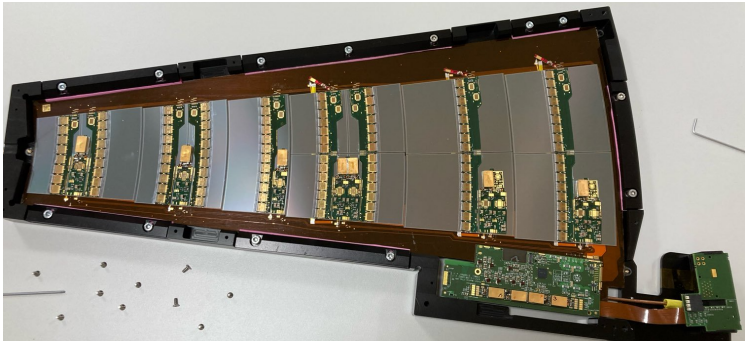
Performance of Stitched Passive CMOS Strip Sensors

M. Baselga, L. Diehl, I-M Gregor, T. Hemperek, J-C Hönig, S. Mädgefessel, U. Parzefall, A. Rodriguez, S. Sharma, D. Sperlich, T. Wang, L. Wiik-Fuchs

Motivation

Why passive CMOS detectors?

- Large area detectors are limited to microelectronics foundries
- This project wants to study the production of strip sensors in a CMOS foundry

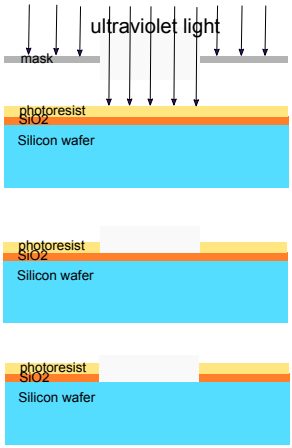


Picture of the petal, ATLAS endcap substructure. The silicon strip sensors have an area around $10 \times 10\,\mathrm{cm}^2$

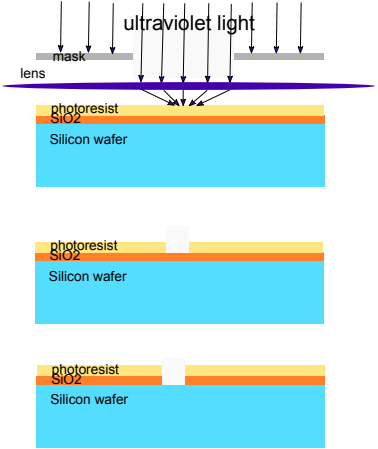
What changes regarding microelectronic foundries?

Photolitography

Microelectronics photolitography



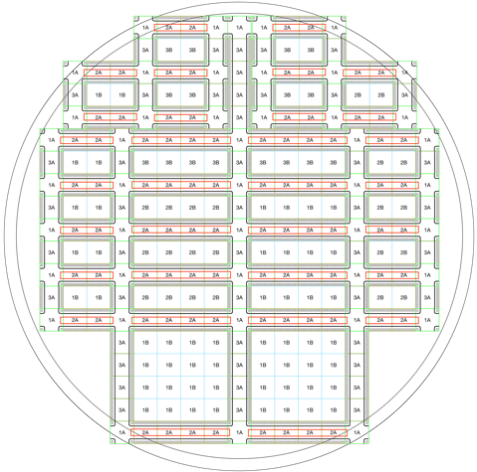
CMOS photolitography



[Image from wikipedia]

Passive CMOS strips

Mask for passive CMOS fabrication

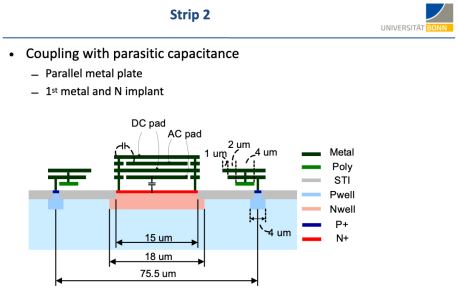


Passive CMOS strips project

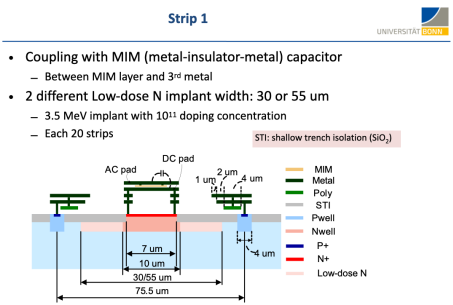
- Collaboration with Uni Freiburg, Uni Bonn and DESY
- Fabricated in LFoundry with 150 nm
- It has strip and pixel sensors (pixel presentation by Yannick Dieter)
- Reticles are around 1 cm^2
- 1A and 2A are the strip (1A is the bottom and top of the strip)
- Strips are 2 cm^2 and 4 cm^2 long

