Monolithic CMOS Strip Sensors for large area detectors

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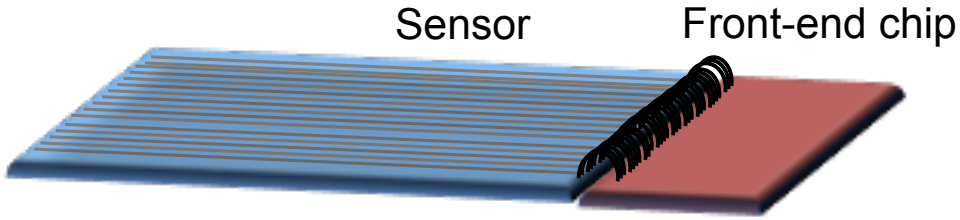
DRD3 - First annual Meeting

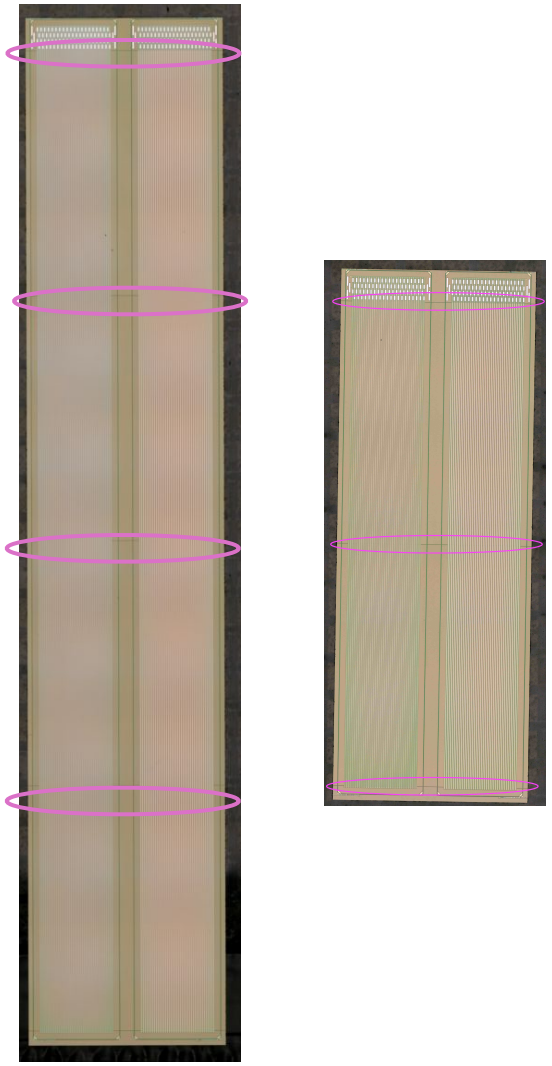
Why Strips?



Microstrips detector

- Large area at large radius in
  - moderate spatial resolution sufficient
  - possible application in medical area
- Large area available per channel
  - Distribute power hungry blocks over large area → cooling efficiency (air?)
  - Potential for increased in-strip functionality
- Simpler power and data distribution (per area) wrt multiple pixel chips
  - No token handling for data-in and data-out lines
  - Fewer TX drivers and voltage regulators per area → smaller power consumption

