


# Magnet Supporting R&D
# status of FY05 tasks
# plan for FY06 and …

LARP Collaboration Meeting,
Port Jefferson, 4/6-8/05
G. Ambrosio

# Supporting R&D – FY05

- **Small Quad re-assembly and test (SQ01b) – DONE**

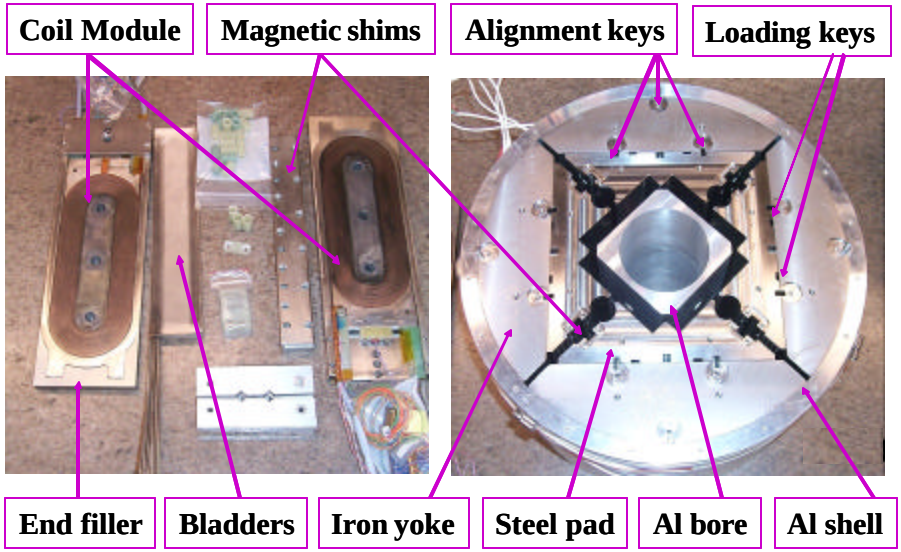
  S. Feher talk:

  Successful test,

  Successful collaboration LBNL-FNAL

  Test report released

  Two abstract submitted to MT18




- **Small Quad fabrication and test (SQ02) – Q3,Q4**

  P. Ferracin talk

- **Preparation of FY06 tasks**

  Thursday talks

# The beginning of FY06 planning

After the 3rd LARP Collaboration Meeting we

- selected some topics on which we should focus the Supporting R&D for the LARP magnets
- assigned each topic to one or more "topic leader" with the goal to:
  - generate their best plan to address each topic
  - aiming at "clear results" (i.e. select/design the mechanical structure based on the goal and not the opposite)
- had several informal meetings and a videoconference to discuss the proposals and generate task sheets.

| | |
|---|---|
| • Long magnet study | Nicolai Andreev (FNAL), Scott Bartlett (LBNL) |
| • High prestress | Nicolai Andreev (FNAL), Paolo Ferracin (LBNL) |
| • End preload | Paolo Ferracin (LBNL), Igor Novitsky (FNAL) |
| • Training studies | Shlomo Caspi (LBNL), Nicolai Andreev (FNAL) |
| • Impregnation with rad-hard mat. | Giorgio Ambrosio (FNAL), … |
| • Quench protection studies | Paolo Ferracin (LBNL), … |
| • R&D for open midplane dipole | Jesse Schmalze (BNL) |

# Supporting R&D – tasks for FY06 and …

| | |
|---|---|
| **SUPPORTING R&D** | Ambrosio (chair) |
| 1000 Report LARP-CARE Insulation Meeting | Mattafirri |
| 1015 Long Magnet Scale-up Meeting Report | Ambrosio |
| 1030 break - 1/2 hr | |
| 1100 Long magnet R&D with racetrack coils | Sabbi |
| 1110 R&D for long W&R coils | Anerella |
| 1120 Tech. dev. for long Nb3Sn coils and magnets | Andreev |
| 1135 Tech. dev. with sub-scale quadrupole | Ferracin |
| 1150 Max coil stress with sub-scale coils | Ferracin |
| 1205 – 1230 Discussion | All |

# $Nb_3Sn$ Magnets Rad-Hard Insulation, FY06 Proposal

Proposed by Sara Mattafirri, LBNL

*Main Objectives and Features, FY06*

Development of Insulation Procedures for new rad-hard materials ( on long cable stack samples) and fabrication of cable stacks samples

