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Study of electromagnetic shielding, a comparison between experiment and FEM simulation

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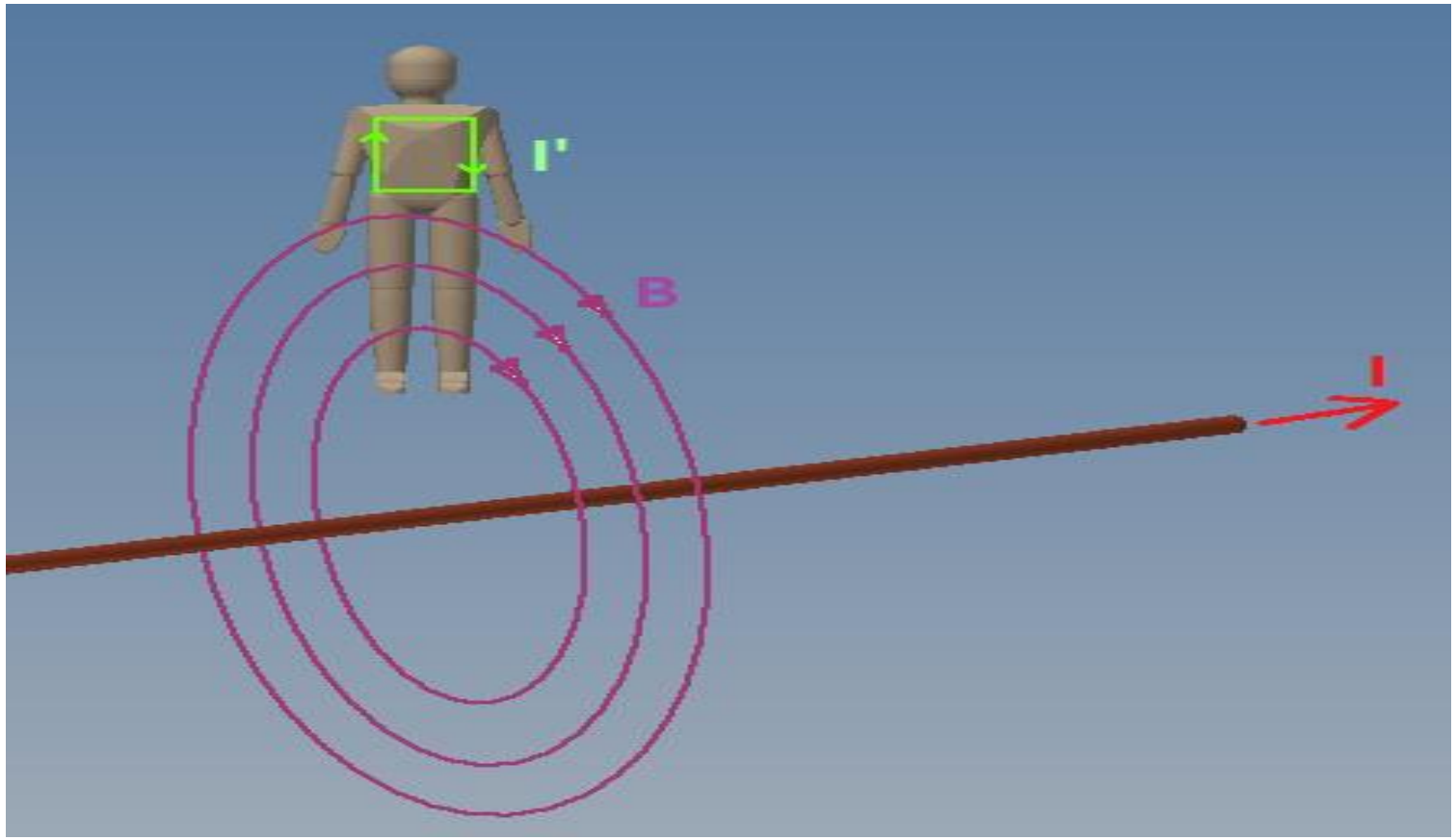
Interaction of time-varying magnetic field with human body

