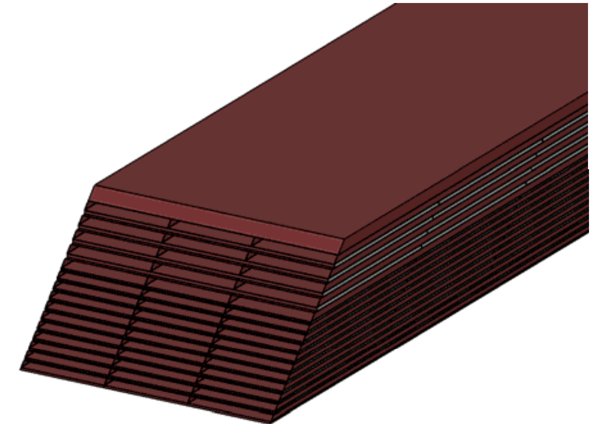
CALICE
Calorimeter for ILC

Mechanical Status of EUDET Module



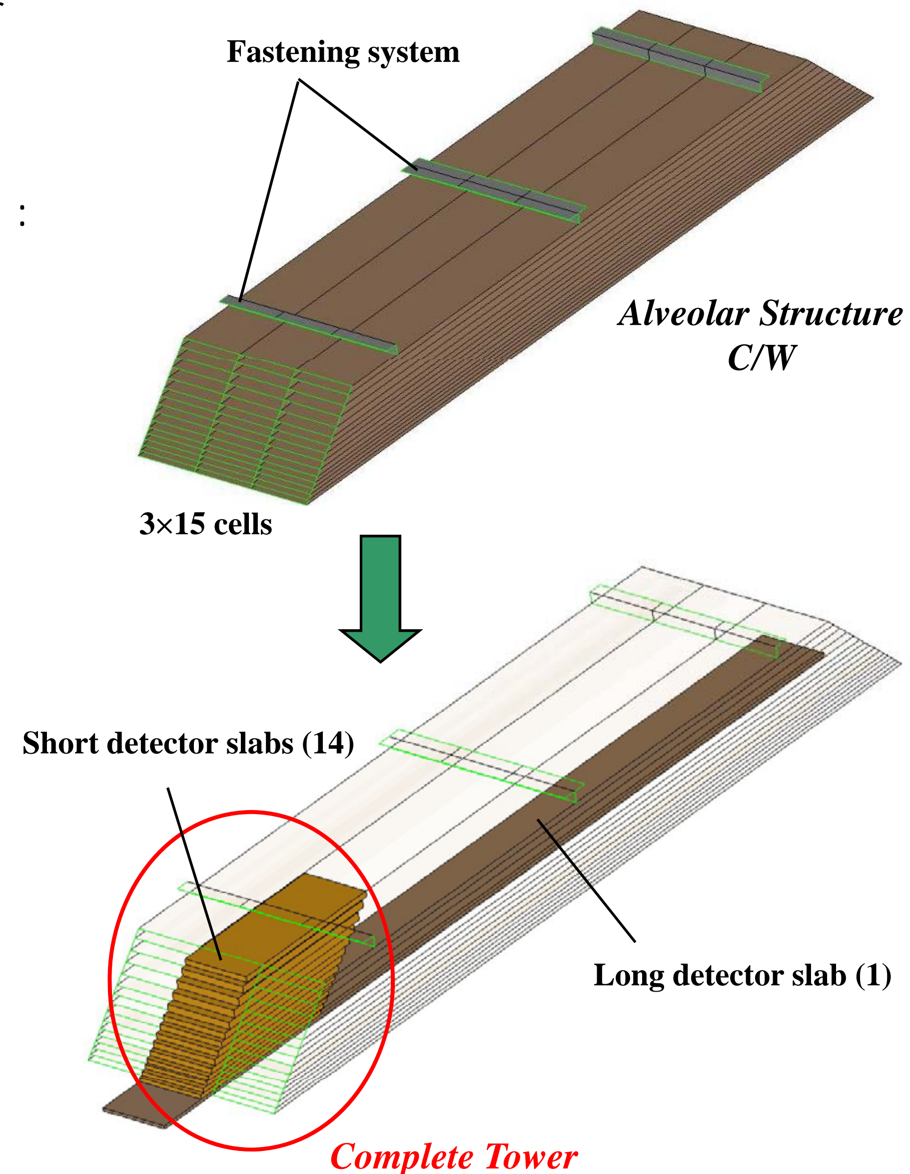
Marc Anduze – 05/04/07

Presentation of EUDET Module

Calorimeter for ILC

Concept : to be the most representative of the final detector module :

- A alveolar composite/tungsten structure with :
  - same W sampling
  - 3 columns of cells to have representative cells in the middle of the structure (with thin composite sheets)
    width : 124 mm ➡ 180 mm
  - Identical global dimensions (1.5m long) and shape (trapezoidal)
  - fastening system ECAL/HCAL (include in the design of composite structure)
- 15 Detector slabs with FE chips integrated
  - 1 long and complete slab ? (L=1.3m)
  - 14 short slabs to obtain a complete tower of detection (typ. L=40 cm)
  - design of compact outlet (support system)



