Realistic alternatives to the current baseline of ILD

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I am not to make here a critical examination of the optimisation results.

Motivations

The ILD parameters chosen in Cambridge were considered as reasonable choices but not as optimal, neither from the point of view of physics, nor detector design or feasibility.

this last point involving also the cost.

For the DBD the cost has been estimated roughly, 380 MILCU, and found heavy compared to

SiD much reduced in size, 325MILCU,

not particularly to LHC detectors

There is a huge difference in manpower in favour of SiD.

But the cost of the SiW Ecal = 160 MILCU !

This drove the optimisation to trying for a smaller silicon area hence maybe less layers, a smaller TPC radius (length).

Yoke

Another important cost issue is the yoke (95 MILCU) with the constraint on the stray field linked largely to the push-pull, and some rather arbitrary choice for a tolerance.

This was and will be discussed by K. Büsser at this conference.

The size of the ILD yoke may also be an overkill. To be (being) optimised !
We should remember for the discussion of alternatives that this yoke question, the stray field question is also linked to the field flux to be returned, field magnitude and coil transverse area, radius squared.

Nevertheless, if that implies quite some engineering work, it does not interfere with physics and detector simulation

I will then not discuss the point of the yoke further here.

A first answer to the SiW Ecal cost problem (if any)
is to optimise the SiW Ecal detailed design to be more tolerant and
then offer the possibility to the manufacturers to propose a more attractive price
and also to find more manufacturers.
This led for the time being to a reduction from 160 to 150 MILCU. 576

We may also, in due time, have the cost of our CMS prototype

A second answer is to switch to another technology if cheaper, working
and acceptable for physics.

A third is to play with local or global parameters

It should also be noticed that the baseline design may not be feasible as such,
this appears to be the case for the thickness of the Ecal which was pretty aggressive,
work is going on to reach the baseline thickness but it could be wise to be currently
more realistic.

This study of some of the parameters has been done by different people in the framework of the optimisation meetings.

Considering the impact
- on tracking, Higgs recoil mass essentially
- on Ecal capability of distinguishing close by particles, tau decay modes
- on global PFA confusion, jet resolution studies.

The parameters under study have then been :
- dimensions, characterised by radius and length of the TPC, aspect ratio
- magnetic field linked to the preceding,
- number of layers for the calorimeters
- cell sizes for the calorimeter.

These studies have most often made use of the scaling possibilities offered by MOKKA leading sometimes to inconsistencies.

It may therefore be better to define 1 or 2 alternatives thoroughly modelled and checked.

The software optima

Remark also that the studies have to be done
with a software for simulation, reconstruction

and the optima found can be linked
to the hardware properties we look for
but also to the software ones.

The case is probably at work when the jet resolution gets worse for Si cells below 5mm.

Before to go to alternative proposals, it is useful to review some of the findings

Tracking studies ; from the physics side they concern essentially the Higgs recoil mass
a place where the momentum resolution is of prime importance

The tracking has been presented
by Mikael just before.

The touchstone

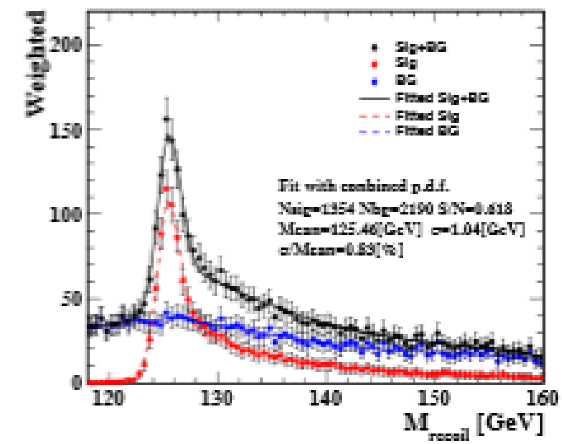
Higgs recoil analysis:

A clear deterioration is observed
when going from 1843mm to 1400.

Caveat: the ultimate resolution is used in both cases,
not considering a more realistic resolution, remember CMS.
The field and the inner radius have not been optimised.

