AIDA 2020

CALICE Calorimeter for ILC

LPNHE PARIS

Si-W electromagnetic calorimeter

Contribution in the development of an assembly line for highly granular calorimeters with semiconductor readout

- Gluing robot system
- PCB Metrology
- Electrical tests
- Quality Insurance
- Industrialisation of the gluing process

ATLAS High Granularity Timing Device

Physicists: 0.5 FTE

J-E. Augustin

D. Lacour

Technical staff: 2 FTE

J. David : electronic

P. Ghislain : mechanic

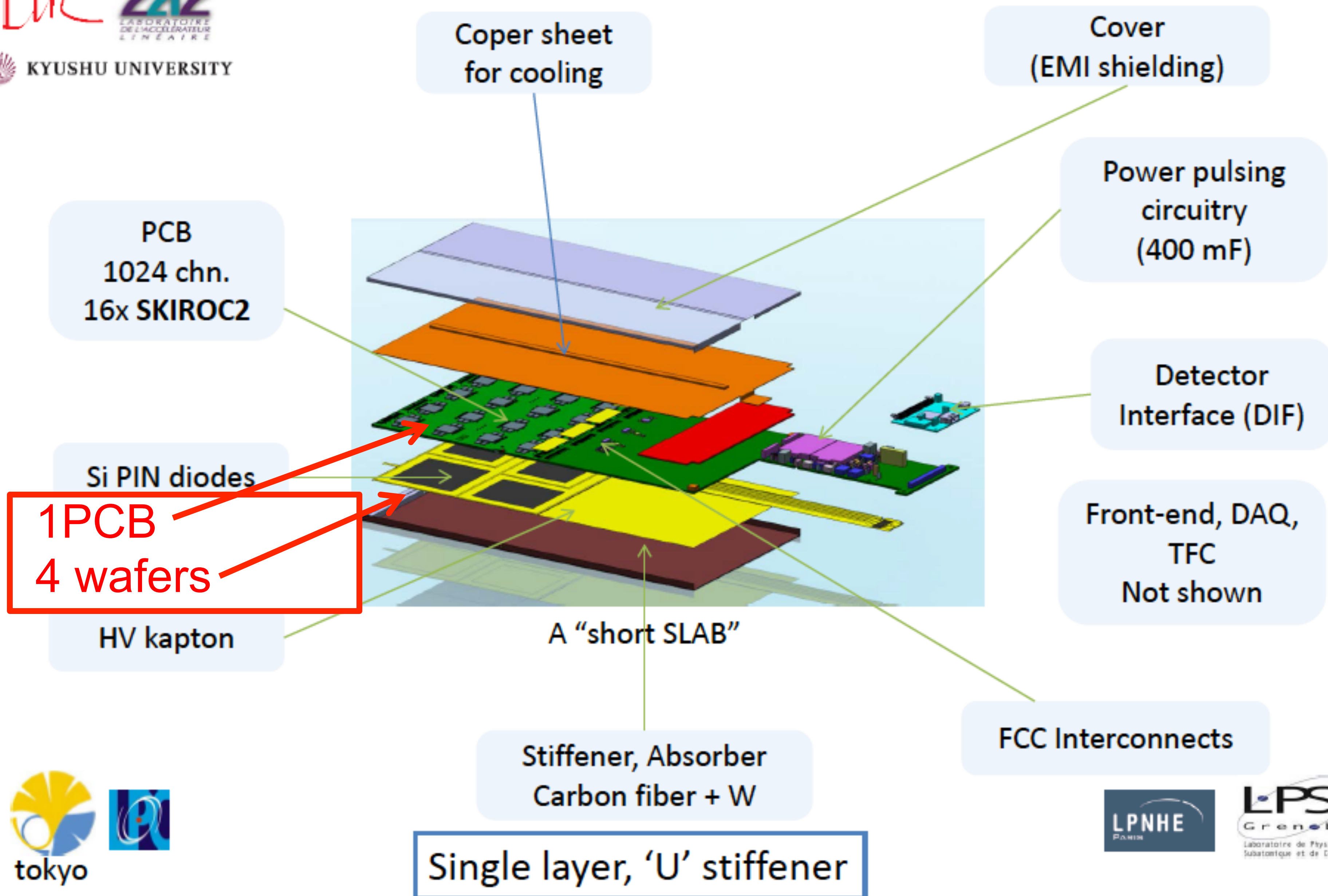
J-F. Huppert : computing

L. Lavergne : instrumentation

J-M. Parraud : electronic

D. Vincent : mechanic

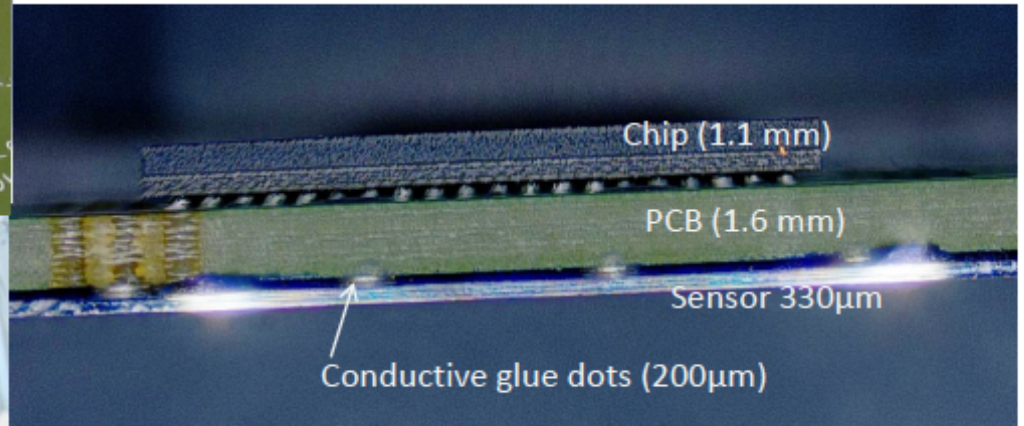
Description of one layer



