SiD Solenoid at Snowmass

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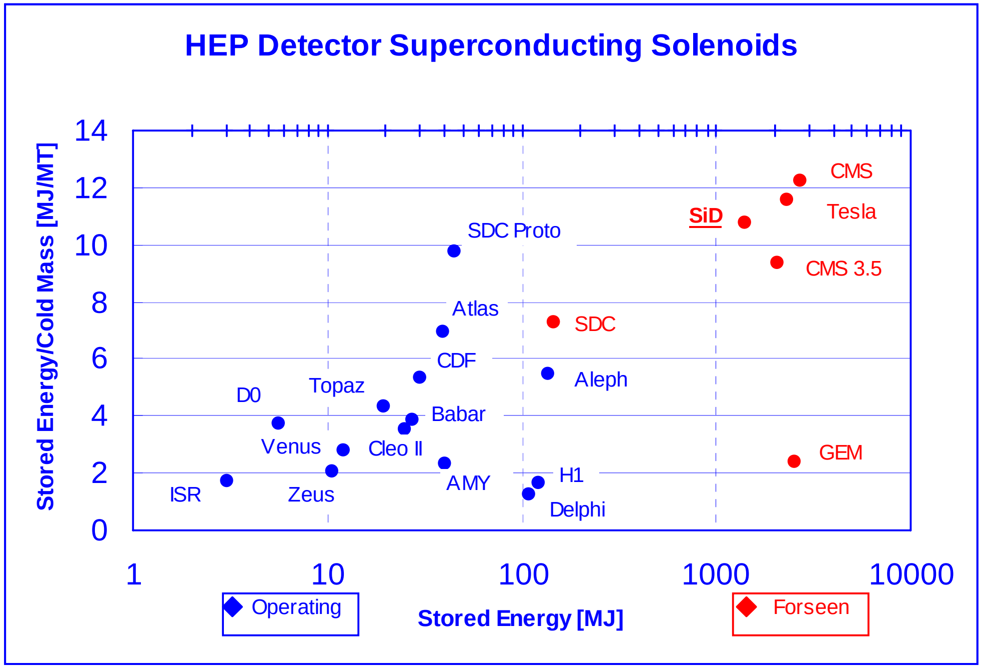
Fermilab

SiD Solenoid since LCWS05

- What is the SiD Solenoid?
- Add Dipole in Detector to SiD model
- "Publish" fieldmaps: "beamline" from 2D model; Inner Detector from 3D model
- Normalize Cost SiD magnet cost model to CMS "as built" data…

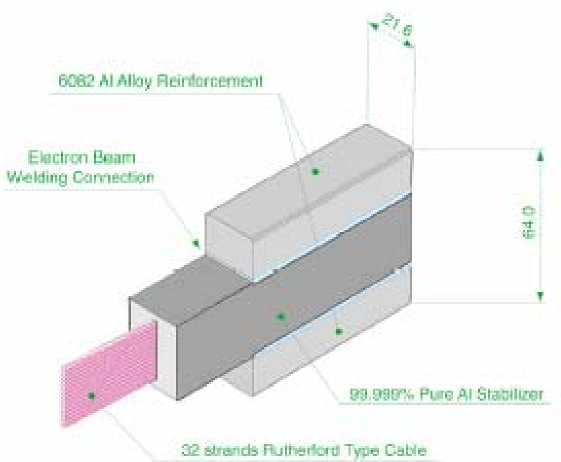
High-Field HEP Solenoids

- High Field, Large Size create many challenges
  - Look for Proof of Principle…
    - Only "High Field" Operating Solenoids at 2T: DØ, Atlas;
      at 3T: AMY (cryostable, heavy/expensive pressure vessel)
  - Closest is (may be?) CMS: 4 T, 2.7 GJ, Ø = 6m, L = 13 m



- Develop Preconceptual Design "Along Lines of" CMS
  - Expedites Approach to Credible Conductor/Winding Designs
  - Credible Engineering Approach for Industrial Fabrication
  - Credible Cost Estimates

