

Joint Universities Accelerator School  
JUAS 2017

# Practical Works at CERN - Magnet Measurements

1<sup>st</sup> – 2<sup>nd</sup> March 2018

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CERN



# Visit our Magnet Measurement Lab



New lab constructed in 2017

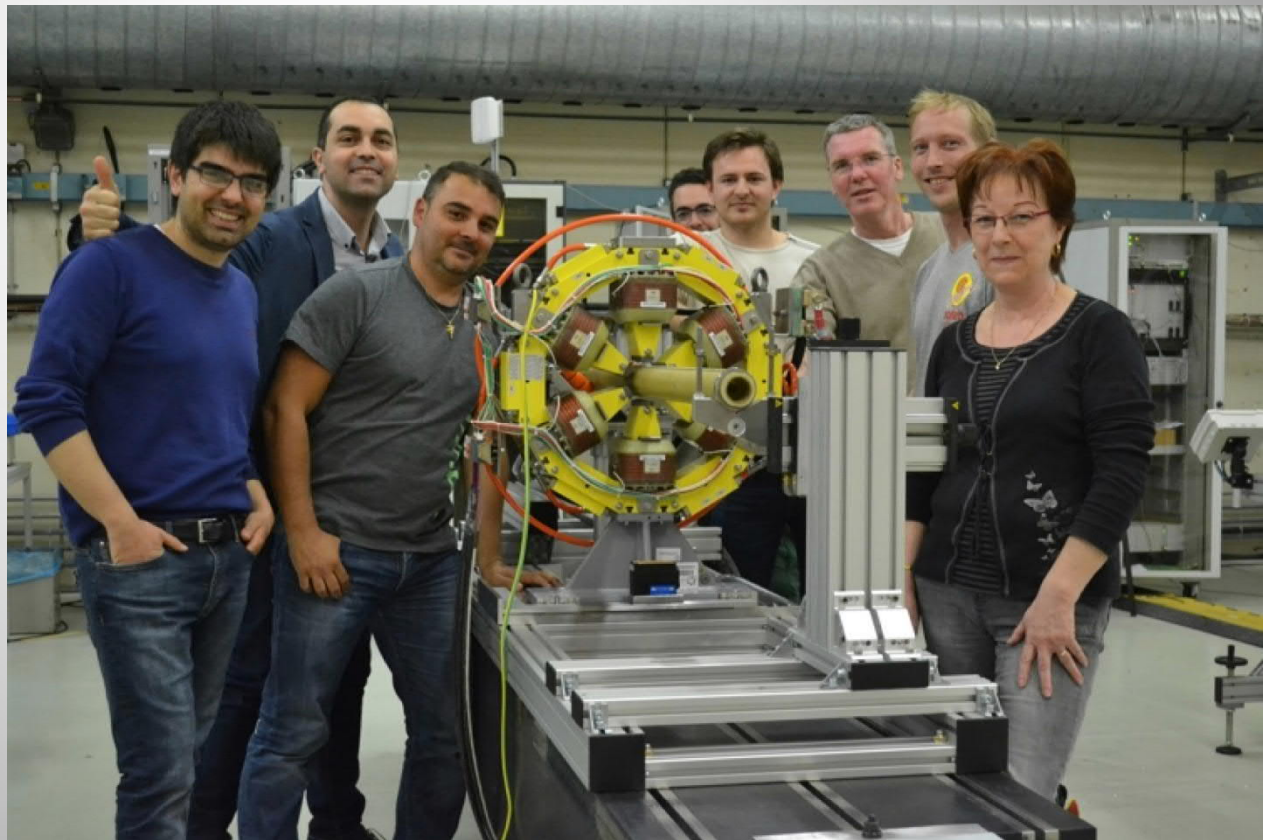




# Meet the experts

Strong team consisting of **+30 experts** (physicists, engineers, technicians and students):

- In charge of testing **all** of CERN's **17000 magnets**
- Magnetic characterization of materials
- R&D of **specialized** equipment
- **60+ years** experience



