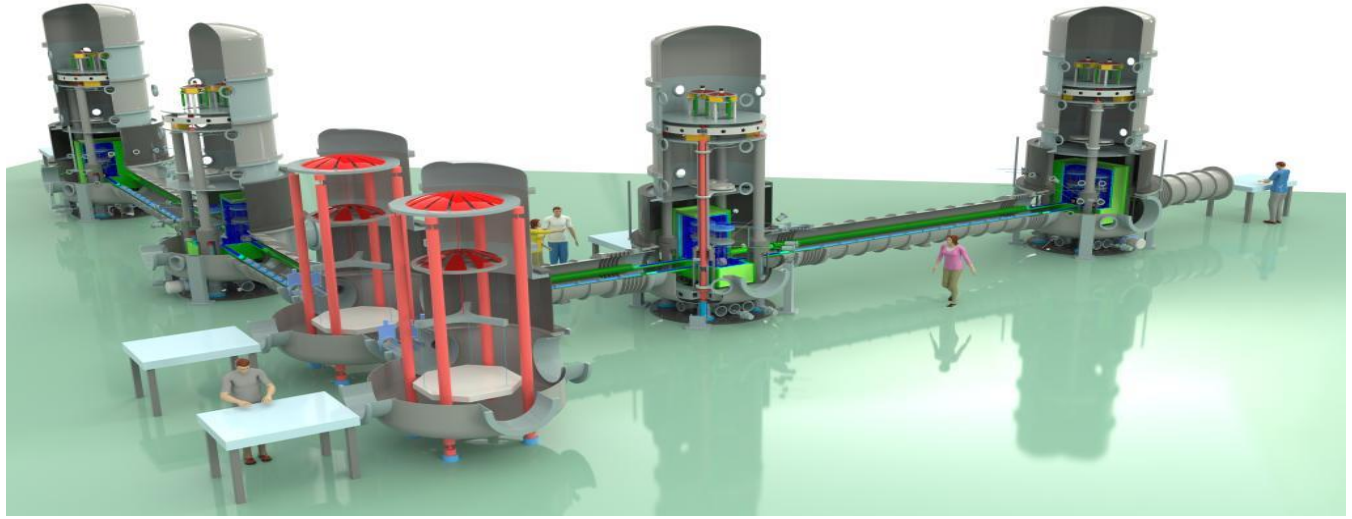
Research and development of novel position sensors and actuators for seismic attenuation systems of the ETpathfinder experiment



11th Belgian-Dutch Gravitational Wave meeting

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Pengbo Li

Michiel Yzewyn

Supervisor :

