Report of Project Manager

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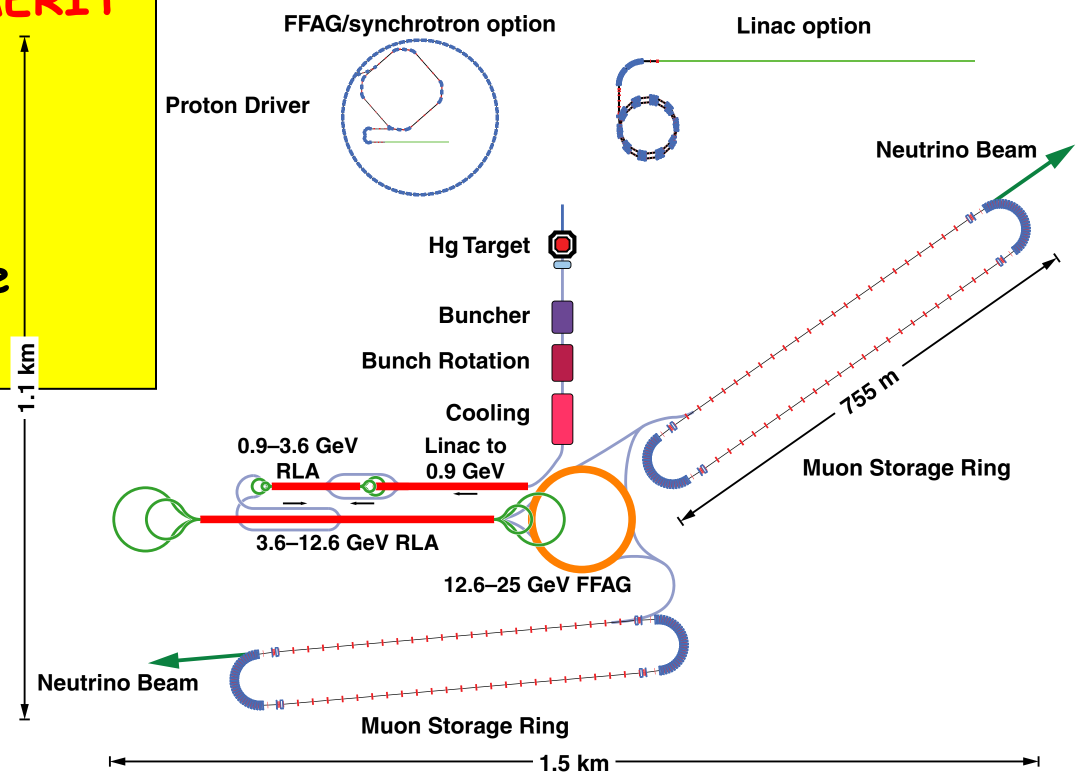
Introduction

- U.S. Neutrino Factory and Muon Collider Collaboration (NFMCC) explores techniques for producing, accelerating, and storing intense muon beams
  - near-term focus: muon storage ring to serve as source of well-characterized neutrinos ("Neutrino Factory") for long baseline experiments (~3000–7500 km)
  - longer-term focus: Muon Collider
    - Higgs Factory operating at few-hundred GeV or energy-frontier collider operating at several TeV
  - both types of machine are difficult, but have high scientific potential
  - common feature of these state-of-the-art machines is the need for a sustained R&D program
    - most modern projects (LHC, ILC, CLIC) share this need
- FNAL directorate and P5 attention have given Muon Collider R&D a higher profile
  - this is reflected in recently submitted 5-year R&D plan

Neutrino Factory Ingredients

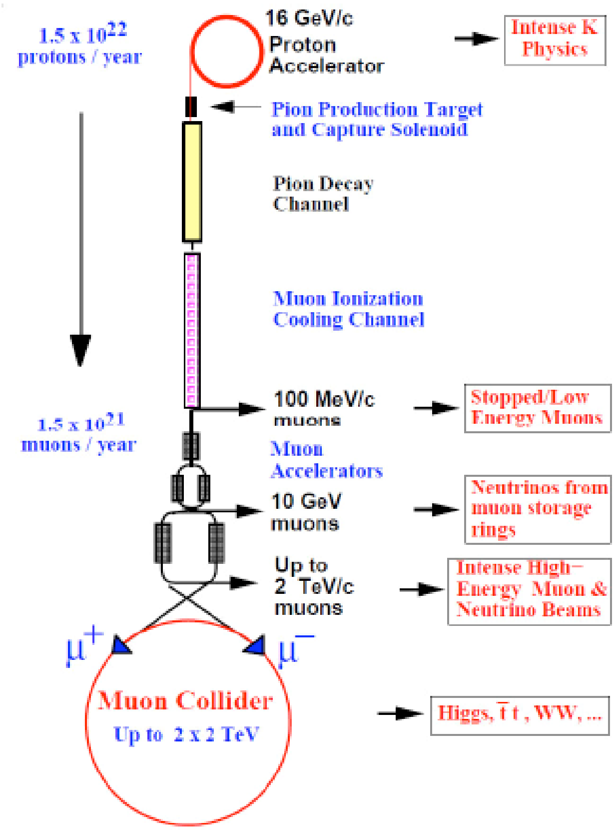
- Neutrino Factory comprises these sections
  - Proton Driver
    - primary beam on production target
  - Target, Capture, and Decay
    - create π; decay into μ ⇒ MERIT
  - Bunching and Phase Rotation
    - reduce ΔE of bunch
  - Cooling
    - reduce transverse emittance ⇒ MICE
  - Acceleration
    - 130 MeV → 20-50 GeV with RLAs or FFAGs
  - Decay Ring
    - store for 500 turns; long straight(s)

IDS-NF Baseline Layout



Muon Collider Ingredients

- Muon Collider comprises these sections (similar to NF)
  - Proton Driver
    - primary beam on production target
  - Target, Capture, and Decay
    - create π; decay into μ ⇒ MERIT
  - Bunching and Phase Rotation
    - reduce ΔE of bunch
  - Cooling
    - reduce long. and transverse emittance ⇒ MICE → 6D experiment
  - Acceleration
    - 130 MeV → ~1 TeV with RLAs, FFAGs, or RCSs
  - Collider Ring
    - store for 500 turns



Much of Muon Collider R&D is common with Neutrino Factory R&D

Muon Accelerator Advantages

- **Muon-beam accelerators can address several of the outstanding accelerator-related particle physics questions**
  - **neutrino sector**
    - Neutrino Factory beam properties

$$\mu^+ \to e^+ \nu_e \overline{\nu}_\mu \Rightarrow 50\% \nu_e + 50\% \overline{\nu}_\mu$$

$$\mu^- \to e^- \overline{\nu}_e \nu_\mu \Rightarrow 50\% \overline{\nu}_e + 50\% \nu_\mu$$

Produces high energy neutrinos

    - decay kinematics well known
      - minimal hadronic uncertainties in the spectrum and flux
    - $\nu_e \to \nu_\mu$ oscillations give easily detectable "wrong-sign" μ (low background)
  - **energy frontier**
    - point particle makes full beam energy available for particle production
      - couples strongly to Higgs sector
    - Muon Collider has almost no synchrotron radiation
      - narrow energy spread at IP compared with e^+e^- collider
      - uses expensive RF equipment efficiently (⇒ fits on existing Lab sites)

Muon Beam Challenges (1)

- **Muons created as tertiary beam ($p \rightarrow \pi \rightarrow \mu$)**
  - low production rate
    - need target that can tolerate multi-MW beam
  - large energy spread and transverse phase space
    - need solenoidal focusing for the low energy portions of the facility
      - solenoids focus in both planes simultaneously
    - need emittance cooling
    - high-acceptance acceleration system and decay ring

- **Muons have short lifetime (2.2 μs at rest)**
  - puts premium on rapid beam manipulations
    - high-gradient RF cavities (in magnetic field) for cooling
    - presently untested ionization cooling technique
    - fast acceleration system

- **Decay electrons give rise to backgrounds in collider detector**

Muon Beam Challenges (2)

- RF challenges (highest priority of MuCool program)
  - high-gradient operation in strong magnetic field
    - or, when filled with LH_2 in an intense beam

- Magnet challenges
  - 20 T magnet in high radiation environment (target)
  - large aperture solenoids (up to 1.5 m) in cooling channel
  - very strong solenoids (~50 T) for final collider cooling stages
  - low fringe fields in acceleration system
    - to accommodate SC RF cavities
  - high mid-plane heat load in decay or collider ring

If intense muon beams were easy to produce, we'd already have them!

