



LCWS 2018 Industry Session

Joel Meissner



Milhou's Company has 41 years of Experience in Electromagnetic Filtration and High Energy Physics Electromagnets.



Capabilities

Magnetic field modeling

Mechanical design

Electrical design

Thermal modeling

Material analysis

Conductor design

CAD drawing

Solidworks 3D modeling

Coil winding and magnet assembly for resistive and superconducting magnet systems

Capabilities

Engineering

Design Assistance

Design Verification

Reverse Engineering

Industry
Focus

DOE

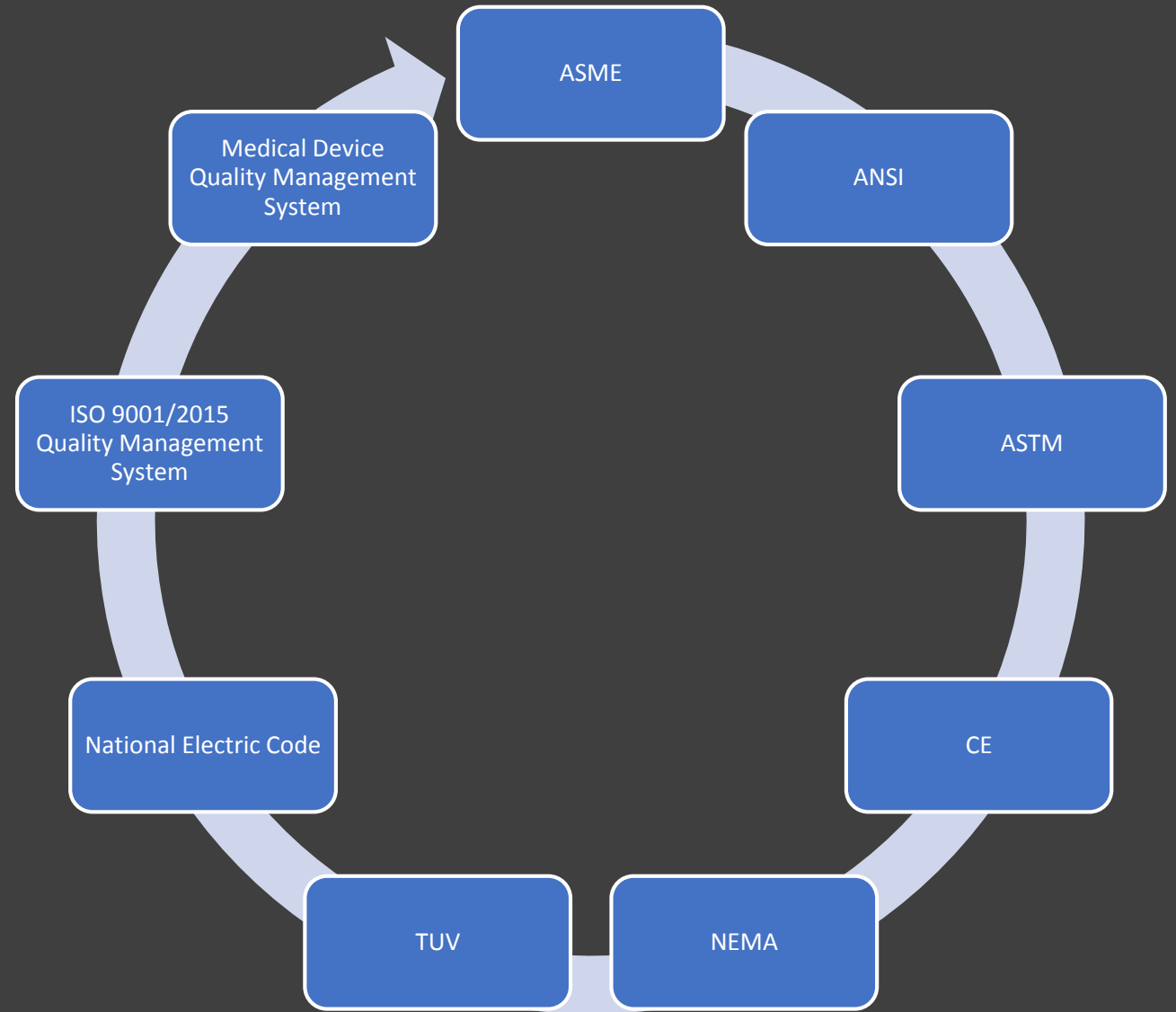
DoD

Medical

HEP

Power Generation

Industry Standards



Machining Center

- HAAS Turning and Milling Workstations
- Better Control of Component Quality and Schedule
- Faster Turn Around of Modifications during Prototyping and Production



