

SYNERGY

between ET and LISA



Gabriele Perna

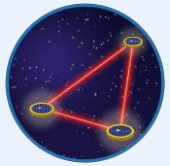
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LGWA Meeting, Liège

29/09/2026

THE PROJECT IN ONE SLIDE

Coordinators
Gabriele Perna
Antonio J Iovino



LISA
Cosmology WG

the first coordinated synergy project

ET
Div2 · Div5

40+
researchers

from **early-stage PhD** students to **senior scientists** with long-standing involvement in major ET and LISA activities

Scientific work groups

SIGW · **Primordial GW** · **Phase transitions** · **Topological defects** · **Code**

January 2026 — *start*

Oct 2026 — *LGWA Meeting*

late 2026 / early 2027 — *completion*

Why a synergy project?

A cosmological GW background

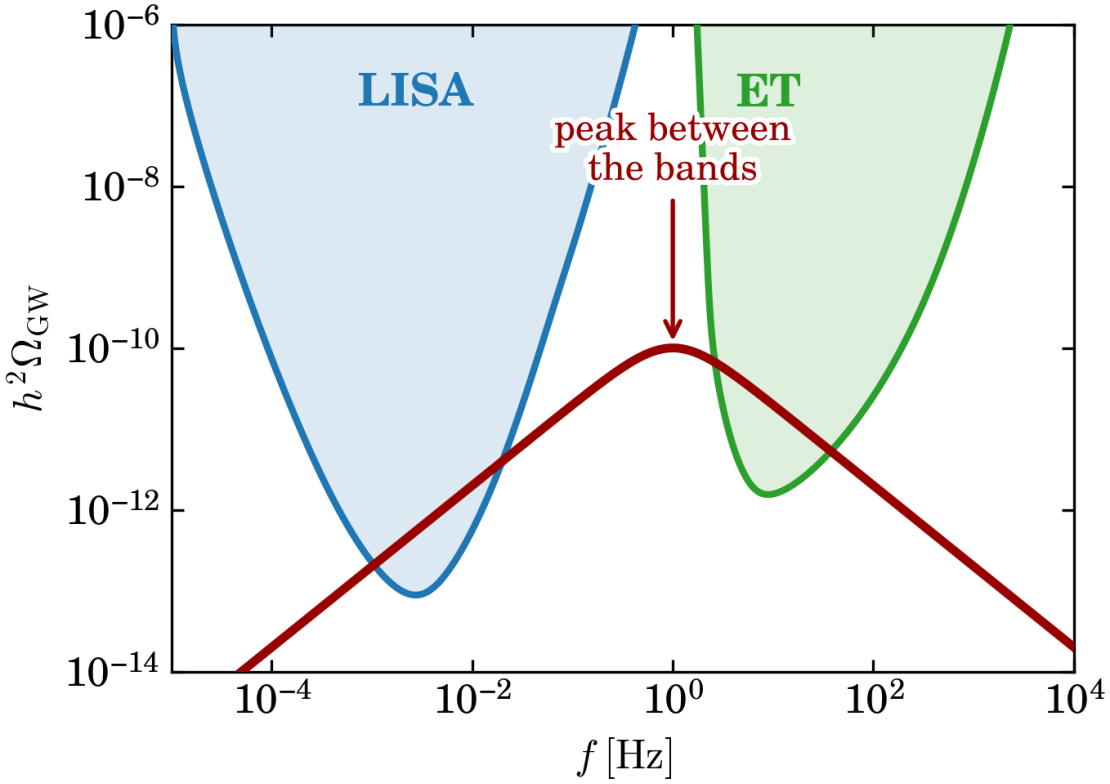
can **shed light** on the nature of our Universe and **place constraints** on specific cosmological models.

Beyond the PTA band

Recent PTA analyses highlight the need to extend GW searches to other frequency ranges: LISA and ET will operate in the coming decades.

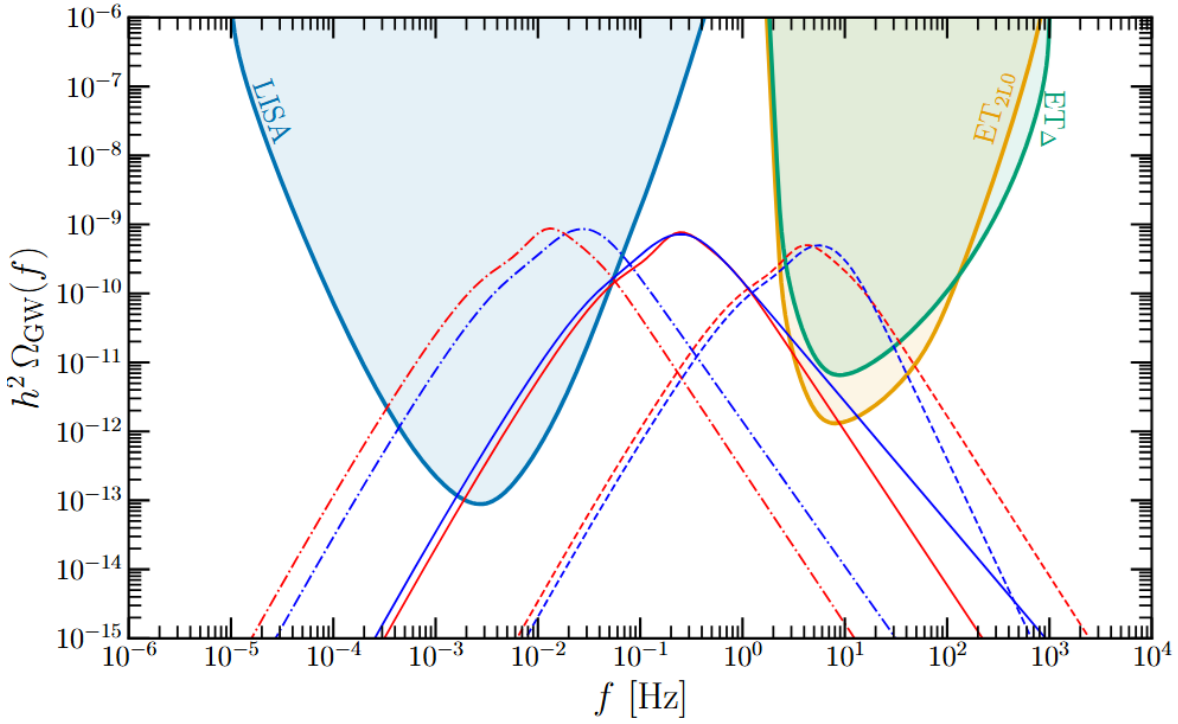
Peaks between detectors

A signal may not peak where a detector is most sensitive: the **synergy** between detectors can play a crucial role.

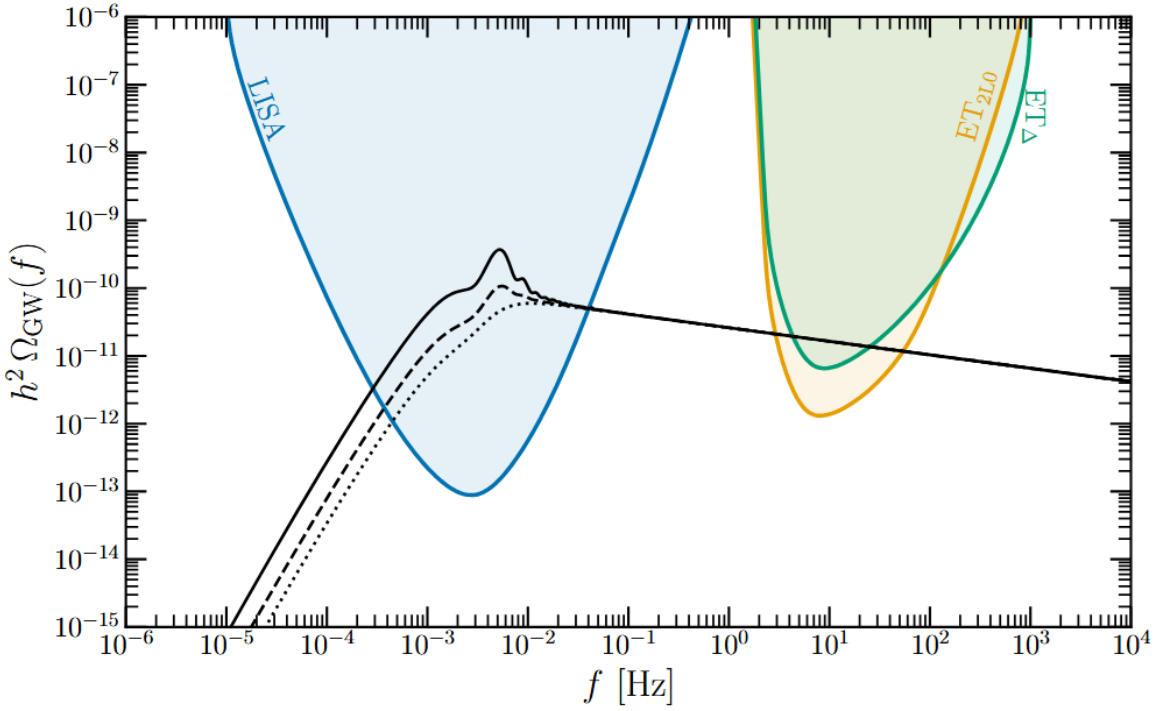


SOME INTERESTING SCENARIOS

- A GW signal with only the tails in the detectors, and the peak in the middle.



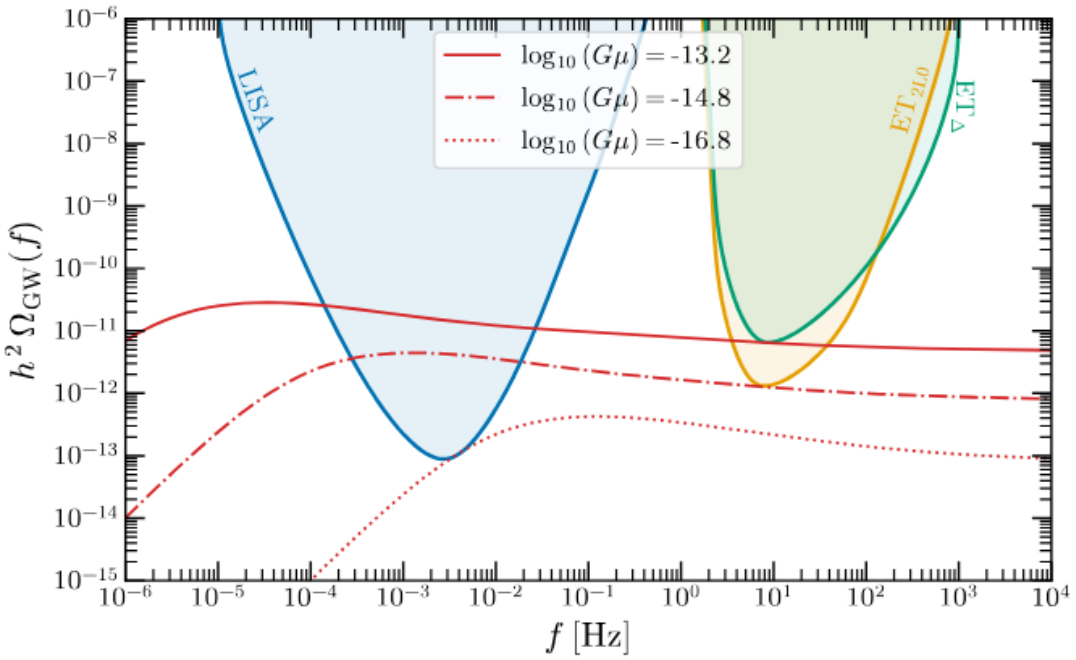
- A GW signal with the main contribution in one detector, and the tails in the other.



