Flux Trapping in Coaxial Superconducting Radiofrequency Cavities

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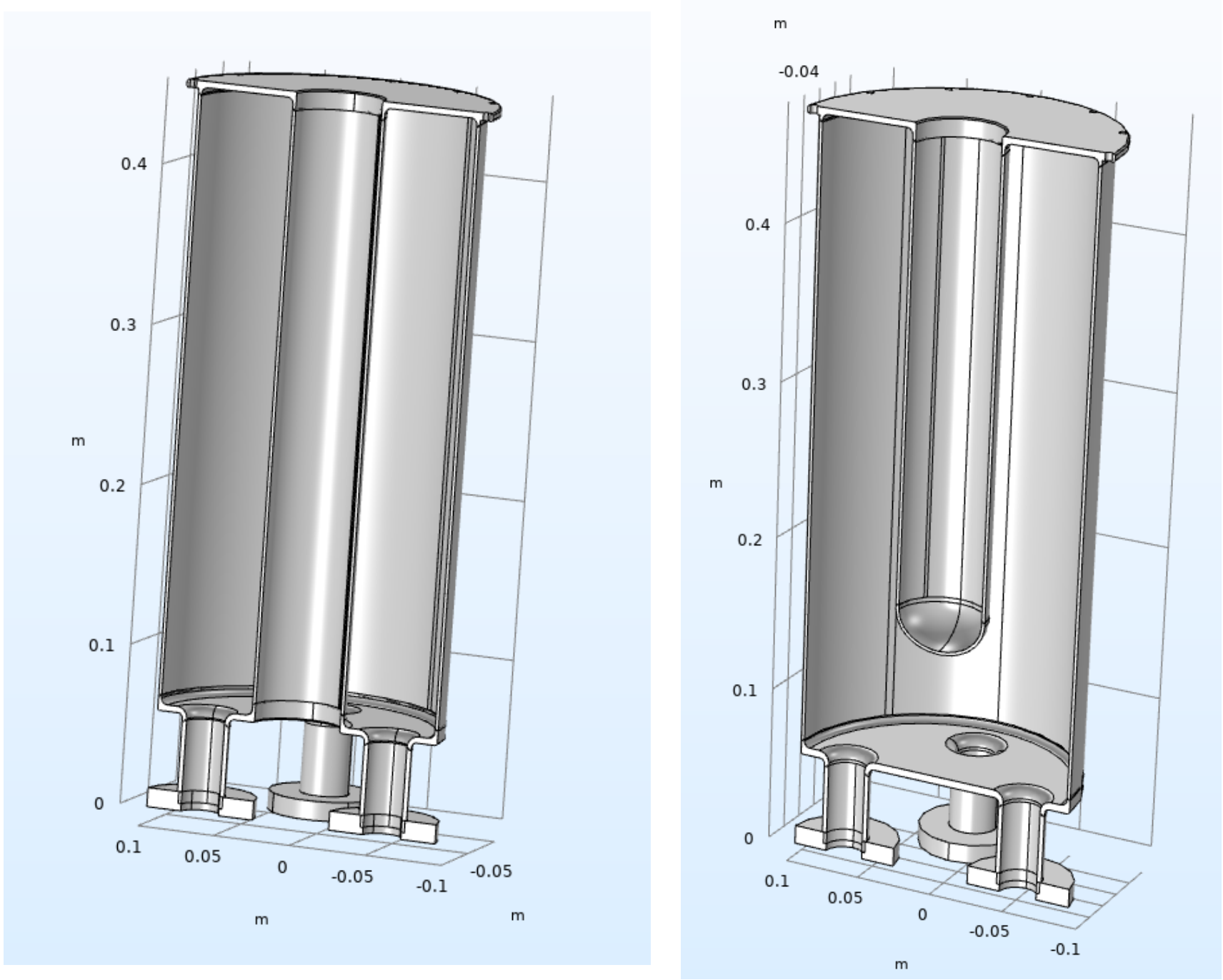
Abstract

TRIUMF has two purpose-built coaxial test cavities, a Half Wave Resonator (HWR) and Quarter Wave Resonator (QWR). These TEM-mode cavities are used to characterize the effects of different surface treatments, cool-down speeds, and applied magnetic filed orientations. Results from cool-downs to superconducting temperatures performed on the QWR with different cool-down characteristics are presented here. These results are informed by COMSOL simulations.

