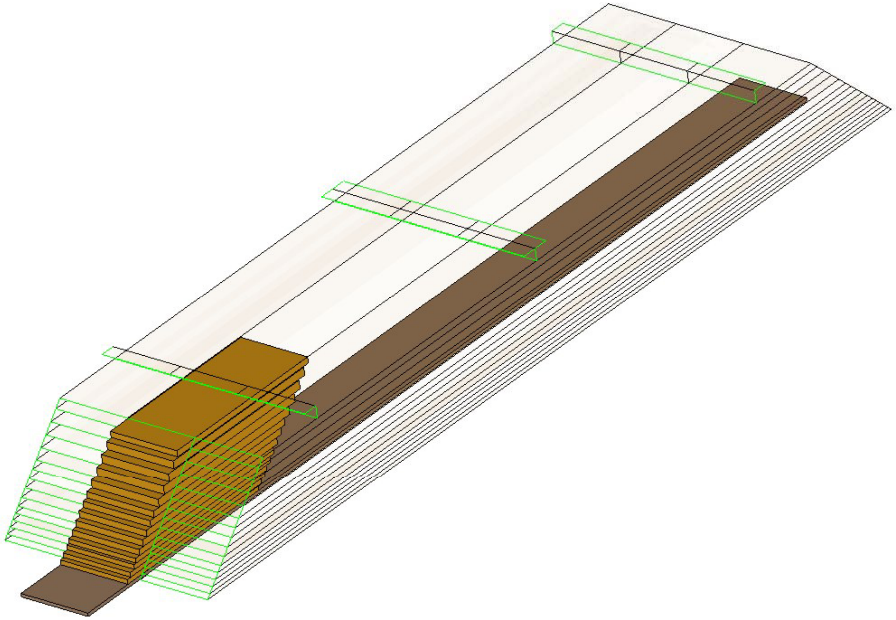


EUDET JRA3 ECAL in 2007 : towards "The EUDET module"

C. de La Taille
IN2P3/LAL Orsay

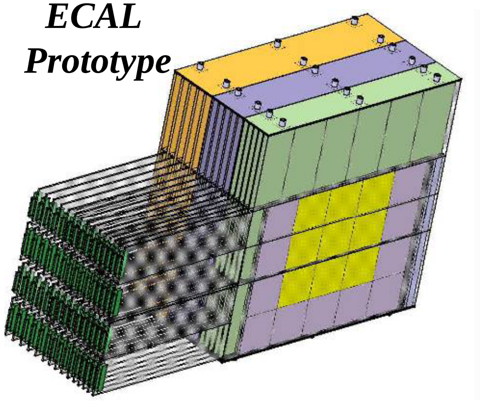
Overview

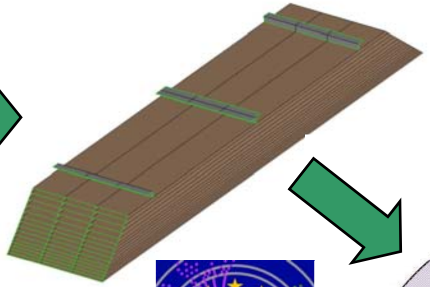
- Mechanics
- Sensors
- PCBs
- Schedule
- Acknolowdegments : most slides from Marc Anduze & Julien Fleury

Why this prototype ? [M.Anduze]

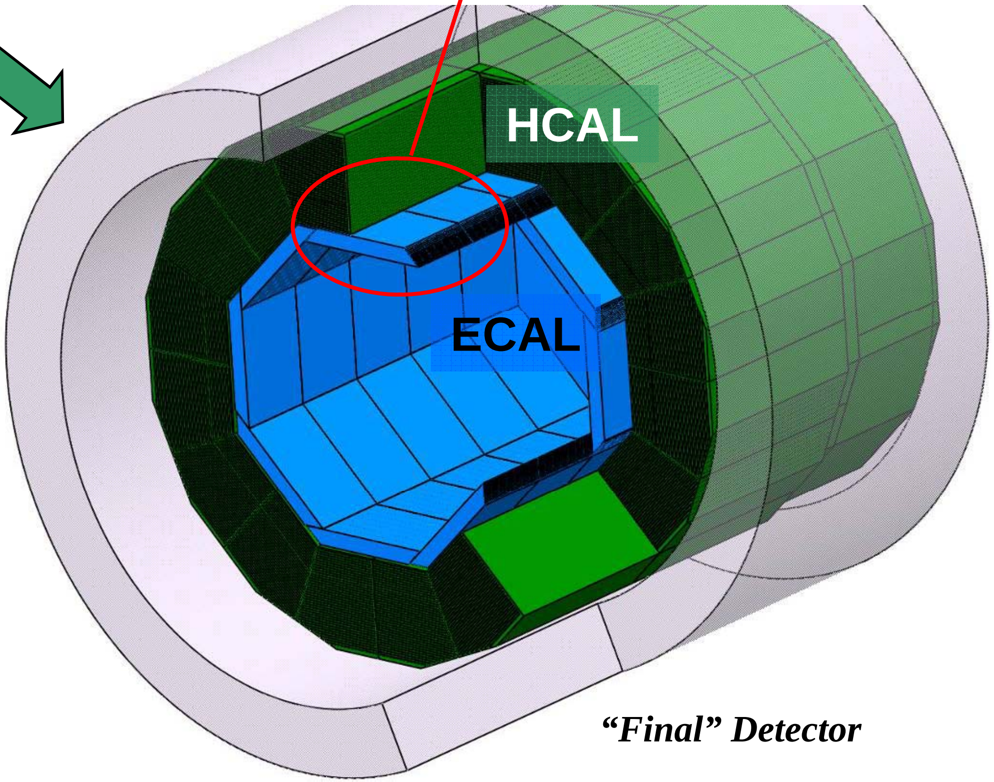
- ❑ Next step after the physics prototype and before the module 0
- ❑ To study “full scale” technological solutions which could be used for the final detector (moulding process, thermal cooling, inlet/outlet, integration tools ...)
- ❑ To take account of the industrial point of view
- ❑ To estimate the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

