Quench Stability against Beam-loss in Superconducting Magnets

at the 50 GeV Proton Beam Line for the J-PARC Neutrino Experiment

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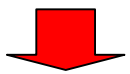
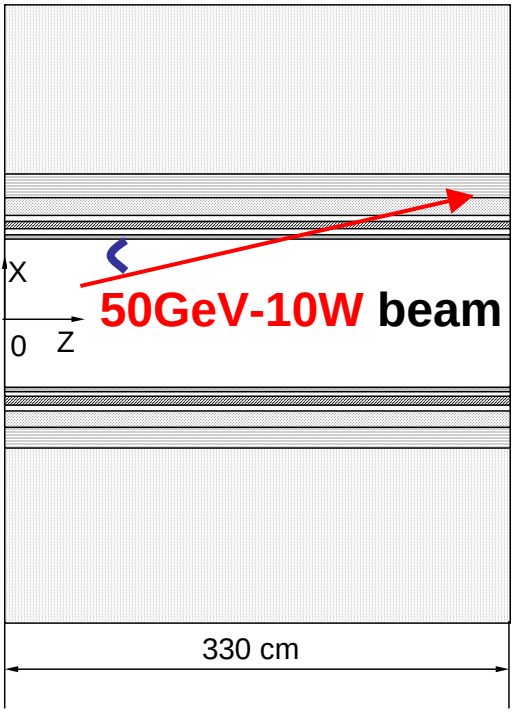
In case of 50GeV-10W/point beam loss

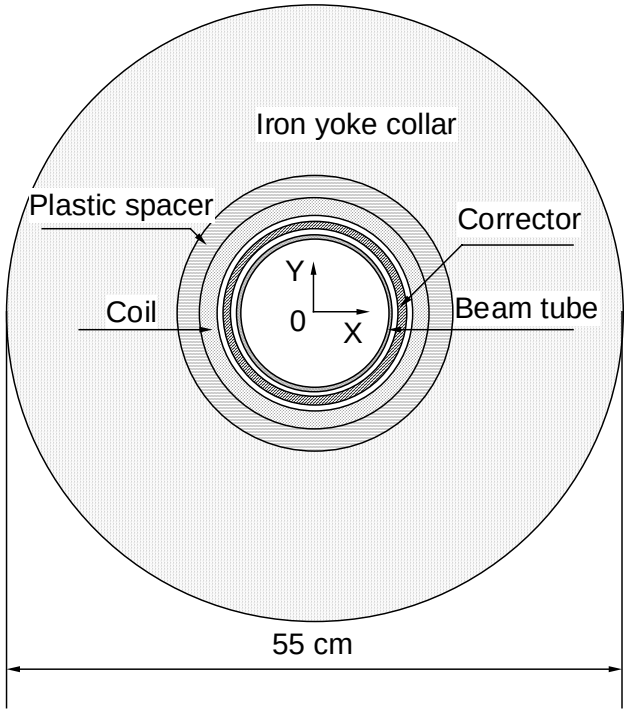
(Acceptable beam loss in view of shielding and maintenance)

