ETO Task Force on the detector layouts meeting.

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Noise budget

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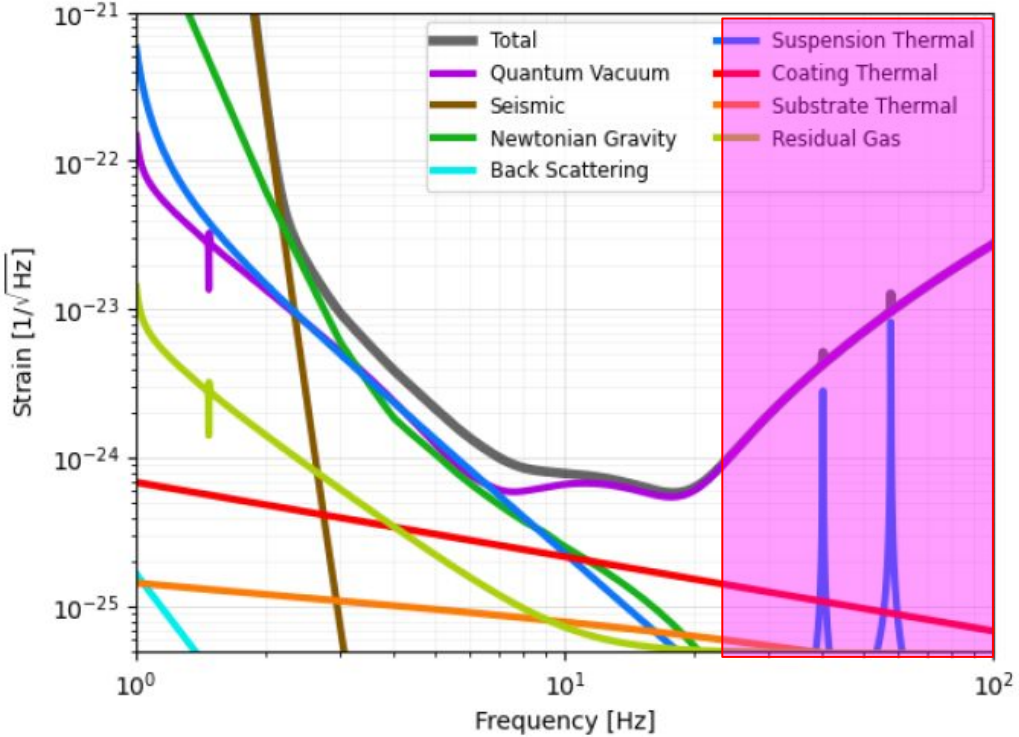
In this presentation…

- ETLF and ETHF limiting noises
- Parameters used for the noise budget calculation
- Some critical parameters
- Py-GWINC
- Interaction with OSD guys

