anau
Montel

THE ERA OF BIG DATA CHALLENGES FOR GRAVITATIONAL WAVES

Supermassive
Black Holes

Extreme Mass Ratio
Inspirals (EMRIs)

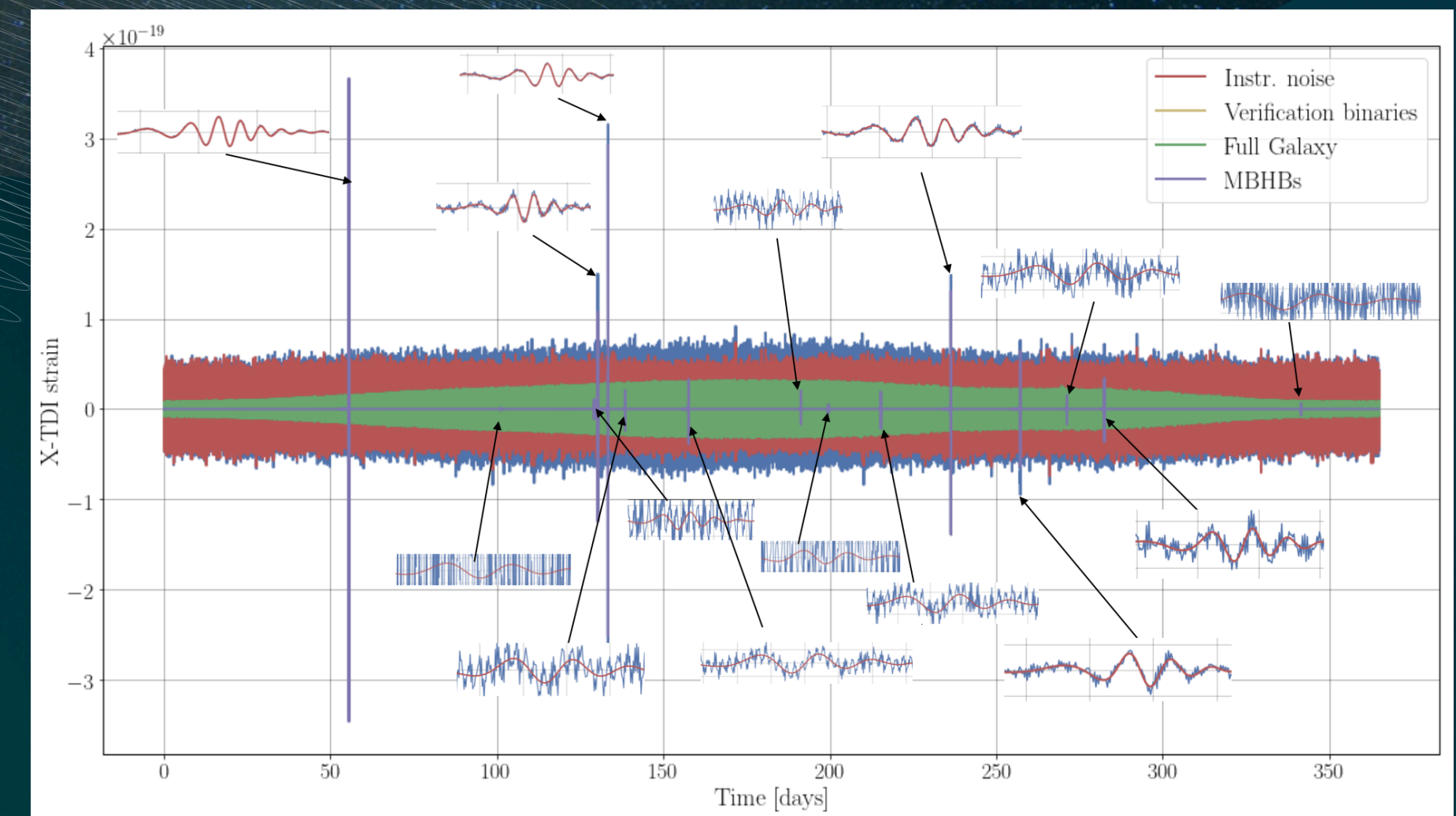
1000s of
Milky Way
Binaries

LISA

The LISA Data
Challenge: How do we
separate and analyse 1000s
of sources in the data?

