FIRST MEASUREMENTS OF THE FAST CORRECTOR MAGNETS FOR PETRA IV

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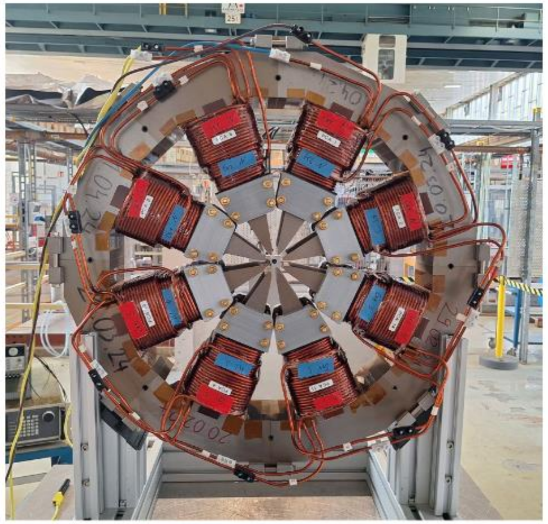

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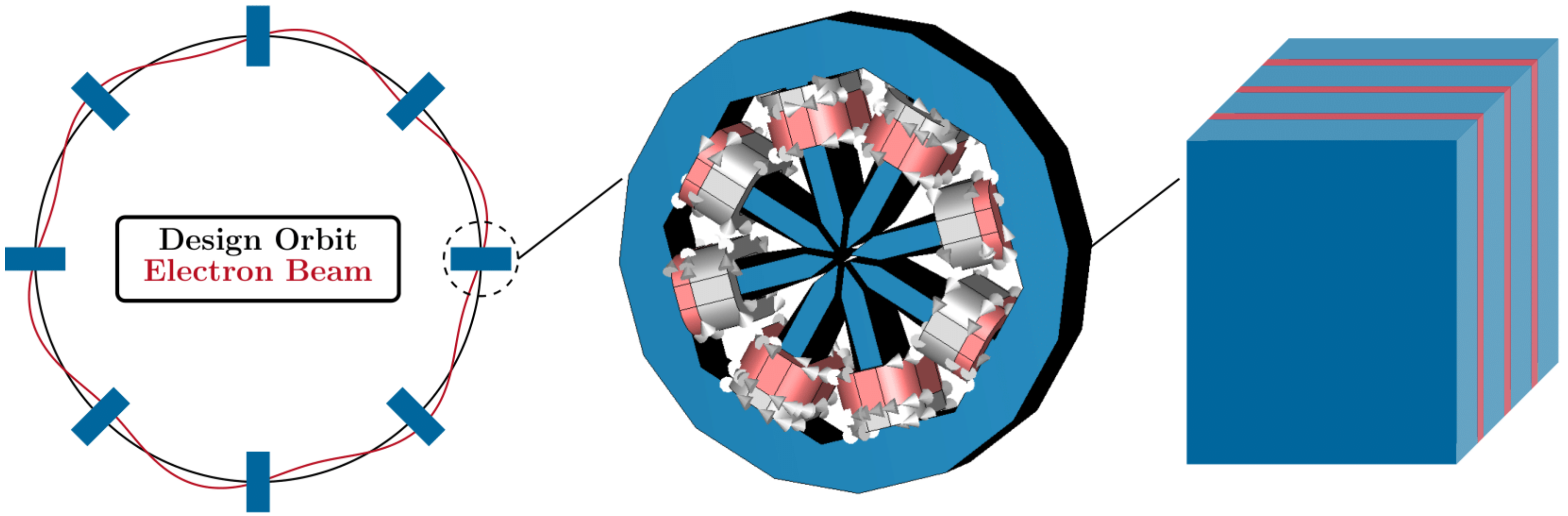
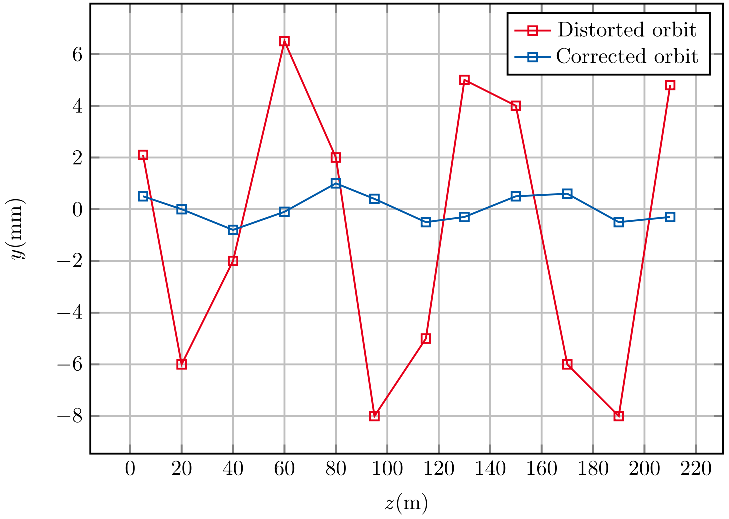
INTRODUCTION

- **PETRA III ➔ PETRA IV:** hor. emittance must be reduced **from 1300 pmrad to 20 pmrad**

➔ Fast orbit feedback system, **fast corrector magnets** with frequencies in kHz range

- **Eddy currents** in yoke and vacuum chamber ➔ Field attenuation and time delay
- To predict the eddy current effects, **simulation strategy was developed** and extensive simulation studies were conducted
- Now we are working on the **corresponding measurements**





