Update on STF and CC Tests

Ruben Carcagno

May 24, 2013

Solenoid Test Facility (STF)

- Use for MAP Support: MICE Coupling Coil Solenoid Test
  - Objective: Test and train 3 Cold Masses
- Obtained a large SMES cryostat from the NHMFL/FSU
- Evaluated several Fermilab locations for this facility (IB1, CDF, CHL). Recommended CHL
- Plan approved by Directorate January 2012
- Obtained ORC April 17, 2013 →
  - Test of first MICE CC started early May 2013

Fast Track, High Priority Effort!

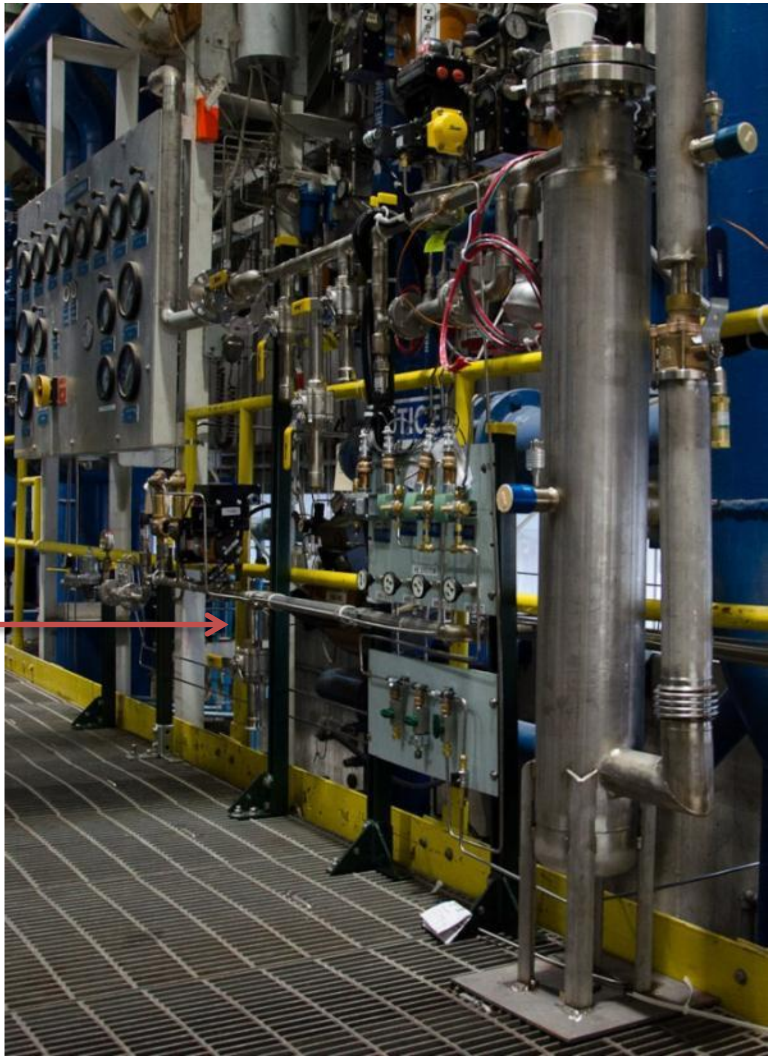
SMES Cryostat : From Florida to CHL

CHL LHe Distribution System

- Liquid Helium (LHe)Transfer Line from 10,000 Gallon LHe dewar to Bayonet Can

CHL Test Stand Cryo

- Bayonet Can to connect LHe to Test Dewar with U-tubes
- Gas supply for controlled cooldown, and Heater to return warm gas to CHL



T&I

First MICE CC Arrived at Fermilab

- First Coupling Coil arrived at Fermilab on 1/31/13 after LBNL fixed cooling pipe leak with a branch pipe