Single layer, 'U' stiffener

Detector module assembly

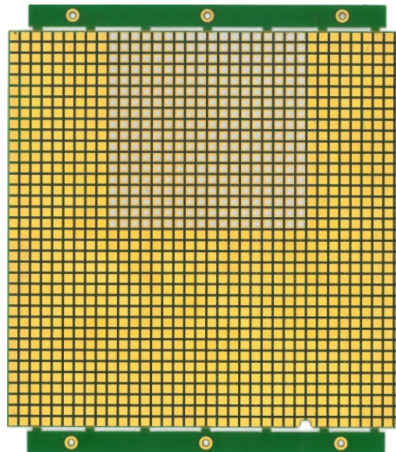
Robots for gluing sensors are developed

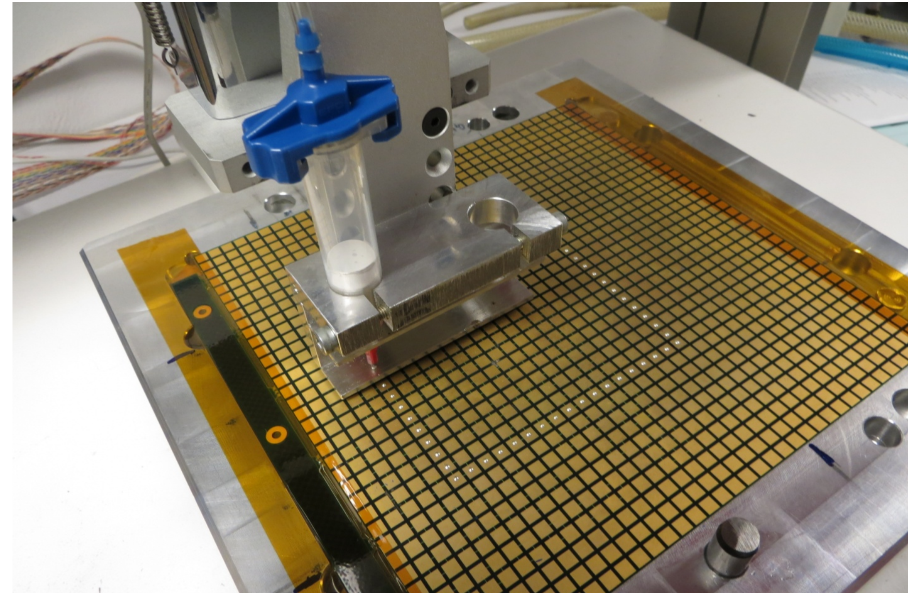


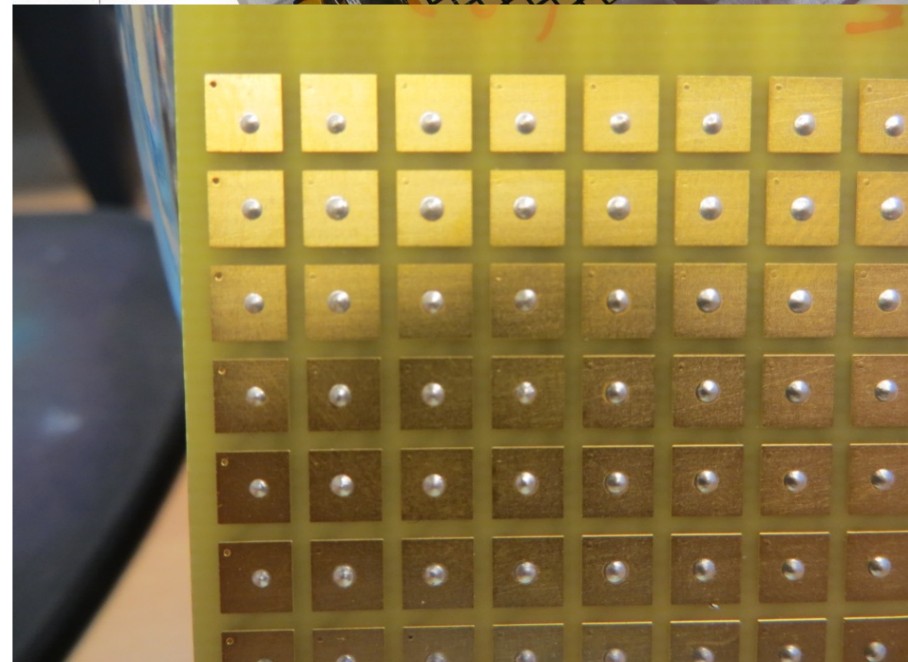
4 wafers 9cm x 9 cm wide can be glued with a 20 µm precision and reproducible process.
Glue is dispensed in order to form 200 µm thick dots

First step : one wafer glued per PCB

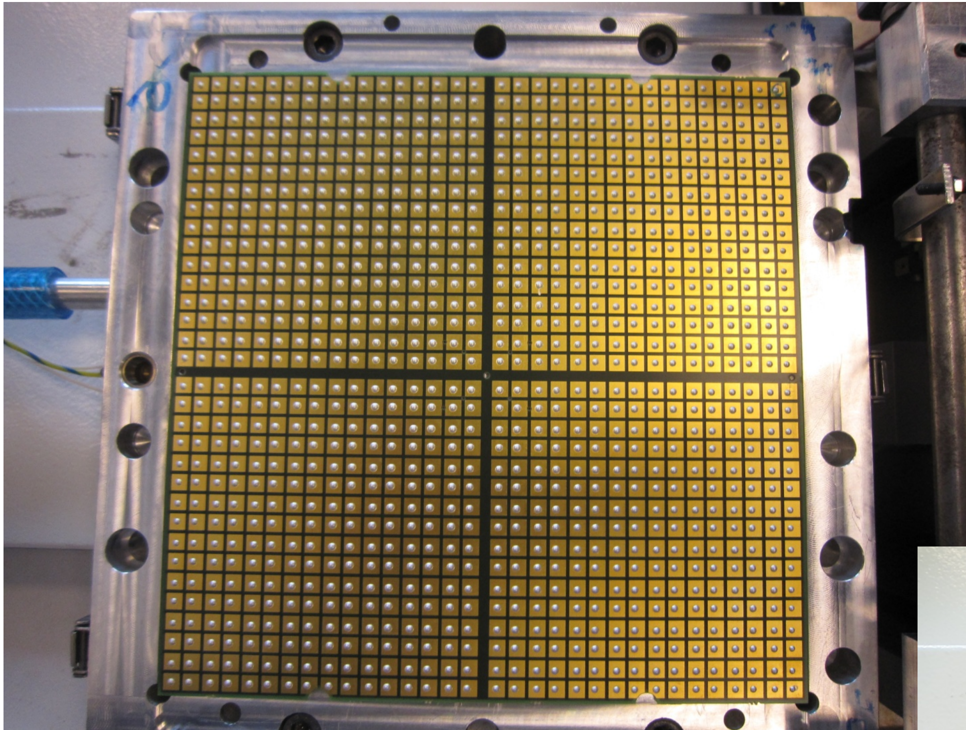
- The parameters of the gluing robot have been optimized to glue a silicon sensor (18x18 pads) on a PCB
- The constraints on the PCB geometry have been identified:
  - Flatness
  - Parallelism of the edges
  - Uniform height of the ASIC soldered on the board