Design of the module…

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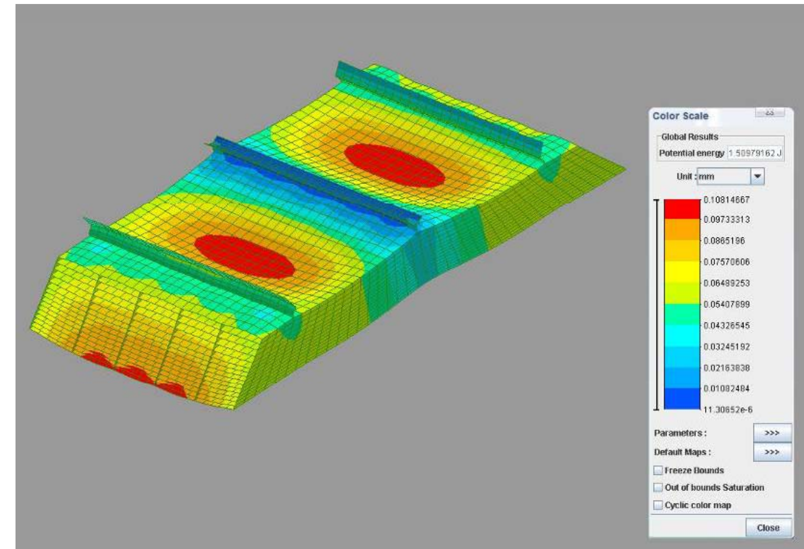
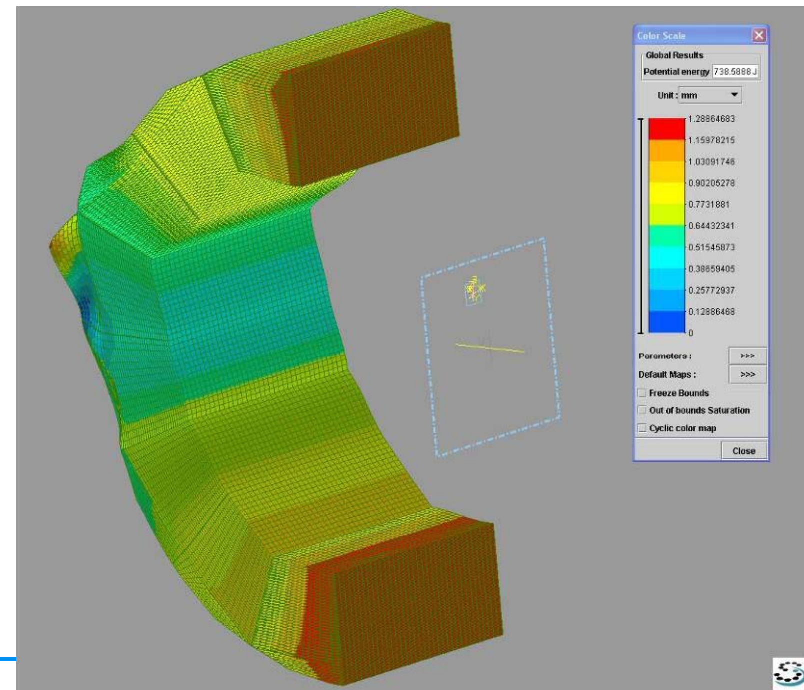
… based on mechanical simulations :

Linear Analysis of "full scale" ECAL and HCAL modules

- Global simulations : global displacements and localization of high stress zone for different solutions (dimensions)
- Local simulations : more precise simulations and study of different local parameters to design correctly each part of this structure (thickness of main composite sheets, choice of fasteners : metal inserts, rails…)
- Check and validate simulation results by destructive tests for each issues





Design of the module …

… while taking into account Slab Thermal analysis

Thermal sources:

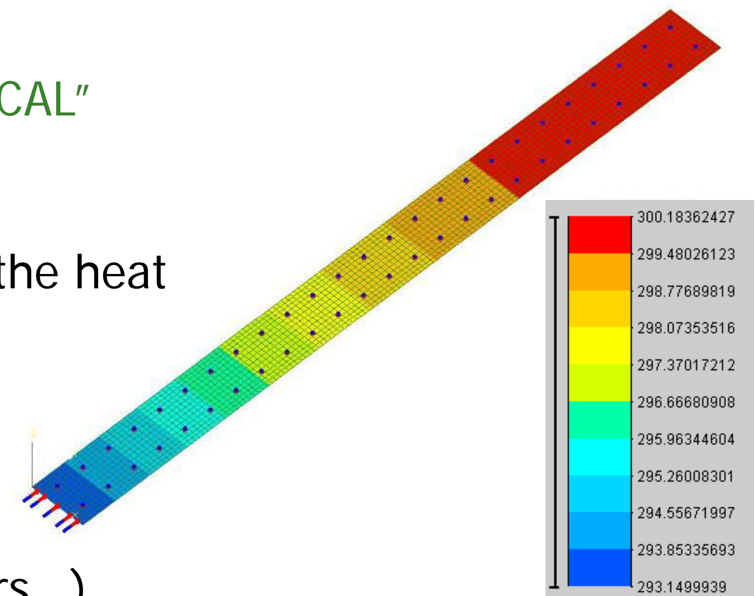
Pad size	Chan/ wafers	Ch/chip	Chip/wafer	Chip size mm²	Chan/barrel	Chan/ End-cap
5*5 mm ²	144	72	2	15x15	60.4 M	21.8 M

⇨ CALICE ECAL: ~ 82.2 M of channels

Assuming that the chip power is 25 μW/channel
total power to dissipate will be : 2055 W

