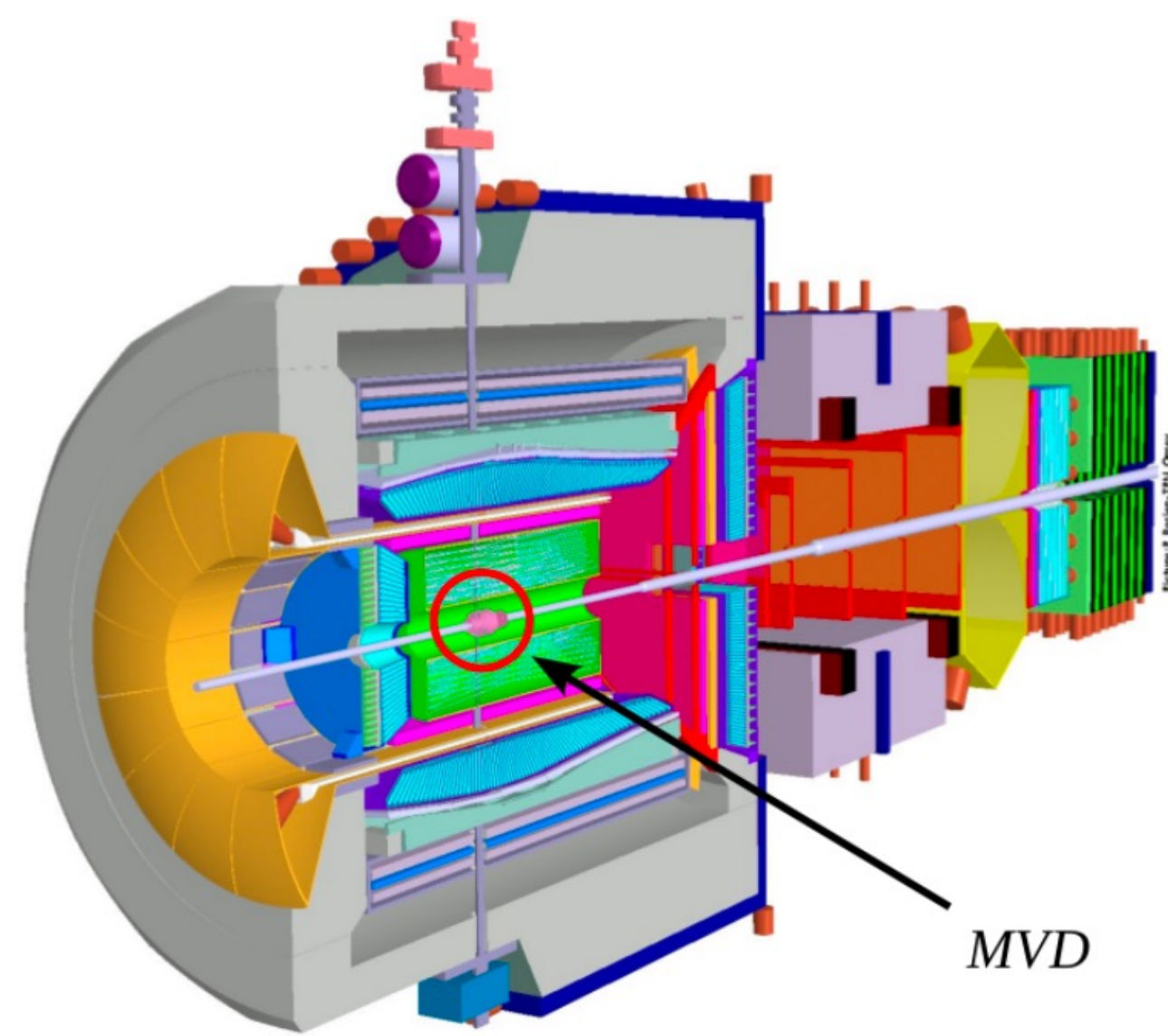


Research context and motivation

- **PANDA experiment** located at the **FAIR** facility in Darmstadt
- **Antiproton-proton** and **antiproton-nuclei** annihilation reactions
- Fixed target (a target pipe intersects the beam pipe)
- **Barrel region** : 2 layers of Silicon Pixel Detectors (SPDs) + 2 of Silicon Strip Detectors (SSDs)
- **Forward region** : 4 SPDs disks, 2 SPDs + SSDs disks
- Triggerless experiment

