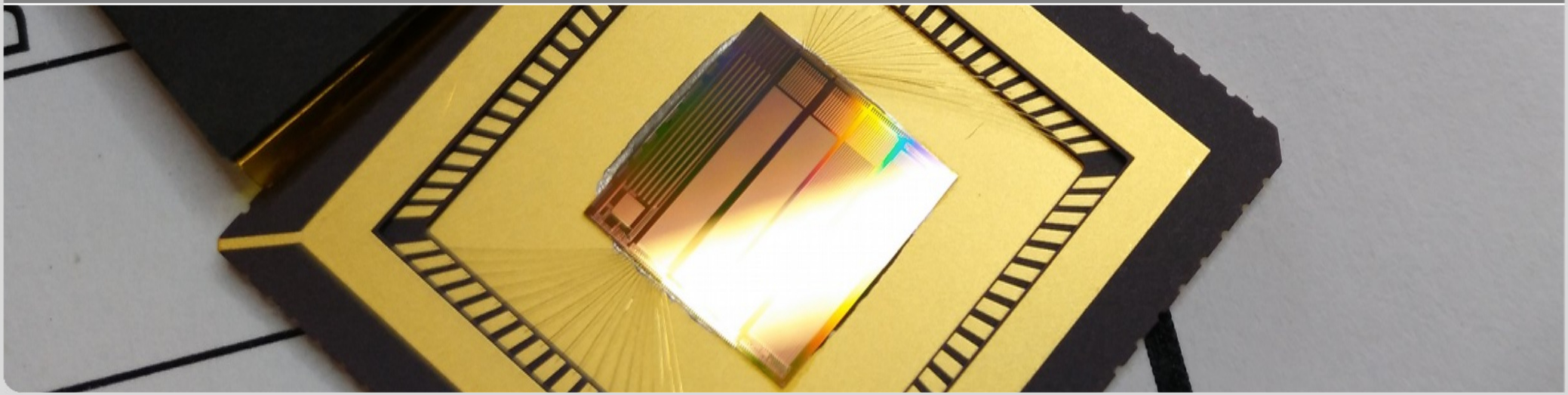
Karlsruhe Institute of Technology

First Measurements on ATLASPix3

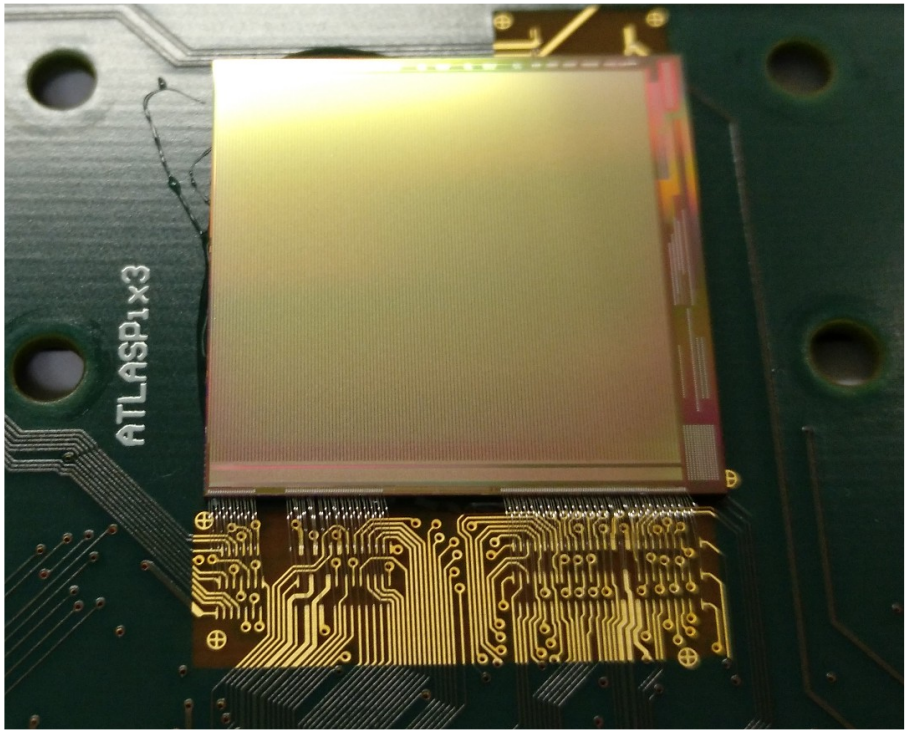
Rudolf Schimassek

Institute for Data Processing and Electronics (IPE)