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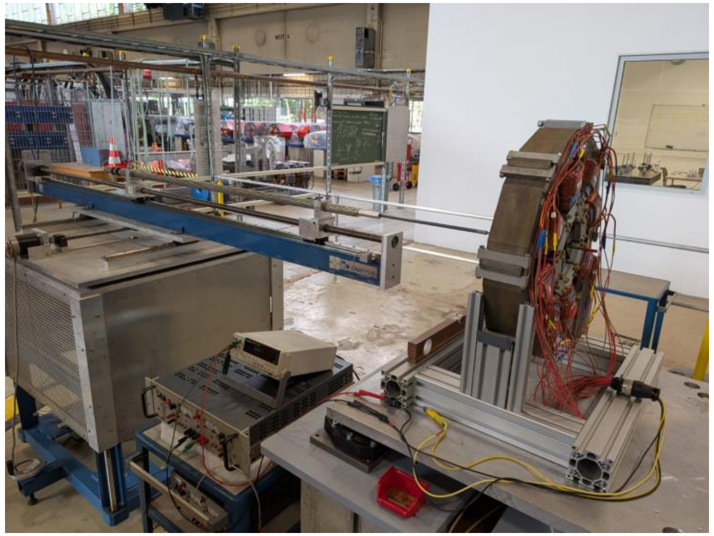
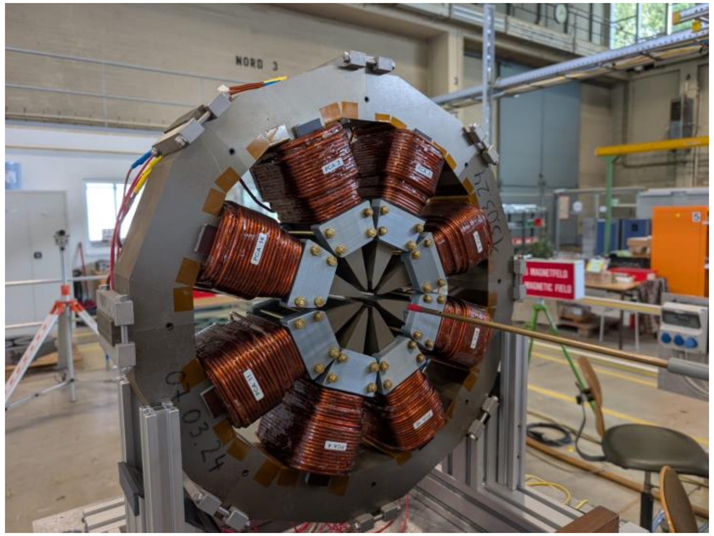
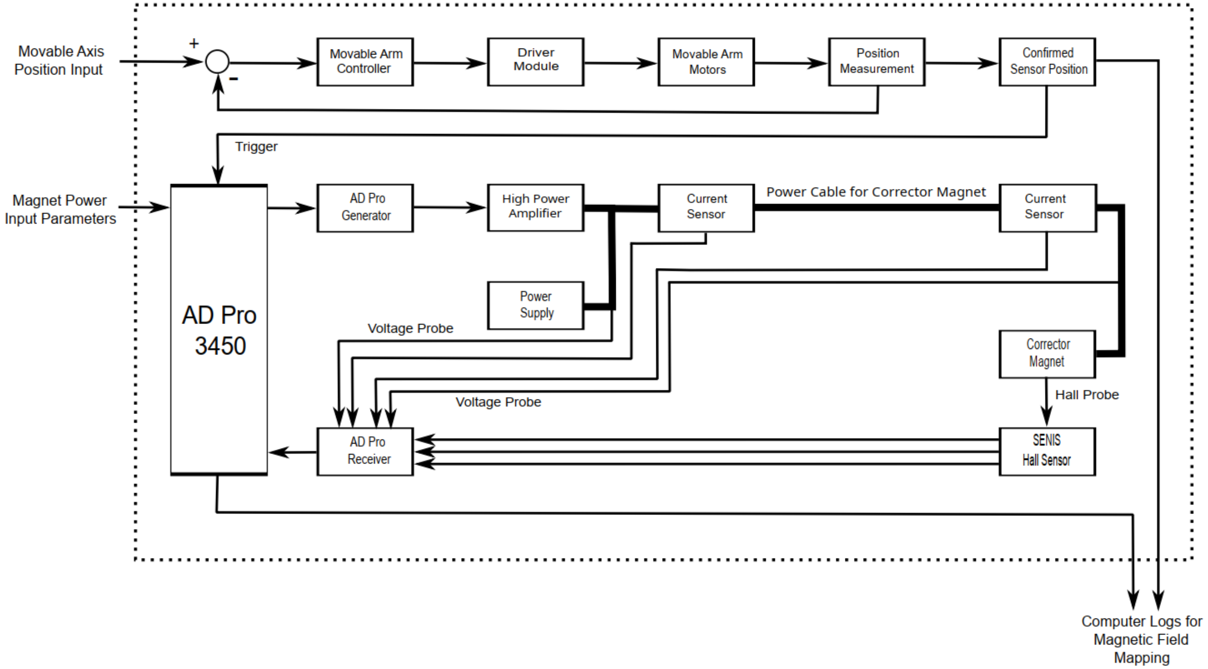
MEASUREMENT SETUP

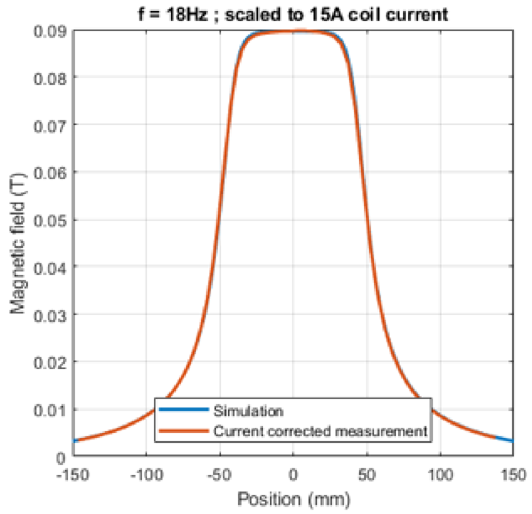


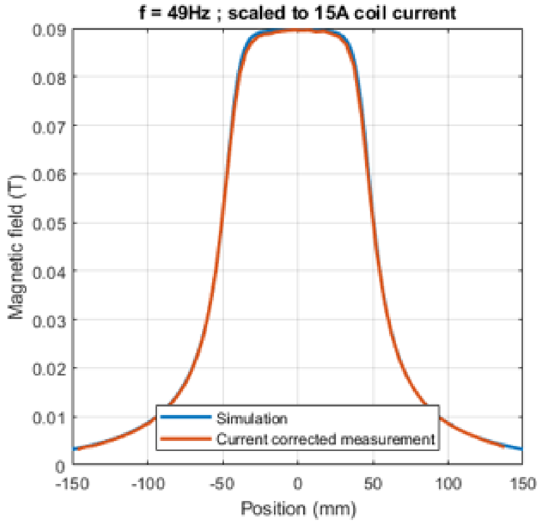


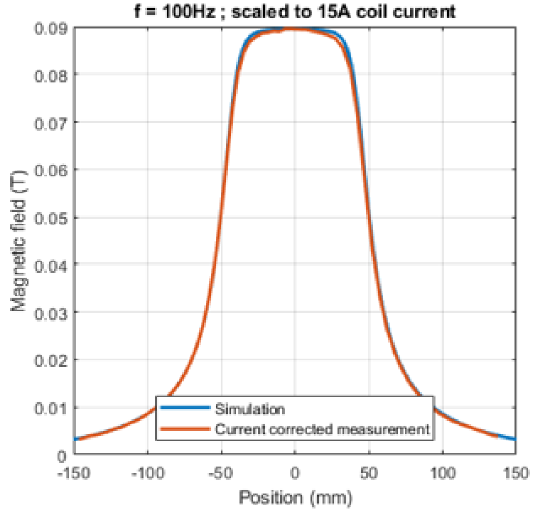


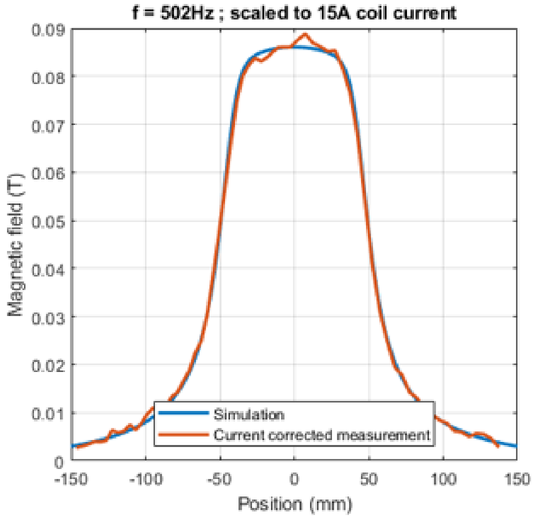
- Prototype of fast corrector magnet with 1 mm laminations
- To power the magnet: AD pro waveform generator + high power amplifier
- To measure the magnetic field along the longitudinal axis: SENIS hall sensor positioned on movable arm

