Nuclear Physics

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Nuclear Physics

- RHIC Superconducting Magnet Systems Support
- RHIC & AGS Helical Magnet Programs
- RIA Program
- Conclusions

Nuclear Physics – RHIC Magnet Support

RHIC has a large inventory of superconducting magnets:

- 360 8 cm dipoles
- 444 8 cm quadrupole/sextupole/corrector (CQS) units
- 72 13 cm IR quadrupoles
- 24 10 cm IR dipoles
- 12 18 cm IR dipoles
- 12 siberian snakes/spin rotators (48 helical dipole units)

- The dipoles and quads are powered on separate circuits.
- The IRs use a complex circuit arrangement to allow adjustment of individual magnet currents.
- There are 144 flow controlled gas cooled leads.
- There are over 2000 Voltage taps that are used for quench detection and fault diagnosis.

Nuclear Physics – RHIC Magnet Support

Magnets, Bus Work, and Lead Failures: (For six runs)

- CQS magnet removed and quadrupole corrector replaced during shut down period.
- CQT magnet removed and trim quad lead repaired during shut down period.
- CQT magnet had to have its quench protection diode replaced, delayed start of a run by 2 weeks.
- Short to ground – found bellows squirmed at D5I which required major mechanical retrofit. Short was found and retrofit done during shut down period.
- Short to ground at Y10D6 – disconnected unused shunt bus.
- Shunt bus short at Y12Q3 – Opened up magnet wiring box and repaired connections.
- Both Y10D6 and Y12Q3 failures happen at the same time, that run was delayed by 4 weeks.
- Corrector lead repair at B5Q3 – New lead spliced to burnt out lead, delayed run by 1.5 weeks.
- Blue 4 valve box - 12 X150 A gas cooled lead had broken ceramic insulator – replaced broken lead, delayed run by 1 week.

Quench Detection:

- There are 24 quench detectors in RHIC and one in AGS.
- These are digital systems that measure magnet voltage and current and determine if a quench has occurred. They also serve as an interlock for gas cooled leads.
- System design has to be fail safe and reliable or magnet or lead damage will occur.
- There are over 1500 Voltage Taps and power supply currents that the quench detectors monitor.
- The quench detector system has its own data archival system, separate from accelerator controls.
- The system has proven to be a powerful diagnostic tool.
- SMD staff maintain the hardware and manage the software of this system.

Nuclear Physics – RHIC Magnet Support

Other support items:

- Engineering support to Collider Power Supply Group.
- SMD personnel are on call 24/7 when RHIC is running to diagnose magnet and power supply problems.
- SMD personnel supervise the magnet testing during cool down, start-up and warm-up of RHIC.
- Developed system to prevent ice build up on gas cooled leads. Before this system was installed, ice on voltage taps would cause trips on the quench detectors.
- Magnetic measurements on spare RHIC magnets to supplement production measurements for new operating conditions.
- Magnetic measurements on RHIC triplet magnet in the tunnel when the magnet where warm.
- Engineering support for future upgrade – e-cooling & e-RHIC.
- SMD personnel loaned to C-AD during shut downs.

