Possible Quench protection & detection methods for a conduction cooled MgB_2 magnet

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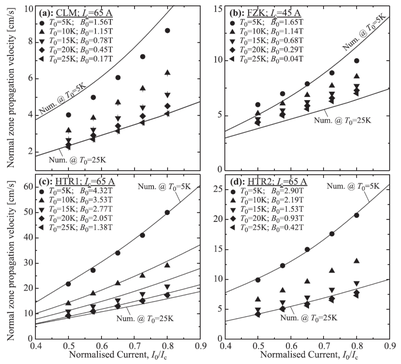
What kind of magnet?

The magnetic density separation (MDS) magnet is shown in the central image.

- a conduction cooled magnet made of MgB_2.
- Poses challenge to the quench detection and protection.
- Less cooling power locally than helium bath.
- MgB2 has anomalous MQE and NZP velocity behavior, this is further discussed in the next box.

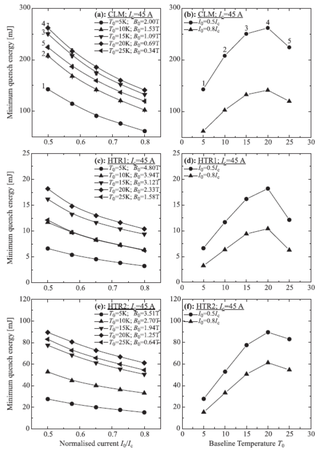
MQE & NZPV of MgB_2



H. van Weeren (2007)

The NZP velocity of MgB_2 conductors is significantly lower than NbTi (cm/s versus m/s). This makes it harder to find an appropriate detection method.

The MQE as function of temperature of MgB_2 has a maximum. This makes the operating temperature very important for the quench protection mechanism.



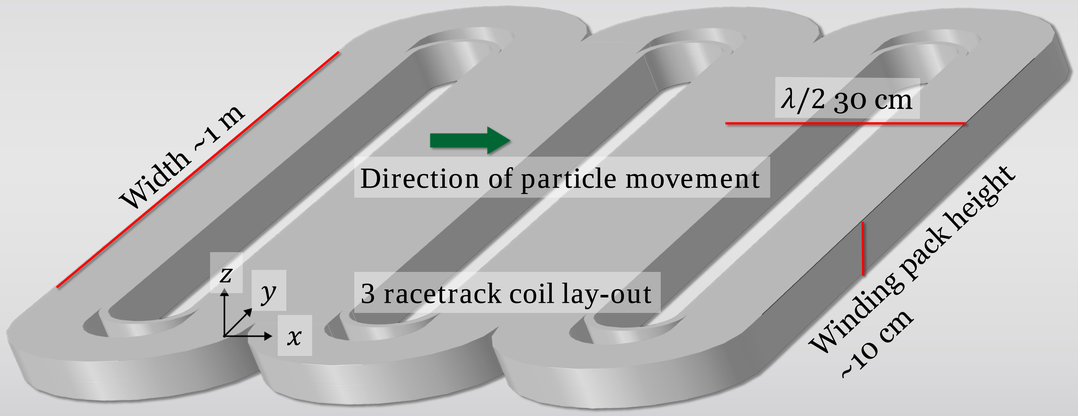
H. van Weeren (2007)

Protection & detection methods

To assist in the choice of quench protection & detection a literature survey is done. The results of this survey is shown in the tables below.

System	Mature technology	Possible detection time	HTS	Quench location	Main advantage(s)	Main disadvantage(s)
Voltage	+	Within tens of milliseconds	-	-	Simple and reliable	A lot of filtering is needed
Active power	+	Within tens of milliseconds	+	-	Low vulnerability to noise, easy to filter	Multi coil systems still needs additional filtering
Optical fiber	-	Within half a second	+	+	Real time sensing	Huge amount of data processing
Acoustic	-	Within milliseconds	+	+	Non-intrusive Easy to install	Hard to filter signal. Not all quenches are detected
Poynting vector	-	NA	+	-	Indirect measurement at room temperature	Not usable on magnets with iron yoke
Split conductor	-	NA	+/-	-	Sensitive to 10^{-12} Q. Sense heating at $I<<I_c$	Engineering challange to split conductor

System	Suitable for HTS	Suitable for high field magnets	Energy dump	Main advantage(s)	Main disadvantage(s)
External dump resistor	+	-	External	Simple and reliable	High resistance means high voltages
Subdivision of coils	+	+	External	Limits voltages. Quench back mechanism	Each subdivision needs protection and detection
Heating up the magnet: Heater	-	+/-	Internal	Uniform heating of outer edges of the magnet	Heat generation causes engineering challenge
Heating up the magnet: CLIQ	-	+/-	Internal	Uniform internal heating	Can cause short circuits
A coupled secondary	+	+	Internal/ Transfer	Fast current decay	additional copper causes AC losses



Possible protection & detection method

For detection voltage taps might be possible

- NZP velocity might be to slow, this needs testing.

For protection heaters are probably needed, due to:

- low NZP velocity
- Details are also dependent on magnet system layout
- Simulations are needed to study this method further.

What's next?

- NZP measurements on MgB_2 wires.
- Development of custom quench analysis code dedicated to MgB_2 magnets

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