MUON ACCELERATOR R&D Dept

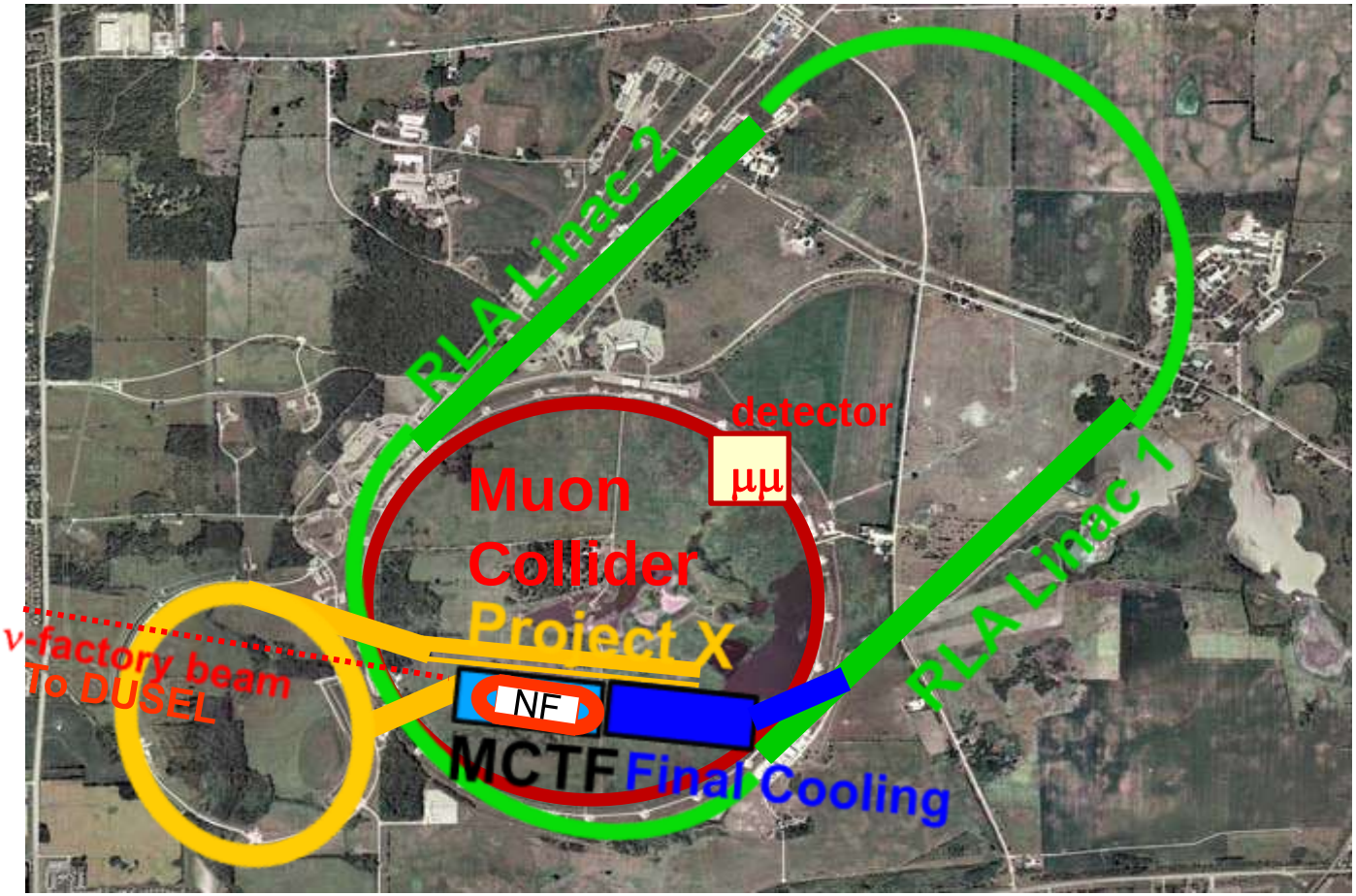
MISSION

To develop the concepts & technologies that will enable future accelerator facilities using high intensity muon sources

FOCUS

Design and development of Muon Colliders and Neutrino Factories, with a hardware emphasis on developing the technologies needed for a muon ionization cooling channel.

VISION


RLA Linac 2
detector
μμ
Muon
Collider
Project X
ν-factory beam
To DUSEL
NF
MCTF Final Cooling
RLA Linac 1

MCTF/NFMCC BACKGROUND

July 12, 2006

To: Vladimir Shiltsev and Steve Geer
From : Pier Oddone

Subject: Muon Collider Task Force

I would like to ask the two of you to form and lead a Task Force to develop a plan for an advanced R&D program aimed at the technologies required to support the long term prospects of a Muon Collider. In doing so I would ask that you operate in consideration of the attached charge, taking special note of the deliverables requested for September 2006: A report outlining a plan for developing the Muon Collider concept based on recent ideas in the realm of ionization cooling, and an associated cooling R&D plan that can be implemented starting in FY2007. Following receipt of this report I will expect to initiate the Muon Collider study, including the associated cooling channel study and development program, in 2007.

