# Update: Muon Magnet R&D Status

## 5 Year Plan Review Preparation

Discussions and plans since September 3, 2009

# Magnet R&D in the 5 Year Plan

## Areas of Study (Section 5.3)

- Magnets for 6-D cooling-emphasis on HCC
- Very high field solenoids for final cooling
- Collider and IR magnets
- Other magnets and magnet issues
  - Fast Ramping Synchrotron Magnets
  - 10-15 T solenoid for late-stage 6-D cooling
  - Cost models for MC magnet components

Not called out explicitly in the magnet plan is Guggenheim or FIFO snakes (although it is part of the Section 5.5 Cooling Tests and Experiments)

# Propose Formation of Magnet Interface Working Groups

Magnet builders, Other Accelerator Technologists (RF for e.g.) and Accelerator Designers

- 6-D Cooling Magnets
  - Magnetic Solution to Full Channel
    - Including RF, magnetic insulation, matching section
    - Efficiency, feasibility, cost etc.
- High Field Solenoids
  - Working Specification
  - Coordination with National HTS Program
    - … which has a need for straw man magnet design
  - Interact with SBIR Programs
- Collider and IR Magnets
  - Lattice Requirements/wish list/what is practically achievable/in what time frame
- Repository of full accelerator magnet parameter list

# Activities during the month

- Last time we reported Fermilab's interest in redirecting magnet resources towards muon collider
  - I'll say a bit more of this topic
  - Also mention some of our infrastructure capabilities
- Concerning these working groups:
  - Sasha Zlobin, Steve Geer, Andreas Jansson and I met to discuss working groups organization
  - Discussions with TD on participation in RF and Magnet Integration for 6-D cooling…. Ongoing…..
  - Detector Machine Interface group is a natural place to discuss IR and even collider magnet specifications.
  - No progress on "high field solenoid" working group….

# Resources that Fermilab might put to MC Magnet Program

- High Field Solenoids
  - Already a team in place to investigate HTS materials for high field solenoid
  - Charter members of the national HTS program
    - Money for FY10 has been dispersed
    - Translates into addition technician and engineer assigned
  - Total effort:
    - Base Program: ~2 FTE engineers and 1.5 FTE technicians
    - National Collab: 0.5 FTE Engineers and 1.5 FTE technicians
    - NOTE: A large fraction of this effort is “contract” or “term”

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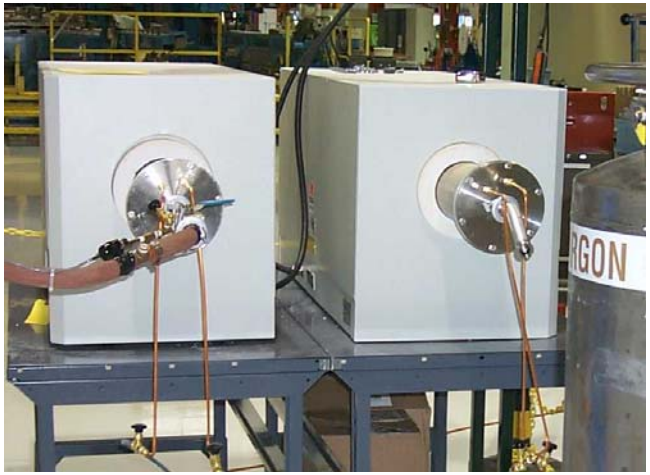
# Facilities for Advanced Superconductor Development

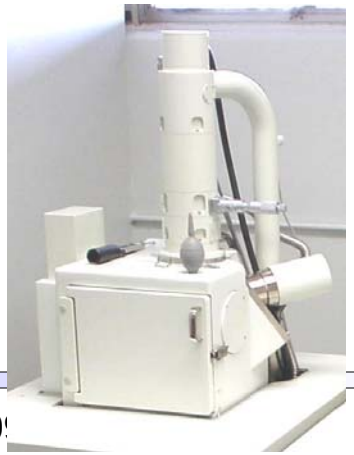
15/17T – 64 mm cold bore

14/16T – 77 mm cold bore

Three 1100°C tube furnaces



SEM and Optical microscopes



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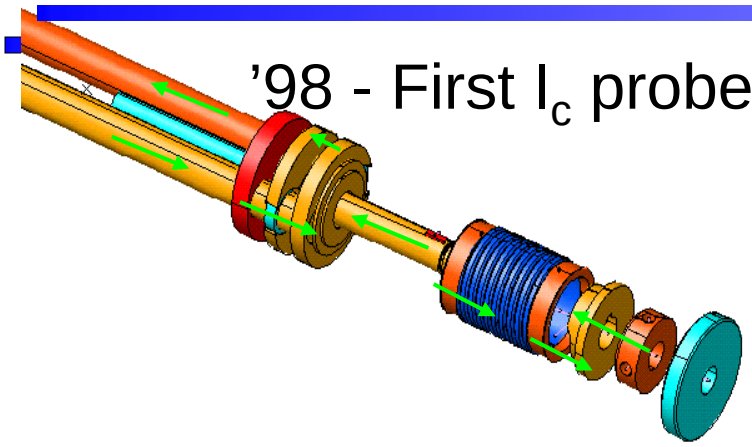
# Probes for Strand Tests

