SuperB
em calorimeter
endcap
Mechanics for BT
(and beyond)

Mechanics for BT: a spin off

Producing a sub-structure for the BT has manifold purposes

1) obviously Physics

2) Communication

   getting physicists and engineers **together**

2) Design

   addressing all possible issues and their evolution

3) Production

   making a first approach to **producers**

A possible line of action for BT

1- CAD drawing of the BT structure (INFN) in **June**

   Solve CAD - GEANT mismatch

2- Draft specification redaction in **June**

3- meeting with potential producer(s)

   (Italy? France?)

   early **July**

4- to adapt BT struct. design and launch production would need a few weeks

   ---> problem with **Summer vacations**

   possible delivery (reception-inspection at producer’s) in **late October (?)**

Baseline for BT structure

a) 5 crystals of rings 6, 7, 8, 9 and 10

option with back < 26,3mm

crack between nominal 0,4mm

b) crystal tolerances +0 -0,1mm

c) alveolar tolerance -0 + 0,1mm

d) minimum play 0,1mm (between xal max. and alveolar min.) to contain estim. max. deformation

e) resulting aveolar wall thickness 0,3mm

may change with producer's inputs **(see further)**

Wall Thickness and Crystal Tolerances

- The BT module will be manufactured without FEA. Wall thickness will be according to:
  - state of the art
  - producer's skill
  - delay
- crystal tendering and bidding can be run with sizes defined with 0,1mm uncertainty (common practice)
- crystal producers **should be able** to process to **+0 -0,1mm** precision
- FEA should validate wall thickness in time for placing the full crystal order with final dimensions

Problems with Crystal tolerances

a) crystal tolerances **+0 -0,1mm**

▲ Saint-Gobain claims **±0,1mm**

b) crack between nominal 0,4mm (cf. next)

c) alveolar tolerance -0 + 0,1mm (kept)

d) min play 0,1mm (between xal max. and alveolar min.) to contain estim. max. deformation assigns xal & alv. nominals

e) max play = min play + xal tol. + alv. tol.

0,3mm **(0,4mm)**

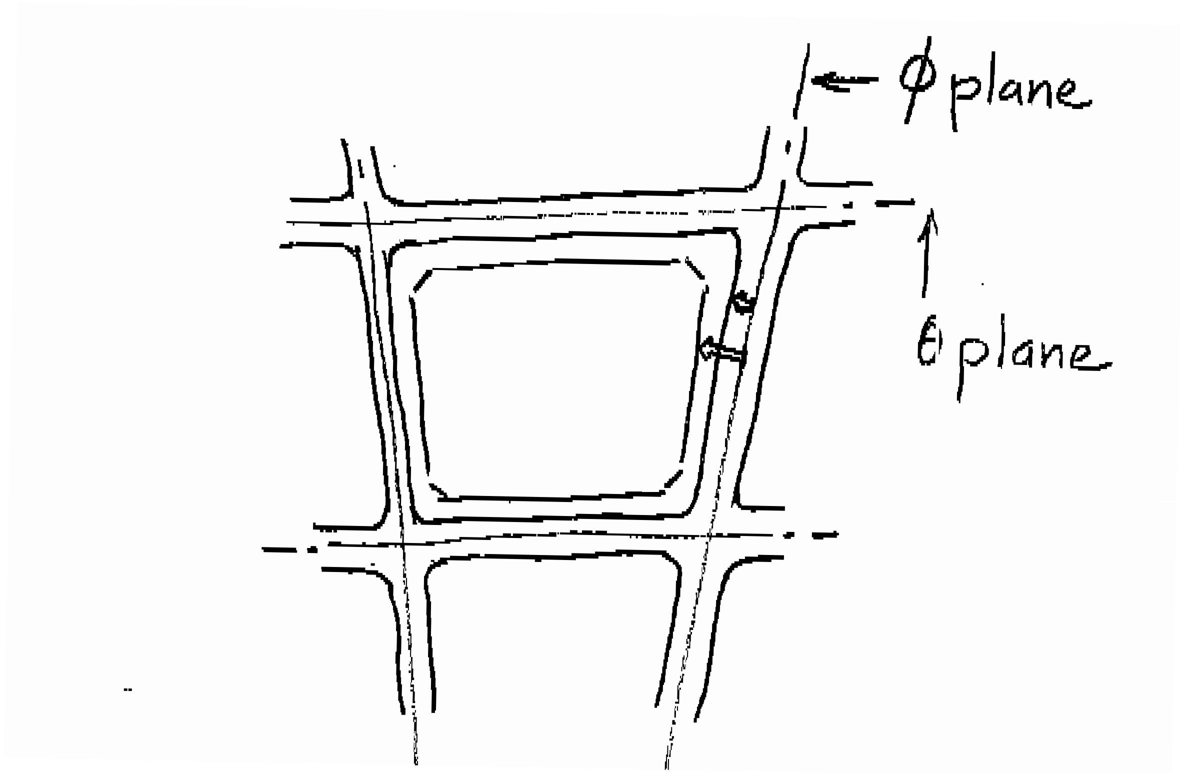
f) resulting alv. wall thickness 0,3mm (cf next)