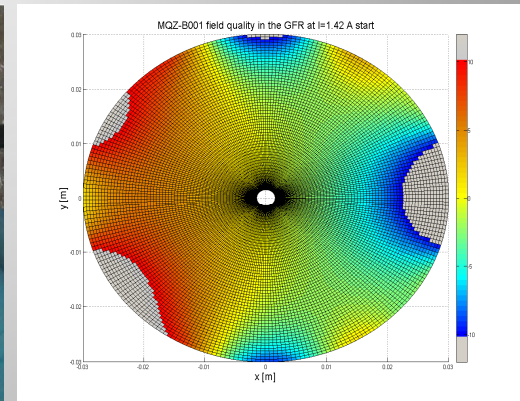
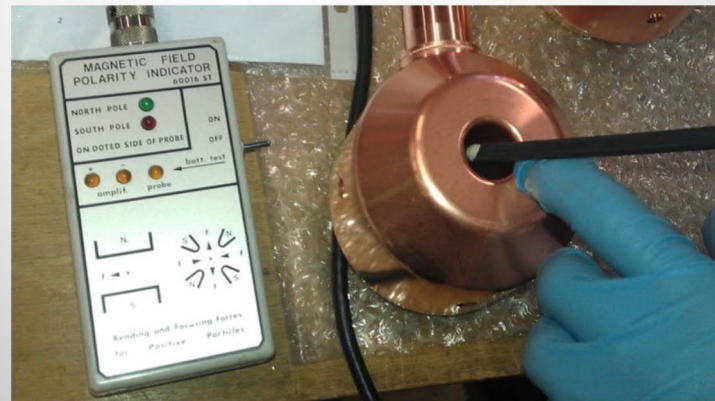
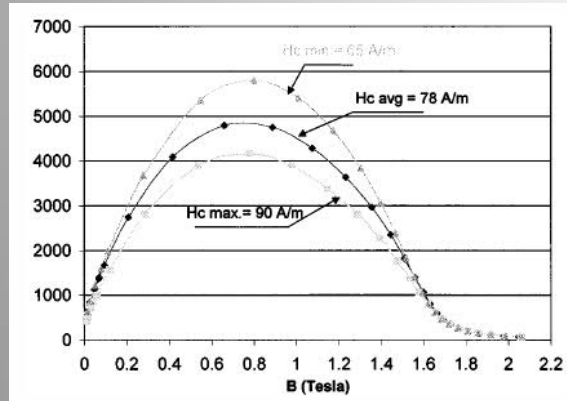


# Understand the motivation for MM



Magnetic measurements are performed to:

- characterize soft (iron) and hard (permanent magnets) ferromagnetic materials
- prove that the electro-magnetic design is correct
- monitor production quality and steer manufacturing
- collect information and data for operation: polarity, transfer function, field uniformity, magnetic axis, dynamic effects (eddy currents) and magnetic cycling effects (hysteresis)
- characterize magnets after repairs or to use in different operational ranges



Characterization (BH-curve) of magnet steel

Polarity check in drift-tube magnets

Field homogeneity in a quadrupole



# Explore different MM techniques



No single instrument or method can cover all requirements

- Multiple instruments are complementary
- Overlaps provide estimation of absolute uncertainty and error correction