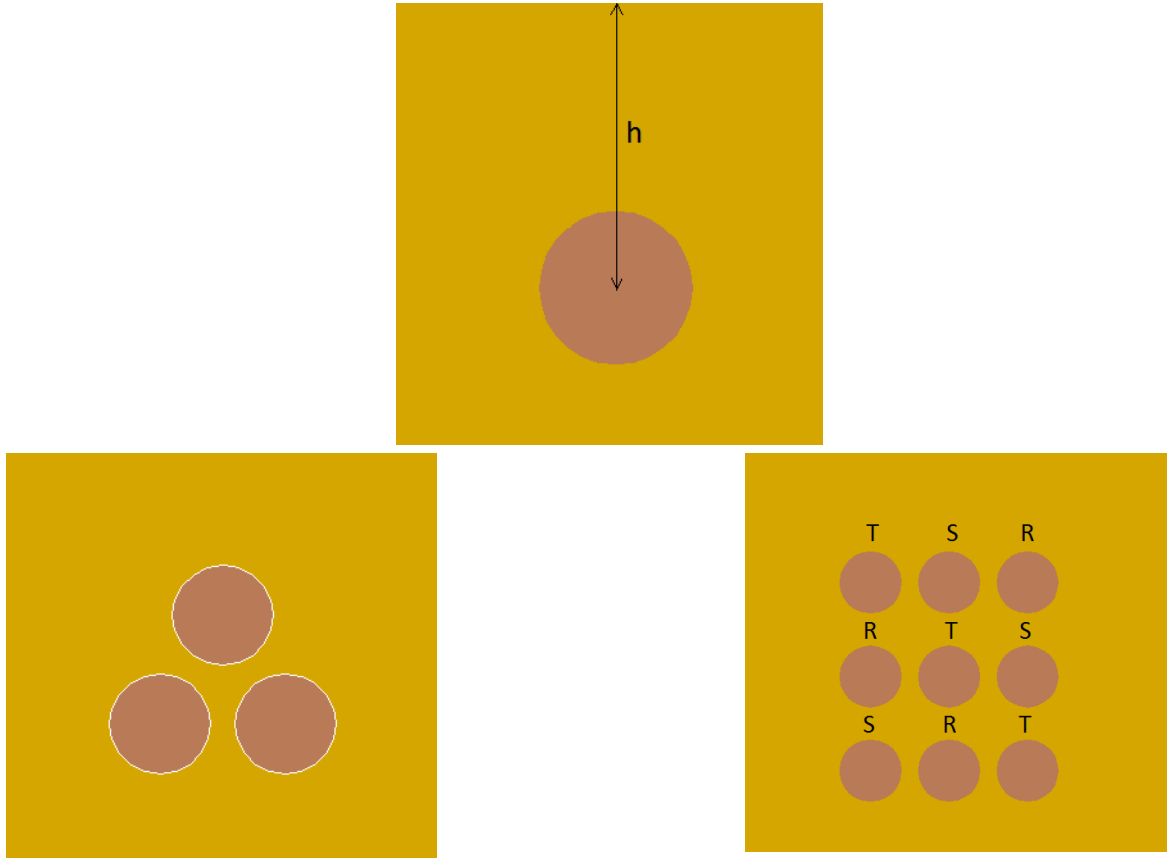


Methods for reducing the magnetic exposure from loaded cable

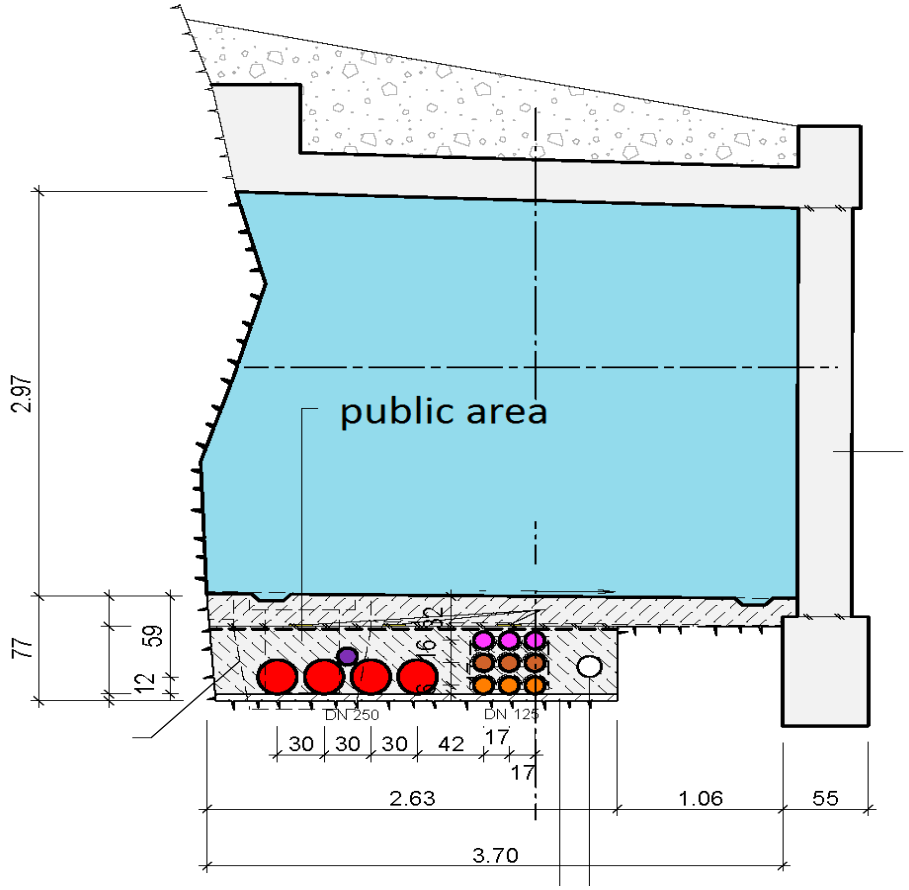
Biot-Savart law

$B=\mu_0 H = 2e\text{-}7^* I/h$

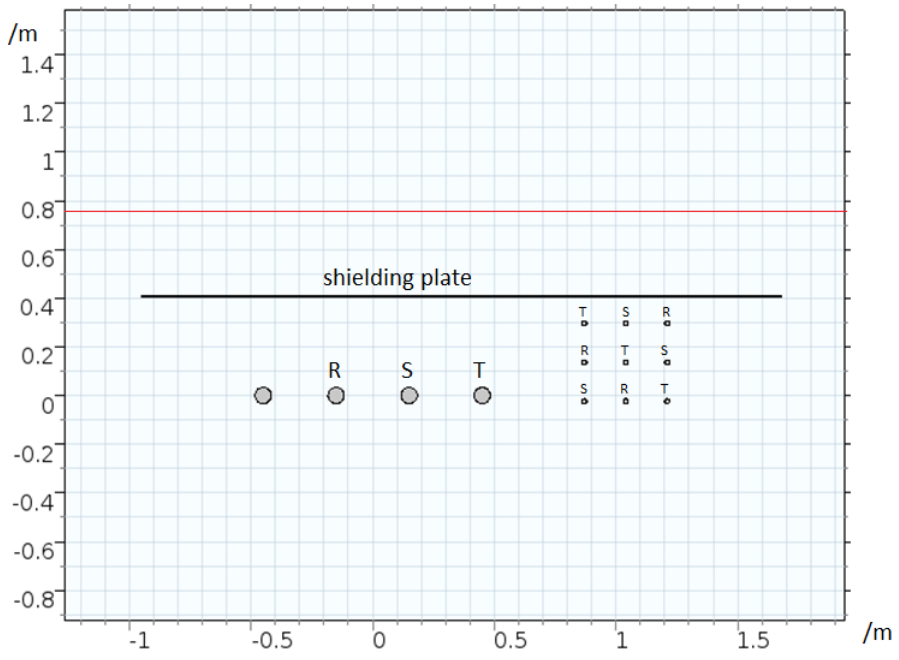
1. large burial depth
2. reduced current rating
3. trefoil distribution with close phase distance
4. optimum the distribution of current phases
5. additional shielding

