ILD Cost Issues

1. LDC cost status in 2006
2. towards ILD. Scaling laws

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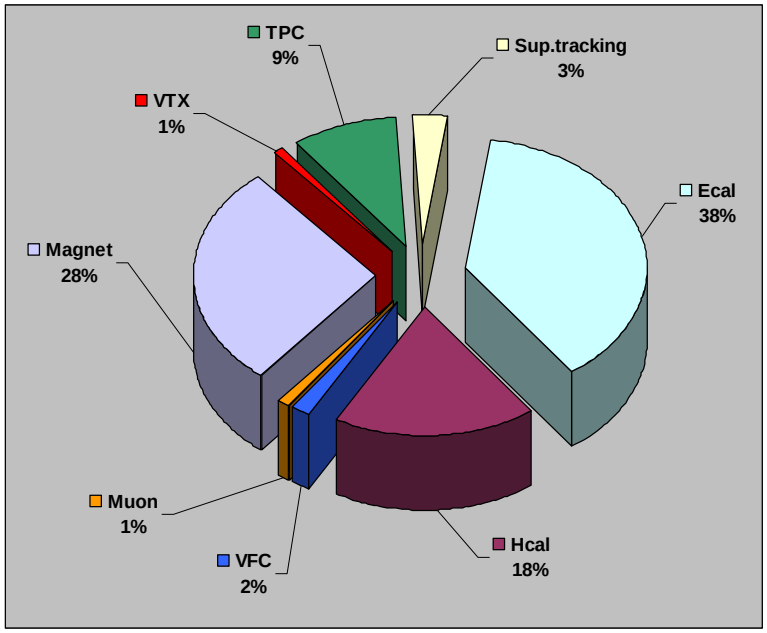
LDC-V4 Cost estimation (nov 2006)

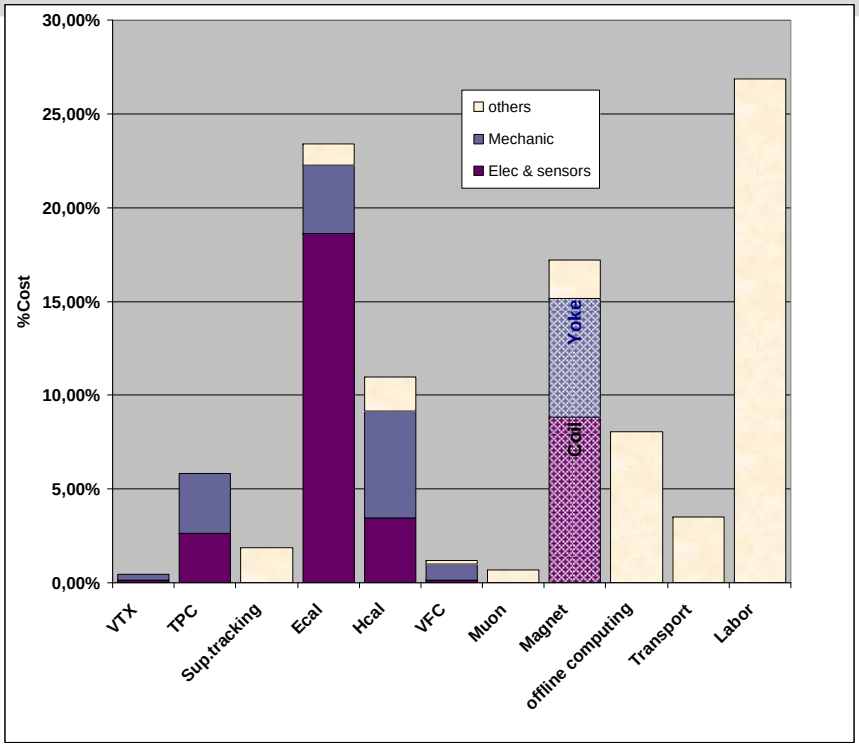
M&S

VTX	**1 700 000,00 €**
TPC	**21 661 500,00 €**
Supp.tracking	**6 900 000,00 €**
Ecal	**87 035 070,00 €**
AnalogHcal	**40 849 900,00 €**
VFC	**4 440 200,00 €**
Muon	**2 500 000,00 €**
Magnet	**64 000 000,00 €**
total	**229 086 670,00 €**