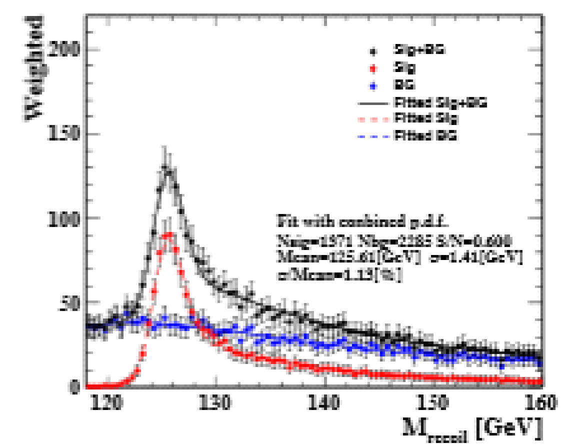
TPC
OuterR_1818
OuterZ_2402
L cut = -0.04

Baseline



TPC
Outer R_1382
Outer Z_1694
L cut = -0.04

Well reduced
radius



Caveat: this study does not vary the magnetic field, done in more recent studies
Go back to Mikael's talk.

Study Higgs Recoil analyses, H->mumu channel:

2. √s=250 GeV, L=250fb^-1 ⇨ If we change R: 1.8 m ⇒ 1.4 m

⇨ σ_resolution	degrades	~	10 %.
⇨ σzh precision degrades		<	5 %.
⇨ Mh precision degrades		~	12 %.

→ ~26% more data to recover nominal precision.

※ (R: 1.8 m ⇒ 1.6 m) Mh precision degrades ~ 4 %.

3. √s=350 GeV, L=350fb^-1 ⇨ If we change R: 1.8 m ⇒ 1.4 m

⇨ σ_resolution	degrades	~	25 %.
⇨ σzh precision degrades		>	5 %.
⇨ Mh precision degrades		~	30 %.

→ ~69% more data to recover nominal precision.

※ (R: 1.8 m ⇒ 1.6 m) Mh precision degrades ~ 10 %.

The very detailed impact on the tracker has been presented by Mikael

It shows the interplay between radius and field and the interest
to switch to 4T when considering reduced radii.
I would take that option !
Some other parameters like TPC inner radius could also be optimised
with the SIT and the forward tracking.

The conclusion seems to me that there exist some possibility to
decrease somewhat the size without much harm.

It is also clear that
we need a SET
and that the case for a simplified ETD
should be looked at again.

Redundancy

The case of the compensation coils should be closed.