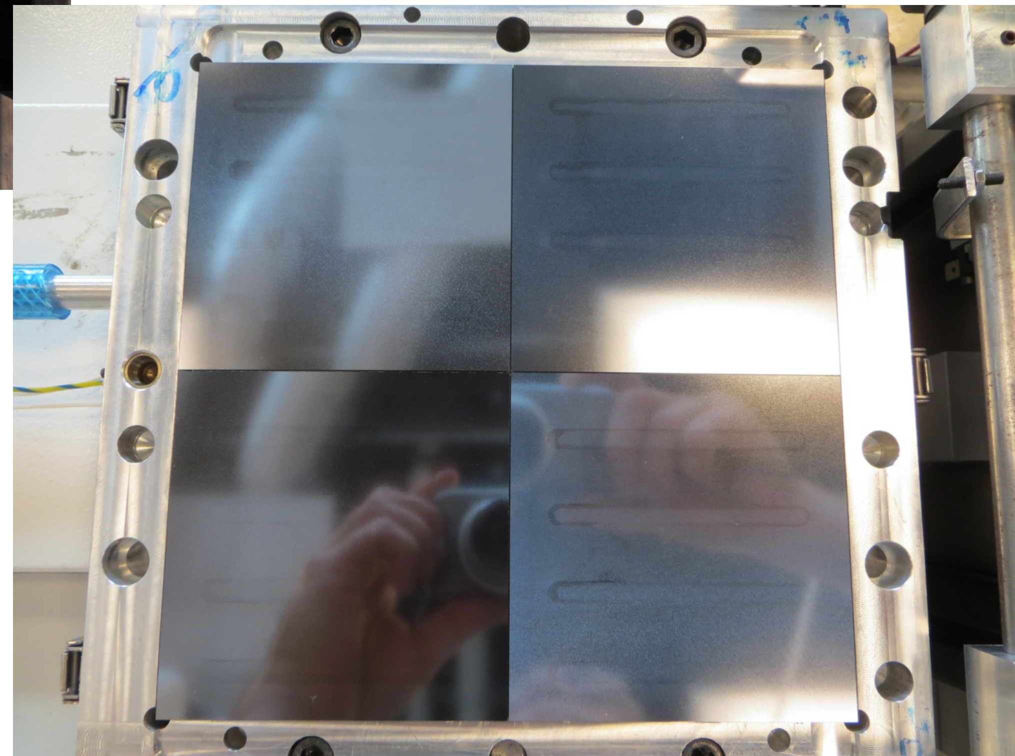




Second step : 4 wafers per PCB



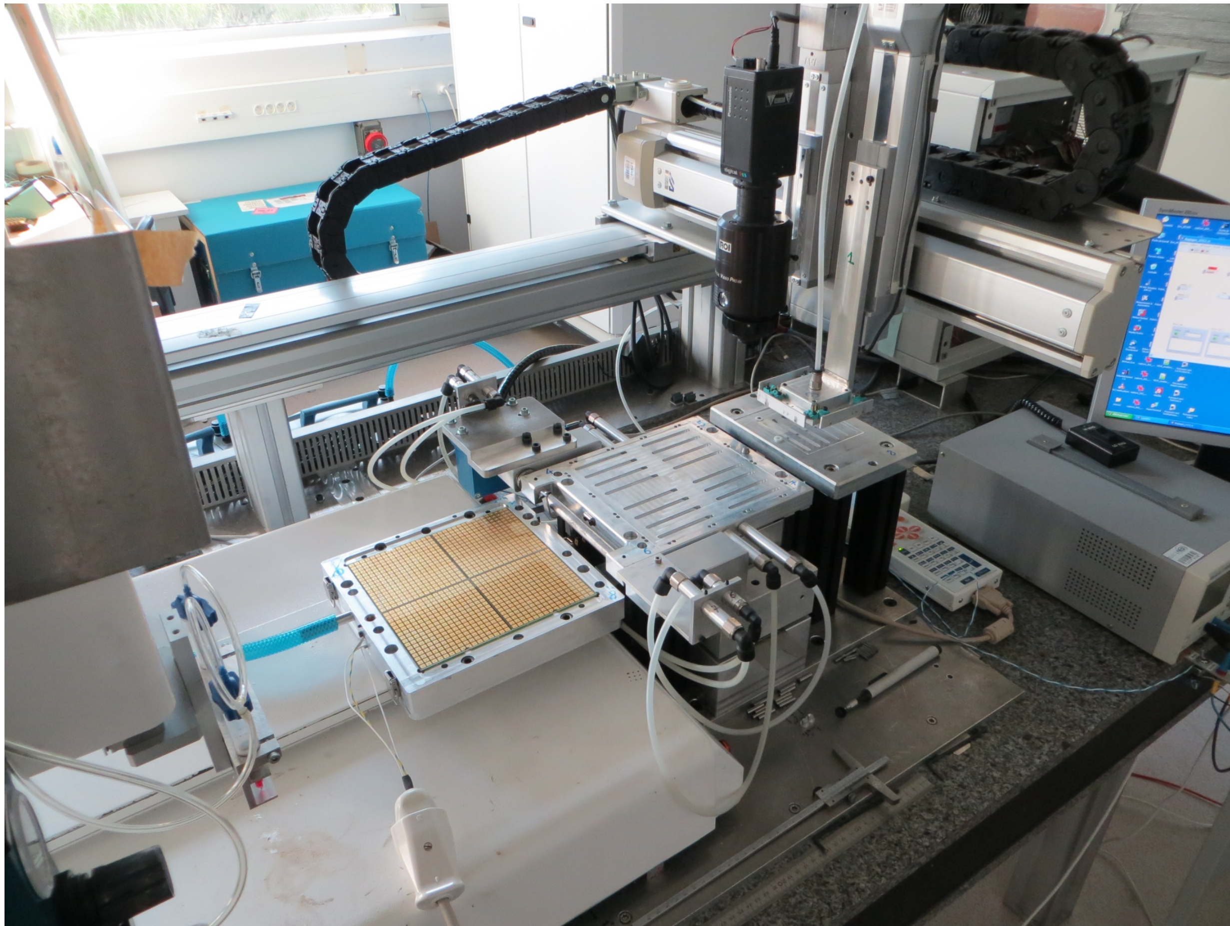
- Deposit of glue on the PCB
  256 X 4 = 1024 dots



- Move the plate with the 4 wafers on the PCB
- The alignment is fundamental :
  - PCB = 180.3 mm maximum
  - Wafer = 90 mm

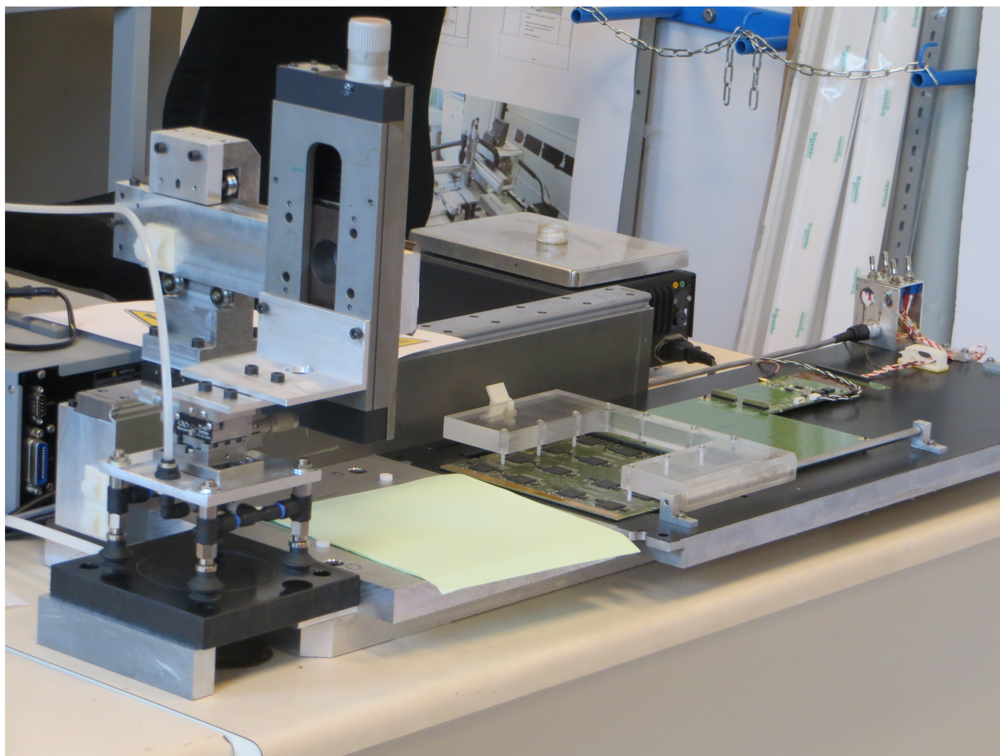
Gluing and positioning automated process