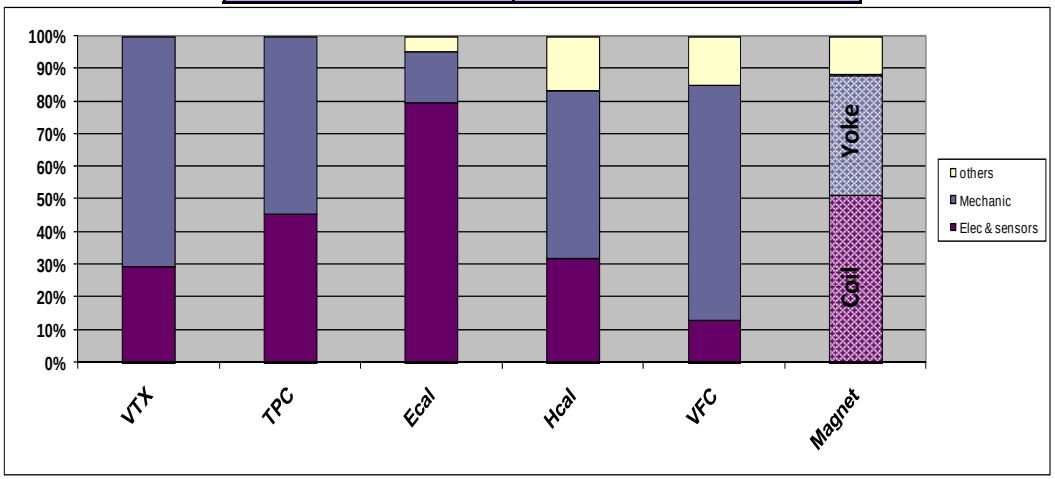


Not included in graph

offline computing	30 000 000,00 €
Transport (≈ 5% total amount)	13 000 000,00 €
Labor (1300 ManYear)	100 000 000,00 €



	Cost (€)	Cost (%)
VTX	1 700 000,00 €	0,5%
TPC	21 661 500,00 €	5,8%
Sup.tracking	6 900 000,00 €	1,9%
Ecal	87 035 070,00 €	23,4%
Hcal	40 849 900,00 €	11,0%
VFC	4 440 200,00 €	1,2%
Muon	2 500 000,00 €	0,7%
Magnet	64 000 000,00 €	17,2%
offline computing	30 000 000,00 €	8,1%
Transport	13 000 000,00 €	3,5%
Labor	100 000 000,00 €	26,9%
	372 086 670,00 €	

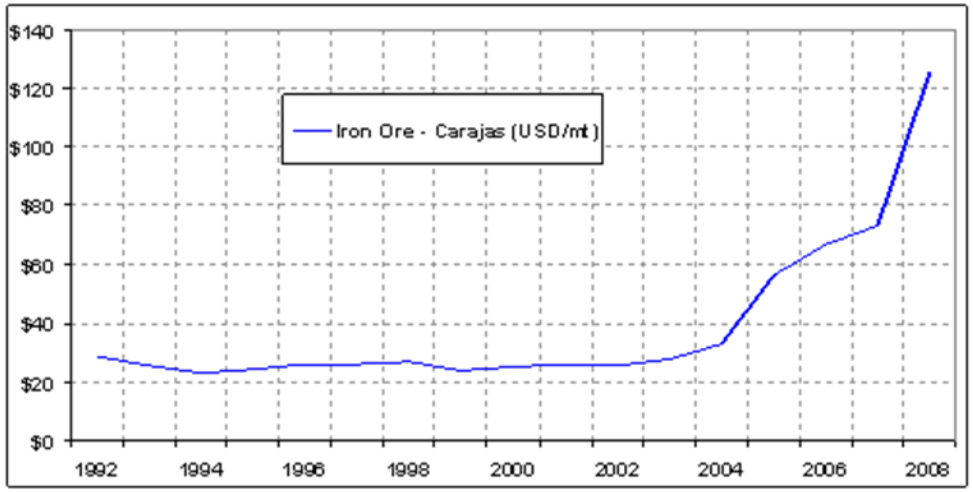


Main costs (2006)

