The project

Implement a readout chip prototype with high granularity and timing capabilities to interface with 4D pixels for detection of MIP (Minimum Ionizing Particles).

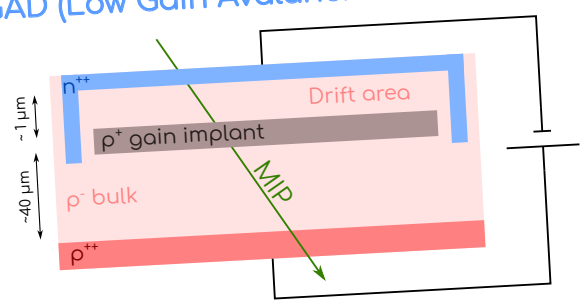
Forseen applications:

- Testing of prototype 4D sensors (LGADs)
- Potential use in CMS TEPX upgrade

Constraints:

- Pixel size ≤ 100×100 μm^2
- Pixel level time resolution ≤ 30 ps
- Power consumption ≤ 1 W/cm^2
- Radiation hardness ≥ 5×10^{15} n_{eq}/cm^2

LGAD (Low Gain Avalanche Detector) [2]

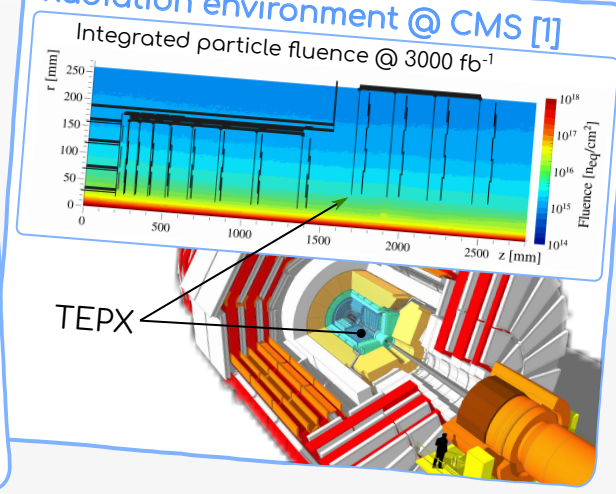


Gain: 10-100

Time resolution: 30-40 ps

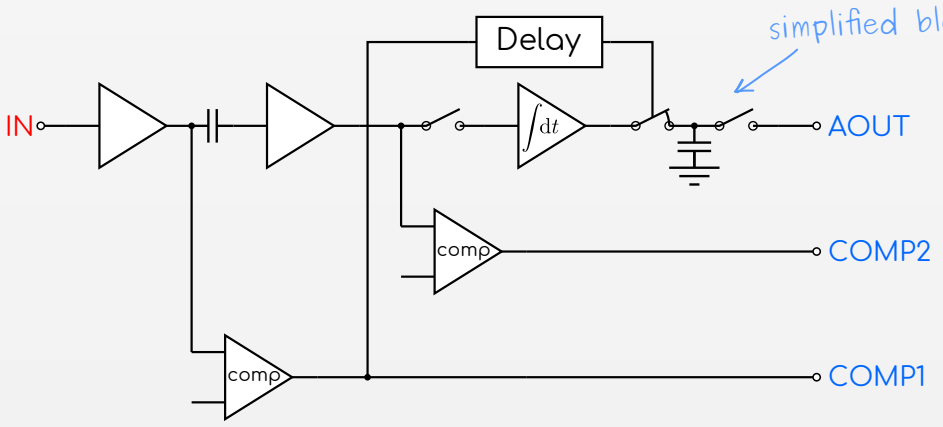
Radiation hardness ≥ 3×10^{15} n_{eq}/cm^2

Radiation environment @ CMS [1]



