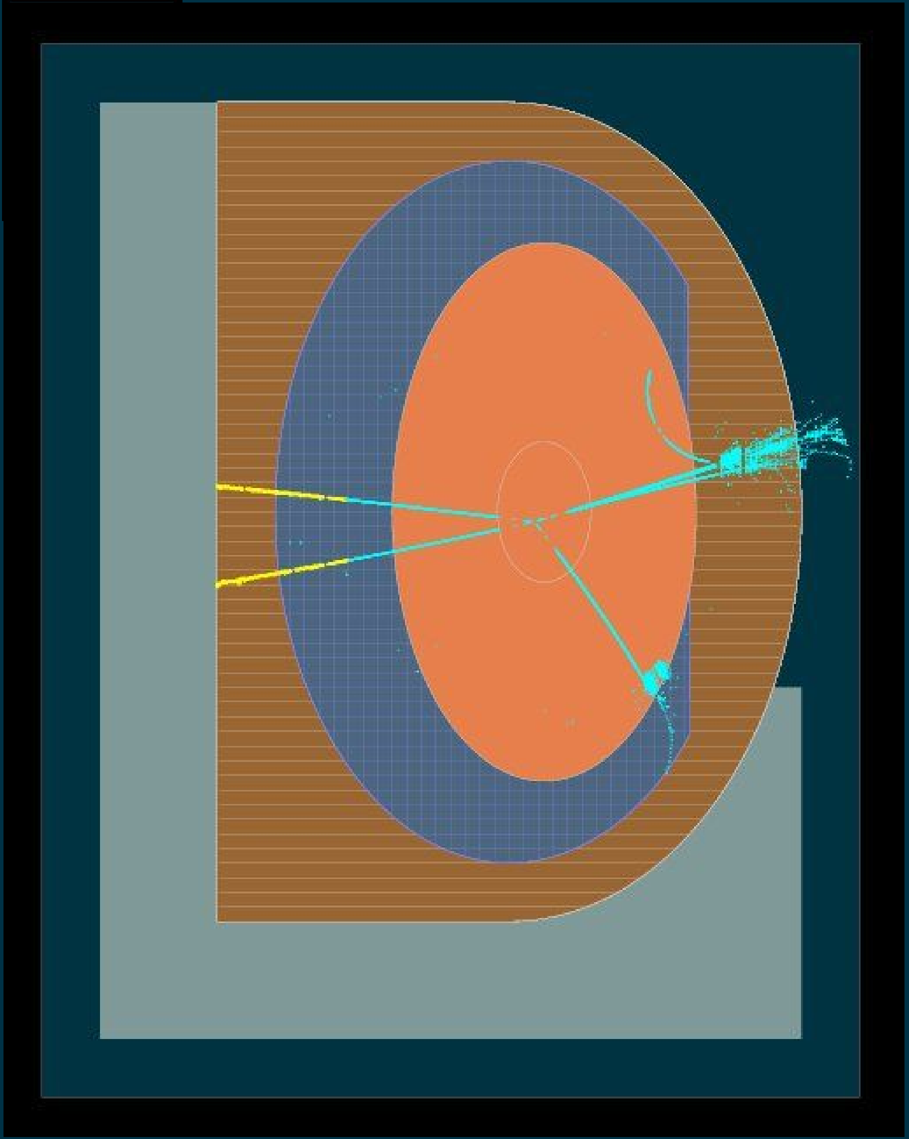

LDC an overview

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Outline

The ideas behind

The global design

The subdetectors, options and technology

The performances

The cost

Optimising the parameters, scaling laws

Any idea behind the design?

LDC is not meant to be a specialized detector
but rather to have the capability of collecting all the physics
available at the ILC in its range of energy,
it intends to make the best use of the available luminosity.
It is not meant to complement any thing.

Handling the “expected” physics,
handling the “expected” collider features
preparing for the “unexpected”.

That is likely to be the same ground as GLD

Three driving points:

the final states of interest are essentially made of bosons W, Z, H,
we need to measure properly their hadronic decays (jets),

it is important to identify properly the charged leptons
and measure them accurately, at any energy,

we have to identify and measure adequately the taus in their
different decay modes to use them as polarimeter.

The PFA approach seems to be the best suited approach for what concerns the first point.

The enemy is confusion:

for a granular and redundant and continuous detector,

tracker as well as calorimeter.

- rather large detector with a TPC for central tracker to provide track efficiency, V's recognition for matching the calorimeter

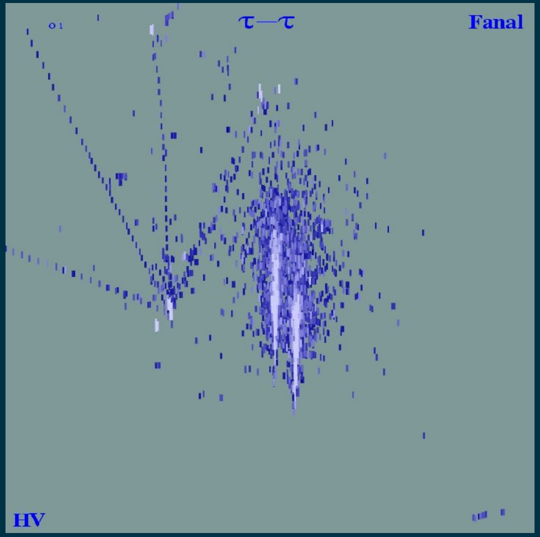
- dense and fine grained calorimeter to allow tracking, shower recognition and separation software compensation.

- precise and efficient vertex detector for flavours.

The leptons:

measuring the muon momenta, Higgs, Susy, tracking
identifying them in the calorimeter and muon system

identifying electrons, calorimeter and dE/dx
matching E and p, bremsstrahlung



identifying the taus and their decays
measuring their polarisation, or correlations

tracking precision $< 10^{-4}$, calorimetric tracking
granularity, energy and position precision

The global design

close to a bubble chamber but ..

A 5 layers Vdet

A large TPC with many precise points

A W-Si E calorimeter with an adequate resolution 15%
very dense, 24 X^0 in 17cm, very granular 5x5 mm^2 cells.

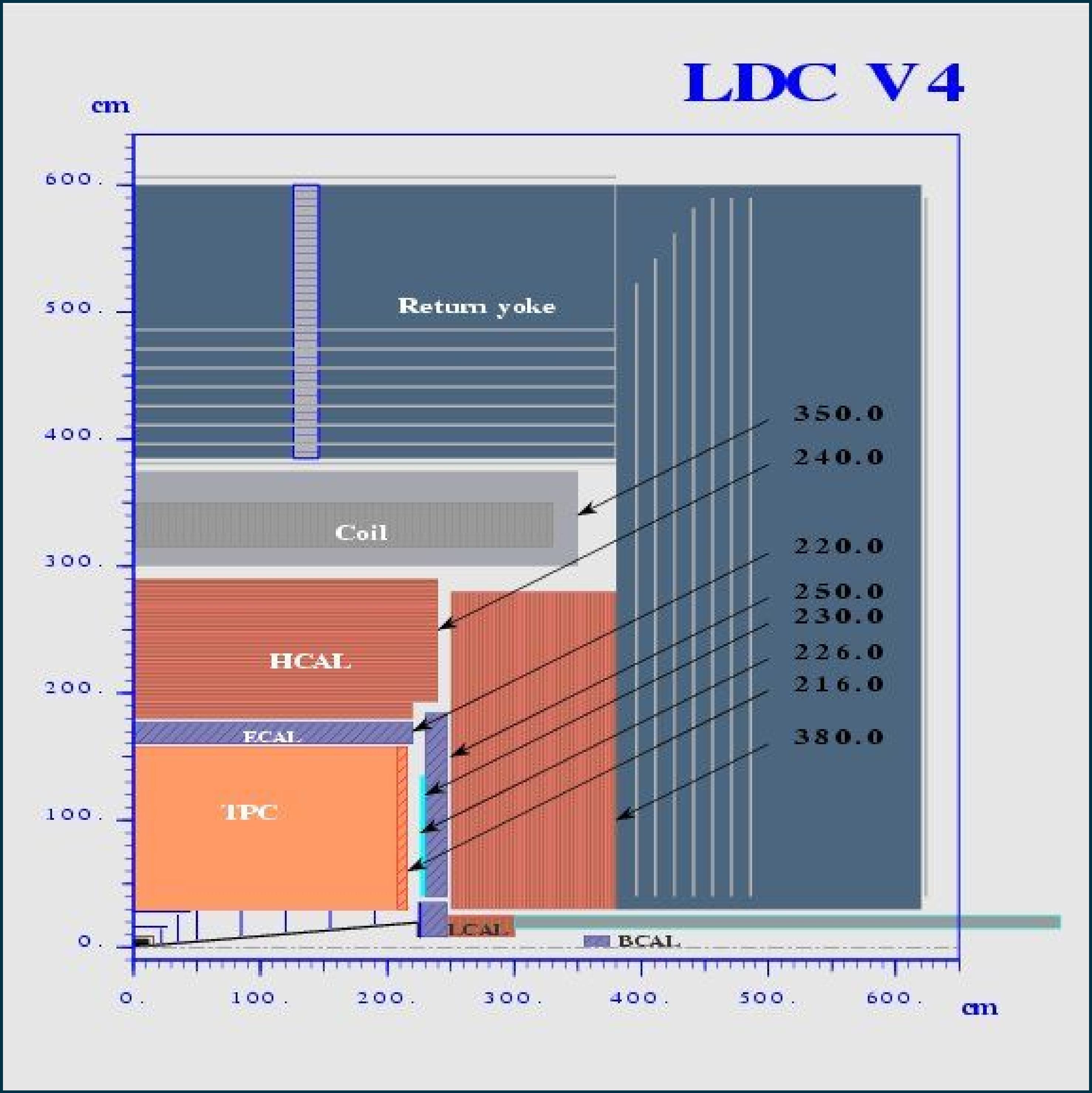
Two alternatives for the HCAL, Sci analogue or gas digital
with iron radiator, 3x3 or 1x1 cm^2.

