NuMI Magnets

or

What to look for in a gift magnet's mouth

David Harding

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Re-using Magnets
Pros & Cons

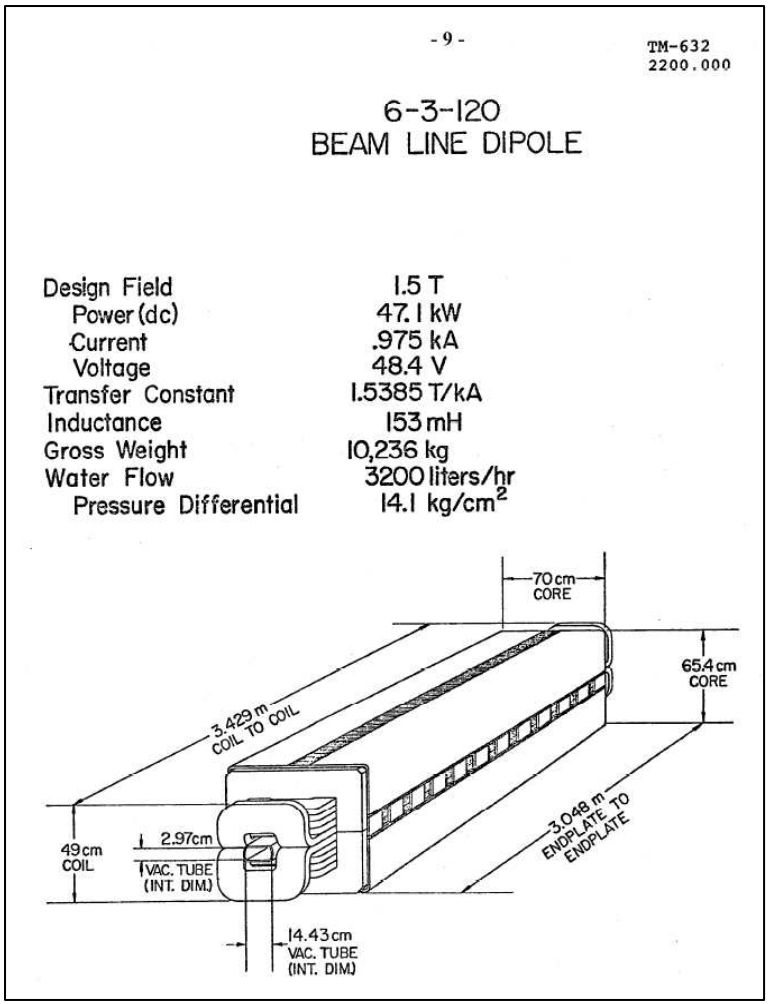
- Cheaper, defined
- Quicker
- Focuses beam design
- Minimizes rad waste
- Known properties
- No surprises

- But not free
- But not instantaneous
- Limits beam design
- Rad exposure
- False assumptions
- Surprises

Metal prices have been volatile

6-3-120 Dipoles

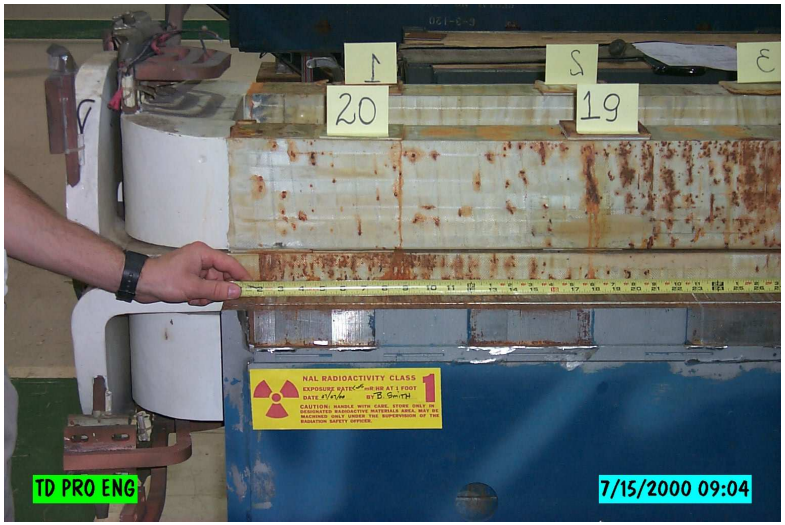
- Not used in final beamline design, but several rehabbed for early design and BNB
- Venerable magnets had been sitting in decommissioned beamlines



