Status of the MuPix HV-MAPS

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March 2021

Overview

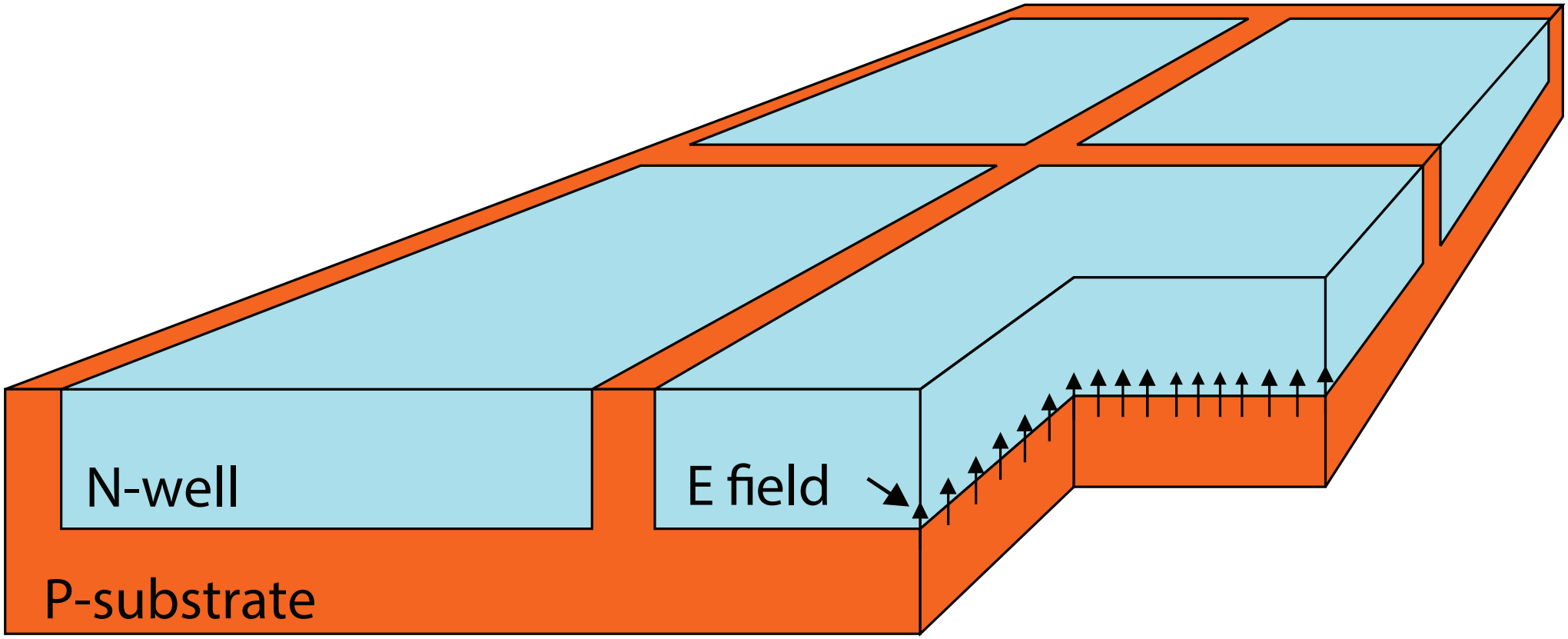
- High-Voltage Monolithic Active Pixel Sensors (HV-MAPS)
- Results from MuPix 10

High-Voltage Monolithic Active Pixel Sensors

Fast and thin sensors: HV-MAPS

High voltage monolithic active pixel sensors - Ivan Perić

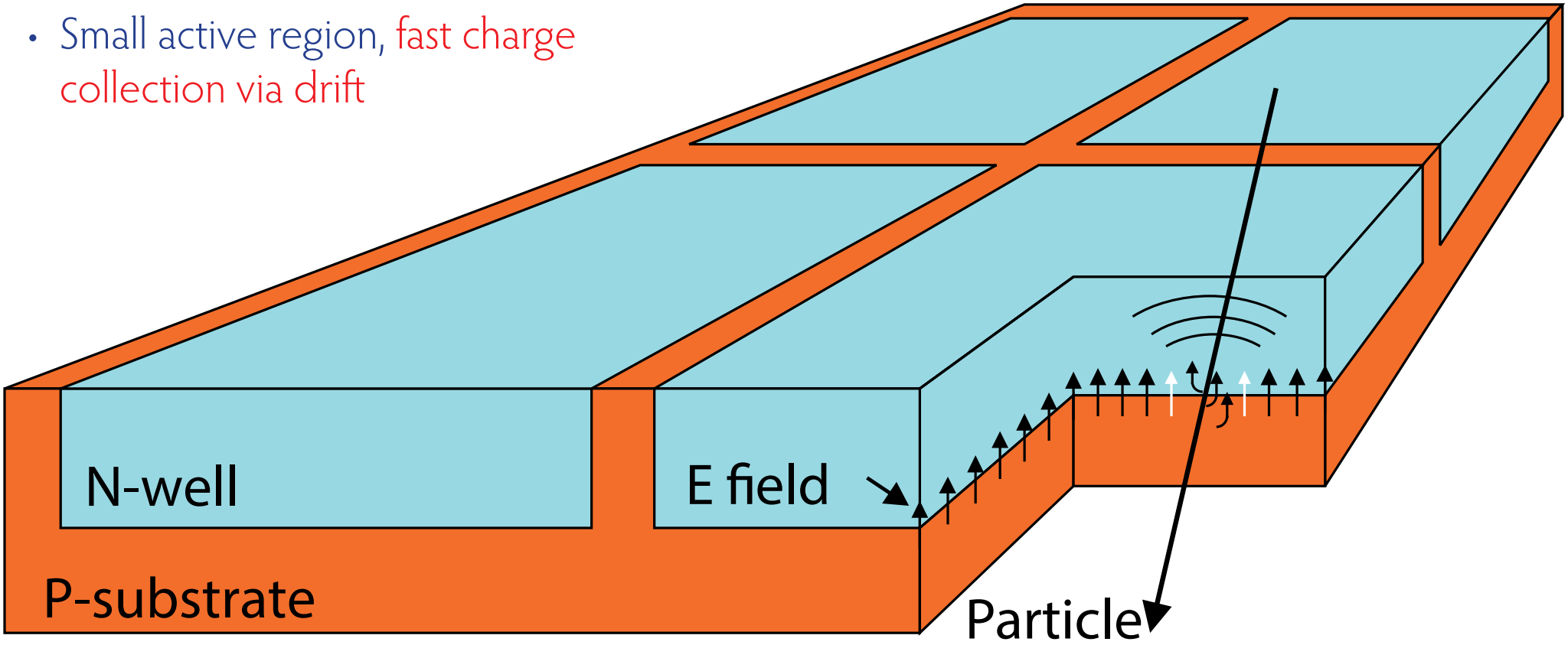
- Use a high voltage commercial process (automotive industry)



