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Heat load for a beam loss on the superconducting magnet

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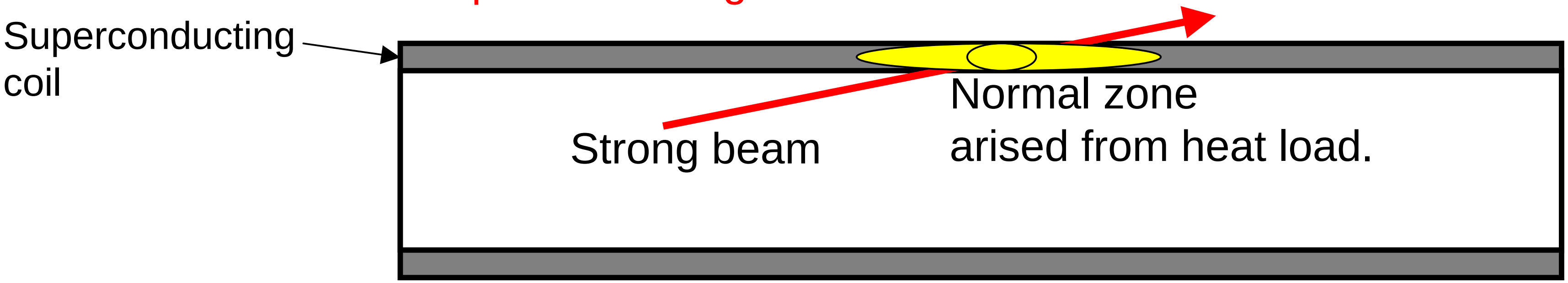
Introduction

"Quenching" occurs when any part of a magnet goes from the superconducting to the normal resistive state.



Investigate the quench stability of the superconducting cables

In case of 50GeV-10W/point **beam loss**
(in view of radiation shielding and maintenance)

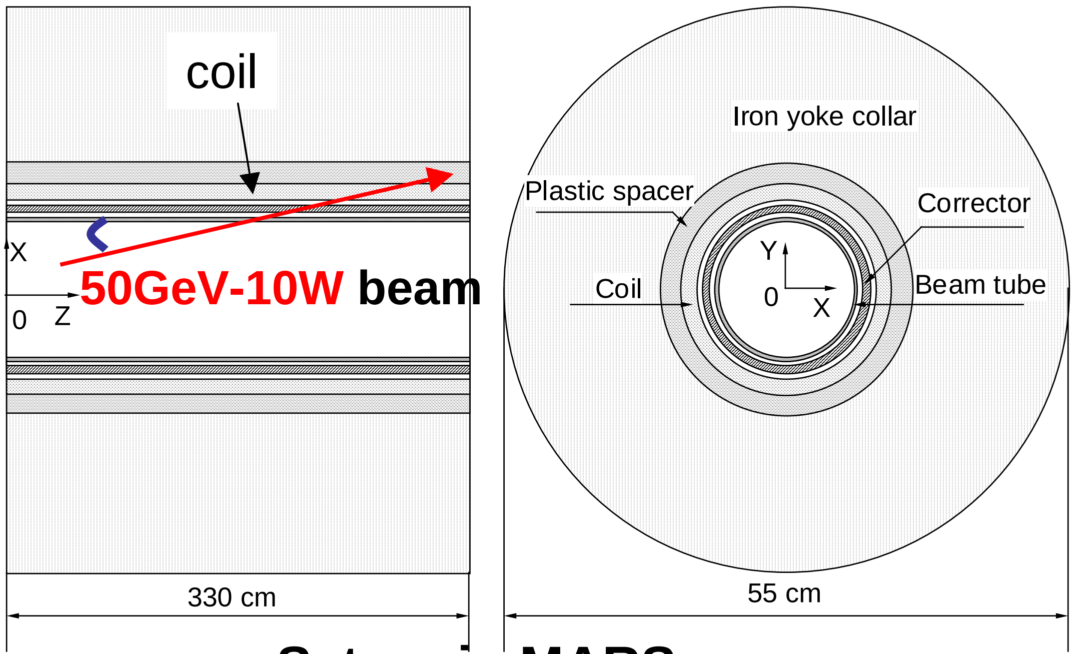
Heat load on the cable was calculated using MARS code.

