ILD detector magnet:

towards the LoI

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Summary

Introduction

1. Version ILD-V3 Saclay for the magnet configuration
   1.1 Parameter list
   1.2 Coil and yoke design
   1.3 Main outputs
   1.4 Comparison CMS-ILD

2. Some other points
   2.1 Modules with correction current
   2.2 Anti DiD coil design

Conclusions

Summary

Introduction

Introduction (1)

. Detector concept

ILD = unification of GLD and LDC projects

. 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-Vn (n=1,3 up to now) Saclay version (magnetic design)

. DESY team (Uwe Schneekloth) :

iron yoke design and B field calculations

(see pm presentation)

. Brett Parker (BNL) :

anti-DID design

Introduction (2)

As magnet parameters are roughly the same, the ILD magnet concept is based on CMS magnet with two extra requests:

. High integral field homogeneity in the TPC volume

. Lower fringing field (push-pull operation)

Summary

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Version ILD-V3 Saclay: parameter list

- Parameters used for ILD detector magnet

  $B_o$design = 4 T (3.5 T field for operation)

  R_{int} cryostat = 3.44 m

  R_{int} coil = 3.59 m

  R_{ext} coil = 3.94 m

  R_{ext} cryostat = 4.19 m

  L coil = 7.35 m

  $B_{ext} \leq$ 100 G @ z=10 m from I.P. and ≤ 50 G @ R=15 m in the radial direction

  Integral of field homogeneity within the TPC volume ≤ 10 mm

- This talk will report mainly on Saclay's results

Versions ILD-V3 Saclay : generalities

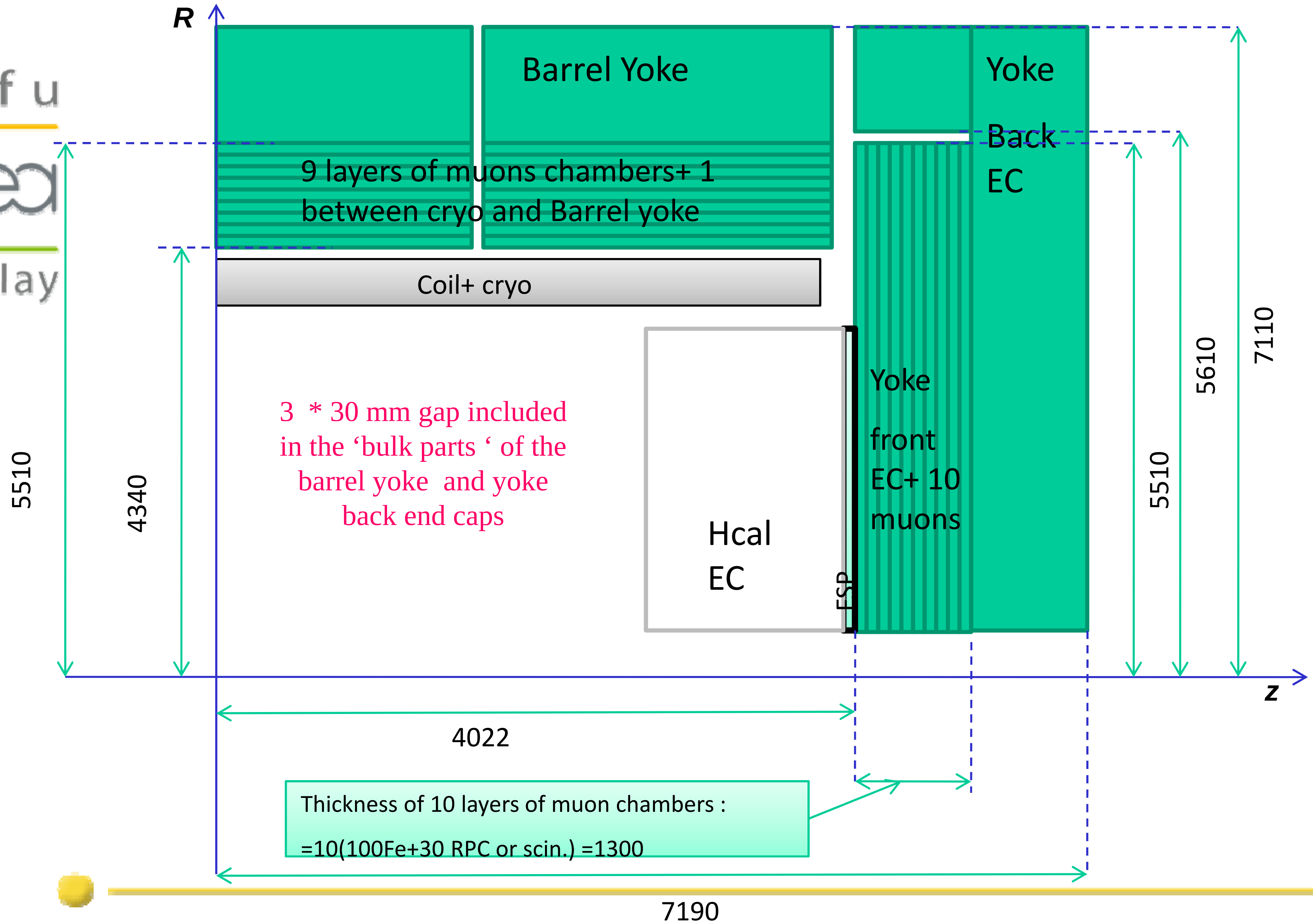
- Magnet = Coil + iron yoke (barrel + end-caps)