PLS obtained with GWBird [arXiv:2507.15791]

SOME INTERESTING SCENARIOS

- Broad GW Signals



- Constrain the parameter(s) of a given model
- Break degeneracies between different cosmological interpretations.
  E.g.: Scenarios with the causality tail

PLS obtained with GWBird [arXiv:2507.15791]

Scalar-Induced GW

Templates on Ω_{GW}

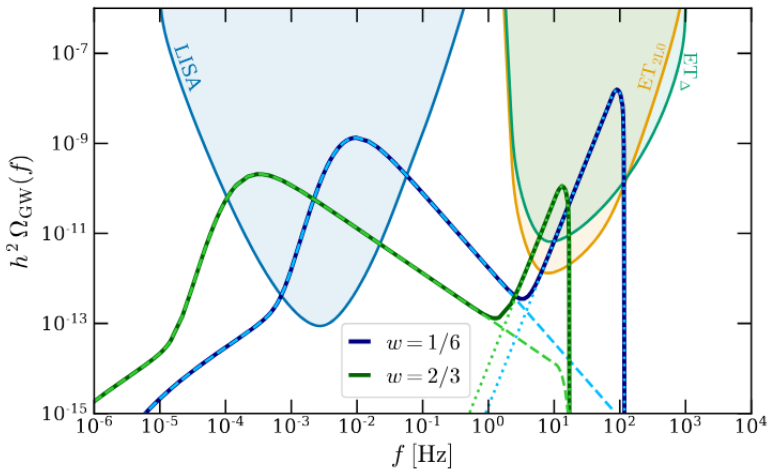
- Power Law
- Broken PL
- Double Peaked

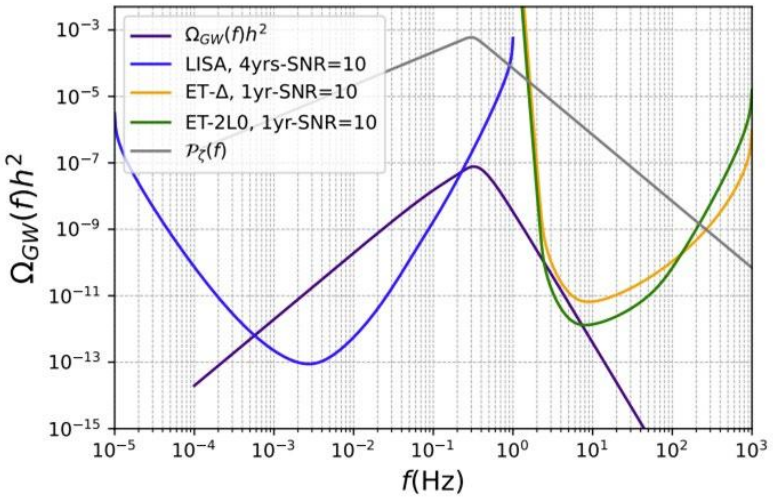
Templates on P_ζ

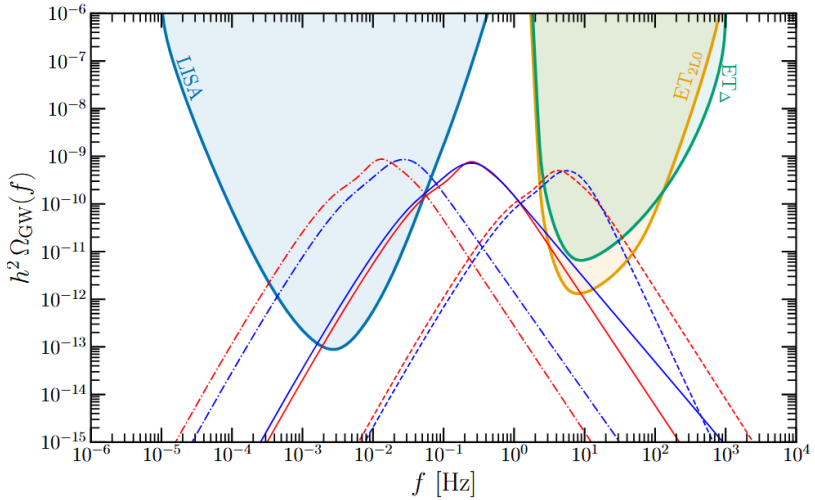
- Broken PL → Analytical
- Step-size
- LN Bump → Analytical
- Sharp Transitions

Numerical Templates

- Ab initio, template on the potential
- Parity violation







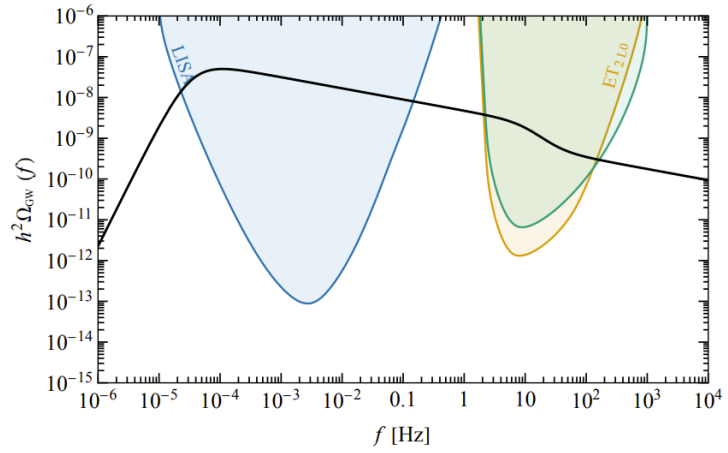
See Angelo Ricciardone's talk tomorrow

PLS obtained with GWBird [arXiv:2507.15791]

Primordial GW

Templates on Ω_{GW}

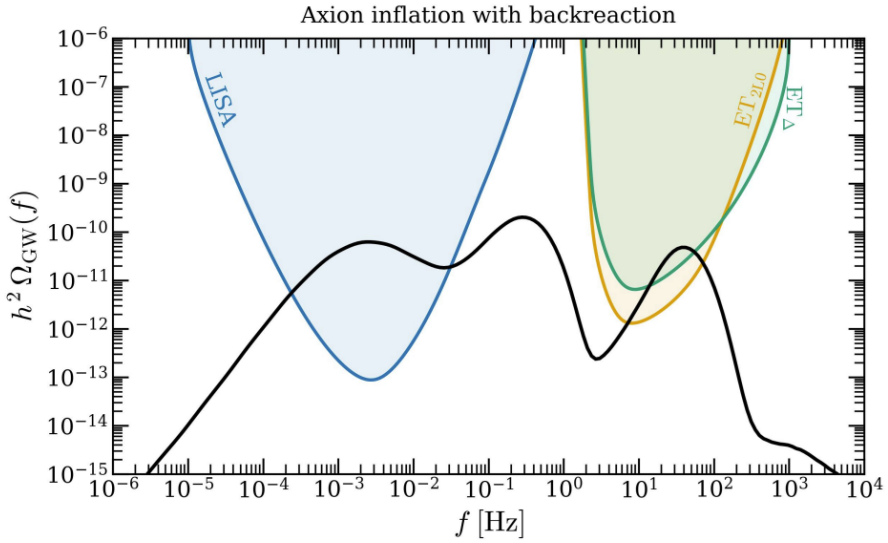
- Power Law: Axion--gauge field inflation
- Broken PL: Thermal-history transition
- Double Broken PL: example of Pre-Big Bang model
- Log-normal bump: Models with spectator field



PLS obtained with GWBird  [arXiv:2507.15791]

Numerical Templates

- Axion inflation with homogeneous backreaction
  → Interpolation grid



See Angelo Ricciardone's talk tomorrow

Phase transitions

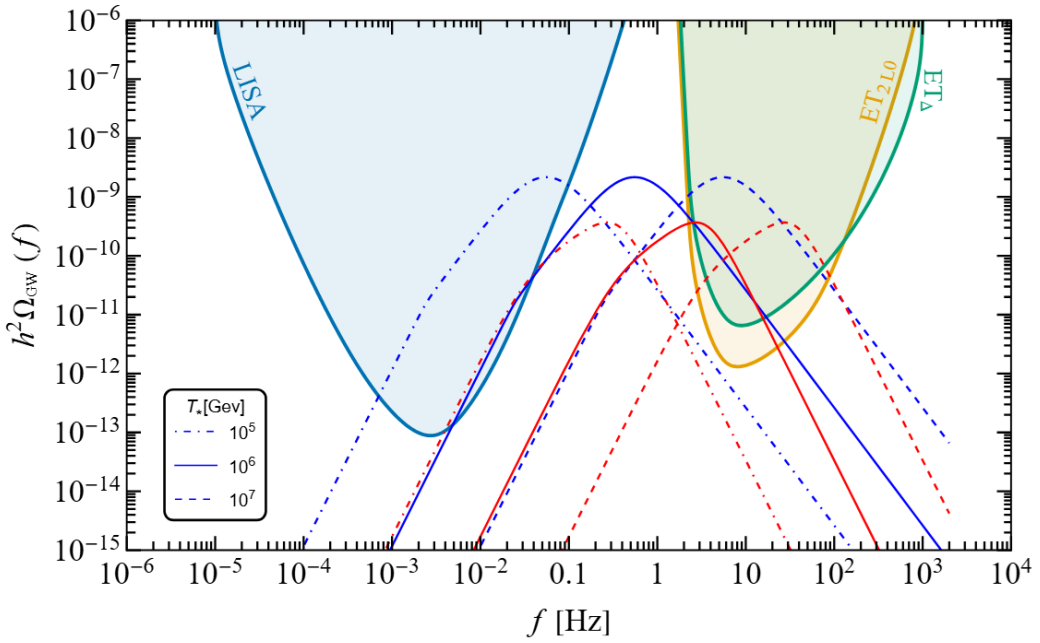
In this case it is possible to group all of the signals in one main template

$$\Omega_{\rm GW}(f) = \Omega_* \frac{\left(\frac{f}{f_1}\right)^{n_1}}{\left[1+\left(\frac{f}{f_2}\right)^{n_2}\right]^{n_4}\left[1+\left(\frac{f}{f_1}\right)^{n_3}\right]^{n_5}}$$

