Universität Hamburg
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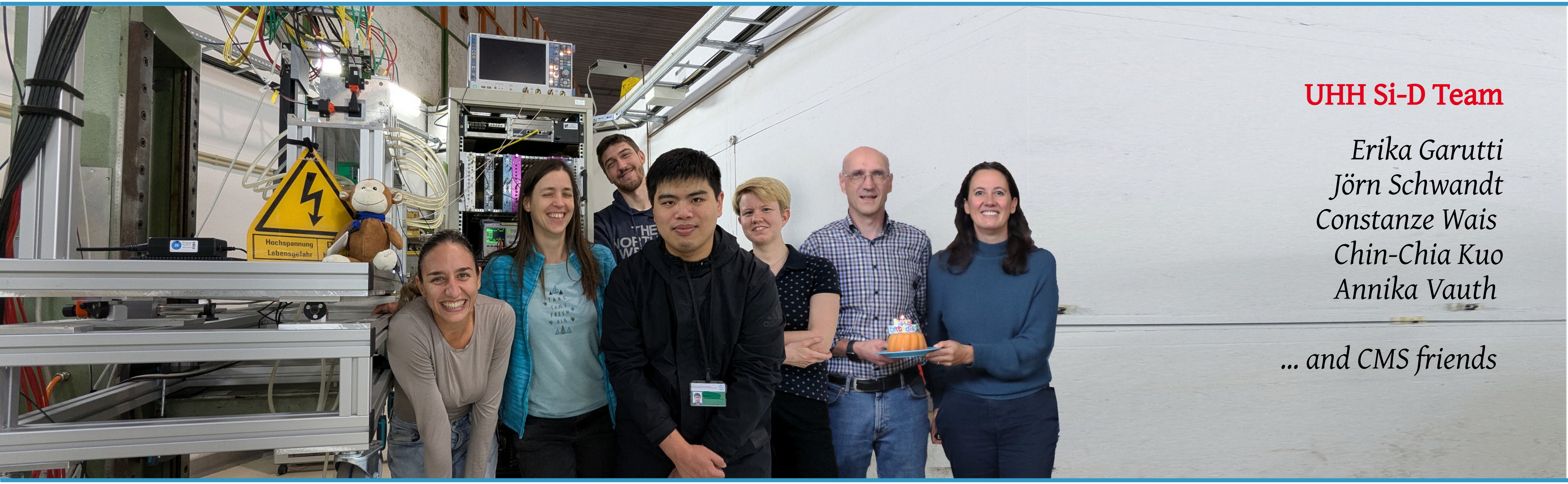
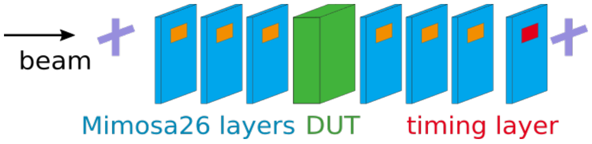
UHH projects



Si-D consortium meeting

28.01.2025

LGAD timing layer



WP2.1

- HEP detector R&D: dedicated beam tests for design, calibrations, commissioning, …
- Testbeam infrastucture includes pixel detectors (“beam telescope”) for reference tracks…
- Current beam telescopes: great spatial resolution (σ ~ 3 µm), but no timing
- To meet requirements of future detector test campaigns: add timing layer

Technology choice: Low Gain Avalanche Diodes

Short term: read out with Timepix3

Long term: Timepix4?

First prototypes: Trench-Isolated LGADs (FBK)

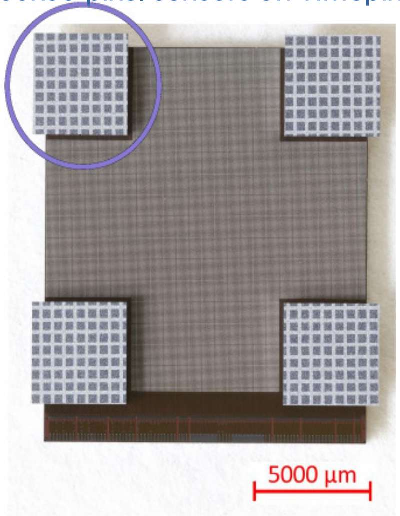
a) small 2x2 pixel samples for characterisation in the lab

→ measurements with IR laser

b) 55µm pitch pixel samples to bond to Timepix3(4)

