Booster Corrector System Review

10 October 2006

David Harding

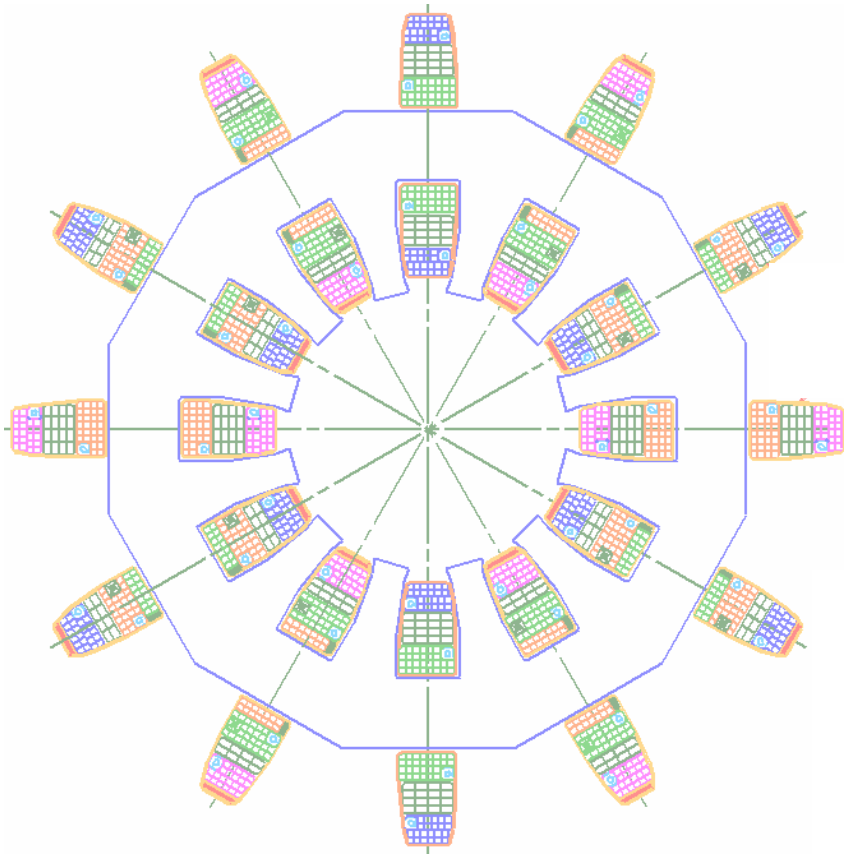
Contents

- Design
- Production plan

Requirements

	Integrated Field	Slew Rate
Horizontal Dipole	0.0090 T-m	3.24 T-m/s
Vertical Dipole	0.0150 T-m	3.24 T-m/s
Normal Quadrupole	0.1600 T-m/m	88 T-m/m/s
Skew Quadrupole	0.0080 T-m/m	0.8 T-m/m/s
Sextupole (both)	1.4100 T-m/m^2	2,350 T-m/m^2/s