Cosmological
Stochastic
Backgrounds

All of these sources, all at once



AMORTISED VS. SEQUENTIAL SBI ALGORITHMS

Amortised SBI

Simulate

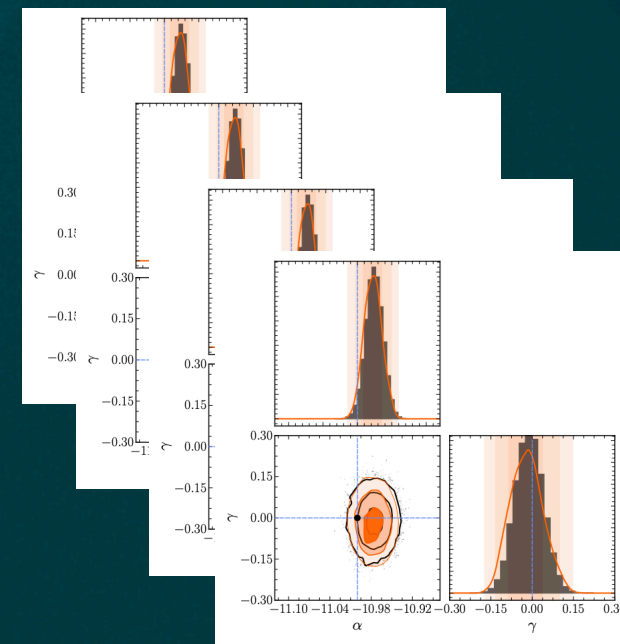
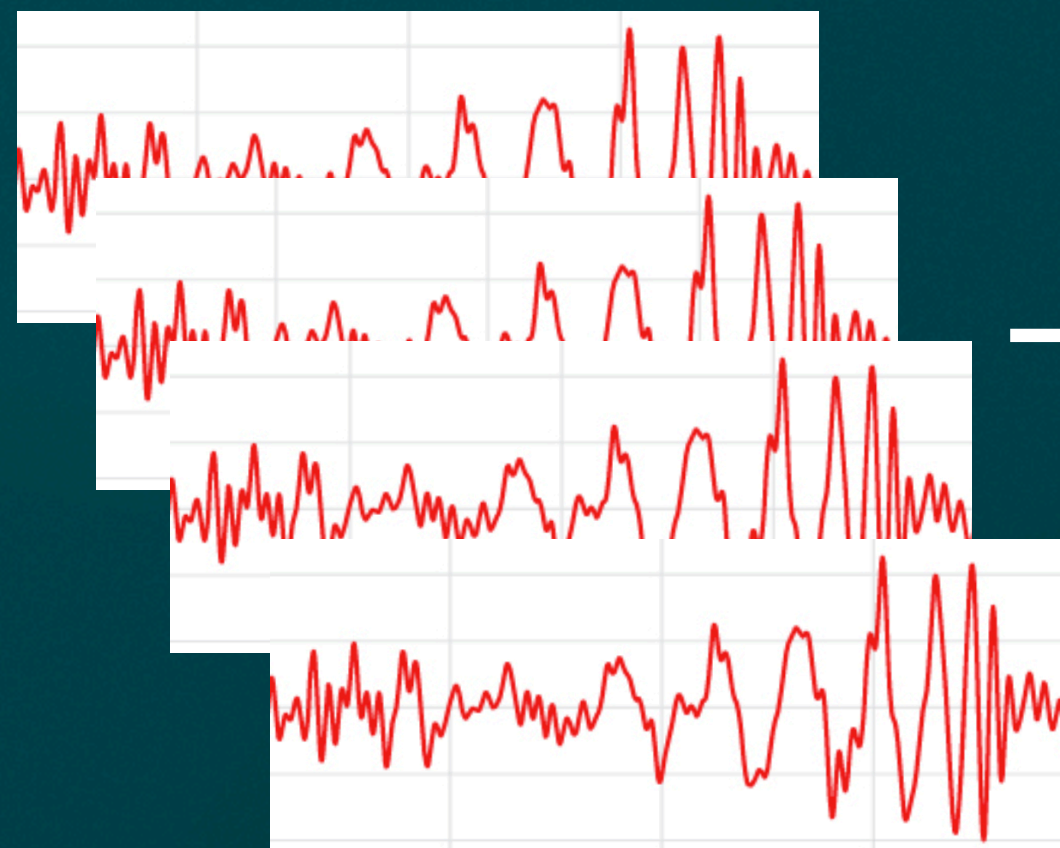


