Karlsruhe Institute of Technology

STREAM

European Commission

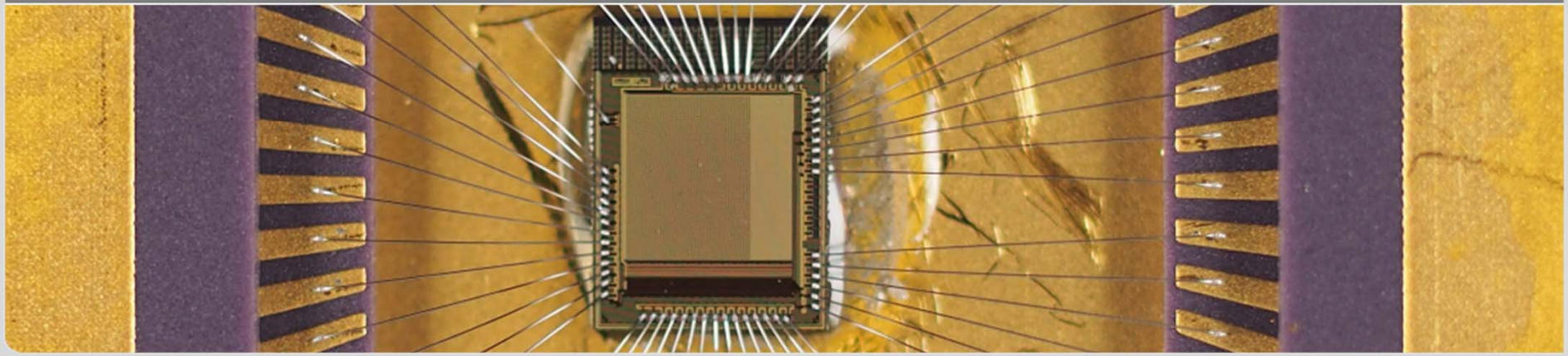
Horizon 2020
European Union funding
for Research & Innovation

# Image Sensor for Electron Microscopy

## Horacio Mateos ESR 4 – WP 2

*Smart Sensor Technologies and Training for Radiation Enhanced Applications and Measurements (STREAM) is a project funded by the European Commission under the Horizon2020 Framework Program under the Grant Agreement no 675587. STREAM began in January 2016 and will run for 4 years.*

