The Muon Ionization Cooling Experiment Run Control System

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for the MICE Collaboration

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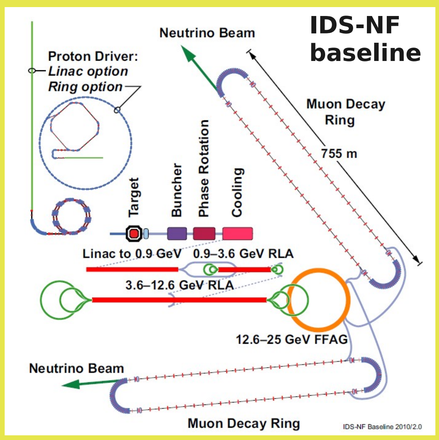
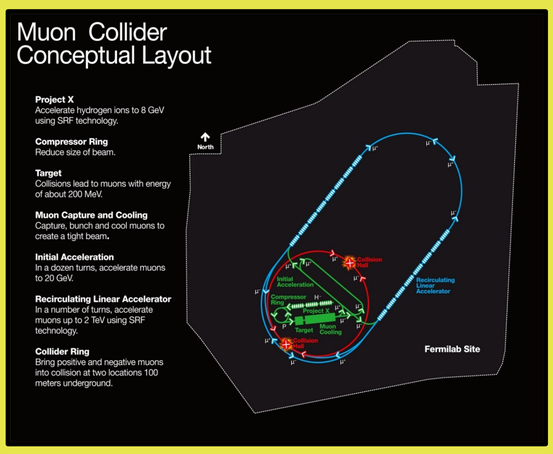
MICE is a staged experiment under construction at Rutherford Appleton Laboratory (UK). Its purpose is to demonstrate the feasibility of 4D muon emittance reduction in a realistic section of cooling channel by measuring single particle x, p_x, y, p_y,z, & t to determine x-x' and y-y' phase space before and after the cooling channel using experimental particle physics techniques.

Motivation:

Muon Cooling – key step in the development of future accelerators: Neutrino Factory and Muon Collider. Benefits include:

NF:
- ultimate tool for precision ν studies
- "Golden channel" for ν measurements $\mu^+ \rightarrow e^+ \nu_e \bar{\nu}_\mu$



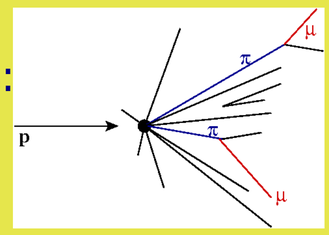


Muon Collider:
- increased luminosity in muon collider
- reduced site boundary radiation

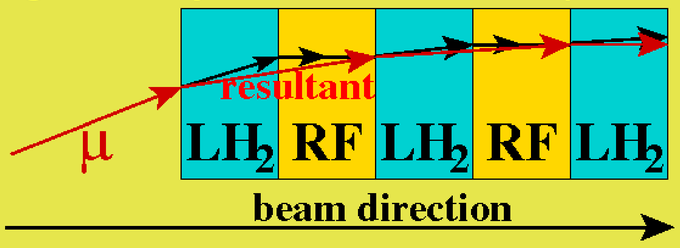
Cooling:

Muons are produced as tertiary particles:

$$p + N \rightarrow \pi + X \hookrightarrow \mu + X$$



Created with large emittance (6D volume/momentum spread) – impractical for an accelerator. "Cooling" reduces beam spread. Short muon lifetime, τ_μ=2.2μs, dictates ionization cooling as only feasible technique.