Train



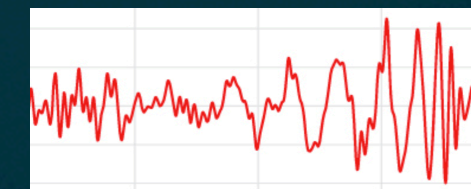
Infer

Can analyse **any** observation with the same trained model



Sequential SBI

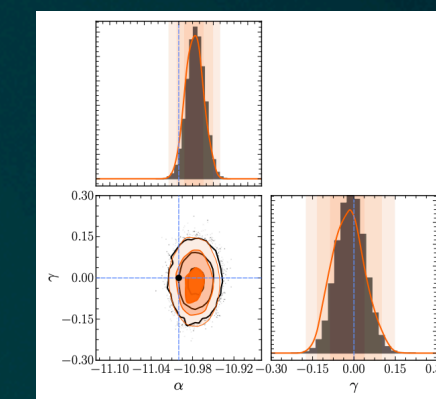
Simulate



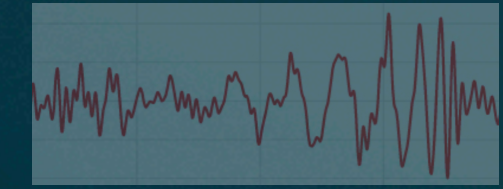
Train

Zoom-in

Infer



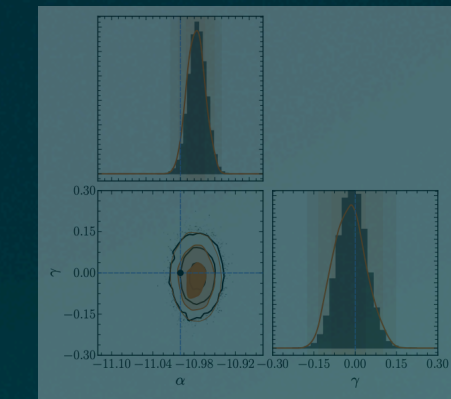
Simulate



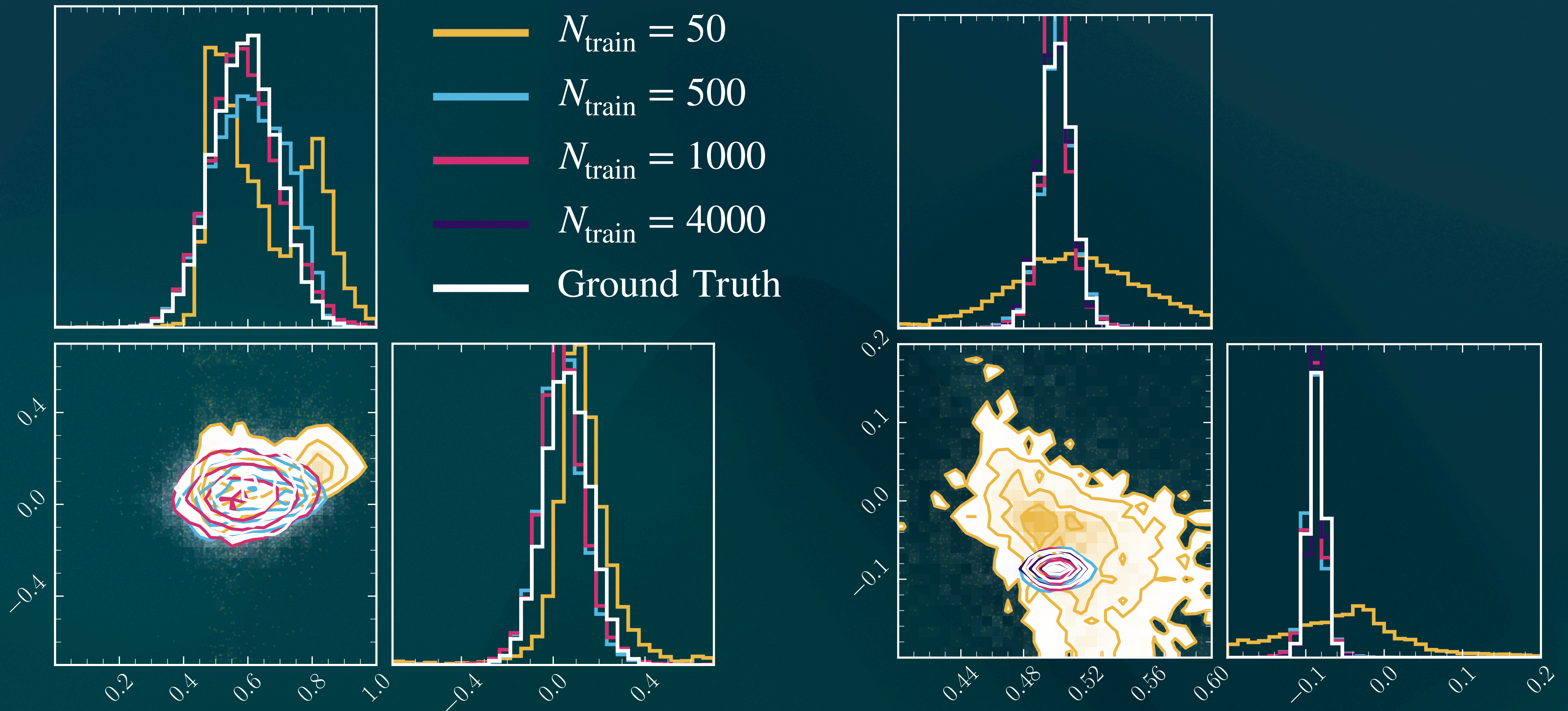
Train

Zoom-in

Infer



HOW CAN AMORTIZED ALGORITHMS BREAKDOWN?

