

Exhaustive model building for the development of the next generation of CMOS pixel sensors

Elio Sacchetti, Maciej Kachel

DRD7: R&D Collaboration on Electronics and On-detector Processing. 3rd workshop

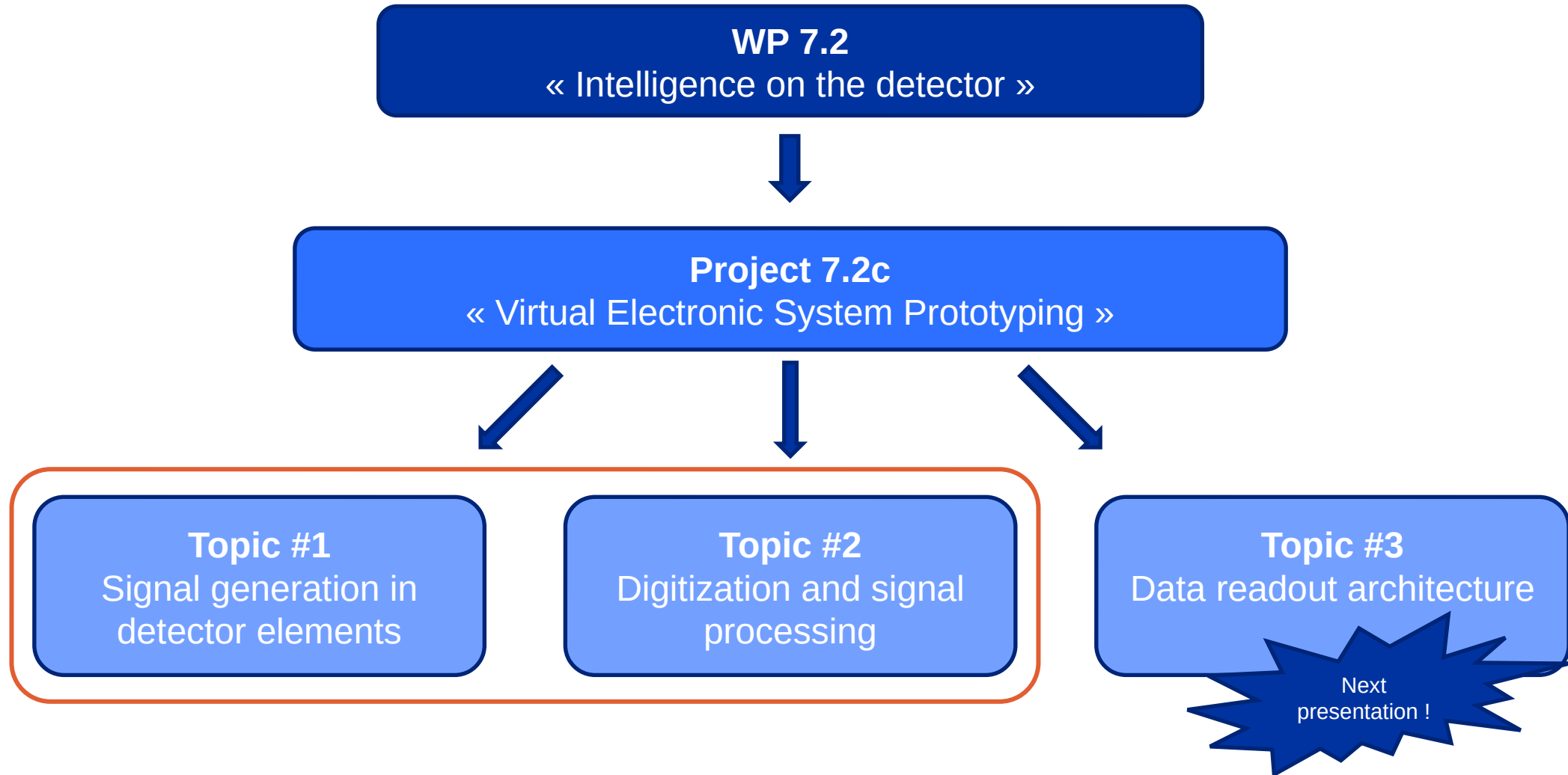


9-10 Sept. 2024 - CERN

Outline

1. Overview of the Project 7.2c
2. Developing a physics → electronics integrated simulation flow
3. Focus on the topics

Overview of the project



Developing a physics → electronics integrated simulation flow

Why do we need such a framework?

Detector with enhanced performances (always more “aggressive”)

→ Requires accurate simulation on the following aspects:

Charge collection, signal digitization, readout architecture, data flow

Several tools/framework/software already exist for specific simulations but nothing unified

→ **A fluid workflow is mandatory**

Developing a physics → electronics integrated simulation flow

From the particle interaction with the sensor...