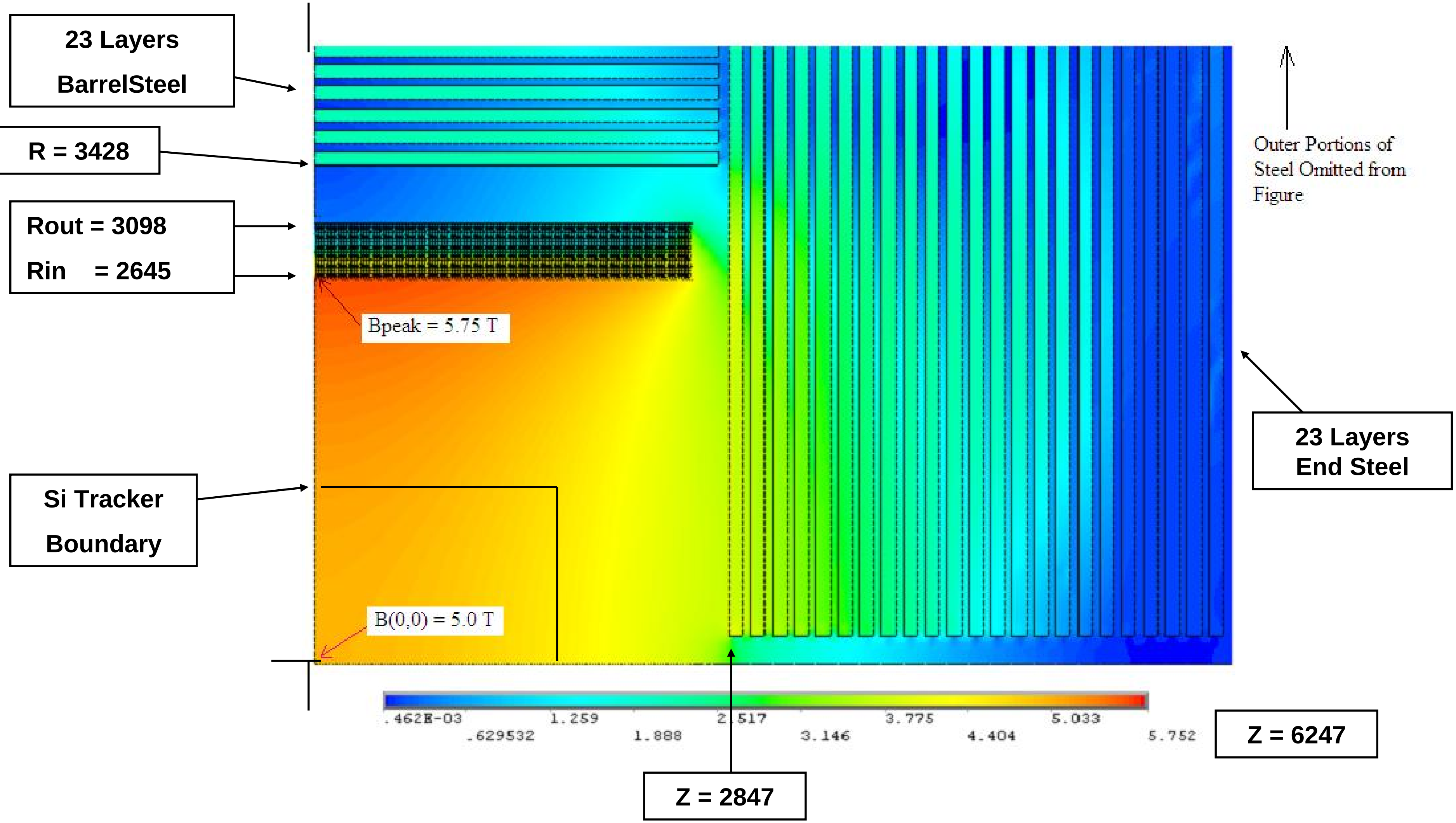
Follow CMS Conductor, Winding Designs



SiD Half-coil 6 layers x116 t/l

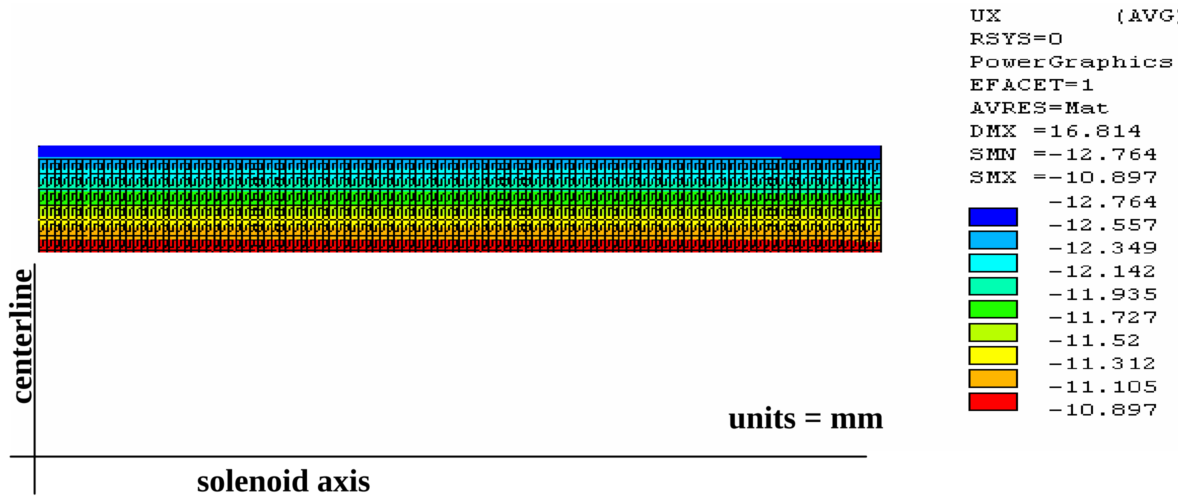
- First Cut: Same conductor as CMS
- Winding Design: CMS (4 layer)➔ SiD (6 layer)
- CMS 5 modules 2.5 m long ➔Sid 2 modules 2.6 m long
- Choose 6 layers (tradeoffs), "derate" CMS conductor to 5.8 T peak field (vs. 4.6 for CMS). I (CMS) = 19500; I (SiD) = 18000.
  - Critical current Ic(4.2K,Bpeak) derates 46900/59000 ~ 0.79
  - Iop derates ~ 0.92
  - Stability expectations require modeling; 32 CMS strands => 34 for SiD

