MICE Overview

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Outline

I Motivation

II Procedure for cooling muons

III MICE description

IV Schedule

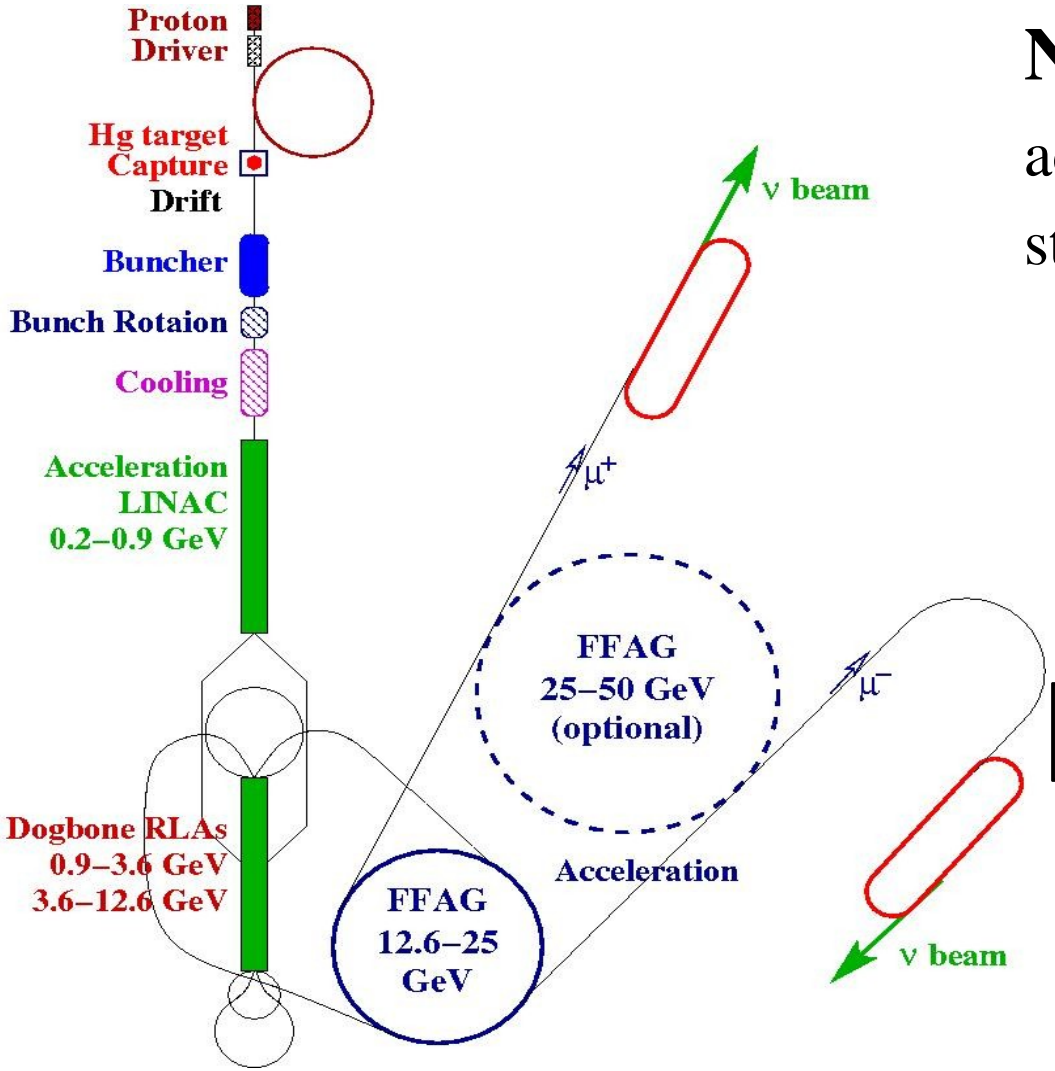
V Status

VI Summary

Motivation

- ***We do MICE because we want to investigate the feasibility of cooling a muon beam for a neutrino factory and a muon collider***
- ***Muons give you:***
  - ***higher CM energies than electrons***
  - ***cleaner neutrino beam -- "Golden channel"***
  - ***reduced synchrotron radiation in ring***
- ***Cool muons allows for:***
  - ***cost saving during acceleration***
  - ***more intense neutrino beam***
  - ***reduced site boundary radiation***
- ***PROBLEM – muons have τ=2.2μs!!!***
- ***Technological challenge, but not impossible***

Motivation: Neutrino Factory



Neutrino Factory:

accelerate muons and store to produce neutrinos

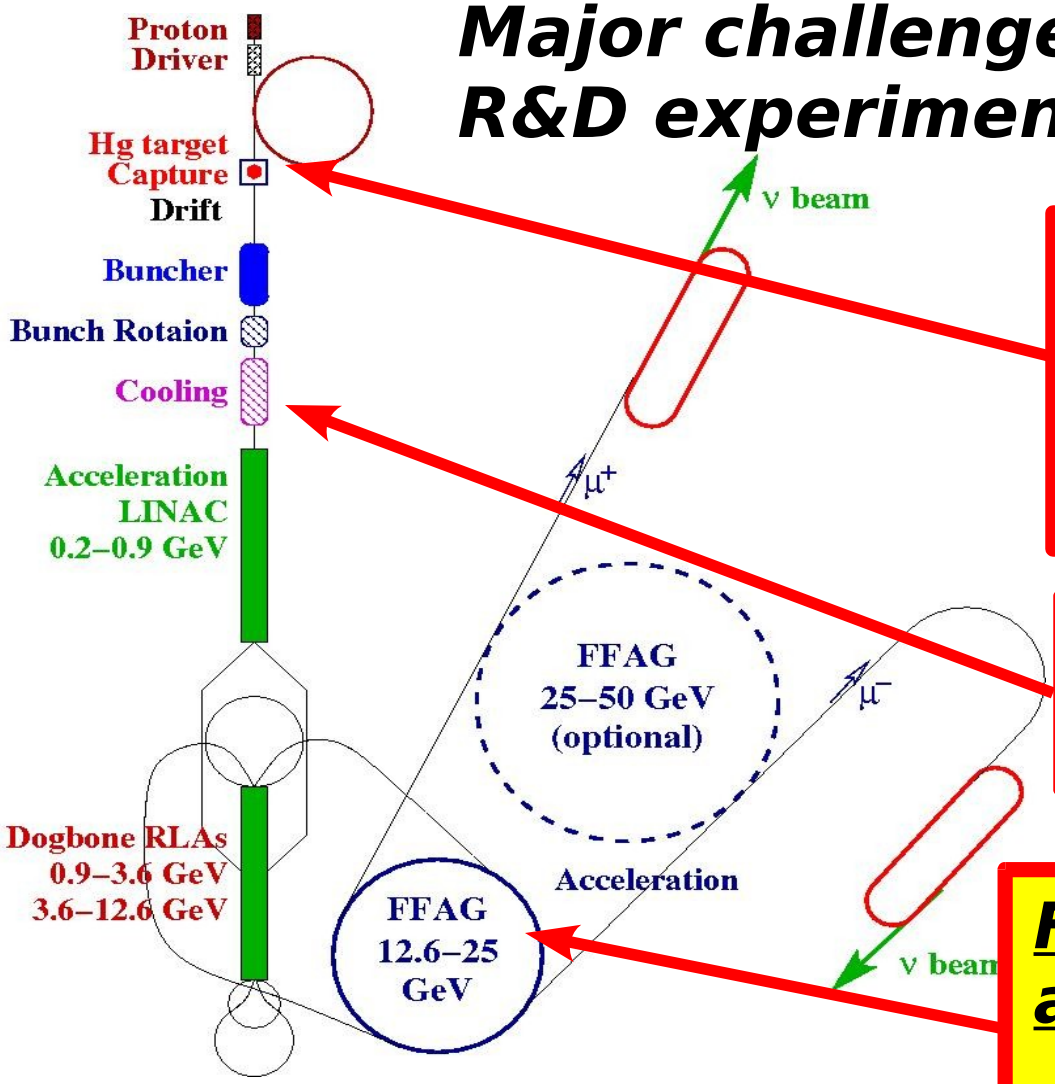
$$\mu^+ \rightarrow e^+ \nu_e \bar{\nu}_\mu$$

High energy ν_e are **unique** to future facilities.

Golden channel: $\nu_e \rightarrow \nu_\mu$ long baseline oscillations manifests itself by wrong sign muons: $\nu_\mu + N \rightarrow \mu^- + X$

Motivation

Major challenges being met by R&D experiments



High-power target:
- 4MW
- good transmission
  - MERIT (CERN)

Fast muon cooling:
- MICE (RAL)

Fast, large aperture accelerator (FFAG)
- EMMA (Daresbury)

Procedure: Ionization Cooling

- *"Cooling" muons refers to reducing the emittance of the muon beam.*
- *Muons are created in tertiary interactions, and so are created with large inherent emittance:* $p + N \rightarrow \pi + X$, $\pi \rightarrow \mu + X$
- *Due to short muon lifetime, the only viable option is ionization cooling. Must cool AND accelerate rapidly:*

Procedure: MICE

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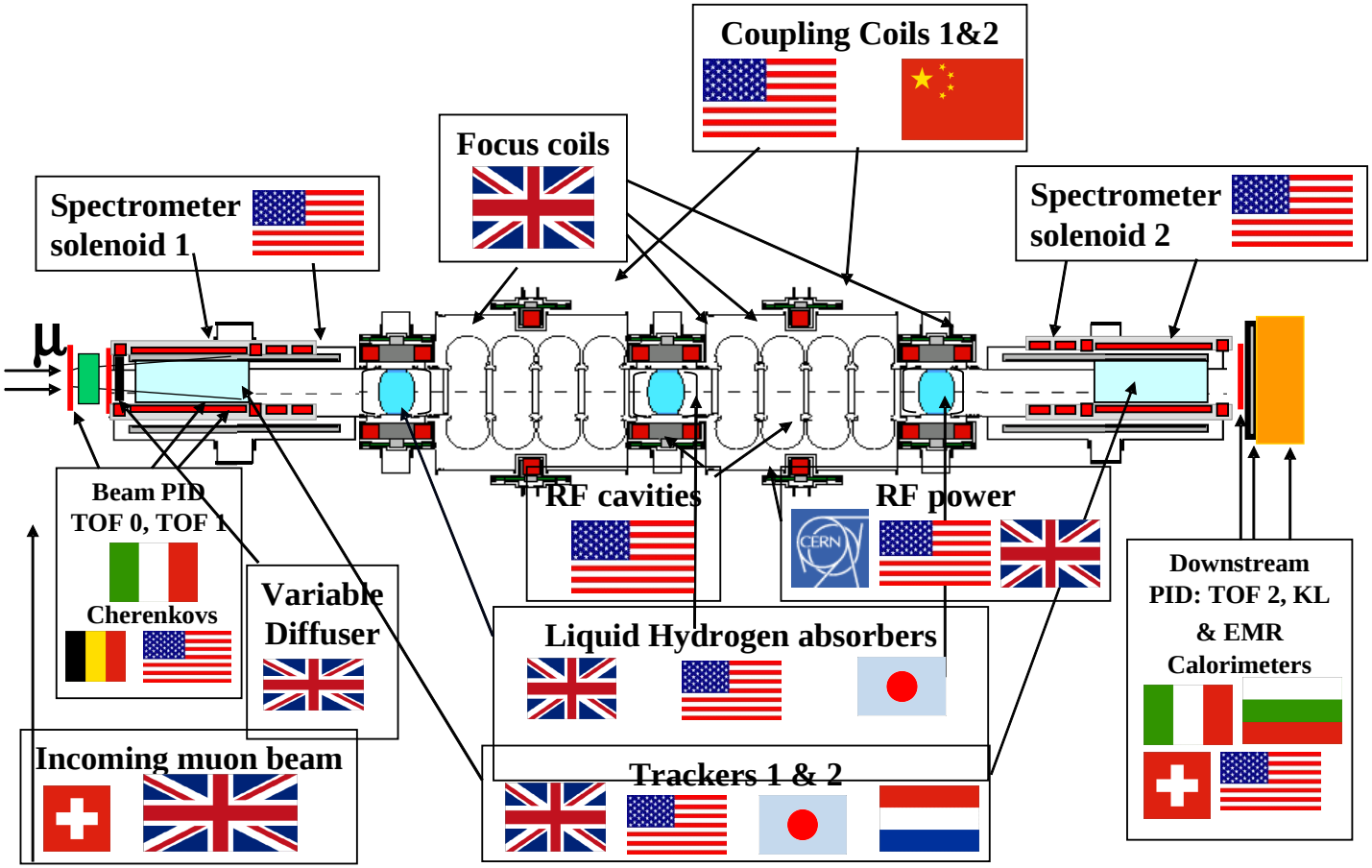
MICE will measure a 0.1% absolute cooling effect