**ASIC and Detector Laboratory (ADL)**
**Institut für Prozessdatenverarbeitung und Elektronik (IPE)**

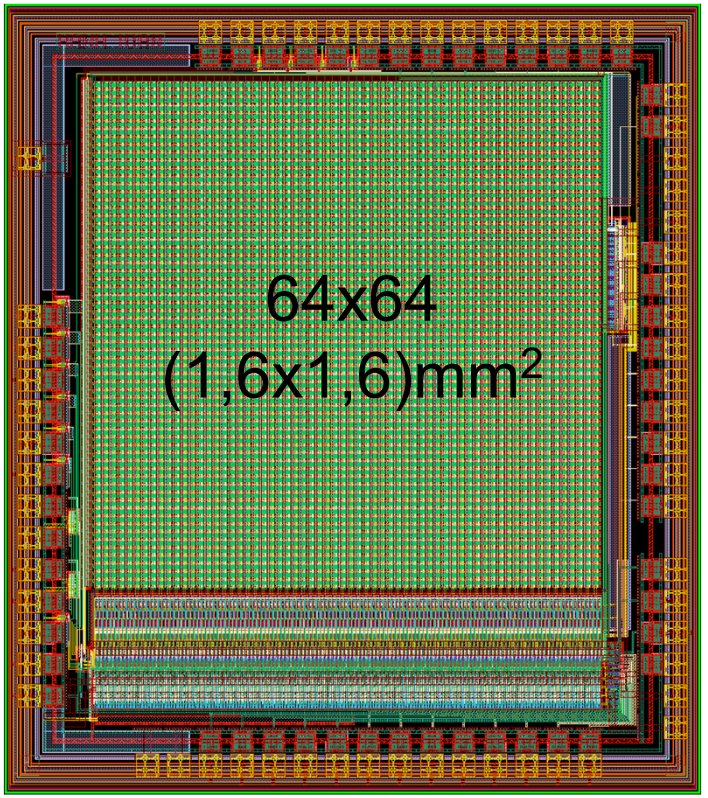


# Introduction

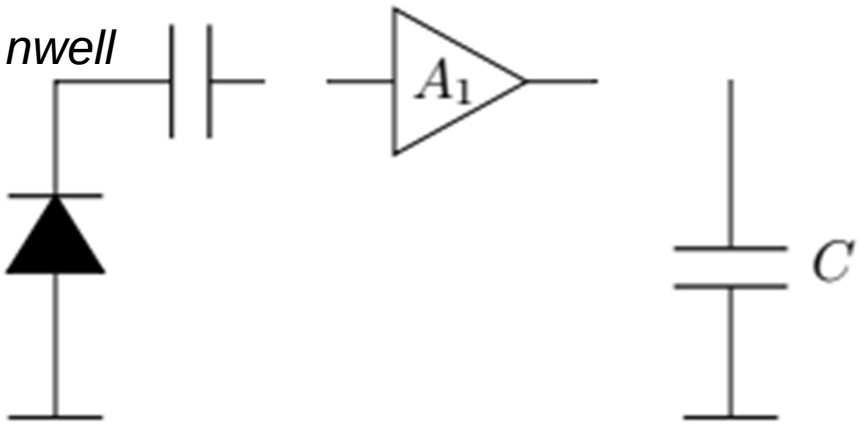
- Start: september 2017
- Supervisor: Prof. Dr. Ivan Peric
- Place: Karlsruher Institute für Technologie
- Project: Test, design and improvement of image sensors for electron microscopy

# The Sensor

- 180 nm, HVCMOS Technology
- 64x64 pixels
- Charge sensitive amplifier
- 128 ADCs
- Low power consumption
- Fast charge collection (HV)



# How it works?



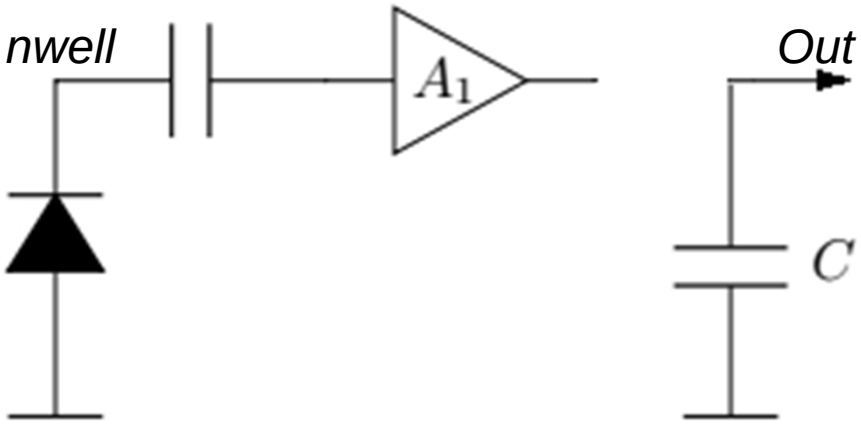

Initial state:

Reset level of the previous frame was stored on capacitor C

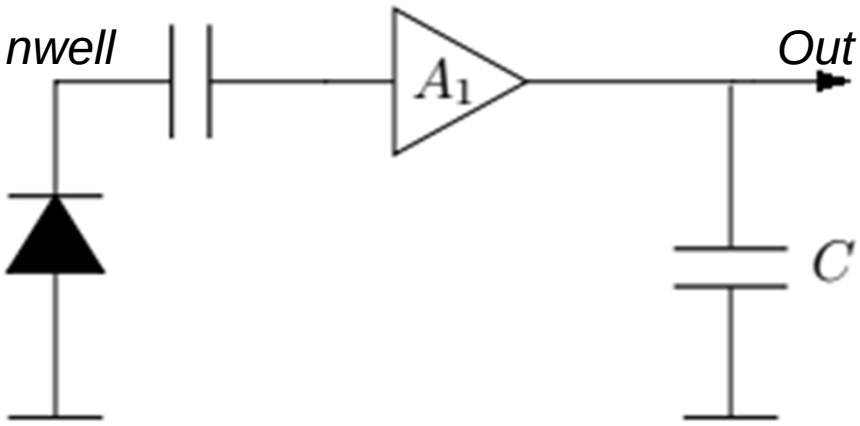
Signal of the previous frame at the node *nwell*

