DESY.

“

It is the part of a wise man to keep himself today for tomorrow, and not venture all his eggs in one basket.

– Miguel de Cervantes (Don Quixote, Part I)

”

Single-Vendor Problem

- Silicon sensors have become indispensable in high energy physics.
- … only available from few foundries

Alternative vendors ?

- Vendor diversification through standardised industrial CMOS process
- Fast, cheap and wafer-scale production

Test Beam Results of Passive CMOS Strip Sensors

Naomi Davis on behalf of the CMOS Strip Detectors Collaboration

SiDet Meeting

November 21st

HELMHOLTZ

technische universität dortmund

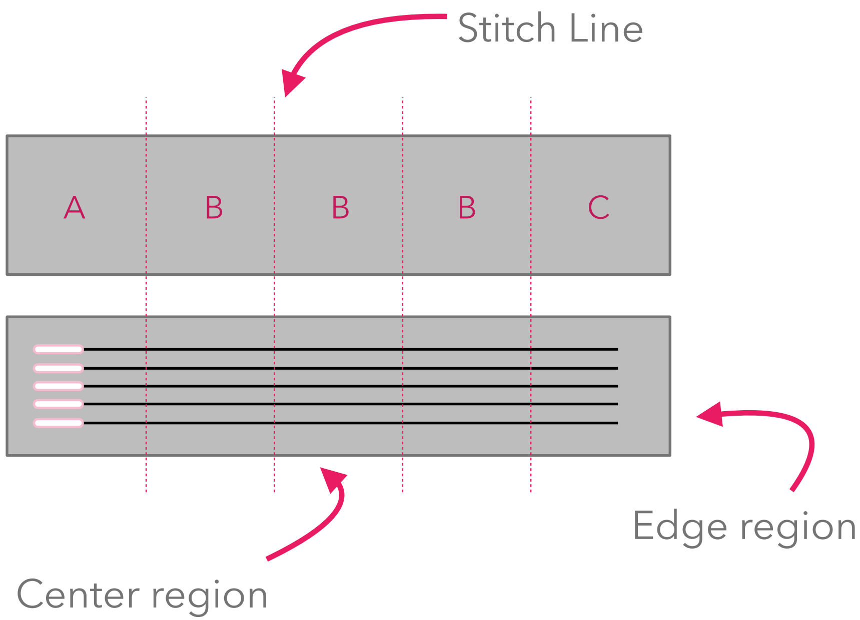
universität freiburg

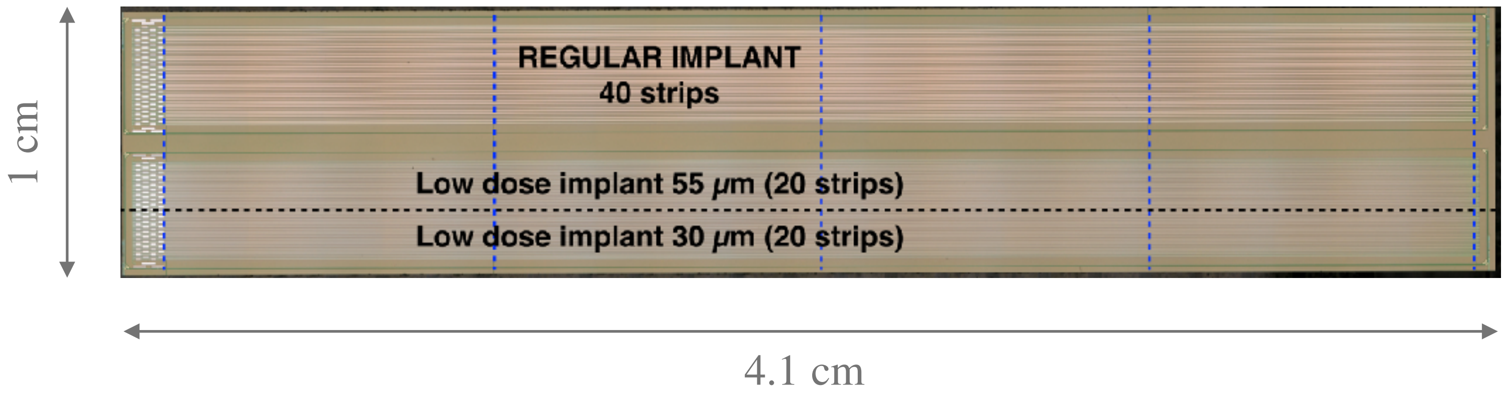
UNIVERSITÄT BONN

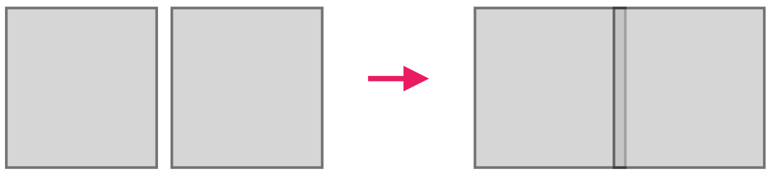
DESY.

CMOS Strip Sensors

- n-in-p sensor, 150 nm LFoundry technology
- 150 ± 10 um thickness, 75.5 um strip pitch
- Varying n-well doping concentration and width



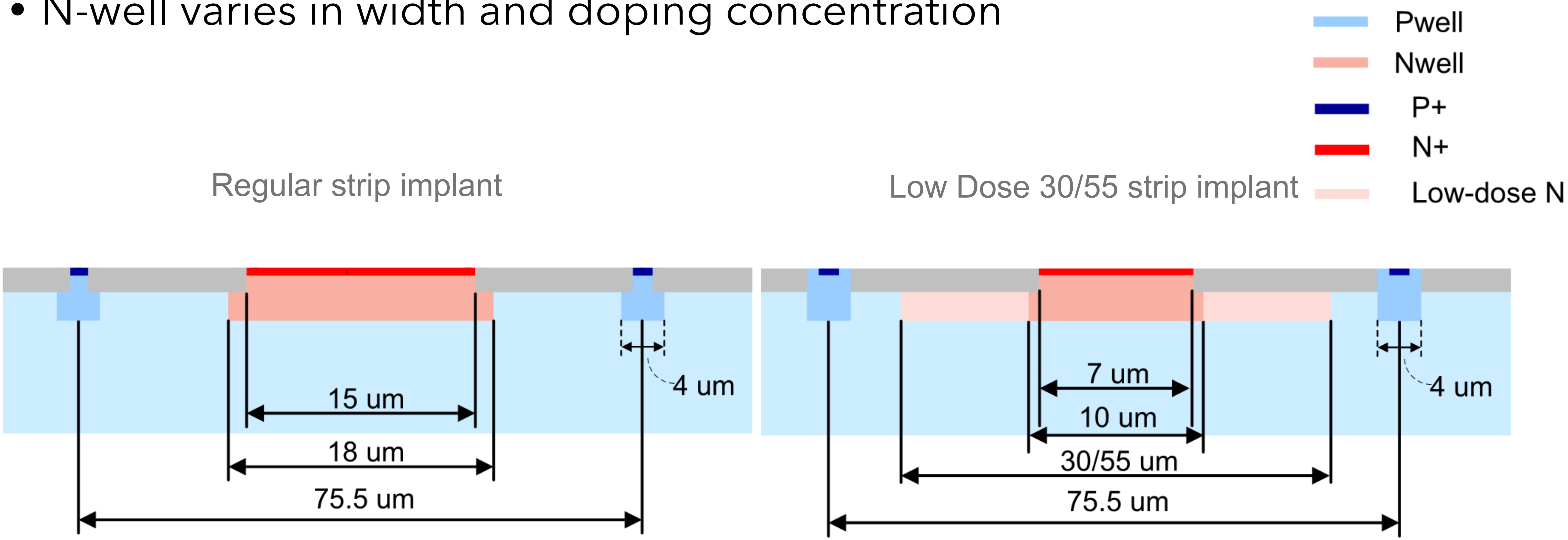




L. Diehl et al., *"Characterization of Passive CMOS Strip Sensors"*, NIMA, Vol 1022 (2022)
https://doi.org/10.1016/j.nima.2022.166671