R&D Management Process

- Each year R&D groups propose annual program to TB
  - based on overall NFMCC budget guidance from DOE
- PM prepares budget based on this input
  - note: budget determined by R&D program, not "institutional commitments"
  - subsequently approved by TB, EB, and Co-Spokespersons
- After budget finalized, PM negotiates milestones with each institution based on R&D plan
  - milestones specify both dates and deliverables
    - "report card" generated at year's end to audit performance
- PM summarizes spending and accomplishments each year in detailed report
  - given to MCOG and DOE at annual MUTAC review

R&D Overview (1)

- NFMCC R&D program has the following components:
  - simulation and theory effort
    - supports both Neutrino Factory and Muon Collider design
      - NF work presently done under aegis of IDS-NF
  - development of high-power target technology ("Targetry")
  - development of cooling channel components ("MuCool")
- We participate in system tests as an international partner
  - MERIT (high-power Hg-jet target) [completed; analysis ongoing]
  - MICE (ionization cooling demonstration)
  - EMMA (non-scaling FFAG electron model)
- Hardware development and system tests are major focus
  - simulation effort has led to cost-effective Neutrino factory design
    - and progress toward a complete Muon Collider scenario
      - just as for NF, simulations will guide hardware and system tests

R&D Overview (2)

- **NFMCC R&D program has already led to many innovative accelerator concepts and approaches**
  - **driven by our desire to solve challenging technical problems in support of the HEP experimental program**
    - **enhanced support will further such innovation**
      - **which will be *needed* to build a Muon Collider**

- **Examples:**

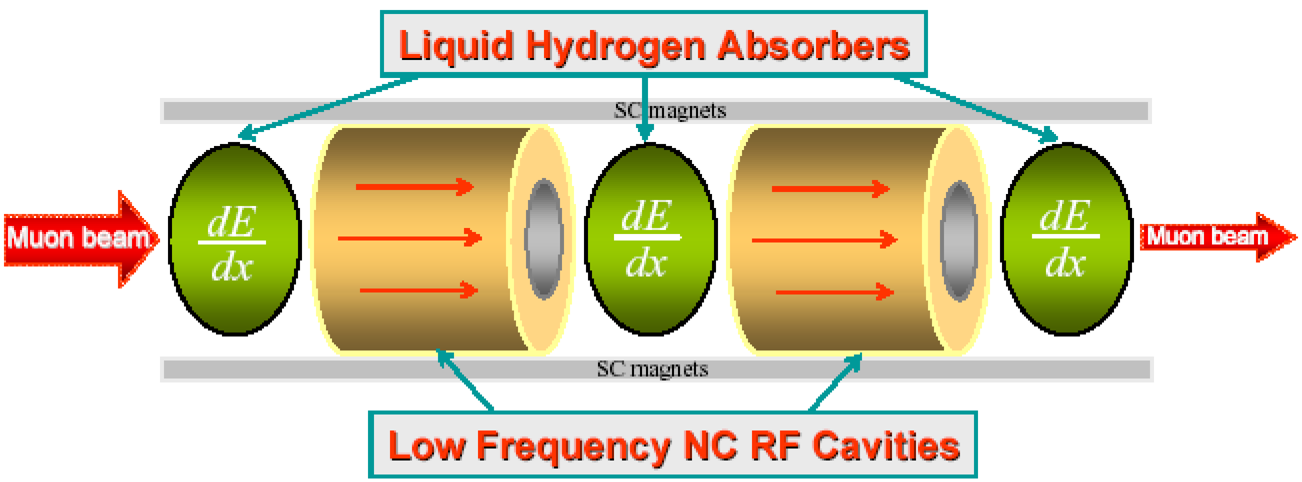
Solenoidal pion capture from target
RF phase rotation and bunching scheme
Non scaling FFAG concept
Muon cooling channels (linear, ring, helix)
Theory of breakdown and conditioning in RF cavities
High-pressure gas-filled cavities for cooling*
Linear 6D helical cooling channel*
High-field HTSC solenoids for giving low emittance*

*Muons, Inc.

Ionization Cooling (1)

- **Ionization cooling analogous to familiar SR damping process in electron storage rings**
  - energy loss (SR or *dE/ds*) reduces p_x, p_y, p_z
  - energy gain (RF cavities) restores only p_z
  - repeating this reduces $p_{x,y}/p_z$ ($\Rightarrow$ 4D cooling)

  - presence of LH_2 near RF cavities is an engineering challenge
    - we get lots of "design help" from Lab safety committees!



Ionization Cooling (2)

- There is also a heating term
  - for SR it is quantum excitation
  - for ionization cooling it is multiple scattering

- Balance between heating and cooling gives equilibrium emittance

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

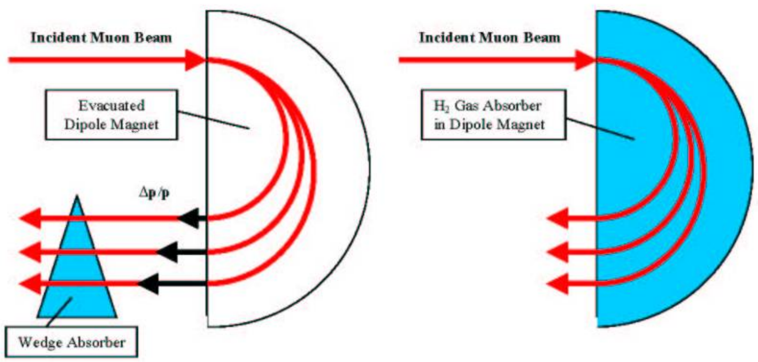
Cooling Heating

$$\varepsilon_{x,N,equil.} = \frac{\beta_\perp (0.014\,\mathrm{GeV})^2}{2\beta m_\mu X_0 \left|\frac{dE_\mu}{ds}\right|}$$

- prefer low $\beta_\perp$ (strong focusing), large X_0 and dE/ds (H_2 is best)

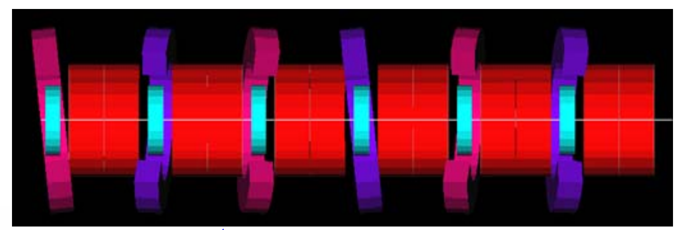
6D Cooling

- **For 6D cooling, add emittance exchange to the mix**
  - **increase energy loss for high-energy compared with low-energy muons**
    - **put wedge-shaped absorber in dispersive region**
    - **use extra path length in continuous absorber**

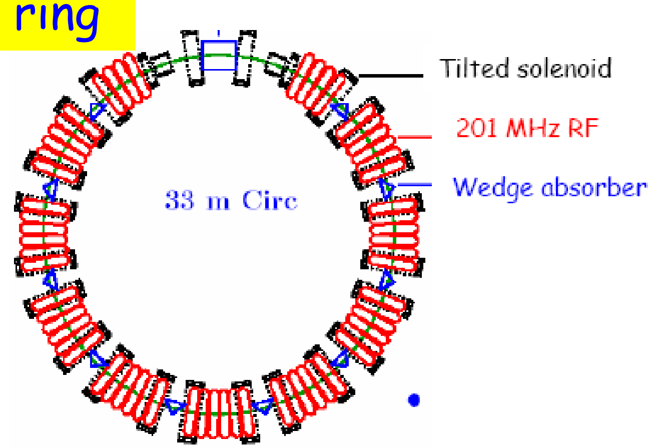


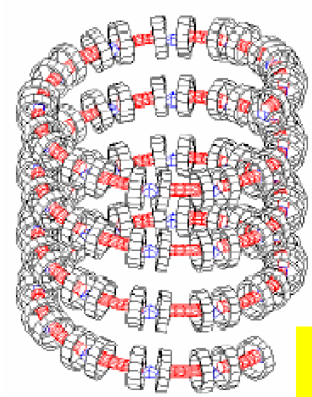
Muons, Inc.

FOFO Snake



Cooling ring





Single pass; avoids injection/extraction issues

"Guggenheim" channel

Funding Status

- Since FY03, NFMCC budget has been nearly "flat-flat"
  - in next 5 years, we desire to increase funds to \$20M (NFMCC+MCTF)

Year	DOE-base (\$M)	DOE-NFMCC (\$M)	TOTAL (\$M)
FY00	3.3	4.7	8.0
FY01	3.0	3.2	6.2
FY02	3.0	2.8	5.8
FY03	2.1	1.4	3.5
FY04	2.2	1.8[a)]	4.0
FY05	1.9	1.7	3.6
FY06	1.8	2.1[b)]	3.9
FY07	1.9	2.4[c)]	4.3
FY08	2.1[d)]	1.8[e)]	3.9
FY09	2.2[d)]	1.6	3.8

[a)] Includes \$0.4M supplemental funds
[b)] Includes \$0.3M supplemental funds
[c)] Includes \$0.7M supplemental funds
[d)] Includes \$0.25M funds at BNL previously designated as AARD
[e)] Includes \$0.1M supplemental funds

  - helped by NSF funding for MICE and DOE-SBIR funding for Muons, Inc.
    - NSF: \$100K per year (FY05–10); \$750K FY06 MRI grant (tracker electronics, spectrometer solenoid); \$133K/year (FY08–10); FY08 MRI grant (\$798K) (coupling coils and MICE RF); \$100K/year (FY09–11)
  - also, UC-Riverside (state) funds for spectrometer solenoid

FY08 Budget

- FY08 budget finalized by Spokespersons and PM in November 2007
  - MICE was the big-ticket item this year
    - LBNL generated MOU with RAL to cover "donation" of spectrometer solenoids (and later donation of RFCC modules)
      - earlier LBNL donation of two RF power stations done separately
    - rules on this keep changing (wanted less formality, so no Addendum)
    - FNAL has similar arrangement for tracker electronics and cryostats

MEMORANDUM OF UNDERSTANDING
Between
THE SCIENCE AND TECHNOLOGY FACILITIES COUNCIL
and
THE UNIVERSITY OF CALIFORNIA–LAWRENCE BERKELEY NATIONAL LABORATORY

FOR THE SCIENCE AND TECHNOLOGY FACILITIES COUNCIL

By Tony Wells

Date 13 October 2008.