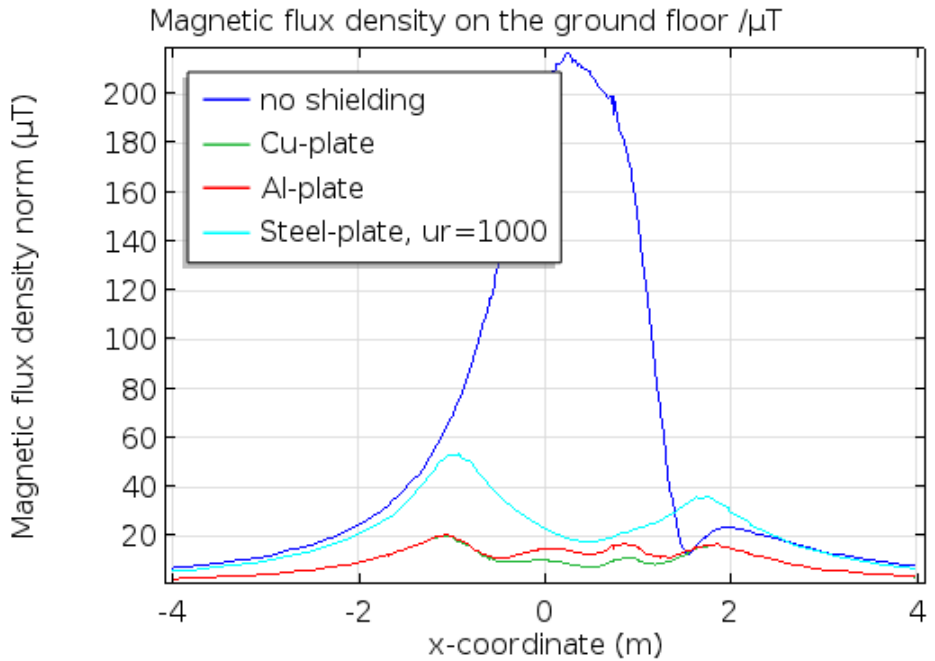


Requested limitation of magnetic exposure to public area < 100 µT for 1200 A current rating



