Normal magnets

From fabrications to magnetic caracterisations

JUAS - 2018

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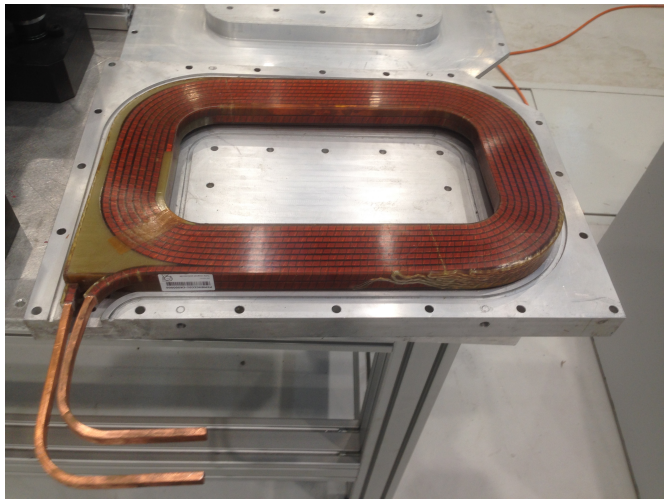
Oral presentations of practicals days at CERN, 12/03/2018

Outline

1. Magnets fabrication
   - Coil construction
   - Yoke construction
   - Current analysis
   - Magnetic flux
   - Coil design
   - Cooling
2. Magnetic Measurements
   - NMR Probes
   - Hall sensors
   - Pick-up coils (fluxmeters)
   - Field caracterisations
   - Rotating coil technique

Outline

Coil construction

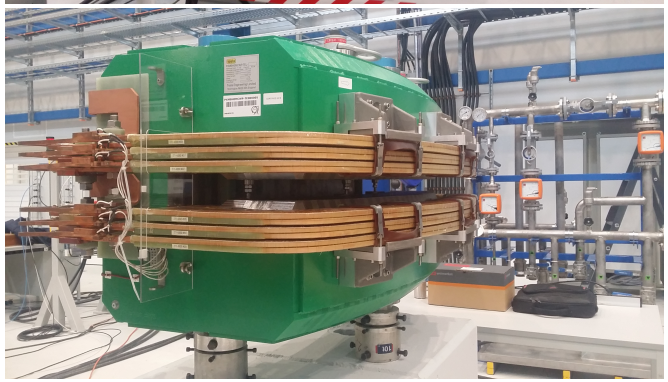


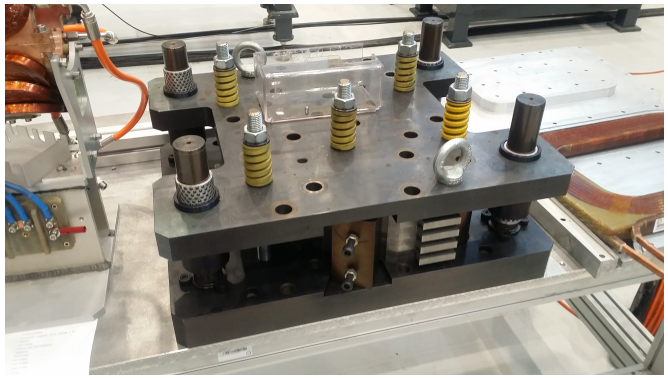
How it's made

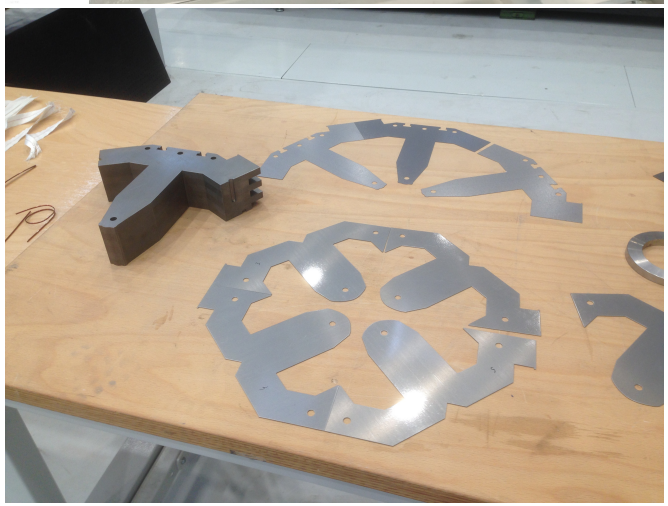
- Coil covered in kapton, glass fiber, then epoxy
- Shape created by bending around a special plate

