Characterization of passive CMOS strip detectors

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CMOS strip - detectors

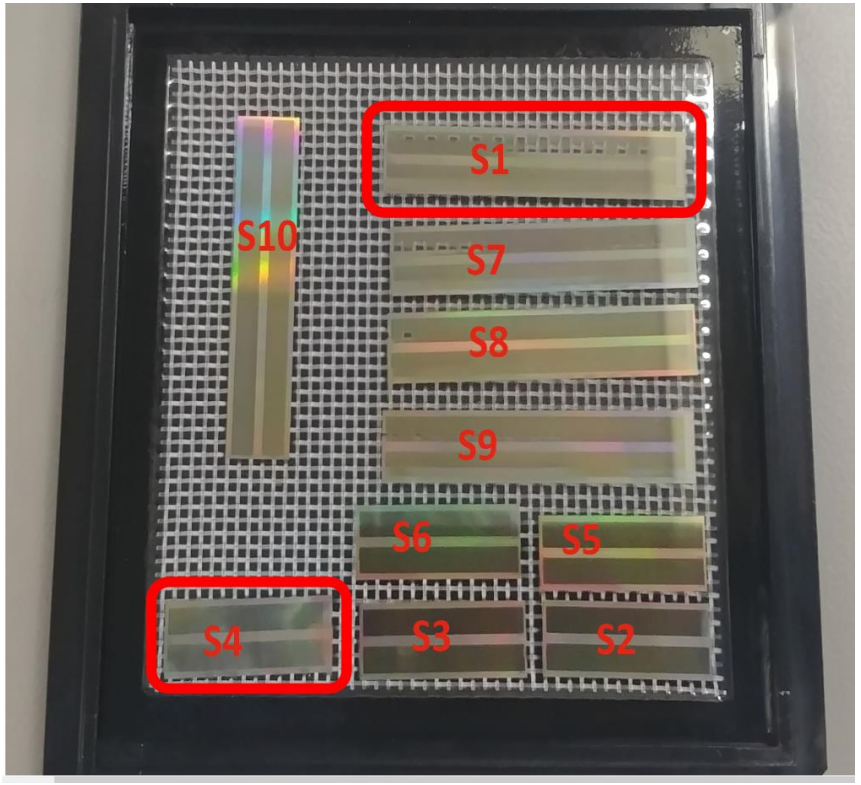
First stitched strip sensors produced on 8" wafer by a commercial high volume foundry.

LFA150:

- L-Foundry 150 nm process (deep N-well/P-well)
- Up to 7 metal layers
- Resistivity of wafer: >2000 Ω·cm
- Float-Zone silicon

Frontside process: Reticle stitching for large sensors

Two sensor lengths 2 cm and 4 cm.

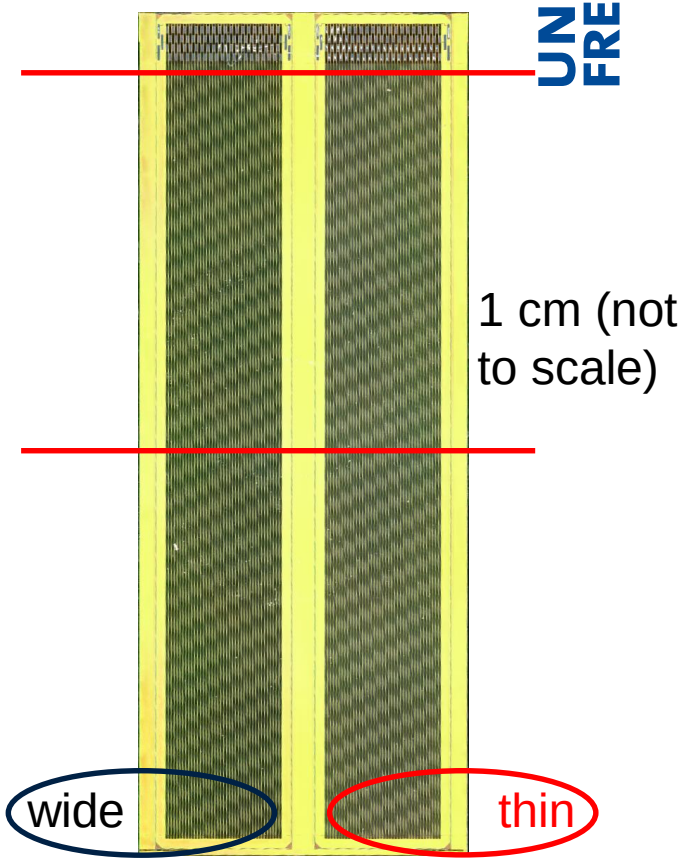


CMOS strip - details

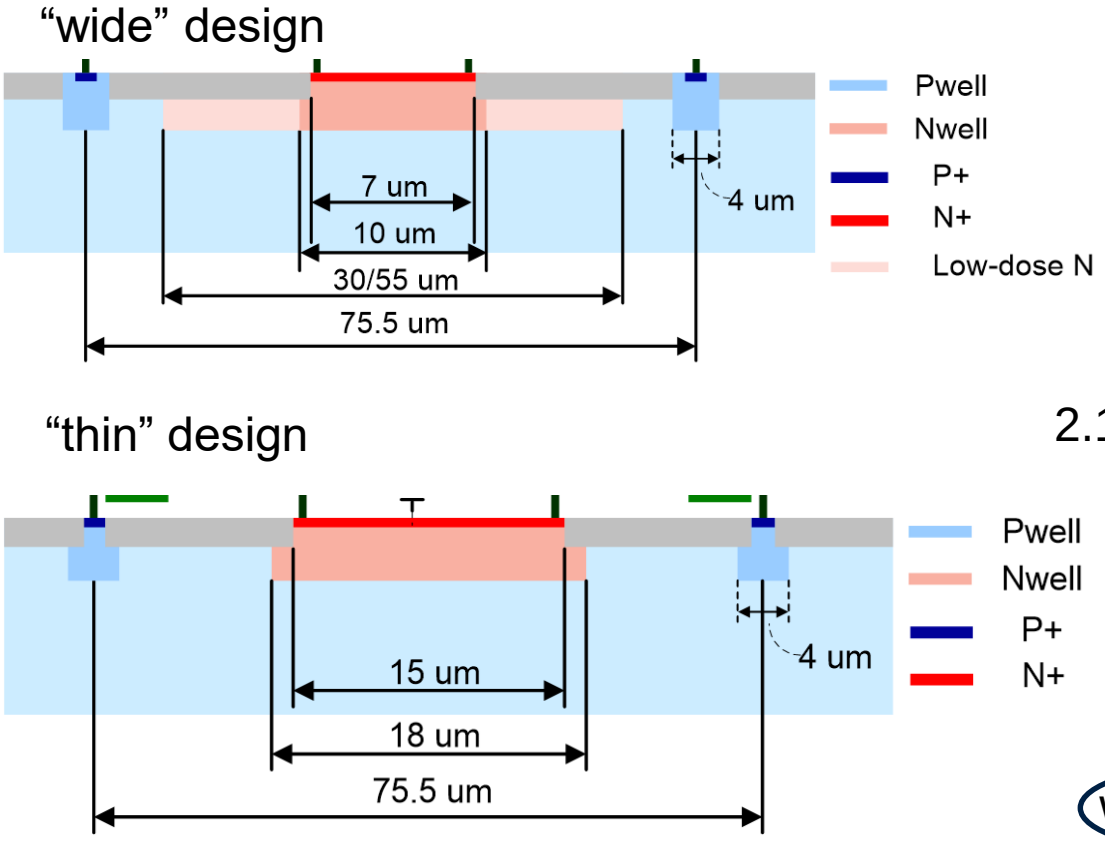
Two sensor lengths 2 cm and 4 cm.
The sensors contain a stich every 1 cm along their length.