2D FEM modelling

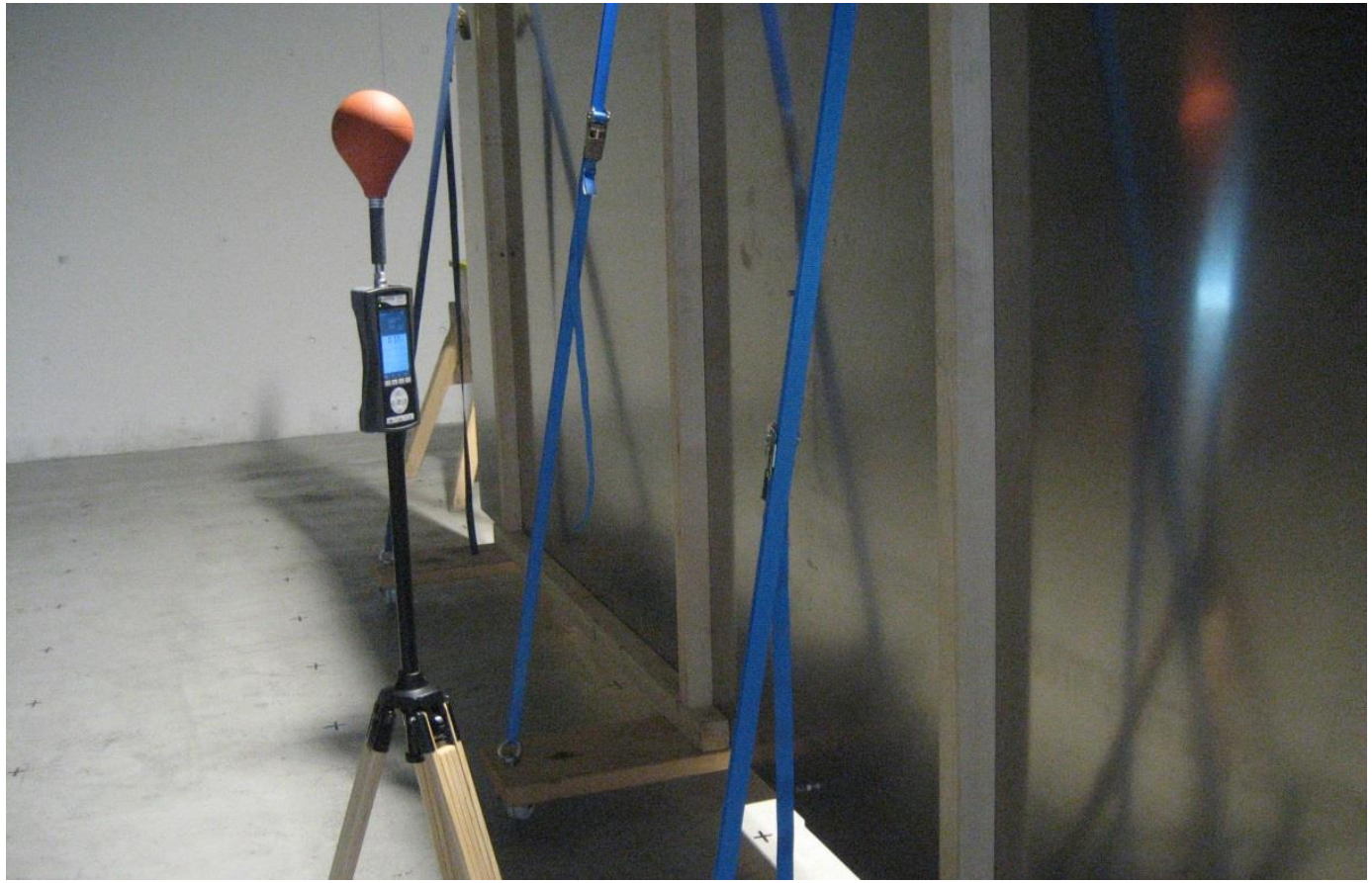




Experiment

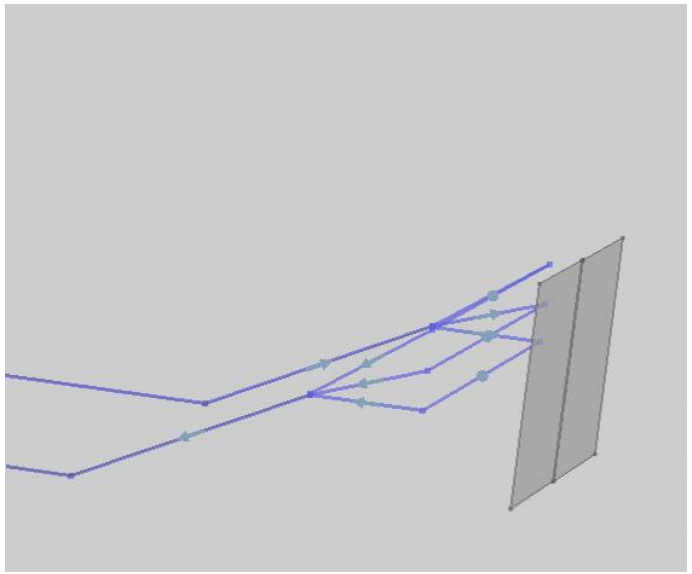
Important: avoiding influence from transformer, concrete reinforcement in building, etc