Nuclear Physics – Helical Magnet Program

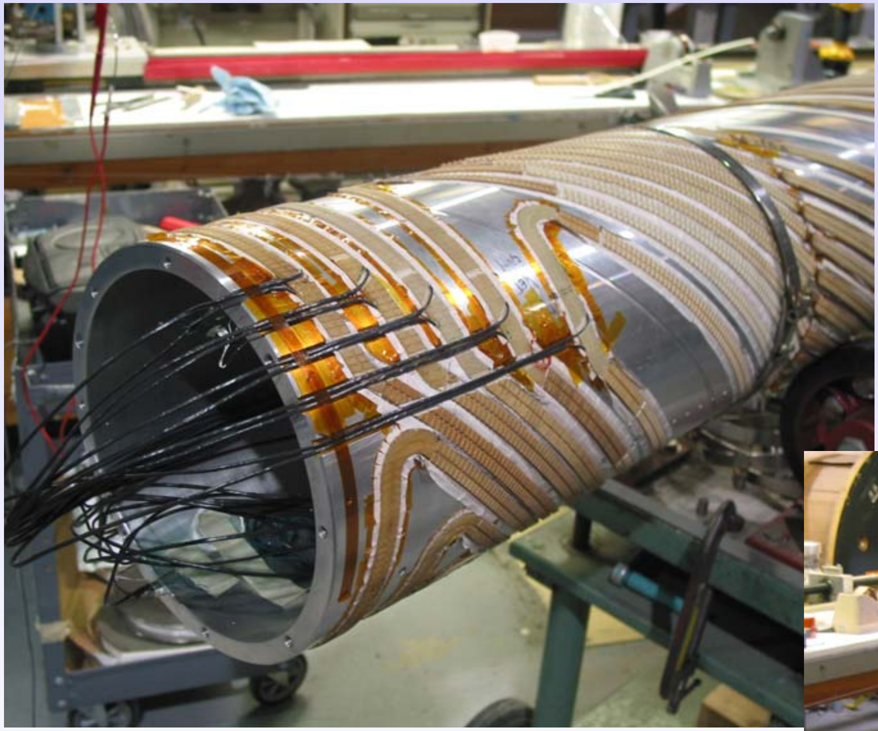
Magnets, Bus Work, & Lead Failures:

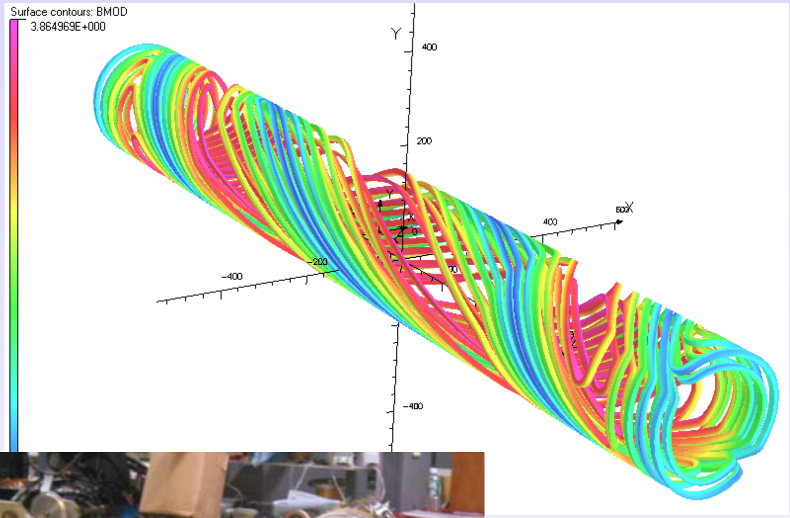
- Y9SNK7 coil 2 opened during an earlier run. The magnet was removed and a coil block replaced during shut down period.
- After extensive cold tests, no clear cause of the fault was found, but a potential problem with quench detection algorithm was found and corrected.
- B9SNK7 ceramic leads developed large leaks and were replaced in the tunnel during shut down period.
- AGS cold snake developed short to coil form, micro surgery was performed to repair the coil.
- **SMD Helical Support:**
- SMD is currently constructing a new helical dipole cold mass.
- SMD will be doing fast magnetic measurements on a helical spare to see how the quench protection resistors across the coil blocks affect the magnet’s field quality during a ramp.

AGS Cold Snake:

- The AGS Cold Snake was a major RHIC program element during FY05.
- Augment the existing partial snake with a more powerful one. Polarization 50% → 70%
- Complex coil geometry (variable pitch helix).
- Complex correction coils wound on bore tube.
- Large aperture, high field (20 cm dia., 3 Tesla).
- No cryogenic infrastructure in AGS – low heat loss design which enabled the use of cryo-coolers.
- Cooling from cryo-coolers for DC operation, 2 W heat load max.
- Cool down or refilling after quench is done from a remote liquid helium dewar.
- Snake magnet required active quench protection. Quench heaters were used and they are triggered by a RHIC type quench detector.