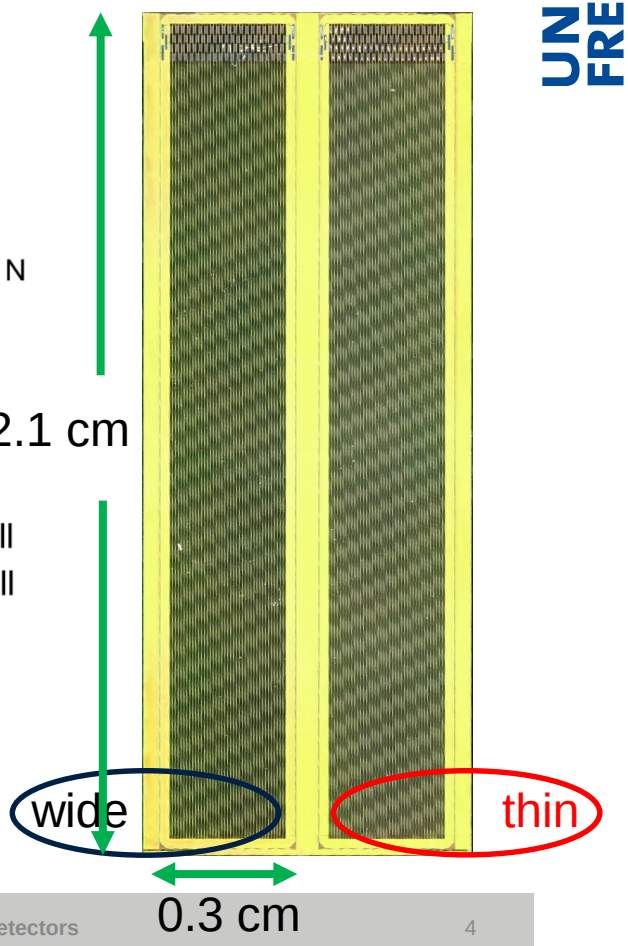
Two different sensor flavours divided in left and right half of the sensor.

The left half (“wide”) is further divided featuring two different implant lengths.