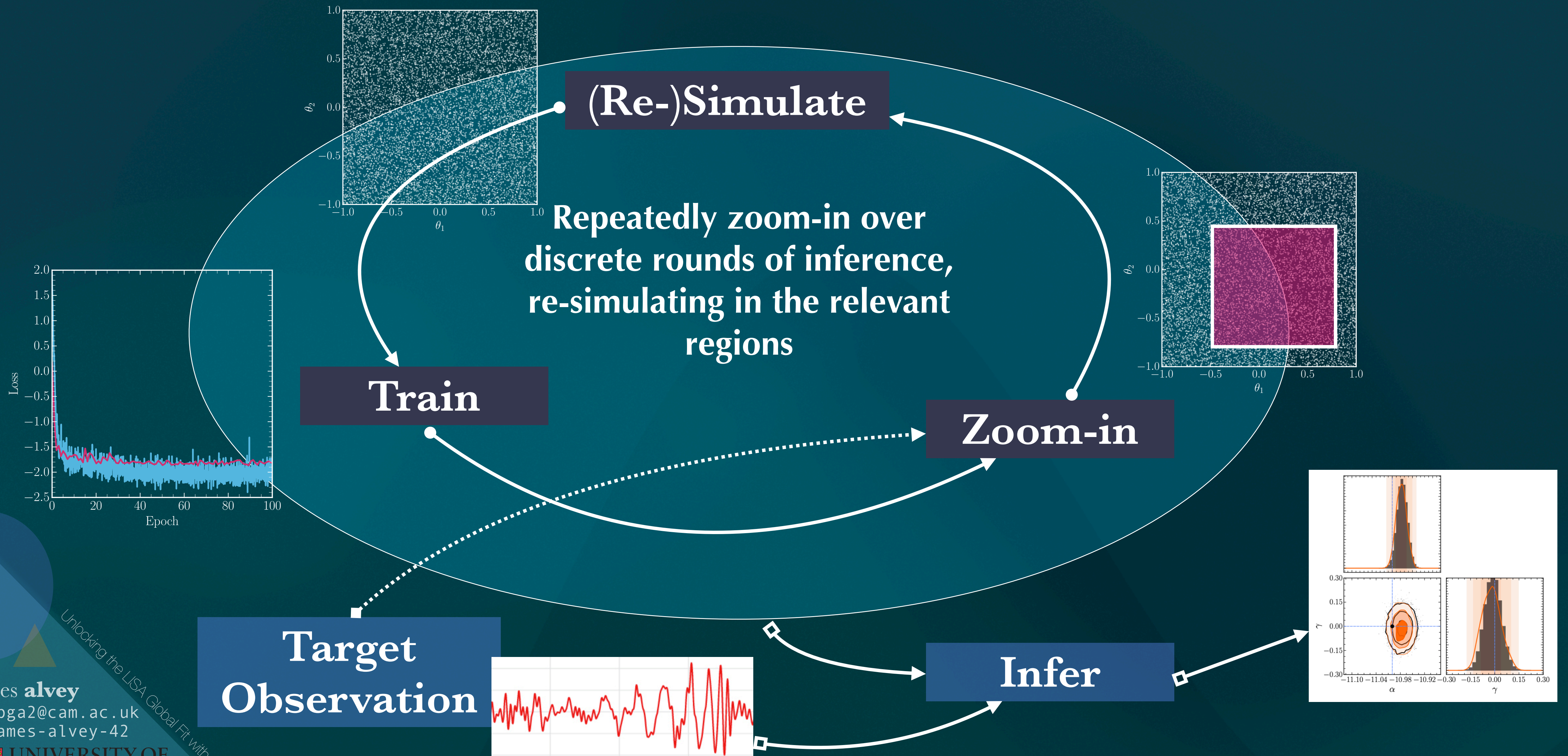


$\sigma = 10^{-1}$

High dimension and/or high
precision can be costly

$\sigma = 10^{-2}$

WHAT IS USUALLY DONE IN SEQUENTIAL ALGORITHMS?

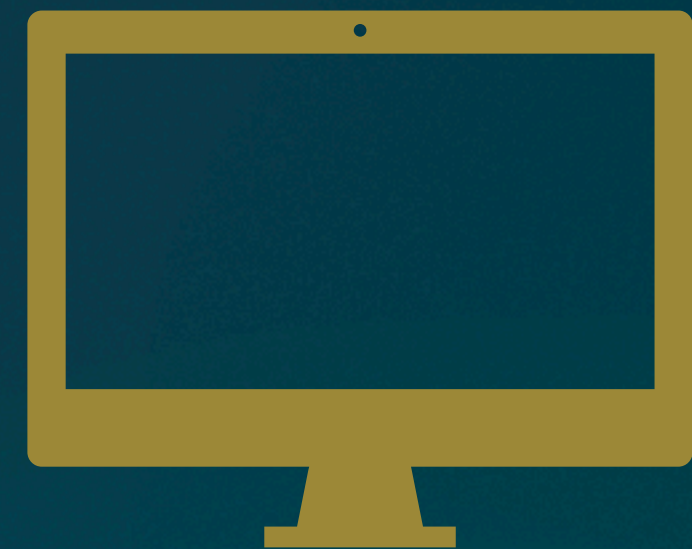


BREAKING THE SIMULATE-TRAIN-SIMULATE LOOP

Simulation Process

Run concurrently

Inference Process

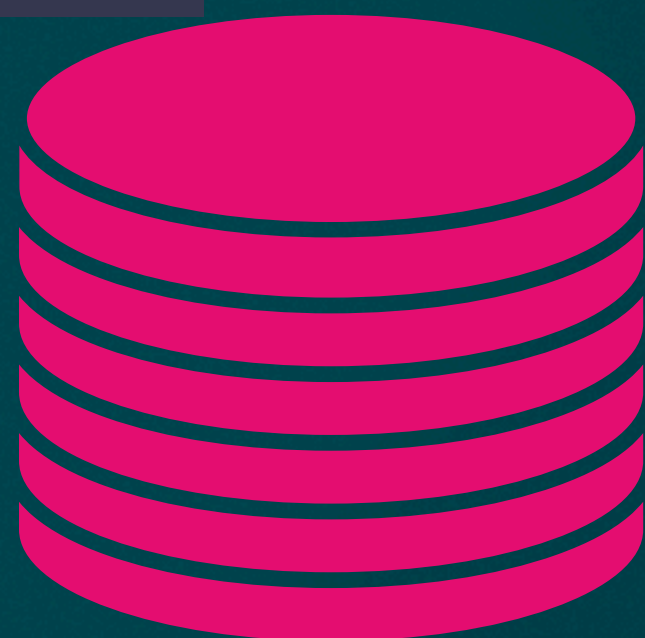


Simulator

Propose new parameters



Store simulations
when ready



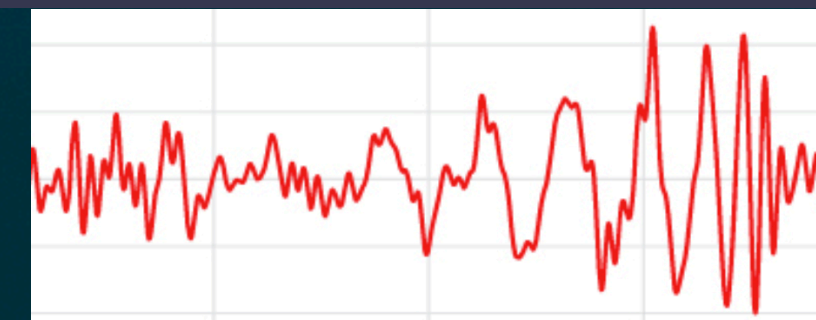
Train network(s) on current buffer

Prune unlikely simulations

Live simulation buffer

Simulation buffer topped up only
when necessary (but ASAP)

