LUXE ECAL activities and plans in Valencia

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GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES
Financiado por la Unión Europea NextGenerationEU
Plan de Recuperación, Transformación y Resiliencia
GENERALITAT VALENCIANA Conselleria de Educación, Universidades y Empleo
Gen—T
AITANA

Outline

- ECAL-e CALICE activities (snapshot)
- ECAL-p activities

- Plans 2024

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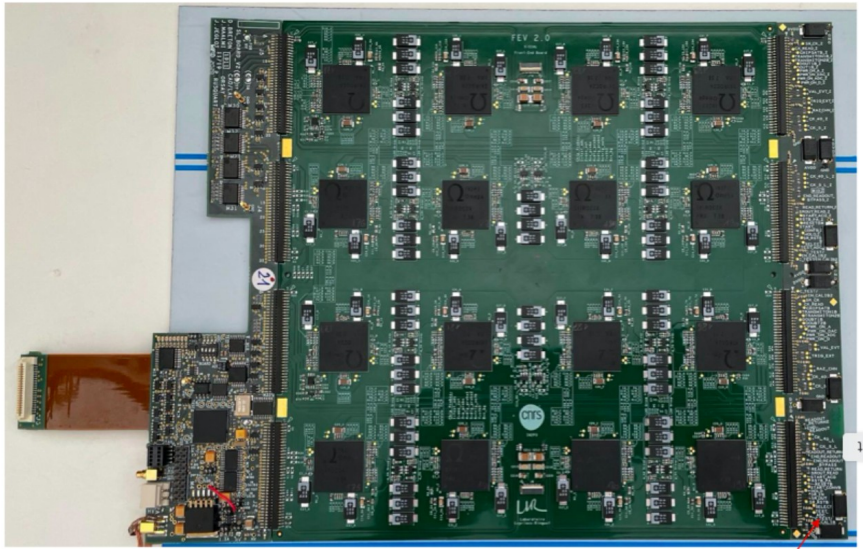
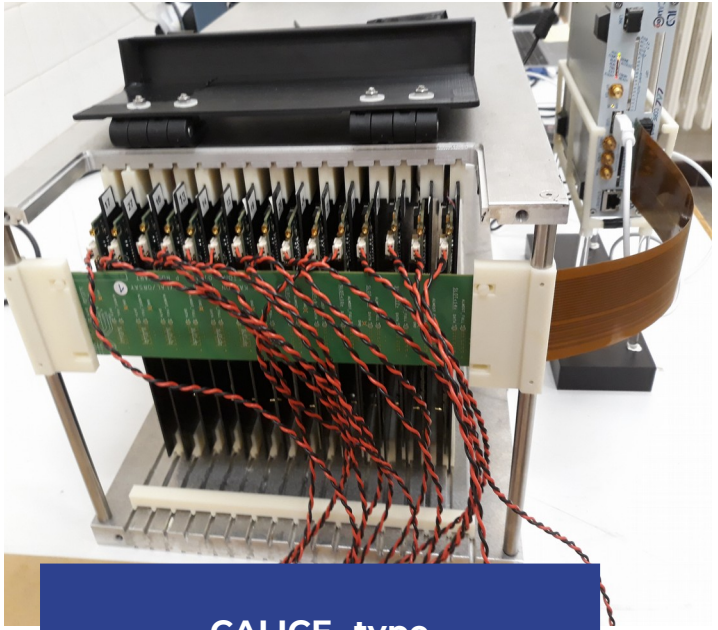
▷Open **challenge**

- Delamination of wafers observed… ¾ of the latest prototype modules are not usable.
- Very busy-dense PCBs → uncontrollable(?) mechanical properties





CALICE -type calorimeter

ECAL -e: PCB metrologies

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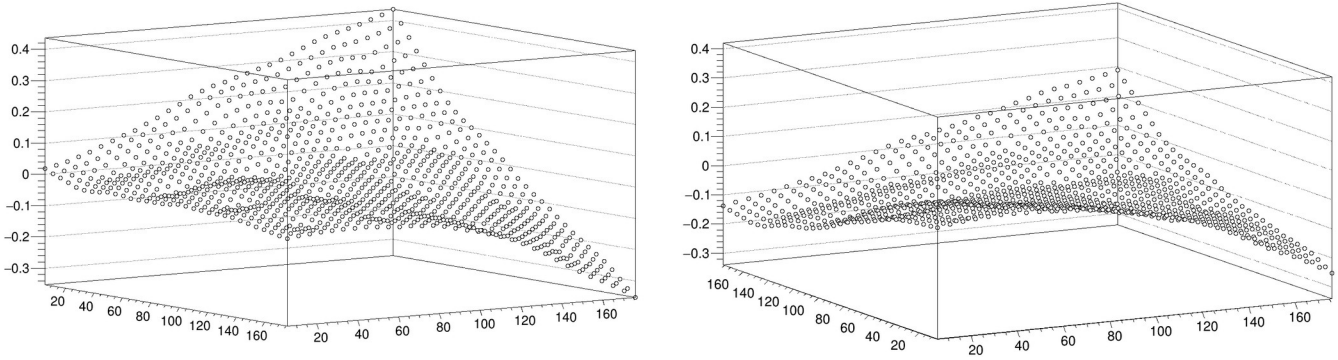
PCB metrology at IFIC

- First time this is systematically done in the project with this precision



First results are surprising(?) ! **To be understood**

- **Left**: the metrology of a equipped PCB after receival from IJCLab → up to ~800um deformation
- **Right:** same PCB after being carefully “dried-out” → deformation reduced to ~450um

Systematic study to be conducted during early 2024 in collab with IJCLab

- Using naked PCBs, following different heat treatments and drying processes

ECAL -e: PCB metrologies

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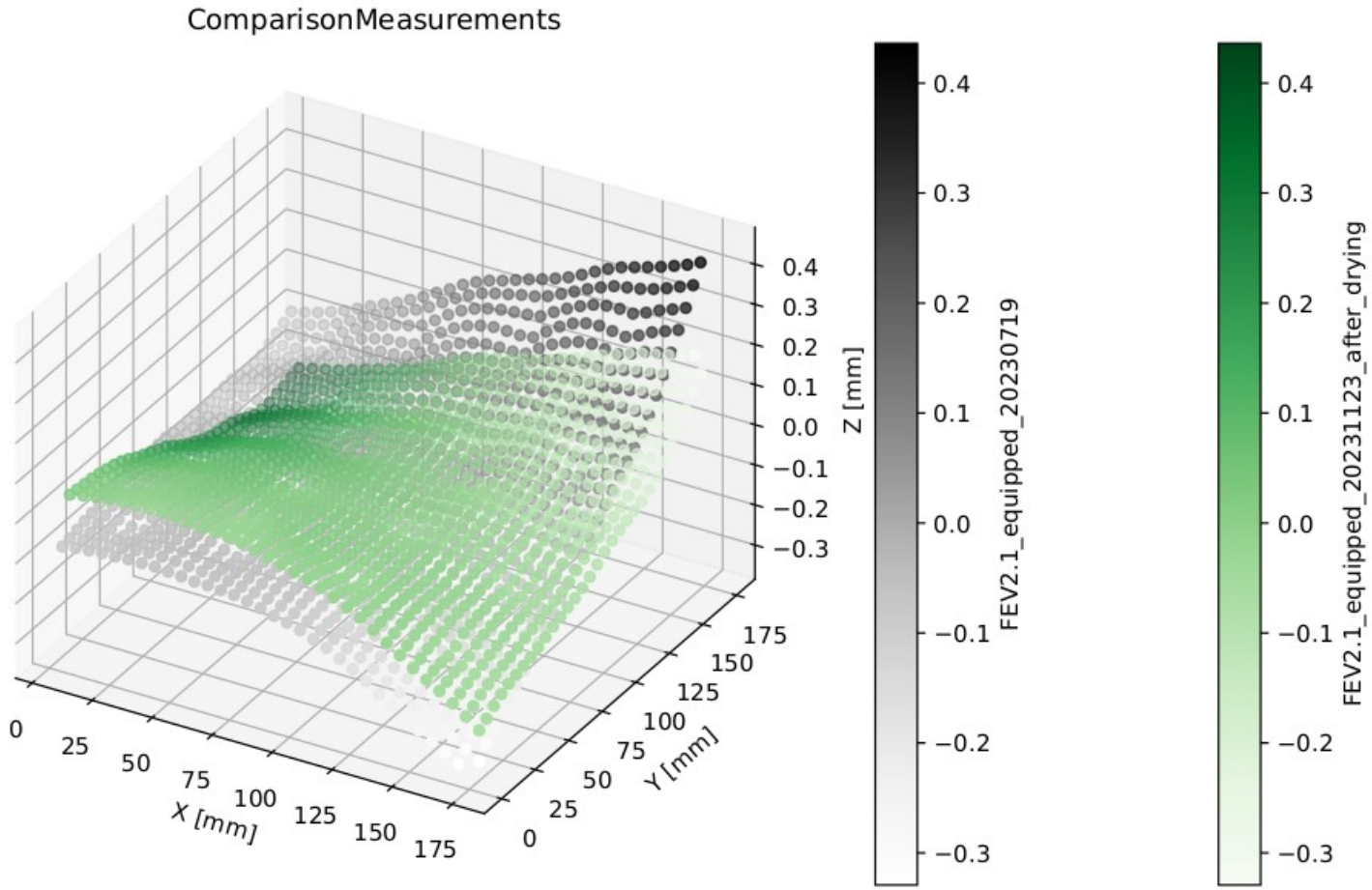
Drying a PCB

- We store it for 10days or more in a dry cabinet (0.5% humidity)
- and/or we heat it up for 24h at 50° → following advice by Rompal (spanish company for PCB component assembly)