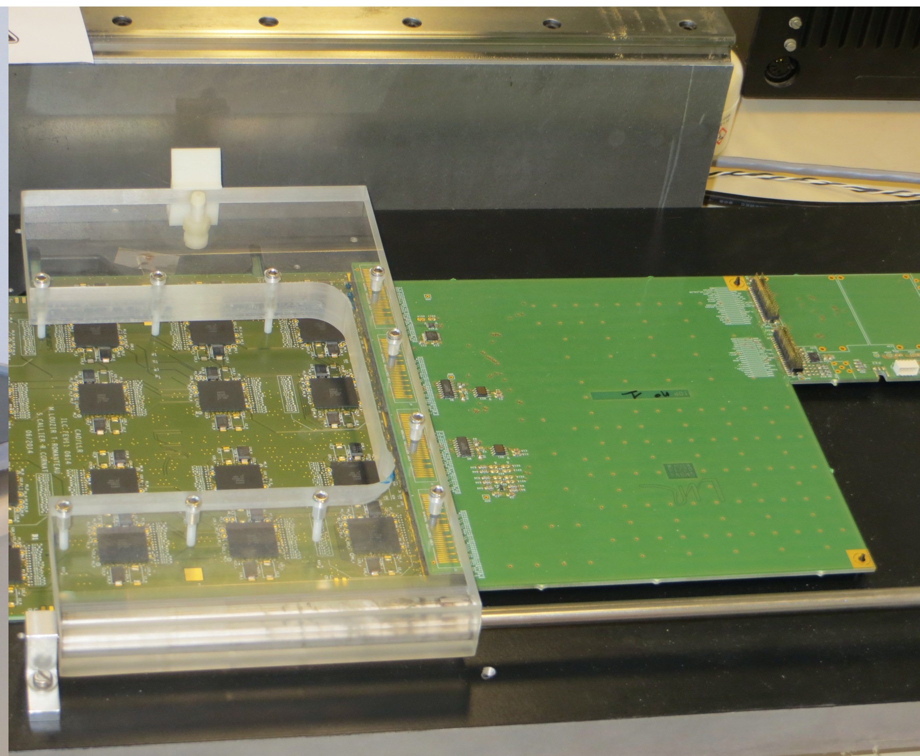
- Software (Labview) for the gluing robot has been implemented
- The second robot for positioning, alignment, and handling has been assembled and its software developed



Electrical tests bench

- A dedicated electrical test system is used
  - to control the wafers before gluing
  - to check the short cuts immediately after gluing
  - to measure the I(V) curves of each wafer and all 4 wafers
- sourcemeter Keithley 2450 + LLR Bench



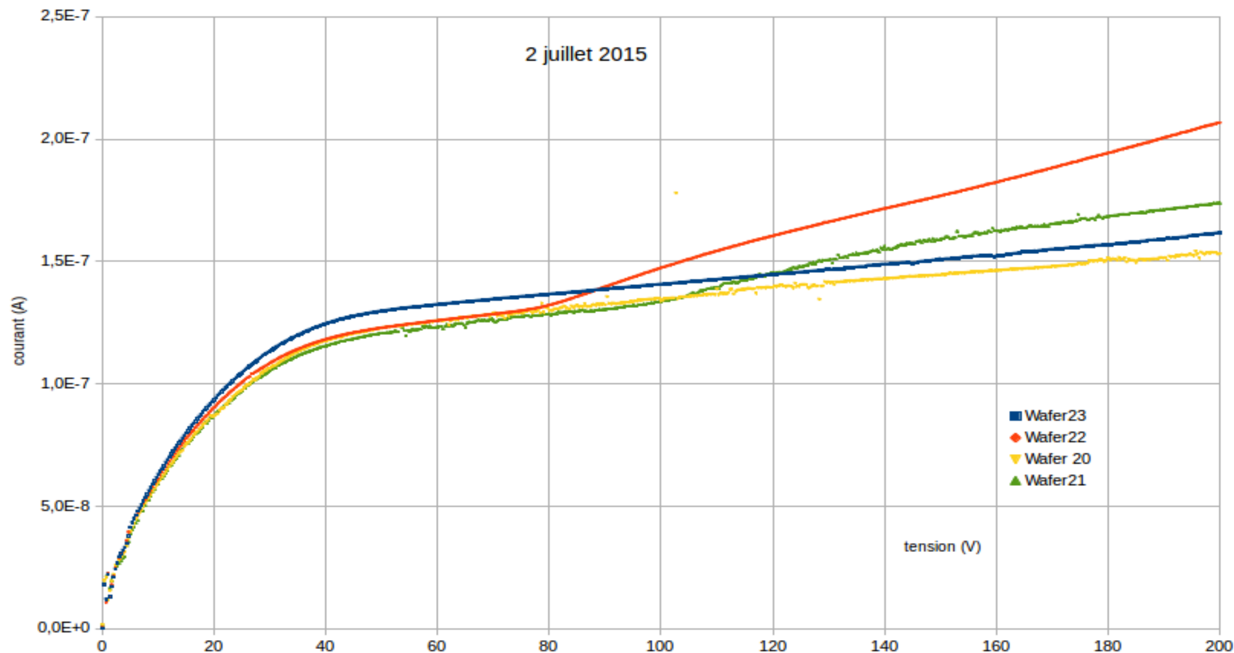


Electrical tests results

- Measurement after gluing onto the PCB
  - 4 ASU tested, all functional (no short cut).
  - Waiting for further tests (mip detection)

