APPLIED METROLOGY IN THE PRODUCTION OF SUPERCONDUCTING MODEL MAGNETS FOR PARTICLE ACCELERATORS

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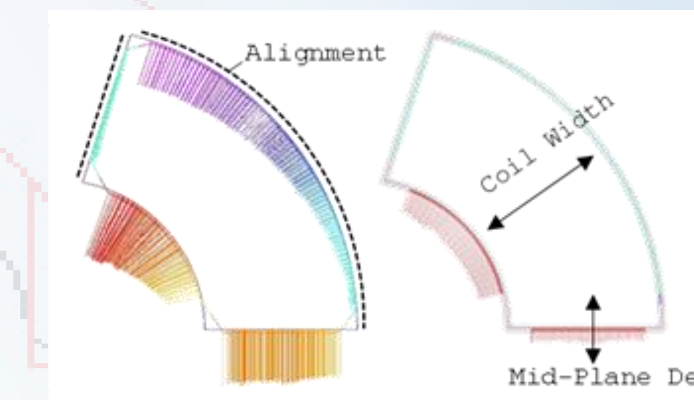
Thu-Af-Po4.01

Abstract

The objective of the poster is to present the experience from systematic geometrical measurements performed during the on-going production of model magnets for HL-LHC. First, the methodology for the data acquisition and its ulterior analysis is shown. Then, the results obtained in terms of coil geometry are explained with the goal of identifying the principal factors causing systematic and unexpected dimensional deviations. Finally, the coil geometry before and after cold test is compared for those coils available.

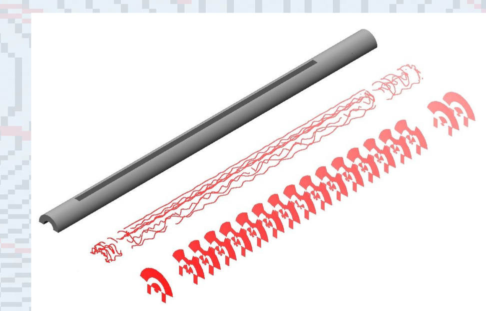


I. Introduction

- For correct operation, the geometry of superconducting coils and structural components must be precise.
- Systematic geometrical checks are performed to guarantee the requirements.
- Coils are fixed on a marble reference surface and measured using a commercial portable Coordinate Measurement Machine (CMM).
  - Volumetric Accuracy: ±41µm*.
  - Single Point Repeatability: 29 µm*.

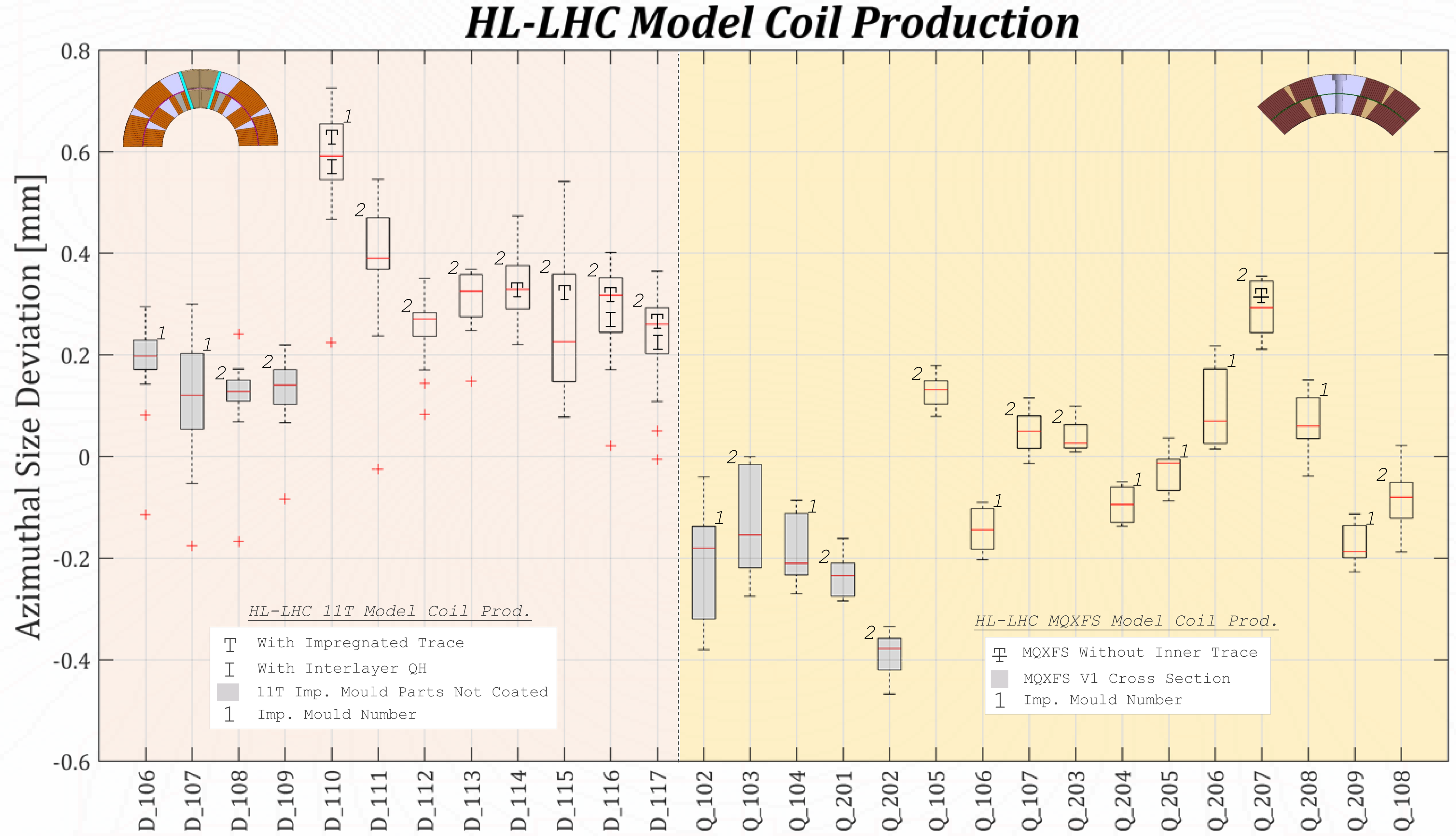
* Values obtained using a subset of test methods given in the ASME B89.4.22 standard.