A silicon tracking, in particular forward

A system of forward calorimetry, LCAL, LHCAL, BCAL

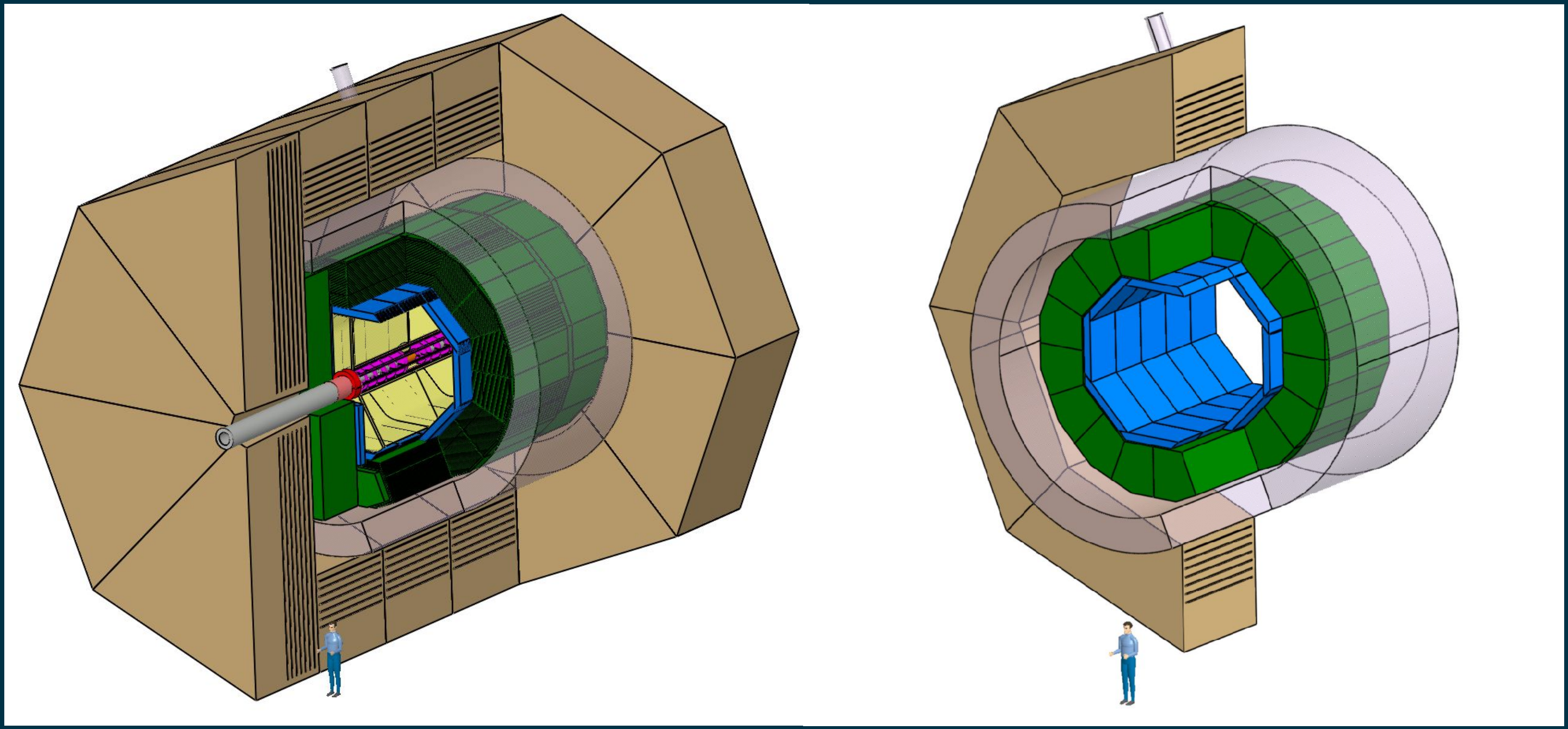
Layout of the detector

The last best guess



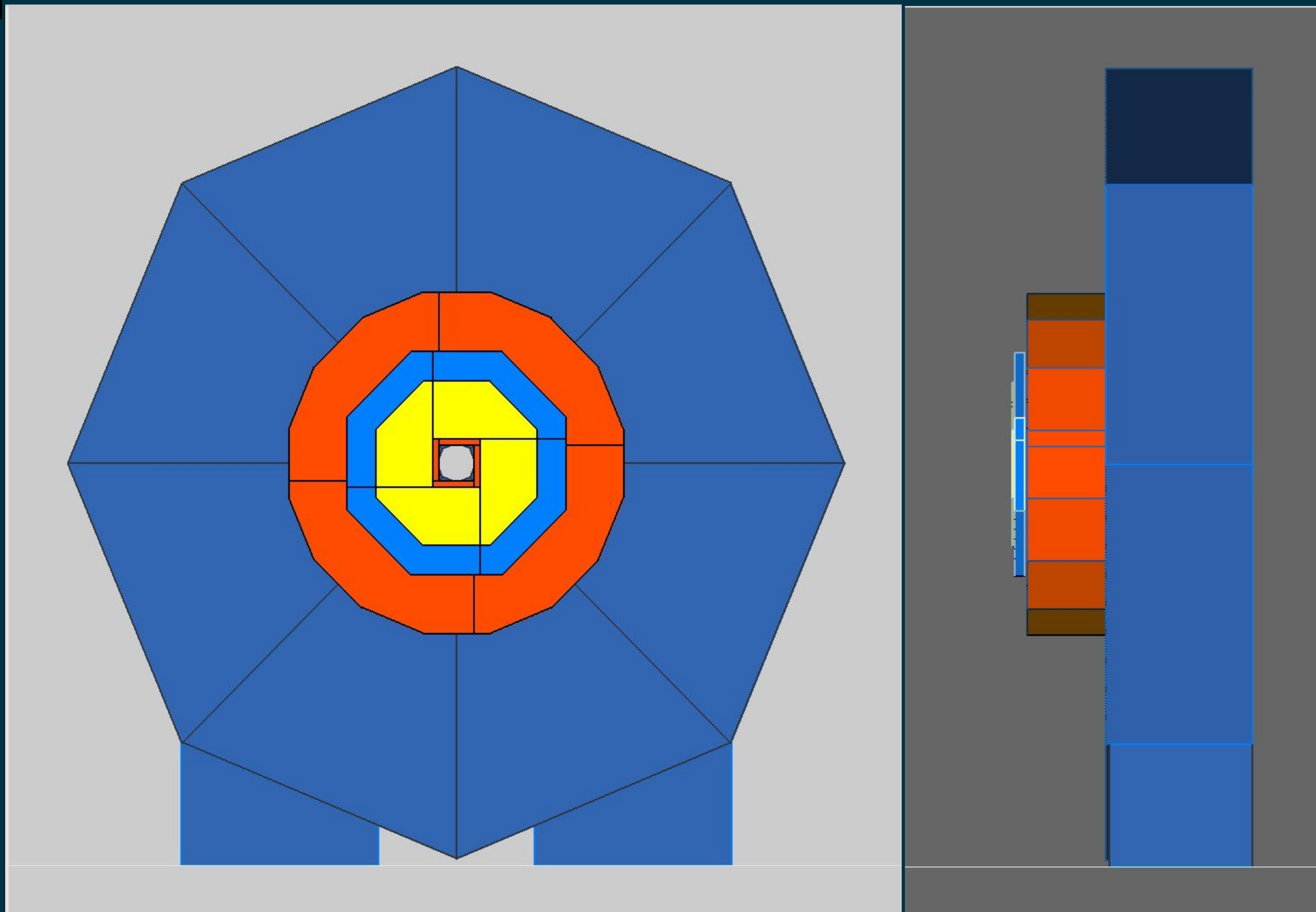
The sub-elements

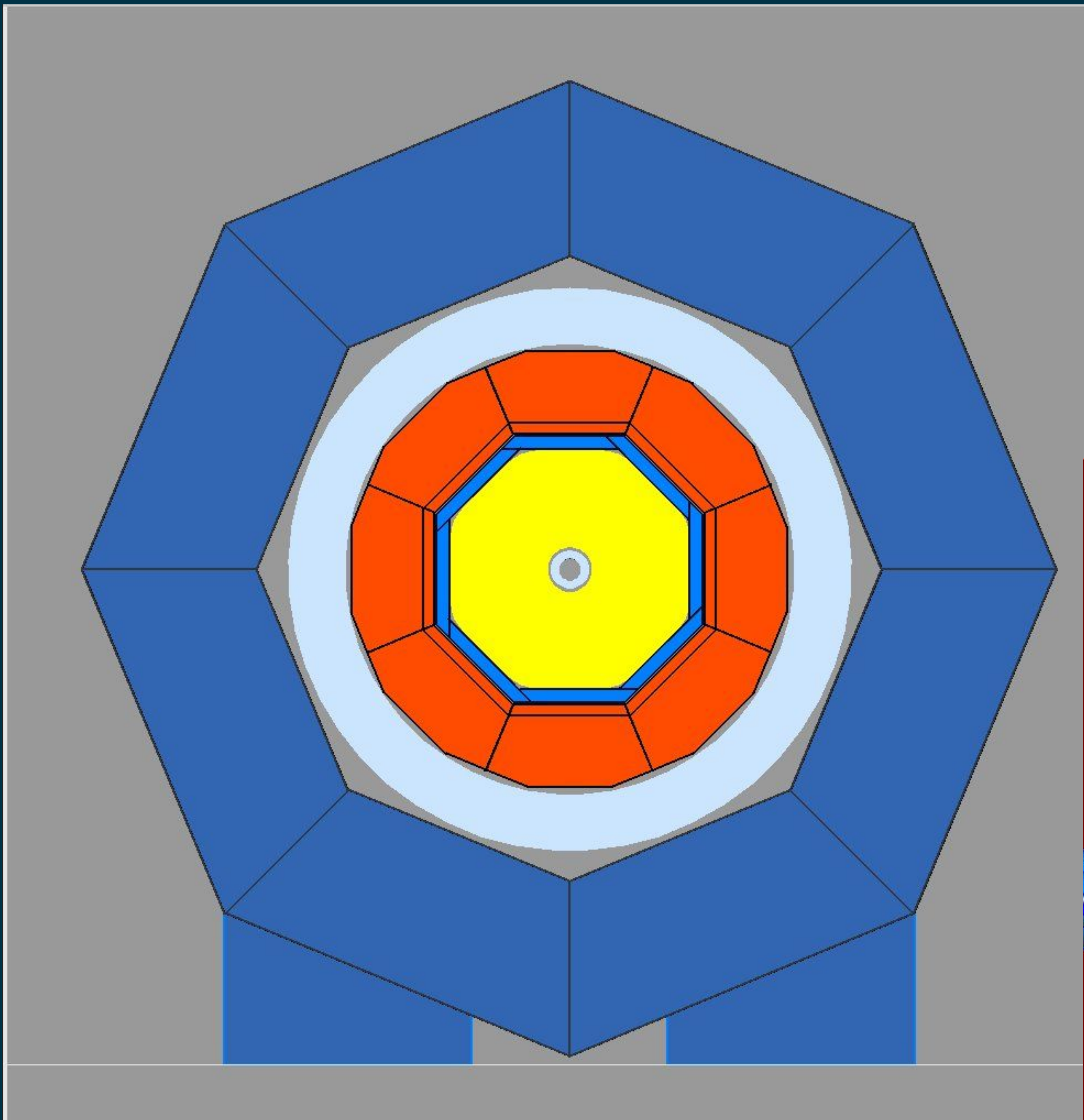
- Coil and return yoke
- Calorimeter
- Central tracking
- Vertex detector
- More tracking
- Handling the forward regions