Outline

Yoke construction

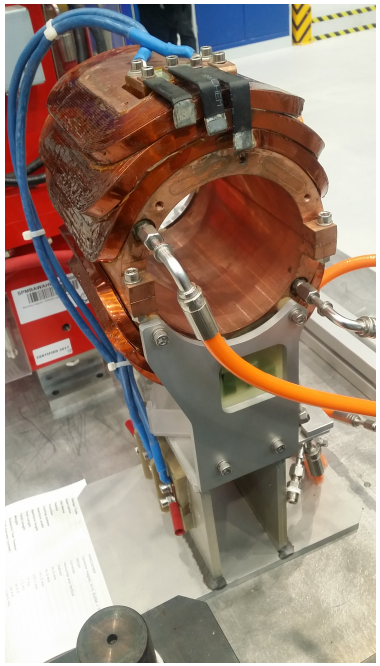


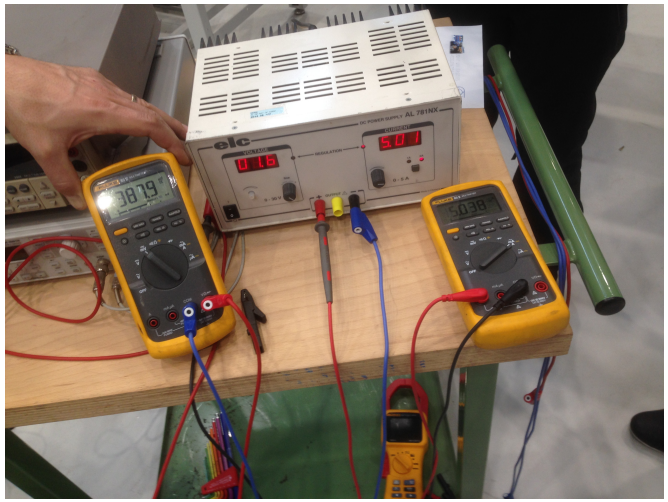


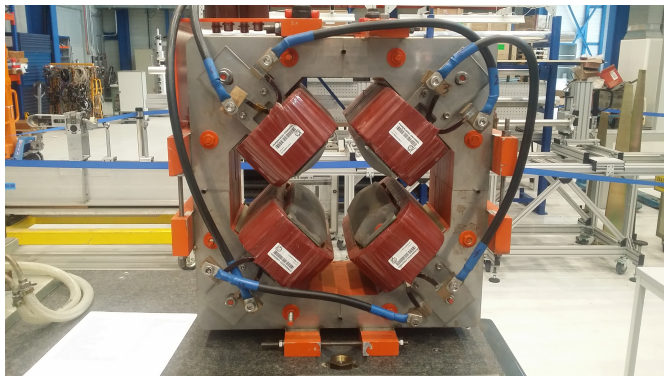


Outline

Current analysis



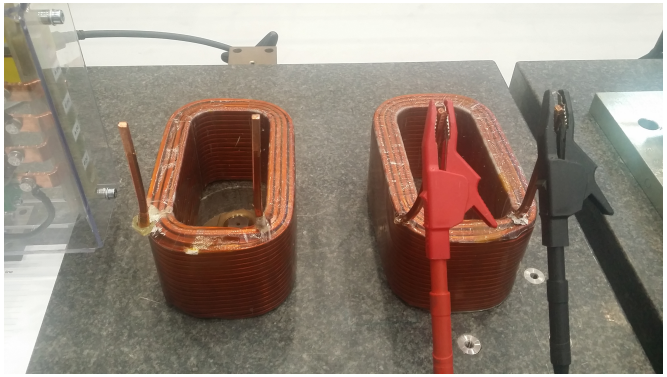


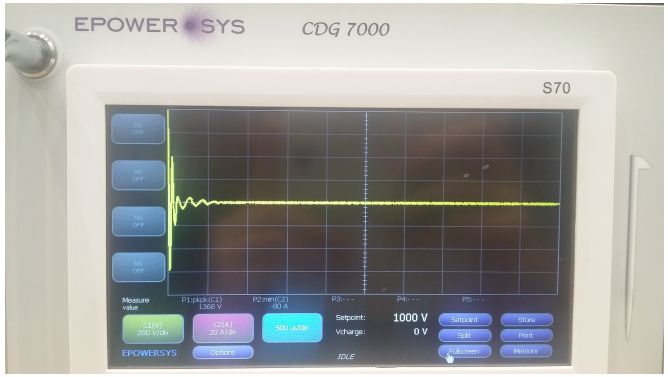


Coil-to-yoke insulation: 1kV, 1,5nA
$\Rightarrow$ 500 GΩ

Coil resistance : 478,7 mΩ

Current analysis





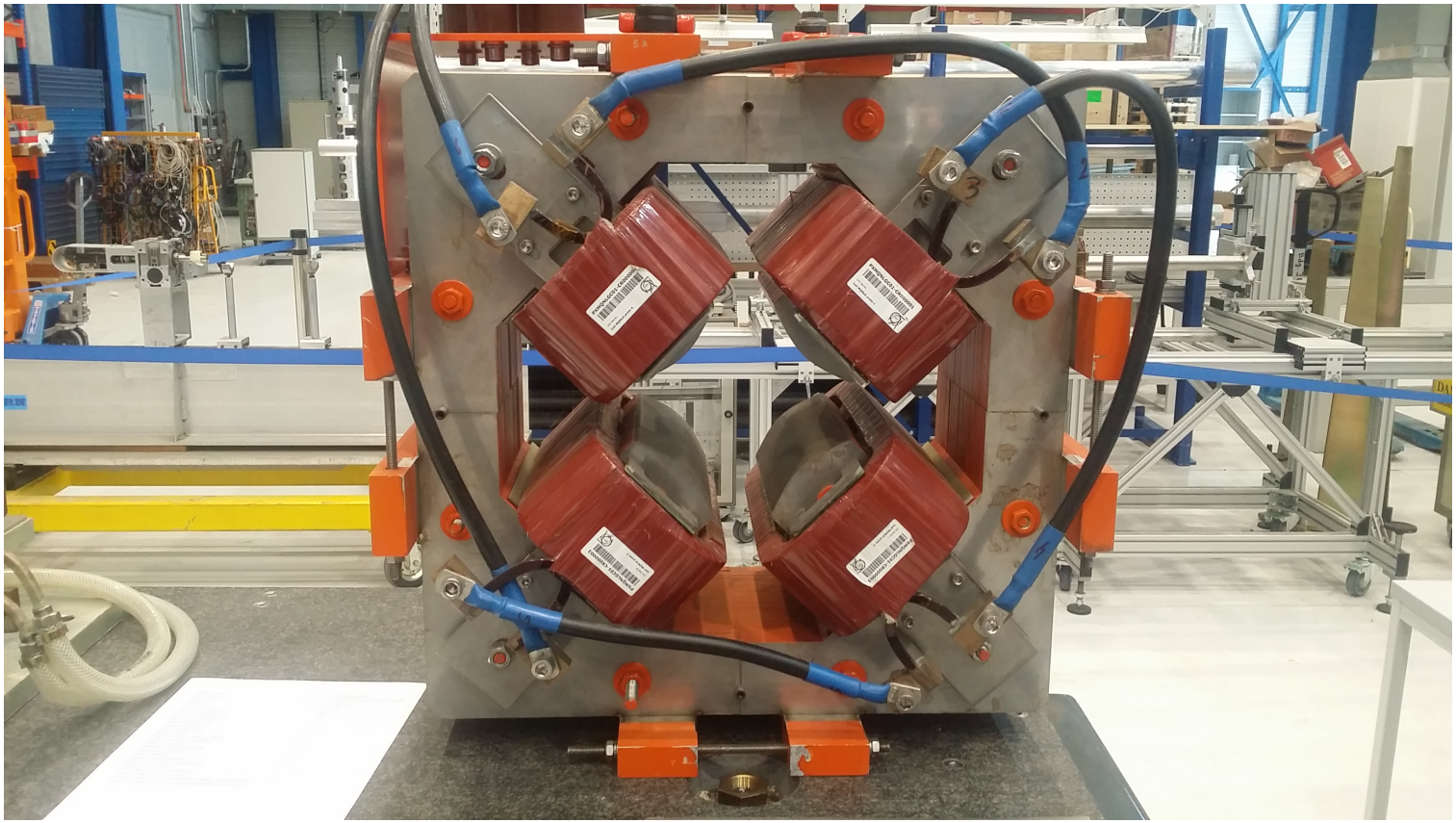
Comparison of 2 coils

Discharge in the coil, observe output current

difference between coils let us know which one is damaged

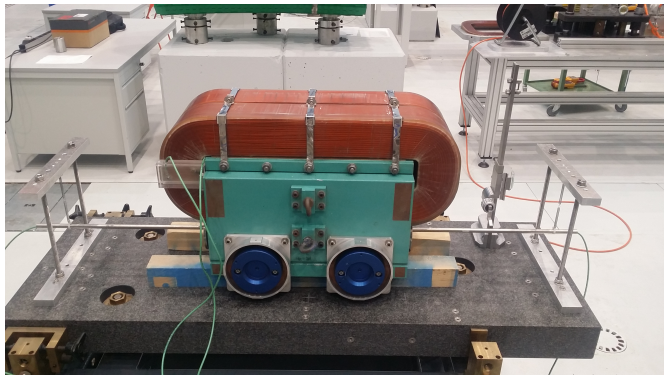
Outline

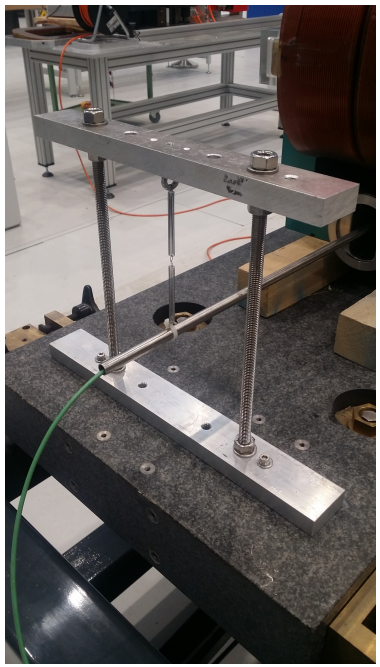