ECAL Prototype



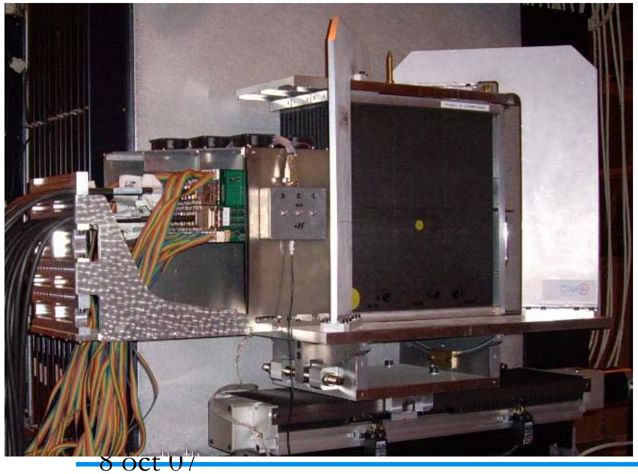


Module



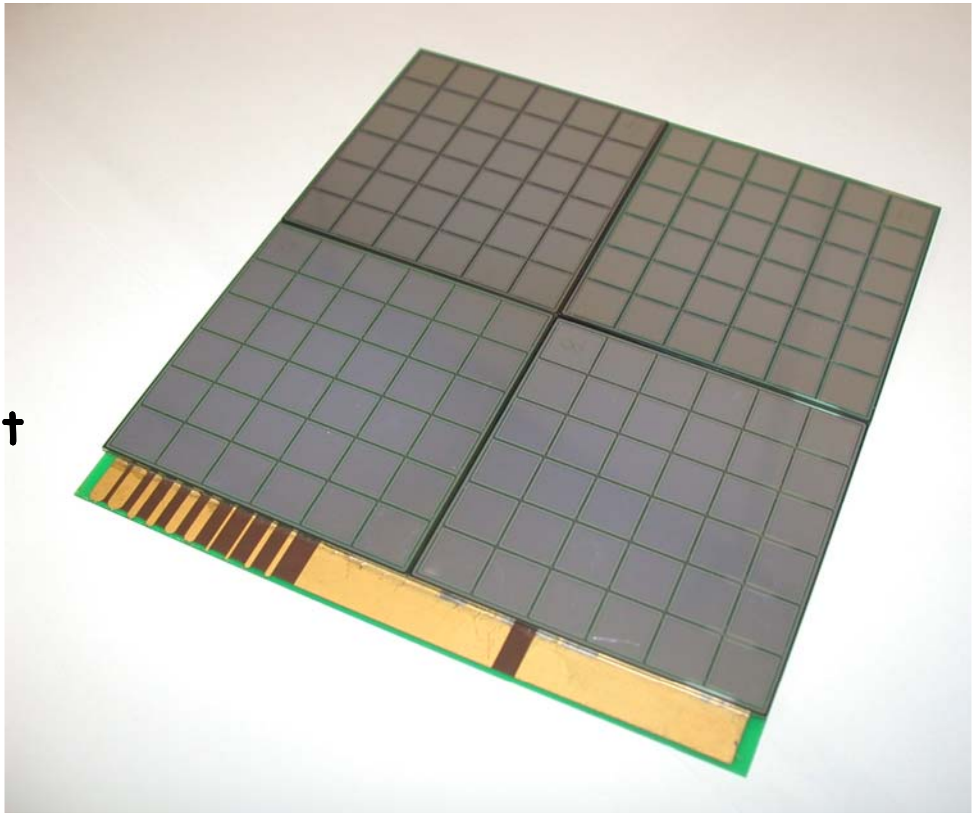
1st ECAL Module (module 0)

“Final” Detector



Sensors

[A. Karar, JC Vanel, R. Cornat]



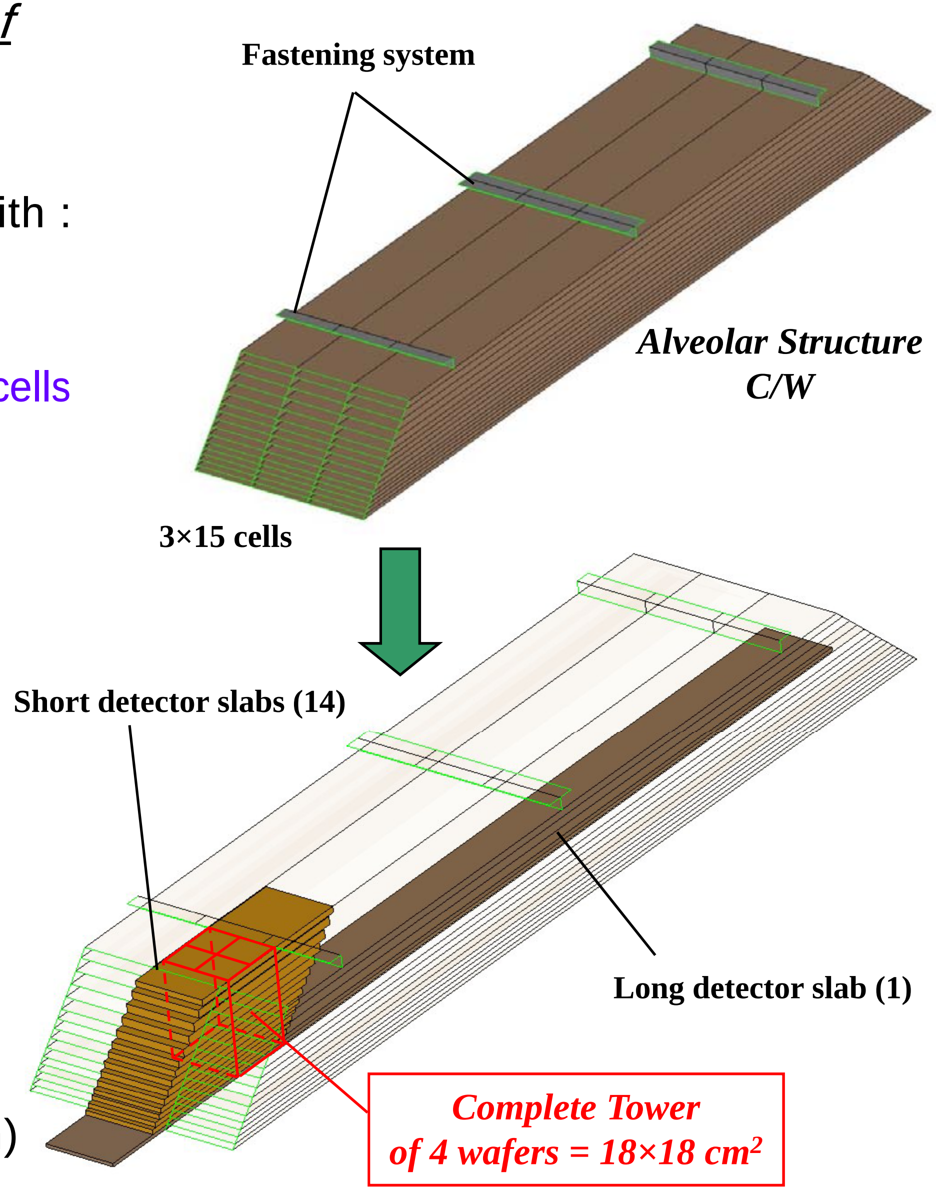
- 6" wafers -> 90x90 mm2
- 300 µm thickness
- 18x18 = 324 pixels of 5x5 mm2
- DC coupling chosen to minimize cost (for large production)
- Order to Hamamatsu & On-semi, delivery expected march 08
- Work going on guard rings and « square events » : LLR+Clermont