Iron Core Welding

MIG and TIG Welding of Half Cores



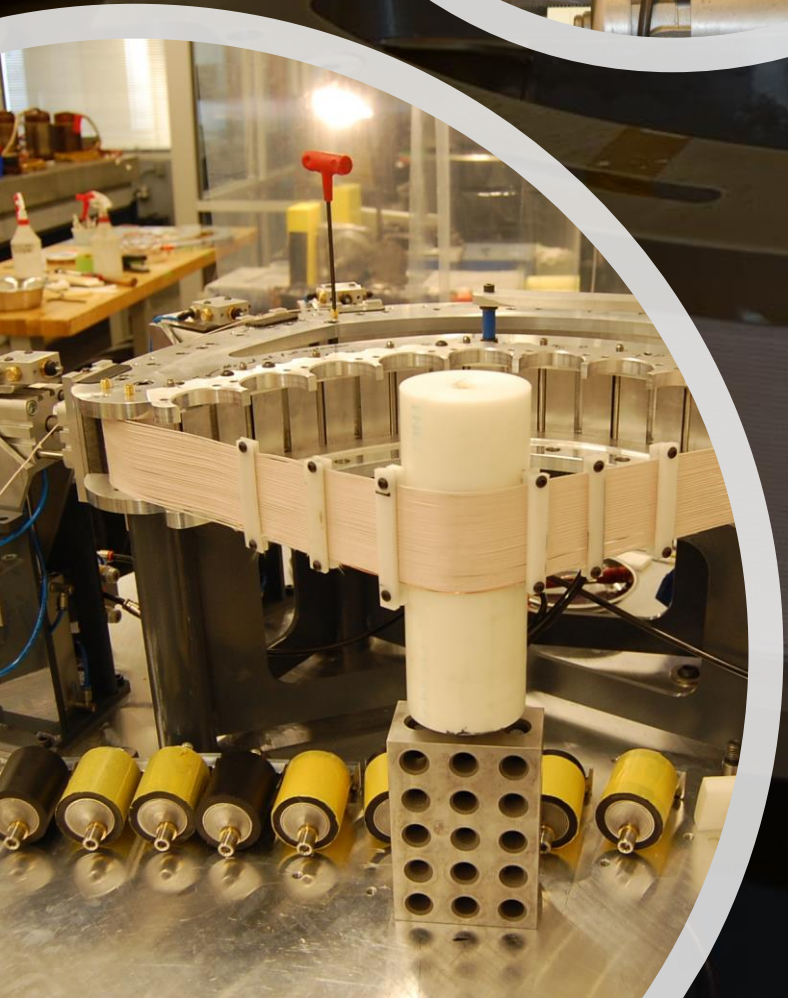
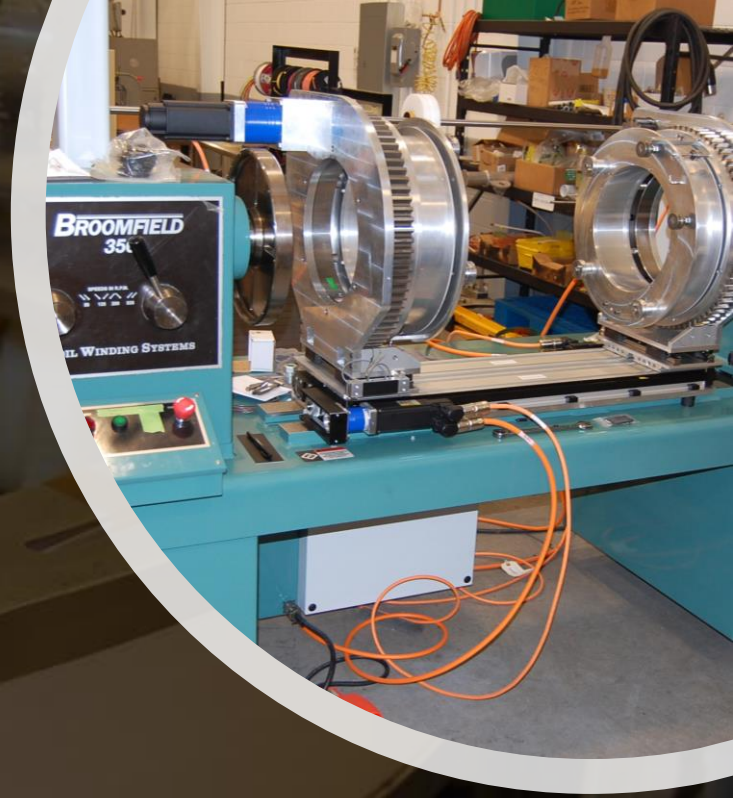
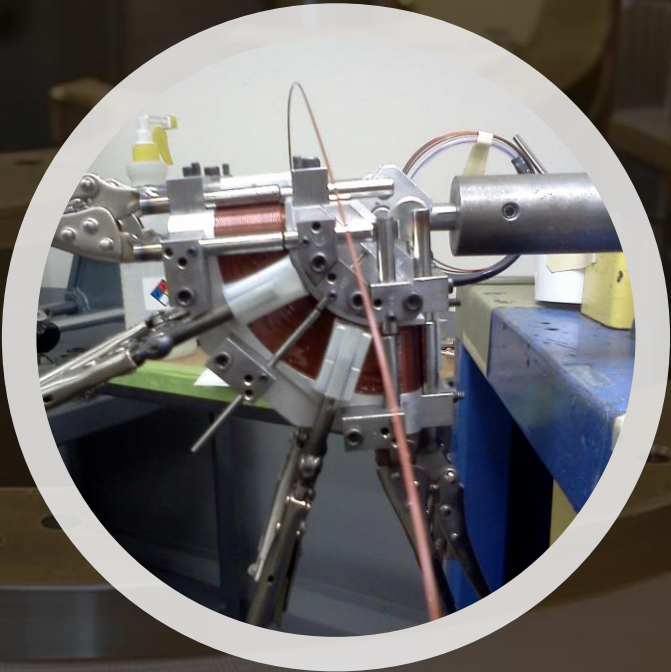
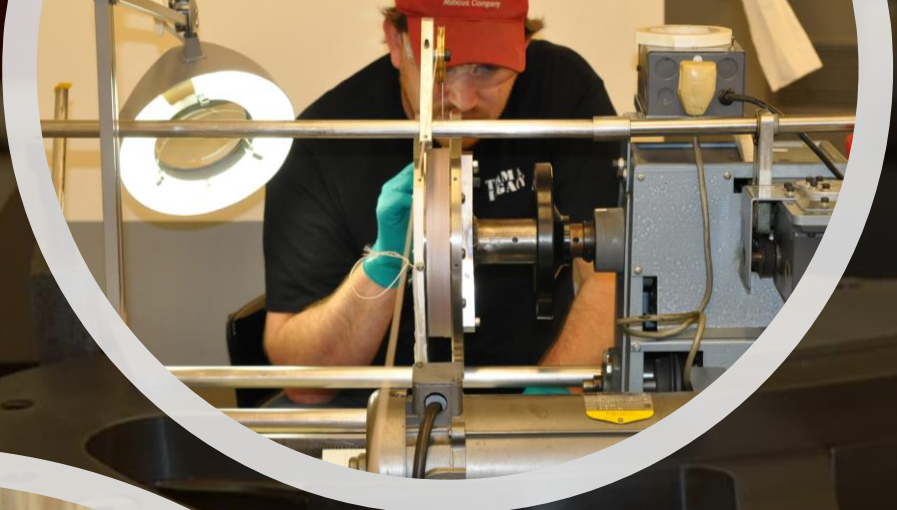
Blanchard Grinding