Magnetic flux



Outline

Coil design



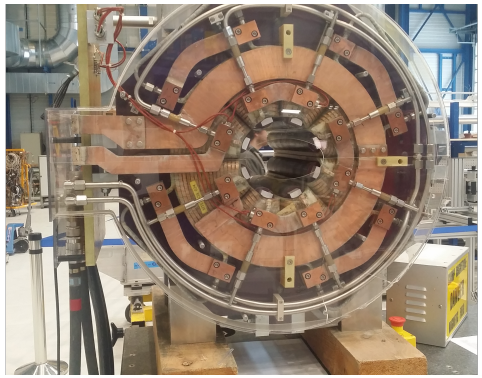


- $F = ILB = k\ \Delta\ h$
- $B = \frac{k\Delta h}{IL_{mag}}$
- $B = 0{,}2292$ T

- $N = \frac{Bh}{2I\mu_0\eta}$
- $N = 1063$ tours

Outline

Cooling



- $P = U \times I$
- $P = 24{,}37 \times 303 = 7{,}384$ kW

- $P = \frac{\Delta Q}{t} = c_p \Delta T D_m$
- $\Delta T = \frac{P}{c_p D_m}$
- $\Delta T = 19{,}271$ K for 2 coils

Outline

NMR Probes

Figure: NMR Probe with acquisiton

Caracteristics

- $F_{RES} = \gamma B$
- 1 PPM sensibility ($10^{-7} T$)
- Precalibrated by builder
- Temperature sensitive
- Slow measurement !

