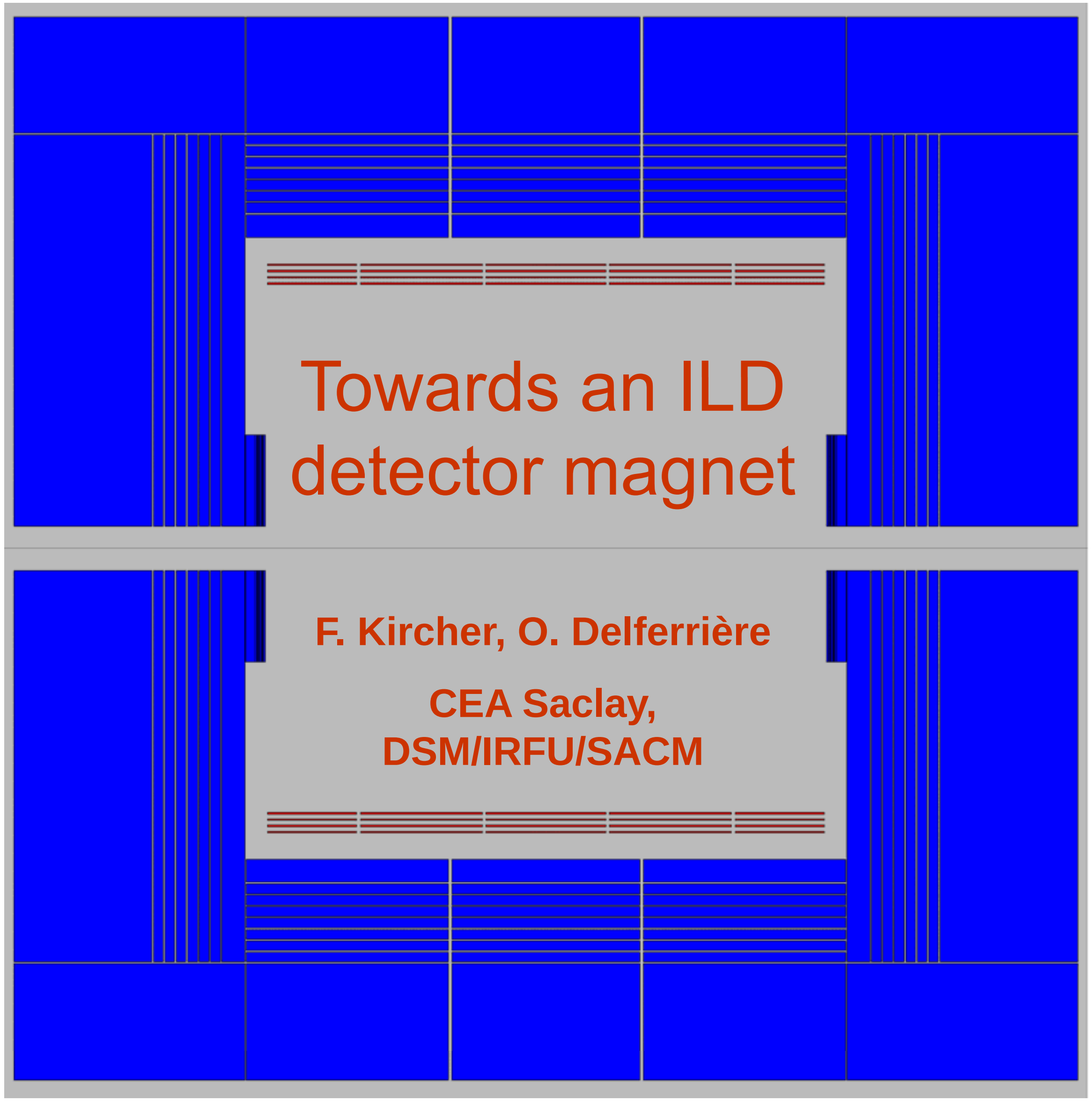


Towards an ILD detector magnet

F. Kircher, O. Delferrière

CEA Saclay, DSM/IRFU/SACM

Summary

Introduction

1. Versions ILD-1 Saclay for the magnet configuration
   1.1 Generalities
   1.2 Various options
   1.3 Homogeneous field in the TPC volume
   1.4 Non homogeneous field in the TPC volume

2. Some other relevant factors
   2.1 Magnetic material influence
   2.2 Cold mass support
   2.3 Anti-DID coil design

Present conclusions

Summary

Introduction

Introduction (1)

. New detector concept

ILD = mixture of GLD and LDC

. Main participants in the magnet effort

. Japanese team (Yasuhiro Sugimoto) :
ILD-G3 version (magnetic design, end cap opening)

. Saclay team (O. Delférrière. F. Kircher)
ILD-V1 Saclay version (magnetic design)

. DESY team (Uwe Schneekloth) :
iron yoke design and B field calculations
(see next presentation)

. Brett Parker (BNL) :
anti-DID design

Introduction (2)

- New parameters used for ILD detector magnet

  B_o = 3.5 to 4 T

  R_{int} coil = 3.4 to 3.6 m

  R_{ext} coil = 3.67 to 3.92 m

  L coil = 7.2 to 7.35 m

  $B_{ext} \leq$ 200 G @ z=10 m from I.P. and at (R_{out} + 0.5 m) in the radial direction

- This talk will report mainly on Saclay's results, but this will be the occasion to adress the basic factors that define the final magnet design

Summary

Introduction

1. Versions ILD-1 Saclay for the magnet configuration
   1.1 Generalities

Versions ILD-1 Saclay : generalities

- Magnet = Coil + iron yoke (barrel + end-caps)

