ILD ECal models

Henri Videau
Laboratoire Leprince-Ringuet

March 21 2017

Duty

We have the duty in the ECal group to provide a design and a simulation for
- a model close to the DBD baseline coined “baseline” with radius at 1843mm
- a small model where almost the only parameters to be changed from the baseline are the barrel inner radius and correlated quantities like the end cap outer radius. The barrel inner radius is defined as close to 1500mm

In addition we consider a version of the small model with a reduced number of layers.

All the information presented here is extracted from the
ECal Technical Design Document currently under development.
Its intent, content and extent have to be defined.
It can be found at
https://llrbox.in2p3.fr/owncloud/index.php/s/S0WrOA6CzINiFwZ
and I beg you to provide feed back and suggestions for this document.
there are contributions from many people, the editing is from Roman and myself.

at some point we may wish to be able to state
that we know how to build at least one model of the ILD ECal

Nota bene: the mechanical structure is meant to be usable for both Sc and Si Ecal but here quite a number of constraints are derived from the Si wafers.

Definition of the global parameters

Depth structure and ECal thickness

Considerations on the silicon wafers

The changes brought to the DBD baseline, definition of the realistic baseline
proposal for a configuration change to the baseline.

Lateral structure, wafers, alveoli, slabs

The “small” model

The 22 layer model derived from the small

Conclusions

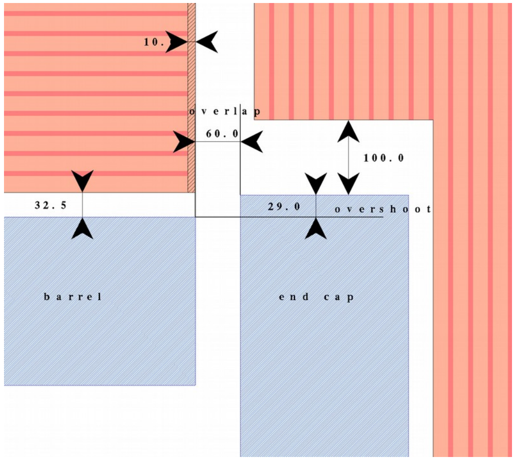
Once the design principles given: Barrel with 8 staves made of 5 modules carbon fibre structure with 5 alveoli columns per module, end caps with 4 quadrants and 3 or 2 modules; I leave aside the ECal ring.

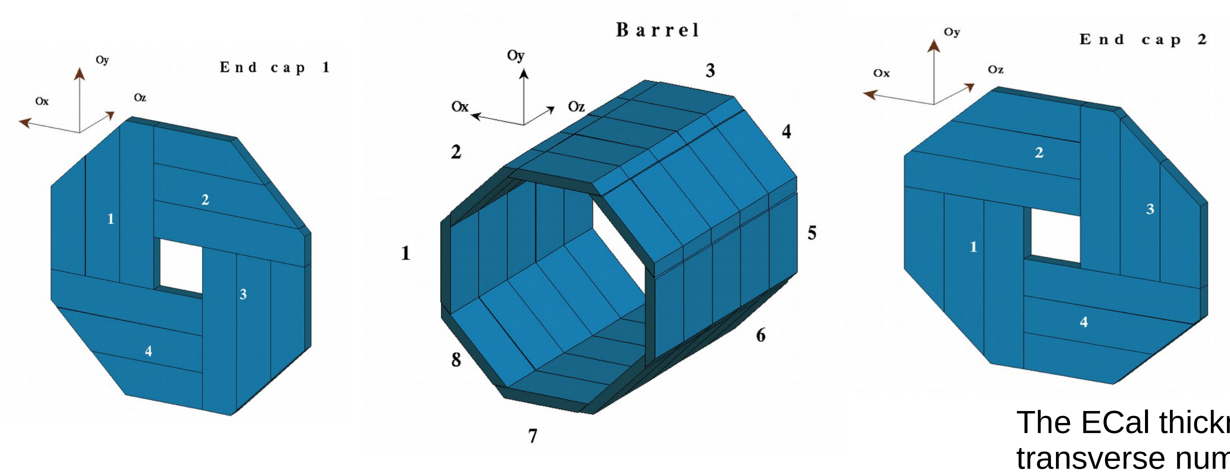
the main parameters are :

