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MICE Stray field mitigation review

23rd & 24th September, 2013, at
The Fisher Room, University of Oxford, Dept of Physics, Denys Wilkinson Building, Oxford, UK.

Review Panel:
Tom Taylor – CERN, Chair, Mark Hatch – CERN, Ken Bell – STFC, Vladimir Kashikin – FNAL, Jim Clarke – STFC, Mike Glover – STFC, Martin Hughes – STFC, John Thomason – STFC

Introduction

The goal of the MICE Project is to provide a working demonstration of muon ionisation cooling. Such a demonstration is a vital precursor for future accelerator systems using muons. The experiment is being carried out on behalf of the International MICE Collaboration at STFC's ISIS facility in the UK. The experiment is split into discrete R&D phases that are presently described as Steps IV and Step VI, with Step VI aiming to be complete by around 2019.

The muon beam transport is contained by a magnetic 'bottle' provided by seven superconducting magnets that do not incorporate field return yokes; these magnets must be operated safely, in terms of risk to personnel, risk to the magnets themselves, and of any detrimental effects to the operation of sensitive equipment belonging to the MICE project and other partners in STFC, in particular the ISIS complex.

Early on in the project the decision was taken to have no return yokes for the solenoids and to rely on walls of thick steel plates at the sides of the hall to shield the stray magnetic field. The shielding walls were built, but studies revealed that equipment in the hall would require additional shielding, even for Step IV, and that with the installation of the much larger coupling coils for Step VI the present walls would certainly be insufficient.

There have been delays due to problems with the magnets, and while it had been hoped to be able to run Step IV of the experiment before the next ISIS shutdown it is now clear that this will not be possible. It has therefore been decided to upgrade the shielding in parallel with the installation of the magnets for Step IV in order to ensure that in the event of having to design and install additional shielding this work would not lead to lost beam time.

The MICE Collaboration has extensively simulated the anticipated magnetic conditions and has proposed and conceptually designed a comprehensive return yoke to contain the stray field within safe limits. The purpose of the present review is to verify the efficiency of the so-

called Partial Return Yoke (PRY) shielding, the realism of the design, and plans for manufacture and installation.

Findings

Over the last months there has been an intensive programme of FE modelling of the magnetic field in the hall R5.2, and of the practical design and costing of adding shielding in closer proximity to the coils. The team is to be congratulated on the effort that has gone into this work. The new shielding being proposed is for Step IV, and attention has been focused on this, with only pre-conceptual studies addressing the requirements of Step VI. The shielding is to be supplied by the US partner and installed by RAL.

The hydrogen delivery system for the target is located on a mezzanine against the south wall. This system has been commissioned, and as it has received the approval of the safety group there is a strong desire to avoid modifications, at least for Step IV. This has constituted an important constraint.

The design of the PRY shielding and the procedure for installation are basically sound; there are details that need to be addressed during the finalization. The engineering design is being done at BNL: it is at the stage of a general assembly; about 80 drawings will be required for the tender process.

The neighbouring ISIS Group is satisfied with the work being done by the MICE Collaboration to control the level of stray field.

The schedule presented contains some (3 months?) float, but leaves no room for complacency. The total cost of the additional shielding is less than 500 k$ in US accounting.

The background of the project and the result of recent studies on improving the shielding were the subject of a number of excellent presentations: these can be consulted at https://indico.cern.ch/conferenceDisplay.py?confId=267759 .

Comments

The strategy of improving the shielding now to reduce the risk of losing running time later is sound. It is recognized that FE modelling of such shielding is difficult, and the committee was impressed by the work done.

While much attention has been paid to the stray field map, it was apparent that less attention has been paid as to the effect of the presence of the new PRY shielding on the coils (and the eventual relation to tolerances on the steel parts).

It would appear that with some small modifications the design could be improved. In particular, the asymmetry of the support structure appears to be unnecessary, and it should be possible to reduce the amount of dismantling required to access the target (and magnets).

For Step VI there will have to be a lot more shielding and this should match in with that being provided for Step IV; now that the design for Step IV is close to an engineering design, it

would be very useful to have at least a conceptual design of the PRY for the large Coupling Coils to be included in Step VI, so that features for connection can be included. The work that has been done so far for Step VI revealed a surprisingly strong dependence of required thickness (and hence mass) on the quality of the steel. Given the constraints on space in the hall, especially on the south side, and the efficiency of the PRY, it was questioned whether consideration should not be given to dismantling the present shielding wall when passing to Step VI.

