Using the code QP3 to calculate quench thresholds for the MB

Arjan Verweij, TE-MPE

The code QP3

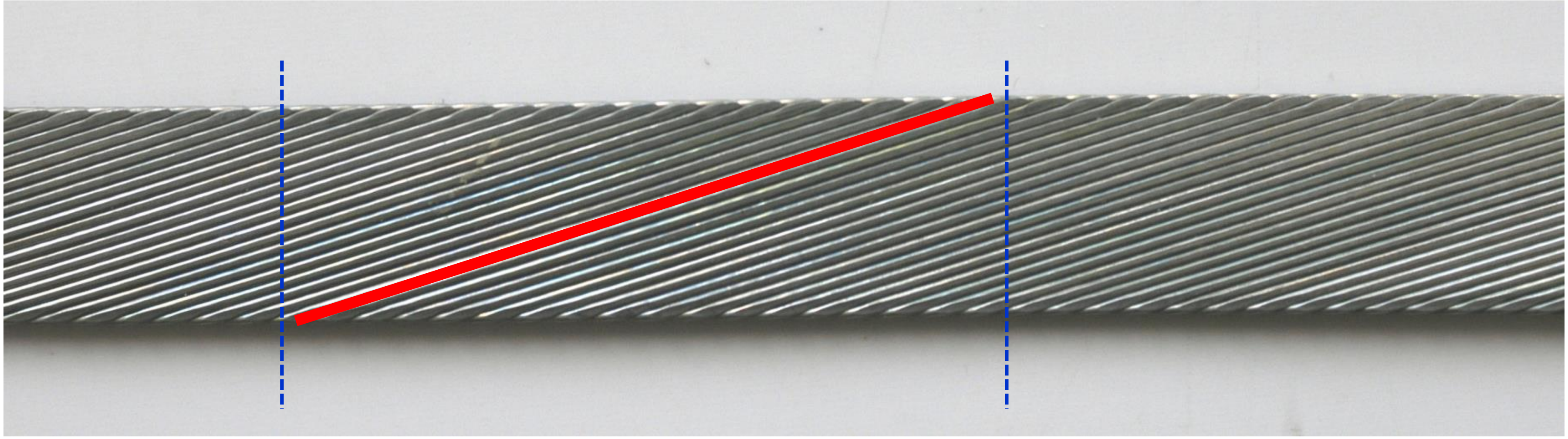
The code QP3 can be used for any electrodynamic-thermal calculation of superconductors (or normal conductors), especially suitable for uncoiled conductors or coils with small heat transfer between the turns.

It is used to calculate:
- QPS thresholds for busbars/coils.
- Quench propagation.
- Hot spot temperatures in coils.
- The 2008 accident.
- The behaviour of defective joints in the 13 kA circuits ('safe current', required shunt size for the repair, tests in FRESCA and SM-18).

….. and can 'easily' be used to calculate the quench thresholds for BLM settings.

Modeling the geometry

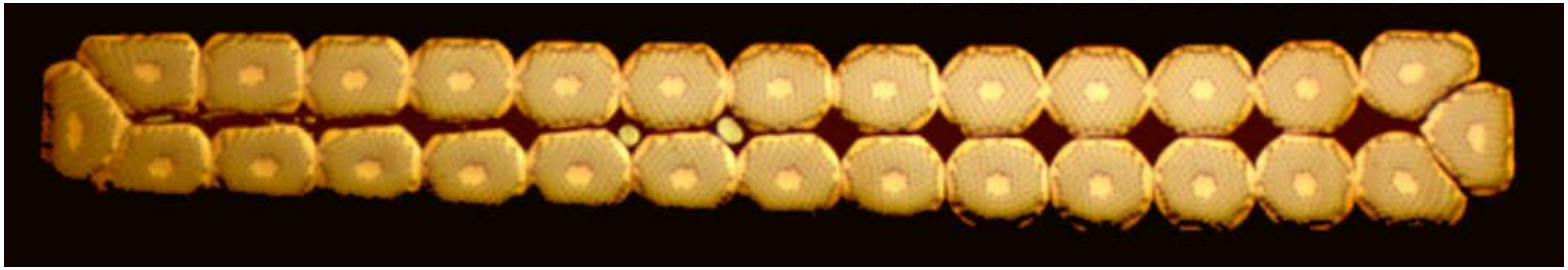
Considering the high contact resistance between the strands in a Rutherford cable, the response of the MB cable due to a beam loss stretching over several meters can be modeled by a single strand with a length of half the cable transposition pitch, and symmetry lines at both ends.



