

ACTIVE LEARNING FOR GW MODELLING

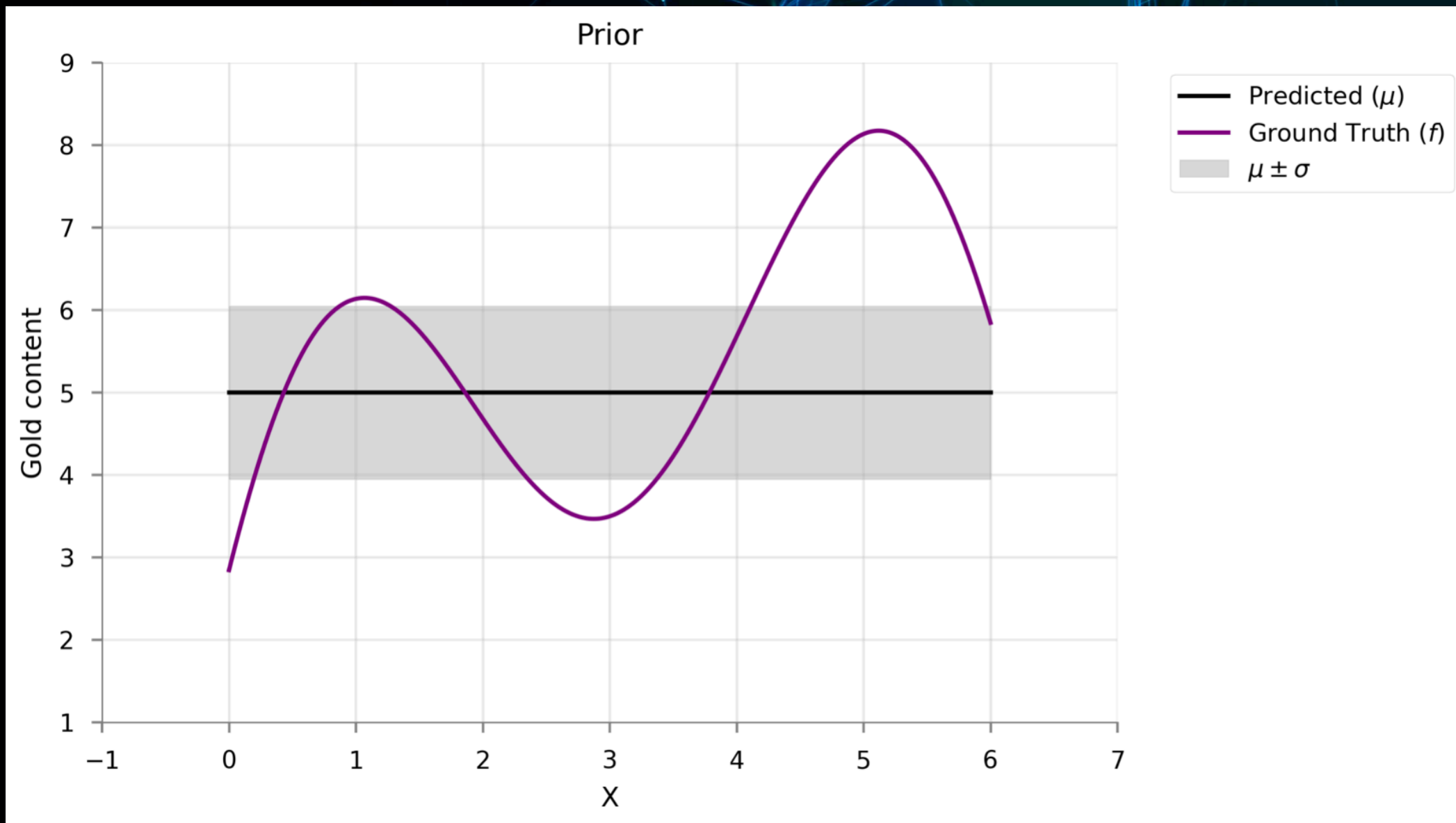
TOMAS ANDRADE



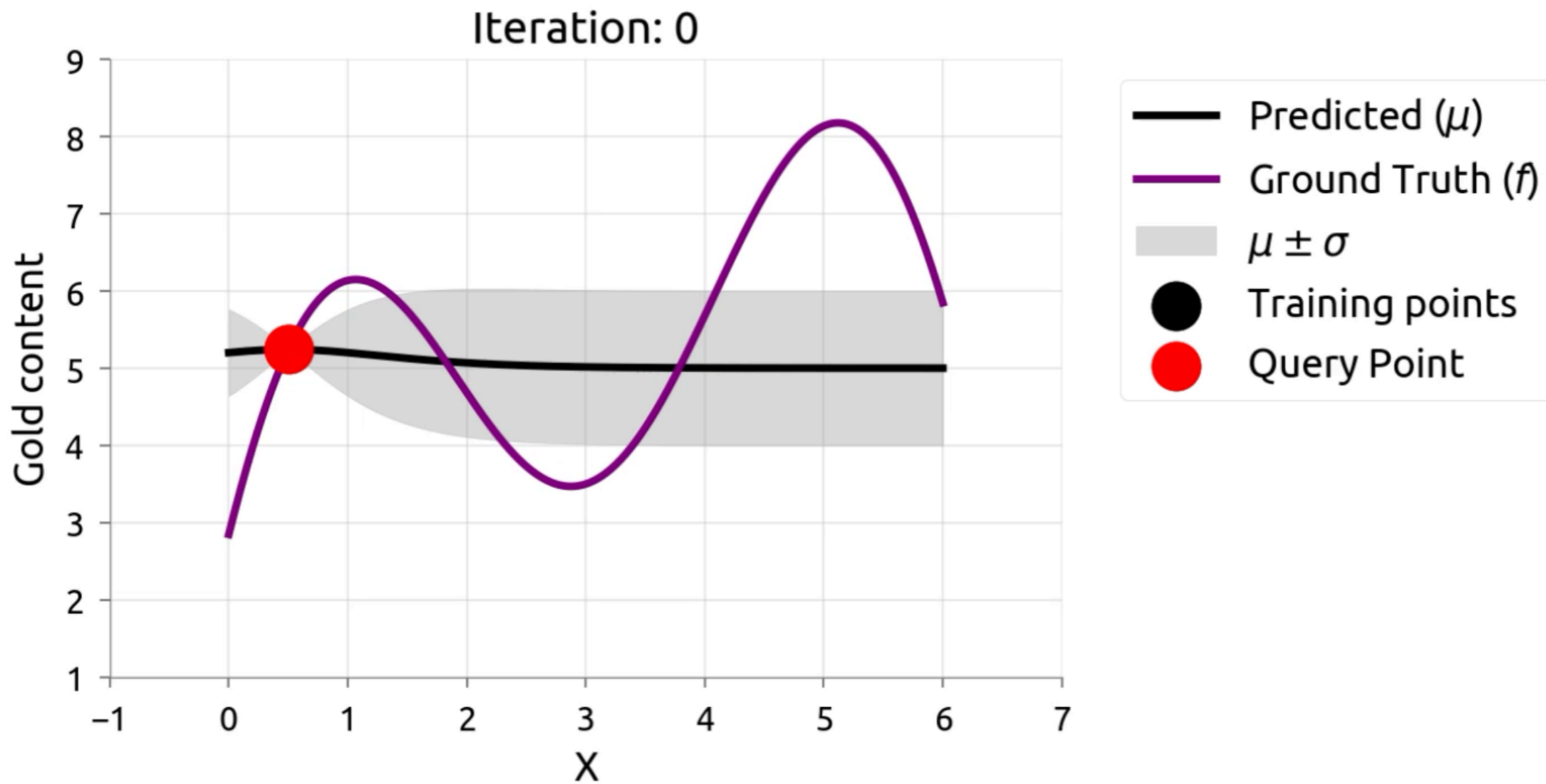


HOW DO YOU EXPLORE?