Magnet Cross-section



Orange – horizontal dipole

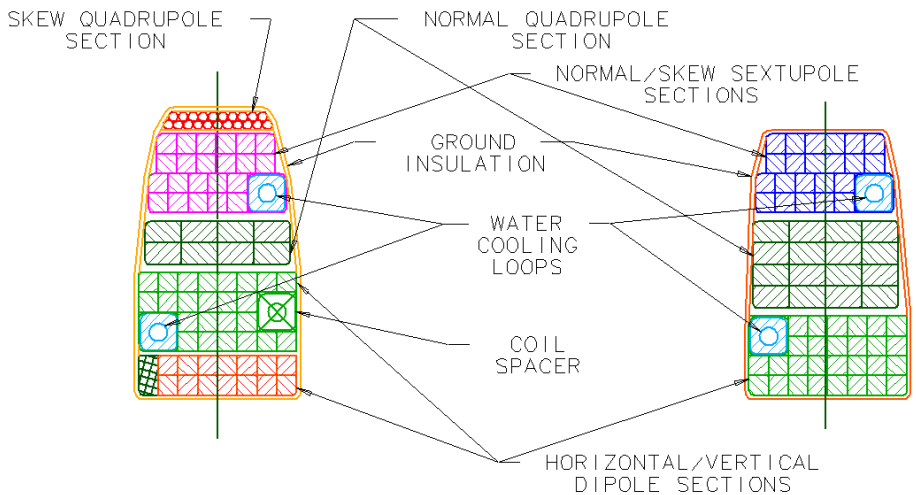
Bright green – vertical dipole

Open green – normal quadrupole

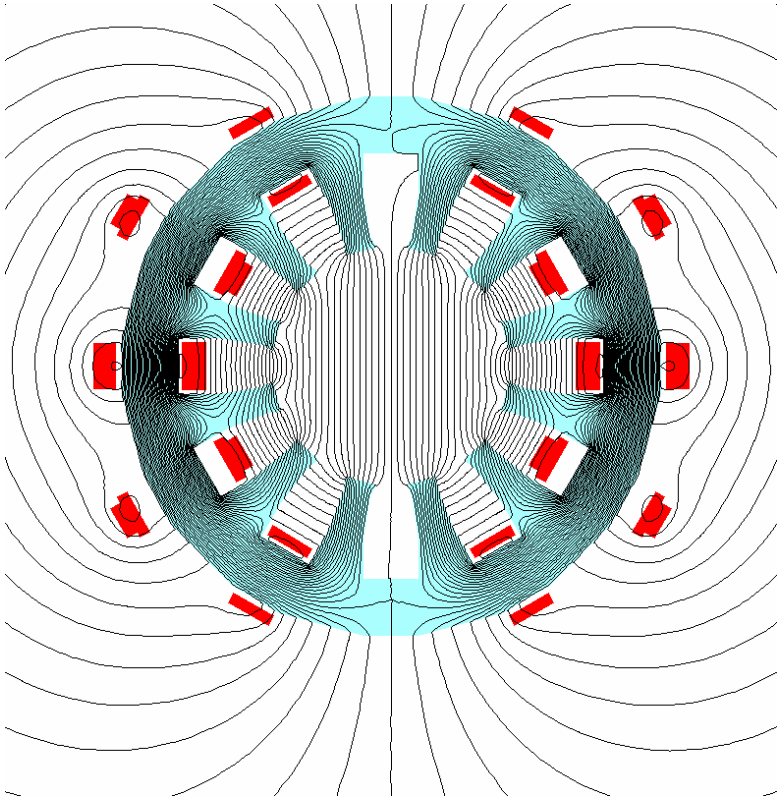
Red – skew quadrupole

Magenta – normal sextupole

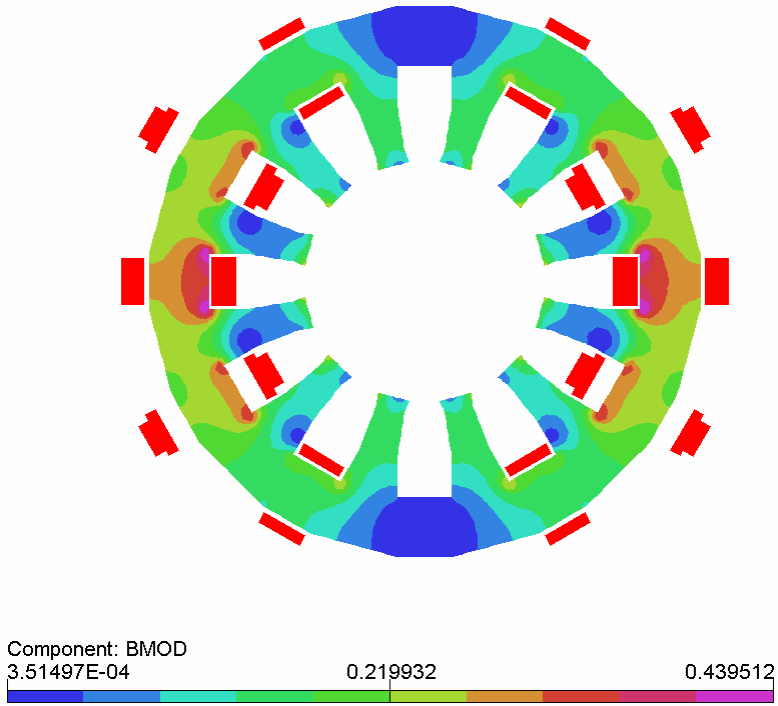
Blue – skew sextupole



Normal Dipole Model

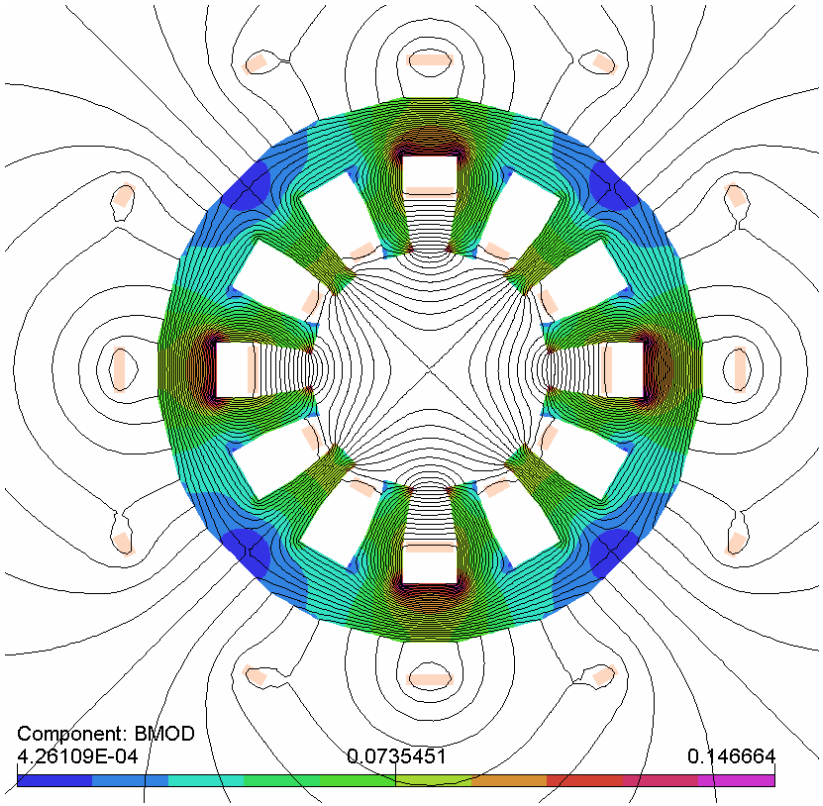


Flux lines

