VLHC High Field Magnet Program at Fermilab

- Talk outline:
  - The Program Goals;
  - First Dipole Model Development;
  - Short Sample Test Facility - First Results;
  - Nb_3Sn Magnet Technology at FNAL
    - insulation study;
    - wire reaction site;
    - first mechanical model status

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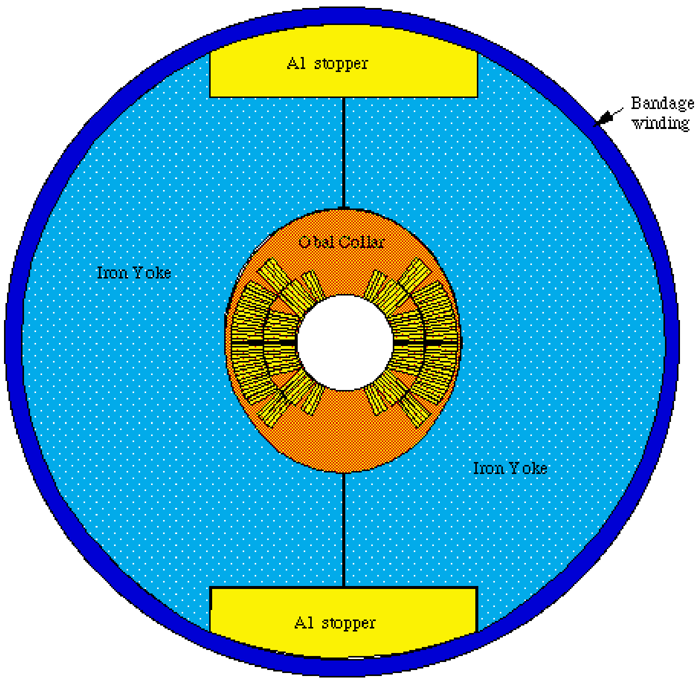
VLHC High Field Magnet Program Goals

- Program goal - to develop inexpensive High Field Magnet for VLHC.

- Short term goal - to develop, fabricate, and test Nb_3Sn, (10 - 11) T, short dipole model.

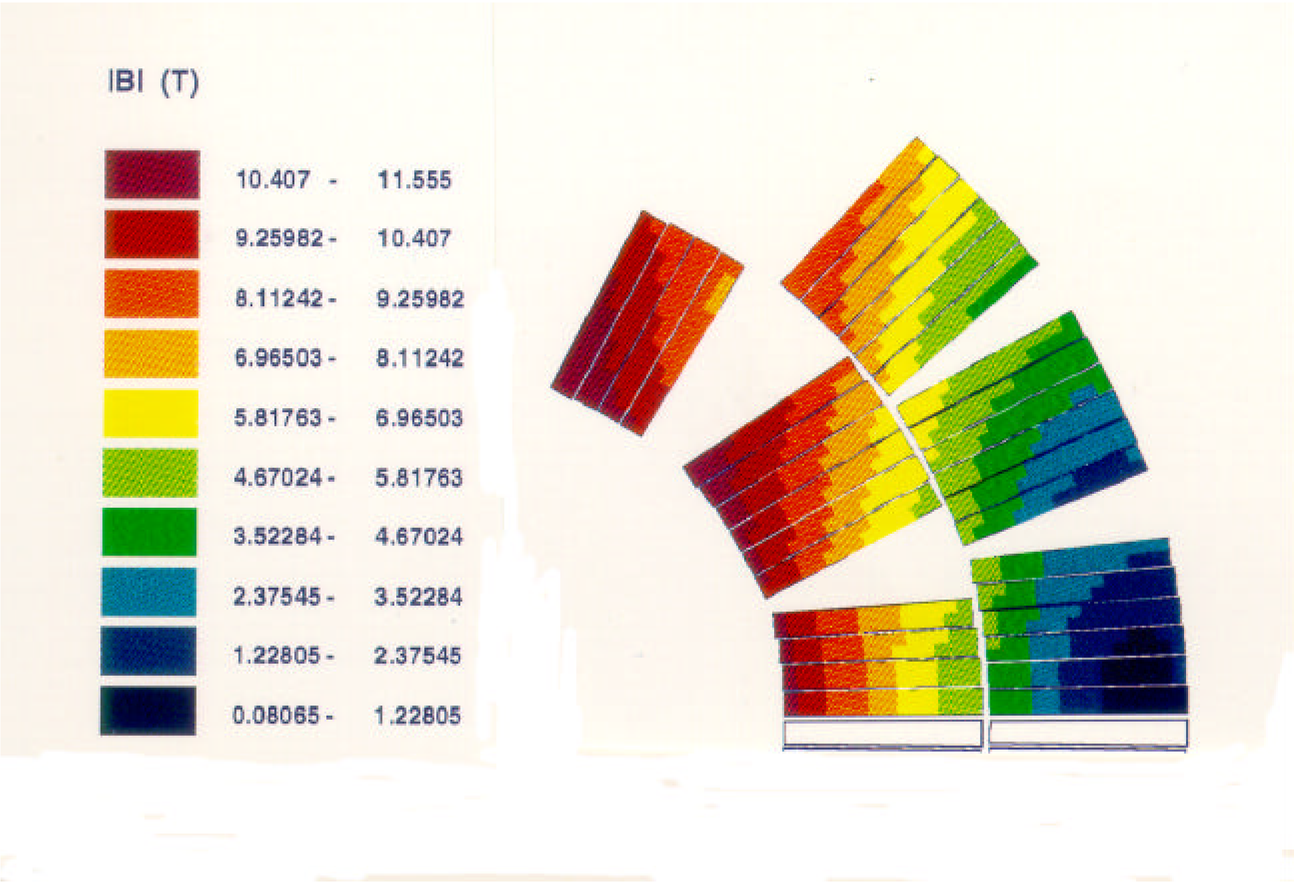
First Nb_3Sn Short Dipole Model



Magnet Parameters:

- two-layer shell design;
- Ø 50 mm bore;
- B = 11.8 T at 17.6 kA;
- $dB/B < 10^{-4}$ at $R < 1.5$ cm;
- length ~ 1 m

