November 7, 2013

MICE report to MICE Project Board

1 Status of MICE

The MICE collaboration activity has been intense in the last 6 months. We give here a few highlights, more information can be found in the material presented at the recent collaboration meeting, https://indico.cern.ch/conferenceDisplay.py?confId=275261 .

1.1 Important milestones

Several important milestones have been passed:

- The stray field mitigation strategy of the experiment has been defined. The construction of a Partial Return Yoke (PRY) was decided. An extensive review took place on 23-24 September 2103. The review endorsed the proposal and recommended a number of subsequent actions that are now being addressed and will be discussed at the MPB.
- The Upstream Spectrometer Solenoid (USS, formerly known as SS2) was successfully tested at Wang NMR for excitations corresponding to various foreseen beam optics. Precise field maps were performed by the CERN team before the magnet was shipped to RAL, where it arrived on 15 October 2013. It is now installed in the R9 building where, after a number of electric tests, the installation of the tracker will proceed before the Solenoid+Tracker assembly is transported to the MICE hall. (Figure 1).
- Meanwhile the Downstream Spectrometer Solenoid (formerly SS1) has been cooled down and tested up to 136 A, when a HTS lead was found to show resistive current. Training is expected to restart end of November 2013. Expected delivery of DSS is now April 2014.
- The refurbishment work on tracker 1 and tracker 2 has now been completed in the new tracker lab, including retro-fitting an LED calibration system. Both trackers now await installation in the spectrometer solenoids.
- The first AFC magnet had been successfully trained to the design current in solenoid mode. The training in flip mode proved to be much more difficult and after many tries the magnet reached a current of 188.06 A, only just above the requested current of 188A for the {P=200 MeV/c, β=42 cm} optics, but short of the design value. The magnet is acknowledged not to be appropriate for operation in MICE. The second magnet AFC2 is now arrived at RAL, and cooling down. It will be tested and powered starting end of November.

- The Electron Muon Ranger detector has been completed in Geneva and after a run of several days with cosmics was shipped to RAL where it arrived on 26 September 2013. The detector was installed in a position close to what it will have for step IV and a successful run took place in October during the ISIS user run. The running mode, interleaving data taking periods on week-ends from Thursdays to Mondays with construction periods during the week proved quite satisfactory. For the first time, all the ‘PID detectors’ (CKOV, TOF0/1/2, KL and EMR) took data together. The first look at results shows the detector to behave very well. (Figure 2).
- The RF amplifier completed at Daresbury Lab reached a power of 2.06 MW. Following this important achievement the amplifier was shipped to RAL and has been installed behind the north shielding wall. The full connection to power, cooling water and controls is proceeding. The first tests should take place end of November and the operation of the amplifier should be demonstrated by Christmas, thus meeting a TIARA milestone. Meanwhile eleven crates with six tons of RF equipment from Mississippi have now arrived in the United Kingdom at MICE including 291 MEGA RF transmission lines, elbows, heliaxes, crossovers... 11 Altronic 200 kiolowatt RF dummy loads 10 Dimtel LLRF4 Amplifie Controller Boards, 4 B1300 Capacitorr SAES Getter Vacuum Pumps. (Figure 3 and Figure 4).

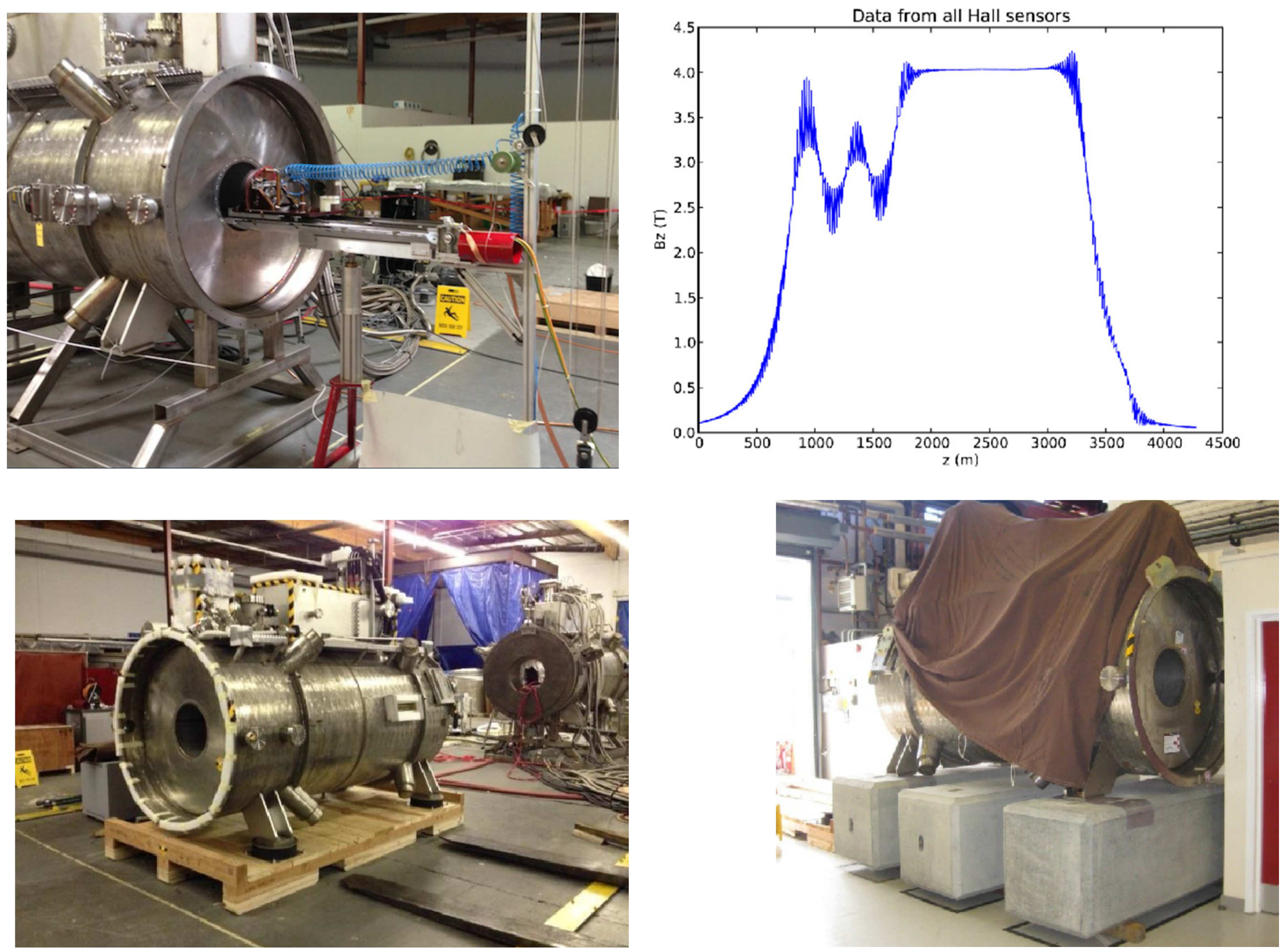


Figure 1Upstream Spectrometer solenoid SS2. 1) at Wang NMR during field mapping. 2) full field map showing the curved for sensors situated at different radii. 3) solenoid on pallet at Wand ready to ship. 4) solenoid at RAL in assembly hall R9.

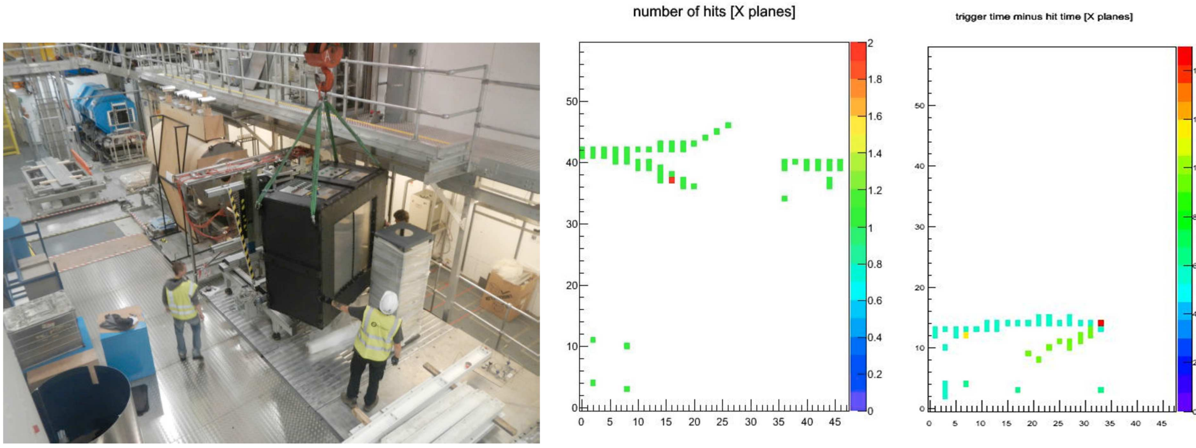


Figure 2 Left installation of the EMR in the MICE hall. Middle: an electron shower in the EMR (readout in the X plane: horizontal axis is depth in the detector, vertical axis is horizontal coordinate); right: a muon stopping and decaying in the detector; the color is associated with the time of the hits, showing that the secondary electron (green) is later than the incoming track (light blue).

