Welcome and introduction

K. Long, 13 February, 2017

Plan

- **Progress since CM46 (Oct16)**
- **Planning for 2016/05 and 2017/01**
- **PPD review of MICE safety management**
- **Upgrade to demo**
- **Personnel**
- **Upcoming review**
- **Dates for your diary**
- **CM47**

Welcome and introduction

PROGRESS SINCE CM46

OCT16

Status at 06Oct16

Operations

- Cycle 2016/03 (14Sep—28Oct 2016):
  - Priority given to completing field-on, LiH scattering
  - Run plan posted at:
    - http://micewww.pp.rl.ac.uk/attachments/7308/2016-08-25_run-settings-v6.pdf
    - Continuing to take a conservative approach:
      - Commission to current/force sufficient for next measurement
    - Implies absorber change around 10Oct16
- Cycle 2016/04 (15Nov—16Dec 2016):
  - Keep LiH absorber in place
  - Complete scattering programme or move to study of reduction of normalised emittance
    - Requires settings that will generate larger forces
    - Decision to be taken over the coming month

Papers in progress

Title	Contact	Comment
Step IV physics		
First measurement of emittance in Step IV	V. Blackmore	Preliminary results made public. Results being finalised so publication can be prepared.
Measurement of scattering distributions in MICE	R. Bayes	Preliminary results made public. Results being finalised so publication can be prepared.
Ionization cooling demonstration		
Design and expected performance of the MICE demonstration of ionization cooling	J.B. Lagrange	Draft with collaboration. Paper being prepared for arXiv/journal

Title	Contact	Comment
Technical		
The design construction of the MICE Electron Muon Ranger	F. Drielsma	arXiv:1607.04955
The Reconstruction Software for the MICE Scintillating Fibre Trackers	A. Dobbs	Being prepared for arXiv/journal submission. One plot to be revised. Final editing pass underway
The MICE Analysis and User Software framework	D. Rajaram	In preparation

- Pressure:
  - Complete present publications
  - Bring forward technical contributions from last Cycle
    - Beam-based alignment
    - Verification of channel optics
  - Keep balls in the air for the field-on scattering programme

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Received: August 2, 20
Accepted: October 15, 20
Published: October 18, 20

TECHNICAL REPORT

The design and construction of the MICE Electron-Muon Ranger

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Abstract: The Electron-Muon Ranger (EMR) is a fully-active tracking-calorimeter installed in t beam line of the Muon Ionization Cooling Experiment (MICE). The experiment will demonstra ionization cooling, an essential technology needed for the realization of a Neutrino Factory and a Muon Collider. The EMR is designed to measure the properties of low energy beams compos of muons, electrons and pions, and perform the identification particle-by-particle. The detec consists of 48 orthogonal layers of 59 triangular scintillator bars. The readout is implemented usi FPGA custom made electronics and commercially available modules. This article describes t construction of the detector from its design up to its commissioning with cosmic data.

Keywords: Calorimeters; Front-end electronics for detector readout; Muon spectrometers; Partic tracking detectors

ArXiv ePrint: 1607.04955

[1] Corresponding author.

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doi:10.1088/1748-0221/11/10/T100

October 19, 2016 Muon Ionization Cooling Experiment

arXiv:1610.05161v2 [physics.ins-det] 18 Oct 2016

The reconstruction software for the MICE scintillating fibre trackers

A. Dobbs, C. Hunt, K. Long, E. Santos[1], M. A. Uchida
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Exhibition Road, London, SW7 2AZ, UK
P. Kyberd
Brunel University London, Kingston Lane, Uxbridge, Middlesex, UB8 3PH, U.K.
C. Heidt
University of California Riverside, 900 University Ave, Riverside, CA 92521, U.S.A.
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University of Sheffield, Western Bank, Sheffield, S10 2TN, U.K.

The Muon Ionization Cooling Experiment (MICE) will demonstrate the principle of muon beam phase-space reduction via ionization cooling. Muon beam cooling will be required for the proposed Neutrino Factory or Muon Collider. The phase-space before and after the cooling cell must be measured precisely. This is achieved using two scintillating-fibre trackers, each placed in a solenoidal magnetic field. This paper describes the software reconstruction for the fibre trackers: the GEANT4 based simulation; the implementation of the geometry; digitisation; space-point reconstruction; pattern recognition; and the final track fit based on a Kalman filter. The performance of the software is evaluated by means of Monte Carlo studies and the precision of the final track reconstruction is evaluated.

1 The MICE Experiment

1.1 Overview

The Muon Ionization Cooling Experiment (MICE) will perform a practical demonstration of muon ioniza cooling. Cooling refers to a reduction in the emittance of a beam, that is, the reduction of the phase-s volume occupied by the beam. Beam cooling is required for any future facility based on high intensity m beams, such as a Neutrino Factory [1], the ultimate tool to study leptonic CP-invariance violation, or a M Collider [2], a potential route to multi-TeV lepton – anti-lepton collisions. Muon beams are generated via decay, and therefore have a large emittance, which must be reduced so that a reasonable fraction of the b will fall within the acceptance of the downstream acceleration system.

The short muon lifetime requires fast beam cooling that traditional techniques are unable to provide. ization cooling was proposed in the early 1970s [3, 4], but has not yet been demonstrated at the energie interest for the Neutrino Factory or Muon Collider. Ionization cooling reduces emittance by passing a b through some suitable material of low atomic-number such as liquid hydrogen. This leads to the reduction c components of momentum due to ionization energy loss. Low atomic number absorbers are preferred bec they minimise multiple scattering which "heats" the beam.