g) Saint-Gobain tol. should be **+0 -0,2mm**

Problems with Crystal tolerances

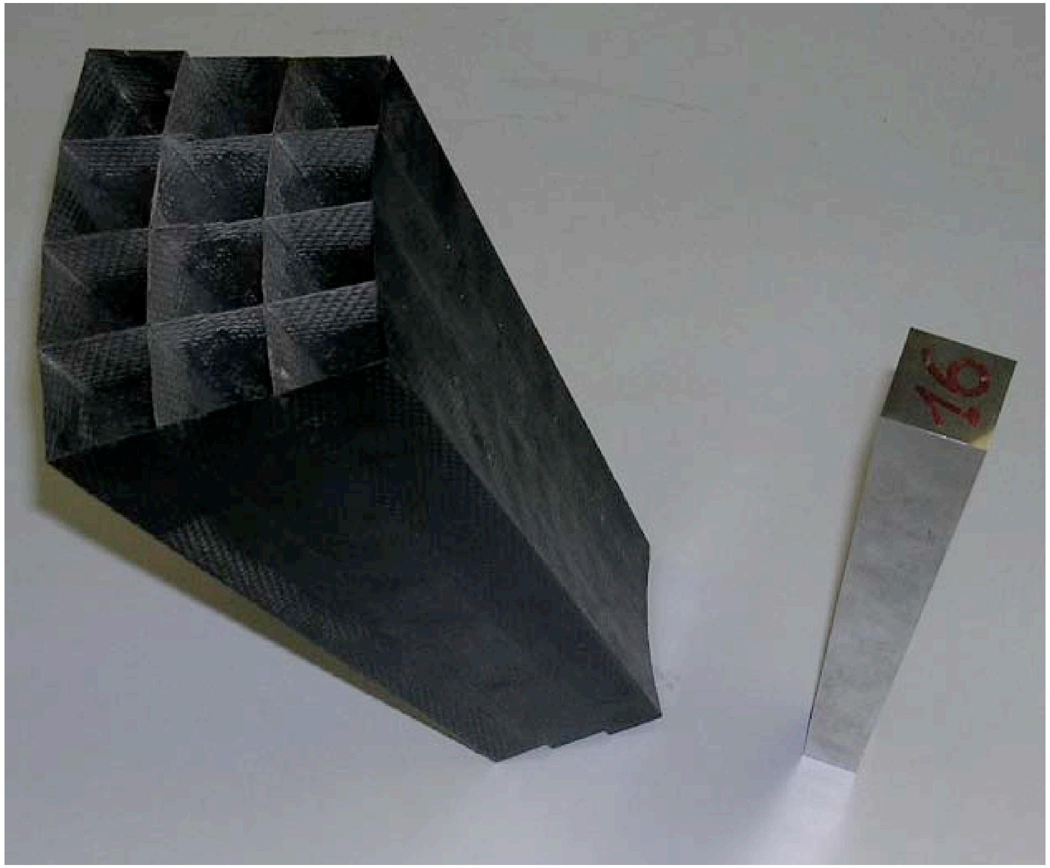
- Although designed for 0,3mm wall thickness, crystals can fit cells with 0,2mm walls, provided cells are shaped on the same mandrels
- There will only be a very small off-pointing effect in the crystal array

