Sensor gluing R&D at Valencia

Adrián Irles*

**AITANA group at IFIC – CSIC/UV*

IFIC INSTITUT DE FÍSICA CORPUSCULAR

AITANA MATTER AND TECHNOLOGY

VNIVERSITAT DE VALÈNCIA

CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

Glue - EJ2189-LV

- "Default" glue used by CALICE
- Designed for reliable low temperature curing
  - Because we have very dense PCBs (aka FEV) that do not get along with high temperatures neither quick temperature changes
- Prix is ~400-500 euros per 1oz
  - My initial estimations is that 1oz could be okay for 10-15 ECAL layers (10-15x4 wafers)
  - (2000euros 8oz)
- Orders take 4-7 weeks
- Lifetime of the glue (not mixed) is 1year at room temperature

EPOXY TECHNOLOGY

EPO-TEK® EJ2189-LV

Technical Data Sheet
For Reference Only
Electrically Conductive Epoxy

Date:	November 2019	
Rev:	X	
No. of Components:	Two	
Mix Ratio by Weight:	10 : 1	
Specific Gravity:	Part A: 3.07	Part B: 0.94
Pot Life:	4 Hours	
Shelf Life- Bulk:	One year at room temperature	

Recommended Cure: 150°C / 1 Hour

Minimum Alternative Cure(s):
May not achieve performance properties listed below
150°C / 15 Minutes
100°C / 1 Hour
80°C / 3 Hours
23°C / 3 Days

NOTES:
- Container(s) should be kept closed when not in use.
- Filled systems should be stirred thoroughly before mixing and prior to use.
- Performance properties (rheology, conductivity, others) of the product may vary from those stated on the data sheet when bi-pak/syringe packaging or post-processing of any kind is performed. Epoxy's warranties shall not apply to any products that have been reprocessed or repackaged from Epoxy's delivered status/container into any other containers of any kind, including but not limited to syringes, bi-paks, cartridges, pouches, tubes, capsules, films or other packages.
- Syringe packaging will impact initial viscosity and effective pot life, potentially beyond stated parameters.

Product Description: EPO-TEK® EJ2189-LV is an electrically conductive, silver-filled epoxy. This two component system is designed for reliable low temperature curing.

1oz available at IFIC
Since Feb 2022

Glue - H20E

- More commercial/standard option
- Offered by the spanish distributor of EPOXY
- NOT low temperature curing !
- Similar price but better availability
- Better tested

EPOXY TECHNOLOGY

EPO-TEK® H20E
Technical Data Sheet
For Reference Only
Electrically Conductive, Silver Epoxy

Date:	November 2019	**Recommended Cure: 150°C / 1 Hour**
Rev:	XVII	
No. of Components:	Two	Minimum Alternative Cure(s):
Mix Ratio by Weight:	1 : 1	*May not achieve performance properties below*
Specific Gravity:	Part A: 2.03 Part B: 3.07 Syringe: 2.67	150°C / 5 Minutes
Pot Life:	2.5 Days	120°C / 15 Minutes
Shelf Life- Bulk:	One year at room temperature	80°C / 3 Hours
Shelf Life- Syringe:	One year at -40°C	

NOTES:

- Container(s) should be kept closed when not in use.
- Filled systems should be stirred thoroughly before mixing and prior to use.
- Performance properties (rheology, conductivity, others) of the product may vary from those stated on the data sheet when bi-pak/syringe packaging or post-processing of any kind is performed. Epoxy's warranties shall not apply to any products that have been reprocessed or repackaged from Epoxy's delivered status/container into any other containers of any kind, including but not limited to syringes, bi-paks, cartridges, pouches, tubes, capsules, films or other packages.

Product Description: EPO-TEK® H20E is a two component, 100% solids silver-filled epoxy system designed specifically for chip bonding in microelectronic and optoelectronic applications. It is also used extensively for thermal management applications due to its high thermal conductivity. It has proven itself to be extremely reliable over many years of service and is still the conductive adhesive of choice for new applications. Also available in a single component frozen syringe.