Global Presentation

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

- 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)

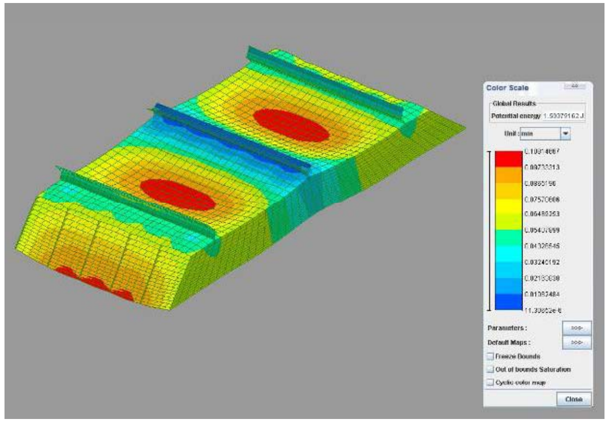


Design of the module…

… based on mechanical simulations :

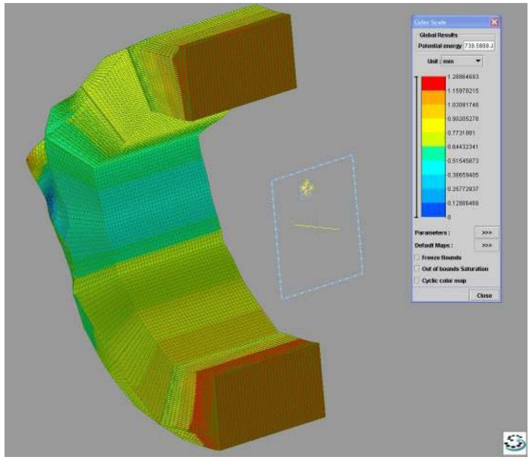
Linear Analysis of "full scale" ECAL and HCAL modules

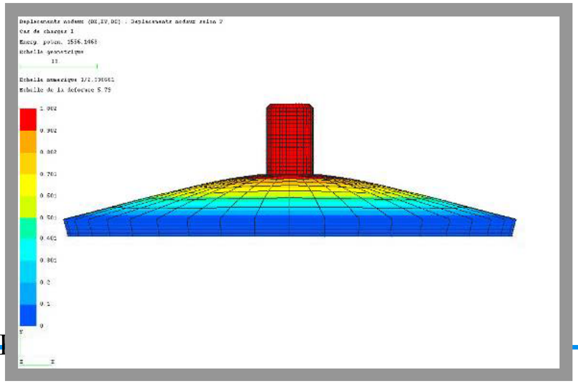
- Global simulations : global displacements and localization of high stress zone for different solutions (dimensions)
- Local simulations : more precise simulations and study of different local parameters to design correctly each part of this structure (thickness of main composite sheets, choice of fasteners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



