MQXFAP1 TEST STATUS UPDATE

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MQXFA TEST PROCEDURES

MQXFA Functional Test Requirements

Each magnet must meet the requirements set forth in *US-HiLumi-doc-137* before shipping to FNAL for assembly into LQXFA cold masses.

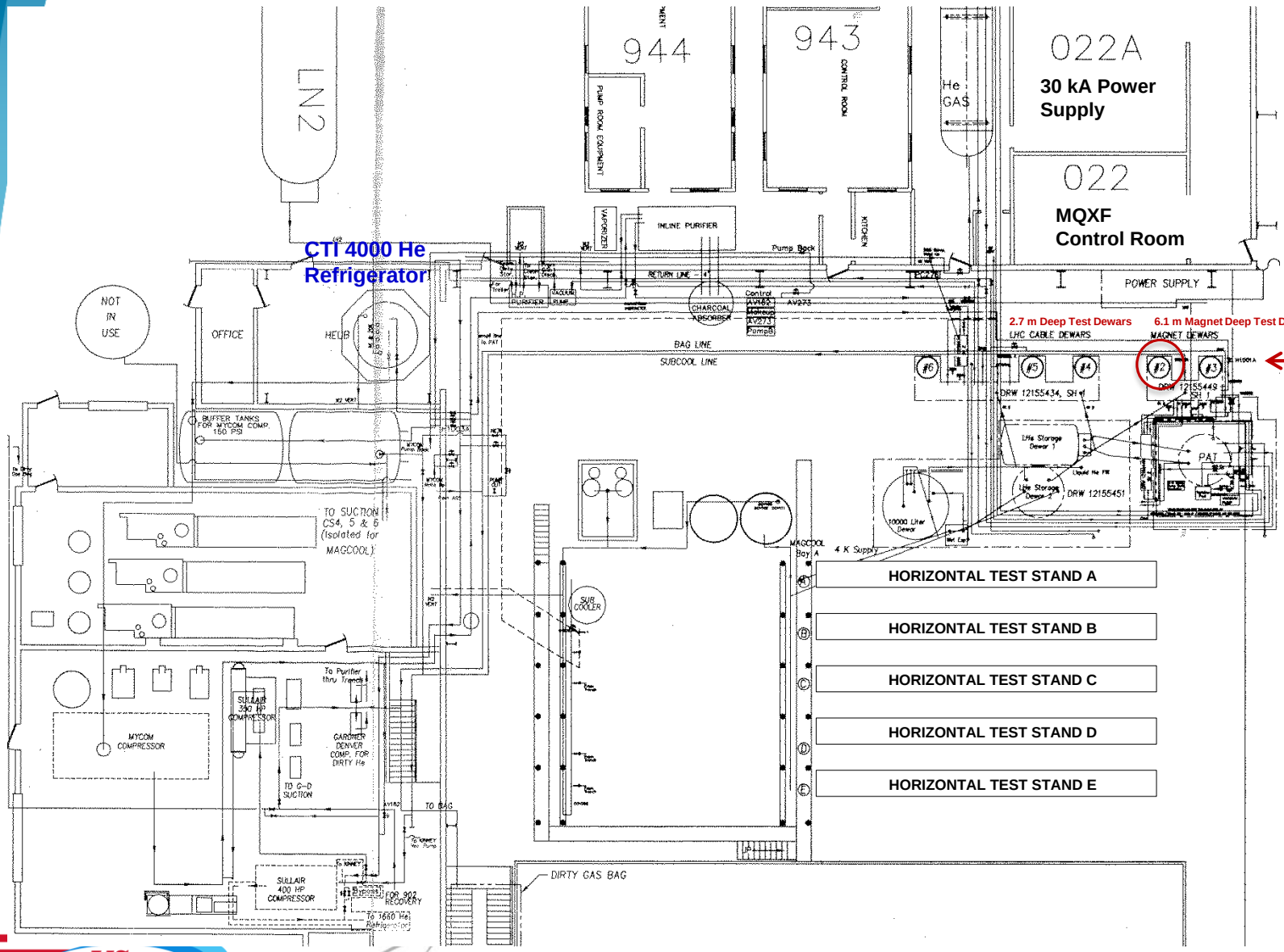
27 MQXFA magnet tests (including prototypes at BNL Vertical Test Facility

Test Parameters and Procedures include:

- Electrical checkout at room temperature and cold (4.5 K or less)
- High voltage withstand tests (hipot) at room temperature and cold (4.5 K or less)
- Verification of quench protection systems at 1.9 K: quench protection heaters, external energy extraction system, CLIQ
- Quench training at 1.9 K and 1 bar to ultimate current with margin (18 kA)
- Quench characterization using voltage taps and quench antenna
- Holding test at ultimate current
- Magnetic field measurements
- Splice joint measurements
- Quench protection studies (CLIQ and quench protection heaters) – prototypes only