CMOS strip - implants



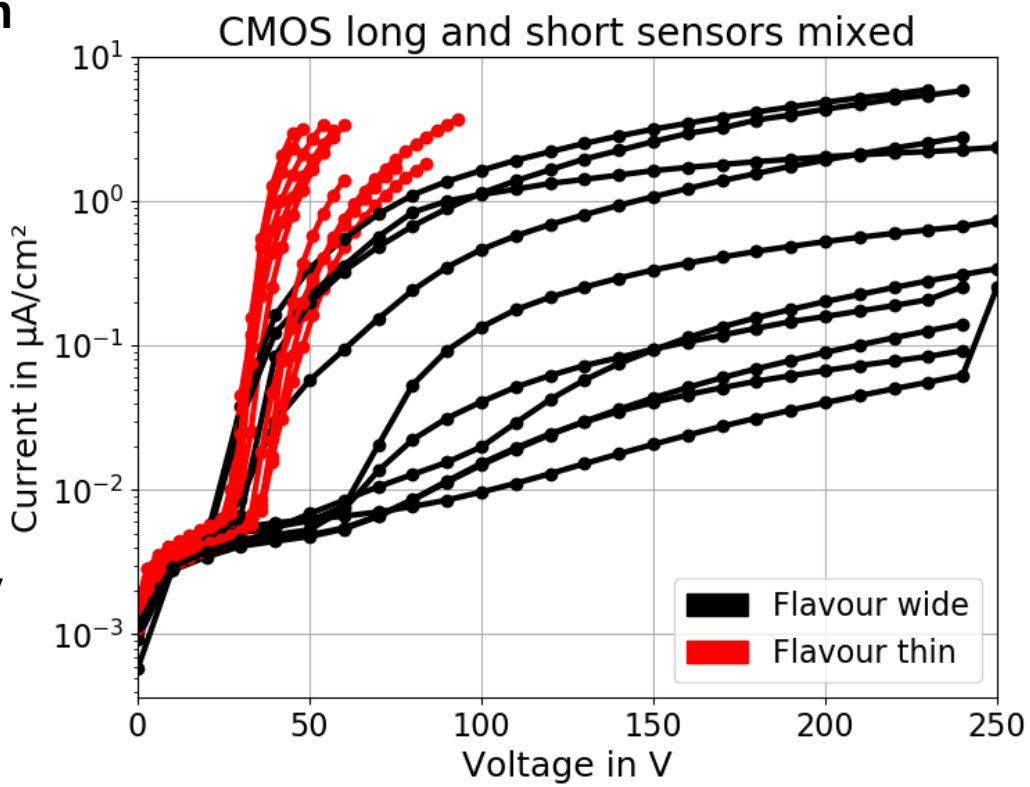


IV results

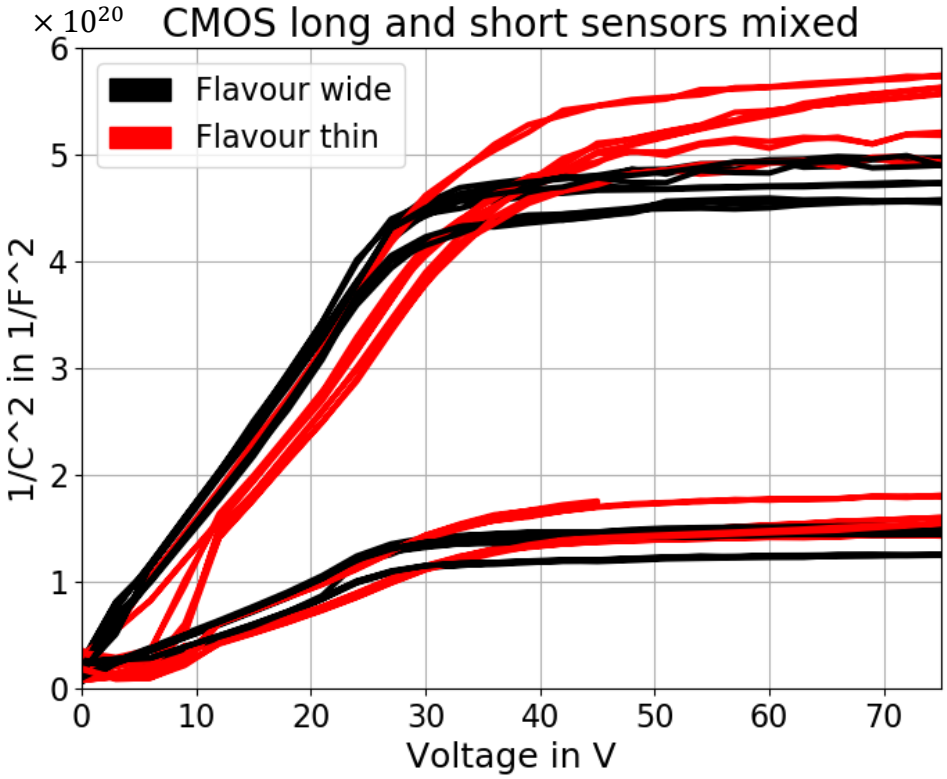
No backside passivation

The left half (“wide”) shows lower power consumption in the majority of sensors.

The right half (“thin”) shows strong increase in leakage current at low voltages, could potentially be problematic after irradiation.



CV results



4 cm sensors

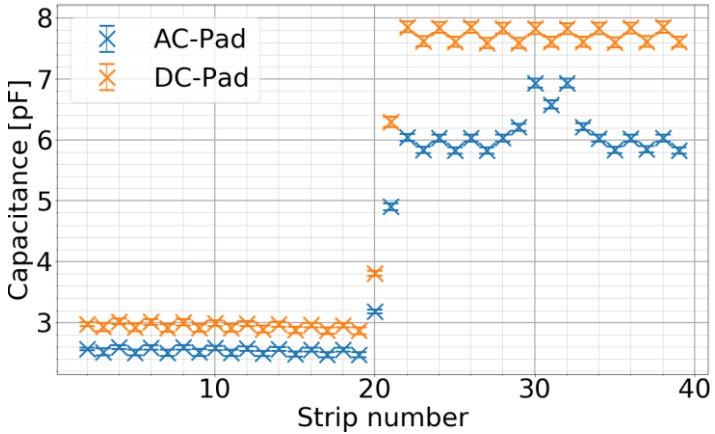
2 cm sensors

Both strip designs deplete around 25 – 40 V

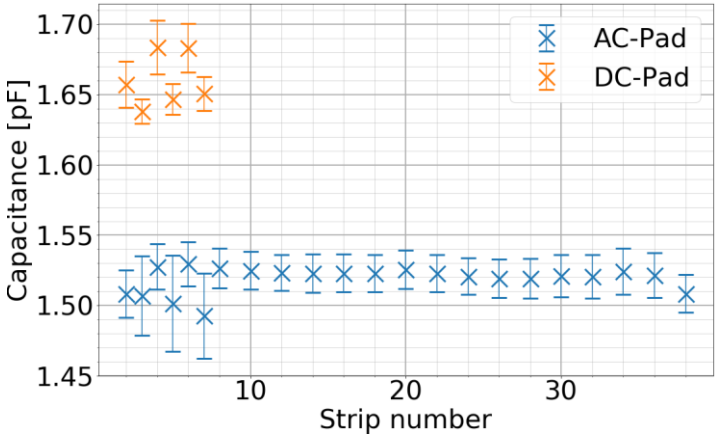
“thin” design has smaller implant < 20 µm with 76 µm pitch

Interstrip capacitance measurement

wide



thin



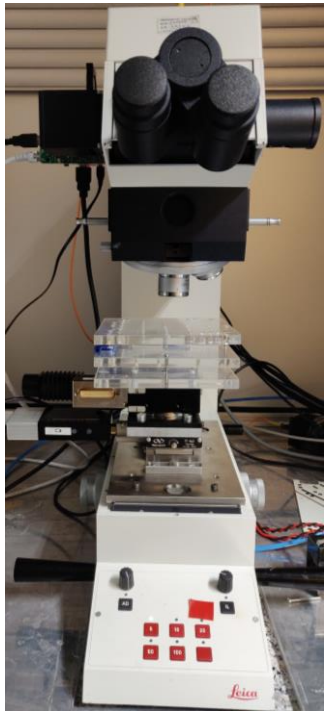
On the left two different strip designs visible.

No effect from stitching visible.

Sensor	Capacity/Length [fF/mm]
“wide” left	62 ± 0.2
“wide” right	144 ± 0.4
“thin”	37 ± 0.1
Hamamatsu	65 ± 0.6