6-3-120 Surprises

- Poor coil-to-ground insulation
- Much work
  - Extra time
  - Extra cost

Inside an old 6-3-120 dipole



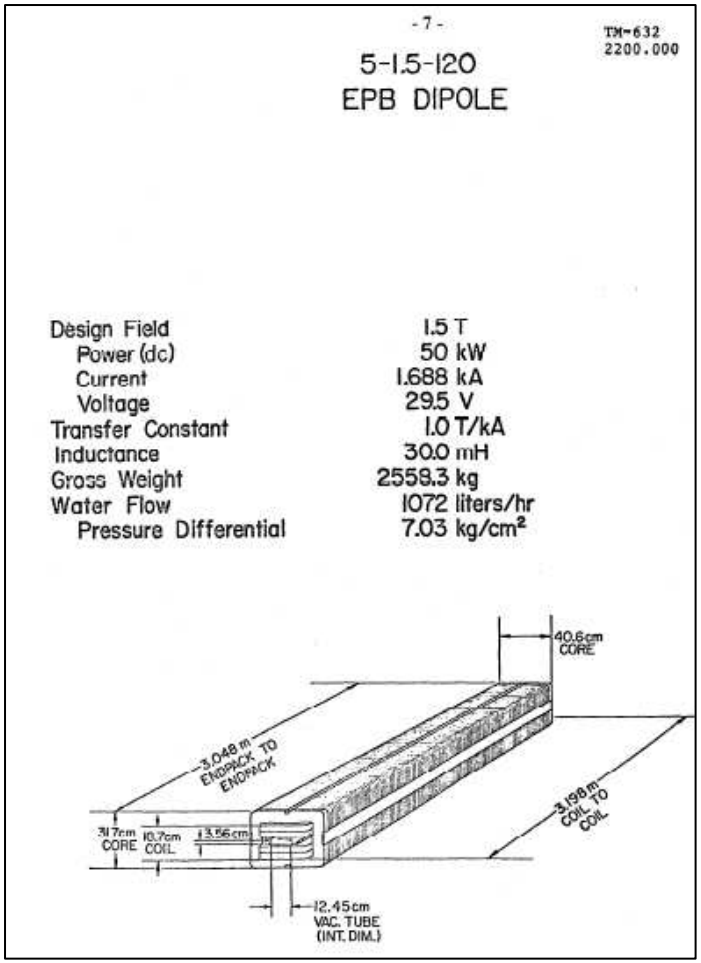
An old 6-3-120

B2 Dipoles

- Specs changed, clarified in process
  - Tolerances on beam tube length and flange position
- Worked out fine in the end
  - Could have been substantial cost increase

EPB Dipoles

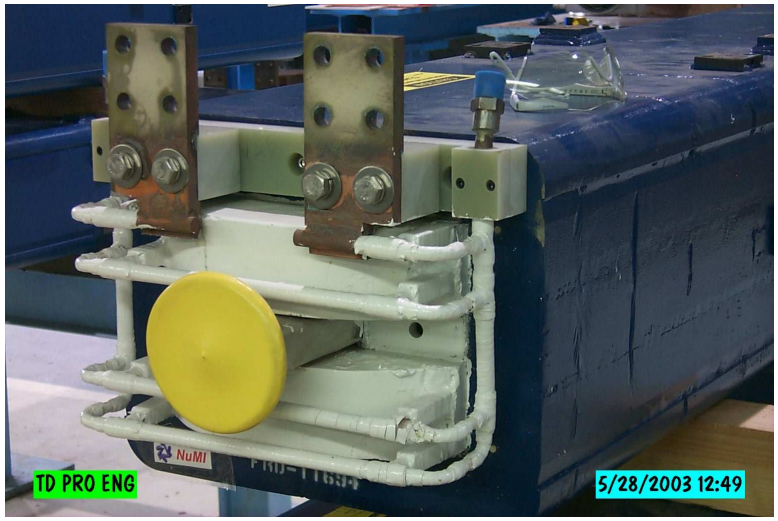
- Extensively used in NuMI and SY120
- Venerable magnets had been sitting in decommissioned beamlines