Figure 3 top: The RF amplifier work at the Daresbury lab; the amplifier reached 2.06 MW. Bottom, arrival of U-Mississippi RF components at RAL.

Figure 4 Installation of the RF amplifier in the MICE hall. Middle: view of the amplifier behind the north shielding wall. Right: view of the amplifier from the mezzanine.

As far as the construction towards step VI is concerned, the construction of the Coupling coil has made progress, with the construction of the cryostat at LBNL; the testing of the first coil in the cryostat at Fermilab has undergone a couple avatars, first with a helium leak in the cryostat and more recently with signs of insufficient thermal insulation. The MLI wrapping is being remade, in view of resuming the tests before the end of 2013. (Figure 5). The RF testing in MTA is proceeding, Figure 6, the critical item being the delivery of the MUCOOL coupling coil, expected in the first half of 2015.

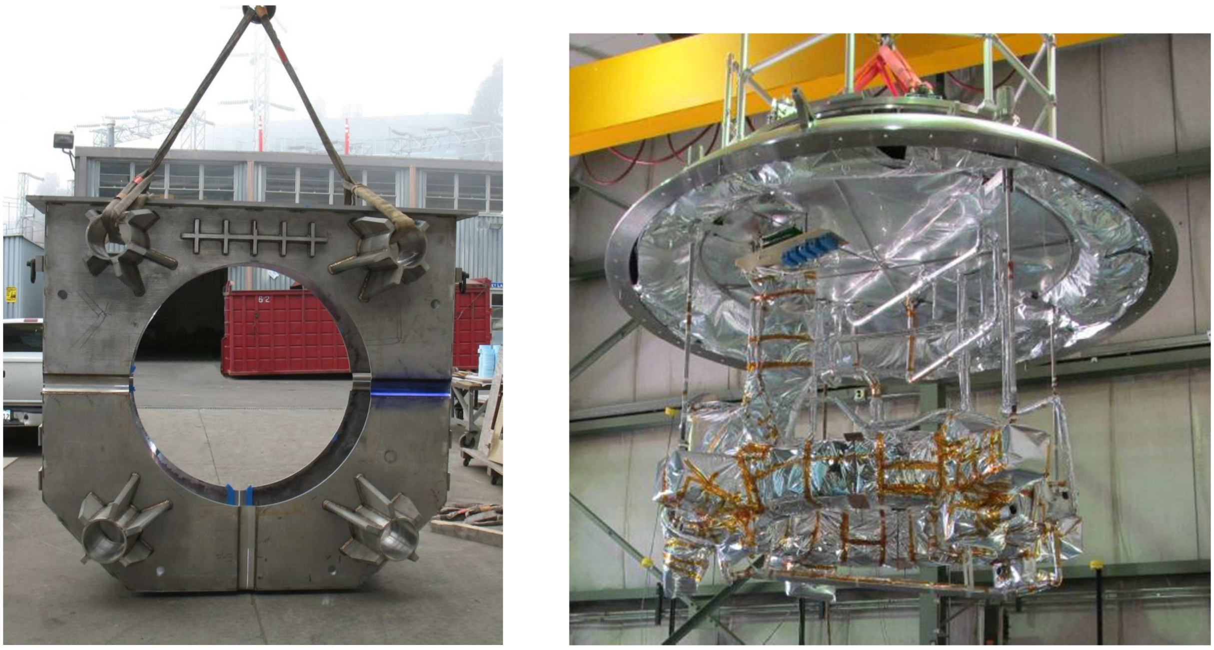


Figure 5Left: the lower part of the coupling coil cryostat at LBNL;right the coil suspended from the cover of the cryostat.

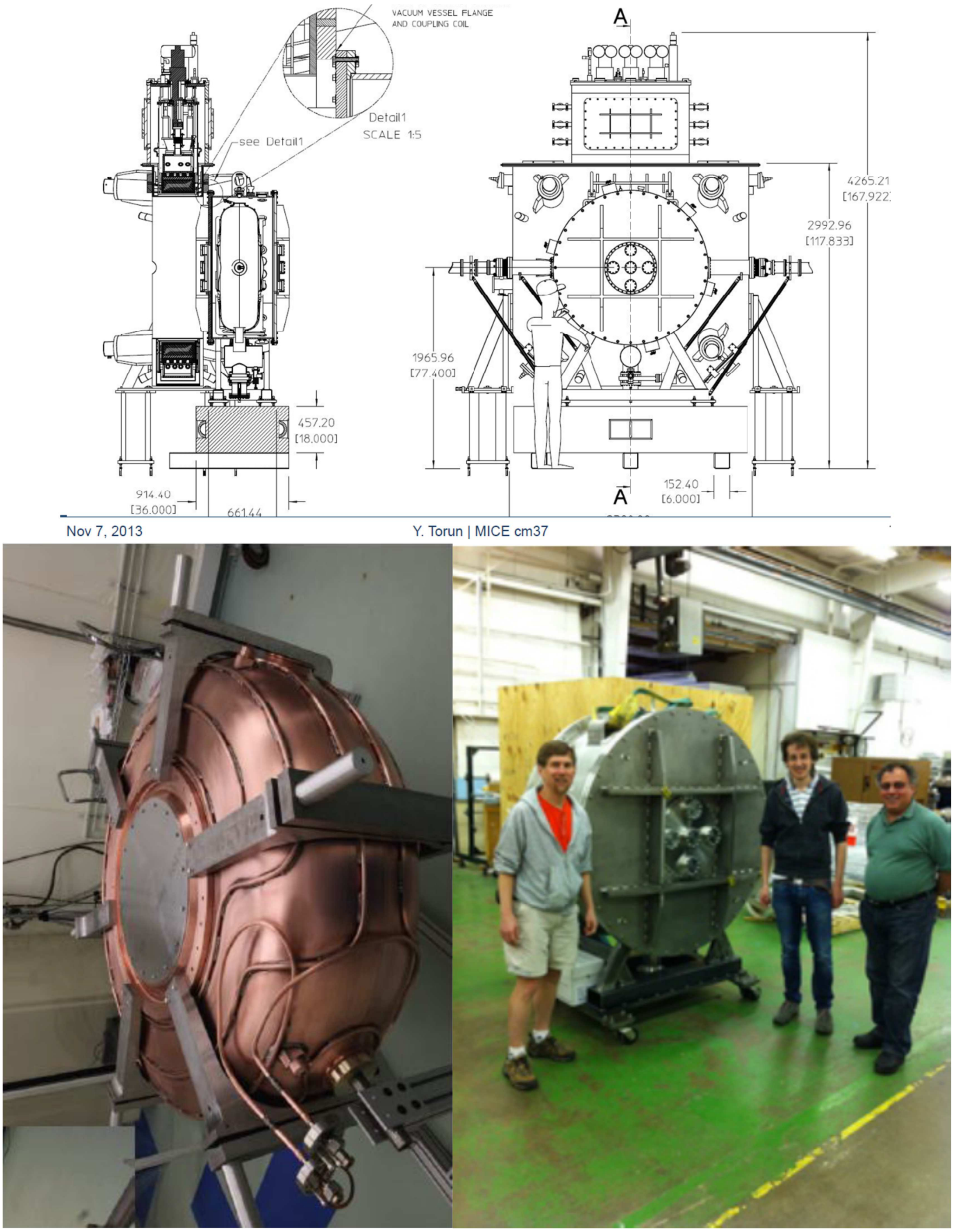


Figure 6 Progress in the RF testing at MUCOOL Test Area in Fermilab. Top: sketch of the test setu-up; bottom left: The RF cavity fit with its tuners; bottom right: the test cavity vacuum vessel.

1.2 Schedule

An update of the schedule was produced by MIPO ahead of the CM 37 collaboration meeting and will have been presented at the RLSR. The top level cartoon can be seen in Figure 7. The implementation of the Partial Return Yoke for stray magnetic field mitigation has been taken into account as well as recent developments in the US funding. It is always assumed that running of one step is interrupted when the hardware for the next step becomes available for installation, although there is no expected impact of this assumption on the physics program.

