Welcome and introduction

K. Long, 20 February, 2019

Status of MICE

PAPERS

Eur. Phys. J. C manuscript No.
(will be inserted by the editor)

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

The 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[a,18], 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[21,16], F. Chignoli[4], M. Chung[10], D. Cline[30,35], 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[26,35]

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RAL-P-2018-007

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

[1]Corresponding author.

Accepted by EU J Phys C
… awaiting proofs

Submitted to JINST
… referees' comments received

Papers

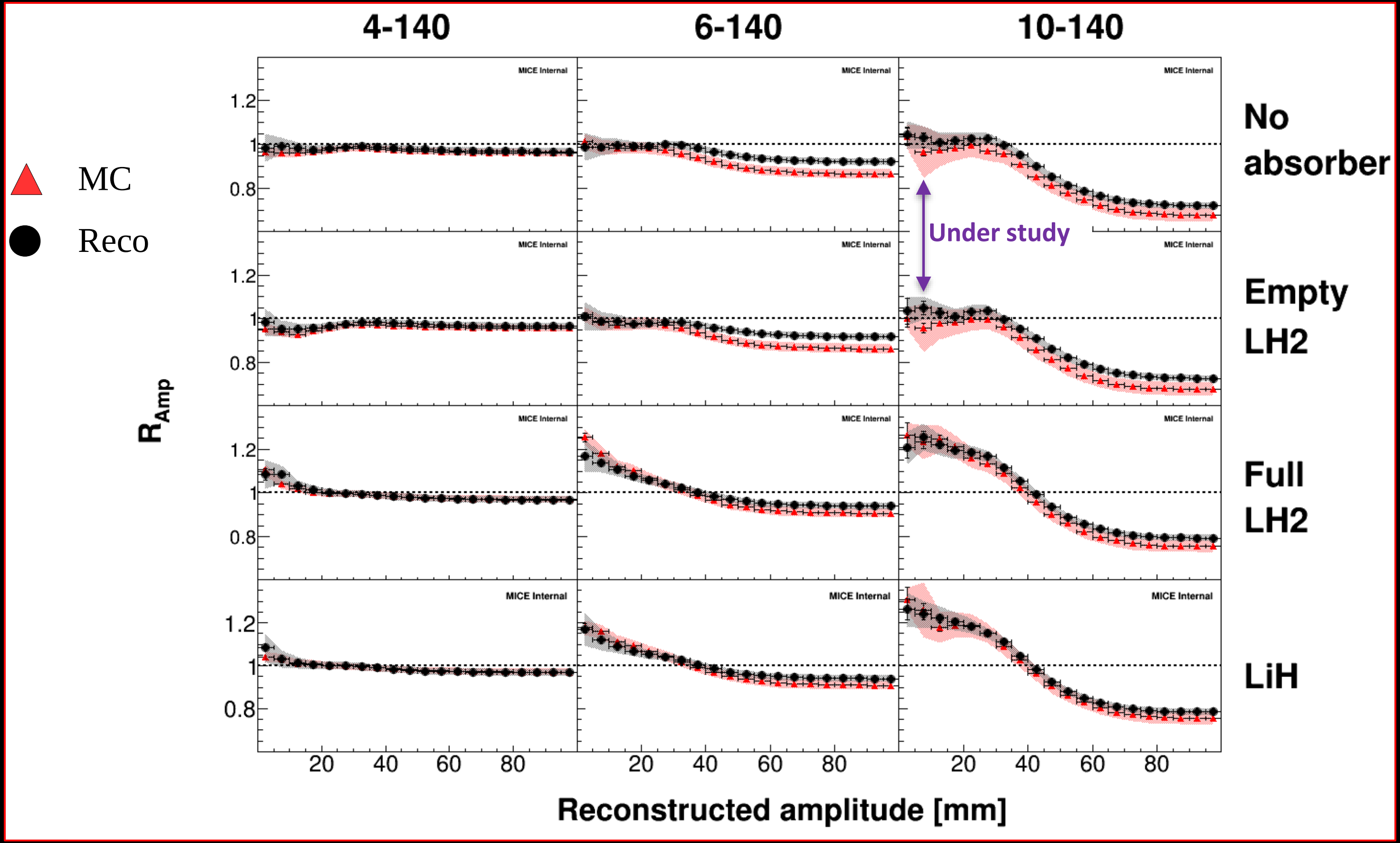
Title	Contact	Target date		Comments
		Preliminary	Final	Jan-19
Phase-space density/emittance evolution; rapid communication	C. Rogers	Apr18 w/s	Apr19	4th referees meeting before around CM53 (21, 22Feb19, RAL)
Measurement of multiple Coulomb scattering of muons in lithium hydride	J. Nugent	Jun18; CM51	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