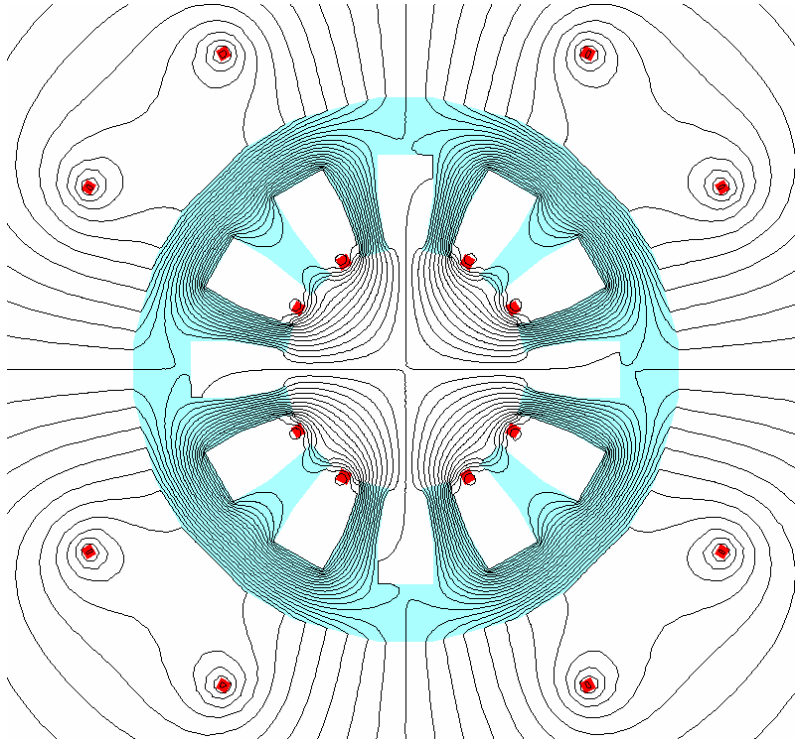


Yoke flux density

Quadrupole Models

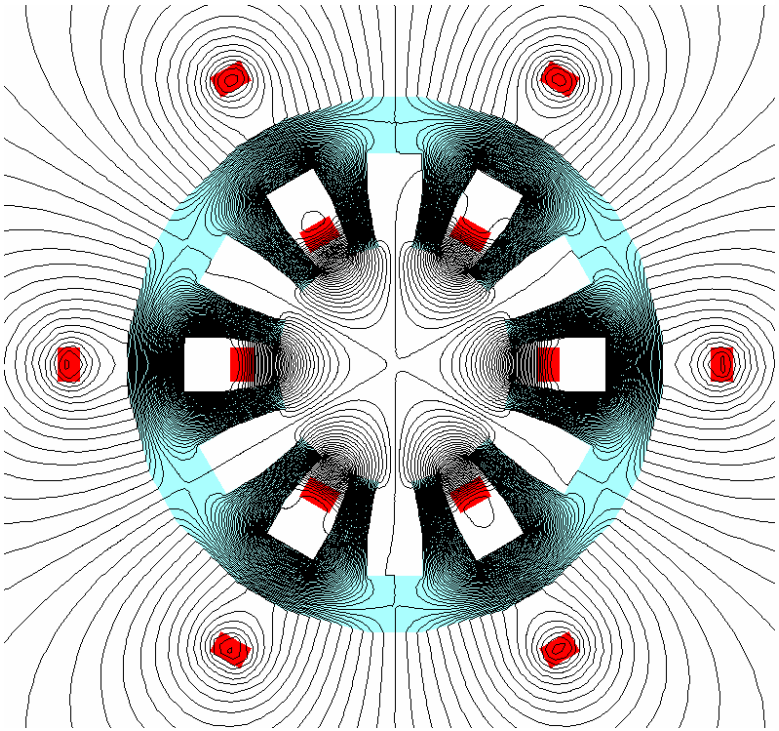


Normal quadrupole flux lines and yolk flux density



Skew quadrupole flux lines

Sextupole Model



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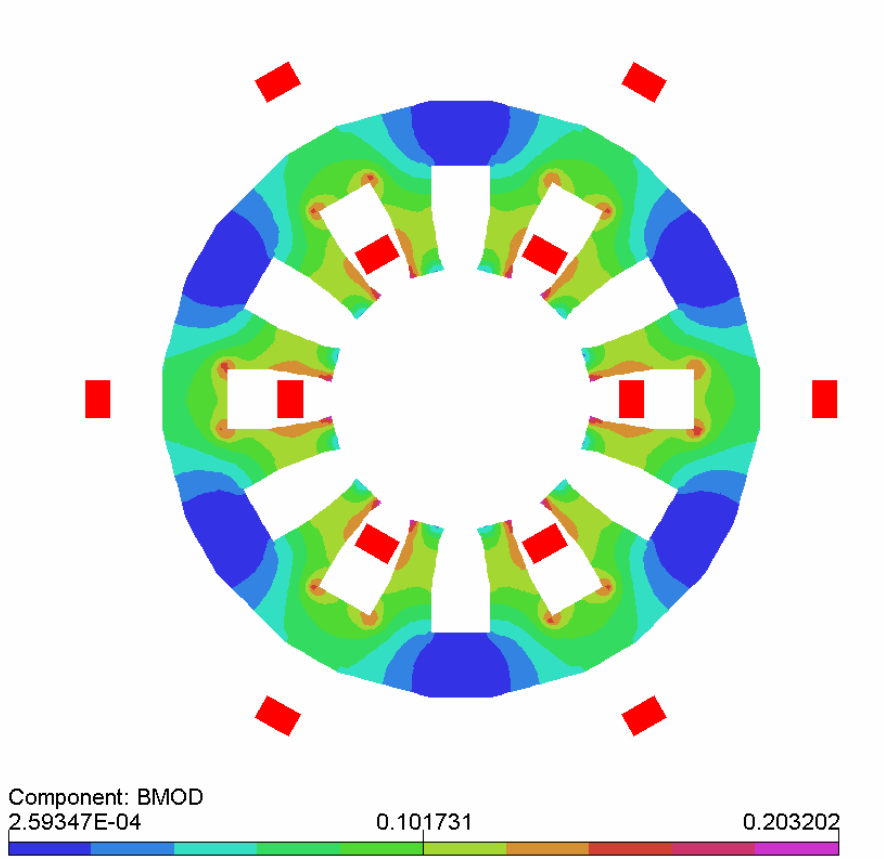

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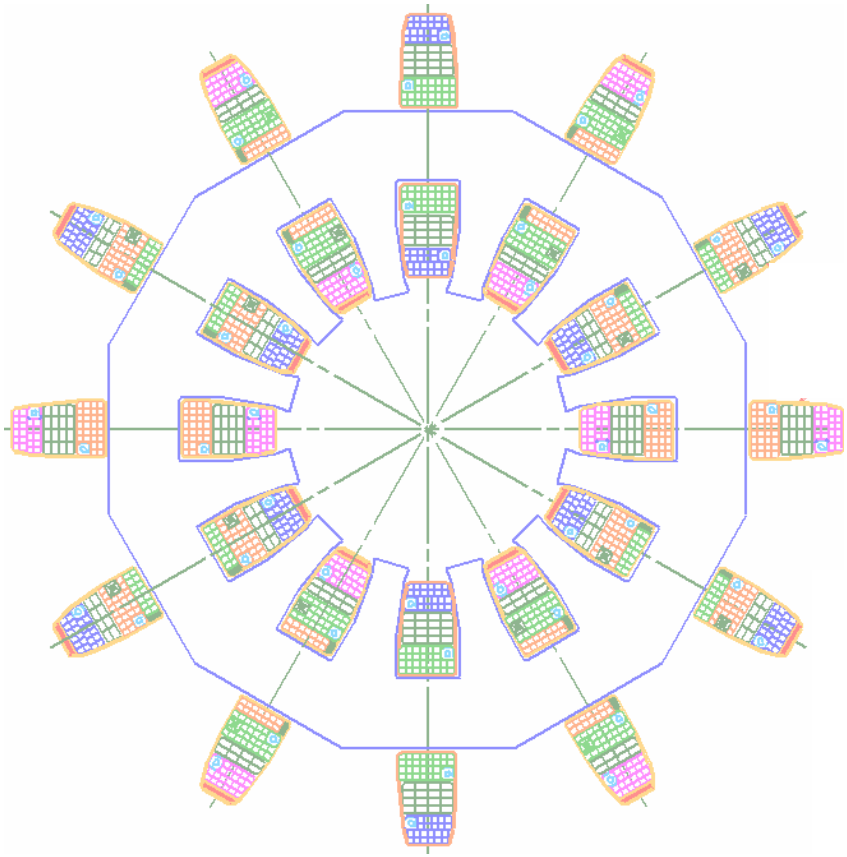