Fast and thin sensors: HV-MAPS

High voltage monolithic active pixel sensors - Ivan Perić

- Use a high voltage commercial process (automotive industry)
- Small active region, fast charge collection via drift



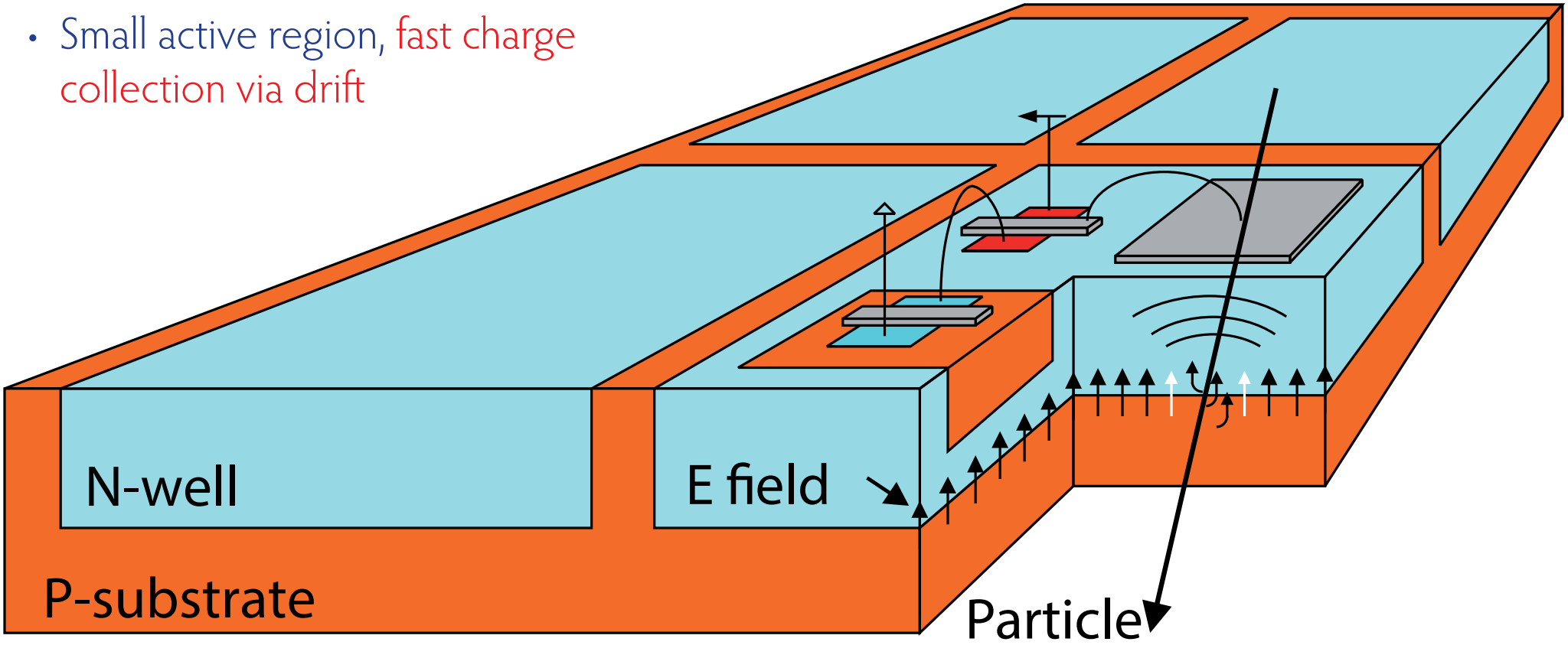
Fast and thin sensors: HV-MAPS

High voltage monolithic active pixel sensors - Ivan Perić

- Use a high voltage commercial process (automotive industry)
- Small active region, fast charge collection via drift