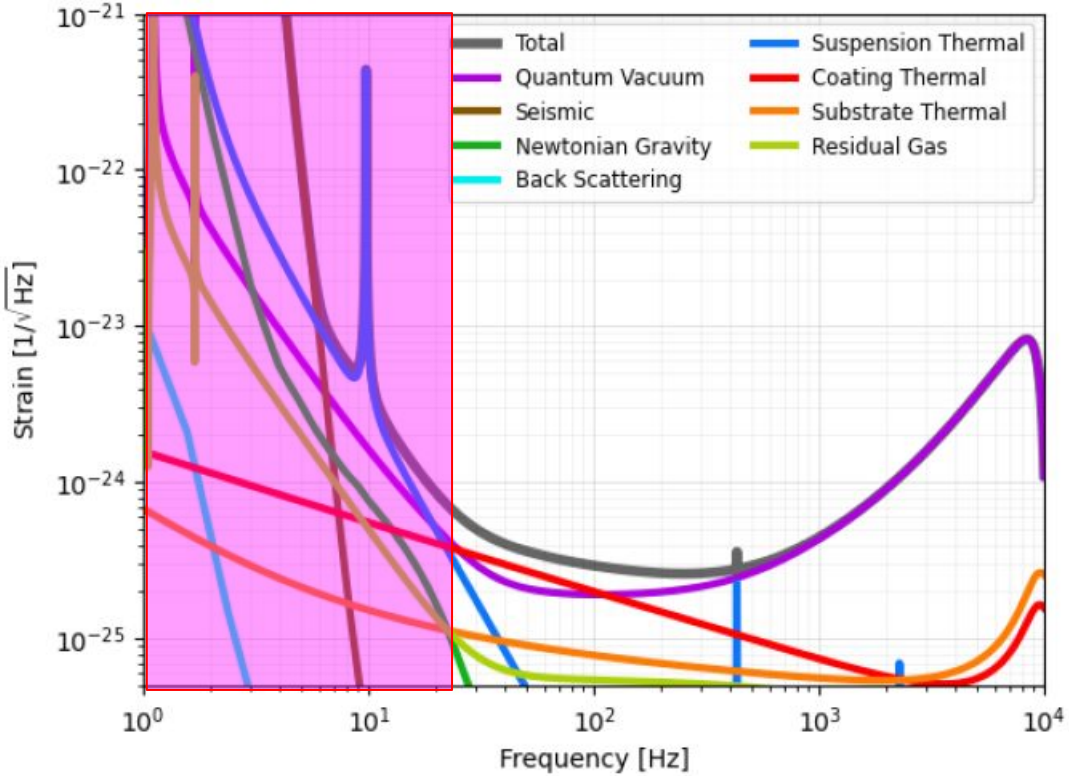
ETLF - 2L configuration



Limiting noises

- **Seismic**
- **Newtonian**
- **Suspension Thermal**
- **Quantum noise**

ETHF - 2L configuration



Limiting noises

- **Quantum noise**
- **Coating thermal noise**

Parameters

Noise budget → parameters listed in **ET-0007C-23 "Conceptual design and noise budget of Einstein Telescope" last update 12 Feb 2025**

For the 2L configuration we need to modify the following parameters:

Parameter	Units	HF detector	LF detector
Arms length	m	15000	15050
SEC length	m	169.6	168.6
SE mirror transmission	%	3.3	15.2
SEC tuning	rad	0	0.54
ITM/ETM curvature	m	7750	10670

Some critical parameters

Seismic Noise (underground seismic waves and ground tilt)

- Super-attenuator height

Newtonian Noise (seismic NN)

- Factor of 3 suppression applied to ETLF
- Cavern diameter (acoustic NN)
- Detector depth

Suspension Thermal Noise

- Temperature
- Mirror and marionette masses/material
- Fiber lengths/materials

Quantum noise

- Circulating power
- Mirror mass (radiation pressure noise)
- Squeezing level;
- Filter cavity length → higher length means less RTL, higher SQZ level due to the reduced “dephasing”;
- SEC detuning;
- SE mirror transmissivity;
- Optical losses;

Coating thermal noise

- Factor of 4 lower mechanical loss of coating compared with second-generation detectors;
- Coating temperature, beam size, wavelength (thermo-optic contribution)

$$S_{\mathrm{TO}}^{\Delta T} = \frac{2\sqrt{2}}{\pi} \frac{k_B T^2}{r_G^2 \sqrt{\kappa C \omega}}$$

Py-GWINC simulation

Py-GWINC: Gravitational Wave Interferometer Noise Calculator based on Python.

Noise budget package available at

https://gitlab.et-gw.eu/et/isb/interferometer/ET-NoiseBudget

Reference person: Mikhail Korobko

NOTE:

Py-GWINC simulates only a single interferometer with an intersection angle of 90 degrees (L shaped). By default in the package there are the parameters used for the triangular configuration. OSD codes will take into account for different number of interferometers and different intersection angles.

Some codes and sensitivity curves already prepared

Mikhail prepared a code and already provided some data vectors to Archisman, Francesco and Ulyana (OSD team).

