LumiCal Thin Detector Module Design and Assembly

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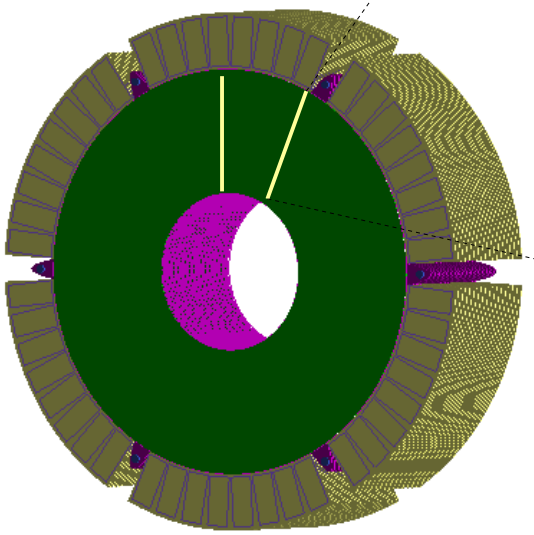
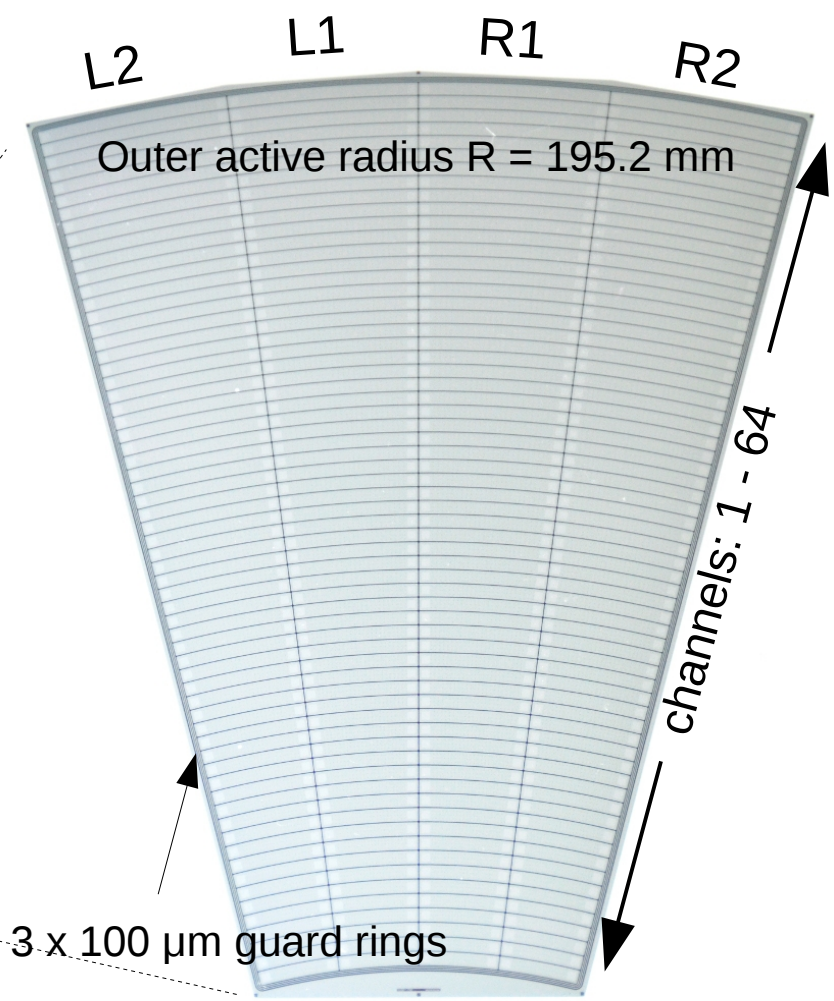
Outline

- Introduction
- Thin module design
  - Support
  - Fanout
- Assembly of thin LumiCal module
- Summary and plans

LumiCal and Sensor Design

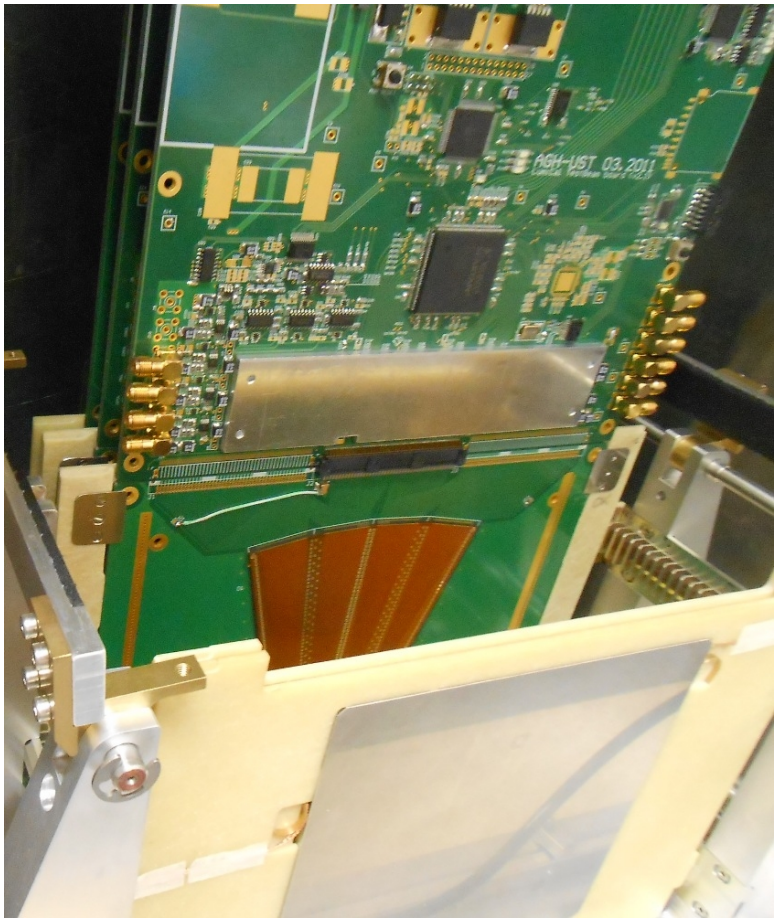
- Silicon sensor
- thickness 320 μm
- DC coupled with read-out electronics
- p+ implants in n-type bulk
- 64 radial pads, pitch 1.8 mm
- 4 azimuthal sectors in one tile, each 7.5°
- 12 tiles makes full azimuthal coverage



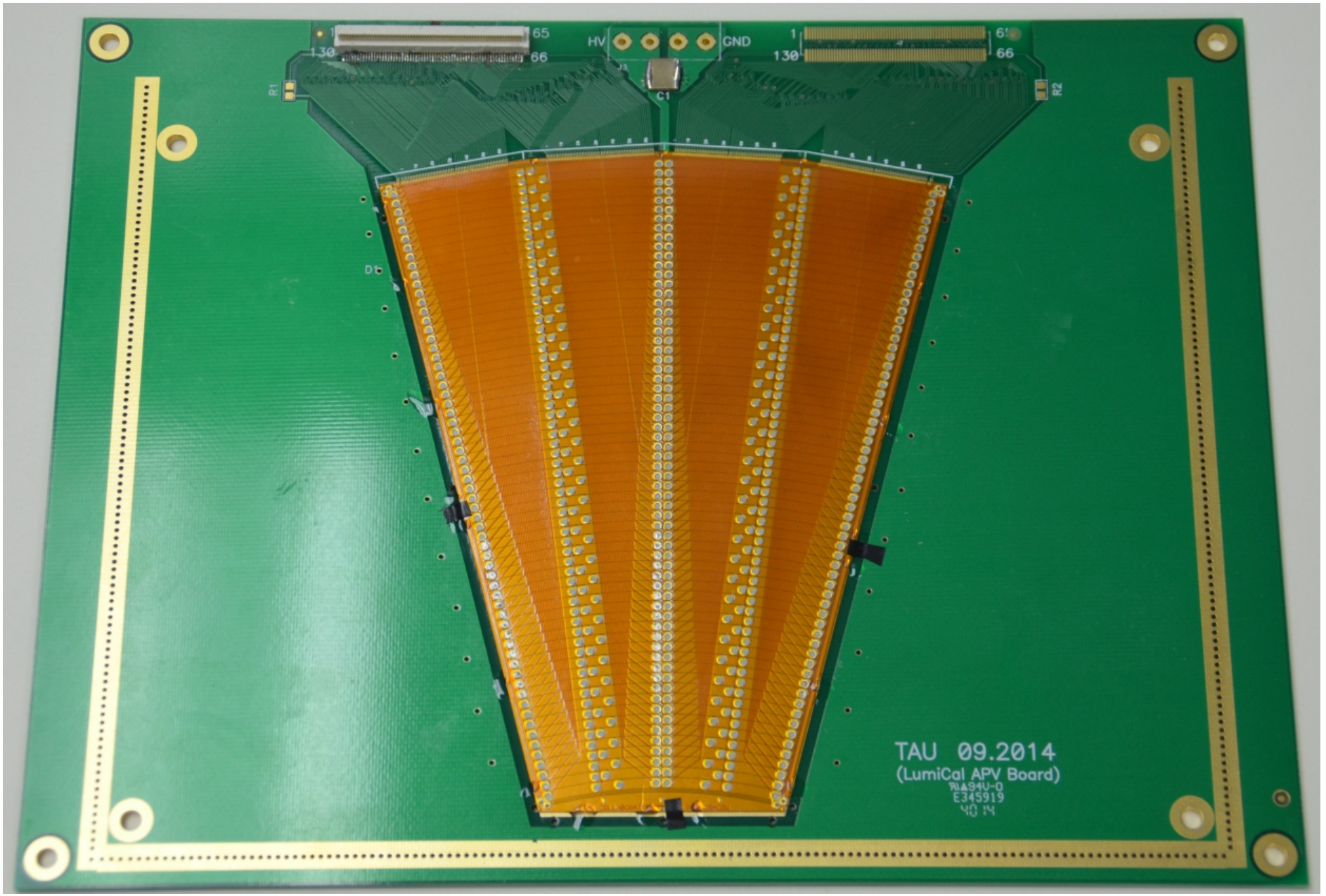


LumiCal Module Modification Goals

- Primary aim is to build LumiCal prototype for beam tests and demonstrate the principle of compact electromagnetic calorimeter;
- Make the geometry of the detector module closer to the designed for LumiCal at LC experiments;
- Reduce the thickness below 1 mm;
- Provide mechanical rigidity for the module to simplify its handling during the assembly of calorimeter prototype;
- Try to read-out all pads of the LumiCal sensor.