Laser measurements

AliBaVa setup

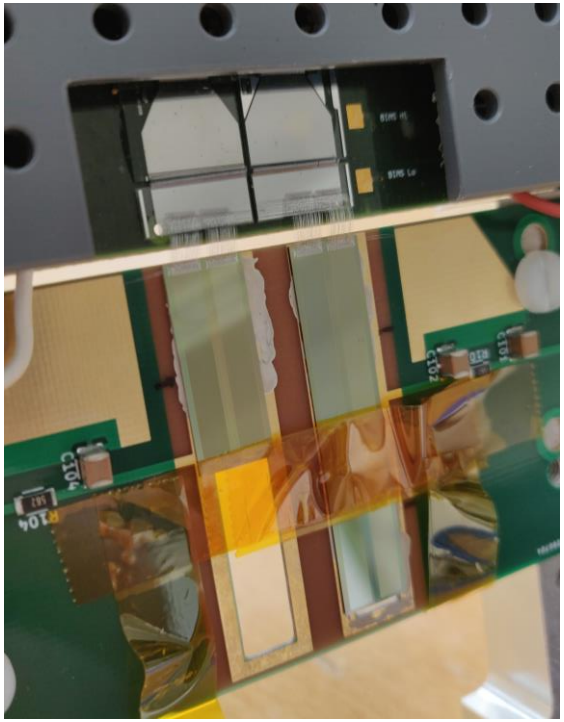


AliBaVa laser setup

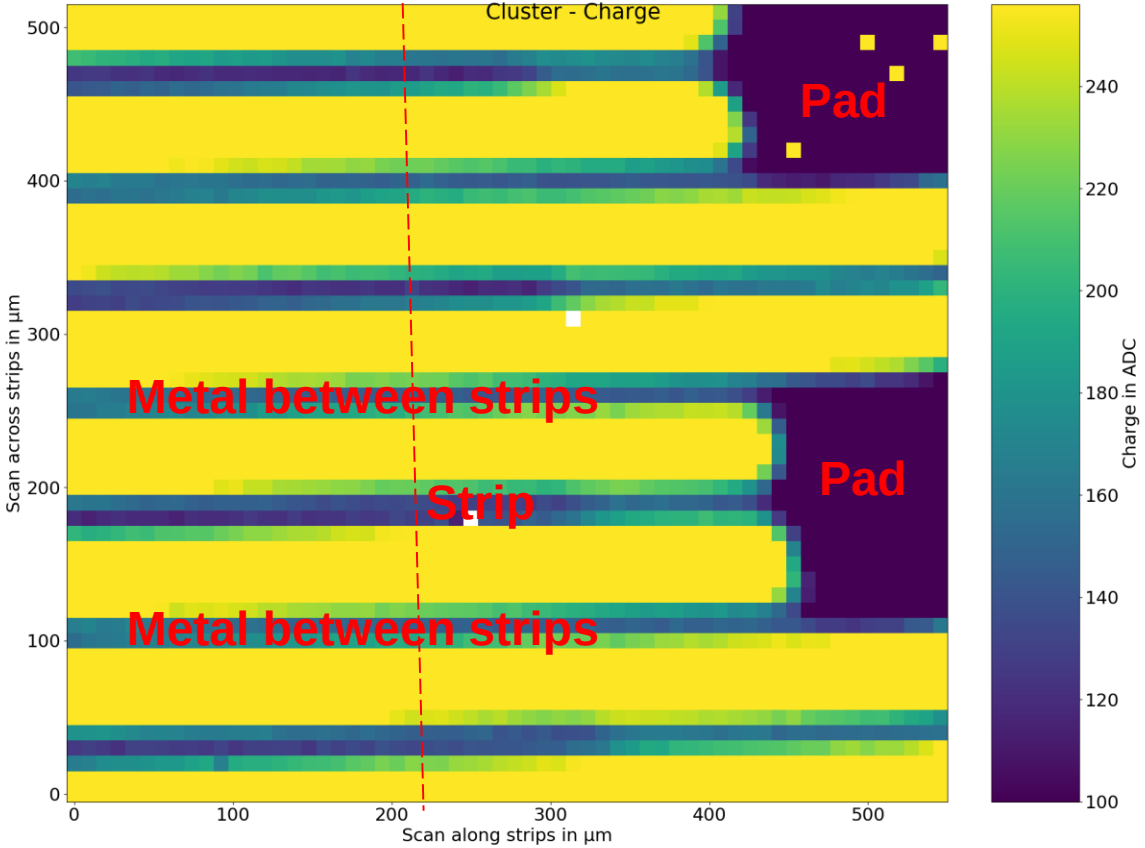
AliBaVa laser setup consists of a fibre coupled infrared laser and two motorstages which move the sample with µm precision.

Sensors are placed on a board with a large cut-out to make the back of the sensor accessible.

Signal is sampled.

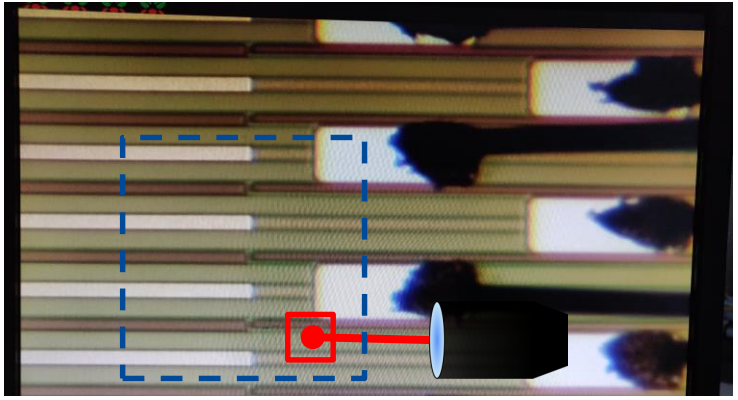


Laser stitch check

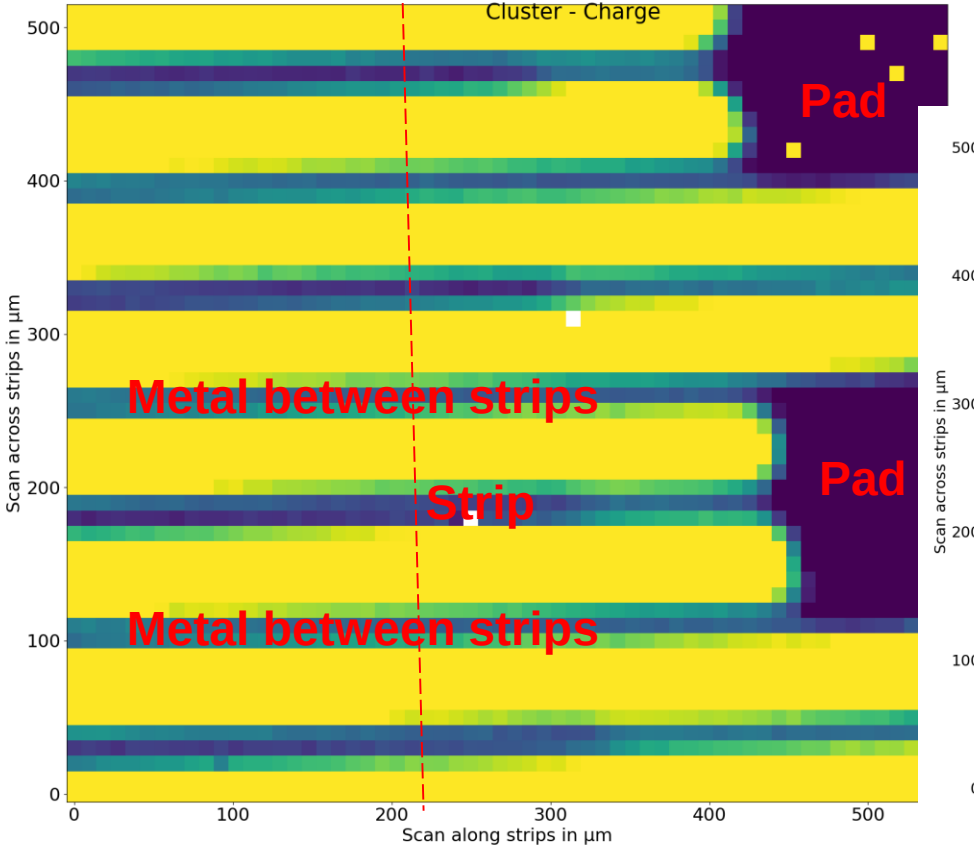


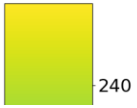
First measurement to check stitch @ 50 V

