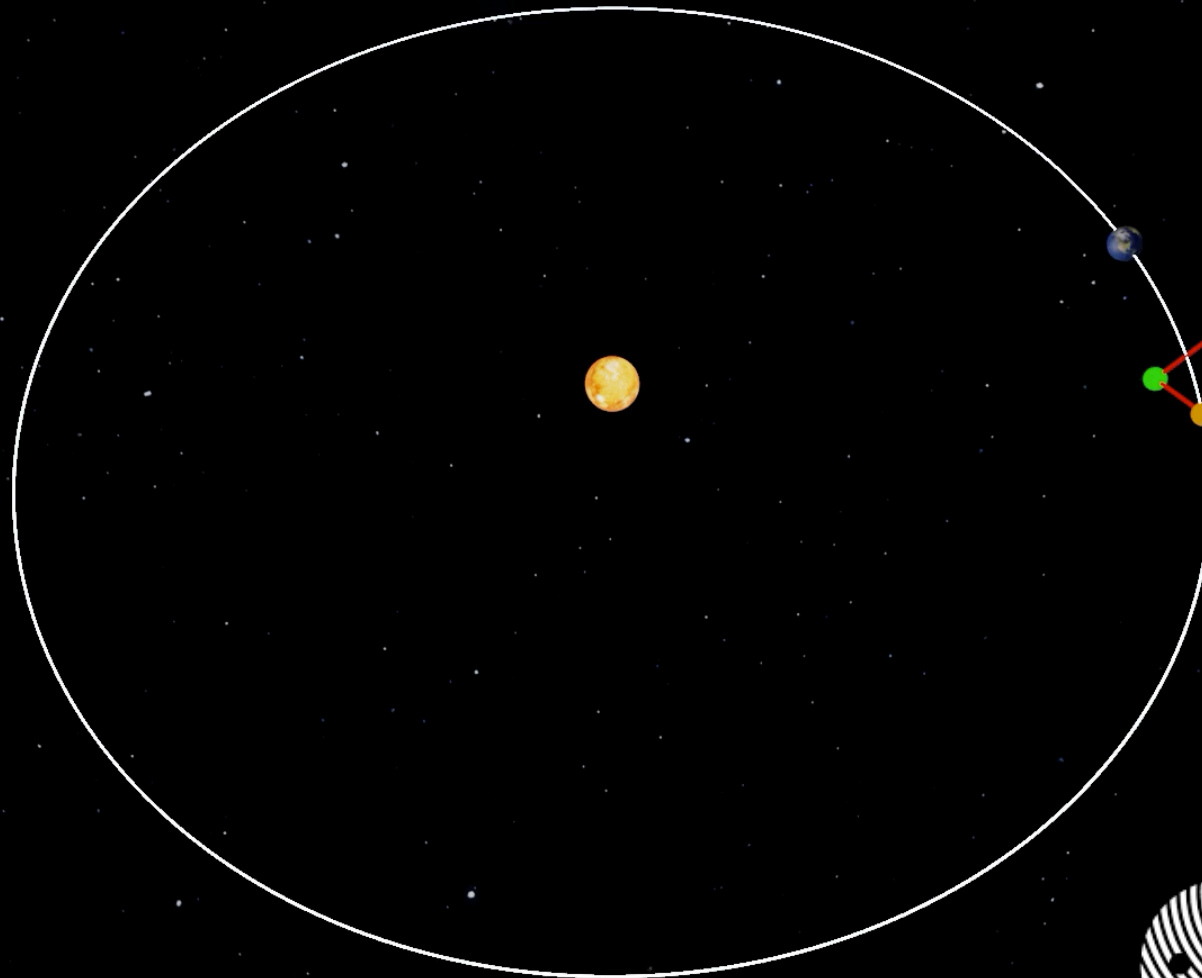


LISA data analysis and waveform challenges

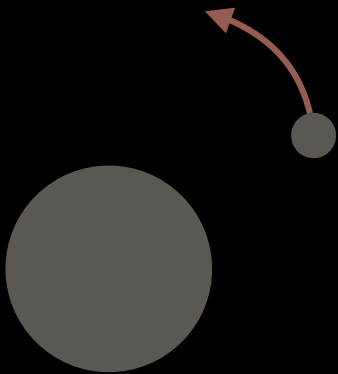
LISA-NL Community Day, 10 Oct 2024

Lorenzo Speri

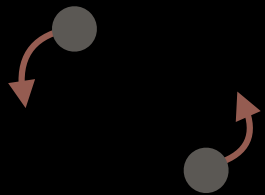
European Space Agency



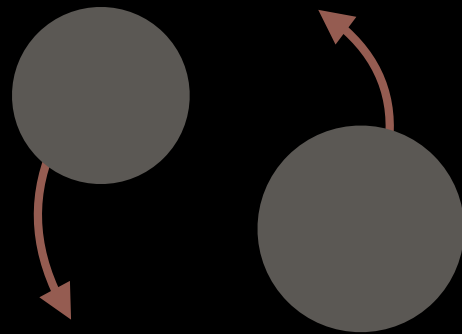
EMRI



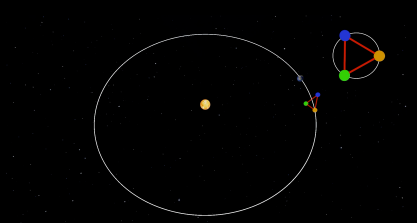
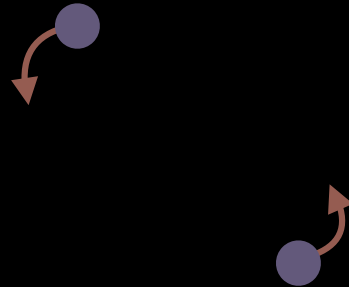
SOBHB



