

# Beam pixel detectors from Mainz - HV-MAPS prototypes

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March 10, 2020

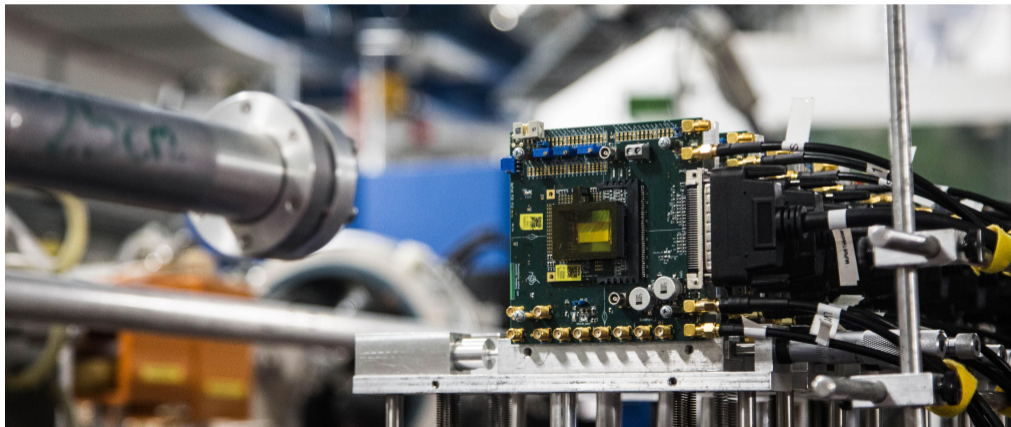


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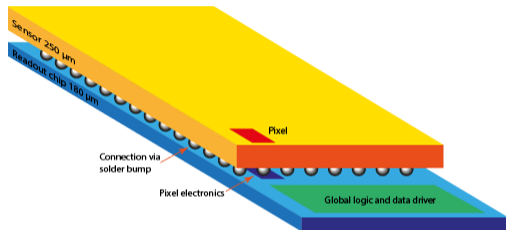


# Outline

- ▶ What is HV-MAPS?
- ▶ The MuPix8 prototype
- ▶ 2019 testbeams
- ▶ Outlook

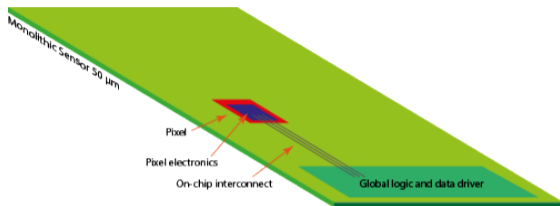


# Monolithic vs. hybrid pixel sensors



**Hybrid**

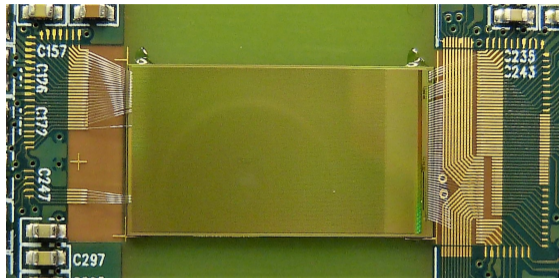
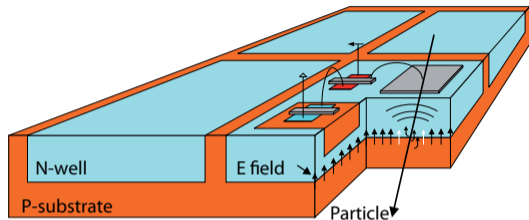
- ▶ Separate detection and readout chip
- ▶ Bump bonds necessary



**Monolithic**

- ▶ Intergration of digitization on chip
- ▶ Thinnable

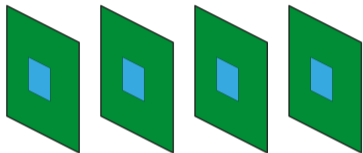
# HV-MAPS - High Voltage Monolithic Active Pixel Sensor