FOR THE UNIVERSITY OF CALIFORNIA–LAWRENCE BERKELEY NATIONAL LABORATORY

By Steven Chu

Date 9/22/08

We ask that you acknowledge, by your signature below, that RAL agrees to accept the aforementioned contribution to MICE.

Sincerely,

Stephen A. Gourlay, Director
Accelerator & Fusion Research Division

Concurrence: Norman McCubbin, RAL/STFC

Signed by U.S. Secretary of Energy!

FY08 Funding Distribution

- FY08 NFMCC budget (only DOE-NFMCC funds)[†]

  [†]Also: salary support from BNL, FNAL, LBNL; support from NSF of ~$1M ($798K MRI + $133+$100K 3-yr grants); support of Muons, Inc. via SBIR grants

Institution	COOLING /MICE	TARGETRY	ACCEL./ COLLIDER	RESERVE	TOTAL ($K)
BNL		145	90		235
FNAL	55				55
LBNL[a]	810			22	832
ANL	190				190
IIT	80				80
Mississippi	20		10		30
Princeton		40			40
UCLA			55		55
UC-Riverside			95		95
ORNL		85			85
Jlab	3		10		13
TOTAL ($K)	**1158**	**270**	**260**	**22**	**1710**

[a]Includes MICE funding of $575K.

Incremental Funding

- Starting last year, $250K of BNL funds previously labeled AARD were relabeled as muon funds
  - our flat-flat base went from $3.6M to $3.85M
    - this was not an increment, just a reassignment

- Supplemental funding request provided additional $100K
  - support for BNL simulation group ($40K)
  - support for MICE operations at FNAL and LBNL ($30K)
    - covered several one-month “MOM” shifts at RAL
  - support to FNAL for fabrication of LiH test absorber for MICE ($30K)

Budget Comments

- By juggling projects across fiscal year boundaries and careful prioritization, we continue to make progress
  - all our R&D efforts, including our international project commitments, have no contingency
    - only recourse for "contingent events" is delay (schedule slippage)
      - in past years, we've been fairly lucky
      - more complicated endeavors now under way caused luck to run out
  - MICE schedule has been delayed 1 year, due to inability to provide components in sufficiently timely way
    - partially, but not exclusively, due to NFMCC-provided items
- Emphasis on hardware development for international experiments comes at price of attrition in effort level
  - trying this year to augment post-docs
    - need growth in this area; many interesting problems to work on
  - Lab budgets, especially BNL's, remain severely strained

FY08 R&D Goals

- **Main goals for FY08 included:**
  - decommission MERIT experiment
  - continue development of MuCool Test Area (MTA)
    - work on implementation of cryogenic system
  - continue high-power tests of 805-MHz cavity
  - continue high-power tests of 201-MHz cavity
    - low availability of RF sources was a handicap here
  - continue fabrication of MICE spectrometer solenoids and begin design work for RFCC modules
  - continue simulation effort in support of IDS-NF
  - continue exploring and optimizing 6D cooling performance
    - in conjunction with MCTF

FY08 Milestones

- **Prior to distribution of funds, each institution provided milestones agreed upon by PM**
  - **these (example below) reflect budget allocations for each institution, including base program funds**

U-Miss. [Summers]

Milestone	Date	Deliverable
Complete machining of second Cherenkov detector and ship to RAL	Jan-08	Inspection
Commission both Cherenkov detectors for MICE	Apr-08	Inspection
Begin manufacture of MuCool coupling coil support	Sep-08	Inspection
Study magnetic field grid for muon inverse cyclotron cooler	Jul-08	NFMCC presentation
Study longitudinal dynamics and magnet design for 750 GeV muon accelerator in Tevatron tunnel	Sep-08	NFMCC note

IIT [Kaplan]

Milestone	Date	Deliverable
Continue web support for MICE experiment	Sep-08	Inspection
Continue MTA radiation measurements with 805- and 201-MHz cavities	Jun-08	NuFact08 presentation
Commission MICE tracker readout system	Feb-08	MICE presentation
Carry out MICE beam line optimization and tuning	Apr-08	MICE note
Continue button tests at 805 MHz	Sep-08	NFMCC note
Carry out MICE background analysis based on MTA data	Jun-08	NuFact08 presentation
Contribute to MICE operations	Sep-08	Inspection
Update MTA DAQ system documentation	Sep-08	NFMCC note

UC-Riverside [Hanson]

Milestone	Date	Deliverable
Hire MICE simulation post-doctoral research associate (NSF-funded)	Sep-08	Inspection
Continue simulations of 6D muon cooling	Sep-08	NFMCC note
Participate in MICE tracker commissioning and operation	Sep-08	MICE note
Participate in muon cooling simulations for the International Design Study	Jun-08	NFMCC note
Participate in design and simulation of 6D muon cooling demonstration experiment	Sep-08	NFMCC/MCTF note

FY08 Accounting

- **Summary of FY08 spending:**

Institution	Collaboration Committed ($K)	Collaboration Uncommitted ($K)	Core Program Committed ($K)	Overall Total ($K)	Contact
ANL	183	7.3	140	322	J. Norem
BNL [1]	224	147	1201	1425	H. Kirk
FNAL [2]	20	105	5110	5130	A. Bross
LBNL [3]	1115	1619	468	1583	M. Zisman
ORNL	52	37	0	52	T. Burgess
Princeton U.	45	0	70	115	K. McDonald
UCLA	55	0	34	89	D. Cline
UC-Riverside [4,5]	78	17	313	391	G. Hanson
Mississippi [5]	30	0	8	38	D. Summers
IIT [5]	82	0	0	82	D. Kaplan
Jlab	11	8	0	11	R. Rimmer
NSF MICE Support [6]	*334*	*819*	*0*	*334*	*D. Summers/G. Hanson/D. Kaplan*
TOTALS [7]	**1895**	**1940**	**7344**	**9239**	
	2229	*2759*		*9572*	

NOTES:

[1] Uncommitted funds for MERIT decommissioning.
[2] Uncommitted funds for LiH absorbers.
[3] Includes $128K in uncommitted Project Reserve funds maintained by LBNL
[4] Base funds are UC-Riverside startup funds.
[5] Only DOE funds. NSF funding reported separately.
[6] Funds allocated to UC-Riverside, IIT, and U.-Miss. as primary contractors.
[7] DOE totals in Roman type; *additional NSF funding shown in italics*.

Note substantial increase in FNAL muon funds (MCTF)

Recent R&D Accomplishments

- **R&D progress made on most fronts:**
  - **Simulations/IDS-NF + MC**
  - **Targetry/MERIT**
  - **Cooling/MICE**

- **Acceleration component work has been on hold due to lack of funding at Cornell**
  - ***trying to restart at Jlab in FY09***