Simulation flow

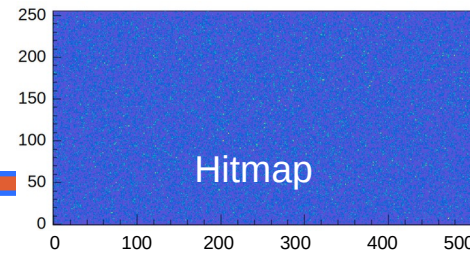
... to the chip digital output

Sentaurus
TCAD
SYNOPSYS

Sensing element design

ap²
allpix²squared

Charge deposition + collection (+ digitization)



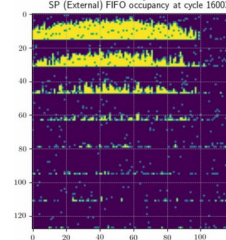
Digitization + signal processing

cadence

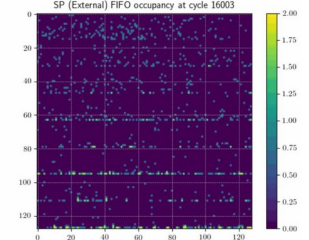
Readout architecture sizing

PixESL

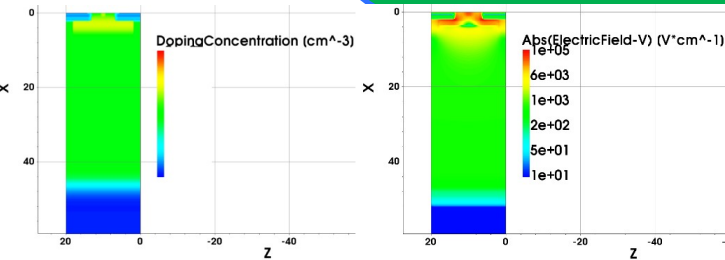
Velopix1



Proposed



From "PixESL: A virtual Electronic System Level prototyping framework", Jashandeep Dhaliwal, 25/09/2023, p.5



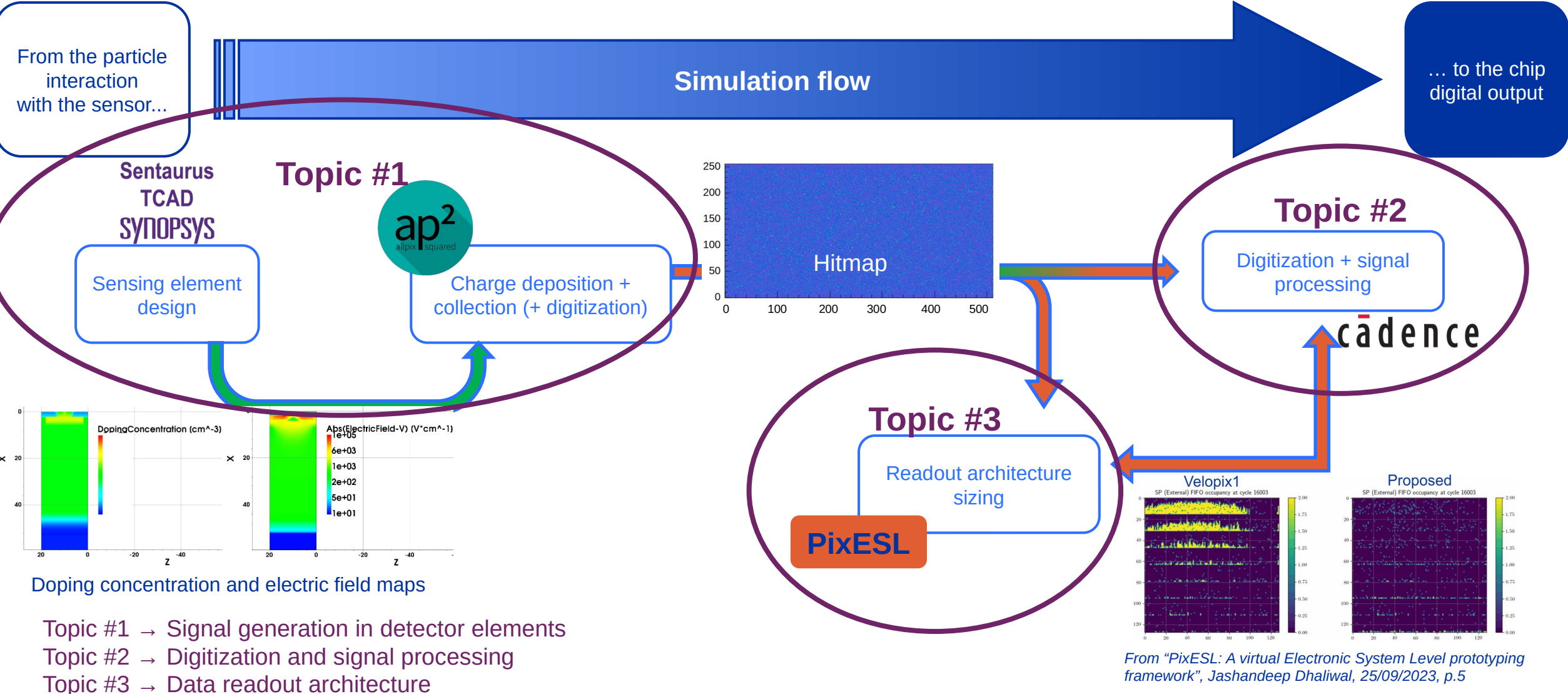
Doping concentration and electric field maps

