LHC IR Upgrade Nb-Ti, 120mm Aperture Model Quadrupole Test Results at 1.8K

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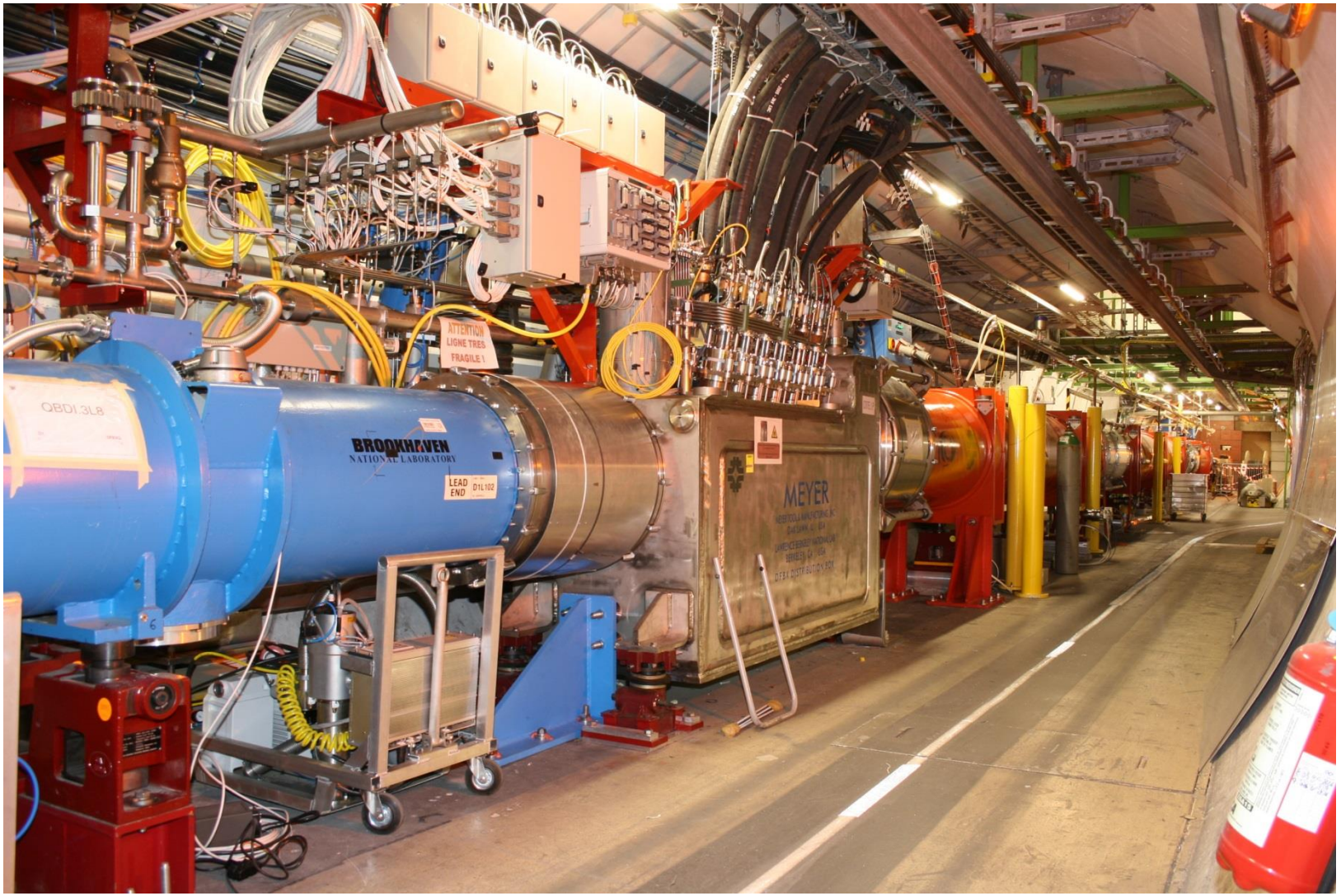
Talk Over View

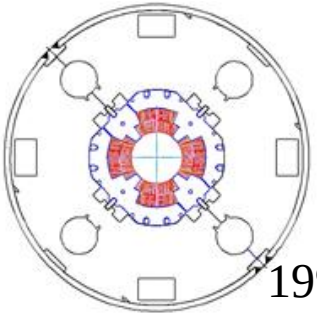
- LHC Insertion history
- MQXC magnet special features
- Test over view
- Training MQXC0 & MQXC2
- Heat extraction.
- Quench heater Delays
- New superconducting magnet protection system!

Triplet Upgrade

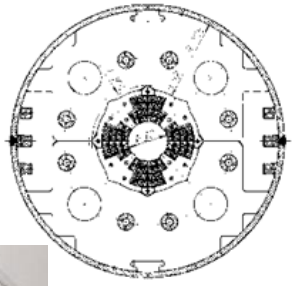


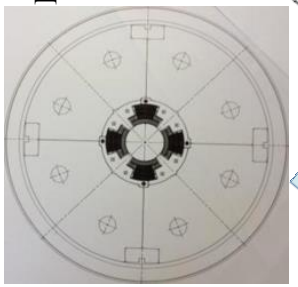
MQXC phase 1 Upgrade, fallback solution, & technology transfer

Today's LHC insertion magnets **70mm**
KEK's - MQXA and FERMI- Lab's-MQXB

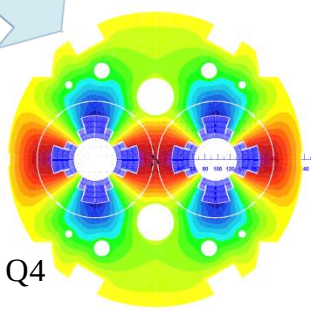


1996



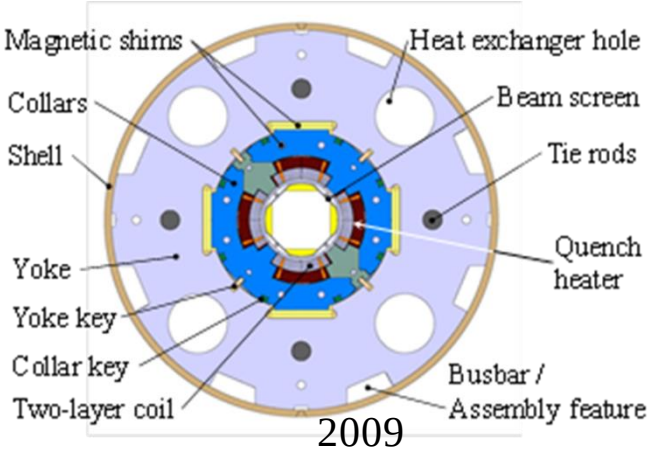


CERN-OXFORD Ins. LHC
1989



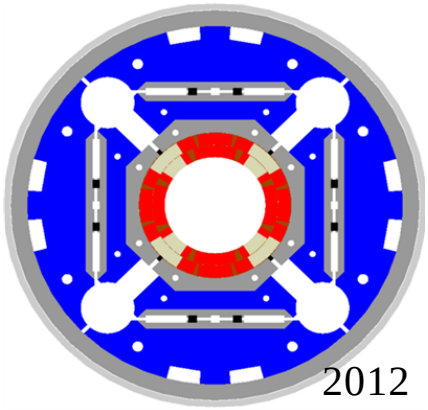
MQY / LHC Q4
1998

All the data for most of the magnets are in
www.cern.ch/hilumi/wp3



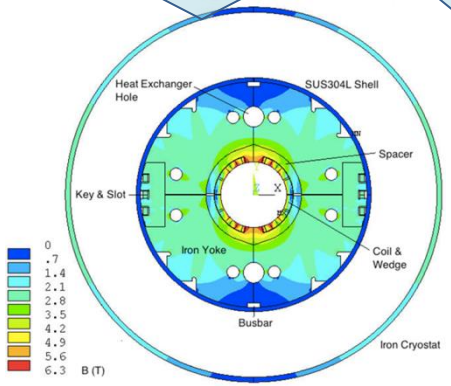
2009

Phase 1 upgrade MQXC cross section **120mm**
120 T/m Nb-Ti high cooling capability

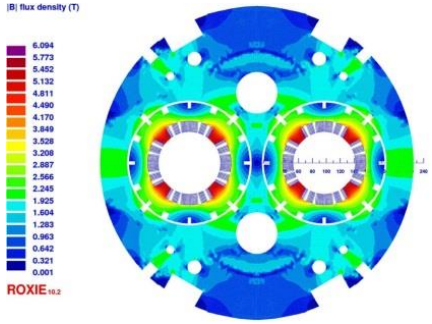


2012

MQXF Nb^3Sn 150mm,
140T/m
Previous talk!