Test of mechanical (shear strength and Young Modulus along radial and azimuthal direction), electrical and heat transfer properties

Assessment of peak dose (range), radiation type and energy spectrum absorbed by the insulation

Optimization of irradiation experiment and residual dose rate assessment (conceptual)

Gas evolution effects on magnet operation -- to determine eventual failure mode and effects on re-training of the magnet-- (experiment planning)

Sub-scale coil fabrication as proof of principle test (selected insulation)

*Work Plan and Schedule*

| | | | |
|---|---|---|---|
| Material & Tooling procurement | | 12/01/2005 | |
| Procedure development and cable stacks fabrication | 03/01/2005 | | |
| Tests | | | 07/01/2005 |
| Radiation damage conceptual studies | | 10/01/2006 | |
| Irradiation experiment planning | | 10/01/2006 | |
| Sub-scale coil fabrication | | 10/01/2006 | |

*Budget:*

M&S + Labor: 25 k$  FTE: 1

# FY07

*FY07 Statement of Work, Preliminary*

- Test of sub-scale coil insulated with selected rad-hard material (to be performed in sub-scale quadrupole magnet)
- Insulation radiation damage studies:
  - Irradiation of insulated cable stacks (selected insulation materials)
  - Post irradiation Tests (mechanical, electrical, heat transfer properties)
  - Test of gas evolution *effects* on magnet operation (to assess eventual failure mode, and impact on re-training)


# Technology development with subscale quadrupoles

Paolo Ferracin

LARP Collaboration Meeting
Port Jefferson
April 6 - 8, 2005

# SQ02 goals, schedule and cost (FY05)

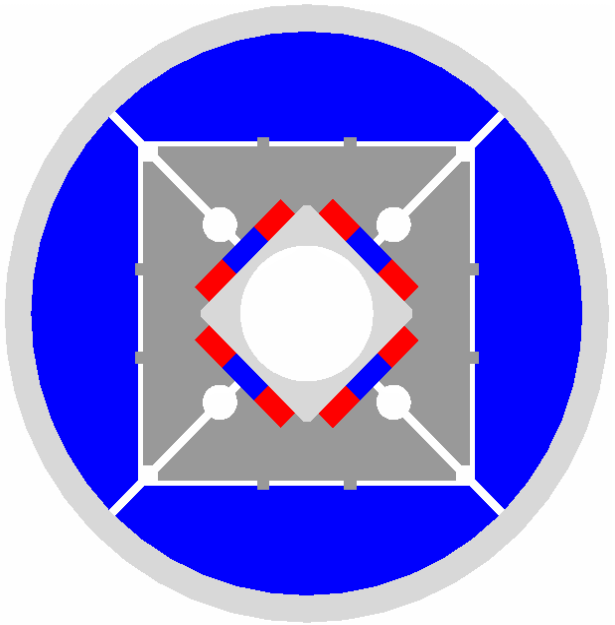
Goals

- Fabricate four new coils
- Test SQ02
  - Training / quench performance
  - Quench propagation experiment
  - Field quality measurements with four identical coils

Schedule

- Cable / coil fabrication
  - April / May
- Magnet assembly
  - June / July
- Test
  - August / September
- Design/data analysis
  - April / September

Total cost: 118 k$



# Effect of axial loading on training: Goals, schedule and cost (FY06)

Goal 1:

- Study the relation between magnet performance and end support, and validate mechanical model

Proposal

- Perform tests of SQ02 with different axial loading

Schedule

- SQ02: nominal axial loading
  - FY05
- SQ02b: 50 % of nominal axial loading
  - FY06, Q1
- SQ02c: no axial loading
  - FY06, Q2
- Data analysis
  - FY06, Q3/Q4

Total cost: 126 k$

# Quench studies:
# Goals, schedule and cost (FY06)

Goal 2:

Measure quench propagation velocity as a function of current and validate thermal model

Proposal

Perform heater induced quenches during SQ02 tests, analyze results and compare with computations

