Status of EUDET Prototype

Roman Pöschl
LAL Orsay

- Status of Mechanical Construction
- Status of Wafer Production and Electronics Development
- Interplay between different components (interleaved)

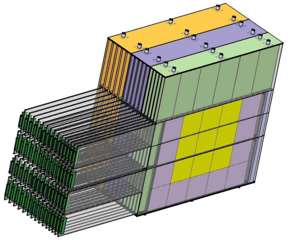
Material for this presentation courtesy of:

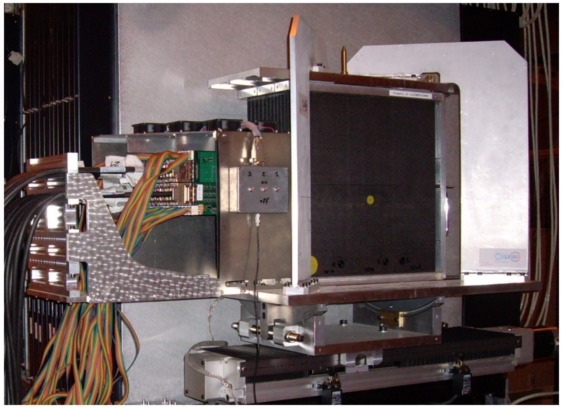
Marc Anduze, Denis Grodin, Ray Thomson, Julien Fleury
Maurice Goodrick, Laurent Royer

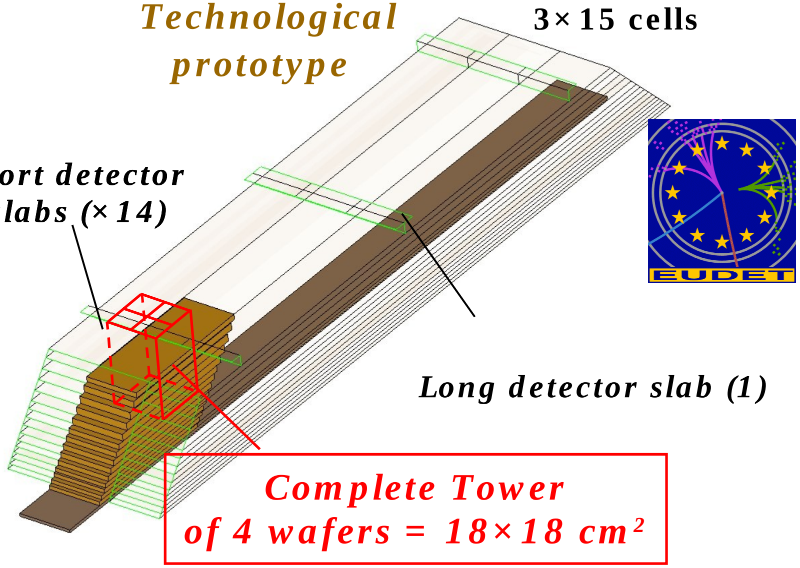
International Linear Collider
ECFA Workshop
9-12 June 2008
Warsaw, Poland

EUDET Prototype

- Logical continuation to the physical prototype study which validated the main concepts : alveolar structure , slabs, gluing of wafers, integration
- Techno. Proto : study and validation of most of technological solutions wich could be used for the final detector (moulding process, cooling system, wide size structures,…)
- Taking into account industrialization aspect of process
- First cost estimation of one module







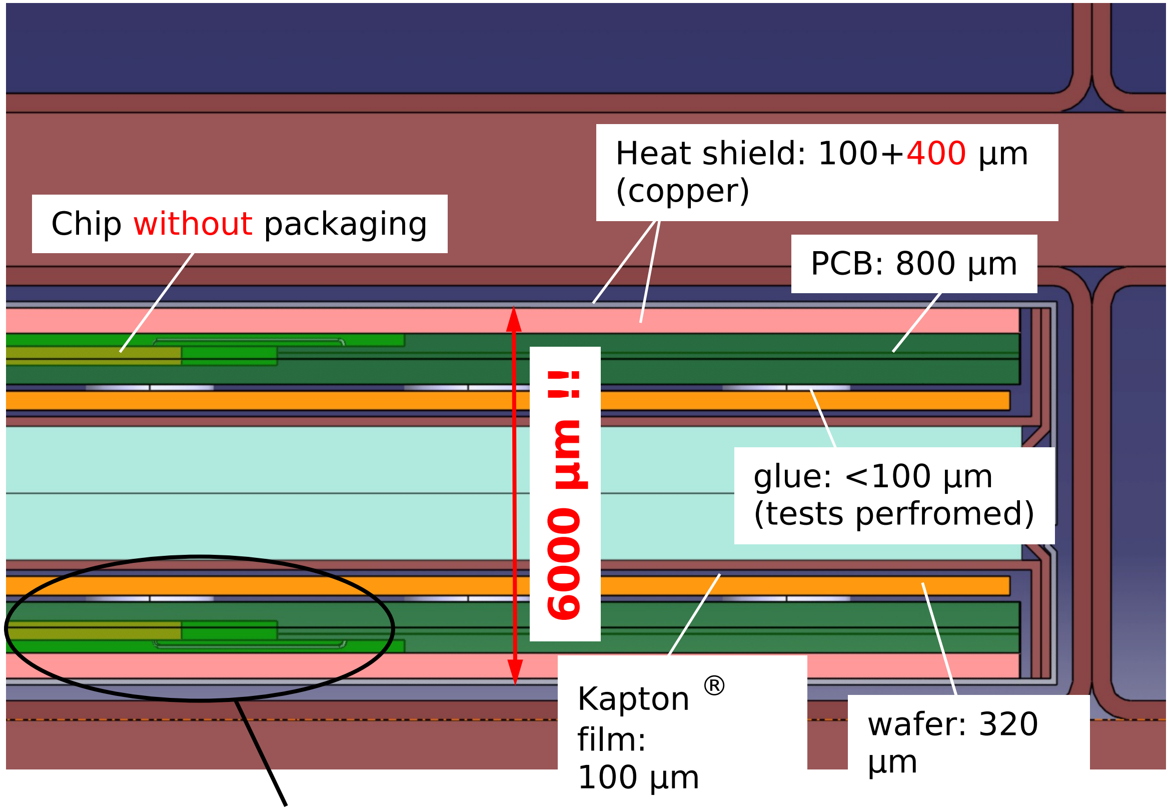
- **3 structures : 24 X_0 (10×1,4mm + 10×2,8mm + 10×4,2mm)**
- **sizes : 380×380×200 mm3**
- **Thickness of slabs : 8.3 mm (W=1,4mm)**
- **VFE outside detector**
- **Number of channels : 9720 (10×10 mm^2)**
- **Weight : ~ 200 Kg**

- **1 structure : ~ 23 X_0 (20×2,1mm + 9×4,2mm)**
- **sizes : 1560×545×186 mm3**
- **Thickness of slabs : 6 mm (W=2,1mm)**
- **VFE inside detector**
- **Number of channels : 45360 (5×5 mm^2)**
- **Weight : ~ 700 Kg**

Design of Slab – Cross Section

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

Design EUDET Slab



Chips and bonded wires inside the PCB

- Gaps (slab integration) : 500 µm
- Heat shield : 400 µm
  dissipation via thermal grease
- PCB : 800 µm
  chips embedded in PCB
  grooves in heat shield
- Thickness of glue : < 100 µm
  study of the size of dots see later
  50 µm aggrssive goal
- Thickness of wafer : 320 µm – (± ?)
  30 matrix ordered (90× 90 mm^2)
- Kapton® film HV feeding :
  100 µm - OK *(DC coupling)*
- Thickness of W : 2100 µm (± 80 µm)

Numbers are Baseline for EUDET Design Memo

Further options under investigation

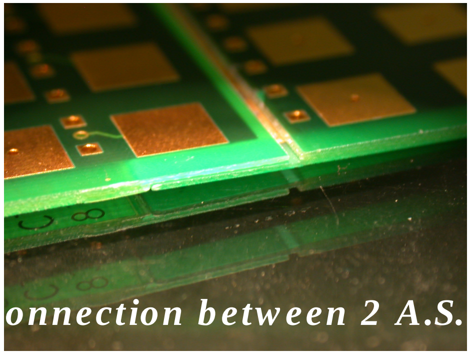
ECFA Meeting Warsaw June 2008

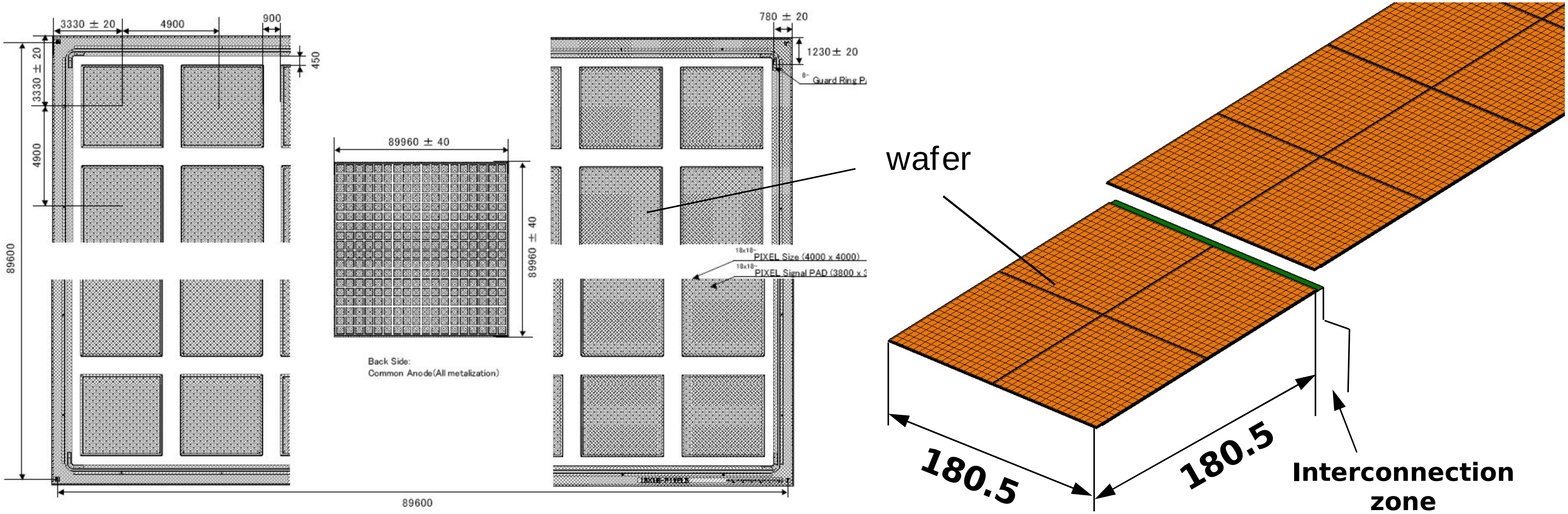
Detector Slab Principle

Long slab is made by several short PCBs :