Templates on Ω_{GW}

- Broken PL

  - Bubble and shell collisions
  - Sound waves
  - (Magneto) hydrodynamic turbulence



See Angelo Ricciardone's talk tomorrow

PLS obtained with GWBird [arXiv:2507.15791]

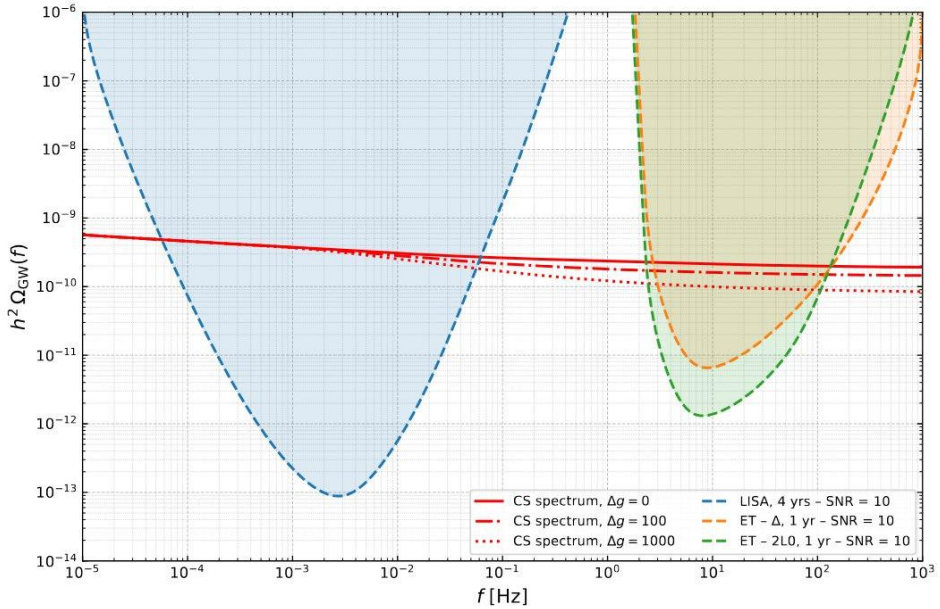
Topological Defects

Cosmic Strings

See Angelo Ricciardone's talk tomorrow

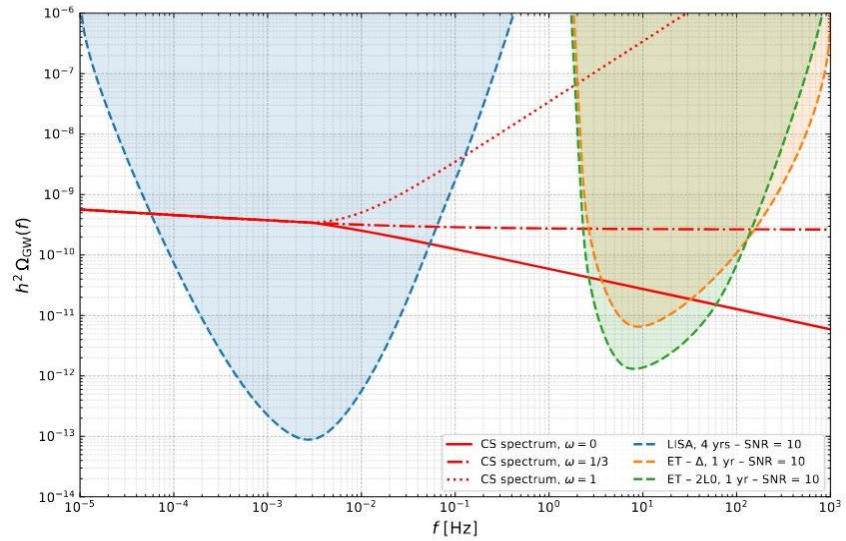
Numerical Templates

- Model I
- Model II
- Model III



\+ expansion histories

\+ BSM radiation



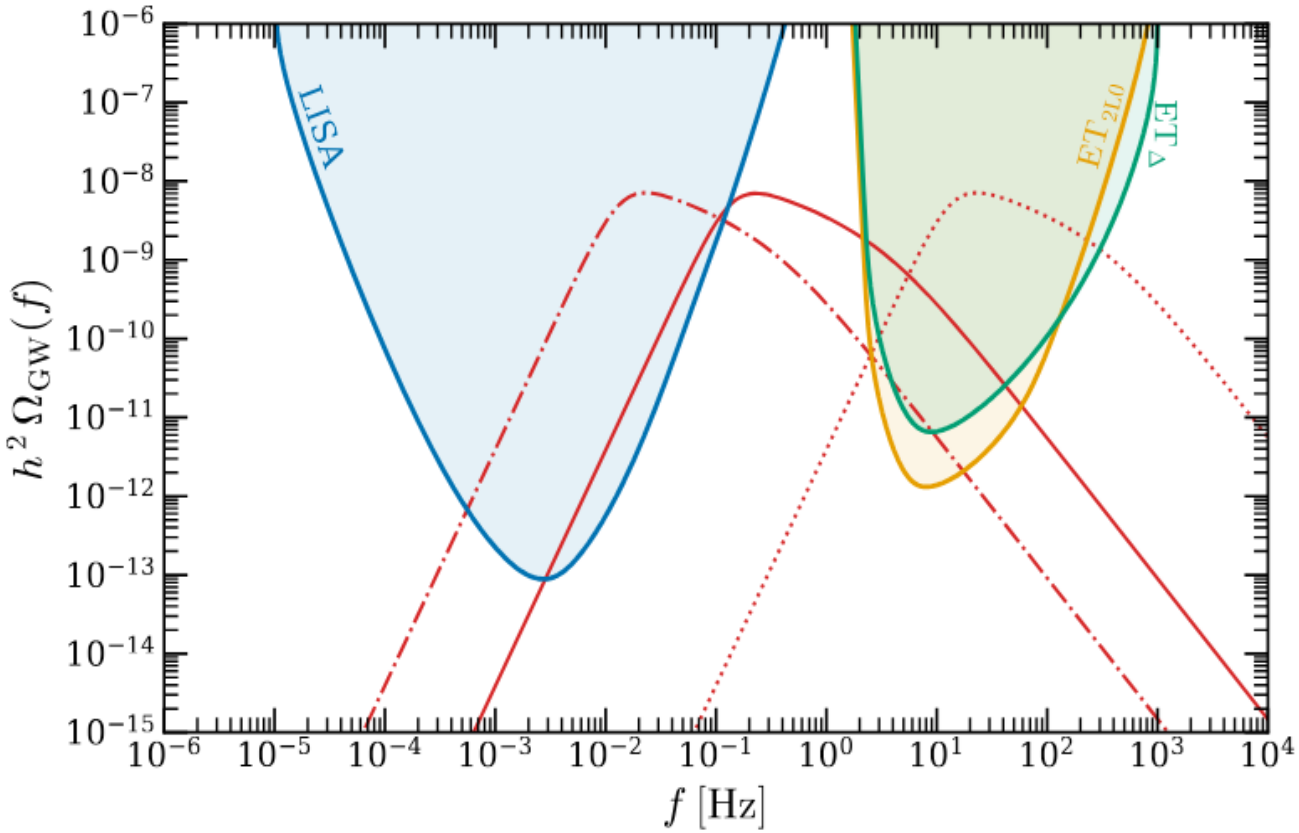
PLS obtained with GWBird [arXiv:2507.15791]

Topological Defects

Domain Walls

Templates on Ω_{GW}

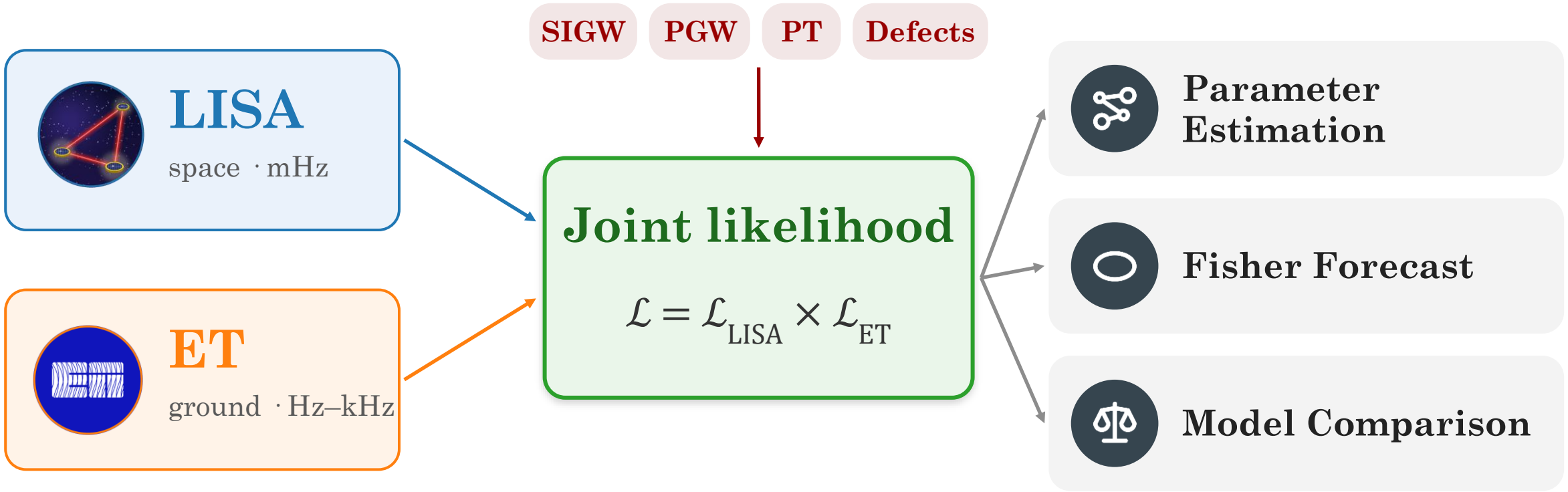
- Broken PL
  (Single or double)



PLS obtained with GWBird [arXiv:2507.15791]