II. Methodology And Analysis Convention



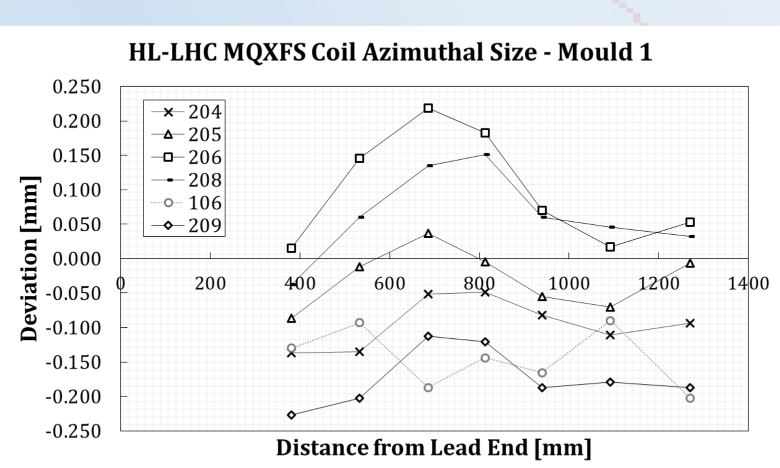
- Coil geometry reproduced using a dense point cloud, divided in global and cross sectional data.
- Individual cross section alignment set to reproduce the magnet assembly.
  - Best-fit algorithm applying a unitary weighing function to all considered points. 5% of outliers excluded.
- We define:
  - Coil Azimuthal **Size = L+R**
  - Coil Azimuthal **Asymmetry = L-R**

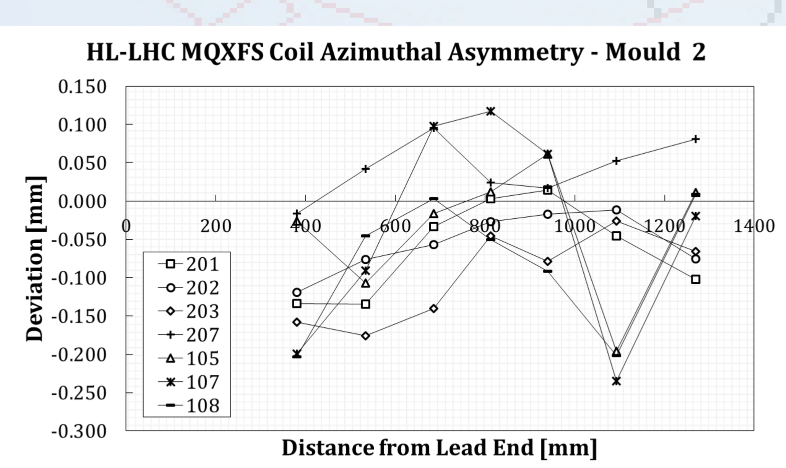
Where L or R = Left or Right mid-plane deviation in azimuthal direction.