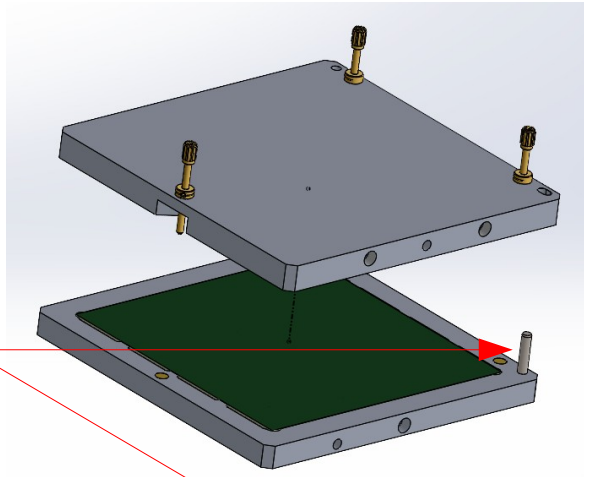
CALICE IFIC INSTITUT DE FÍSICA CORPUSCULAR

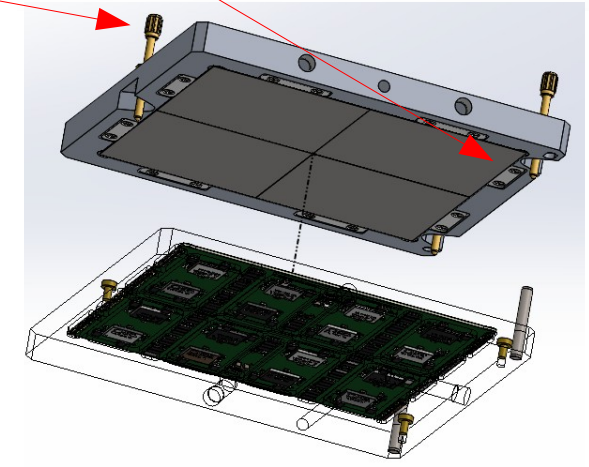
Activities at IFIC

- Activity 1 → design and construction of a set of aspiration plates for CALICE-FEVs + wafers
  - Fix position of FEV during the glue dots deposition
  - Fix the position of wafers
  - Align wafers and PCB in x-y and Z (with micrometric screws)
  - Distribute heat for low temperature curing (30-80degrees, to be studied)
- Activity 2 → study of the use of stencils instead of robots for glue-dot depositions
  - To be integrated in the aspiration plates
- Activity 3 → study of options for glue-dot depositions using robots or pick-and-place machines
  - Highly dependent on pending budget requests

