Magnetic System Overview
Solenoid and Anti-DID

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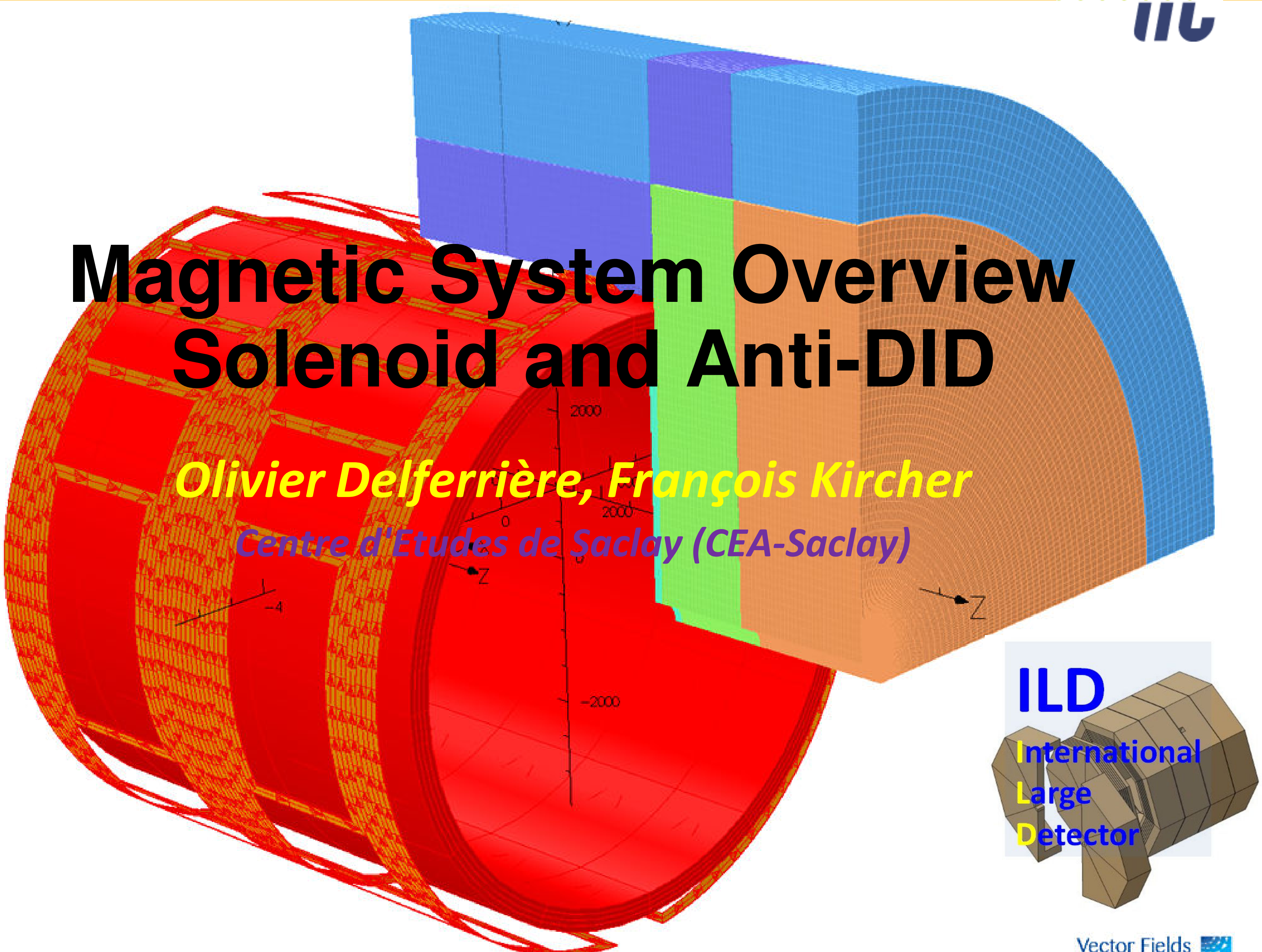

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Summary

Introduction

1. Version « ILD-V5 Saclay » for the Solenoid configuration
   - Optimized solution without anti-DID
   - Homogeneous field in the TPC volume

2. Introduction of the Anti-DID
   - Anti-DID coil design – *Brett Parker design*
   - Air-coil and anti-DID in ILD design comparison
   - TPC Field Homogeneity study: Correction coils and anti DID

Conclusions and remarks

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Introduction

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- New detector concept for ILC:
  ILD = mixture of GLD and LDC
- *Saclay* ILD electromagnetic simulations by :
  O. Delferrière, F. Kircher
- ILD V5 – *Saclay* version = last version before LOI
- 2D axisymmetric electromagnetic simulations (OPERA-2D©) for :
  1) Stray field optimization including all gaps
  2) TPC homogeneity without anti-DID

BARREL YOKE

12-fold shape. It is longitudinally split into three parts. In the radial direction, the inner part of the yoke is made of 10 iron plates, with a space of 40 mm between each to house the muon detectors. 3 external thick plates, each 560 mm thick with 40 mm space in between, make up the total iron thickness.

END CAP YOKE

12-fold shape, similar split structure, with 10 iron plates in the inner part, with a space of 40 mm between each to house the muon detectors, and 2 external thick plates, each 560 mm thick, to make up the total iron thickness.

FIELD SHAPING PLATE

A 100 mm thick field shaping plate (FSP) will be added inside each end cap to improve the field homogeneity.

- **3D electromagnetic simulation for TPC homogeneity with anti-DID (OPERA-3D/TOSCA©) – cylindrical geometry assumed**

Simplified geometry without all the 40 mm internal gaps for muon detectors

Only the main “mechanical gaps”

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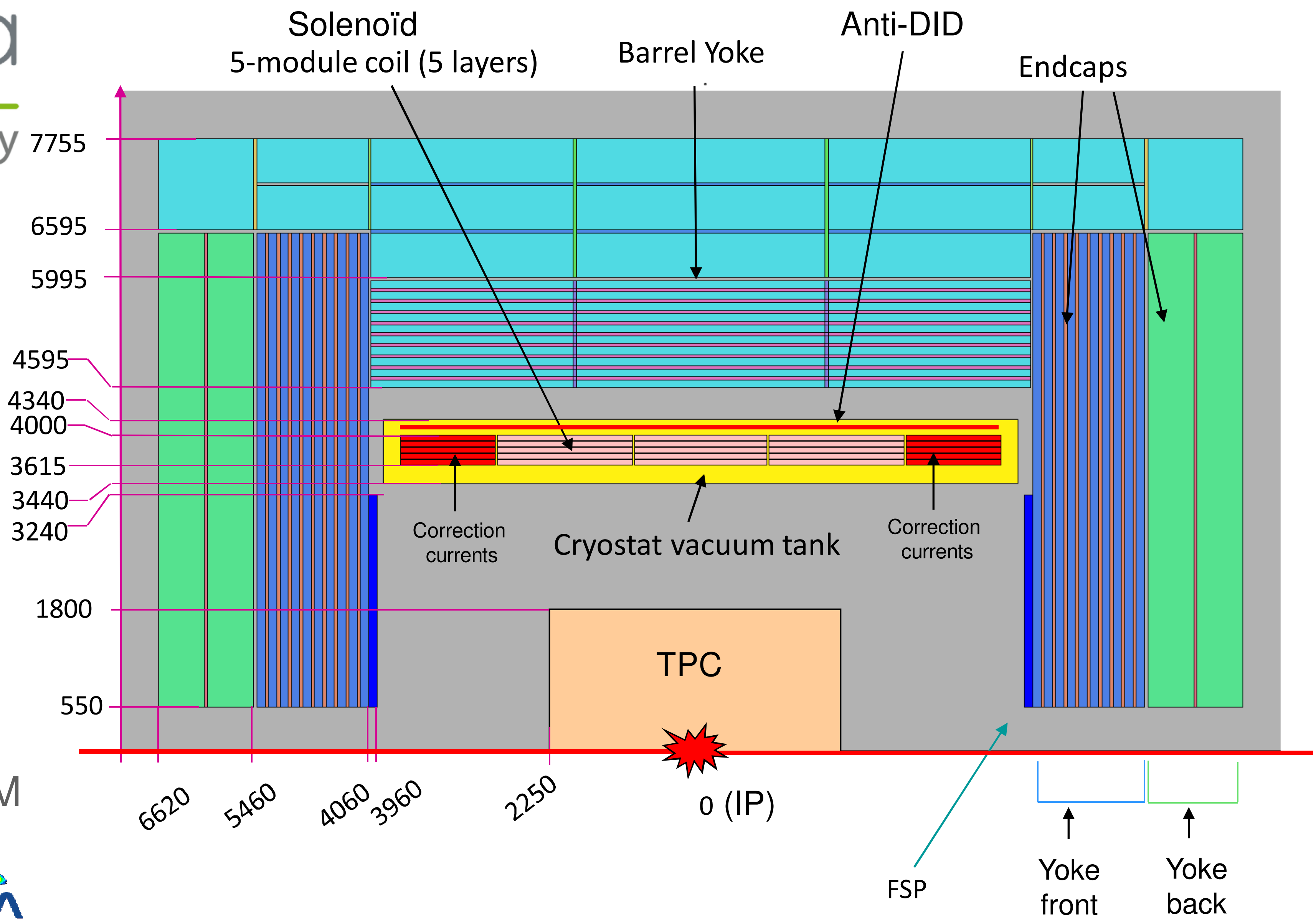
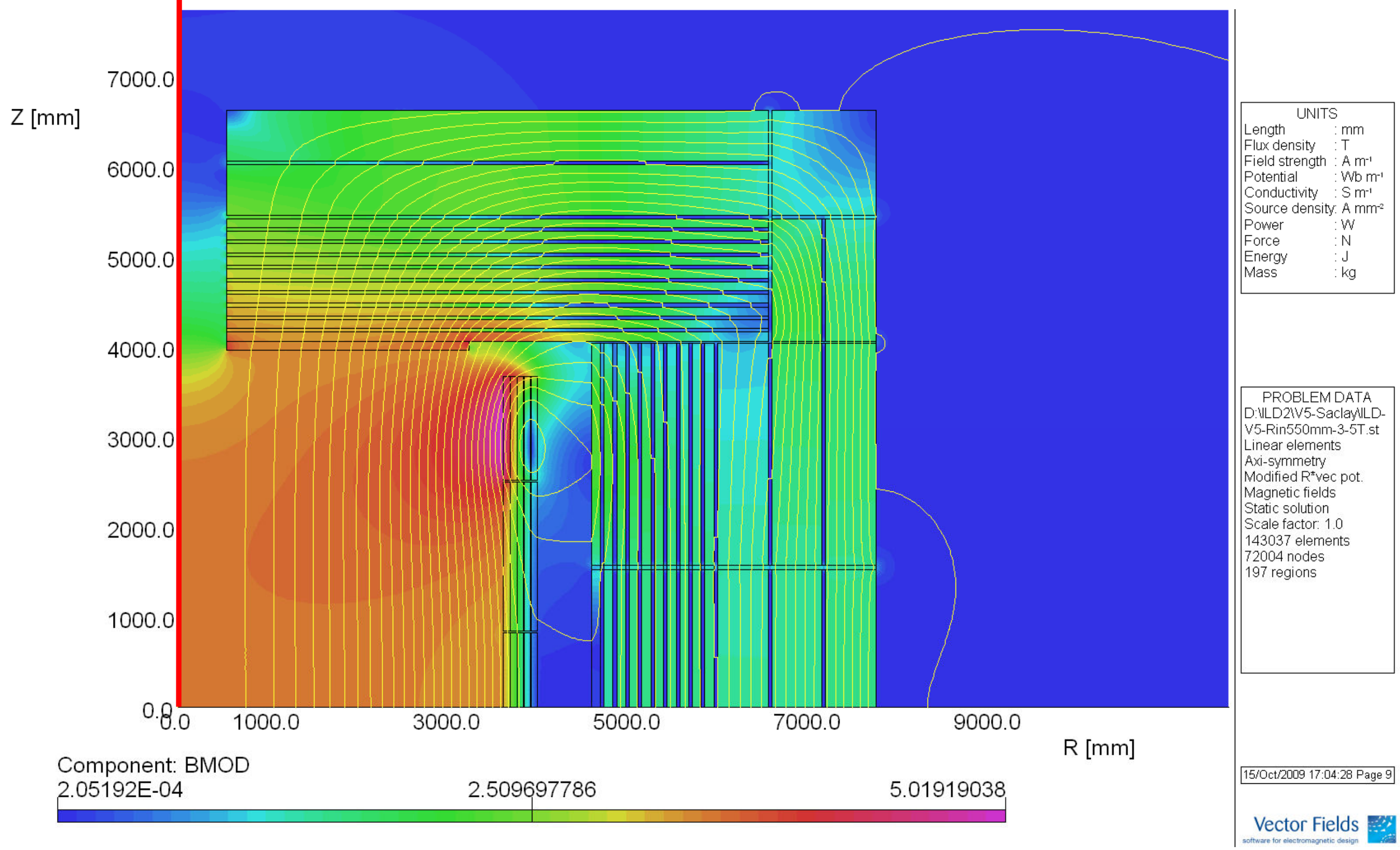
ILD cross section