- Implement logic directly in N-well in the pixel - smart diode array
- Can be thinned down to < 50 µm

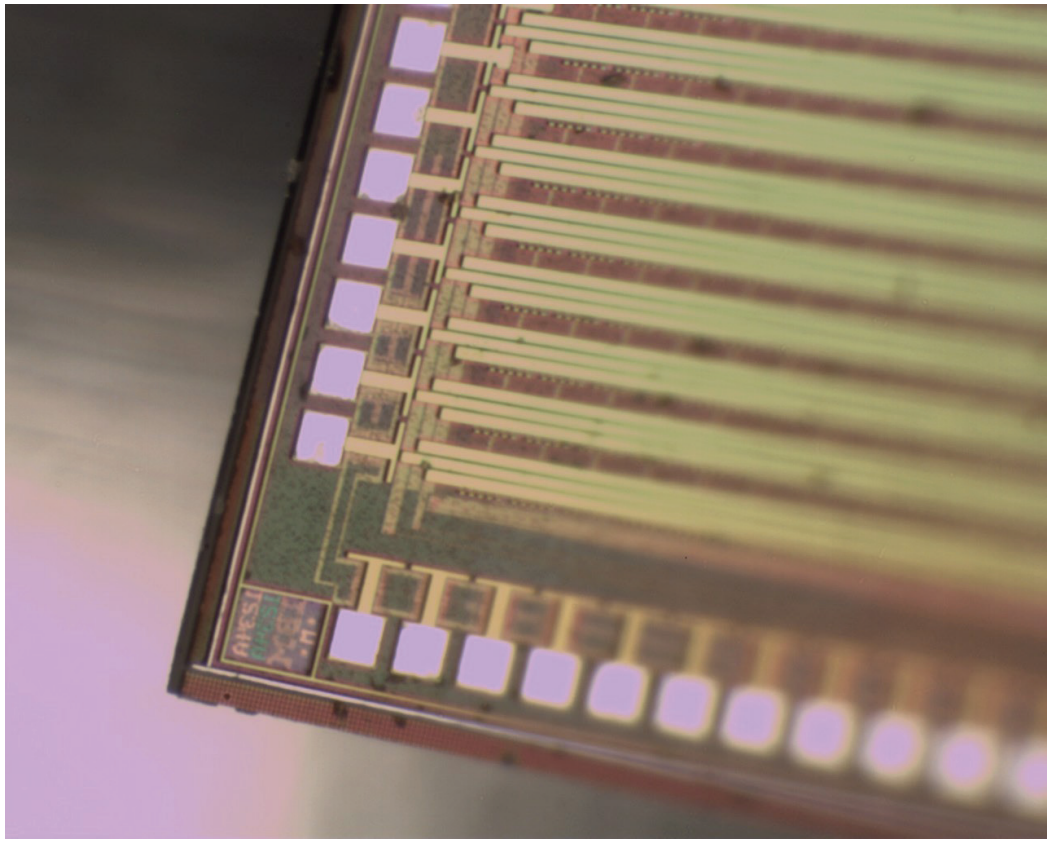
(I.Perić, P. Fischer et al., NIM A 582 (2007) 876)



The MuPix Prototypes

Developed a series of HV-MAPS prototypes

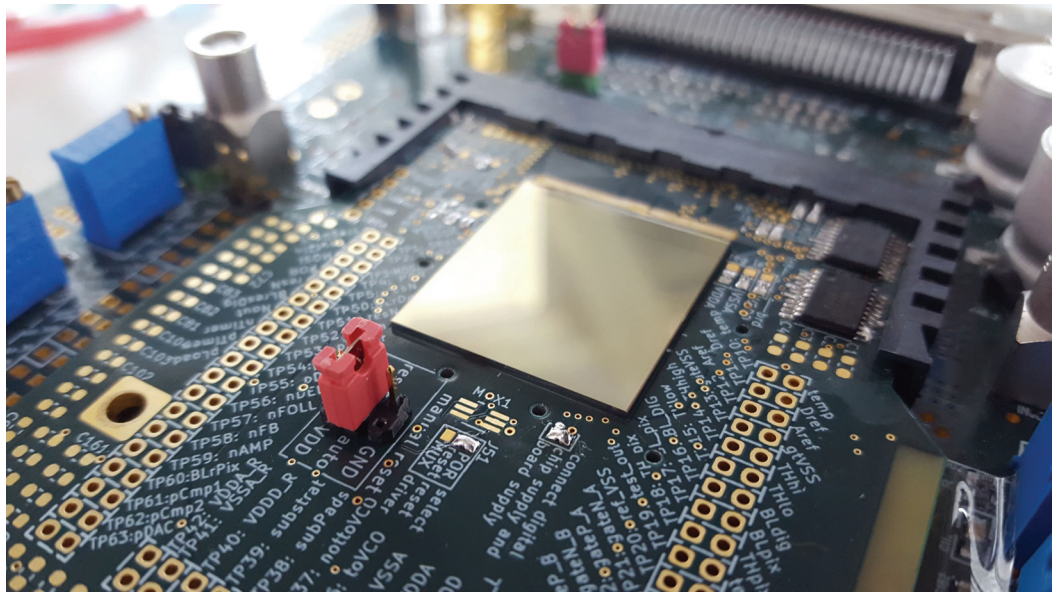
- Goal: Detection and signal processing with just 50 µm silicon
- 6th chip, MuPix7, was first full system-on-a-chip
- MuPix8 was the first large sensor with 2 x 1 cm^2 - used for the test beams in A2 and X1
- MuPix9 was a small test chip mostly for configuration logic and voltage regulators
- MuPix10 is a large 2 x 2 cm^2 prototype with all features needed for Mu3e - results in the following
- MuPix11 to be submitted this summer



