The Muon Ionization Cooling Experiment: Controls and Monitoring

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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 (beam spread) reduction in a realistic section of cooling channel by measuring single particle x-x' & y-y' phase space before and after the cooling channel using experimental particle physics techniques.
MICE is a precision experiment: it will measure a 10% cooling effect with 1% resolution – a 0.1% absolute measurement.

Motivation:

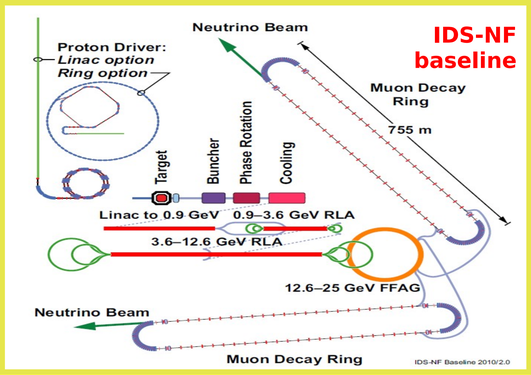
Muon Cooling – key step in the development of future accelerators: Neutrino Factory (NF) and Muon Collider. Benefits include:

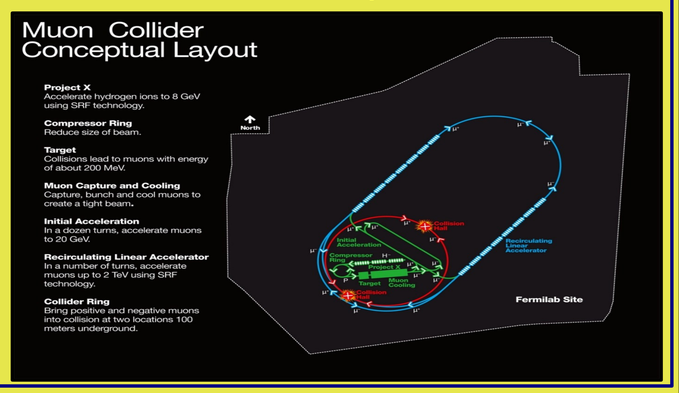
NF:

- 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

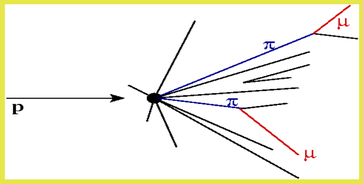




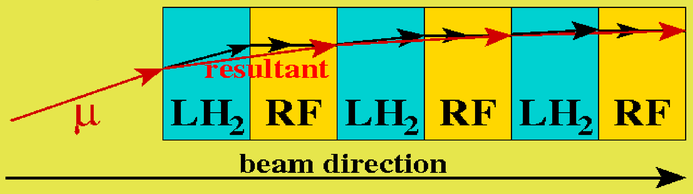
Cooling:

Muons are produced as tertiary particles:

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



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



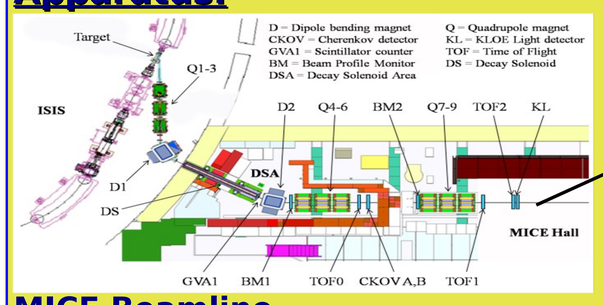
Cooling is:
1) Momentum loss in all dimensions via dE/dx
2) Replace longitudinal momentum with RF

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

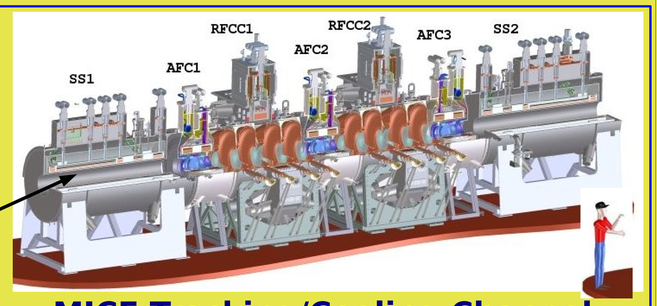
cooling | heating

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):