Strip designs. Sensors have two flavours (acctually they are 3)

Regular implant



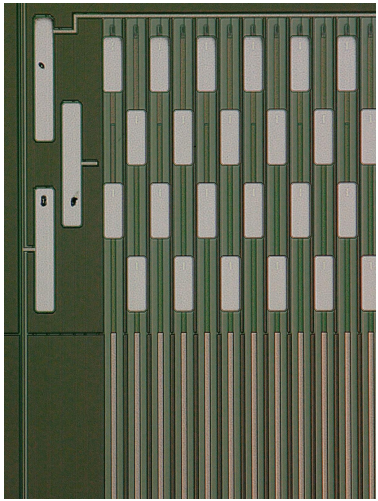
Low dose implant



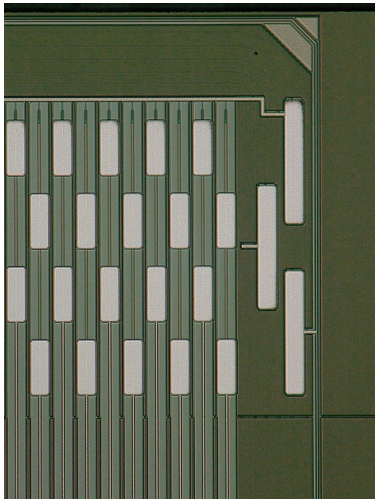
- Wafer is 150 µm thick
- There are 2 strip sensors which 40 strips each
  1. 40 regular implant strips
  2. 40 low dose implant strips (20 strips with 30 µm and 20 strips with 55 µm)

