Quench protection task

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Goals of quench protection task

Plan for the first 10 months (June 2015 – march 2016):

1. Parametric analysis
   - How different aspects of magnet design impacts the quench protection
   - Required protection efficiency characteristics
   - Feedback to magnet design

Topic of this talk

2. Review of potential quench protection strategies

based on

3. Evaluate the different protection options and choose the baseline

4. Identify the modeling tools to use and the needed updates

The following 30 months: Protectability of the design options, protection schemes for long and short version of the chosen magnet, magnets connection in a string

Distribution of work

First 10 months

- Conceptual quench studies for 16 T dipole: TUT
- Review and baseline for protection: TUT + ALL
- Basic simulation tool comparison: TUT + INFN/Milano

- Then
  - Detailed analysis of individual design options
  - Work to be shared later

- Later
  - Extend analysis to strings of magnets

Let's fill this together for the first parametric analysis

Cable parameter	Ref. value	Range of variation	Ref. in HL-LHC QXF
Width, bare (mm)			18.4
Thickn., bare (mm)			1.6
Insul. thickn. (mm)			0.145
Filling factor ($A_{strands}/A_{bare}$)			~0.80
Cu RRR			140
Strand Cu/SC			1.15
# of strands			40

+ Critical surface

Godeke fit for a measured QXF strand (RRP_1501)

Operation conditions	Ref. value	Range of variation	Ref. in HL-LHC QXF
Iop (A)			16500
Bop (T)			11.4
Top (K)			1.9

Magnet	Ref. value	Range of variation	Ref. in HL-LHC QXF
Lop (H/m)			8.2
# of coil turns			50
Magnet length (m)			4 or 7

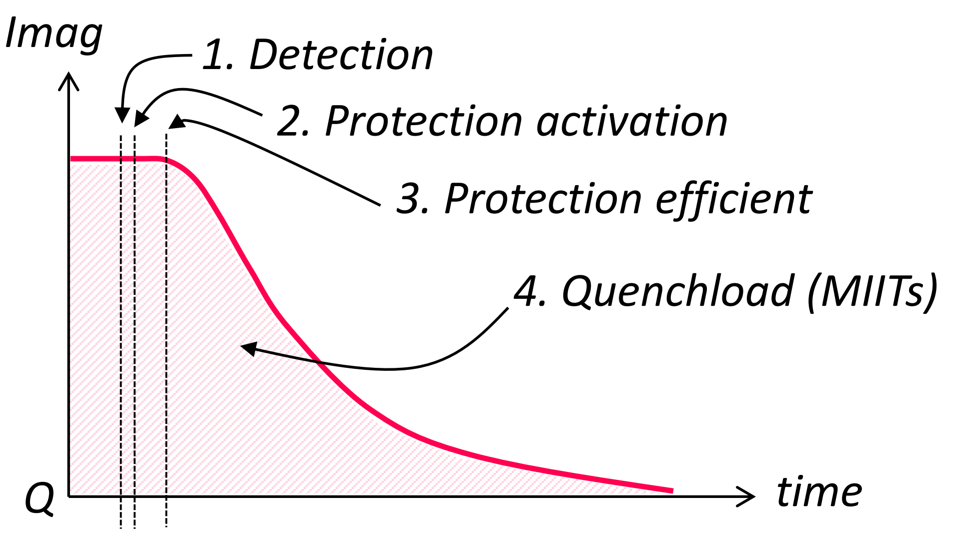
Design v.2. (from ROXIE)

+ Field map or distribution of margin

Basics of quench protection

- The problem with a quench is that the current heats the cable via resistive losses.

- The goal of the protection is to discharge the magnet current <u>fast</u> (within ~100-500 ms).

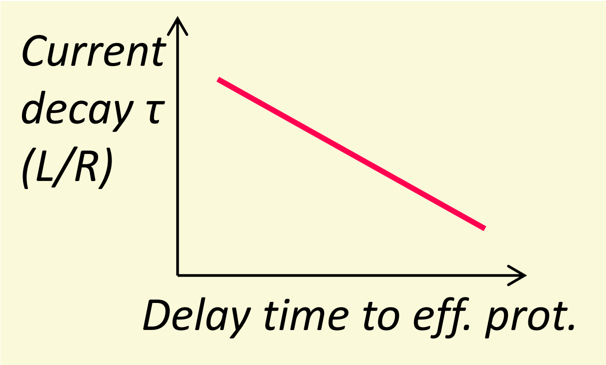


Starting point assumption: The windings absorb the stored energy ↔ the current decay driven by the coils resistance.