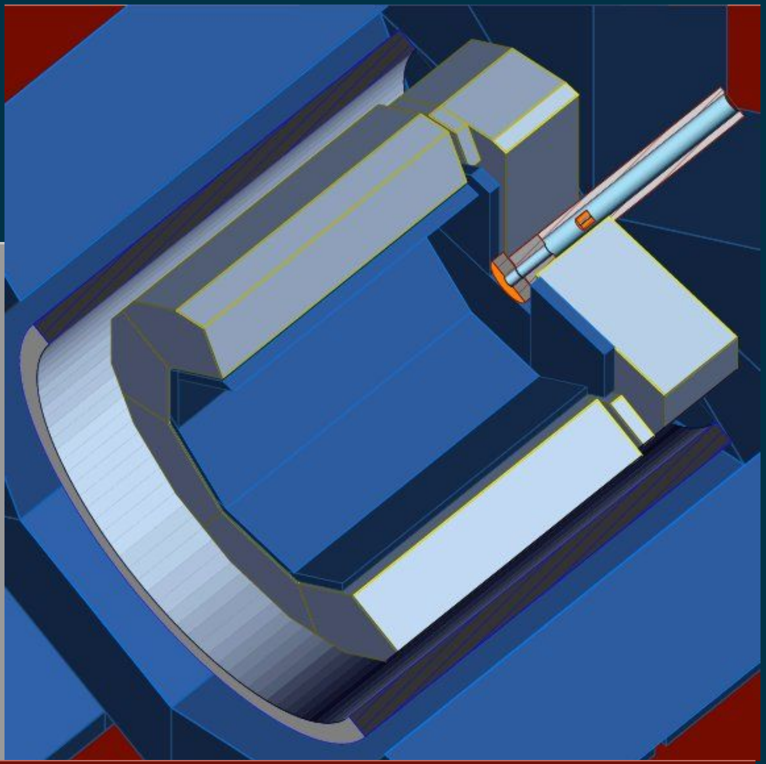


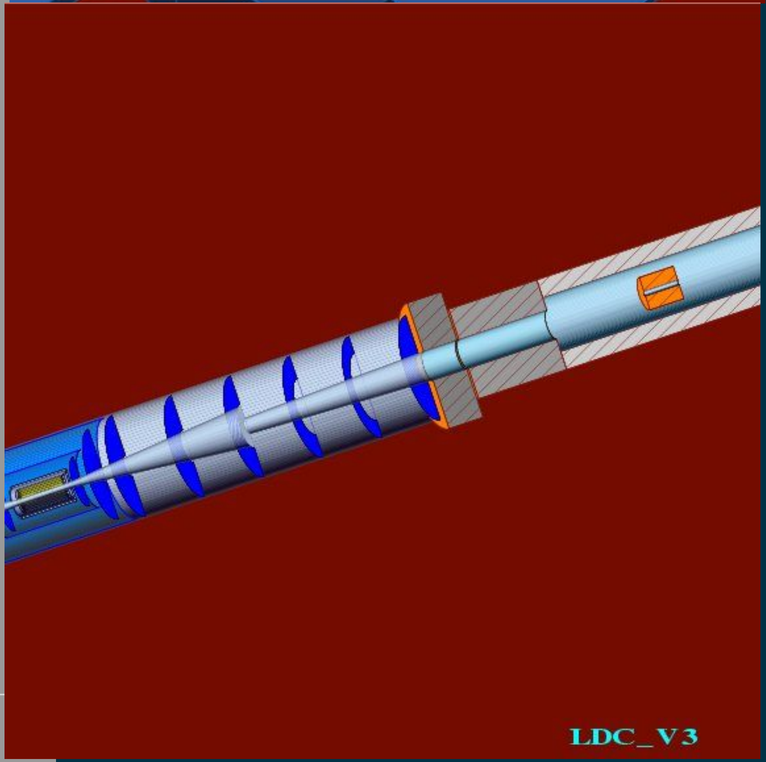
A magnetic structure like CMS 4T

but much shorter





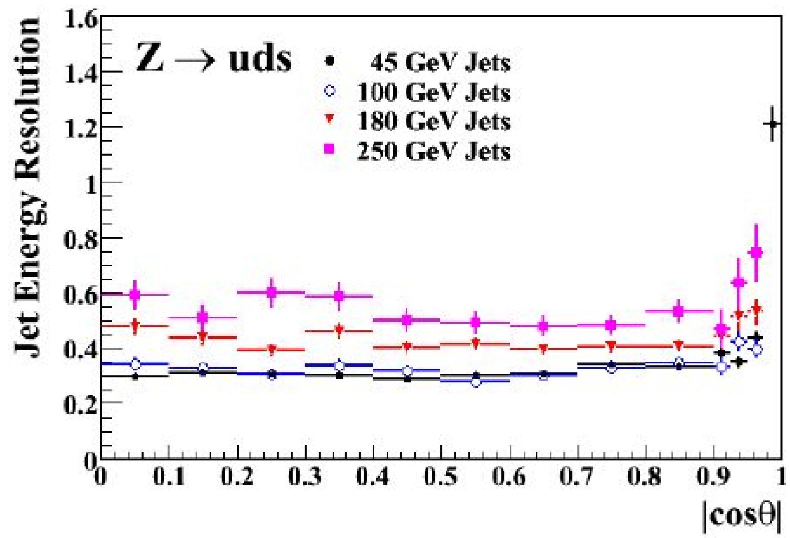



LDC_V3

Performances

Current performance

E_{JET}	$\sigma_E/E = \alpha\sqrt{(E/GeV)}$ $\lvert\cos\theta\rvert<0.7$ (rms90)
45 GeV	0.295
100 GeV	0.305
180 GeV	0.418
250 GeV	0.534



we start loosing when the jet axis is at 80 cm from the axis.
Is it really due to the hole? role of the LCAL or LHCAL

Caveat:

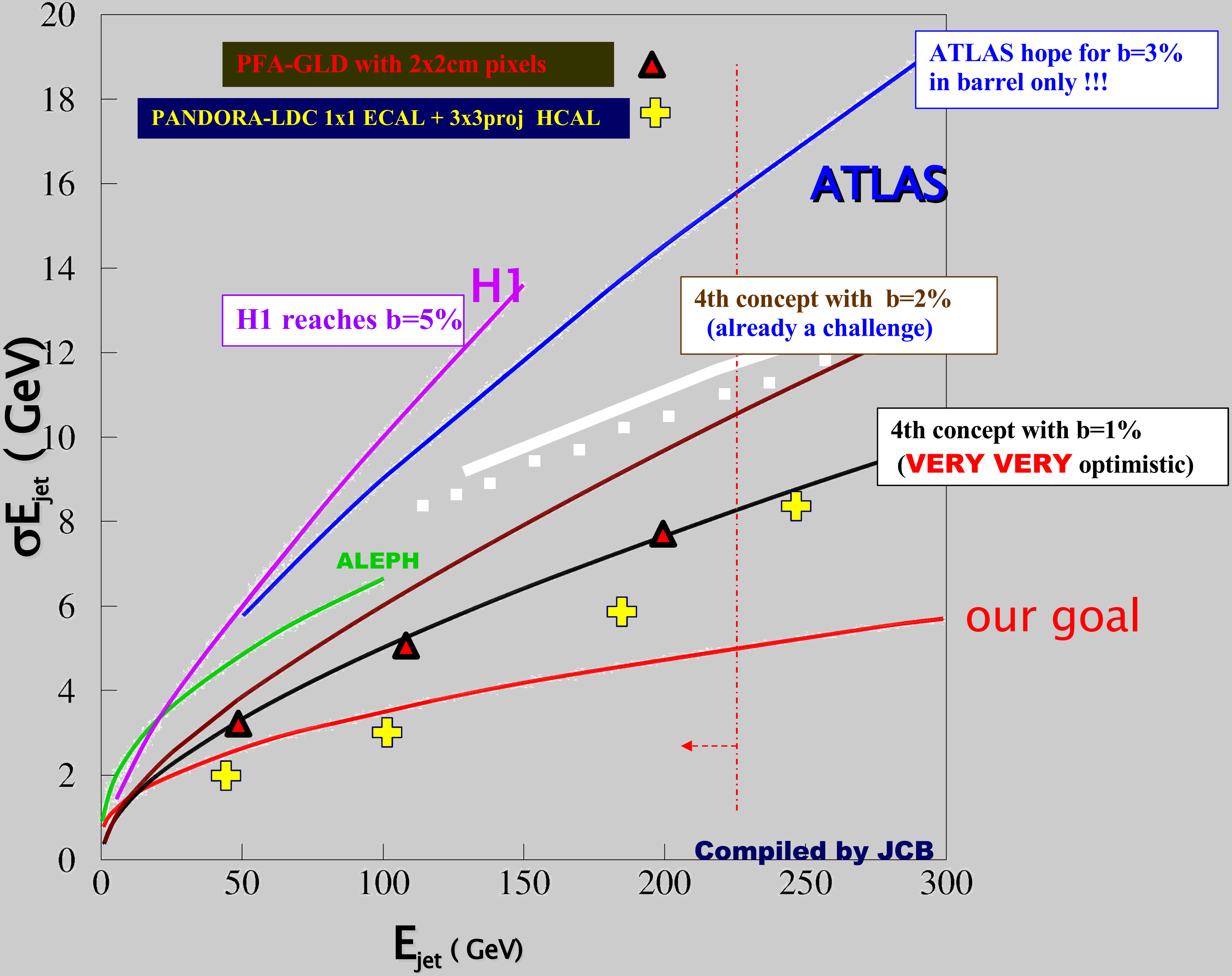
★ Is the current PFA performance good enough to start to characterise the PFA performance of the LDC detector ?