Test Facility Infrastructure

Nash "high capacity" vacuum Pump (1.9K)



Vertical Test Dewars 2-6

Building 902 Test Facility Floor Plan and Overview

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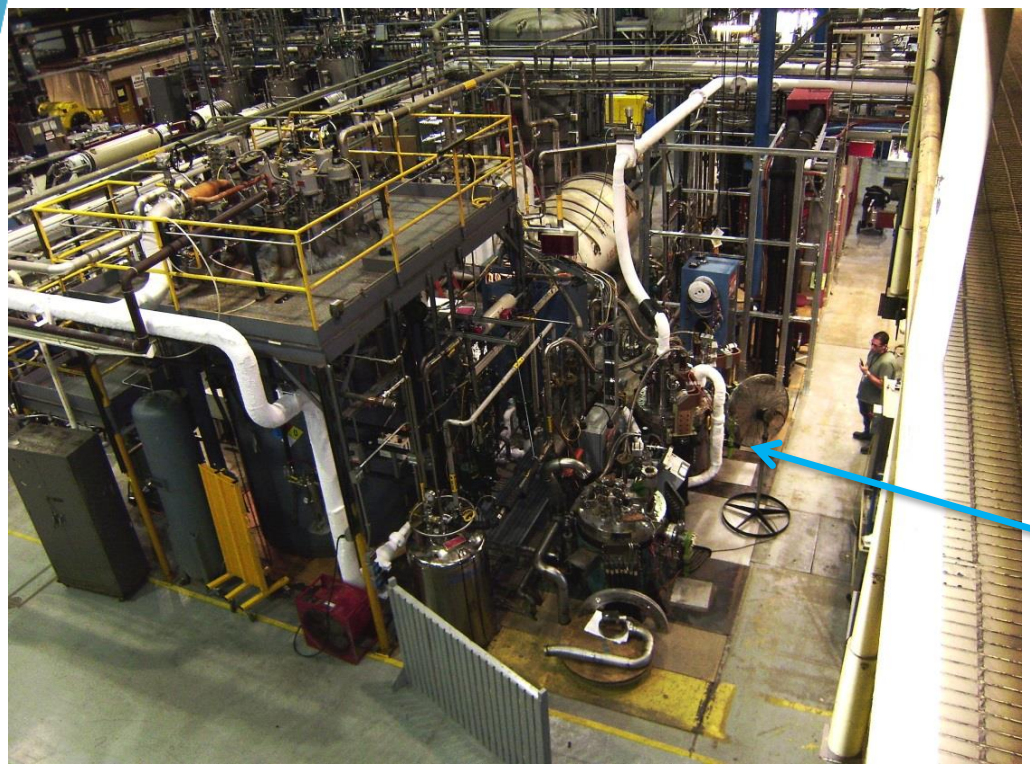
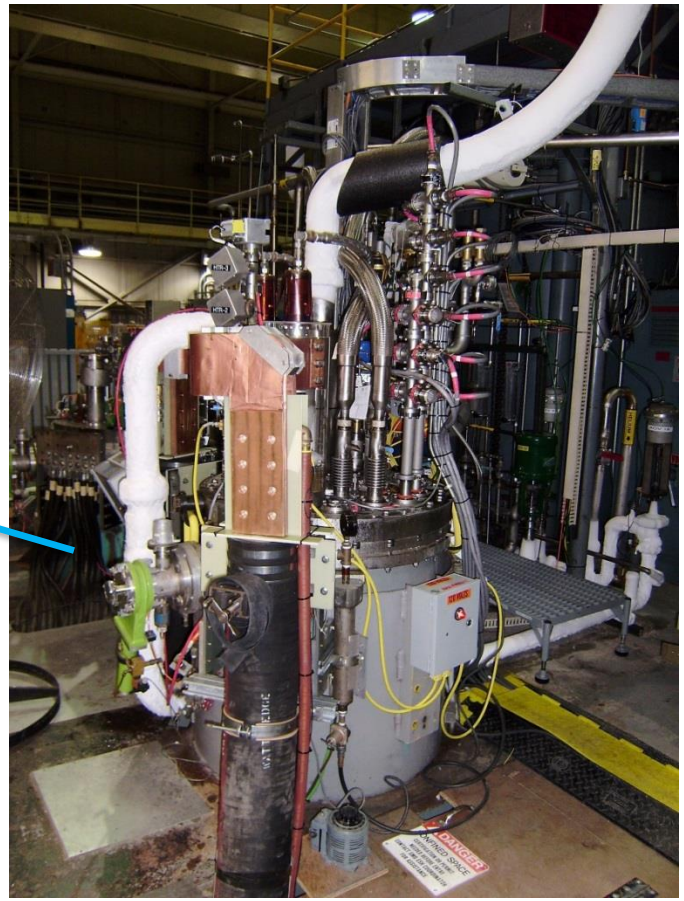
Test Facility Infrastructure



Vertical Test Facility at BNL, showing two of the five test cryostats and the backup refrigerator. Arrow points to **Vertical Test Cryostat 2 (1.9K and 24kA)**.