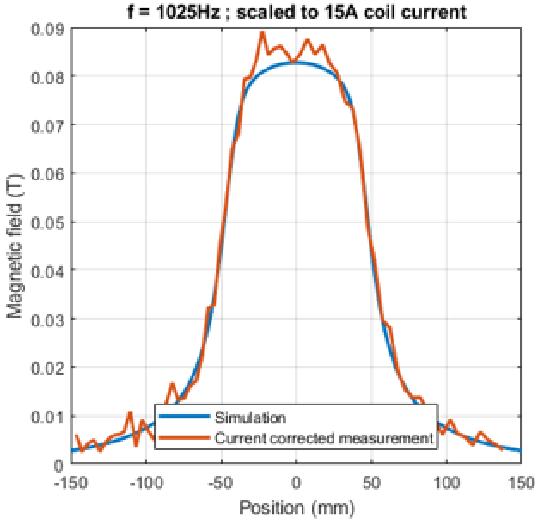
RESULTS WITHOUT VACUUM CHAMBER

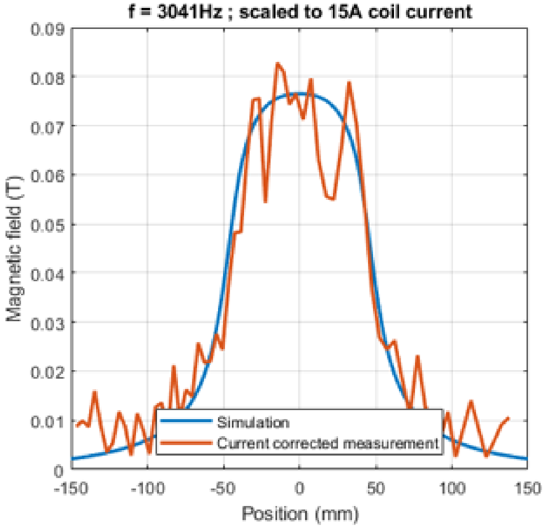






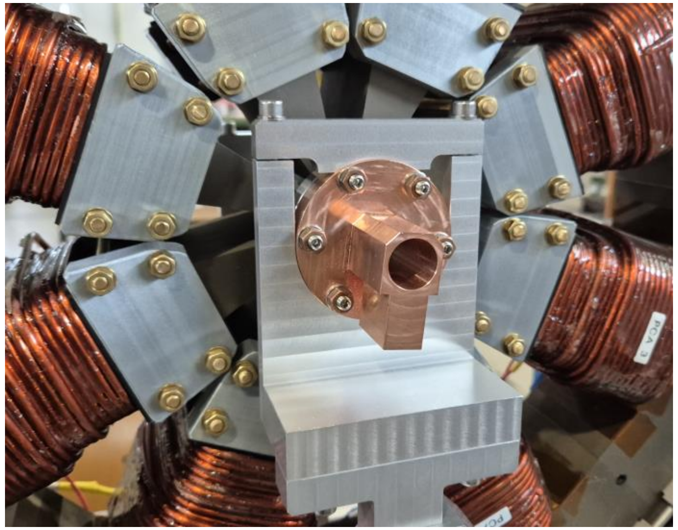


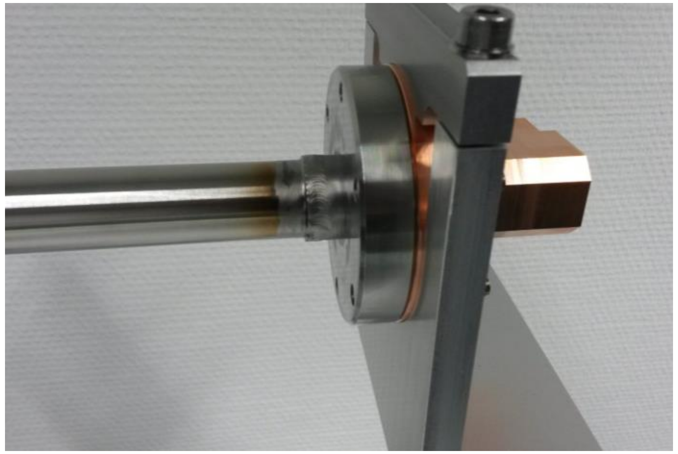


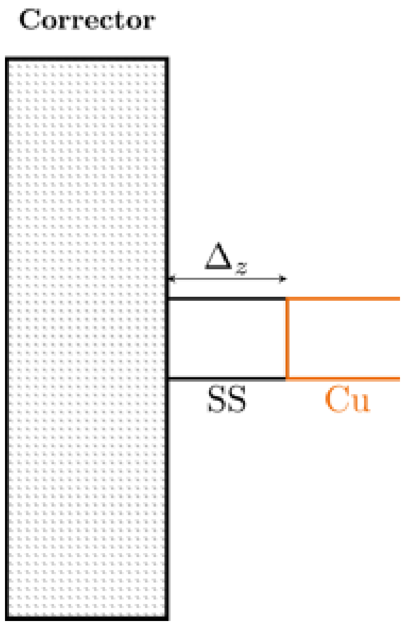


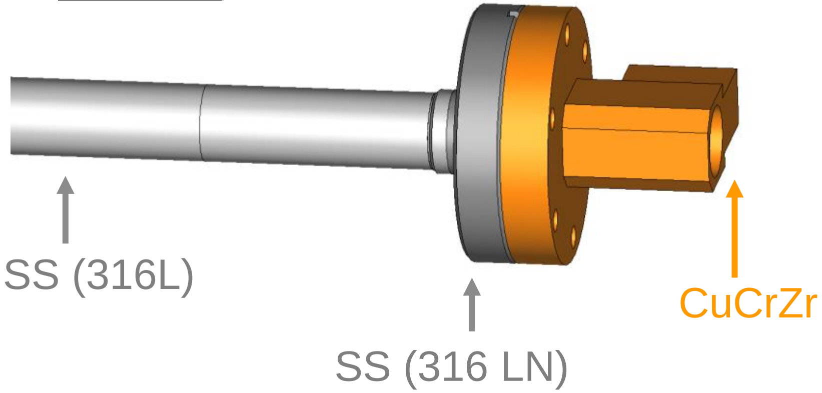
- Magnetic field profiles along longitudinal axis measured vs. simulated
- Good agreement up until $f = 1\ \mathrm{kHz}$
- Above $f = 1\ \mathrm{kHz}$ measurements too noisy