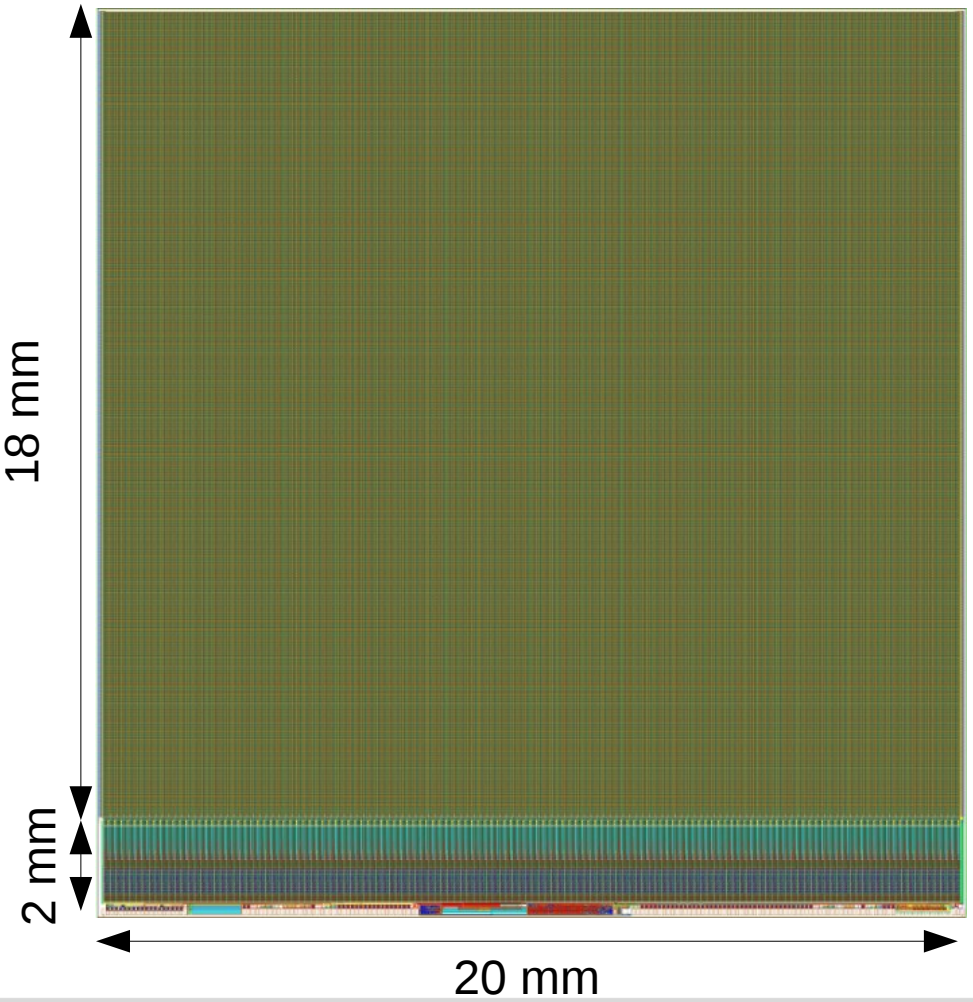
Outline

- ATLASPix3
- IV characteristics
- Power Regulators
- Untriggered Readout
- Matrix Trimming



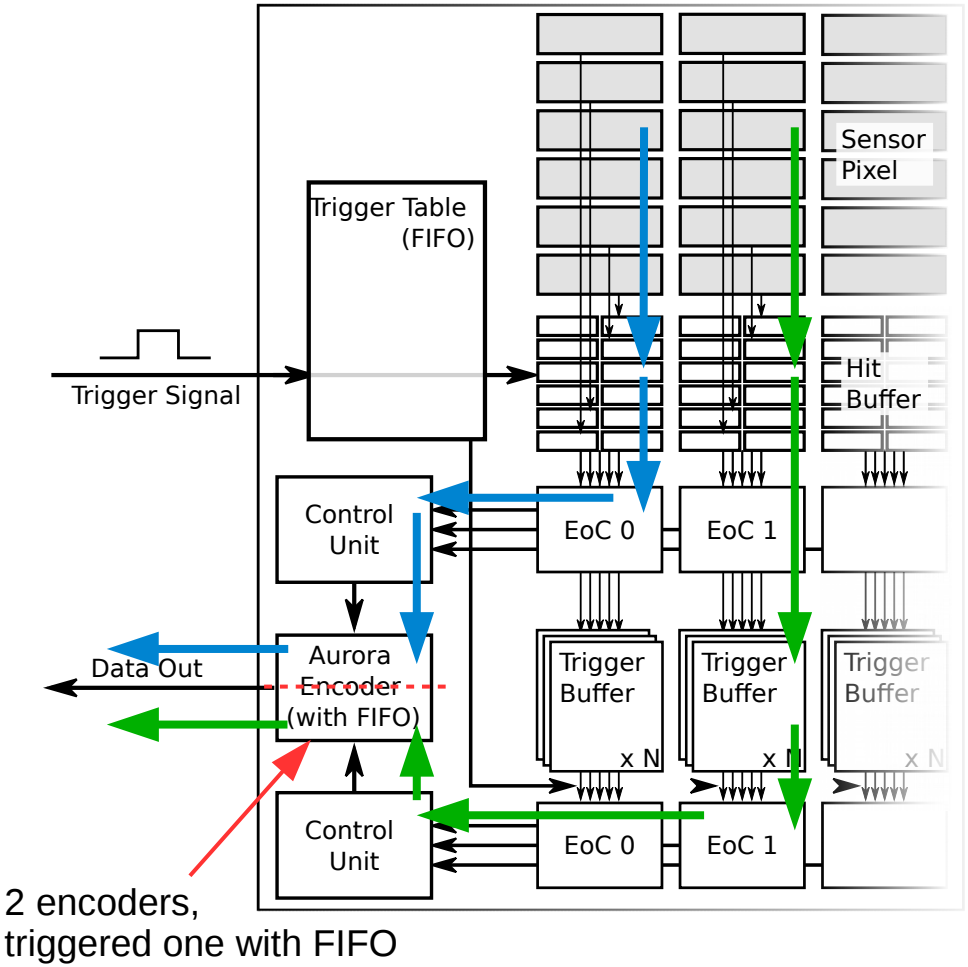
ATLASPix3

- Single matrix: 132 x 372 pixel
  - Pixel size 150 x 50 µm²
- Column drain readout with and without trigger
- Radiation hard design with SEU tolerant global memory
- In-pixel comparator
- 64/66 bit Aurora encoder
- Command decoder with clock recovery



