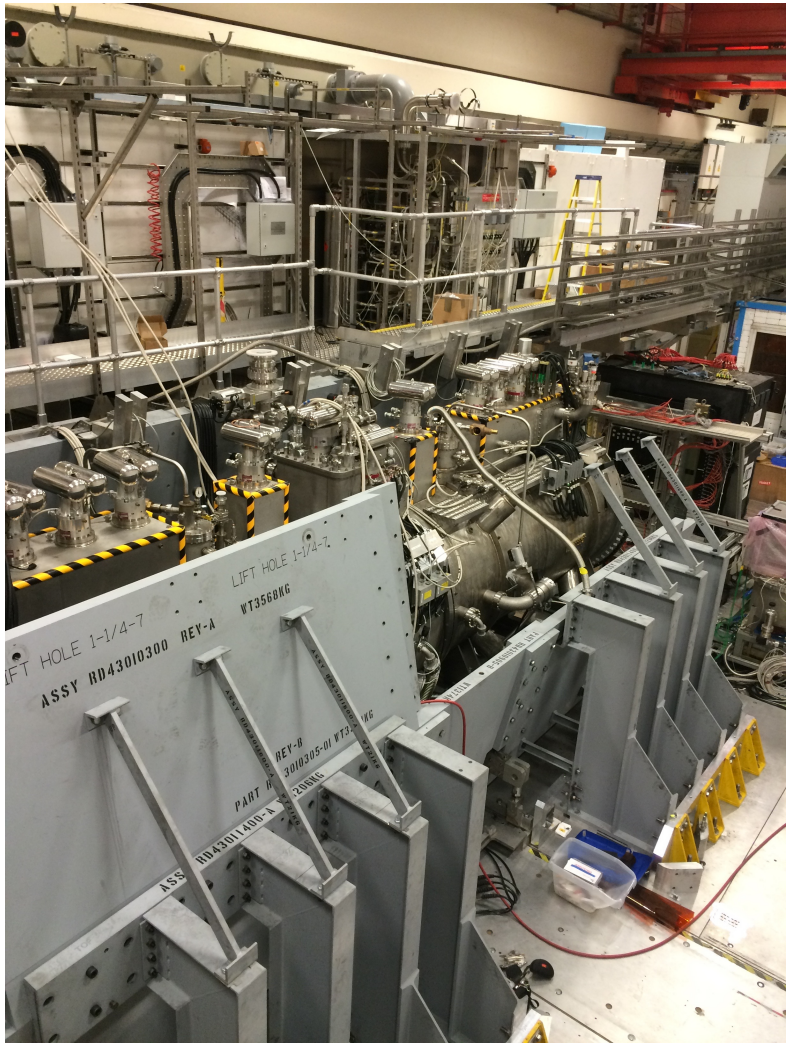
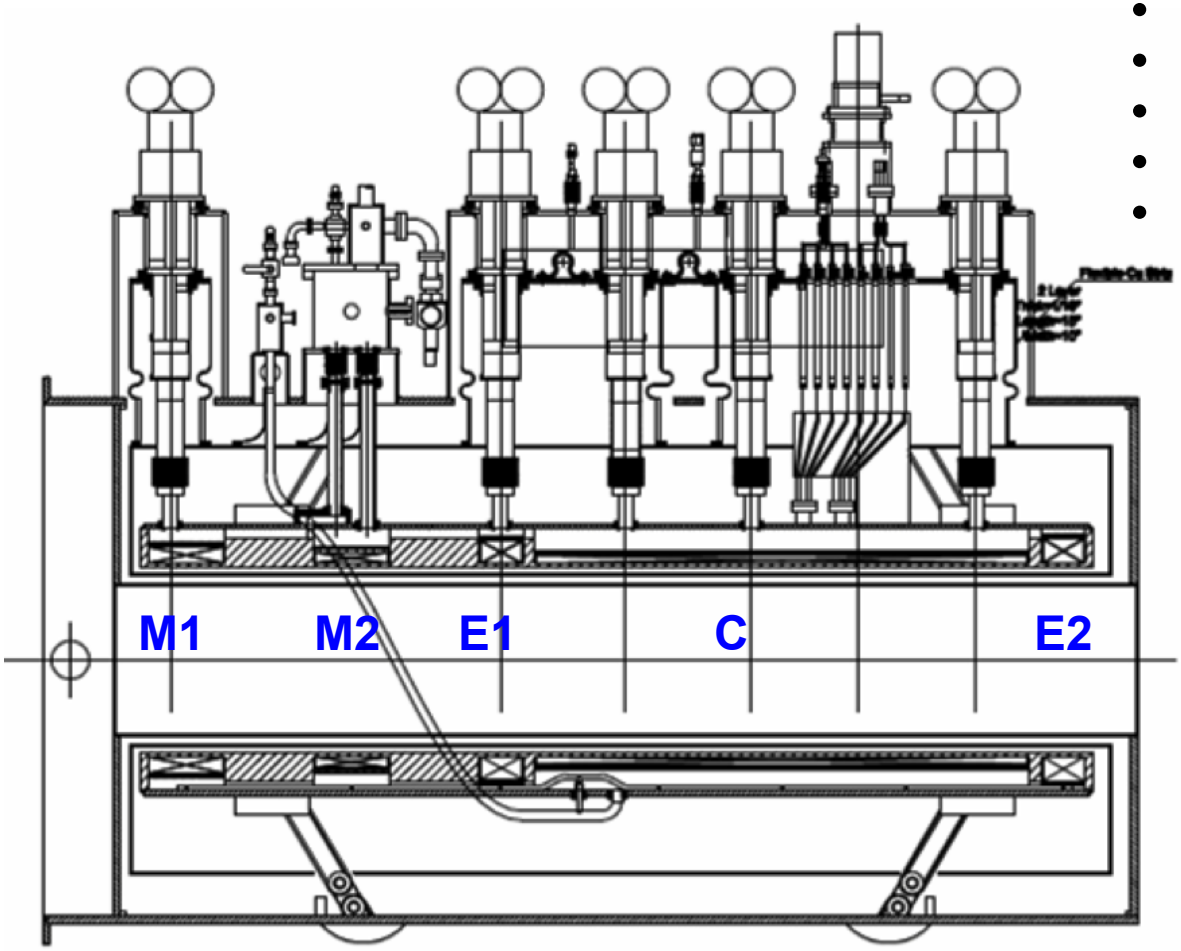
MICE Spectrometer Solenoid Repair



MICE Spectrometer Solenoids

- These magnets have had a long history and I will make NO attempt to review it in any detail here.
- Both magnets met the full specification at the vendor and were fully mapped.
  - Cryogenic operation was very good. Both magnets had significant cooling headroom (SS2 more than SS1)
- SS2 (in upstream position of the beam line – SSU) has reached full operating current at RAL, but full training (soak, solenoid mode) has not been completed.
- SS1 (in downstream position – SSD) had a lead failure during training.
- What is the optimal path forward?