Schedule

Test of SQ02 / SQ02b / SQ02c

FY05-FY06

Data analysis and modeling

FY06, Q1/Q4

Total cost: 36 k$ + student

# Alignment of bladder / key structures: Goals, schedule and cost (FY06)

Goal 3:

Study alignment of magnet components and coils

Proposal

Analyze magnetic measurements performed during SQ02 tests

Schedule

Test of SQ02 / SQ02b / SQ02c

FY05-FY06

Data analysis and modeling

FY06, Q1/Q4

Total cost: 18 k$

# Maximum coil stress studies

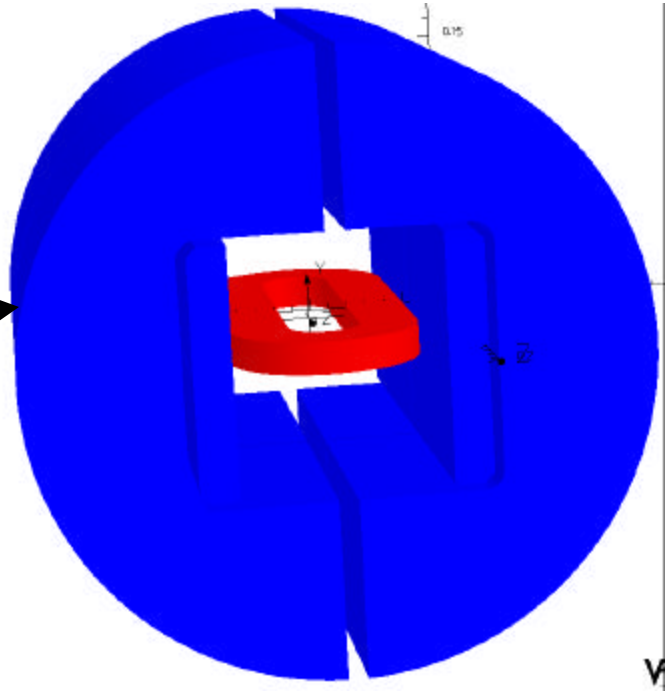
Goals:

- Evaluate stress limits for $Nb_3Sn$ coils
  - Permanent degradation of superconducting cable as a function of compressive stress
  - Realistic magnet conditions

Proposal

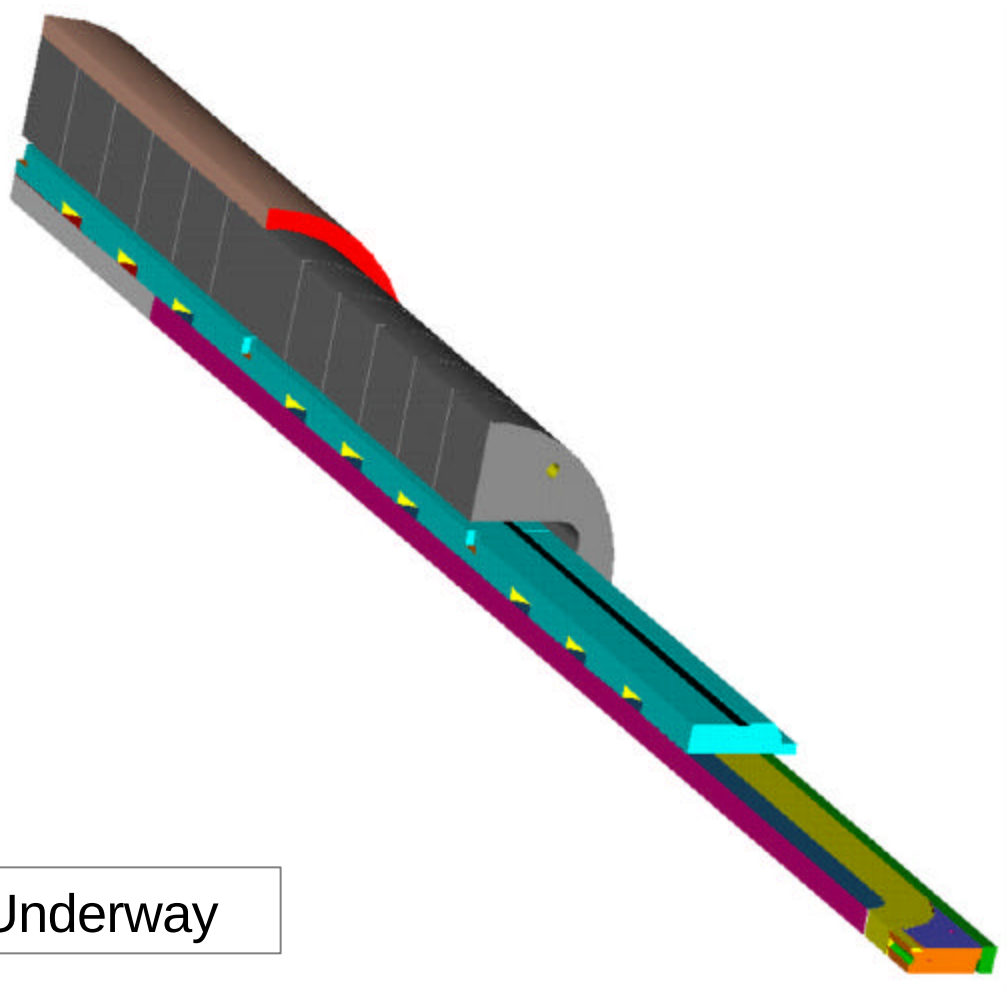
- SQ02
  - Peak field in the ends
- Subscale dipole
  - Same field ends – straight section
  - Total cost design → test: 143 k$
- HD1
  - Peak field in the straight section

