Characterization of the **RD50-MPW4** HV-CMOS pixel sensor

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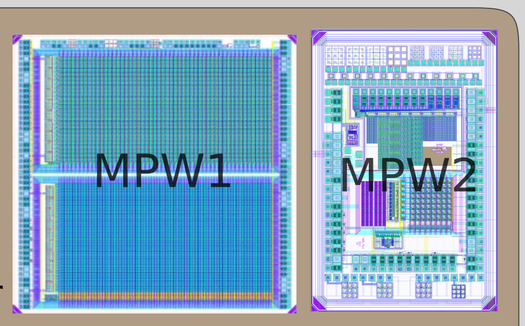
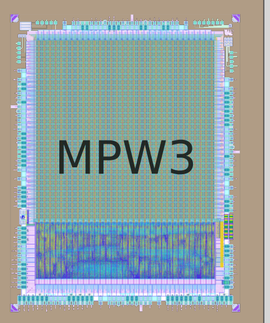
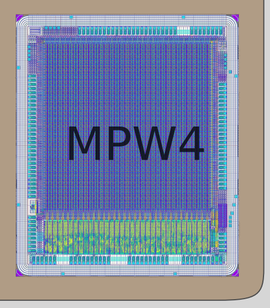
The RD50-MPW series

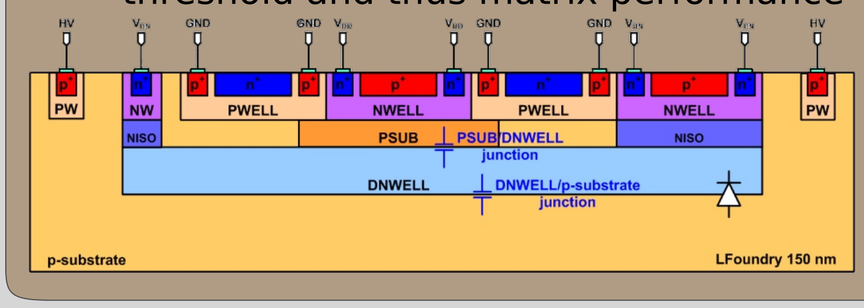
- HV-CMOS sensors fabricated in **LFoundry 150nm** process
- Large collection electrode design
- **Goal**: Evaluation of technology for radiation hard, high granularity, cost efficient DMAPS



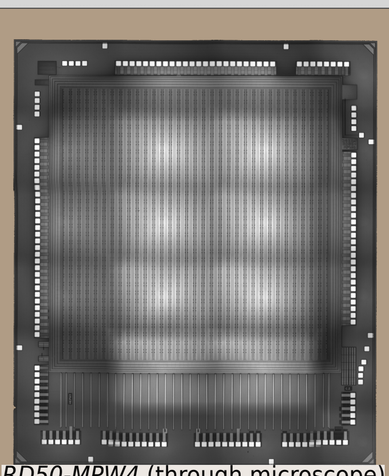




- *RD50-MPW1*: high leakage current
- *RD50-MPW2*: analog only
- *RD50-MPW3*: advanced digital periphery,
  Noise due crosstalk → Limitations on pixel threshold and thus matrix performance



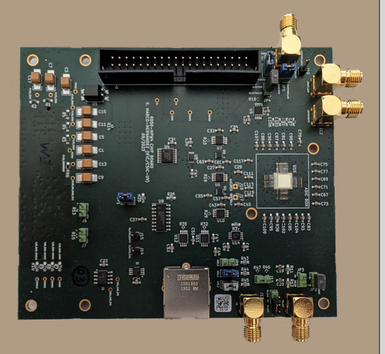
RD50-MPW4



RD50-MPW4 (through microscope)

Characteristics

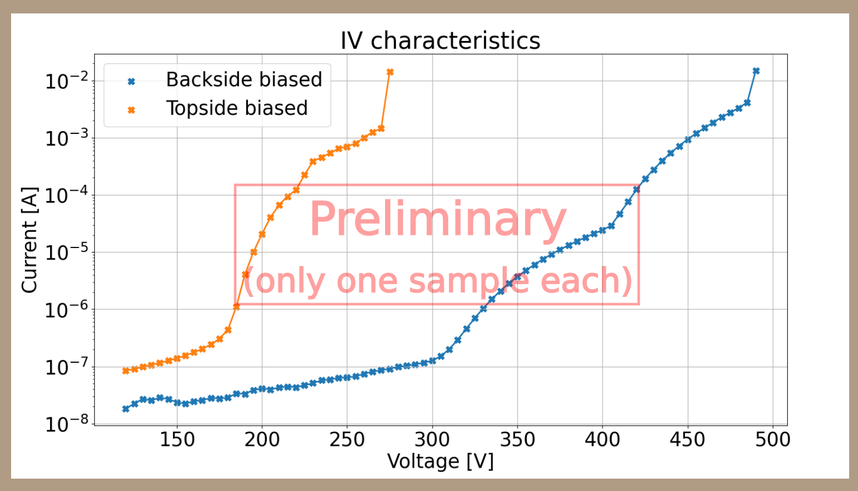
- 64x64 pixel arranged in 32 FEI-3 style double columns
- 62 x 62 µm^2 pitch
- 4 x 4 mm^2 active area
- 8 bit TS information (LSB: 25ns)
- 4 bit in-pixel trimming
- 640MHz readout