New & updated results for IPAC18

- Emittance evolution paper:
  - Rogers, Drielsma: proceeding to paper
    - 3 referees' meetings; 4^{th} in next week
- LiH scattering paper:
  - Nugent et al:
    - Unfolding issues, perhaps being resolved; will review at CM 53 21, 22 Feb 19
    - Nugent now 50% T2K
- System performance paper:
  - Franchini et al: almost full draft available
    - Franchini now ~50% SuperNEMO
- Field-on scattering:
  - Young et al:
    - Processing being transferred to the GRID, progress being made
- Emittance exchange (wedge absorber):
  - Brown:
    - Student of Rogers and Kyberd; making progress
- Long cooling paper:
  - Hunt, Jurj et al:
    - Analysis underway, hampered by uncertainty created by imminent end of Hunt's contract

Cooling: rapid communication

- Many details have been tidied addressing issues raised by referees
- Substantive points at last PSAG:
  - Behaviour of data as Amp->0;
    - Resolved
      - Improved correction algorithm
  - Track-finding efficiency, especially in d/s tracker:
    - Resolved:
      - Track chi2/NDF cut too tight



Status of MICE

MICE LEGACY

Legacy…

- Agreed with STFC to work together to publicise the MICE legacy at the time of the submission/publication of first cooling results in Nature Physics
- Examples of impact to bring forward:
  - Scientific:
    - Papers, conference proceedings, theses, talks, …
  - Impact:
    - Direct:
      - E.g. g-2 ring may use wedge absorber to improve beam
    - Legacy:
      - Muon Collider, nuSTORM, novel neutrino-beam discussions in ESPPU
    - Impact:
      - Investment in high-tech, UK, local, EU and other industry (quantifiable);
      - Outreach (e.g. national competition for schools organised on the back of Neutrino 2016)
      - Trained personnel: technical, engineering (cryo, mech., elec, electronic, s/w), analysis, accelerator scientist
- Topic for EB tomorrow; please be ready to become involved

European Strategy for Particle Physics Update

nuSTORM at CERN: Executive Summary

Contact*: *K. Long*
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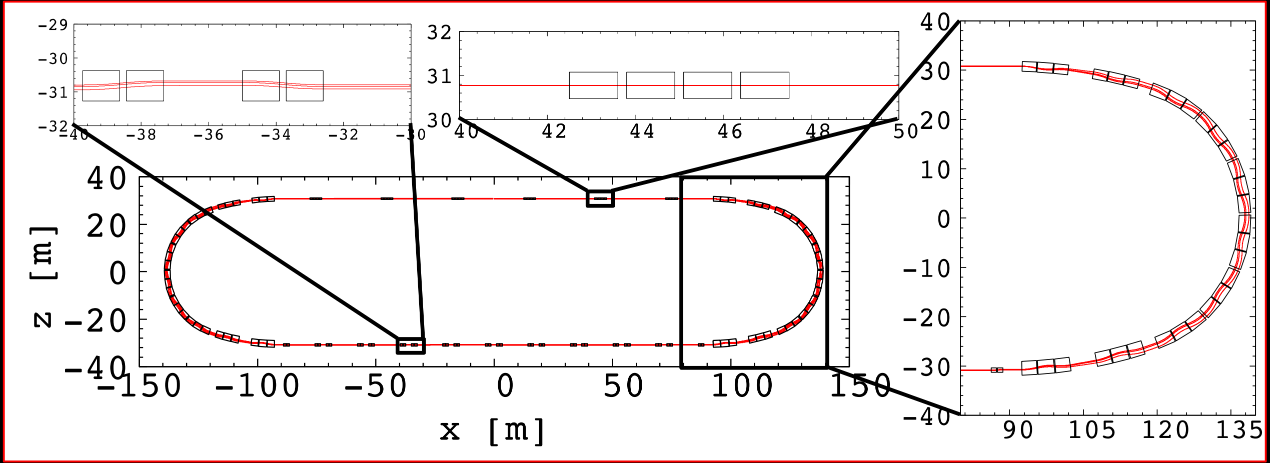
Abstract
The Neutrinos from Stored Muons, nuSTORM, facility has been designed to deliver a definitive neutrino-nucleus scattering programme using beams of $\overset{(-)}{\nu}_e$ and $\overset{(-)}{\nu}_\mu$ from the decay of muons confined within a storage ring. The facility is unique, it will be capable of storing $\mu^\pm$ beams with a central momentum of between 1 GeV/c and 6 GeV/c and a momentum spread of 16%. This specification will allow neutrino-scattering measurements to be made over the kinematic range of interest to the DUNE and Hyper-K collaborations. At nuSTORM, the flavour composition of the beam and the neutrino-energy spectrum are both precisely known. The storage-ring instrumentation will allow the neutrino flux to be determined to a precision of 1% or better. By exploiting sophisticated neutrino-detector techniques such as those being developed for the near detectors of DUNE and Hyper-K, the nuSTORM facility will:

- Serve the future long- and short-baseline neutrino-oscillation programmes by providing definitive measurements of $\overset{(-)}{\nu}_e A$ and $\overset{(-)}{\nu}_\mu A$ scattering cross-sections with percent-level precision;
- Provide a probe that is 100% polarised and sensitive to isospin to allow incisive studies of nuclear dynamics and collective effects in nuclei;
- Deliver the capability to extend the search for light sterile neutrinos beyond the sensitivities that will be provided by the FNAL Short Baseline Neutrino (SBN) programme; and
- Create an essential test facility for the development of muon accelerators to serve as the basis of a multi-TeV lepton-antilepton collider.

