

# MICE-U.S. Progress Report

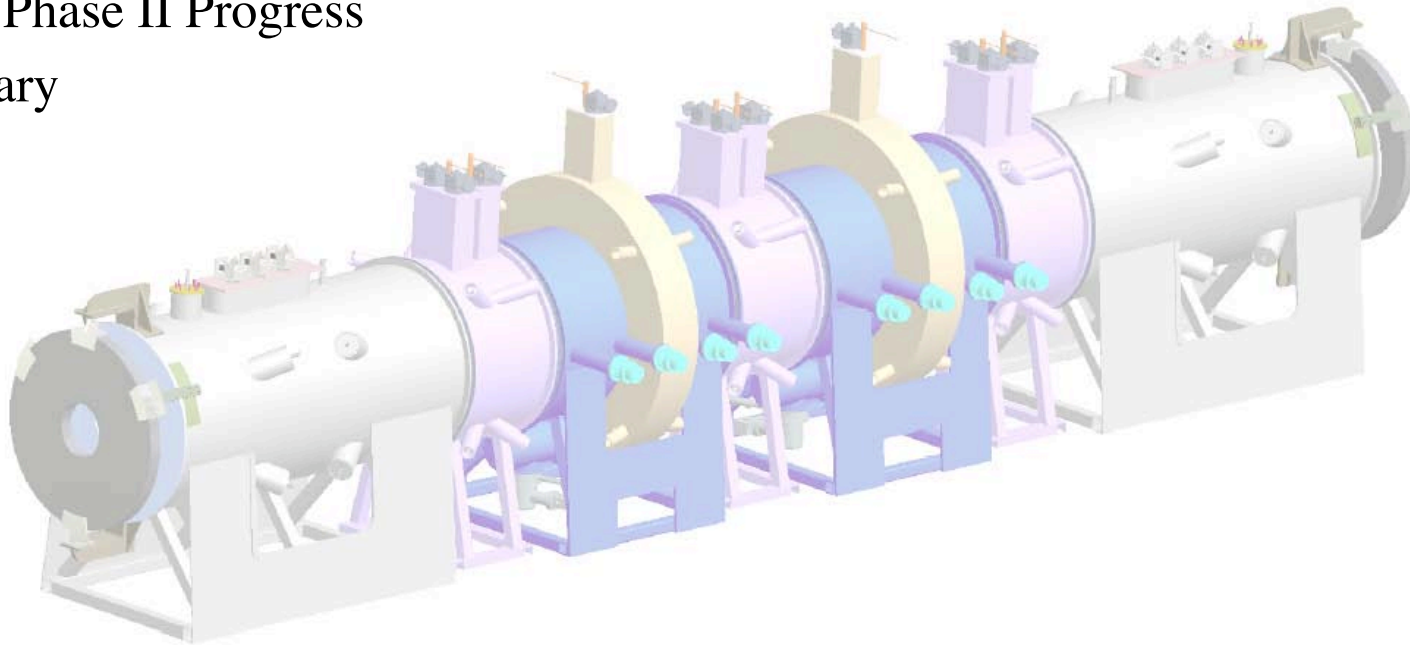
Daniel M. Kaplan  
US Spokesperson, MICE Collaboration



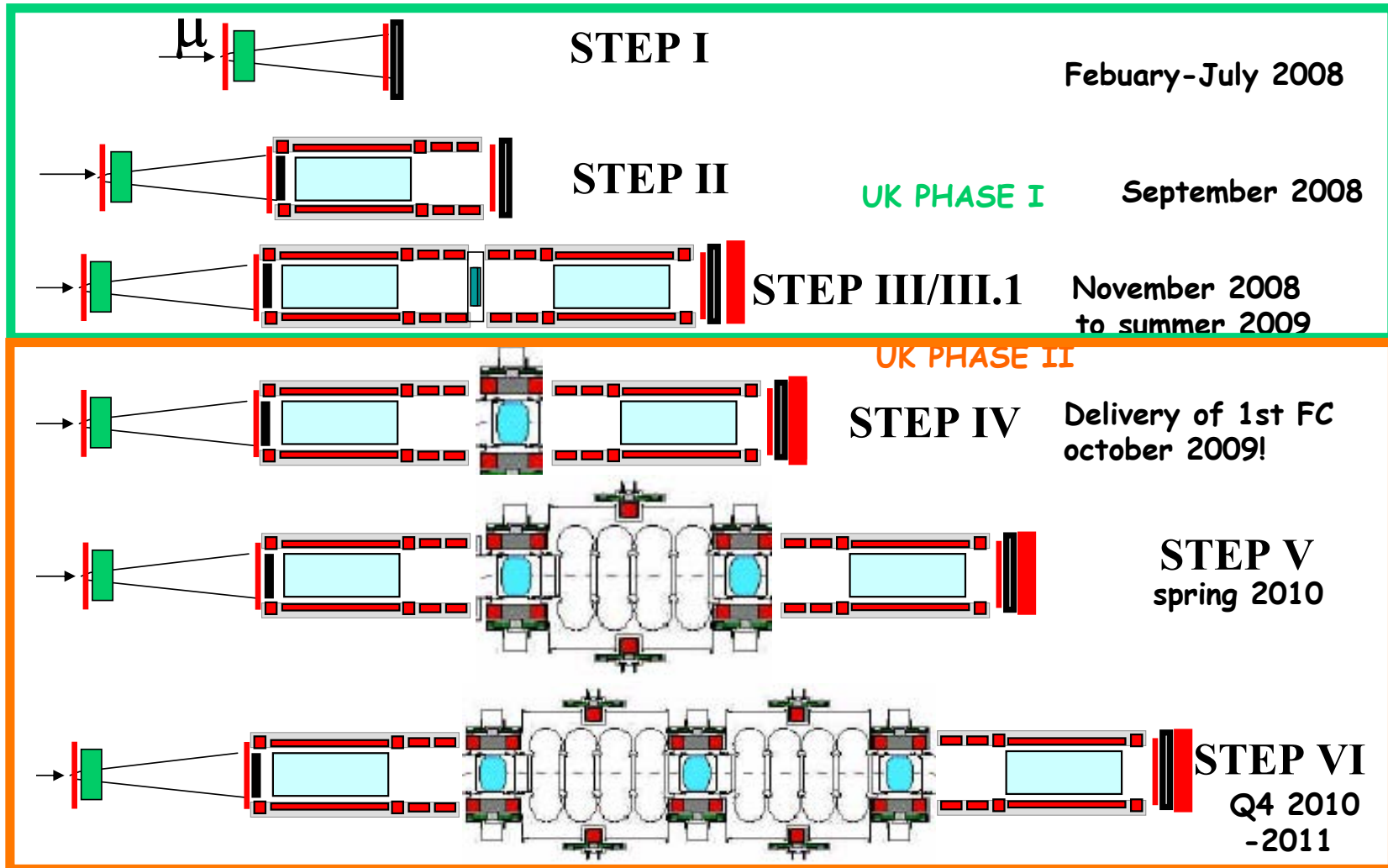
MuTAC Review  
Lawrence Berkeley National Laboratory  
8 April 2008

# Outline

1. MICE Phases
2. PID Detectors
3. Spectrometer Solenoids
4. Tracking Detectors
5. Beamline
6. MICE Phase II Progress
7. Summary

