Status of the CMOS Strip Detector Project in Freiburg

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What is CMOS?

- **C**omplementary **m**etal-**o**xide-**s**emiconductor
- combine n- and p-MOSFETs on one substrate
  $\rightarrow$ circuits integrated in substrate
- used in computers, phones, cameras, ...

- many vendors, established industry production lines, fast, cheap and bulk production capabilities

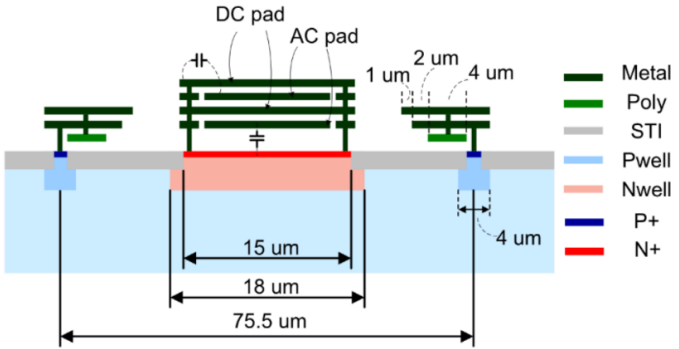
Why CMOS?

- current and future colliders rely on silicon detectors
- need to cover big areas and be radiation hard
- large areas limits us to microelectronics foundries
- only few vendors meet requirements

$\rightarrow$ silicon is and will be a big cost driver

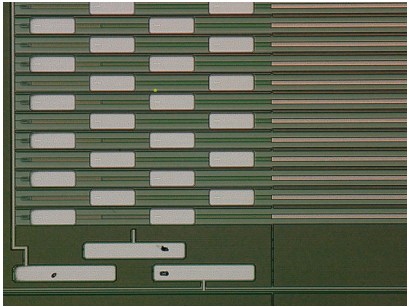
Passive CMOS Strip Sensors

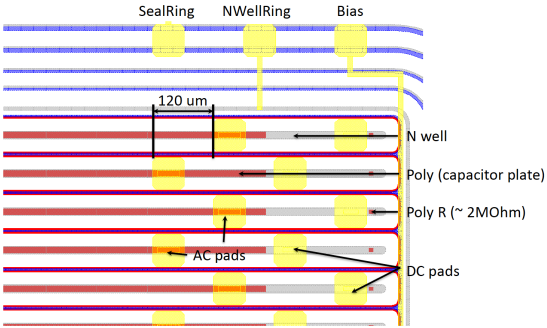
- L-Foundry 150 nm process
- float-zone silicon, 3-5 kΩ cm resistivity
- (150 ± 10) µm thickness
- 40 strips with 75.5 µm pitch
- $4.1 \times 1\,\mathrm{cm}^2$ or $2.1 \times 1\,\mathrm{cm}^2$
- 3 designs on one unit: regular & low dose 30/55

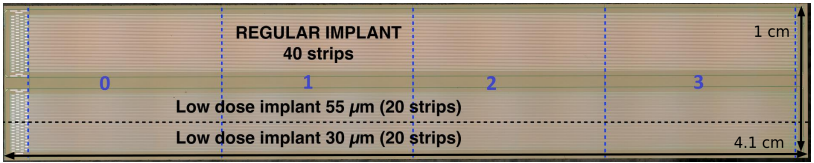


- frontside processing: reticle stitching with $1\,\mathrm{cm}^2$ masks for larger areas
- backside processing: 2nd batch has additional metal and p^+ layer