1) create beam of muons
2) identify particles and reject background
3) measure single particle emittance
4) "cool" muons in low-Z absorber
5) restore longitudinal momentum component with RF cavities
6) identify particles to reject electrons from muon decay

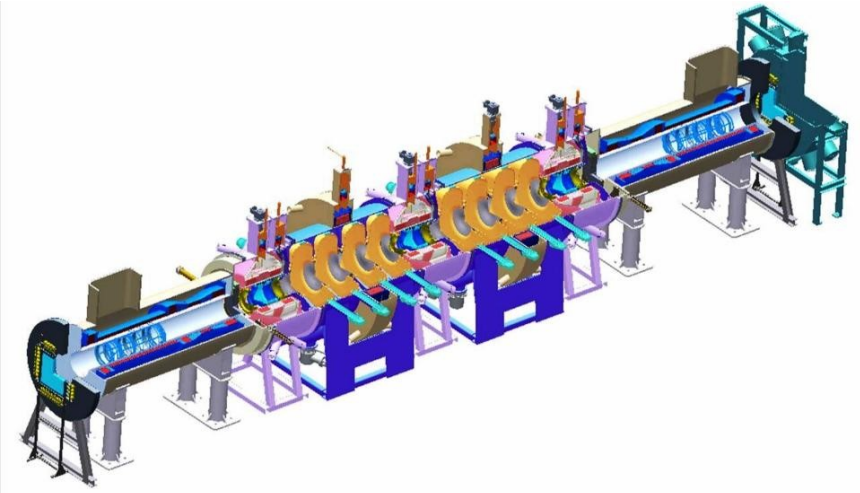
Description

Description: Who are MICE?

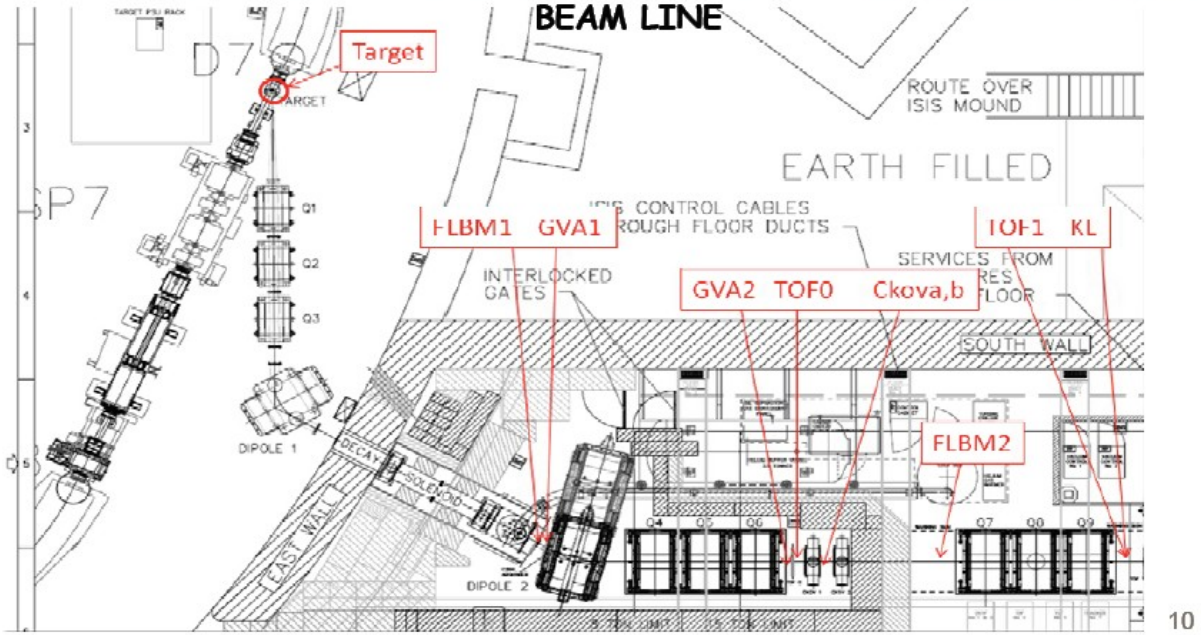


Description: MICE

- *Beamline – create beam of muons*
- *Particle ID – verify/tag muons*
- *Tracker – measure emittance*
- *Absorber (LH2 or LiH) – cooling*
- *RF – reestablish longitudinal p*

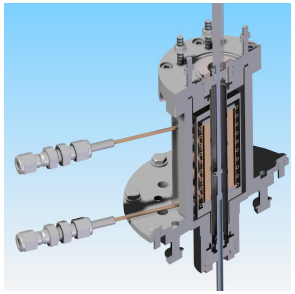


Description: Beamline

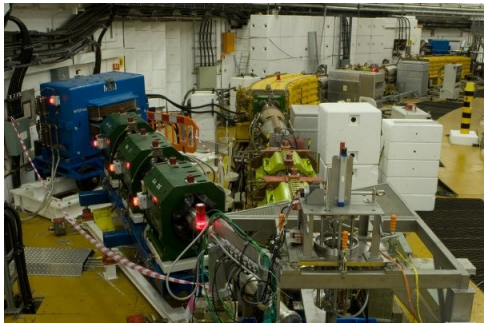


(L. Coney's talk)