2D up to date cross section for OPERA-2D simulations

	3.5 (500 GeV op.)	4.0 (design)
Central field (T)	3.5 (500 GeV op.)	**4.0 (design)**
Maximum field on conductor (T)	4.82	**5.50**
Stored energy (GJ)	2. 1	**2. 7**
Stored energy per unit of cold mass (kJ/kg)	9.0	**11.9**
Main coil current (kA)	**15.8**	**18.4**
Extra correction current (kA)	**16.2**	**18.4**
Ampere-turns main coil (MAt)	19.4	**22.5**
Ampere-turns correction coils (MAt)	6.5	**7.4**

Beam axis



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Homogeneity criteria

Field homogeneity:

homogeneous field in the volume of the TPC:

$$\Delta l\,(R) = \int_{0}^{z_{max}} (B_r\,(R) \,/\, B_z\,(R)\, dz$$

within the TPC volume:

$z_{max} = 2.25$ m

$R_{max} = 1.8$ m

The field homogeneity is adjusted with a FSP (Field Shaping Plate) and correction currents in some places of the coil at both ends.

Initial requirements :
Field homogeneity for ILD : $\Delta l\,(R) < 10$ mm

Optimized results@3.5T without anti-DID

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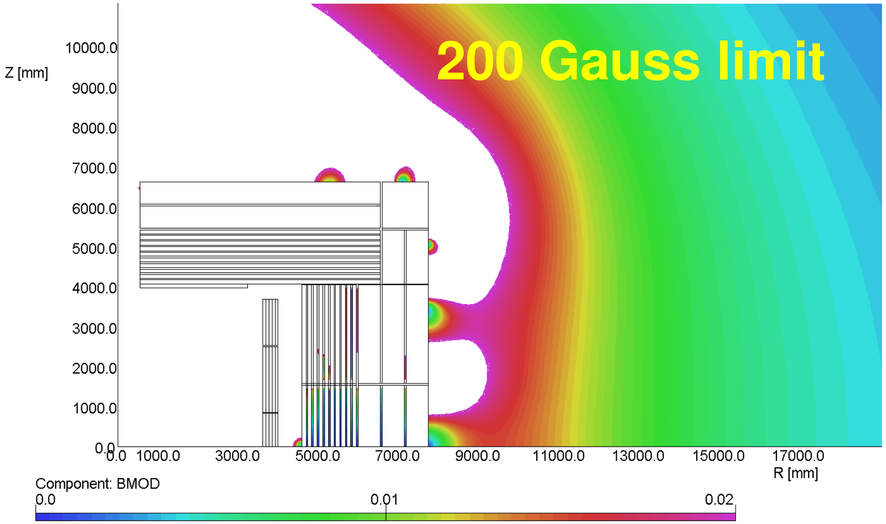
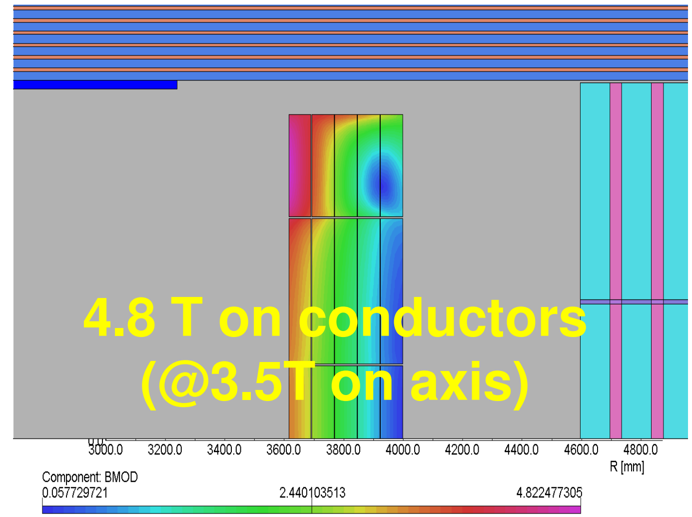
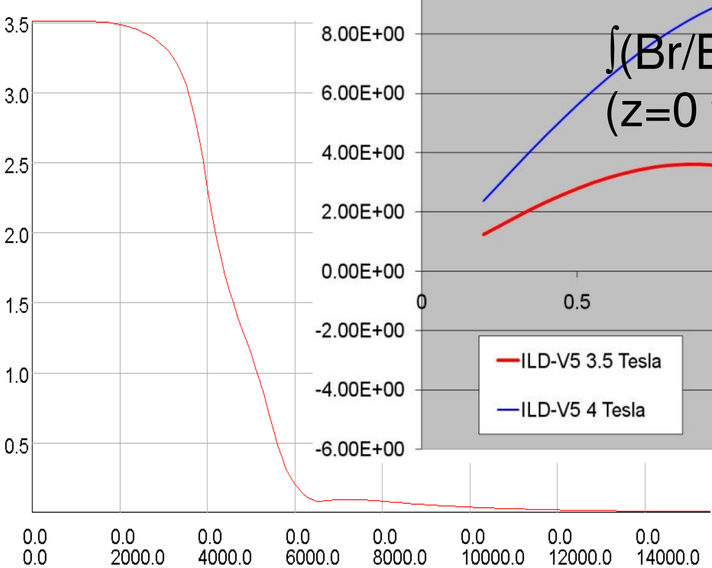
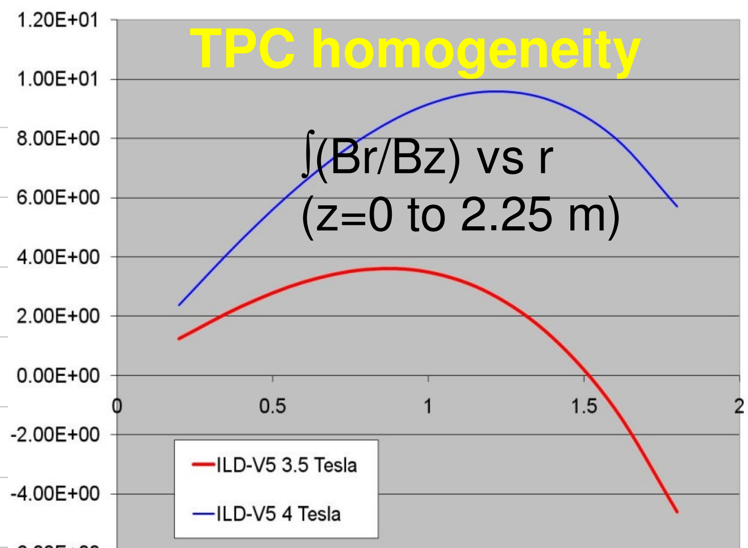
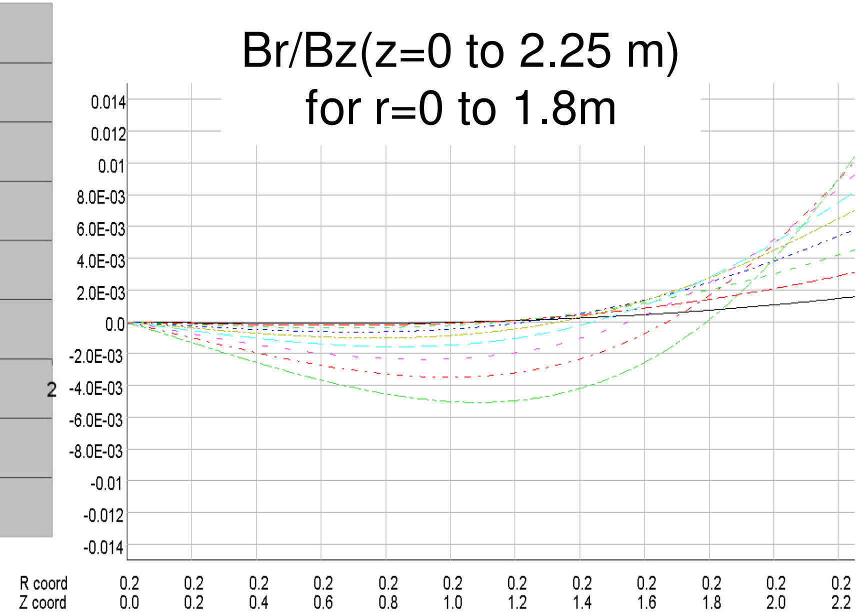


