Report of Project Manager

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Muon Collaboration Project Manager

Muon Collaboration Meeting–Riverside
January 31, 2004

Outline

- Introduction
- FY03 accounting
- FY03 R&D accomplishments
- FY04 budget
- FY04 plans
- Summary and outlook

Introduction

- In FY03, the MC budget was halved
  - $2.809M→$1.429M

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	2.1	1.4	3.5

- We had expected better news in FY04
  - restoration to FY02 level was anticipated
    - no such luck!
- By juggling projects across fiscal year boundaries and careful prioritization, we have continued to make progress
  - this was recognized by MUTAC and MCOG last year

Introduction

- **Comments from January '03 MUTAC report**

"The committee notes with pleasure the enthusiasm evident at the MUTAC Review, and the refreshing ideas and progress made over the past year. This is particularly noteworthy since this progress has been made in the face of very difficult funding conditions."

"An additional ~$1M would make a considerable difference to the time scale on which a 200 MHz cavity could reach the testing stage."

"Overall, MUTAC was impressed by the accomplishments since the last meeting, particularly given the strained financial situation. MUTAC can enthusiastically assure MCOG that the limited funding is being well and carefully utilized. Present funding is substantially below the ~$8M level endorsed by the HEPAP Report. Additional funding would certainly be helpful in the implementation of the 200 MHz warm rf tests. However, the committee cannot make rational recommendations for increments at a time of total HEP funding limitations without knowing the impact on other HEP programs. We do however note that the Muon Collaboration is a fine example of laboratory–university collaboration on accelerator R&D. It also illustrates the need for increased accelerator R&D funding across the fields of HEP, NP, and BES."

Introduction

- **MCOG comments**

MCOG is concerned by the continuation of severe budget cuts in each of the last three years. These cuts in the level of support accorded to the muon R&D work of the Collaboration have severely impeded progress, especially in the attempts to advance the experimental work of Muon Cooling and High-Power Target R&D. Of particular concern is the projected level of support for FY 2003 and FY 2004, both in the explicit R&D funding directed to the Collaboration, and in the base program support provided by the supporting laboratories. MCOG has concluded that it is imperative that DOE seek to provide enhanced R&D funding for this work if it is to meet either the intent or the recommendations of the Long Range Plan laid out in the 2002 Gilman Report of HEPAP.

Introduction

- Hardware development continues as major focus of FY04 activity
- Simulation effort aimed at ring coolers made good progress last year
  - where is this effort going?
    - Neutrino Factory or Muon Collider?
- Effort toward MICE proposal is coming to fruition
  - now have scientific approval from RAL
    - but still no real funding
- MICE is already draining resources from MC programs
  - an investment in our future, but still hard to accommodate
- Here I will cover:
  - FY03 accounting and R&D accomplishments
  - FY04 budget and plans

FY03 Accounting

- FY03 budget finalized by Spokespersons and PM in November
- FY03 budget was tight ($1.429M → $1.403M)
- Supplemental funding request submitted in May, 2002
  - and subsequently ignored
- Simulations and Theory group was reconstituted by Spokespersons in FY03
  - led by R. Raja, with lieutenants for various subgroups
  - now led by R. Fernow
- Another "initiative" requiring resources: International Muon Ionization Cooling Experiment
  - presently requires mostly "effort" (base program funds)

FY03 Accounting

- **FY03 MC budget (approved by MCOG):**

Institution	COOLING	TARGETRY	COLLIDER	EFFORT[a]	RESERVE[b]	TOTAL ($K)
BNL		300				300
FNAL	400					400
LBNL	204				26[c]	320
ANL				144		144
IIT				75		75
Mississippi				50		50
Princeton		50				50
UCB			5			5
UCLA	25		50			75
UCR			90			
ORNL						0
JLab				10		10
TOTAL ($K)	**629**	**350**	**145**	**279**	**26**	**1429**

[a] Includes beam simulation and diagnostics effort.
[b] Modest project reserve used to account for uncertainties in R&D activity costs.
[c] Eventually lost due to "recision" by DOE late in the year.

- **Also: salary support from BNL, FNAL, LBNL; support from NSF (mainly Cornell) of ≈$1M; and support from ICAR (≈12 FTE)**

FY03 Accounting

- **Supplemental request submitted to DOE in May, 2002 (priority order)**
  - **priorities decided in discussions at Columbia**
    - **no response from DOE**

Item	Request ($K)
0) AGS operation	50
1) 201 MHz RF cavity fabrication	350
2) Targetry magnet fabrication	400
3) Cooling simulation effort	200
4) 805 MHz RF cavity R&D	100
5) LH_2 absorber fabrication	100
6) Target studies	50
7) Solenoid coil design	150
8) Target simulations	50
TOTAL	1450

FY03 Accounting

- Main goals for FY03
  - engineer target 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)
  - begin fabrication of 201-MHz NCRF cavity
  - submit technical proposal for MICE
  - continue exploring and optimizing cooling ring performance
- Aspirations modest this year due to severe budget shortfall

FY03 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 pillbox cavity tests with copper windows	Dec-02	Inspection
Install Be windows in pillbox cavity and begin testing	Dec-02	Inspection
Complete initial analysis of pillbox cavity results with copper windows	Jan-03	Presentation
Report surface analysis of copper windows	Apr-03	MC note prepared
Complete first tests of Be windows in pillbox cavity	Apr-03	Inspection
Complete report on analysis of RF tests	Apr-03	MC note prepared
Complete design of 805 MHz grid structure	Jun-03	MC note prepared
Sign contract for MUCOOL Test Area Phase-II construction	Dec-02	Signed contract
Begin MTA site mobilization	Jan-03	Inspection
Beneficial occupancy of MTA	Dec-03	Inspection
Organize emittance exchange workshop	Nov-02	Workshop
Implement ring cooler with realistic fields in GEANT	May-03	Presentation
Match RF phase rotation channel to cooling channel	May-03	Presentation

ANL [Norem]

Milestone	Date	Deliverable
Study conditioning and dark currents with Be RF windows	May-03	MC report prepared
Continue optimization of dark currents and x-rays for MICE and MUCOOL	Sep-03	MC report prepared
Organize workshop on surface effects and breakdown in RF cavities	Apr-03	Inspection
Preliminary evaluation of RF breakdown mechanisms	May-03	PAC03 paper prepared
Complete experimental setup to study RF breakdown effects	Sep-03	Inspection
Perform (with IIT and NIU) experiment on e-beam generated turbulence in water with schlieren system	Jun-03	MC report prepared