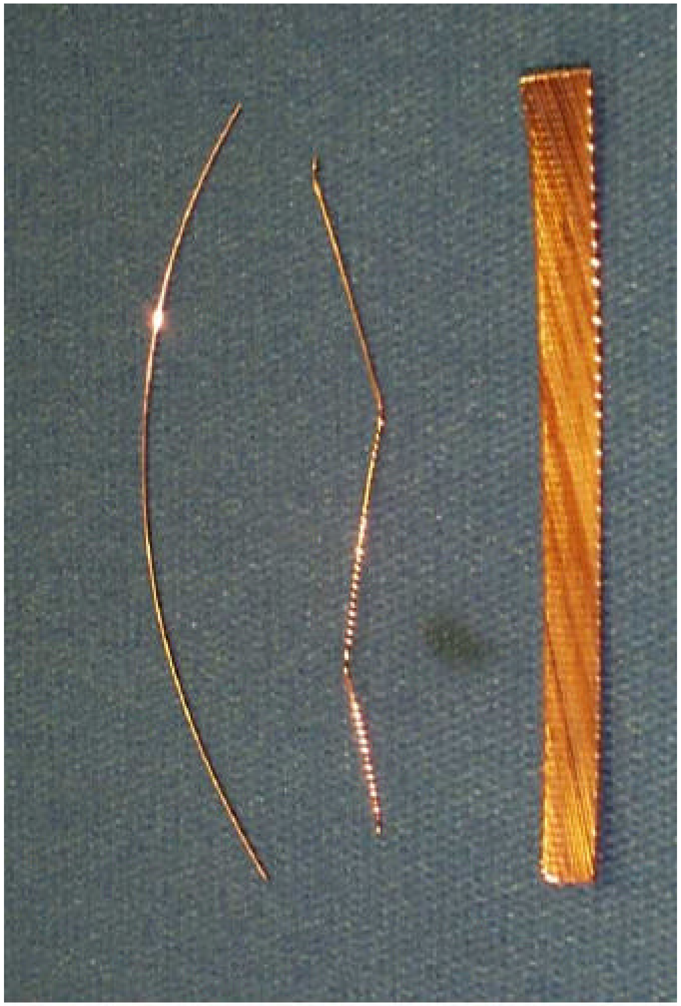
High Field Dipole Model Cross-Section



Bc = 10.8 T

b3 = -0.026
b5 = 0.0012
b7 = -0.00465
b9 = -0.254
b11 = 0.273
b13 = -0.0009

SC Strand and Cable



Strand: Nb_3Sn (IGC, IT), ø 1.00 mm

J_C (12 T, 4.2 K) = 1886 A/mm^2

Cable: N = 28,

(1.661 - 1.909) x 14.238 mm^2

- 20 kg of 1 mm strand was delivered in July

- 70 meters of cable are available now for sample testing.

- 75 kg of 1 mm strand is expected in January

Short Sample Test Facility
SSTF

Superconducting solenoid

* Central field: 15 T @ 4.2 K / 17 T @ 2.2 K
* Bore: 64 mm diameter

Variable temperature insert (VTI)

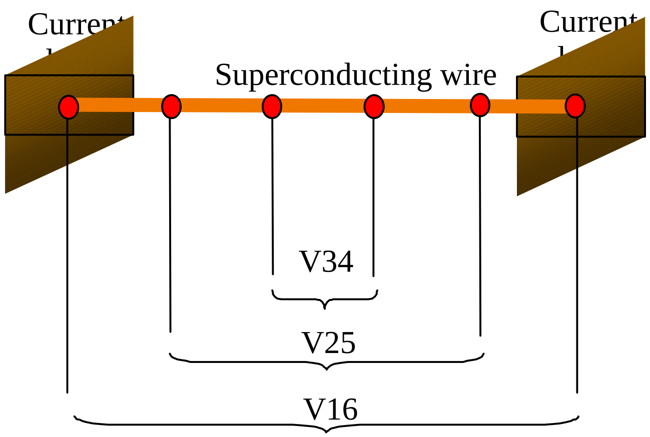
* Temperature range: 1.5 ÷ 200 K
* Bore: 49 mm