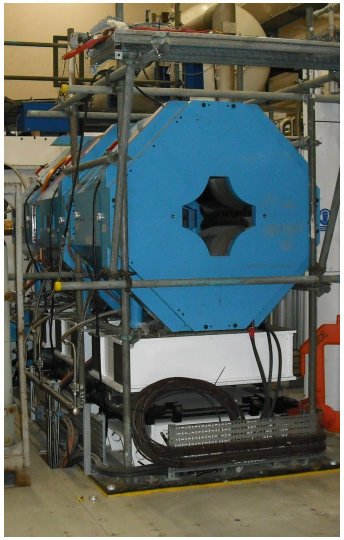
Description: Beamline



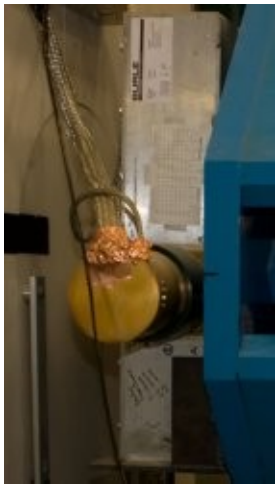
MICE Beamline consists of:

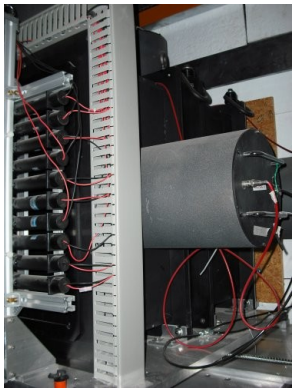


- Target
  - dips into ISIS accelerator
  - 1 Hz
- Conventional magnets
  - 2 dipoles – select pion momentum
  - select muon after pion decay
  - 3 quadrupole triplets for focusing
- Superconducting decay solenoid
  - extends pion decay path
  - 5 T
  - 5 m long



Description: PID





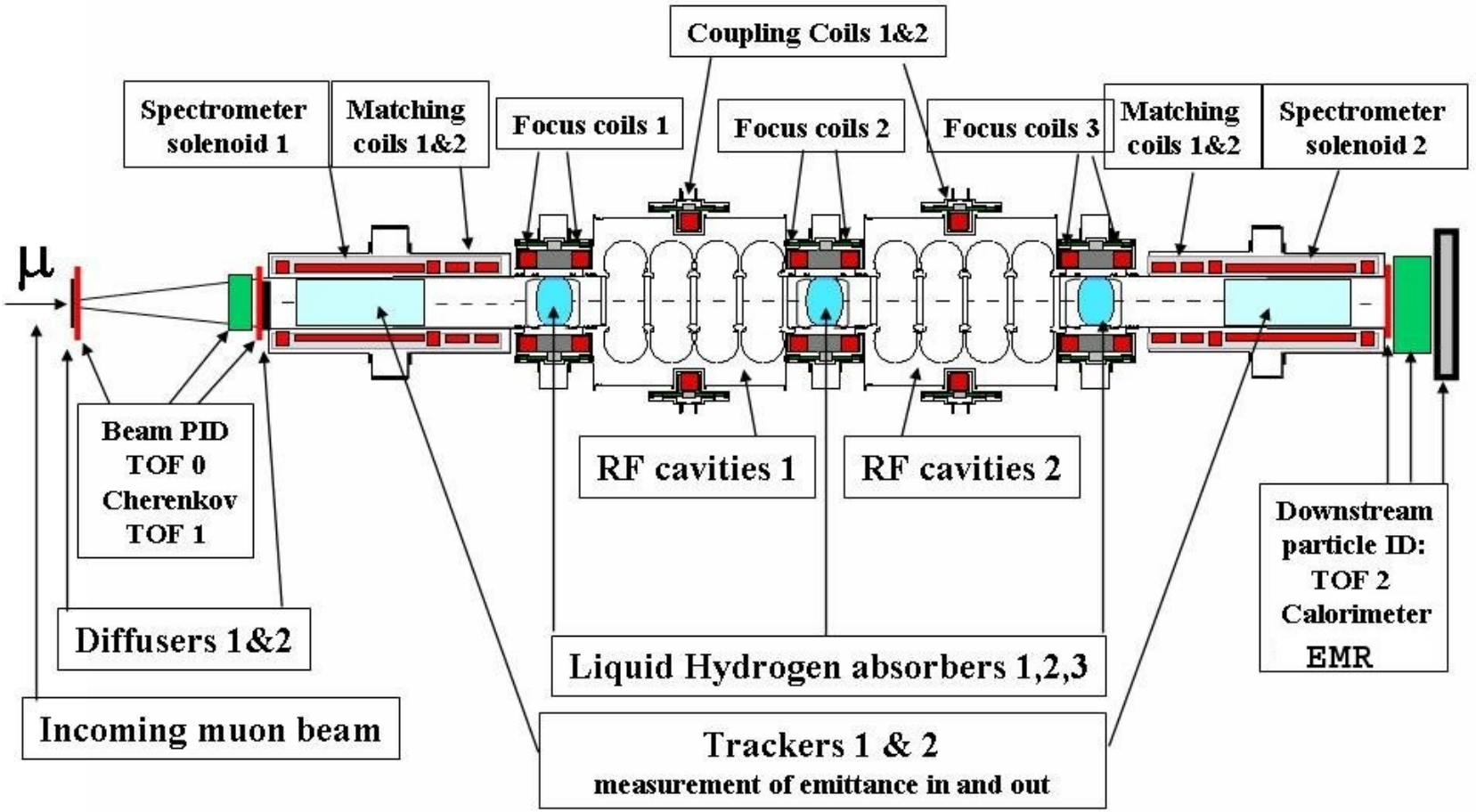
Upstream PID: discriminate p, π, μ

- Beam profile monitors
- Threshold Cerenkov
- Time of Flight – ToF0 & ToF1

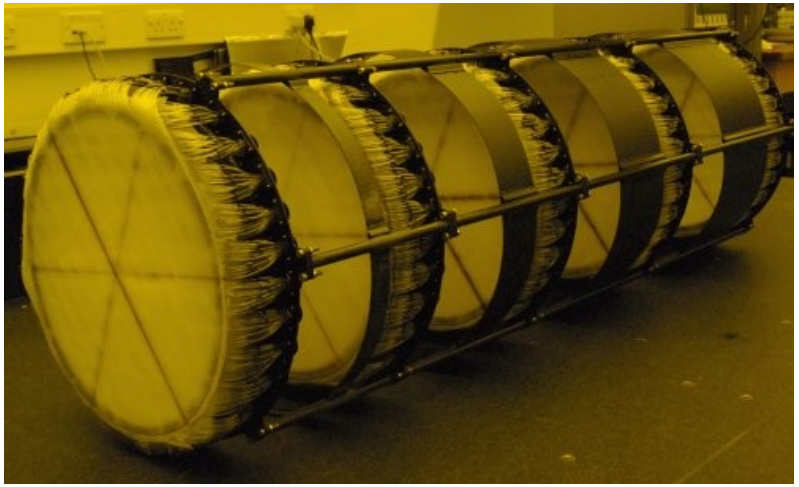
Downstream PID: reject decay electrons

- Time of Flight - ToF2
- Kloe-like Calorimeter - KL
- Electron-muon Ranger - EMR