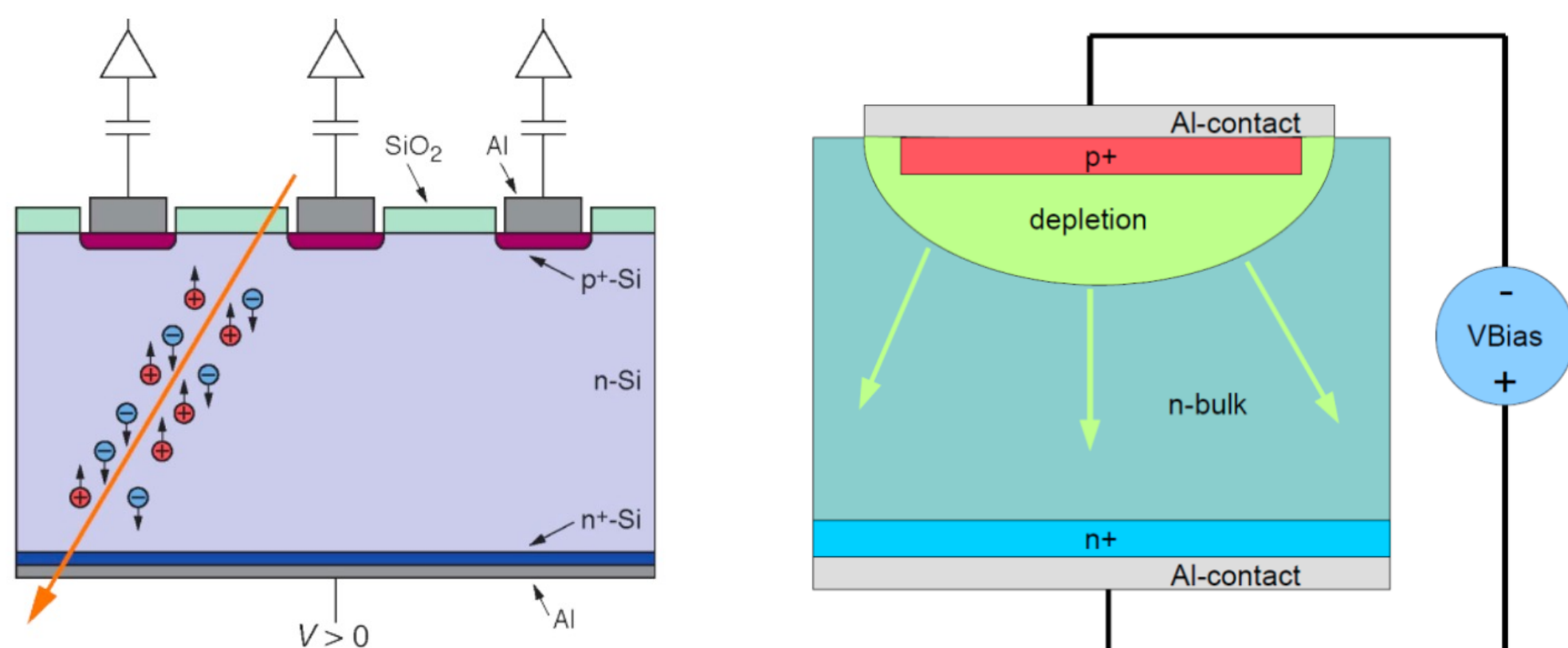


Addressed research questions/problems

Necessary to design a new ASIC due to triggerless experiment → there is not an external signal that validates the data in a certain time interval and all must be transmitted

Double side SSDs :

- Doped silicon semiconductor
- PN-junction
- Reverse bias voltage
- Breakdown voltage > 200 V
- Depletion voltage ≈ 100 V



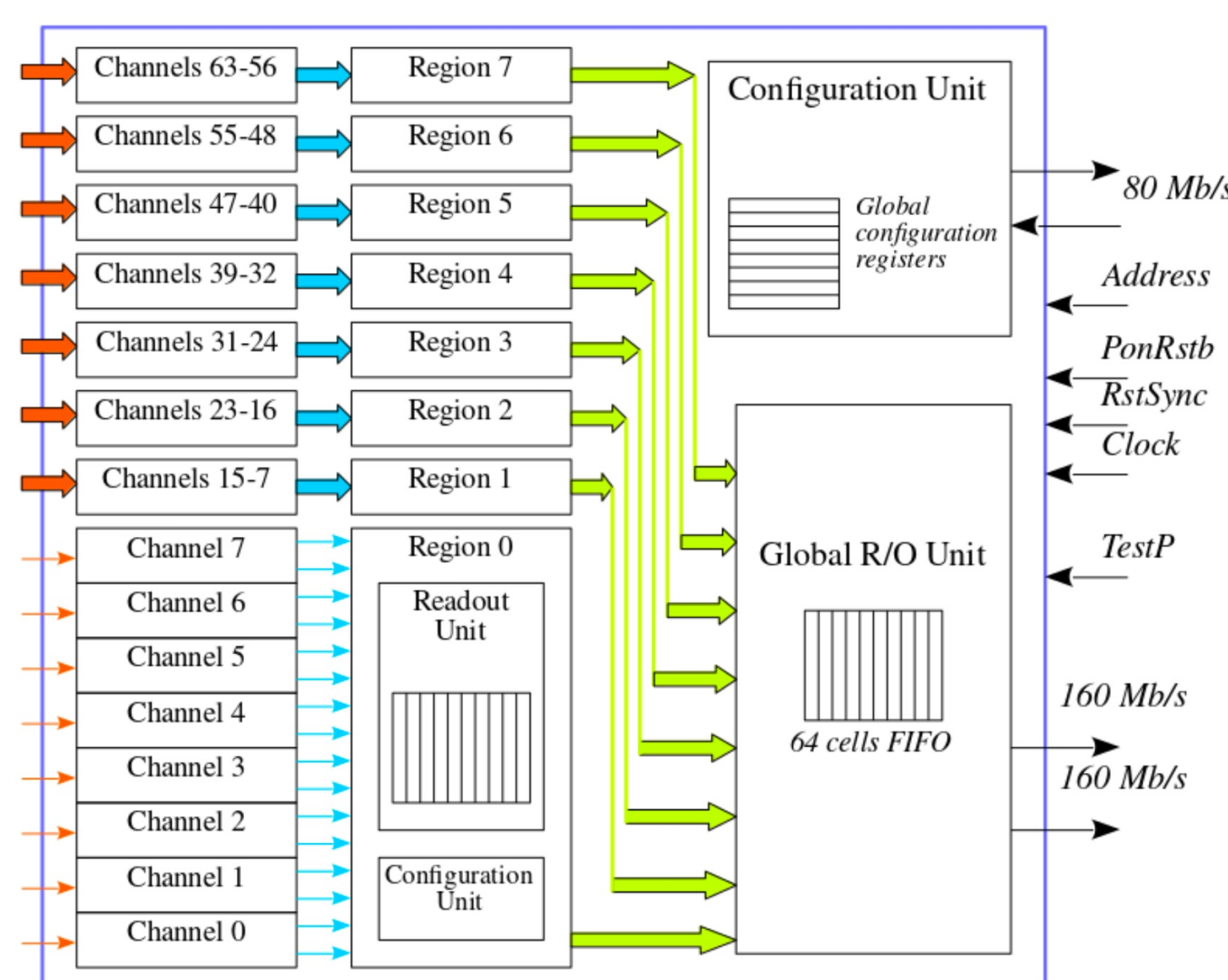
SSDs readout requirements:

Channels per chip	64
Charge resolution	8 bits
Input charge	1 – 40 fC
Noise	max 1500 e ⁻
Reference clock	160 MHz
Power consumption	max 256 mW
Radiation tolerance	20 kGy
Chip dimensions	4.5 x 3.5 mm ²

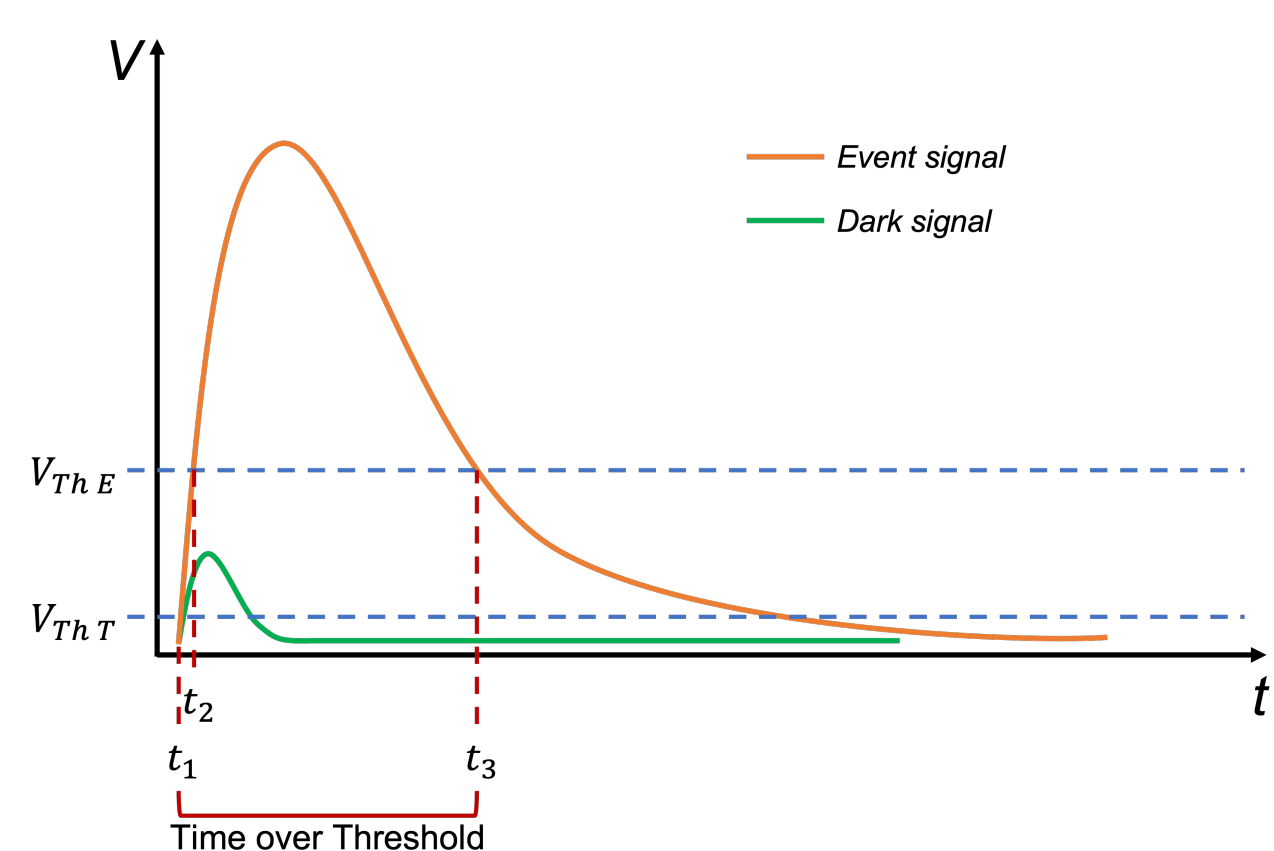
Adopted methodologies

ToAST specifics and architecture:

- Commercial 110 nm CMOS technology
- Triplicated logic to protect against single event upsets
- 64 readout channels
- 8 regions with local FIFO
- Each channel provides the ToA and the charge measurement
- 160MHz clock
- Two 160 Mb/s serial lines
- Configuration serial link running at half the master clock frequency (80 Mb/s)
- Fully digital interface in order to avoid the transmission of noise sensitive analog signals