Vertical Test Stand 2, upgraded to provide 1.9 K at 1 bar (nom) and 24 kA, for testing of the 4.2 m-long MQXFA quadrupoles. The picture shows the test stand with the mirror MQXFPM1 under test.

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TEST FACILITY STATUS

Recent work during thermal cycle and during present cooldown cycle:

1.FPGA-based quench detector system – much work done troubleshooting noise issues and implementing improvements with digital filtering for half coil difference and I-dot signals (whole coil – Ldi/dt); SC lead signals added. Delays and validation times have been verified as reliable and accurate.

2. PXI quench detector (first system, used during mirror test) now being used as backup and also for gas-cooled lead voltage and other signals that would result in slow discharge (ramp down). Former issues with unpredictable delay times have been rectified with programming improvements and noise reduction.

3. Quench antenna: repairs to solder joints damaged in shipping and assembly and wiring for 16 modules; independent quench antenna PXI DAQ chassis assembled and tested; signal generation and acquisition by DAQ tested with permanent magnet as at LBL – presently installed in warm bore.

4. CLIQ system has been assembled and complete with diodes; testing on dummy inductance and resistor load is in progress.

TEST FACILITY STATUS

Recent work during thermal cycle and during present cooldown cycle:

5. Hipoting issues at room temperature due to structures on top plate have been identified. But still struggling with cold hipot issues, despite the installation of sealed Plexiglas covers with N_2 gas flow on copper lead insulators.

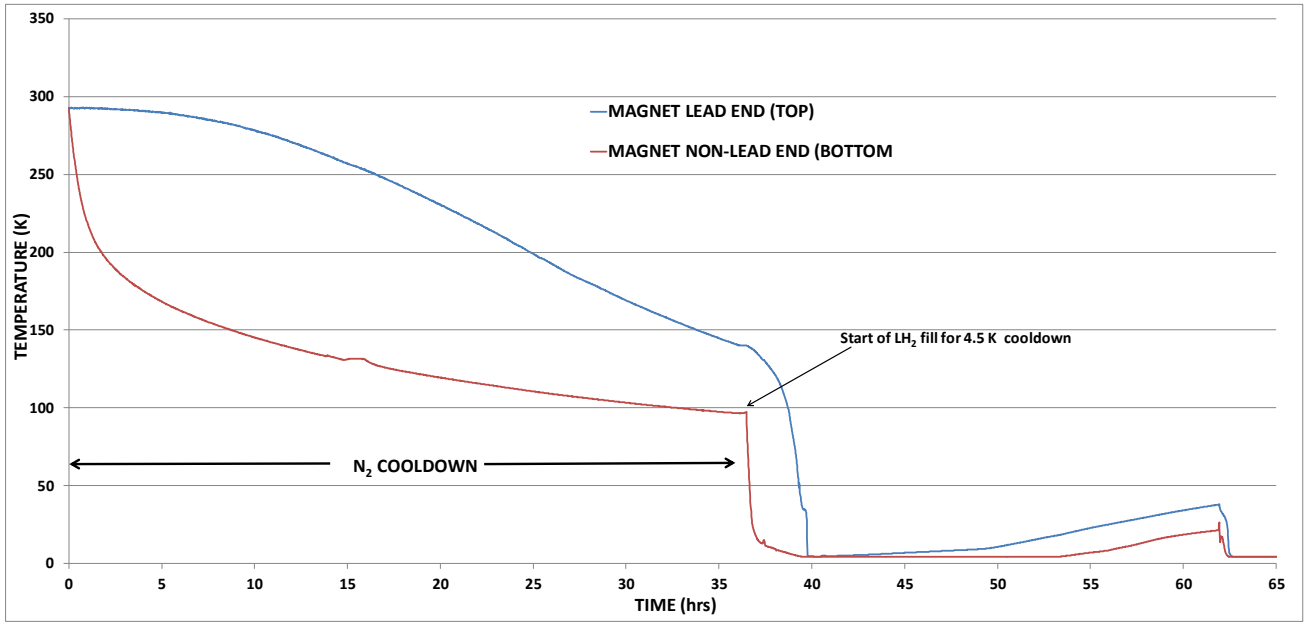
6. 12 quench protection heater firing units can now be fired independently to induce quenches in quench protection studies.