Using calculated heat load……

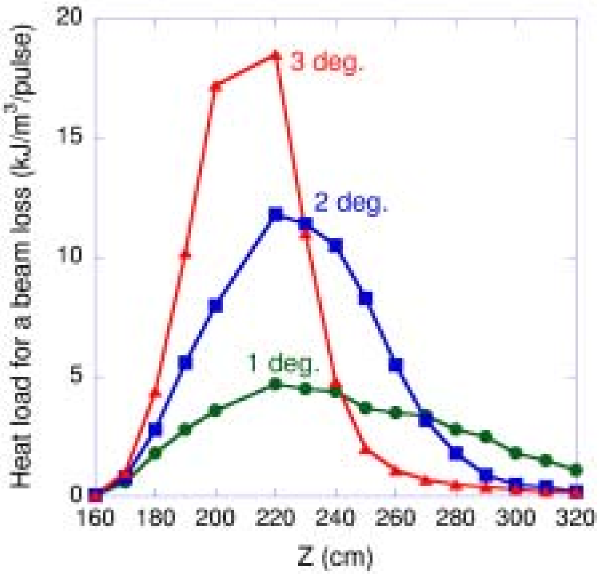
Measurements
of temperature rise of the cable

Quench stability simulation

Calculation of heat load on the coil– for a 10 W/point loss by using MARS code.



Set-up in MARS



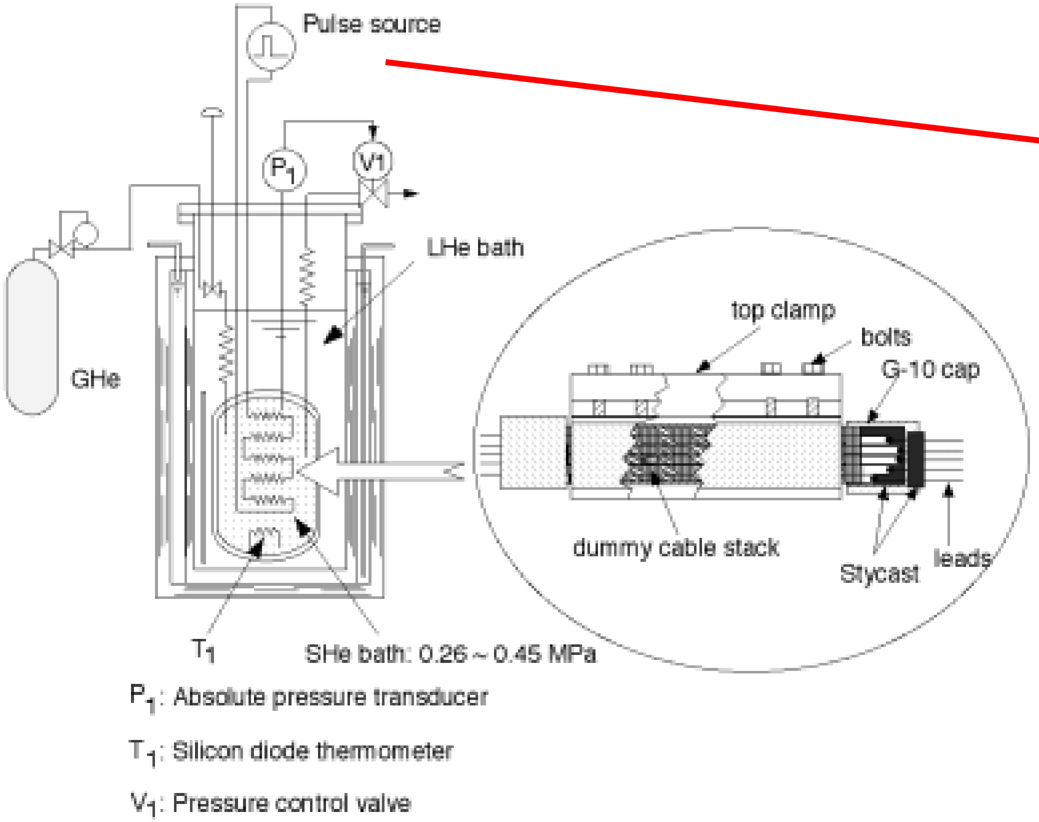
Heat load on the coil

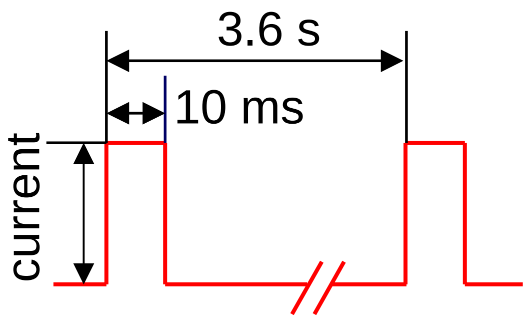
Heat load will be up to **20 kJ/m³/pulse.**

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

Measurement of temperature rise of the cable

It is difficult to make an experiment using actual beam.
The cable was heated with a pulse generator.
The cable was used the same structure of LHC superconducting magnet.

