Welcome and introduction

K. Long, 12 October, 2018

Status of MICE

PAPERS

PREPARED FOR SUBMISSION TO JINST

The liquid-hydrogen absorber for MICE

MICE collaboration

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ABSTRACT: The Muon Ionization Cooling Experiment (MICE) has been built at the STFC Rutherford Appleton Laboratory to demonstrate the principle of muon beam phase-space reduction via ionization cooling. Muon beam cooling will be required at a future proton-derived neutrino factory or muon collider. Ionization cooling is achieved by passing the beam through an energy-absorbing material, such as liquid hydrogen, and then re-accelerating the beam using RF cavities. This paper describes the hydrogen system constructed for MICE including: the liquid-hydrogen absorber, its associated cryogenic and gas systems, the control and monitoring system, and the necessary safety engineering. The performance of the system in cool-down, liquefaction, and stable operation is also presented.

KEYWORDS: Accelerator subsystems and technologies, Beam optics, Gas systems and purification

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Journal of Instrumentation

The liquid-hydrogen absorber for MICE

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+ Article information

Abstract

The Muon Ionization Cooling Experiment (MICE) has been built at the STFC Rutherford Appleton Laboratory to demonstrate the principle of muon beam phase-space reduction via ionization cooling. Muon beam cooling will be required at a future proton-derived neutrino factory or muon collider. Ionization cooling is achieved by passing the beam through an energy-absorbing material, such as liquid hydrogen, and then re-accelerating the beam using RF cavities. This paper describes the hydrogen system constructed for MICE including: the liquid-hydrogen absorber, its associated cryogenic and gas systems, the control and monitoring system, and the necessary safety engineering. The performance of the system in cool-down, liquefaction, and stable operation is also presented.

Export citation and abstract BibTeX RIS

Preprint typeset in JINST style - HYPER VERSION

MAUS: The MICE Analysis User Software

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ABSTRACT: The Muon Ionization Cooling Experiment (MICE) collaboration has developed the MICE Analysis User Software (MAUS) to simulate and analyze experimental data. It serves as the primary codebase for the experiment, providing for offline batch simulation and reconstruction as well as online data quality checks. The software provides both traditional particle-physics functionalities such as track reconstruction and particle identification, and accelerator physics functions, such as calculating transfer matrices and emittances. The code design is object orientated, but has a top-level structure based on the Map-Reduce model. This allows for parallelization to support live data reconstruction during data-taking operations. MAUS allows users to develop in either Python or C++ and provides APIs for both. Various software engineering practices from industry are also used to ensure correct and maintainable code, including style, unit and integration tests, continuous integration and load testing, code reviews, and distributed version control. The software framework and the simulation and reconstruction capabilities are described.

KEYWORDS: MICE; Ionization Cooling; Software; Reconstruction; Simulation.

Almost final draft prepared — check and submit!

Direct measurement of emittance in the Muon Ionization Cooling Experiment

MICE collaboration

The Muon Ionization Cooling Experiment (MICE) seeks to demonstrate the feasibility of ionization cooling, the technique by which it is proposed to cool the muon beam at a future neutrino factory or muon collider. The emittance is measured from an ensemble of muons assembled from those that pass through the experiment. A pure muon ensemble is selected using a particle-identification system that can reject efficiently both pions and electrons. The position and momentum of each muon is measured using a high-precision scintillating-fibre tracker in a 4 T solenoidal magnetic field. This paper presents the techniques used to reconstruct the phase-space distributions and reports the emittance of the muon beam as a function of muon-beam momentum.

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 for a neutrino factory, and luminosity for a muon collider, 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. An alternative approach to the production of low-emittance muon beams through the capture of $\mu^+\mu^-$ pairs close to threshold in electron–positron annihilation has recently been proposed [5]. To realise the luminosity required for a muon collider using this scheme requires the substantial challenges presented by the accumulation and acceleration of the intense positron beam, the high-power muon-production target, and the muon-capture systems to be addressed.