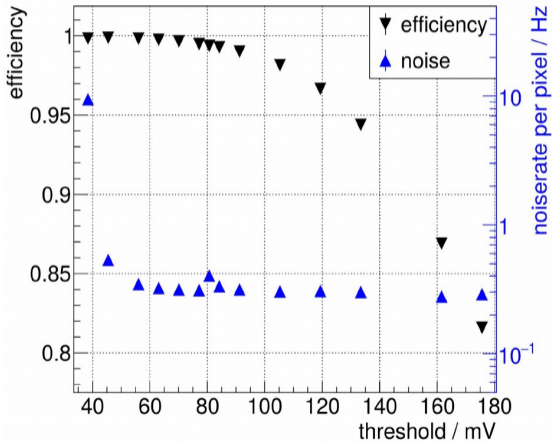
- ▶ 180 nm HV-CMOS technology
- ▶ Reverse biased up to 90 V
- ▶ Readout logic on chip
- ▶ Thinnable down to 50  $\mu\text{m}$

- ▶ MuPix8
- ▶ Pixel size:  $80 \times 81 \mu\text{m}^2$
- ▶ Sensor size:  $2 \times 1 \text{ cm}^2$
- ▶ Used in Mu3e, P2, Panda...

# Efficiency measurement - The MuPix telescope

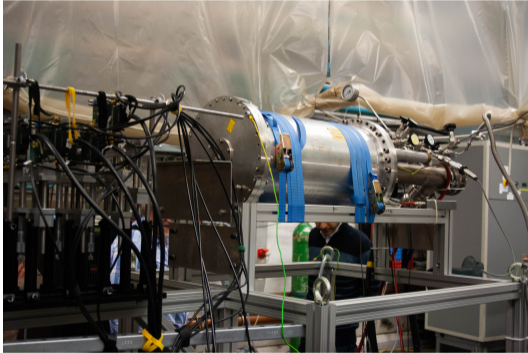


- ▶ 4 layer telescope
- ▶ 2nd layer as device-under-test (DUT)
- ▶ Measure efficiency