[1] Now at Winton Capital Management
[2] Now at Deutsches Elektronen-Synchrotron

January 24, 2017 Muon Ionization Cooling Experiment RAL-P-2017-002

arXiv:1701.06403v1 [physics.acc-ph] 23 Jan 2017

Design and expected performance of the MICE demonstration of ionization cooling

The MICE collaboration

Muon beams of low emittance provide the basis for the intense, well-characterised neutrino beams necessary to elucidate the physics of flavour at a neutrino factory and to provide lepton-antilepton collisions at energies of up to several TeV at a muon collider. The international Muon Ionization Cooling Experiment (MICE) aims to demonstrate ionization cooling, the technique by which it is proposed to reduce the phase-space volume occupied by the muon beam at such facilities. In an ionization-cooling channel, the muon beam passes through a material in which it loses energy. The energy lost is then replaced using RF cavities. The combined effect of energy loss and re-acceleration is to reduce the transverse emittance of the beam (transverse cooling). A major revision of the scope of the project was carried out over the summer of 2014. The revised experiment can deliver a demonstration of ionization cooling. The design of the cooling demonstration experiment will be described together with its predicted cooling performance.

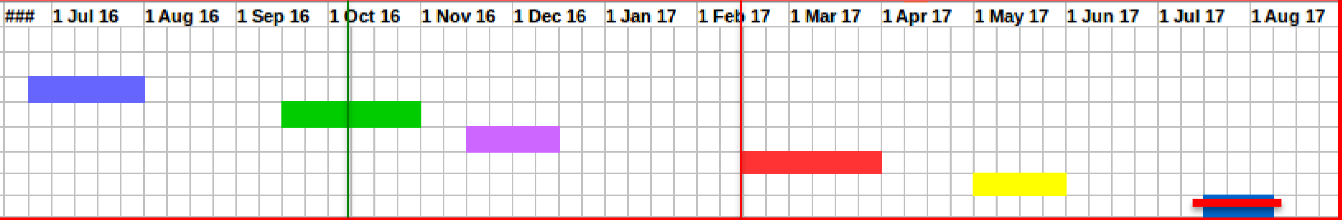
1 Introduction

Stored muon beams have been proposed as the source of neutrinos at a neutrino factory [1, 2] and as the means to deliver multi-TeV lepton-antilepton collisions at a muon collider [3, 4]. In such facilities the muon beam is produced from the decay of pions generated by a high-power proton beam striking a target. The tertiary muon beam occupies a large volume in phase space. To optimise the muon yield while maintaining a suitably small aperture in the muon-acceleration system requires that the muon beam be "cooled" (i.e., its phase-space volume reduced) prior to acceleration. A muon is short-lived, decaying with a lifetime of 2.2 μs in its rest frame. Therefore, beam manipulation at low energy ($\lesssim 1$ GeV) must be carried out rapidly. Four cooling techniques are in use at particle accelerators: synchrotron-radiation cooling [5]; laser cooling [6, 7, 8]; stochastic cooling [9]; and electron cooling [10]. Synchrotron-radiation cooling is observed only in electron or positron beams, owing to the relatively low mass of the electron. Laser cooling is limited to certain ions and atomic beams. Stochastic cooling times are dependent on the bandwidth of the stochastic-cooling system relative to the frequency spread of the particle beam. The electron-cooling time is limited by the available electron density and the electron-beam energy and emittance. Typical cooling times are between seconds and hours, long compared with the muon lifetime. Ionization cooling proceeds by passing a muon beam through a material, the absorber, in which it loses energy through ionization, and subsequently restoring the lost energy in accelerating cavities. Transverse and longitudinal momentum are lost in equal proportions in the absorber, while the cavities restore only the momentum component parallel to the beam axis. The net effect of the energy-loss/re-acceleration process is to decrease the ratio of transverse to longitudinal momentum, thereby decreasing the transverse emittance of the beam. In an ionization-cooling channel the cooling time is short enough to allow the muon beam to be cooled efficiently with modest decay losses. Ionization cooling is therefore the technique by which it is proposed to cool muon beams [11, 12, 13]. This technique has never been demonstrated experimentally and such a demonstration is essential for the development of future high-brightness muon accelerators.

The international Muon Ionization Cooling Experiment (MICE) collaboration proposes a two-part process to perform a full demonstration of transverse ionization cooling. First, the "Step IV" configuration [14] will be