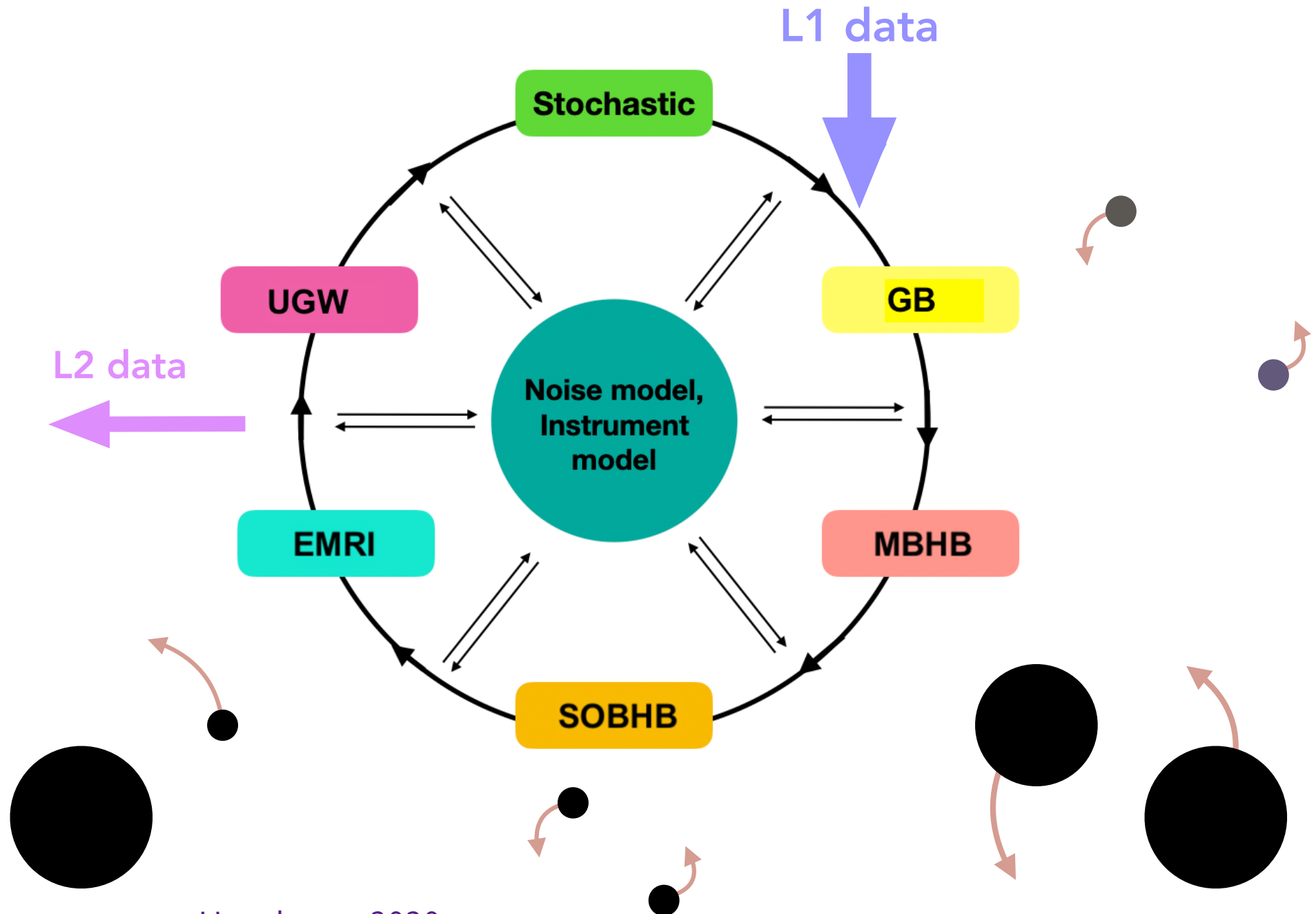
MBHB



GB

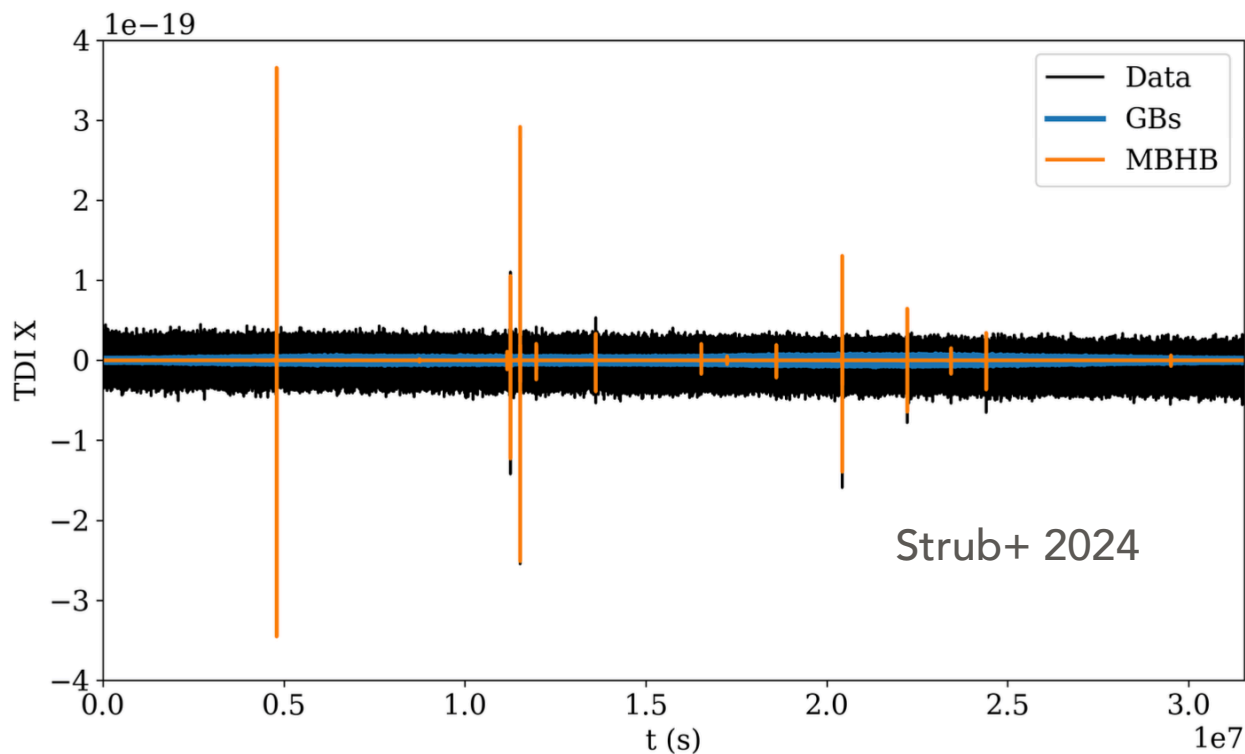
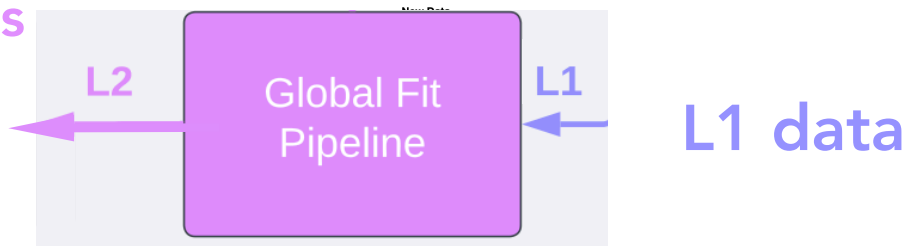
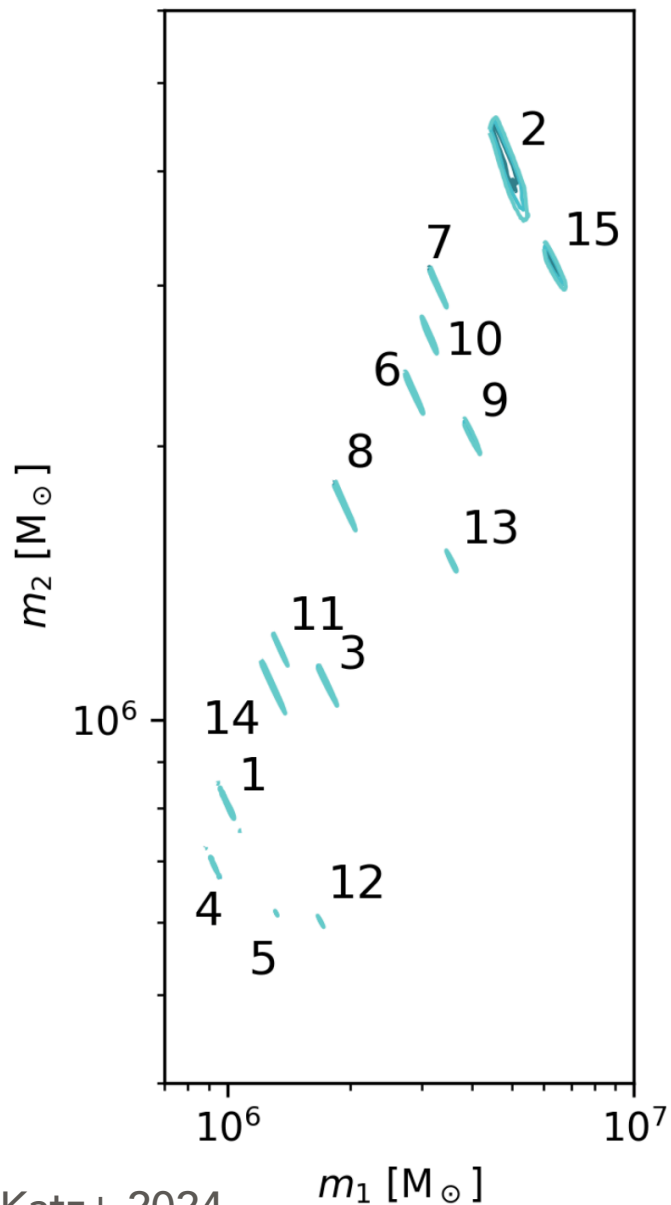