- Coil
  - 5 modules (2 different lengths)
  - 4 layers in each module
  - correction current in some parts of the coil to adjust the field homogeneity

- Yoke configuration:
  - as described by Catherine on January 8 2009
  - 30 mm gaps have been included in the ‘bulk part’ of the barrel and endcap yokes for engineering reasons
  - In some calculations, a packing factor has been introduced to simulate the filling of the gaps with iron

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

Versions ILD-V3 Saclay : yoke



Version ILD-V3 Saclay: field homogeneity

- Request

- homogeneous field in the volume of the TPC:

$$\Delta l\,(R) = \int_0^{z_{max}} (B_r\,(R) / B_z\,(R)\,dz \leq 10\text{ mm}$$

within the TPC volume:

$z_{max} = 2.25$ m

and R = 0 to $R_{max} = 1.8$ 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-V3 Saclay: main outputs

Electrical parameters (4 T)

Inom (kA)	18.1	
Eng. J (A/mm^2)	11.0	(for Inom)
ΔIcor (kA)	21.5	(3 layers * 2 modules)
Stored energy (GJ)	2.05	
Ws density (kJ/kg)	12.4	

Integral homogeneity in TPC volume (mm) ≤ 10

Yoke dimensions

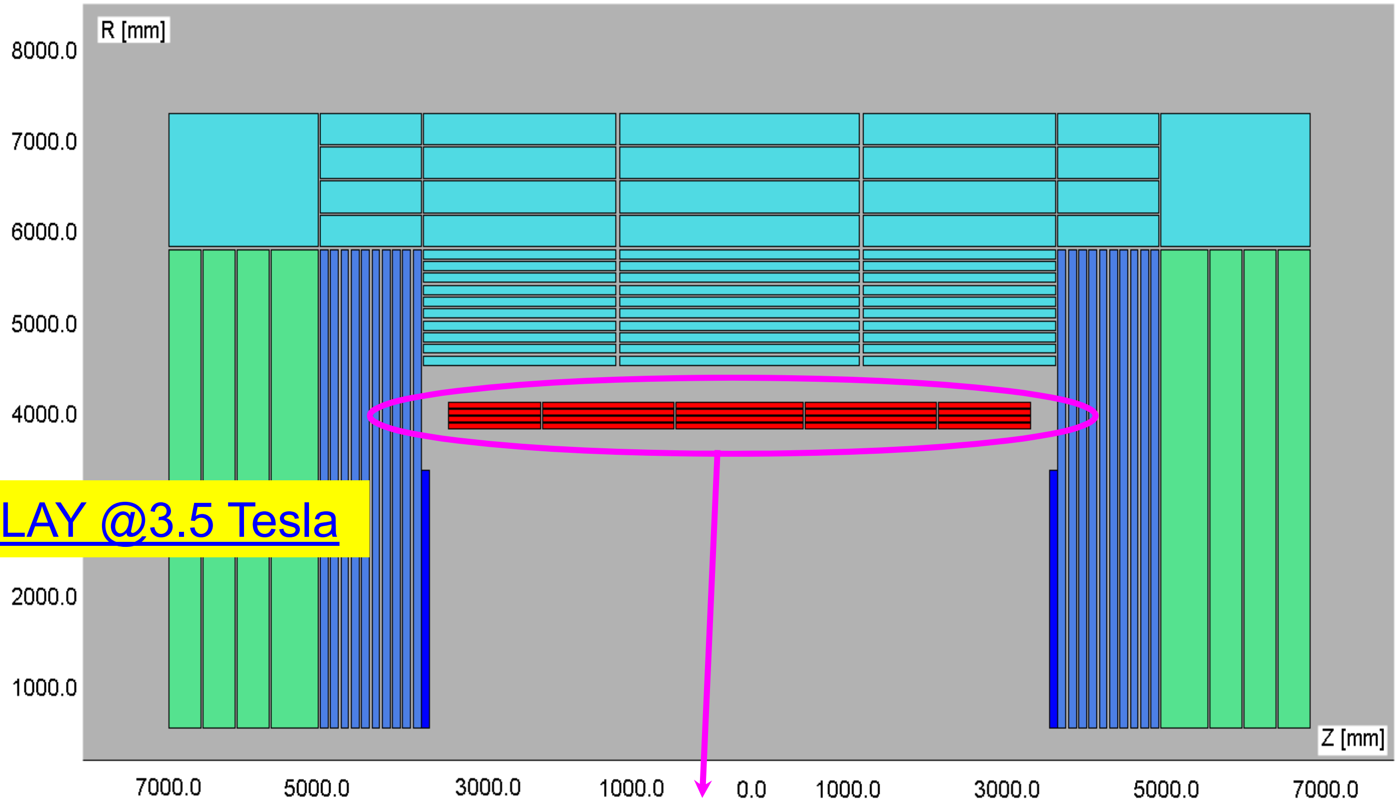
Rout barel yoke (mm)	7 110
Zout endcap yoke (mm)	7 190

Stray field (no gap filling)

Bext = 225 G @ Z = 10 m from I.P. and 4 T

Bext = 100 G @ R = 15 m from I.P. and 3.5 T

Version ILD-V3 Saclay: magnet configuration



ILD-V3 SACLAY @3.5 Tesla

Current distribution : (KA)		3 layer corrections		
15.90	15.90	15.90	15.90	15.90
34.00	15.90	15.90	15.90	34.00
34.00	15.90	15.90	15.90	34.00
34.00	15.90	15.90	15.90	34.00