Gold mining



Gold mining



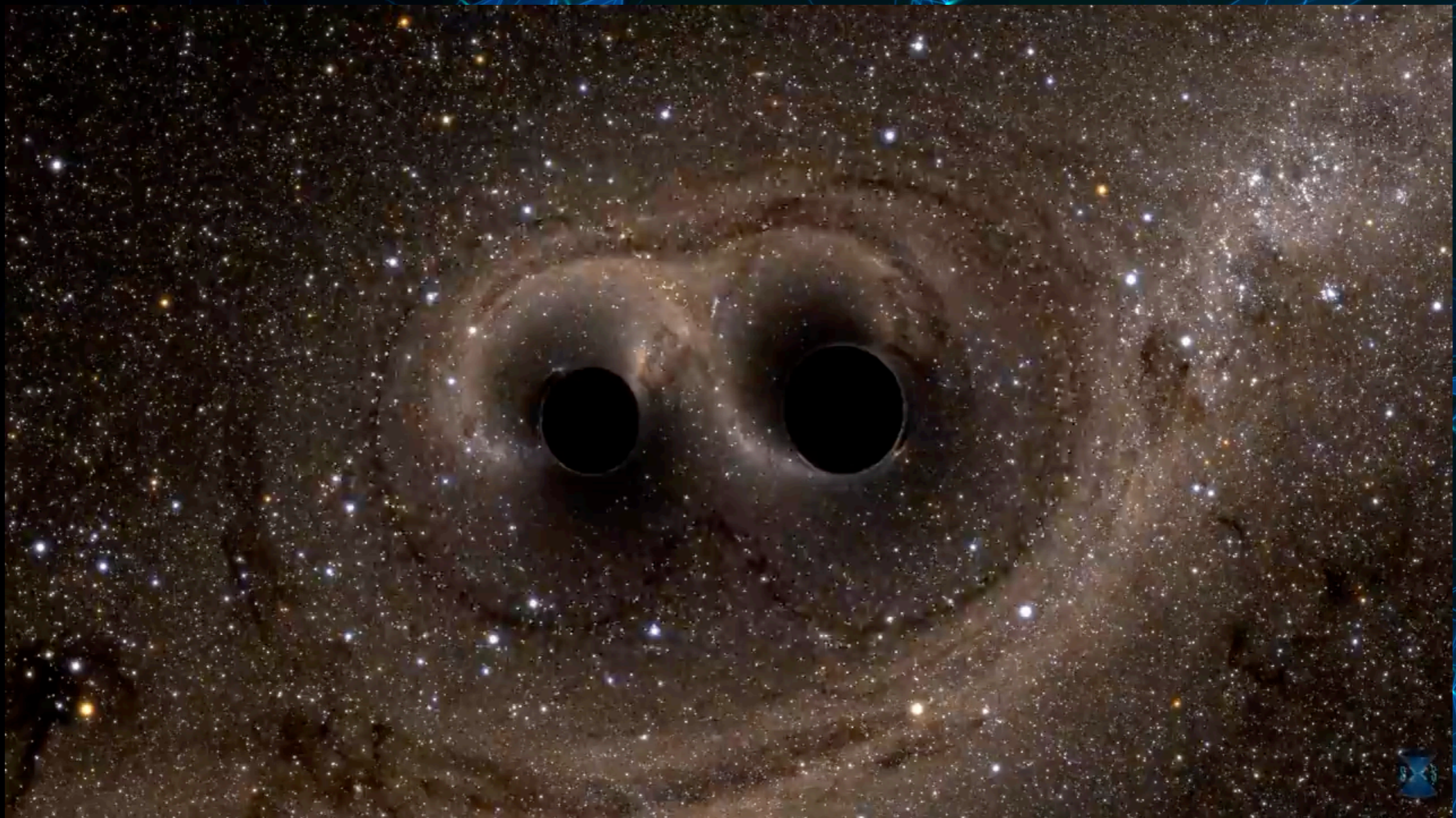
Prediction + Uncertainty



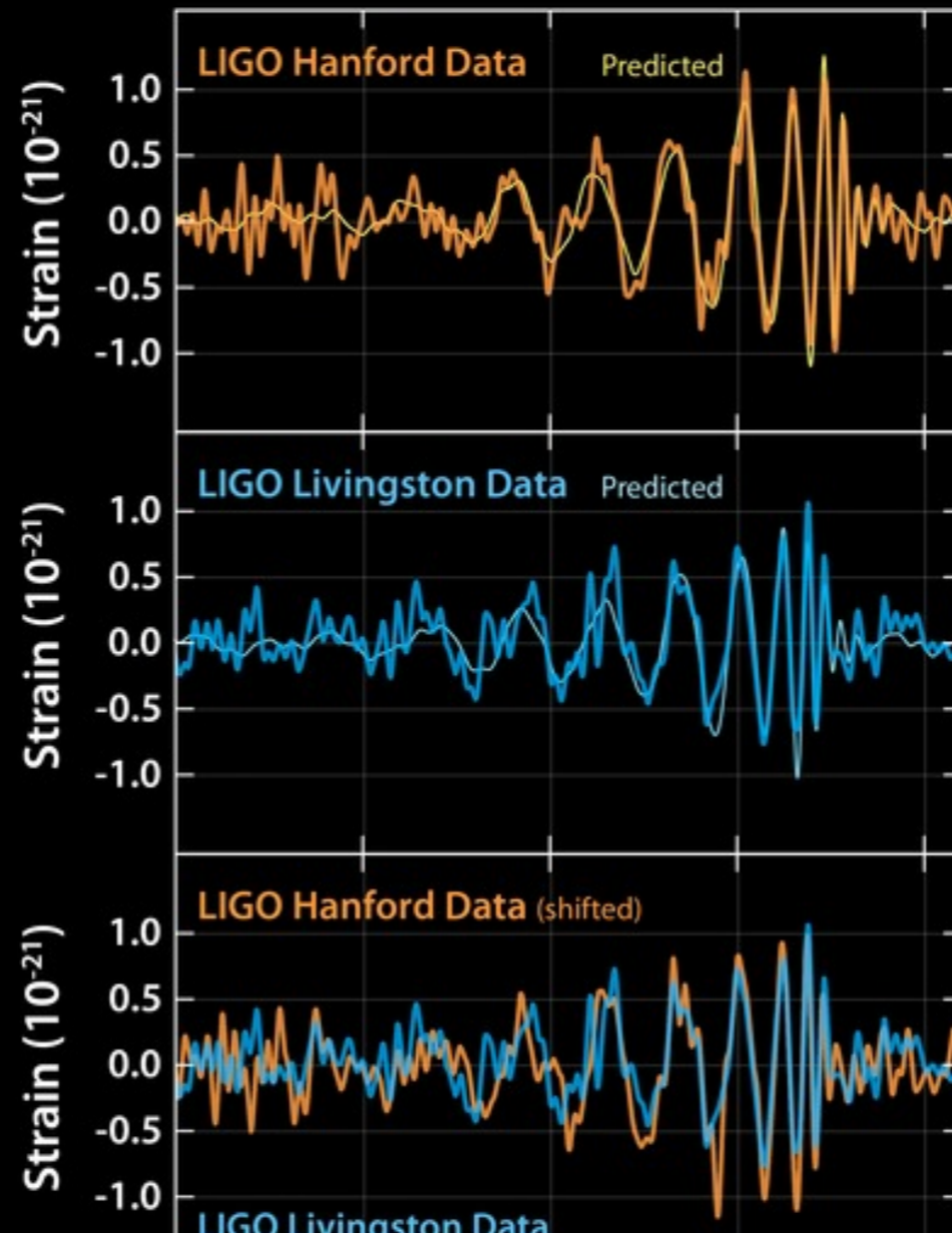
WHY ARE HE HERE TODAY?

All GW Talks Start Like This....

1.3 billion years ago in a galaxy
far away ...



What the Actual Data Looks Like



How (On Earth) Do We Know!?