Time measurement:



Two threshold:

- store the time stamp on the low threshold (Vth_T)
- validate it with the high threshold (Vth_E)

$$\text{ToT} = t_3 - t_1$$

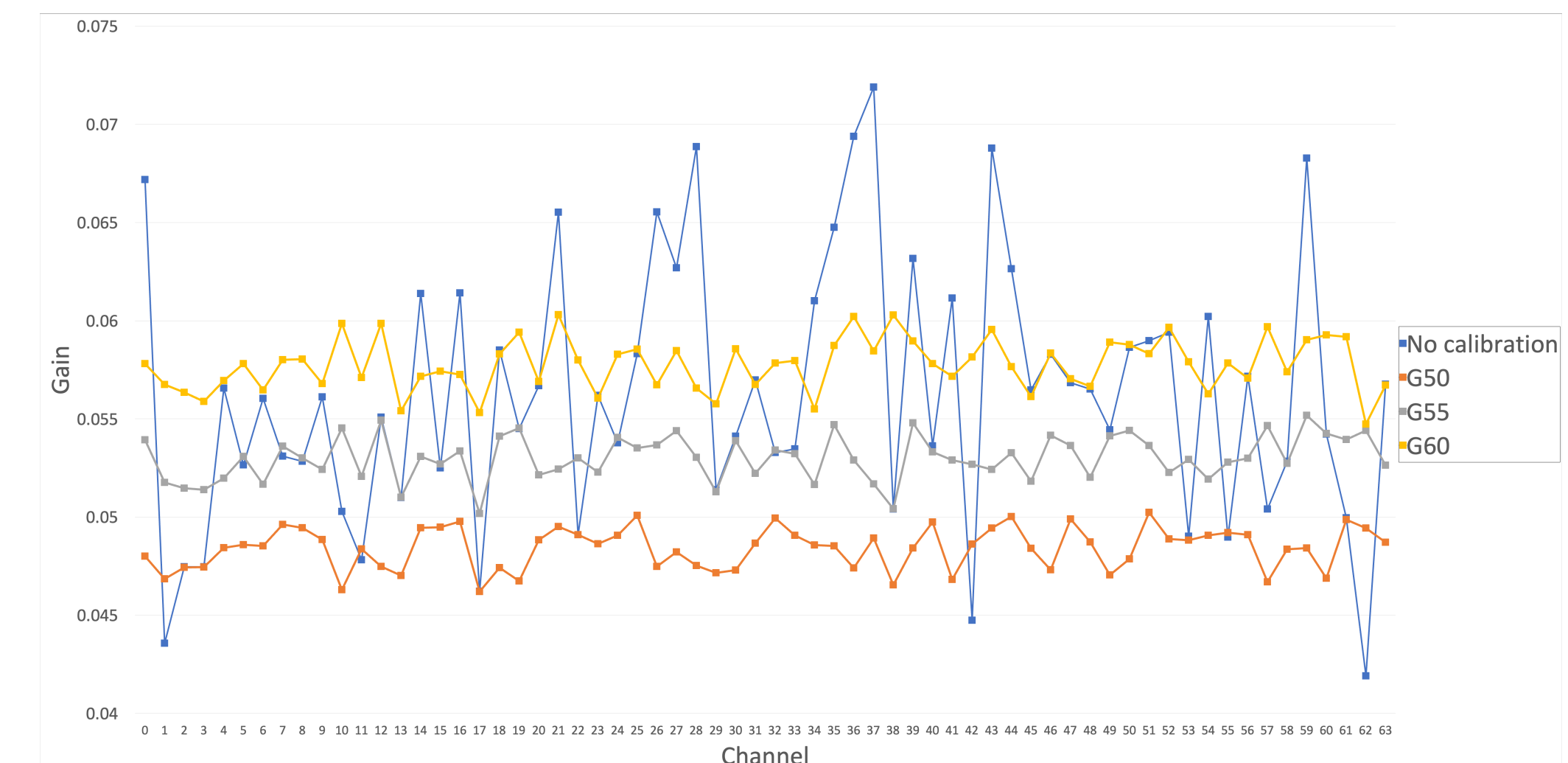
Possibility to disable the double threshold

