MICE bimonthly project update ♯3

1 Introduction

This, the third bimonthly progress report, presents the status of the project at the end of July 2015. The updated project dashboard may be found at `http://micewww.pp.rl.ac.uk/dashboard/`.

2 Schedule

Figure 1 shows the project dashboard and the milestone-slip chart. There was only one milestone in the current reporting period; the completion of the Step IV construction. This milestone is now complete, though commissioning continues.

The completion of the milestone was delayed to complete additional electrical work that was required to improve the robustness of the magnet systems in operation. Significant effort from the electrical team, above that planned, was required to prepare and commission the many electrical systems crucial to the safe operation of the magnet systems and to respond to additional requirements that were identified during commissioning. Many safety critical systems such as the Oxygen Depletion System were installed commissioned and tested during this period.

An additional time pressure arose during the completion of the Partial Return Yoke (PRY). Personnel not associated with the installation of the PRY were excluded from the Hall during the construction activities to minimise the risks to personnel while heavy lifting operations were in progress. This activity reduced the time available to complete electrical works.

All high-pressure-helium lines and supporting structures for the compressors were installed to plan and with no issues. All compressor and cryocooler cold-head pairs were run and terminated and a cleaning cycle was completed for each cold-head. The cleaning process uses a cooling cycle to "freeze" any contaminants introduced during installation of the cold-head. The system was then switched off, the compressor lines disconnected at the cold-head and contaminants vented from the system before refilling it with high purity helium. This process is a pre-requisite for reliable cooling performance during Step IV operations. During this operation a reduced cooling margin was noted on the focus-coil module. The only difference to the system in place in the Hall compared to that which was used during acceptance tests in R9 was that the length of the high-pressure hoses has been increased, preparations have been made to move the focus-coil compressor to allow the original hoses to be used.

The critical path for the construction of the MICE demonstration of ionization cooling is shown in figure 2.

Effort is being directed towards gaining a deeper understanding of the RF aspects of the cooling demonstration and understanding how the construction and commissioning of the systems in the MICE Hall can be advanced. A review of the RF aspects of the project has been set for the 9^{th} and 10^{th} September 2015 at RAL. The review will address all aspects of high-power-RF generation, the RF cavities and the interaction of these systems with each other, the experiment and the beam line will be reviewed.

The milestone-waterfall chart is shown in figure 3. Milestone dates for the tasks required to deliver the demonstration of ionization cooling have not changed since the last report to the MICE Project Board.

