To: The MICE Executive Board　　Revision 4　　May 4, 2016

From: K. Long　　Final

Redefining the scope of the cooling demonstration

Context

National and international reviews of the project over the past six weeks culminated in the STFC cost-to-completion review of MICE-UK, which took place on the 26th April 2016. Each of the review panels concluded that:

- The collaboration had made strides in the commissioning and operation of Step IV, the preparation of its software and and analysis frameworks and in the publication of its results;
- The Step IV science programme was important and must be completed, including operation with both LiH and LH_2; and that
- The cooling demonstration was important and should be completed.

The cost-to-completion review panel:

- Decided that the schedule, financial and reputational risks associated with the procurement required to recover the downstream solenoid were too large for them to recommend that STFC allow the collaboration to continue with the procurement; and
- Identified the timing of the long ISIS shutdown, which may start just as the recovered solenoid is delivered, as an additional, external, constraint on the programme.

The MICE-UK collaboration is now required to prepare, over the next three months, a proposal for the execution of the cooling demonstration that exploits those components that are already in hand or are being manufactured (PRY, single-cavity modules and high-power RF amplifiers).

Implications

In order to preserve the cooling demonstration, the MICE collaboration must now redefine the cooling demonstration such that:

- The integrated cost to the UK is in the region of £7M–£9M and the cost to the other international partners must remain within the known constraints;
- Risk of further delay, cost overrun, equipment failure or reduced availability is reduced to a minimum; and
- A significant data-taking programme may be carried out before the long ISIS shutdown. The date of the shutdown is not know, but, it is likely to be around 2019.

Since the recovery of the downstream spectrometer solenoid is no longer an option, the largest risk to the full exploitation of the cooling demonstration as presently configured is the further failure of the magnet. Therefore, either:

- A configuration that uses only one spectrometer solenoid and yields satisfactory performance must be developed;
- The downstream spectrometer solenoid (E-C-E only or E-C-E and M1) must be shown to be stable through operation at Step IV; or
- It must be demonstrated that the downstream solenoid E-C-E combination can be made stable through a relatively low-risk intervention.

To reduce the resource requirement and improve the likelihood of high-availability in operation, the experiment should be reconfigured based on the assumption that a single high-power RF amplifier will serve the two single cavity modules.

Outline of cooling-demonstration configurations to be developed

Two-solenoid configurations:
Initial studies of the performance of the experiment in which spectrometer solenoid (SS) ♯2 is placed upstream and SS ♯1 is placed downstream have been carried out. These studies indicate that transmission is poor with either M1 or M2 unpowered. Initial consideration should also be given to a configuration in which SS ♯2 is placed upstream such that the “patch-panel end” is adjacent to the cooling cell.

In parallel to evaluating the optical properties of such a configuration, it is essential to consider stablisation of the magnet through the “blanking off” of the feed-through that serves M1 and M2. Conceptually, this may be attempted by accessing the cold mass through the turret. By developing a detailed plan now, we shall be in a position to consider stablise the magnet fail in Step IV and to consider stablising the magnet in parallel to the reconfiguration of the MICE Hall for the cooling demonstration.

Single-solenoid configurations:
Measurements at Step I and now at Step IV indicate that the instrumentation of the MICE Muon Beam is capable of determining the phase-space coordinates of muons passing into the experiment. Without field, the upstream solenoid would provide a long drift (in excess of 4 m between TOF1 and the focus-coil). The result of this drift will be to remove high-amplitude particles, reducing the maximum input emittance that can be accepted. Therefore, a configuration in which SS ♯1 is removed from the lattice must be adopted.

Practical configurations are sketched in figure 1. The ordering of the components of the cooling cell and its instrumentation should not be regarded as fixed. The five stations from the downstream tracker, and the five spare scintillating-fibre stations, may be used to improve the instrumentation of the downstream section of the MICE Muon Beam. The position of the stations shown in the figure is indicative only. The two options differ, principally, in the position of the spectrometer solenoid. With the spectrometer solenoid placed downstream of the cooling cell, the beam can be matched into the tracking volume with the aim of ensuring good capture of the beam into the downstream instrumentation. With the tracker upstream of the cooling cell, the beam can be matched into the cell; the acceptance and resolution of the EMR in this configuration needs to be studied to ensure that the performance is sufficient to allow the emittance-change measurement to be made.