A muon is short-lived, with a lifetime of 2.2 μs in its rest frame. Beam manipulation at low energy ($\leq$ 1 GeV) must be carried out rapidly. Four cooling techniques are in use at particle accelerators: synchrotron-radiation cooling [6]; laser cooling [7–9]; stochastic cooling [10]; and electron cooling [11]. In each case, the time taken to cool the beam is long compared to the muon lifetime. In contrast, ionization cooling is a process that occurs on a short timescale. A muon beam passes through a material (the absorber), loses energy, and is then re-accelerated. This cools the beam efficiently with modest decay losses. Ionization cooling is therefore the technique by which it is proposed to increase the number of particles within the downstream acceptance for a neutrino factory, and phase-space density for a muon collider [12–14]. This technique has never been demonstrated experimentally and such a demonstration is essential for the development of future high-brightness muon accelerators.

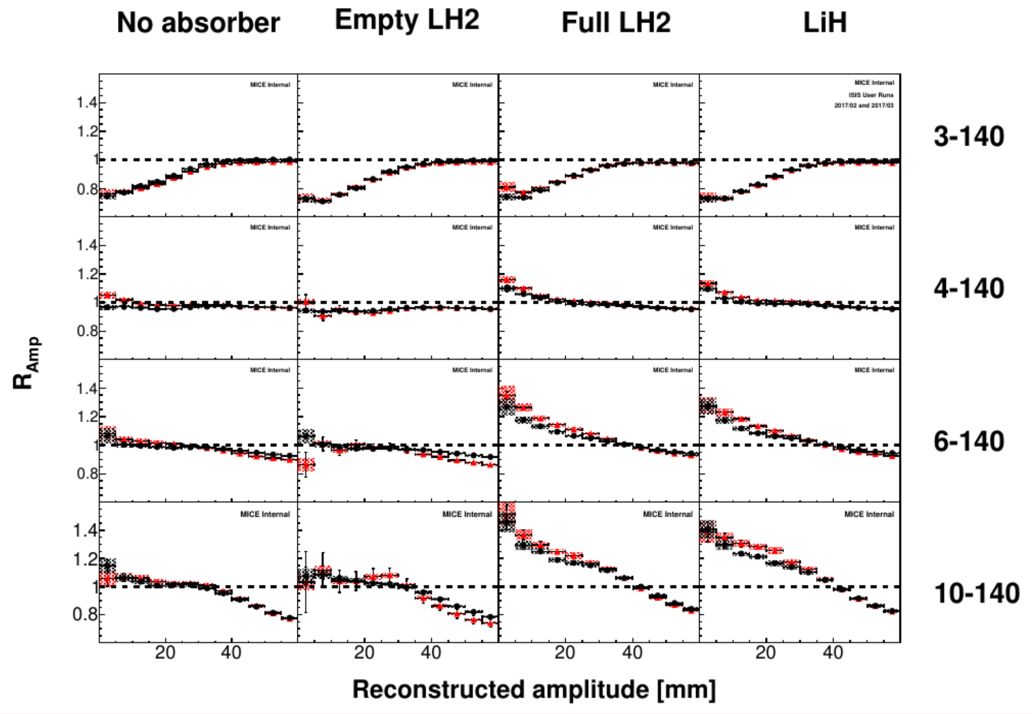
The international Muon Ionization Cooling Experiment (MICE) has been designed [15] to perform a full demonstration of transverse ionization cooling. Intensity effects are negligible for most of the cooling channels conceived for the neutrino factory or muon collider [16]. This allows the MICE experiment to record muon trajectories one particle at a time. The MICE collaboration has constructed two solenoidal spectrometers, one placed upstream, the other downstream, of the cooling cell. An ensemble of muon trajectories is assembled offline, selecting an initial distribution based on quantities measured in the upstream particle-identification detectors and upstream spectrometer. This paper describes the techniques used to reconstruct the phase-space

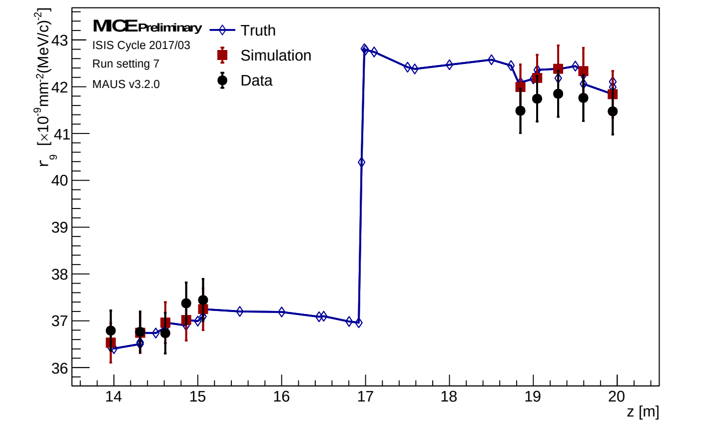
Updated to include 'hybrid MC' to account for magnetic-field alignment