RESULTS WITH VACUUM CHAMBER A









- **Vacuum Chamber A**: SS flange to Cu flange transition
- Distance yoke – material transition $\boldsymbol{\Delta_z = 44\ \mathrm{mm}}$

Material	Conductivity (MS/m)	Relative Permeability
CuCrZr (warmausgehärtet)	43	1
SS 316 L	1.351	1.05
SS 316 LN	1.351	1.1

RESULTS WITH VACUUM CHAMBER A

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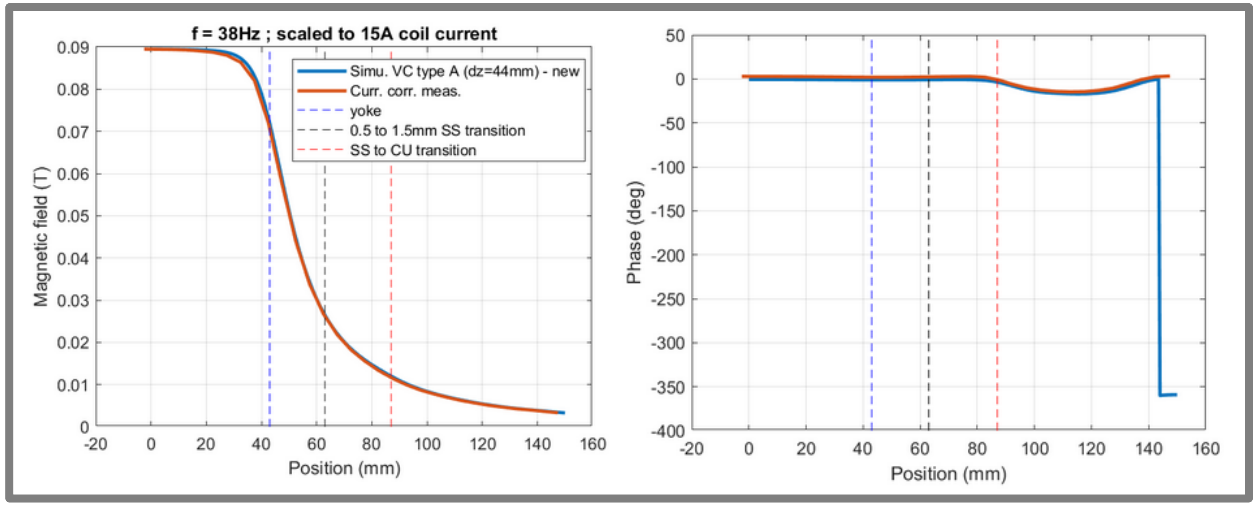
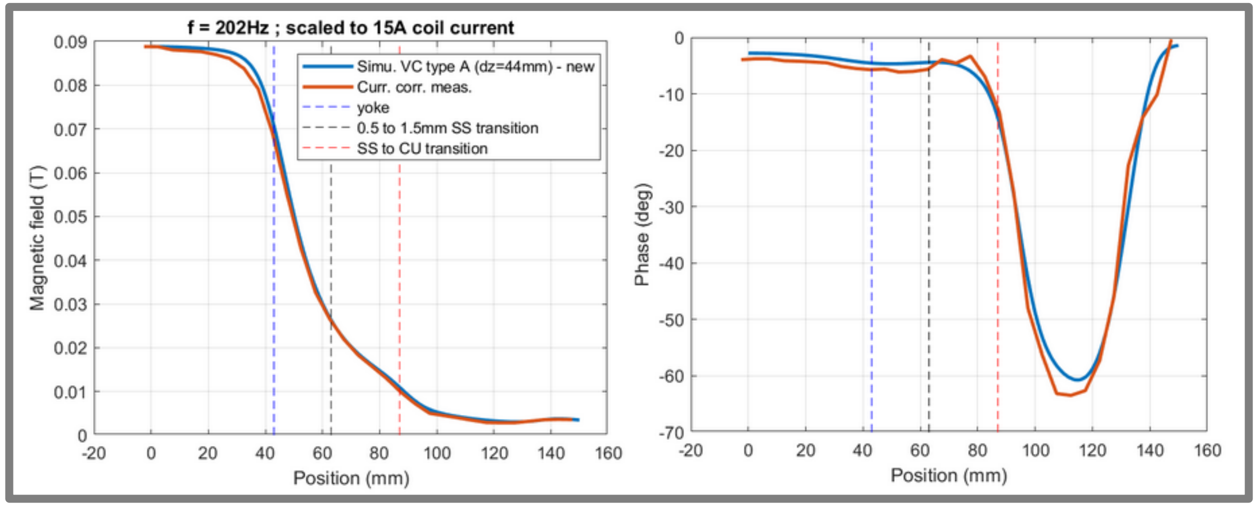
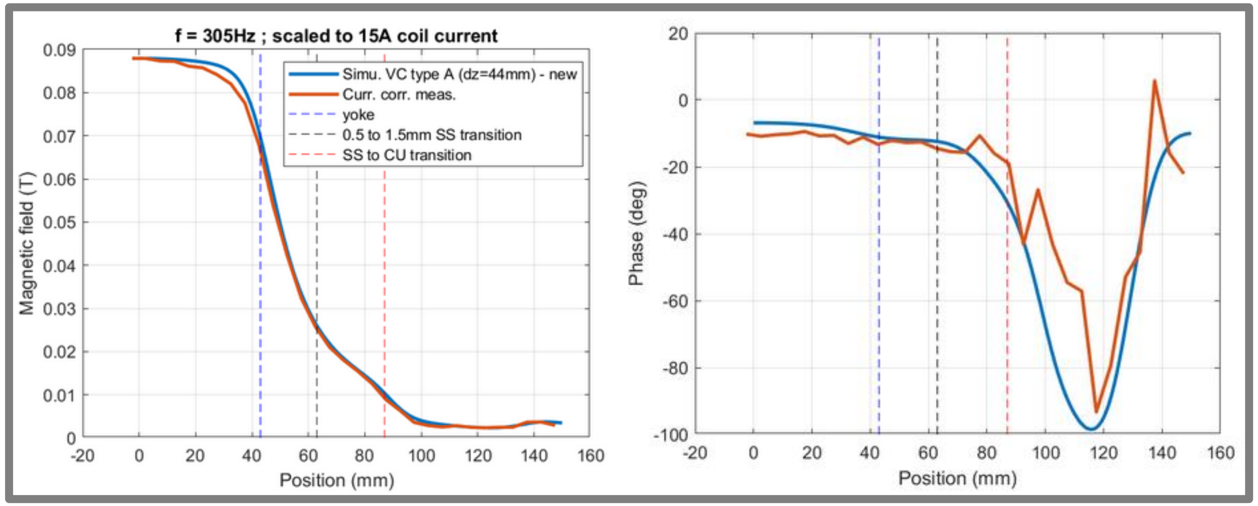
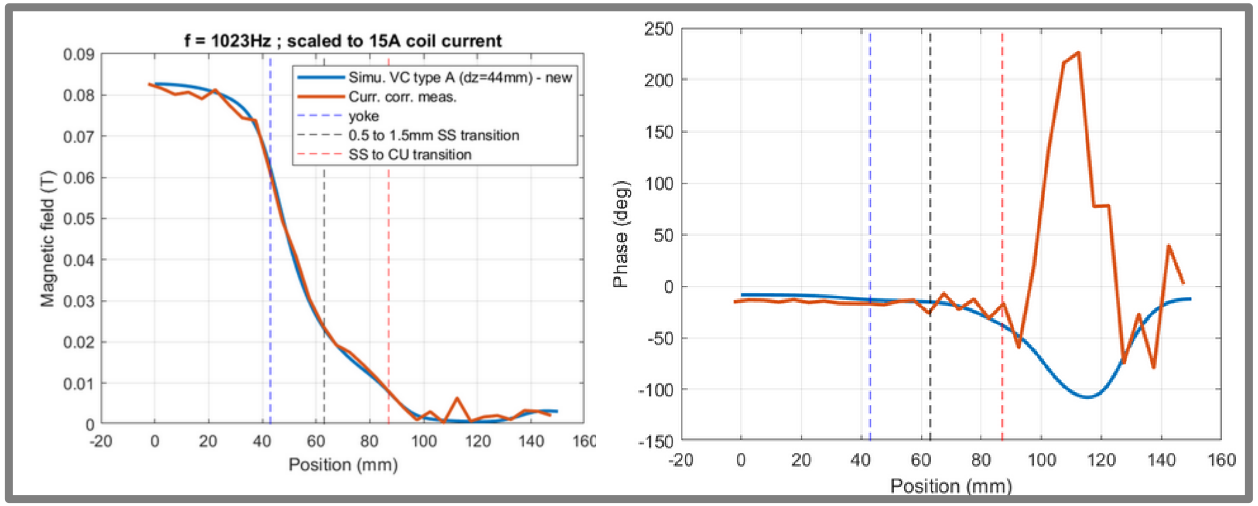
$f = 38$ Hz