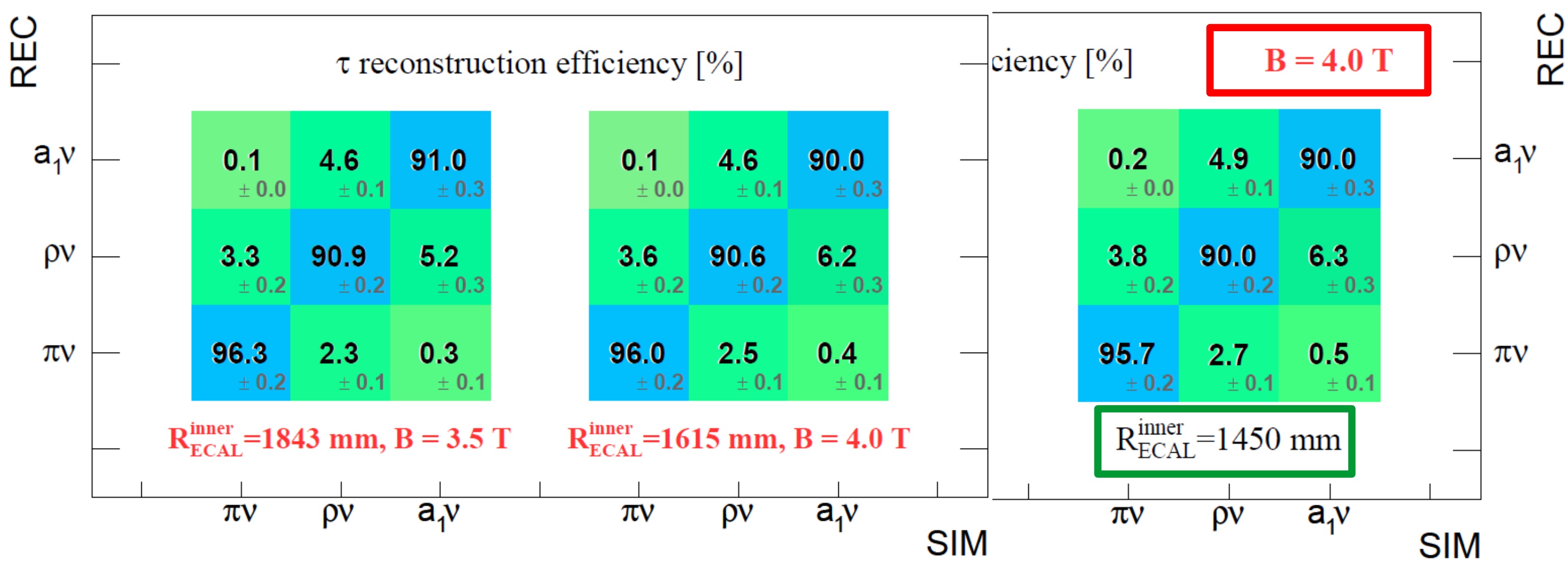
Concerning the Ecal by itself

The intrinsic resolution is linked to sampling in a known simple way,
The confusion is linked to Molière radius / cell size in a software way.

A way to test the ability of the ECal to separate close by photons and hadrons :

study the identification of the tau decay modes, mostly π / ρ.
It measures also the adequacy of the cell size.