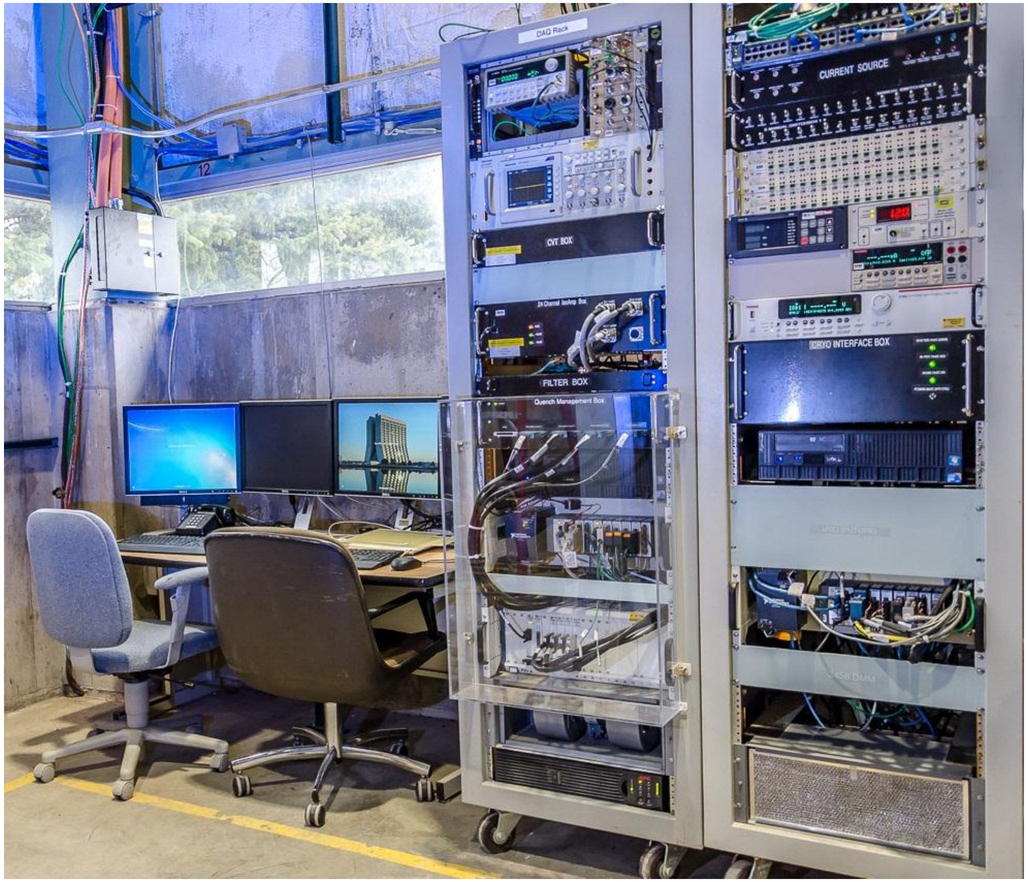
- Coil passed hipot, leak check, and instrumentation check

Top Plate Insert with Coil at CHL

- New Dished Head
- Mechanical Supports
- Cryo Piping
- Current Leads
- Valves, Instrumentation
- Pressure Test
- Leak Check
- Hipot