Additional studies required to choose best option



# LC Structure Cost (Common Coil)

G.L. Sabbi, S. Bartlett



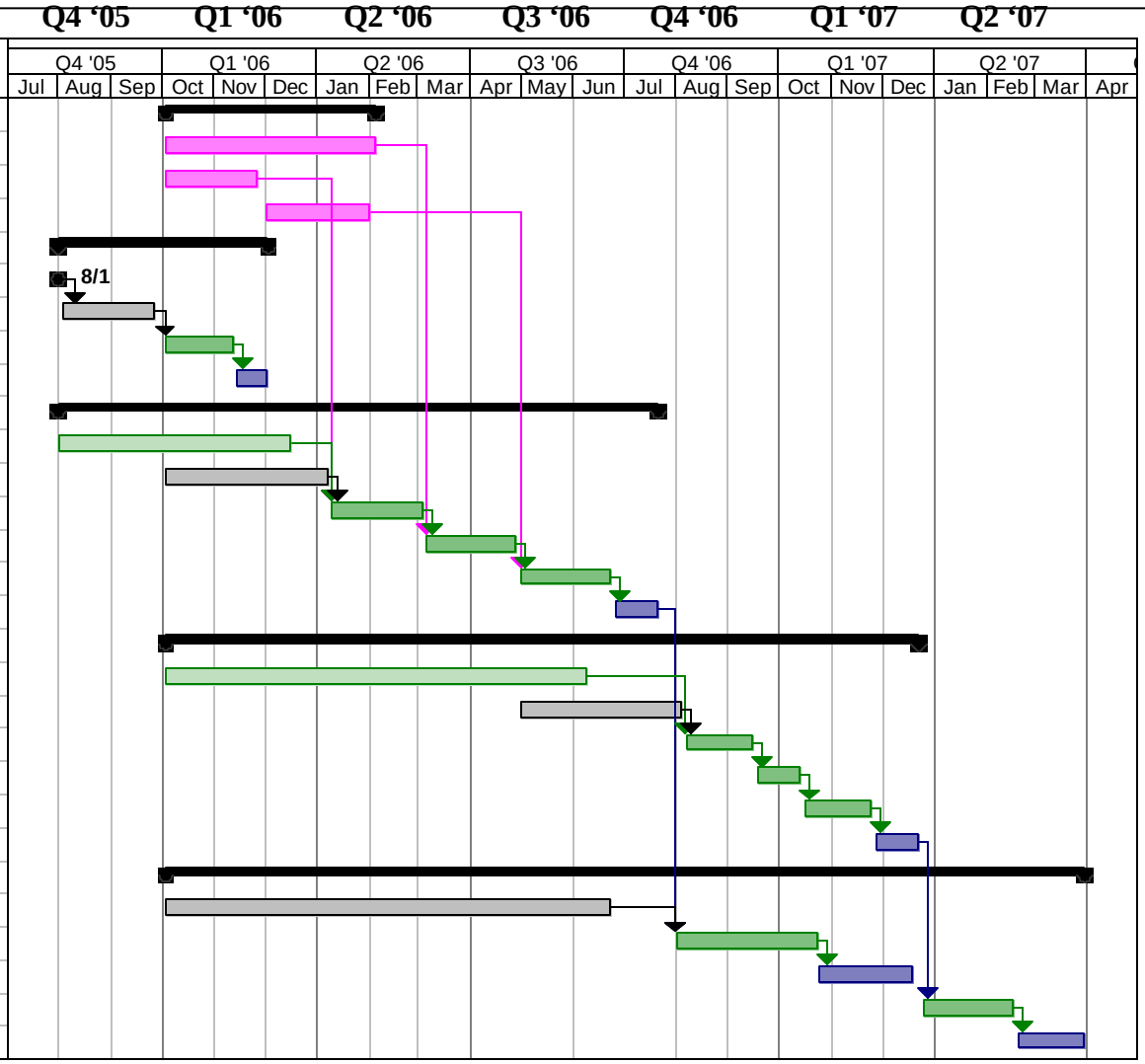
Preliminary Cost Analysis

Shell…….$7K
Yokes…….. $8K
Load Pads……..$6K
Bladders…….$2K
Total……$23K

4 Meter SQ Cost Analysis Underway

# Long SC Accelerated Schedule

| ID | Task Name |
|---|---|
| 1 | **Infrastructure** |
| 2 | Reaction Oven |
| 3 | Coil Winder |
| 4 | Potting Vessel |
| 5 | **LC Design Validation** |
| 6 | LC Design Review |
| 7 | SC conductor/parts |
| 8 | SC fabrication/assembly |
| 9 | SC test (common coil) |
| 10 | **LC01-LC02** |
| 11 | Conductor & cable |
| 12 | Tooling & parts |
