TAB Technology for LumiCal

Oleksandr Borysov
Tel Aviv University

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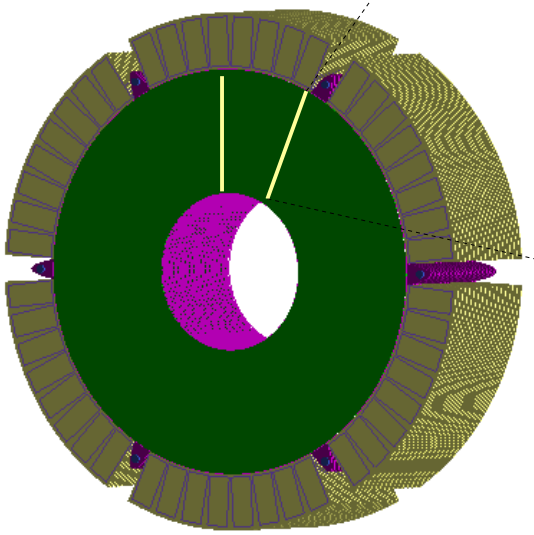
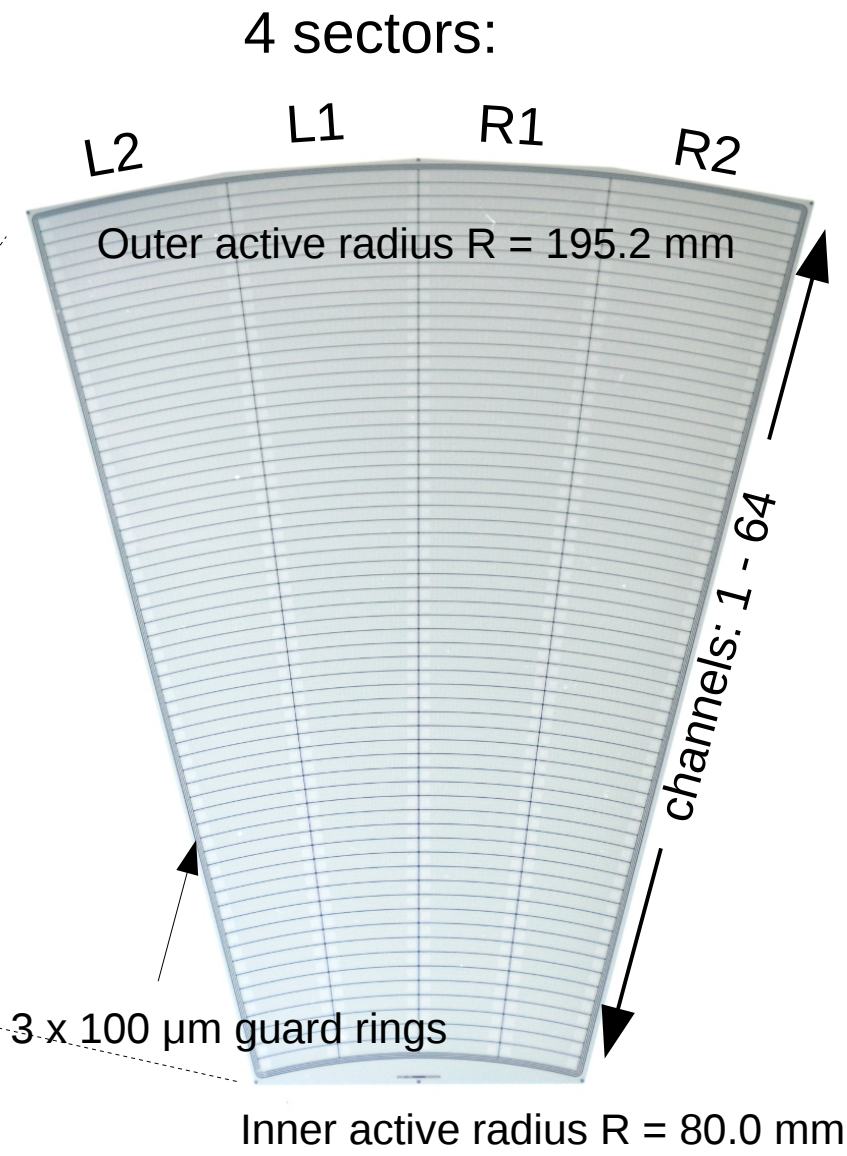
Outline

- Introduction
- Thin module design
- TAB fanout design
- LumiCal module assembly using TAB technology
- Summary