★ Don't forget : ultimately want multiple PFA algorithms
   – check robustness of any conclusions

Assuming it is, what can we learn…

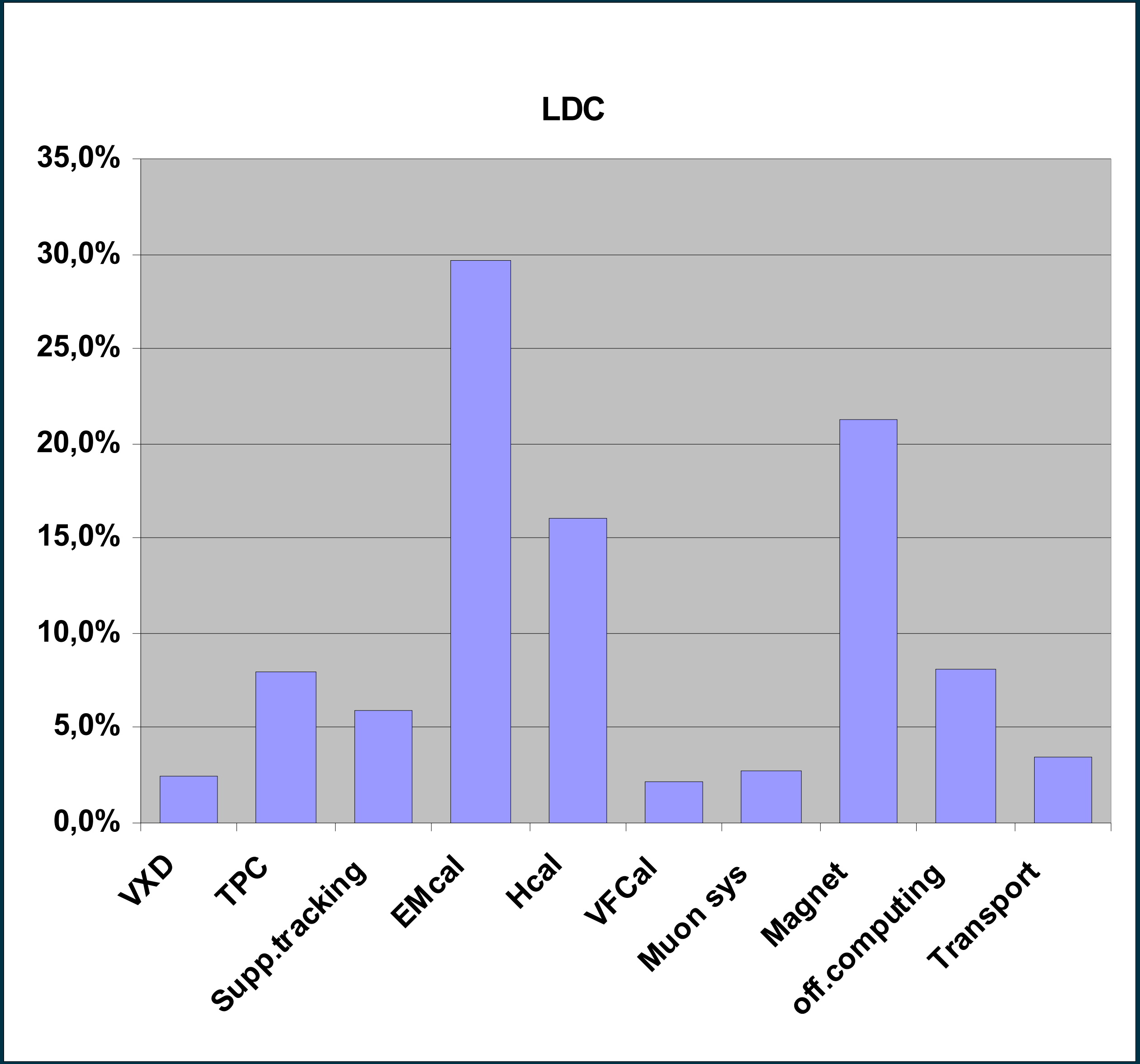
No attempt to compensation!

LDC meeting., Paris 4/5/2007 Mark Thomson 4


PFA-GLD with 2x2cm pixels
PANDORA-LDC 1x1 ECAL + 3x3proj HCAL
ATLAS hope for b=3%
in barrel only !!!
ATLAS
H1
H1 reaches b=5%
4th concept with b=2%
(already a challenge)
4th concept with b=1%
(VERY VERY optimistic)
ALEPH
our goal
Compiled by JCB
σE_jet (GeV)
E_jet (GeV)
0
2
4
6
8
10
12
14
16
18
20
0
50
100
150
200
250
300

Cost

Sharing



Driving costs

WBS Number		LDC	M&S	subdetector		
1		inner detectors			30,261,500.00 €	11.68%
1.1		Vertex detector		1,700,000.00 €		0.66%
1.2		Time projection Chamber		21,661,500.00 €		8.36%
1.2.1		Mechanics	9,860,000.00 €			3.81%
1.2.2		Electronics	11,801,500.00 €			4.56%
1.3		SIT/FTD/ETD		6,900,000.00 €		2.66%
2		Calorimeters			132,325,170.00 €	51.07%
2.1		Electromagnetic Calorimeter		87,035,070.00 €		33.59%
2.1.1		Barrel & endcaps				
2.1.1.1		Mechanics	13,445,000.00 €			5.19%
2.1.1.2		Detectors and sensors	69,320,070.00 €			26.76%
2.1.1.3		Power supplies	1,770,000.00 €			
2.1.1.		Integration and installation	2,300,000.00 €			
2.1.3		DAQ	200,000.00 €			
2.2	(analog)	Hadron Calorimeter		40,849,900.00 €		15.77%
2.2.1		Barrel,endcap and rings				
2.2.1.1		Mechanics	12,950,000.00 €			5.00%
2.2.1.2		Detectors & sensors	14,746,900.00 €			5.69%
2.2.1.3		Electronics	6,286,000.00 €			2.43%
2.2.1.4		control				
2.2.1.5		Calibration systems	4,167,000.00 €			1.61%
2.2.1.6		Cabling and cooling				
2.2.1.7		Assembly and installation	2,500,000.00 €			
2.2.2		DAQ	200,000.00 €			
2.3		Very Forward Calorimeters		4,440,200.00 €		1.71%
3		Muon Detector		2,500,000.00 €	2,500,000.00 €	0.96%
4		Magnet			64,000,000.00 €	24.70%
4.1		Coil		32,800,000.00 €		12.66%
4.2		Yoke and vacuum tank		23,600,000.00 €		9.11%
4.3		ancillaries		7,600,000.00 €		2.93%
5		Electronics/DAQ				
6		Offline computing		30,000,000.00 €		
7		Infrastructure				

TPC FE : 6.4 M€

µstrips : 4M€

W: 11.6M€
Si: 53.25 M€

Steel: 13M€
SiPM: 14.5 M€

Magnet : 64 M€

Off.Computing
30 M€

- M&S → 259 M€
- Transport : (≈ 5% total amount) → 13M€
- Labor(MY) Average cost including overheads (2005) : 77K€

VTX	100
Sup.Tracking	200
TPC	100
Ecal	300
Hcal	300
Magnet	200
Muons	100

→ 1300MY= 100M€

Uncertainty 20%?

Σ = 372 M€

Conclusion (1)

- 1st number → 372M€ -/+ 20% contingency

But

✓ **Few details on some inner detectors**

✓ **informations still missing on**

- **DAQ**
- **Infrastructure**
- **Integration (mainly manpower)**
- **Logistic**
- **MDI**

✓**R&D needed to refine the costing**

CMS :