Existing CMOS Sensor structure

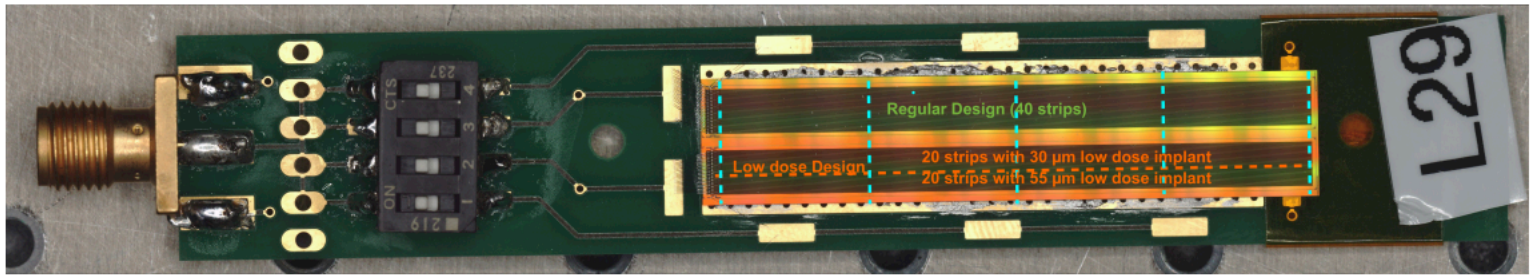


- Based on sensor design for ATLAS ITk strip, first stitched strip sensor produced on 8” wafer by a commercial foundry

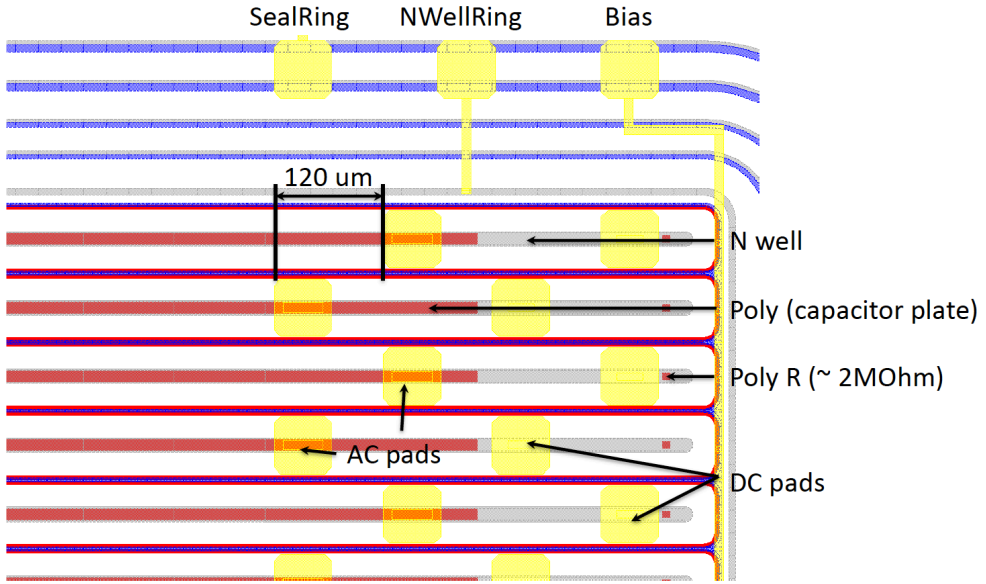
- **LFA150:**
  - L-Foundry 150 nm process (deep N-well/P-well)
  - Up to 7 metal layers
  - Resistivity of wafer: >2000 Ω·cm
  - Float-zone processing

- Frontside process: Reticle stitching for large sensors

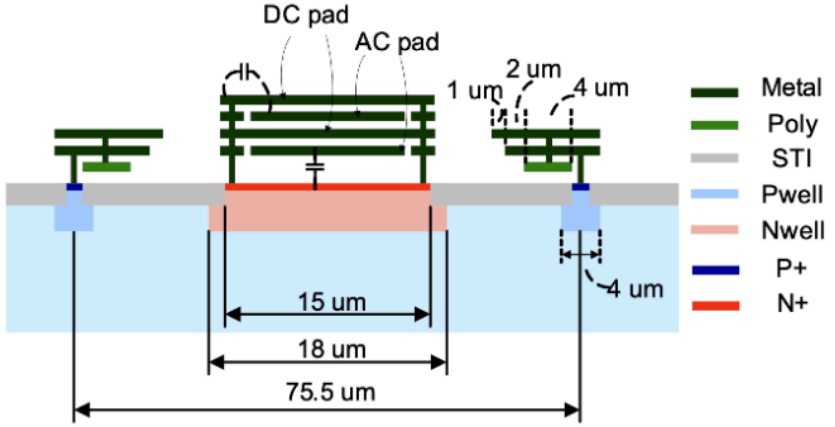
- The strip sensors has 2 different lengths : 2 cm and 4 cm