Reminder: Basic design



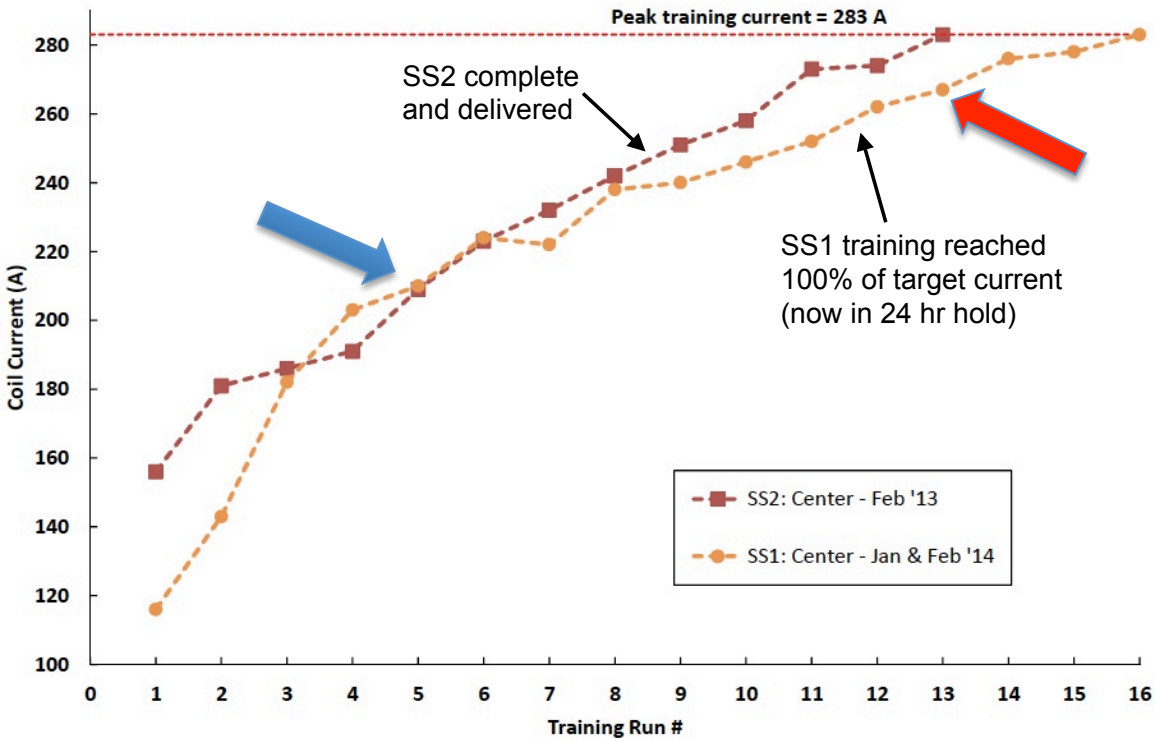
- 5 2-stage CCs
- 1 single-stage CC
- 5 Coils
- Max current ~300A
- High inductance 10-40H

Training SSD

- SSD has been a bit problematic at RAL
  - Some vacuum issues
  - Lost voltage tap on LTS lead of M2 coil
- In the training run of September 11th, 2015 all was going very well.
  - Implementation of additional QP for the M2 lead had not yet been done, so the decision was made to ramp only M1 and ECE
  - A quench occurred at ~ 260A in ECE (much higher than expected, next slide).
- QP system performed as expected, nothing outwardly unusual except for the large current.

Training history

SS1 Training Progress



Lead failure

- However, upon entering the hall the odor of burnt FR4/ G10 was extremely strong. Strongest at He relief valve
- After a great deal of analysis, it has now been determined that (see diagram on next slide):
  - One leg of M1 dead short to ground. This is LTSA lead.
  - LTSB lead not connected to coil (open), but connected to LTSA with ~ 2.4KOhm resistance.
  - M1 coil OK.
  - No damage seen anywhere else.
  - AC measurements show that QP on M1 not active indicating a break in the internal QP circuit. Most likely point is indicated in the figure on the next slide (x next to diodes) because there is another short to ground on this leg of the circuit.
  - All other coils OK (including their QP circuit).