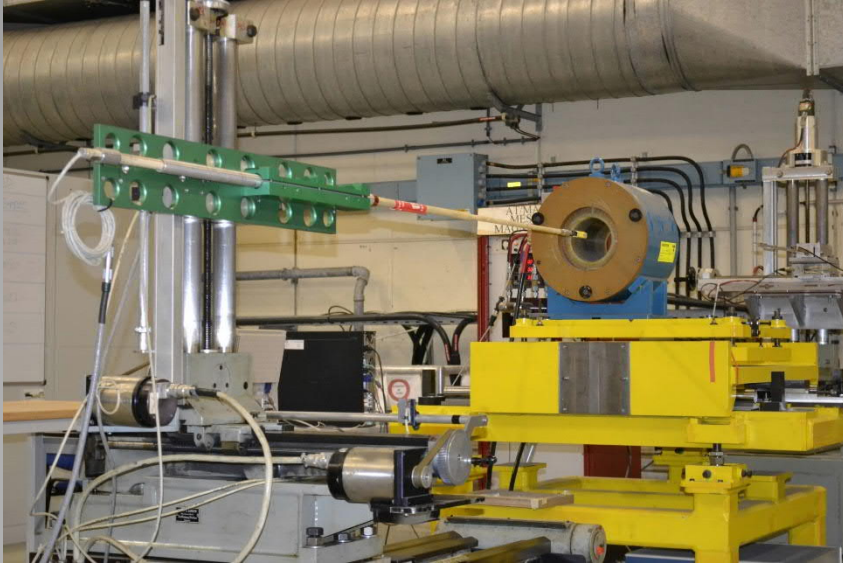
Courtesy www.metrolab.com



demodulated RF output in "marker mode"



# Explore different MM techniques



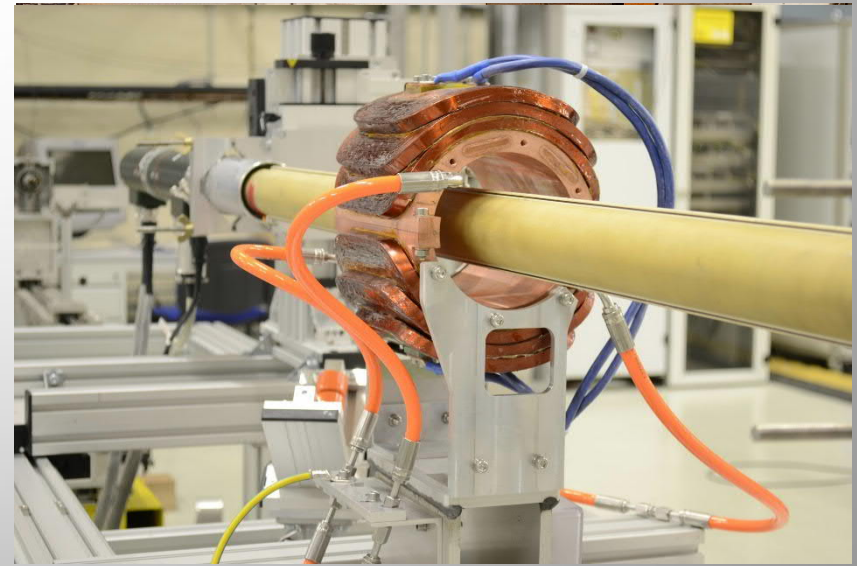
Hall probe mapper



Single stretched wire bench



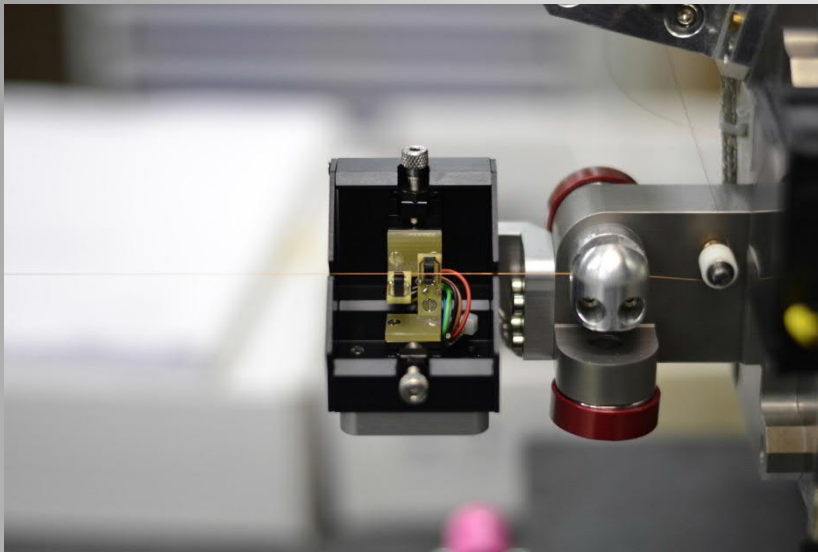
Induction coil magnetometer ("Fluxmeter")