Prof. Hans Van Haevermaet

Universiteit Antwerpen

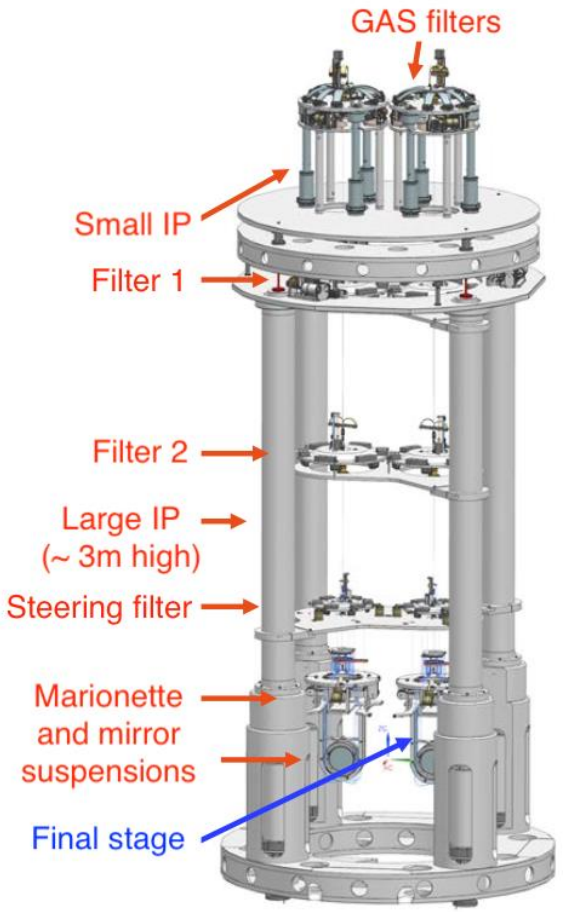
ETpathfinder

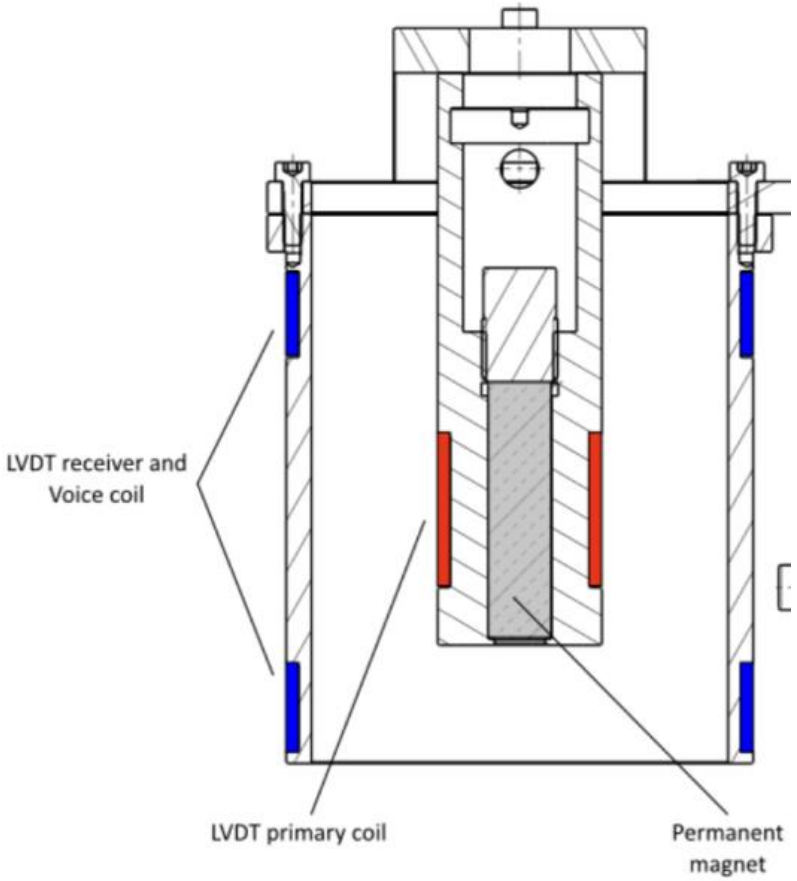
R&D facility for testing and prototyping the technologies for ET

- Temperatures – 120K & 15K
- Mirror - Silicon
- Wavelength – 1550nm, 2090nm
- Quantum noise reduction

LVDTs and control systems

(Linear Variable Differential Transformers)





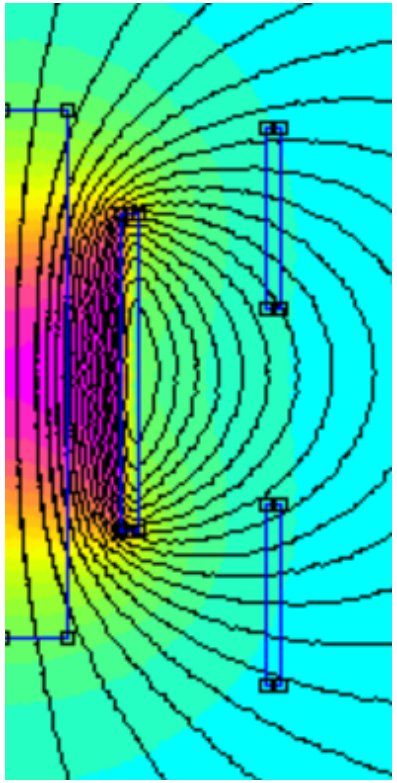
Working principle – Mutual Induction

- Non-contact position sensor
- UHV compatible
- Non-conducting
- Linear response

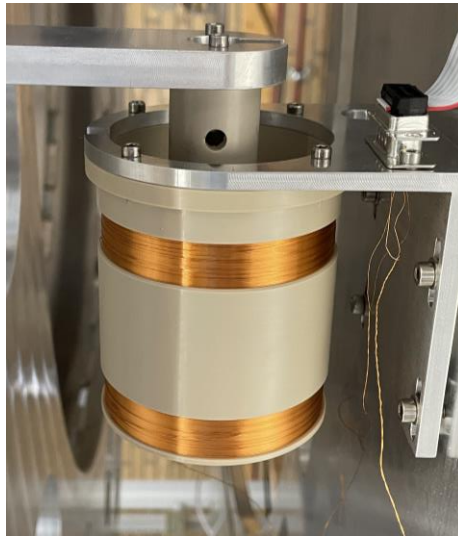
VOICE COIL

Placing a magnet inside the primary coil and applying a DC voltage to the secondary coils results in a force on the primary coil.

