Report of Project Manager

Michael S. Zisman
CENTER FOR BEAM PHYSICS

Muon Collaboration Project Manager

Neutrino Factory and Muon Collider Collaboration Meeting–LBNL
February 17, 2005

Outline

- Introduction
- FY04 accounting
- FY04 R&D accomplishments
- FY05 budget
- FY05 plans
- Longer-term plans
- Summary and outlook

Introduction

- Since FY03, the MC budget has been nearly flat-flat
  - it is expected to remain at that level for the next several years

Year	DOE-base ($M)	DOE-MC ($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	1.4	3.6
FY05	1.9	1.7	3.6

- Starting this year, we have DOE permission to commit funds to MICE
  - level is $300K
    - for FY05–07
- By juggling projects across fiscal year boundaries and careful prioritization, we have continued to make progress
  - but it is getting harder

Introduction

- **Comments from April '04 MUTAC report**

"The Muon Collaboration continues to make significant progress, but with very constrained M&S funding. As last year, 1M$ more would make a significant impact. This is especially true in light of the questionable ICAR funds, and the opportunity to do the CERN target experiment."

"...US support on MICE is important for the international preparation to proceed. Approval of the US MICE proposal would have significant positive impact on the Muon Collaboration and its ability to develop hardware."

"The Committee notes the significant progress achieved in establishing a worldwide collaboration and the integration of the various R&D programs. In particular Japanese participation has increased in many areas such as MuCool, MICE, targetry, FFAG and NuFact workshops. The MICE proposal is an example of the effective operation of this larger collaboration."

Introduction

- **MCOG FY04 comments**

"MUTAC and MCOG note the continuing successes in the muon R&D work accomplished during the past year, especially the technical creativity shown in Neutrino Factory conceptual designs utilizing FFAG machine concepts for accelerating muons, as well as the significant progress in establishing worldwide collaboration in the study of important technical R&D topics. We are particularly pleased with the continuing progress by university-based groups in advancing some of the important machine R&D topics associated with cooling and the Muons, Inc. conceptual work on high-pressure, cold hydrogen gas forming an absorber mass inside a normal rf cavity to provide an integrated muon cooling environment. This progress has occurred in spite of four successive years of severe budget decreases that have strongly restricted the scope of experimental R&D work able to be carried out by the Muon Collaboration."

"...MCOG accepts and endorses the MUTAC Report attached here and urges the DOE to seek ways of supplementing R&D funding for the Muon Collaboration. An additional amount of $1M or more, per year, would provide important relief to the program and improve the rate of advance in the technical areas of study. We urge the DOE to consider such an increase in funding as they prepare future budgets for the muon R&D program."

Introduction

- Hardware development continues as major focus of FY05 activity
- Simulation effort aimed at reducing Neutrino Factory cost ("Study IIa") gave good results
  - a substantial part of the working group report based on this work
- Effort toward MICE proposal is coming to fruition
  - passed Gateway 2-3 review on Phase 1 of MICE in December 2004
    - hope PPARC will release UK funds (£9.7M) in March 2005
- MICE funding is now available from MC funds
  - need more; applied for NSF MRI grant (Kaplan)
- Here I will cover:
  - FY04 accounting and R&D accomplishments
  - FY05 budget and plans

FY04 Accounting

- FY04 budget finalized by Spokespersons and PM in November
- Supplemental funding request submitted in September, 2003
  - and generated $400K!
- International Muon Ionization Cooling Experiment is starting to become a significant draw on resources
  - last year required mostly "effort" (base program funds)
  - this changed in FY05
    - M&S funding is now needed

FY04 Accounting

- **FY04 MC budget (approved by MCOG):**

Institution	COOLING	TARGETRY	COLLIDER	EFFORT[a]	RESERVE[b]	TOTAL ($K)
BNL		275		10		285
FNAL	400					400
LBNL	100				104	204
ANL				144		144
IIT				77		77
Mississippi	30			20		50
Princeton		50				50
UCB				5		5
UCLA	25		50			75
UCR						0
ORNL						0
JLab	100			10		110
TOTAL ($K)	**655**	**325**	**50**	**266**	**104**	**1400**

[a] Includes beam simulation and diagnostics effort.
[b] Modest project reserve used to account for uncertainties in R&D activity costs.

- **Also: salary support from BNL, FNAL, LBNL; support from NSF (mainly Cornell) of ≈$1M; and support from ICAR (≈9 FTE)**

FY04 Accounting

- **Supplemental request submitted to DOE in September, 2003 (priority order)**
  - **priorities decided in Technical Board discussions**
    - **DOE approved $400K in July, 2004**

Item	Request ($K)
1) 201 MHz RF testing	400
2) LH_2 absorber test capability	460
3) Targetry magnet fabrication	400
4) Coupling coil design and construction	300
TOTAL	1560

FY04 Accounting

- Main goals for FY04
  - begin fabrication of targetry test magnet
  - continue development of MUCOOL Test Area (MTA) at FNAL
  - continue high-power tests of 805 MHz cavity
  - continue 201-MHz SCRF development (NSF supported)
  - continue with LH_2 absorber development (includes ICAR support)
  - complete fabrication of 201-MHz NCRF cavity
  - obtain funding for MICE
  - continue exploring and optimizing cooling ring performance
- Aspirations this year consistent with modest budget

FY04 Accounting

- **Before funds were distributed, each institution provided milestones agreed upon by PM**
  - **milestones (example below) reflect budget allocations for each institution, including base program funds**

FNAL [Geer]

Milestone	Date	Deliverable
Complete HVAC installation in MTA	May-04	Inspection
Install 805 MHz RF capability in MTA	May-04	Inspection
Relocate Lab G solenoid to MTA	May-04	Inspection
Install 201 MHz RF capability in MTA	Sep-04	Inspection
Test solid 4x4 grid structure at 805 MHz	Sep-04	MC note prepared
Test curved Be windows in 805 MHz pillbox cavity	Sep-04	MC note prepared
Study RF buncher, phase rotation and cooling channel performance for APS Neutrino Study	Jun-04	MC note prepared
Complete design of cooled 805 MHz grid structure	Sep-04	MC note prepared
Participate in APS Neutrino Study	Jun-04	Write-up prepared

ANL [Norem]