- Saclay's (and DESY) yoke configuration for all designs:
  - Endcaps: 5 tail-catcher layers, each 3 cm thick, with 10 cm steel in-between, then towards outside, four slides, about 400 mm thick, with 3 cm slits in-between
  - Barrel: similar design, except only 4 tail-catcher layers

- For all cases: 2D calculations (cylindrical symetry)
  3D calculations underway

Summary

1.2 Various options

Version ILD-V1 Saclay: various options

- Two options for field homogeneity:
  - option 1: homogeneous field in the volume of the TPC:

$$\Delta I\ (R) = \int_0^{z_{max}} (B_r\ (R)\ /\ B_z\ (R)\ dz$$

within the TPC volume:

z_{max} = 2.25 m
R_{max} = 1.8 m

The field homogeneity is ajusted with a FSP (Field Shaping Plate) and correction currents in some places of the coil. No more iron nose, as in the previous LDC yoke design, is used to adjust the homogeneity

➔ version ILD-V1 Saclay

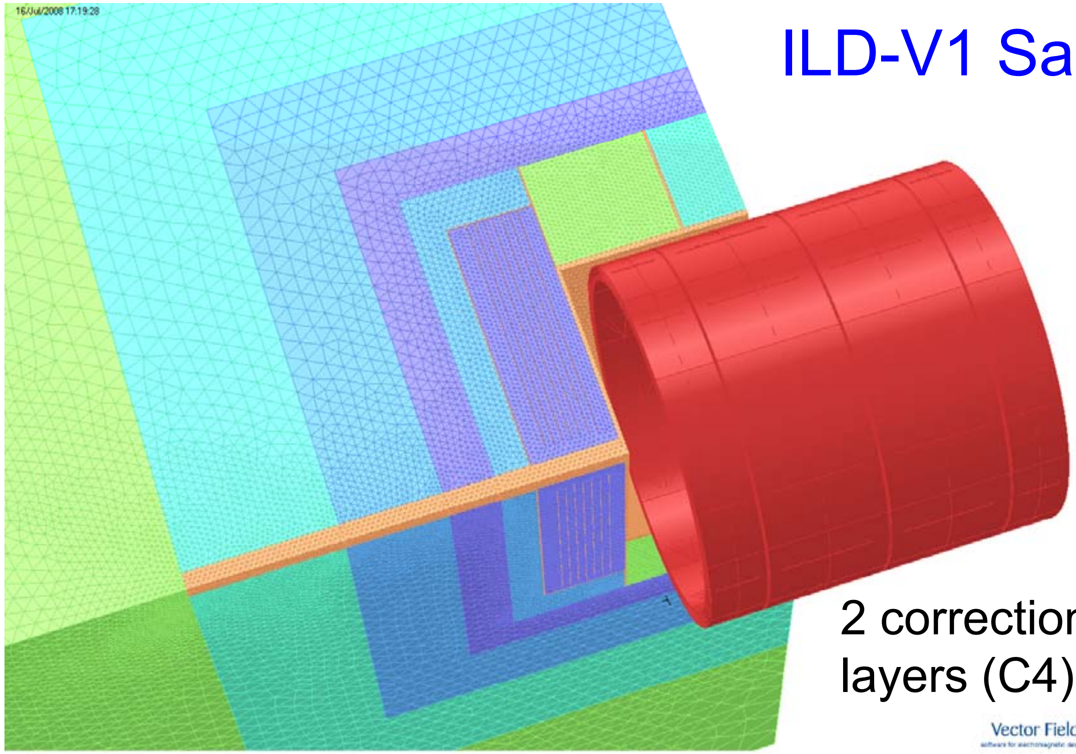
  - option 2: no constraint on ΔI (R)

➔ version ILD-V1 Saclay light

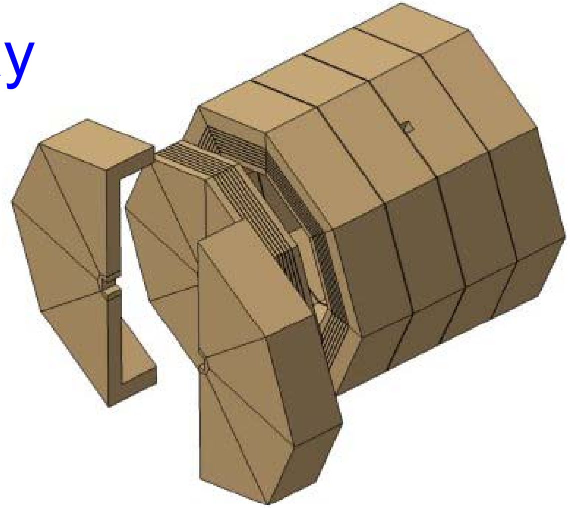
Note that for ILD-G3, the field homogeneity is reached with extra correction coils

Summary

1.3 Homogeneous field in the TPC volume

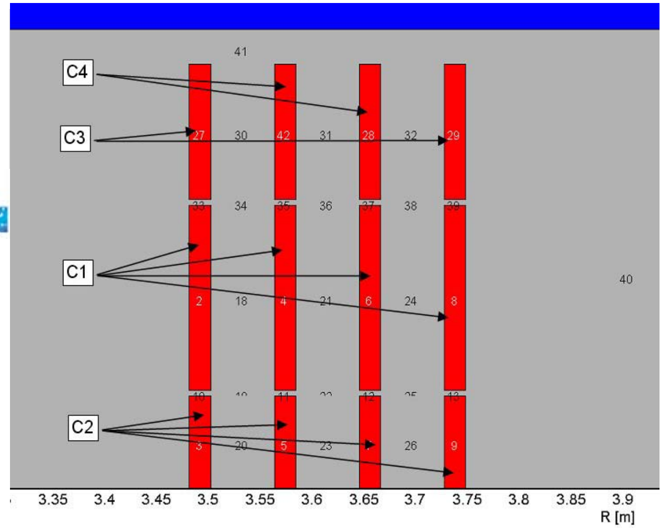


ILD-V1 Saclay



2 correction layers (C4)