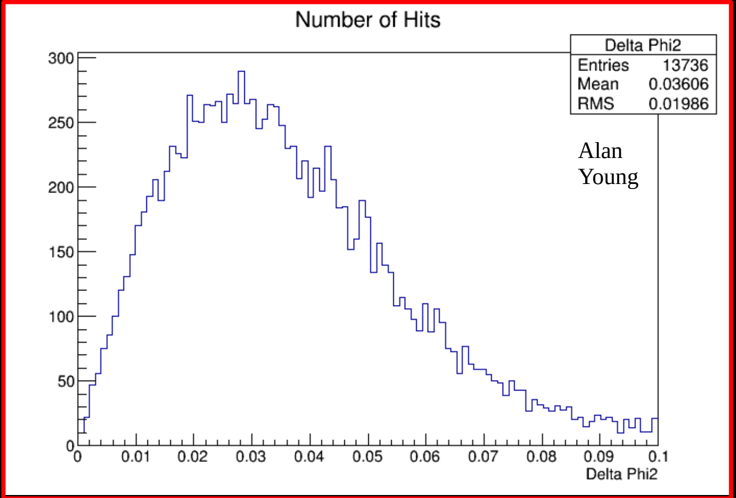
October ‘16 to February ‘17

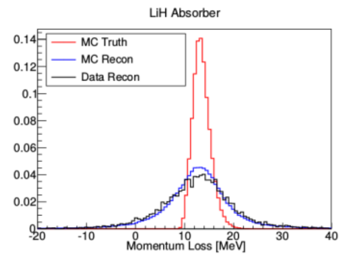
ISIS Cycle	Date From	Date To	# Days
2015/04	16 Feb 16	25 Mar 16	46
2016/01	12 Apr 16	20 May 16	38
2016/02	28 Jun 16	29 Jul 16	31
2016/03	13 Sep 16	28 Oct 16	45
2016/04	15 Nov 16	16 Dec 16	31
2016/05	14 Feb 17	31 Mar 17	45
2017/01	2 May 17	2 Jun 17	31
2017/02	11 Jul 17	4 Aug 17	24

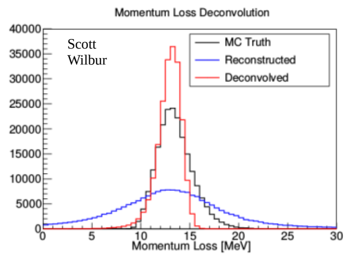


- Cycles:
  - 2016/03:
    - Completed LiH field-on data taking
    - MICE Muon Beam tuning
    - Effect of diffuser studied
  - 2016/04:
    - More MICE Muon Beam tuning
    - Study of emittance evolution with LiH in solenoid mode
- Excellent performance:
  - “Over delivered” on data taking promises!

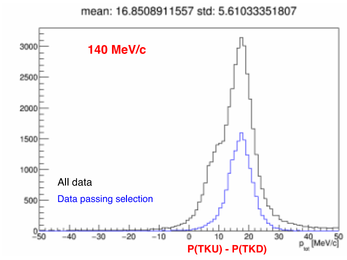
Highlights

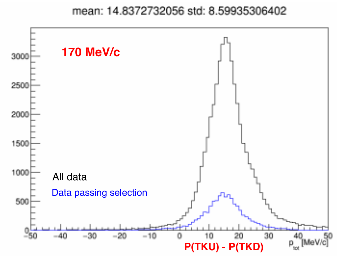


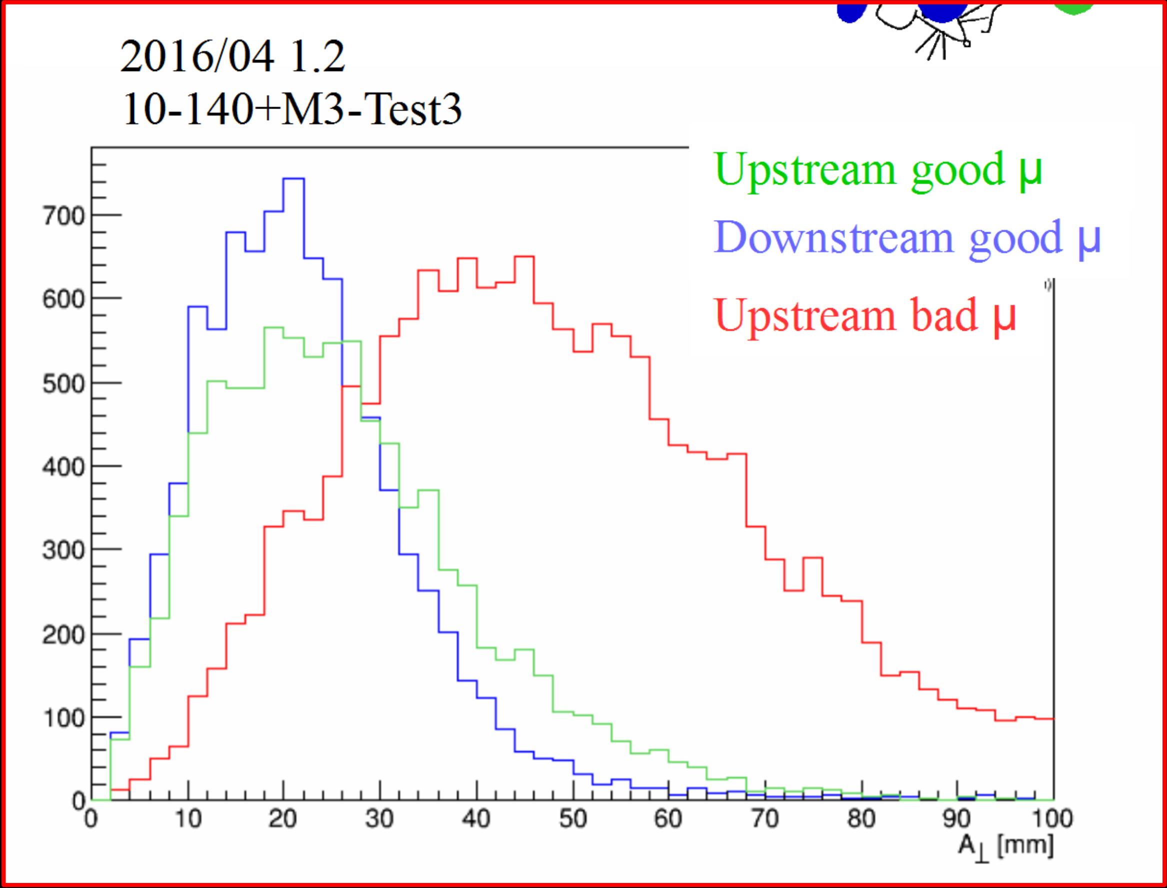




Data taken 25Oct16







Papers

Papers in progress

Title	Contact	Comment
Step IV physics		
First measurement of emittance in Step IV	V. Blackmore	**Preliminary results made public.** Results being finalised so publication can be prepared.
Measurement of scattering distributions in MICE	R. Bayes	**Preliminary results made public.** Work continues following meeting with referees.
Ionization cooling demonstration		
Design and expected performance of the MICE demonstration of ionization cooling	J.B. Lagrange	**arXiv:1701.06403; submitted to PRAB**