Coaxial Cavities

TRIUMF has a Half Wave Resonator (HWR) and Quarter wave Resonator (QWR). Multiple resonant modes can be tested after one cool-down. The cavities are made of bulk niobium.

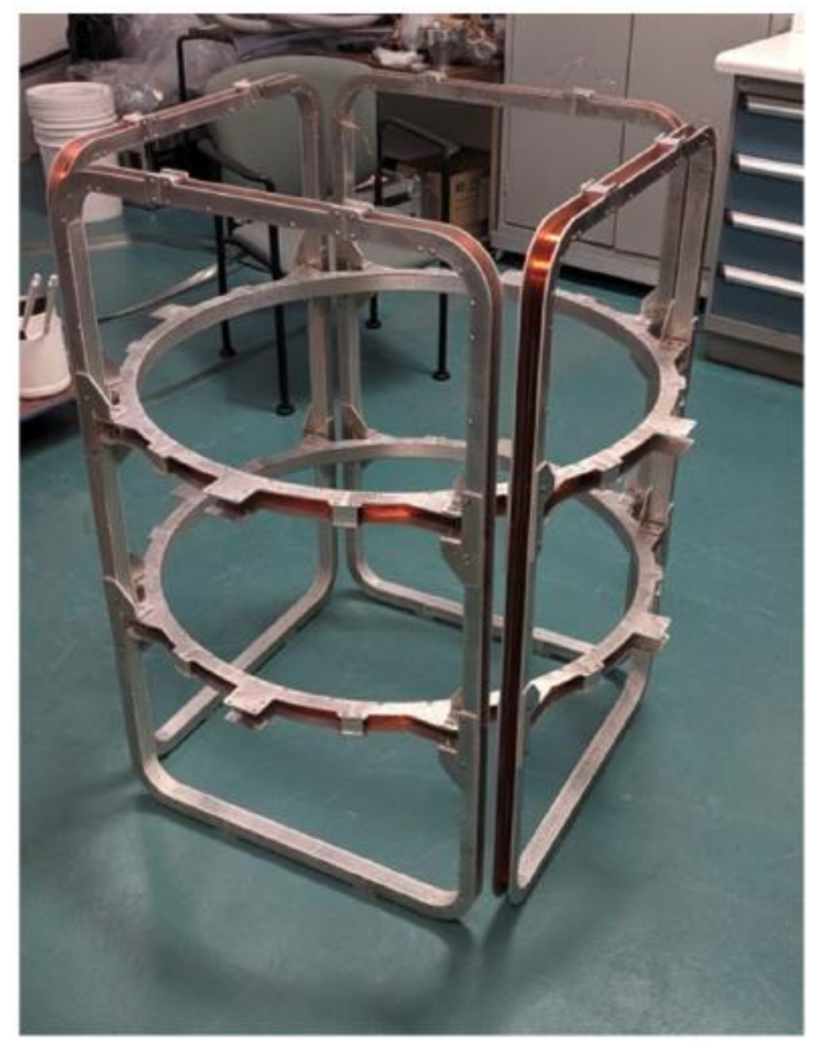
Photo of Coaxial Cavities: HWR (left) and QWR (right)



Cut outs of the HWR (left) and QWR (right). These images were generated using COMSOL Multiphysics ®.

Helmholtz Coils

The Helmholtz coils produce a very uniform magnetic fields in all three spatial dimensions that surrounds a cavity during a cool-down.

