Laboratory Measurements of Stiched Passive CMOS Strip Sensors

16th (Virtual) "Trento" Workshop on Advanced Silicon Radiation Detectors

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CMOS Passive Strip Detectors

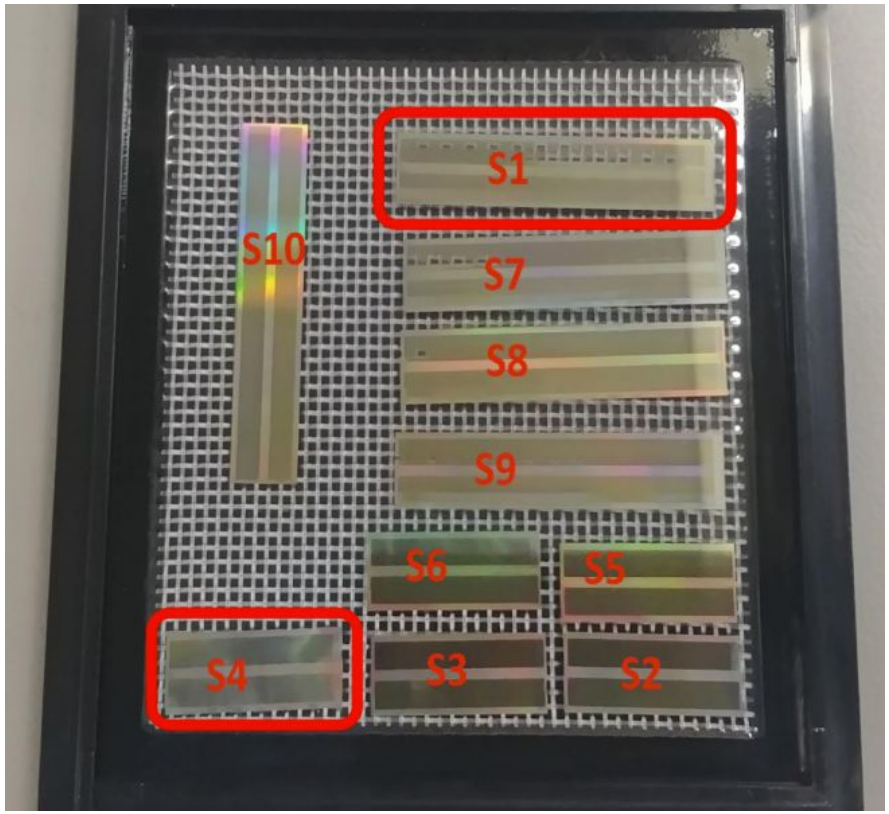
First stitched strip sensors produced on 8" wafer by a commercial high volume foundry.

- L-Foundry 150 nm process (deep N-well/P-well)
- Up to 7 metal layers
- Wafer Resistivity: > 2 kΩ·cm
- Float-Zone silicon

Frontside process: Reticle stitching
⇒ larger sensors

Two different batches:

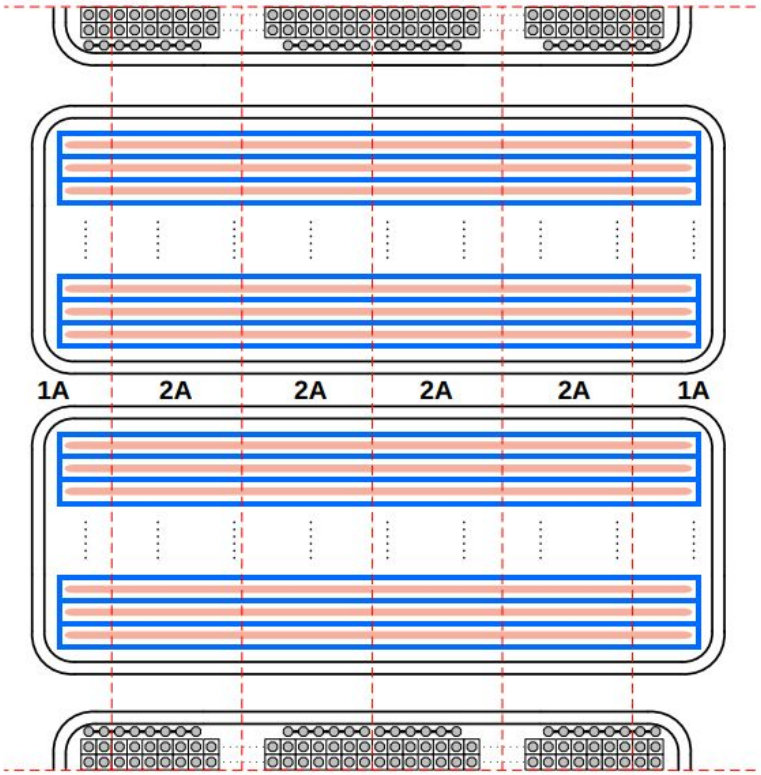
- low concentration backside implant and not metallization
- higher concentration backside implant and metallization

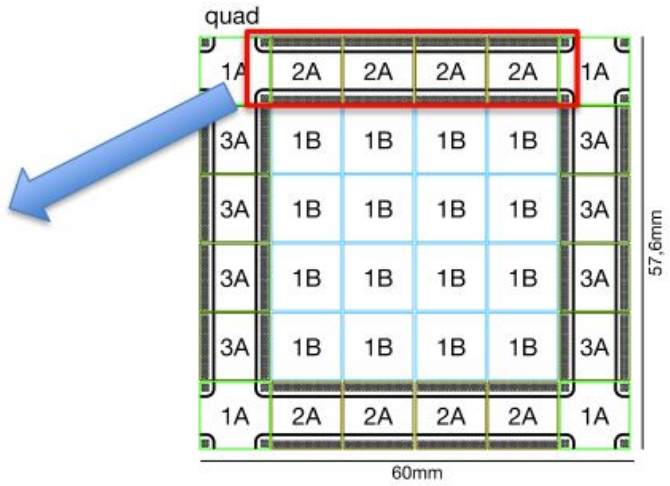


Two sensor lengths:

- 2 cm (short sensor)
- 4 cm (long sensor)

CMOS Passive Strip Detectors



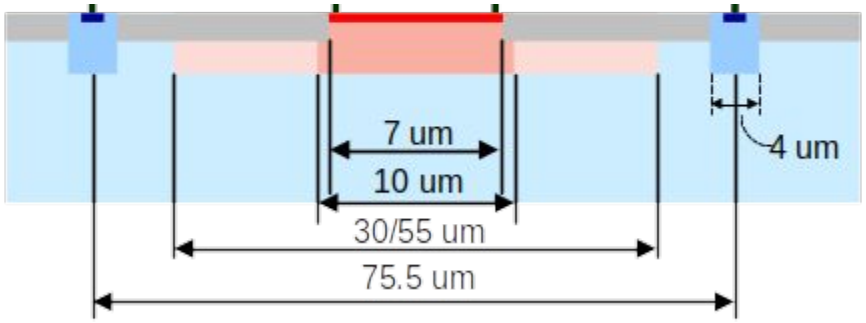


- Strip sensor implemented in 1/2A
- Stitched every ~1 cm along strip length
- Strip pitch: 75.5 µm

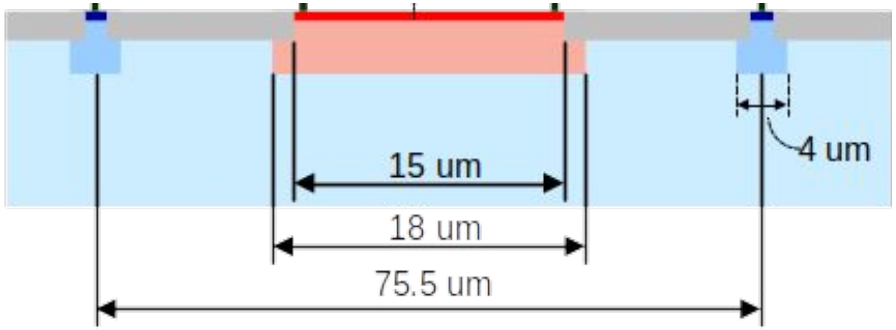
Stitching crucial for large area sensors

CMOS Passive Strip Detectors

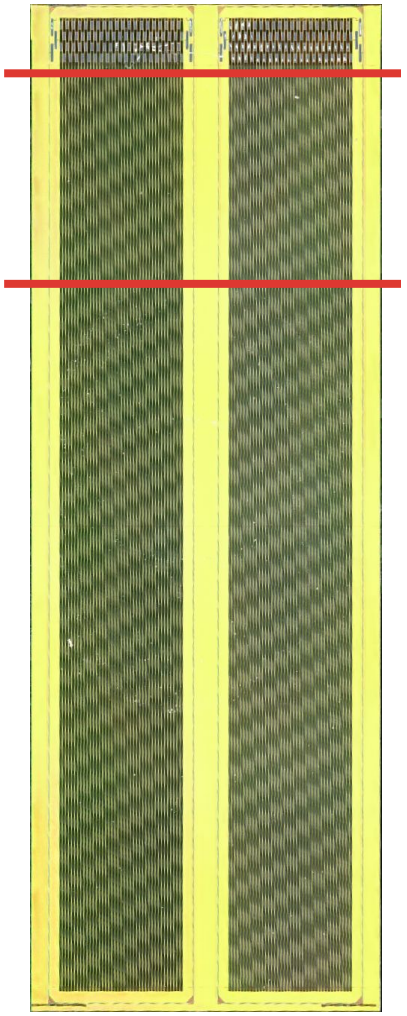
Wide implant (two widths)



Thin implant



- 40 strips for each side
- Three types of implants per sensor
- Four total combinations



~1 cm
(Not to scale)