M1 circuit after fault

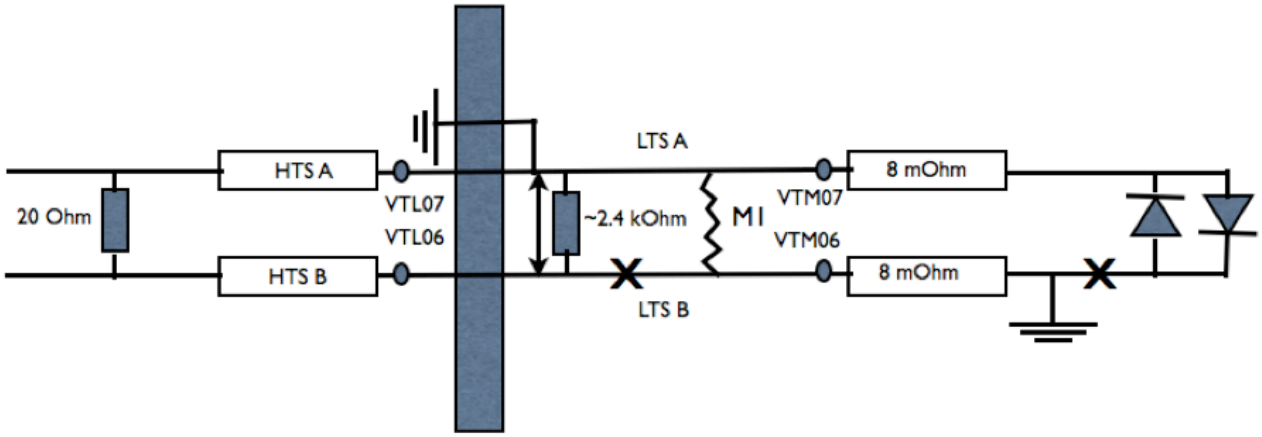
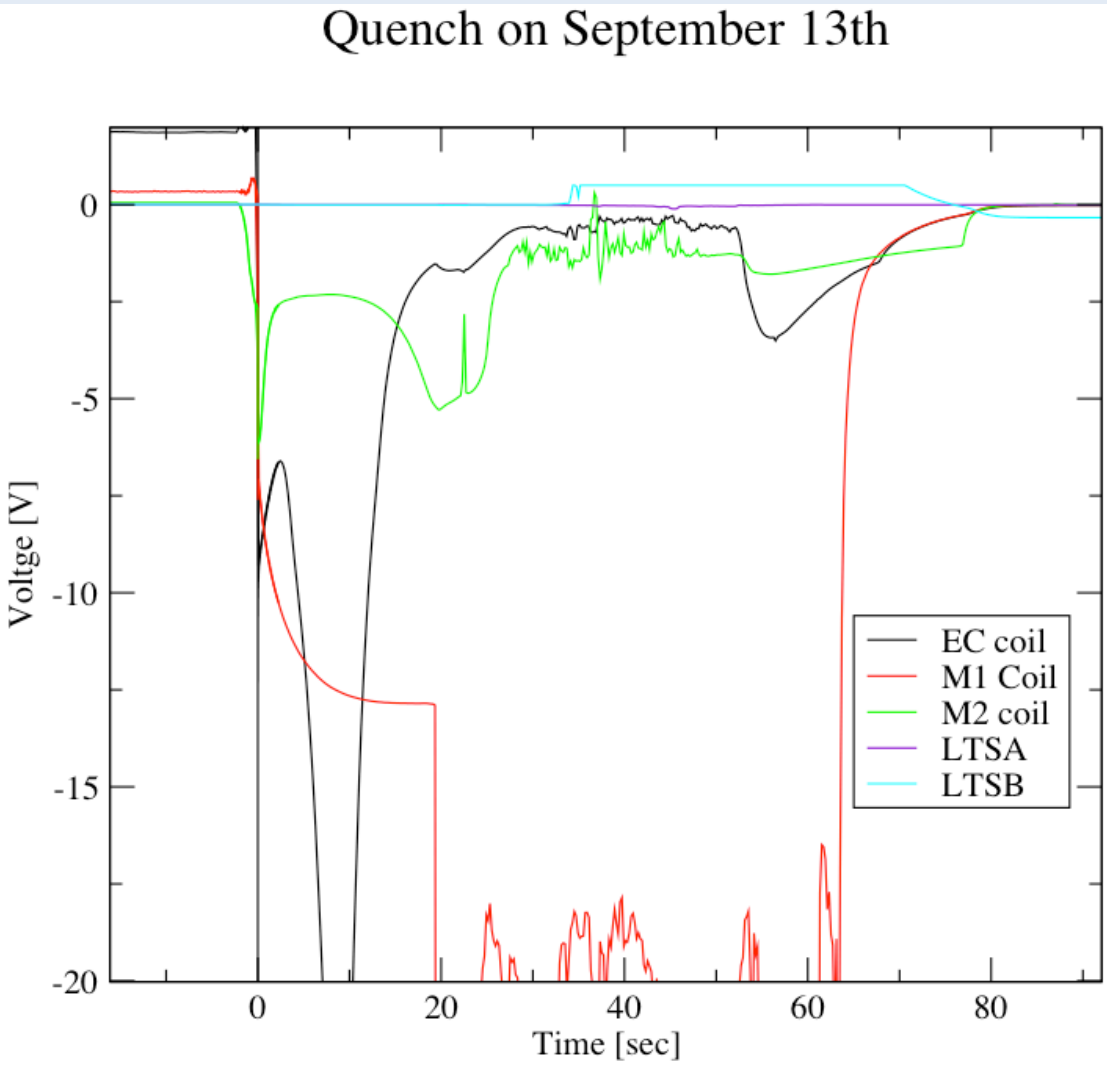


Diagram of the M1 circuit. Resistance (four wire and two wire) measurements revealed:
i) Lead A has hard short to ground,
ii) LTSB is shorted to LTSA through 2.4 kOhms and LTSB is not connected to the M1 coil on the Lead B side.

