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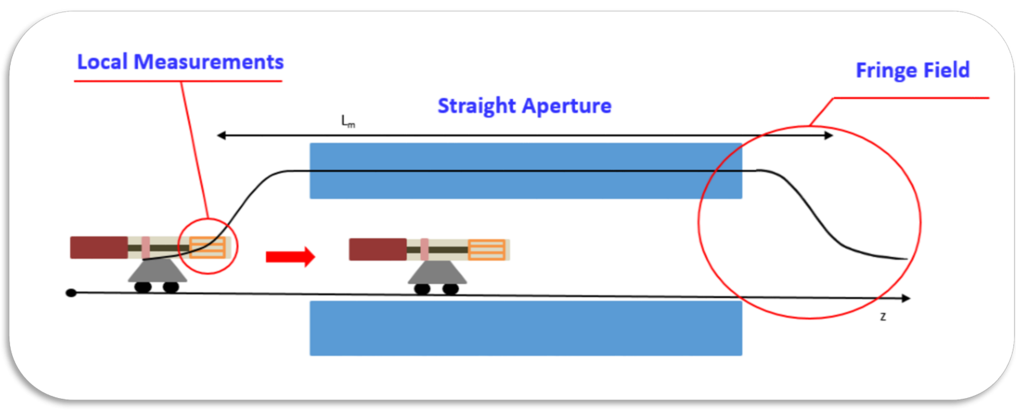
Tutors: Pasquale Arpaia – Stephan Russenschuck

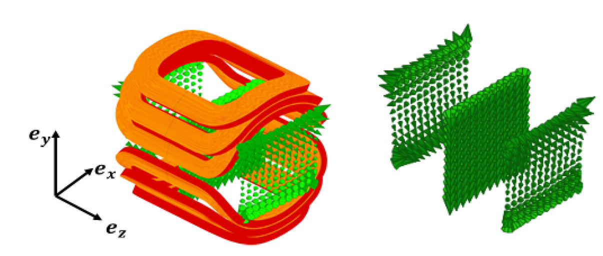
XXXI Cycle - II year presentation

Rotating Coil Sensor for Transversal Field Harmonics

Measuring the **transversal field harmonics** with a very-**short rotating induction-coil sensor** is a way to extract the coefficients of a Fourier-Bessel series (**Pseudo-Multipoles**), which can be used to compute the full field map of accelerator magnets.

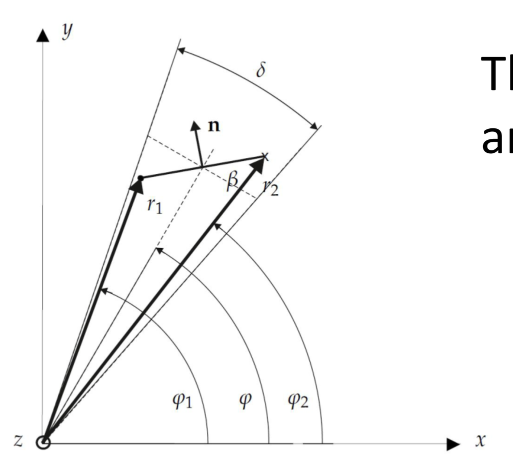


Research efforts are required to develop a mathematical model that links magnetic measurements with pseudo-multipoles, to design and procure a short sensor insensitive to the longitudinal field component and sensitive to high-order harmonics with a resolution of 100 ppm.



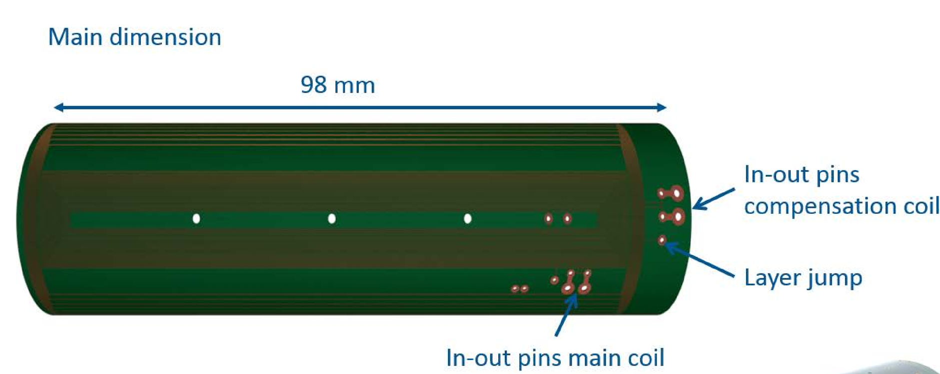
Local field distribution measurements are required for describing the **longitudinal field profile** and studying the **particle-beam dynamics**.

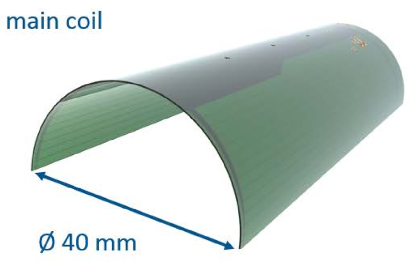
The design of the **iso-perimetric, saddle-shaped** coil has been based on the standard equation of the coil-sensitivity factors. The main parameters have been adapted to the chosen production technology; that is the **flexible circuit board technology.**



The design has been optimized tanking into account the mathematical analysis results achieved during the PhD first year.

