MICE Overview
- Physics Goals and Prospects -

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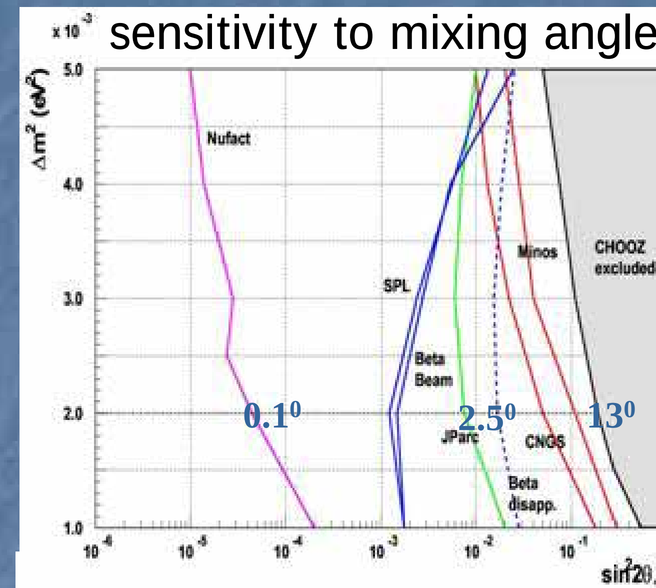
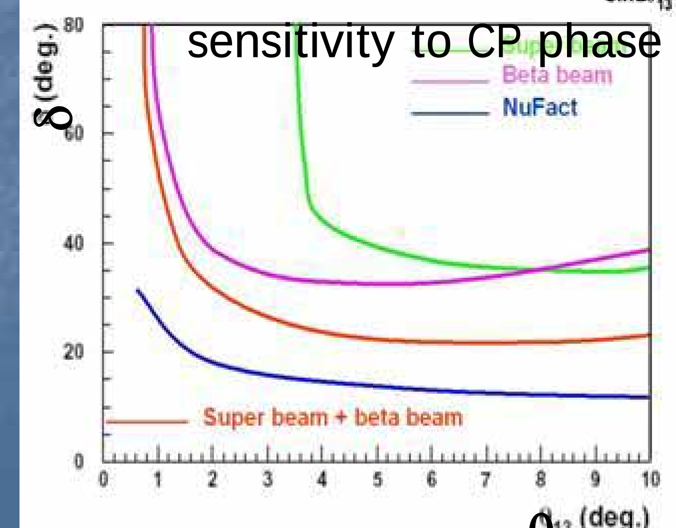
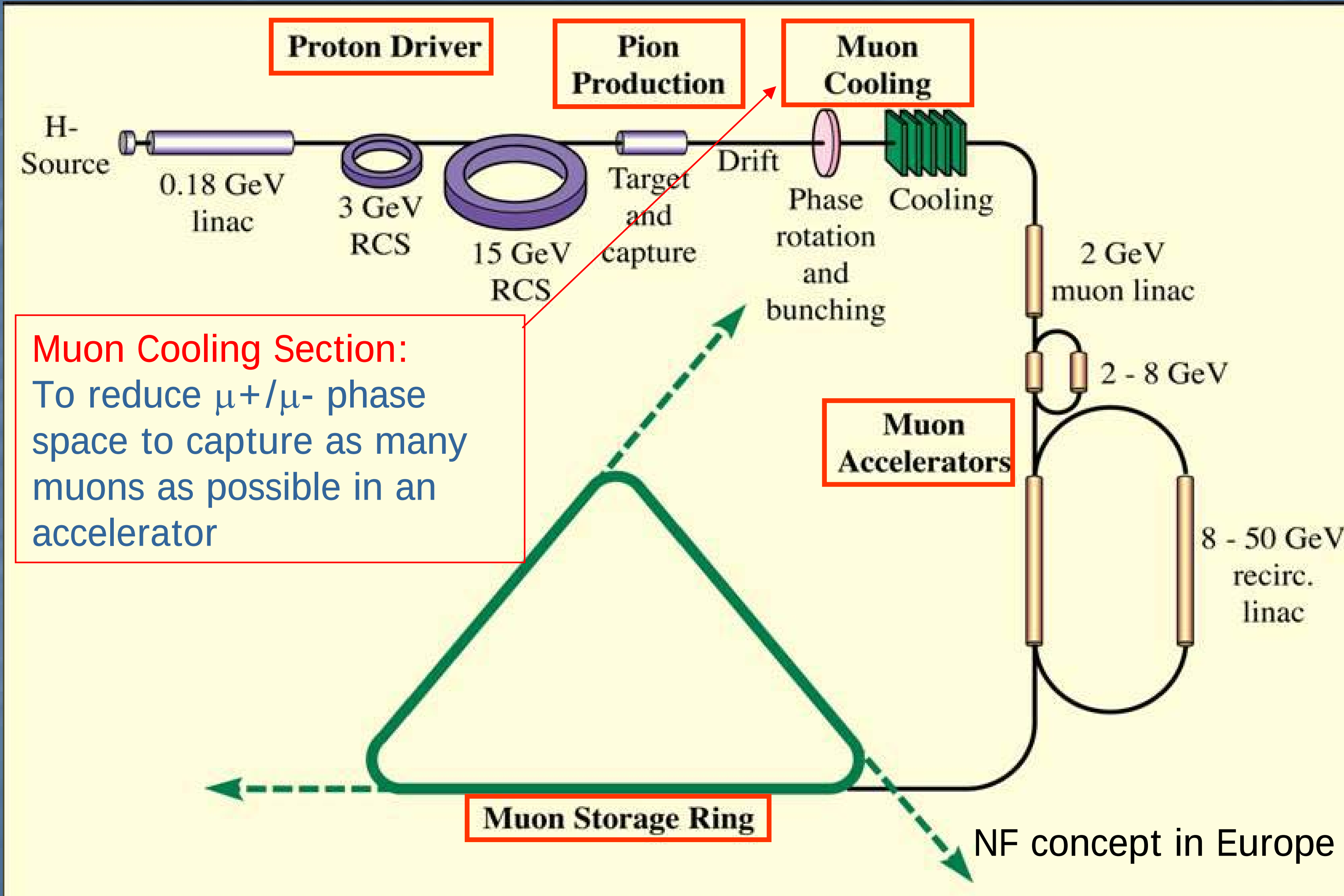
Motivation