The result is quite impressive with little dependence on the radius



125 GeV taus analysed with Garlic

Concerning the overall detector,

jet energy resolution as a test bench for samplings, cell sizes, sizes

Samplings

Little impact of Ecal sampling except at low CM energy

Very little impact of Hcal sampling for same interaction length S. Green

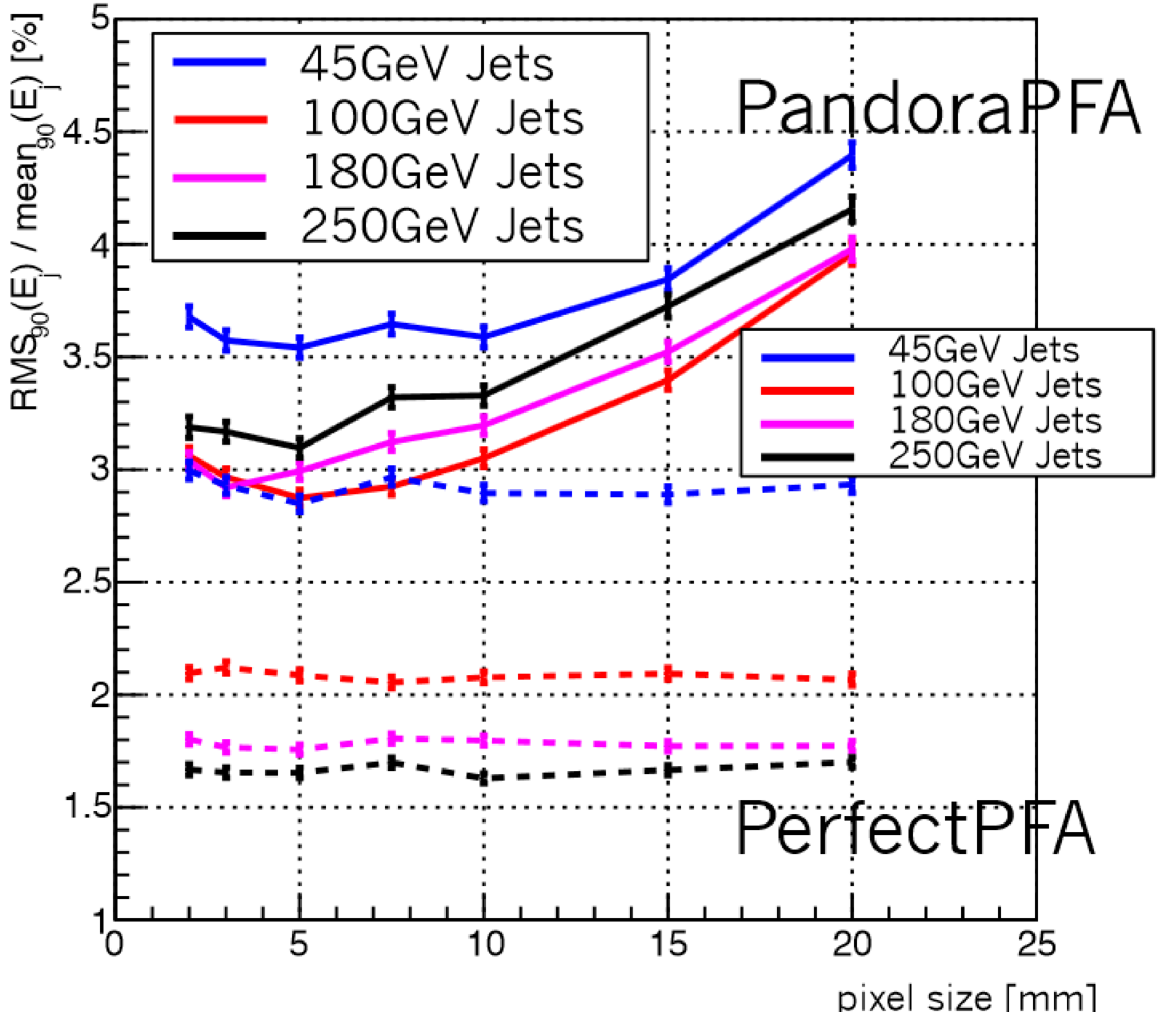
Cell sizes

Ecal : small seems to help clearly,
strange behaviour of Pandora optimisation below 5x5mm2 .
Anyway no prospect of getting smaller as shown on previous slide.

Hcal : small seems, up to a point, to help according to Pandora studies

Software may as often provide a lot of opportunities to improve.
We look here for trends.

