

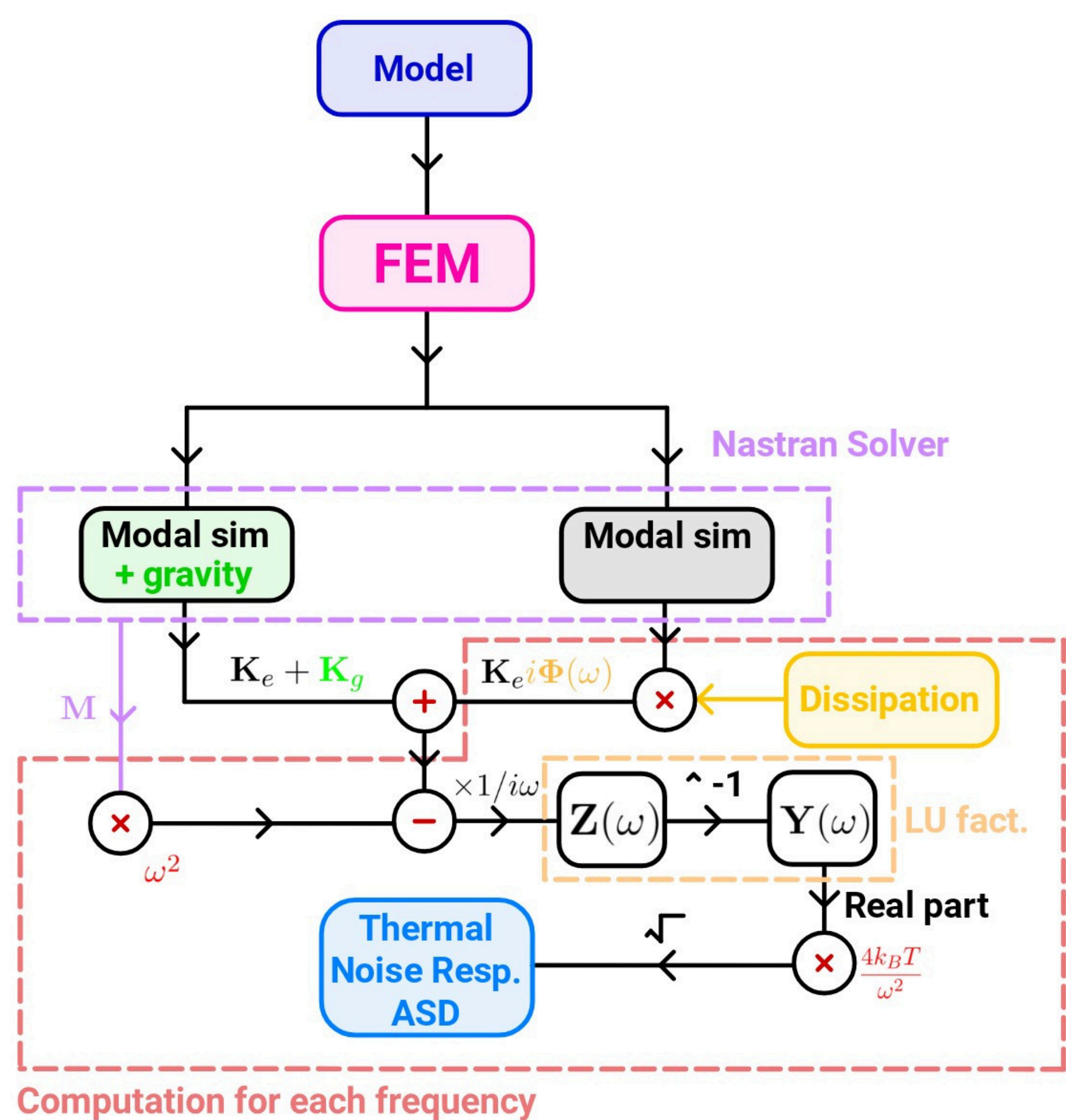
Thermal noise modelling for the ET-LF payload in the case of radiative cooling

