ACTIVE LEARNING FOR GW MODELLING

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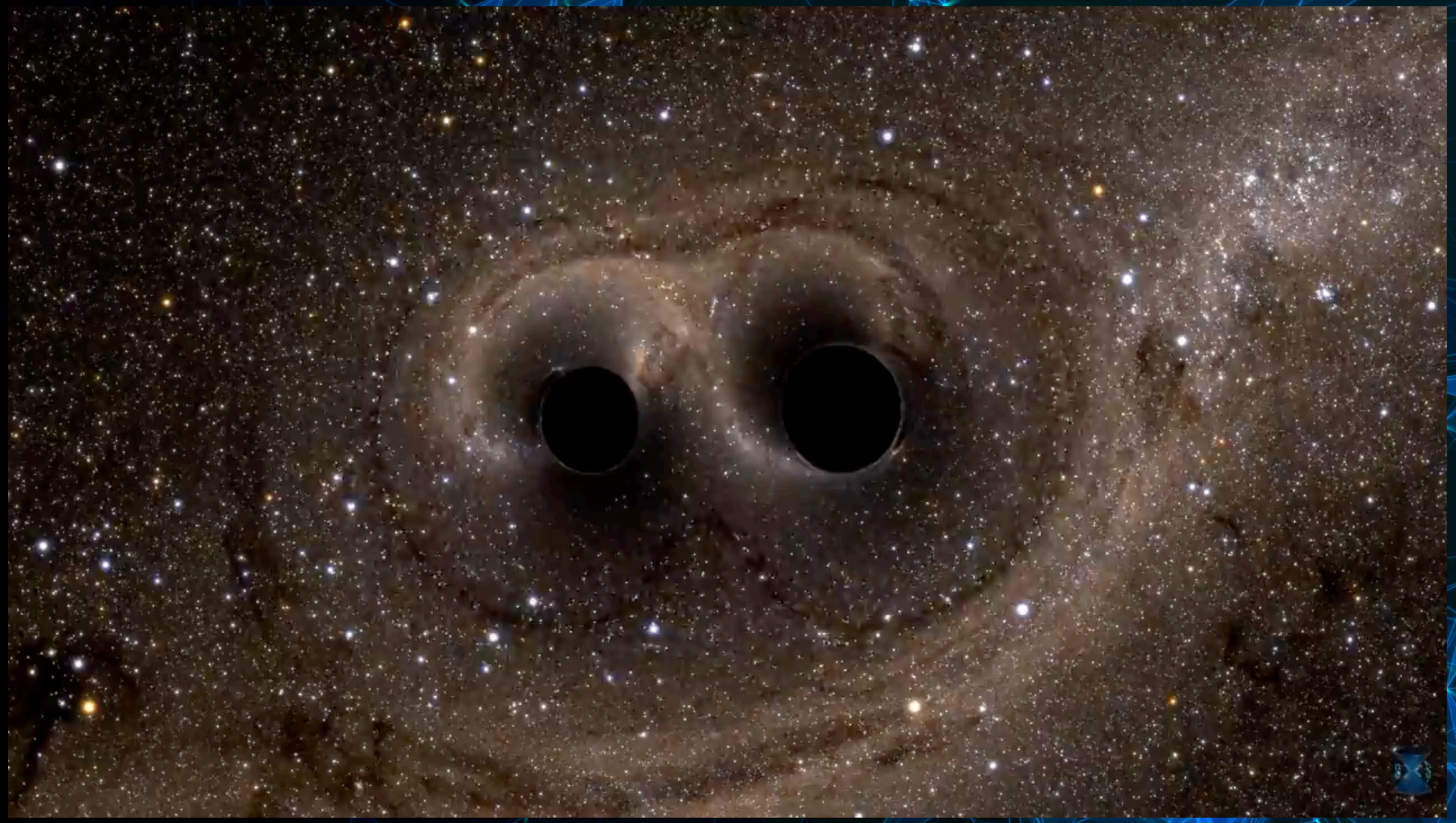
VIRGO