Current distribution :		2 correction layers		
12948	12948	12948	12948	12948
32136	12948	12948	12948	32136
32136	12948	12948	12948	32136
12948	12948	12948	12948	12948



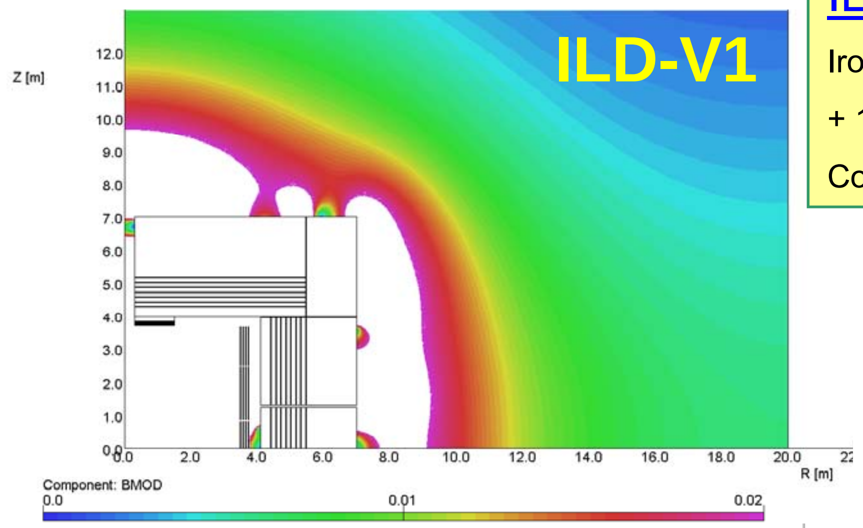
	NI (MA)	J (A/mm²)	N (turns/layer)	I per turn (kA)	I correction (kA)	Length (m)
C1	1.29	40.0	100	12.9	0	1.65
C2	0.65	40.0	50	12.9	0	1.65
C3	0.95	40.0	73	12.9	0	1.21
C4	2.35	93.0	73	32.1	19.2	1.21

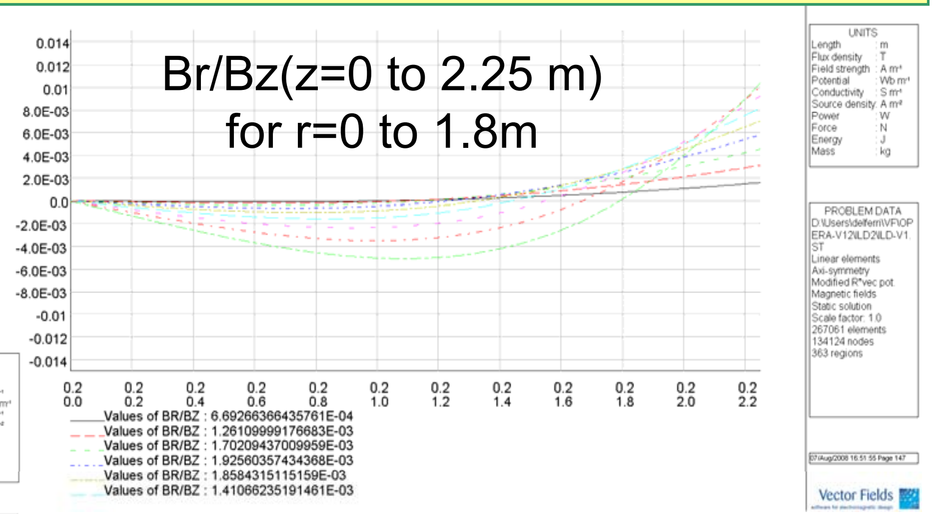
ILD-V1 configuration

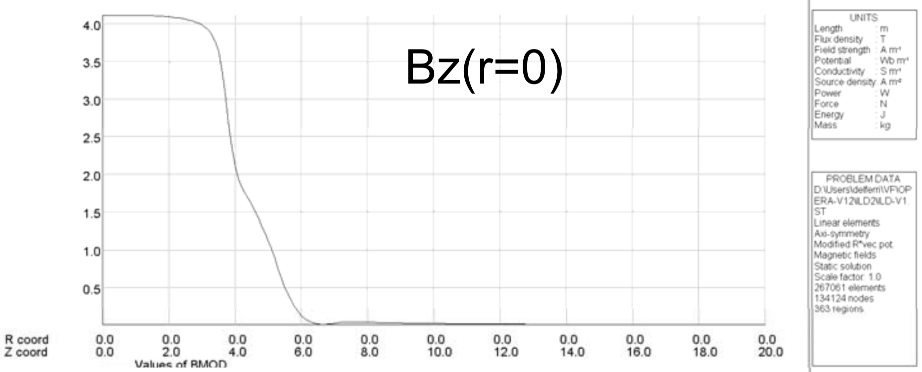
Iron : up to R=7m, up to Z=+/-7m (~3m thickness)

+ 100 mm FSP (Field Shaping Plate)