Sensor Layout

- N-well varies in width and doping concentration



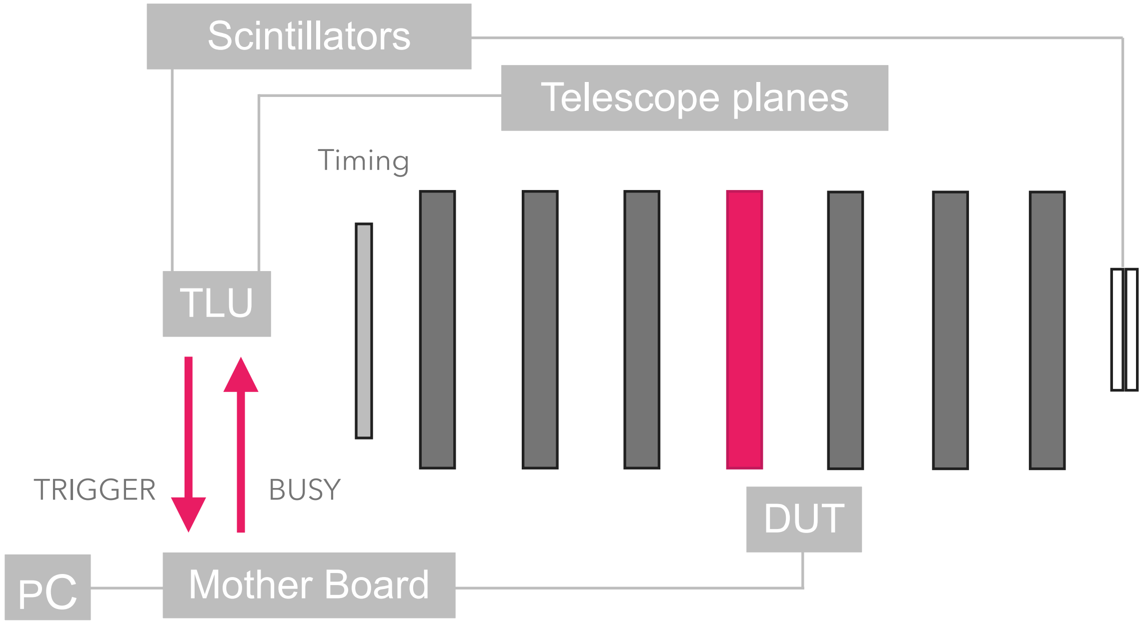
L. Diehl et al., *"Characterization of Passive CMOS Strip Sensors"*, NIMA, Vol 1022 (2022)
https://doi.org/10.1016/j.nima.2022.166671

Test Beam at DESY II

- TB campaigns in May22, Mar23 at DESY-II TB Facility
- EUDET telescope with 6 ALPIDE planes as reference (+ timing plane in Mar23)
- e^- beam energy: $3.4\ \mathrm{GeV}$, $4.2\ \mathrm{GeV}$
- Styrofoam cold box, cooling with dry ice

Mar23:
Unirradiated,
@100V bias, short

May22:
Irradiation with reactor neutrons in **Ljubljana**
3e14 @250V bias, long



J. Dreyling-Eschweiler et al., *"The DESY II test beam facility"*, NIMA, Vol 922 (2019)
https://doi.org/10.1016/j.nima.2018.11.133
H. Jansen et al., *"Performance of the EUDET-type beam telescopes"*, EPJ Techn Instrum 3, 7 (2016)
https://doi.org/10.1140/epjti/s40485-016-0033-2