# How it works?

State 1:
Reset level at the output *Out*
Amplifier enabled

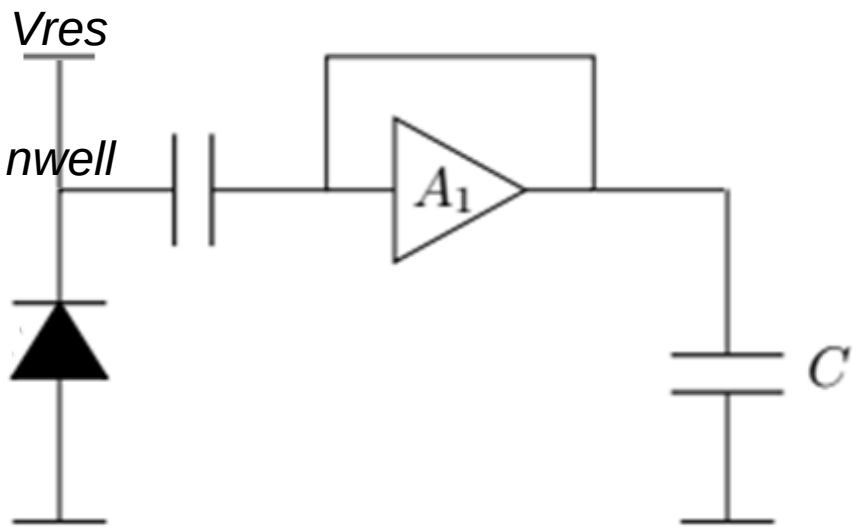


# How it works?




State 2:
Signal-level at the output
The pure signal is the difference of the voltage at *Out* in this (signal level) and previous state (reset level)

# How it works?




State 3:

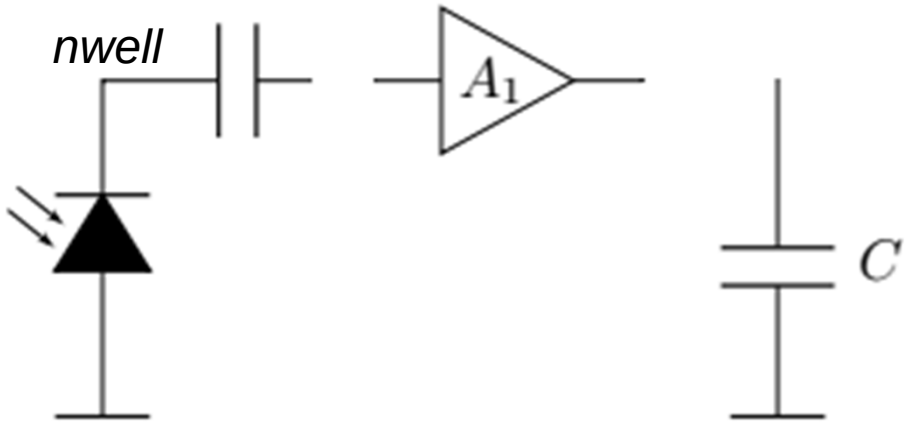
Reset of the pixel. The node *nwell* is re-seted

Amplifier output drops, the new reset level is at the electrode of *C*

Notice that the signal pixel is disconnected from node *Out*

**During this time the next pixel is in state 1**

# How it works?



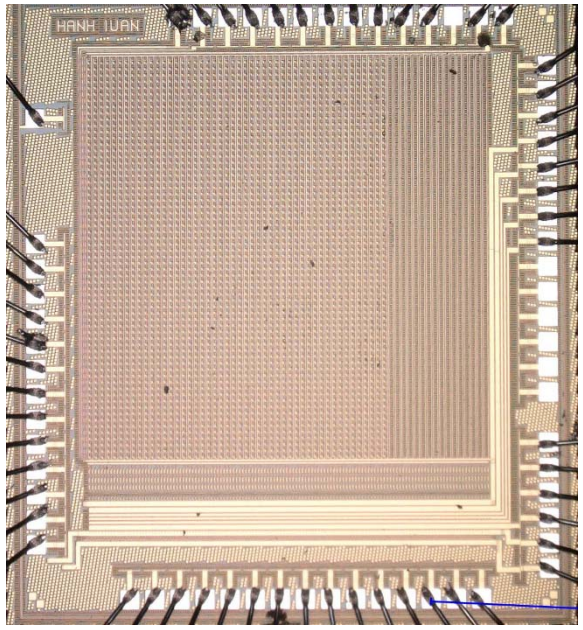

State 4:
Measurement state = initial state.
The new reset level is stored at the electrode of *C*