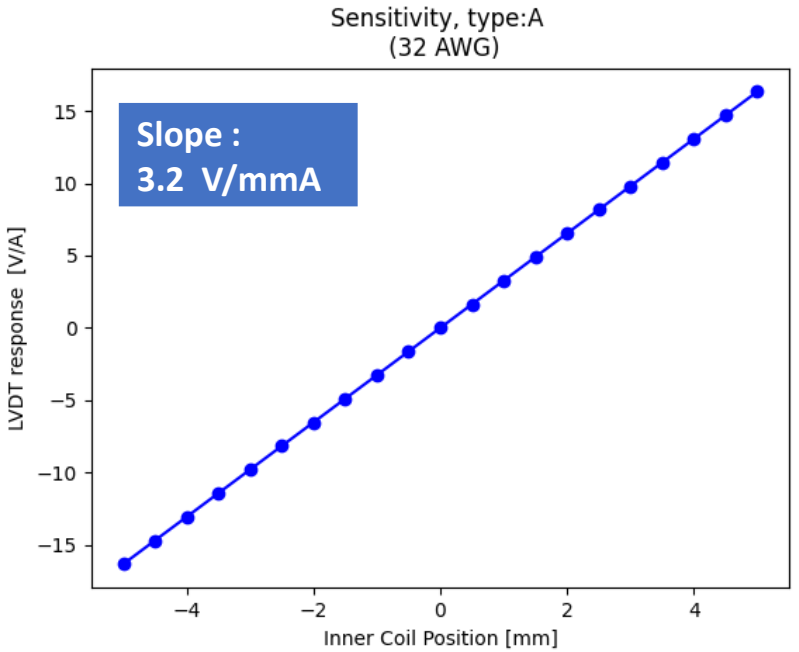
LVDT simulation results

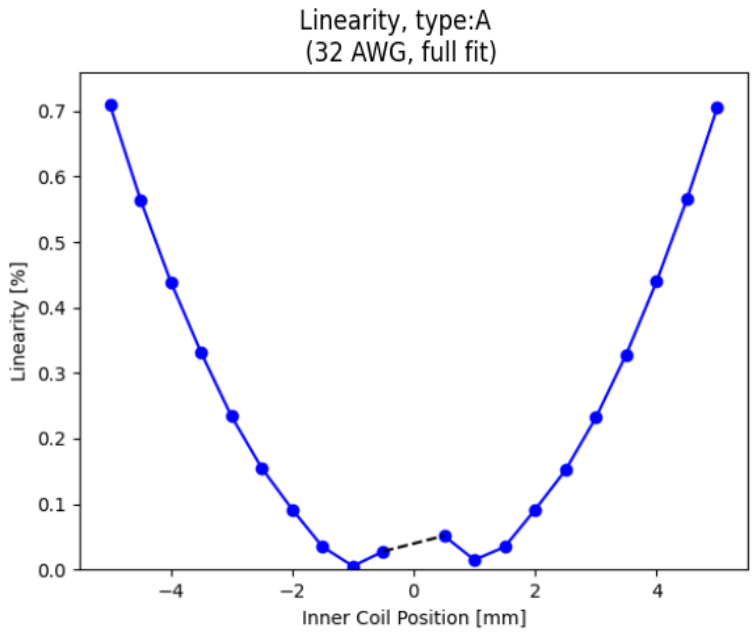


Flux density
(AC Inner coil excitation)



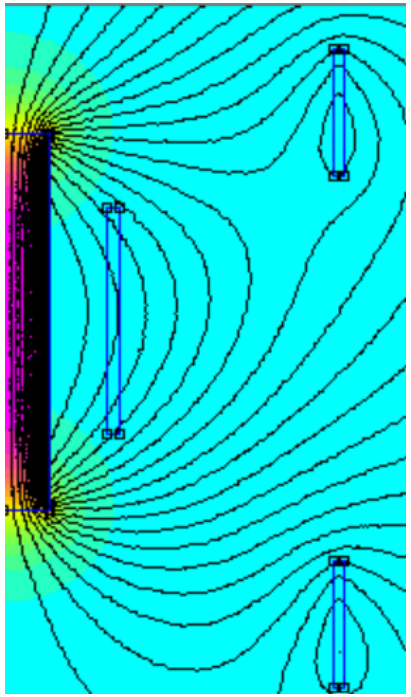
LVDT





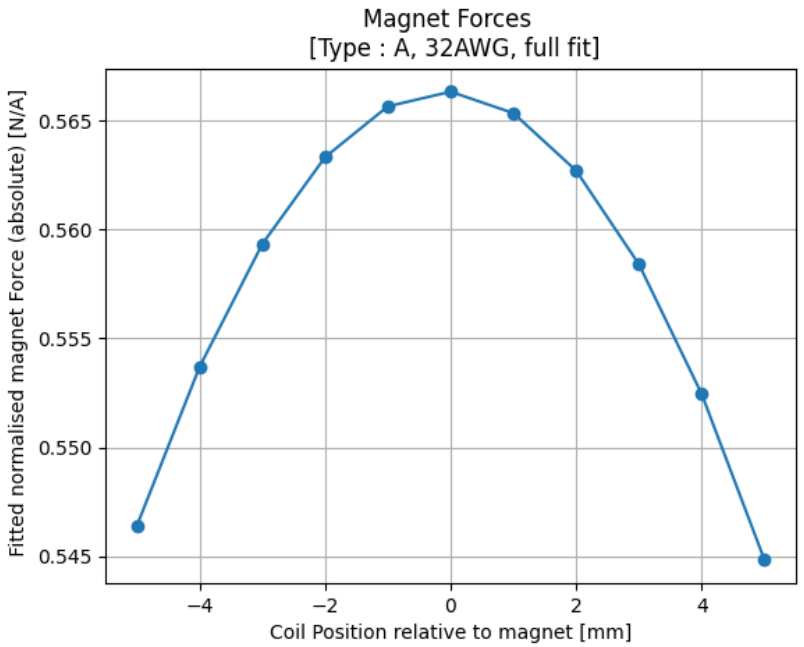
- Change in the position of the inner coil induces a voltage on the outer coil
- Normalized fit error of the signal is less than a percent

