Welcome and introduction

K. Long, 12 March, 2020

Welcome

Thanks for coming!

Covid-19 makes travel not so straightforward

My thoughts, and best wishes, to our Italian colleagues who have been and are in the fore-front of the European Covid-19 epidemic

Status of MICE

PAPERS


Article

Demonstration of cooling by the Muon Ionization Cooling Experiment

https://doi.org/10.1038/s41586-020-1958-9

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Open access

MICE collaboration*

The use of accelerated beams of electrons, protons or ions has furthered the development of nearly every scientific discipline. However, high-energy muon beams of equivalent quality have not yet been delivered. Muon beams can be created through the decay of pions produced by the interaction of a proton beam with a target. Such 'tertiary' beams have much lower brightness than those created by accelerating electrons, protons or ions. High-brightness muon beams comparable to those produced by state-of-the-art electron, proton and ion accelerators could facilitate the study of lepton–antilepton collisions at extremely high energies and provide well characterized neutrino beams[1–6]. Such muon beams could be realized using ionization cooling, which has been proposed to increase muon-beam brightness[7,8]. Here we report the realization of ionization cooling, which was confirmed by the observation of an increased number of low-amplitude muons after passage of the muon beam through an absorber, as well as an increase in the corresponding phase-space density. The simulated performance of the ionization cooling system is consistent with the measured data, validating designs of the ionization cooling channel in which the cooling process is repeated to produce a substantial cooling effect[9–11]. The results presented here are an important step towards achieving the muon-beam quality required to search for phenomena at energy scales beyond the reach of the Large Hadron Collider at a facility of equivalent or reduced footprint[6].

High-quality muon beams

Fundamental insights into the structure of matter and the nature of its elementary constituents have been obtained using beams of charged particles. The use of time-varying electromagnetic fields to produce sustained acceleration was pioneered in the 1930s[12–14]. Since then, high-energy and high-brightness particle accelerators have delivered electron, proton and ion beams for applications ranging from the search for new phenomena in the interactions of quarks and leptons to the study of nuclear physics, materials science and biology.

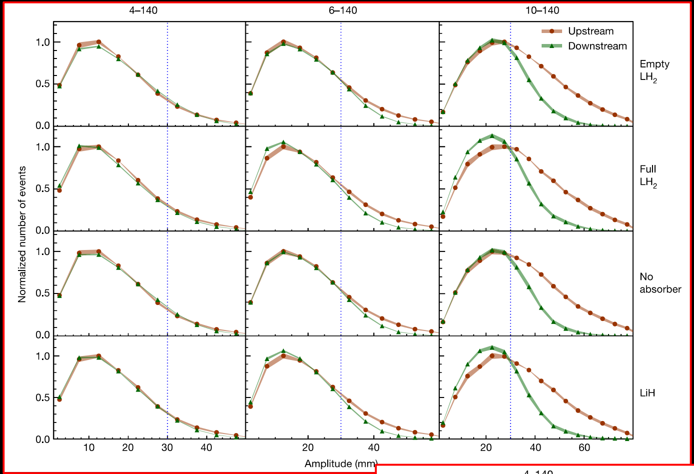
Muon beams can be created using a proton beam striking a target to produce a secondary beam comprising many particle species including pions, kaons and muons. The pions and kaons decay to produce additional muons, which are captured by electromagnetic beamline elements to produce a tertiary muon beam. Capture must be realized on a timescale compatible with the muon lifetime at rest, 2.2 μs. Without acceleration, the energy and intensity of the muon beam is limited by the energy and intensity of the primary proton beam and the efficiency with which muons are captured.