The Muon Collider represents a possible long term path for extending the energy frontier in lepton collisions beyond 1 TeV. It is important to establish the possibilities and to outline the R&D program that will be necessary to develop the underlying technology base. I look forward to working with you to formulate and execute a plan to explore these possibilities and to provide options for Fermilab and the world HEP program in the future.

Fermilab initiative, July 2006

The Neutrino Factory and Muon Collider Collaboration Charter

Adopted 1-27-03

Goal

The goal of this organization (referred to hereinafter as the Muon Collaboration) is to study and develop the theoretical tools, the software simulation tools, and to carry out R&D on the hardware that is unique to the design of neutrino factories and muon colliders. An important part of the program will be an extensive experimental program to verify the theoretical and simulation predictions and to gather the necessary data for a future facility.

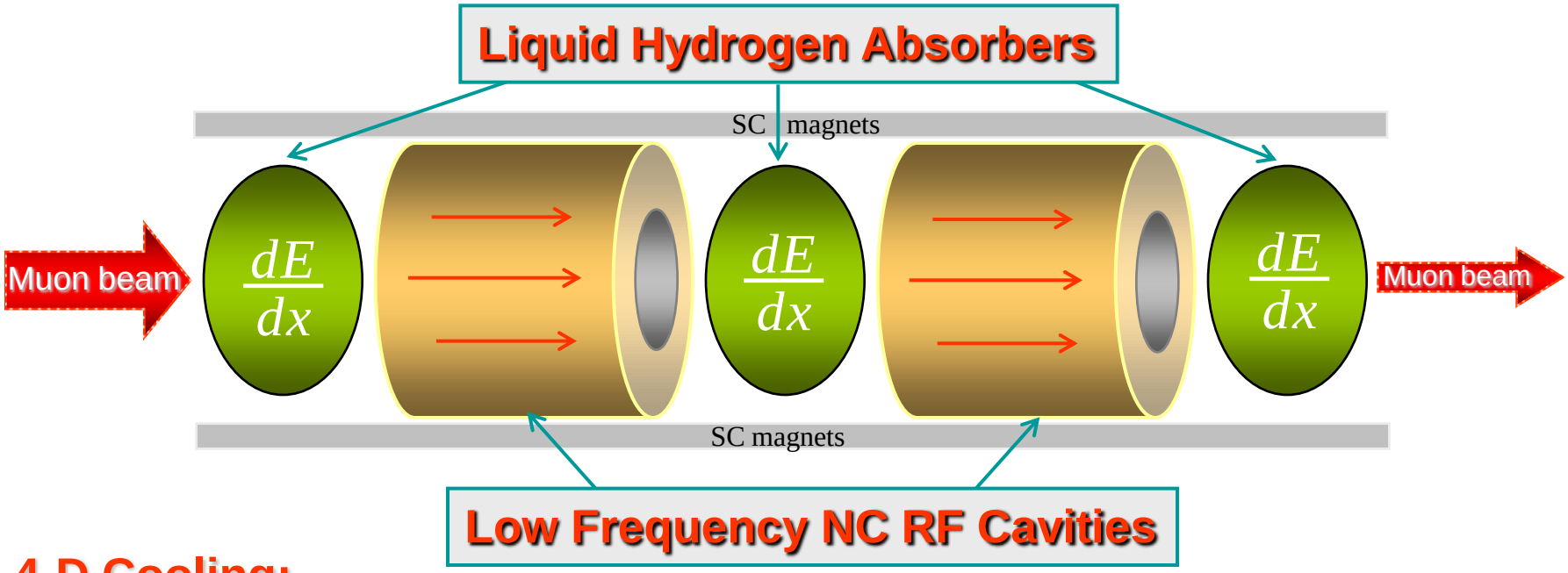
[…]

Formal entity since May 1997
(first funding Spring 1998)
~135 members from Nat'l Labs, Universities and Foreign Institutions.

ACTIVITIES

- NFMCC Group (A.Bross)
  - MUCOOL - Vac. RF R&D
  - MICE
  - Low energy NF design
- MCTF Group (A.Jansson)
  - Beam to MTA
  - MC Ring & Cooling Channel Studies
  - HPRF beam test preparation
  - HTS & HCC Magnet R&D
- NFMCC + MCTF Groups
  - 5 Year Plan

IONIZATION COOLING



4-D Cooling:

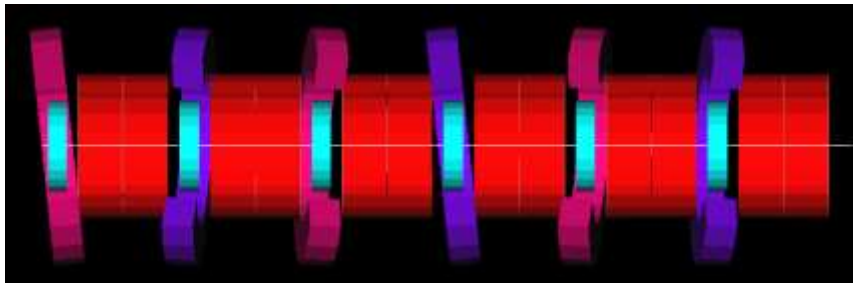
- **High gradient RF cavities to compensate for lost longitudinal energy**
- **Strong magnetic field to confine muon beams**
- **Energy loss in LH_2 absorbers**