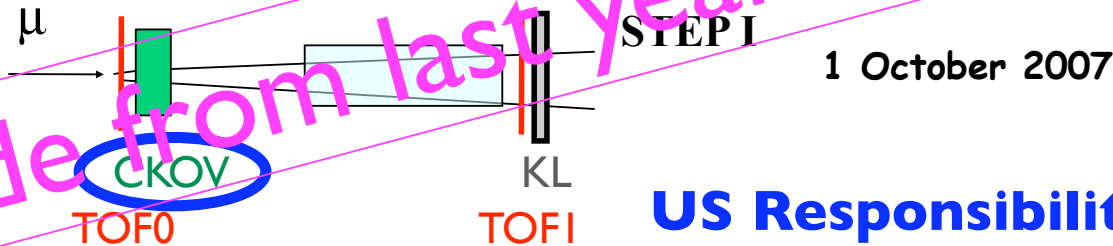


# Current MICE Schedule



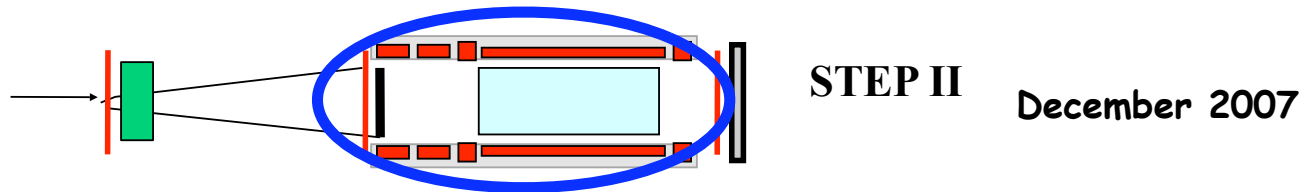
# MICE Phase I

- Want 1st PID detectors installed & working when beam turns on (Aug. '07):

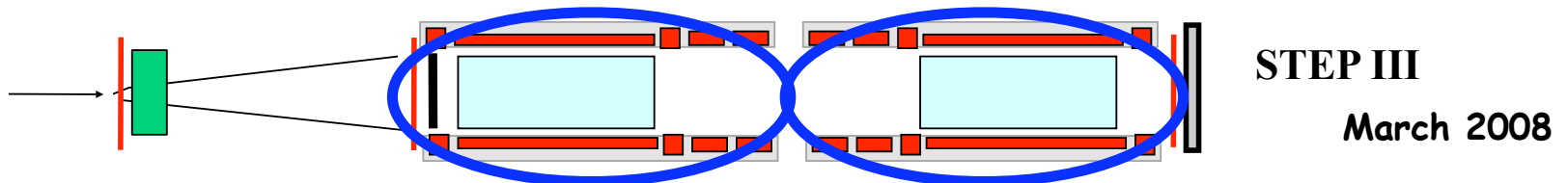


## US Responsibilities

- Want 1st tracker installed & working by Oct. '07...



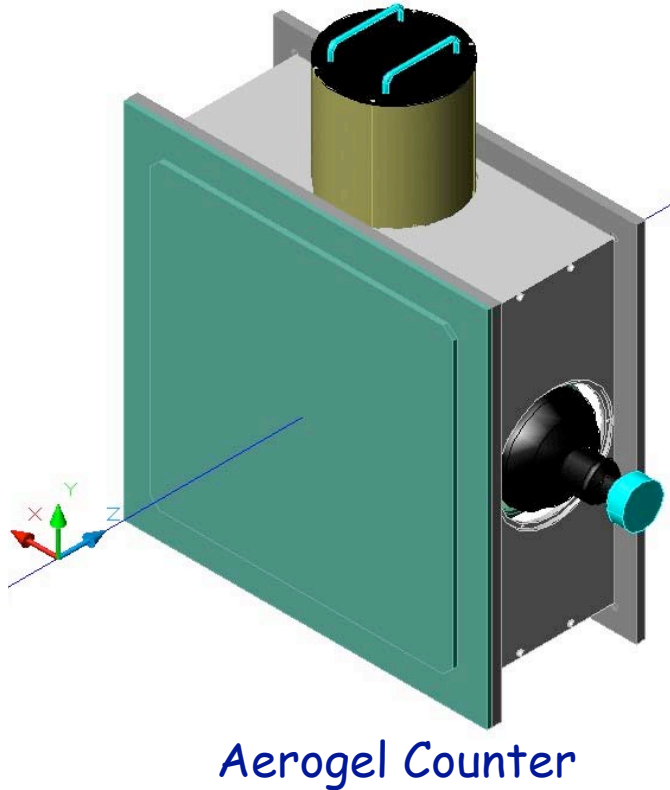
...and 2nd tracker a few months thereafter



# CKOV

L. Cremaldi & D. Summers, UMiss; G. Gregoire, Louvain (ret.)

- **Concept:** Aerogel Cherenkov counters with radiators of 2 refractive indices distinguish  $\pi$  from  $\mu$ 
  - Built in past yr at U Miss, IIT, U Iowa
  - Shipped to RAL, tested, moved to MICE



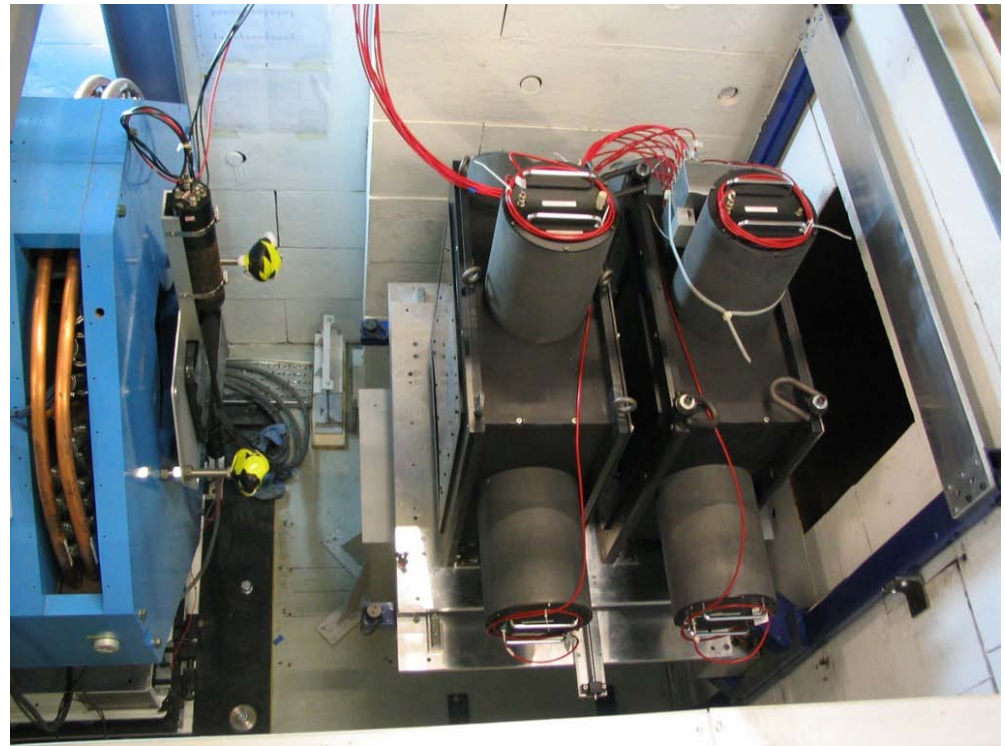


# CKOV

- Aerogel inserted in its holder



- Detectors in place in MICE



- Current status:
  - detectors working (LED test, cosmic rays)
  - waiting for beam (see below...)