The LISA Global Fit



The LISA Global Fit

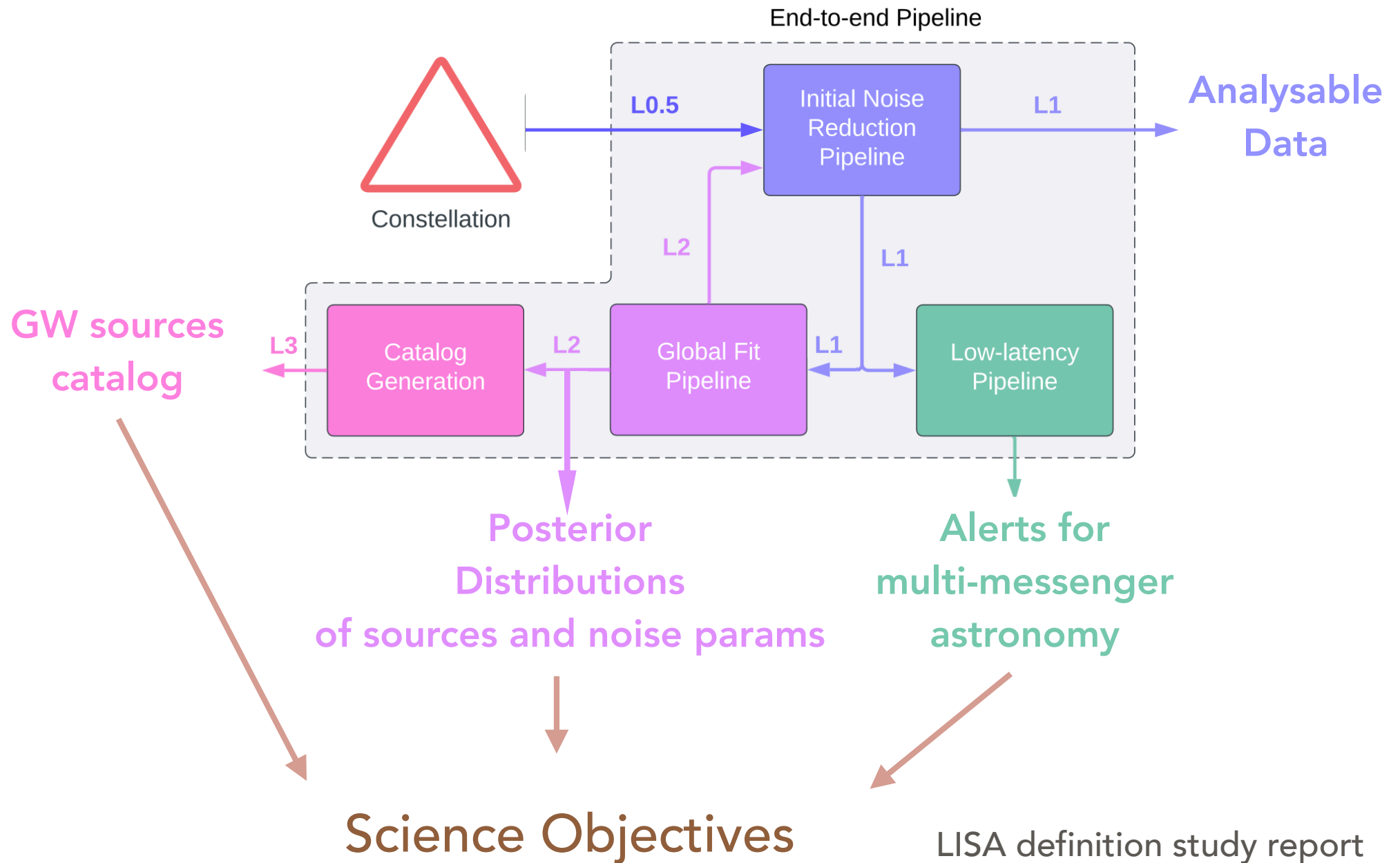
L2 data
Posterior Distributions



Katz+ 2024

$$d = \sum_{s \in \text{sources}} h_s(\theta_s) + n$$

LISA data analysis

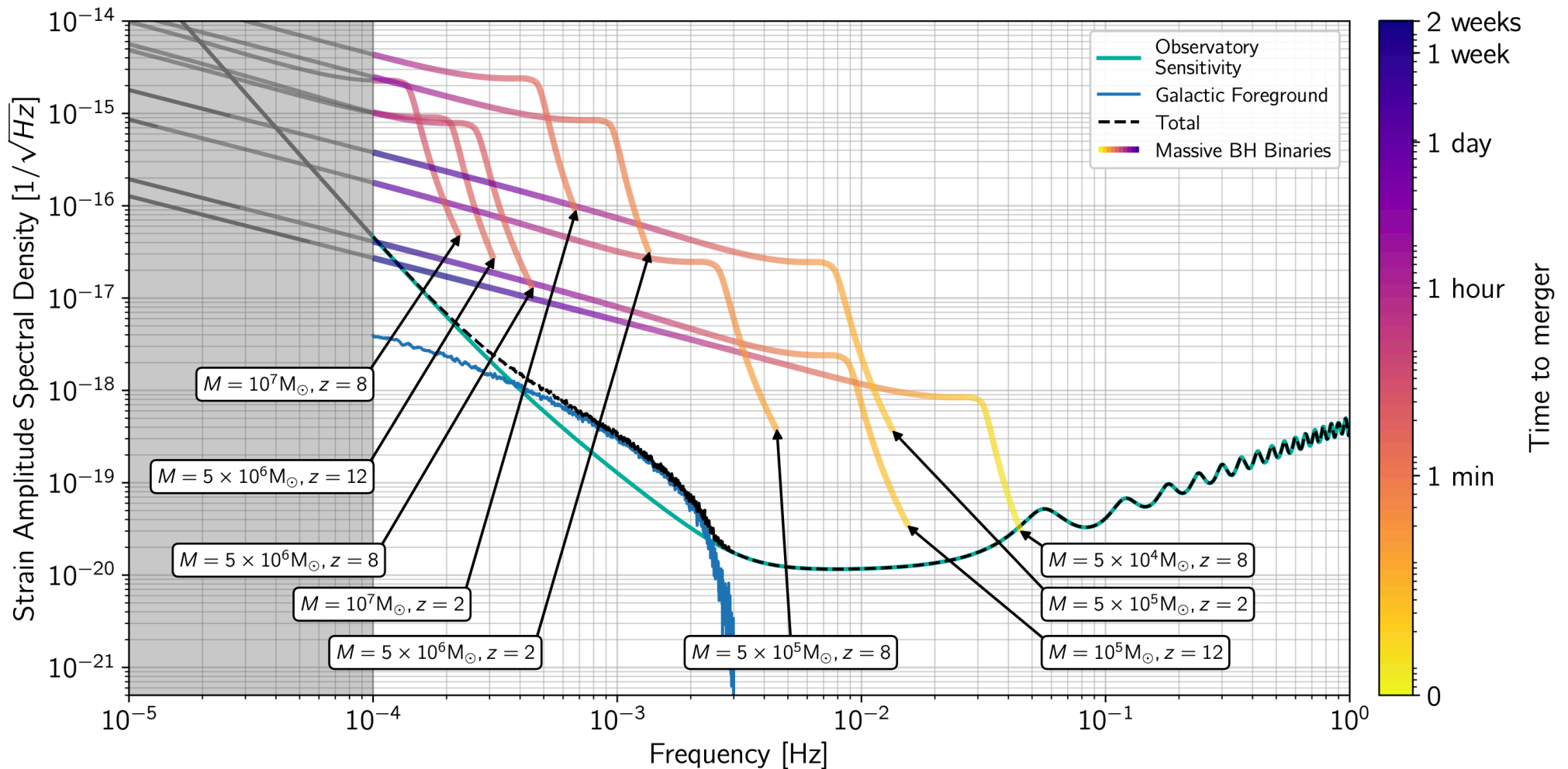
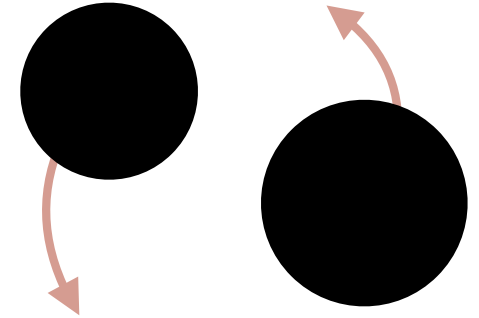


LISA definition study report
Colpi+2024

Massive Black Hole Binaries

Loud transient sources

SNRs up to 10^3

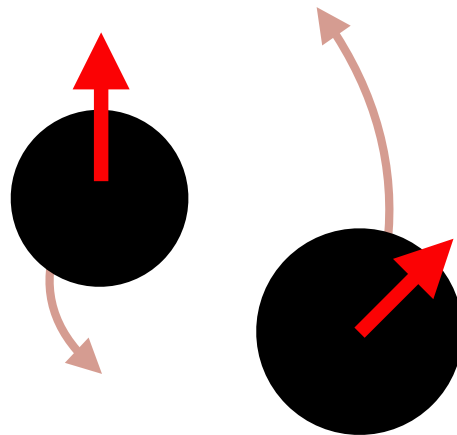
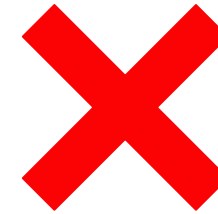