Novel contributions

Characterization of the ToAST ASIC v1

Gain and ToT offset calibration

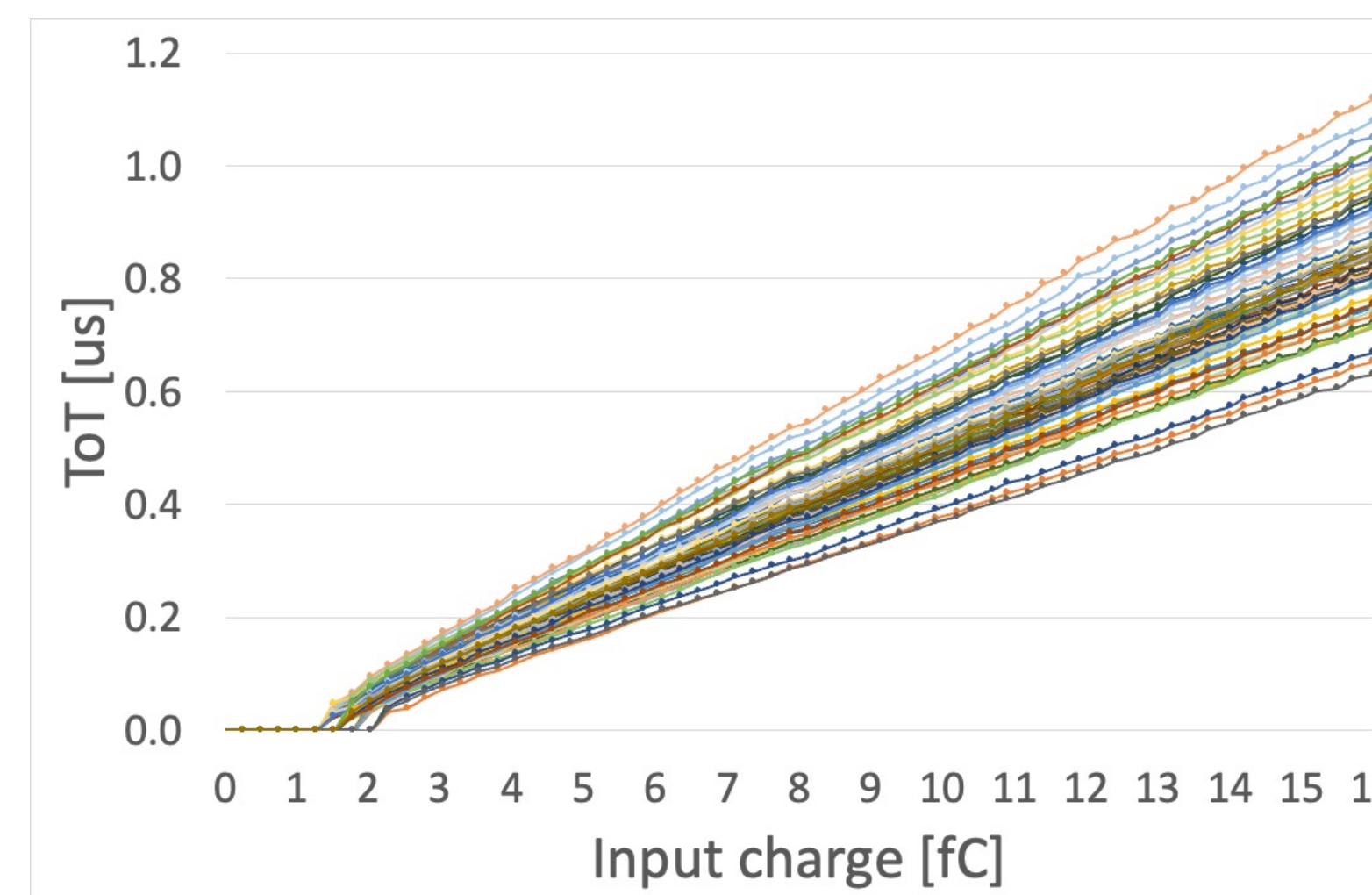