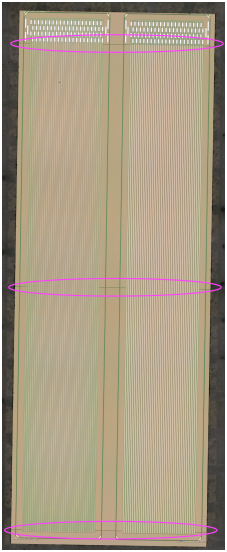
Pictures of the stitching

Regular implant



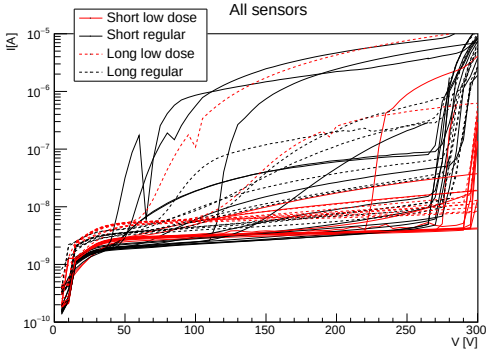
Low dose implant



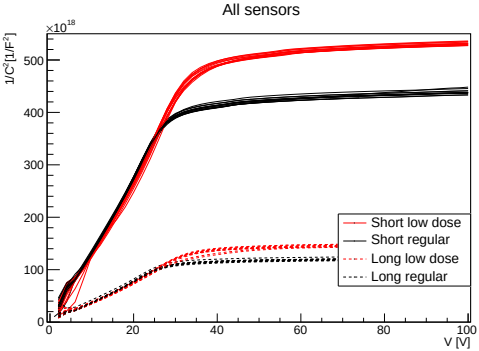


IV and CVs

IV curve



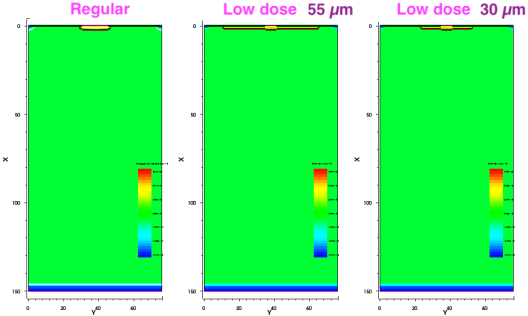
CV curve



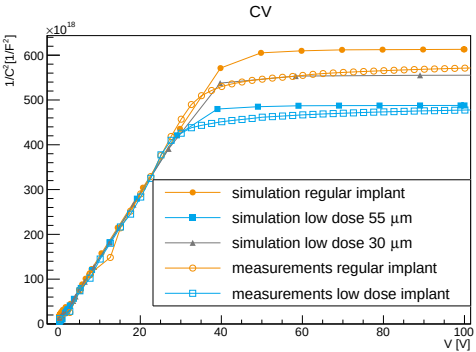
- The detectors show good electrical performance till breakdown 300 V
- Due to differences of the strips, they show differences with the CVs
- They have full depletion at 30 V and 36 V

TCAD simulations

Doping

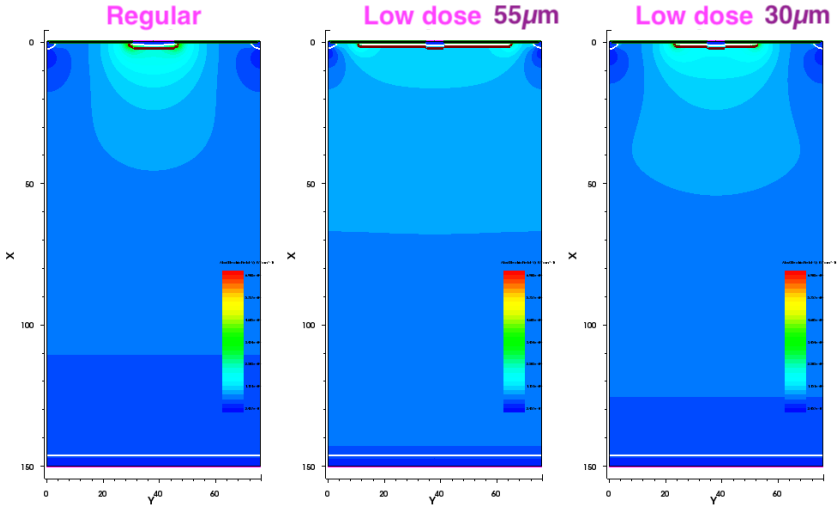


CV comparison



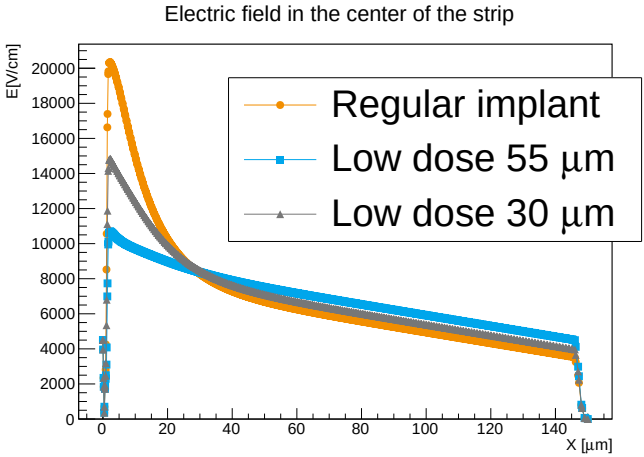
TCAD simulation

Electric field



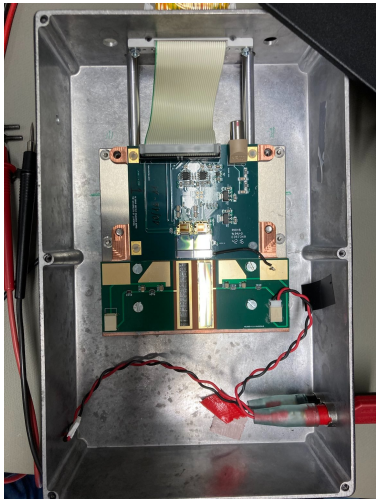
TCAD simulation

Electric field at 100 V

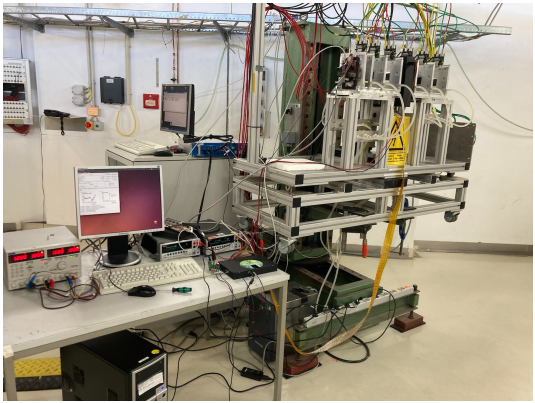


Testbeam at DESY (done in April 2021)