Description: Cooling Channel



Description: Tracking

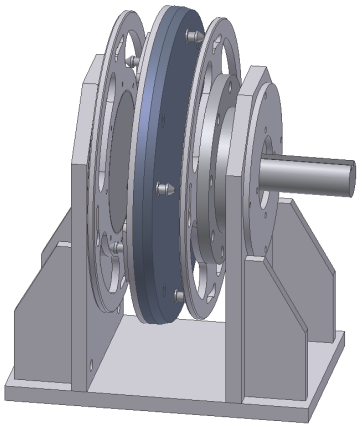


- *Two trackers – before/after absorber*
- *Measures x, y, x', y'*
- *5 stations/tracker*
- *3 stereo planes/station (U/V/W)*
- *1400 350μm fibers/plane*
  double layer, 7 fibers/group
- *<0.2% dead channels*
- *>10.5 photoelectrons/MIP*
- *430μm RMS position resolution*

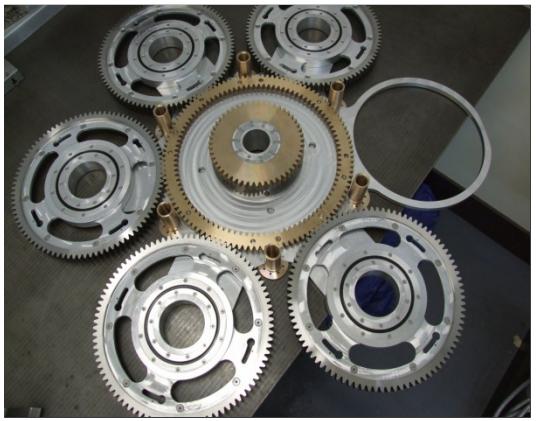
- *4 T superconducting*
- *2 m long*
- *20 cm warm bore*
- *5 coils:*
  - *1 main tracker coil*
  - *2 end coils*
  - *2 matching coils*
- *closed-cycle pulse-tube cryo-coolers*

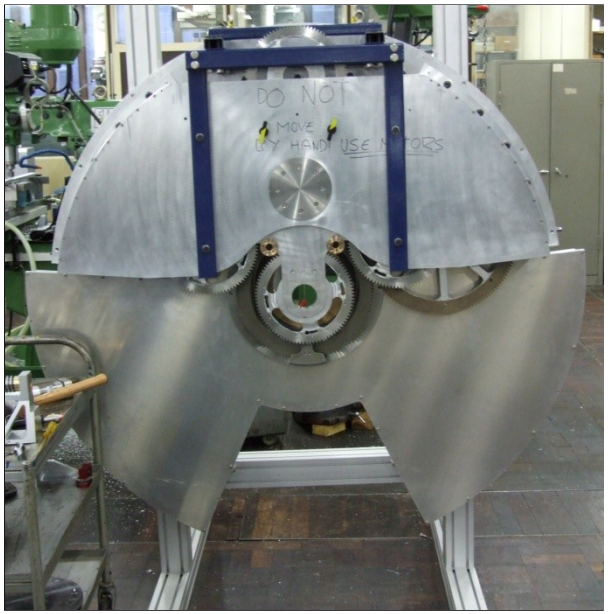
(M. Zisman's talk)

Description: Diffuser



- Manufacture complete at Oxford, UK
- Integral part of Step II
- Variable thickness Pb disks
- Disks inserted upstream end of 1^{rst} tracker
- Operate in high magnetic fields:
  - non-magnetic components
  - air motor driven

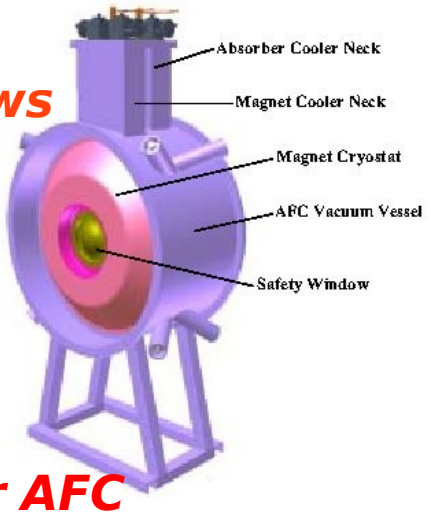




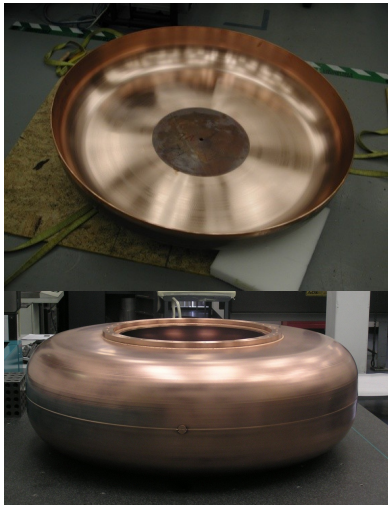
Description: Absorber - AFC

Absorber-Focusing Coil – AFC

- Absorber Built at KEK
- Focusing Coils designed by Tesla
- 3 modules
- Absorber:
  - 20.7 l LH_2 or LiH
  - 35 cm long (on axis)
  - 15 cm radius
  - 2 180 μm thick Al windows
- Focusing Coils:
  - 2 coils
  - 26.3 cm radius
  - 5.0 T in solenoid mode
  - 7.7 T in gradient mode
- Separate vacuum vessels
- Single 4.2 K cryocooler for AFC