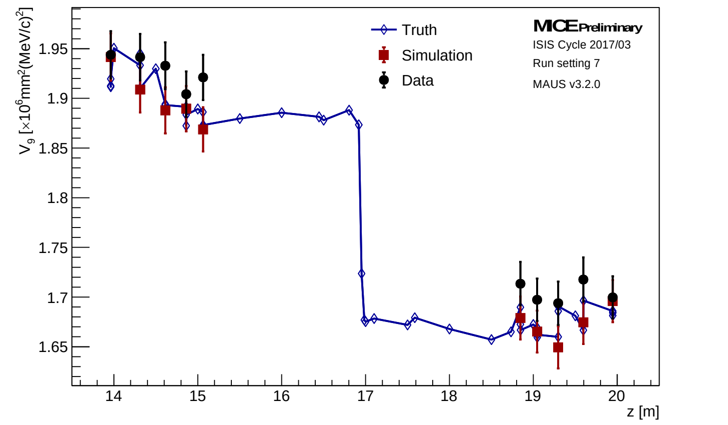
New & updated

- Emittance evolution paper:
  - Rogers et al: proceeding to paper
    - First referees’ meeting last week
- LiH scattering paper:
  - Nugent et al:
    - Ongoing alignment and unfolding issues (systematics limited measurement)
- System performance paper:
  - Franchini et al: Expecting first full draft at CM next week
- Field-on scattering:
  - Young et al:
    - In progress
- Emittance exchange (wedge absorber):
  - Mohayai et al:
    - Thesis published on KDE analysis; paper to be picked up by C. Brown
- Emittance measurement:
  - Blackmore, Hunt et al: Paper has been circulated around collaboration twice
    - Circulate after final check today; one week for final comments

Cooling: rapid communication







Papers

		12-Oct-18	v9	
Title	**Contact**	**Target date**		**Comment**
		Final	**Preliminary**	**Oct-18**
Direct measurement of emittance using the MICE scintillating-fibre tracker	V. Blackmore	Jun18 CM51		Final draft to collaboration NOW!
The MICE liquid-hydrogen absorber	C. Whyte/J. Boehm	Jun-18	Apr18 w/s	Publishhed in JINST
The MICE Analysis and User Software framework	D. Rajaram	Jun18 CM51	May18 w/s	Draft circulated; final draft almost ready for submission
Phase-space density/emittance evolution; rapid communication	C. Rogers	Jun18 CM51	Apr18 w/s	First referees meeting 03Oct18
Measurement of multiple Coulomb scattering of muons in lithium hydride	J. Nugent	Jun18 CM51?		**Alignment and unfolding issues**
Performance of the MICE diagnostic systems	S. Wylbur/P. Franchini		Jun-18	First full draft CM52 (12Oct18)
Beam-based alignment	C. Hunt		Jun-18	
Muon Ionization Cooling Experiment (h/w)	C. Whyte/P. Franchini		Jun-18	C. Whyte pushing for draft
Phase-space density/emittance evolution review paper	C. Hunt			
Phase-space density/KDE/6D-emittance evolution	T. Mohayai		Jun-18	Thesis published on initial analysis
Measurement of multiple Coulomb scattering of muons in LH2	J. Nugent			Awaits completion of LiH paper
Field-on measurement of multiple Coulomb scattering	A. Young			Initiated

Status of MICE

DECOMMISSIONING

Equipment and office

- Essentially complete
  - All equipment repatriated, scrapped or left in place
  - Walk the Hall with Colin and John to check!
    - More details from CW

- Office in R1:
  - In anticipation of request to reduce footprint:
    - We need to execute a clear out … so … please:
      - During *THIS* collaboration meeting, please check and collect anything you wish to be saved and take it with you … or … put it in one of the red boxes John Govans has provided so that it can be archived
      - We'll then organise the clear out!