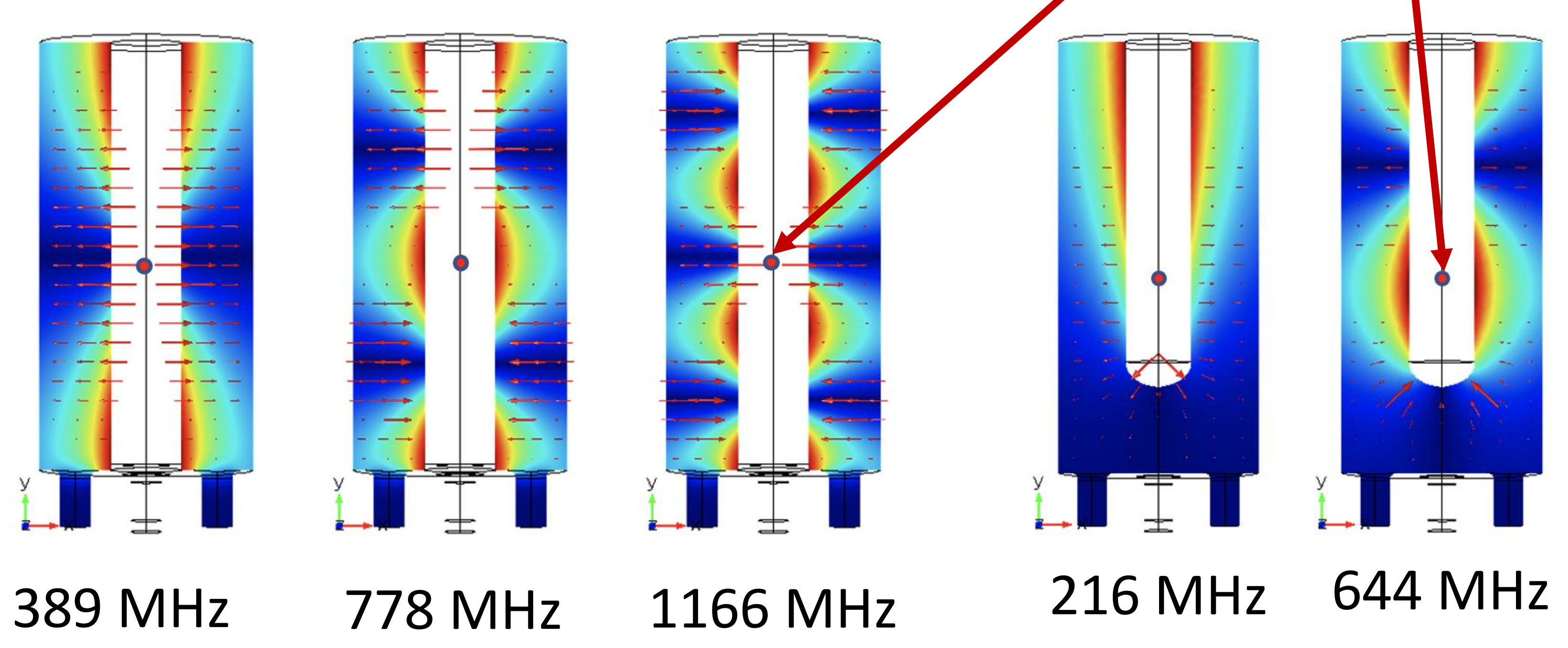


Helmholtz Coils

RF Magnetic Field

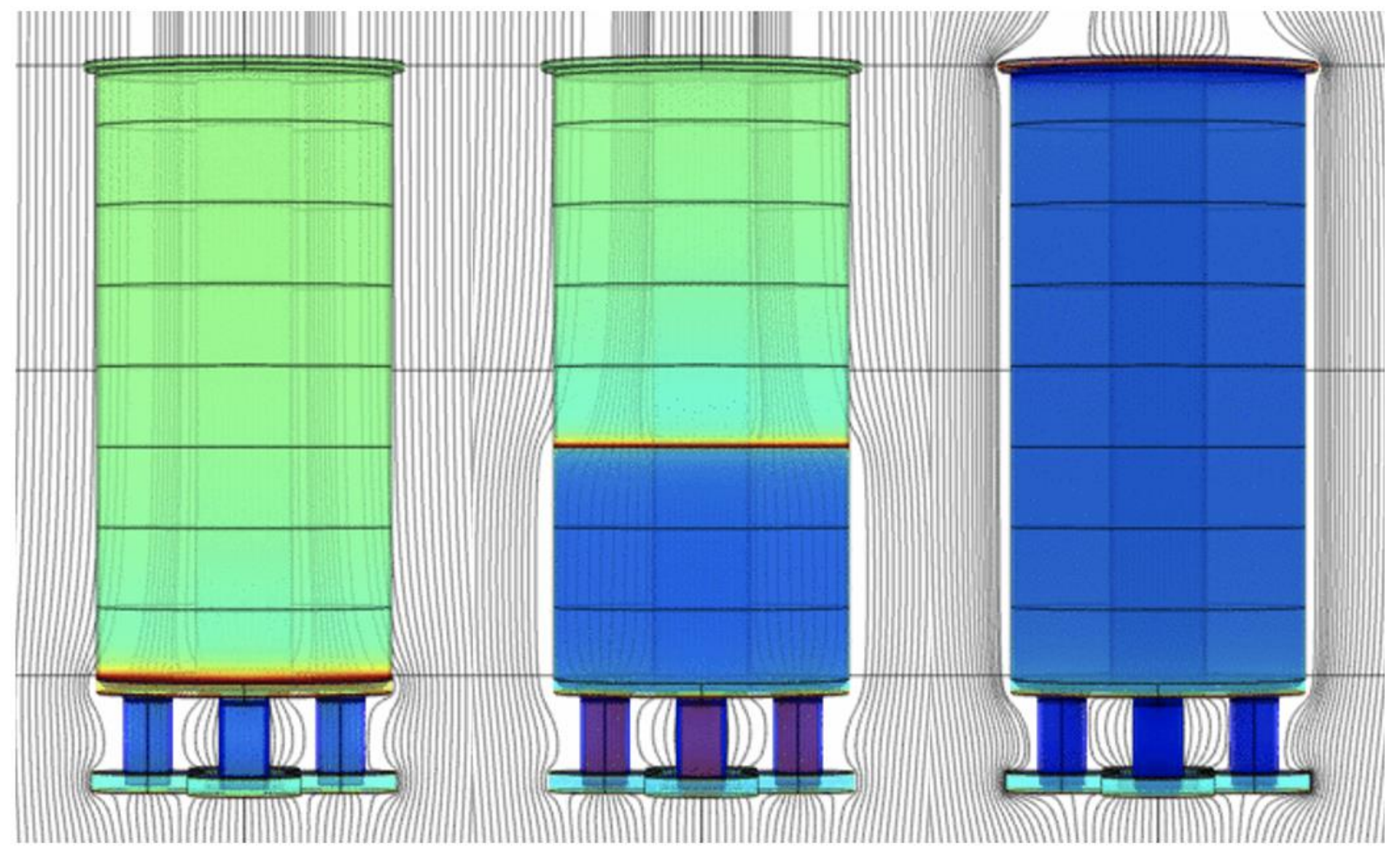
Fluxgate probes measure the magnetic fields in three orthogonal spatial dimensions during and after the cool-downs. The rf magnetic field distributions and location of the fluxgate probe is shown below.