ECAL

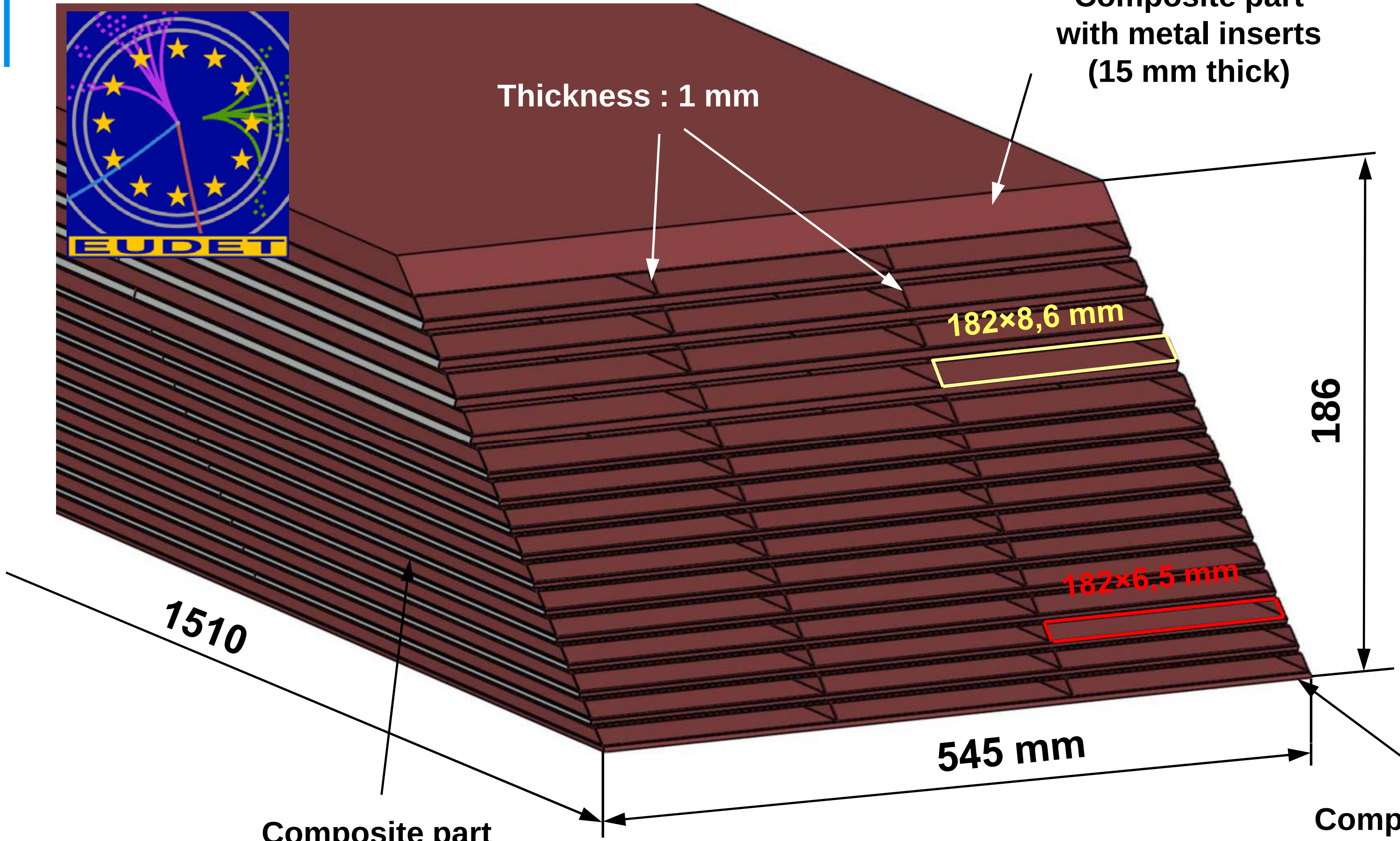
HCAL





behaviour of an insert in composite with tensile loads

The Design of alveolar *(infra)*structure



Thickness : 1 mm

Composite part with metal inserts (15 mm thick)

Composite part (1 mm thick)

Composite part (2 mm thick)

Weight ~ 650 Kg

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 ?

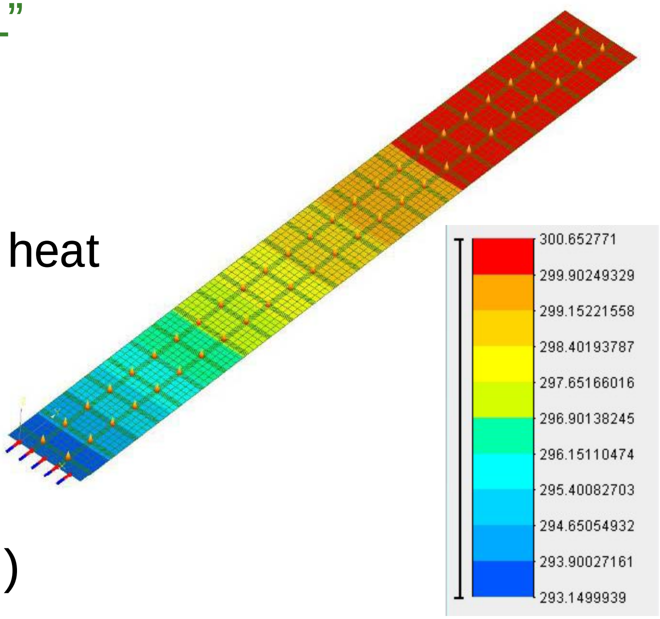
Ex: Pessimist simulation of heat conduction just by the heat shield : λ = 400 W/m/K (copper) ; S = 180*0,4 mm^2

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 :

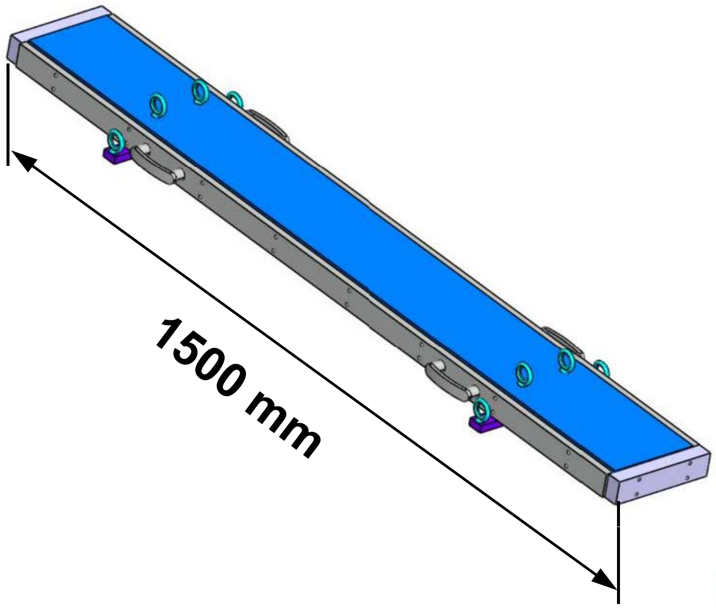
Thermal conductors (heat shield) can be added in the slab to carry heat more efficiently along the slab direction.