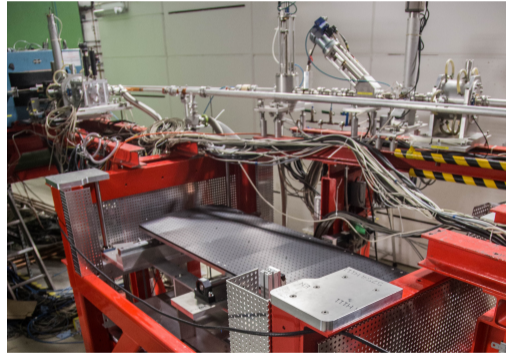


# 2019 testbeams

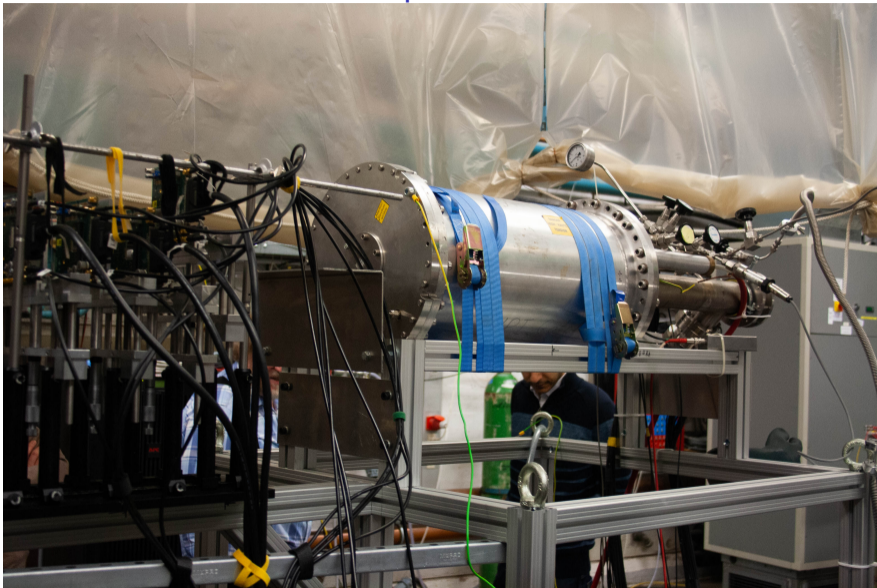
**March - A2**



**November - X1**

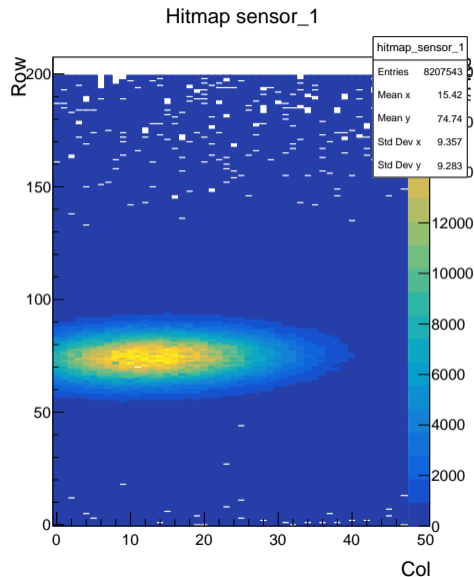


## March 2019 testbeam in A2 - Setup



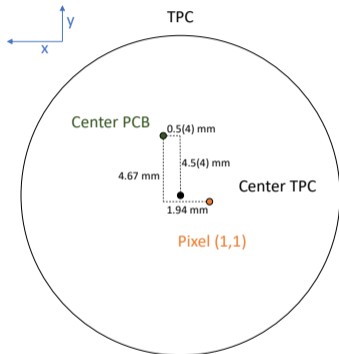
## March 2019 testbeam in A2 - Observations

- ▶ MuPix8 mounted to TPC front flange
- ▶ Grounding scheme revised
- ▶ beam rate up to 2 MHz
- ▶ beam spot  $\approx 800 \times 800 \mu\text{m}^2$



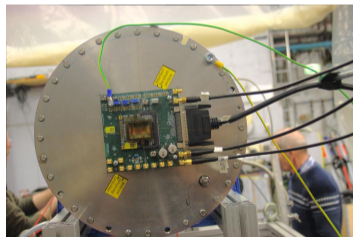
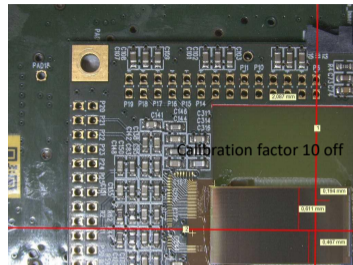


# Calibration of sensor position



Pixel (row=1;col=1) is at

- $x : -1.44(40)$
- $y : -0.17(40)$

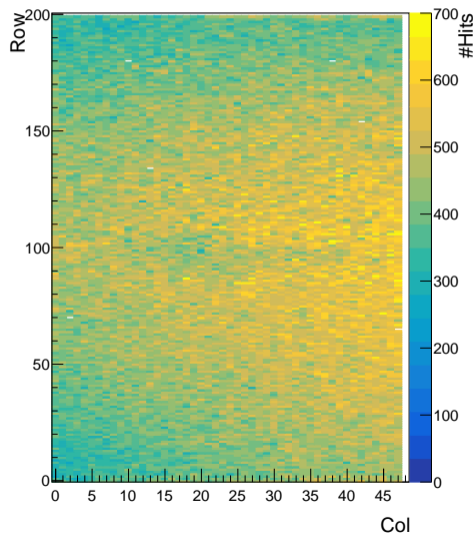


- ▶ uncertainty of 400  $\mu\text{m}$  (5 pixels)