Important magnet parameters

1. ***Peak field and cable parameters:*** → MIITs for 350 K

2. ***Operation current and inductance(/m)*** →



3. **Critical surface** → Detection delay

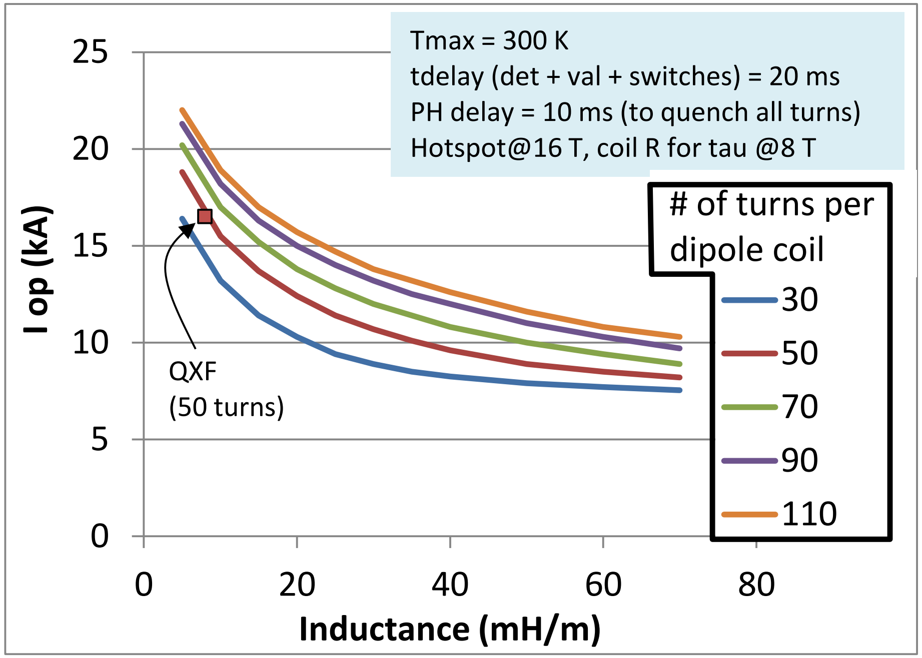
4. ***#of coil turns, distribution of field / margin*** → Estimation of heater (or quench) delays

5. ***Magnet length*** (only if ext. dump)

   → <u>**Hotspot temperature**</u>

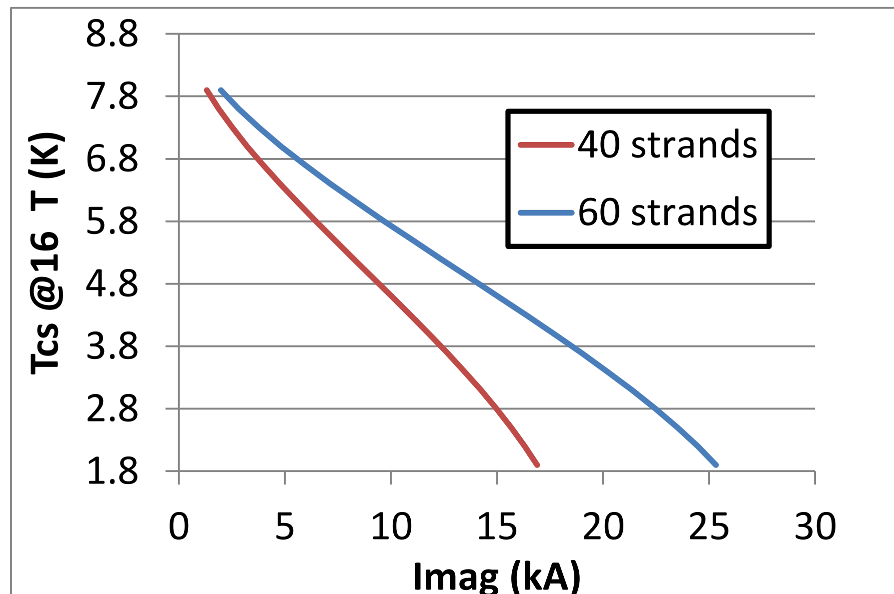
This analysis does not consider the technology: E.g., how difficult will be to build those heaters. The length of the magnet <u>**strongly**</u> impacts the difficulty.

Example results using the QXF cable



Below these lines the $T_{hotspot}$ < 300 K. In this example assumed 30 ms total delay from quench start to all coils quenched.

Note how small temperature margins will be at 16 T!!



These are preliminary results just to show an example of a type of analysis that can be used to guide the magnet design.