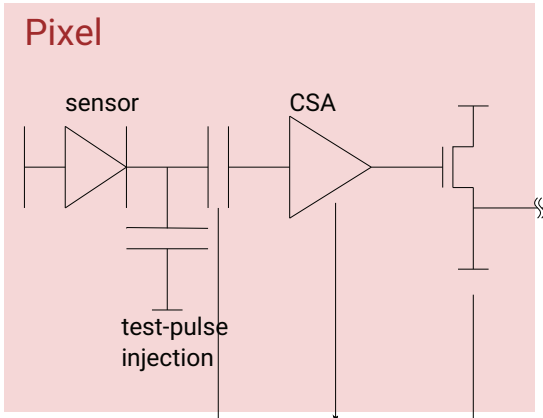
MuPix10 Results

Specs

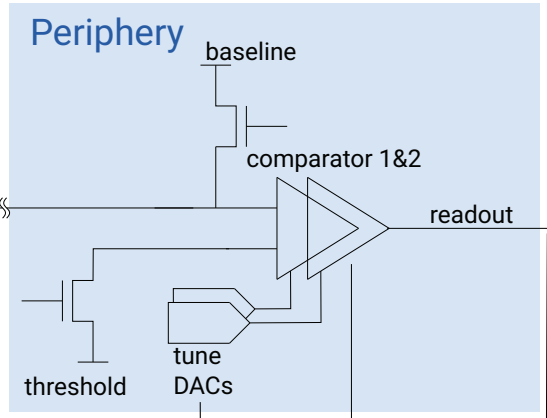
Matrix [pixel]	256×250
Pixel size [μm²]	80×80
Active area [mm²]	20.48×20.0
ToA+ToT [bits]	11+5
Tuning+Masking [bits]	2x3+1
LVDS links	3+1
resisitivity [Ω cm]	20, 200