# Spectrometer Solenoids

LBNL, IIT

- At last year's MuTAC Review, designs (M. Green, S. Virostek, LBNL) were complete & ass'y begun



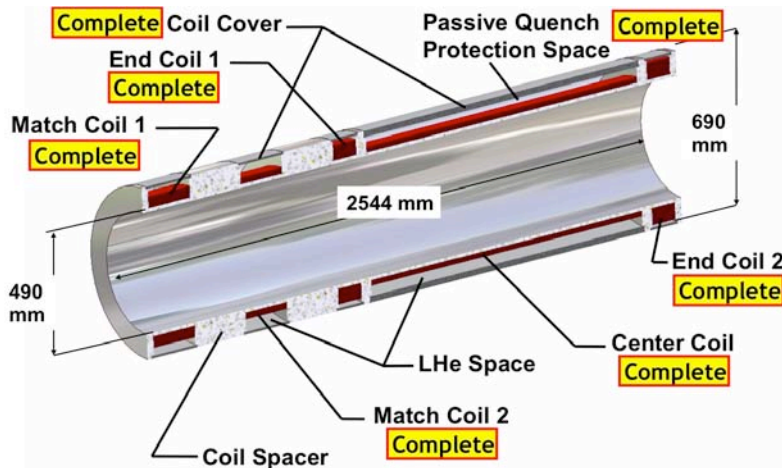
- Solenoid ass'y now nearly complete at Wang NMR (Livermore, CA)
- 4 cryocoolers purchased, delivered to Wang, & successfully tested
- P/S delivered to Wang



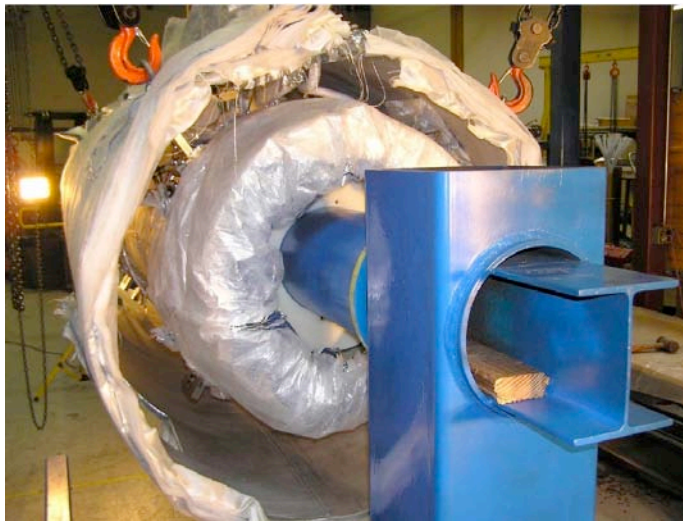


# Spect. Solenoid Progress

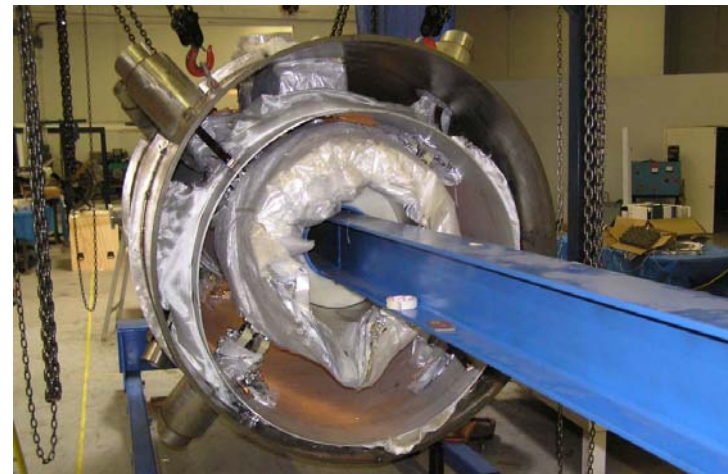
- Solenoid-I cold mass done...



...& installed in its thermal shield



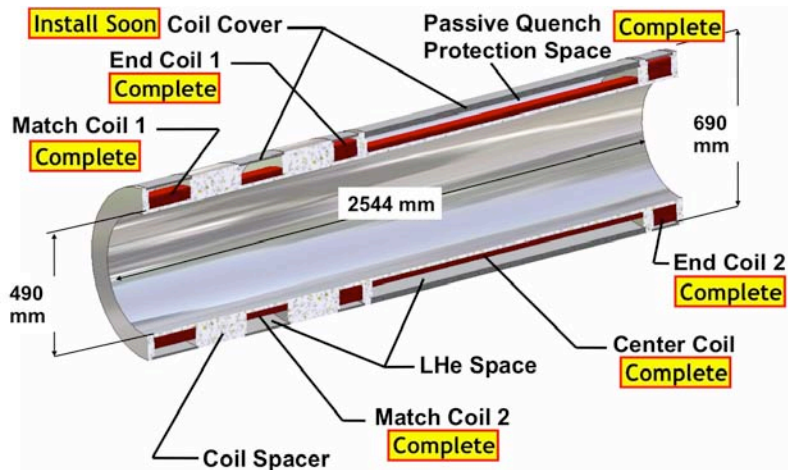
- Then install in vacuum vessel/support stand



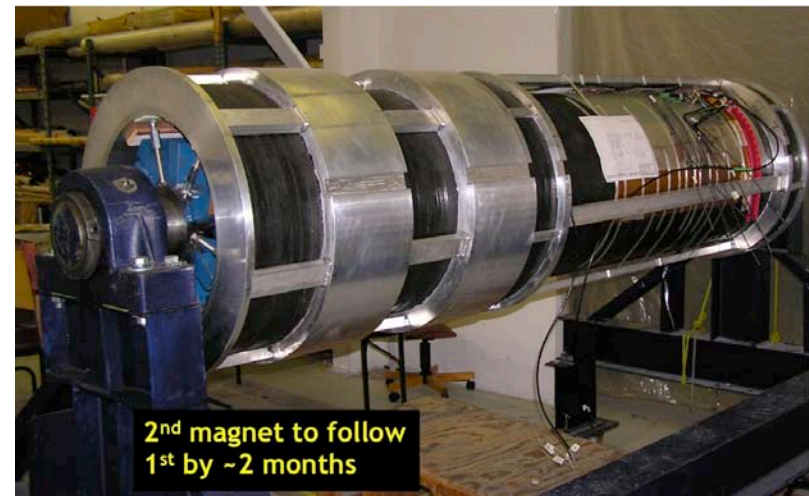


# Spect. Solenoid Progress

- Solenoid-2 cold mass nearly done...



Cold mass 2 on its winding ass'y



- Cryocooler exp't completed successfully @ Wang
  - Purpose: measure cooler performance @ 2.5-22 K
  - Confirm "drop-in" mode, measure heat leak
- Commenced Nov. '07, various difficulties found & overcome
- 1.5 W cooling power at 2nd stage now confirmed



# Spect. Solenoid Schedule

Task Description	2006						2007						2008																
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Place Magnet Order with Wang NMR (LBNL)	◆	Complete																											
Complete Magnet System Design & Review			◆	Complete																									
Deliver Superconductor to Wang (LBNL)		◆	Complete																										
Procure Coil Formers, Leads, Instrumentation, etc.				Complete																									
Wind Coils on Coil Formers																													
Deliver 4 ea Cryocoolers to Wang (LBNL)																													
Buy Power Supplies & Send to Wang (LBNL, UCR)																													
Assemble and Leak Check He Shell																													
Fab System & Perform Cryocooler Tests																													
Fab and Load Test Cold Mass Supports																													
Assemble Shield, Vac Vessel, Cold Mass Suppts																													
Install Hi-Tc Leads, Recondensers & Cryocoolers																													
Leak Checks, Cooldown & Acceptance Tests																													
Prepare, Package and Ship Magnets																													
Magnet Setup at FNAL																													
Magnetic Measurements & Commissioning at FNAL																													
Ship Magnets to RAL for Installation																													

- Will ship 1st to **FNAL** for field mapping, then to **RAL**
  - ≈ 8 mos.' slippage since '07 review – but worst probs. now behind us