$f = 202$ Hz







$f = 305$ Hz

$f = 1023$ Hz

RESULTS WITH VACUUM CHAMBER B

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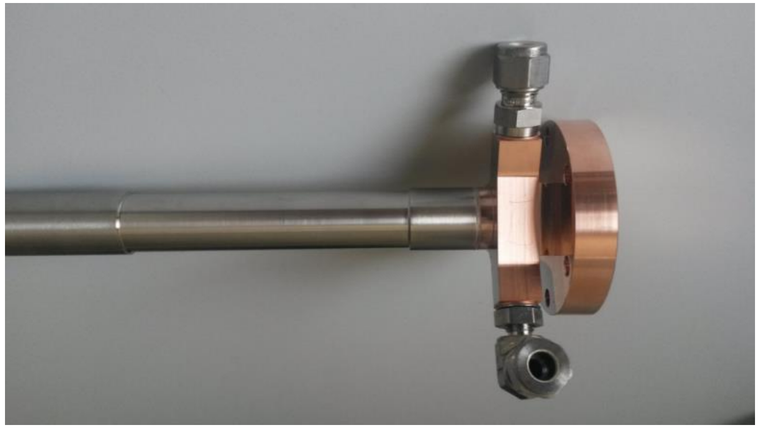
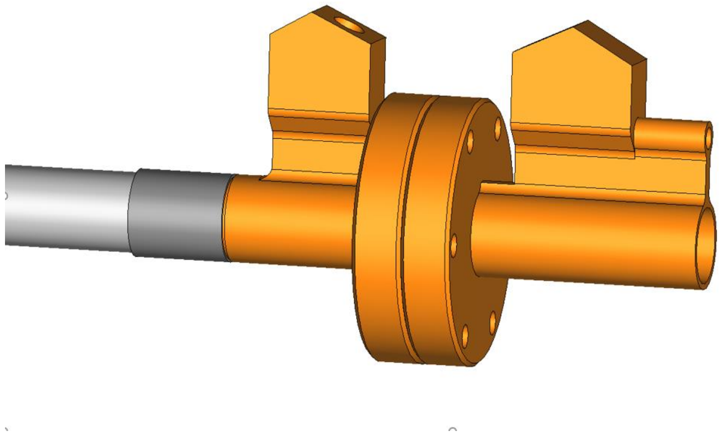
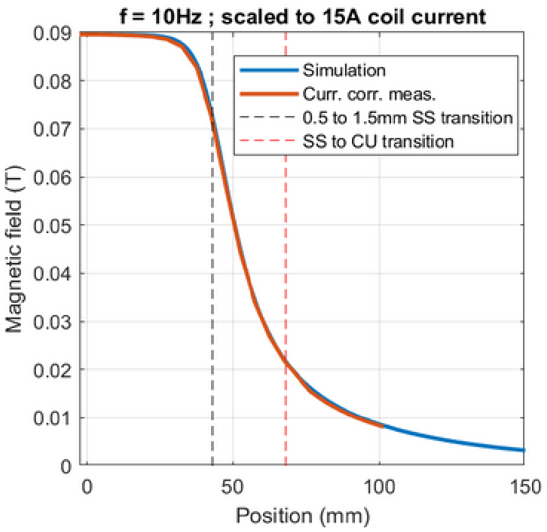
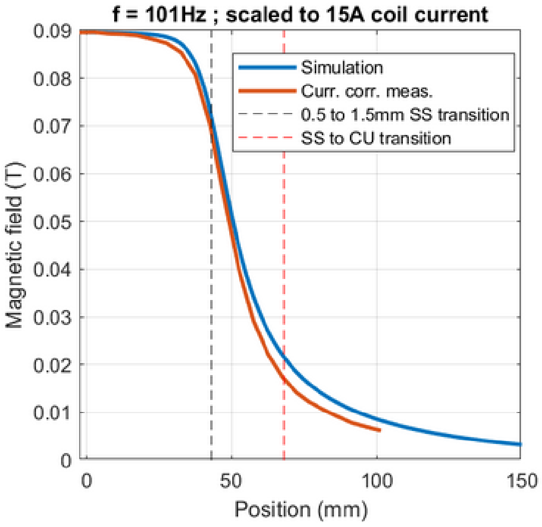
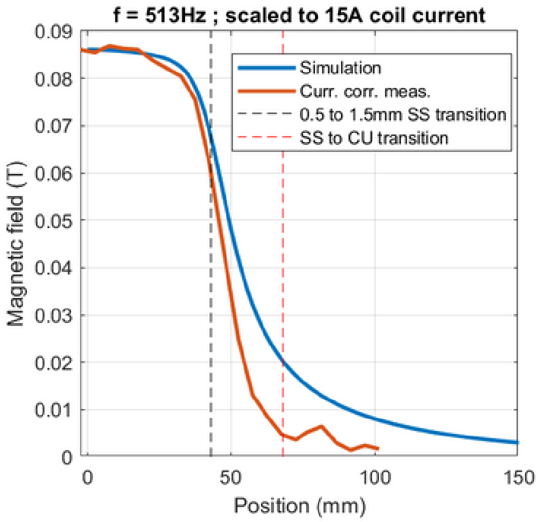
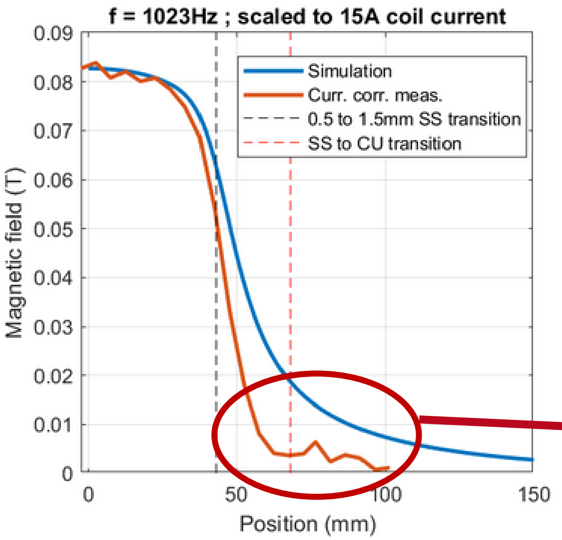








