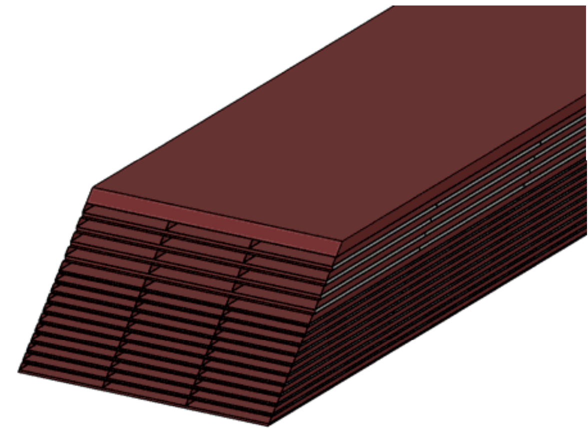
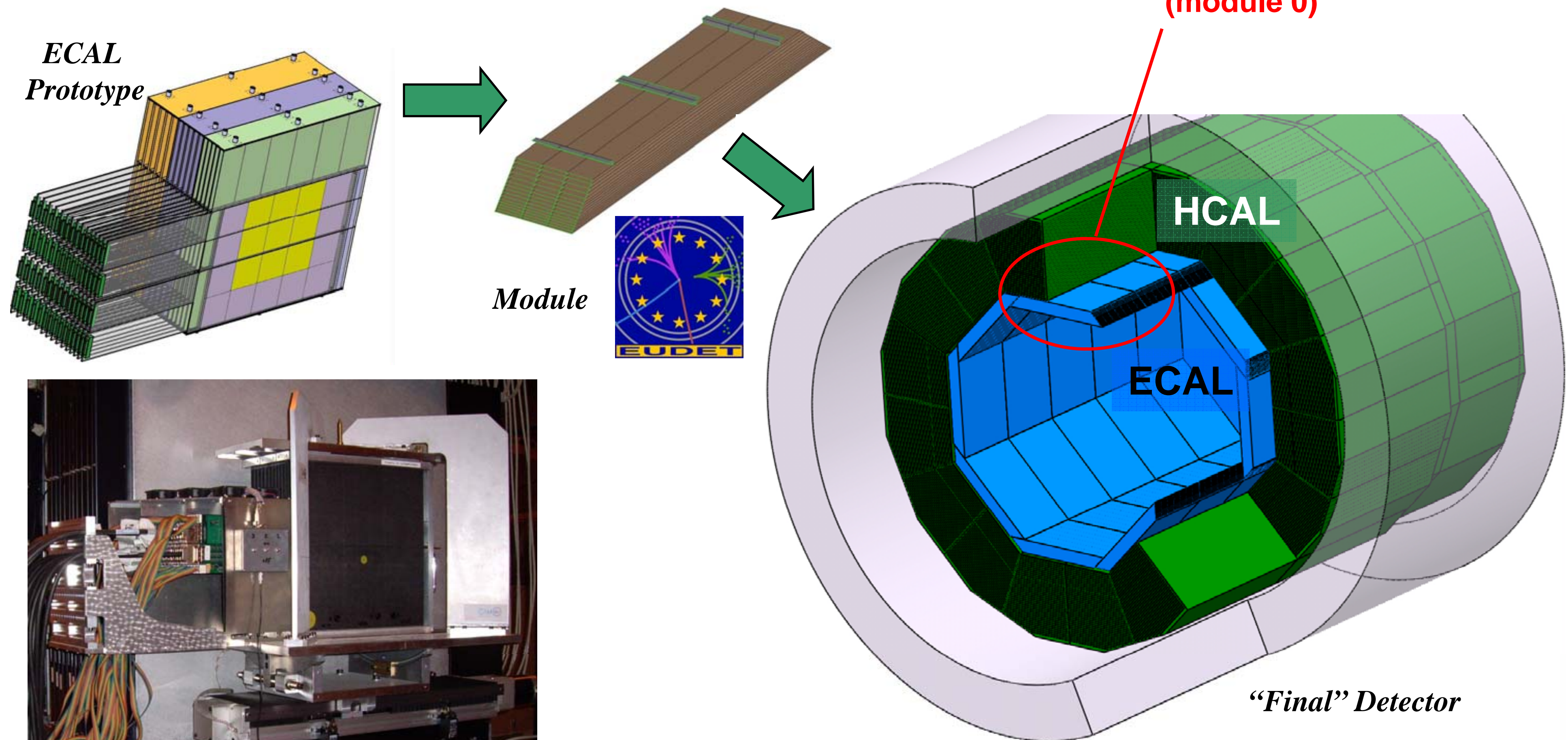
Mechanical R&D for EUDET module



Marc Anduze – EUDET Meeting – PARIS 08/10/07

Why this prototype ?

- Next step after the physics prototype and before the module 0
- To study "full scale" technological solutions which could be used for the final detector (moulding process, thermal cooling, inlet/outlet, integration tools …)
- To take account of the industrial point of view
- To estimate the cost of the future Si/W ECAL