- **Raw Material** : 10% for Ecal and Hcal absorbers
  - Tungsten :100€/kg (from industrial quotations for 40t)
  - Stainless Steel : AHCal 15€/kg (from ATLAS)
- **Sensors/ detector** : 30%
  - Si supp tracking : Single side 3€/cm²
  - Silicon sensors Ecal : 2,5€/cm²
  - SiPM : 2,5€ (estimation from producer)
- **Magnet : 25%**
  - Based on industrial offers for CMS , scaled to LDC

Coil : SS304 12€/kg
Yoke: SS 3,6€/kg

But



Today's price:

- Si sensors (from producer 30 pieces) : 8€/cm²
- SIPM (for T2K ≈ 10 000 pieces , simplier techno) : 10 € each

Unit costs should be updated for LOI

Baseline parameters used in the following

➢LDC-V5 :

- R tracker= 1.6 m,
- Hcal 40 layers,
- Yoke : Rout = 6m; Zout= 6.3m

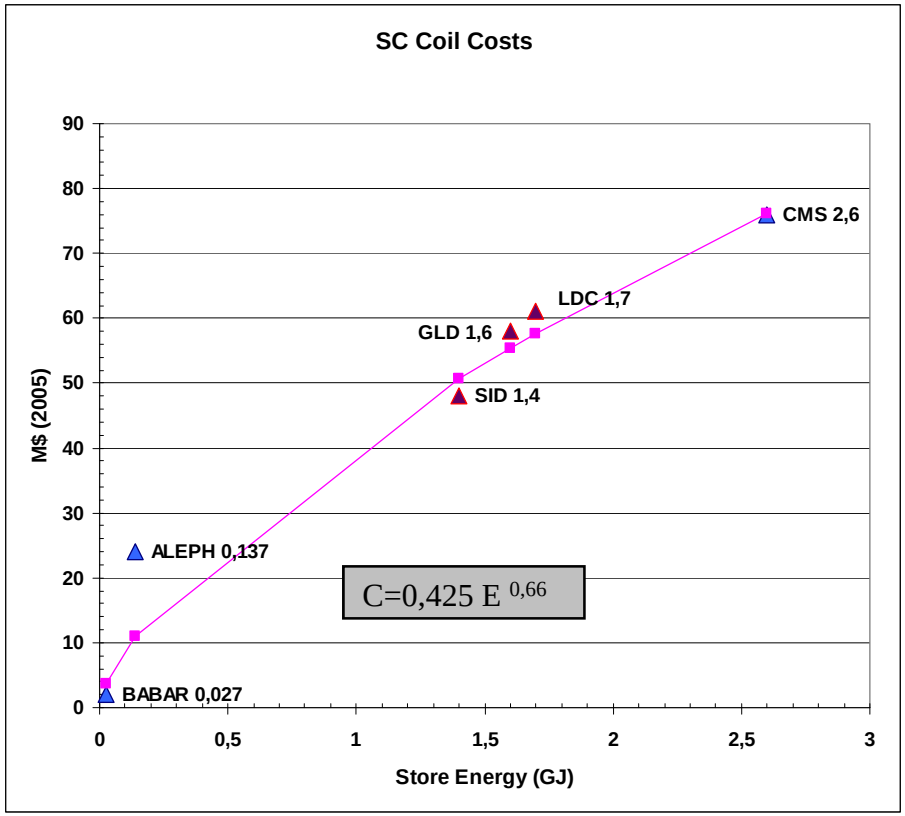
➢ Cost : M&S, without Manpower

VTX	1 700 000,00 €	0,62%
TPC	21 661 500,00 €	7,96%
Sup.tracking	6 900 000,00 €	2,54%
Ecal	87 035 070,00 €	31,99%
Hcal	40 849 900,00 €	15,01%
VFC	4 440 200,00 €	1,63%
Muon	2 500 000,00 €	0,92%
Magnet coil	32 800 000,00 €	12,05%
yoke	23 600 000,00 €	8,67%
magnet ancillaries	7 600 001,00 €	2,79%
offline computing	30 000 000,00 €	11,03%
Transport	13 000 000,00 €	4,78%
total	272 086 671,00 €	

Will be considered :

- Ecal : 32 %
- Hcal: 15 %
- TPC : 8 %
- Coil : 12 %
- Yoke : 9 %

- Others : 24 %



The main parameters involved in the cost of the magnet are the surface of the cryostat, S, and the stored energy, E, in the magnet. The formulas used for the calculations are the following:

- $S = 2\,\pi\,(1.1 \times R)\,L$ (1) Surface of the cryostat
- $V = \pi\,R^2\,L$ (2) Mean magnetized volume
- $E = V\,B^2 / 2\,\mu 0$ (3) Stored energy

Where:

- R is the mean radius of the solenoid
- L is the length of the solenoid
- B is the central induction in the solenoid
- $\mu 0 = 1.257\ 10\text{-}6$ H/m

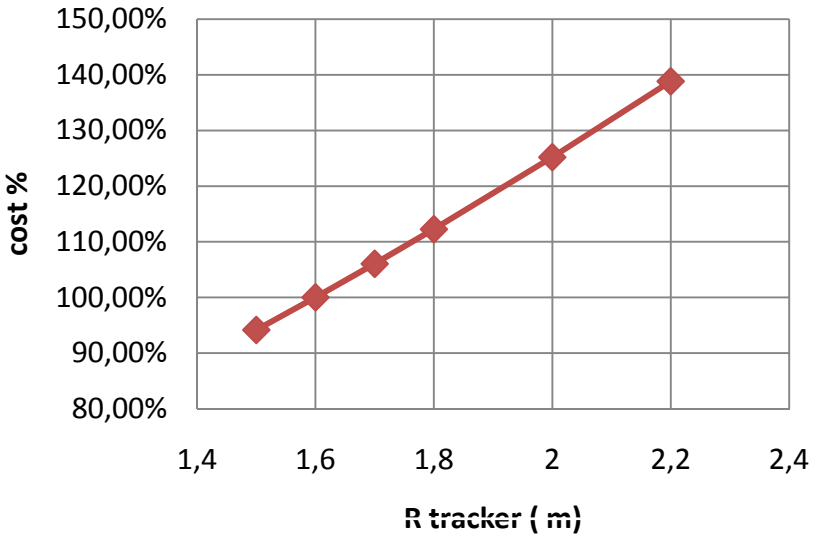
(MUC/NOTE/COOL-EXP//216, V.Balbekov & al)

From the curve: $C=0{,}425\ E^{0{,}66}$ and with $tg(\alpha)=R/L$

$$C \propto Cst \times B^{1.32} R^{1.98} \quad with Cst = 0.425 \times \left(\pi / 2\mu 0 * tg(\alpha) \right)^{0.66}$$

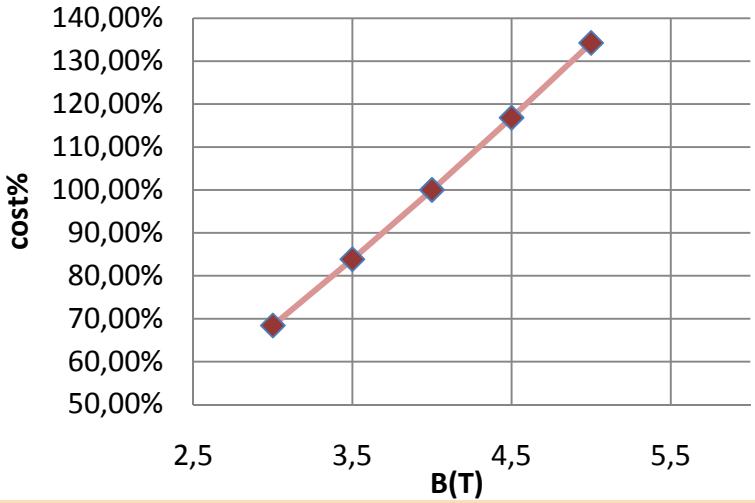
$$C \propto Cst \times B^{1.32} R^{1.98}$$