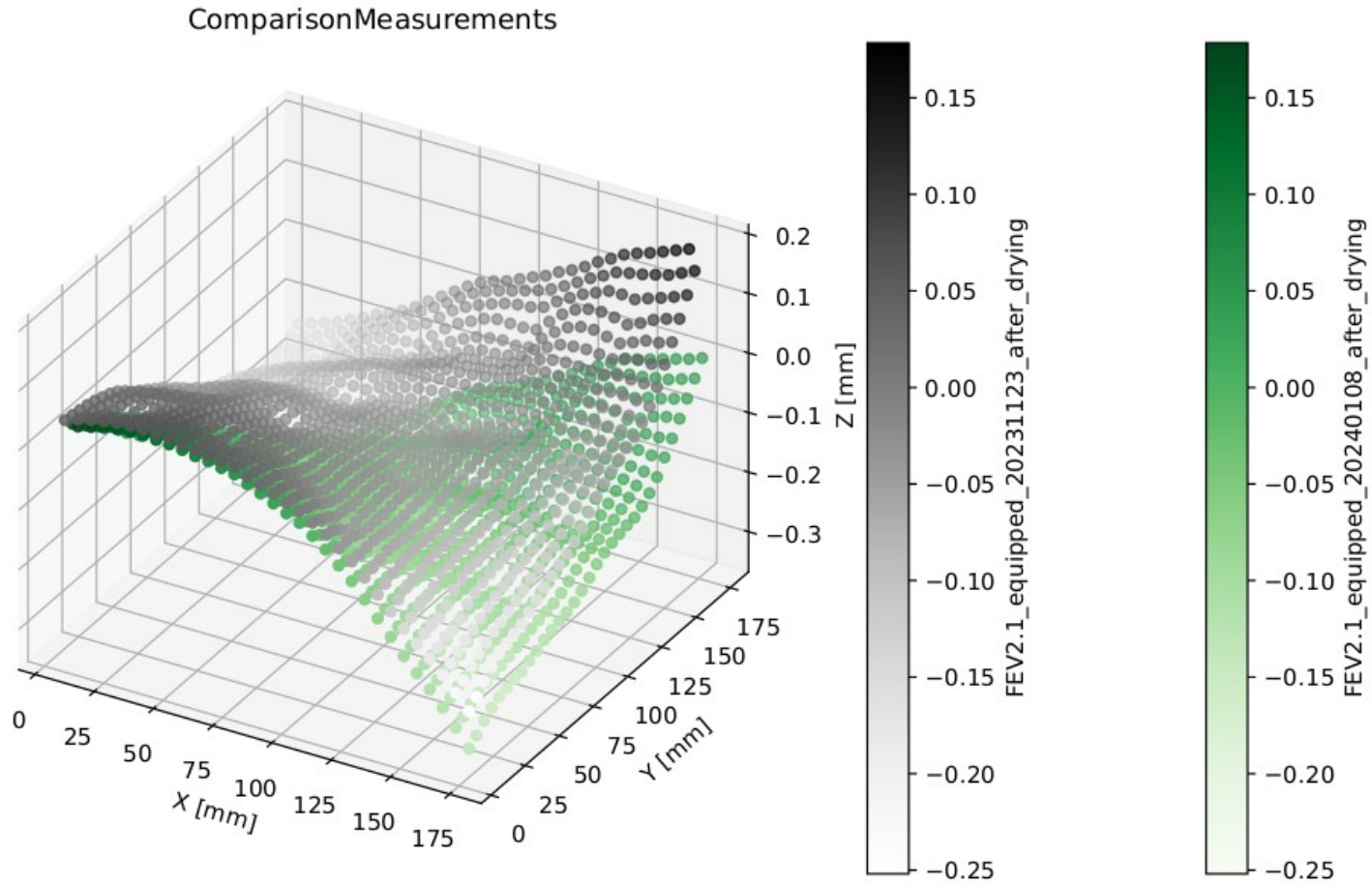
Humidity cycles

- Cycles in a climatic chamber at 90% humidity and 30°
- 1 week of 72h cycles

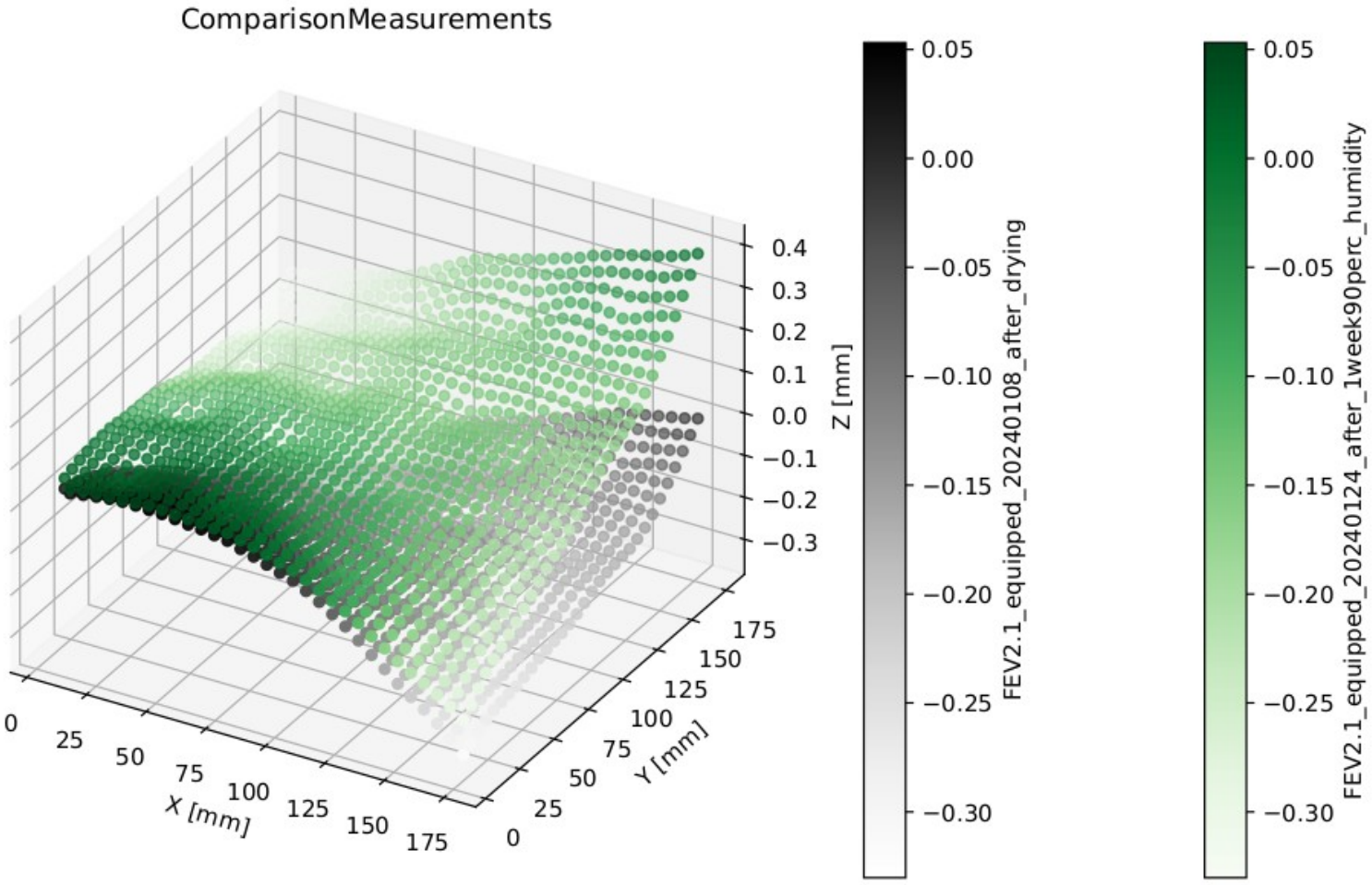
ECAL -e: PCB metrologies



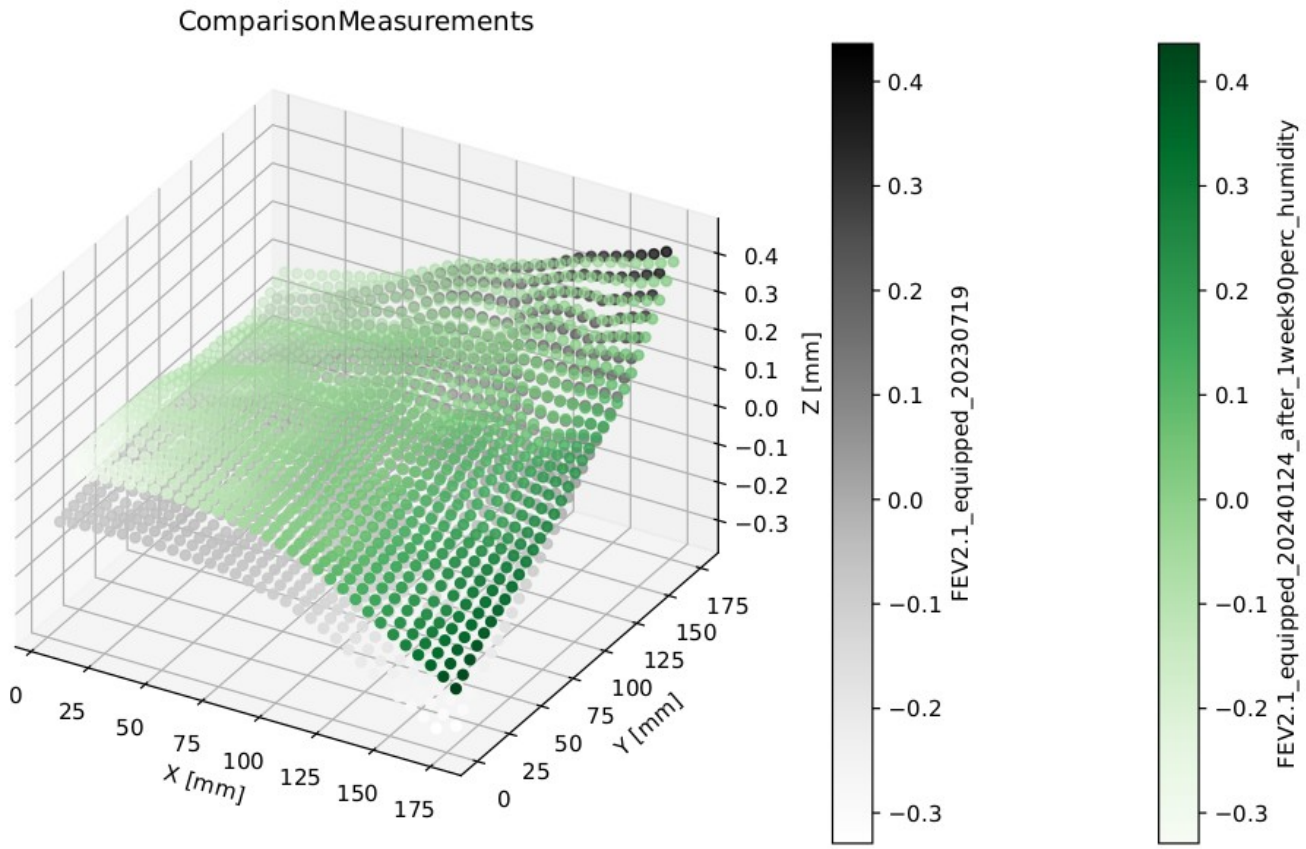
ECAL -e: PCB metrologies



ECAL -e: PCB metrologies



ECAL -e: PCB metrologies



ECAL -e: tape+glue solution for hybridization

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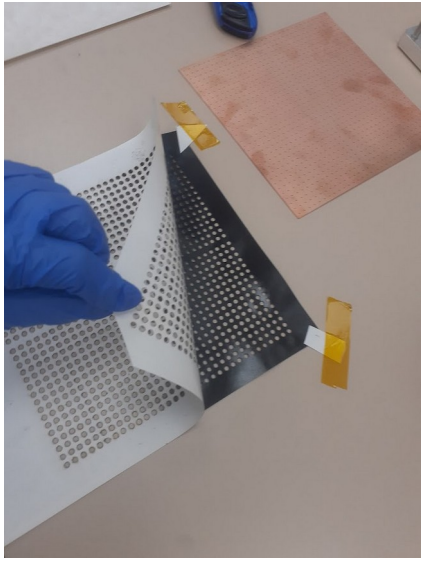
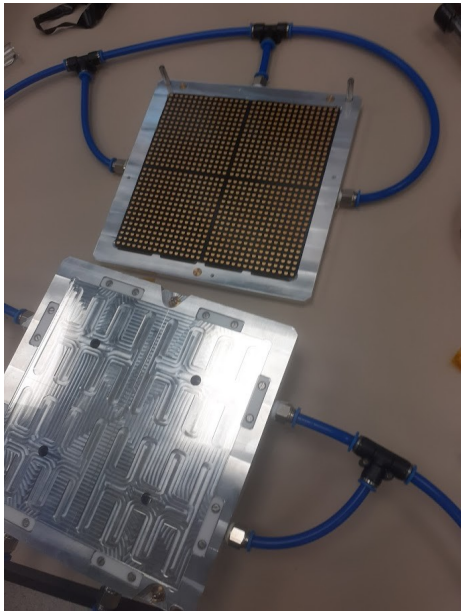
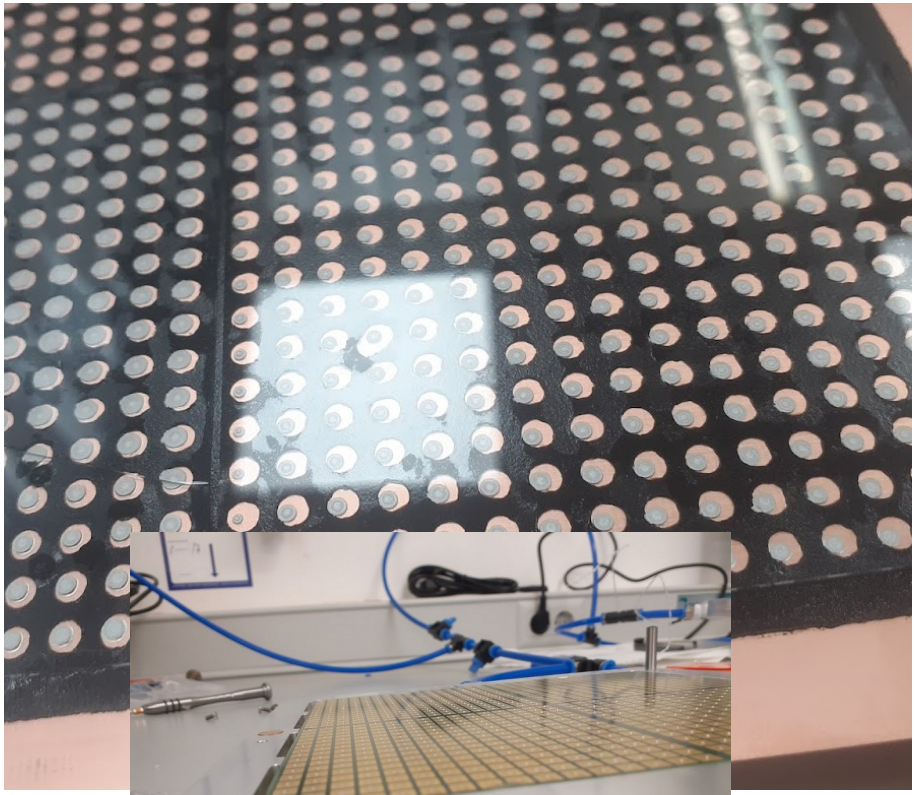
Mixed solution:

- **Perforated stencil** of thin (250um) double tape VHB 5907F **for adherence**
- **Silver Epoxy dots for electrical conductivity**



Stencil made at IFIC (laser drill)





ECAL -e: tape+glue solution for hybridization

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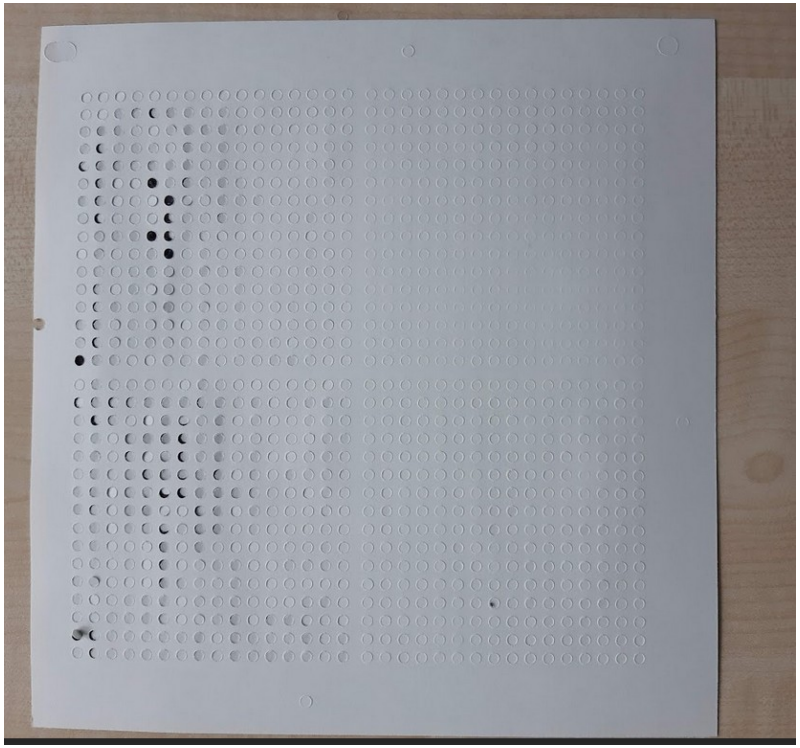
- Perforation of stencil with ARISTO machine (DESY-IJCLAb)



ECAL -e: summary & plans

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- **Metrology studies will take 1-2 month (probably more)**
  - IJCLab+IFIC
  - To be started in January 2024
- **Establishment of the procedure for using the tape+glue hybridization solution**
  - Tooling + training ongoing
  - A particular challenge is the perforation of the 3M tape in a semi-automatized way. Currently using laser drill… 1st try was perfect, the 2nd one not so much → Also now: ARISTO SOLUTION (WIP)
- **Tooling for alignment and positioning → requires person-power: design and manufacturation**
  - IJCLAB?
- **June: TB at DESY**
  - 1-2 modules glued at IFIC… wip
  - Commissioning etc would depend on person power available from France.