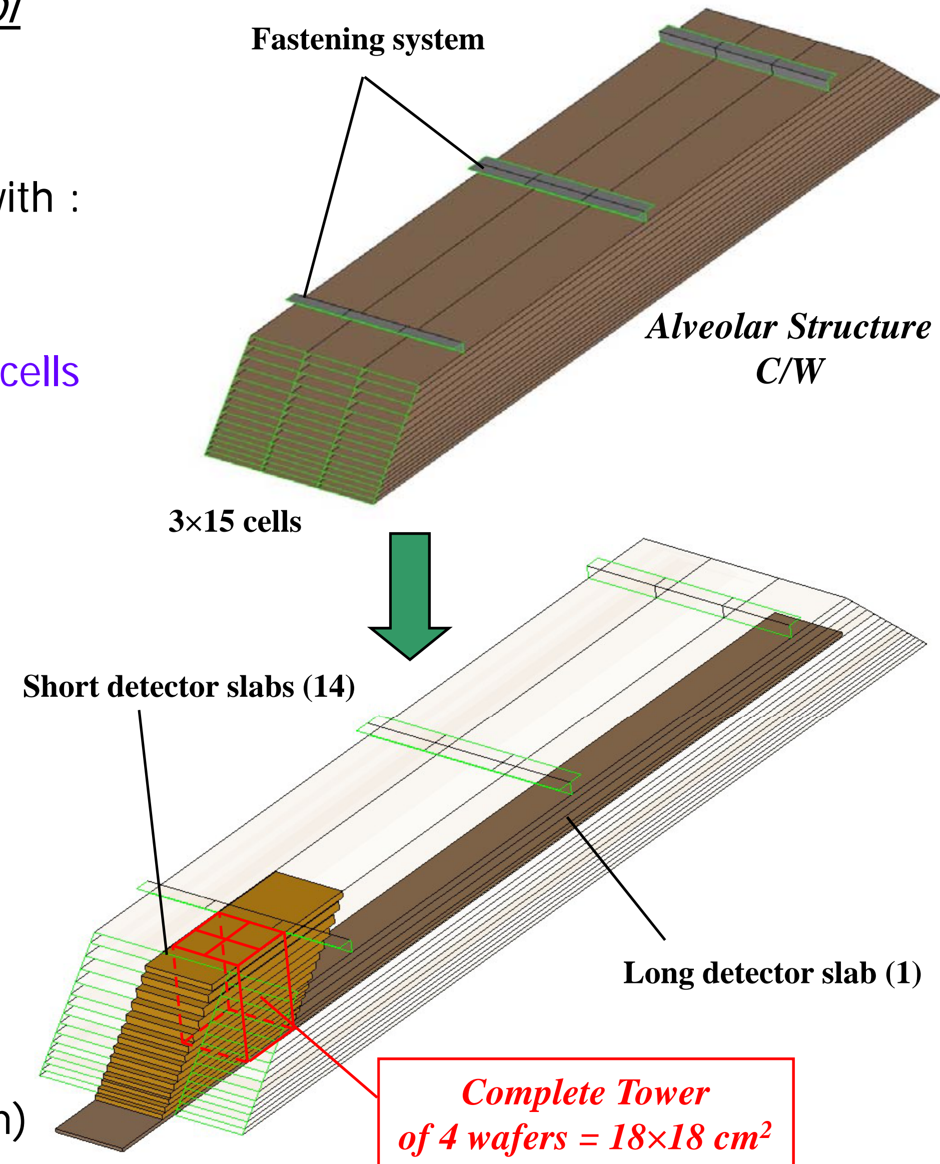


Global Presentation

<u>*Concept : to be the most representative of the final detector module :*</u>

- An alveolar composite/tungsten structure with :
  - same W sampling :
    20×2.1 mm and 9×4.2 mm thick
  - 3 columns of cells to have representative cells in the middle of the structure (with thin composite sheets)
    width : 124 mm ➡ **182 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 (backend system)

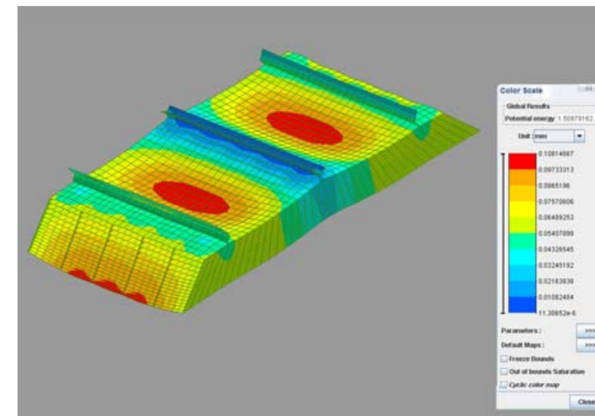


Design of the module…

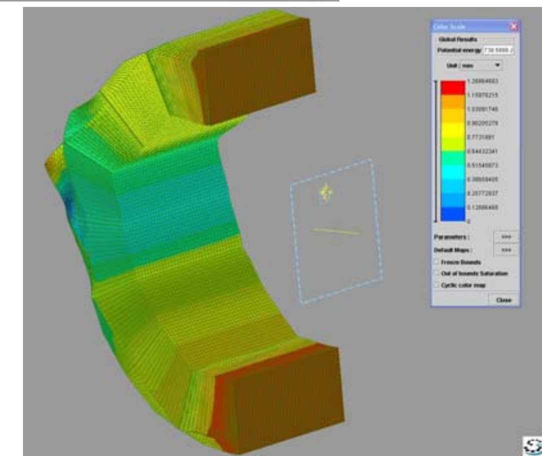
… based on mechanical simulations :

Linear Analysis of "full scale" ECAL and HCAL modules

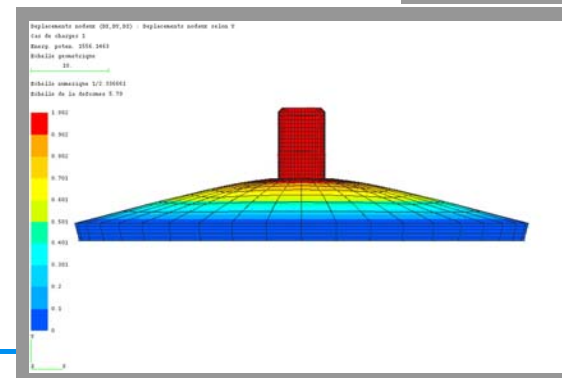
- Global simulations : global displacements and localization of high stress zone for different solutions (dimensions)
- Local simulations : more precise simulations and study of different local parameters to design correctly each part of this structure (thickness of main composite sheets, choice of fasteners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



ECAL



HCAL



behaviour of an insert in composite with tensile loads

Design of the module…

… while taking account of 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	324	36	9	15x15	60.4 M	21.8 M

➡ CALICE ECAL: ~ 82.2 M of channels

total power to dissipate will be : ~2100 W

⇨ external cooling OK for the "full scale ECAL"