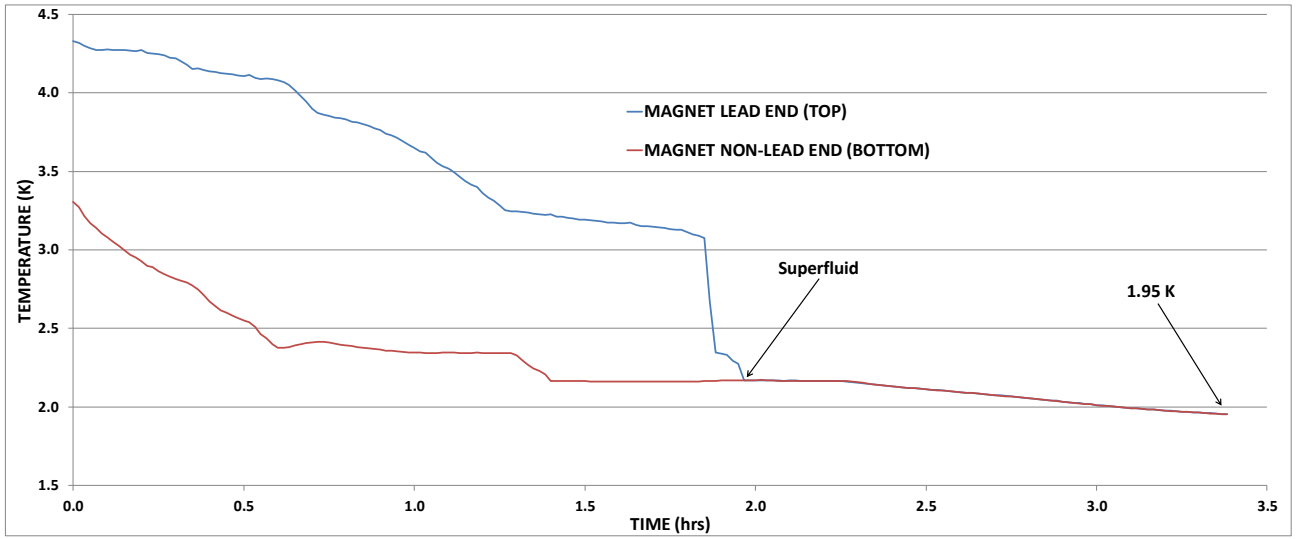
7. The addition of new calibrated temperature sensors and more level probes now allows for more precise cryogenic control in cooldown from 4.5K to 1.9K.

8. Non-working strain gauges have been identified and wiring re-configured to remove them from current source. 12 coil gauges have stopped working, including one after quench on Monday.

9. Frequent lost voltage taps have required wiring and data logger re-configuring.

COOLDOWN





Cooldown from 4.5K to superfluid takes about 2 hrs; then to 1.9K, another 1.5 - 2 hrs

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MQXFAP1 QUENCH #1

I_Q = 15476 A (T = 2 K)

Half coil difference voltage threshold = 275 mV

Validation interval = 4 ms

R_{dump} = 37.5 mΩ

$\int I^2 dt$ = 34.4 MIIts (253 K, from ER simulation)

E_{tot} = **3.95 MJ**

E_{dump} = **1.29 MJ (33%)**

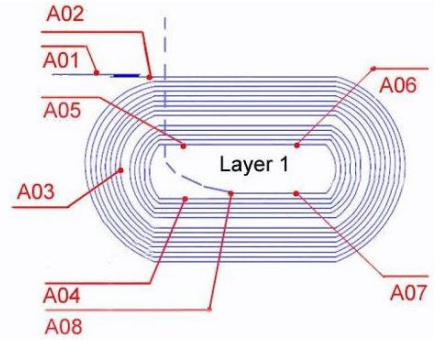
<u>Measurement of Inductance at 15476 A</u>