| 13 | Winding |
| 14 | Reaction |
| 15 | Potting |
| 16 | Evaluation |
| 17 | **LC03-LC04** |
| 18 | Conductor & cable |
| 19 | Tooling & parts |
| 20 | Coil Winding |
| 21 | Reaction |
| 22 | Potting |
| 23 | Evaluation/Test |
| 24 | **LC Structure** |
| 25 | Parts |
| 26 | LC01-02 assembly |
| 27 | LC01-02 test |
| 28 | LC01-02 assembly |
| 29 | LC01-02 test |



# $Nb_3Sn$ Dipole in Mirror Configuration – Cheapest Way for Long Coils Study.

N. Andreev

**Front view of Fermil magnet HFDM-04.**

design uses a one half-coil
iron half-cylinder as a
mirror to produce the
dipo

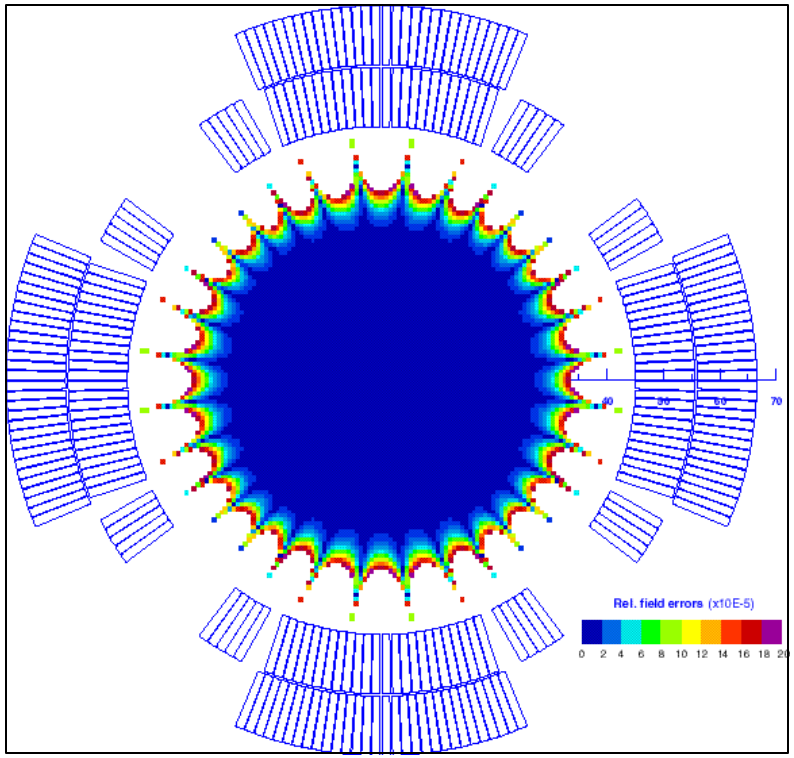
Advantag irror configuration :