Step IV field-on papers

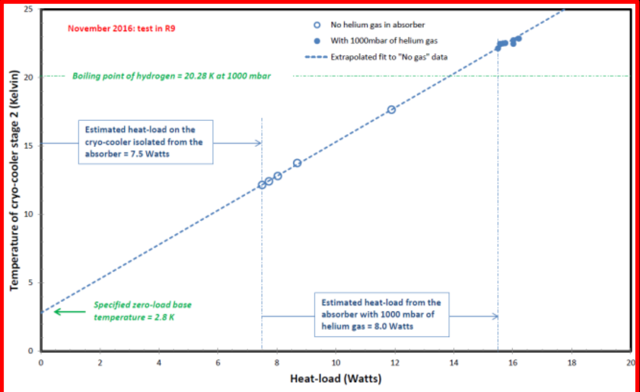
Title	Contact	Comment
Step IV physics		
Field-on measurement of multiple Coulomb scattering	A. Young	Analysis underway
Measurement of energy-loss distributions	S. Wilbur	Analysis underway
Beam-based alignment	A.N. Other	Analsis underway
Emittance reconstruction	A.N. Other	Analsis underway
Emittance evolution; rapid communication	A.N. Other	Analsis underway
Emittance evolution review paper	A.N. Other	Analsis underway

- Completion of "milestsone papers" will require completion of a number of detailed analyses, e.g.:
  - Transfer matrix approach to magnetic alignment;
  - Study of effect of non-linear terms in the Hamiltonian (field) expansion;
- Each of these analysis may warrant a paper of its own.

Papers in progress

Title	Contact	Comment
Technical		
The MICE Analysis and User Software framework	D. Rajaram	**In preparation**

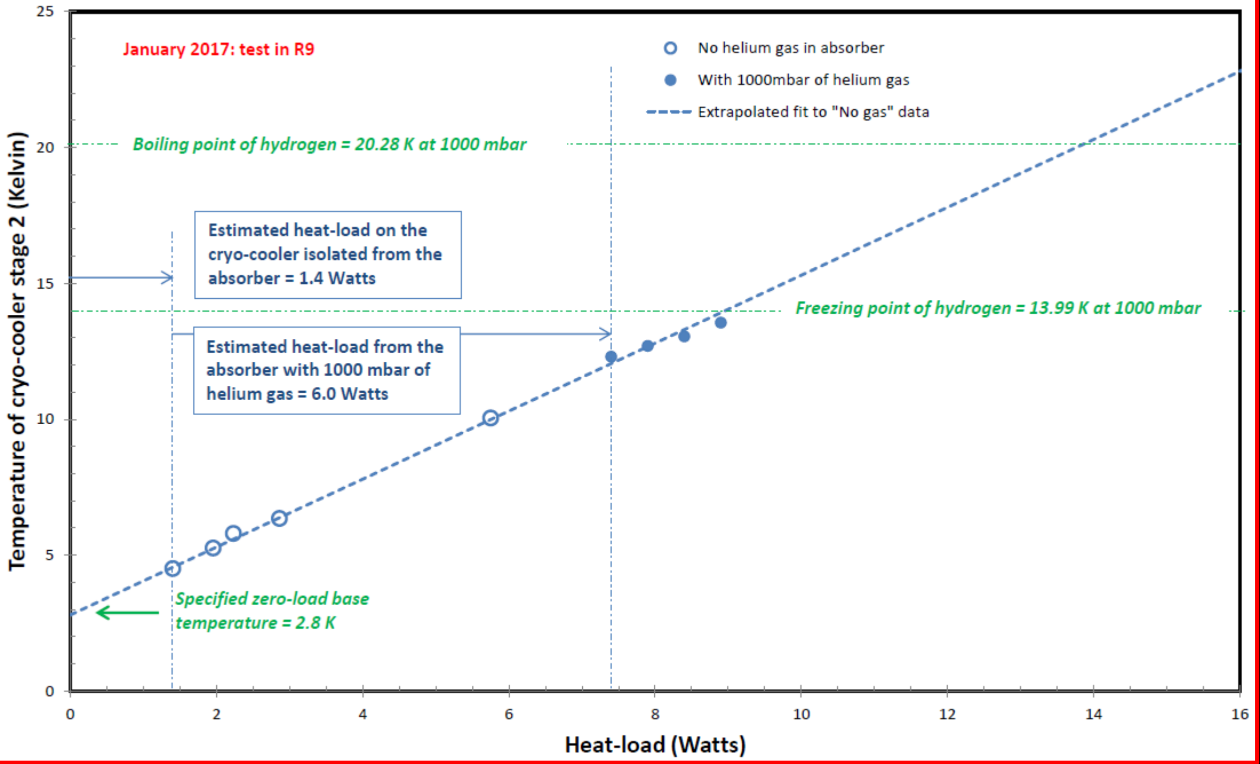
Liquid-hydrogen absorber



To cool the system to liquefy hydrogen, we need to reduce both the heat load through the turret and the heat load from the absorber.