⇨ external cooling OK for the "full scale ECAL"

inside each slab :
necessity of cooling system but active or passive ?
Ex: Pessimist simulation of heat conduction just by the heat shield : λ = 400 W/m/K (copper) ; S = 124*0,4 mm^2
L = 1,55 m ; $\Phi = 50^* \Phi_{chip}$ = 0,18 W



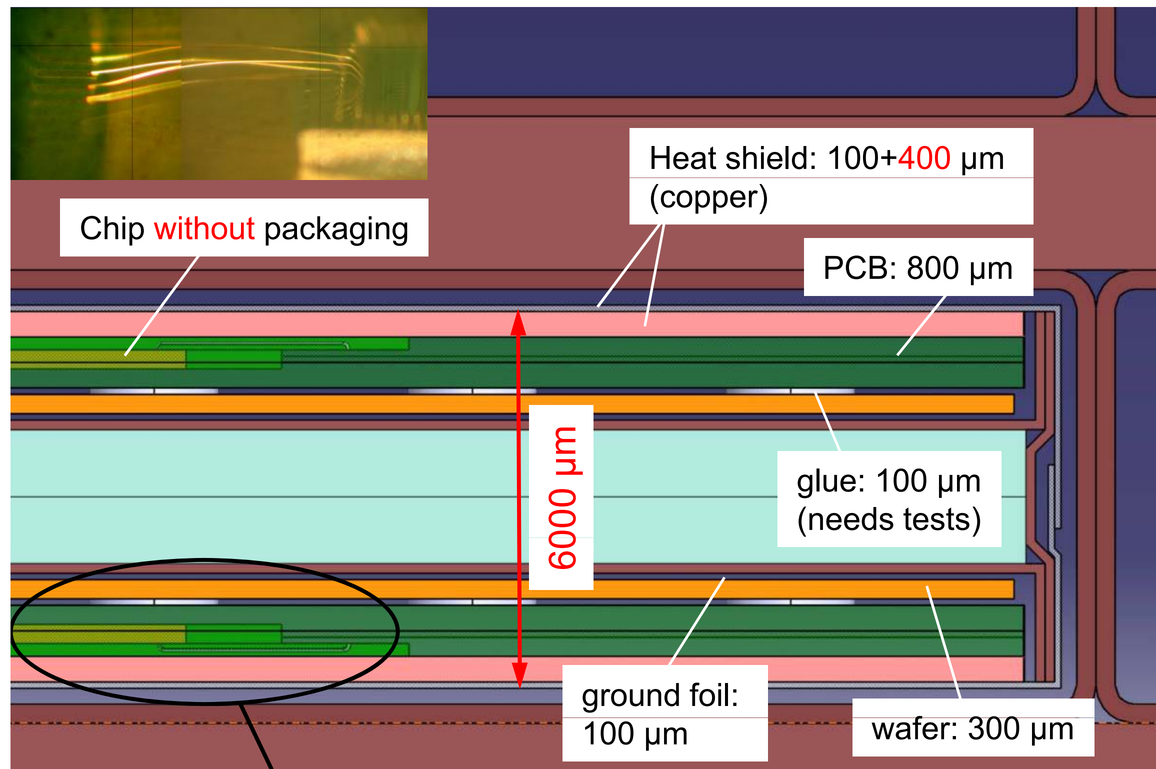
We can estimate the temperature difference along the slab layer around 7°C and without contribution of all material from slab (PCB, tungsten, carbon fibers…)

⇨ passive cooling OK :

Thermal conductors (heat shield) can be added in the slab to carry heat more efficiently along the slab direction.

Design of the module…

… based on the definition of the detector slab :



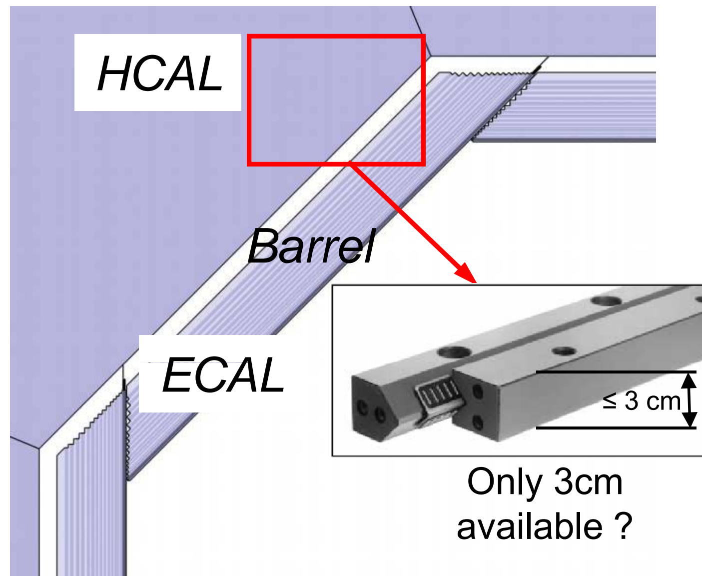
Chips and bonded wires inside the PCB

Design EUDET Slab

The alveolar thickness is defined by :

- ⇨ Gaps (slab integration) : 500 µm - OK
- ⇨ Heat shield : 400 µm ?
  but real thermal dissipation (active cooling ?)
- ⇨ PCB : 800 µm with interconnection ?
- ⇨ Thickness of glue : 100 µm ?
  size of dots ?
- ⇨ Thickness of wafer : 300 µm ?
- ⇨ Ground or isolate foil : 100 µm ?
  AC vs DC ?
- ⇨ Thickness of W : 2100 µm - OK
  and 4200 µm - OK