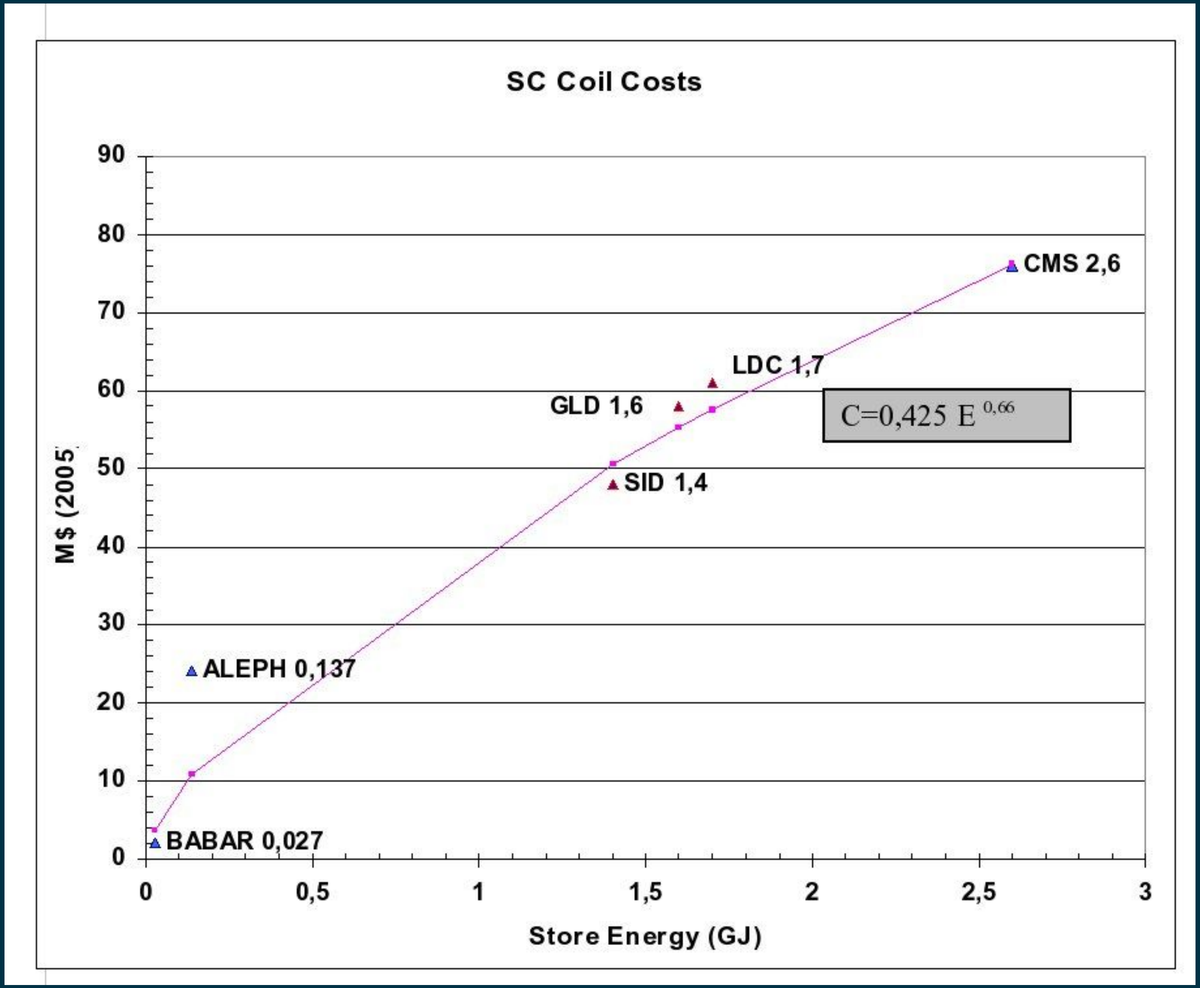
360M (2006)

Ecal : 82 M€

(without MY)