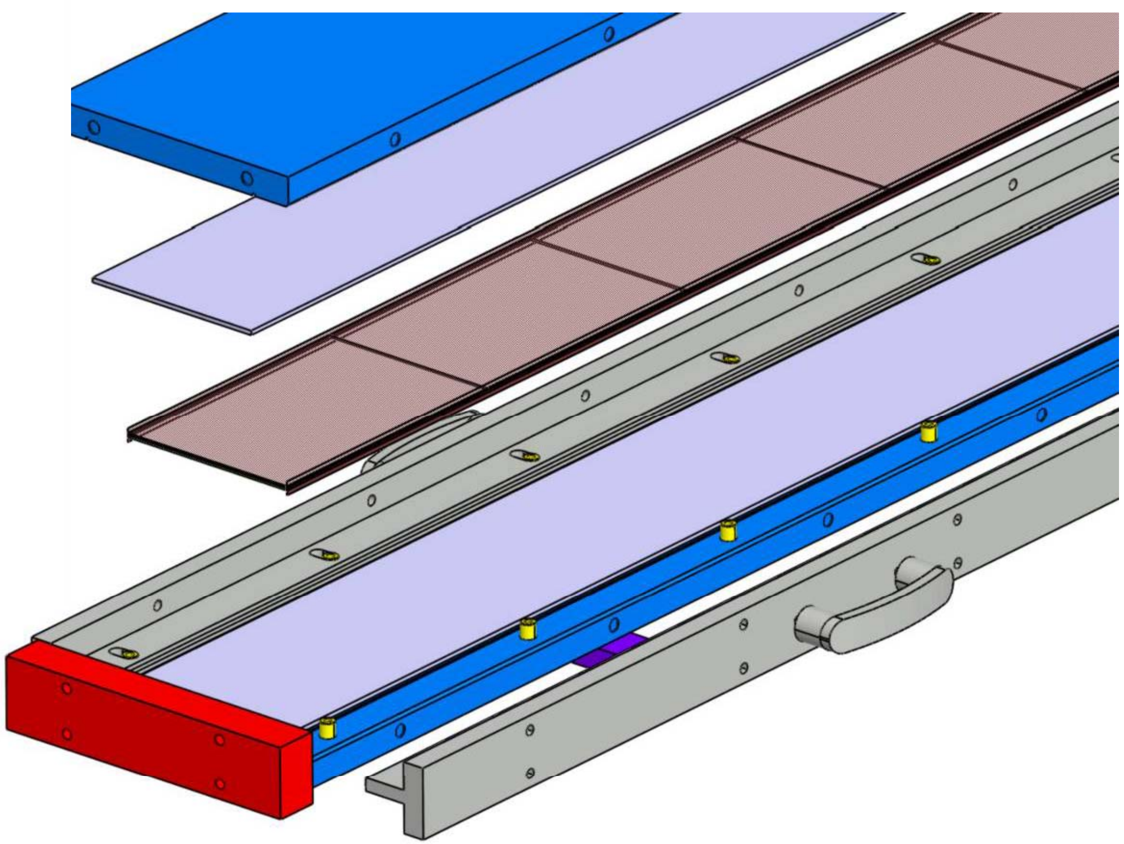


Composite H structure

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



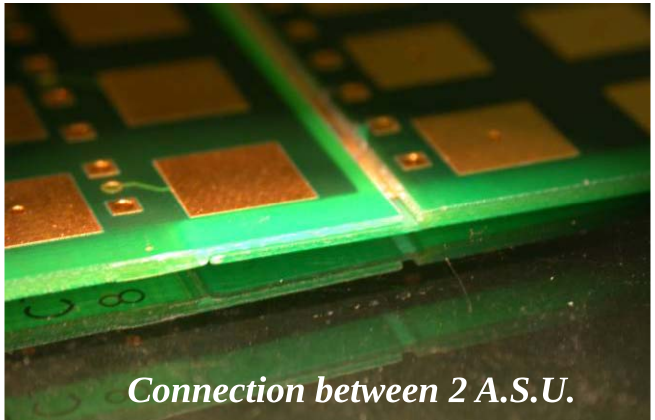


Detector slab - principle

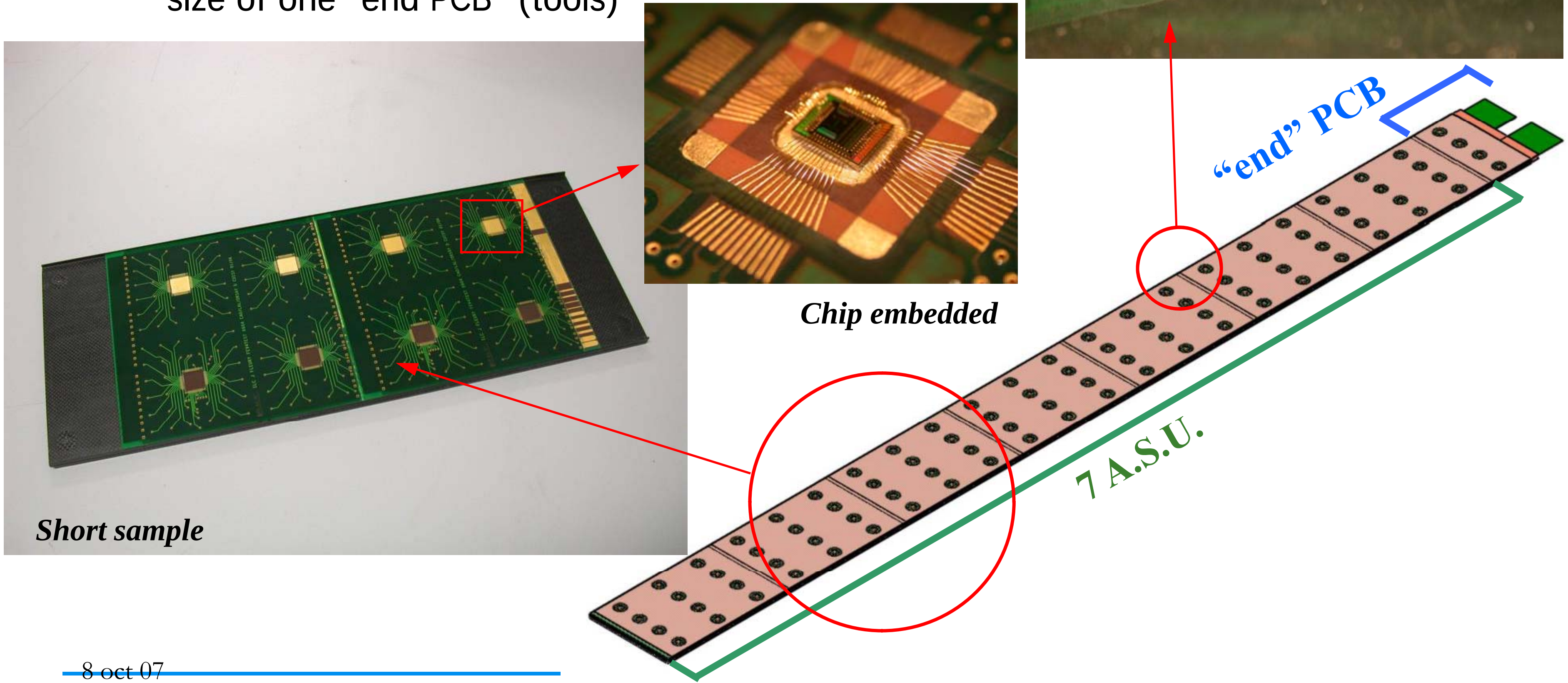
Long slab is made by several short PCBs :

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.