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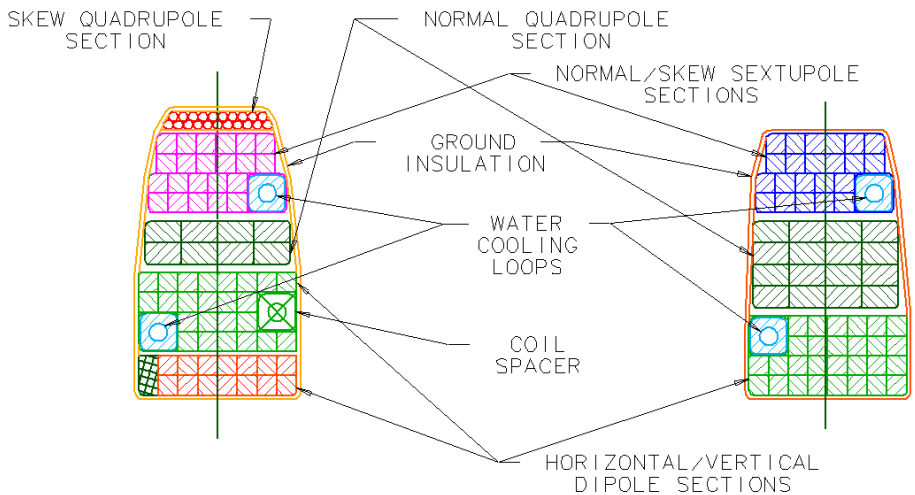
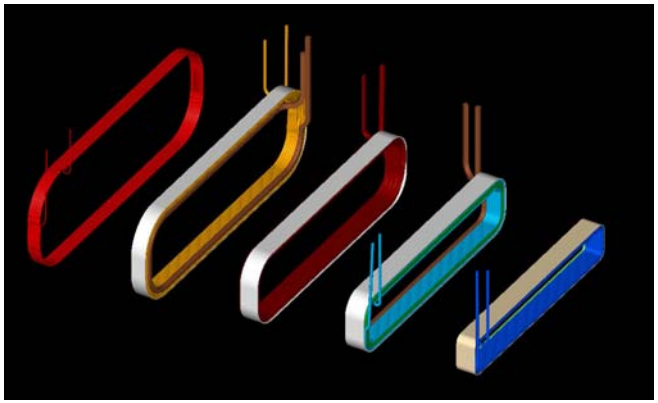
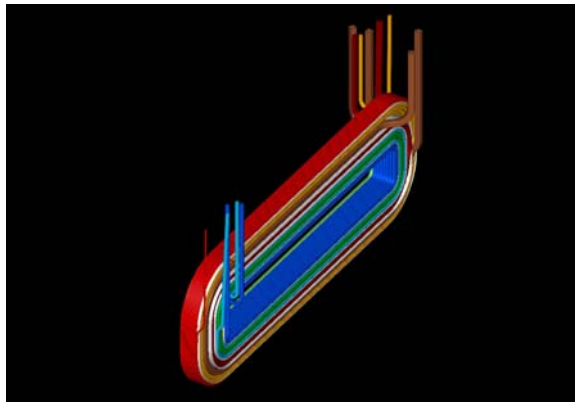
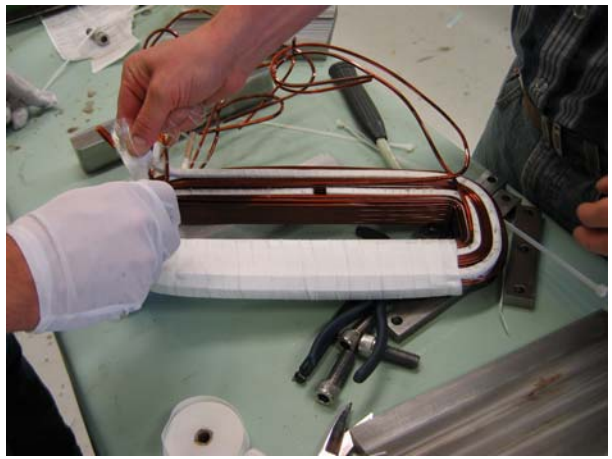
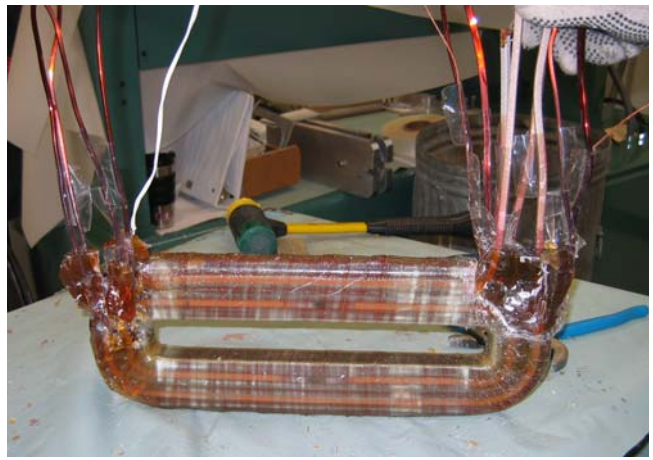


