Plan for MICE During ISIS User Run 1a/1b

Change History

Version	Changes	Author	Date
1	First draft	C. Rogers	12/03/2015
2	Added contingency	C. Rogers	24/03/2015

1 ISIS User Run 2015 1a/1b

During ISIS user run 1a and 1b, MICE intends to finish commissioning detectors and beamline, whilst simultaneously training the MICE cooling channel magnets. In this note the plan for MICE data taking is outlined. The currently planned dates of the ISIS user run are outlined below, all in calendar year 2015.

1.1 ISIS User Run Dates

The most up-to-date ISIS run plans are available from [ISIS Beam Status].

MICE is not expected to operate in any machine physics period, except for a 16 hour duration activation run that has been requested. This will be scheduled by ISIS.

User run cycle	**Start**	**End**	**Maintenance day**
Machine Physics[1]	Monday 25 May	Sunday 31 May	
2015/01a	Tuesday 2 June	Sunday 5 July	Wednesday 17 June
Machine Physics[1]	Monday 6 July	Monday 13 July	
2015/01b	Tuesday 14 July	Friday 24 July	
Machine Physics[1]	Saturday 25 July	Sunday 26 July	

Table 1: ISIS running periods

1.2 Magnet Commissioning

The MICE magnet commissioning plan is described in [Magnet and Beam Commissioning at Step IV]. Magnet commissioning is planned to start on 2nd June 2015.

The current estimates for required times to commission the MICE superconducting channel at Step IV are as summarised in the table below. Commissioning is expected to finish between 25th June and 18th July.

The fractional time available for beam were found by discussion with magnet experts.

- The spectrometer solenoids training is likely to require significant intervention in the MICE hall during the cool down and ramp procedure. One spectrometer solenoid will be cooling down while the other ramps. The spectrometer solenoid team does not intend to staff the midnight shift (00:00 – 08:00) and this will be available for data taking. The hall will be open during SS cooldown and so a full start-up procedure will be required during this period (search and secure, conventional magnet run-up, etc). This will leave approximately 6 hours for data taking.
- Focus coil training will require a manual intervention following a quench to refill the cryostat and manual interventions during ramping (2 hours per ramp). A conservative estimate has been made that beam will be available for 24 hours per 48 hours cooldown/ramp/quench cycle.
- Combined training will require a cool down of the full magnet string. The focus coil is the

1 Operational priorities to be determined by ISIS. Not open to regular data taking.

slowest magnet to cool down, and as this requires less manual intervention it may be possible that there is more data taking opportunity during this time. There is considerable variability in estimates for the amount of time available for beam.

Once magnet training begins, a residual field will be present in the cooling channel due to the iron shields. This is expected to cause a measurable curvature in particle trajectory between upstream and downstream trackers.

Check numbers in table - Pasternak

Task	Estimated Duration	Fractional time available for beam	Number of available 8 hour shifts
Electrical Tests			
Pump Down			
Spectrometer Solenoids Training	15-21 days	6/24	15-21
Focus Coil Training	4-6 days	24/48	12-18
Combined Training	4-42 days	12-24/48	6-126

Table 2: Expected time available for data taking during magnet commissioning

1.3 Operations Status

It is expected that MICE will be able to operate with a full shift team with data taking available 24 hours per day 6 days per week. Operation in this mode is subject to ISIS approval, which has not yet been received.

Wednesdays will be reserved for system maintenance and no data taking will be performed on Wednesdays.

1.4 Expected Data Rate and Trigger

ISIS is expected to be operational at 800 MeV. The target is expected to dip at 50/64 Hz at a maximum 4 Vms, subject to an activation study, usually performed during ISIS machine physics periods. If the activation study cannot be performed, the target may dip at 2 Vms at 50/64 Hz.

The number of triggers at TOF1 with decay solenoid powered is expected to be 50-100 for the muon beam. The tracker DAQ approaches saturation when the number of triggers increases beyond this point.

Where through-going tracks are required, it is desirable to use a TOF2 trigger as events can scrape out between TOF1 and TOF2, especially when the cooling channel magnets are off. This can reduce saturation effects, but requires development work on the trigger.

The number of events entering the downstream diagnostics system is assumed to be reduced by a factor 10 when the cooling channel fields are off, leading to an estimate of 5-10 muons per spill. Note that most measurements outlined in this note do not require a matched beam or muons in a small momentum band (as is required for the cooling channel measurements proper).

2 Detector Commissioning and Calibration

The TOF, KL, EMR and Cerenkov detectors have all been commissioned, although some recalibration will be required. The upstream and downstream tracker has not yet been commissioned, and this will be the initial focus of the data taking.

2.1 Tracker Hardware Commissioning

Measurement Coordinator: Ed Overton

Two tasks are required for tracker commissioning in beam.

