Characterization of passive CMOS strip detectors

Marta Baselga[1,*], Leena Diehl[2], Ingrid-Maria Gregor[1,3], Marc Hauser[2], Tomasz Hemperek[3], Jan Cedric Hönig[2], Sven Mägdefessel[2], Ulrich Parzefall[2], Arturo Rodriguez Rodriguez[2], Surabhi Sharma[1], Dennis Sperlich[2], Tianyang Wang[3], Liv Wiik-Fuchs[2]

DESY[1], University of Freiburg[2], University of Bonn[3]

Abstract

Silicon detectors are currently filling the trackers of largest particle accelerators and colliders. Their radiation hardness, spatial resolution and availability in large volume foundries make silicon the best candidate for tracking detectors. Current experiments such as ATLAS in the LHC and future experiments foresee to populate the innermost tracking layers with silicon detectors. But not so many foundries are capable of fabricating large area silicon detectors with a production line, therefore CMOS foundries are excellent candidates to be explored.

Introduction

- In this project we want to investigate passive strip sensors fabricated in a CMOS foundry
- The strip sensors are fabricated in LFoundry with a 150 nm process. They used a float zone p-type, 150 µm thick wafer, with a resistivity of 2 kΩ cm
- Strips were fabricated stitching a reticle of 1 cm^2
- There are two different sensors (fig. 3):
  1. Regular implant (40 strips) (fig. 1)
  2. Low dose implant (fig 2):
     - 20 strips with 30 µm width implant
     - 20 strips with 55 µm width implant