Prototype Coil Fabrication

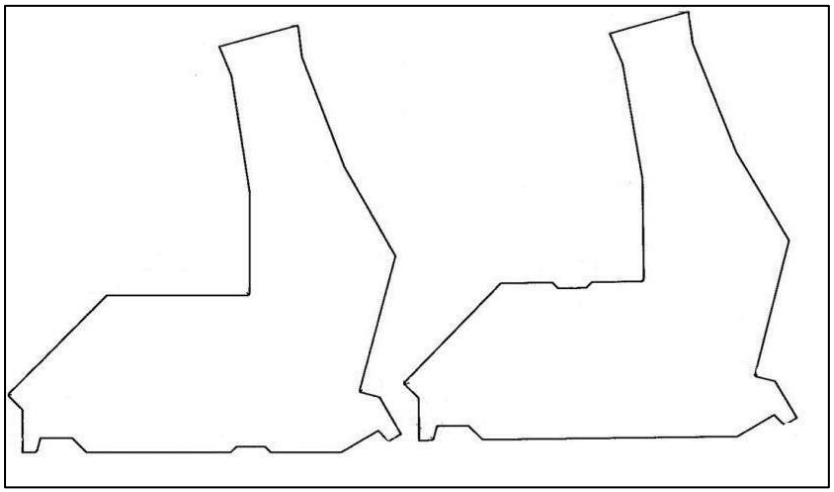


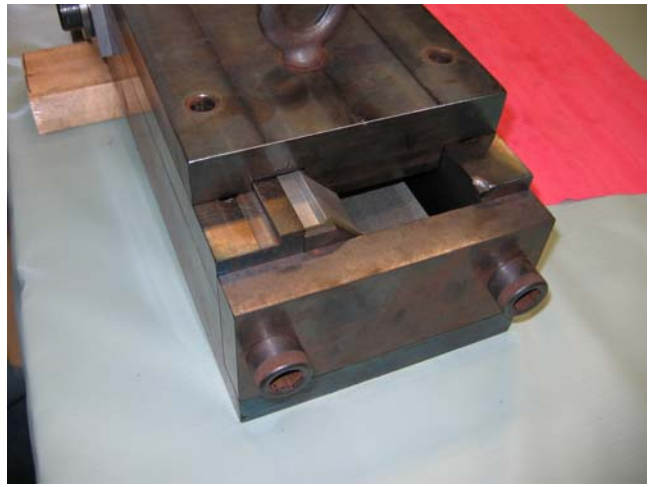




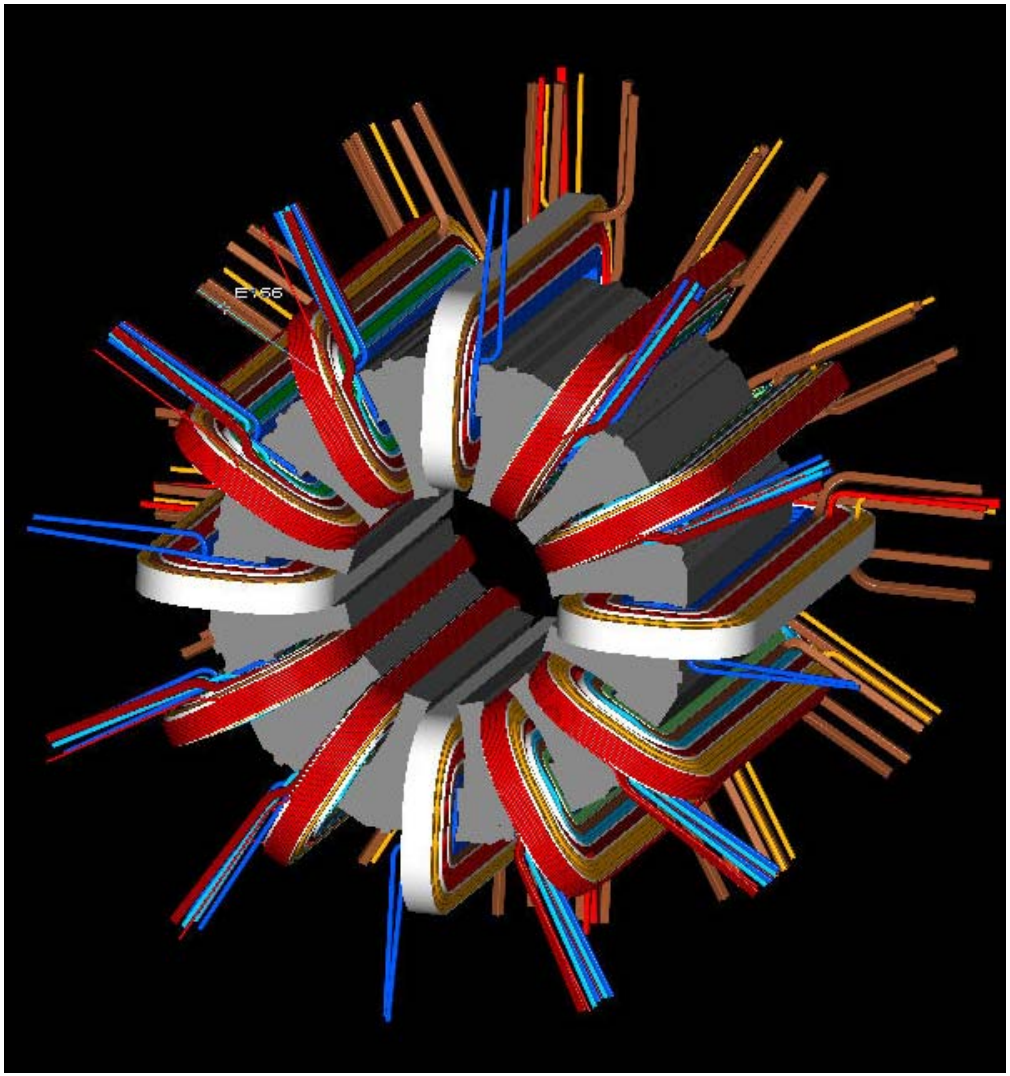


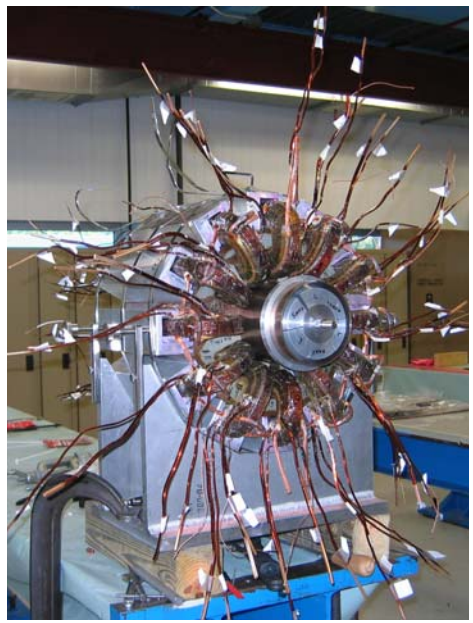
Prototype Core Assembly





Magnet Assembly