FY03 Accounting

- **Summary of FY03 spending is shown below**

Institution	Collaboration		Base Program	Overall	Contact
	Committed ($K)	Uncommitted ($K)	Committed ($K)	Total ($K)	
ANL	144	0	144	288	J. Norem
BNL	164	316	1054	1218	H. Kirk
FNAL [1]	1205	155	700	1905	S. Geer
LBNL [2]	248	376	282	531	M. Zisman
Princeton U.	50	0	195	245	K. McDonald
UC-Berkeley	30	16	23	53	J. Wurtele
UCLA	75	0	71	146	D. Cline
Mississippi	50	12	17	67	D. Summers
IIT	75	0	0	75	D. Kaplan
Jlab	10	0	0	10	A. Bogacz
Cornell + NSF Contracts [3]	*1049*	*1886*	*0*	*1049*	*D. Hartill*
TOTALS [4]	**2052**	**876**	**2487**	**4538**	
	3100	*2762*		*5587*	

NOTES:

[1] Includes $380K of GPP funds from FY01 and
$580K of GPP funds from FY02 committed in FY03.

[2] Includes $174K in uncommitted Project Reserve funds maintained by LBNL.

[3] Includes carryover from previous years.

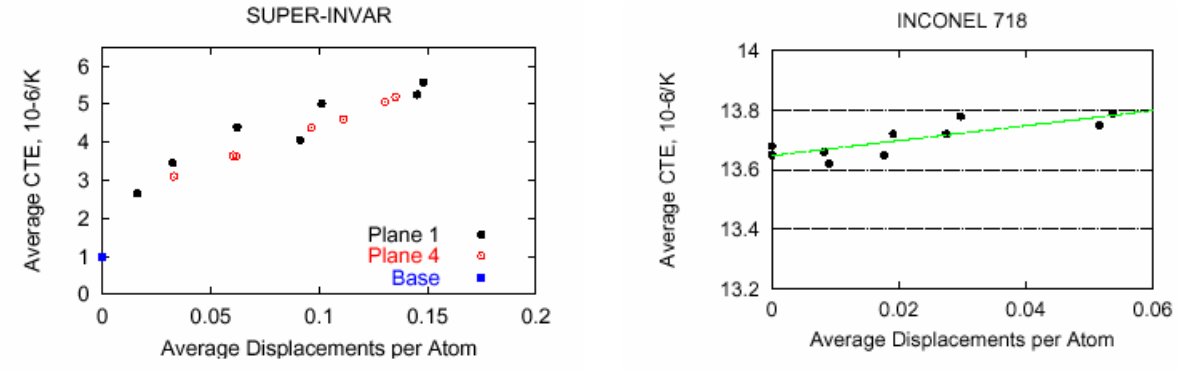
[4] DOE totals in Roman type; *additional NSF funding shown in italics*.

FY03 R&D Accomplishments

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

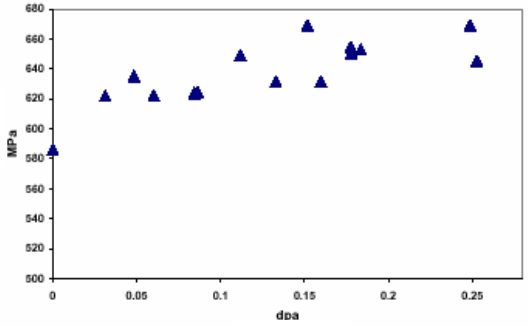
FY03 R&D Accomplishments

- Radiation testing of candidate solid-target materials (Super-Invar and Inconel) carried out at BNL with 200 MeV p beam
  - looked at both CTE and tensile strength changes
    - big changes in Super-Invar CTE with dose, less with Inconel



    - yield strength increases but material gets more brittle

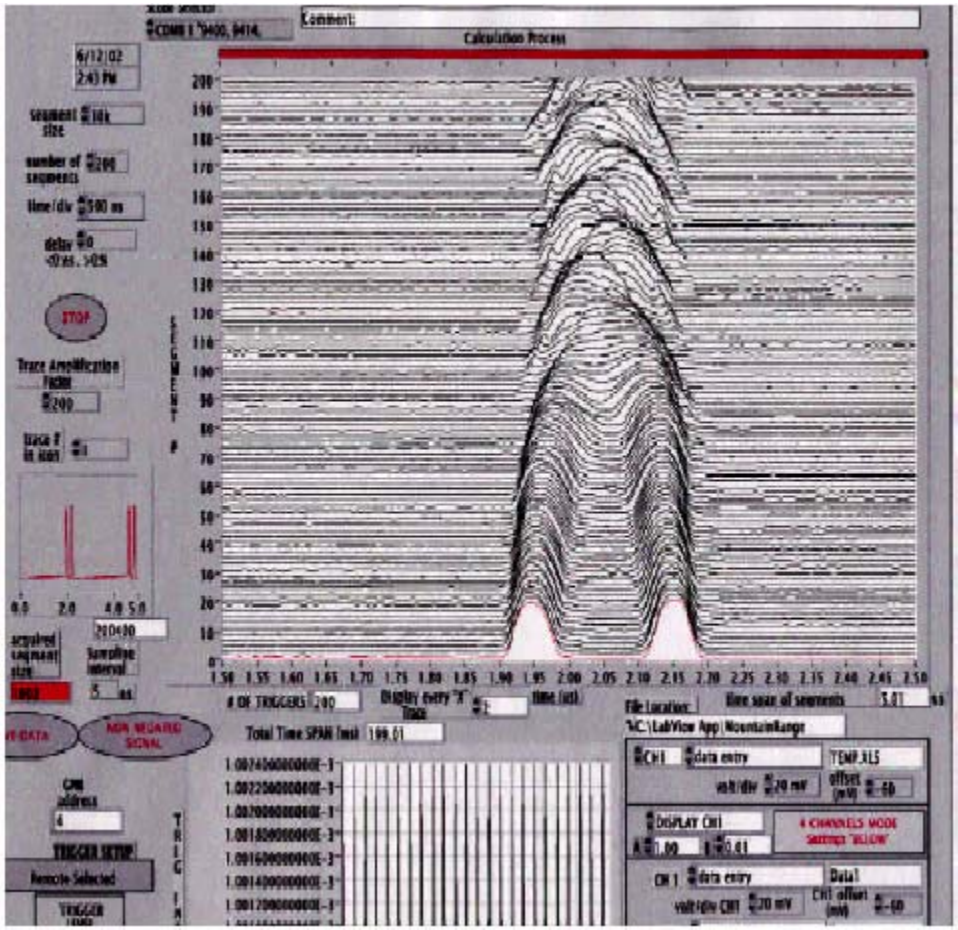
Yield (MPa)