Version ILD-V3 Saclay: coil configuration

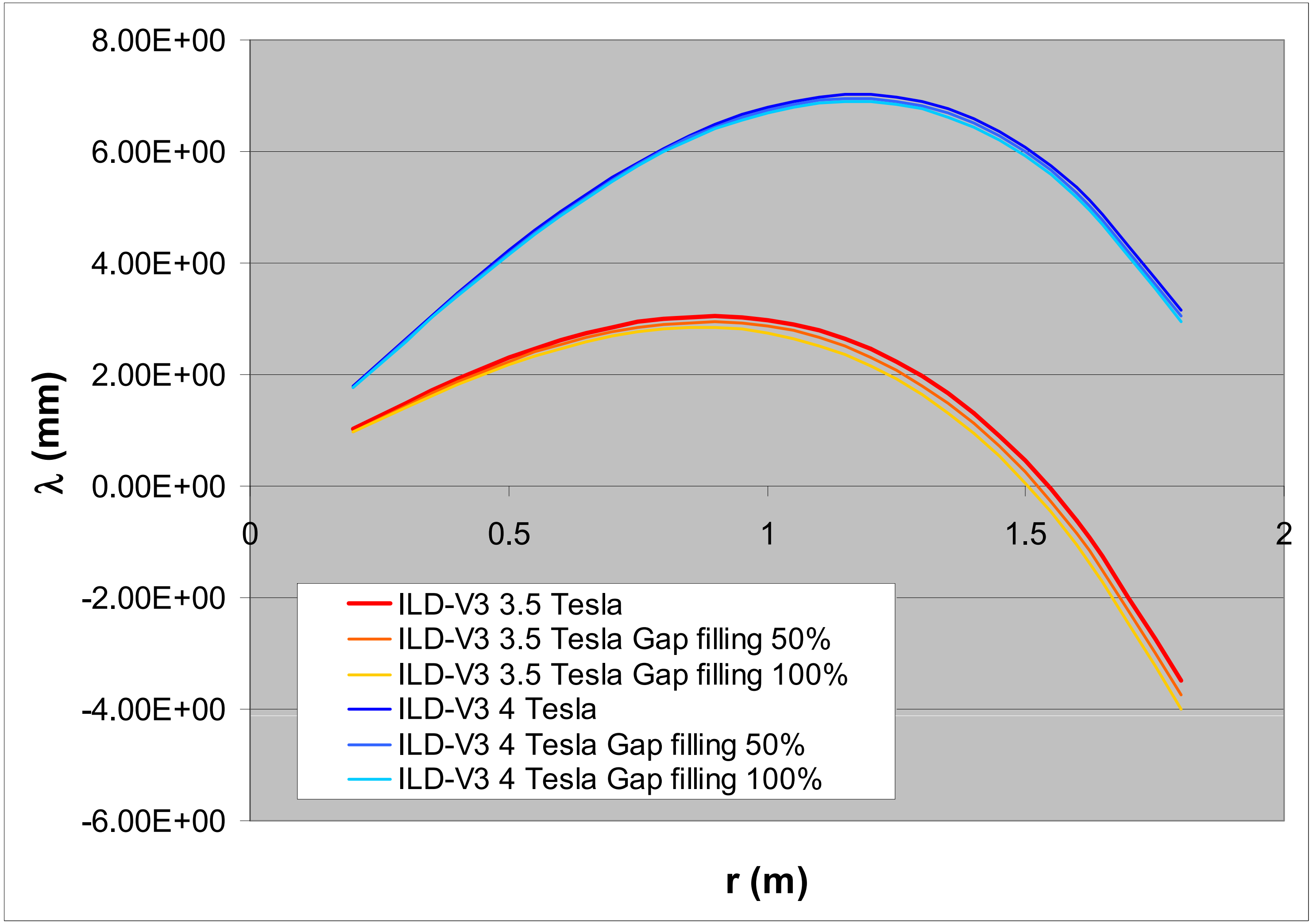
C2	C1	C1	C1	C2
C3	C1	C1	C1	C3
C3	C1	C1	C1	C3
C3	C1	C1	C1	C3

3.5 T	NI (MA)	J (A/mm²)	N (turns/layer)	I per turn (kA)	I correction (kA)	Length (m)
C1	1.11	9.65	70	15.9	0	1.65
C2	0.78	9.65	50	15.9	0	1.2
C3	1.7	21	50	34	18.1	1.2