The Code

The code will allow for joint inference between LISA and ET

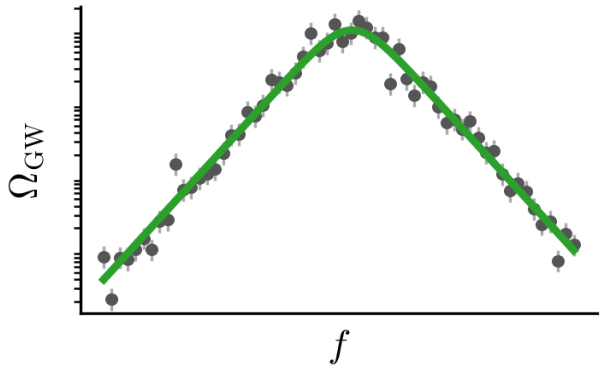


The Code: fully customisable

Plug in your own ingredients — the inference machinery stays the same

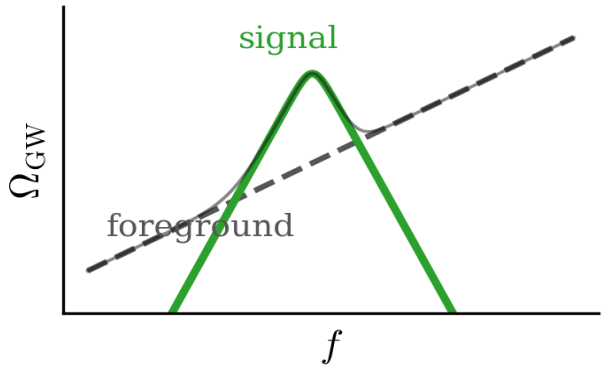
Custom Likelihood

Implement your own likelihood



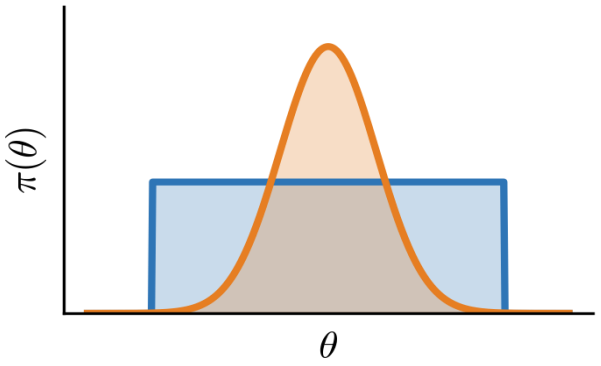
Custom Foregrounds

Add your own models for the foregrounds



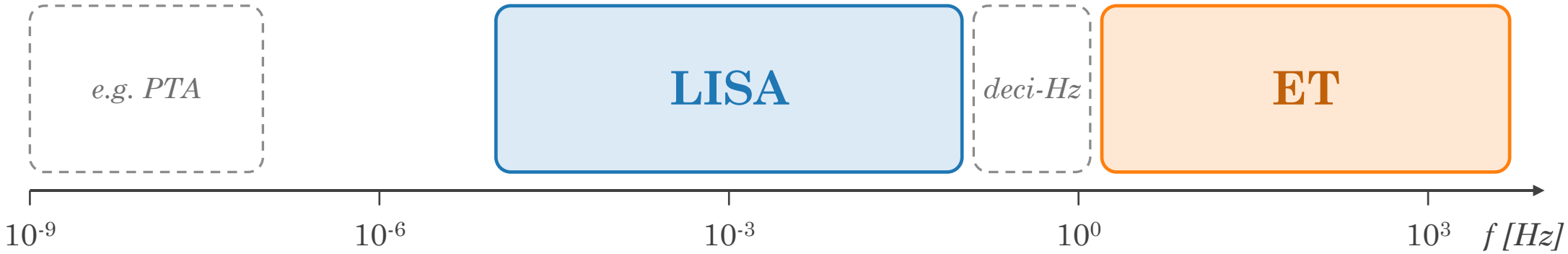
Custom Priors

Choose the prior on every parameter

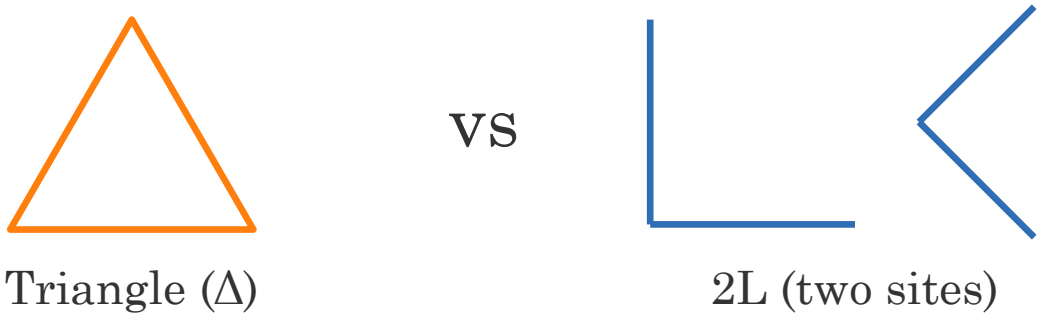


The Code: built to be extended

Detectors in different frequency ranges



Different configurations and locations for ET

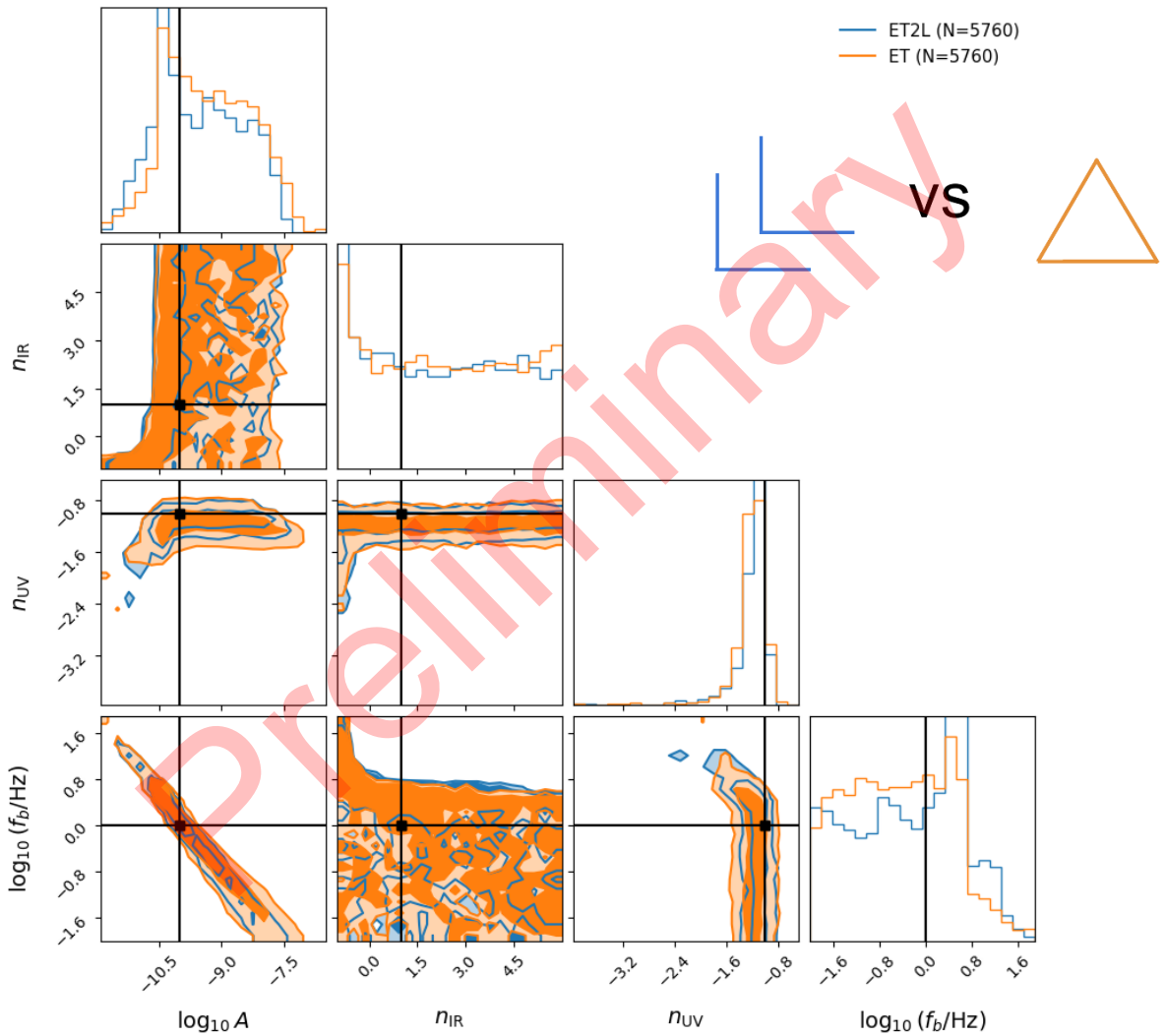


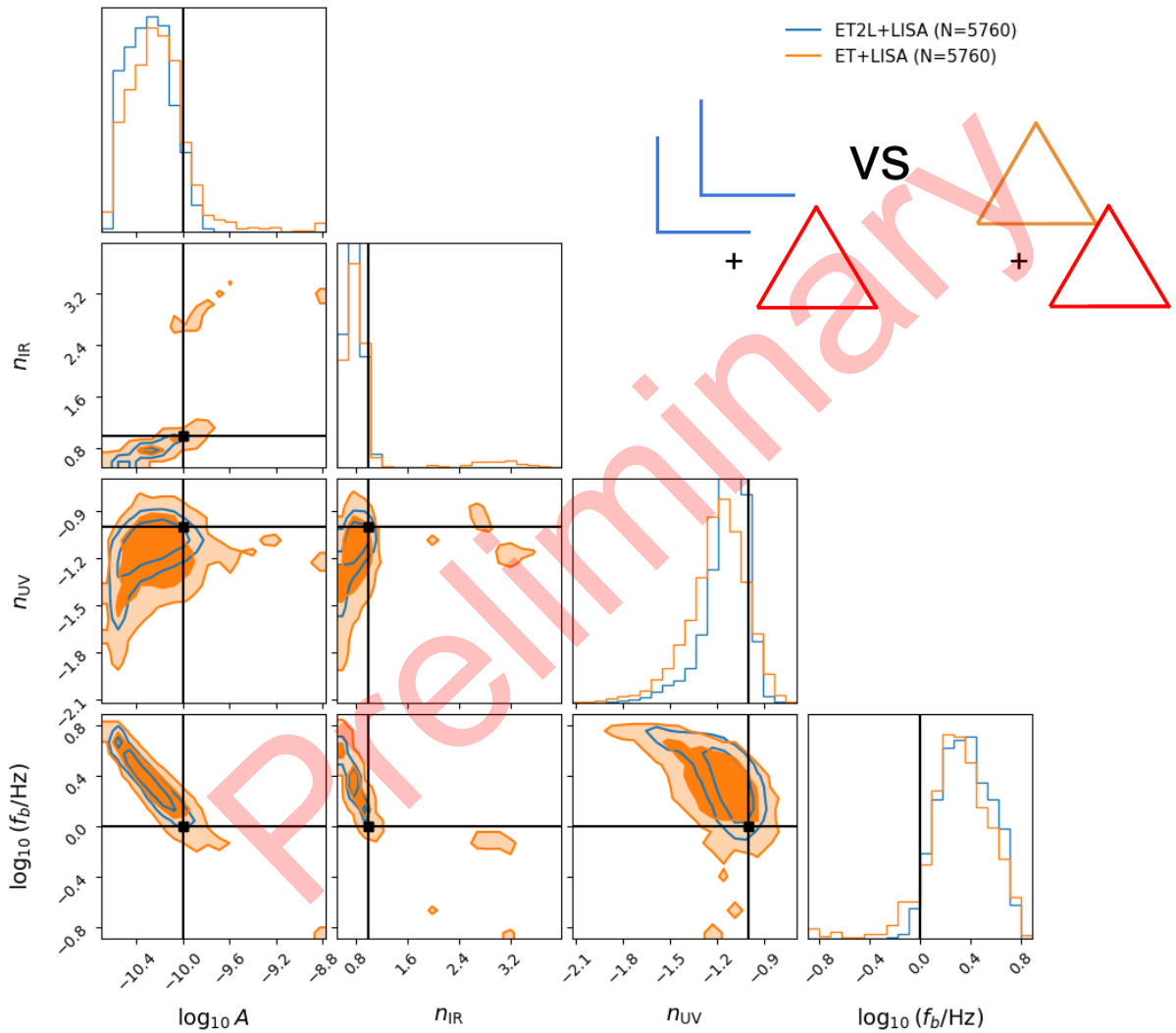
Triangle (Δ)