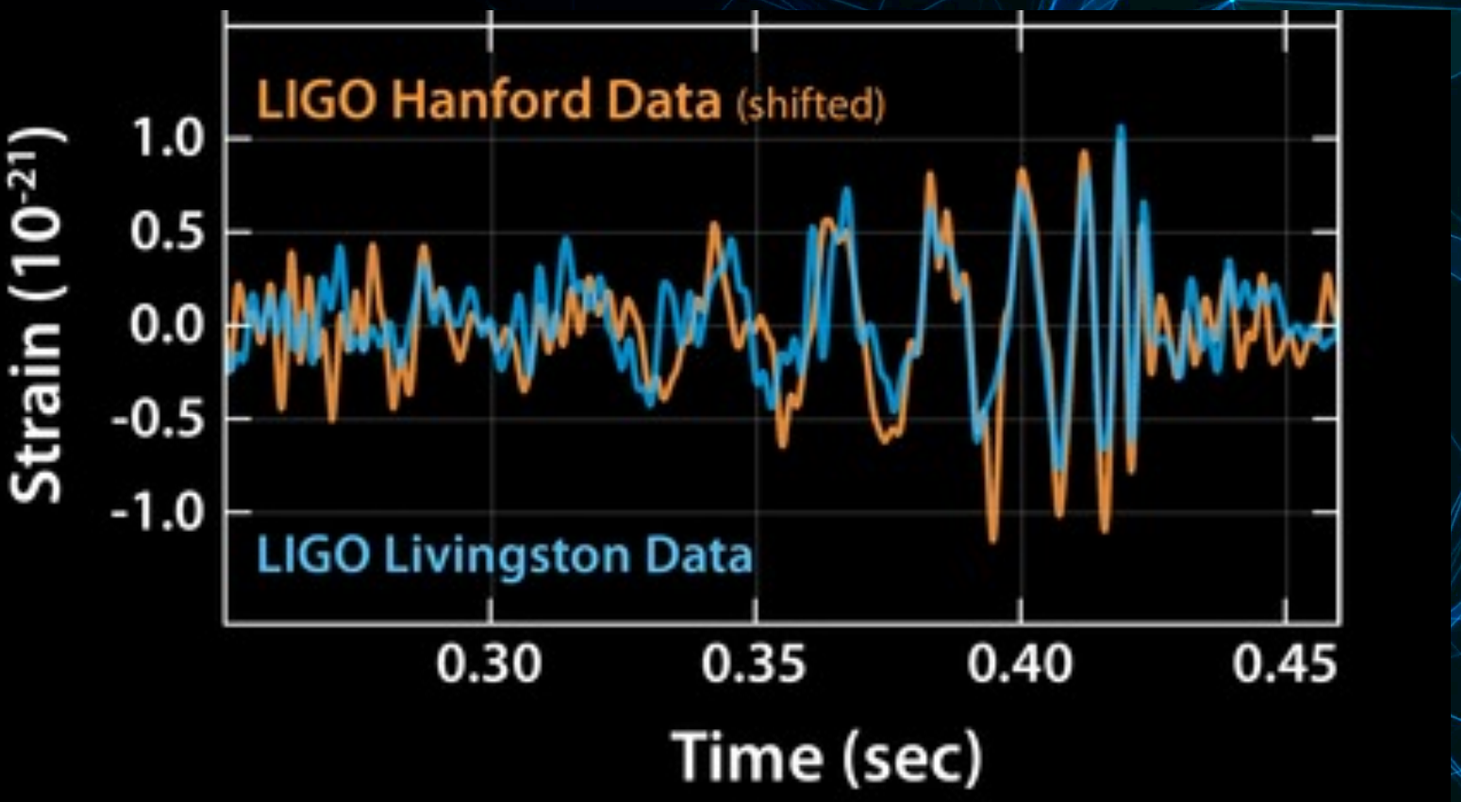
ET EINSTEIN TELESCOPE

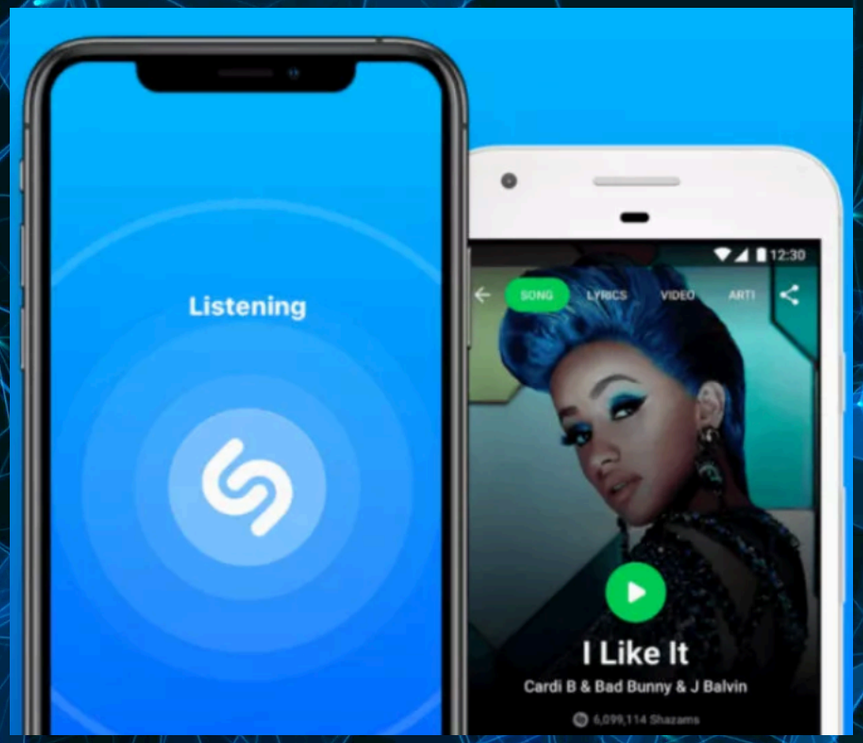
All GW Talks Start Like This…