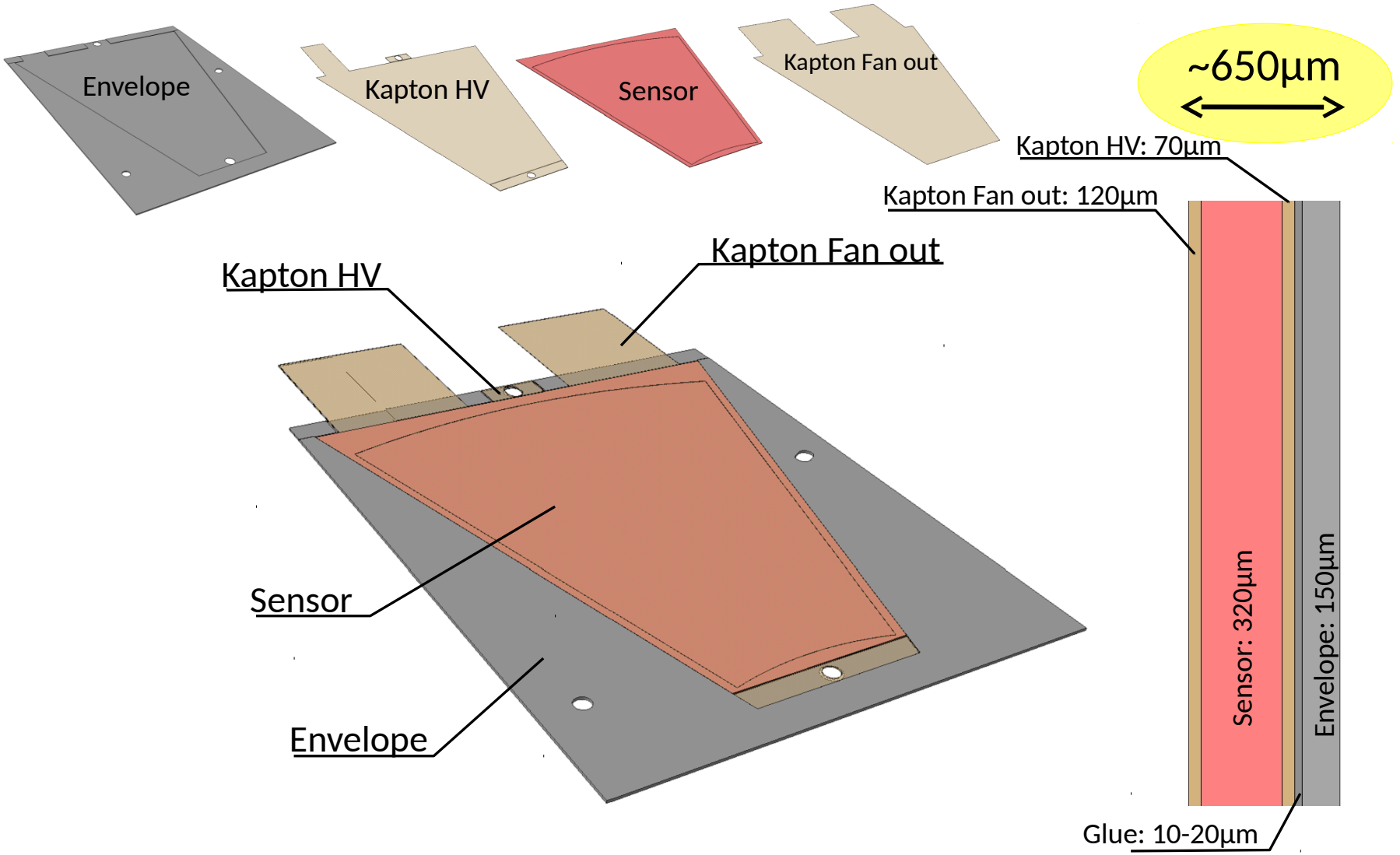
LumiCal and Sensor Design

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





Design of the Thin LumiCal Module

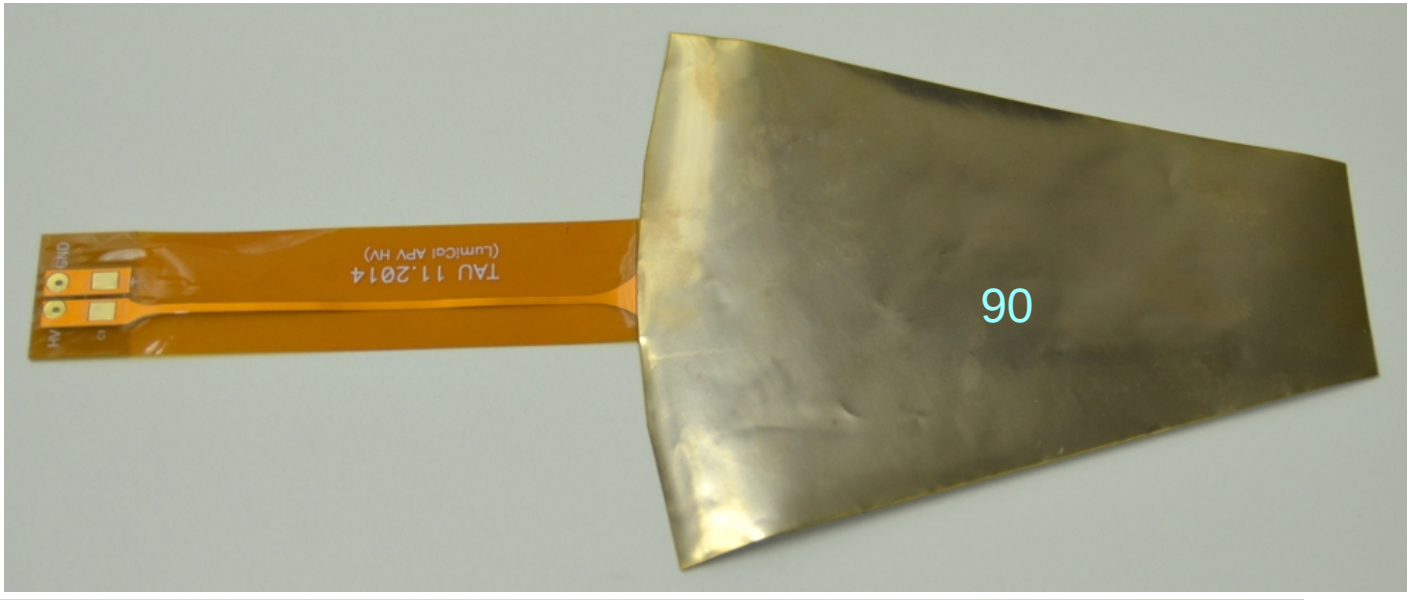


HV and Fan-out

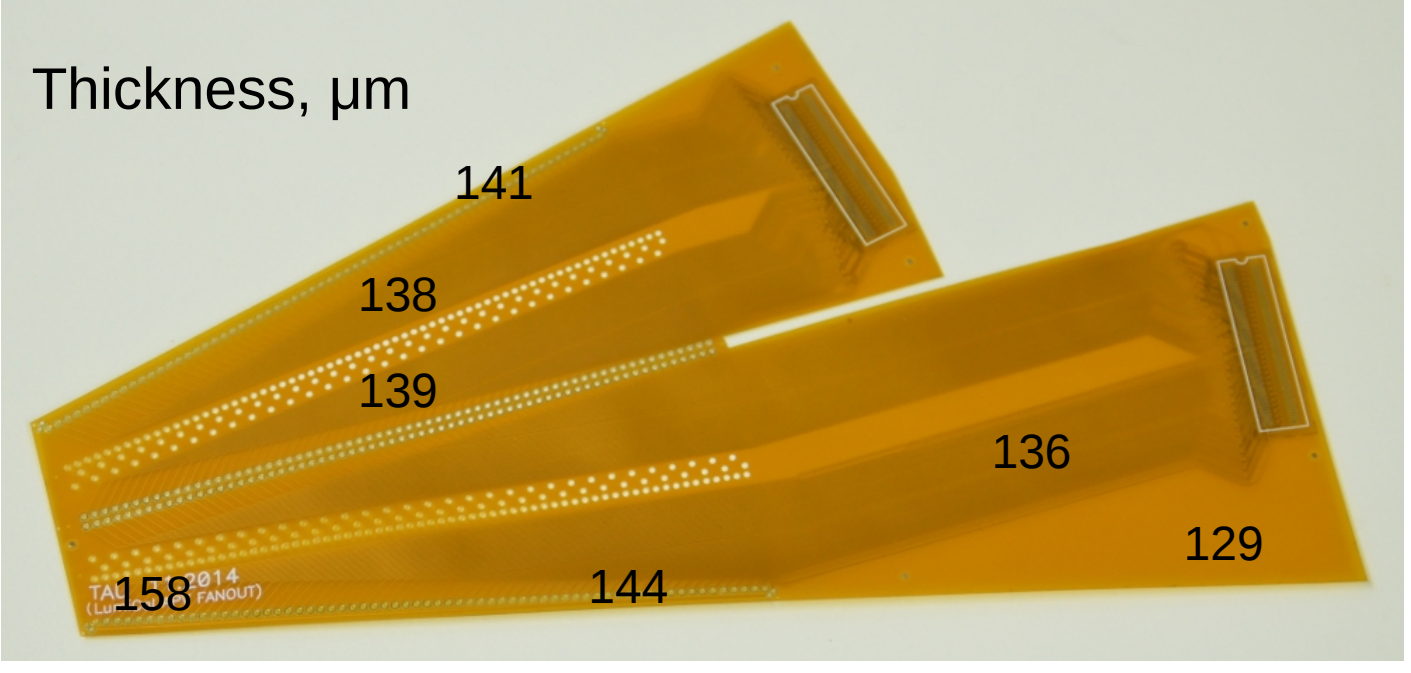
The thickness of the gluing area is 90 μm.

Contact area:

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



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

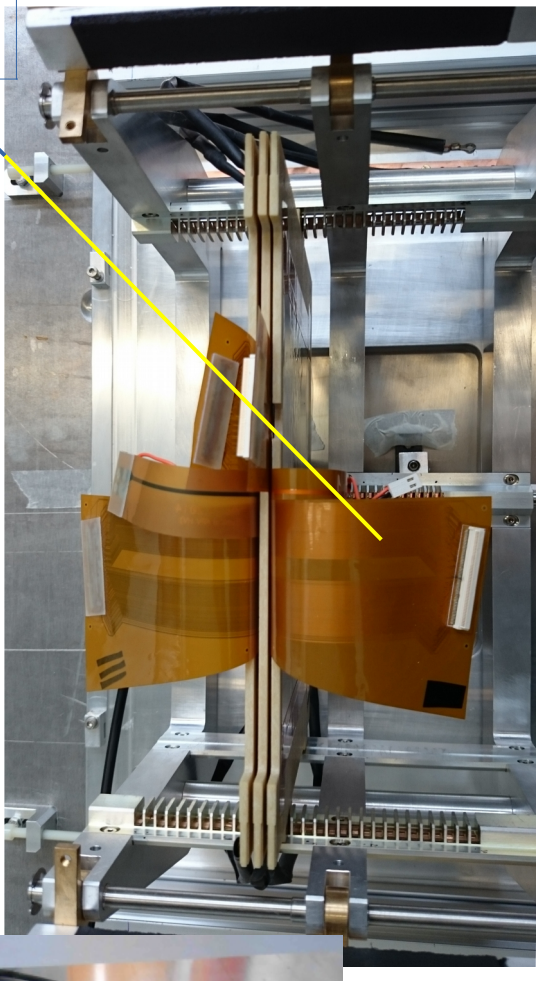


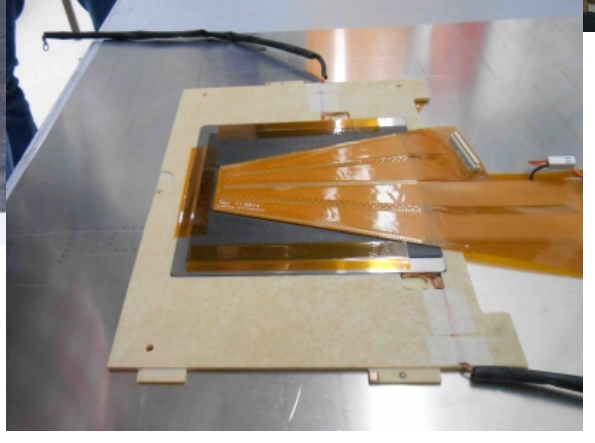
Thin LumiCal Module in Mechanical Frame

Kapton fanout

130 pin Panasonic connectors provides interface to APV-25 hybrid and SRS DAQ system.

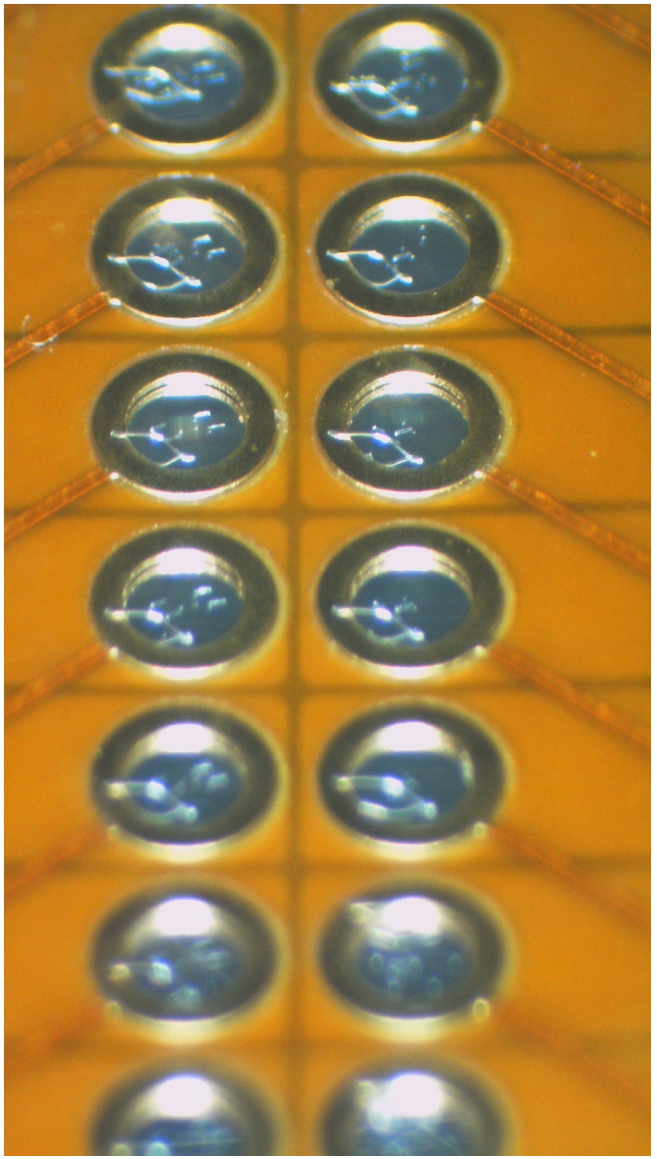
Carbon fiber supporting structure (“envelope”) provides mechanical stability and easy stack assembly.





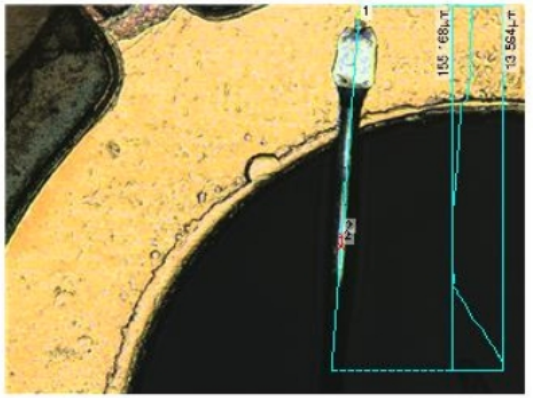
- 4 modules were successfully tested with e- beam at DESY in October 2015. Data analysis is in progress.
- 4 additional modules were prepared for the beam test in August 2016 including one assembled with TAB bonding technology.

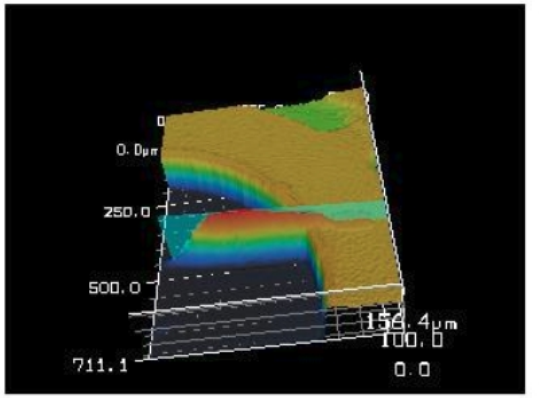
Wedge Wire Bonding for Front-end Contact

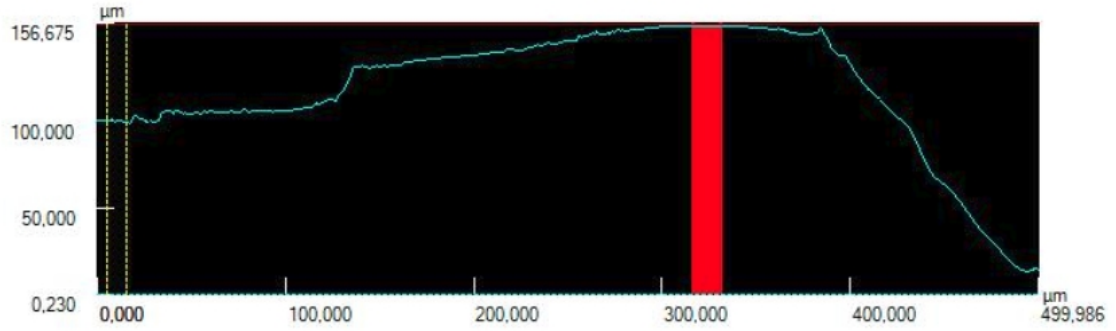


Achievable size of the bonding loops is in the range 50 µm - 100µm.

Bonding loop measured with 3D laser scanning confocal microscope at DESY Zeuthen.