Rotating coil magnetometer



# Find out about latest developments



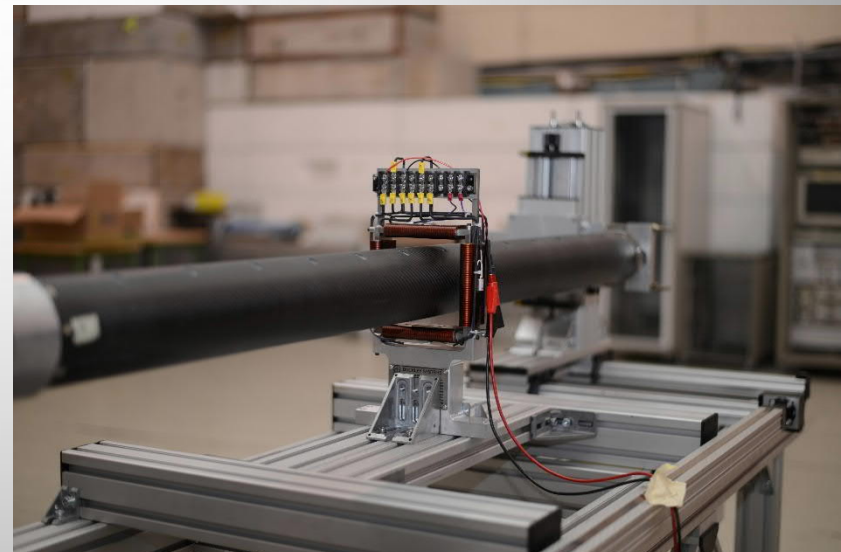
Photodetectors in the vibrating wire system



Fast digital integrator module



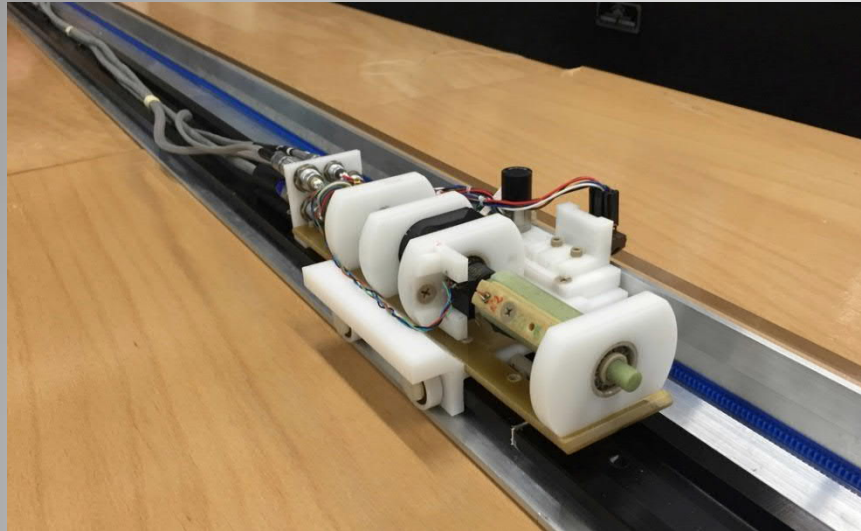
Nine-coil fluxmeter for the ELENA B-Train