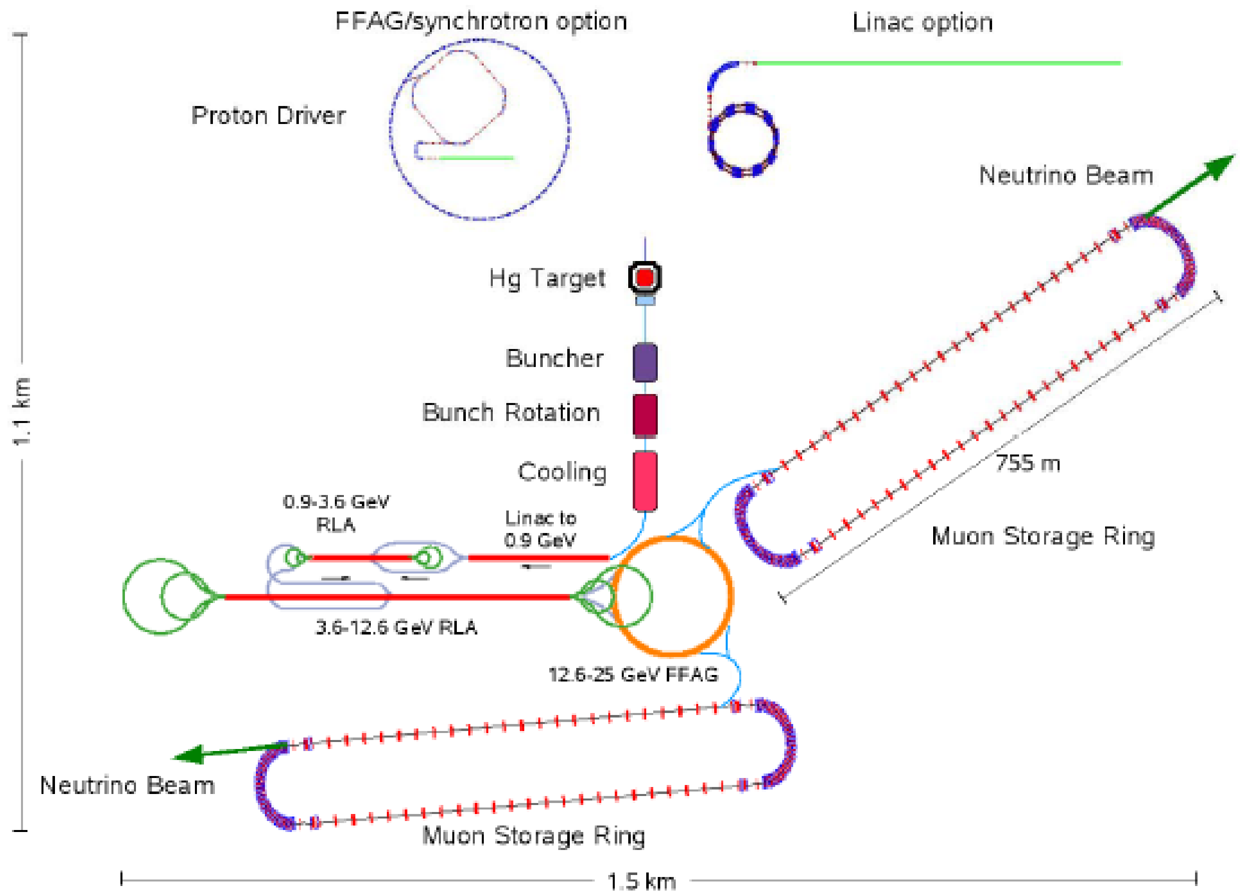
Simulations

- NFMCC has been engaged in a number of efforts
  - Feasibility Study I (with FNAL)
  - Feasibility Study II (with BNL)
  - APS Multi-Divisional Neutrino Study ("Study IIa," see http://www.aps.org/policy/reports/multidivisional/neutrino/)
  - International Scoping Study (see http://www.hep.ph.ic.ac.uk/iss/)
    - Accelerator Working Group Report submitted to JINST
  - follow-on IDS-NF to develop engineered facility design and corresponding cost estimate is under way (see http://www.hep.ph.ic.ac.uk/ids/)
    - Berg playing a lead role in this enterprise; MZ is member of steering group

- Accomplishments
  - simplification of NF front-end design while maintaining performance
    - "simplification" ⇒ cost savings of roughly 1/3 cf. study II
  - development of international consensus on NF design aspects
  - working with MCTF toward MC facility design (increasing interest here)

IDS-NF Baseline

- A baseline configuration for the Neutrino Factory has been specified
  - based in large measure on the Study IIa cooling channel design



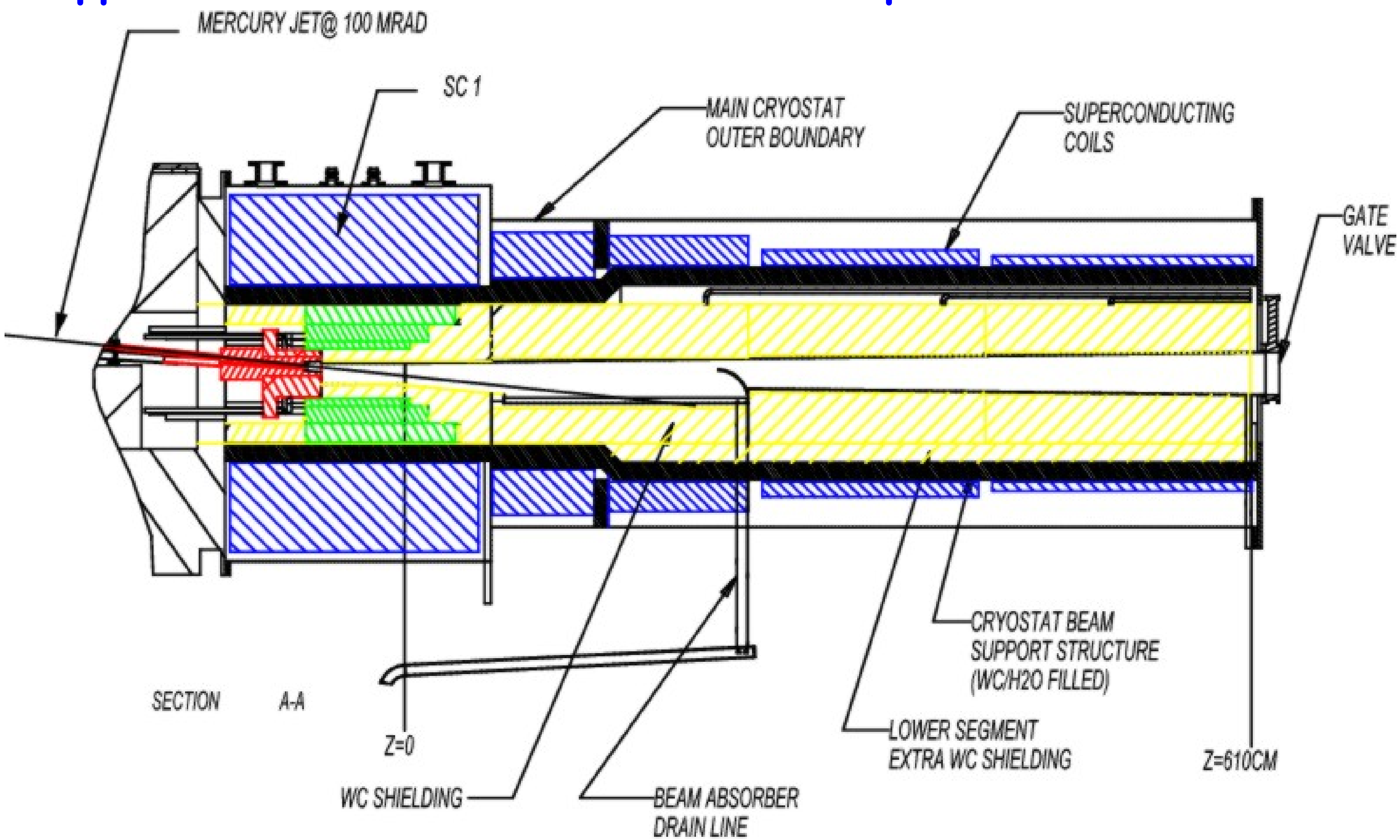
IDS-NF Baseline Parameters

Proton Driver	
Proton power	4 MW
Proton kinetic energy	5–15 GeV
Pulses per second	50
Bunches per pulse	3
Minimum time between bunches	17 µs
Maximum time for all bunches	40 µs
RMS proton bunch length	1–3 ns
Target	
Material	Hg
Type	Liquid jet
Jet diameter	1 cm
Jet velocity	20 m/s
Jet angle to axis	100 mrad
Jet angle to proton beam	33 mrad
Proton beam angle to axis	67 mrad
Solenoid field at interaction point	20 T
Front End: Pion Collection, Tapered Solenoid Channel	
Length	12 m
Field at target	20 T
Diameter at target	15 cm
Field at exit	1.75 T
Diameter at exit	50 cm
Front End: Decay Channel	
Length	100 m
Front End: Adiabatic Buncher	
Length	50 m
Front End: Phase Rotator	
Length	50 m
Energy spread at exit	10.5 %
Front End: Ionization Cooling Channel	
Length	80 m
RF frequency	201.25 MHz
Absorber material	LiH
Absorber thickness	1 cm
Input emittance	17 mm mrad
Output emittance	7.4 mm mrad
Central momentum	220 MeV/c
Solenoidal focusing field	2.8 T

Acceleration	
RF Frequency	201.25 MHz
RF type	Superconducting
Total energy at injection	244 MeV
Transverse normalized acceptance at input	30 mm
Longitudinal normalized acceptance at input	150 mm
Stage 1, type	Linac
Stage 1, lattice cell	Solenoid FOFO
Total energy, stage 1–2 transition	0.9 GeV
Stage 2, type	Dogbone RLA
Stage 2, cavity aperture diameter	30 cm
Stage 2, energy gain per cavity cell	12.75 MV
Stage 2, lattice cell	FODO
Stage 2, linac passes	4.5
Total energy, stage 2–3 transition	3.6 GeV
Stage 3, type	Dogbone RLA
Stage 3, cavity aperture diameter	30 cm
Stage 3, energy gain per cavity cell	12.75 MV
Stage 3, lattice cell	FODO
Stage 3, linac passes	4.5
Total energy, stage 3–4 transition	12.6 GeV
Stage 4, type	Linear non-scaling FFAG
Stage 4, cavity aperture diameter	30 cm
Stage 4, energy gain per cavity cell	12.75 MV
Stage 4, lattice cell	FODO
Stage 4, cavity cells per lattice cell	2
Storage Ring	
Total muon energy	25 GeV
Type	Racetrack
Straight section length	600.20 m
Race-track circumference	1608.80 m
Number of rings	2
RMS angular divergence, production straight	$0.1/\gamma$
Gap between bunch trains	100 ns
Possible simultaneous signs per ring	2
Total production straight µ decays in 10^7 s	10^{21}
Short baseline	3000–5000 km
Long baseline	7000–8000 km