Massive Black Hole Binaries

Search and parameter estimation



Eccentric precessing MBHB waveforms



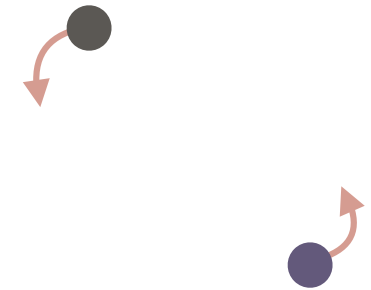
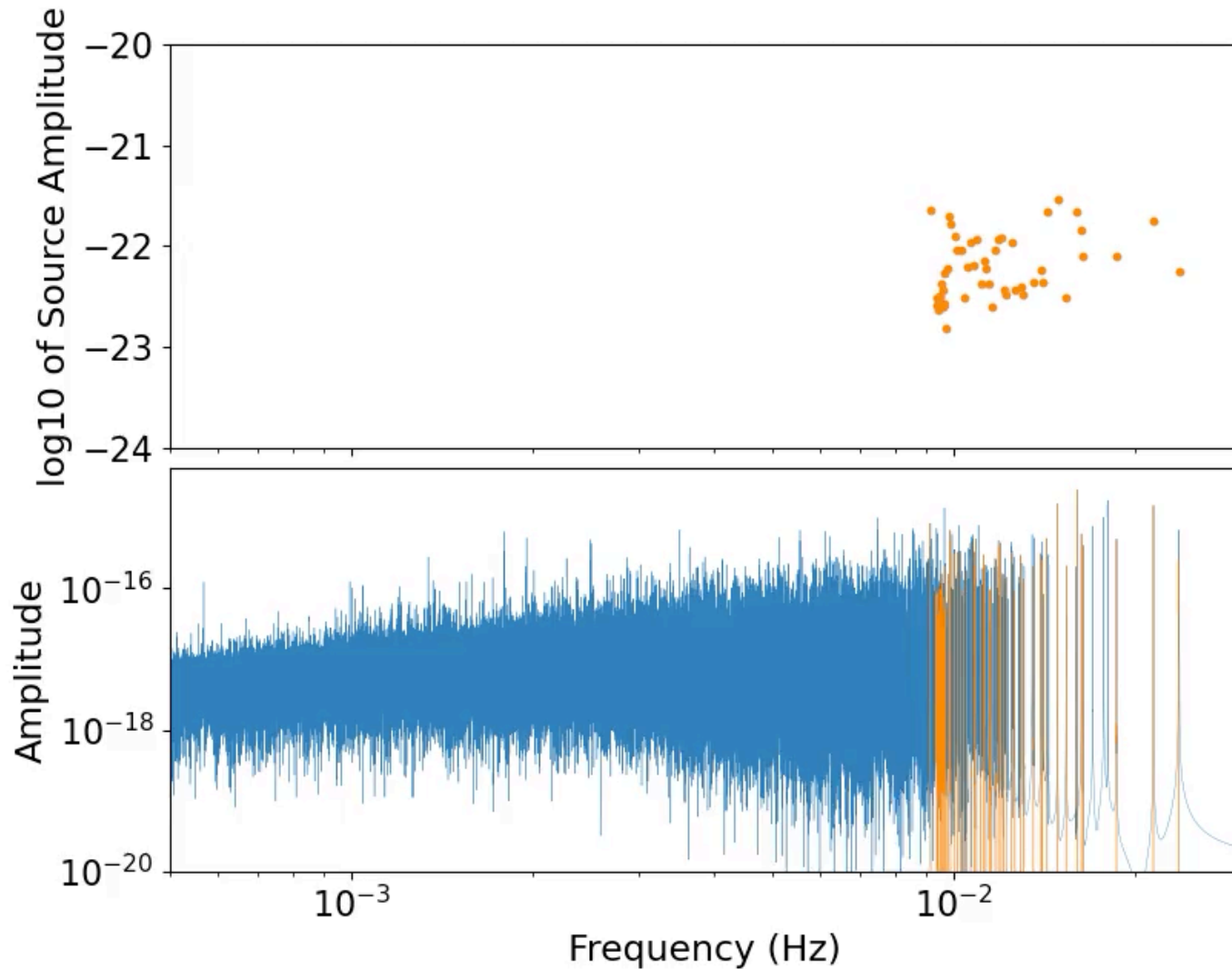
Inaccurate waveforms induce systematic errors and leave residual signals in the data stream

Galactic Binaries

always in band quasi-monochromatic signals

10^6 sources

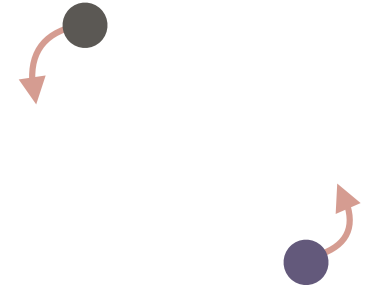
10^4 resolvable



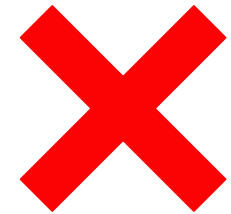
credit: M. Katz

Galactic Binaries

Search and parameter estimation



Understand if the GF pipeline can handle eccentric, triple, or accreting systems



Population analysis of GBs



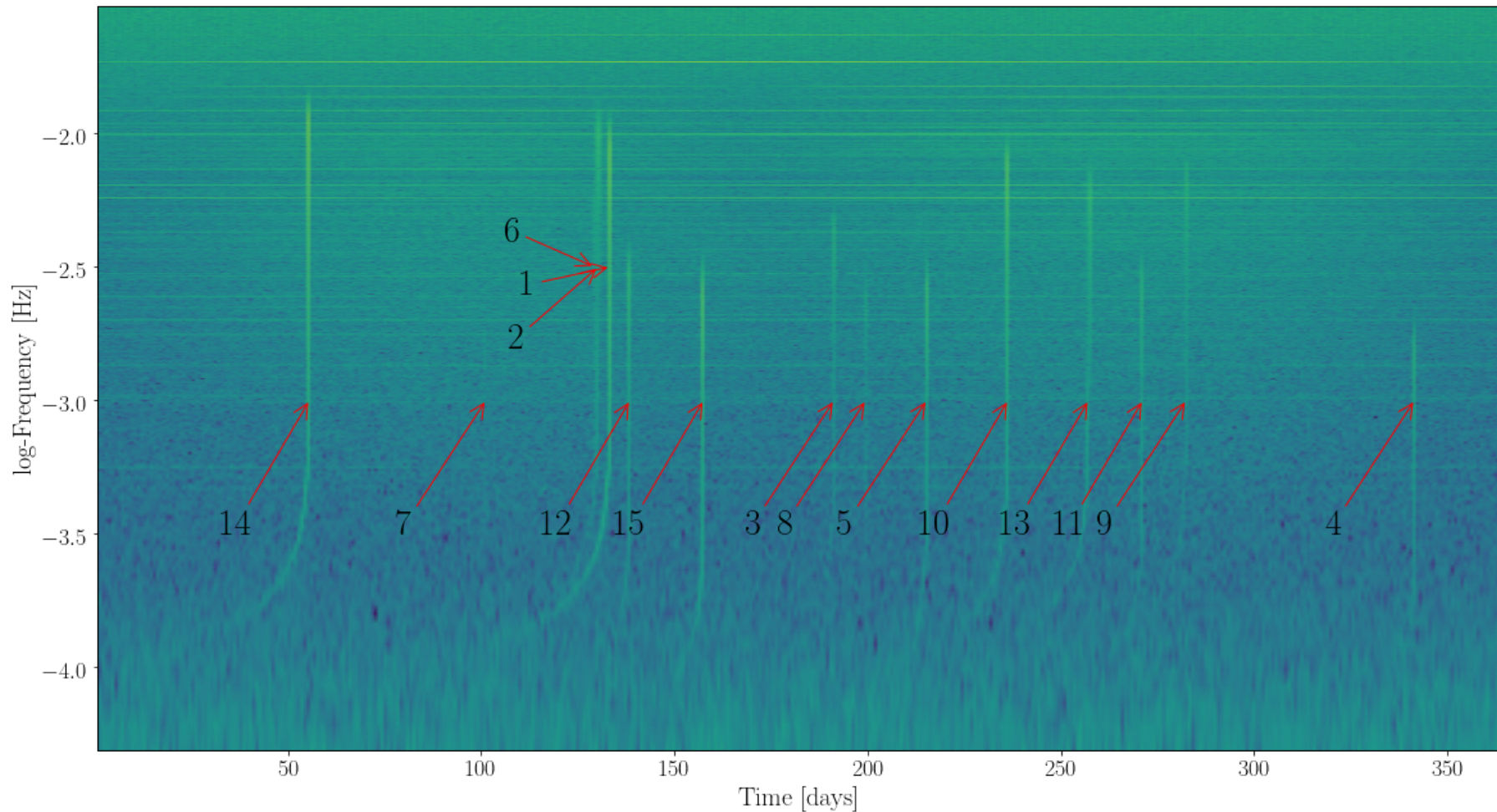
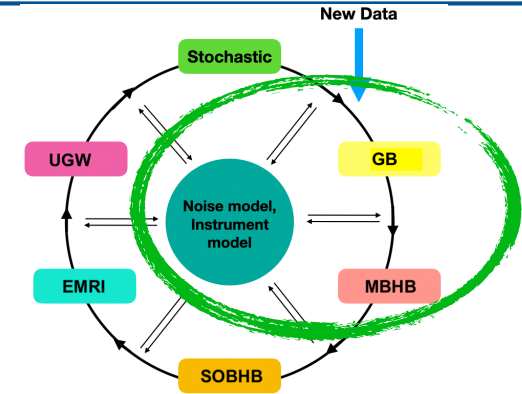
LISA Data challenges: MBHBs + GBs + noise