A.S.U. : Active Sensors Unit

- ❑ Design of one interconnection « **inside** » PCB
- ❑ Easier development : study, integration and tests of A.S.U in parallel with other components of the project
- ❑ The length of each long slab will be obtained from the size of one “final PCB”

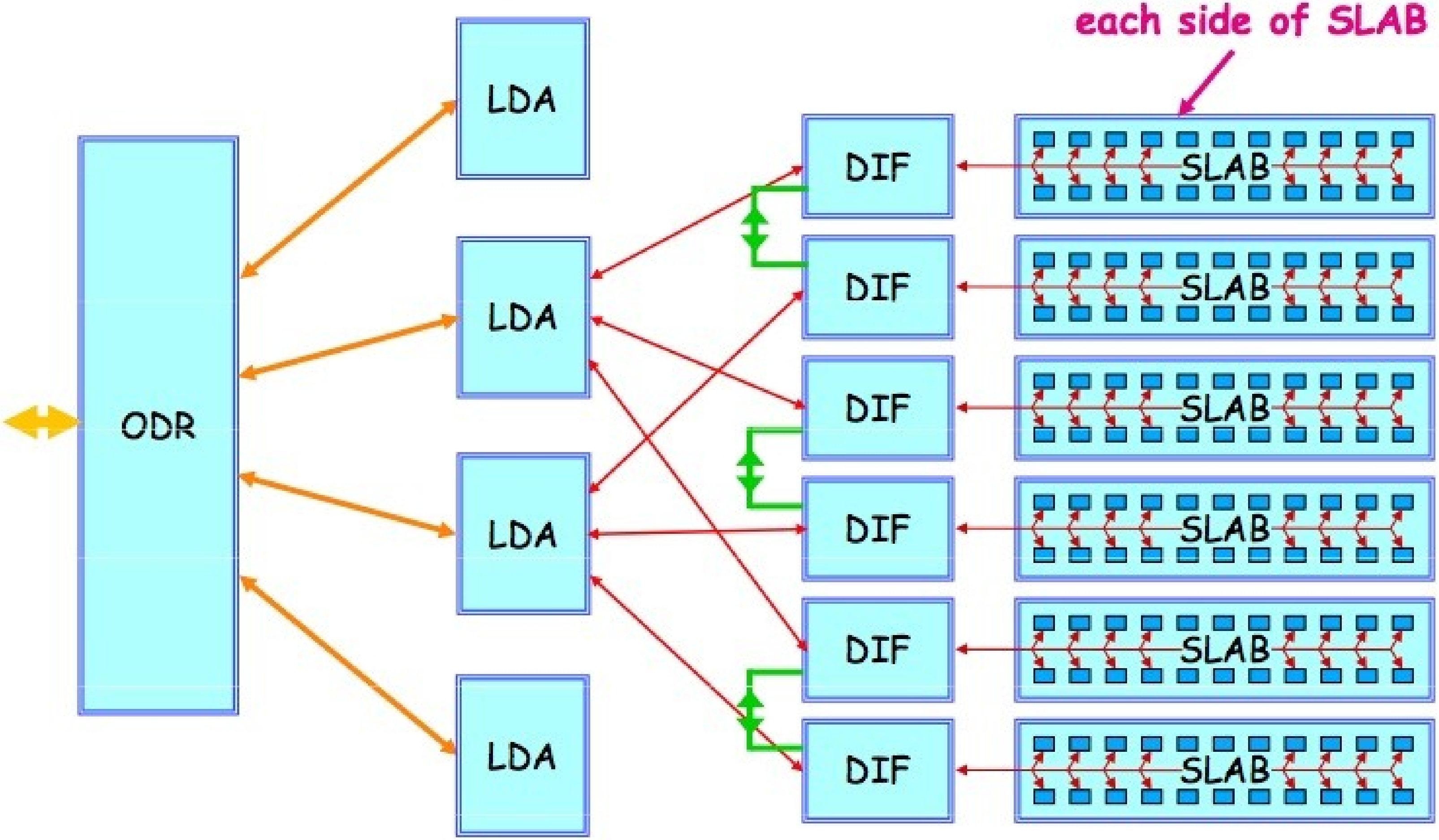

onnection between 2 A.S.



ECAL SLAB Interconnect

UNIVERSITY OF CAMBRIDGE

DAQ Architecture – Overall view



~150 VFE ASICs on each side of SLAB

Maurice Goodrick & Bart Hommels , University of Cambridge

ECAL SLAB Interconnect

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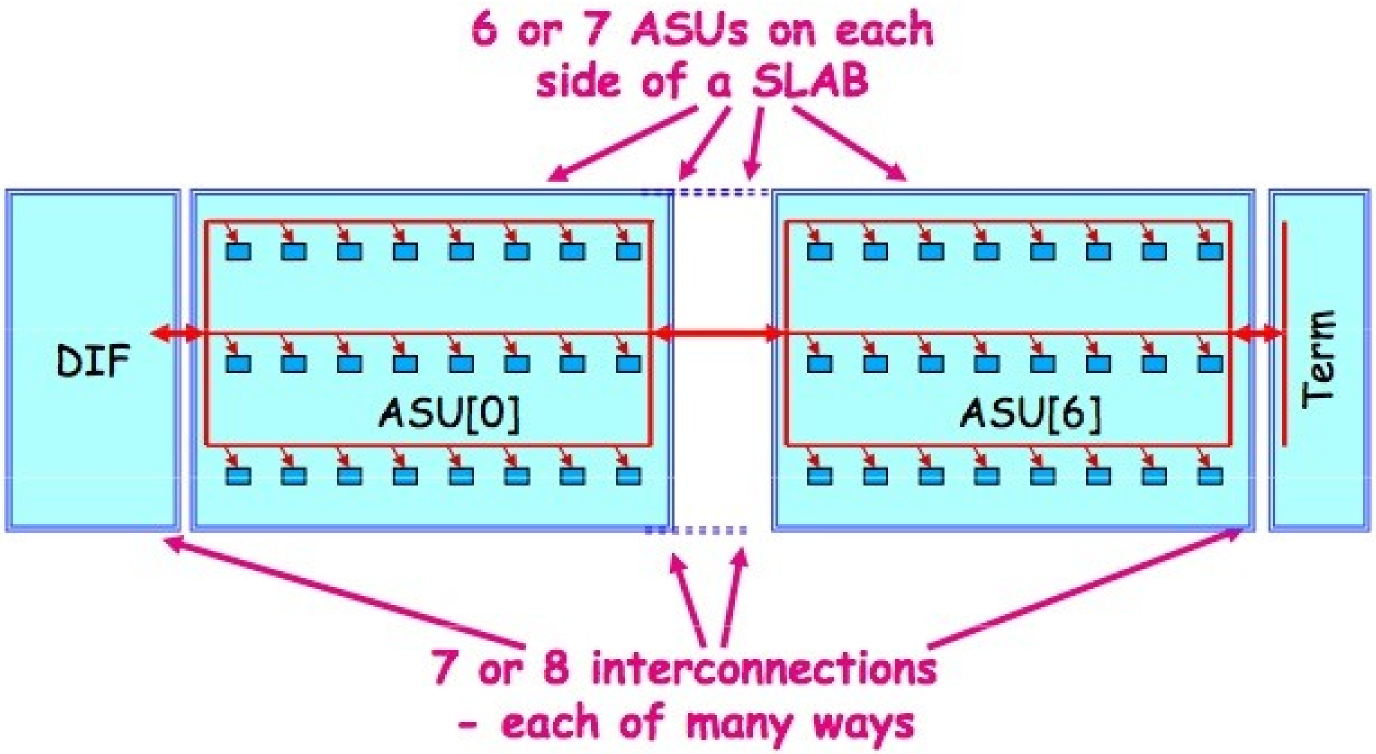
Interconnections

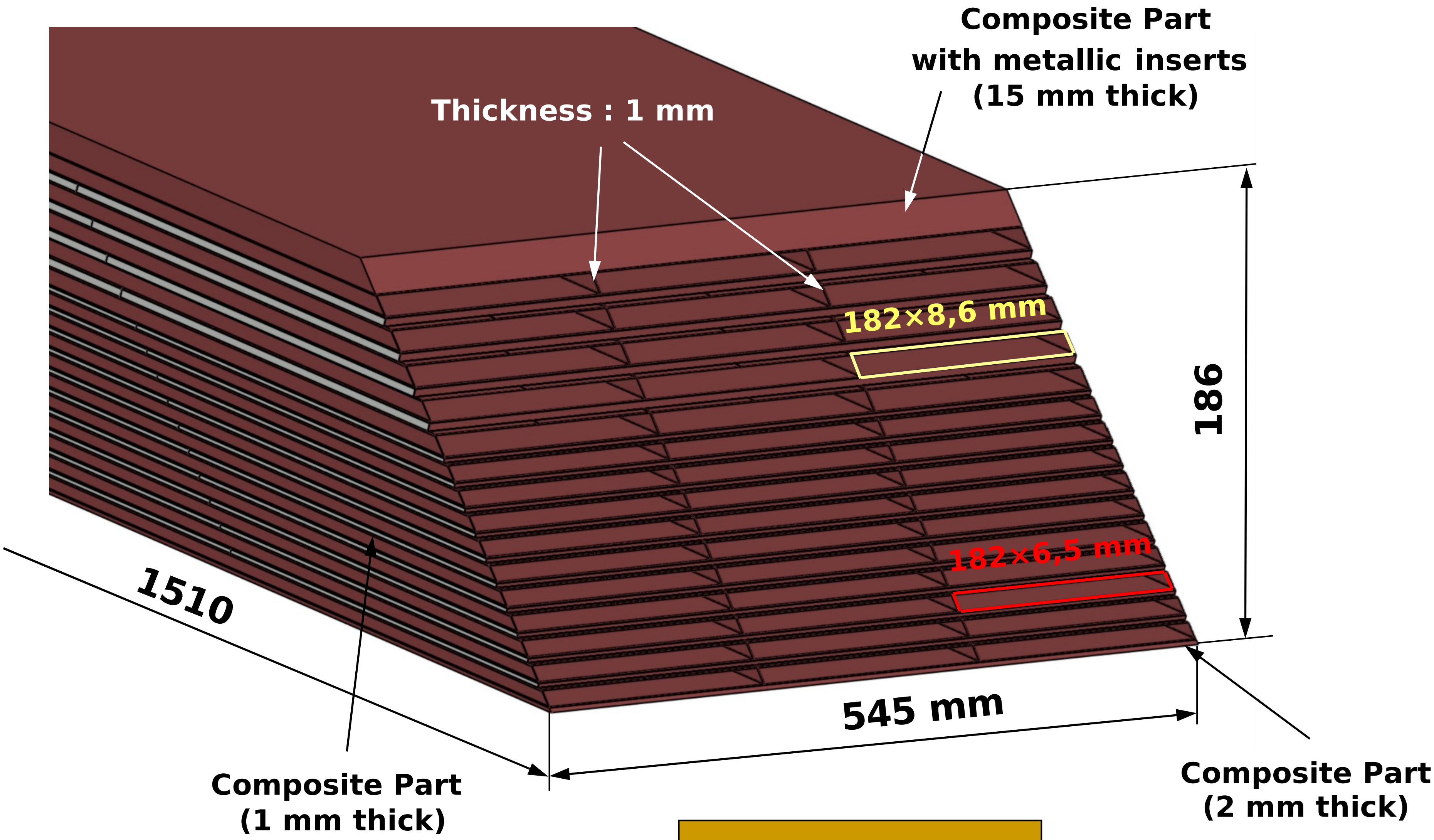


Options for Interconnection of ASU:

- glued joint step
- (glued) direct stitching
- FFC (Flat Flexible Cable)
- Bridges by 'Mini PCB'

Read out Mode (Single line, multiple lines?)