Fluxgate probe location

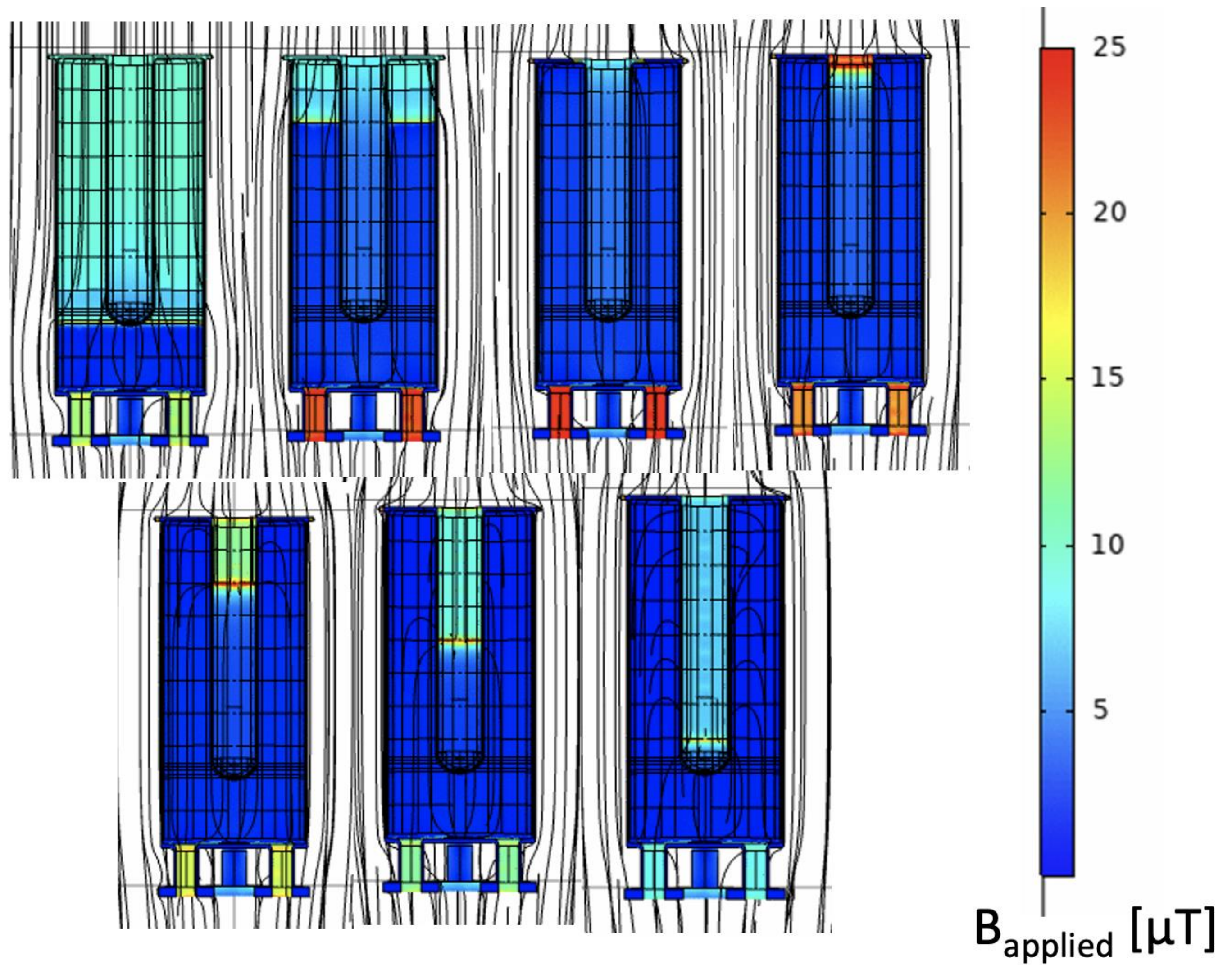


Cavity Cool-down Simulations

Cool-downs of the HWR (left) and QWR (right) are simulated using COMSOL Multiphysics ®.



HWR simulation. The cavity is cooled from bottom to top.