- **Modifications:**
  - Redundant pipework removed
  - Radiation shield modified to increase critical clearance
  - Thermal shorts from 20K surfaces to room temperature removed
  - 50K thermal intercept installed
  - MLI on turret improved
  - Pre-cool pipework to absorber removed
  - Absorber pipework “pulled off” FC warm bore
  - Additional MLI on absorber windows

Cooldown Dec 16/Jan 17



Welcome and introduction

PLANNING FOR 2016/05 AND 2017/01

Scientific programme

Step IV:

Material properties of LH_2 and LiH that determine the ionization-cooling performance

Observation of $\epsilon_{\perp}^{n}$ reduction

MICE demonstration of ionization cooling:

Observation of $\epsilon_{\perp}$ reduction with re-acceleration

Observation of $\epsilon_{\perp}$ reduction and $\epsilon_{||}$ evolution

Observation of $\epsilon_{\perp}$ reduction and $\epsilon_{||}$ and angular momentum evolution†

† Requires systematic study of "flip" optics.

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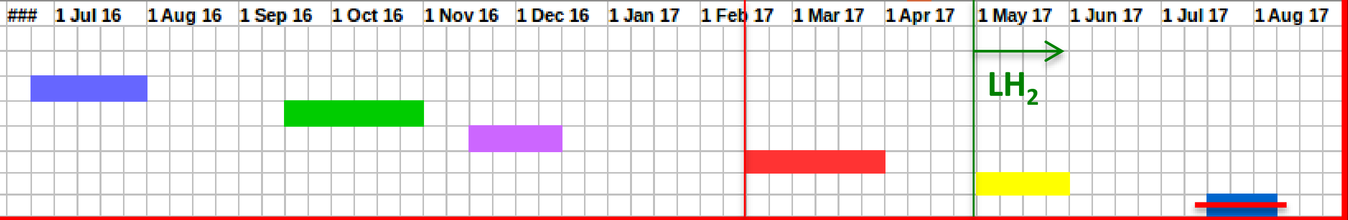


Preparation for Cycle 2016/05

- Focus coil commissioned in flip mode
  - Cycle 2016/05: emittance evolution in flip mode
- Spectrometer-magnet commissioning:
  - SSD rewired in flip mode
  - Cryogenically stable
  - Controls system revision now underway:
    - Magnets run to 15A to test stability and operation of QD/QP
    - Powering will recommence when CAM gremlins addressed

Run plan

- **2016/05:**
  - **First three weeks:**
    - **Flip-mode, emittance evolution (cooling) data taking**
    - **Initial settings have been defined by optics crew**
  - **Second three weeks:**
    - **Preparations for installation of liquid-hydrogen absorber**
- **2017/01:**
  - **Data taking with liquid hydrogen**
    - **Discussion in session …**
- **Replacement for cancelled 2017/02?**
  - **Request to replace lost cycle will be made at the next RLSR/MPB**

Welcome and introduction

PPD REVIEW OF MICE SAFETY MANAGEMENT

Safety

- Unexpected "autonomous" ramp resulted in "SOPS" review
- Outstanding actions:
  - Independent review of MICE Safety Management:
    - Carried out by PPD:
      - T. Durkin (PPD, Chair), S. Haywood (PPD), M. Van der Grinten (PPD), S. Crothers(RALSP), C. Foulkes-Williams (CSD)
    - One day:
      - Presentations, tour of MICE Hall, discussion
      - Addressed two "Serious or potentially serious incidents" and one procedural error
    - Awaiting formal feedback, informally:
      - Encouraged by MICE processes and appropriate and timely responses to incidents
  - Rolling review of MICE Controls and Monitoring …

Extract from terms of reference

Goal: either determine cause of the autonomous ramps, or give sufficient assurance that system is stable in operation

Background

Recently there have been a small number of incidences where a single power supply on one of the spectrometer solenoids has started to ramp to a current without a command from an operator. Such "autonomous" ramps put the integrity of the data-taking and the safety of the equipment in the MICE Hall at risk.

A number of measures have been taken to reduce or remove the risk of another autonomous ramp. The magnet controls have been modified to limit the instructions that can be sent to the magnet power supplies and to provide two levels of confirmation for an instruction to ramp. In addition, the shift crew make regular checks of the status of the magnet power supplies which are logged on paper.

The present review is being carried out at a time when the principal author of the "user layer" of the MICE controls and monitoring code may be preparing to move to a new job. Therefore the review must be conducted with a view to ensuring the continued maintenance and development of the system for the duration of the experiment.

Process

Initial investigation of possible causes of the autonomous ramps have not identified the cause. It is therefore necessary to take an approach that scrutinises all levels of the system. The process for the rolling review will be an initial meeting in which the architecture, structure and philosophy of the system is presented. This will be followed by a targeted investigation of the individual components of the controls-and-monitoring system related to the powering of the superconducting magnets. The review will encompass the low-level code, networking and serial communications and the high-level code.

Constraint

Since MICE is now in production data taking for Step IV, the work of the rolling review must be carried out in such a way that the experiment is at all times ready to take data.

Charge

Execute a detailed investigation of the controls and monitoring code and the associated communication systems that control the power system for the superconducting magnets.