Littenberg & Cornish 2023
Phys. Rev. D 107, 063004

Strub+ 2024
arxiv 2403.15318

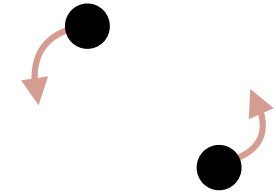
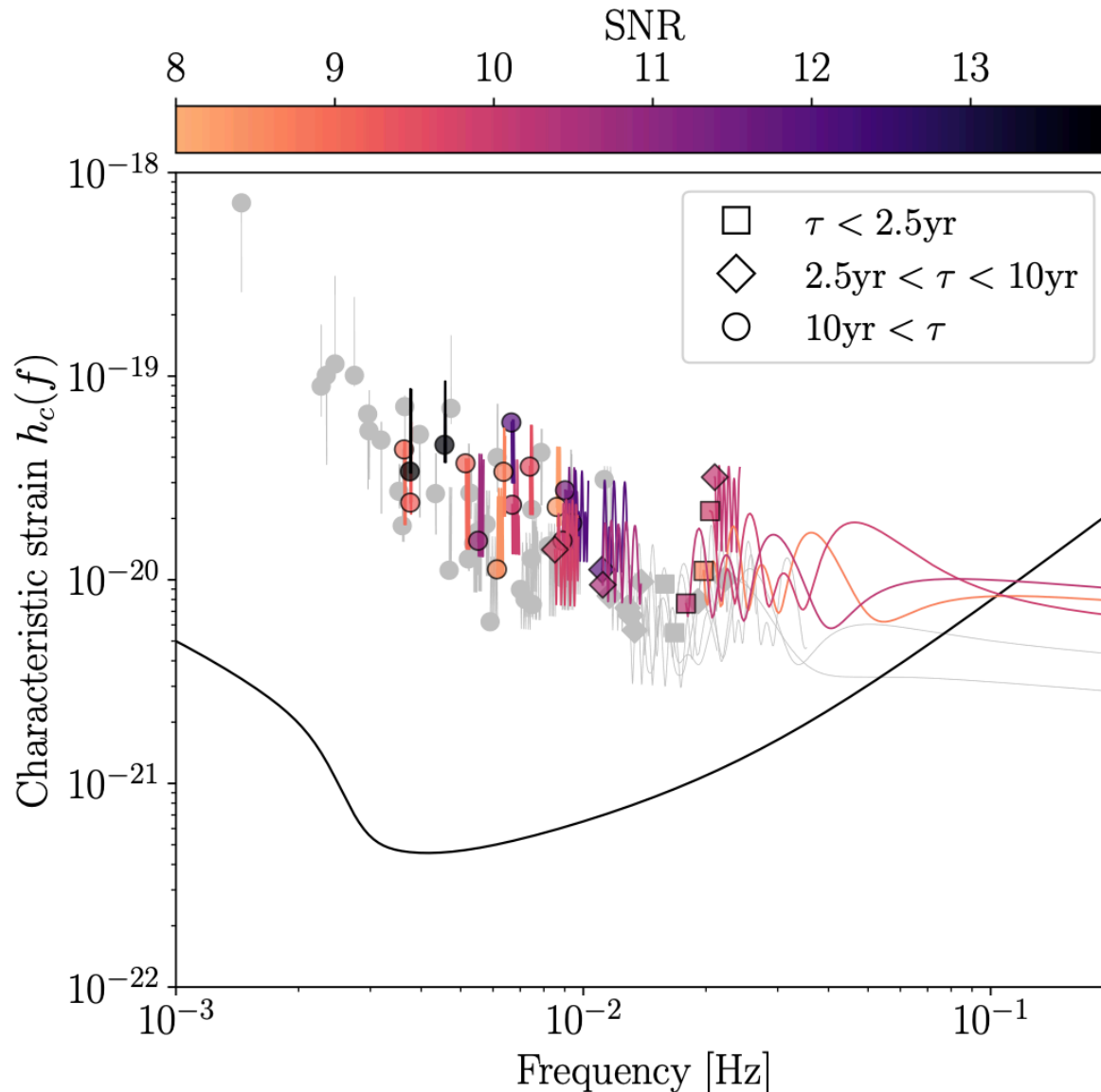
Katz+ 2024
arxiv 2405.04690

