LARP Magnet Program

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LAPAC Review
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Outline

Program Overview

FY04 Accomplishments and Activities

“Three-Year” Plan

FY05 Program

FY06 and 07

Magnet R&D for a Luminosity Upgrade

- Magnet R&D will eventually become the largest part of LARP
- Three elements
  - Develop new magnet technology – “Research”
  - LHC luminosity upgrade – “Development”
  - Promote international collaboration

Magnet Program Goals

Improve long-term physics research opportunities of the LHC by providing magnet options for an LHC luminosity upgrade

Large aperture, high gradient quadrupoles (main emphasis)

Large aperture dipoles for the extreme radiation environment of a dipole-first IR

Deliverables will be a successful R&D program, leading to accelerator-ready magnet design(s) (production magnets are out of scope)

Develop a collaborative environment between US national labs

Develop world-wide collaboration on high field magnets

Interactions with other Magnet R&D Programs

The LARP cannot deliver accelerator-ready designs for all of the new IR magnets by itself.

- The LARP R&D program will be built upon and well coordinated with the on-going U.S. base program in high-field magnet development.
  - DOE funded program to develop Nb_3Sn superconductor.
  - High-field dipole programs at BNL, FNAL and LBNL.
- We will work in close collaboration with non-U.S. programs.

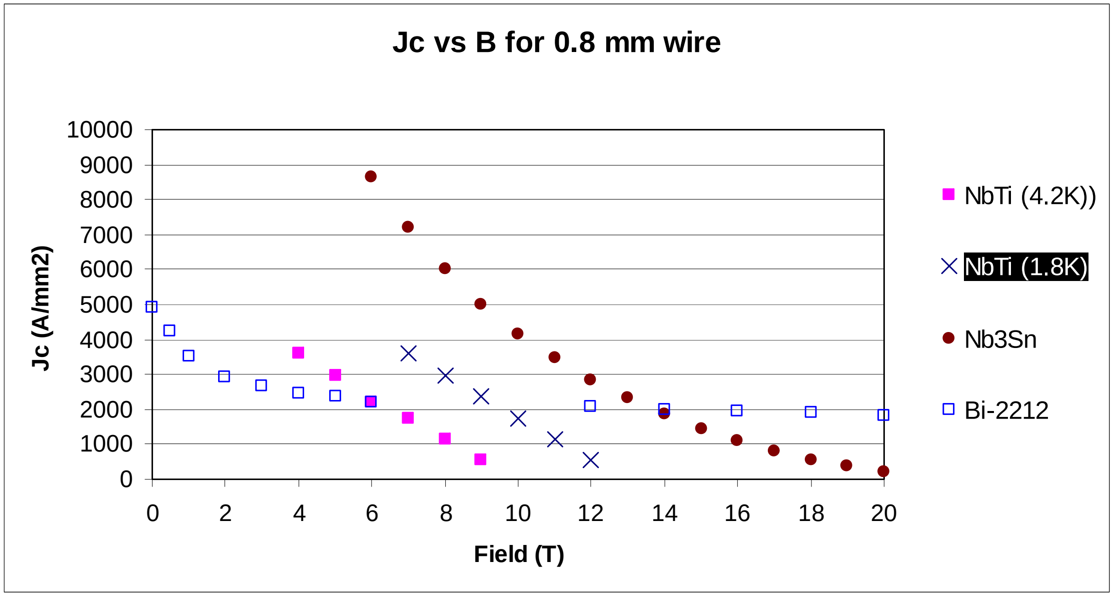
Program based on Nb_3Sn

Main Issues

High fields and gradients

Large beam-induced heat loads

Nb_3Sn →



Extend and quantify limits on key performance parameters

Issue-driven program designed to develop an enabling technology base for LHC upgrades

Material Options

NbTiTa

Most optimistic performance gives little margin over NbTi

Cryo system must absorb 100's – 1000's of watts at 1.9K → $$

Low T_c

(Higher operating cost, lower temperature margin, fewer options and limited potential)