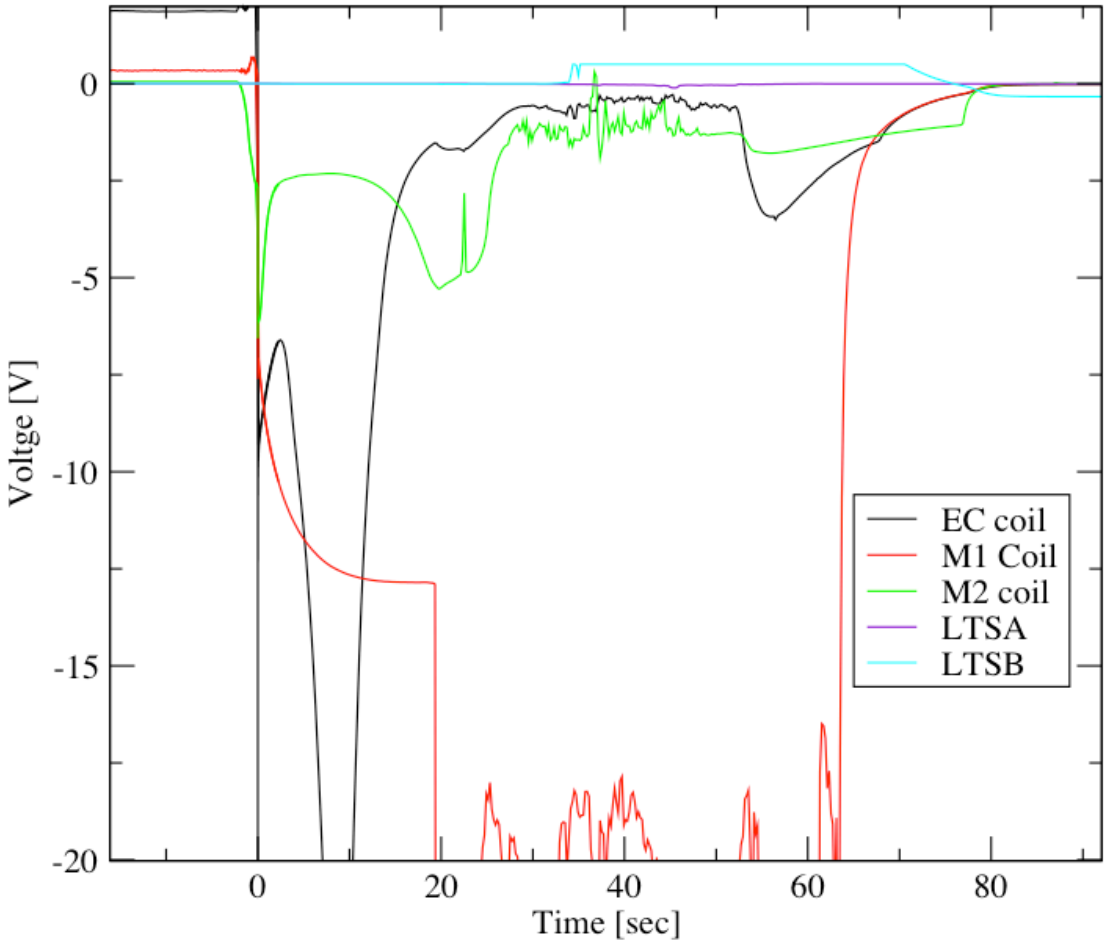
QP data – M1 (80 sec)



QP data – M1 (80 sec)

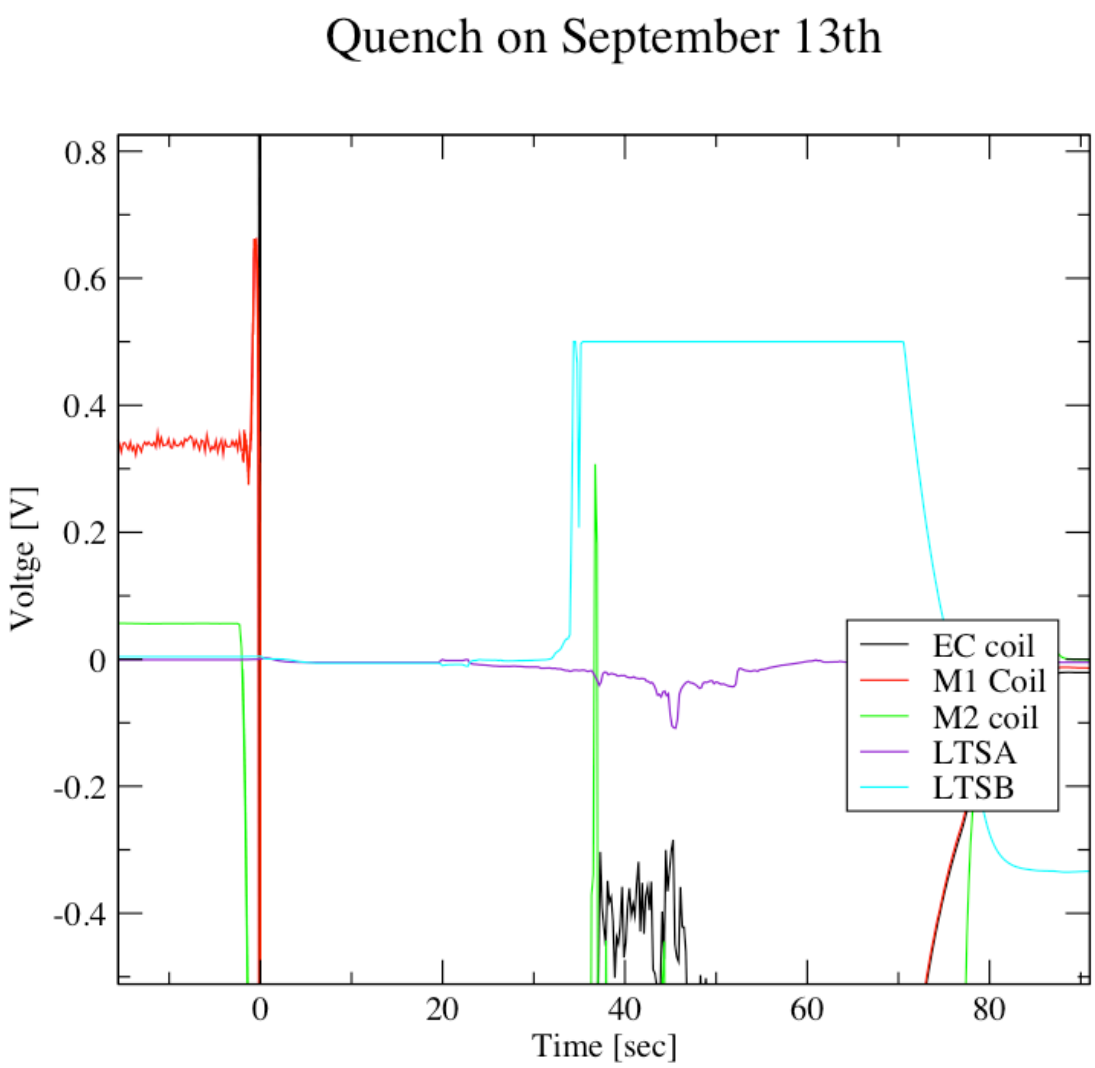
Expanded V scale

Quench on September 13th



QP data – M1 (80 sec)