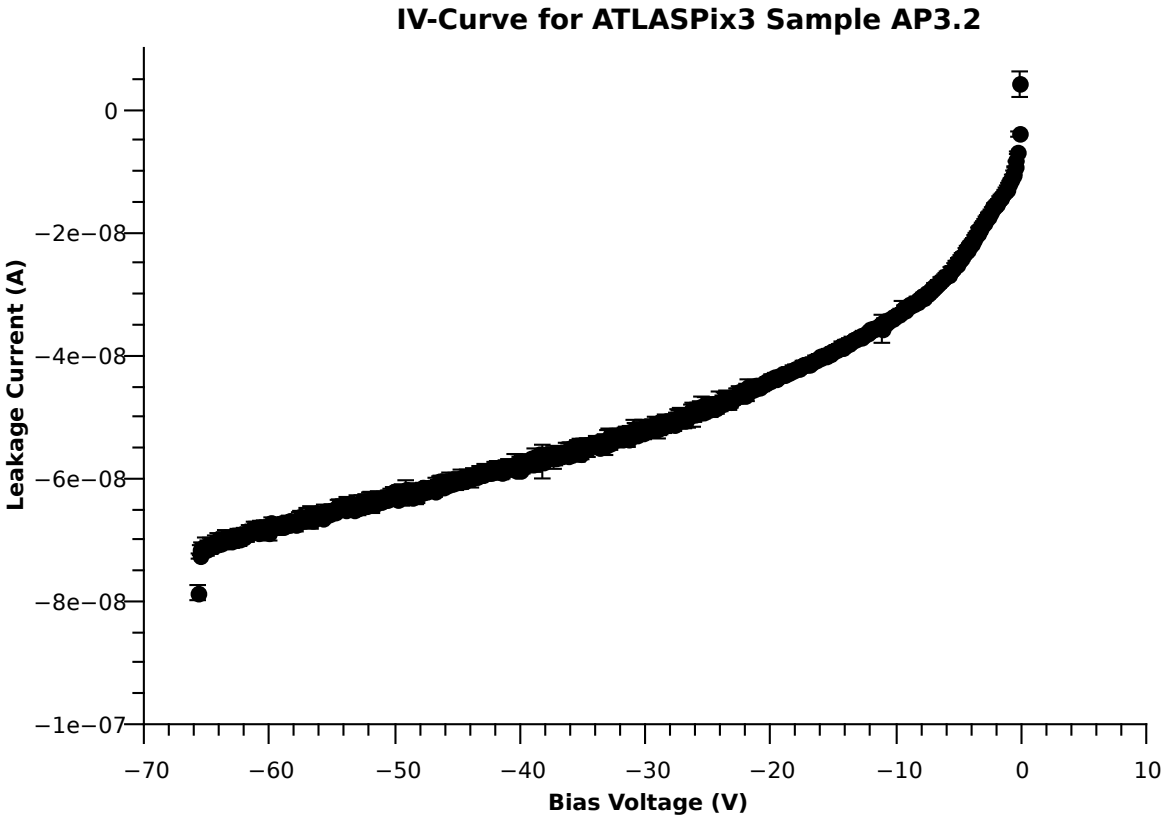
ATLASPix3 – Readout Structure

- Triggered and triggerless readout possible via two concurrent readout structures
  - separate control units
  - Configuration via SEU tolerant registers
- Data transmitted:
  - triggerless: 8/10b Aurora encoded
  - triggered: 64/66b Aurora encoded



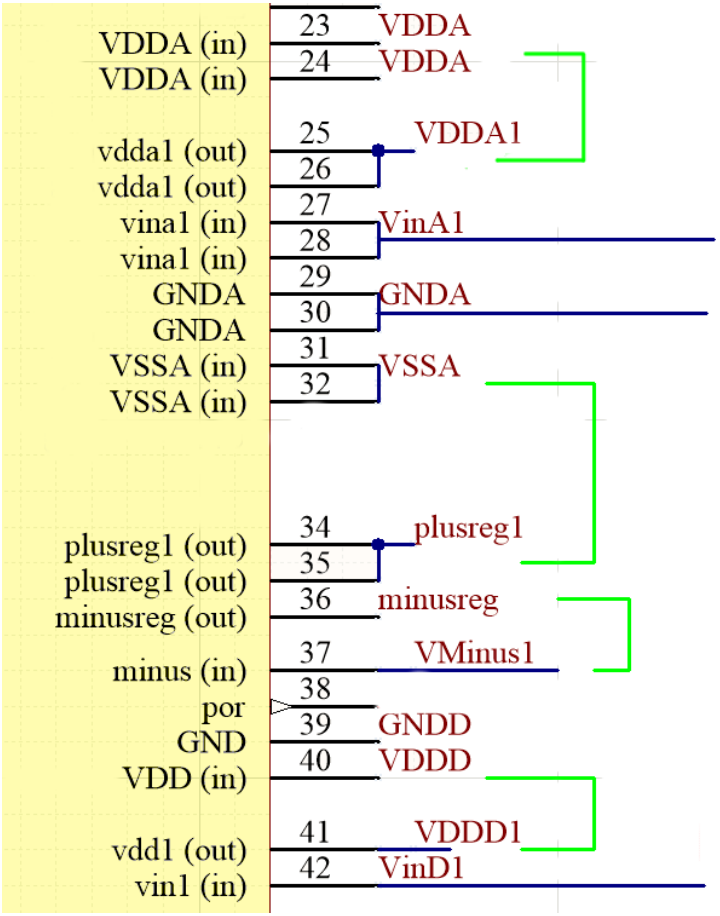
IV Characteristics

- Low leakage current of < 50 nA @ -20 V
- Breakdown at -65.8 V
  - Chip powered during measurement
  - Current jumps to compliance (100µA)



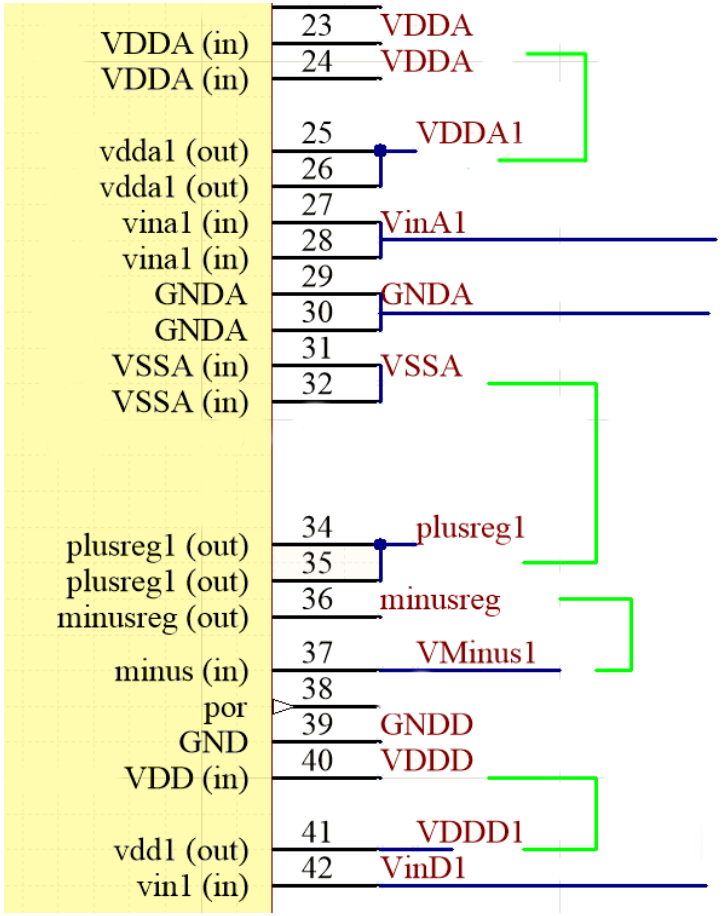
Power Regulators

- ATLASPix3 has regulators for
  - V_{DD}
  - V_{DDA}
  - V_{plus}
  - V_{minus}
- Implemented as optional feature
- All regulators have tuning means