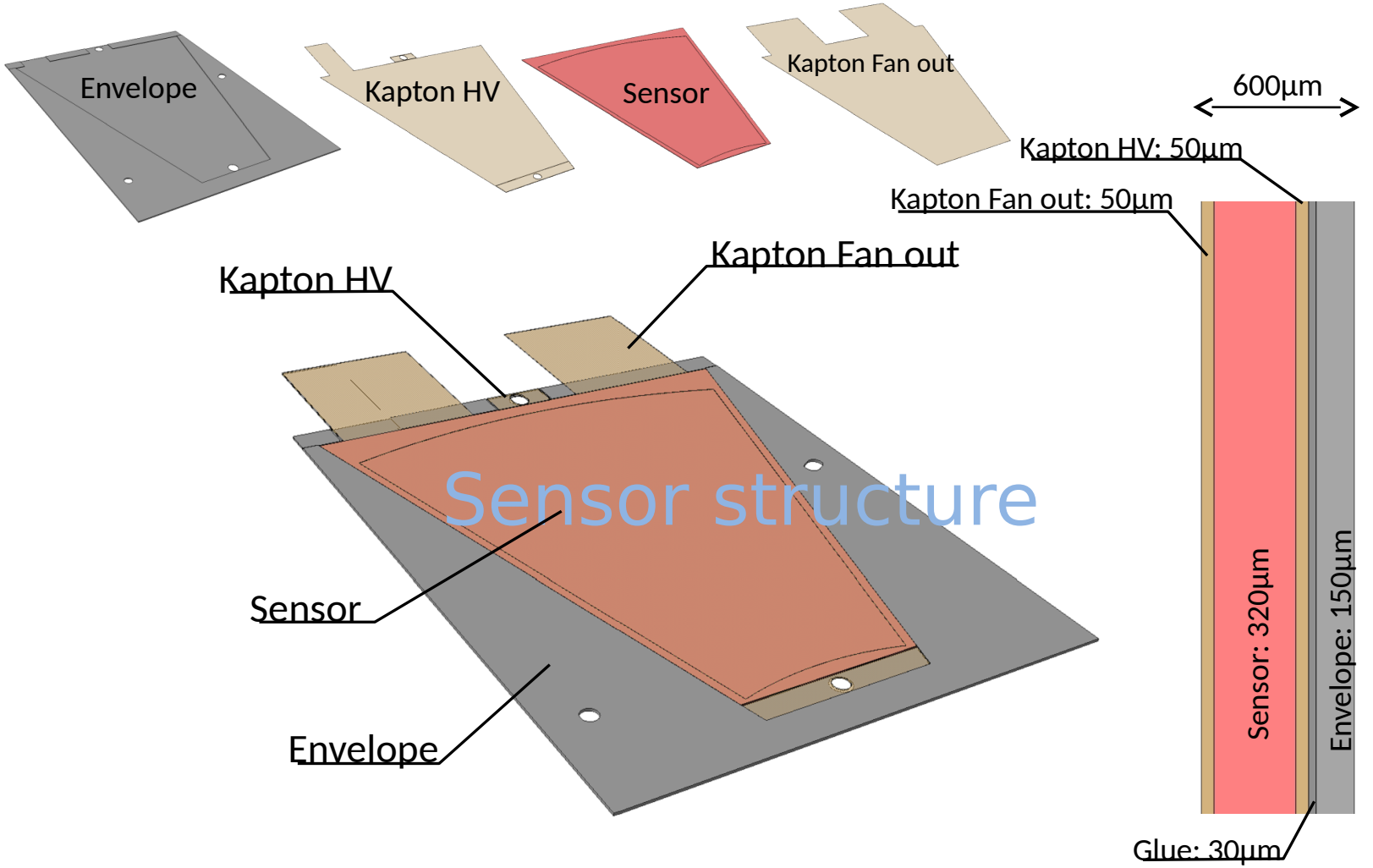


LumiCal Module for APV Test



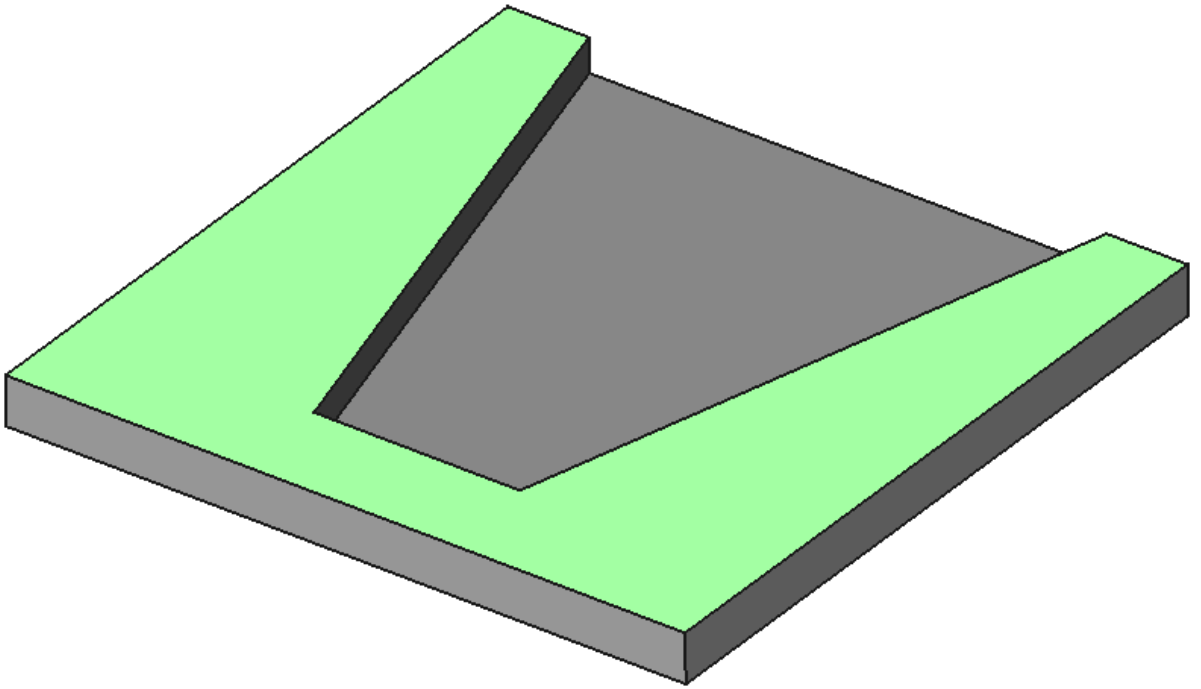
New LumiCal Module Design

- Current LumiCal modules are based on 3.5 mm thick PCB.
- Compactness of LumiCal is essential requirement to provide small Molière radius and accurate shower position reconstruction.
- In current LumiCal conceptual design the space between absorbers is 1 mm!



Mechanical Support

- We considered a 3D printing as a possible approach for the production of the container;
- We collaborated with CERN team:
  - One container has been printed on 3D printer;
  - Another has been made from carbon fiber;