1.3 billion years ago in a galaxy far away …



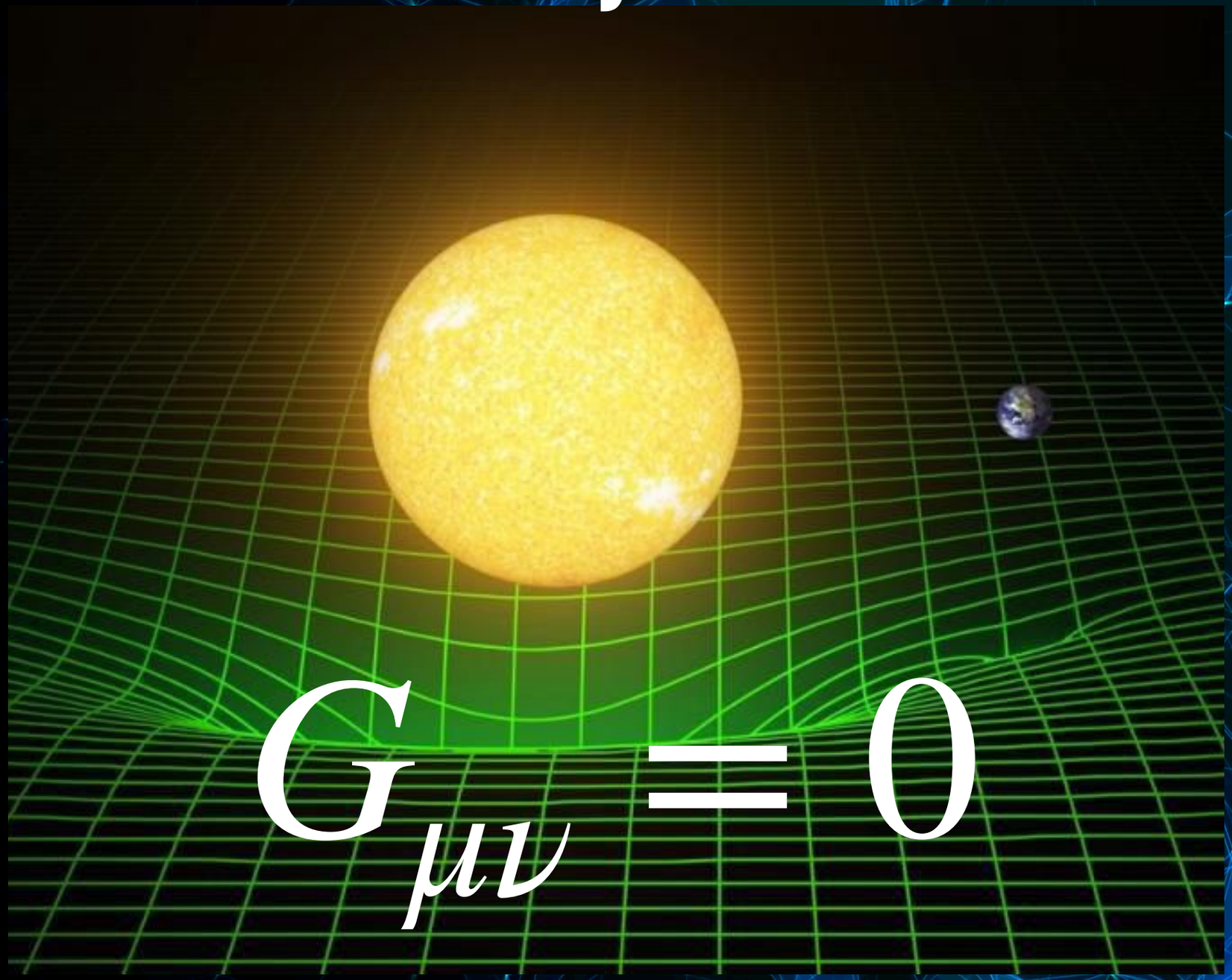
What the Actual Data Looks Like





Need a model!!

We have a theory!