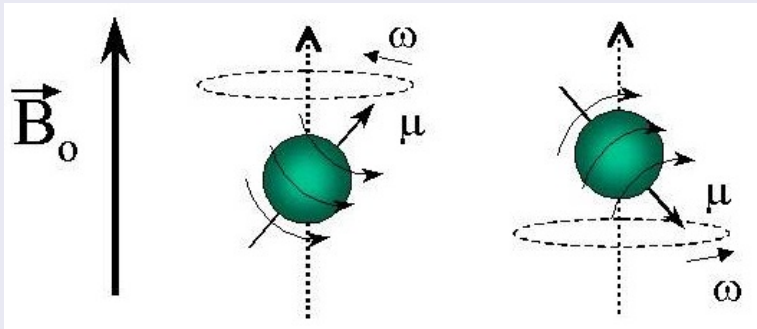


Figure: NMR principle

Outline

Hall sensors

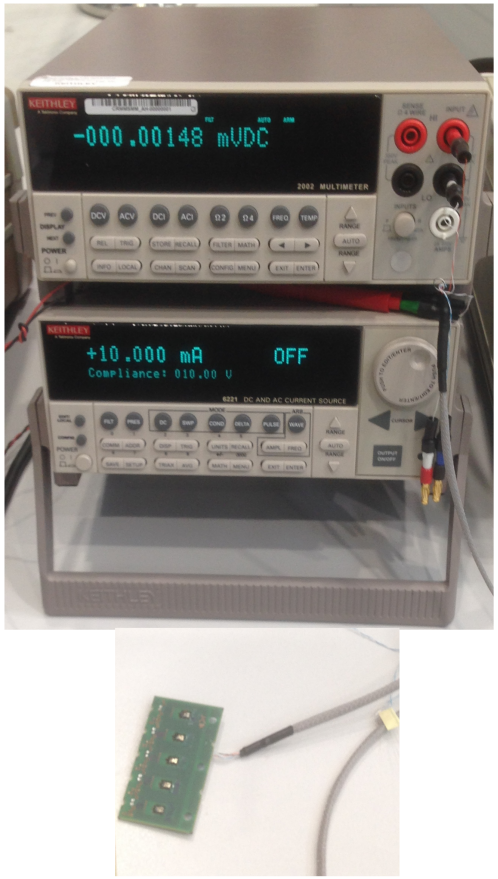


Figure: Hall probe with acquisiton

Caracteristics

- $V_H = GR_H IBcos\theta$
- sensibility of 10^{-3} to 10^{-4} V
- Can measure varying fields
- Works at low temperatures
- Temperature calibrated

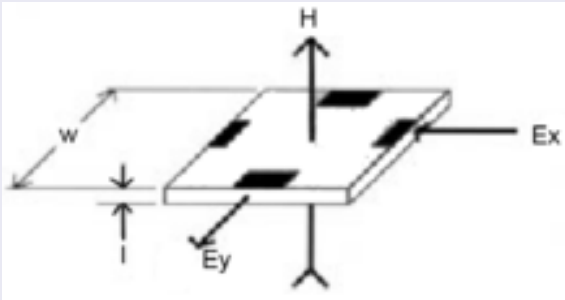
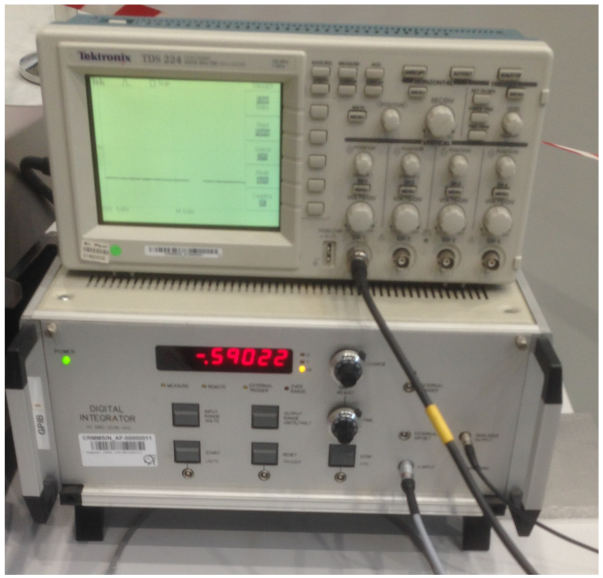


Figure: Hall probe principle

Outline

Pick-up coils (fluxmeters)



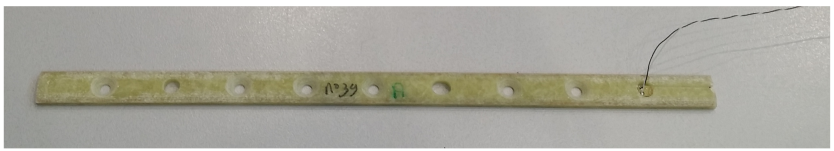


Figure: Pick-up coil with acquisiton

Caracteristics

- $V(t) = -\frac{d\Phi}{dt} = -\frac{d}{dt}[\oint_S B.dS]$
- sensibility of 10^{-3} to 10^{-4} V.s
- Needs an integrator
- Needs movement / varying field
- Uses induction law