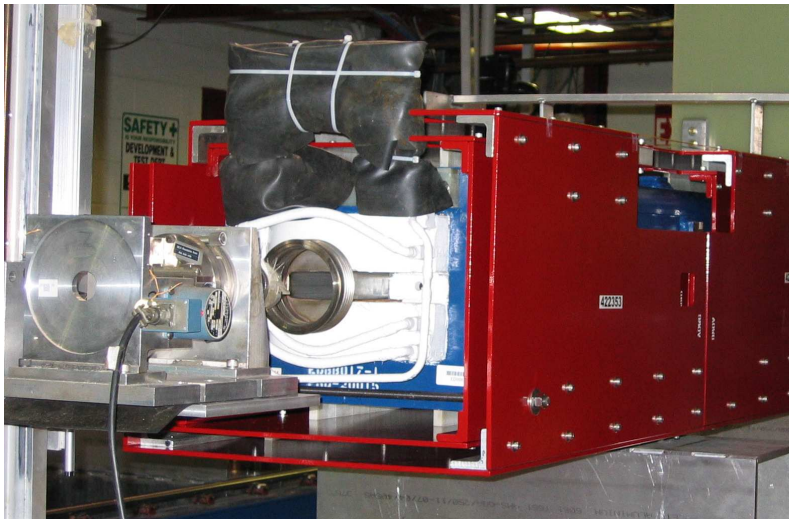


EPB Dipole comments

- As with B2 dipoles, beam tube length, flange position, squareness issues
- Multiple bus, manifold possibilities
- Magnetic shielding effort successful
- Notoriously fragile insulators
  - Have been problematic
  - Upgrade designed, tested, to be installed