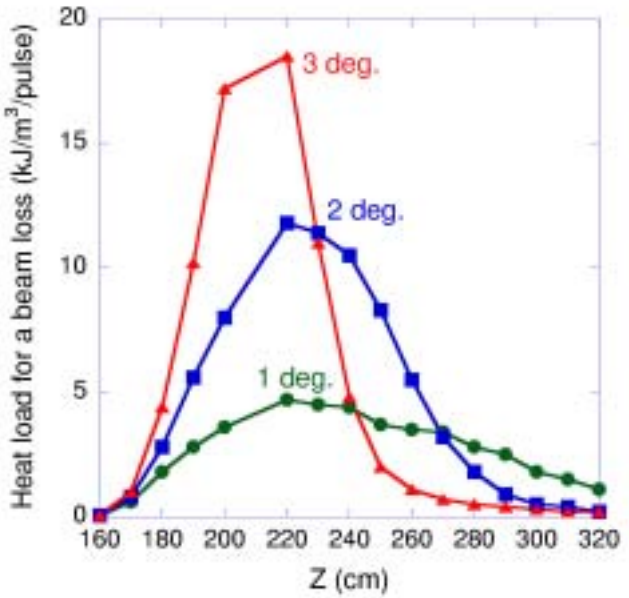


Calculate heat load for a 10 W/point beam loss in the cable by MARS code

Heat Load Simulation using MARS code







Heat load will be up to **20 kJ/m³/pulse.**

Heating of 0-40 kJ/m³/pulse was used in experiment and the quench simulation.

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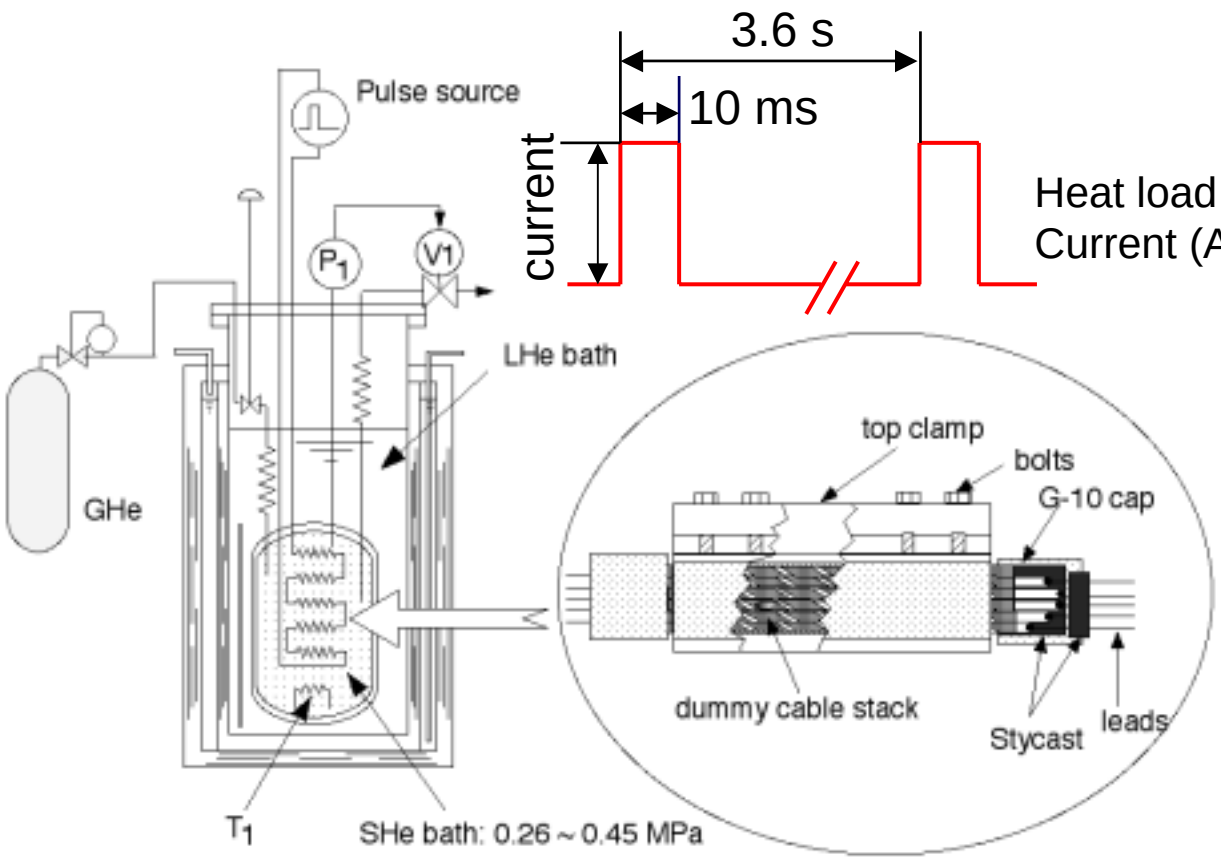
Using Heating of **0-40 kJ/m3/pulse**