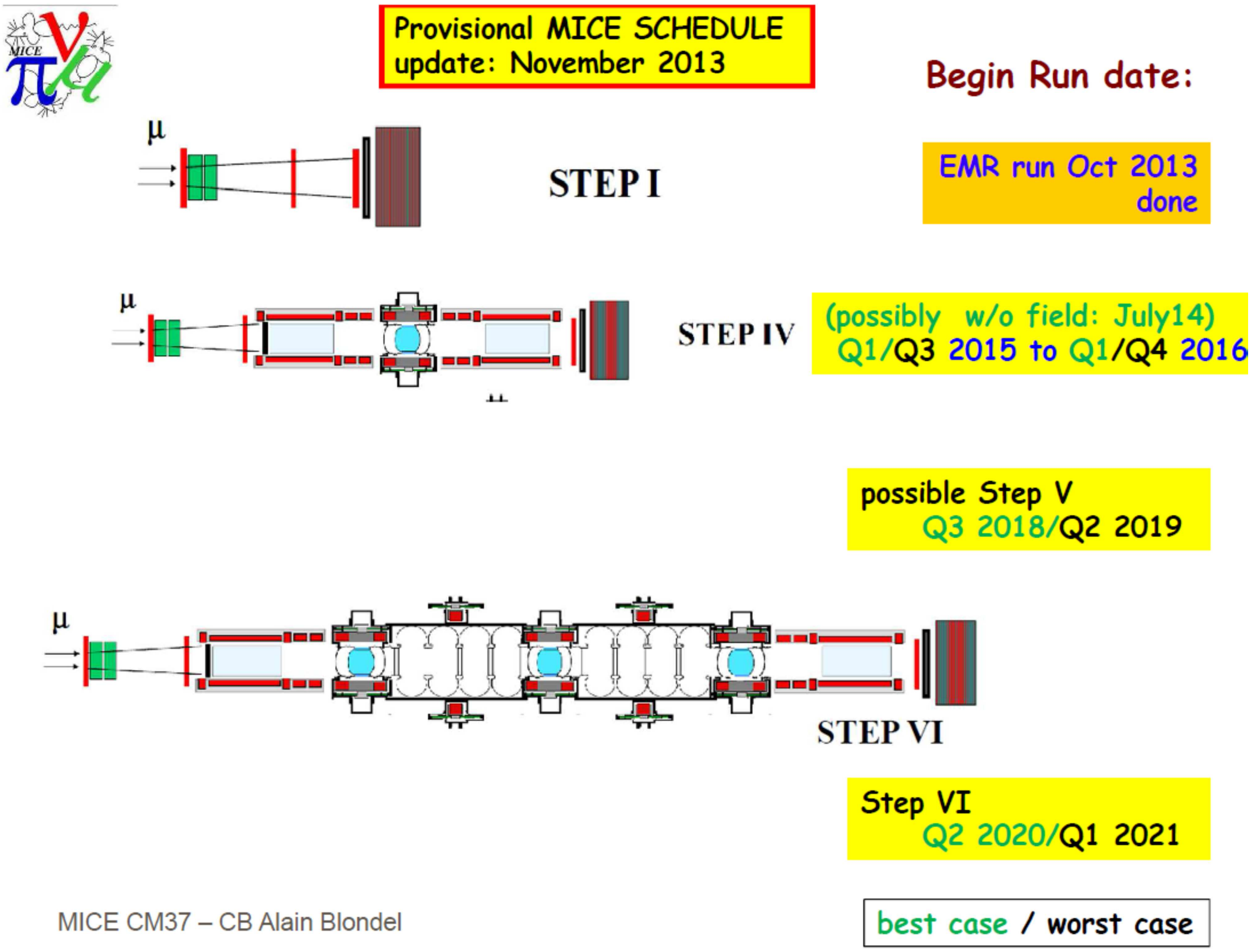


Figure 7: top level MICE schedule; the best and worst case dates for the various steps are indicated.

1.3 Collaboration changes

Collaboration changes have taken place. The spokesperson Alain Blondel has decided not to seek re-election and has been replaced by Ken Long starting 7 November 2013. Planned changes in the management of the collaboration will be described orally to the board. The project manager role will be supplemented with a technical coordinator. Roy Preece will take over as Project manager and Andy Nichols will continue as Technical coordinator.

2 Responses of the MICE collaboration to the MPB Recommendations

2.1 Overview

1. **Create a living, accessible and regularly updated one-page “dashboard” summary of milestone achievements demonstrating the evolving status of deliverables (eg magnets), initially focusing on Step IV, as soon as possible.”**

   The milestone table is a similar request from the RLSR and so a similar approach to the recommendation has been taken. The milestone tracker webpage can be found at the following link: http://micewww.pp.rl.ac.uk/dashboard/. The milestones show critical points of the Step IV, V and VI. During monthly project updates the milestones given will be changed to reflect the current understanding of how the project is progressing and so will therefore give the progression over time. Each new update will attract a specific colour to each milestone that is updated, the key can be seen under the main table, the colour will relate to changes in date since the last update. The base line milestone date will be constant. There is a section at the bottom of the page where a summary of the updates and changes made to the project will be written.

2. **Produce a one-page specification for the operation of the MICE International Project Office and present at the next MPB meeting.**

   The MIPO terms of reference have been written approved by the MICE executive board, and are in the process of approval by the collaboration board.

MICE International Project Office (MIPO)

Revision 3, 31st July, 2013

Background

The MICE International Project Office (MIPO) serves to manage and execute the constructional phase of the MICE project, as distinct from its operational and experimental aspects. This phase encompasses the engineering design, manufacture, installation, testing and commissioning of large superconducting magnet systems, an RF power station and liquid hydrogen delivery systems, along with all necessary civil, mechanical and electrical engineering to support same, to acceptance criteria defined by the MICE project. As far as possible the entire construction will address the R&D risks involved so that a realistic, timely and affordable delivery can be achieved.

MIPO organisation, management and responsibilities

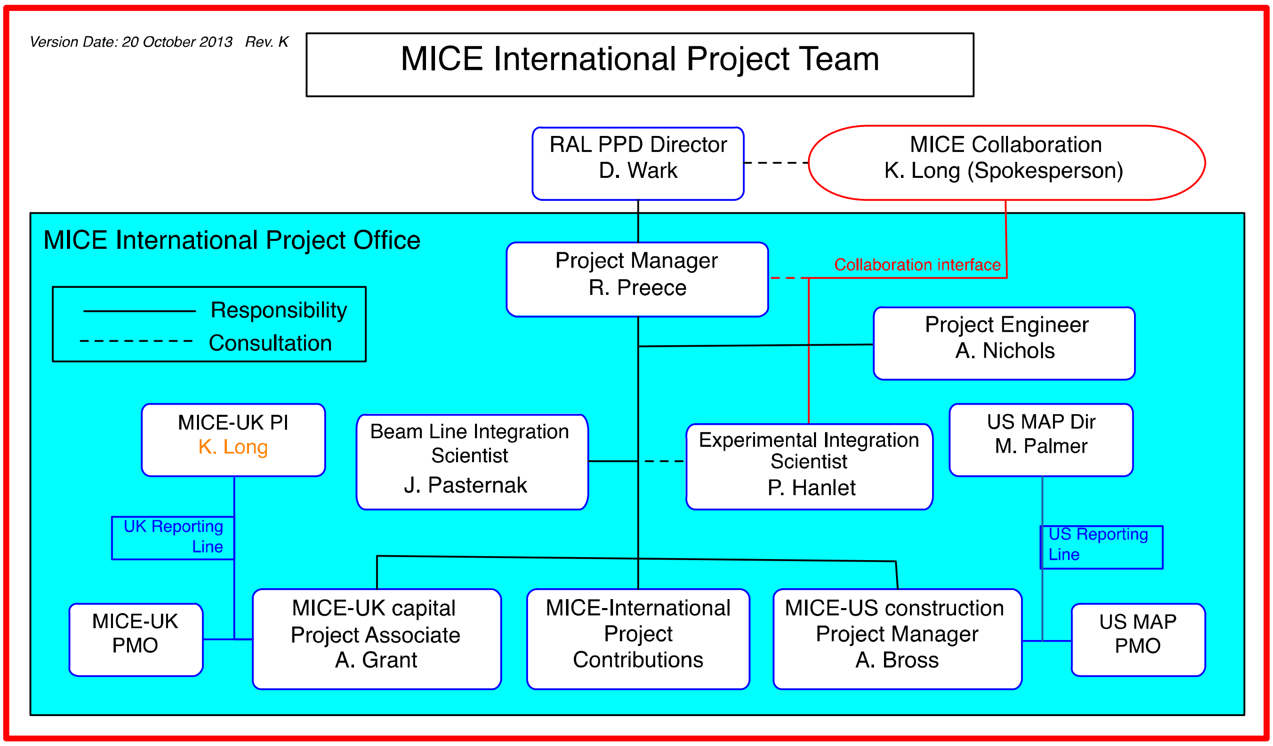
In order to provide Director-level responsibility at the host lab, which is a requirement of STFC for high safety risk work areas such as liquid hydrogen and RF technology, Dave Wark, Director of PPD has been appointed to carry overall responsibility for MICE safety and for the implementation of the project at RAL. The MIPO is headed by The MICE Project Manager, who reports to Dave Wark. The Project Manager has delegated safety responsibility for the project at RAL and is expected to fulfil the everyday managerial and engineering requirements of the project, both in the UK and abroad. The strong links with MICE’s operational and experimental teams will be maintained and to this end the

Project Spokesman and Head of operations group will attend the MIPO meetings in an ex-officio capacity

MIPO Operation and reporting, support and consultation

The MIPO will meet twice per month. These meetings will include costing and scheduling, milestone tracking, technical topics, risk management, safety and staffing concerns. A new Work Breakdown Structure (WBS) will be compiled that reflects the constructional elements of the project only and will be used to derive the major milestones for each work package. The work package manager (WPM) of each work package will be required to play a leading role in milestone tracking. The present MICE Technical Board (TB) and MICE Installation and Commissioning (MICO) meeting will continue to provide the project with experimental and running advice and oversight, but in order to avoid confusion with the MIPO, the leadership and scope of these two bodies will need to be reviewed

The International Project Manager will appoint an Advisory Board, which will include experts on each of MICE's major subsystems. The MIPO will assist the MICE Project Manager in formally reporting at the MICE Project Board (MPB). Ownership and monitoring of MICE's top-level constructional project schedules, risk registers and cost tables will be by the MIPO.