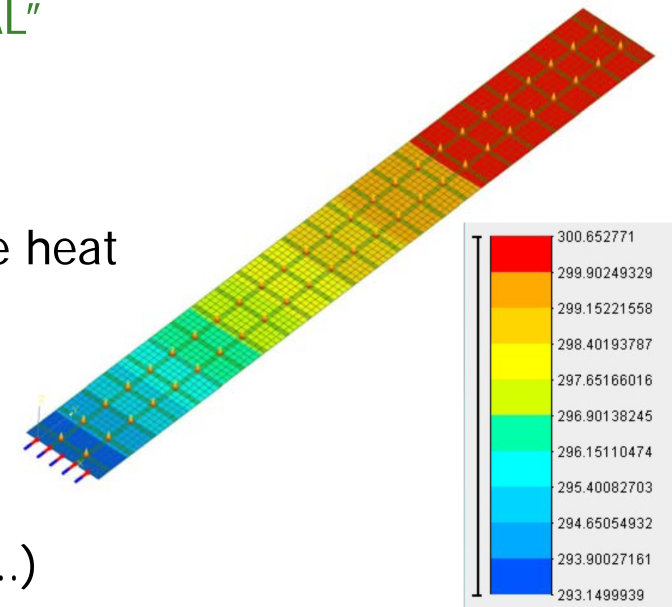
inside each slab :

Assuming that the chip power is 25 μW/channel

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 = 180*0,4 mm^2

L = 1,55 m ; Φ = 0,27 W



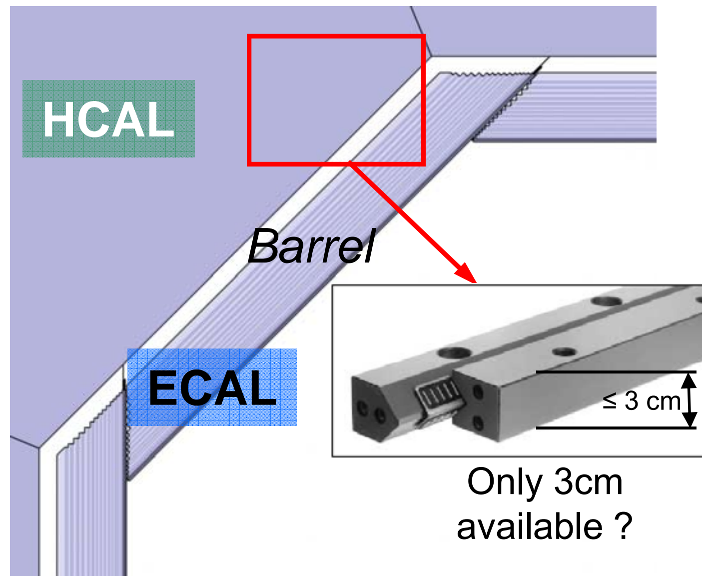
We can estimate the temperature difference along the slab layer around 8°C and without contribution of all material from slab (PCB, tungsten, carbon fibers…)

⇨ 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…

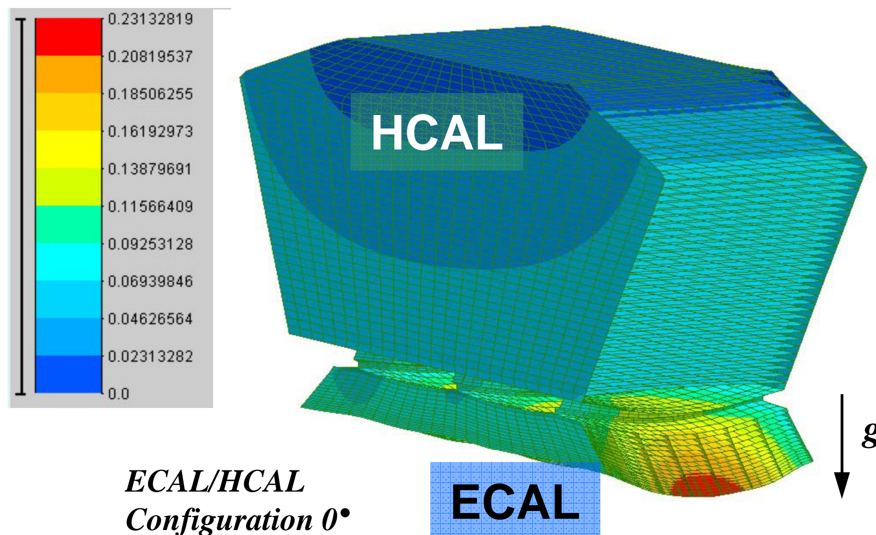
Calorimeter for ILC



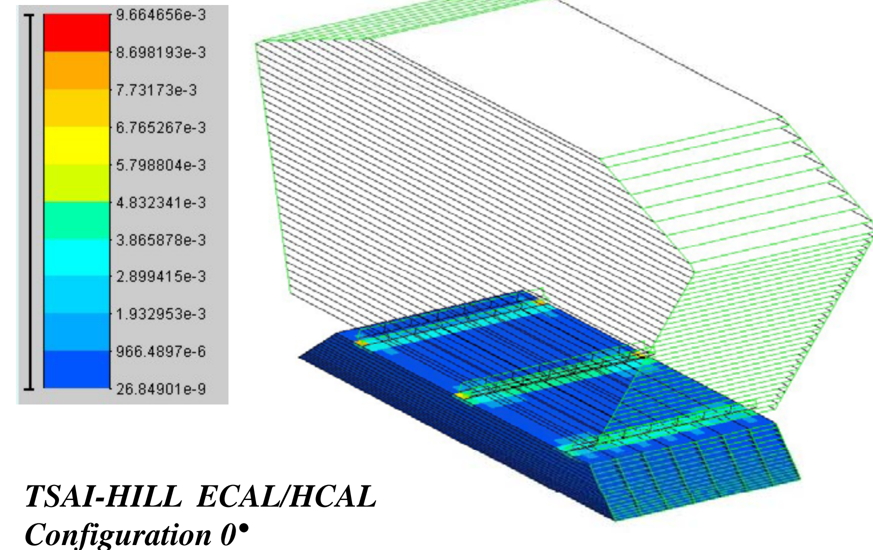
… including ECAL/HCAL interfaces (+ inlet/outlet) :

The fastening and connection system for the 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 of its influence
- Design of connection system (power supply + cooling + outlets) : backend system ?