Problems with Crystal generation by CAD and GEANT



Attention! Volume generation by translation and rotation of **middle** planes, not by wall or crystal faces

L3 ECAL endcap alveolar



CFRP alveolar
of 3x4 cells and
inspection mandrel

BT Alveolar Production

Composition

- 2 or more pre-preg layers
- Inner lining of reflector

Assembly

- Wrapping (by hand) on mandrel
- layers do not overlap (gap)
- Gaps are covered by next layer
- Constant thickness all around

Process

- Wrapped mandrels piled into a mould with alveolar outer shape
- Press and cure
- Pull when cold
- Machine-finish ends

Reflecting foil from CMS ecal

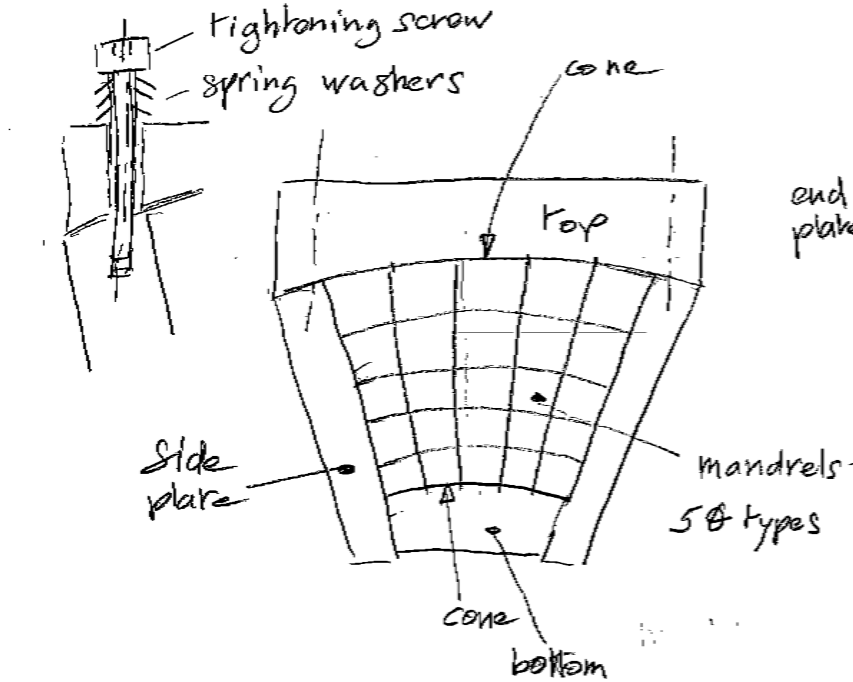
Supplied in 2000 to CMS by Frauenhofer, Dresden, DE

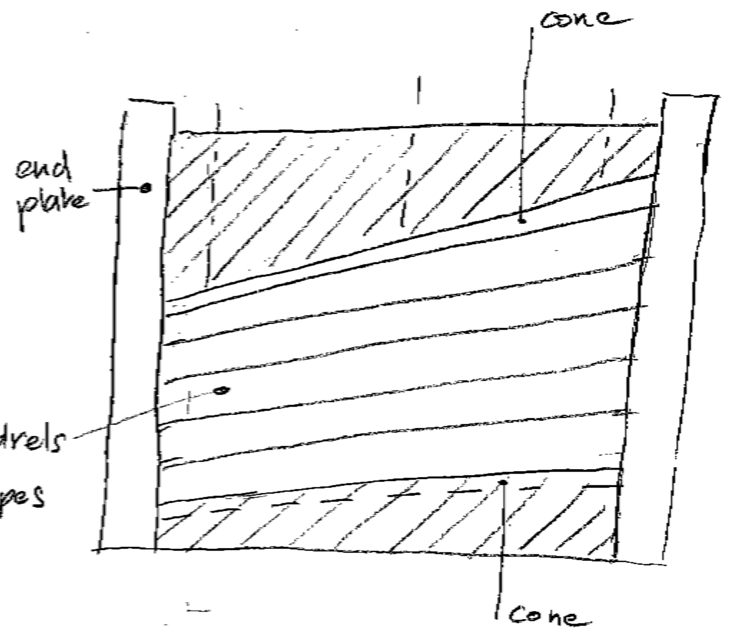
A few m^2 stored at CERN

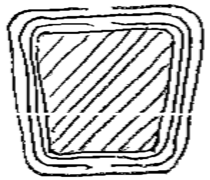
- 25μm Al (99,9%?)
- 3μm xparent glue
- 6μm PET xparent polymer
- 10nm Cr
- 90nm Al (vapour-deposited)
- 10nm quartz (vapour-deposited SiO_2)

May have been developed for GLAST (?)