2D, 3D ANSYS Models

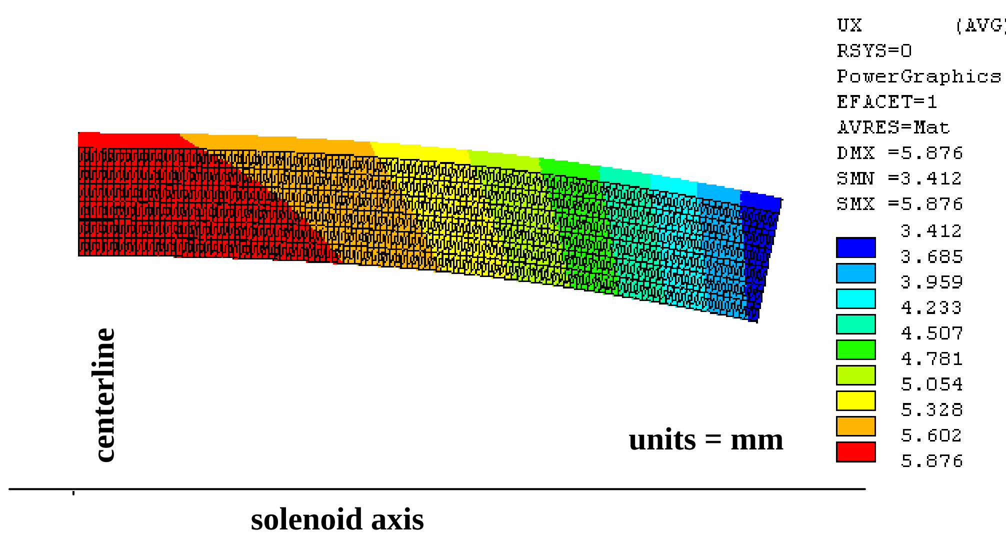


Strains from Cooldown, Energization

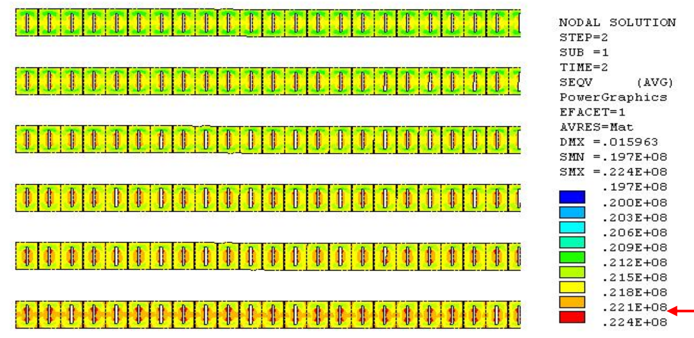
Uniform radial (and axial) strain from cooldown



"Barrel" shape from energization



Von Mises Stress in Winding Pack, Cold & Energized



HP Al:

22 Mpa = 3190 psi

Quantity	SiD	CMS
Von Mises Stress in High-Purity Al	22.4 MPa	22 MPa
Von Mises Stress in Structural Al	165 Mpa	145 MPa
Von Mises Stress in Rutherford Cable	132 MPa	128 MPa
Maximum Radial Displacement	5.9mm	~5mm
Maximum Axial Displacement	2.9mm	~3.5mm
Maximum Shear Stress in Insulation	22.6 MPa	21 MPa

Compare with CMS

Quantity	SiD	CMS
Radial Decentering	38 kN/mm	38 kN/mm
Axial Decentering	230 kN/mm	85 kN/mm
Stored Energy	1.4 GJ	2.8 GJ

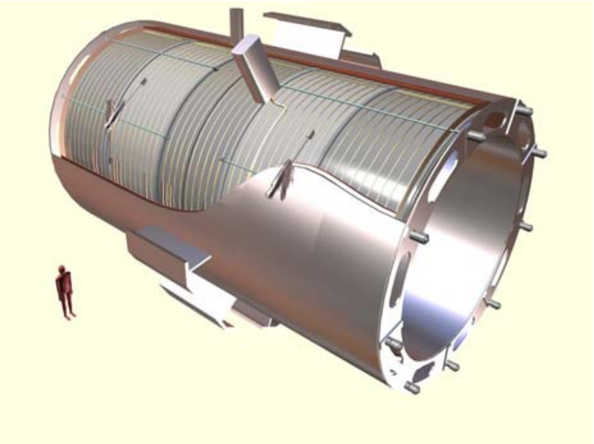
Requirements

- Cold mass support – 130 Mt
- React decentering forces, seismic, cooldown, steady-state operation

