Anti DID
Alternative Option

Mainly slides presented by Brett Parker at
MDI mini workshop
Sept. 2016 KEK

LAL Workshop

Nov, 2016

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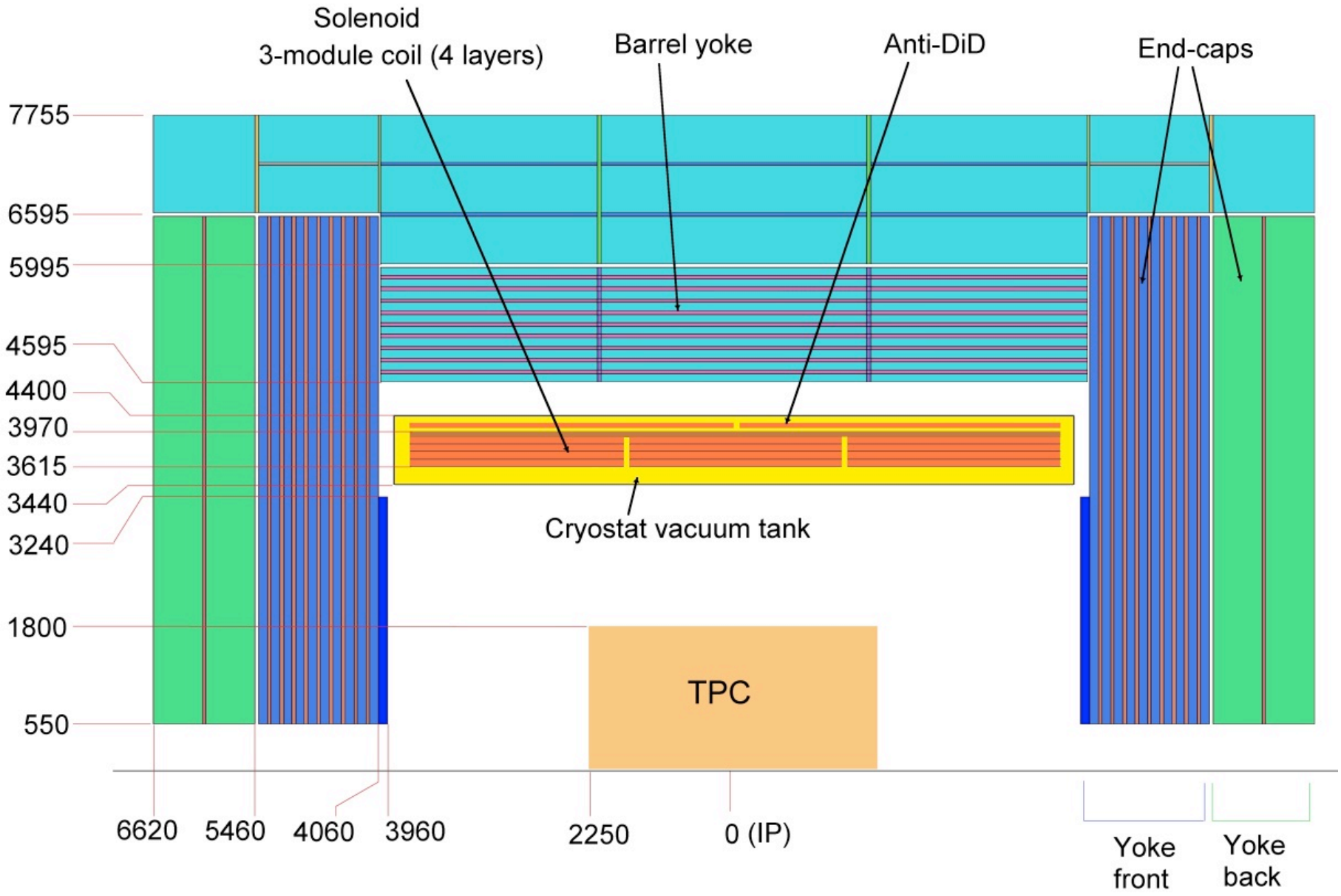
HELMHOLTZ ASSOCIATION