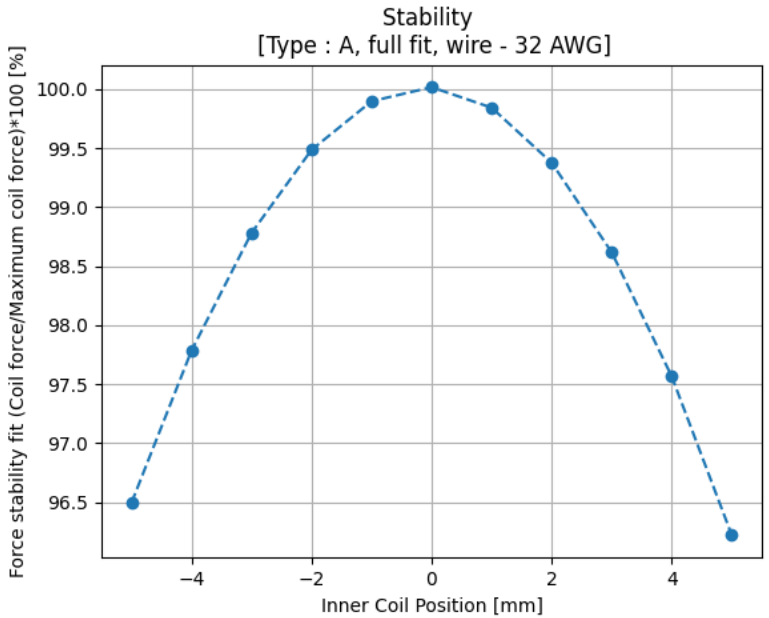
VC Simulation results



Flux density
(DC Outer coil excitation)