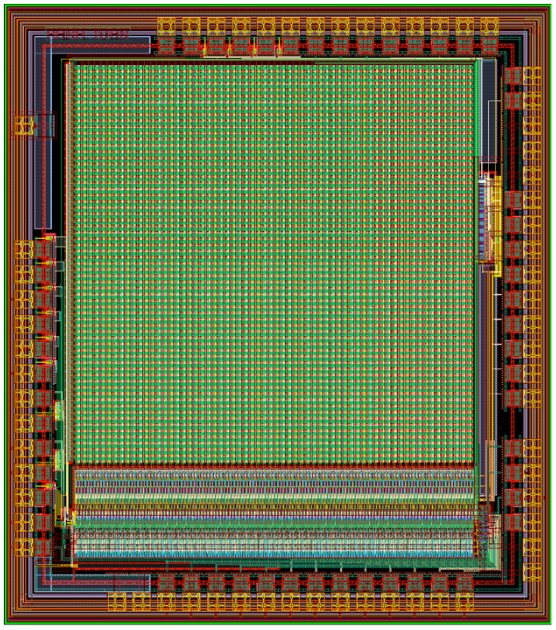
# Interface between Chip and PC

- Nexys Video (Artix 7)
- Fast
- Easy to configure

# What has been done

- **Successfully designed and fabricated the new version of the imaging sensor called HPIXEL**

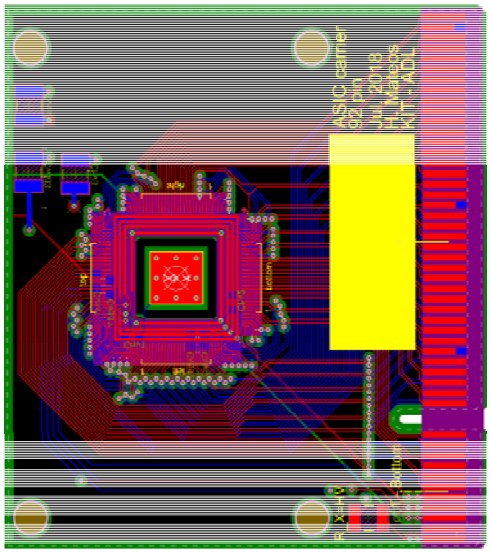


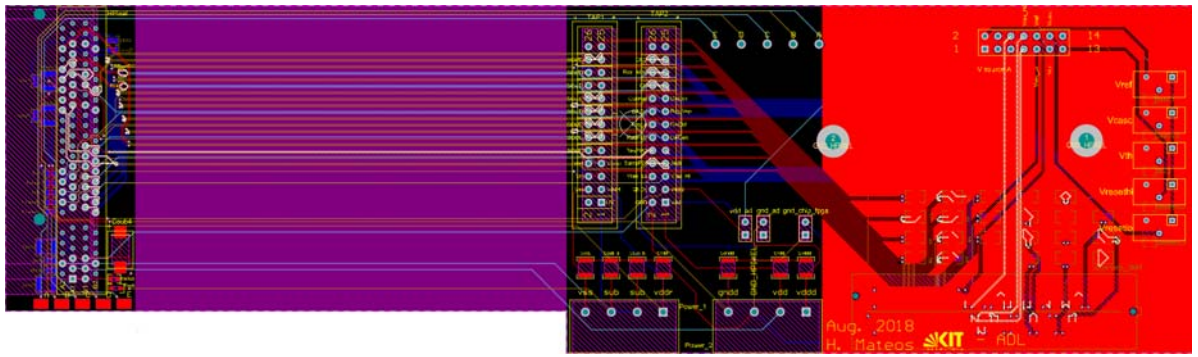
# What has been done

- PCBs has been re-designed and manufactured to meet the vacuum specifications of the microscope, and to reduce noise

