Quench Propagation in Nb_3Sn cos-theta 11 T Dipole Model Magnets in High Stress Areas

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INTRODUCTION

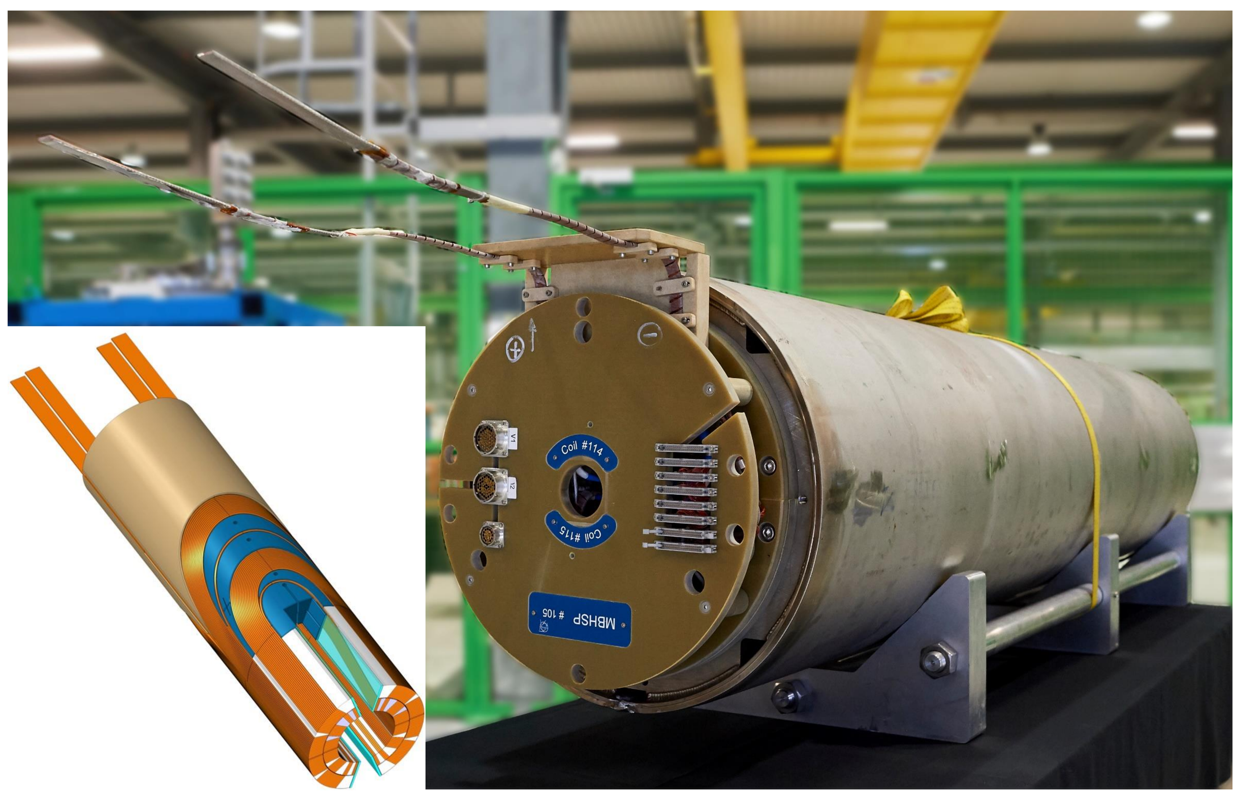
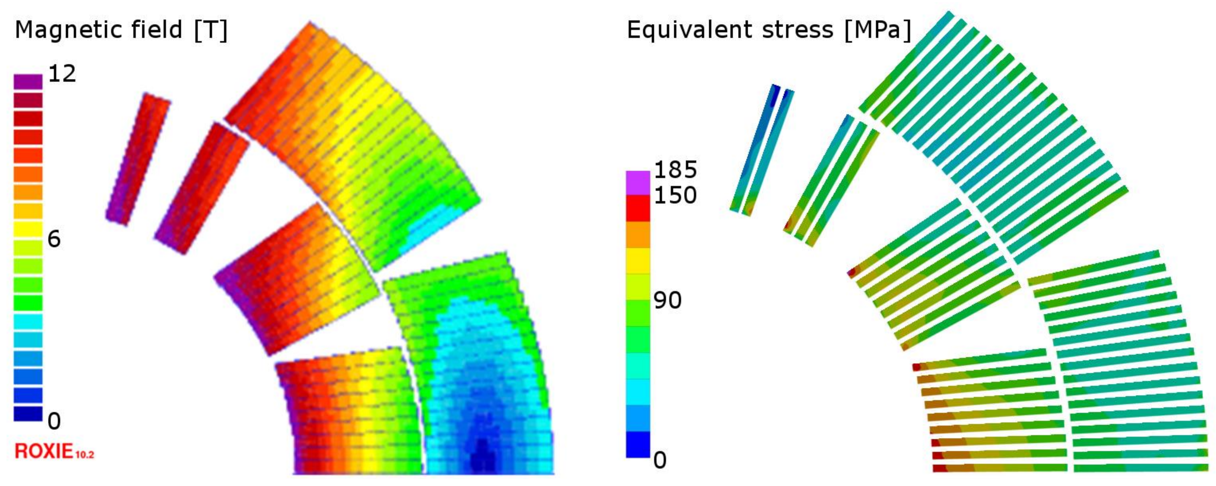