III. HL-LHC MQXFS

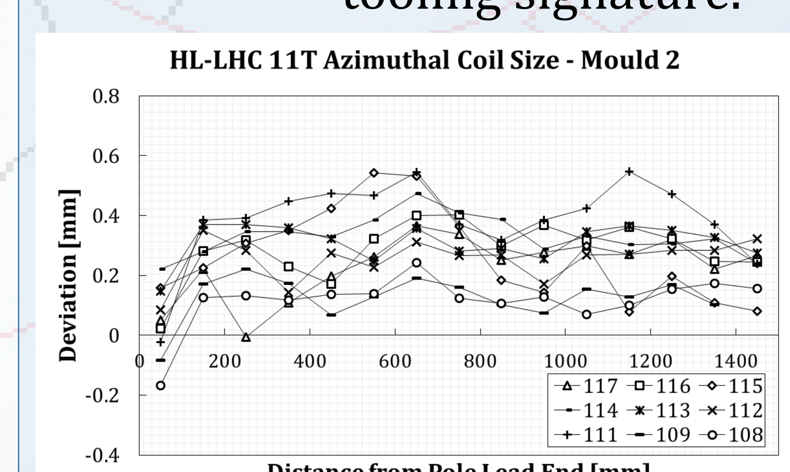
- Range for the average coil azimuthal size dev. along production = 0.679 mm / σ = 0.168 mm
- Impregnation tooling signature in coil size longitudinal variation. No systematic trend in coil asymmetry, governed by pole parts geometry.
- Bigger size when mould compaction is increased.

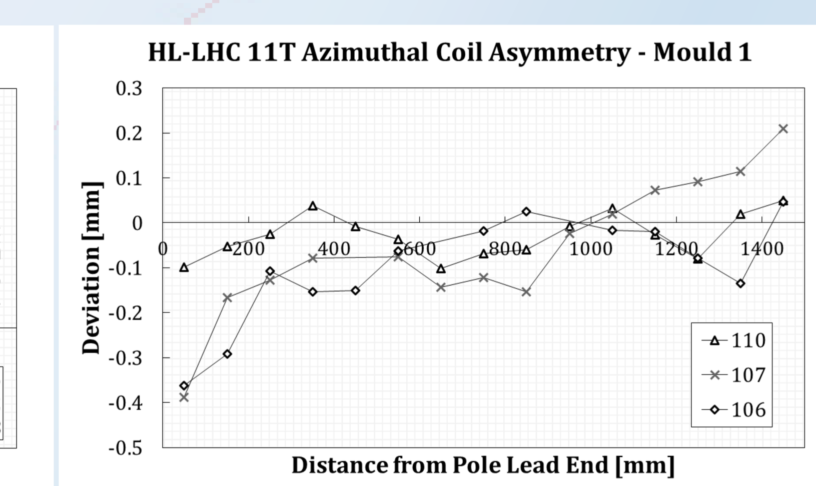




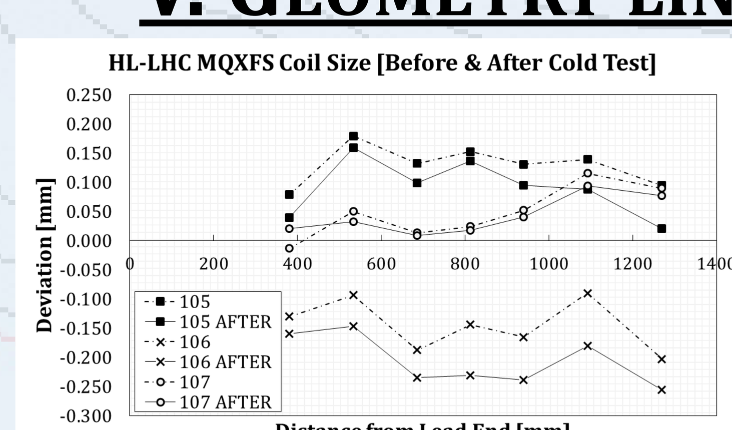
IV. HL-LHC 11T Dipole

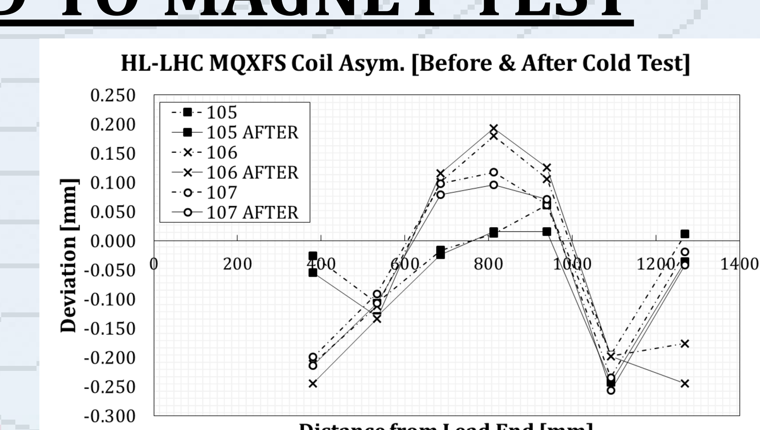
- Range for the average coil azimuthal size dev. along production = 0.461 mm / σ = 0.132 mm
- For both magnets, the same trend as in azimuthal size is seen in radial direction.
- Higher mould compaction compared to MQXFS: Coils have been always bigger than nominal size. Less clear tooling signature.





V. Geometry Linked to Magnet Test





MQXFS3a Coils: Decrease in size, asymmetry maintained.

CONCLUSIONS: Similar scattering in the absolute value of coil size dev. for both magnets, but dipole aperture ≈ 1/3 quadrupole aperture. Key aspects: Mould compaction, stress release, tolerances and production variations.