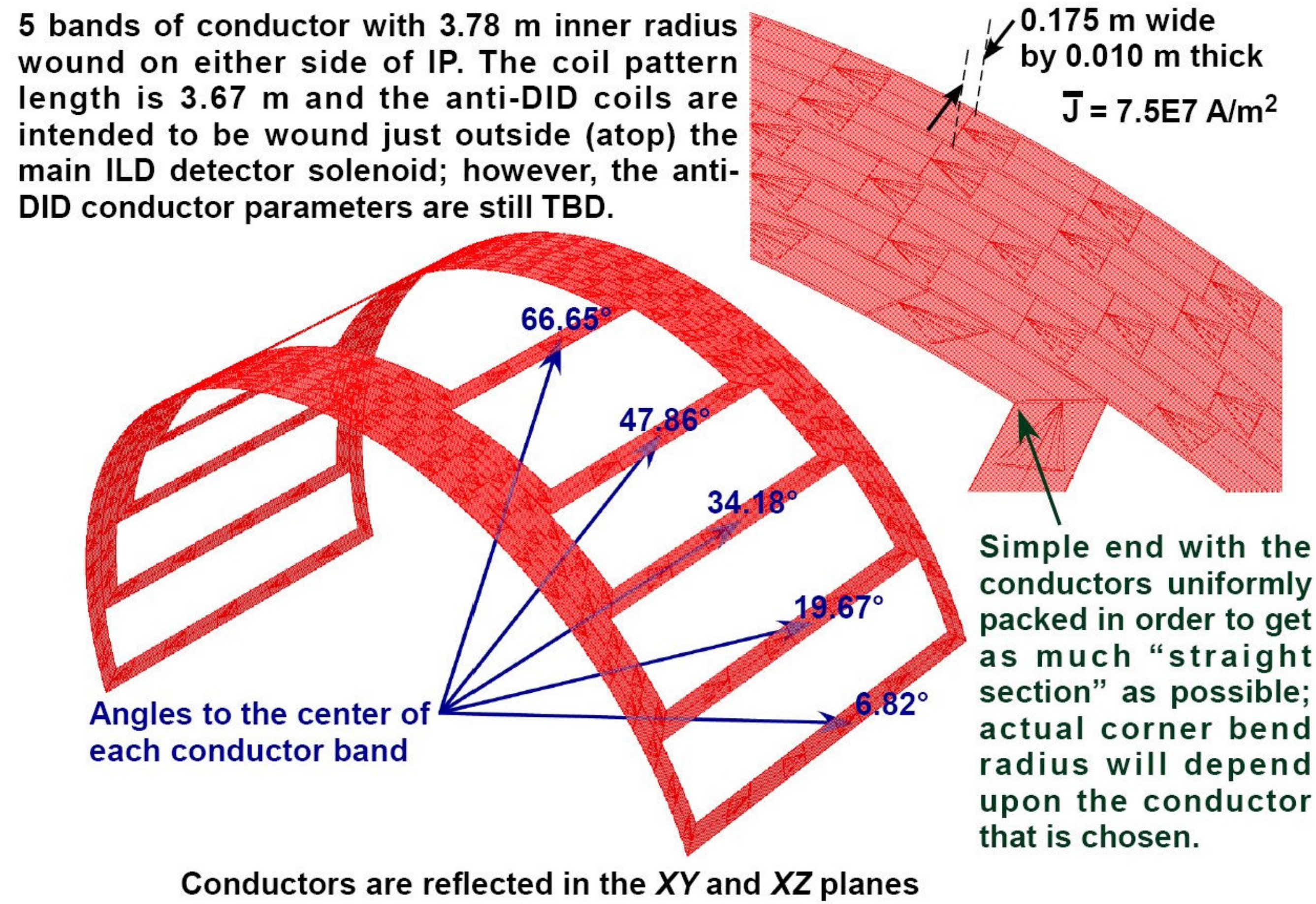








Anti DID coil definition *(Brett Parker-August 2008)*



In the ILD design the outer radius of solenoid coil is : **R_{out}= 4.00 m**

External radius of the Anti-DID has been extend to: **R_{AD}=4.3 m**

The thickness and width are unchanged : **10 mm**, **175 mm**

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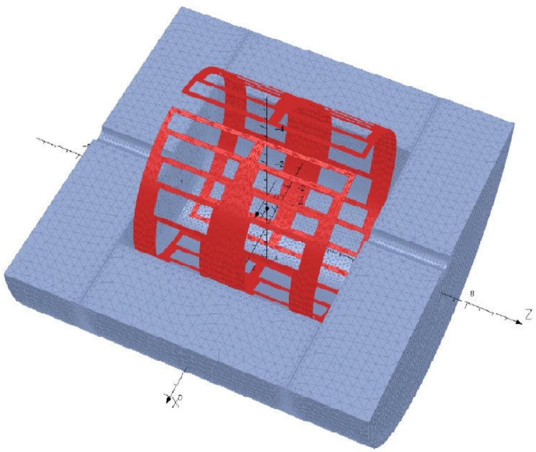
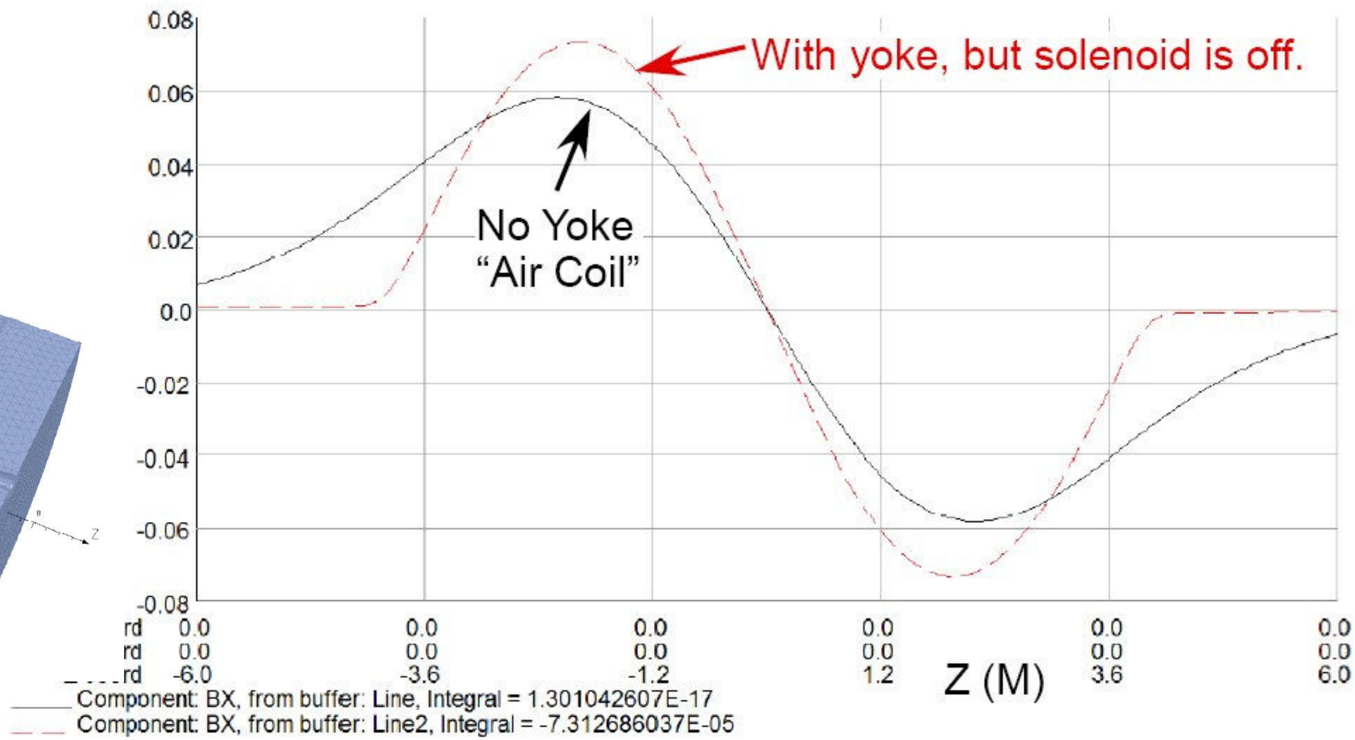
Distance between solénoid and anti-DID: **0.3 m has to be optimized**

Anti DID coil definition *(Brett Parker)*





Design might not be optimized for the actual ILD Magnet ?

This model does not yet include the ILD solenoid, so the yoke is unsaturated. Note the sharp reduction compared to the “air coil” field near the endcap plate at Z = 4 m. When the inner layers of the endcap do become highly saturated with the main solenoid being energized, the result for the anti-DID field will lie between these curves in the near endcap region.