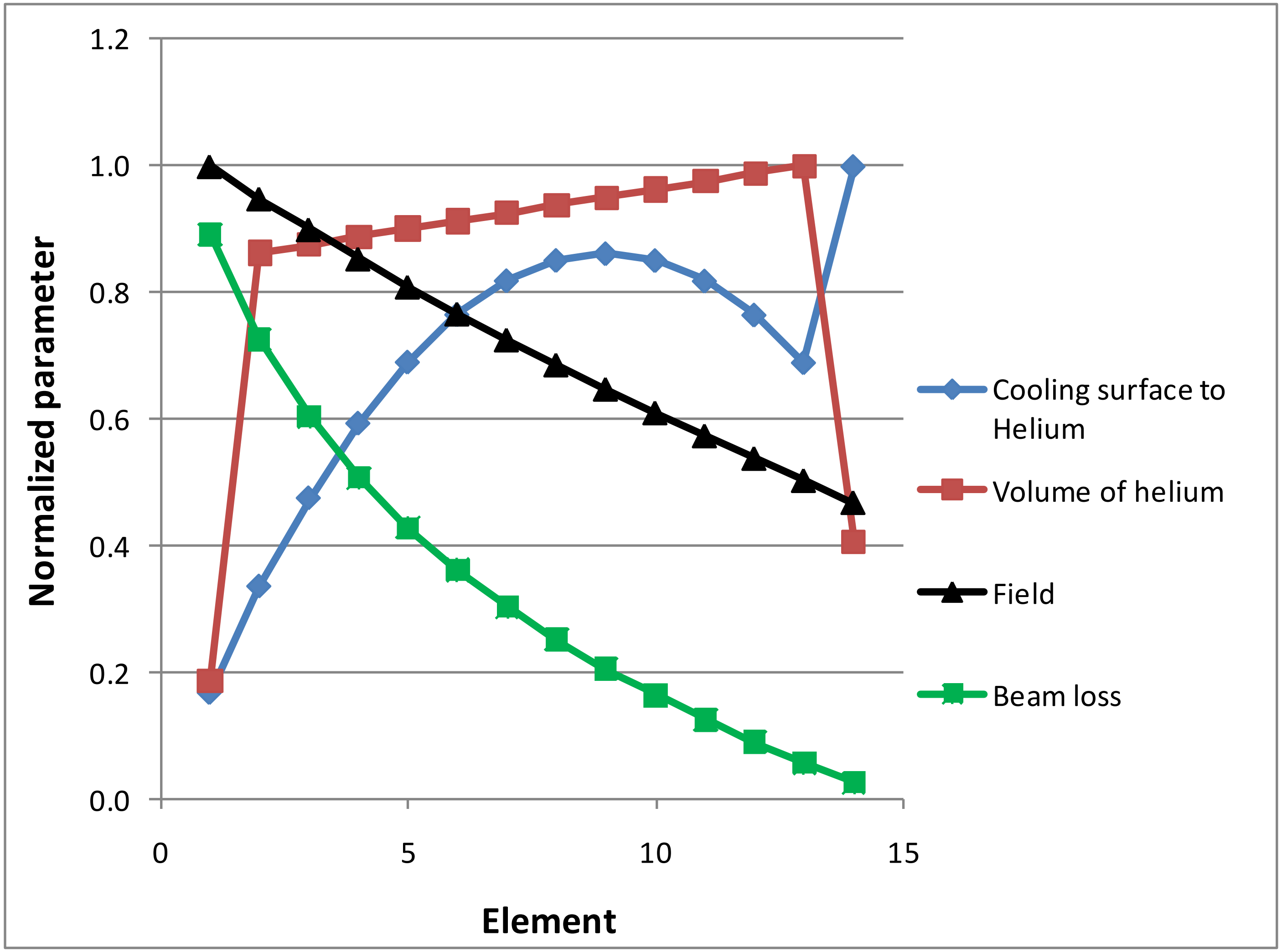
Variations over the cable width

QP3 takes realistic variations (over half a pitch) of the following parameters:

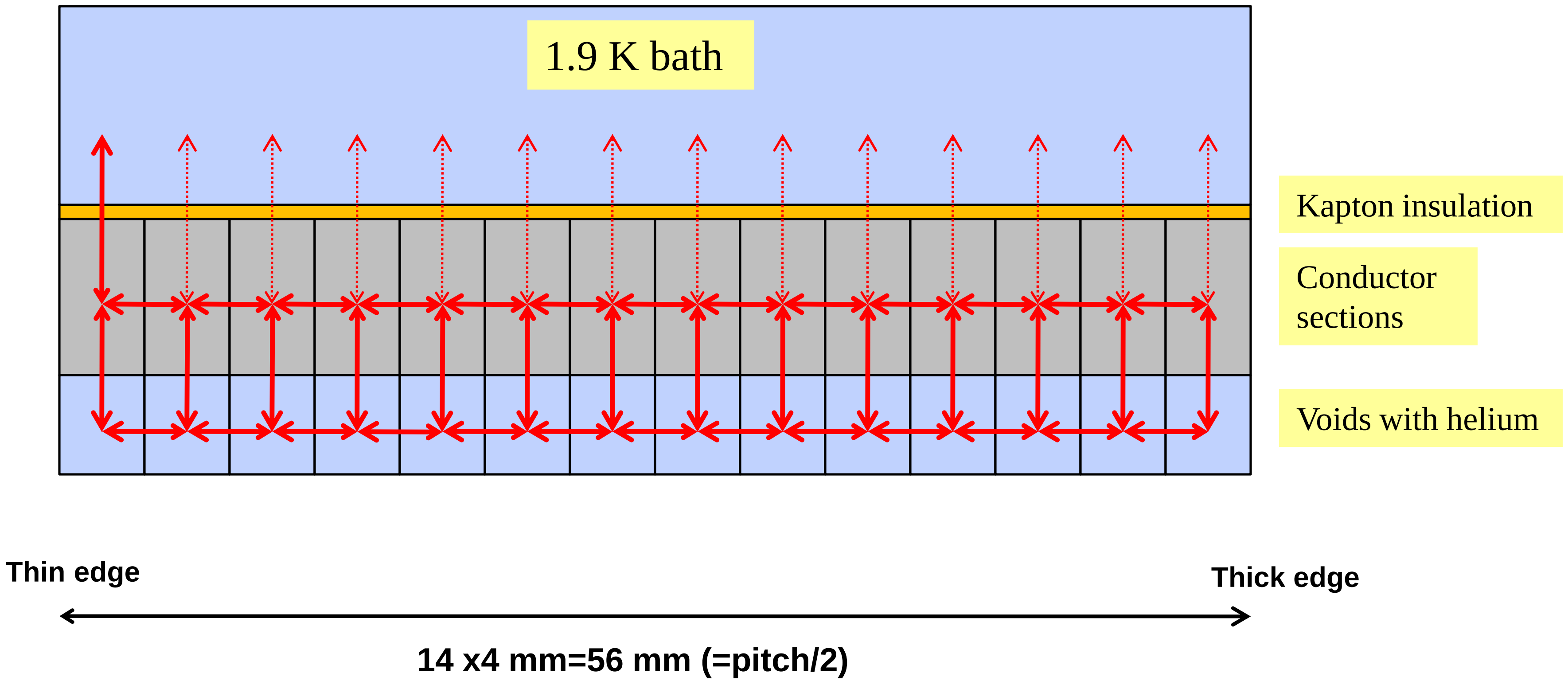
- Field (input from Roxie)
- Void volume (input from tomography measurements from TE-MSC)
- Cooling surface with helium inside the voids (input from tomography measurements from TE-MSC)
- Beam losses (input from Note 422)
- Cooling to the helium bath (input from heat transfer measurements at CERN and Saclay on dummy LHC coils).



Variations over the cable width



The model



An external heat pulse (i.e. beam loss) can be applied with arbitrary shape (both in space and in time).

Inputs

Resistivity=f(B, T, RRR)

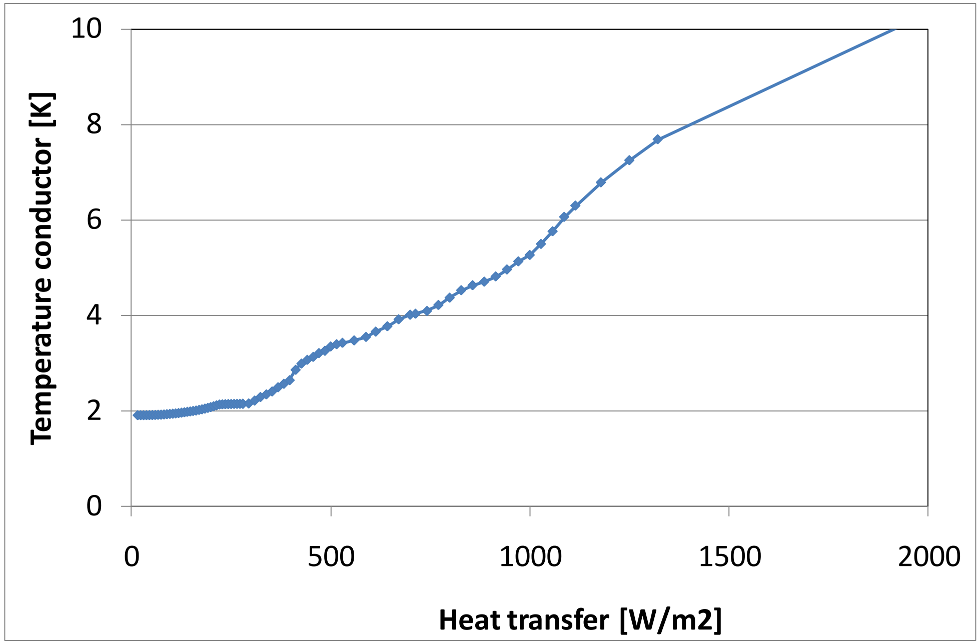
k_{Cu}=f(B, T, RRR)

k_{kapton}=f(T)