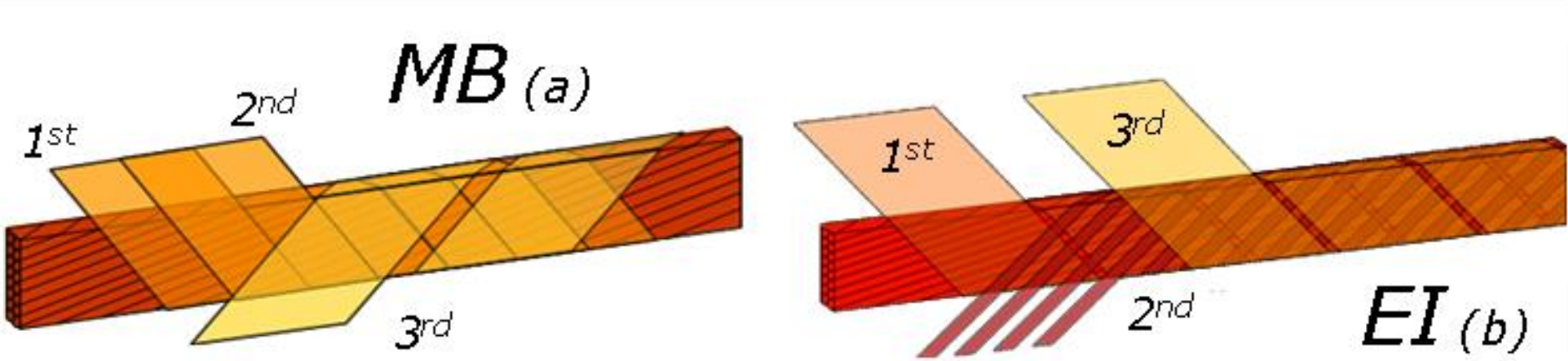


D1 Nb-Ti separation dipole
Nb-Ti out line proposal at KEK

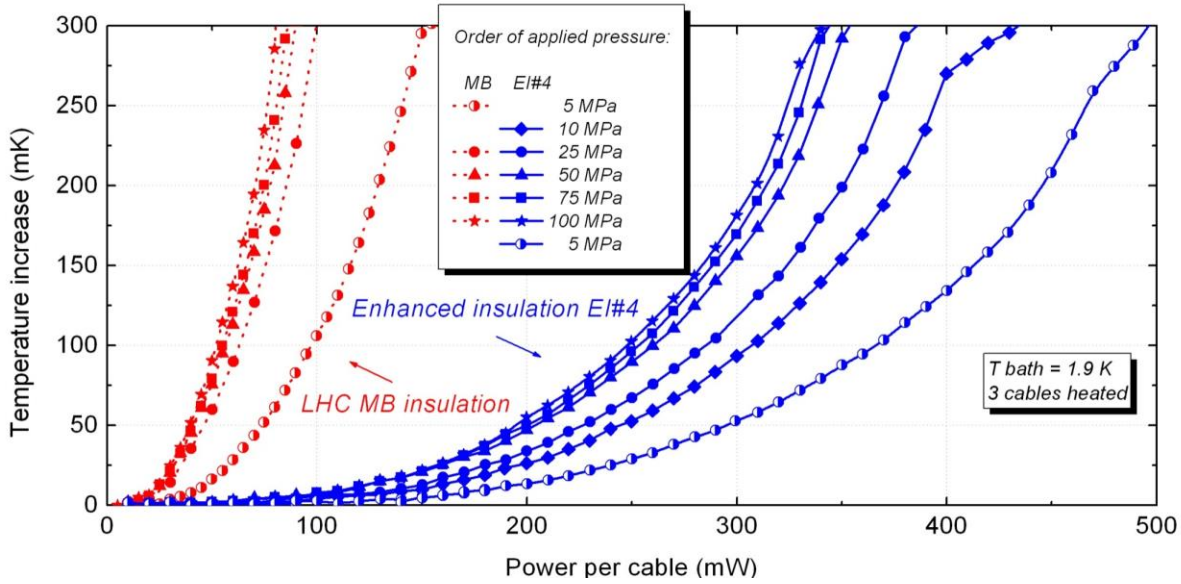


Q4 Nb-Ti Quad
Nb-Ti out line
proposal at CEA Saclay

The Enhanced Cable Insulation



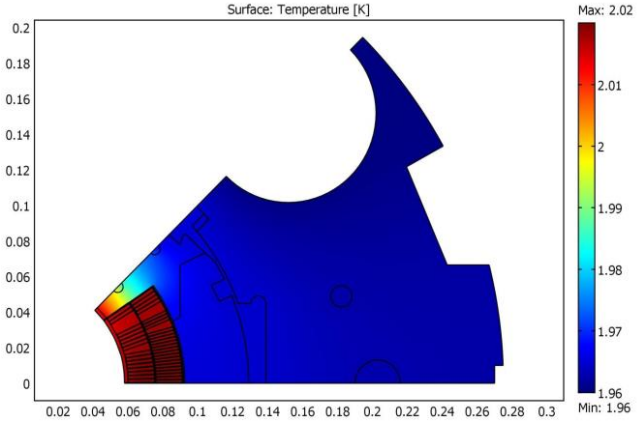
Enhanced insulation system from Davide TOMMASINI



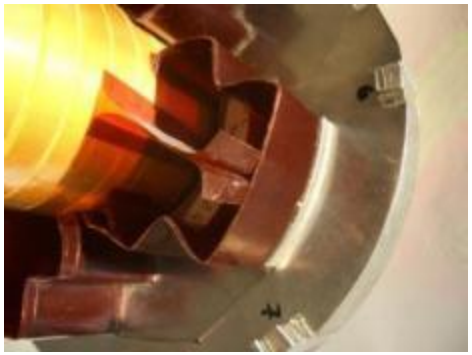
Heat extraction plot from Pier Paolo Granieri PhD theses