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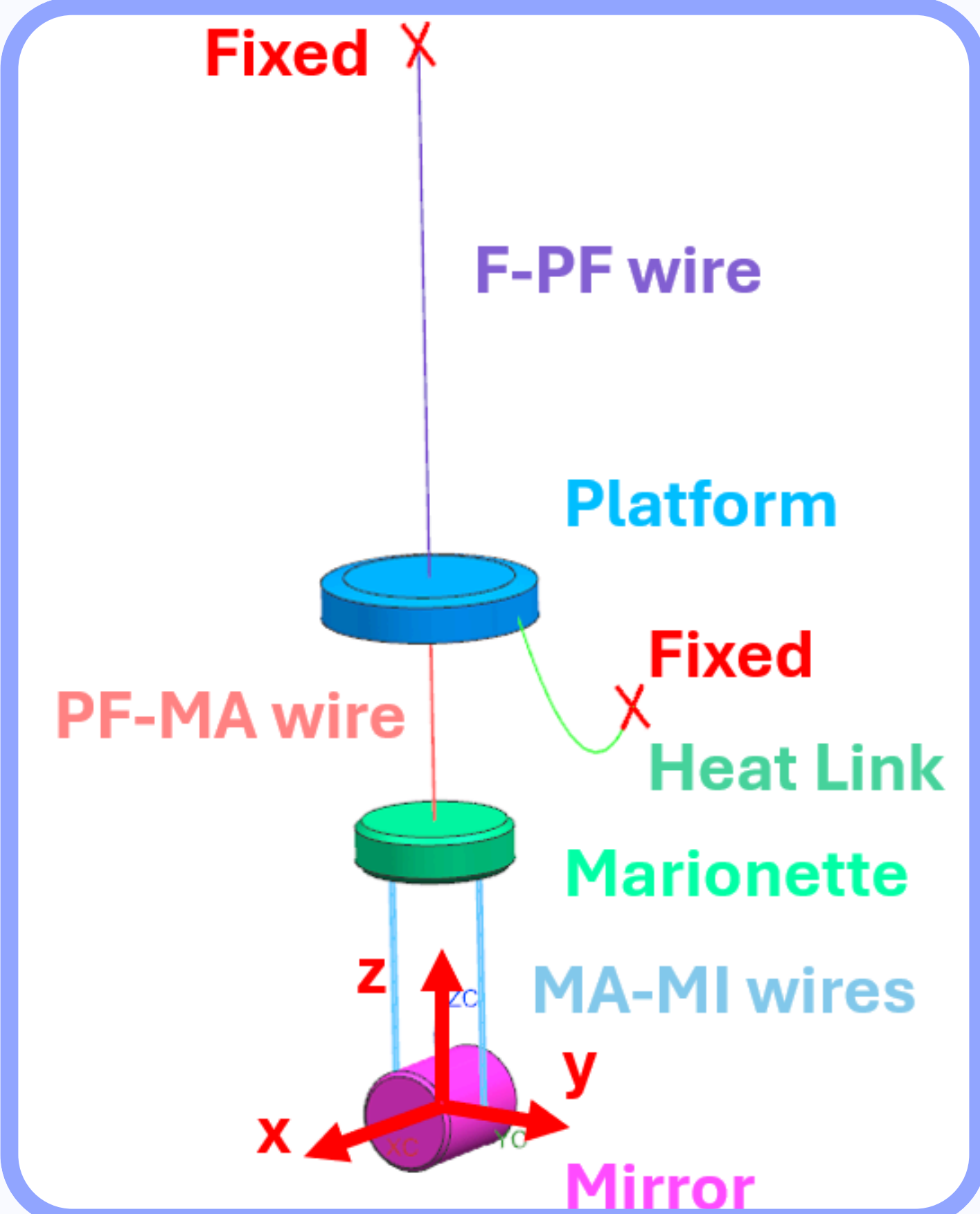
Context & Motivations

In the context of the **third-generation gravitational wave detector** design, several noises must be understood and minimized. One of them is **Thermal Noise (TN)**, described theoretically by the **Fluctuation and Dissipation Theorem (FDT)**. This study aims to mainly describe the impact of introducing a **radiative heat exchanger** in terms of thermal noise. Although thermal noise has been assessed for classical **conductive cooling** of the **ET-LF payload**, this has never been done for radiative cooling. The **radiative cooling** of the payload requires adding a significant amount of exchange area and this amount of surface might be a source of thermal noise. Moreover, the description of such a noise has been mainly **analytical** and applied to **simple systems**.