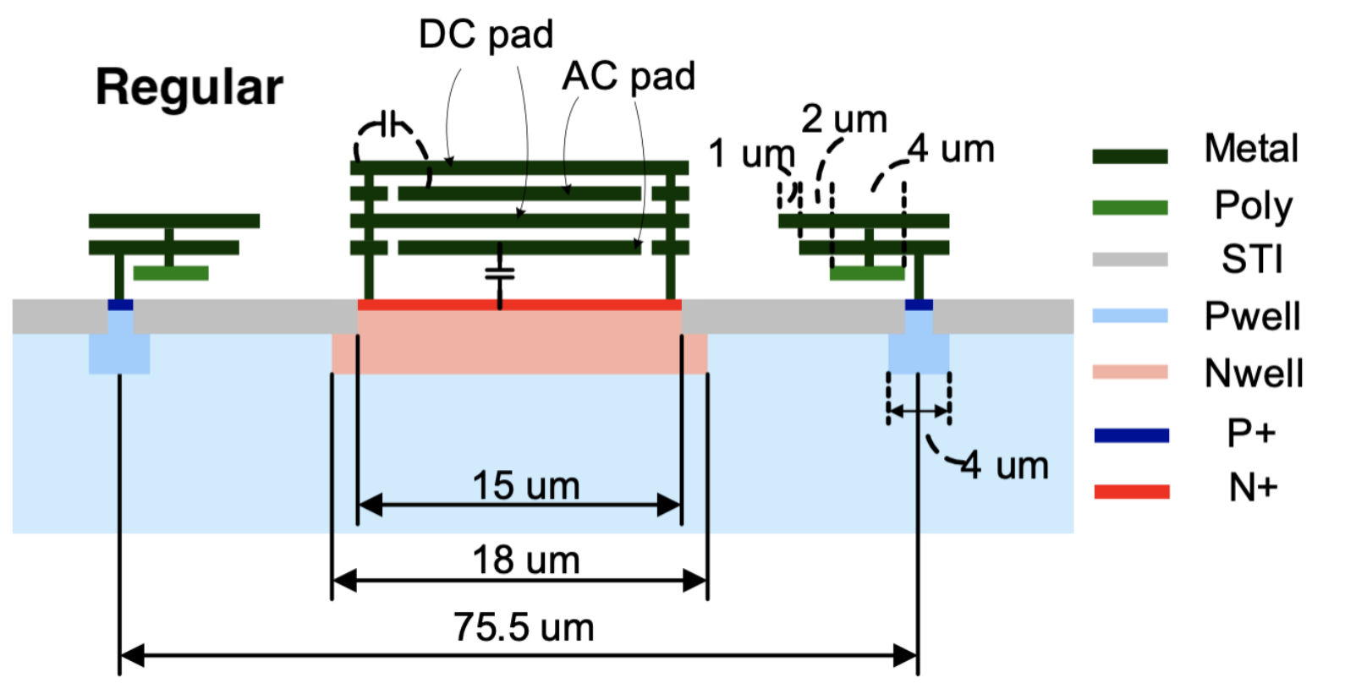

Figure 1:Regular implant cross section

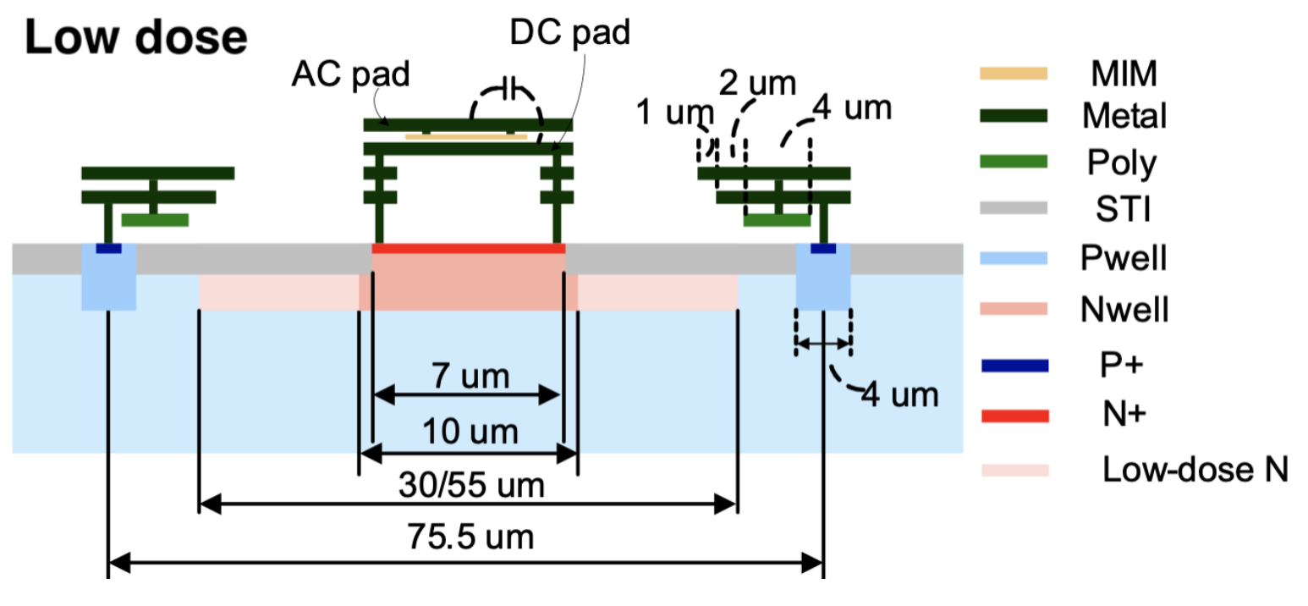

Figure 2:Low dose implant cross section

- Sensors have two length, 2 cm (short) and 4 cm (long)

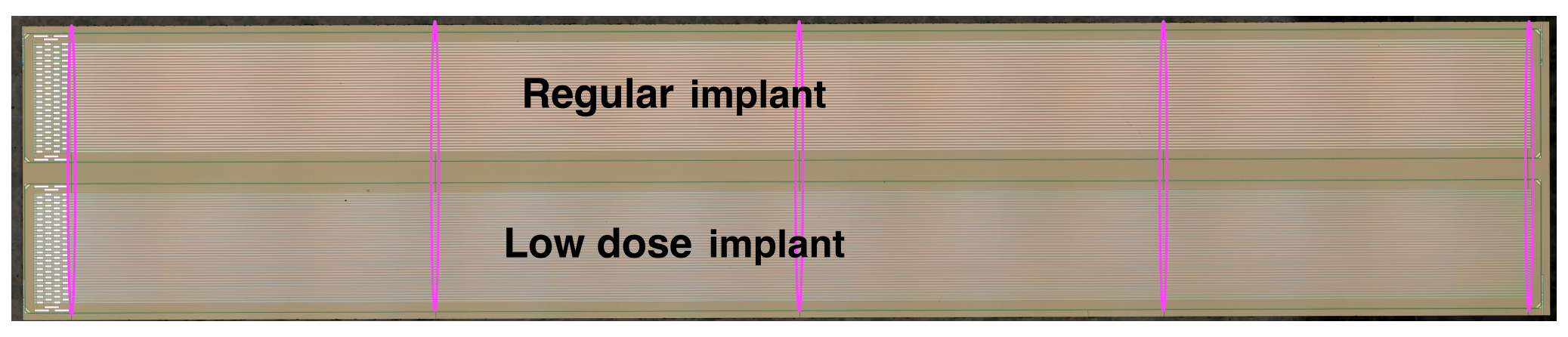

Figure 3:Image of the 4 cm sensor (long). In pink are the stitching points

Measurements of unirradiated sensors

Electrical characterization at room temperature:

- Sensors reach 300 V before breaking down (fig. 4)
- Sensors are fully depleted between 30 V and 36 V (fig. 5)