Measurements

of temperature rise of the cable

Experiment



P_1: Absolute pressure transducer

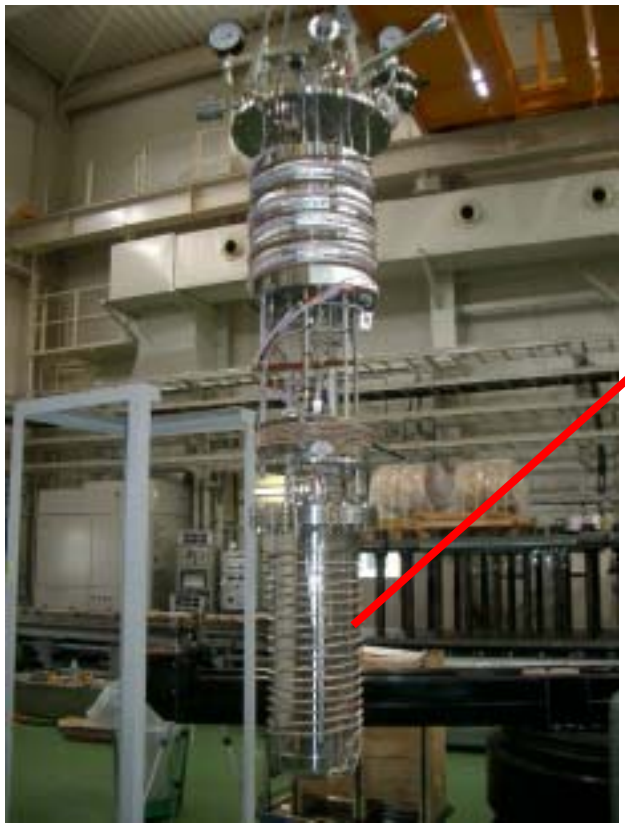
T_1: Silicon diode thermometer

V_1: Pressure control valve

Heat load (kJ/m^3/pulse) 8, 14, 20, 28, 37

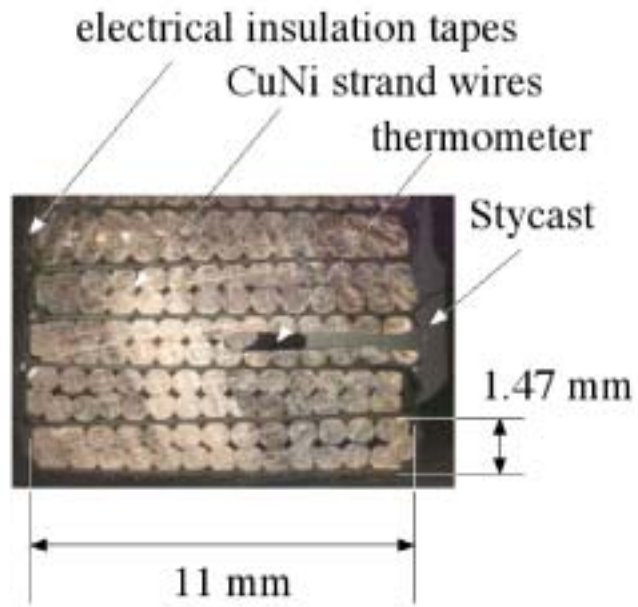
Current (A) 30, 40, 50, 60, 70

The cable used the same structure of superconducting magnet.
It was made of CuNi in order to generate Joule heating.