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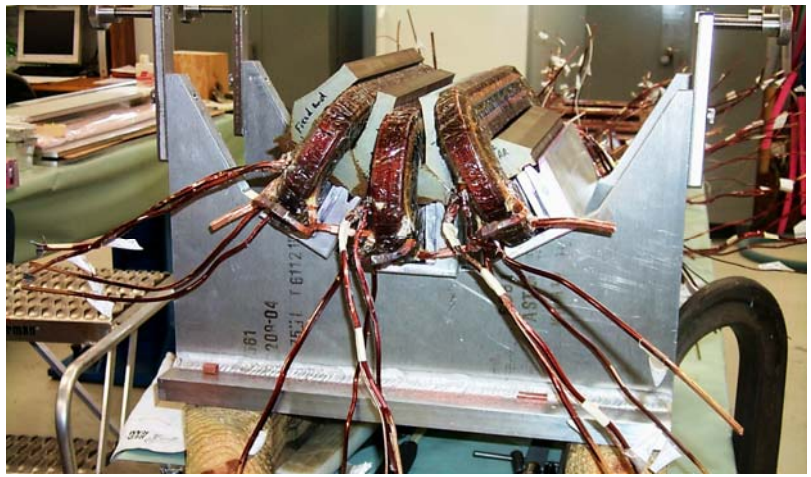
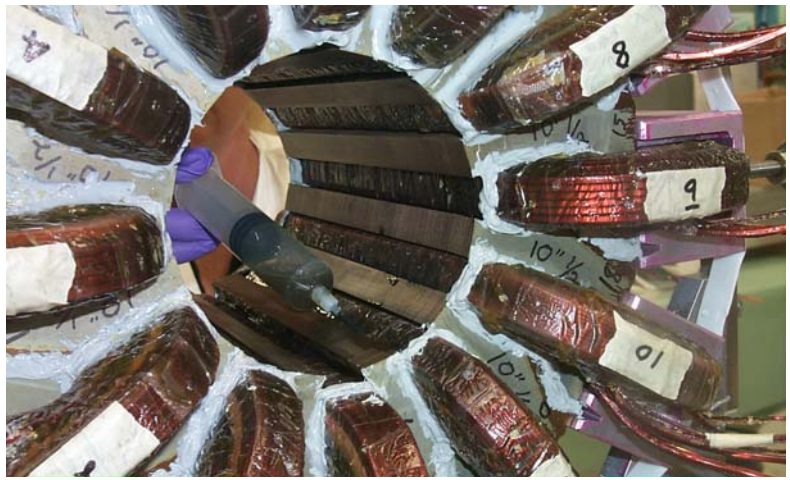
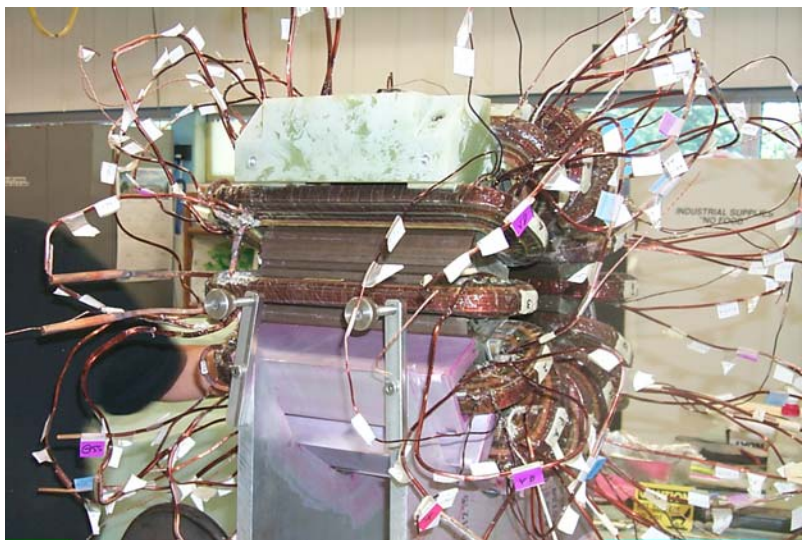
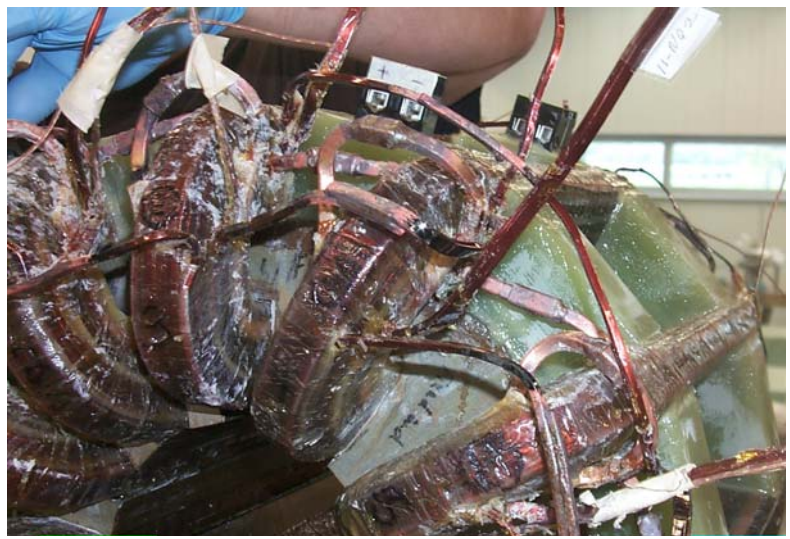
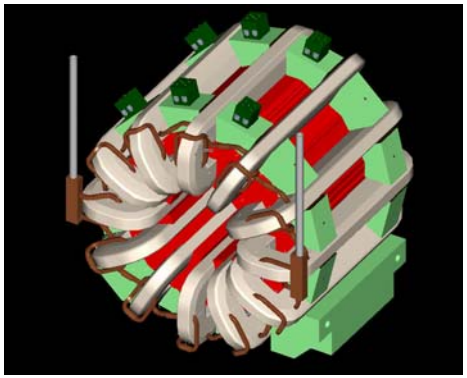