Observational Data



Inference/Proposal Networks

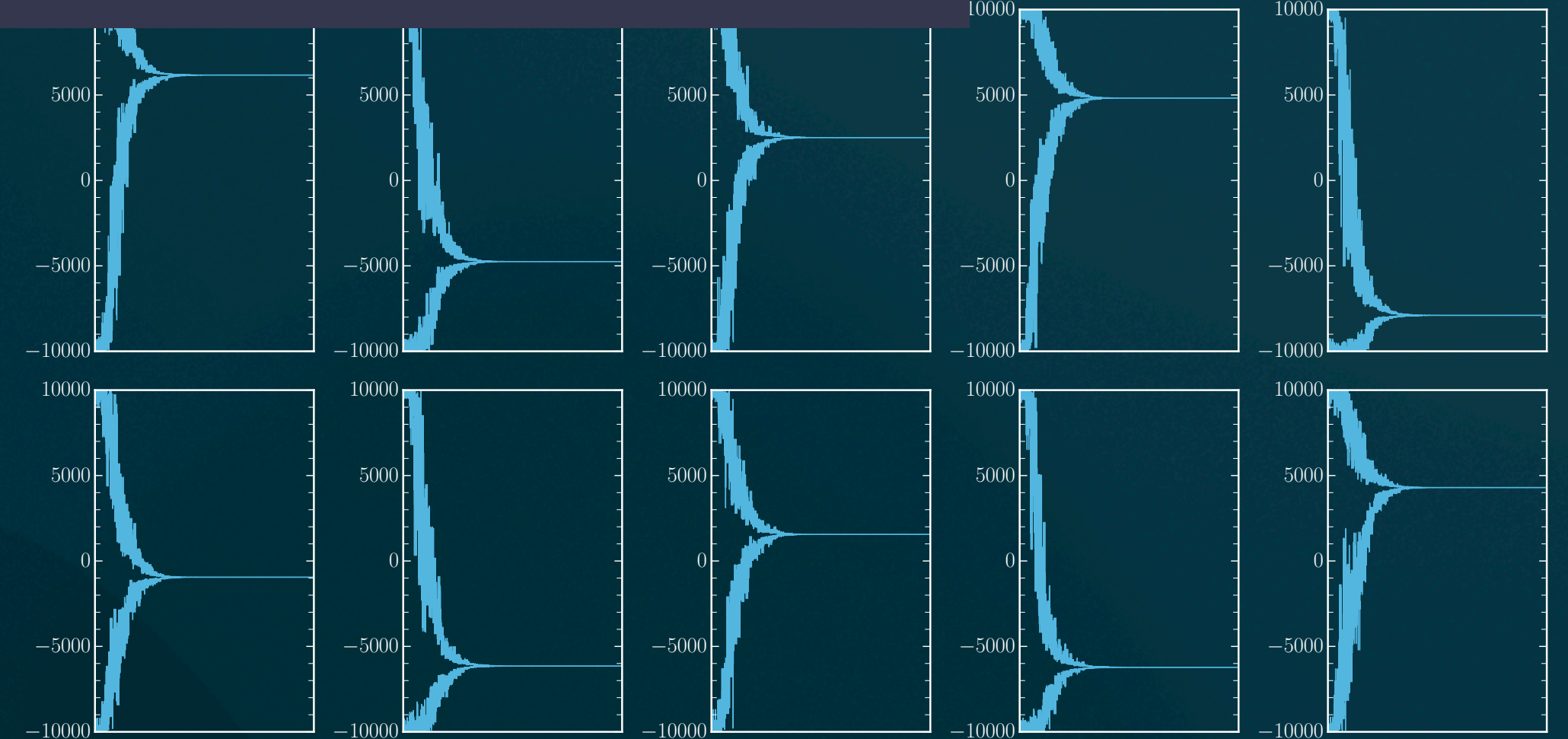
Inference Results