Due to the metallization (blue horizontal lines): results are only hints

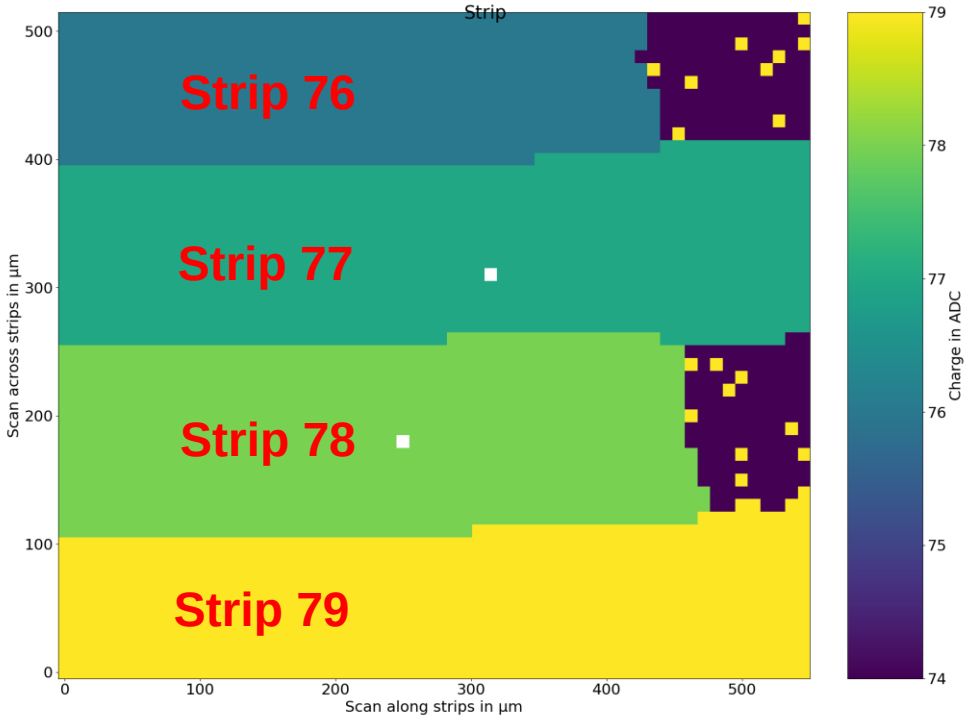


Laser stitch check



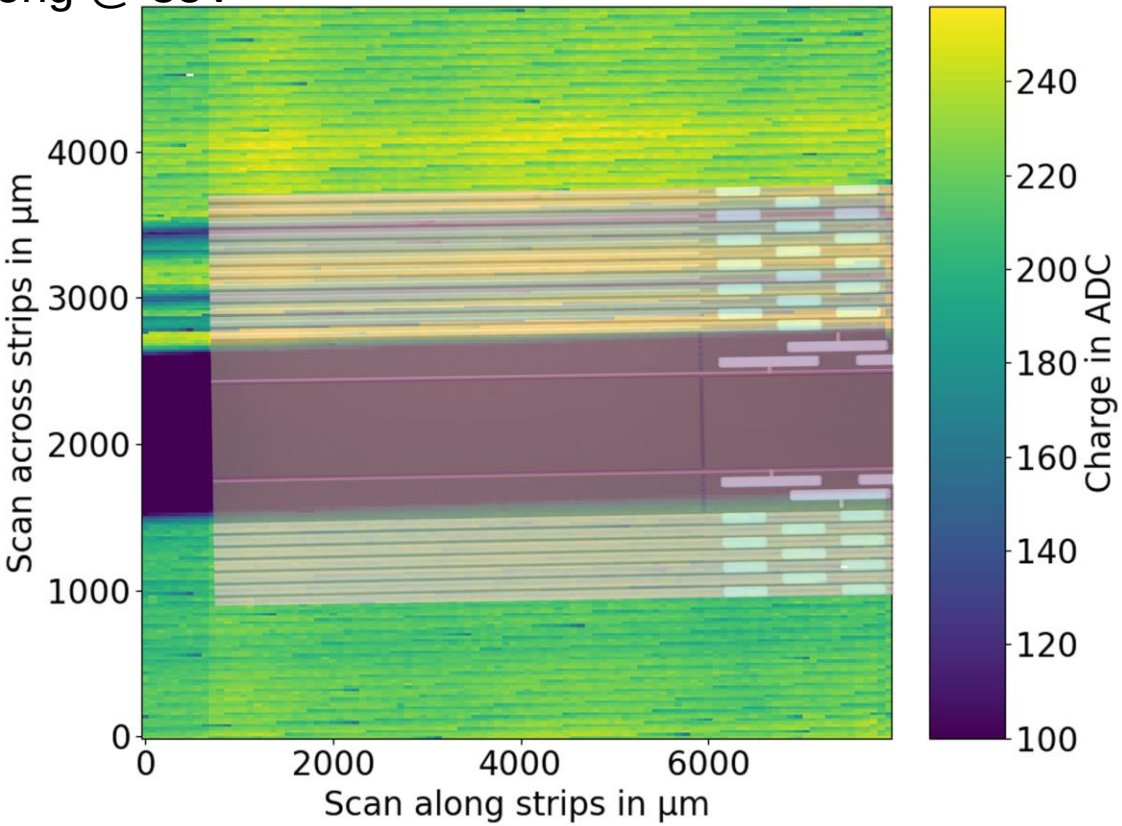


First measurement to



Scan for homogeniety

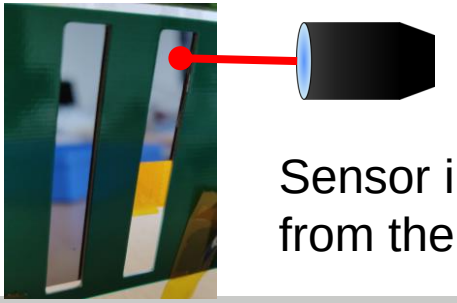
Long @ 35V



Sensor “thin” shows
228 ± 12 ADC

(these numbers still contain systematic noise from our system in the order of 1.8 ADC)

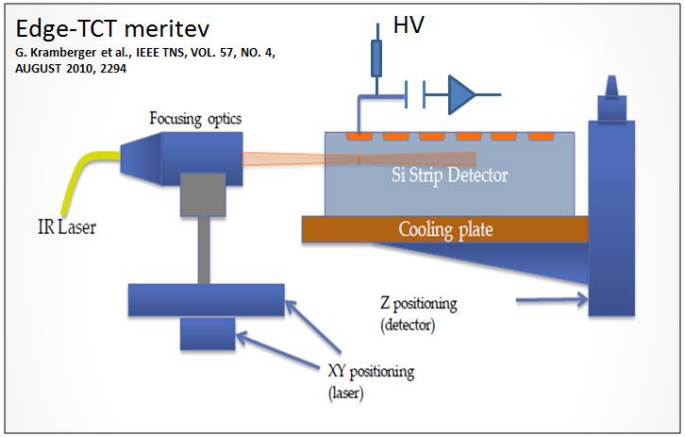
Sensor “wide” shows
213 ± 8 ADC

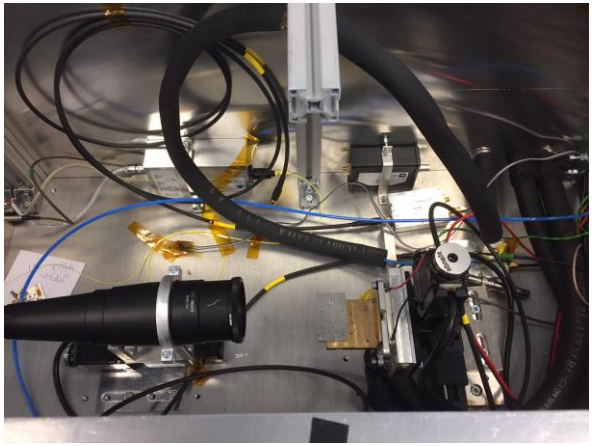


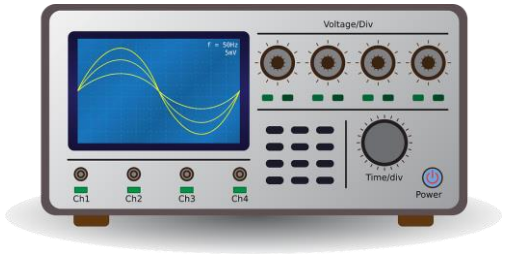
Sensor illuminated from the back.