# Spectrometer Solenoid Field Mapping



FNAL, IIT

- Will be done in collab. with FNAL “Machine Development and Maintenance” and “Precision Metrology” Groups using “Ziptrack”
  - well-developed system
  - has been used for decades, e.g., for fixed-target-experiment spectrometer magnets
  - recently rebuilt & upgraded for improved precision
- Measurement plan now being worked out

# Spectrometer Solenoid Field Mapping

FNAL, IIT

- Ziptrack:

- long metal beam passes through magnet bore
  - ends translatable under computer control using LabView interface
  - cart w/ Hall probes rides on beam, controlled & read out via LabView
    - position resolution:  $x, y - 10 \mu\text{m}; z - 10 \mu\text{m}$
    - position repeatability:\*  $x, y - 10 \mu\text{m}; z - 10 \mu\text{m}$
- \*current performance goals – R&D in progress

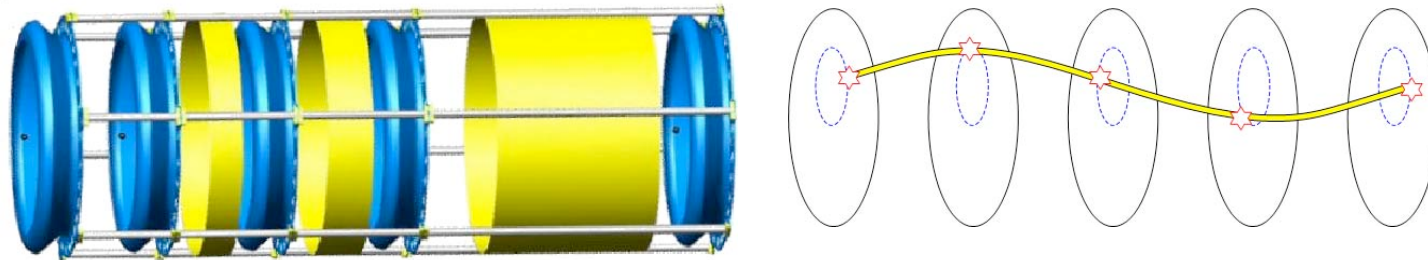




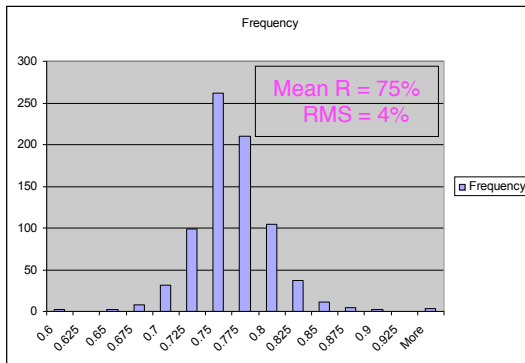
# SciFi Trackers

UK / US / Japan

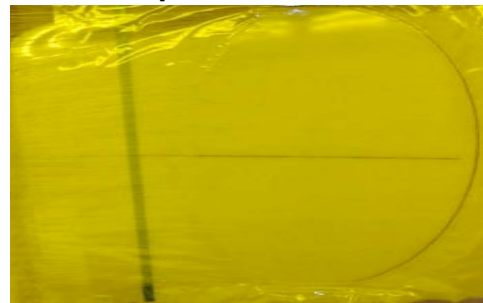
- Will sit inside solenoids, reconstruct helical muon tracks



- Fiber-end mirroring done (FNAL)



- Ribbon production done (FNAL)



- Station assembly & QC done (UK, FNAL, Osaka)



# SciFi Trackers

UK / US / Japan

- Tracker I complete
  - installed at RAL in cosmic-ray test stand
  - stand can be rotated for tracker installation in beamline prior to solenoid availability
- Tracker II stations and parts ready for assembly at Imperial College London

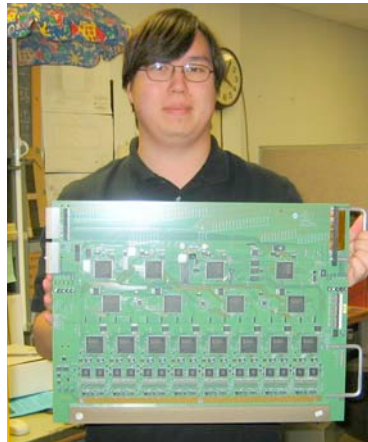


# Tracker DAQ

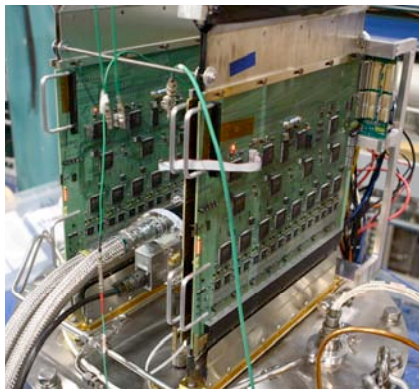
IIT / FNAL / RAL

- Uses AFE-IIt boards designed & built for D0 upgrade

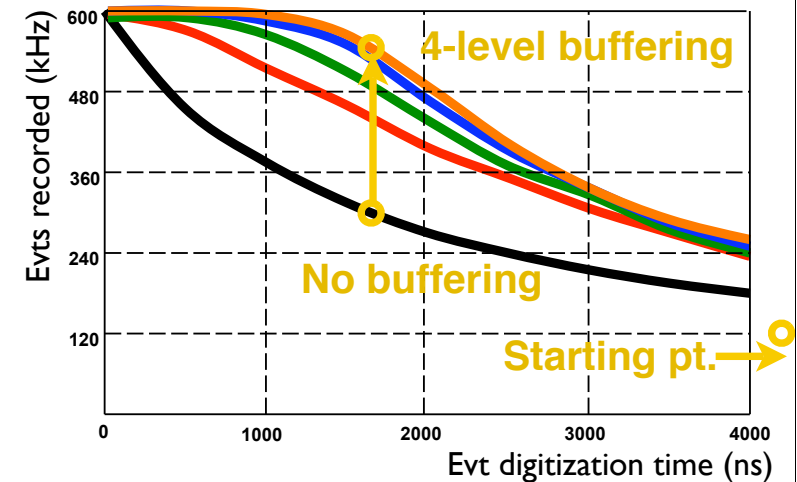
- Tested '06-'07 by IIT summer students (shown: M. Wojcik)
- New firmware for MICE devel. by IIT/ FNAL/RAL team
- Use VLPC photo-detectors at 9 K



- Firmware status: nearly complete; integration in progress (T. Hart & W. Luebke, IIT, K. Bowie, T. Fitzpatrick, P. Rubinov, FNAL, S. Galagedera, RAL)
- Goal: x4.5 increase in live-time wrt D0  $\mu$ code via 4-level analog buffering & zero-suppression