The sensor carrier PCB



The adapter PCB (FPGA to sensor carrier)

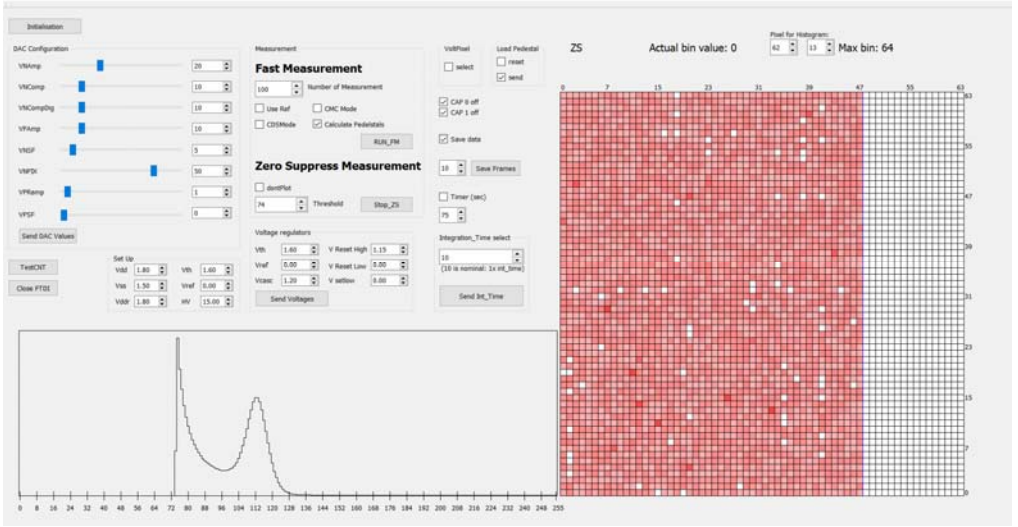


# What has been done

- **Successfully tested the functionality of the HPIXEL**
  - The system was tested with X-rays (8,6 KeV ~ 25.3 KeV)
  - The system has a lower level of noise
- Simulations of the chip performed where the external voltages and DAC values are changed
- Measurements of the chip inside the electron microscope

# What has been done

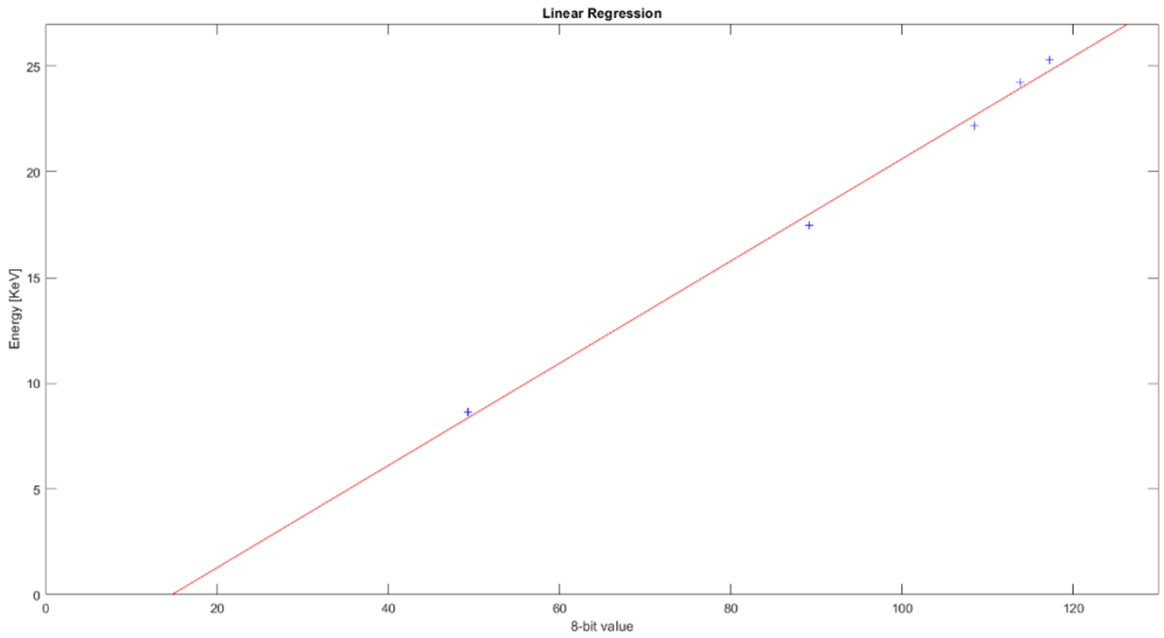
- **X_Ray chip irradiation**
  - Noise levels around 46 $e^-$ (for the lowest energy)
  - Resolution: ~ 241 $\frac{eV}{bit}$