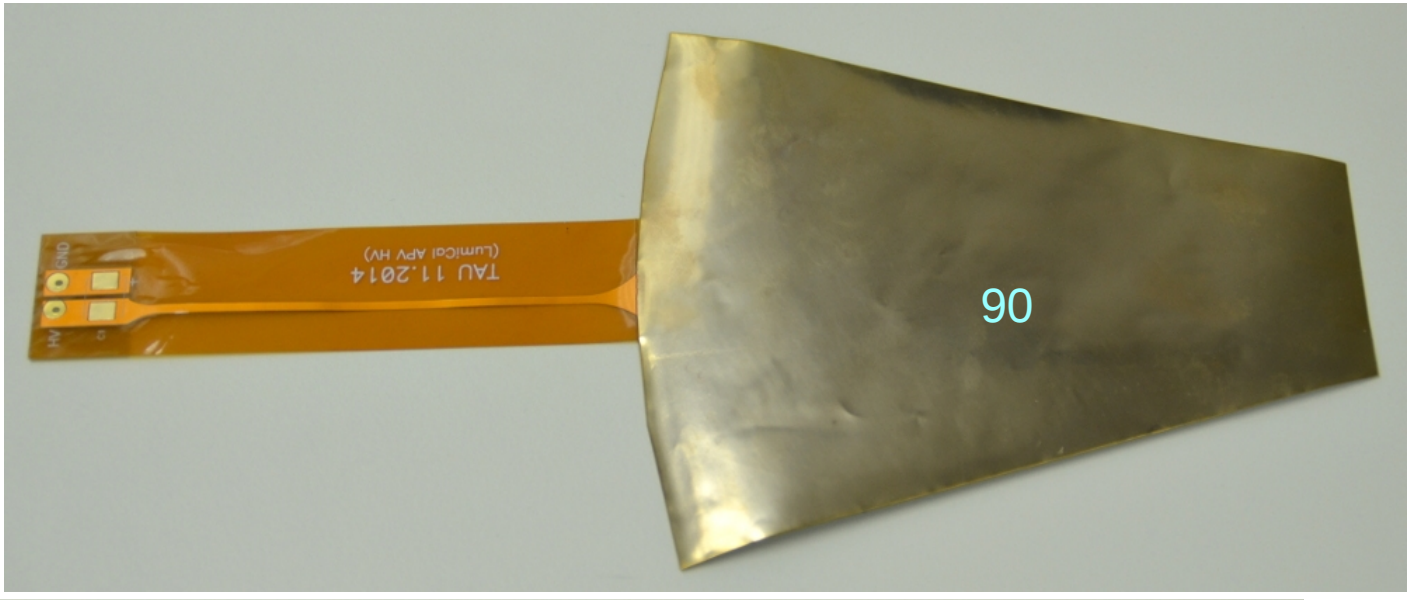


HV and Fan-out

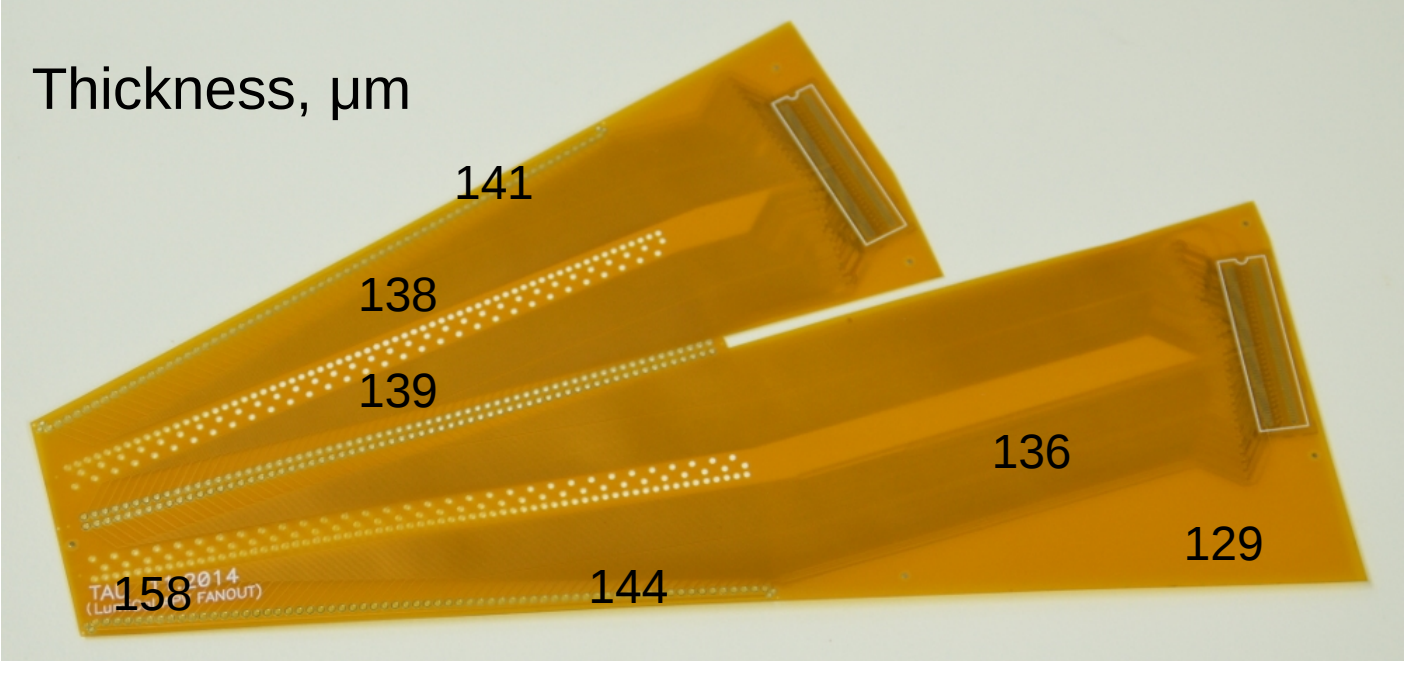
The thickness of the gluing area is 90 µm.

Contact area:

- Kapton: 116 µm,
- Conductor: 136 µm.



Thickness of fan-out varies in different areas from
129 µm to 158 µm

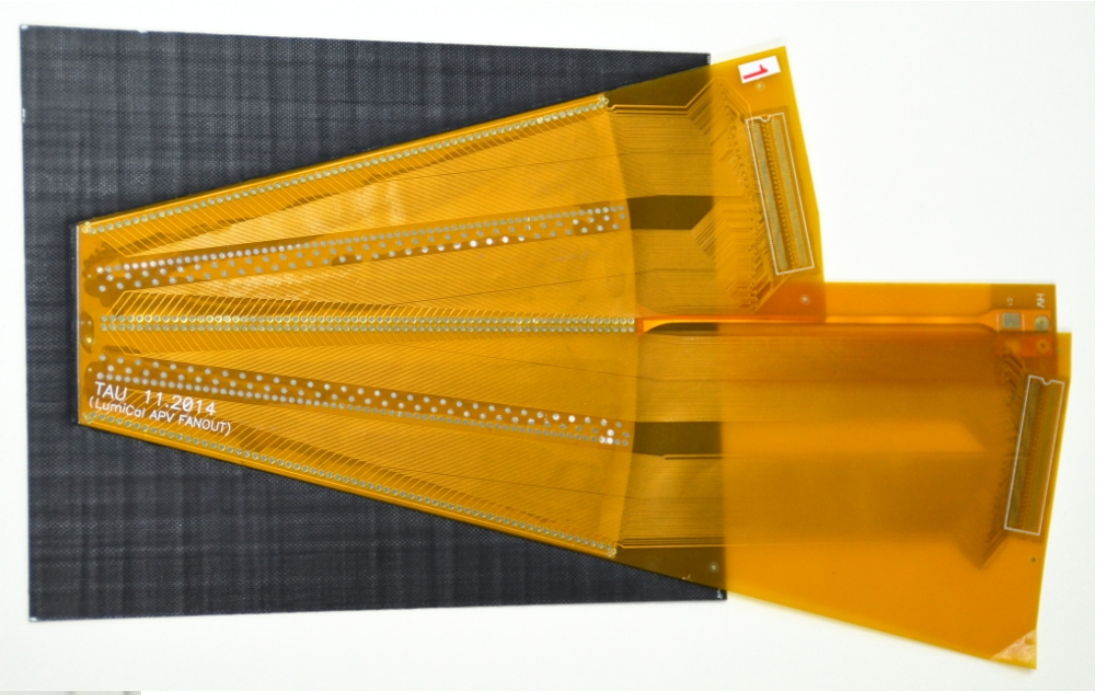


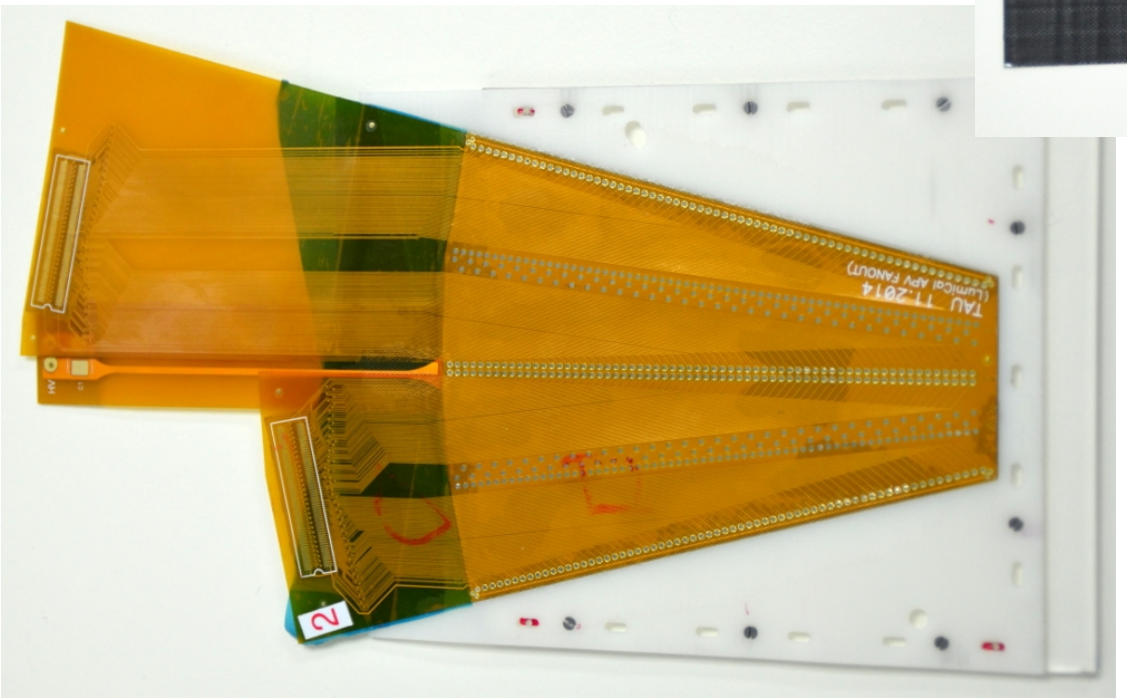
Thin LumiCal Mechanical Prototypes

Total assembly thickness:

- less then 900 µm for carbon fiber
- less then 800 µm for 3d printing

Carbon fiber module significantly more rigid.