sens_baseline.csv — baseline sensitivity curves

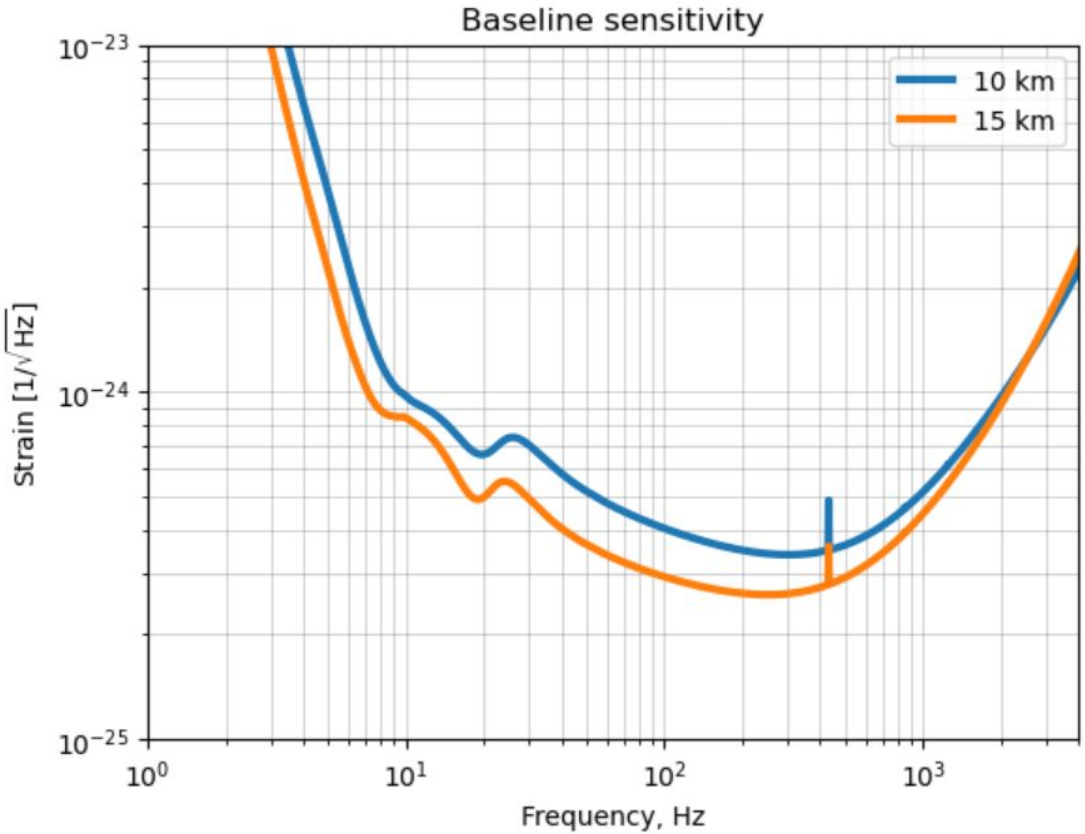
sens_10km_LF_FC_length.csv — changes to the sensitivity as a function of LF FC length for the 10km detector.

sens_15km_LF_FC_length.csv — changes to the sensitivity as a function of LF FC length for the 15km detector.

sens_ifo_lengths.csv — 4 different combinations of arm cavity length

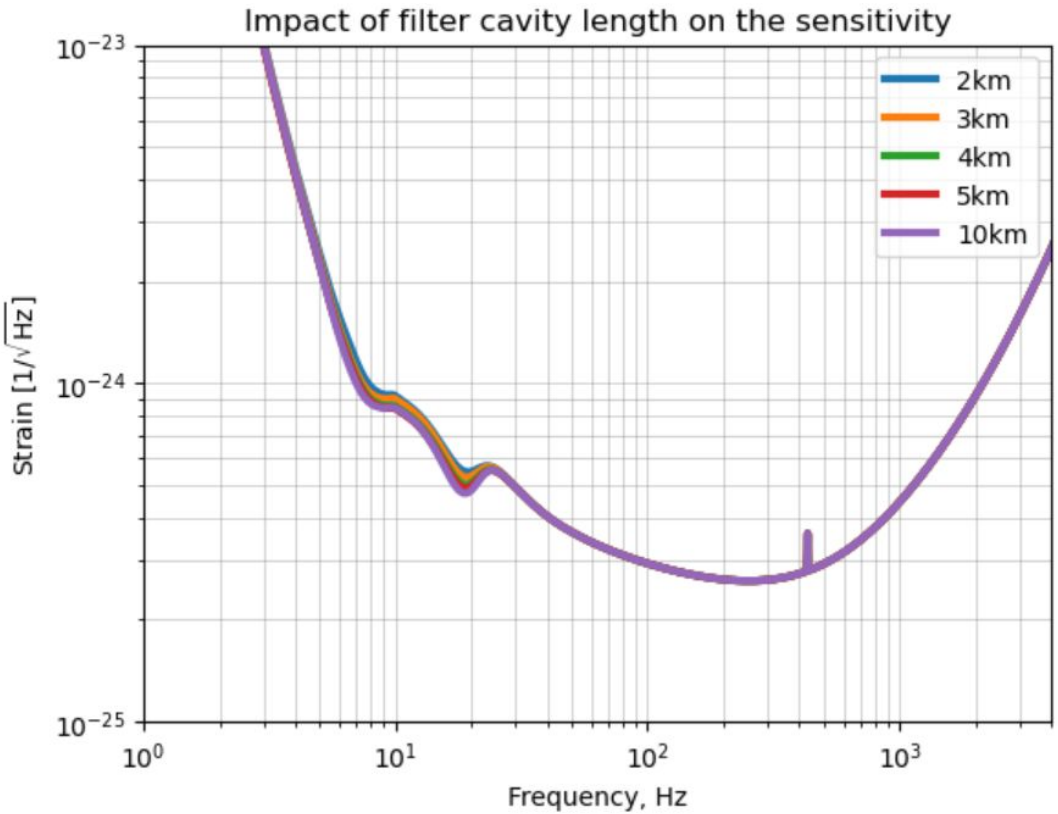
sens_SEC_length_15km_hbf.csv — dependence on the SEC length for HF detector for the 15km detector (standard configuration)