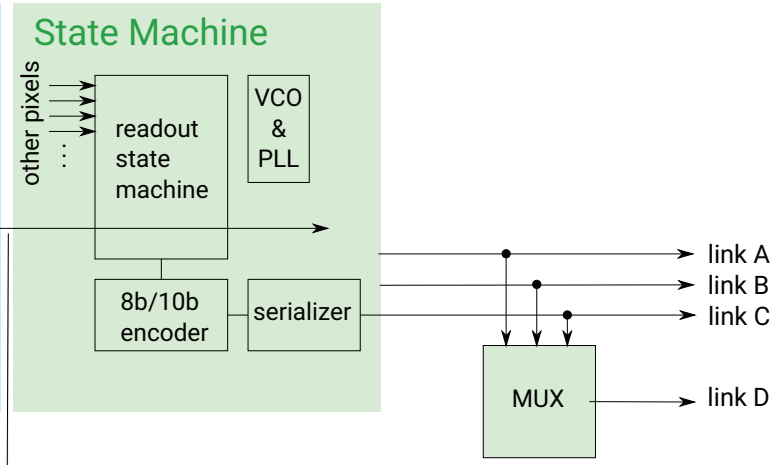
per pixel



per pixel

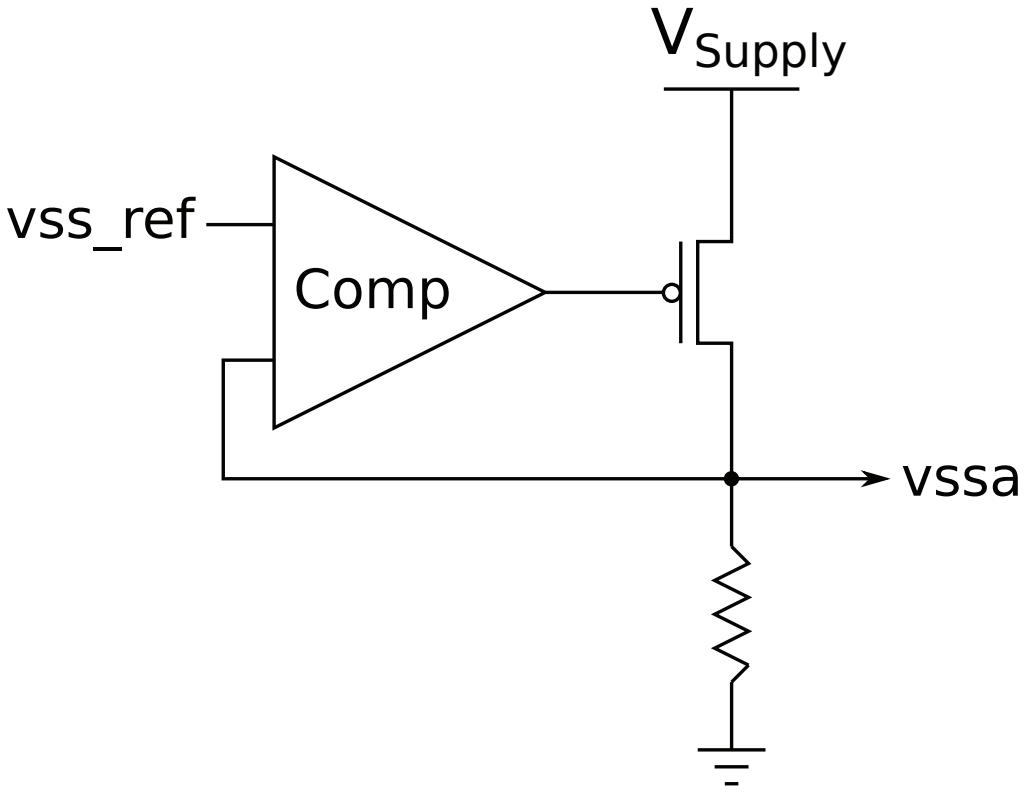


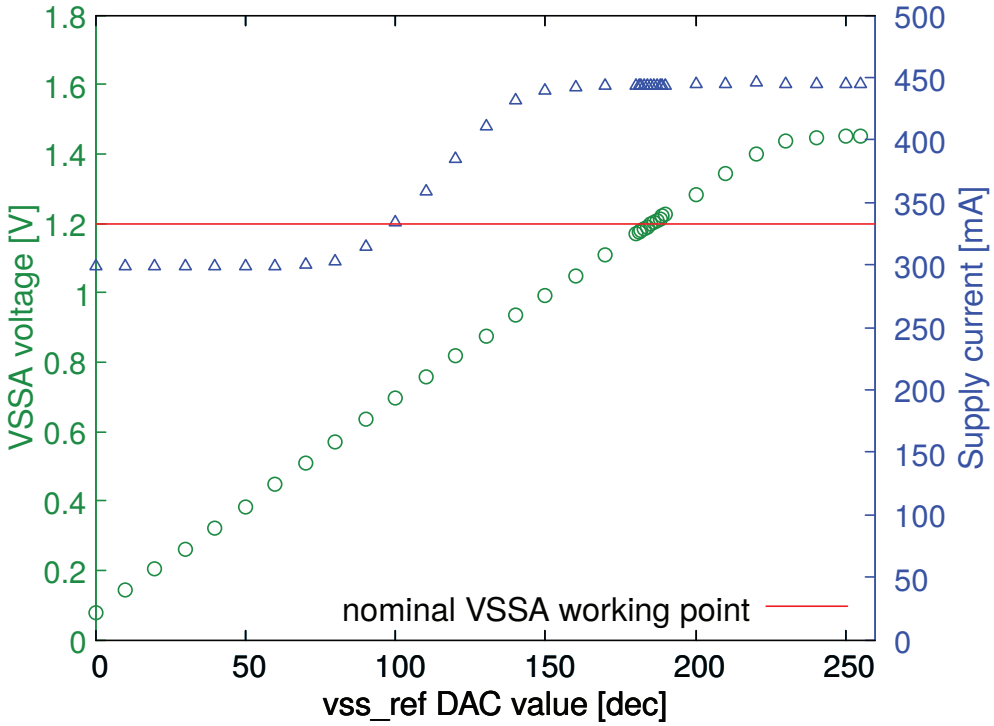
per submatrix



New Features I: Internal regulator for VSSA

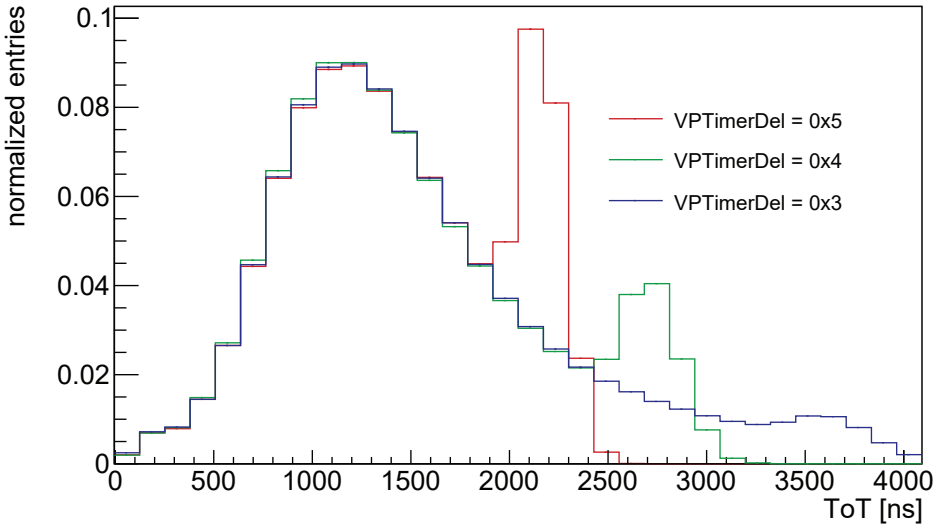
- As opposed to earlier variants, the MuPix10 only needs one supply voltage of ~ 2V
- Internal regulator works