Sensor setup with ALiBaVa



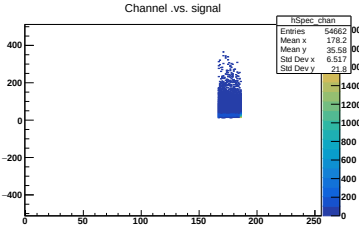
Testbeam at DESY (TB22)

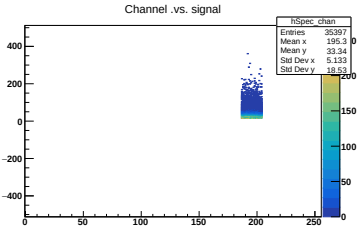


Output from alibava at 100 V

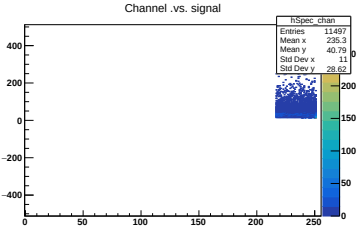
The channels are separated for the three different sensor flavours

Low dose implant (separated 20 strips)





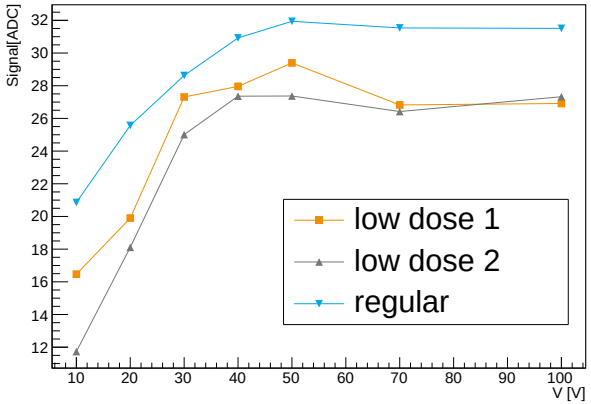
Regular implant



Preliminary results of testbeam Alibava data

DESY testbeam (using 4.6 GeV electrons)

Alibava signal (Preliminary), not including telescope data



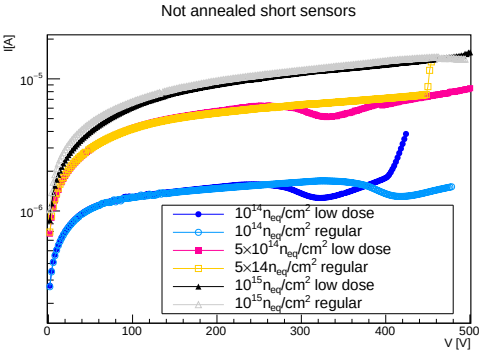
Preliminary results

- Regular and low dose implant have different signal, calibration needs to be done
- Full reconstruction of the testbeam data ongoing

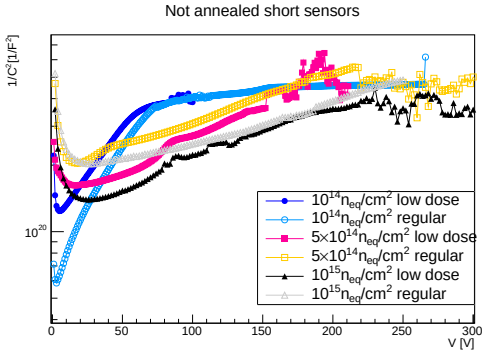
Short sensors irradiated with protons at KIT (23 MeV)

Measured at $-20\,^{\circ}C$

IV



CV at 1 kHz



- Annealing steps needs to be followed but they show good behaviour after irradiation
- Freiburg University colleagues are investigating neutron irradiated samples

Future steps

Conclusions

- No negative effects from stitching so far, first IV's and CV's after irradiation do not show any problem