3rd August 2015 Update	South side yoke material delivered	South side return yoke installation complete	North side yoke material delivered	Compressors ready for Cooling channels tests	Rack Room 2 Complete	North side return yoke installation complete	MICE step IV installation complete	Combined magnet operational tests complete	End of Step IV Operations	Partial Return Yoke materials arrive at RAL	RF Cavities arrive at RAL	Step IV De-Commissioning complete	RF Amplifier delivered	RF Amplifier 1 ready for electrical commissioning	RF Amplifier 2 ready for electrical commissioning	Installation of PRY South starts	Installation of RF Cavities and Chambers starts	Installation of PRY North complete	Cooling Demonstration complete	Cooling Demonstration commissioning complete	End of data taking in the Cooling Demonstration configuration
Baseline	16/03/15	01/04/15	28/04/15	29/01/15	02/02/15	14/05/15	02/06/15	11/08/15	01/06/16	10/05/16	18/05/16	22/07/16	31/08/16	06/10/16	07/11/16	14/12/16	19/01/17	01/02/17	24/03/17	02/05/17	31/03/18
Dec-14	16/03/15	01/04/15	28/04/15	29/01/15	02/02/15	14/05/15	02/06/15	11/08/15	01/06/16	10/05/16	18/05/16	22/07/16	31/08/16	06/10/16	07/11/16	14/12/16	19/01/17	01/02/17	24/03/17	02/05/17	31/03/18
Jan-15	16/03/15	01/04/15	28/04/15	13/02/15	25/02/15	14/05/15	02/06/15	11/08/15	01/06/16	10/05/16	18/05/16	22/07/16	31/08/16	06/10/16	07/11/16	14/12/16	19/01/17	01/02/17	24/03/17	02/05/17	31/03/18
Feb-15	16/03/15	01/04/15	28/04/15	13/02/15	27/02/15	14/05/15	02/06/15	11/08/15	01/06/16	10/05/16	18/05/16	22/07/16	31/08/16	06/10/16	07/11/16	14/12/16	19/01/17	01/02/17	24/03/17	02/05/17	31/03/18
Mar-15	30/03/15	09/04/15	08/05/15			19/05/15	09/06/15	18/08/15	01/06/16	12/04/16	16/06/16	08/07/16	31/08/16	06/10/16	07/11/16	30/11/16	25/01/17	17/02/17	31/03/17	09/05/17	31/03/18
Apr-15		02/04/15	12/05/15			19/05/15	09/06/15	18/08/15	01/06/16	12/04/16	16/06/16	08/07/16	31/08/16	06/10/16	07/11/16	30/11/16	25/01/17	17/02/17	31/03/17	09/05/17	31/03/18
May-15			12/05/15			28/05/15	25/06/15	15/09/15	01/06/16	12/04/16	16/06/16	08/07/16	31/08/16	06/10/16	07/11/16	30/11/16	25/01/17	17/02/17	31/03/17	09/05/17	31/03/18
Jun-15							06/07/15	23/09/15	01/06/16	12/04/16	16/06/16	08/07/16	31/08/16	06/10/16	07/11/16	30/11/16	25/01/17	17/02/17	31/03/17	09/05/17	31/03/18
Jul-15							14/08/15	16/10/15	01/06/16	12/04/16	16/06/16	08/07/16	31/08/16	06/10/16	07/11/16	30/11/16	25/01/17	17/02/17	31/03/17	09/05/17	31/03/18
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	Date	No Change	Date	Reduction	Date	0-1 Month	Date	1-2 Months	Date	2-4 Months	Date	4+ Months	Date	Complete	Date						