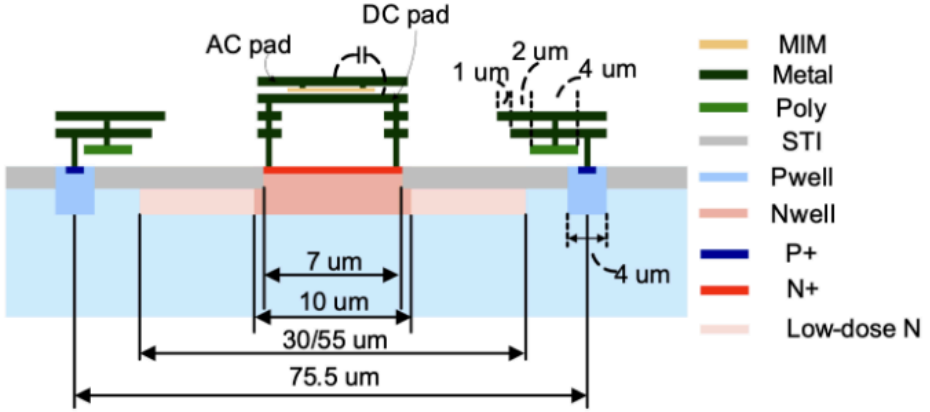
Some Sensor details



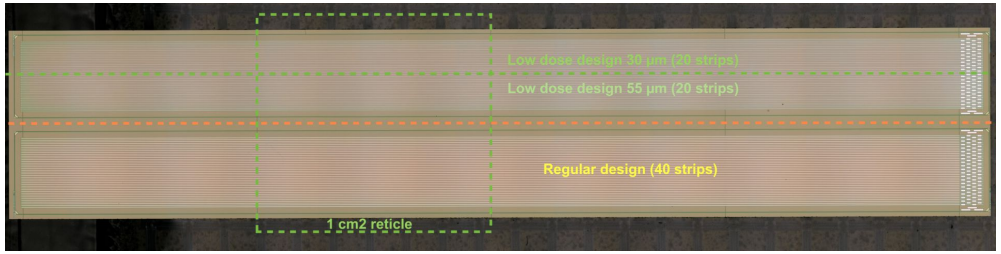
Regular implant



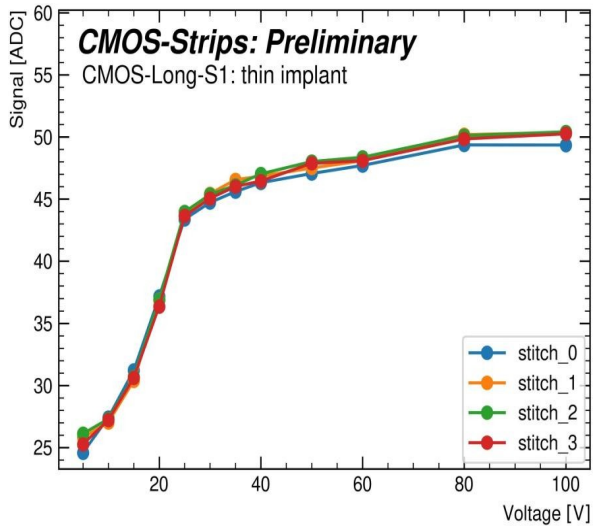
Low Dose implant

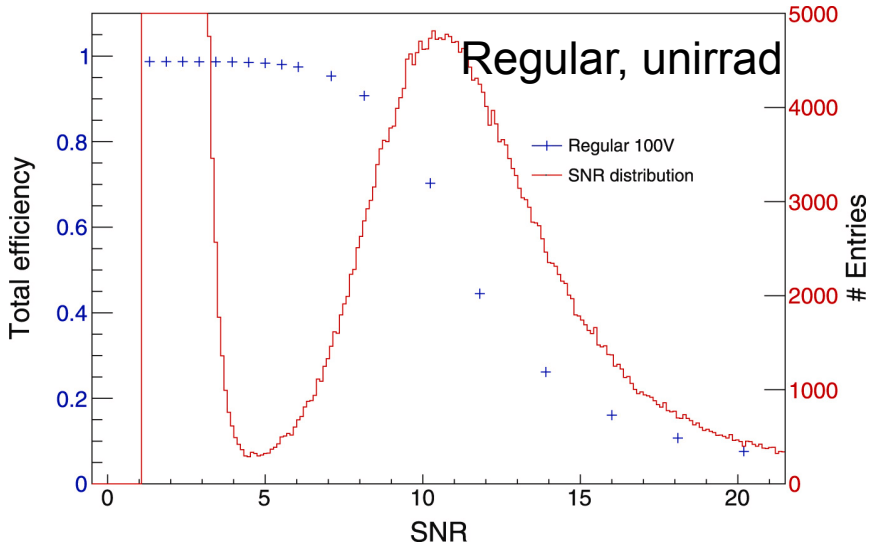