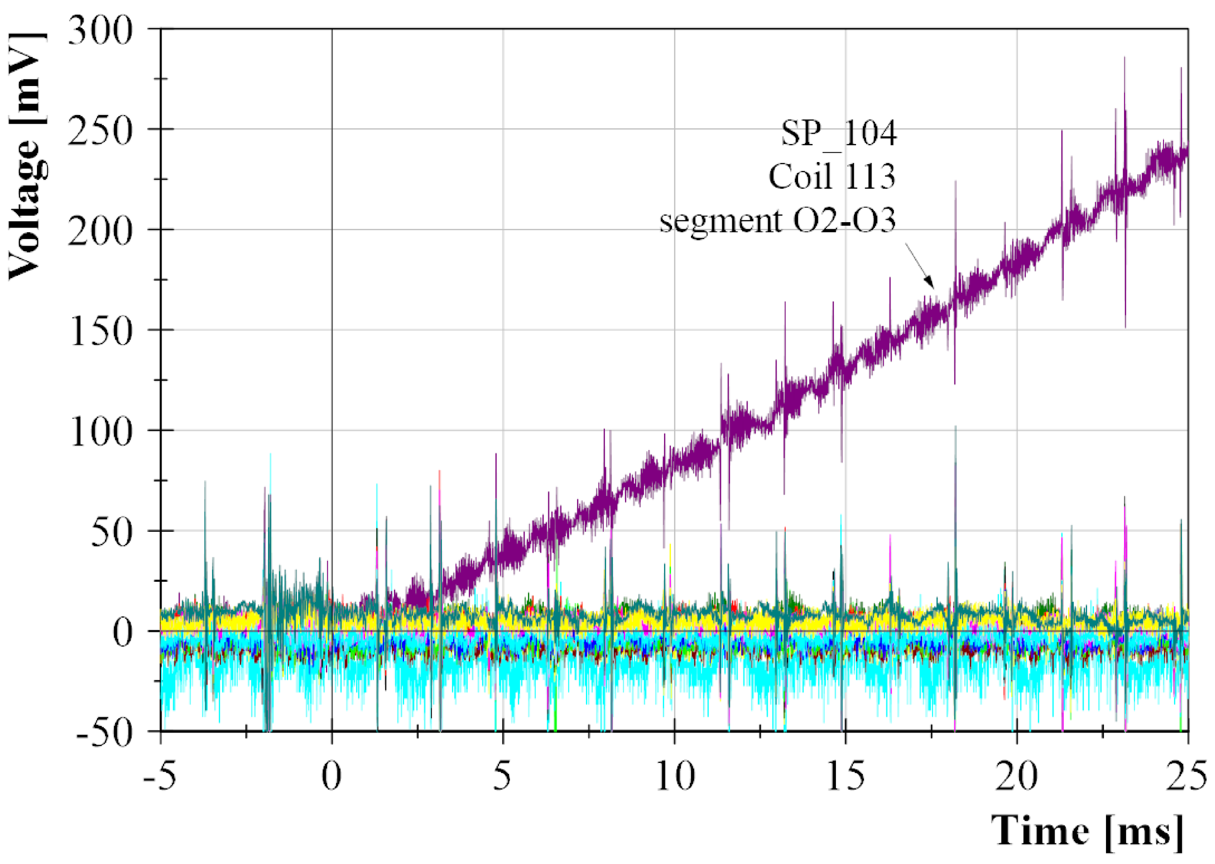
Photo of SP_105. Inset: solid model of the magnet's winding