Documentation of review

- Meetings, actions and notes can be found at:
  - http://micewww.pp.rl.ac.uk/projects/memo/wiki#Reviews
- Issues addressed include:
  - Conditions under which “stale values” may arise
  - Serial communications
  - Command set (including monitoring commands)
  - Expert-user dialogue
- Review process successful:
  - Now working towards concluding the review

Draft conclusions

- It was possible for “stale” values” to be left in the “SET VALUE” register such that a subsequent “RAMP” command would generate a ramp to an “unsolicited” current

- This could have caused the autonomous ramp

- Mitigations:
  - Command set reduced
  - “SET CURRENT” set to 0A on open or close of contactors
- Additional experience:
  - Running of power supplies for two User Cycles has not shown additional issues
- No single action can enable a ramp
  - 3 actions required to initiate ramp:
    - So reduced probability of a future incident

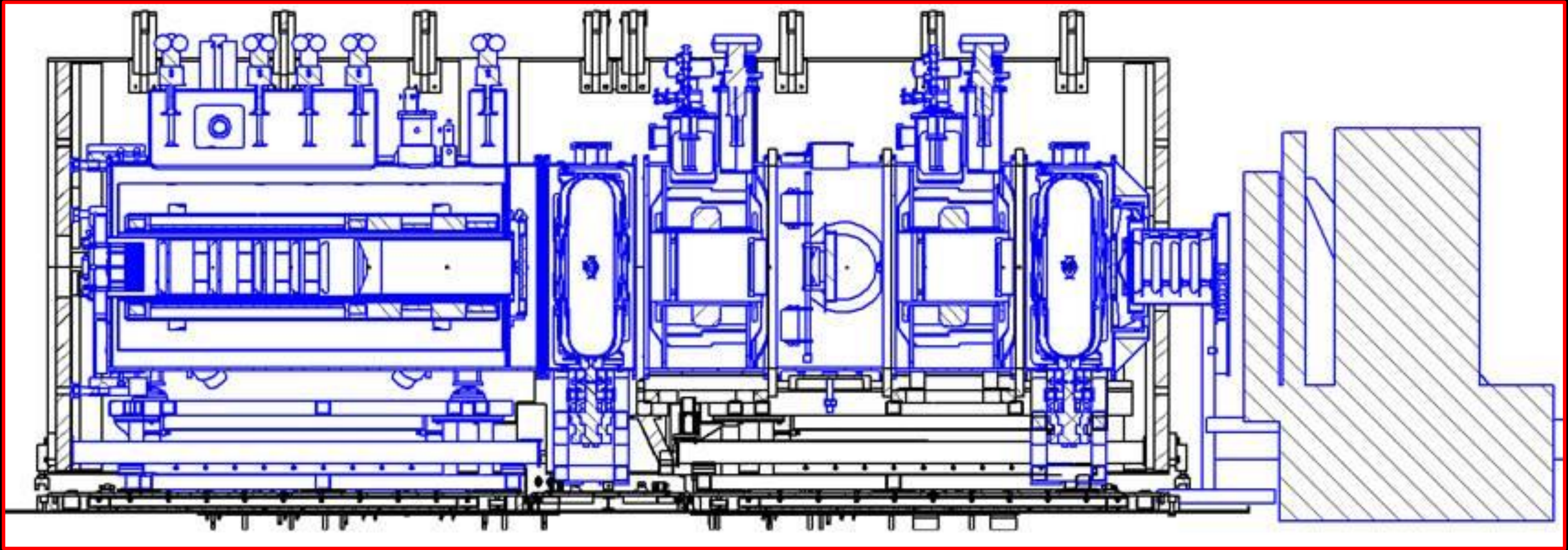
Welcome and introduction

UPGRADE TO DEMO

Risk mitigation and upgrade to demo

- Noted at MICE-UK Oct16 OsC:
  - Risk to scientific programme if
    - Remedial work on LH2 system failed; and/or
    - SSD failed
- Initiated cost-neutral steps towards upgrade to Step IV to deliver a demonstration of ionization cooling
  - NIKHEF have made pieces for reconfigured tracker
  - Layout complete; optimisations underway
  - Cost and schedule analysed (CW)
- New interest:
  - FREIA Laboratory (T. Ekelof et al) in Uppsala may be interested to participate, perhaps as part of a wider collaboration on RF development with RAL
  - UNIST (Korea) will apply to join MICE at CM47 to take part in the demo
- International perspective:
  - International collaboration signed up for, and were funded for, demonstration of ionisation cooling
  - All have incurred additional cost as a result of delays
  - Pressure to complete the programme
- Proposal:
  - Upgrade Step IV to deliver demonstration to be brought forward at the time of MPB