“how do we know” has two parts

Detection

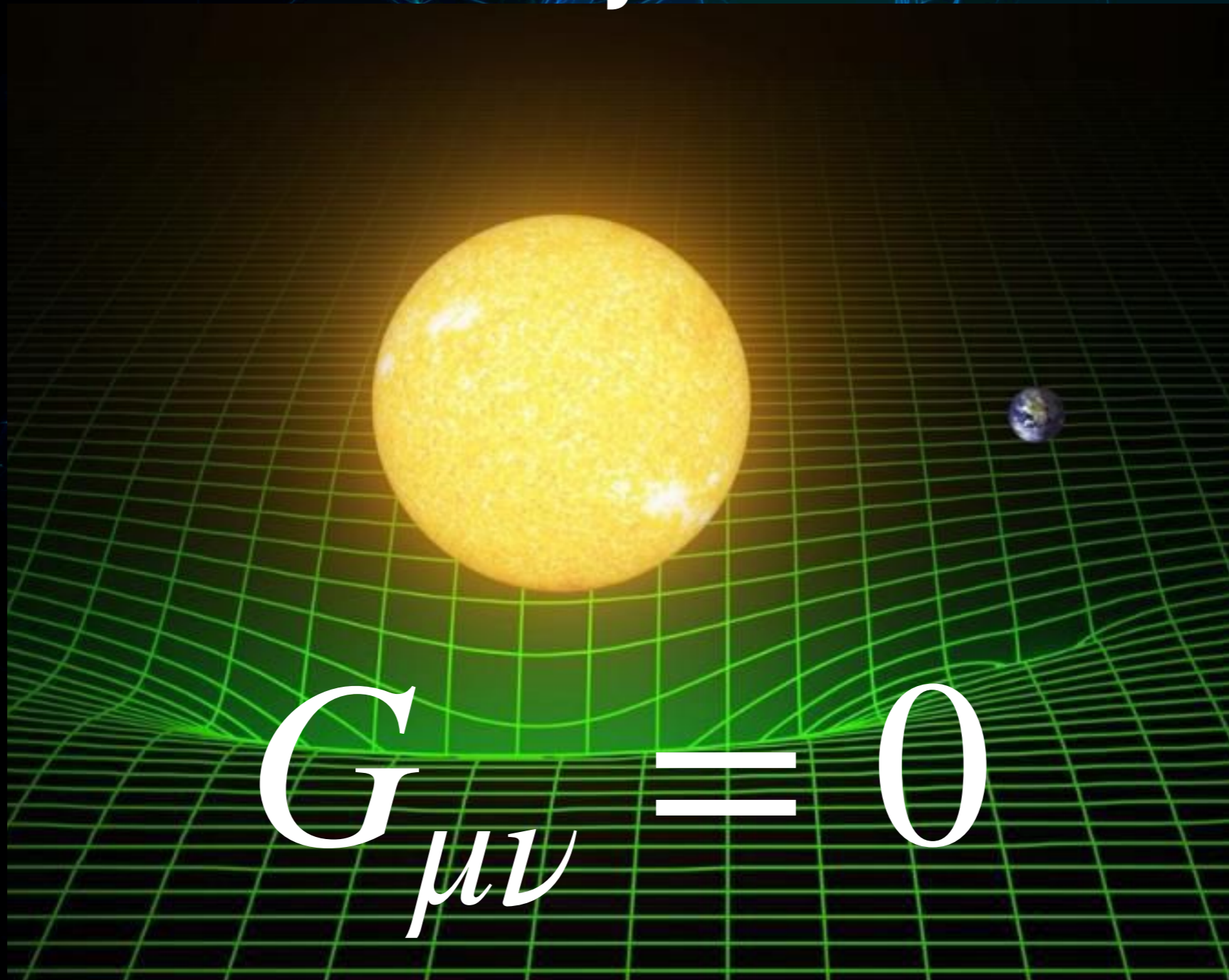
Matched Filtering

Parameter Estimation

Bayesian Inference

BOTH REQUIRE A MODEL

We have a theory!

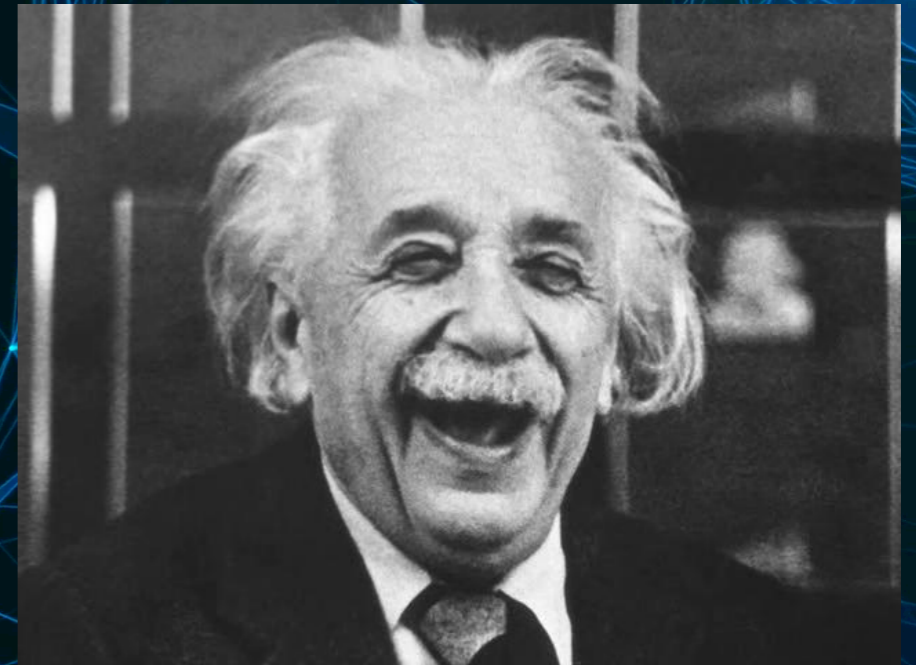


JUST DO LOTS OF SIMULATIONS

EXPENSIVE

days - weeks for BBH

Need about 10^6



PARAMETER SPACE IS HUGE

10 parameters

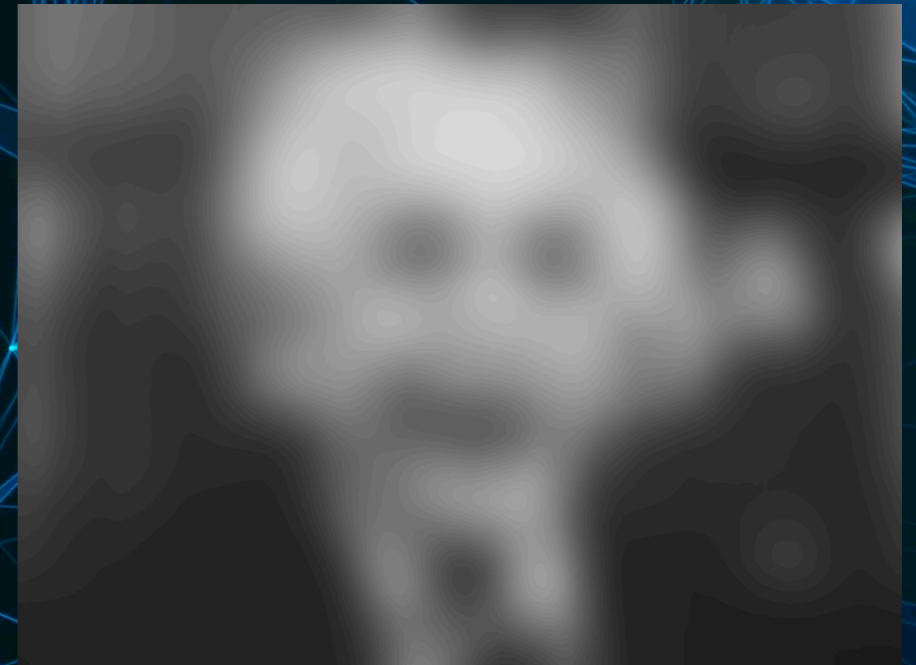
In practice use approximants

Approximate models
require calibration from NR

free parameters!

Sacrifice accuracy
weeks to seconds!