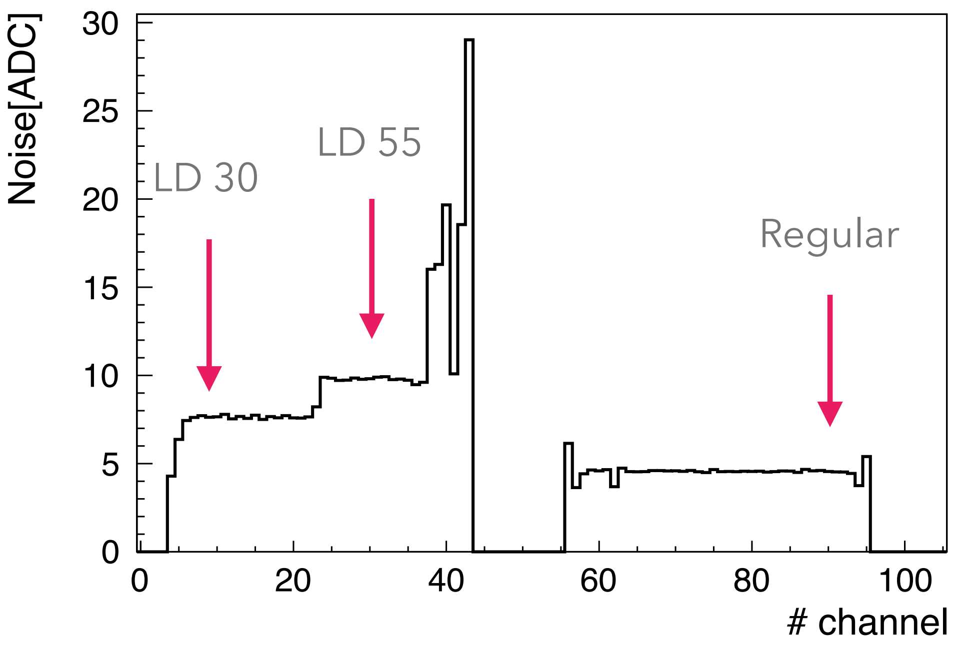
Sensor Readout

Unirradiated,

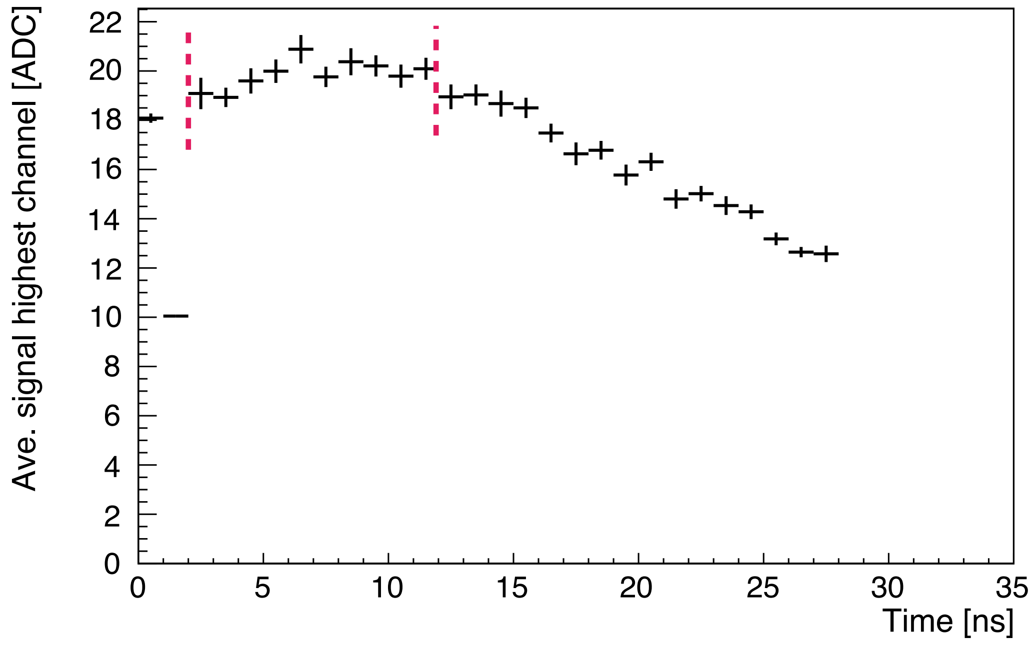
@100V bias, short

- DAQ: ALiBaVa readout system with a 128-channel Beetle r/o chip
- Reconstruction and Analysis with Corryvreckan: [EventLoaderALiBaVa]

Sensor noise per r/o channel



Average signal pulse shape



D. Dannheim et al., *"Corryvreckan: a modular 4D track reconstruction and analysis software for test beam data"*, J. Instr. 16 (2021) https://doi.org/10.1088/1748-0221/16/03/P03008

R. Marco-Hernandez et al., *"ALIBAVA: A portable readout system for silicon microstrip sensors"*, NIMA, Vol 623 (2010) https://doi.org/10.1016/j.nima.2010.02.197

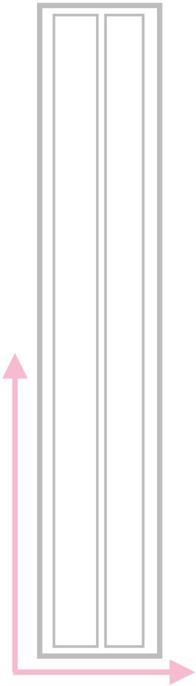
In-Strip Efficiency

Efficiency within the strip of an unirradiated sample

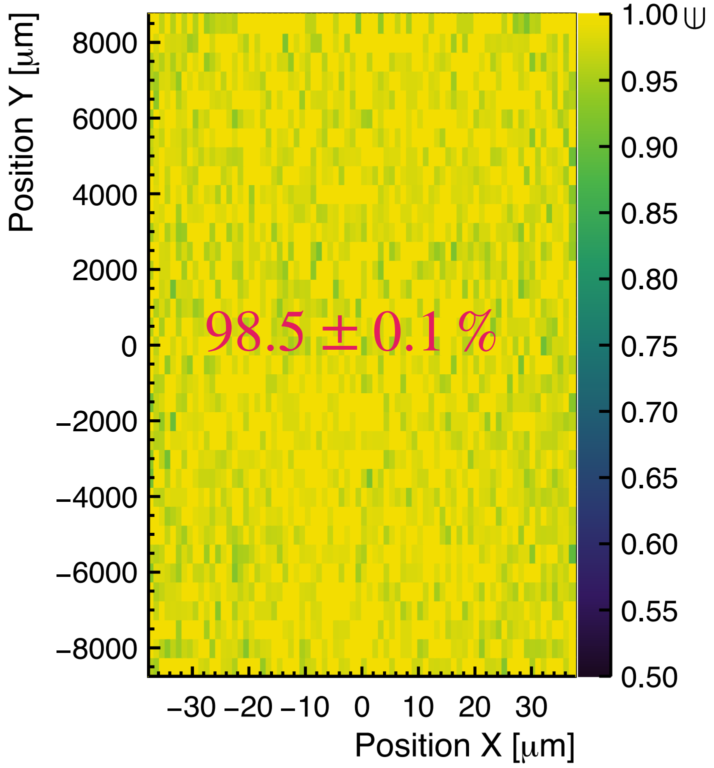
Unirradiated

@100V bias, short

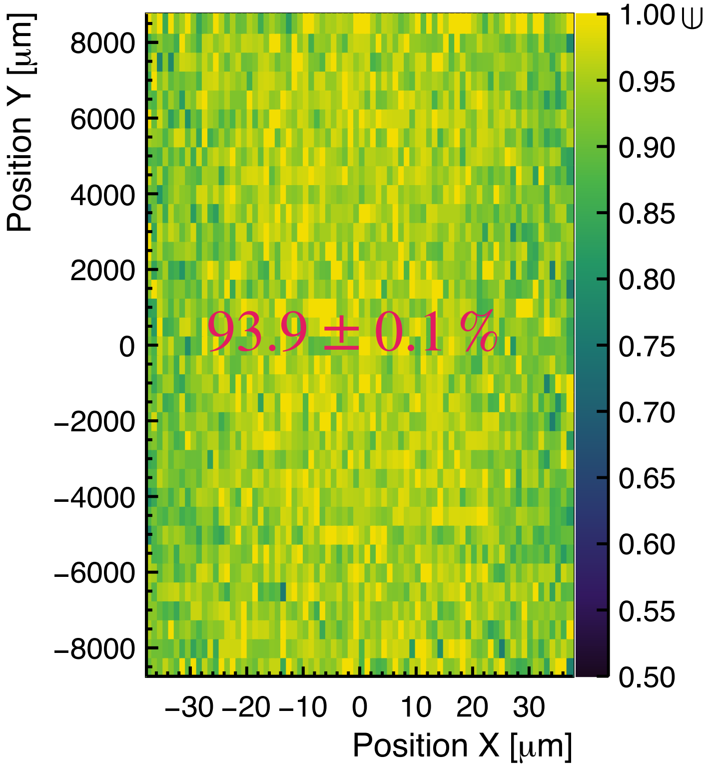
- Homogeneous distribution along strip length