2.2 Superconducting magnets

1. **Investigate the potential reasons for the slow and unusual training of Spectrometer solenoid 2 (and Focusing Coil 1). Check the protocols (eg travelers) for the Spectrometer Solenoids and Focusing Coils, to establish the level of quality assurance and to seek explanations for slow training. Present results at the next MPB meeting.**

We have found no really compelling explanation of ‘why magnets train”. However we have collected the training history of the focus coils and preformed a number of tests to verify that no obvious defect in the construction would cause anomalous behaviour. This is reported in the following subsection “focus coil”. The second subsection reports the observations made on the spectrometer solenoid 2.

It is worth stressing at this point that the maximum current achievable in a given magnet leads to a limitation in the phase space of {momentum, beta function at the absorber}. The study of implications of a possible limitation in the operating currents of the coils on the phase space that can be explored in MICE has started. A status of the study can be found in MICE note 434 http://mice.iit.edu/cgi-bin/note2LinePrint and will be given orally at the MPB meeting. This should be seen in the context of the run plan and MICE criteria for success of step IV described in MICE note 432, and reported at the RLSR.

2.2.1.1 Focus coil

Figure 8 shows the training history of FC1 in Flip Mode, i.e. with opposite currents in the two coils. The maximum current reached was 188.05A, a whisker above the 188A required for running at 200MeV/*c*. For stable operation in the presence of the other MICE magnets an overhead of a few percent is desirable; it appears that this module is unlikely to achieve this criterion even with more training. Whilst the technical specification for the coils was for operation at 200 MeV/*c*, all design calculations were made for 240MeV/*c* (225A), (for the same value of the beta function, 42cm, at the absorber) i.e. an overhead of twenty percent.

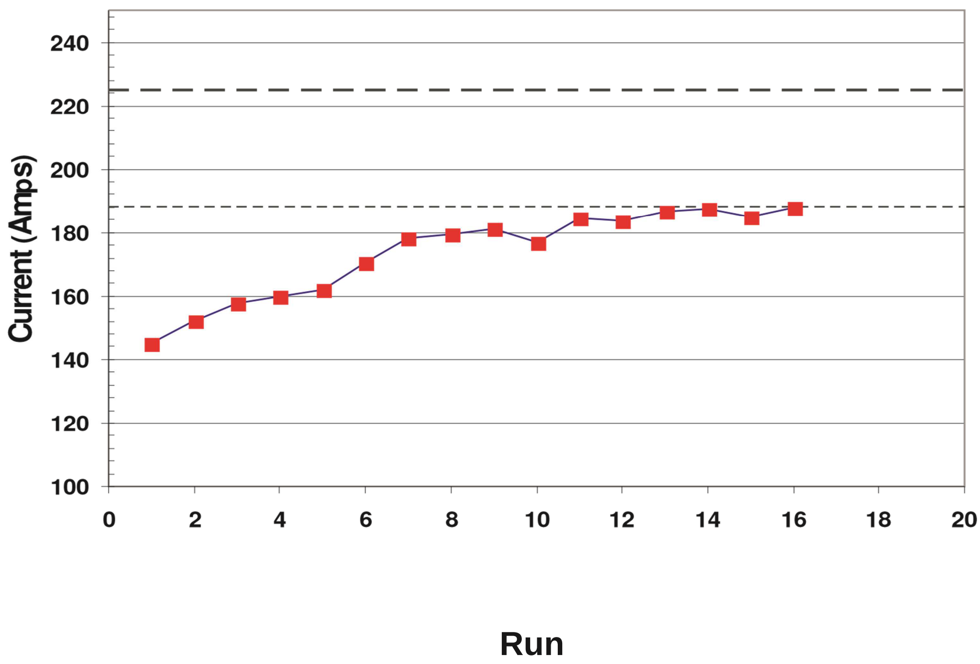


Figure 8 Training history of FC1. The two lines indicate the minimum currents for 200MeV/c and 240MeV/c running of 188A and 225A respectively.

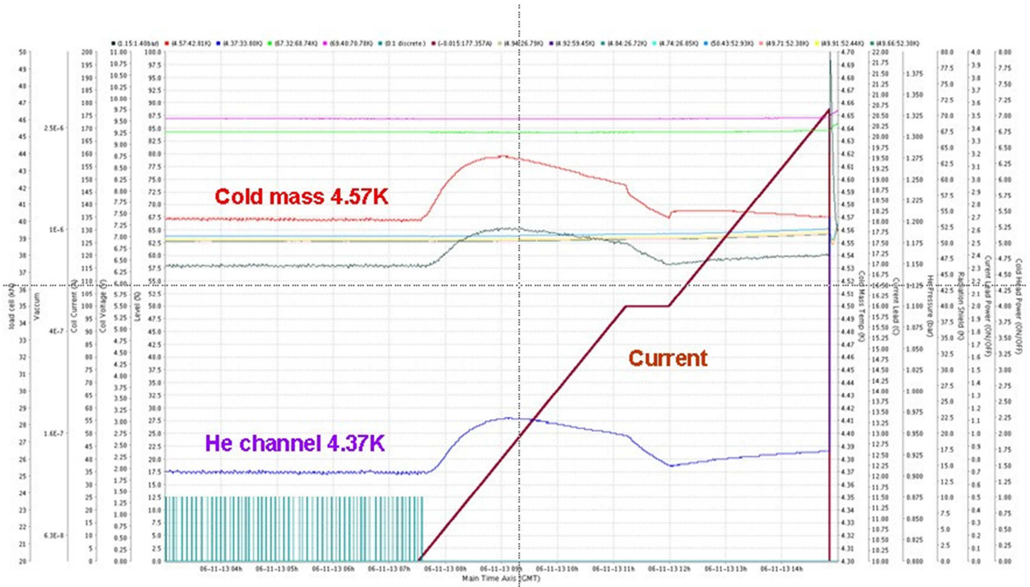


Figure 9 Cold mass and helium channel temperatures during a current ramp up to a quench. The 50mK bump is due to AC losses in the coil and bobbin.

The testing of the coils was limited due to the availability and cost of liquid helium. Since cooling the coils with liquid helium immediately after a quench is very inefficient, the cold mass was cooled by the cryocoolers until a substantial amount of gaseous helium had condensed in the helium channels; this was then topped up from a dewar of liquid or, in some cases, the helium was obtained entirely by condensation. Because commissioning the module remains the responsibility of the manufacturers (Tesla UK) a representative was required for each training run. In most cases the coils were ramped to 50A and soaked overnight before the final ramp. The ramp rate was limited to 0.0075A/sec by the cooling power available from the cryocoolers (≈ 0.2W) to remove the heat generated by AC losses during ramping. The mean turnaround time between quenches was fourteen days; as will be discussed below we anticipate that this will be shorter for module FC2.

The reason for the difficult training of the coils is not yet fully understood. As discussed in the following sections the most likely explanation is 'stick-slip' movements of the coils. The voltage traces and measurements of the the resistances of the coils immediately after a quench show that, with one exception, the quenches all originated in Coil 1, suggesting an anomaly with that coil.

2.2.1.1.1 Thermal behaviour

The temperature records show that the temperatures of the cold mass and other critical parts of the system are stable until a quench occurs. Figure *9* shows a typical temperature record during a current ramp. The cold mass temperature was 4.57K when the coils quenched. The expected temperature margin is ≈1.4K. After a few quenches there was slight evidence that the increment in current, ΔI, between consecutive quenches depended on the time elapsed between the quenches, suggesting imperfect removal of residual heat from the cold mass or coils. Figure 10 shows ΔI versus the time between consecutive quenches for all training ramps. The absence of any obvious correlation excludes this hypothesis.