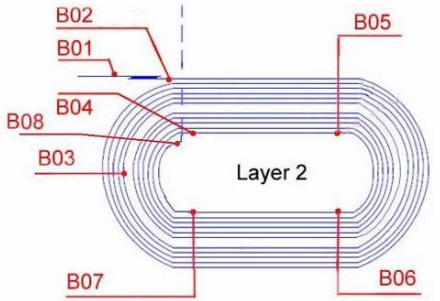
$L_{Coil2+5}$ = 16.537 mH

$L_{Coil3+4}$ = 16.547 mH

L_{whole} = 33.086 mH

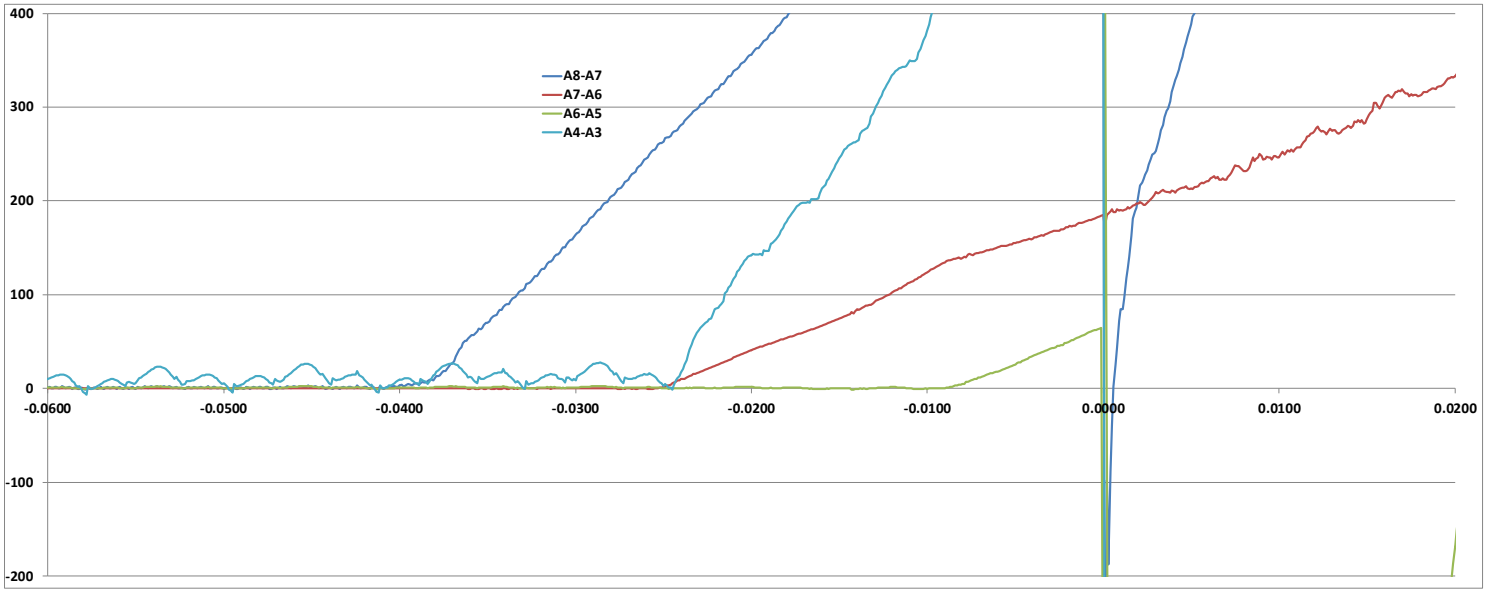
MQXFAP1 QUENCH #1





I_Q = 15476 A (T = 2 K)

Location: Coil 2	A8-A7	Inner Layer Short SS	-38.3 ms
	A7-A6	Inner Layer Nonlead End	-25.0 ms
	A4-A3	Inner Layer Multiturn	-24.5 ms
	B3-B4	Outer Layer Multiturn	-7.9 ms



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MQXFAP1 QUENCH #2

I_Q = 15440 A (T = 1.9 K)

Half coil difference voltage threshold = 150 mV

Validation interval = 5 ms

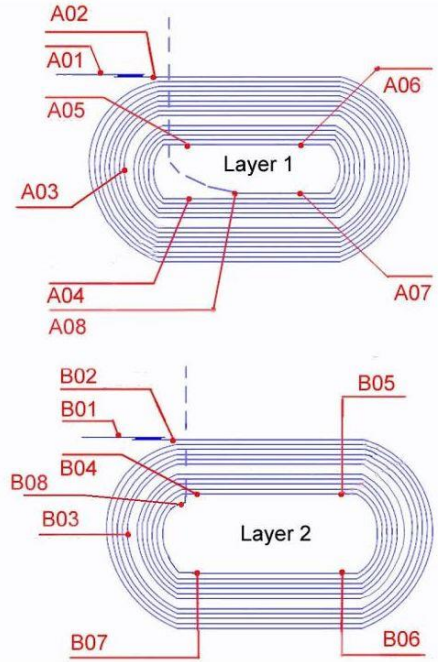
R_{dump} = 37.5 mΩ

$\int I^2 dt$ = 29.8 MIIts (210 K, from ER simulation)

