Investigation of REBCO Roebel Cable Irreversible Critical Current Degradation Under Transverse Pressure

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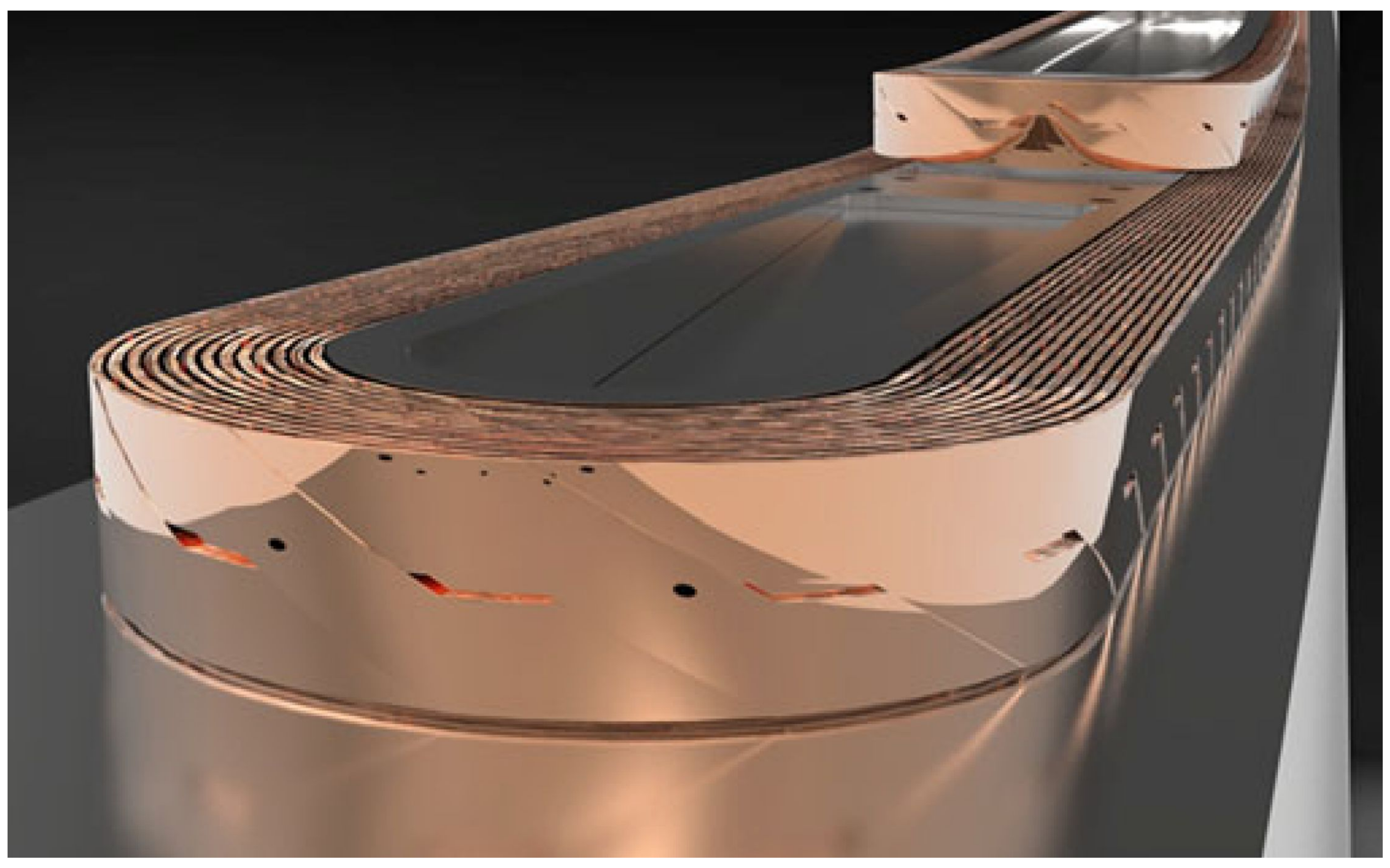
Feather M2.