- ToT programmable Gain between 50 to 60 ns/fC for both polarities



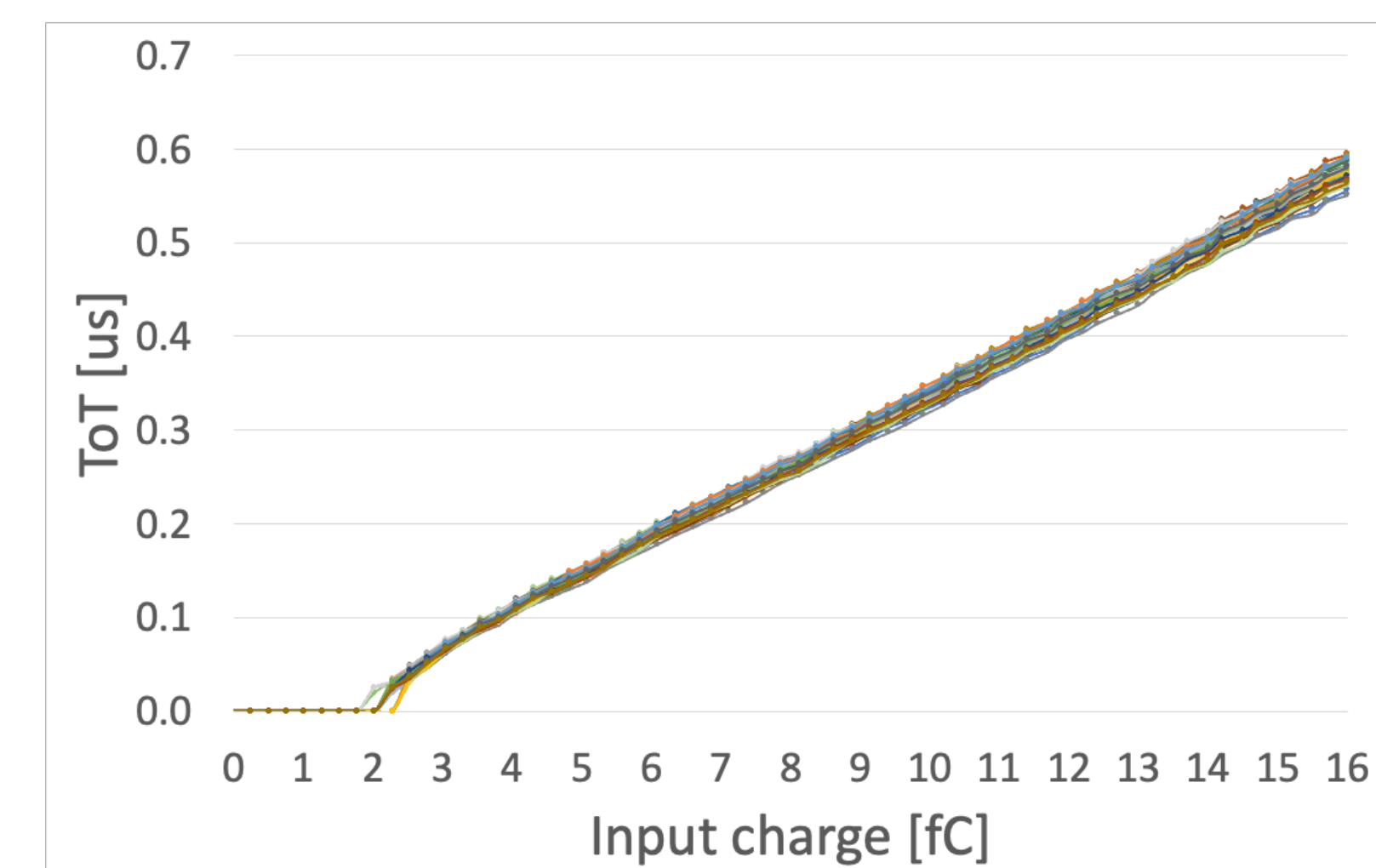
Calibration procedure:

- For each channel, measure the transfer curve for each channel ToT Ibias DAC value
- Select a reference gain
- For each channel, select the DAC value providing the gain closest to the reference
- For each channel, measure the offset of the ToT
- Select a reference offset
- For each channel, select the DAC value providing the offset closest to the reference

Before calibration



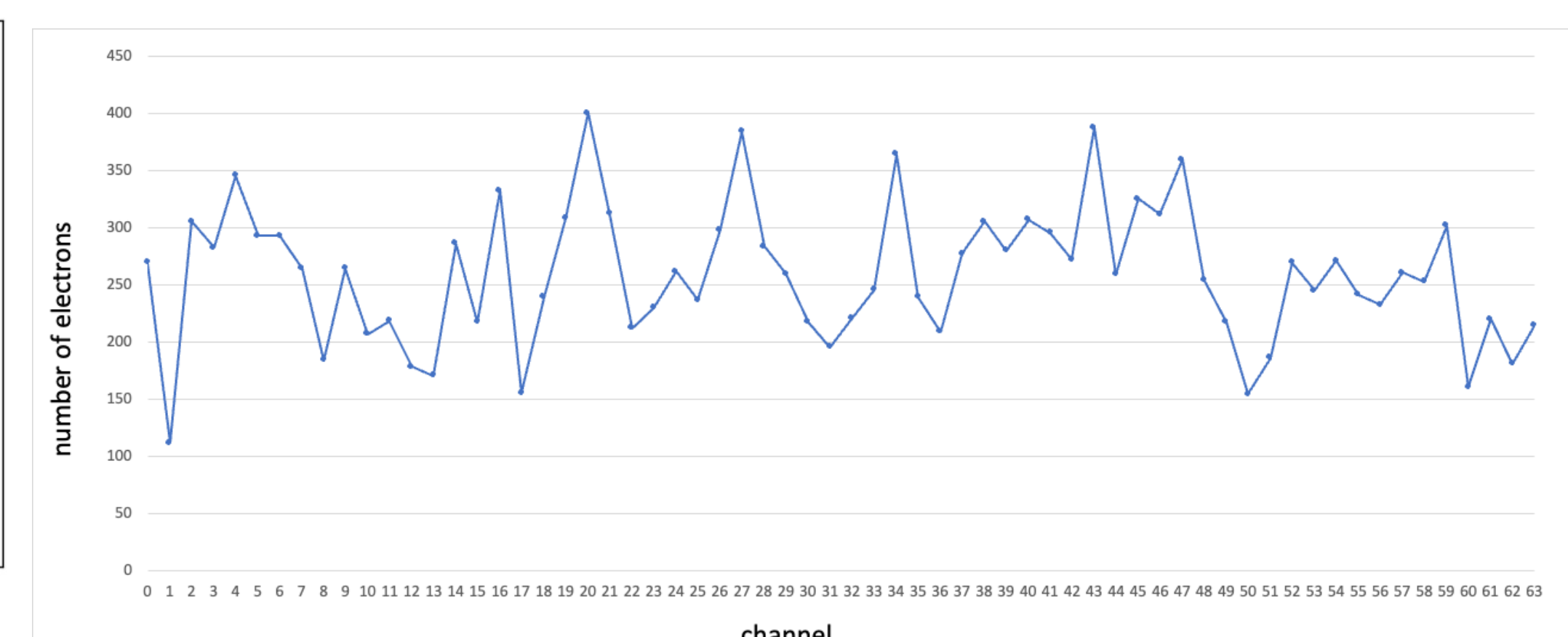
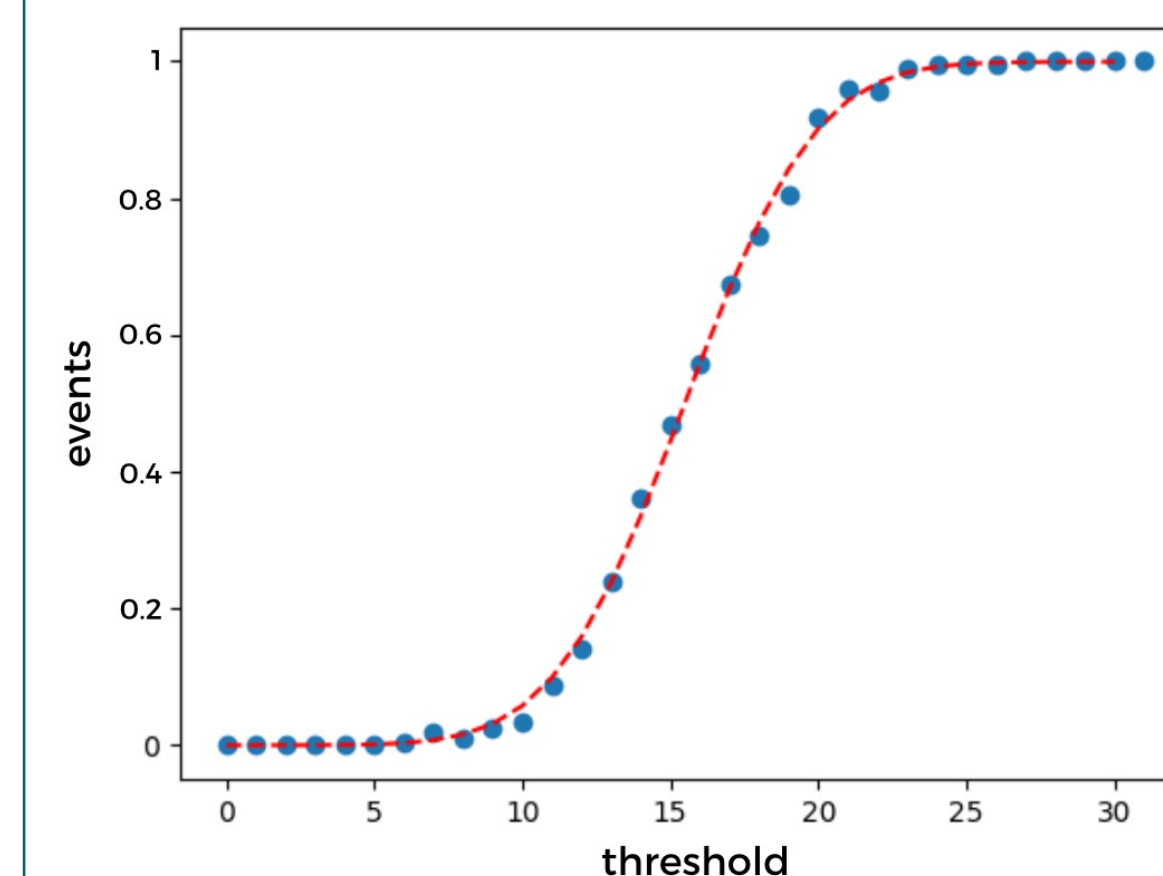
After calibration