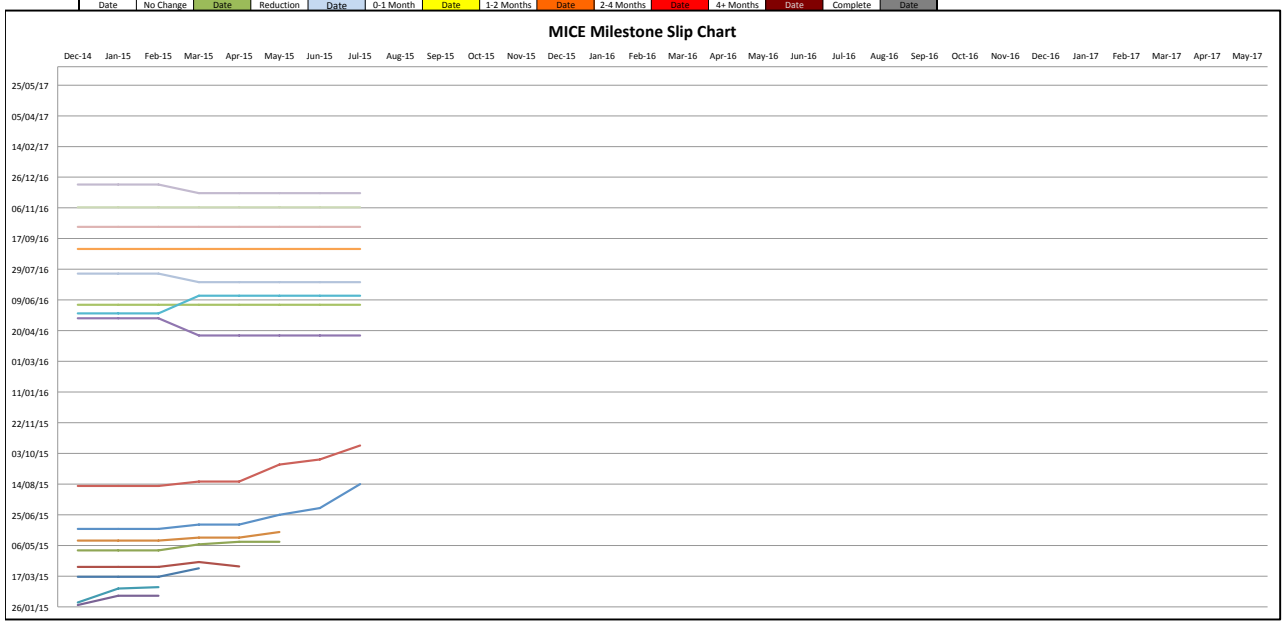


Figure 1: Top: MICE project dashboard: changes in the predicted milestone-completion dates are indicated using the colour code defined in the legend. Completed milestones are shaded grey. Bottom: milestone-slip chart.

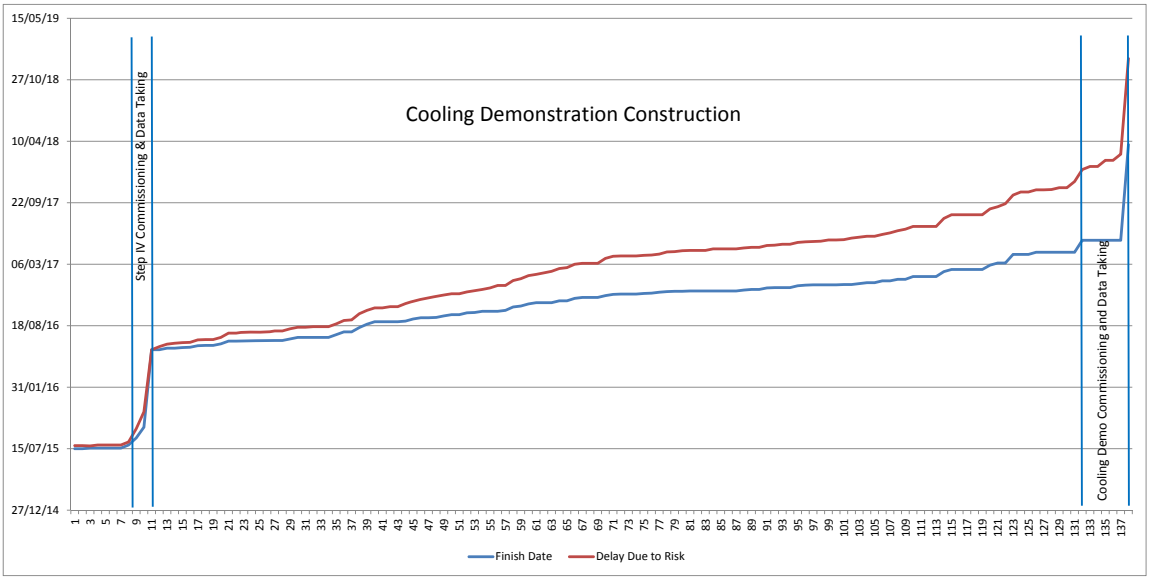


Figure 2: Critical Path to the completion of the MICE project with the implementation of the cooling-demonstration configuration. Commissioning and Data taking periods are included. The vertical lines denote each stage of the project.

3 Commissioning

A significant achievement during the reporting period was gaining permission to operate the magnets at Step IV. Procedures and responsibilities have been discussed and agreed between MICE and ISIS with relevant safety procedures and risk assessments completed and "signed-off".