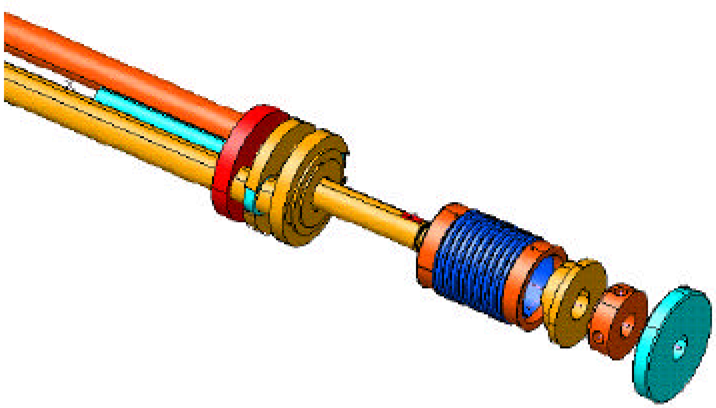
Current Leads

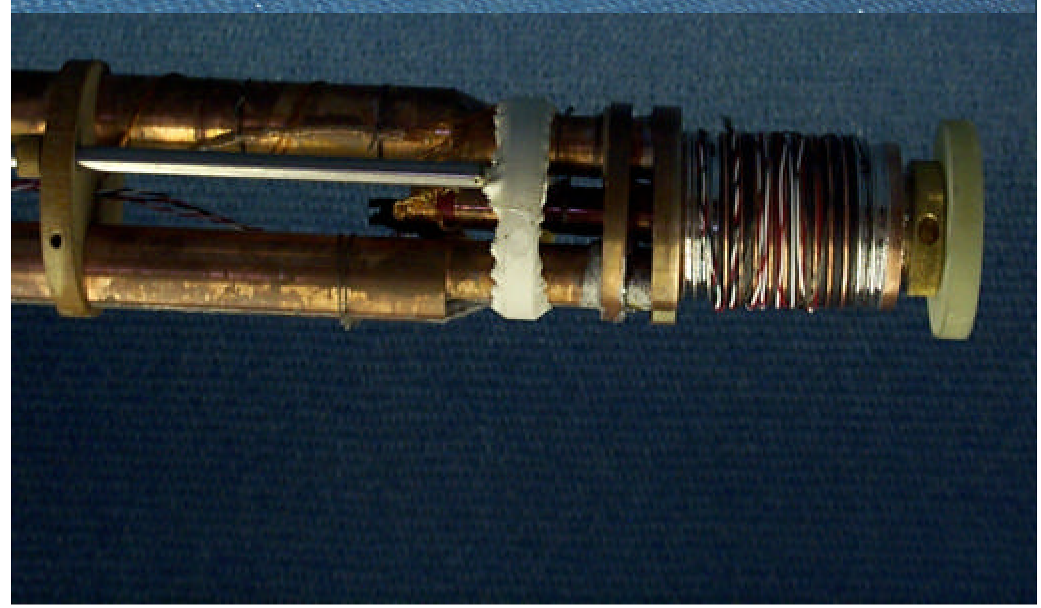
* 600 A DC
* 2000 A DC

SSTF

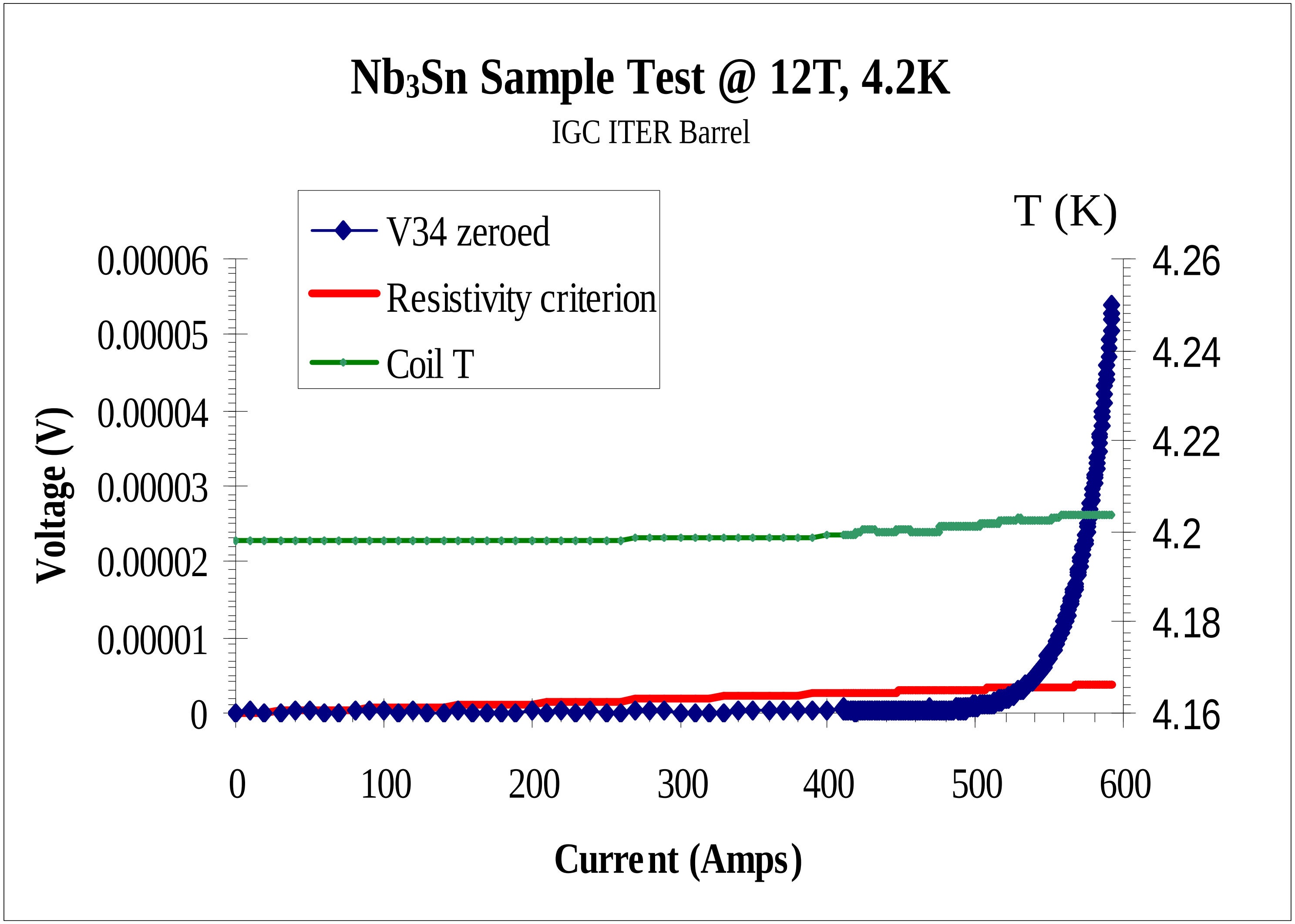
Sample Holders & Voltage Measurement