Wide implant **Thin implant**

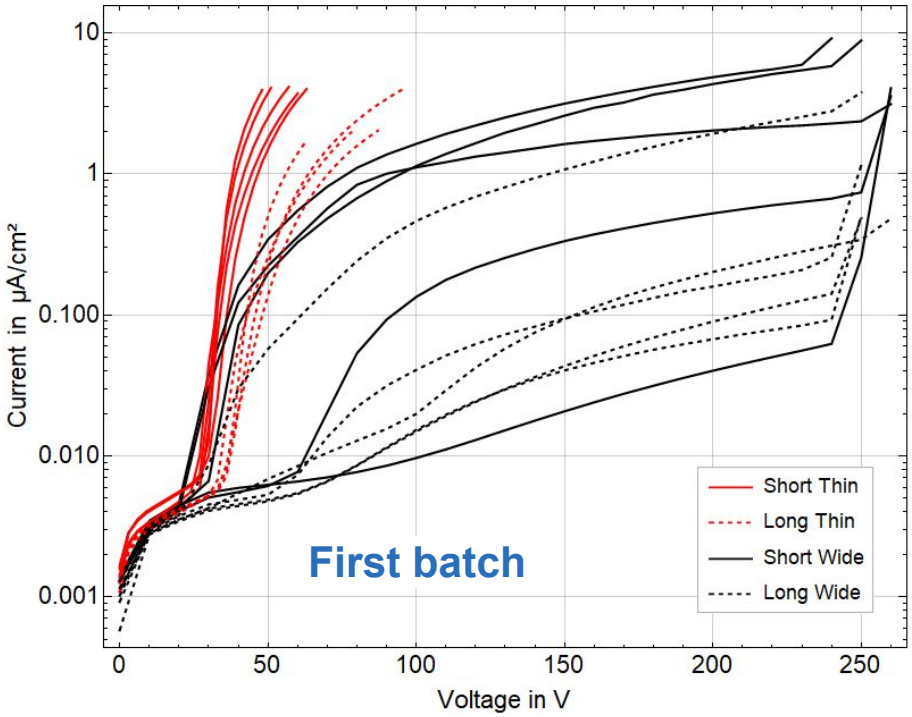
IV Results

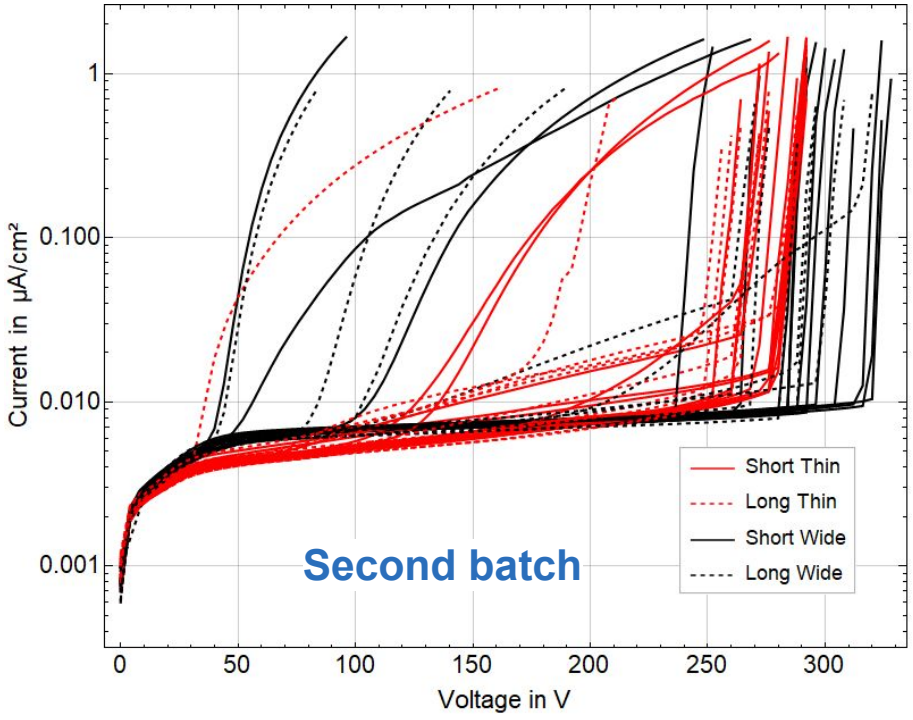
First batch ⇒ low concentration backside implant, no metallization

- Early breakdown for both designs
- Thin design shows strong increase in leakage current at low voltages
- Poor stability for Wide design

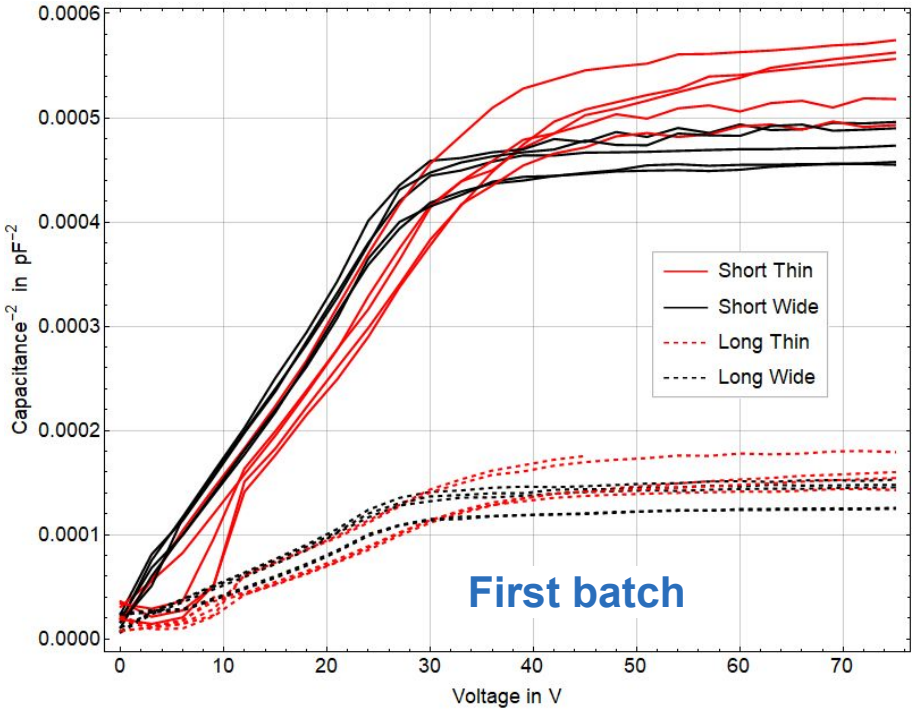
Second batch ⇒ higher concentration backside implant and metallization