LVDT combined with VC

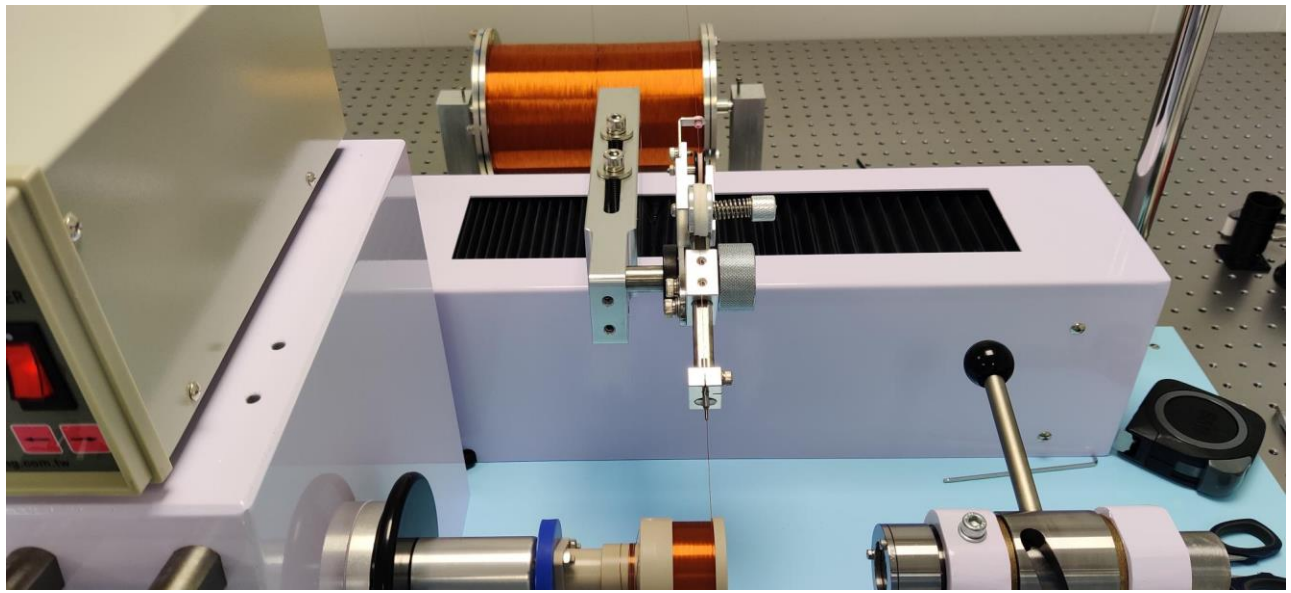




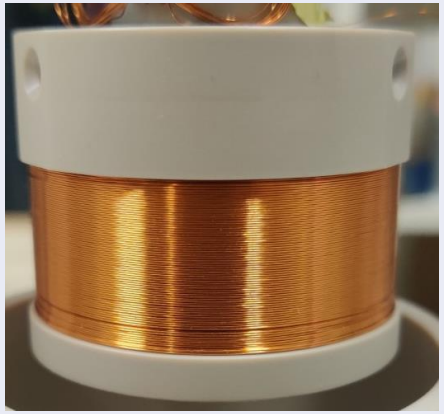
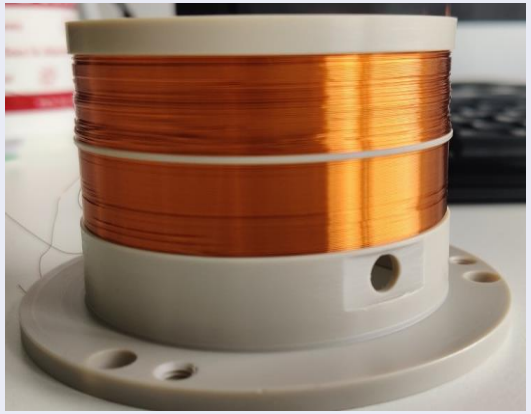
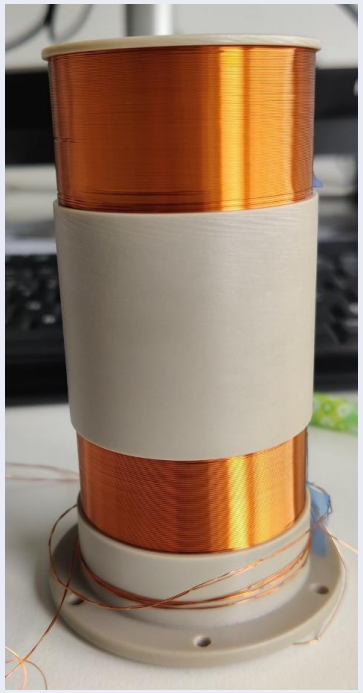
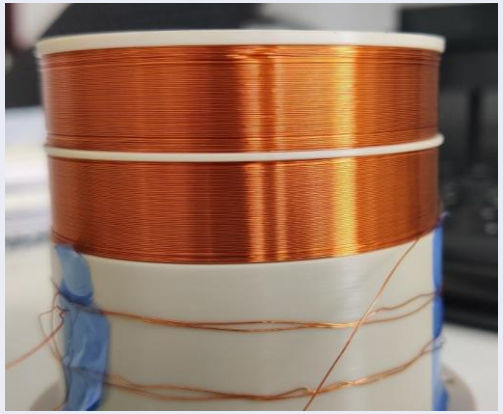
- ~0.56N force is exerted on the primary coil
- Stable behavior of forces

Clean room (Maastricht University)

Winding setup in clean room



Winded coil types for bench tower

Type-F		Type-J	
Inner coil	Outer coil	Inner coil	Outer coil
			

The coils are now UHV cleaned and ready to be placed inside the first bench tower