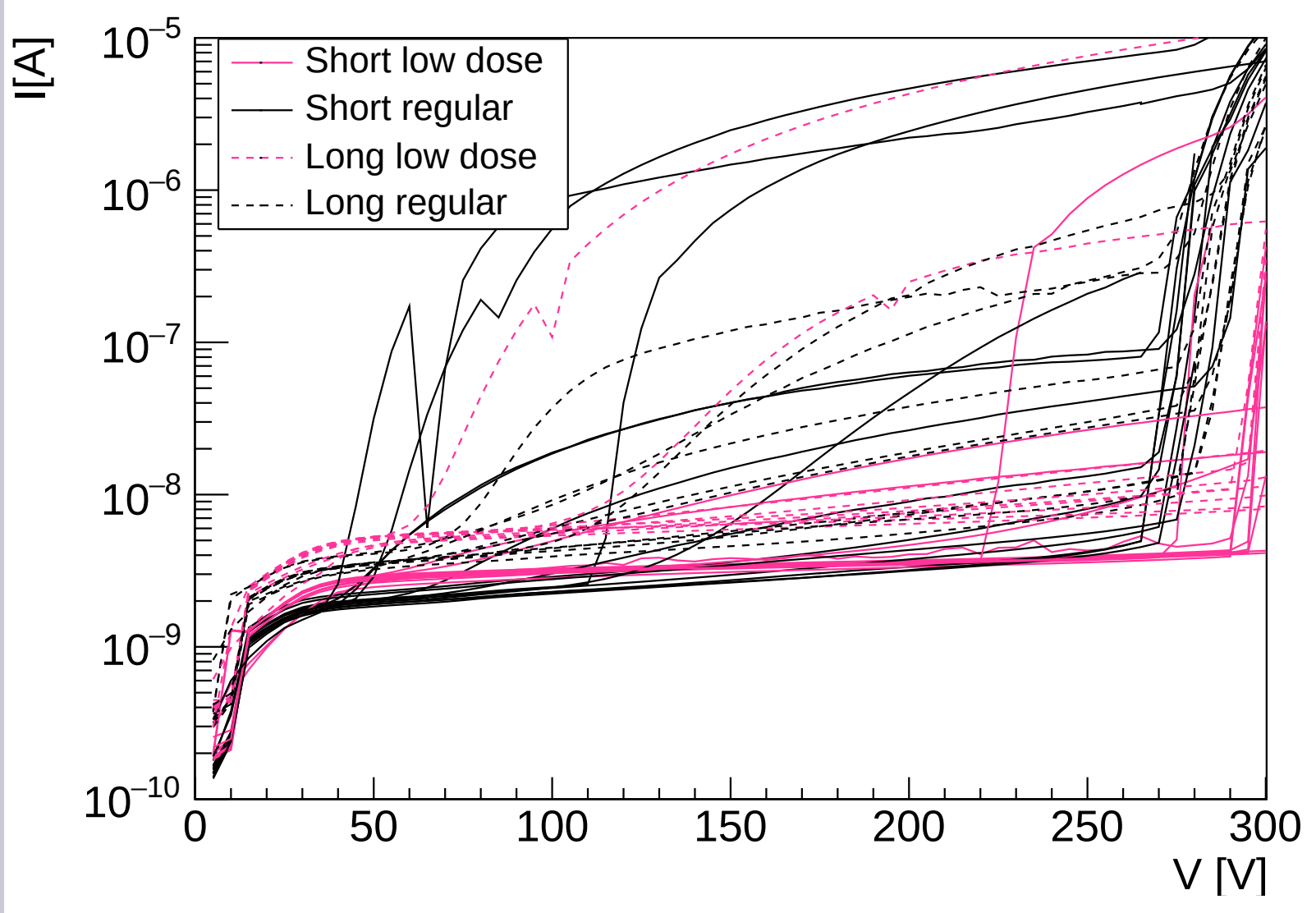

Figure 4:Current voltage characteristics

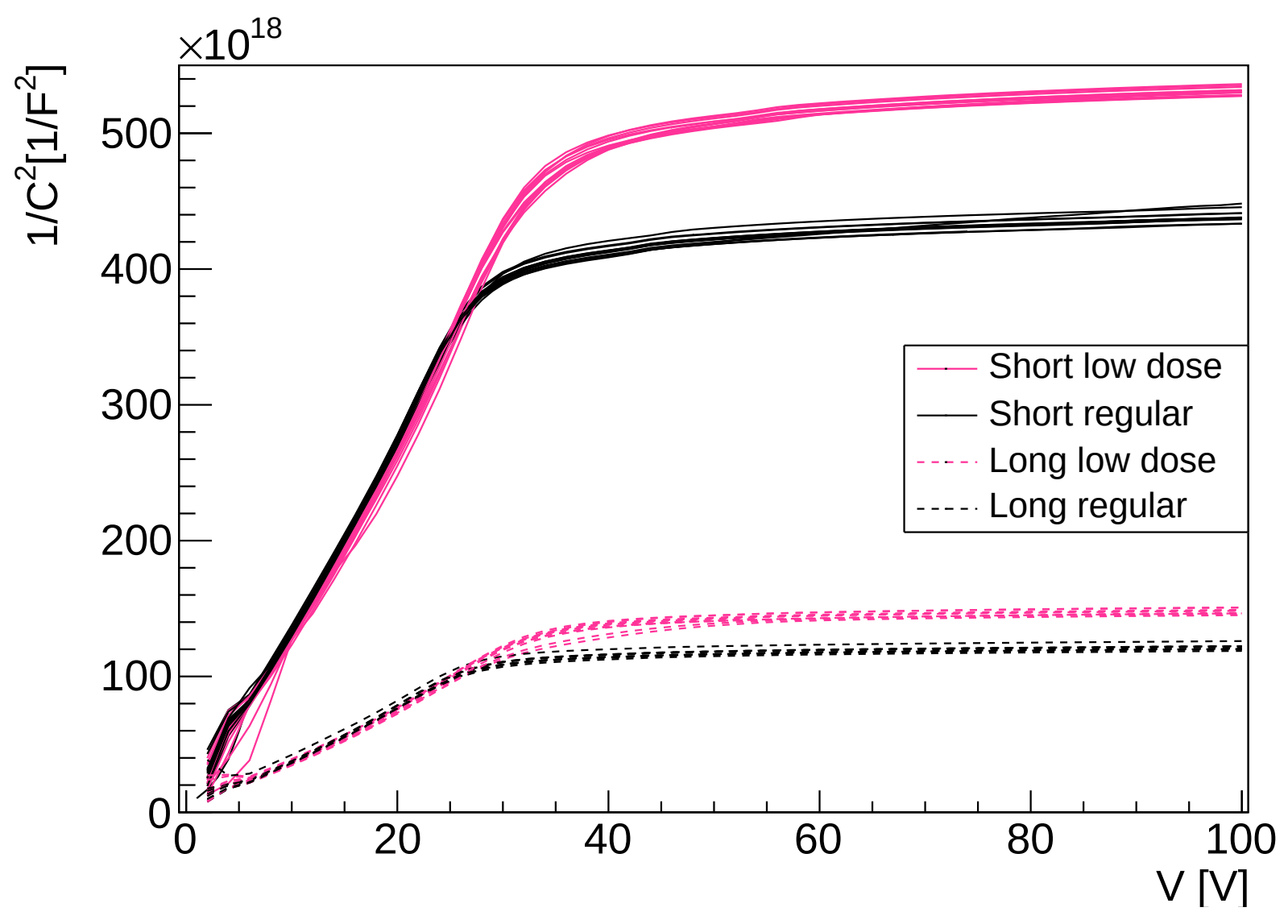

Figure 5:Capacitance voltage characteristics

Source measurements:

- A sensor was tested with an ALiBaVa setup (ref. [1]) using a Sr^{90} radioactive source at room temperature (fig. 6)
- The charge, in fig. 7, is higher for the regular implant sensors than the low dose implant one, as shown in ref. [2, 3]. That is due to higher capacitance of the geometry (shown in simulations in ref. [4]).