Coil cost vs R Tracker

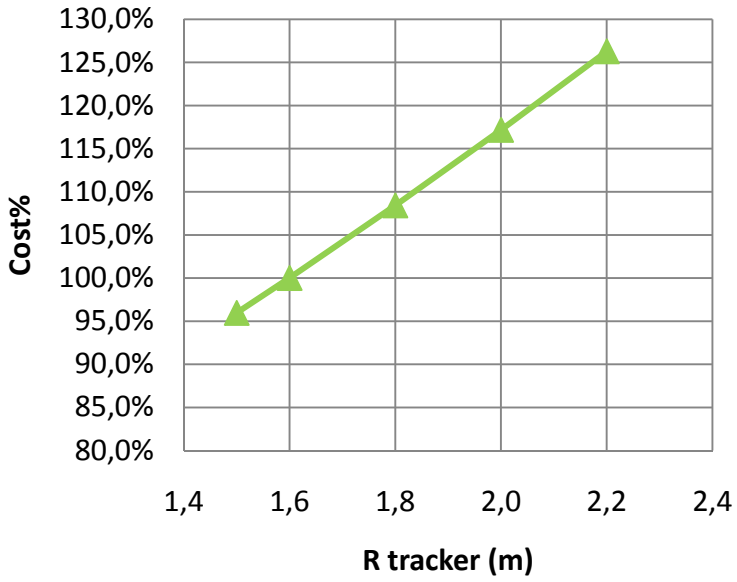


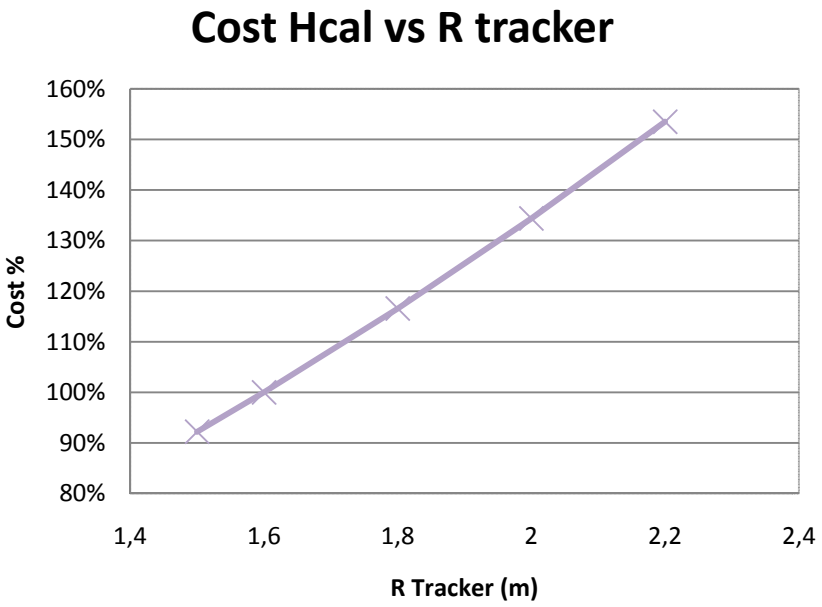
Coil cost is half of the total magnet price
Yoke is 37% of total magnet price

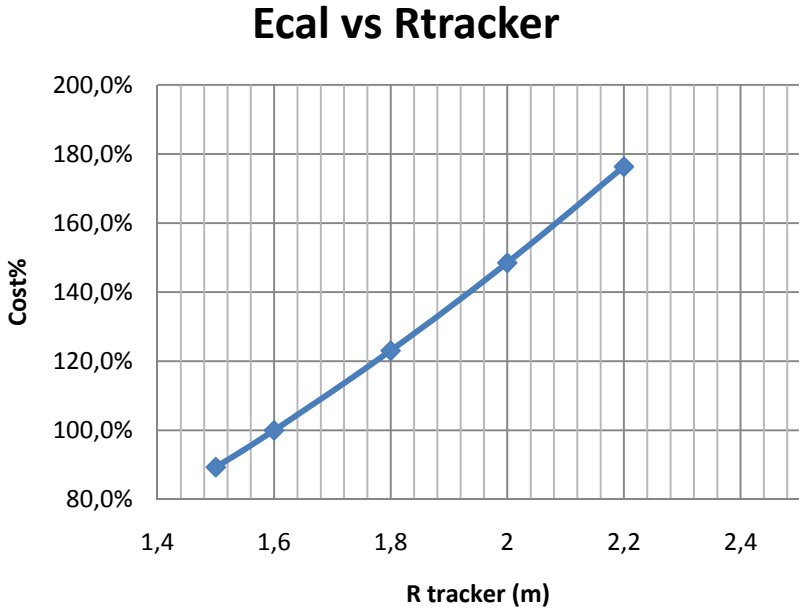
Coil cost vs B(T)