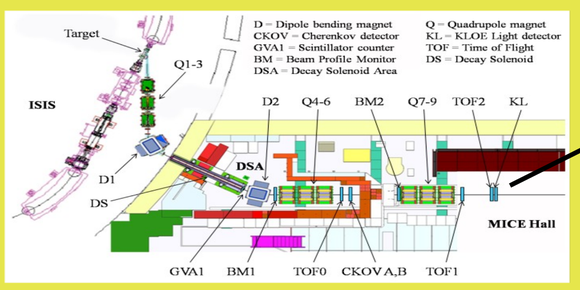
Cooling is:
1) Momentum loss in all dimensions via dE/dx
2) Replace longitudinal momentum with RF

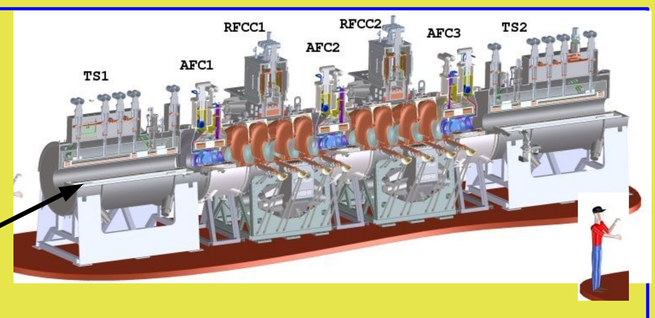
$$\frac{d\,\varepsilon_N}{ds} = -\frac{1}{\beta^2}\left\langle \frac{d\,E_\mu}{ds} \right\rangle \frac{\varepsilon_N}{E_\mu} + \frac{1}{\beta^3}\frac{\beta_\perp (0.014\,GeV)^2}{2\,E_\mu m_\mu X_0}$$

cooling **heating**

MICE will demonstrate ionization cooling for a variety of beam optics, muon momenta (140-240 MeV/c), absorbers and diffuser settings.

Apparatus:





MICE Beamline
Commissioned summer 2010

MICE Tracking/Cooling Channel:
- TS 1/2 – tracking spectrometers
- AFC 1/2/3 – absorber/focusing coils
- RFCC 1/2 – RF/coupling coils

Controls and Monitoring (C&M):

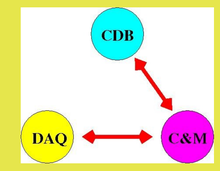
MICE is a precision experiment: it will measure a 10% cooling effect with 1% resolution – *a 0.1% relative emittance measurement!* All parameters must be carefully controlled and monitored so as to minimize systematic errors.

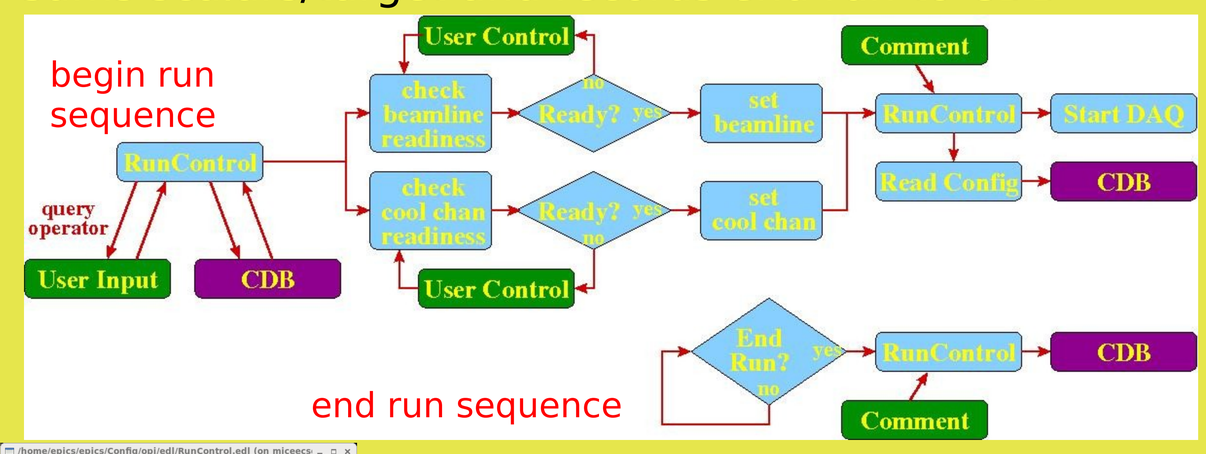
C&M Organization:
- **Beamline**
  - target
  - conventional magnets
  - proton absorber
  - beam stop
  - diffuser
- **Particle ID (PID)**
  - GVa1
  - ToF 1/2/3
  - CKOV A/B
  - KL
  - EMR
- **Environment**
  - temperature/humidity…
- **Facilities**
- **Tracking Spectrometers**
  - spectrometer solenoids
  - trackers **(see CHEP #345)**
- **AFC**
  - absorbers
  - focusing coils
- **RFCC**
  - RF (acceleration)
  - coupling coils