Alveolar Structure



Weight ~ 650 Kg

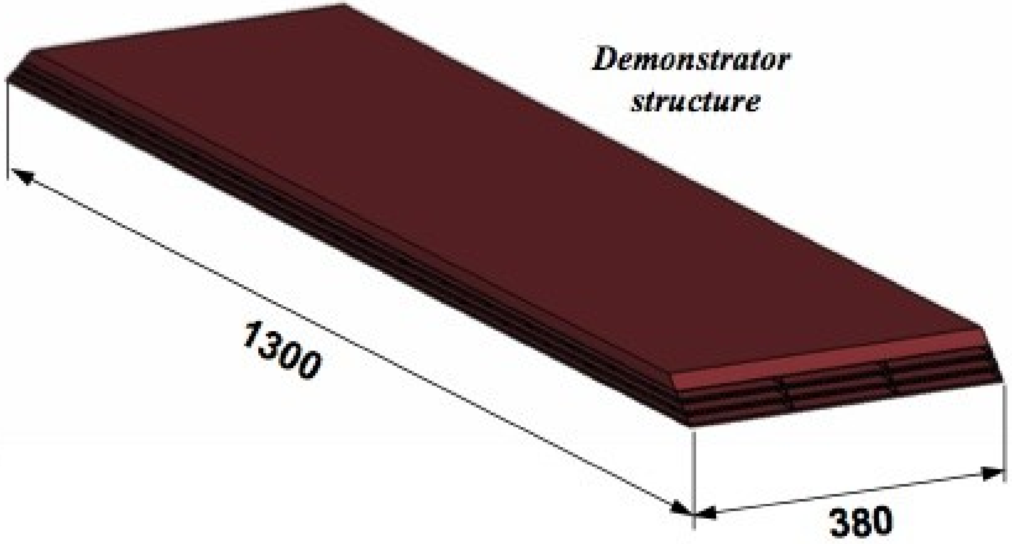
Demonstrator design

- We plan to build a first small demonstrator to validate all process before the EUDET module
- Dimensions based on physic prototype (cells width : 124 mm)

➡ need to validate all Eudet dimensions !!!

- Could be used for thermal studies and analysis : design of a thermal PCB and cooling system.

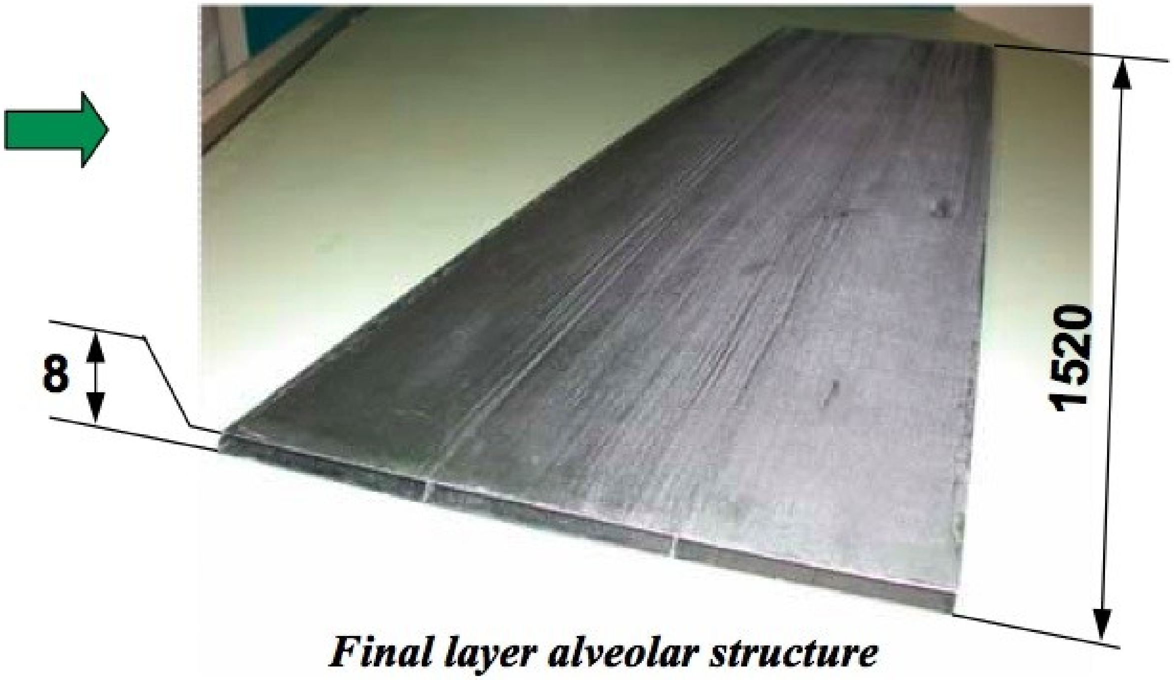
- 3 alveolar layers + 2 W layers
- 3 columns of cells : representative cells in the middle of the structure
- Thermal studies support
- Width of cells : 124 mm
- Identical global length : 1.3m and shape (trapezoidal)
- Fastening system ECAL/HCAL



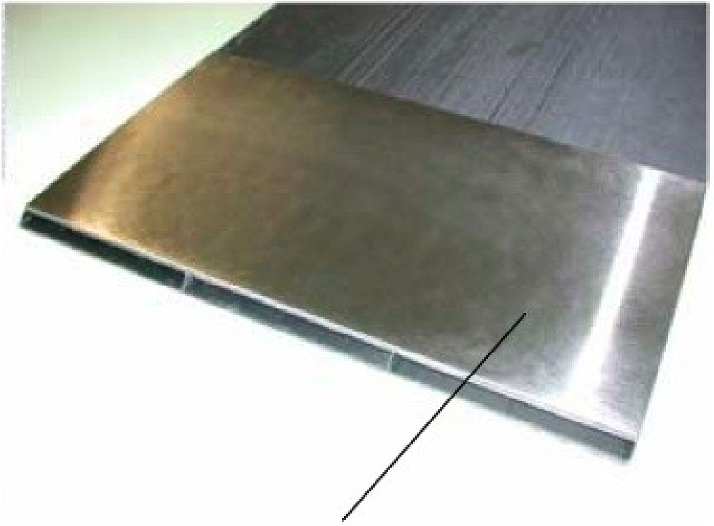
M.Anduze, LLR

Building the first real pieces

First alveaolar structure produced



Final layer alveolar structure

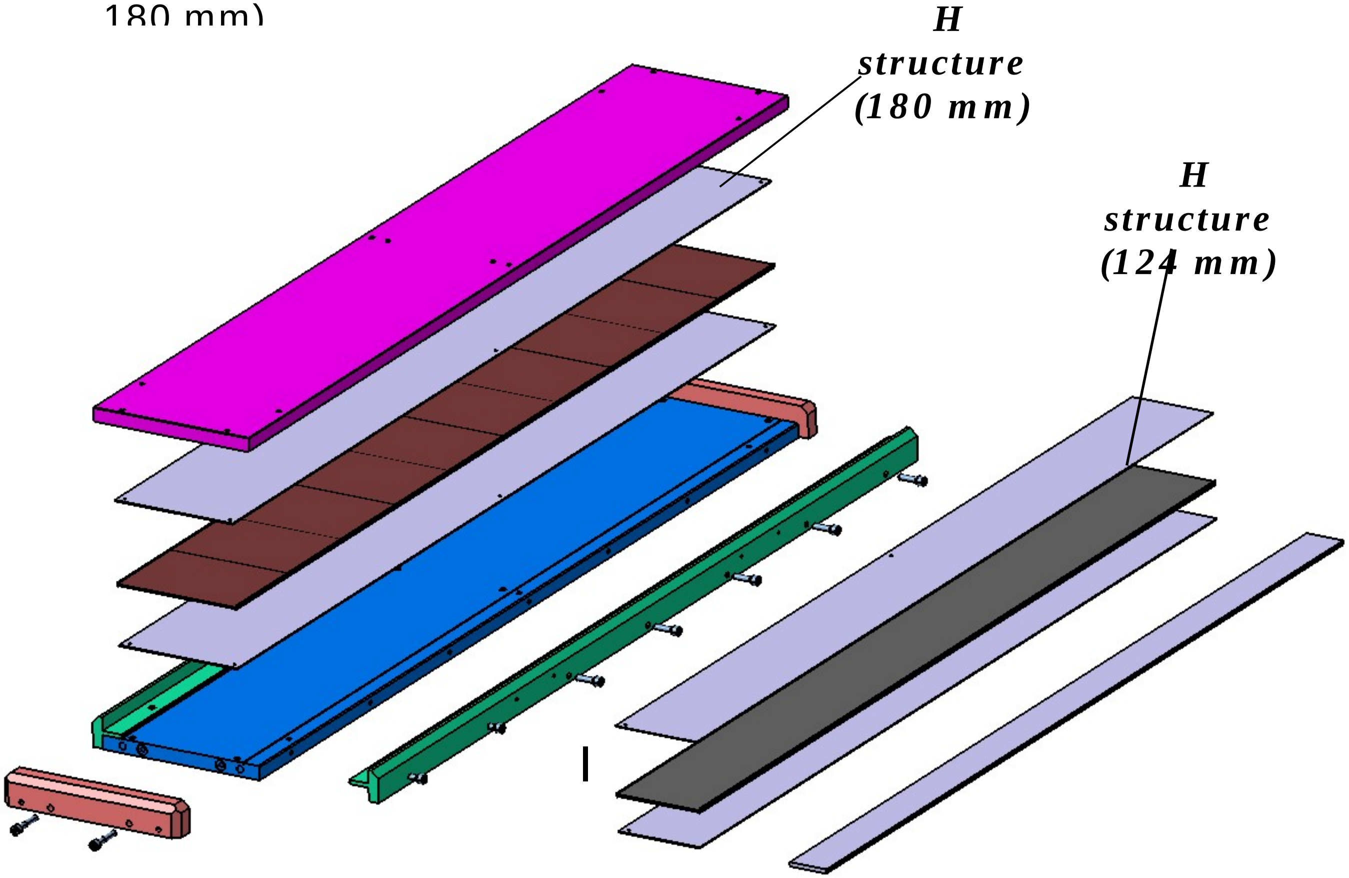


W plate (2.1 mm thick)

