The MuPix8 Chip
A monolithic large scale pixel sensor

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DPG Spring Meeting: T 5.8
19. March 2018
The Mu3e Experiment

Searching for the charged Lepton Flavor Violating decay $\mu^+ \rightarrow e^+ e^- e^+$

- sensitivity goal of one in $10^{16}$ decays, requires high muon rates of $10^9 \text{ s}^{-1}$
- reconstruction of electron trajectories in a 1 T solenoidal magnetic field
- multiple coulomb scattering dominated ($p_e < 53 \text{ MeV}/c$)
low ohmic substrate  
(20 Ω cm - 200 Ω cm) 
high voltage (−120 V) 
AMS 180nm HV-CMOS
Road to the first full scale Mu3e Pixel Sensor

MuPix8

MuPix7

First fully monolithic prototype

MuPix9

Scalability

Detector Integration

Full scale Mu3e sensor chip

MuPix10

MuPix8

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MuPix8 Design Features

- $2 \times 1 \text{ cm}^2$ chip size
- pads on one edge $\rightarrow$ flexprint readiness
- improve time resolution
- radiation hard design
- increase active volume (80 $\Omega$ cm substrate)
81 \times 80 \mu m^2 \text{ pixel size}

128 \times 200 \text{ pixels}

16 \times 10 \text{ mm}^2 \text{ active area}

3 \text{ matrix partitions}
- timewalk reduction circuitry
- 3 sub-matrices with dedicated data output
- additional merged data output
Crosstalk and Signal Transmission

- very dense routing:
  - 2 metal layers, 200 signals
  - 300 nm spacing
- 1 sub-matrix source follower
- 2 sub-matrices current driven
Crosstalk and Signal Transmission

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2-threshold
On-Chip correction

- 3 time walk correction approaches
- 2 comparators
- 5 tune bits + pixel switch
- 10(+6) timestamp bits
Pixel Digital Cell

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**voltage ramp**

**Off-Chip correction**
Pixel Digital Cell

- 3 time walk correction approaches
- 2 comparators
- 5 tune bits + pixel switch
- 10(+6) timestamp bits
6 single ended signals
- no chip address
- readback of DAC values
⇒ not feasible for module production with two layer flexprints
- reduction of I/O connections
- differential Inputs → solved
- using a SC Bus (Chip Address)
- readback of Chip Information via Data stream
Slow Control Interface - Required Changes

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19/03/18
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Slow Control Interface - The MuPix9

- custom 32bit protocol
- chip address
- broadcast synchronous reset
- standalone and integrated available
- expected this summer

More on MuPix9 by Alena Weber (T 5.10)
**Slow Control Interface - The MuPix9**

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More on MuPix9 by Alena Weber (T 5.10)
more to explore on MuPix8: Bandgap, merged link, ...

- many parts silicon proven
- design decisions have to be made
- start of MuPix10 design soon