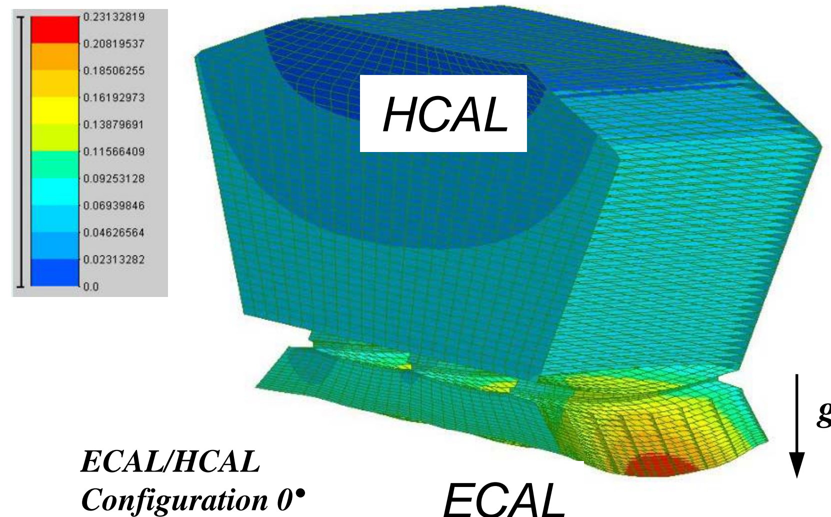
Design of the module …



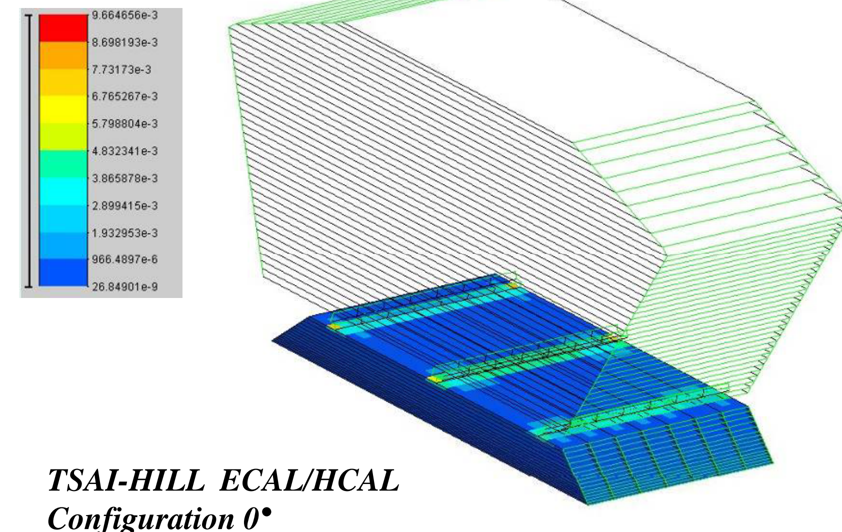
… including the ECAL/HCAL interfaces :

The fastening and connection system for the EUDET module has to be representative of the ECAL/HCAL interfaces.

- Choice of fasteners : rails directly glued on composite or metal inserts inside the structure ?
- Mechanical simulations of the ECAL/HCAL interface to take into account its influence
- Design of connection system (power supply + cooling + outlets) : backend system ?