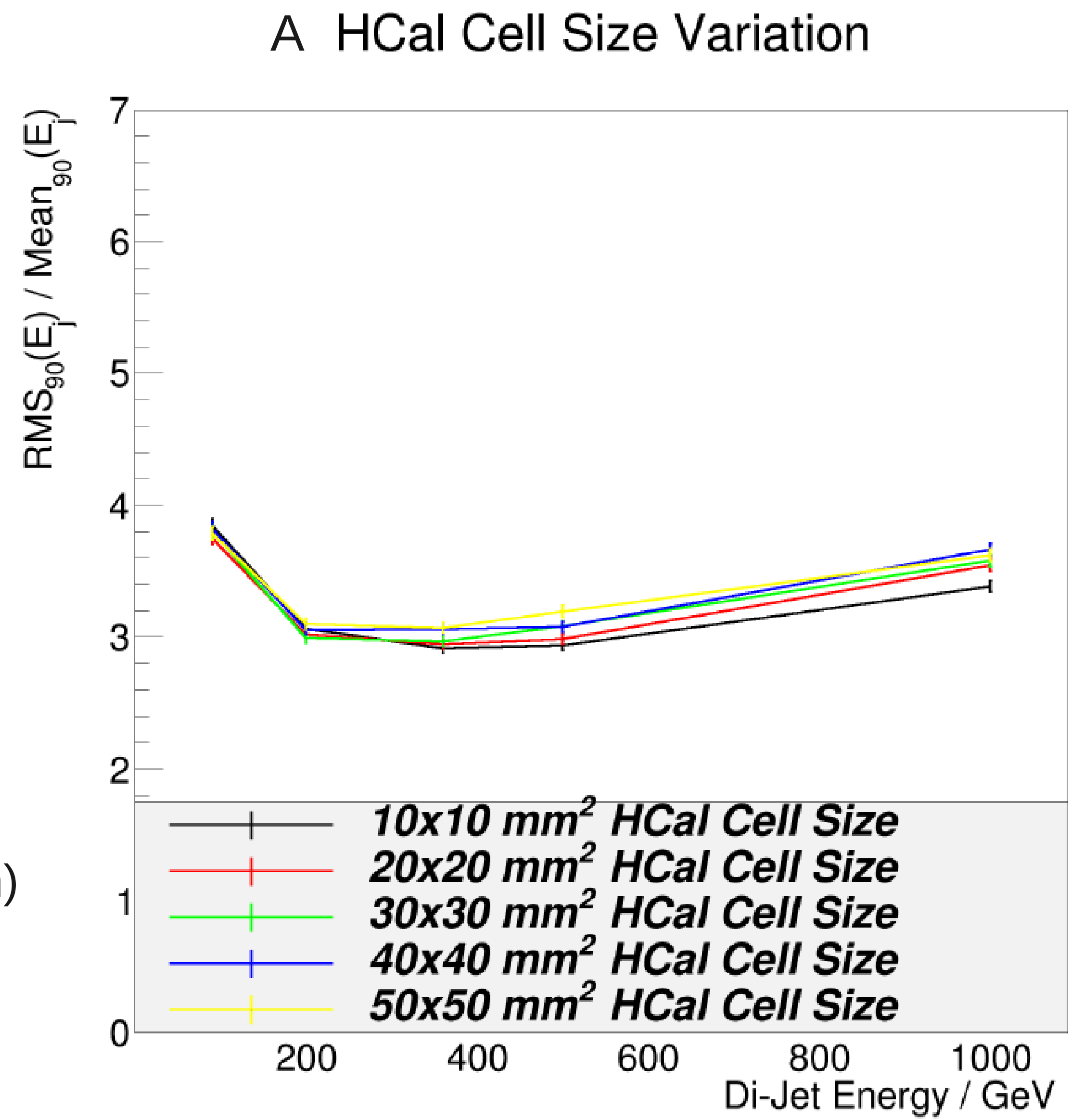
SiW JER vs. ECAL pixel size



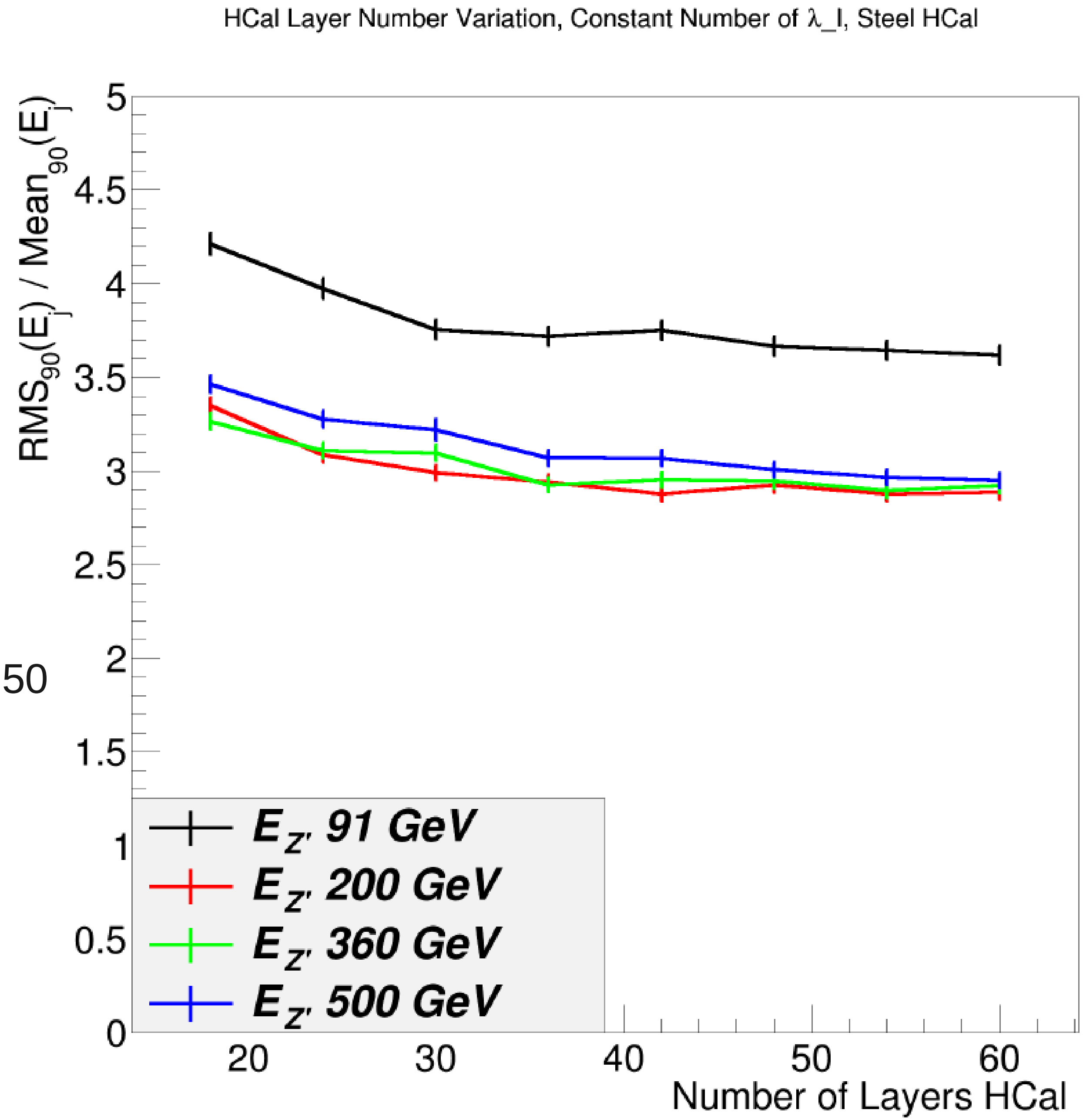
Hiroki Sumida

Look also at the effect of the confusion

Steve Green
Pandora
Within errors except at high energy
where small is slightly better



sDHCAL no real study on cell size
up to now
because cell size impacts confusion
and intrinsic resolution (compensation)



Steve Green
Pandora

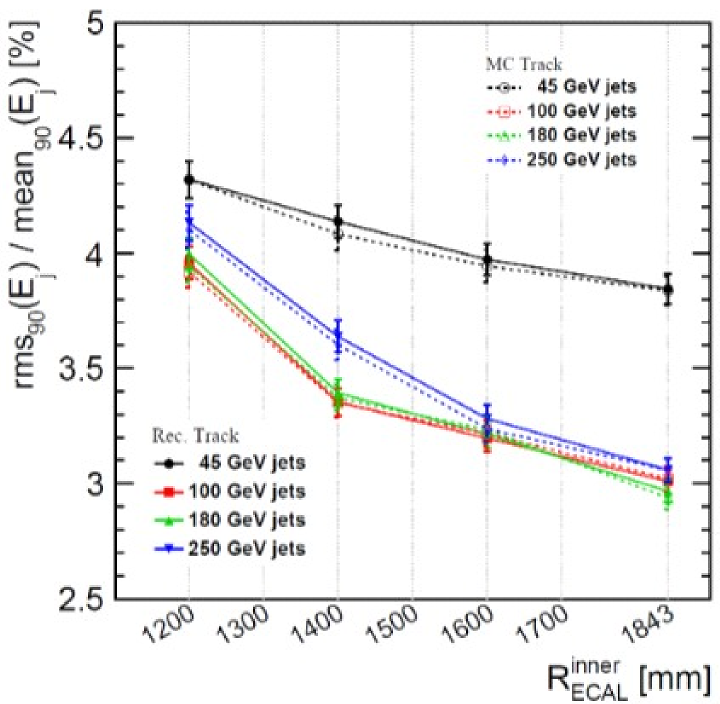
Dijets of different energies
Rather flat between 40 and 50

Sizes : radius and length

Radius and length are linked here by a common aspect ratio probably adequate for the calorimeter.

As can be expected, things go better with larger sizes and stronger fields, up to a certain point.

The first helps confusion between neutrals and charged, the second diverts only charged ones, Both may degrade very low energy tracks, tracks not reaching the barrel calorimeter



Interplay between field and size.

Notice that the effect appears moderate (< 10%)
for moderate changes (going to 1600).
How moderate is adequate ?
And this study does not play with the field,
1600 could be with 4T.