Optimisation

The price does not include the yoke but has an estimate of the in house manpower



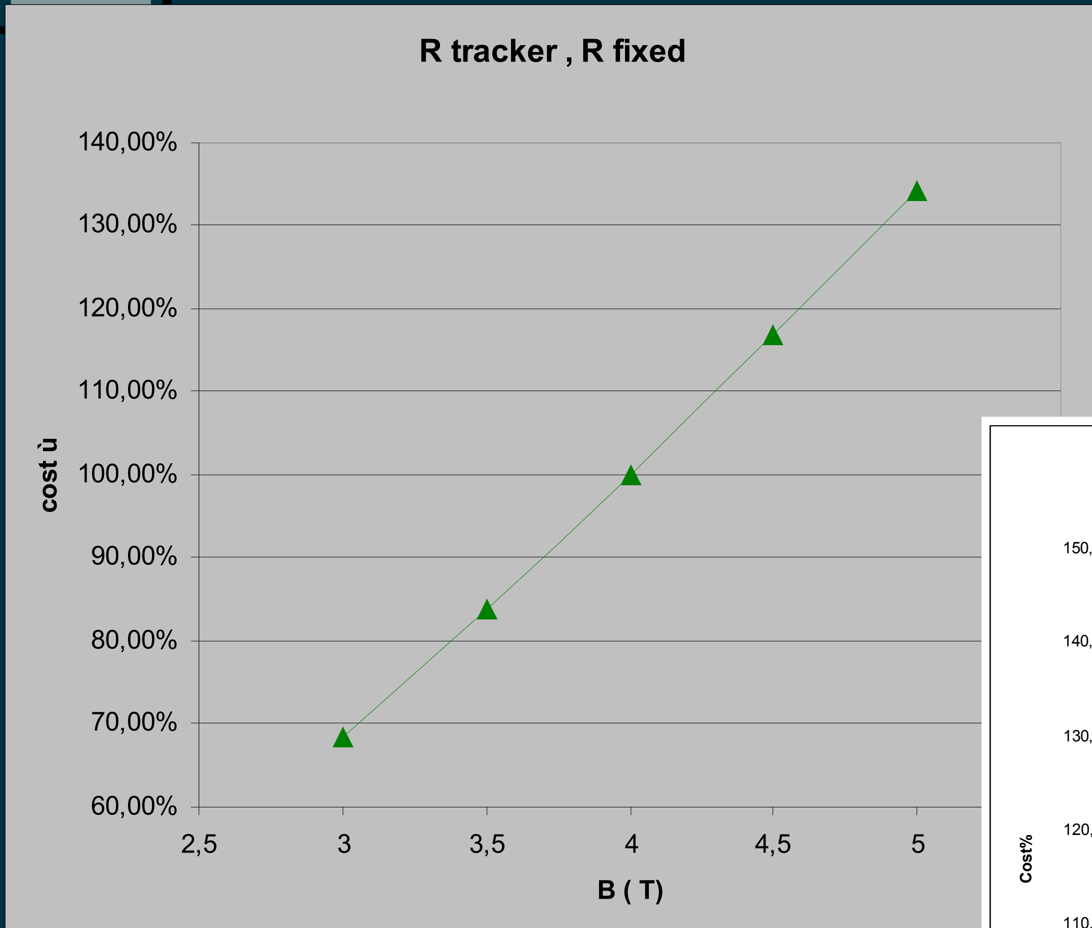
Stored energy in B^2R^2

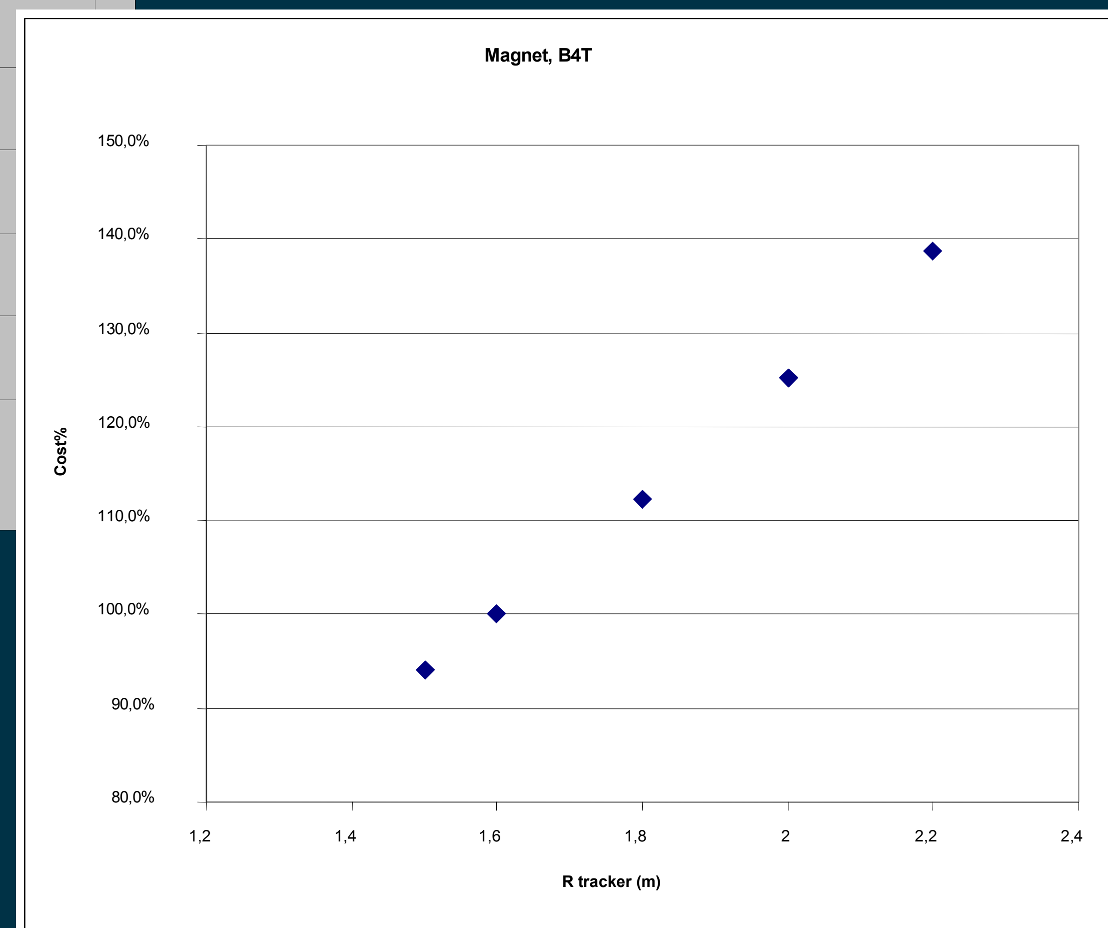