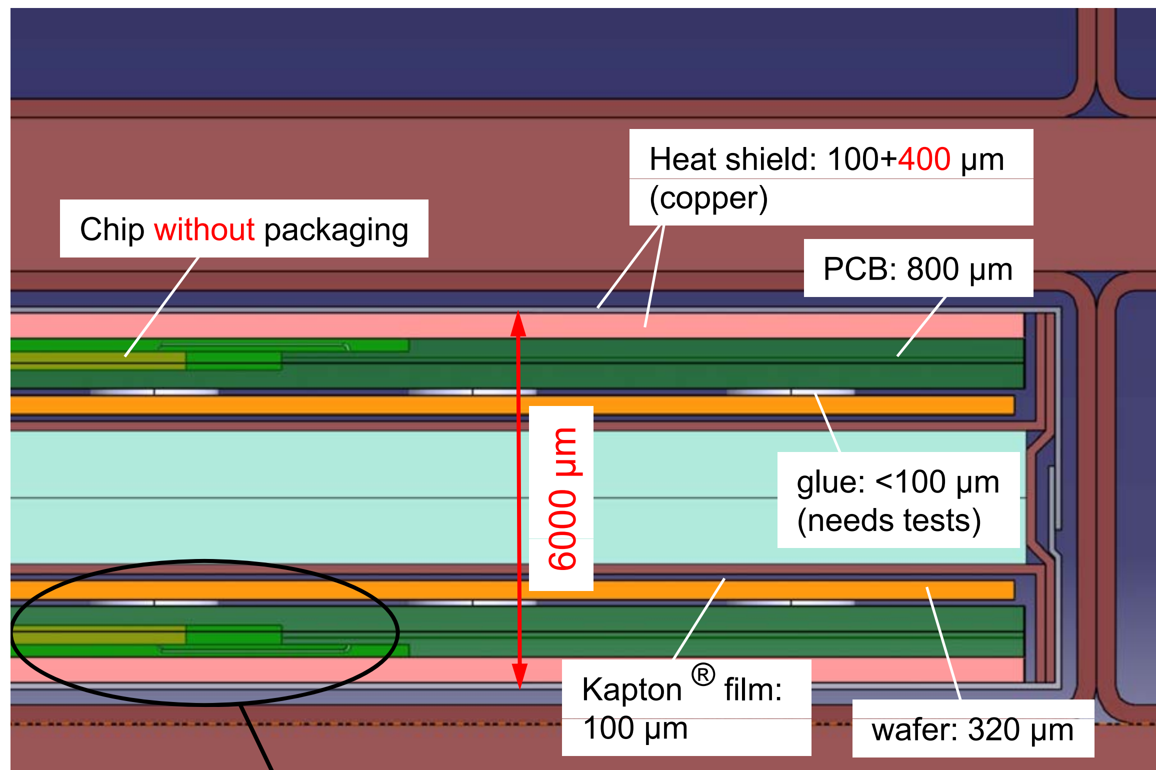
ECAL/HCAL Configuration 0°



TSAI-HILL ECAL/HCAL Configuration 0°

Design of the module…

… based on the definition of the detector slab :