Topic #1 → Signal generation in detector elements

Topic #2 → Digitization and signal processing

Topic #3 → Data readout architecture

Developing a physics → electronics integrated simulation flow

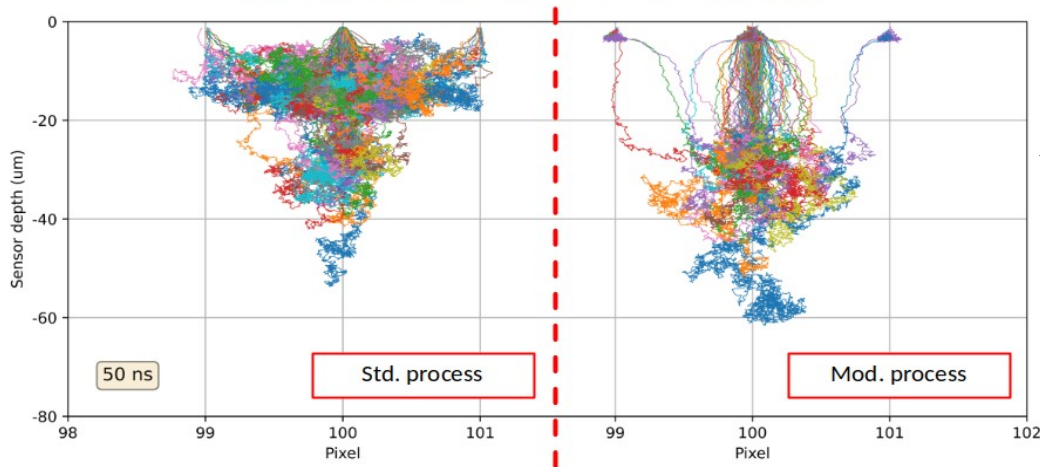


Topic #1: Signal generation in detector elements



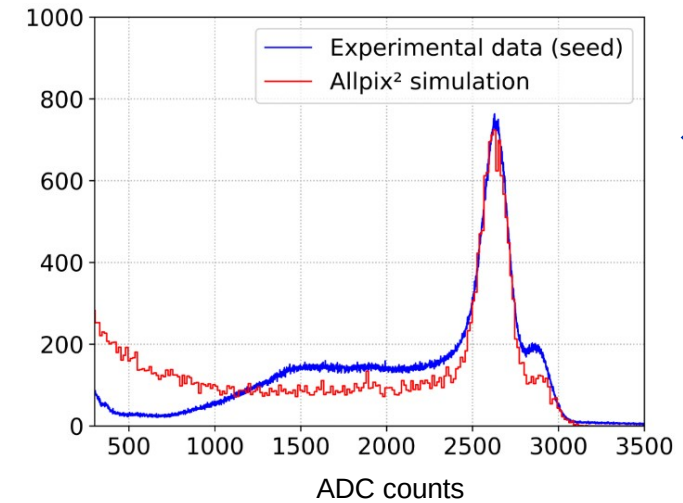
Allpix² flow

S. Spannagel et al., "Allpix²: A modular simulation framework for silicon detectors",
Nucl. Instr. Meth. A 901 (2018) 164 – 172, doi:10.1016/j.nima.2018.06.020,
arXiv:1806.05813



Charge propagation study :
Comparison between standard and modified CMOS imaging processes