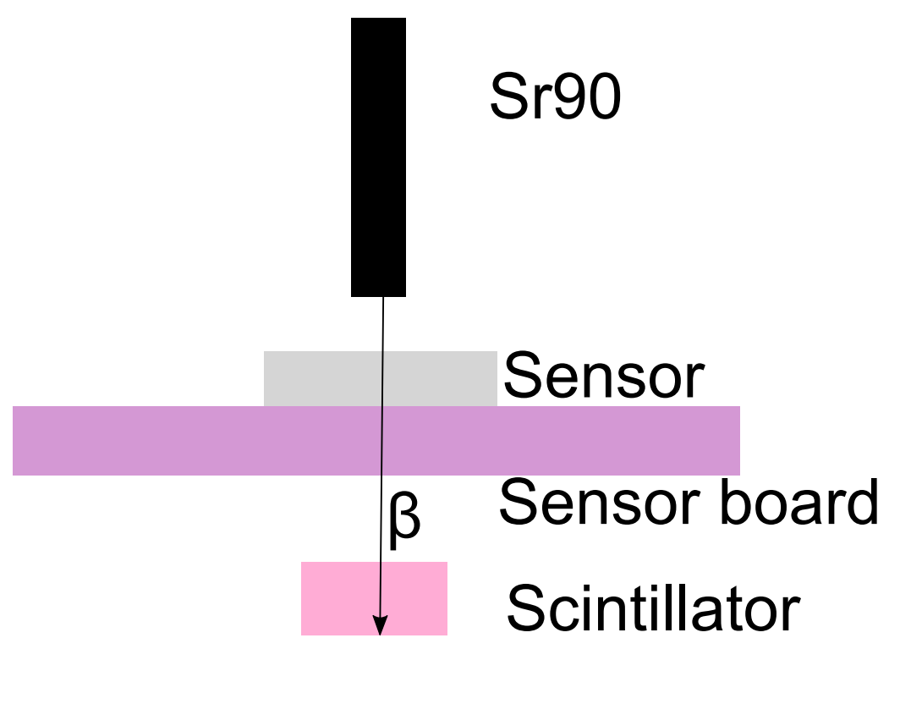

Figure 6:Sketch of the setup

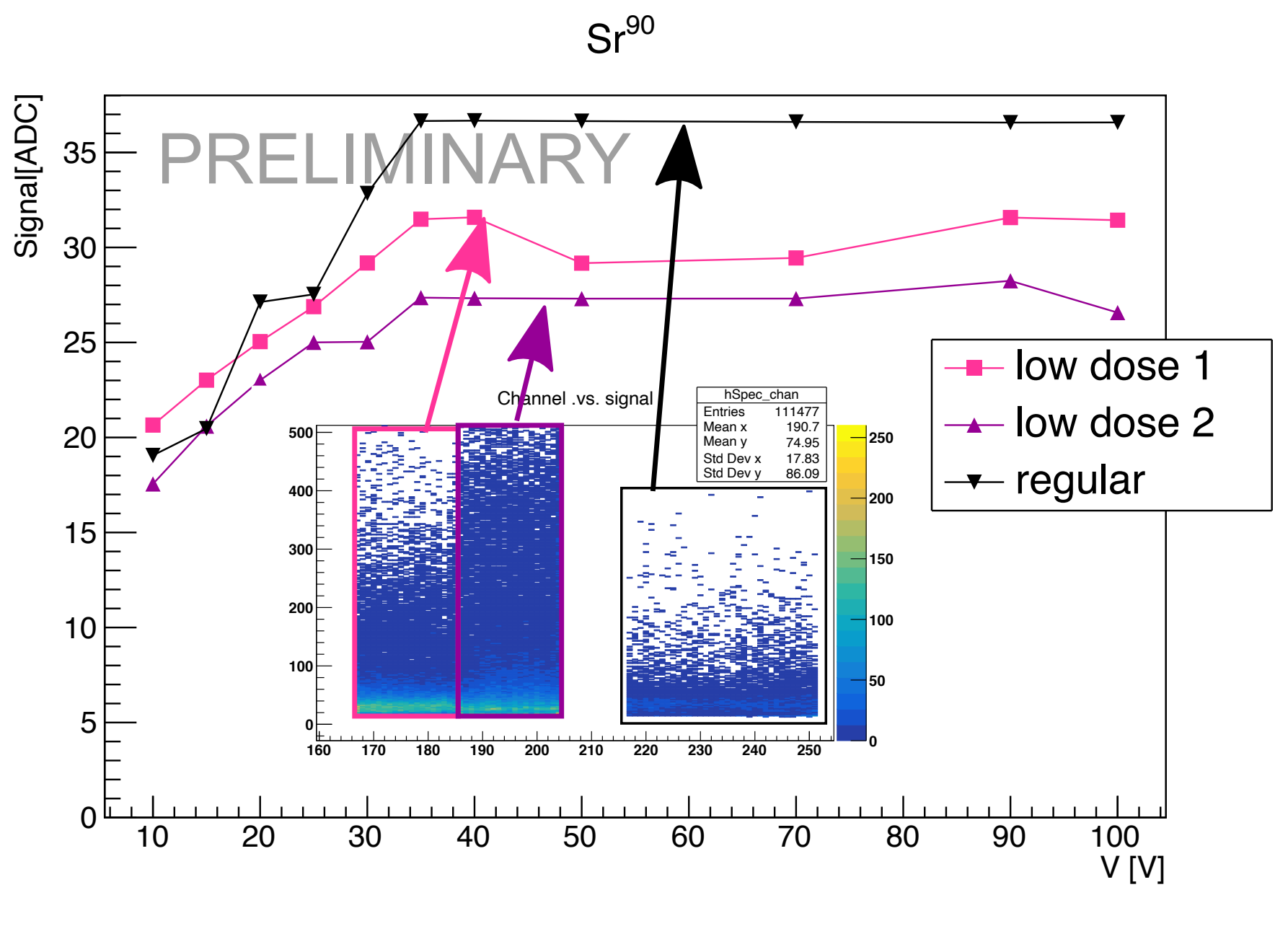

Figure 7:Signal in ADC separated by the 3 different implants

Irradiated sensor

- The sensors were irradiated with 23 MeV protons in Karlsruhe with different fluences and annealed for 80 min at 60 °C

Electrical characterization:

- Measurements taken at −20 °C
- The sensors irradiated with $5 \times 10^{14}\,n_{eq}/cm^2$ can stand up to 500 V without breaking down and are fully depleted ∼ 60 V (fig. 8, 9)