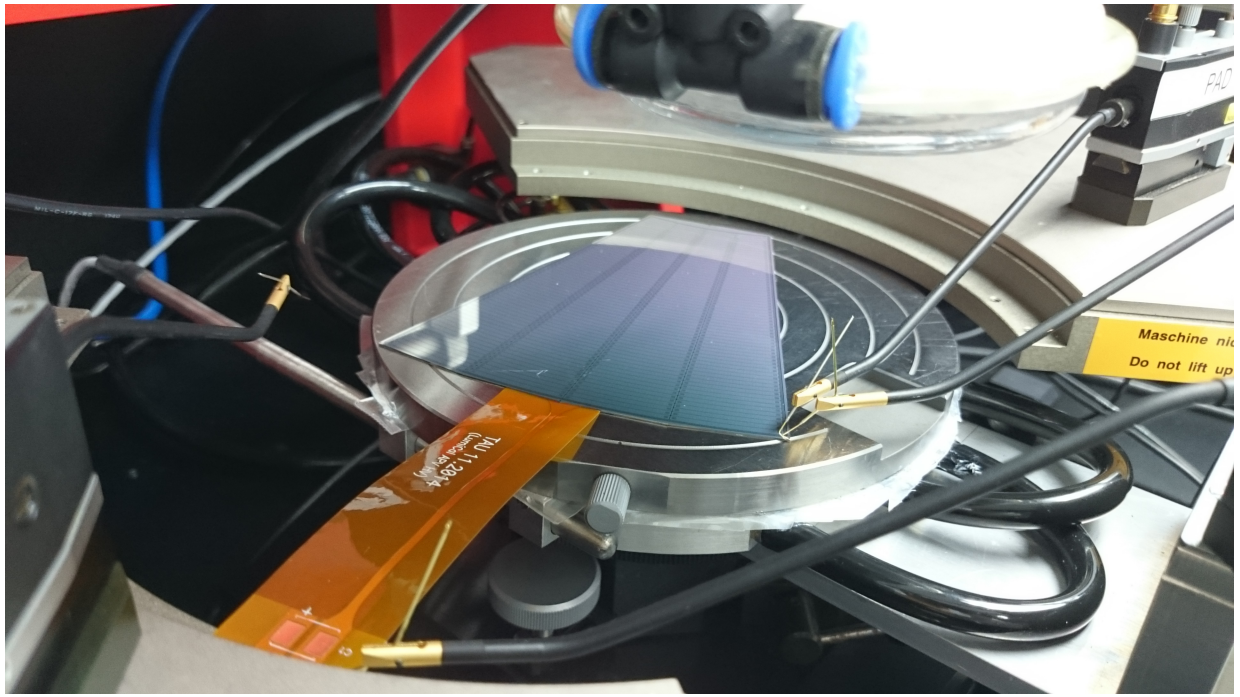


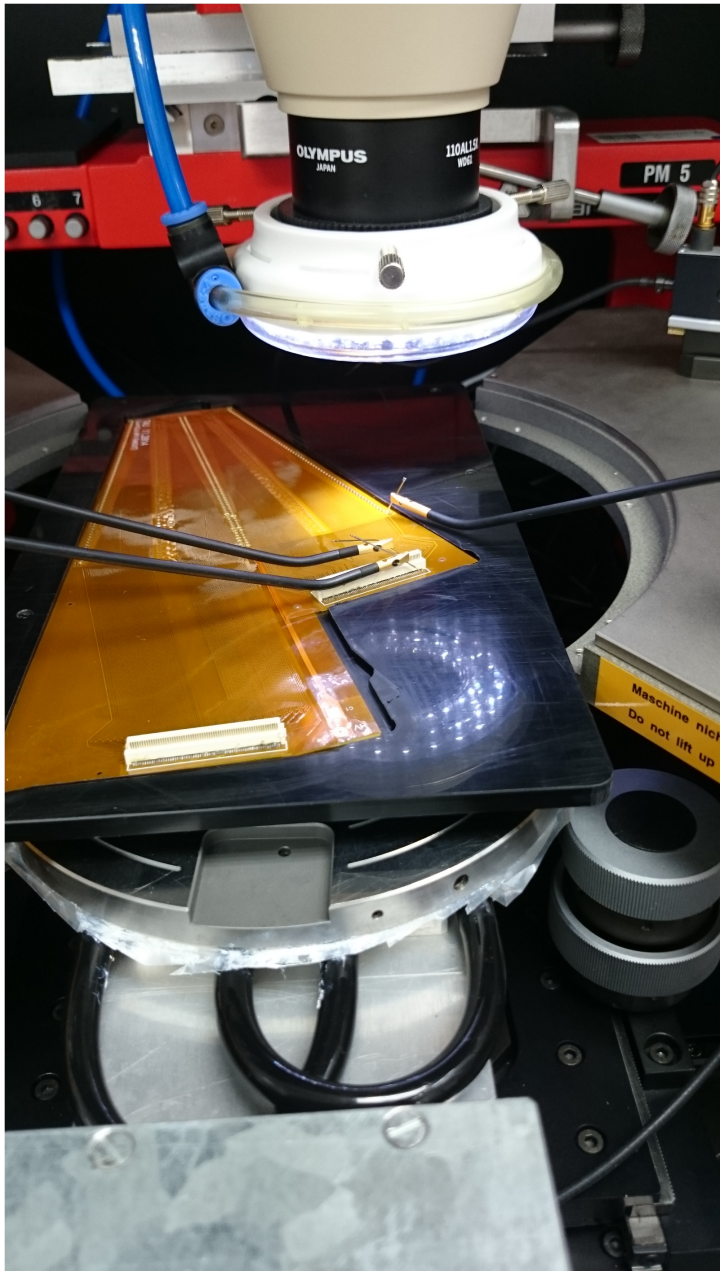


Procedure was destructive for wire bonding connections.

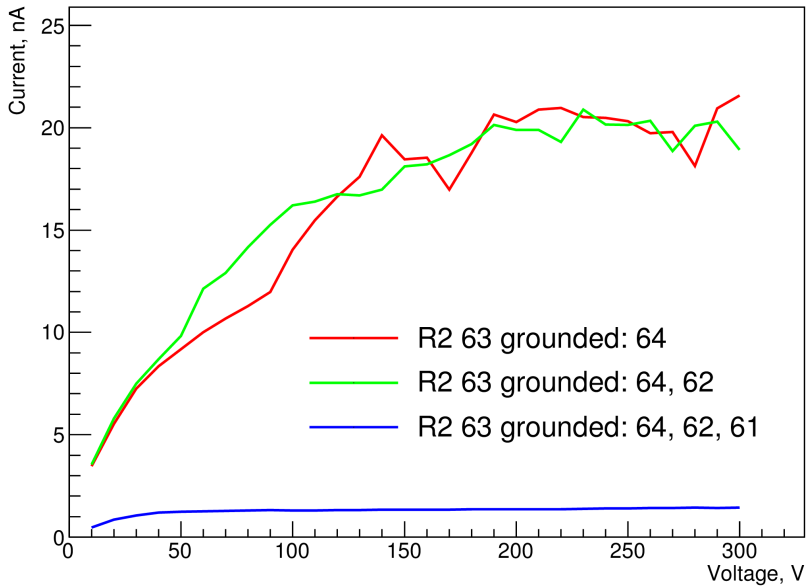
Module Assembly and Tests

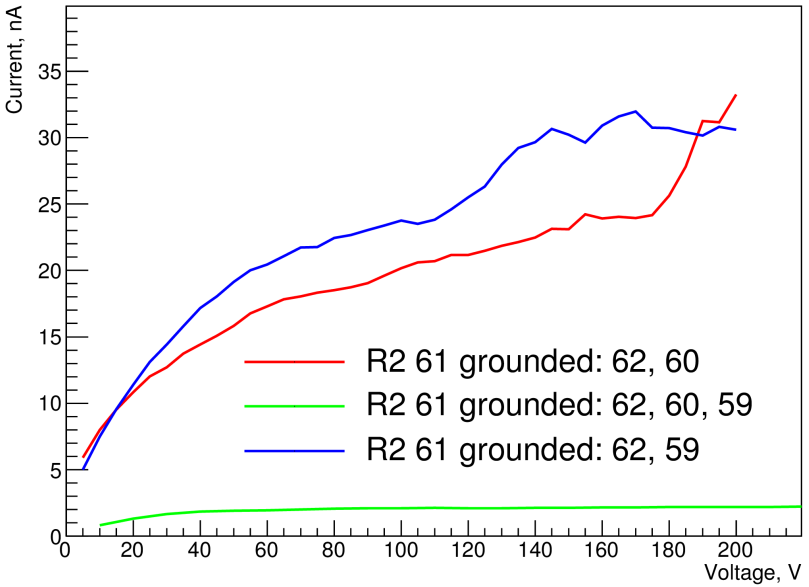
- HV kapton is glued to the n-side of the sensor using conductive glue;
- Fanout with Panasonic connector soldered was glued to the p-side of the sensor;
- Traditional ultrasonic wire bonding was used to connect sensor pads to fanout traces;
- Conductive glue worked well;