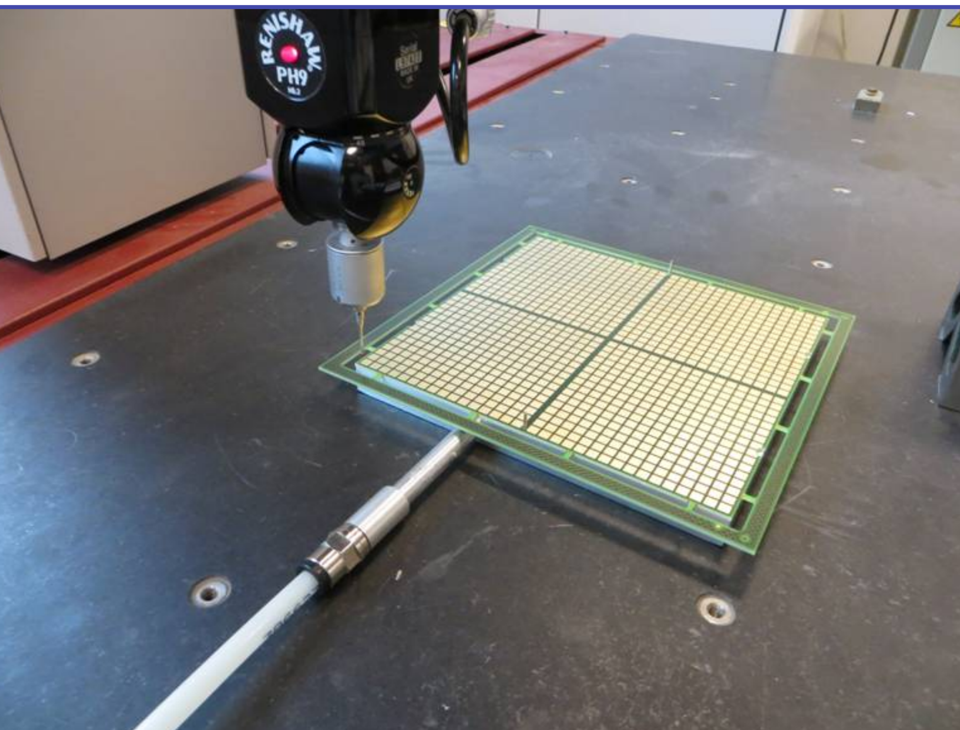
ASU	23	33	34	42
I total (µA)@140V	1.9	11	15	5

- I(V) measurement for each wafer before gluing – leakage current 150 nA @ 140 volts



PCB Metrology

- Development of an automatic process using a coordinate measuring machine (tri-dim machine)
- Before cabling :
  - Squaring
  - Parallel edges
  - Size
  - Thickness (flatness in depression)
  - Flatness
- After cabling : flatness and thickness

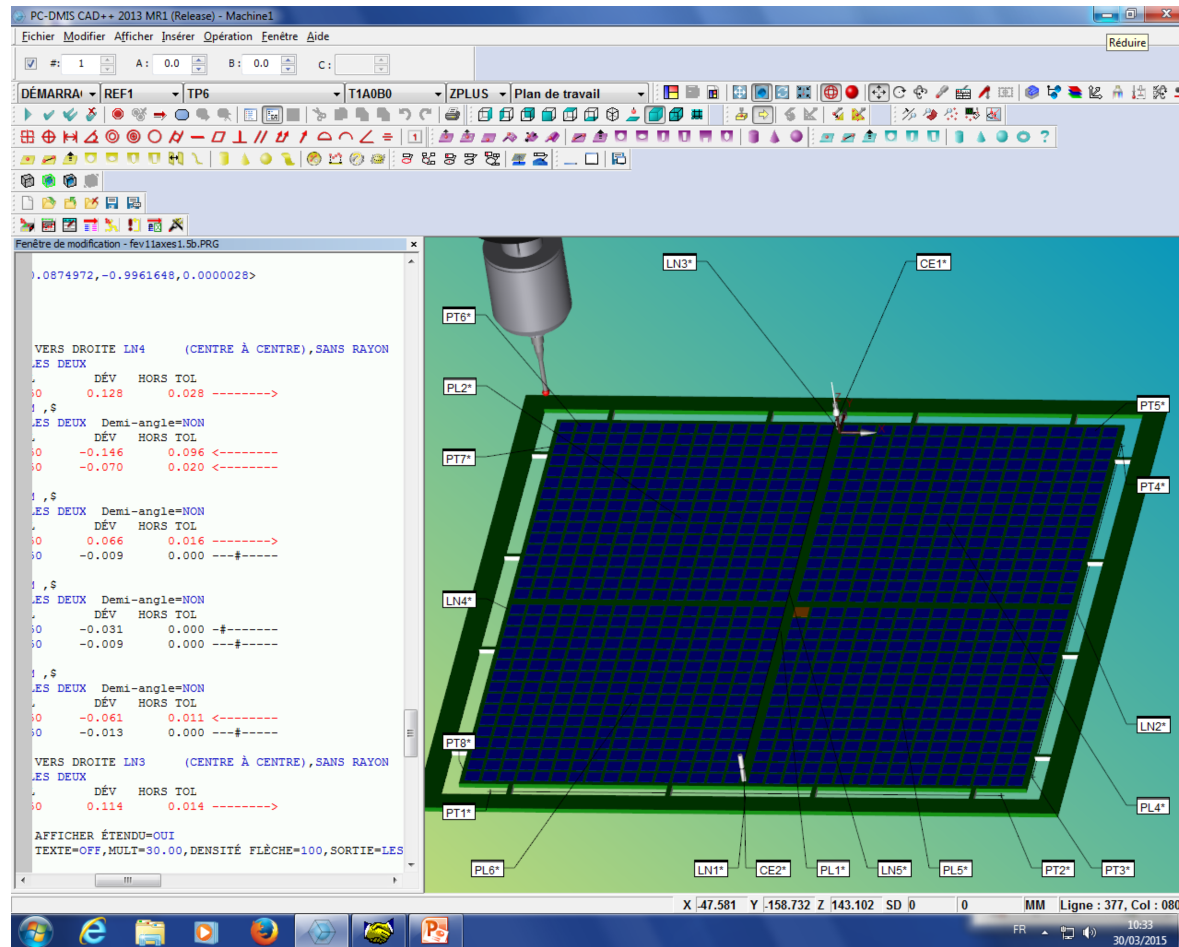


PCB Metrology results

40 PCB controlled

Criteria (measurements before cabling)