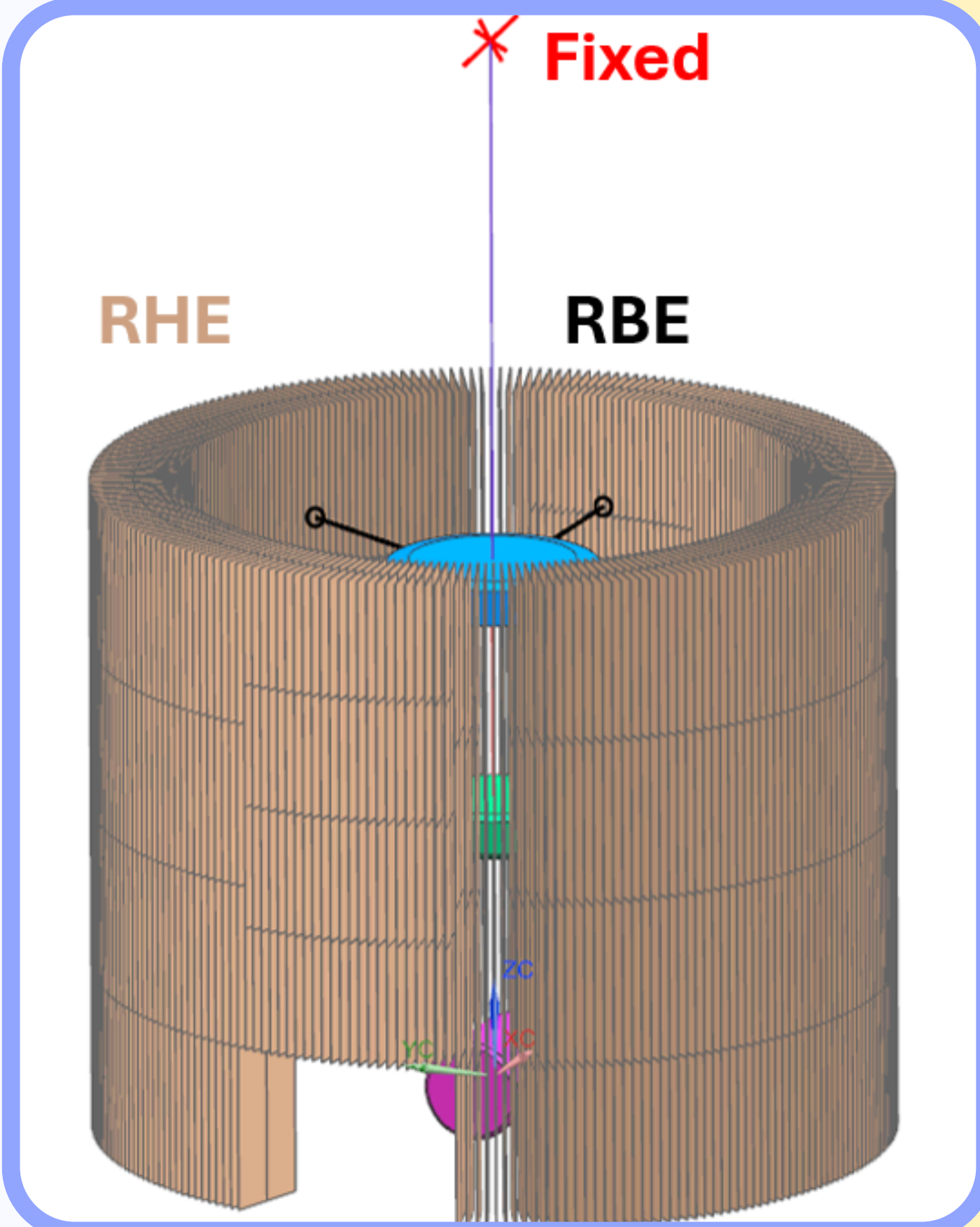
Thermal Noise estimation scheme



ET-LF Finite Element Models



Conductive cooling strategy



Radiative cooling strategy

To describe higher order models, this study is based on a **Finite Element approach**, using the **state space matrices**. Firstly, a comparison between analytical and FEM predictions is performed to **validate the approach**. Then, a sensitivity analysis is carried out to assess the influence of the fin properties, from the **radiative heat exchanger (RHE)**, on thermal noise. In the end, studies of the **E-TEST** and **ET models** are performed to evaluate the impact of considering an **RHE**.