$$G_{\mu\nu} = 0$$

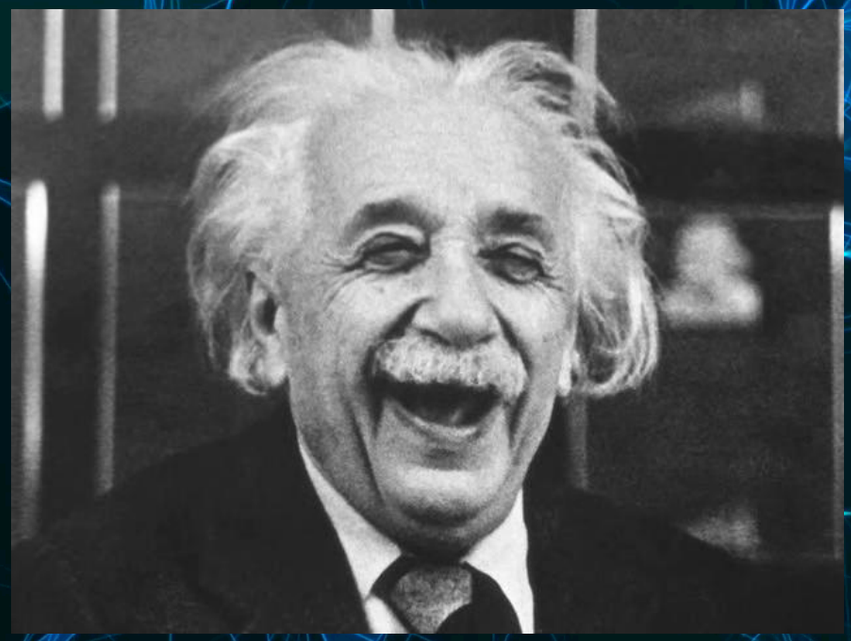
Just do lots of simulations

Expensive

days - weeks for BBH

Need about 10^6

10 parameters

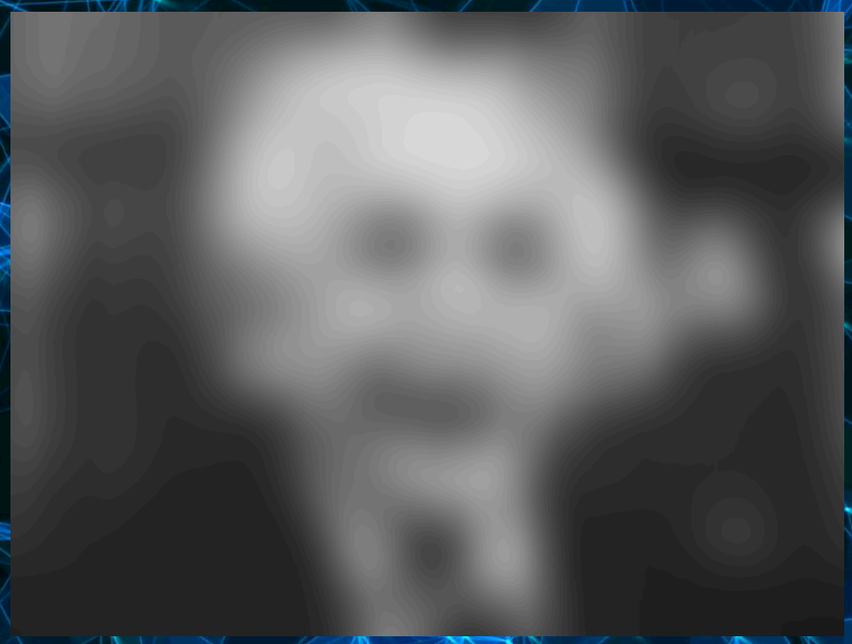


Use approximants!