Nb_3Sn

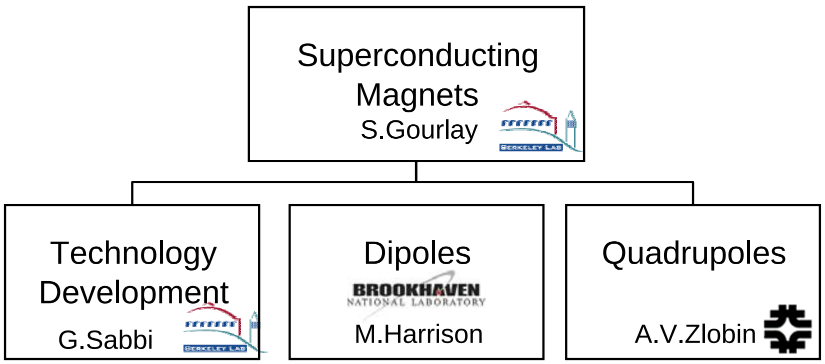
Much higher current density → larger aperture (G x A) → reduced heat load

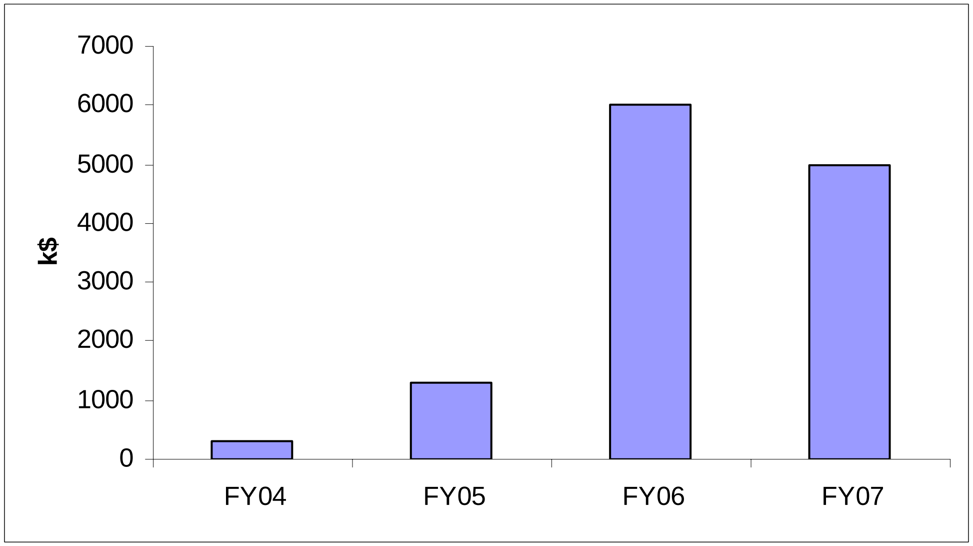
(Lower operating cost, higher temperature margin, more options and greater potential)