(alternative solutions with underfill-glue are investigated at IJCLab)

ECAL-p

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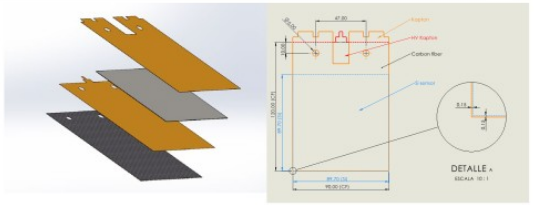
- Gluing procedure being established
  - Experience on the robot acquired during the ECALe tests
  - Design and manufacturing of tools for gluing (see https://indico.desy.de/event/42289/)

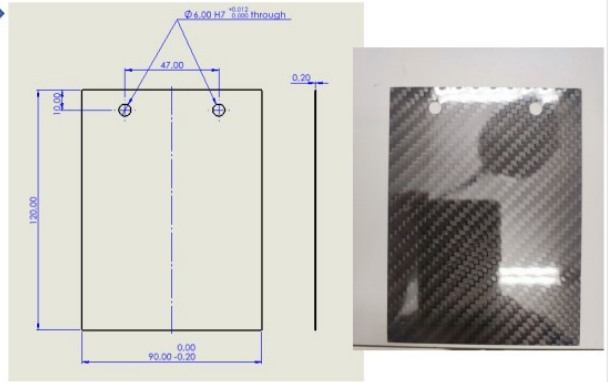
- Challenge to be addressed in the coming weeks: are the 50um for glue dots realistic ?
  - After several “manual tests”: t seems so…
  - More systematic studies ongoing.

- We found a company that produces thin Carbon Frames.
  - 10CF acquired
  - Metrology studies ongoing

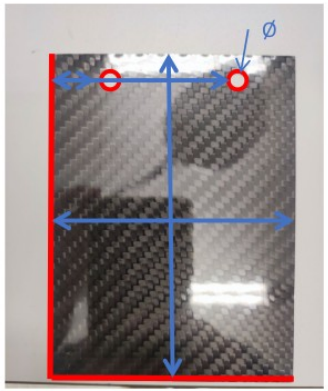
Carbon frame metrology

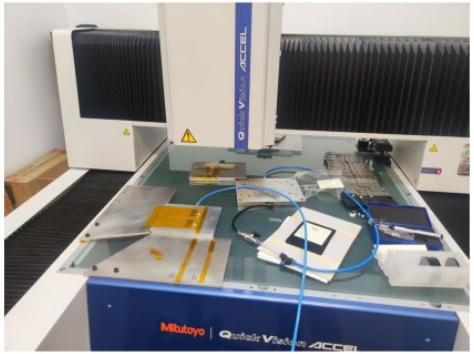


- 10 CF samples received manufactured according to the drawing
  - Dimensions: 90x120x0,2mm
  - 2 holes Ø6 mm for positioning pins



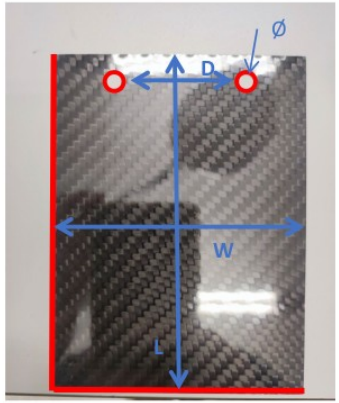
- Metrology in progress
  - Vision measurement machine
    - 2 measurement methods:
      - Focus by vision (slower but seems more accurate)
      - Focus by laser (faster but seems less accurate)
  - Measure dimensions, thickness, and alignment holes position
  - Vacuum aspirated to ensure the position
    - Need to measure the aspiration tooling (for thickness measurements)



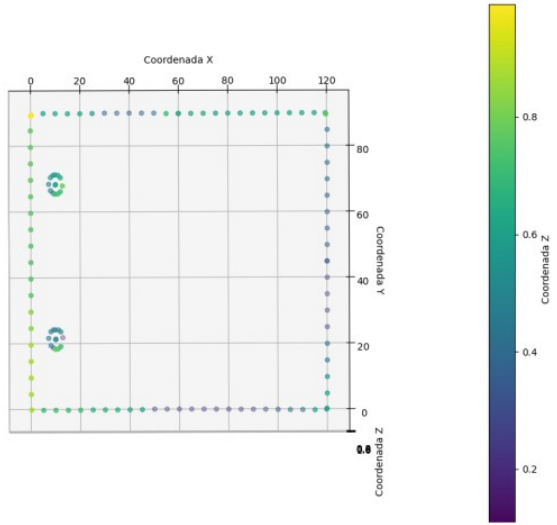


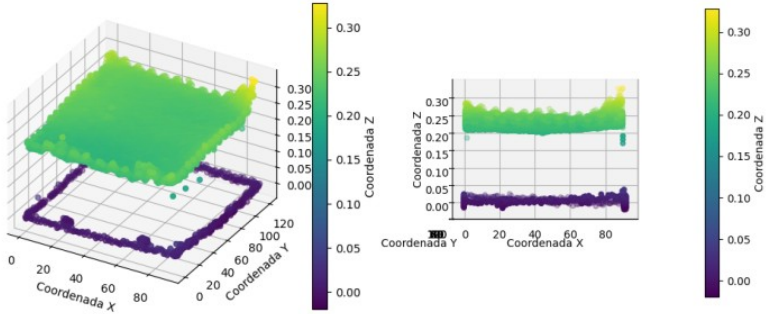
Carbon frame metrology

- Vision machine measurements
  - Measurements with focus by laser method in progress
  - XY measurements to determine dimensions.
  - Z measurements to determine thickness