Experiment

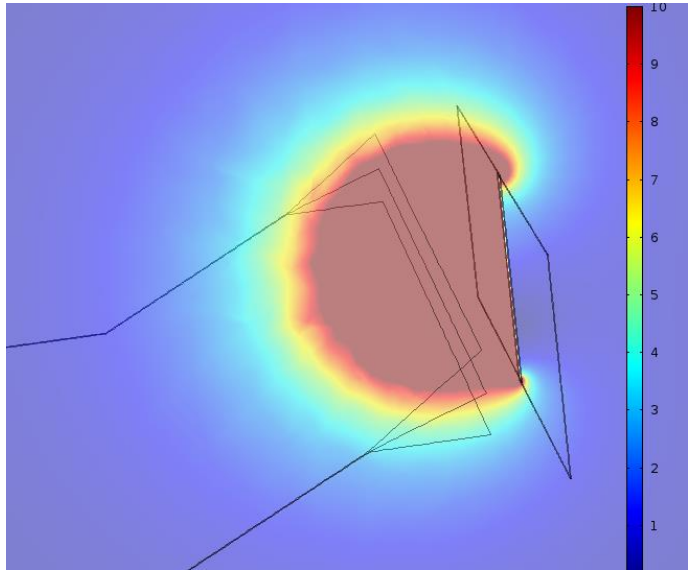


3D FEM modelling

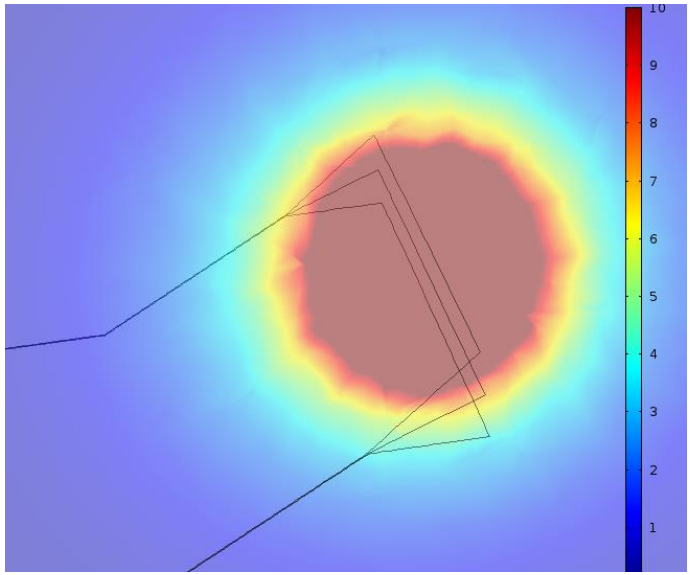
Geometry



Magnetic flux density around cables



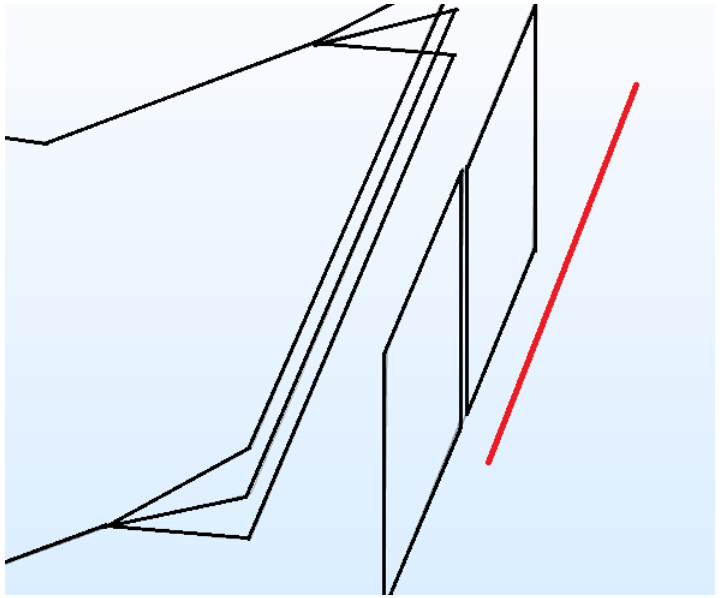
using Al plate for shielding

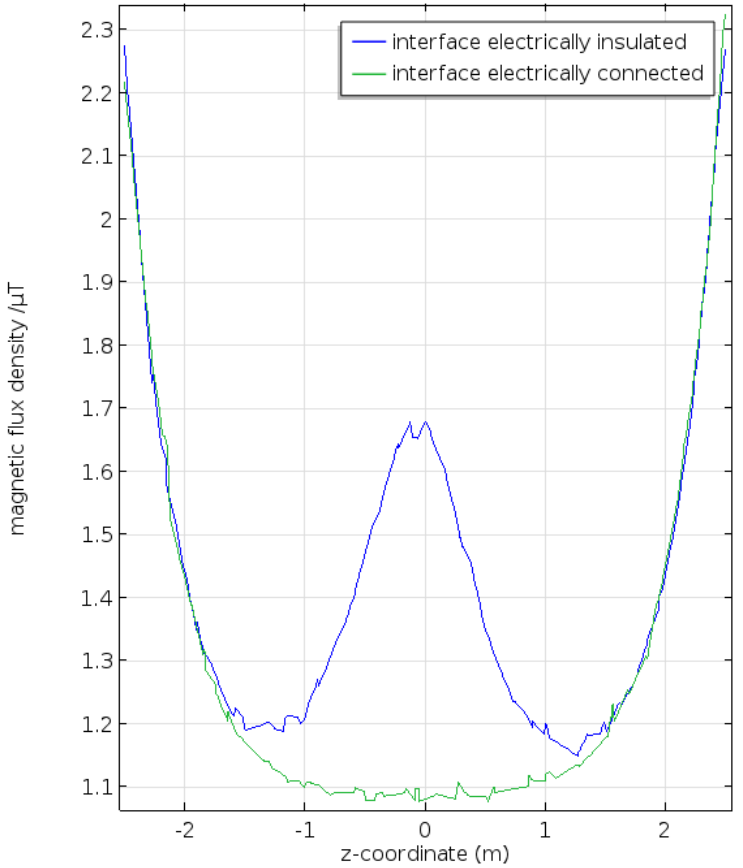