Sensor Design

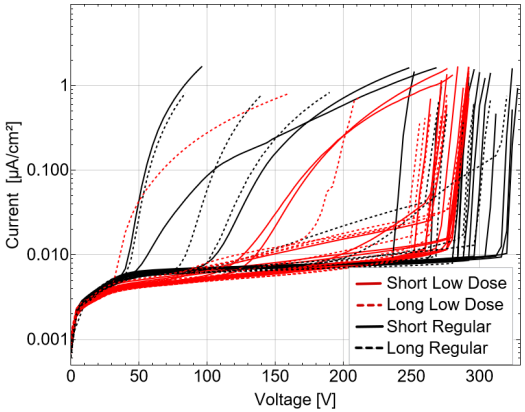




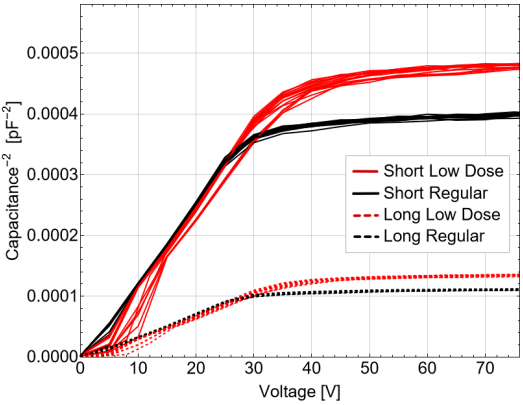


IV & CV measurements

IV



CV

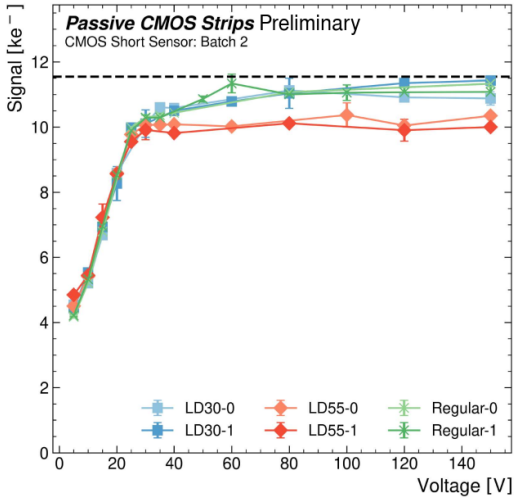


- breakdown at $\sim 250\,\mathrm{V}$
- full depletion at $\sim 30\,\mathrm{V}$
- second batch improved over first batch

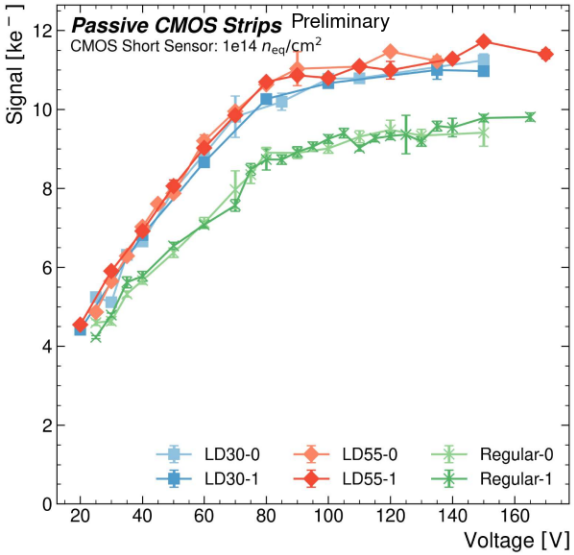
charge collection - unirradiated

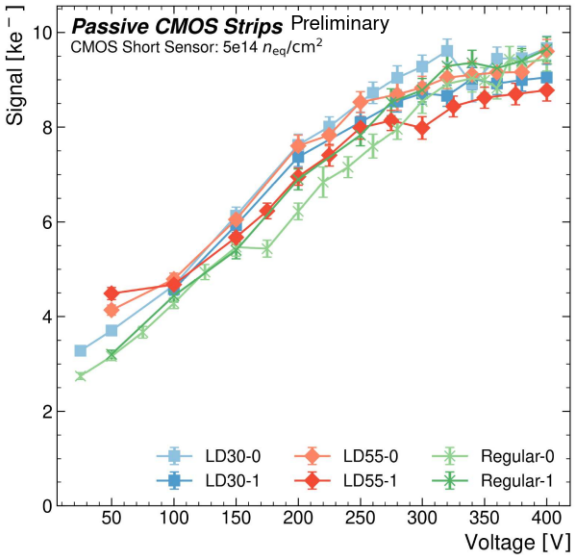
- collimated ^{90}Sr β-decay source
- MIP-like e^-
- placed in front of different design and stitch regions

- regular and low dose 30 reach expected charge of $\sim 11.5\,\mathrm{ke}^-$
- low dose 55 systematically low charge $\rightarrow$ highest capacitance, maybe read-out electronics unable to handle it
- no stitching effect



