Pulsed Dipole Design and Tests

D. Summers, L. Perera, T. Hart, L. Cremaldi
University of Mississippi-Oxford

S. Hansen, M. L. Lopes, Fermilab

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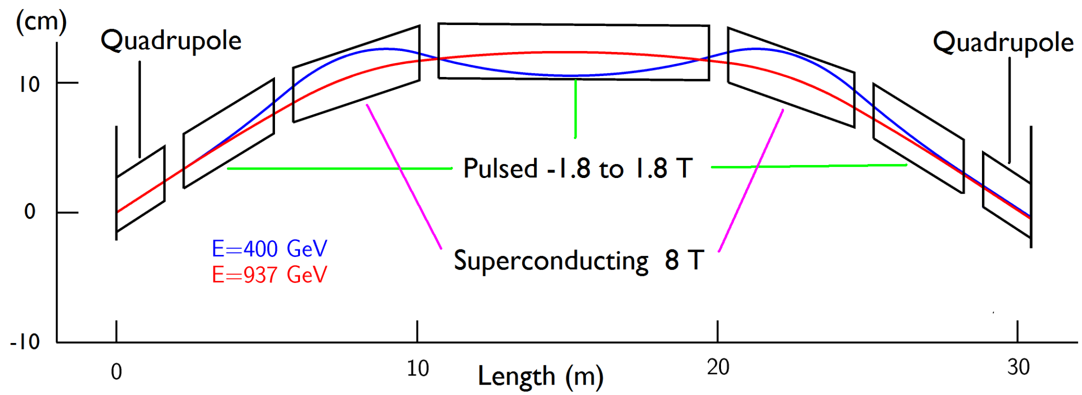
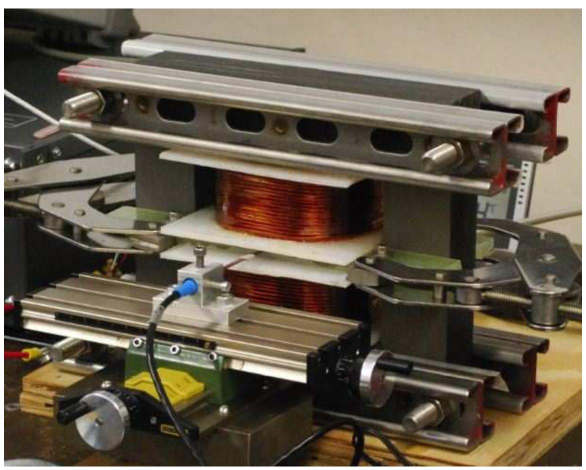
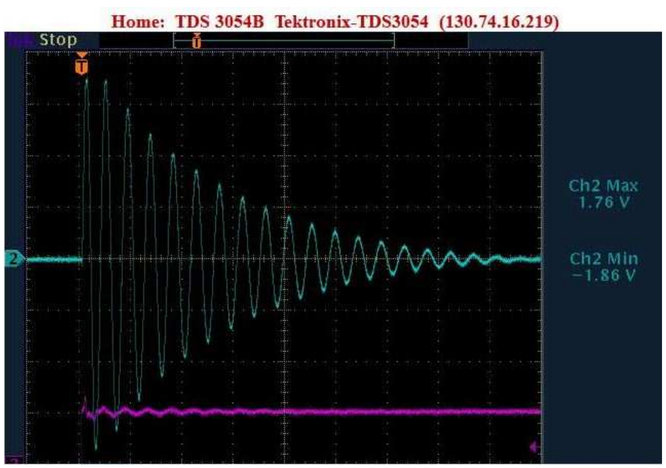
Past: Muon Synchrotron Acceleration Dipoles

- **Interleave fixed 8T & pulsed $\pm$ 1.8T dipoles.** **Berg & Garren, Summers et al., arXiv:0707.0302. "Lattice" MAP-4335 (2012)**