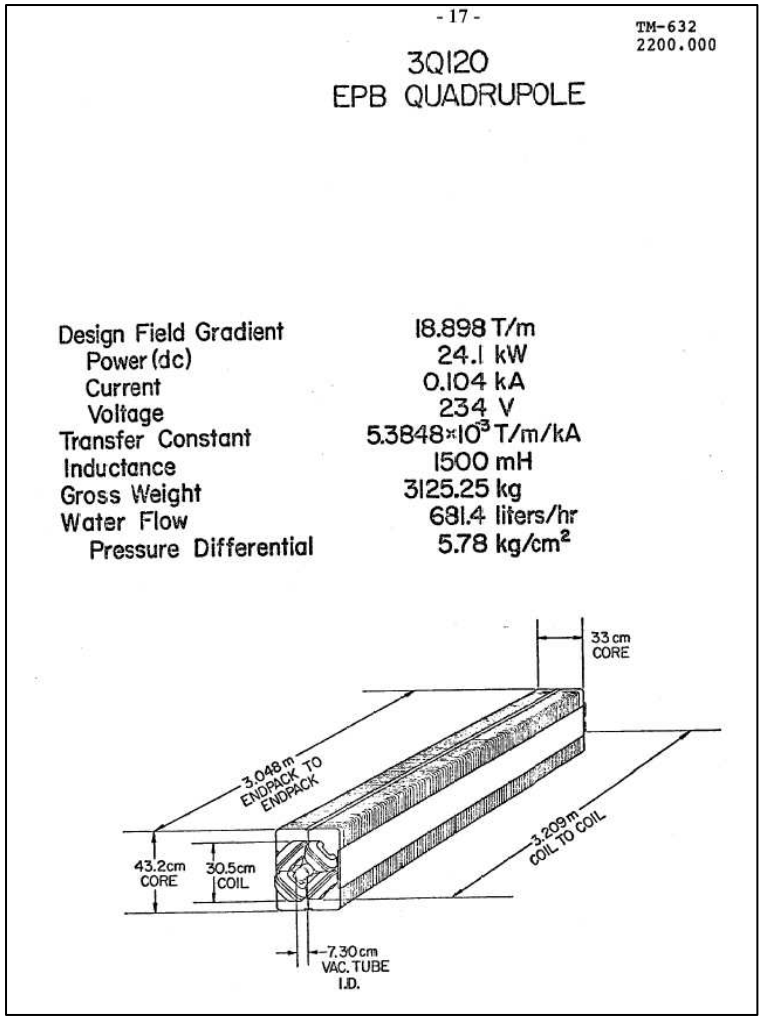
EPB Dipole photos





3Q120 Quadrupoles

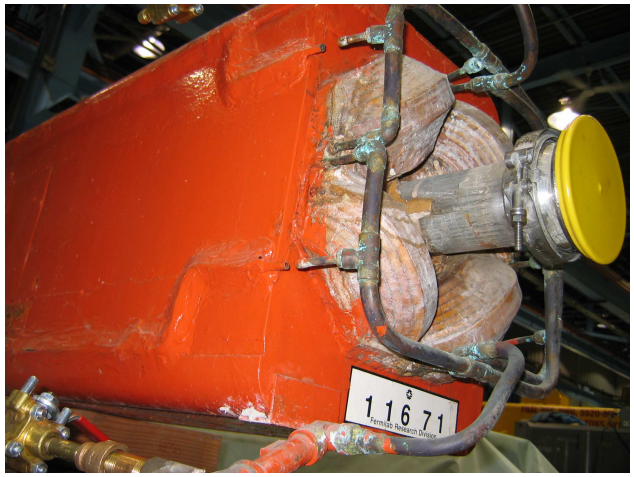
- Extensively used in NuMI and BNB
- Venerable magnets had been sitting in decommissioned beamlines

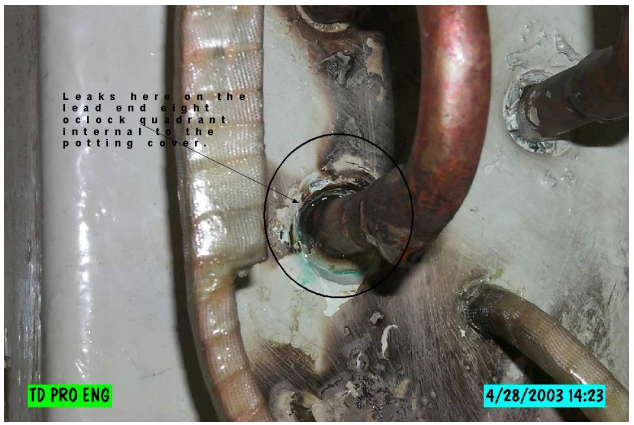


3Q120 Surprises

- Many variants
- Many ground faults and water leaks
- Mostly not repairable
- Water needs
- Power supply needs

3Q120 photos





3Q120 Variants

- Two core sizes
  - Better high field performance? No!
- Solid conductor or hollow →
  - 118 turns/pole or 28 turns/pole
- Cooling fins (solid conductor)
  - 8 fins or 12 fins (and variants on manifolding)
  - Copper or aluminum
- Cooling paths (hollow conductor)
  - 8 paths or 16 paths
- Beam tube
  - Round or star

3Q120 Failures

- Some magnets rejected before attempting rework
  - Ground faults
- About ¼ of magnets selected for rework failed
  - Mostly water leaks
- Generally not repairable
- Competing with other projects for good ones