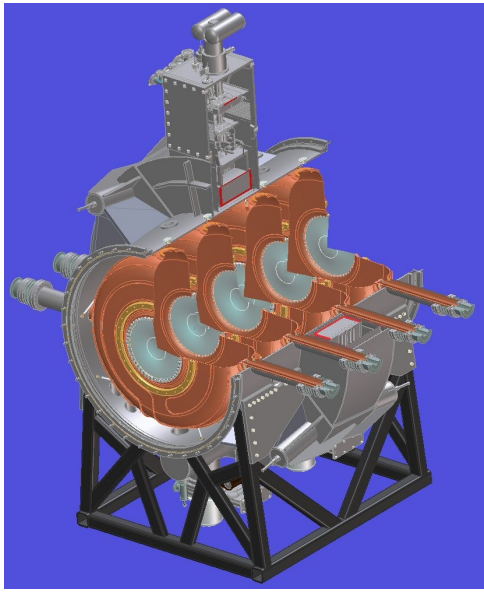


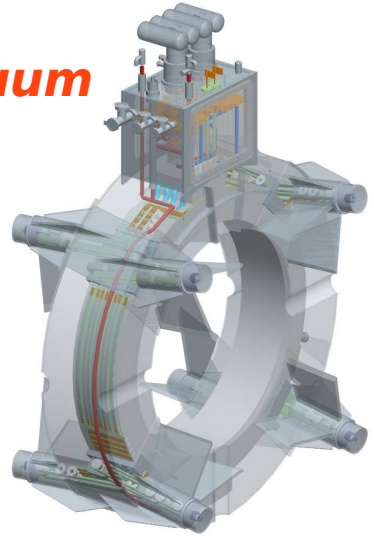
Description: RF - RFCC



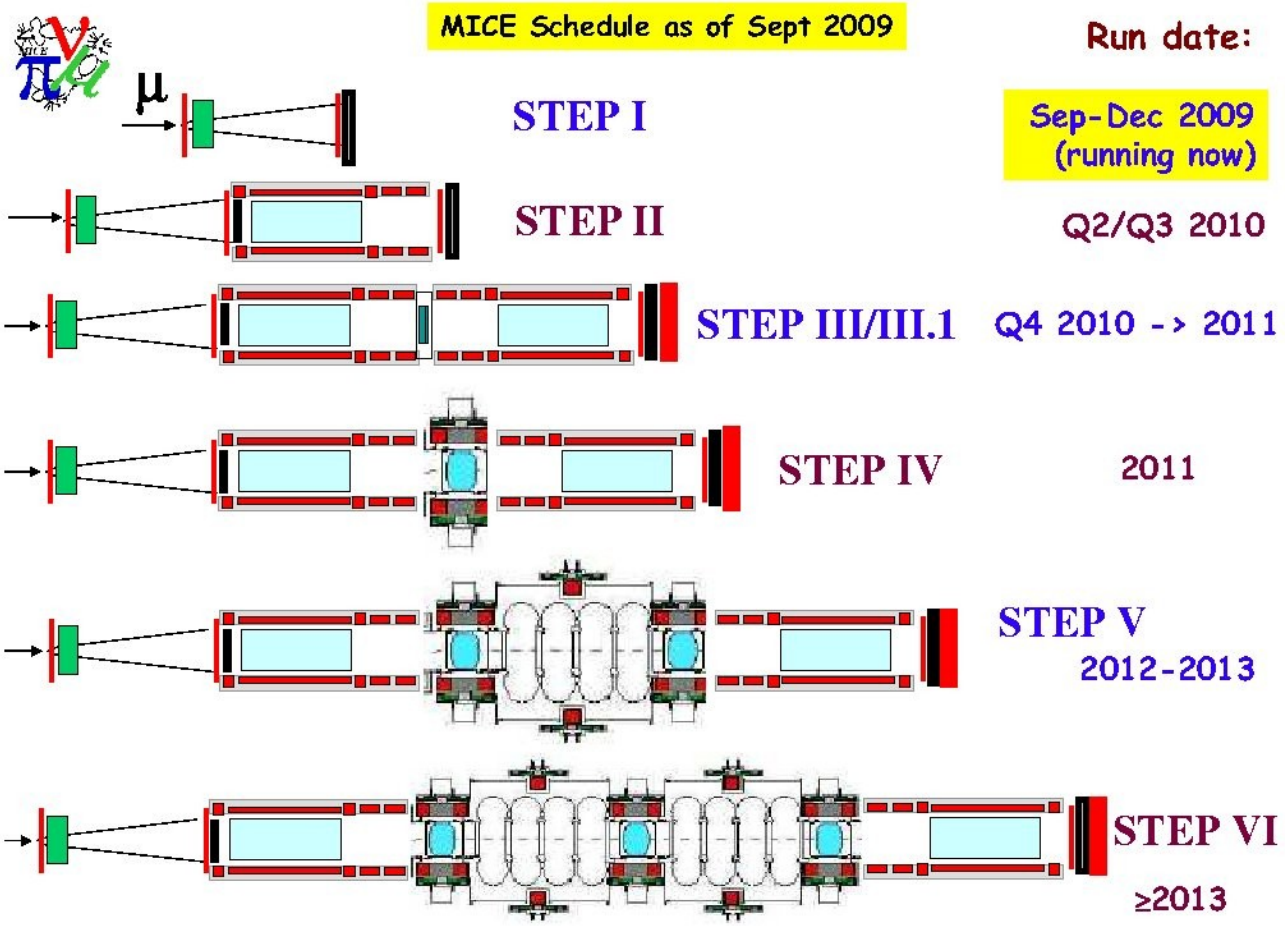
RF Coupling Coil – RFCC

- 2 modules
- Restore longitudinal momentum
- RF cavities from Applied Fusion
- Coupling coils designed at Harbin
- RF Cavities:
  - 5 cavities/module
  - 201.25 MHz
  - e-beam welded Cu half shells
  - 2 180 μm thick Al windows
  - Be windows
  - Structures & cavities share vacuum
- Coupling Coil:
  - single coil
  - 72.5 cm radius
  - 11.6 cm long
  - 7.8 T
  - single cryocooler