sens_SEC_length_15km_lbw.csv — an alternative configuration, with narrower bandwidth but higher peak sensitivity.



10 km → parameters from the optical layout document for the **triangular configuration**.

15 km → parameters from the optical layout document for the **2L configuration**.

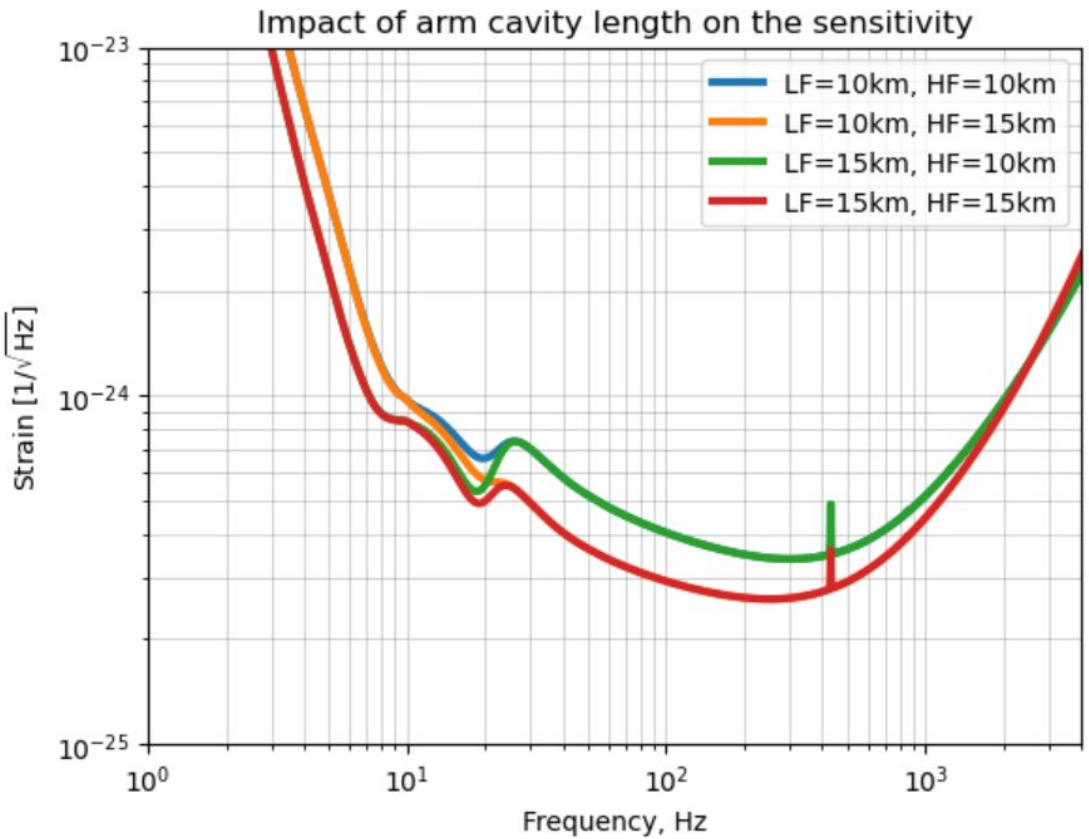


Overall sensitivity for different lengths of ETLF filter cavities.

They are considered of the same length.

For each curve has been considered a different squeezing amplitude.