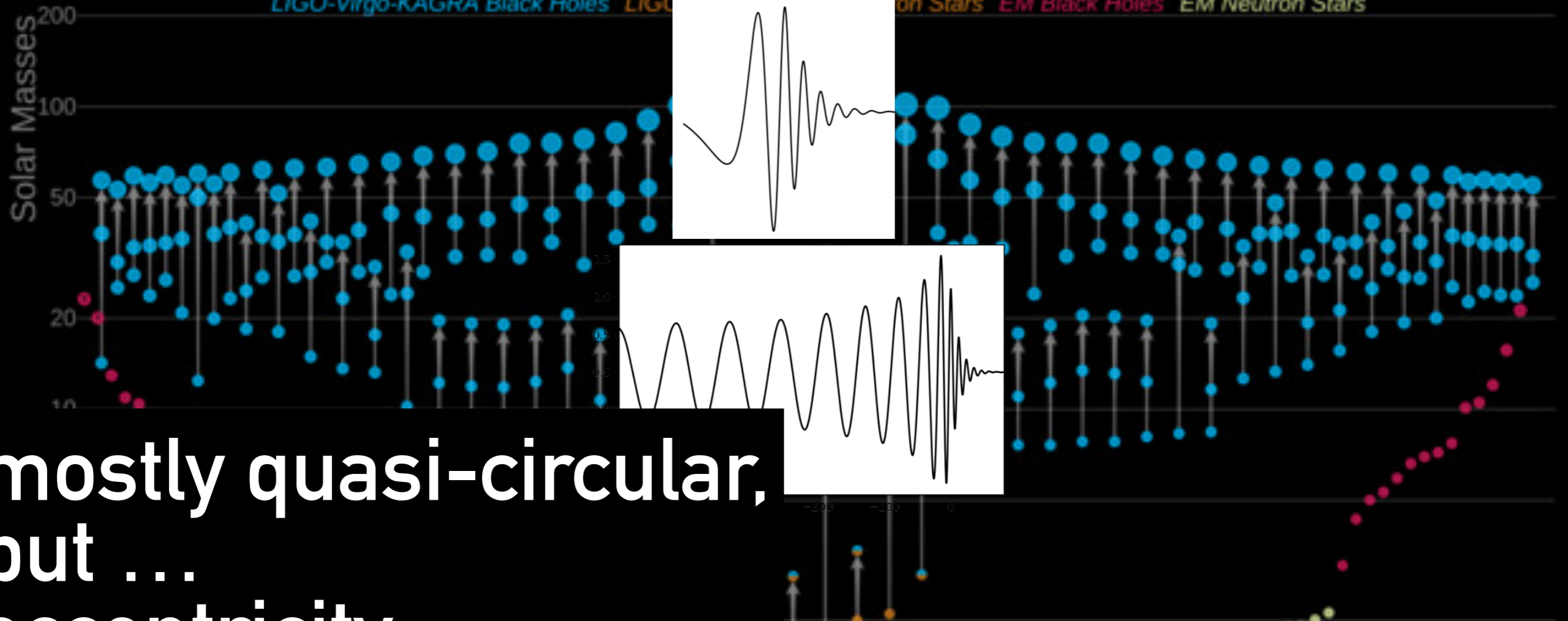
INFORM APPROXIMANTS WITH NR



State of the Art

Masses in the Stellar Graveyard

LIGO-Virgo-KAGRA Black Holes LIGO-Virgo-KAGRA Neutron Stars EM Black Holes EM Neutron Stars



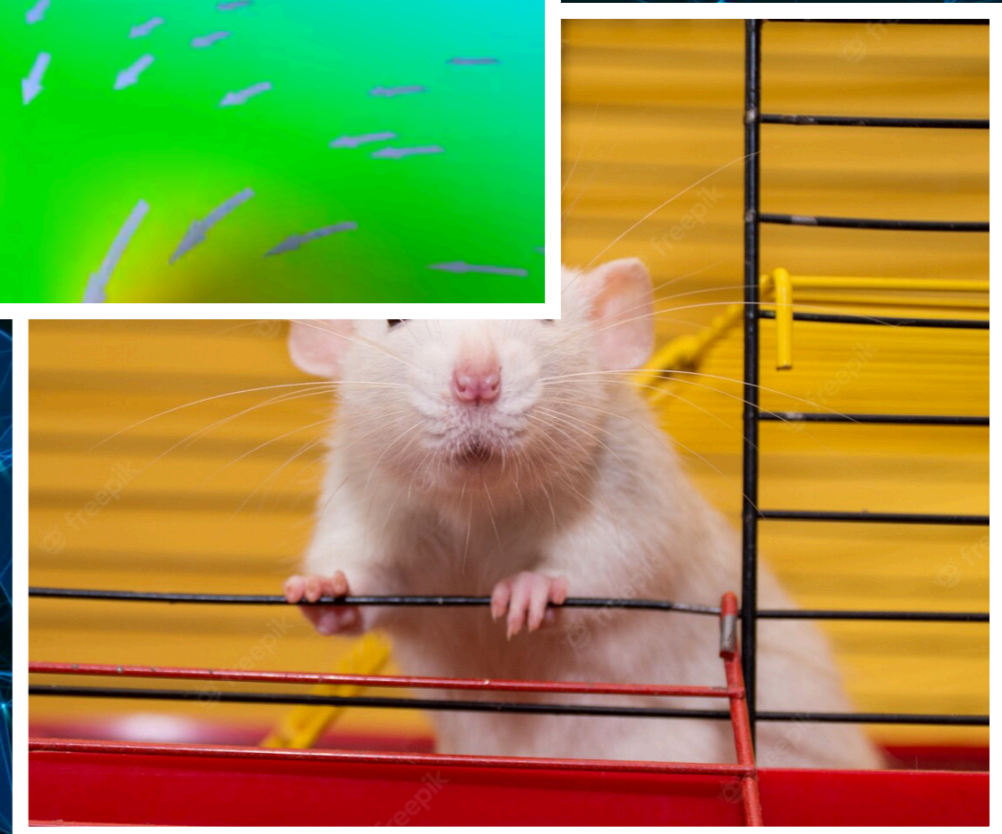
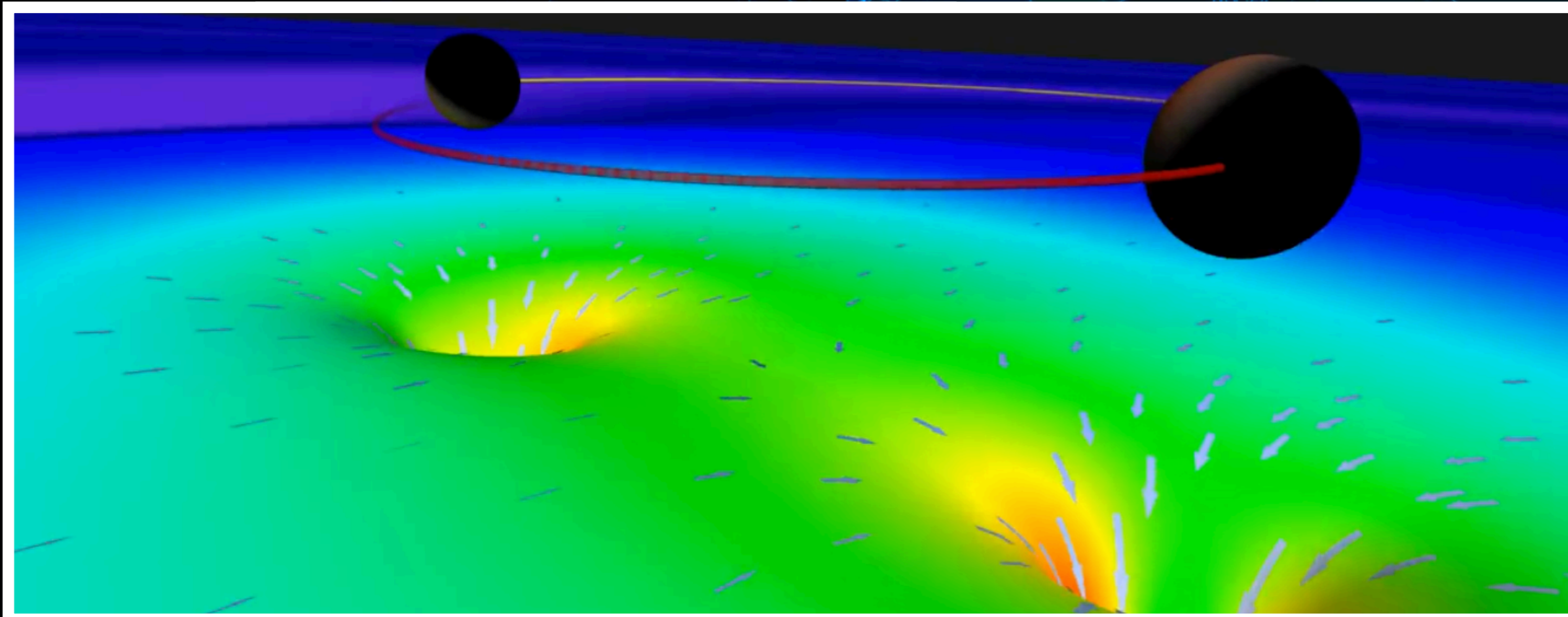
mostly quasi-circular,
but ...
eccentricity
precession
high q , spins...

**MORE DIVERSE
TEMPLATE BANKS**



EXPLORING PARAMETER SPACE

THOUGHT-PROVOKING MULTIDISCIPLINARY SLIDE



Bayesian Experimental Design: A Review

Kathryn Chaloner and Isabella Verdinelli

For one particular drug under study, 54 similar experiments were performed and the same type of design was used for each of the experiments. The design usually consisted of 6 equally spaced doses with 10 mice exposed to each dose. Sixty animals were required for each experiment. Occasionally less than 60 animals were available, in which case less than 10 animals were exposed to the highest

Journals & Magazines > Proceedings of the IEEE > Volume: 104 Issue: 1 ?