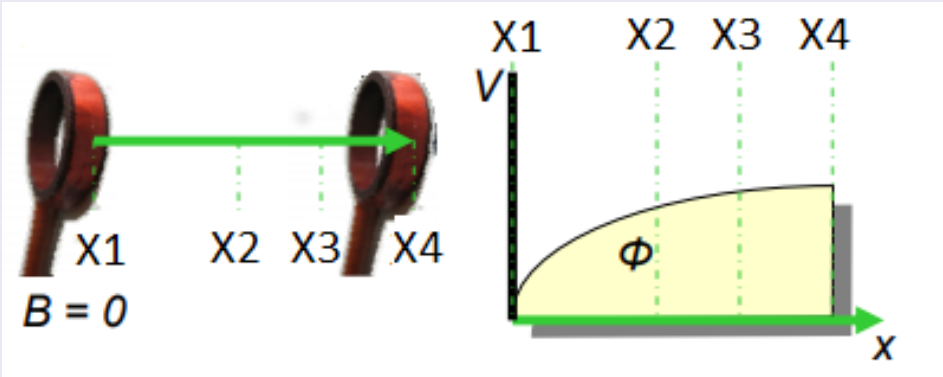


Figure: Fluxmeter principle

Comparison

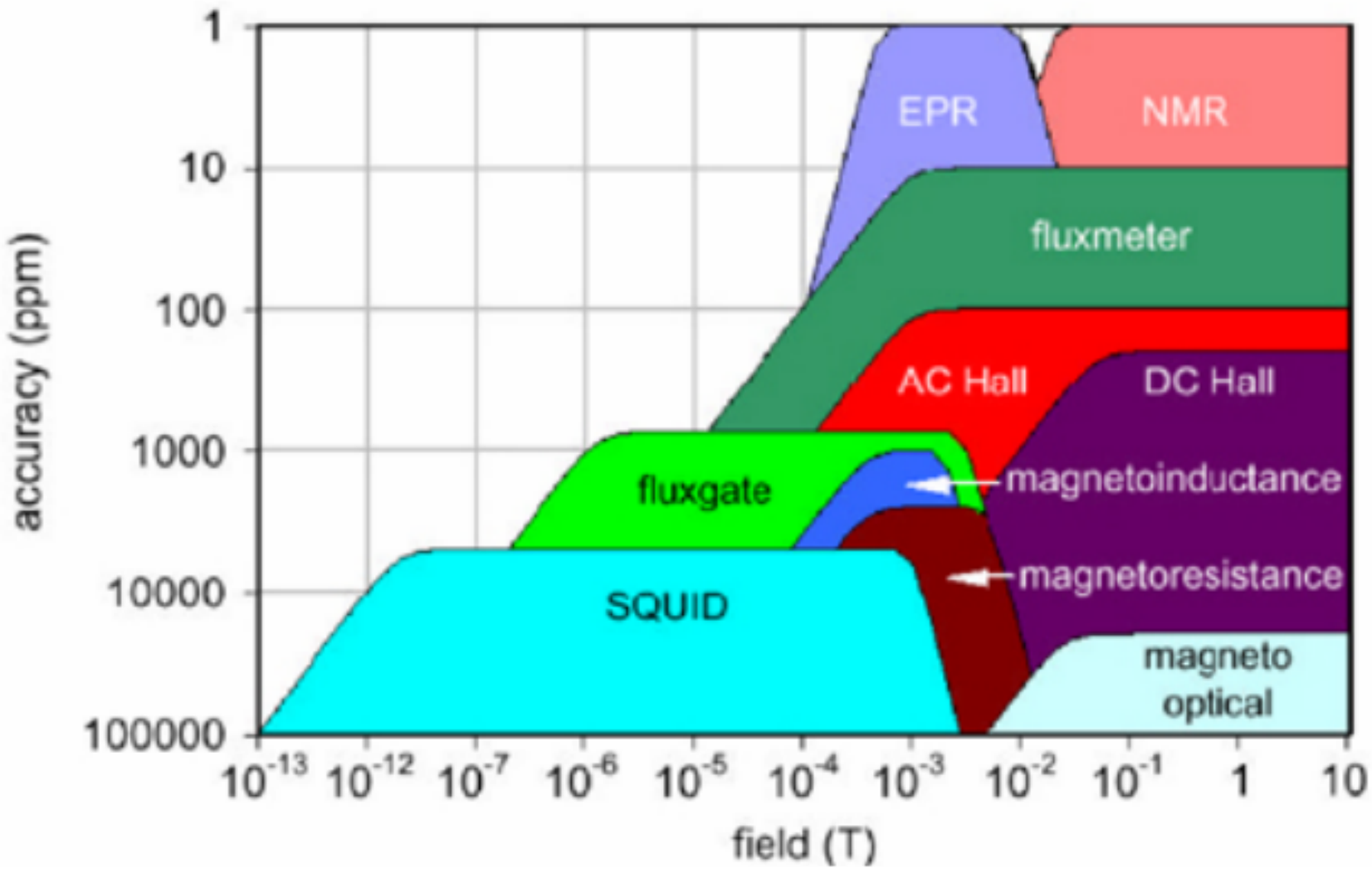


Figure: Comparison of all technique's sensitivities and maximal field

Outline

Field caracterisations

Figure: Magnet that has been caracterised during the 2nd part of the practical