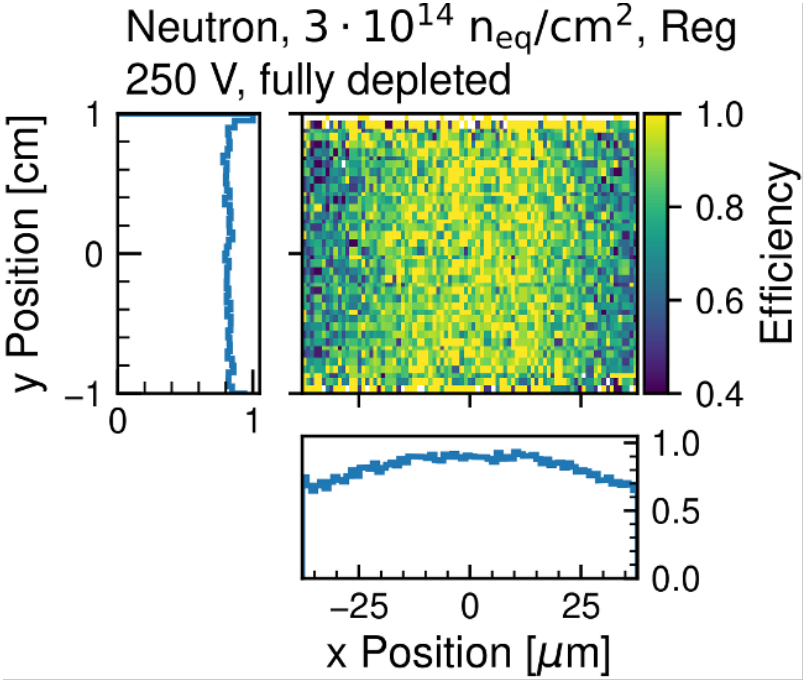
- Sensor thickness ~150 µm
- Sensor has 40 strips with strip pitch = 75.5µm
- LowDose has 20 strips with 30 µm implant length and other 20 strips has 55 µm implant length