Taking the Human Out of the Loop: A Review of Bayesian Optimization

Publisher: IEEE

Cite This

PDF

Bobak Shahriari ; Kevin Swersky ; Ziyu Wang ; Ryan P. Adams ; Nando de Freitas [All Authors](#)

2388

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Full
Text Views

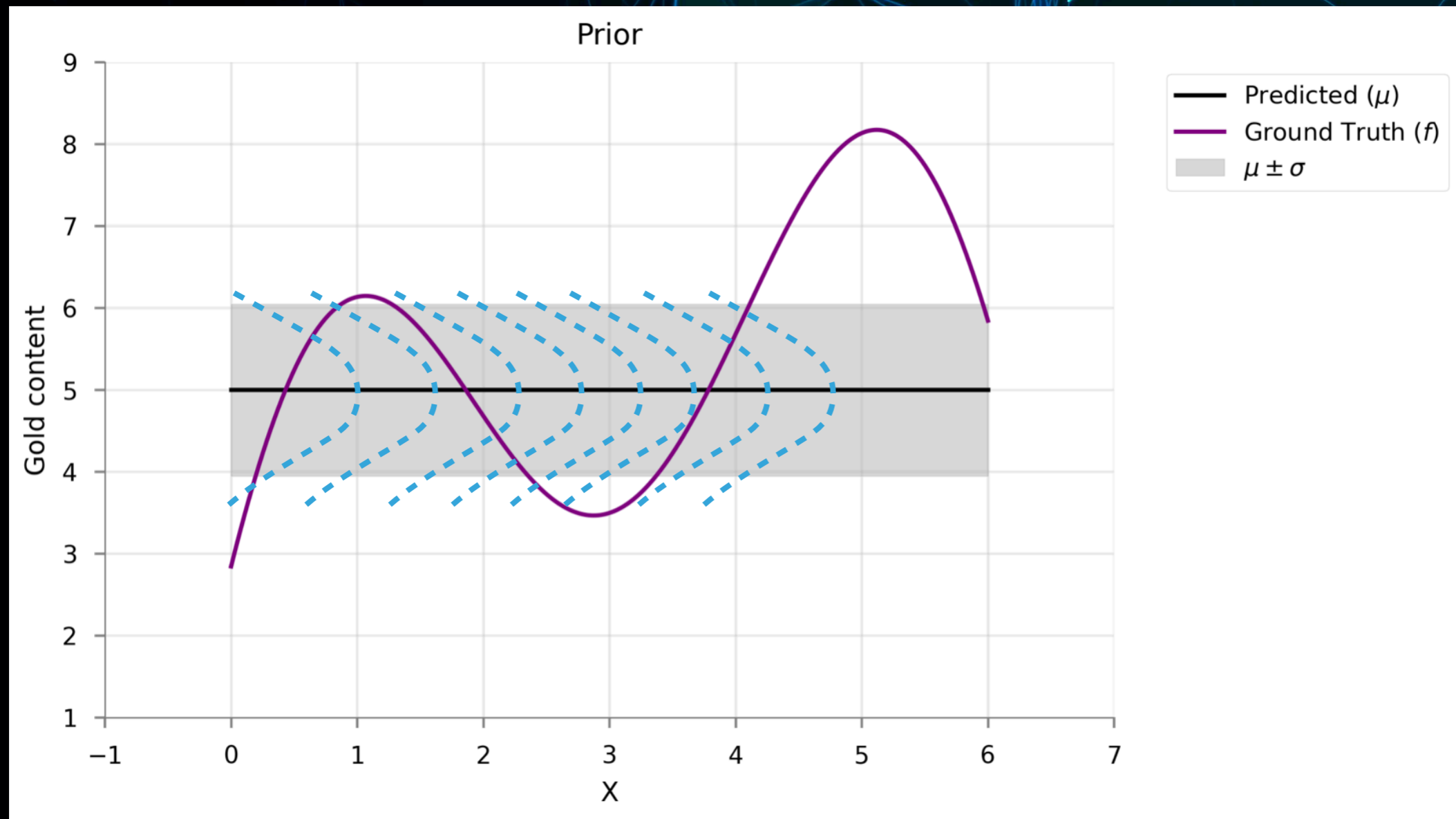


Open Access

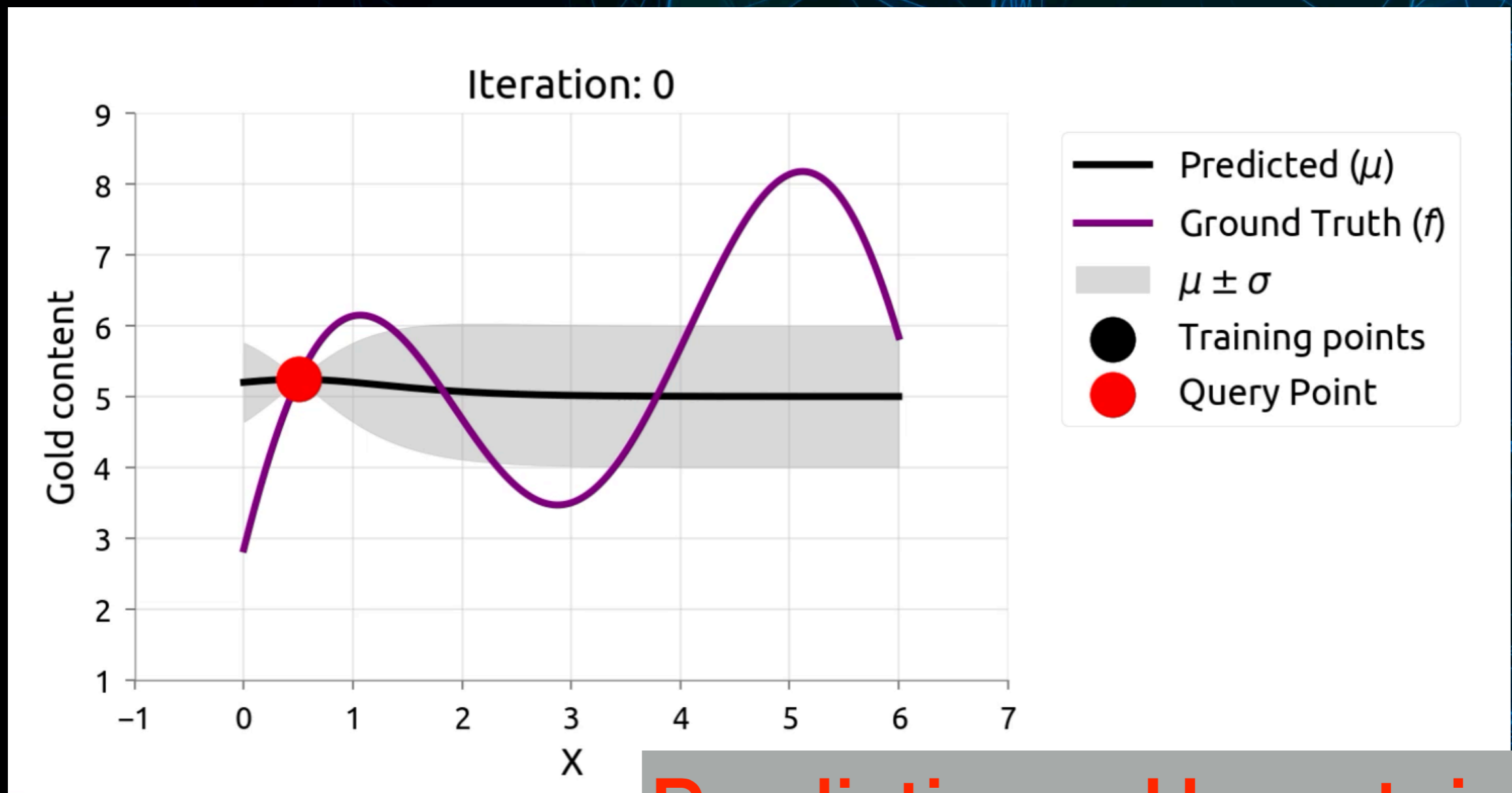
[Krige 1951-mining]

ACTIVE LEARNING with Gaussian Processes

[Chang et al 2021
Cog. Psy]

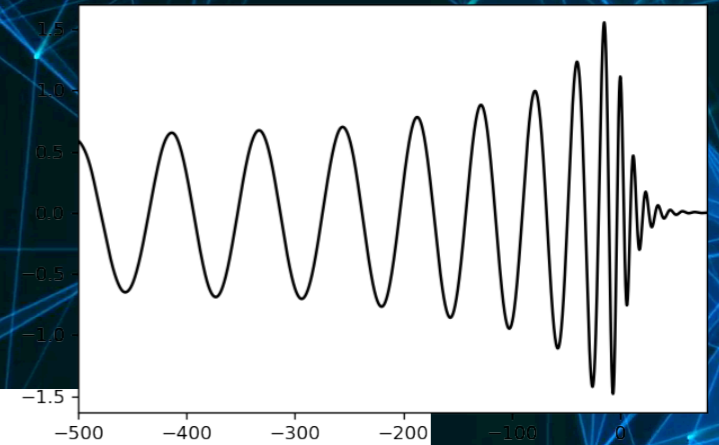


ACTIVE LEARNING WITH GAUSSIAN PROCESSES



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?