TCT technique

Side view: Particulars **EdgeTCT** setup



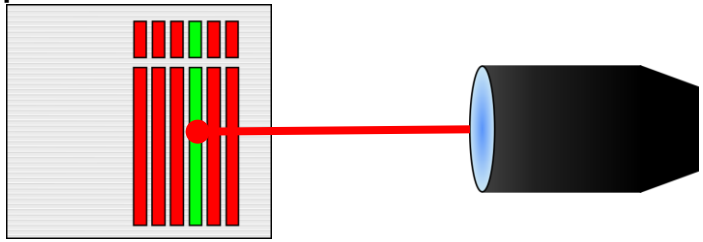




Signals are “fully” recorded with an oscilloscope.

Top view: Sensor

Laser



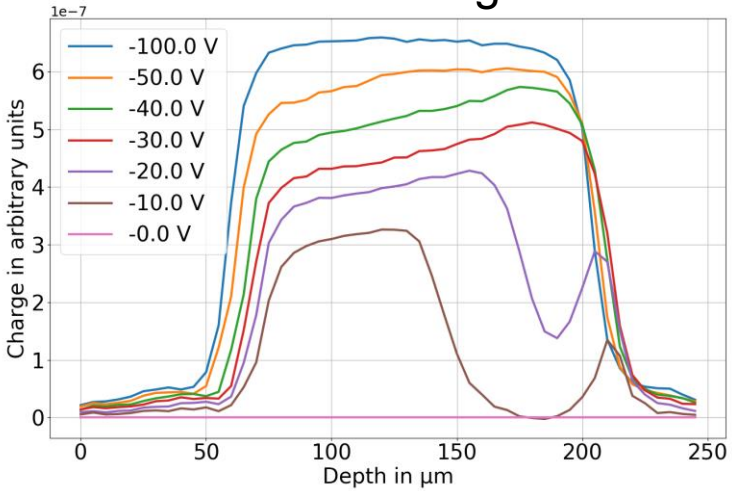
Strip - grounded

Strip - measured

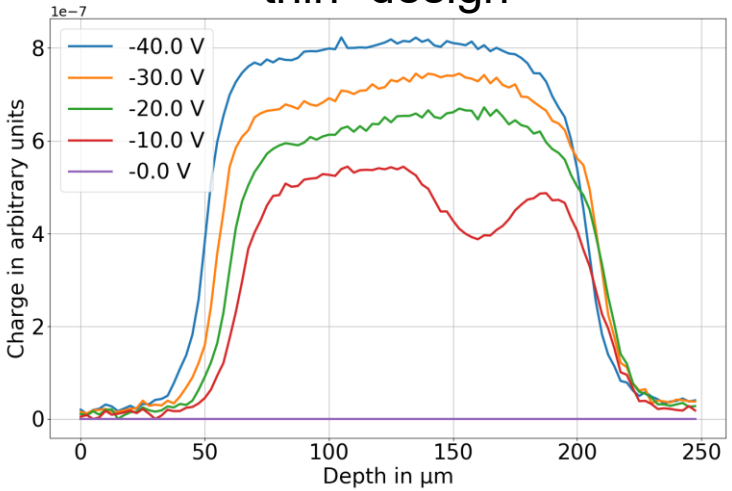
TopTCT – illuminate sensor from top instead of edge.

E-TCT charge collection

“wide” design



“thin” design



E-field changes shape until around 50 V bias.

E-field changes shape until around 30 V bias.

Probably connected to backside processing issues.

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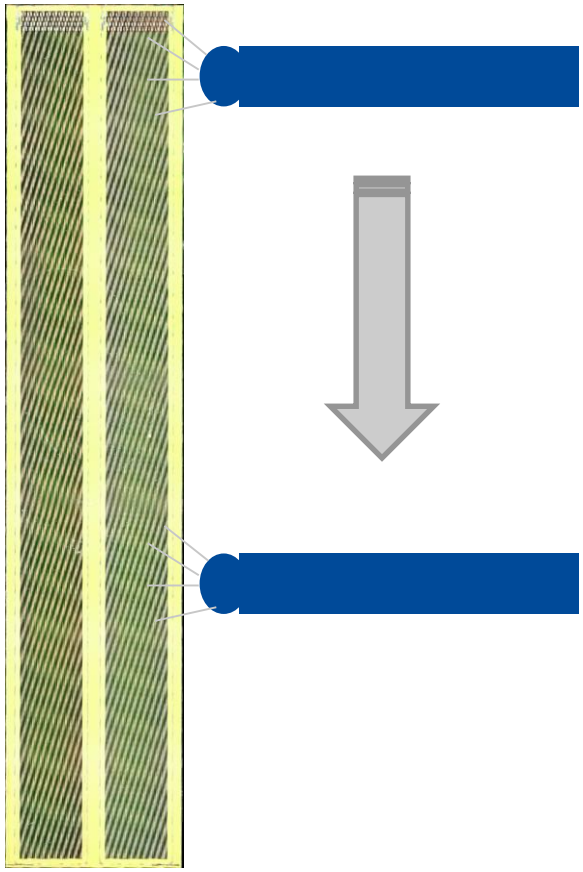
Source measurements

