# The Muon Ionization Cooling Experiment Run Control System

**Pierrick Hanlet, Illinois Institute of Technology**
**for the MICE Collaboration**

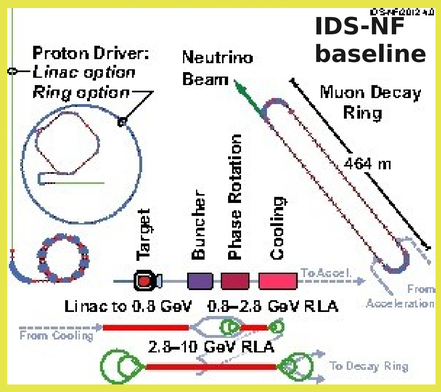
**Hanlet's work supported by U.S. Department of Energy Office of Science through the Muon Accelerator Program**

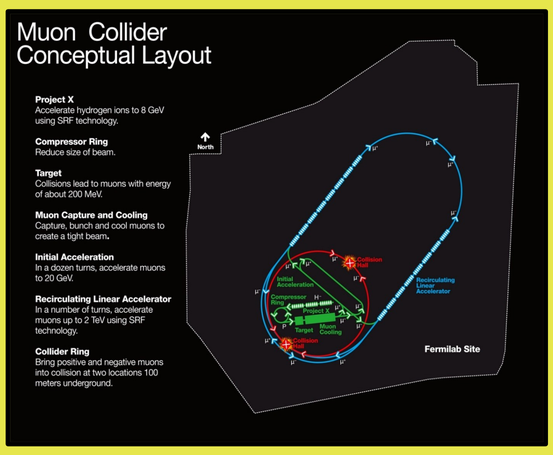
**MICE** is a staged experiment under construction at Rutherford Appleton Laboratory (UK). Its purpose is to demonstrate the feasibility of 4D muon emittance reduction in a realistic section of cooling channel by measuring single particle x, $p_x$, y, $p_y$,z, & t to determine x-x' and y-y' phase space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

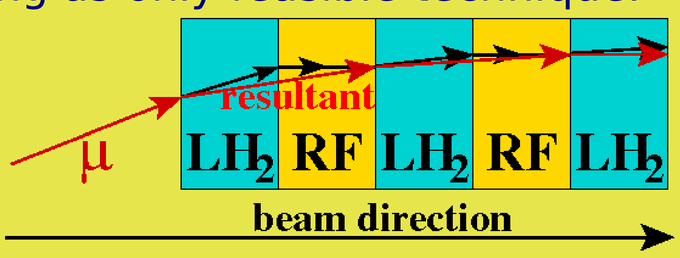
## Cooling:

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, $\tau_\mu$=2.2μs, dictates ionization cooling as only feasible technique.



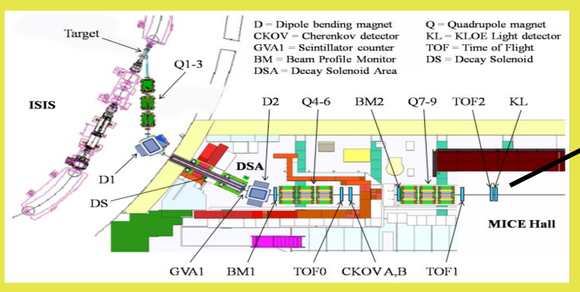

**Cooling is:**
**1) Momentum loss in all dimensions via dE/dx**
**2) Replace longitudinal momentum with RF**

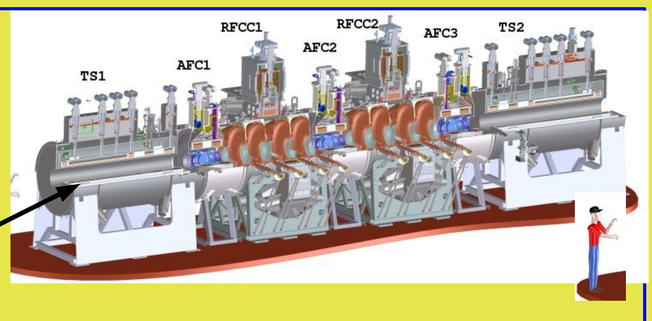
$$\frac{d\,\varepsilon_N}{ds} = -\frac{1}{\beta^2}\left\langle\frac{d\,E_\mu}{ds}\right\rangle\frac{\varepsilon_N}{E_\mu} + \frac{1}{\beta^3}\frac{\beta_\perp (0.014\,GeV)^2}{2\,E_\mu m_\mu X_0}$$