TOY MODEL

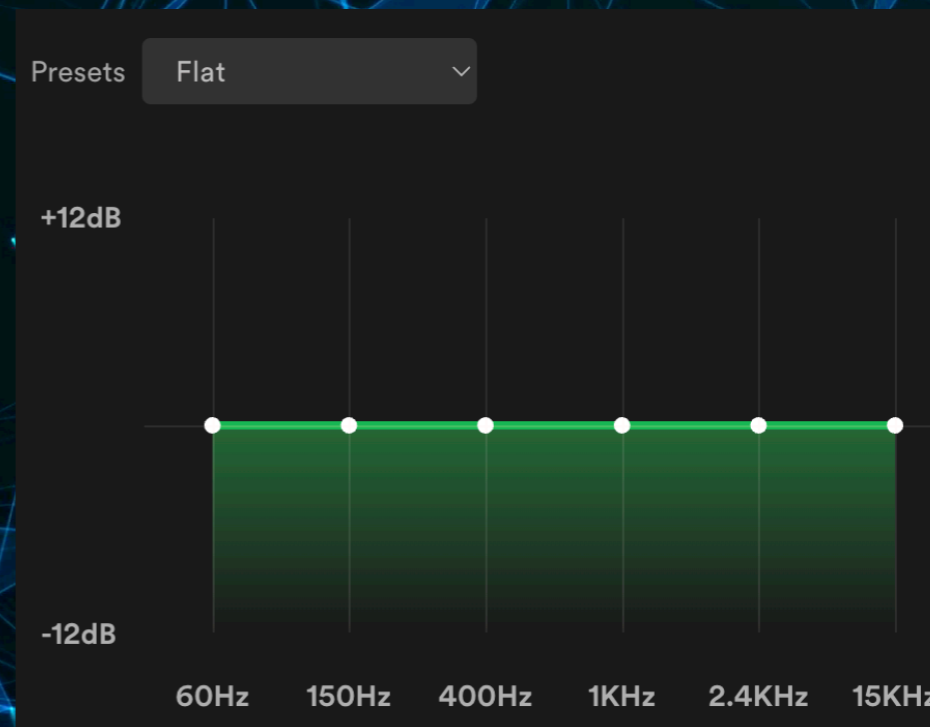
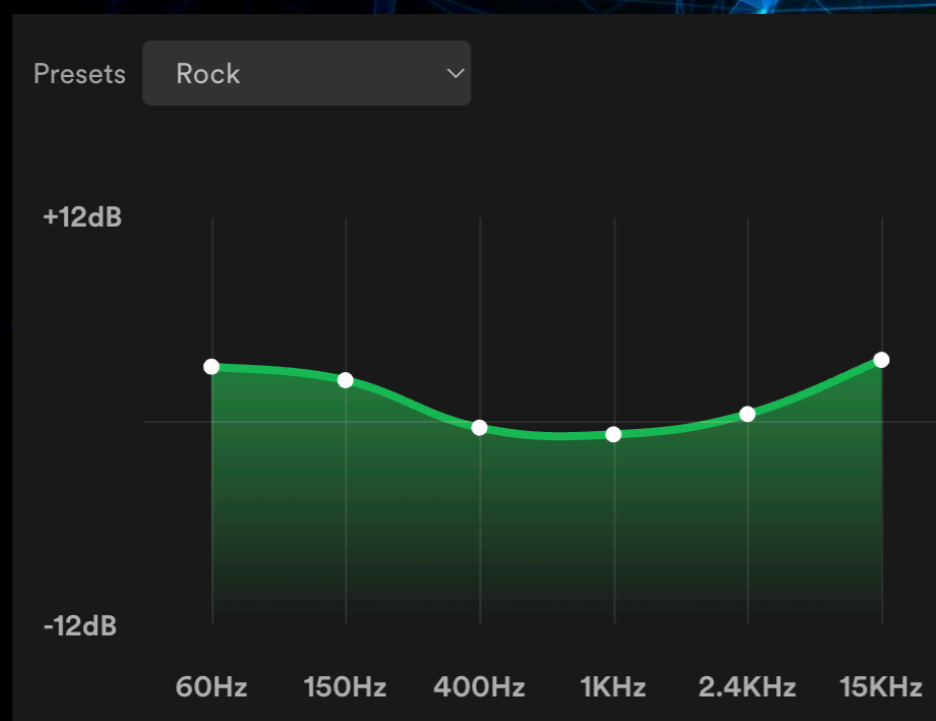
[TA, Gamba, Trenado 2023 GW]

Train an approximant with itself

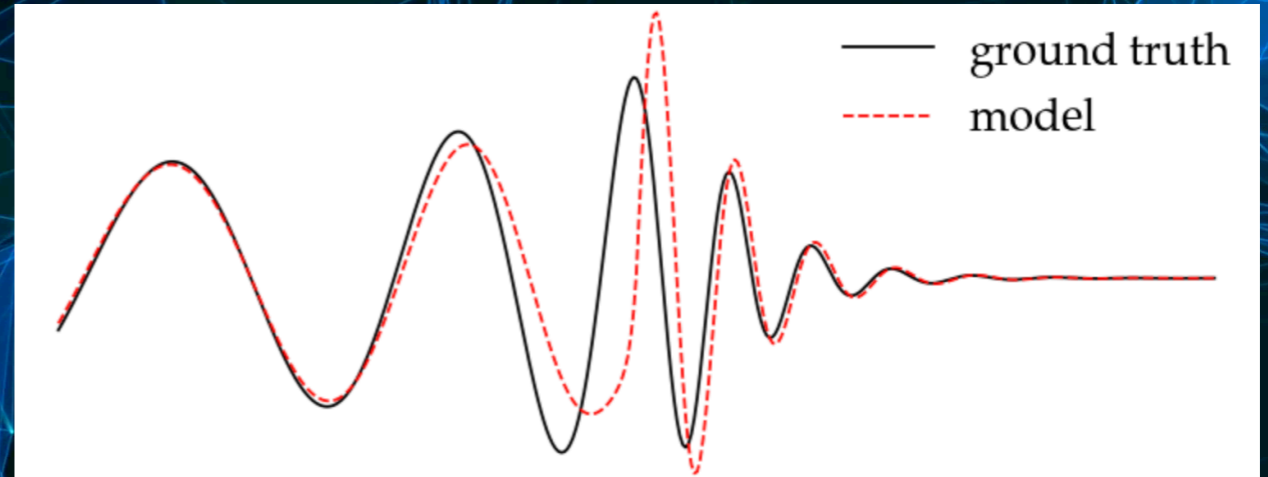
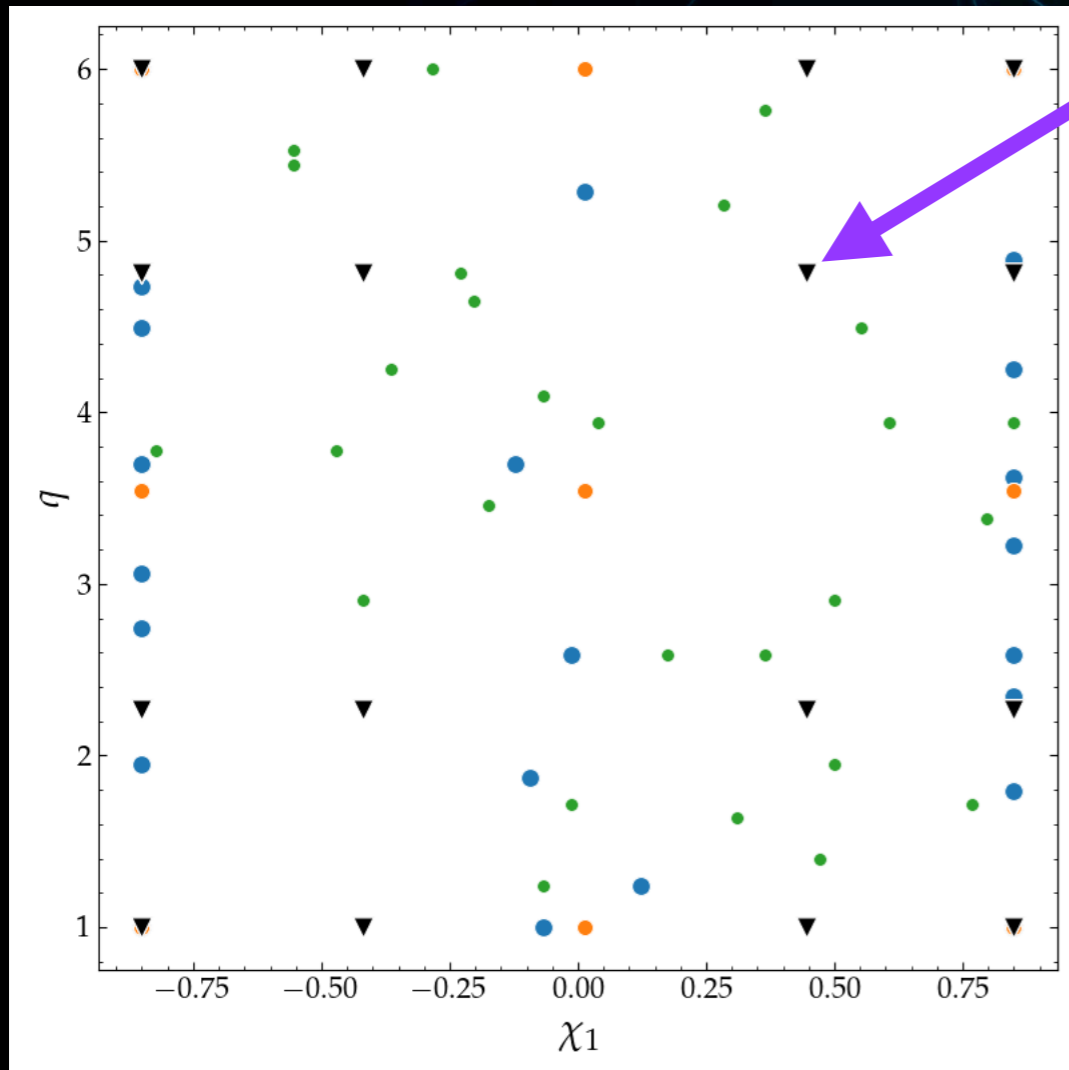
TEOBRResumS

