Closing remarks

K. Long, 22 February, 2019

Papers

Title	Contact	Target date		Comments
		Preliminary	Final	Jan-19
Phase-space density/emittance evolution; rapid communication	C. Rogers	Apr18 w/s	Apr19	4th referees meeting before around CM53 (21, 22Feb19, RAL)
Measurement of multiple Coulomb scattering of muons in lithium hydride	J. Nugent	Jun18; CM51	Apr19	Unfolding issues; perhaps resolved; CM53, 21,22Feb19, RAL
Performance of the MICE diagnostic systems	P. Franchini	Feb19; CM53		Almost complete draft
Phase-space density/emittance evolution review paper	C. Hunt	TBD		Analysis now advancing
Phase-space density/KDE/6D-emittance evolution	C. Brown	TBD		Thesis published on initial analysis; taken over by C.Brown
Measurement of multiple Coulomb scattering of muons in LH2	J. Nugent	TBD		Awaits completion of LiH paper
Field-on measurement of multiple Coulomb scattering	A. Young	TBD		Analysis underway
First particle-by-particle measurement of emittance in the Muon Ionization Cooling Experiment	V. Blackmore		Jun18, CM51	Accepted by EU Phys. J C; awaiting referees
The MICE Analysis and User Software framework	D. Rajaram	May18 w/s	Jun18, CM51	RAL-P-2018-007; 1812.02674; submitted to JINST; referees comments received

Breaking news

Eur. Phys. J. C _####################_
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THE EUROPEAN PHYSICAL JOURNAL C

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Regular Article - Experimental Physics

Author Proof

First particle-by-particle measurement of emittance in the Muon Ionization Cooling Experiment

MICE Collaboration

D. Adams[15], D. Adey[25,34], R. Asfandiyarov[13], G. Barber[18], A. de Bari[6], R. Bayes[16], V. Bayliss[15], R. Bertoni[4], V. Blackmore[18,a], A. Blondel[13], J. Boehm[15], M. Bogomilov[1], M. Bonesini[4], C. N. Booth[20], D. Bowring[25], S. Boyd[22], T. W. Bradshaw[15], A. D. Bross[25], C. Brown[15,23], G. Charnley[14], G. T. Chatzitheodoridis[16,21], F. Chignoli[4], M. Chung[10], D. Cline[30], J. H. Cobb[19], D. Colling[18], N. Collomb[14], P. Cooke[17], M. Courthold[15], L. M. Cremaldi[28], A. DeMello[26], A. J. Dick[21], A. Dobbs[18], P. Dornan[18], F. Drielsma[13], K. Dumbell[14], M. Ellis[23], F. Filthaut[11,32], P. Franchini[22], B. Freemire[27], A. Gallagher[14], R. Gamet[17], R. B. S. Gardener[23], S. Gourlay[26], A. Grant[14], J. R. Greis[22], S. Griffiths[14], P. Hanlet[27], G. G. Hanson[29], T. Hartnett[14], C. Heidt[29], P. Hodgson[20], C. Hunt[18], S. Ishimoto[9], D. Jokovic[12], P. B. Jurj[18], D. M. Kaplan[27], Y. Karadzhov[13], A. Klier[29], Y. Kuno[8], A. Kurup[18], P. Kyberd[23], J-B. Lagrange[18], J. Langlands[20], W. Lau[19], D. Li[26], Z. Li[3], A. Liu[25], K. Long[18], T. Lord[22], C. Macwaters[15], D. Maletic[12], B. Martlew[14], J. Martyniak[18], R. Mazza[4], S. Middleton[18], T. A. Mohayai[27], A. Moss[14], A. Muir[14], I. Mullacrane[14], J. J. Nebrensky[23], D. Neuffer[25], A. Nichols[15], J. C. Nugent[16], A. Oates[14], D. Orestano[7], E. Overton[20], P. Owens[14], V. Palladino[5], M. Palmer[24], J. Pasternak[18], V. Pec[20], C. Pidcott[22,33], M. Popovic[25], R. Preece[15], S. Prestemon[26], D. Rajaram[27], S. Ricciardi[15], M. Robinson[20], C. Rogers[15], K. Ronald[21], P. Rubinov[25], H. Sakamoto[8,31], D. A. Sanders[28], A. Sato[8], M. Savic[12], P. Snopok[27], P. J. Smith[20], F. J. P. Soler[16], Y. Song[2], T. Stanley[15], G. Stokes[14], V. Suezaki[27], D. J. Summers[28], C. K. Sung[10], J. Tang[2], J. Tarrant[15], I. Taylor[22], L. Tortora[7], Y. Torun[27], R. Tsenov[1], M. Tucker[14], M. A. Uchida[18], S. Virostek[26], G. Vankova-Kirilova[1], P. Warburton[14], S. Wilbur[20], A. Wilson[15], H. Witte[24], C. White[14], C. G. Whyte[21], X. Yang[30], A. R. Young[21], M. Zisman[26]