Abstract—The Roebel cable utilized in High Field accelerator magnets is subject to high electromagnetic forces. Transverse pressure and axial strain may cause conductor fracture. A transverse pressure test was recently performed for an impregnated cable in cryogenic conditions. The test revealed that the Roebel cable can withstand elevated pressure levels common to High Field Magnets, but the mechanism for irreversible current degradation during the transverse loading remains so far unknown. This paper focuses on finding the likely failure mechanisms when the magnet is powered. The cable is wound with a glass-fiber sleeve and impregnated with epoxy. Impregnation (epoxy) has much lower stiffness than the coated conductor tape. When the conductor cable is subjected to transverse loading, abrupt changes in cable thickness and material properties produces high bending strains near such locations. As the tape crosses the epoxyfilled central gap region of the cable, the discontinuous change of the support stiffness creates excess bending strains in the conductor. Using refined mechanical modelling, the tape behaviour at cross-over region with discontinuous stiffness change is carefully studied. This connects the transverse pressure limit of the cable to measured axial strain limit of the conductor.



Feather M2 coil model rendering (van Nugteren).

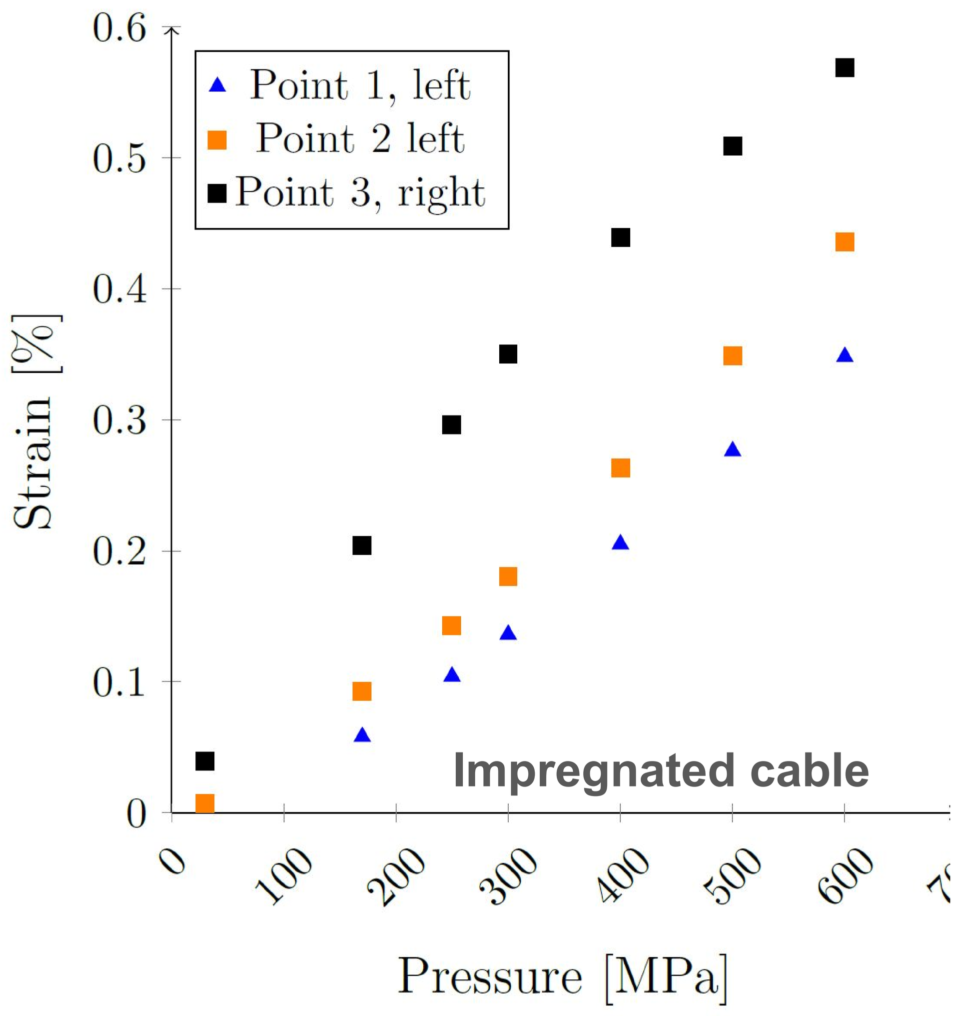


Fig. 2. Strain as a function of pressure along the width of the top tape (x-axis). The substrate thickness is 100 µm, and copper thickness is 20 µm. The cable is impregnated.