quasi-circular

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

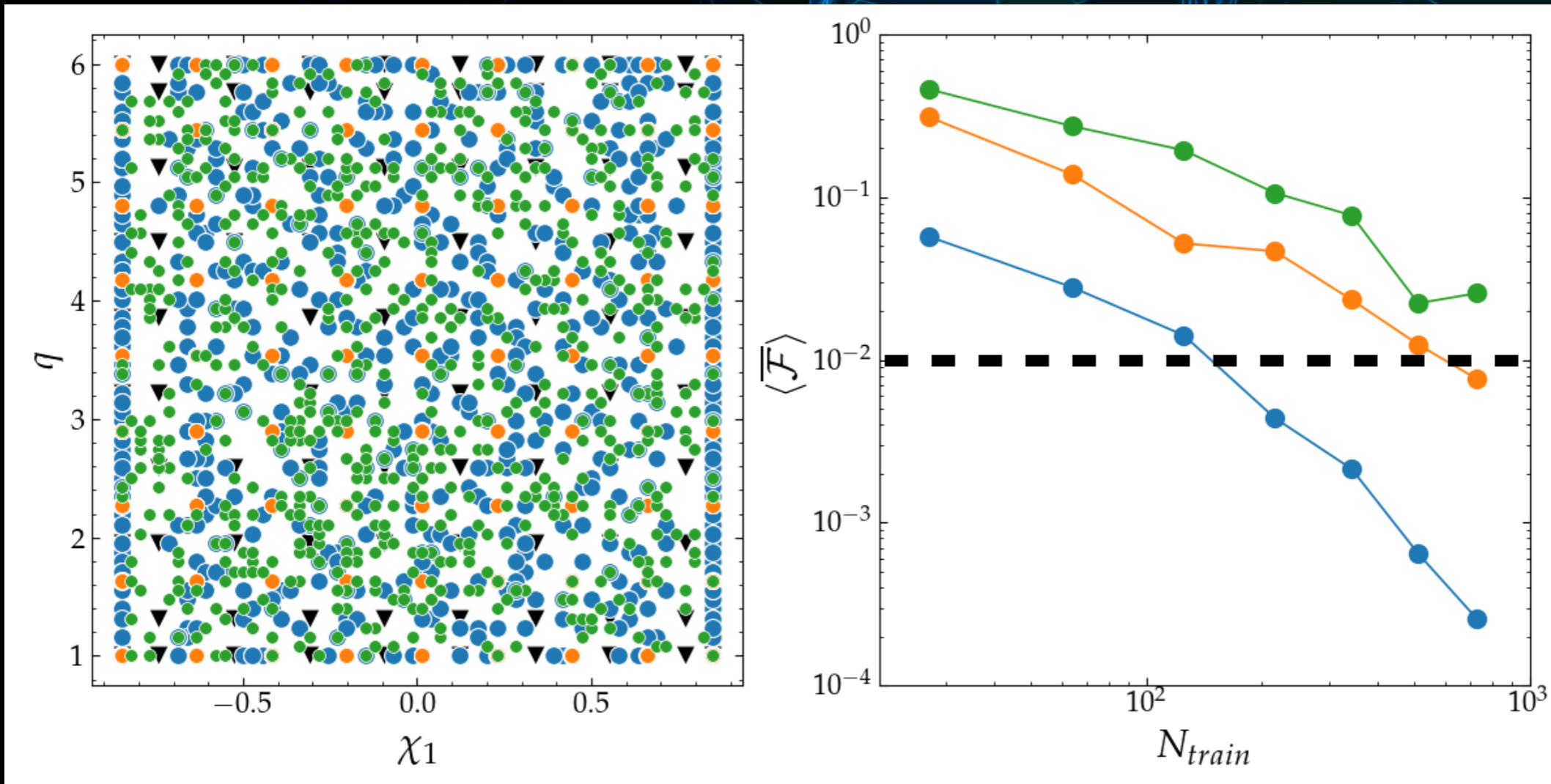


TRAINING STRATEGIES



▼ test ● active ● uniform ● random

EVALUATION



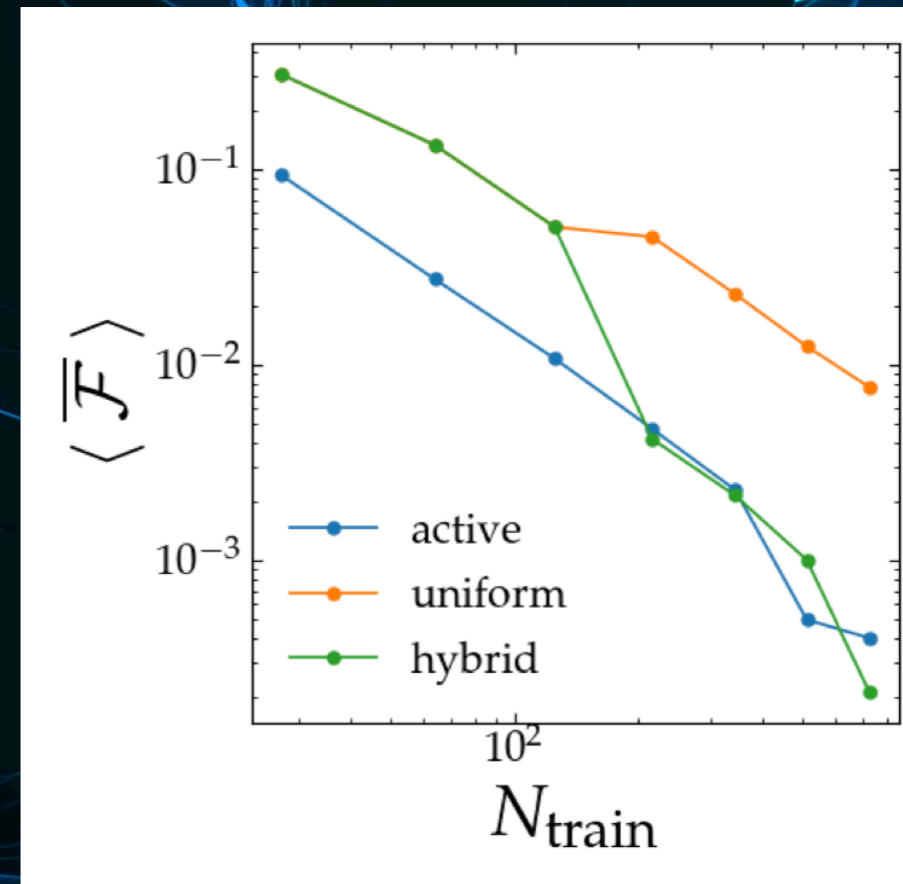
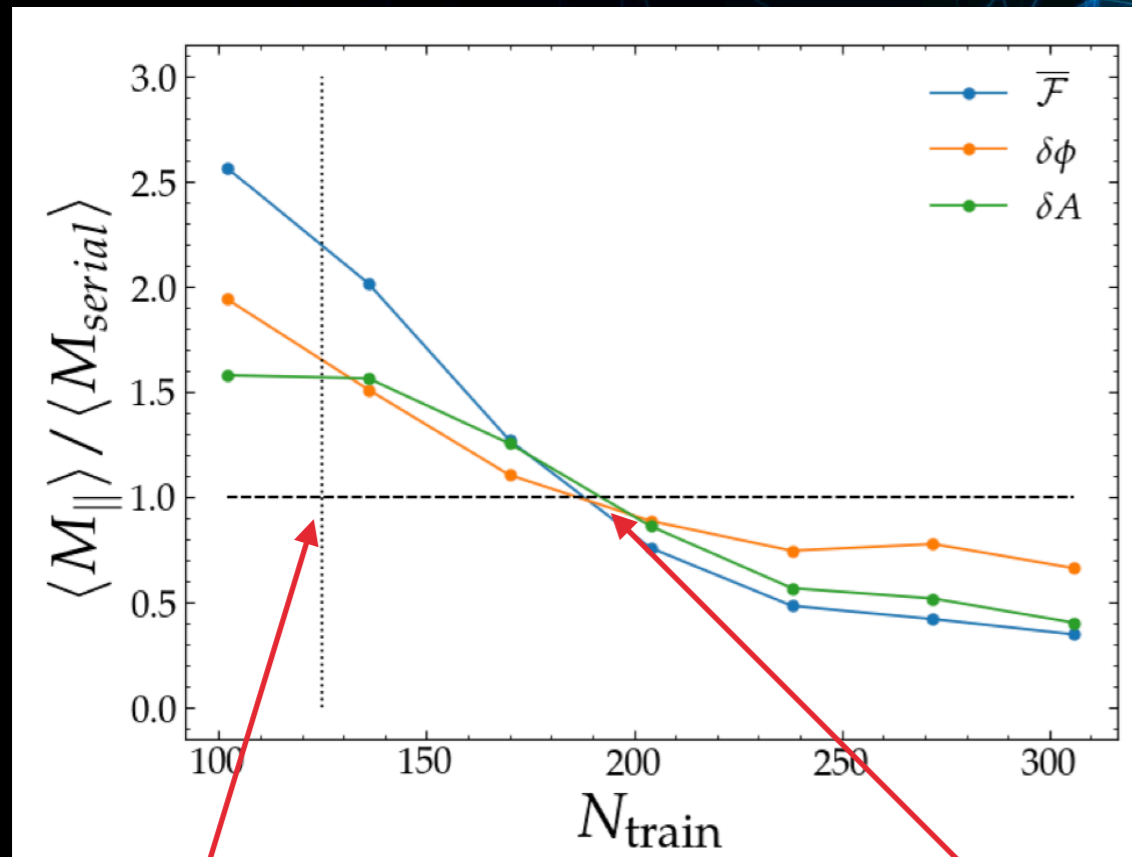
▼ test ● active ● uniform ● random

REDUCE COST BY 4X

THIS IS GREAT BUT...

Sequential?

Re do?



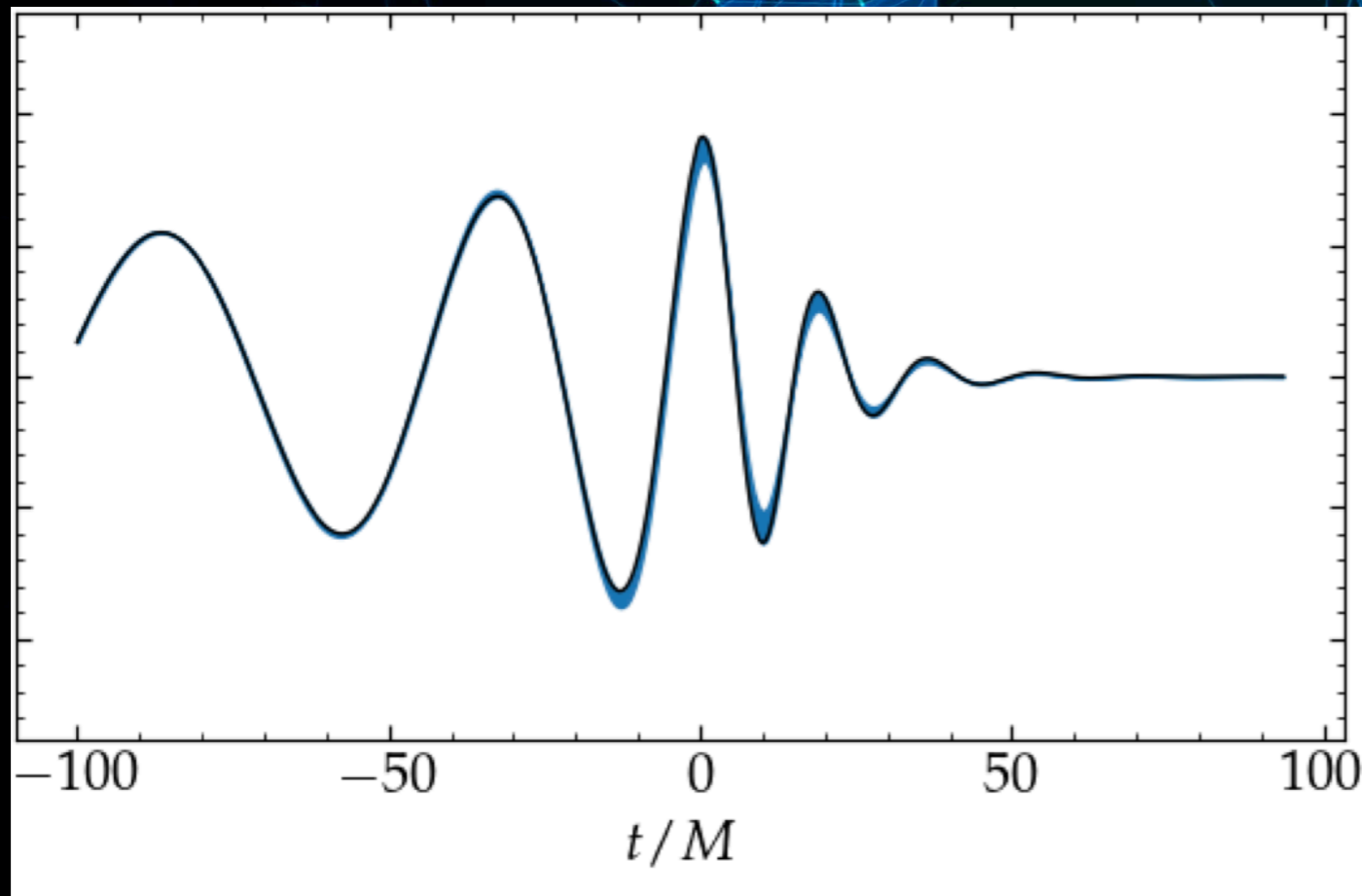
$N_{serial} = 125$ $N_{\parallel} = 180$

**SWITCH TO ACTIVE
W/ SAME RESULTS**

REDUCE TIME BY 3X

Notion of Waveform Uncertainty

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



USEFUL FOR DATA ANALYSIS!

TAKE HOME

GW need modelling

NR informs approximants

Quasi-circular \rightarrow eccentric...

Need to explore parameter space

**GUIDE SEARCH WITH ACTIVE LEARNING
WORK TO DO!**



THANK YOU!