- Some results for sample 1:
  - W= 89,93mm
  - L= 119,89mm
  - D= 46,98mm
  - Ø= 5,94mm
  - Z= 0,215mm (average plane)
  - Z values increase on the edges of the CF, probably due to the lack of aspiration on that place





Carbon frame metrology

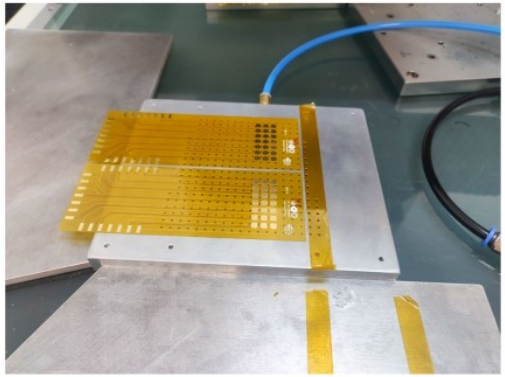
- Manual measurements with external micrometer
  - Thickness measurement at 6 points

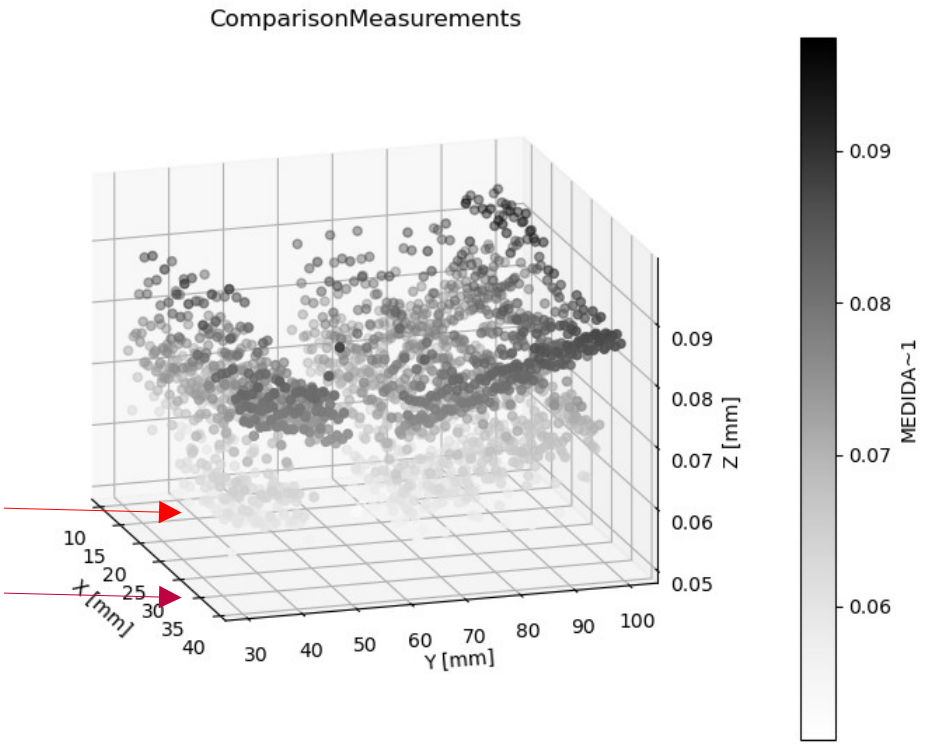
	Measure point						
Nº Sample	1	2	3	4	5	6	AVG
1	208	213	237	236	246	242	230.33
2	207	216	220	237	229	238	224.50
3	215	206	220	214	219	206	213.33
4	220	233	222	240	226	230	228.50
5	215	214	224	207	217	207	214.00
6	229	231	242	244	235	233	235.67
7	219	214	241	242	245	246	234.50
8	213	215	234	238	242	247	231.50
9	227	227	238	239	226	227	230.67
10	233	229	236	239	228	226	231.83

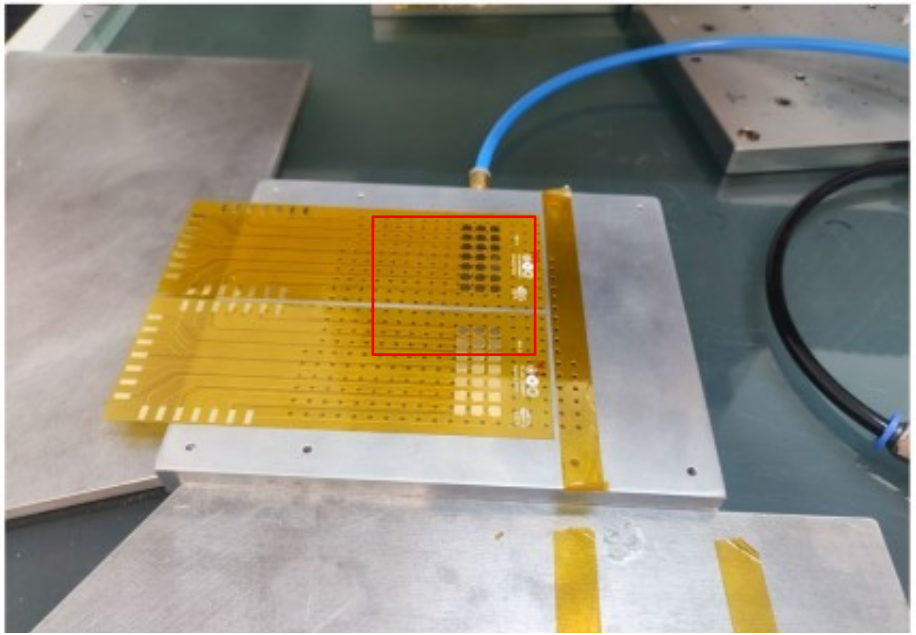
- Measures between 207 and 247 µm
- ~225 µm average thickness
- To crosscheck with the vision measurement machine

Sensors glueing metrology

- The goal is to measure the glue thickness after glueing process.
- Vision measurement machine
- Vacuum aspirated to ensure the position
  1. Flex PCB thickness measurements
  2. Sensor thickness measurements
  3. To Ggue the PCB to the sensor
  4. Final thickness measurements PCB+glue+sensor



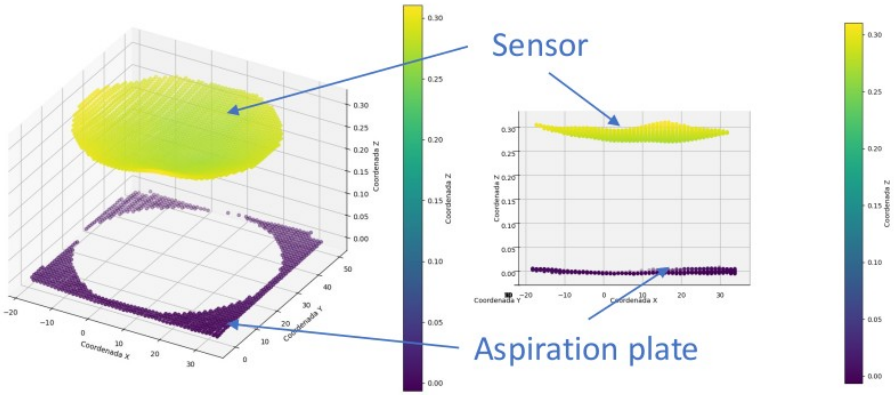


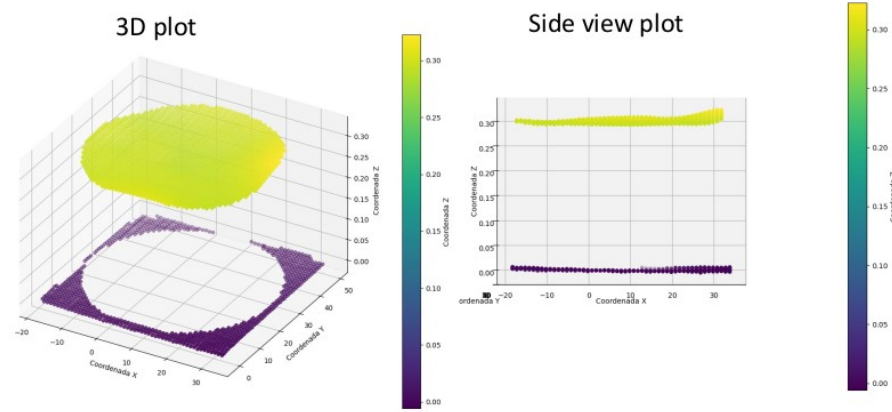


- Inconclusive measurements → two sets of measurements (because the semi-transparency of the flex ??)
- Even after subtracting the measurement of the tooling, there is a curvature that seems unphysical!. Checked with manual measurements

Sensors glueing metrology

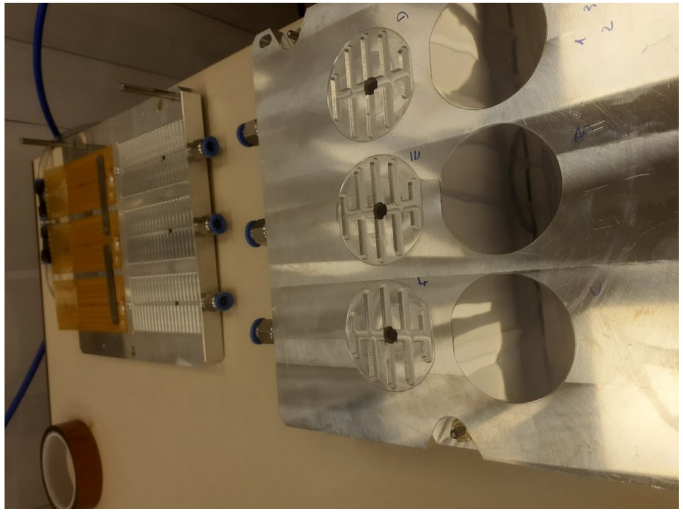
- 6 fake Si sensors already measured
  - Still the data needs to be analysed
  - The aspiration plate is not completely plane so it seems that it induces an error in the thickness measurement.
  - So the aspiration plate will be measured and subtracted to the sensor measurement to compensate the error.
- PCB measurements in progress (expected to be finished by the end of this week)
- Then we will glue the sensor to the PCB and will measure again the pack