Alveolar wrapping & moulding







Mandrel wrapping

1 conical bottom
2 endplates (//)
2 side plates (φ angle)
} Monoblock

1 conical top : mobile
25 mandrels

MOULD CONCEPT
2009 05 27 ML

Structural details

Even simple, the BT alveolar must integrate basic features of the final structure

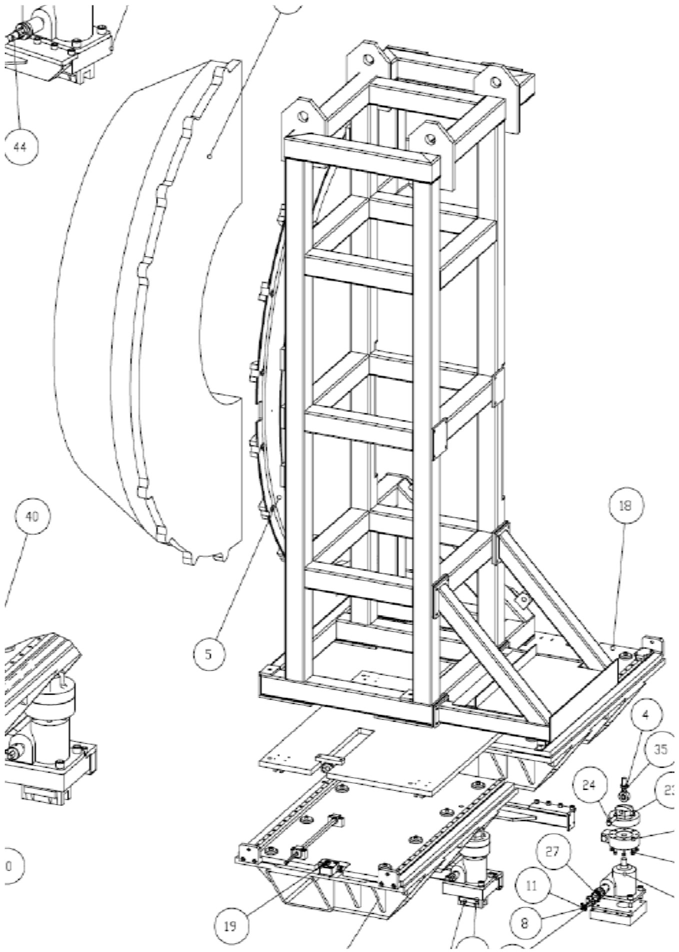
1. Open alveolar bottom for services (monitoring fibre, themal sensor, etc.)
2. Rear part of walls featured for mechanical connections
3. Optical layer