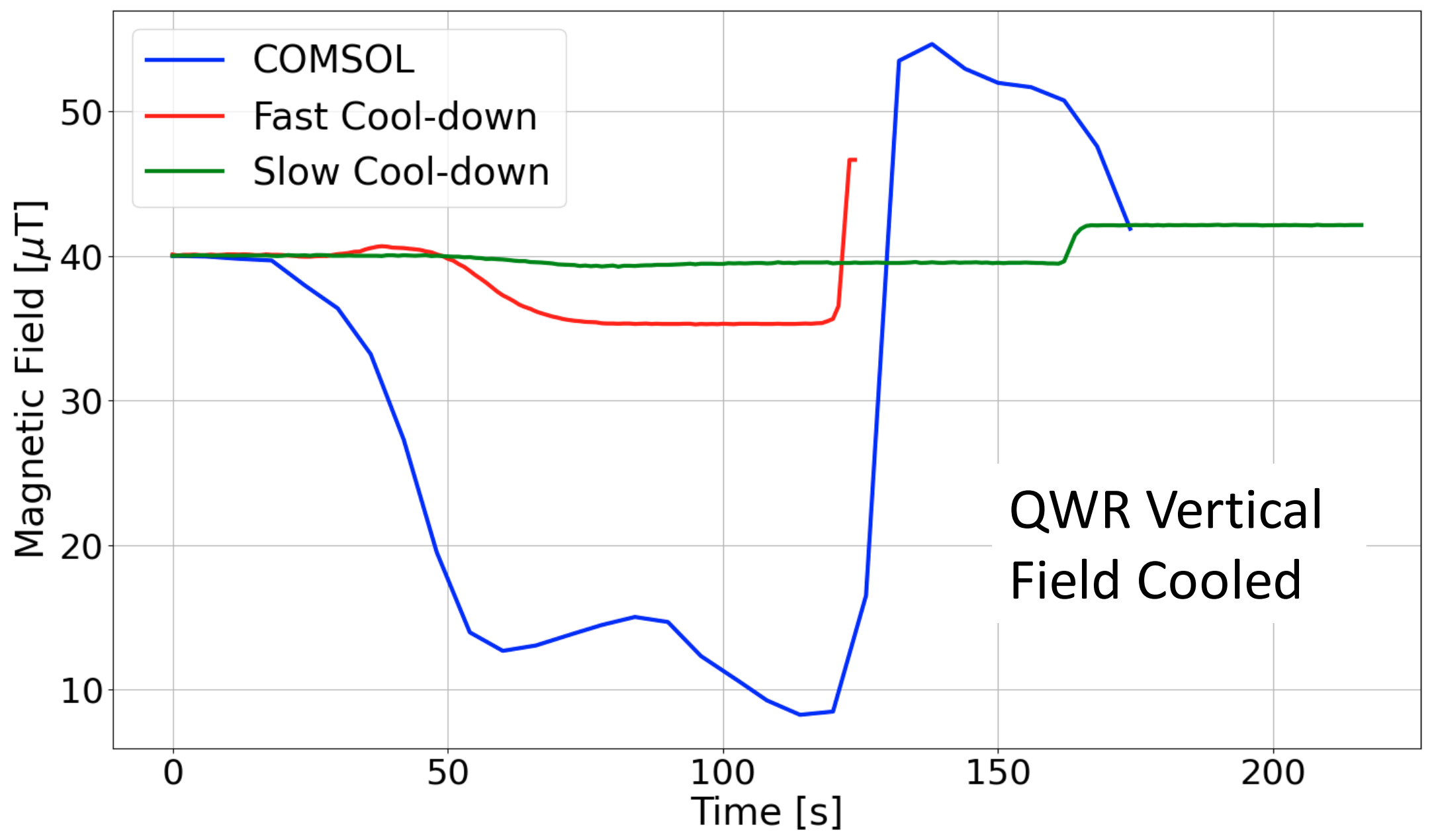


QWR simulation. The outer conductor is cooled from bottom to top, followed by the inner conductor which is cooled from top to bottom.