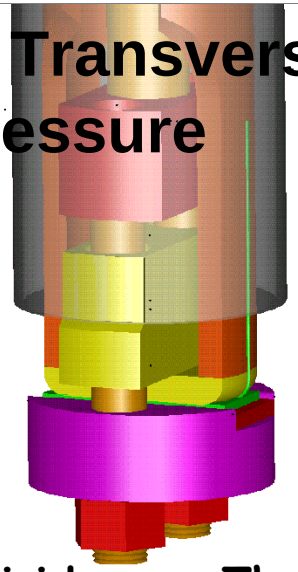


'98 - First $I_c$ probe

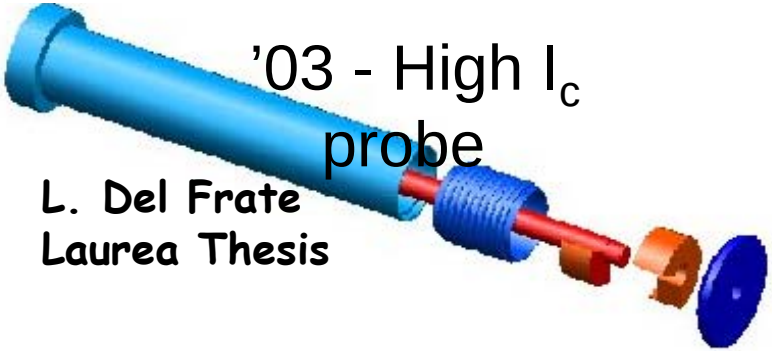
'99 - Magnetization

C. Boffo Laurea Thesis

**'01 - Transverse pressure**



M. Fratini Laurea Thesis

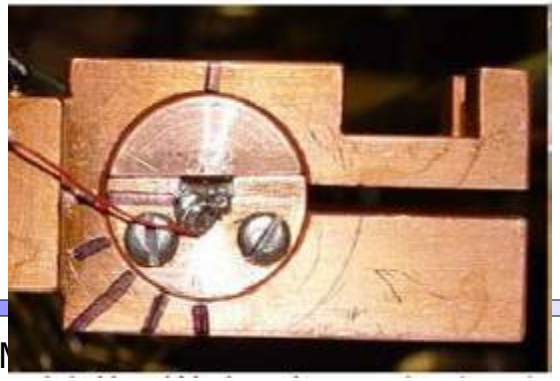


'03 - High $I_c$ probe

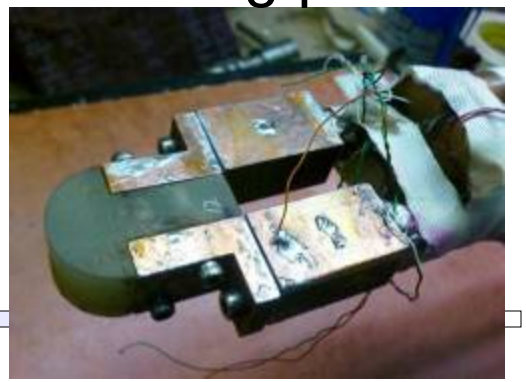
L. Del Frate Laurea Thesis

'05 - First HTS probe

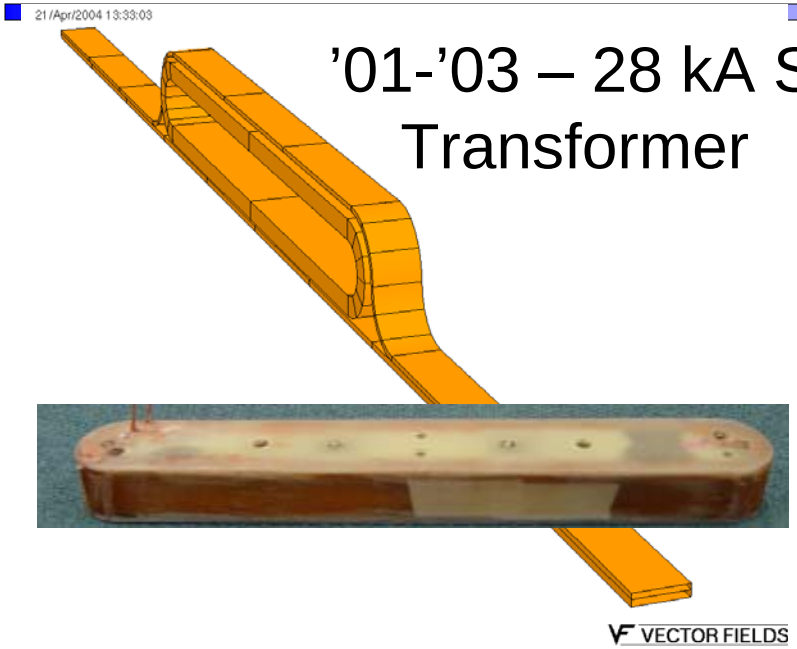
'07 - HTS Angular probe



'08 - HTS Bending probe

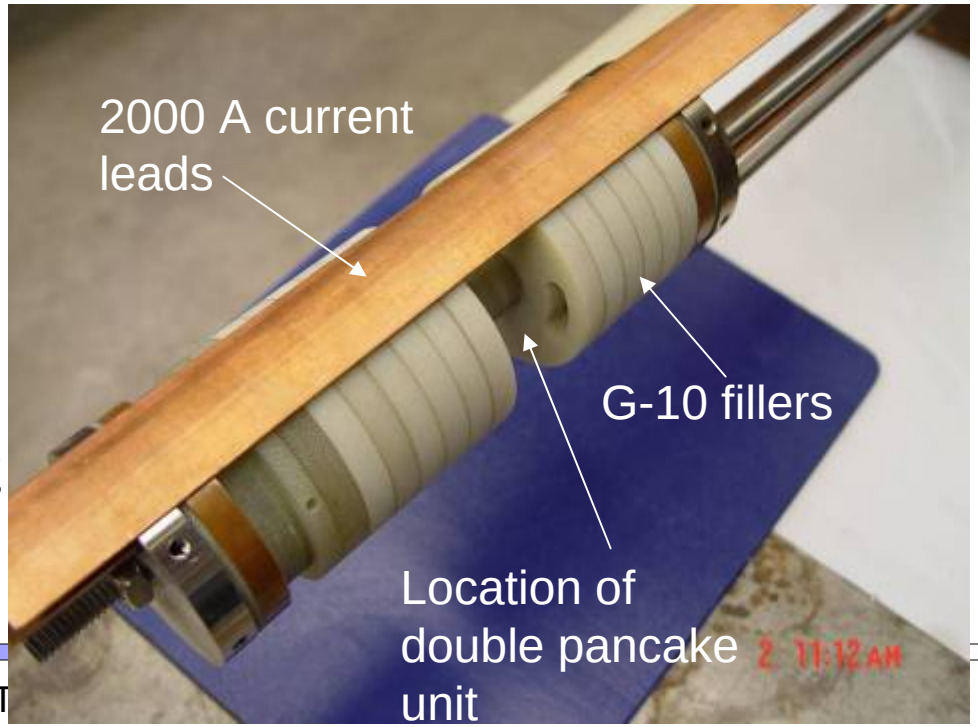


# Fixtures for Cable and Small Coil Tests




’01-’03 – 28 kA SC Transformer

’09 – Double Pancake Unit




’09 – Modular Insert Test Facility

# Cable Machine

- Strand number: up to 42
- Strand diameter: 0.3-1.5 mm
- Cable transposition angle: 8-16 degree

# Resources that Fermilab might put to MC Magnet Program

- Collider and IR Magnets in FY10
  - Based on the conclusions and recommendations of the Collider Magnet working group, magnet R&D program will be launched
    - Probably focus on one or possible two magnet designs
    - Goal to build accelerator magnets suitable for IR or Collider, working towards fields of up to 15 T
  - Design study of magnet(s)
  - Tooling design (trying to leverage as much as possible existing tooling)
  - Proposing building program for FY11
  - Available staff for FY10 depends critically on other commitments
    - Winding down LARP support
    - Mu2e, Project X etc…
    - Estimated effort in FY10: ~1 FTE Scientist, 1-2 FTE engineer

