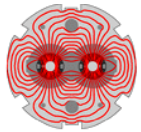


US LHC Accelerator Research Program

bnl - fnal- lbnl - slac

LARP Joint IR Studies

A. Zlobin, Fermilab

CARE-HHH-APD
Mini-Workshop IR'07
Frascati (Italy), November 7-9, 2007

Introduction

What are JIRS?

- LARP "Joint IR Studies" begin in FY08, extending and bringing together connected tasks that were previously situated either in Accelerator Systems or in Magnet Systems.
- JIRS tasks are placed under LARP Program Management
  - improve efficiency and communication between tasks and with CERN.

Why now?

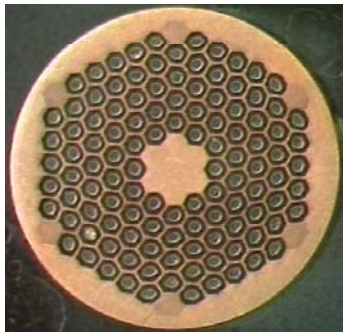
- Significant progress in accelerator magnet R&D in U.S.
  - LARP
  - Core programs

Nb3Sn Technology R&D in U.S.

Nb3Sn strand:

High-performance strand produced by OST

- 127 design – available
- 217 design – work in progress



Coils:

More than 50 1-m long Nb3Sn dipole and quadrupole coils were fabricated and tested in 6 dipole and 7 quadrupole models, several dipole mirror and racetrack configurations

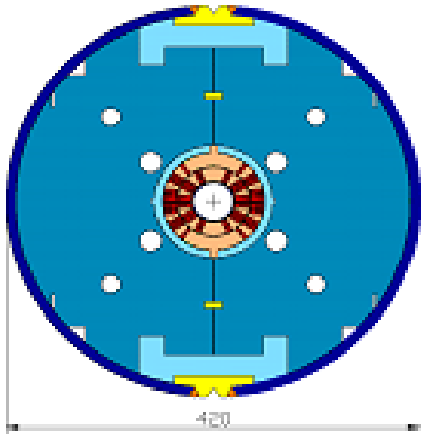
- good reproducibility
- fabrication time and cost comparable with NbTi coils
- multiple reassembly without degradation
- transportation across the country

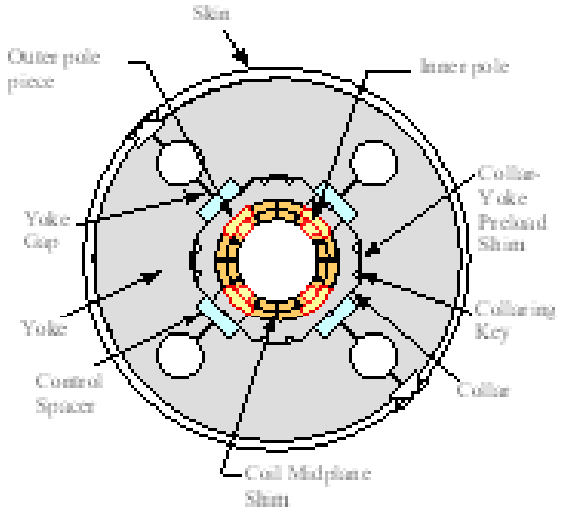
Mechanical Structures

The traditional collar-based structure and new shell-type structures (with both SS and Al shells) and assembly procedures for Nb3Sn dipole and quadrupole coils were developed and tested

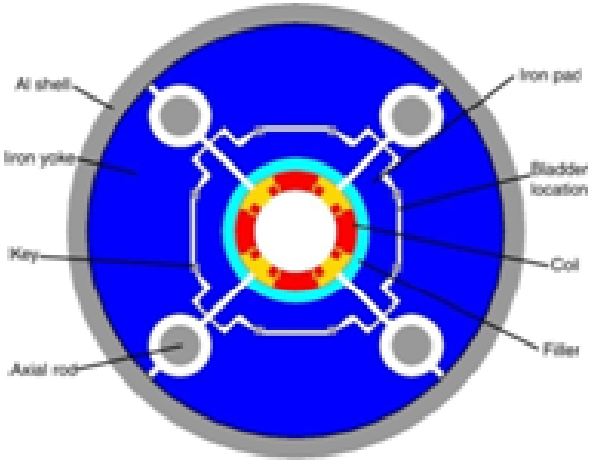
- coil pre-stress up to 150+ MPa
- Robust reproducible assembly procedures.