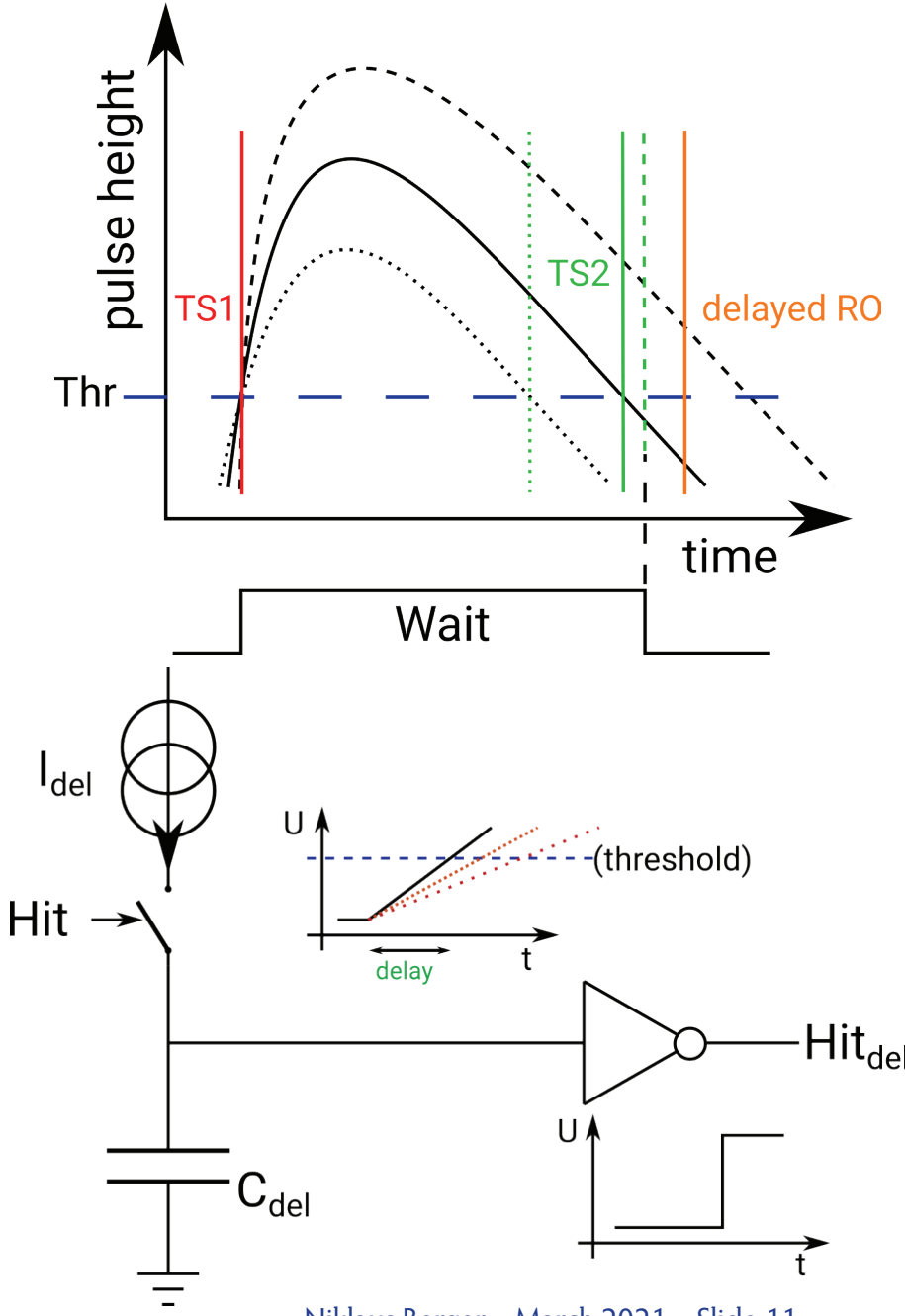




New Features II: ToT sampling with delay

- Hits are sampled on falling edge, allowing reliable ToT measurement (~ charge)
- Delay circuit to set maximum delay working - not mixup of hit chronology