Design EUDET Slab

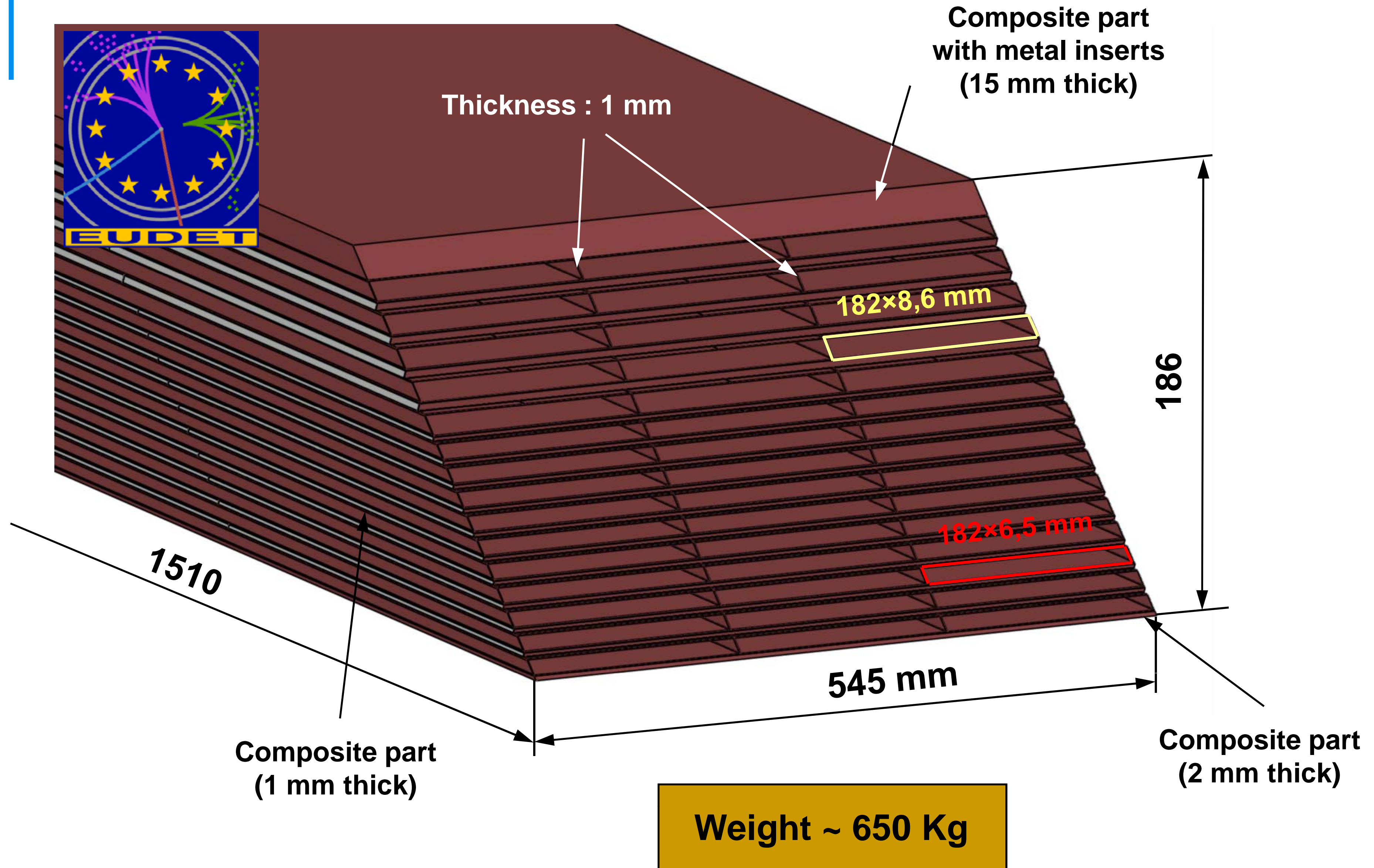
Chips and bonded wires inside the PCB

The expected alveolar thickness is 6.5 mm **if** :

- ⇨ Gap (slab integration) : 500 µm ?
- ⇨ Heat shield : 400 µm ?
  but real thermal dissipation ?
  (active cooling ?)
- ⇨ PCB : 800 µm ?
  but chips embedded in this thickness ?
- ⇨ Thickness of glue : <100 µm ?
  study of the size of dots
- ⇨ Thickness of wafer : 320 µm - OK
  30 matrices ordered (90×90 mm²)
- ⇨ Kapton® film for HV distribution :
  100 µm - OK *(DC coupling)*
- ⇨ Thickness of W : 2100 µm - OK

Several technological issues have to be studied and validated

The Design of alveolar structure



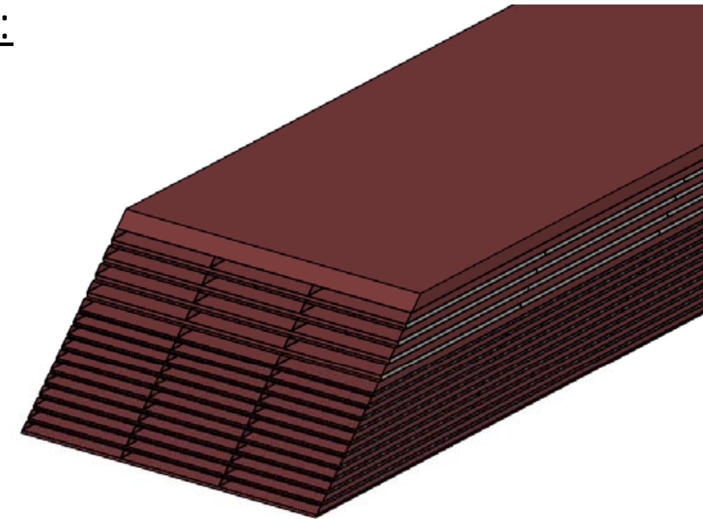
Composite Alveolar structure

Study of different principle (with industrial expertise):

- Principle #1 : "one block" structure

  One curing step to obtain the final structure

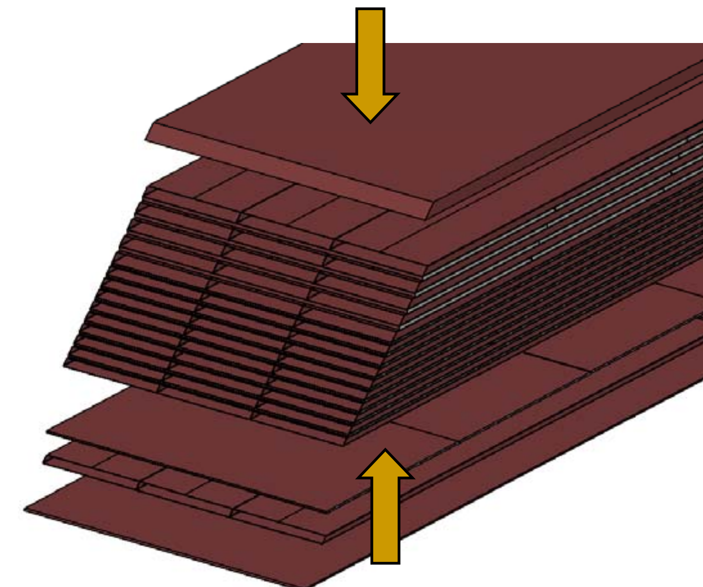
  - Final piece in one step
  - Better mechanical strength
  - Only one but more complex mould (45 cores)
  - Curing problems : thermal inertia, weigh of metal mould, control of curing parameters …
  - Important risks to fail the structure : what about W plates ?