- the length of the barrel frozen to be equal in all models 4700mm

this is related to the wafer size and the module/alveoli structure

- the barrel inner radius defined as 1843mm for the baseline, 1500 for the others
- the front of the end caps linked to the barrel length through the “overlap” size
- the end cap inner radius frozen to be 400mm, linked to the detector inner part and the forward structure
- the end cap outer radius linked to ECal thickness and to the “overshoot” size

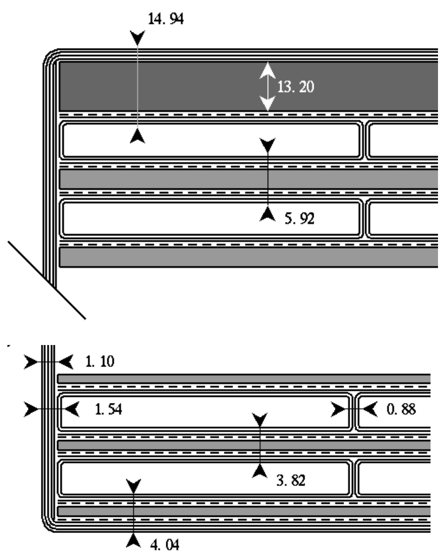




The ECal thickness appears as a technical constraint as soon as the total transverse number of radiation lengths is chosen (24).

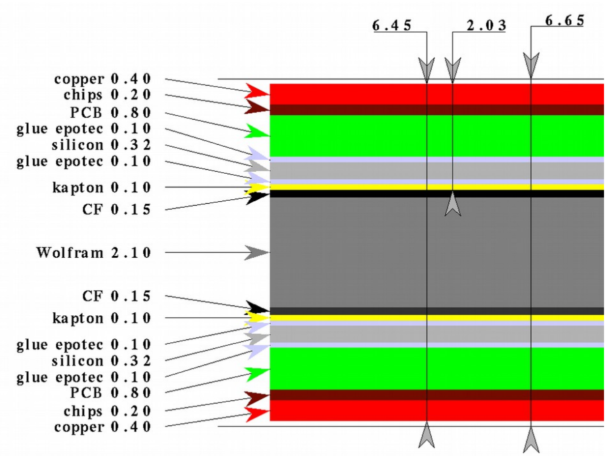
In the current design the ECal is made out of a carbon fibre structure embedding half of the tungsten plates and offering alveoli where slabs can be slid. The slabs have a tungsten core surrounded by the sensitive region.

The DBD design was very aggressive on the slab thickness and slightly aggessive on the structure.
Following the realisation of the EUDET module the structure has been reinforced by one more sheet of CF, which induces a tiny thickening.
For the slabs the DBD version had 325µ wafers instead of 525 and the PCB/chip design was very optimistic.
This has been revised which increases the thickness from 185 to 223 a 38mm increase.
For the end caps, it is necessary to add one more layer of CF around the modules