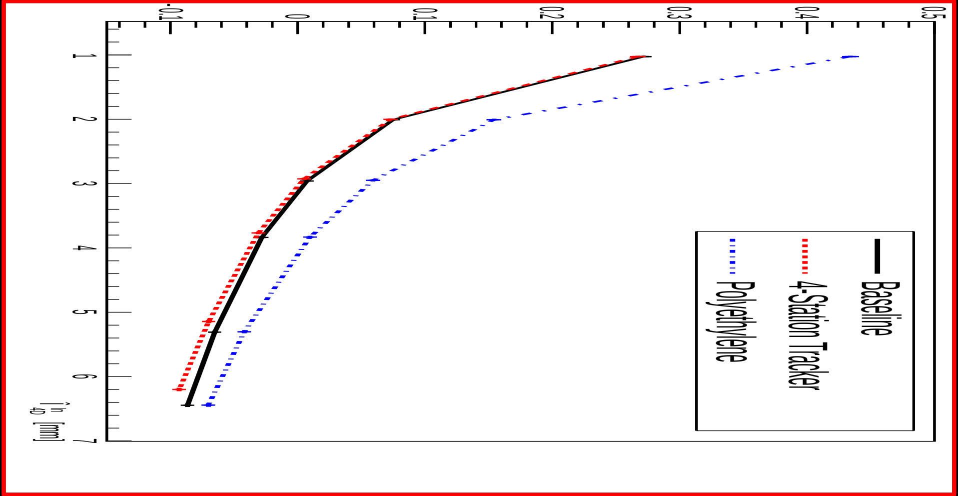
Upgraded configuration

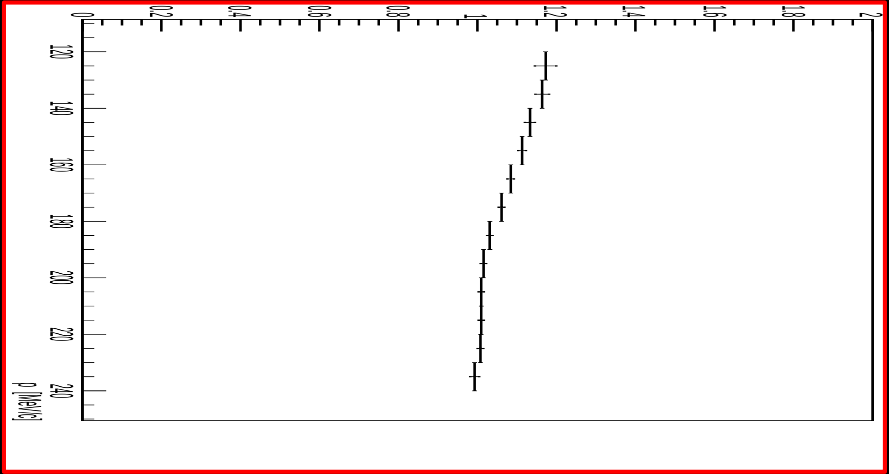


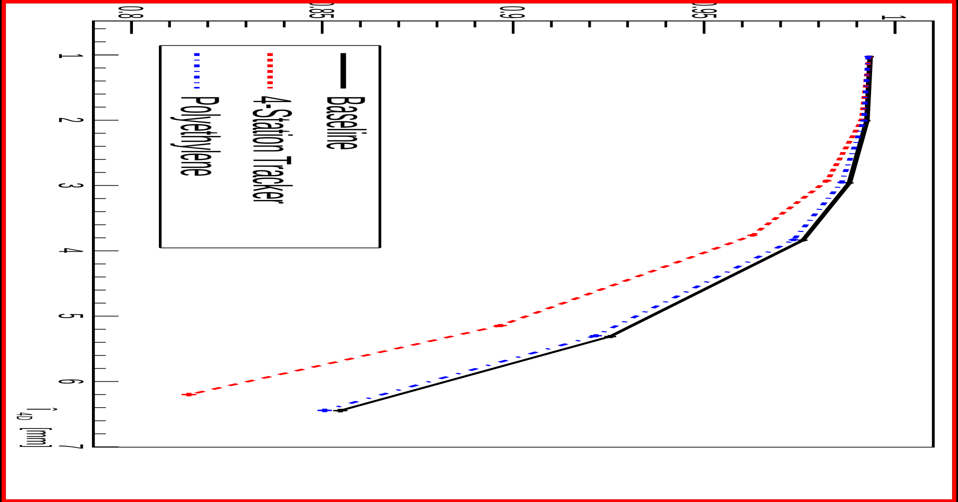
J. Tarrant

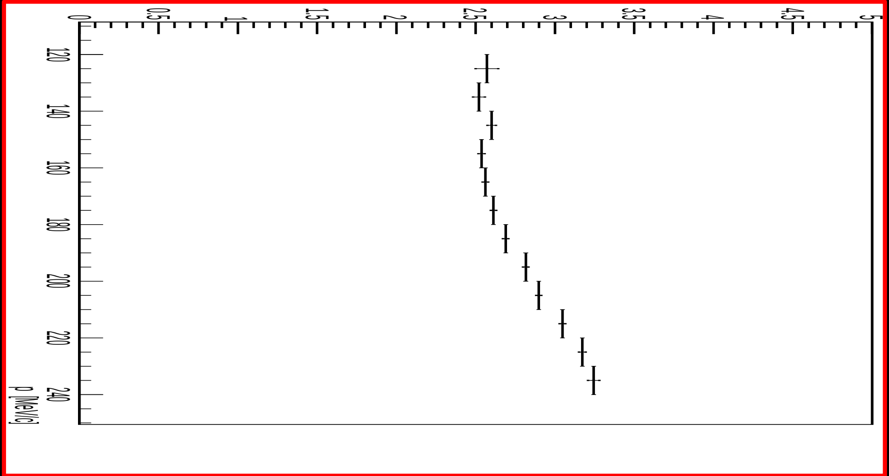
Performance

A.Dobbs, C.Hunt,
J.Pasternak et al.