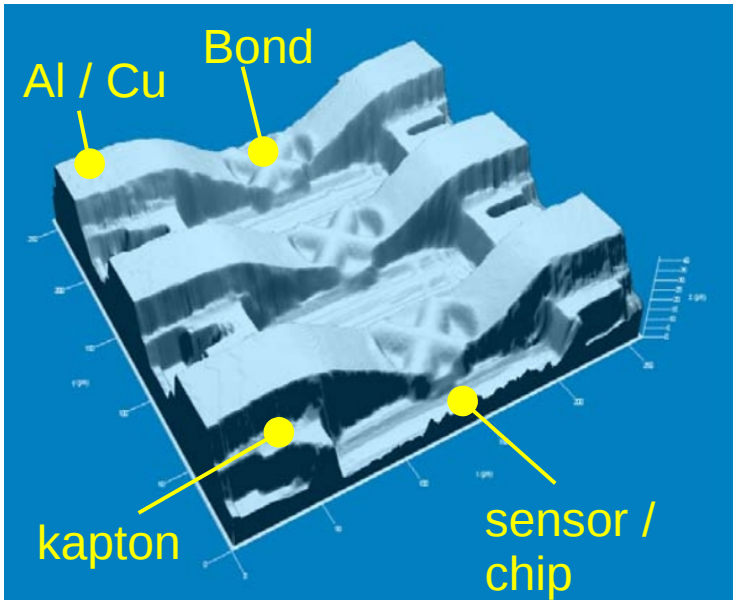




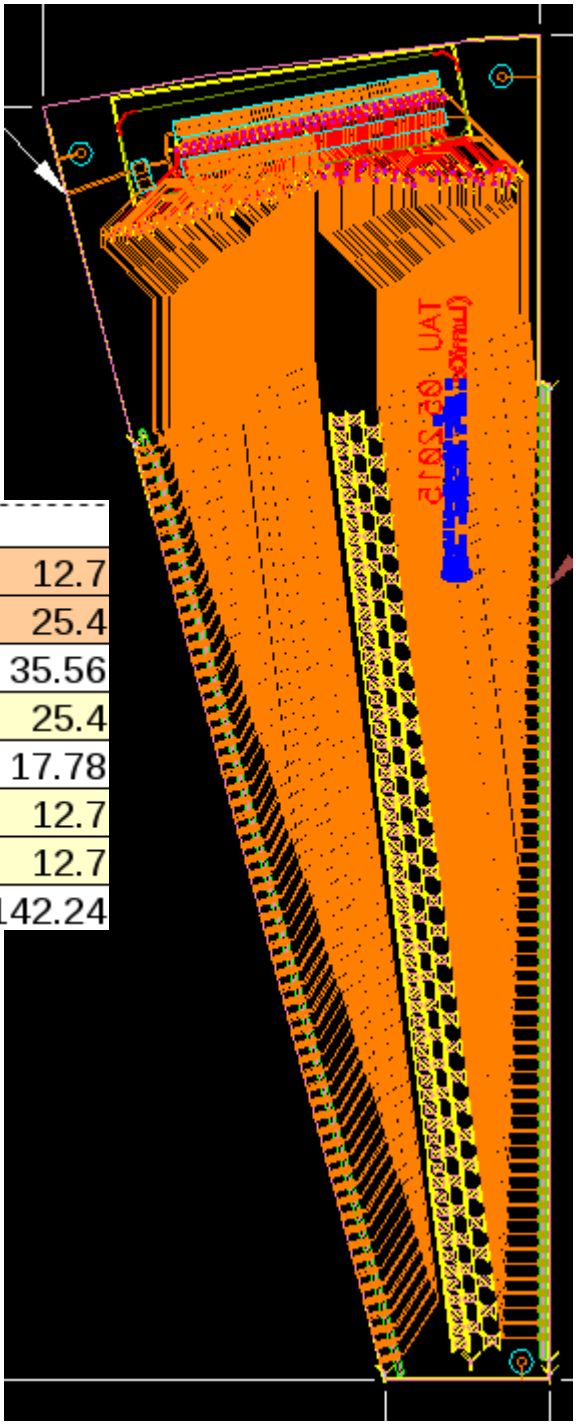


TAB Technology

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



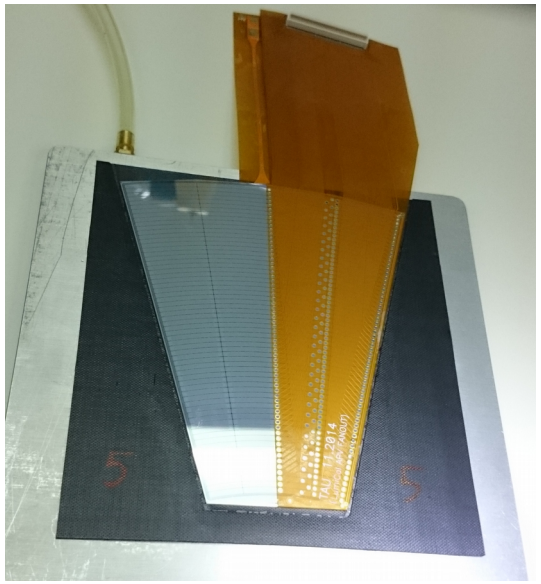
Material	Thickness (in)	um
polyimide	0.0005	12.7
adhesive	0.001	25.4
copper	0.0014	35.56
polyimide	0.001	25.4
copper	0.0007	17.78
adhesive	0.0005	12.7
polyimide	0.0005	12.7
Total:	0.0056	142.24

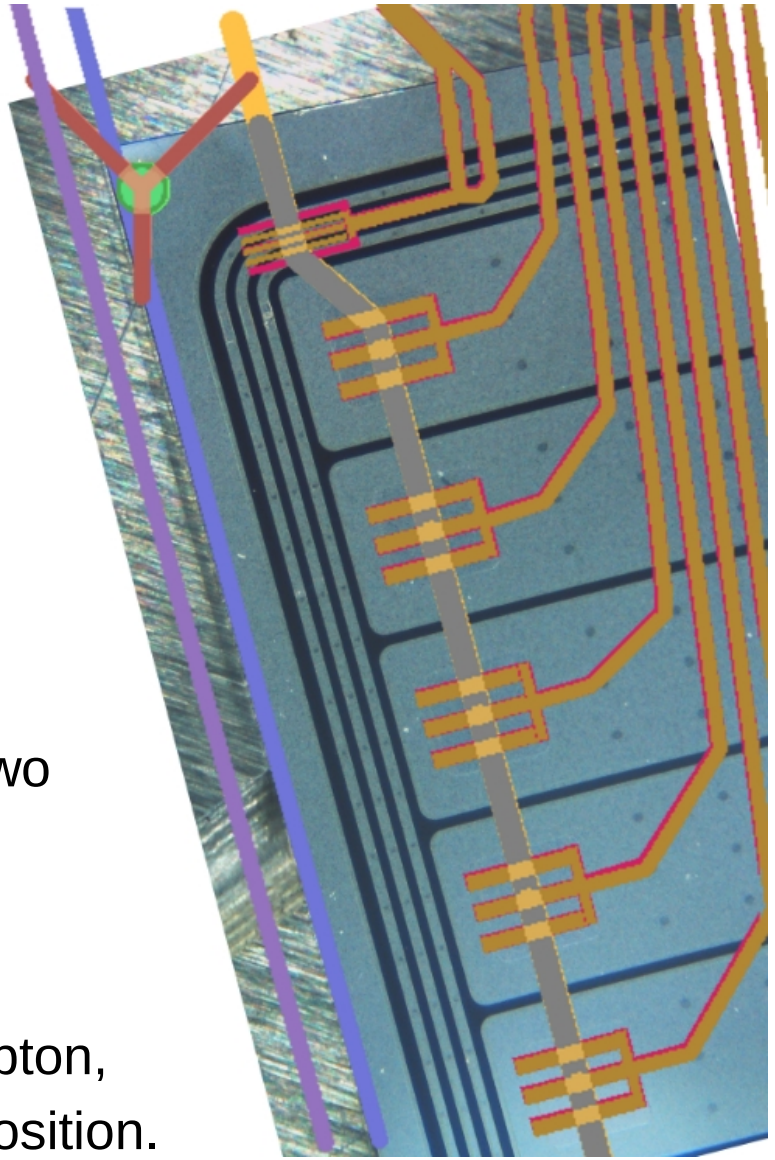


Single point Tape Automated Bonding (TAB):

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

TAB Fanout Geometry





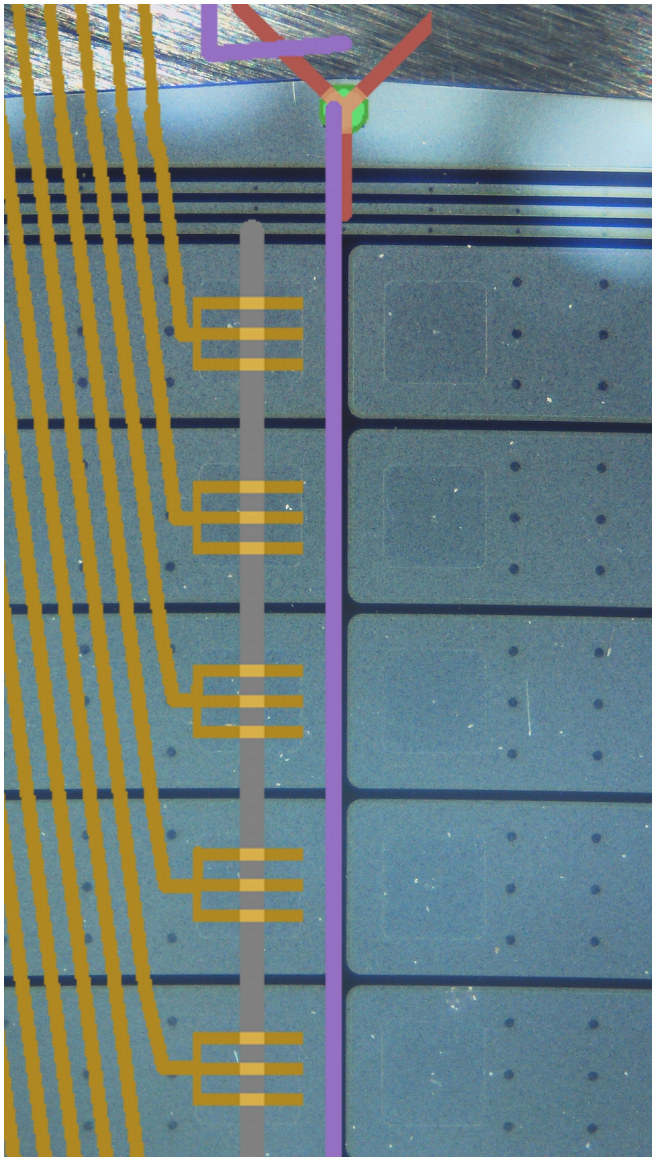
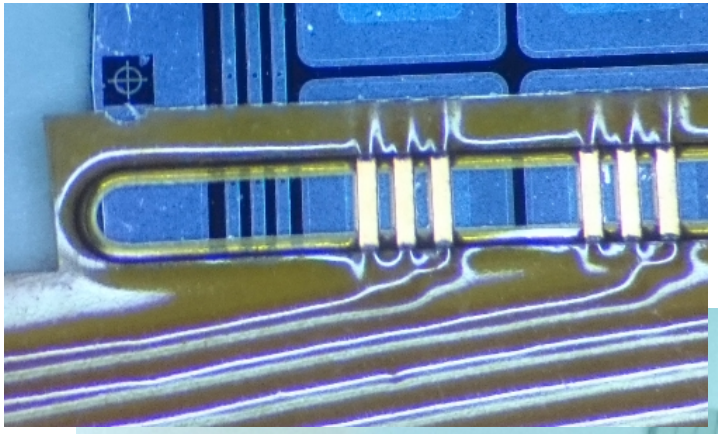