Field caracterisations

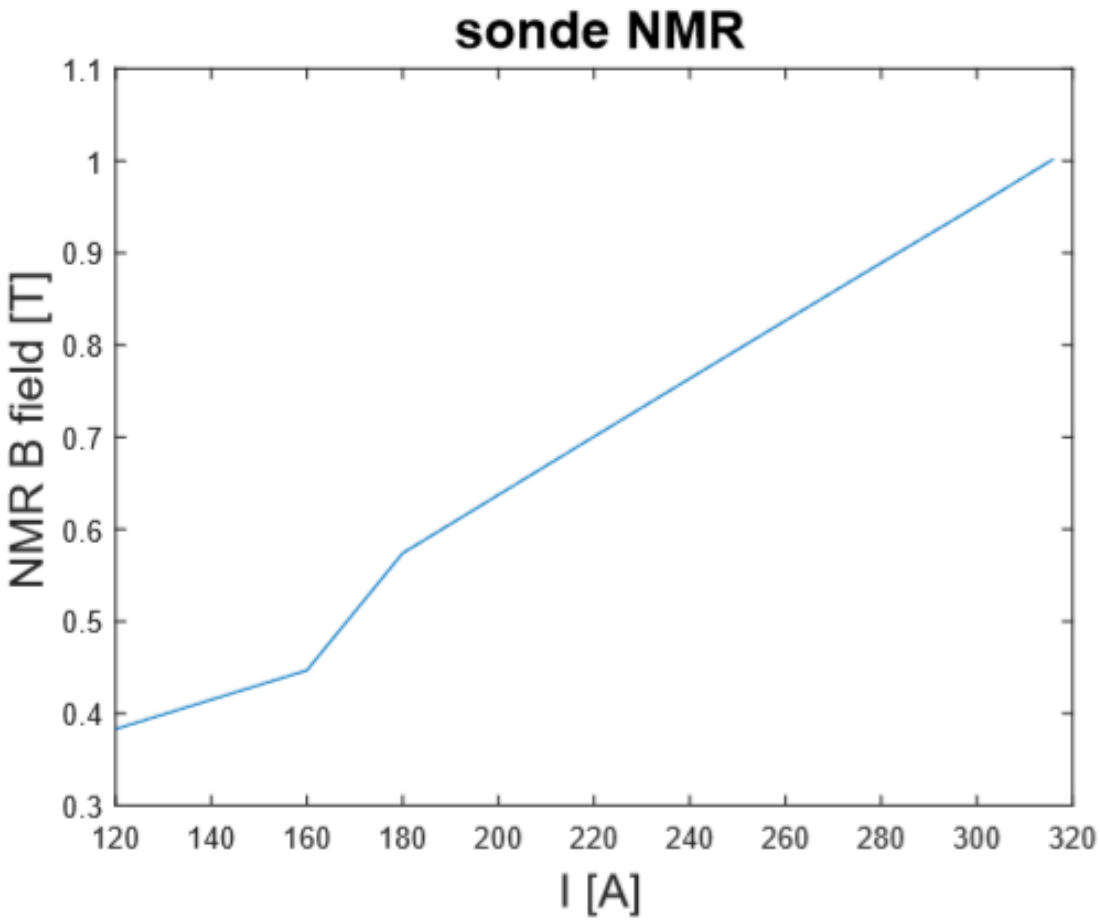


Figure: Curve obtained with the NMR probe absolute [B] measurements

Field caracterisations

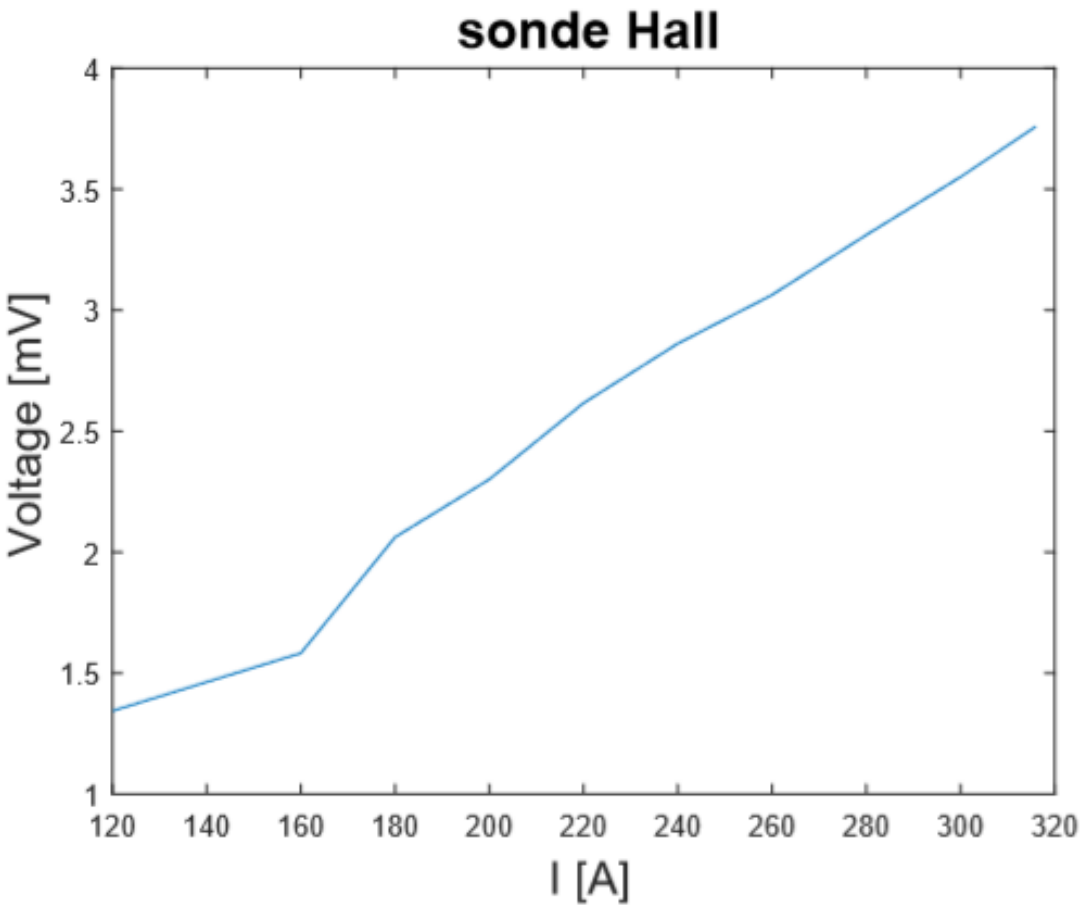


Figure: Curve obtained with the Hall probe [V] measurements