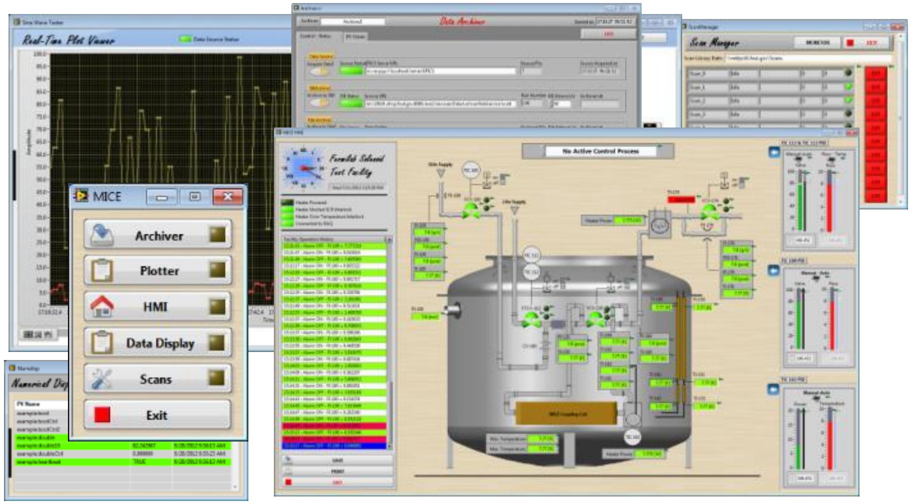
Controls, DAQ, Power System

- Cryo Controls, DAQ, and Power System racks

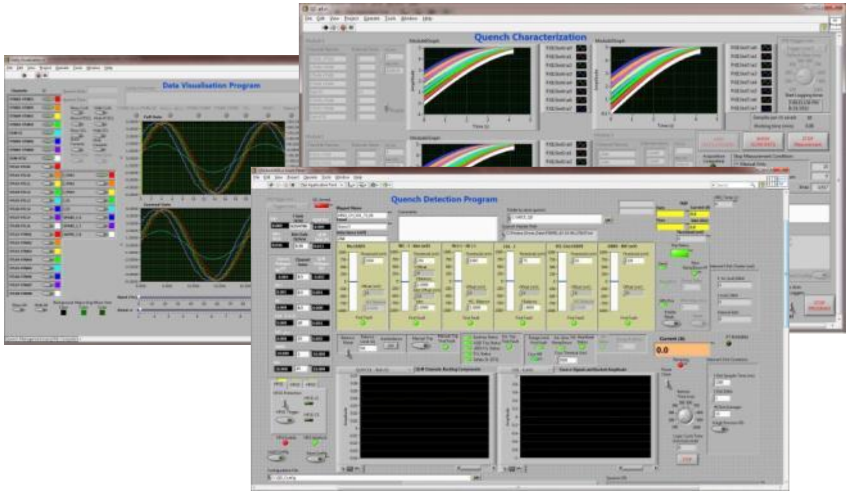


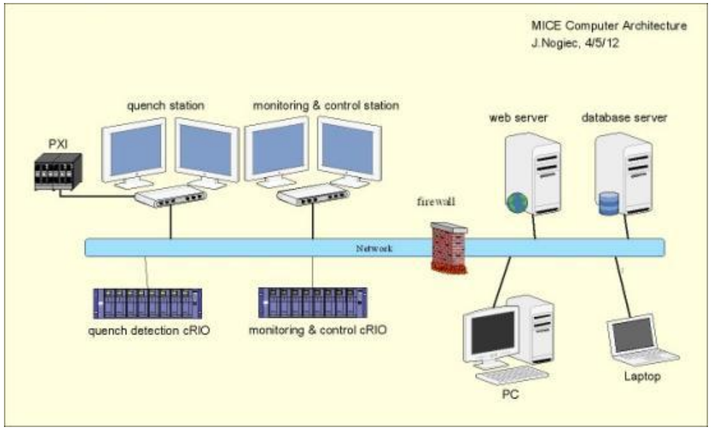
Software User Interface

Monitoring & Control Subsystem UI