2L (two sites)

Any geometry, any site: compare ET designs directly

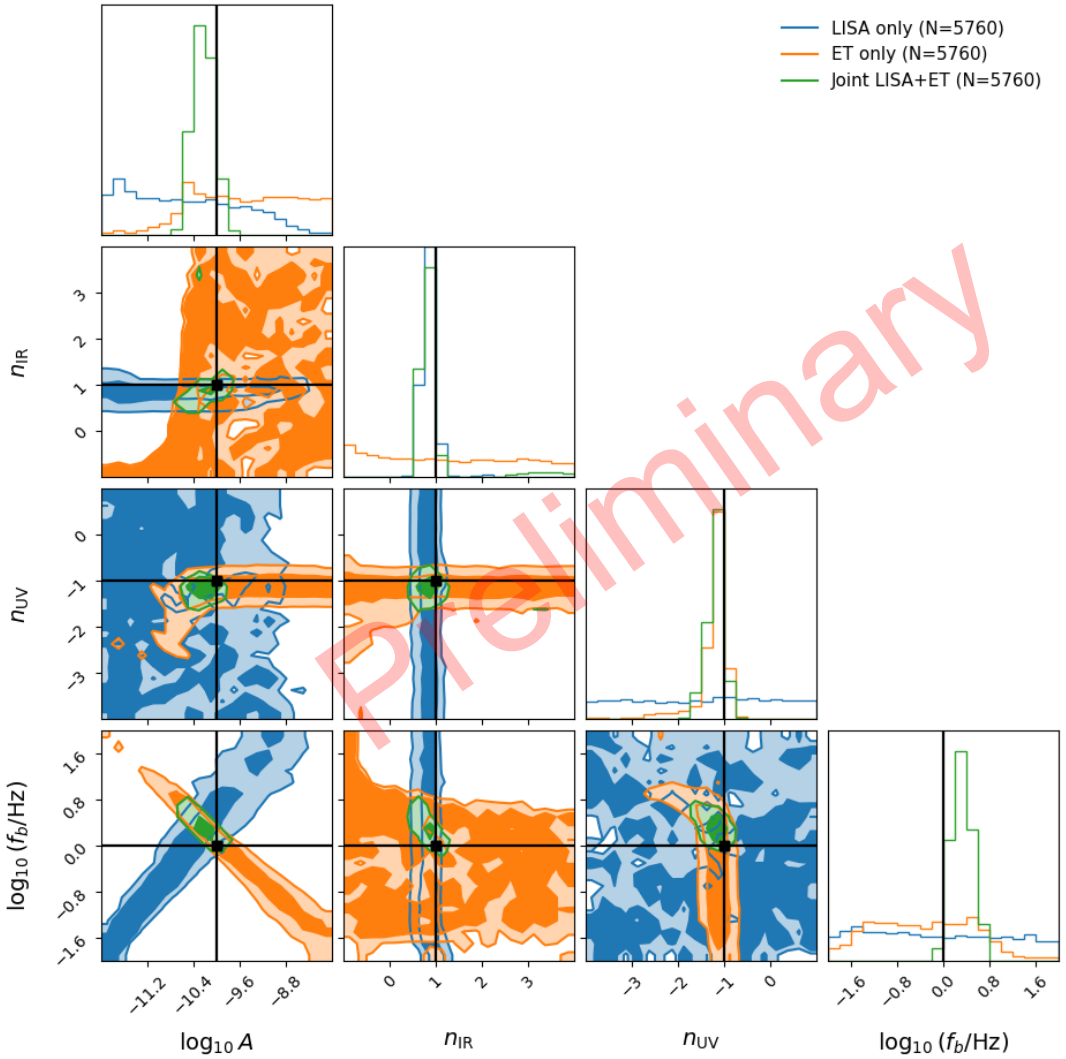
Comparison ET2L/ET-Triangular



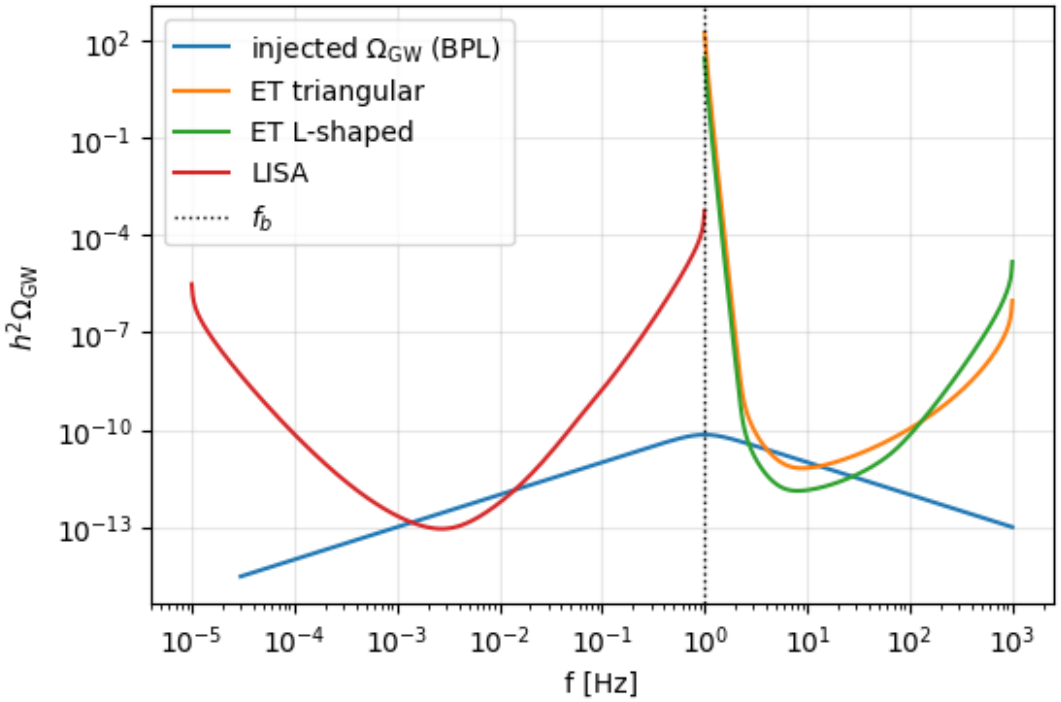


Preliminary
Preliminary

Broken PL Signal



Preliminary



LISA only

ET only

LISA + ET

Injected:

$$\log_{10} A = -10$$

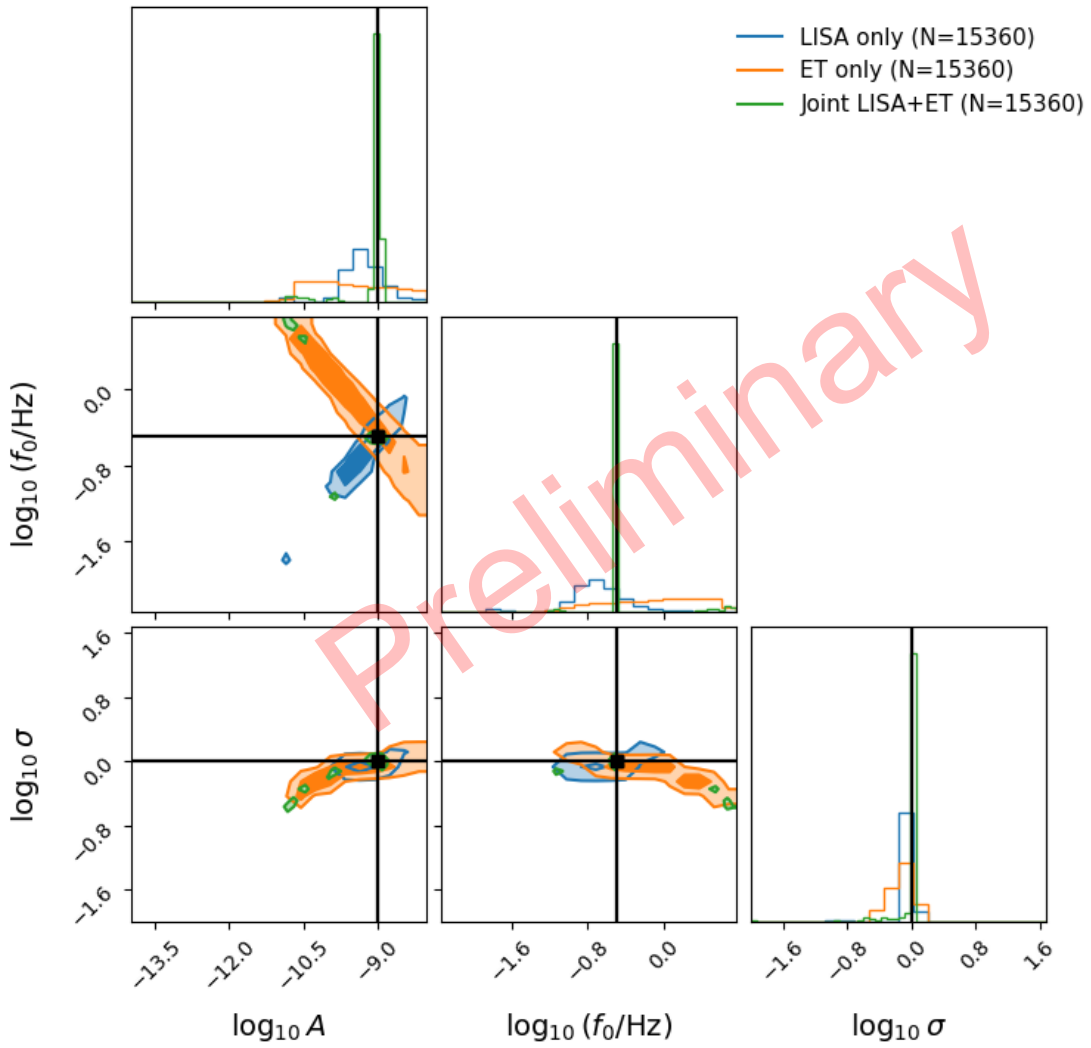
$$n_{\mathrm{IR}} = 1.0$$

$$n_{\mathrm{UV}} = -1.0$$

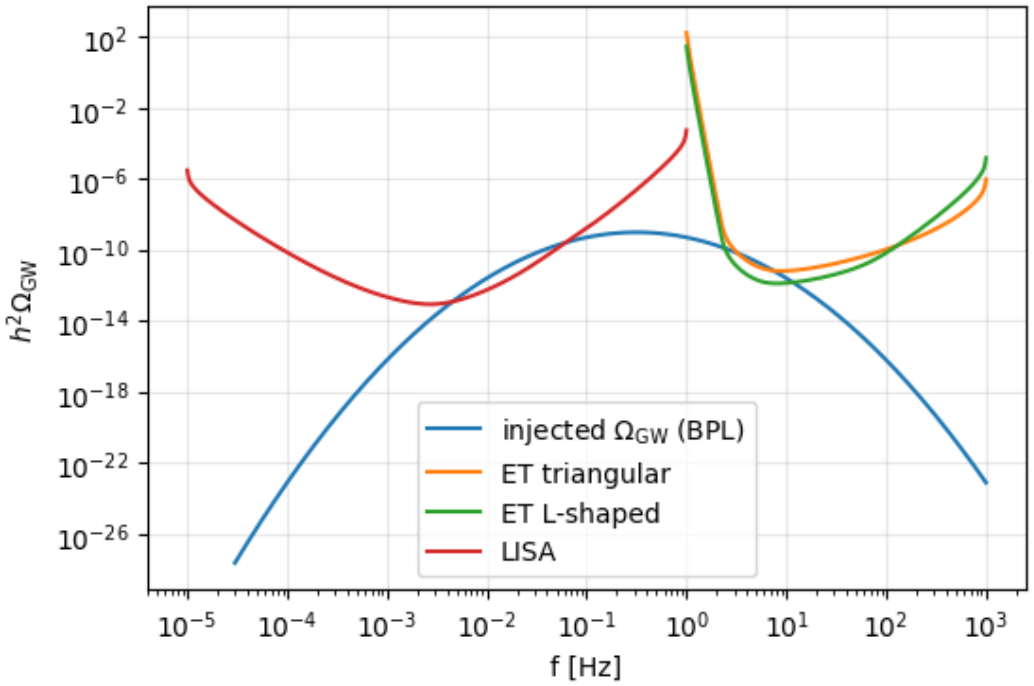
$$\log_{10} f_b = 0.0$$

LogNormal Signal

$$\Omega_{\rm GW}(f) = A \exp\left[-\frac{1}{2\sigma^2}\ln\left(\frac{f}{f_0}\right)^2\right]$$



Preliminary



LISA only

ET only

LISA + ET

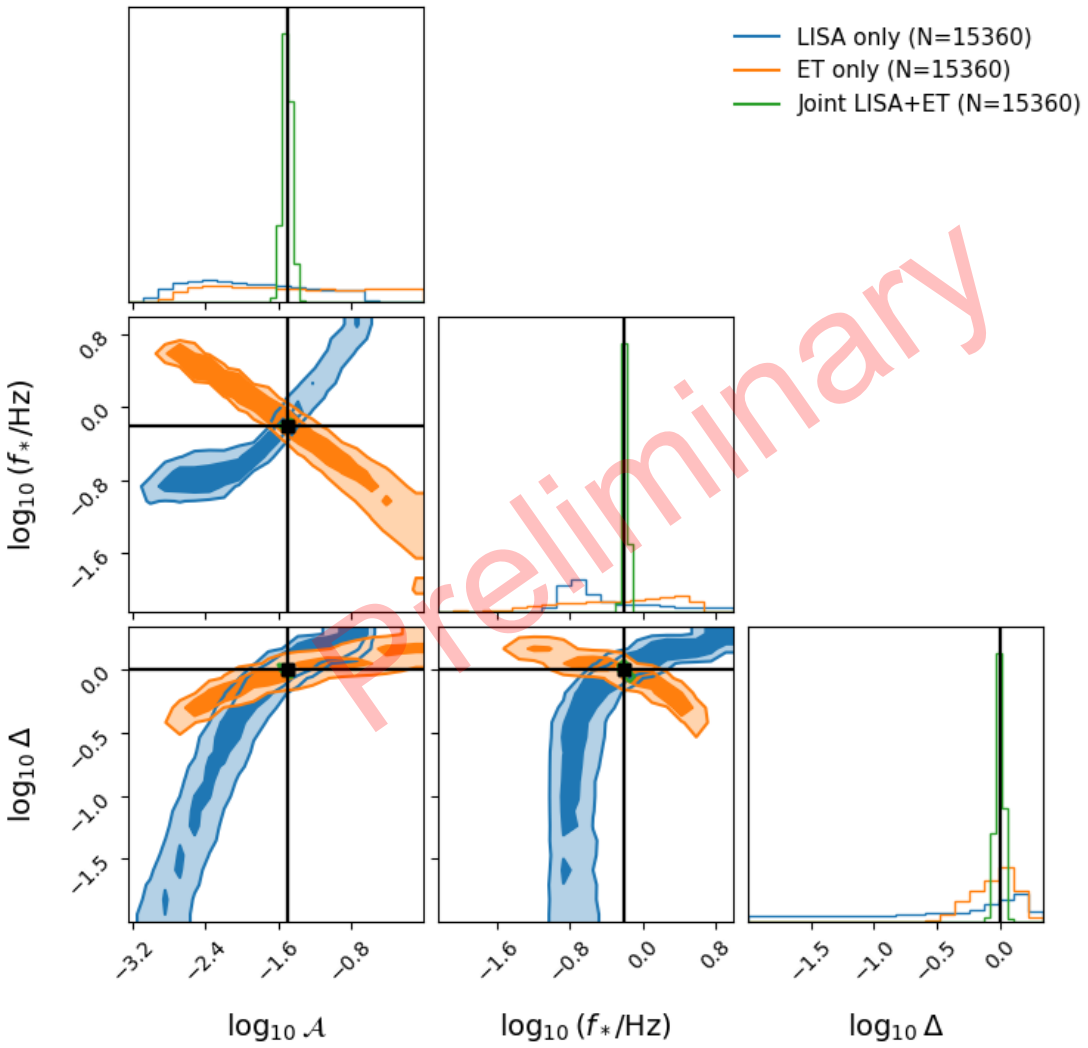
Injected:

$$\log_{10} A = -9$$

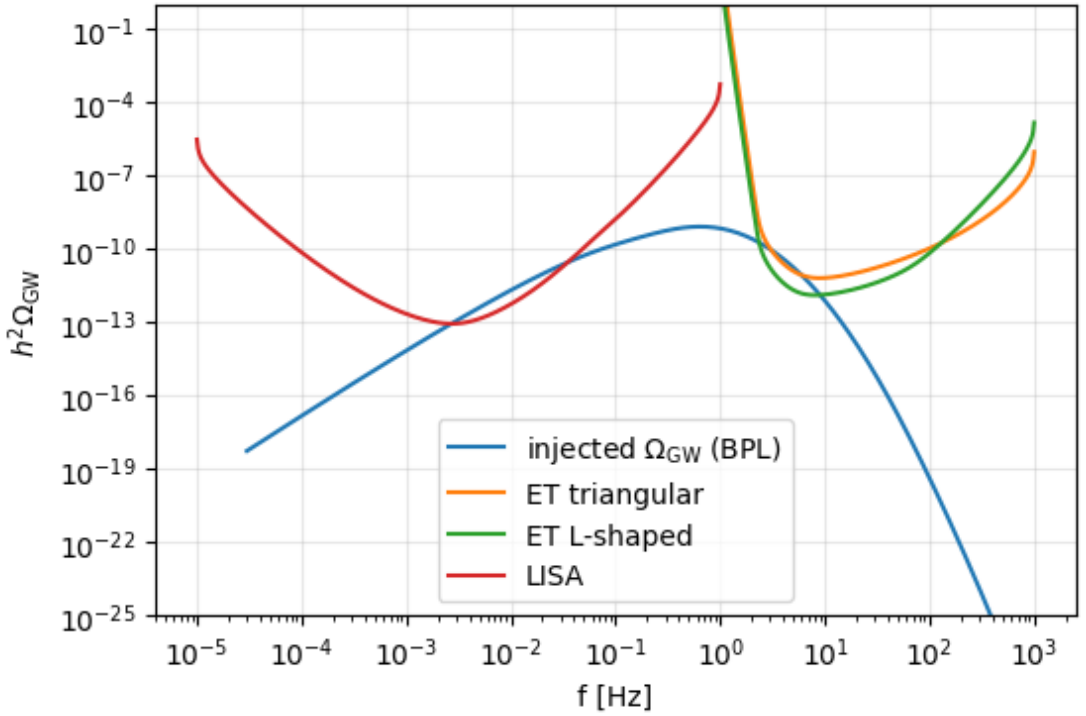
$$\sigma = 1$$

$$\log_{10} f_0 = -0.5$$

SIGW, LN Signal



Preliminary



Template from [Pi, Sasaki; '20, arXiv:2005.12306]