- Six 11 T dipole model magnets have been tested:
  - Five single aperture: SP_101...105
  - One double aperture: DP_101
- The magnets' largest stress area during powering is the inner midplane, a location with large magnetic field gradients.
- Additionally, stress may be concentrated in the highest field area due to C-shaped mica insulation
- High quench propagation velocity (QPV) was observed in the midplane of SP_105 and DP_101.



Top: magnetic field (left) and stress (right) map in the magnets. Bottom: pressure distribution at warm in the inner midplane (left), schematic cross section of the cable (middle), photo of the cable (right)

QUENCHES IN THE 11 T NB_3SN MODEL DIPOLES

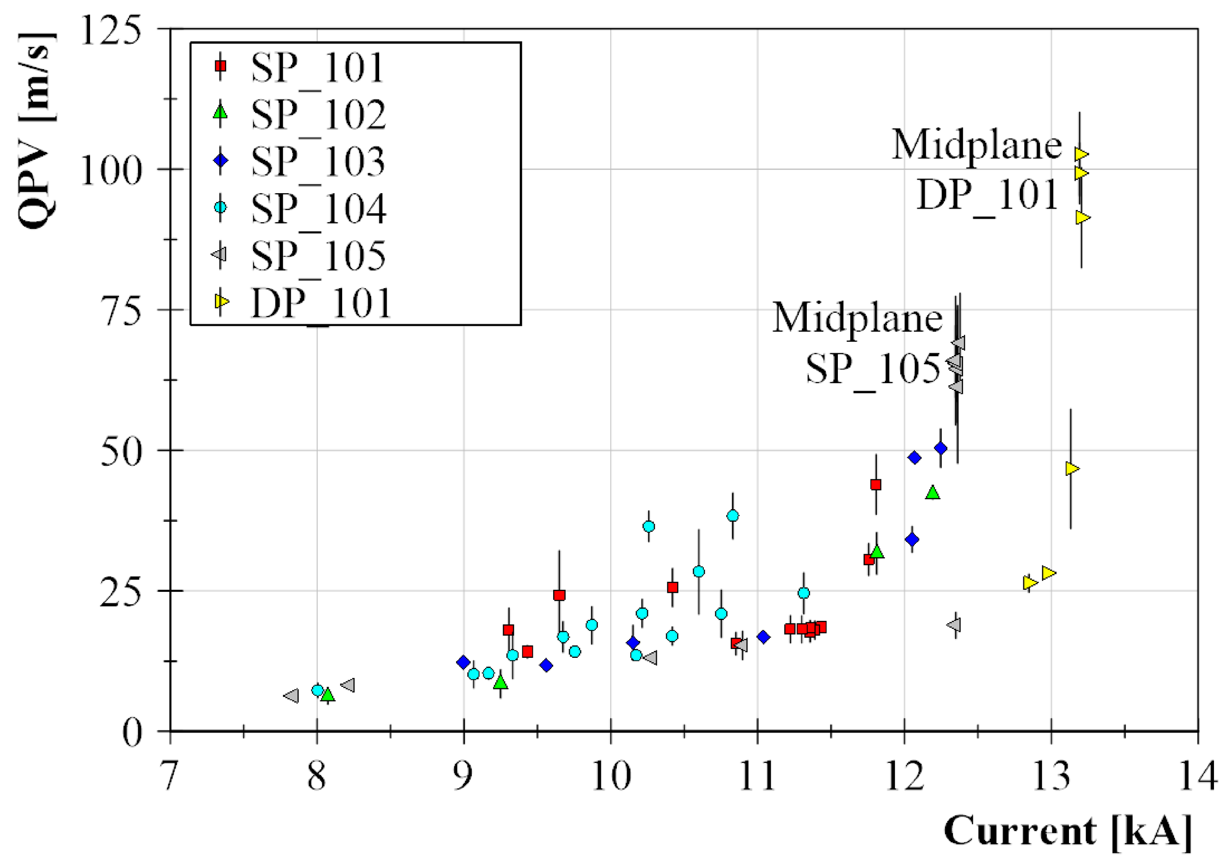


Voltage rise during a quench

- Quench propagation velocity (QPV) calculated from the voltage rise during quench:

$$QPV = \frac{1}{2}\frac{dl_R}{dt} \approx \frac{A_{cu}}{2I\rho_{cu}}\frac{dV_R}{dt}$$

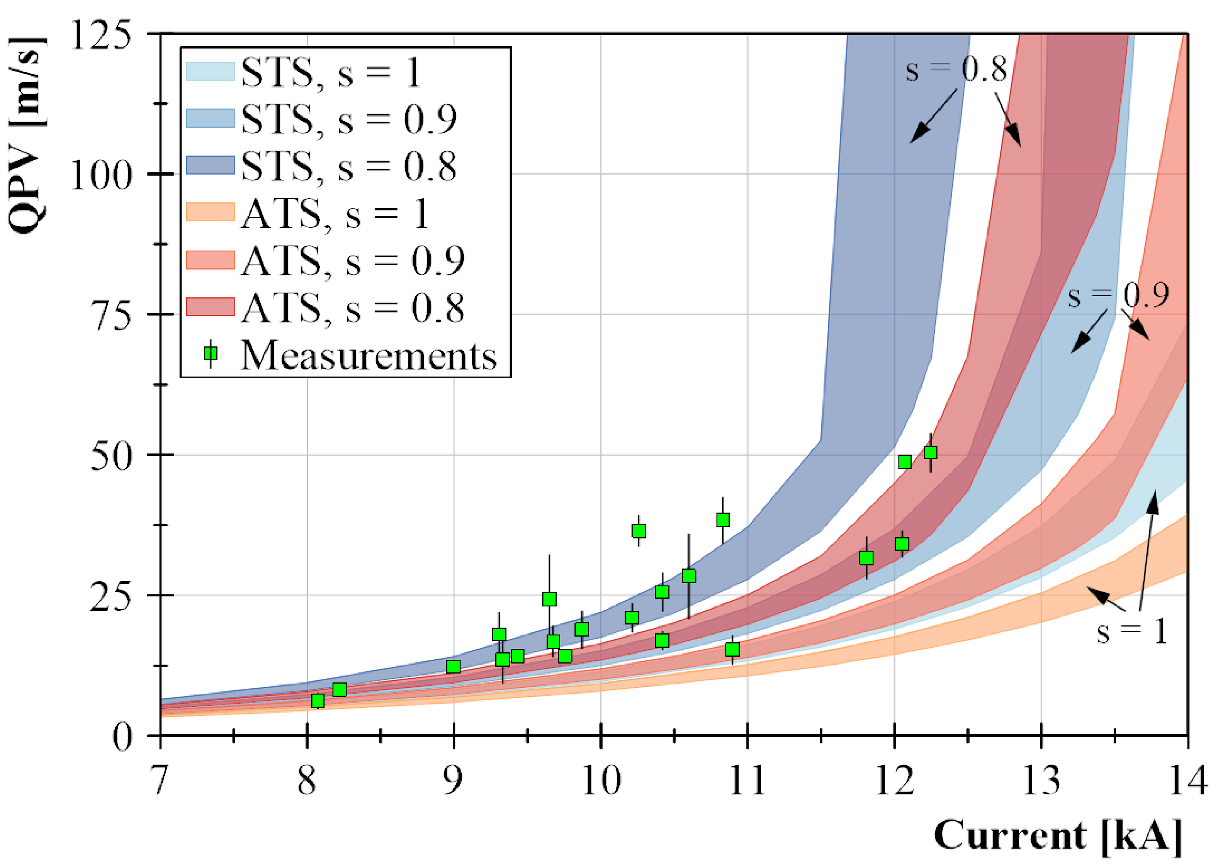
- Applied only in single turn quenches (otherwise it overestimates the QPV) at 1.9K
- Larger QPV can be explained by large disturbance or by reduced critical current
- Observation: repetitive, very high QPV in midplane quenches in magnets SP_105 and DP_101
  - Probably due to a reduction of I_c