1. The tracker will need to be integrated with the trigger system. This is expected to require two 8 hour shifts.
2. The time delays in the tracker will need to be identified so that the tracker read out is coincident with the trigger. This is expected to require eight 8 hour shifts.

Tracker commissioning in beam is optimistically expected to begin on the weekends of April 18/19 and April 25/26, (which is ISIS user run 2014/03). There is some risk that it will not be possible to start the tracker commissioning in ISIS user run 2014/03 in which case it will begin in ISIS user run 2015/02.

In both cases the tracker expert is required, so the shifts must be on separate days.

In both cases the tracker group will require control over the run settings.

There is a small risk for item (1) that the trigger firmware will require an update, in which case the TOF calibration can become invalid. Item (2) will require interventions in the MICE hall.

It is noted that the equivalent tasks during the single station test in 2012 required 3-6 days for one station.

Tracker calibration can be performed without beam data.

2.2 Tracker Validation (Straight Tracks)

Measurement Coordinator: Melissa Uchida

Validation of the tracker is required before the tracker can be declared as fit for physics analysis. The straight tracks validation will seek to establish that space points and tracks can be reconstructed.

It is estimated that 1000-5000 hits per channel should be sufficient to calculate light yields and examine efficiencies. As each view has 212-214 channels, it is expected that 200,000 - 1,000,000 events at the downstream tracker should be sufficient. Higher momentum muons are preferred as part of the analysis is to check for straight tracks. A smaller sample of low momentum muons is desirable to validate the handling of multiple coulomb scattering and energy loss.

2.3 TOF Calibration and Cerenkov Commissioning

Measurement Coordinator: Durga Rajaram

TOF and Cerenkov require calibration data, with settings as per the study made in June 2014 [2014-06-29 Run]. As the decay solenoid will be available during this period, it is anticipated that this will take two shifts.

The TOF data is required to calibrate the detector. The Cerenkov data is required to calibrate light yields as a function of momentum.

2.4 EMR Commissioning

Measurement Coordinator: Francois Drielsma

The EMR calibration will be performed using cosmics following PRY installation.

Beam data will be used to study penetration depth compared to TOF time. This cross check will enable the EMR group to refine the choice of PID variables.

In order to recommission the detector, the EMR will require a momentum scan with a electron and pion beams in positive and negative polarities. A TOF2 trigger may help to prevent DAQ saturation. Between 11th October and 21st October 2015 8 12-hour shifts were taken with no decay solenoid. As the decay solenoid will be functioning in this user run, giving an increase of rate of around a factor three, 6 shifts of 8 hours will be assigned.

2.4.1 KL Calibration

KL will be calibrated using cosmic ray data. KL does not require any dedicated beam.

3 Beam Based Alignment of Detectors

The detector alignment will be measured by allowing straight tracks (no field) to pass through a set of detector systems. The position and trajectory of the tracks in neighbouring detectors will be used to determine the relative alignment.

3.1 Tracker External Alignment

Measurement Coordinator: Melissa Uchida

The upstream and downstream tracker alignment will be measured first. This will validate and improve on the surveyed position of the trackers, defining the axis of the experiment and enabling it to be related to the physics coordinate system. Muon beams will be used because stochastic effects such as straggling and decay are expected to be minimal.

The main systematic is expected to arise due to residual fields from the PRY, so it is desired to measure the beam based alignment before the magnet commissioning commences. The alignment will be performed with muons of different momenta in order to constrain the bias due to residual fields and the earth's magnetic field.

If it is not possible to measure the alignment before magnet commissioning, then the PRY should be de-Gaussed prior to making the alignment measurement. This will only be possible once the cooling channel is commissioned.

It is expected that 10,000 muons will be required at the downstream diagnostics at each of 140 MeV/c, 200 MeV/c and 240 MeV/c. It is estimated that the rate to the downstream diagnostics will be 6 muons per spill, as the cooling channel magnets will be switched off. A TOF2 trigger may be used so that DAQ saturation does not constrain the data rates. Each run will take 30 minutes of data taking at 50/64 Hz or 1 hour at 50/128 Hz.

3.2 Alignment to Other Detectors

Measurement Coordinator: Melissa Uchida

A beam-based alignment to the other detectors will be performed to validate the survey. As these detectors are not principally concerned with measuring particle position, it is expected that worse resolution will be available (and required).

The procedure for beam based alignment of these detectors will be the same. Owing to the shorter distances involved and the worse resolutions, it is expected that residual field effects will be less significant and it may be possible to perform the alignment despite residual fields from the PRY.

4 Absorber-Full Test

Measurement Coordinator: Chris Rogers

It is desired to perform an absorber-full test in order to validate the absorber filling procedure in the context of data taking and make a first measurement of multiple Coulomb scattering. If the cooling channel magnets are available, this could form the first measurement of reduction of normalised transverse emittance.