Milestone	Date	Deliverable
Initial tests with field ion microscope	Mar-04	MC report prepared
Prepare proposal for RF surface studies (DOE, DARPA, NASA, or EPRI)	Mar-04	Proposal submitted
Prepare paper on MICE cavity surface treatment	Sep-04	Paper prepared
Evaluate 805 MHz pillbox cavity performance with precurved Be windows	Sep-04	MC report prepared
Test breakdown behavior of small samples in 805 MHz cavity	Sep-04	MC report prepared
Calculate shielding requirements for MICE experiment	Apr-04	MICE note prepared
Review MICE rf backgrounds for rebaselined configuration	Sep-04	MICE note prepared

FY04 Accounting

- **Summary of FY04 spending is shown below**

Institution	Collaboration		Base Program	Overall	Contact
	Committed ($K)	Uncommitted ($K)	Committed ($K)	Total ($K)	
ANL	145	0	145	290	J. Norem
BNL	241	0	1056	1297	H. Kirk
FNAL [1]	45	355	952	997	S. Geer
LBNL [2]	281	562	309	590	M. Zisman
Princeton U.	20	30	190	210	K. McDonald
UC-Berkeley	15.5	5.5	3	18.5	J. Wurtele
UCLA	75	0	59	134	D. Cline
Mississippi [3]	62	0	21	83	D. Summers
IIT [4]	38.5	0	0	38.5	D. Kaplan
Jlab	43	67	25	68	R. Rimmer
Cornell + NSF Contracts	*898*	*988*	*0*	*898*	*D. Hartill*
TOTALS [5]	**966**	**1019**	**2760**	**3726**	
	1864	*2007*		*4624*	

NOTES:

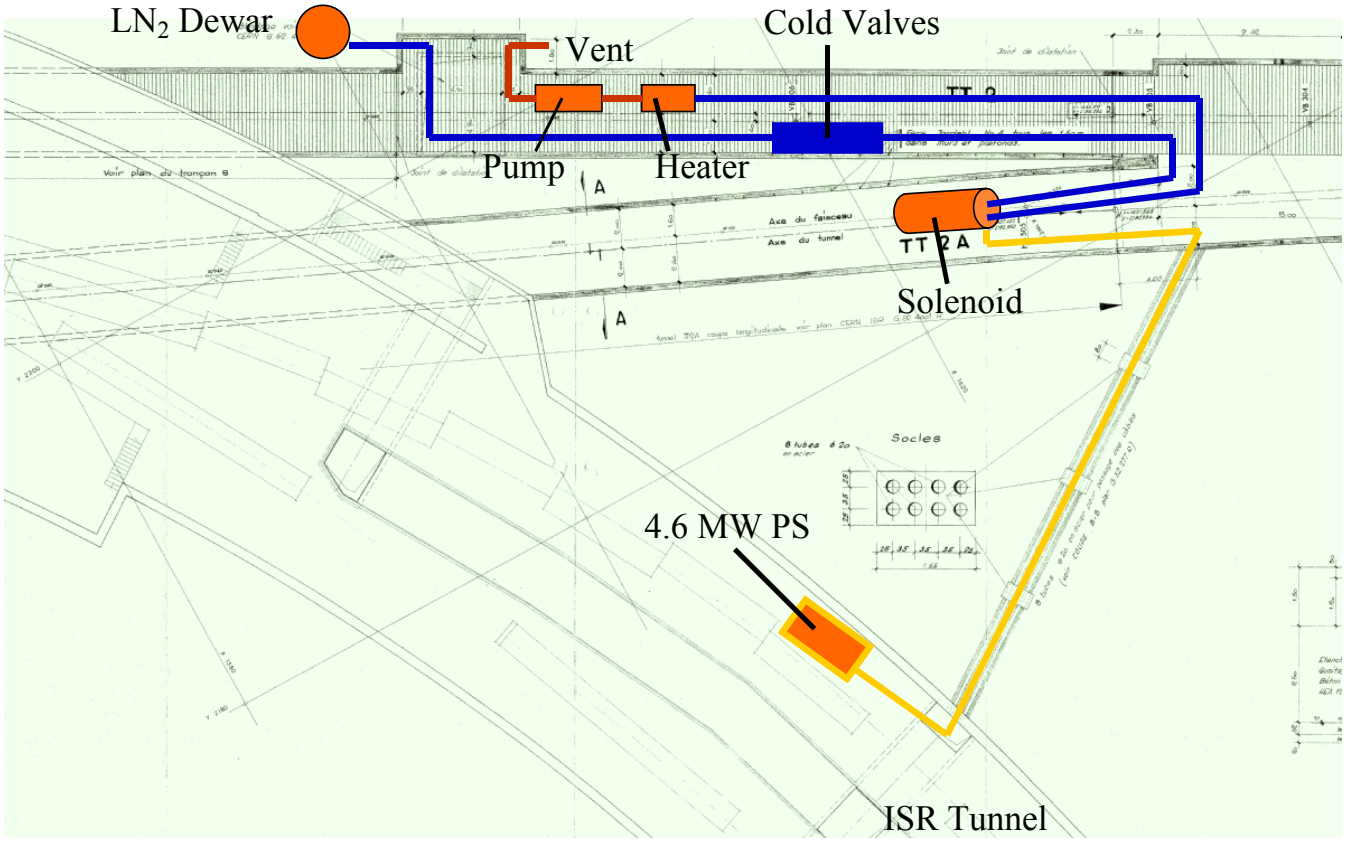
[1] Uncommitted funds for MTA cryogenic system, to be installed in FY05.
[2] Includes $162K in uncommitted Project Reserve funds maintained by LBNL and $250K of FY04 supplemental funds received in August '04.
[3] Includes carryover from FY03.
[4] $38.5K of planned FY04 funding was deferred until FY05.
[5] DOE totals in Roman type; *additional NSF funding shown in italics*.