E_{tot} = **3.93 MJ**

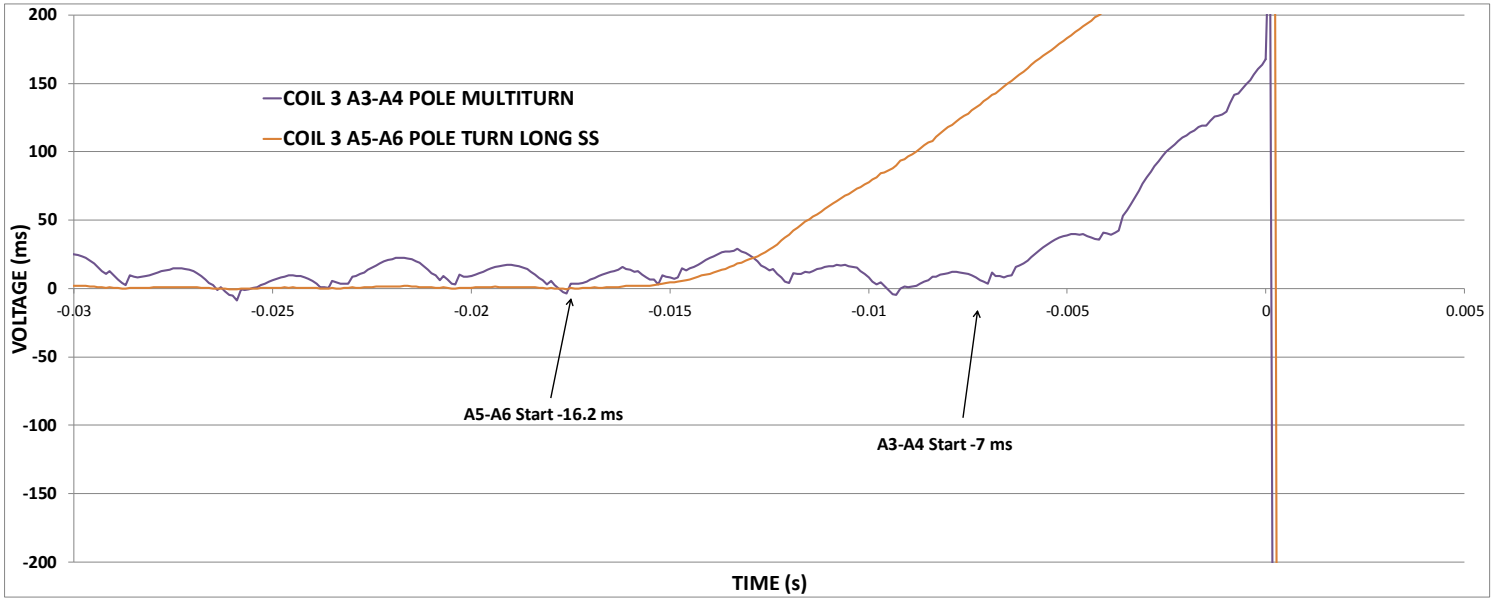
E_{dump} = **1.12 MJ (28%)**

MQXFAP1 QUENCH #2

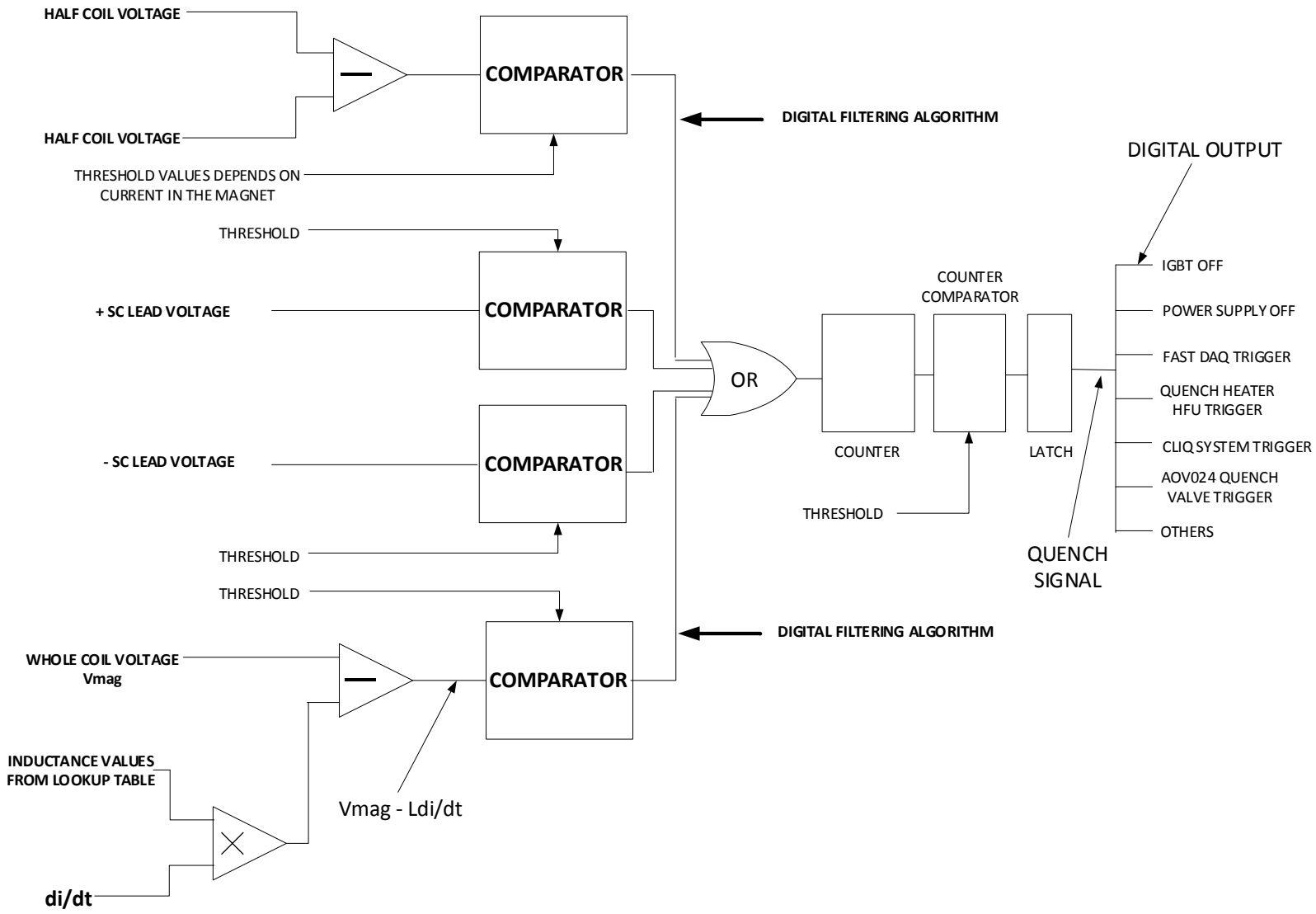


I_Q = 15440 A (T = 1.9 K)

Location: Coil 3 A5-A6 Inner Layer Long SS -16.2 ms