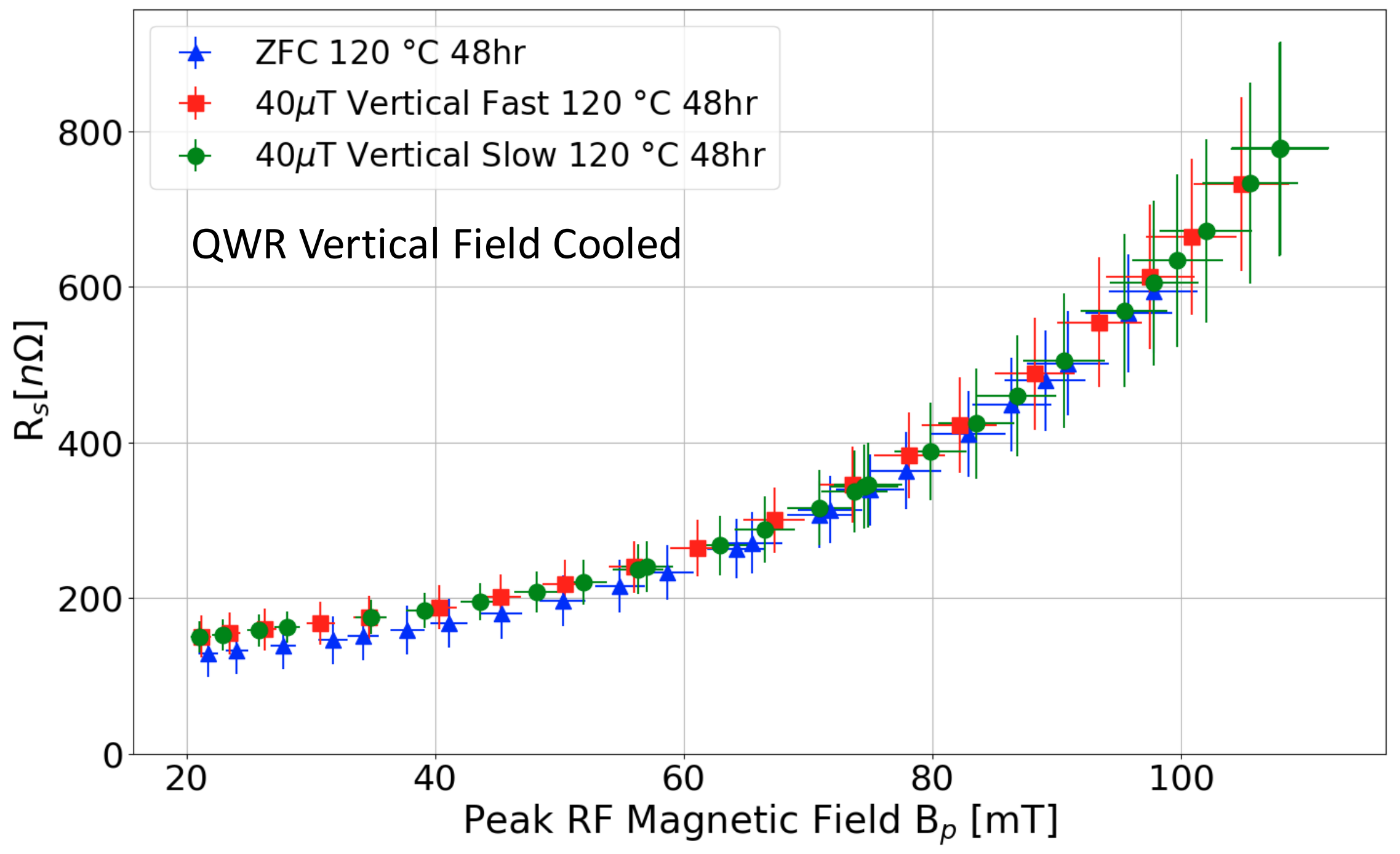
Conclusion

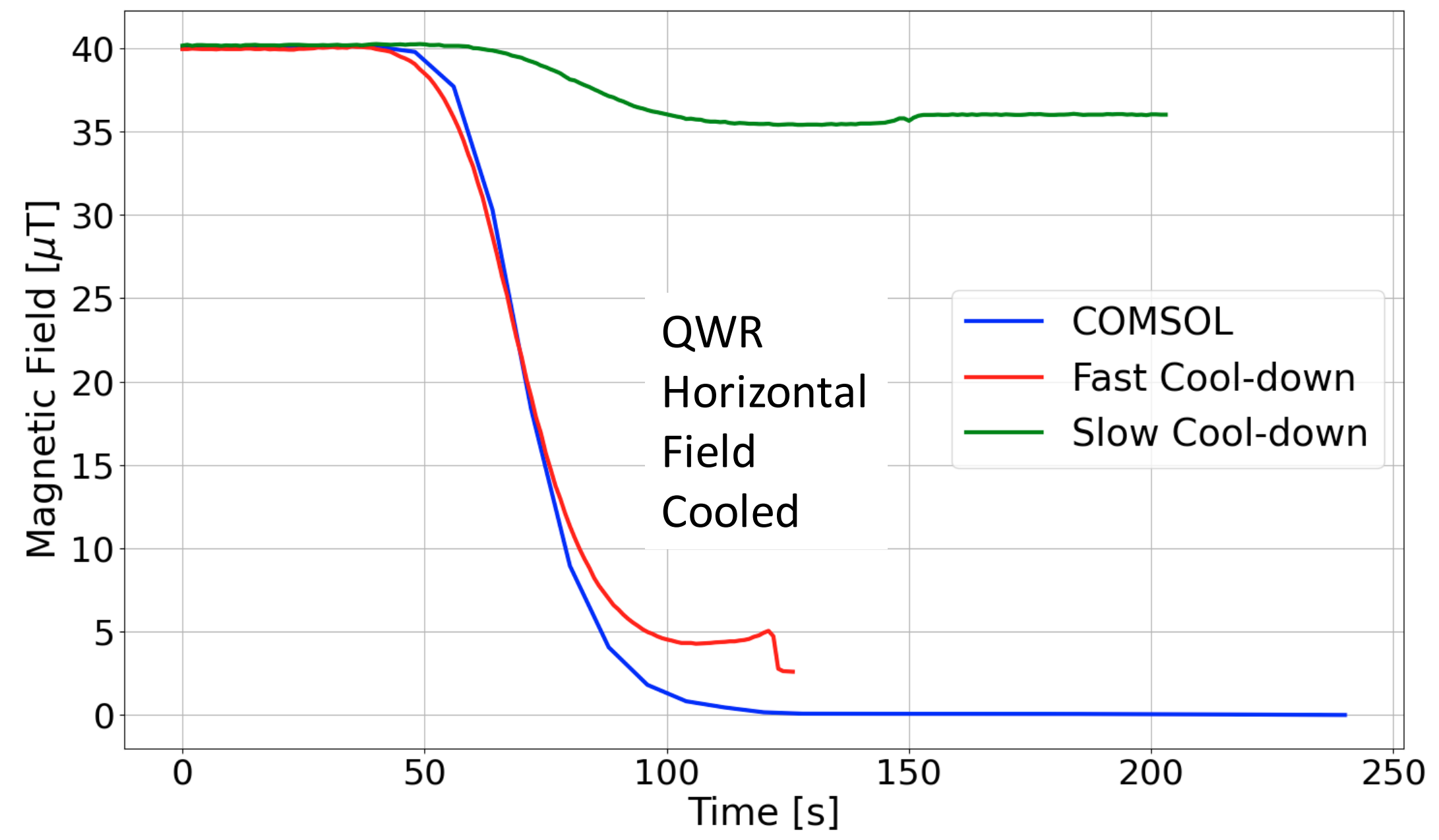
For the QWR cooled with a vertical applied magnetic field, flux is likely trapped in the inner conductor for both cool-down speeds. For a horizontally applied magnetic field, most of the magnetic flux is expelled for a fast cool-down and trapped for a slow cool-down.