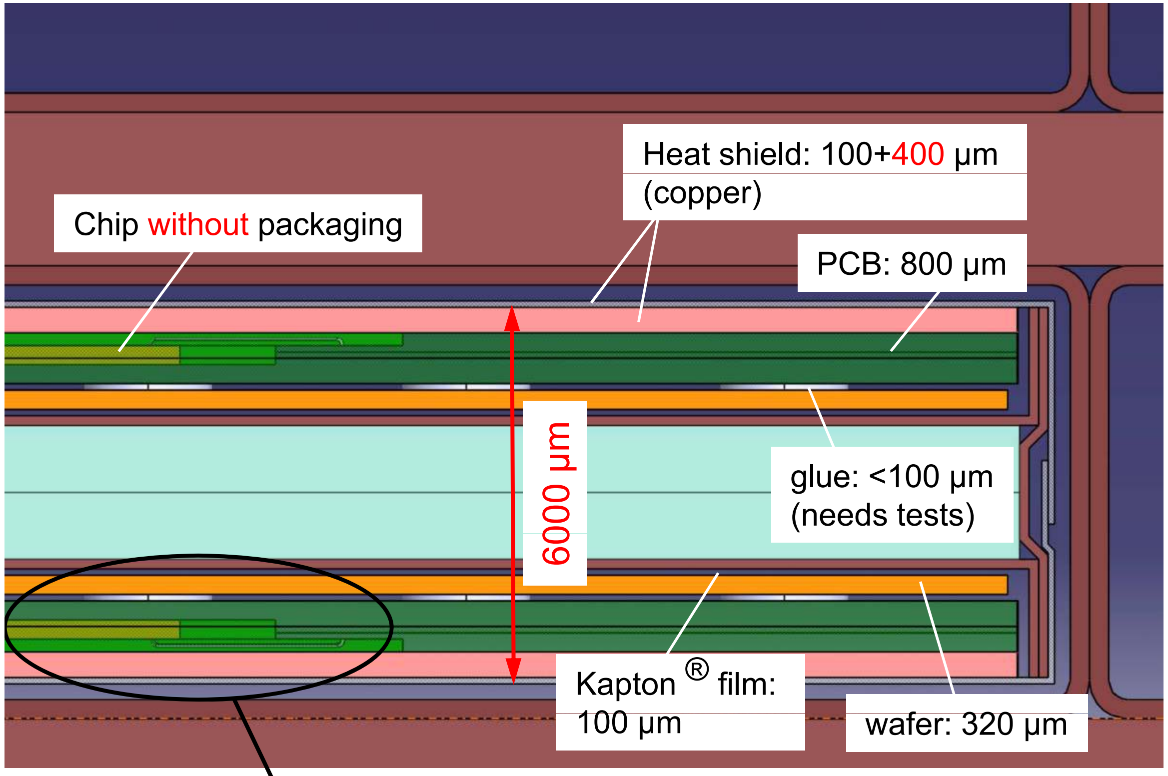


Chip embedded

Short sample

Design of the module…

... based on the definition of the detector slab :