- Principle #2 : 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

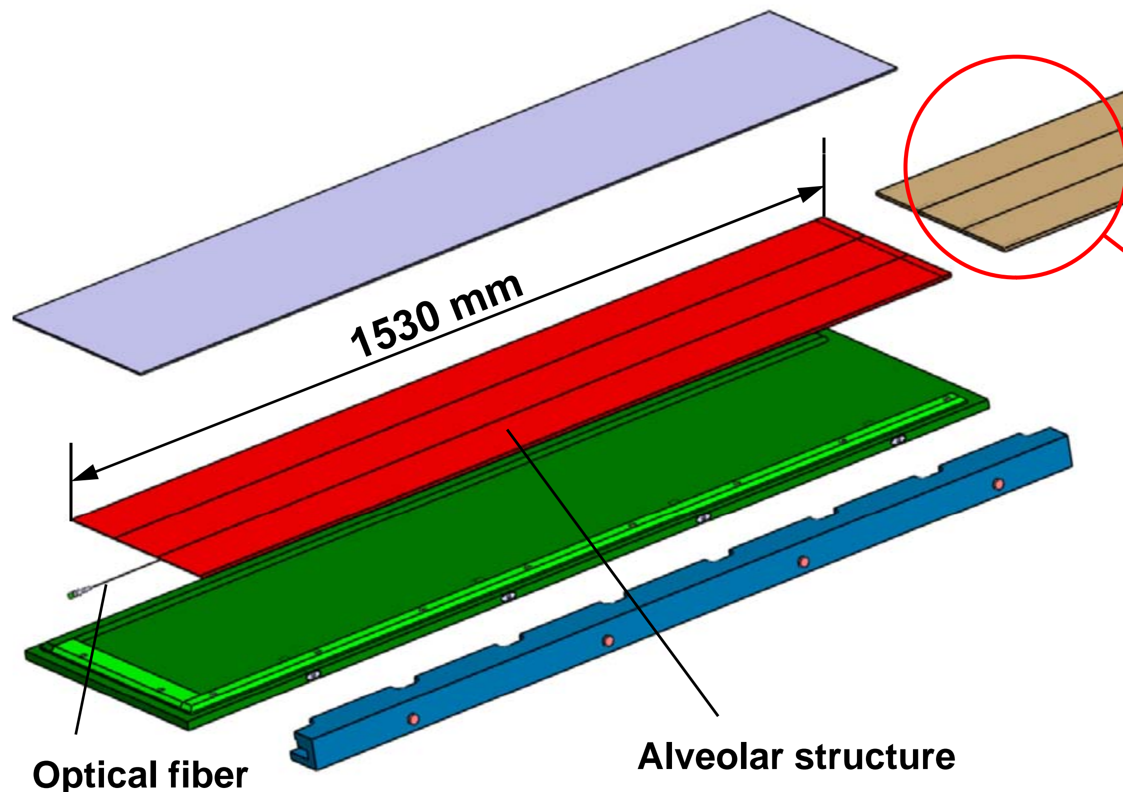
  - Individual inspection and choice
  - Limit risks to lose W plates
  - Reduction of cost (simpler moulds)
  - 2 polymerization process : 2 moulds
  - Mechanical strength of "gluing" structures



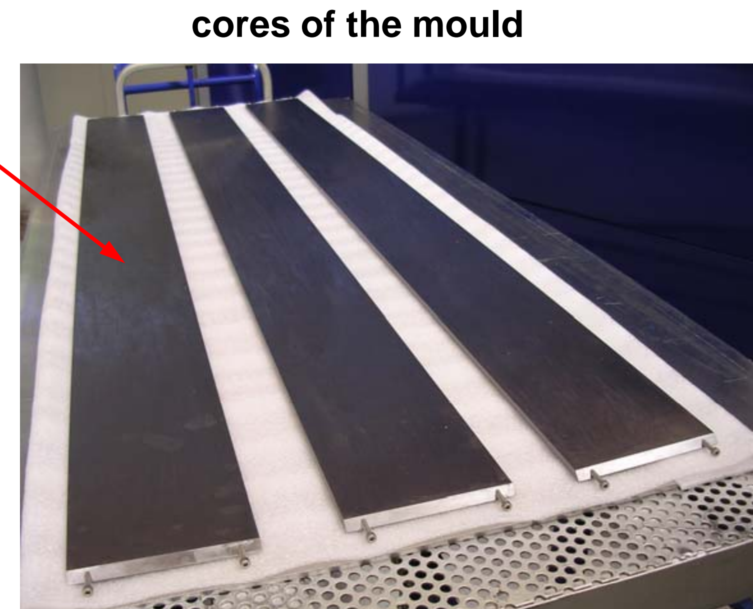
« Alveolar layer » mould

Study of one first mould based on principle#2 :

- 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 …)