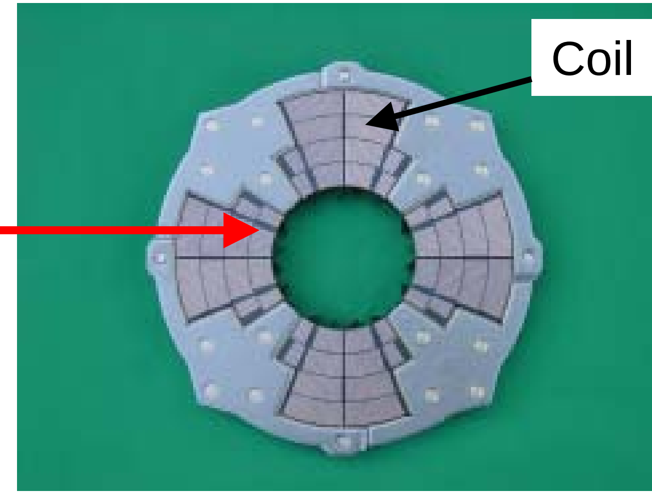




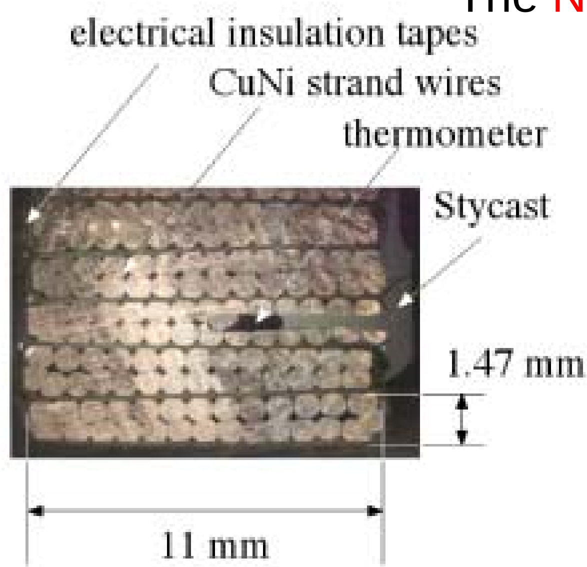
Heat load (kJ/m^3/pulse) 8, 14, 20, 28, 37
Current (A) 30, 40, 50, 60, 70

The cable that is used for the coil of the LHC magnets will be used for the J-PARC coil.

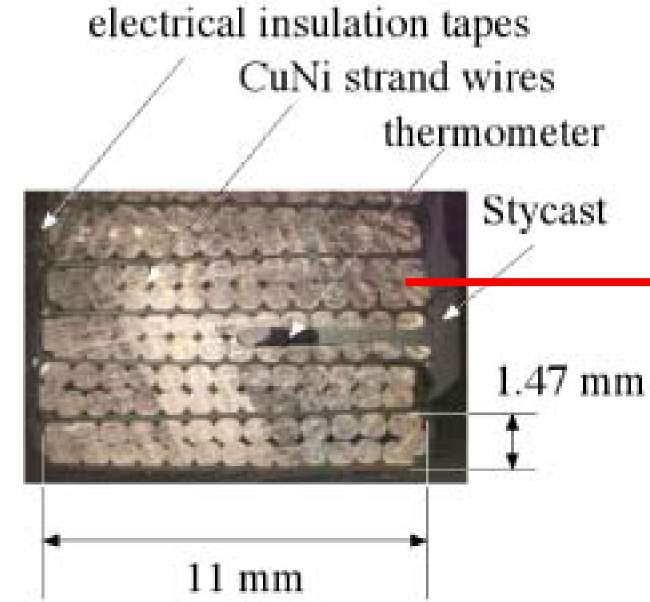
The LHC insertion region quadrupole, MQXA magnet



Cross section of the MQXA magnet.
The NbTi/Cu strand wires are used.



