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First demonstration of ionization cooling

16 May 2018 Core Value: Excellence

Congratulations to collaborators on the Muon Ionization Cooling Experiment (MICE) for presenting the first ever demonstration of ionization cooling at the recent International Particle Accelerator Conference in Vancouver.

Since the early 20th century physicists have been accelerating electrons, protons and ions in order to understand the nature of matter. In the last few months, STFC scientists and engineers, in collaboration with international partners, have taken and analysed data to demonstrate muon ionization cooling, a key technology in the design of a particle accelerator that can accelerate an entirely different form of matter, a subatomic particle known as a muon.

In ionization cooling a muon beam is passed through liquid hydrogen or lithium hydride while being focussed extremely tightly by the large magnetic field produced by a super-conducting solenoid. This process, referred to as 'cooling', reduces the transverse size of the beam, which allows the beam to be accelerated to high energy. The muons in the beam oscillate about the beam centre and the amplitude of the oscillations determines the size of the beam. Muons with a small oscillation amplitude are said to be 'cold'.

> Chris Rogers (ISIS), who led the data analysis team, said: "Ionization cooling was the main technical hurdle in constructing a muon accelerator. With these results we have shown that ionization cooling works, meaning that muon colliders could be the successor to the LHC. The results have impact beyond the high energy physics community as well - accelerator physicists have proposed using ionization cooling in 'internal target' systems for nuclear waste transmutation, medical radioisotope production and cancer treatment, so these results could have impact over a wide range of very important applications."

Using the MICE Muon Beam on ISIS, the MICE collaboration has measured the amplitude of the muon oscillations before and after a cooling system using state-of-the-art detector systems. The results show the number of cold muons is increased by their passage through the cooling system. This is the first time that the ionization-cooling of muons has been observed.

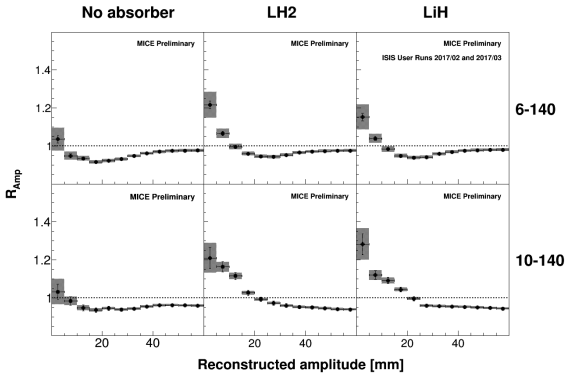
> Tanaz Mohayai (Illinois Institute of Technology), who presented the results, said: "It was an honor to present the MICE first cooling results at the International Particle Accelerator Conference, IPAC in Vancouver, Canada. These first results demonstrate that ionization cooling works and that muon accelerators can be built. These accelerators will enable us to probe the limits of the Standard Model, the Higgs particle and Neutrino oscillations with unprecedented precision."

The result was a real cross-campus success, with contributions in every major subsystem from ISIS, ASTeC, PPD, CCD and Technology. The expertise from both DL and RAL was crucial to the successful delivery of the MICE programme.

Chris

Contacts

Rogers, Chris (STFC,RAL,ISIS)



Above:
Ratio (Ramp) of number of muons observed downstream of the cooling system to the number observed upstream as a function of muon amplitude. Beams with a nominal momentum of 140 MeV/c were used to make the measurement. The top row shows beams with an initial nominal emittance of 6 mm, the nominal input emittance for the bottom row was 10 mm. The left-most column shows the results with no material in the focus-coil module. The centre and right-most column show the result obtained when liquid-hydrogen (LH2) and lithium hydride (LiH) was used respectively. Ionization cooling is demonstrated by the points that lie significantly above the line at Ramp=1 for muons at low amplitude, showing an increase in the number of 'cold' muons. Cooling is observed for both liquid hydrogen and lithium hydride, while no cooling is observed when no absorber was present.

* Top image: Members of the analysis team at the IPAC conference. From left to right: Paolo Franchini (Warwick University), Tanaz Mohayai (Illimois Institute of Technology), Victoria Blackmore (Imperial College London) and Chris Rogers (ISIS).