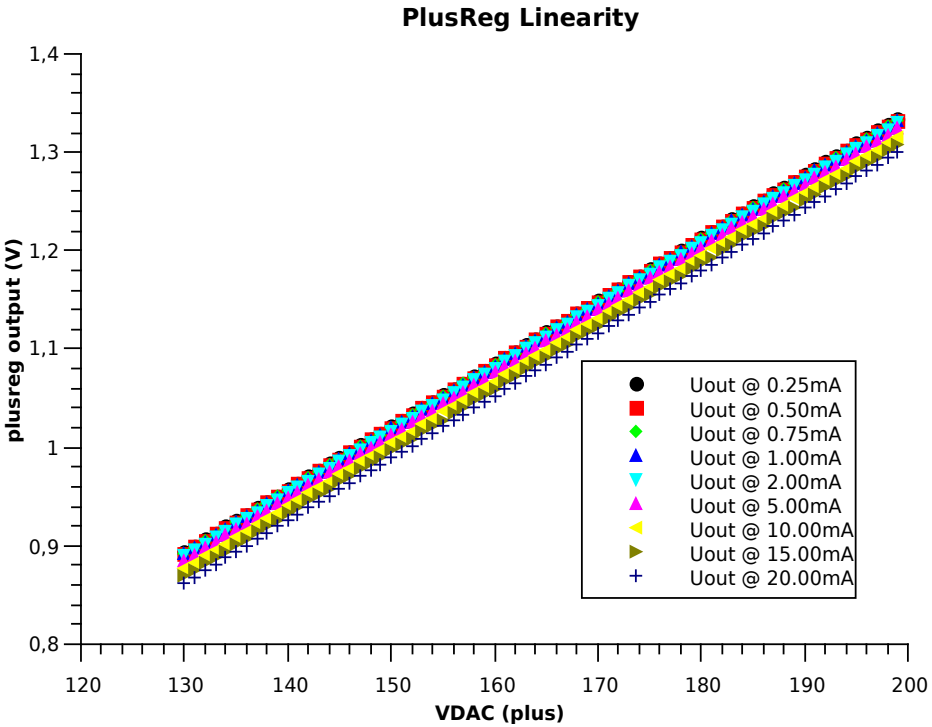
Power Regulators – V_{plus}, V_{minus}

- Regulators for V_{plus} and V_{minus} use V_{DDA} as supply voltage
- Can be configured using voltage DACs
- Behaviour similar, therefore only plots for V_{plus} are shown



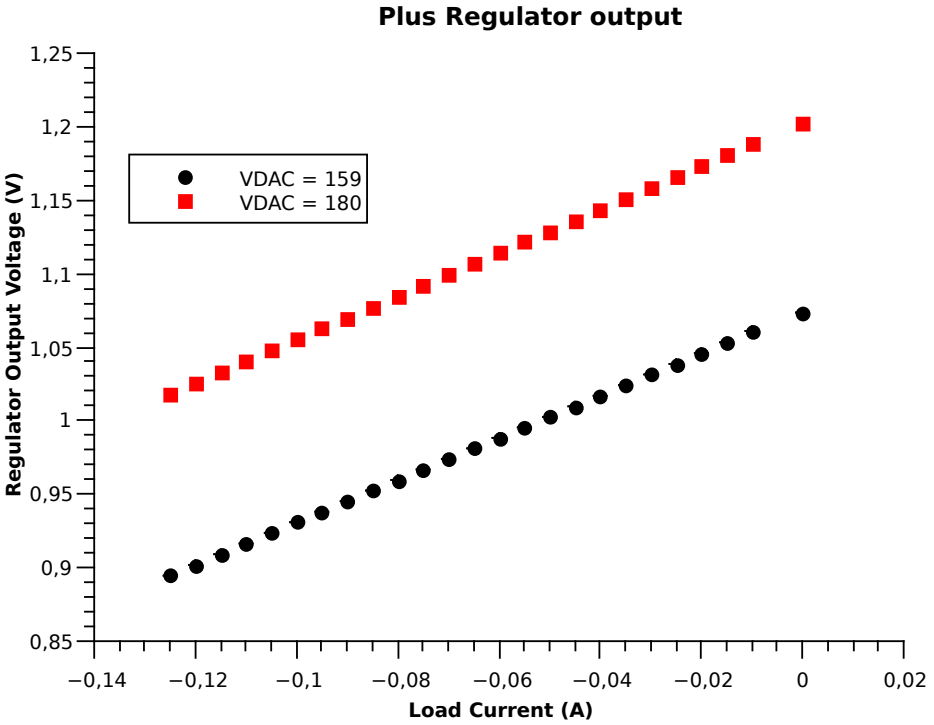
Power Regulators – V_{plus}

- Both regulators show good linearity with the voltage DAC controlling them
- A small series resistance of about 1Ω is visible



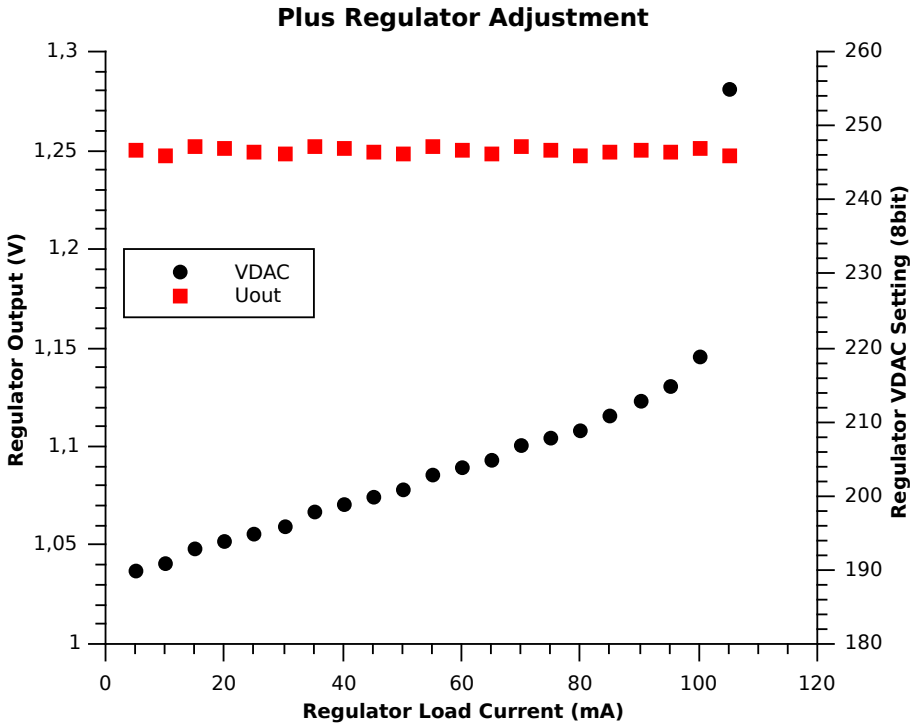
Power Regulators – V_{plus}

- Both regulators show good linearity with the voltage DAC controlling them
- A small series resistance of about 1Ω is visible
  - Probably in the measurement setup, not the chip itself
- Currents above 100 mA drawn for testing