FY04 R&D Accomplishments

- R&D progress being made on all fronts:
  - Targetry
  - Cooling
  - Acceleration
  - Simulations
  - MICE

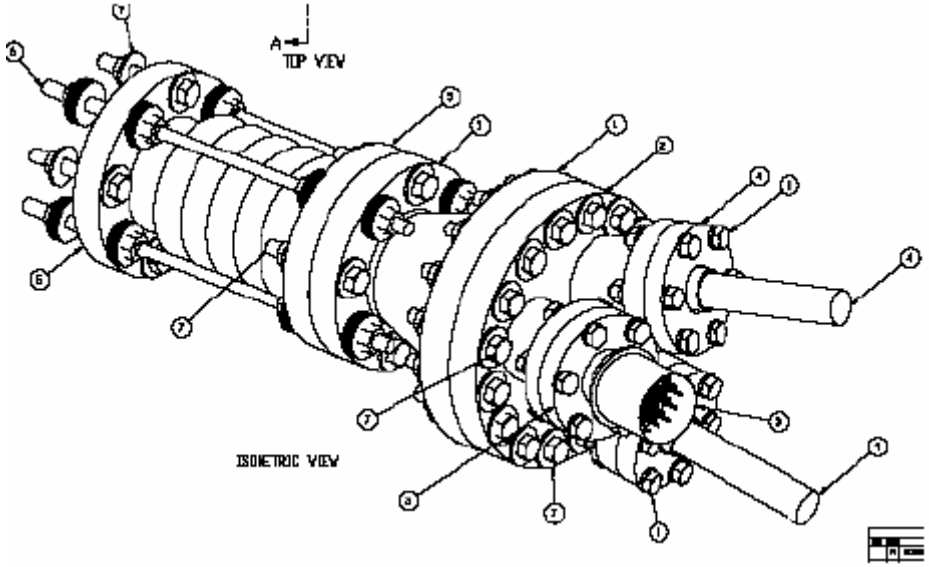
FY04 R&D Accomplishments

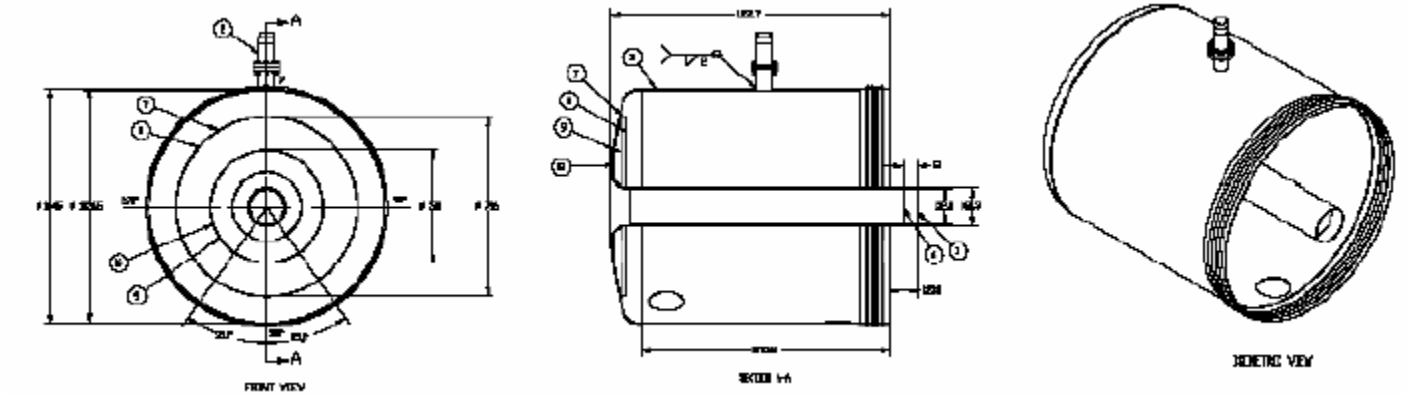
- Proposal for targetry experiment (P186 TT2A) at CERN submitted April, 2004 (and now close to final approval)
  - venue change necessitated by elimination of continued A3 line running at BNL