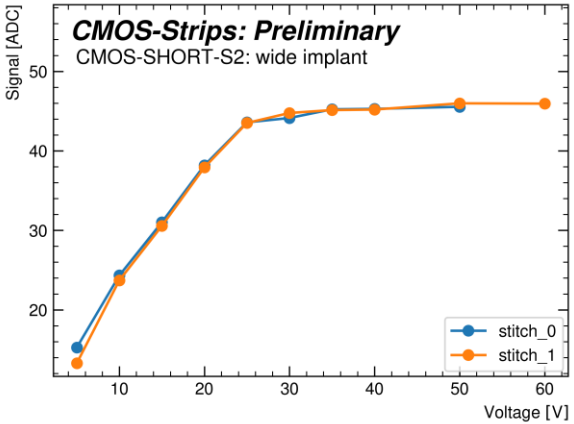
Source measurement – the method

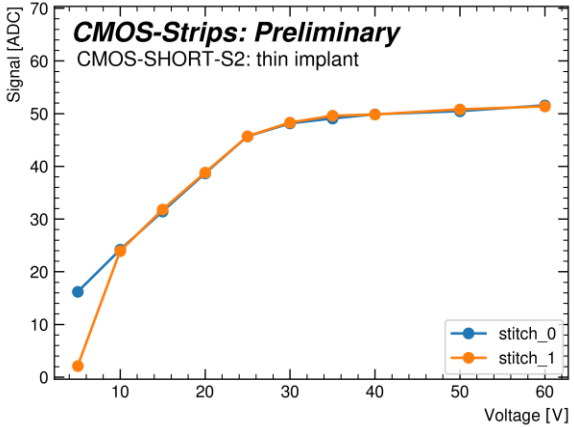


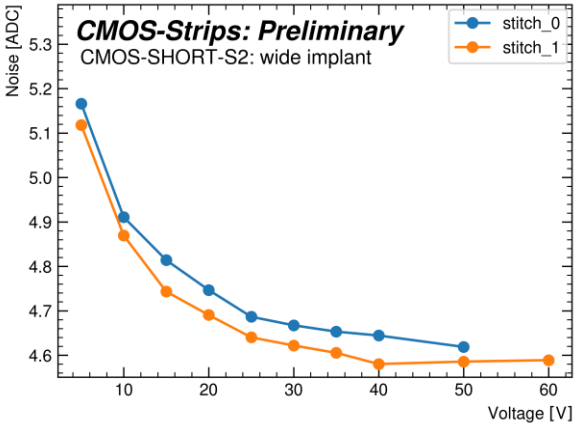
We use the AliBaVa readout system.

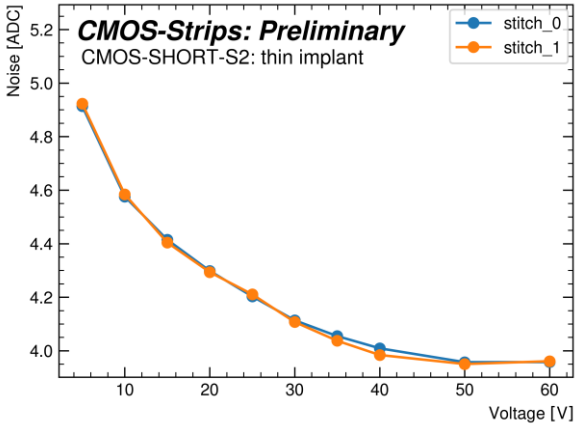
Move the source between measurements by 1cm.
Majority of electrons pass through a different stitch after every move.

Source measurement



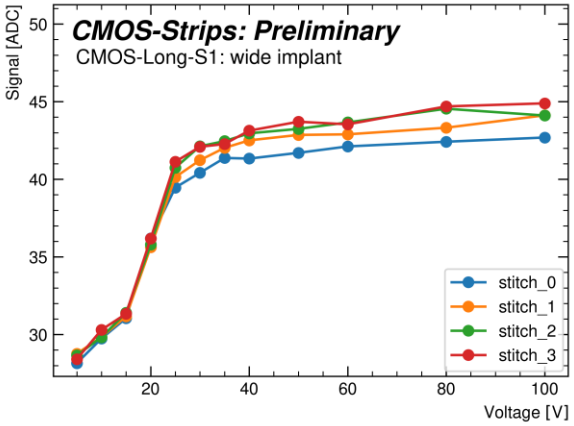


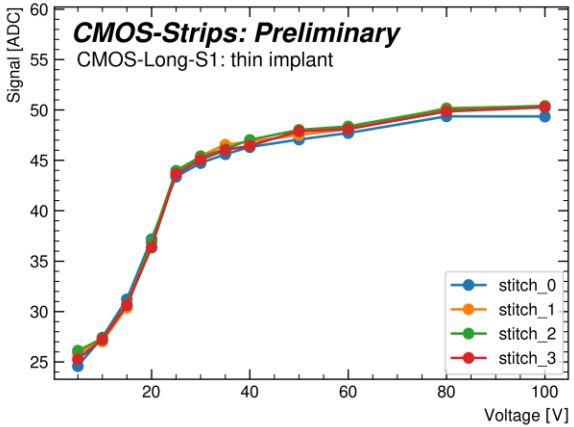


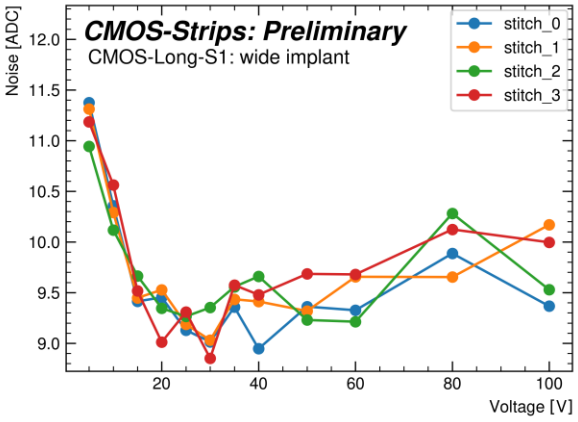


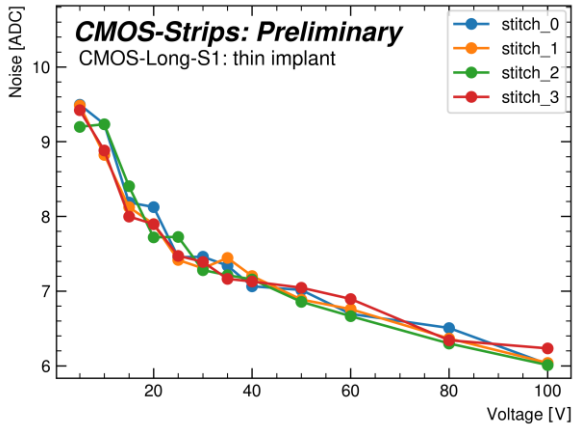
No degrading visible along stitches.

Source measurement









No degrading visible along stitches.

Need to understand effect of the 2 different designs used in the “wide” sensor.

Low S/N

Conclusion & Outlook

Sensor

The “wide” sensor design is better suited to withstand high voltages. Break down for healthy sensors is larger than 250 V.

At low bias voltages (around 50 V), the “thin” sensor design shows better charge collection.

Stitching

No negative effect from stitching could be observed in the measurements conducted so far.