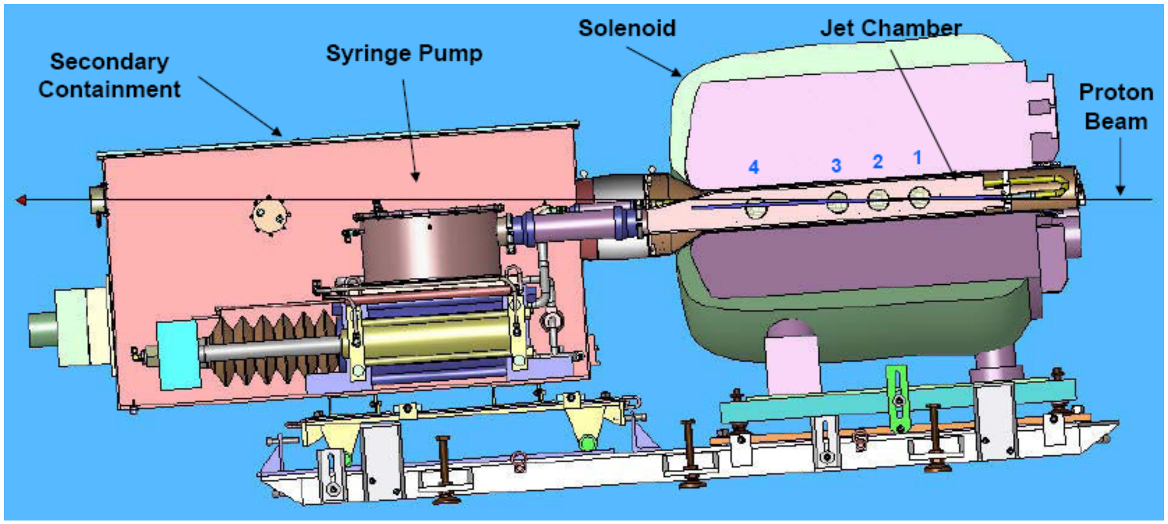
Targetry R&D

- **Target concept uses free Hg jet in 20-T solenoidal field**
  - **jet velocity of 20 m/s establishes "new" target for each beam pulse**
  - **this approach served as basis of MERIT experiment**

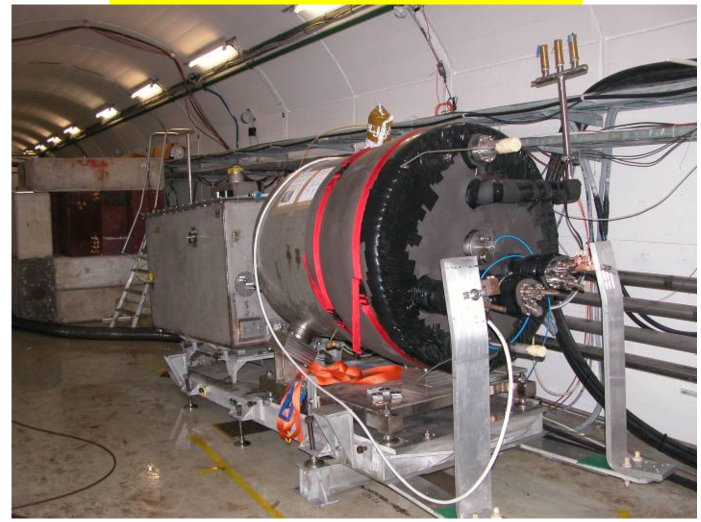


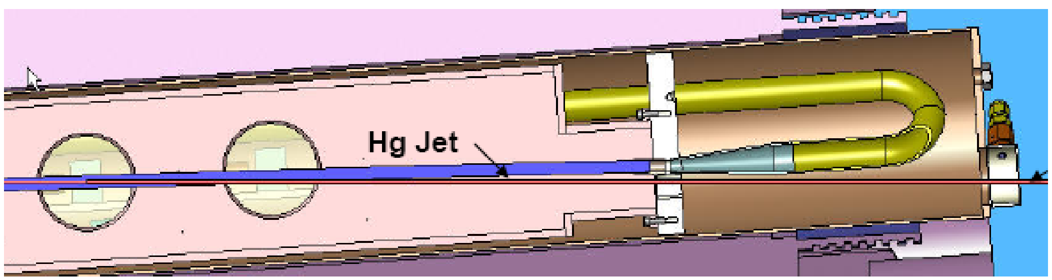
MERIT Experiment

- MERIT completed beam test of Hg-jet target in 15-T magnetic field using CERN PS

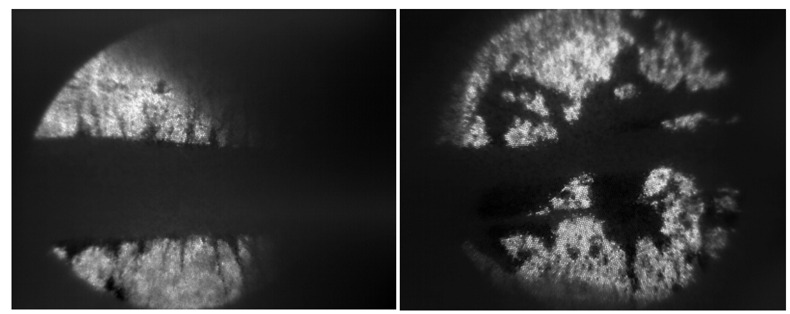


Installation at CERN





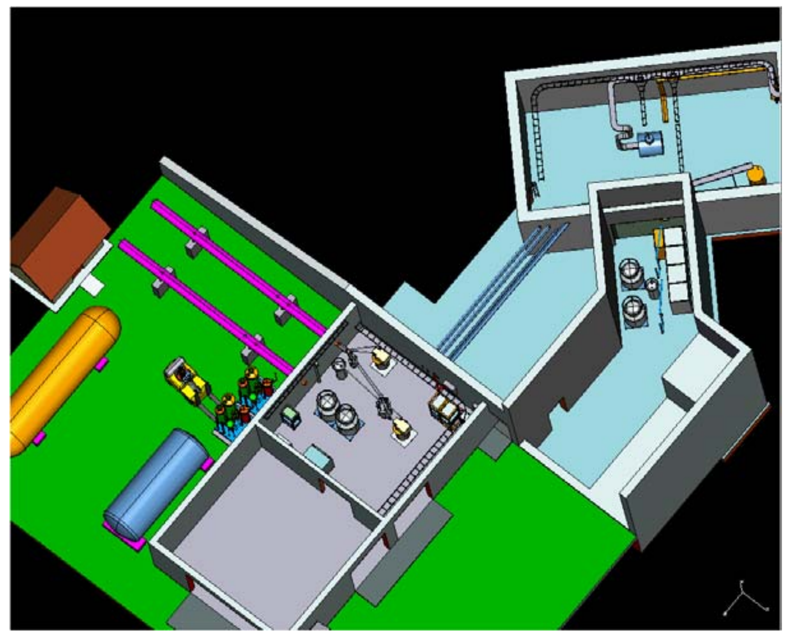
Schematic of MERIT experimental setup



During After
10 Tp

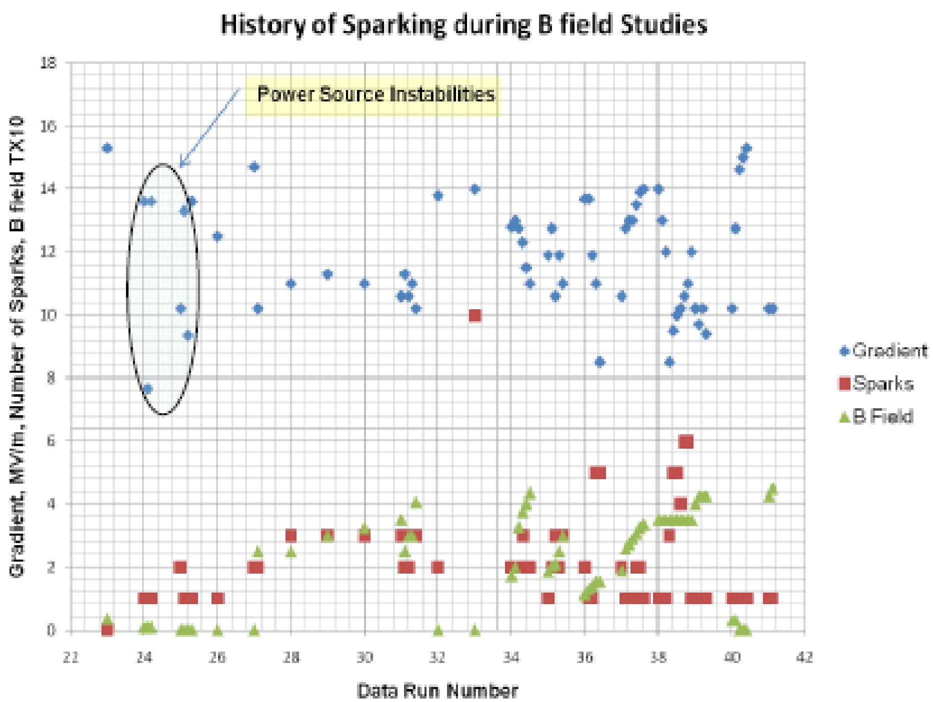
MuCool R&D (1)