- Muon storage ring is needed for the next generation of physics studies
- Physics with intense muon/neutrino source
  - Neutrino oscillations
  - Muon rare decay search
  - Muon collider
- Neutrino factories are being studied in Europe, USA and Japan
- Advantage of neutrino beam based on muon storage ring
  - well-known energy and composition
  - high intensity $>10^{20}\nu$/year





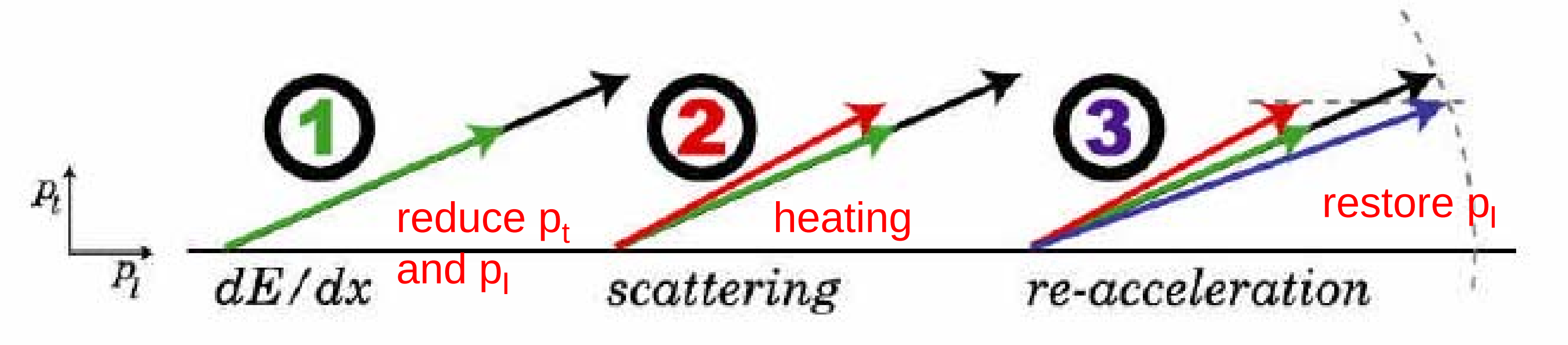
Neutrino Factory Concept

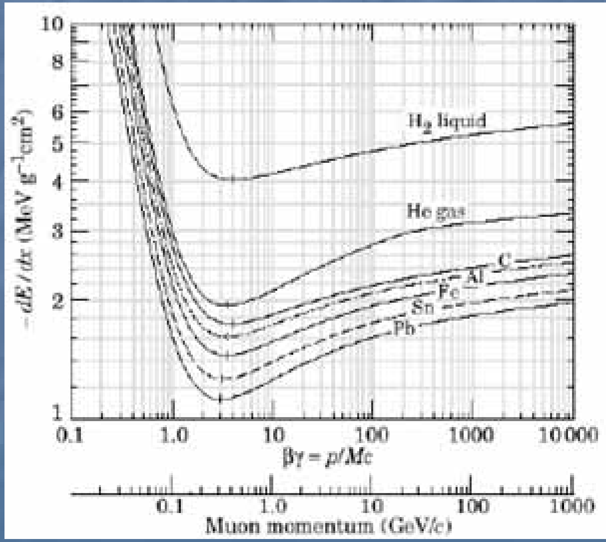


Muon Cooling Section:
To reduce $\mu+/\mu-$ phase space to capture as many muons as possible in an accelerator

NF concept in Europe

Ionization Cooling





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

Advantage:
- fast in principle (muon life ~ 2μs)
- available for both μ^+ and μ^-

Liquid Hydrogen is suitable for the absorber
- large energy loss
- low multiple scattering

So far, ionization cooling has not been demonstrated.

→ MICE

MICE collaboration

International collaboration of 39 institutes

Europe

Louvain la Neuve, Sofia, Milano, Napoli, Roma III, Trieste, NIKHEF, Novosibirsk, CERN, Genève, PSI, Brunel, Edinburgh, Glasgow, Imperial College, Liverpool, Oxford, RAL, Daresbury, Sheffield, Cockcroft Inst.