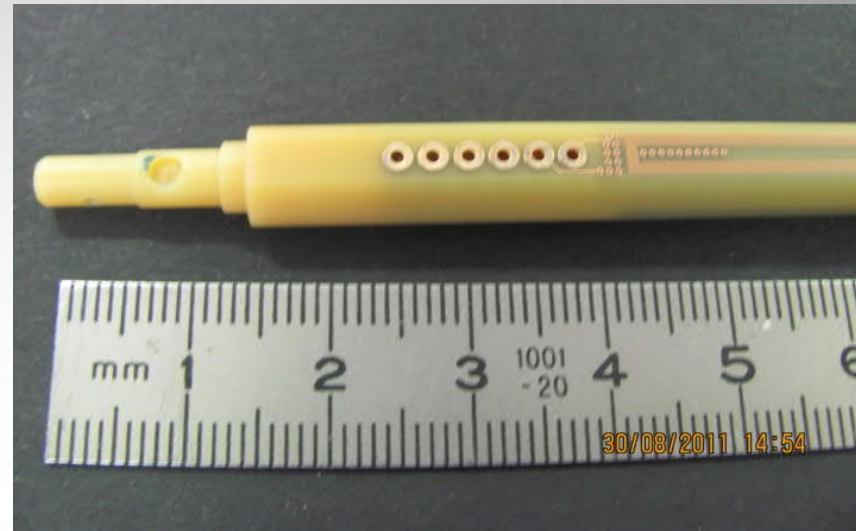
Large-diameter carbon fibre shaft



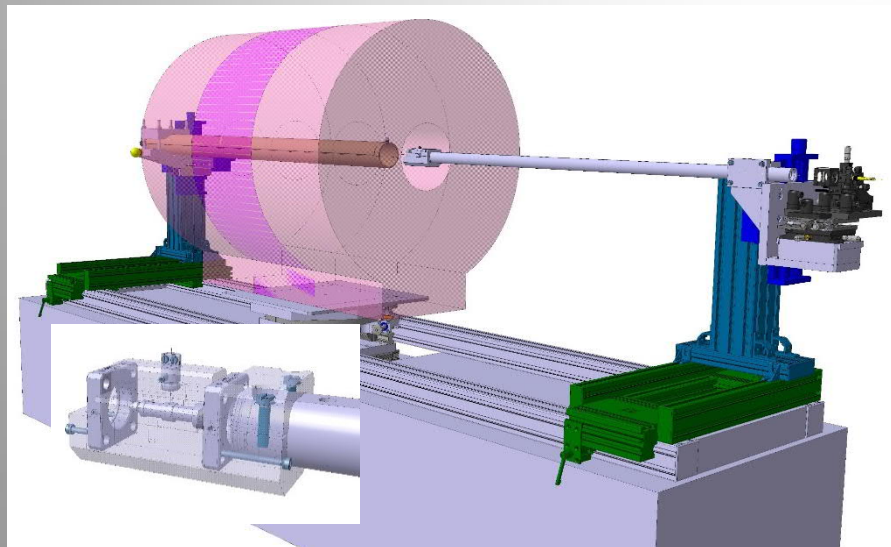
# Find out about latest developments



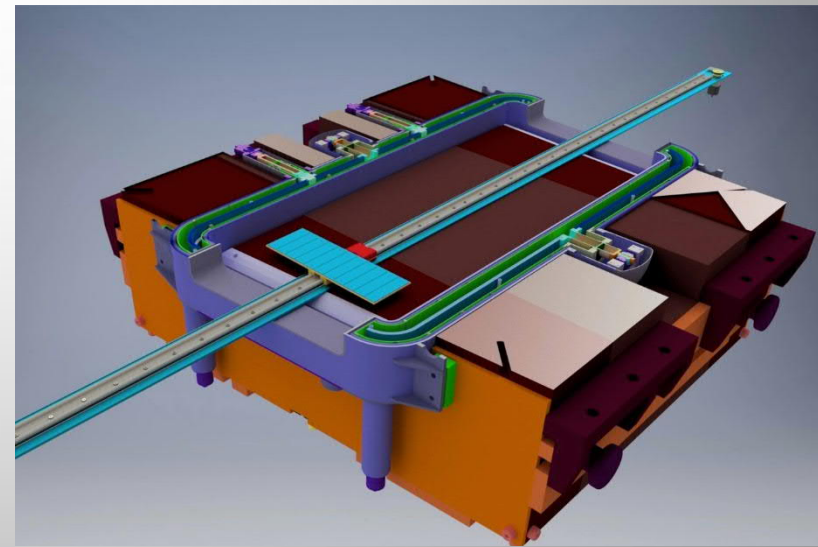
Rotating Coil Mapper (alias 'Toy Train')