A3-A4 Inner Layer Multiturn -7 ms



FPGA-BASED QUENCH DETECTOR



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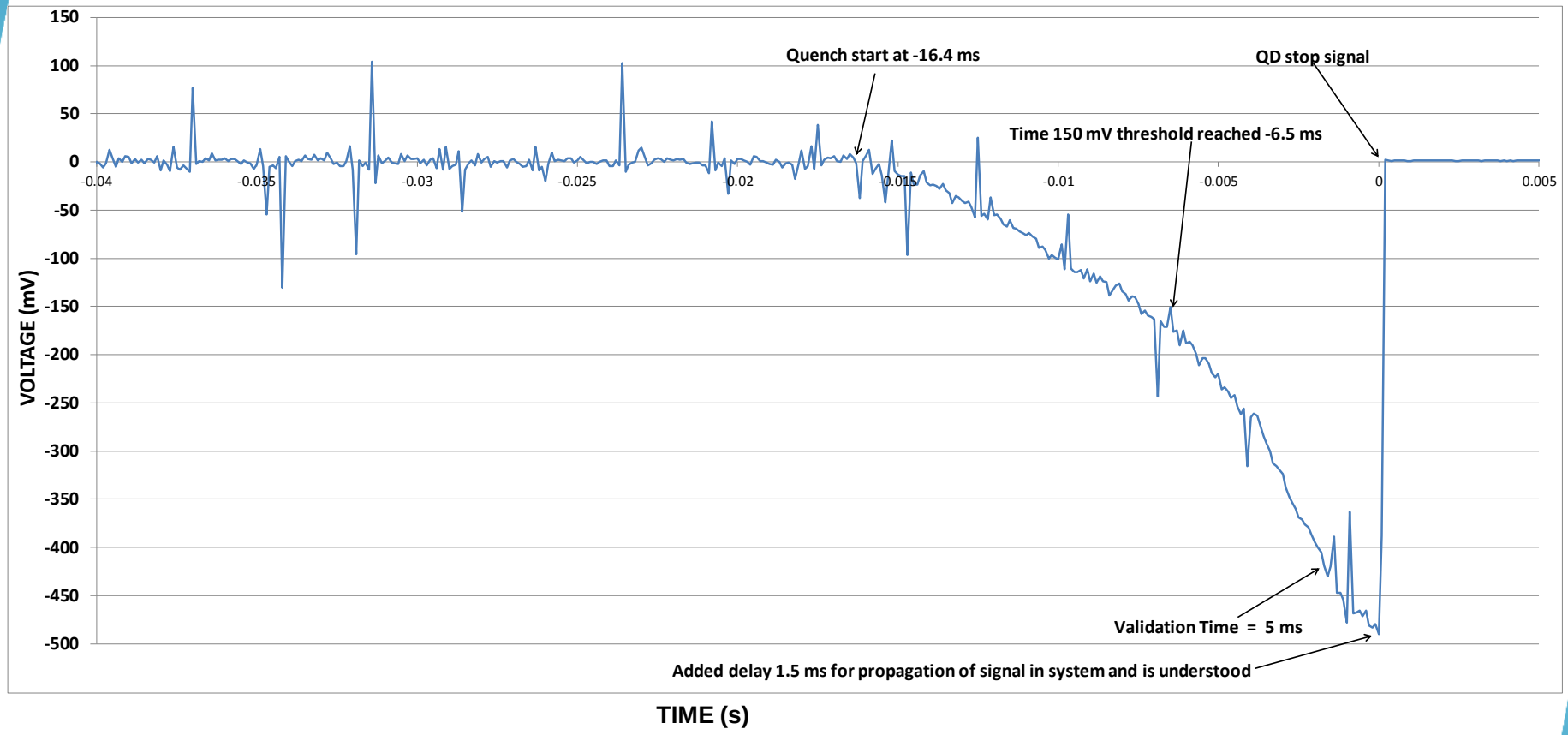
FPGA QUENCH DETECTOR TIMING