Composite H Structure

Study and manufacturing of one mould for whole structures (feb 2008):

- Same principle than the mould used to do H physical prototype structures (autoclave)
- One long mould for both long and short H structures and 2 width (124 and 180 mm)



⇨ Design : OK

⇨ Machining : on going

⇨ Ready (W + C) to mould first H structure (1300×124)

Expected to be ready by Mid of June 08

EUDET Milestone report on moulds and structures by end of June

Destructive Tests

Mechanical tests of interface (feb 2008):

- Destructive tests of fastening elements:

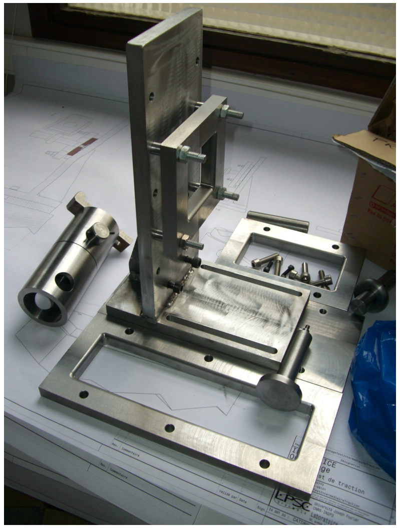
  until breaking of interface in order to evaluate constraints and elongations under different loading cases:

  - Tensile / Compression
  - Cutting / Bending

- Study and fabrication of testing tools: OK

- Check and validate simulation results by destructive tests for each issues

- Similar type of tests to be performed for characterization and calculation of inter- alveoli thin sheets of composite



tools for tensile and compression tests

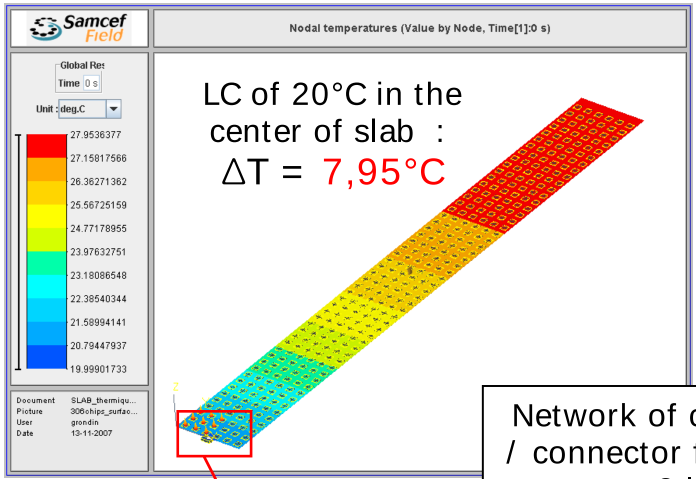
Machine for destructive tests

Test pieces (interface)

Thermal Analysis of Slab

Simulation of heat conduction just by the heat copper shield :

Influence of the FPGA dissipation (DIF) on current design of cooling system (Limit Condition of 20°C) :

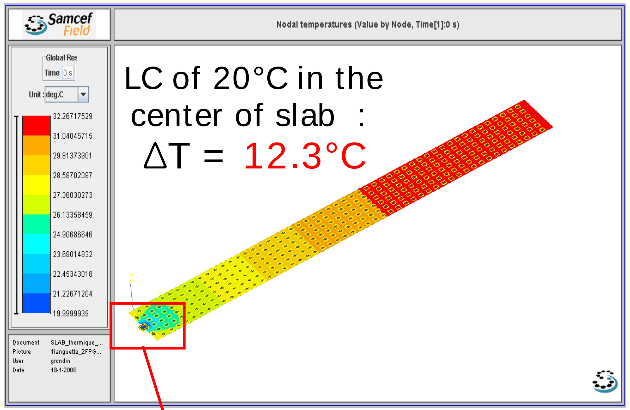


Document SLAB_thermiqu...
Picture 306chips_surfac...
User grondin
Date 13-11-2007

LC of 20°C in the center of slab :
ΔT = 7,95°C

$\leftarrow \Phi$= **0,27 W/layer**
(25 μW per channel)
Φ_{FPGA} **= 3 W/layer** →

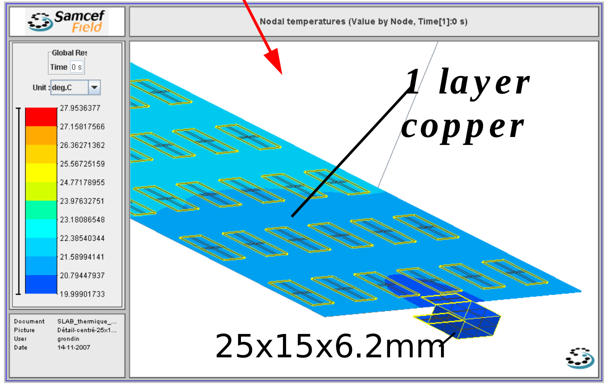
Copper layer : λ = 400 W/m/K
S = 180*0,4 mm2 ; L =



Document SLAB_thermique_...
Picture 1languette_2FPG...
User grondin
Date 18-1-2008

LC of 20°C in the center of slab :
ΔT = 12.3°C

Network of contact areas / connector fixed on the 2 layers



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Picture Détail-centré-25x1...
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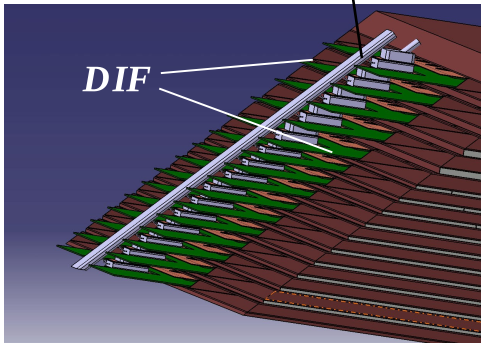
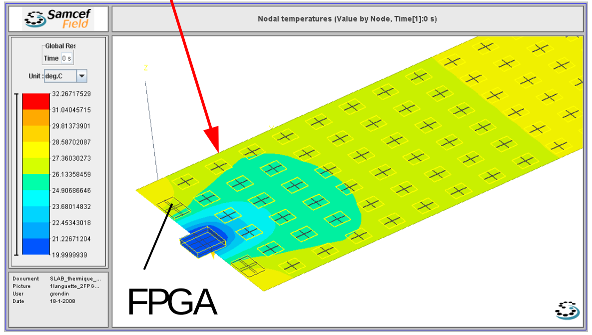
Date 14-11-2007





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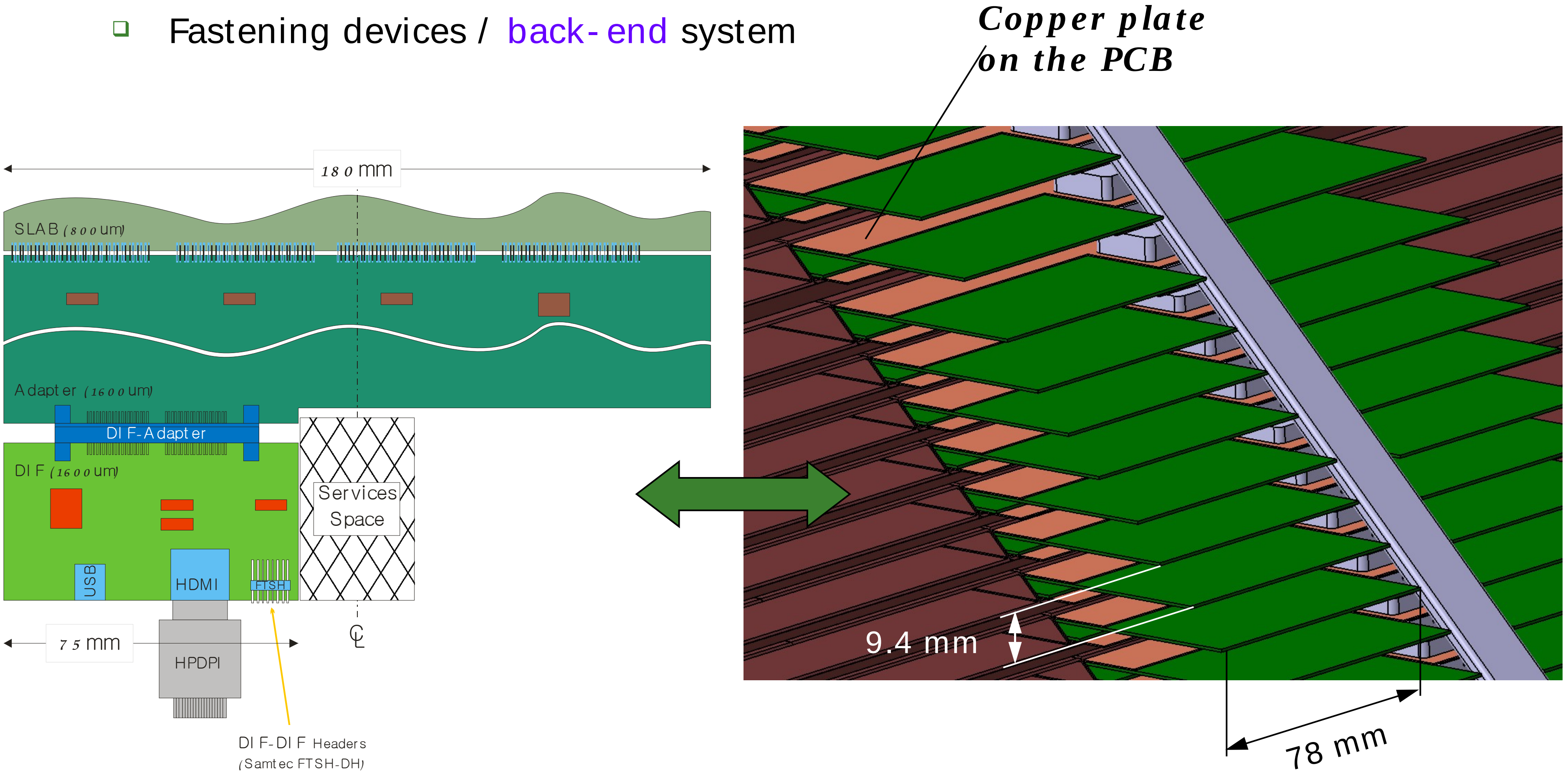
User grondin
Date 18-1-2008

→ **ΔT** and **size** of cooling pipe increase (ΦT = 8.1 W (SKIROC) to 98.1 W) (SKIROC + DIF)

Interface SLAB <-> DIF

Current Module design compatible with this proposal fromCambridge?