dpa

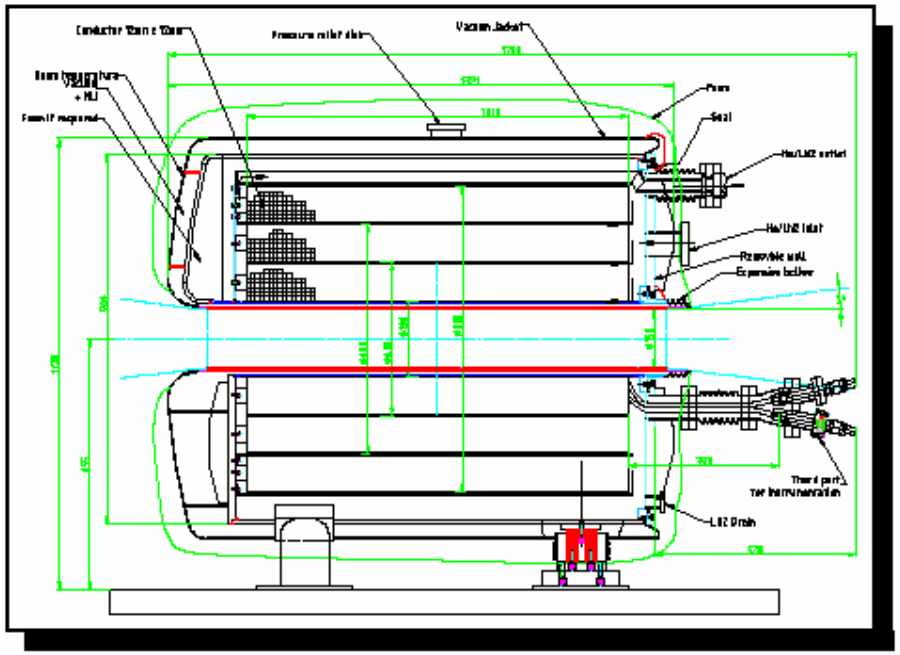
FY03 R&D Accomplishments

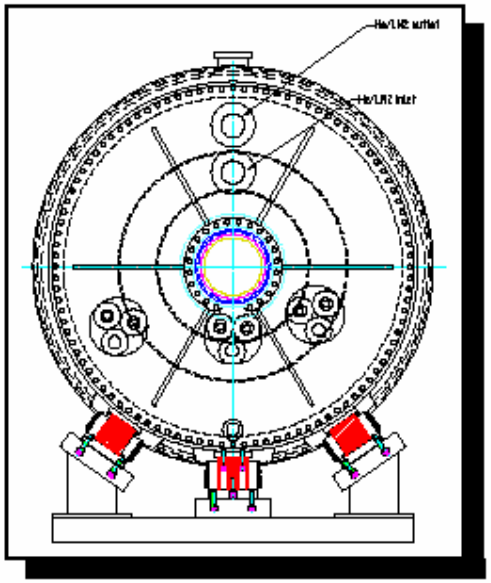
- Bunch merging (h = 12 → h = 6) at AGS gave extracted proton bunch of 10 Tp (desire 16 Tp)
  - technique needs development, but is clearly workable



FY03 R&D Accomplishments

- **Contract awarded for 5–15 T magnet fabrication (for E951 at BNL ?)**





Stage	Field (T)	Power (MW)	Coolant	Temperature (K)
1	5	0.6	N_2	84
2	10	2.2	N_2	74
3	15	2.2	H_2	30
3a	15	4.5	N_2	70

FY03 R&D Accomplishments

- looking seriously into using battery power (suggested originally by Summers)

Battery and charger (12 V, 1400 A)

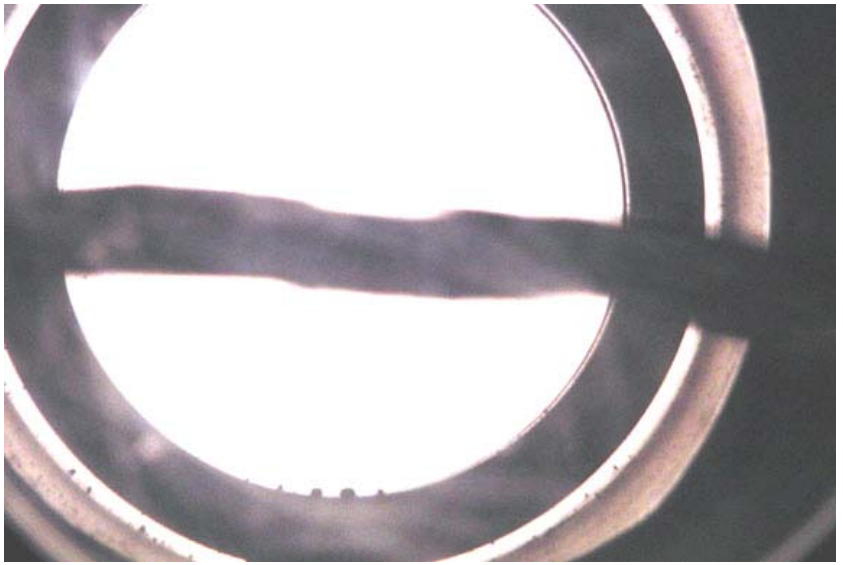
Mechanical switch for 4.4 MW

- if power supply fails, we call AAA!