Zn X-Ray (8,6 KeV), 1:48 hs irradiation

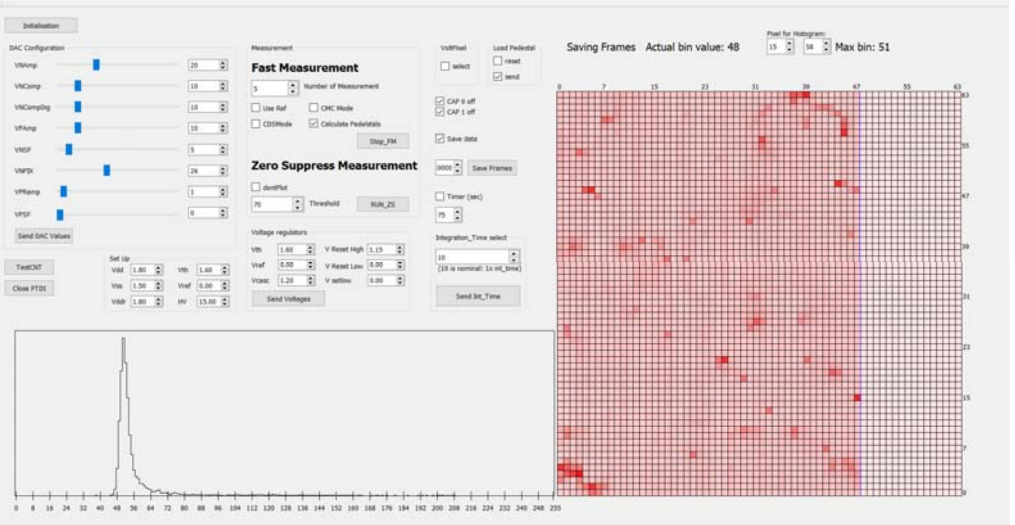
# What has been done

- X_Ray chip irradiation



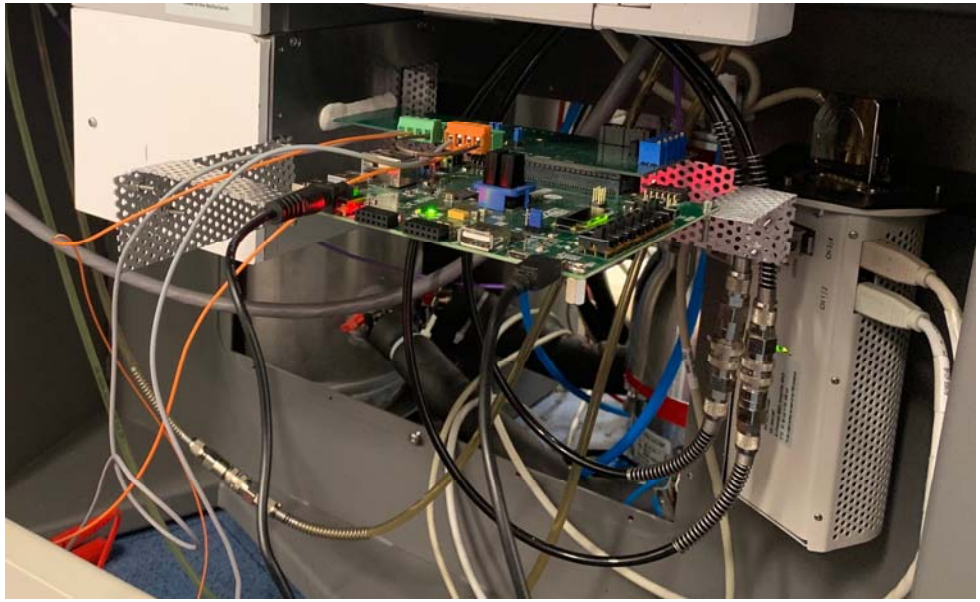
# What has been done

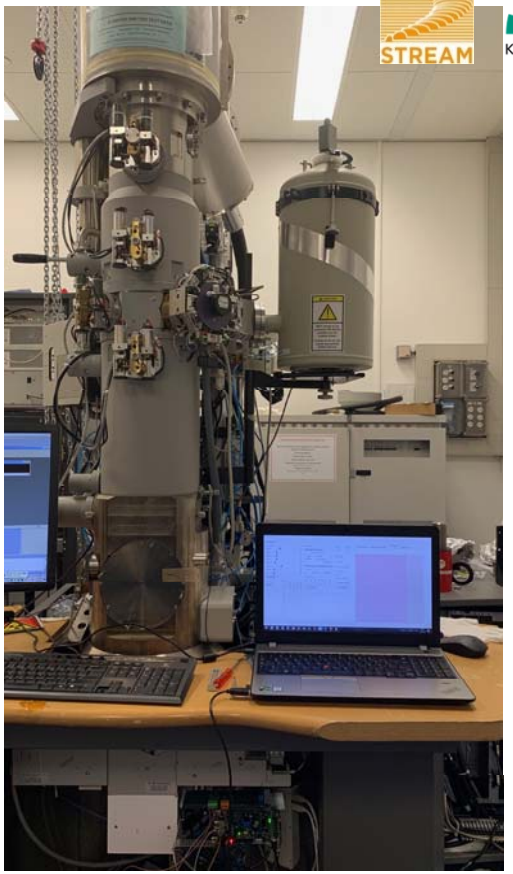
- **Electrons chip irradiation**
  - Measurements with different gain were taken
  - Measurements with different HV were taken
  - The chip stops working after some time under the beam




Electrons (80 KeV)