DESY

Coil and Yoke Cross-Section

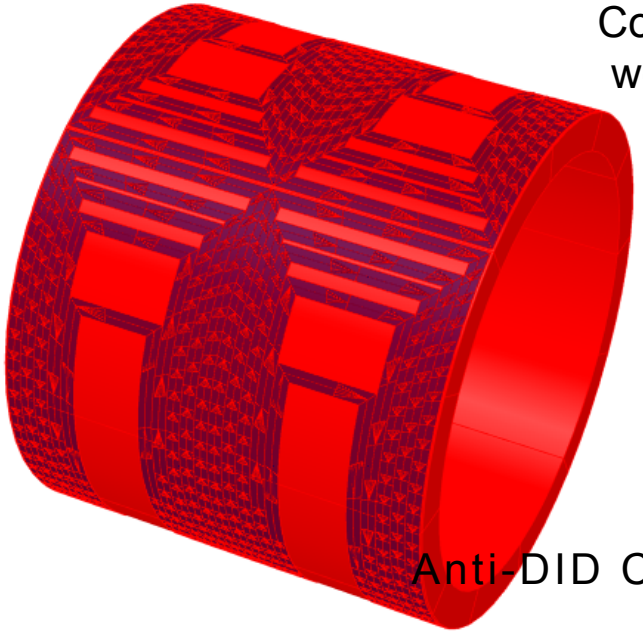


Short Anti-DID Design History Review

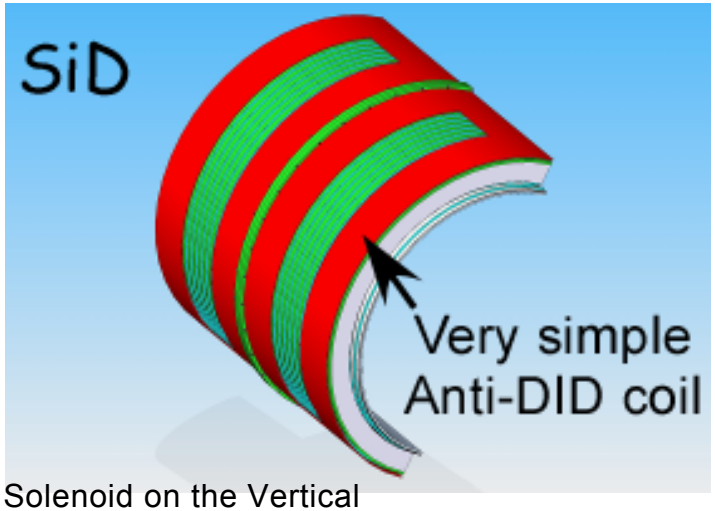
- Detector Integrated Dipole (DID) was first proposed by A. Seryi & B. Parker† to enable use of the large crossing angle needed for the ILC Gamma-Gamma IR scheme.
- With the present 14 mrad crossing angle, an opposite polarity DID (Anti-DID) can be used to help guide beamstrahlung produced pairs out of the detector to reduce the background.
- While incorporating the DID coils with the main detector solenoid avoids introducing material inside the detector acceptance (that would adversely impact physics), coming up with a practical scheme for implementing the anti-DID coils is by no means trivial!
- Directly winding a complex coil structure outside the detector solenoid is challenging (production infrastructure) and wrapping a flat wound anti-DID coil around the solenoid is not easy either (anti-DID conductor stress).

Slide B. Parker

Coils are directly wound on cylindrical surface



One Early Anti-DID Coil Concept



†B. Parker and A. Seryi, "Novel Method of Compensation of the Effects of Detector Solenoid on the Vertical Beam Orbit in a Linear Collider," Rev. Mod. Phys. 2727(84) , April 2005. DOI: 10.1103/PhysRevSTAB.8.041001