- Adapter board (size, thickness ...)
- Components size
- Connectors size
- Fastening devices / back-end system



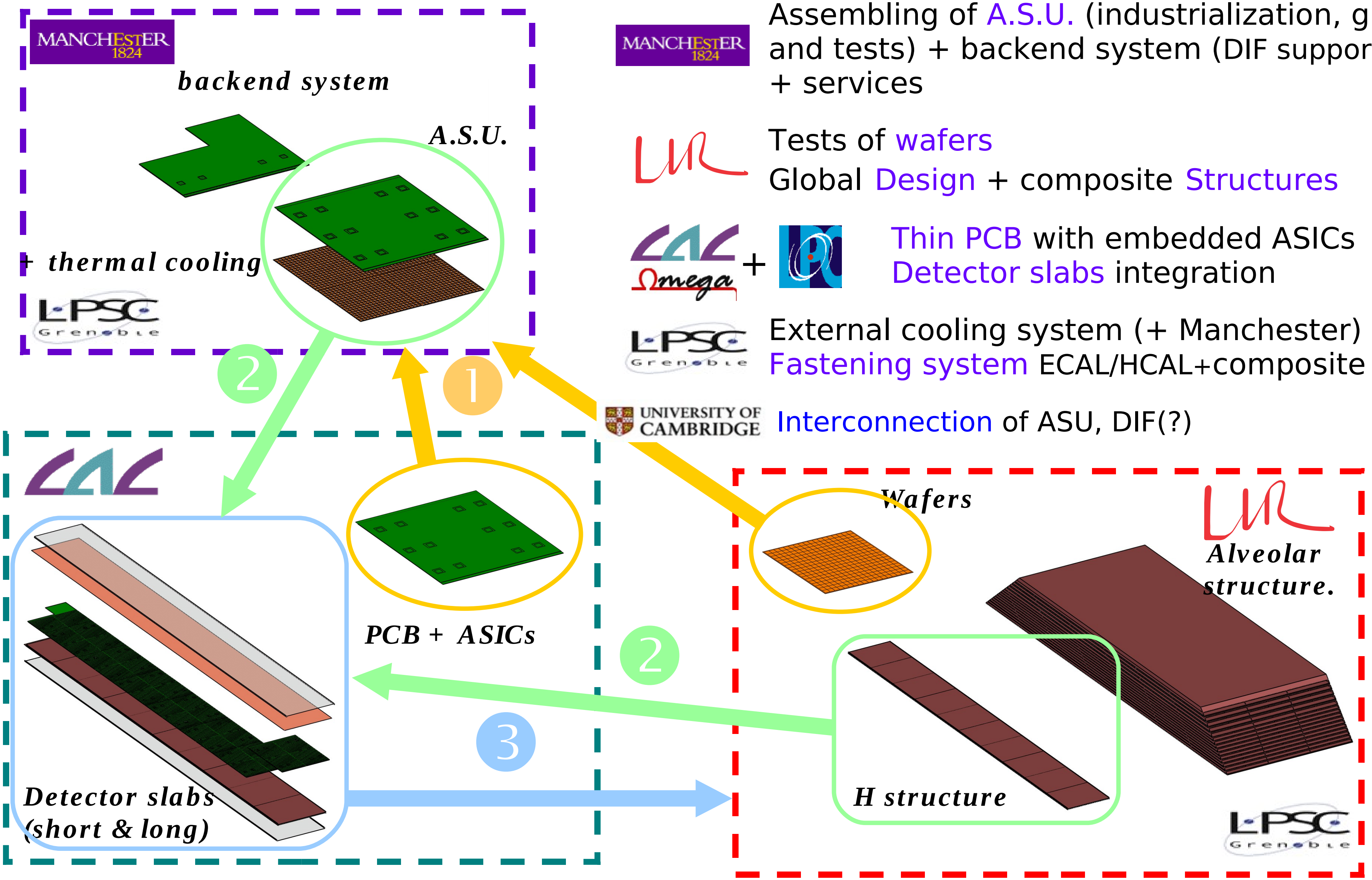
(from Maurice Goodrick, Bart Hommels)

One of the biggest unknowns in the game!!!

Parties Involved

6 Laboratories are sharing out tasks in according to preferences and localization:

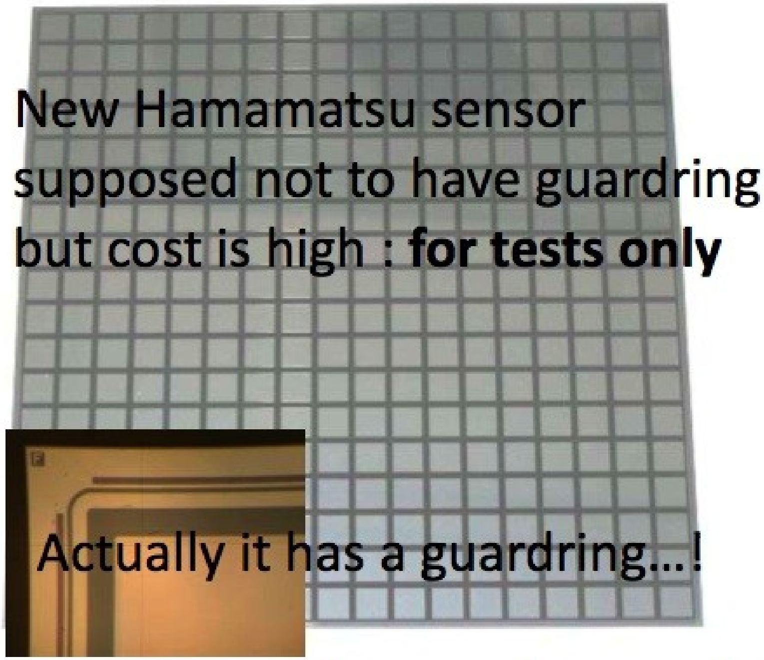
- Assembling of A.S.U. (industrialization, gluing and tests) + backend system (DIF support) + services
- Tests of wafers
Global Design + composite Structures
- Thin PCB with embedded ASICs
Detector slabs integration
- External cooling system (+ Manchester)
Fastening system ECAL/HCAL+composite plates
- UNIVERSITY OF CAMBRIDGE: Interconnection of ASU, DIF(?)



Status of Wafer Production

- 30 Wafers arrived from Hamamatsu arrived middle of April

  - 90x90mm2 wafers for 324 cells per wafer
  - 5x5 cell size
  => 324 Cells/wafer



New Hamamatsu sensor supposed not to have guardring but cost is high : **for tests only**

Actually it has a guardring...!

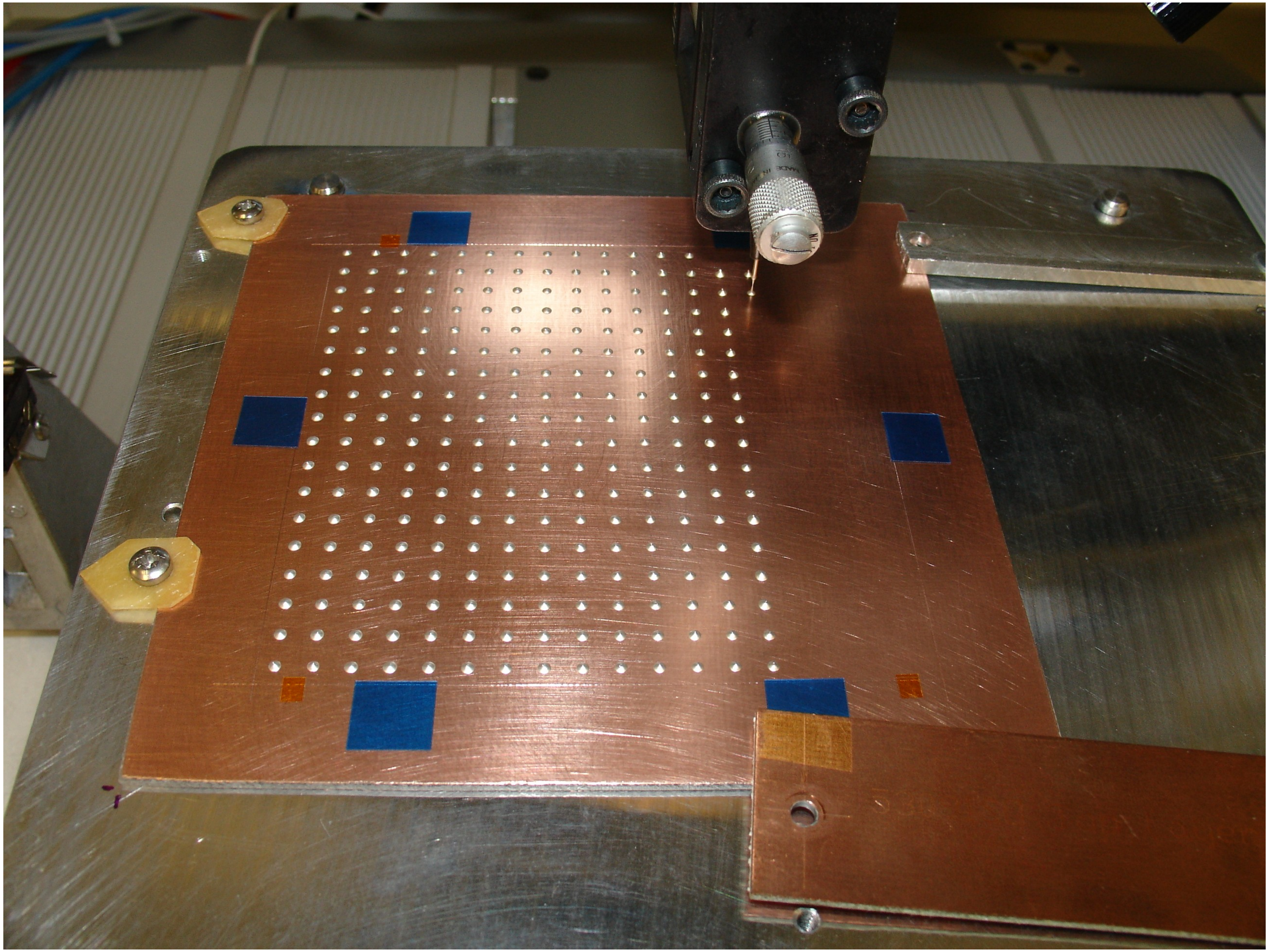
Study of guardring effects within EUDET Project

- Immediate start of Characterisation
  - Leakage Current (I-V curves)
  - Full depletion Voltage (C-V Curve)
  - 29/30 Wafers are found to be ok