Open Ground Insulation

Thermal plots thanks to : E. Bielert

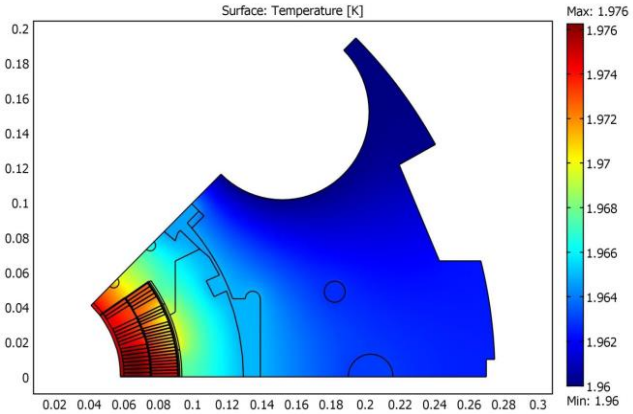


Closed ground insulation

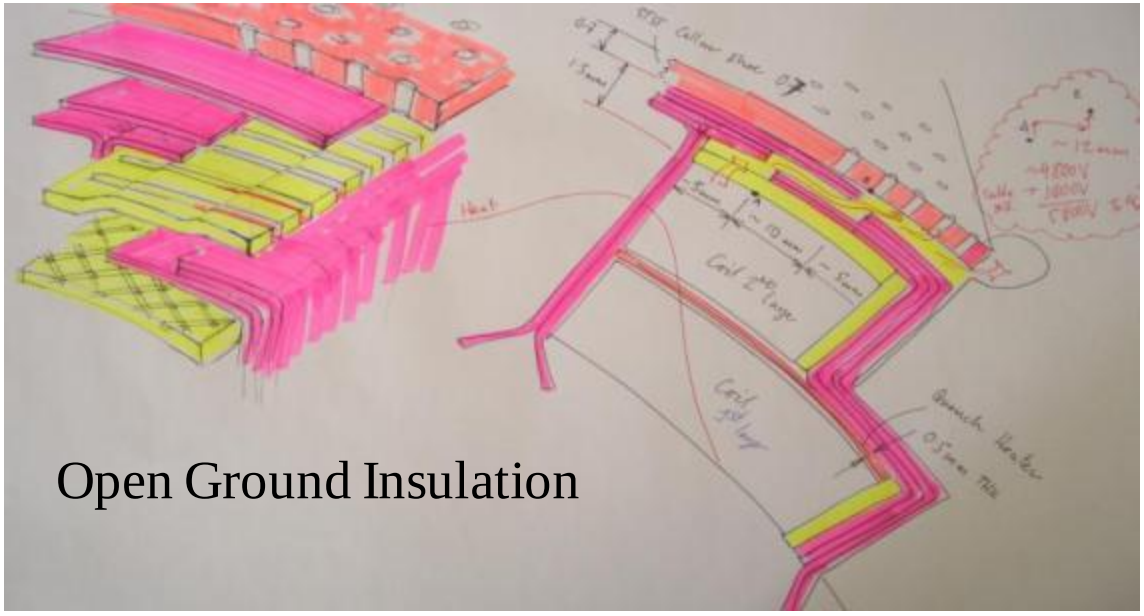


Closed ground insulation

Open collaring shoe



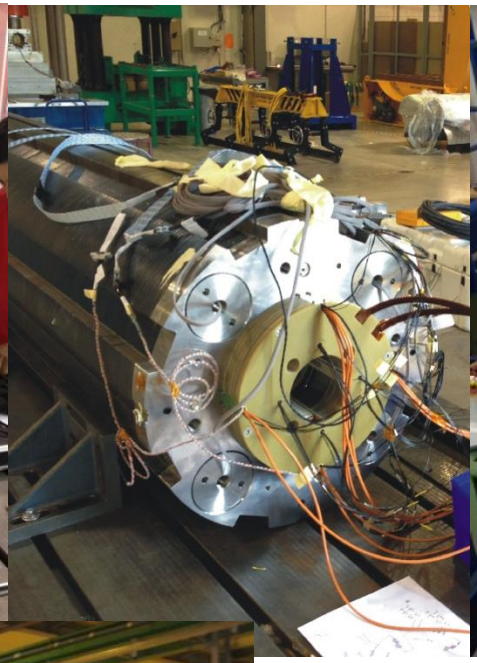
Open ground insulation

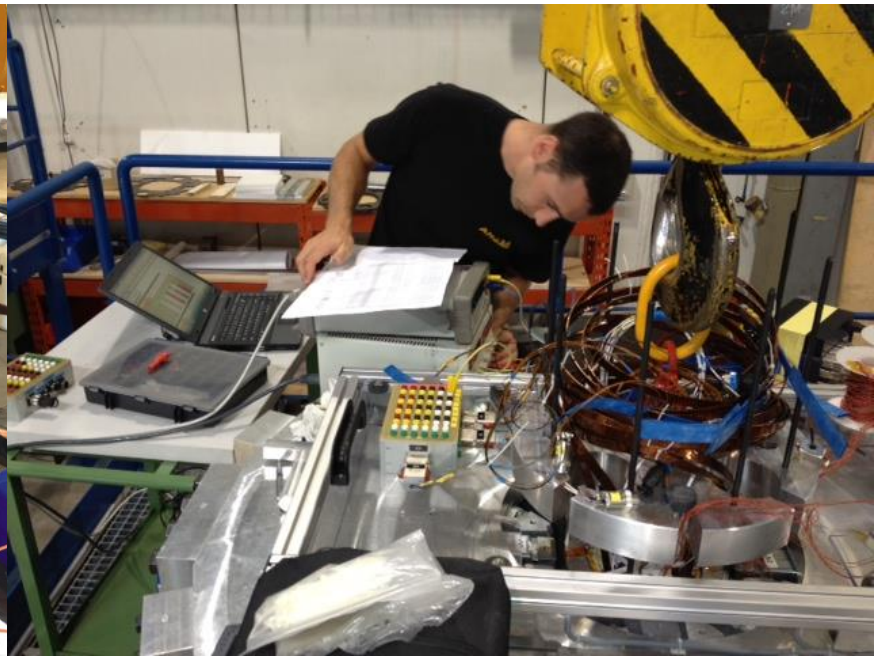


MQXC High Heat Extraction Design

Open cable insulation, open ground insulation

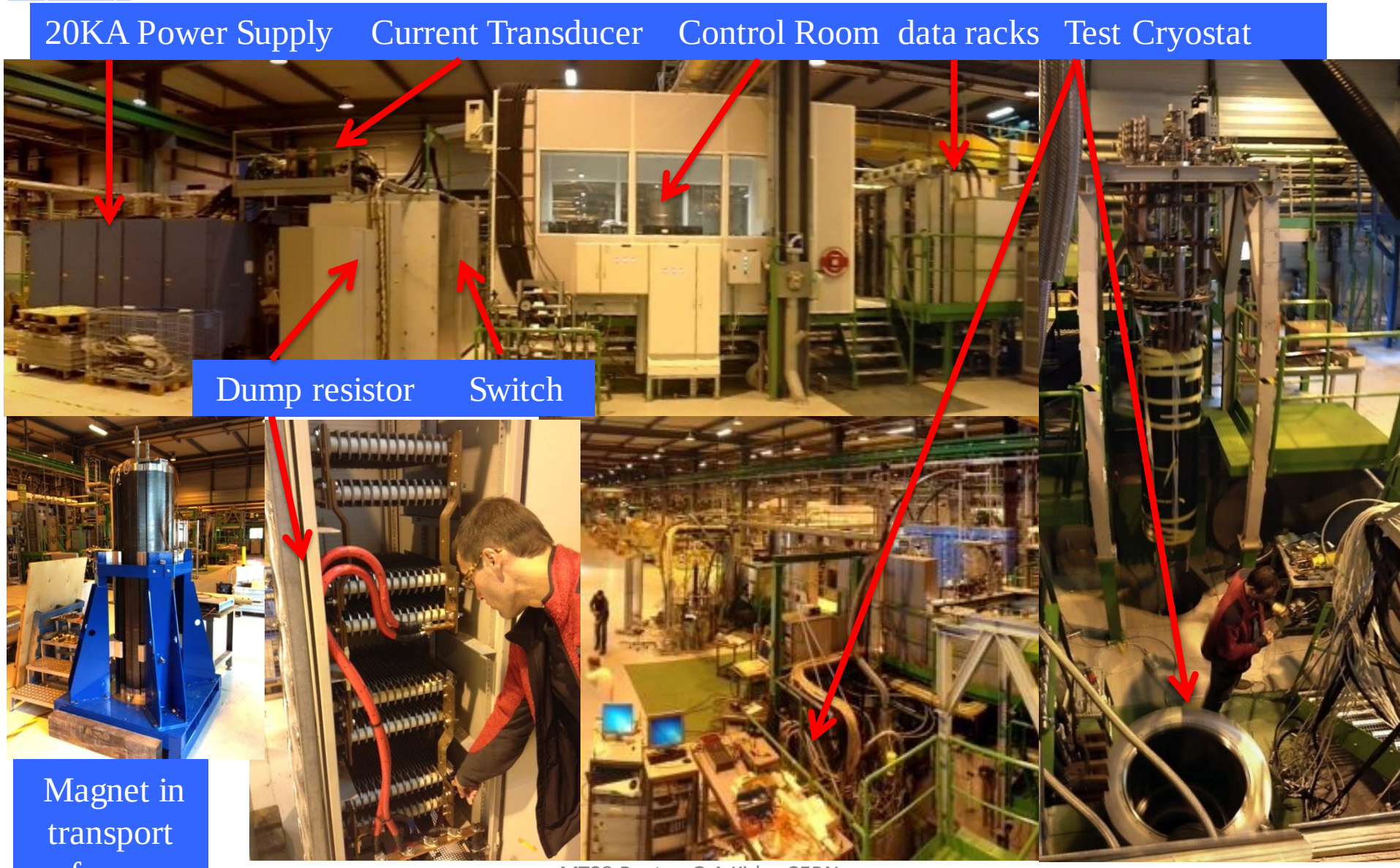
Electrical checks



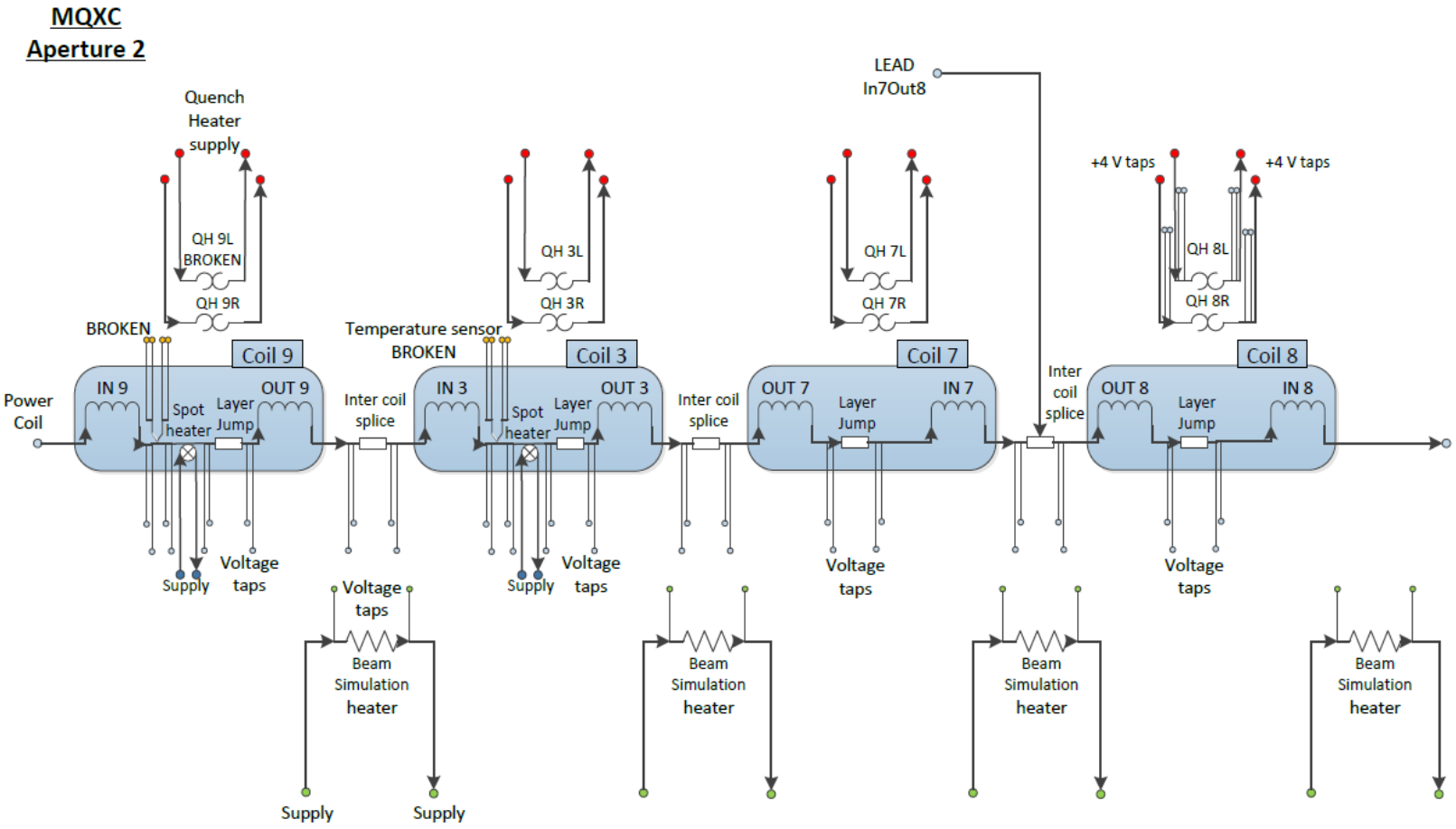


We performed electrical checks at each stage of production.
1KV pulse test looking for shorts in the coils.
5KV ground insulation tests.
Resistance and inductance of coils
Insulation between all circuits.
Quench heater firing at full 850V, 80A