ALGORITHM IN ACTION: HIGH-PRECISION GAUSSIAN

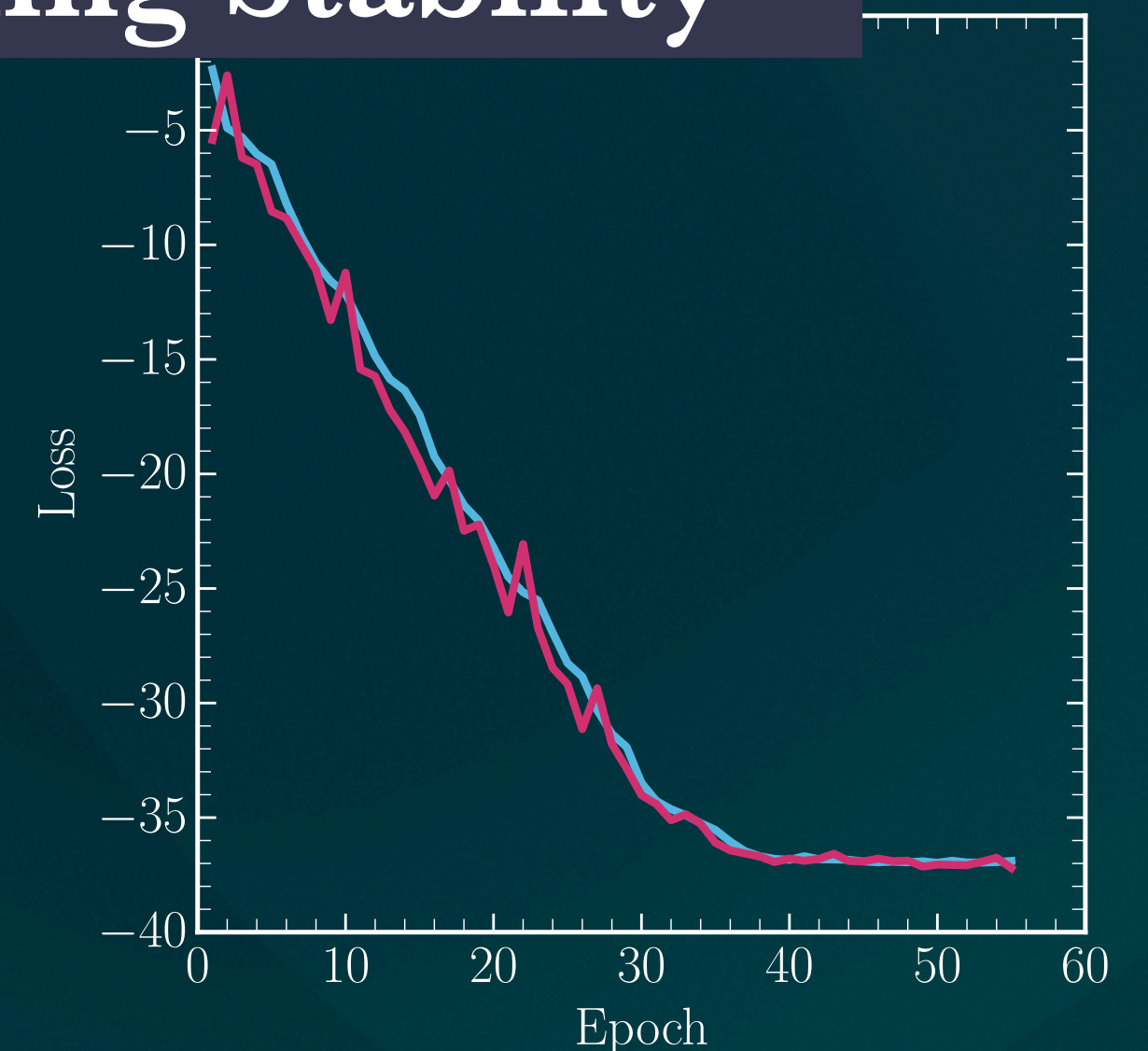
Still resolve the
details of the
1024 modes