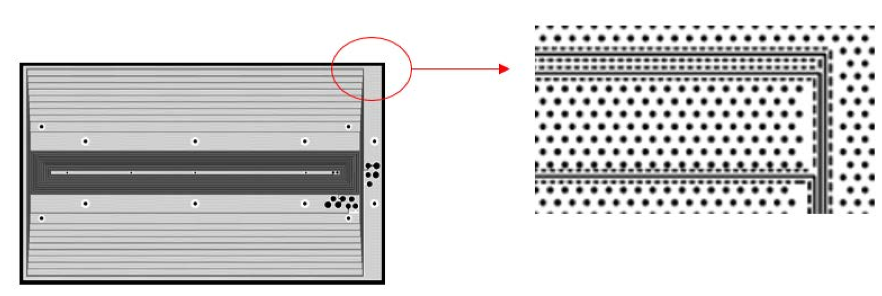
$$K_n = K_n^{rad} + iK_n^{tan} = \frac{Nl}{n}(r_2^n e^{in(\varphi_2-\varphi)} - r_1^n e^{in(\varphi_1-\varphi)})$$

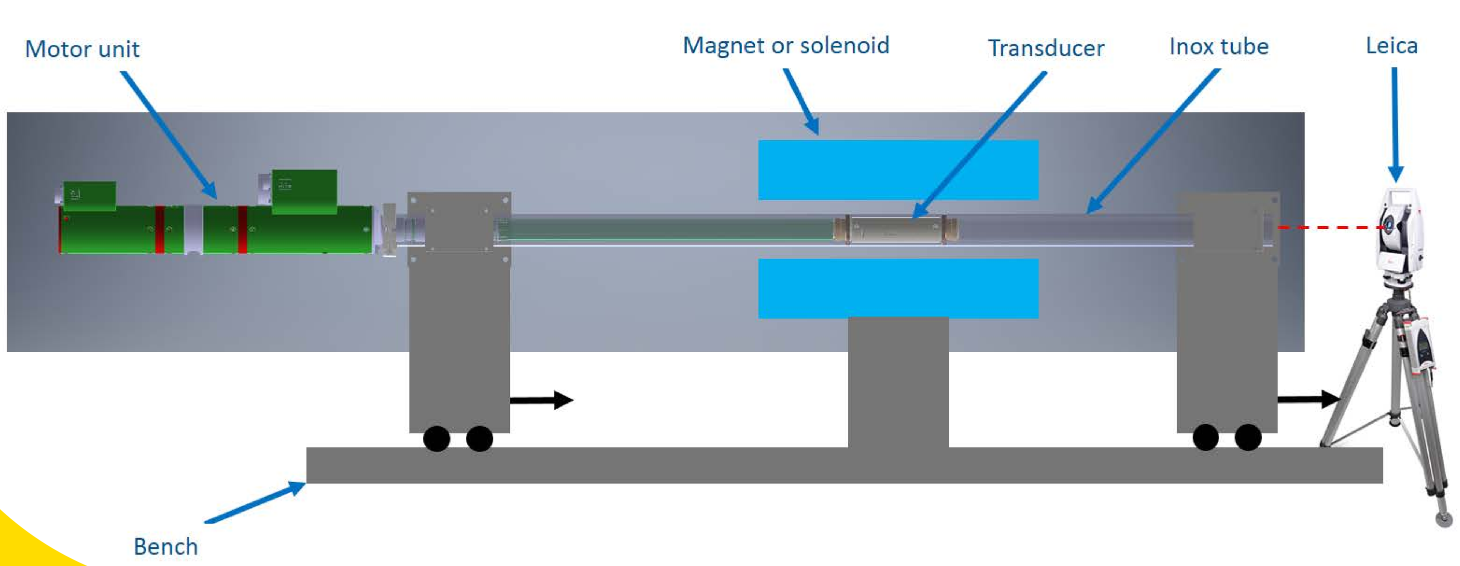




The sensor will have two coils; a ***main*** and a ***compensation coil***. The main coil for measuring the multipole field components and the compensation coil (mainly sensitive to the dipole and quadrupole field distribution) to realize the ***compensation scheme***. Since the two coils (connected in anti-series) are designed to have the same sensitivity for the dipole field component, it is possible to increase the signal-to-noise ratio by the factor of about 1000. A particular challenge was to design the layer jumps between the four layers, by minimizing the differences between theoretically best and actual paths.

The sensor prototype was not satisfactory. Errors on the tracks dimension were detected, which were due to the larger quantity of corrosive acid around the external paths. As a solution, some dashed copper lines were added around each single tracks. This required to check for eddy current effects and perform a sensitivity analysis to calculate the production uncertainty (track position errors, PCB thickness tolerance and shaft radius tolerance).





The design process has involved the transducer as a whole. In fact, it will be assembled with an iso-perimetric induction-coil, a standard radial coil, two hall probes and a temperature sensor for reference and cross-calibration.

The measurement setup for the proof of principle has been designed to have all the needed measurements to validate the new sensor design on a unique transducer.

Contacts

- **CERN - Technology Department (TE) – Magnetic Measurement Section (MM)**
- **University of Naples "Federico II" - DIETI**
- **Instrumentation & Measurement for Particle Accelerator Lab (IMPALab)**

Università degli Studi di Napoli Federico II

Magnetic Measurements

Instrumentation & Measurement for Particle Accelerator Lab IMPALab

Future Activity

- Complete ***WP1-Transducer concept design and experimental proof of principle*** (90%)
- Complete ***WP2-Transducer physical design and implementation*** (60%)
- Advance on ***WP3-Tranducer metrological characterization*** (20%)
- Launch ***WP4-On field testing*** (new superconducting magnet for HI-LUMI HL-LHC project) (10%)