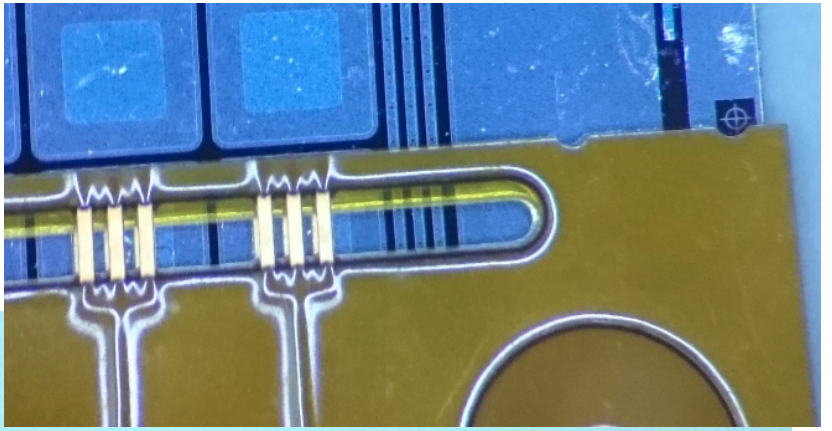
Photo overlapped by two versions of drawings:

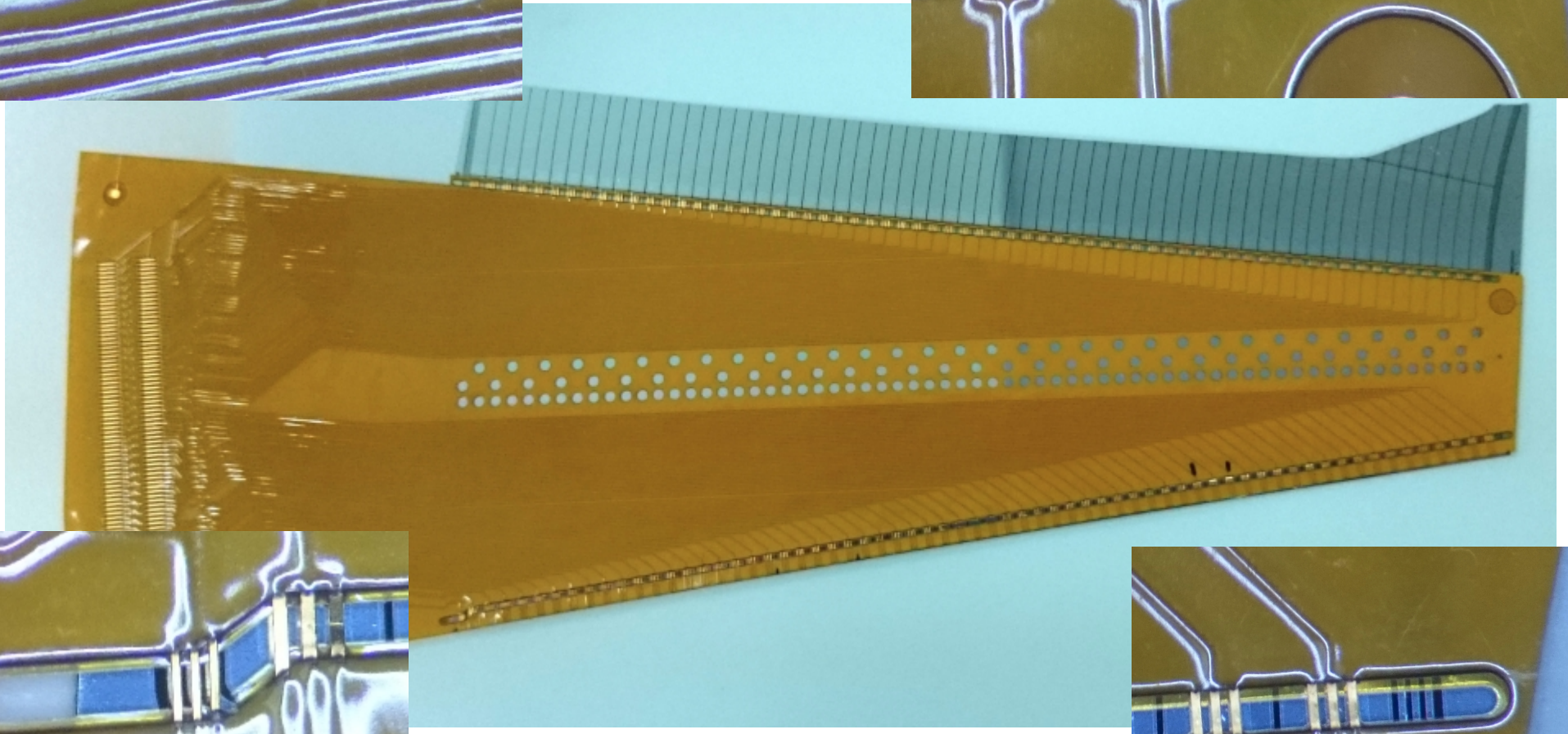
The last version:

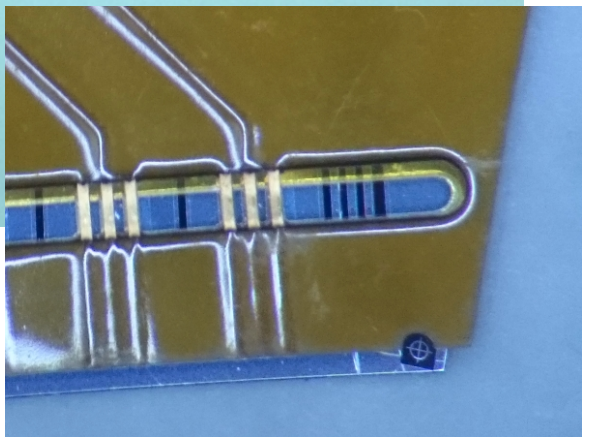
- Yellow - traces,
- Grey – window in kapton,
- Blue - fanout edge position.

TAB Fanout Test









Wedge Bonding

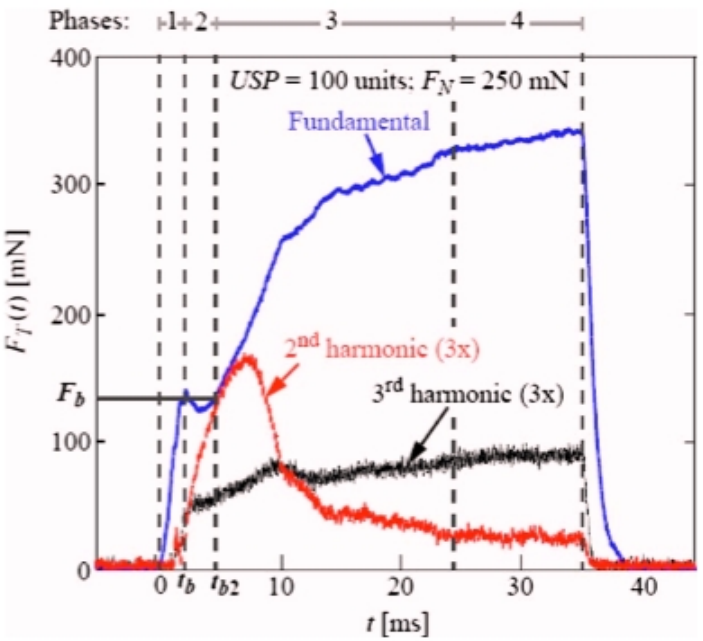


FIG. 8. (Color online) Amplitudes of harmonics of ultrasonic force signal of Al–Al wedge bonding process shown in Fig. 7(a).

- 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.
- Bonding is expressed by the formation of welded areas. The sum of all bonded areas is the effective bonded area, which is growing due to the friction power that continues to clean the interface.

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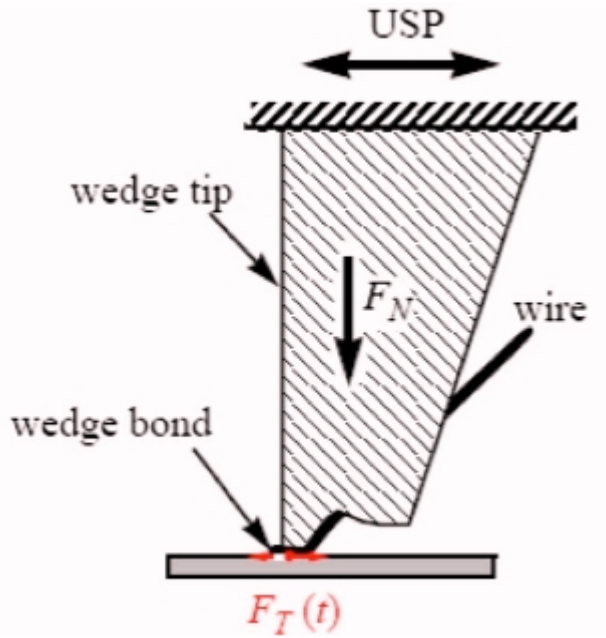
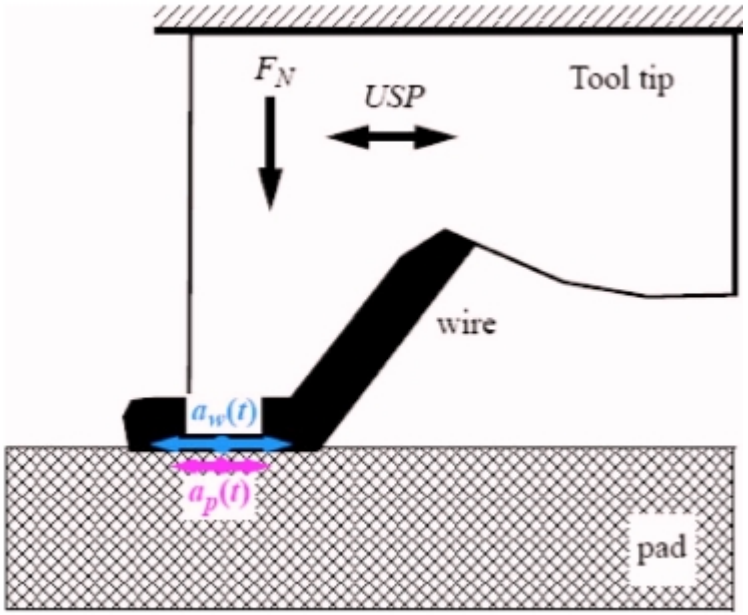