Tight Tolerance Control with Surface Grinding





Quality Control
Certified ISO 2001:2015

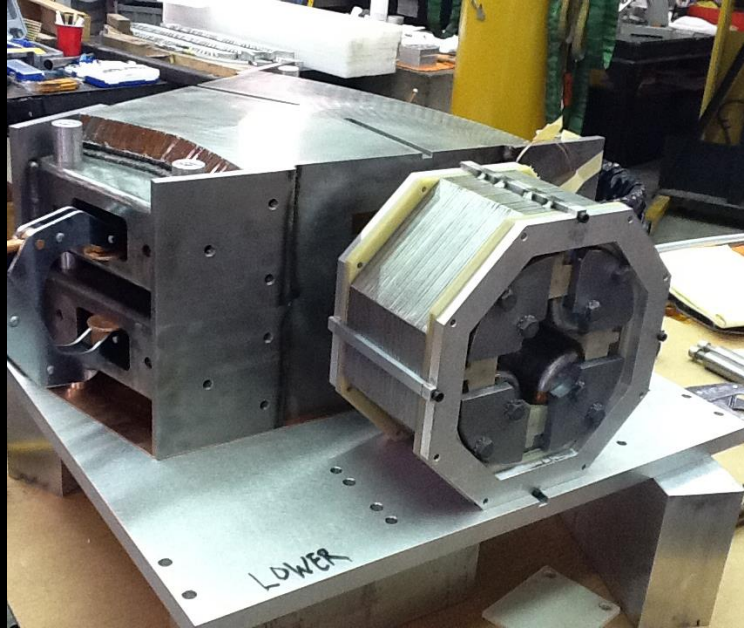


Milhou's Designs and Builds Specialty Winding Machines for
the Most Challenging Coil Shapes