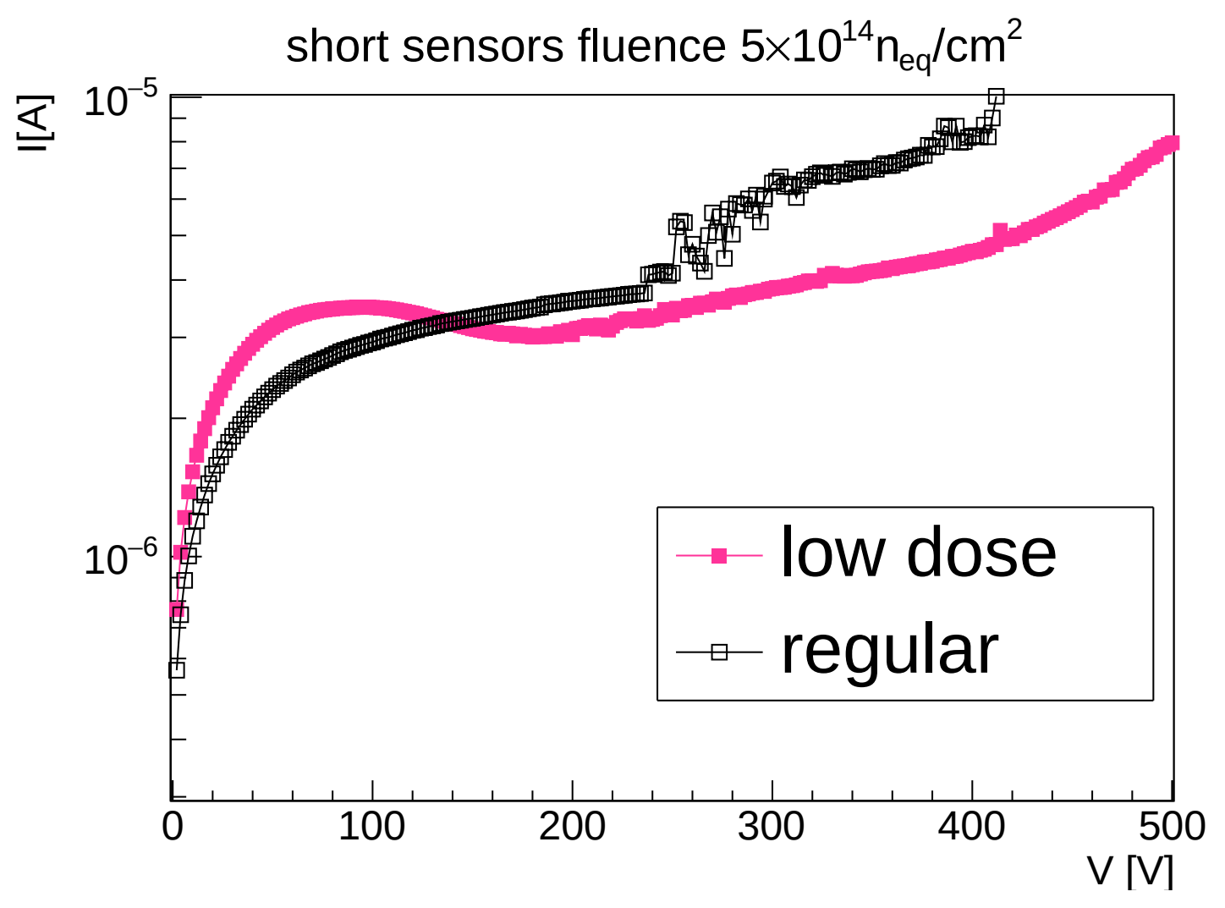

Figure 8:Current voltage of the irradiated sensor

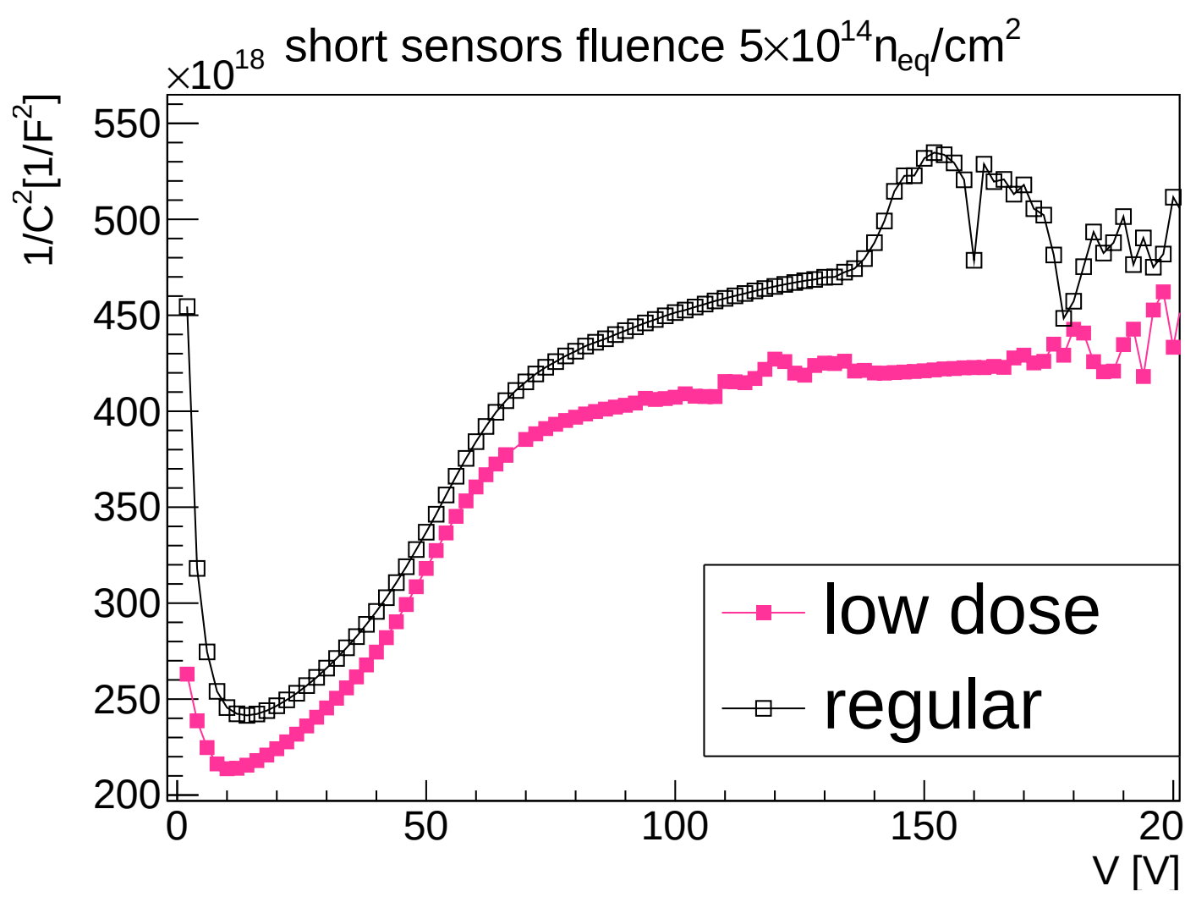

Figure 9:Capacitance voltage of the irradiated sensor

Source measurement:

- The sensor was tested with the ALiBaVa readout setup with a Sr$^{\mathbf{90}}$ radioactive source in a cold environment (fig. 10)

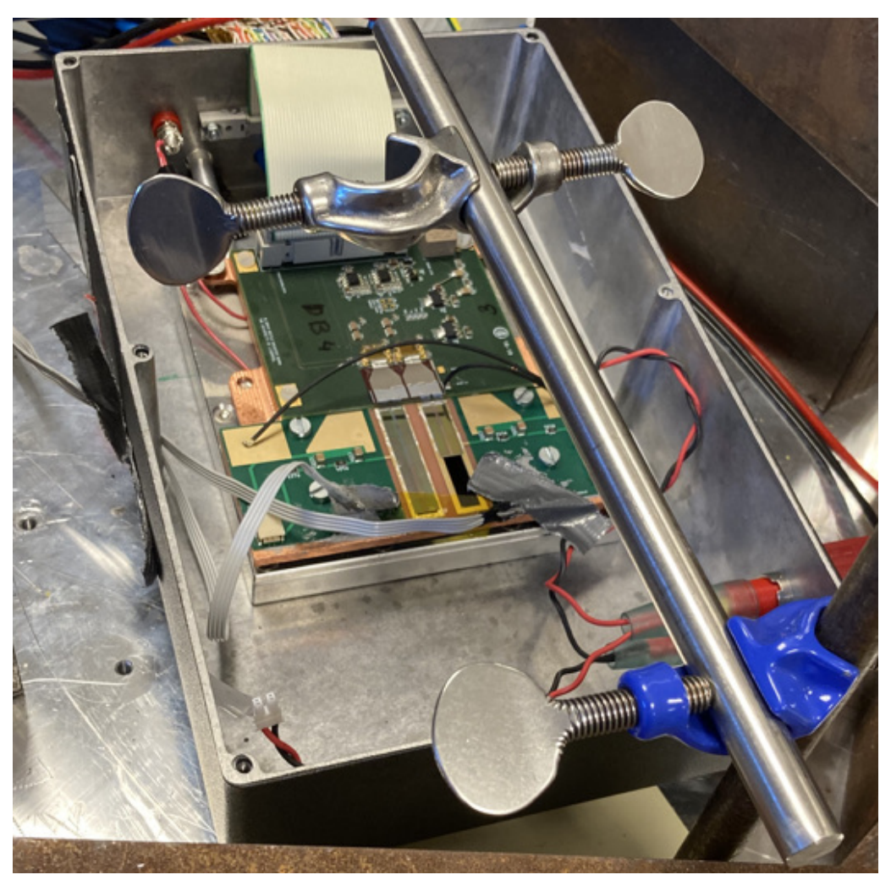

Figure 10:Image of the setup. The sensors are bonded to the ALiBaVa daughter board