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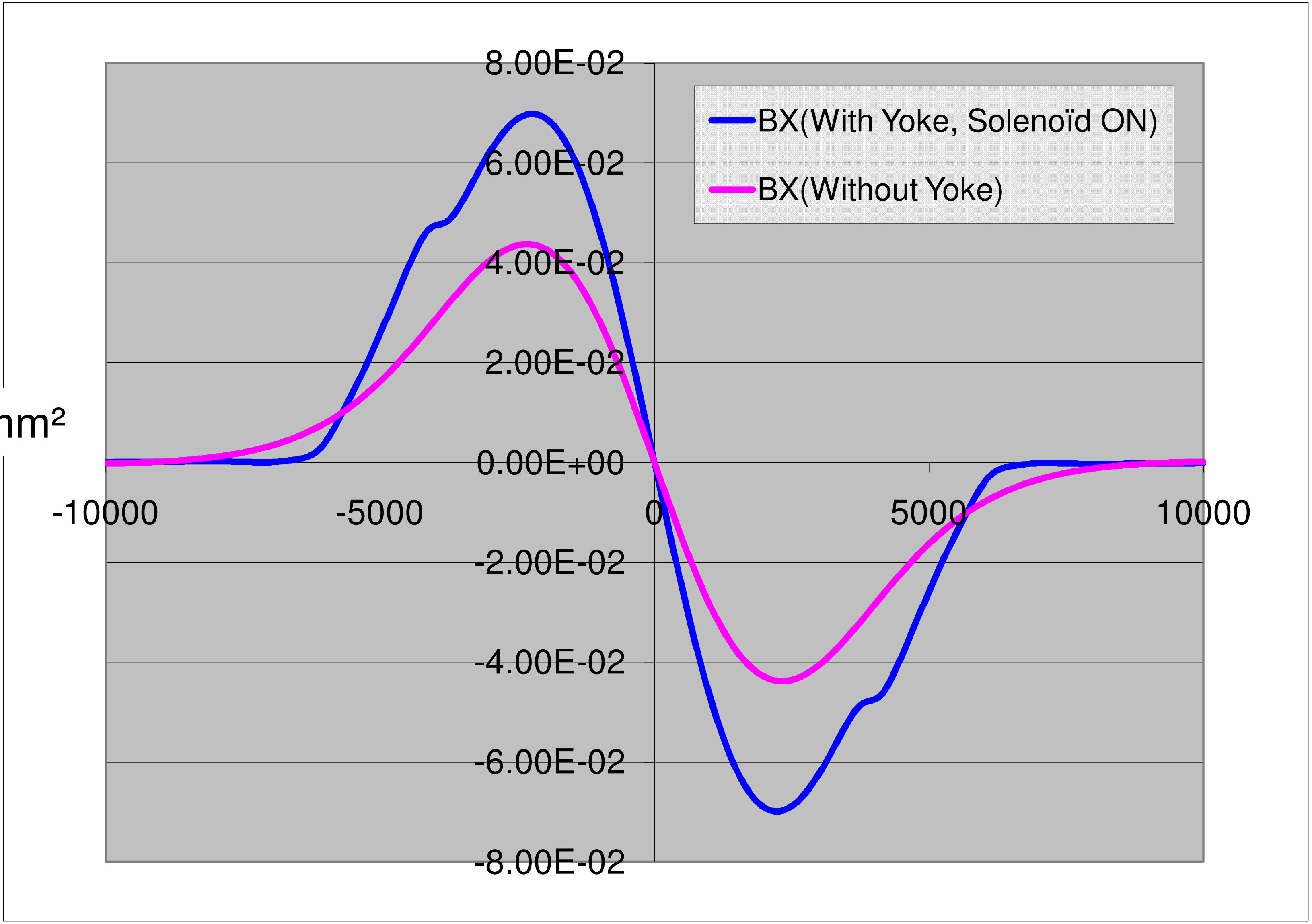
Anti-DID in ILD V5 - *Saclay*

J=75 A/mm²



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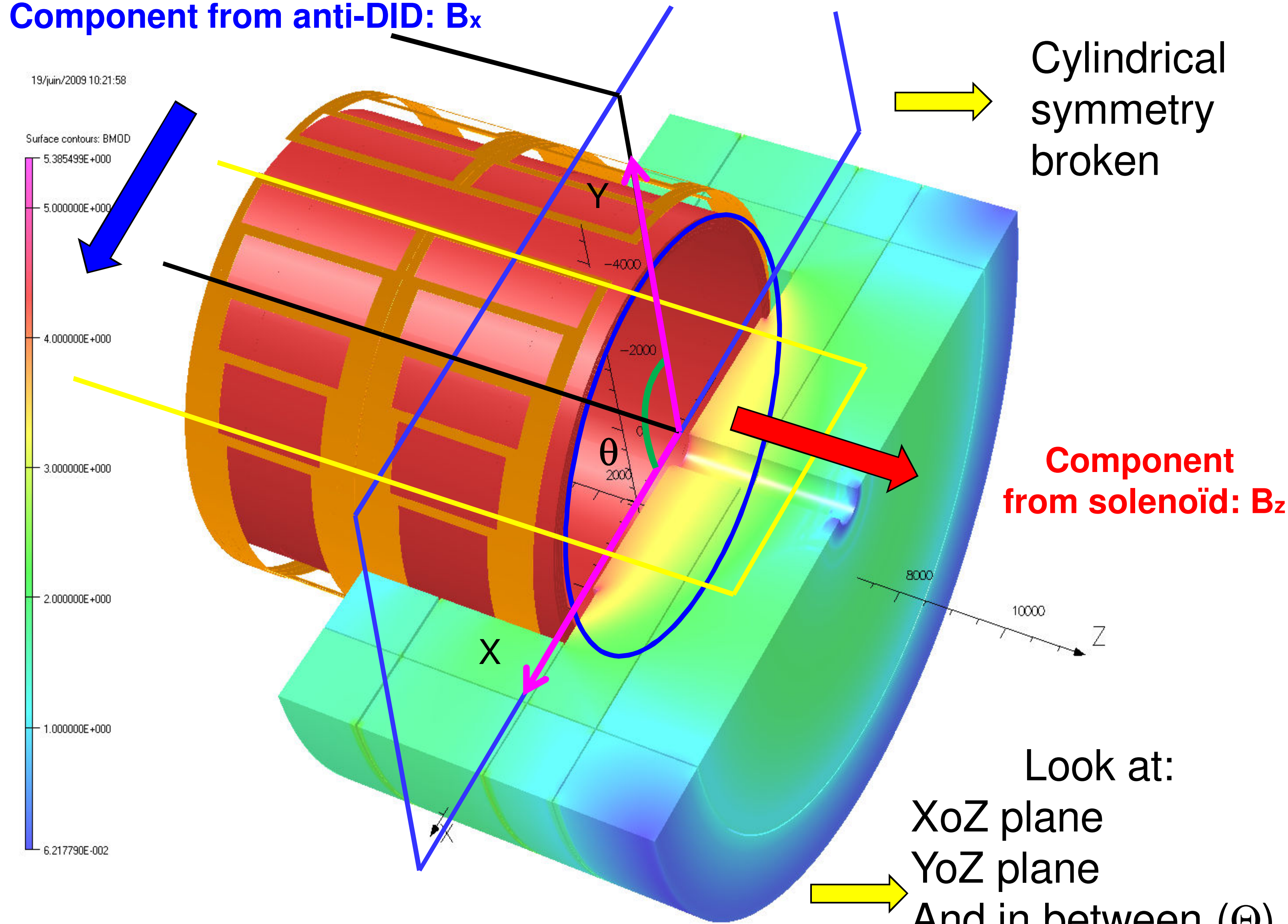
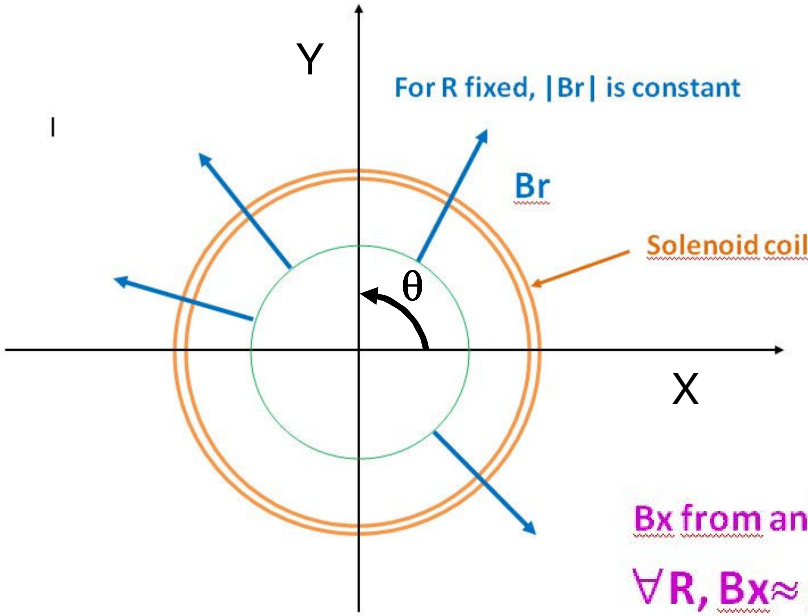
Simplified iron geometry for Solenoid+Anti DID



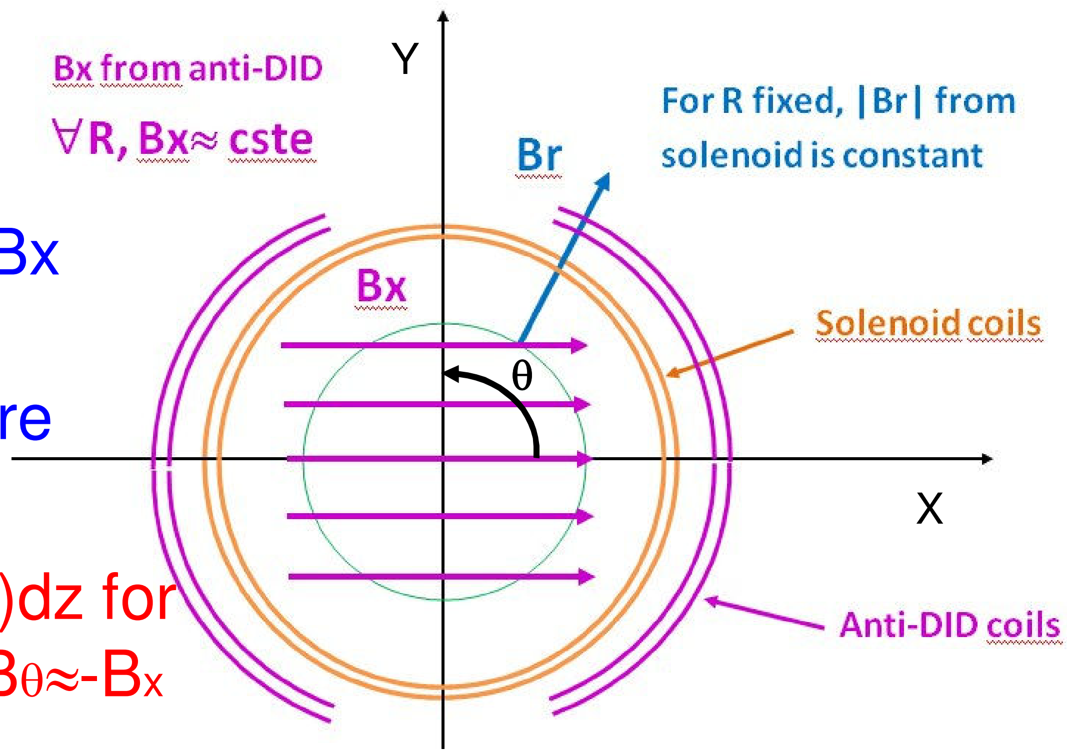
Cylindrical symmetry broken

Look at:
XoZ plane
YoZ plane
And in between (Θ)