Japan

KEK, Osaka, Kyoto

China

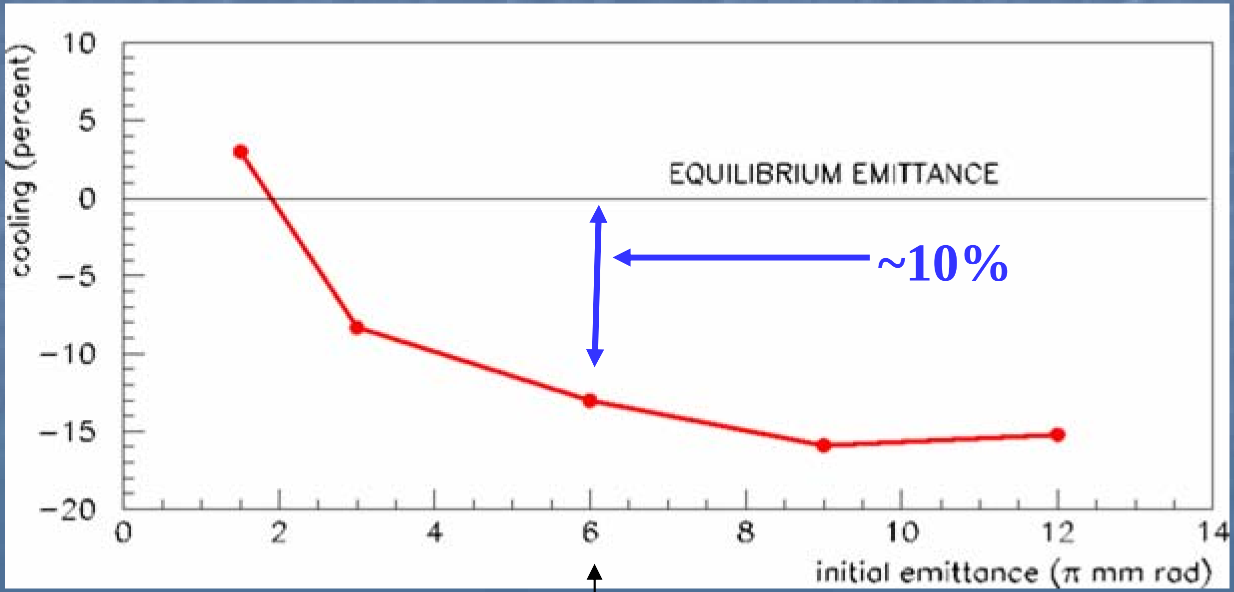
ICST Harbin

United States of America

ANL, BNL, FNAL, IIT, Chicago Enrico Fermi Inst., LBNL, UCLA, NIU, Mississippi, Riverside, Fairfield, JLAB, Iowa, Illinois

MICE Goals (Cooling Channel)

- To design, engineer and construct a section of realistic cooling channel
  - Safe and robust system of liquid hydrogen absorber
  - High gradient RF cavity for fast cooling
    - ~20MV RF is required to achieve 10% emittance reduction in ~10m
  - Integrate components into high solenoid magnetic field



