MICE-US: Status and Plans

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MUTAC Review
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Outline:

1. MICE
2. US Contributions to MICE
3. Funding
4. Summary
Ionization Cooling: Background

- Absorbers:
  \[ E \rightarrow E - \left( \frac{dE}{dx} \right) \Delta s \]
  \[ \theta \rightarrow \theta + \theta_{\text{rms}}^{\text{space}} \]

- RF cavities between absorbers replace \( \Delta E \)

- Net effect: reduction in \( p_\perp \) w.r.t. \( p_\parallel \), i.e., transverse cooling

Note: The physics is not in doubt
  \[ \Rightarrow \] in principle, ionization cooling has to work!
... but in practice it is subtle and complicated so a test is important
MICE

Goals of MICE:

- to show that it is possible to design, engineer and build a section of cooling channel capable of giving the desired performance for a Neutrino Factory;
- to place it in a muon beam and measure its performance in a variety of modes of operation and beam conditions.
Current Status:

24 Oct ’03: MICE approved!
• CCLRC (letter from John Wood, Chief Exec., Council for the Central Laboratory of the Research Councils)
  “...accepts the strong endorsement of the proposal by the Astbury panel and consequently considers the proposal to have full scientific approval.”
  “...approves the project subject to satisfactory passage through Gateway.”

20–21 Dec ’04: Gateway 2/3 Review (prerequisite to funding – passed)

21 Mar ’05: MICE (Phase 1) funded!
• UK Science and Innovation Minister, Lord Sainsbury:
  “It is a testament to the UK’s world class science and facilities that leading experimental physicists from across the globe have supported conducting a project of this calibre in the UK. The Government’s investment in this experiment will provide a unique showcase of UK scientific and engineering technology...”
• £9.7M UK funds released ≈April ’05
US Contributions to MICE:

• Muon Collaboration developing cooling-cell components to be tested in MICE, including
  – high-gradient 201-MHz RF cavities
  – LH$_2$ absorbers

• Within MICE, US collaborators responsible for
  – cooling-cell concepts and simulation (Palmer/Fernow/Gallardo, BNL)
  – beamline simulations (T. Roberts, Muons, Inc.)
  – software development and simulation (Y. Torun, IIT)
  – RFCC cooling-cell modules (LBNL)
  – thin windows for LH$_2$ absorbers (Cummings et al., NIU/IIT/FNAL/UMiss/Oxford)
  – upstream Cherenkov counter for incoming-muon ID (UMiss)
  – VLPC readout & fiber prep for SciFi trackers (FNAL/IIT/UCLA/UCR)
  – oversight & leadership (Zisman/Bross/Kaplan/Torun)

• Additional responsibilities we have taken on:
  – spectrometer solenoids (so far not funded by Italy, 1st one needed on “Day 1”)
  – RF power (2 surplus supplies contributed by LBNL)
Performance Simulation (nominal SFOFO mode):
(BNL ICOOL simulation)

→≈10% transverse emittance reduction, measurable to 0.1% (abs.) given precise spectrometer, clean beam, and efficient, redundant particle ID
While at IIT, T. Roberts developed “g4beamline” to simulate MICE beam:

- Simulation takes into account fringe fields and fields in iron
- Used to optimize beamline design and obtain rates in detectors

Optimized beam rates per “target-in” ms (occurring once per s):

<table>
<thead>
<tr>
<th>Description</th>
<th>LAHET</th>
<th>Geant4</th>
<th>MARS</th>
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<td>1mm x 100mm, 10m from target</td>
<td>33,400</td>
<td>482</td>
<td>507</td>
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<tr>
<td>TOF0</td>
<td>2355</td>
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<tr>
<td>TOF2</td>
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<td>321</td>
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<tr>
<td>Good μ⁺</td>
<td>277</td>
<td>316</td>
<td>333</td>
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</table>
G4MICE Experiment Simulation
(IIT / BNL / Geneva / ICL / UCR et al.)

• Under development by international team under leadership of Y. Torun

Screen shot of the magnetic lattice:

View with the solenoid removed showing scintillating-fiber tracking stations:

Cooling 1/2-cell: two absorbers (blue), three coils (brown), two focusing and one coupling, and four rf cavities (red)

• Geant 4 simulation generates hits on detectors taking all relevant physics processes into account

• Used to study effectiveness of PID, systematics of emittance reconstruction, etc.
Tracker Progress:
(UK / FNAL / IIT / KEK / Osaka / UCLA / UCR)

Assembly of 3-station SciFi prototype

Mounted in D0 cosmic test stand

7 planes built

“Typical” event

Pulse-height spectrum (mean ≈ 11 p.e.)
Tracker Performance Simulation:
(C. Rogers, ICL G4MICE simulation)

- Correctable \~1\% bias due to scattering in detectors:

- Key physics goal of NSF MRI proposal:
  - demonstrate bias correction to <10\% of itself, as needed for 0.1\% emittance measurement
  - requires 2 spectrometers
SciFi Tracker Test at KEK
(KEK / UK / FNAL / IIT / UCR / Osaka)

• Assembling 4-station prototype to operate in 1T SC solenoid:

• 1st run ≈ end May; 2nd run Sept. or Oct.
Tracker Solenoid Design
(Genoa / LBNL / Oxford)

- Cutaway 3D rendering:

- Turret detail:
Absorber/Focus-Coil Module Engineering
(IIT / KEK / LBNL / NIU / Oxford)

- Internal safety review passed 12/03

- a) Windows are mounted off RT interface
- b) Space for change in pipe dimension close to magnet
- c) Large “bucket” at base to contain any rupture
**RF Cavity/Coupling-Coil Module**

(LBNL)

- Detailed module engineering proceeding:
  - Revised coil design much narrower than previously allows normal coupler geometry and increases interior clearance for tuners.
  - Tuner design verified by FEA.
  - Prototype now under low-power test at JLab.
Upstream Cherenkov Detector
(UMiss)

- Concept: liquid radiator w/ mirrors focusing Cherenkov light on PMTs
- Approach looks workable
- Optimization studies in progress...

- Simulated performance for 2 beam momenta:
US MICE Funding:

- Funds currently available:
  - DOE: $300k/y for 3 years starting in FY05
  - NSF: $100k/y for 3 years starting in FY05
  - DOE/MC: variable year by year depending on other priorities (see Zisman R&D talk)

- Additional funds requested from NSF:
  - MRI proposal (DMK, PI): $2M over 2 years for 1st tracking solenoid and US tracker contributions
  - University Consortium proposal (G. Hanson, PI): $3.5M requested over 3 years for muon-cooling R&D and MICE

- MICE US plan must be understood in context of MC 5-year R&D plan
  → see Zisman’s talk tomorrow for the details
Summary

- MICE is now approved and Phase 1 is funded
- Progressing well technically
- Some US MICE funding in place, more requested
- US has played a major role
- On track to exploit first beam in 2007