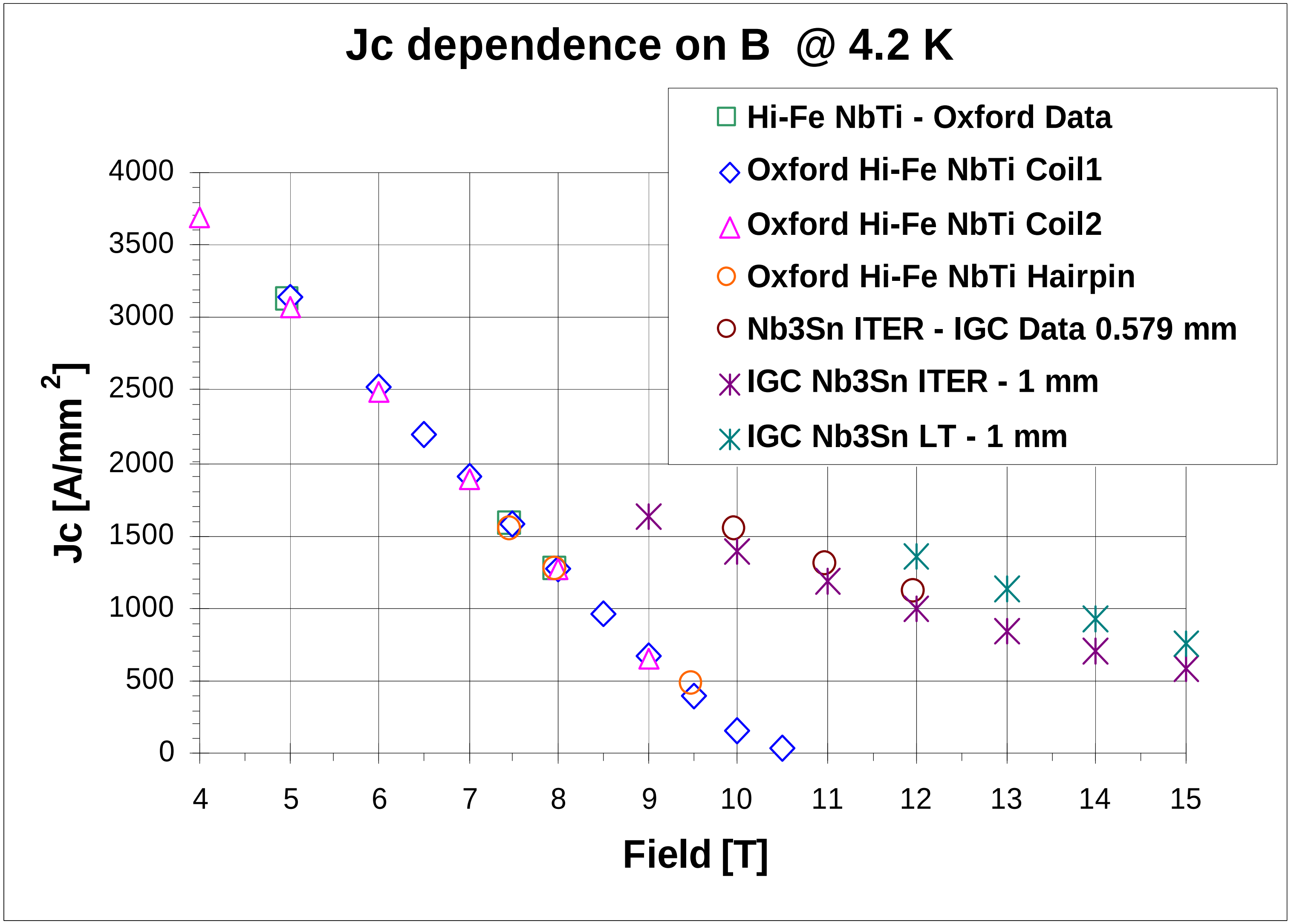




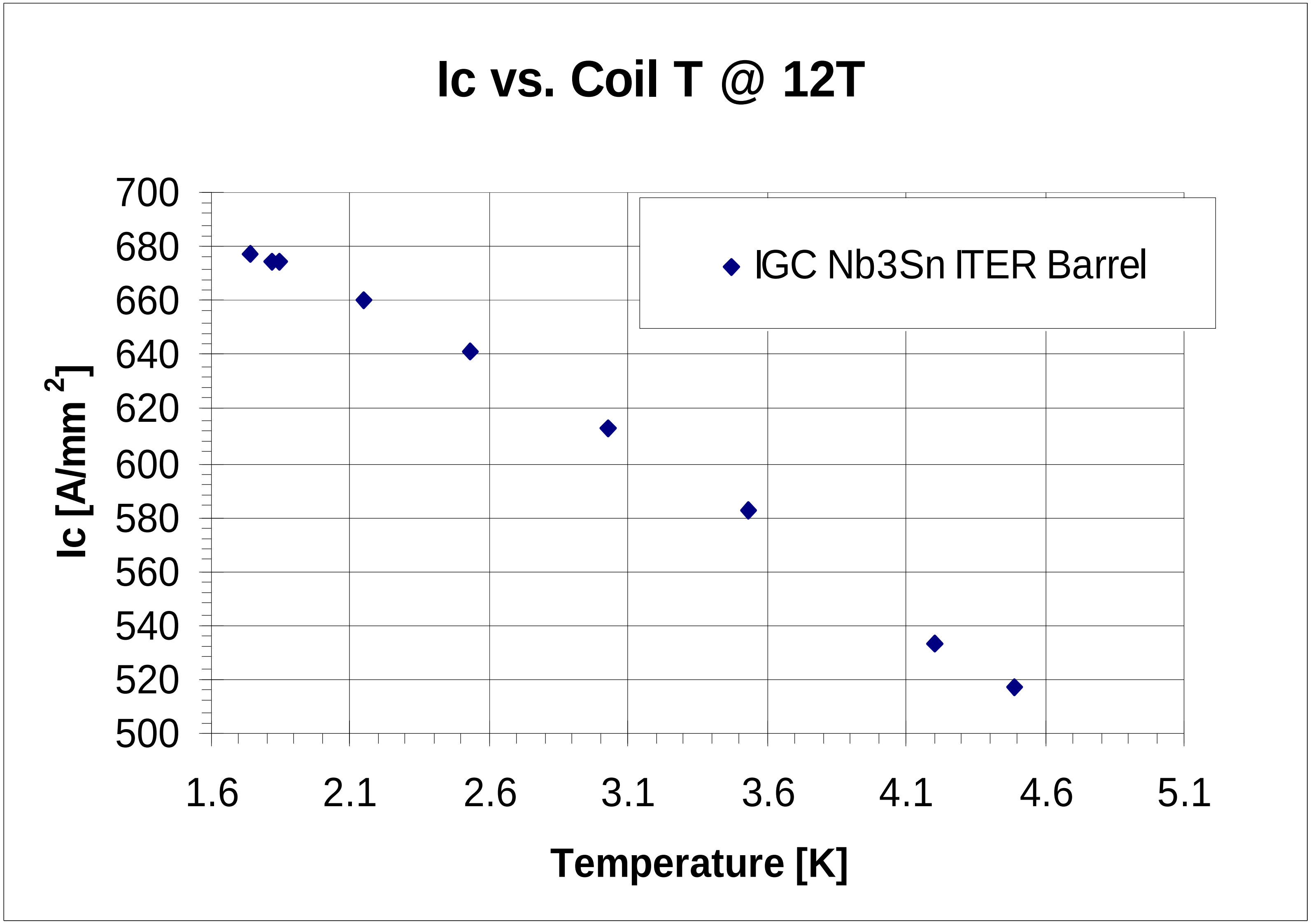
SSTF
Measurement Procedure



SSTF First Results



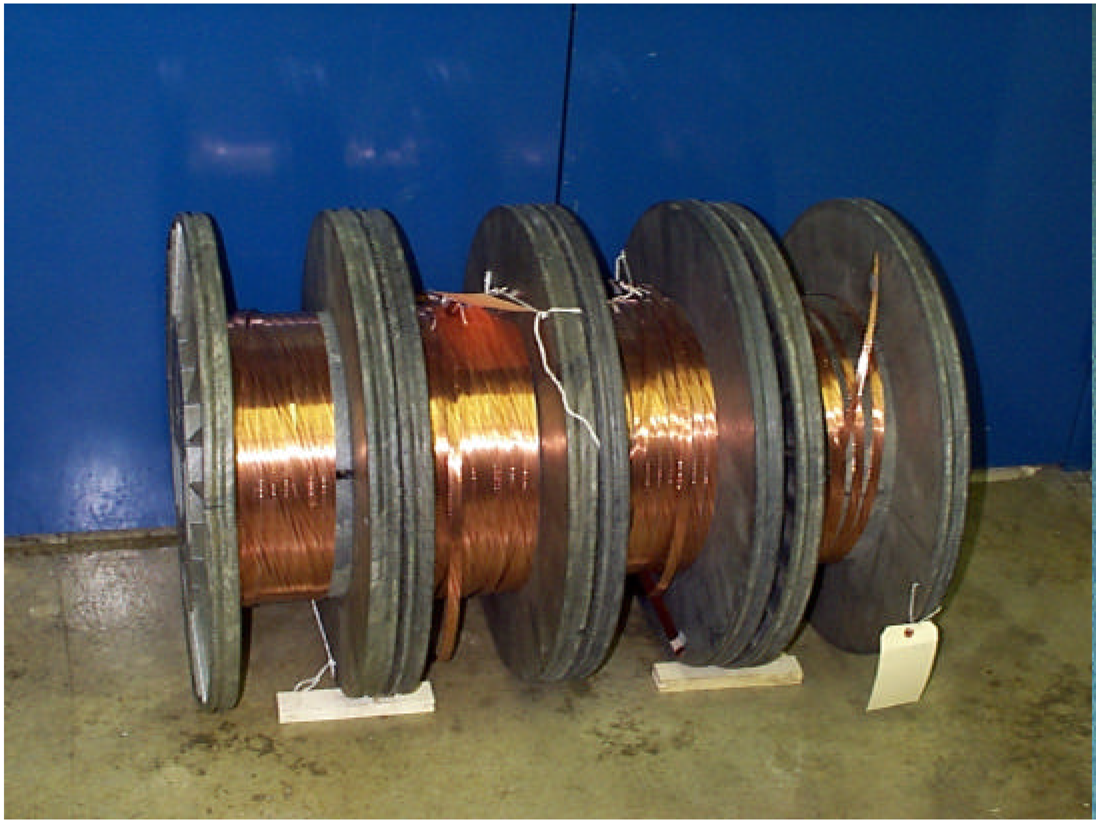
SSTF
Low Temperature Results

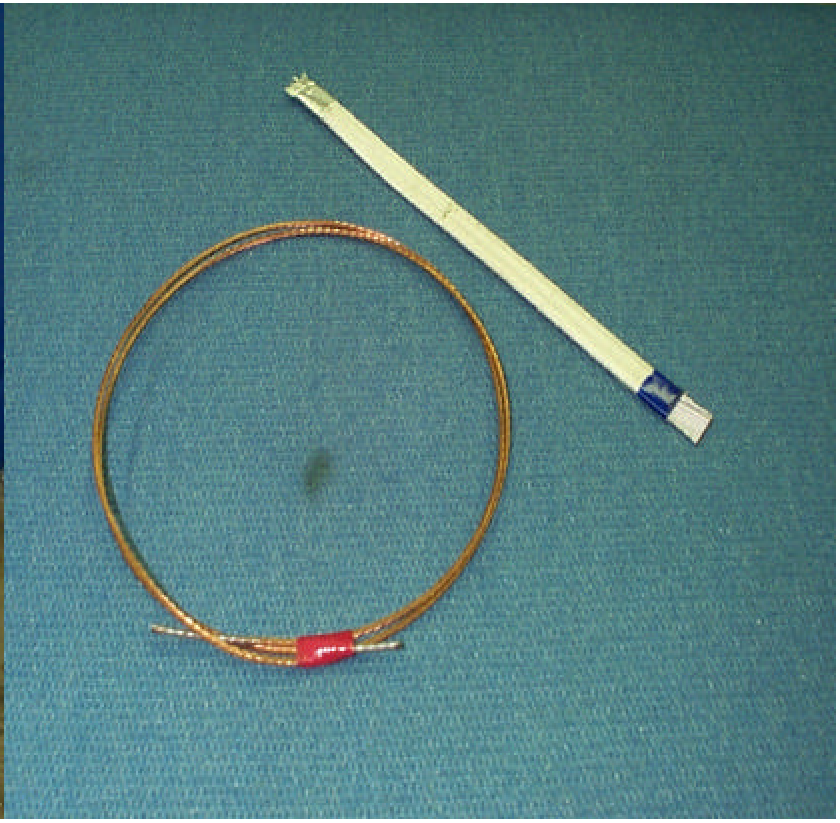