Status of MICE

UPDATE

Staffing

- STFC SPD support to bring D.Rajaram back into project
  - Excellent — welcome back!
    - DR ‘super-post-doc’; directed at key analysis bottle necks
- P.Franchini, S/w&C Coordinator:
  - Handover planning underway

Status of MICE

MUON COLLIDER W/G

MICE CM52

9-13 October 2018
Other Institutes
Europe/London timezone

Search...

Timetable

Tue 09/10 | Wed 10/10 | **Thu 11/10** | Fri 12/10 | Sat 13/10 | All days

Print | PDF | Full screen | Detailed view | Filter

Session legend

14:00	**Welcome and introduction**	*Kenneth Richard Long*	*Other Institutes*	14:00 - 14:10
	Proton-based muon collider and neutrino factory: status, options and R&D needs	*Dr Mark Palmer*	*Other Institutes*	14:10 - 14:35
	Positron-based muon collider: overview, issues and R&D needs	*Manuela Boscolo*	*Other Institutes*	14:35 - 15:05
15:00	**Ionization cooling; recent results from MICE; implications for neutrino factory and muon collider schemes**	*Chris Rogers*	*Other Institutes*	15:05 - 15:30
	Refreshment break: Coffee		*Other Institutes*	15:30 - 16:00
16:00	**nuSTORM: physics and detectors**	*Paul Soler Jermyn*	*Other Institutes*	16:00 - 16:25
	nuSTORM: accelerator design and status of PBC study	*Jaroslaw Pasternak*	*Other Institutes*	16:25 - 16:50
	Muon collider compared to other options for the high-energy programme	*Jean-Pierre Delahaye*	*Other Institutes*	16:50 - 17:10
17:00	**High-brightness muon beams for particle physics: review of opportunities**	*Alain Blondel*	*Other Institutes*	17:10 - 17:30
	Discussion		*Other Institutes*	17:30 - 18:00

February 2018

European Strategy Update

Contact:
EPPSU-Strategy-Secretariat@cern.ch

Guidelines for submitting input for the 2020 update of the European Strategy for Particle Physics

Cover page (1 page)
Each document submitted should carry a single cover page containing no more than the title, the contact person(s) and an abstract.

Comprehensive overview (maximum 10 pages)
This core part of the document must be no more than 10 pages long (excluding the cover page) and must provide a comprehensive and self-contained overview of the proposed input. It should address:

- scientific context,
- objectives,
- methodology,
- readiness and expected challenges.

Addendum
A separate addendum is to be provided addressing the following topics (where relevant):

- interested community,
- timeline,
- construction and operational costs (if applicable),
- computing requirements.

Format and deadline for submission
The cover page and the comprehensive overview are to be submitted as a single file, the "main document", in portable document format (pdf) by 18 December 2018. The addendum is to be submitted as a separate file by the same deadline. A dedicated submission portal will be available on the EPPSU website as of October 2018, once the Strategy update has been formally launched by the Council at its September 2018 Session. The link to the EPPSU website will appear on the CERN Council's web pages - https://council.web.cern.ch/en - and be widely communicated through the appropriate channels.

Distribution
Both documents submitted (main and addendum) will be passed on to the Physics Preparatory Group (PPG) and the European Strategy Group (ESG). Unless explicitly requested otherwise, they will also be made public. The option not to make either document public will be available upon submission via the dedicated portal.

Deadline 18Dec18; submission to process?

MICE CM52

9-13 October 2018
Other Institutes
Europe/London timezone

Search...

Phone-bridge details are to be found at: http://mice.iit.edu/phonebridge.html

Overview
Scientific Programme
Timetable
Contribution List
Registration
Participant List

The 52nd Muon Ionization Cooling Experiment (MICE) Collaboration Meeting will be held at the Rutherford Appleton Laboratory from Thursday 11th October to Saturday 13th October 2018 inclusive.

The MICE Analysis will preceed this and will be held on the 9th and 10th October 2018 in the PPD Meeting Room R1 2nd Floor.

Registration: £45 **Collaboration Dinner: £35**

Payment method: Overseas attendees cash only

If you haven't paid, please pay me (or Colin) in cash at coffee or lunch!

MICE Admin

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Starts 9 Oct 2018, 10:00
Ends 13 Oct 2018, 15:30
Europe/London

Other Institutes
Conference Rooms 12 and 13 Building R68
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www.stfc.ac.uk

Over to you!