FY04 R&D Accomplishments

- Fabrication of 15 T magnet cryostat under way at CVIP





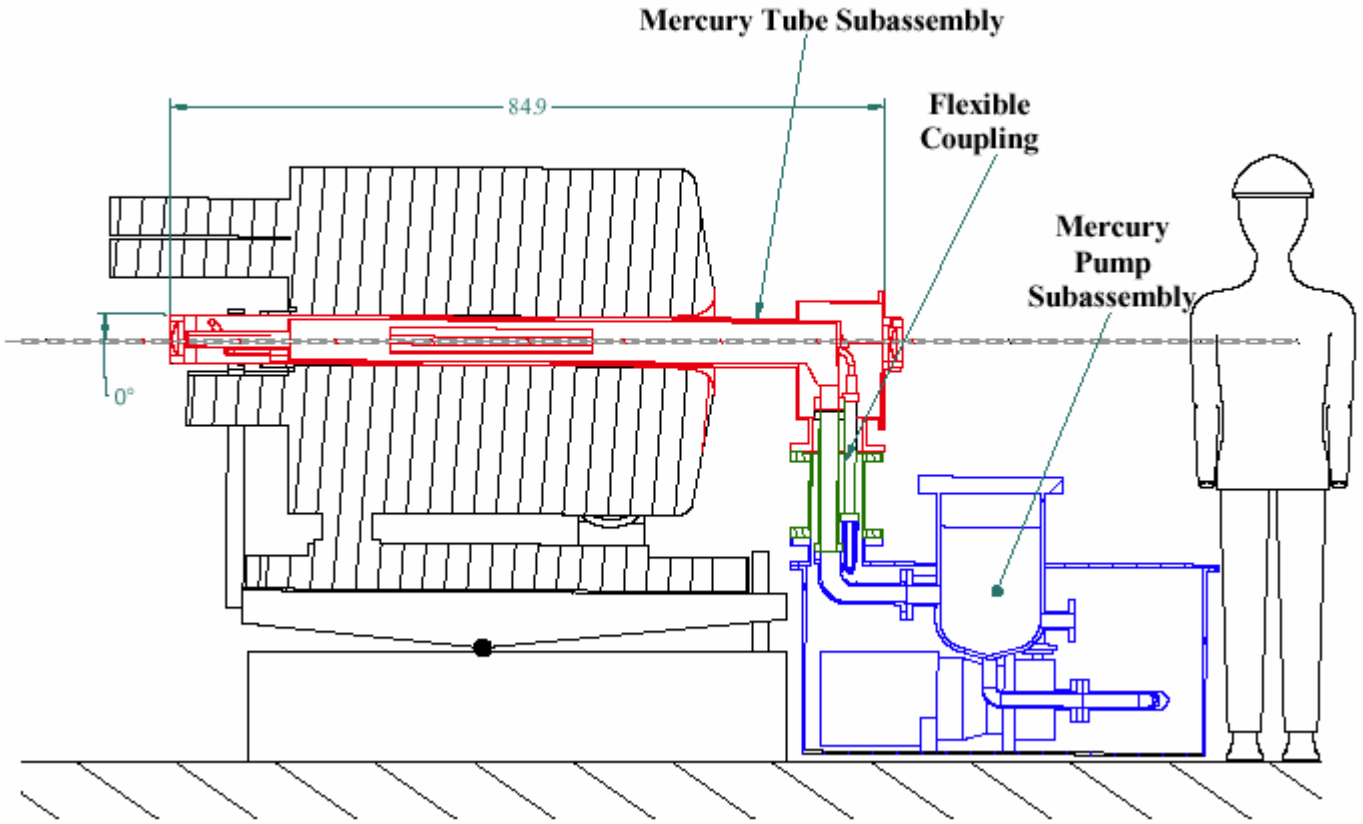
FY04 R&D Accomplishments

- coil winding is also in progress at Everson-Tesla

First layer, coil segment 2

FY04 R&D Accomplishments

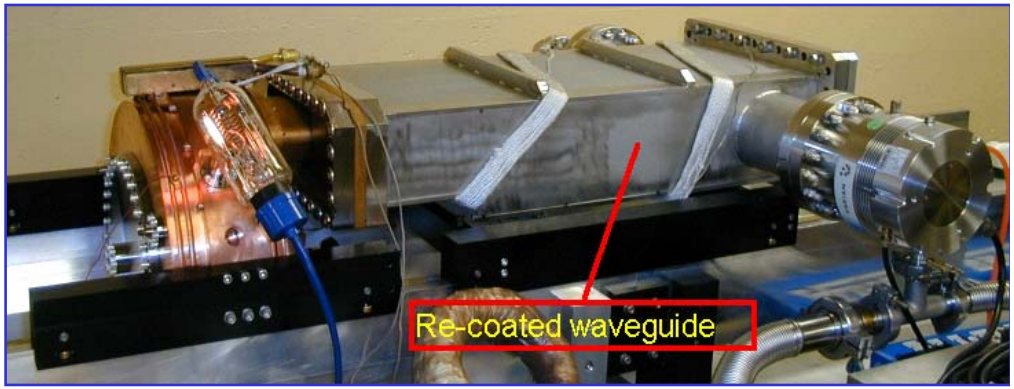
- Concepts for Hg jet system for CERN target test experiment are being developed in collaboration with ORNL

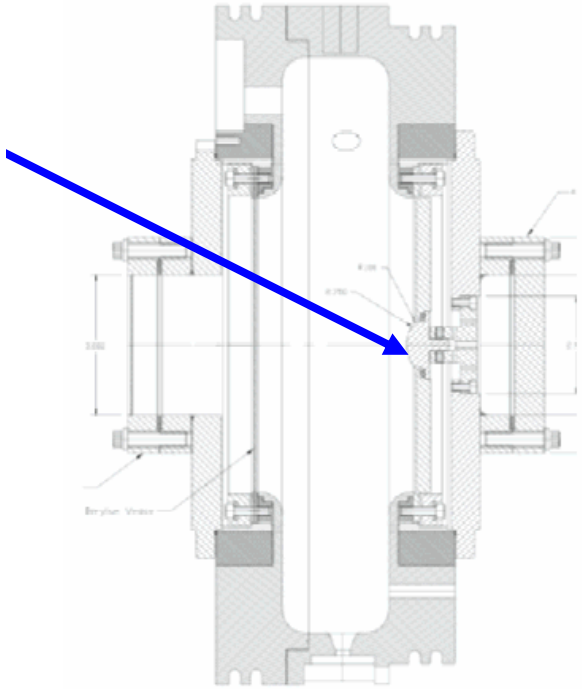


FY04 R&D Accomplishments

- Planned tests using pillbox cavity with replaceable windows, grids, or "buttons"
  - cavity fits in bore of Lab G solenoid
  - tests delayed by abrupt termination of Lab G RF capability in December 2003

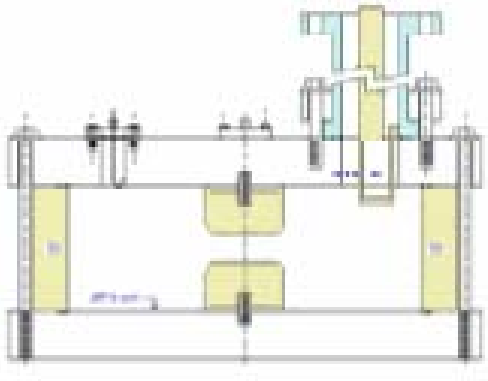
"Button" for materials tests





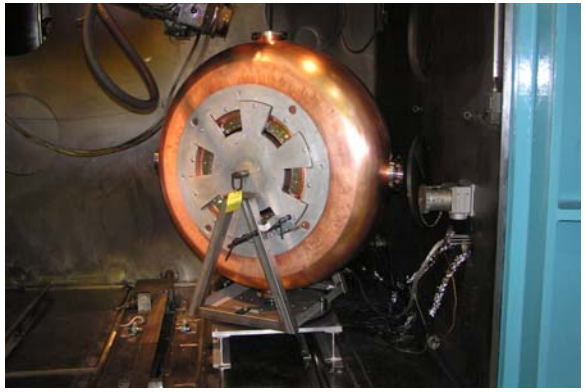
FY04 R&D Accomplishments

- Also plan to test pressurized version of button cavity (Muons, Inc.)
  - use high pressure H_2 gas to limit breakdown
    - this project also put on hold due to demise of Lab G facility



FY04 R&D Accomplishments

- RF test plan has been prepared for both 805 MHz and 201 MHz
  - could not (yet) carry it out due to lack of RF test facility
- 805 MHz program will resume this year (FY05) when MTA is outfitted with RF capability
- Initial tests of 201 MHz cavity will also commence
- 201 MHz rf cavity under construction
  - LBNL, Jlab, and U-Miss collaborating on cavity fabrication
    - fabrication nearly complete (but running late)