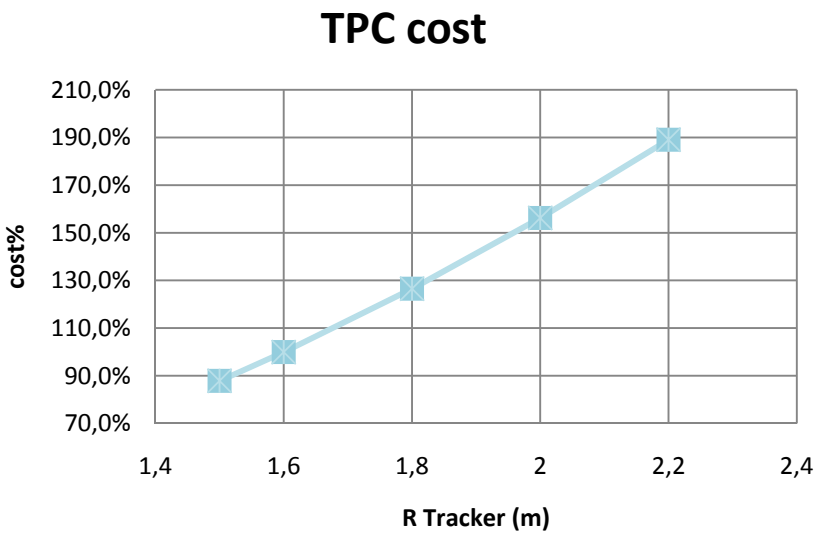


Yoke cost vs RTracker









➢Ecal and Hcal are varying the same way

$$V = 2\pi \int_{Rin}^{Rout} \int_{Zin}^{Zout} R.dR.dz$$

(changing the thickness affects only R in barrel, but R and z in endcaps).

➢TPC, considered as first approach, to vary according to the surface of endcaps

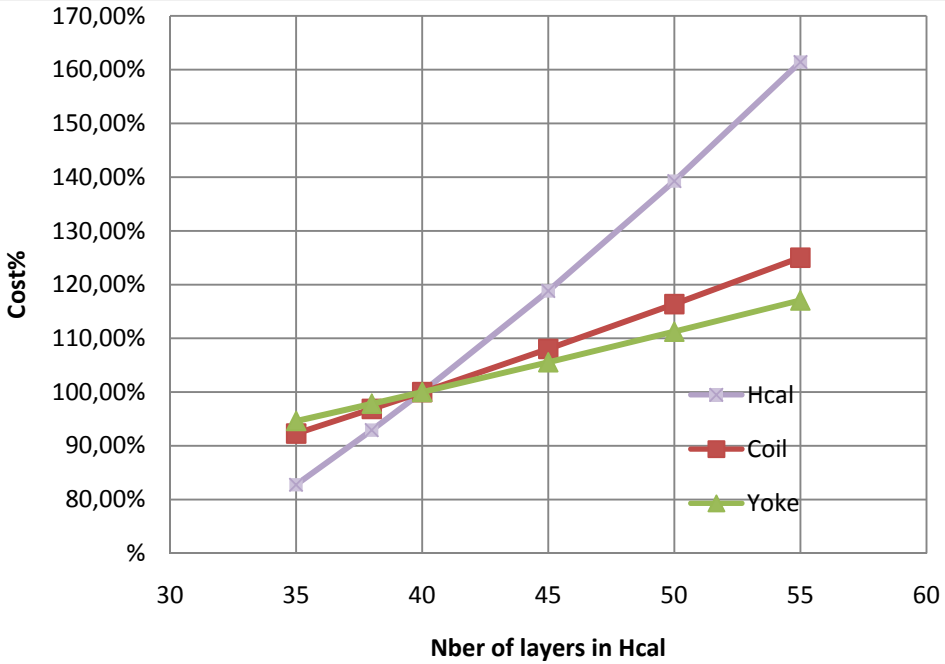
Incidence of the number of layers in Hcal

