HL-LHC updates

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28th of August, 2019
Training behavior of the first 11 T series magnet

First 11 T series magnet → Excellent test results

- Two training quenches to reach nominal current + 100 A
- After thermal cycle: Excellent memory and no observed degradation (30 K gradient during cooling)
- High voltage insulation tests: Proven 3.3 kV tolerance at 1.9 K, 660 V at room temperature
- No spurious quench detection due to flux jump
- Etc. etc.

MCBXF magnets, aka Spanish motors

- Individual magnets (inner and outer) perform at ultimate current, without training quenches in the inner dipole

- However, combined powering limited to typically 40% of nominal torque, and below 60% of nominal torque

- After modification of the support structure, the second series of tests in July 2019 showed marginal improvement

- Next round of test results after further modifications to be presented 28/8/19

- Busbar studies of RCBXF circuits to be submitted for comment and approval

F. Toral, WP3 meeting, 31/7/19
Cross-check of HL-LHC high-order correctors

▲ Cross-checks of the self-protected HL-LHC high-order correctors [2], specifically the MCTX dodecapole (= worst case):
   ▪ **Worst-case conditions (no crowbar discharge, slow power supply response [3]),** the hotspot temperature in the MCTX magnet remains below 200 K at ultimate current
   ▪ However, connection box featuring bare Nb-Ti conductor: Worst-case quench integral results in hotspot temperature >> 400 K under adiabatic conditions
   ▪ Following Mariotto’s argument [4]: If the length of bare conductor is limited to 16 mm, the worst-case hotspot temperature is below 200 K after considering axial heat flow
   ▪ However [5]: “INFN did not make a commitment to have a maximum distance of the single bare wire of 16 mm, but this is still under discussion”

→ Without commitment to limit the bare strand length, protection studies of the connection box are on hold

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Expected worst-case quench integrals, courtesy S. Mariotto [3]
To limit worst-case hotspot temperature in MCBRD magnets to below 200 K: Either Varistor 2 ($V_{gnd,max} = 440$ V) or regular 1.29 Ω resistor ($V_{gnd,max} = 560$ V) is sufficient.

- Voltage withstand of energy extraction and power supply [6]: 1000 V
- Maximum voltage withstand of magnet: Unclear but expected to be very high
- N-line busbar, assuming 10 mV detection voltage, 0.5 s validation time and worst-case discharge quench integral: Expected combined quench integral < 150 kA²s, with $T_{Hotspot} << 100$ K
- Proposed baseline energy extraction resistor of 1.5 Ω [7] seems appropriate
- Documentation of RCBRD protection studies in progress

[7] M. Mentink, email 10/12/18