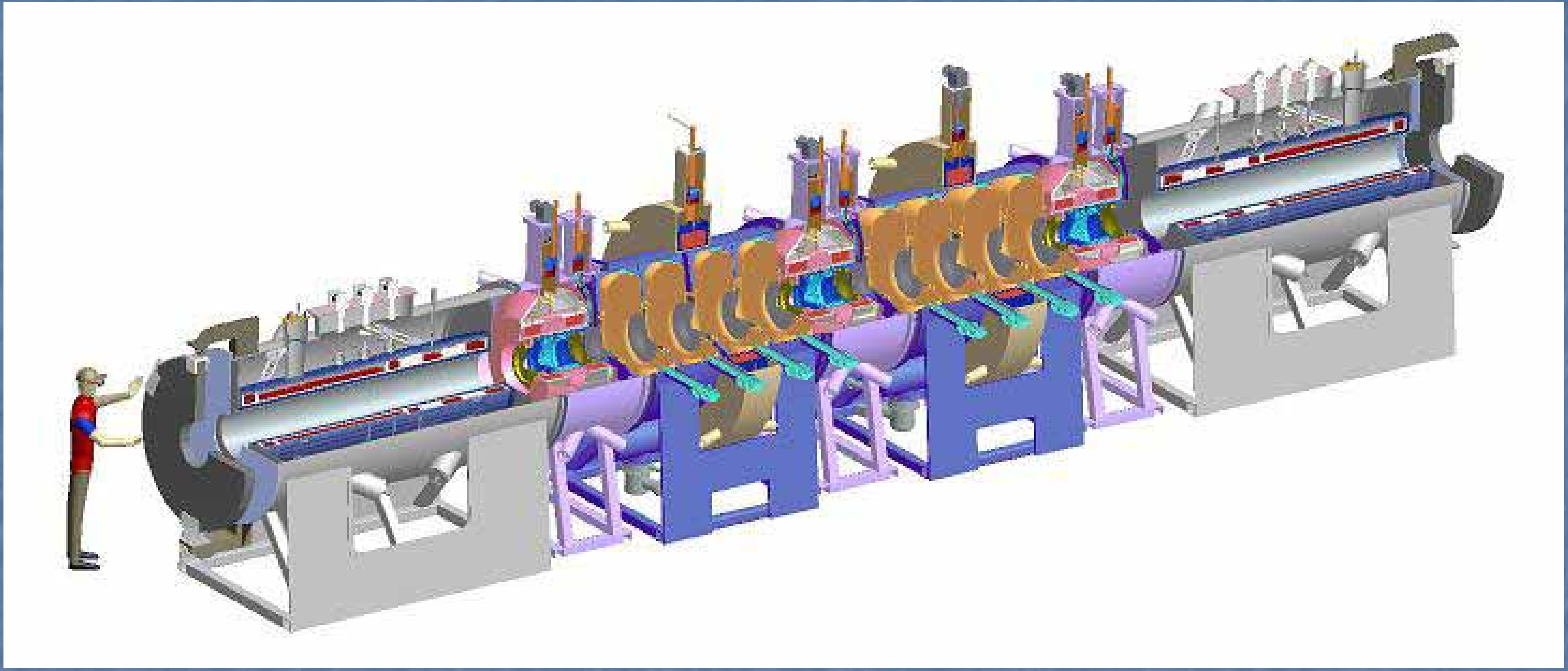
nominal input emittance

Curves for 21 MV, 3 full absorbers

MICE Goals (Detectors)

- Achieve 0.1% accuracy in the measurement of emittance ($1-\varepsilon_{out}/\varepsilon_{in} \sim 10\%$)
  - Measure space and time coordinates of individual particles before and after cooling channel
  - Any desired input beam condition can be reconstructed by appropriate weighting of the observed particles → feedback with cooling channel design
  - Particle ID to reject background pions and electrons
- Need careful integration of particle detectors to the cooling channel
  - Low material to avoid scattering in the detectors
  - Robust operation in the magnetic field and background from RF

MICE Cooling Channel



- 3 Liquid Hydrogen absorbers with thickness of 35 cm
- 5T SC focusing coil for small β_t=42cm
- Two sets of 4 201MHz RF cavities with 8MV/m
- Two coupling coils

Liquid Hydrogen Absorber

- Convection-type absorber cooled by He flow
  - Successfully filled with LH2 in MTA at FNAL
- Test cryostat cooled by cryo-cooler for MICE LH2 absorber is designed