Experimental setup at Antwerp University

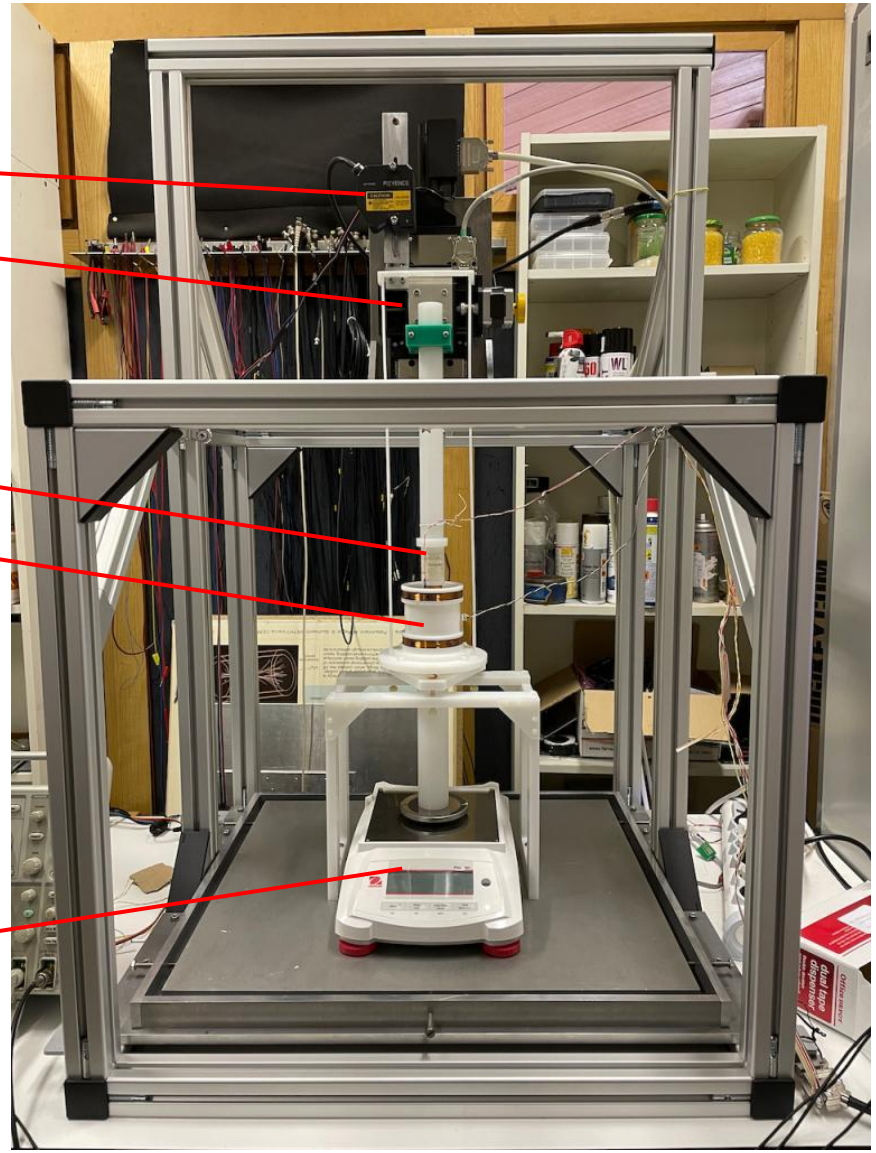
Laser

PI stage

LVDT inner coil

LVDT outer coil

Balance

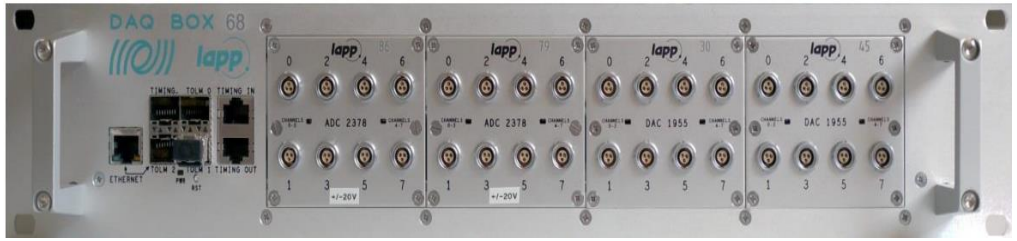


LVDT setup

Signal from secondary coils

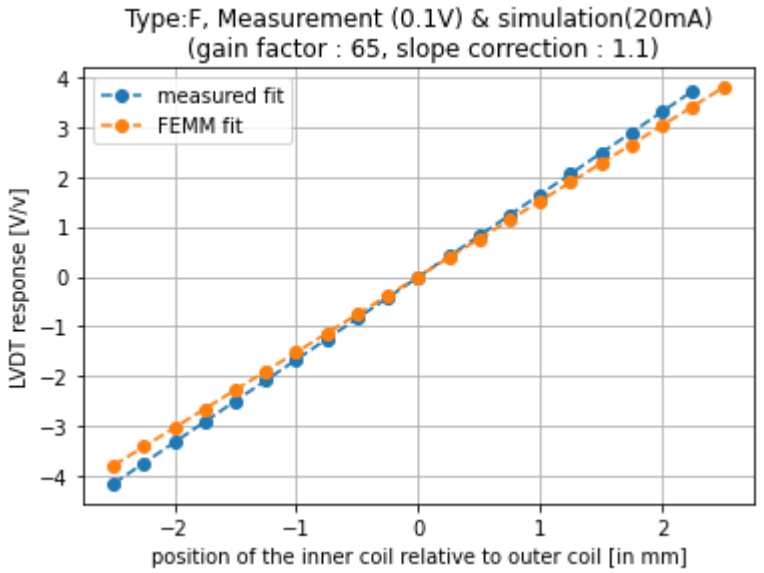
Amplification board

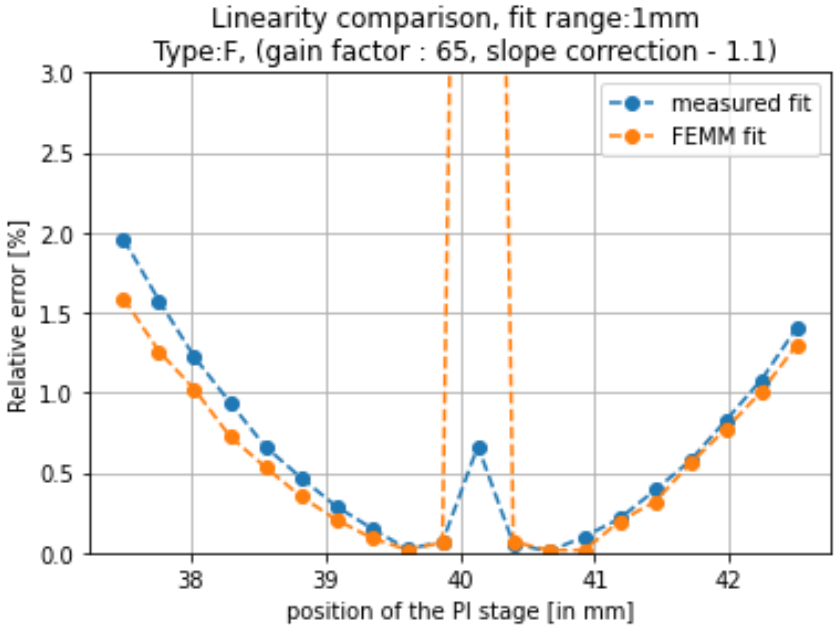