Fe55 spectrum

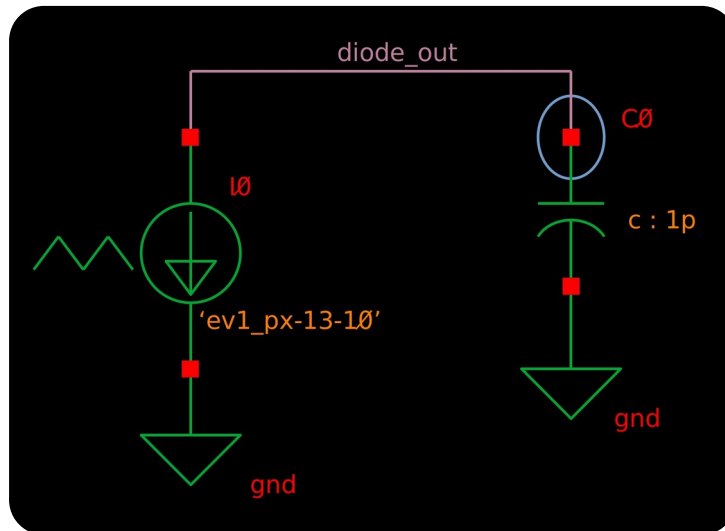


Monolithic Imager 1 sensor is used for experimental results

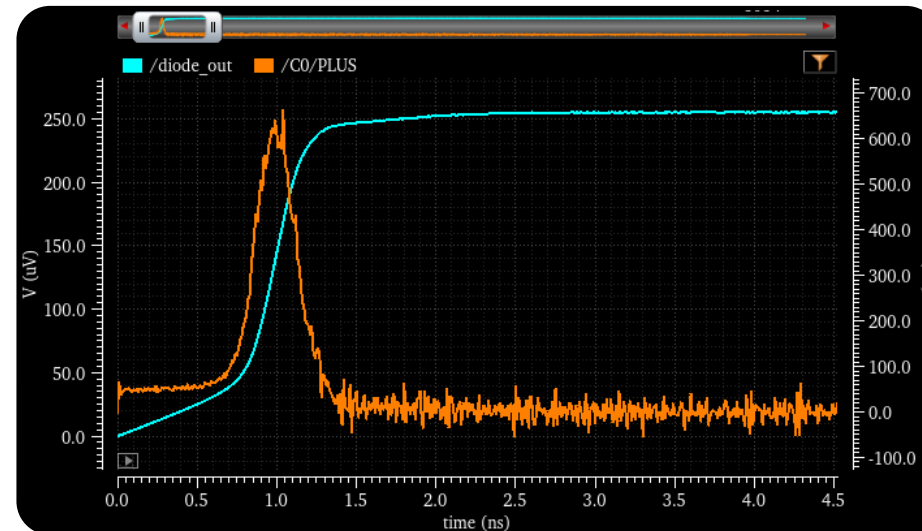
Topic #2: Digitization and Signal Processing

Inject Allpix² simulation output in the CADENCE framework

First attempt with a single event on a single pixel



Current pulse in .txt format (time + current)