Deng+ APC



Stellar Origin Black Hole Binaries

LVK binaries in their early inspiral

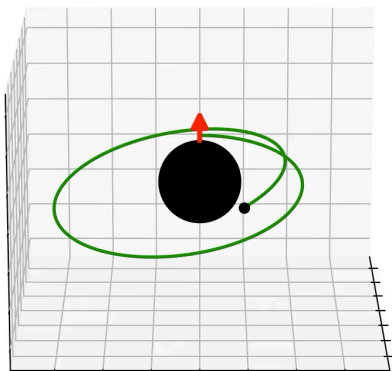
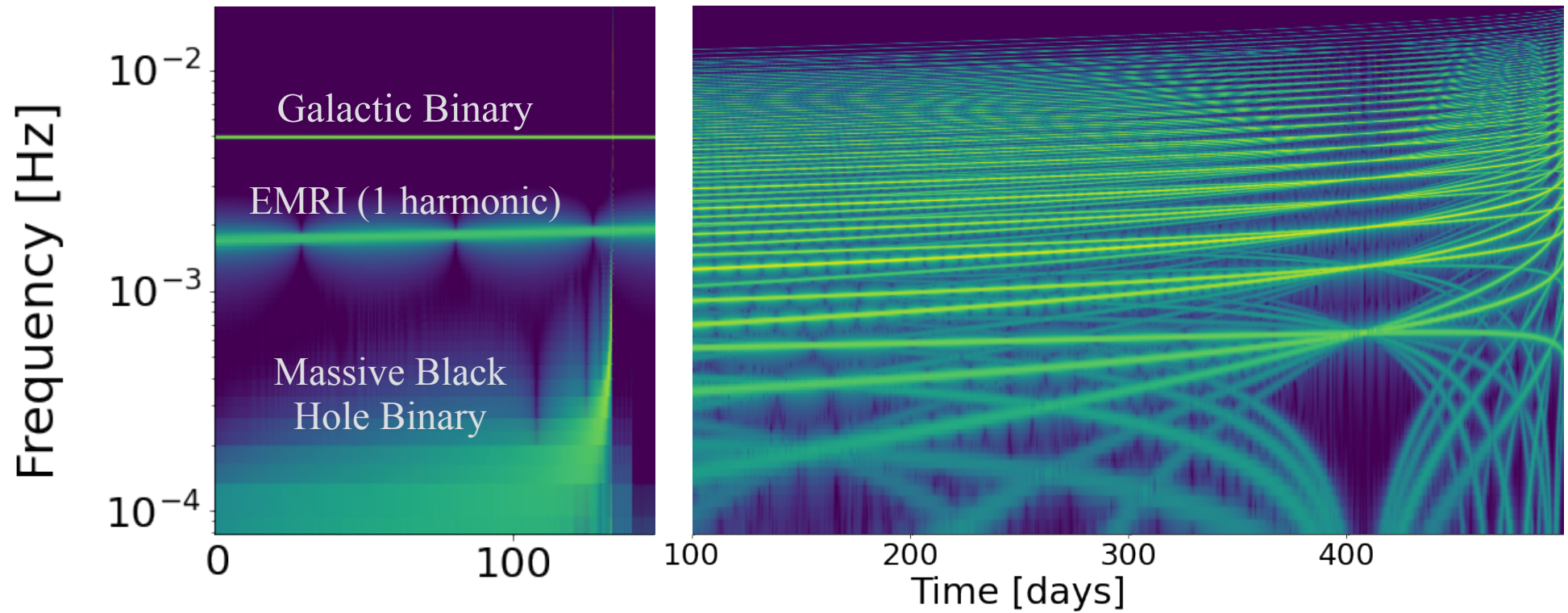