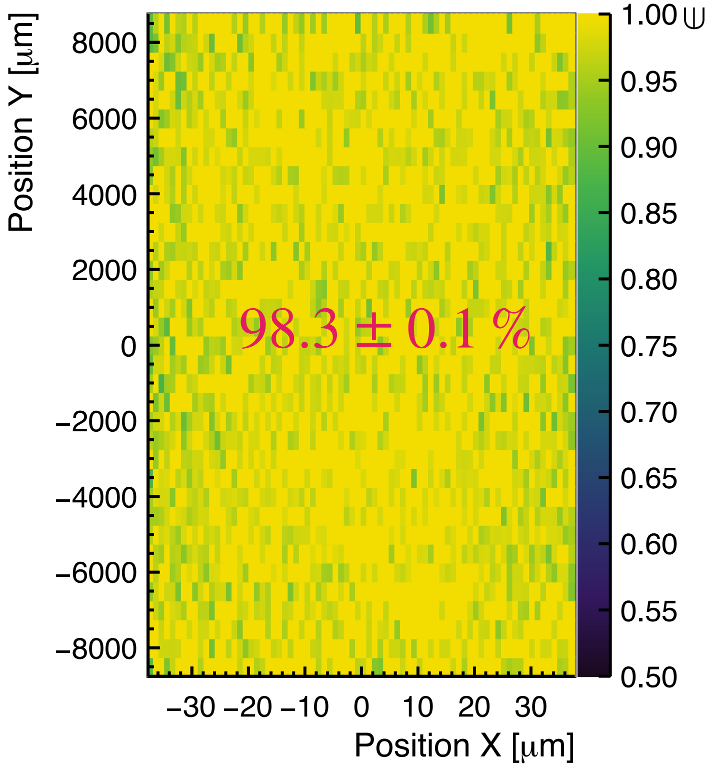
Regular



Low Dose 55



Low Dose 30



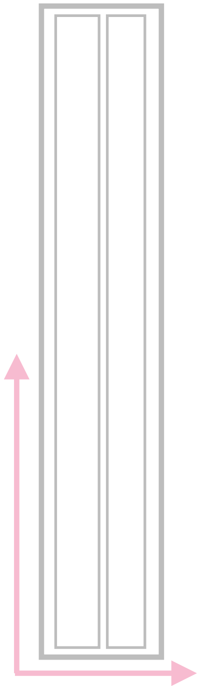
In-Strip Efficiency

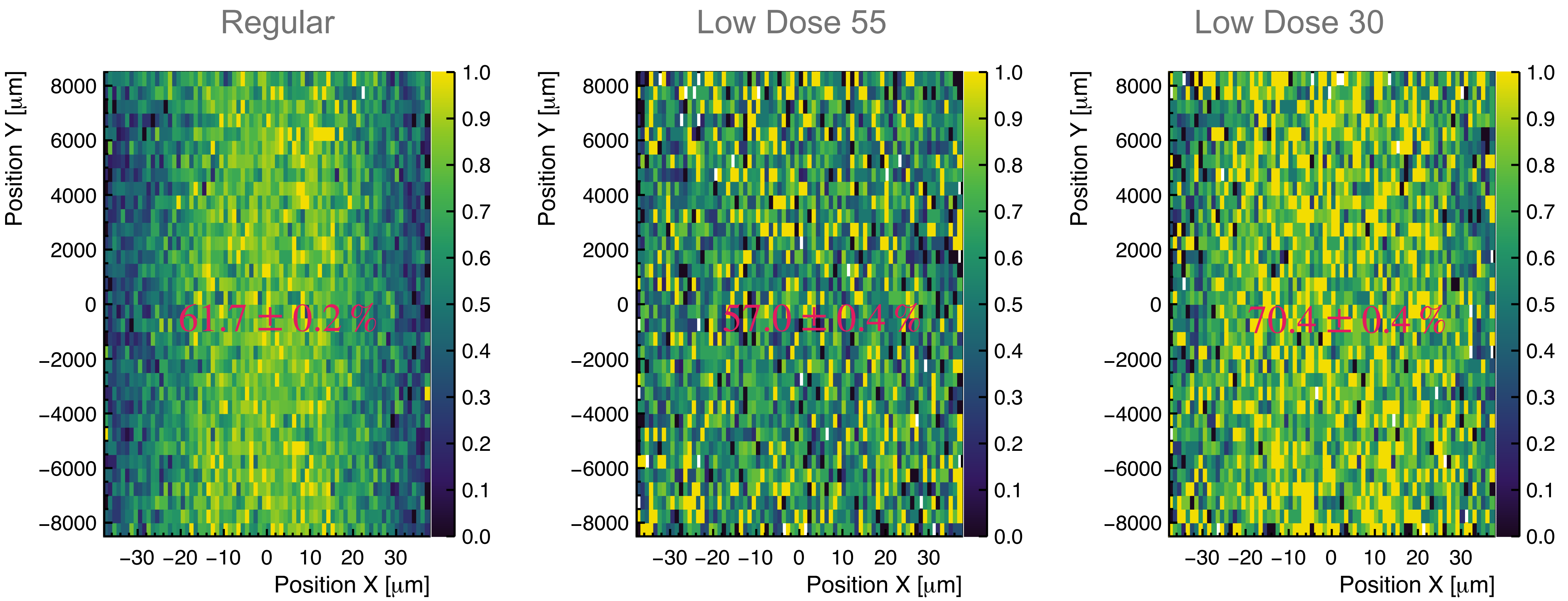
Efficiency within the strip of an unirradiated sample