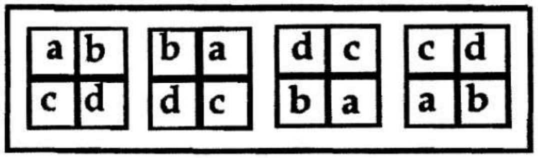


- **1.8T @ 1410 Hz achieved, but field quality only 1:1000 Summers et al., arXiv:1207.6730**





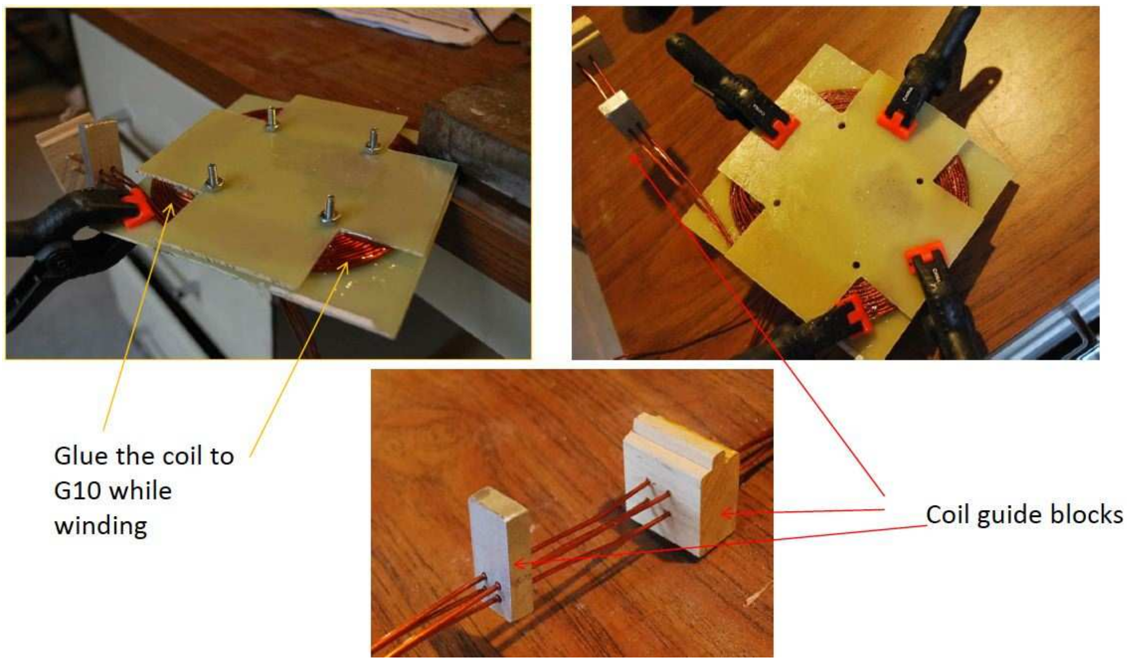
Latest work: Reduce coil losses with transposed strands



Standard transposition to avoid excessive eddy loss; The conductors a, b, c, and d making up one turn are transposed into different positions on subsequent turns in a coil to equalise flux linkage.

Box 2: Transposition of conductors

Neil Marks transposes strands
Same flux through each loop
Low longitudinal eddy currents



- **Lalith Perera: Prototype transposed strands pancake coils**
- **Dipole #3 in progress. Higher field accuracy, lower losses**