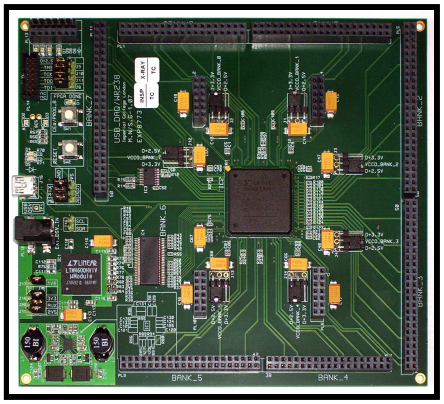
Schedule

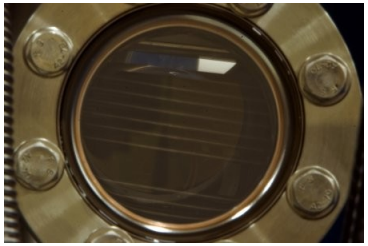

MICE Schedule as of Sept 2009
Run date:
μ
STEP I
Sep-Dec 2009
(running now)
STEP II
Q2/Q3 2010
STEP III/III.1
Q4 2010 -> 2011
STEP IV
2011
STEP V
2012-2013
STEP VI
≥2013

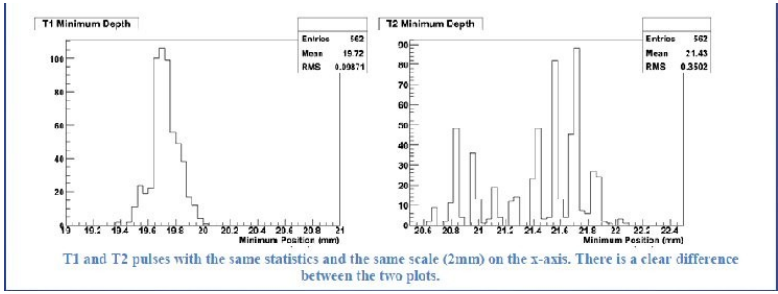
Status: Target

Since December 2008:

- new target hardware design
  - first target works flawlessly
  - demo target failure under investigation
- new target DAQ (coming soon)







T1 and T2 pulses with the same statistics and the same scale (2mm) on the x-axis. There is a clear difference between the two plots.

Status: Decay Solenoid

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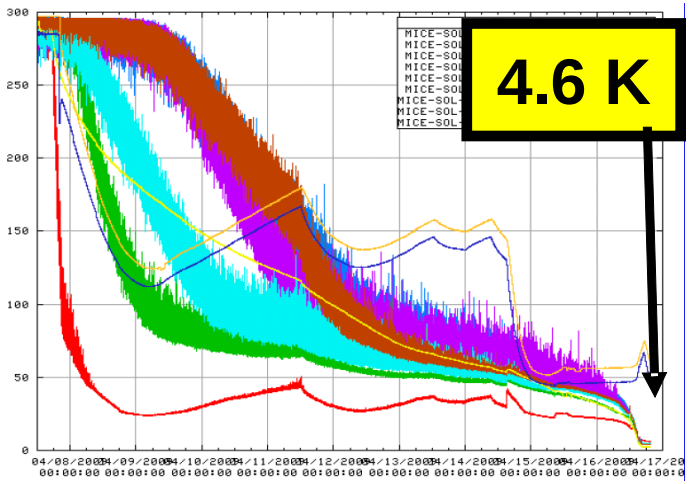
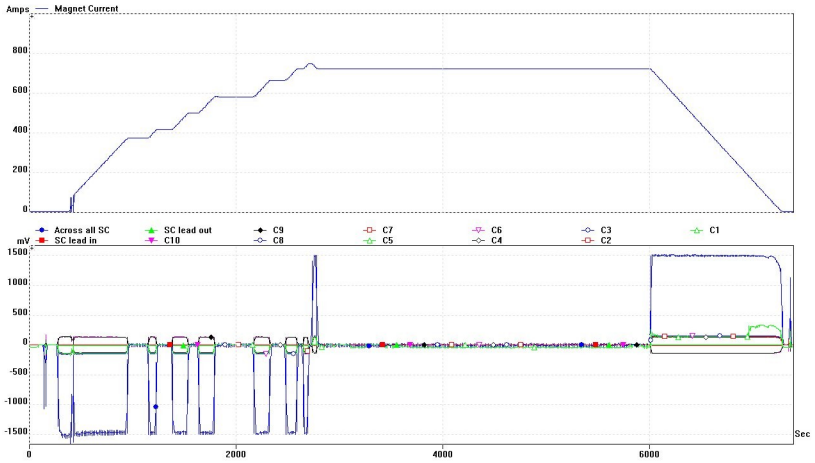
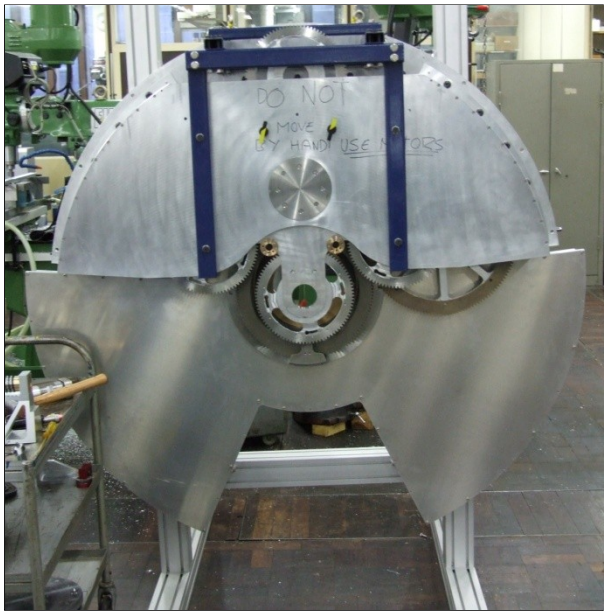
Since January 2009:

- ***Decay solenoid repaired with new MLI***
- ***Operating regularly since summer***
- ***Added to alarm monitoring***
- ***Linde Decay solenoid compressor & cold box presently having yearly service during Janaury ISIS shutdown***