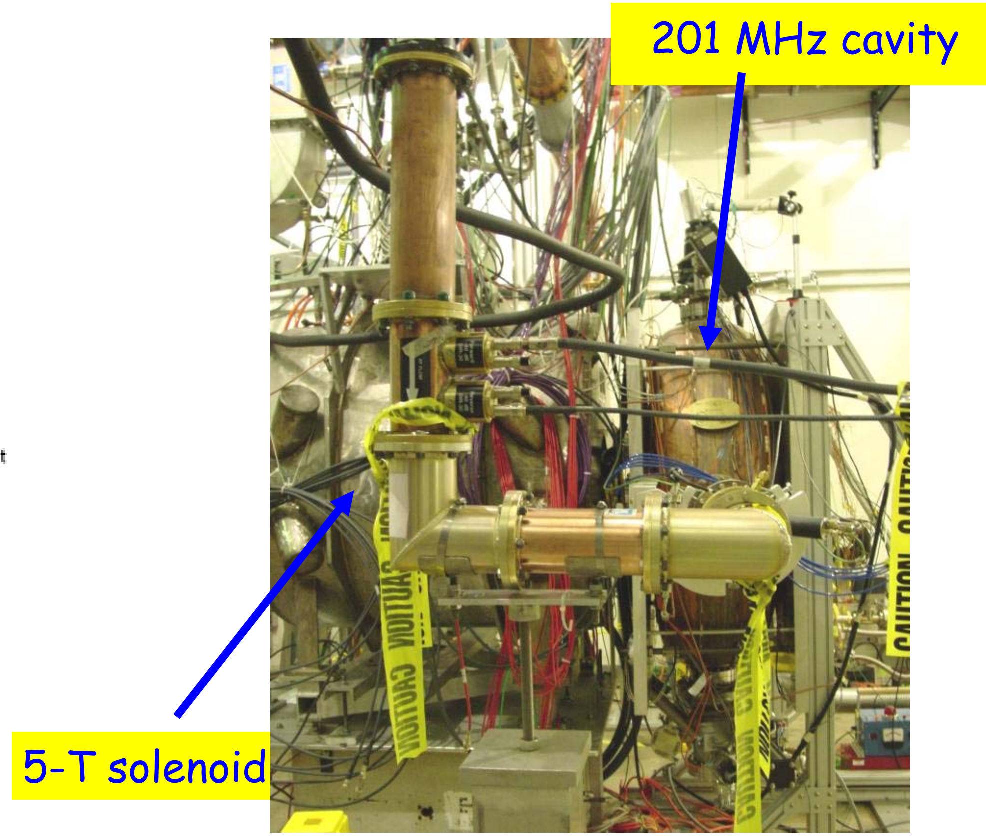
- **MuCool program does R&D on cooling channel components**
  - **RF cavities, absorbers**
- **Carried out in MuCool Test Area (MTA) at Fermilab (funded by NFMCC)**
  - **located at end of 400 MeV linac and shielded for upcoming beam tests**



MuCool R&D (2)

- **Motivation for cavity test program: observed degradation in cavity performance when strong magnetic field present**
  - **201 MHz cavity easily reached 19 MV/m without magnetic field**
  - **initial tests in fringe field of Lab G solenoid show some degradation**
    - **and lots of scatter**

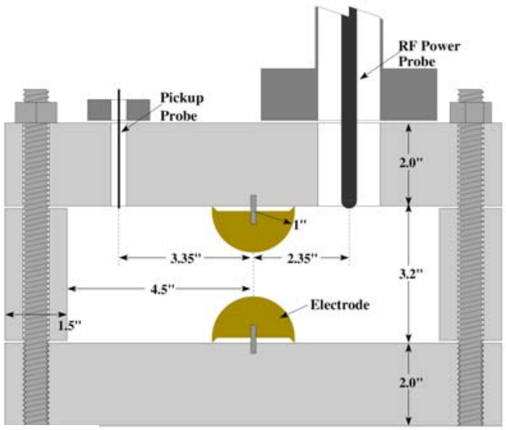


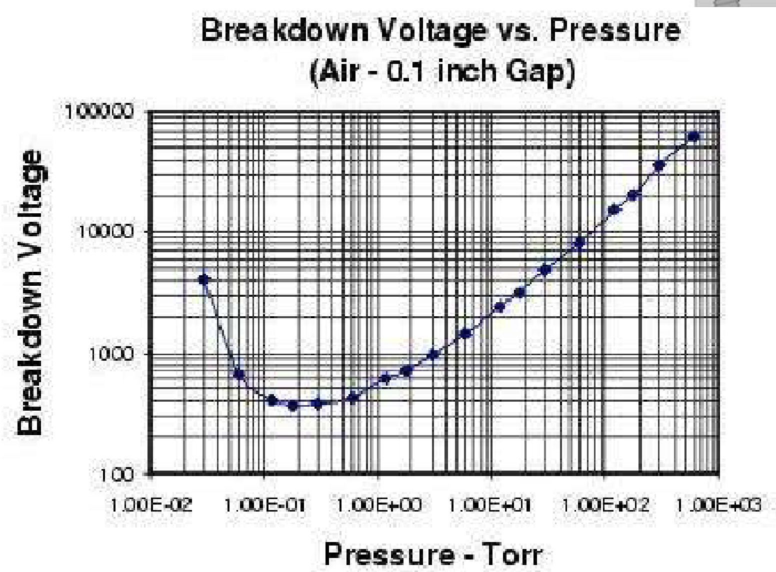


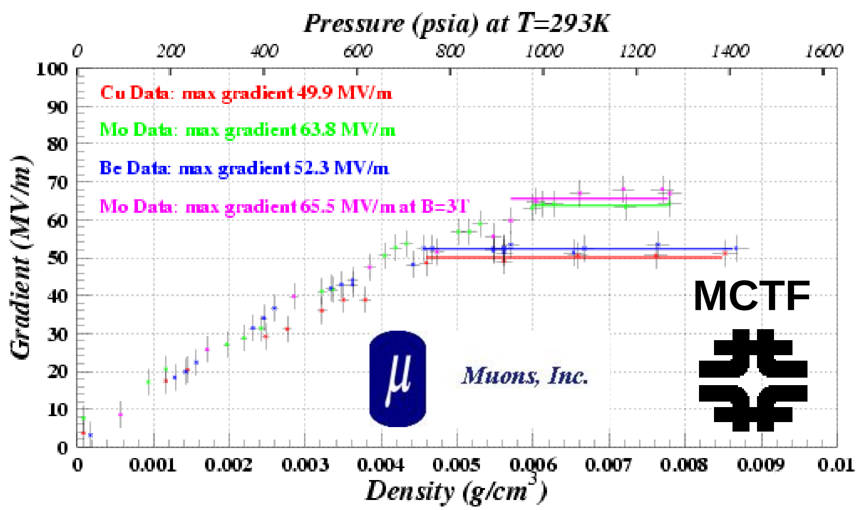
MuCool R&D (3)

- **Tested pressurized button cavity at MTA** FNAL + Muons, Inc.
  - *use high-pressure H_2 gas to limit breakdown (⇒ no magnetic field effect)*

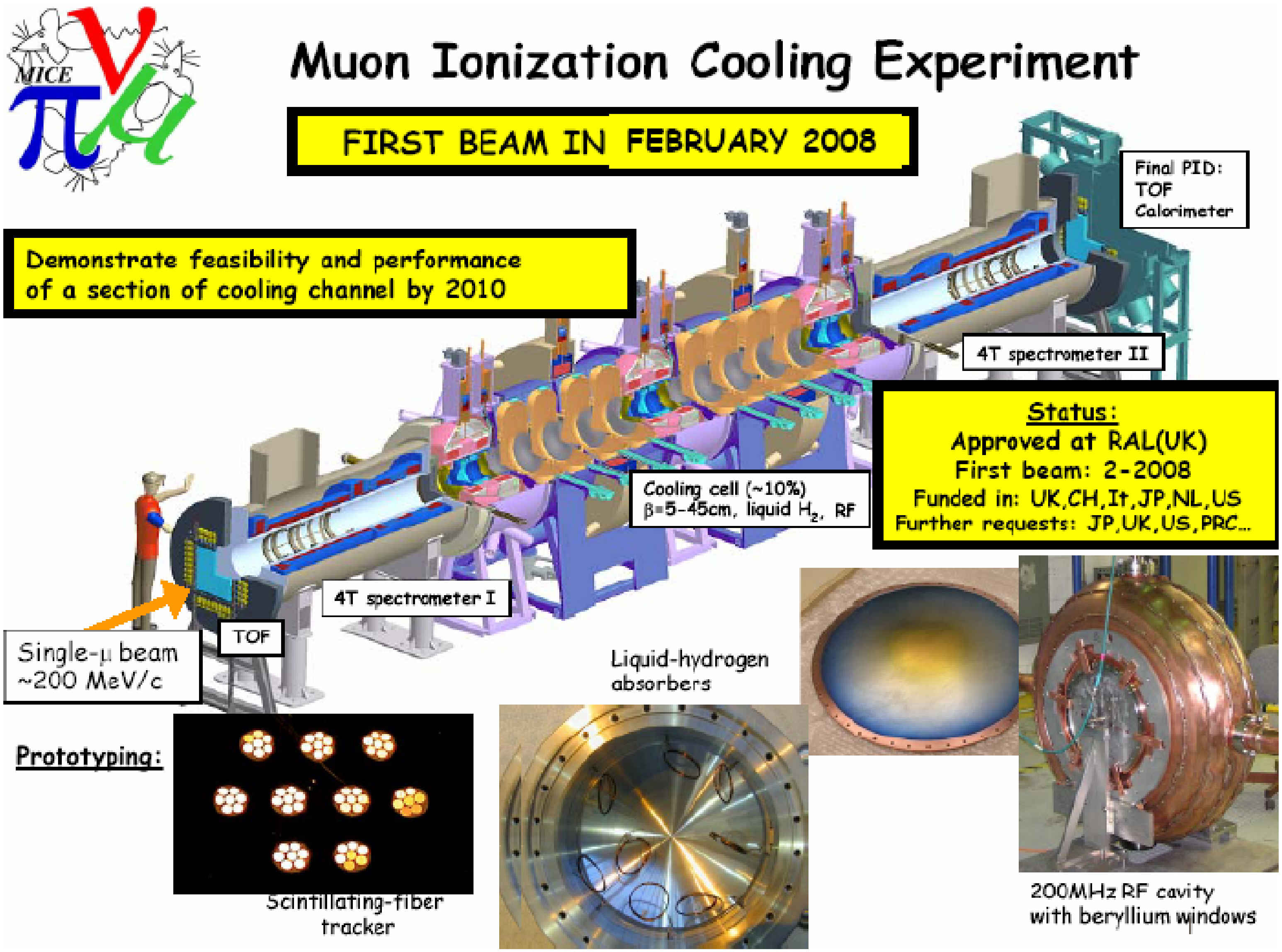
Remaining issue:
What happens when high intensity beam traverses gas?