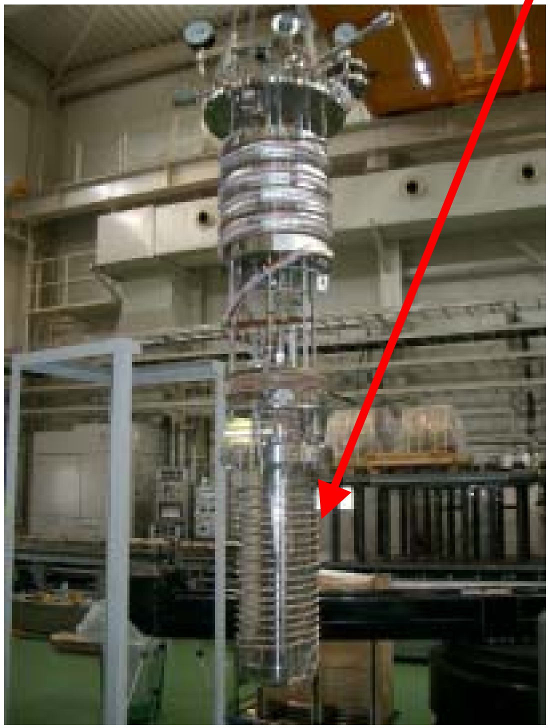
Cross section of the cable using this work .
The CuNi strand wires were used in order to generate Joule heating.
However, This cable is same structure of the coil stack for the MQXA magnet.



Cross section of the cable

Specimen

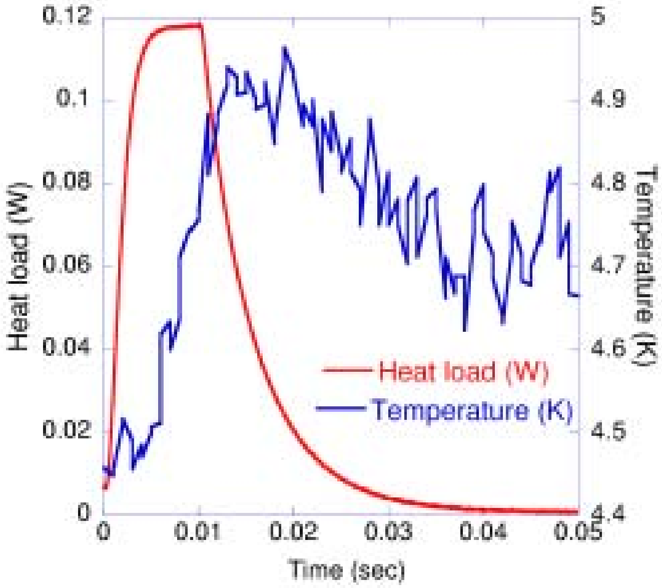
It was installed in supercritical helium bath.
(4.4 K, 0.3 MPa)

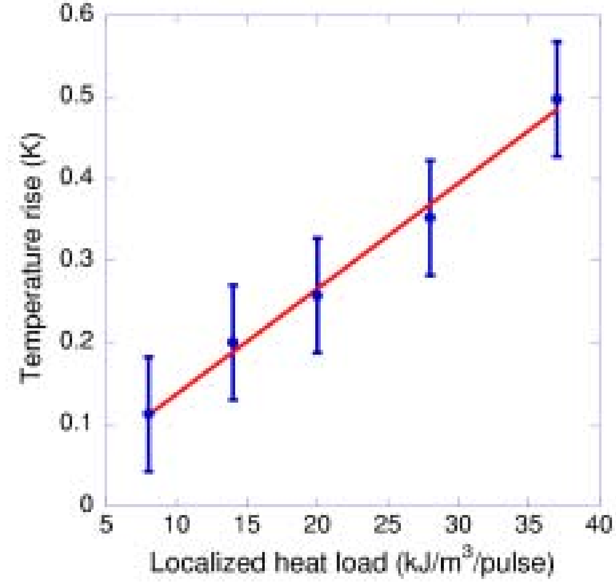


Overview

It was installed in cryostat.