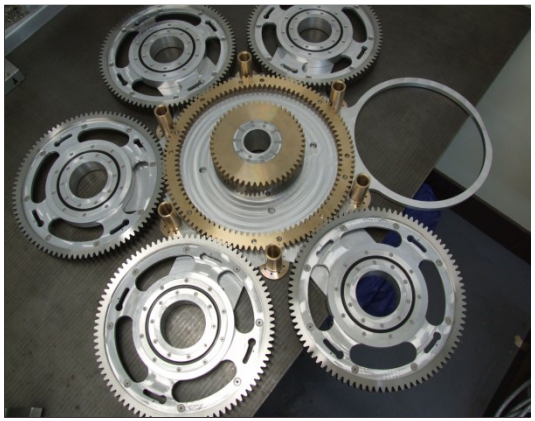




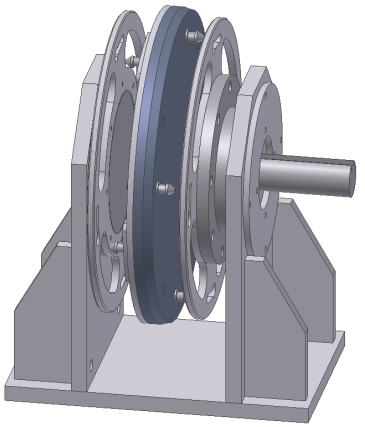
Status: Diffuser



- Pb disc transfer, making mock-up on bench to try principle
- Air pressure problems – affects motor speed, should be better at RAL with 7 bar supply
- Manual control interface is working, would do in extremis for Step II operation
- Automated system ready by Easter
- Diffuser delivery to RAL still under review, regular Friday meetings



Not on Critical path till late Autumn 2010



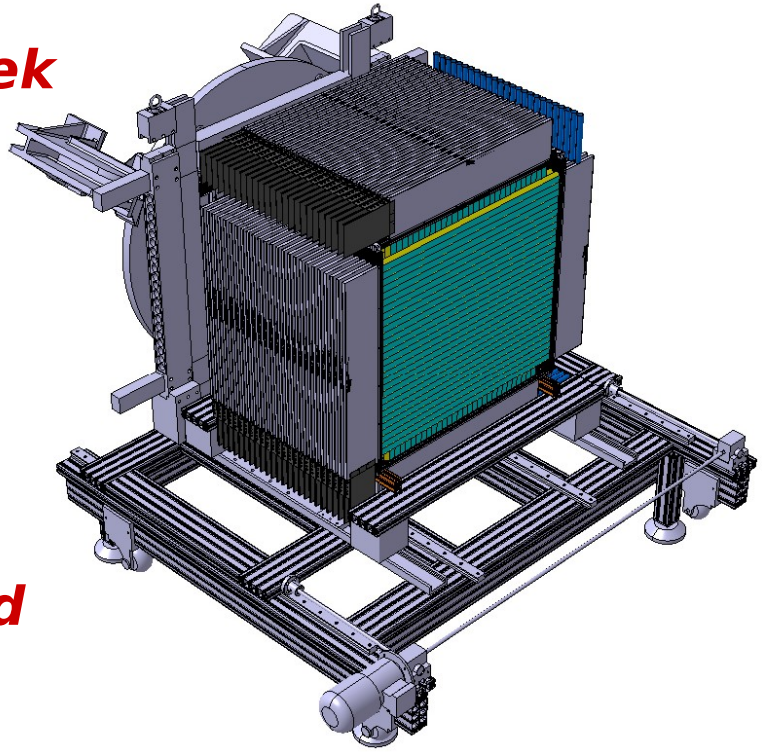
Status: Where are we?

- ***Beamline magnets ready***
- ***All PID detectors (other than EMR), installed***
- ***ToF0, ToF1, Ckov calibrated***
- ***Await data for calibration of ToF2 and KL***
- ***Using ToF hodoscope for first emittance measurements (Coney's talk)***

Step I nearing completion!

Status: EMR

- Scintillator planes are well in manufacture and QA at UNIGE
- Need to go at two planes per week for schedule
- Magnetic shielding around PMTs needs to be understood
- Design of flex circuits to PMTs need to be frozen soon
- Some minor clashes with R5.2 infrastructure anticipated – exchange of CAD models required
- Delivery of EMR scheduled for July/August, 2010



Status: Tracker

Steps II and III require trackers for first emittance measurements

- ***Both trackers ready and tested with cosmic rays***
  - ***High efficiency tracking***
- ***Delays in spectrometer solenoids – critical path***

Status: AFC

Steps IV requires absorber for first cooling measurements

- Absorber 1 ready and tested
  - Cool down to 20K: 1 day with LN_2
  - LH_2 liquification at 2.5 l/day
  - Delivery end January or early February
- Absorber 2 being tested, delivery May

- Focusing coils are delayed (Zisman)

Status: RFCC

Steps V requires RFCC module for replenishing longitudinal component of momentum

- ***RF cavity fabrication underway***
  - ***Delivery to LBNL in January(???)***
- ***Power infrastructure being refurbished at Darsebury***

- ***Coupling coils are delayed***

Status: Step VI

Steps VI has approval but awaits full funding

Status: Hall miscellaneous

- Water system for CCR compressor cooling is 95% done
- Luminosity monitor & cabling and connectors installed
- PPS safety accreditation is approaching final hurdle
- Next step is to integrate with ISIS PPS
- Drilling of false floor for Step III is 50% complete
- All electrical work that can be done up to delivery of spectrometer solenoid is complete
- Material for CCR compressor stands (for Step II & III) is on order, arrives in next week or so.
- Remote level sensing of magnet header tank working
- Lighting & fire alarm project finally finished
- Painting will be completed before end January
- To sum up, there is nothing (known) on the critical path to get Steps II & III ready for February 2011 (end of ISIS moderator change long shutdown)

Summary

- ***Muons observed at MICE!***
- ***Target and Decay Solenoid operational***
- ***PID detectors in place and being calibrated***
- ***Step I is well underway!***
- ***Absorber and RF cavities near delivery***
- ***Infrastructure mostly in place***
- ***Delay in spectrometer solenoid***
- ***Delay in focusing coil – not a show stopper yet***
- ***Delay in coupling coil – not a show stopper yet***