Welcome and introduction

PERSONNEL

Personnel changes

- Controls and Monitoring Coordinator:
  - P. Hanlet has left for Tokamac Energy
    - Congratulations to Pierrick! (and Tokamak Energy)
    - Pierrick has done so much for MICE …
      - Wish him the very best going forward …
  - A. Kurup has taken over as Controls Coordinator
- Integration Scientist:
  - P. Hodgson has taken over from P. Hanlet
- Online coordinator:
  - E. Overton has taken over from Y. Kharadzhov

Welcome and introduction

UPCOMING REVIEW

International review of project

- Resource Loaded Schedule Review: 07Mar17
- MICE Project Board: 07—08Mar17
- Funding Agency Committee: 08Mar17

Welcome and introduction

DATES FOR YOUR DIARY

Dates for your diary

- **CERN Physics Beyond Colliders workshop:**
  - nuSTORM at CERN: a work package in the workshop
  - A first meeting to discuss how to proceed:
    - 16Feb17; 13:00—16:00 GMT at Imperial College London
      - Teleconferencing facilities will be provided

- **IPPP/NUSTEC topical meeting on neutrino cross sections:**
  - HEP and nuclear experimenters, phenomenologists and theorists … and lattice QCD experts
  - Will take place in Durham 18—20 April 2017
  - Goals of the meeting will include initiation of discussion of:
    - Scientific programme for HEP, nuclear, QCD, structure of matter …
    - Experimental programme, i.e. what experiments/facilities are required
      - Test case for nuSTORM among the relevant peer group through this process

First discussion of nuSTORM in the context of the Physics Beyond Colliders workshop

Thursday 16 Feb 2017, 13:00 → 16:00 Europe/London

Seminar Room 109 (Sir Alexander Fleming Building, Imperial College London)

Kenneth Richard Long (Imperial College (GB))

https://indico.cern.ch/event/606246/

Description

The physics potential of nuSTORM was presented in the September 2016 "Physics Beyond Colliders" (PBC) workshop kick-off meeting. A work-package has been created in the PBC workshop to consider the feasibility of implementing nuSTORM in the North Area at CERN and to evaluate its performance.

The meeting will review briefly the neutrino physics of nuSTORM and the work that has been done to date on its design. Time has been set aside in the agenda of the meeting for the discussion of the studies to be pursued in the context of the PBC workshop.

Please make your way to the Exhibition Road entrance of Imperial College London. The Sir Alexander Fleming (SAF) building is located on the road that leads from entrance to the College on the left-hand side. It is a large, modern glass structure. Please see the map of the College below.

To reach Seminar Room 109, enter the SAF building and go up the short flight of stairs directly opposite the entrance. Walk to the end of the mezzanine. Seminar Room 109 is located on the right hand side towards the end of the passage.

The times in the agenda below are local times; i.e. all times are in GMT.

Phone conference details for remote participants are listed in the second attachment below.

Map-of-South-Kensin... Phone-details.pdf

Registration

This event is open to new participants. Register

Participants

Alan David Bross, Ao Liu, Jingyu Tang, Matheus Hostert, Mike Lamont, Paul Kyberd, Peter Sievers, Yoshiharu Mori

IPPP/NuSTEC topical meeting on neutrino-nucleus scattering

http://conference.ippp.dur.ac.uk/event/583/

18-20 April 2017
Europe/London timezone

IPPP Durham

Search

- Overview
- Timetable
- Contribution List
- Accommodation
- Travel Information

Support

l.a.wilkinson@durham...

Neutrino-nucleus scattering is a critical input to present and future neutrino experiments. Uncertainties related to νA cross sections make a substantial contribution to the systematic-error budgets of, for example, T2K and NOνA, while hadronisation uncertainties need to be addressed in sterile-neutrino-search experiments such as MicroBooNE.

The future sensitivity of DUNE and Hyper-K will be no less sensitive to our understanding of νA scattering. The statistical weight of the data sets collected by each of these experiments will be such that uncertainties on the cross-section themselves and the uncertainty on the ν_e A to ν_μ A cross-section ratio must be reduced to the percent level. Such precise knowledge is required not only to manage the overall systematic uncertainty but also to avoid biases in the oscillation parameters extracted from the data. Evidence for CP-invariance violation (CPiV) will be sought by measuring the rate of ν_e appearance in a ν_μ beam. Therefore, a lack of understanding of ν_e A scattering will be a pernicious source of bias or uncertainty in the interpretation of any evidence for CPiV.

The measurement, theoretical understanding and phenomenological description of νA scattering are each challenging. To understand νA scattering in sufficient detail for the future neutrino-physics programme to reach its full potential will require the effective collaboration of experimenters, theorists and phenomenologists. Indeed, in the energy range of interest, the combined expertise of nuclear and particle theorists and phenomenologists will be required. Such a collaboration is also likely to generate new insights into long-range QCD and nuclear phenomena.

The goals of the workshop will be to:

- Take stock of the current status of , νA scattering data, the nuclear and particle theory through which it is understood and the phenomenological description of the cross sections and hadronic final states;
- Discuss the programme of measurement, theory and phenomenology required to develop an understanding commensurate with the future neutrino-physics programme; and to
- Evaluate the path towards "global fits" that can be used to make reliable predictions of neutrino-nucleus scattering.

The workshop will be organised jointly by the IPPP and NuSTEC and will include discussion, and appropriate development, of the NuSTEC white paper on neutrino scattering. The desired output of the workshop is a short document in which the status of the field is briefly reviewed and the way forward — experimental, theoretical and phenomenological — is outlined.

Welcome and introduction

CM47

MICE CM47

13-15 February 2017
RAL
Europe/London timezone

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The 47th Muon Ionization Cooling Experiment (MICE) Collaboration Meeting will be held at the STFC Rutherford Appleton Laboratory, Harwell Oxford Campus, Oxfordshire from 13 to 15 February 2017 inclusive

Registration £45.00

Collaboration Dinner £35.00

Starts 13 Feb 2017 08:55
Ends 15 Feb 2017 17:00
Europe/London

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