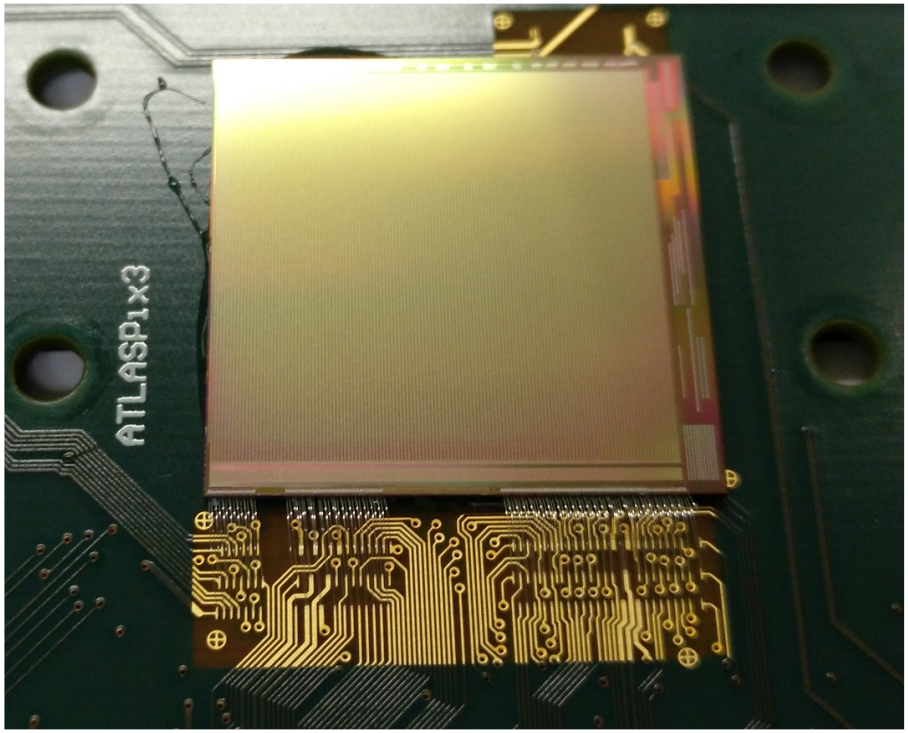
Power Regulators – V_{plus}

- Stable voltage achieved by adjusting the VDAC setting
- 100 mA output for 1.25 V achieved
  - About V_{SSA} power consumption for unoptimised settings
- Untriggered Readout working with V_{SSA} provided from plusreg
  - At 100 mA, V_{SSA} can be increased above 1.25 V with VDAC > 180
  - Strong indication that the series resistance was in the measurement setup not in the regulator



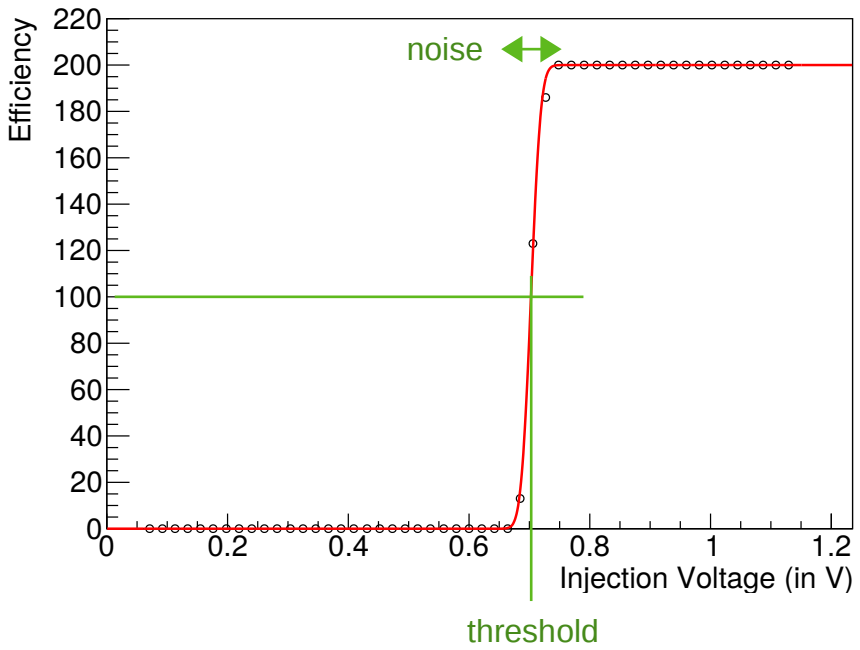
Configuration and Readout

- Serial and SPI configuration tested to work
- RAM writing is working
- Reference clock output works
- Untriggered readout tested to work at 400 Mbps (DDR, results in 25 ns time stamp)



