Model Magnet R&D

LARP Collaboration Meeting 4

Port Jefferson, April 6-8, 2005

Gian Luca Sabbi

FY09 Milestones

LHC requirement:

Technology demonstration for an IR Quad upgrade by FY09

LARP response:

A focused program directed towards the following targets:

At **4-meter** length:	
• Coil Aperture	**90 mm**
• Nominal Gradient	**>200 T/m**
• Design Margin	**>15%**
• Max. Coil Field	**>12 T**

At **1-meter** length:	
• Coil Aperture	**90 mm**
• Nominal Gradient	**>250 T/m**
• Design Margin	**>15%**
• Max. Coil Field	**>15 T**

Main Components

Model Magnet R&D:

- Quad models with L=1 m, D=90 mm, G_{ss} = 230-260 T/m
- Quad models with L=4 m, D=90 mm, G_{ss} = 230-260 T/m
- Quad models with L=1 m, D=90 mm, G_{ss} = 280-310 T/m

Supporting R&D:

- Sub-scale dipoles & quads with L=0.3 m, B_{coil} = 11-12 T
- Long coil tests with L=4 m, B_{coil} = 11-12 T

Short Quad Models: FY05-FY07

Two designs based on same coil, but different mechanical support:

- TQ1a: shell-based structure. Task leader: S. Caspi
- TQ2a: collar-based structure. Task leader: R. Bossert

Coil parameters:

- Simple double-layer w/conservative cable design
- 1 m length, 90 mm aperture, 230-260 T/m

Objectives: feedback on cable, coil and structure development

- check basic design/fabrication, *demonstrate quench performance*
- study mechanical structure, conductor, quench protection issues
- evaluate (keystoned) cable performance: stability, stress

Optimization & mechanical studies:

- Further mechanical tests with TQ1a/2a in FY06
- One additional model of each type will be tested in FY07

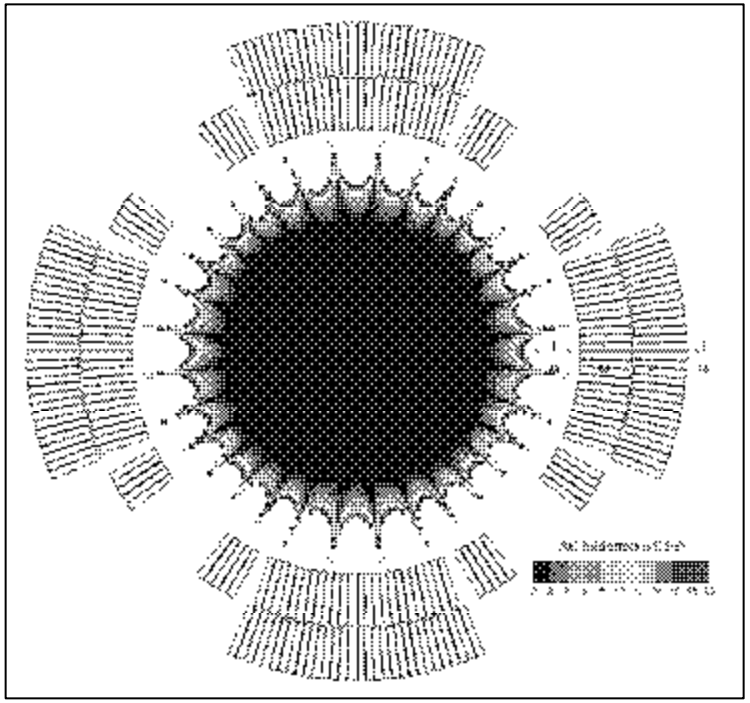
TQ1a/2a Conductor & Coil Design

Conductor:

- 0.7 mm strand
- 27 strands
- 1.0 degrees keystone
- Width: 10.05 mm
- Mid-thickness:1.26 mm
- Insulation: S-2 glass sleeve

Coil:

- double-layer shell
- one (inner layer) wedge/octant



TQ1a/2a coil cross-section

TQ1a: Shell-based Structure

Concept:

- Aluminum shell over yoke and pads
- Assembly based on bladders and keys

Advantages:

- Can deliver very high pre-stress
- Large pre-stress increase at cool-down
- Easy assembly/disassembly/reassembly

R&D issues:

- Coil alignment, field quality
- Long vs. segmented shells

TQ2a: Collar-based Structure

Concept:

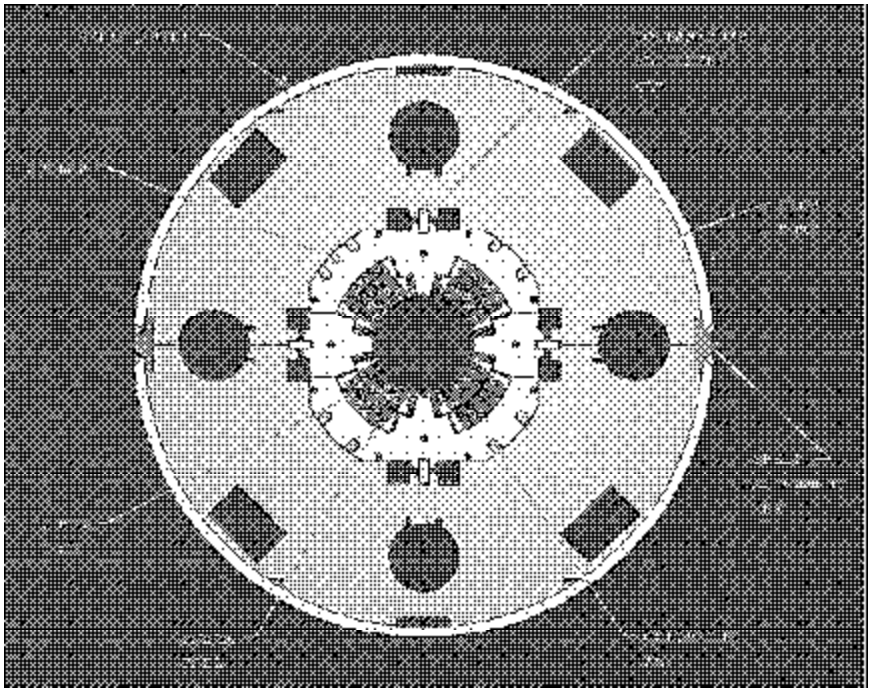
- Support by thick SS collars
- Assembly w/external press

Advantages:

- Proven coil positioning
- Proven length scale-up

R&D issues:

- Deliver required pre-stress
- Pre-stress overshoot
- Flexibility for R&D



TQ1a Work Plan & Schedule

Work Plan, Distribution, and Schedule:

FY05

- Design of cable, coil, and tooling:	FNAL+LBNL;	02/28/2005
- Fabricate/Insulate cable:	LBNL;	04/01/2005
- Procure coil fabrication tooling/parts:	FNAL;	04/15/2005
- Design and fabricate pad inserts	LBNL	04/31/2005
- Design and fabricate axial rods + end plates	LBNL	04/31/2005
- Fabricate practice coil:	FNAL+LBNL;	06/25/2005
- Wind/cure coils:	FNAL+LBNL;	08/25/2005
- React/impregnate coils:	LBNL;	10/15/2005

FY06

- Assemble magnet:	LBNL;	12/15/2005
- Test magnet:	BNL;	02/01/2006

TQ2a Work Plan & Schedule

Work Plan, Distribution, and Schedule:

FY05

- Design of cable, coil, and tooling:	FNAL+LBNL;	02/28/2005
- Fabricate insulated cable:	LBNL;	04/01/2005
- Procure coil fabrication tooling/parts:	FNAL;	04/15/2005
- Fabricate practice coil:	FNAL+LBNL;	06/25/2005
- Procure collars (modified from MQXB):	FNAL;	06/15/2005
- Assemble and test mechanical model:	FNAL;	08/15/2005
- Wind and cure coils:	FNAL;	10/25/2005

FY06

- React and impregnate coils:	FNAL;	12/25/2005
- Assemble magnet:	FNAL;	02/15/2006
- Test magnet:	BNL;	03/31/2006

TQ1a & TQ2a Budget

TQ1a	LARP		Base Program		Total
	FY05	FY06	FY05	FY06	
FNAL	236	0	0	0	236
LBNL	329	42	0	0	371
BNL	24	89	0	0	113
Total	589	131	0	0	720

TQ2a	LARP		Base Program		Total
	FY05	FY06	FY05	FY06	
FNAL	150	344	234	0	728
LBNL	36	0	0	0	36
BNL	23	89	0	0	112
Total	209	433	234	0	876

TQ1a/TQ2a Optimization: FY06-FY07

Mechanical studies using the first set of coils:

- Effect of pre-load adjustments (axial & transverse) on training
- Exchanging TQ1a/2a coils & structures

Fabrication of a new set of coils:

- Optimize tooling and refine fabrication procedures
- Use of improved conductor
- Improve consistency of comparison

Long Quad Models: FY06-FY09

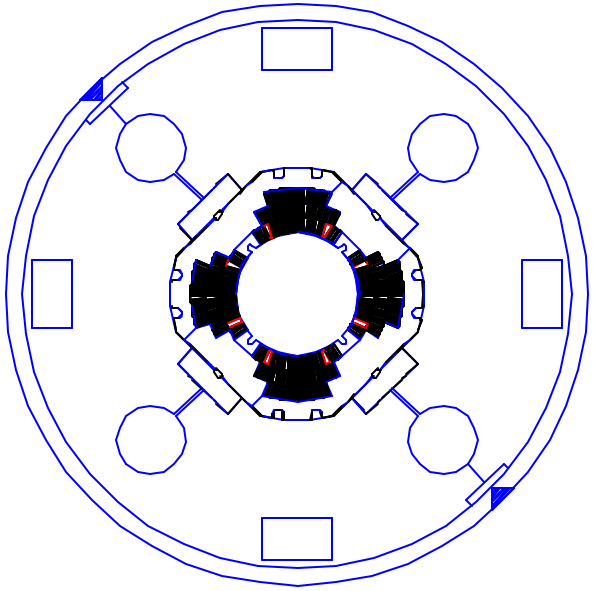
Goal: extend TQ1a / TQ2a coil and structure to 4-meter length

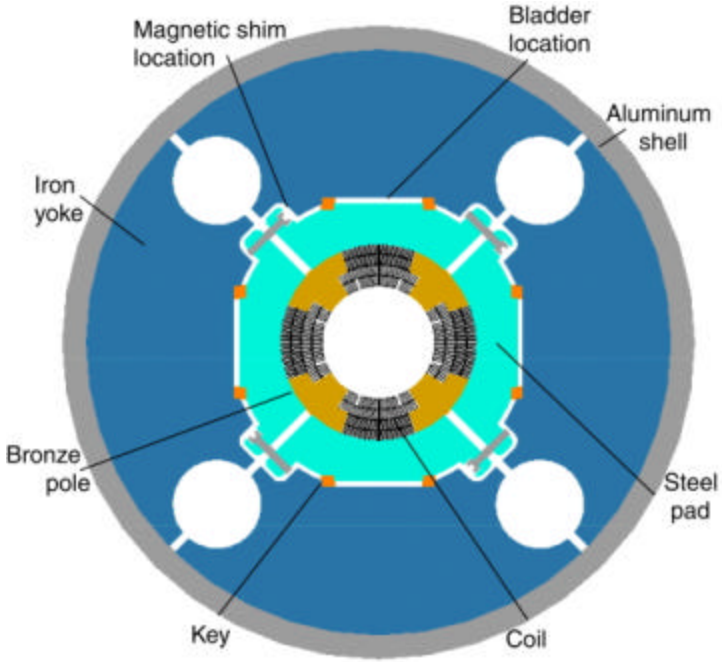
- Long coil infrastructure procurement starts in FY06
- Requires demonstration of good performance in short models
- Requires demonstration of length scale-up in simpler coils
- Coil design & tooling design/procurement starts in FY06