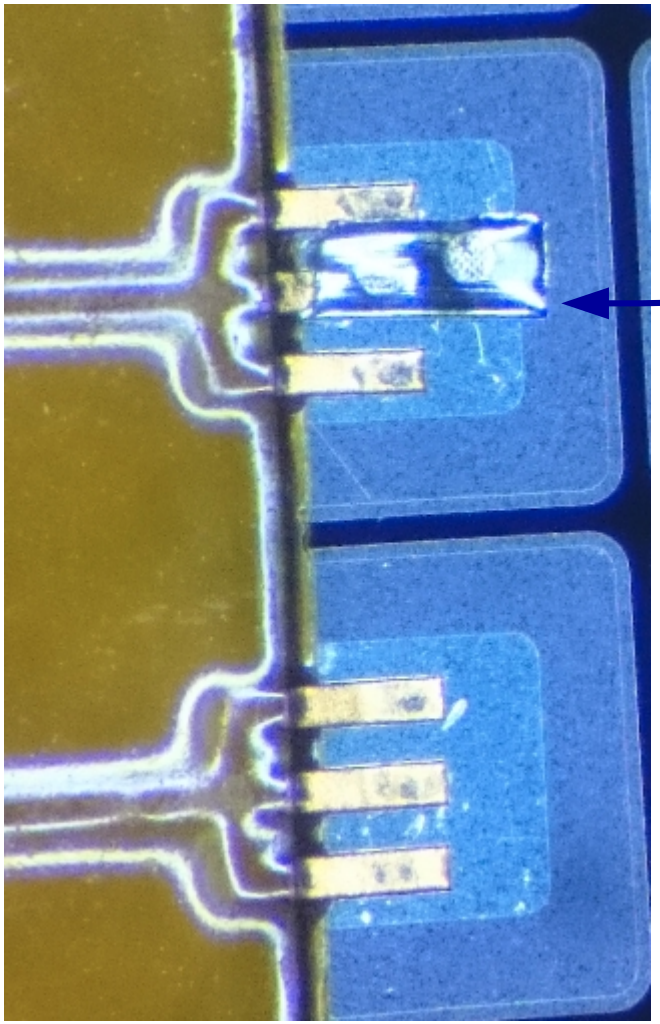


US Bonding Conditions

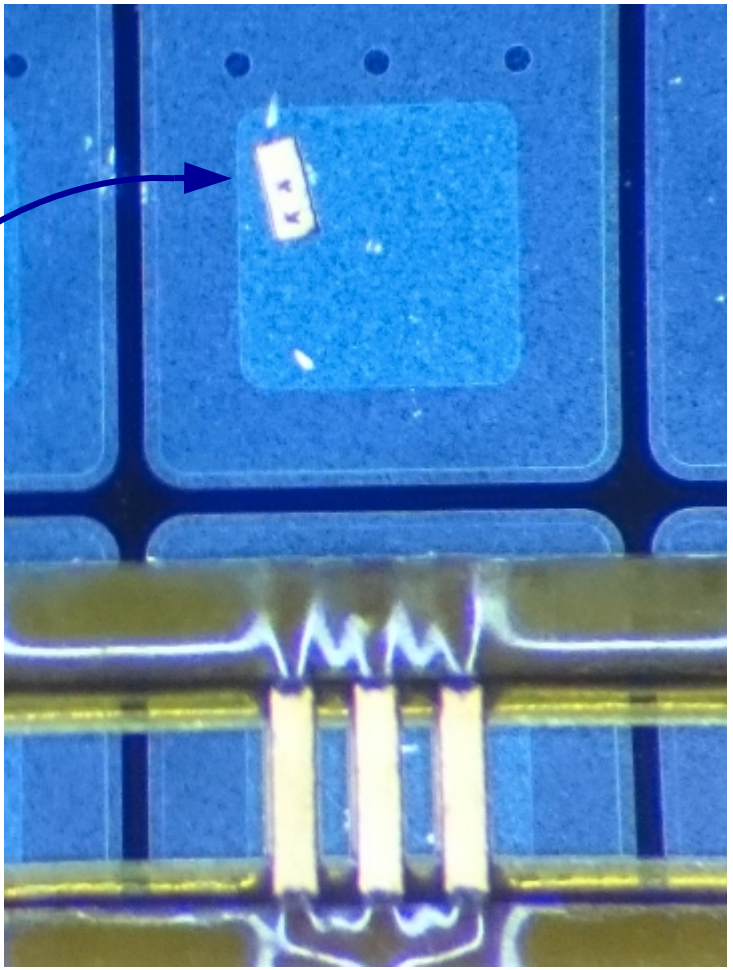
- For ultrasonic bonding both materials must have similar hardness.
- Soft gold plating: 9 microinches +/- 6 microinches which is 230 nm +/- 152 nm.
- More gold is better for bonding, but bad for soldering.
- The original idea was to use the force applied by bonding tool both for:
  - plastic deformation of the opened lead – bending it close to the sensor surface
  - provide bonding formation in combination with US power.

TAB Tests with LumiCal Sensor

Aluminum foil folded twice and successfully bonded to opened lead and sensor pad



Opened lead cut out from the kapton substrate and successfully bonded



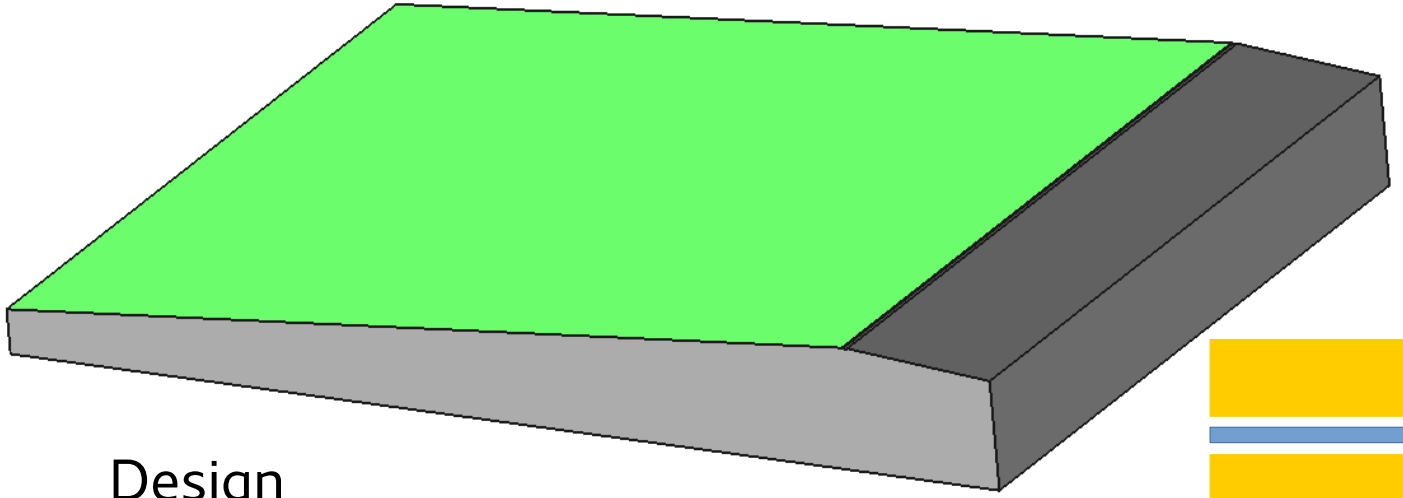
Bonding is successful when two surfaces are in good contact

US Bonding Conditions

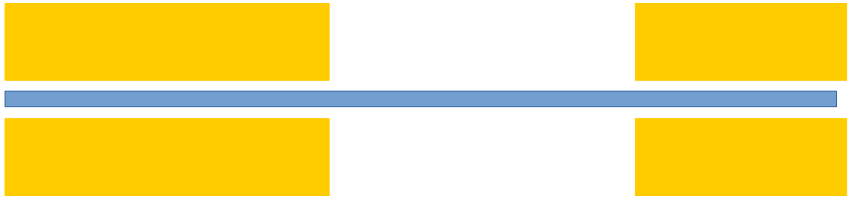
- For ultrasonic bonding both materials must have similar hardness.
- Soft gold plating: 9 microinches +/- 6 microinches which is 230 nm +/- 152 nm.
- More gold is better for bonding, but bad for soldering.
- The original idea was to use the force applied by bonding tool both for:
  - plastic deformation of the opened lead – bending it close to the sensor surface
  - provide bonding formation in combination with US power.