Different Anti-DID Production Geometry

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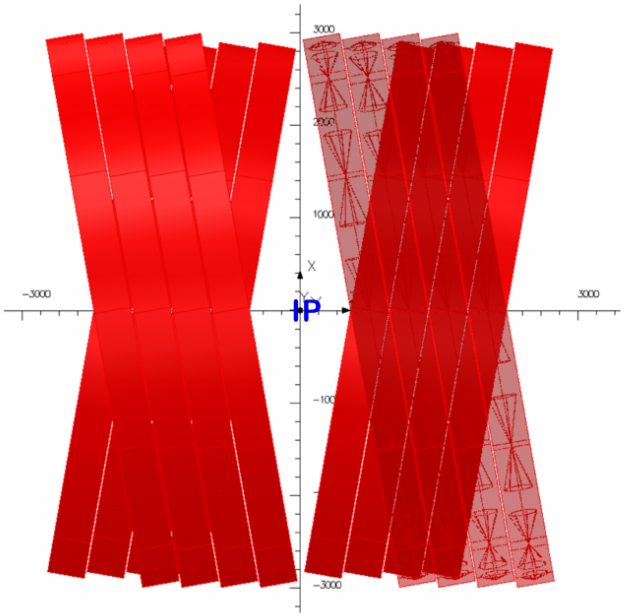
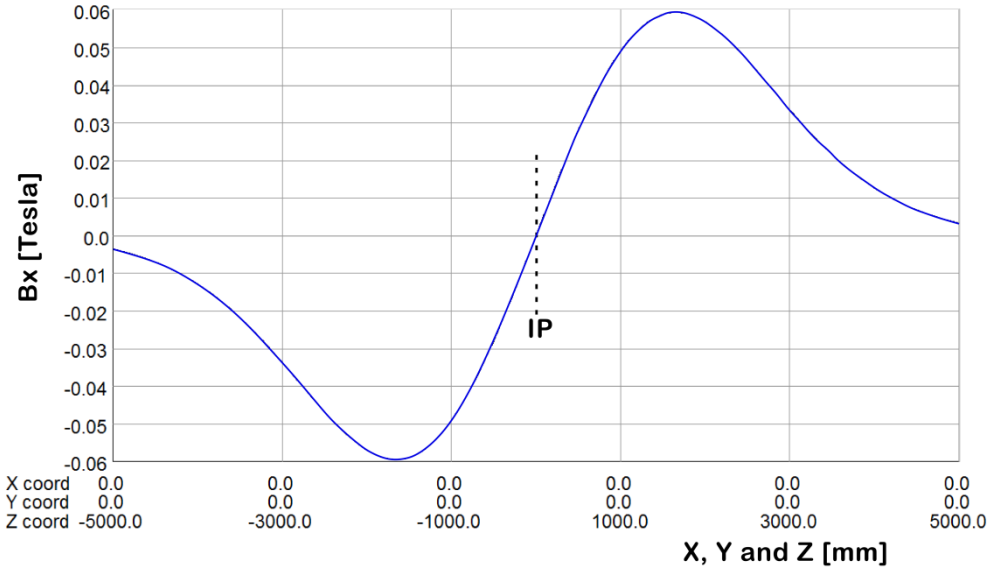
Simple Two Layer Anti-DID Coil, Top View



Plot of Horizontal Field, Bx, at the Detector Axis



- Consider using helical coil† (also know as canted coil) winding technique to produce anti-DID; this setup makes transverse field but does not couple to main solenoid.
- This scheme is schematically illustrated above where we have tilted the solenoidal turns in two different radial layers in opposite directions and given them opposite currents.
- The longitudinal field, B_z, from the two layers cancels but the transverse field component, B_x, adds constructively to give the field profile shown ("air coil" example).
- Should consider winding such "solenoid like" coils on separate structure. They could be integrated with the main solenoid cold mass and independently powered.

†H. Witte, et.al., "The Advantages and Challenges of Helical Coils for Small Accelerators—A Case Study," IEEE TRANSACTIONS ON APPLIED SUPERCONDUCTIVITY, VOL. 22, NO. 2, APRIL 2012.