Irradiation with reactor neutrons in **Ljubljana**

3e14 @250V bias, long

- Efficiency drop towards inter-strip region for regular design



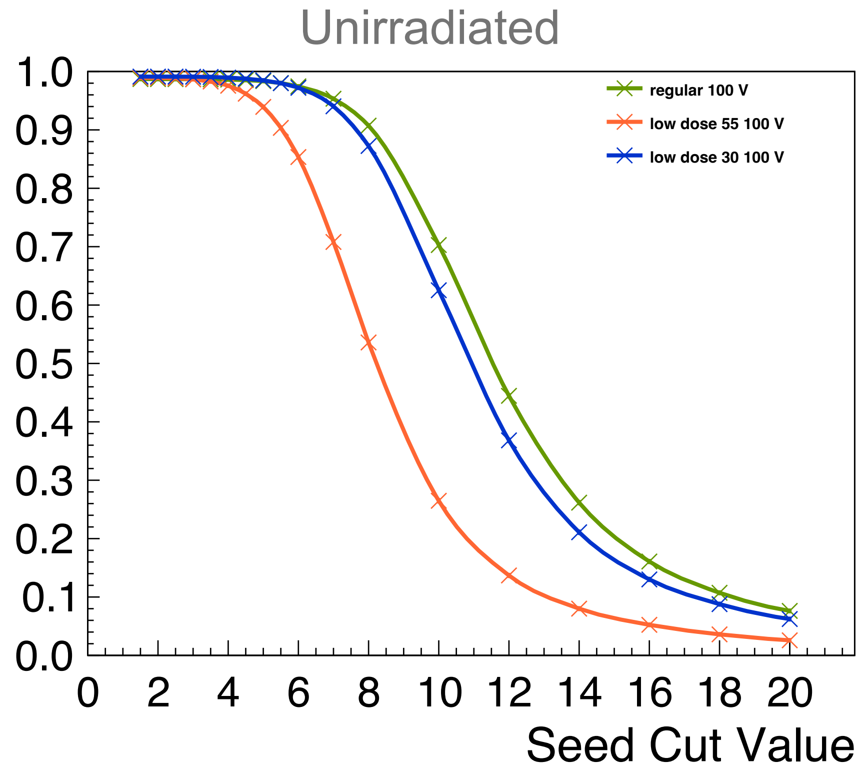


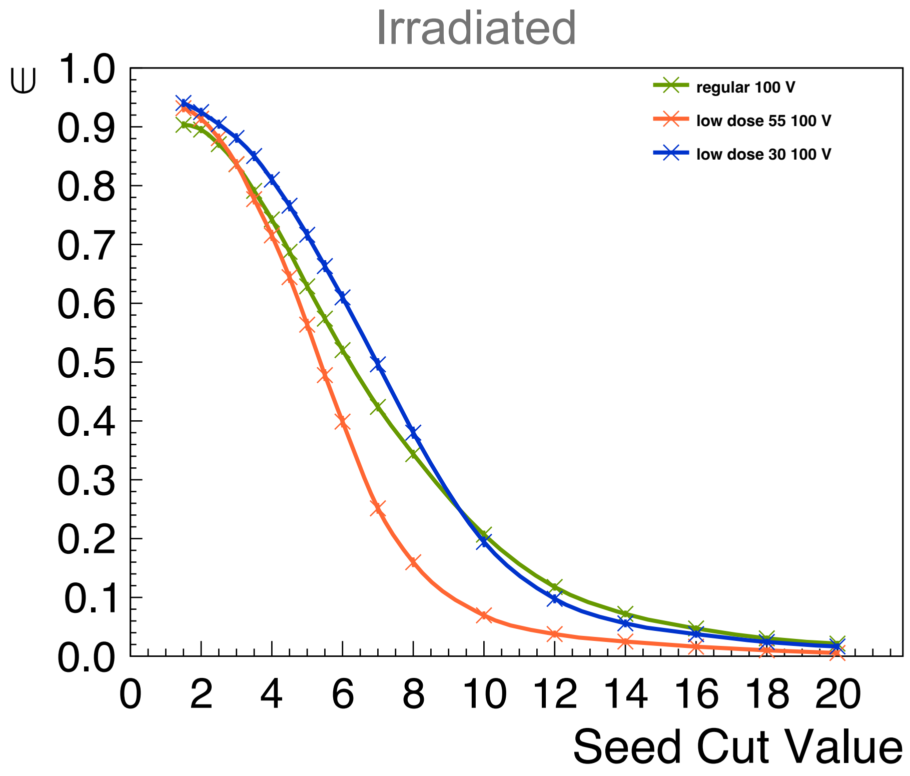
Total Hit Detection Efficiency

Hit detection efficiency of unirradiated and irradiated sample

- Unirradiated Sensors: High efficiency region at low seed cuts

- Irradiated Sensors: Lower efficiency and steep decrease of efficiency





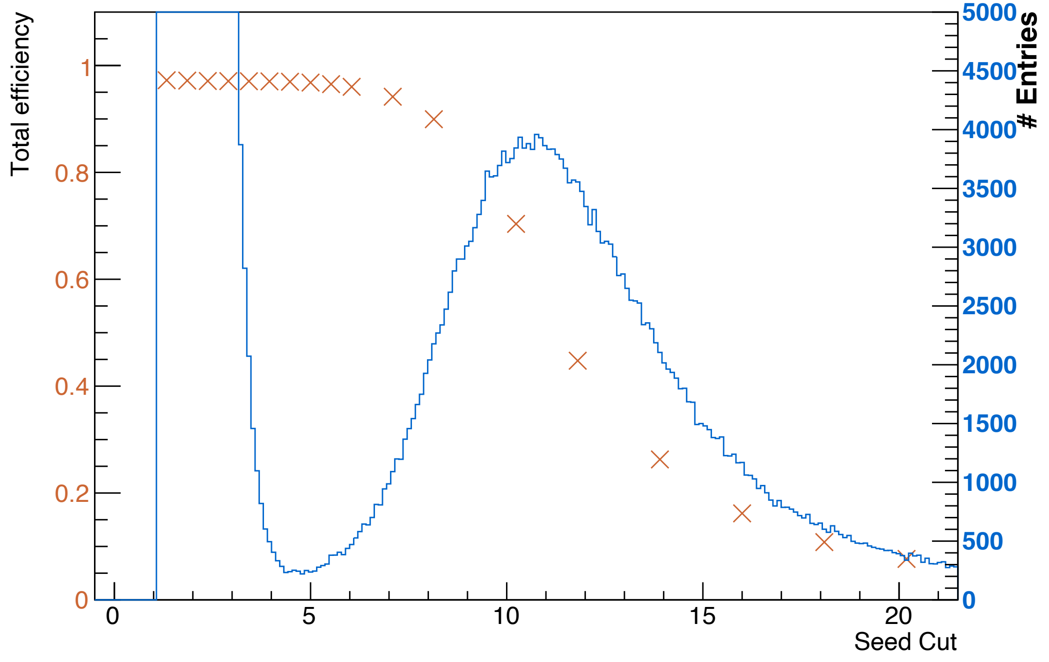
Signal distribution

Total hit detection efficiency

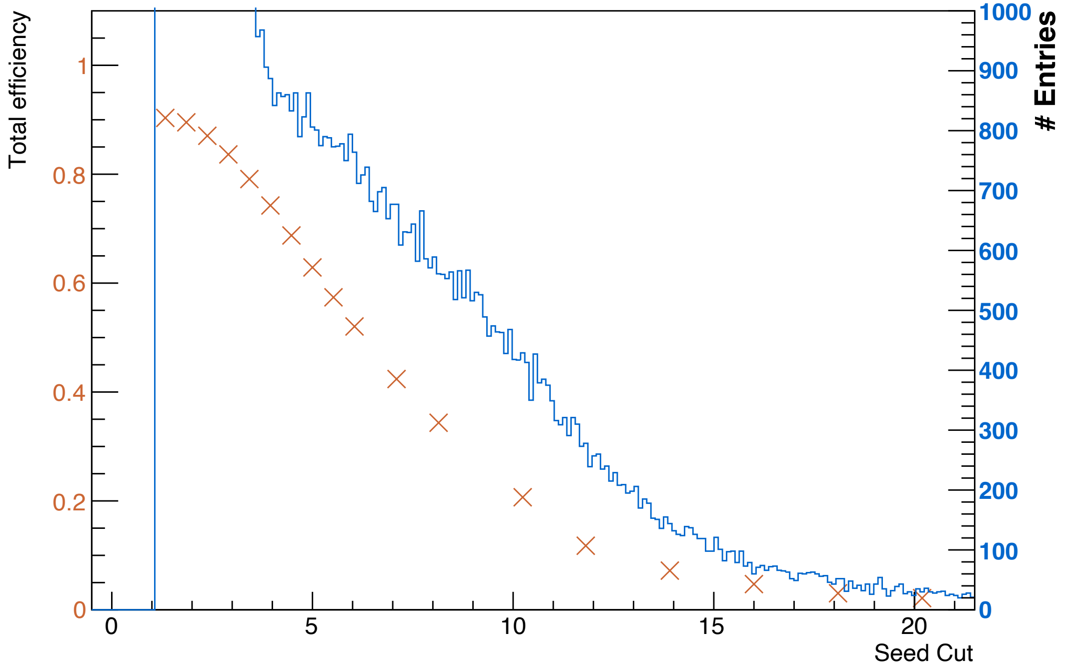
- Unirradiated Sensors: High efficiency region at low seed cuts