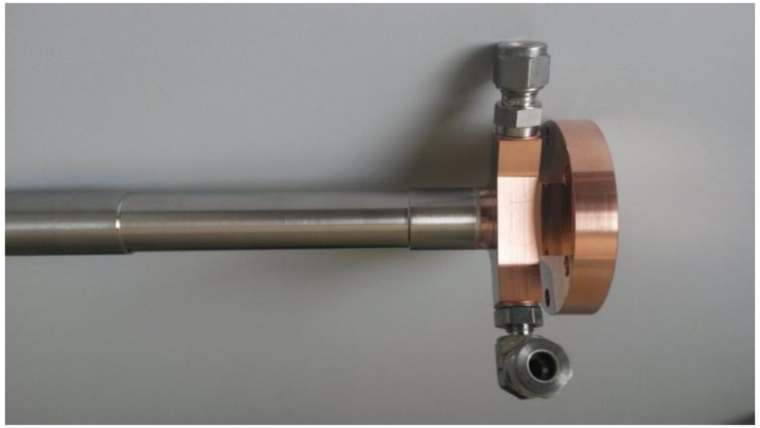


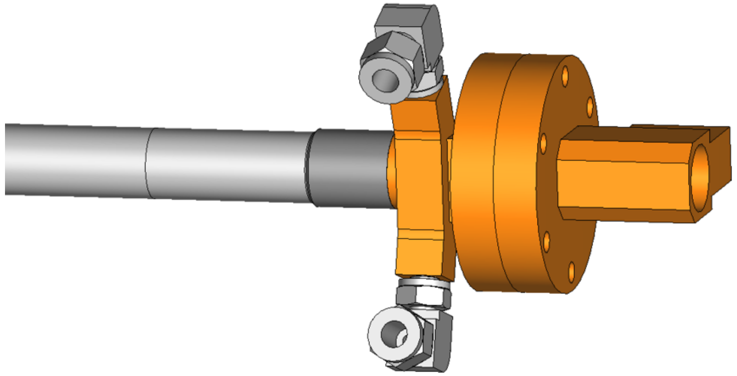


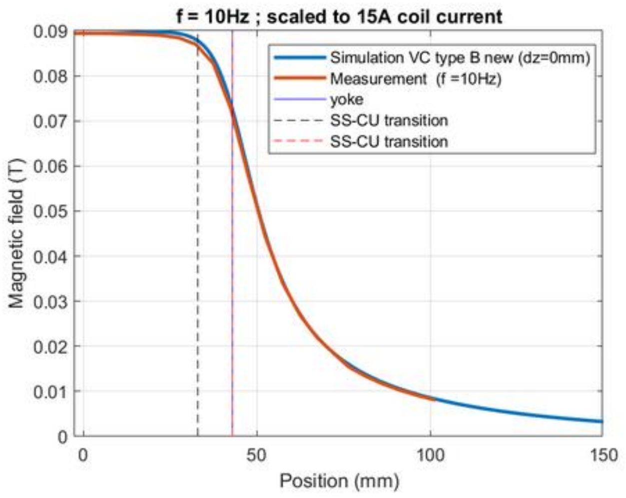
- **Scenario B**: both flanges are made of copper
- Distance yoke - material transition $\boldsymbol{\Delta_z = 0\ \mathrm{mm}}$

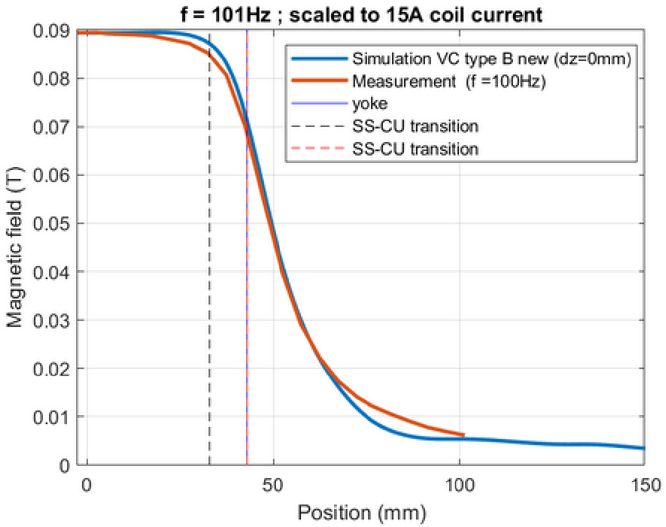
Model of the vacuum chamber was outdated !