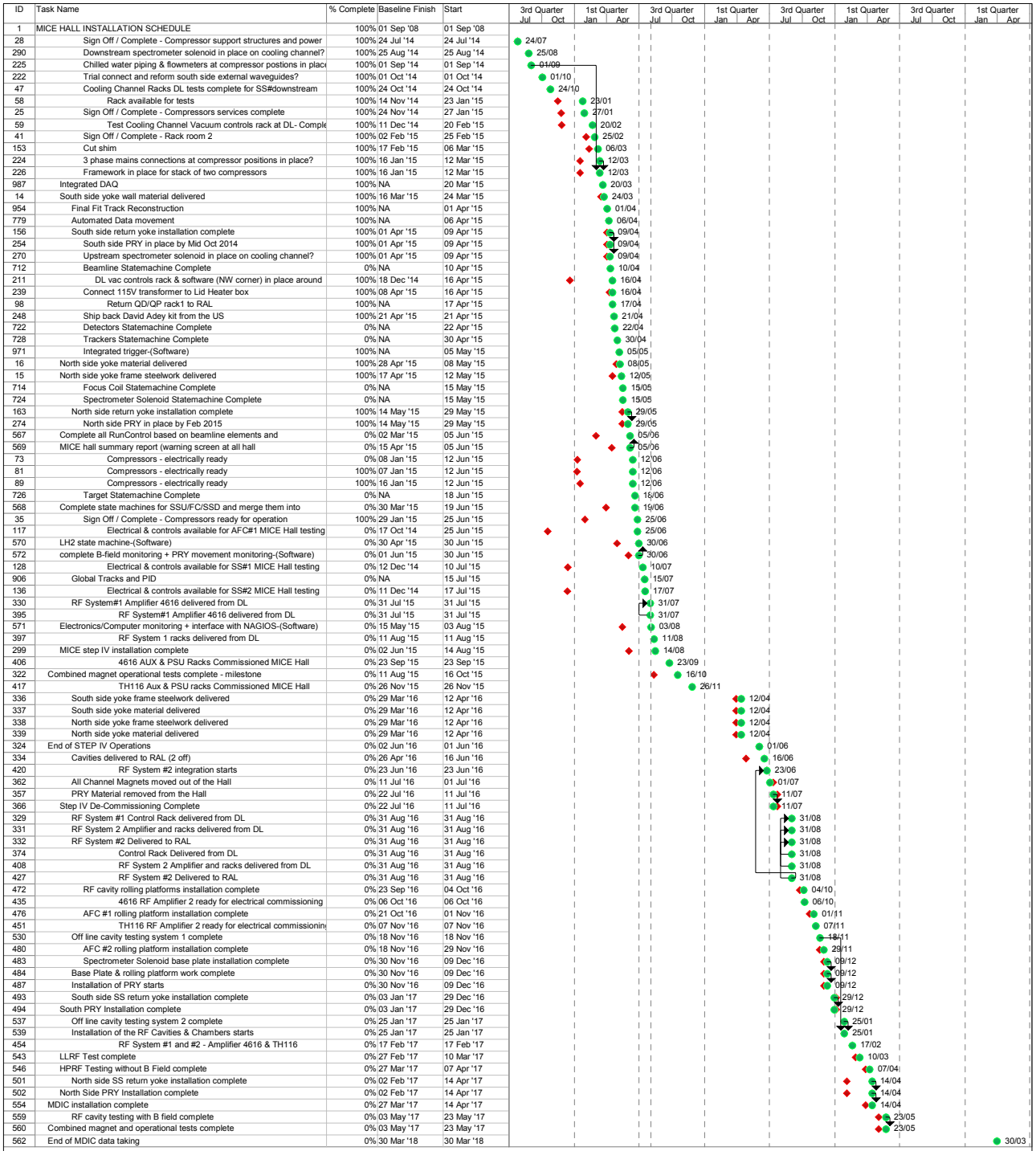
Over the past month there has been an enormous effort by the US magnet team. Both spectrometer solenoids achieved good vacuum conditions and were cooled to stable operating temperature. The quench detection systems were verified and both magnets were powered at 10 A. The team were able to start the training of the downstream solenoid and to bring it into stable operation at 100 A for data taking during the night of the 24^{th} July 2015. On Saturday, 25^{th} July 2015, the downstream spectrometer solenoid was powered to 203 A, around two thirds of the operating current of 283 A, before it quenched.