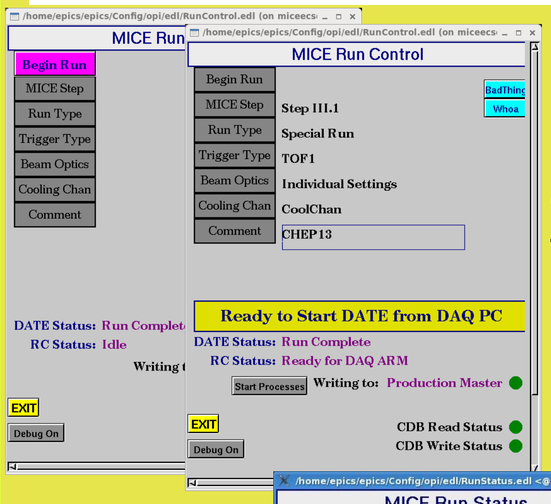
These require:
- vacuum
- cryogenics
- power supplies

Run Control:

- integrates DAQ, target, CDB, beamline, environment
- operational configurations from configuration DB (CDB)
- flexible to allow for unique configurations
- capable of tagging run configurations in CDB
- single point of control for data taking
- sequences initialization
- verifies and writes run configuration to CDB
- sums scalars/target and records end run to CDB



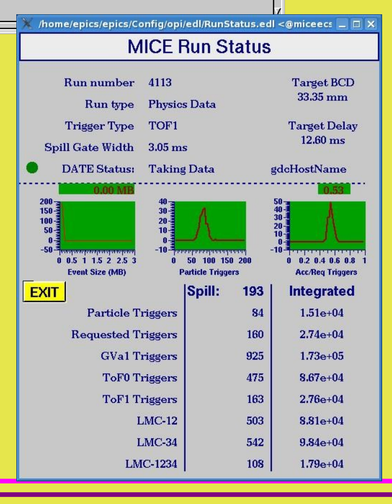


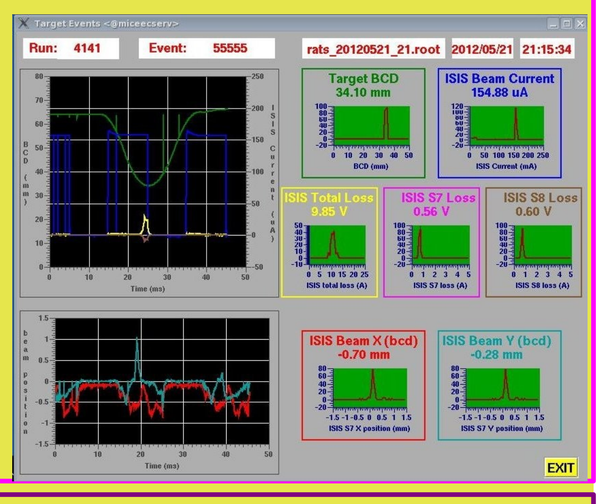


RunControl: examples of begin run configuration to begin run screens

Target monitoring

Run Status screen





Future:

Major systems still to be introduced into MICE hall: TS1, TS2, and AFC1 in 2013-2014. Finite state machines using EPICS SNL (CHEP13 - #447) will be used for superconducting magnet operation and interface with RunControl for proper sequencing of operations.