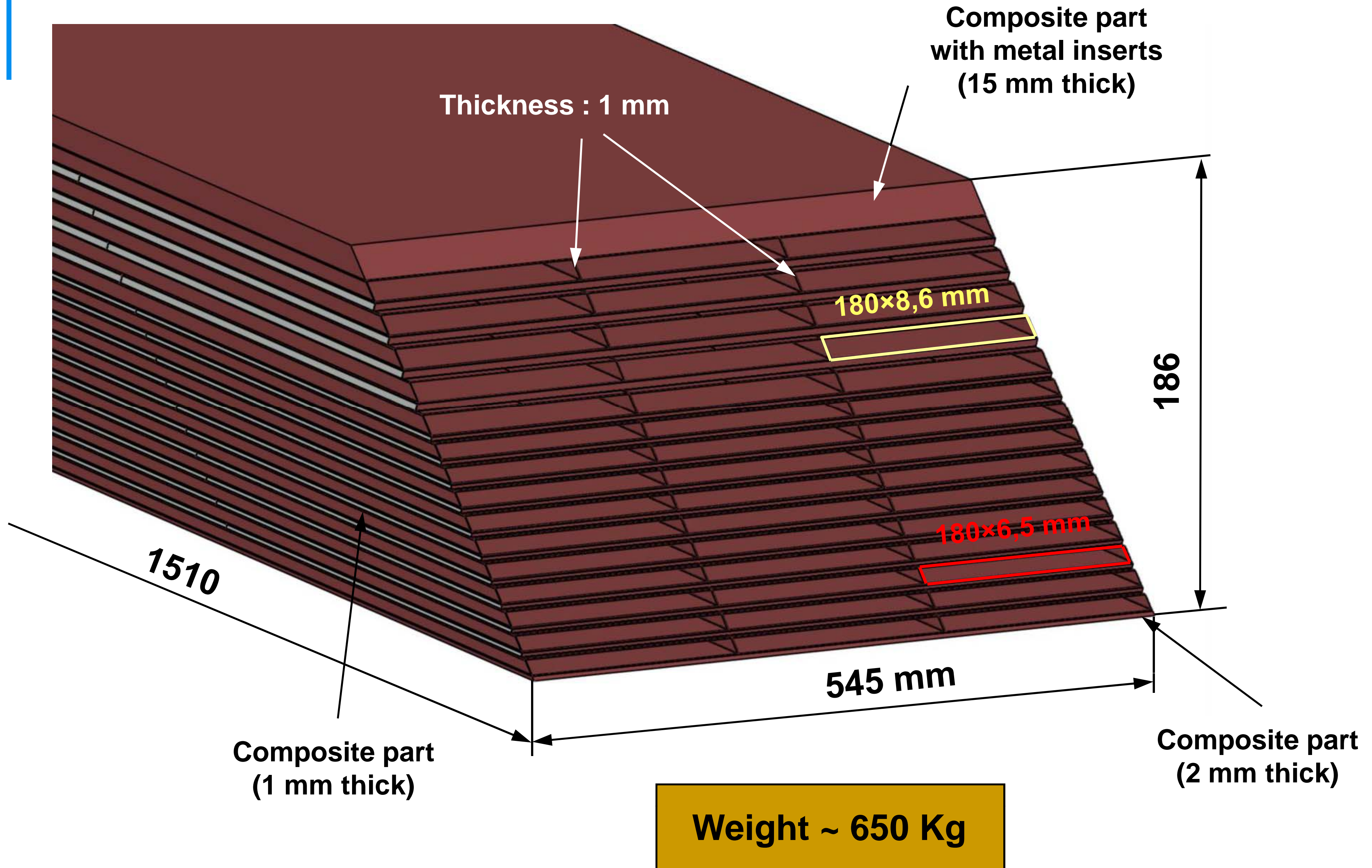


ECAL/HCAL Configuration 0°



TSAI-HILL ECAL/HCAL Configuration 0°

The Design of Eudet structure



Composite H structure

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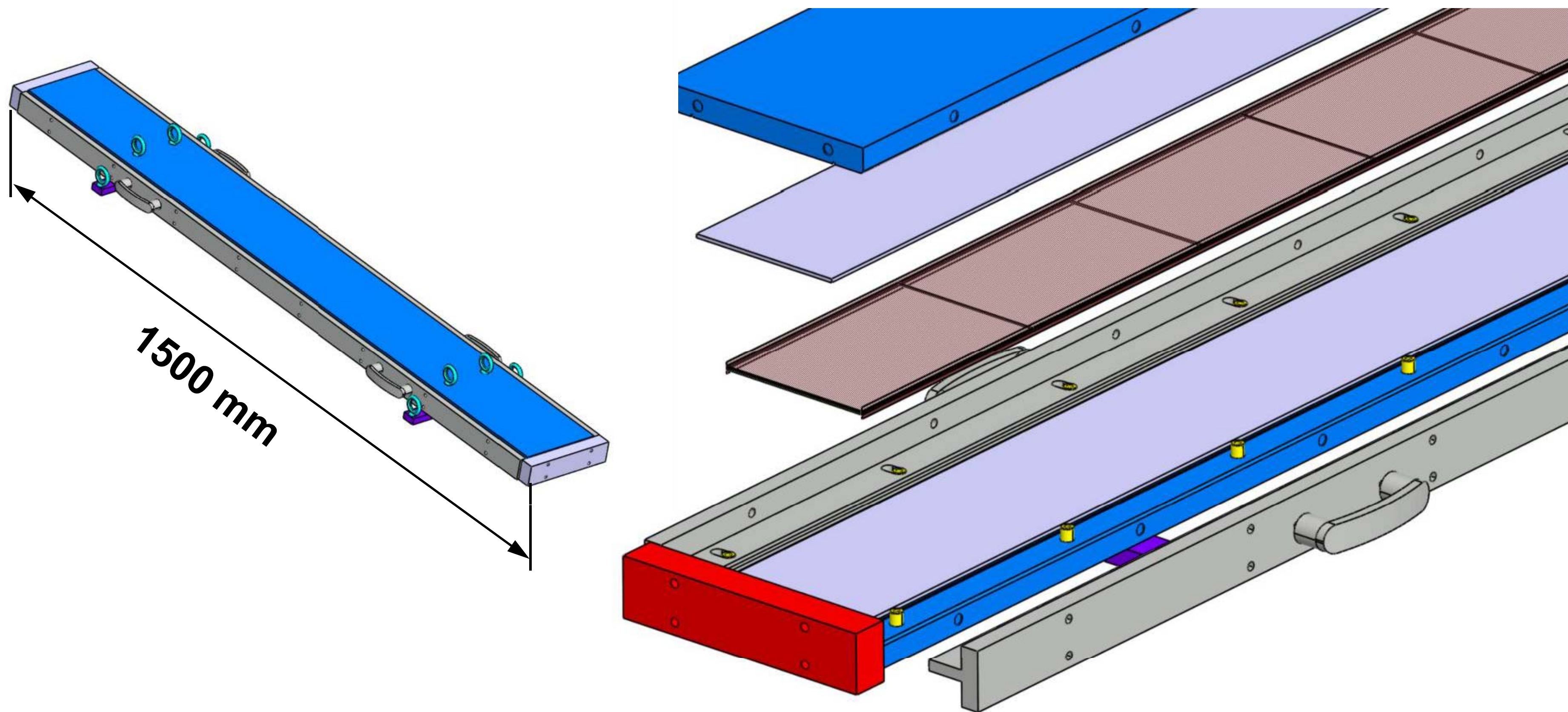
Study and definition of the long mould :