Amplified 10Khz output signal



DAQ

First measurements of type:F

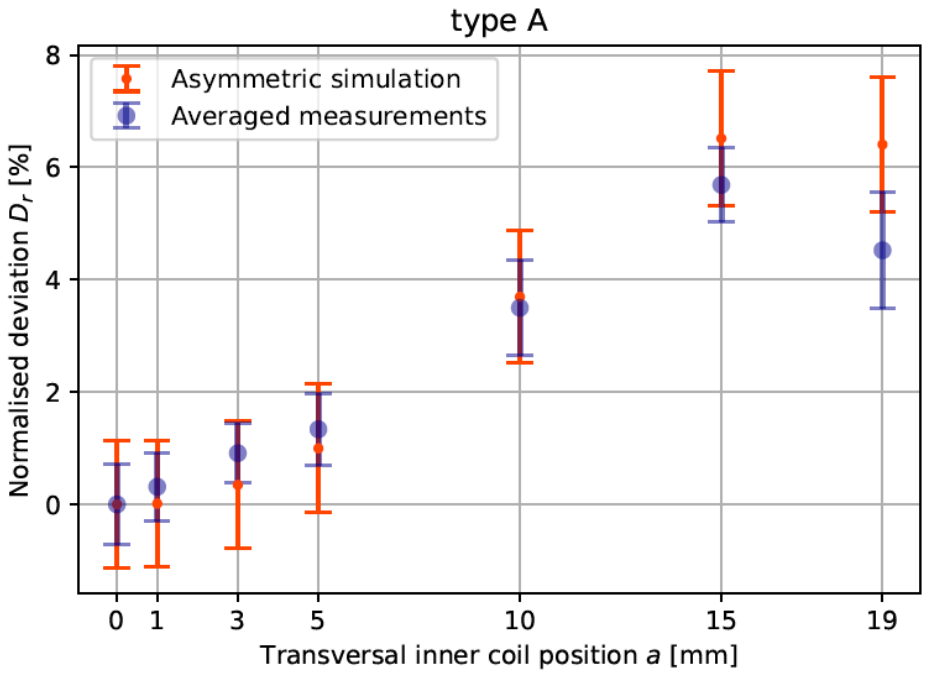


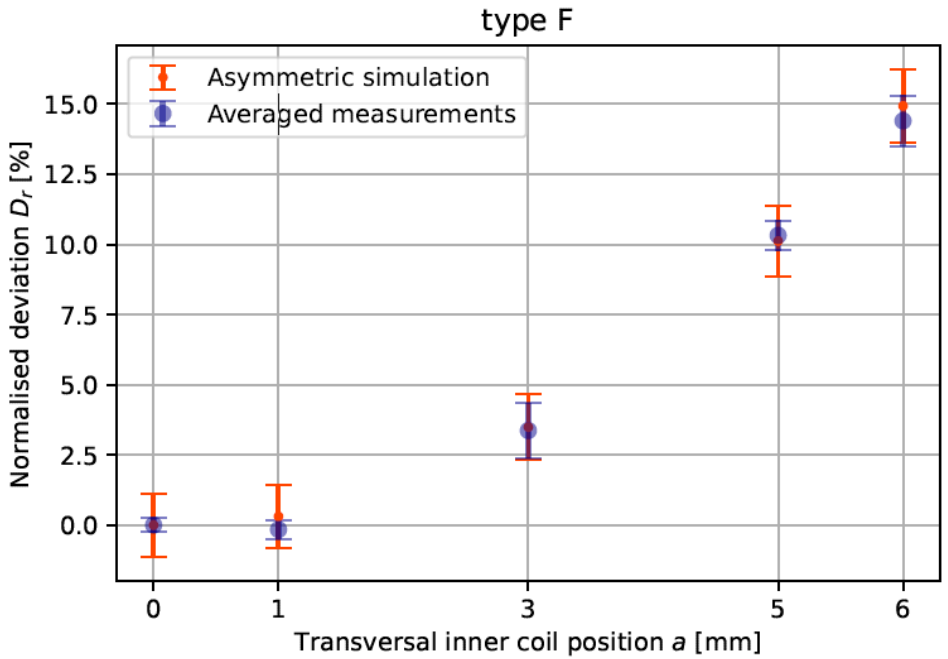


Measured slope [V/mmV]	Simulated slope	Deviation (%)
1.55	1.49	~3

- Measured sensitivity deviates 3% compared to the expected
- Observed and expected linearities are very close