no shielding

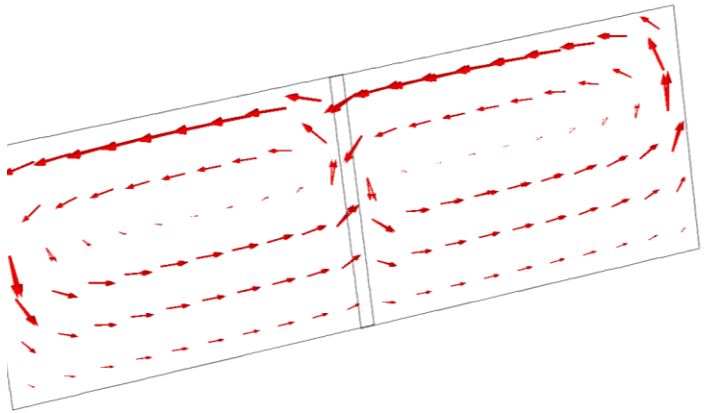
Result of 3D simulation

Cut (red) line for distribution of magnetic field

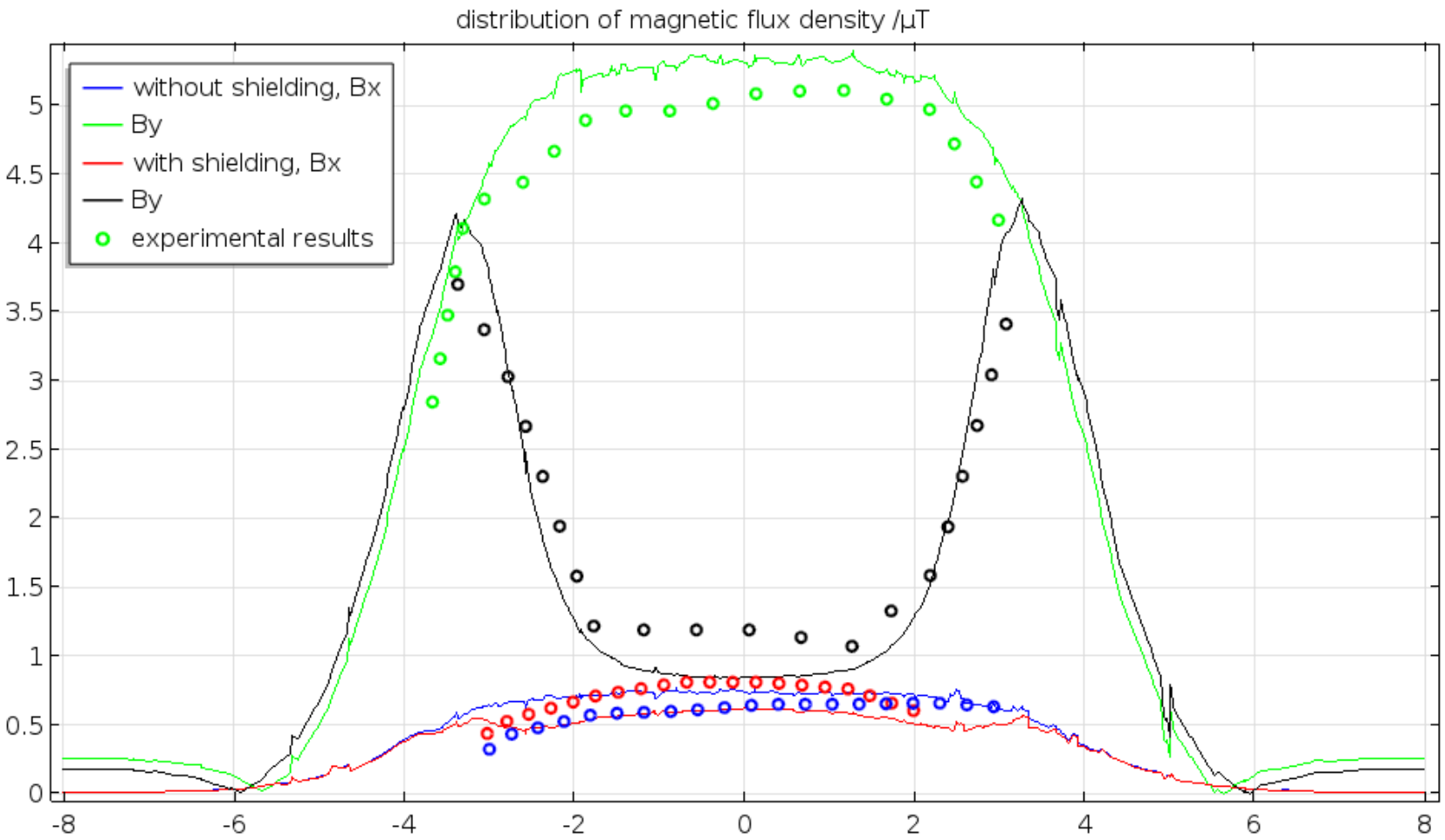




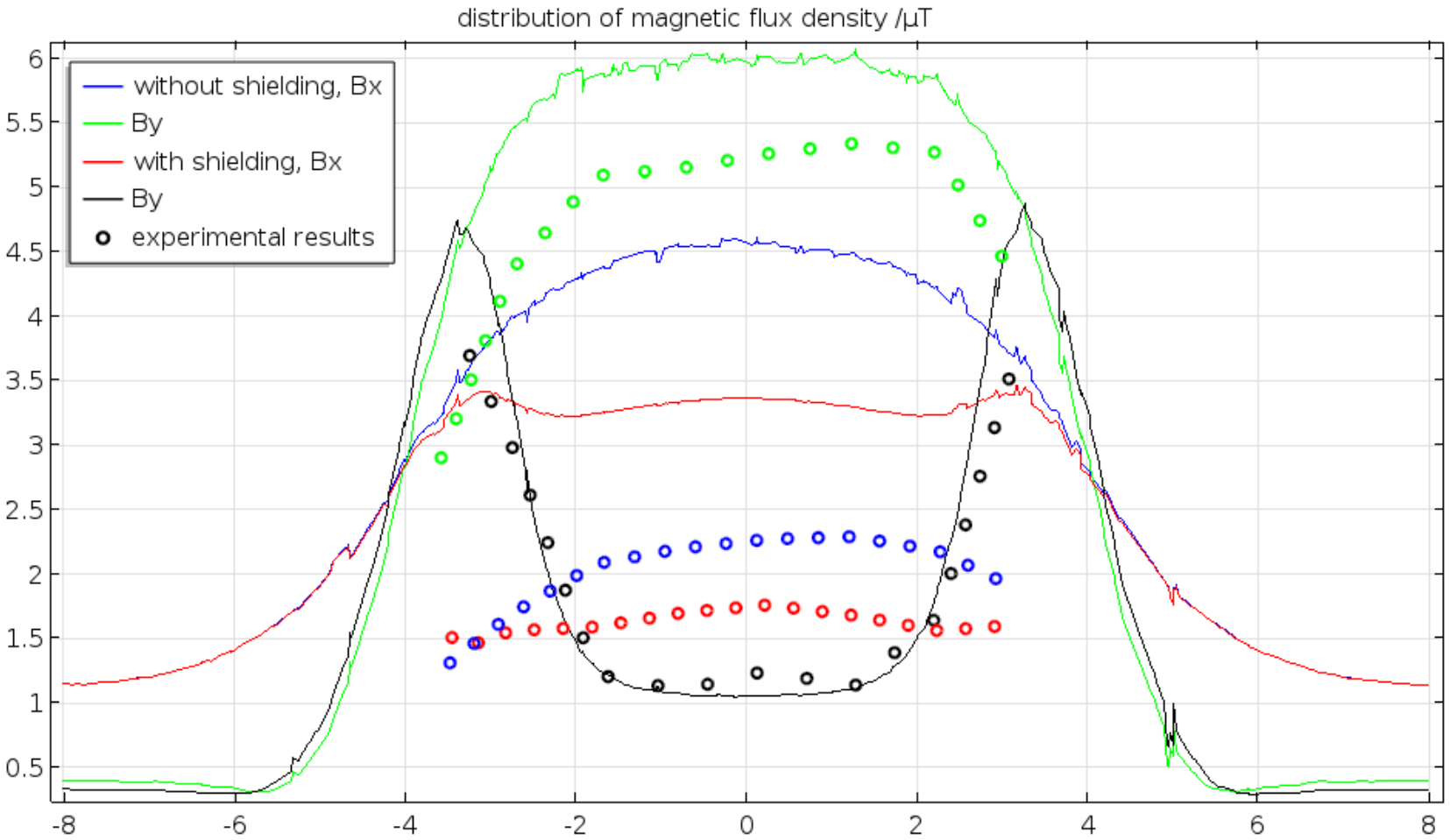
Induced current in separate shielding plates