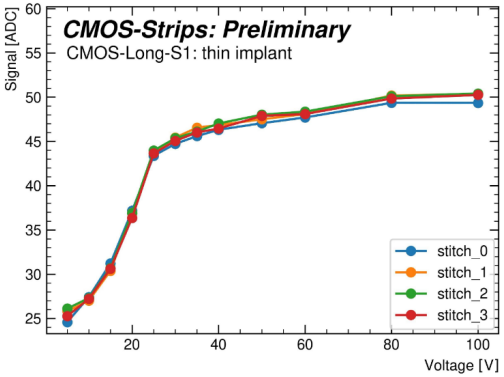
Future steps

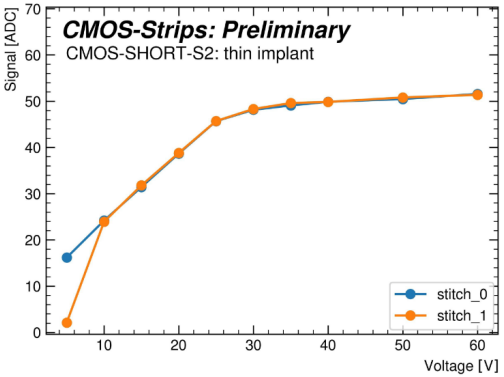
- Further electrical studies of the irradiated samples
- Test with a radioactive source
- Testbeam with the irradiated sensors

The measurements leading to these results have been performed at the Test Beam Facility at DESYHamburg (Germany), a member of the Helmholtz Association (HGF).

backup

Alibava measurements regular sensor

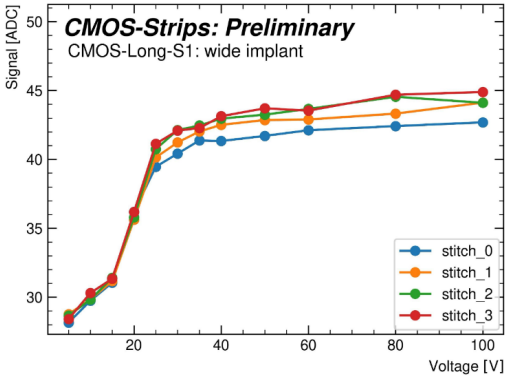


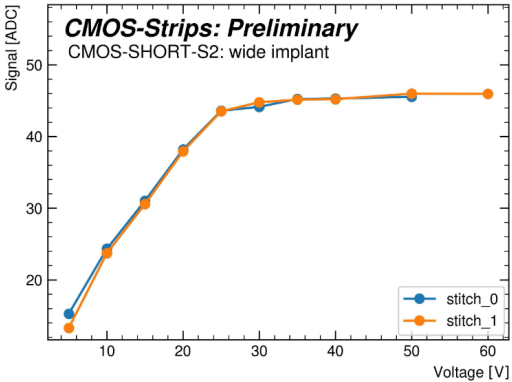


[Arturo Rodriguez, Trento meeting 2021]

- Measurements taken with an ALiBaVa setup with Sr^{90} source at 4 different stitching points of the sensors
- No effect of stitching

Alibava measurements low dose

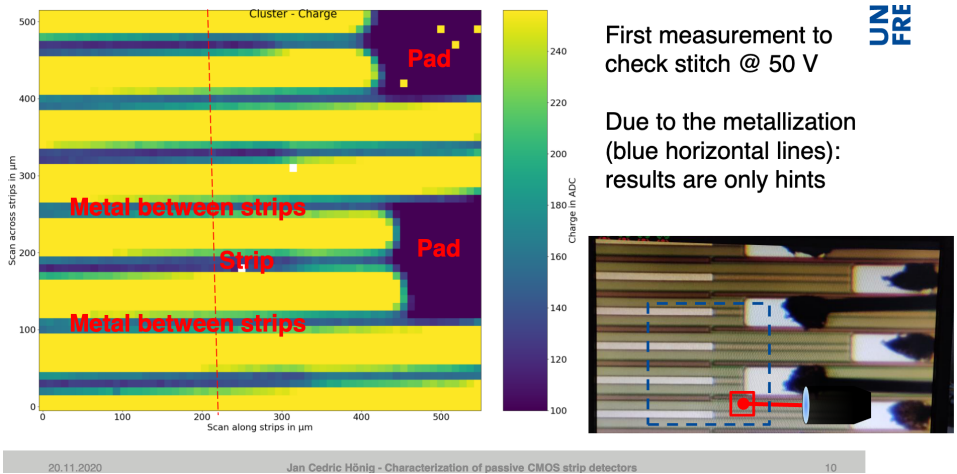




[Arturo Rodriguez, Trento meeting 2021]