QWR Results

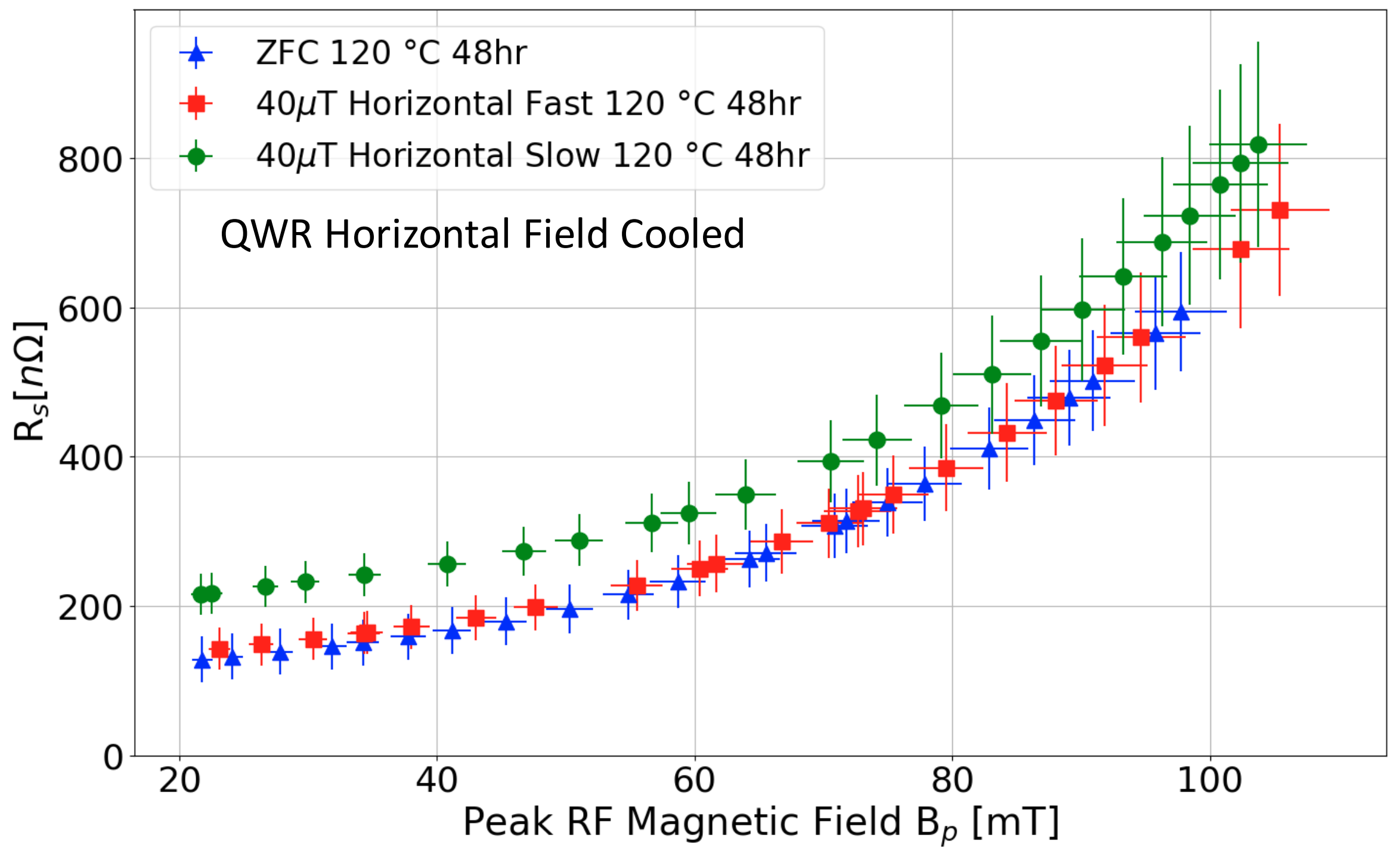


The fast and slow cool-downs with a vertical applied field lead to similar levels of surface resistance.





For the horizontal field cooled results, the fast cool-down leads to lower surface resistance and higher Q values.



The fast cool-down with a horizontal applied field yields near complete flux expulsion.

Discovery, accelerated