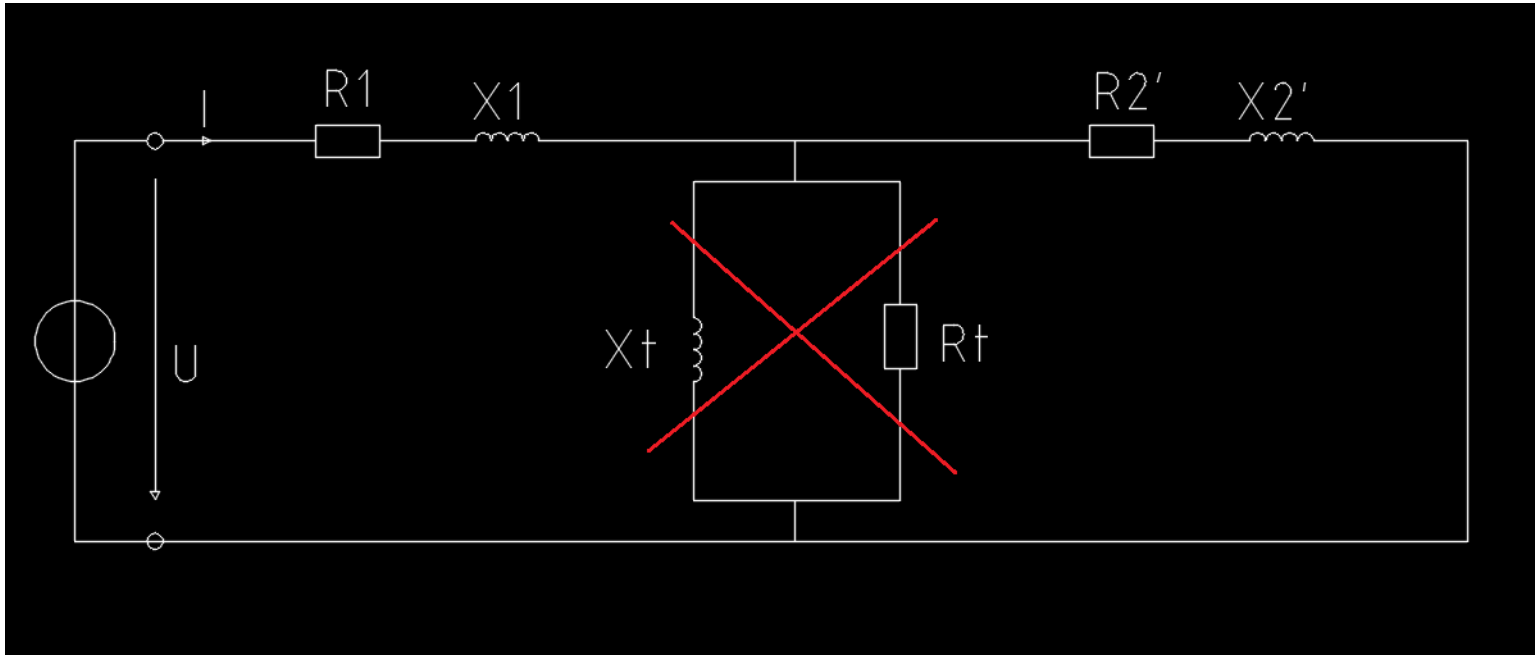
Comparison of experimental and simulation result, for symmetric loading, each phase with I=100 A



Comparison of experimental and simulation result, for unsymmetrical loading, I1=115 A, I2=145 A, I3=115 A

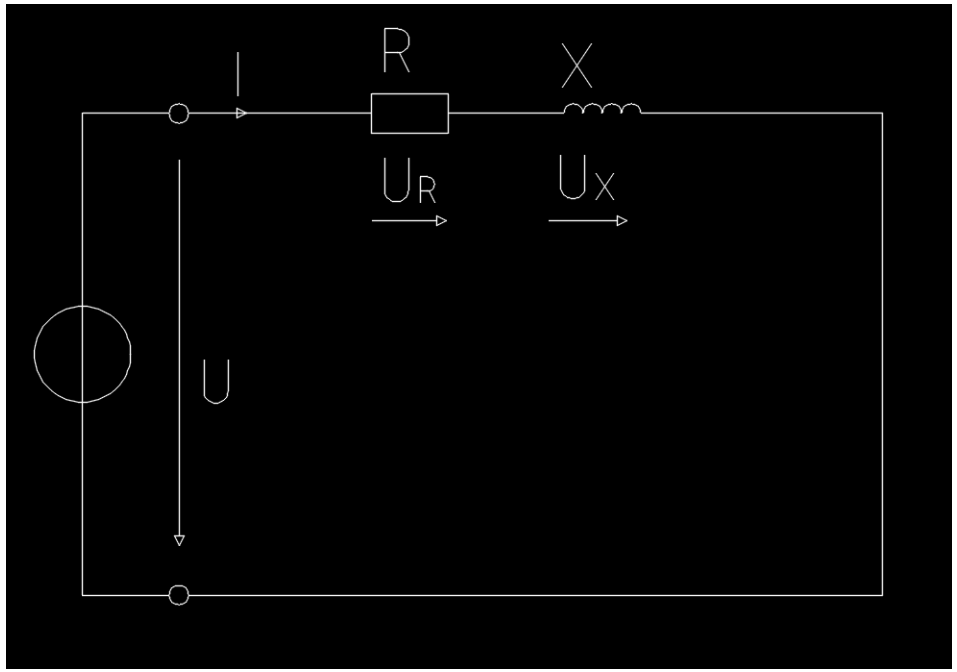


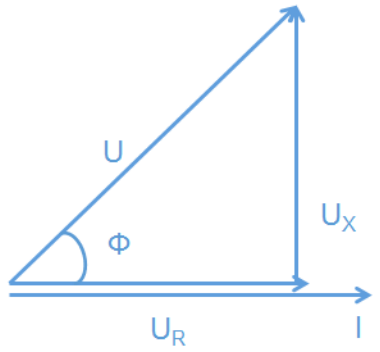
Phase shift of current for unsymmetrical loading