Field caracterisations

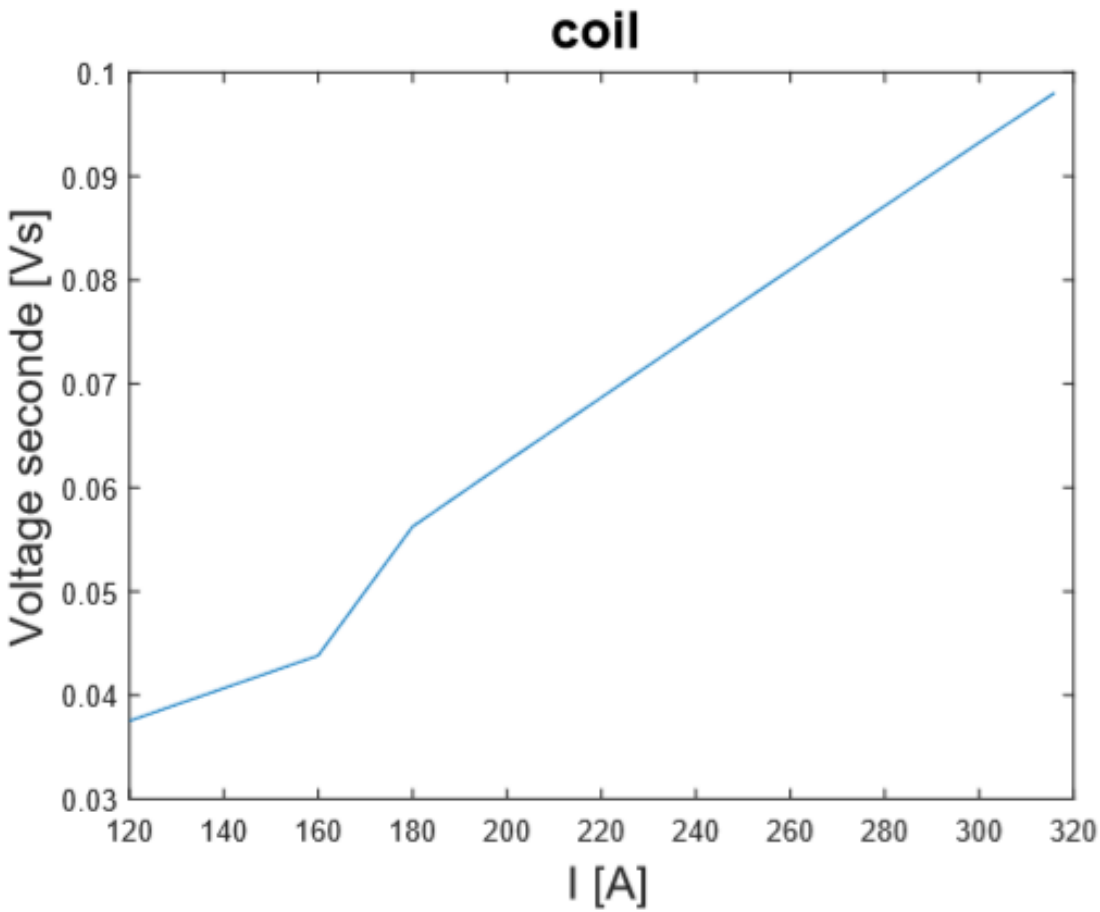


Figure: Curve obtained with the Pick-up coil [V.s] measurements

Results comparaison

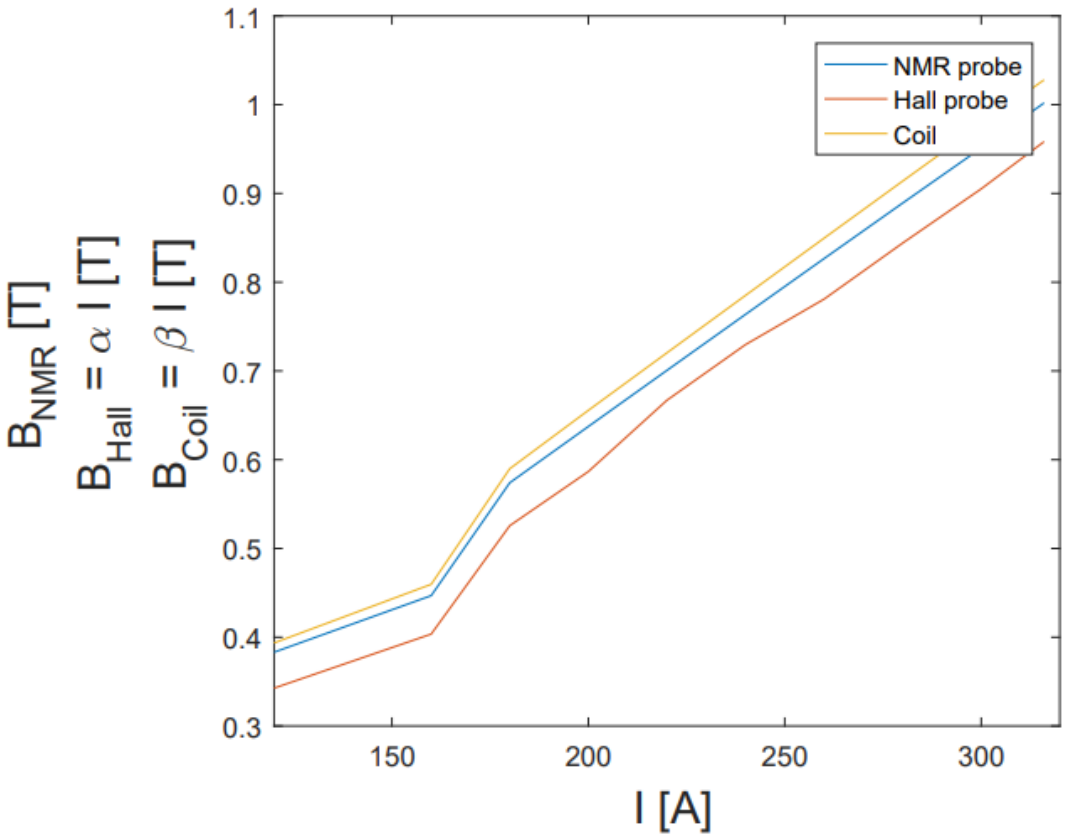


Figure: Adjusted curves obtained in magnetic field [B] units with the 3 techniques