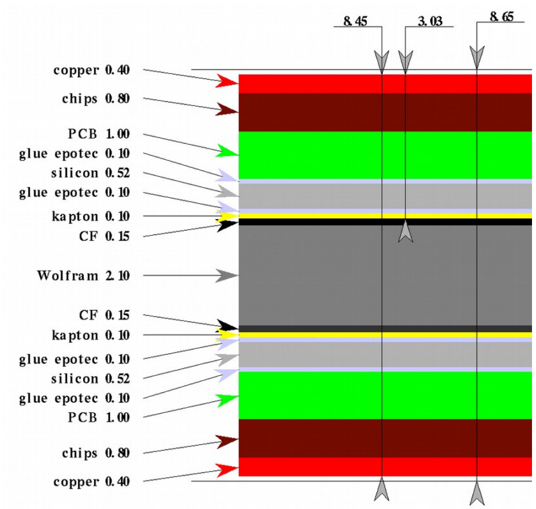


Scheme for the structure

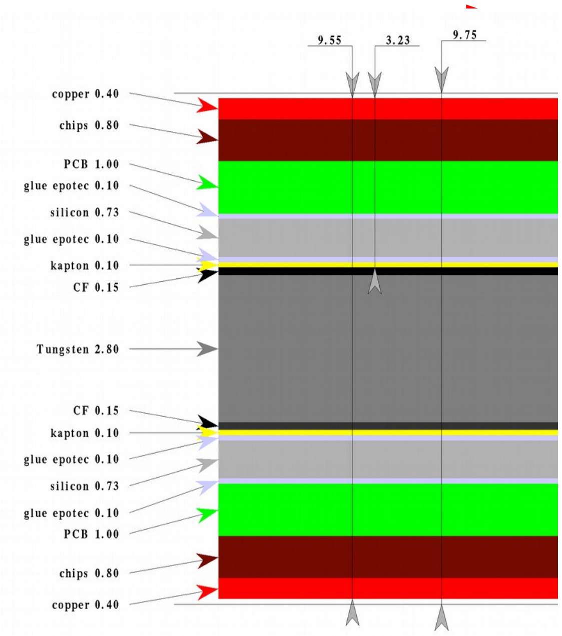
Scheme for the slabs



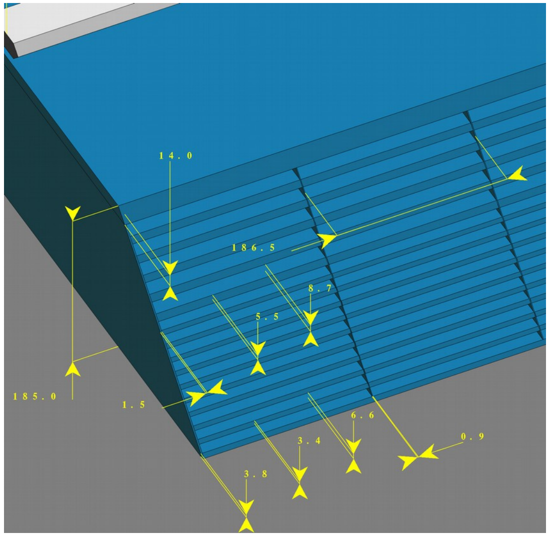
baseline slab structure



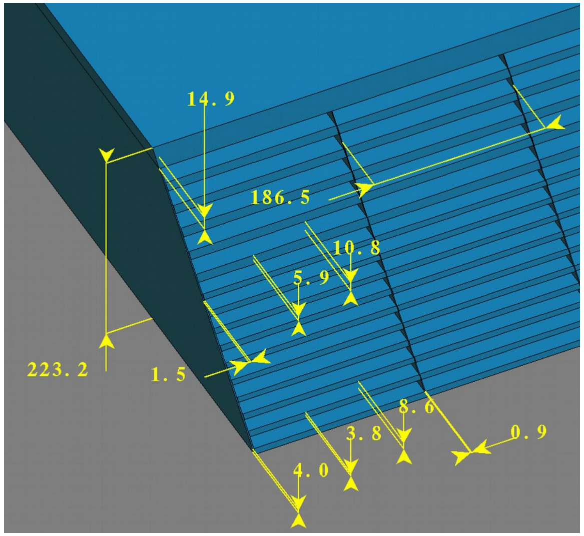
realistic slab structure



22 layers slab structure



baseline module structure



realistic module structure

in construction

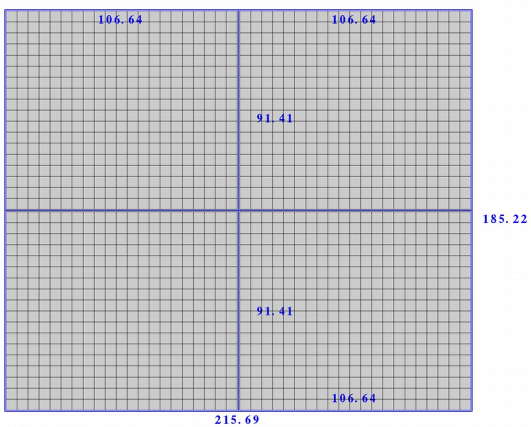
22 layers module structure

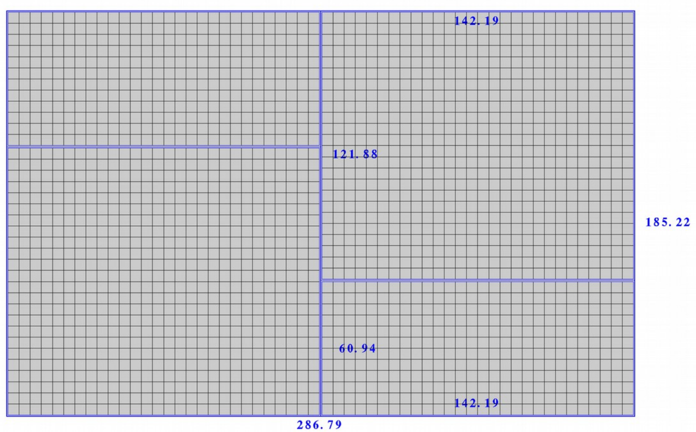
Therefore we request a configuration change
which goes beyond the sole ECal

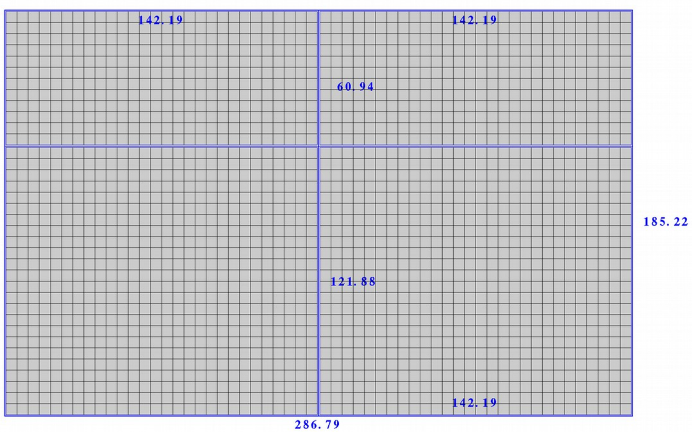
Insert a W layer in front of the first sensitive layer. Already agreed, no impact on interfaces.
Two rails instead of three to suspend a module. Already agreed, impact for the HCal interface.
Barrel length and inner radius kept unchanged.
The thickness of the ECal grows to 223.2.
The overlap gap size is reduced to 60 allowing the HCal end caps and followers (and L*) to stay identical but the TPC cables and patch panels have to be checked.