The possibility that the thermal behaviour of the two coils is different was investigated by measuring the resistances of the coils during the cooldown after a quench. Figure 11shows the resistances of the coils after a quench. Both coils become superconducting (≈9K) within one minute of each other about 35 hours after a quench. Figure 12 shows the temperatures of the coils deduced from the resistance measurements versus time after a quench. Until the coils become superconducting the estimated temperature of the conductors closely follows the temperature of the helium channel. There is no evidence of any difference between the thermal behaviour of the two coils from these measurements.

One unexplained anomaly is that the cold mass temperature does not track the helium channel temperature until the latter is nearly full. The relatively large ΔT of 0.2K between the cold mass and the helium channel is also not understood. Both these observations are suggestive of less than optimum thermal contact between the helium channel and the cold mass. This is not thought, however, to be the cause of the slow training behaviour.

2.2.1.1.2 Voltage records

Voltage logging for most of the runs was made with a sixteen channel 'Picologger' – a commercial general purpose ADC system – which recorded the signals used by the quench protection (QP) system. The signals recorded were the amplified voltage differences between adjacent pairs of voltage taps on each coil and the amplified difference between the voltages across each coil. The latter was logged on two channels. Attentuated absolute coil voltages were also recorded. The time resolution of this system is about 10mS and, since it samples the channels sequentially with a cycle time of about 200mS, it could not record short transients occurring simultaneously on two channels.

The use of the QP signals and the limited time resolution meant that the records were slightly difficult to interpret, especially immediately before a quench. Nevertheless, the Picologger records show that the quenches originate neither in the HTS leads nor the LTS tails of either of the two coils. The coil voltage difference traces show precursor 'spikes' shortly before a quench at times corresponding approximately to the last few amps of the current ramp; an example is shown in figure 13. The precursors are too small and too short (≤10mSec) to trigger the quench protection system; they seemed to occur equally with either polarity. The occurrence of the precursors was analysed for several training runs. On average seven precursors were visible above noise before each quench.

Figure 14 shows the amplitude of the largest precursor versus the time before the coils quenched. Whilst the statistics are small, the trend seems to be that the amplitude of the precursors increases towards the time that the coils quenches. There was no obvious 'memory' of the currents at which the precursors occurred between training runs; Figure 15 shows the currents at which the largest precursors occurred and the currents at which the coils quenched. The interpretation of the precursors is that they are caused by small 'stick-slip' movements of the coils where movement is impeded by small irregularities which are ironed out by training.

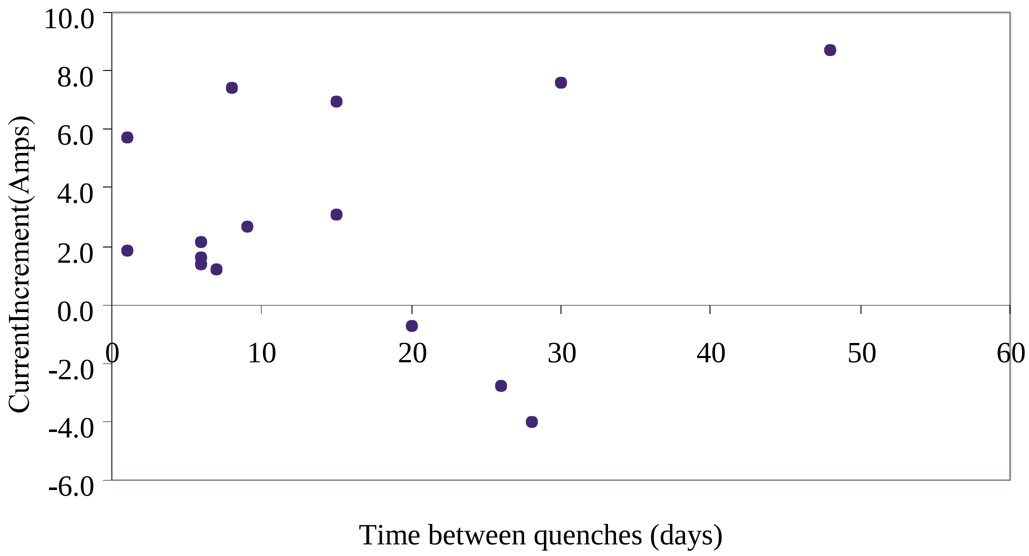


Figure 10 The current increment between consecutive quenches versus the time between quenches; a positive correlation would possibly indicate a problem with residual heat in the coils.

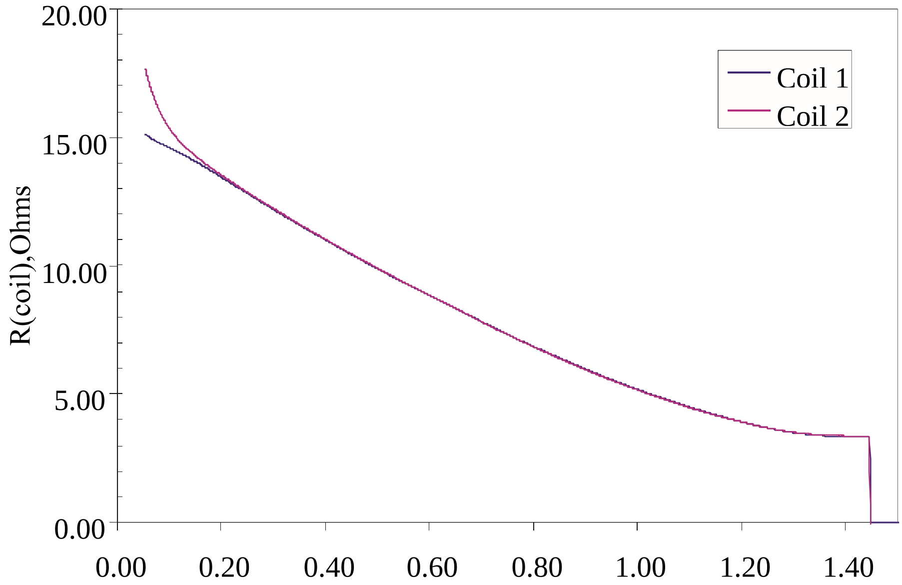


Figure 11 Resistances of the two coils versus time after a quench. (Horizontal axis: Days after quench)

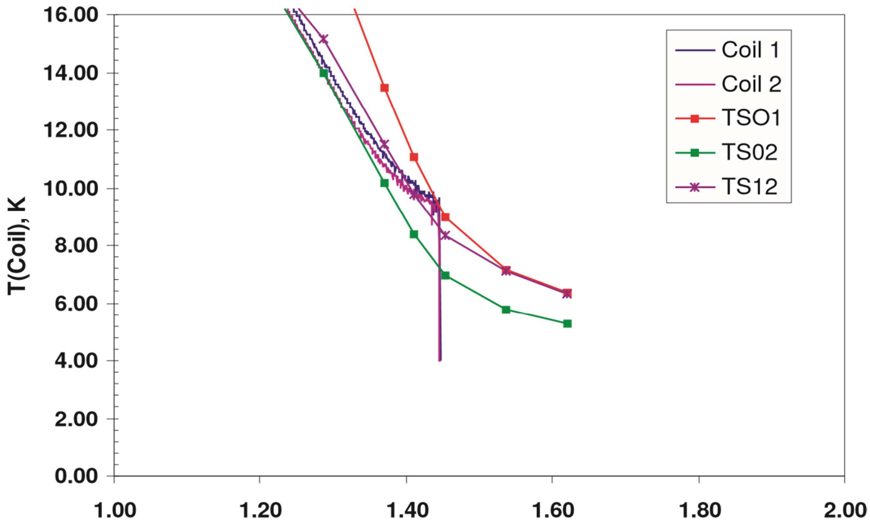


Figure 12 Coil temperatures deduced from resistance measurements versus time after a quench. TSO1 is the cold mass temperature, TS02 is the helium channel and TS12 is the cold end of an HTS lead. (Horizontal axis: Days after quench)

Whilst the Picologger system was adequate for determining which coil quenched and produced some useful diagnostic information, it proved to be too slow to determine the exact sequence of events immediately preceding a quench. A new sixteen-channel voltage logging system based around NI ADC cards was therefore built by the Daresbury group. The new system has a 1mSec time resolution and samples all voltages simultaneously; it was set up to record the absolute voltages (which can reach over 1000V after a quench) between adjacent coil voltage taps. It was installed in time for the last training run of FC 1.