**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.

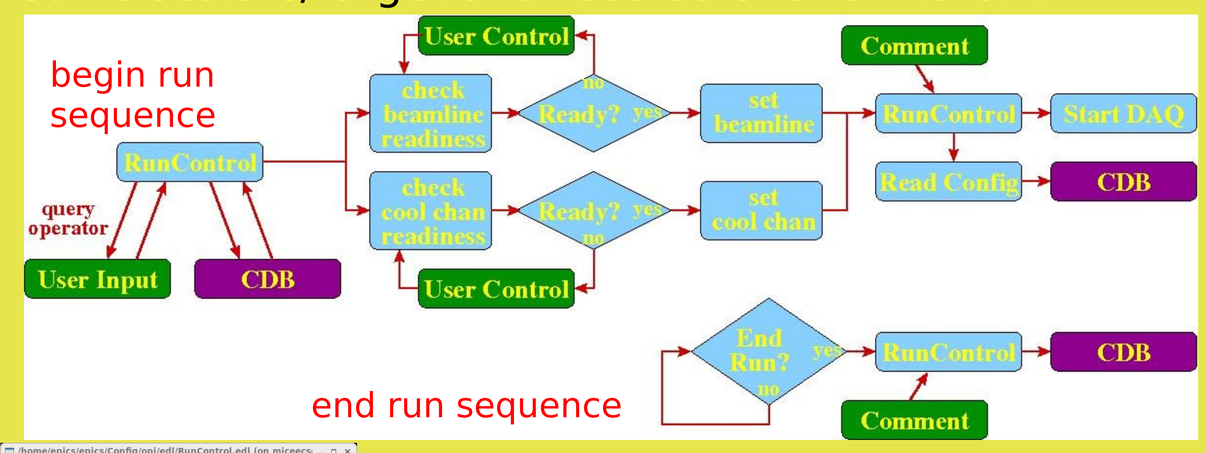
**C&M Organization:**
- **Beamline**
  - **target**
  - **conventional magnets**
  - **proton absorber**
  - **beam stop**
  - **diffuser**
- **Particle ID (PID)**
  - **GVa1**
  - **ToF 1/2/3**
  - **CKOV A/B**
  - **KL**
  - **EMR**
- **Environment**
  - **temperature/humidity…**
- **Facilities**
-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

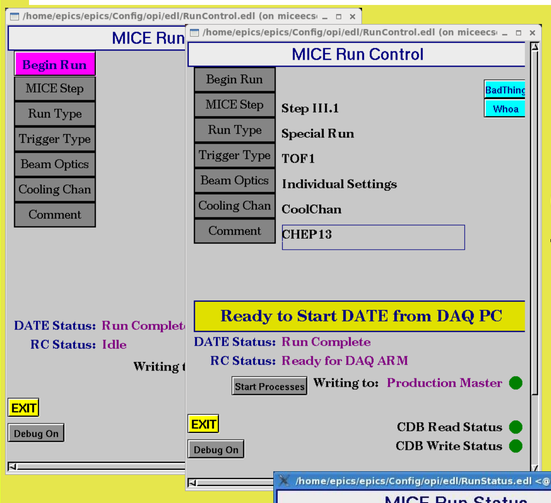
**These require:**
- **vacuum**
- **cryogenics**
- **power supplies**

## 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



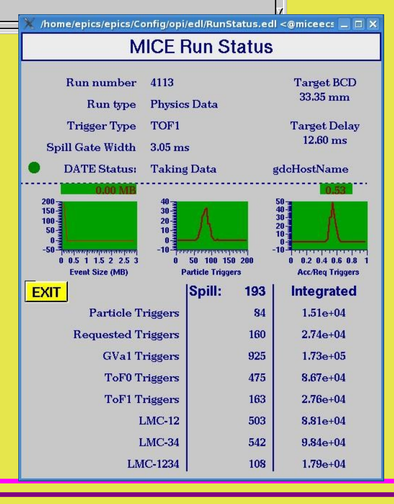



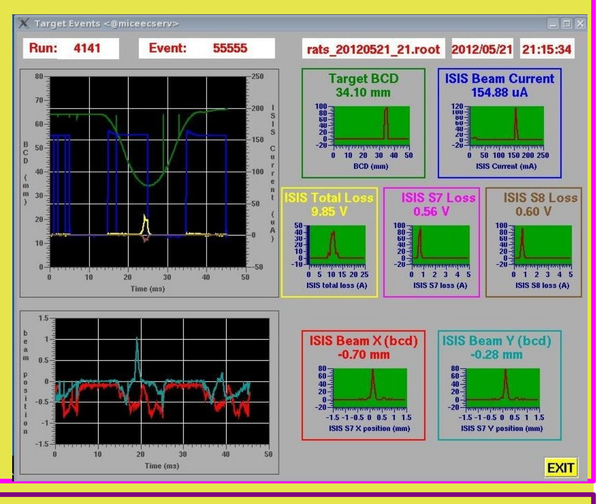




RunControl: examples of begin run configuration to begin run screens

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.