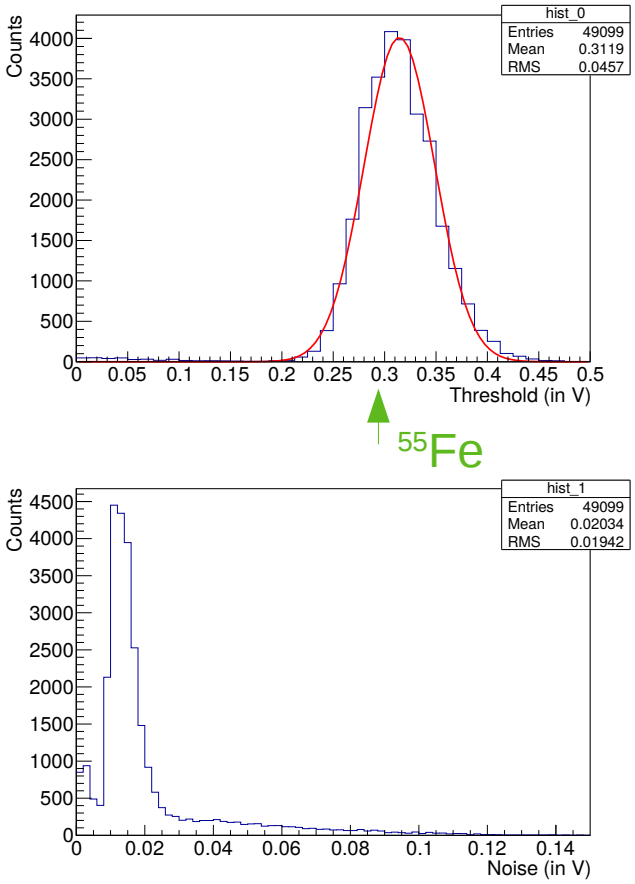
Threshold and Noise Definitions

- Charge injections of increasing strength are sent into a pixel
- Count number of detected signals → detection efficiency
- Shifted and scaled gaussian error function is fitted to the data points



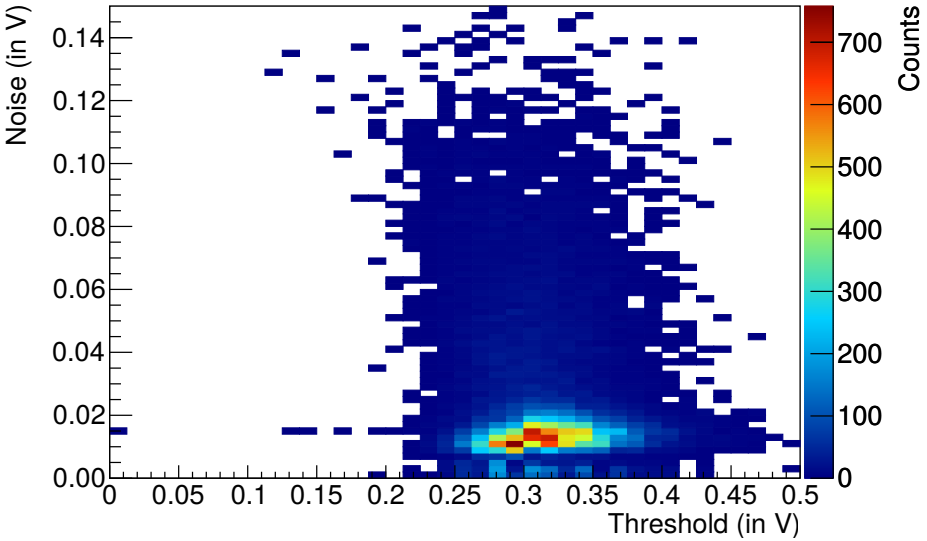
Threshold Distribution

- Using untriggered digital readout and charge injections, a threshold scan has been performed for the whole matrix
- ^{55}Fe decay signals equal a charge injection of about 300 mV
- Untuned matrix



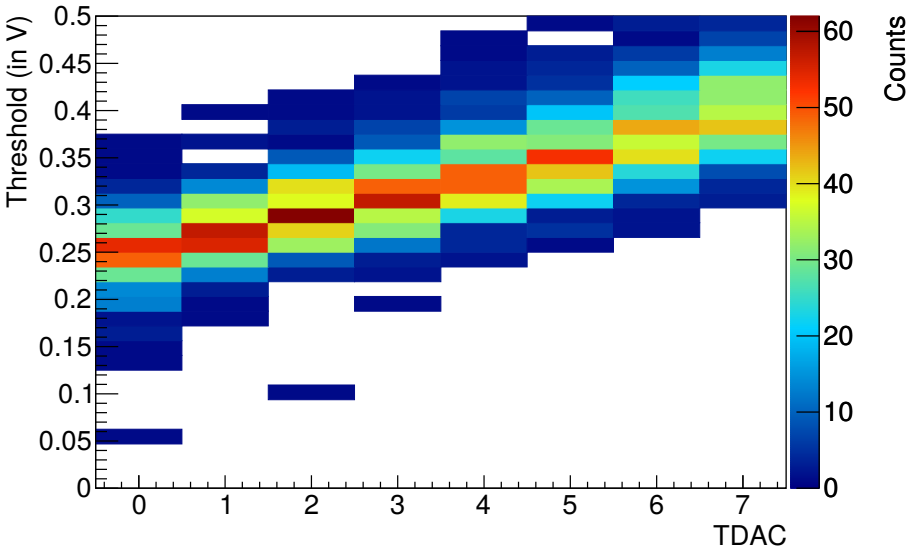
Threshold Distribution

- Large noise for some pixels due to measurement algorithm
- Threshold in same range as for good fits



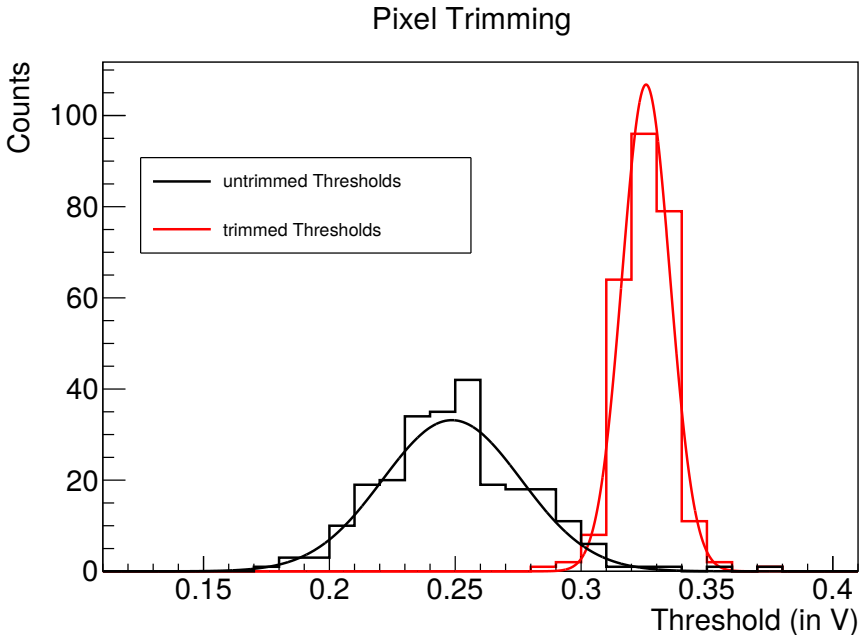
Matrix Tuning

- The matrix implements a 3 bit tuning DAC and a disable bit for each pixel
- Writing of the pixel memories is working and the detection threshold changes linearly with the setting