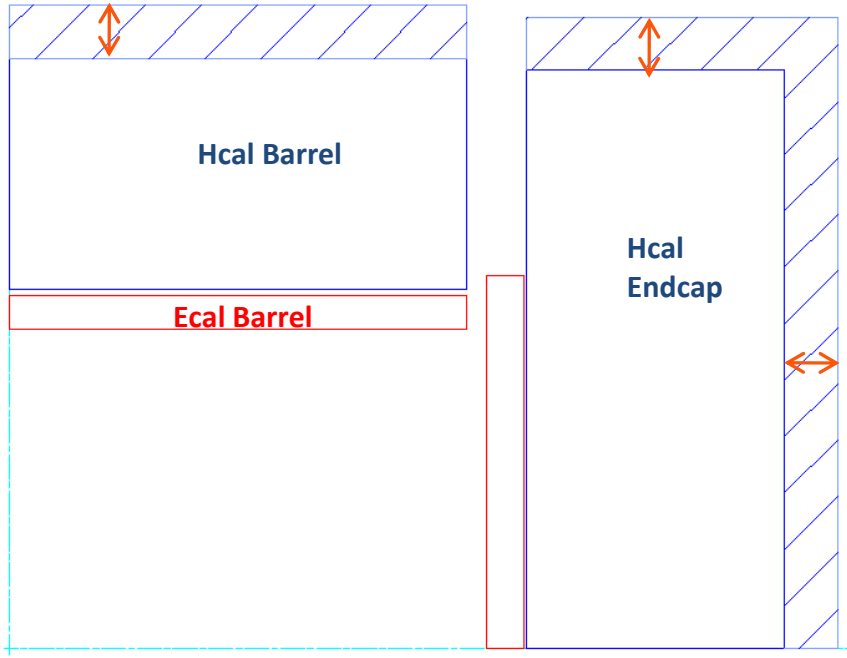
From 40 to 48 layers (Rtracker=1.8 m):

=8x(20 (abs) + 6.5(sensor)) mm

+12% on Coil
+ 11 % on yoke
+ 30 % on Hcal

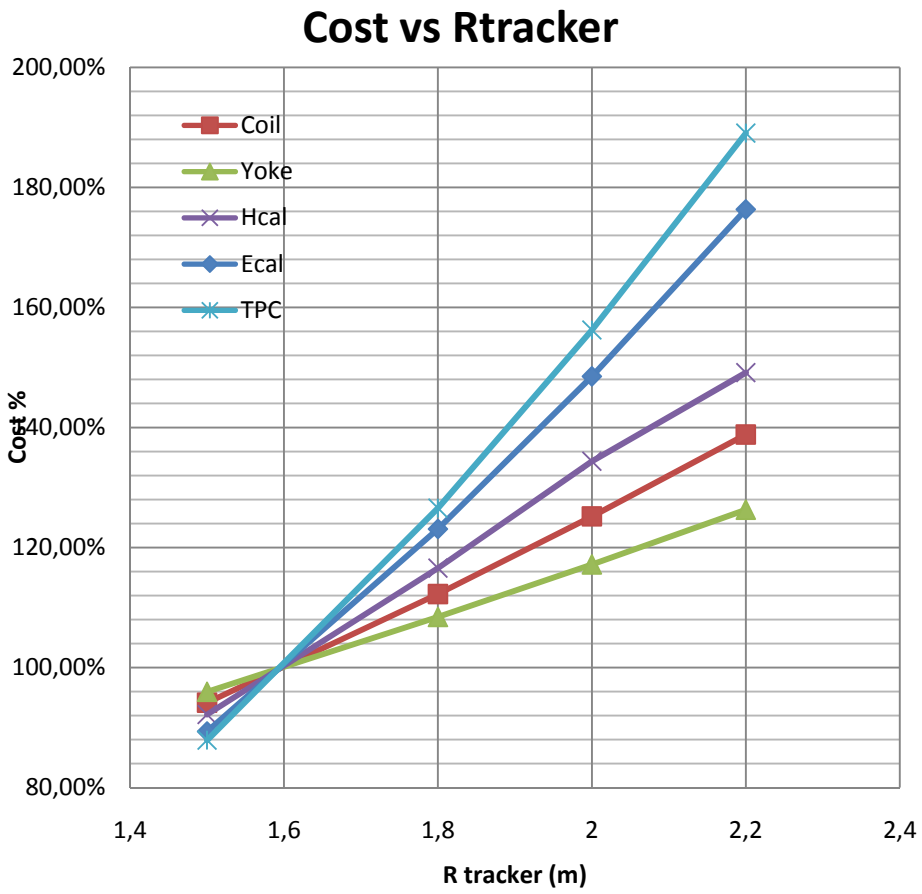
} 7% on detector (ILD size)