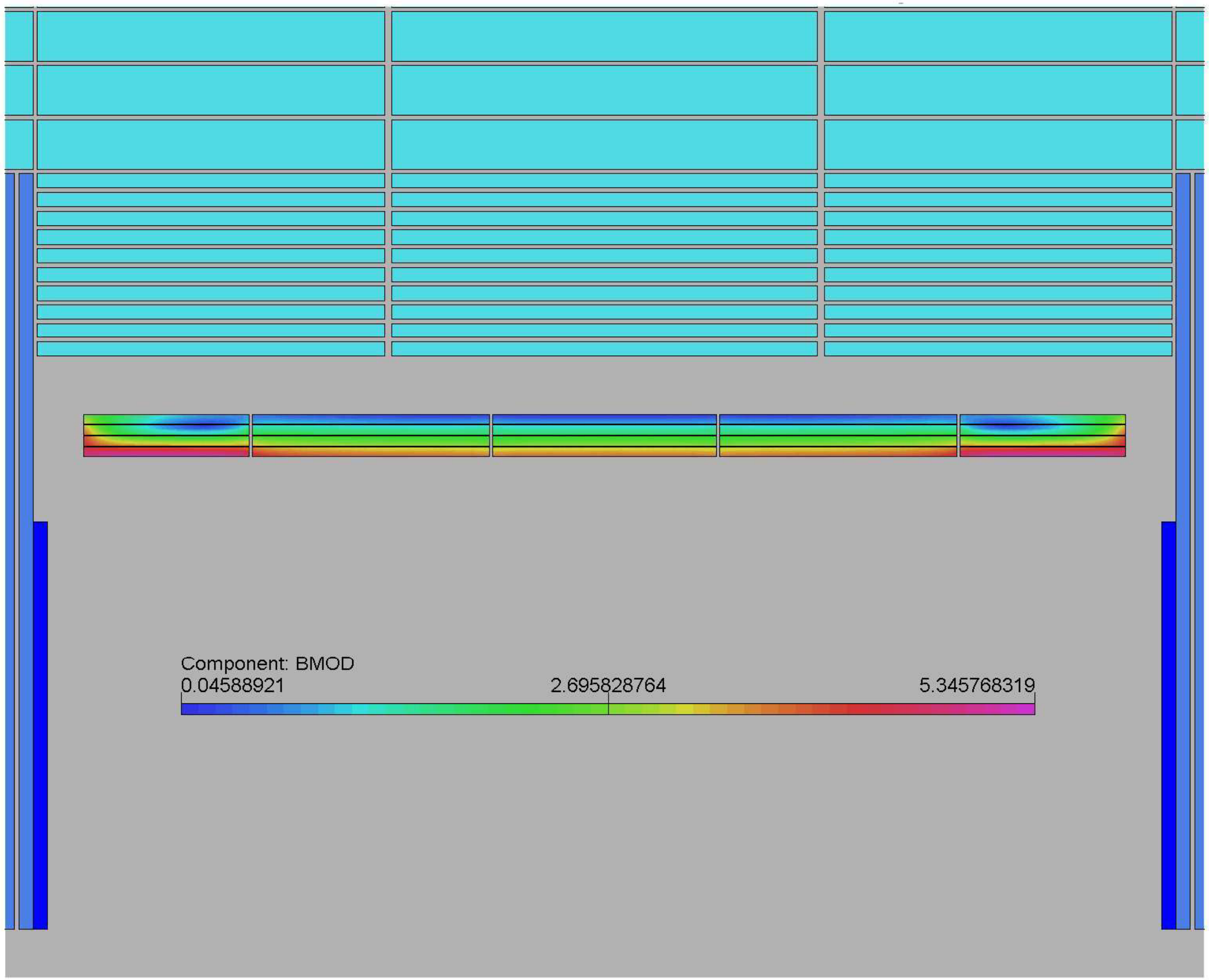
4. T	NI (MA)	J (A/mm²)	N (turns/layer)	I per turn (kA)	I correction (kA)	Length (m)
C1	1.27	11	70	18.1	0	1.65
C2	0.89	11	50	18.1	0	1.2
C3	1.94	24	50	39.6	21.5	1.2

Version ILD-V3 Saclay: field homogeneity

$\int(Br/Bz)dz$ *vs* r (z=0 to 2.25 m)