Cost in $B^{1.3}R^2$

Performance in BR^2 close to 90°

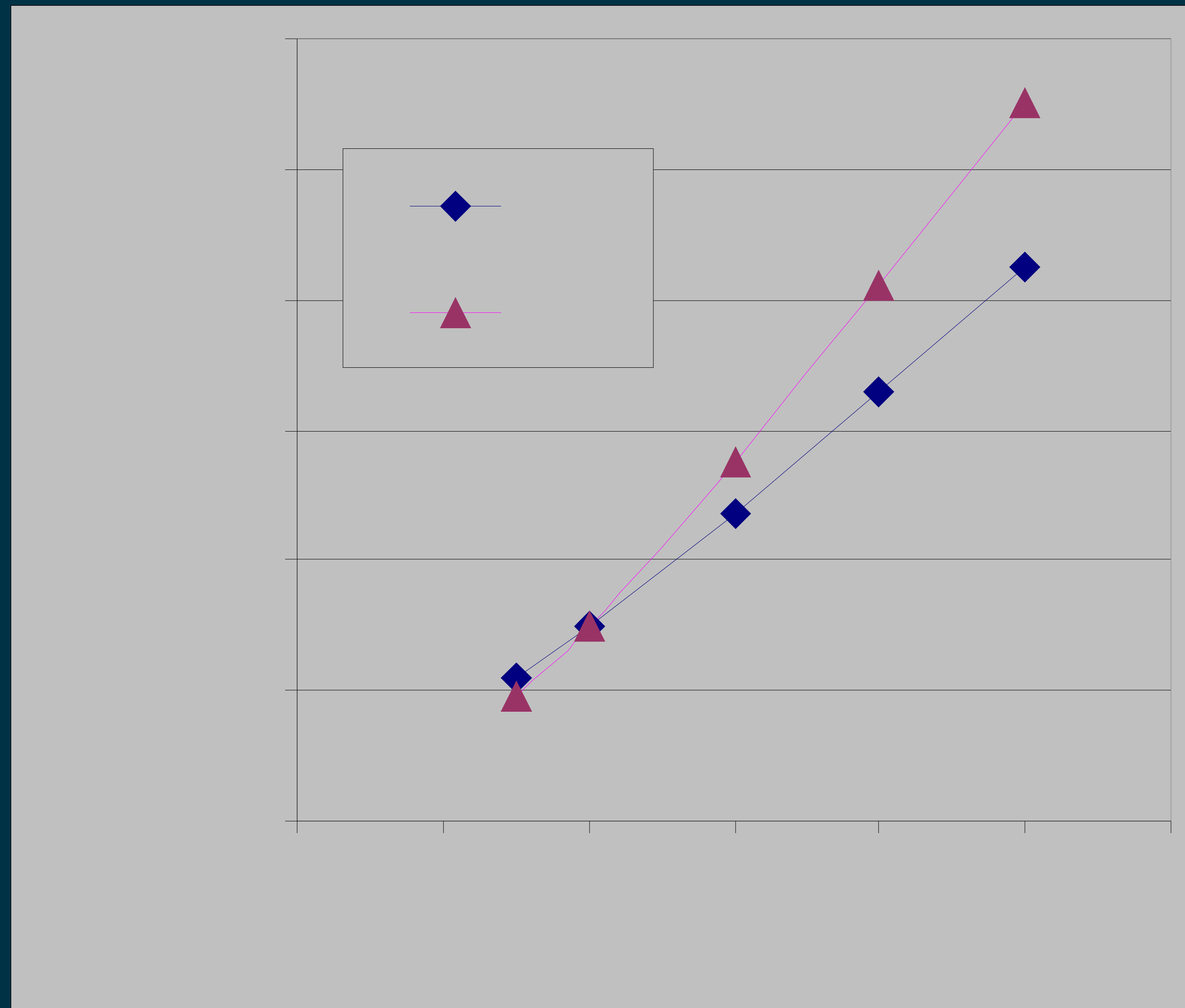
favour pushing R

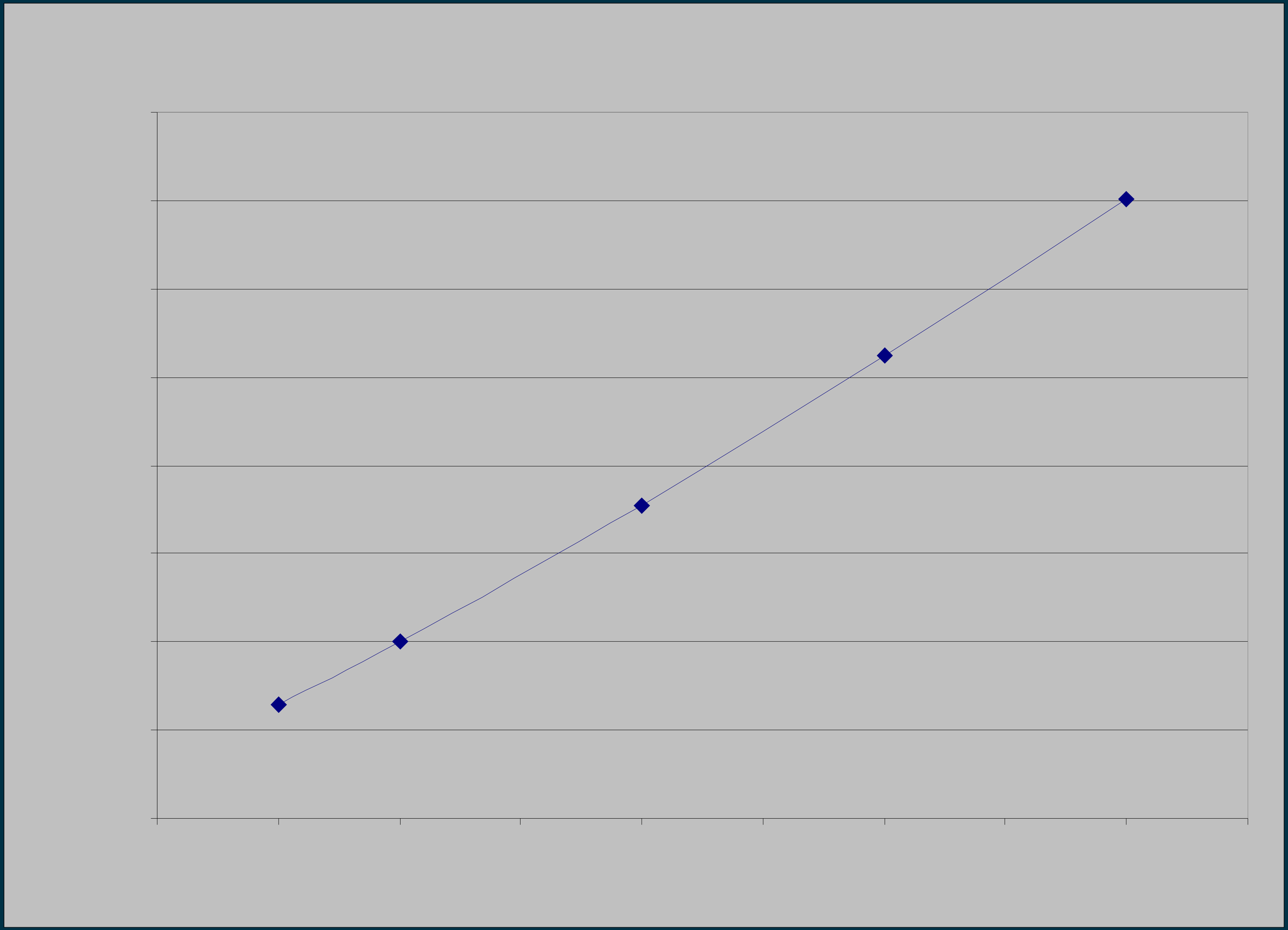
where R is the coil radius, not the tracker