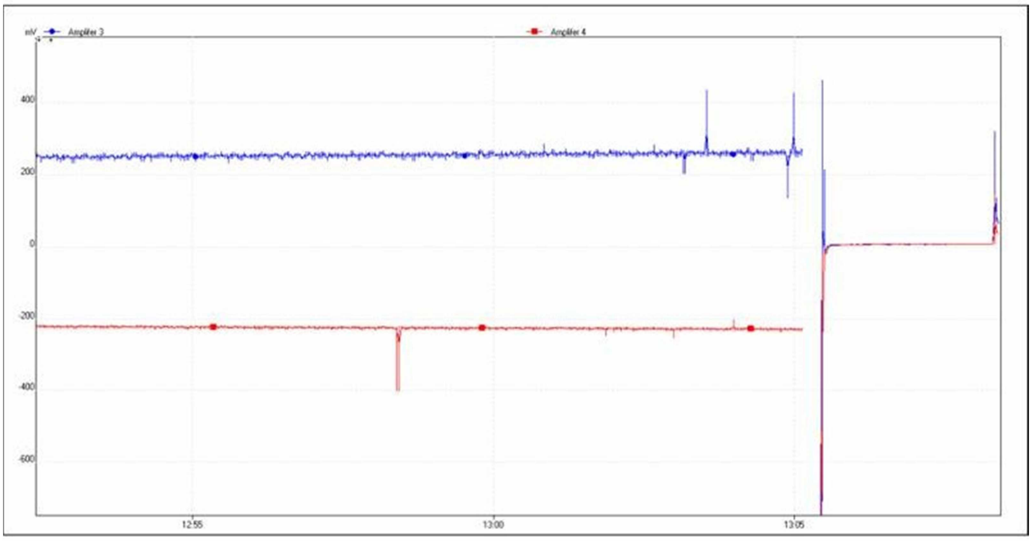


Figure 13 Quench precursors on the difference between coil voltages recorded with the Picologger; the traces go off-scale (negative) when the quench occurs. The horizontal time scale is five minutes per large division (approximately twenty minutes full scale). Both channels record the same signals but with an offset.

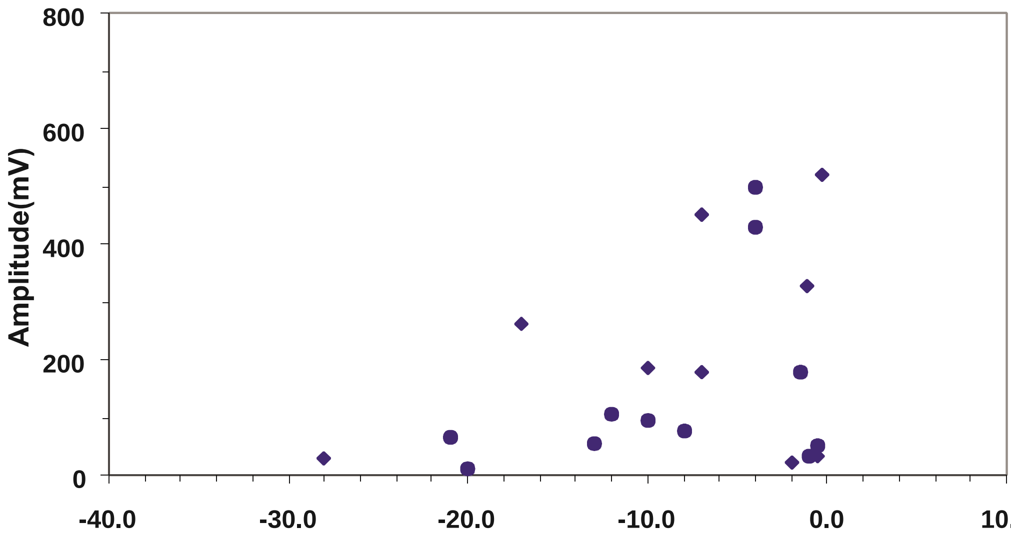


Figure 14 Amplitude of the largest precursor versus the time it occurred relative to the quench (t =0). (horizontal axis: time before quench (min))

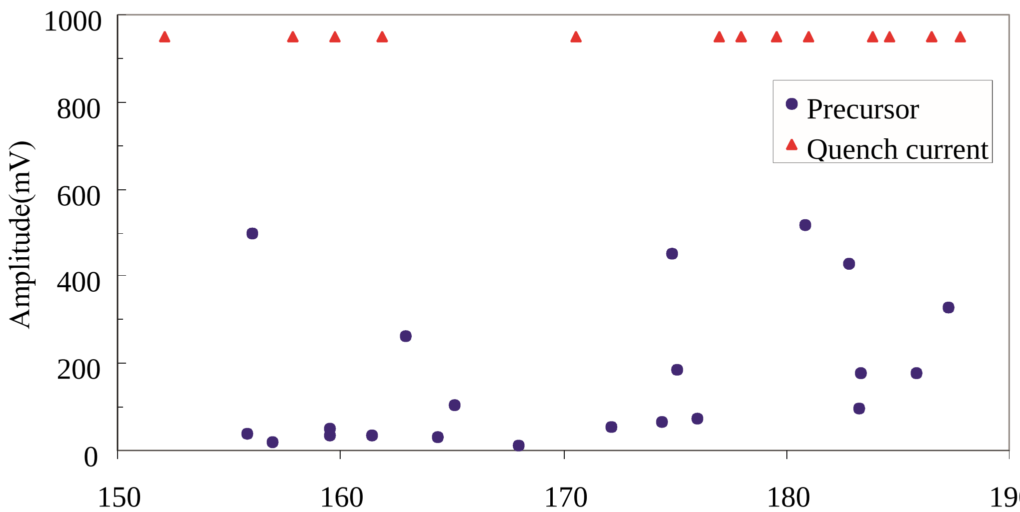


Figure 15 Amplitude of the largest precursor versus current. The currents at which the coils quenched are also indicated. (Horizontal axis: current (Amps))

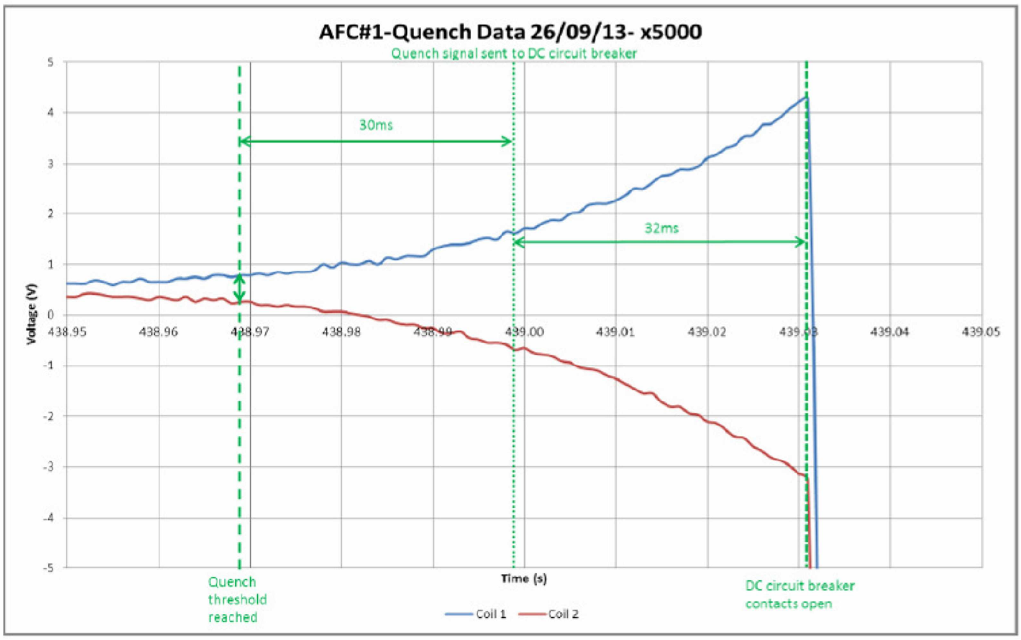


Figure 16The development of a quench as recorded by the new voltage logging system. The time axis is 10mSec per division.

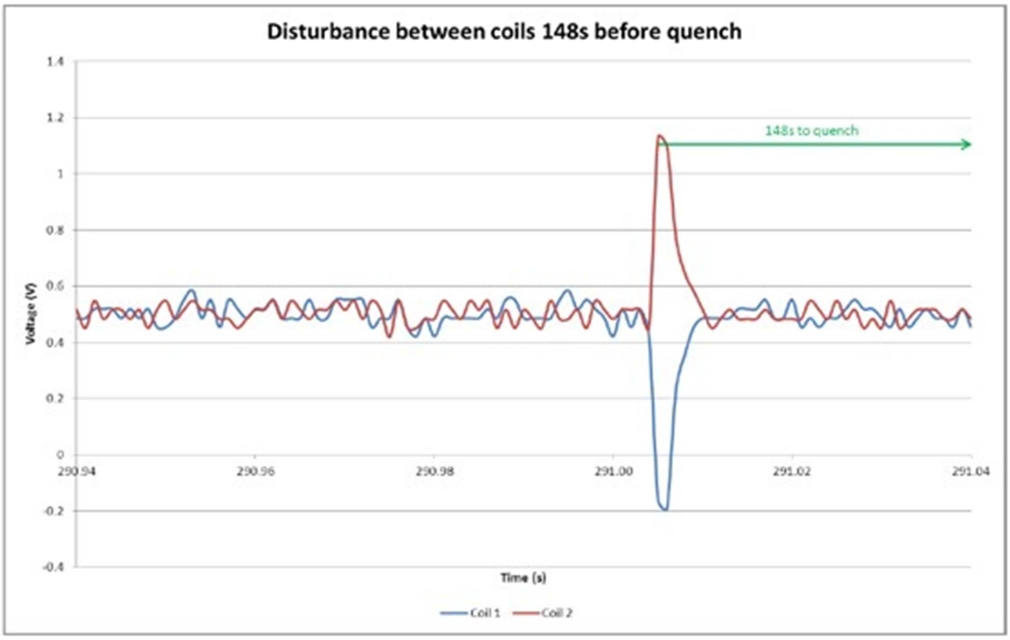


Figure 17: The quench precursor observed with the new voltage logging system. The range of the time axis is 100mSec.