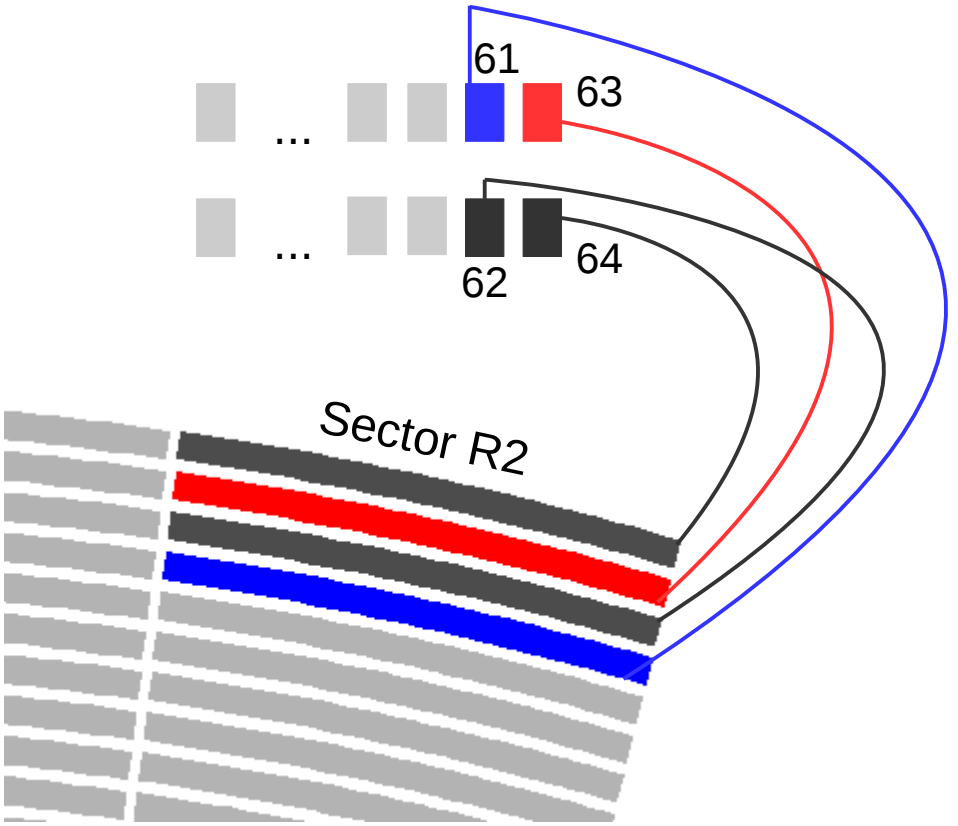




Module 17, Right Side Tests

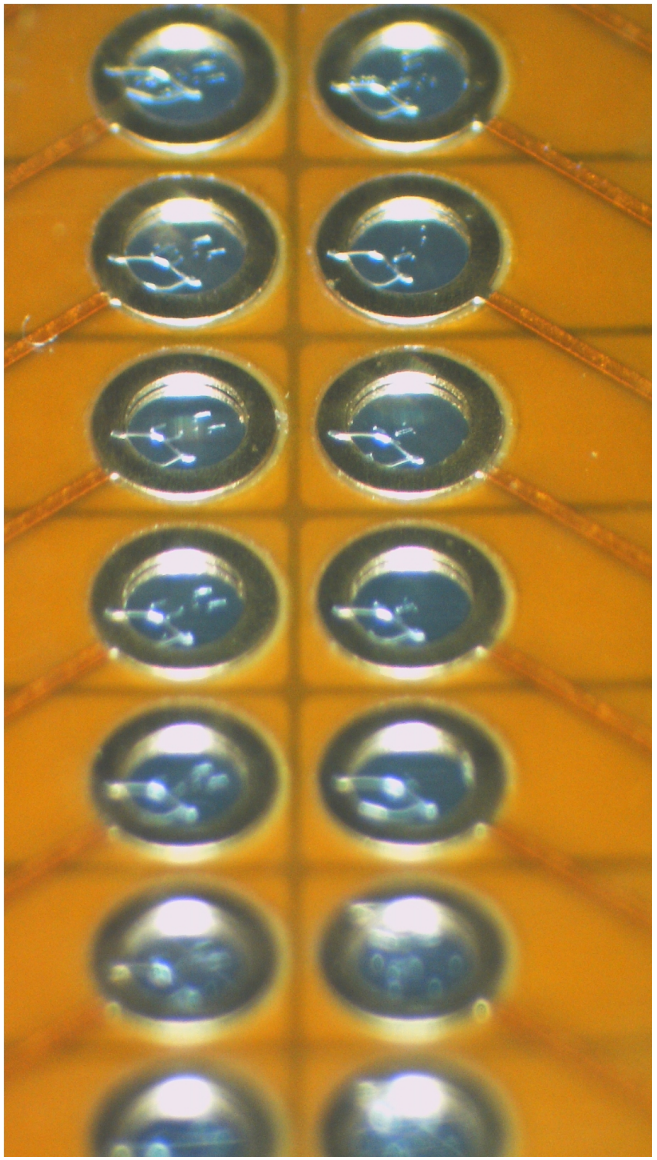


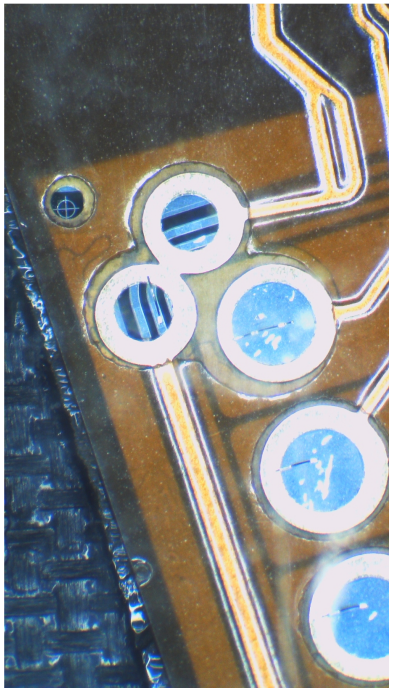


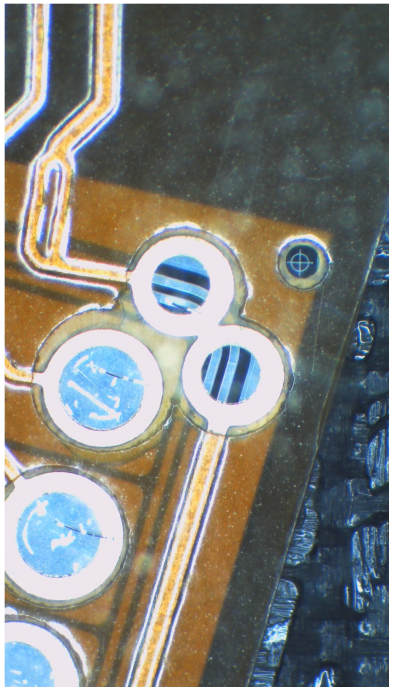


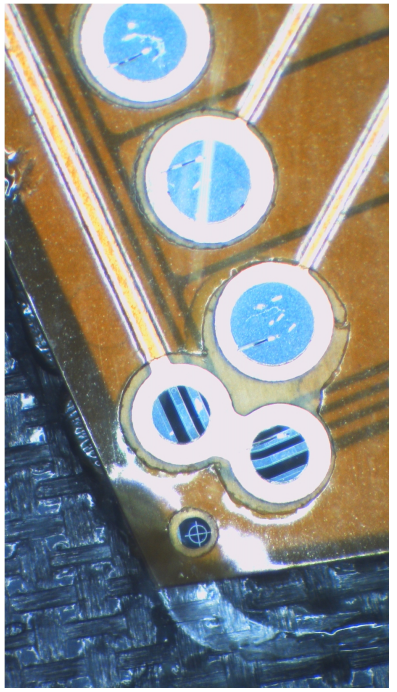
- Grounding the adjacent pin in Panasonic connector which is connected to the sensor pad next to the one which is grounded reduces the measured dark current from the pad.
- There is some essential conductivity between Panasonic connector pins.
- Further tests with confirmed that the problem was created by soldering flux.

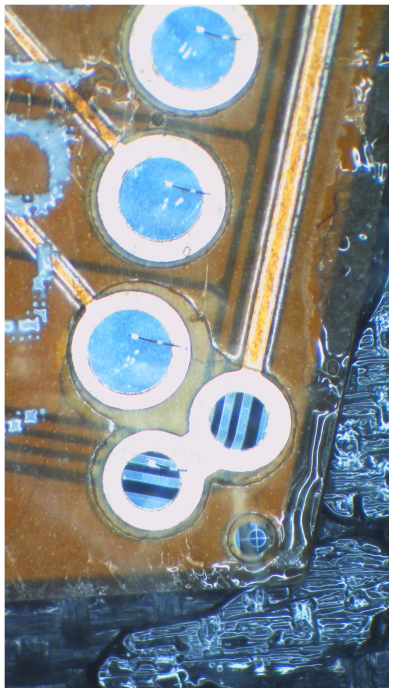
Module 18











Wedge Bonding

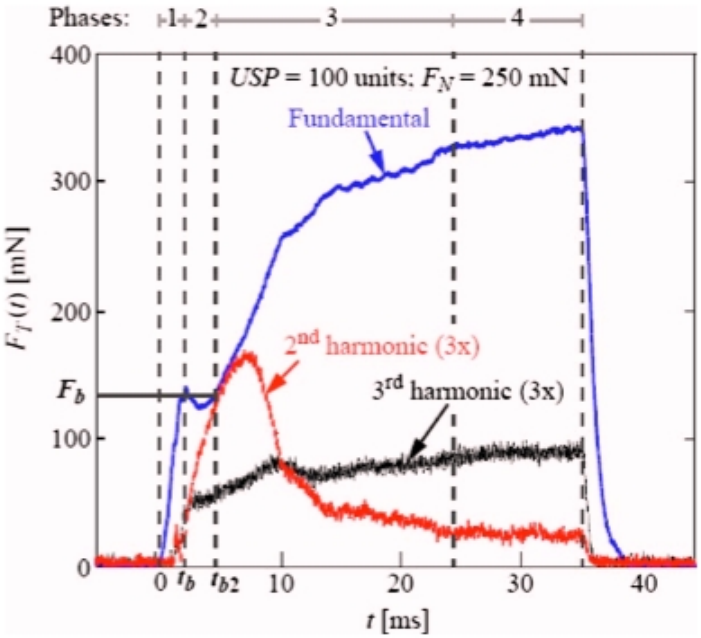


FIG. 8. (Color online) Amplitudes of harmonics of ultrasonic force signal of Al–Al wedge bonding process shown in Fig. 7(a).

- Relative motion of wire and substrate in combination with friction on their interface facilitates the relative sliding of the wire on the pad causing bond area cleaning from the native oxide layers at the interface and bond formation.
- To provide relative motion between the wire and bonding pad the last one in our case must be fixed well by the glue.