Some AD Construction Considerations

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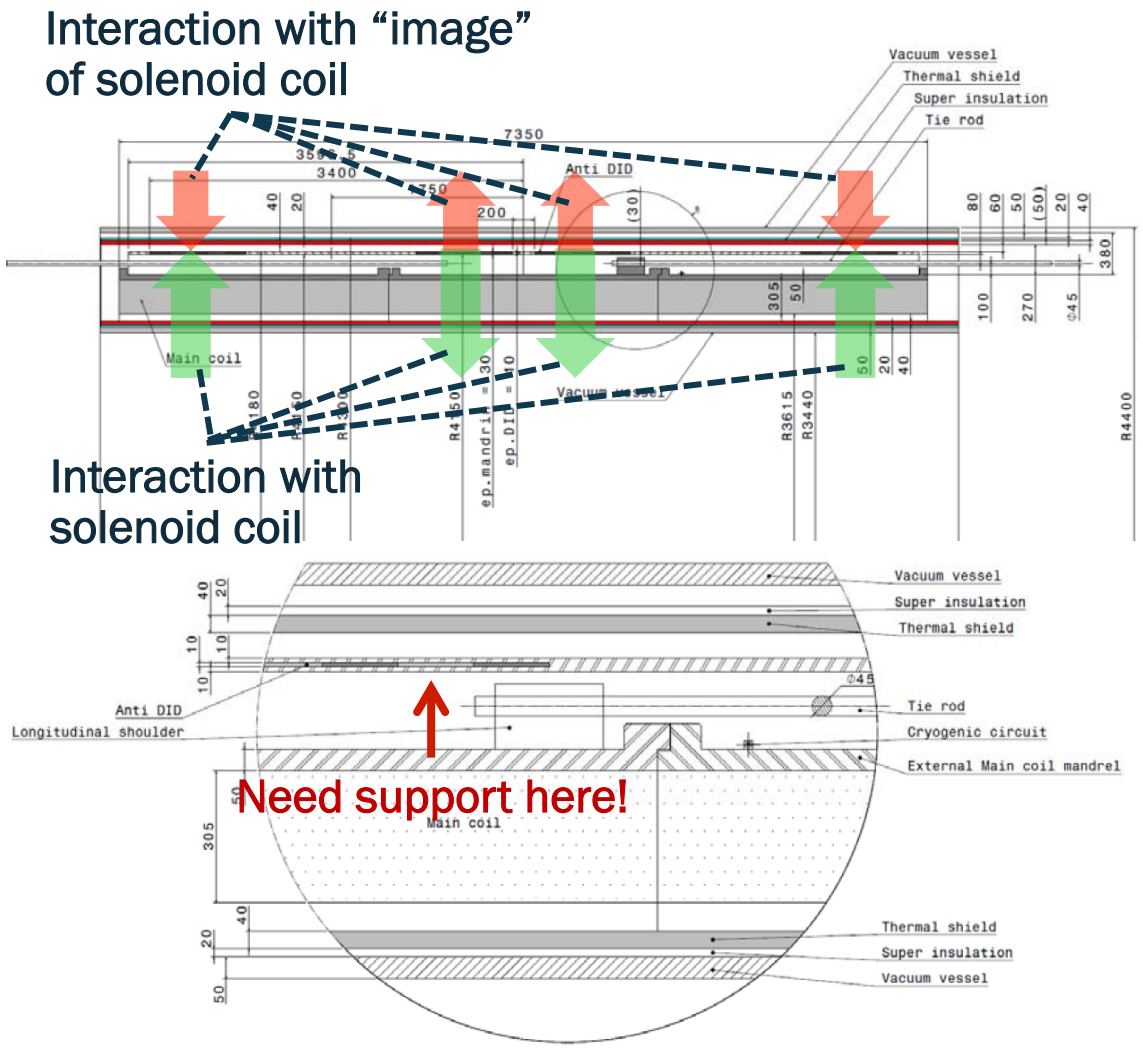
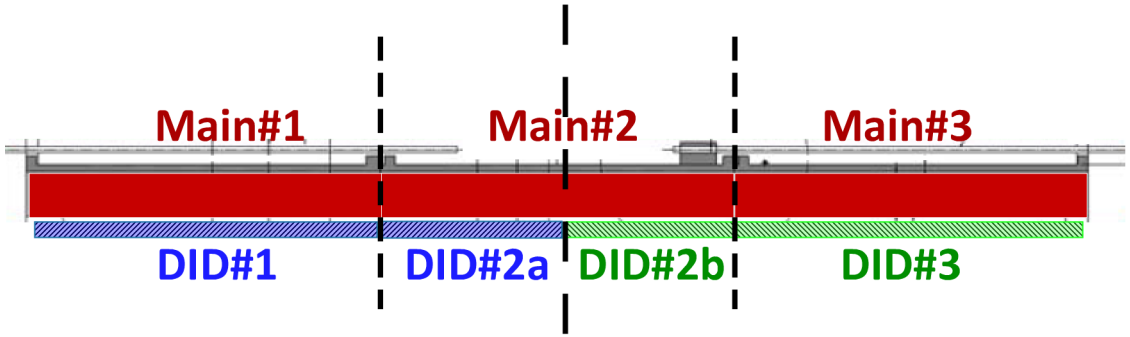


- AD should not experience any net force due to main solenoid but each AD half experiences net torque from forces at ends.
- Torque leads to a bending moment in horizontal plane.
- End turn forces are reduced a bit due to magnetic interaction with yoke (image of main solenoid in the highly saturated yoke).
- Bending forces should be calculated if AD structure is not supported at critical points (structure looks quite thin).
- Method A has pattern gaps to make radial connections to outer cryostat; the Method B coil covers most of the available surface.