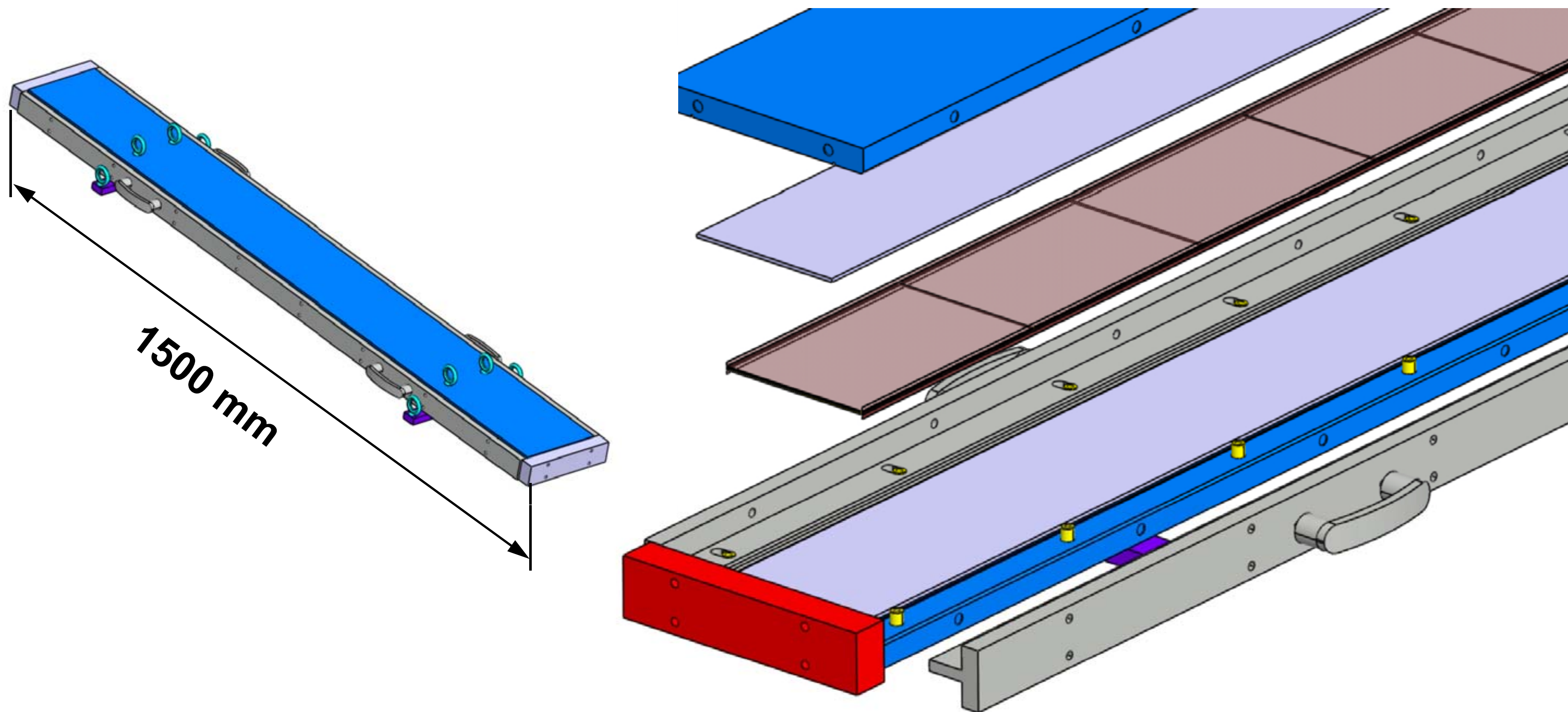
cores of the mould



Composite H structure

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



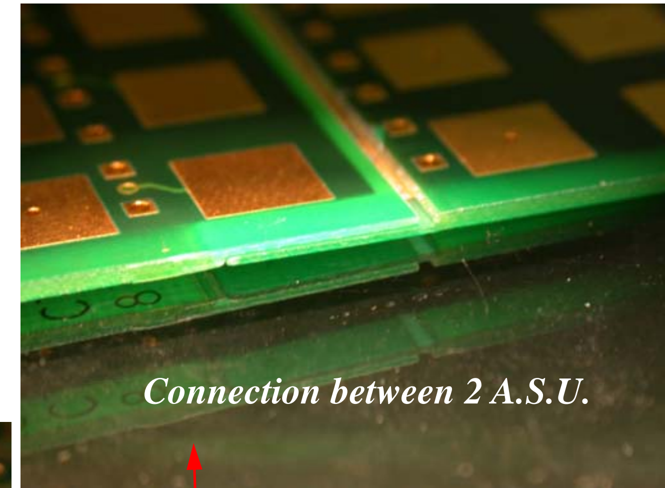
Detector slab - principle

Calorimeter for ILC

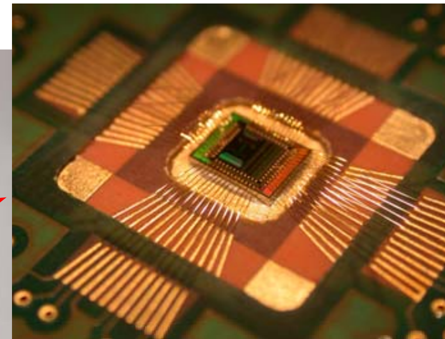
Long slab is made by several short PCBs :

A.S.U. : Active Sensors Unit

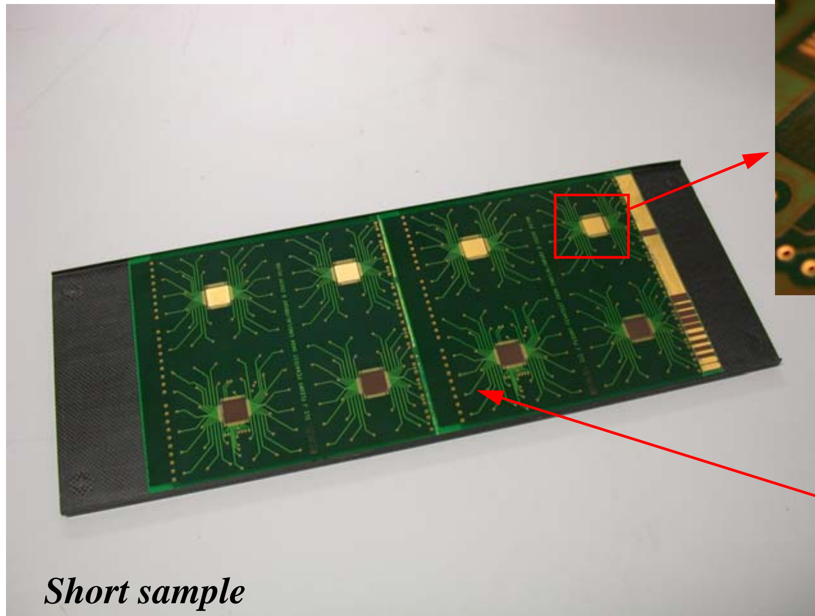
- Design of one interconnection (glue ?)
- Development easier : study, integration and tests of short PCB (with chips and wafers) before assembly
- The length of each long slab will be obtained by the size of one "end PCB" (tools)