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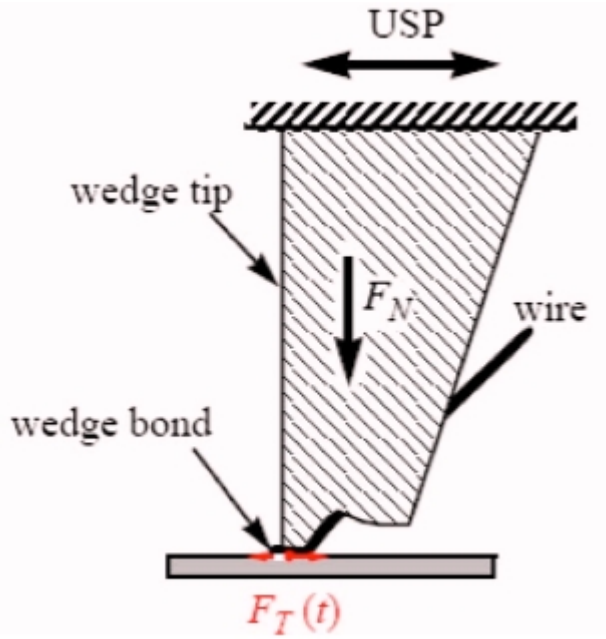
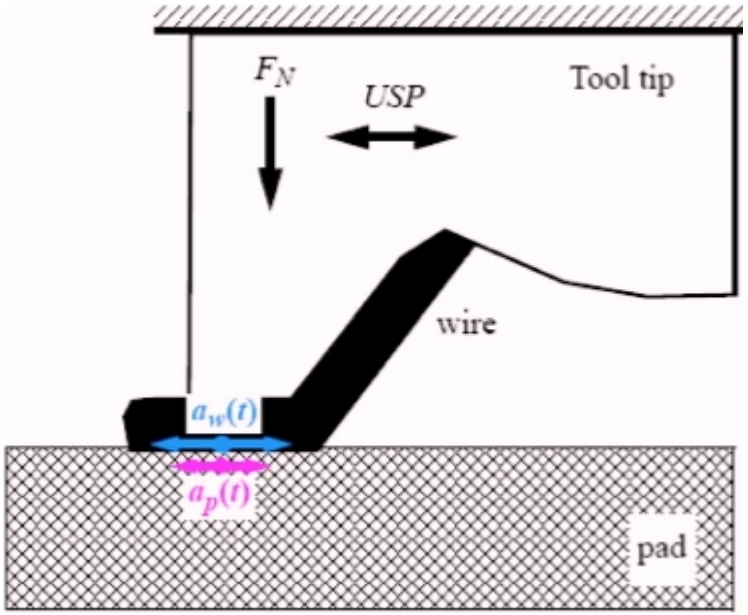
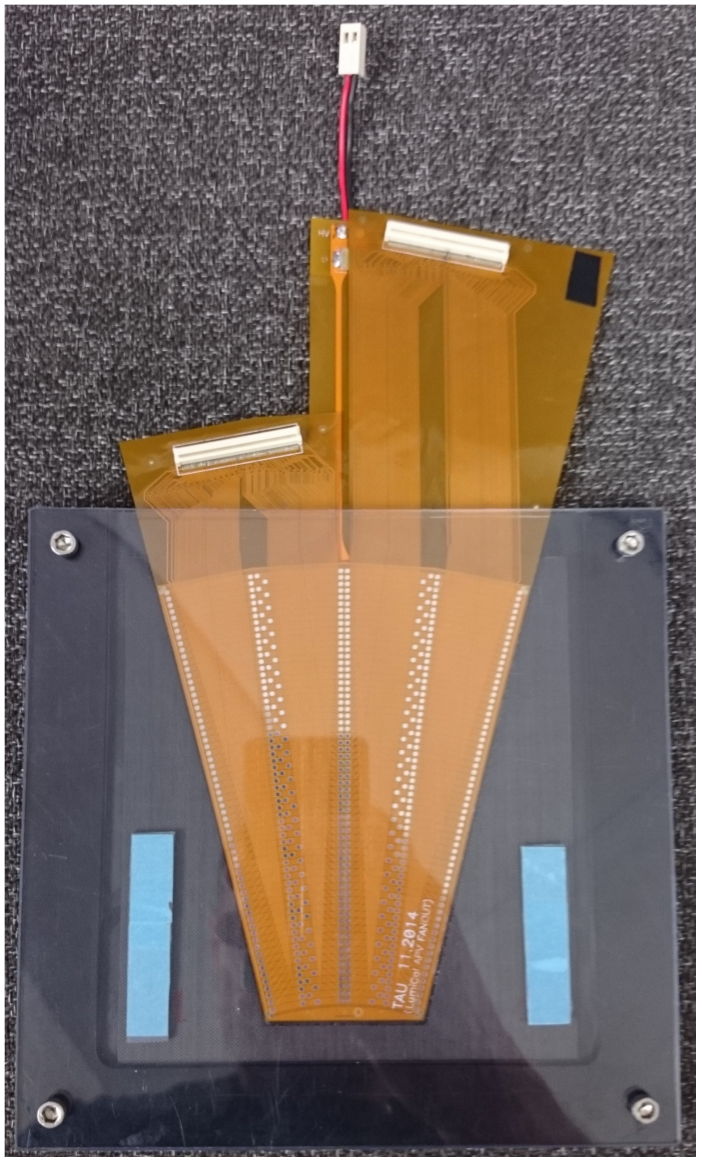
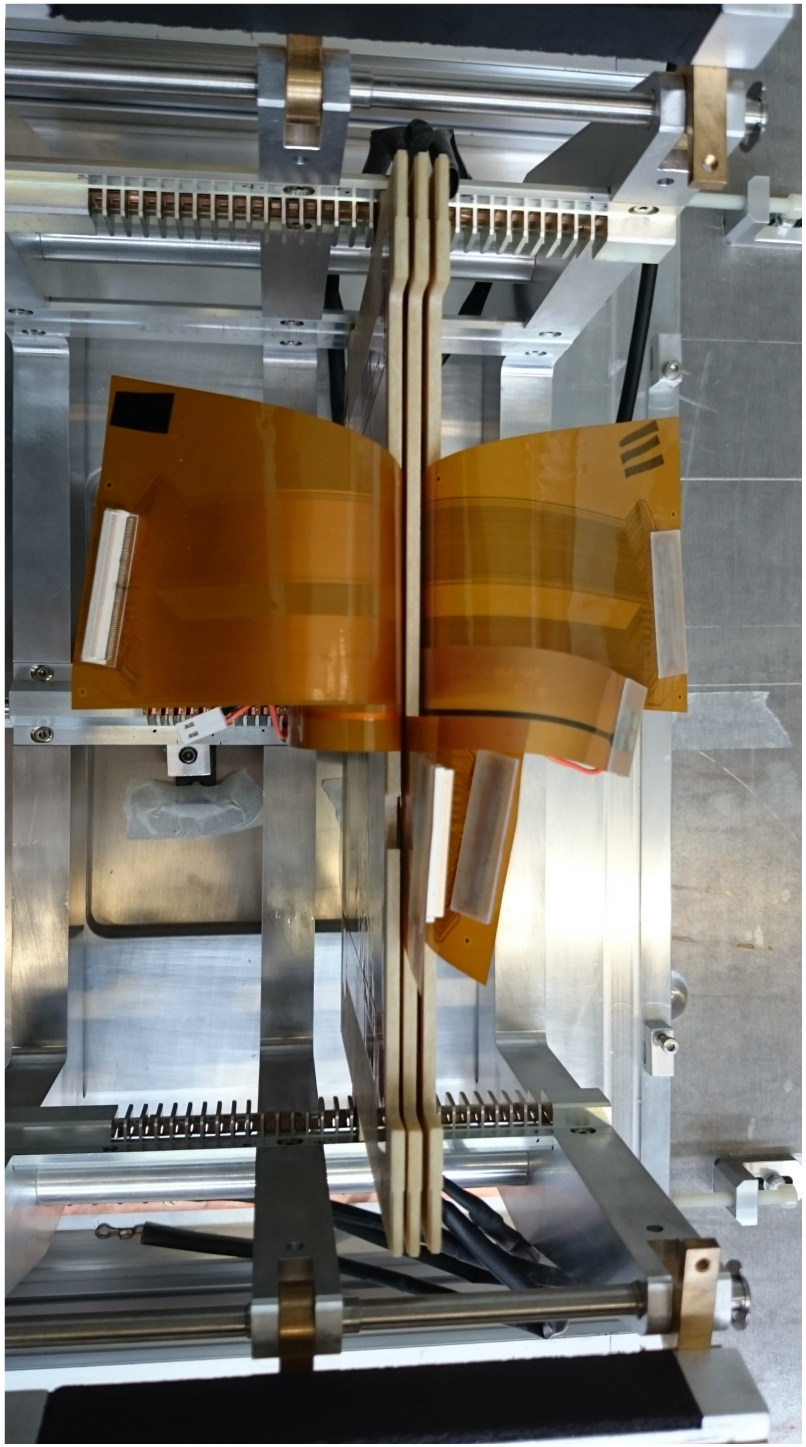