The track resolution does not enter in the game

With all that in mind

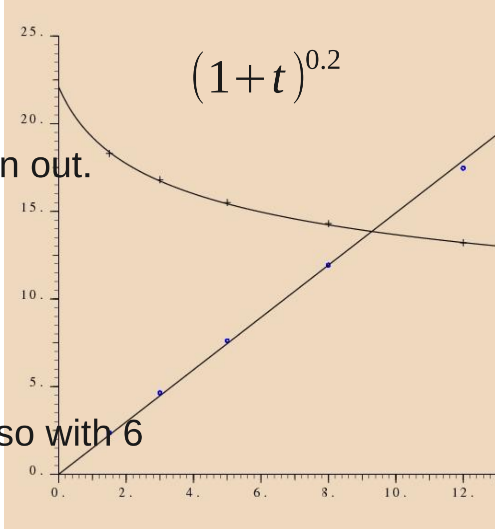
Proposal for alternative parameters

Remember that the point is
to propose models which could provide justification for a baseline change,
not to propose today a new baseline.

Starting from parameters which could optimise the Ecal
and be in a reasonable range in view of what we quickly saw.

Ecal models.

As the ancillaries of the « sensitive layer » grew thicker for technical reasons,
the Moliere radius is degraded,
on the other side as it helps cost wise, we consider going for



- 22 layers instead of the baseline 29. The first layer without W is anyway taken out.
increasing the Si thickness to 725µ to help the resolution
Impact on light Higgsinos, play with Ecal ring.

- 8 inches wafers to reduce further the dead zones
In fact, as we do not know fully about the possibilities of manufacturers, we work also with 6 inches wafers 525µ thick making use of the fact that 3x8 = 4x6.

To set the landscape
using 22 layers with 1615mm radius brings down the Ecal cost to ~93MILCU
with 1480mm down to ~81 MILCU.

Optimising the mechanical structure of the Ecal for these wafers generates

- A barrel length of 3977mm or 3716mm
- An end cap outer radius of 1834.5 or 1699.5

We draw from that two models with the following parameters :

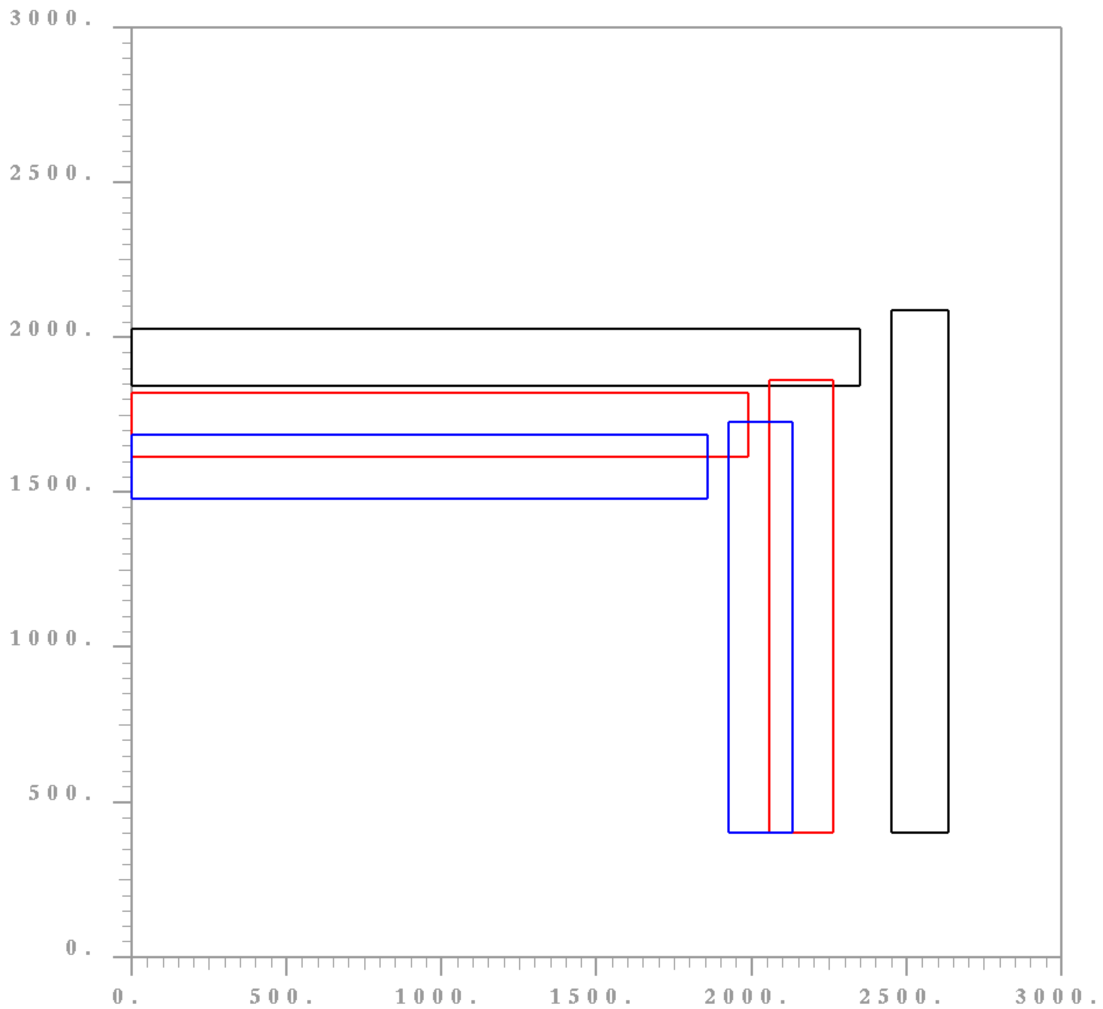
	Barrel length	barrel inner radius	barrel outer radius	end cap front	end cap outer radius
Model 2 : Khephren	3977	1615	1834.5	2058.5	1860
Model 3 : Mykerinos	3716	1480	1699.5	1958.	1725