- Irradiated Sensors: Lower efficiency and steep decrease of efficiency

Unirradiated, regular

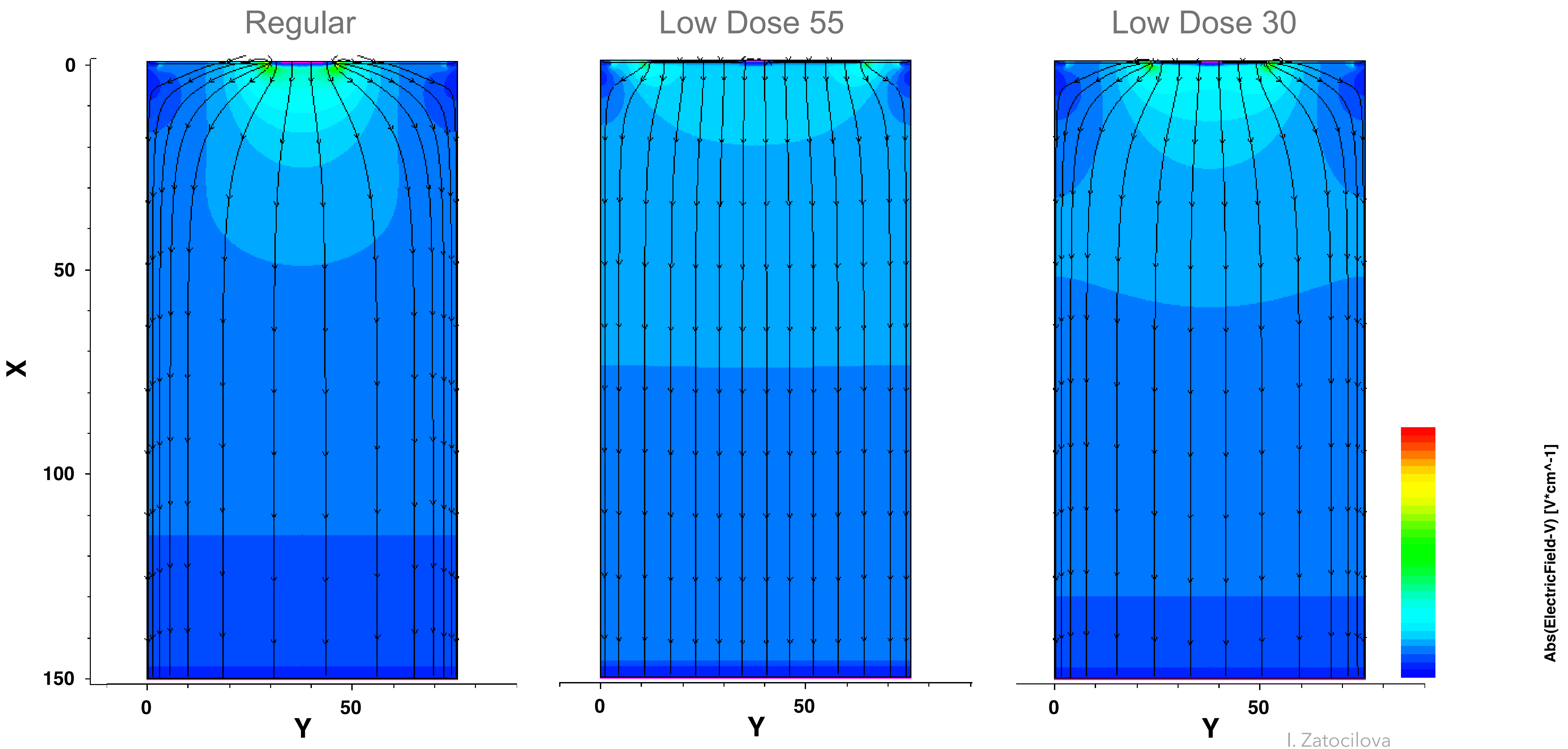


Irradiated, regular



Electric field inside the strip sensor

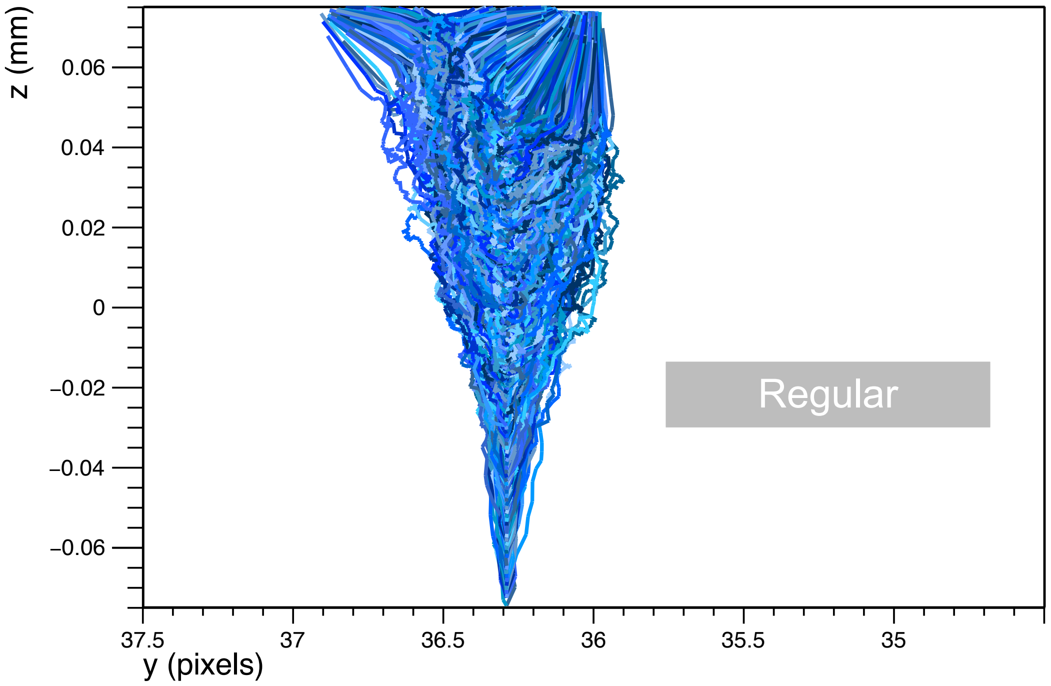
TCAD Simulation of the electric field @100 V