B_r and B_θ



$$\int (B_r/B_z)dz = cste$$
$$\forall\ \theta$$



$\int (Br/Bz)dz$ increased by Bx from Anti-DID

$\int (Br/Bz)dz$ same as before for $\theta=90°$ (yoz plane)

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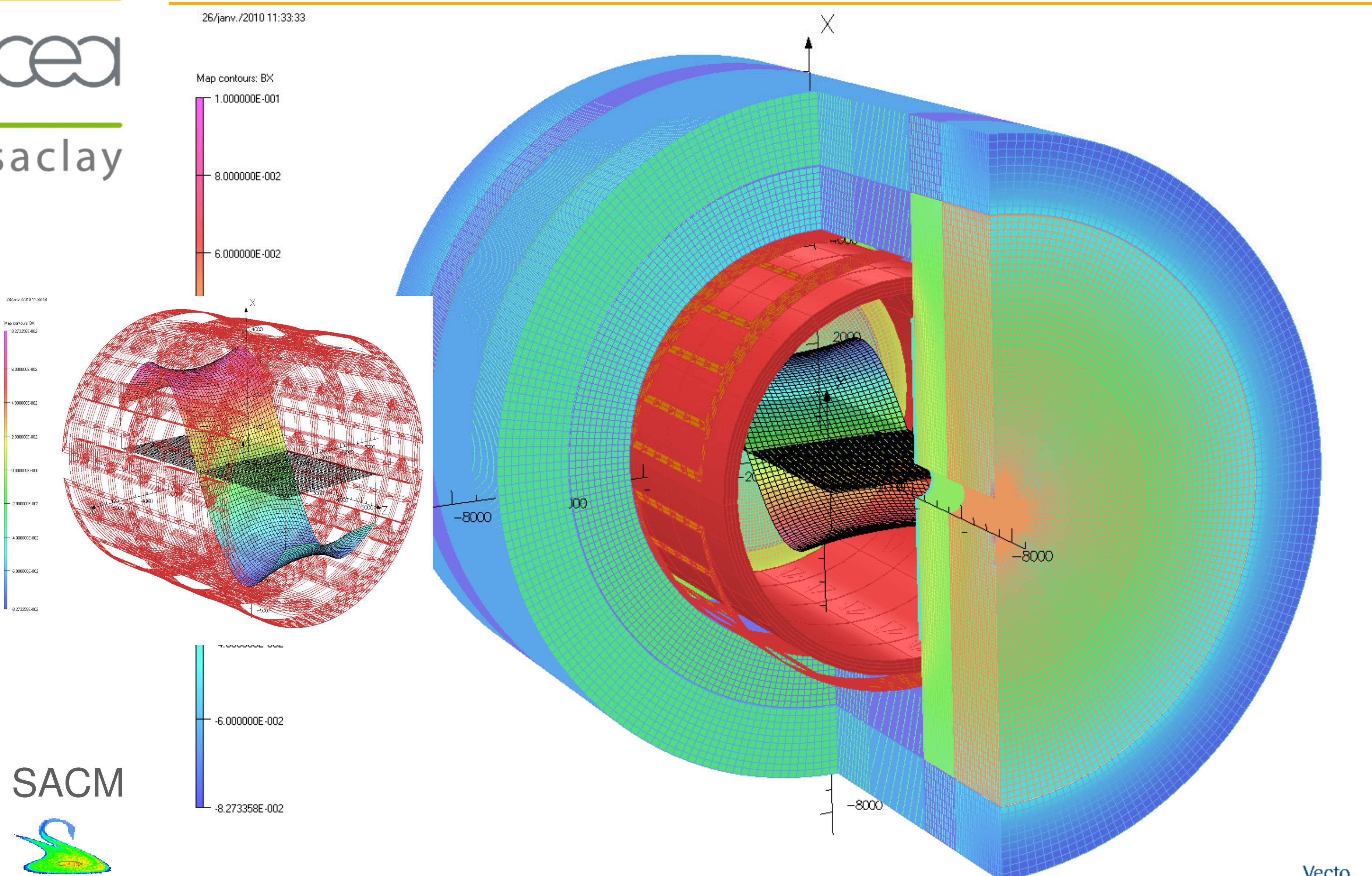
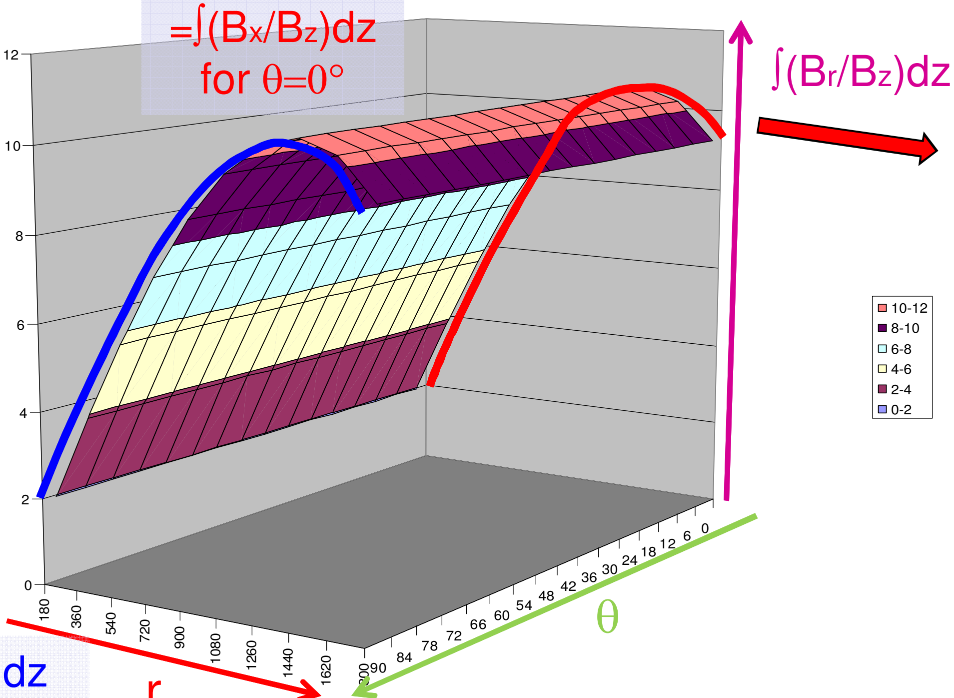
Also look at $\int (B_\theta/B_z)dz$ for $\theta=90°$ (yoz plane) $B_\theta \approx -B_x$

Anti-DID in ILD

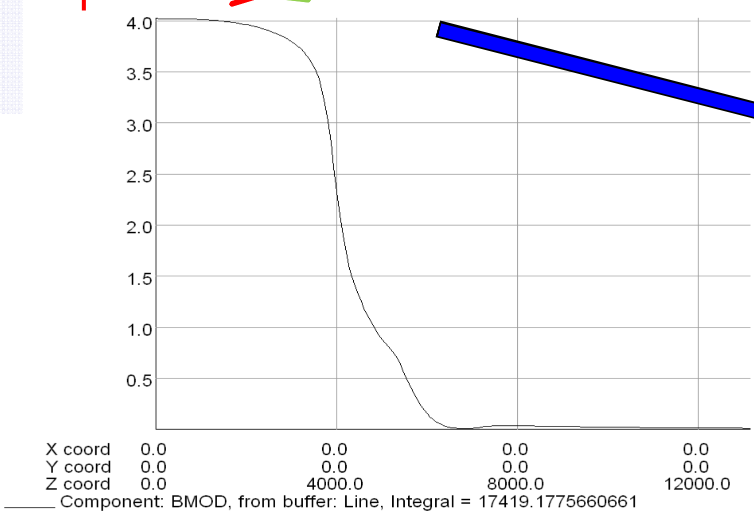


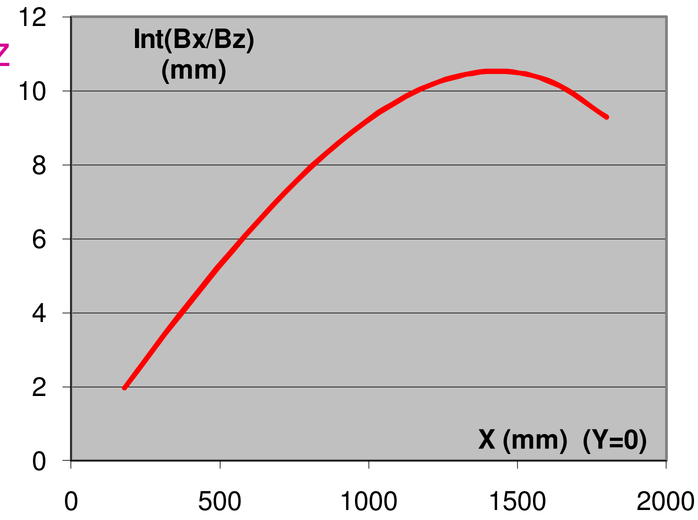
Solenoid + Icor, no anti-DID

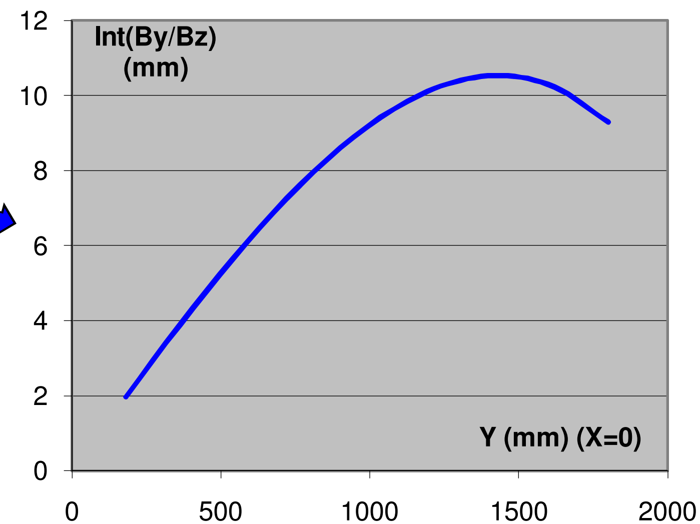
$\int (B_r/B_z)dz = \int (B_x/B_z)dz$ for $\theta=0°$