A clearance of 2.5mm is added to the gap between ECal and HCal barrels, there was none.
The ECal end cap outer radius grows to 2095.2 not needing any change to the HCal ring.
The inner radius of the HCal is brought to 2098.7

Points to check:
Reduced overlap size: check for the ECal cooling, TPC cables and TPC patch panel.
Impact of increasing the HCal barrel radius on the HCal and on the followers.

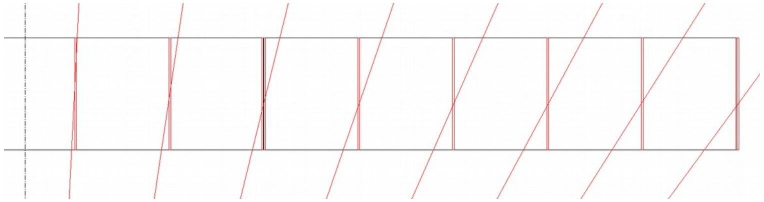
The barrel length plus the module and alveolar structure defines the transverse size of the alveoli (186.5mm) in which the slabs are slid.
Then we have to pave the slabs with Si wafers which can come from 150mm diameter ingots or 200mm (8”).
We can then have different models for the tiling which present different properties for the interwafer dead zones.







But except for the z=0 interwafer dead zone in the 150mm case (cured with 200mm) the main issues are the interalveoli, central specifically, and the intermodules dead zones.