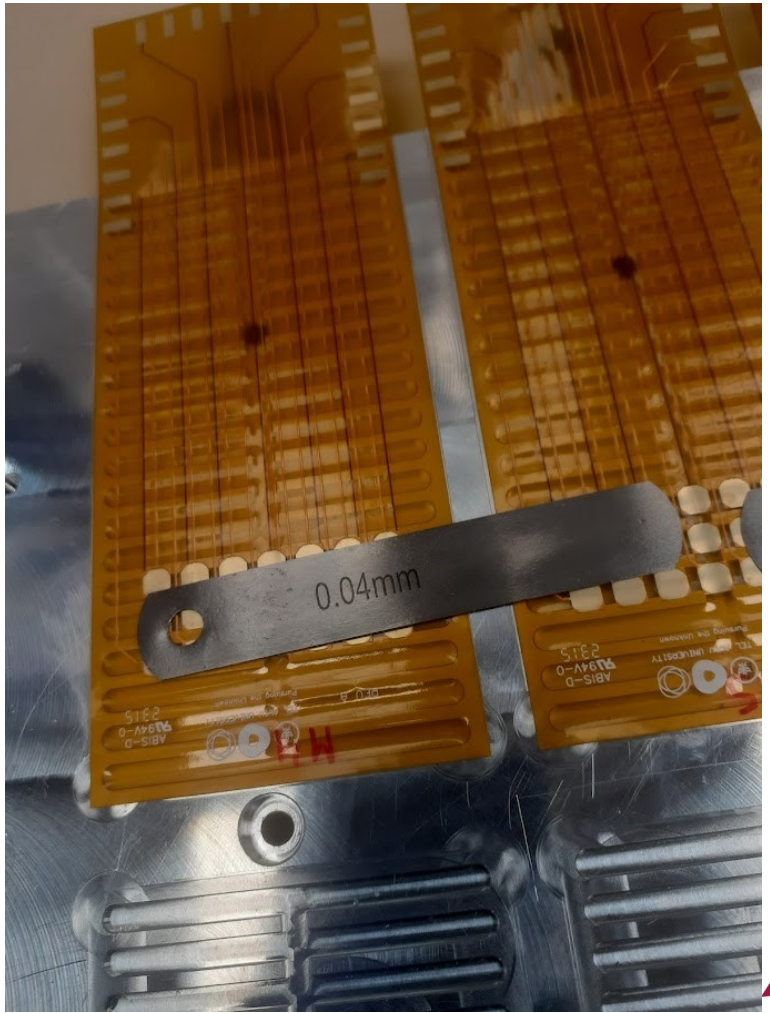




Gluing tests for glue thickness measurements

- Started end of january
- Using the robot and procedure defined and tested with the ECALe modules
- Play with different approaches to define thickness:
  - Feeler gauges, glue dots size, etc
- Perform metrology after the gluing.

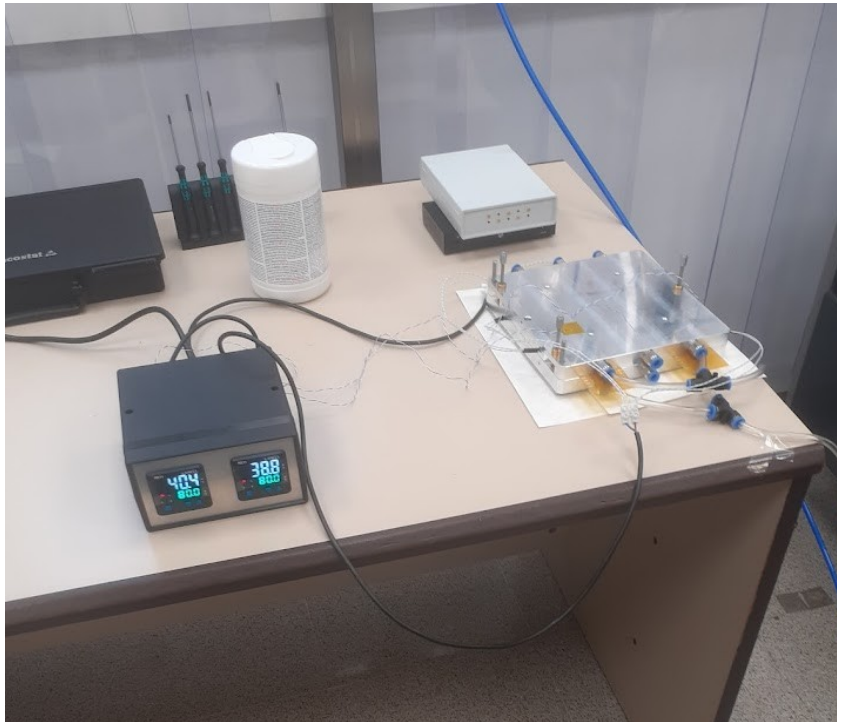


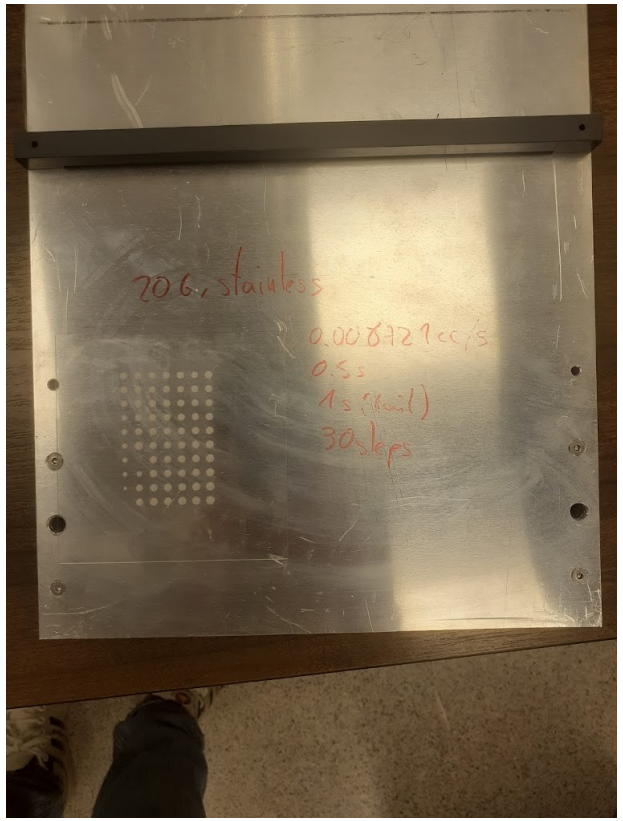


Gluing tests

Set	Comments setup gluing	Comments gluing	Comments curing (in oven, 80º more than 4h each)
M1	30/01: same than M5, M6 but we decrease the thickness by unscrewing ~ turn of the screw	20G st steel, 0.008721/s, 30 steps, 0.5s,1s	using resistors for precuring – remove the screw limiter of thickness during the curing
M2	30/01: same than M5, M6 but we decrease the thickness by unscrewing ~ turn of the screw	20G st steel, 0.008835/s, 30 steps, 0.5s,1s	using resistors for precuring – remove the screw limiter of thickness during the curing
M3	30/01: same than M5, M6 but we remove the screw limitation	20G st steel, 0.008835/s, 30 steps, 0.5s,1s	using resistors for precuring – remove the screw limiter of thickness during the curing
M4	30/01: same than M5, M6 but we remove the screw limitation	20G st steel, 0.009006cc/s, 30 steps, 0.5s,1s	using resistors for precuring – remove the screw limiter of thickness during the curing
M5	29/01: using feeler gauges of 40um to define the thikcness. We set the micrometric screws to that value. usamos galgas 40um para definir espesor, también los tornillos micrométricos	20G st steel, 0.009006cc/s, 30 steps, 0.5s,1s	moved during curing
M6	29/01: using feeler gauges of 40um to define the thikcness. We set the micrometric screws to that value. usamos galgas 40um para definir espesor, también los tornillos micrométricos	20G st steel, 0.009060cc/s, 30 steps, 0.5s,1s	

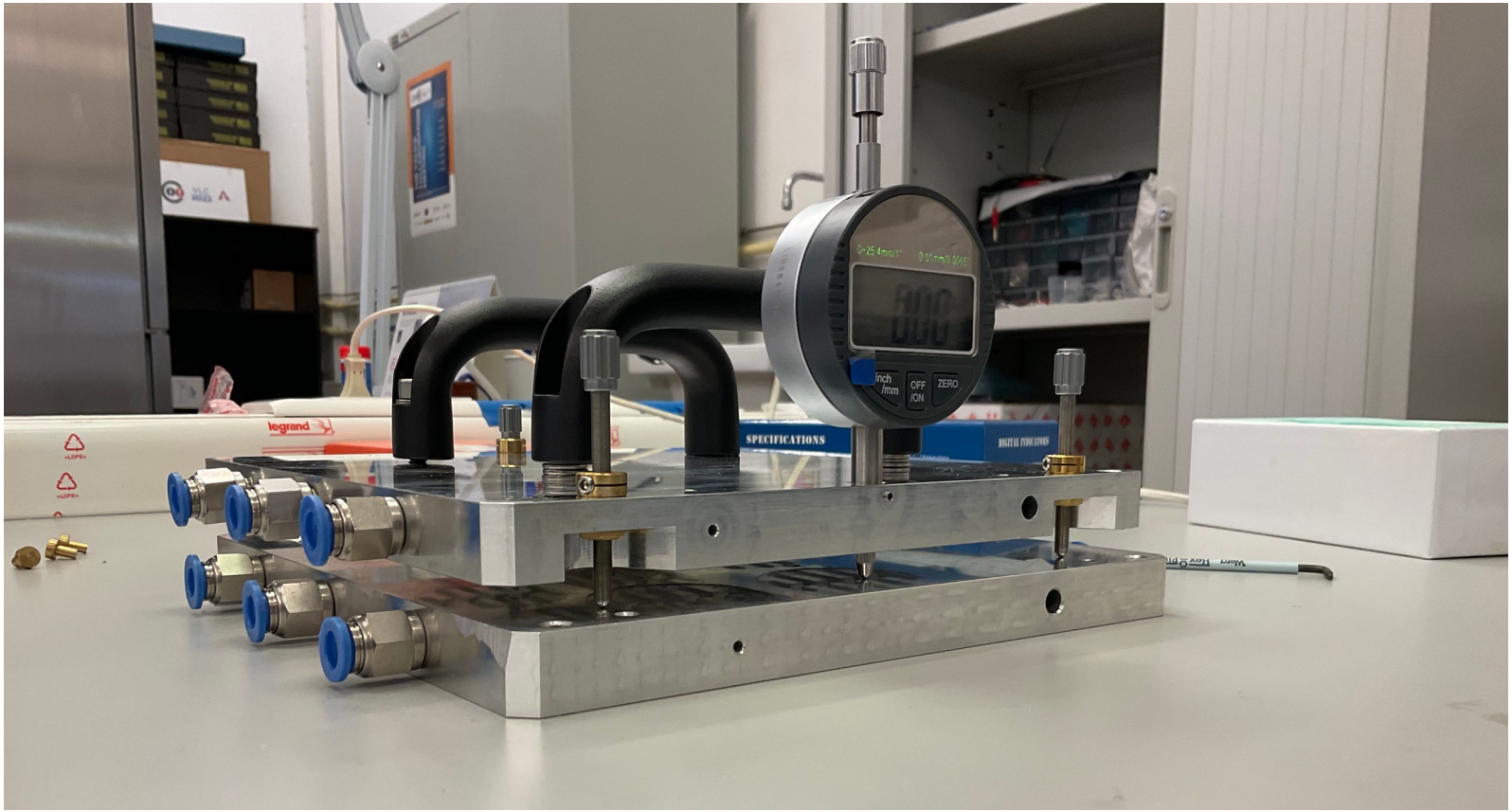
Gluing tests





Gluing tests

Gluing tests



Gluing tests

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- All manual measurements
  - Comparator with 10um resolution