Stainless Steel Shell (Fermilab)





Aluminum Shell (LBNL)

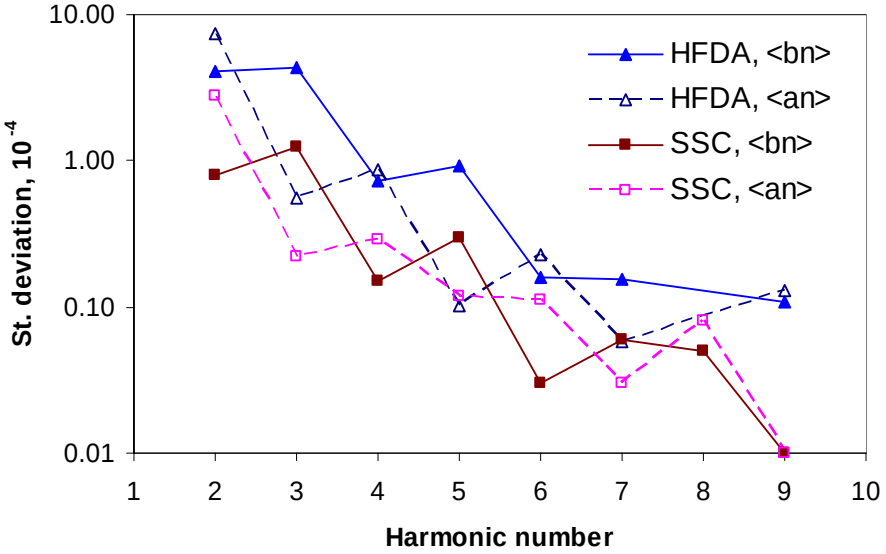


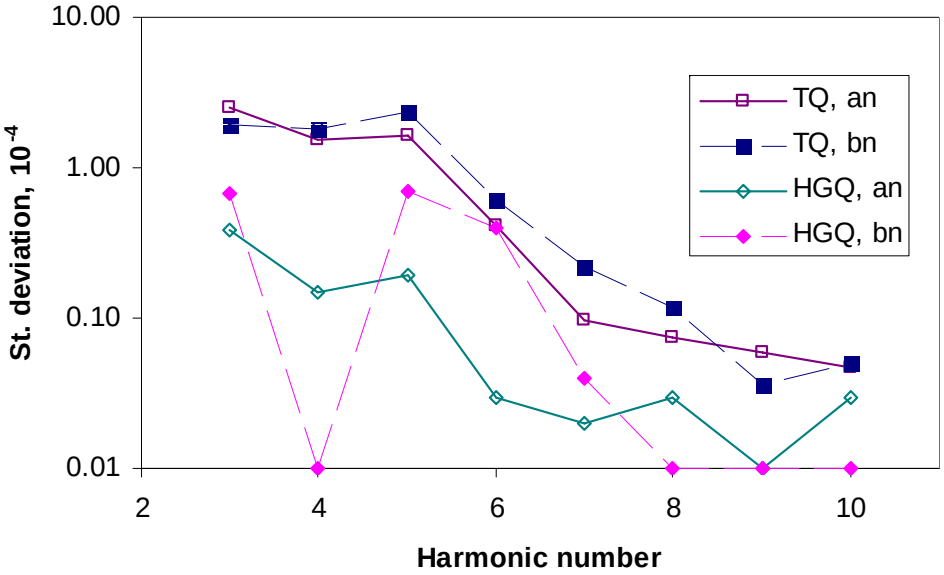
Nb3Sn Model Maget Performance

The design field of 10-16 T was reached in several dipole, quadrupole and racetrack short models (BNL, Fermilab, LBNL).

The possibility of reaching accelerator field quality in Nb_3Sn dipoles and quadrupoles was demonstrated

- 6 1-m long cos-theta dipole models (HFDA, Fermilab)
- 4 1-m long cos-2theta quadrupole models (TQ, Fermilab/LBNL)





Nb3Sn Technology Scale Up

Nb3Sn accelerator magnet technology scale up was successfully started

- 2-m long cos-theta coil (Fermilab, June 2007)
- 3.6-m long racetrack coils (BNL/LBNL, July 2007).
- 4-m long cos-theta coil has been assembled into a mirror configuration and will be tested in November 2007 (Fermilab)
- Next step: LARP 4-m long quadrupoles of TQ series (BNL/FNAL/LBNL).

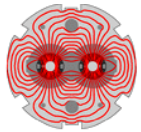
JIRS Focus

In FY08-09 LARP Magnet R&D will focus on:

- LQ series - the goal to demonstrating the viability of long (up to 4-m) Nb3Sn quads.
- HQ series - the goal to extend parameter space to higher fields and apertures.

After FY09 LARP Magnet R&D will focus on the development of Nb3Sn *accelerator* magnets suitable for Phase-2 upgrade

- need joint (integrated) studies of accelerator and magnet experts.



JIRS Mission and Tasks

JIRS are mostly concerned with the post-LQ magnet series:

- ✓ QA quadrupole – accelerator quality magnet.
- ✓ QB quadrupole – Phase 2 upgrade magnet.
- ✓ "Slim" magnets in front of Inner Triplets.