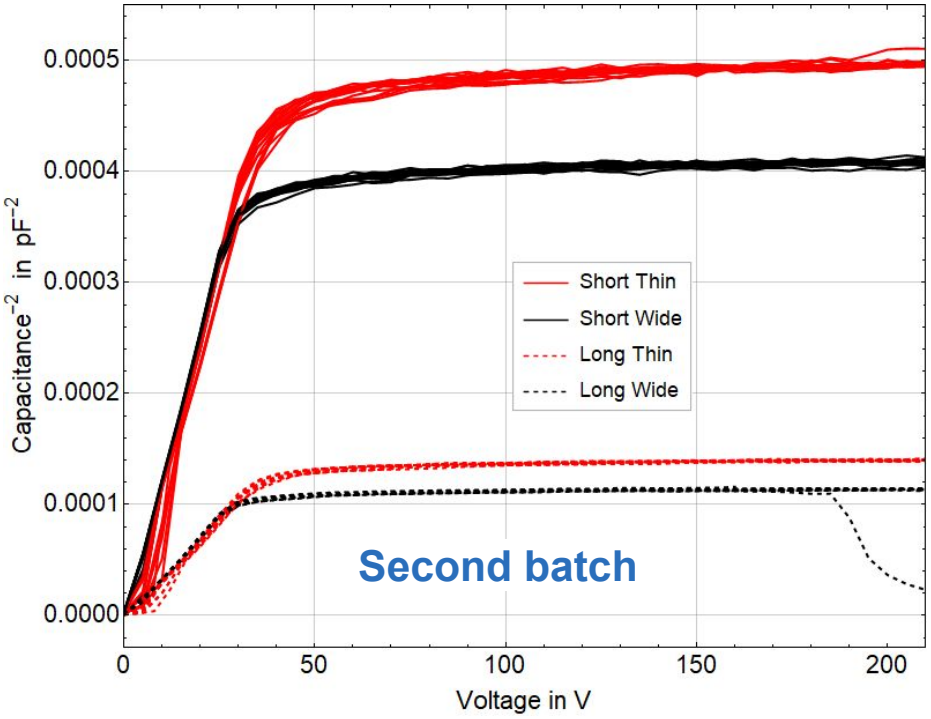
- Breakdown above 220 V (improved)
- Wide design more stable along the range of voltages





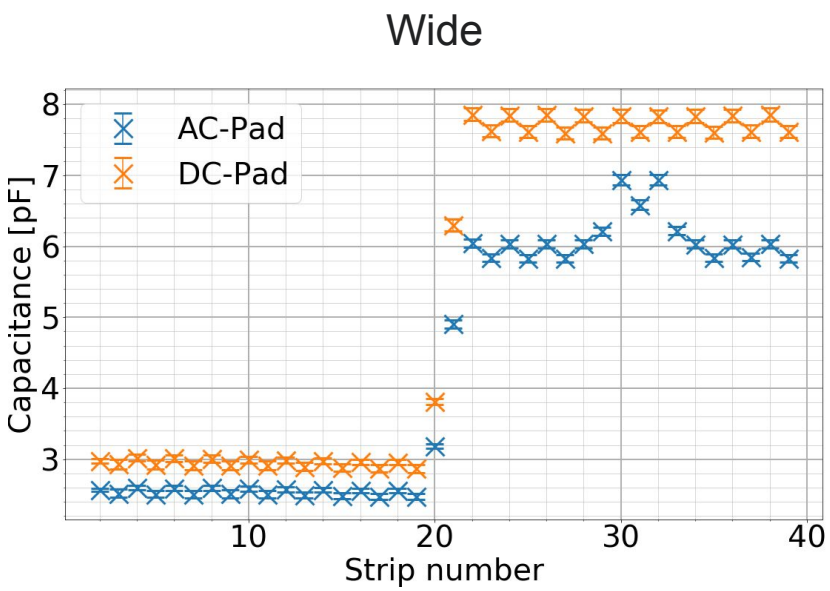
CV Results

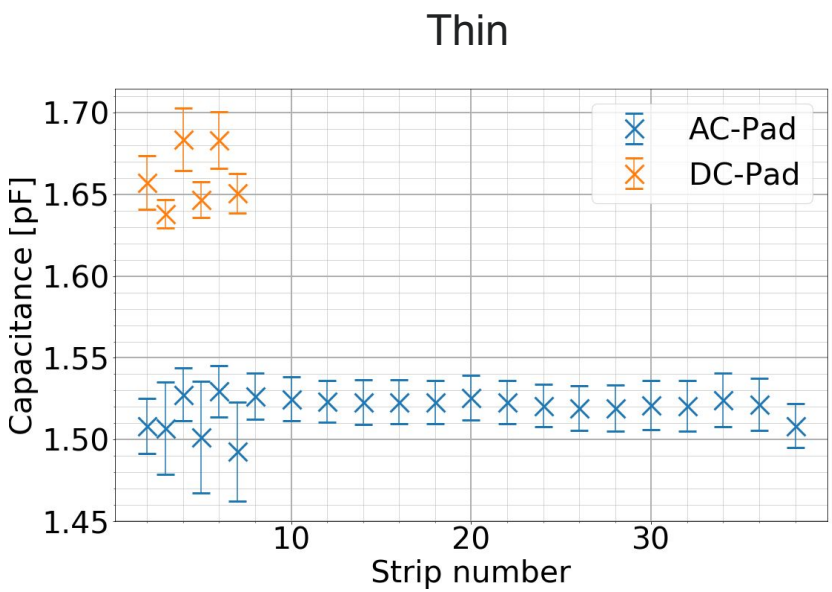




- Full depletion voltage around 25-40 V for both designs
- Different full depletion capacitance for thin and wide design ⇒ Different effective thickness
- More homogeneous capacitance
- Strong strip impact on capacitance for thin design at low voltages up to 10 V
- **No negative effect from stitching visible**