SC Magnet Division – Director's Program Review
Nuclear Physics – Helical Magnet Program

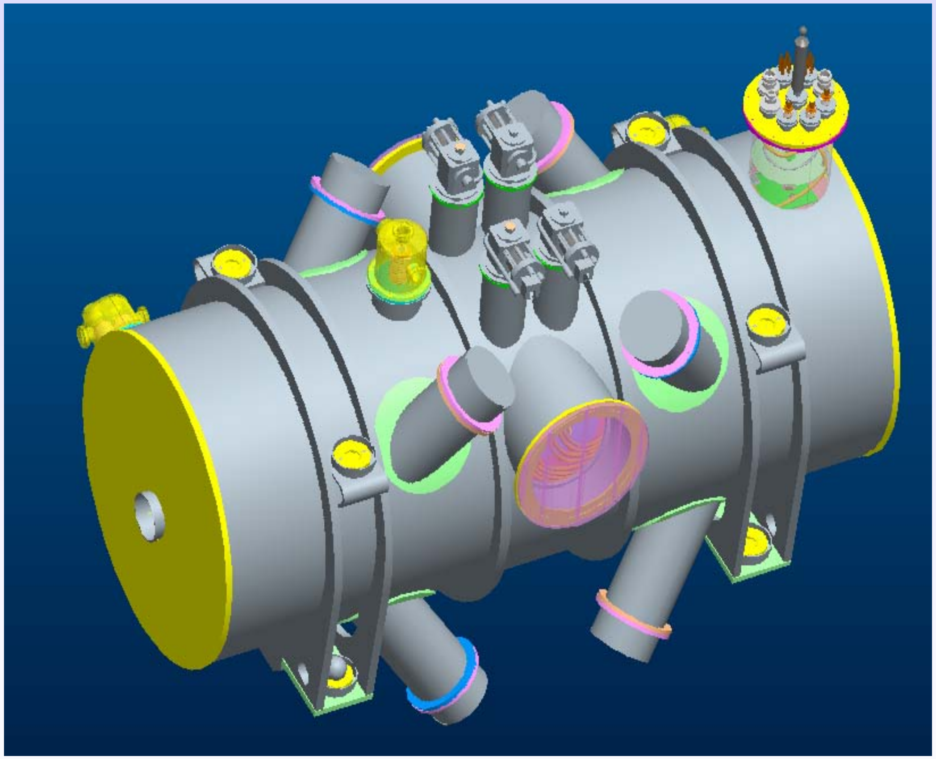




AGS Cold Snake

Inner and outer coils

Nuclear Physics – Helical Magnet Program



In the AGS tunnel
(delivered in March 05)

3D model done in Pro-E

This magnet was built with out a prototype being done.

Nuclear Physics – RIA Program

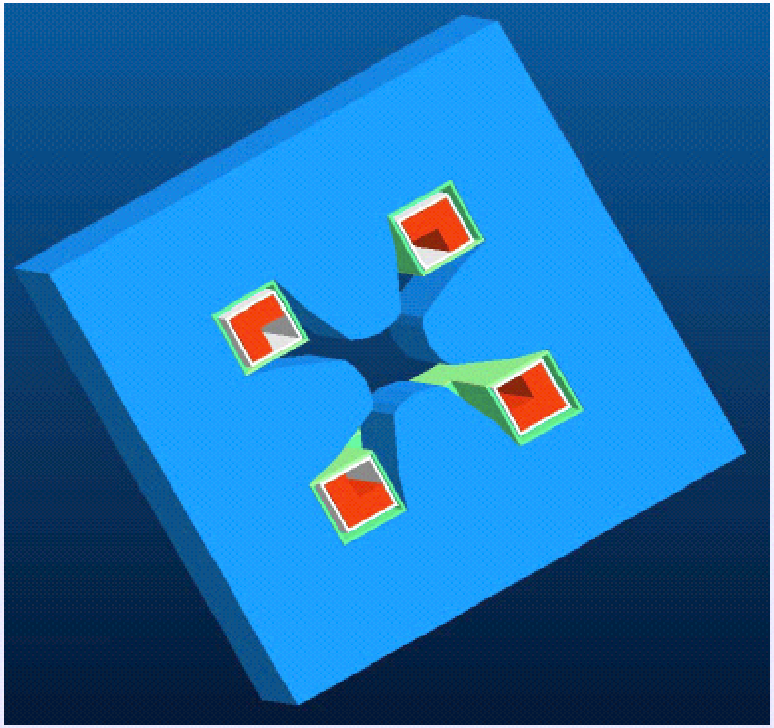
RIA – Rare Isotopes Accelerator:

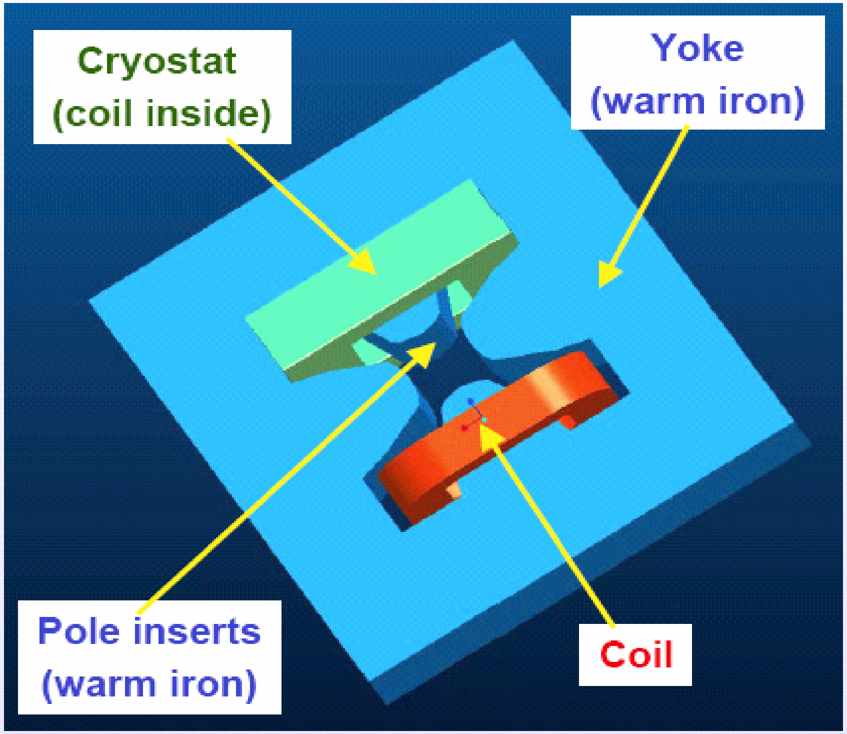
RIA requires a quadrupole magnet with high pole tip field of 1.5 Tesla (as compared to a conventional magnet) and very high radiation resistance. (RIA quadrupole is subjected to a lifetime dose of 10^19 n/cm^2 of high energy (several hundred MeV) neutrons.)

- SMD's program for RIA is to develop a quadrupole magnet using HTS coils mounted in separate cryostats assembled in warm iron.
- Some design features:
  - Coils use BSCCO 2223 tape with stainless steel backing.
  - HTS critical current falls slowly as a function of temperature.
  - Can operate at 20-40 K while giving twice the gradient of conventional magnets.
  - A large amount of energy can be deposited in the magnet coils. (~ 130 Watts)
  - Operation at 20-40 K gives a much simplified cryogenic system.
  - Precise temperature control not necessary.
  - Radiation resistant design using stainless steel as an insulator.

A simple warm iron super-ferric quad design with two racetrack HTS coils

Note that only a small fraction of mass is cold (see green portion), and also that it is at a large solid angle from the target