End Cap
Mechanical Structure
Projections onto Design

Re-use maximum of Babar End Cap installation tooling

pt.6 of David's minutes

Re-use maximum of Babar End Cap installation tooling



Inspection of existing tooling

Re-condition if required

Create ad hoc interface for new design

Retrieve the Interfaces of Babar Recycled Parts

pt.6 of David's minutes

Tentative Re-use of Babar End Cap Support Structure

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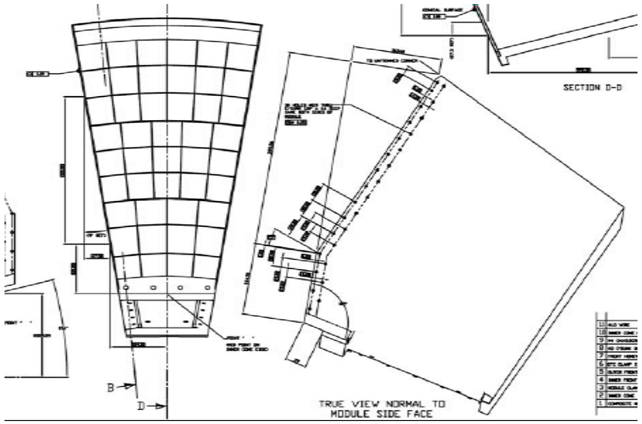
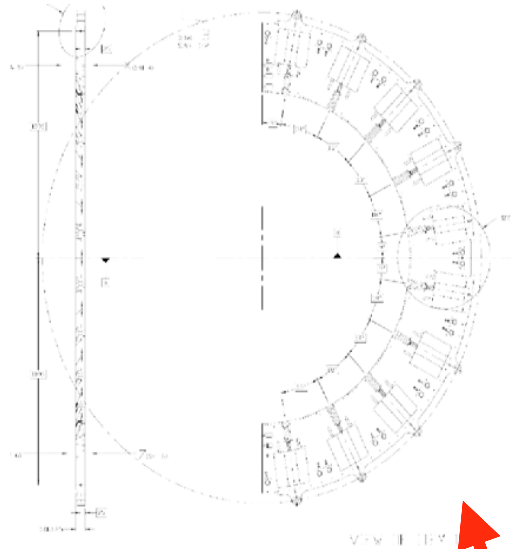
Re-use of Babar End Cap Support Structure





Different design concepts:
- Babar separate modular building blocks
- **SuperB integer alveolar structure**

Possible re-use of back plates?

Structural design bases

- The structural design **starting base** is inspired from previous similar structures (L3, Babar, CMS) **see arguments next**
- Design evolution (hopefully progress) will integrate information from
  - **BT** structure production itself
  - **Tests** specifically defined for structural information
  - Finite Element Analysis ***(FEA** specialist needed)*
  - Space for **services**
  - Boundaries imposed by **integration**

Discussion: no load sharing

Actually, the huge crystal mass of the endcap array plus the limits to its geometrical accuracy make the risk of crystal contact, load transmission and breaking very high if play as describe above is not guaranteed by design and construction. **The idea of uniform crystal load sharing remains theoretical**: would require in practice unaffordable technical and cost levels.

discussion: brittle crystals

LYSO, like BGO and PWO, are brittle minerals with high Young's modulus: stress quickly increasing with strain. LYSO mechanical properties are currently being studied at Ancona Polytechnical University on small samples ($5x5x100mm^3$) as compared to the SuperB sizes (ca $25x25x200mm^3$). In brittle materials where no compliance occurs, **breaking stress usually follows a scale law** that depends on defect types and density (Griffith, Weibull). For the L3 BGO we found $s_1 = s_0$ x sqrt (V0 / V1) with V the stressed volume.

Discussion: brittle crystals

Furthermore, LYSO is anisotropic: tests result and their application to actual SB crystals should take lattice orientation on account, if possible. Very aptly un-annealed and annealed samples will be compared. The annealing temperature is expected to be according to the crystal producer practical experience.

Discussion: crystal residual stresses

However, it should also be considered that **cutting down ingots into smaller pieces releases a considerable portion of the thermally-induced residual stresses** by changing the boundary conditions. Small samples, even un-annealed, may have much less residual stress than the large SB pieces (parabolic law).

Discussion: no load added to crystals

For these reasons a safe "egg-rack" concept is recommended to hold each crystal individually. The guaranteed minimum play of a crystal inside its alveolar cell should safely contain the maximum processing tolerance of both objects, plus the structural elastic deformation at the place of concern.

Discussion: boundary conditions vs. life phases

The strain field computation accuracy is limited by software performance (type and number of finite elements), geometrical simplifications, boundary conditions hypotheses, and also differences between actual and model materials. Deformations and displacements have to be considered for the conditions of every step in the life of the structure: Z vertical at assembly, then horizontal. Lifting, transport, installation and seismic accelerations have also to be introduced