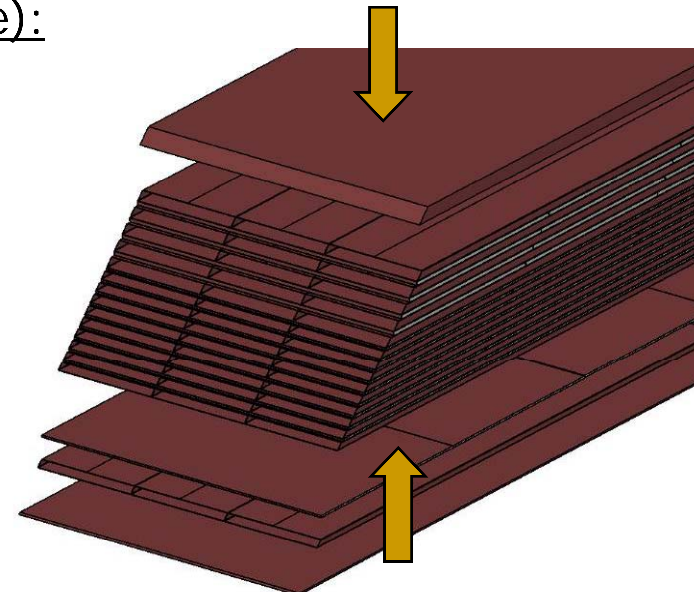
- Same principle than the mould used to do H prototype structures
- One mould for long and short structures



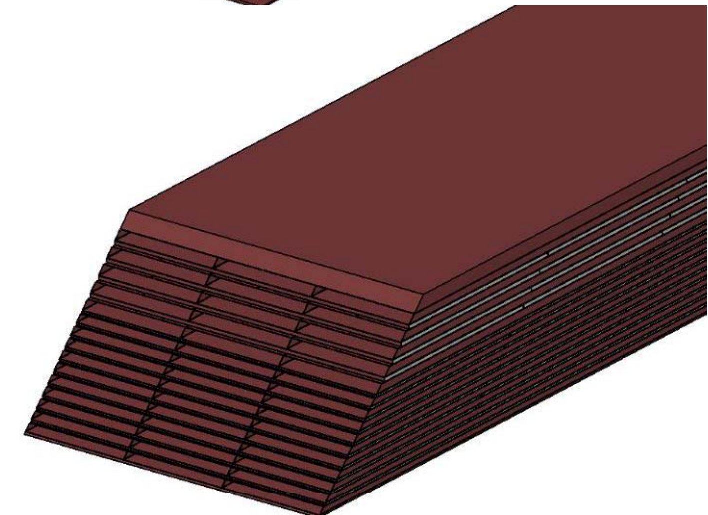
Composite Alveolar structure

<u>Study of different principle (with industrial expertise):</u>

- *Principle #1* : Assembled structure
  - Each alveolar layer are done independently, cut to the right length (with 45°) and assembled with W plates in a second curing step
    - Individual inspection and choice
    - Limit risks to lose W plates
    - Reduction of cost (simple moulds)
    - 2 polymerization process : 2 moulds
    - Mechanical ability of "gluing" structures



- *Principle #2* : "monobloc" structure
  - One curing step to obtain the final structure
    - Final piece in one step
    - Better mechanical ability
    - Only one but more complex mould (45 cores)
    - Curing problems : thermal inertia, weigh of metal mould, control of curing parameters …
    - Important risks to fail the structure : what about W plates ?



« Alveolar layer » mould

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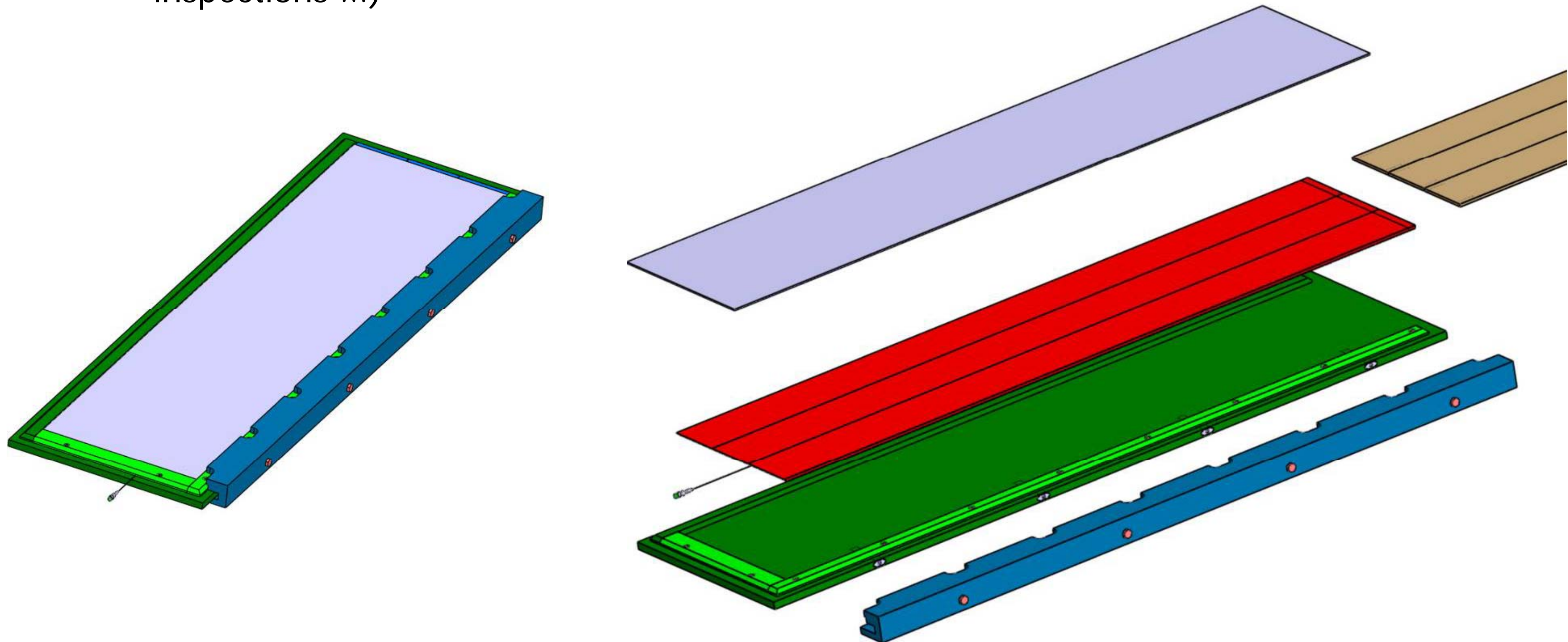
- <u>Study of one first concept based on principle#1 :</u>
  - Design of one mould for all alveolar layers
  - Possibility to integrate optical fiber with Bragg grating for Tests-Simulations Dialogue
  - The length of each layer will be obtained by machining one side (tools)
  - First samples will use to study mechanical behavior (destroy tests, dimensional inspections …)