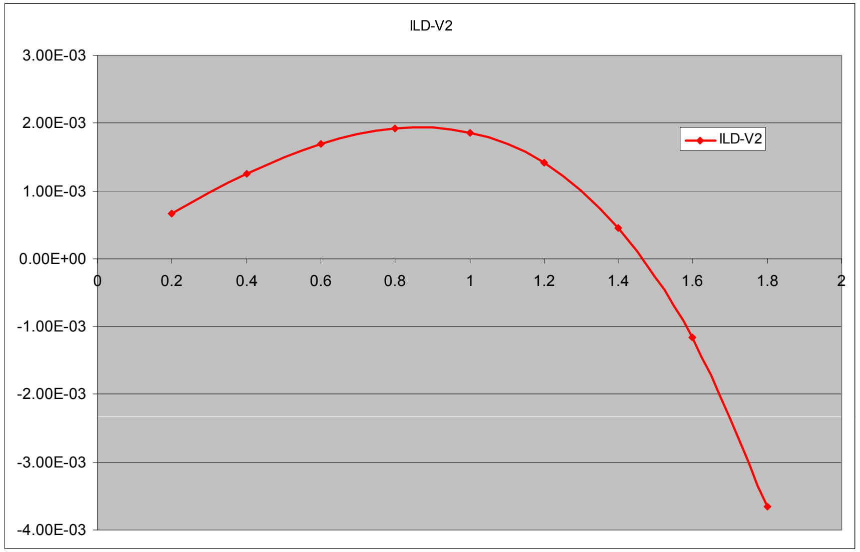
Coil : 4 layers ,7.35 m length subdivided in 5 parts

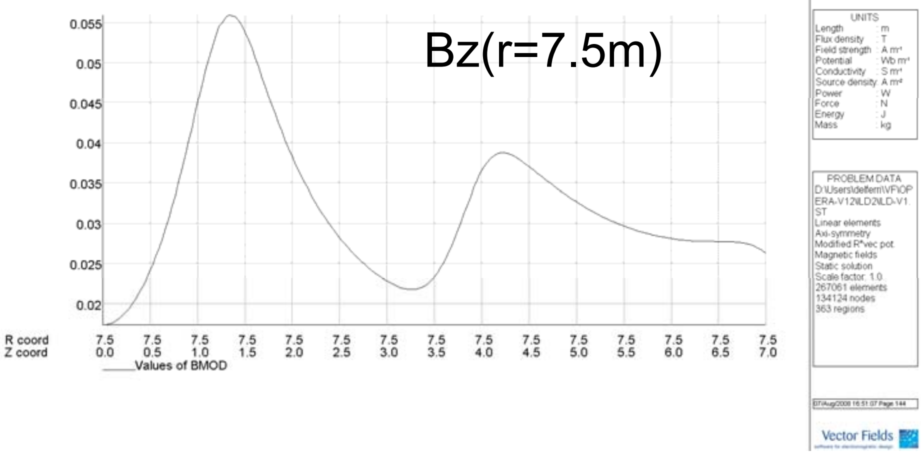






∫(Br/Bz) vs r (z=0 to 2.25 m)





Stray field for ILD-V1

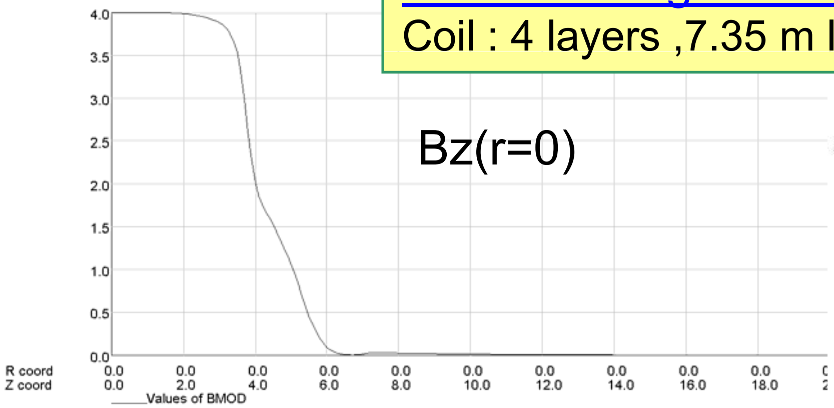
R (m)	Z (m)	B stay (G)
0	10	200
7.5	1.5	550 (max. value)
9	0	200

More iron is needed to reduce the stray field.

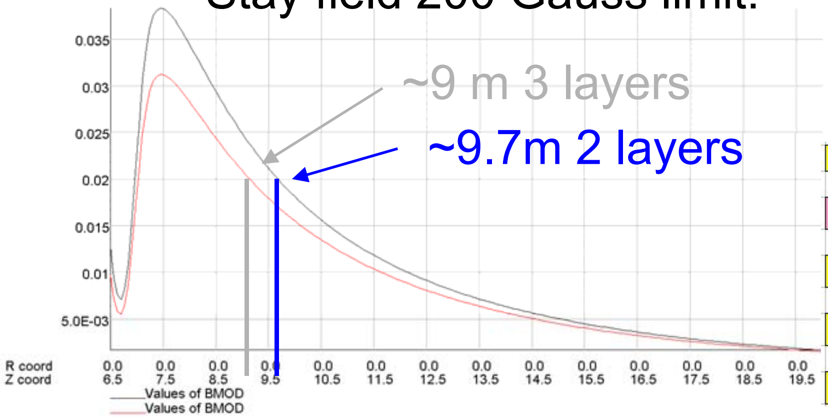
This is costly in term of money, space and yoke mechanical design.