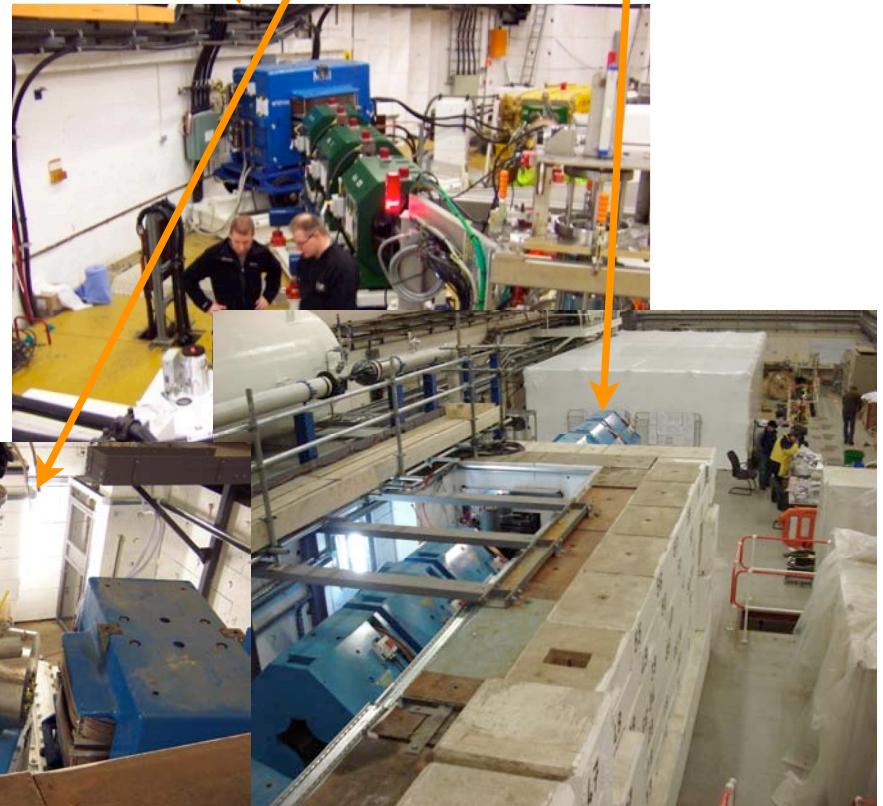
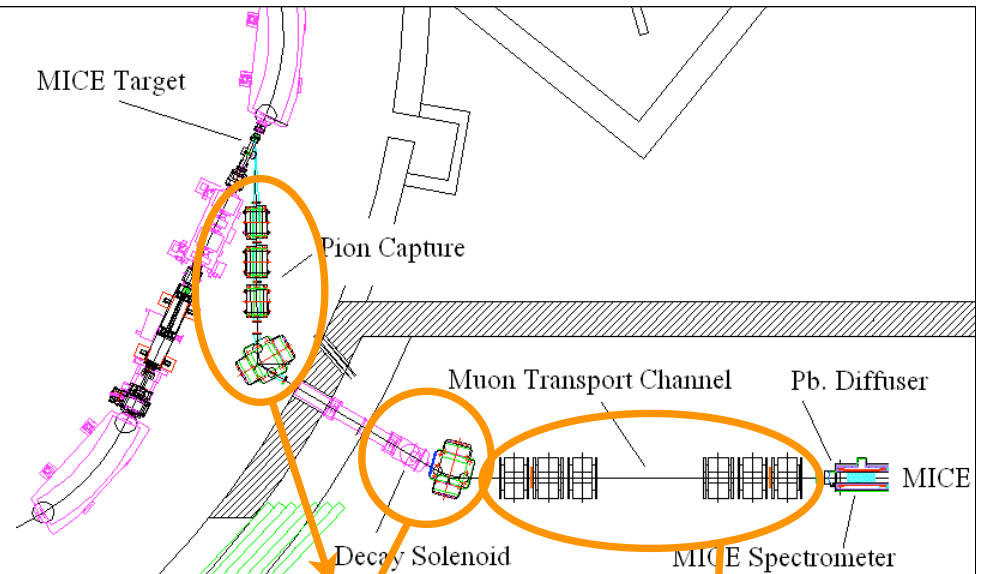
- 4 cryo-cooled VLPC cryostats built (R. Rucinski et al., FNAL)
- All now working stably with sufft. margin for UK 50 Hz AC



- AFE-IIt readout via VLSBs (T. Hart, IIT, B. Haynes & N. Wilcer, FNAL)

# Beamline

- Primarily a RAL responsibility
- T. Roberts developed (at IIT) G4beamline code for the purpose and continues to participate (now at Muons, Inc.), assisted by IIT postdoc D. Huang
- Design passed 6/12/06 & 11/16/07 external reviews
- Magnets installed & dipoles powered; shakedown in progress

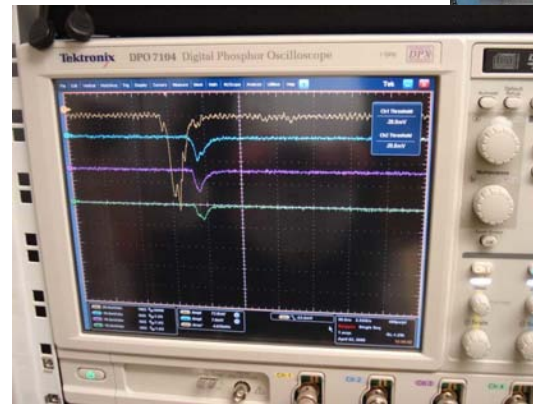
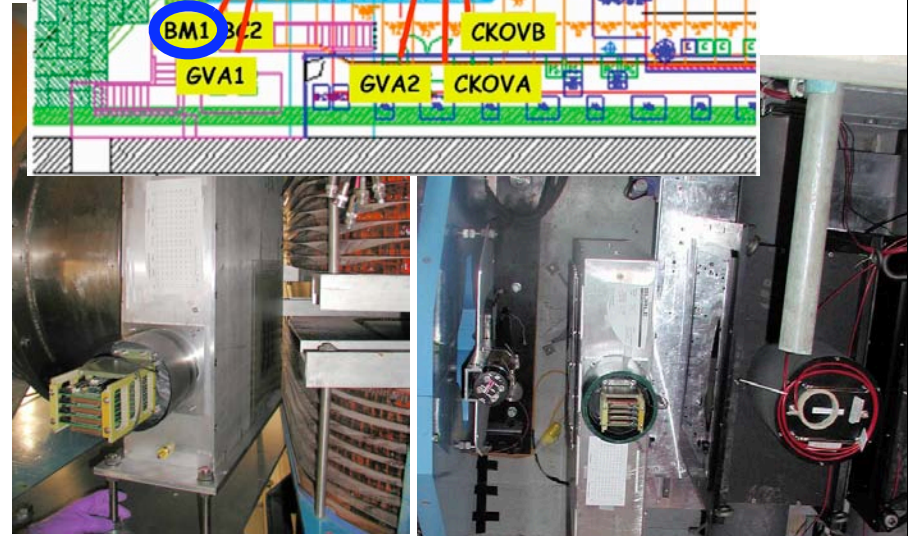
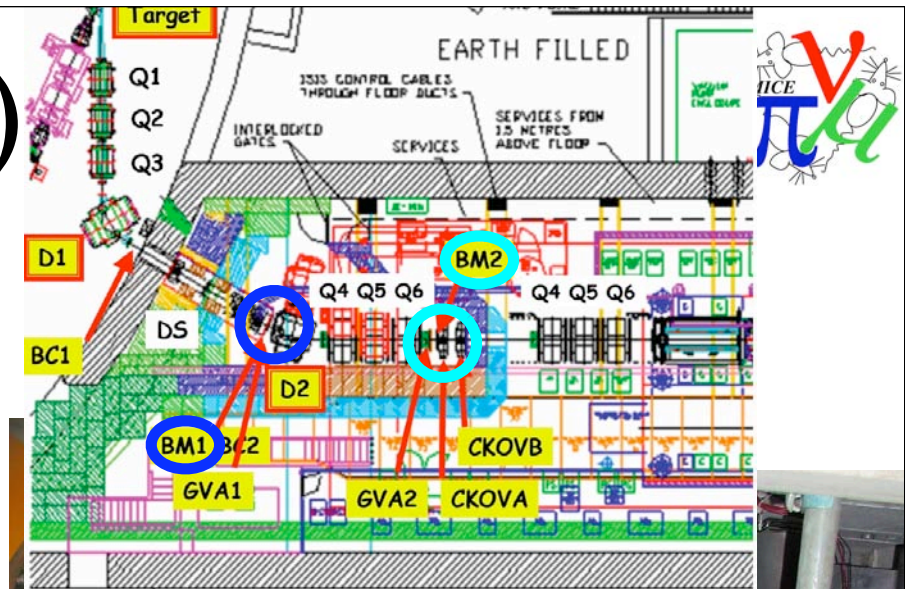


U.S. MICE



# Beamline (cont'd)

- Fermilab provided 2 SciFi beam-profile monitors
  - 1st in ISIS vault,  $19 \times 19 \text{ cm}^2$
  - 2nd in DSA,  $43 \times 43 \text{ cm}^2$
  - installed & working
- Current beam status:
  - target installed and working since February
  - plan is to debug w/  $p$ 's &  $\pi$ 's until decay solenoid oper'l
  - 1st pion from target detected in CKOV last week!