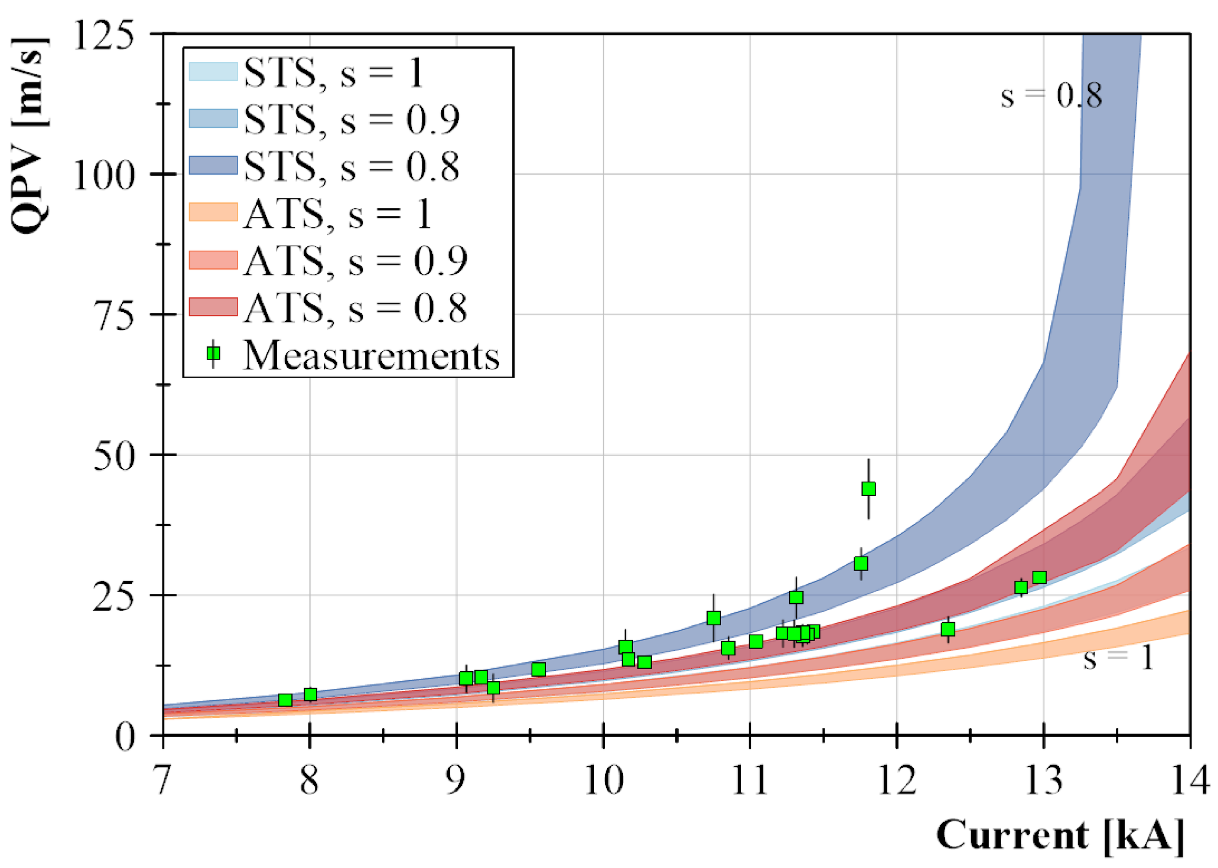
Measured QPV of the qualifying quenches

1-D LUMPED MODEL SIMULATION RESULTS & COMPARISON

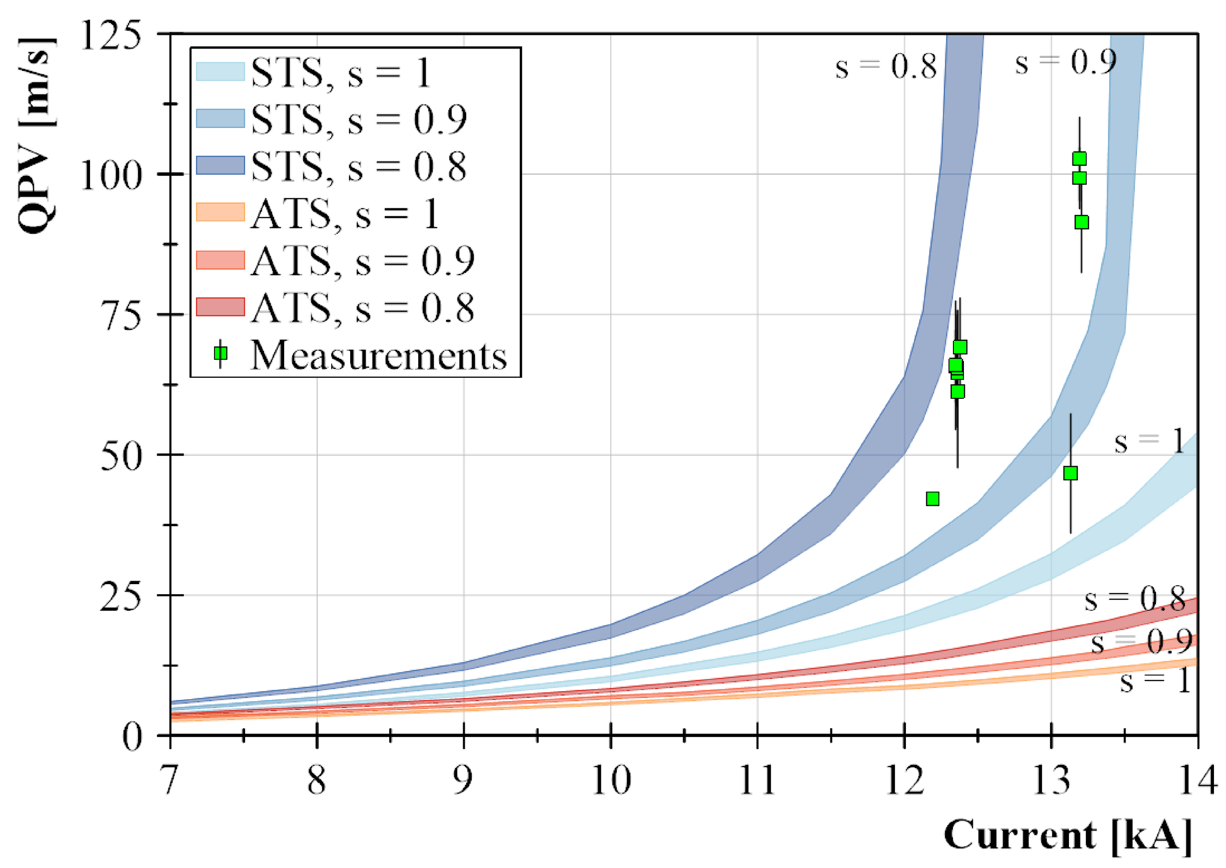
- 1-D lumped model used to simulate the QPV Along-The-Strand (ATS) and Strand-To-Strand (STS).
- Variables: transport current, quench location, strain function "s", cable properties. The bands in the plot represent different cable properties.



Measured and simulated QPV in the inner pole turn



Measured and simulated QPV in the outer pole turn



Measured and simulated QPV in the inner midplane

DISCUSSION

- In inner and outer pole turns, the measurements match better with STS than with ATS for lower strain.
- In inner midplane the measurements fit well with STS at high strain.
  - In this area, the reduction of I_C expected from the QPV measurements (25-50%) is much larger than the expected from the stress simulations (12-17% at 135-145 MPa).
  - This effect is probably caused by stress concentrations due to the mica insulation.

CONCLUSIONS

- Quench propagation in the 11 T model magnets: most likely always STS.
- High QPV in the inner midplane consistent with a reduction of I_C caused by high stress in the area and aggravated by the mica insulation.