Some AD Construction Considerations

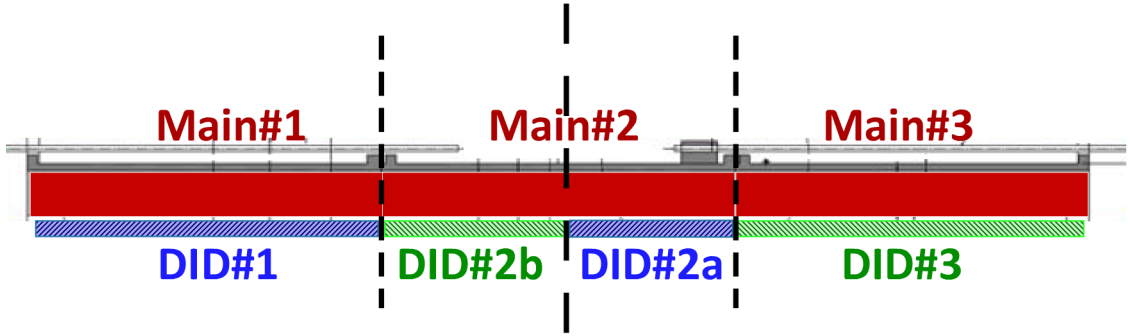
Slide B. Parker

Anti-DID wound with three sections



... and full asymmetry.

Anti-DID wound with three sections



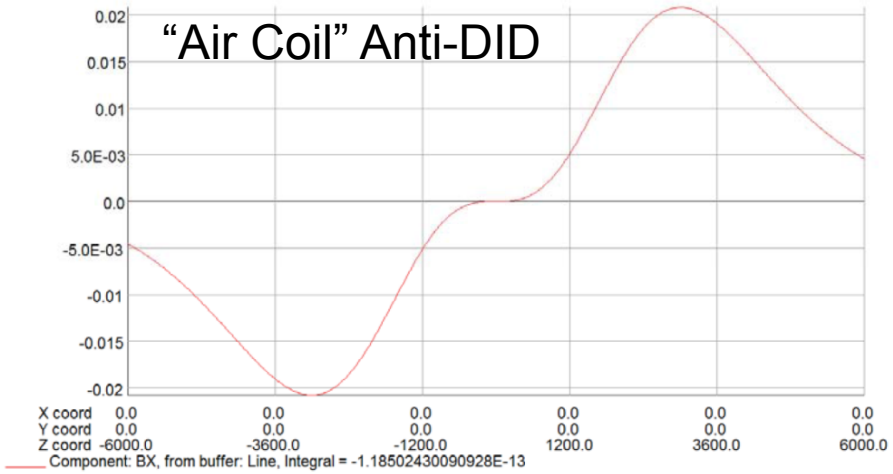
... and reduced central field.

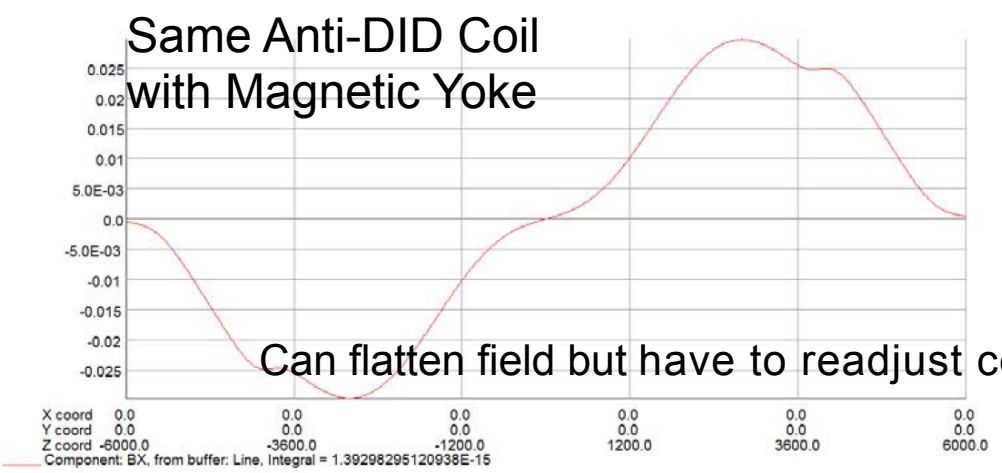
- With main ILD solenoid being wound in three sections, consider also winding helical coil option (Method B) in three independent sections.
- Fundamentally not possible with standard outside surface winding (Method A).
- Note to preserve proper anti-DID symmetry central section must be subdivided into two shorter coils.
- But if there is still a desire to “flatten” the central field region, this could be accomplished by swapping the center section anti-DID polarities.

Option to wind anti-DID on one (or two) section(s) and then integrate it with main solenoid by insertion after the three main sections are vertically stacked.