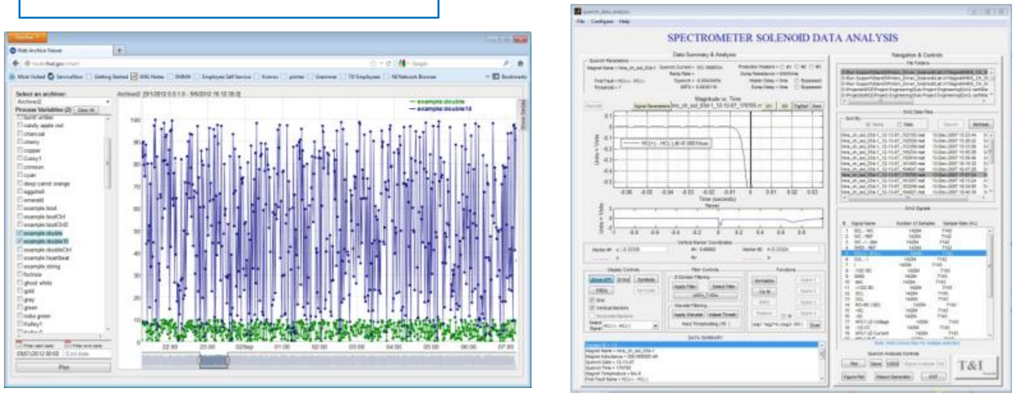


Quench Subsystem UI

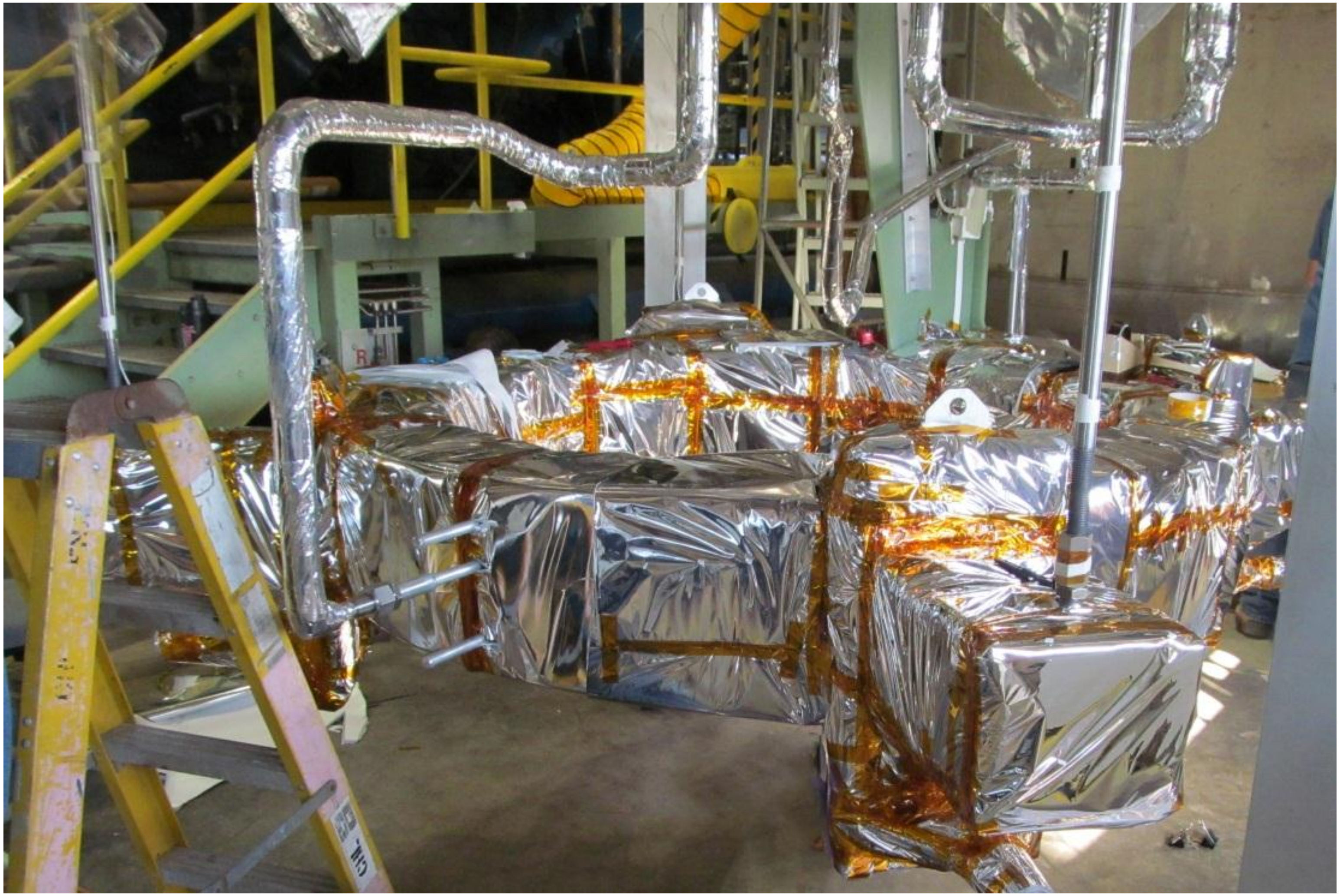




Web-based Data UI



Coil Wrapped in MLI and Inserted in Vacuum Vessel



Operational Readiness

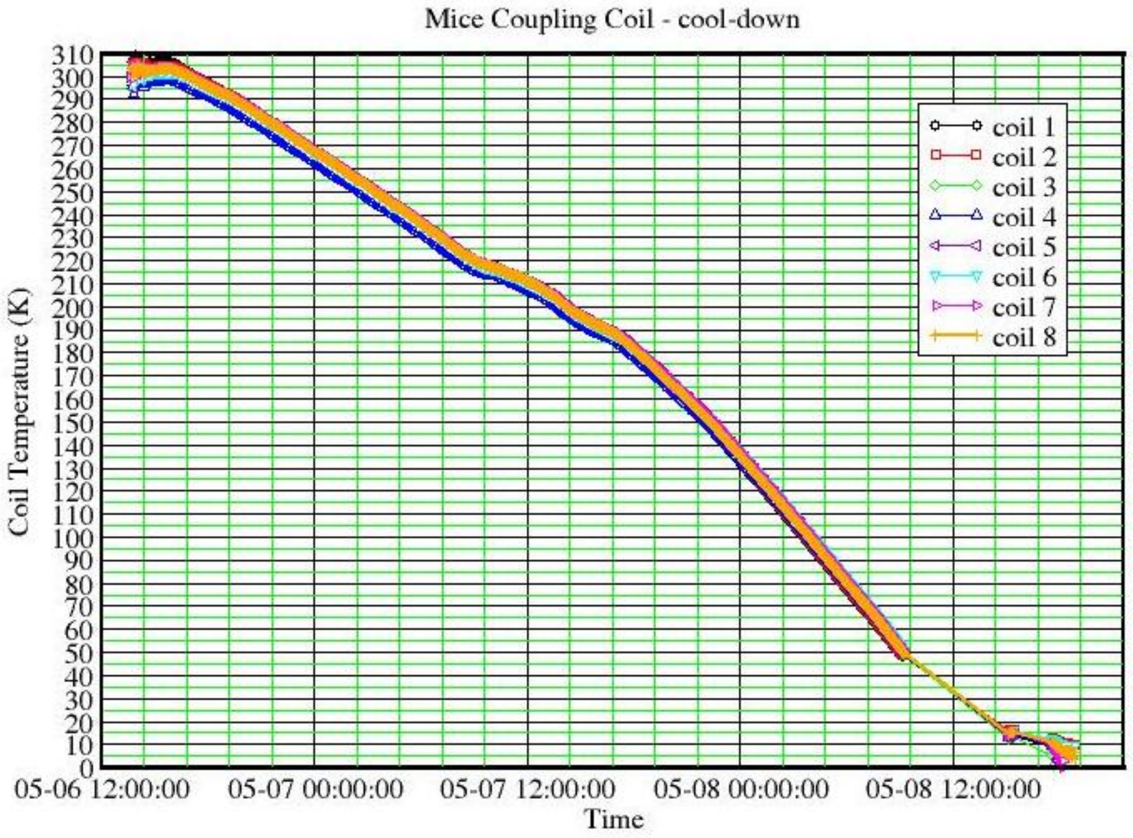
Operational Readiness Clearance (ORC) granted April 17, 2013

Test Stand Commissioning

- In the interest of expediting the schedule, a decision was made to commission the test stand together with the test of the MICE Coupling Coil

- Therefore, first cooldown was made with the coil in the system.

