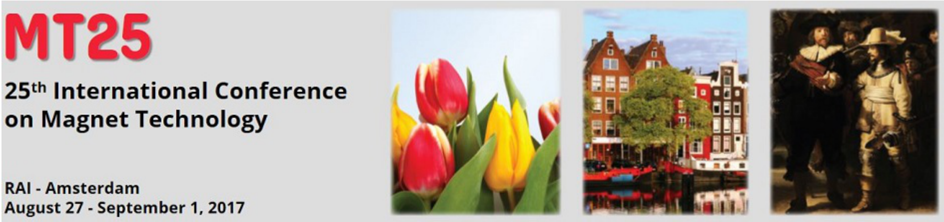

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Ultimate Forces of the Grenoble Hybrid Magnet

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We present results of calculations of the ultimate forces for the worst-case scenario, an important safety concern in hybrid magnets. They appear during a simultaneous and immediate burnout of some or all upper or lower resistive coil halves, or shorts between the coils in the mid-plain. Because of their intensity, they have a dramatic impact on the mechanical layout of a hybrid magnet. An electromagnetic shield between insert and outsert, as it is the case for the Grenoble hybrid magnet, takes up part of these forces and reduces them considerably. It makes the calculation of the now time dependent forces rather complex.
The ultimate forces have been calculated for two models: a) conservation of magnetic flux with instantaneous energy transfer from the shorted coils to the remaining parts, and b) conservation of energy of the whole hybrid system, including the power supplies, with energy transfer via mutual axial and radial coupling to the other coils. Only for case a) we find an instantaneous force of 6 MN between resistive magnet and its housing at t = 0. The maximum force between resistive magnet and shield appears, when the resistive power supply is switched off at t = 50/100 ms: it is 3.7 MN/4.4 MN for case a) against only 1.5 MN for b). The force on the superconducting magnet is reduced from 210 kN for a) to 130 kN for b).
The results underline the usefulness of a shield between insert and outsert to reduce their electrodynamic interaction. They also confirm that the Grenoble Hybrid Magnet is well suited for inserts of much higher power levels.
Our findings have also consequences for the layout of hybrid magnets without shield.

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