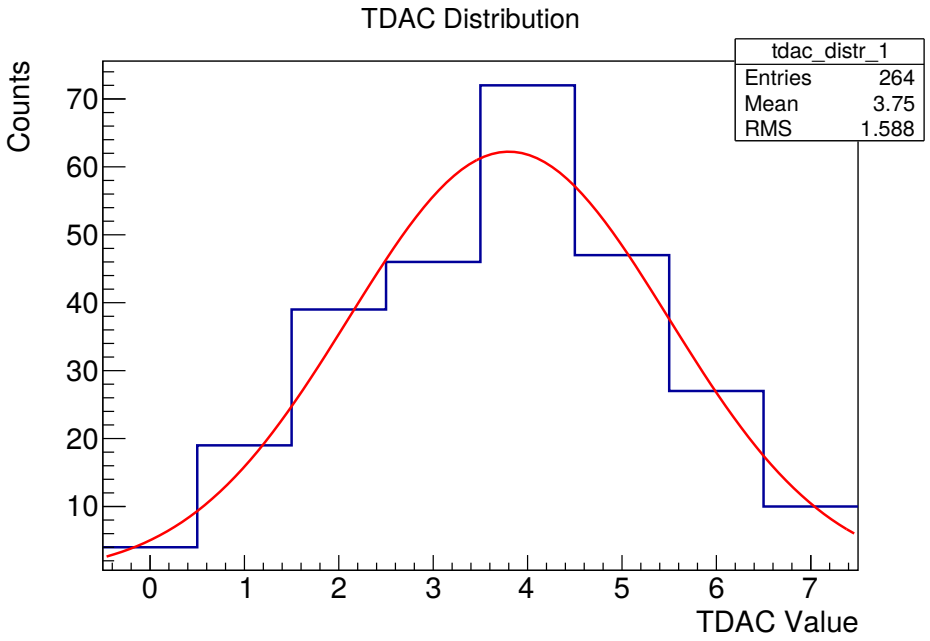
Matrix Tuning

- Threshold tuning implemented:
  - Detection thresholds are adjusted to μ+3σ of untuned distribution
- Conducted for 2 rows (in total 264 pixels):
  - Distribution width ~3x smaller
  - $\sigma_{trimmed}$ = 9.5mV ↔ ~ 50 e^-



Matrix Tuning

- Threshold tuning implemented:
  - Detection thresholds are adjusted to μ+3σ of untuned distribution
- Conducted for 2 rows (264 pixels):
  - Distribution width 3x smaller
  - σ = 9.5mV ↔ ~ 50 e^-
  - TDAC setting distribution is gaussian like and using the whole range



Conclusions

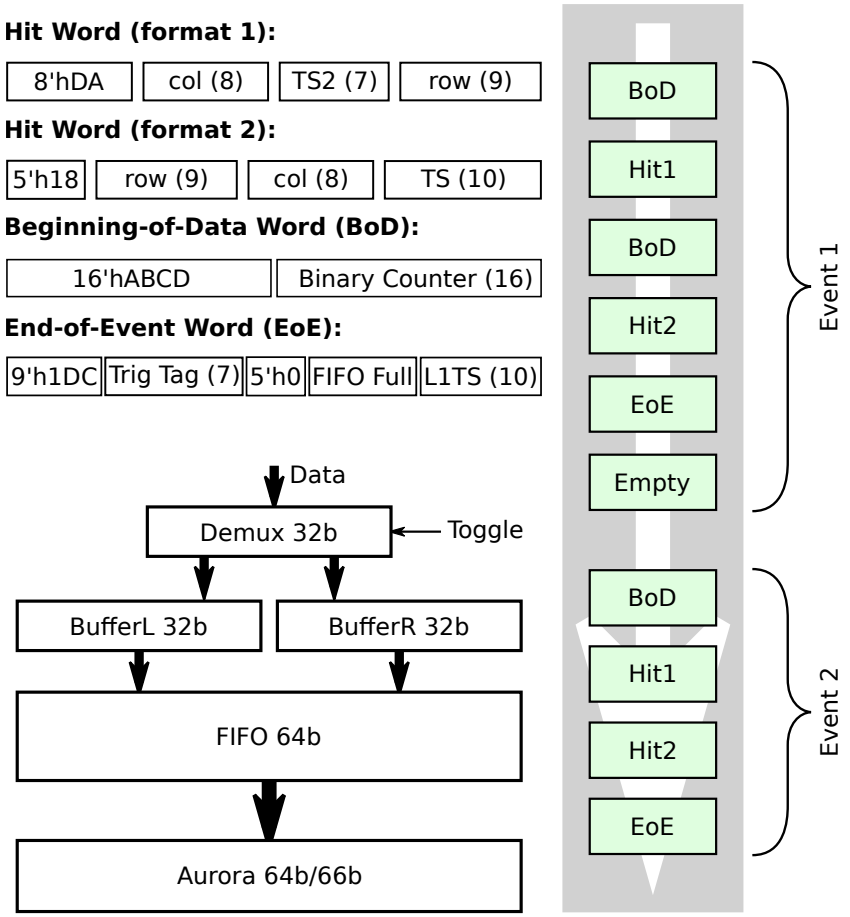
- ATLASPix3 is being tested and is working up to the expectations
  - Serial configuration and SPI configuration are working
  - Regulators are working, measurements ongoing
  - Untriggered readout is working at 25 ns time stamping
  - Trimming of the matrix is possible

- Many more measurements to come:
  - Triggered readout
  - Command decoder
  - Clock recovery

BACKUP

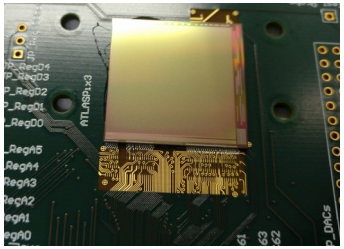
ATLASPix3 – Triggered Readout Data Structure

