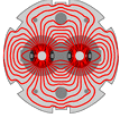

Topical meeting on QXF quench protection

MQXF Quench Protection and Meeting Goals

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April 29, 2014

Outline

- Status at MT23 (First complete analysis)
- Progress
- Goals for this meeting

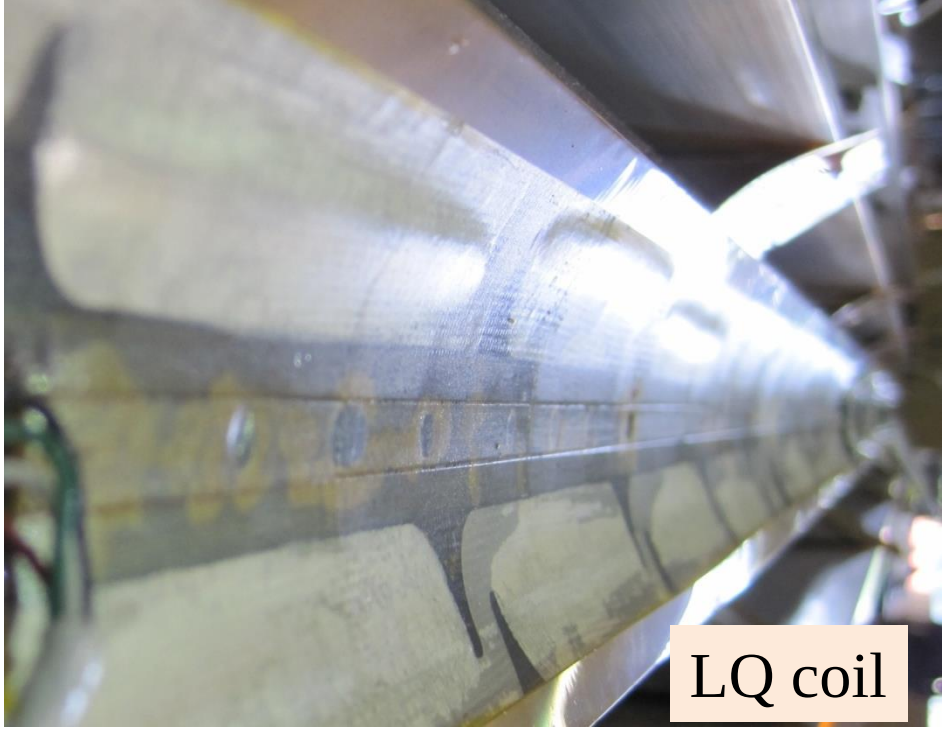
Status at MT23

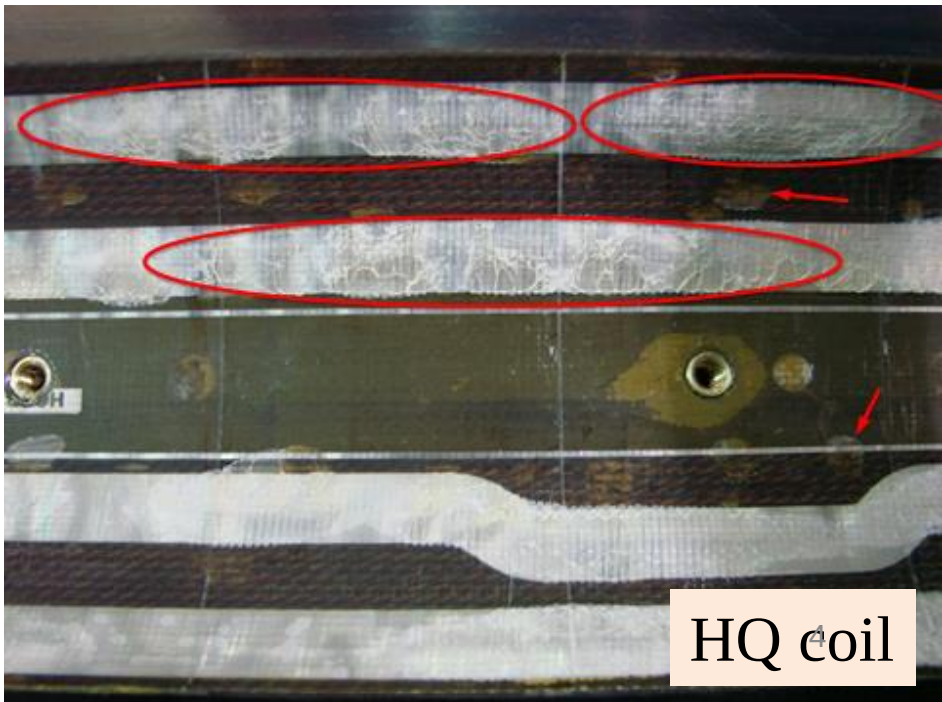
- Simulations performed with QLASA and ROXIE using MATPRO material property database
  - Using preliminary MQXF requirements
  - Assuming heaters only on the outer layer
  - With conservative assumptions:
    - Layer-layer propagation
    - No bronze in strands
    - No dynamic effects