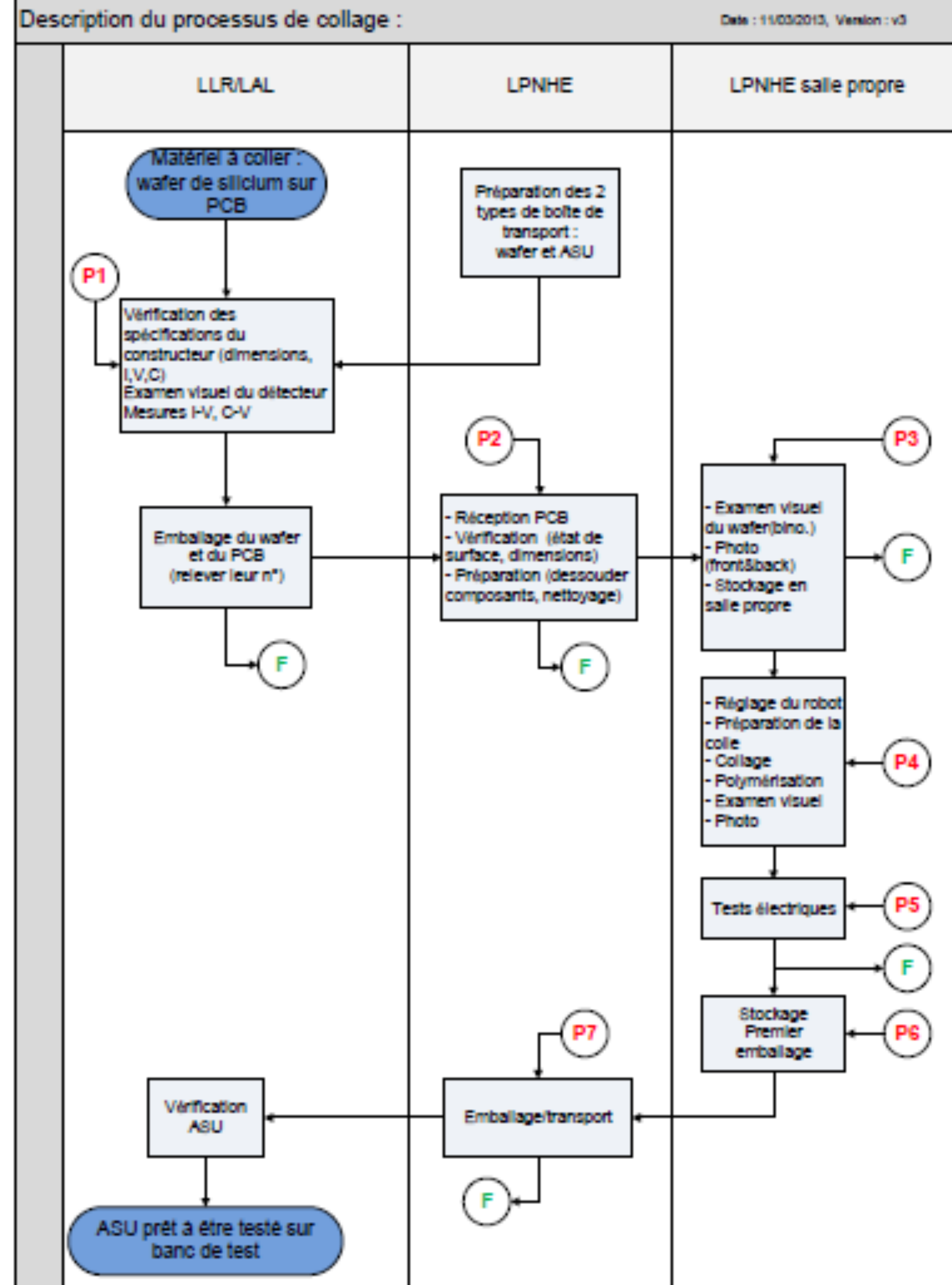
- Planarity tol.0.4 mm
- Size : 180.20 to 180.30 mm
- Thickness: 1.55 to 1.70 mm
- Squaring: tol. 0.05 mm
- Edge parallelism tol.0.05 mm



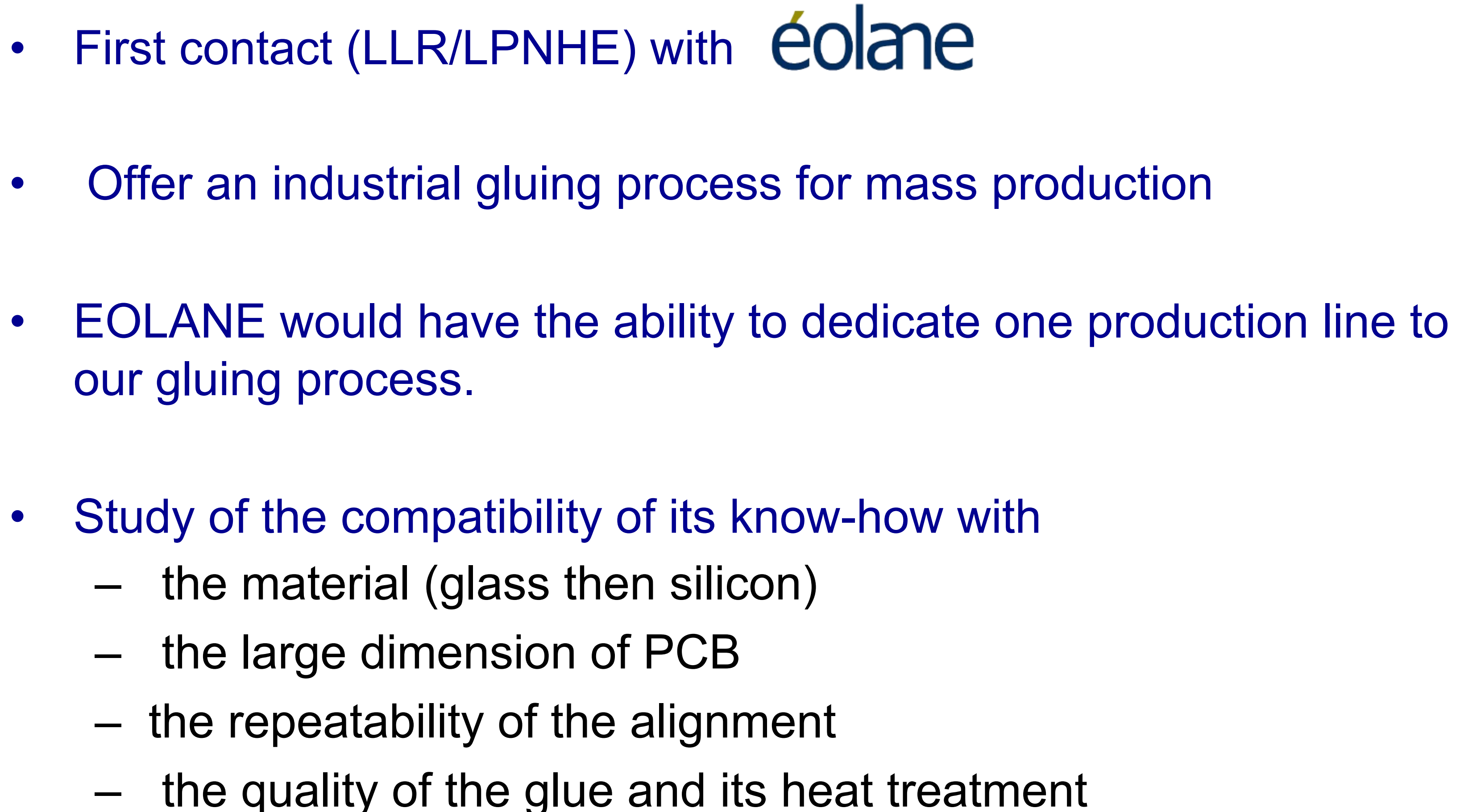
Rejection yield : ~40% (essentially due to a too large size for alveola)

Quality insurance

- Task flow completed
- Reception and gluing procedures for 1 and 4 silicon sensors written
- Operation on PCB monitored (follow up)
- Gluing tests registered
- ….