Does not work

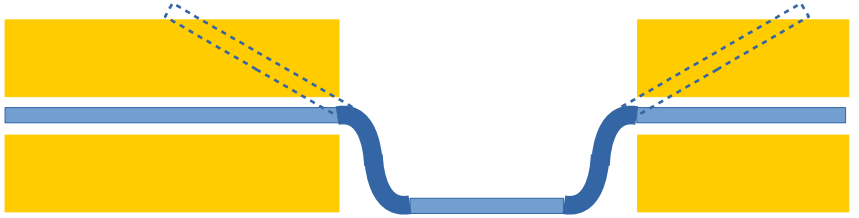
Molding / bending Tool

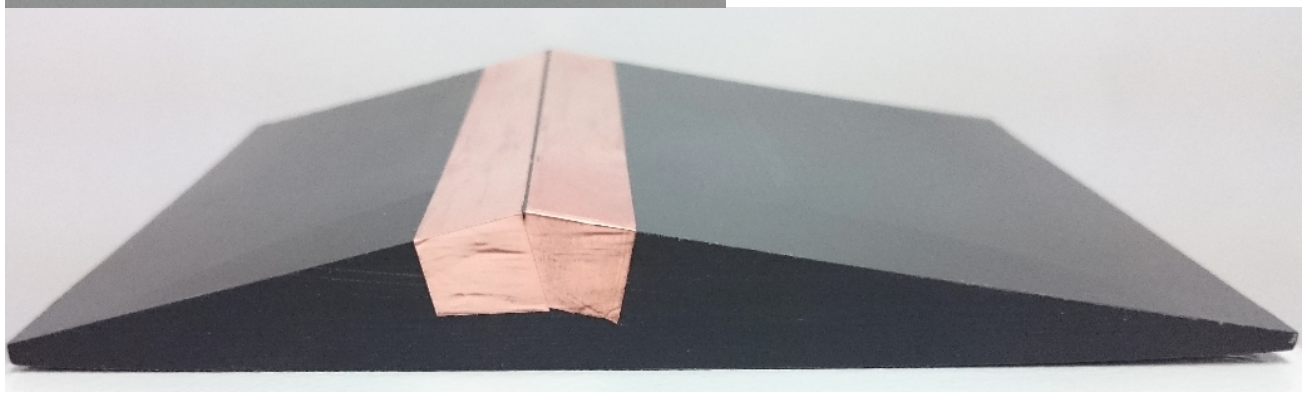


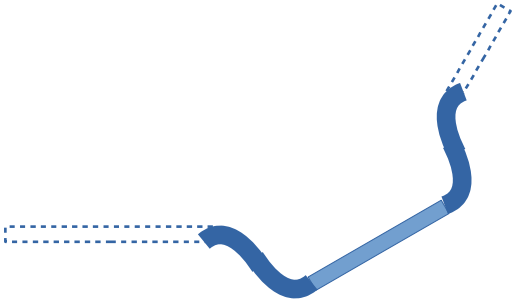
Design



Implementation

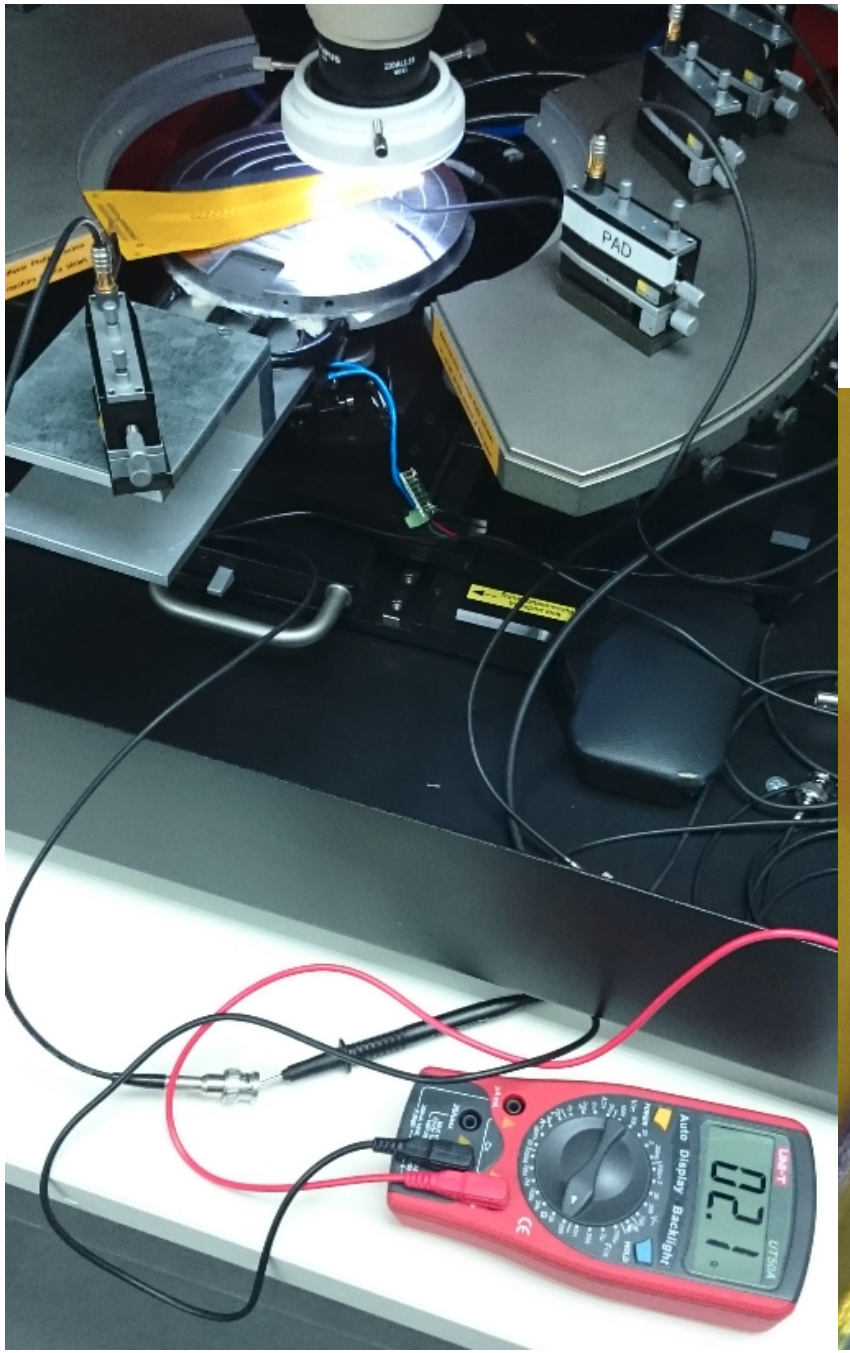


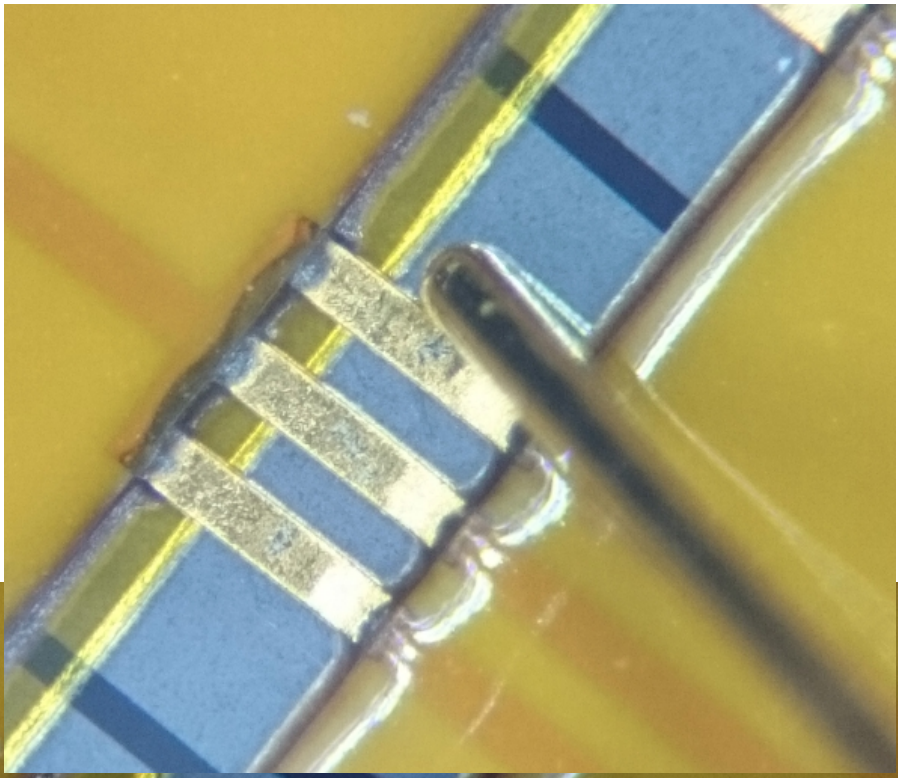