Design EUDET Slab

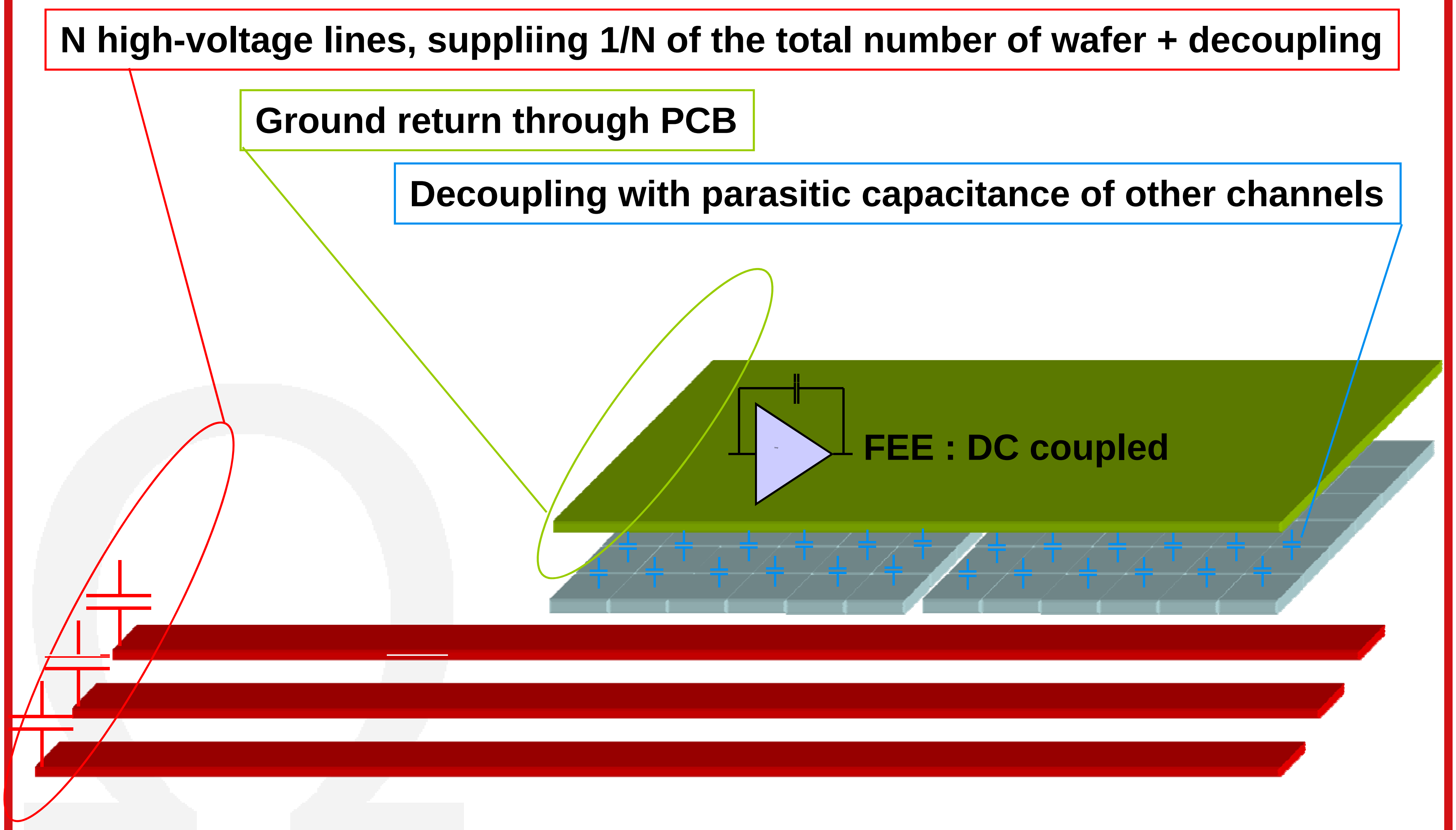
Chips and bonded wires inside the PCB

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 mm^2)
- ⇨ 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

Solution for HV decoupling



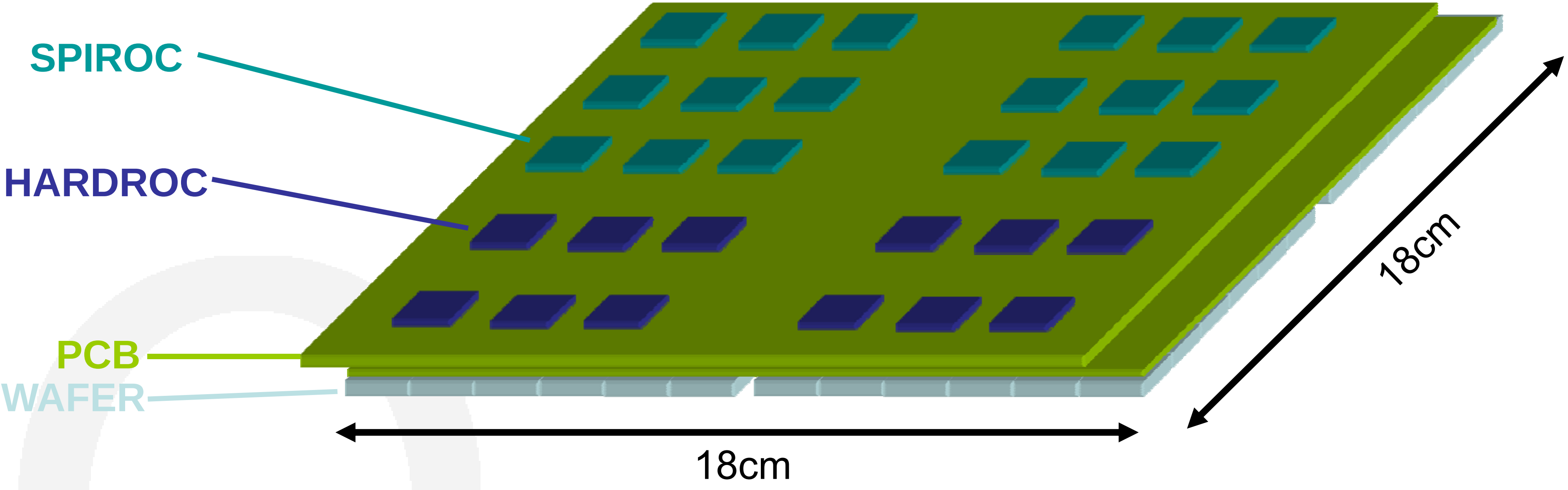
N high-voltage lines, suppliing 1/N of the total number of wafer + decoupling