Structural design bases

Support structure example:
a CFRP dish in the shape of
a *"Kugelhopf"* form

conical rim

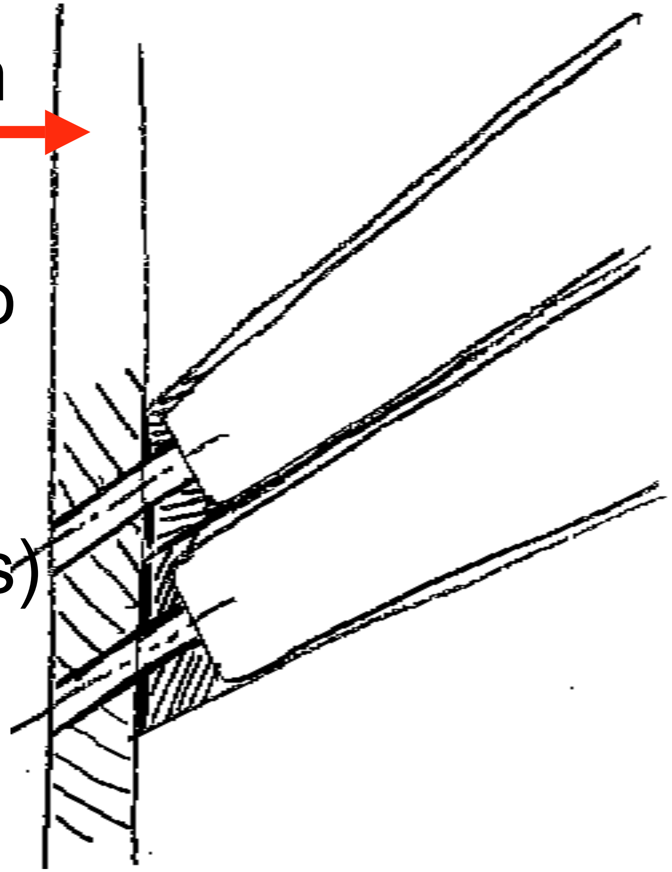
dish flat bottom

central cone ("*chimney*")

strut

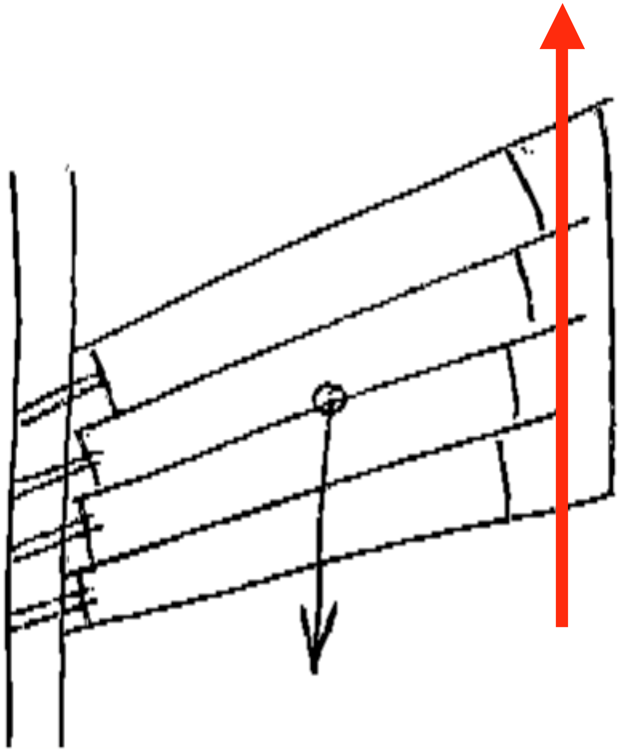
MODULE FRONT CONNECTION

dish flat bottom



Module connection to dish flat bottom is by gluing and use of shear pins (or dowels)