Short Quad Models: FY08-FY09

Goal: increase Quad gradient using 3-layer and/or 4-layer coils

Engineering design starts in FY06 and fabrication in FY07

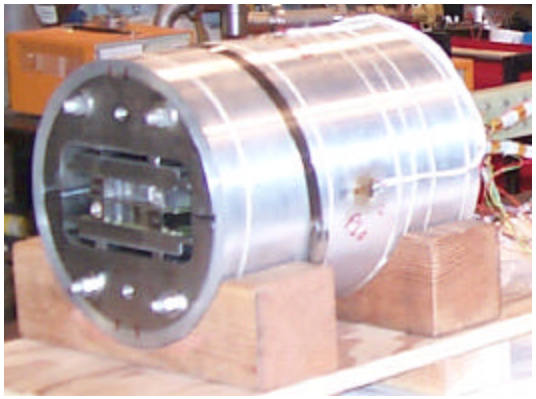




3-layer: G=260-290 T/m

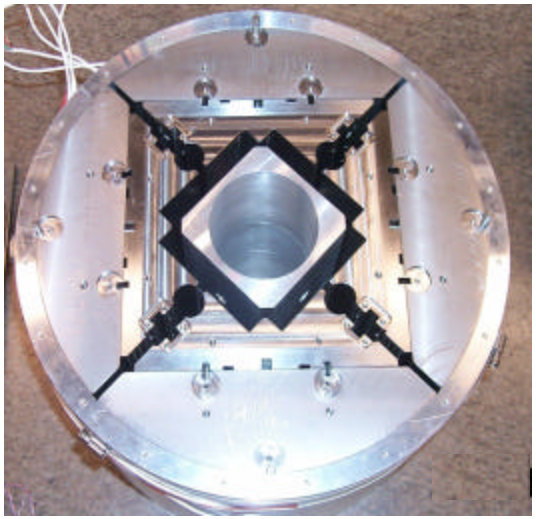
4-layer: G=280-310 T/m