2 km, 3 km → 12 dB
4 km → 14 dB
5 km → 15 dB
10 km → 18 dB

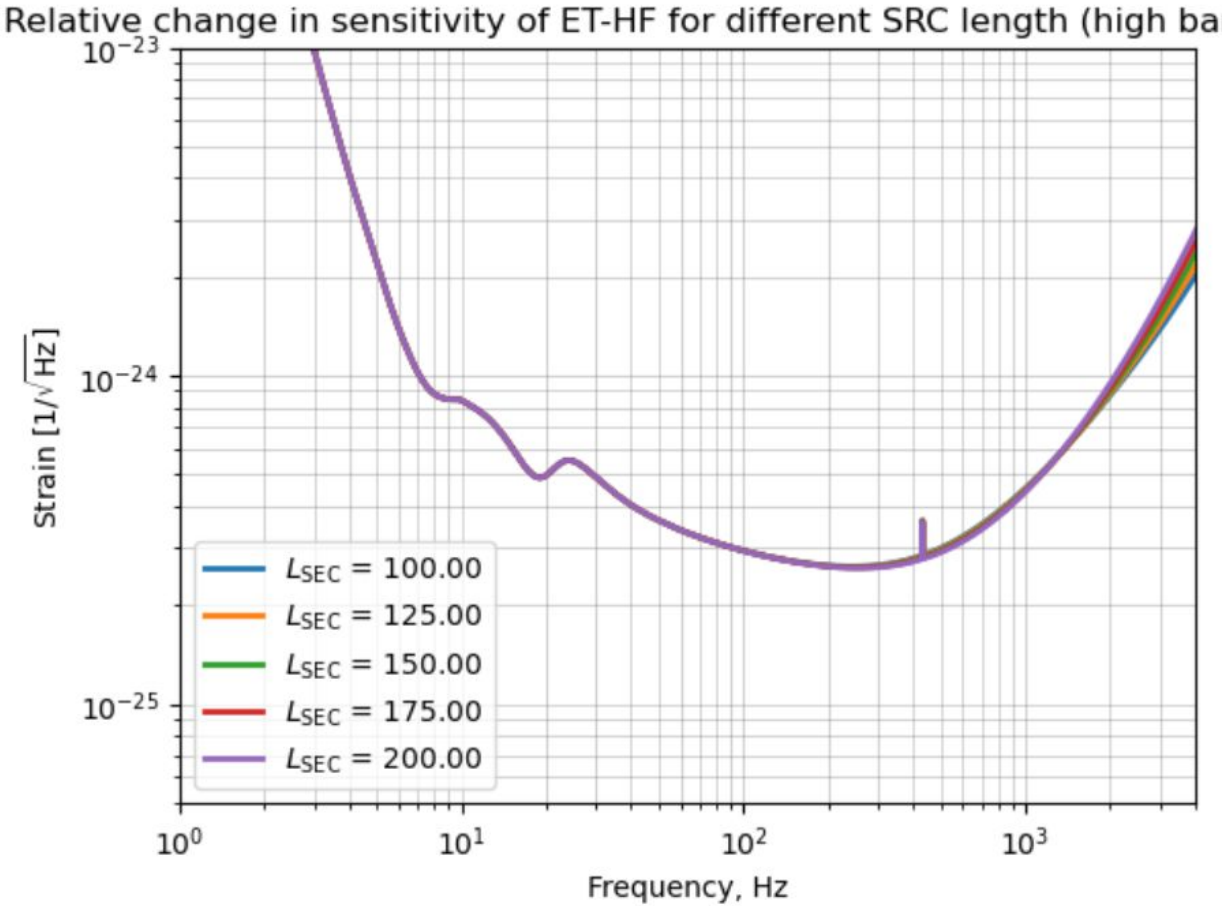


10 km - 10 km
→ default parameters (LF and HF triangle)