Interstrip capacitance





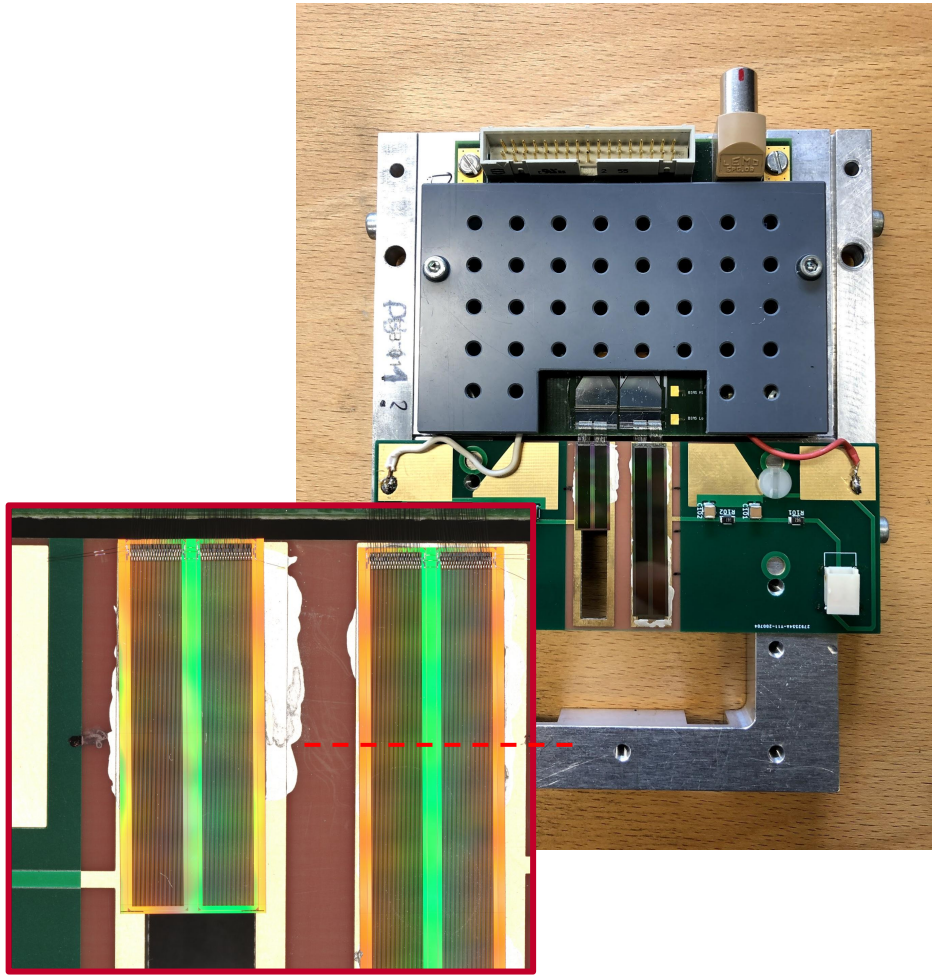
First batch

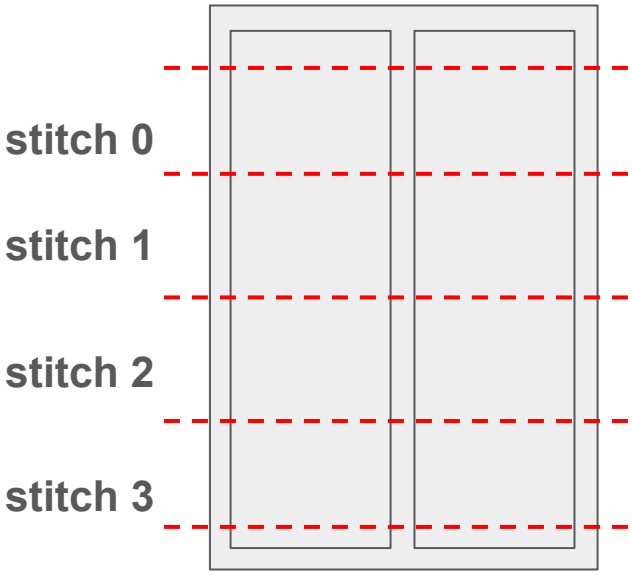
- Two different strip implants visible on the “wide” design
- **No effect from stitching visible**

Sensor	Capacitance/Length (fF/mm)
“wide” left	62 ± 0.2
“wide” right	144 ± 0.4
“thin”	37 ± 0.1