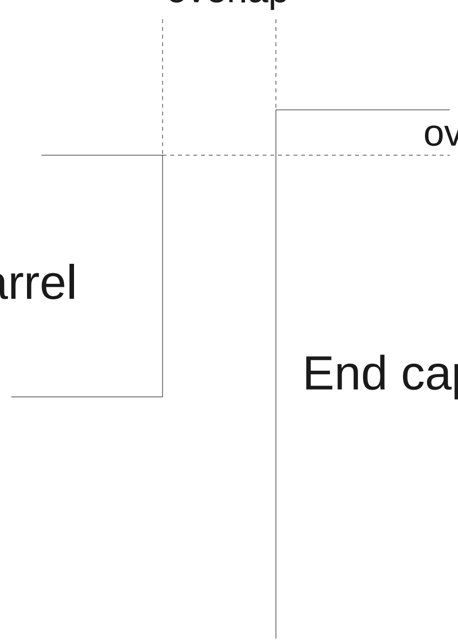
These values are derived from the previous slide numbers by
choosing the combination preserving at best the aspect ratio which seems adequate,
deriving the outer barrel radius from the end cap outer radius by subtracting
an overshoot of 40mm and the thickness of the Ecal,
deriving the end cap front from the barrel length by adding an overlap distance of 70mm

These two numbers are related and also linked to the thickness of a possible ETD.

Drawing of the 2 options on top of the baseline

Black baseline
Red model 2
Blue model 3





Overshoot such that end cap inside Hcal barrel size : 40 < 15 + 30

Not knowing other technical reasons to define dimensions

And considering that these dimensions are in the reasonable range,
for testing alternatives
I would propose that we agree on these for new models
probably choosing a field of 4T for them.

Clearly that does not define everything.

It provides the start of the Hcal, not the end

It provides the end of the TPC, not the start
and that may be of interest
But we have to know what we do for the inner detectors, beam tube, ..

The SET is mandatory, could we hang it from Ecal ?   A WG ?
cooling

The ETD may be useful, two directions enough, what thickness ?

Considerations on L*, would we gain what we loose ?

I do not forget that it is likely that the start will be at 500 or rather 550 GeV :
We can in no way disregard the high energies.
Nevertheless the study at 1480 mm may provide a useful lever arm.

A wide discussion now is very useful

But it should be pursued by
a **working group** to clear up all what we have to know
before freezing any model
and write an explicit and comprehensive document.

To properly define what should be these two alternatives

The END