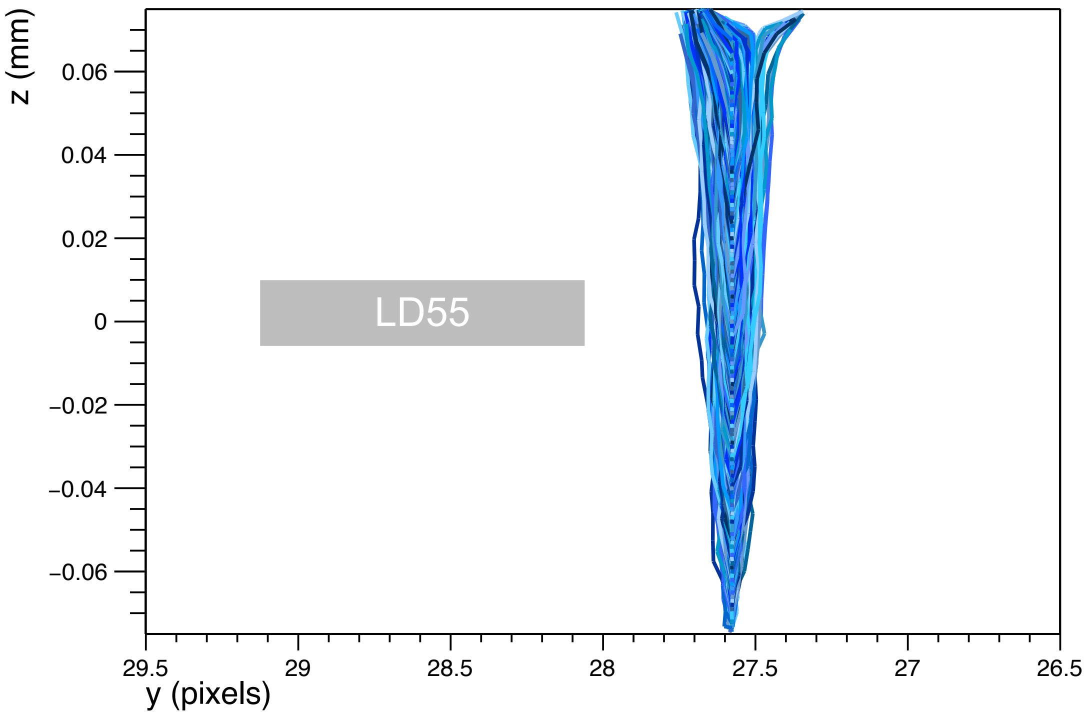


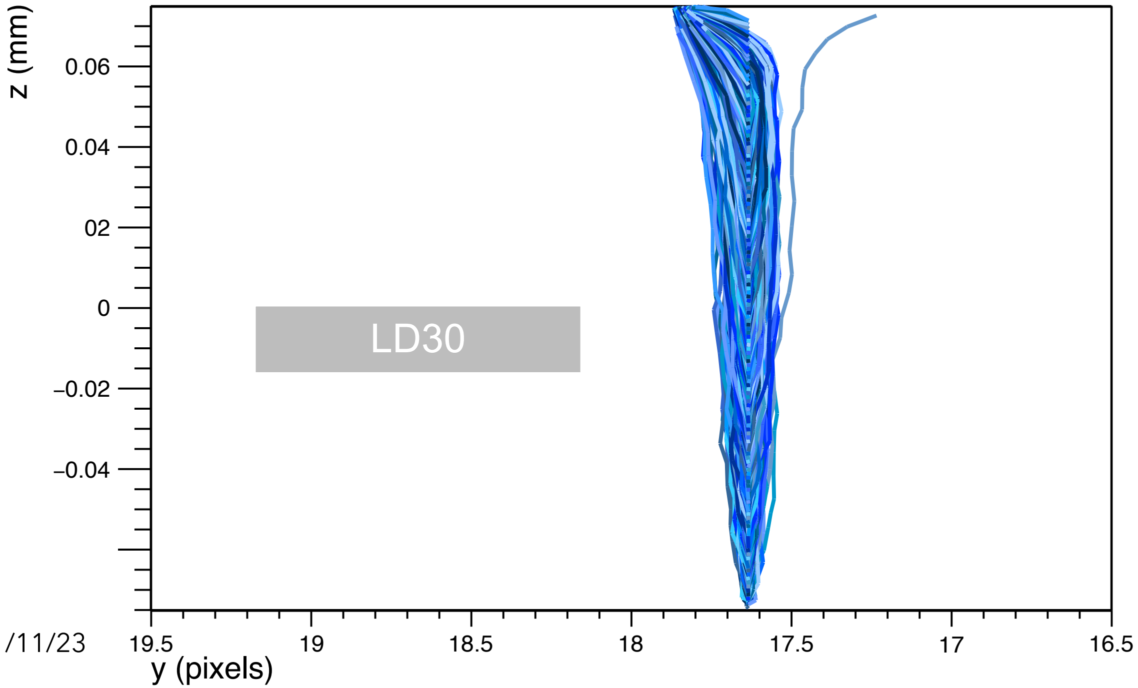
I. Zatocilova

Charge charrier propagation

Simulating the charge carrier path with Allpix2







Conclusion & Outlook

What we have learned and what's next …

- Stitching does not impact hit detection efficiency!
  - Efficiency drop for LD designs and irradiated samples

- Analysis of Oct23 TB campaign
  - higher fluences, proton irradiation
- TB data comparison with simulation
- New (active) sensor submission in discussion

Thank you,
Questions?

Naomi Davis

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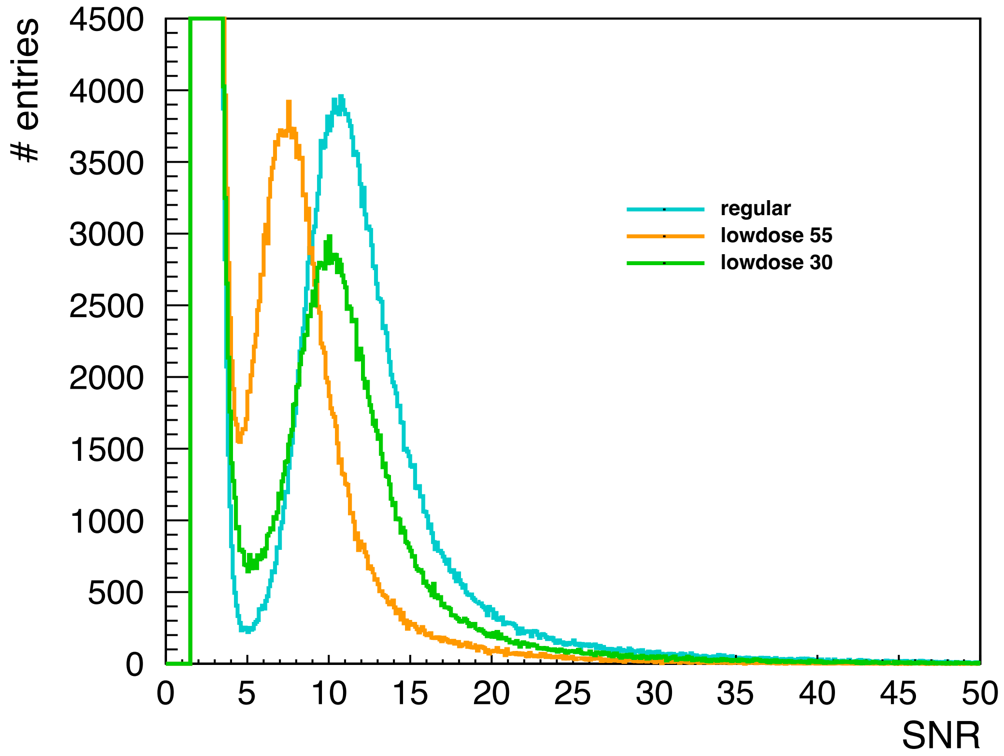
Deutsches Elektronen-Synchrotron DESY