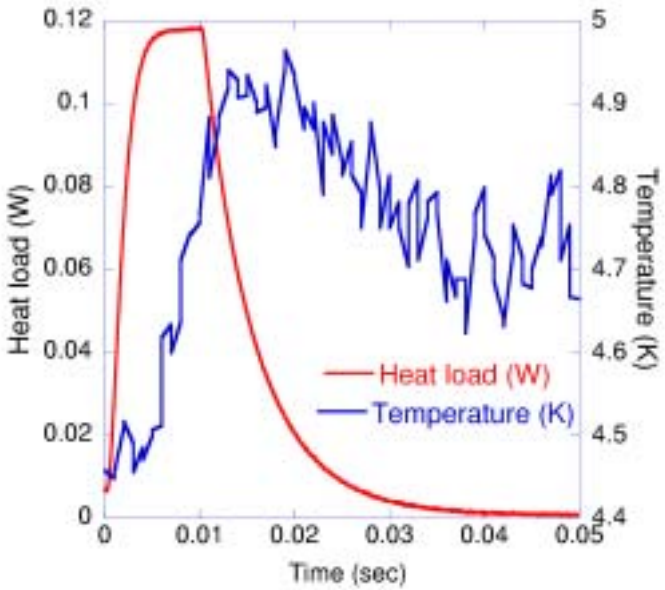
overview

Specimen

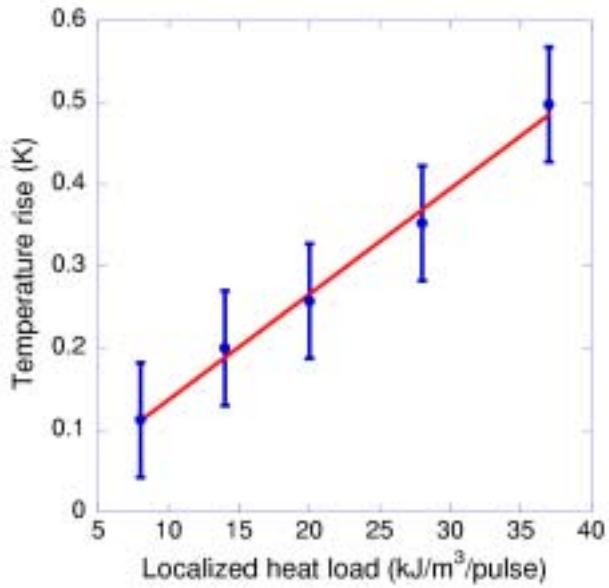


Cross section of the cable

Experimental result



28 kJ/m^3/pulse heat load.
0.46 K temperature rise.



Temp. rise is proportional to heat load.

20 kJ/m^3/pulse for a 50GeV-10W loss

Instantaneous temp. rise = 0.25 K

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Using Heating of **0-40 kJ/m3/pulse**

Measurements
of temperature rise of the cable
is **0.25 K** for a **20kJ/m^3/pulse loss**.

Quench stability simulation.