$\int (B_r/B_z)dz = \int (B_y/B_z)dz$ for $\theta=90°$







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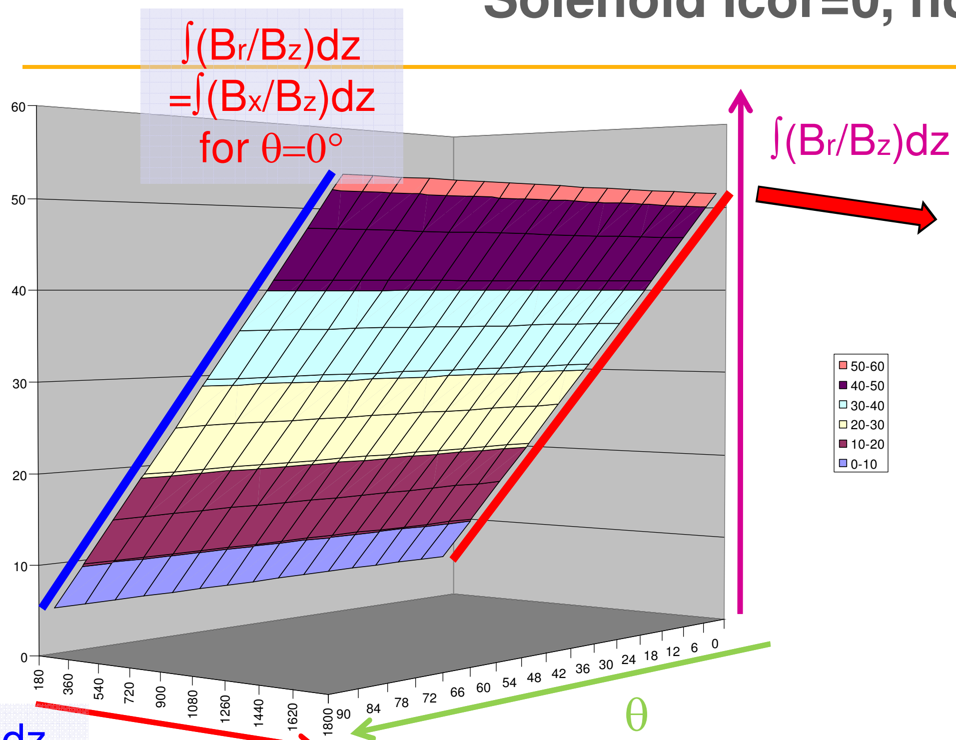
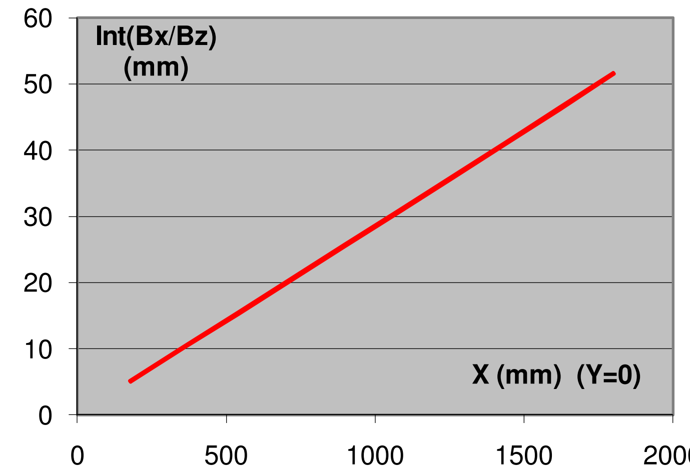
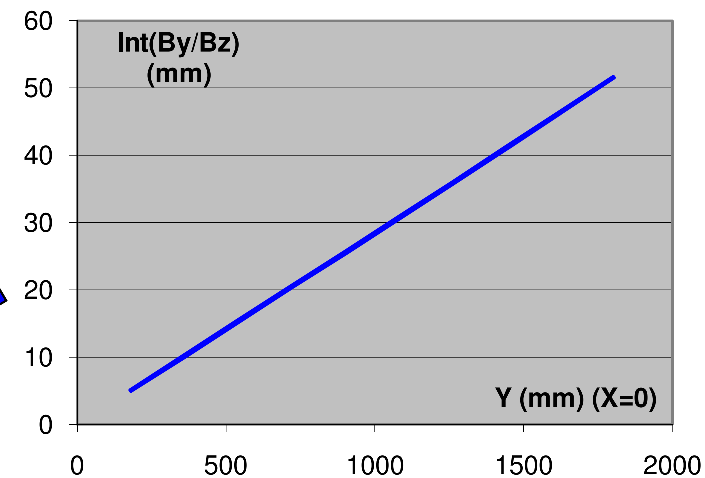
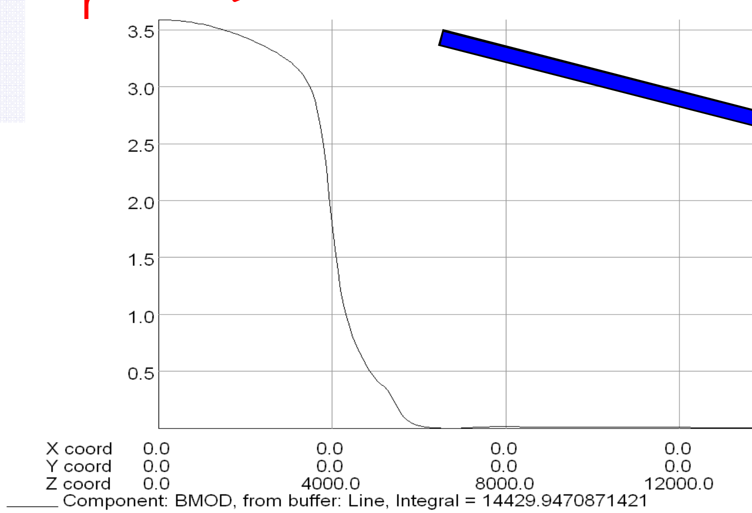
Solenoid Icor=0, no anti-DID





∫(Br/Bz)dz
=∫(By/Bz)dz
for θ=90°





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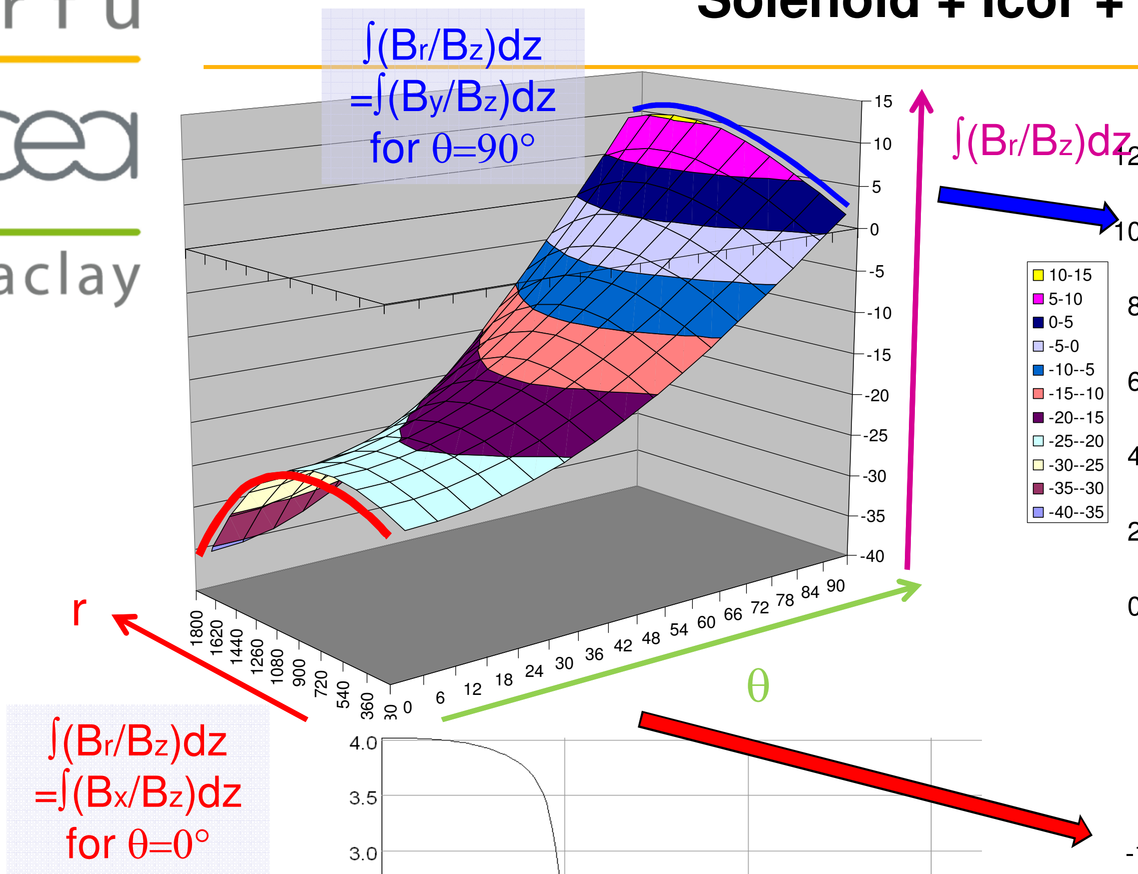
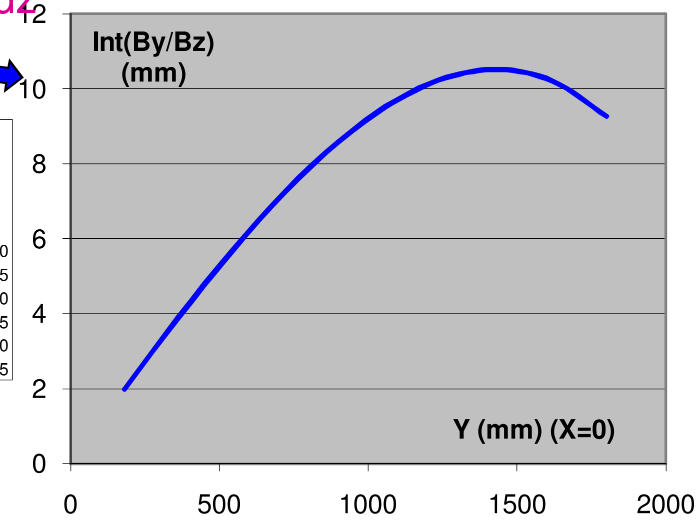
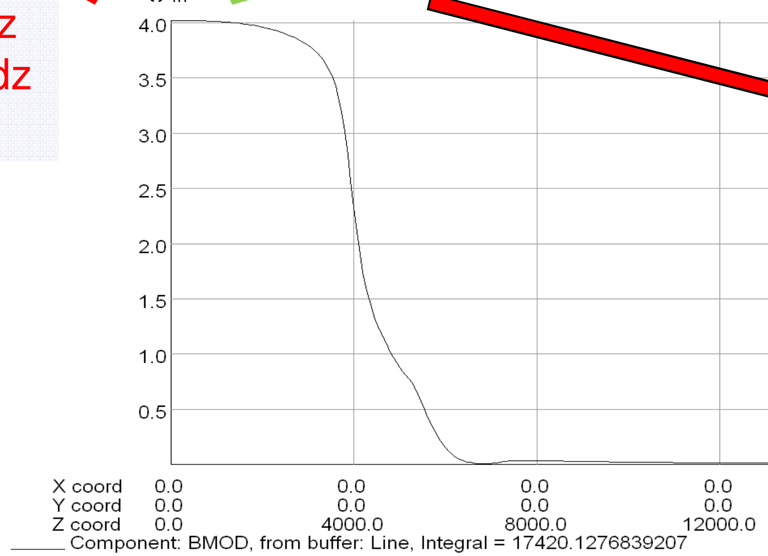
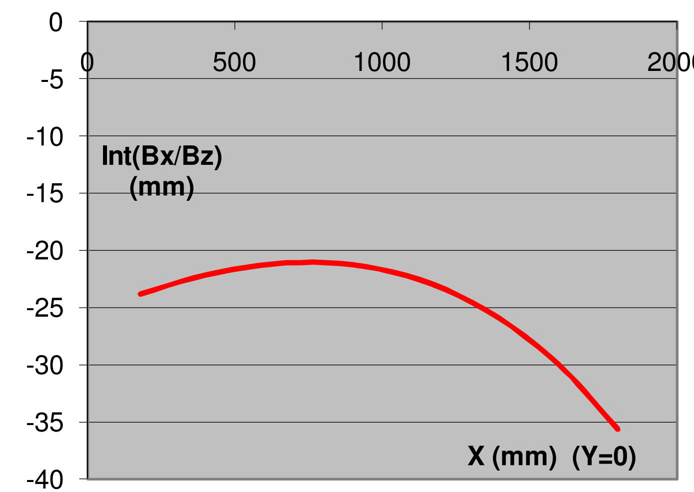
Solenoid + Icor + anti-DID