Set	Thickness Sensor (centro)	std	Thickness Flex (centro)	std	Thickness Total (manual meas)	std	Thickness Glue (manual)	std
M1	280	15	80	5	395	16	35	22
M2	300	5	85	5	397	7	12	10
M3	290	10	80	5	371	5	1	12
M4	300	5	80	5	401	8	21	10
M5	300	5	75	10	392	8	17	14
M6	300	5	75	10	440	37	65	38

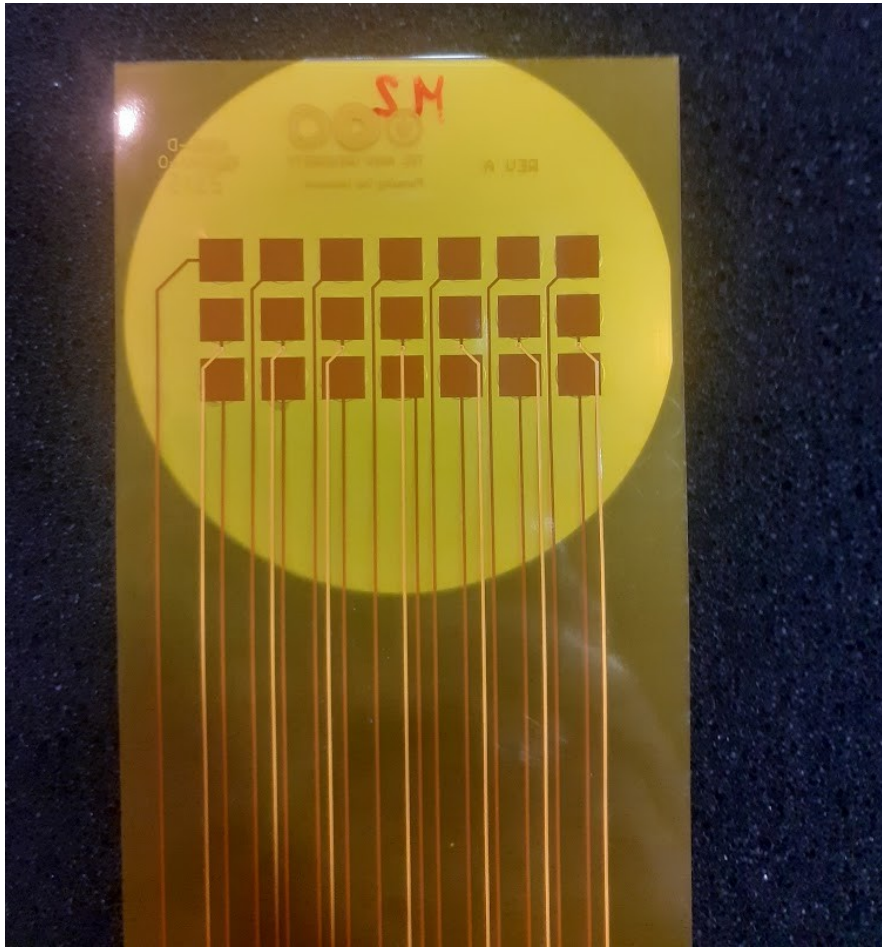
M5&M6 → tests with too large glue dots

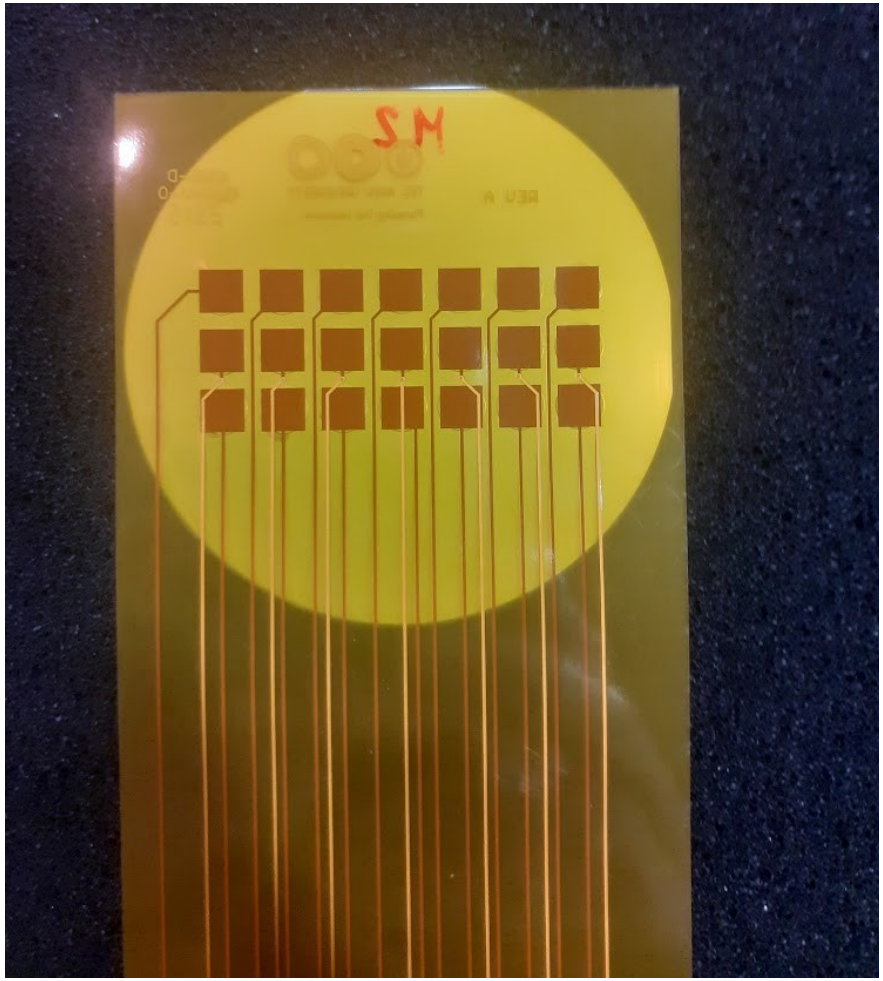
M3&M4 → good tests with small glue dots but not using feeler gauges → the weight of the aluminum plates makes the pressure
(M3 sensor seems deformed, measurement of its thickness does not show good planarity...)