Some AD Construction Considerations

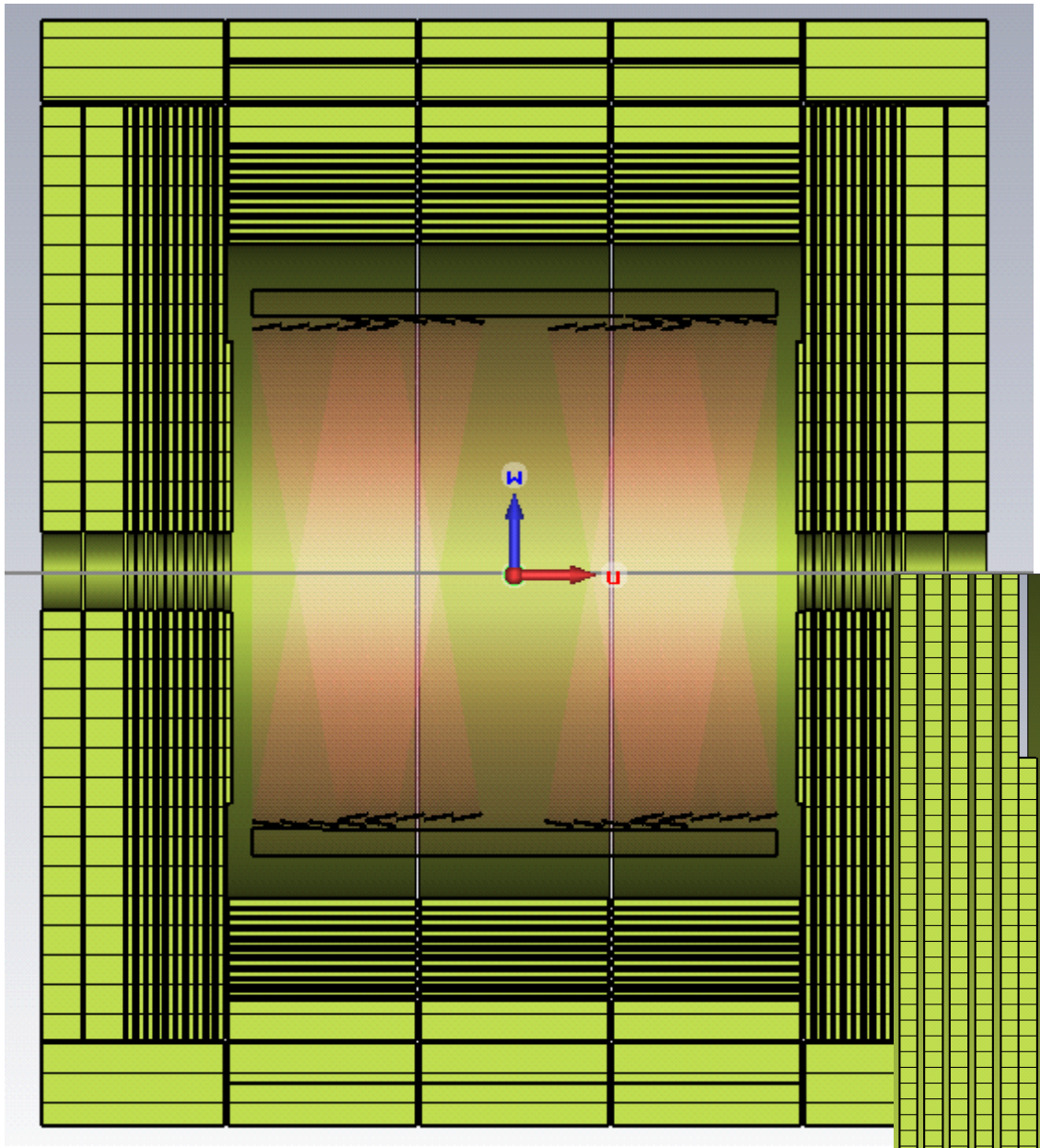
Slide B. Parker



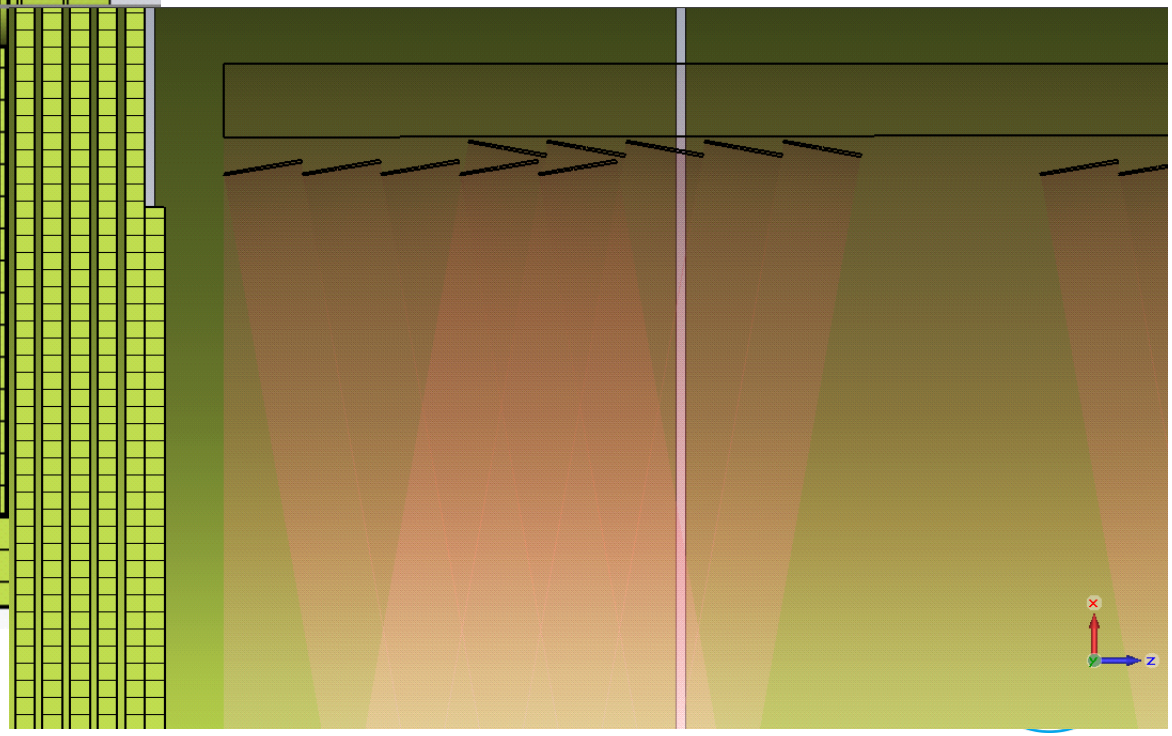


- Recently became aware of Linear Collider Report LC-DET-2012-08, "Conceptual Design of the ILD Detector Magnet System," where the implication seems to be that one cannot flatten the central-most anti-DID field in the ILD detector when the yoke is included.
- While I actually agree with the conclusion that the added complexity of the anti-DID coil needed to flatten the central field is not worthwhile, the above example given in the report is a bit misleading.
- For field optimization the "air coil" design was only used to get an approximate anti-DID coil geometry; then when this coil is put with the main solenoid in the yoke, the anti-DID (in my case the coil currents) must be re-optimized to achieve the desired field shape.
- You certainly should be able to reduce the anti-DID field perturbation in the central region; however, the resulting solution will be sensitive to small errors and yes I would advise against the added complexity if you can live without it.