charge collection - irradiated





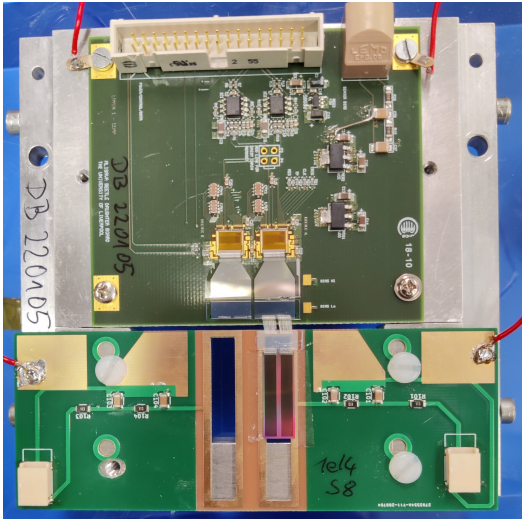
Conclusion

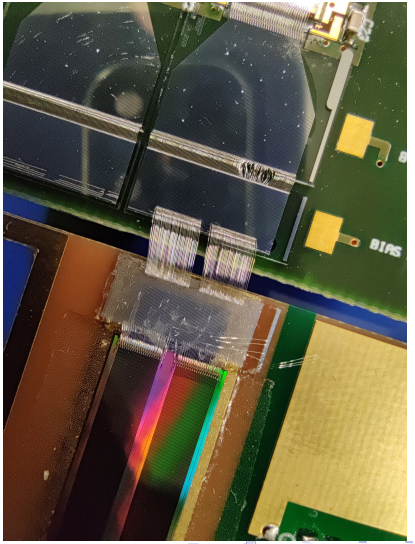
- no effects of stitching detected
- promising radiation hardness
- BUT still ongoing investigation: more sensors, more fluences

- larger areas, more strips
- fully utilise CMOS process and include electronics on substrate

Back-up

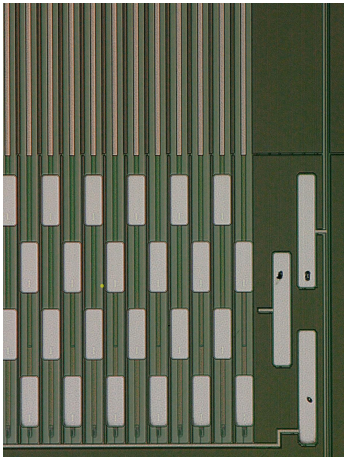
DB & Bonds



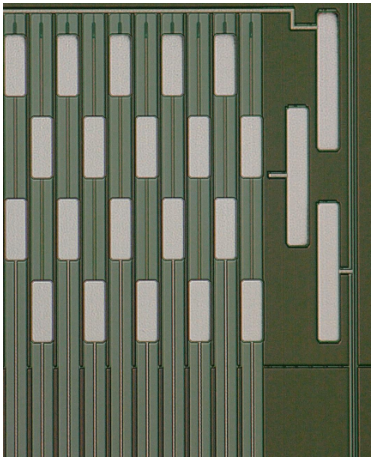


Sensor Design

regular

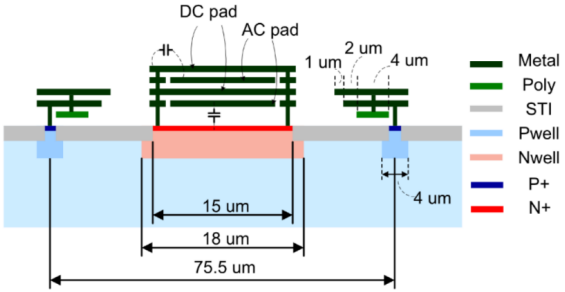


low dose 30/55

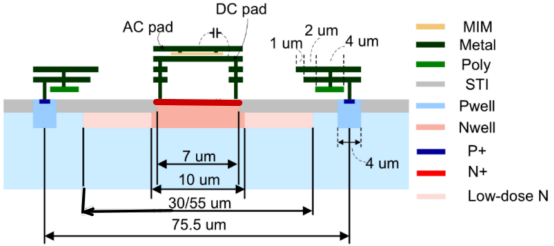


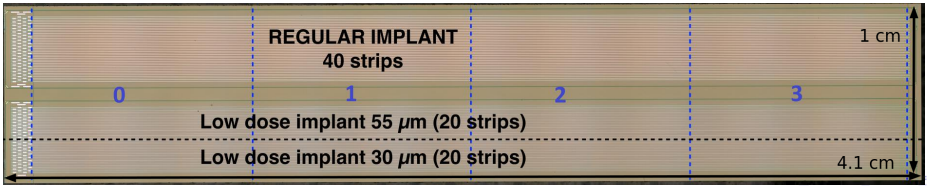
Sensor Design

regular design



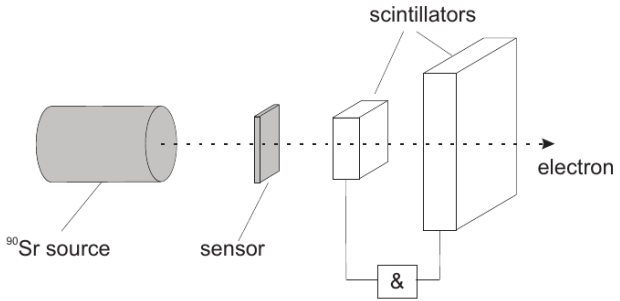
low dose 30/55 design





ALIBAVA setup

- ^{90}Sr β-decay source
  - collimated
  - gives MIP-like e^-
- two scintillators
  - trigger in coincidence
  - low energy cut
- sensor on daughterboard with beetle electronics