Front end interface

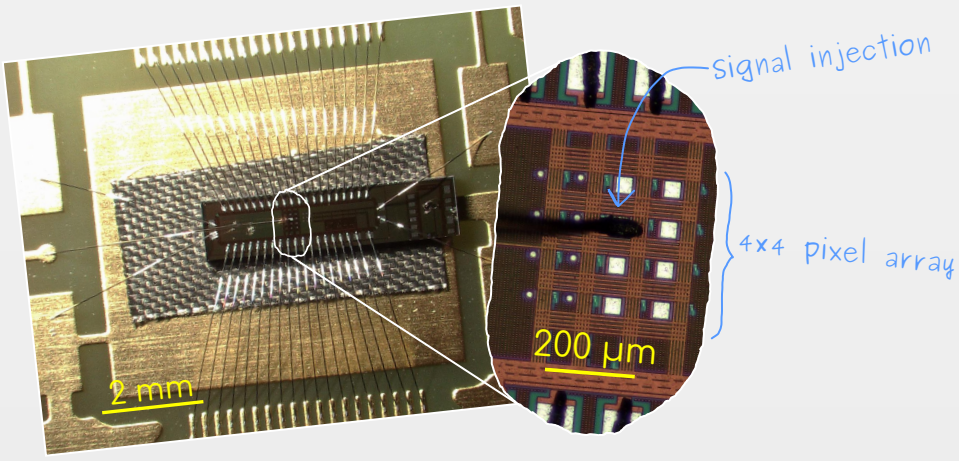
simplified block diagrams



- AOUT: Charge measurement
- COMP1 & COMP2: TOA (Time Of Arrival) & rise time measurements

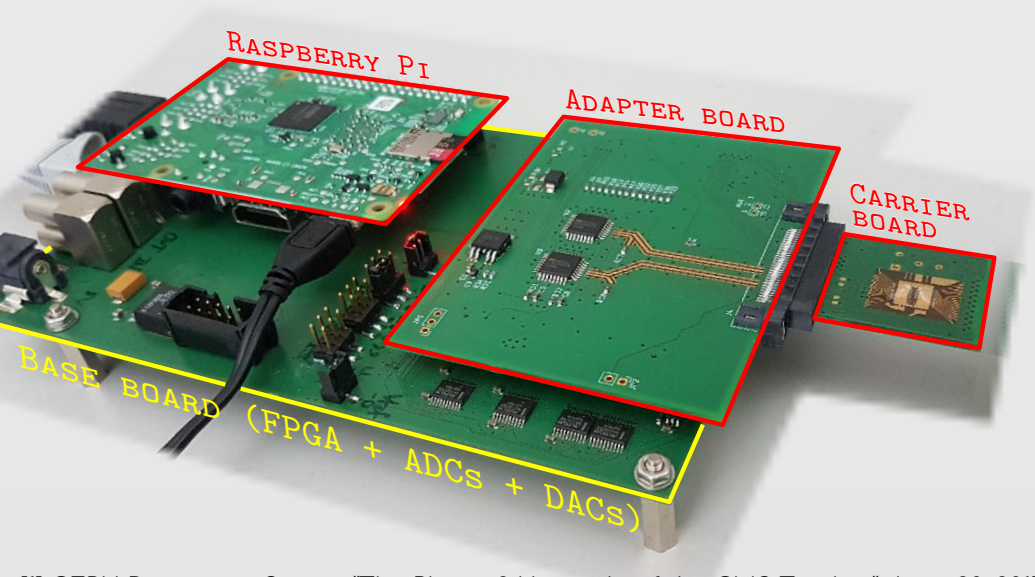
  ⇒ Constant fraction discriminator correction for Landau fluctuations

Prototypes produced in UMC 110 nm technology, still under test.