The framework of JIRS is determined by ***The mission of LARP "Joint Interaction Region Studies"*** **.**

FY08-09 Joint IR Studies tasks and Task Leaders

3.3 Joint IR Studies – Alexander Zlobin (Fermilab)

3.3.1 Simulation

3.3.1.1 Operating Margins - Nicolai Mokhov (Fermilab)

3.3.1.2 Accelerator Quality & Tracking - Guillaume Robert-Demolaize (BNL)

3.3.2 Studies

3.3.2.1. Optics & Layout - John Johnstone (Fermilab)

3.3.2.2. Magnet Feasibility Studies - Peter Wanderer (BNL)

FY08 budget 320k$.

QA quadrupole

1. Define and evaluate a list of potential QA locations in LHC in full communication with CERN
   - Q1-3 in a potential Pase-1 “hybrid” upgrade
   - quadrupoles vulnerable to accidental radiation in the collimation region
   - etc.
2. Develop specifications for the accelerator-quality parameters of QA magnets
   - Aperture, gradient, alignment, field quality, persistent current fluctuations, snap-back, power supply regulation, etc.
3. Examine the possibility of using LQ or HQ- derived designs and tooling to build QA magnets.
4. Identify bench tests on QA (or LQ or HQ) magnets that would help to explore and demonstrate Nb3Sn accelerator magnet performance (except radiation)
   - could be done by LARP within Magnet Systems or at CERN.

QB Quadrupole

1. Perform preliminary paper and computer magnet studies to generate a self-consistent set of “best guess straw man ” parameters for QB magnets, including all possible accelerator quality parameters, based on 1 (or more) upgrade scenarios
   - guide magnet studies, well before CERN definitively states the QB length(s), aperture, gradient and peak coil field.

2. Use straw man design and accelerator-quality parameters to estimate and simulate correction system parameters and possible issues, in a QB implementation.

Slim magnets

1. List and evaluate preliminary parameters (aperture, length, OD, field/gradient, field quality, alignment, etc.) and operation conditions (radiation deposition, forces and fields from detector magnet, dynamic and static heat load, etc.) for slim magnets located inside ATLAS and/or CMS.

2. Evaluate the usefulness of conventional NbTi technology, or of alternative magnet technologies (Nb3Sn, Nb3Al or HTS) in terms of operational margin, magnet life-time, etc.

Crab cavities

Crab cavity R&D fits naturally into the LARP mission statement, and LARP could be the basis for U.S. participation in this strategic emerging enabling technology.

LARP would like to take a significant role in crab cavity R&D, with explicit support from CERN and the DOE.

Initial JIRS activities do not include crab cavity issues, despite that fact that LARP is coming to participate modestly in a crab cavity collaboration between many labs.

A Crab Cavities task may be hosted inside JIRS at some point in the future, for example in FY09.

Phase-1 Upgrade

Lucio Rossi proposed that the U.S. participate in the Phase-1 Interaction Region (IR) upgrade, nominally scheduled for 2012

- U.S. would provide 4 or 8 Nb3Sn quadrupoles out of the 16 new magnets required, with the complement of NbTi quadrupoles made at CERN.

The hybrid proposal is an exciting challenge for LARP

- recognition of success of Nb3Sn accelerator magnet R&D in U.S.
- needs careful evaluation and detailed discussion between CERN, DOE and LARP before any commitment can be made
- any delivery of Nb3Sn magnets would need additional funding to a construction project separate from LARP
- some LARP R&D re-programming will be necessary with a modest funding increase beyond current LARP budget.

JIRS role

LARP will immediately start evaluation of the development and delivery of ***Nb3Sn*** quadrupoles (or D1 dipoles?) for Phase-1 upgrade

- JIRS working group will evaluate accelerator upgrade performance parameters and requirements
  - CERN's "LHC Insertions Working Group" (LIUWG) is evaluating all aspects of the Phase-1 upgrade
  - JIRS will maintain broad and unrestricted communications with LIUWG, but will work independently
    - need an effective, mutually acceptable format of communication
- The cost and schedule analyses of the hybrid proposal will be presented to the DOE review in June 2008, at about the same time that the report from the LIUWG becomes available.
- A final commitment to U.S. deliverables in a hybrid Phase-1 upgrade will occur after a technical review including the magnet cost and schedule.

Summary

JIRS will guide LARP magnet R&D towards its ultimate goal – LHC Phase-2 upgrade based on Nb3Sn accelerator magnets.

JIRS work will proceed in close communication with the AB and AT divisions at CERN

- the LARP goal is to pursue magnet R&D and to suggest magnet parameters, without unduly favoring one or another Nb3Sn upgrade design proposal
- CERN will definitively state upgrade parameters, on a timescale that may be informed by, but will not driven by, the LARP magnet R&D schedule.

JIRS primary focus in FY08 is to evaluate the possibilities of LARP contribution to the LHC Phase-1 upgrade.