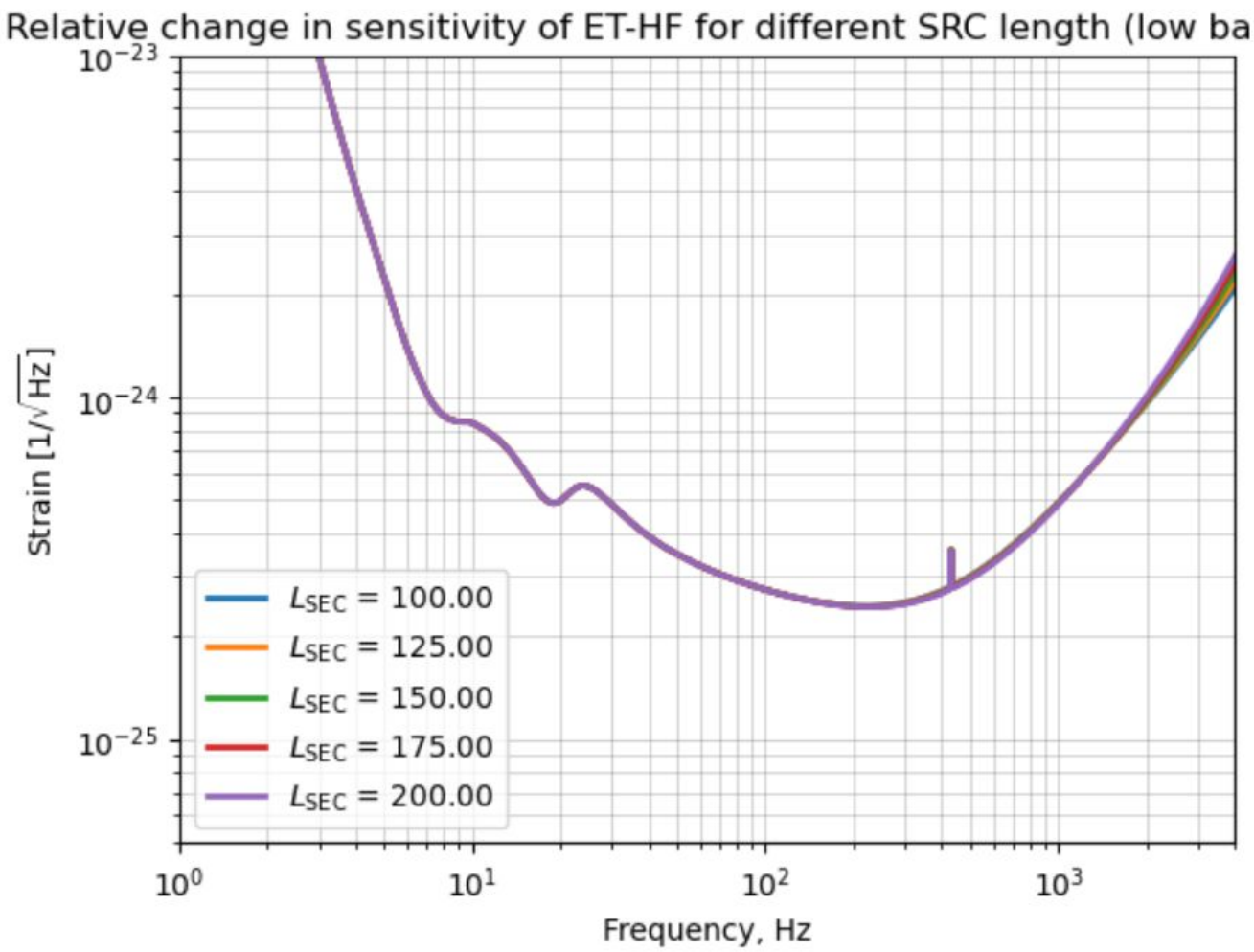
10 km - 15 km
→ triangle parameters (LF) + 2L parameters (HF)

15 km - 10 km
→ 2L parameters (LF) + triangle parameters (HF)

15 km - 15 km
→ 2L parameters (LF+HF)


Relative change in sensitivity of ET-HF for different SRC length (high bandwidth)
Strain [1/√Hz]
Frequency, Hz
10^{-23}
10^{-24}
10^{-25}
10^{0}
10^{1}
10^{2}
10^{3}
L_{SEC} = 100.00
L_{SEC} = 125.00
L_{SEC} = 150.00
L_{SEC} = 175.00
L_{SEC} = 200.00

Tsrm = 0.033


Relative change in sensitivity of ET-HF for different SRC length (low bandwidth)
Strain [1/√Hz]
Frequency, Hz
10^{-23}
10^{-24}
10^{-25}
10^{0}
10^{1}
10^{2}
10^{3}
L_{SEC} = 100.00
L_{SEC} = 125.00
L_{SEC} = 150.00
L_{SEC} = 175.00
L_{SEC} = 200.00

Tsrm = 0.05