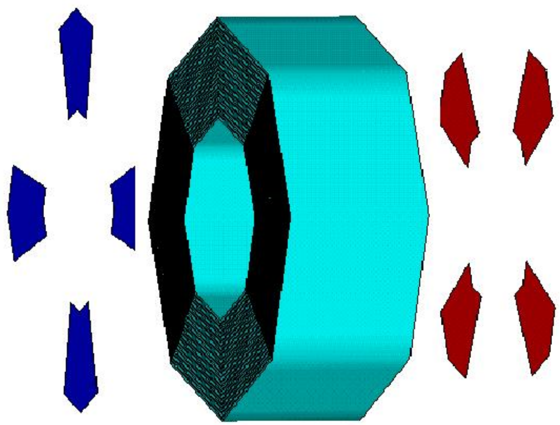
CMS Concept

- Thin metallic rods preloaded in tension
- Axial rods for axial loads
- Vertical rods for dead weight
- Additional tangential rods (in preloaded pairs) for radial loads

- **Conclude cryostat approach can be like CMS:**



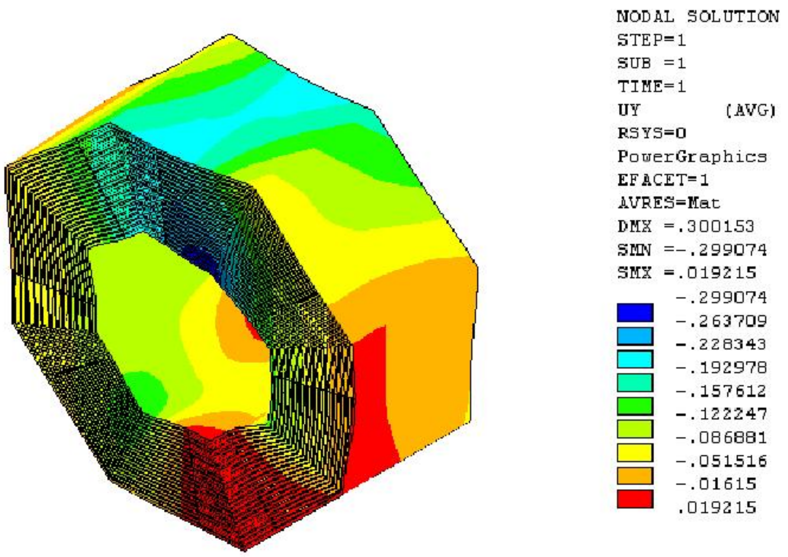
Iron Yoke Issues



Barrel (and End Caps):
Steel plates 10 cm thick,
5 cm gaps

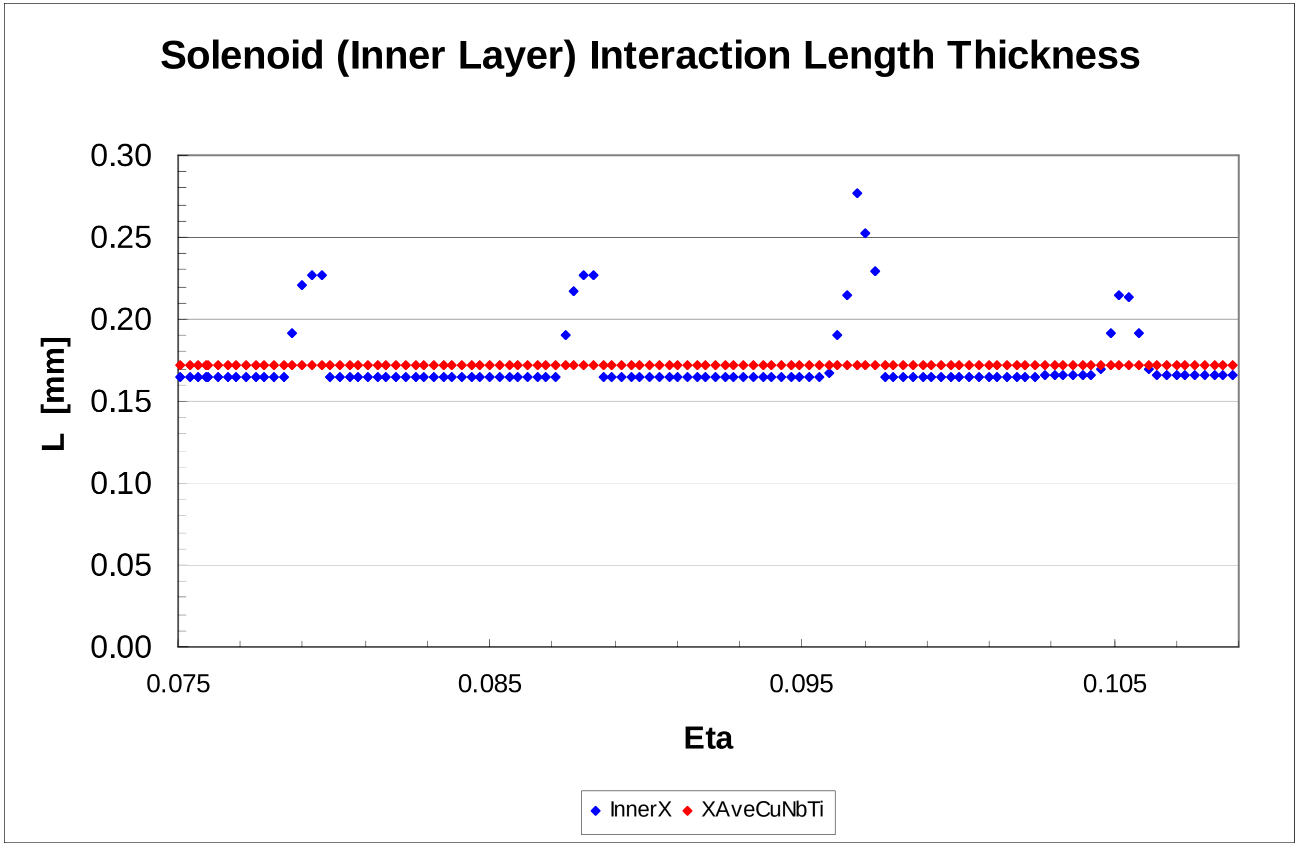
Endplate gussets support barrel Layers, allow insertion of muon chambers