Figure 16 shows the coil voltages recorded with the new logging system at the time of the last quench. The coil voltages are clearly running away; the positive sign of the Coil 1 voltage indicates that the quench started in this coil (i.e. it has the higher resistance). Figure 17shows an expanded region around the only precursor observed for this run (the full features of this would not have been captured by the Picologger system). The precursor occurred two and a half minutes before the quench. It is notable that the energy associated with this precursor, dU ≈ IV dt ≈0.5J is many times the estimated minimum quench energy of the coils of 1.5 – 3mJ. If this energy were deposited resistively in the coils it would have caused a quench[1]. An interpretation of the signal is that it represents an emf induced in the coils by a change of flux linkage caused by a small movement. A very preliminary back-of-envelope estimate suggests that a sudden movement of the coils by the order of microns would be sufficient to cause such a pulse. It would have been desirable to attach a microphone to the cold mass to detect such movements but that is not possible at this stage; the possibility of instrumenting the second module with a small external pickup coil which would be sensitive to small changes in flux due to movement of the coils is being evaluated.

2.2.1.1.3 Field measurements

A simple jig was constructed to allow the axial field – the primary component – on the axis of the coils to be measured with a commercial Hall probe. Measurements made at three stable currents are shown in figure 18. The measured fields are within 1.5 percent of the calculated values, and the fields at the centres of the two coils are within better than 0.5 percent of one another which excludes the possibility of a short-circuited layer in one of the coils (each coil has 84 layers).

[1] At the current of 188A the voltage step of 0.6V corresponds to a change of resistance of approximately 3.5mΩ, equivalent to ≈ 25m of the conductor having gone normal.

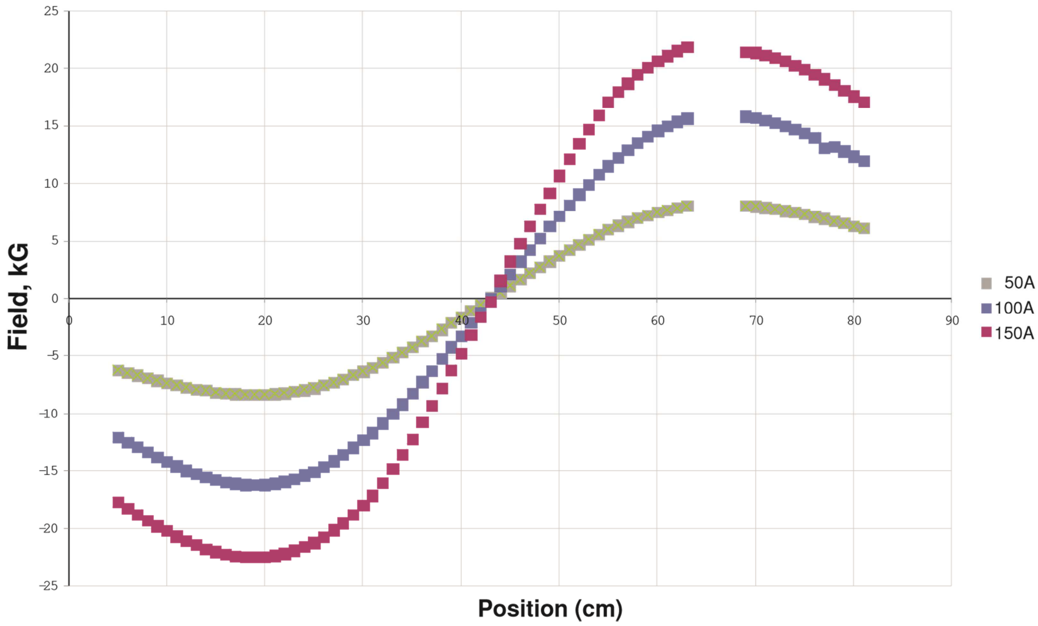


Figure 18 Measured magnetic induction on axis of FC1 at 50, 100 and 150A. The gap in the measurements is due to the safety window flange in the cold bore which is too small to allow passage of the Hall probe.

2.2.1.1.4 Focus Coil 2 and future plans

The second Focus Coil was delivered to R9 at RAL on 4 October 2013. At the time of writing the vacuum vessel is being pumped out. The first module has now been warmed up to room temperature. It is expected that the modules will be swapped during the week of 21 October and that, depending on how long the cooldown takes, the first powering tests of FC2 will take place in the week of 18 November.

An important difference between modules 1 and 2 is that some internal insulation between the two stages of the cryocoolers of FC1 was deliberately omitted by the manufacturers because they were concerned that it would fragment at low temperatures. The effect of this was to reduce the second stage (4K) cooling power. A suitable material has now been identified and the insulation is present in the cryocoolers of FC2 and the anticipated fivefold increase in cooling power should reduce the turnaround time between quenches substantially.

It has been agreed with Tesla that the fate of the first module and any possible remedial action will not be decided until the second module has been tested.

2.2.1.2 Spectrometer solenoid

The second Spectrometer Solenoid (SS2) was trained in its original configuration with three 2-stage cryocoolers in July of 2009. The coils reached a current of 238 A when a high temperature superconducting (HTS) lead burned out due to inadequate cooling. The magnet was modified by adding a one-stage cryocooler in order to maintain the temperature of the HTS leads. This version of SS2 was trained to 259 A in March of 2010 when a low temperature superconducting (LTS) lead burned out at the feedthrough to the cold mass. This version of the magnet was also unable to maintain the liquid helium (LHe) within the cold mass without boil-off due to excessive heat leak and inadequate cooling power.

A final redesign and modification of SS2 incorporated five 2-stage cryocoolers along with the one single stage cooler. Other enhancements included reinforced LTS leads, improved MLI, an upgraded radiation shield and a more direct connection from the shield to the cryocoolers. In July of 2012, the training reached 245 A after 7 runs when an HTS lead burned out. After repair, subsequent training in September 1012 reached 274 A in 15 runs when an ice blockage occurred in the vent lines, requiring warm up of the magnet. The training current reached the target of 283 A (in the center coil) after 13 runs in February 2013. The magnet's cooling performance was sufficient to maintain the LHe in the cold mass at all times. Full 3D magnetic mapping of SS2 was completed in June of 2013 with the magnet arriving at RAL in early October 2013.