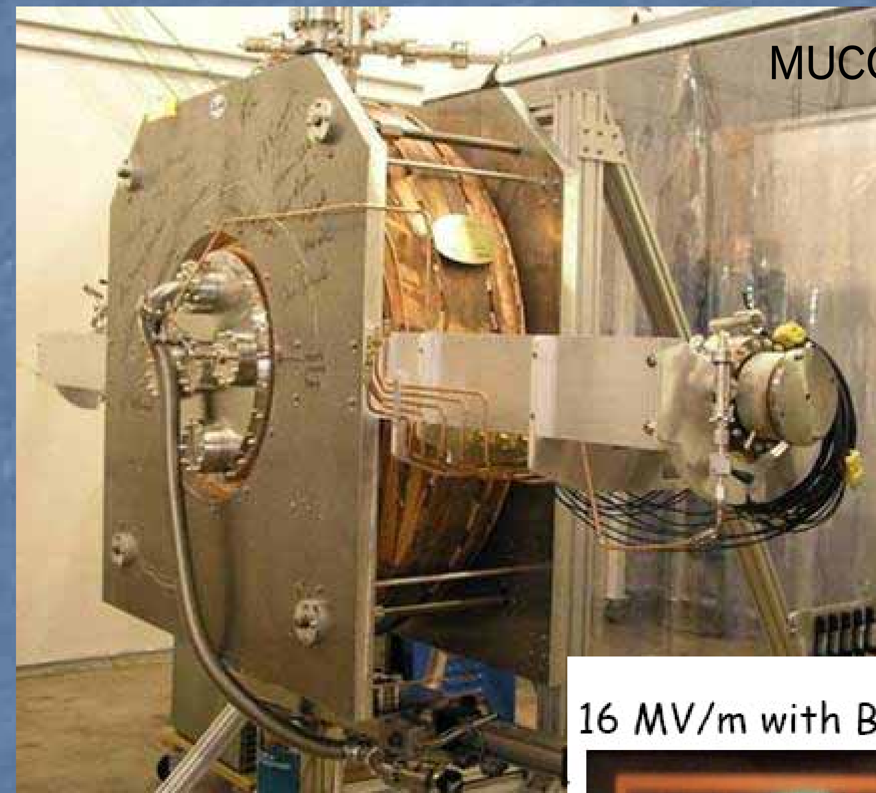
KEK absorber II

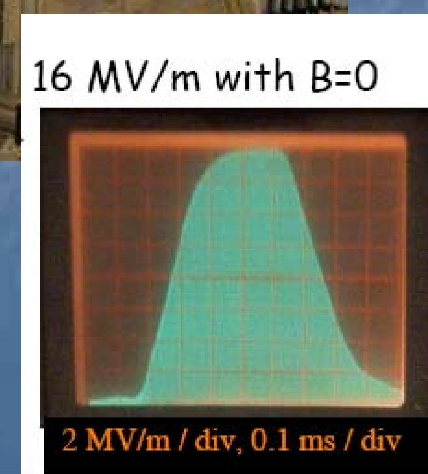
KEK test cryostat sitting in MTA/FNAL

201 MHz RF Cavity

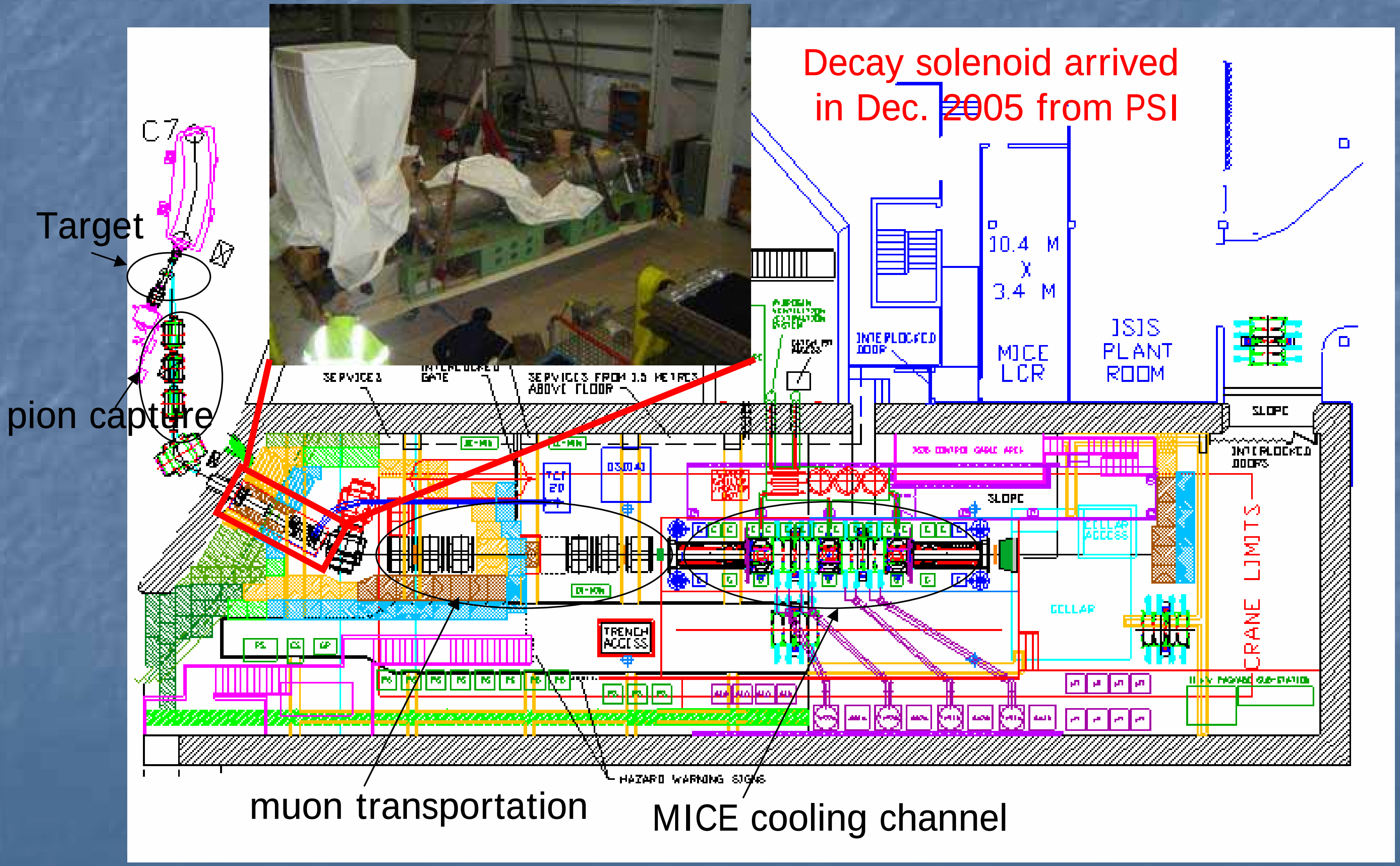
- MICE specification
  - Accelerating gradient : 8 MV/m
  - Axial magnetic field : 4 Tesla
  - Thin beryllium windows for good conducting boundary at big beam aperture
- Developed in MUCOOL R&D program
  - Cavity has been operated at 16 MV/m