LISA only

ET only

LISA + ET

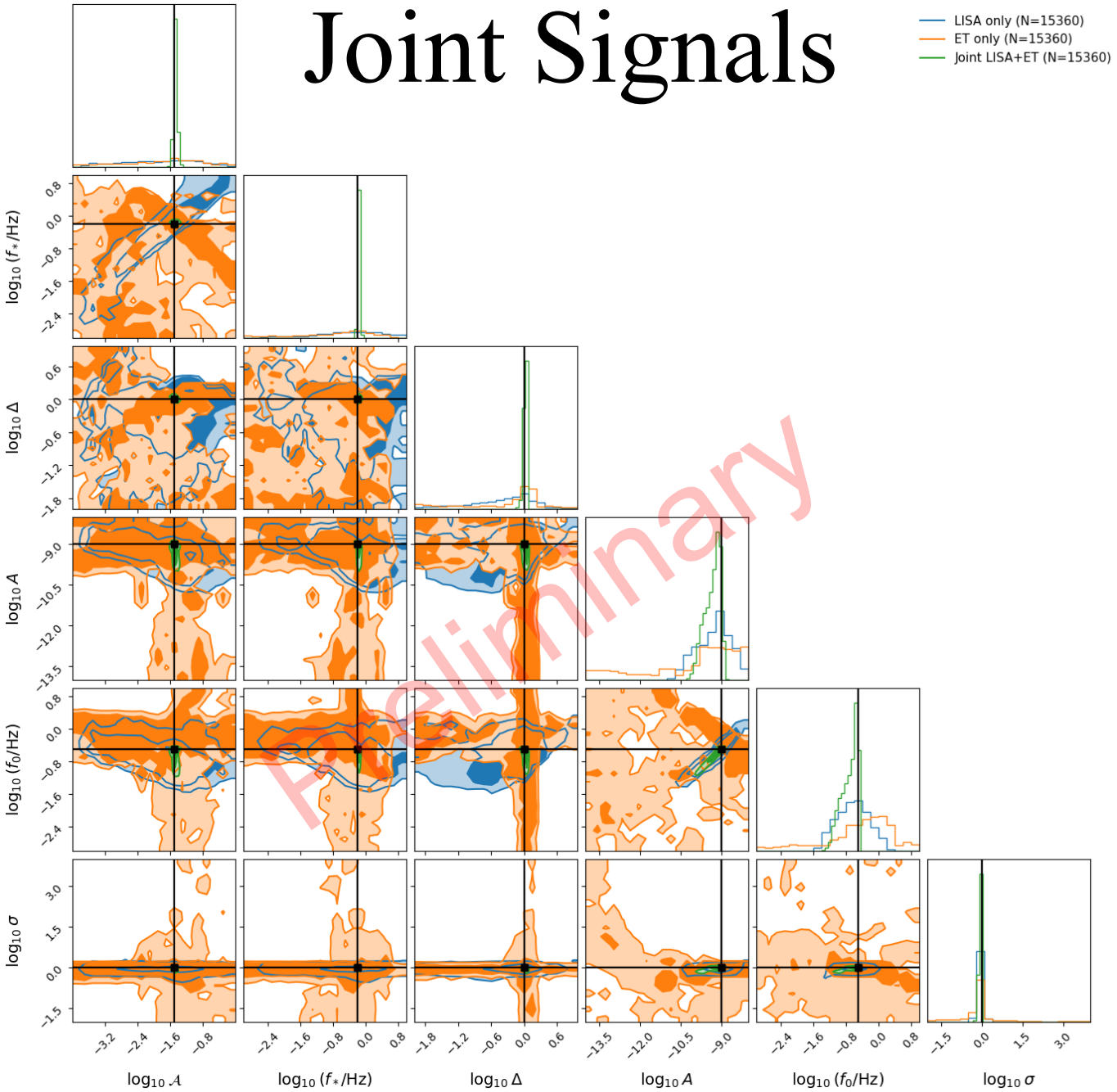
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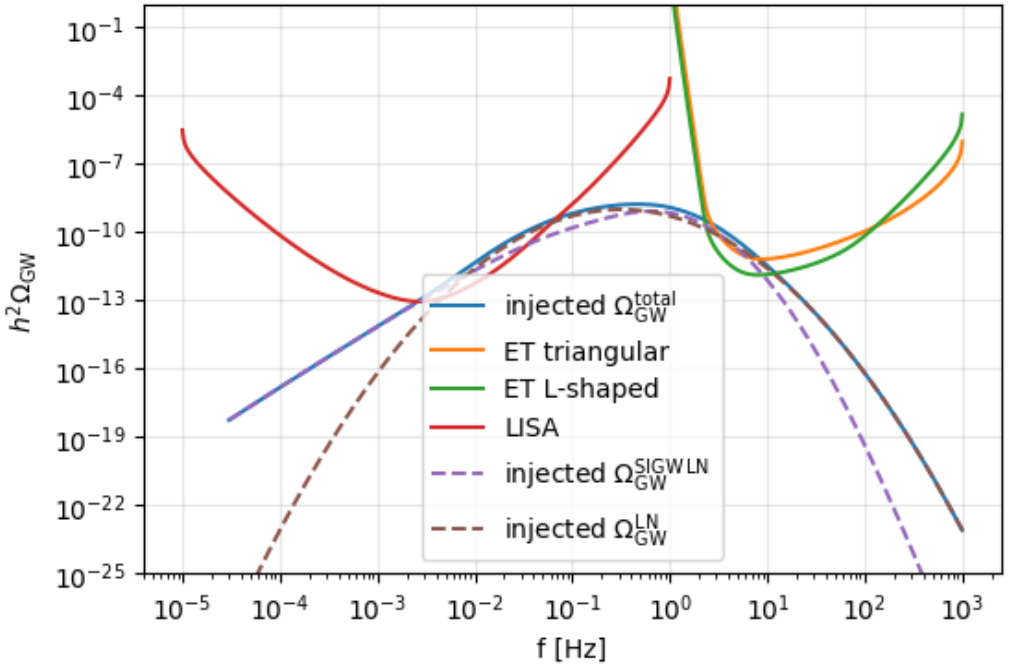
$$\log_{10} A = -1.5$$

$$\sigma = 1$$

$$\log_{10} f_0 = -0.2$$

Joint Signals





Injected:

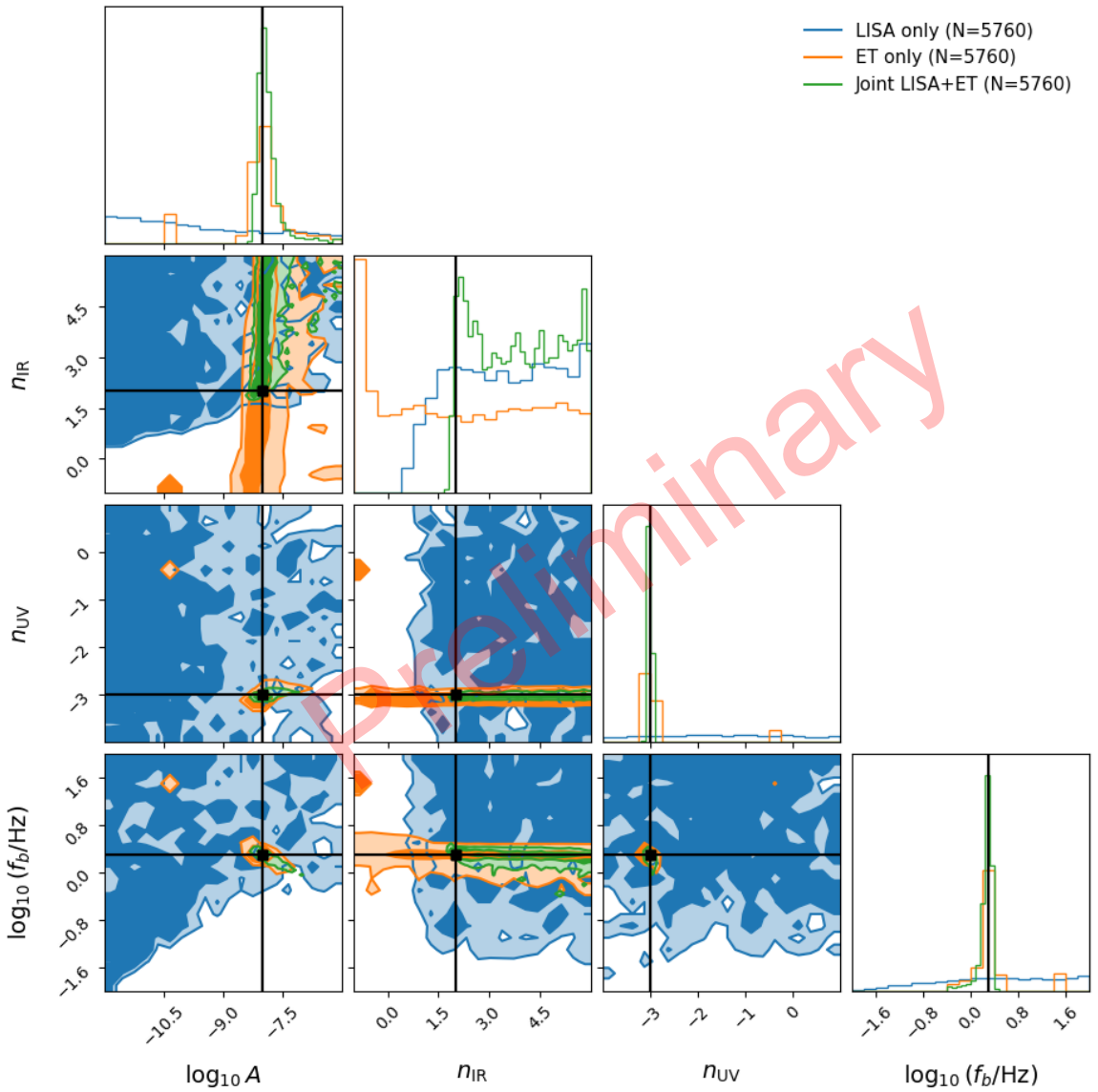
LISA only

ET only

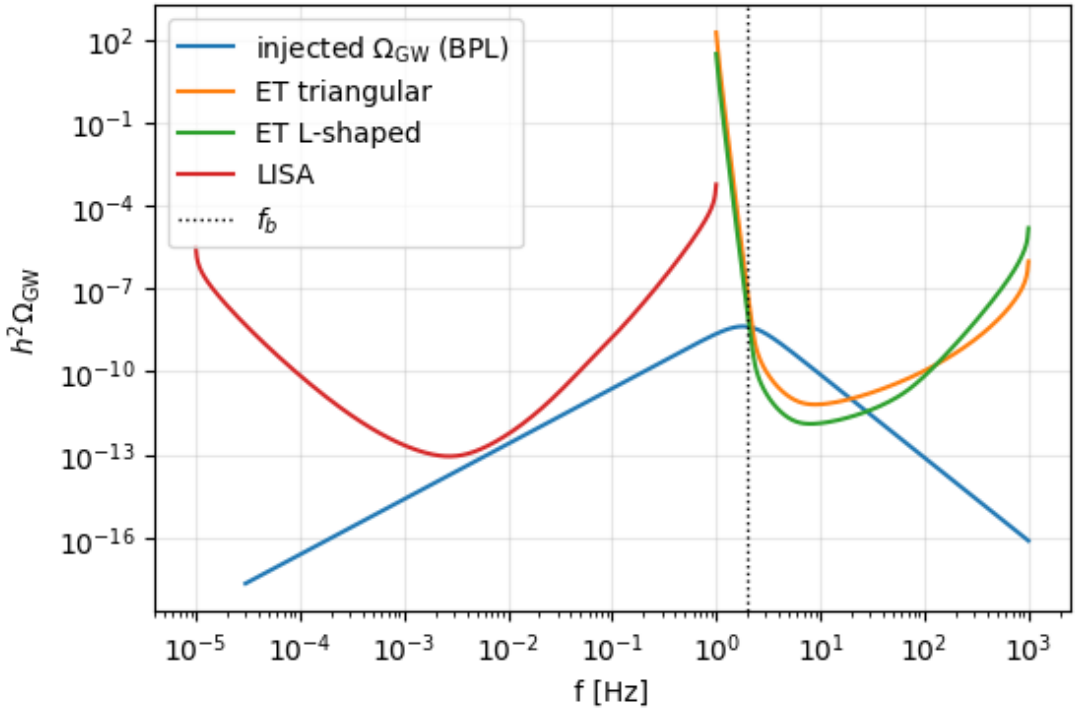
LISA + ET

$$\log_{10} \mathcal{A} = -1.5$$
$$\log_{10} f_* = -0.2$$
$$\log_{10} \Delta = 0$$
$$\log_{10} A = -9$$
$$\log_{10} f_0 = -0.5$$
$$\log_{10} \sigma = 0$$