Maximum deflections (loaded with calorimeters, solenoid) ~0.3 in



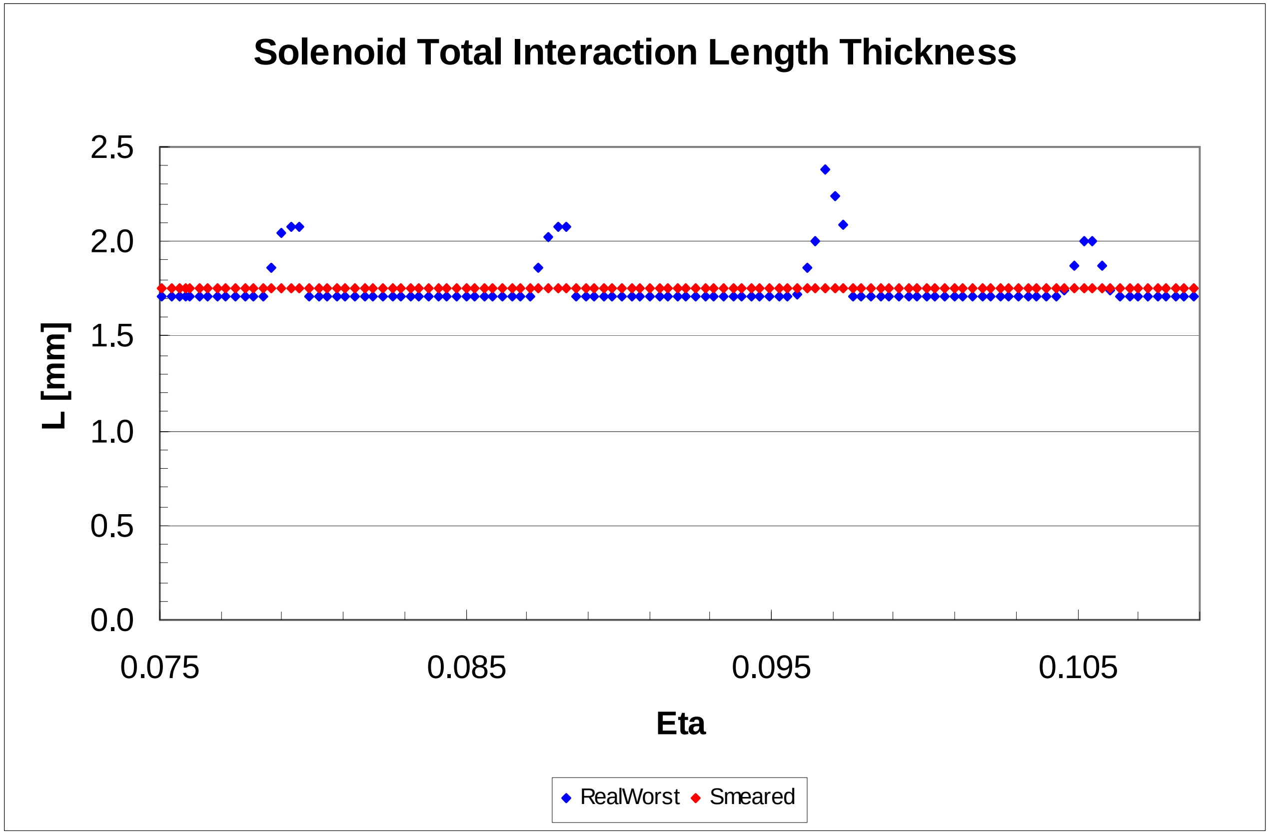
Vertical Deflections for Staggered Barrel Iron Connections (units = inches)