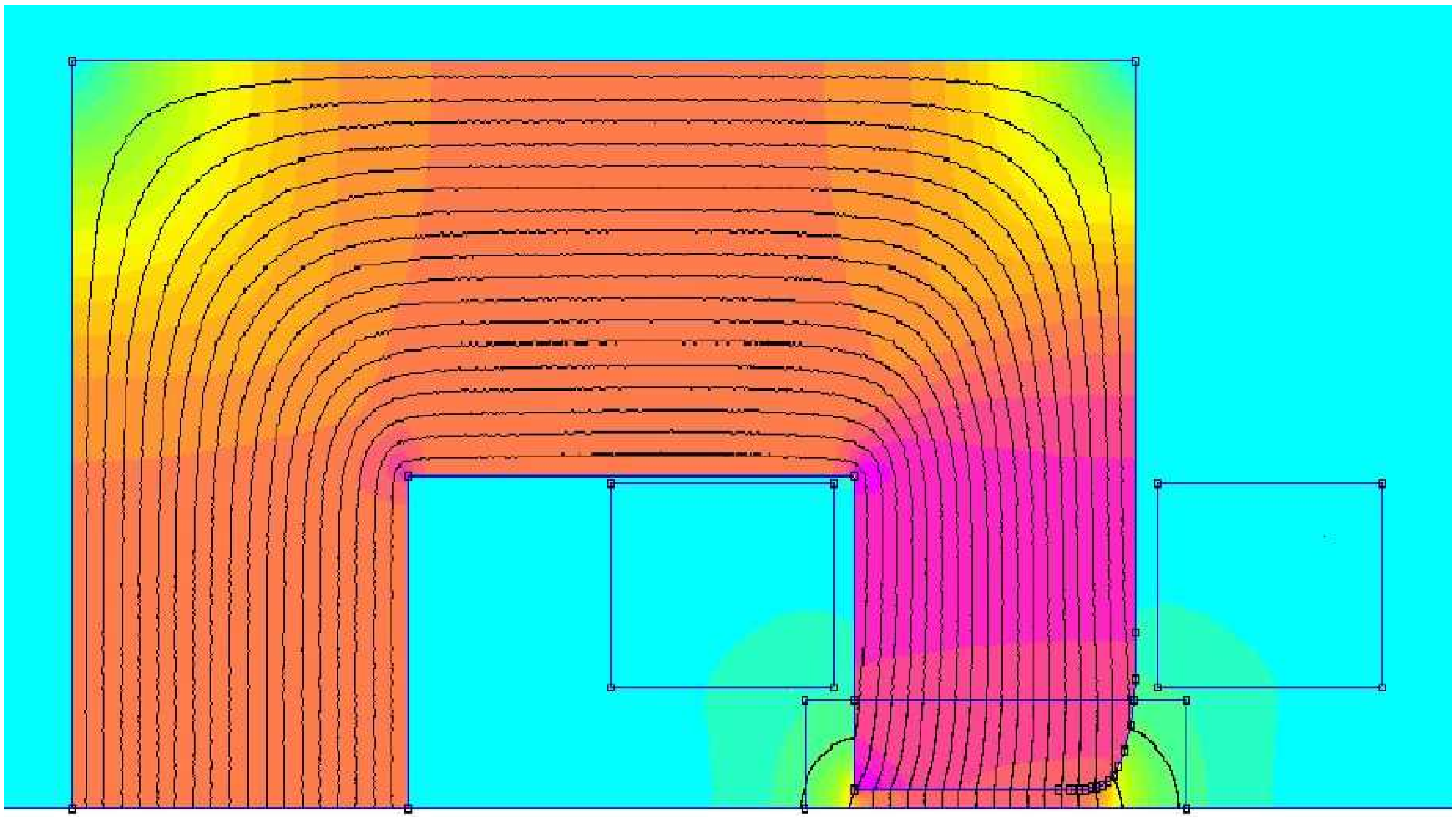
In Progress: Larger capacitor bank for larger dipole #3 gap