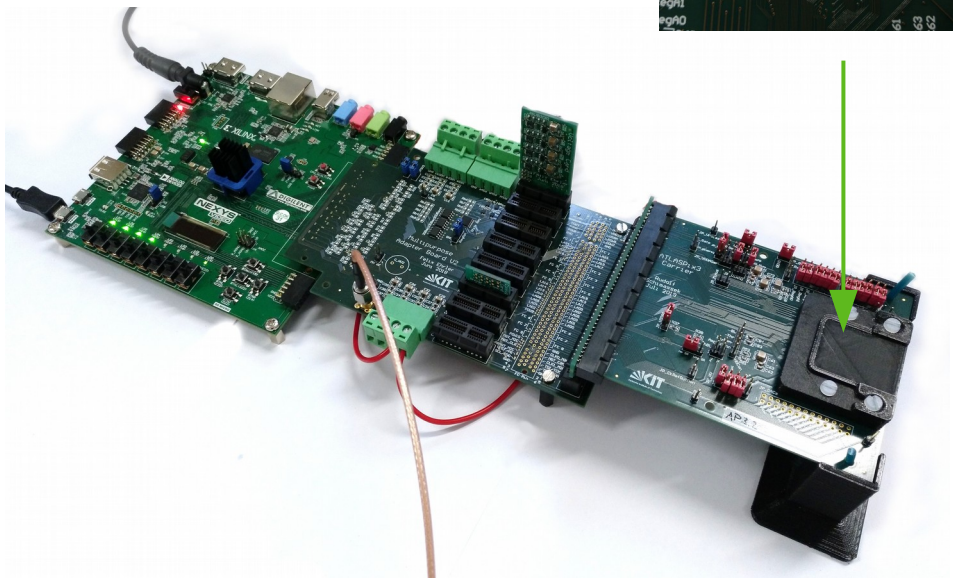
- Data transmission in 32 bit words:
  - beginning-of-data word
  - Hit word
  - End-of-event word
  - Spacing word
- Multiplexer structure to use full width of the Aurora code
- Spacer words used to make event word number even
- Configurable data contents



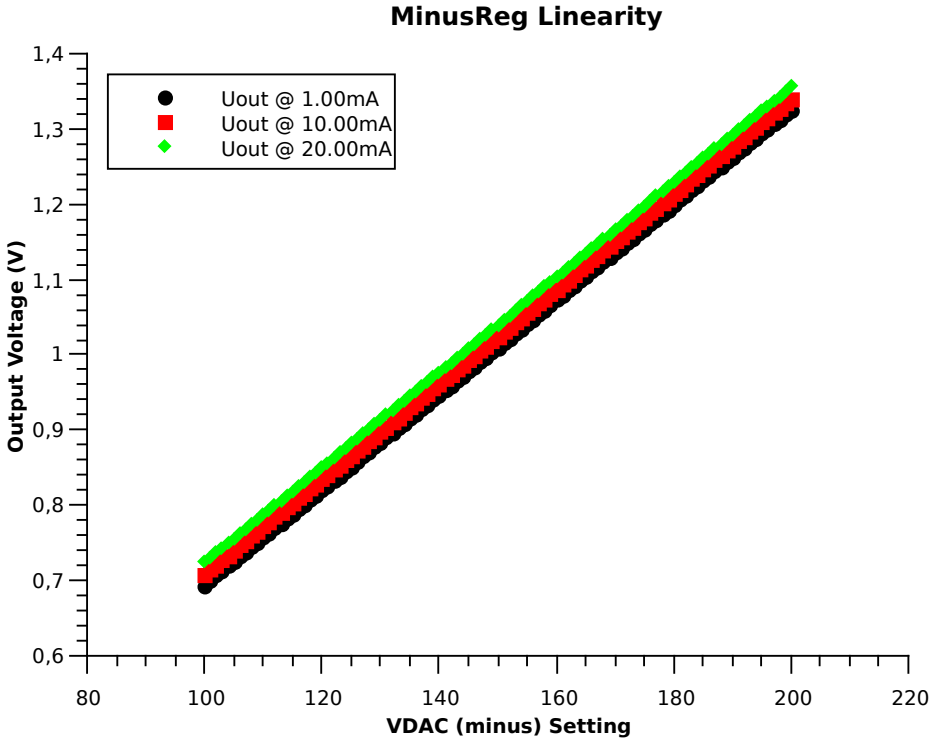
Measurement Setup

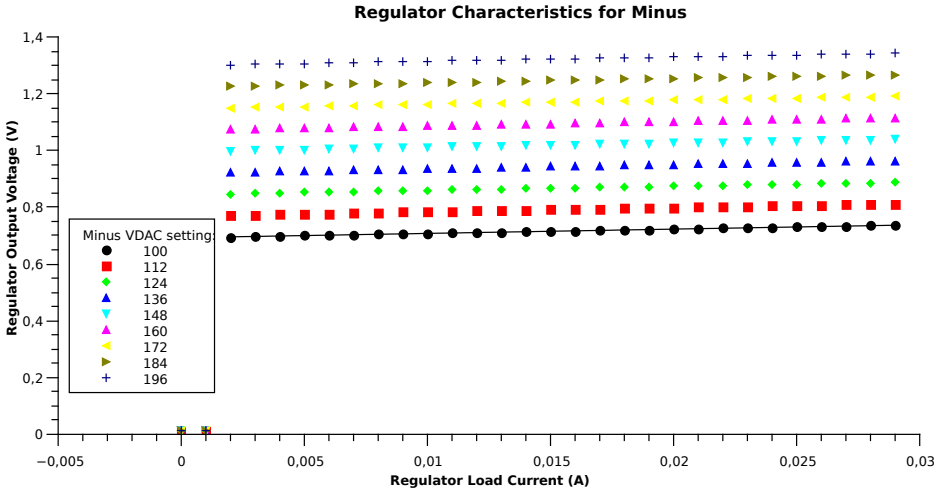
- Artrix-7 FPGA board
- GECCO adapter board
  (GEneric sensor Configuration and COntrol System)
  - PCIe connector
  - Highly modular with function cards
  - No cable connections to carrier PCB
- ATLASPix3 carrier PCB
- Firmware
  - Chip configuration
  - Data decoding and reduction
- Software (Qt based)





Power Regulators – MinusReg





TDAC Effect

- Single pixels show linear threshold changes
  - No fluctuations canelling out in the histogram for 264 pixels
- Slope of the connection changeable via a global DAC