M1&M2 → good tests with small glue dots and

M3&M4

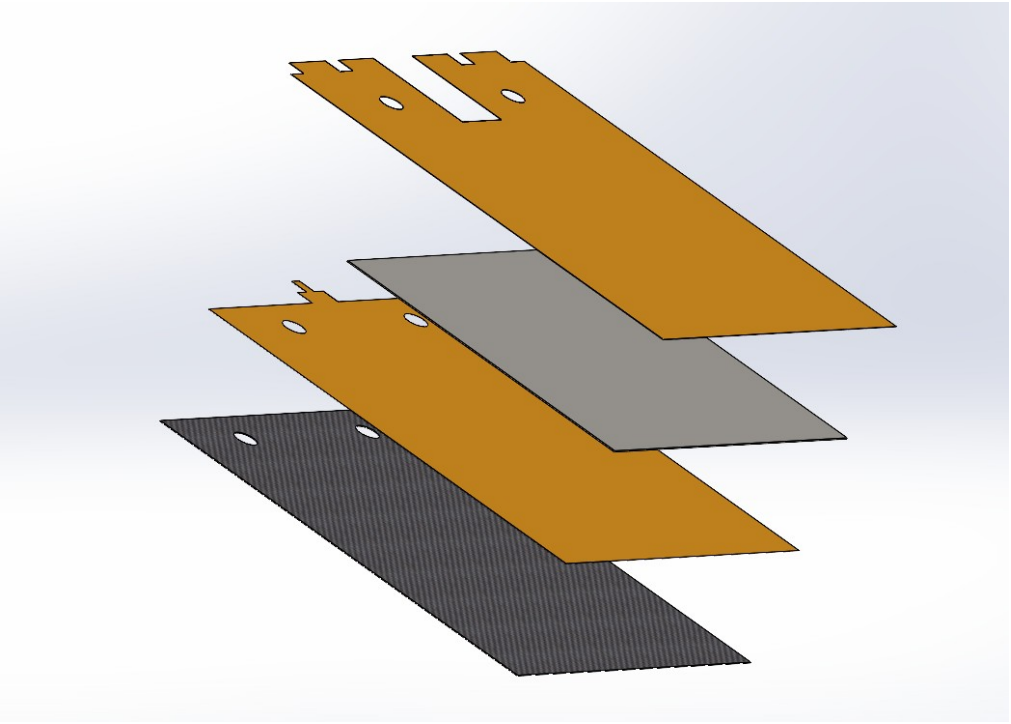
M1&M2

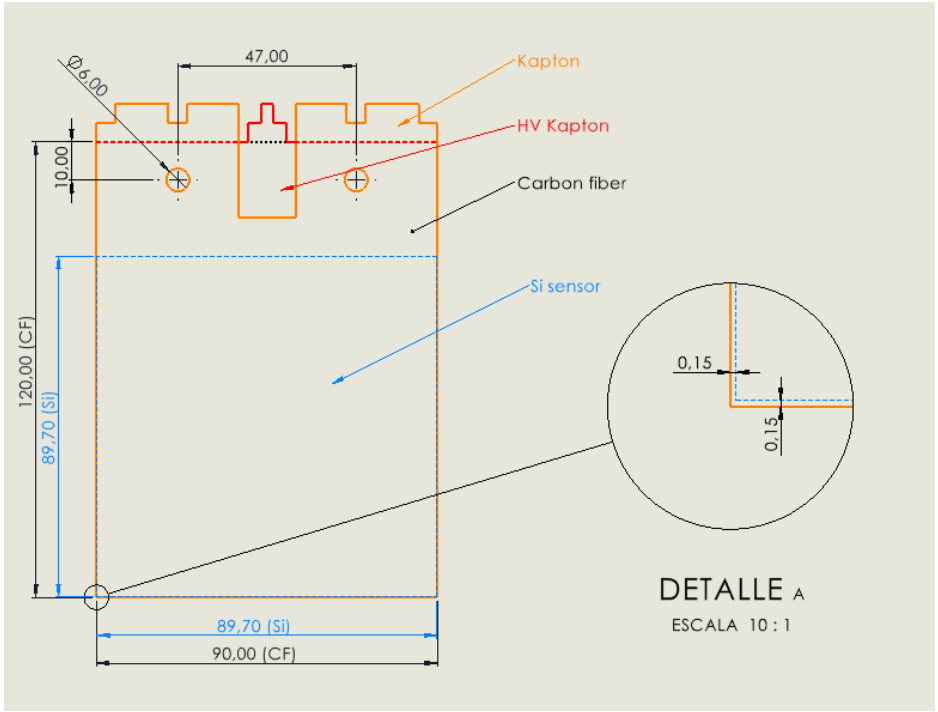




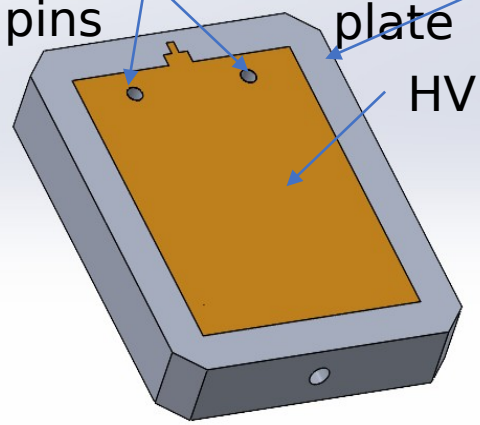
Jig prototypes for gluing

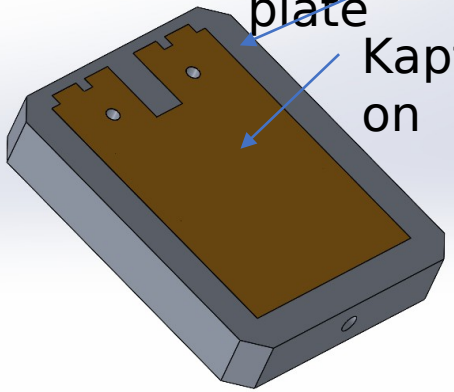
SANDWICH STRUCTURE

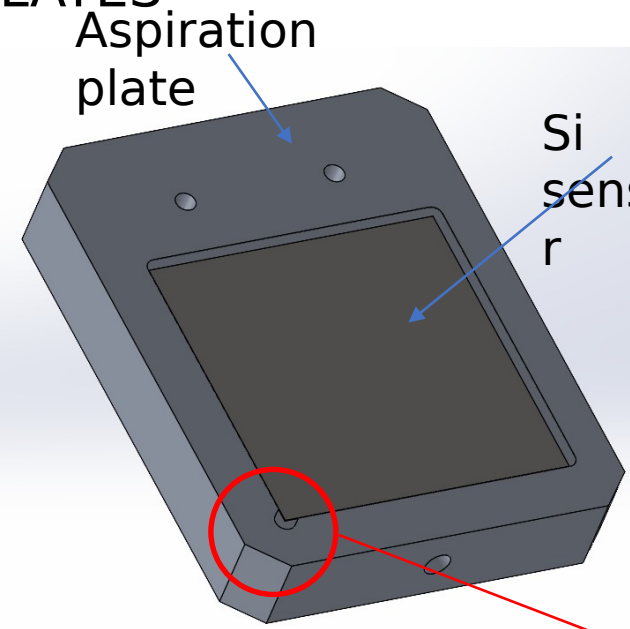


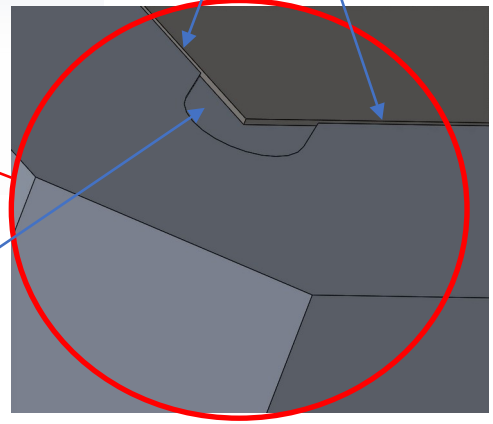


ASPIRATION PLATES





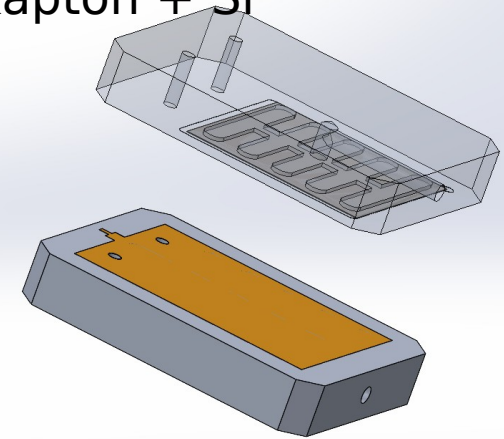




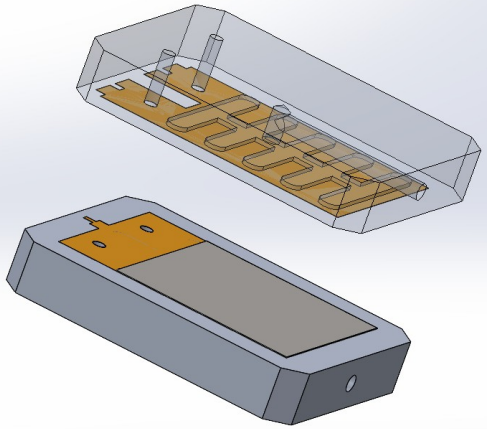
Surface depth: 0,15mm
Si thickness: 0,32mm

GLUEING

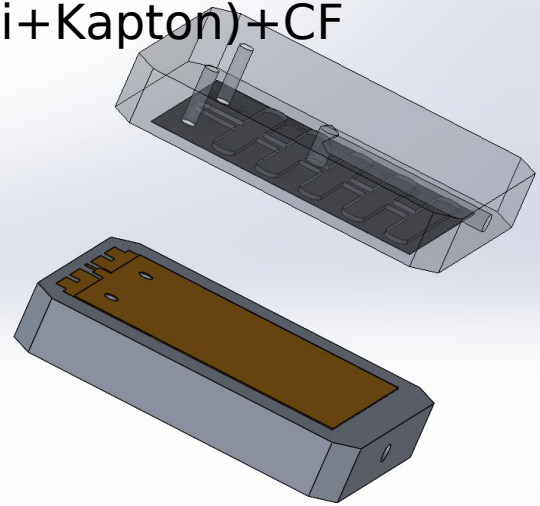
1st glueing step: HV kapton + Si

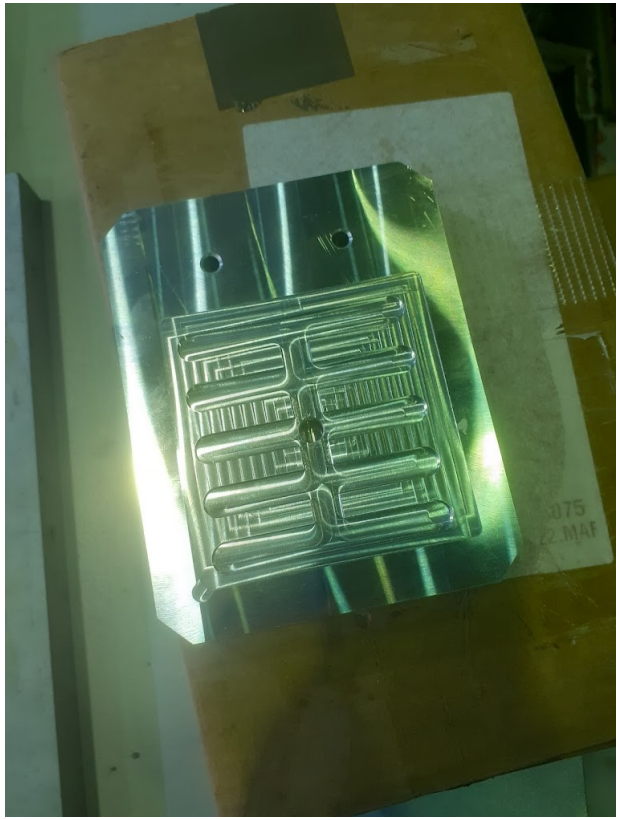


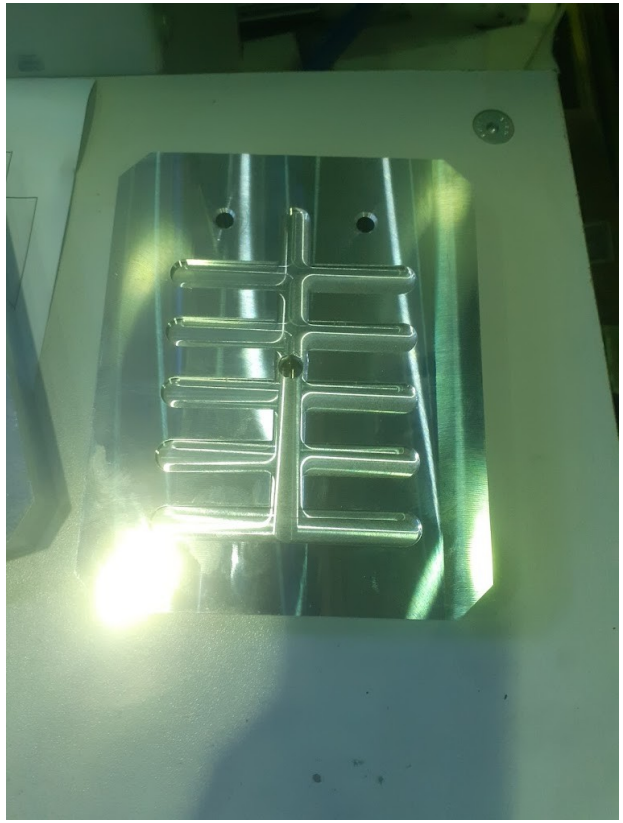
2nd glueing step: (HV kapton + Si)+Kapton

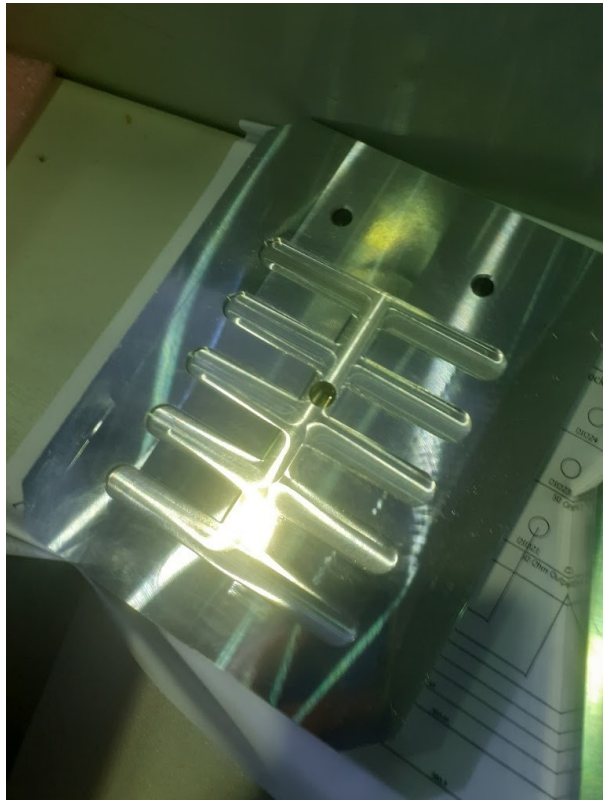


3rd glueing step: (HV kapton + Si+Kapton)+CF









ECAL -p: summary & plans

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CarbonFrame

- Metrology in progress.
- Samples available for Warsaw.
- Seem valid for TB in 2024
- Improving them? Discussions with the company and or alternative solutions for cutting, etc ?