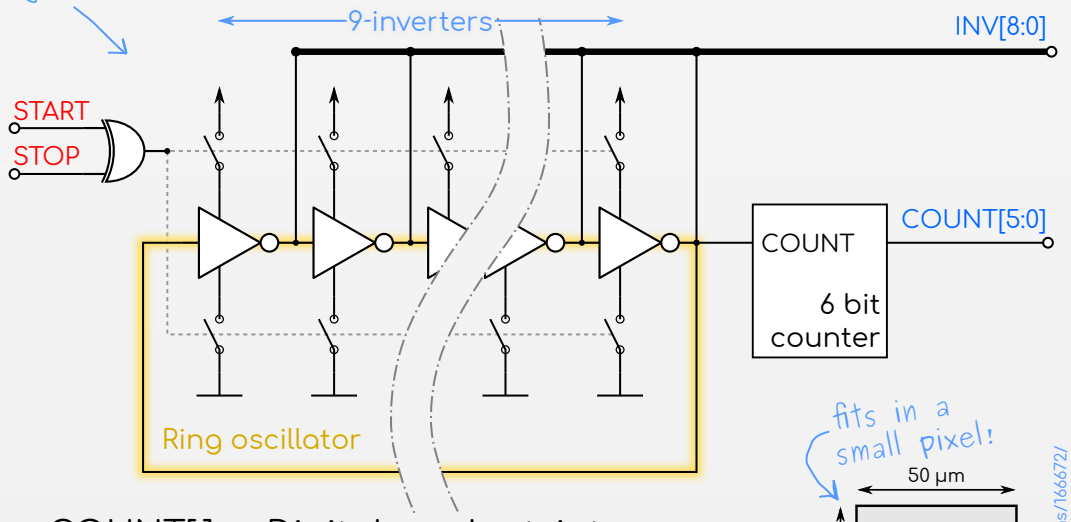


Test setup

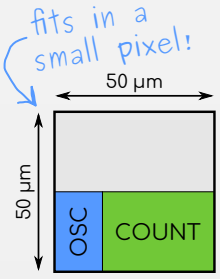
- Flexible design allows testing the two prototypes with the same "base board".
- Raspberry Pi: Allows easy automation and data acquisition.
- Base board: Flexibility to produce and read analog voltages and implement arbitrary fast logic.
- Adapter board: Specific interface required for each test structure (e.g. precise production of delay signals for the TDC test structures).
- Carrier board: Low cost board to mount the structures to test.



Pixel level TDC



fits in a small pixel!

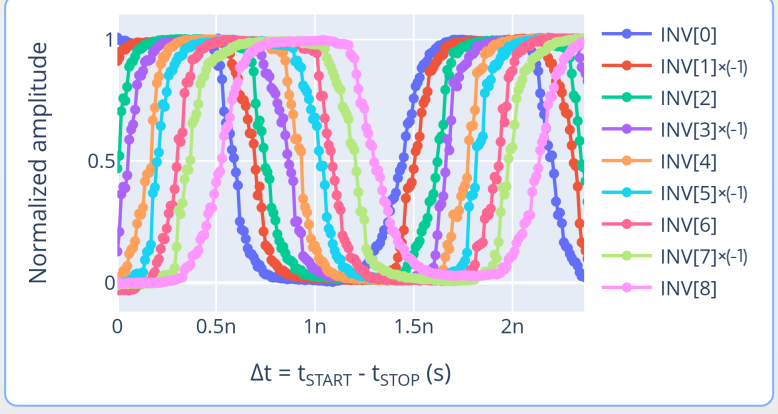


- COUNT[:] → Digital readout, integer part of time measurement
- INV[:] → Analog readout , fractional part of time measurement measurement

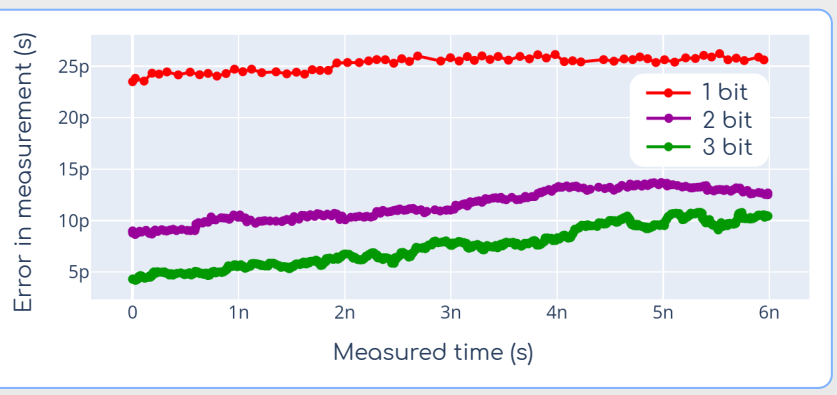
Prototypes produced in LFoundry 110 nm technology and tested.

TDC results

Analog bus INV[:] measurements:



Time resolution depends on number of bits used to digitize INV[:] as shown below:



Conclusions and outlook

- A front end and a TDC were designed and produced.
- The front end test structure is currently under test.
- The results from the testing of the TDC are very promising with a time resolution on the order of 10 ps.
- Next step is to assemble the full chain LGAD→front end→TDC and evaluate the performance.

[1] CERN Document Server. "The Phase-2 Upgrade of the CMS Tracker," June 30, 2017. https://cds.cern.ch/record/2272264.
[2] Ferrero M., Arcidiacono R., Mandurrino M., Sola V., and Cartiglia N. An Introduction to Ultra-Fast Silicon Detectors: Design, Tests, and Performances. Boca Raton: CRC Press, 2021. https://doi.org/10.1201/9781003131946.

Progress towards readout chip for pixels with timing capabilities. M. Senger[1], B. Kilminster[1], L. Caminada[1,2], A. Macchiolo[1], B. Meier[2] - [1]UZH, [2]PSI - 15th Pisa Meeting on Advanced Detectors - https://agenda.infn.it/event/22092/contributions/166672/