Detector slab - principle

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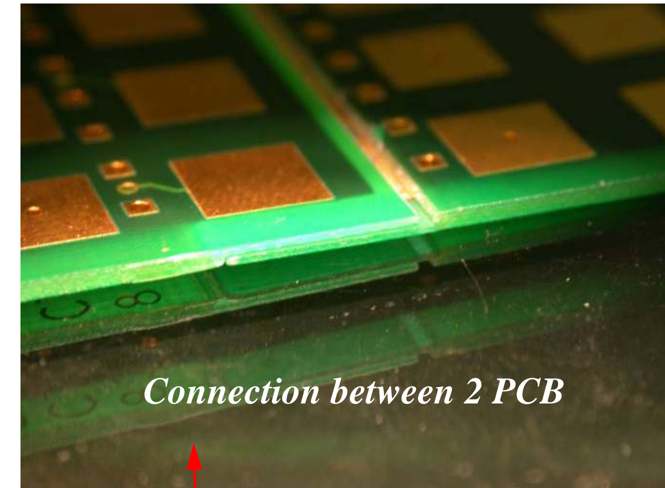
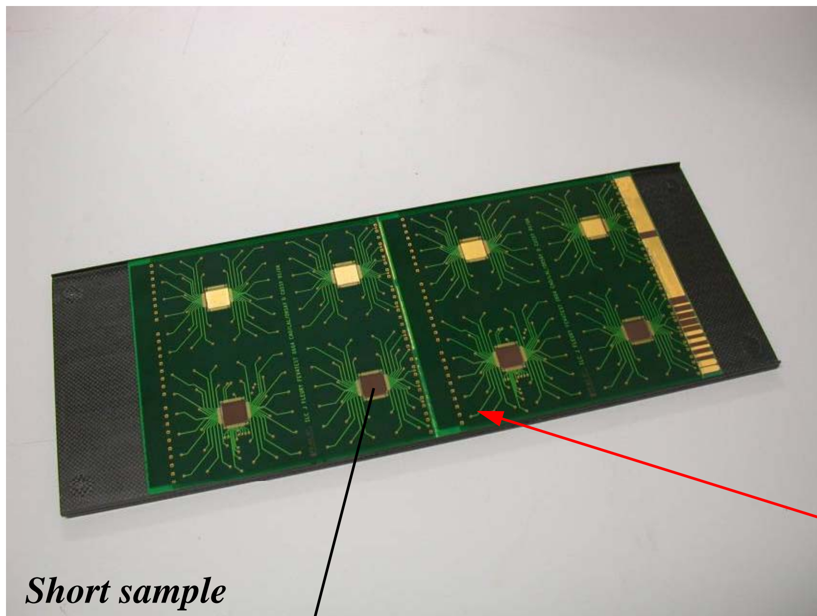
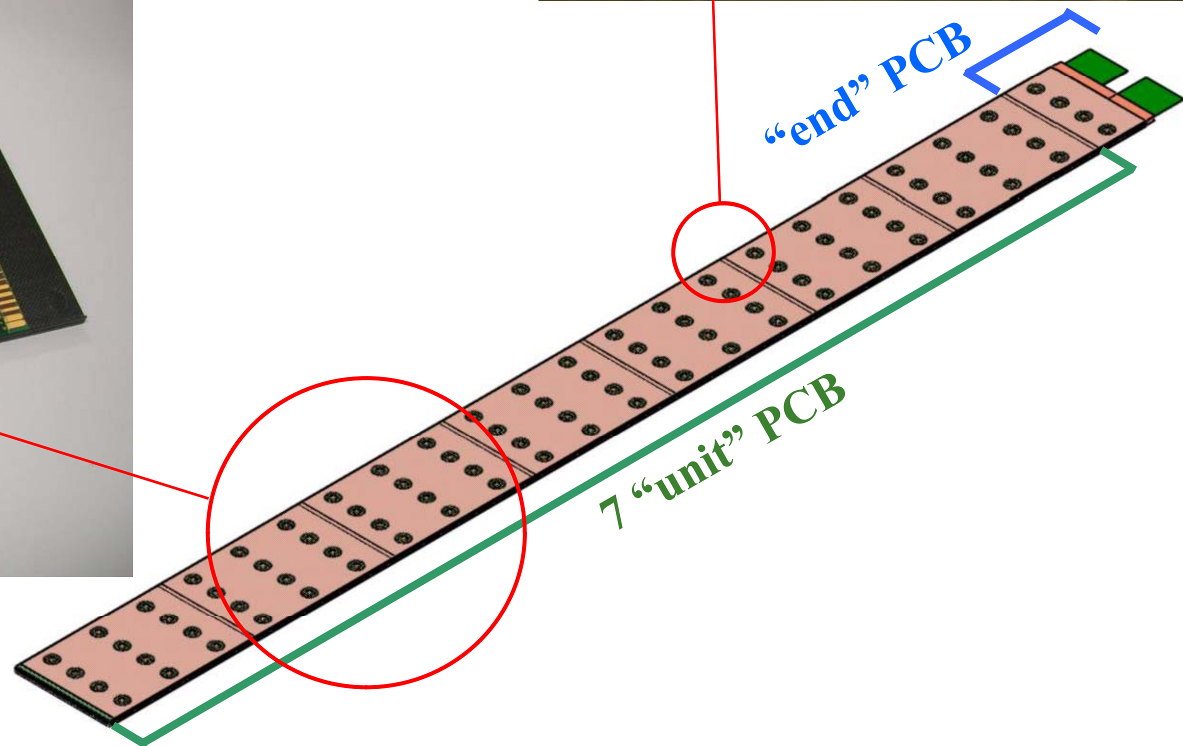
- Long slab is made by several short PCBs :
  - Design of one interconnection (glue ?)
  - Development easier : study, integration and tests of short PCB (with chips and wafers) before assembly
  - The length of each long slab will be obtained by the size of one "end PCB" (tools)