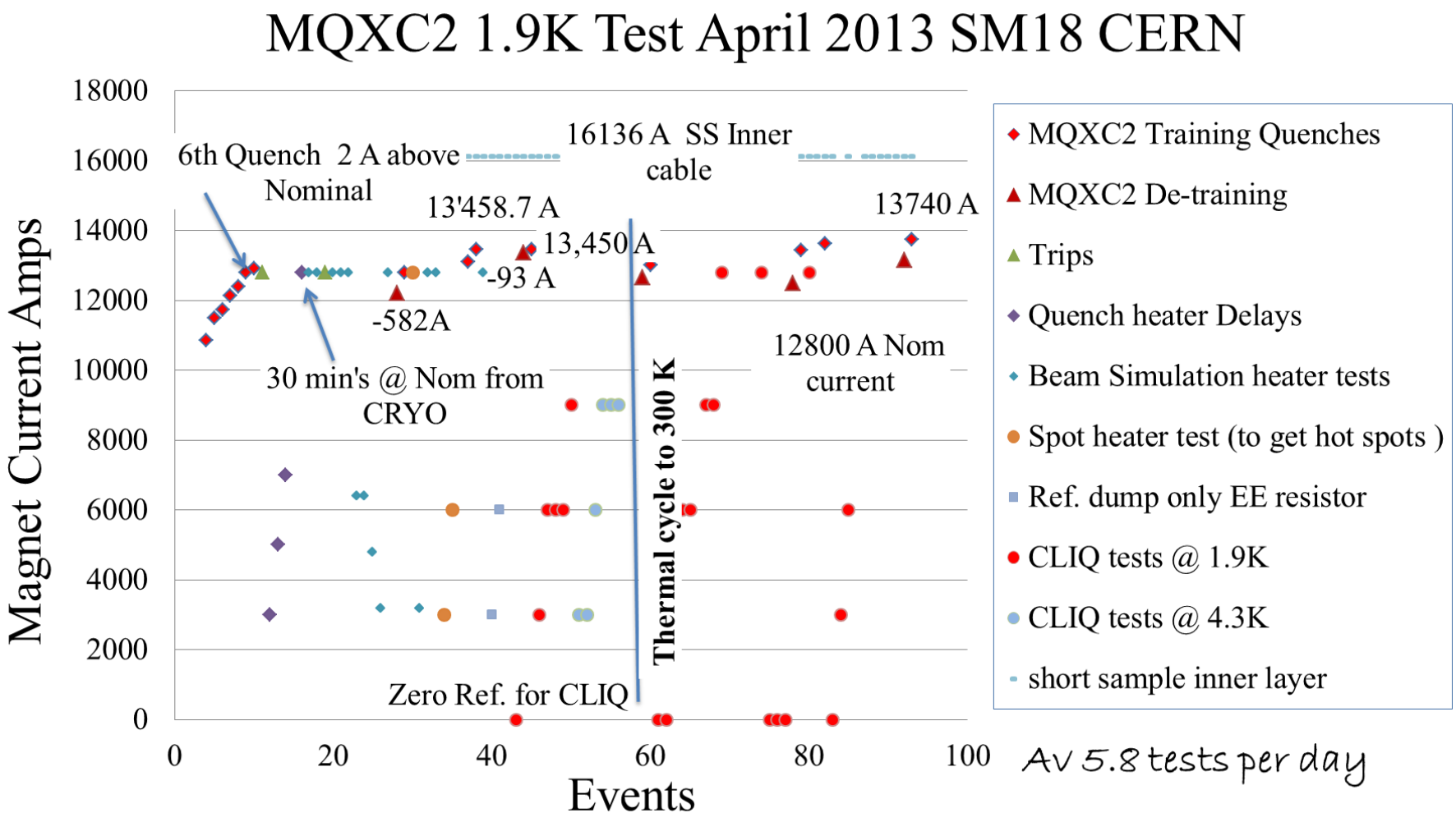
Test lab. For Model magnets at CERN



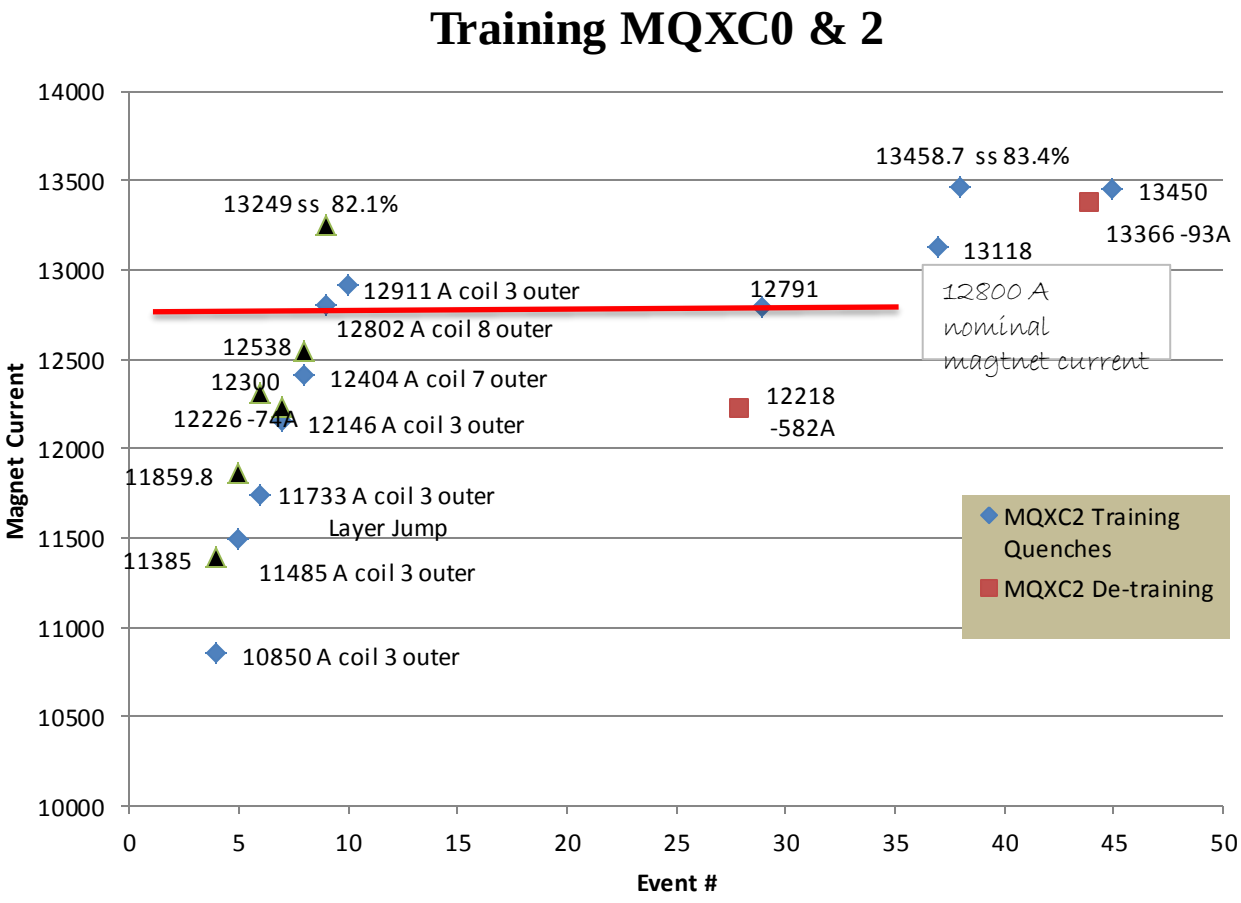
Magnet Circuit

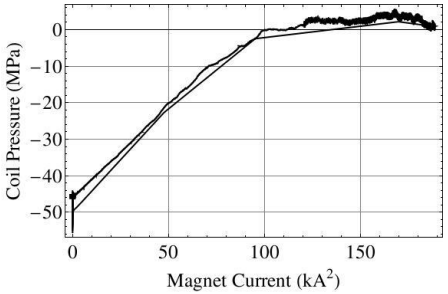


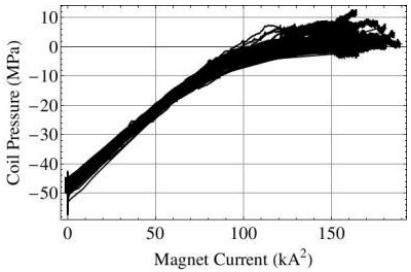
Test Over View

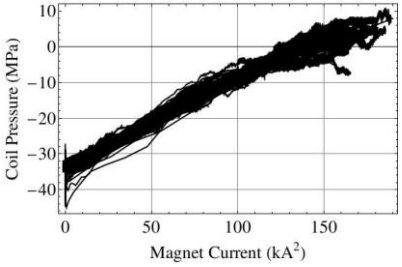


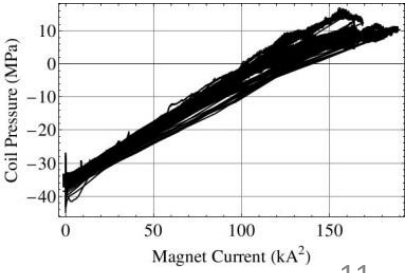
MQXC2 training comparison with MQXC0



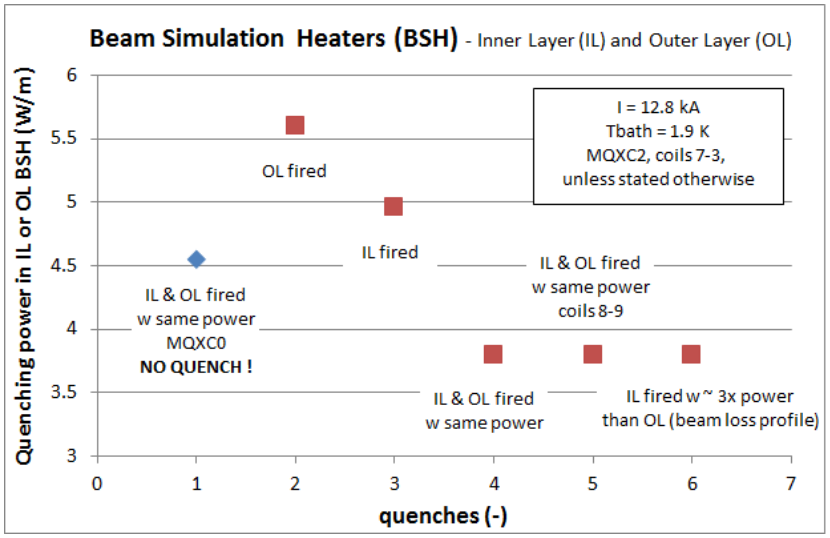