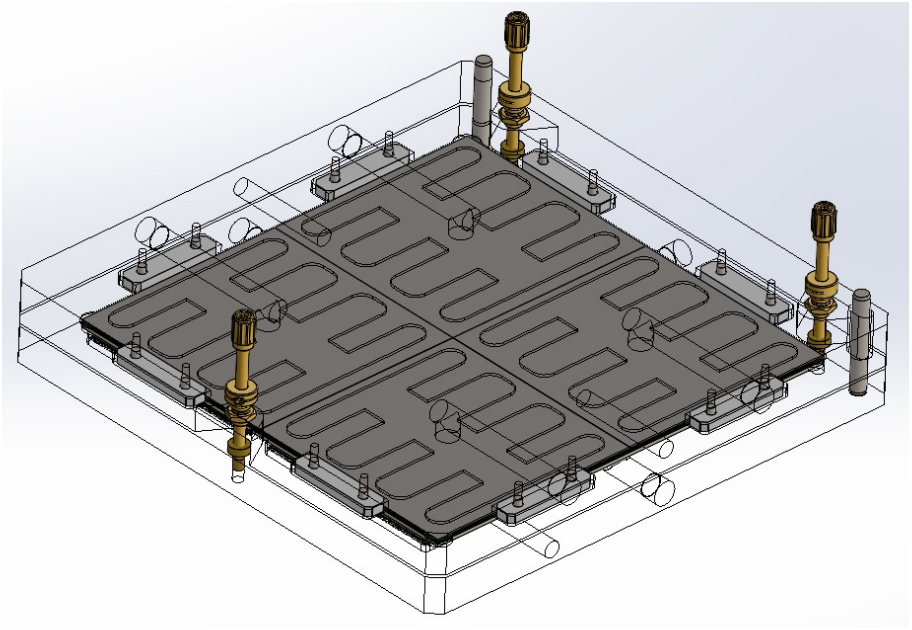
Activity 1 – aspiration plates design

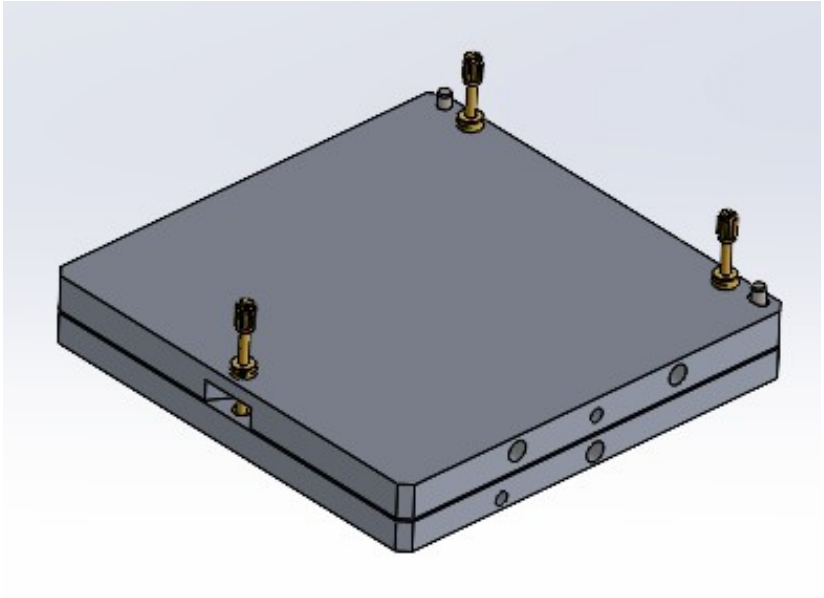
- Sandwich-maker style
- Two aspiration plates
  - One for the wafers
  - One for the PCBs (with components in it)
- Alignment in x-y done by the aspirations themselves and pivot tools
- Alignment in z done with micrometric screws
  - To deal with the PCB thickness tolerances (of possible hundreds of um)