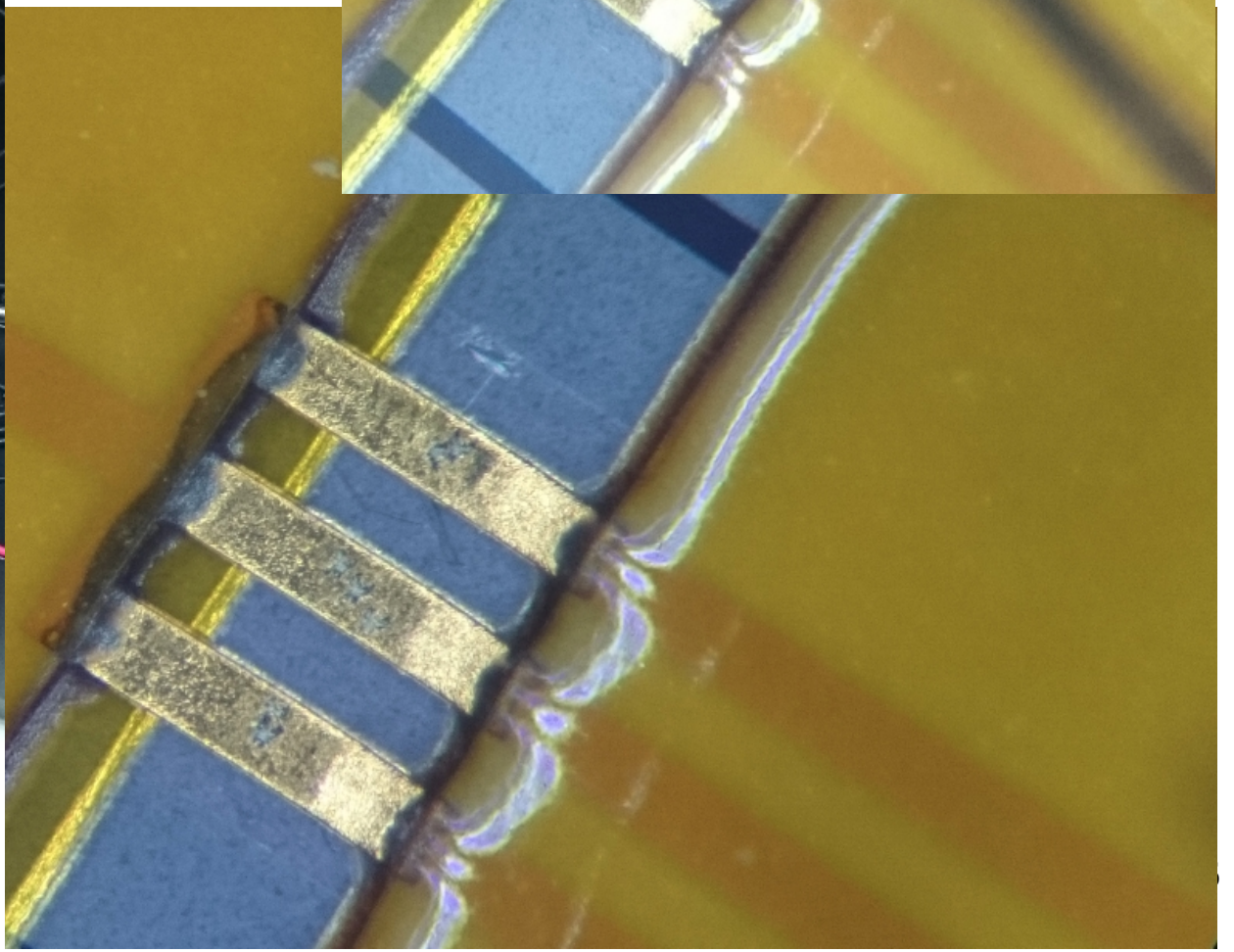


Spring back effect

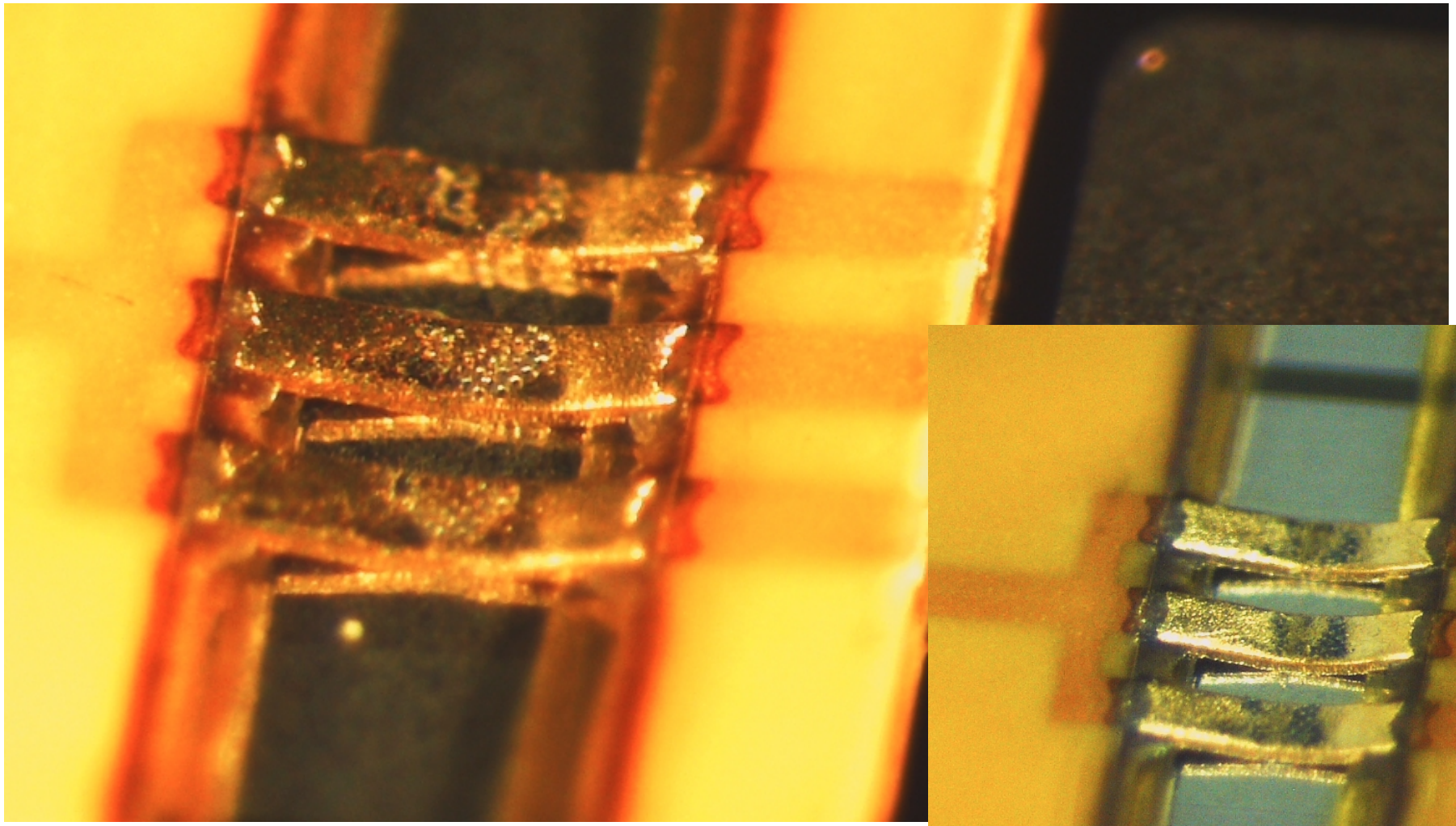
TAB Test



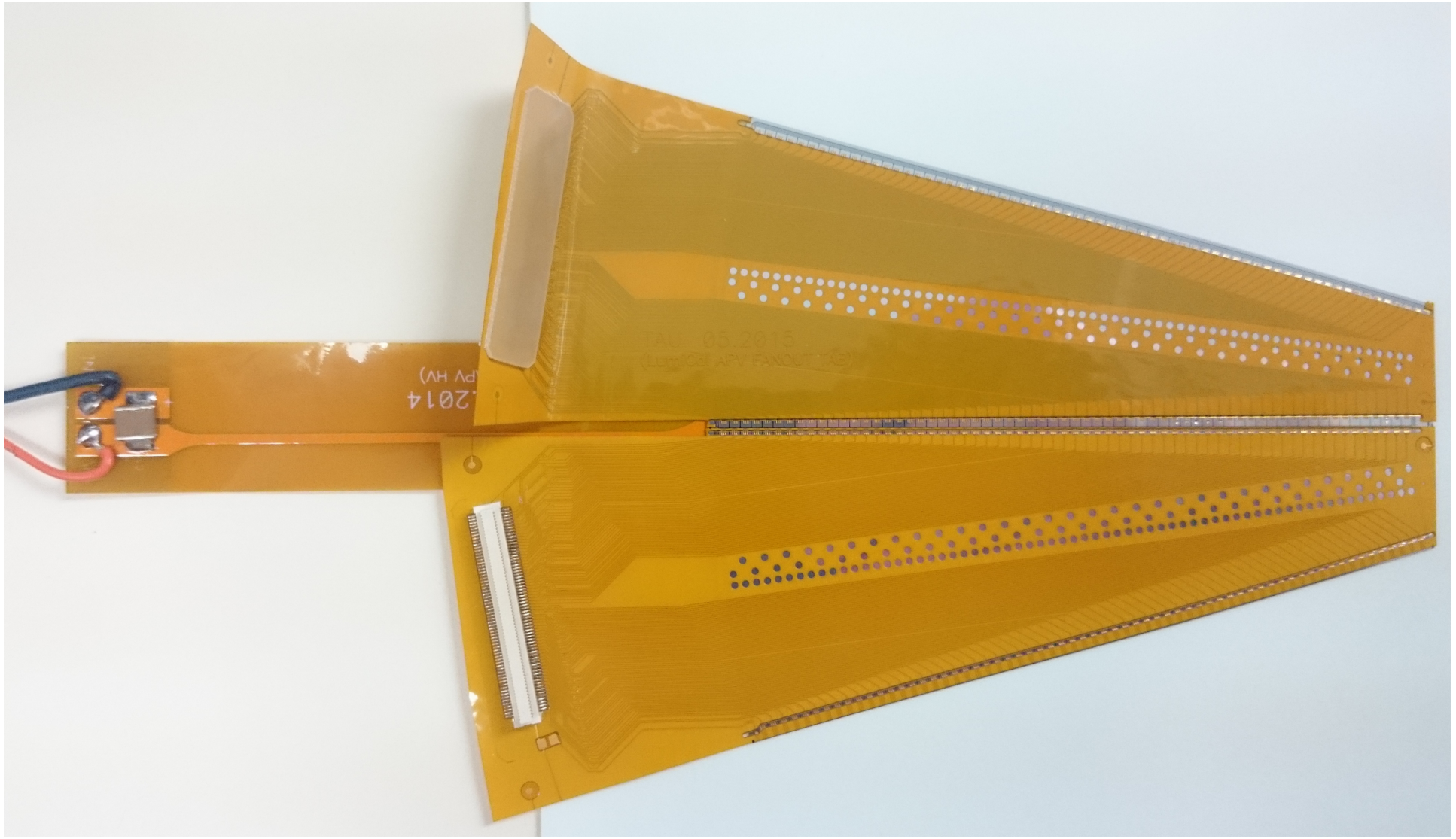




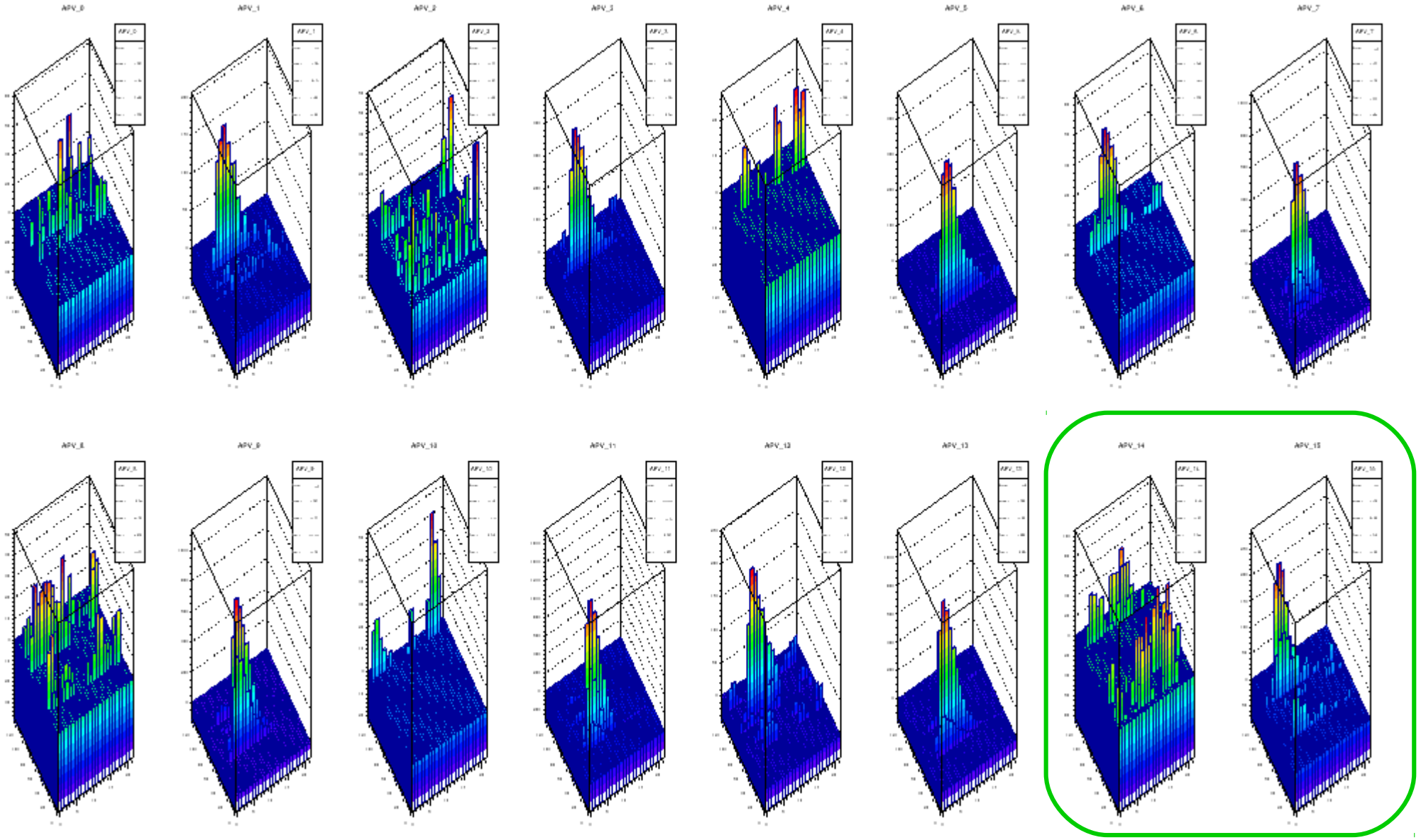
TAB Test with Broken Sensor after Bending Leads