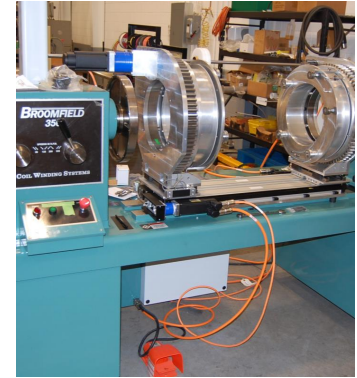
Coil Winding



Epoxy Impregnation – Vacuum and Pressure

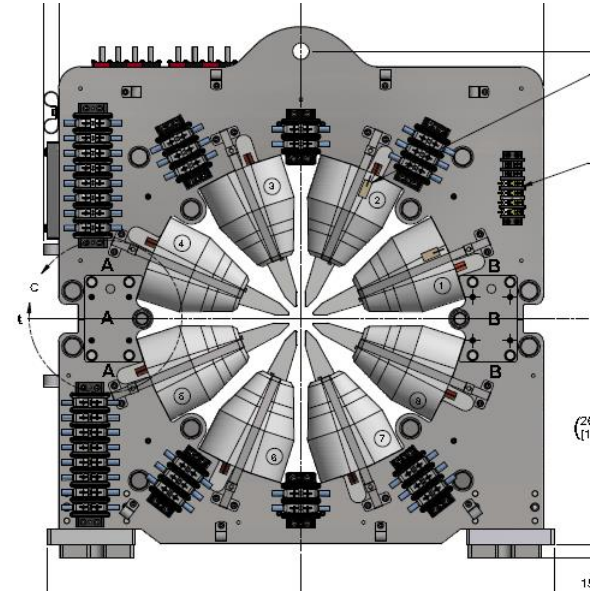
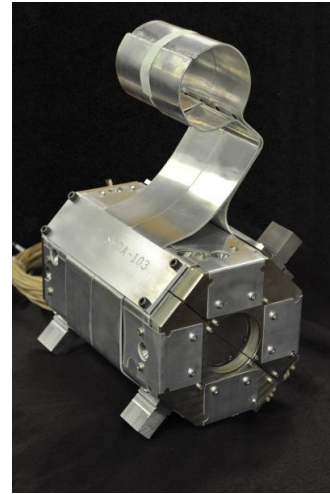


Past Projects

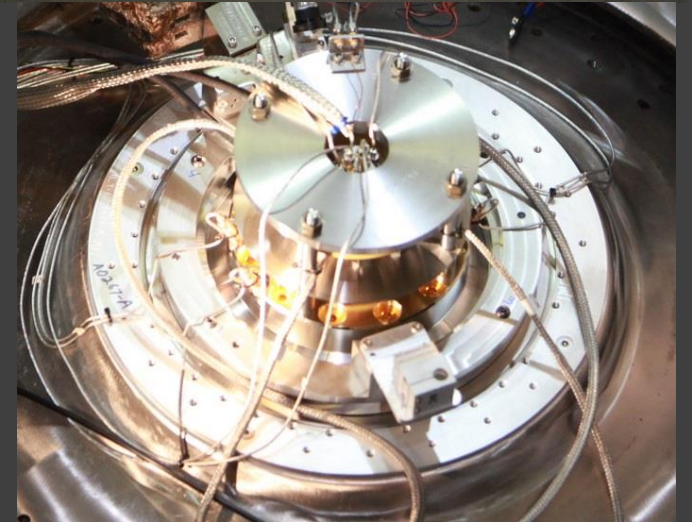
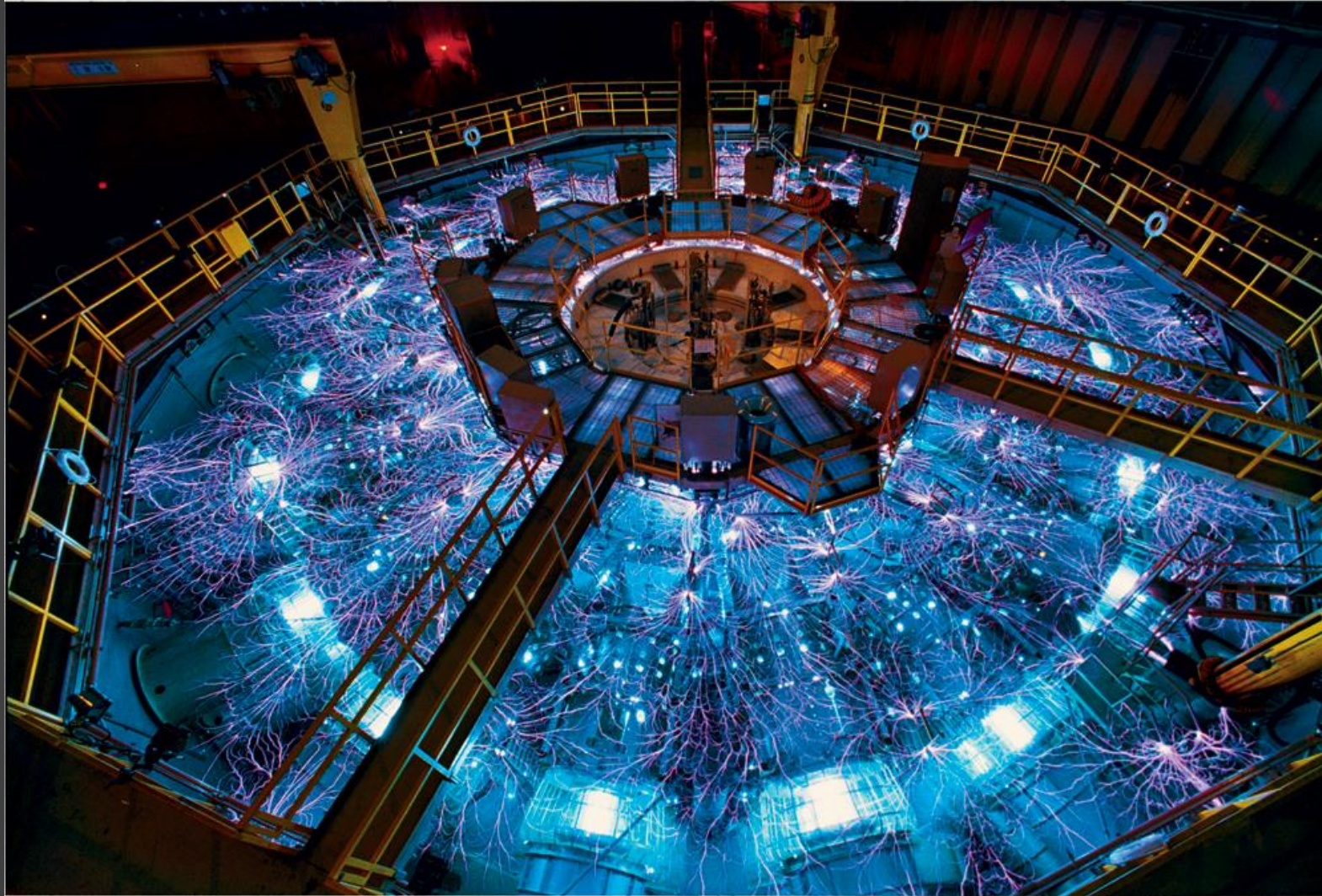