6-D Cooling:

- **Mix transverse & longitudinal degrees of freedom → helical magnet geometry**

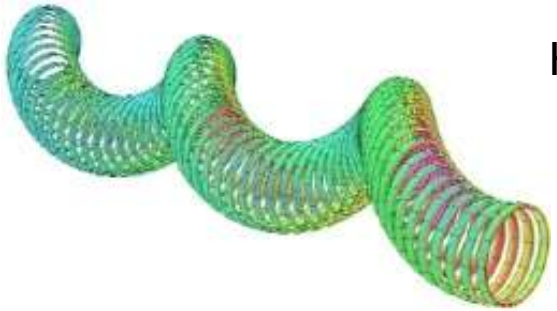
6D COOLING DESIGN

Steady progress on the conceptual development, but the challenges are great. We must know how to build complicated magnet geometries, how to include the RF cavities, and how to obtain high gradient RF operation in multi-Tesla magnetic fields.



FOFO snake:
Y. *Alexahin, et.al*

HCC: Initial concept *Derbenev/Johnson et .al*

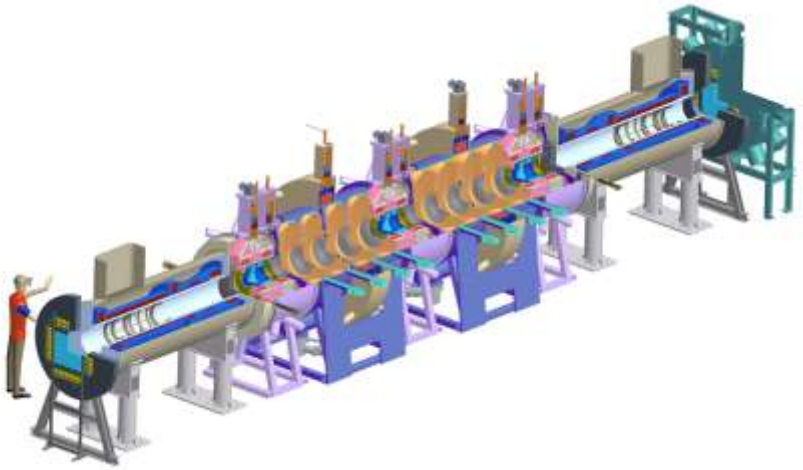


HCC design concept V.Kashikin
HCC Design development: K. Yonehara
HCC Simulations: K. Yonehara, V. Balbekov

MTA, MUCOOL & MICE

→ **cryogenic capabilities**
→ **RF power at 201 MHz & 805 MHz**
→ **Liquid H_2 absorber filling capability**
→ **5 T SC Solenoid with 30 cm bore (805 MHz Cavity fits inside)**
→ **400MeV/c protons**