Timetable

In view of the timetable laid out by the STFC, it is urgent to make an initial assessment of the options outlined above. I would like to ask:

- C. Whyte to lead the consideration of the engineering, cost, schedule and issues associated with both the two- and single-solenoid configurations; and
- C. Rogers to lead the consideration of the simulation of the performance of both the two- and single-solenoid configurations.

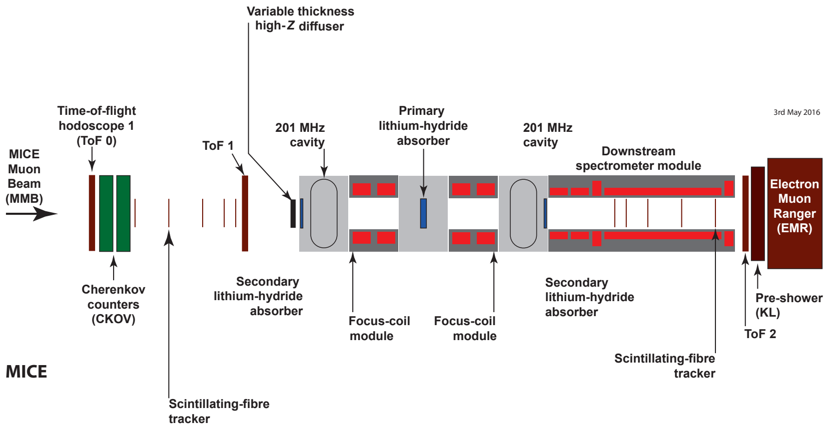
In order to converge on a single plan that can be taken forward to a detailed cost and schedule analyis in time for teh MICE-UK proposal to be submitted in less than three months, it is essential to obtain rapid feedback on the following questions:

1. What is the risk to the success of the cooling demonstration if the experiment proceeds with the two-solenoid options? And, what are the additional risks of the two-solenoid options over the risks that pertain to the single-solenoid options?
2. What is the resolution with which the parameters of the muons can be determined in the one-solenoid options? Is this sufficient to allow the cooling demonstration to proceed?
3. What is the schedule for the implementation of the single-solenoid and two-solenoid options and what is the likely cost to the UK and the other international partners?
4. Can a satisfactory MICE Muon Beam and ionization-cooling cell optics be found for the single-solenoid and two-solenoid options?

I will follow up with C. Whyte and C. Rogers to agree a timetable on which answers to these questions can be obtained.

Decision point:
Given the timetable on which the MICE-UK proposal must be submitted, the date on which a decision on the cooling demonstration configuration must be made is:

- **27$^{\text{th}}$ May 2016**.



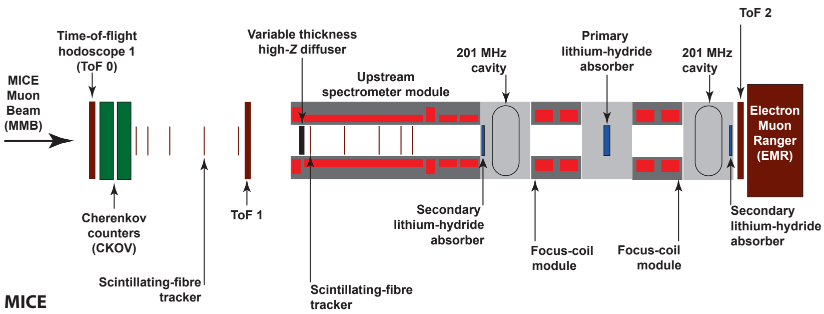


Figure 1: Schematics of configurations prepared to meet the constraints imposed by the reviews of the project in March and April 2016. Top: spectrometer solenoid placed downstream of the cooling cell with the advantage of allowing the beam to be matched into the tracker. Bottom: spectrometer solenoid placed upstream of the cooling cell and with the EMR moved as close as possible to the exit of the cooling cell. The ordering of the components of the cooling cell should not be regarded as fixed; it is likely that a configuration in which the RF cavities are sandwiched between the focus-coil modules will be preferred. The position of the upstream tracker is indicative and should be taken to indicate that a redistribution of the five stations that make up the present downstream tracker, together with some or all of the five spare stations, may be used to enhance the instrumentation of the MICE Muon Beam.