## March 2019 testbeam - Observations from 2018 testbeams

Hitmap sensor\_0

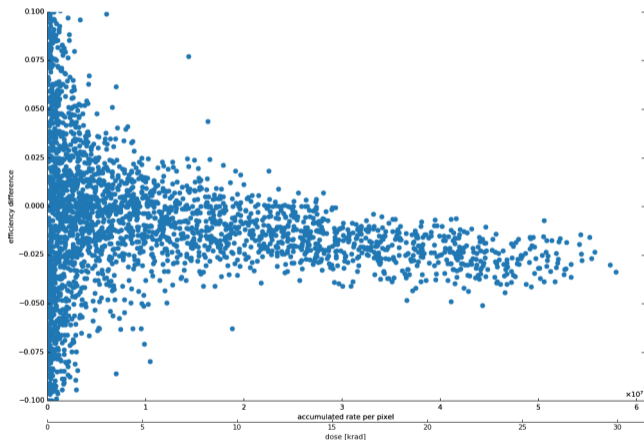
- ▶ MuPix8 high rate test (up to 10 MHz)
- ▶ observed efficiency loss
- ▶ dose/rate dependency?
- ▶ hitmap: Sr-90 response after testbeam



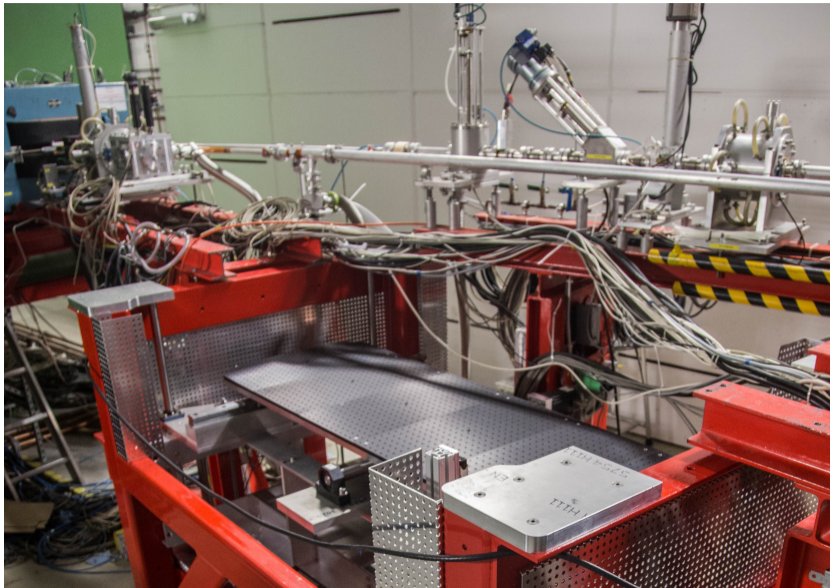
## March 2019 testbeam - Efficiency loss versus acumulated hits (dose)