LVDT – first measurement of transverse offset





Deviation

$$D_r = (m_a - m_o)/ m_o$$

m_o: *sensitivity without offset*
m_a: *sensitivity with offset* 'a'mm

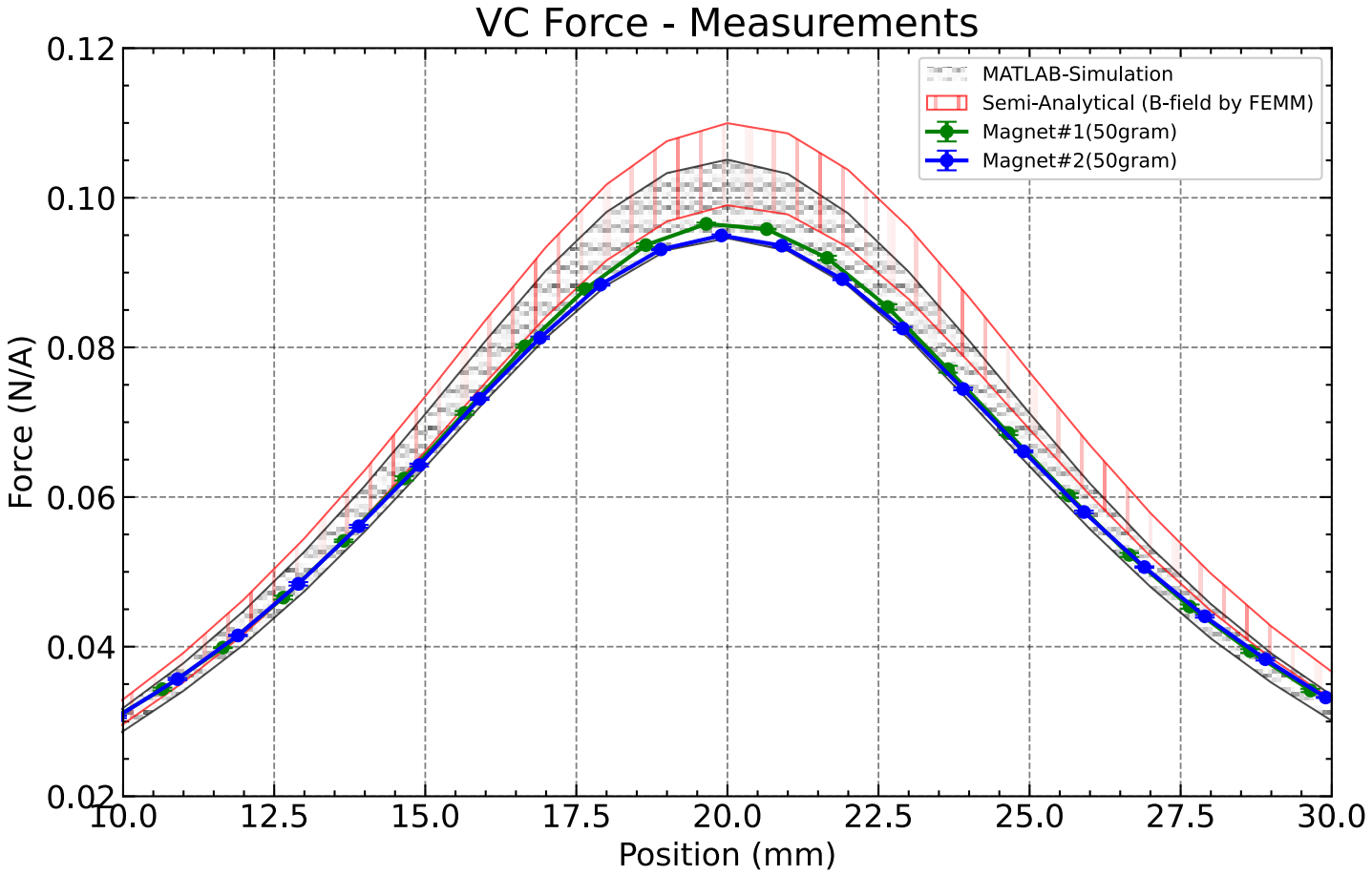
- Relative response deviation increases with transversal offset for both type A and type F. Minimizing the transverse offset during installation is important to obtain nominal performance and to avoid additional noise. Deviation is less than a percent for a millimeter offset for both the types.

Available as ETpathfinder master thesis by Michiel Yzewyn on ET TDS : https://apps.et-gw.eu/tds/ql/?c=16722

Voice Coil force

- The setup consists of coil holder, plastic spring and precision balance
- The measured weight does not indicate the real weight of the object due to the presence of springs. Reference weights are used to calibrate the relation between actual weight and measured weight
- A correction factor of 1.19 is obtained, which can be used in the actual measurements.

First trial VC Force measurement



Magnets	Max. norm. force (mN/A)
N40 1	96.513 +/- 0.5
N40 2	94.958 +/- 0.3

- First results indicate our setup works as expected, found out differences in simulation

Conclusion

- A robust python pipeline has been developed to simulate & analyze LVDTs (integrated with VCs) that can be used universally for any detectors.
- A comprehensive checklist outlining the settings, operational & working procedure for both the winding machine and LCR meter has been created. In total, 2 type-J coils, 5 type-F coils, and 2 type-A coils have been successfully wound.
- First measurements of impedance, sensitivity, and linearity of ETpathfinder designs were done. Considering the correct signal gain and impedance correction, the observed results indicate a proper performance of the setup and analysis method.
- First measurements of transverse motion has been done. Optimal operating offset for is constrained to a small portion of the available transverse space. It is necessary to precisely align LVDT coils for optimal performance.
- First trial measurements of VC force have been done. Obtained force is closer to the expected, again indicating a proper performance of the setup and analysis method.

Dank je wel