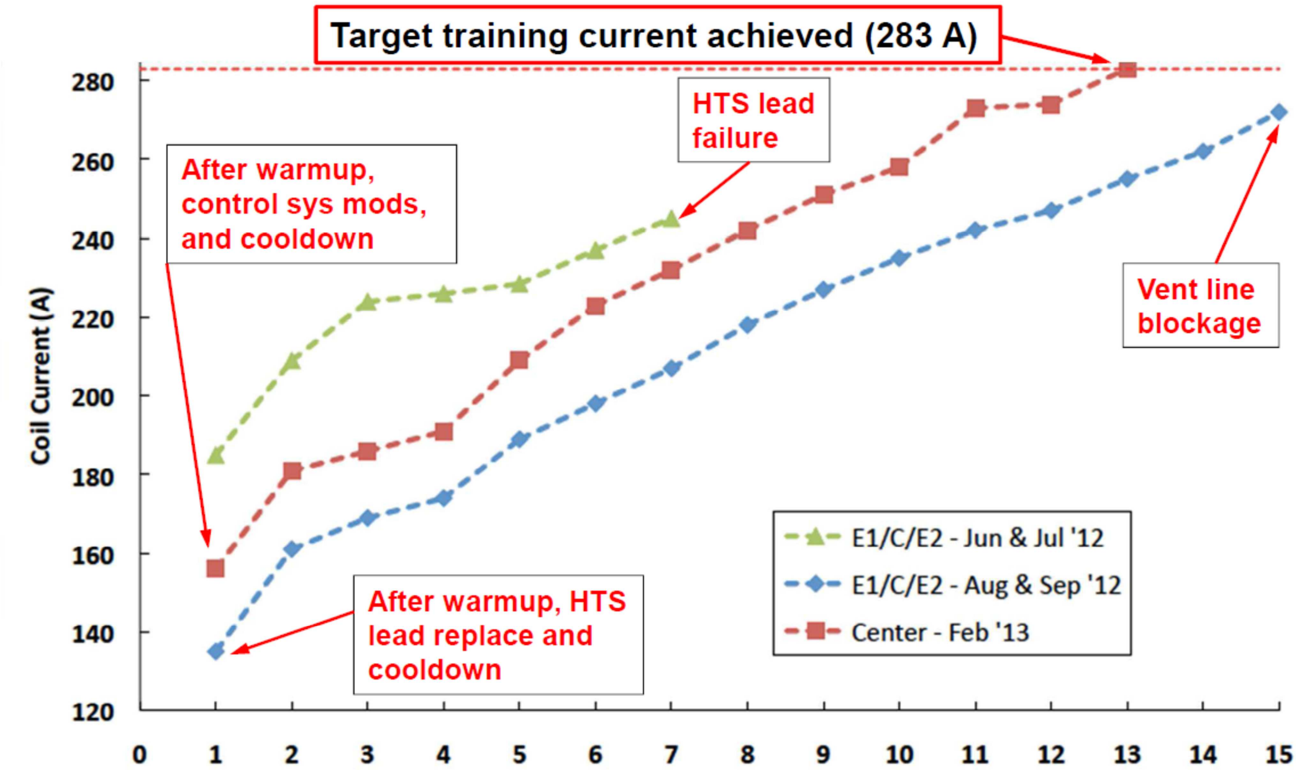


Figure 19 Training history of the Spectrometer Solenoid 2

2. **Re-evaluate the possibility of proximity shielding (partial yoke) that takes into account the detailed situation of the present infrastructure in the MICE hall and present a plan for future work at the mitigation shielding review at RAL in August/September.**

   The constraints within the MICE Hall have been investigated in detail in the development of the design and implementation plan for the partial return yokes. The resulting design was presented to the stray magnetic-field mitigation review that was held on the 23rd and 24th September 2013. The review documents and presentations can be found here:

   http://indico.cern.ch/conferenceDisplay.py?confId=267759.

   The review panel recommendations are attached as a separate document on the MPB indico page. The oral presentation will go into more detail into the actions taken by the collaboration to respond to the recommendations by the review panel.

2.3 RF systems

Prepare a plan to test a prototype Low Level RF system with the RF Coupling Coil at the Fermilab MTA, and present the plan at the next MPB meeting.

The project team agrees with the MPB that a system test that involves the low-level RF system and an active load is essential. Doing such a test at the MTA is not feasible because the power source is an active spare for the FNAL linac. The project team is developing a plan for the implementation of a system test in the MICE Hall as part of the preparation of the RF system for Steps V and VI.

2.4 Commissioning, controls and operations

1. **Present an integrated plan for all aspects of the control system at the next MPB meeting.**

   The group responsible for MICE controls and monitoring (C&M) has prepared a first (Draft) version of an Integrated Controls & Monitoring System, which is posted as MICE note 431,

   http://mice.iit.edu/micenotes/public/pdf/MICE0431/MICE0431.pdf

   and provided to the board for information. This is very much work-in-progress and was presented to the collaboration at its plenary meeting on 6 November 2013. The challenge is that the system is due to operate hardware which presents significant operational risks (liquid hydrogen and superconducting magnets) while providing the necessary stability and precision recording to match the precision goals of the experiment.

   The general principle is that Run Control provides a framework and user interface to operate all of the subsystems in a uniform fashion. The subsystems, including - but not limited to - target, conventional magnets, superconducting magnets, trackers, liquid H2 absorber, and RF, are each operated by so-called 'state machines'. The operating parameters of each state of each subsystem are stored in (retrieved from) a configuration database (CDB) to ensure proper settings. The configuration parameters for each of these configurations include lists of variables of interest, alarm limits and archiving features for these variables, and a list of critical variables. In this way the alarms are appropriately monitored, parameters of interest are correctly archived, and critical variables identified for each state. In this model, Run Control is only required to monitor the states of the subsystems, rather than the details of each system. Experts, e.g. cryogenics and power supply, are being identified to work with subsystem owners and the C&M team to develop the state machines.

   Alarm limits are set to warn operators that parameters: 1) which may affect data quality or 2) equipment is approaching operational limits, are changing. In this way, operators can intercede (if necessary) before data are lost or equipmenttrips on hardware interlocks. The state machines also continuously monitor for errors and interlocks and transitions appropriately.

Run configuration information is stored in and retrieved from the CDB at the beginning and the end of each run. In addition, interesting parameters are continuously stored in an archiver for later use; e.g. debugging equipment failure or corrections to data analysis. In addition, the DAQ will store selected configuration information; e.g. subsystem states and data quality flags, on a spill-by-spill basis.

Comments by the collaboration pointed to the need to group and operate together the superconducting magnets, on one hand, and the detectors (including the tracker) on the other. The outputs of the monitoring task need to be better specified. This work will continue and the need for a dedicated MICE workshop on this important issue was identified.

2. **Present the requirements and design of the MICE timing system at the next MPB meeting, with particular emphasis on absolute calibration by particle arrival phase measurement.**

Pending additional input from the analysis section, the key requirements for the Muon Transit RF Phase diagnostic is to determine the phase of each particle at some time, T_n, computed from the transit time through ToF1, and projected exploiting the measurements from the momentum spectrometer (Tracker), to the transit in the first cavity. This requires:

(a) Knowledge of systematic delays in both ToF and RF diagnostics. This overall offset can be determined on large sample of muons by comparison of the time dependence of the momentum difference measured between the first and the second tracker.

(b) Matching the thermal sensitivity of the two detectors (principally the cables)

  i. Achieve by using the same cables (and hardware if possible)

  ii. Run RF signal out to ToF in precision cable and return on RG213

(c) Providing a measurement of the zero crossing time of the RF

  i. Need only acquire this at some fraction of the RF frequency (~1/20th)

  ii. Use exisiting LeCroy/Caen ToF acquisition system with external analogue style Interpolator

  iii. Use Veto on LeCroy discriminators to reduce data acquisition to acceptable level

  iv. Perform periodic burst mode sequencial digitisation or undersampled digitisiation with DSP reconstruction to measure amplitude (and phase).

A more complete description is given in Mice Note RF-433.

3. **Explore the potential to achieve synergistic economies of scale in the maintenance and operation of the liquid hydrogen system by working with the ISIS moderator cryogenics team, and present at the next MPB meeting.**

Since the last MPB meeting discussions have been initiated between MICE (K. Long, A. Nichols, R. Preece) and ISIS (Z. Bowden, J. Thomason) with a view to defining a new operational model for MICE. In addition to the hydrogen system, MICE requires access to the technical expertise necessary to run the MICE Muon Beam (water, power supplies, etc.), the MICE instrumentation, high-field, superconducting solenoids (cryogenic systems, power supplies, etc.) and high-power RF amplifier systems. Prior to the renewed negotiations with ISIS, MICE had defined a core operations team of four persons chosen for their expertise in cryogenic systems (including liquid-hydrogen), high-field, superconducting magnets, RF power systems and the provision of services to large accelerator systems. Of this team of four, two individuals are now in post (M. Tucker, cryogenic systems and T. Stanley RF-power systems). Agreement has been reached with a third individual with extensive expertise in the provision of services and of running an operations team. Appointment awaits final agreement with the individual’s line management. The magnet expert remains to be recruited.

The discussion with ISIS will now proceed in three steps. First, the level of support required to maintain and operate the experiment given the existence of the core operations team will be agreed between MICE and ISIS. The ISIS operations team (lead by Z. Bowden) will consider whether the required level of support can be provided with the present complement of personnel. If additional personnel are required a recruitment exercise will be initiated. Finally, the resources necessary to support the MICE element of the ISIS operations team will be agreed between MICE, ISIS and the Science Programmes Directorate of the STFC.

4. **Develop an on-site support plan for day-to-day operations, maintenance and repair of the MICE hardware, and present at the next MPB meeting.**

The MICE collaboration is in the process of defining the “MICE Experiment Management Office” to take responsibility for the day-to-day running of the operations and analysis activities. The negations with the ISIS operations group referred to in response to item 3 above are part of this reorganisation. The MICE collaboration has agreed that responsibility for the maintenance and operation of a particular piece of equipment remains the responsibility of the group or groups that contributed the piece of equipment in question. The responsible group or groups are required to define appropriate arrangements for the coordination of the maintenance and operations activities related to the equipment for which they are responsible. As part of these arrangements, the owners of each system are expected to designate a “system expert”, or a team of experts one of whom is resident at the laboratory during operations.

The MICE core operations team, supported by the ISIS operations group as outlined in response to item 3 above, will respond to routine maintenance and operational issues. The core team will respond to requests from the MICE Operations Manager, the shift leader or the system expert as appropriate. Where intervention with a particular system is required, the work will be coordinated by the designated system expert. If the system expert, in collaboration with the operations team, cannot carry out the relevant maintenance the issue will be escalated to the MIPO for the relevant mediation work to be planned and executed.