Miniature rotating coil using PCB technology



Compass-Laser probe for Solenoids



Translating Fluxmeter for the FAIR project

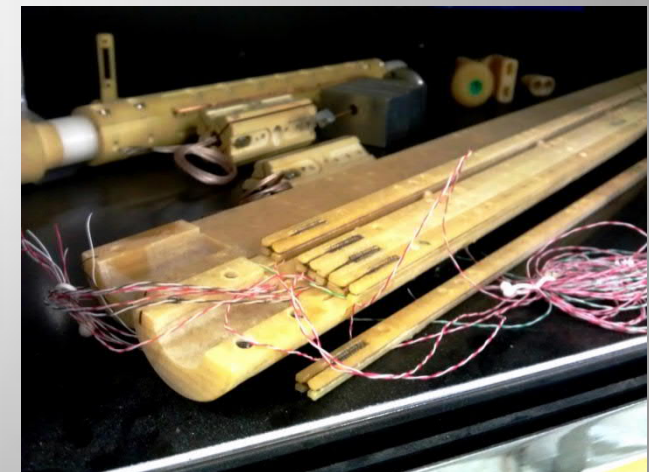
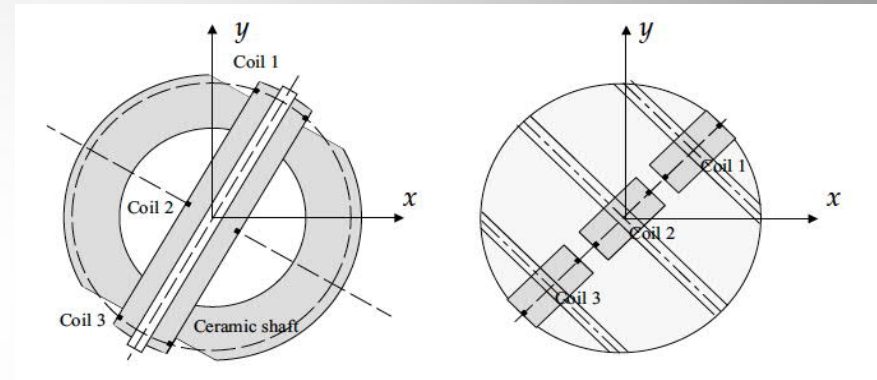
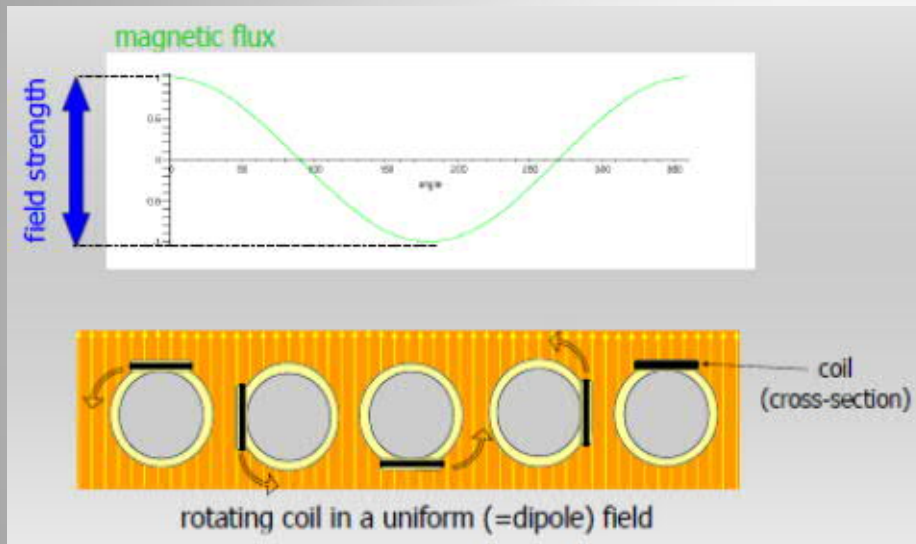




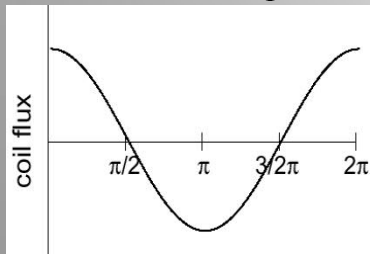
# Learn...