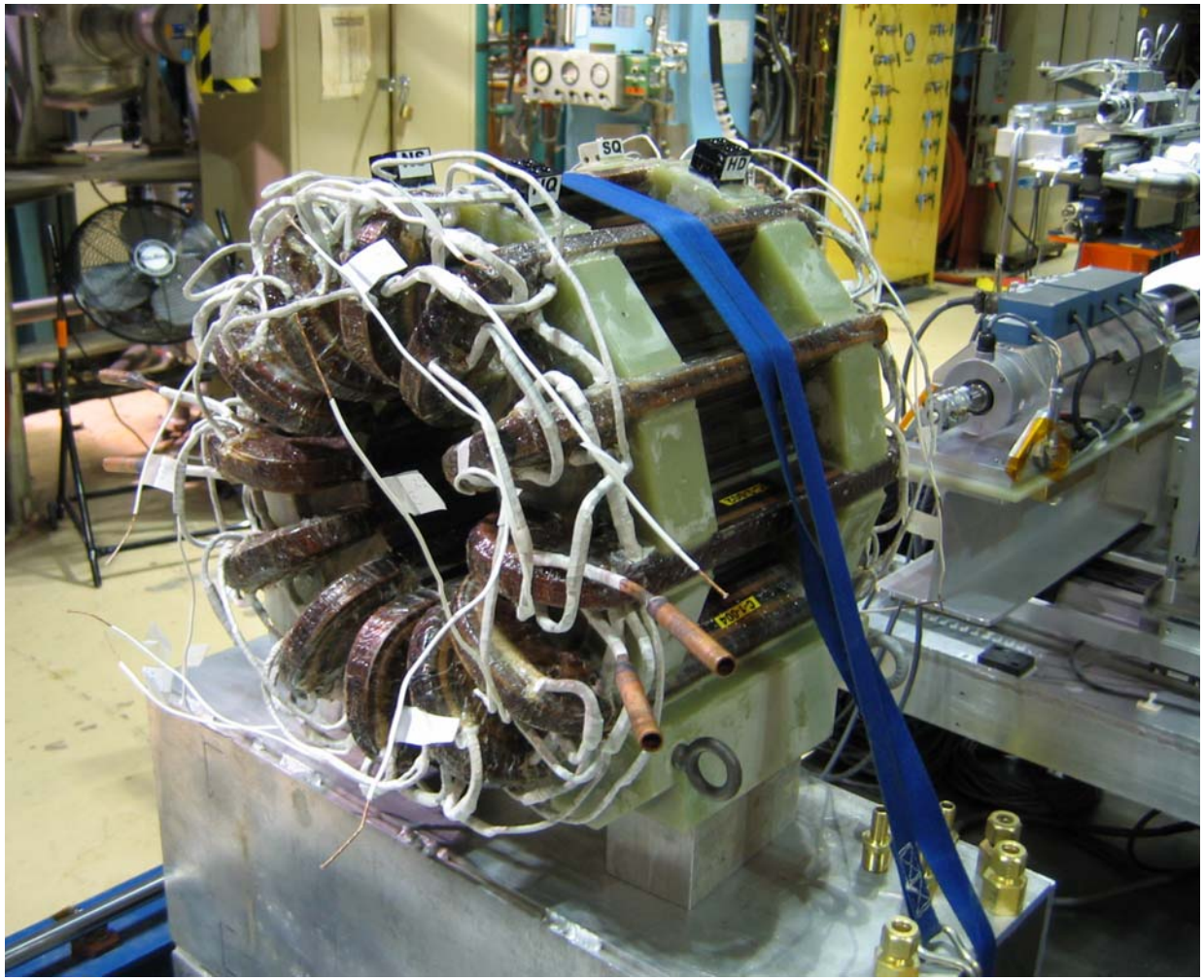




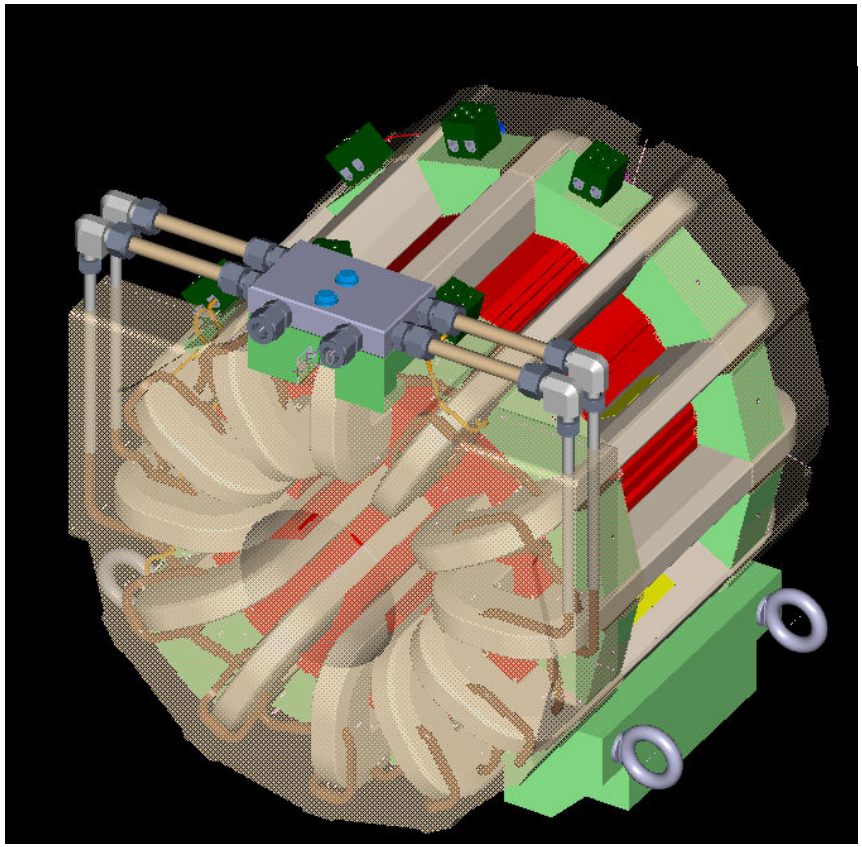


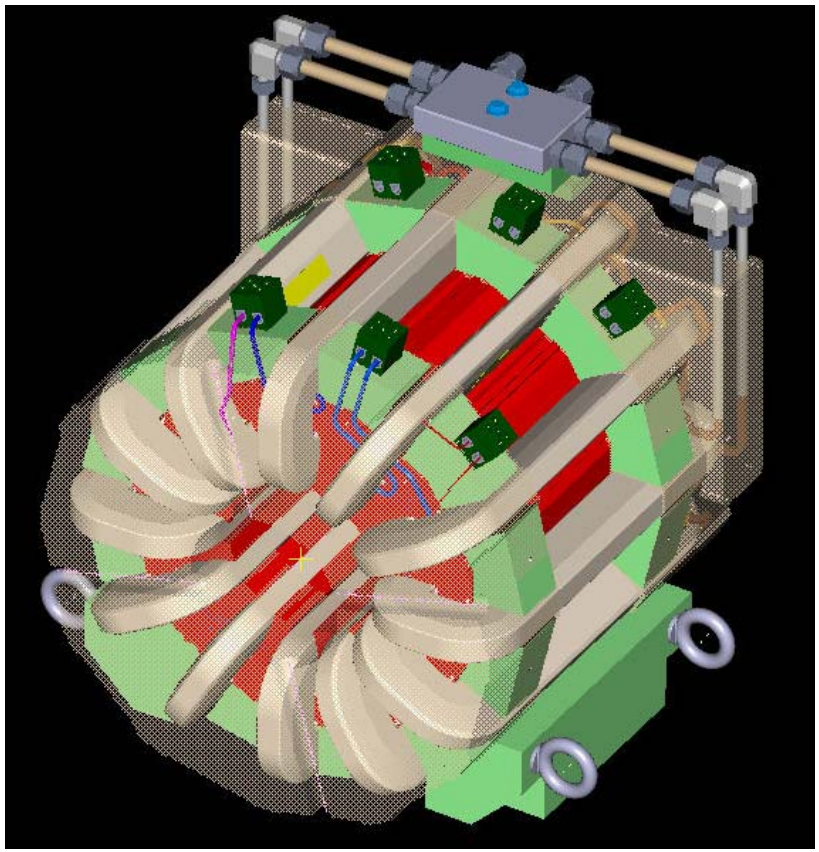
Prototype Magnet at MTF





Finished Magnet





Lessons from the Prototype Fabrication

- Coil winding not as difficult as we feared
  - We hope that this translates into good prices on the coil winding contract.
- Heat transfer to water exceeds expectations
  - We can probably even run with one water circuit blocked.
- There are subtleties in core stacking and bonding
  - We have built new stacking tooling to improve on early, crooked cores.
- QA will be essential
  - We were able to recover from losing two turns on the first coil package wound, but we don't want to make a habit of it.
- Will continue to work on assembly procedures
  - We have not yet potted this magnet.

Production Plan

- Contract for coil fabrication
- Contract for core fabrication
- Assemble magnets at Fermilab
- Test magnets at Fermilab

- Contracts
  - Base quantity for Long Straight Sections + spares
  - Option for Short Straight Sections

Coil Contract

Request For Information sent in June

- Part drawings
- Specifications
- Tooling drawings
- Traveler
- Video of our coil winding

- Responses received in August – vendors interested
- Visited domestic vendors in August
- Requests For Proposals out, due 18 October
- Award contract November, will try to accelerate
- Start deliveries February, will try to accelerate

Magnet Assembly

- Six parallel assembly stations
  - Coils assembled onto cores
  - Cores built into magnet on rotating mandrel
  - Water lines trimmed and brazed
  - "Dry" connection of leads and in-process check
  - Normal windings trimmed and brazed
  - Full magnet testing
  - Ends potted
- Will consume all technicians available (adding, training two contract techs this fall)
- Buying extra coils, cores in case we lose a few

QA/QC

- Incoming inspection of components
  - Coils (100%)
    - Dedicated system to check inductance (number of turns)
    - Hi-pot
    - Water flow, pressure
    - Gauge to check dimensions
  - Cores (% to be determined)
    - Flatness
    - Length

QA/QC (continued)

- "Travelers" to manage assembly
- In-process inspection