SSTS
Nearest Future Plans

I_C degradation vs Packing factor

A15 material study

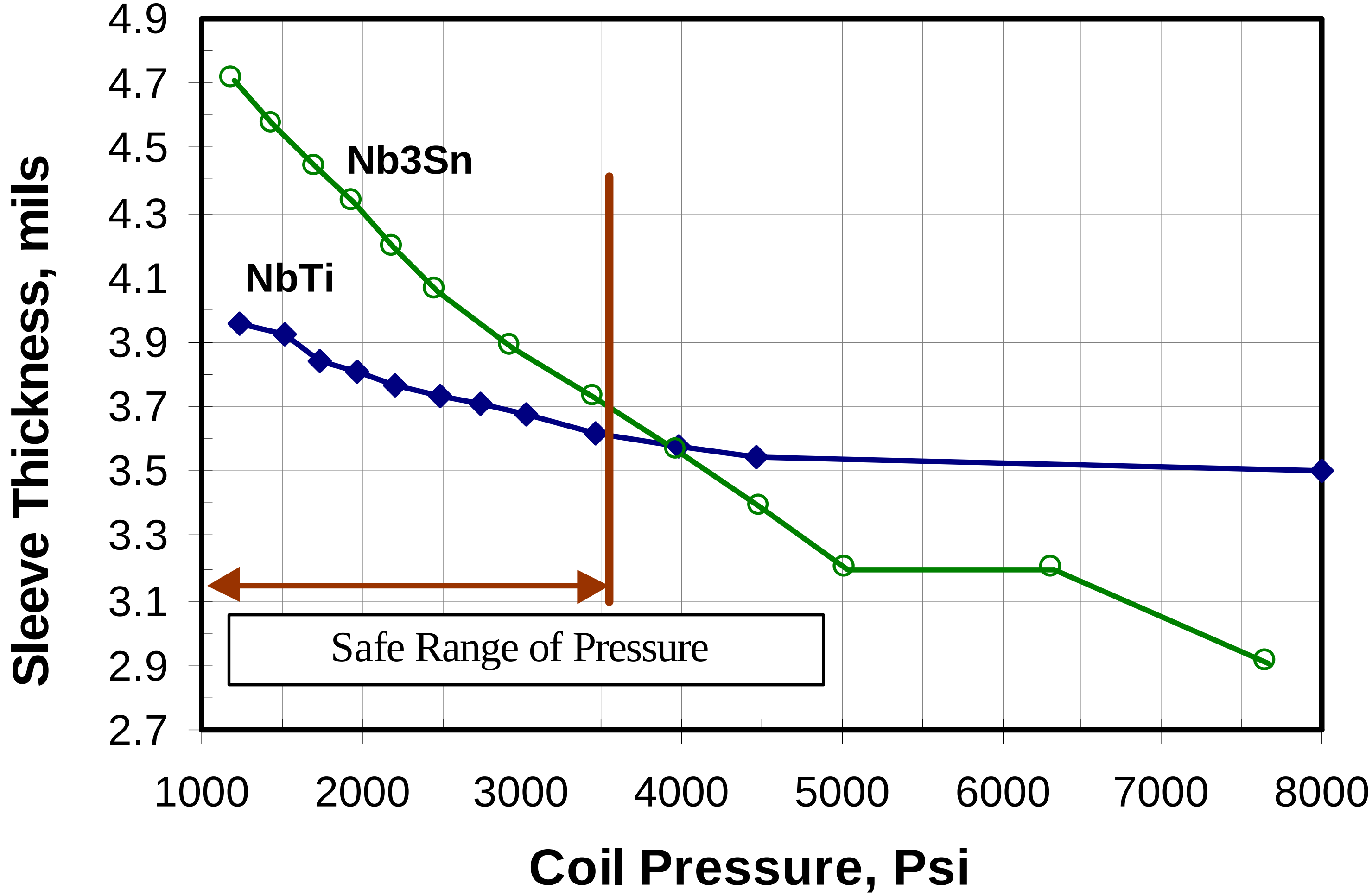




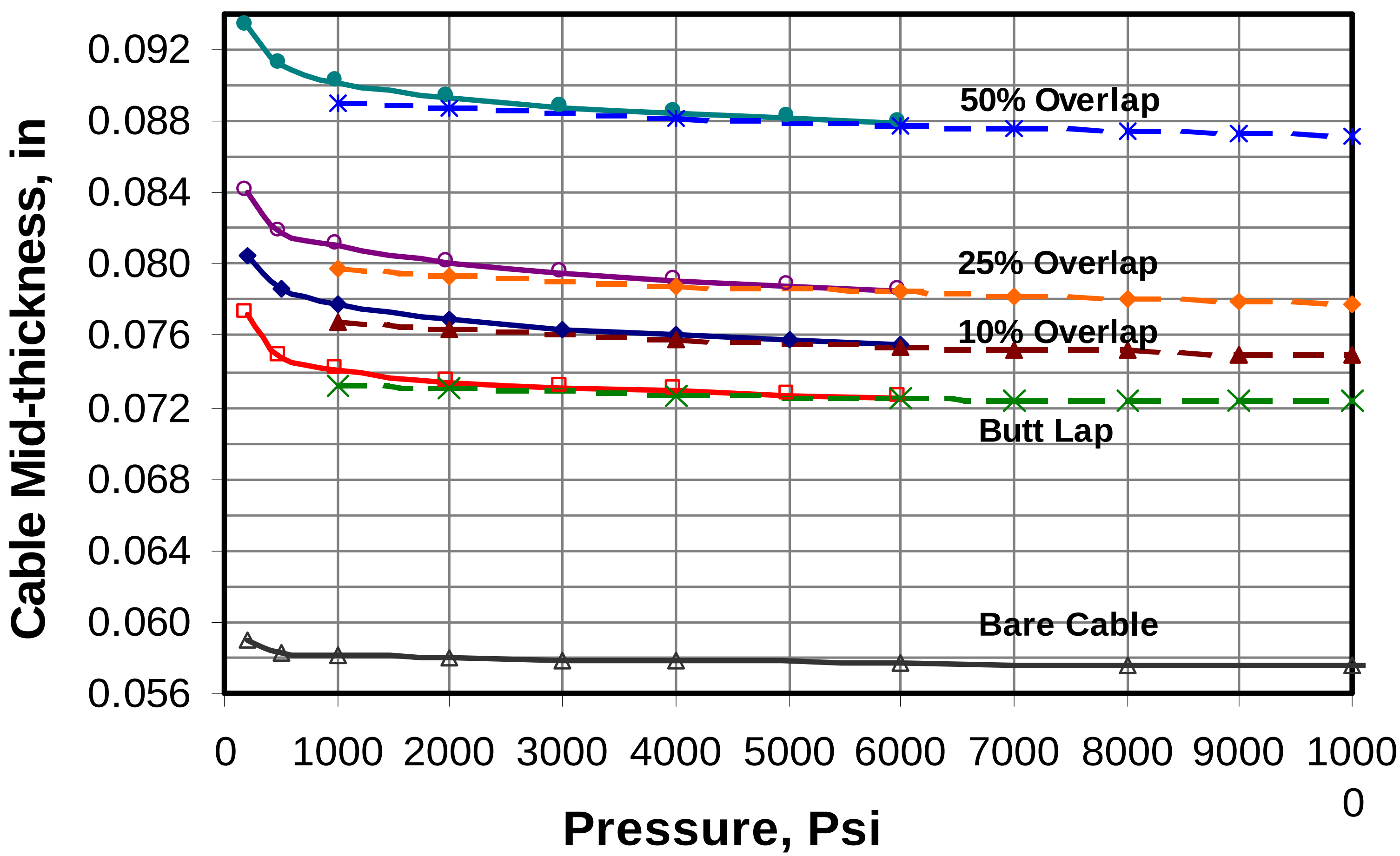
Magnet Fabrication Stages & Equipment Needed