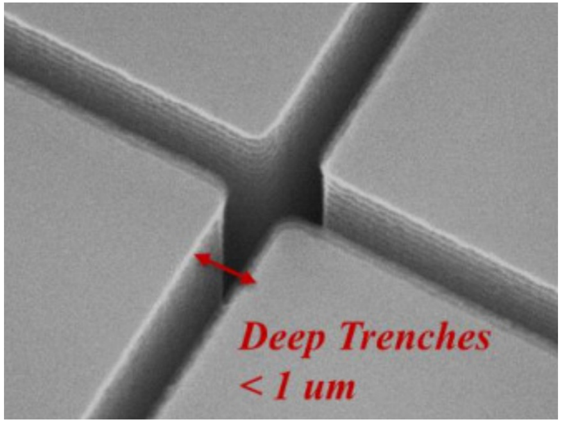
→ first test in the DESY II testbeam end of last year

55x55 pixel sensors on Timepix3

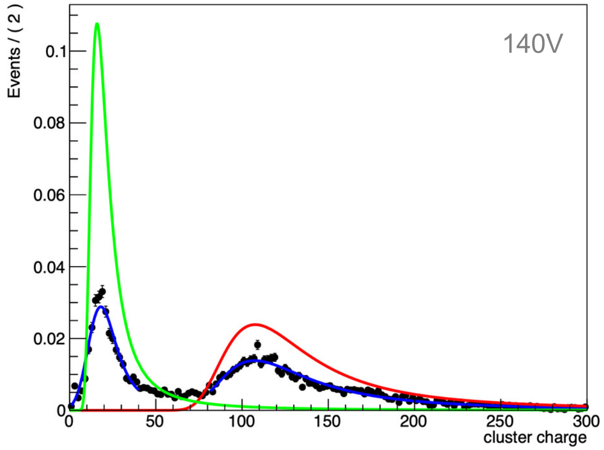


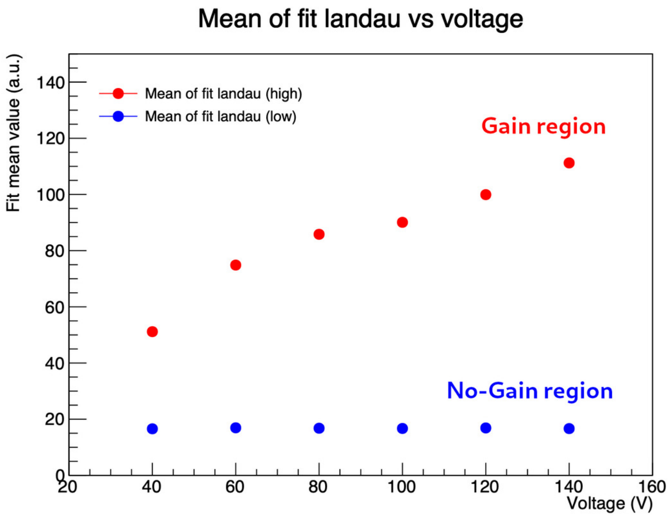
2x2 pixel samples in the lab

LGAD testbeam results

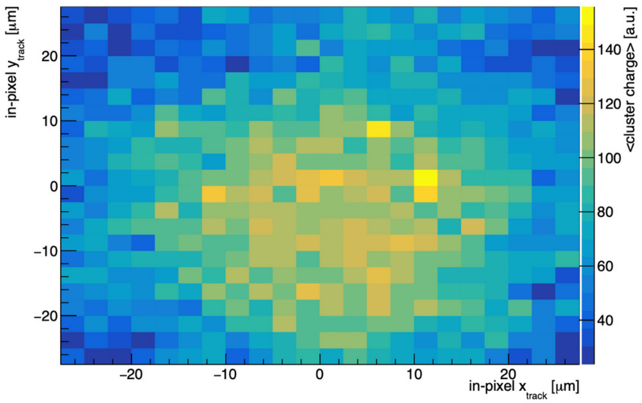


Fitting of charge distribution





Mean cluster charge map (1-pixel)