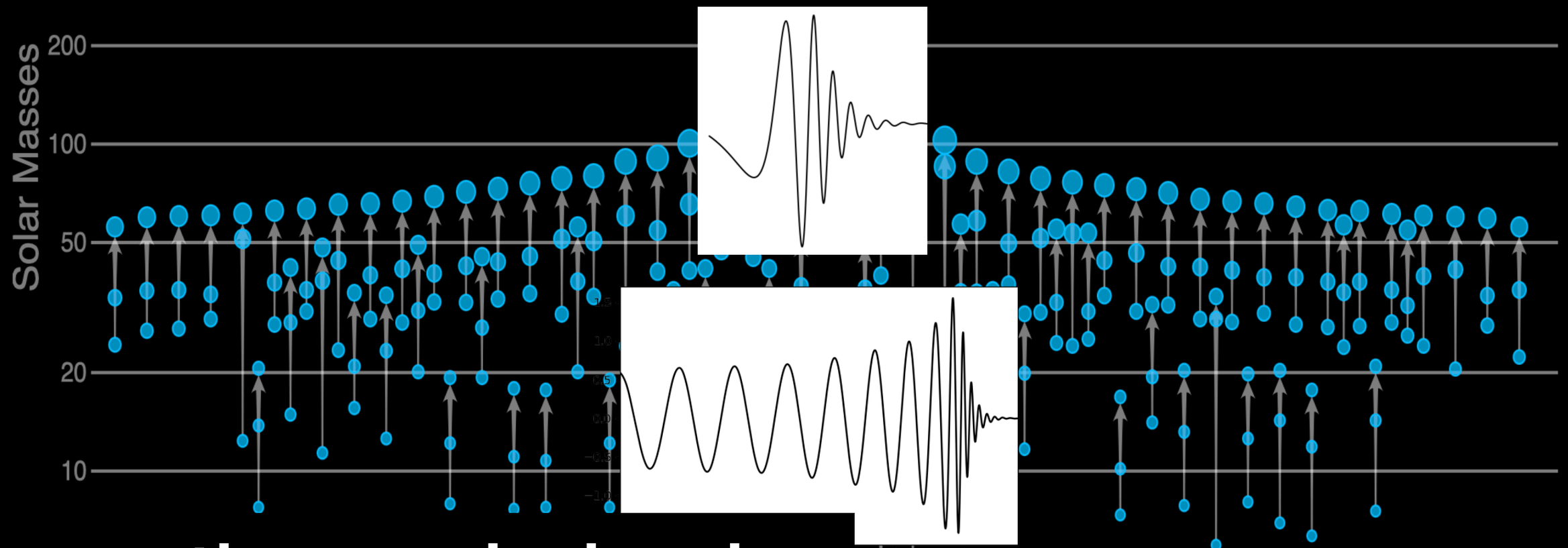
require calibration

free parameters

computation time ~ 1s



Masses in the Stellar Graveyard



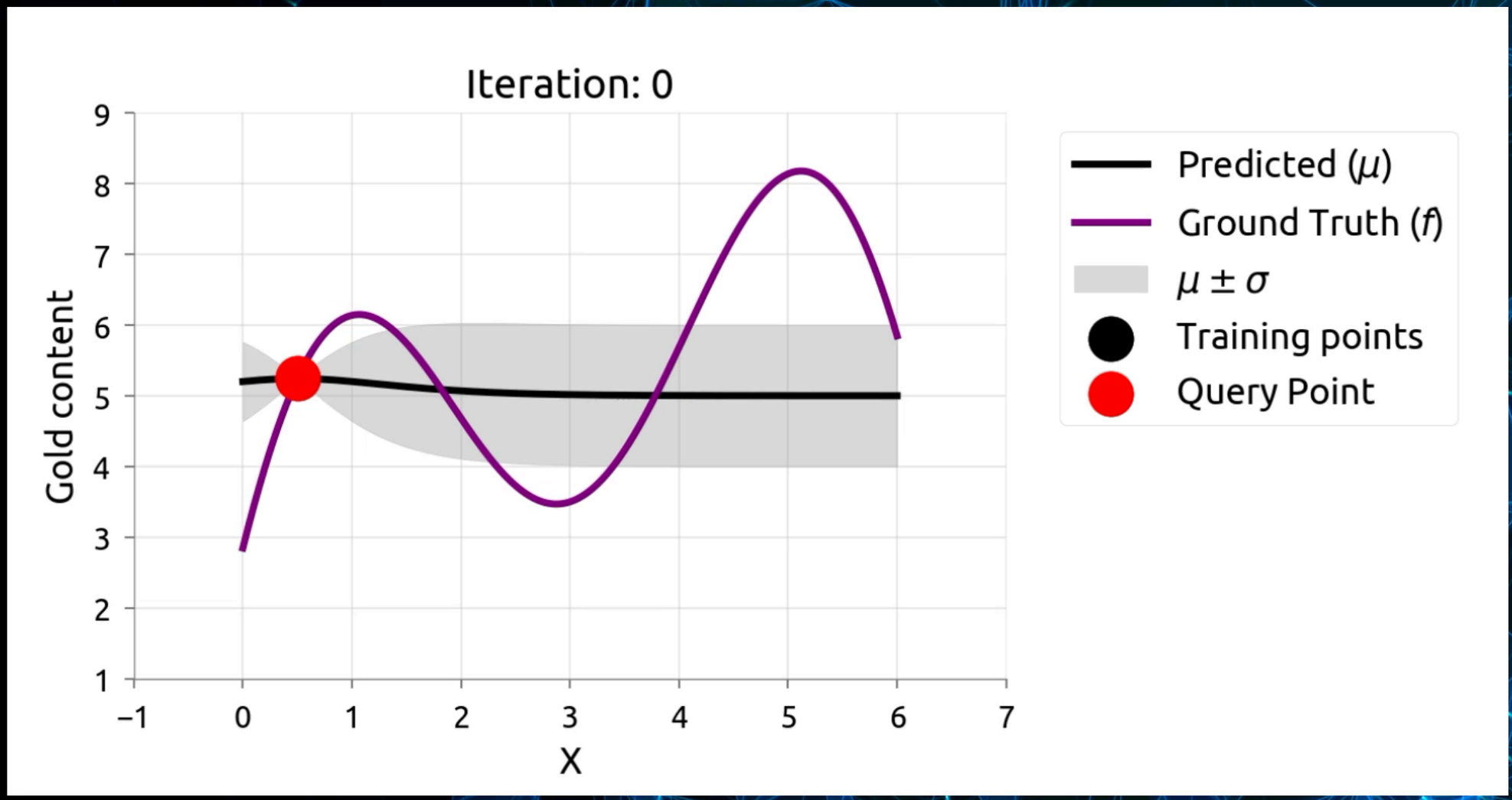
mostly quasi-circular,
but …
eccentricity
precession
high q, spins…

more diverse
template banks

EXPLORING PARAMETER SPACE

J Chang et al (2021) [Cog. Psy]

Active Learning
with Gaussian Processes



Prediction + Uncertainty

My job on one slide

$$h(X;t) \approx h_{approx}(c_i(X);t)$$

Construct training set $\{X_A\}$ (domain knowledge)

Interpolate $c_i(\{X_A\}) \rightarrow c_i(X)$ (ad-hoc fits)

Use Active Learning

+ Gaussian processes

HOW TO TEST THIS IDEA?

Proof of principle

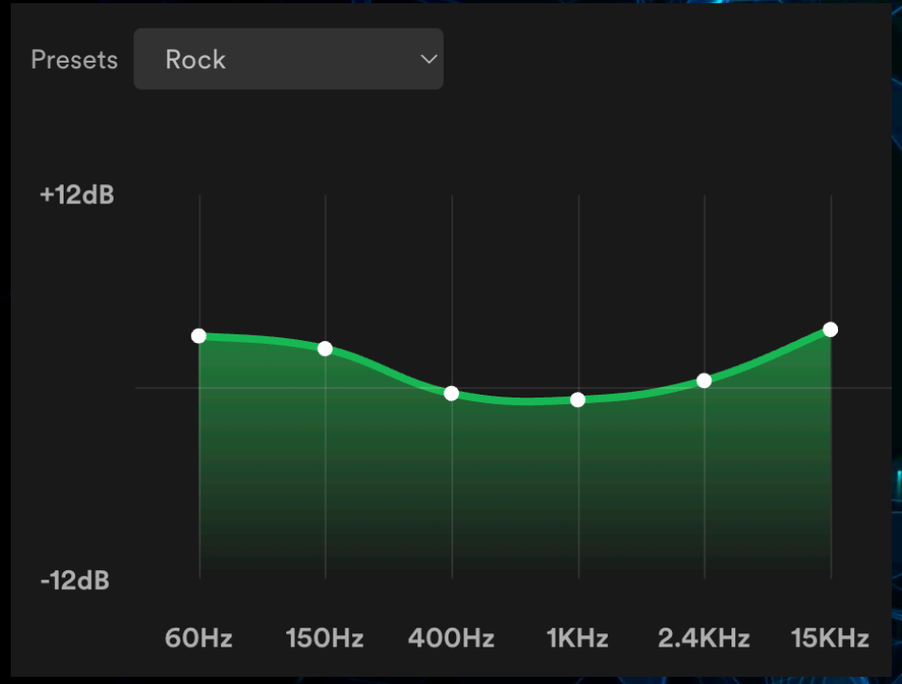
TA, R Gamba, J Trenado (2023)