➔ Hot spot temp. ~ 350 K
  - Without margin nor redundancy
  - Close to epoxy glass transition temperature
    - ~max acceptable temp. if there is no earlier detraining

"Bubbles" Issue

- "Bubbles" on coils inner surface
  - Coil-insulation separation
  - Heater-coil separation
- Seen in TQ, LQ, HQ coils only non inner layer
  - TQ coils showed small "bubbles" (no heaters on IL)
  - HQ coils showed small "bubbles" and cracks along heaters
  - LQ coils had long "bubbles"





Progress so far

- Demonstrated that bronze (30% in RRP) reduces the effective strand resistance
  - ➔ Hot spot temperature lower by ~ 30K
  - ➔ Should be taken into account in all simulations
- Compared property databases
  - ➔ MATPRO is most conservative
  - ➔ Use MATPRO until we do a controlled experiment
- Compared HQ02a test data with simulations (using MT23 assumptions)
  - Next slides
- Performed QP tests on HQ02b
  - Next talks

Simulations vs. HQ02a Measurements

- Under the assumptions used for MQXF, the heaters-induced quench simulations are **conservative**.
- At the current of interest (0.8 of SSL), the MIITs are **overestimated by 13-16 %** (65-80 K)
- Margin is due to:
  - dI/dt effects
  - conservative assumptions in modeling of heaters and propagation OL to IL

Most significant case for MQXF

Current/SSL	0.8	0.7	0.6	0.5
MIITs difference % (no dump case)	14.5	13.2	9.6	10.7
MIITs difference % (3 mΩ dump case)	13.4	11.1	6.4	5.3
MIITs difference % (5 mΩ dump case)	16.5	13.3	4.8	2.4

Work in Progress

- The improvements presented may not be sufficient to provide redundancy and margin
- Further improvements:
  - Development of heaters for Inner Layer w/o bubbles
  - Optimization of heater design and materials
  - Exploring the use of CLIQ
  - Testing max acceptable temperature (HQ02b)
- Longer magnets with lower gradient are the back up solution (with several drawbacks)

GOALS for this meeting

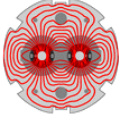
- Assess status of MQXF protection
  - after most recent HQ test results and with latest heater designs
- Plan next steps
- Abandon option of longer magnets?

Guidelines for QP analyses

- It is very important to use the **same criteria** when doing HQ analyses and QXF simulations

  Ex: HQ data ➔ T max ➔ HQ simulations

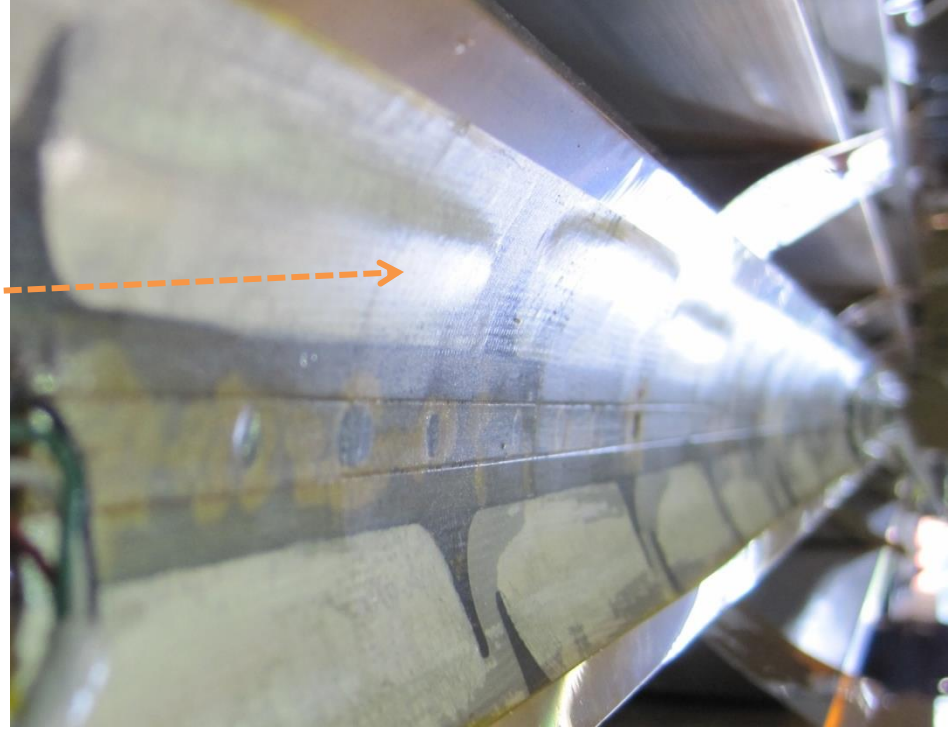
  - Adiabatic approximation
  - Unreacted strand & cable dimensions
  - Actual/nominal Cu%, RRR, Jc, … (HQ/QXF)
  - Actual/nominal cable insulation thickness (HQ/QXF)
  - Half interlayer insulation included in each layer for enthalpy computation (?)
  - Include bronze (30% for RRP) among strand materials
  - Use MATPRO material properties