Activity 1 – aspiration plates design

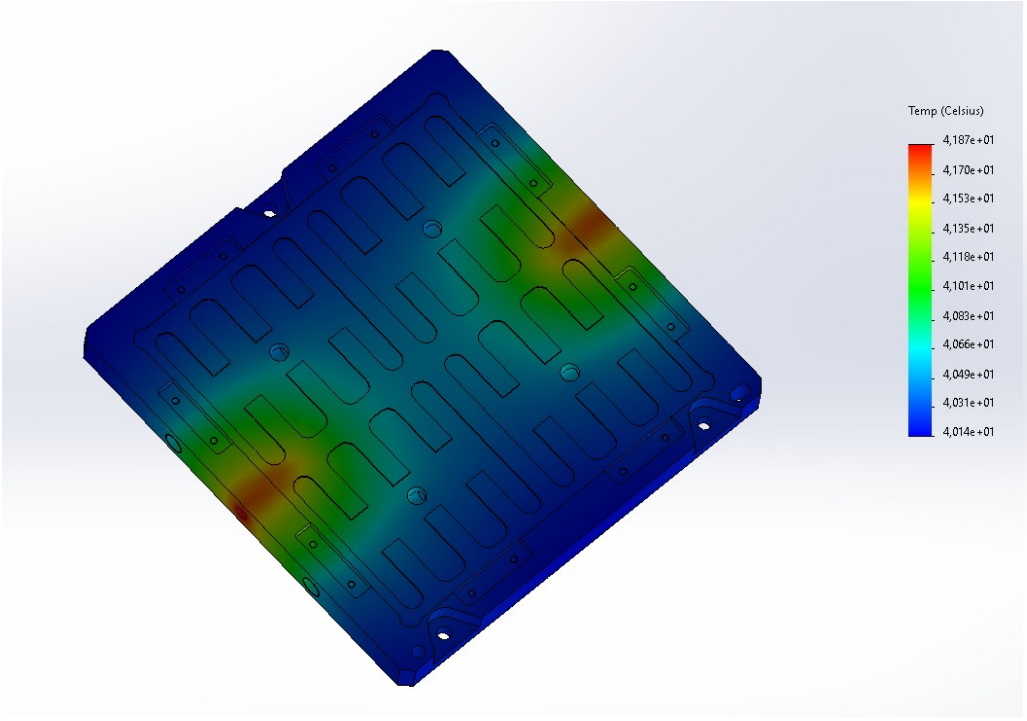


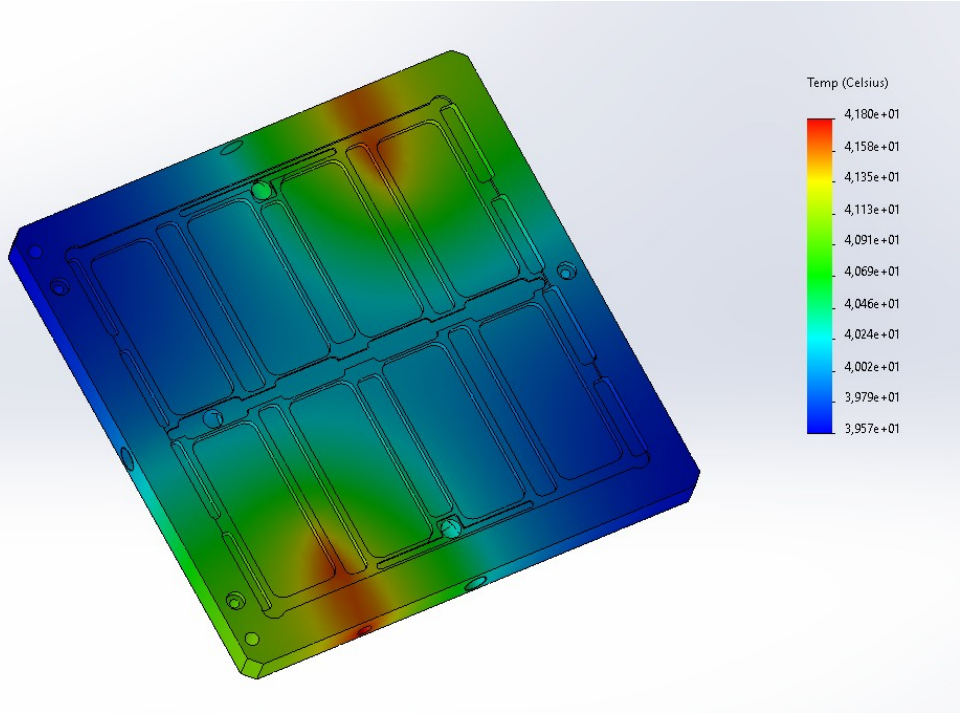


César Blanch

Activity 1 – aspiration plates design