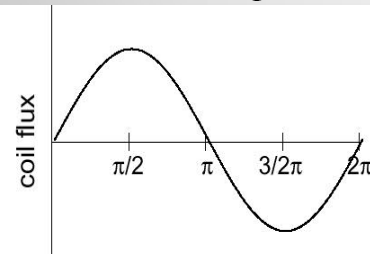
... how a rotating coil system works in detail



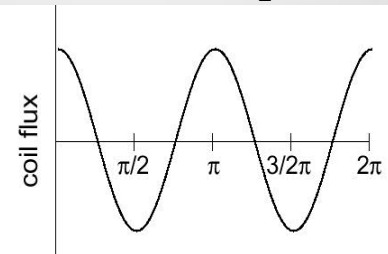
$n=1, B_1 \neq 0$



$n=1, A_1 \neq 0$



$n=2, B_2 \neq 0$

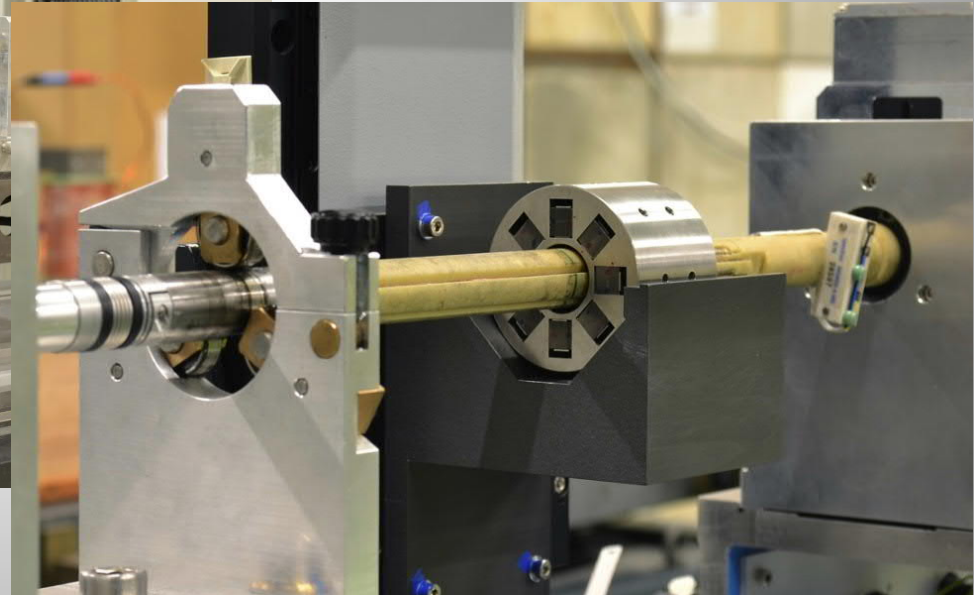
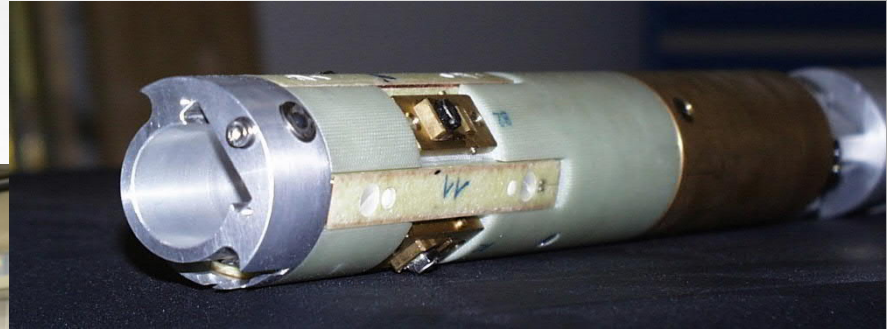