Operation	Equipment availability
- cable insulation;	Fabrication stage
- end piece design & fabrication;	To be optimized
- coil winding;	Fabrication stage
- coil reacting;	Fabrication stage
- epoxy impregnation;	Available
- collaring;	Available
- yoking;	Available
- welding;	Available
- magnet testing	Available

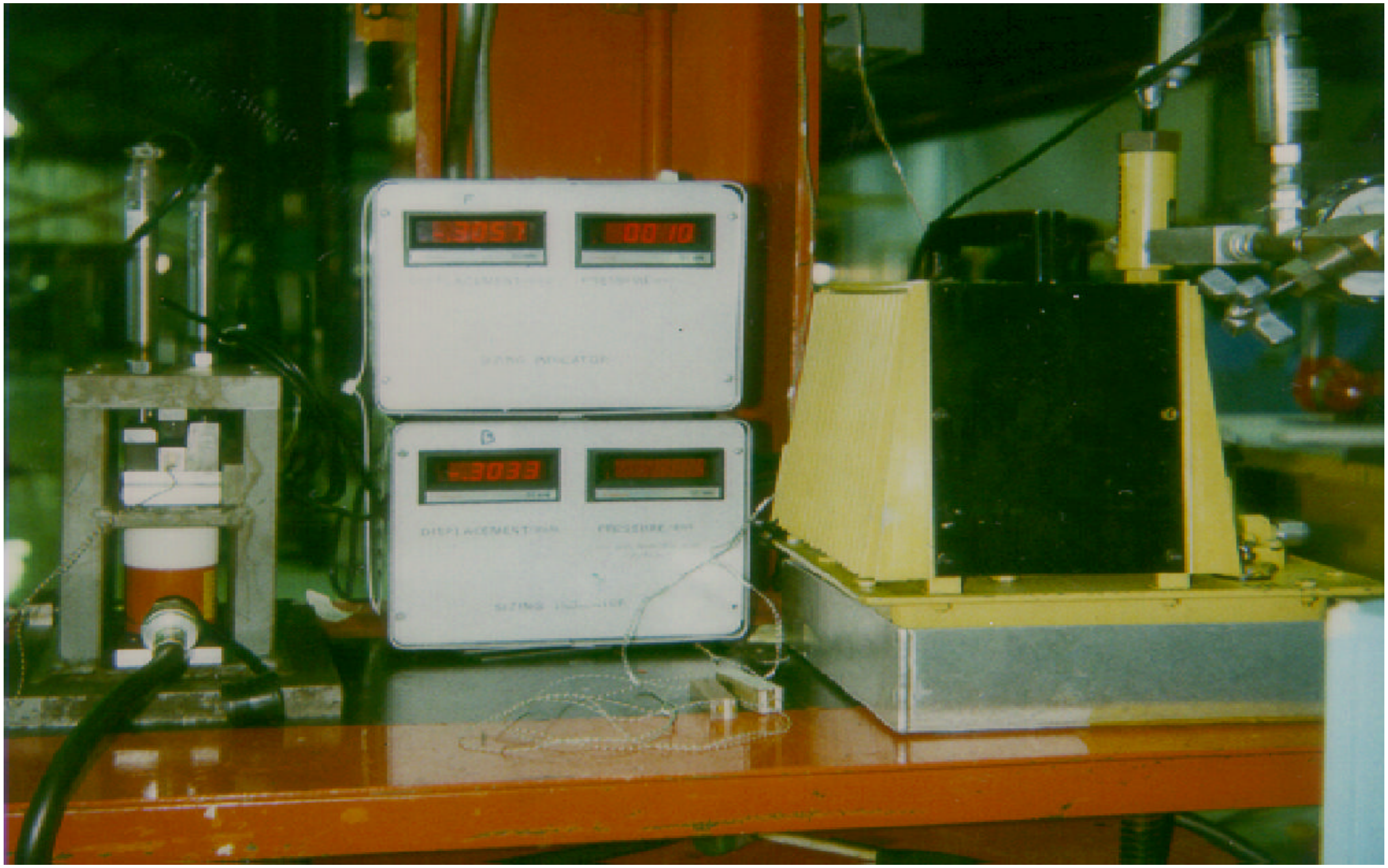
Insulation Thickness Study
S-2 Fiber Glass Sleeve



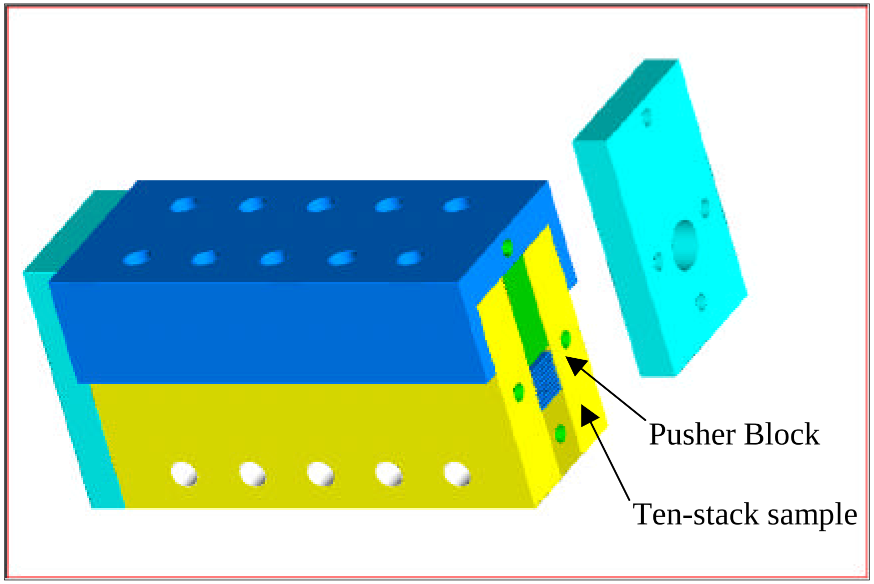
Insulation Thickness Study
S-2 Fiber Glass Tape