→ **First beam seen at RAL**
→ **Significant APC involvement**

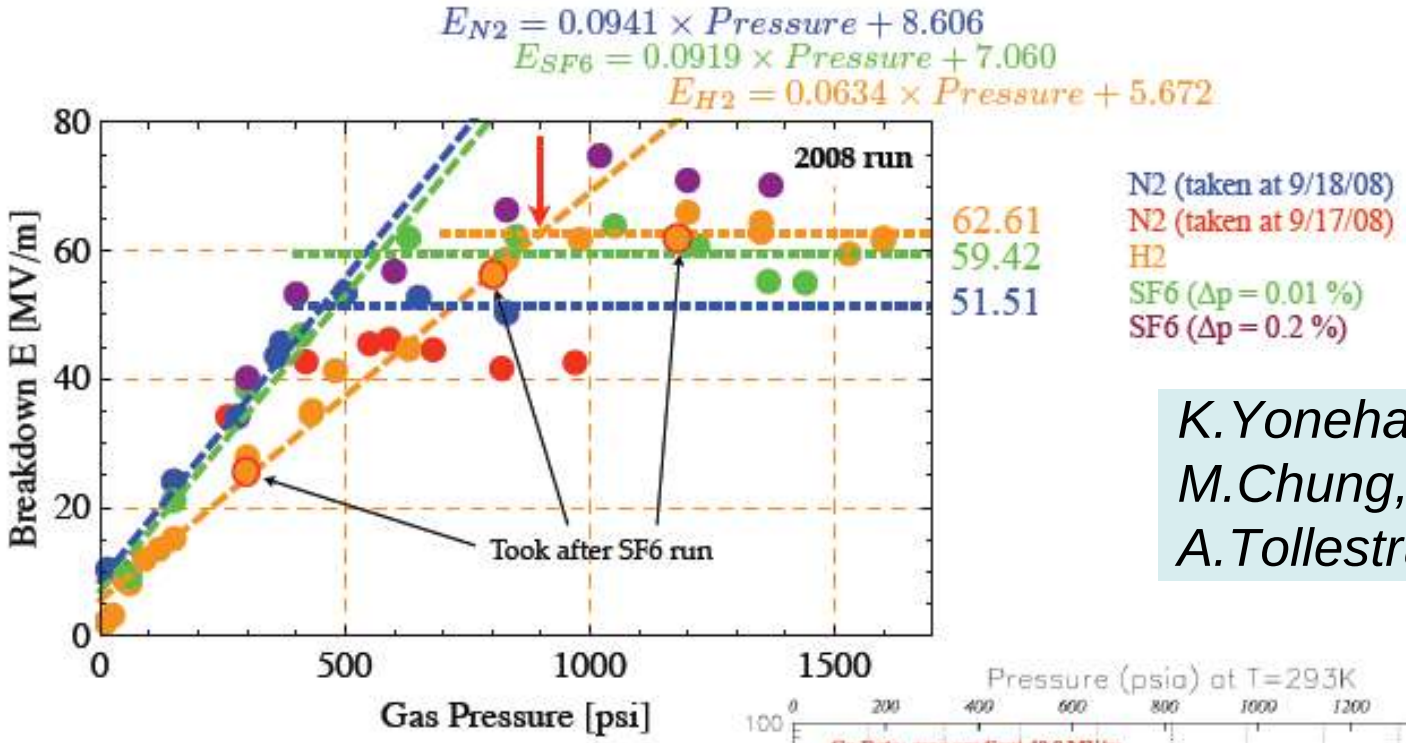


BEAM TO THE MTA

Beam dump is installed
Shielding re-installation shortly
Beam into hall possible once shielding assessment completed and approved