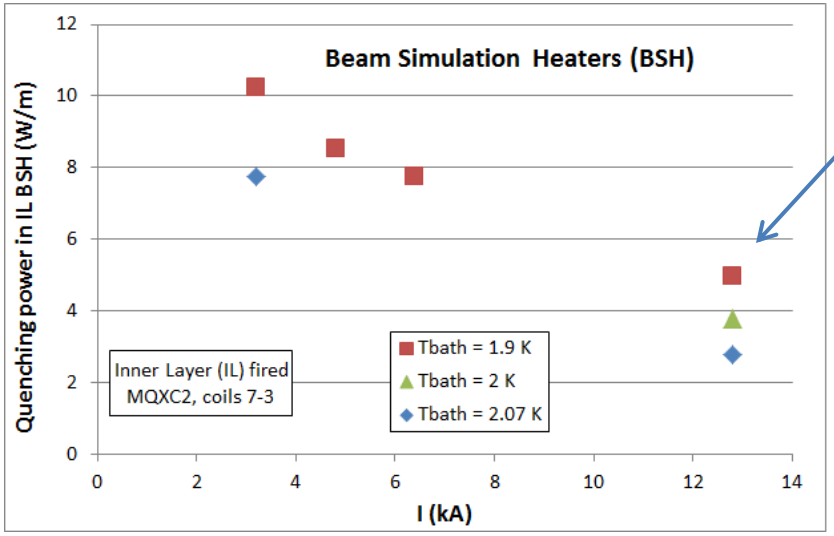


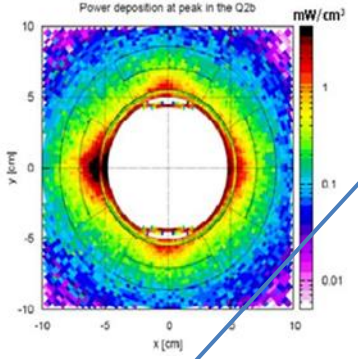




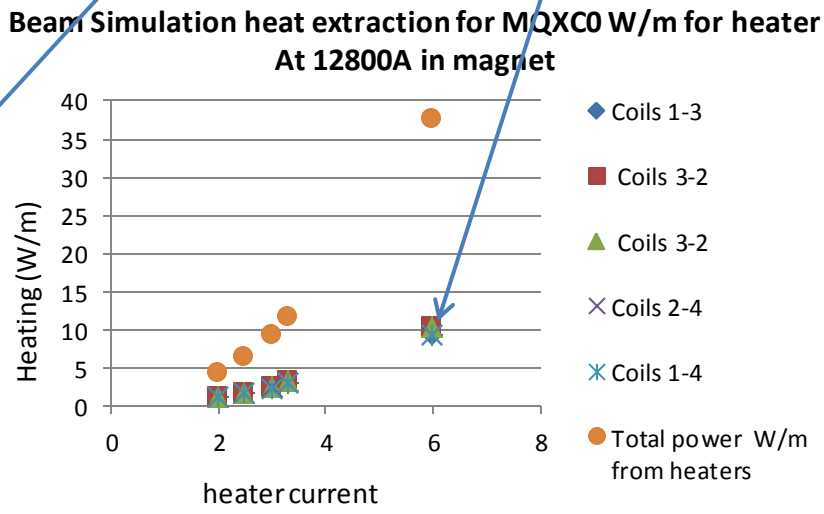
Heat Extraction
Beam Simulation Heaters



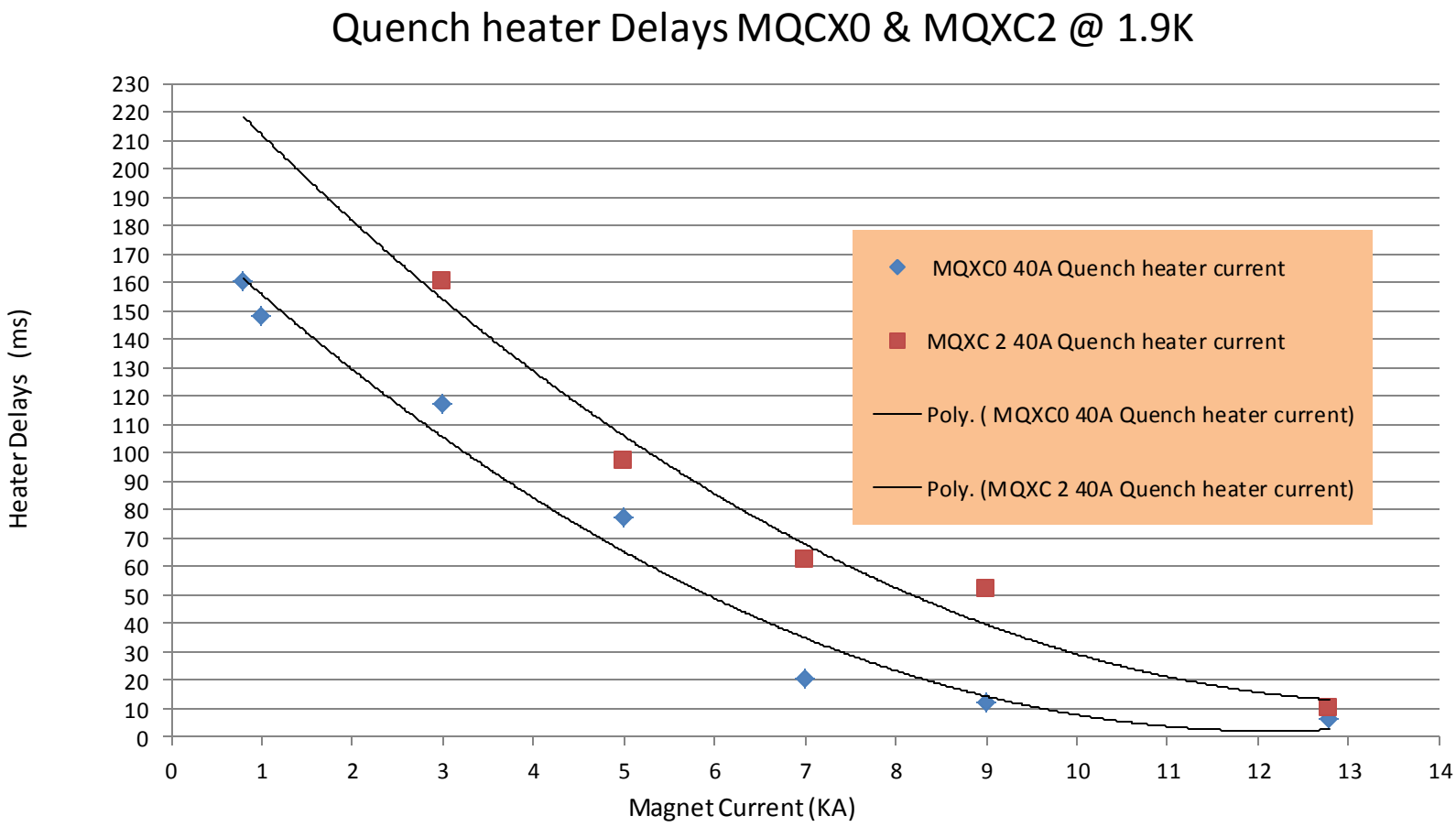




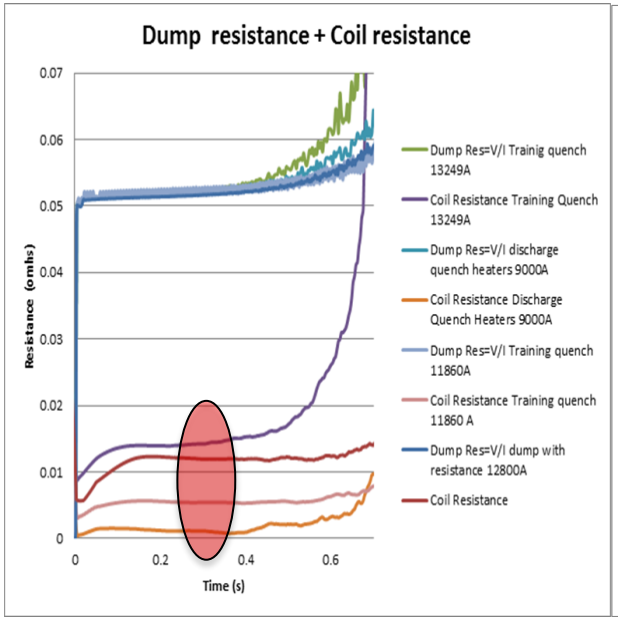
Initial observations
MQXC2 ~ 5W/m
MQXC0 ~ 10W/m

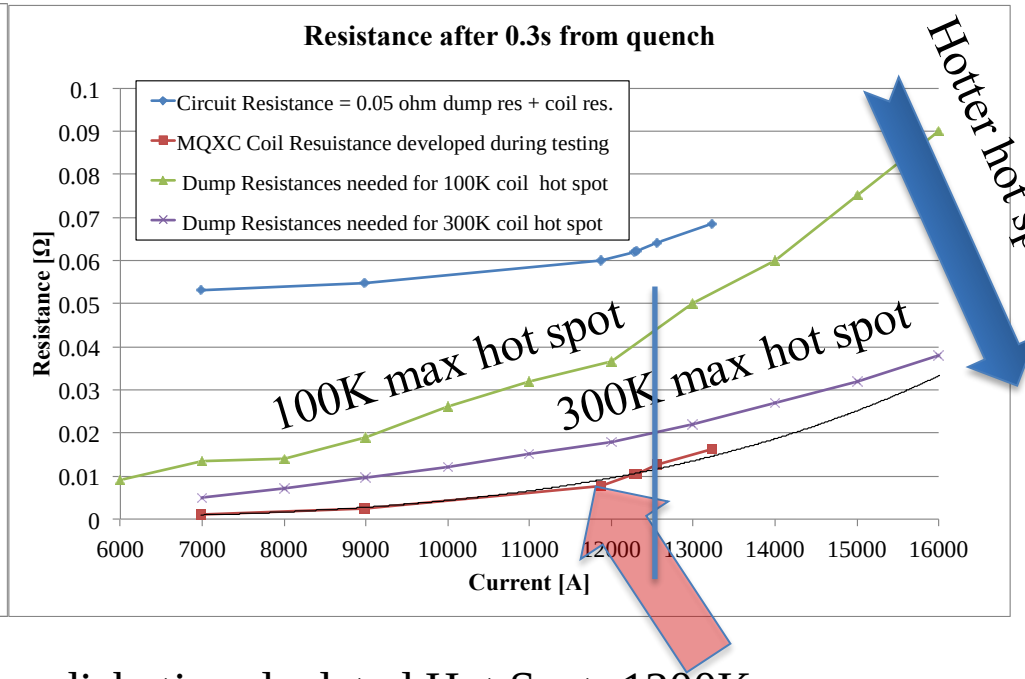


Quench heater performance



Coil Resistance during Quench.