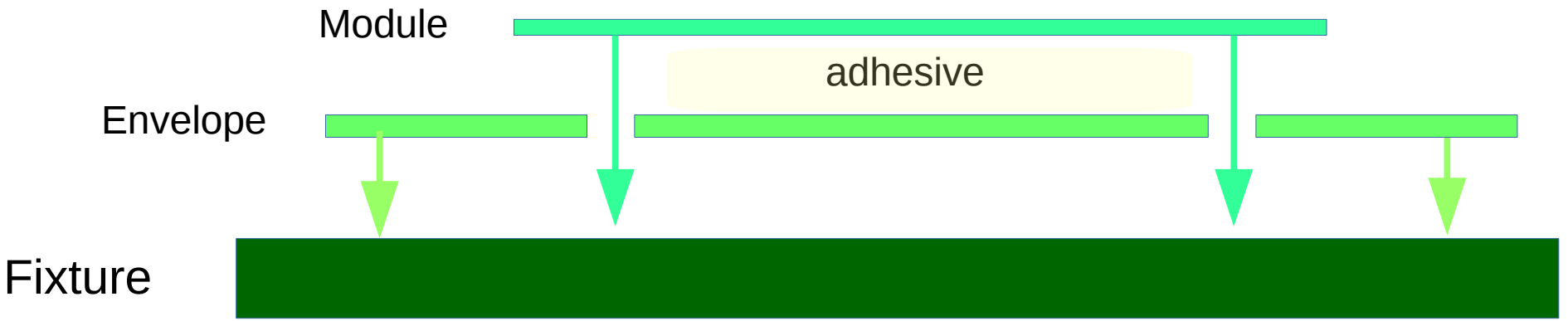
Module 18 and Preliminary Test at CERN





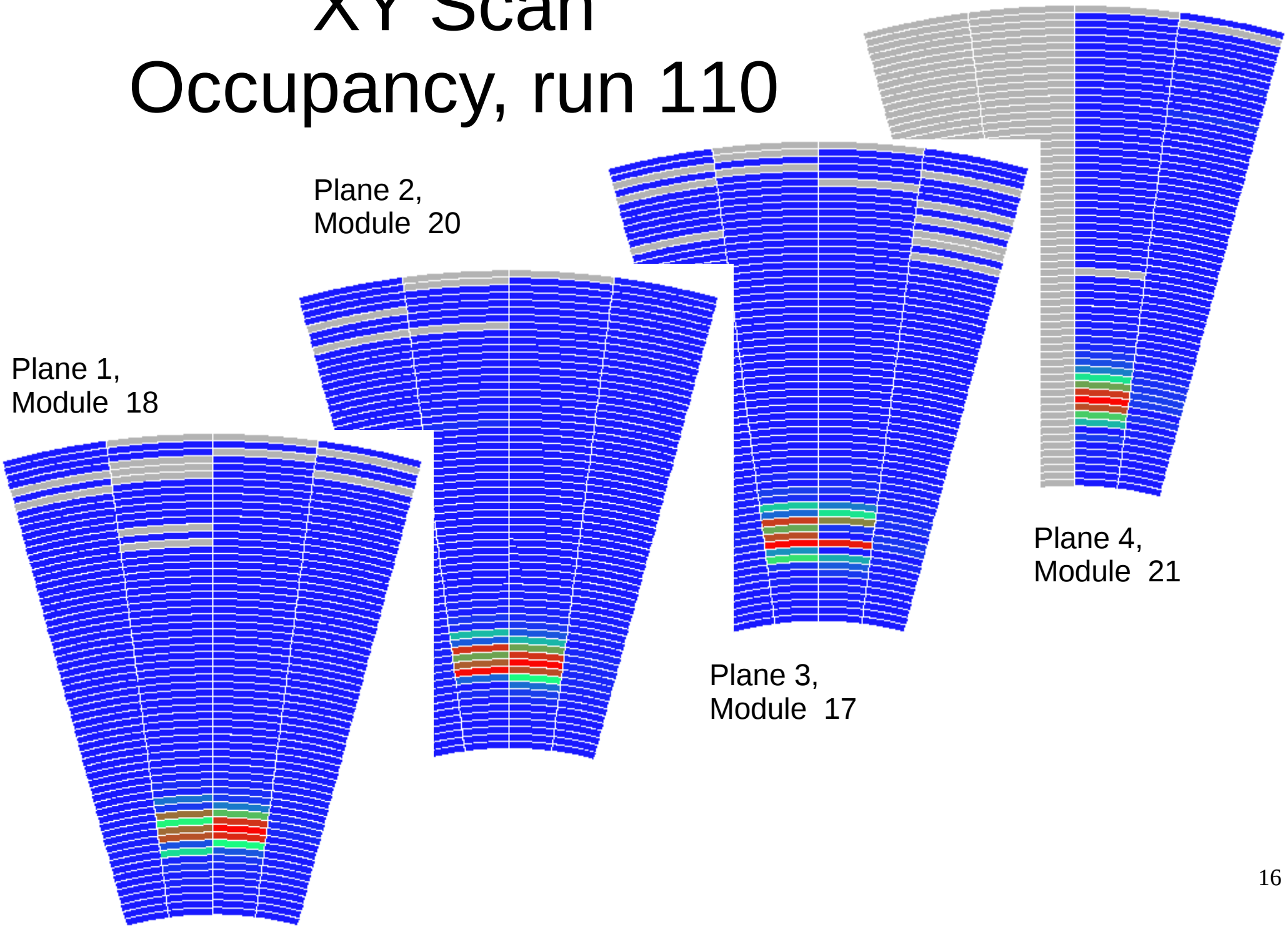
Gluing LumiCal Module to the Envelope

- Wire bonding loops does not allow to apply uniformly distributed pressure on top of the module using simple weight;
- Ball soldering or TAB bonding could also create areas with local rigid structures which prevent uniform pressure distribution over the silicon sensor area;
- Applying the pressure with simple weight increase the risk of sensor damage;
- Possible solutions:
  - Fixture which eliminate contact with sensitive areas of the module (wire loops, soldering balls);
  - Fixture which creates vacuum below.

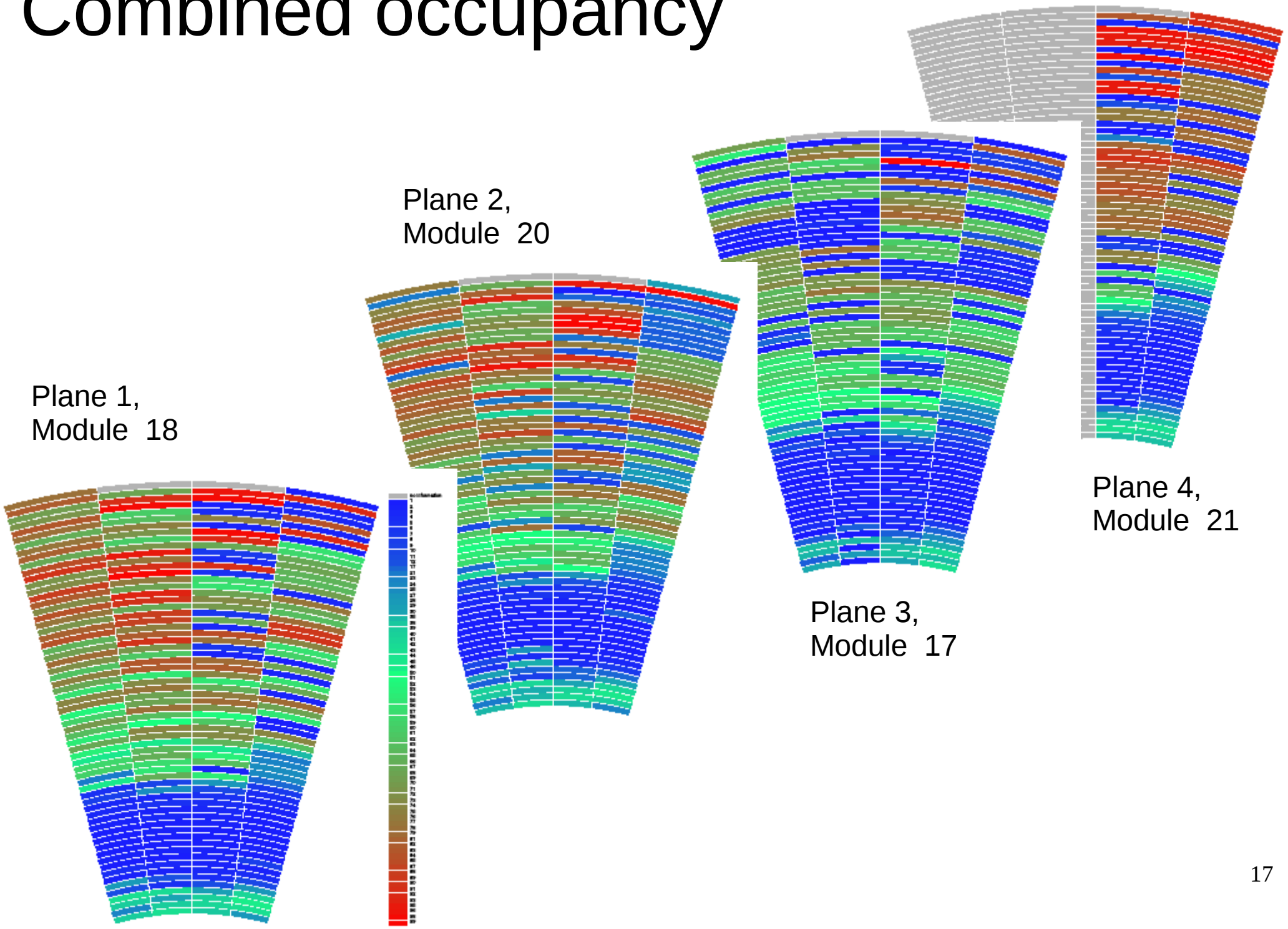


This method was successfully realized to glue the envelope for module 17.