Absorber filling is estimated to require between 1-5 days. Absorber emptying is estimated to require < 1 day.

A sample of 100,000 - 1,000,000 muons would be required at the downstream diagnostics. If field is available, then it may be prudent to take even more data at this point and postpone the remaining absorber-empty analyses

5 Diagnostic Validation with Field

Once the individual detectors have been calibrated and the alignment has been performed, the diagnostics will be validated in field.

5.1 Validation of Track Matching in Field

Measurement Coordinator: Melissa Uchida

It should be validated that the detector reconstructions are consistent and that tracks can be matched from the tracker to the TOF and other detectors. 100,000 muons at each of three momenta are required for this measurement. **Rogers guess, Uchida to check**

5.2 Validation of Particle Identification

Measurement Coordinator: Celeste Pidcott

It should be validated that the particle identification routines function as expected. Pion and muon beams will be required at each of the three momenta. 100,000 muons and pions at each of three momenta are required for this measurement. **Rogers guess, Pidcott to check**

6 Beamline Commissioning

The beamline commissioning activity falls into two portions. Beamline pre-commissioning can be performed without fields. Beamline commissioning can be performed with only the upstream spectrometer available. The plan for beamline pre-commissioning and beamline commissioning is described in [Magnet and Beam Commissioning at Step IV].

6.1 Beamline Pre-commissioning

Measurement Coordinator: Jaroslaw Pasternak

Beamline pre-commissioning will commence on March 28/29, where four shifts worth of data are expected to be collected. It is expected a further four shifts worth of data will be required during this data taking period.

6.2 Beamline Commissioning

Measurement Coordinator: Jaroslaw Pasternak

Beamline commissioning requires the upstream tracker to be operational in the solenoidal field. 15 shifts are estimated to be required for this commissioning.

7 In-Beam Cooling Channel Validation

Commissioning of the cooling channel magnets in-beam will require two phases. In the first phase, the trajectory through the cooling channel will be measured and the magnet alignment will be calculated using a beam-based alignment technique. In the second phase, a beam will be passed through the cooling channel and the optical properties of the beam will be measured and validated to match the expected optical properties.

7.1 Beam-Based Alignment

Measurement Coordinator: Chris Rogers

For the beam based alignment, each module will be powered independently and the trajectory of muons will be measured. By comparing the measured trajectory with the expected trajectory, the alignment of each module can be validated. For this measurement, 100,000 muons at each of three momentum settings will be required for each of the three modules (300,000 muons per module) at the downstream diagnostics. Three shifts per module is assigned for this task.

7.2 Optics Validation

Measurement Coordinator: Jaroslaw Pasternak

The optics of the cooling channel will be validated in a variety of different momentum and emittance configurations. The trajectory of the beam centroid will be compared with the beam-based alignment. The beam optics will be compared with the expected beam optics. This is outlined in more detail in [Magnet and Beam Commissioning at Step IV]. 21 shifts have been allocated for this task.

8 MICE Physics Programme

Any time available following the completion of this programme would be spent pursuing the full MICE physics programme.

9 Summary of Required Data

The required data is summarised in the table below. A 50 % contingency was added. The tracker external alignment will be the first measurement with fully integrated detectors and so the a 6 day contingency was added for this measurement. Contingency has already been included in the estimates for beamline commissioning and optics validation.

Task	**Number of 8 hour Shifts**	**Contingency**	**Requires Channel Magnets**
Tracker Hardware Commissioning	6-10	3-5	N
Tracker Validation	2-6	1-3	N
TOF Calibration and Ckov Commissioning	2	1	N
Tracker External Alignment	1	6	N
EMR Commissioning	6	3	N
Alignment to Other Detectors	1	1	N
Beamline Pre-commissioning	4	2	N
Absorber-Full Test	2-6	1-3	(Y)
Total number of shifts without channel magnets	**22-36**	**18-23**	**N/A**
Validation of Track Matching	1	1	Y
Validation of Particle Identification	2	1	Y
Beamline Commissioning	15	Included	Y
Beam-Based Alignment	9	5	Y
Optics Validation	21	Included	Y
Total number of shifts with channel magnets	**48-54**	**8**	**N/A**
MICE physics programme	...	...	...

Table 3: Expected shift requirement for data taking.

10 Bibliography

[ISIS Beam Status] outline schedule available at http://www.isis.stfc.ac.uk/beam-status/

[Magnet and Beam Commissioning at Step IV] Magnet and beam commissioning plan is at http://micewww.pp.rl.ac.uk/documents/96

[2014-06-29 Run] A sample Cerenkov commissioning and TOF calibration run plan is available at http://micewww.pp.rl.ac.uk/projects/operations/wiki/RunPlan20140629