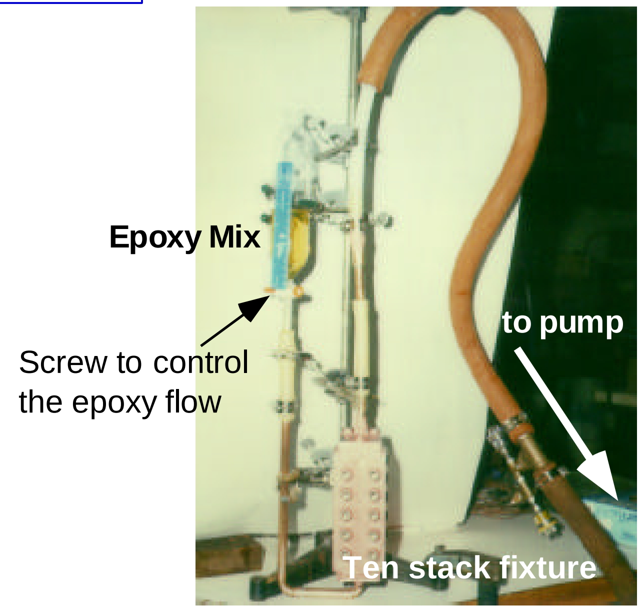
Insulation Thickness Study



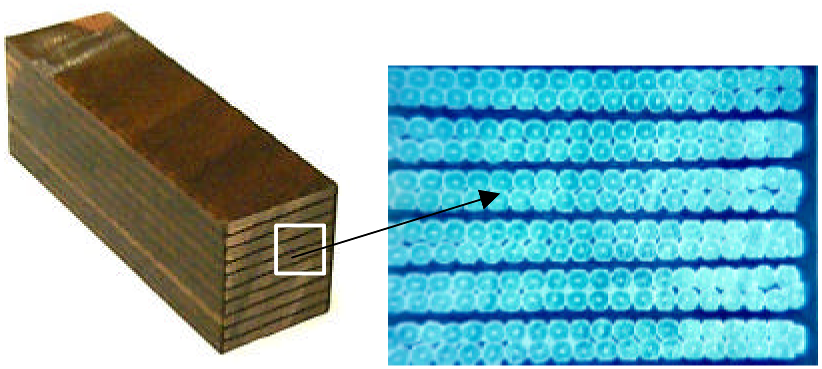
Epoxy Impregnation



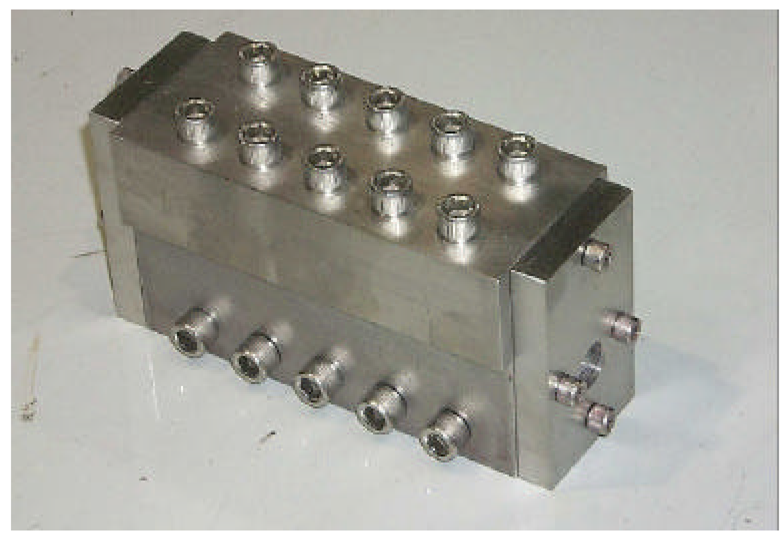
Ten-Stack Fixture



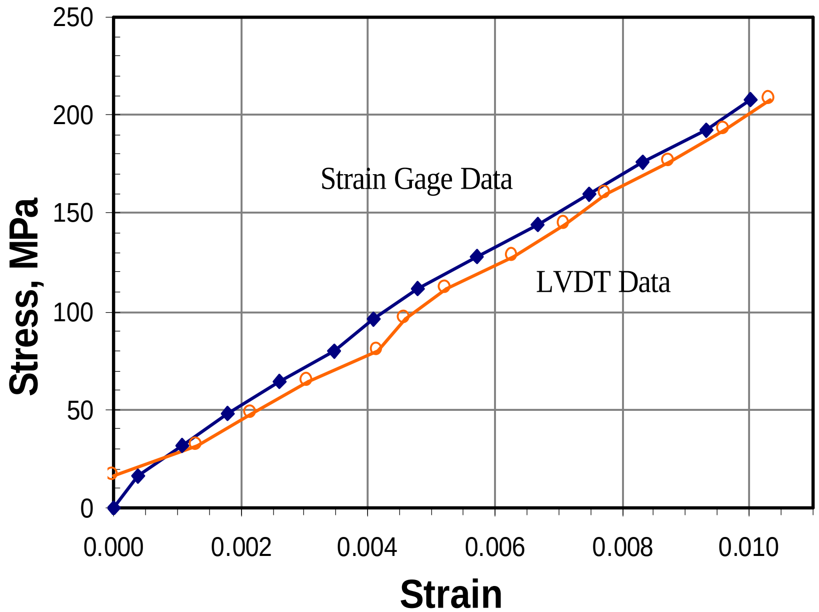
Vacuum Impregnation

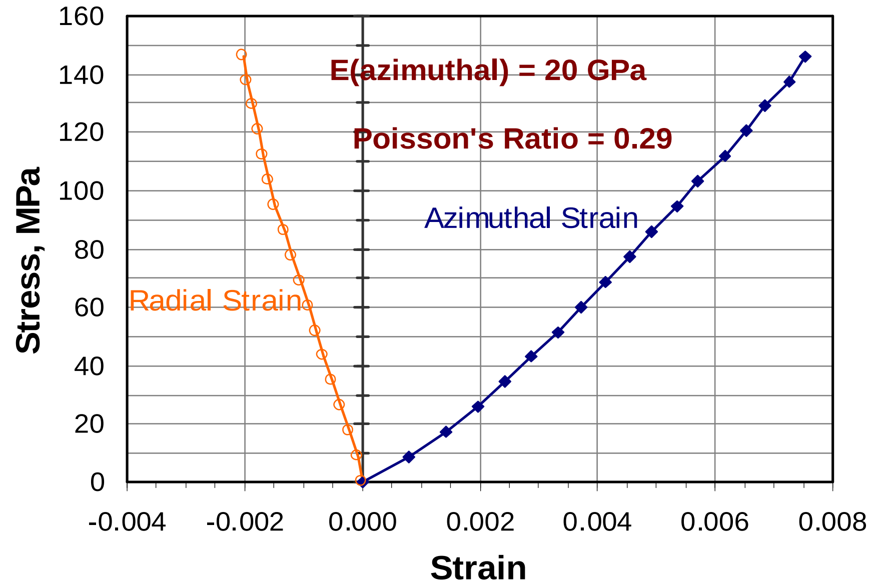


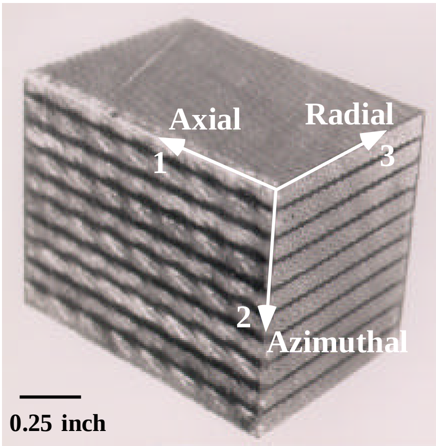
Epoxy Impregnated NbTi Composite



Mechanical Properties of Epoxy Impregnated NbTi Composite







Sample Young's modulus (Gpa)