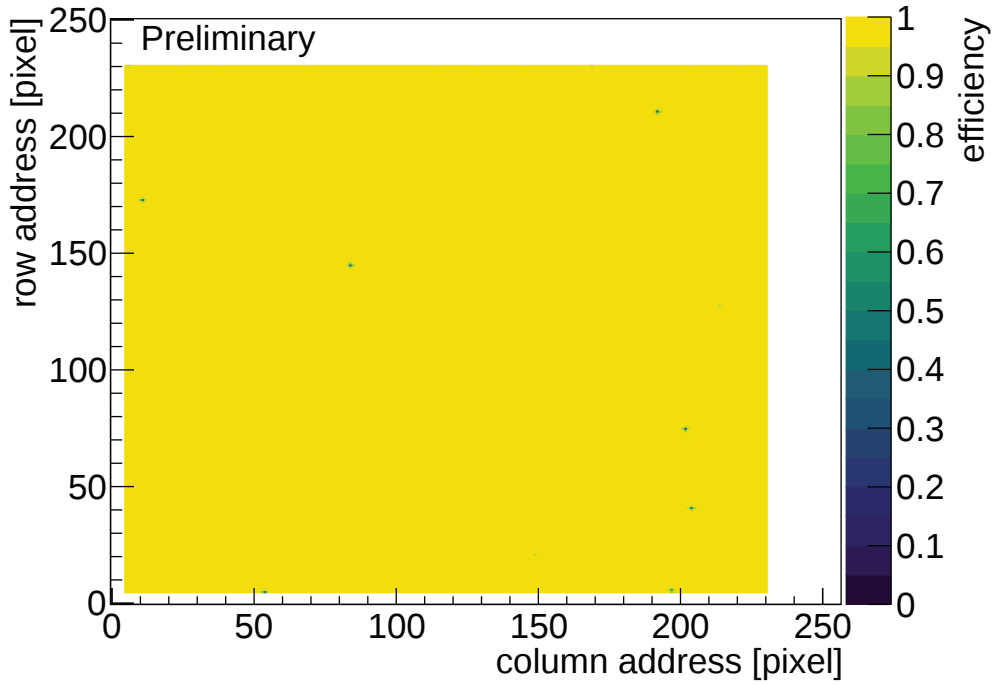


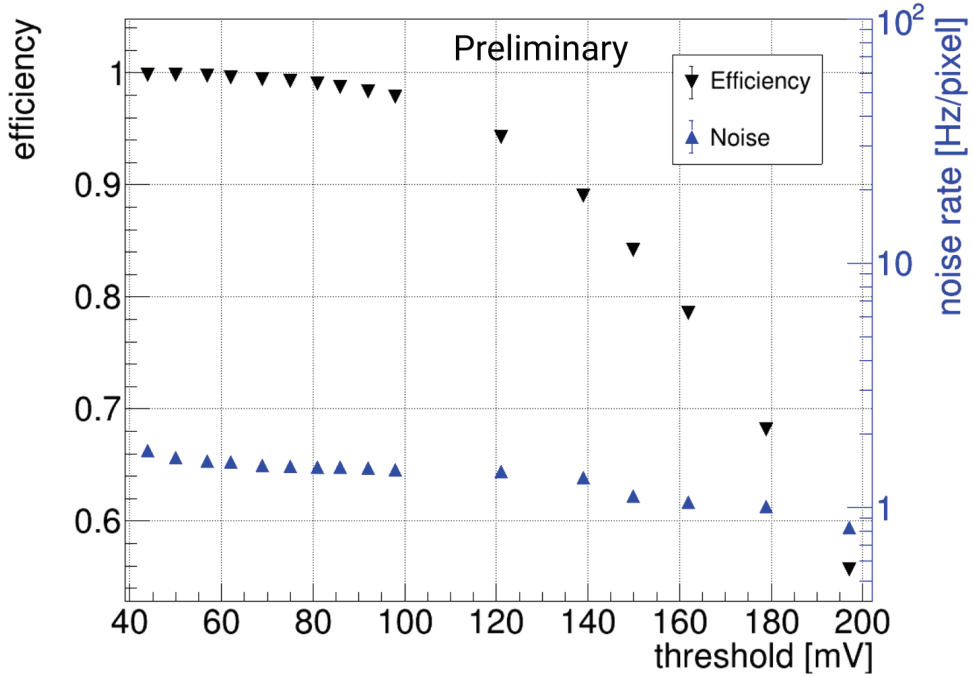


Beam test at PSI

Efficiency	$> 99\,\%$
Noise Rate	$< 2\,\mathrm{Hz/Pixel}$
Power Consumption	$< 200\,\mathrm{mW/cm^2}$