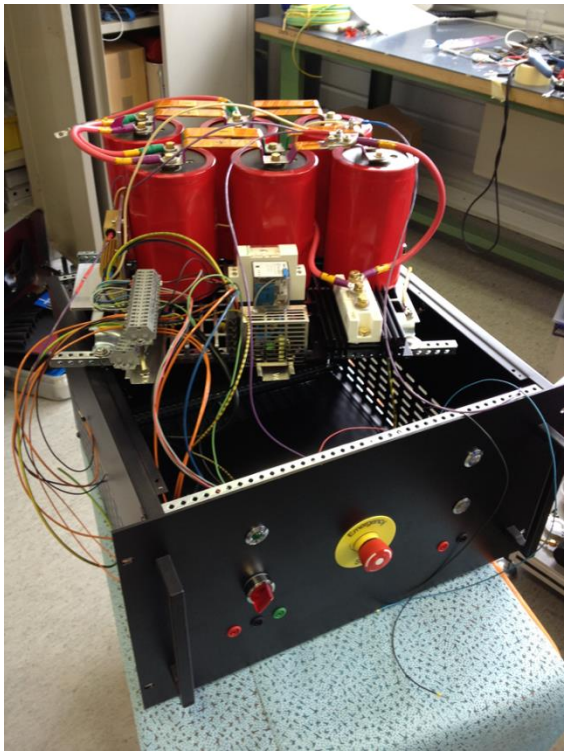
Without Dump adiabatic calculated Hot Spot 1200K

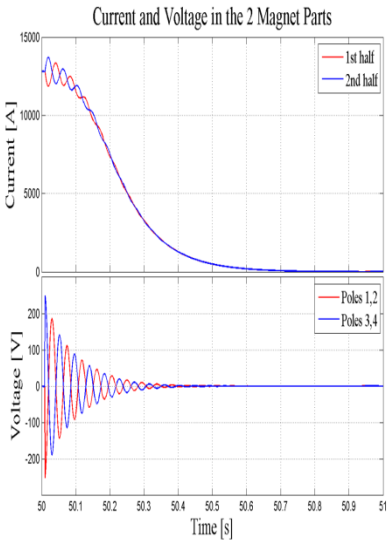
Two curves are plotted, giving the circuit resistance needed to limit the hot spot temp. One limiting the cable hot spot to 300K and the second limiting, HS. to 100K. With a 0.012 s detection delay.

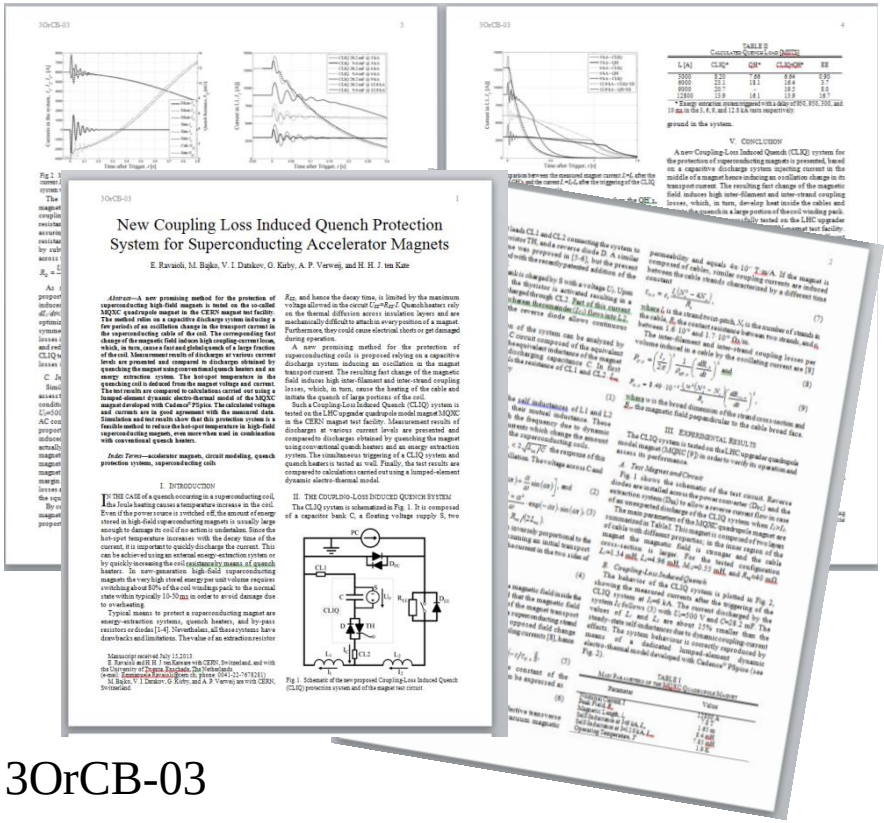
We see from the tests that the internal coil resistance is insufficient at all currents to protect the magnet.

With 60% quenched cable we could protect the magnet!

New Coupling Loss Induced Quench Protection System for Superconducting Accelerator Magnets "CLIQ"



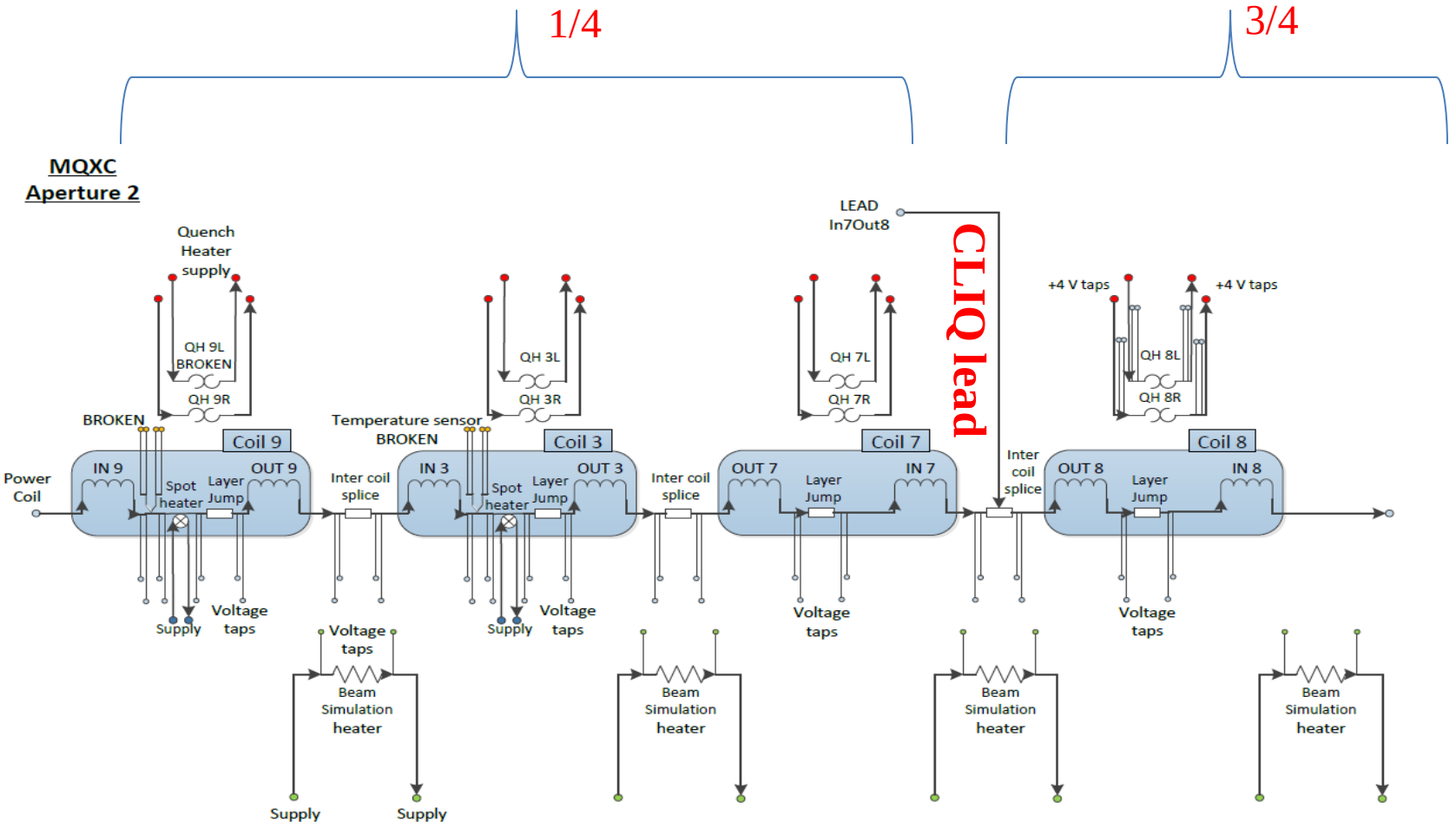




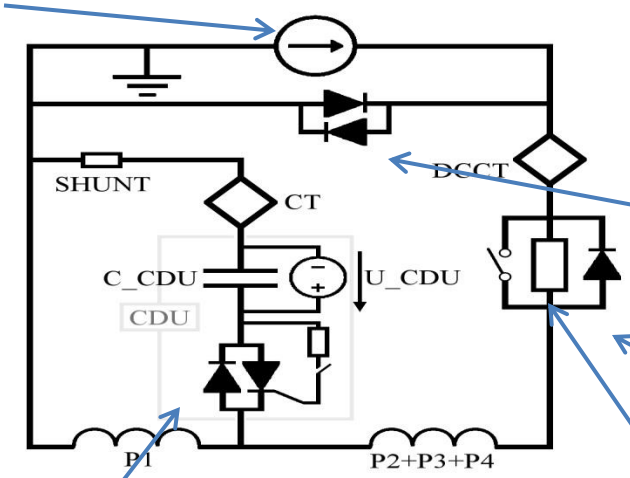
3OrCB-03

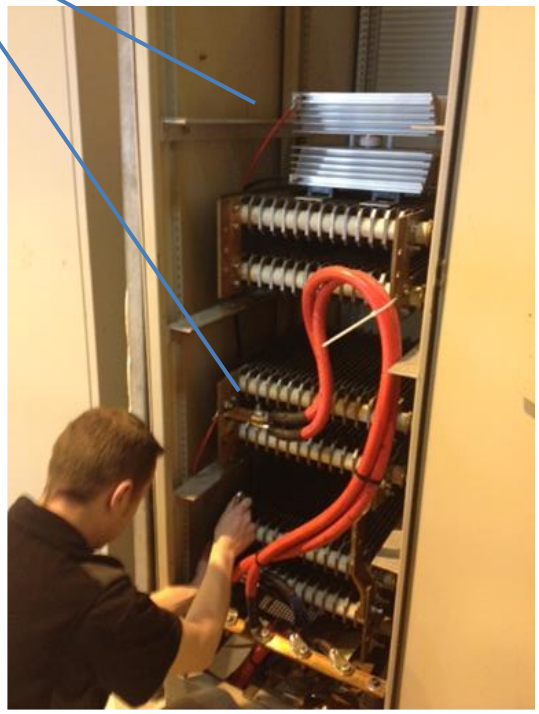
"AC-Current Induced Quench Protection system", application has been filed with the European Patent Office on June 28, 2013 under the application number **EP13174323.**