Results Overview

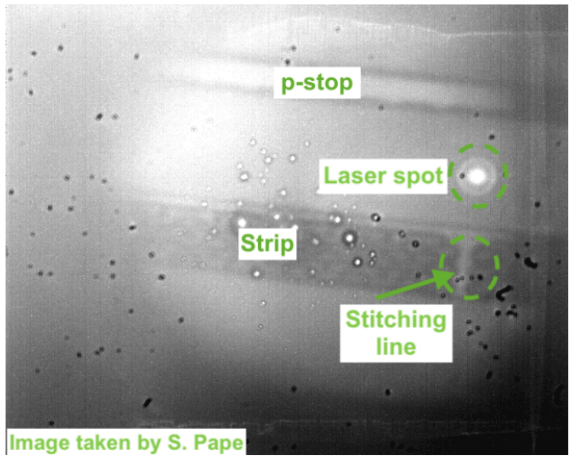




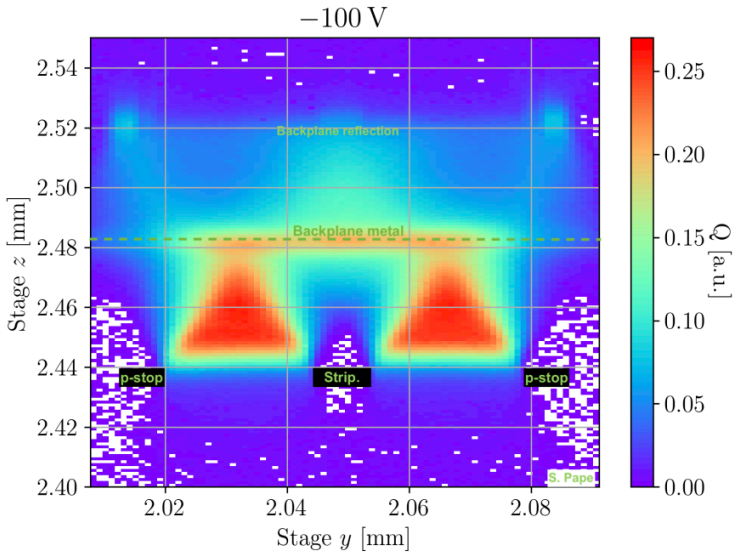


- Sensors tested extensively in the lab (laser, sources, TCT) and at test beam (DESY electron beam)
- Several test beam campaigns with unirradiated and neutron/proton irradiated sensor show sensors still working after irradiation (up to 1e16 neq/cm^2 tested)
  - stitching has no impact
- "Regular" design displays better performance than "Low dose" 30/55 designs
- Further investigation of some unexplained behaviours, study of bond pad region ongoing