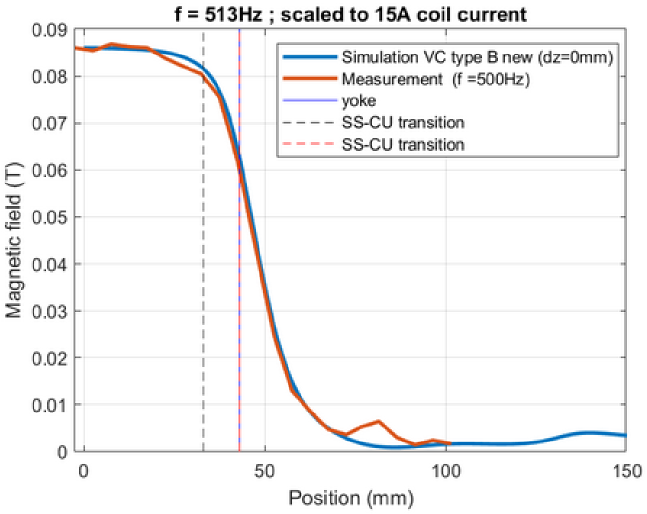
RESULTS WITH VACUUM CHAMBER B

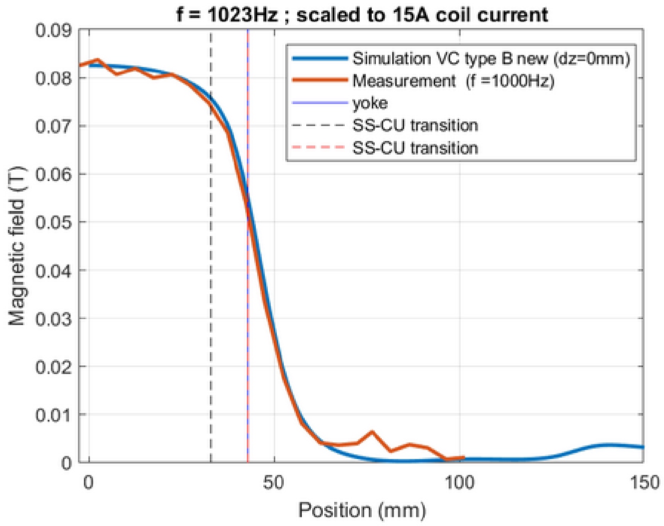






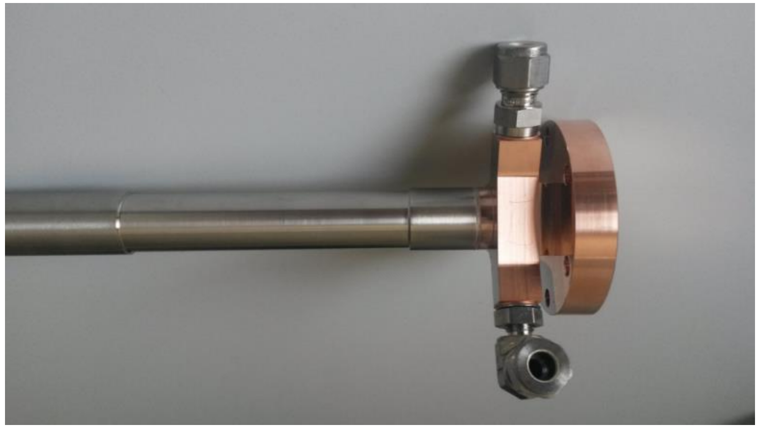


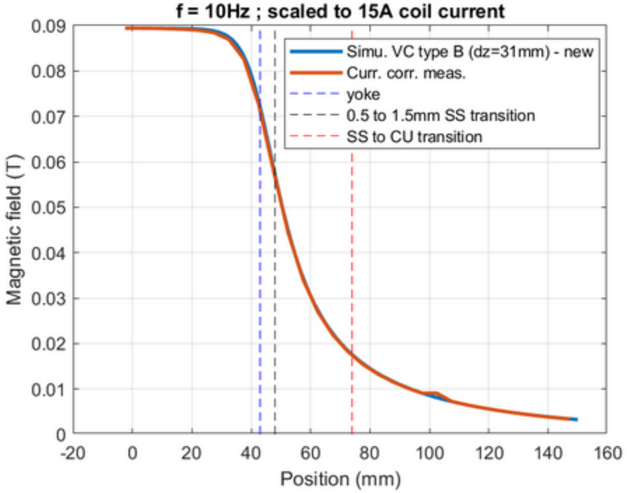


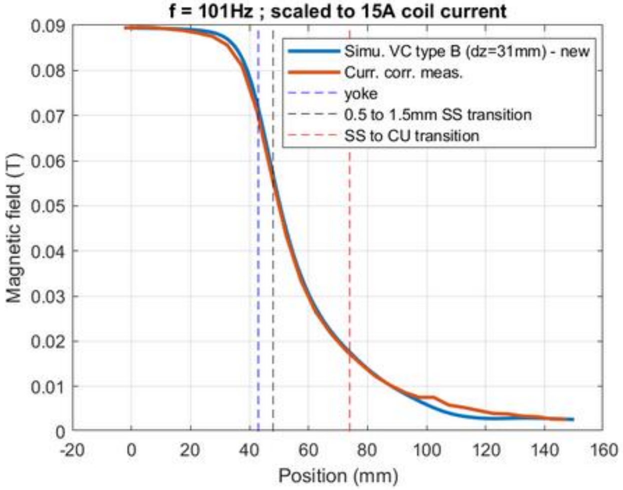


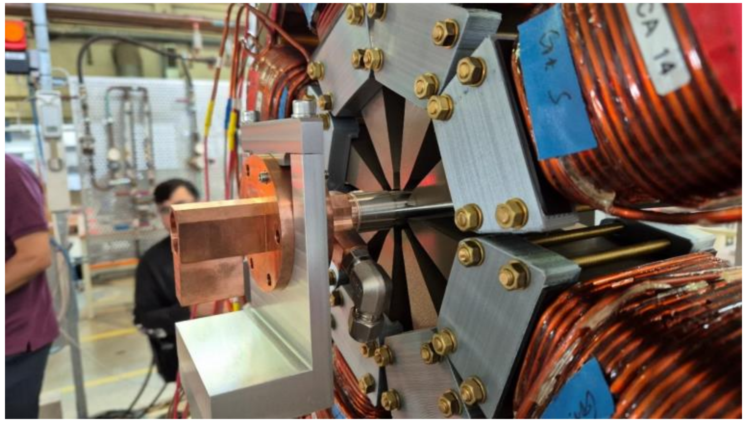
Updated vacuum chamber model clearly leads to much better results!