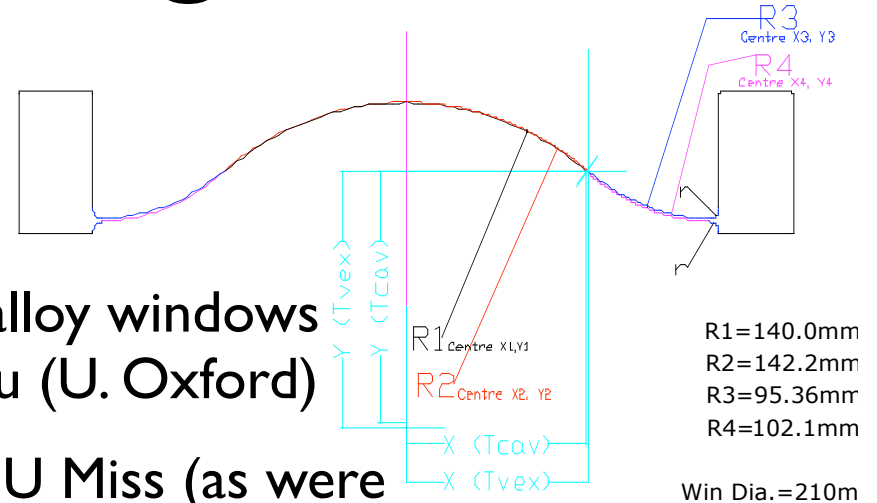


# Phase II Progress

## U.S. ΦII contributions:

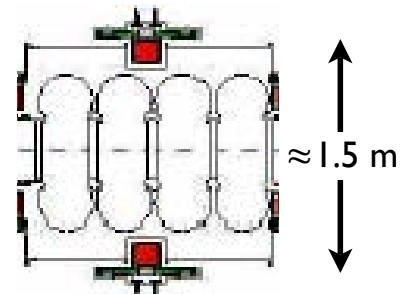
- Absorber windows

- Absorbers have thin, tapered, Al-alloy windows designed by E. Black (IIT) & W. Lau (U. Oxford)
- Plan: windows to be machined at U Miss (as were prototypes) & QC'ed at Fermilab
- 4 / 8 / 12 (+ spares) needed for Steps IV / V / VI  
⇒ plan to deliver starting 2009



- RFCC Modules

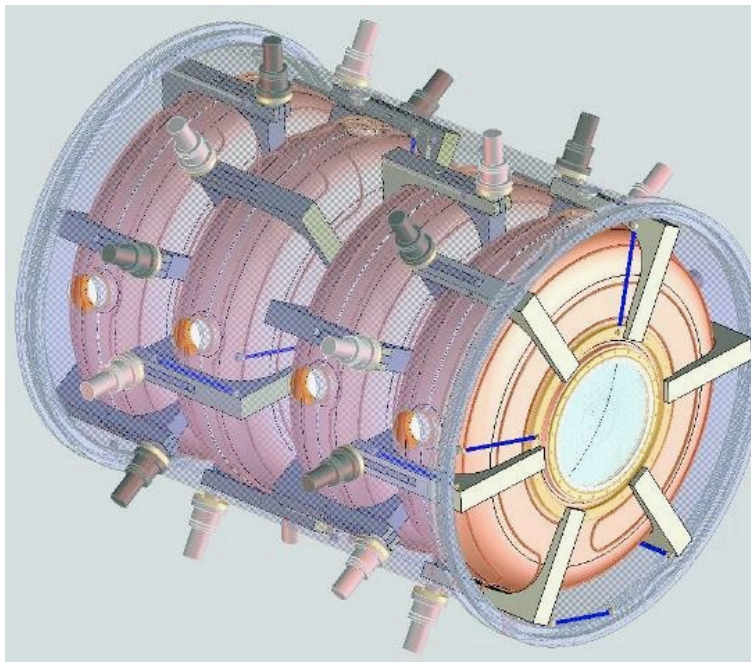
- 1 needed for Step V and 2 for Step VI  
⇒ need by 2010
- Each includes 4 RF cavities and 1 Coupling Coil



# RFCC Design

LBL

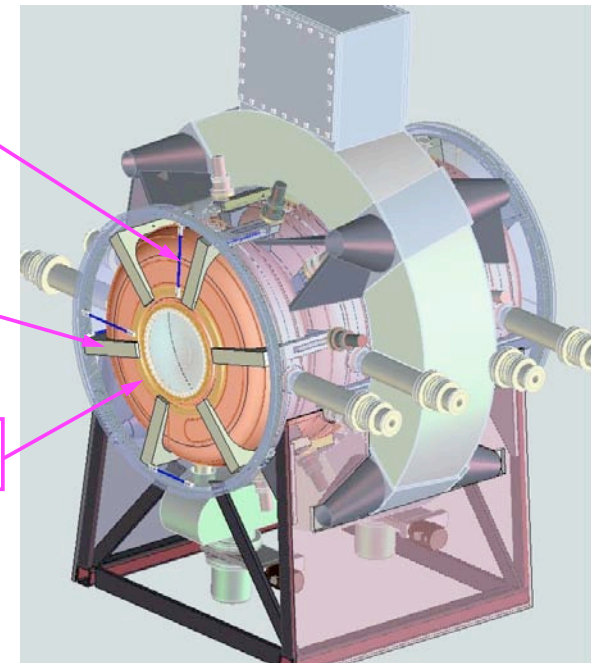
- 3D CAD model refined



Cavity suspension

Automatic tuners

201 MHz RF cavity



- Further review in progress, along with component procurement & fabrication (see schedule below)



# RFCC Design

LBNL

- Detailed WBS prepared...