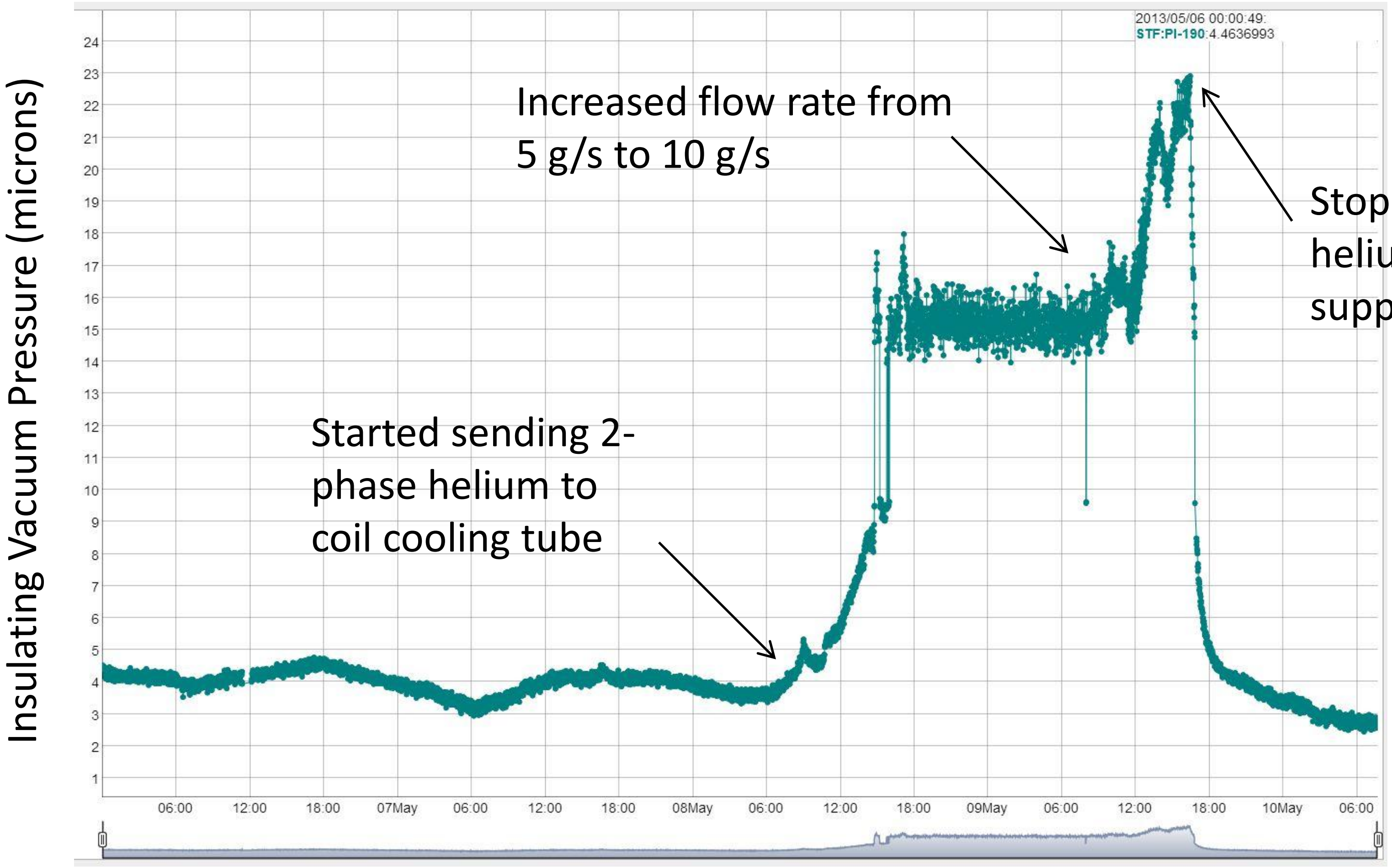
First Controlled Cooldown



- Started Monday 5/6/13 at noon
- Automatic cooldown with < 50 K Delta T proceeded very well
- Coil < 10 K by Wednesday 5/8/13 afternoon
- Shlomo Caspi from LBNL followed the cool down closely and analyzed strain gauge measurements

A Cold Leak!

- Insulating vacuum quickly degraded when we started sending two-phase helium to the coil cooling tube on Wednesday evening!