[1] Department of Atomic Physics, St. Kliment Ohridski University of Sofia, Sofia, Bulgaria
[2] Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China
[3] Sichuan University, Chengdu, China
[4] Dipartimento di Fisica G. Occhialini, Sezione INFN Milano Bicocca, Milan, Italy
[5] Sezione INFN Napoli and Dipartimento di Fisica, Università Federico II, Complesso Universitario di Monte S. Angelo, Naples, Italy
[6] Sezione INFN Pavia and Dipartimento di Fisica, Pavia, Italy
[7] INFN Sezione di Roma Tre and Dipartimento di Matematica e Fisica, Università Roma Tre, Rome, Italy
[8] Department of Physics, Graduate School of Science, Osaka University, Toyonaka, Osaka, Japan
[9] High Energy Accelerator Research Organization (KEK), Institute of Particle and Nuclear Studies, Tsukuba, Ibaraki, Japan
[10] UNIST, Ulsan, Korea
[11] Nikhef, Amsterdam, The Netherlands
[12] Institute of Physics, University of Belgrade, Belgrade, Serbia
[13] DPNC, Section de Physique, Université de Genève, Geneva, Switzerland
[14] STFC Daresbury Laboratory, Daresbury, Cheshire, UK
[15] STFC Rutherford Appleton Laboratory, Harwell Oxford, Didcot, UK
[16] School of Physics and Astronomy, The University of Glasgow, Kelvin Building, Glasgow, UK
[17] Department of Physics, University of Liverpool, Liverpool, UK
[18] Blackett Laboratory, Department of Physics, Imperial College London, London, UK
[19] Department of Physics, University of Oxford, Denys Wilkinson Building, Oxford, UK
[20] Department of Physics and Astronomy, University of Sheffield, Sheffield, UK
[21] SUPA and the Department of Physics, University of Strathclyde, Glasgow, UK
[22] Department of Physics, University of Warwick, Coventry, UK
[23] Brunel University, Uxbridge, UK
[24] Brookhaven National Laboratory, Upton, NY, USA
[25] Fermilab, Batavia, IL, USA
[26] Lawrence Berkeley National Laboratory, Berkeley, CA, USA
[27] Illinois Institute of Technology, Chicago, IL, USA
[28] University of Mississippi, Oxford, MS, USA
[29] University of California, Riverside, CA, USA

Author Proof

[30] University of California, Los Angeles, CA, USA
[31] *Current address:* RIKEN, Wako, Japan
[32] *Also at* Radboud University, Nijmegen, The Netherlands
[33] *Current address:* Department of Physics and Astronomy, University of Sheffield, Sheffield, UK
[34] *Current address:* Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China

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Abstract 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 are 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 in the upstream tracking detector and reports the first particle-by-particle measurement of the emittance of the MICE 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 the 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 or intense muon facilities.

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 distributions in the spectrometers. It presents the first measurement of the emittance of momentum-selected muon ensembles in the upstream spectrometer.

2 Calculation of emittance

Emittance is a key parameter in assessing the overall performance of an accelerator [17]. The luminosity achieved by a collider is inversely proportional to the emittance of the colliding beams, and therefore beams with small emittance are required.

D. Cline, M. Zisman: Deceased.

[a] e-mail: v.blackmore@imperial.ac.uk

Progress CM53; impressive detail

	Coffee		Other Institutes	10:30 - 11:00
11:00	System Performance Paper	Paolo Franchini	Other Institutes	11:00 - 11:45
	Tracker Performance	Christopher Hunt	Other Institutes	11:45 - 12:15
12:00	Global Tracks and Optical Alignment	Mr Joe Langlands	Other Institutes	12:15 - 12:45
	Discussion		Other Institutes	12:45 - 13:00
13:00	Lunch		Other Institutes	13:00 - 14:00
14:00	4D Amplitude Evolution - Rapid Communication	Chris Rogers	Other Institutes	14:00 - 14:45
	4D emittance evolution - detailed paper	Christopher Hunt	Other Institutes	14:45 - 15:15
15:00	Discussion		Other Institutes	15:15 - 15:30
	Tea		Other Institutes	15:30 - 16:00
16:00	Optics evolution in the cooling channel	Mr Paul Jurj	Other Institutes	16:00 - 16:30
	Wedge and 6D Emittance Evolution	Mr Craig Brown	Other Institutes	16:30 - 17:00

09:00	LiH Scattering Analysis	John Nugent	Other Institutes	09:00 - 09:45
10:00	LH2 scattering analysis	Gavriil Chatzitheodoridis	Other Institutes	09:45 - 10:15
	Discussion		Other Institutes	10:15 - 10:30
	Coffee		Other Institutes	10:30 - 11:00
11:00	Field on scattering analysis	Dr Alan Young	Other Institutes	11:00 - 11:20
	Energy loss analysis	Scott Wilbur	Other Institutes	11:20 - 11:40
	Collaboration Board summary	Paul Kyberd	Other Institutes	11:40 - 12:00
12:00	Closing remarks	Kenneth Richard Long	Other Institutes	12:00 - 12:20

Future meetings

- 2019:
  - CM53:
    - February 2019: 21st and 22nd February 2019
  - CM54:
    - June 2019: 27th and 28th June 2019
  - CM55:
    - October 2019: 24th and 25th October 2019

- Analysis workshops:
  - April 16th 17th in Glasgow
  - Subsequent meetings to be announced by C. Rogers

- Video conferences:
  - 18Apr19
  - 16May19

Thanks to:

- **You all for coming, presenting and arguing!**
- **The local team:**
  - **Trudi, Gill, Debbie**
- **See you at CM54 at RAL in Jun19**
- **… my best wishes for a safe journey home …**