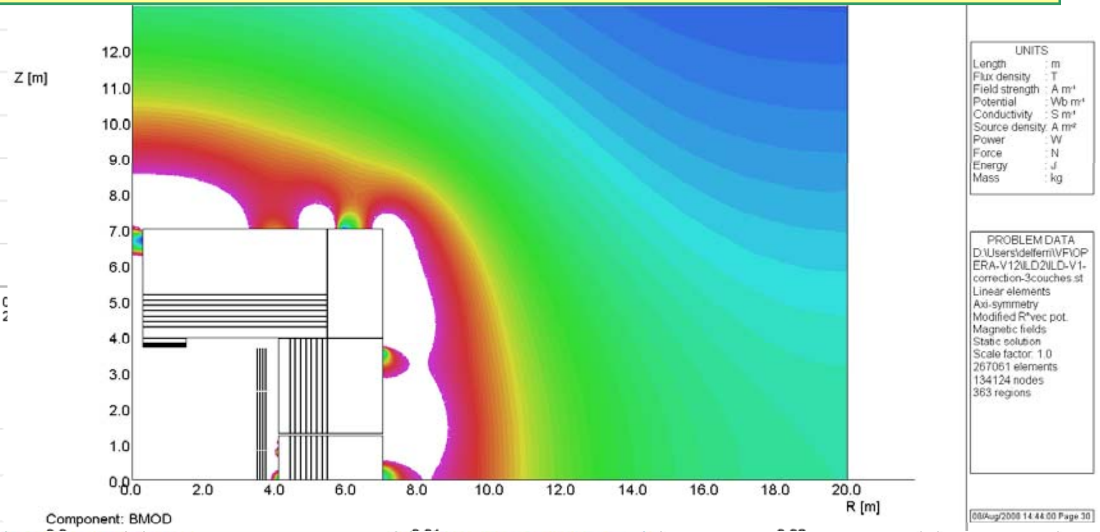
It must be confirmed that the value of 200 G for stray field is really a must.

ILD-V1 configuration Iron : up to R=7m, up to Z=+/-7m (~3m thickness)
Coil : 4 layers ,7.35 m length subdivided in 5 parts, 3 correction layers



Stay field 200 Gauss limit:





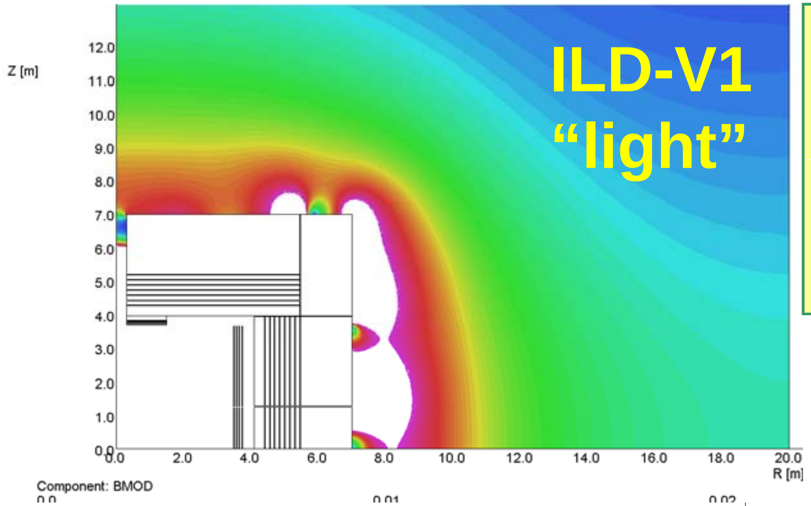
Current distribution :		3 layer corrections		
12714	12714	12714	12714	12714
24425	12714	12714	12714	24425
24425	12714	12714	12714	24425
24425	12714	12714	12714	24425

Vector Fields

	NI (MA)	J (A/mm²)	N (turns/layer)	I per turn (kA)	I correction (kA)	Length (m)
C1	1.27	38.5	100	12.7	0	1.65
C2	0.64	38.5	50	12.7	0	1.65
C3	0.93	38.5	73	12.7	0	1.21
C4	1.79	74.0	73	24.4	11.7	1.21

Summary

1.4 Non homogeneous field in the TPC volume

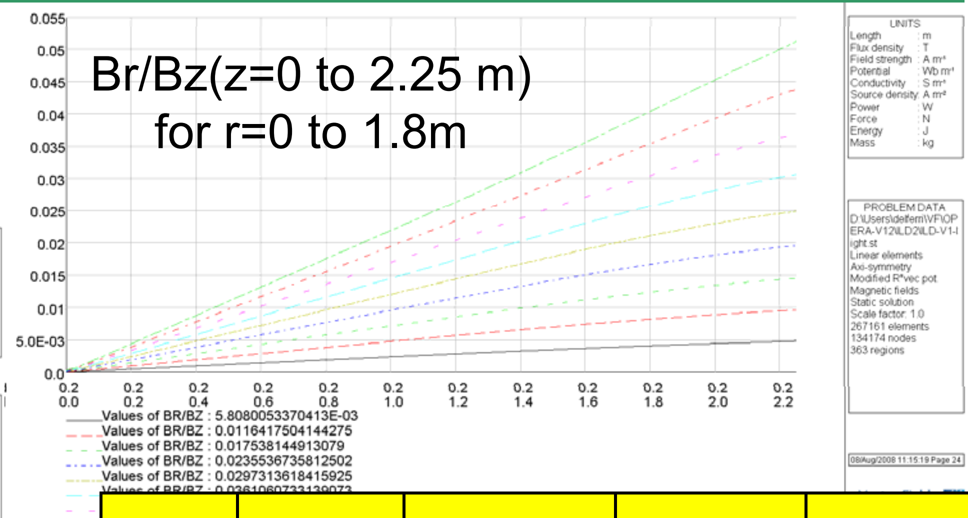


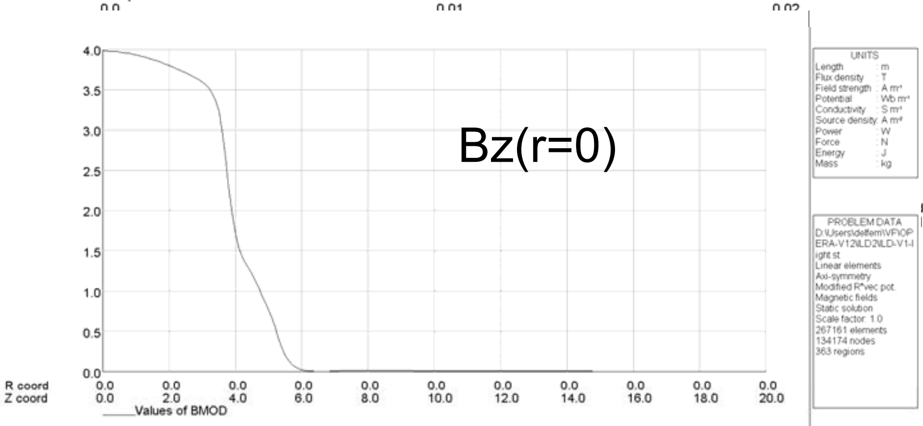
ILD-V1 light configuration

Iron : up to R=7m, up to Z=+/-7m (~3m thickness)