R tracker , R fixed
140,00%
130,00%
120,00%
110,00%
100,00%
90,00%
80,00%
70,00%
60,00%
cost ù
2,5
3
3,5
4
4,5
5
B (T)


Magnet, B4T
150,0%
140,0%
130,0%
120,0%
110,0%
100,0%
90,0%
80,0%
Cost%
1,2
1,4
1,6
1,8
2
2,2
2,4
R tracker (m)

But

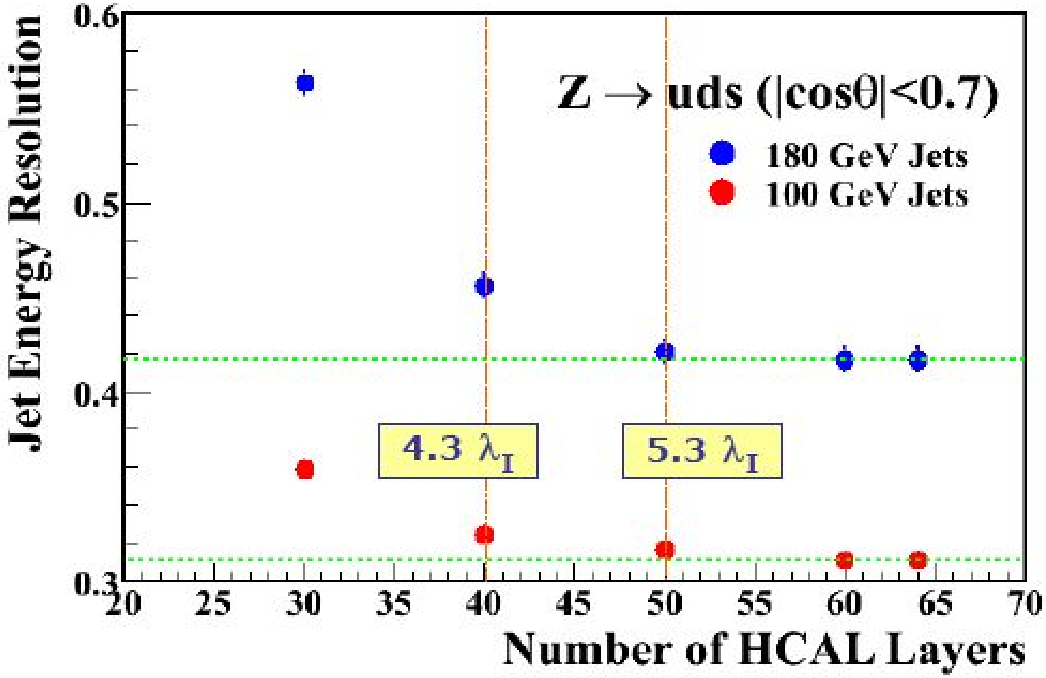




where we keep the aspect ration constant

HCAL Depth

- Investigated HCAL Depth (interaction lengths)
  - Generated **Z→uds** events with a large HCAL (63 layers)



- HCAL leakage is significant for high energy
- Argues for ~ **5** λ_I **HCAL**
- Consistent with J-C's talk

The end cap is already 53 layers thick adding 10 layers to the barrel costs 5% of the detector

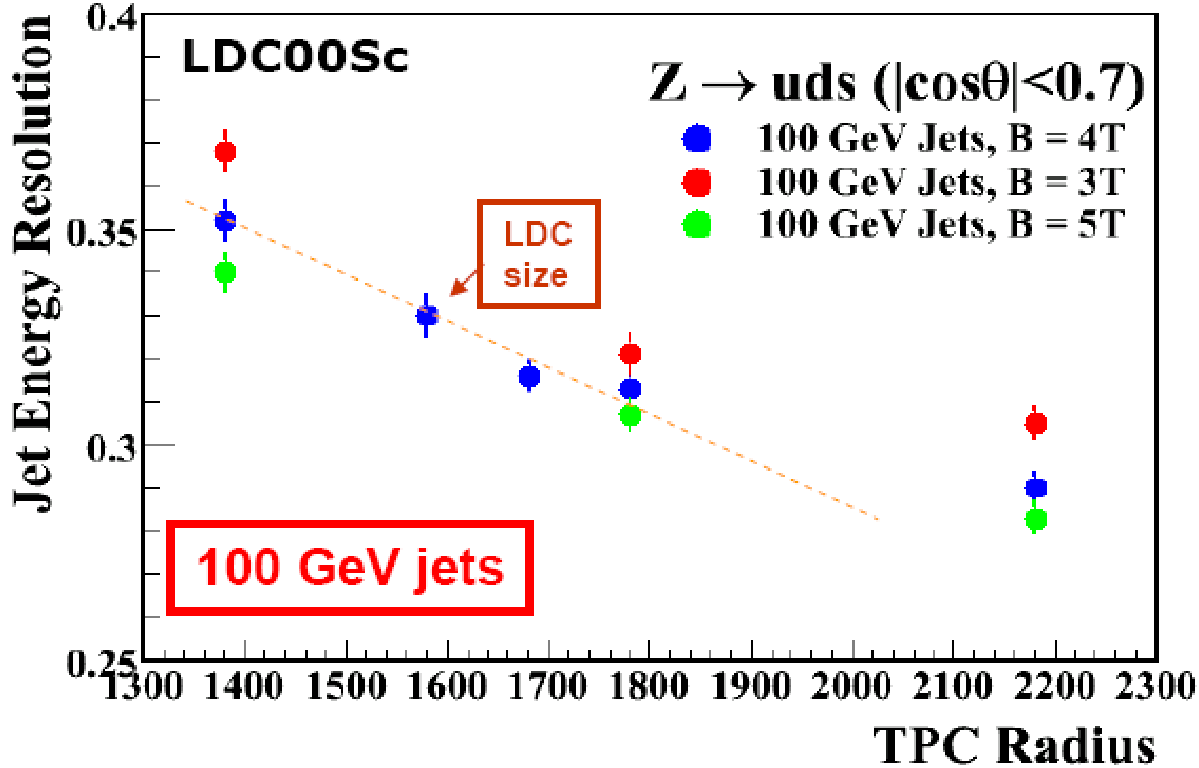
NOTE: no attempt to account for leakage – i.e. using muon hits - this is a worse case

Increase number of HCAL layers in "default" LDC model

Also study alternative with current HCAL depth to study use of muon chamber as tail-catcher (personpower?)

I doubt this is an option unless the coil can be made "thin"

Radius vs Field



Radius more important than B-field

impact of field on Vdet radius!

Going from R=1.6 , B=4 to R=1.8 B=3.5 does not change the overall price and gains 10% on momentum resolution and 3% on jets

Suggests : size ⇧
B ⇩

Cost benefit of going to 3.0 T or 3.5 T ?

- **Cost related to stored energy:** Stored energy ~ LB^2R^2

Conclusion

LDC: a general scheme

with different options

quite some optimisation to be done

on the parameters

quite some choices to make

on the technologies

why not doing both, GLD and LDC, optimisations together?