ET-only Signal



Preliminary



LISA only

ET only

LISA + ET

Injected:

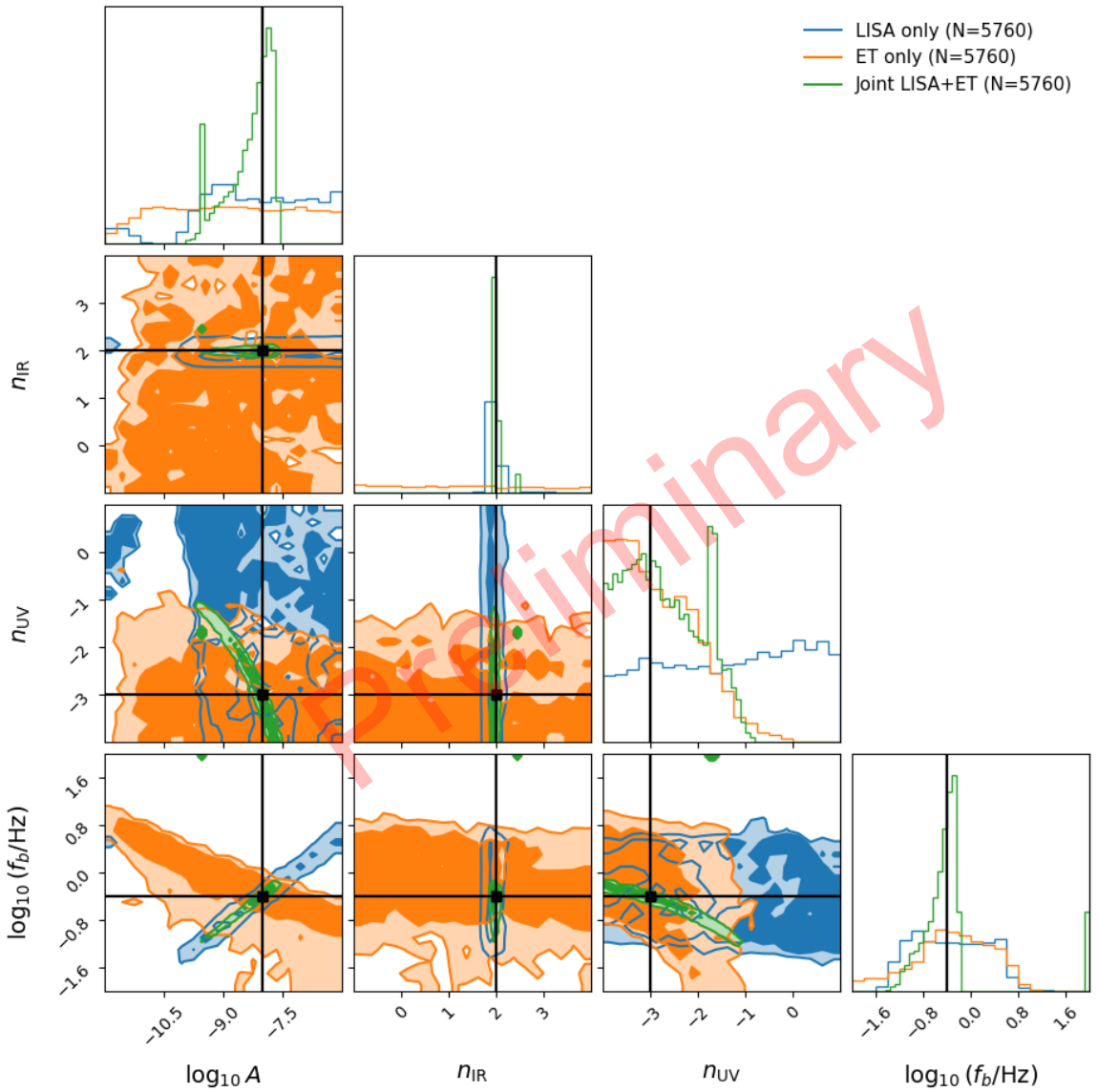
$$\log_{10} A = -8$$

$$n_{\mathrm{IR}} = 2.0$$

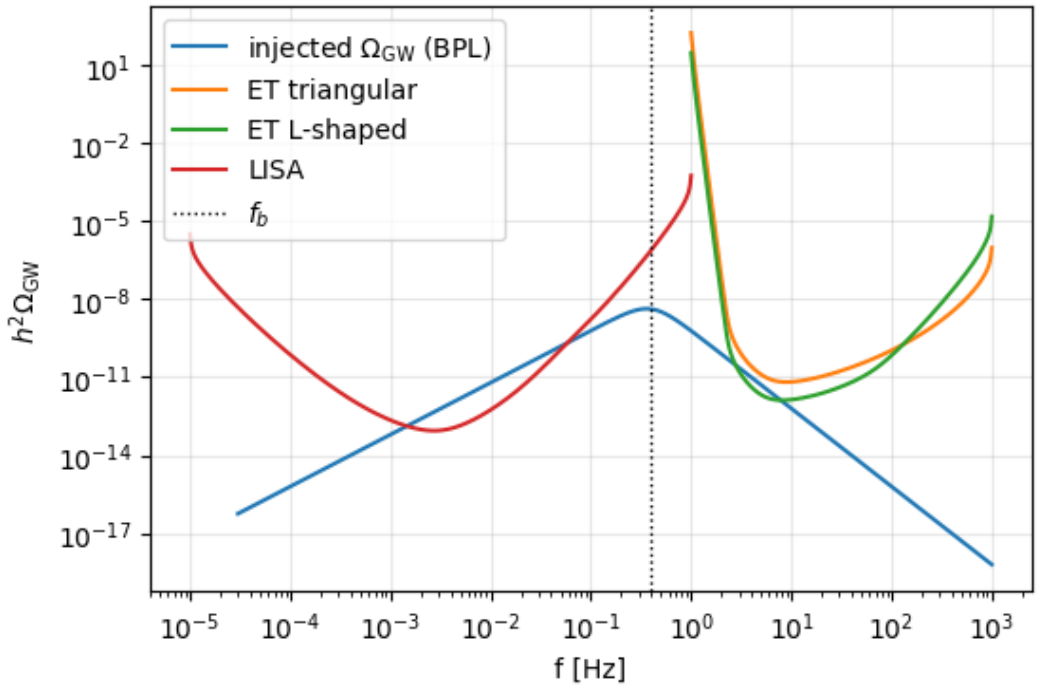
$$n_{\mathrm{UV}} = -3.0$$

$$\log_{10} f_b = 0.3$$

LISA-only Signal



Preliminary



LISA only

ET only

LISA + ET

Injected:

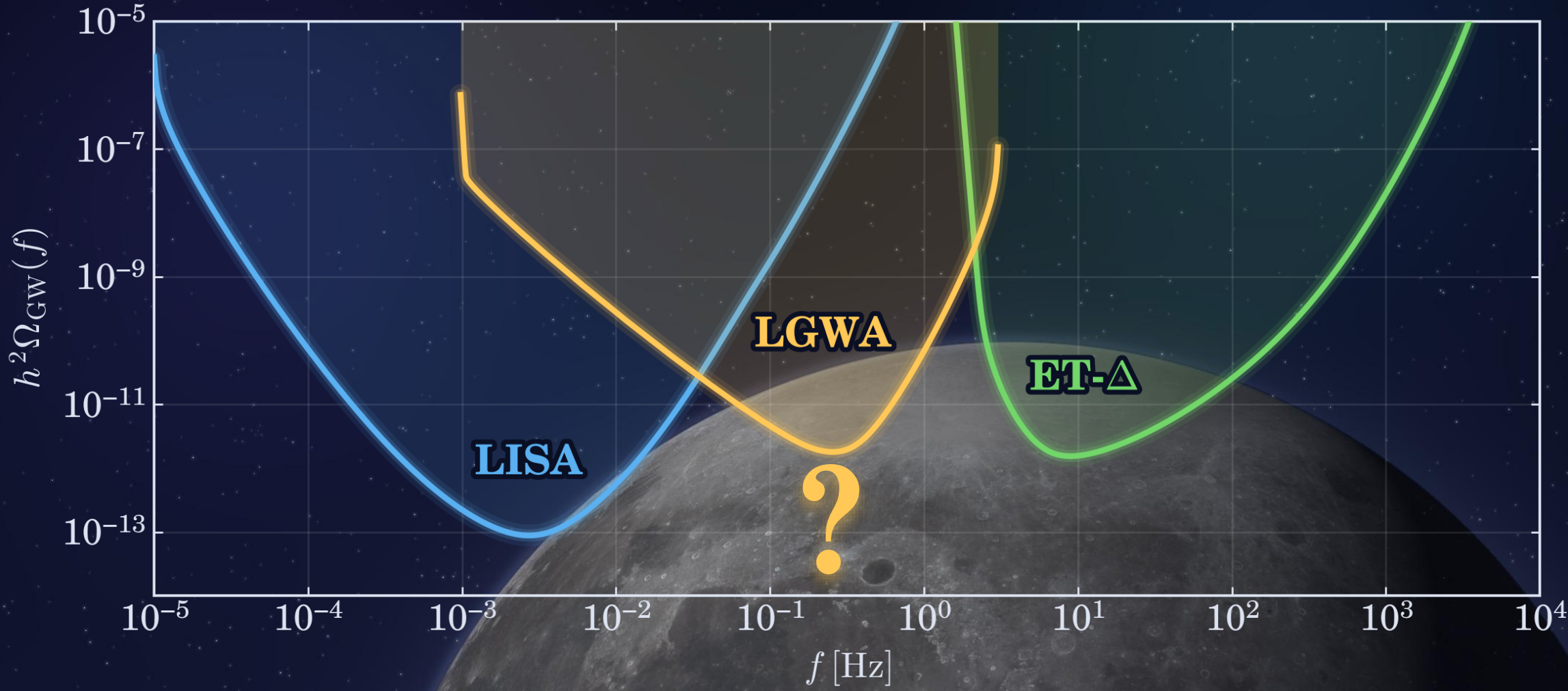
$$\log_{10} A = -8$$

$$n_{\mathrm{IR}} = 2$$

$$n_{\mathrm{UV}} = -3$$

$$\log_{10} f_b = -0.2$$

Adding the Moon: LGWA



Thanks for the attention!