HTS

Not yet an engineering material

Organization and Budget

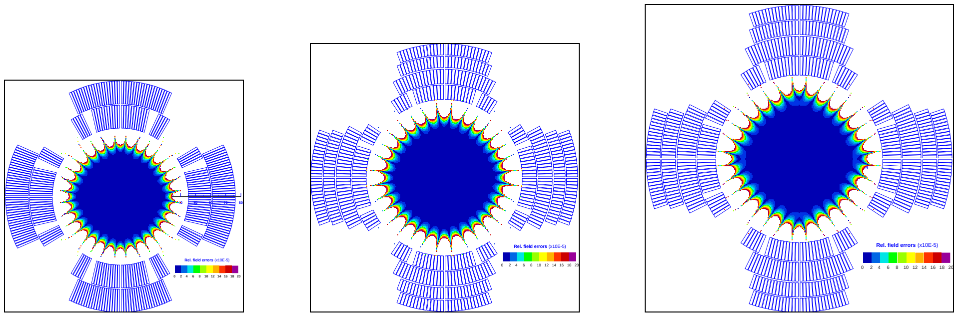




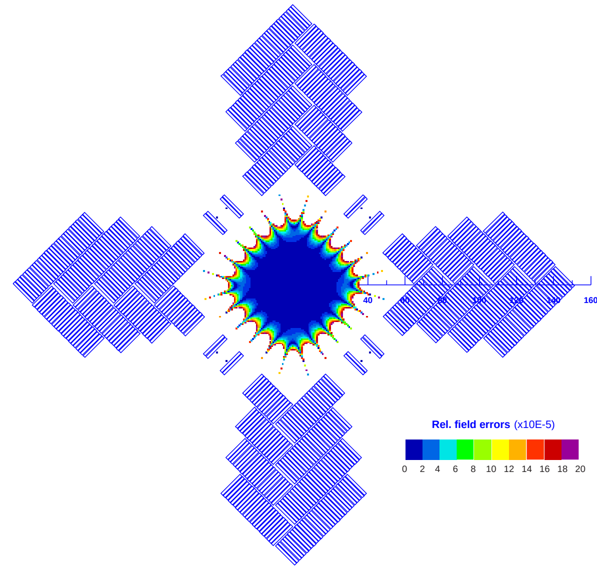
Lab representatives oversee tasks/sub-tasks at host laboratory