- Probably some difference due to higher noise of the sensor (noise plot in backup slides)

TCT measurements



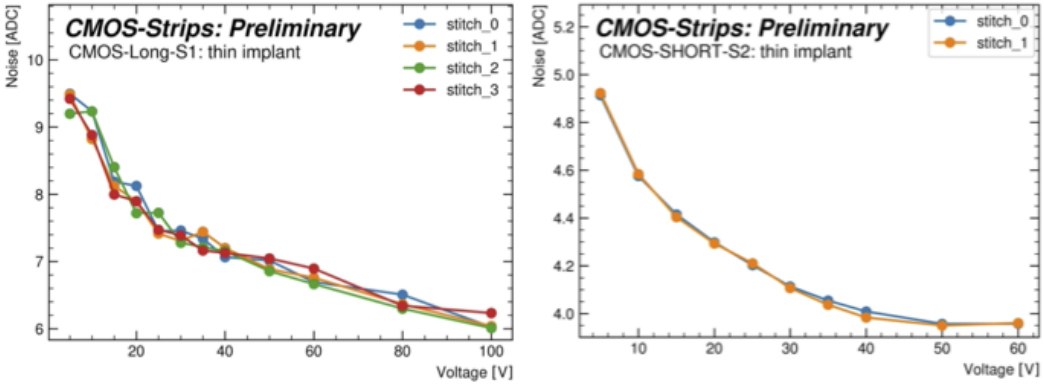
First measurement to check stitch @ 50 V

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

20.11.2020 Jan Cedric Hönig - Characterization of passive CMOS strip detectors 10

[Cedric Hoenig, RD50 2020]

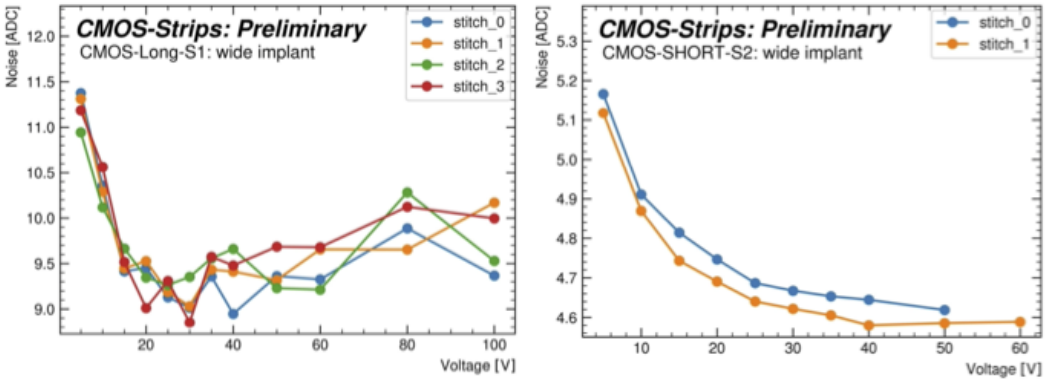
Alibava measurements → Noise



- No effect of stitching

[Arturo Rodriguez, Trento meeting 2021]

Alibava measurements→ Noise



- More difference in the regions, maybe due to higher noise

[Arturo Rodriguez, Trento meeting 2021]

Strips layout

Strip design – pad

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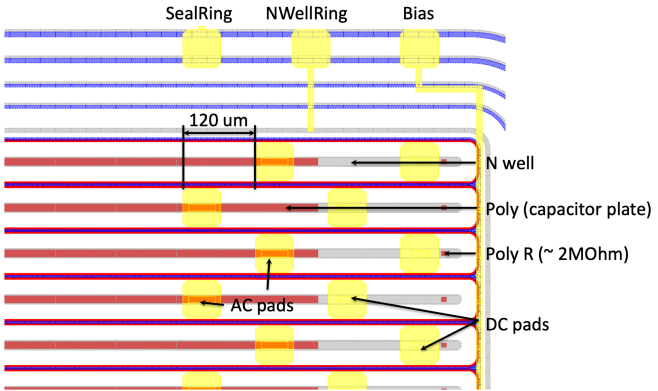

CV measurement with frequency