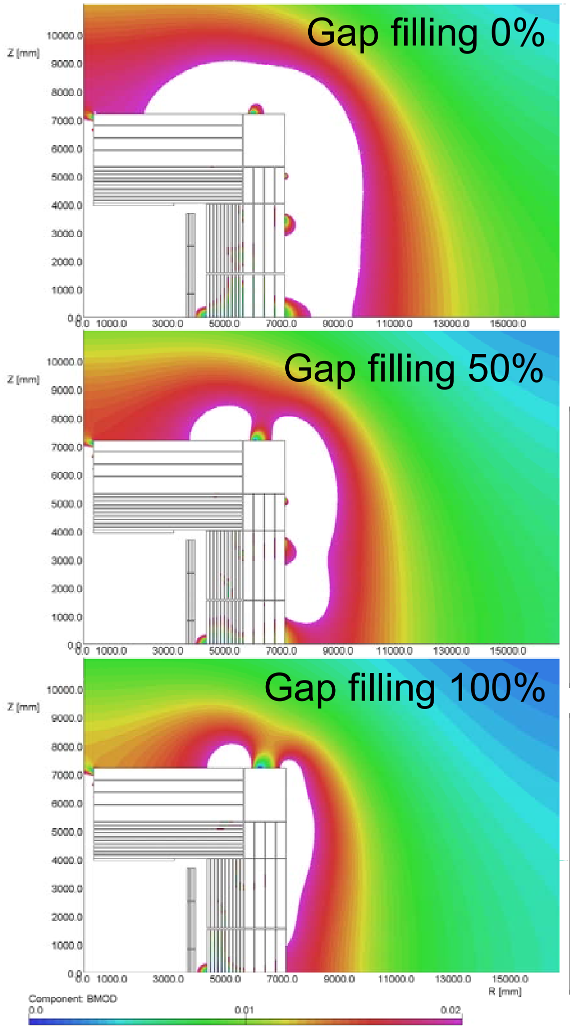


Version ILD-V3 Saclay: maximum field @4T



Version ILD-V3 Saclay: fringing field

ILD-V3 SACLAY @3.5 Tesla



Fringe Field
(200 Gauss limit)

Influence of radial gap filling %

Requirements

50 Gauss @15m @4T

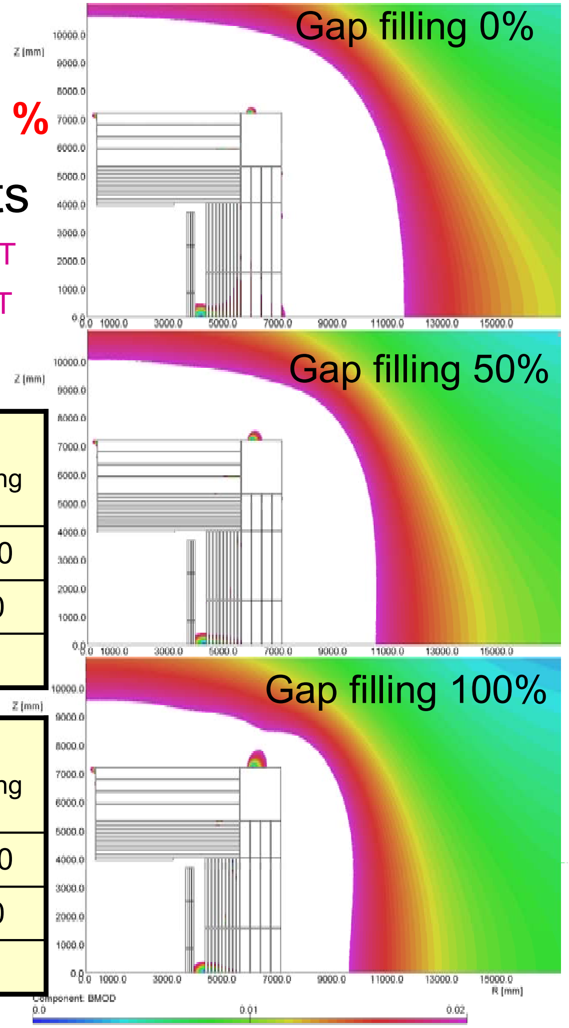
100 Gauss @10m @4T

Simulations

B@ 3.5T Z=10m B(Gauss)	**B@ 4T Z=10m** B(Gauss)	Filling %
100	180	100
120	200	50
150	225	0

B@ 3.5T R=15m B(Gauss)	**B@ 4T R=15m** B(Gauss)	Filling %
55	90	100
75	110	50
100	130	0

ILD-V3 SACLAY @4Tesla



Version ILD-V3 Saclay: comparison with CMS

Parameter	CMS	ILD-V3 Saclay
Useful aperture (m)	6	6.9
Length (m)	12.5	7.35
Design field (T)	4	4
Max. field (T)	4.6	5.35
Nominal current (kA)	19.1	18.1
Extra correction current (kA)	0	21.5
Coil configuration	5 modules * 4 layers, same length	5 modules * 4 layers, 2 ≠ lengths
Stored energy (GJ)	2.6	2.05
Density of stored energy (kJ/kg)	11.6	12.4

Summary

2. Some other points
   2.1 Modules with correction current
   2.2 Anti DiD coil design

Modules with correction current

This is one of the main novelty from CMS.