Backup

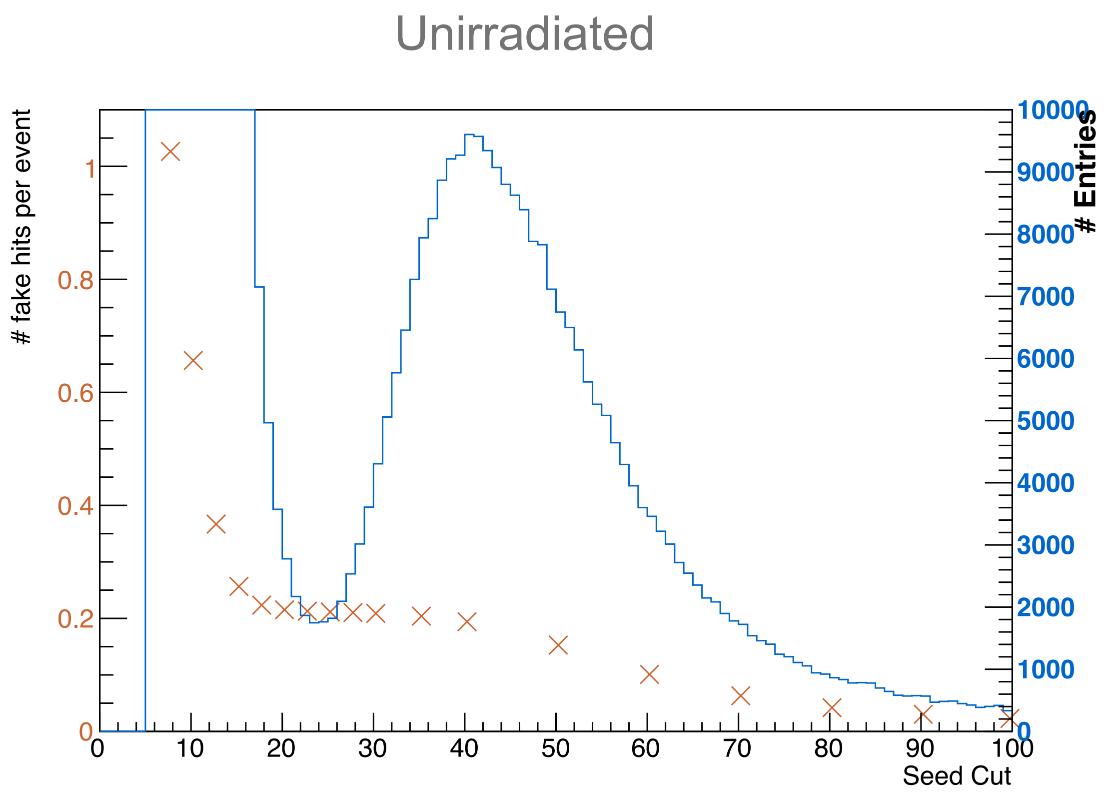
SNR

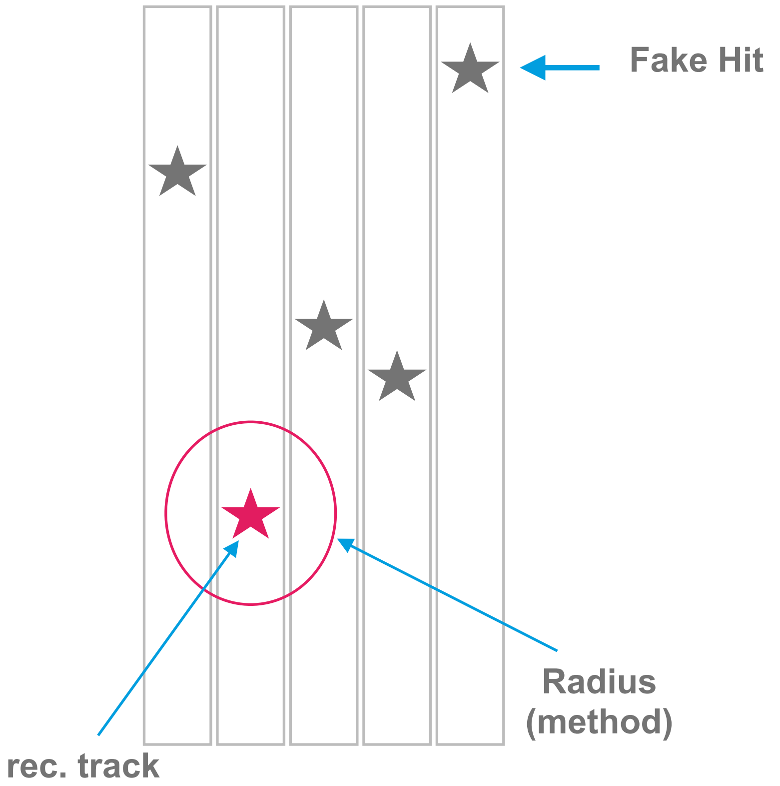
- LD 55: lowest SNR
- Highest sensor noise, larger input capacitance



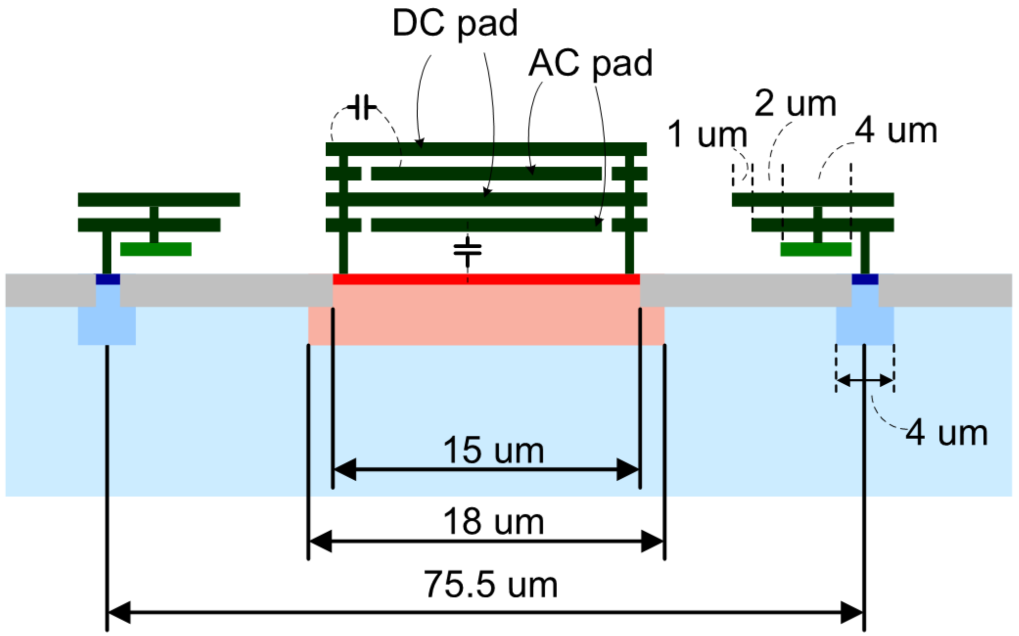
Signal distribution

Fake Hit Rate

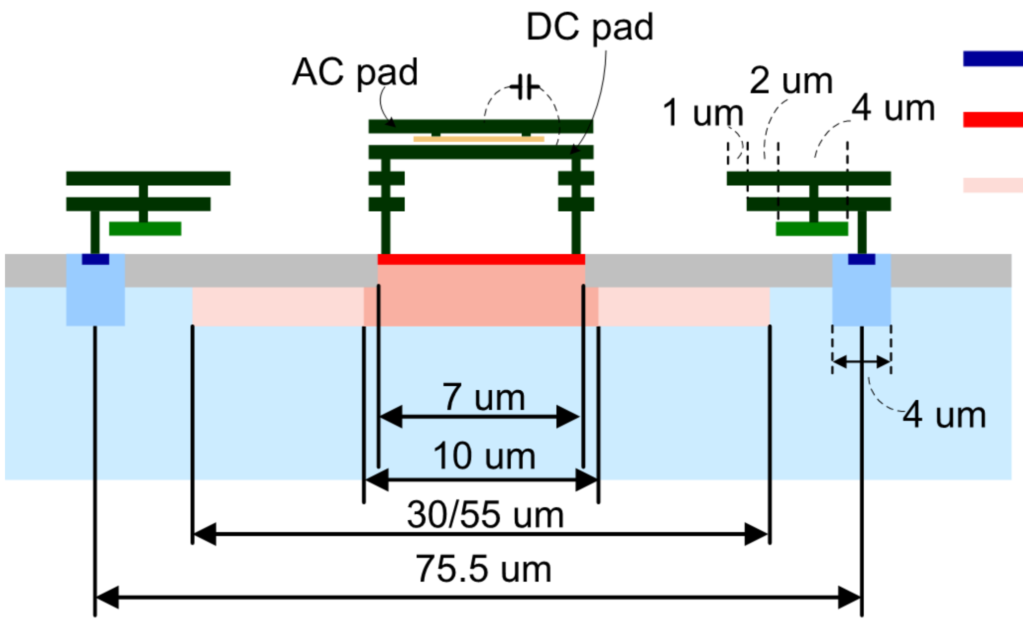




Full Sensor Layout



Regular strip implant



Low Dose strip implant