Current and Recent Projects

- Sextupoles for DUNE
- Corrector Magnets for APS upgrade
- LCLS II Quadrupoles
- MagLIF Magnets for Z-Machine
- Orbital Winding Machine for Sandia



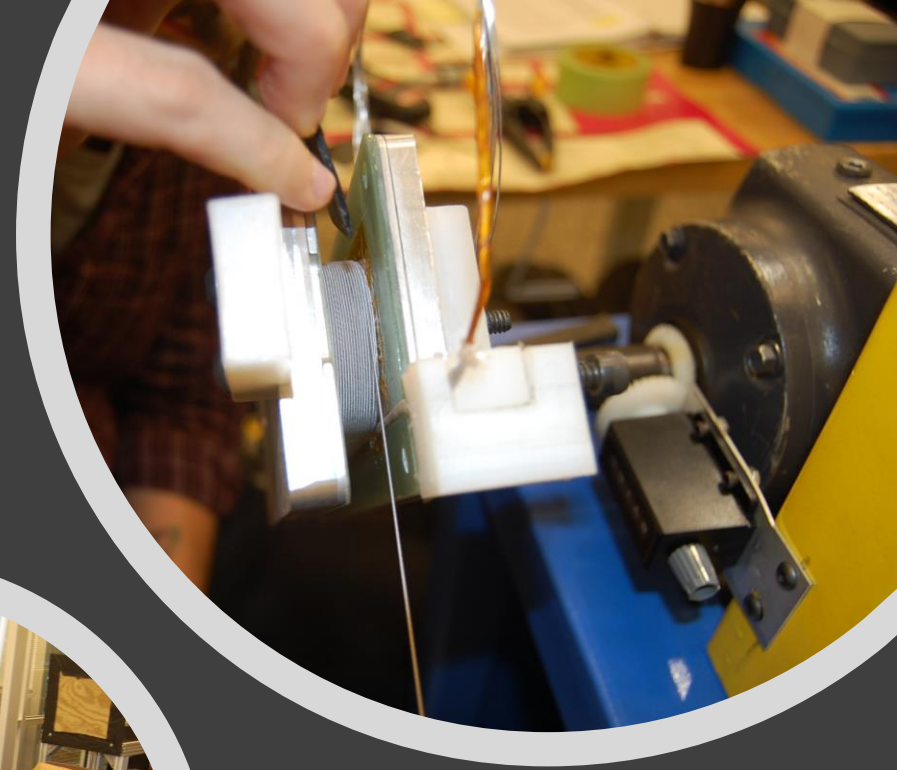
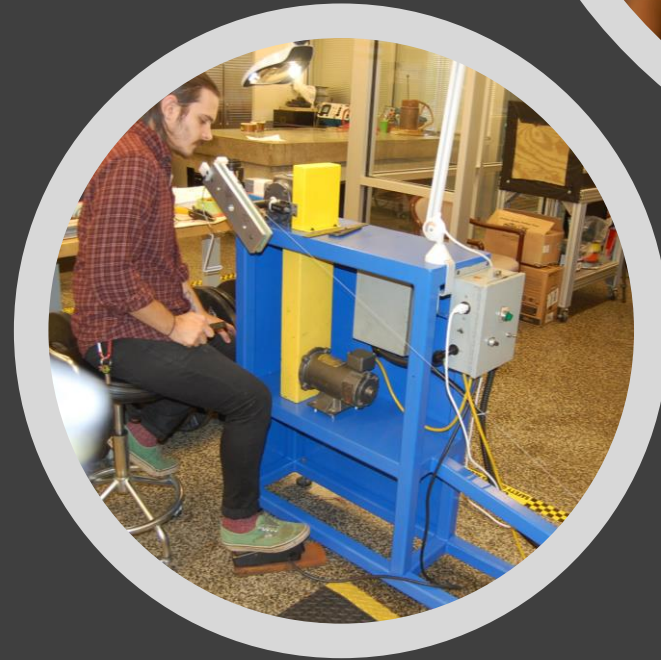
Magnetized Liner Inertial Fusion (MagLIF) for Sandia National Laboratories