FY03 R&D Accomplishments

- Developed a 2.5 m/s continuous Hg jet system for E951 at Princeton
  - never used with beam due to elimination of AGS HEP running
  - Wood's metal (heated) version was started but put on hold for now

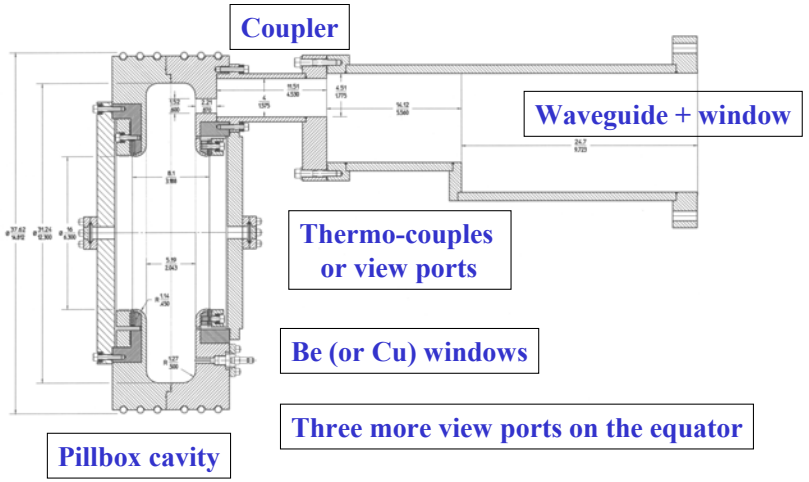
Test apparatus

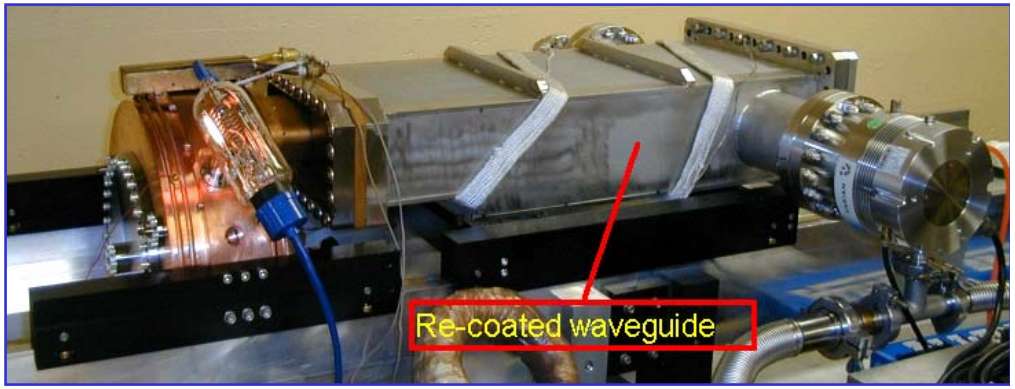


Mercury jet…on a good day

FY03 R&D Accomplishments

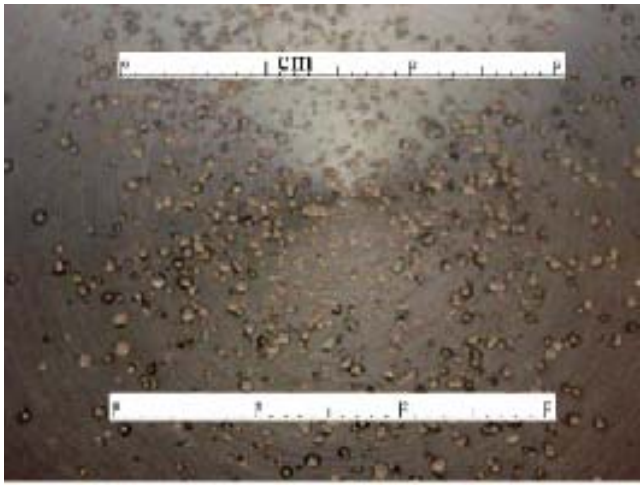
- Present tests use pillbox cavity with replaceable windows (or grids) (Li)
  - cavity fits in bore of Lab G solenoid





FY03 R&D Accomplishments

- Pillbox cavity reached 40 MV/m in Lab G with no solenoid field
  - with solenoid performance worse (18 MV/m), radiation levels higher
    - field seemingly enhances likelihood of physical damage
      - but, some evidence for healing by reprocessing without field
- Cavity disassembled in December to inspect windows, internal surfaces
  - pitting of window seen, with copper "dust" at bottom of cavity

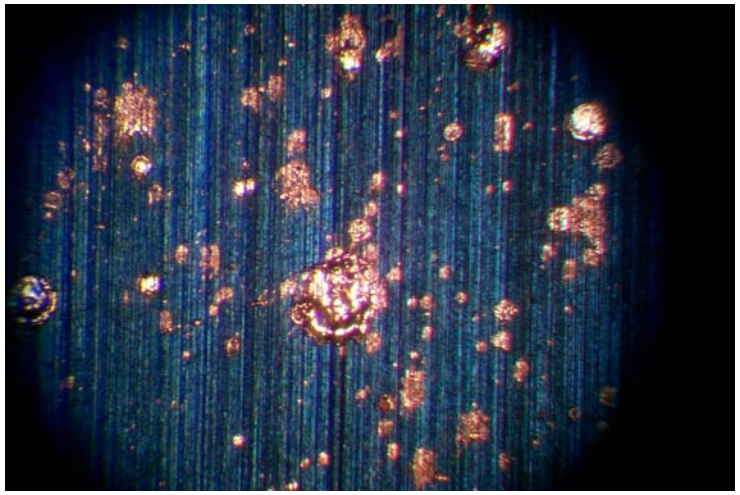


Copper window after using solenoid

FY03 R&D Accomplishments

- TiN-coated Be windows were next installed and tested
  - no conditioning problems seen without magnetic field

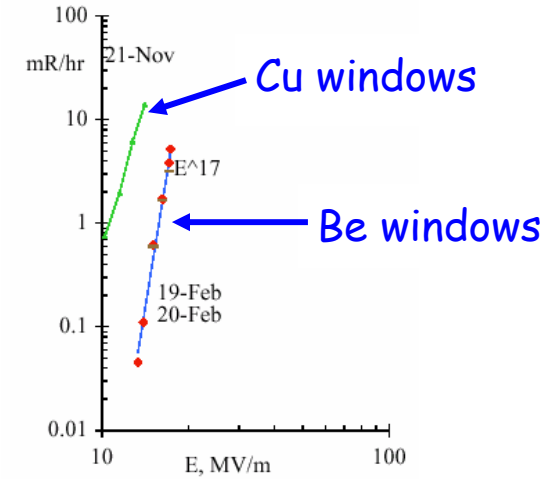
    ⇒parallel plate geometry does not cause big problems
- Found no damage to Be surface, but sputtered Cu is present
  - suggests need to focus more on copper body than on windows
- We will explore coatings that may help