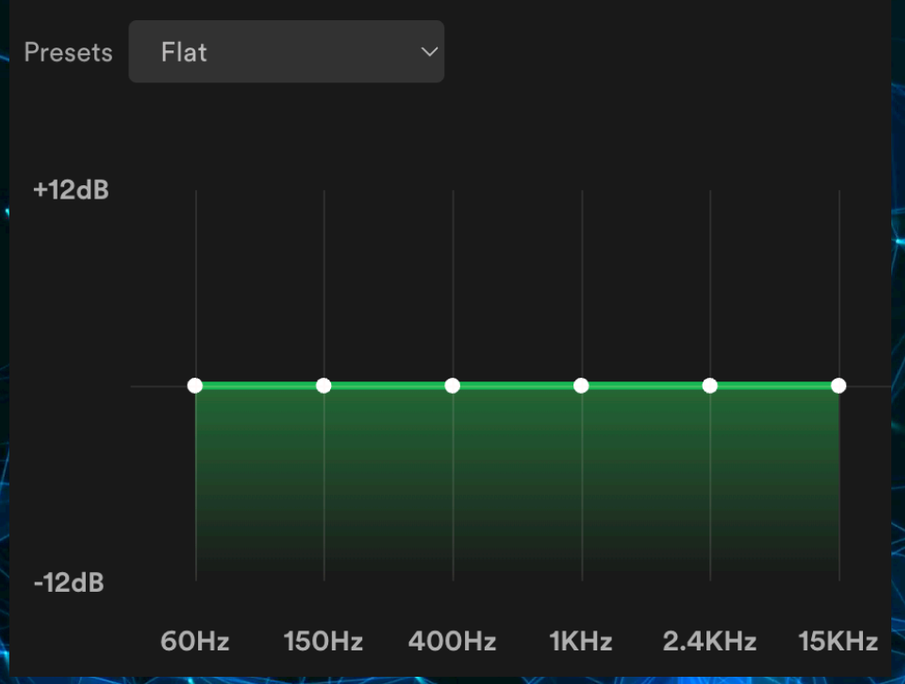
Train an approximant with itself

TEOBResumS

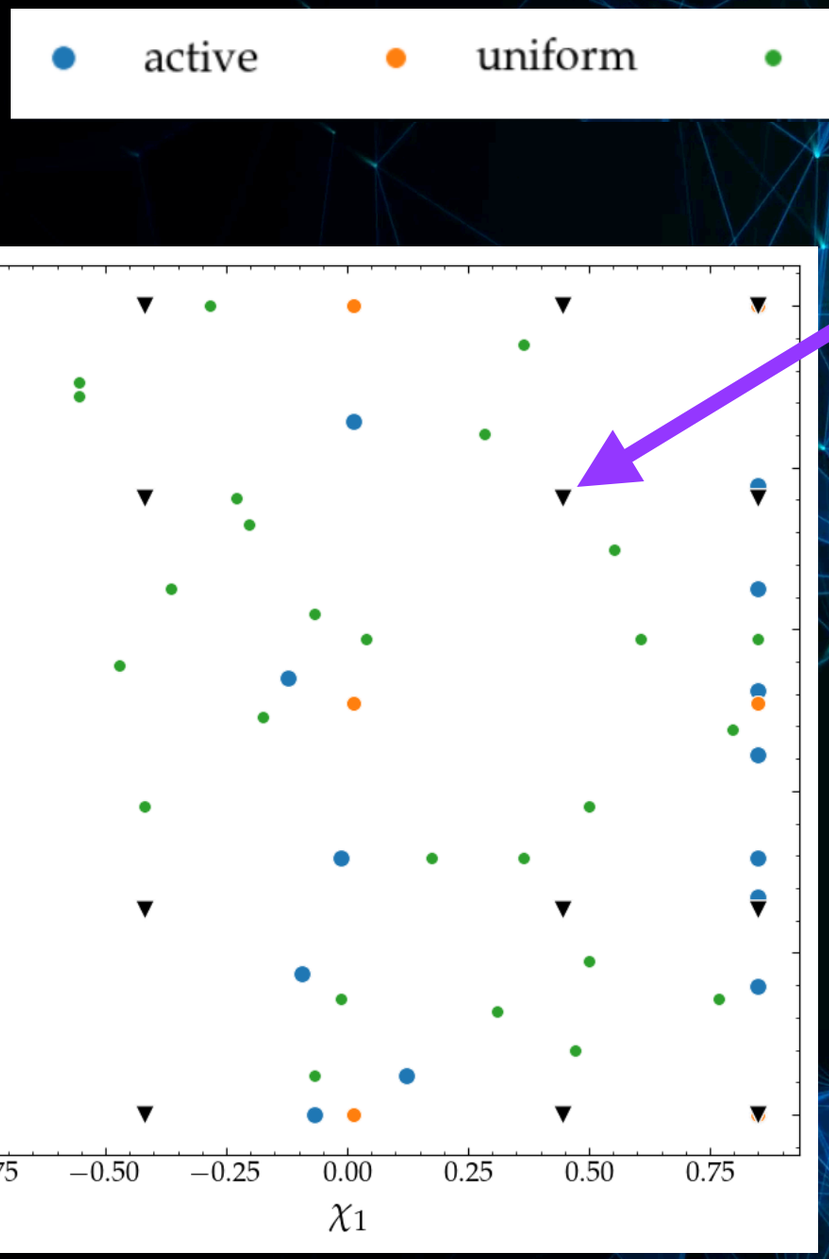
quasi-circular

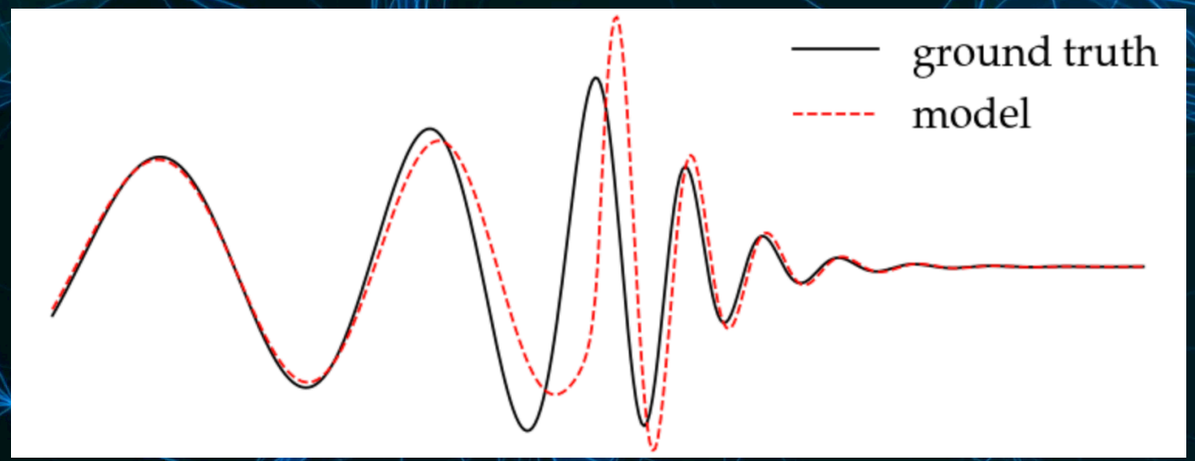
$$X = (\chi_1, \chi_2, q)$$





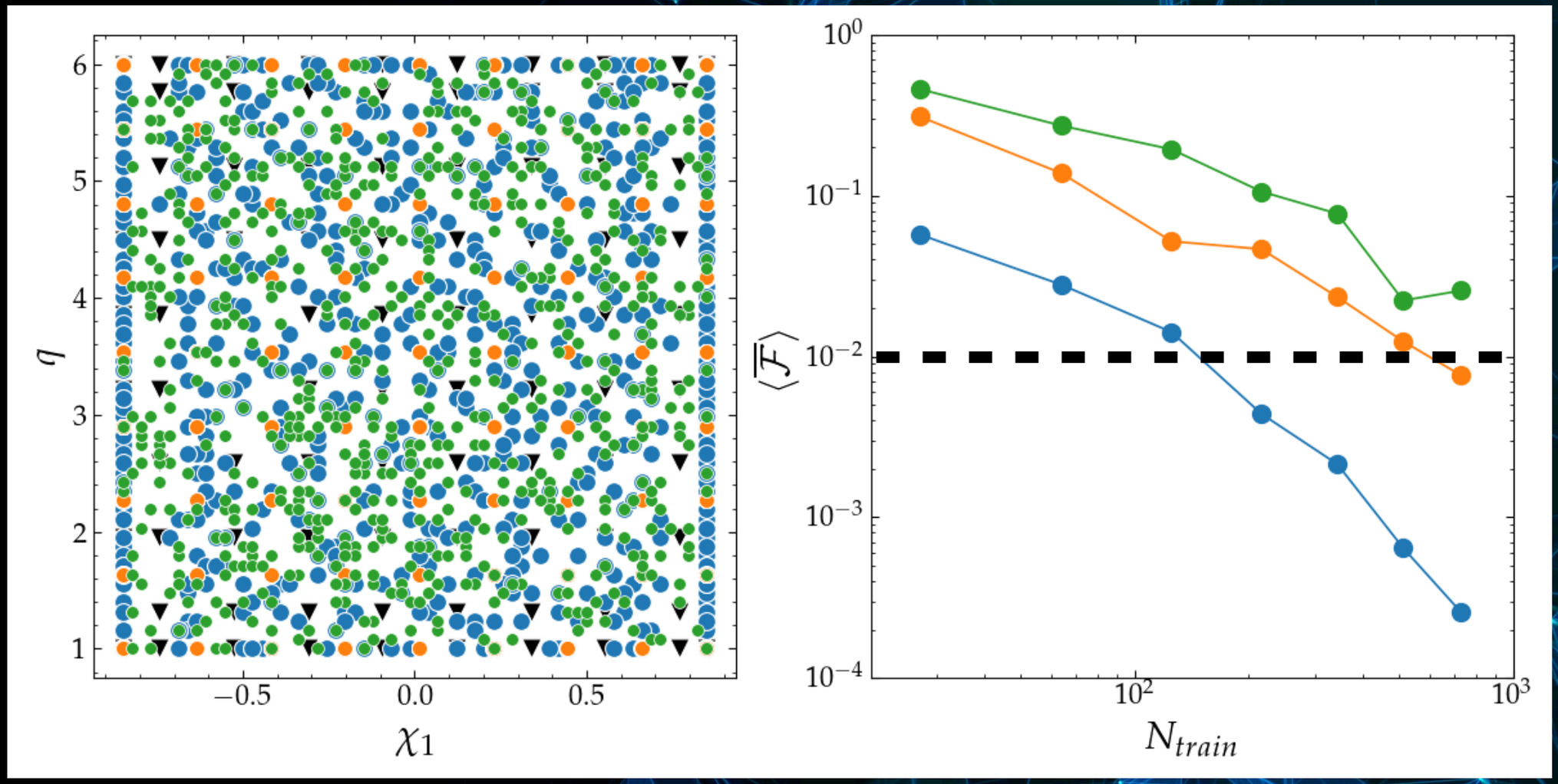