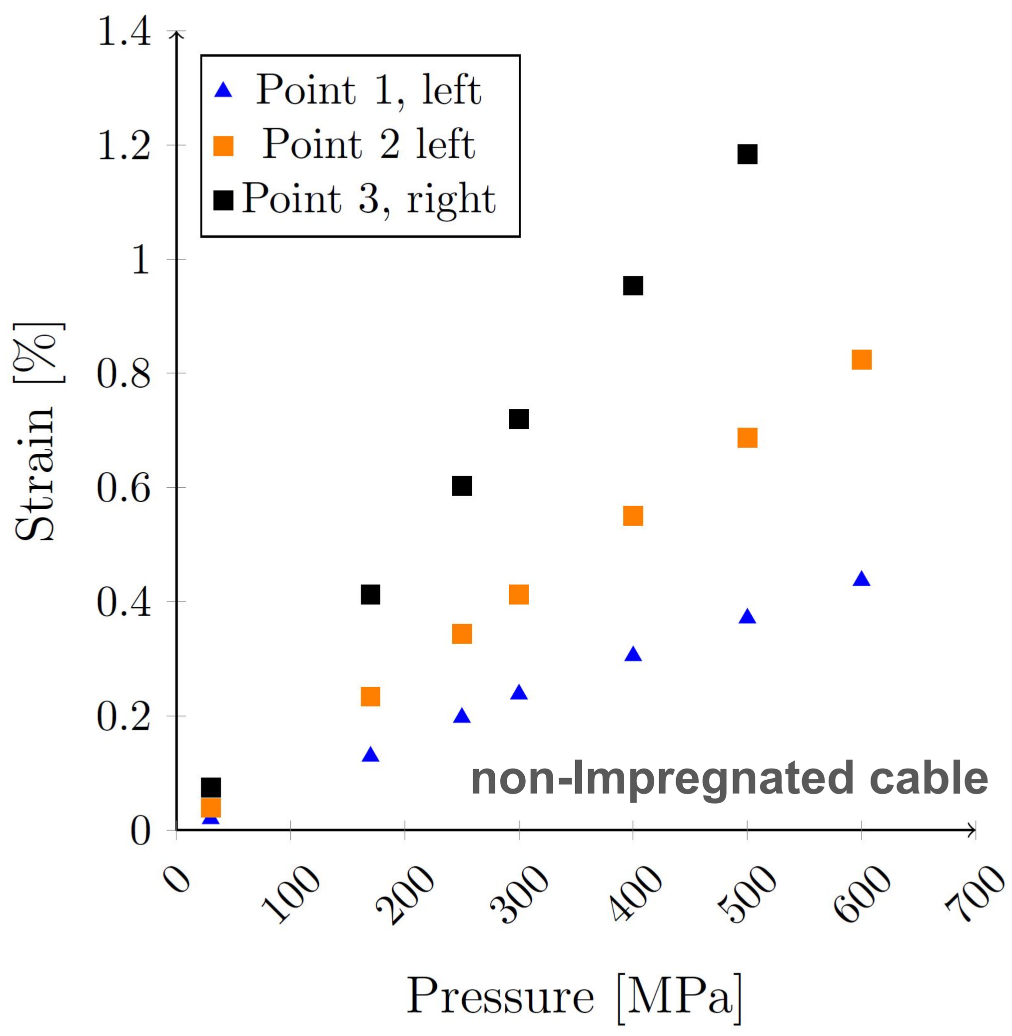


Fig. 5. Strain for a non-impregnated cable as a function of pressure along the width of the top tape (x-axis). The substrate thickness is 100 µm, and copper thickness is 20 µm.