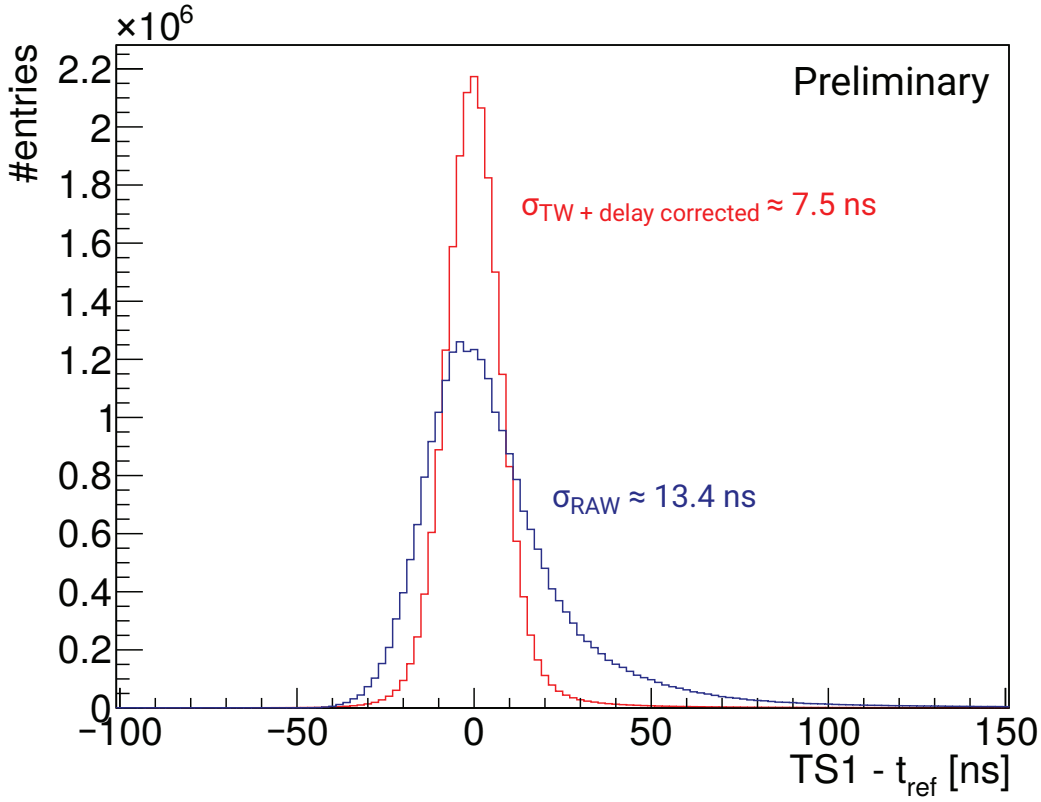
- No pixel tuning applied





Time resolution

- Raw about 13 ns
- 7.5 ns after correcting for known delays and time-walk

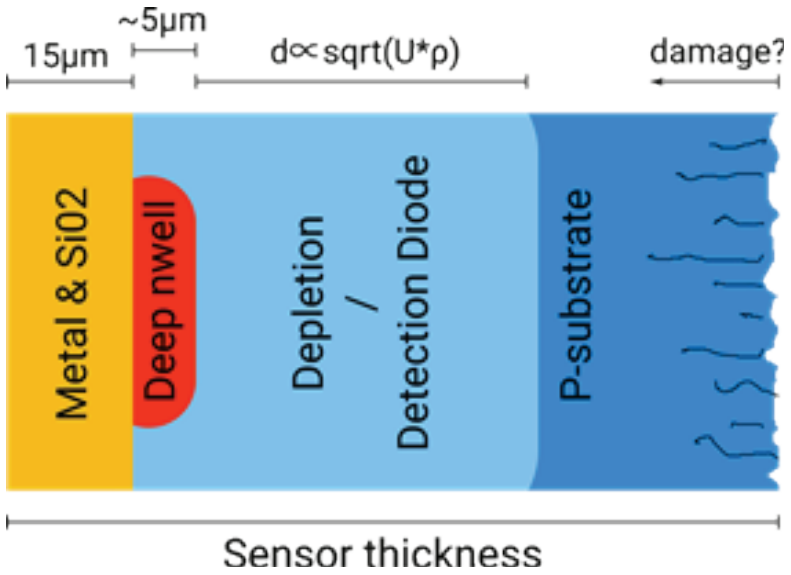


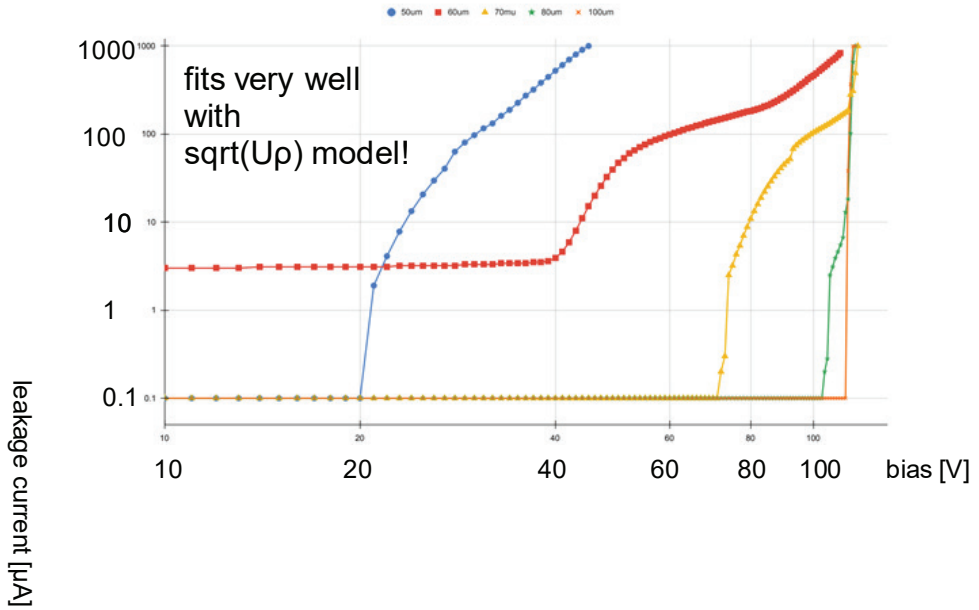
Issue 1: Configuration logic

- Several options for configuration
- Mu3e plans to use a single differential signal: this is not working
- Simple SPI configuration works, load signal has to be kept low
- Source likely understood and fixed - different cell library
  (also not seen in recent submissions using same logic but correct library)

Issue 2: Early breakdown

- Thin chips hold less HV
- Understood: Depletion region reaches part of the substrate damaged by grinding
- Can maybe be improved by an etching step
- Efficiencies still good at lower HV, but some trade-off between thickness and efficiency





Summary

- MuPix chips made good progress
- Should work for the TPC experiment
- Tests with MHz irradiation on small spots to be repeated once MAMI up and running again
- Chips also operated successfully in Mu3e modules with thin flexes