- **Power supply with fast 1200 volt, 600 amp IGBT switch.**

D. J. Summers
U. of Mississippi–Oxford

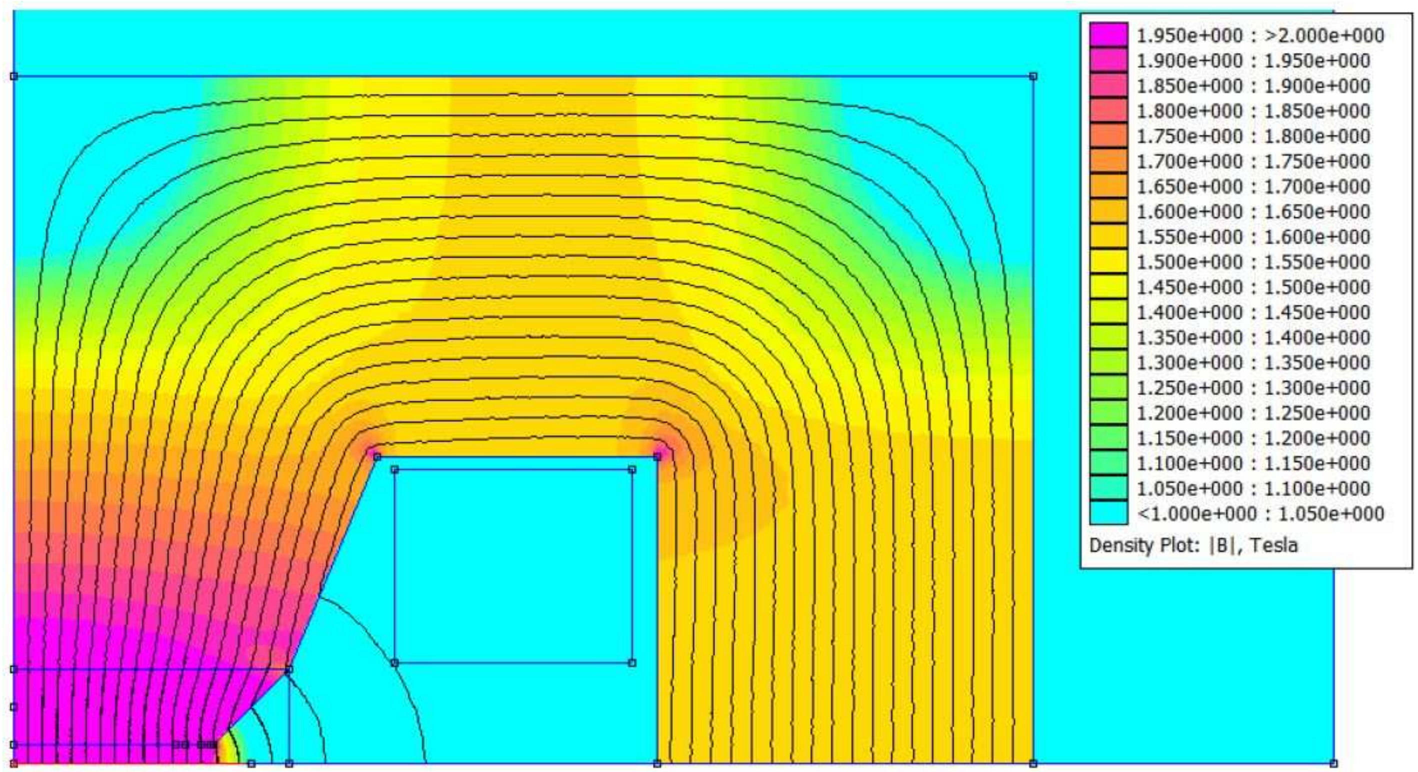
New: Rogowski pole face end profile to lower eddy currents

- **Rogowski:** $y = g/2 + (g/\pi)\exp((\pi x/g) - 1)$, **g = 6mm gap**
  End profile prevents field lines from crossing steel laminations
  Whole point of thin laminations depends on parallel fields
  Modeling convenience: Return yoke is actually rotated 90^0