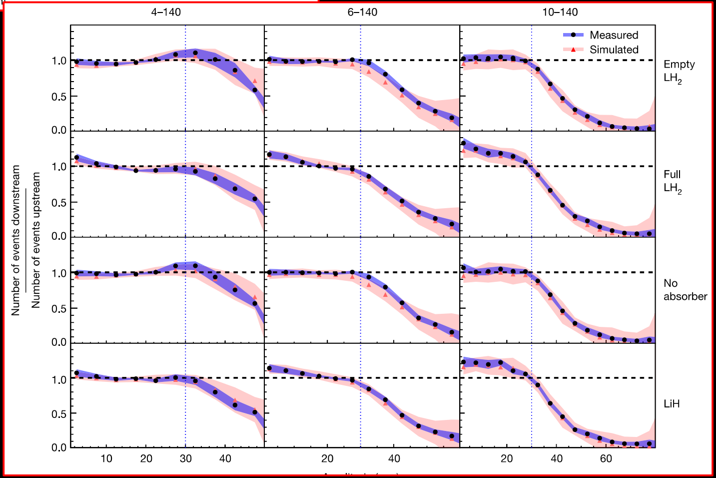
Accelerated high-brightness muon beams have been proposed as a source of neutrinos at neutrino factories and for the delivery of multi-TeV lepton–antilepton collisions at muon colliders[1–6]. Muons have attractive properties for the delivery of high-energy collisions. The muon is a fundamental particle with mass 207 times that of the electron. This high mass results in suppression of synchrotron radiation, potentially enabling collisions between beams of muons and antimuons at energies far in excess of those that can be achieved in an electron–positron collider, such as the proposed International Linear Collider[15], the Compact Linear Collider[16], the Circular Electron–Positron Collider[17] and the electron–positron option of the Future Circular Collider[18]. The virtual absence of synchrotron radiation makes it possible to build a substantially smaller facility with the same or greater physics reach.

The energy available in collisions between the constituent gluons and quarks in proton–proton collisions is considerably less than the energy of the proton beam because the colliding quarks and gluons each carry only a fraction of the proton's momentum. Muons carry the full energy of the beam, making muon colliders attractive for the study of particle physics beyond the energy reach of facilities such as the Large Hadron Collider[19].

Most of the proposals for accelerated muon beams exploit the proton-driven muon-beam production scheme outlined above and use beam cooling to increase the brightness of the tertiary muon beam before acceleration and storage to ensure sufficient luminosity or beam current. Four cooling techniques are in use at particle accelerators: synchrotron radiation cooling[20], laser cooling[21], stochastic cooling[22] and electron cooling[23]. In each case, the time required to cool the beam is long compared to the muon lifetime. Frictional cooling of muons, in which muons are electrostatically accelerated through an energy-absorbing medium at energies significantly below 1 MeV, has been demonstrated but with low efficiency[24–26].

*A list of participants and their affiliations appears at the end of the paper.





Published in Nature

https://doi.org/10.1038/s41586-020-1958-9

Papers

		01-Feb-20	v21		
Title	**Contact**	**Target date**		**Comments**	**Target**
		Preliminary	**Final**	**Jan-20**	**journal**
Measurement of multiple Coulomb scattering of muons in lithium hydride	J. Nugent	Jun18; CM51	Apr19	Progress	Euro Phys C? PRAB?
Performance of the MICE diagnostic systems	P. Franchini	Feb19; CM53		KL part of the problem. Commit to new draft for analysis meeting.	
Phase-space density/emittance evolution review paper					
Flip mode	P. Jurg	TBD		Full analysis chain in place.	
Solenoid mode	T. Lord	TBD			
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	
LH Scattering	Gavril	TBD		Analysis underway	

Outreach to go alongside Nature paper

- Press release:
  - STFC lead, coordinate through existing lab network
    - Need to coordinate at institute level through CB
- Peer-group seminar at RAL
- Event at RAL/DL:
  - Peer-group meeting:
    - MICE results, impact on muon collider/neutrino factory
    - nuSTORM
  - Early-evening public lecture
- Film with Science Animated
- News/article in, e.g., CERN Courier, Symmetry
  - Perhaps also newspaper

Finaised.

27Feb20; 15:00 GMT; RAL and broadcast to DL

Stalled.
Reinitiate.

P. Kyberd now underway

Published online
will be in next hardcopy

P.Kyberd, KL, C.Rogers

MICE

INTERNATIONAL MUON IONIZATION COOLING EXPERIMENT

FOR THE PUBLIC — THE MICE DEMONSTRATION OF IONIZATION COOLING EXPLAINED

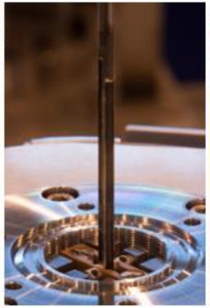
Breaking News: *Demonstration of cooling by the Muon Ionization Cooling Experiment* published in Nature 578(2020)53
Breakthrough made on the next big step to building the world's most powerful particle accelerator, UKRI STFC News
Nuova Tecnica apre a future acceleratore di muoni, News INFN
Muon colliders come a step closer, Nature News and Views
Release the Muons! Physics Breakthrough Will Lead to a New Kind of Particle Collider, Gizmodo
MICE Cold: Collaboration Demonstrates Muon Ionization Cooling, Scientific American
A barrier to colliding particles called muons has been smashed, ScienceNews
New Kind of Particle Collider Could Reach Higher Energy at a Lower Cost, Inside Science
MICE brings muon collider closer to reality, Symmetry
MICE experiment demonstrates key technique for future muon colliders, Fermilab News
MICE demonstrates muon cooling, CERN Courier