Modifications / Improvements

- Noise significantly reduced by
  - separating power domains of in-pixel and peripheral digital readout
  - improved routing
- Optimized guard rings
  - allow higher breakdown voltages
- Length of EOC readout signals adjustable
- Backside processing for better biasing

Lab Measurements

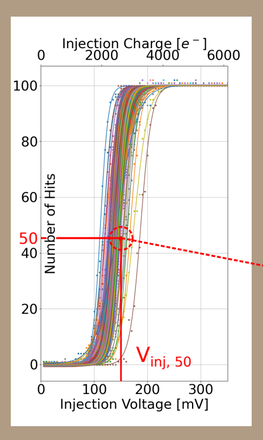


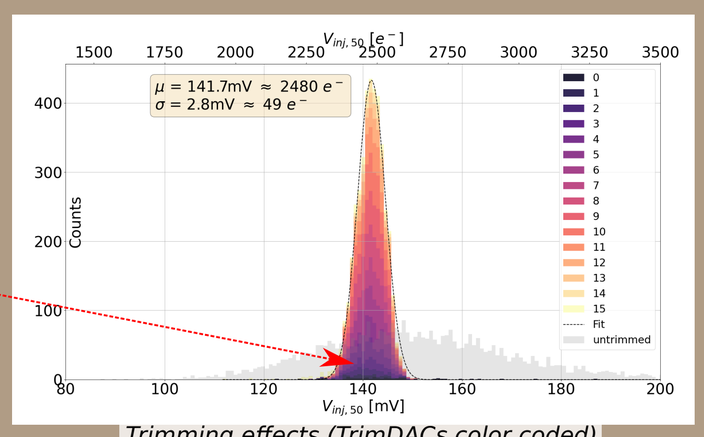
IV characteristics (of whole chip)

- Breakdown: topside biased V≈270V
  backside biased V≈490V

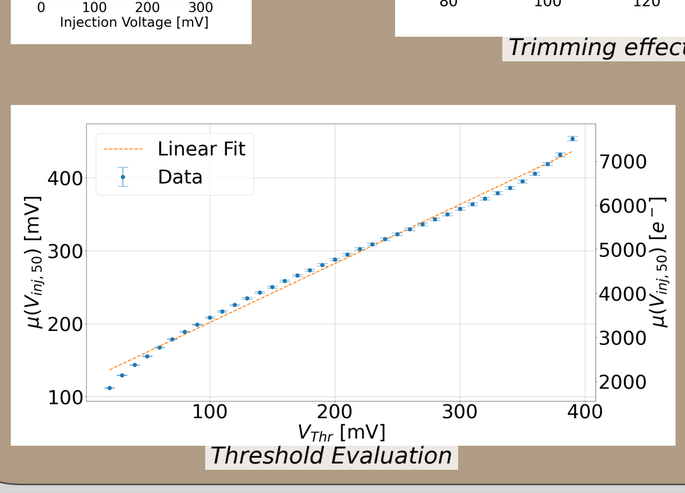
Injection Scans

- In-Pixel injection capacity 2.8fF
- After trimming pixel response σ ≈ **50e$^-$**
- **E**quivalent **N**oise **C**harge: **480(±42)e$^-$**

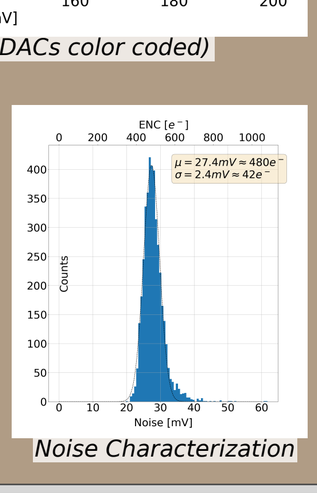




Trimming effects (TrimDACs color coded)