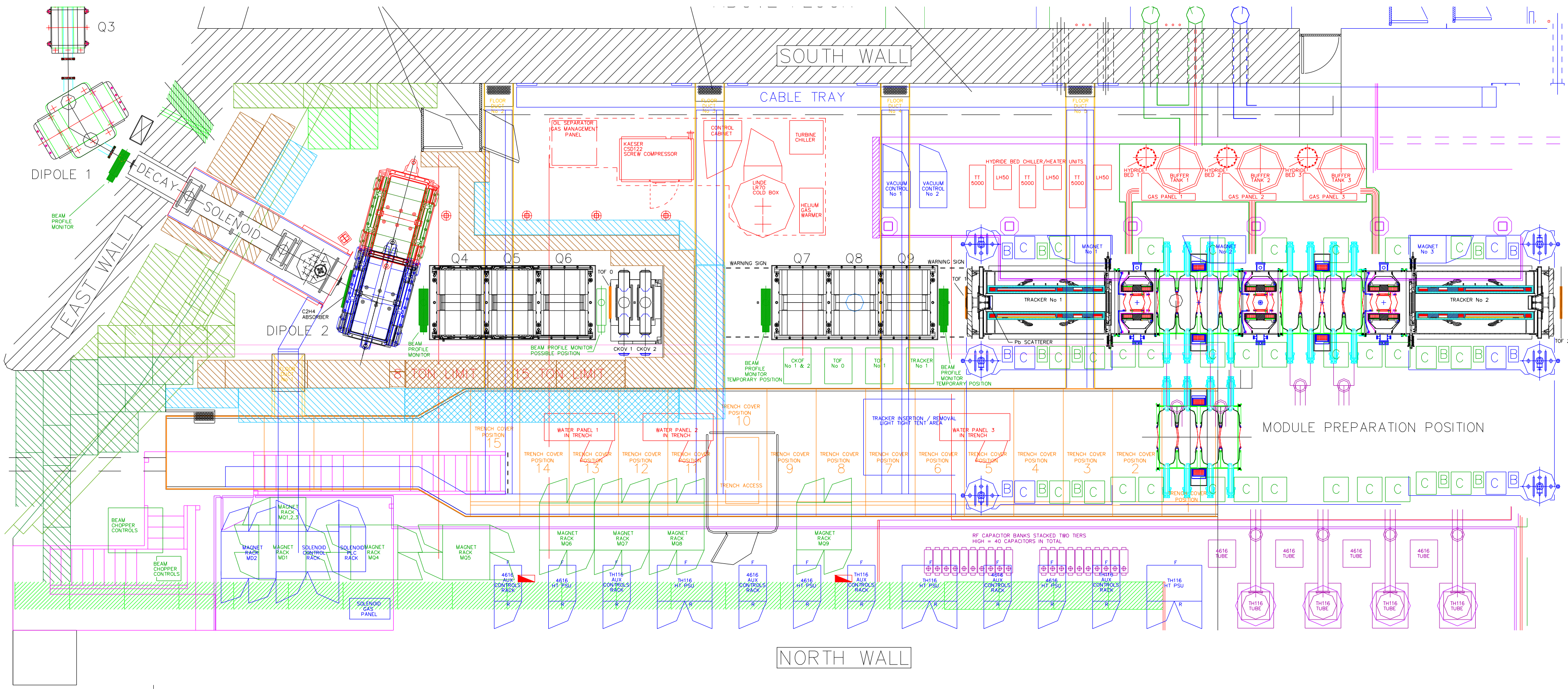


MICE Schematic



MICE Hall (1)

- Hall will contain a *lot* of equipment



MICE Hall (2)

- Beam line portion is in place and being commissioned
- Magnetic shielding walls in place
  - raised floor for experiment being installed

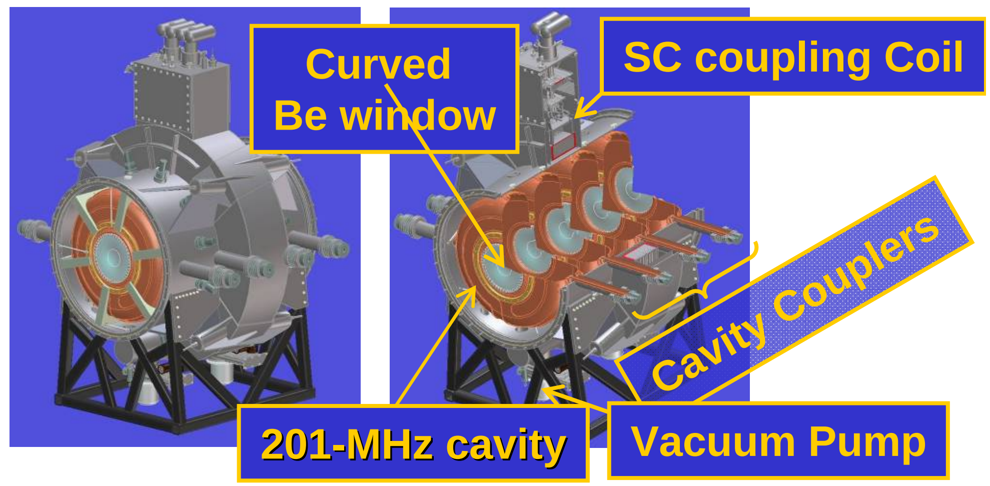
MICE Hardware Status (1)

- Beam line components in and working
  - no correctors or collimators available

- Detectors and DAQ
  - TOF0 and TOF1 installed and operating
    - TOF2 available "soon"
  - CKOVs 1 and 2 installed and operating
  - KL layer of calorimeter delivered
    - design for remainder of EMR completed (Trieste and Geneva)
      - Geneva will fabricate
  - SciFi trackers completed and tested with cosmic rays
    - installation awaits spectrometer solenoids to house them
  - DAQ is functional but needs user interface improvements
    - better integration with slow controls is required
      - "on-line" group set up to deal with this
        - includes Coney and Hanlet

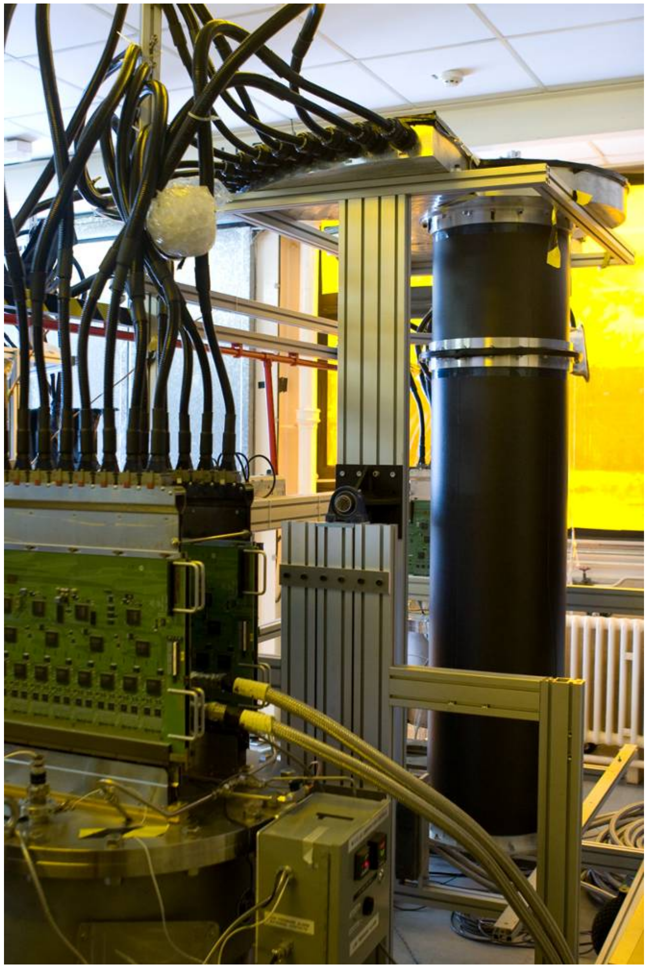
MICE Hardware Status (2)

- **NFMCC delivering Spectrometer Solenoids and RFCC modules**
  - spectrometer solenoids almost done, but late due to vendor delays
  - coupling coil prototype test (ICST/HIT) will get under way next month
  - RF cavity contract in place
    - RFCC module *design* (LBNL) is essentially complete