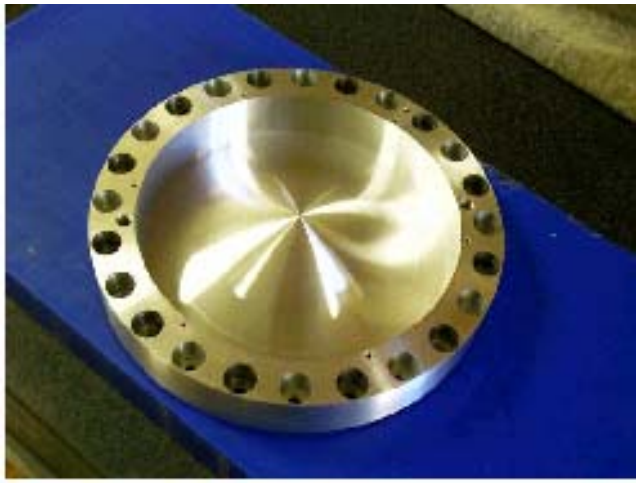


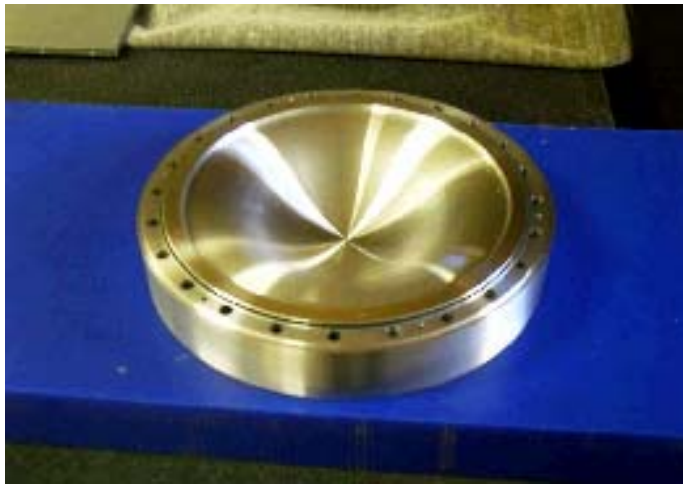
FY04 R&D Accomplishments

- Remaining fabrication steps:
  - clean interior and electropolish
  - attach input coupler
  - attach tuning apparatus
  - attach pump
  - complete low-power tests
- Anticipate delivery to MTA in April *if things go as planned*
- Curved window for 201 MHz cavity being fabricated in industry
  - accidents during fabrication destroyed first two windows
    - another being fabricated now

FY04 R&D Accomplishments

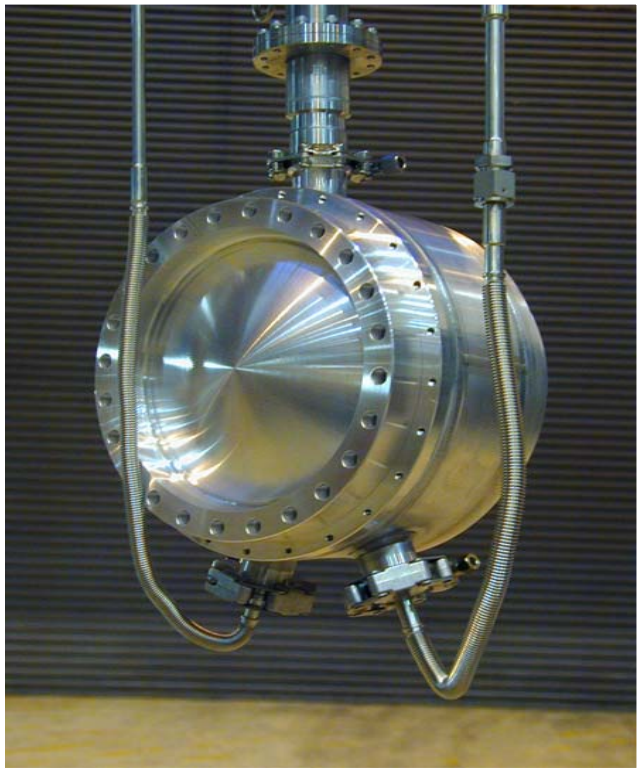
- Absorber group has developed strong, thin windows
  - new stronger (⇒thinner) design built (at U.-Miss.) and tested successfully at Fermilab
    - 125 μm window is 3x stronger than original design
    - burst at 140 psi





FY04 R&D Accomplishments

- Initial absorber LH_2 filling tests carried out at MTA last summer
  - convection-cooled absorber prototype fabricated at KEK