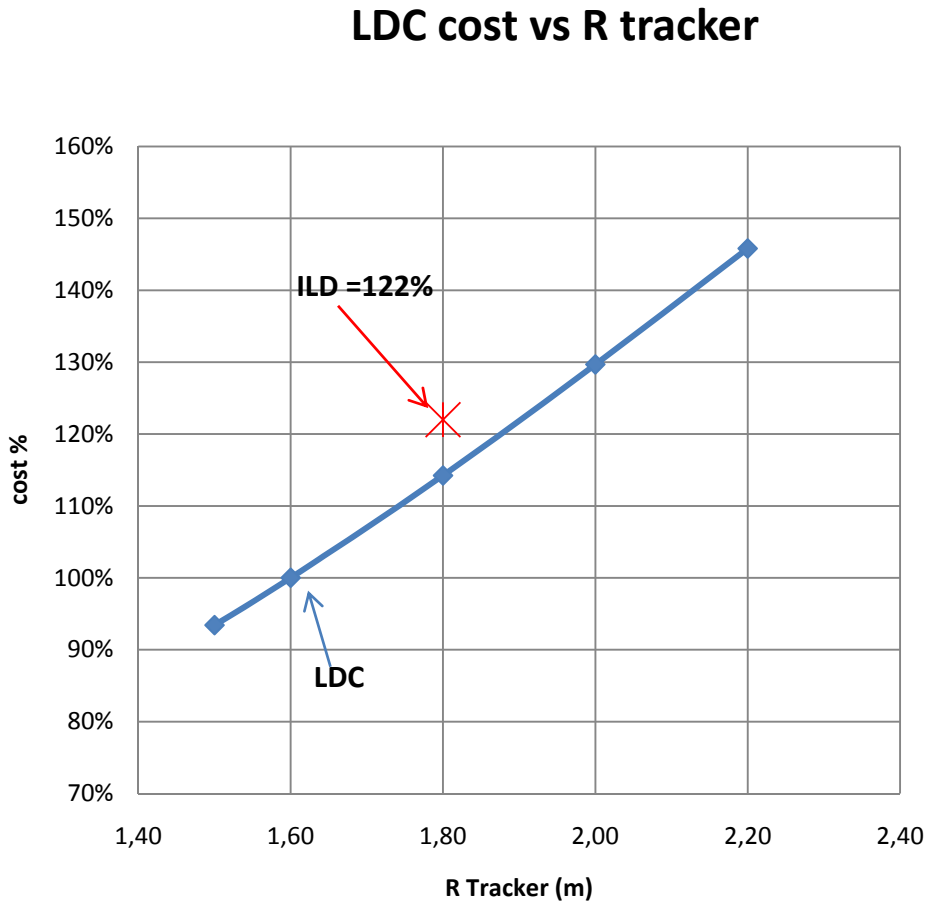




$$V = 2\pi \int_{Rin}^{Rout} \int_{Zin}^{Zout} R.dR.dz$$

Changing the number of layers affects only R in barrel, but both R and z in endcaps).





- LDC: Hcal 40 layers , R TPC= 1.6 m, B=4T
- ILD : Hcal 48 layers , R TPC= 1.8 m, B= 4T

Influence of Stray field
(from O.Delferrière simulations)

LDC-V5e : Rout TPC 1,58m, 1/2 coil= 3,5m, B= 4 T

Rin coil = 3,23 m; Rout coil = 3,5 m

Rout(m)	Zout(m)	Stray field(G) at z=10m	Stray field (G) at Rout=50 Cm	Yoke cost increase (%)	detector cost increase (%)
7	7	90	420	147,7%	**104,3%**
5,9	7	270	1000	116,1%	101,4%
7	6,3	270	420	131,7%	102,9%
5,9	6,3	400	1000	100,0%	100,0%

Conclusions :

- ✓ Update of cost values for LOI

- ✓ LDC to ILD = + 22% on total cost including 7% from Hcal thickness.
- ✓ Stray field : important on point of view of Yoke thickness, but less on cost (4%)