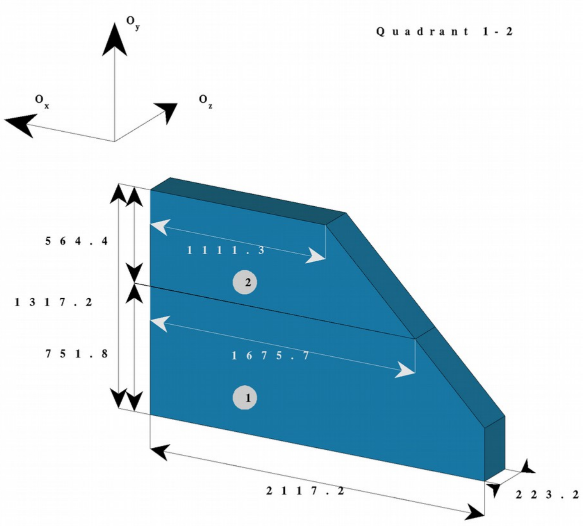
Proposal, simulation, decision?

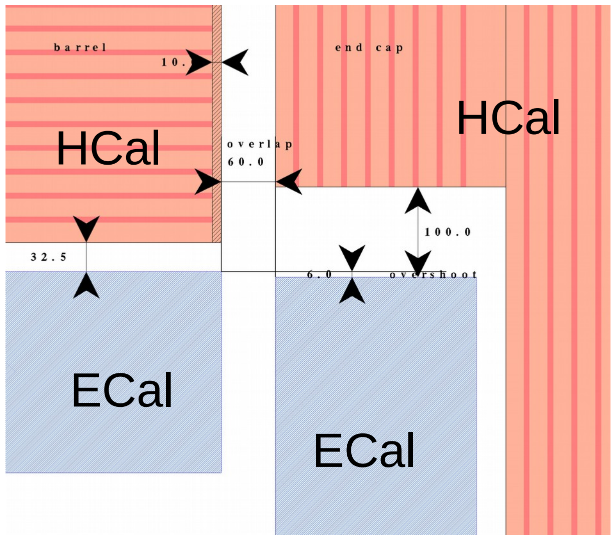
For your fun, the formulas on the right are provided in reverse polish notation

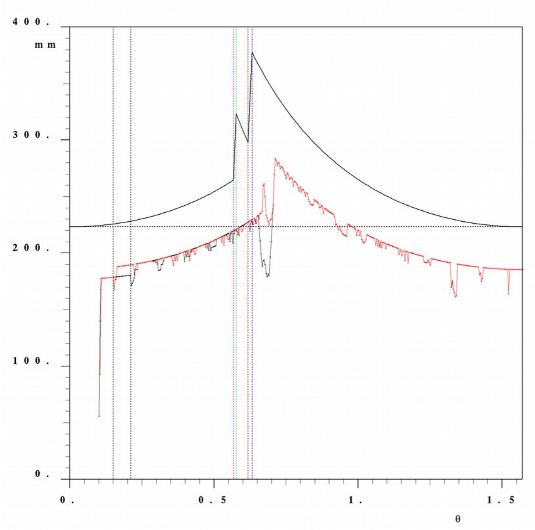
Code name	value	meaning	Formula
Ec_BA_stave_nb	8	Barrel stave number	Input kept
Ec_BA_mod_nb	5	Barrel stave module number	Input kept
Ec_EC_quad_nb	4	End cap quadrant number	Input kept
Ec_EC_mod_nb	3	End cap quadrant module number	Input kept
Ec_BA_L	4700.0	Barrel length	Input kept
Ec_BA_Z	2350.0	Barrel end in Z	Ec_BA_L / 2
Ec_mod_clearance	1.0	Clearance between adjacent modules in Z	Input kept
Ec_BA_phi_clear	2.0	Clearance between modules in phi	Input kept
Ec_BA_mod_Z	939.2	Barrel module length in Z	Ec_BA_L Ec_mod_play 4 * - 5 /
Ec_thickness	223.2	Calorimeter thickness	Derived from the inner structure
Ec_back_plate_th	14.9	Back plate thickness	13.2 Ec_CF_sheet_th 7 * + Ec_structil_th +
Ec_front_plate_th	4.0	Front plate thickness	Ec_CF_sheet_th 7 * Ec_structil_th 2 * + Ec_Wplate1_th +
Ec_BA_stave_back_width	1372.	Width of the back of the stave	Computed from radius and thickness
Ec_BA_stave_front_width	1818.	Width of the front of the stave	Ec_BA_stave_back_width Ec_thickness 2 * +
Ec_BA_iR	1843.	Inner radius of the barrel	Input kept
Ec_BA_oR	2066.2	Outer radius of the barrel	Ec_BA_iR Ec_thickness +
Ec_EC_iR	400.0	Inner radius of the end cap	Input
Ec_EC_oR	2095.2	Outer radius of the end cap	Ec_BA_oR Ec_overshoot +
Ec_overshoot	29.0	Overshoot of the end cap over the barrel	Input
Ec_BA_EC_clearance	60.0	Distance along z between barrel and end cap, also called overlap	Input
Ec_EC_iZ	2410.0	End cap front	Ec_BA_Z Ec_BA_EC_clearance +
Ec_EC_oZ	2633.2	End cap back	Ec_EC_iZ Ec_thickness +