Increased flow rate from 5 g/s to 10 g/s

Stopped helium supply

Started sending 2-phase helium to coil cooling tube

Attempted to overcome cold leak

- Added more insulating vacuum pumping capacity
  - Increased capacity from 80 l/s to 240 l/s
- Shortened pipe length between vacuum pumps and cryostat from 30 ft. to 12 BD ft.
- These actions helped, but not enough. The lowest we could get the insulating vacuum pressure was around 7 microns.
- Under these conditions, equilibrium was reached with a cooling tube helium gas outlet temperature of 5.5 K at the maximum cooling flow rate of 10 g/s. Outer cold mass temperatures were between 8K and 11K.
- Based on voltage tap measurements, the entire coil was not superconducting but some portions probably were.
- A decision was made on 5/15/13 to warmup the coil, find and repair the leak.

- Prior to warmup, a cold hipot was conducted and the coil passed: less than 0.1 uA leakage current at 150 V (the specification is 2 uA leakage current at this voltage)

Leak Size

- We measured the leak size at various temperatures during warmup by isolating the pumps and monitoring the vacuum space pressure rise. Results are:
  - At 5K: 0.2 atm-cc/s
  - At 40K: 0.009 atm-cc/s
  - At 100K: 0.0016 atm-cc/s
  - At 200K: undetectable by this method
- For comparison, the specification for leaks is < 10^-8 atm-cc/s
- As suspected, the leak will probably be closed at room temperature.