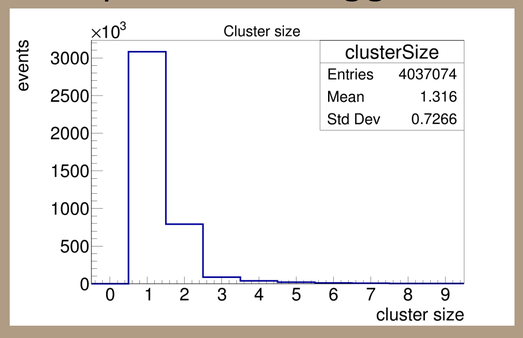
Threshold Evaluation

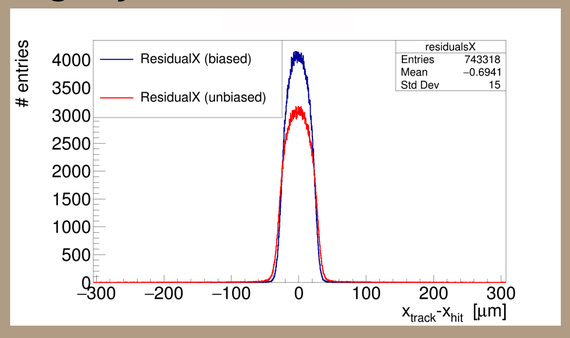


Noise Characterization

Test-Beam

- Test-Beam at *DESY* in Apr. 2024
- Focus on non-irradiated samples/comparison of top- and backside biasing
- 4.2GeV e$^-$ at f ≈ 10kHz
- *Adenium* (*Alpide* based) telescope
- *AIDA 2020 TLU* for synchronization
- *Telepix* as ROI trigger and timing layer



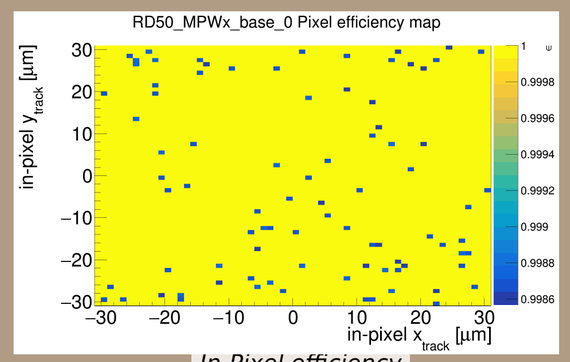


"Standard" Settings

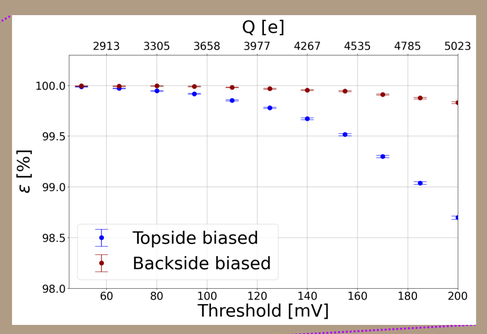
- Threshold ≈ 2500e$^-$
- Bias -190V

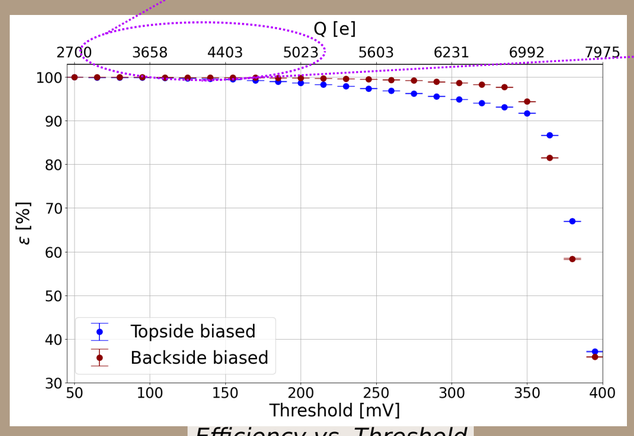
Results

- *Clustersize* ≈ **1.3**
- *Spatial Resolution* (from σ of Residuals):
  - Unbiased: 18.87µm
  - Biased: 15.0µm
  - Geometric mean: **16.8µm**
- *Total efficiency* **>99.99%**



In-Pixel efficiency





Efficiency vs. Threshold

Efficiency >99%
up to thresholds of

- Topside: 4800e$^-$
- Backside: 6000e$^-$

Summary

Finding and fixing the problems of RD50-MPW3 lead to the development of the **RD50-MPW4**.
This protype was successfully characterized in the laboratory and at beam tests.
The measurements show a high breakdown voltage of a few 100V,
a uniform pixel response (σ ≈ 50e-), a spatial resolution of ≈17µm and an efficiency >99.99%.

Acknowledgements:

This work has been partly performed in the framework of the *CERN-RD50* collaboration.

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