Industrialization



ATLAS High Granularity Timing Device

Barrel Cryostat

Endcap Cryostat

ID PPF1

EC SERVICES ENVELOPE

TRT SERVICES ENVELOPE

SERVICES ENVELOPE

R=1000

R=600

Δz_{max}=70

z=3475

R=90

HEX – STFT ENVELOPE

POLYMODERAT FIXE

ID END PL

BEAMPIPE Z-FIXED SUPPORT

MODERATOR PLUG

PIXEL PP1

BEAM PIPE ADJUSTER

FLEXIBLE JOINT

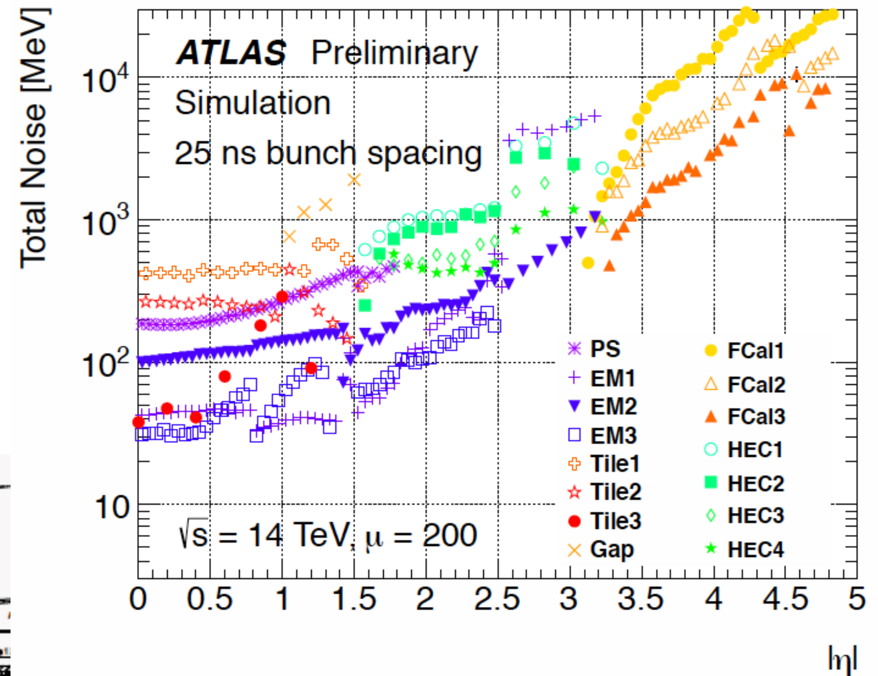
2.5

3.0

+Z

C-C 1:100

D 1:6



- in the gap between the LAr barrel and end-cap cryostats
- Gap occupied by ITk services, ITk end-plate and MBTS
- Reconfiguration is possible
- Envelope of Delta z =70 mm available

HGTD ATLAS based on CALICE

ATLAS
- measurement: t and E
- 4 layers in depth (z)
- Granularity: 5mm x 5mm
  - option: mix with 1cm x 1cm
- Same basic structure
- Options: No absorber/Absorber

Weaker constraints:
- 4 layers in 6cm ~1.5cm per layer: Chip+PCB+Glue+Wafer=3.225mm, leaves 1cm for cooling and absorber (tungsten 3mm or Pb 5.6mm 1X0 in support structure)

Harsher constraints:
- Cooling of sensors -20deg
- RadHardness of FE electronics
- RadHardness of Glue (measurements foreseen in 2015-2016)
- Time measurement (order 50 ps)
- Smaller peaking time
- 40MHz

ILD
- Measurement: E (and t)
- 30 layers
- Absorber: tungsten
- 30 layers in 18cm ~0.6cm per layer
- includes tungsten absorber
- Cooling of electronics (passive)
- Zero suppression/Power pulsing
- 5Hz 1ms bunchtrain

Sketch of an implementation in ATLAS

Preserve basic CALICE structure

Slabs CALICE-like:

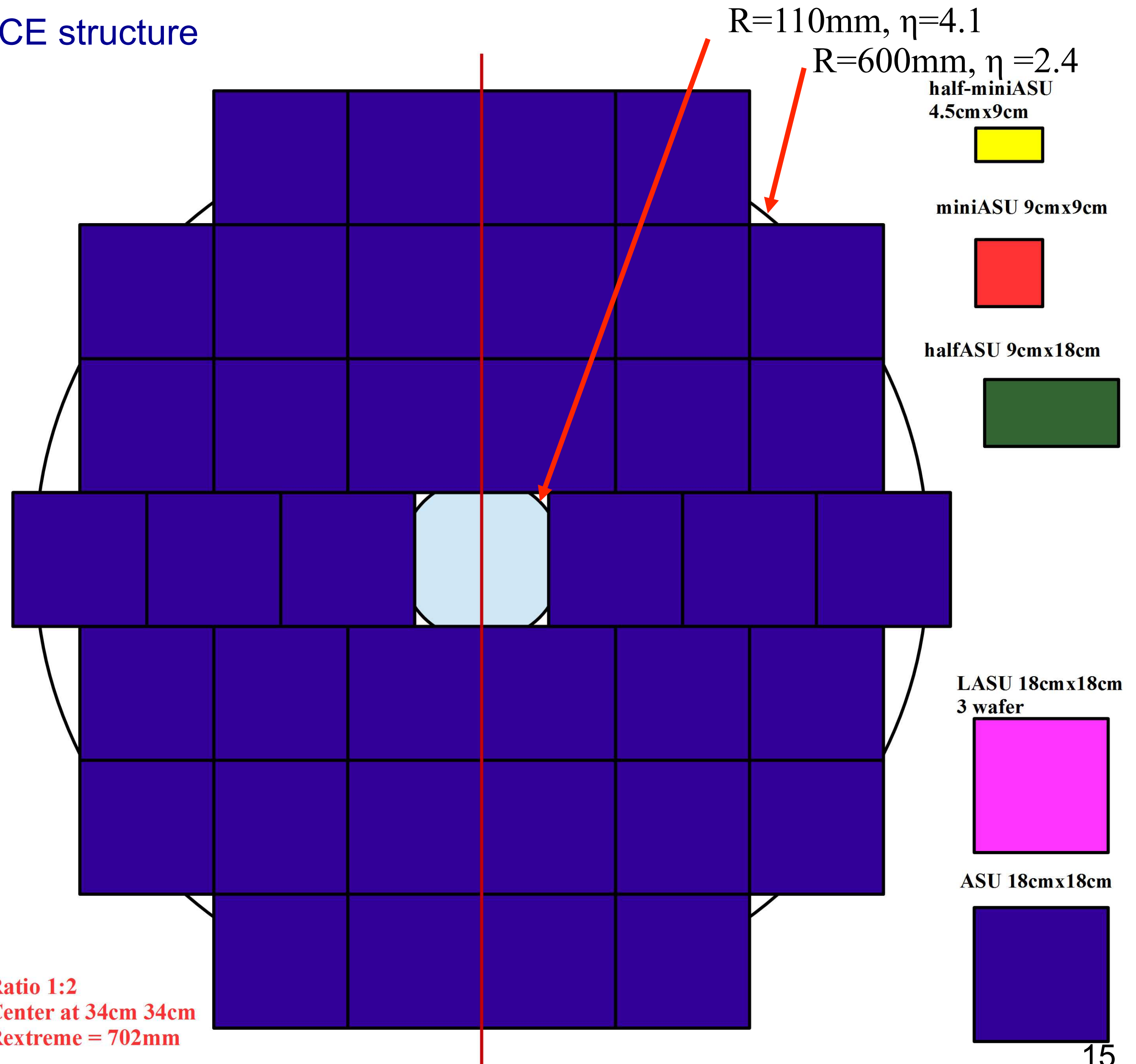
- 2ASUs
- 3ASUs

Alternative:

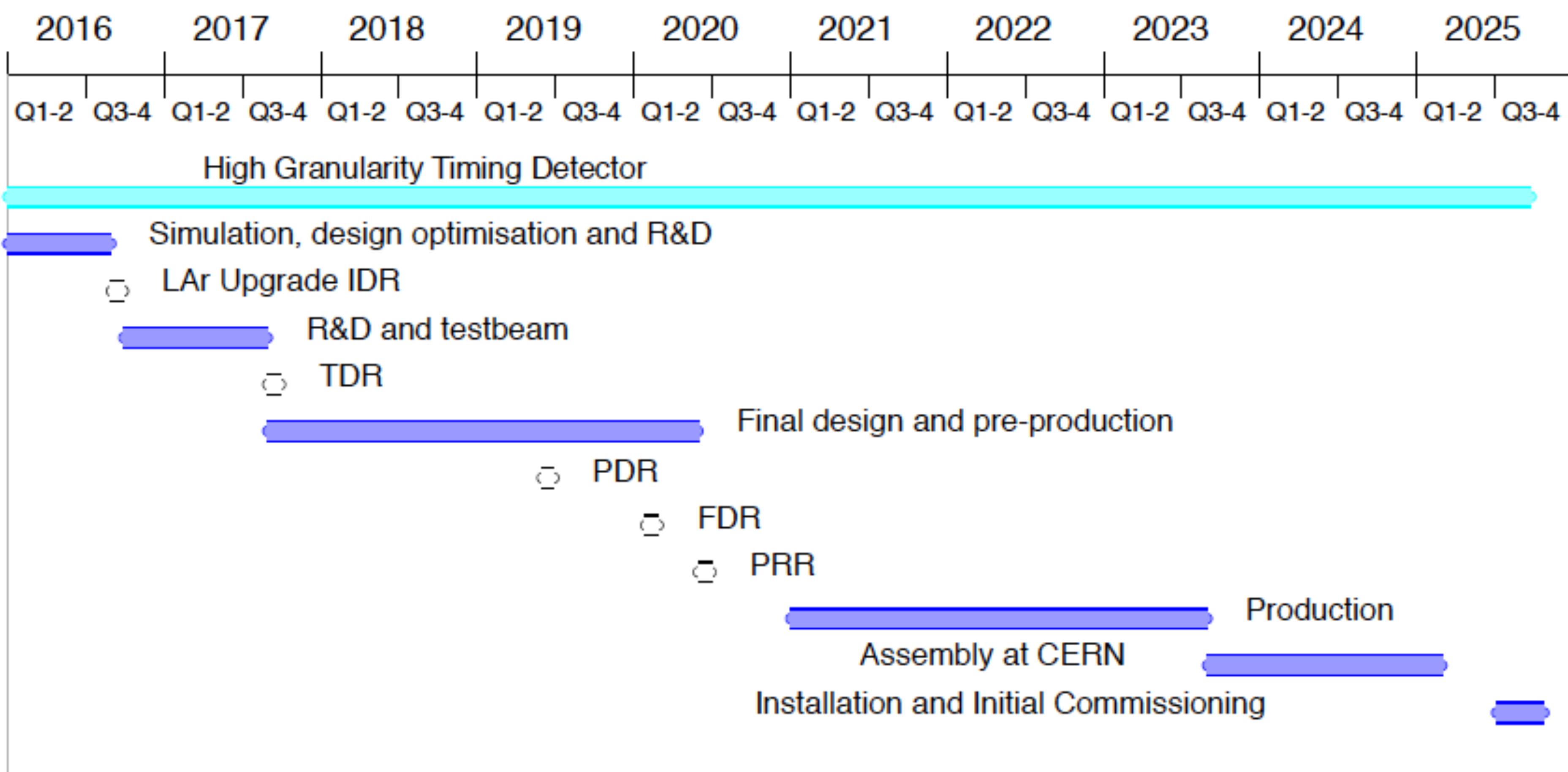
- Single PCB
- Pro: less interconnections
- Con: planarity

Support structure (attached to cryostat)

- Material?
- Alveola?
- Direct mounting?



Time-line and milestones for the implementation of the HGTD



Expressions of interest

Text for IN2P3 circulation

Détecteur haute granularité avec très bonne résolution en temps pour la région $2.4 < \eta < 4$

D. Fournier[i], D. Lacour[ii], C. de La Taille[iii] L. Serin[i] , D. Zerwas[i]

Expression of interest for ATLAS
September 4th ATLAS meeting on
High Granularity Timing Detector

Expression of Interest for the ATLAS HGTD project

D. Breton[i], D. Fournier[i], D. Lacour[ii], C. de La Taille[iii] L. Serin[i], D. Zerwas[i]

The ATLAS High Granularity Timing Device
September 10th at CALICE Collaboration Meeting at MPP Munich

“High Granular Timing Device”(HGTD) pour la phase II de ATLAS
September 30th ATLAS-IN2P3 - Projets pour 2016

Summary

- A fully automated gluing process is operational at LPNHE
  - Many tests have been performed with glass plates and with one wafer glued per PCB
  - The system is now used for the standard configuration (4 wafers /PCB)
  - 4 ASU have been done and will be used in test beam
  - 3 ASU will be done in the 2 coming weeks
- Quality Insurance and controls put in place
  - PCB geometrical measurements
  - Electrical tests
  - Procedures
  - Data bookkeeping
- Contacts for industrialization of the gluing process started

- ATLAS HGTD possible contributions
  - Modules assembly
  - Characterization of wafers and ASUs: geometry and electric I(U)
  - *Silicon wafers optimisation: design and measurements, simulation (silvaco)*
  - *Tests beam of prototypes*
  - *Detector geometry optimisation (MC)*

1 - Demande de crédits sur projet

Fournitures et équipements scientifiques : 4000

(pompes 24 volts, plaques de verre haute précision, colle conductrice, maintenance robot)

Missions, déplacements colloques et communications : 9000

Informatique (portables, serveurs de manip) : 2000

Salaires (stagiaires) : 3 mois, étudiant instrumentaliste, type M1 ou L3 : 1500

TOTAL : 16500

2 - Demande de crédits sur réseau R&D instrumentation - Détecteurs semi-conducteurs

Les équipements : pico-ampèremètre ; onduleur ; salle propre modulaire (plafond soufflant)

Les montants : 5000 + 3000 + 10 000

tests des wafers avant et après collage sur PCB ; sécurisation du robot de collage en prévention de coupures de courant ; assurer une qualité optimum du collage des wafers

TOTAL : 18 000

3 - Demande de chercheurs CDD 3 ans - Physicien instrumentaliste (Priorité 1 LPNHE)

- Participation aux tests en faisceau
- Analyse des données
- Etudes monte carlo pour l'optimisation des géométries des détecteurs ILD et ATLAS
- Mise en place d'études des capteurs silicium grâce à la simulation Silvaco et leurs caractérisations (machine à pointes ou système dédié)