Interaction Thickness, Inner Winding Layer



Calculation for single winding layer highlights nonuniformity of conductor

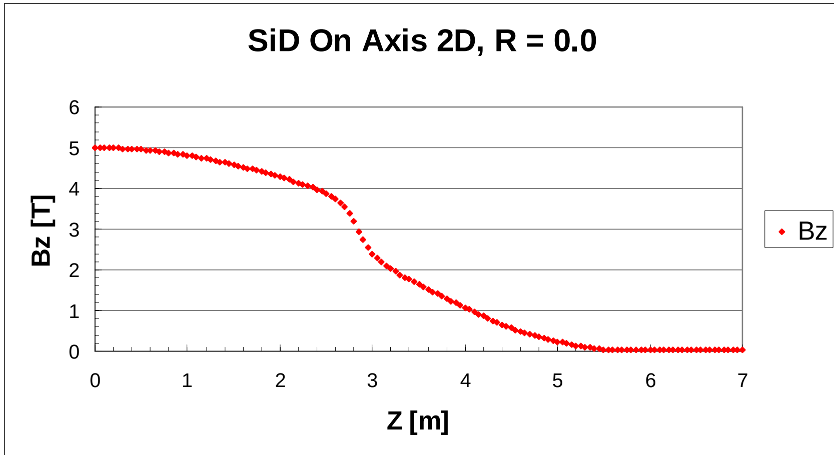
Interaction Thickness, Entire Solenoid

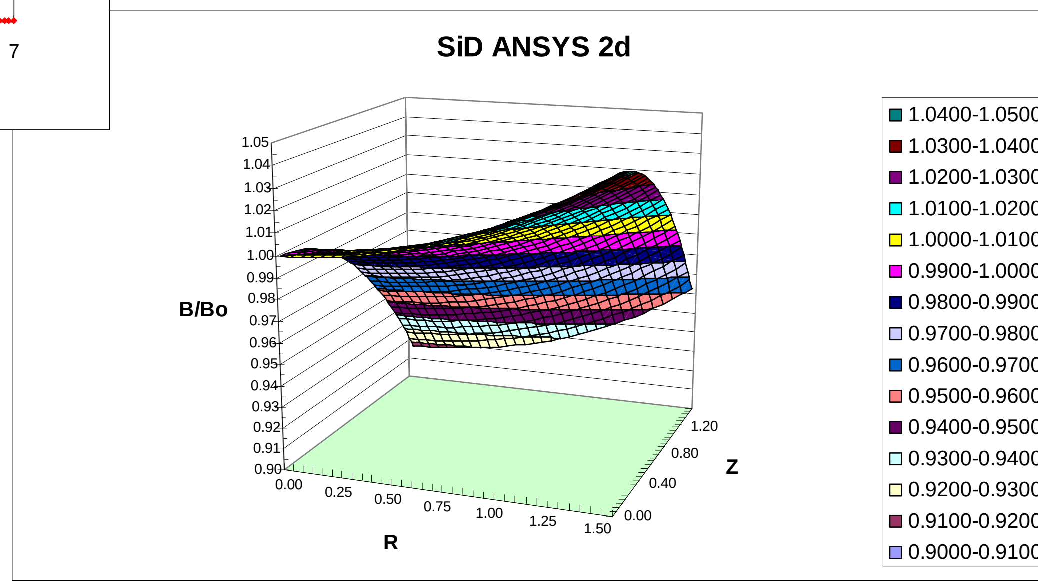


Layers aligned to maximize nonuniformity of conductor

Fieldmaps

- Near-axis field out to Z=20 m

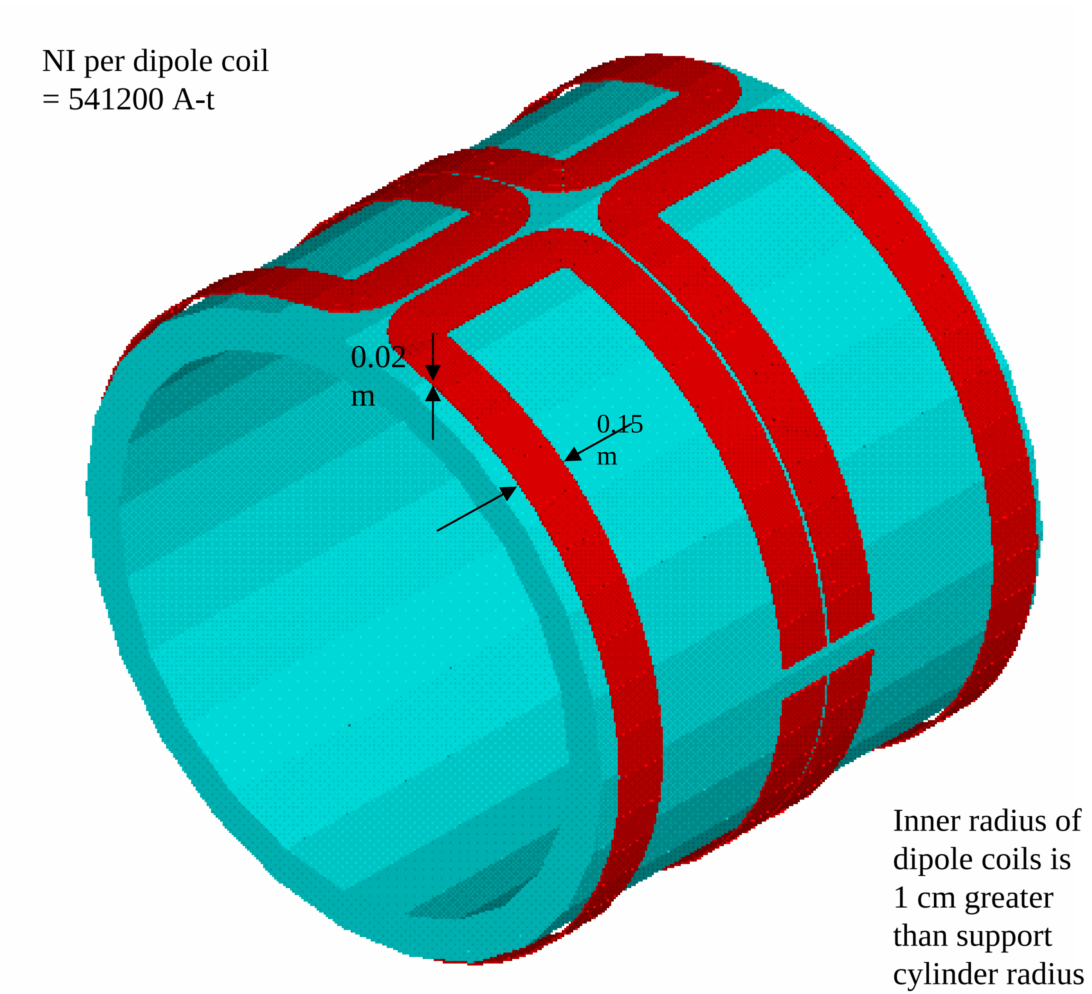




On the SID website…

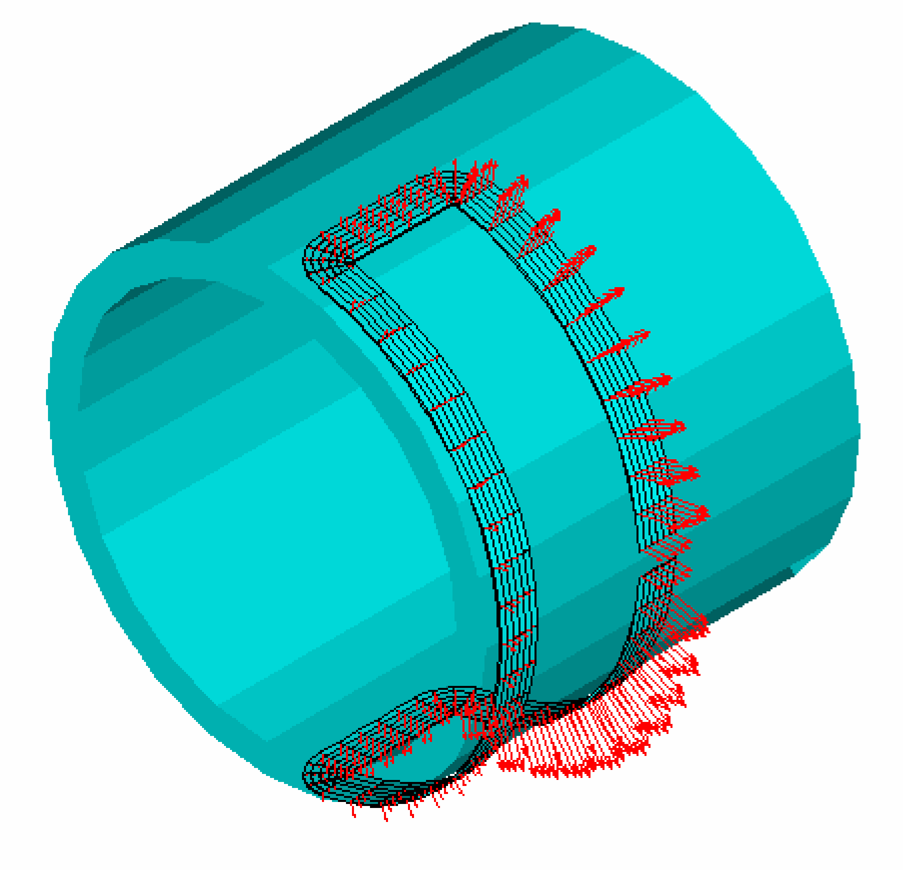
- Central Field – uniformity, etc