Ground return through PCB

Decoupling with parasitic capacitance of other channels

Nb of channel/HV line > 1000 → Crosstalk < 1/1000

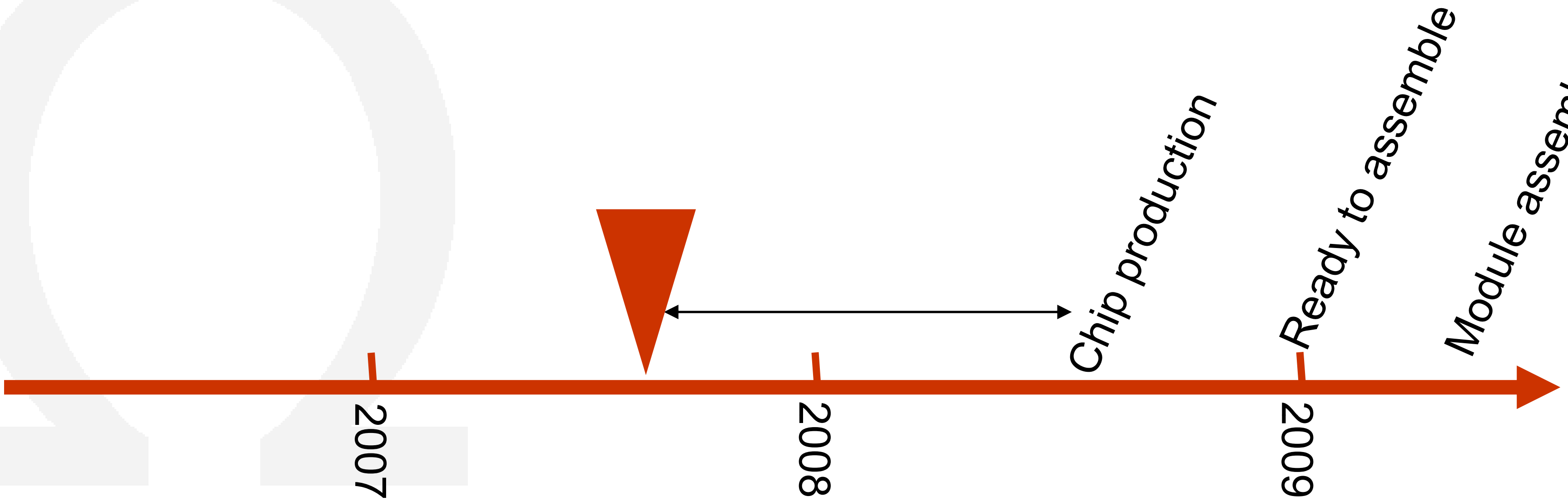
FLC_FEV5 presentation



1296 channels. Half SPIROC (18 chips) / half HARDROC (12 chips)

PCB design schedule

- Schedule
  - ASICs production to be started in summer 2008
  - ASICs have to be tested on PCB to validate daisy-chain
  - « communication module » is the same for the three chips :
    - SKIROC (ECAL)
    - HARDROC (DHCAL)
    - SPIROC (AHCAL)
  - Roughly : PCB R&D finishes when ASIC production starts



Tasks distribution (proposal)

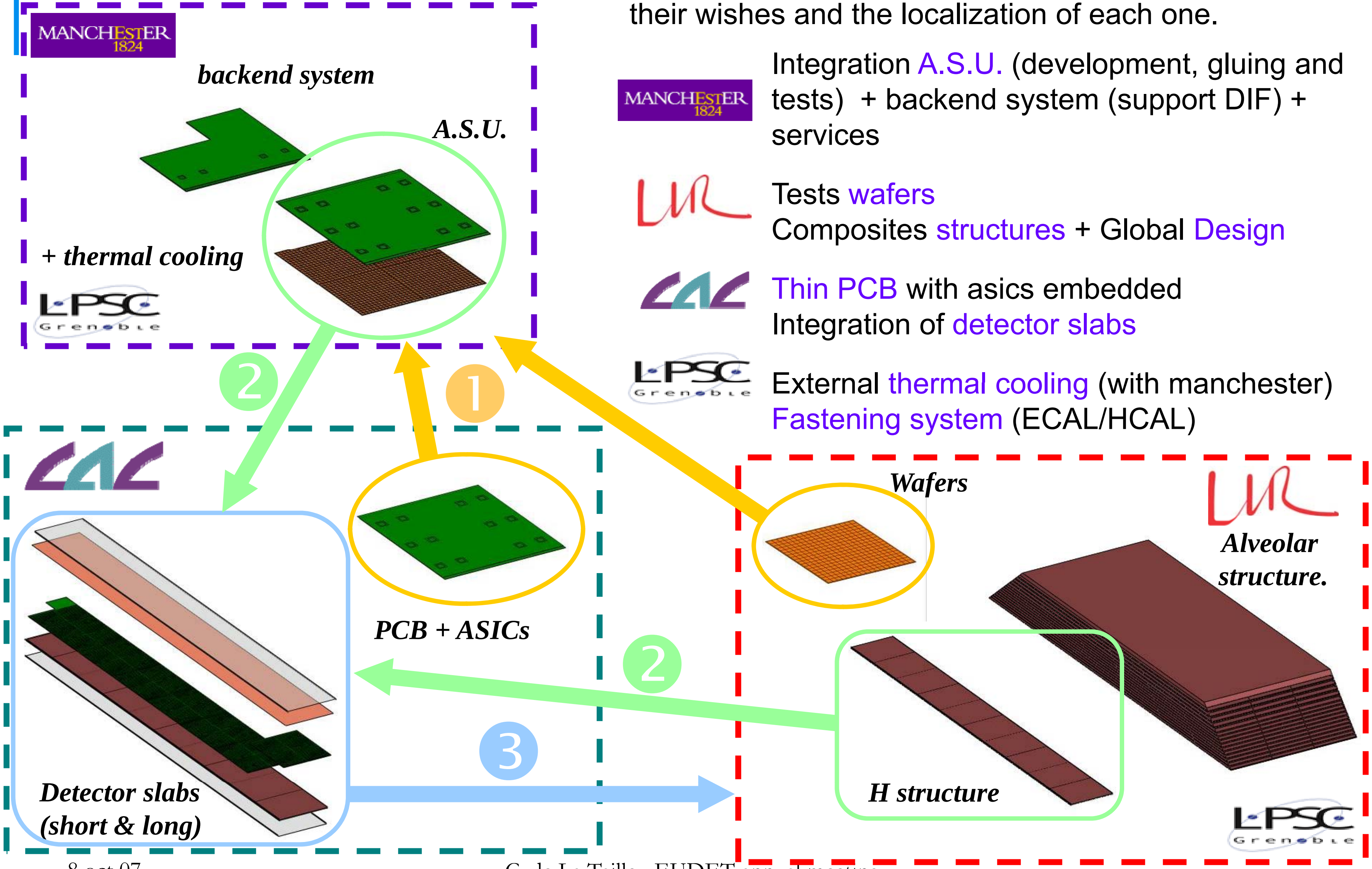
4 Laboratories : Share tasks with taking into account of their wishes and the localization of each one.

MANCHESTER 1824 Integration A.S.U. (development, gluing and tests) + backend system (support DIF) + services

LLR Tests wafers
Composites structures + Global Design

LAL Thin PCB with asics embedded
Integration of detector slabs

LPSC Grenoble External thermal cooling (with manchester)
Fastening system (ECAL/HCAL)



Conclusion

- **Global design of the ECAL EUDET module is well going on:**
  - 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 have been chosen, but still need to be validated**
  - HV connection and wafer decoupling
  - Guard rings design
  - Thin "stitchable" PCBs with chips embedded
  - Power pulsing
  - Thermal behviour
  - Coherent noise

- **EUDET modules in 2009 is challenging, but very exciting !**
  - Production of all elements mid 2008 !
  - Organization coming in place