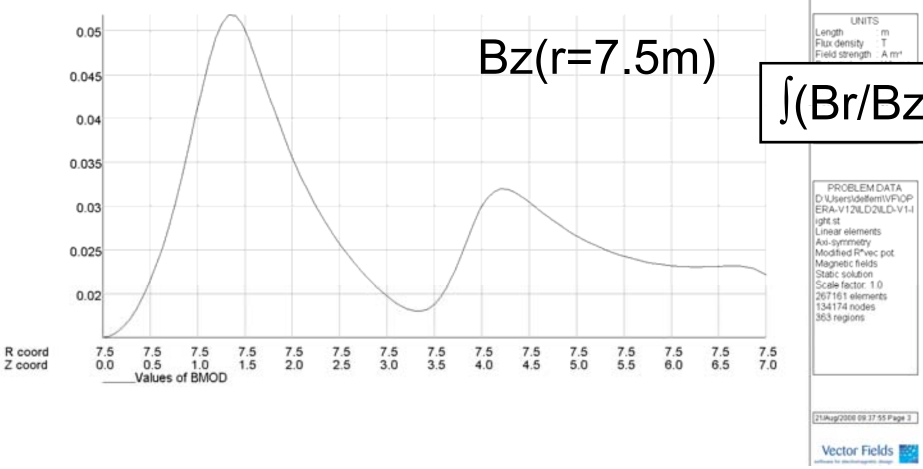
Coil : 4 layers ,7.35 m length subdivided in 3 parts

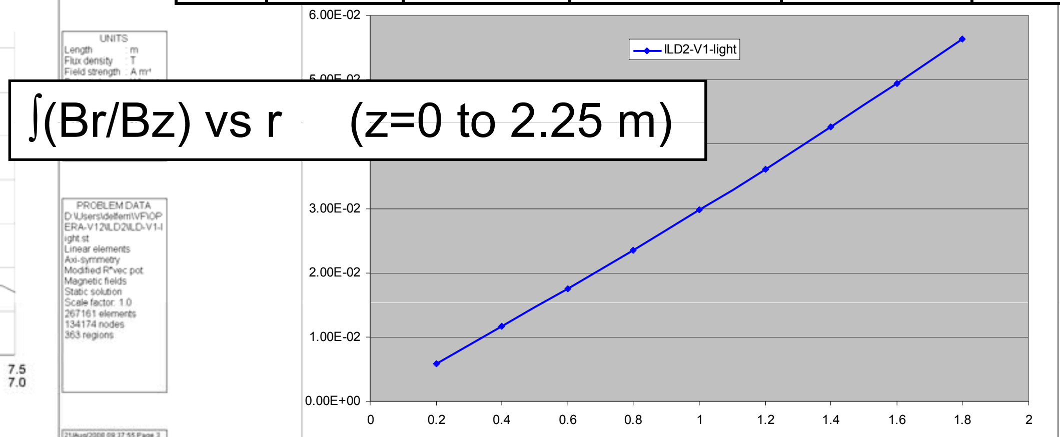
No correction windings





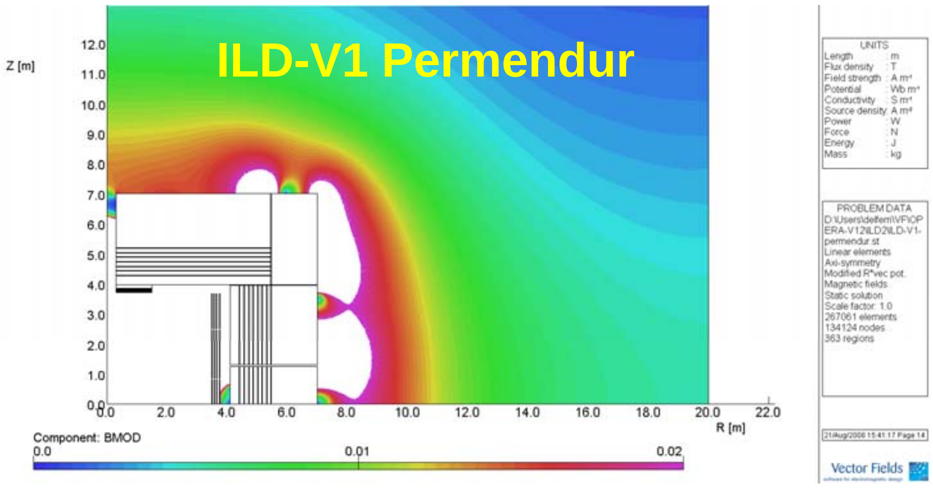
	NI (MA)	J (A/mm²)	N turns/layer	I nom. (kA)	Length (m)
Coil	2.14	43.0	100	21.4	2.42