Training strategies





$$\overline{\mathcal{F}} = 0.12$$

Evaluation

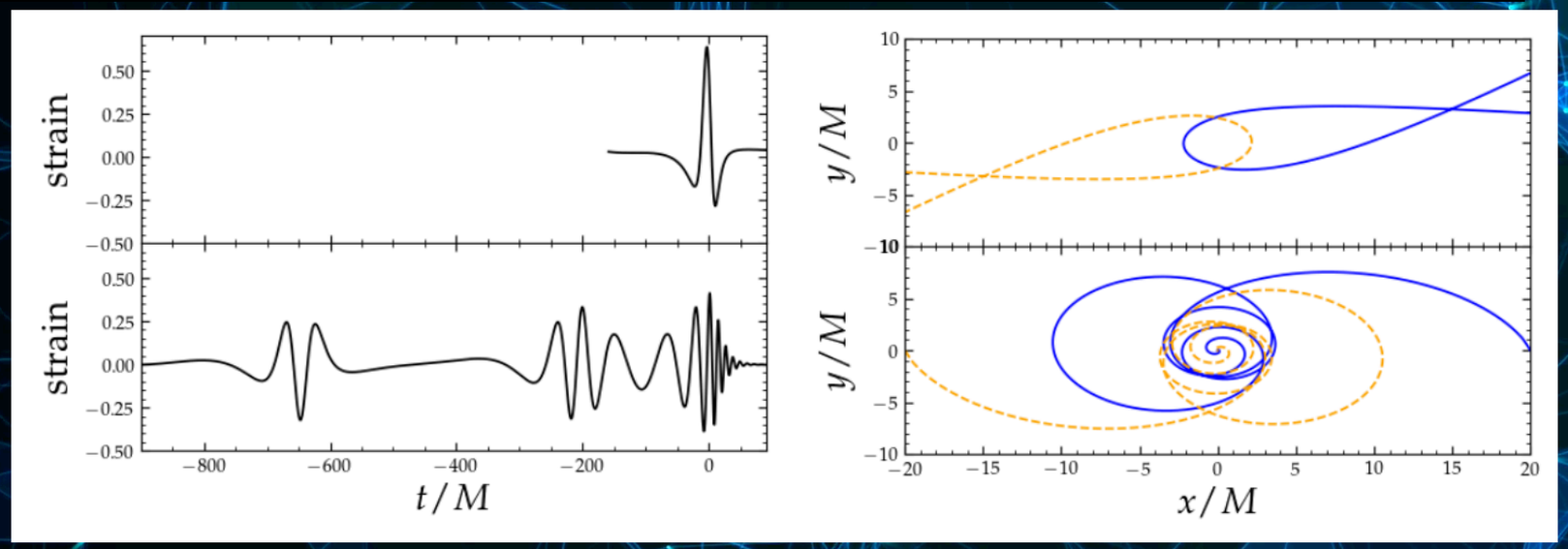


reduce cost by 4x

in parallel, reduce time by 3x

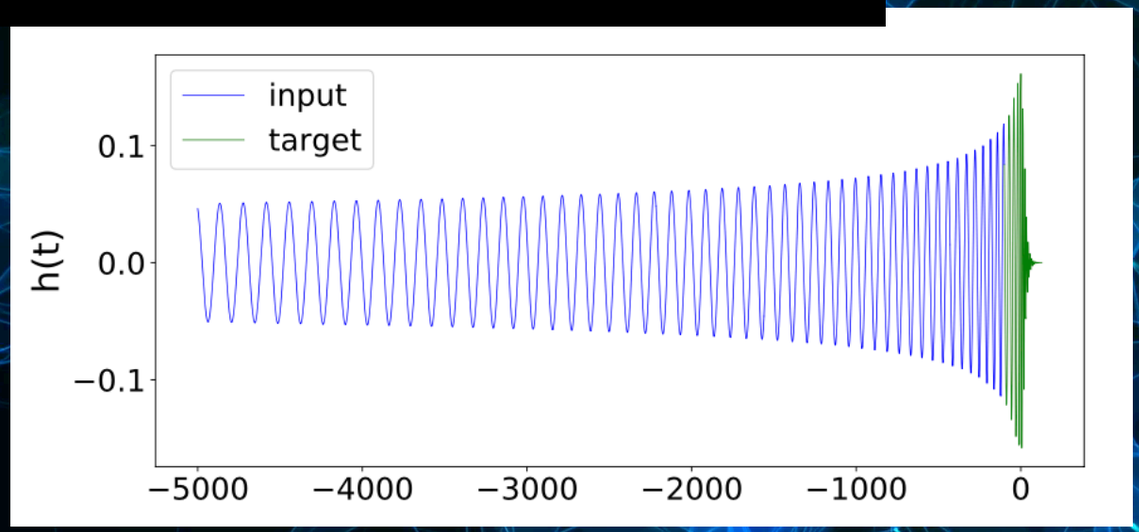
work in progress

Surrogate models for dynamical captures



Transformer based models for GW

(2021) Khan Huerta Zheng



Take home

GW need modelling

NR informs approximants

Quasi-circular -> eccentric…

Need to explore parameter space

guide search with Active Learning

Lee Cronin (2023)

Thank you!