BNL TESTING EXPERIENCE

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BROOKHAVEN NATIONAL LABORATORY

a passion for discovery

Office of Science
U.S. DEPARTMENT OF ENERGY

OUTLINE

- Prehistory
- BNL Magnet Test Experience
- Magnetic Field Measurements
- Cryo Plant History

PREHISTORY

- BNL Site:
  - World War I – Camp Upton – recruits from NYC reported here, were shipped out. Some training (zig-zag trenches)
  - World War II – Rehabilitation → tennis courts, swimming pool, bowling alley, gym.
  - Several universities in the Northeast proposed a national lab that would build facilities for users from universities etc.
  - Site options: surplus land owned by U.S. government. Lab founders chose Camp Upton. Lab opened in 1947.
  - First accelerator: Cosmotron, 1 Gev, 1952-1966. Magnet Division now occupies this space.
  - The AGS (30 GeV) followed the Cosmotron.
  - 1968 BNL Summer Study – Superconducting Accelerator Magnets.

MAGNET CRYOGENIC TEST PROGRAMS: ISA

- ISA (Intersecting Storage Accelerator) – 200 GeV
  - 1970's. 4T, 4.5 m (defined by hook height of Cosmotron crane), training to 4T was a reasonable goal
  - NbTi, single layer coil, wide superconducting cable (~ 2X cable for RHIC) ⇨braided conductor (hard to make, some places cable thickness was three strand thicknesses) ⇨large eddy currents.
  - ISA users wanted 400 GeV – ISA design reworked to achieve this – magnet goal was 5T, longer length, larger aperture ⇨much larger stored energy

ISA (continued)

- One magnet reached 5T (Mark V). However, later magnets did not. Problems controlling eddy currents.
- BNL started alternative magnet program under Bob Palmer. Two layers, Rutherford (Fermilab) cable for demonstration magnets, which worked. This indicated that BNL had put together a team that could build superconducting magnets for accelerators. (Palmer's suggestion for a 2-in-1 was not accepted by the accelerator physics group.)
- However, the user community pushed for the SSC. Isabelle R&D ended 1983. By then SSC R&D money was available. BNL joined Fermilab and LBNL in this work.

The Superconducting Super Collider

- Initial design very aggressive: pre-reacted Nb_3Sn, 17m length, 32 mm i.d., flared (“dogbone”) coil ends. After some repairs, the first magnet worked ok.
- However, when the project office took over, NbTi was selected: 17m length, 40 mm i.d. The magnets worked reasonably well.
- Westinghouse Corporation won the contract for the dipoles. Westinghouse staff worked at BNL for about a year.
- During that time, the effect of magnetization currents at injection was discovered at DESY. For the SSC, this meant that the dipole aperture had to be increased to 50 mm.
- The succession of cost increases, the loss of political support, the change to Clinton as president, and economics of the time led to the termination R&D of the SSC in 1993.

The Relativistic Heavy Ion Collider

- RHIC R&D began to receive significant funding in 1993 (“just in time”). Lattice was redesigned to increase Quad/Dipole to provide greater focusing needed for fully-stripped heavy ions (e.g., gold).
- Dipoles: 10 m length, 80 mm aperture, curved to follow the beam, 3.45T central field. 10 R&D magnets worked well. Contract awarded to Grumman. Two additional magnets made as part of tech transfer. (One is in front of the Magnet building.)
- SSC conductor spec. – saves R&D time and money

RHIC(continued)

- Cold testing: First 10% (30 magnets) -- every dipole cold tested; remainder of production run: only 10% cold tested.
- 2000 “magnetic elements” altogether.
- RHIC polarized proton program: snakes to control spin in lattice, rotators to orient spin axially at collision points. 4T, 100 mm i.d., helix rotates 360° in 2.4 m, 48 units needed. NbTi 6-around-1 cable, strand diameter 0.33 mm.
- RHIC has been operating ~ 18 years.

US-LHC: IR and RF locations

- Variations of RHIC arc dipole:
  - Straight (not curved) coil
  - D1 (single aperture) 5 made (including spares)
  - D2 and D4: twin apertures in single yoke 15 made
  - D3: two cold masses in one cryostat. 6 made
- APUL: made two additional D1's. (In the spare D1, one of the quench protection heaters had a short.)

MAGNETIC FIELD MEASUREMENTS
(special thanks to Erich Willen)

- During ISA R&D, Morgan Coils were used to measure magnetic fields. (Morgan coils are wound with the same nθ wiring as the harmonics they were measuring.) Results were unreliable because the wiring was often wrong.
- Erich Willen and John Herrera were asked to develop a better system. They chose tangential coils because they judged it easier to machine accurate cylinders. Coils had five windings: two dipole bucks, two quad bucks, one tangential.
- Accurate (6 digit) DVMs from H-P became available in the same time frame. This allowed digital bucking.
- Coils were time consuming to wind (50 micron wire …)
- AUP will use printed circuits from Fermilab.

CRYOGENIC TEST FACILITY

- Cryogenic group established for bubble chamber detectors in the 1960s.
- Magnet test facility dates from the 1970s. Mycom compressor dates from that time. Facility provided supercritical helium.
- Horizontal testing: 4.5 m extended to 10 m.
- Vertical testing: 6 dewars. Used for both magnet and short-sample testing.

Cryo Test Facility (continued)

- Later added:
  - Refrigerator from AGS beam line
  - Helium tank farm, partly from Lakehurst NJ (blimps…)
  - Nash high-capacity pump from SSC (1999) ⇨ 1.9 K He
  - 10,000 liter liquid storage (2000)
  - Sullair backup compressor (from g-2 experiment)
- Next addition:
  - Linde 1610 (80 liters/hour) from DOE lab in Washington state – PO for shipment is underway. Will enable three quenches per day for AUP.

Beyond HiLumi

- Next Nuclear Physics large facility: EIC (electron-ion collider).
  - Favorable report from National Academy of Sciences expected this summer.
- Two possible locations: BNL, Jlab
- Both designs require superconducting IR magnets
  - Novel designs needed to handle the very different energies of the electrons and heavy ions.