More sources: Nature Asia, Imperial College London, University of Glasgow, University of Strathclyde, Brunel University, The University of Sheffield, The University of Warwick, University of Oxford, Illinois Tech, Berkeley Lab News, The Daily Express, myScience UK, SciGlow, Inverse, govirall.net, breakingnews.fr, Public, ScienceBlog, phys.org, wired-gov.net, Mirage News, Science Springs, Ein NewsDesk, Internet Shots, Mashable India

MICE Demonstration of Ionization Cooling

The MICE collaboration have had a paper published in Nature 05/02/2020, in which they demonstrate a technique that could carry the search for new phenomena in lepton-antilepton collisions to extremely high energy and provide uniquely well-characterized neutrino beams.

You can find a list of articles and publications covering this here.

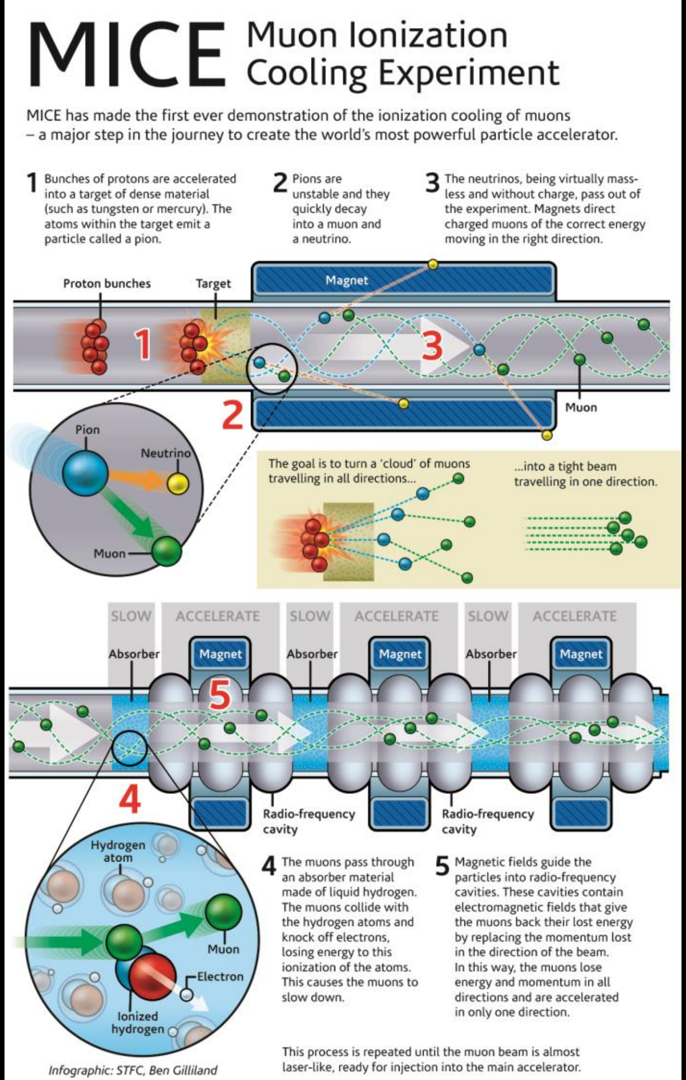



A brief introduction

Since the 1930s, scientists have been using particle accelerators to make beams of protons, electrons and ions. These have been used in practically every scientific field, from colliding particles in the LHC to measuring the chemical structure of drugs and even treating cancer. We have made a major step in building an accelerator for an entirely different sort of particle, a muon. A muon accelerator could replace the LHC, providing dramatically improved performance.