Supporting R&D

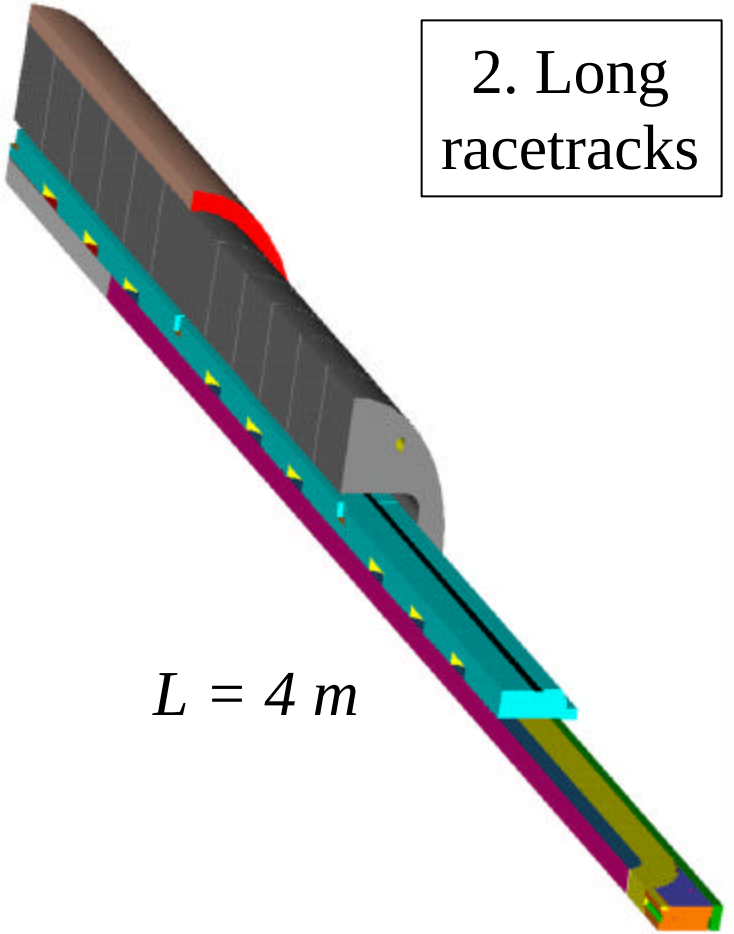


1. Subscale models

L = 0.3 m

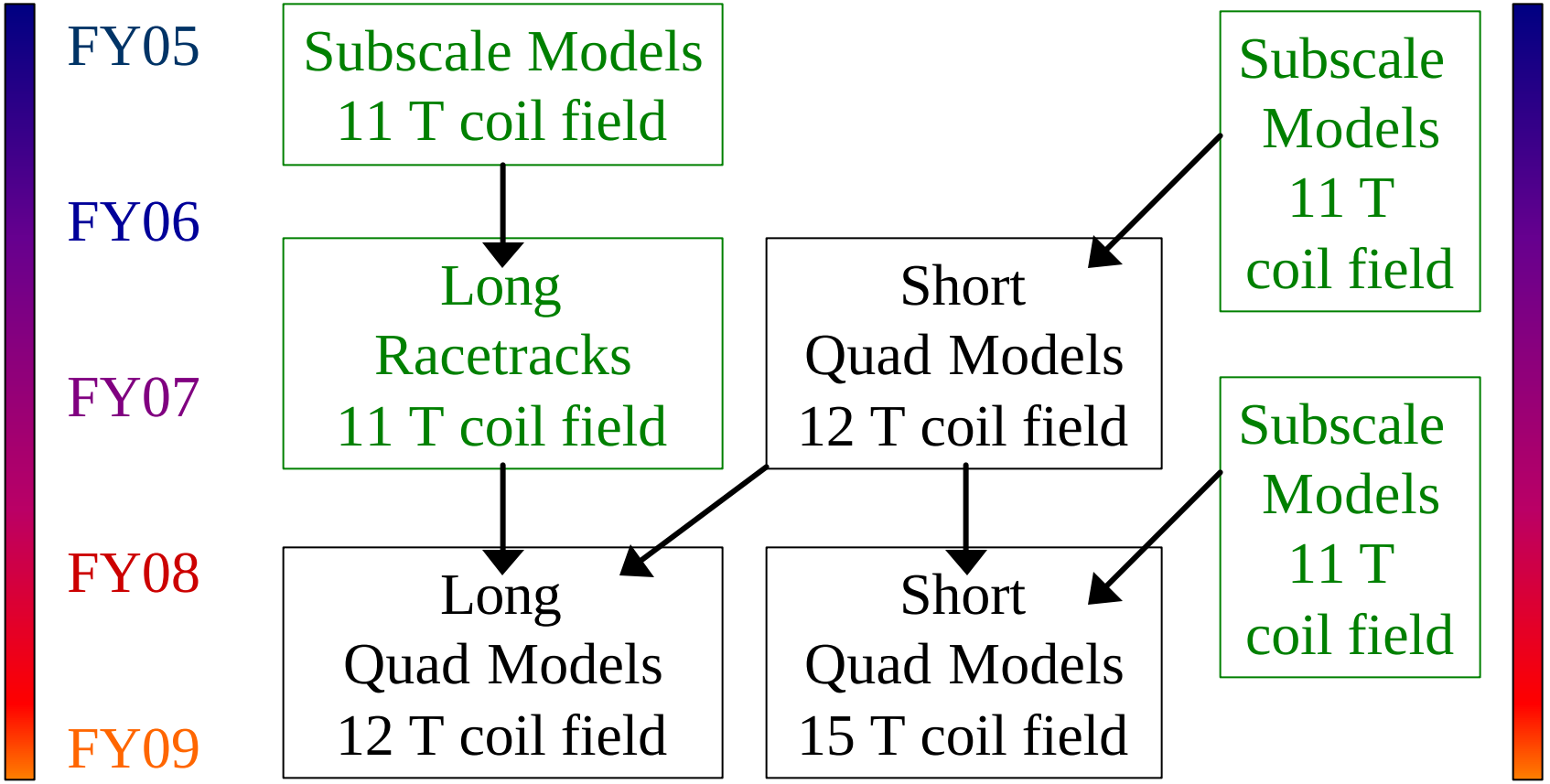


2. Long racetracks



L = 4 m

Task Organization

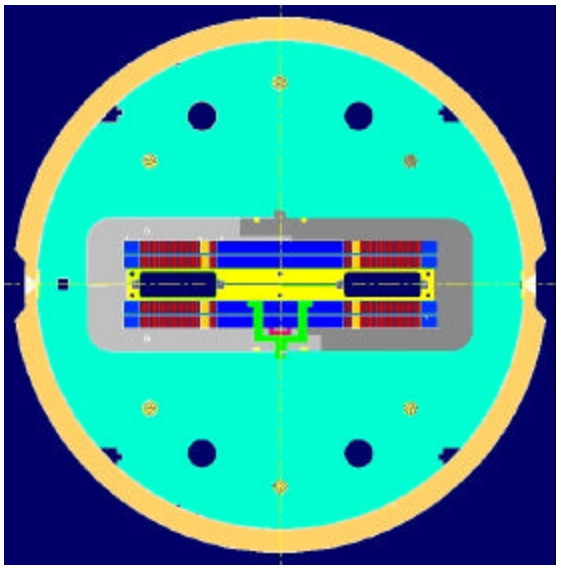


Long Coil R&D: Shell vs Racetrack (A. Lietzke)