These points were discussed constructively with the RAL and Fermilab personnel present at the meeting.

Recommendations

- The committee endorses the strategy of improving the shielding prior to installation of Step IV to avoid the risk of losing beam time due to having to shield individual items.
- The concept of the Partial Return Yoke is sound, and it should perform as required, but some simplification may be possible, and it must be verified that the new shielding does not increase the risk of failure of a magnet.
- FE modelling should continue with the accent on providing information for the specification of the magnetic characteristics and tolerances of the steel shielding components, and on the conceptual shielding for Step VI.
- RAL should consider building a platform on the north side of the experiment (e.g. a steel plate on the “weak” concrete, partially supported on simple pillars in the trench) so that the shielding support structure can be identical on the N and S sides.
- The design should be modified to make it possible to change the target and access the magnets (e.g. to fix a leak), without having to dismantle the mezzanine extension.
- It should be verified that the shielding being purchased is compatible with the shielding for Step VI. To this end there should be a conceptual design of the shielding for Step VI.
- A commissioning plan for Step IV should be devised to ensure personnel safety when the magnets are first switched on, and to test that PRY performance is as predicted by the models.
- The result obtained for Step IV should be validated and used to bench-mark the calculations, so as to refine the result of modelling for the design of the PRY for Step VI.
- In order to converge rapidly on the final design for Step IV it is recommended that Steve Plate (BNL) spend a week with the engineers at RAL.
- A close watch should be kept on the schedule.

Appendix

Review Charge

The MICE Project aims to make an engineering demonstration of muon ionisation cooling as a vital component of future accelerator complexes. The experiment is being carried out on behalf of the International MICE Collaboration at STFC's ISIS facility in the UK. The experiment is necessarily split into three discrete R&D phases that are described as Steps IV to Step VI, with Step VI aiming to be complete by around 2019.

The muon beam transport is contained by a magnetic 'bottle' provided by seven superconducting magnets that *do not incorporate field return yokes*; these magnets must be operated safely both in terms of risk to personnel and of any detrimental effects to the operation of sensitive experimental equipment belonging to the MICE project and other partners in STFC.

The MICE Collaboration has extensively simulated the anticipated magnetic conditions and has proposed and conceptually designed a comprehensive return yoke to contain the stray fields within safe limits; the Review Committee is asked to review this design in terms of:

- Efficiency of magnetic containment; will the solution meet its technical requirements for both MICE, ISIS and STFC?
- Overall effect on the integration of the experiment, its services and surroundings
- The practicality, safety and affordability of the installation
- Flexibility of assembly for future phases of the project
- Realism of the design, procurement, manufacturing and installation schedule in broad terms, noting that the detail of this will be covered by a later Production Readiness Review.

The Committee is asked to provide MICE with a written report of its conclusions before the next meeting of the MICE Project Board on 14th November, 2013

Agenda:

Day One:

11:00 – Introduction, domestics, charge and agenda – A. Nichols

11:05 – MICE Overview, including magnetic configuration – A. Blondel

11:20 – Specification and history of the stray field issue – P. Smith

12:20 – Major items from the affected component list – A. MacWaters

12:45 – Lunch

13:30 – Overview of strategy – K. Long

14:00– PS Field mitigation steps presently being taken – J. Tarrant

14:35 – Partial return yoke overall concept of magnetic design – H. Witte

15:15 – Partial return yoke mechanical design – S. Plate (telephone conference)

15:45 – Coffee

16:15 – Review Committee session – Committee

16:45 – close

Day Two:

09:00 – Transport from Oxford to RAL

09:45 – Tour of MICE Hall – All

10:45 – Transport from RAL to Oxford

11:30 – Coffee

11:45 – Implementation of return yoke in R5.2 – J. Tarrant

12:15 – MM cost, schedule and risk analysis – A. Grant

12:45 - lunch

13:30 – ISIS equipment perspective – M. Hughes

14:00 – Questions and discussion – All

14:30 – Coffee

14:45 – Review Committee session

15:45 – Initial verbal feedback by Committee to MICE

16:15 - Close