This model is derived from the realistic baseline

The inner radius of the barrel is chosen to be 1500mm.
The barrel length is kept at 4700mm
The barrel structure is the same but for the slab lengths
The end cap outer radius is reduced and a quadrant can now be built
out of 2 modules, one with 4 alveoli, the second with 3. improved intermodule crack
The outer radius goes to 1717mm with a very acceptable overshoot of -6mm



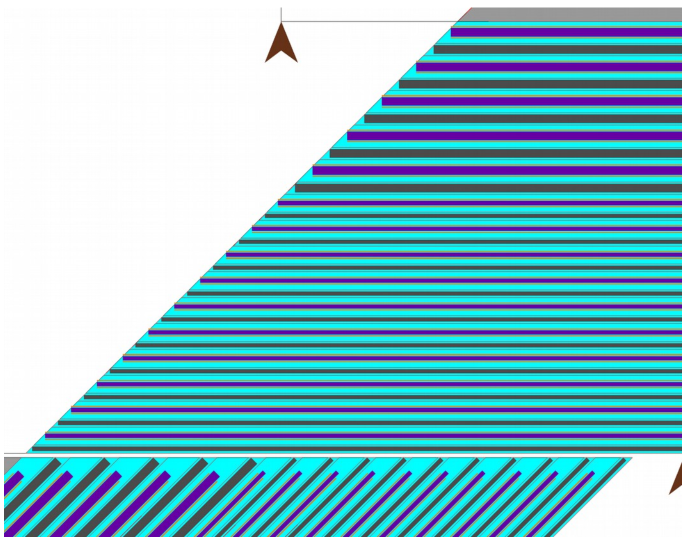




Depth of the calorimeter along a projective line, in red number of X0 in baseline by MOKKA

Slab terminations

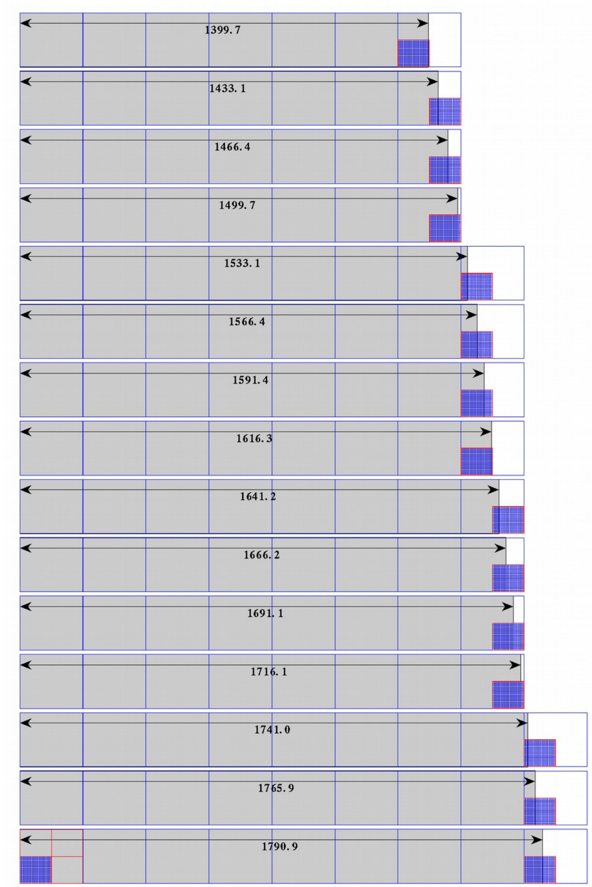
The model dimensions being given we can attempt to draw a sketch of the ASUs and diode matrices.
But we need to know about the slab terminations toward the electronic exit and the other