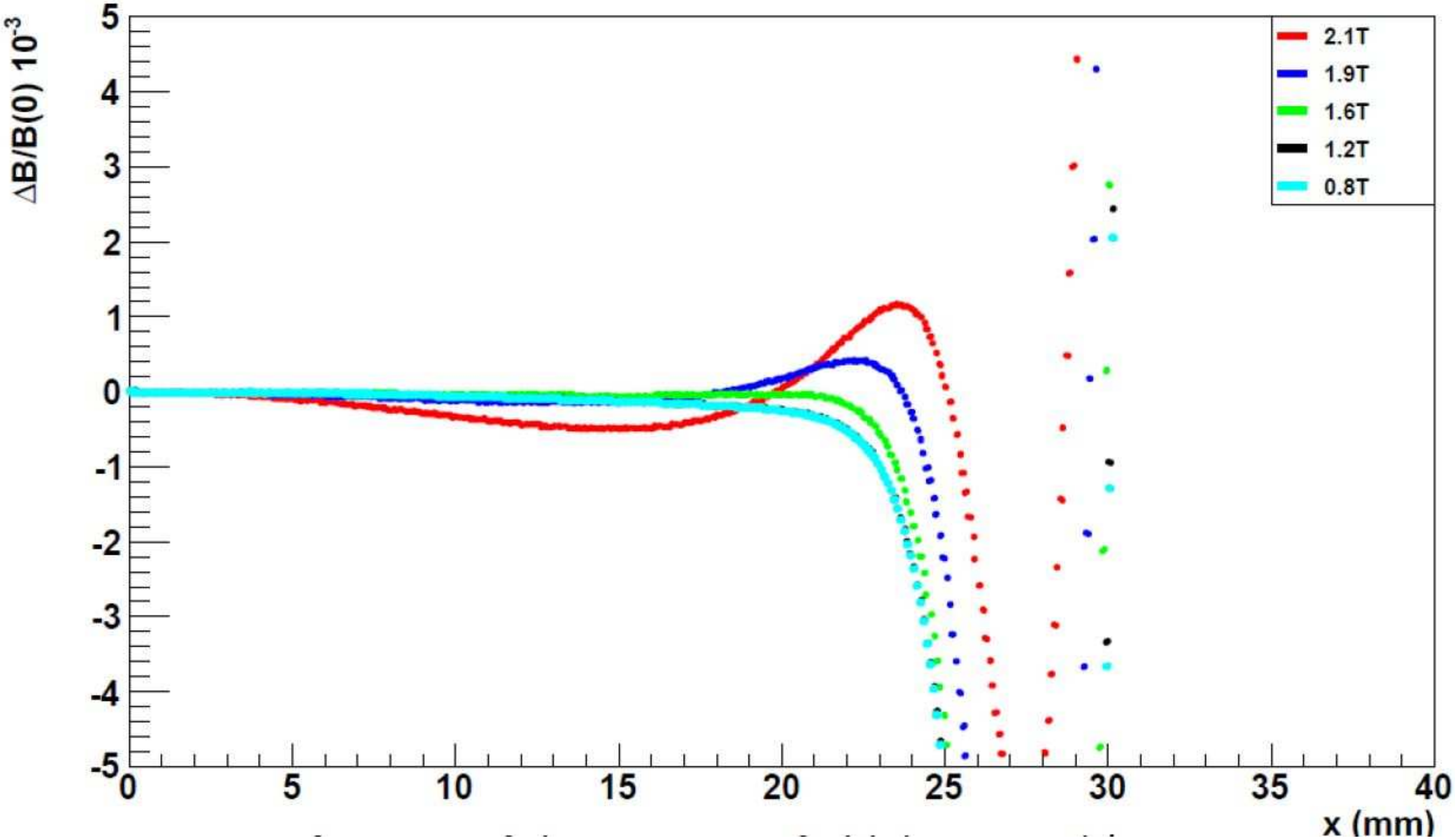


New: Shape pole faces to improve magnetic field quality

- **Add 0.1mm bump to each pole face edge. 6 mm gap**
  Copy Fermilab main ring dipole concept
  Many thanks to:
  Bob Wilson, M. L. Lopes, Bruce Brown, and Dave Harding