MUCOOL



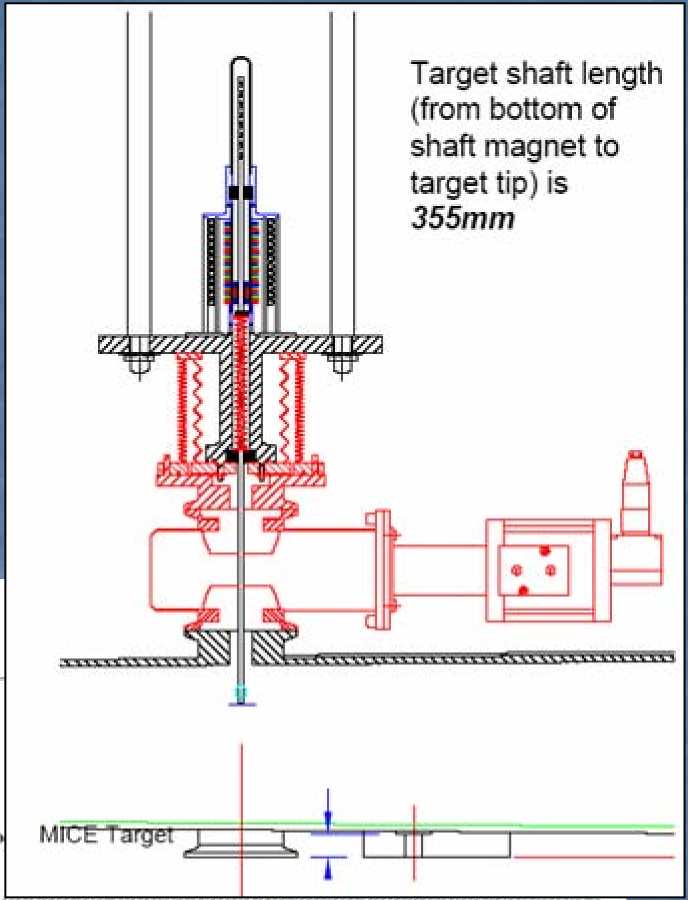


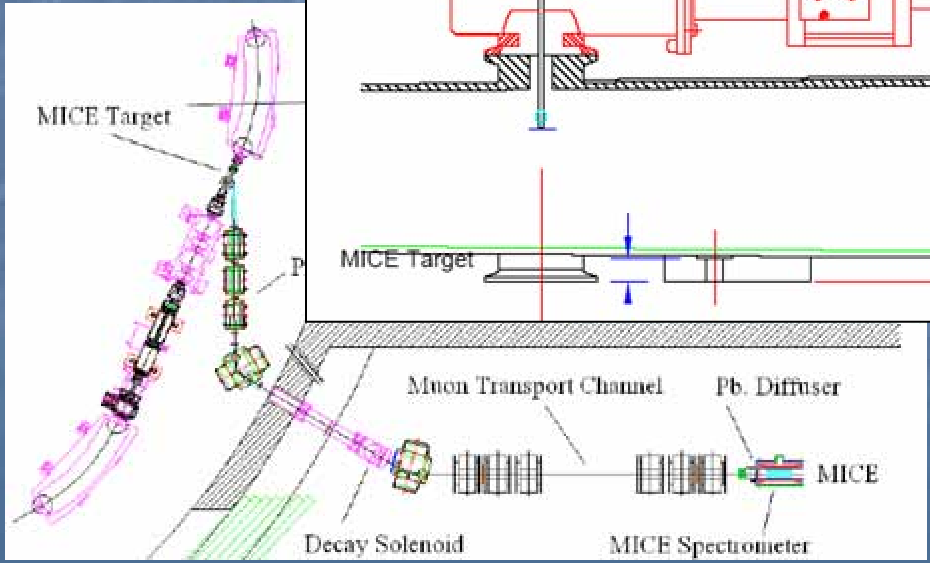
MICE hall at RAL



MICE Target

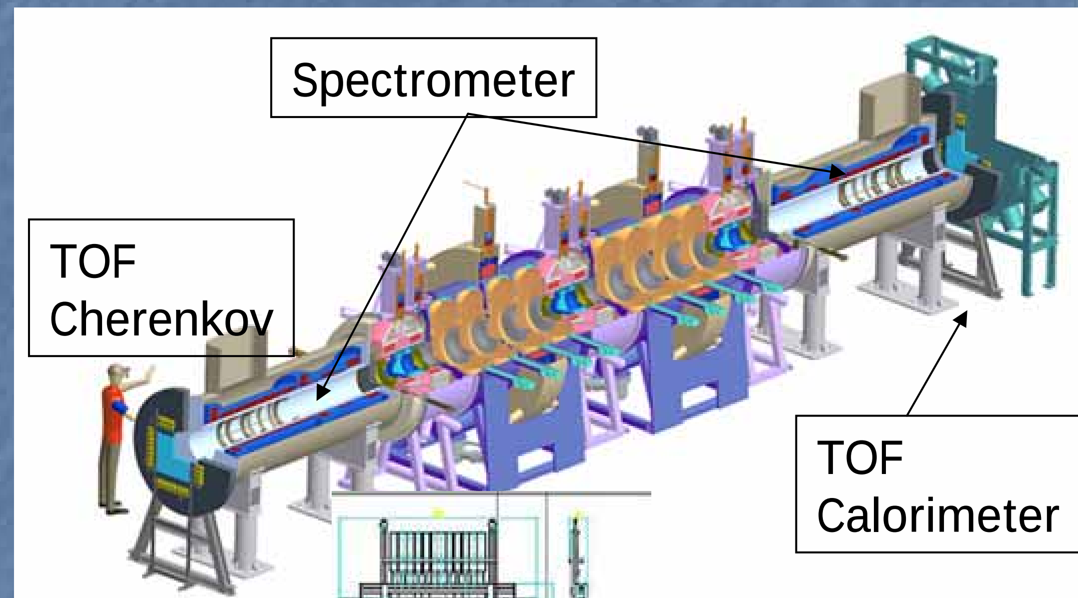
- Target moved by linear actuator scrapes halo of ISIS beam
  - On demand
  - 1 – 3 Hz operation
- Testing the target system
  - Planed in Oct. 2006
  - background measurement
  - building the system