Outline

Rotating coil technique

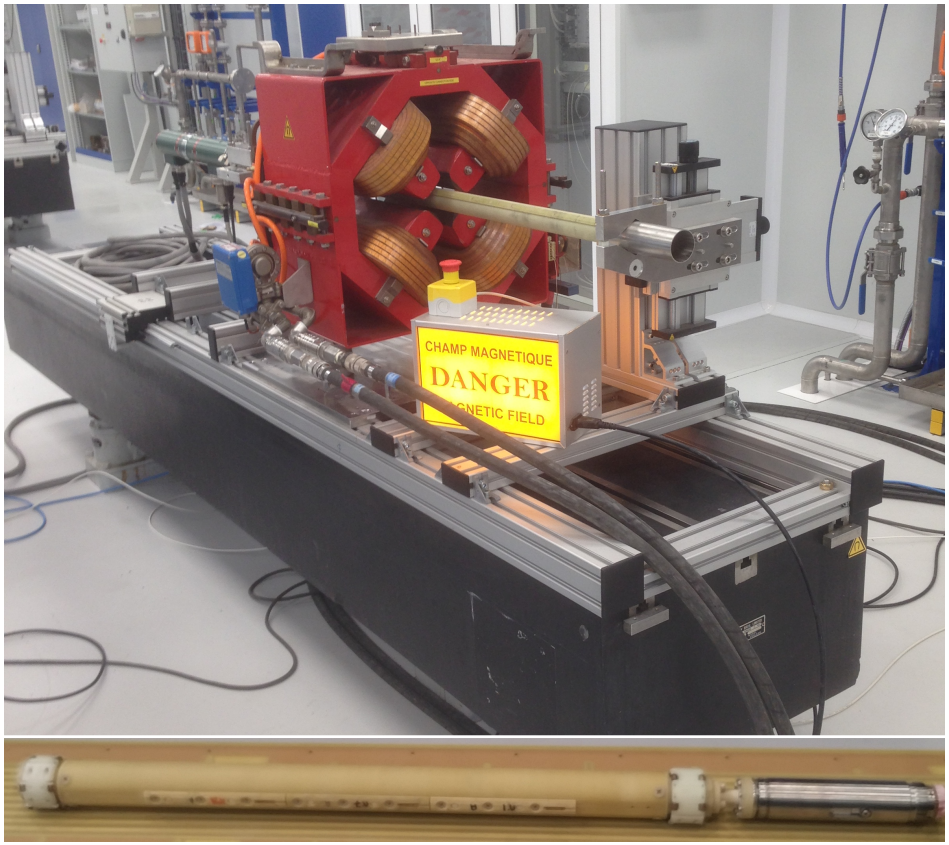


Figure: Rotating coil on a test bench with a quadrupole

Caracteristics

- 1,2 meter long coils on rotating shafts
- 5 coils superposed on all the height
- Extremely sensitive in position and field
- Measures the magnetic center position
- Determines the higher order fields induced by poles positioning

Rotating coil technique

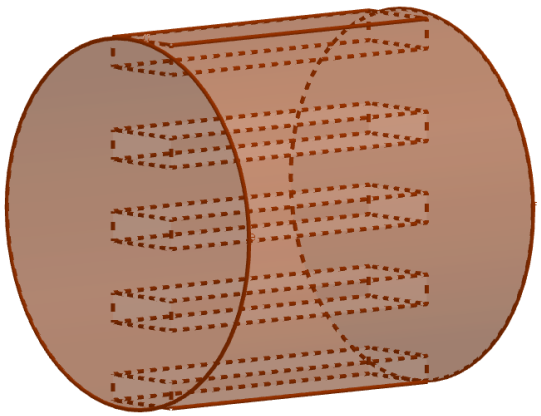


Figure: Structure of the rotating coil

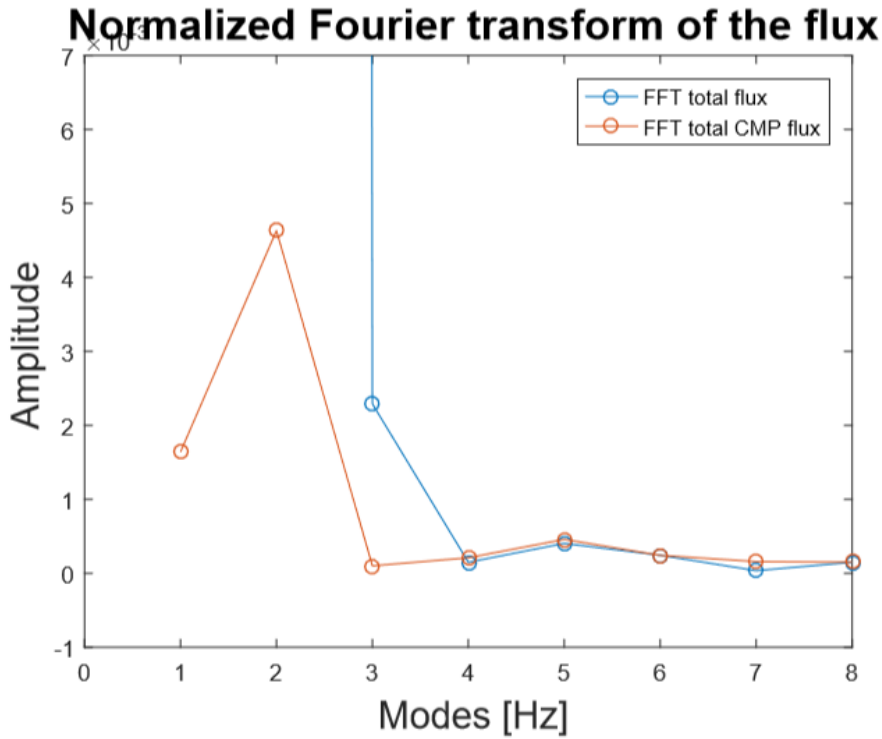


Figure: Modes excited by a missalignement (on magnetic center)

THANK YOU
FOR YOUR ATTENTION