WBS	Task Name	Duration	Start	Finish	Work	Original Fixed Cost [\$]	Predecessor
1	MICE	797.5 days	Mon 10/2/06	Wed 10/21/09	7,809.87 hrs	\$3,647,068	
2	1.1 MICE Integration	1 day	Mon 10/2/06	Mon 10/2/06	0 hrs	\$0	
3	1.2 Muon Beam Line & Infrastructure	1 day	Mon 10/2/06	Mon 10/2/06	0 hrs	\$0	
4	1.3 MICE Cooling Modules	797.5 days	Mon 10/2/06	Wed 10/21/09	7,809.87 hrs	\$3,647,068	
5	1.3.1 Absorber and Focus Coil Module	1 day	Mon 10/2/06	Mon 10/2/06	0 hrs	\$0	
6	1.3.2 Cavity and Coupling Coil Module	797.5 days	Mon 10/2/06	Wed 10/21/09	7,809.87 hrs	\$3,647,068	
7	1.3.2.1 RF Cavities	395 days	Mon 10/1/07	Fri 4/3/09	3,809.87 hrs	\$2,112,368	
8	1.3.2.1.1 Engineering Design & Inspection	395 days	Mon 10/1/07	Fri 4/3/09	2,617.87 hrs	\$319,448	
9	1.3.2.1.1.1 RF Cavity Analysis and Design	110 days	Mon 10/1/07	Fri 2/29/08	592 hrs	\$67,680	
10	1.3.2.1.1.1.1 Complete Final Cavity Conceptual Design	8 wks	Mon 10/1/07	Fri 11/23/07	128 hrs	\$21,120	
11	1.3.2.1.1.1.2 Complete Final Cavity RF and Structural Analysis	4 wks	Mon 11/26/07	Fri 12/21/07	64 hrs	\$10,560	
12	1.3.2.1.1.1.3 Generate Detailed 3D Model of Cavity Body	4 wks	Mon 12/24/07	Fri 1/18/08	160 hrs	\$14,400	
13	1.3.2.1.1.1.4 Complete Detail and Assembly Drawings for Cavity Fab	6 wks	Mon 1/21/08	Fri 2/29/08	240 hrs	\$21,600	
14	1.3.2.1.1.2 Tuner Mechanism Analysis and Design	45 days	Mon 2/18/08	Fri 4/18/08	224 hrs	\$24,960	
15	1.3.2.1.1.2.1 Complete Final Cavity Shell Stiffness Analysis	1 wk	Mon 2/18/08	Fri 2/22/08	16 hrs	\$2,640	
16	1.3.2.1.1.2.2 Complete Final Tuner Conceptual Design & Analysis	3 wks	Mon 2/25/08	Fri 3/14/08	48 hrs	\$7,920	
17	1.3.2.1.1.2.3 Complete Detailed Drawings for Tuner Fab	3 wks	Mon 3/24/08	Fri 4/11/08	120 hrs	\$10,800	2
18	1.3.2.1.1.2.4 Specify Procurement of Tuner Components	1 wk	Mon 4/14/08	Fri 4/18/08	40 hrs	\$3,600	
19	1.3.2.1.1.3 Cavity Window Analysis and Design	20 days	Mon 12/24/07	Fri 1/18/08	64 hrs	\$10,560	
20	1.3.2.1.1.3.1 Complete Window Geometry Conceptual Design	2 wks	Mon 12/24/07	Fri 1/4/08	32 hrs	\$5,280	
21	1.3.2.1.1.3.2 Specify Procurement of RF Windows	2 wks	Mon 1/7/08	Fri 1/18/08	32 hrs	\$5,280	
22	1.3.2.1.1.4 RF Couplers Analysis and Design	45 days	Mon 1/21/08	Fri 3/21/08	184 hrs	\$21,360	
23	1.3.2.1.1.4.1 Complete Final RF Coupler Conceptual Design	2 wks	Mon 1/21/08	Fri 2/1/08	32 hrs	\$5,280	
24	1.3.2.1.1.4.2 Complete RF Coupler Design Details	2 wks	Mon 2/4/08	Fri 2/15/08	32 hrs	\$5,280	
25	1.3.2.1.1.4.3 Complete Detailed Drawings for RF Coupler Fab	3 wks	Mon 3/3/08	Fri 3/21/08	120 hrs	\$10,800	1
26	1.3.2.1.1.5 Module Vacuum System Analysis and Design	35 days	Mon 3/17/08	Fri 5/2/08	144 hrs	\$17,760	
27	1.3.2.1.1.5.1 Develop Final Vacuum System Layout	2 wks	Mon 3/17/08	Fri 3/28/08	32 hrs	\$5,280	
28	1.3.2.1.1.5.2 Perform Final Vacuum System Analysis	1 wk	Mon 3/31/08	Fri 4/4/08	16 hrs	\$2,640	
29	1.3.2.1.1.5.3 Specify Vacuum Components	1 wk	Mon 4/7/08	Fri 4/11/08	16 hrs	\$2,640	
30	1.3.2.1.1.5.4 Complete Detailed Drawings for Vacuum System Components	2 wks	Mon 4/21/08	Fri 5/2/08	80 hrs	\$7,200	1
31	1.3.2.1.1.6 Module Vacuum Shell Analysis and Design	35 days	Mon 4/14/08	Fri 5/30/08	256 hrs	\$30,240	
32	1.3.2.1.1.6.1 Develop Final Vacuum Shell & Support Conceptual Design	2 wks	Mon 4/14/08	Fri 4/25/08	32 hrs	\$5,280	
33	1.3.2.1.1.6.2 Perform Vacuum Shell and Support Stress Analysis	4 wks	Mon 4/28/08	Fri 5/23/08	64 hrs	\$10,560	
34	1.3.2.1.1.6.3 Complete Detailed Drawings for Vacuum Shell & Support	4 wks	Mon 5/5/08	Fri 5/30/08	160 hrs	\$14,400	3
35	1.3.2.1.1.7 Fabrication, Assembly and Testing Follow On and Coordination	355 days	Mon 11/26/07	Fri 4/3/09	1,153.87 hrs	\$146,888	

...with cost estimate & schedule

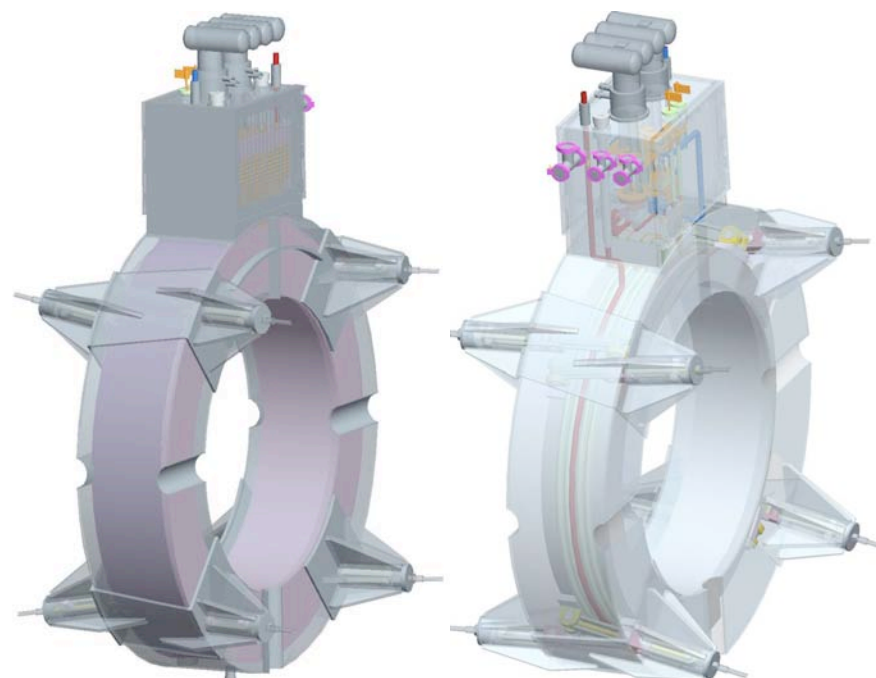
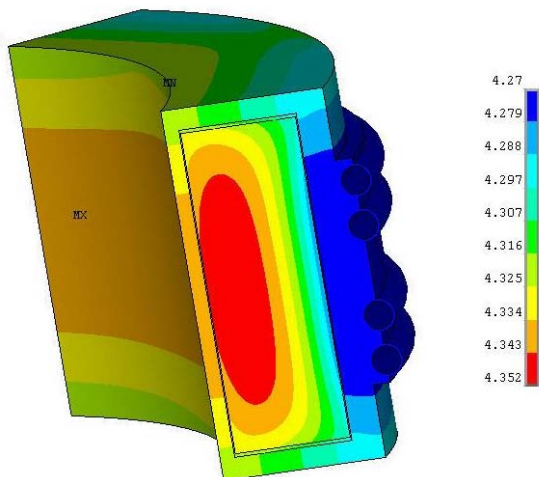