# Learn...



... how to prepare and run the system to measure a quadrupole magnet yourself

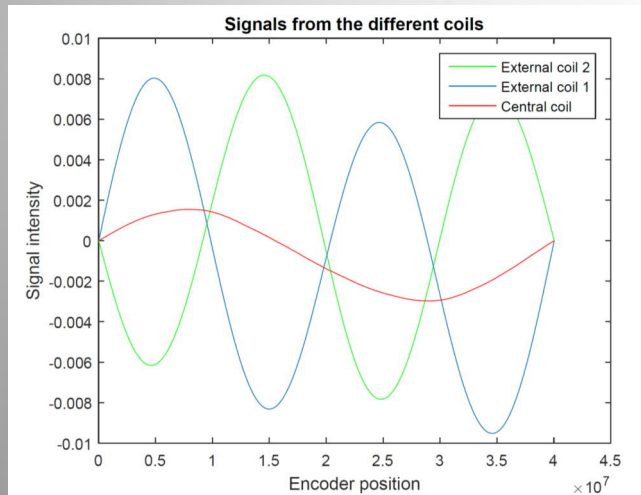
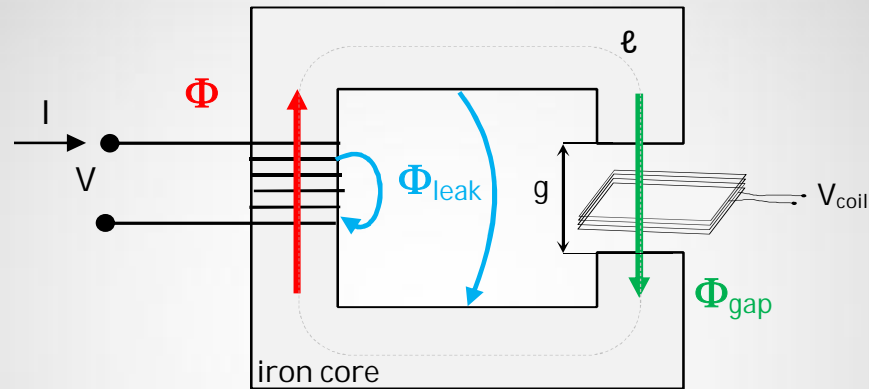




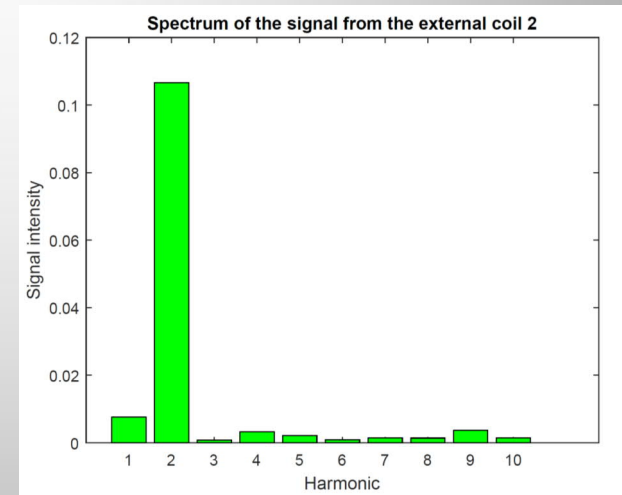
# Learn...



... how to analyse and interpret the results










Fourier transform





# Safety remarks

-  The laboratory is a workplace with associated hazards
-  Wear closed, flat or block-heel shoes
-  Eating, drinking and smoking are forbidden during the visit
-  Always follow the instructions of the guide
-  Don't touch any equipment unless explicitly asked by the guide
-  Never get away from the guide
-  No pacemakers allowed!





# Additional references



- L. Bottura, K. N. Henrichsen, "Field Measurements", Proceeding of CAS - CERN Accelerator School on Superconductivity and Cryogenics for Accelerators and Detectors, 2002
- A.K. Jain, "Measurements of Field Quality Using Harmonic Coils", US Particle Accelerator School (USPAS) on "Superconducting Accelerator Magnets", 2001
- M. Buzio, "Fabrication and calibration of search coils", Proceedings of CAS - CERN Accelerator School on Magnets, 2009
- L. Walckiers, "Magnetic measurement with coils and wires", Proceedings of CAS - CERN Accelerator School on Magnets, 2009



We are looking forward to  
welcome you at CERN!

Special thanks to my colleagues for providing the nice material and pictures