Muon beam production

> *The experiment took place in the UK using the MICE muon beam-line, part of the ISIS neutron and muon source . Muons can be produced by smashing a beam of protons into a target. The debris from the collisions include particles known as pions. The pions are separated from the other particles produced in the collision and directed along a series of magnetic lenses where they decay into muons.*
>
> *Because of the rough-and-ready production mechanism, these muons form a diffuse cloud that that occupies a large volume. This means we need big magnets to contain the beam. It also means that when we eventually collide the muons, the chances of them hitting each other and producing interesting physics is really low. We want them all close together and moving in the same direction and to do this we need beam cooling.*



Useful links

Nature article and accompanying pieces

- The Nature Article
- Nature, News & Views: Muon colliders come a step closer
- Nature Asia: Cutting the cost of colossal colliders
- Rutherford Appleton Laboratory Lecture (Requires Adobe Flash plugin)

Institutional press releases following publication in Nature

- STFC: Breakthrough made on the next big step to building the world's most powerful particle accelerator
- Fermilab: MICE experiment demonstrates key technique for future muon colliders
- Berkeley Lab: A Breakthrough on the Next Big Step to Building the World’s Most Powerful Particle Accelerator
- University of Strathclyde: Breakthrough in quest to build the world’s most powerful particle accelerator
- The University of Sheffield: Breakthrough made towards building the world’s most powerful particle accelerator
- Brunel University: Muon over LHC: Next-generation particle accelerator takes 'game-changing' step forward
- Warwick: Breakthrough made on the next big step to building the world’s most powerful particle accelerator
- Fermilab today: MICE brings muon collider closer to reality
- Imperial: World’s most powerful particle accelerator one big step closer
- University of Glasgow: The most powerful new particle accelerator could be a muon collider
- CERN Courier: MICE demonstrates muon cooling
- INFN: NUOVA TECNICA APRE A FUTURO ACCELERATORE DI MUONI
- University of Oxford: A step closer to building the first muon collider

Press and online media articles following publication in Nature

- Science Blog: A Breakthrough on the Next Big Step to Building the World's Most Powerful Particle Accelerator
- PhysOrg: World's most powerful particle accelerator one big step closer
- Gizmodo: Release the Muons! Physics Breakthrough Will Lead to a New Kind of Particle Collider
- symmetry: MICE brings muon collider closer to reality
- Inverse: Milestone particle physics study could change science as we know it
- Express: Science news: World's most powerful particle accelerator will open door to 'new physics'
- Scientific American: MICE Cold: Collaboration Demonstrates Muon Ionization Cooling
- ScienceNews: A barrier to colliding particles called muons has been smashed
- Inside Science: New Kind of Particle Collider Could Reach Higher Energy at a Lower Cost
- myScience: The most powerful new particle accelerator could be a muon collider
- SciGlow: Breakthrough made on the next big step to building the world's most powerful particle accelerator
- goviral: A Barrier To Colliding Particles Called Muons Has Been Smashed
- Breaking News: MICE Cold: une collaboration démontre le refroidissement par ionisation des muons
- PublicNow: World's Most Powerful Particle Accelerator One Big Step Close
- X-Mol: Demonstration of cooling by the Muon Ionization Cooling Experiment
- Wired Gov: Breakthrough made on the next big step to building the world's most powerful particle accelerator
- Mirage News: Breakthrough made on next big step to building world's most powerful particle accelerator
- sciencesprings: From Science and Technology Facilities Council: "Breakthrough made on the next big step to building the world's most powerful particle accelerator"
- EIN Newsdesk: A Breakthrough on the Next Big Step to Building the World's Most Powerful Particle Accelerator
- Internet Shots: MICE brings muon collider nearer to actuality
- Mashable India: Muon Collider Discovery Will Lead To World's Most Powerful Particle Accelerator
- TechQuila: Coming Soon: Muon Colliders

Radio and podcasts

- BBC World Service Science in Action
- Naked Scientists/BBC Radio

Amy Pollock (Comms), Josephine Taylor (PPD)
C. Rogers (ISIS)

Welcome and introduction

AND NOW …

MICE CM56

12-13 March 2020
Other Institutes
Europe/London timezone

Search...

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

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The 56th Muon Ionization Cooling Experiment (MICE) Collaboration Meeting will be held at RAL on Thursday 12th and Friday 13th March 2020

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

Payment method: Overseas attendees cash only

We have following rooms booked at Ridgeway House. You must do the room booking yourself, quoting booking reference 61591. The rooms will be released on **Monday 2nd March**. Room bookings are on a first come, first served basis.

10th March (1 night) – 1 Room
11th March (1 night) – 3 Rooms
12th March (1 night) – 5 Rooms
13th March (1 night) – 2 Rooms

We will be in room **CR20 R106** not the normal meeting room. R106 is at the far end of site from main reception, round the back of Target Station 2 building - map

Over to you!

Starts 12 Mar 2020, 12:30
Ends 13 Mar 2020, 15:00
Europe/London

Other Institutes
Building R106 CR20