Cp_{He}=f(T)

Cp_{Cu}=f(T)

Cp_{NbTi}=f(T,B)

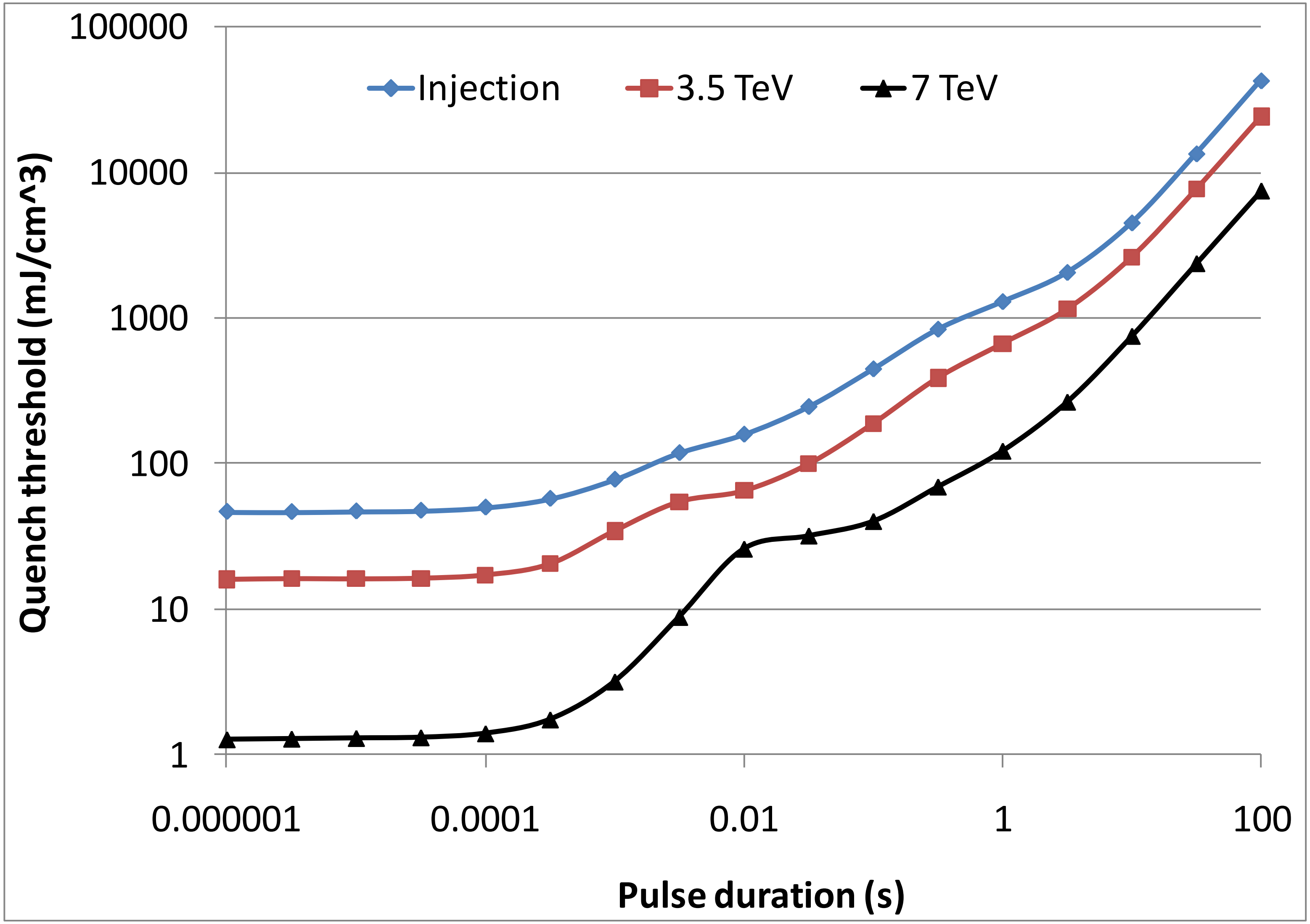


Steady-state heat transfer from conductor to bath through kapton (to be checked if for single cable or coil)

Cooling to helium inside voids:

- Transient Kapitza cooling up to Tλ or up to maximum heat flow (35000 W/m^2), and film boiling afterwards.
- Infinite heat flow between the helium in the voids up to Tλ and no heat flow above Tλ.

Results



100000
10000
1000
100
10
1
Quench threshold (mJ/cm^3)
Injection
3.5 TeV
7 TeV
0.000001
0.0001
0.01
1
100
Pulse duration (s)

Changing some input parameters…..