- Also thermal curing using resistance and APDs for temperature control

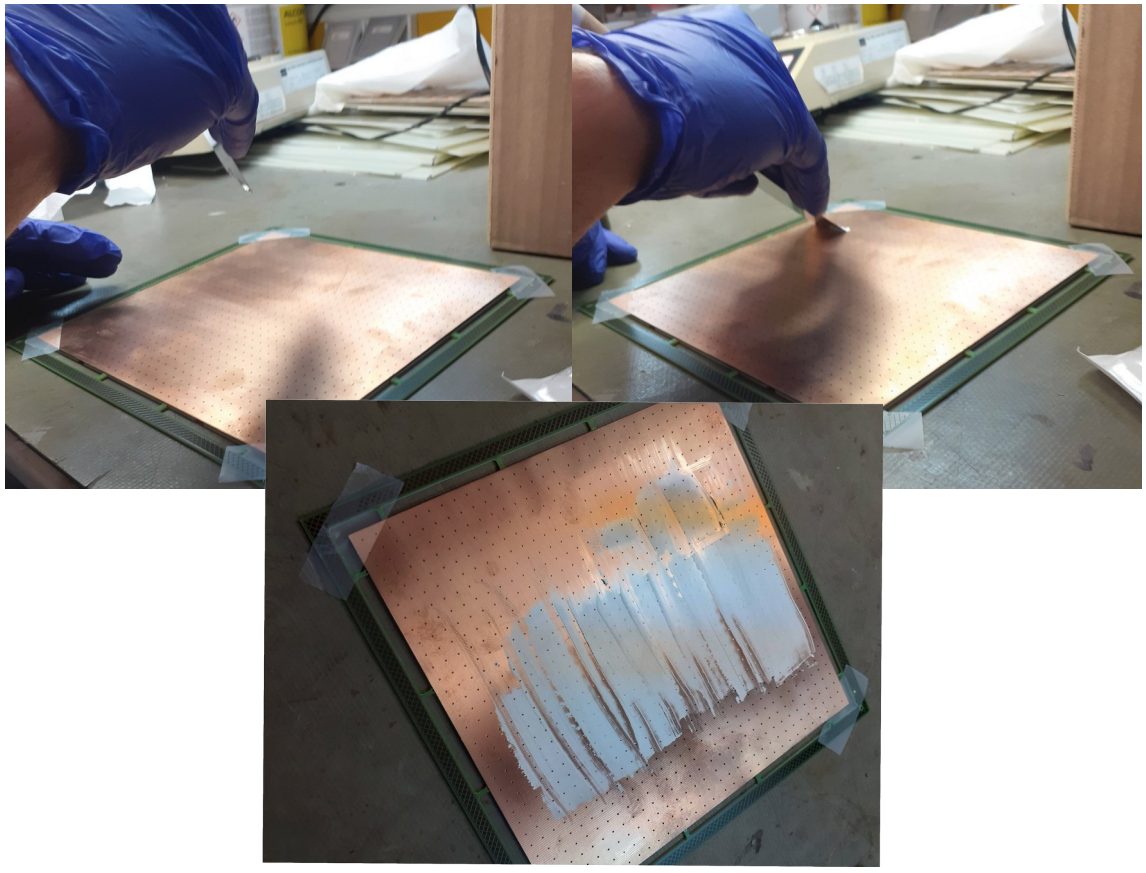




César Blanch

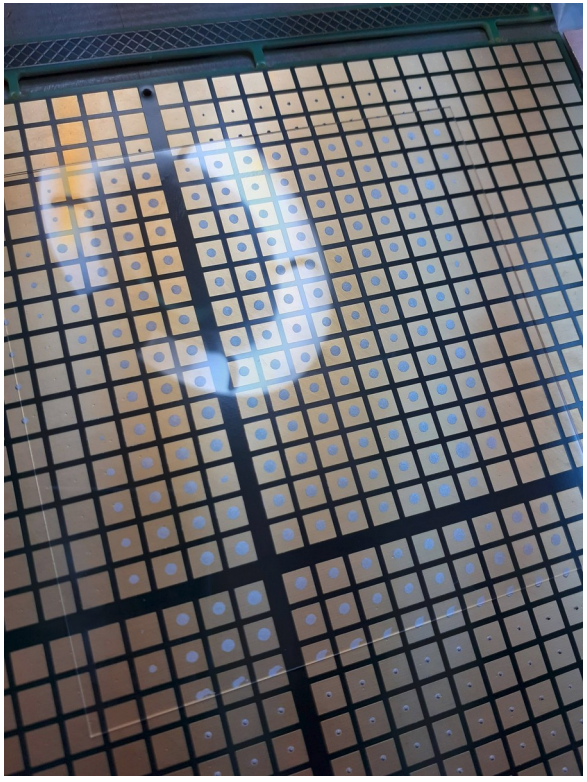
Activity 2 – stencils instead of robot ?