To maximise its impact, nuSTORM should be implemented such that data-taking begins by $\approx 2027/28$ when the DUNE and Hyper-K collaborations will each be accumulating data sets capable of determining oscillation probabilities with percent-level precision.

With its existing proton-beam infrastructure, CERN is uniquely well-placed to implement nuSTORM. The feasibility of implementing nuSTORM at CERN has been studied by a CERN Physics Beyond Colliders study group. The muon storage ring has been optimised for the neutrino-scattering programme to store muon beams with momenta in the range 1 GeV to 6 GeV. The implementation of nuSTORM exploits the existing fast-extraction from the SPS that delivers beam to the LHC and to HiRadMat. A summary of the proposed implementation of nuSTORM at CERN is presented below. An indicative cost estimate and a preliminary discussion of a possible time-line for the implementation of nuSTORM are presented the addendum.

*Author list presented in the addendum.



113 authors; 45 from the UK
47 groups; 13 from the UK

European Strategy for Particle Physics Update

Input to the European Particle Physics Strategy Update

Muon Colliders

The Muon Collider Working Group

Jean Pierre Delahaye[1], Marcella Diemoz[2], Ken Long[3], Bruno Mansoulié[4], Nadia Pastrone[5] (chair), Lenny Rivkin[6], Daniel Schulte[1], Alexander Skrinsky[7], Andrea Wulzer[1,8]

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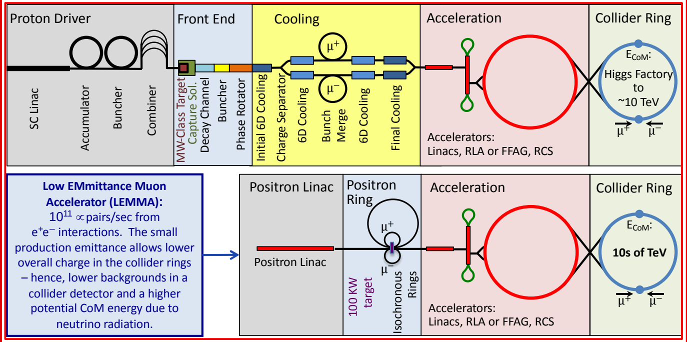

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Webpage: https://muoncollider.web.cern.ch

6 Conclusions and recommendations

Muon-based technology represents a unique opportunity for the future of high energy physics research: the multi-TeV energy domain exploration. The development of the challenging technologies for the frontier muon accelerators has shown enormous progress in addressing the feasibility of major technical issues with R&D performed by international collaborations. In Europe, the reuse of existing facilities and infrastructure for a muon collider is of interest. In particular the implementation of a muon collider in the LHC tunnel appears promising, but detailed studies are required to establish feasibility, performance and cost of such a project. A set of recommendations listed below will allow to make the muon technology mature enough to be favorably considered as a candidate for high-energy facilities in the future.

Set-up an international collaboration to promote muon colliders and organize the effort on the development of both accelerators and detectors and to define the road-map towards a CDR by the next Strategy update. As demonstrated in past experiences, the resources needed are not negligible in terms of cost and manpower and this calls for a well-organized international effort.
For example, the MAP program required an yearly average of about 10M$ and 20 FTE staff/faculty in the 3-year period 2012-2014.

Develop a muon collider concept based on the proton driver and considering the existing infrastructure. This includes the definition of the required R&D program, based on previously achieved results, and covering the major issues such as cooling, acceleration, fast ramping magnets, detectors, ...

Consolidate the positron driver scheme addressing specifically the target system, bunch combination scheme, beam emittance preservation, acceleration and collider ring issues.

Carry out the R&D program toward the muon collider. Based on the progress of the proton-driver and positron-based approaches, develop hardware and research facilities as well as perform beam tests.

Preparing and launching a conclusive R&D program towards a multi-TeV muon collider is mandatory to explore this unique opportunity for high energy physics. A well focused international effort is required in order to exploit existing key competences and to draw the roadmap of this challenging project.
The development of new technologies should happen in synergy with other accelerator projects. Moreover, it could also enable novel mid-term experiments.