Be windows with sputtered copper

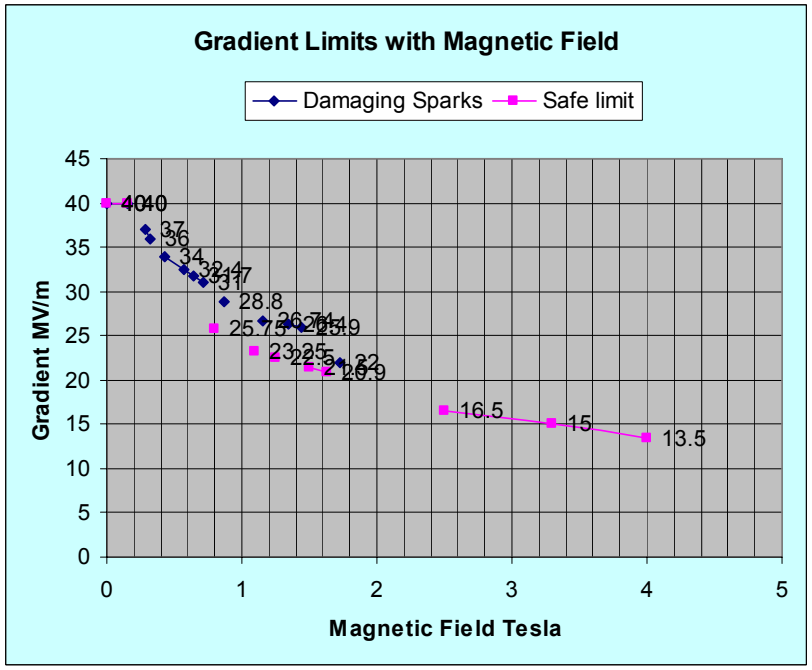
FY03 R&D Accomplishments

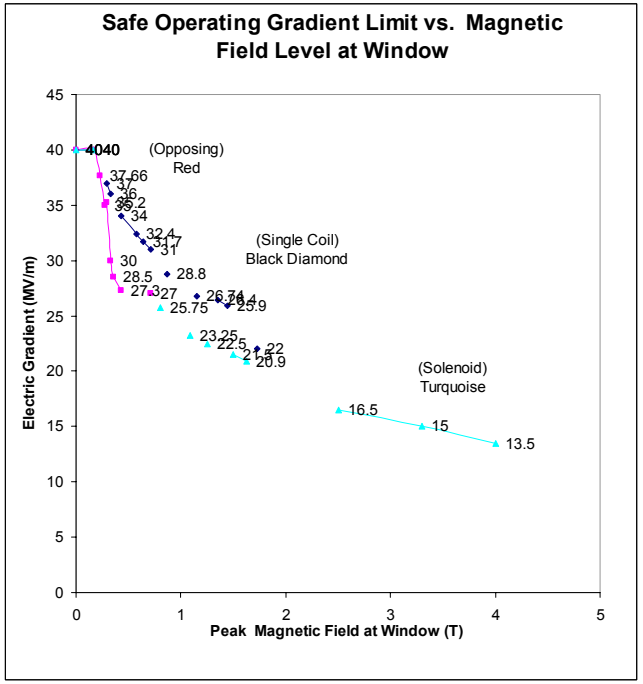
- Even with magnetic field present, background rates for Be are lower than for Cu under comparable conditions



FY03 R&D Accomplishments

- With magnetic field, maximum gradient lower, dark currents higher

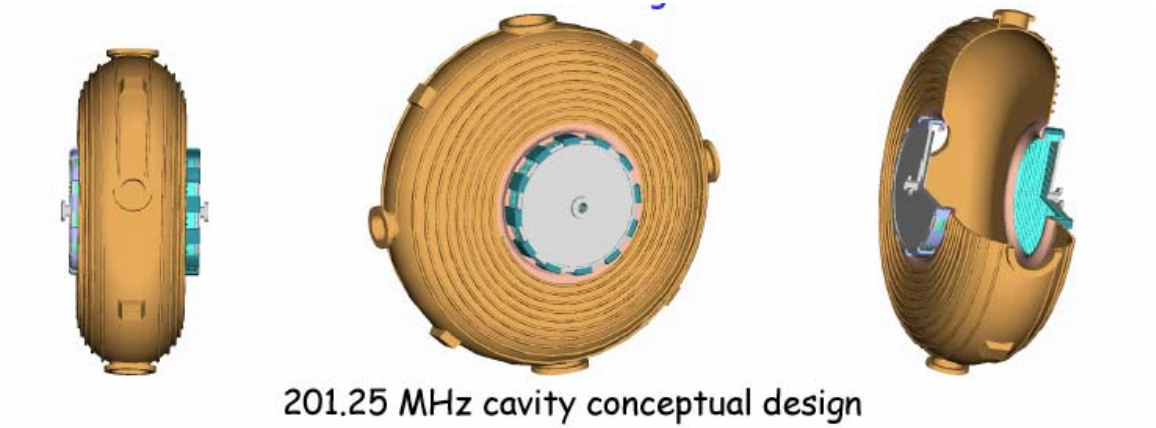




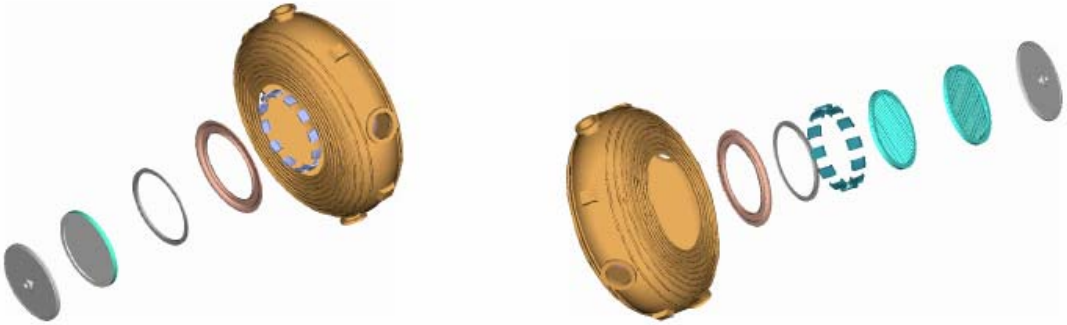
- Workshop on high-gradient rf limitations was held at ANL, October 7-9, 2003
  - URL: http://www.mice.iit.edu/rfworkshop/

FY03 R&D Accomplishments

- 201 MHz rf cavity under construction (Li, Virostek, Rimmer)