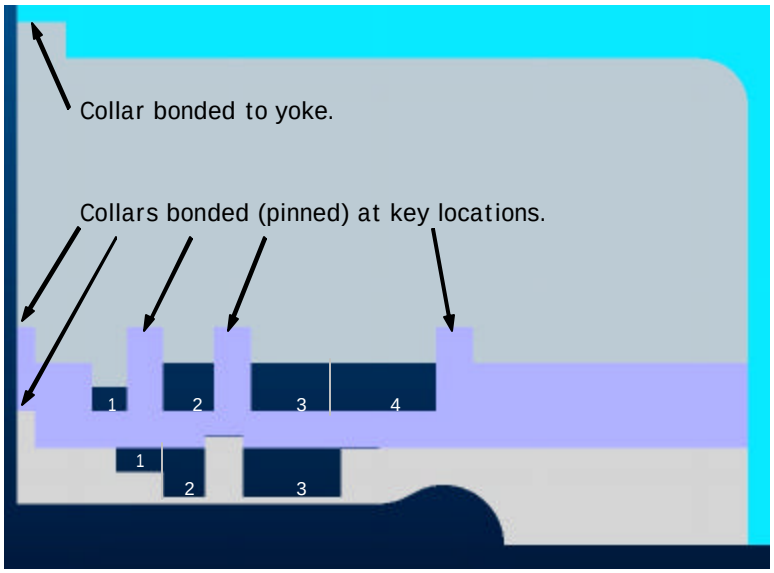
		LC1-LC4: Racetrack Coils				LC5-LC8: Cos-2-theta Coils			
Issue #	**Winding**	**LC1**	**LC2**	**LC3**	**LC4**	**LC5**	**LC6**	**LC7**	**LC8**
1	Long-coil winding problems	X	X	X	X	X	X	X	X
2	Coil twist control	X	X	X	X	X	X	X	X
3	Long-coil quality-checks	X	X	X	X	X	X	X	X
4	Cos-2-theta winding problems					X	X	X	X
5	Cos-2-theta spacer problems					X	X	X	X
Issue #	**Reaction**								
1	Differential shrinkage problems	X	X	X	X	X	X	X	X
2	End-shoe gaps	X	X	X	X	X	X	X	X
3	Coil support & handling problems	X	X	X	X	X	X	X	X
4	Long-coil quality-checks	X	X	X	X	X	X	X	X
5	Cos-specific reaction issues					X	X	X	X
Issue #	**Impregnation**								
1	Protection and instrumentation	X	X	X	X	X	X	X	X
2	Impregnation problems	X	X	X	X	X	X	X	X
3	Coil support & handling	X	X	X	X	X	X	X	X
4	Long-coil quality-checks	X	X	X	X	X	X	X	X
5	Cos-2-theta instrumentation issues					X	X	X	X
6	Cos-2-theta impregnation issues					X	X	X	X
7	Cos-2-theta quality issues					X	X	X	X
Issue #	**Assembly & pre-stress**								
1	Long bladder problems	X	X	X	X	X	X	X	X
2	Long shell problems	X	X	X	X	X	X	X	X
4	Long-coil quality-checks	X	X	X	X	X	X	X	X
5	Common 4-coil assembly issues			X	X	X	X	X	X
6	Cos-specific 4-coil issues					X	X	X	X
Issue #	**Testing**								
1	Test setup & plan integration	X	X	X	X	X	X	X	X
3	Cold pre-stress adequacy	X	X	X	X	X	X	X	X
2	Protection performance	X	X	X	X	X	X	X	X
3	Conductor performance	X	X	X	X	X	X	X	X
4	Data analysis and publication issues	X	X	X	X	X	X	X	X
5	Quad training			X	X	X	X	X	X
6	Common quad harmonic control			X	X	X	X	X	X
7	Cos-2-theta training							X	X
8	Cos-2-theta harmonic control							X	X

Dipole Models

Several possibilities were presented:



Reconfigured 12 T



PoP / D1

- Present resources/priorities do not allow a parallel program
- Reconfigured 12 T may be pursued by BNL base program

Model Magnets FY05-FY09

Technical program summary:

	Nominal Gradient	Length	Aperture	FY05	FY06	FY07	FY08	FY09
	[T/m]	[m]	[mm]					
Model Magnets								
High gradient (cos-theta)	> 200	1	90		X X	X X		
Ultimate gradient	> 250	1	90				X	X
Long length, high gradient	> 200	4	90				X	X
Supporting R&D								
Sub-scale tests		0.3		X X	X X	X X	X X	X
Practice coils		4			X	X		
Long coil tests		4				X	X	

- Need to develop detailed cost estimates and resource loaded plan
- This plan implies substantial contributions from the base programs