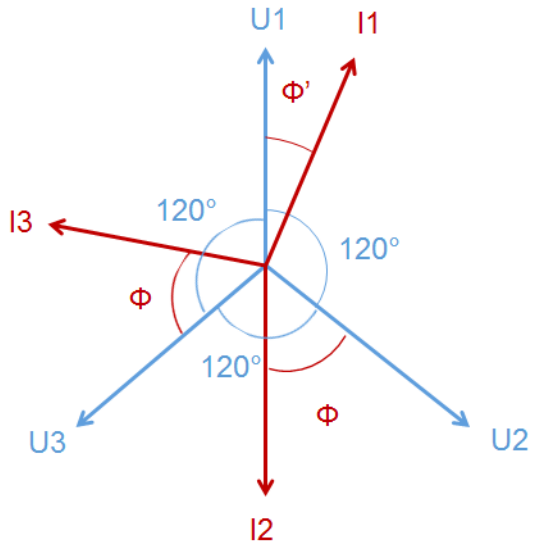


Xt: inductive reactance of transformer
Rt: iron loss resistance of transformer
R1, R2': coil resistance
X1, X2': leakage reactance

Phase shift of current for unsymmetrical loading

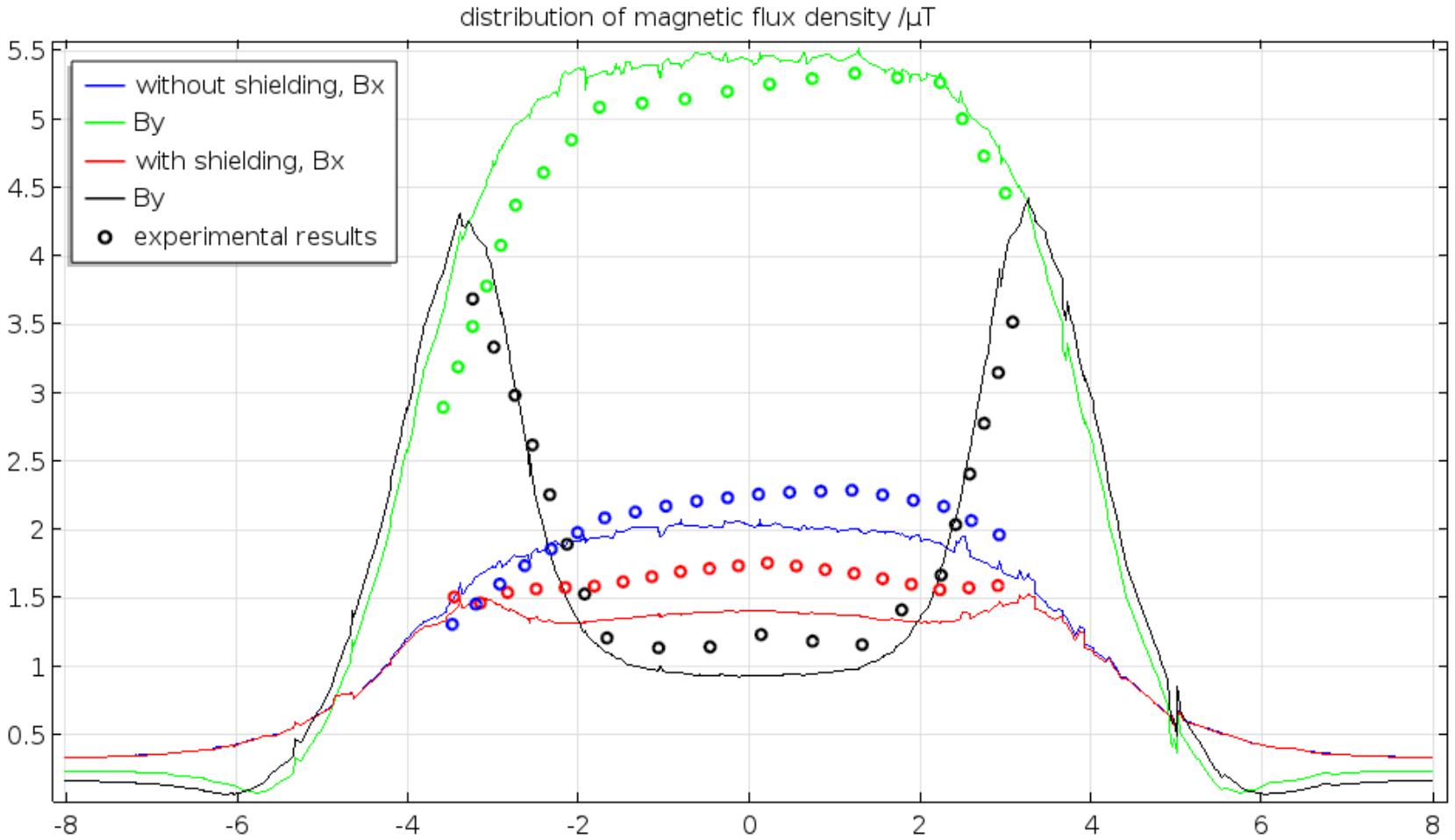






R=R1+R2', X=X1+X2'

Comparison of experimental and simulation result, for unsymmetrical loading, with phase correction



Conclusions

- Al plate can shield effectively the magnetic field from loaded cable
- Al Plates should be electrically connected to avoid higher magnetic exposure at the interface
- Shielding effect doesn’t depend on the electric condition at the border of Al plate, it is suggested however to be grounded for avoiding possible high voltage in fault case
- Experimental data are consistent with FEM results

COMSOL helps to find the answer of discrepancy

Thank you !

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