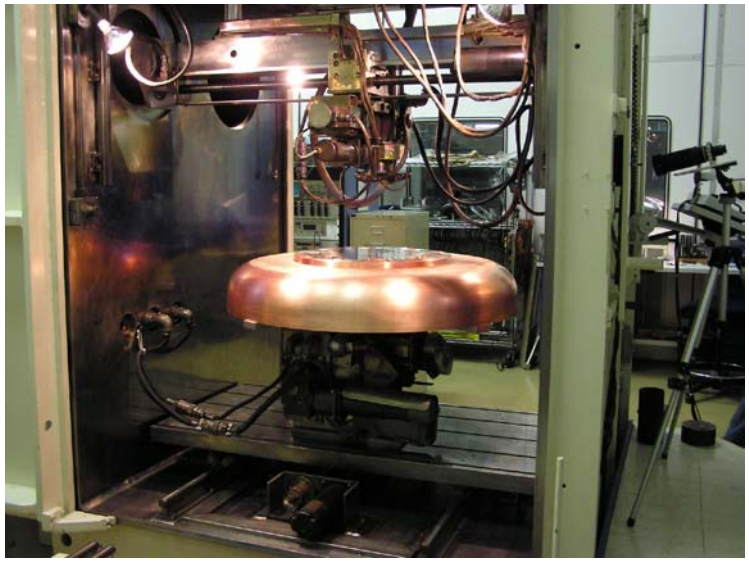
201.25 MHz cavity conceptual design



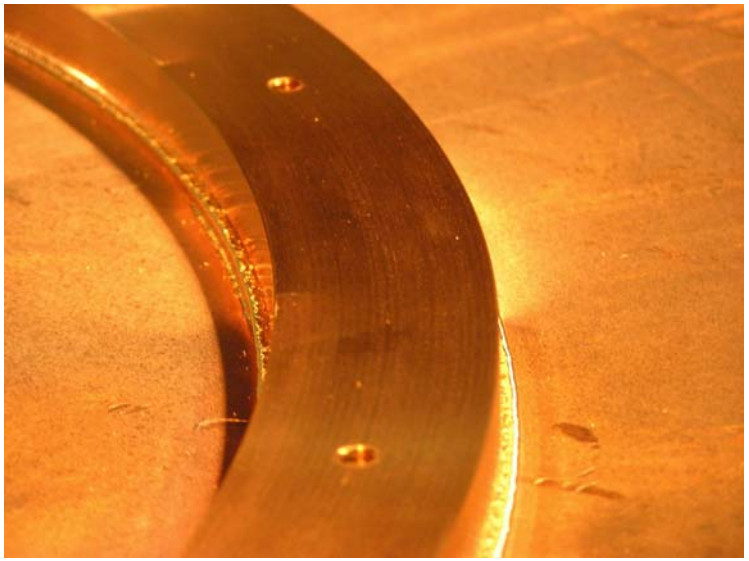
Exploded views showing foil and grid mounting hardware

FY03 R&D Accomplishments

- fabrication began this year; completion in about 1 year
  - Jlab and U-Miss collaborating on cavity fabrication



Setup for welding stiffener ring



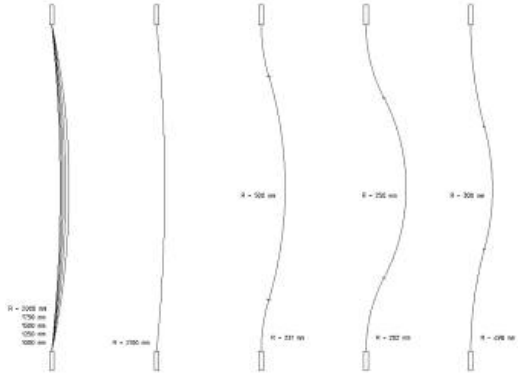
After e-beam weld to half-shell

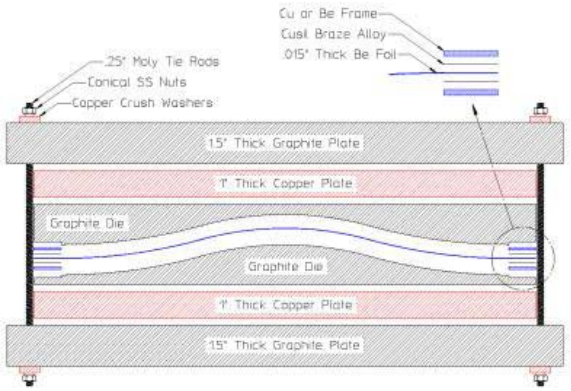
FY03 R&D Accomplishments

- Next step: mechanically polish cavity surfaces prior to equatorial weld
  - this step is under way

FY03 R&D Accomplishments

- Ideal cavity termination would be perfectly conducting and transparent to muon beam, and would not affect cavity frequency
  - initial concept was to use prestressed flat Be foils
    - even at 805 MHz, difficult to maintain flatness when window is heated by rf
    - frame must be very thick, making windows costly
  - new concept (Virostek, Lau, Li) uses pre-curved windows that bow predictably
    - with proper design, stresses remain quite low as the foil heats





FY03 R&D Accomplishments

- Formed required shape for 805 MHz with stainless steel foil at LBNL
  - but failed with Be foil (cracked)