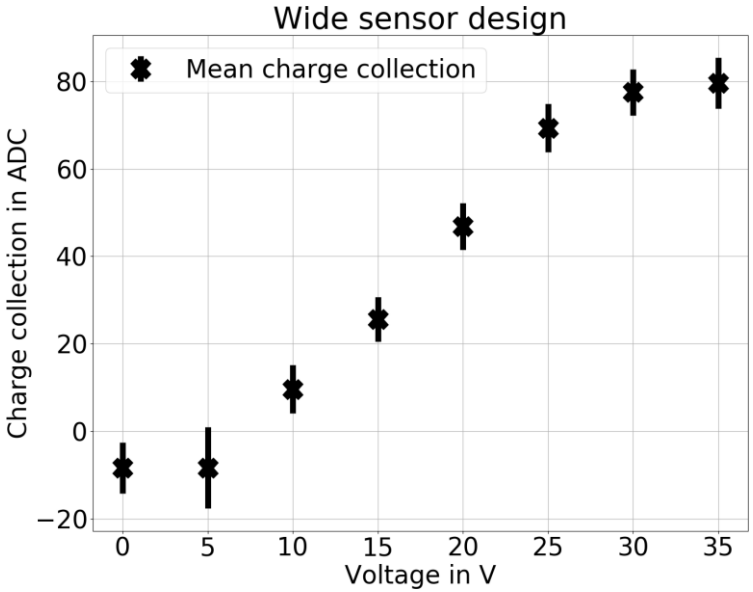
Outlook:

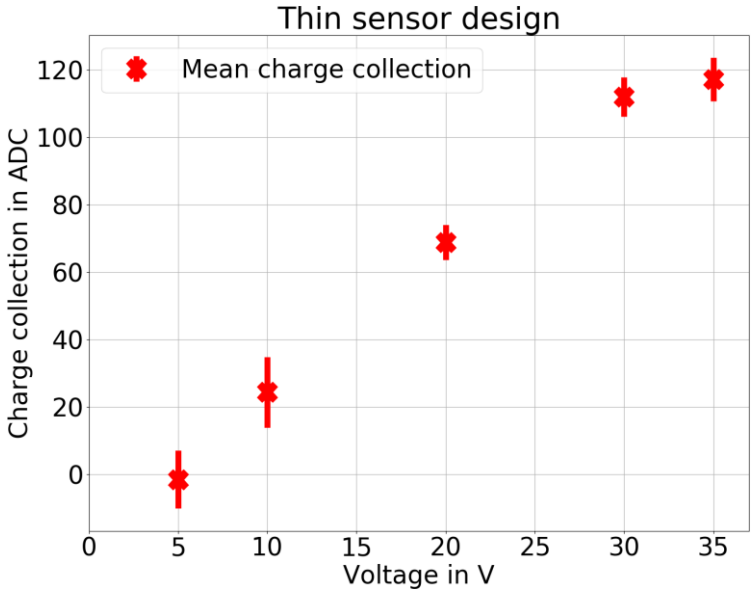
Sensors were measured at the testbeam facility in DESY recently.

Irradiation studies planned.

First batch had backside processing issues, better electrical results expected for the next batch.

Charge collection vs voltage



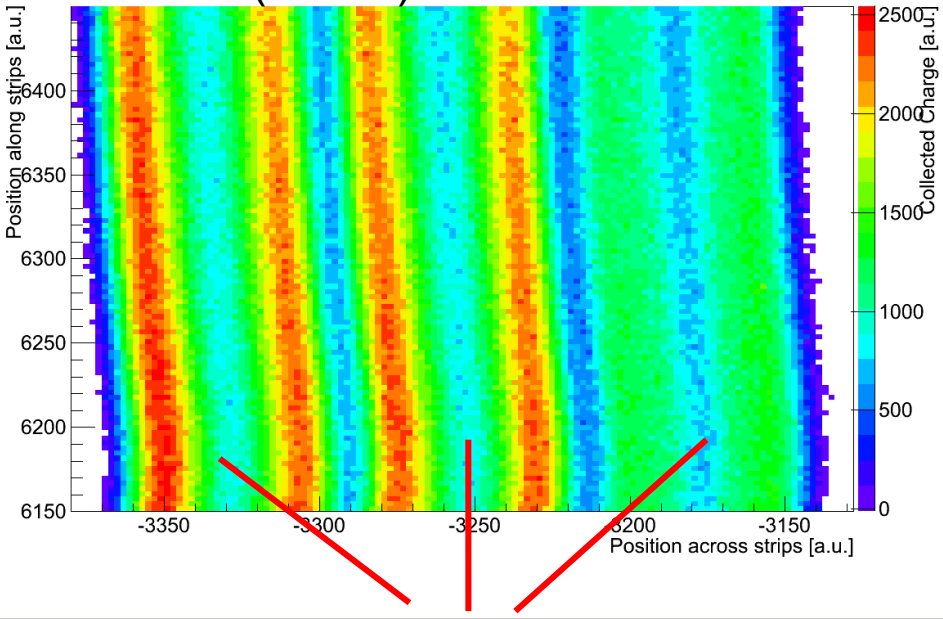


Results from laser measurements.

TopTCT measurement

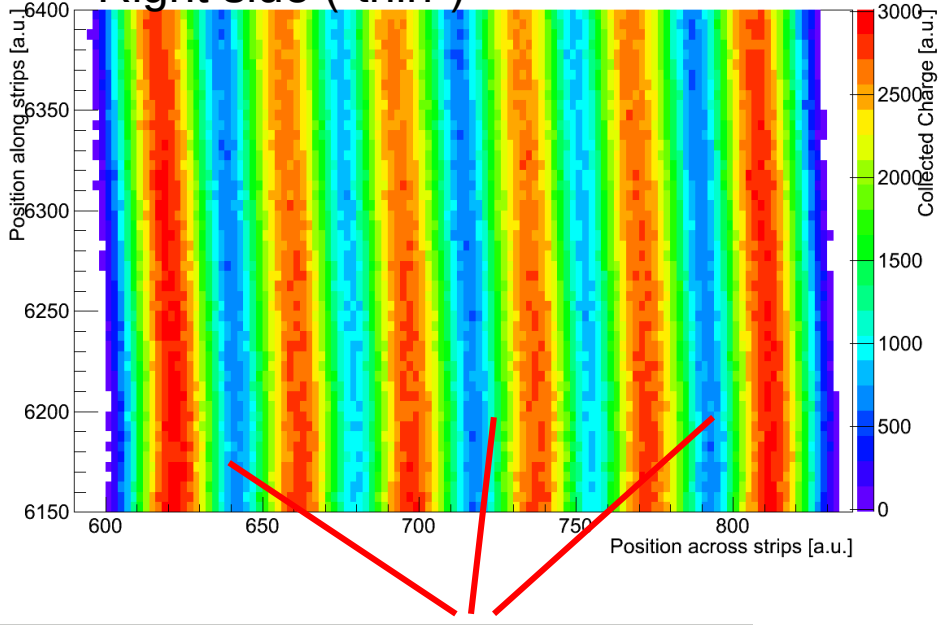
- Left side: Probably one bond lost -> See only the shared charge
- Collected Charge slightly higher for right side of the sensor

Left side (“wide”)



Strips

Right side (“thin”)



Strips