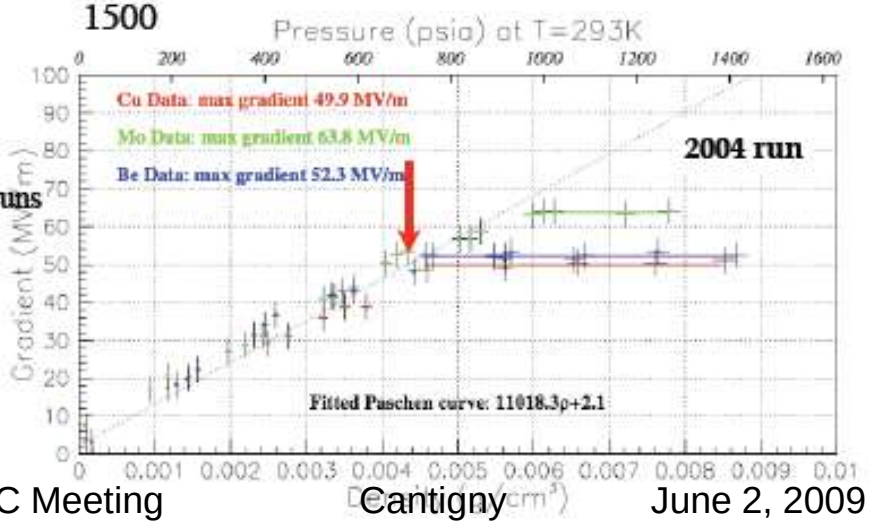
May 5th, 2009

HPRF TESTS W/O BEAM



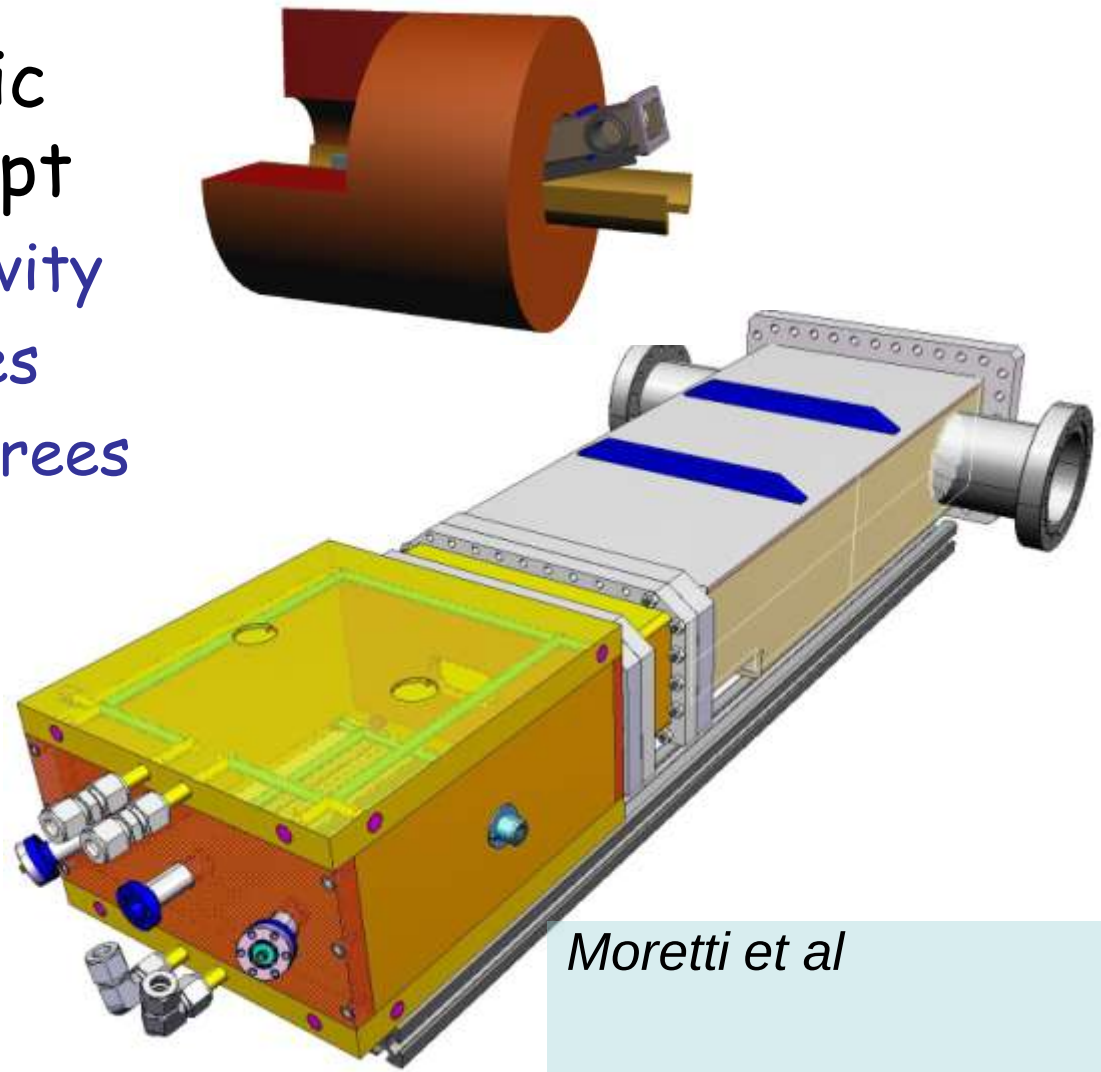
K.Yonehara , M.Chung, A.Jansson, A.Tollestrup

- Procedure: N2 run → H2 run → SF6 run
- Maximum field in 2008 run is ~20 % increased
- Good agreement of the Paschen slope between both ('08 & '04) runs
- Knee pressure (red arrow in upper plot) in 2008 run is 900 psi while that in past run (red arrow in lower plot) is 700 psi
- Increment of field in 2008 run can be real
- Plateau is different with different gas
- SF6 has big ambiguity



RF R&D

- Test of "magnetic insulation" concept
  - simple square cavity
  - parallel flat faces
  - rotatable 15 degrees from E⊥B in 5T magnet
- Follow-on with E||B square cavity



Moretti et al

4-COIL MODEL HSM01

Table 1: Solenoid Parameters

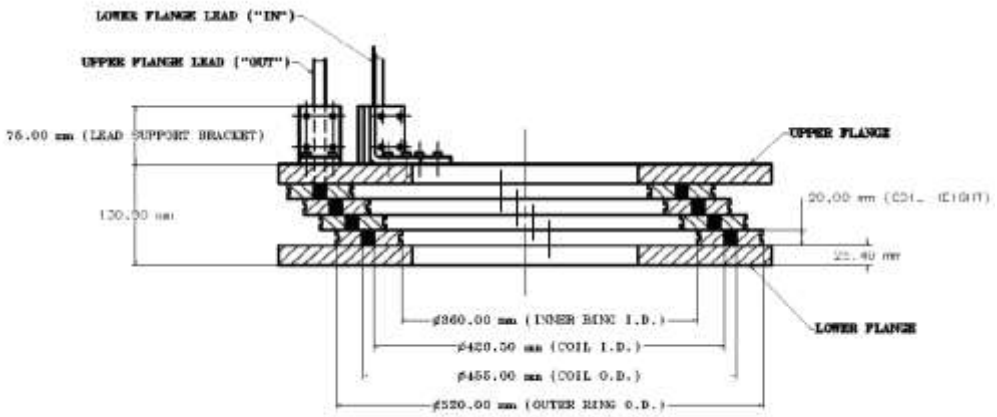
Parameter	Units	Value
Coil inner diameter	mm	426
Coil outer diameter	mm	455
NbTi superconducting cable	mm	12.34 x 1.46
Cable critical current at 7 T, 4.2 K	A	9660
Jc (non-Cu)	A/mm^2	1730
Copper to superconductor ratio		1.5:1
Strand diameter	mm	0.8
Helical orbit radius	mm	255
Number of turns per coil		10
Coil width	mm	20