During the night of 24^{th} July 2015 helical tracks were observed for the first time in the downstream tracker; this is a major achievement producing the first data with magnetic field for the collaboration.

ISIS Cycle 2015/01b is now complete and the first data with field has been taken.

During the preparation for training, a problem was identified in SSU which required physical intervention inside the vacuum vessel. The likely cause was identified, the work required to rectify the fault was planned while the magnet system was warmed to room temperature. The work plan was carried out successfully within 1 week of the identification of the problem and the magnet is now being prepared once more for cool-down. Due consideration was given to early detection of similar issues and a robust test-and-monitor procedure has been implemented.

Monitoring of the downstream spectrometer solenoid revealed a power-supply control and stability issue for one of the coils ("M1"). This has been investigated by running the suspect power supply into a short. Initial indications from the tests are that one of the diode packs has a fault. The cause of the instability at high current and the issues related to the control of the M1 power supply continue to be investigated. Partly in remediation of the magnet power-supply control issue, supplementary "magnet-off buttons" are being implemented in the



ID	Task Name	% Complete	Baseline Finish	Start
1	MICE HALL INSTALLATION SCHEDULE	100%	01 Sep '08	01 Sep '08
28	Sign Off / Complete - Compressor support structures and power	100%	24 Jul '14	24 Jul '14
290	Downstream spectrometer solenoid in place on cooling channel?	100%	25 Aug '14	25 Aug '14
225	Chilled water piping & flowmeters at compressor postions in place	100%	01 Sep '14	01 Sep '14
222	Trial connect and reform south side external waveguides?	100%	01 Oct '14	01 Oct '14
47	Cooling Channel Racks DL tests complete for SS#downstream	100%	24 Oct '14	24 Oct '14
58	Rack available for tests	100%	14 Nov '14	23 Jan '15
25	Sign Off / Complete - Compressors services complete	100%	24 Nov '14	27 Jan '15
59	Test Cooling Channel Vacuum controls rack at DL- Comple	100%	11 Dec '14	20 Feb '15
41	Sign Off / Complete - Rack room 2	100%	02 Feb '15	25 Feb '15
153	Cut shim	100%	17 Feb '15	06 Mar '15
224	3 phase mains connections at compressor positions in place?	100%	16 Jan '15	12 Mar '15
226	Framework in place for stack of two compressors	100%	16 Jan '15	12 Mar '15
987	Integrated DAQ	100%	NA	20 Mar '15
14	South side yoke wall material delivered	100%	16 Mar '15	24 Mar '15
954	Final Fit Track Reconstruction	100%	NA	01 Apr '15
779	Automated Data movement	100%	NA	06 Apr '15
156	South side return yoke installation complete	100%	01 Apr '15	09 Apr '15
254	South side PRY in place by Mid Oct 2014	100%	01 Apr '15	09 Apr '15
270	Upstream spectrometer solenoid in place on cooling channel?	100%	01 Apr '15	09 Apr '15
712	Beamline Statemachine Complete	0%	NA	10 Apr '15
211	DL vac controls rack & software (NW corner) in place around	100%	18 Dec '14	16 Apr '15
239	Connect 115V transformer to Lid Heater box	100%	08 Apr '15	16 Apr '15
98	Return QD/QP rack1 to RAL	100%	NA	17 Apr '15
248	Ship back David Adey kit from the US	100%	21 Apr '15	21 Apr '15
722	Detectors Statemachine Complete	0%	NA	22 Apr '15
728	Trackers Statemachine Complete	0%	NA	30 Apr '15
971	Integrated trigger-(Software)	100%	NA	05 May '15
16	North side yoke material delivered	100%	28 Apr '15	08 May '15
15	North side yoke frame steelwork delivered	100%	17 Apr '15	12 May '15
714	Focus Coil Statemachine Complete	0%	NA	15 May '15
724	Spectrometer Solenoid Statemachine Complete	0%	NA	15 May '15
163	North side return yoke installation complete	100%	14 May '15	29 May '15
274	North side PRY in place by Feb 2015	100%	14 May '15	29 May '15
567	Complete all RunControl based on beamline elements and	0%	02 Mar '15	05 Jun '15
569	MICE hall summary report (warning screen at all hall	0%	15 Apr '15	05 Jun '15
73	Compressors - electrically ready	0%	08 Jan '15	12 Jun '15