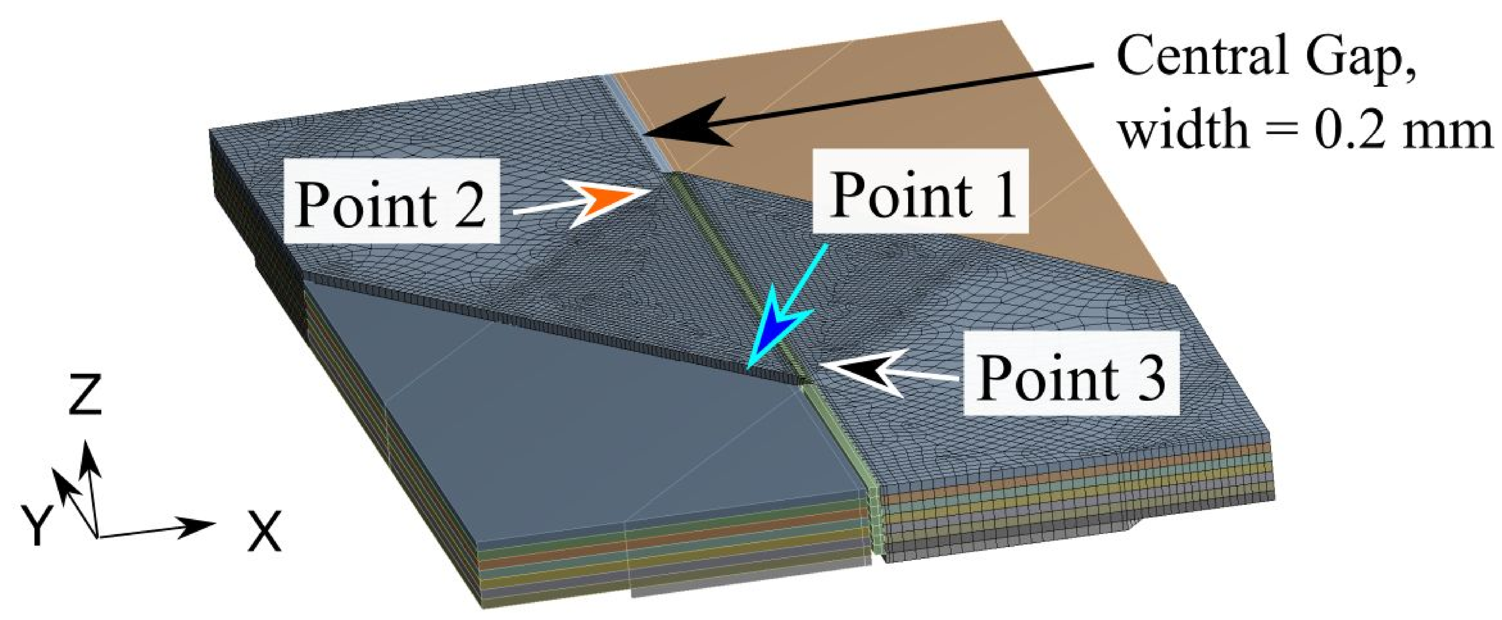


Fig. 1. The Roebel cable unit-length geometry. Meshed areas in the figure are used for computation in this paper. Points indicate the locations where the results are plotted. The central gap between the left and right sides of the cable can be seen. Y-axis is the cable axis. The z-axis is oriented perpendicular to the cable axis.