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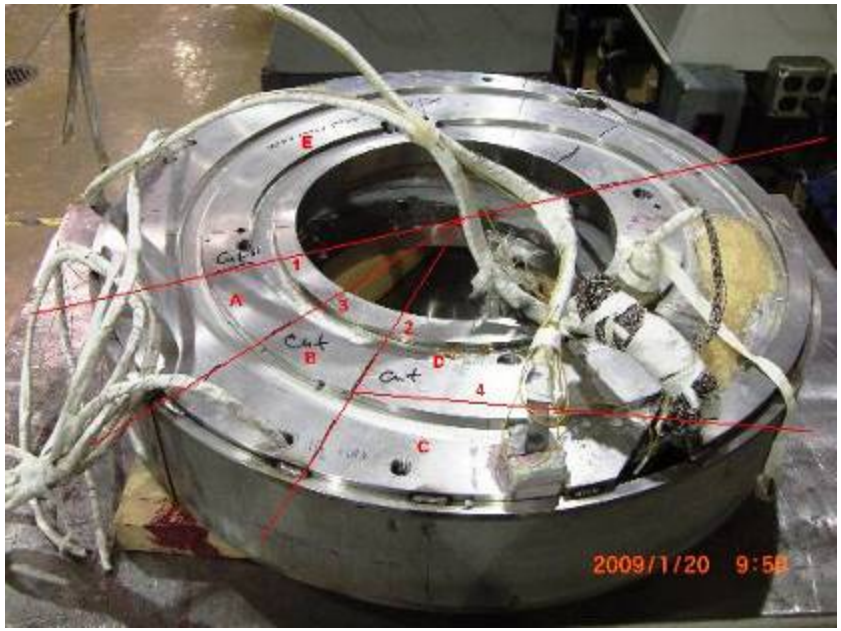
# Resources that Fermilab might put to MC Magnet Program

- 6-D Cooling Magnets
  - We plan to build and test 3 “4 coil magnets”
    - NbTi and Nb3Sn
  - Play lead role in demonstration magnet working group
  - The amount of further work here depends on the leading technology and the support for the “following” technology
  - Expected support
    - ~0.5 FTE Scientist
    - ~1.5 FTE engineers
    - ~1.5 FTE technicians



# Comparing 5 year plan FY09 vs. FY10 Preliminary

| ITEM | DESCRIPTION | M&S K$ | SWF K$ | ENGS FTE | TECHS FTE | PDOCS FTE | SCIENTS FTE | FTE SUM FTE |
|---|---|---|---|---|---|---|---|---|
| **2.3** | **Magnets** | **655** | **2215.5** | **5.6** | **3.6** | **0.6** | **3.15** | **12.95** |
| 2.3.1 | High Field Solenoid | 200 | 635 | 2 | 1.5 | 0 | 0.5 | 4 |
| 2.3.2 | Helical Cooling Channel Magnets | 150 | 860 | 2 | 2 | 0.5 | 1 | 5.5 |
| 2.3.3 | Special Accelerator Magnets | 60 | 580.5 | 1.35 | 0 | 0 | 1.35 | 2.7 |
| 2.3.4 | Rapid Cycling Magnets | 25 | 81 | 0.2 | 0.1 | 0.1 | 0.1 | 0.5 |
| 2.3.5 | Target Capture Solenoid | 20 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2.3.6 | Cost model for magnetic components | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2.3.7 | 10-15T Solenoids | 200 | 59 | 0.05 | 0 | 0 | 0.2 | 0.25 |

- Total People resources for fy10:
  - Scientists: 1.5
  - Engineers: 5
  - Techs 3

# Conventional Magnet Capabilities

1.) Grit blast both (maximum size objects: 5' W 21' L 4' H) - cleaning the impurities from the metals (paint, rust, oxidation), magnet coils cores and etc
2.) Vacuum Oven (maximum size objects: 4' W 22' L 3' H) – vacuum impregnation of coils, potting of kickers and etc.
3.) Wisconsin Oven maximum size objects: 5' W 24' L3' H) - curing of the impregnated coils
4.) Screw Stacker 1 (maximum size objects: 30"w 20' L 18"H) - stack the cores for conventional magnets.
5.) Screw Stacker 2 (maximum size objects: 30"w 20' L 24"H)
6.) Screw Stacker 3 (maximum size objects: 36"w 21' L 48"H)
7.) De-bonding oven (maximum size objects 42"W 20' L 48"H) -
8.) Coil winding (maximum length of the coil 20'L) – it is used mostly for conventional magnets
9.) Building 2a (maximum size objects 40' L X 32' W) – working with Rad 2 objects, cleaning the objects after the de-bounding owen
10.) 7 Assembly Tables (maximum size objects 18" W X 24' L)
11.) 6 Assembly Tables (maximum size objects 18" W X 12' L)
12.) Magnetizer: use to magnetize the ferrite brick for permanent magnets, the existing fixture could do brick 6x4x1 inch, but this is not the limitation of the magnet aperture, up to 0.5 T.