LCLS II Experience

Coil Winding

- One Quadrupole and Two Dipole Correctors Wound on Common Bobbin



Configuration

- There are 4 racetrack coil blocks in the magnet.
- Each block has:
 - - quadrupole coil;
 - - vertical dipole coil;
 - - horizontal dipole coil;
 - - heater coil.
- All coils connected in series forming quadrupole or dipole field configuration.
- To monitor the magnet performance, each coil end has voltage tap connected to the cryomodule instrumentation electronics.
- 3 superconducting current lead coil pairs (6 total) go to the cryomodule top flange.
- Because the magnet split vertically, there are 6 superconducting coil splices between two halves of the magnet mounted on the Al magnet bottom plate.

Coils Potting

- Coils Inserted into a Mold and Vacuum Pressure Impregnated with Epoxy Resin
- Baked Under Pressure to Assure Void Free Results

Iron Cores

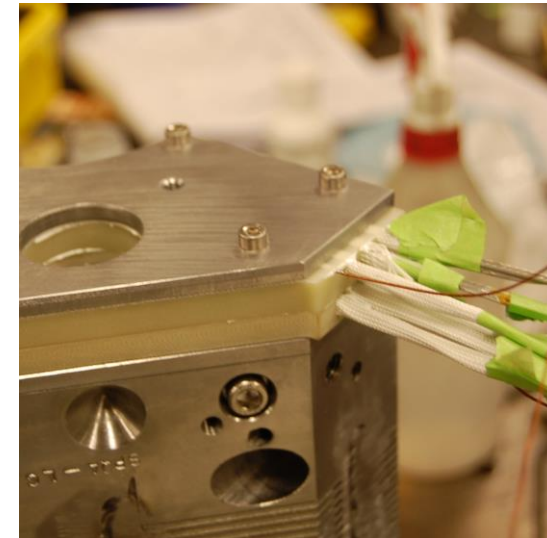
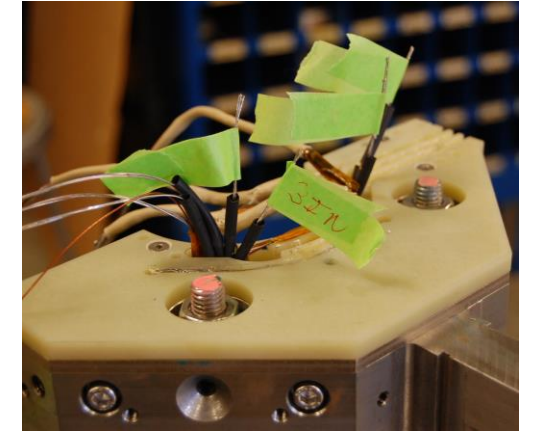
- Lamination Stacked by Alternating Grain Directions
- Reduced Dimensional Impact of Stamping Burrs
- Reduced Field Errors Due to Grain Direction

Assembly

- Coils Glued to Cores With Heat Transferrable Epoxy
- Wedges Inserted and Glued Between Coils for Support

