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MuPix9 - a HV-MAPS prototype with serial powering

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The Mu3e experiment is searching for the charged lepton flavour violating decay $\mu^+ \rightarrow e^+e^-e^+$. The core elements of the detector are High Voltage Monolithic Active Pixel Sensors (HV-MAPS).

The actual status of development and testing will be presented together with the latest test version of the chip. This version, the MuPix9, takes into account the testing results of the large-scale prototype MuPix8.

Design aspects such as serial powering and first measurement results on the MuPix9 will be shown.

Summary

The Mu3e experiment is searching for the charged lepton flavour violating decay $\mu^+ \rightarrow e^+e^-e^+$ with a sensitivity of up to one in 10^{16} decays at Paul Scherrer Institute (PSI), Switzerland. In order to build such an extreme sensitive detector, it is required to have a vertex resolution of about 100 µm, a time resolution of 20 ns and detector thickness of only 50 µm.

These demands can only be satisfied by cutting edge technology.

High-Voltage Monolithic Active Pixel Sensors (HV-MAPS) are depleted active pixel sensors implemented in standard commercial CMOS processes. The sensor element is a diode formed by the deep n-well and p-substrate. The sensor diodes are depleted by high voltage of up to 160 V in order to increase the active volume. Complex low-voltage electronics can be implemented inside the pixel's deep n-well or in the periphery of the sensor (as floating logic). The combination of fast charge collection by drift granting a good time resolution and advanced on-sensor electronics make the AMS aH18 HV-CMOS technology suitable for the challenges of the Mu3e experiment. The combination of sensor and readout electronics on the same piece of silicon meet the requested low material budget. Furthermore, HV-CMOS sensors are proposed as an option for 2024's ATLAS upgrade (CERN, Switzerland).

A series of prototypes, called MuPix, have been developed for the Mu3e experiment.

In 2017 the largest prototype MuPix8 (1 x 2 cm^2) was designed, submitted, fabricated and has already passed the first tests successfully. In testbeam at SPS, CERN (120 GeV pions) the MuPix8 shows an efficiency of greater 99.5 % and good time resolution. Currently, we are working towards the final MuPix design.

For the final version, several new features are required. One of these features is an innovative powering method. To characterize new circuits, a smaller sensor prototype has been developed, the MuPix9. On this chip, novel serial powering concepts for the Mu3e experiment were realized using two power regulators. Furthermore, the powering of the analog and digital part was separated. This allows the chip to maintain two different power levels. The concept of serial powering leads to a significant reduction of the power supply current and power connections to the sensor-chip. The MuPix9 was designed in a way to either characterize the two power regulators and the pixel matrix separately or evaluate the combination.

This poster will present the design of the MuPix9 and shortly point out the differences to the large-scale prototype MuPix8, e.g. the serial powering concept. Furthermore first measurement results on the MuPix9 will be shown together with the latest results of the large-scale prototype MuPix8. Additionally we plan to grant a glimpse on the upcoming submission of the final MuPix version.

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