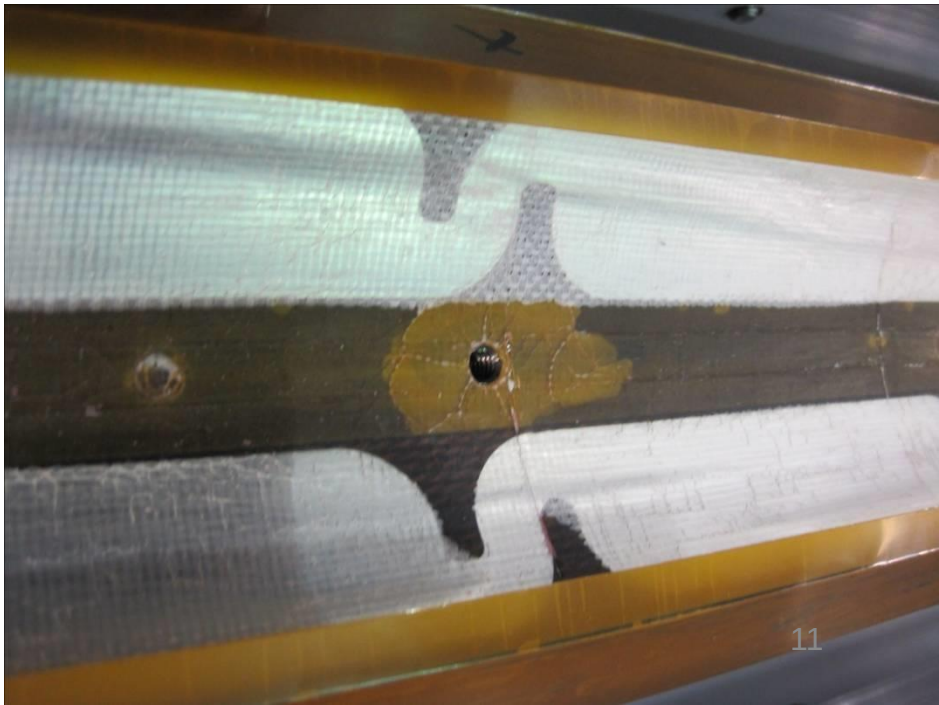


Back up Slides

Coils after Test

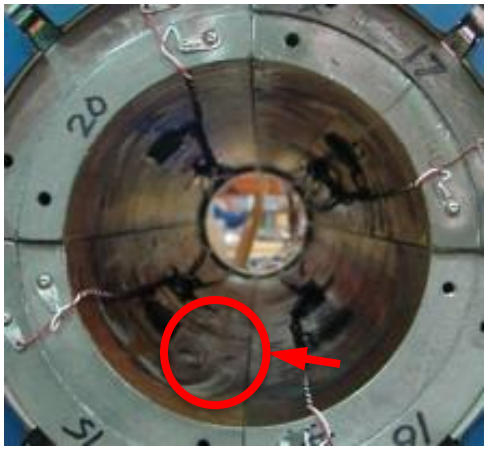
- Some “bubbles” on coils inner layer
  - Coil-insulation separation
- Possible causes:
  - Superfluid helium and heat during quench
    - Seen in TQ coils
  - Heat from heaters on inner layer
    - Only in LQ coils
- Plans:
  - Strengthen insulation or
  - Change heater location or
  - Add support on coil ID



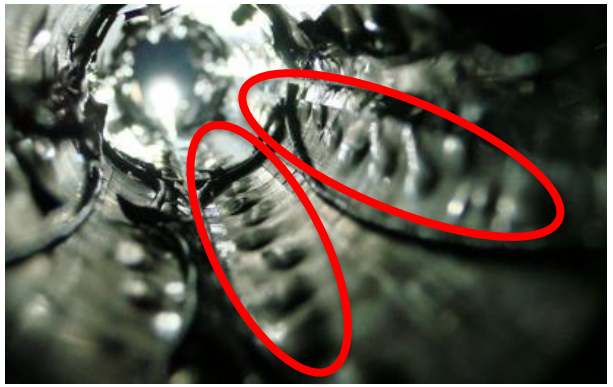


Coil Processing: Impregnation

- Instrumentation traces
  - Do laminated polyimide trace materials pose problems for impregnation?
  - Trace behavior (bubbles) on inside bore after testing cycle have continued



Inside bore of HQ02a during assembly (Coil 15 was previously tested in HQ mirror)



Bubbles on inside bore of LQS03 after magnet test