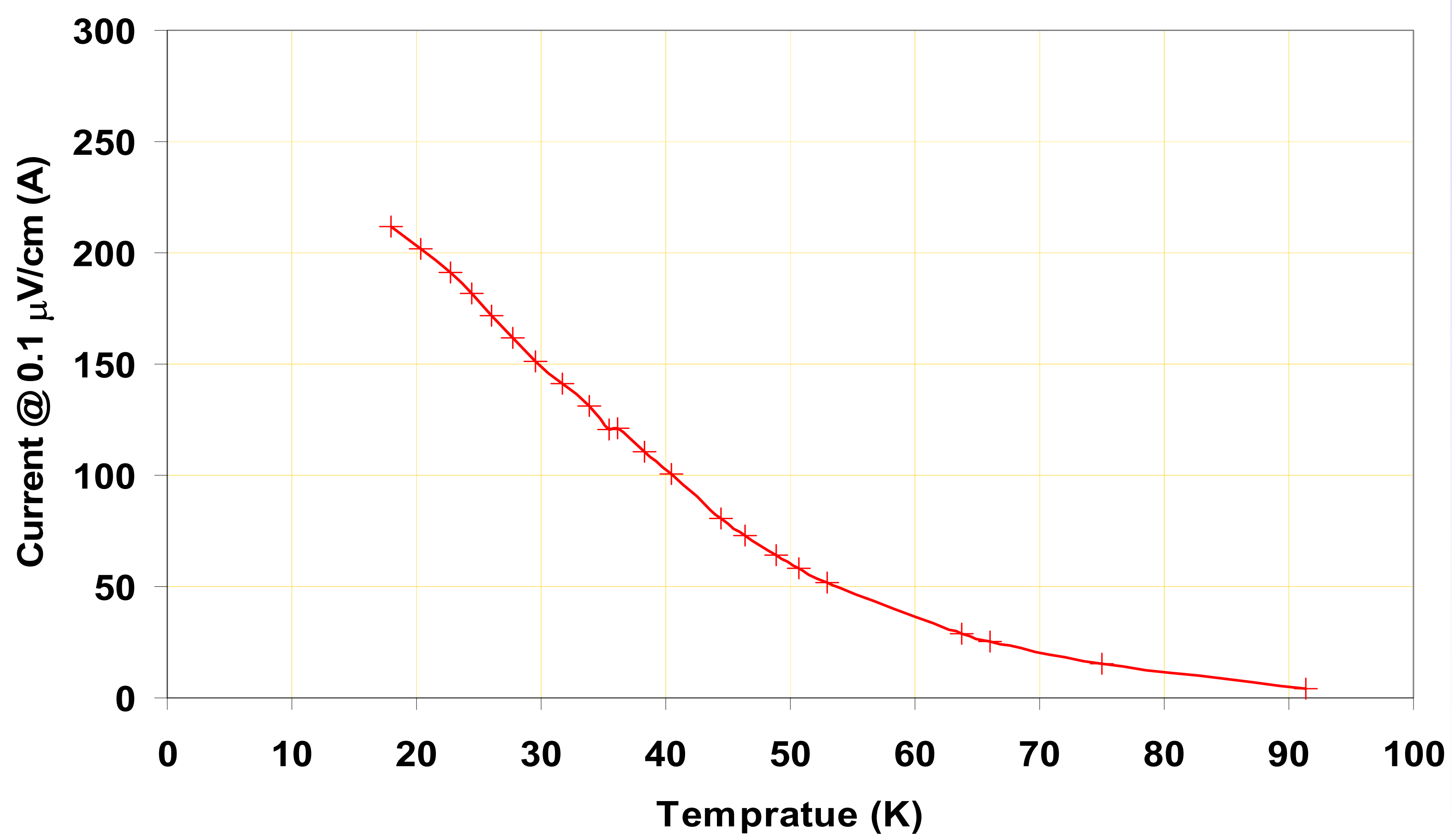
Energy deposition in RIA quad iron is 15 kW.
Warm iron 2 coil design is developed in a way to reduce this load on the coil by over 2 orders of magnitude (~15 kW to ~130 W) in HTS coils.

SC Magnet Division – S&T Committee Program Review
Nuclear Physics – RIA Program

A coil being wound on the new computer controlled winding machine

6 layer coil going for test in VTF

Recent Successful Test results of a 12 layer Coil



Nuclear Physics – Conclusions

- **RHIC**
  - SMD personnel play a critical role in the operation and repair (when needed) of RHIC.
  - When the detailed design starts for RHIC upgrades, SMD personnel's vast knowledge of the magnet system will be vital to that effort.
- **Helical Magnet Program**
  - The RHIC spare helical magnets are going to reduce risk to the program. (There were not enough spares.)
  - The AGS cold snake was one of the most challenging magnet systems SMD has developed. Few organizations can build a device that complicated and get it right the first time.
- **RIA**
  - The experience SMD personnel are getting from this program is invaluable for future HTS projects.
  - Viability of HTS in accelerator type magnets is demonstrated
  - Technology developed at SMD can have wide ranging applications.