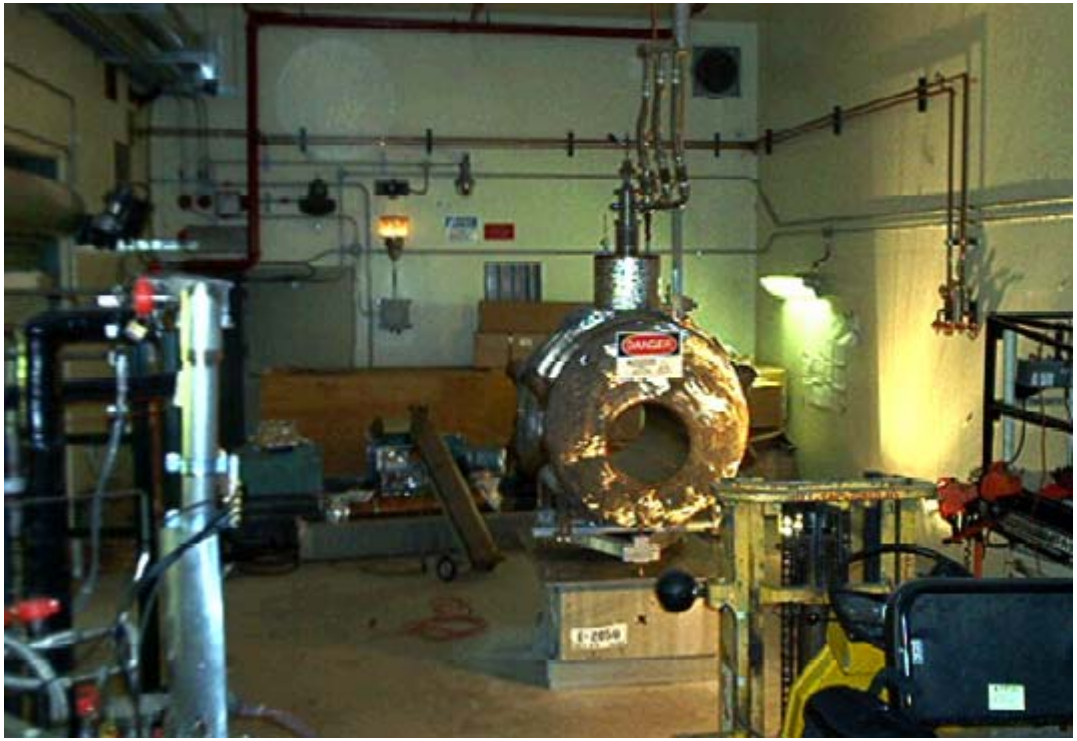


Prototype LH_2 absorber

Test cryostat at MTA

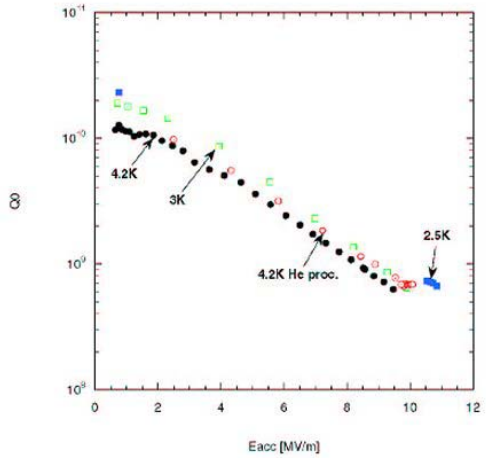
FY04 R&D Accomplishments

- Construction of MUCOOL Test Area at Fermilab completed
  - absorber, solenoid, and 201 MHz rf cavity will be integrated here
    - infrastructure for RF and absorber tests almost completed



FY04 R&D Accomplishments

- Work on 201 MHz scrf cavity for the acceleration system has shifted gears (and lost funding traction as well!)
  - now trying to understand *Q* slope in terms of impurities and Nb coating properties



- Cavity back at CERN for recoating
  - building 500 MHz cavity to study Nb sputtering techniques
    - can study phenomena more cost-effectively with smaller cavity

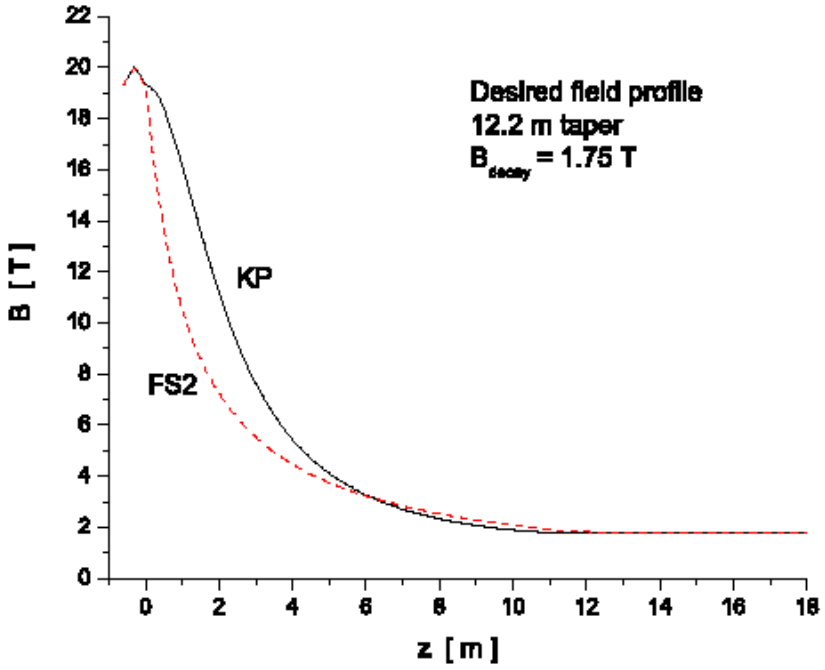
FY04 R&D Accomplishments

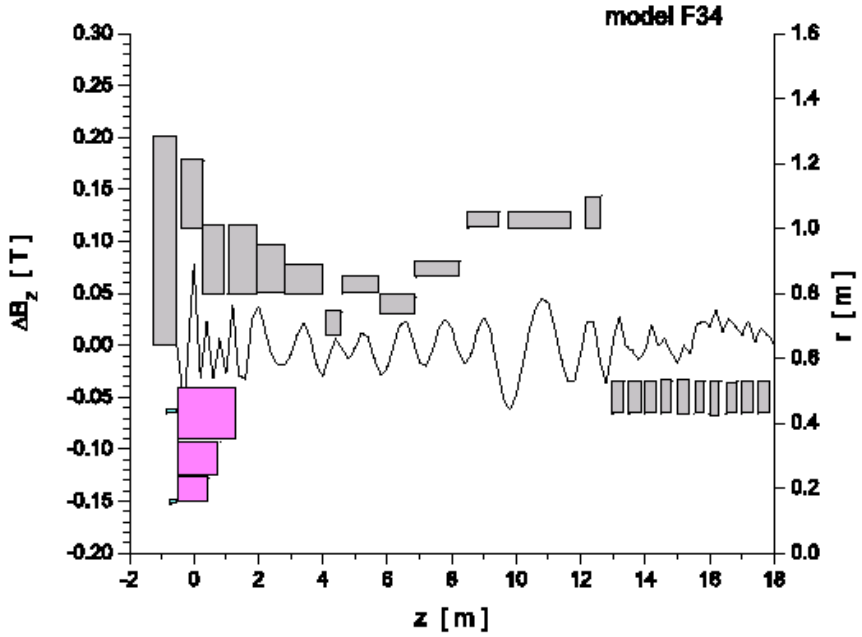
- Simulations
  - main focus was to participate in APS Multi-Divisional Neutrino Study (http://www.aps.org/neutrino/)
  - detailed report written by "Neutrino Factory and Beta Beams Experiments and Development Working Group"
    - http://www.aps.org/neutrino/loader.cfm?url=/commonspot/security/getfile.cfm&PageID=58766
  - considerable progress made in simplifying front-end systems while maintaining performance
    - developed RF bunching and phase rotation scheme
    - simplified cooling channel
    - adopted FFAG scheme for final acceleration stages
      - preceded by linac and dogbone RLA

      ⇒something for everyone!