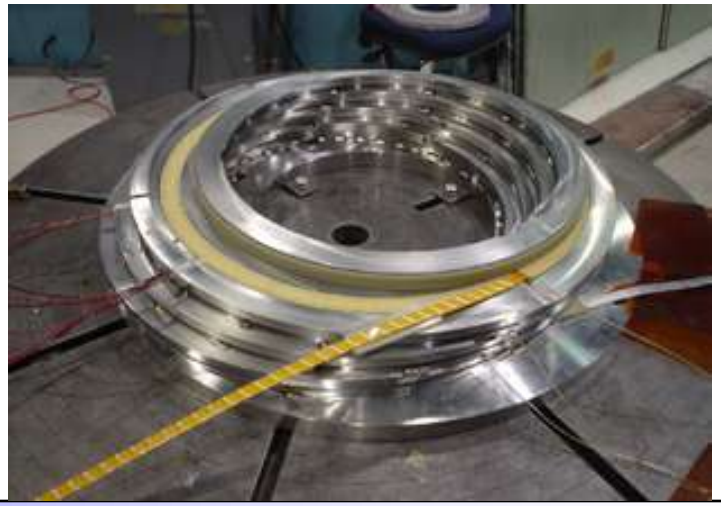
M.Lamm, A.Zlobin, et al
Muons Inc

Coil is wound from Rutherford-type superconducting cable (SSC) on a stainless steel bobbin

The short model consists of four superconducting coils with support structures and end flanges

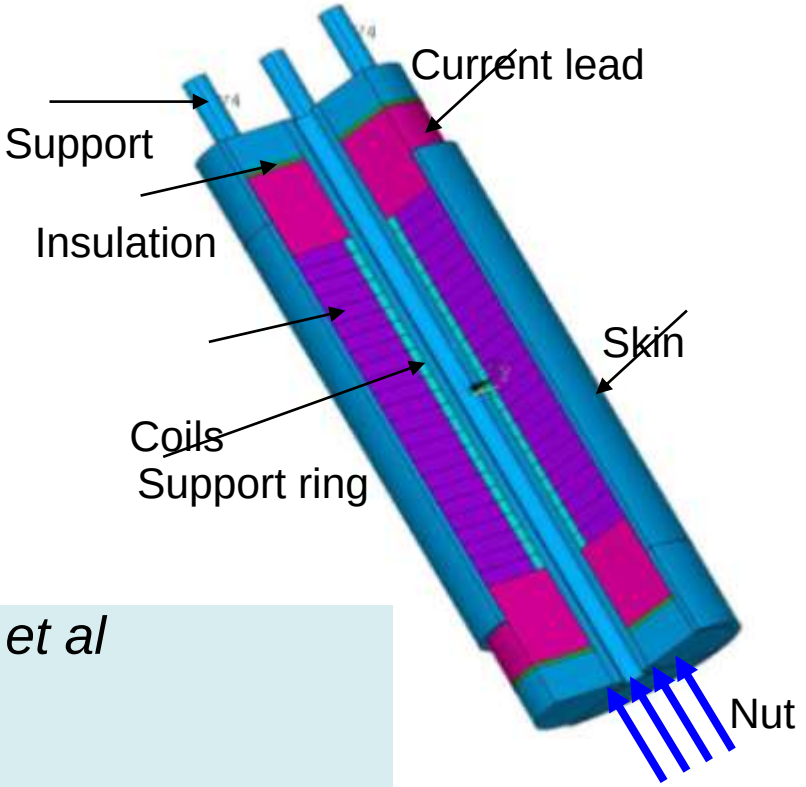
Achieved 85% of short-sample limit!





MAGNET R&D

- Single and double layer HTS coils designed and tested:
  98%-22% of SSL!
- Modular HTS test facility designed and being procured
  - Test many coils inside 16T solenoid
  - Central peak field >25T
- BSCO-2212 cable and wire work will be done within National Collaboration