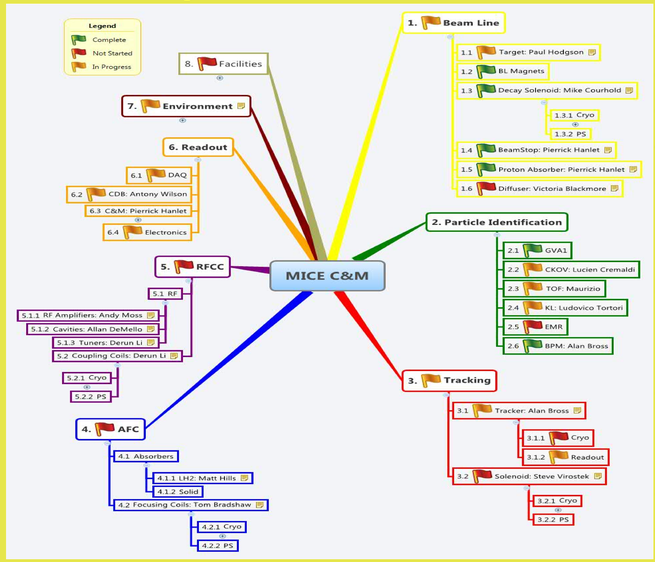
Controls serve to:

- control/Operate/Protect experimental equipment
- provide information between subsystems for inter-dependent operation
- provide user interface to control hardware
- properly sequence equipment operations
- ensure appropriate resource sharing of subsystems
- interface w/configuration database to systematically set/record configurations
- interface w/DAQ to ensure readiness/stability of equipment during running
- user interface to start/stop runs

Monitoring serves to:

- provide feedback for control sequencing
- give early notification of potential equipment failures
- provide software interlocks to protect equipment
- protect data quality
- archive pertinent data which may later be needed for debugging
- archive pertinent data which may later be needed in data analysis corrections

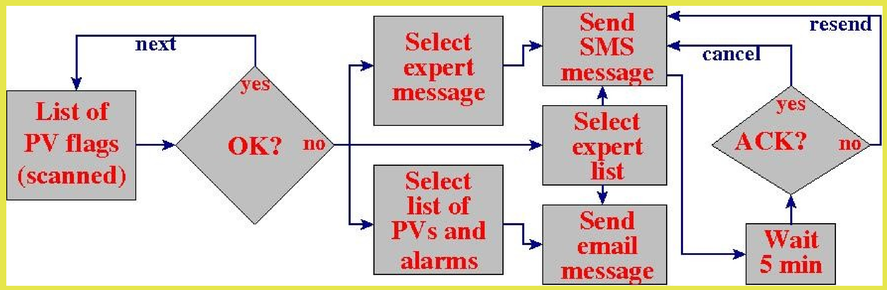
MICE Subsystems



C&M Organization:

- **Beamline**
- **Particle ID (PID)**
- **Environment**
- **Tracking Spectrometers**
  - **spectrometer solenoids**
  - **fiber trackers**
- **AFC**
  - **absorbers**
  - **focusing coils**
- **RFCC**
  - **RF (acceleration)**
  - **coupling coils**
- **Environment/Facilities**
- **Computing/Electronics**

Higher Level C&M:

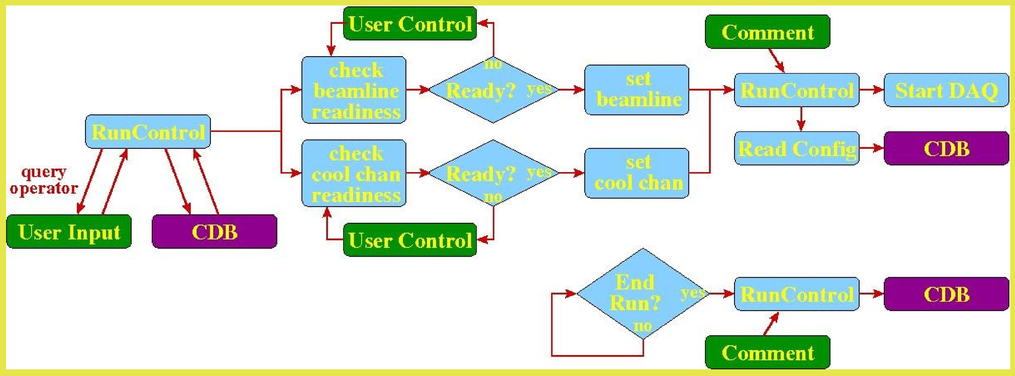


AutoSMS:

- Used as poor-man's auto-dialer
- Makes use of email to SMS gateway

RunControl:
Integrates

- equip. IOCs
- DAQ
- target DAQ
- MICEStates
- DAQMon
- CDB



MICEStates:

- use EPICS SNL
- to be used in all major subsystems
- sets PV fields depending on state
- sets archiver features
- sets AutoSMS flags
- presently used in SS tests
- transition to state
- read CDB for subsystem/state
- set PV ALH fields/archive configuration
- perform checks on software interlocks
- perform checks for errors
- perform checks for new transition