- It minim nductor volume.
- It allows long shell-type coils
- It uses av e coil winding and curing to winding tables, andre sses, etc.).

ha tructure and tooling
m long and for long
long magnets.

# TQa coil – Good Candidate for LARP Long Coil Study

N.Andreev




Coil:

- 2-layer shell-type
- Inner-layer wedges
- Inner-layer pole glued into the coil

Cable:

- Strand – Nb3Sn, 0.7 mm
- Number of strands – 27
- Keystone angle – 1 deg
- Width – 10.05 mm
- Thickness – 1.26 mm

Insulation: 0.125 mm.

# Cost Estimates

Cost estimates for shell-type TQ quad coils
and shell-type HFDA dipole coils is summarized in Table

| Parameter | TQa | TQa | Mirror | Mirror |
|---|---|---|---|---|
| Coil length, m | 2 | 4 | 2 | 4 |
| Cable cost, k$ | 110 | 220 | 25 | 50 |
| Coil & Magnet parts, k$ | 115 | 160 | 12 | 42 |
| Tooling modification, k$ | 25 | 100 | 23 | 72 |
| T&D Labor cost, k$ | 450 | 550 | 144 | 173 |
| Total cost, k$ | 700 | 1,030 | 204 | 337 |

Cost of Long Furnace is not included.

# Supporting R&D at BNL

M. Anerella

Goals: develop in-house expertise to support LARP program

- 0.5M coils for initial learning (existing infrastructure; tooling, oven, etc. – no equipment needed)
- 1M coils (moderate tooling only - no oven needed)
- 4M coils (need new oven & equipment)

# List – Major Tools and Equipment Needed, Status

Existing:

1. Winding Machine
2. Curing Station
3. Vertical Testing Equipment, Dewar*

to be extended later for 1M, 4M coils

***** Dewar already has capacity for 4M coils

Needed:

1. Reacting mandrel & associated equipment
2. Reacting oven (buy vs. share)

# Conclusions… for now

Very successful collaboration meeting, showing a stronger collaboration among the three labs and flexibility in responding to new requests

These tasks were generated before the rethinking of magnet program priorities (up to FY09) caused by L. Rossi's letter and the roundtable discussion on long magnet R&D at CERN

➔ in the next couple of weeks we are going to rearrange the Supporting R&D plan giving the highest priority to the R&D for long coils and long magnets

- test of 1st 4m small coil ASAP (BNL and LBNL)
- start the fabrication of practice coil for the 4m long quadrupole (2 layer 90mm aperture) ASAP (FNAL)

➔ We will generate a bottom up plan for these tasks

➔ Remaining budget and resources will be distributed among the other tasks

# Magnet R&D FY05-FY09

| | Length [m] | Aperture [mm] | FY05 | FY06 | FY07 | FY08 | FY09 |
|---|---|---|---|---|---|---|---|
| **Model Magnets** | | | | | | | |
| **Quads** | | | | | | | |
| Reduced Gradient (costheta) | | 90 | | X X | | | |
| Full gradient (costheta) | 1 | 90 | | X | X | X | |
| Large Aperture Quad | 1 | ~120 | | | X | X X | X |
| Field quality | 2 | | | | | | X X |
| Full length, full gradient | 4 | | | D | D | X | X |
| **Dipoles** | | | | | | | |
| Open mid-plane PoP | 1 | | | | | X | X |
| **Supporting R&D** | | | | | | | |
| Sub-scale tests | | | X X | X X | X X | X X X | X X |
| Long coil tests | | | | | X | X | |

**CERN request: successful long quad by 2009**

"*The manufacturing of a successful prototype for 2009 is real vital to the whole magnet program, on both side of the Atlantic*"