Solenoid Icor=0, + anti-DID

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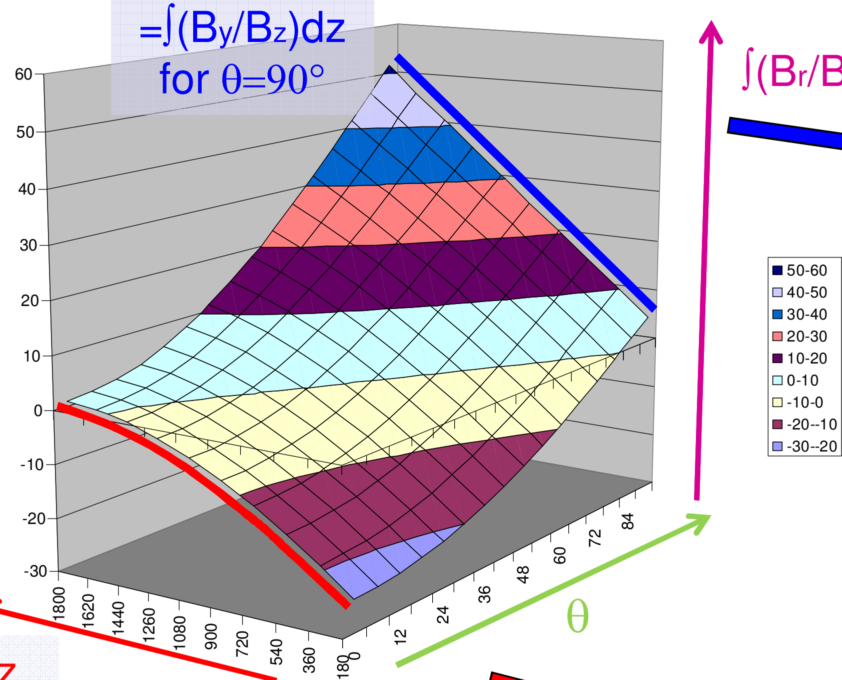
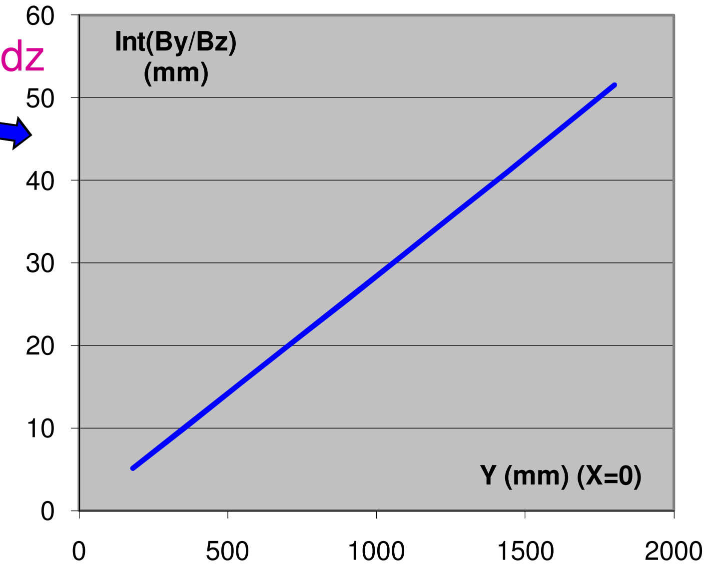
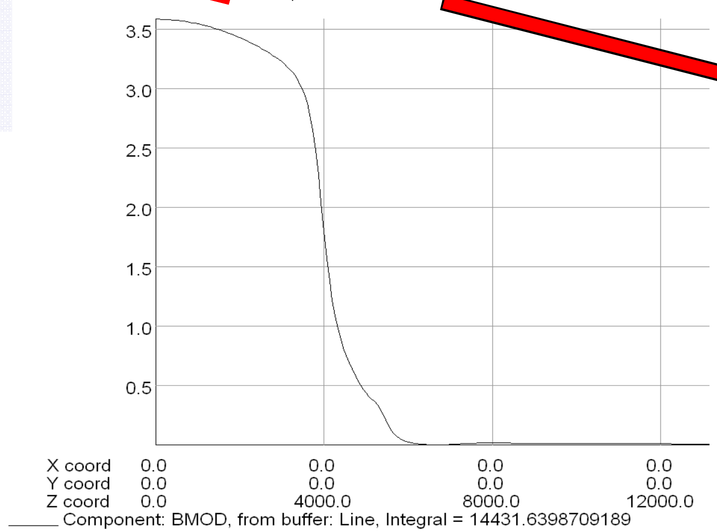
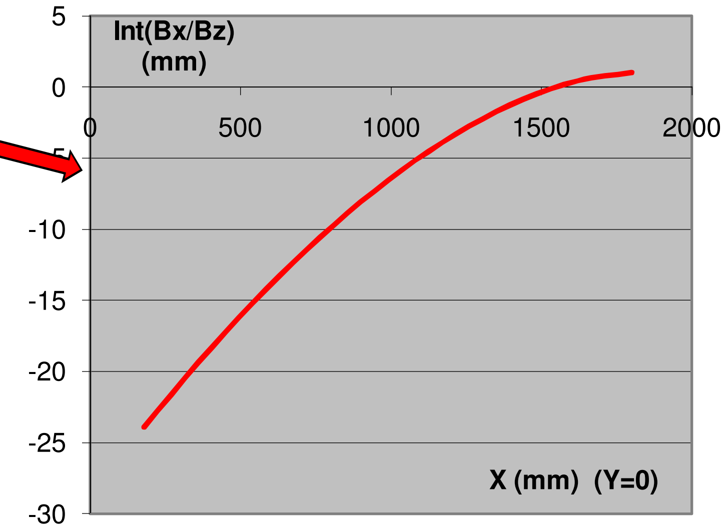
$\int(B_r/B_z)dz$
$=\int(B_y/B_z)dz$
for $\theta=90°$