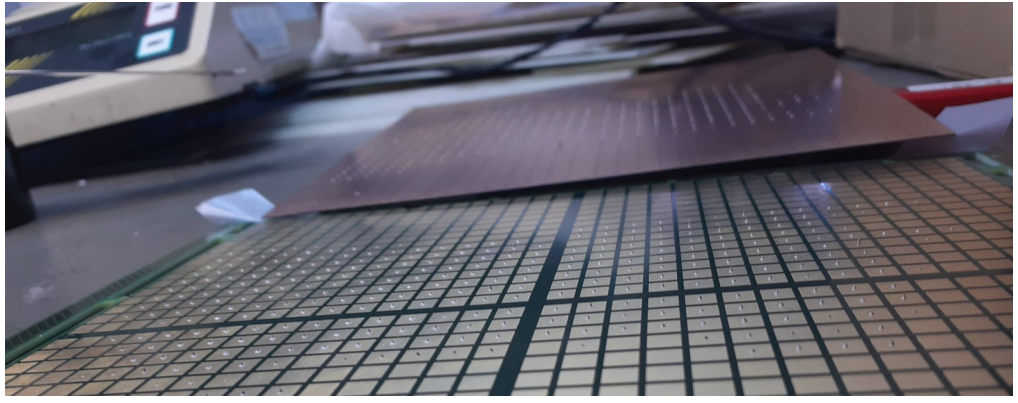
- Design of stencil with made of copper 500um thick
  - 1024 holes of 0.4mm of radius
  - Glue dots expand up to 0.8mm of radius when the sensor will be pressed up to 100um distance of the PCB
- Very easy to produce at IFIC (and cheap)
- **Tests with EJ2189-LV glue**
- ~1gr of mix prepared
- Several tests. The most optimal conditions reached after 1h of the mix (at ~23degrees)
  - Because the glue became “very similar in density and texture as standard soldering paste”
- Total time of the test:
  - few minutes to prepare the mix (manually)
  - 1h of waiting time
  - Few minutes to spread the glue along the stencil



Activity 2 – stencils instead of robot ?

- Test with fake wafers (glass)
- Using “manual” pressure
  - Excellent results → the holes of the stencil limit the final glue dot size
- Very simple procedure and not very time consuming.
  - Success at the very first try.
- Margin to improve:
  - Use aspiration plate system to define the “pressure” to be implemented
  - Optimize fixation of the stencil





Activity 3 – automatized gluing process?

- Option 1: purchase a specialized robot
  - Depends on budget requests
  - Requires new expertise (although these new-generation robots seem rather easy to program)
  - State of the art tools → industrializabilty?

- Option 2: use existing pick-and-place machine at IFIC
  - Existing expertise at IFIC
  - Possible mechanical constraints to use the aspiration plates (but maybe not needed at this step)