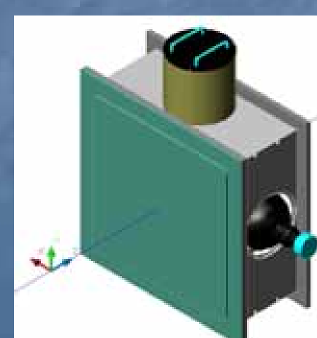


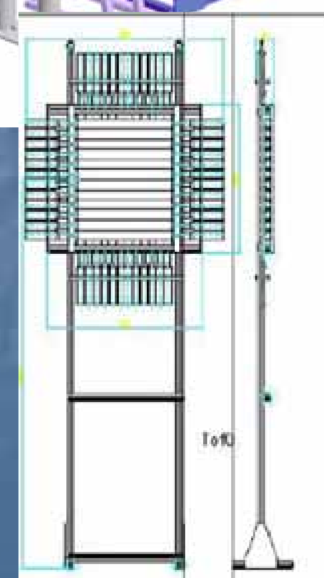


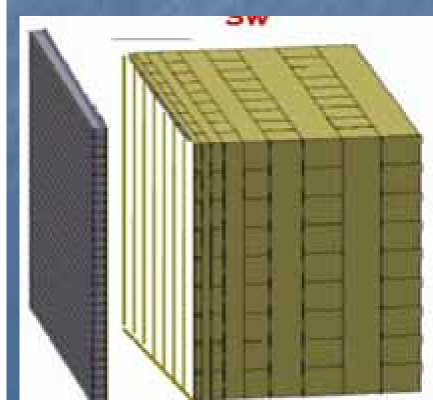
Detectors

- Two trackers in 4T SC solenoid
- TOF system / Cherenkov counter
  - reduce pion contamination to be less than 1%
- Calorimeter
  - reduce decay-electrons to the order of 10^{-3}
- Prototype of TOF system and calorimeter are tested now at INFN Frascati BTF