FY04 Accomplishments and Activities

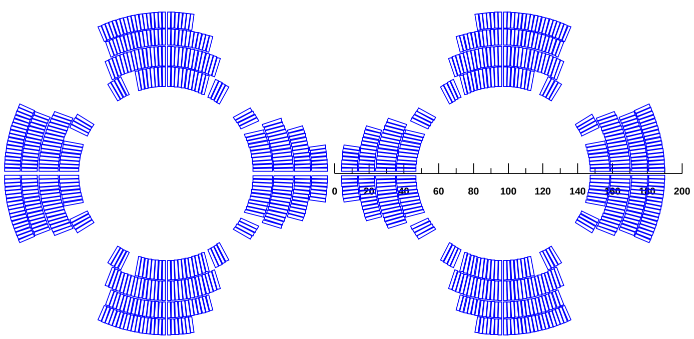
Studies and concepts



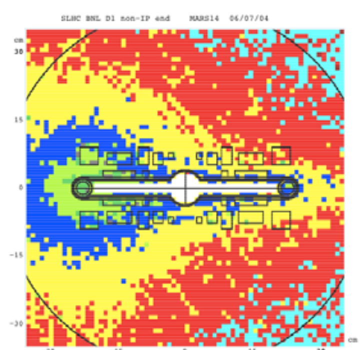
Aperture studies



Racetrack geometries



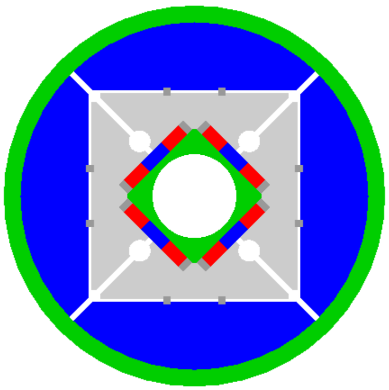
Dual-aperture options



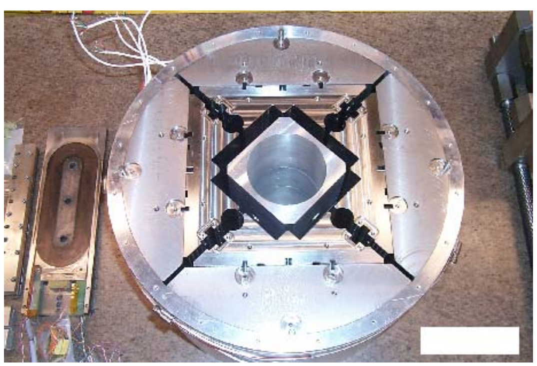
Open-midplane dipole concept

FY04 Accomplishments and Activities

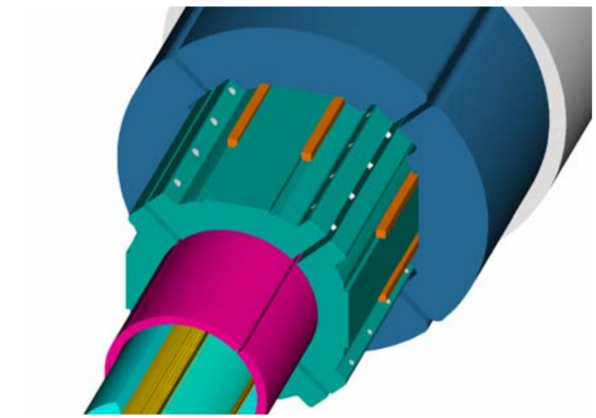
Structure design and hardware



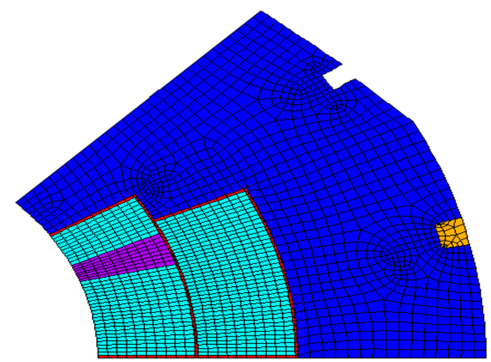
SM Quadrupole (SQ-1)



Quadrupole Structure



Mechanical models



Program Elements and Timeline

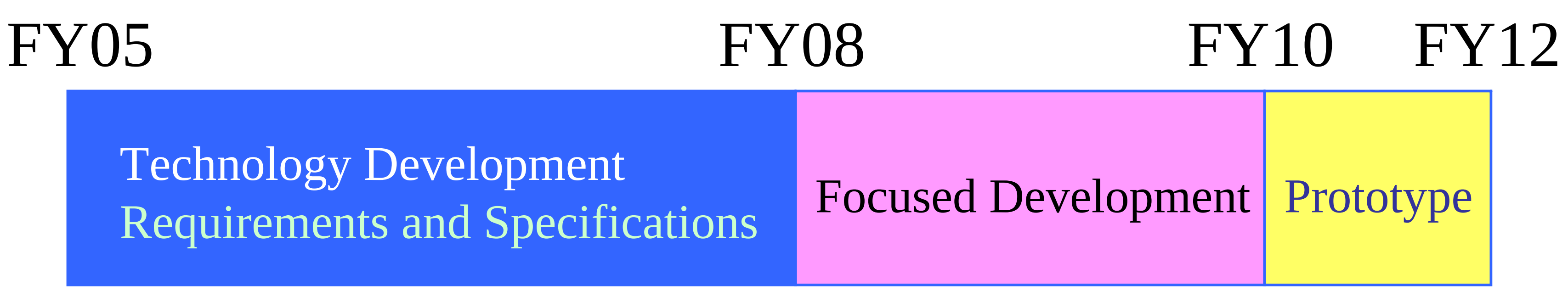
"Three-year plan" to focus initial effort (FY05 – FY07)

Must include development of technology for future US projects

But . . . be conservative and focused enough to meet LHC goals.

Start aggressively

evaluate our status and the challenge ahead



Goals of the Three-Year Plan

Assess challenges

Determine parameter "reach" and scope for development program

Aperture

Quads and high-rad dipoles

Mechanical structures

Provide AP with range of options* and understand trade-offs

*Key to "dipole first" option is a large aperture dipole in high radiation environment

Aperture

Bigger is better

- IR performance
- Radiation load

90 mm is initial baseline aperture

- Challenging enough!
- Leaves option of 2-layer coil with G > 200 T/m

Start with 2 layers of a 4-layer design (TQ4L1a)

- Affordable in FY05
- Simple cable parameters (2-layer design requires time to study cabling issues)
- Quick start

Quads and High-Rad Dipoles

Majority of R&D is "generic" with respect to dipoles and quads

- Insulation
- Fabrication techniques
- Mechanical structures and related analysis
- Quench protection
- Rad-hard materials
- Field quality reproducibility

Many issues can be addressed via a "sub-scale" program. Either the standard common coil configuration or more sophisticated and mechanically relevant dipole or racetrack quad configuration.

(Note that force distributions are similar in racetrack and cos2theta quad configurations)

Mechanical Structures

The “Three-year” program includes two mechanical structure schemes

Key and bladder

- Very inexpensive – excellent choice for R&D
- Is it length scalable?
- Can we control coil size?

Conventional collars and yoke

- Expensive for R&D (aperture variation)
- Good geometric control
- Can stress be limited?