MODULE REAR CONNECTION

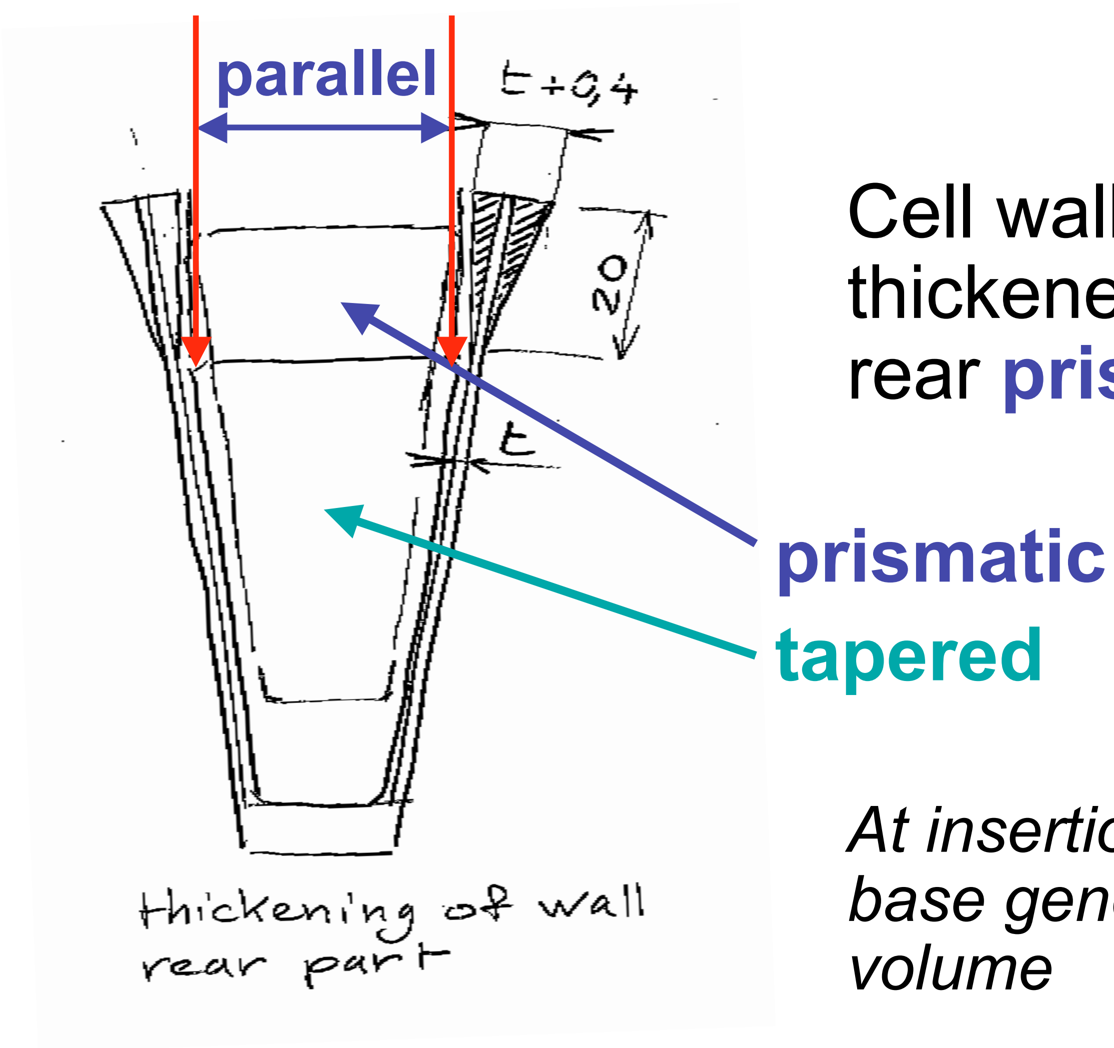


reduces the bending moment of the alveolar

A key feature of the structure

to be assessed by FE Analysis with some test inputs

MODULE REAR CONNECTION

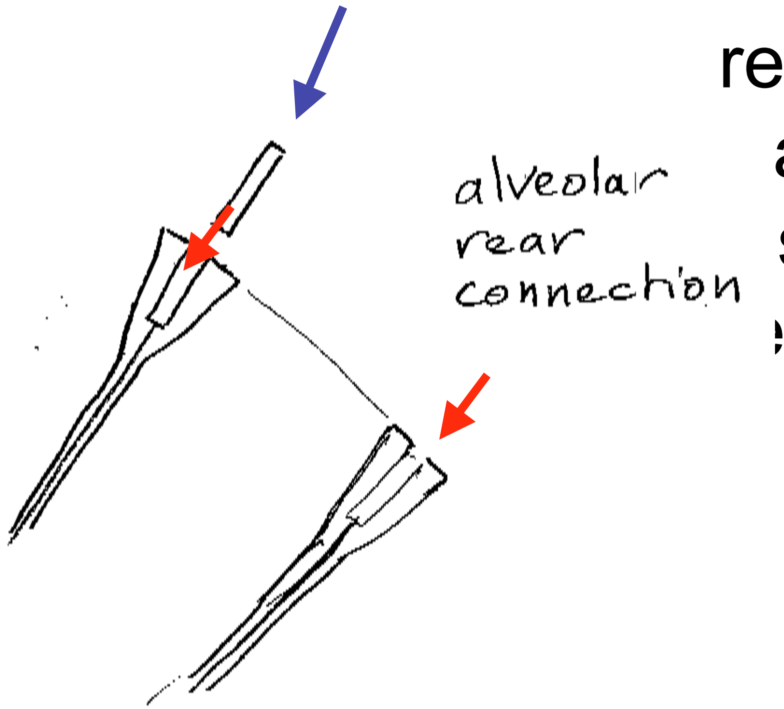


Cell walls can be thickened by making cell rear **prismatic**

At insertion the crystal rear base generates a prismatic volume

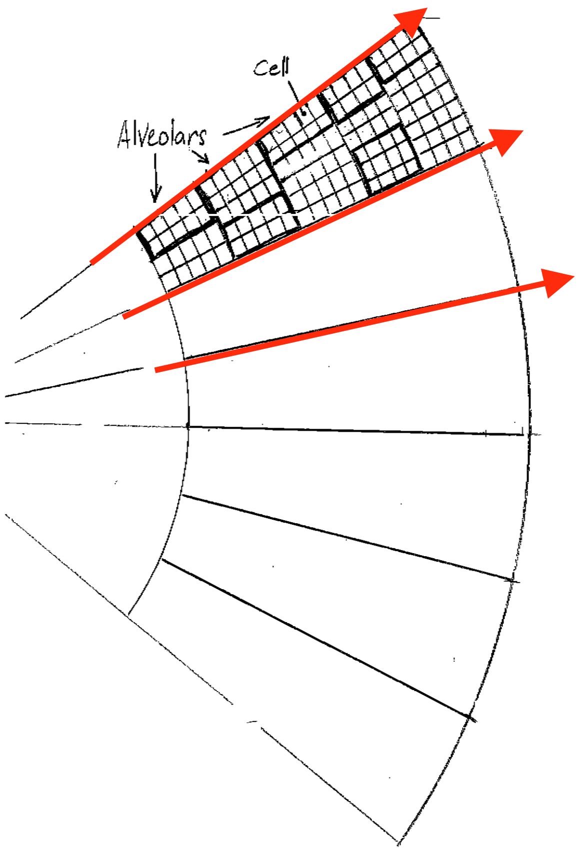
MODULE REAR CONNECTION

CFRP ribbon



rear (thick) end of cell
all can be recessed to
sert a connection
.g. CFRP ribbon)

MODULE REAR CONNECTION



- Rear part of cell walls results after module assembly in a kind of rigid **lattice**
- Radial (straight) connections can only go through modular splits given by some ϕ **symmetry**
- ϕ symmetry contributes to precision in the construction process by forming **assembly steps**

Symmetry

pt.5 of David's minutes

- The two new geometries in Perugia document 2008 05 08 have only one ϕ symmetry of 5, which is used for the modular cell array ($\phi x \theta$ = 5x5 and 5x3)
- After division by 5, the ϕ numbers (i.e. how many modules in one ring) have no common multiples
  - case 1: 35 - **41** - 45 - 53 **41 chosen for BT**
  - case 2: 33 - 36 - 40 - 45 - 53 - 50 - 54
- This poses a problem for the modularity of the full endcap, **even in one solid ring**, to make structural connections at the rear

Symmetry exercise

Number of 5x5 modules in case 1:

35 **41** 45 53

Suggested evolution for symmetry 2 x 3

36 42 48 54

i.e.

6x6 6x7 6x8 6x9

Size changes in R$\times\phi$

-2,86% -2,44% -6,67% -1,89%

DESIGN RULES

*What are the Rules applied to **Follow-up** and to **Review** the Design and Construction Progress?*

What are the Design & Construction ***Standards*** *at LNF?*

What are the
Seismic Rules
applied at LNF?

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