81	Compressors - electrically ready	100%	07 Jan '15	12 Jun '15
89	Compressors - electrically ready	100%	16 Jan '15	12 Jun '15
726	Target Statemachine Complete	0%	NA	18 Jun '15
568	Complete state machines for SSU/FC/SSD and merge them into	0%	30 Mar '15	19 Jun '15
35	Sign Off / Complete - Compressors ready for operation	100%	29 Jan '15	25 Jun '15
117	Electrical & controls available for AFC#1 MICE Hall testing	0%	17 Oct '14	25 Jun '15
570	LH2 state machine-(Software)	0%	30 Apr '15	30 Jun '15
572	complete B-field monitoring + PRY movement monitoring-(Software)	0%	01 Jun '15	30 Jun '15
128	Electrical & controls available for SS#1 MICE Hall testing	0%	12 Dec '14	10 Jul '15
906	Global Tracks and PID	0%	NA	15 Jul '15
136	Electrical & controls available for SS#2 MICE Hall testing	0%	11 Dec '14	17 Jul '15
330	RF System#1 Amplifier 4616 delivered from DL	0%	31 Jul '15	31 Jul '15
395	RF System#1 Amplifier 4616 delivered from DL	0%	31 Jul '15	31 Jul '15
571	Electronics/Computer monitoring + interface with NAGIOS-(Software)	0%	15 May '15	03 Aug '15
397	RF System 1 racks delivered from DL	0%	11 Aug '15	11 Aug '15
299	MICE step IV installation complete	0%	02 Jun '15	14 Aug '15
406	4616 AUX & PSU Racks Commissioned MICE Hall	0%	23 Sep '15	23 Sep '15
322	Combined magnet operational tests complete - milestone	0%	11 Aug '15	16 Oct '15
417	TH116 Aux & PSU racks Commissioned MICE Hall	0%	26 Nov '15	26 Nov '15
336	South side yoke frame steelwork delivered	0%	29 Mar '16	12 Apr '16
337	South side yoke material delivered	0%	29 Mar '16	12 Apr '16
338	North side yoke frame steelwork delivered	0%	29 Mar '16	12 Apr '16
339	North side yoke material delivered	0%	29 Mar '16	12 Apr '16
324	End of STEP IV Operations	0%	02 Jun '16	01 Jun '16
334	Cavities delivered to RAL (2 off)	0%	26 Apr '16	16 Jun '16
420	RF System #2 integration starts	0%	23 Jun '16	23 Jun '16
362	All Channel Magnets moved out of the Hall	0%	11 Jul '16	01 Jul '16
357	PRY Material removed from the Hall	0%	22 Jul '16	11 Jul '16
366	Step IV De-Commissioning Complete	0%	22 Jul '16	11 Jul '16
329	RF System #1 Control Rack delivered from DL	0%	31 Aug '16	31 Aug '16
331	RF System 2 Amplifier and racks delivered from DL	0%	31 Aug '16	31 Aug '16
332	RF System #2 Delivered to RAL	0%	31 Aug '16	31 Aug '16
374	Control Rack Delivered from DL	0%	31 Aug '16	31 Aug '16
408	RF System 2 Amplifier and racks delivered from DL	0%	31 Aug '16	31 Aug '16
427	RF System #2 Delivered to RAL	0%	31 Aug '16	31 Aug '16
472	RF cavity rolling platforms installation complete	0%	23 Sep '16	04 Oct '16
435	4616 RF Amplifier 2 ready for electrical commissioning	0%	06 Oct '16	06 Oct '16
476	AFC #1 rolling platform installation complete	0%	21 Oct '16	01 Nov '16
451	TH116 RF Amplifier 2 ready for electrical commissionin	0%	07 Nov '16	07 Nov '16
530	Off line cavity testing system 1 complete	0%	18 Nov '16	18 Nov '16
480	AFC #2 rolling platform installation complete	0%	18 Nov '16	29 Nov '16
483	Spectrometer Solenoid base plate installation complete	0%	30 Nov '16	09 Dec '16
484	Base Plate & rolling platform work complete	0%	30 Nov '16	09 Dec '16
487	Installation of PRY starts	0%	30 Nov '16	09 Dec '16
493	South side SS return yoke installation complete	0%	03 Jan '17	29 Dec '16
494	South PRY Installation complete	0%	03 Jan '17	29 Dec '16
537	Off line cavity testing system 2 complete	0%	25 Jan '17	25 Jan '17
539	Installation of the RF Cavities & Chambers starts	0%	25 Jan '17	25 Jan '17
454	RF System #1 and #2 - Amplifier 4616 & TH116	0%	17 Feb '17	17 Feb '17
543	LLRF Test complete	0%	27 Feb '17	10 Mar '17
546	HPRF Testing without B Field complete	0%	27 Mar '17	07 Apr '17
501	North side SS return yoke installation complete	0%	02 Feb '17	14 Apr '17
502	North Side PRY Installation complete	0%	02 Feb '17	14 Apr '17
554	MDIC installation complete	0%	27 Mar '17	14 Apr '17
559	RF cavity testing with B field complete	0%	03 May '17	23 May '17
560	Combined magnet and operational tests complete	0%	03 May '17	23 May '17
562	End of MDIC data taking	0%	30 Mar '18	30 Mar '18