E. Barzi et al

FERMILAB-PUB-09-001-APC

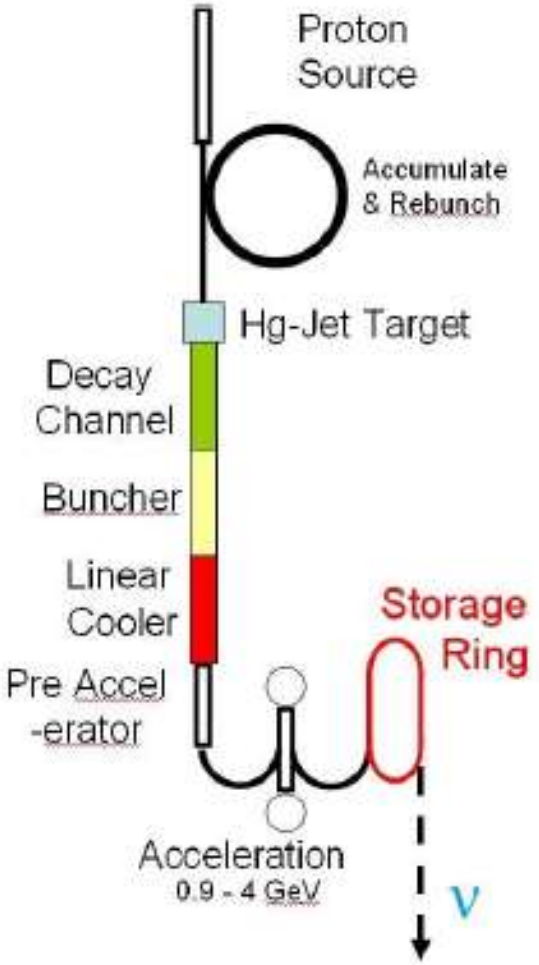
Low Energy Neutrino Factory Design

C. Ankenbrandt[1,3], S. A. Bogacz[2], A. Bross[1], S.Geer[1], C. Johnstone[1], D. Neuffer[1], M. Popovic[1]

1) Fermi National Accelerator Laboratory, P.O. Box 500, Batavia, Illinois 60510
2) Center for Advanced Studies of Accelerators, Jefferson Lab, Newport News, Virginia 23606
3) Muons, Inc.

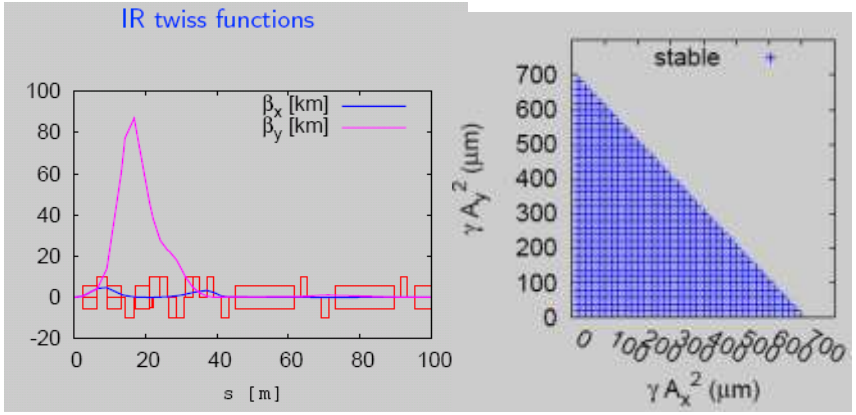
Abstract

The design of a low energy (4 GeV) Neutrino Factory is described, along with its expected performance. The Neutrino Factory uses a high energy proton beam to produce charged pions. The $\pi^{\pm}$ decay to produce muons ($\mu^{\pm}$), which are collected, accelerated, and stored in a ring with long straight sections. Muons decaying in the straight sections produce neutrino beams. The scheme is based on previous designs for higher energy Neutrino Factories, but has an improved bunching and phase rotation system, and new acceleration, storage ring and detector schemes tailored to the needs of the lower energy facility. Our simulations suggest that the NF scheme we describe can produce neutrino beams generated by $\sim 1.4 \times 10^{21}$ μ^{+} per year decaying in a long straight section of the storage ring, and a similar number of μ^{-} decays.