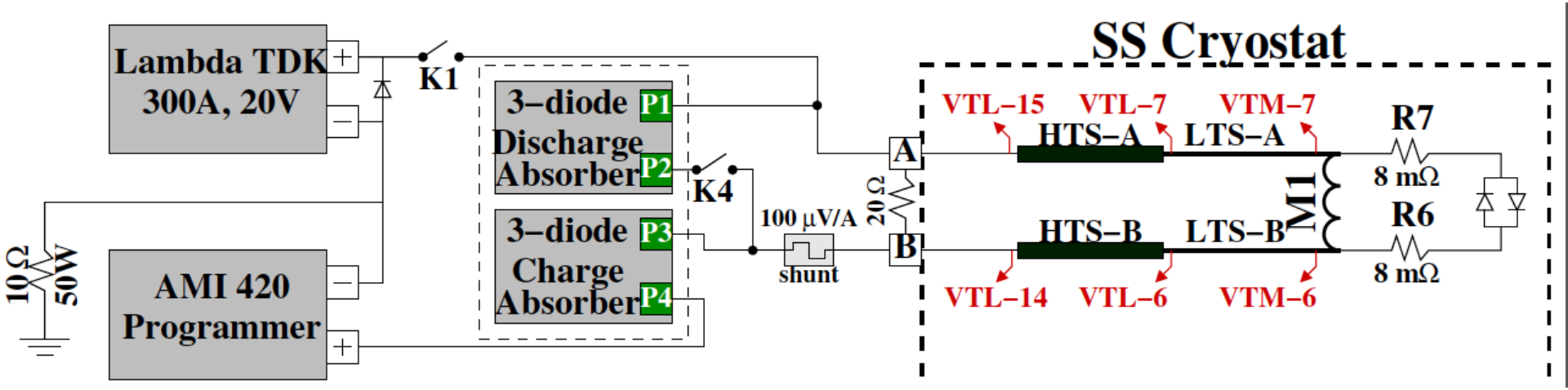
Expanded V scale II



Analysis

- Quench initiated on ECE and initially proceeded normally
  - There is no evidence that any LTS leads were involved initially
- At ~ 20 sec, the internal QP for coil M1 failed
  - The voltage on the coil increased rapidly and, it appears that an arc at the LTS power feed through (from vacuum to LHe volume) occurred which burnt out the lead and effected M2 (the power leads for M1 and M2 utilize the same 4 pin feed through).
- What caused the QP failure?