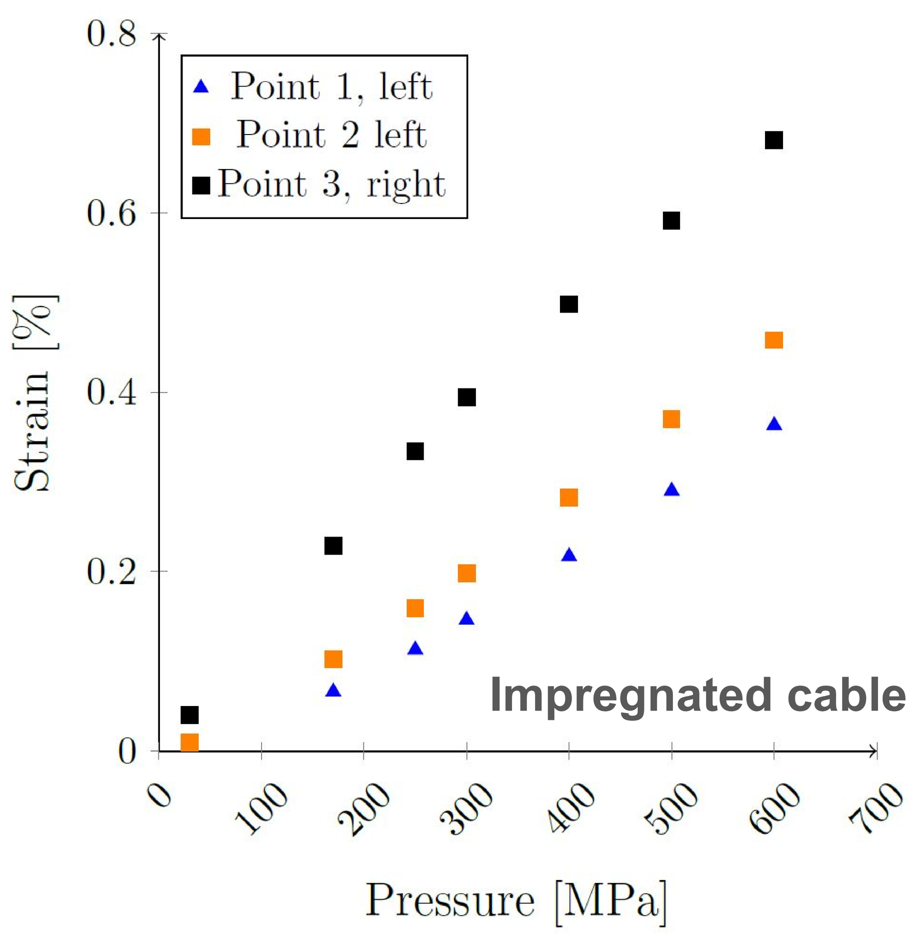
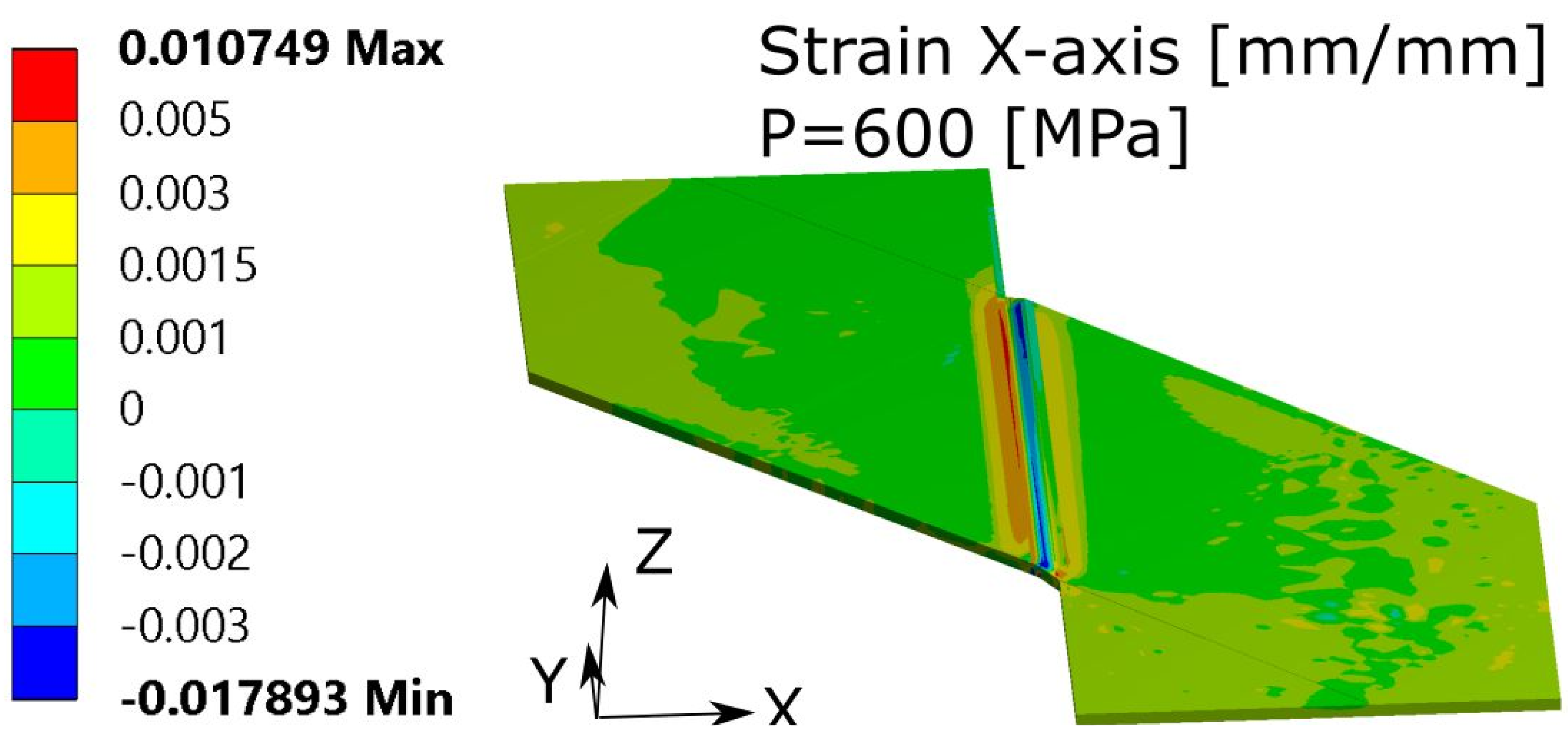