FY04 R&D Accomplishments

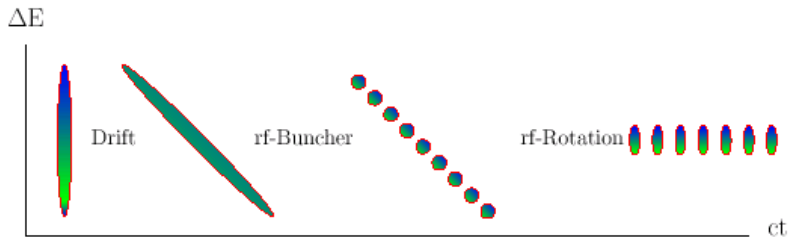
- Reoptimized capture section field profile
  - not much different, but 10% intensity gain
    - field tapers to 1.75 T (vs. 1.25 T in FS2)

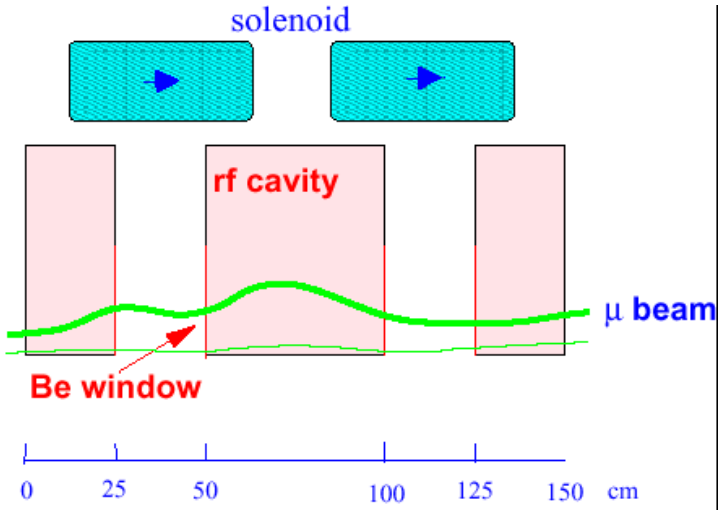




FY04 R&D Accomplishments

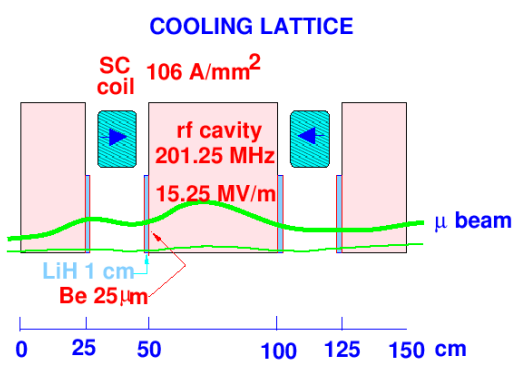
- Use RF to bunch, then to phase rotate
  - performance acceptable and less expensive than induction linacs
    - uses "standard" cooling channel components
    - keeps both μ^+ and μ^-
  - RF frequencies vary along the beam channel

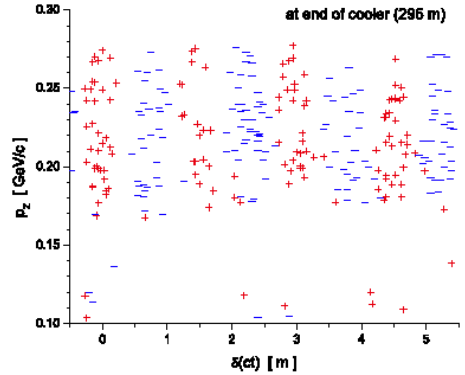


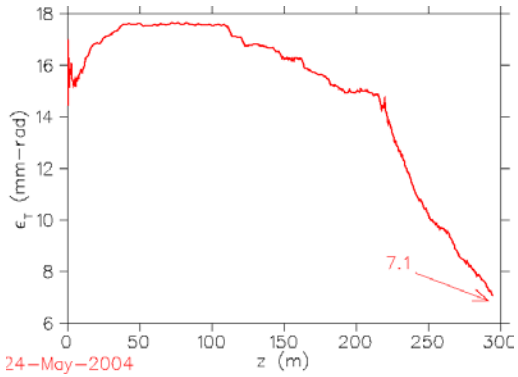


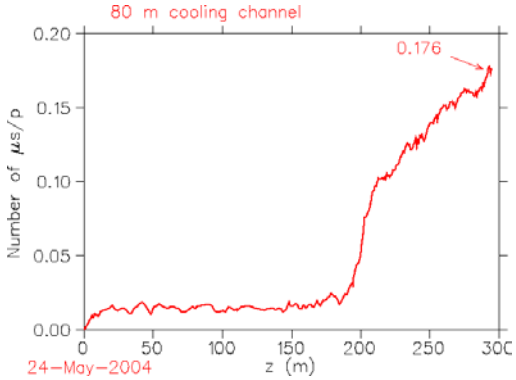
FY04 R&D Accomplishments

- Use simplified cooling channel
  - shorter, fewer magnets and cavities, simpler absorbers (replace LH_2 with LiH)
  - performs acceptably for both μ^+ and μ^- (with larger downstream acceptance)