Zoom-in by a
factor of 10^6 in
all 10 dimensions
across training

Dataset Evolution



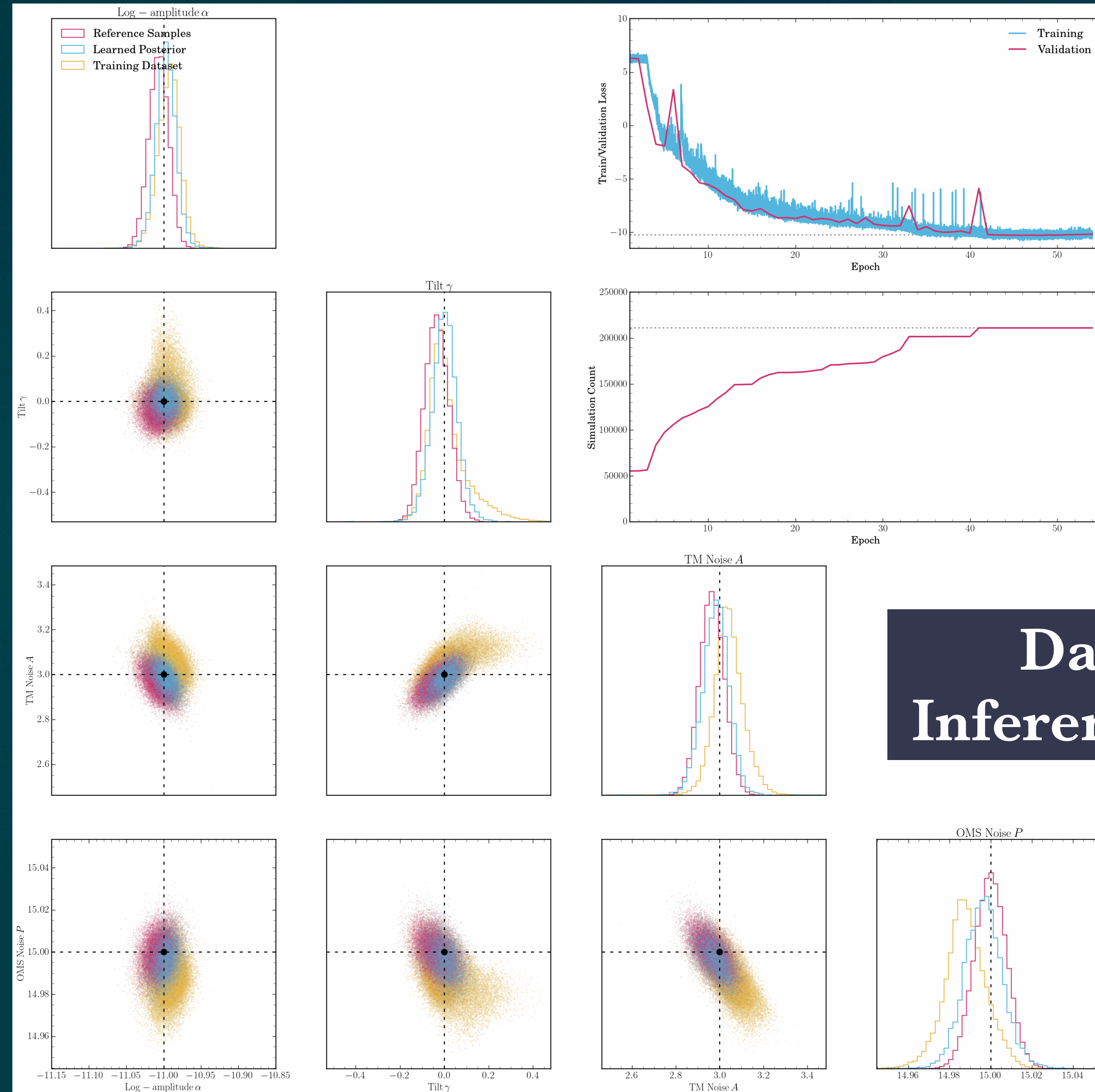
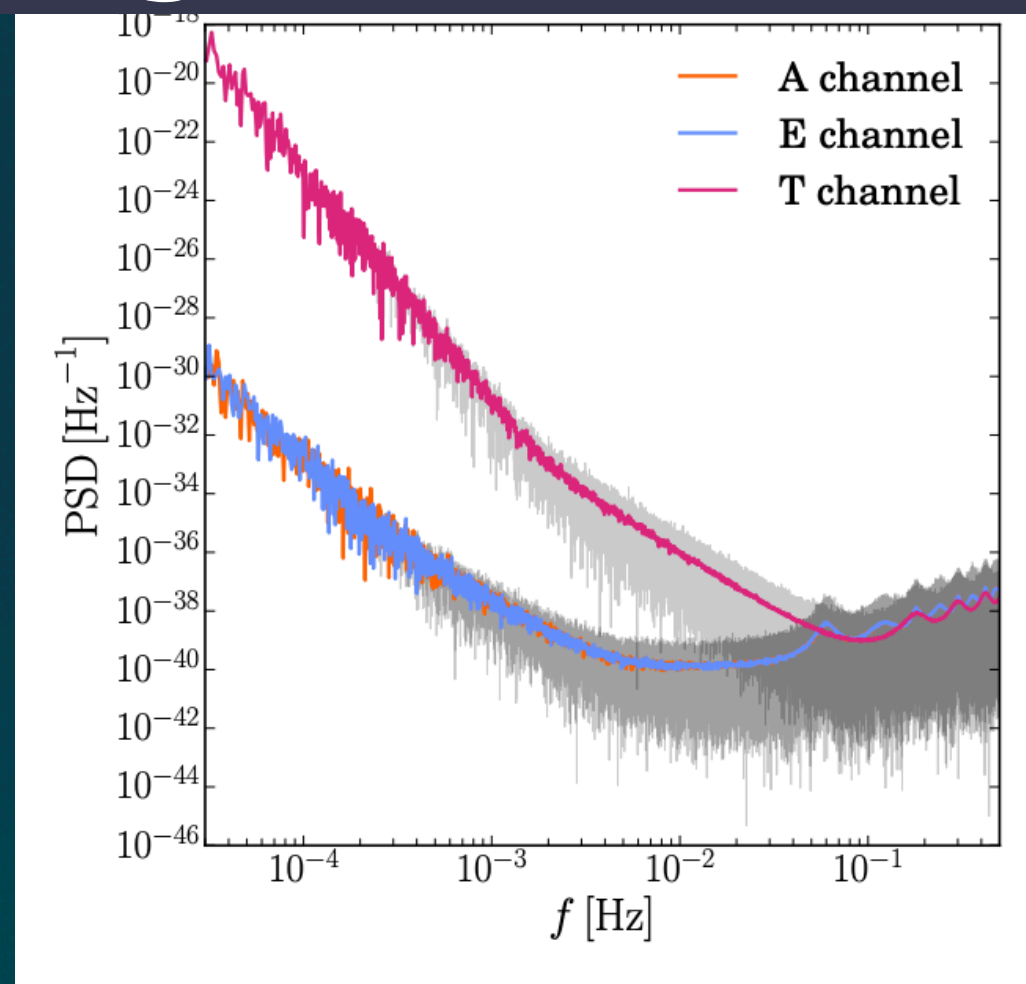
Training Stability