Fig. 4. Max principal strain as a function of pressure. The substrate thickness is 100 µm, and copper thickness is 20 µm. The cable is impregnated.



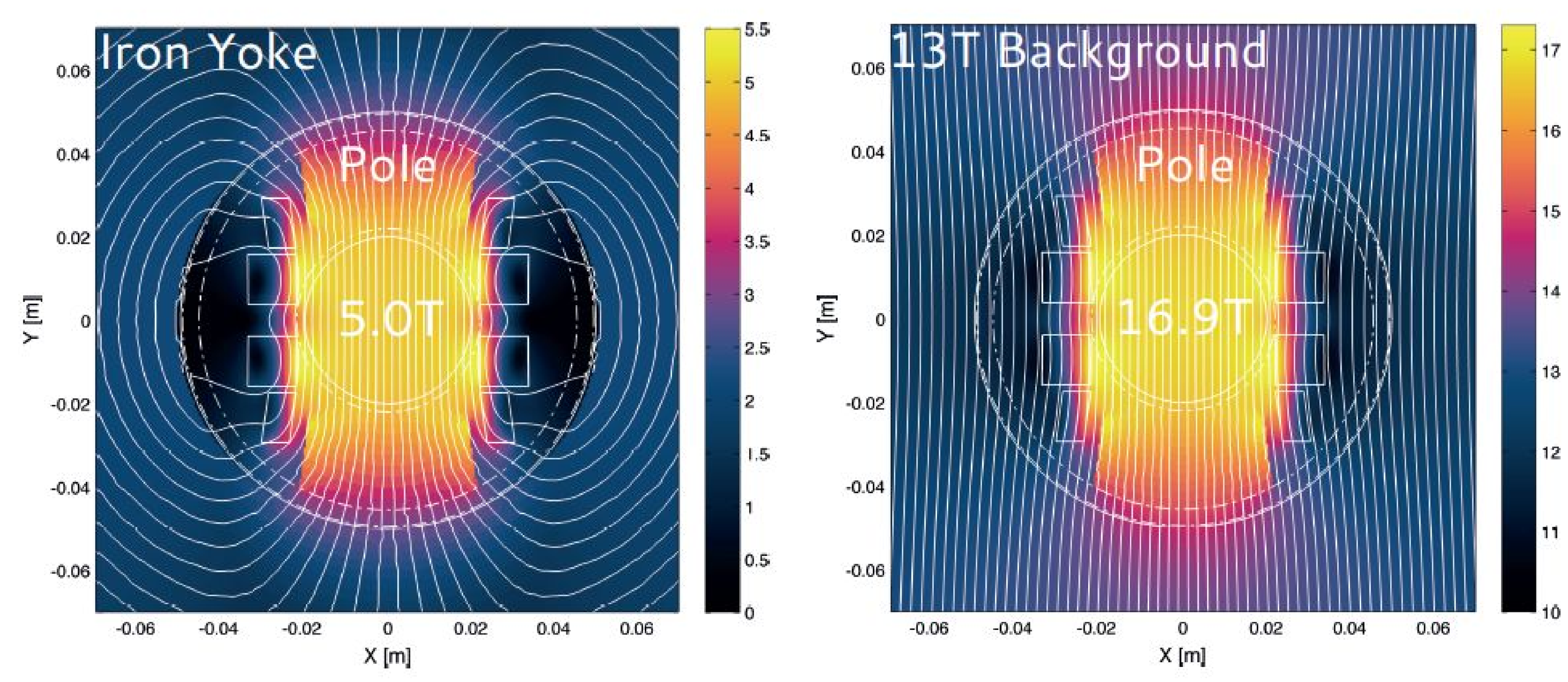


Figure 2.11: Calculated fieldlines for a 2D cross section of the Feather-M2 magnet. On the left side standalone in iron yoke and on the right side in a 13 T background field.