Basic concepts:

- the conductor with the extra correction current has:

  . the same overall dimension as the conductor with the main current, typically 80*22 mm^2 without insulation (a little bit longer than the CMS conductor)

  . but a higher current transport capacity to work with about the same safety margin with respect to the critical current (40 strands * Ø 1.7 mm vs 32 strands * Ø 1.3 mm)

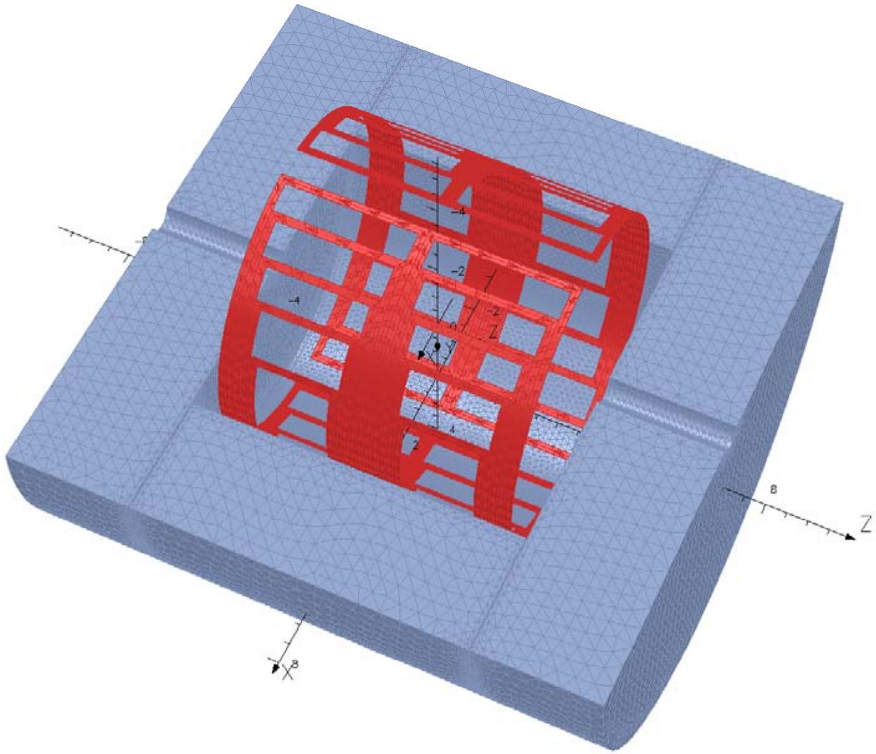
- a stronger mechanical support: at least for the conductor with the extra correction current, the ratio of structural material is close to 1 (cf conductor for the ATLAS Central Solenoid developed by Akira Yamamoto et al.), vs 0.6 for CMS

- in case of quench, the extra local Joule heating is absorbed by the quench-back phenomenon, much quicker than the increase of temperature of the coil, and which diffuses the uniformly the heat

Anti-DID coil design

The anti-DiD allows to zero the crossing angle for the outgoing beam (and pairs) behind the I.P.

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

. $B_{anti\text{-}DID} \sim 0.065$ T

Summary

Conclusions

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- Magnetic calculations have been done with the LoI parameters. Solutions which meet the specifications have been found

- Most of the CMS concepts can still be used. Some R&D on a conductor with a ratio of structural material close to 1 would strenghten the mechanical design of the most solicited modules

- Conceptual design of the anti-DID has started, and must continue with the present detector magnet configuration

- Even if some points can still evolved and/or need some more studies , the present design seems at an acceptable level of study for the LoI