Stainless steel window

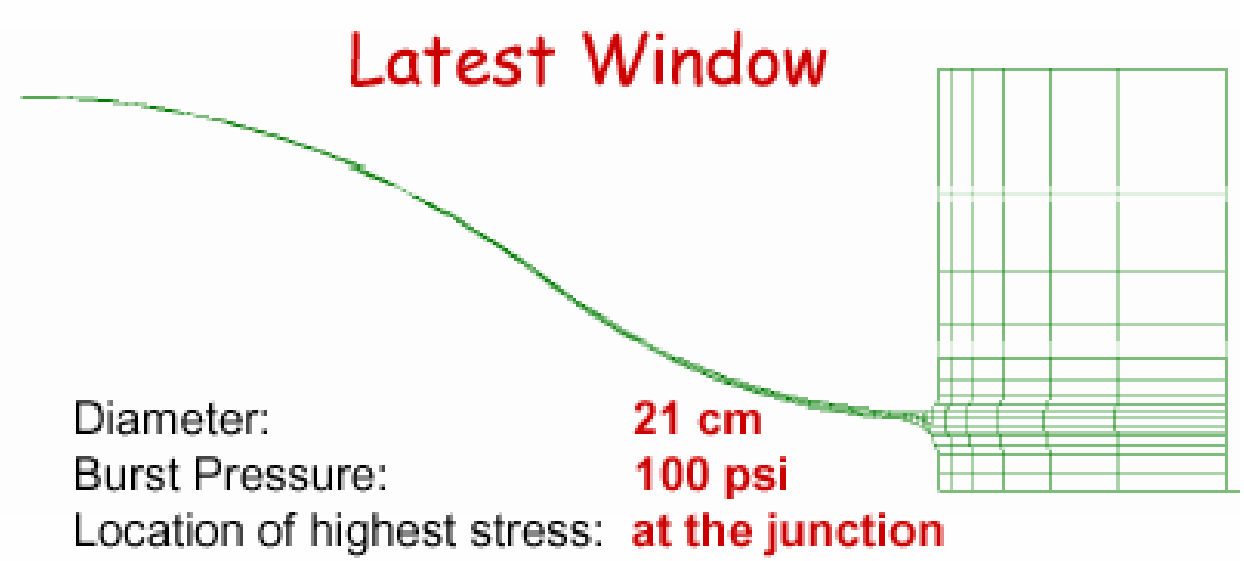
Be window

FY03 R&D Accomplishments

- **Ordered shaped Be foils from Brush-Wellman**
  - they are confident they can make them
  - delivery due in early February
- Test these at 805 MHz before ordering the 201 MHz Be version
  - may build some stainless steel or copper versions of curved 201 MHz windows in-house
    - these are backup or comparison cases for the desired Be windows

FY03 R&D Accomplishments

- Absorber group has developed strong, thin windows (Cummings, Kaplan)
  - windows as thin as 125 μm machined from solid Al (Summers)
  - new stronger (⇒thinner) design (Lau) to be built and tested next



  - none built last year but fabrication is under way now
    - we again need to destruction test them to certify design

FY03 R&D Accomplishments

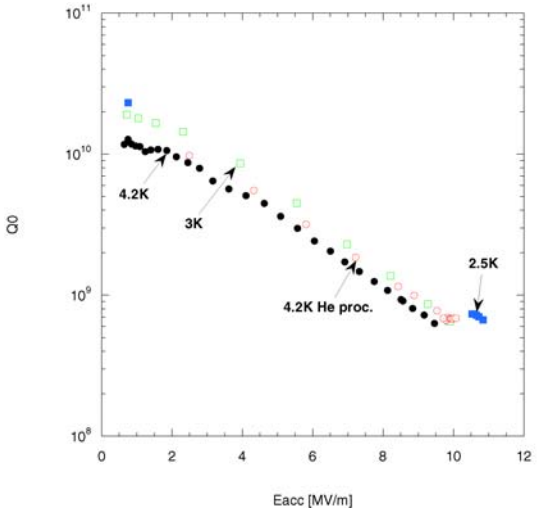
- To test hardware, built MUCOOL Test Area at Fermilab (Popovic)
  - absorber, solenoid, and 201 MHz rf cavity will be integrated here
    - is observed tilt to the right for political reasons??

Completed MTA (as seen by Project Manager)

Completed MTA (as seen by Lab Director)

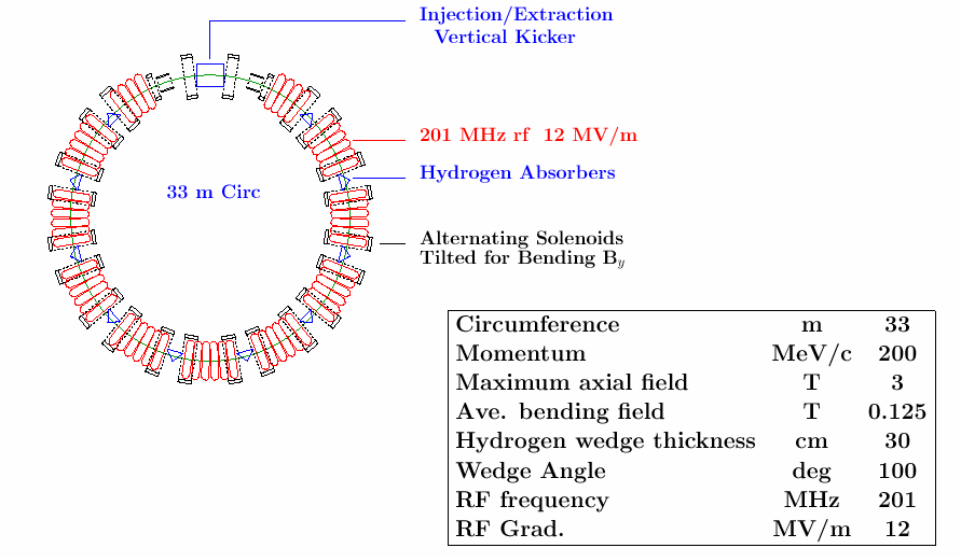
FY03 R&D Accomplishments

- Work on 201 MHz scrf cavity for the acceleration system made good progress (Hartill, Padamsee; NSF)
  - focusing on achieving gradient, Q, mechanical stability
    - reached 11 MV/m after re-cleaning cavity
    - low-power $Q_0 = 2 \times 10^{10}$ (at 2.5 K)
  - now trying to understand Q slope in terms of impurities and Nb coating properties

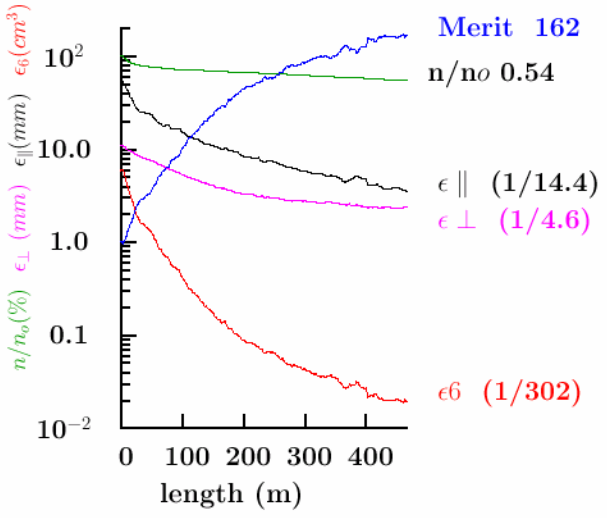


FY03 R&D Accomplishments

- **Simulations**
  - **main focus on emittance exchange**
  - **ring coolers (Balbekov, Palmer) important due to potentially significant cost reduction (Neutrino Factory and/or Collider)**
    - **6D cooling looks promising; injection is an issue**