INTERACTION WITH OTHER APC GROUPS

Collider Ring Optics

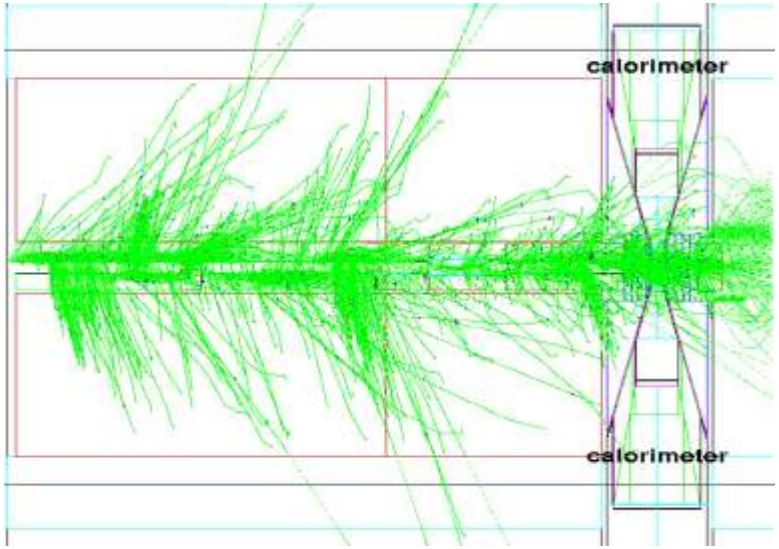


Promising approach for β*=10 mm

Good DA for dP/P=±0.5%

Yu.Alexahin, E.Gianfelice-Wendt

Detector Simulations



Simulations of background

N. Mokhov, I. Rakhno

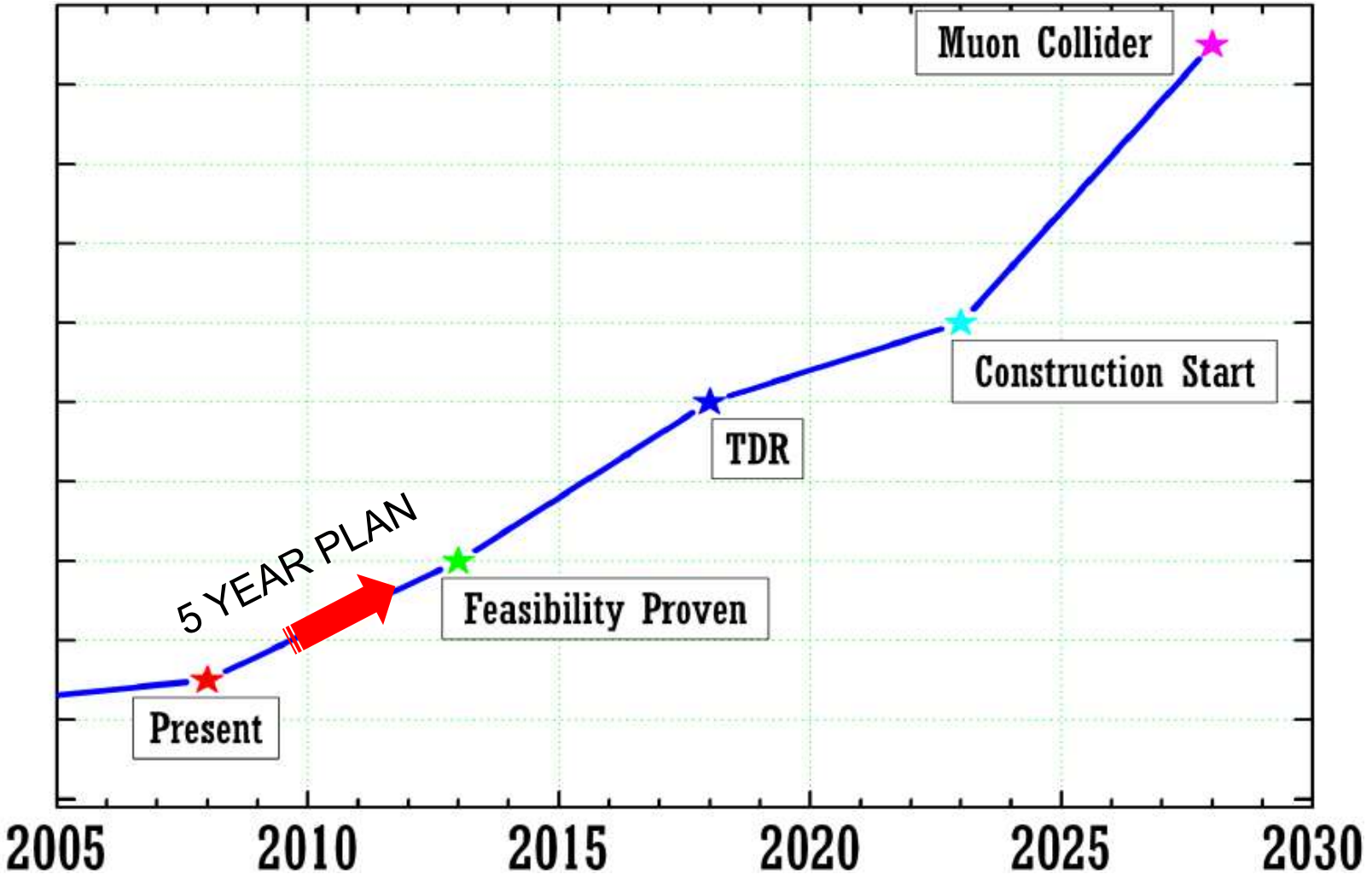
FIVE YEAR PLAN

- Plan for the next big step towards Muon Colliders & Neutrino Factories requested by our technical review (MUTAC) & oversight (MCOG) groups
- Joint MCTF/NFMCC plan, designed to meet existing commitments to international NF effort, and to do enough on MC R&D to get us a place at the table when big decisions are made (in about 5 years)
- Plan/proposal put together and reviewed by MUTAC summer 2008, presented to DOE (heads-up) in the December accelerator science review, & formally submitted to DOE in December.
  - Requires approximately x3 increase in funding
- Waiting for the 5 year plan to be reviewed.

OTHER 5-YEAR PLANS…

"We Will Turn the Five Year Plan into a Four Year One" (1930)

WHERE ARE WE HEADING



CONCLUDING REMARKS

- The goal of the Muon Accelerator R&D Department is to develop concepts & technologies that would enable future muon accelerator facilities (i.e. possible future options for Fermilab)
  - Muon Collider
  - Neutrino Factory
- Main focus right now is on demonstrating RF operating in strong magnetic fields
  - MTA is key facility
- Also e.g. magnet development and simulation work.
- A nationally coordinated 5-year plan, with the aim of demonstrating feasibility of a Muon Collider, has been submitted to DOE.
  - Requires significant increase in funding
  - Waiting for a review of the plan.