ECAL -p: summary & plans

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Gluing thickness

- We can be bellow the 50um without problem
- Optimization and know-how still improving
- Results need to be tested in beam facility !!

Metrology

- Technically complicated and with some caveats. Alternative and more manual solutions being explored.

ECAL -p: summary & plans

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Gluing thickness

- We can be bellow the 50um without problem
- Optimization and know-how still improving
- Results need to be tested in beam facility !!

Metrology (flex, toy sensors)

- Technically complicated and with some caveats. Alternative and more manual solutions being explored.

ECAL -p: summary & plans

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JIGS

- Recently arrived, to be tested, polished, etc

ECAL -p: summary & plans

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Probe station

- Slowly ramping-up.
- Not primary effort but something that we think very useful in the future and of academic use for the group

Clean room

- Operative but still not clean
- Benches are on their way
- Almost ISO5

ECAL -p: summary & plans

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- Mechanics division at IFIC is being rearranged
  - Less person power available from February until… ?
- February
  - Study of all the metrology data we have
  - Finalizing material and equipment of the clean-room.
  - Probe station is taking longer than hoped: the switch card is still missing and part of the laboratory benches needed.
- March/April (we are waiting for new batches of glue and material)
  - CF metrology → analysis of the data
  - Repeat the gluing tests making use of all the expertise gained and using a comparator clock from the beginning (1um resolution)
  - Melissa and AI to gain expertise.

We are getting ready for BT

Back-up slides

ECAL-e: sensor delamination

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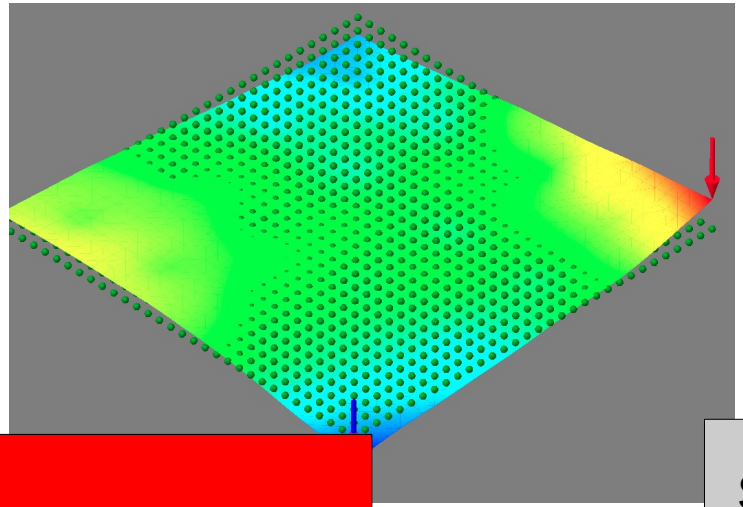
Gluing procedure?
Glue choice,
Mixing,
curing process...

Glue degradation?
Chemical oxidation
(silver vs aluminum),
Lifetime of glue...



Mechanical deformation of the PCBs
Complex PCBs with “intense” thermal processes
for the assembly of the components

Storage and manipulations
Lots of traveling
Commissioning procedure
etc

ECAL-e: sensor delamination

Gluing procedure?
Glue choice,
Mixing,
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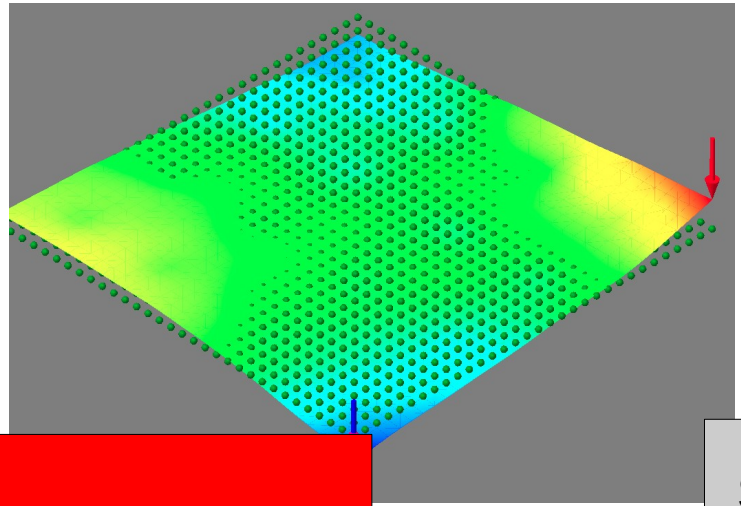

Glue degradation?
Chemical oxidation
(silver vs aluminum),
Lifetime of glue...

Clean room.
Cold plasma to clean sensors.
Alternative epoxies.
Dry-cabinet.
Dry-curing-cabinets

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Complex PCBs with “intense” thermal processes
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ECAL-e: sensor delamination

Gluing procedure?
Glue choice,
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curing process...

Clean room.
Volumetric dosification and deposition
More modern robot

Glue degradation?
Chemical oxidation
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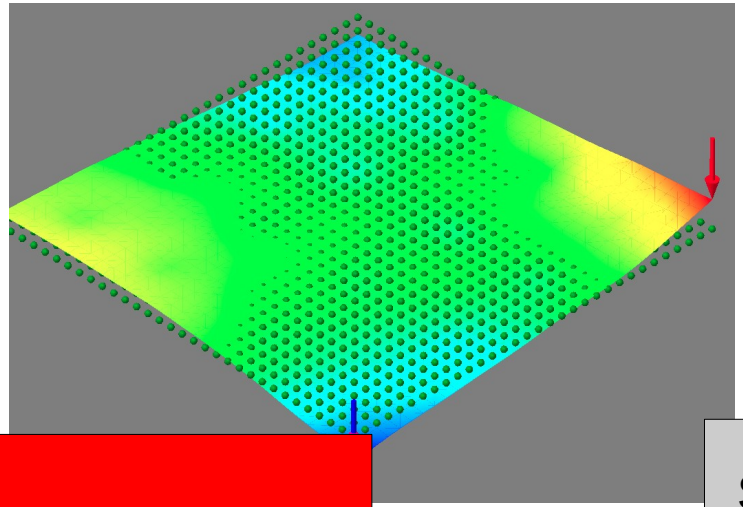
Lifetime of glue...



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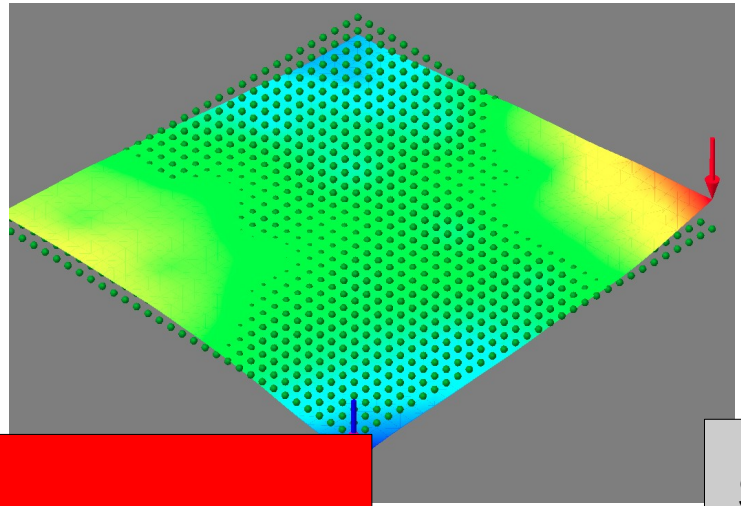

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4. Criterios de aceptación:

Tabla 1 – Clases ISO de limpieza del aire mediante la concentración de partículas

Número de clasificación ISO (*N*)	Concentraciones máximas admisibles (partículas/m³) para partículas iguales o mayores a los tamaños indicados a continuación [a]					
	0,1 µm	0,2 µm	0,3 µm	0,5 µm	1 µm	5 µm
1	*10*[b]	[d]	[d]	[d]	[d]	[e]
2	100	*24*[b]	*10*[b]	[d]	[d]	[e]
3	1 000	237	102	*35*[b]	[d]	[e]
4	10 000	2 370	1 020	352	*83*[b]	[e]
5	100 000	23 700	10 200	3 520	832	[d, e, f]
6	1 000 000	237 000	102 000	35 200	8 320	293
7	[c]	[c]	[c]	352 000	83 200	2 930
8	[c]	[c]	[c]	3 520 000	832 000	29 300
9[g]	[c]	[c]	[c]	35 200 000	8 320 000	293 00

[a] Todas las concentraciones en la tabla son acumulativas, por ejemplo, para la clase ISO 5, las 10 200 partículas mostradas en 0,3 µm incl todas las partículas iguales y superiores a este tamaño.
[b] Estas concentraciones conducirán al grandes volúmenes de muestras de aire para la clasificación. Se pueden aplicar procedimientos de ton muestras secuenciales; véase el anexo D.
[c] Las concentraciones límite no son aplicables en esta región de la tabla debido a la muy alta concentración de partículas.
[d] Las limitaciones estadísticas y de toma de muestras para las partículas en concentraciones bajas hace inapropiada la clasificación.
[e] Las limitaciones de recogida de muestras tanto para ambas partículas en concentraciones bajas y tamaños mayores de 1 µm hace inapropia clasificación en este tamaño de partícula debido a las potenciales pérdidas de partículas en el sistema de toma de muestras.
[f] Con el fin de especificar este tamaño de partícula en asociación con la clase ISO 5, el descriptor M de macropartículas se puede adaptar y ut junto con al menos otro tamaño de partícula (véase C.7).
[g] Esta clase es aplicable únicamente para el estado operacional.

PÓRTICO

VERIFICACIÓN FUNCIONAMIENTO MANDOS Y CONTROLES

MANDOS-CONTROLES (acústicos y visuales): OK	COMPROBACIÓN DE MONTAJE DE FILTROS: CORRECTO
SENSORES DE FLUJO: OK HORAS UV: --	ESTABILIDAD CABINA: CORRECTA
MATERIALES, VIDRIOS Y CABLEADO: OK	ABERTURA DE GUANTES Y GUANTES: NO PROCEDE

PARÁMETRO				RESULTADOS. VALOR PROMEDIO		NIVEL DE REFERENCIA
Integridad filtros	Tipo filtro: HEPA Filtro 1 Filtro 2 Filtro 3			<0.3 µm <0.3 µm <0.3 µm	Conforme: OK OK OK	Sin hallazgos ≥ 0.3 µm
Contaje de partículas	Nº partículas				Alcanza:	Valor referencia
	0,3 µm /m³	0,5 µm /m³	5,0 µm /m³			
3 filtros en uso	-	3615	135		ISO 7	ISO 7 0.5 µm <352.000 5.0 µm <2.930
Confort termo-higrométrico	Temperatura °C			20.5		Valor informativo
	Humedad relativa %			55.2		
Nivel lumínico	Lux			-		Valor informativo
Nivel sonoro	dB			58.6		Valor informativo