Passive Magnetic Shielding for Test-Mass Towers

A proof of concept

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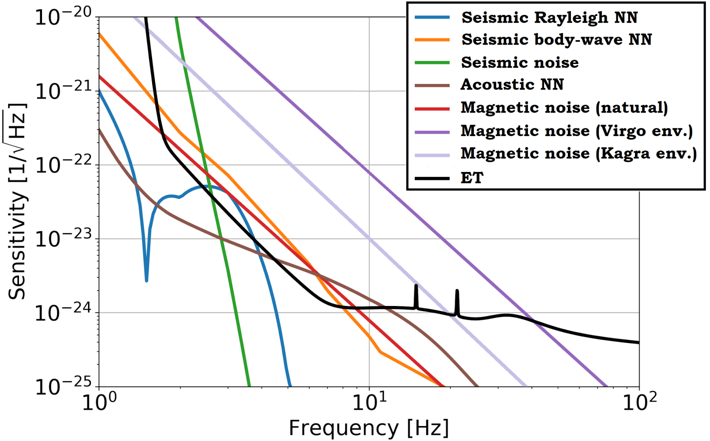
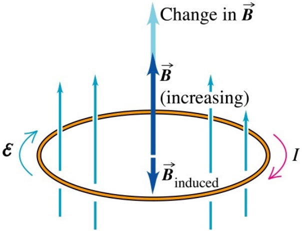
Dominant environmental noises at low frequencies



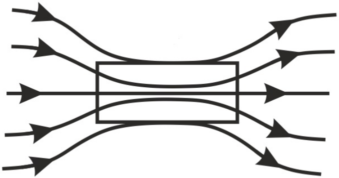
In a range between a few Hz and about 100 Hz the magnetic noise has a big impact!

Passive techniques



INDUCED CURRENTS

FERROMAGNETIC SHIELDS

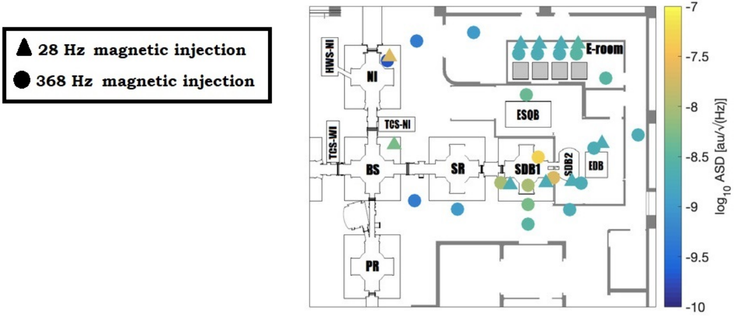


Comparison between passive and active techniques

PASSIVE SOLUTIONS	ACTIVE SOLUTIONS
cheaper	more expensive
less complex	more complex
maintenance free	need maintenance
safer	risk of unwanted fields
less effective	more effective

Passive solutions could be an excellent starting point to eventually be integrated with active solutions where necessary!

Which part of the system should we immediately shield? Test-mass towers

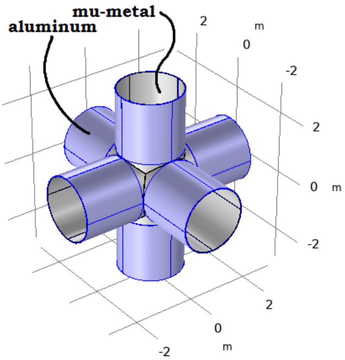


The response of the interferometer to injections of the same oscillating magnetic field depends on the location!

The shielding configuration

We simulated a tower crossed by the two interferometer's arms and:

- we covered the arms of the interferometer and the tower itself near the intersection area with mu-metal;
- we placed 6 aluminum hollow cylinders in the same area.



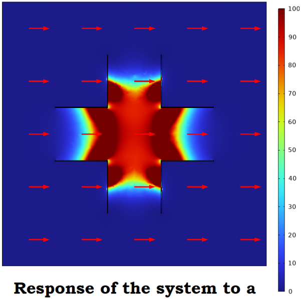
mu-metal thickness: 1mm
mu-metal permeability: 100.000

aluminum thickness: 2cm
aluminum conductivity: 35.000.000 S/m

cylinder height: 2m

tower radius: 1m
arm radius: 1m

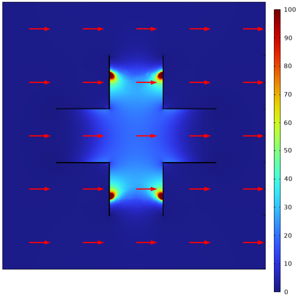
Shielding Factor



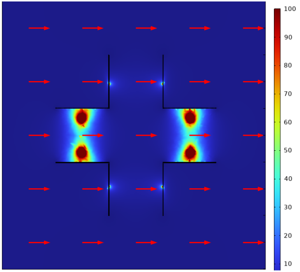
Response of the system to a 200Hz Uniform Magnetic Field along one of the arms of the interferometer