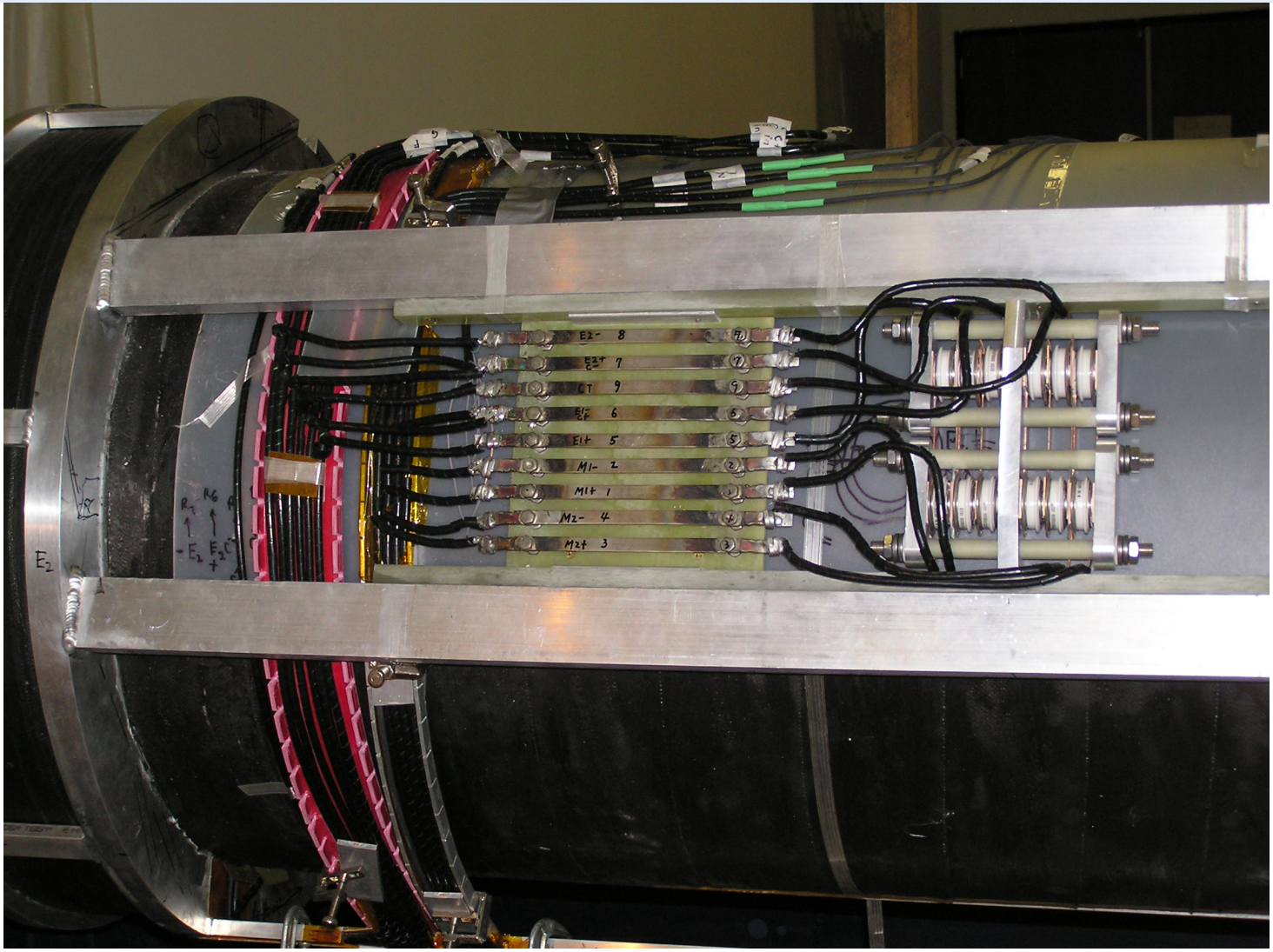
Circuit diagram



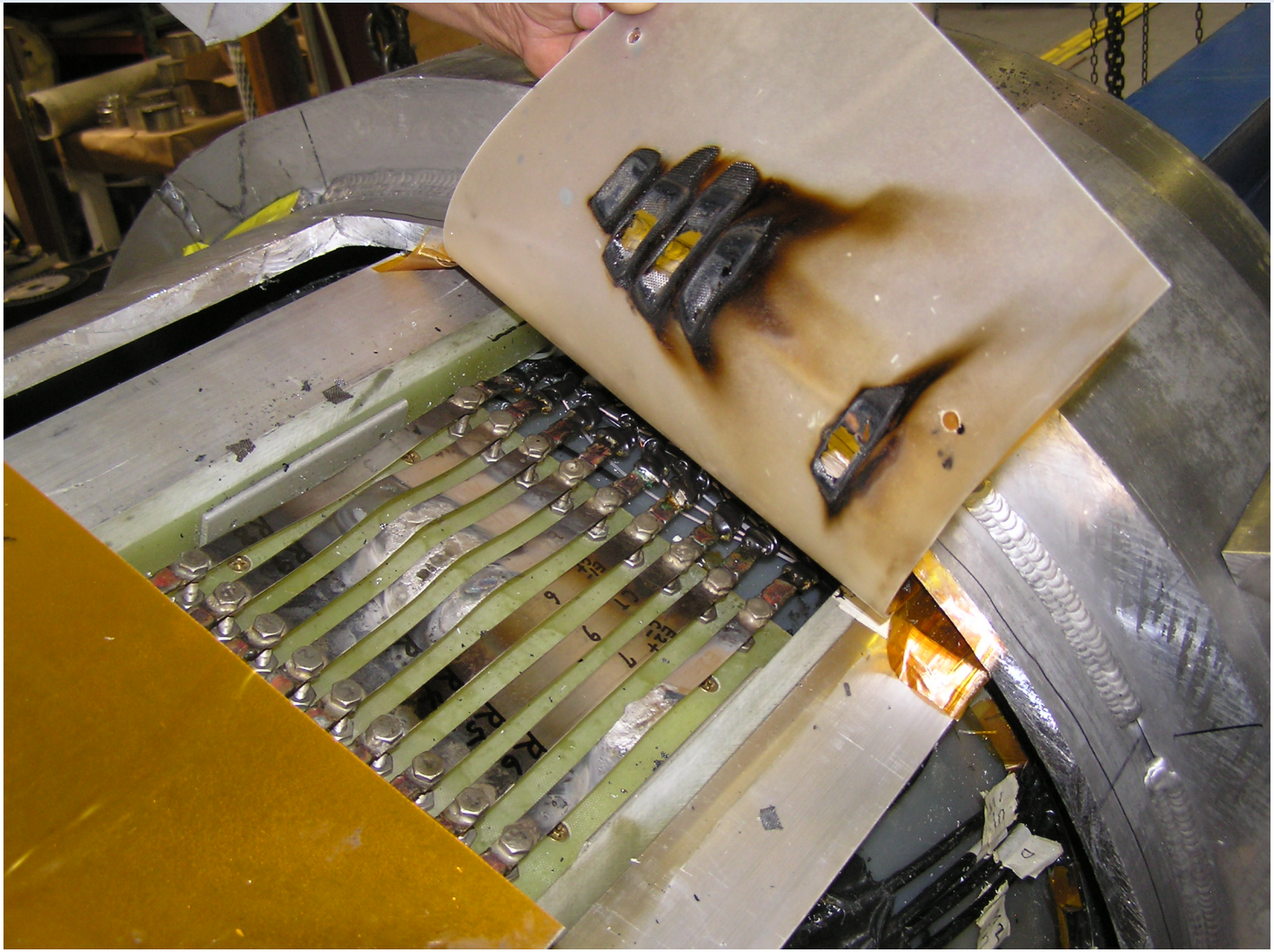
Failure in electrical circuit from the point of VTM-7 to VTM-6
as indicated in diagram on Slide 7