LumiCal Module Assembled with TAB

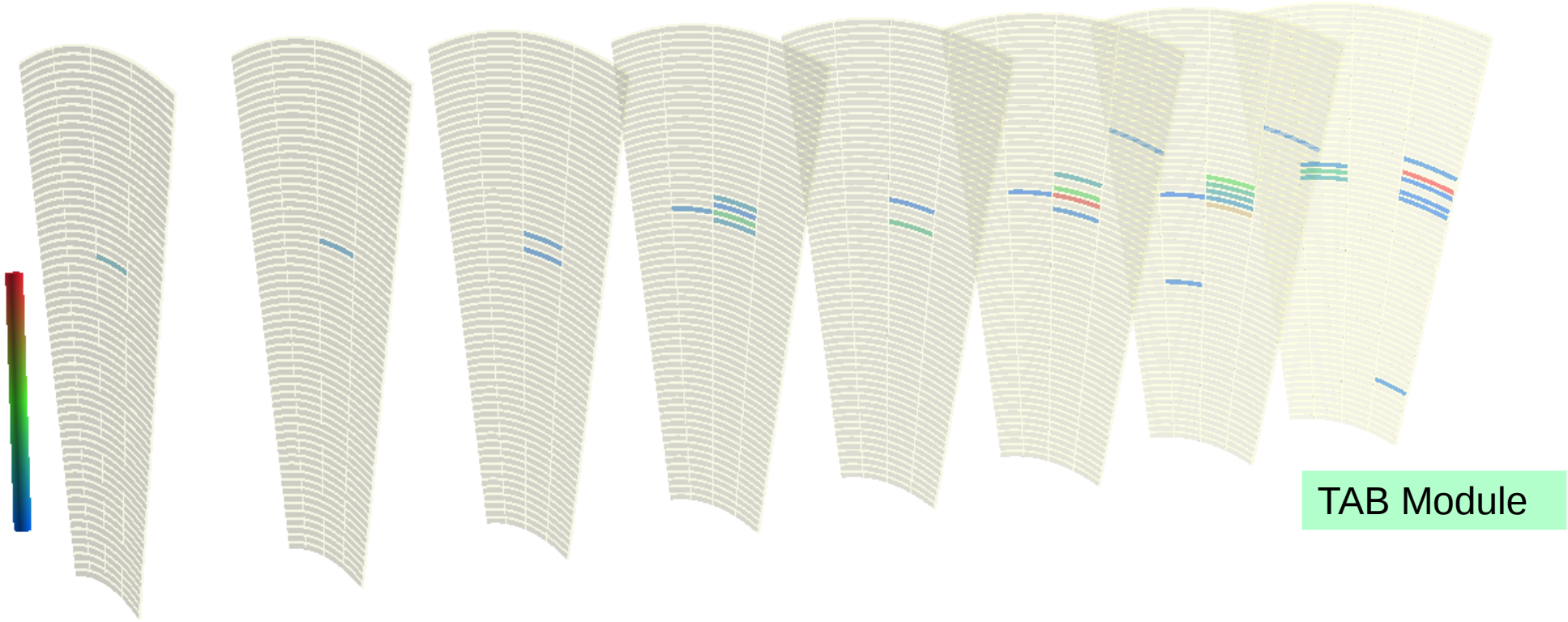


Run 755, event 10



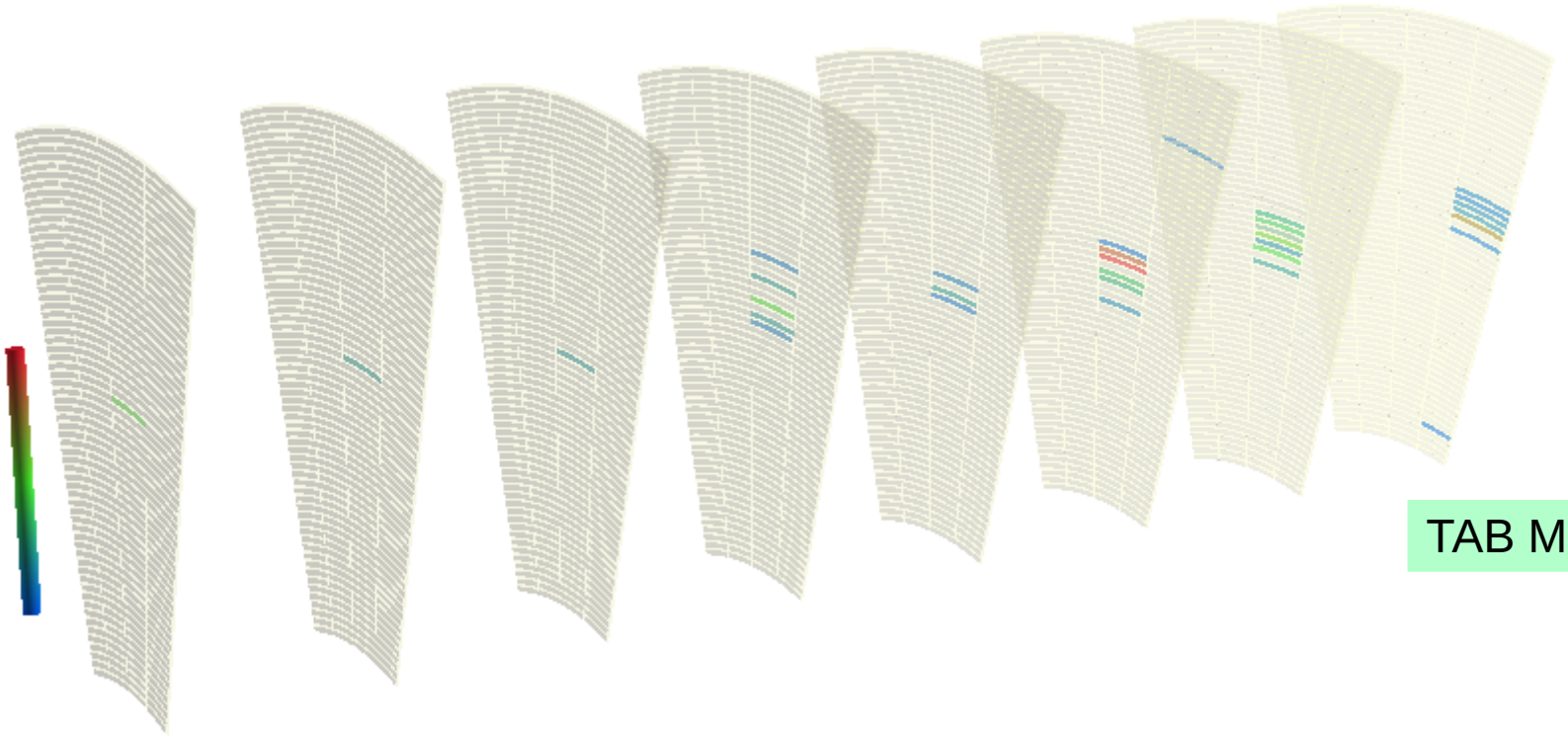
TAB Module

Run 771, event 21



Sectors R1 and R2 for TAB module are swapped because of incorrect APV channels map. Work in progress ...

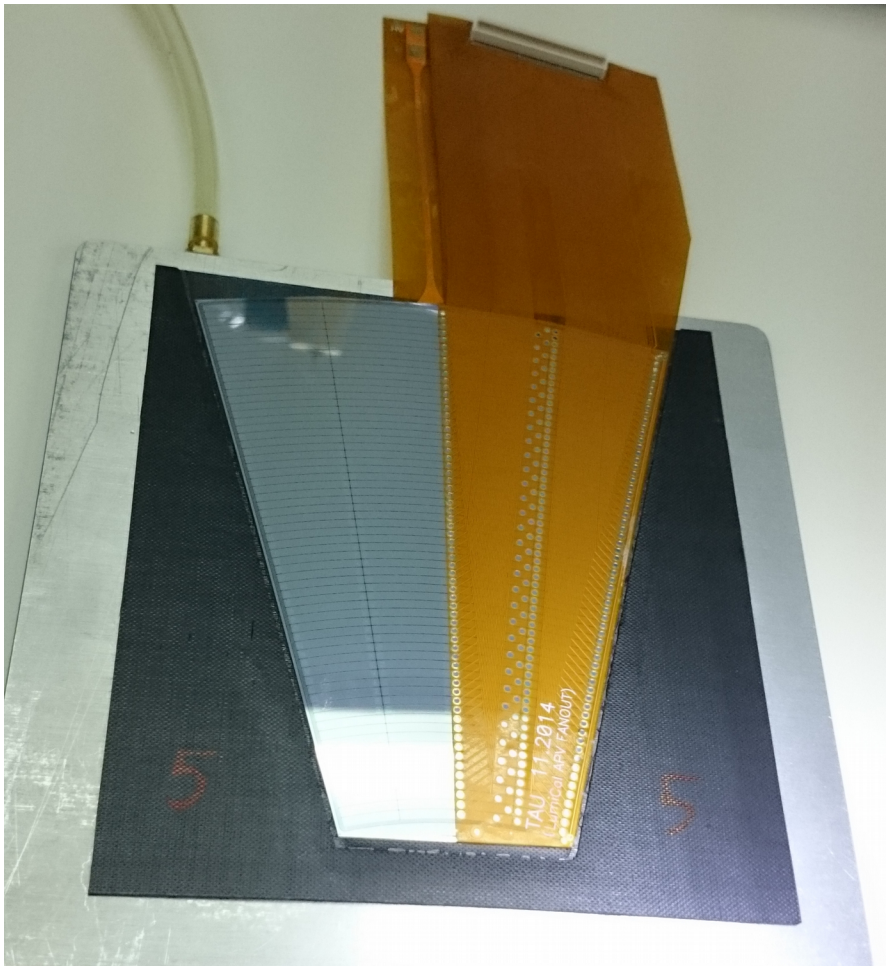
Run 771, event 22

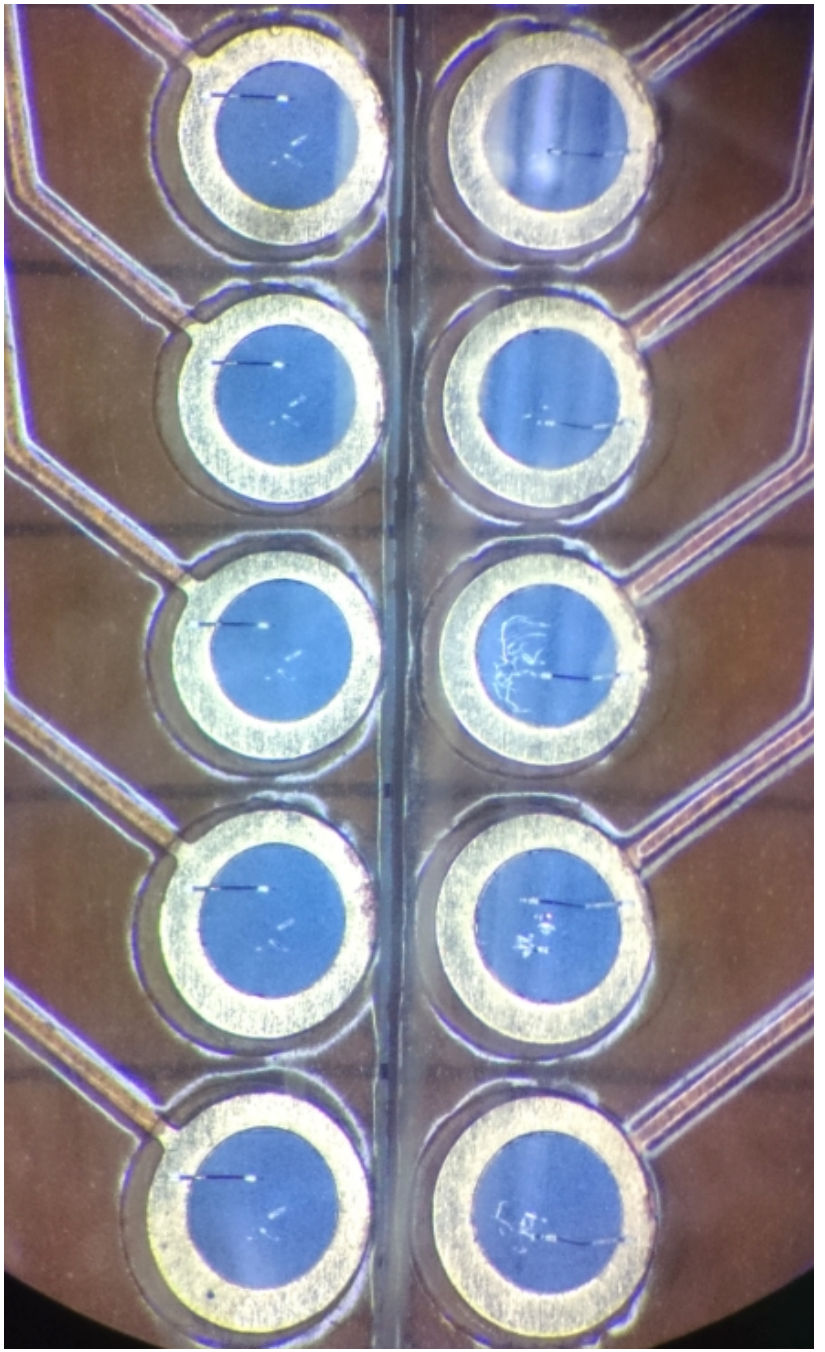


TAB Module

Sectors R1 and R2 for TAB module are swapped because of incorrect APV channels map. Work in progress ...

TB2015 Half Module was completed with the second half of the fan-out which was previously cut to use for TAB





Summary

- Significant amount of bondings were not succesful (~50%):
- Bending tool is far from perfect: does not provide the identical bending of all opened leads;
- The improvement of the bending tool is expected to improve the TAB;
- Thicker layer of gold plating could also be helpful.
- The module assembled using TBA technology was installed in the last plane during the TB2016.
- The supporting structure (carbon fiber envelope) was not used. The module was attached to tungsten by scotch over the protective layer of thin film.
- During the beam test we saw the reasonable signal from the connected channels.
- In addition, the lab measurements of IV were made.
- All data need to be studied.