Half Coil Voltage Difference: (Coil 2 + Coil 5) – (Coil 3 + Coil 2)

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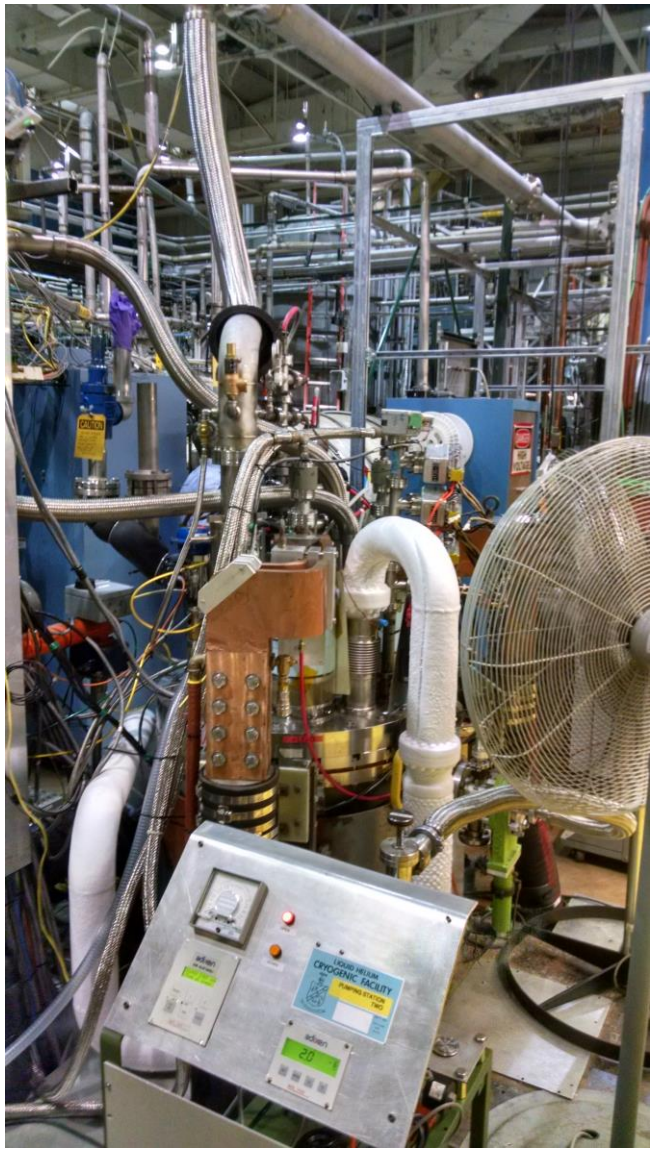
PRESENT MQXFAP1 TEST STATUS



One quench before thermal cycle.

Quench protection heaters verified at 4.5 K.

One quench after thermal cycle so far.

Magnet presently at 4.5 K or less.

Quench testing to resume today Wed.

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