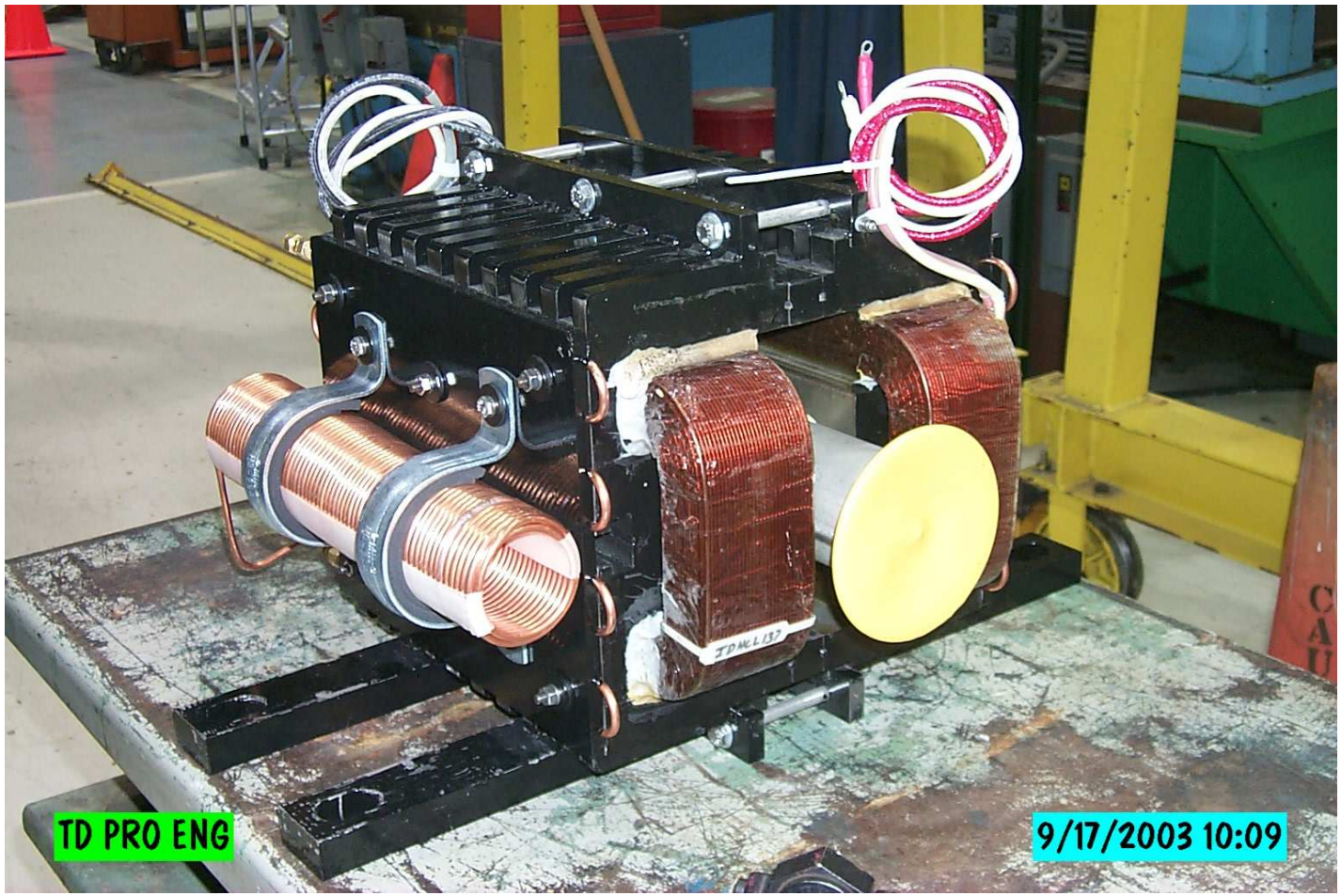
3Q120 Cooling

- Confusion regarding
  - Current needs for working gradients
  - Power for DC operation
  - Water needs for adequate cooling
  - Actual water flow
- Ramp the magnets or add cooling?
  - Added external cooling jackets for hottest magnets
  - Will eventually replace with hollow conductor
- All worked out in the end with some anquish

Trim Dipoles

- Commitment to MI style trims
- Requirements changed with beam design
- Had to add external cooling

Magnet with spacers, coolers



Closeout magnet reports

- http://tdserver1.fnal.gov/project/JobFiles/Current_Jobs/0201_BDP/Closeout/0201-BDP_summary.doc
- http://tdserver1.fnal.gov/project/JobFiles/Current_Jobs/0191_QQM/Closeout/0191-QQM_summary.doc
- http://tdserver1.fnal.gov/Project/JobFiles/Current_Jobs/0188_IDH/closeout/0188-IDHx_summary.doc

Lessons Learned

- Re-used magnets can be good
- Look that gift horse in the mouth
- Ask the experts rather than relying on 20+ year old notes
- System integration is critical
  - Optics, magnets, power, water, operations
- Changing course in mid-stream adds cost
- Close communication is essential