Assembly

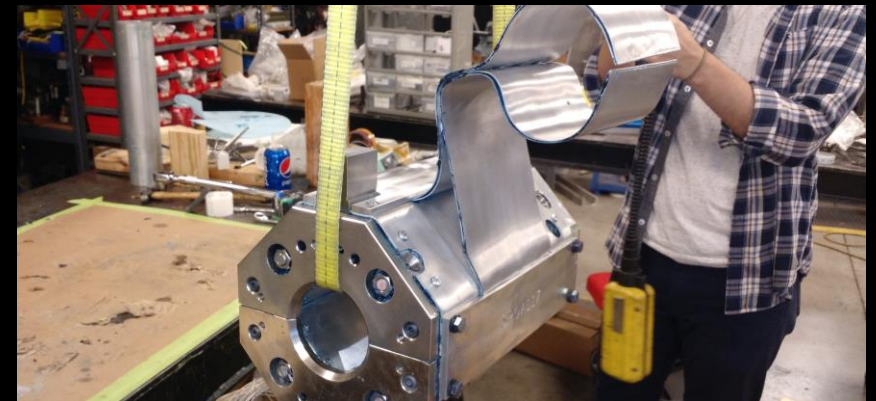
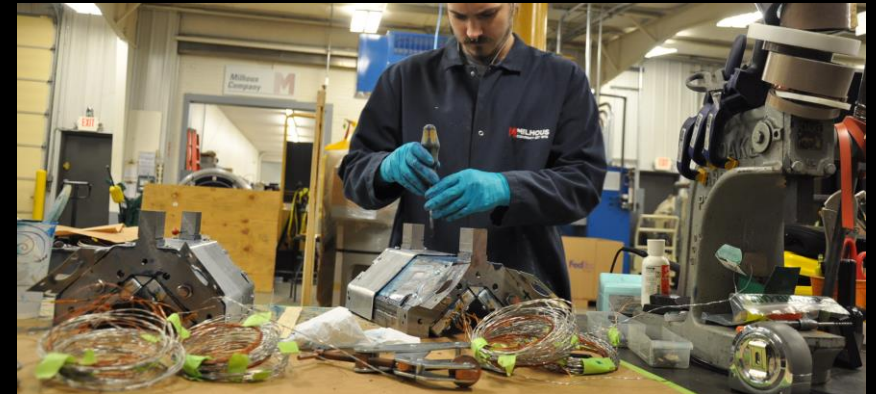
- Coil Leads Secured Within G-10 Plates
- Superconducting Splices Had to be Made With Leads in the Grooves
- Insulating of the Splices also Performed in the Grooves

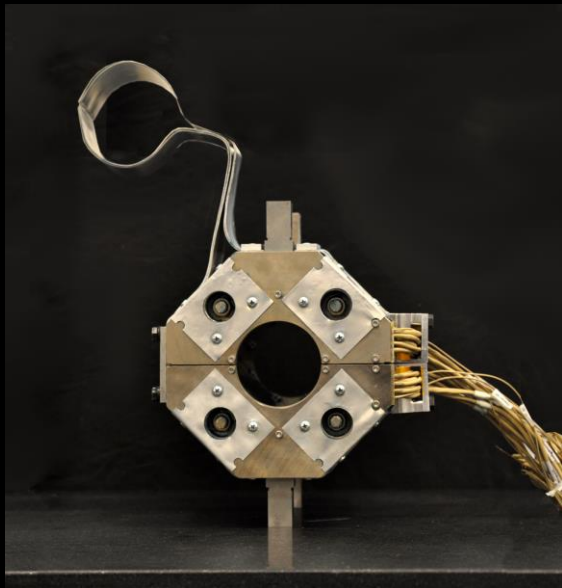
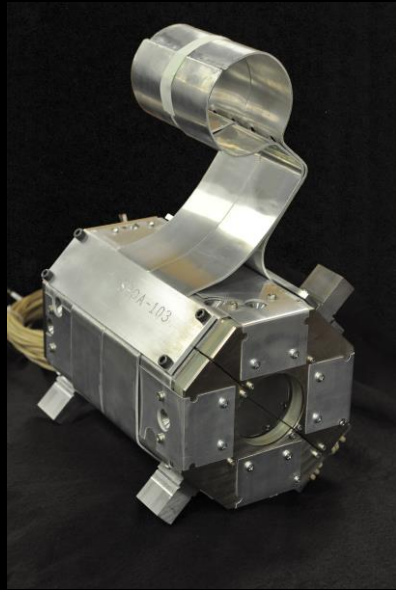




Assembly

- 5N Aluminum Wrapped Around Magnet and Affixed with Heat Transferrable Epoxy
- 5N Aluminum Thermal Cooling Straps Glued to the Magnet Cores and Clamped with Aluminum Blocks