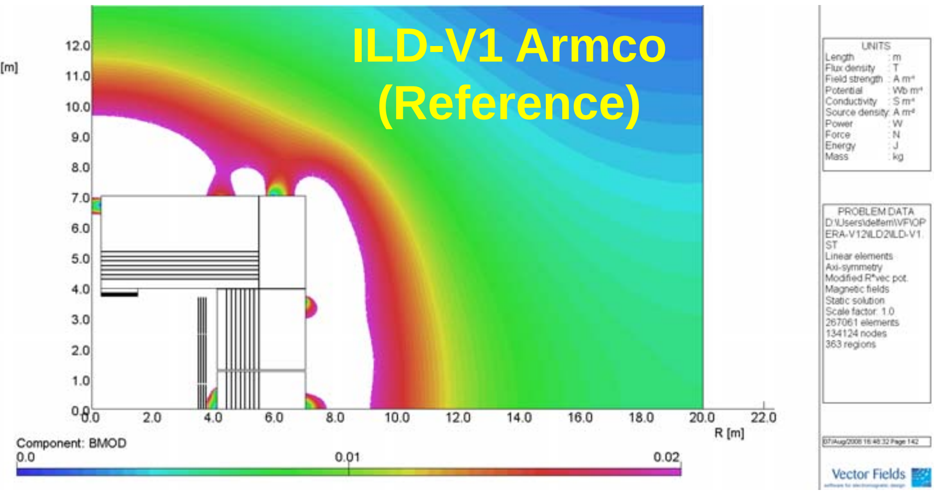


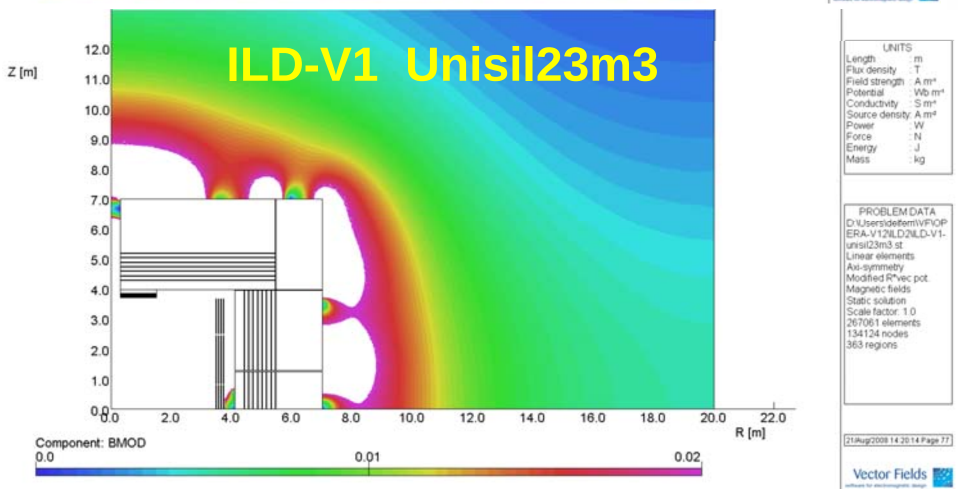


Summary

2. Some other relevant factors
   2.1 Magnetic material influence

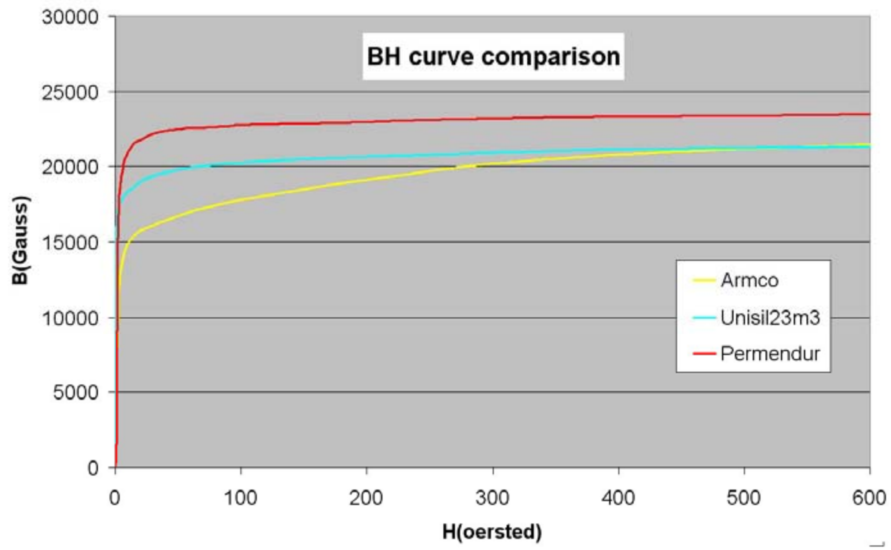


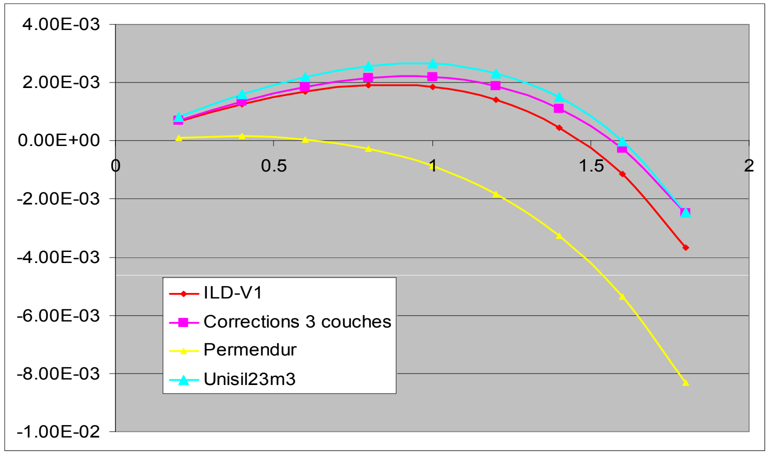




Material influence on stray Field and B_r/B_z integrals

(Currents are fixed – ILD-V1 2 correction layers distribution)