European Strategy for Particle Physics Update

Future Opportunities in Accelerator-based Neutrino Physics

The Participants of the European Neutrino Town Meeting
22–24 October, 2018
CERN, 1 Esplanade des Particules, 1211 Geneva 23, Switzerland

Editors: Alain Blondel[a], Joachim Kopp[b], Albert de Roeck[c]
(full author list in the appendix)

(Dated: December 2018)

This document summarizes the conclusions of the Neutrino Town Meeting held in October 2018 to review the neutrino field at large with the aim of defining a str accelerator-based neutrino physics in Europe. The importance of the field across complementary components is stressed. Recommendations are presented regarding erator based neutrino physics, pertinent to the European Strategy for Particle Ph address in particular i) the role of CERN and its neutrino platform, ii) the importa cillary neutrino cross-section experiments, and iii) the capability of fixed target exp as well as present and future high energy colliders to search for the possible mani of neutrino mass generation mechanisms.

2. Recommendations

A. Neutrino physics is one of the most promising areas where to find answers to some of the big questions of modern physics; it covers many disciplines of physics complementing each other, and some coordination should ensure that each of these essential aspects is strongly supported.

B. Neutrinos at accelerators, pertinent to ESPP, are an important component because of:
   1) the search for CP violation, and the full determination of the oscillation parameters;
   2) the possibility to discover heavy neutrinos or other manifestations of the mechanism for neutrino mass generation.

   Consequently Europe (and CERN in particular) should provide a balanced support in the world-wide LBL effort, with its two complementary experiments DUNE and T2K/HyperKamiokande ("HyperK") (and its possible extension with a detector in Korea), in both of which strong EU communities are involved, to secure the determination of oscillation parameters, aim at the discovery of CP violation and test the validity of the 3-family oscillation framework; these experiments also have an outstanding and complementary non-accelerator physics program.

C. Extracting the most physics out of DUNE and HyperK will require ancillary experiments:
   1) CERN should continue improving NA61/SHINE towards percent level flux determinations;
   2) a study should be set-up to evaluate the possible implementation, performance and impact of a percent-level electron and muon neutrino cross-section measurement facility (based on e.g. ENUBET or NuSTORM) with conclusion in a few years;
   3) a strong theory effort should accompany these experimental endeavours.

D. If, for instance, the CP phase δ_{CP} is close to $\pm\pi/2$ or of $\sin\delta_{CP} = 0$, improved precision w.r.t. DUNE and HyperK should be considered. Studies of feasibility and performance of and ESSnuSB and Protvino to Orca (P2O) should be pursued to quantify their feasibility, realistic potential and complementarity with the present program.

E. Fixed target and collider experiments have significant discovery potential for heavy neutrinos and the other manifestations of the neutrino mass generation mechanisms, especially in Z and W decays. The capability to probe massive neutrino mechanisms for generating the matter—antimatter asymmetry in the Universe should be a central consideration in the selection and design of future colliders.

Status of MICE

MUON COLLIDER W/S

Next w/s

- **Not yet announced, but, it will be at CERN on 10/11Apr19**

Status of MICE

ADMINISTRATION

Office in R1

- Have now been asked to reduce footprint:
  - Slim by factor of 2:
    - Have prepared to ask for partition to be replaced;
      - MICE retained half by the door marked 'MICE Office'

- Please remove any items you wish to retain before you leave!

Request to remain a CERN Recognised experiment

- Granted!
  - More precisely RE Committee will recommend continuation to CERN Research Board
  - For final 3-year period.

- CERN Grey Book:
  - Needs to be updated:
    - Records collaboration members
  - Required support for a pitch to Nature Physics for open access publishing:
    - Condition of funding by (at least) UK and US funding agencies
    - Paul Kyberd is working to do the update through the CB

MICE CM53

21-22 February 2019
Other Institutes
Europe/London timezone

Search...

- Overview
- Timetable
- Contribution List
- Registration
- Participant List

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The 53rd Muon Ionization Cooling Experiment (MICE) Collaboration Meeting will be held at RAL on Thursday 21st & Friday 22nd Feb 2019.

The MICE Analysis workshop will preceed this and will be held on the 20th February 2019 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!

NB: **BLOCK BOOKING AT COSENERS HAS BEEN RELEASED. ~~PLEASE CONTACT COSENERS HOUSE~~ DIRECT. 01235 523198**

RIDGEWAY HOUSE IS FULLY BOOKED, ONLY THREE ROOMS WERE AVAILABLE FOR ALL NIGHTS.

Starts 21 Feb 2019, 09:00
Ends 22 Feb 2019, 17:00
Europe/London

Other Institutes

Conference Rooms 12 and 13 Building R68
STFC, Rutherford Appleton Laboratory
Harwell Oxford Campus
Chilton
Oxfordshire OX11 0QX UK

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Over to you!