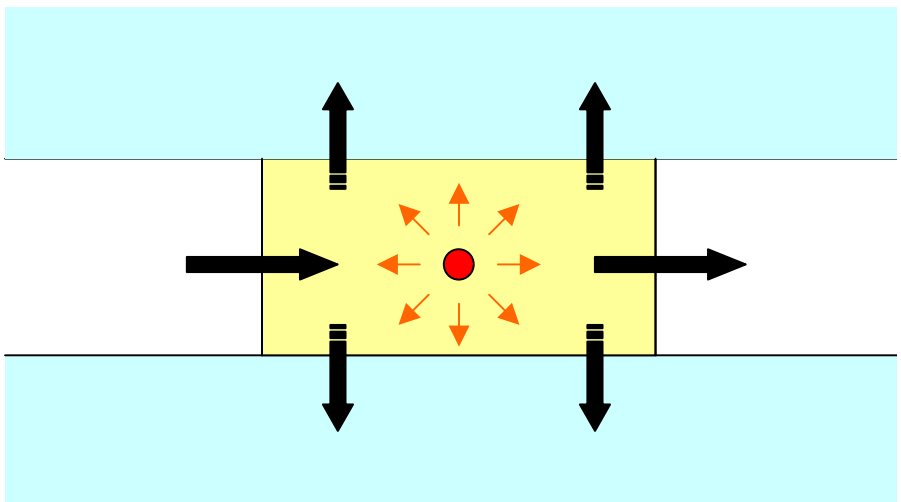
Quench Stability Simulation

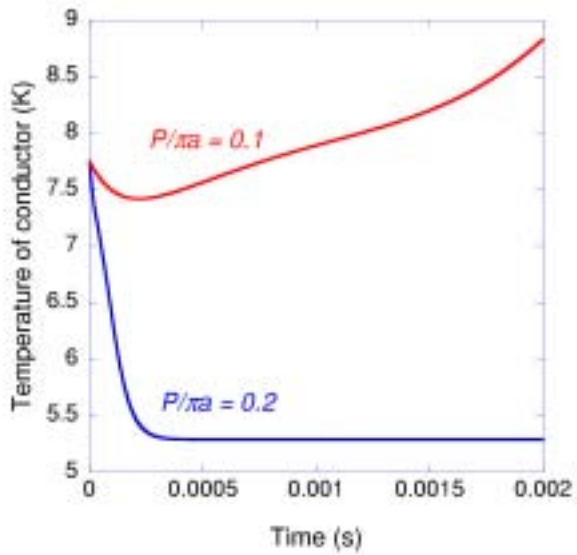
Heat balance equation

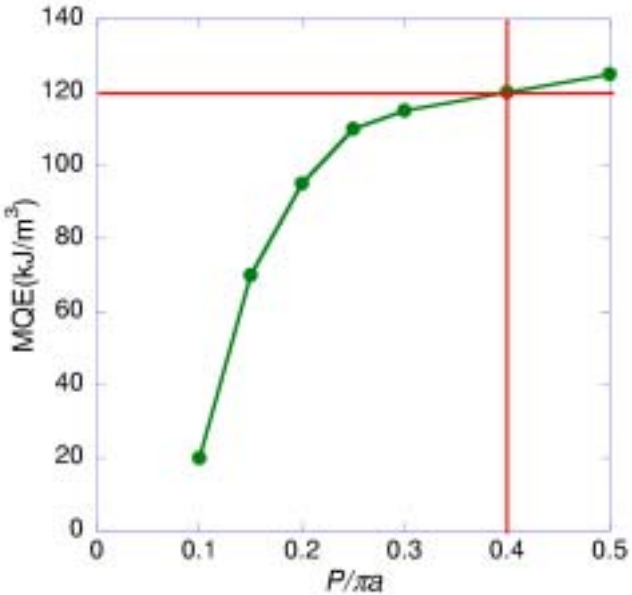
$$A\frac{d}{dx}\left(k(T)\frac{dT}{dx}\right)-Pq_s+gA=AC_p(T)\frac{dT}{dt}$$

$$q_s=h(T-T_b)$$

A: the overall cross section
K(T): thermal conductivity of conductor
P: strand's wetted perimeter
q_s: heat transfer to SHe
g: Joule heating in conductor
$C_p(T)$: volumetric specific heat of conductor







P/πa ~ 0.4 (the actual cable)

20 kJ/m³/pulse heat load is OK (for a 50GeV-10W beam loss)

120 kJ/m³/pulse heat load (for a 50GeV-60W beam loss) may be acceptable.

Summary

Calculation result by MARS which simulate the actual magnet in the J-PARC neutrino beam line

Heat load in coil will be up to 20 kJ/m^3/pulse
for a 10W/point beam loss

Experimental result

Instantaneous temp. rise in the cable = 0.25 K

Quench simulation result

Not induce a quench.
At least,
120 kJ/m^3/pulse heat load
for a 50GeV-60W beam loss
may be acceptable.