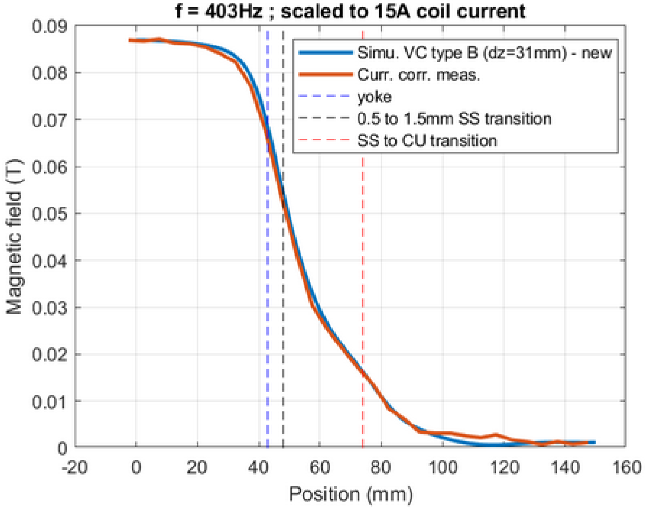
RESULTS WITH VACUUM CHAMBER B

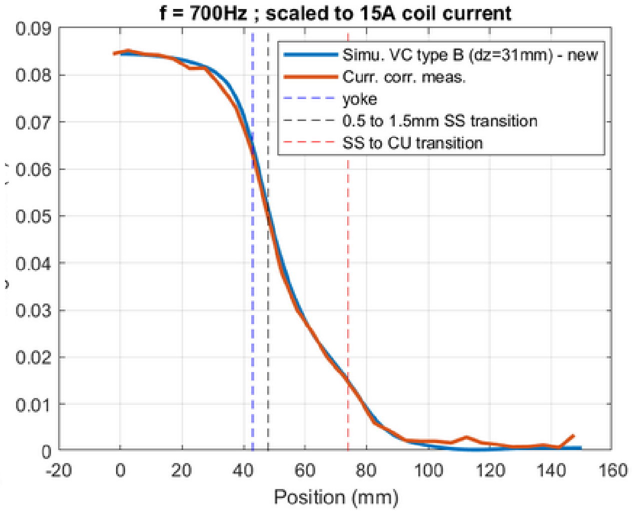












- **Scenario B**: both flanges made of copper
- Distance yoke - material transition $\boldsymbol{\Delta_z = 31\ \mathrm{mm}}$

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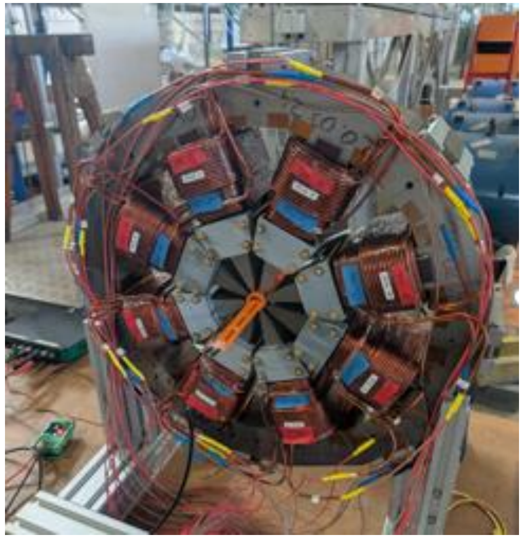
MEASUREMENT SETUP



- Magnet powered by AD pro waveform generator + high power amplifier
- Measure induced voltage of search coil up to roughly $f = 100\ \mathrm{kHz}$
- Compute integrated field from induced voltage

  $\int_l \ |\underline{B}_y(z,f)|\,\mathrm{d}z = |\frac{\underline{U}}{j2\pi f N A}|\ l$
- From integrated field at given frequency, compute integrated transfer function

  $$\mathrm{ITF}(f) = \frac{\int_l \ |\underline{B}_y(z,f)|\mathrm{d}z}{\int_l \ B_{y,\mathrm{DC}}(z)\mathrm{d}z}$$

  ➔ Measure for field attenuation due to eddy currents
- Here we do not have conclusive results yet

PROBLEMS

- Coil current decays as frequency is increased

$$\underline{I} = \frac{U}{R + j\omega L}$$

➔ Two options:

A) subtract this attenuation from the measured one

➔ **Black curve**

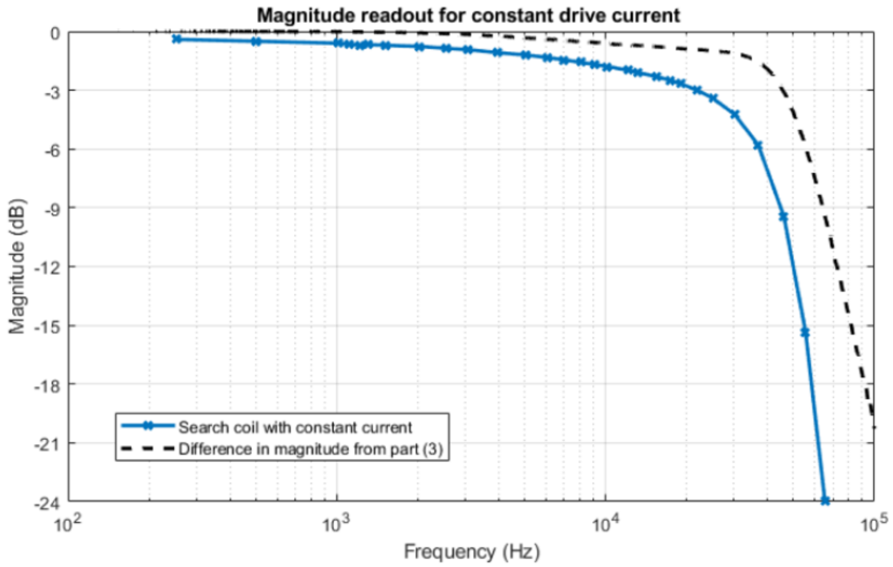
B) Increase voltage accordingly to keep current constant

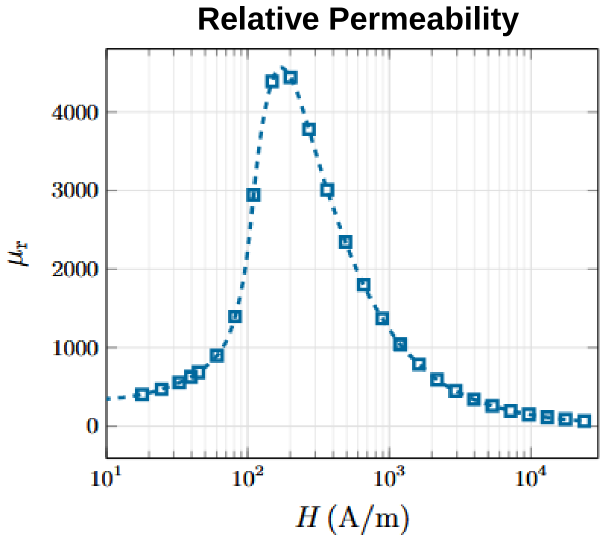
➔ Blue curve

- Results from B) suggest much lower bandwidth than those from A)

- Simulations suggest even lower bandwidth
- Suspected reason: simulation assumed much higher current, thus averaged permeability was much higher
➔ Eddy currents start to have an effect at much lower frequencies

➔ All of this needs further investigation





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CONCLUSION

- **Magnetic field profile measurement**
  - Hall sensor on movable arm to measure magnetic field at different positions along the longitudinal axis
  - With and without vacuum chamber
  - Up to roughly $f = 1\ \mathrm{kHz}$ good agreement with simulations, for higher frequencies measurements too noisy

- **Integrated transfer function measurements**
  - Search coil ➔ Measure induced voltage up to $f = 100\ \mathrm{kHz}$
  - Compute integrated field and integrated transfer function
  - No vacuum chamber included
  - No final results yet, work in progress