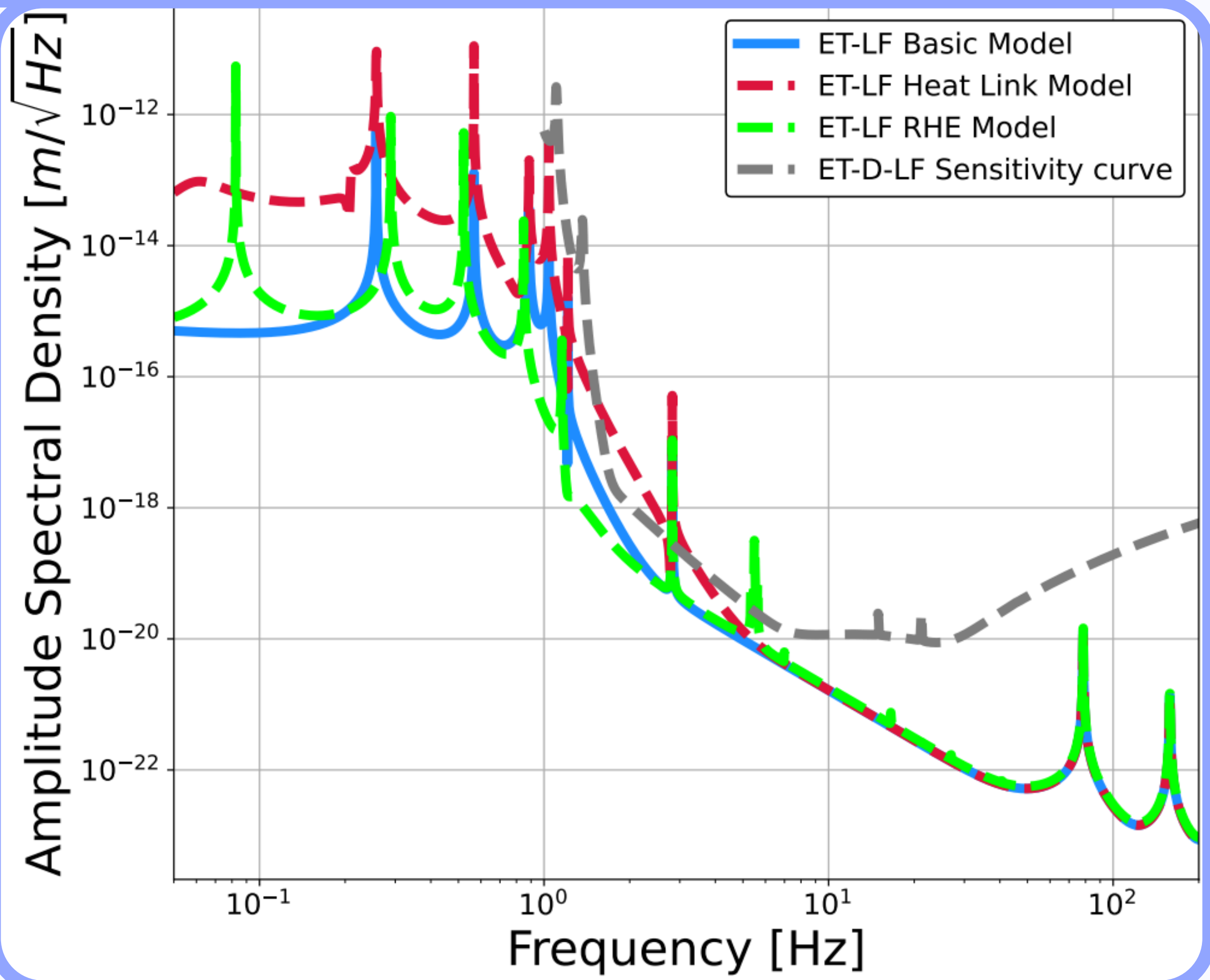
Results

The results show the **interest of using a radiative, rather than conductive, cooling strategy**.