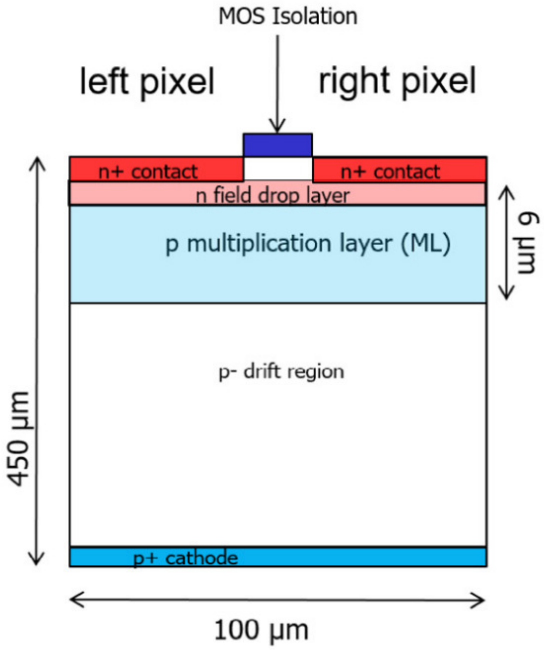


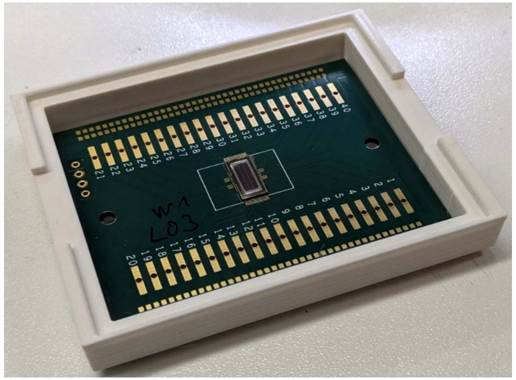
- Assume the landau on the right comes from gain region, while the landau on the left comes from no-gain region
- Fit with $Gauss_L * Landau_L + (Gauss_R * Landau_R) \times factor$
- A short range between two peaks is excluded from fit to mitigate the effect from transition region

$\Rightarrow$ Can determine absolute gain

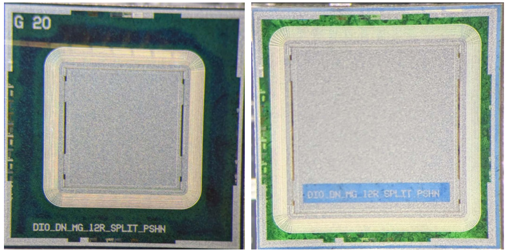
MARTHA

- Conventional LGADs have problems with edge breakdown. Common ways to prevent this, lead to “blindness” in the interpixel region.
- **M**onolithic **A**rray of **R**each **TH**rough **A**valanche photo diodes (MARTHA): approach developed by HLL-MPG to produce pixelated LGADs
- In addition to preventing the edge breakdown with an additional n-doped layer (FDL), this approach also promises 100% fill factor





Strip sensor on PCB



Diodes

First test structures of two different wafers have already been delivered. These include diodes and strip sensors.

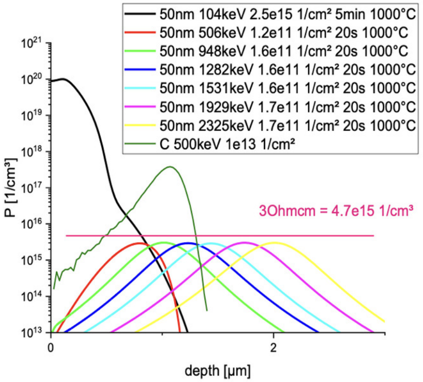
⇒ The analysis of the diodes with C-V and I-V techniques has already started, a readout for the strip sensors has been designed and ordered

Radiation hardness

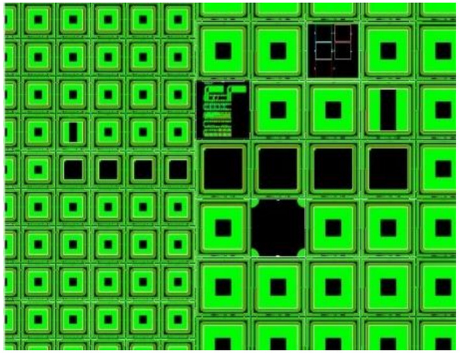
WP3.6

- RD50 project “Defect engineered diodes mimicking the gain layer in LGADs”
- 18 differently defect engineered wafers with respect to B, O and C impurities as well as with P in compensated n++-p+ diodes

P and C implantations in compensated n^{++}-p^{+} diodes with 50 nm of oxide



layout design including samples for Hall measurements and diodes with fully transparent electrodes.



Expected results

- Reveal the microscopic radiation induced effects above 10^{15} n_{eq}/cm^2 and identify the reasons for losing the gain in LGADs.
- Reveal the role of O, C and P impurities in low resistivity B doped Si and of defects impacting on the gain layers in LGADs
- Detection and characterization of new defects induced by irradiation above 10^{15} n_{eq}/cm^2 (e.g. 2nd order defects)
- provide real inputs for modelling the radiation damage above 10^{16} n_{eq}/cm^2, allowing the development of accurate parametrization models validated on the entire range of fluences, from low to extreme;

- First samples expected in Feb. 2025 (project will continue within DRD3)