james **alvey**
✉ jbga2@cam.ac.uk
🌐 james-alvey-42

ALGORITHM IN ACTION: STOCHASTIC GRAVITATIONAL WAVE BKG

Target Observation



O(5 - 10)x overall speed-up compared to previous sequential implementation

Dataset and Inference Evolution

james **alvey**
✉ jbga2@cam.ac.uk
📱 james-alvey-42

VISION FOR THE LISA GLOBAL FIT

Simulation Processes

Inference Processes

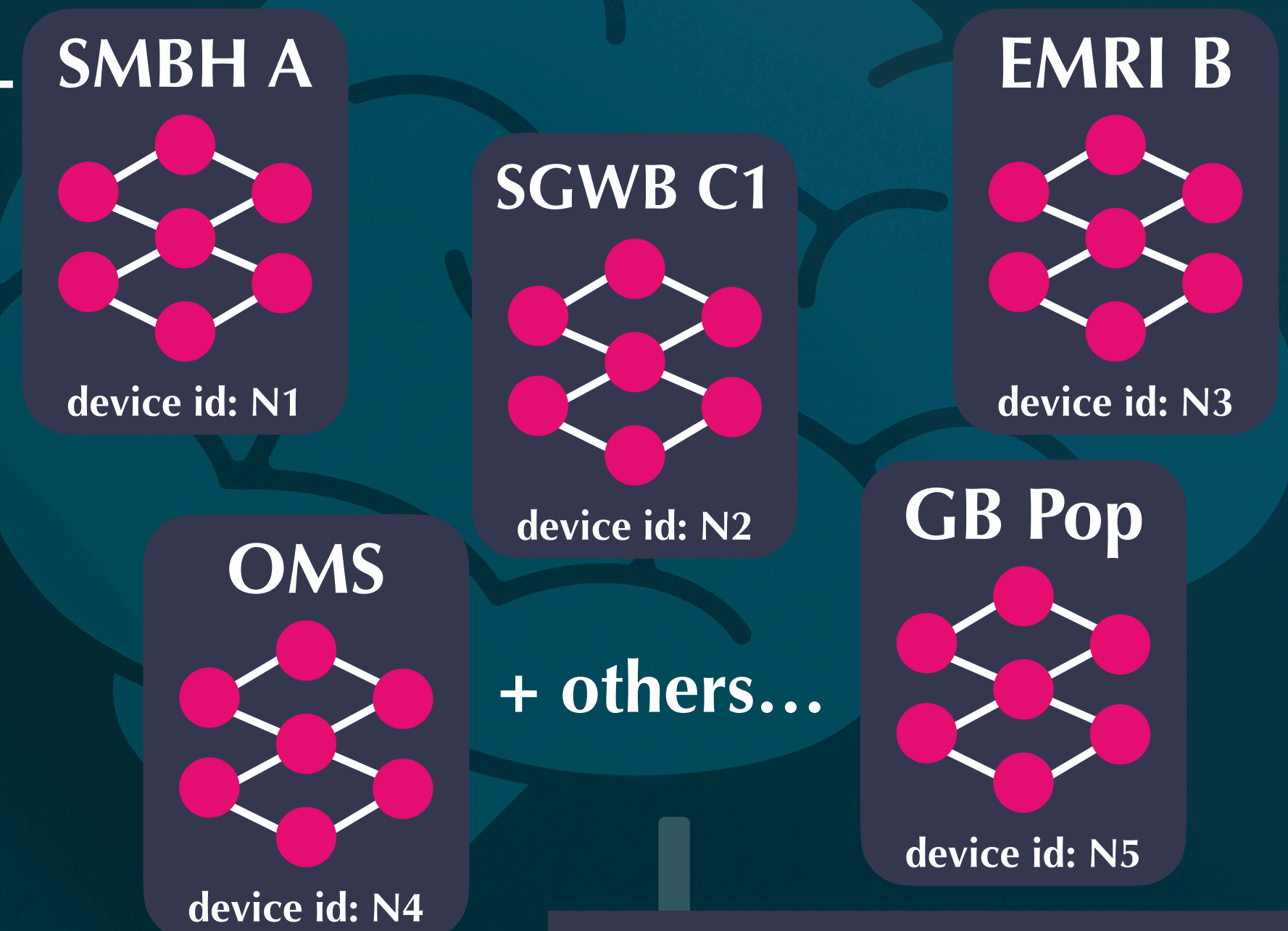
A. Database



Communicate: Remove unlikely parameter sets + trigger resim

Custom data loaders per network

C. Inference Networks



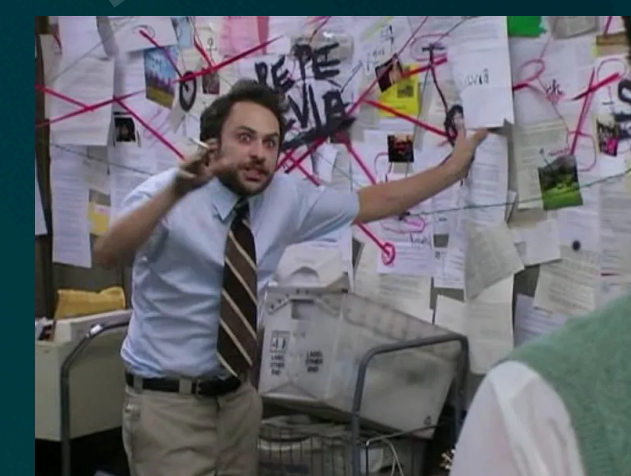
Return: Completed sim

Request: Sim with new param set

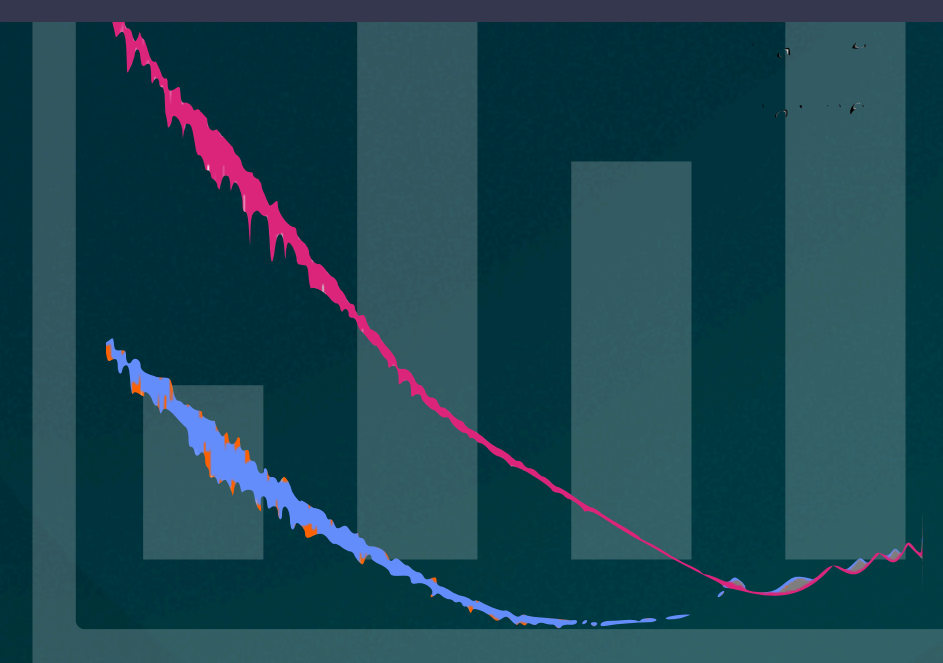


B. Simulation Nodes

D. Observed Data



Appreciate this slide gives these vibes...



WRAP-UP AND CONCLUSIONS

Concluding Question: Can round-free or “one-shot” SBI unlock the LISA global fit?

LISA