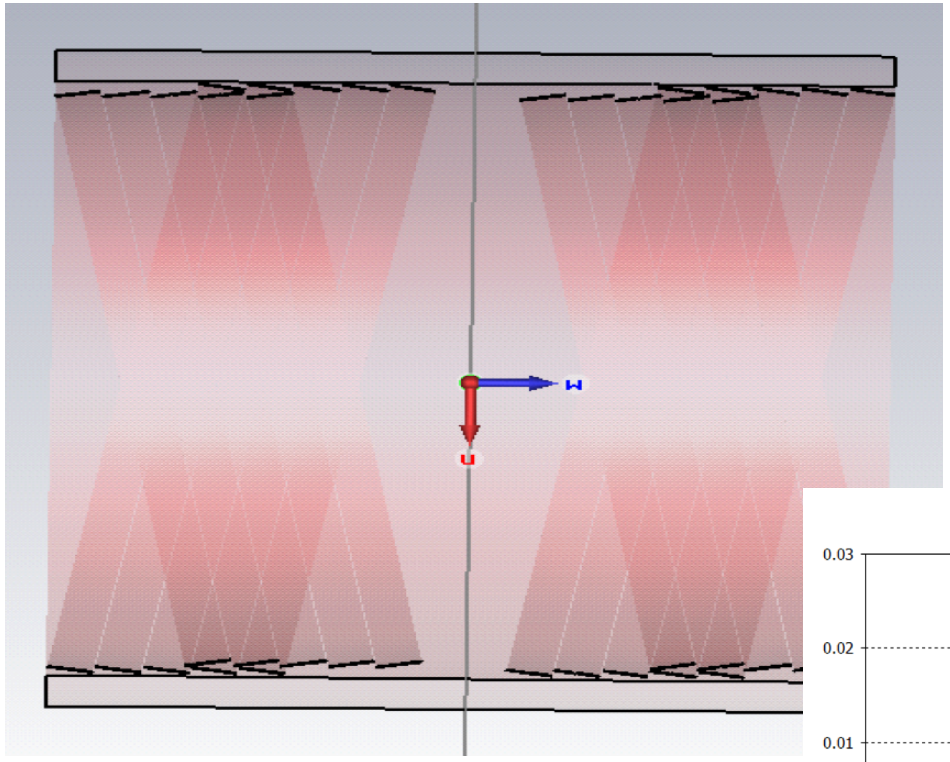
Field Calculations



- Very recently implemented simplified helical anti-DID in CST Studio model
- Planning to calculated field, stored energy, currents… , with and w/o yoke
- Optimize field if necessary
- Option anti-DID in 3 sections

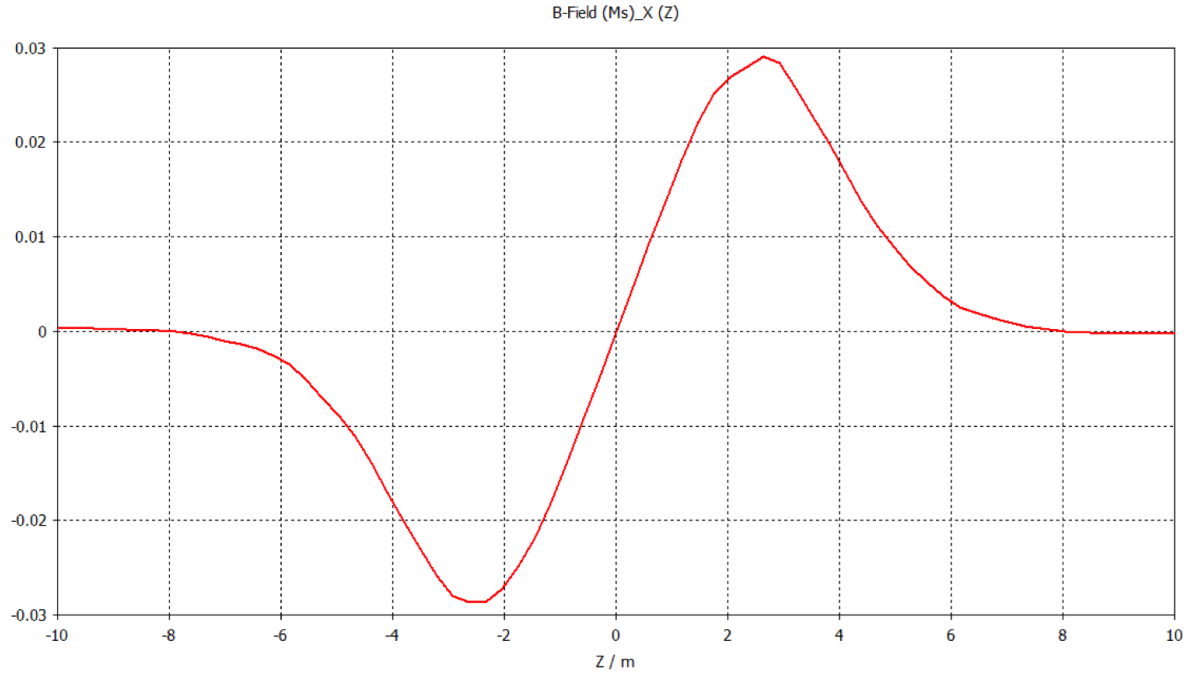


Very Preliminary Field Calculations



Currens not yet optimized

B_x vs. z



Conclusions

Alternative helical anti-DID (B.Parker)

- Proposal, no design yet
  - Separate coil or directly wound onto solenoid
  - Have to check forces
- Advantages
  - Construction probably easier
  - No additional support structure needed if directly wound onto solenoid (less radial thickness?)
  - Can be split into sections or small parts for easier assembly and field optimization
- Disavantages
  - Larger stored energy, due to cancellation of solenoidal fields
  - (Small increase of solenoid radius (10,20mm?)
- Planning to do some field calculations