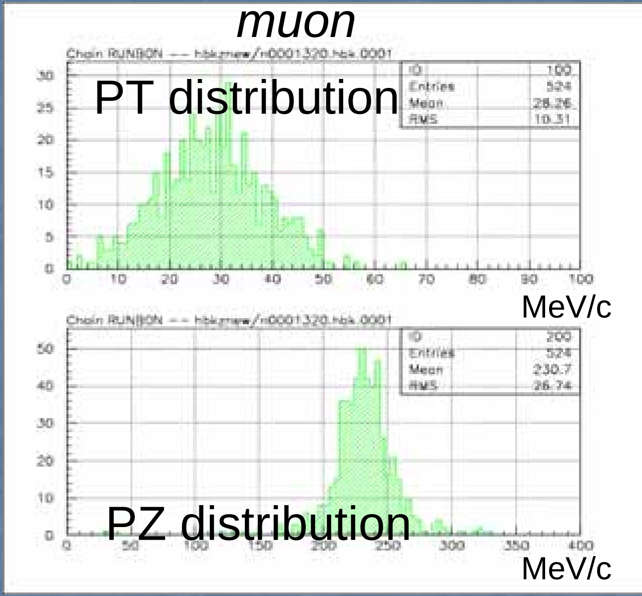


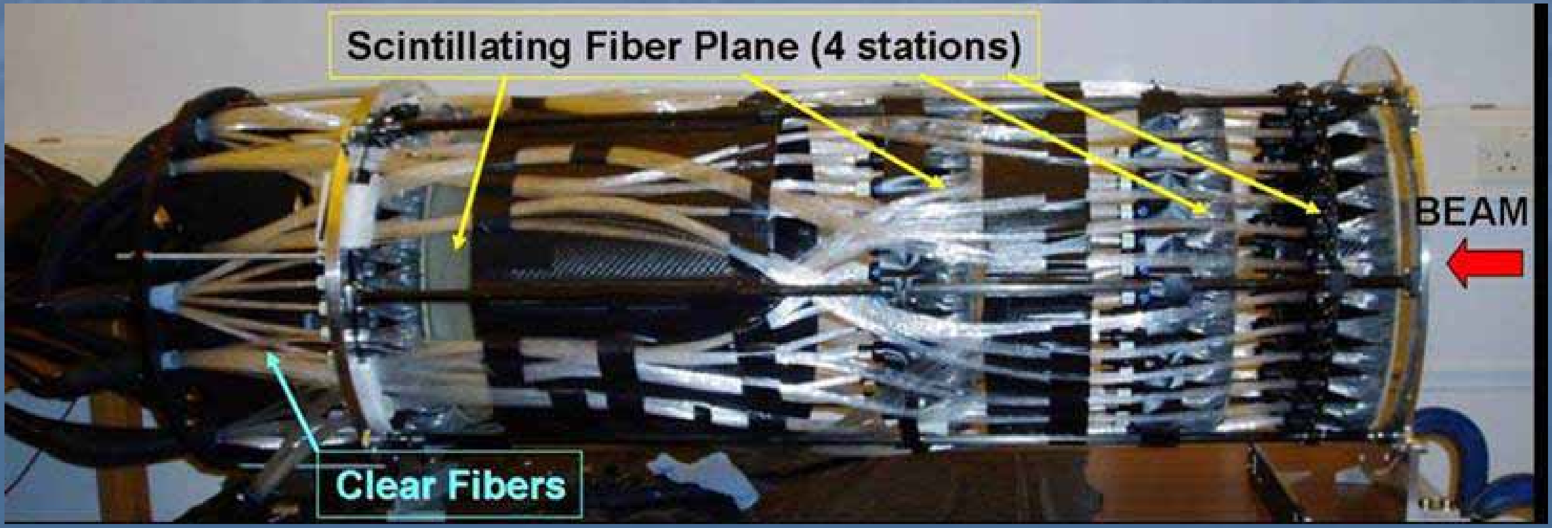




SciFi tracker

- Five stations of 350 μm scintillating fiber planes
- Visible Light Photon Counter (QE>80%) to cover low light yield (~10 p.e.)
- Prototype of 4 stations (Oct. 2004)
  - tested at KEK test beam



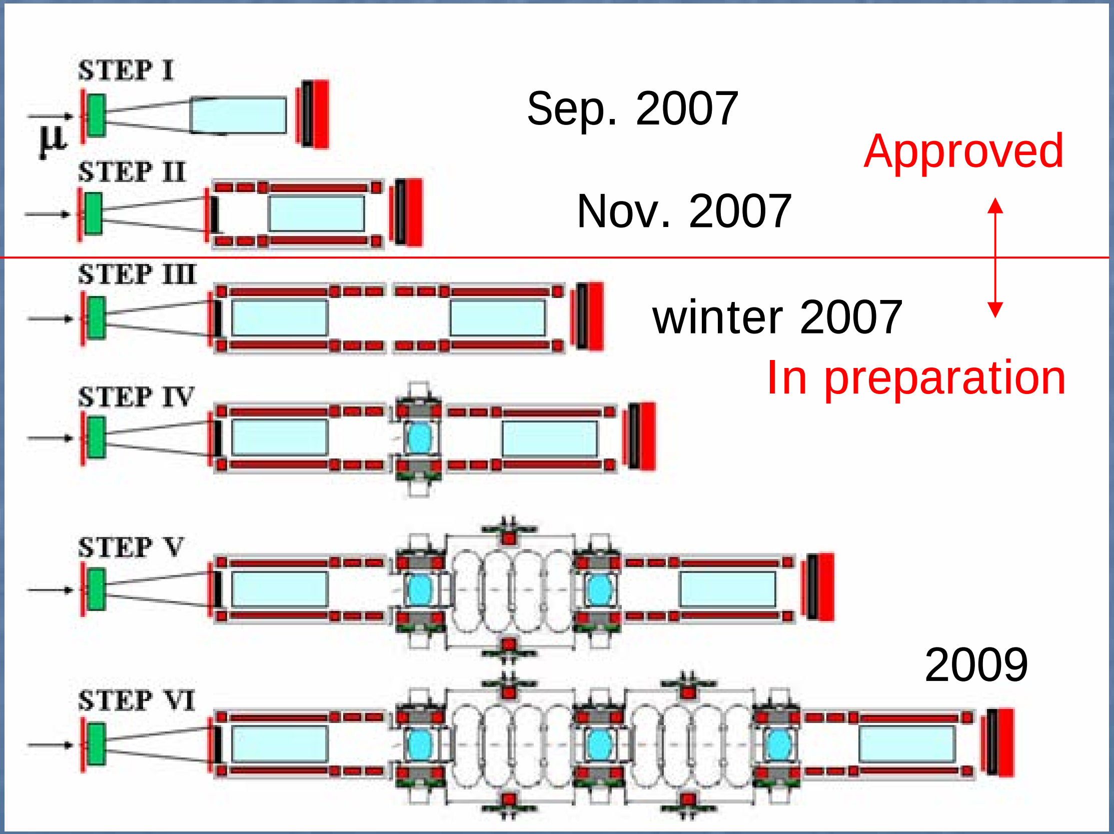


Tracker front-end electronics

- 2-slot Cryostat with Sumitomo cryocooler
  - developed for MICE
- Two VLPC cassettes and prototype AFE II boards borrowed from D∅
- Successful operation in KEK test beam
  - good long term stability for more than 1 month
- Production for MICE Phase-I has been started

Staged Approach

- Step I
  - commissioning of detectors
- Step II
  - precise measurement of beam emittance by a spectrometer
- Step III
  - systematic studies of emittance measurement with two spectrometers
- Step IV
  - precise studies on energy loss and multiple scattering in the absorber
- Step V, VI
  - establish the performance of the realistic cooling channel



Summary

- The international muon ionization cooling experiment (MICE) aims to demonstrate a realistic cooling channel for a muon storage ring.
- Hydrogen absorber cooled by cryocooler is tested
- Target in ISIS is under construction, and will be tested in Oct. 2006
- Tracker prototype was exposed to KEK test beam, and successfully operated in 1-Tesla solenoid magnetic field
- TOF and Calorimeter prototypes are about to be tested at INFN Frascati
- MICE phase-I has been approved, and preparing for Phase-II
  - MICE will start in September, next year (2007)
- Hope to establish the performance of muon ionization cooling in 2009, and to feed back to NF cooling channel design