Source Measurements

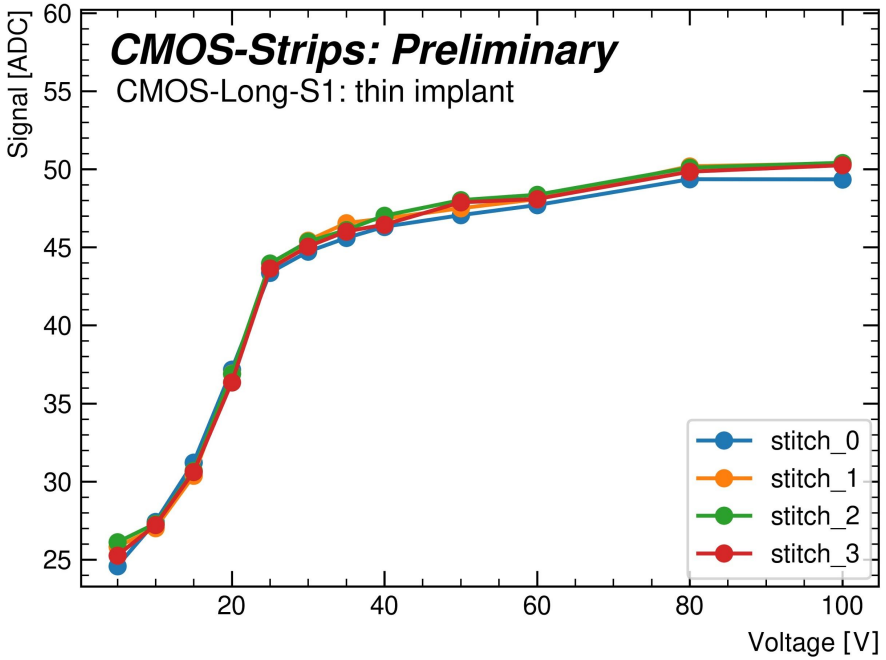
- Both strip designs bonded to one chip
  - Maximum bias voltage 100 V
- Twelve voltages measured:
  - 5 - 40 V in 5 V steps
  - 50, 60, 80 and 100 V
- Only sensors from first batch tested