- inside freezer, additional liquid nitrogen cooling possible
- external motherboard for further signal processing and communication with software

ALIBAVA measurement & analysis

- position source for different sensor design & stitch regions
- pedestal and source run
- motherboard 40 MHz signal sampling (LHC timing, 25 ns)
- TDC compares signal sample and trigger times
  $\rightarrow$ sort *snapshots* of signals acc. to time
- time cut: bias to smaller charge collected if too long
- seed & neighbour cut $\rightarrow$ cluster algorithm
- get collected charge from Landau-Gauss signal-fits

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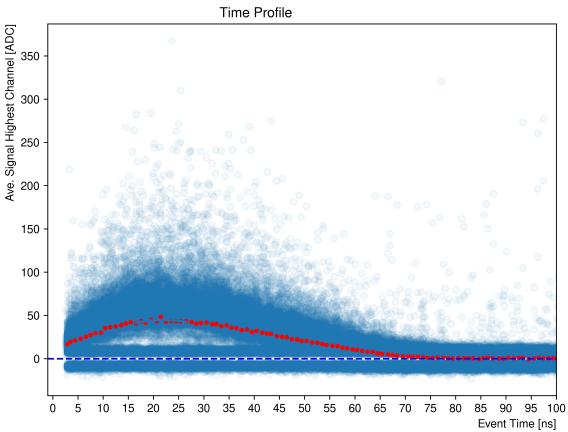

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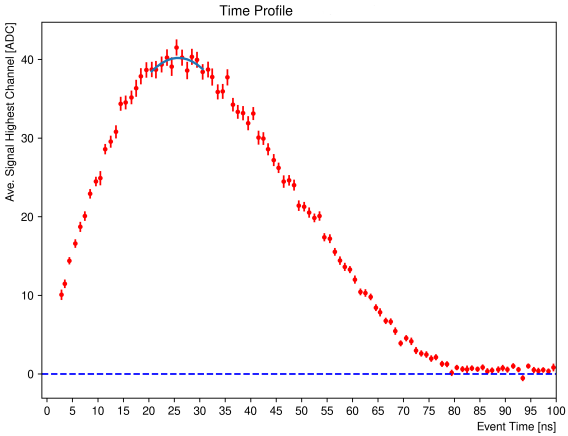

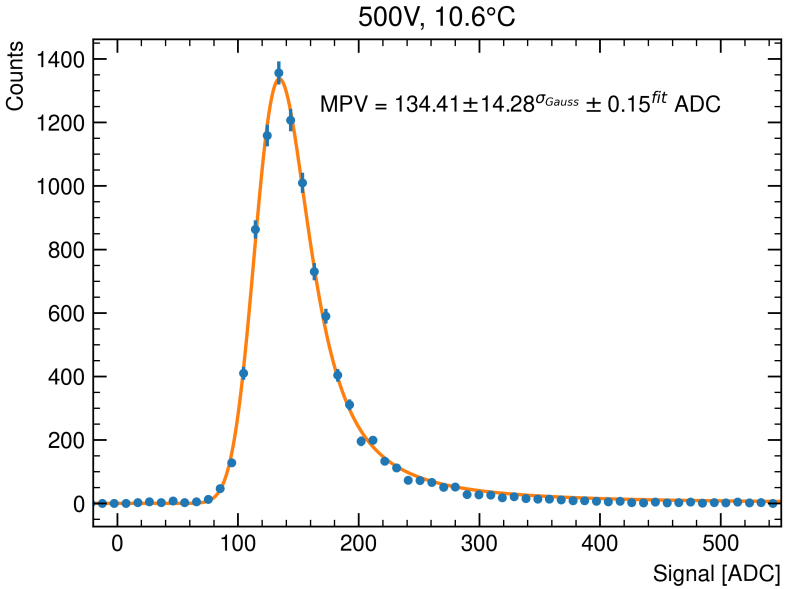
500V, 10.6°C
Counts
MPV = 134.41±14.28$^{\sigma_{Gauss}}$ ± 0.15^{fit} ADC
Signal [ADC]
0
200
400
600
800
1000
1200
1400
0
100
200
300
400
500