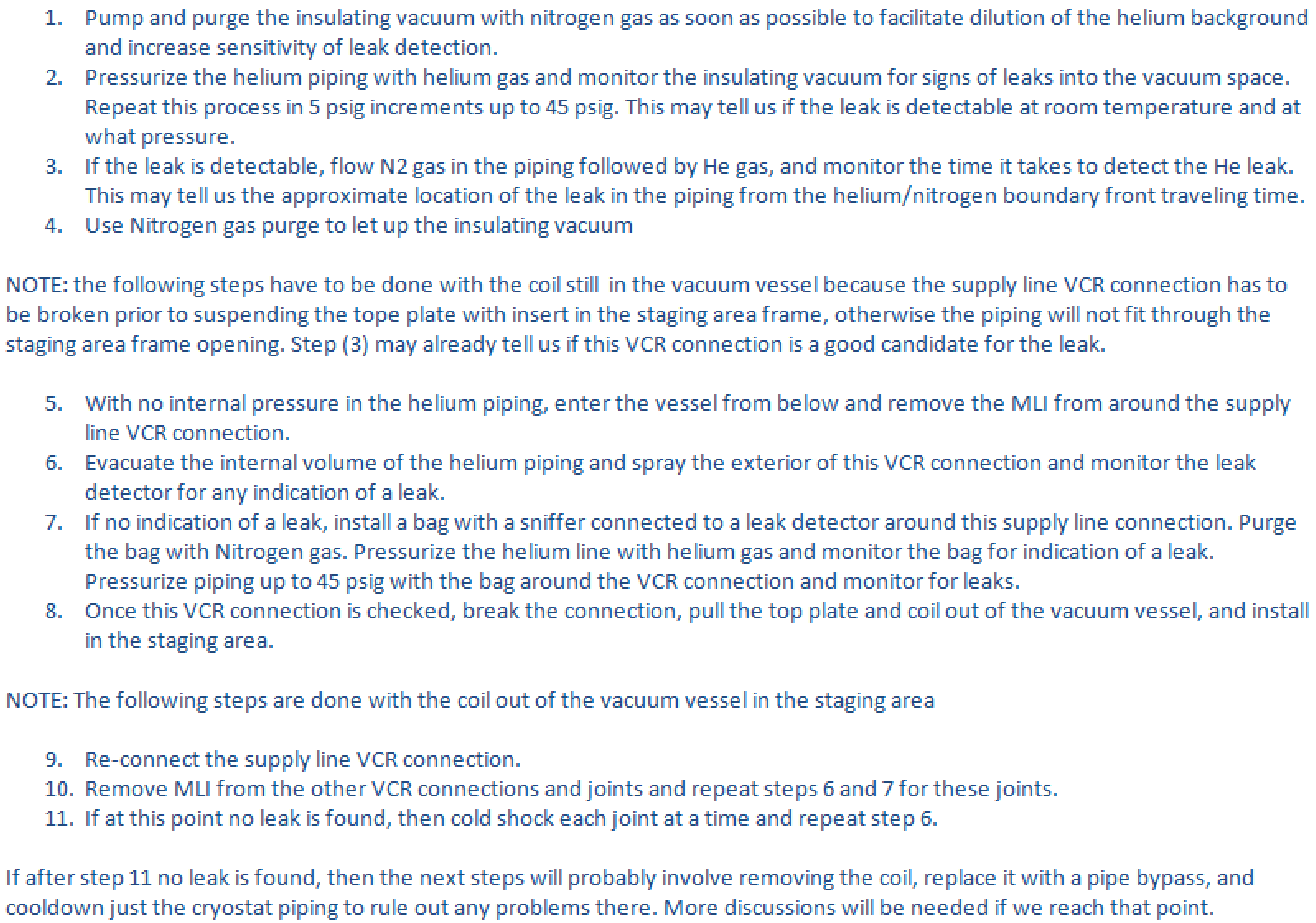
Leak Location

- At the moment we do not know if the leak is located in the test cryostat piping, the coil cooling tube, or at a connection between the two.

- Given the behavior observed, a possible leak location is at the bi-metallic VCR connection between the cryostat piping and the coil cooling tube. This is the first joint we are going to leak-check, before pulling the coil out of the vacuum vessel.

Leak Check Plan

- A detailed plan was developed to leak-check the system. Steps include:



1. Pump and purge the insulating vacuum with nitrogen gas as soon as possible to facilitate dilution of the helium background and increase sensitivity of leak detection.
2. Pressurize the helium piping with helium gas and monitor the insulating vacuum for signs of leaks into the vacuum space. Repeat this process in 5 psig increments up to 45 psig. This may tell us if the leak is detectable at room temperature and at what pressure.
3. If the leak is detectable, flow N2 gas in the piping followed by He gas, and monitor the time it takes to detect the He leak. This may tell us the approximate location of the leak in the piping from the helium/nitrogen boundary front traveling time.
4. Use Nitrogen gas purge to let up the insulating vacuum

NOTE: the following steps have to be done with the coil still in the vacuum vessel because the supply line VCR connection has to be broken prior to suspending the tope plate with insert in the staging area frame, otherwise the piping will not fit through the staging area frame opening. Step (3) may already tell us if this VCR connection is a good candidate for the leak.

5. With no internal pressure in the helium piping, enter the vessel from below and remove the MLI from around the supply line VCR connection.
6. Evacuate the internal volume of the helium piping and spray the exterior of this VCR connection and monitor the leak detector for any indication of a leak.
7. If no indication of a leak, install a bag with a sniffer connected to a leak detector around this supply line connection. Purge the bag with Nitrogen gas. Pressurize the helium line with helium gas and monitor the bag for indication of a leak. Pressurize piping up to 45 psig with the bag around the VCR connection and monitor for leaks.
8. Once this VCR connection is checked, break the connection, pull the top plate and coil out of the vacuum vessel, and install in the staging area.

NOTE: The following steps are done with the coil out of the vacuum vessel in the staging area

9. Re-connect the supply line VCR connection.
10. Remove MLI from the other VCR connections and joints and repeat steps 6 and 7 for these joints.
11. If at this point no leak is found, then cold shock each joint at a time and repeat step 6.

If after step 11 no leak is found, then the next steps will probably involve removing the coil, replace it with a pipe bypass, and cooldown just the cryostat piping to rule out any problems there. More discussions will be needed if we reach that point.

Schedule

- Warmup is complete and the coil is at room temperature. Leak-check activities are underway.

- Depending on how many steps we need to follow to identify and repair the leak(s), we estimate that it will take between 2 to 3 weeks to complete this process.

- Given this repair estimate, the earliest we could be ready to cooldown the coil again is in approximately one month.

- Once the coil is cold, we estimate that it will take approximately two months to complete the coil test and training.