XY Scan
Occupancy, run 110

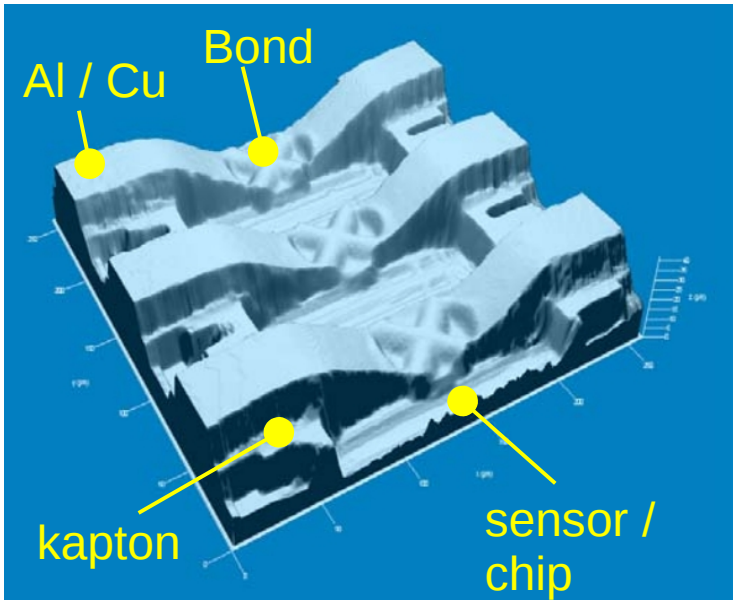


Combined occupancy

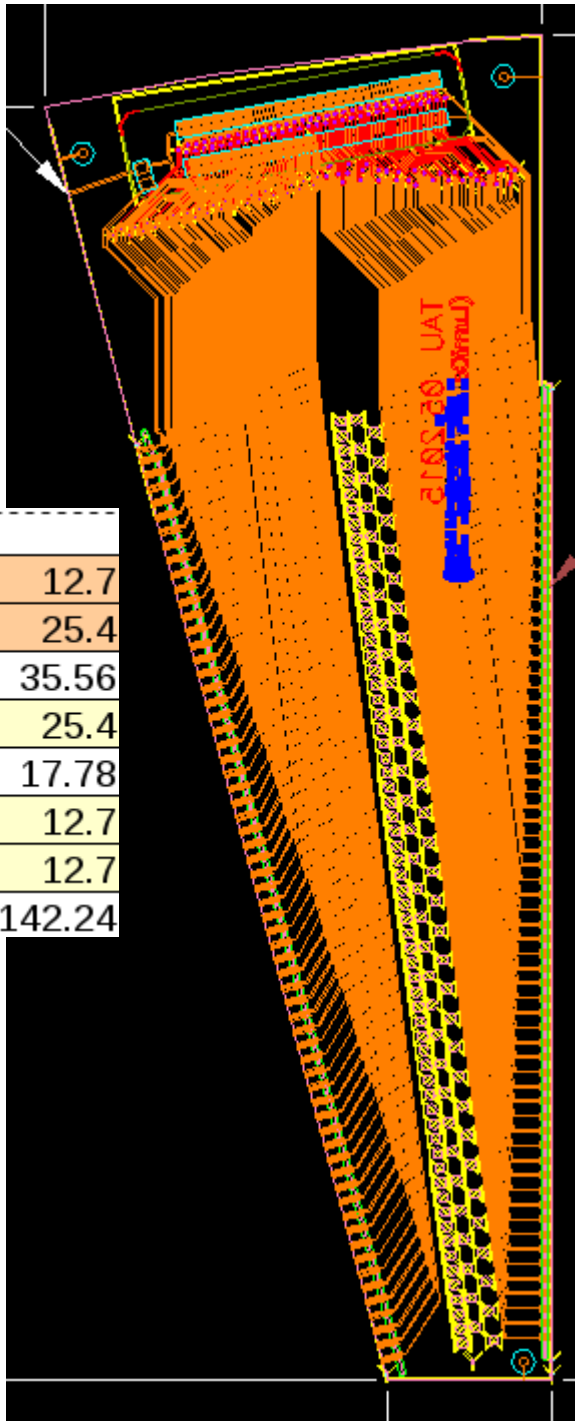


TAB Technology

Stable contact between sensor and readout electronics which meets LumiCal geometrical (compactness) requirement



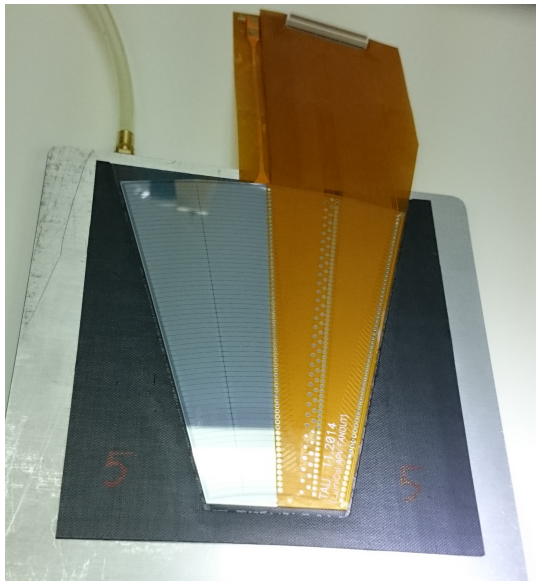
Material	Thickness (in)	um
polyimide	0.0005	12.7
adhesive	0.001	25.4
copper	0.0014	35.56
polyimide	0.001	25.4
copper	0.0007	17.78
adhesive	0.0005	12.7
polyimide	0.0005	12.7
Total:	0.0056	142.24

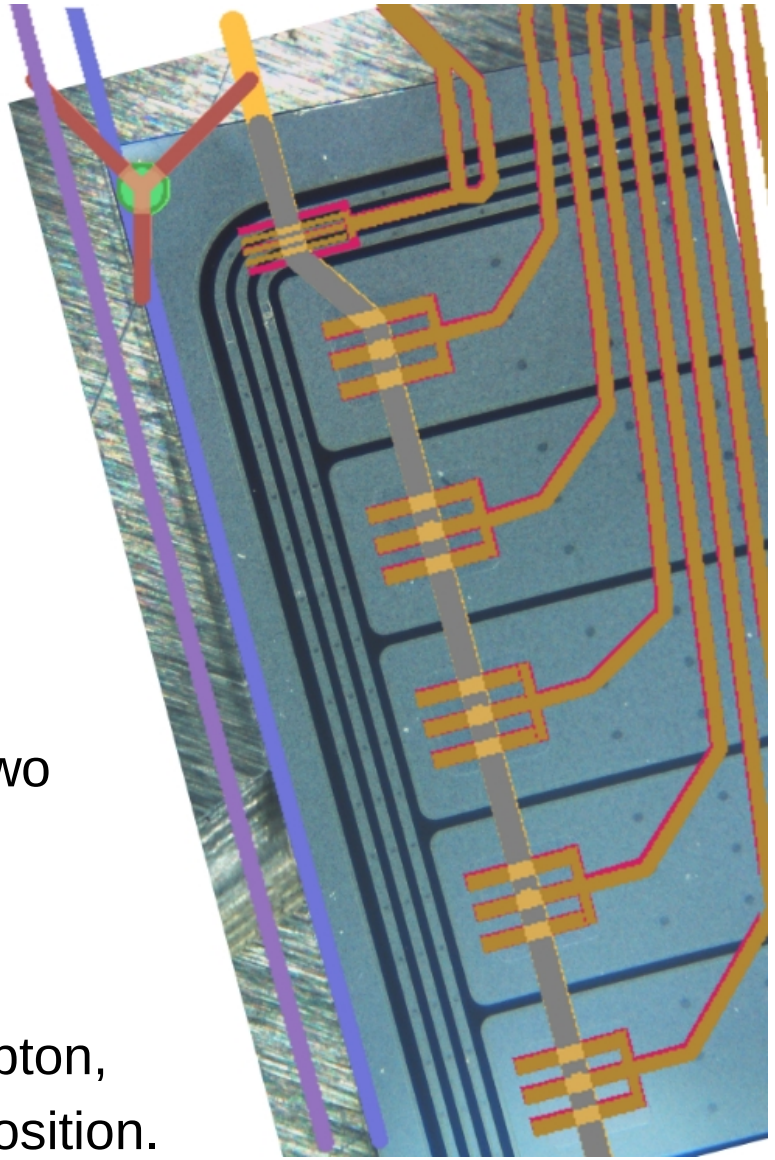


Single point Tape Automated Bonding (TAB):

- No wire loop;
- The bond can be covered by the glue for better protection;
- It is difficult to repair bonding defects;
- Fanout was shipped by manufacture.

TAB Fanout Geometry





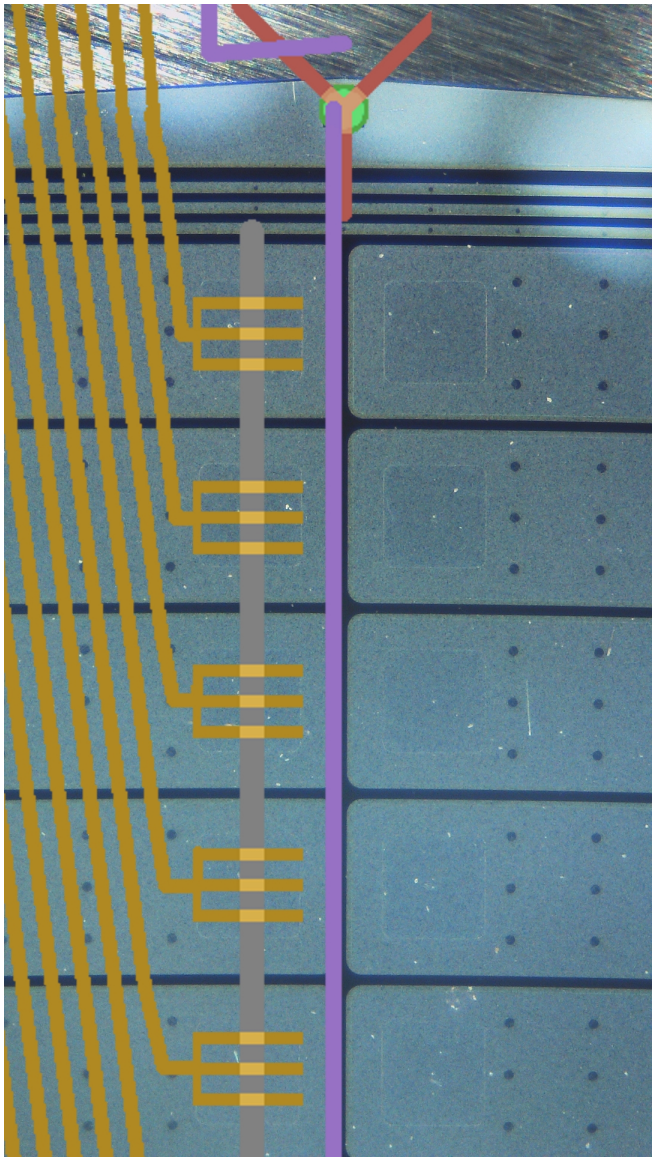


Photo overlapped by two versions of drawings:

The last version:

- Yellow - traces,
- Grey – window in kapton,
- Blue - fanout edge position.

Summary

- Thin LumiCal detector module based on the same Si sensor has been developed and produced.
- Assembly procedure was constantly optimized during the production of 3.5 modules to improve its reliability.
- 3.5 modules were prepared for the beam test.
- Further development is ongoing to address the drawbacks of the module and the assembly procedure. TAB fanout has been produced and shipped to TAU.