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 beam loss)**

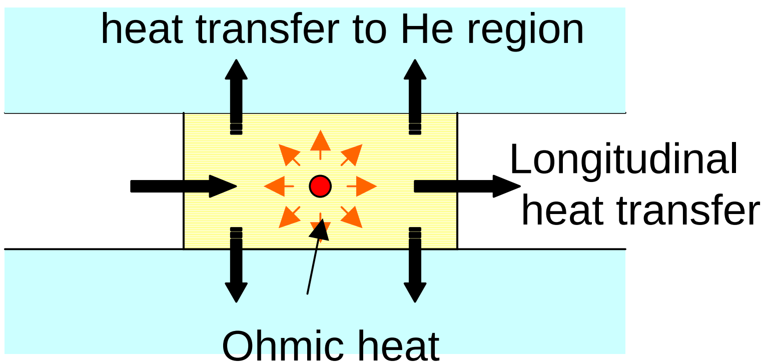
Instantaneous temp. rise = 0.25 K

Quench Stability Simulation

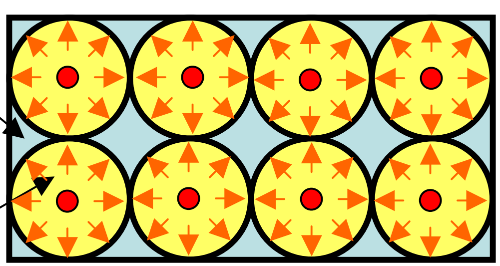
Heat balance equation

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

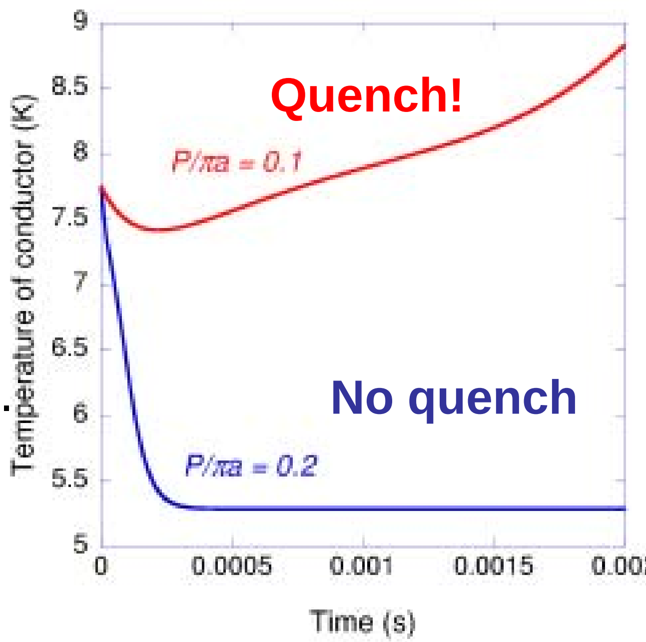
A: the overall cross section
K(T): thermal conductivity of conductor
P: strand's wetted perimeter
q_s: heat transfer to SHe
g: Joule heating in conductor
$C_p(T)$: volumetric specific heat of conductor



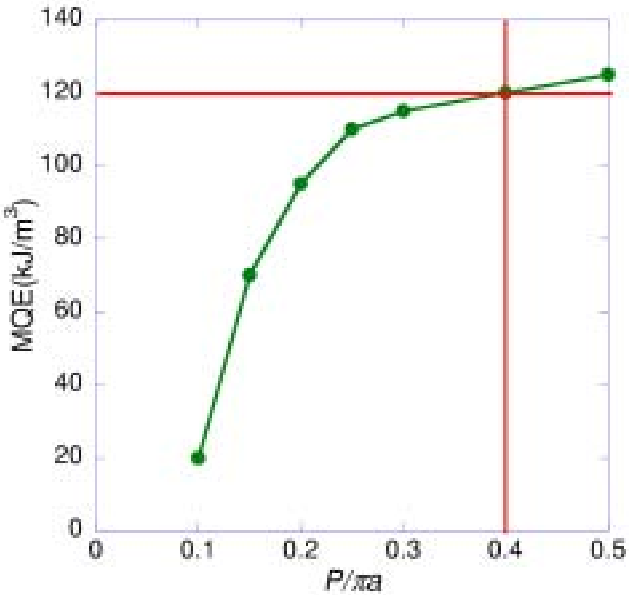
Quench tends to be influenced on parameter, ***p/πa***.
p/πa indicates the contact ratio with He and conductor.



Cross section of the cable.



Simulation result of temp. versus time.
20kJ/m³ heat load into conductor



Stability margin.

P/πa ~ 0.4 (the actual cable)

20 kJ/m^3/pulse heat load is **OK**
(for a **50GeV-10W beam loss)**

120 kJ/m^3/pulse heat load
(for a **50GeV-60W beam loss)**
may be **acceptable.**

MQE is minimum quench energy.
pl/πa is the contact ratio with He and conductor.

Summary

Heat load on the coil will be up to **20 kJ/m^3/pulse** for a **10W/point beam loss** by **MARS** code.

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.