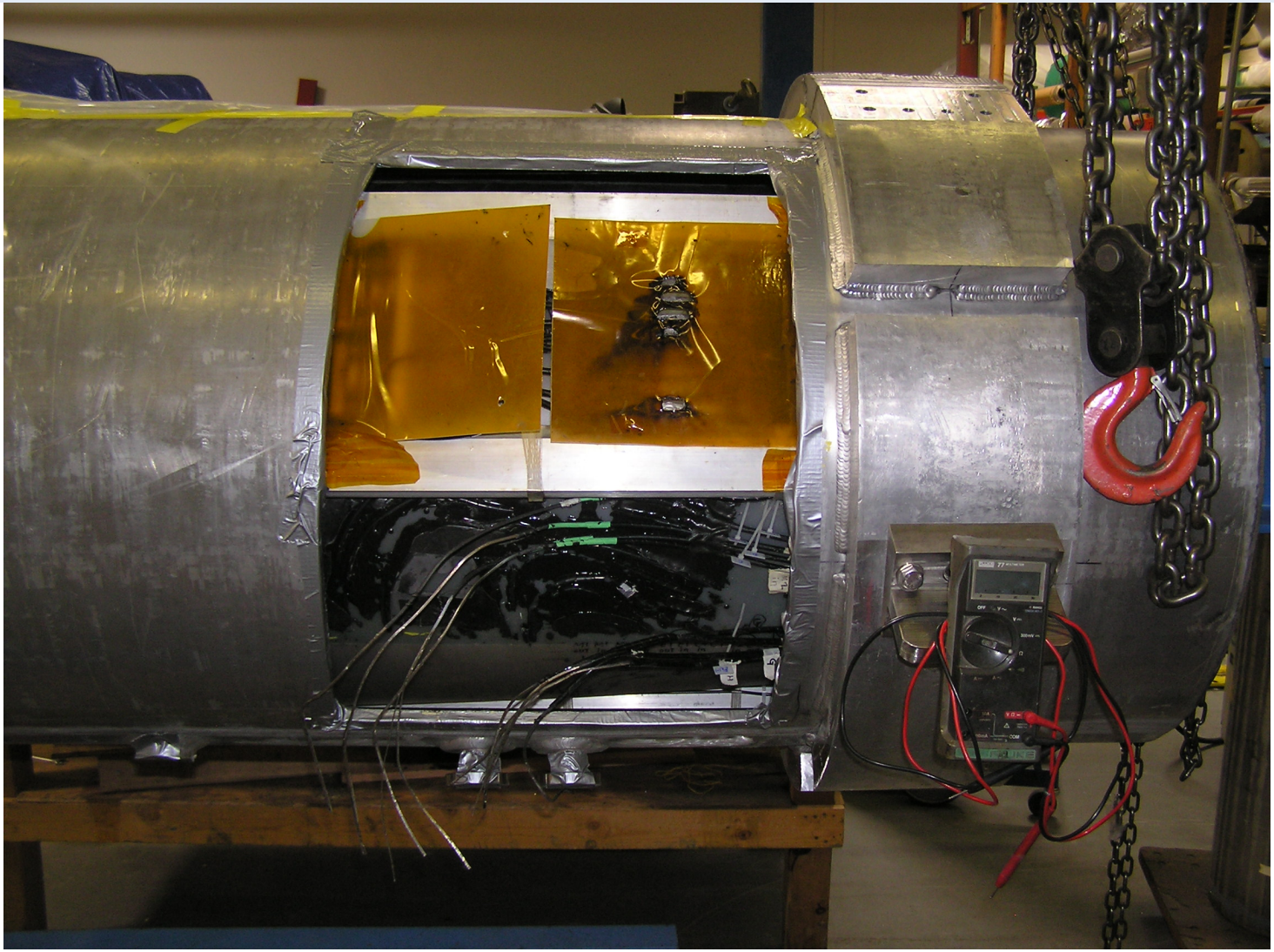
Internal QP

Original Wang configuration



We have add previous issues



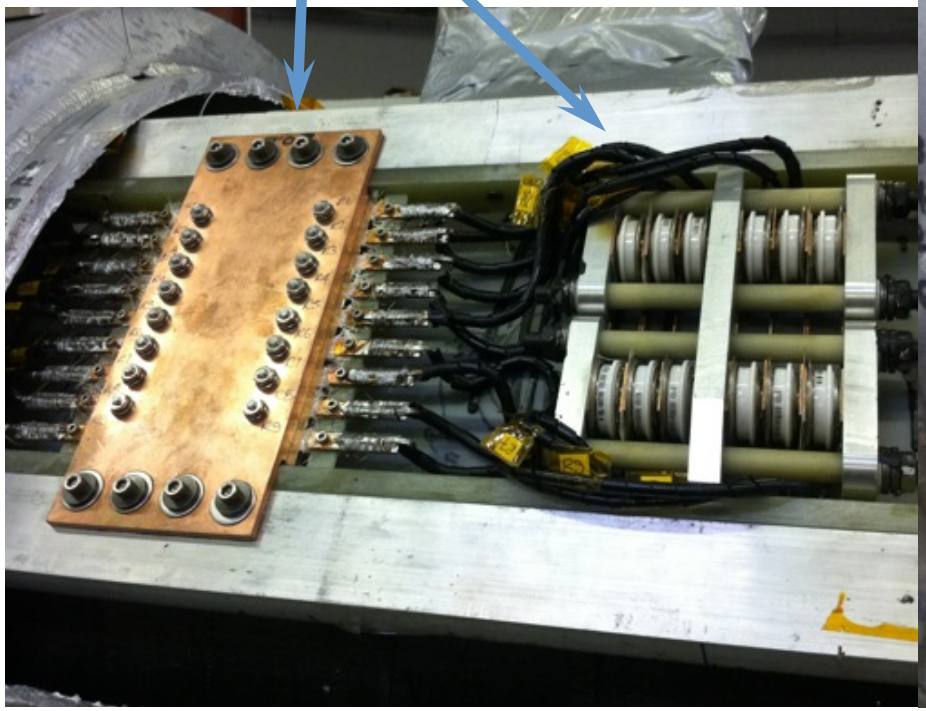


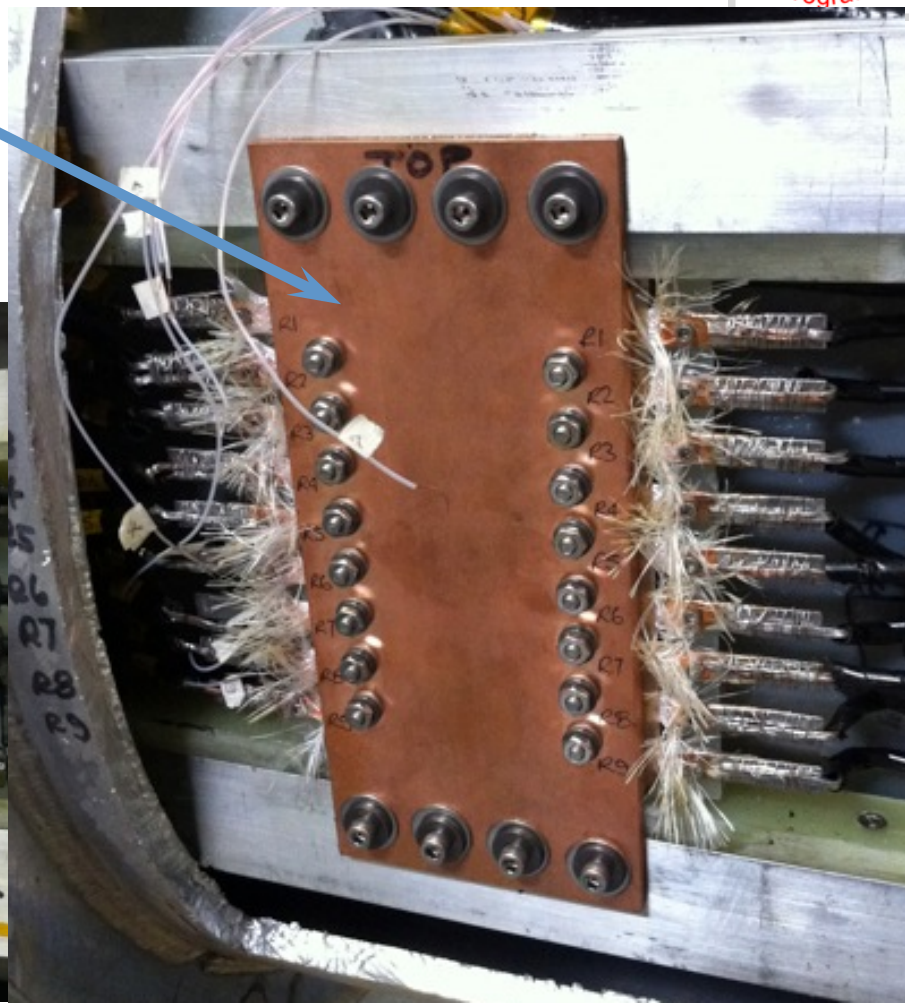
LBNL re-design

Picture of final configuration for SS2/SSD

Conductively cooled resistors

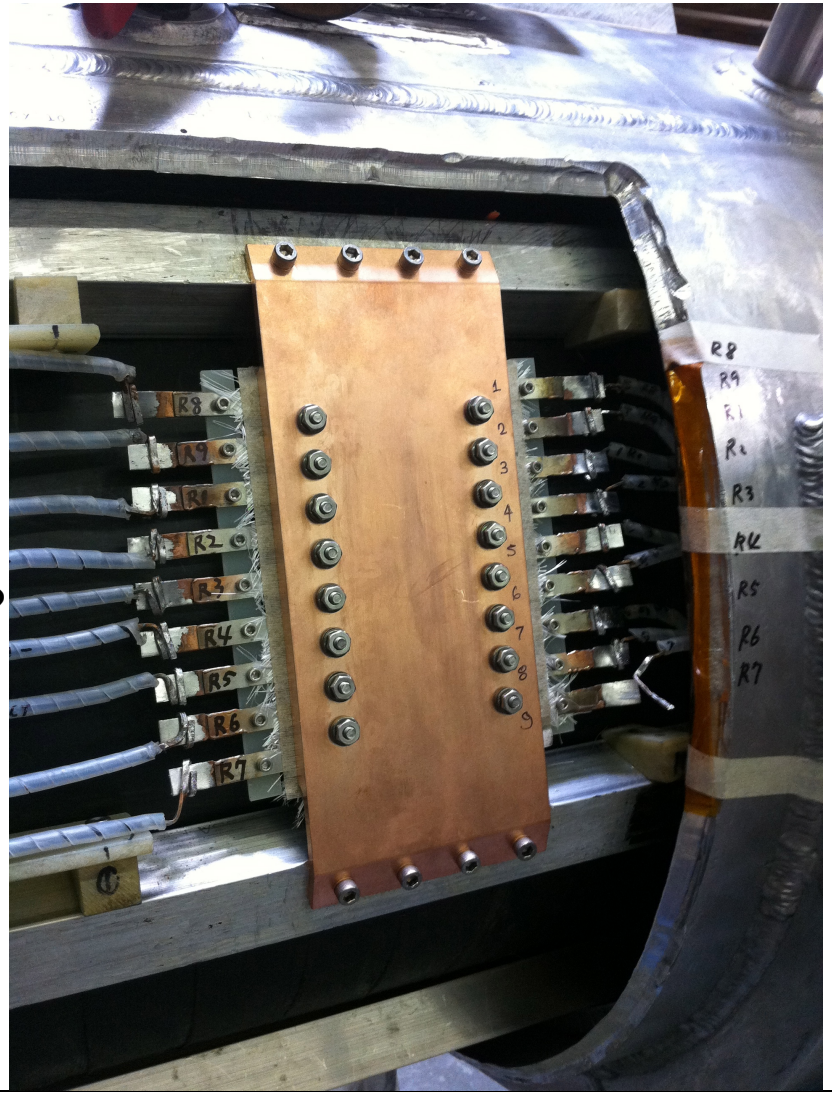
Quench protection circuitry





SSD/SS1

This is a photo of the QP pack for SSD/SS1. What is not known at this time is whether or not the terminations of the leads where complete when the photo was taken or exactly how the terminations were made. Did Wang follow the procedures used on SSU/SS1?



Moving Forward

- Can obtain lattice to allow MICE Step IV running without SSD M1 coil. However, limits momentum scan
- Harder when RF is added
  - Impossible?
- However, risk that a M2 lead will fail is high at this point
  - M2 has been powered at low current (5A) and all looked good.
- Need guidance on how to proceed

An assortment of Possible futures

In order of risk (my assessment)

A. Do nothing & hope SSD-M2 has a long and prosperous life
B. Run Step IV (to end or M2 failure) and then cut into SSD to repair
   - There are a number of sub-options here
   - Risk of compromising cold-mass supports
C. Run Step IV (to end or M2 failure) and then pull cold mass and repair and replace
   - Maybe the most straight forward option, but potentially longest calendar time
D. Immediately start process to build new cold mass (we have SC) with upgraded design and fully train in stand-alone cryostat (Training issues, Power feed throughs, QP)
   - Disassemble SSD (at end of Step IV or M2 failure) and integrate vacuum vessel, cryo-system, shields, etc. with new cold mass. And yes, be ready by June, 2017
E. +???

Comments