Moreover, additional studies were performed to highlight the **potential sources of discussion** for the next TN studies of the model.

- Effect of the **temperature** of the **top wire**
- Effect of the **diameter** of the **top wire**
- Effect of the **reinforcement** of the **RHE**
- Effect of the **PF-RHE connection**

Eventually, a Section was dedicated to the comparison with the model of *Korovesi et al.* that shows the **huge impacts** of the **approximations** and **assumptions** that can be considered in TN studies.



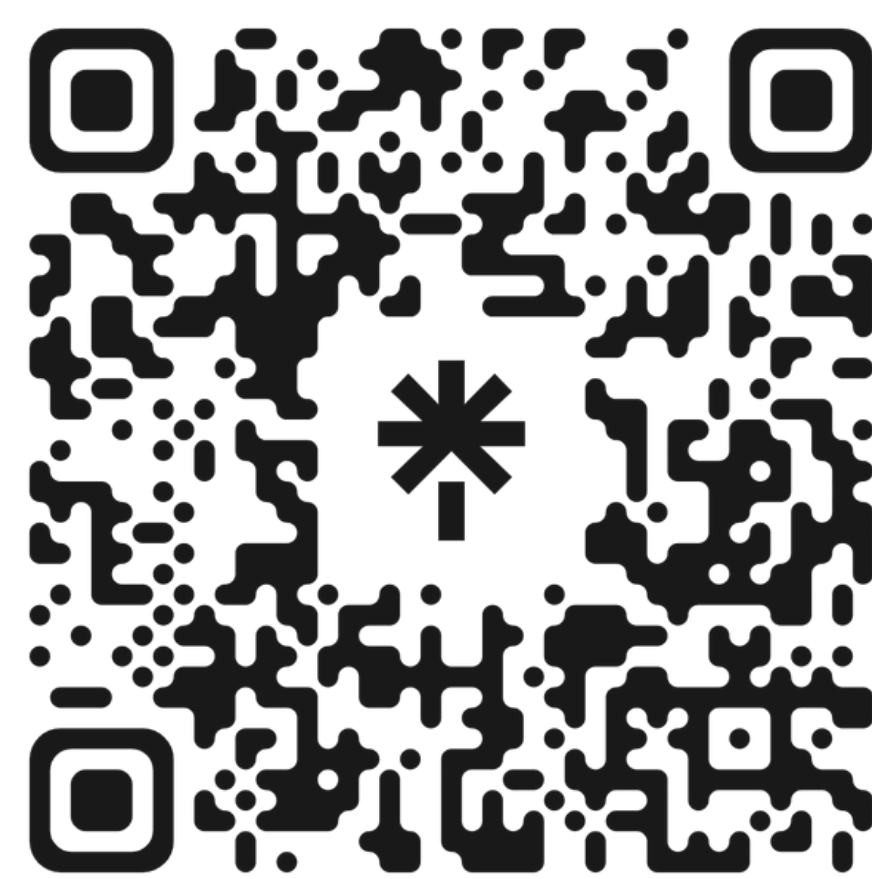
Advantages

- ✓ **Easy to implement** and to **adapt** to any **complex model**, which is favorable for **TN design**.
- ✓ Can take into account **non-uniform temperature** in the system.
- ✓ Might compute the TN for **temperature gradients**, **non-uniform cross sections**, **local dissipations**, in the system.
- ✓ Can be implemented in **Finite Element software** that would make the estimate of the TN easier.
- ✓ Was verified to be **exact** through the comparison with **analytical results**.
- ✓ From the FEA, **mode shapes** can be determined. The model might then be correlated with **experimental modal measurements**.

Drawbacks

- ✗ **High computation time** since the computations must be done at each frequency. This drawback might be **mitigated** using other computation techniques or by using **parallel computation**.
- ✗ **High computation cost** since the complete inverse of the transfer matrix should be known for the Adapted Fluctuation and Dissipation Theorem (AFDT). The cost increases with the number of DoF considered.
- ✗ The method is not yet applicable to complex systems, since the matrices are **post-processed**. In future work, this drawback should be **mitigated** by the implementation on **FE solvers**.
- ✗ The method is still not adapted to **3D meshes**.

More informations



References available via the QR code