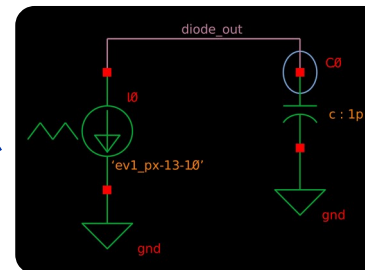
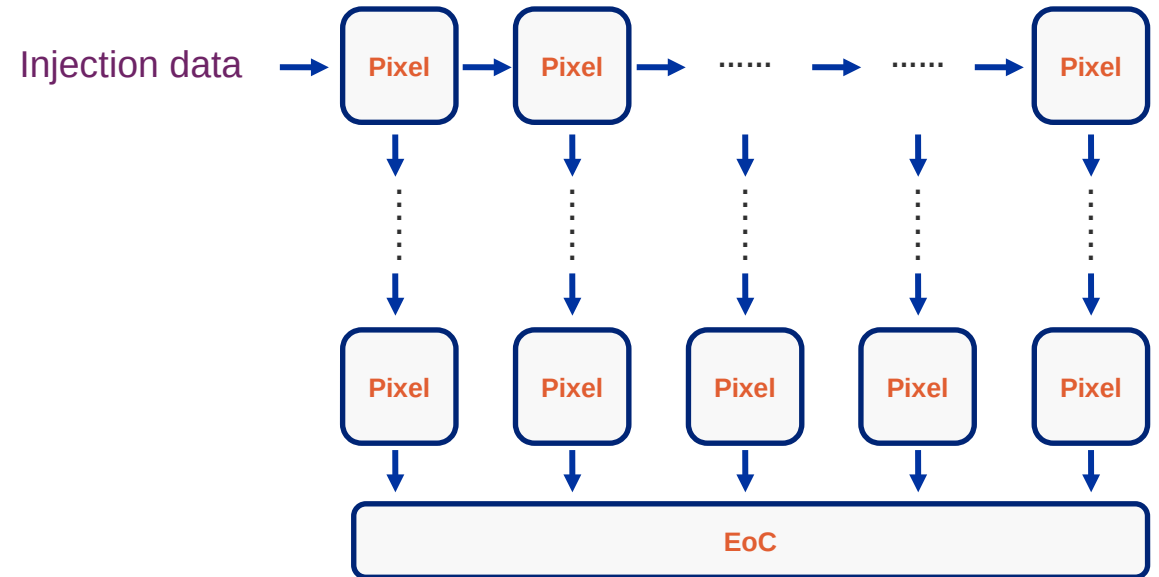
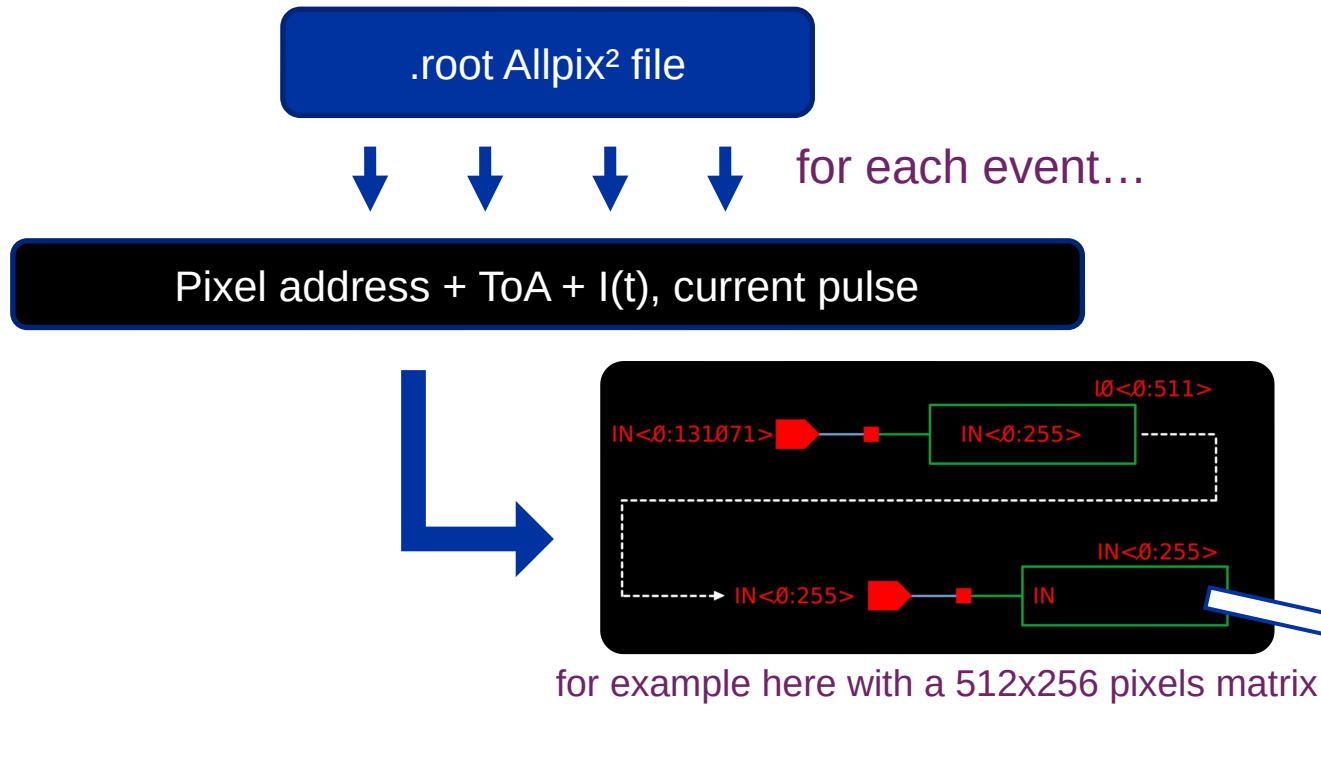


Current pulse extracted from Allpix² simulation
Storage capacitance voltage

Topic #2: Digitization and Signal Processing

Inject Allpix² simulation output in the CADENCE framework

In the next months: Automating the flow



Conclusion

- **A simulation flow including all the chain from the particle interaction with the sensor to the chip digital output is being developed**

- **The proposed framework will help the development of future CMOS MAPS sensors**

Thank you !

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