Dipole-Integrated-Detector facilitates Crossing Angle



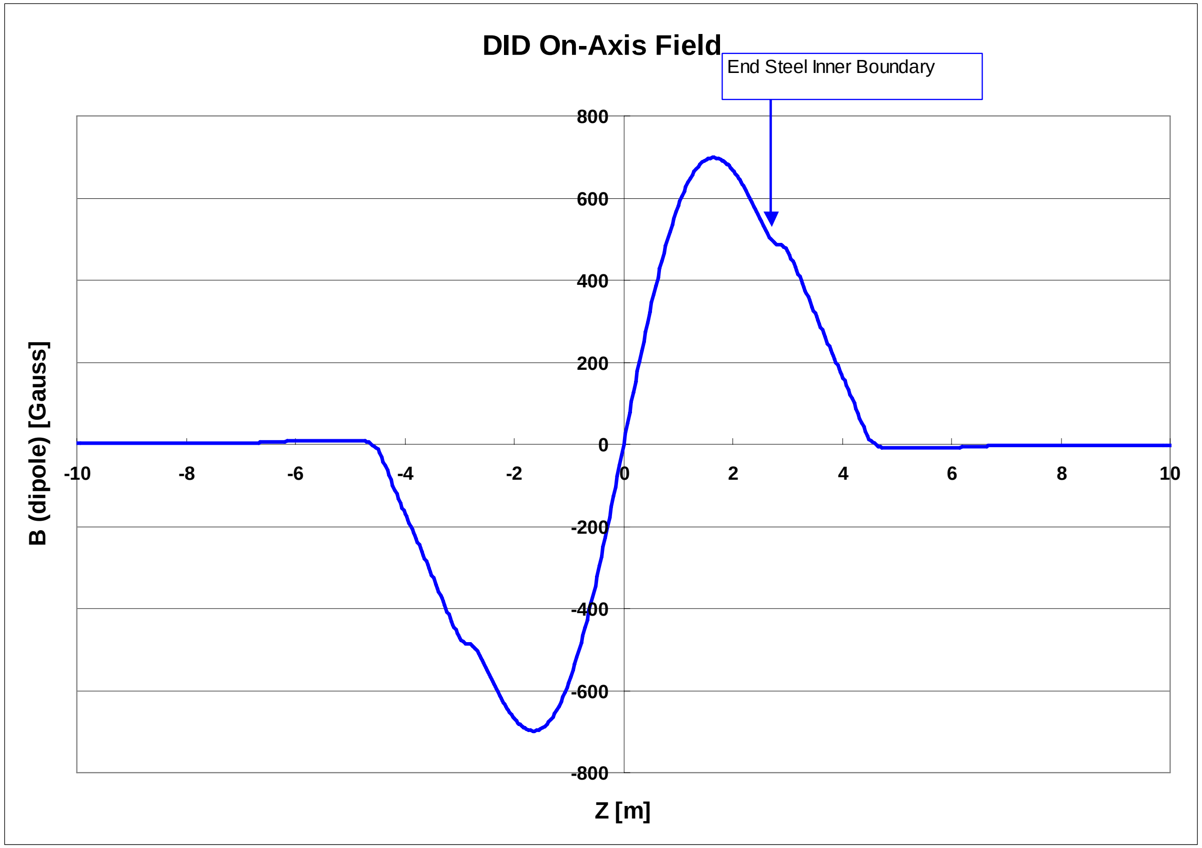
"Saddle-coil" dipole wrapped onto outer support cylinder of solenoid

Forces on Dipole Burdensome, May be Manageable



- Fx = 400K lbs (radial, summed)
- Fz = 1754K lbs (axial, summed)

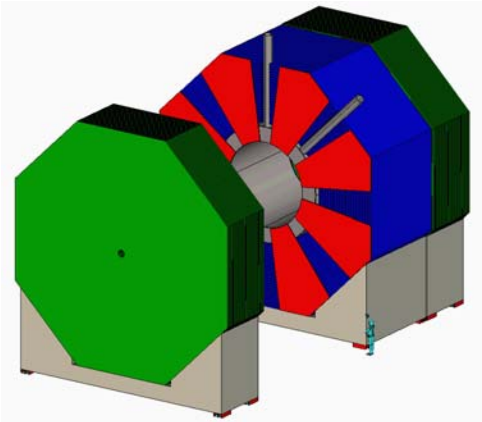
DID Field on SiD Axis



- DID (zeroes IP vertical angle, SR vertical beamsize growth) compatible with Antisolenoids used for beam-size compensation from solenoid fringe

Conclusions

- Need iterations with Detector/Physics Groups to select "most probable" performance parameters
  - How to "Open" detector ?
  - Must Detector Roll "off beamline" ?
  - Anti-solenoids in forward region
  - EndCap steel support details
  - Muon steel plate/gap thicknesses



- Field Homogeneity not specified (Must we?)
- Radiation Transparency not specified (OK?)
- "Fallback" field (below which physics is compromised not specified (SiD should specify)
- Develop Cost Model based on CMS actuals