Figure 3: Waterfall chart showing the milestones defined for the MICE project.

Hall and in Rack Room 2. Direct current measurement is also being implemented to deal with such issues should they re-appear in the future.

During one of the periods of SS commissioning, the temperature of the radiation shield in the focus coil was seen to rise by 10 K over a 24-hour period after which it stabilised. Investigations suggest a small vacuum leak may have been the cause. Detailed investigations, which include a search for any connection between the absorber and magnet vacuum spaces, are underway. At present the magnet is being warmed to remove any ice that may have formed on the cold surfaces. In parallel, robust physical protection for all components on the focus coil will be implemented, a requirement now that intensive access to the top of the cooling channel is required during magnet training.

The MICE Hall is currently being prepared for continued magnet training, additional access hardware is being installed following feedback from the magnet teams. The commissioning of the spectrometer solenoids will recommence and the focus-coil commissioning will begin in the second half of August 2015.

The timescales are such that it is likely that a portion of Cycle 2015/02 will be required for magnet training. While this is regrettable, the most important consideration is to optimise our procedures to maximise the efficiency of our expert teams. If we can do this effectively, and support those working over the coming month or so, we will be in a much stronger position to execute our data-taking campaign for Step IV.

4 Data taking and analysis

The focus of the analysis of the data taken during ISIS Cycles 2015/01a and 2015/01b is to determine the mechanical alignment of the experiment and to determine the magnetic axis of the downstream spectrometer. Good progress is being made with both these analyses with first results being discussed within the analysis group. The results of this analysis are required to finalise the design of "bespoke bellows" should they be required to bring the magnetic axes of the superconducting magnets that make up the MICE channel into alignment.

A first full processing of the data is being prepared. This processing will use a consistent set of geometry and calibration constants. The consistent processing will allow the analyses that are presently underway to be advanced using all the data that has been taken.