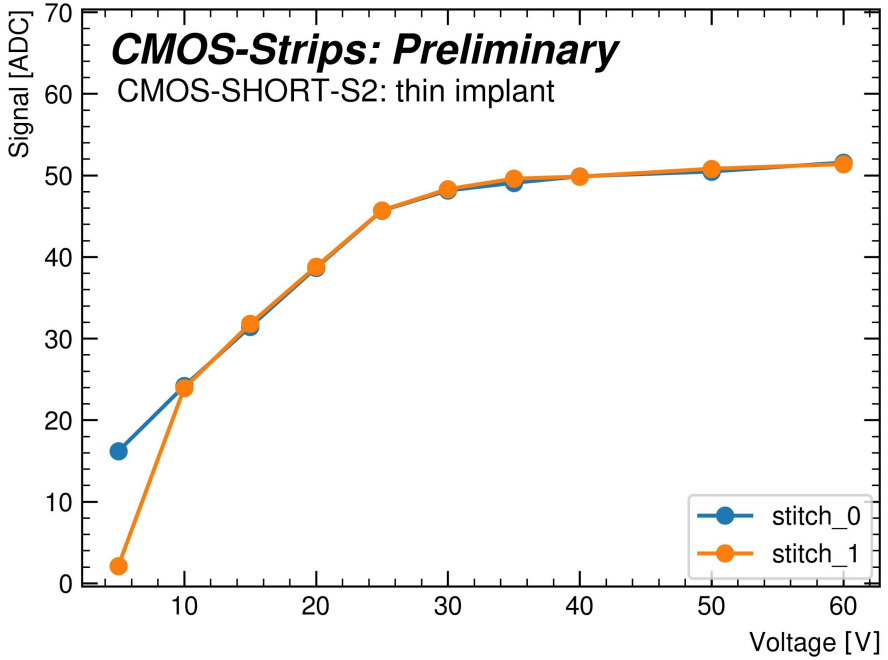




⇒ Move source to scan each stitched area

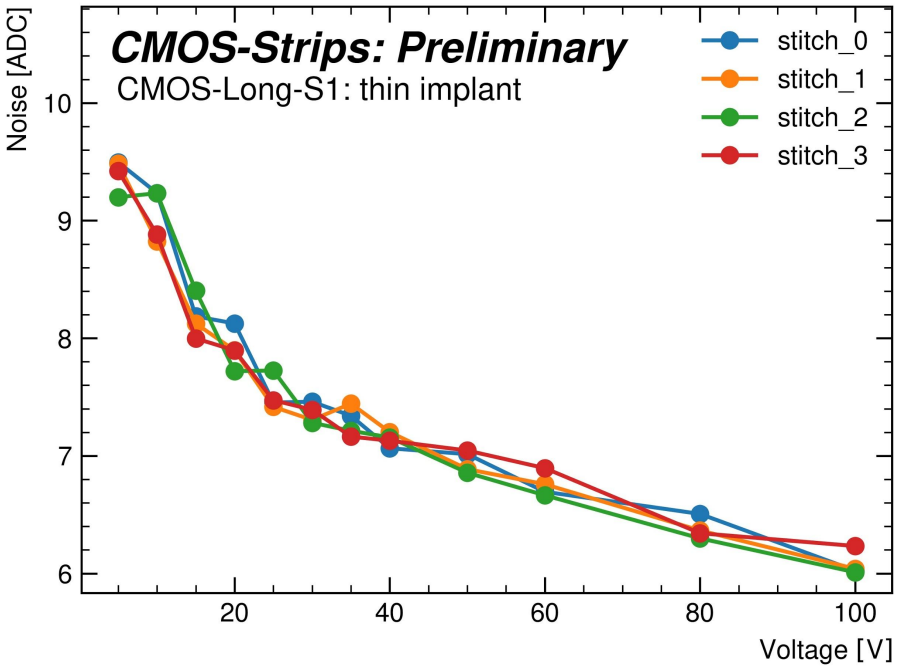
Source Measurements Results - Signal

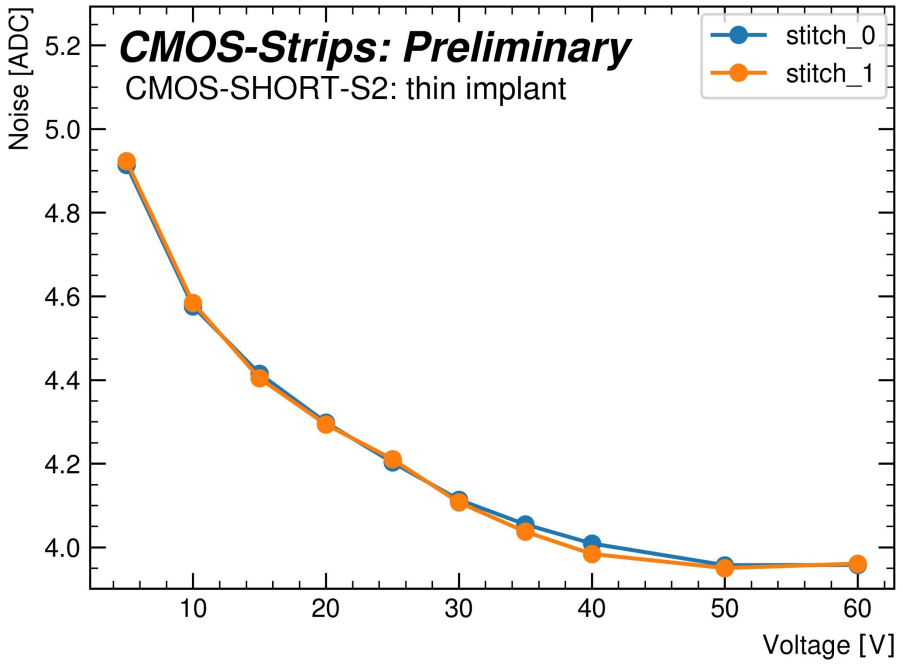




- **No evidence of any effect of stitching on the charge collection for the thin implant design**
- No differences between long and short sensors

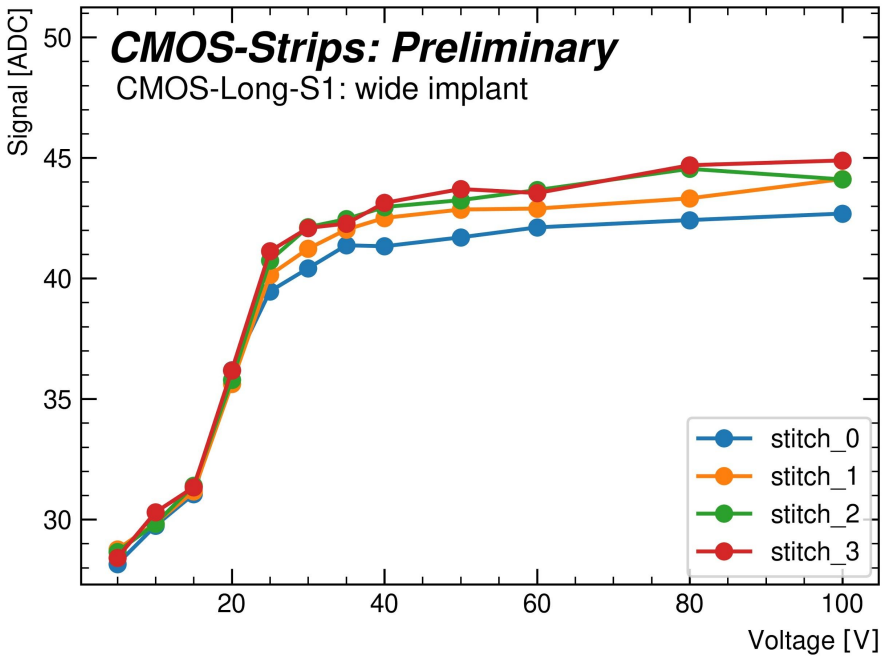
Source Measurements Results - Noise

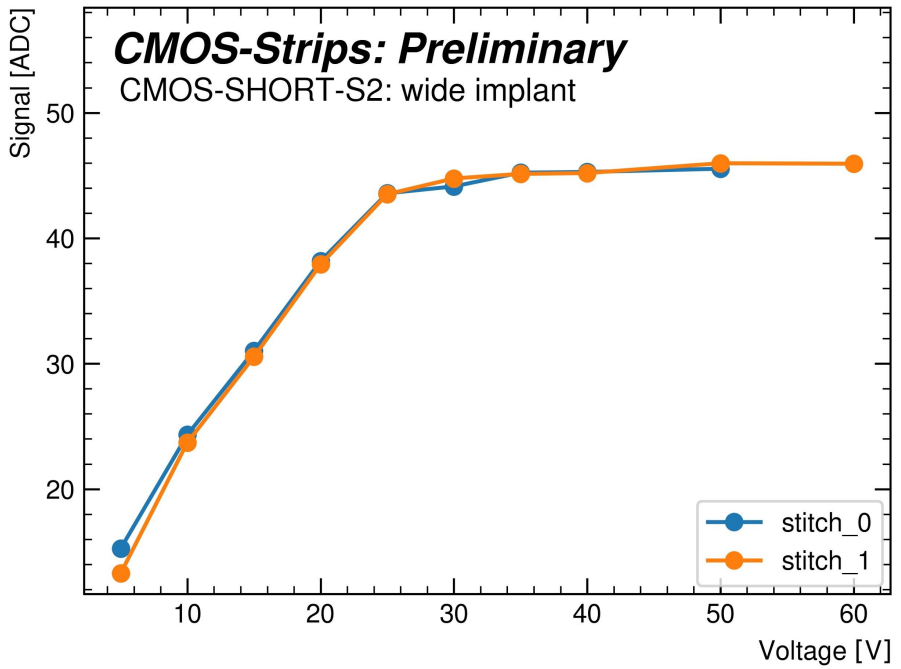




- **No evidence of any effect of stitching on the charge collection for the thin implant design**
- Low signal-to-noise ratio