***Reference ~ CMS iron measured data**

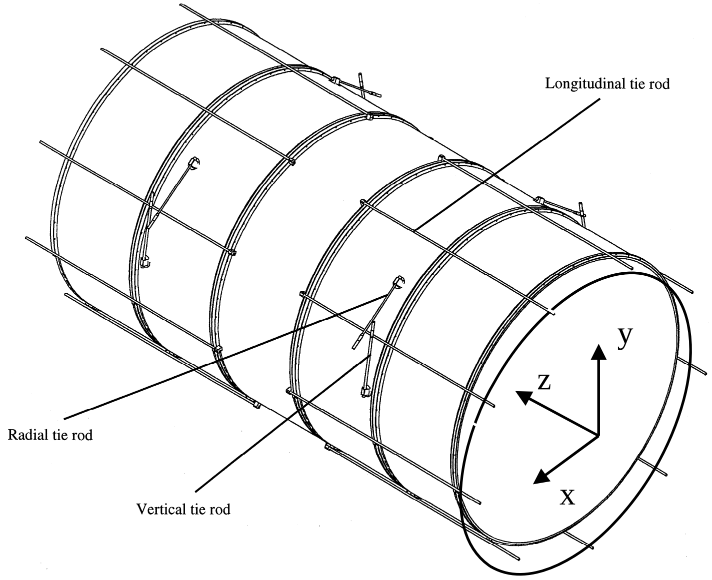
*** Magnetic materials with properties lower than reference to be looked at.**

Summary

2.2 Cold mass support

Present Conclusions

Cold mass support



The support of the cold mass inside the vacuum tank is designed to withstand:
. the weight of the cold
. the off-centering of the cold mass in the yoke
. some possible earthquake effect

CMS Solenoid Tie Rod Test System
CEA-Saclay 21 03 01 K 1770 004

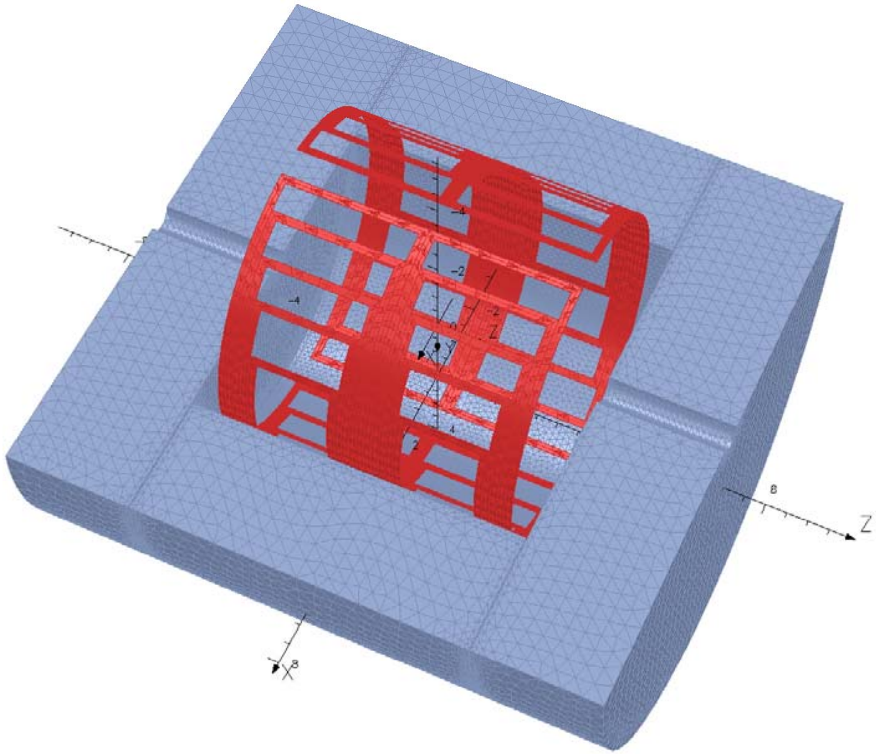
For push-pull operation with the magnet cold, the vibrations generated during this operation must be calculated and added to the previous effects. Careful choice of the material to be used and test of the final system in final conditions will give confidence.

Summary

2.3 Anti-DID coil

Anti-DID coil design

In case an anti-DID coil is needed, Brett Parker has started some conceptual design study



. Two dipole coils, anti-symetric with respect to the I.P.

. Proposal to wind the anti-DID coil outside the main solenoid coil (reduced field region)

. Field maps (3D) do not yet include the ILD solenoid

. $B_{anti\text{-}DID}$ ~ 0.65 T

Summary

Present Conclusions

Present conclusions (1)

- New magnetic calculations are going on with ‘ILD-like’ parameters, and in the continuity of previous calculations. Solutions which meet the specifications can be found

- Points to be mostly frozen to continue to make progress towards the ILD baseline: magnetic and geometrical parameters, in particular:
  - central field Bo
  - kind of field homogeneity for the TPC if any is requested (integral of Br /Bz over the TPC length, field homogeneity $\Delta B/B$ in the central part of the TPC, or no special specification)
  - allowable stray field in z and R directions

Present conclusions (2)

- If no field homogeneity is requested
  - ILD detector magnet will be very similar to the CMS one, with 3 modules of about 2.5 m long each, instead of 5
- If some field homogeneity is requested
  - Most of the CMS concepts can still be used, and different ways are technically available to reach the requested field homogeneity
- Conceptual design of the anti-DID has started and must continue
- Up to now, most of the calculations have been on the magnetic design. Calculations for mechanical design must now be completed, mainly for the coil support structure, including the push-pull operation, iron yoke and integration of the anti-DID in the main solenoid.