- Can be used to test gluing with 'real' wafers

Mechanical/Electrical Connection between Wafer and PCB – Gluing T

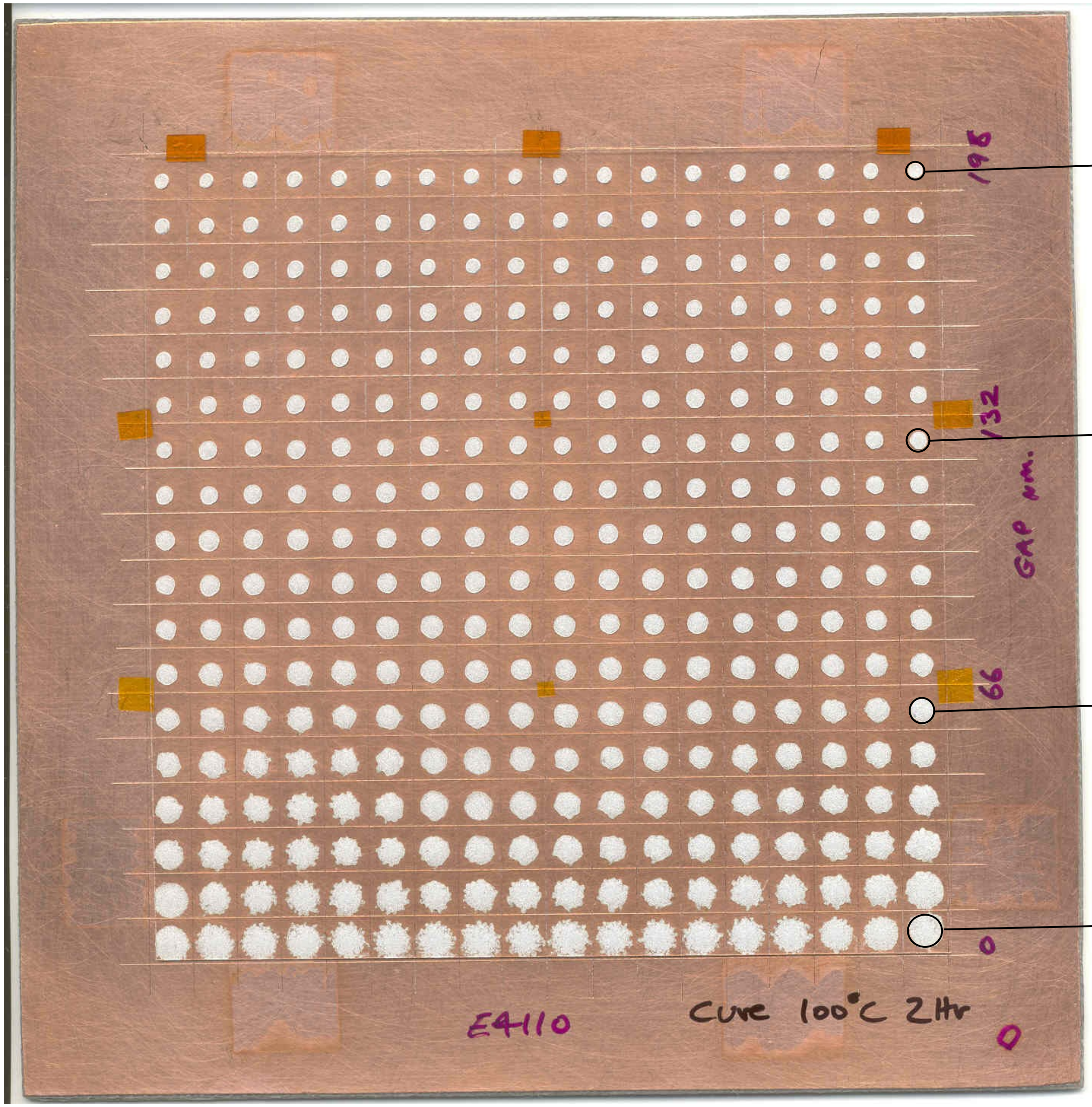
Using simple glass plates to mimic wafers



Placing glue dots

18 x 18 (324) dots on 5mm grid takes ~5min

Wedge Shaped Glass Plate



Ø1.6 mm

200 µm
space between
glass and pc board

Ø2.0mm

132 µm
space between
glass and pc board

Ø2.5mm

66 µm
space between
glass and pc board

Ø3.6mm

zero
space between
glass and pc board

Glass Plate #2

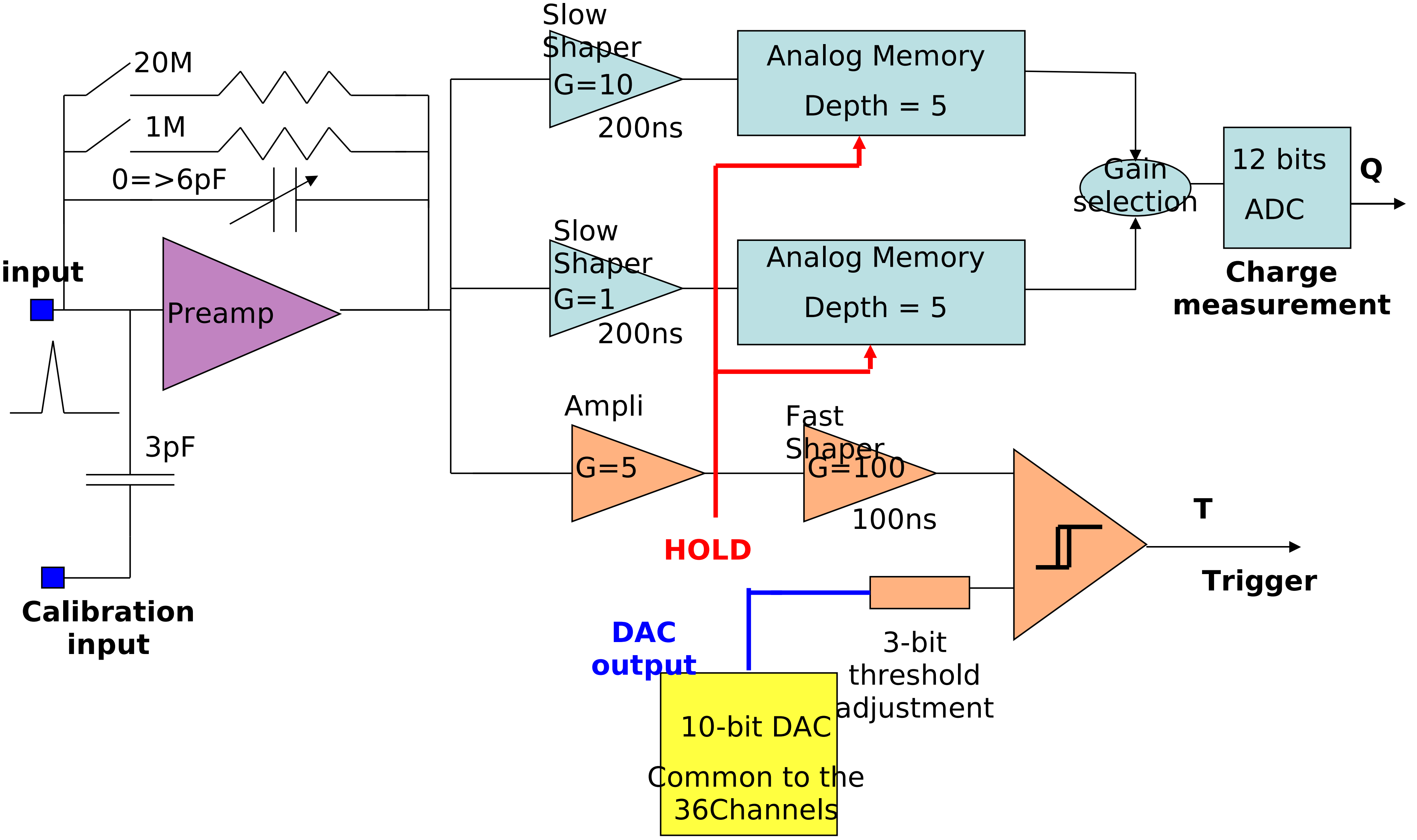
0.2 sec per dot

Mid spacers under plate

Net Conclusion: Gluing of tight wafer matrix can be done
Dot thickness/width influences resistivity: Diameter control within 50µm seems feasible

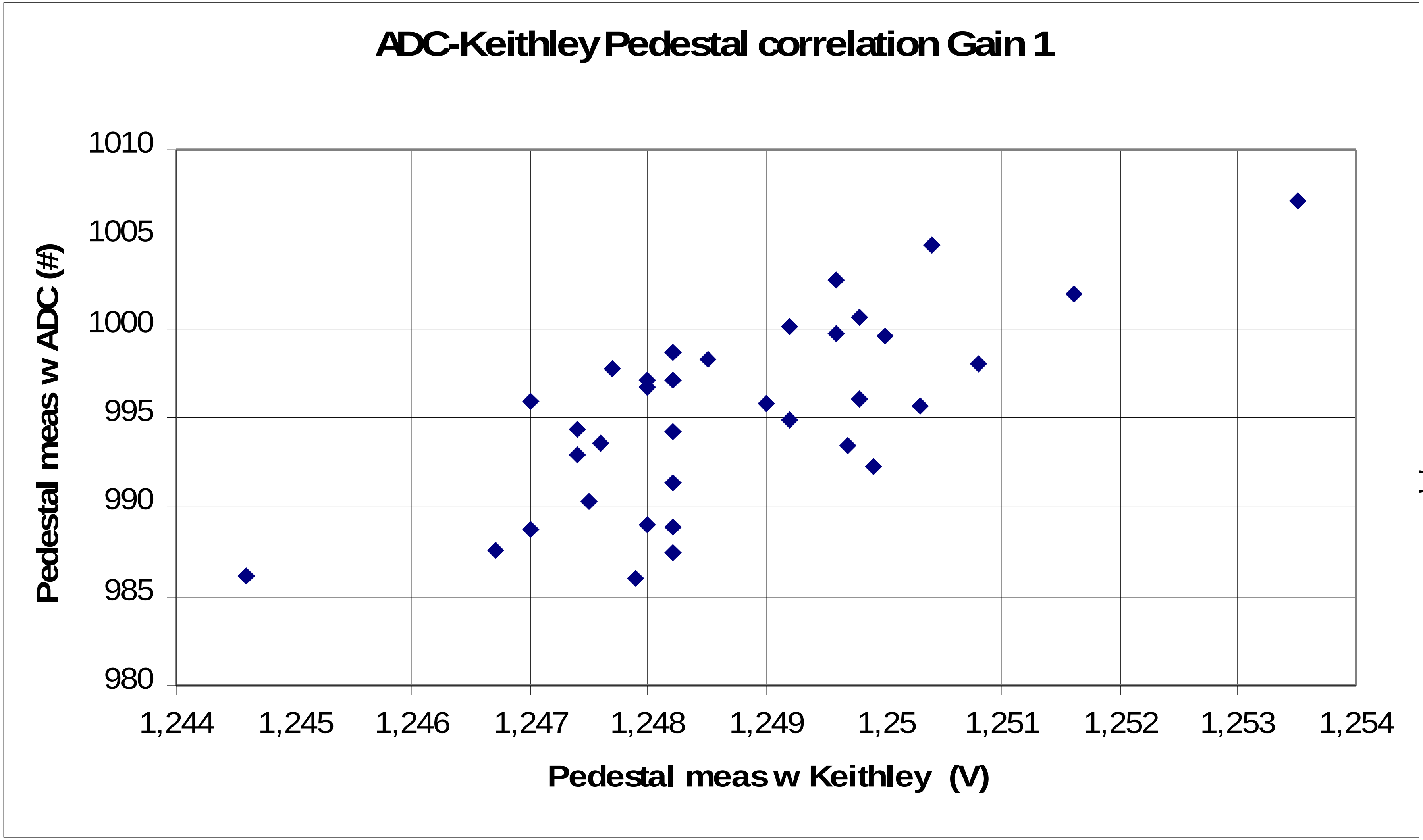
SKIROC Chip

One Channel:



Test with 36 Channel Chip
SKIROC Chip still in design phase mainly due to high demands on compactness
Pixel Calorimeter is challenging technology

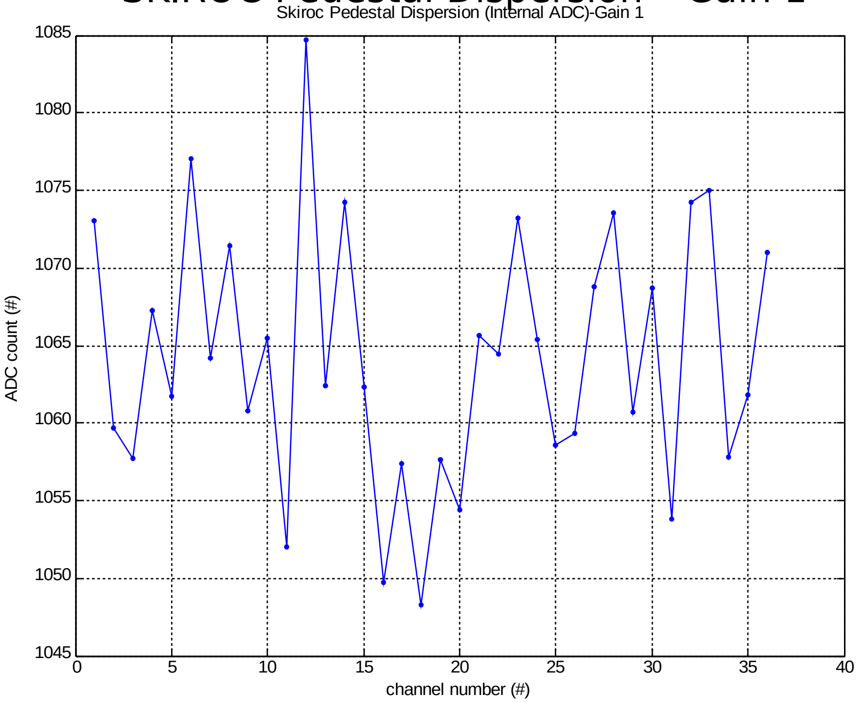
SKIROC Measurements



Counts
mV/Count)

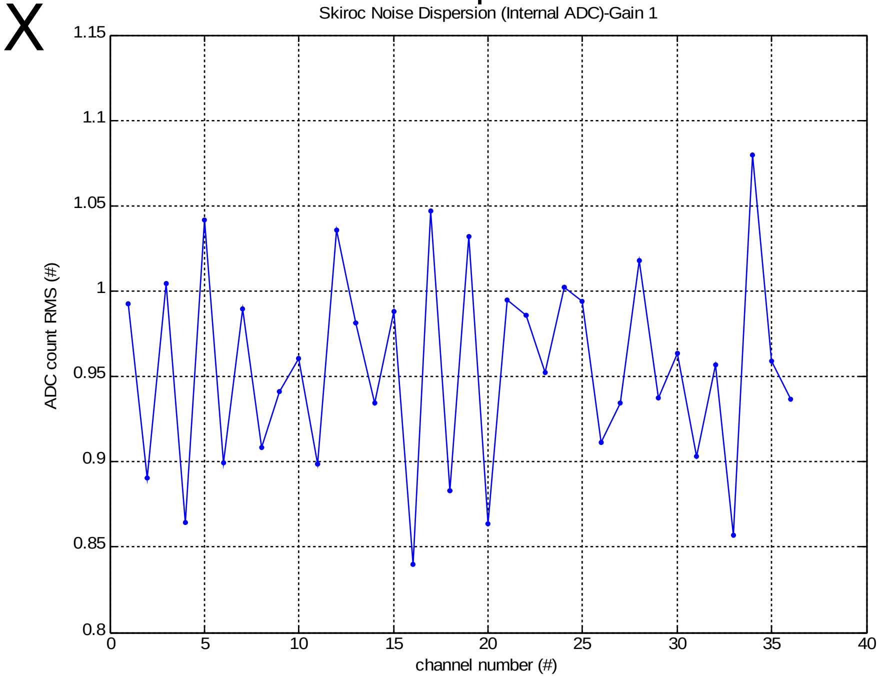
Independent measurements of pedestals compatible

SKIROC Pedestal Dispersion – Gain 1

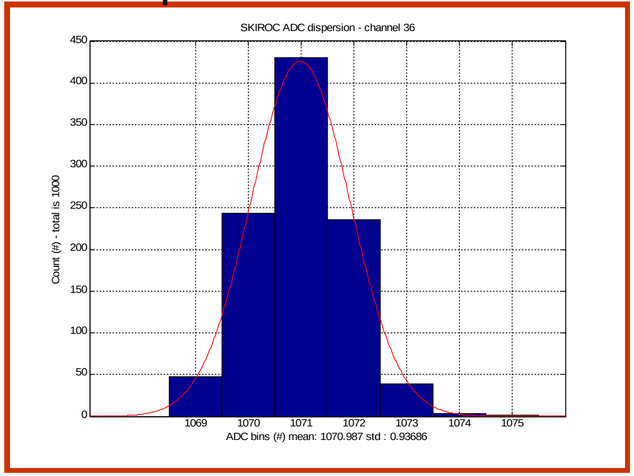


X

SKIROC Noise Dispersion – Gain 1



Example for one channel

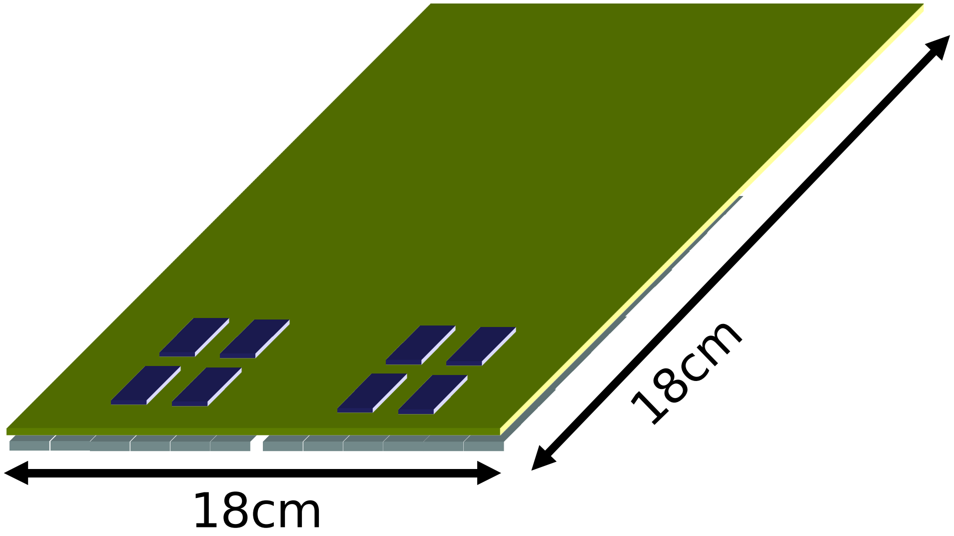


Random Distribution
of Pedestals

Gaussian Noise
~0.95 ADC Counts = 330 μV

PCB Design: FEVN – Parallel developments

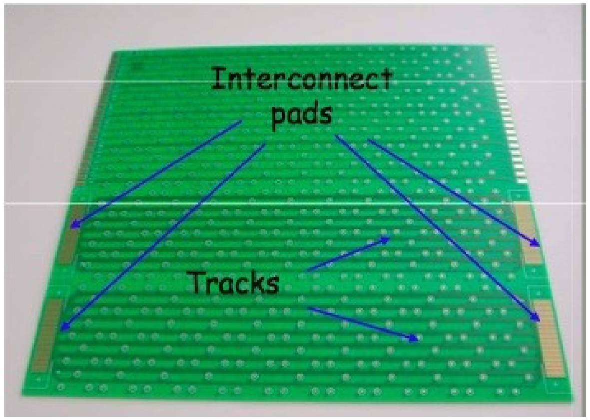
FEV5



Test interplay with
DIF cards
Dimensions?

Use HARDROC Chip (for EU-DHCAL)
to advance in PCB design
Engineering done
Expected to be ready in Jan.09

FEV6



Gluing tests
ASU Interconnection
Temperature Dissipation
Mechanical Rigidity
Dimensions

Designed and Produced

Rather a Mockup than
a fully qualified PCB

FEV7

To be designed
this summer

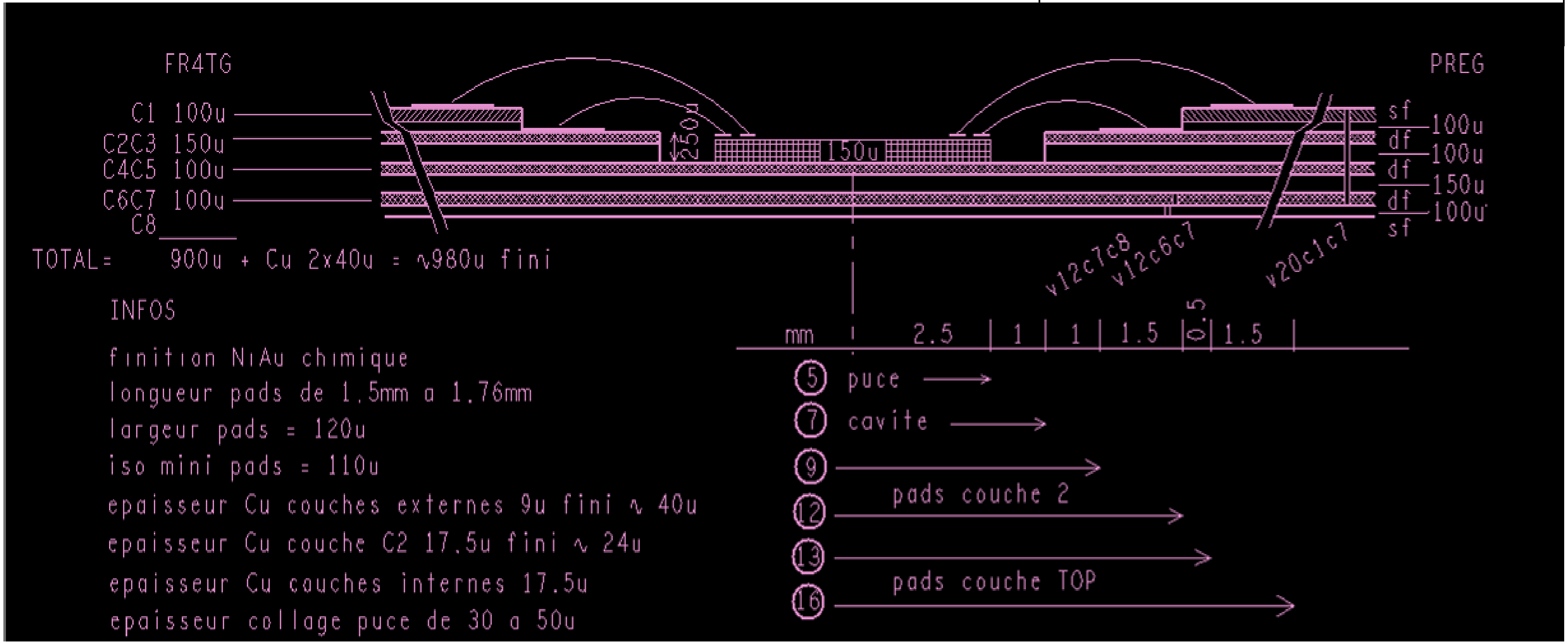
Employed
with
Hamamatsu
Wafers

Chip Integration in PCB

<u>Pile-up</u>

TOP	GND+routing
C2	AVDD+routing
C3	AVDD+DVDD
C4	GND + horizontal routing
C5	AVDD+ vertical routing
C6	GND+pads routing
C7	GND (pads shielding)
BOT	PADS