Magnet Circuit

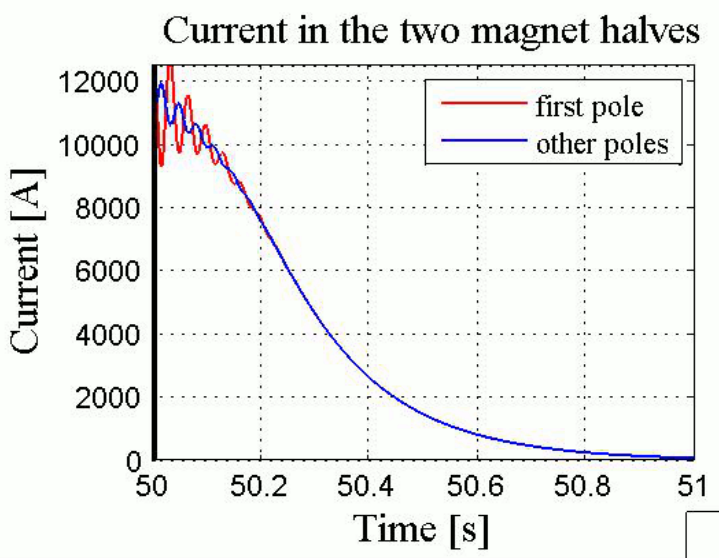


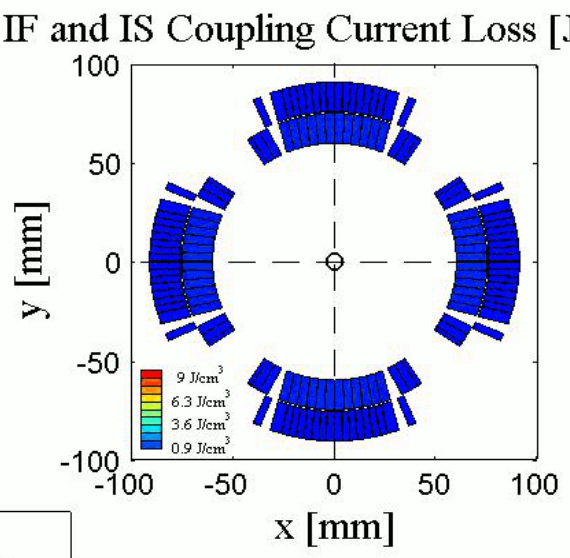
CLIQ set up & PSU modification



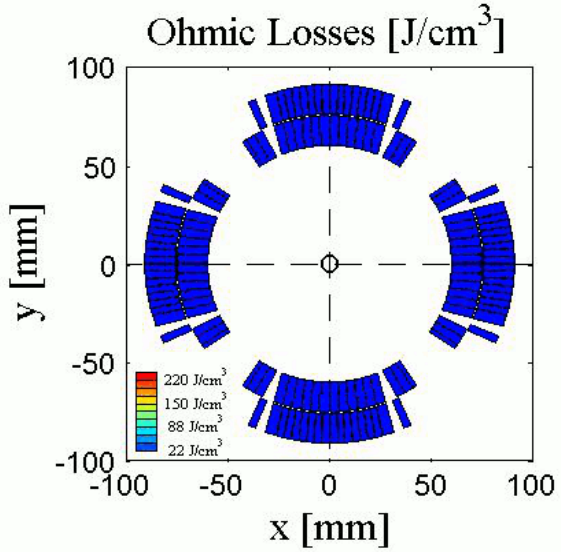


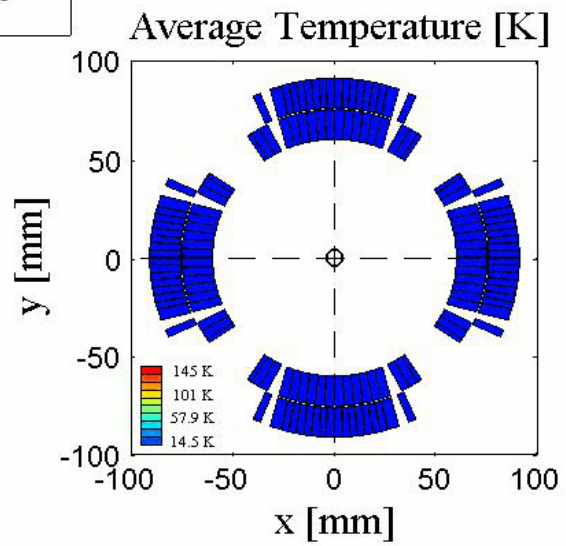
Simulation of a Quench induce by a Capacitive Discharge