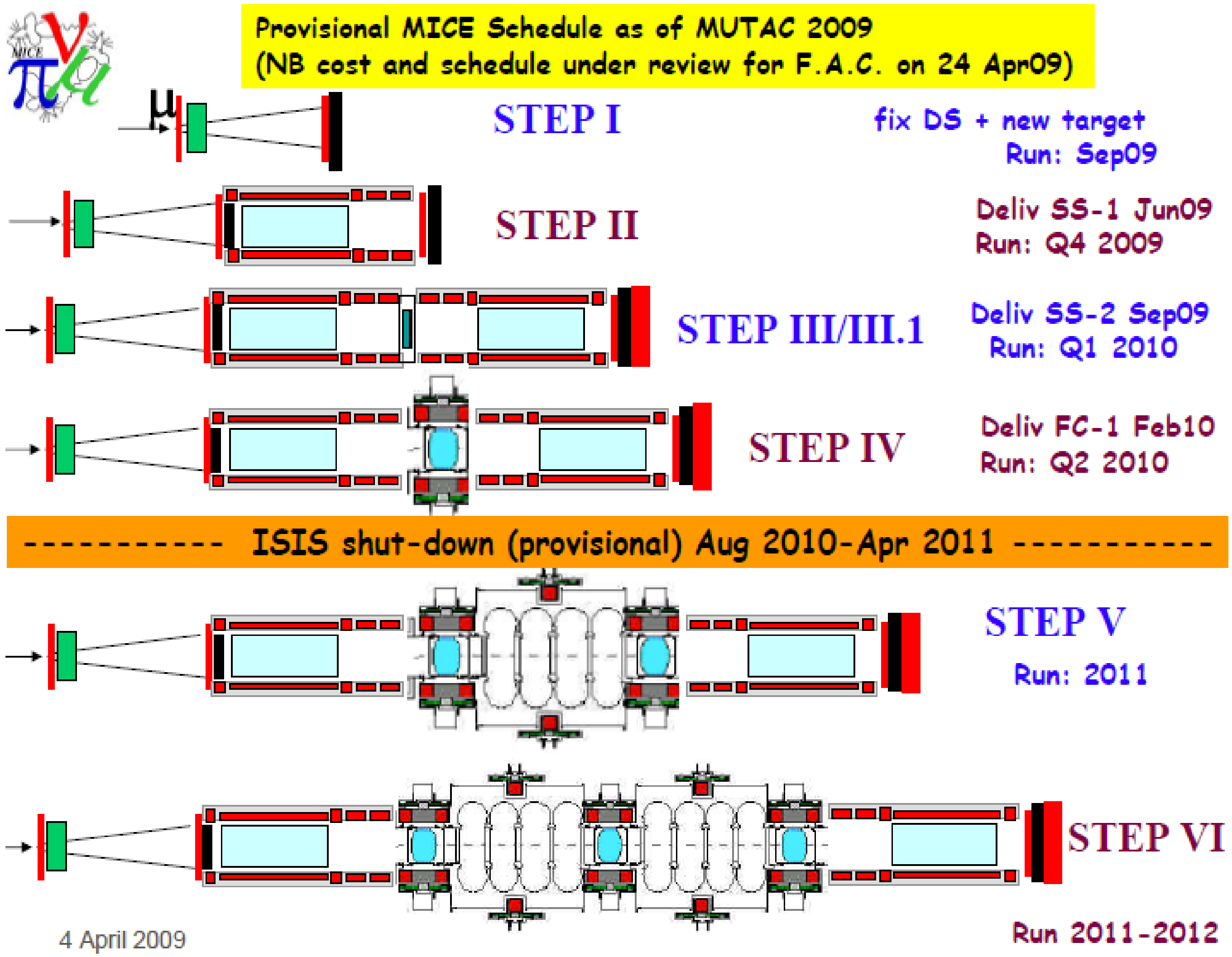
MICE Hardware Status (3)

- FNAL has already delivered tracker readout systems and associated cryostats to RAL



MICE Stages

- Provisional staging plan (some delays have occurred)



MICE Collaborators

- **Collaborating institutions**

Europe
Bari
Brunel
CERN
Daresbury Lab
Edinburgh
Genève
Genova
Glasgow
Imperial College
Liverpool
LNF Frascati
Louvain la Neuve
Milano
Napoli
NIKHEF
Novosibirsk
Oxford
Padova
Pavia
PSI
RAL
Roma III
Sheffield
Sophia
Trieste
Warwick

Asia
ICST-Harbin
KEK
Osaka

U.S.
ANL
BNL
FNAL
Illinois Institute of Technology
TJNAF
LBNL
Mississippi
Muons, Inc.
New Hampshire
UCLA
UC-Riverside

Shows broad international support for muon cooling study

International Perspective

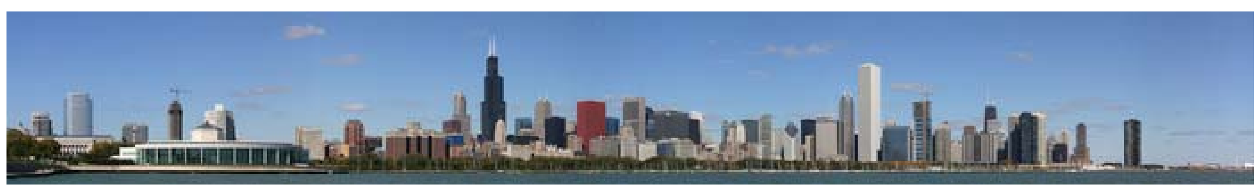
- **International community holds annual "NuFact" workshops**
  - provides opportunity for physics, detector, and accelerator groups to plan and coordinate R&D efforts at "grass roots" level
  - venue rotates among geographical regions (Europe, Japan, U.S.)

Year	Venue
1999	Lyon, France
2000	Monterey, CA
2001	Tsukuba, Japan
2002	London, England
2003	New York, NY
2004	Osaka, Japan
2005	Frascati, Italy
2006	Irvine, CA
2007	Okayama, Japan
2008	Valencia, Spain
2009	Chicago, IL

NuFact09

July 20-25, 2009

IIT-Chicago



FY09 Budget

- Prepared initial budget for FY09 based on CR guidance of "flat-flat – 2%" funding
  - requesting supplemental funds now that CR has ended
- Discussed and approved by TB, EB, and MCOG
- Goal: keep simulation activities viable while making progress on key fabrication activities
  - also try to mitigate attrition in Lab funding
- R&D objectives
  - proceed with MICE RFCC module fabrication
  - decommission MERIT experiment
  - participate in IDS-NF and MICE (⇒ common fund payment)
  - continue RF test program at MTA
  - expand effort on collider design

FY09 Funding Distribution

- FY09 NFMCC budget (only DOE-NFMCC funds)†

  †Also: salary support from BNL, FNAL, LBNL; support from NSF of $1.1M ($798K MRI + $133K+2x$100K 3-yr grants); support of Muons, Inc. via SBIR grants

Institution	COOLING /MICE	TARGETRY	ACCEL./ COLLIDER	RESERVE	TOTAL ($K)
BNL		95	100		195
FNAL	70				70
LBNL[a]	740			10	750
ANL	190				190
IIT	82				82
Mississippi	18		12		30
Princeton		20			20
UC-Berkeley			3		3
UCLA			55		55
UC-Riverside			95		95
ORNL		45			45
Jlab	5		35		40
TOTAL ($K)	**1105**	**160**	**300**	**10**	**1575**

[a]Includes MICE funding of $690K.

FY09 Supplemental Funding

- DOE has requested supplemental funding proposals
  - NFMCC has requested $970K
    - MuCool program ($450K)
      - 805 MHz circulator and switch ($85K)
      - post-doc (at LBNL) ($165K)
      - quarter-scale model of 201 MHz cavity + vacuum vessel for cryogenic tests ($200K)
    - Targetry program ($520K)
      - continuous Hg jet engineering design ($400K)
      - optimized nozzle design ($120K)

- Hope for the best!

FY09-10 Plans

- Targetry
  - publish MERIT results

Take guidance from new 5-year R&D plan (NFMCC + MCTF)

- Cooling/MICE
  - continue testing 805- and 201-MHz cavities with magnetic field
  - test gas-filled cavity with beam at MTA (MCTF)
  - complete MICE beam line commissioning
    - reach Step 3 configuration for cooling channel
- Acceleration
  - continue participation in EMMA design
  - revive SRF R&D
- Simulations
  - participate in IDS-NF
  - continue collider studies with MCTF
    - aim for feasibility study in FY11-FY12

Issues

- Three categories where additional support is needed:
  - completing our hardware commitments to international experiments
    - MICE commitments will be honored with present budgets, but ~1 yr late
      - any substantial need for contingency would result in further delays
      - getting STFC to commit to Step 6 is critical
  - restoring the health of our simulations and theory effort
    - manpower has eroded away after years of flat budgets
      - need effort for IDS-NF, MICE analysis, EMMA design, and MC design work
        - need to assess resource needs ("people" issue, not just $)
  - launching new initiatives, especially RF work
    - takes additional NFMCC M&S funds plus at least one post-doc

- 5-year R&D plan (~$90M) has been submitted to DOE
  - no response yet; expect formal review, hopefully later this year
  - support from MUTAC will be very helpful to launching this initiative

Summary and Outlook

- Despite limited funding, NFMCC continues to make progress on carrying out its R&D program
  - initial 201-MHz cavity tests with magnetic field under way
  - MICE spectrometer solenoid fabrication nearly completed
  - completed ISS; paper "almost" published (JINST)
    - IDS-NF under way
  - completed MERIT beam run
    - data analysis under way
- Our work provides potential choices for HEP community
  - muon-based accelerators/colliders offer advantages over other approaches
    - they also provide an intense source for low-energy muon physics
- NFMCC has been disciplined and effective in carrying out its R&D tasks and continues to make good use of its funds
  - the scientific potential of the effort justifies nothing less