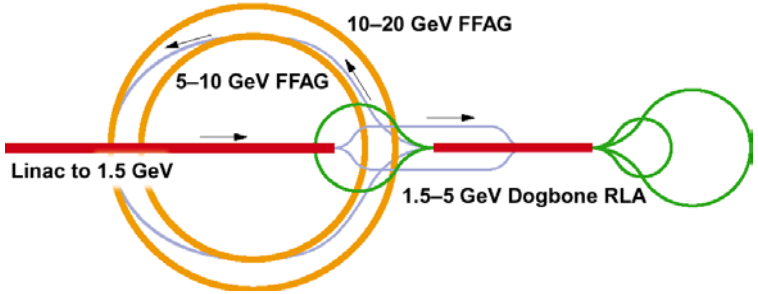


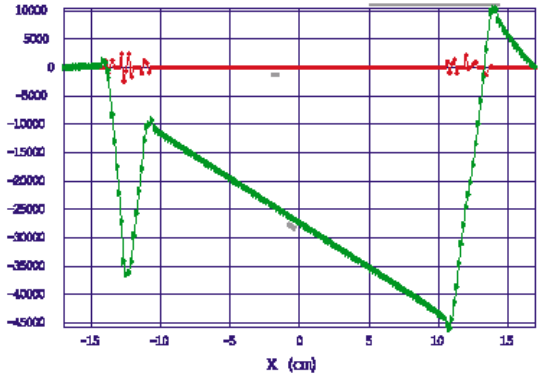


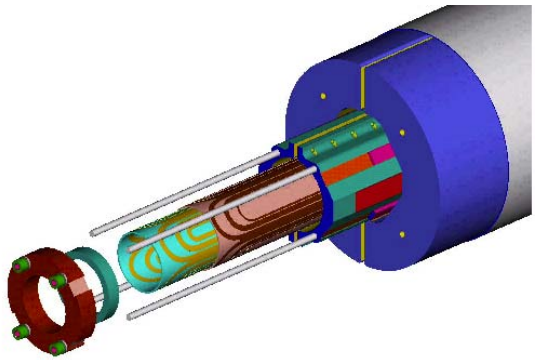


FY04 R&D Accomplishments

- Looked at FFAG scheme for cost-effective acceleration
  - below 5 GeV, linac + RLA scheme looks more cost effective
  - required combined-function dipoles appear feasible and affordable
  - discussion of building an electron model of FFAG continues







FY05 Budget

- Prepared initial budget for FY05 based on guidance of flat budget
  - Tech Board discussed and approved it
- Budgetary "goal" is to maintain university programs while making some progress on key fabrication activities
- More recently, got permission from DOE to earmark $300K to MICE (for 3 years)
- Difficult to maintain a reasonable reserve due to the low funding

FY05 Budget

- **FY05 MC budget (only DOE-MC funds)†**

Institution	COOLING /MICE	TARGETRY	ACCEL./ COLLIDER	EFFORT[a]	RESERVE	TOTAL ($K)
BNL		578				578
FNAL	187					187
LBNL[b]	365				50	415
ANL				150		150
IIT				115		115
Mississippi	20			15		35
Princeton		40				40
UCB				5		5
UCLA	25		50			75
UC-Riverside						0
ORNL		85				85
Jlab	5		10			15
TOTAL ($K)	**602**	**703**	**60**	**285**	**50**	**1700**

[a]Includes beam simulation and diagnostics effort.
[b]Includes MICE funding of $300K.

†Also: salary support from BNL, FNAL, LBNL; support from NSF of $1M (uncommitted from last year)

FY05 Budget

- **Supplemental request submitted to DOE in September 2004 (priority order)**
  - **priorities decided in discussions between Spokespersons and PM**
    - **no response from DOE yet (and I'm not optimistic)**

Item	Request ($K)
1) Targetry magnet cryogenics system	525
2) Coupling coil design and construction	400
3) Tests of RF surface techniques	100
TOTAL	1025

FY05 Plans

- Targetry
  - complete fabrication of 15 T magnet and acquire power supply
- Cooling
  - test 201 MHz high-gradient cavity (17 MV/m)
  - test 805 MHz cavity with curved window, grid, and "buttons"
- Acceleration
  - study *Q* disease and develop mitigation techniques
  - continue design work on FFAG-based systems
- Simulations
  - continue developing cost-optimized front-end for Neutrino Factory
  - develop realistic and detailed Muon Collider scenario

FY05 Plans

- MICE
  - develop plan for Phase 1 fabrication
  - continue to seek funding
- Management*
  - develop 5-year R&D plan for MCOG and MUTAC

*Yes, even we must work sometimes!

Longer-term plans

- Decrease in available funding and launching of MICE pose challenges for the MC
  - MCOG has asked us (Geer, Palmer, MZ) to prepare a 5-year R&D plan and indicate the corresponding funding needs
    - realistic plan should assume "flat-flat" funding
    - optimistic plan could perhaps double our directly funded program
- MCOG wants evidence that we have a plan and that we have (roughly) the wherewithal to follow it
- I have prepared a strawman budget for the realistic case
  - activities lumped into four broad categories
    - Cooling: MUCOOL component R&D
    - Targetry: development of high power targets and collection systems, including beam tests at BNL, CERN, or elsewhere
    - System Studies: work on acceleration, ring coolers, colliders, performance studies
    - MICE: purchase or fabrication of MICE components

Longer-term plans

- **Summary is**

Activity	FY05	FY06	FY07	FY08	FY09	FY10
Cooling	492	555	555	605	605	605
Targetry	713	650	650	400	400	400
System Studies	195	195	195	195	195	195
MICE	300	300	300	500	500	500
TOTAL	1700	1700	1700	1700	1700	1700

  - **comments:**
    - **assumes base program funds remain as now: BNL ($1.0M); Fermilab ($0.6M); LBNL ($0.3M)**
    - **assumes we can maintain "extra" $300K per year for MICE**
    - **priority in FY05–07 is CERN targetry experiment**
    - **allocation of MICE funding depends on what happens with NSF MRI proposal**
    - **split between Cooling and MICE somewhat arbitrary (⇒ flexible)**
    - **must assess realistic Targetry and MUCOOL "out year" needs**

Summary and Outlook

- Past year productive but more difficult than usual for the MC
  - fabrication of Targetry test magnet progressing, but a bit late
  - 201 MHz NCRF cavity fabrication making progress, but late
  - cost-effective Neutrino Factory design developed ("Study IIa")
  - improved absorber window design tested, and first absorber filled with LH_2 (slowed by ICAR demise)
  - SCRF cavity R&D direction changed to "get back to basics"
  - Muons, Inc. gas-filled cavity tests encouraging, but stalled
- MICE gaining momentum
  - PPARC approval for Phase 1 likely soon (£9.7M); some U.S. funding in place (DOE: $900K over 3 yrs; NSF: $300K over 3 yrs)
- Strong MUTAC and MCOG endorsements of R&D accomplishments and plans have so far only kept us "flat-flat"
  - *MC must continue to hold up its end of the bargain!*