<u>3 drilling sequences</u> :
- Laser C7-C8 120µ filled
- Laser C6-C7 120µ
- Mechanical C1-C7



- Bonding wires from Chip to PCB challenging due to large number of channels
- Has to fit into overall mechanical tolerances (see above)

Summary and Conclusion

- EUDET Prototype is logical continuation of CALICE SiW Ecal Prototype

- Next steps towards ILC Detector Module
  - Addresses technological challenges of detector construction
  - Large scale integration
  - Power consumption

- First long structure produced
  - First long H-Structure until next week

- Mechanics is heading towards two Milestone reports
  - On Moulds and Structures by End of June
  - On design by Middle of September

- Wafer tests successful

- Electronics is extremely challenging
  - Analog and digital part on one chip
  - Limited space for PCB

- Lots of important studies going on (Not presented today)
  - E.g. Effect of wafer guardring

Backup Slides ...

Schedule (Taken from Marc Anduze)

Assembling of **A.S.U.** (industrialization, gluing and tests) :

first gluing studies (glass on PCB)	**March 08**
first resistive tests according to the size of the dot	**March 08**
Backend system (DIF support)	**Jan 09 ?**
Services (cooling system participation ?)	**Jan 09 ?**

Tests of **wafers** :

reception 30 first wafers	**April 08**
set-up (“mechanical box”)	

Global Design

Composite **Structures** :

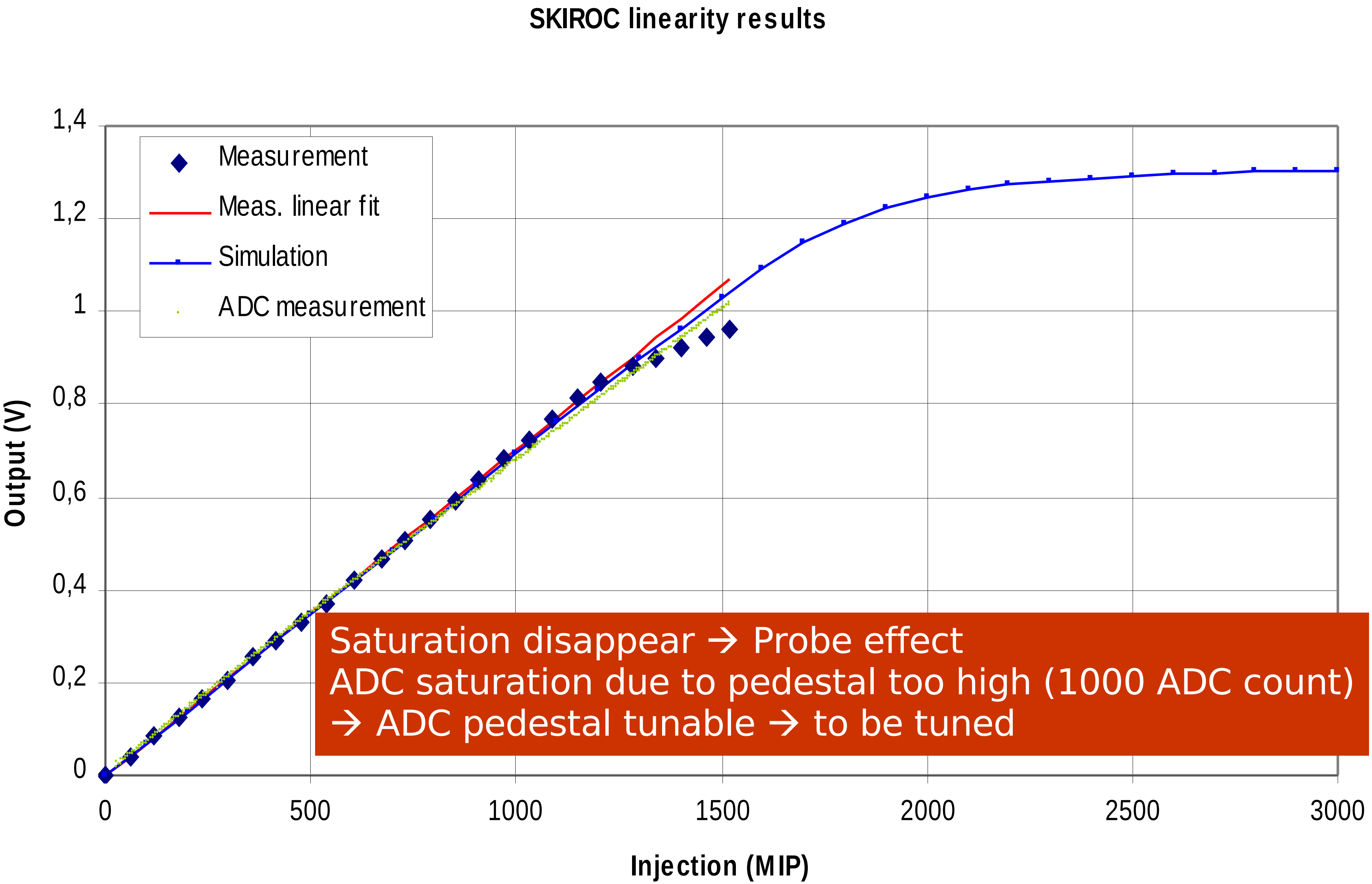
mould + first H structure (126 mm)	**March 08**
“alveolar layer” mould + first layer	**April 08**
assembly mould	**June 08**
demonstrator (2 or 3 layers – 126mm)	**Sept 08**

Thin PCB with embedded ASICs	**Jan 09 ?**
Detector slabs **integration**	**Jan 09 ?**

External **cooling system** (+ Manchester)	**June 08**
Fastening system ECAL/HCAL	**March 08**
composite plates	**Feb 08**

Lot's to be done

SKIROC - Linearity



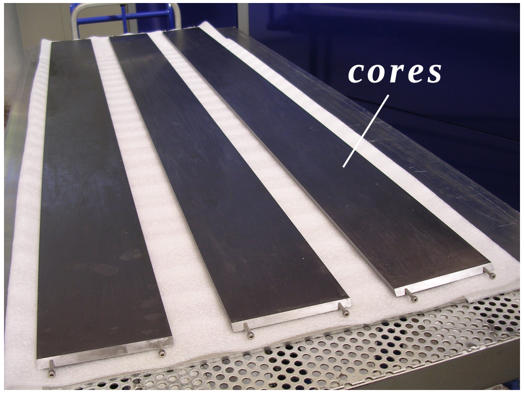
Saturation disappear → Probe effect
ADC saturation due to pedestal too high (1000 ADC count)
→ ADC pedestal tunable → to be tuned

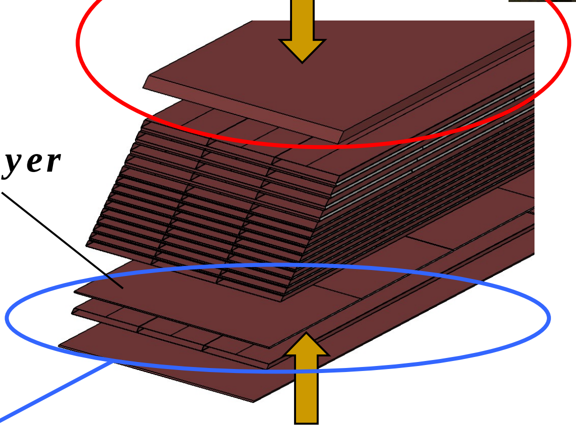
- Saturation also observed in independent measurements
- Effect about to be understood

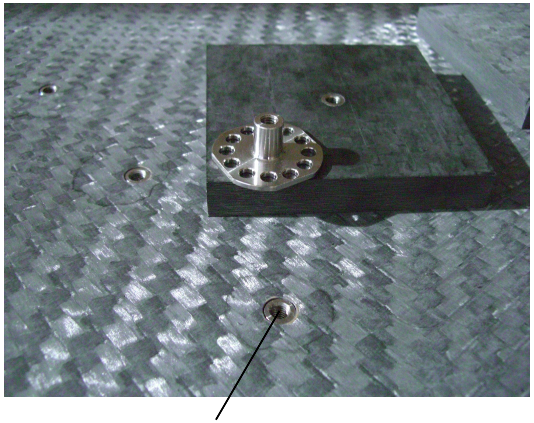
Alveolar Structure 1/2

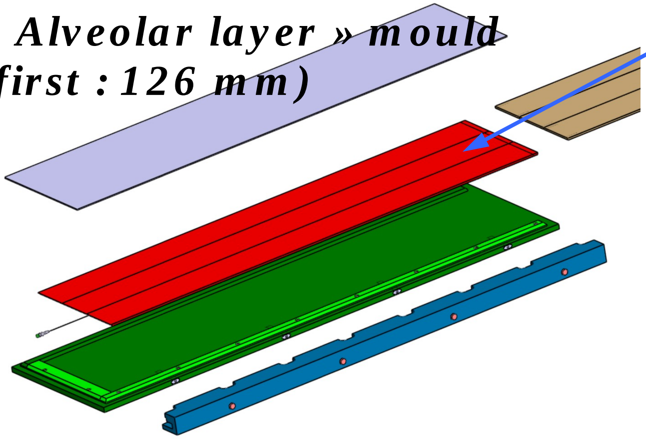
Assembled structure : Each alveolar layer are done independently, cut to the right length (with 45°) and assembled alternatively with W plates in a second curing step

(2 width of cells : 126 mm and 182 mm)









- ⇨ Global design : OK
- ⇨ “Alveolar layer” mould machining : on going
- ⇨ Design of assembly mould : on going
- ⇨ Ready : 4 composite plates (15mm and 2 mm)