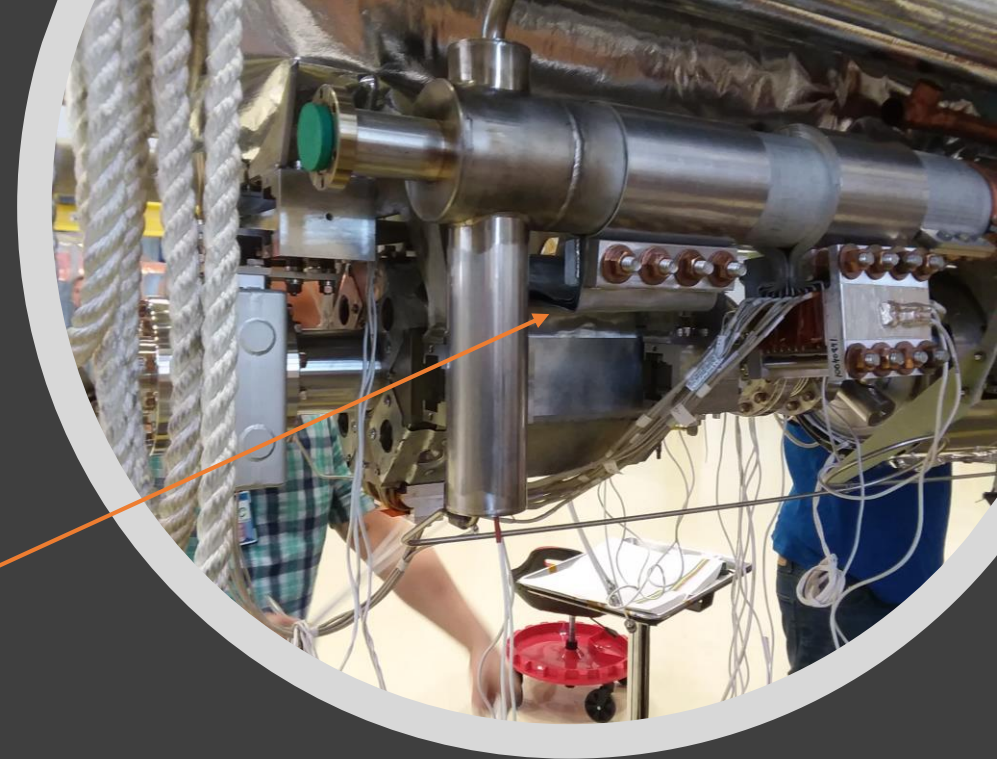


Final Magnet Cleanup and Testing

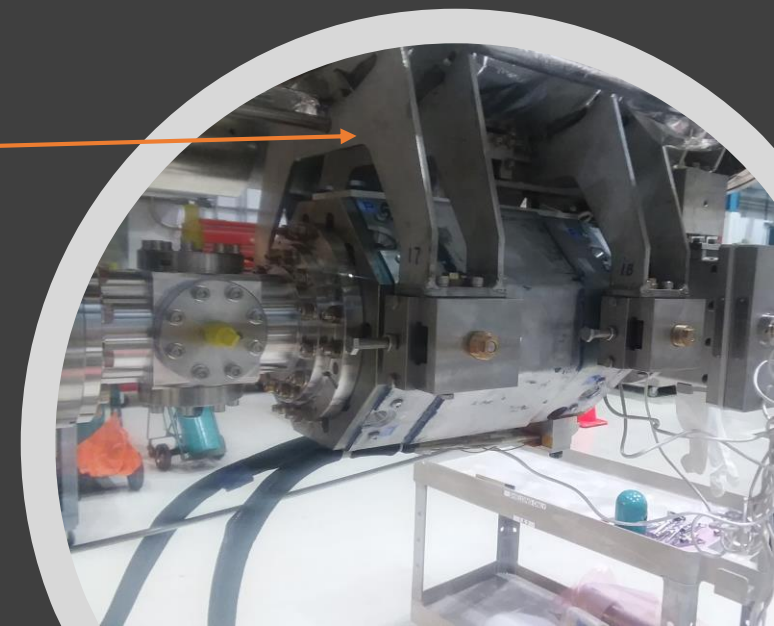
- Excess Epoxy Sanded Off Magnet and Surfaces Polished and Cleaned
- Room Temperature Coil Measurements Performed
 - ✓ Resistance
 - ✓ Inductance
 - ✓ Ringing Test
 - ✓ Polarity
 - ✓ Hi-Pot

Installation into Cryomodule Performed at Fermilab and Jefferson Lab

Magnet Cooling Straps Attached to Helium Pipe



Magnet Supports



Cryomodule Assembly at Fermilab



Lessons Learned / Suggestions for ILC

- Half-Cores
 - Flatness can be improved with surface grinding after welding and US cleaning to remove particles
- Coil Lead Splicing
 - Splicing and insulating should be performed prior to lead plate installation
- Lead Plate Alignment
 - Lead plates should include positional adjustment slots or through holes
 - Lead plates should be assembled around a beam tube alignment fixture
- 5N Aluminum Cooling Straps
 - 1 piece construction – minimal work hardening induced
 - Extremely difficult to glue up multiple layers and then bend to shape without cracking epoxy bond