long-lived sources

Search and PE
Diganta+ 2024

Buscicchio+ 2021

Extreme Mass Ratio Inspirals



EMRI Waveforms

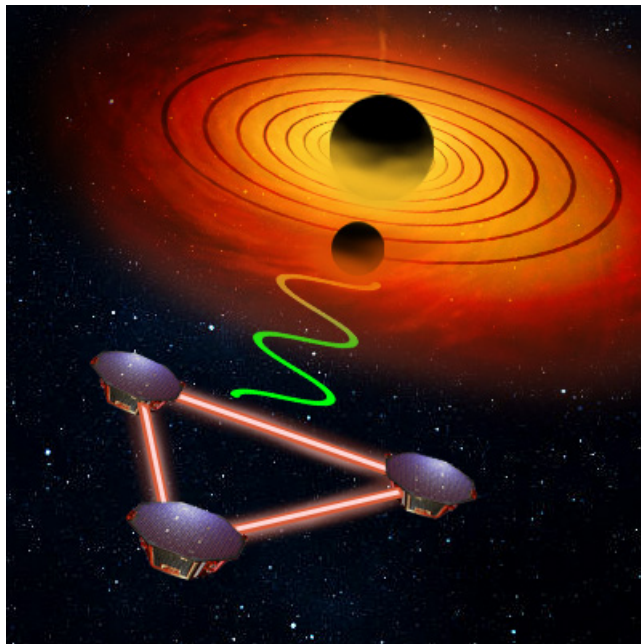
FastEMRIWaveforms

Time Domain
Chua+ 2020 Katz+ 2021

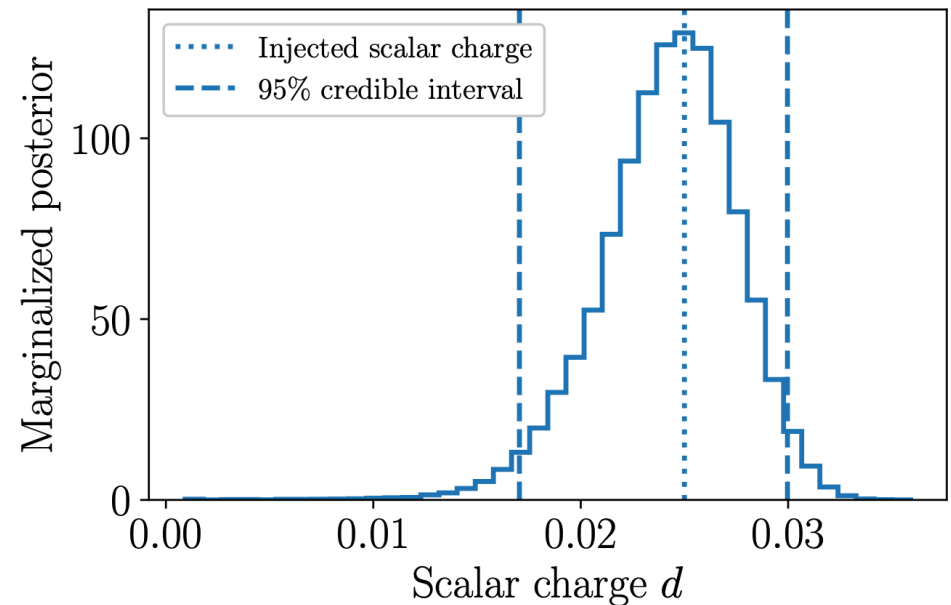
Frequency Domain
Speri+ 2023

Speri+ Phys. Rev. X 2023

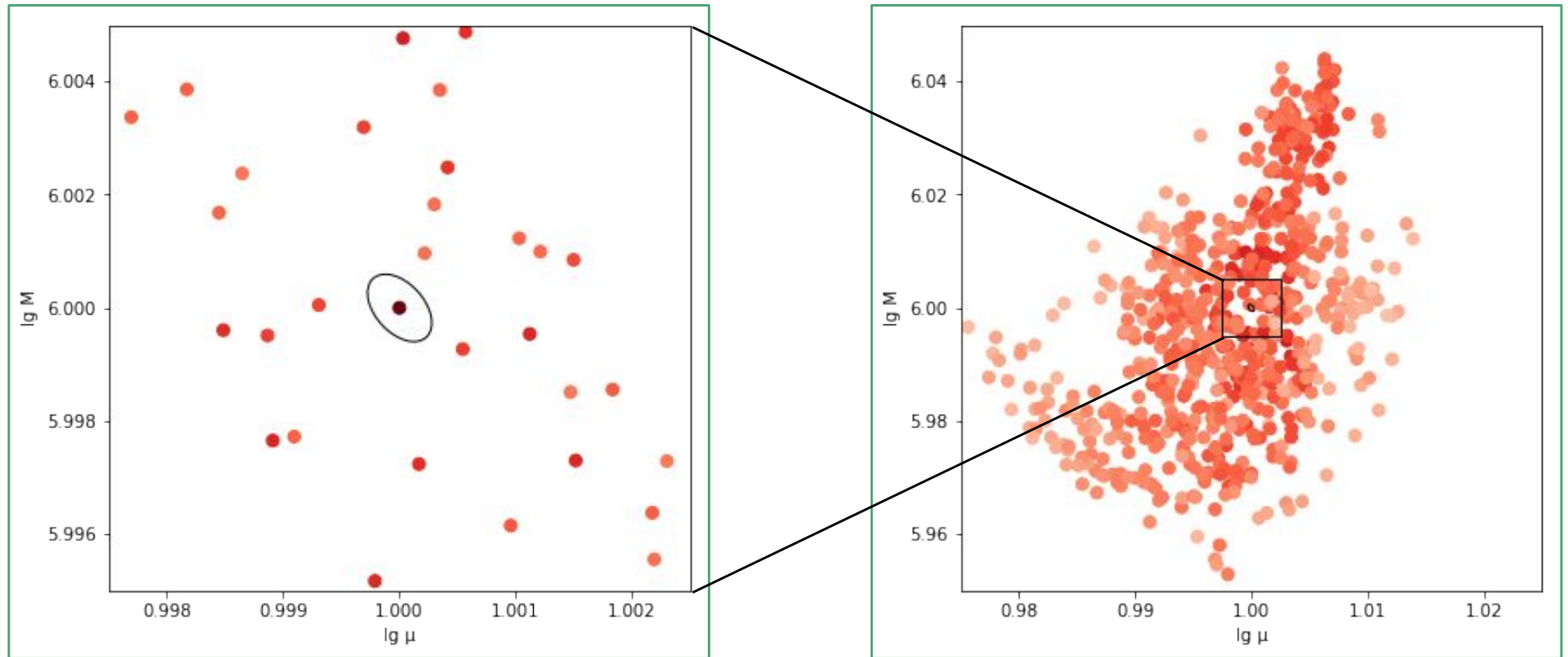
EMRIs as probe of
MBHs environments



Speri+ 2024
Test of GR with
Eccentric Spinning EMRIs



EMRI search



Cutler & Chua 2021

The size of the posterior is small compared to the size of the prior

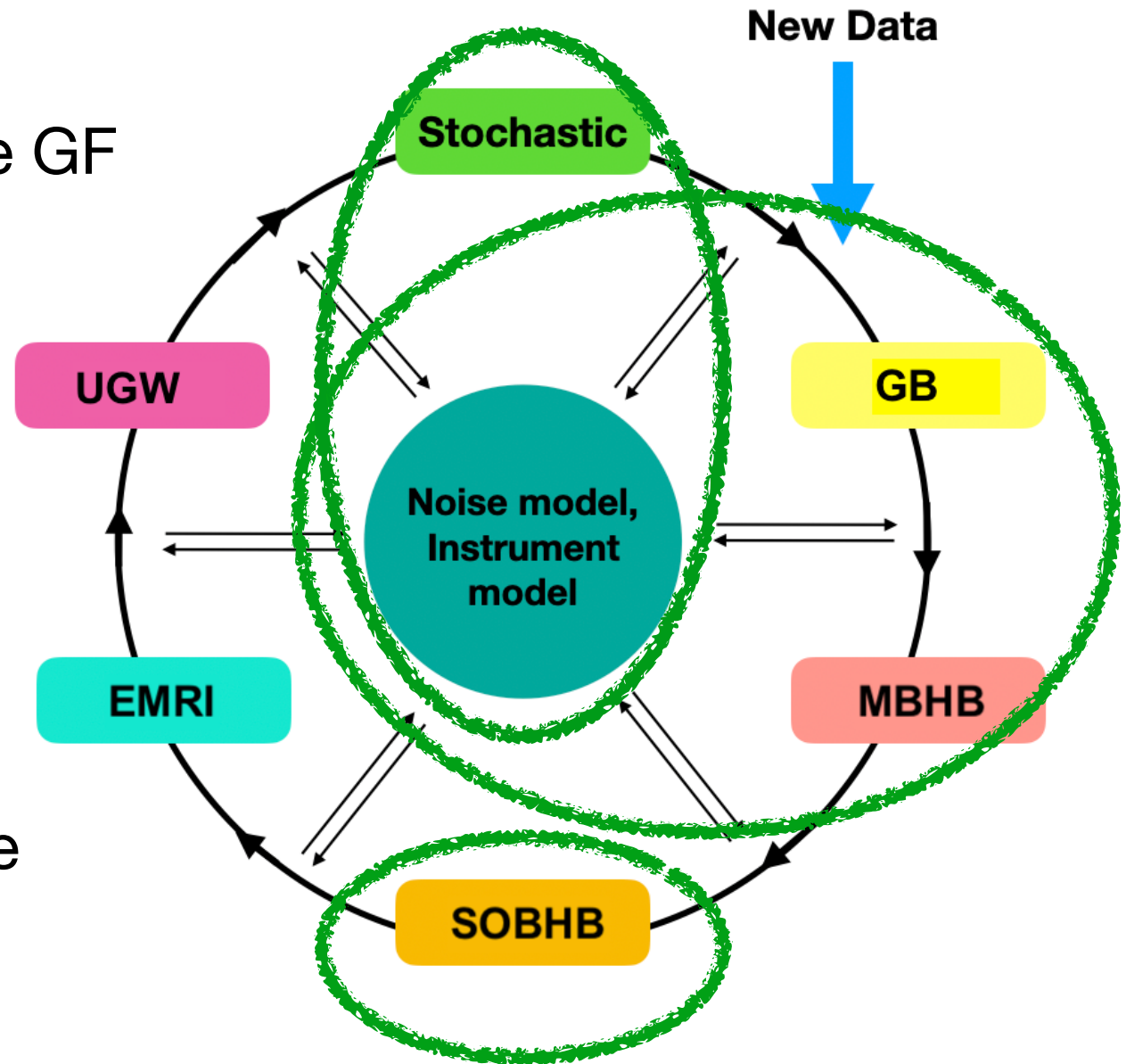
The likelihood surface has many local maxima

Future challenges

Inclusion of EMRI and SOBHB searches in the GF

develop accurate waveforms for EMRIs and MBHBs

add more realistic noise effects: glitches, gaps, non-stationarities



Conclusions

Waveforms

- Parameter space extension of waveforms
- Fast and accurate waveforms
- Beyond vacuum effects

Data analysis

- Search and identification of EMRIs and SOBHBs
- Multiple source and noise types in the global fit
- Assess the performance of GF pipelines

Join the DDPC efforts to prepare for the mission!

LISA Analysis Tools Workshop

EMRI Parameter Estimation

Beyond Vacuum EMRI Waveform modeling

EMRI search