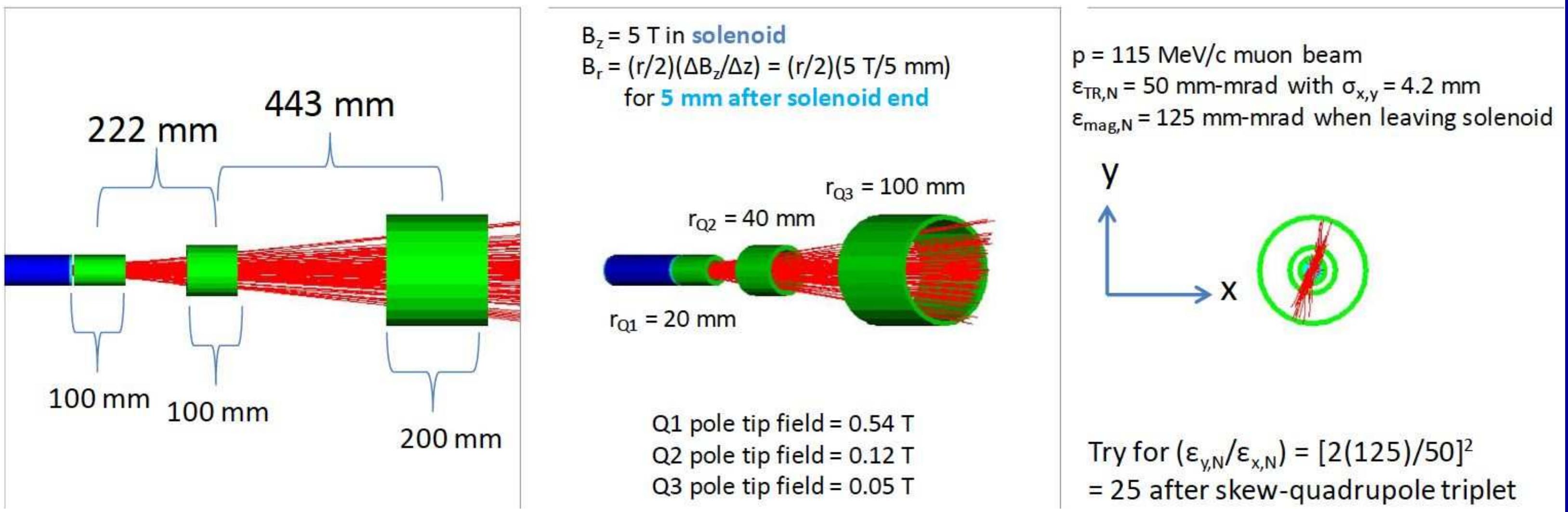
New: Uniformity approaches 1:10,000 @ 1.8T with bumps



- This is plain 1010 low carbon steel.
  Better CMI-B "LEP" magnet steel is being laser cut for BH measurement on Epstein frame and Hysteresigraph 5500.
  Reasonable permeability needed at 1.8 T.

10 μm beams easier fit into dipoles than 25 μm beams

- **G4Beamline μ: Round spinning to 25:1 flat non-spinning**
  Use XYZ emittance exchange.
  $\epsilon_{\rm larger}/\epsilon_{\rm smaller} \approx (2L/\epsilon_{\rm intrinsic,\,N})^2$ **PRSTAB 4 (2001) 053501**
  $L = e\, B_{\rm solenoid}\, R^2_{\rm cathode}\,/8mc$ **NJP 8 (2006) 286**
  5 T solenoid, Skew quad pole tip fields = 0.54, 0.12, 0.05T
  50 μm $\rightarrow$ 10, 250 μm + dilution, σ_x = R/2 = 4.2mm initial



- **Cut 25 slices: 0.1mm electrostatic septa, magnetic septa...**
  $x_{\rm max} = \sqrt{\epsilon_x\,\beta_x} = \sqrt{(250\mu{\rm m})(10{\rm m})}$ **= 50 mm**
  Loss $= 4w/[x_{\rm max} \cos\theta]$ **Edwards and Syphers, p. 126**
  Loss $= 4 \times 0.1{\rm mm}/[50{\rm mm}\,\cos{(45^0)}] = 0.011$ **total**
- **Recombine 25 slices longitudinally at higher energy with RF**