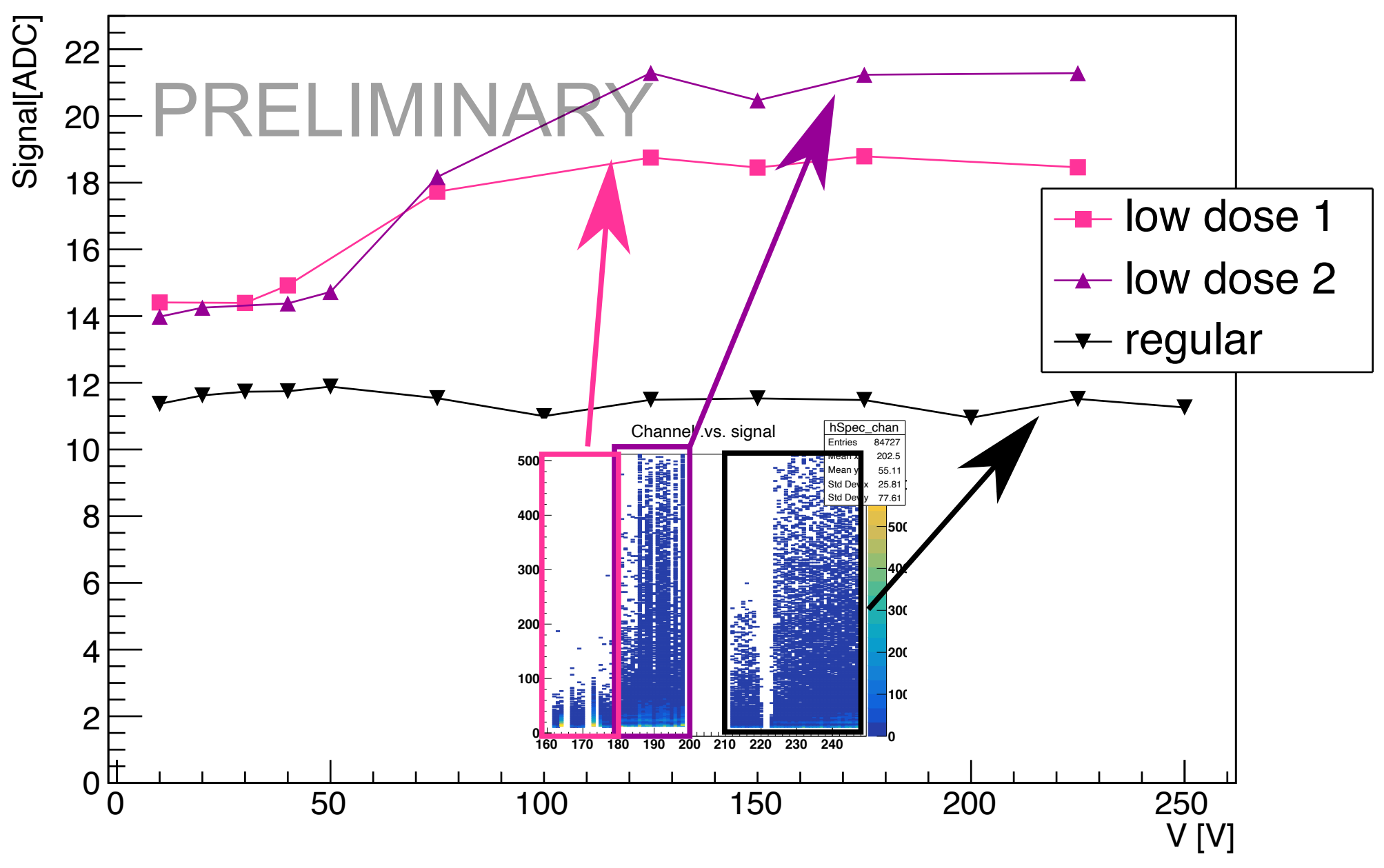

Figure 11:Signal in ADC of the sensor irradiated with $5 \times 10^{14}\,n_{eq}/cm^2$. The regular implant part has the charge decreased substantially after irradiation.

- The detector after being irradiated with protons with the fluence $5 \times 10^{14}\,n_{eq}/cm^2$ is still showing charge
- The regular implant detector has lower charge after irradiation than the low dose implant detector (fig. 11). That is the opposite behaviour than the unirradiated detectors (fig. 7). The higher signal after irradiation for the low dose implant design was expected.

Conclusions

- CMOS passive strips show excellent results before irradiation
- First measurements after irradiation show no negative effect of the stitching process
- Further investigation to more fluences, neutron irradiated sensors and testbeam analysis ongoing

References

[1] R. Marco-Hernández et al., *ALIBAVA: A portable readout system for silicon microstip sensors*

[2] Jan Cedric Hoenig et al., 37th RD50 workshop 2020 on-line

[3] Arturo Rodriguez Rodriguez et al., Trento workshop 2021

[4] Marta Baselga et al., 38th RD50 workshop 2021 on-line

12th Position Sensitive Detectors 2021 - Birmingham

*marta.baselga@cern.ch