  - Water flow, pressure
  - Total magnet electrical checks
  - Dedicated field polarity tester to check connections
- Magnet measurements before potting
  - 100% testing
  - 1.5 day per magnet
  - Specific measurements to be determined
- In-process inspection (continued)
  - Repeat electrical measurements before potting
  - Repeat electrical measurements after potting

Safety

- The magnet fabrication and measurements are typical of the Technical Division projects.
  - Every activity is guided by a "traveler" that is reviewed
  - Technicians are trained in general and job-specific activities such as brazing
  - The test stand was subject to a review before it received its operational readiness clearance.
- The greatest hazard to TD and vendor technicians is probably repetitive strain injuries.
  - We are very conscious of the danger and are working to optimize the ergonomics
- All Fermilab-standard ES&H language will be in the contracts with vendors, will be evaluated in selecting the primary vendors, and will be monitored.

Risks

- Delivery of components
  - Work with management, BSS Procurements Department
  - Detailed information provided to potential vendors
  - Careful selection of vendors
  - Close monitoring of vendor performance
- Assembly errors
  - Quality Assurance – see earlier slide for sample details
- Equipment failures
  - Spares of electronics
  - Overtime
- Extra labor needed
  - Other technicians from TD
  - Overtime

Milestones

- 11/3/06 Award coil contract
- 11/14/06 Award core contract
- 12/13/06 Vendors production plan approval
- 1/10/07 Vendors start production
- 1/31/07 Receive first core set
- 2/2/07 Receive first coil set
- 2/14/07 Start assembly first magnet
- 3/2/07 Start assembly second magnet
- 4/5/07 First magnet to MTF
- 5/18/07 First magnet complete
- 6/6/07 Twelve magnets complete
- 7/11/07 Twenty-four magnets complete

Cost Estimate

Item	Per magnet	Unit cost	Total for 24
Components	1 lot	$ 26,200	$ 628,800
Assembly labor	203 hr	$ 9,100	$ 218,400
EDIA			$ 117,500
Total			$ 964,700

Summary

- We have a robust design
- We have a sound production plan
- We have a vigorous QA/QC plan

- We are ready to move forward with procurements