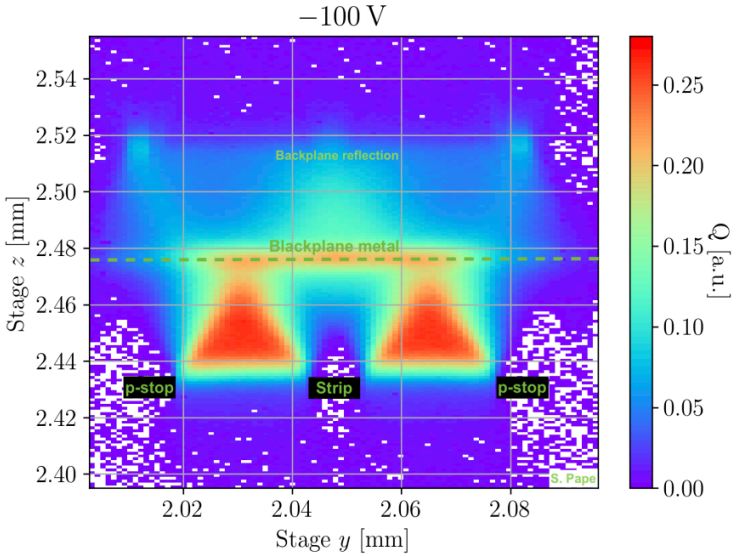
Two Photon Absorption TCT Measurement



IR image



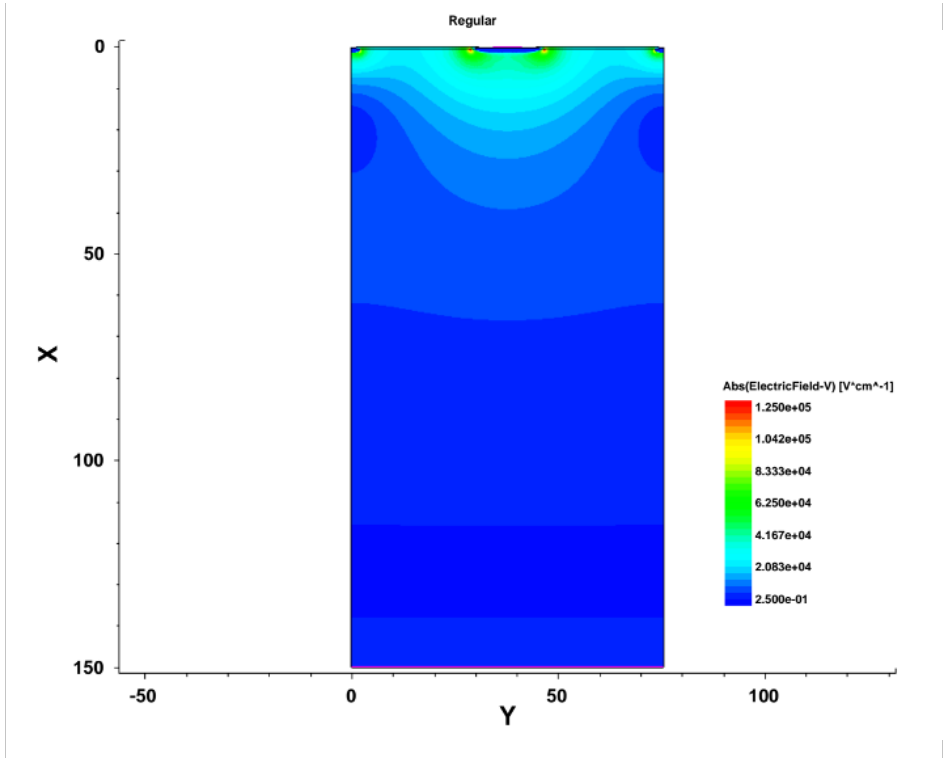
within stitched area

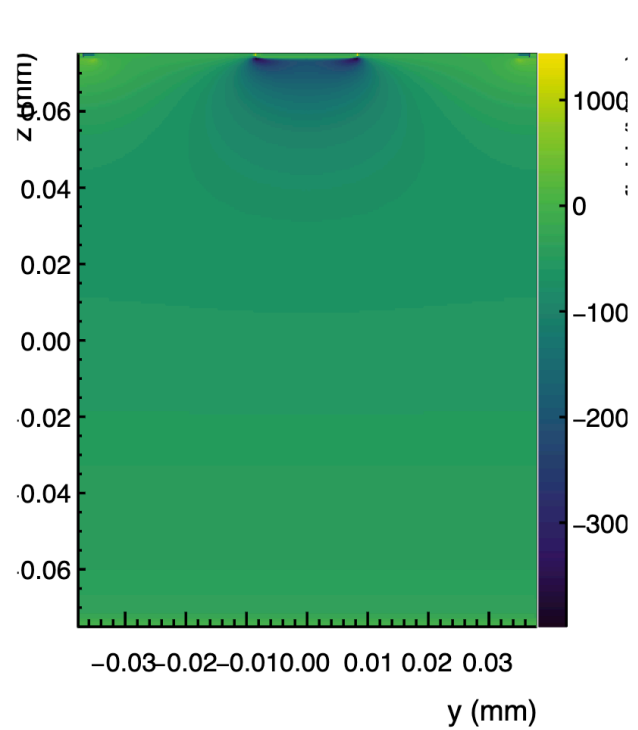


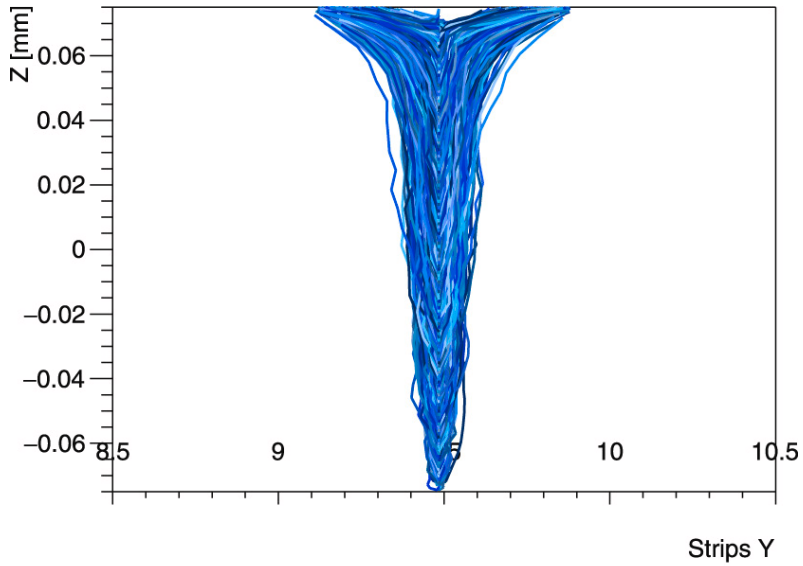
outside stitched area

- TPA-TCT measurements were performed at CERN SSD
- The charge in stitching and outside stitching does not show any difference

TCAD and Allpix² Simulations Ongoing







Line graph visualising the drift path of electrons

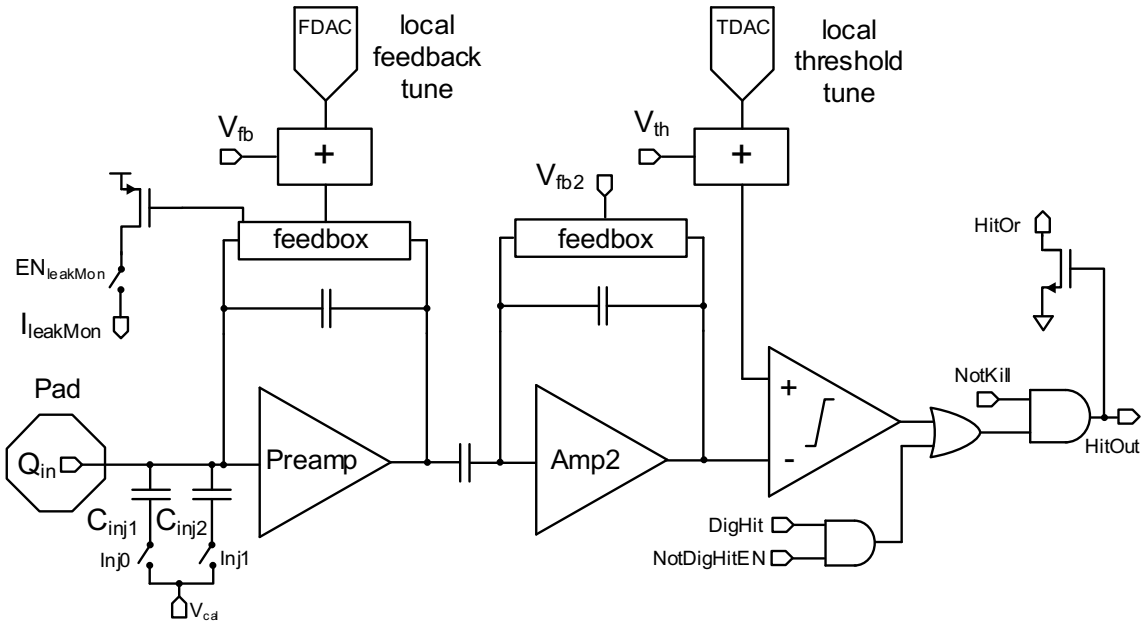
- Simulations of all three structures show so far good agreement with measurements
  - Simulation of irradiated structures and charge depositions (Allpix²) still ongoing

Next Steps

- Test monolithic analogue design for the large sensor capacitance of a strip detector
  - Foresee to test with different strip lengths by wire bonding long strips to the test chip
- Basic digital functionality (shortness of digital chip design person-power)
- Develop in FPGA before test submission ➔ Crucial due to funding situation

Going Fully Monolithic

- Dream for large area tracking detectors - minimise bonds (wire and/or bump bonds)
- Fully monolithic would ease the design significantly while possibly being more cost effective
- Working on the implementation of a front-end on strip level
  - **Submission spring 2025**



ATLAS FE-I4 style front-end

Collaborators welcomed in all areas (especially ASICS design)