Long Magnet R&D

Primarily funding limited

- Infrastructure
  - Reaction furnace
  - Handling
  - VPI chamber or fixture
  - Materials cost

FY04, 05 – Study issues (No budget – base program)

FY06 – Infrastructure development

FY07 – Fabrication and test of 3 – 4 m coil (long sub-scale) if $$

Will address most issues

At the end of the "Three-year" plan

- Expect vigorous R&D program at CERN
- CARE program
  - Networking activities (ongoing)
  - NED's birthday
- Participation by KEK?

New collaborative opportunities

- Several LARP magnets (new experience base)
- Conductor progress
- Maybe some LHC operating experience

New directions?

FY05 Program

TQ4L1a – 2/4 layer 90mm quad

Fabricate and test

Highest Priority

TQ2L1 – 2-layer 90mm quad

Engineering design

Conductor and Cable

Conductor procurement*
Cable R&D

*Conductor Development Program

Open-midplane dipole

3-D mechanical design

Thermal analysis

Sub-scale magnets

Dipole and/or quad as resources permit

Heat x-fer, support structure, fab, assembly, etc.

Combine with materials studies?

Long magnet issues

Base program

FY05 Task Distribution

TQL1a

Design/Analysis – LBNL/FNAL

Winding – FNAL

Reaction – LBNL

Impregnation – LBNL

Assembly – LBNL

Test – BNL

Sub-Scale Tests

Fabrication – LBNL/BNL

Test - BNL

Quadrupole Development

Design Studies - FNAL/LBNL

Dipole Development

Design Studies – BNL

Conductor and Cable

Spec Development – BNL/LBNL/FNAL

Cabling – LBNL

Measurements - BNL

FY06

TQ4L1b – 2/4 layer 90mm quad

Complete 4-layer model
Fabricate and test

TQ2L1 – 2-layer 90mm quad

Fabricate and test

Conductor and Cable

Conductor procurement

Replace CDP, FY06,07

Cable R&D

TD-1 - Open-midplane dipole

Simplified model

heat load tests

Sub-scale magnets

Dipole and/or quad as resources permit

Long magnet issues

Develop infrastructure

Materials development

Rad-hard components

Common Coil Sub-scale

FY07

TQ4L2 – 4 layer 90mm quad

Fabricate and test

TQ2L2 – 2-layer 90mm quad

Fabricate and test

Conductor and Cable

Conductor procurement

Replace CDP, FY06,07

Cable R&D

TD-2 - Open-midplane dipole

Simplified model

heat load tests

SD-2/3 – subscale dipole

Support structure, heat x-fer, etc.

SQ-4 – subscale quad

Fabrication and assembly techniques, training and quench studies, etc.

Long magnet issues

Fabrication and test?

Materials development

Rad-hard components

Common Coil Sub-scale

Program Schematic

FY05	FY06	FY07	
	TQ2L1	**TQ2L2 – TQ?L2***	
TQ4L1a	**TQ4L1b**	**TQ4L2**	
	or	**TQ4L2 (100mm+)**	
	SC-1 **SC-2**	**SC-3** **SC-4**	Reassess program
SD-1	**SD-2**	**SD-3**	
SQ-2	**SQ-3**	**SQ-4**	
TD-1 **design**	**TD-1**	**TD-2**	
Length studies	**Long magnet infrastructure**	**Long magnet Fab**	
Cable R&D	**Cable R&D Procurement**	**Cable R&D Procurement**	

*alternative structure

Budget and FTE's

	FY05		FY06		FY07	
	FTE	M&S	FTE	M&S	FTE	M&S
Quadrupoles	0.8		1	10	1	10
Dipoles	0.9		1	10	1	10
Technology Dev	4.65	132	18.76	1630	20.65	1730
Cable R&D/Fab	0.6	12	2.5	35	2.6	35
Cable Procurement		0		440		400
Totals	6.95	144	23.26	2125	25.25	2185
k$		**1298**		**5986**		**6377**

Summary

Proposed funding profile is modest given program goals

- We must maintain expected funding and base program support in order to be successful

The program integrates resources of the three labs and balances effort

- Broad-based R&D to establish a firm technological foundation and provide a variety of options
- Focused development to achieve LHC priorities