Noise

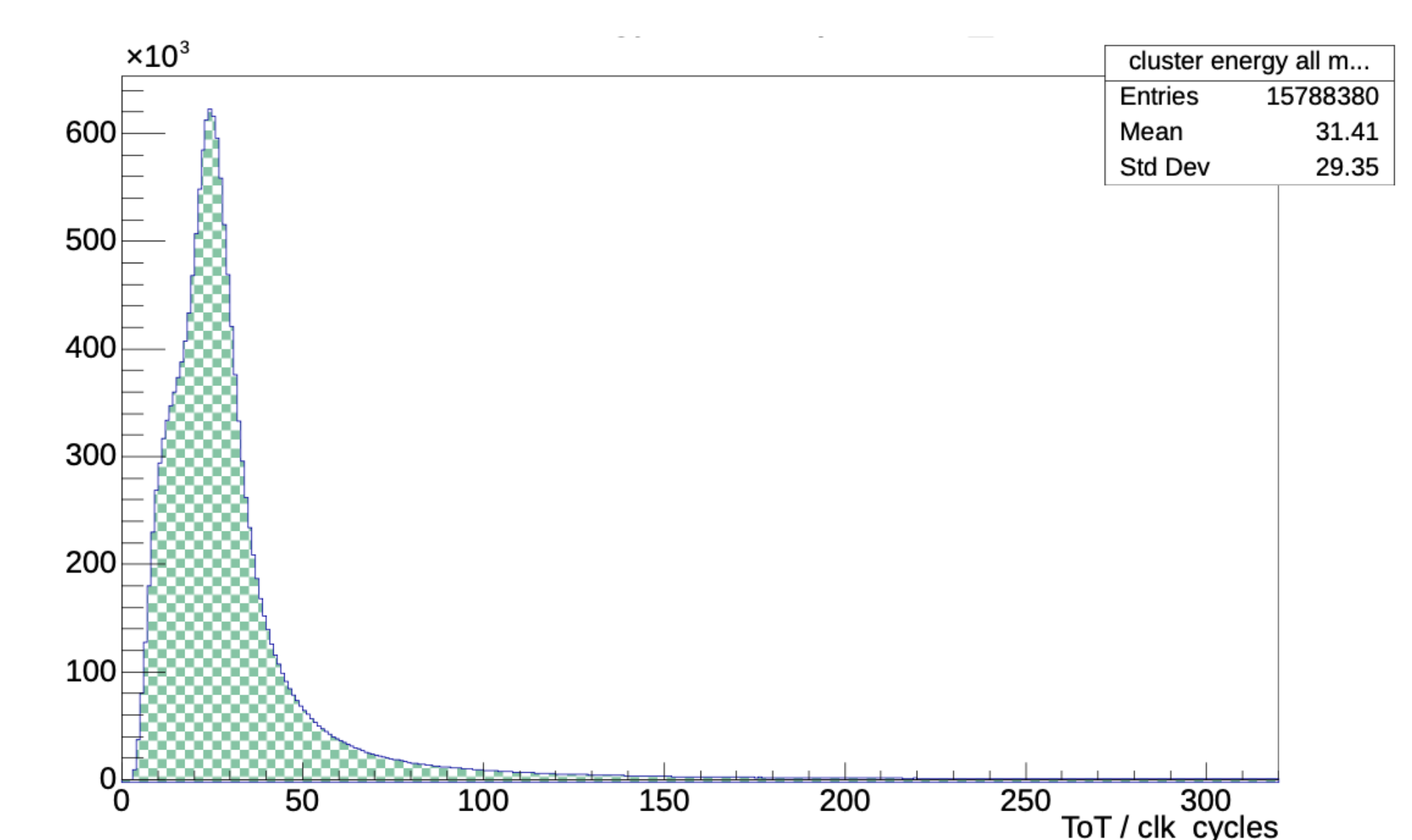
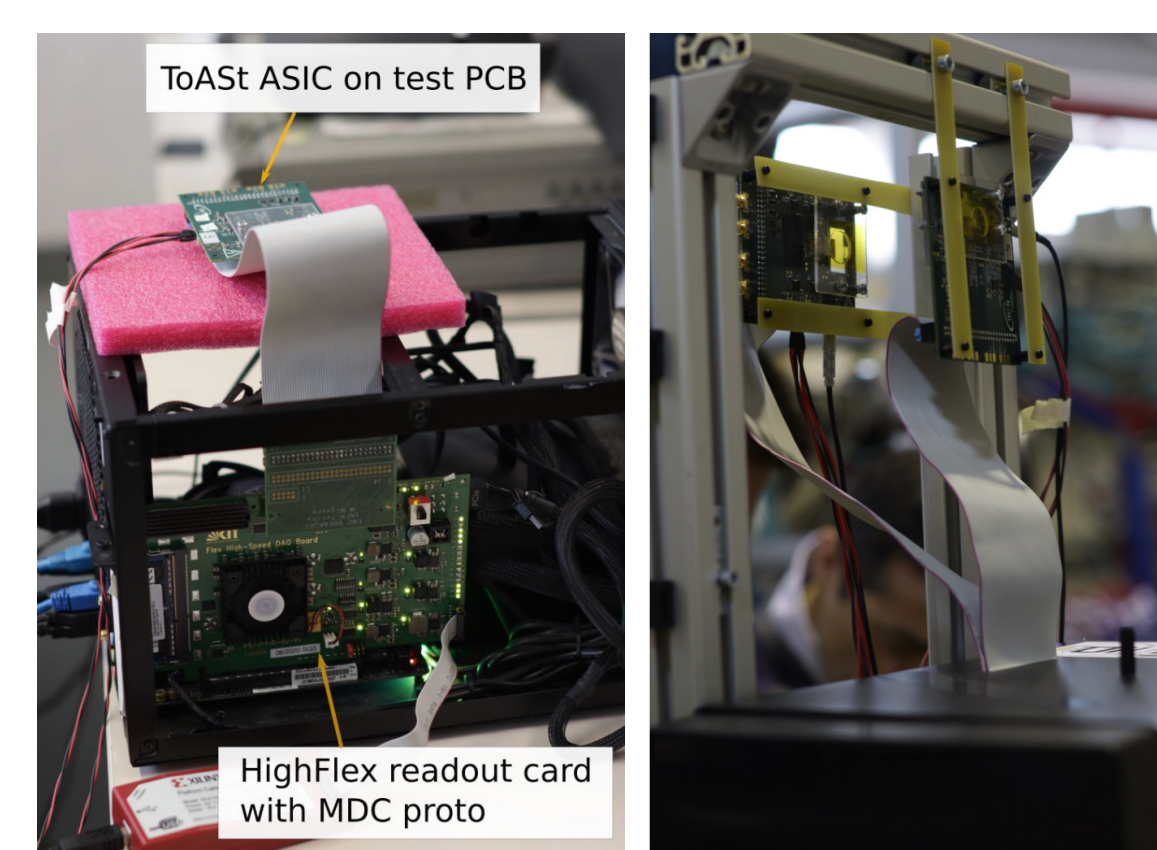
Scan performed with a fixed number of pulses and changing the threshold

$$f(x') = \frac{N}{2} \left(1 + \frac{2}{\sigma\sqrt{\pi}} \int_0^{x'} \exp(-s^2) dx \right), \quad s = \frac{x-\mu}{\sigma}$$



Preliminary beam test

Test at COSY facility (Juelich, Germany)
Data collected are under analysis



Future work

Test:

- Performances are as expected
- Tested with detector under preliminary beam test → results under analysis
- Test for radiation tolerance (TID and SEU) are not fully satisfying → improvement required

Future works:

- Beam test data analysis
- Next version of ToAST (ToAST v2)

Publications

- **Presentation** at the **IPRD23** conference in Siena “Characterization of the radiation tolerant ToAST ASIC for the readout of the PANDA MVD strip detector”