Magnetic noise mitigation for the Einstein Telescope: optimization of ferromagnetic shielding

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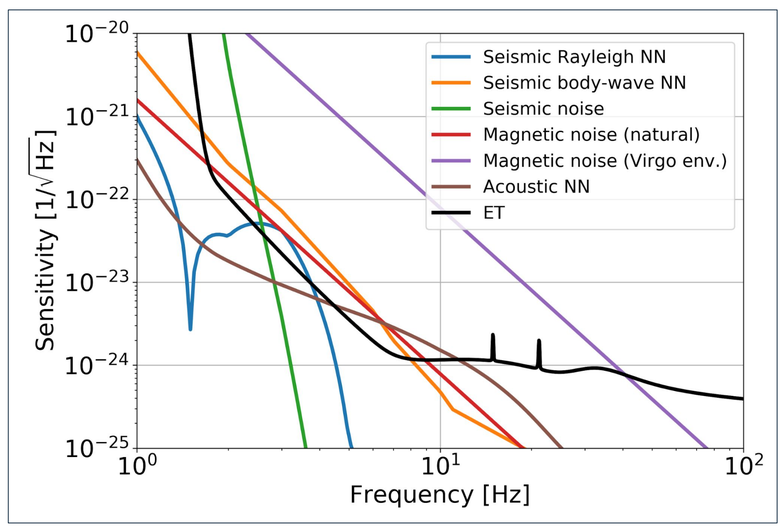
INTRODUCTION

At low frequencies (1-100 Hz), the dominant noise sources for the Einstein Telescope (ET) will be of seismic and magnetic origin.

Based on experience from Virgo, achieving the target sensitivity will require reducing natural magnetic noise by at least a factor of 3 and self-inflicted noise by at least a factor of 100.



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MAGNETIC NOISE

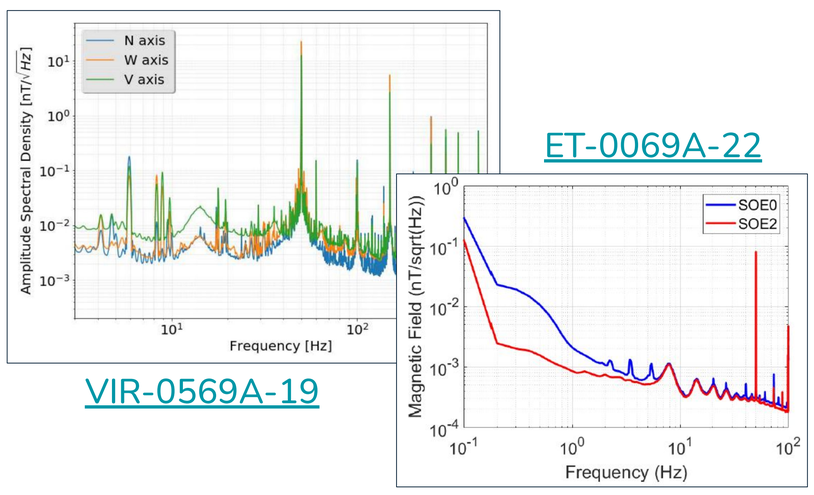
The term magnetic noise is somewhat misleading. Unlike other types of noise, such as quantum and thermal noise, which are intrinsic to the interferometer, magnetic noise results from the interaction between external magnetic fields and specific interferometer components. Without this coupling, magnetic noise would be absent, even in the presence of strong and fluctuating magnetic fields.

FERROMAGNETIC SHIELDING

Ferromagnetic shields utilize materials with high magnetic permeability to redirect magnetic field lines.
Materials typically used are Ni-Fe alloy systems known for their extremely high permeability and narrow hysteresis loop.

MAGNETIC SOURCES

Regarding the sources of magnetic noise, we can distinguish two main categories: natural magnetic noise, essentially the Schumann Resonances, and the so-called self-inflicted magnetic noise, which is caused by human activity.



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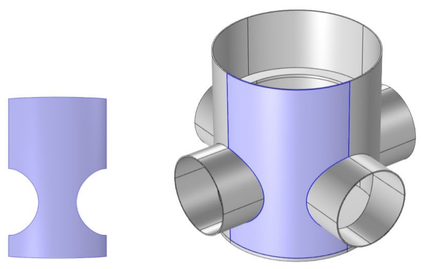
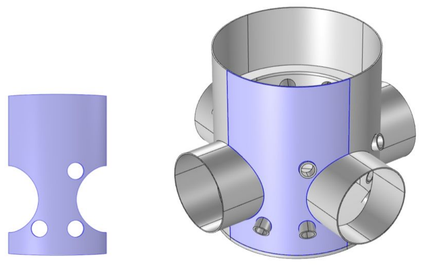
APPLICATION

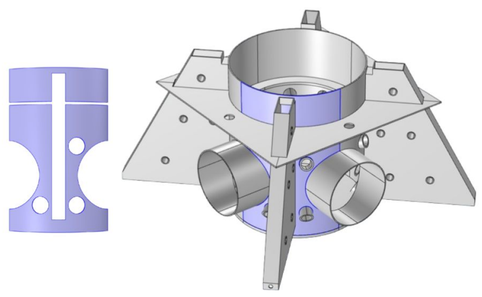
Ferromagnetic shielding of the lower part of the TM tower with a 1mm thick mu-metal layer:



Frequency [Hz]	Relative Permeability	Shielding Factor
0	57 000	10.40
10	48 000	9.43
100	40 000	8.45



Frequency [Hz]	Relative Permeability	Shielding Factor
0	57 000	9.89
10	48 000	8.95
100	40 000	8.02



Frequency [Hz]	Relative Permeability	Shielding Factor
0	57 000	4.07
10	48 000	3.69
100	40 000	3.34

CONCLUSION

The implementation of such a mitigation system would be:

- sufficient to adequately reduce natural magnetic noise;
- insufficient to address the issue of self-inflicted noise -> need to shield also the magnetic noise source itself and to employ other mitigation techniques.

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