Idea: run at lower rate,  
accumulated same number  
of hits

- ▶ beam rate: 1 MHz
- ▶ 2018: up to 10 MHz

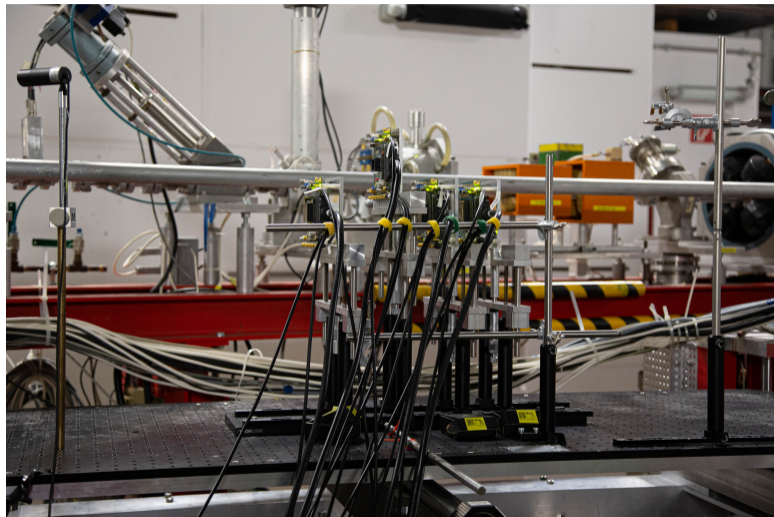


## November 2019 testbeam - X1



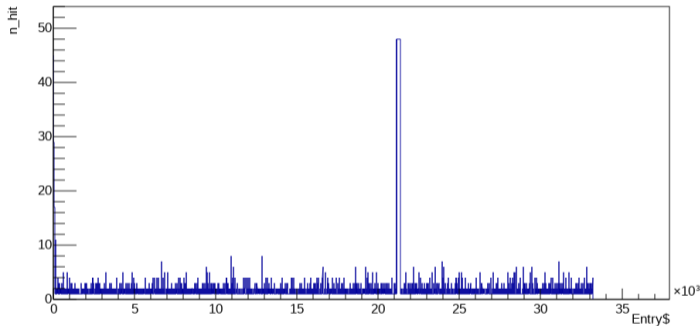
## November 2019 testbeam - MuPix8 setup

- ▶ MuPix8 telescope reference
- ▶ single MuPix8 in pulsed beam
- ▶ MuPix8 telescope ref. again
- ▶ also: MuPix7, AtlasPix



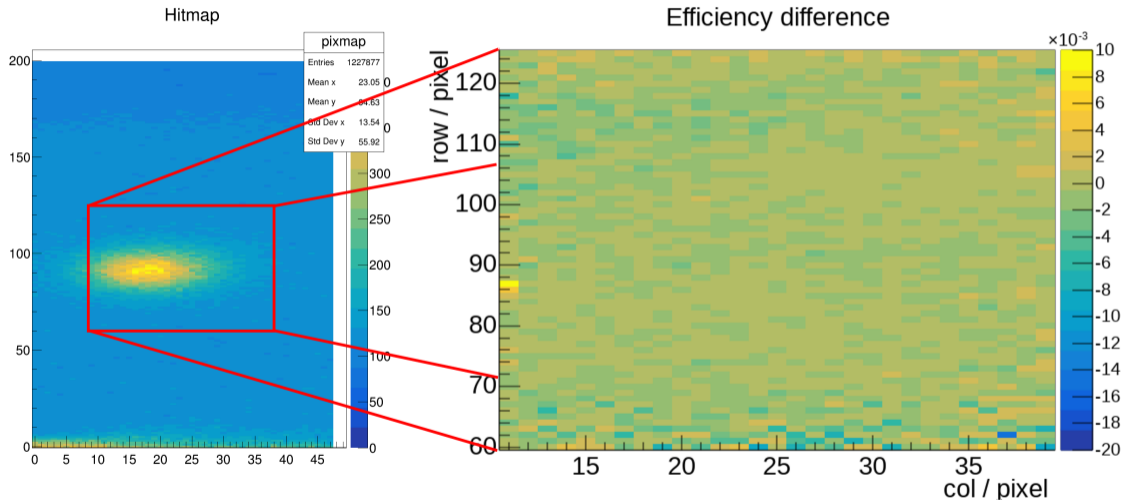
## November 2019 testbeam - Pulsed electron beam

- ▶ square pulses,  $40\ \mu\text{s}$
- ▶ beam current  $< 250\ \text{nA}$
- ▶ simulate beam loss
- ▶ shared with Belle II group, testing switcher ASIC

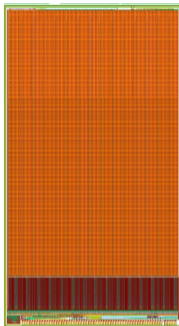


Number of hits per readout frame

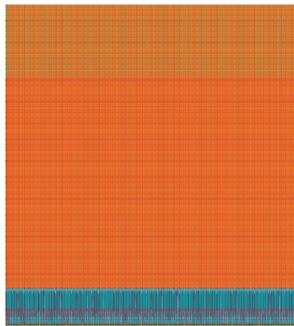
# November 2019 testbeam - No efficiency loss observed



## Outlook - From MuPix8 to MuPix10



- ▶ Sensor size:  $2 \times 1 \text{ cm}^2$
- ▶ 3 different submatrices



- ▶ Sensor size:  $2 \times 2 \text{ cm}^2$
- ▶ 3 identical matrices



# Summary

- ▶ HV-MAPS detector prototype: MuPix8
- ▶ 2 testbeam campaigns in 2019
- ▶ efficiency loss at high rates observed
- ▶ position calibration needs to be developed