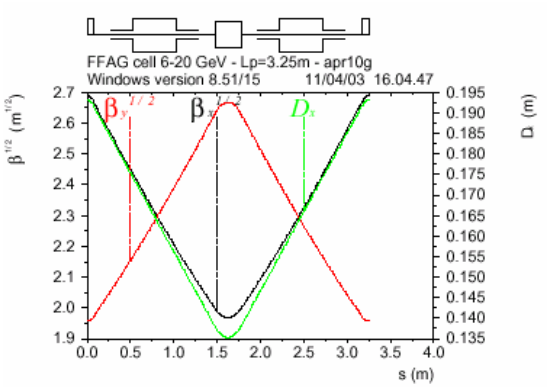
Circumference	m	33
Momentum	MeV/c	200
Maximum axial field	T	3
Ave. bending field	T	0.125
Hydrogen wedge thickness	cm	30
Wedge Angle	deg	100
RF frequency	MHz	201
RF Grad.	MV/m	12

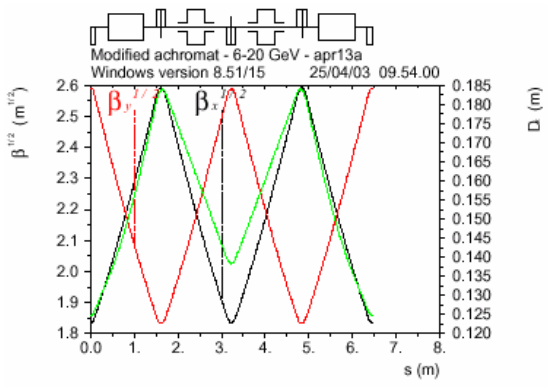


- **dipole rings also being explored; some configurations look promising**

FY03 R&D Accomplishments

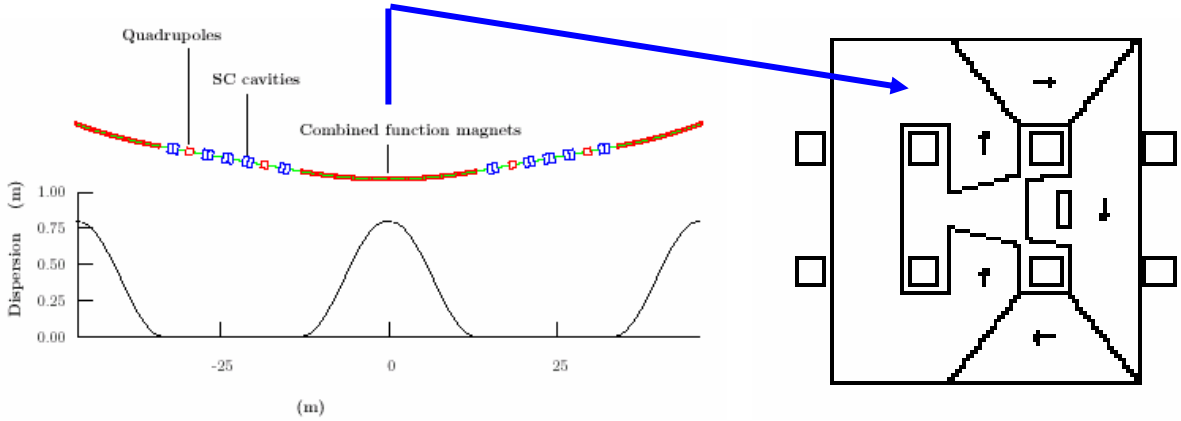
- Looking at alternative acceleration schemes
  - RLA with FFAG arcs (Berg, Johnstone, Keil, Sessler, Trbojevic)





  - very rapid cycling booster (Summers)

Grain-oriented Si steel



FY03 R&D Accomplishments

- discussion of building an electron model of FFAG has started
  - would need to identify funding and host institution (U.S.-Japan?; NSF?, TRIUMF?)
  - hard to see how to pry this out of existing budgets

FY04 Budget

- Prepared initial budget for FY04 based on present budget guidance
  - Tech Board met three times to discuss it
  - original guidance was (sadly) accurate
- Given so many uncertainties, we have chosen to maintain a reasonable reserve despite the low funding
  - money for this was available due to the failure to hire a simulations post-doc last year
- A small amount of funding will be transferred to BNL for offsetting travel expenses of consultants
  - this allows Kathy Tuohy to off-load some of the administrative work from me
- Tech Board has now finalized budget
- Budgetary goal is to maintain university programs while making some progress on key fabrication activities

FY04 Budget

- **FY04 MC budget (only DOE-MC funds)†**

Institution	COOLING	TARGETRY	ACCEL./ COLLIDER	EFFORT[a]	RESERVE	TOTAL ($K)
BNL		275	10			285
FNAL	400					400
LBNL	100				104	204
ANL				144		144
IIT				77		77
Mississippi	50					50
Princeton		50				50
UCB	5					5
UCLA	25		50			75
UC-Riverside						0
ORNL						0
Jlab	110					110
TOTAL ($K)	**690**	**325**	**60**	**221**	**104**	**1400**

[a]Includes beam simulation and diagnostics effort.

†Also: salary support from BNL, FNAL, LBNL; support from NSF (mainly Cornell) of $1M; and support from ICAR (≈12 FTE)

FY04 Budget

- **Supplemental request submitted to DOE in September, 2003 (priority order)**
  - **priorities decided in discussions between Spokespersons and PM**
    - **no response from DOE yet**

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 Plans

- Targetry
  - complete fabrication of 15 T magnet and begin power supply
- Cooling
  - complete fabrication of 201 MHz high-gradient cavity (17 MV/m)
  - test convection-cooled LH_2 absorber with all safety aspects
- Acceleration
  - continue effort to increase 201 MHz SCRF cavity gradient
  - continue design work on FFAG-based systems
- Simulations
  - develop cost-optimized front-end for APS Study
- MICE
  - continue to seek funding

Summary and Outlook

- The past year was productive for the MC
  - fabrication of Targetry test magnet started
  - NCRF cavity tests made progress (at 805 MHz)
  - 201 MHz NCRF cavity fabrication launched
  - approaches to study cooling rings developed
  - improved absorber window design developed
  - SCRF cavity testing reached 11 MV/m
- MICE gaining momentum
  - scientific approval from RAL; U.S. funding proposal under review
- Strong MUTAC and MCOG endorsements of R&D accomplishments and plans will hopefully help our budget eventually
  - *the MC is certainly continuing to hold up its end of the bargain!*