Where to fix the slabs?
dead zone created, impact

Hear Marc and Daniel

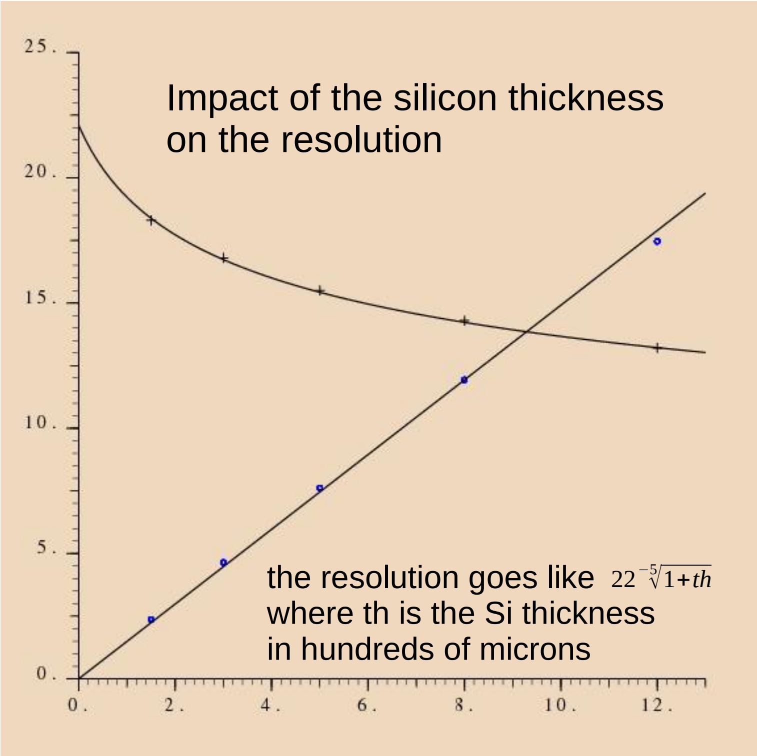
On the electronic exit side hear Roman
ending of the ASUs and matrices
space for the cooling.



In order to reduce the cost and improve marginaly the Moliere radius, hence the separation at the expanse of the intrinsic resolution,
we consider going to 22 layers instead of 30 (it was 29 but the tungsten was not amounting to 24 X0, thickness to be discussed anyway, leakage study)
but increasing the Si thickness to 725µ, if really feasible.
The first action degrades the resolution by 1.168, the second improves by 1.066 with respect to 500µ.

For the DBD the influence on JER was studied,
an effect smaller than 10% was observed
everywhere but the comparison was with
20 layers keeping the Si thickness at 500.
Study to be redone focalising on a precise design
for the intrinsic resolution and JER.

Remember that grossly the cost
varies from 150MILCU for 30 layers baseline
to 120 for 22 layers
and 95 for 1500mm radius.
-That will be redone,
-May be we should not choose 22, but an even #
-No reconstruction program does any
resolution optimisation.



For the global parameters all remains the same except
the ECal thickness, hence the overshoot.
The 22 layers are divided in 14 layers with 2.8mm thickness
and 8 layers with 5.6 shared between structure and slabs.

The ECal thickness becomes 190.1 close to the baseline thickness.

Details should be worked out but the main point
is to go back to the separation, resolution and efficiency to low energy
to assess better our performances.

We need manpower on the software/analysis side.

Three models being developped: realistic baseline, “small”, reduced layer #

they raise questions: configuration change to become realistic

choices remain to be done because they determine a little the performances through the presence of dead zones:

200/150mm ingots and interwafers aligned dead zones

staggered alveoli to cure interalveoli aligned dead zones

that concerns theta and phi behaviour.
but also inquire more about 200mm/725µm, resolution, which may need money.
Study of larger modules should be done, pursued, which need money.

The assessment of the performances remains largely to be surveyed, which is the purpose of defining these models.
A lot of work has been done but we still lack a lot of information

synthesis and a more evolved reconstruction.