Sample temperature	300 K	4.2 K
E_{11} (axial)	19.5	Data not available
E_{22} (azimuthal)	20.1	32
E_{33} (radial)	24.0	36

L&L Special Furnace Co, Inc.
Model XLE3360 Reaction Furnace

Inside dimensions -
31 x 33 x 61 in^3

6 heat zones

$\mathbf{T}_{max}$ = 1287 °C

Temp. uniformity - 5 °C

Power - 60 kW

Lindberg/Blue M Tube Furnace

Vacuum Rack

Tube diameter - 6 in

Heated length - 36 in

3 heat zones

T_{max} = 1100°C

Temp. uniformity - ±2 °C

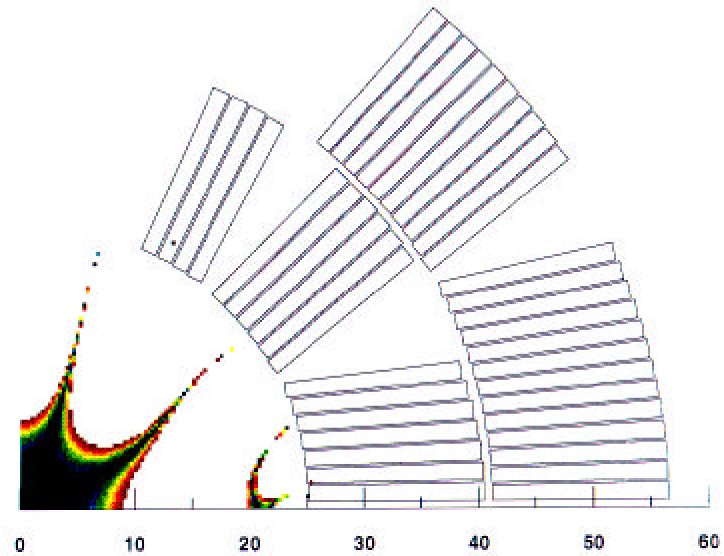
W = 11,000 W

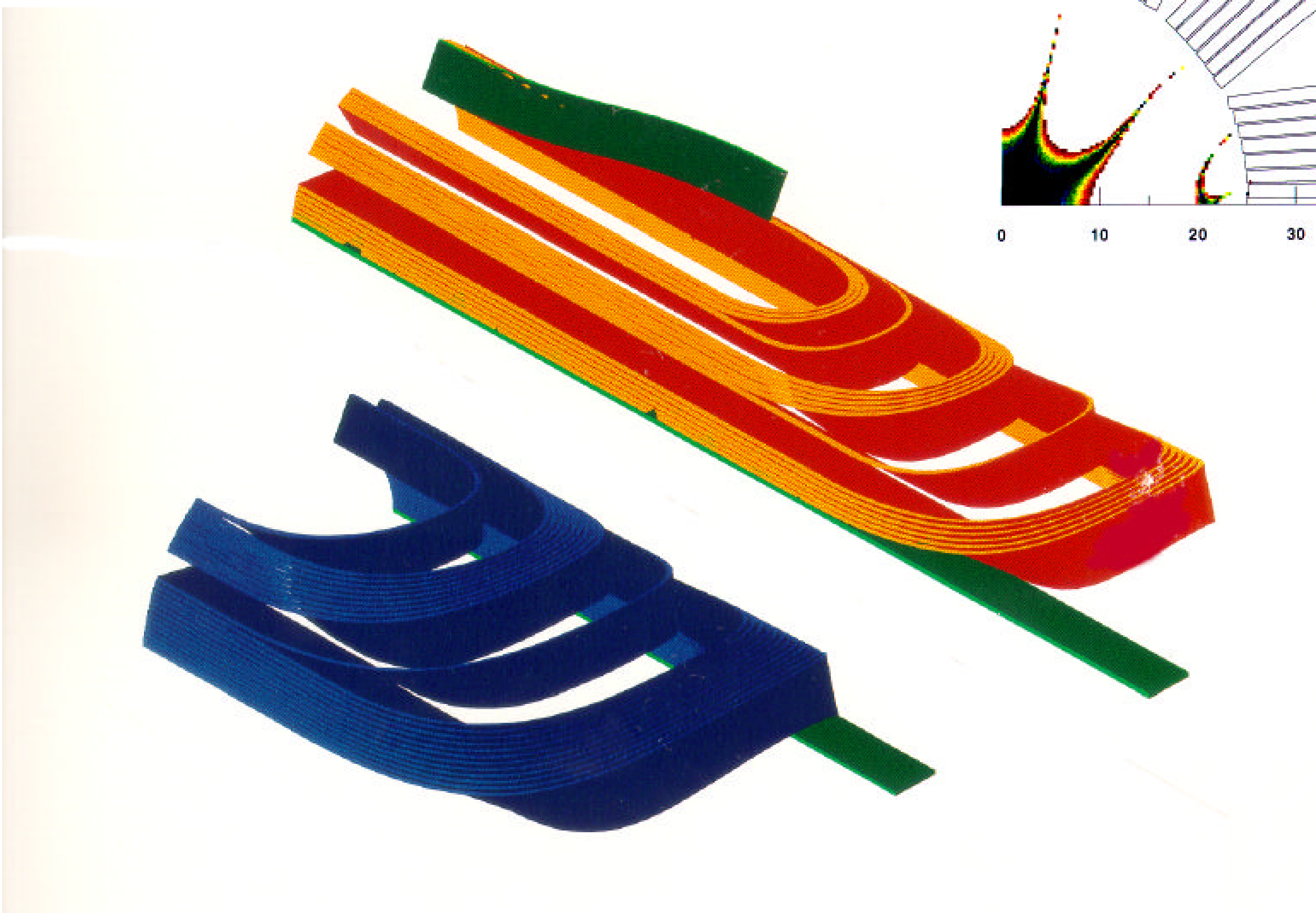
Nb_3Sn Wire and Cable Reaction Site

First Mechanical Model Goals

- to choose and to try CAD-CAM software for coil end part design and production;
- to set up equipment and tooling needed for coil fabrication;
- to study insulation properties at different production steps;
- to get experience handling insulation;
- to check coil impregnation procedure;
- to measure mechanical properties of wound and impregnated coil;
- to verify chosen assembly technology.

HFM Mechanical Model
Cross-Section & Lead End





HFM Mechanical Model
Outer Layer End Parts

Conclusion:
HFM R&D Status

1. Dipole model conceptual design is in progress.
2. SSTF has been commissioned and is active.
3. Insulation study is in progress; results are used for coil design.
4. Reaction furnaces were bought and activated; first reaction cycle is in progress.

Short Term Plans

Fabrication and test of the mechanical model - January 1999

Magnet design - September 1999

Tooling design - December 1999

Tooling and magnet part fabrication - February 2000

Magnet fabrication - July 2000

Magnet test - September 2000

Conclusion:
HFM R&D Plans

1. High Field Magnet design and technology R&D:

- design optimization (block/shell type) and cost reduction (smaller bore);
- new fabrication methods development (winding / assembly / reacting / impregnating / collaring)

2. Superconductor R&D:

- Nb_3Sn, and Nb_3Al strand study in collaboration with industry.

HFD manpower in 1998