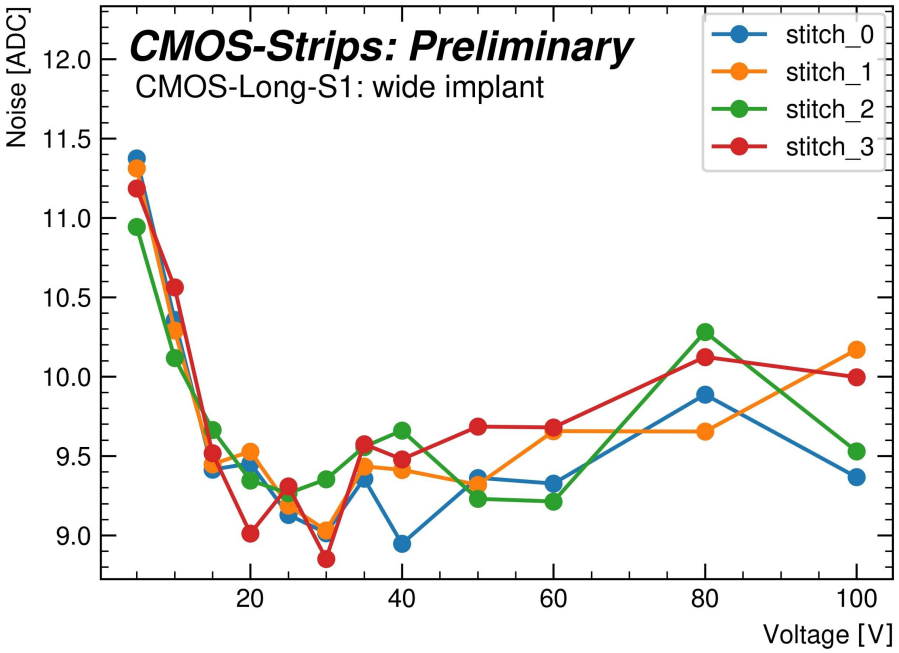
Source Measurements Results - Signal

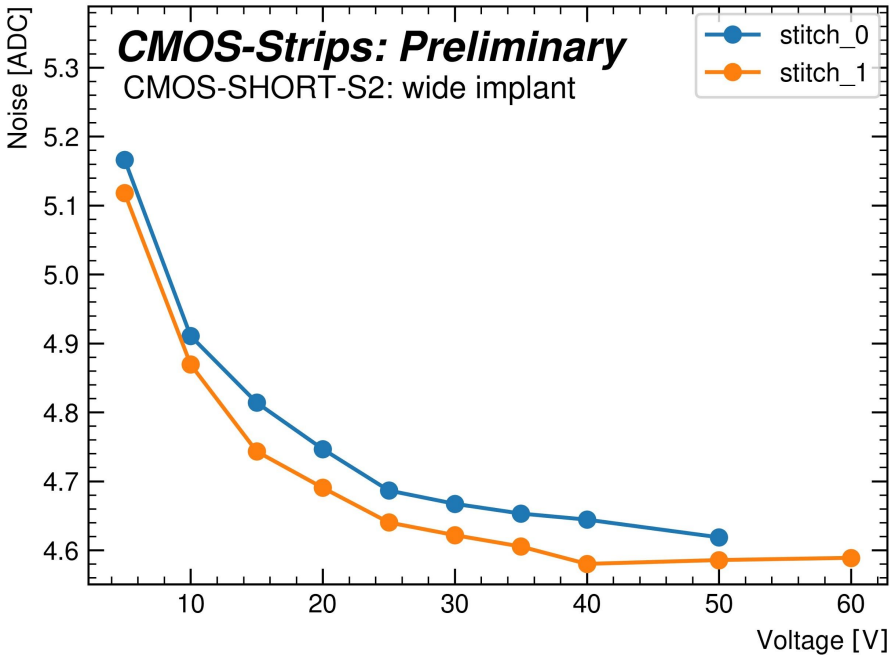




- **No evidence of any effect of stitching on the charge collection for the wide implant design**
- Need to understand effect of the 2 different strip designs used in the “wide” sensor

Source Measurements Results - Noise





- **No evidence of any effect of stitching on the charge collection for the wide implant design**
- Low signal-to-noise ratio

Summary and outlook

- Successful design, production and measurements of first passive CMOS strip sensors
- “Wide” sensor design is better suited to withstand high voltages
- Breakdown voltage for good sensors is larger than 250 V
- **No negative effect from the stitching could be observe in the measurements conducted**
- First batch with backside processing issues showed electrical problems ⇒ ***solved in the second batch***
- Charge collection measurements for the second batch are currently performed
- Irradiation studies are planned
- Sensor were measured at the DESY test beam facility and analysis is ongoing

Thanks for your attention

Source Measurements - Setup

- Radioactive source housed in a plexiglas cylinder
  - Collimates the electrons towards the silicon sensor
  - Provides shielding
- Two plastic scintillator-photomultiplier combinations
  - trigger for the readout of the sensor
  - Area of 4 x 4 mm2 and 45 x 45 mm2
  - 4 mm thickness