Development of A High Field Magnet for Neutrino Factory Storage Rings

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Guiding Principles:

- Decay products clear s.c. coils
  - Flat coils with open midplane gap
- Minimize environmental impact
  - High field magnets, efficient design

Technical Issues:

- Brittle High field superconductors
  - Nb₃Sn “React & Wind” Technology
- Large Lorentz forces
  - Support structure for various configurations
  - An integral design for dipole & quadrupole
- Large heat leak
- Compact cryostat
- Tooling design for magnet
- Magnet test configuration setup
**Past Progress and Future Plans**

**FY 2001**
- Innovative magnet and machine design concepts developed
- Initial engineering design for 8T (machine magnet) & 4T (free SC)

**FY 2002 (first half)**
- Magnetic design for machine & test magnet (8 T & 4 T) completed
- Structural analysis for test and machine magnet performed
- Engineering design of the magnet and cryostat assembly completed
- Superconducting wire received; cable is being manufactured
- Tooling design for winding and impregnating coil nearly completed
- Magnet test setup design completed

**FY 2002 (second half)**
- Complete remaining tasks and wind coils

**FY 2003 (early part)**
- Test magnet in various configurations to prove the design
Structural Analysis for Machine Magnet (8T)

Finite Element Analysis of the Support Structure

Maximum Deflection in the coil < 10 mil

Maximum Stress in S.S. < 50 kpsi
Attractive (dipole configuration) and repulsive (quadrupole configuration) vertical forces are taken by support keys (posts).

Must balance between heat leak and deflections (after basic design and materials are carefully selected). Estimated heat load ~ 7 W.

Support keys (posts) are designed for 8 T machine magnet.

However, in 4 T test magnet, the number and length are reduced to test the influence of similar deflections as in 8 T machine magnet.
Prototype Coil and Coldmass Assembly

Two double-pancake Nb3Sn coils
(A lot of similarities to 10 turn coil program)

Prototype coldmass
We are testing the performance under various force conditions!

Magnet system layout in the proposed V factory storage ring:

- Reverse Coils
- Skew Quad
- Normal Coils
- Dipole
- One Coil
- 1/2 & 1/2

**Note:** Errors get automatically cancelled

From normal coil

From reverse coil

b2 error thru the ends

-150
-100
-50
0
50
100
150
0 100 200 300 400 500 600 700 800 900 1000

Dipole/Quad test setup (switch relative current direction)

Staggered coil setup

New Magnet System Design

> Good field quality
> Makes storage ring small

Important for BNL site
Similarities between the test magnet and 10-turn coil program

- ITER Nb$_3$Sn (brittle) superconductor
- React and wind technology
- Flat racetrack coils
- Bend radius 80 mm Vs. 70 mm
- S.S. 26 cm Vs. 30 cm
- Vacuum impregnation, splice, etc.

Test Results: Quench performance measurements were limited by power supply. Reached > 85% of short sample. The magnet is now being prepared for another test with high current supply.

However, the conductor X-section and forces are much larger in the test magnet.

So while we learn a lot from the technology magnet, we build and wait for the results of the test magnet before drawing conclusions!