R&D – Cost

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Based on physical prototype

(EUDET part) → **used**

mould structure H	Internal/External	12 k€
Validation H model (20kg of W, composite)	Internal	4 k€
Design, mechanical and thermal, simulation	Internal/External	25 k€ **(22 k€)**
industrial partner	External	100 k€ → DDL expertise : 29 k€
Studies (fasteners, composite sheets …)	Internal/External	20 k€
mould alveolar structure	Internal/External	120 k€ **(70 k€)** → 1 layer mould : 21 k€
Transport tools	Internal	8 k€
Fabrication of the structure (500 kg of W + 100 m^2 of composite)	Internal	75 k€ **(60 k€)** ; 8 k€ → 70k€ (+40 k€) ; composite : 10 k€

Schedule 2007-2008

Timeline: Dec 2006 – Mar 2008 (2007: Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec; 2008: Jan, Feb, Mar)

ID	Task Name	Bar label
2	**Mechanical concept developpement**	
3	W selection and supplying	IR 20%
4	Dimensionnal inspection (W)	T 100%;external ?
5	mechanical studies (global simulations)	IR 30%
6	DDL expertise reports	
7	Mechanical concept available (2 concepts)	29/12
8	**EUDET alveolar structure design**	
9	**concept 1 (assembled structure - 124mm)**	
10	**first alveoar structure layer**	
11	**design and construction mould (optical fiber ?)**	
12	design	
13	construction mould	external
14	structure test	IR 50%;T 50%
15	**length machining process (tools, industrial partners)**	
16	study cutting solution (with industrial partners ?)	IR 20%
17	tools	IR 20%;T 50%
18	first complete structure	T 50%
19	***alveolars structures (3)***	IR 50%;T 50%
20	**tests**	
21	destructive samples (tools & tests)	T 30%;external ?;IR 20%
22	behaviours of structure with optical fiber	T 20%;IR 30%
23	**assembly process**	
24	design mould	IR 30%;expertise
25	***test gluing 2 layers + W plates***	IR 50%;T 50%
26	behaviour tests (+tools)	T 30%;IR 30%
27	**external plates (15 mm and 2 mm)**	
28	study of fastening system (matel inserts)	IR 20%;LPSC
29	plates fabrication 15mm and 2mm	LPSC
30	**Concept 2 (180mm) or/and concept 3 (monobloc structure)**	IR 50%
31	**Design external support "backend"**	
32	**LONG SLAB design**	
33	H structure (mould, sample, tests)	IR 20%
34	**Glue (dots size, tooling, ageing)**	
35	dots size study	IR 30%
36	tools	IR 30%
37	ageing	UK
38	**Thermal studies**	
39	thermal simulations	
40	thermal tests	
41	**PCBs structure (feasibility, segmentation)**	
42	integration studies (tools)	IR 50%
43	Integration	
44	**Moulds design**	
45	Moulds drawing, materials supplying	

Conclusions (CdLT)

- Nice progress recently on slab layout : choice of DC coupling and HV distribution => mechanical dimensions can be frozen
- Mechanical tooling can now proceed
- First PCB to be fabricated in fall 07
- Still in (desperate) need of EUDET Si wafers
- Manpower still critical on mechanics
- Spent : 18k€ for mould study and realization