# Coupling-Coil Status

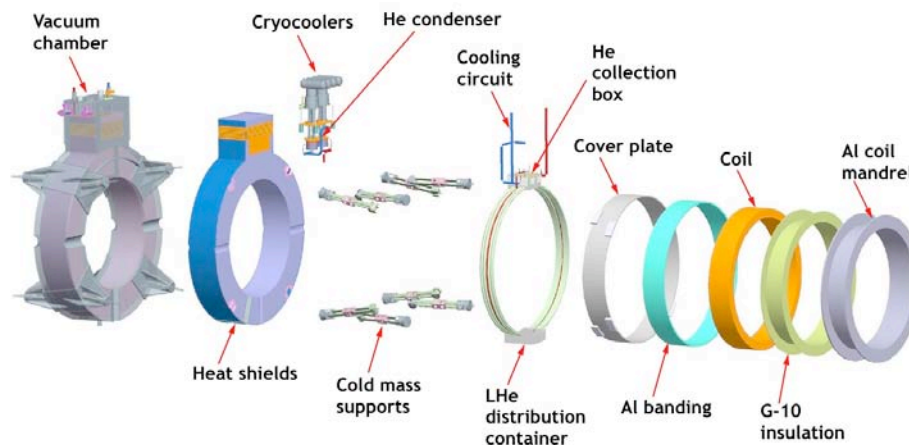
ICST Harbin / LBNL (see M. Green talk tomorrow)

- Detailed design studies and analyses completed at ICST

SUB =1  
 TIME=12201  
 TEMP (AVG)  
 RSTS=0  
 SHV =4.27  
 SHX =4.352



- Materials ordered for delivery to Harbin
- MOU w/ LBNL in place
- Plan MICE Coupling Coil ass'y fall '08 (1st CC is for MuCool)



# Coupling-Coil Status

ICST Harbin / LBNL (see M. Green talk tomorrow)

- Latest photos from ICST
- Winding of test S/C coil now in progress

Completed winding of second layer of test coil



Application of fiberglass for winding of second layer



# RFCC Schedule

ICST Harbin / LBNL (see M. Green talk tomorrow)

- Done in FY09 or FY10...

Task Description	2007							2008							2009															
	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N
Cavity and Subcomponent Engineering Design																														
Cavity Body Fabrication																														
RF Couplers and Windows																														
Cavity Thin Beryllium Windows																														
Tuner Mechanisms and Cavity Suspension																														
Cavity Assembly and Testing																														
Module Vacuum Systems																														
RF Module Vacuum Vessels																														
Coupling Coil LBNL Engineering & Purch Overhead																														
LBNL Supplied Materials for Coupling Coils (3 ea)																														
MuCool Coil and Support Fabrication (\$ to ICST)																														
Coupling Coil and RFCC Module Shipping																														
Development of Interface Specifications																														
RFCC Module Assembly, Installation and Integration																														

...depending on need for contingency



# Recent MICE Publications



M. Apollonio	Measuring Single Particle Amplitudes with MICE	PAC07 Proceedings	2007
M. A. Green et al.	Progress on the design of the coupling coils for MICE and MUCOOL	PAC07 Proceedings	2007
T. L. Hart	MICE: the International Muon Ionization Cooling Experiment: Phase Space Cooling Measurement	PAC07 Proceedings	2007
S. P. Virostek et al.	Progress on the design and fabrication of the MICE spectrometer solenoids	PAC07 Proceedings	2007
M. S. Zisman	Status of the International Muon Ionization Cooling Experiment MICE	PAC07 Proceedings	2007
D. M. Kaplan and K. Long	MICE: The International Muon Ionization Cooling Experiment.	LP07 Proceedings	2007
M. Bonesini	The Design of the time-of-flight system for MICE	EPS-HEP2007 Proceedings	2007
D. M. Kaplan	Muon cooling and future muon facilities	ICHEP06 Proceedings	2007
M. Bonesini	The R & D effort towards a neutrino factory	NOW 2006 Proceedings	2007
M. Bonesini et al.	A systematic study to characterize fine-mesh PMTs in high magnetic fields	Frontier Detectors for Frontier Physics	2007



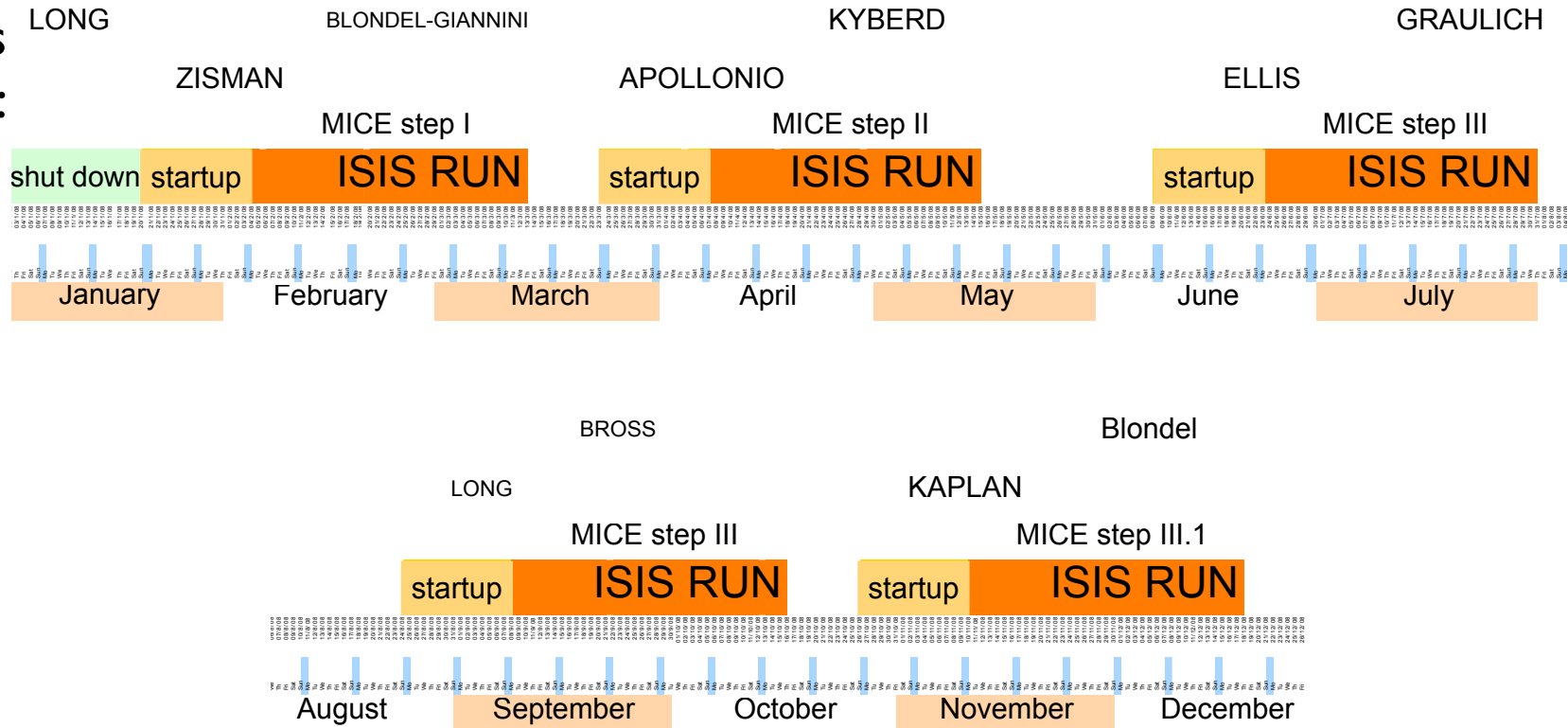


# Run & MOM Schedule



(as of 12/07)

MICE  
Op's  
Mgr:



- Revision in process to provide better MOM coverage between runs



# Summary

- Much progress
  - Schedule slipping and becoming more realistic!
  - Shakedown and some shift-work have begun
- ... and will continue until measurement program completed in 2010 or '11