$\int(B_r/B_z)dz$
$=\int(B_x/B_z)dz$
for $\theta=0°$





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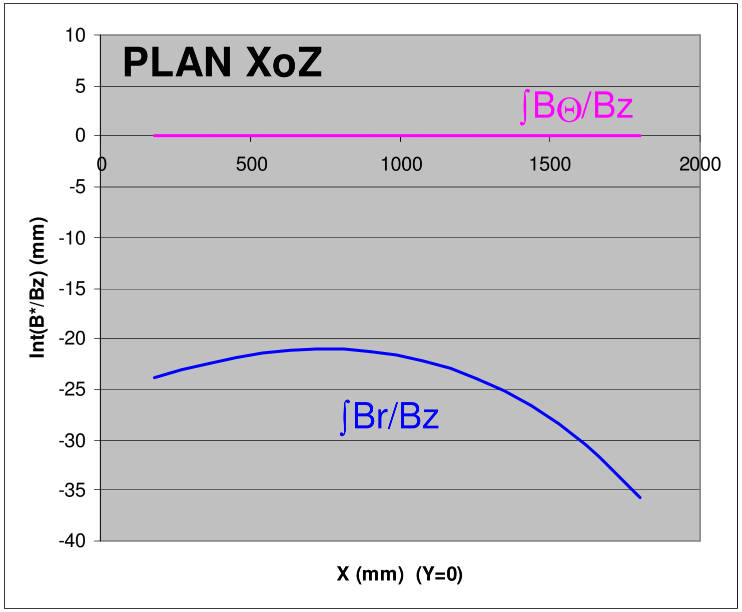
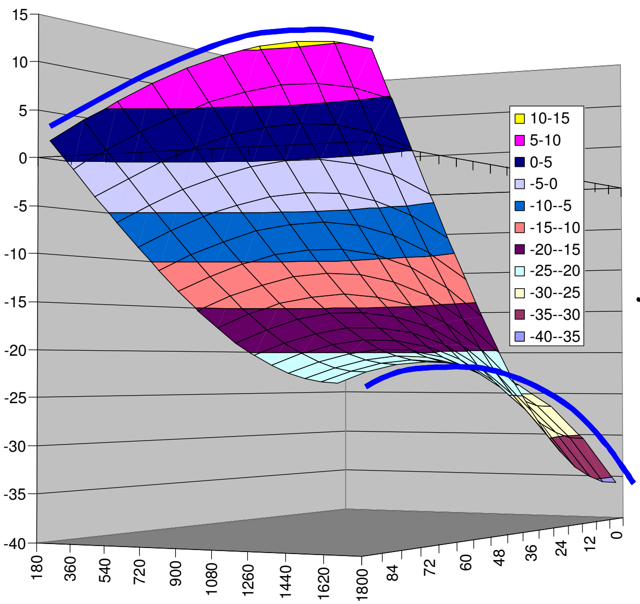
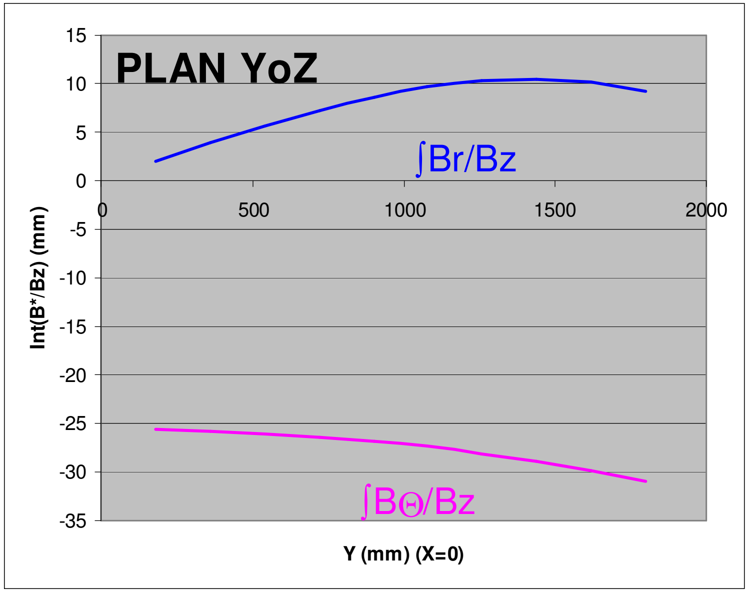
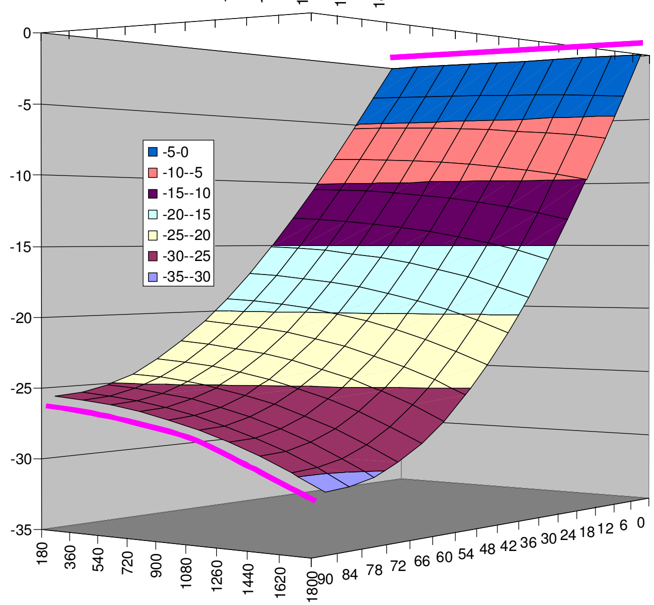
Solenoid + Icor + anti-DID: ∫Br/Bz.dz and ∫Bθ/Bz.dz





∫Br/Bz.dz





∫Bθ/Bz.dz

Correction currents and Anti-DID

Summary

	Solenoid +correction No Anti-DID	Solenoid No correction No Anti-DID	Solenoid + correction + Anti-DID	Solenoid No correction +Anti-DID
∫Br/Bz.dz	10 mm	50 mm	-35 < <10 mm	-25< <50 mm

≈Same effect on **∫Bθ/Bz.dz**

So: Main questions are:

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If anti-DID, do we need correction currents ?
And: Do we really need Anti-DID if we ask for homogenous field?

Conclusions and remarks

-Yoke dimension & Solenoid coil dimensions frozen

-**Anti-DID first simulation with solenoid and yoke**
Homogenous field is lost

-**No optimization of Anti-DID** position, geometry or current since first design of *Brett Parker*.

-Optic simulations are underway at Saclay :
Reine Versteegen, PhD , *«Conception et Optimisation de la Région d'Interaction d'un futur collisionneur linéaire électron-positon »*.

-Preliminary results show that the strength of the anti-DID seems oversized.
- **More optics calculations are needed to optimize the anti-DID**.

-Correction coils increase the peak field, the stored energy and the forces and stress. They need extra hardware (conductor with higher current, current leads, power supply, electrical circuit, instrumentation). This has non negligible consequences on the cost and safety of the magnet.
-**Consequently, the settling of the correction coils must be strongly justified.**

Thank you for your attention

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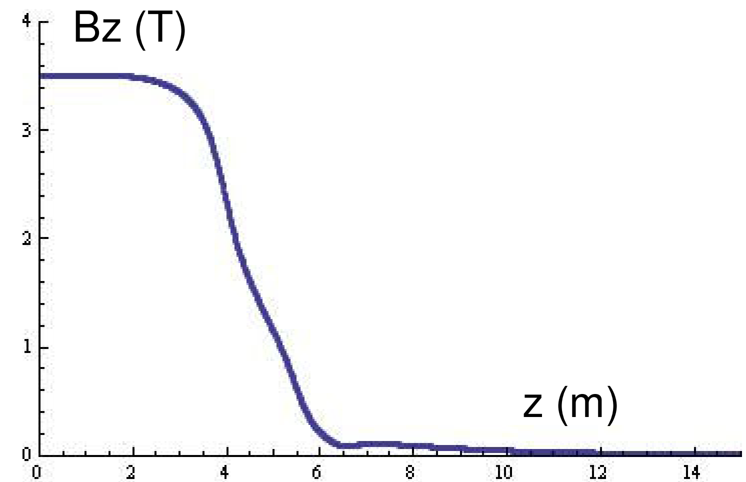
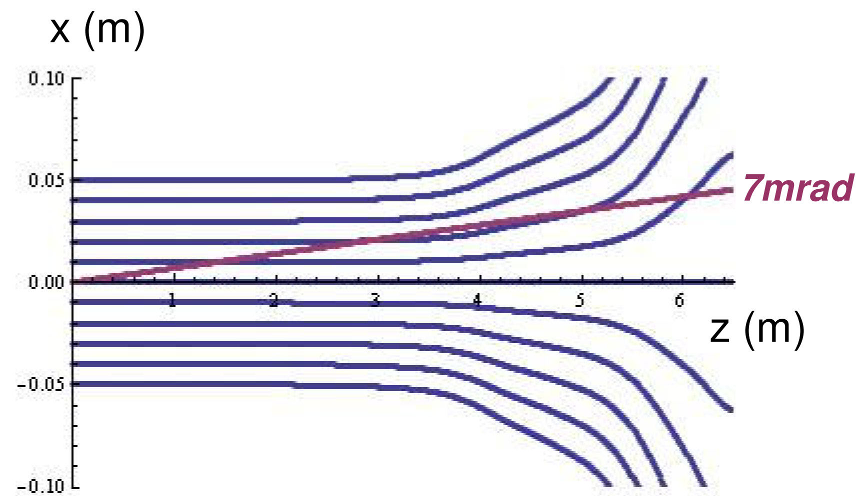
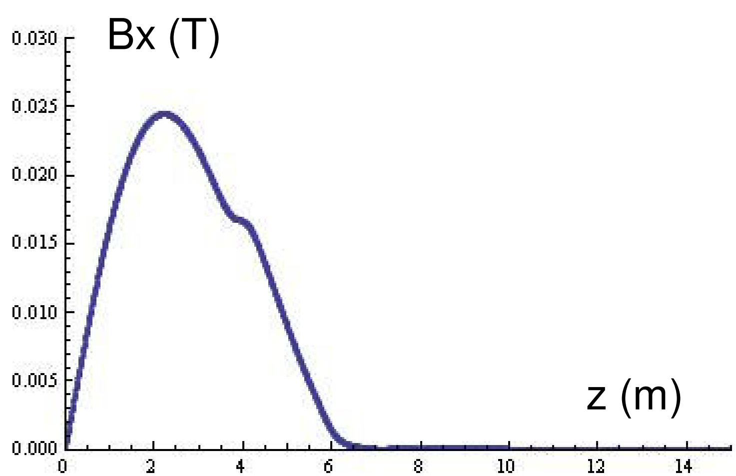
ILD Solenoid :



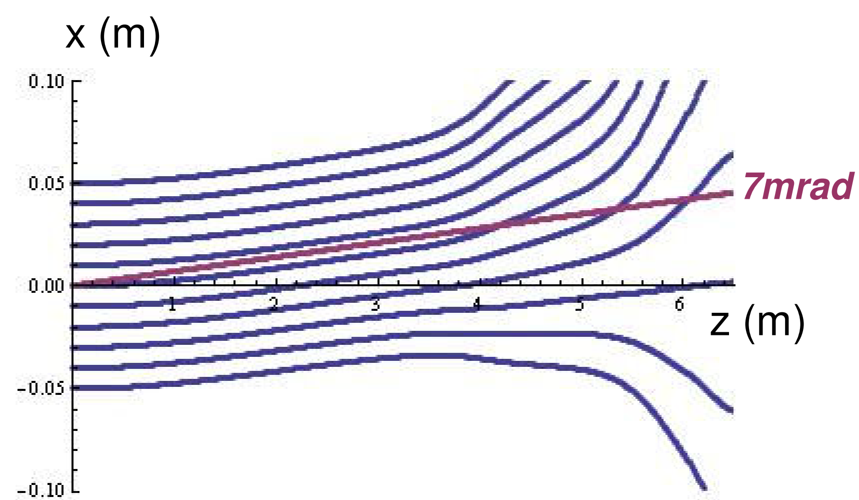
Solenoid field lines:



Anti-DID :



Solenoid+Anti-DID field lines:



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