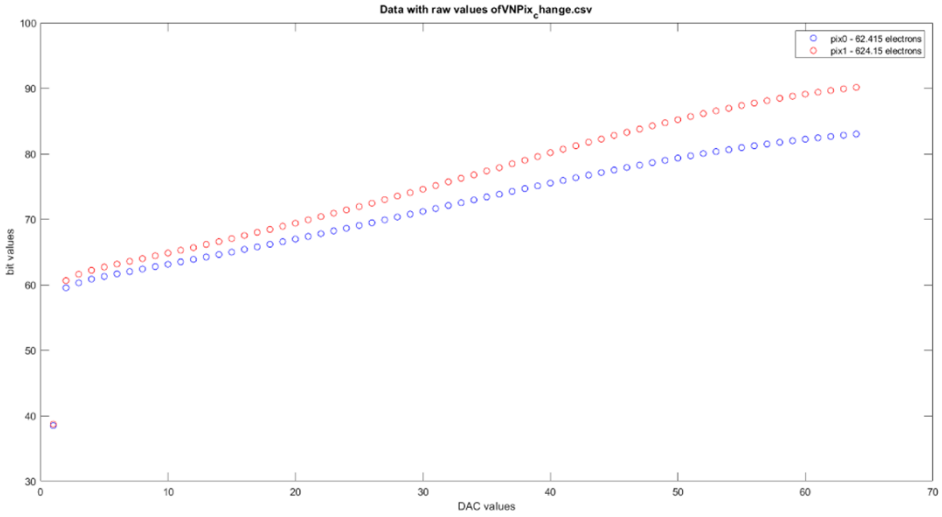
# What has been done





# Current work

- Testing chip with X-Rays
- Testing in the vacuum chamber of the Electron Microscope with electrons
- Chip behavior simulations with Cadence



# Next steps

- Near future:
  - Full test against photon and electrons radiation
- Long term:
  - Improve the HPIXEL
    - Eg.: Faster, bigger, better noise level, etc.
  - Design a new chip version
  - Test it



# Thank you!