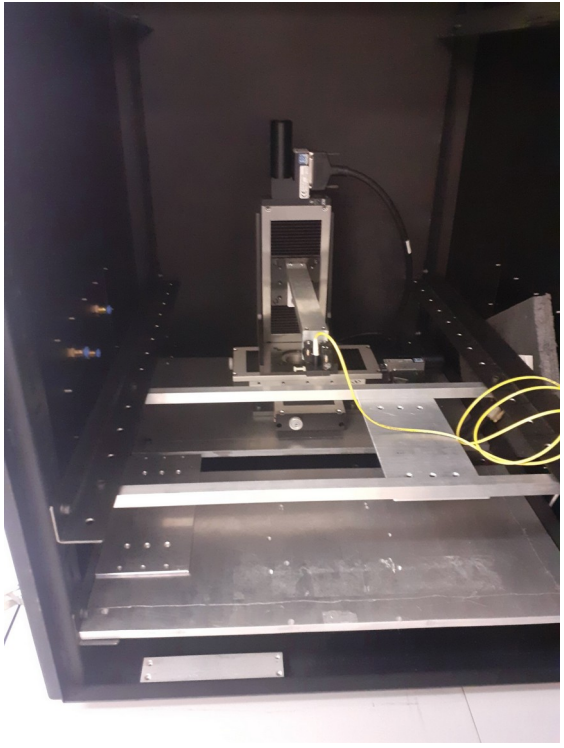
Would any of these offer better results than the “stencil option” ??
(for a relatively small production as ours)

What about ECAL-e

- Simpler procedure ?
  - Not complex/dense PCB → we could use higher temperature curing (which is supposed to be more reliable)
  - Simpler mechanical supports ?
- We would need to have access to the electronics (or electronics mock-ups) in order to evaluate the complexity of the process and adapt the tools to it

Tests with radioactive sources

- We are allowed to use radioactive sources in the Future Colliders – AITANA lab at IFIC
  - Availability of some Sr90 – beta sources
  - Preliminary tests with them to be conducted in September (with an old COB used for debug)
- Dark-box and automatizable device for positioning of the source for fulls can of the sensor
  - The box is required for security reasons: it is closed, it is large (ensures distance of the operator with the source) and it can't be moved easily.



Plans for the coming months

- Manufacturing of the aspiration plates and stencils
- Preparation for tests with radioactive sources
- Gluing tests with fake wafers
  - Equip 2 naked FEV12s (8 wafers)
  - Equip 1-2 ECAL-e sensors ?
- Tests of stability of glue
  - Temperature tests can be conducted at IFIC
  - Humidity? Vibrations ? Where ?
  - Only very visible effects could be observed (no way to check the connectivity)
- Test with real wafers and “real electronics”
  - One CALICE single ASU
  - 1-2 ECAL-p individual modules
- Tests with radioactive sources → January/February

Today to end of september

September October

October - December

December January

Ideally before the Christmas break!
(glue lifetime ends in february and January is always a busy month)

Plans for the coming months (continuation)

- Open questions
  - how long will take the adaptation of the tools to the ECAL-e ?
  - Will the electronics be ready by the end of the year? Or at least mechanical mock-ups of the electronic?
  - How/where do we test the stability of the gluing? Stress tests?
- The results of these exercise in 2022 will define the timeline in 2023
  - Will more tests with real wafers be needed ?

Stock of material at IFIC for R&D phase

- 3 naked FEV12 PCBs for tests with fake wafers
- 1 equipped COB with chips that can be used to glue real wafers
  - Note: the aspiration table is designed for the FEV2x.
- Fake wafers
  - 10x 9cmx9cmx550um thick (measured at lab)
  - To equip 2 naked FEV glued with them + 2 ECAL-e sensors
- Real wafers
  - 8x 9cmx9cmx500um thick (specifications)
  - 4 to be glued into a COB/FEV2.X
  - 2 to be glued into ECAL-e electronics
- 1oz of EJ2189-LV glue (lifetime ends in february 2023)
  - In principle should be enough for the discussed tests
- The cost of this R&D phase can be covered with current budgets
  - Including design, manufacturing of tools etc...
  - Also possible to buy Sr90 source if needed
- Complete set of CALICE electronics and power supplies
  - Spare slboards
  - Core-module and core-kapton
  - HV Keithley picoamperemeter/sourcemeter 6487 and picoamperemeter 6482 and sourcemeter 2410
  - Several LV power supplies

Back -up