Frequency [Hz]	Shielding Factor
0	19.52
5	69.33
10	76.85
50	86.17
100	88.01
200	89.14

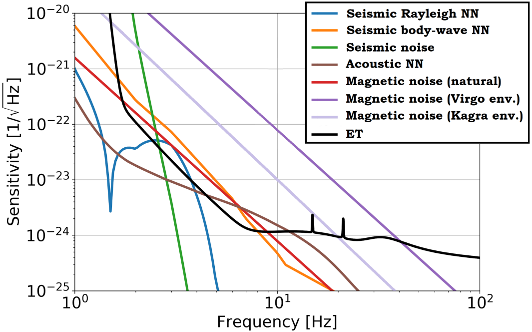
ONLY MU-METAL RESPONSE

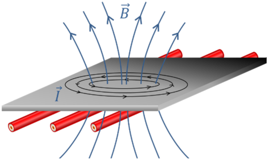


ONLY INDUCED CURRENTS RESPONSE

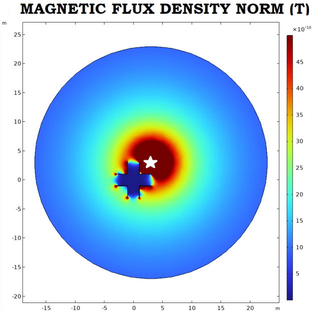


Source Mitigation



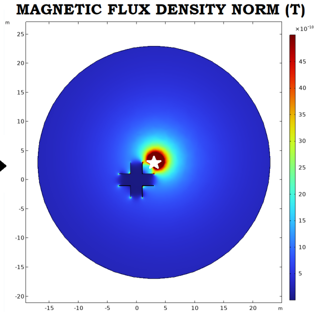


If we only screen the interferometer it will be hard to reduce the environmental magnetic noise under the designed ET sensitivity curve!



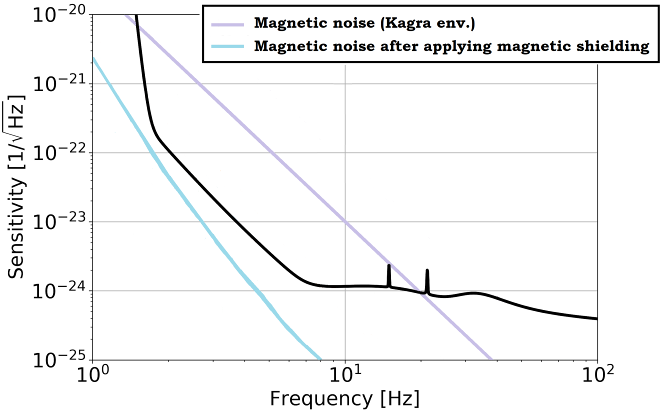
Shielded tower response to the magnetic field produced by a current-carrying wire

Shielded tower response to the magnetic field produced by a screened current-carrying wire



Frequency [Hz]	SF without aluminium foil	SF with aluminium foil
0	17	17
5	81.01	140.73
10	90.77	221.48
50	98.71	383
100	100.27	402.68
200	101.44	410.83

Conclusion



The use of passive magnetic shielding in principle could allow to reach levels of sensitivity equal or greater than those desired for ET!

A proof of concept

"Is possible to reduce magnetic noise through passive techniques?"

"Yes"

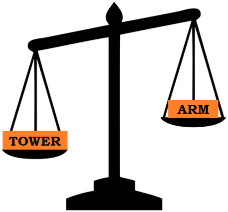
However...

- Magnetic noise not only affects the interferometer towers but also other parts.
- We have considered a current-carrying wire as a magnetic source, but many other couplings are possible (see Irene's talk).

Towards the future

Therefore if we wanted to implement these solutions we should:

1. Quantitatively evaluate how much the different parts of the interferometer contribute to the magnetic noise (coupling coefficient map);



Towards the future

Therefore if we wanted to implement these solutions we should:

1. Quantitatively evaluate how much the different parts of the interferometer contribute to the magnetic noise (coupling coefficient map);
2. Establish which shielding factor is needed for each component of the interferometer (cost-benefit ratio);

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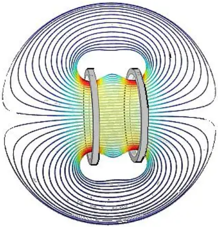
3. Choose where and if integrate with active solutions;



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Therefore if we wanted to implement these solutions we should:

1. Quantitatively evaluate how much the different parts of the interferometer contribute to the magnetic noise (coupling coefficient map);
2. Establish which shielding factor is needed for each component of the interferometer (cost-benefit ratio);
3. Choose where and if integrate with active solutions;
4. Locate the main sources of magnetic noise and screen them.

Thank you for listening!