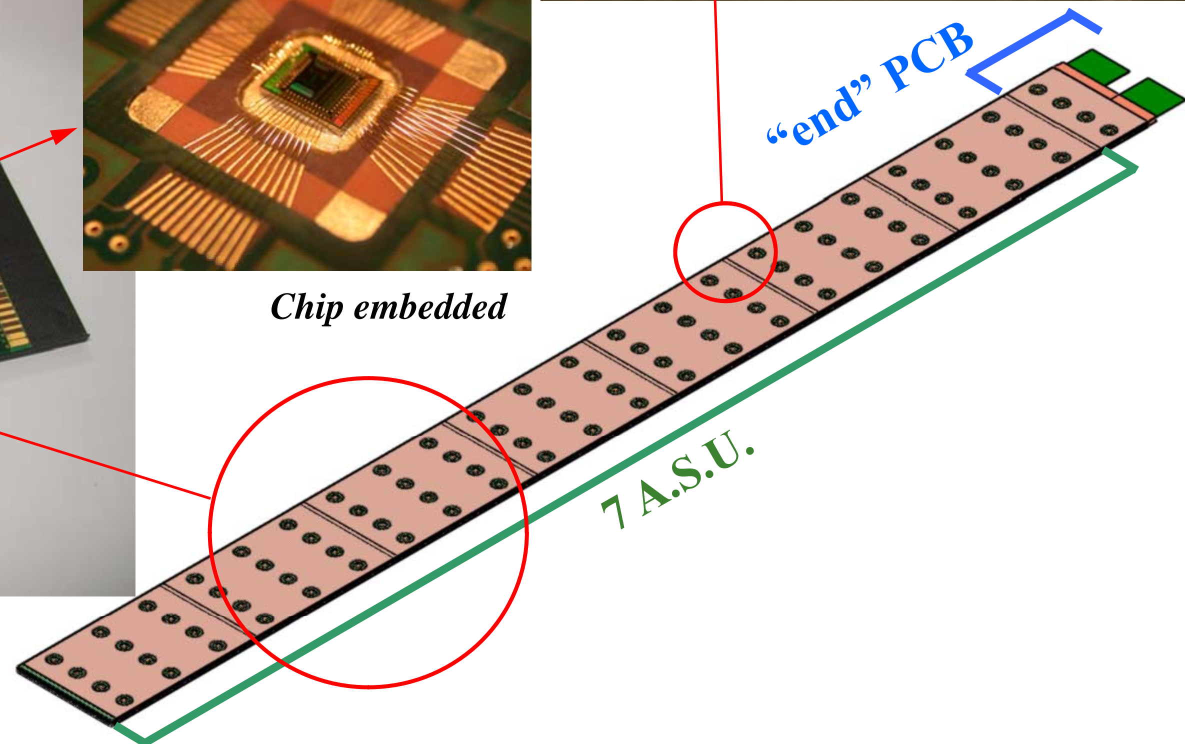
Connection between 2 A.S.U.



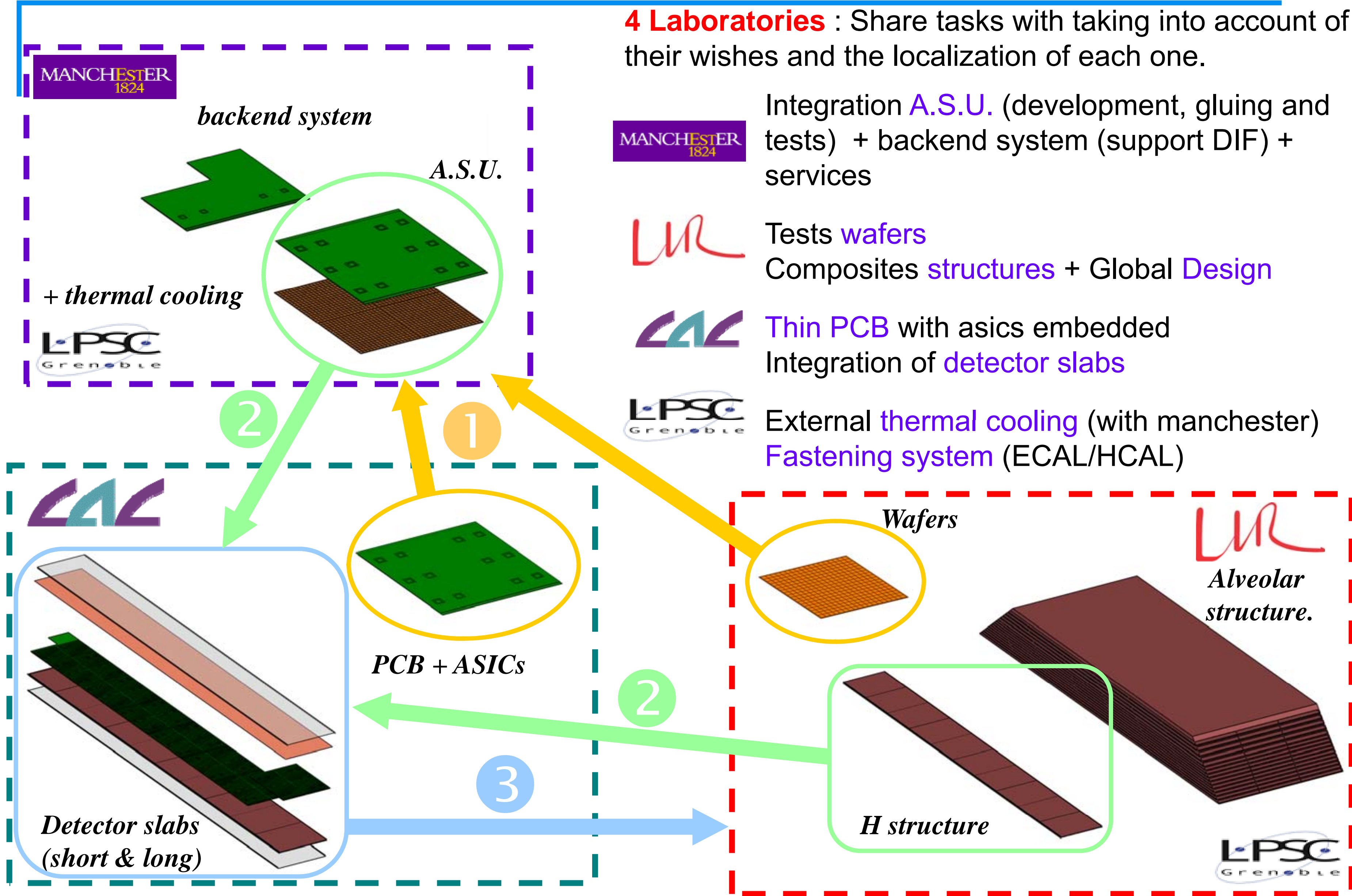
Chip embedded



Short sample



Tasks distribution (proposal)



Conclusions

Calorimeter for ILC

- Global design of the ECAL EUDET module is well on going :
  - Main dimensions are fixed (checked by mechanical simulations)
  - W plates will be ordered soon, composite OK
  - First samples of wafers have been ordered

- Several technological issues are still under study and need to be validated (process for long composite structure, thin PCB with ASICs inside…)

- 4 laboratories are interested on mechanical R&D :
  One proposal to share responsibilities and start main studies in parallel :
  A.S.U – Long SLAB – Composite Structures – Services

- Dead line for the ECAL EUDET module construction : mid 2009