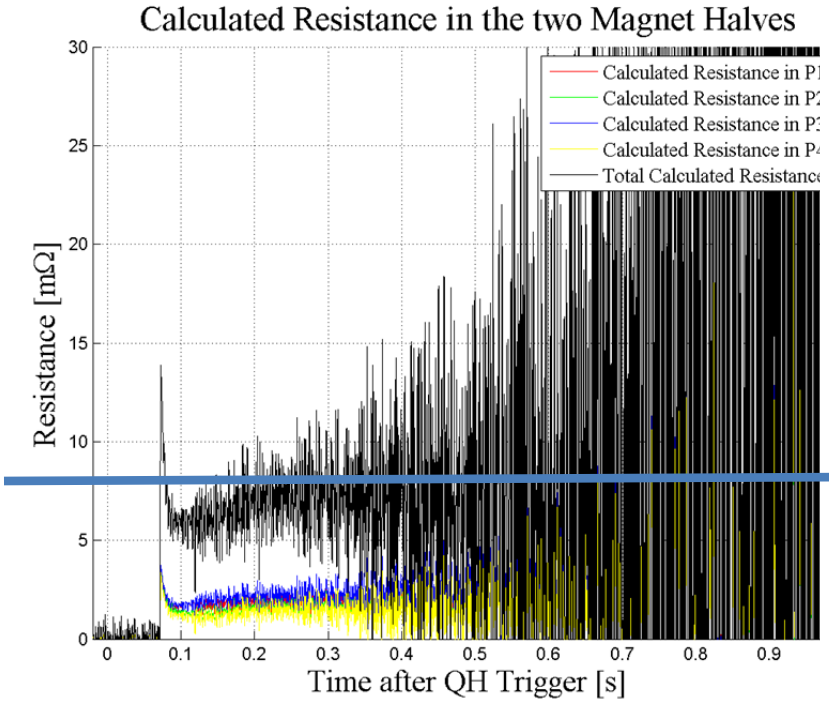


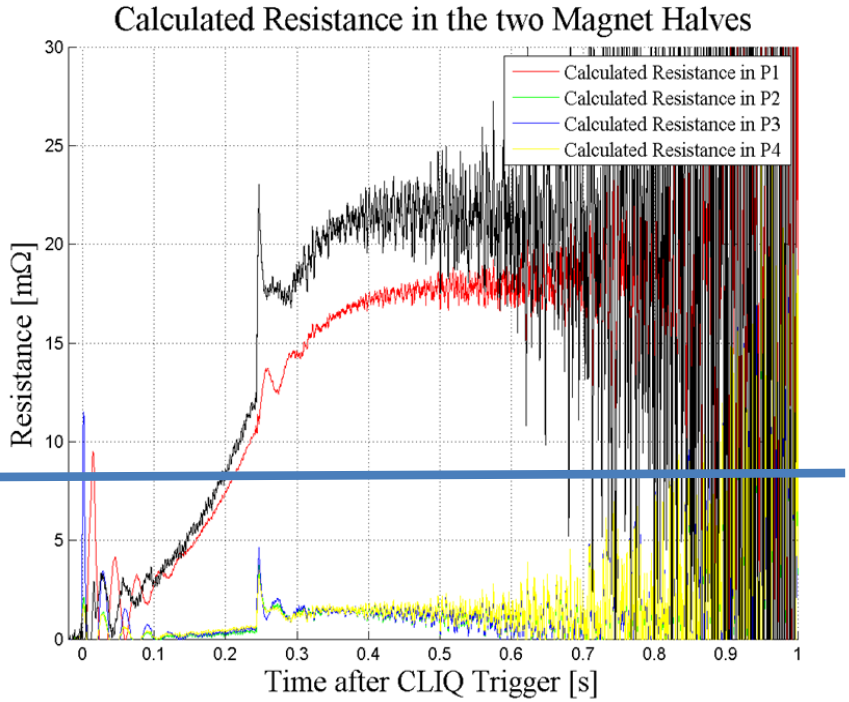
t=0 ms



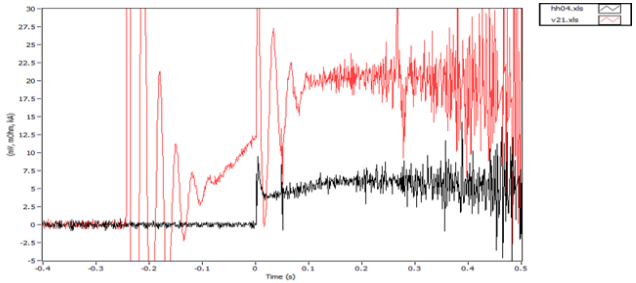


9KA comparison Quench heaters and CLIQ



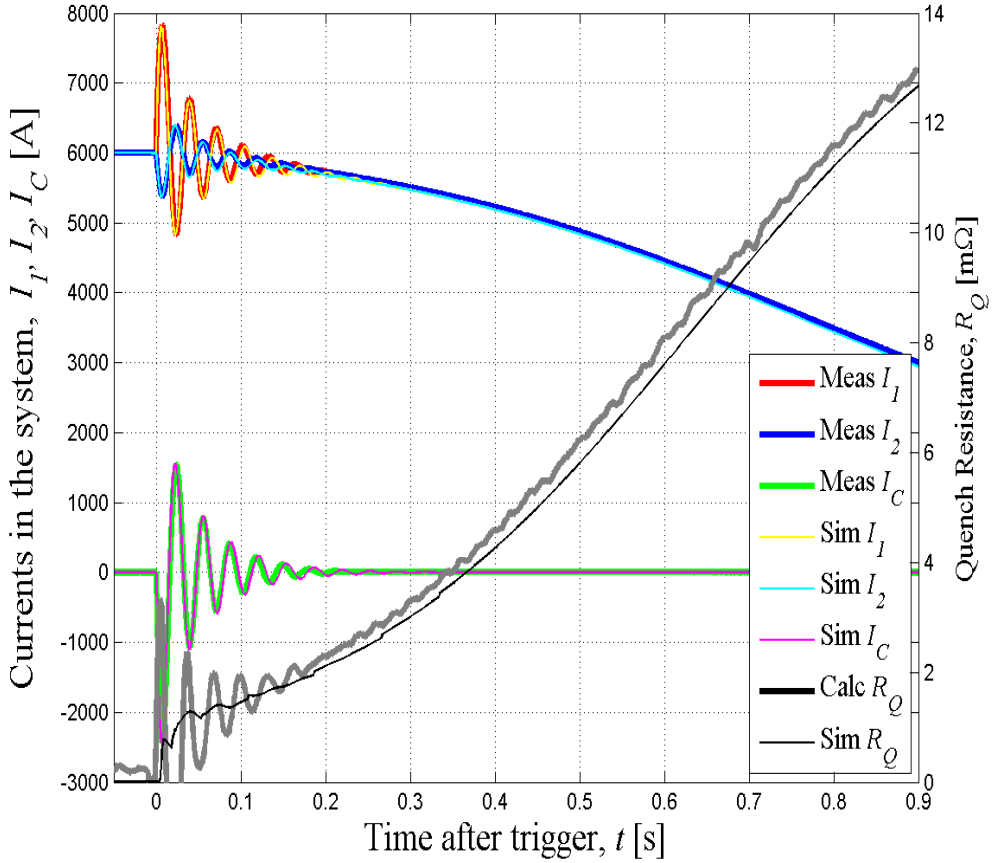


9KA, QH @40A +EE



9KA, CLIQ + EE @150ms
(capacitor voltage at 400V)

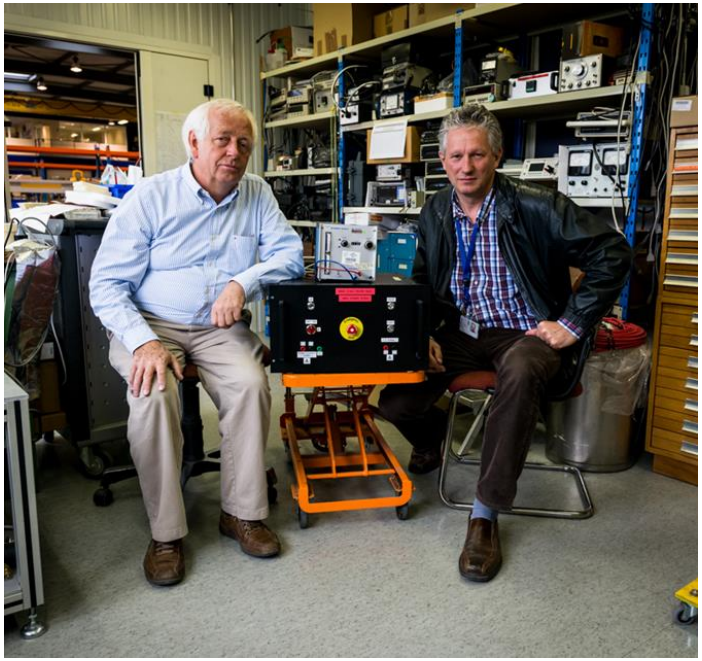
Simulation v Measurements



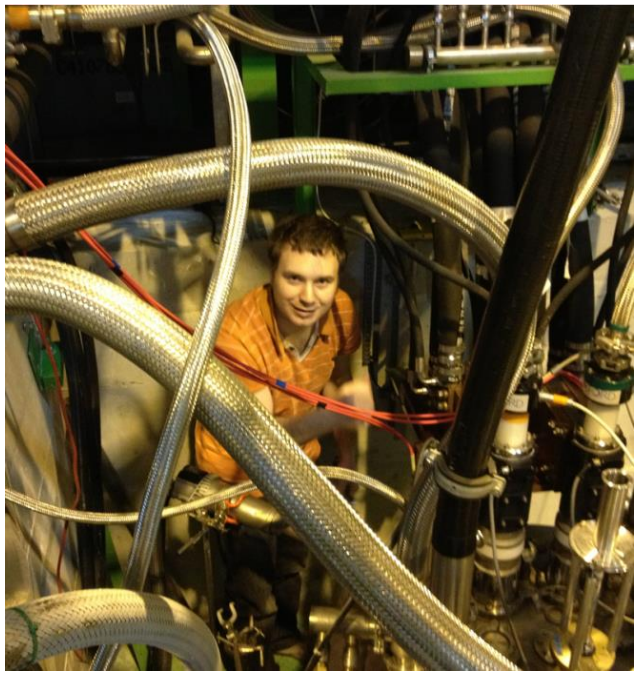
CLIQ possibilities :
- Fast repair to existing systems
- Nb-Ti, Nb^3Sn and HTS protection
- Fast protection
- Uses no real-estate in magnet
- Good prediction of effects.

Best performance: (symmetric, 500 V, 12.8 kA)
In 20 ms 50% coil quenched
In 50 ms 80% coil quenched

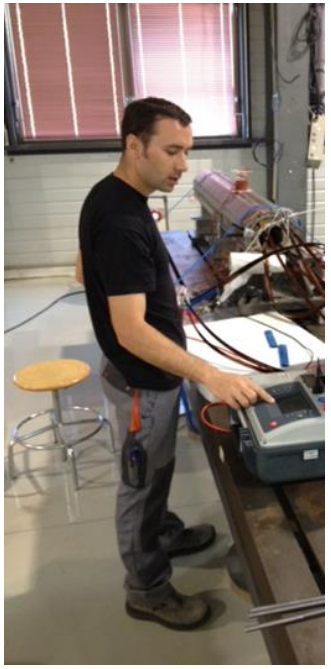
Special thanks to the rest of CLIQ team



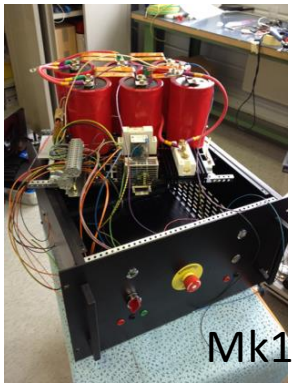
Vladimir Datskov

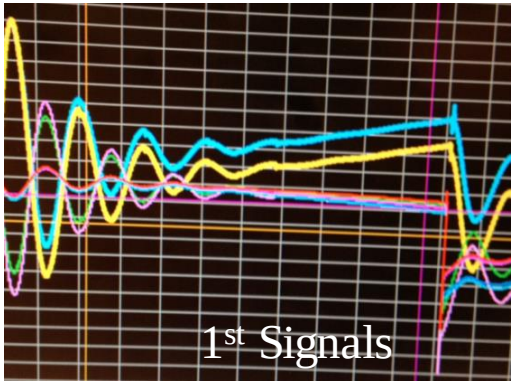


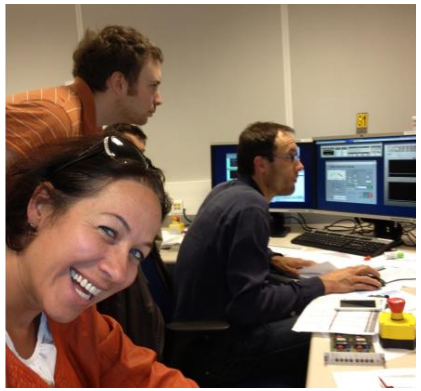
Emmanuele Ravaioli



Francois-Olivier Pincot

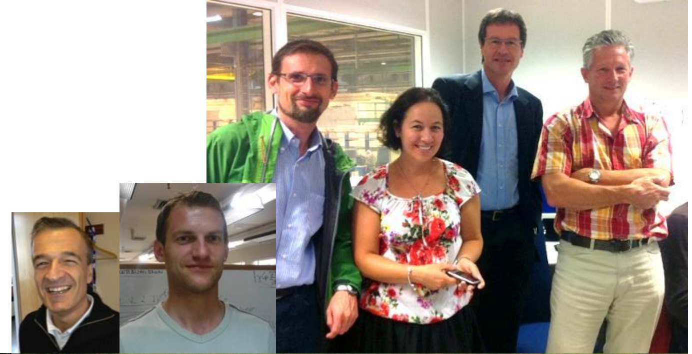






Marta Bajko, Jerome Feuvrier

Thanks to the teams.



The many people that have worked on the Nb-Ti MQXC over last 5 years.

High Luminosity LHC

The HiLumi LHC Design Study is included in the High Luminosity LHC project and is partly funded by the European Commission within the Framework Programme 7 Capacities Specific Programme, Grant Agreement 284404

Any Questions