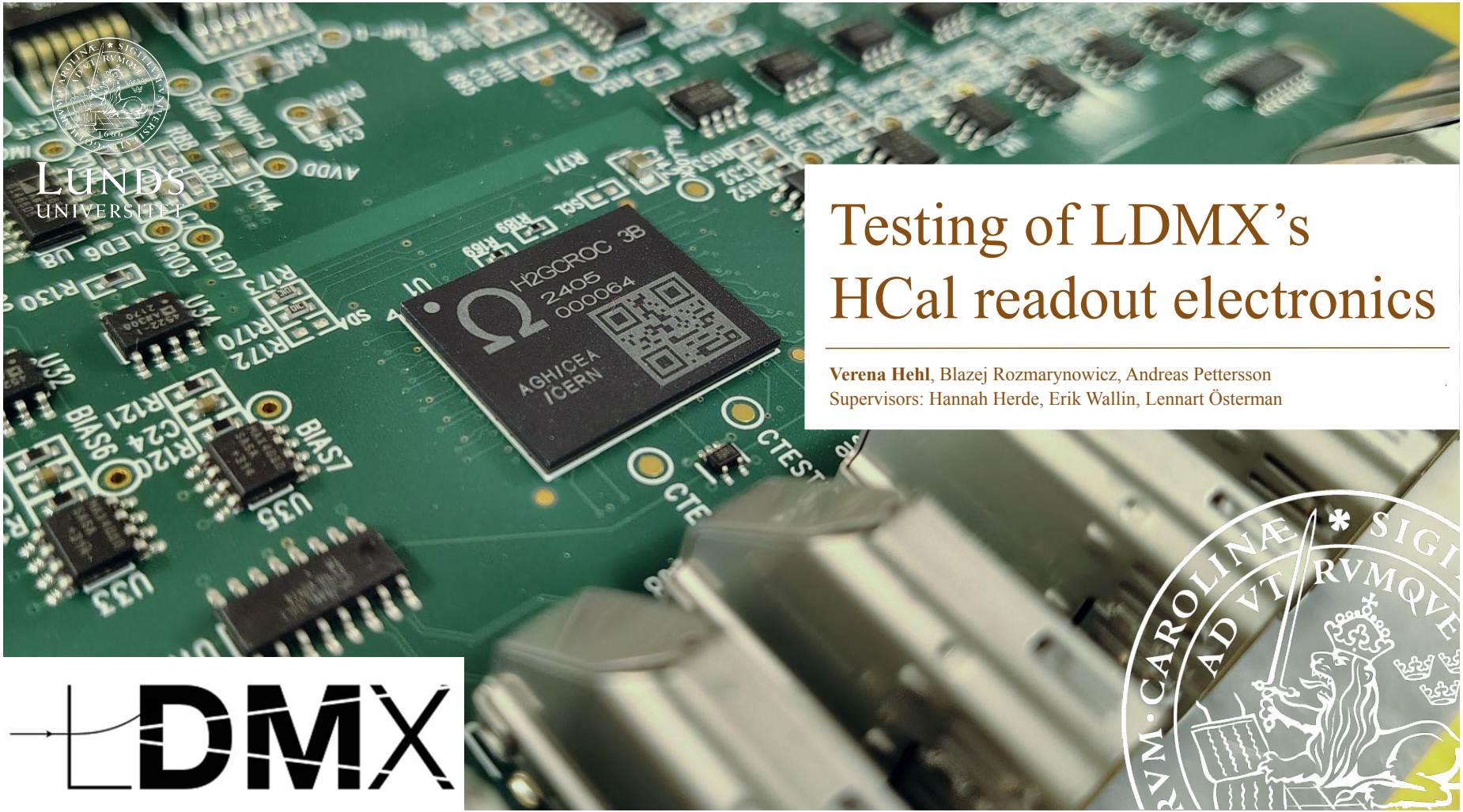

Testing of LDMX's HCal readout electronics

Verena Hehl, Blazej Rozmarynowicz, Andreas Pettersson
Supervisors: Hannah Herde, Erik Wallin, Lennart Österman

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LDMX

Introduction of the team

Blazej “Blaise” Rozmarynowicz

Andreas Pettersson

Verena Hehl (Speaker)

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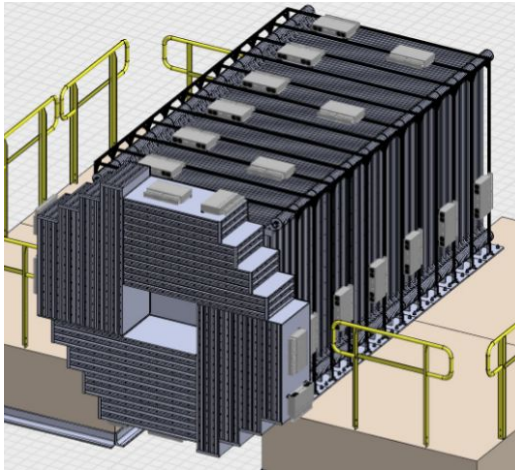
HCal signal readout path

LDMX HCal



T. Akesson et al. *LDMX – The Light Dark Matter eXperiment*. arXiv:2508.11833, August 2025.

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HCal signal readout path

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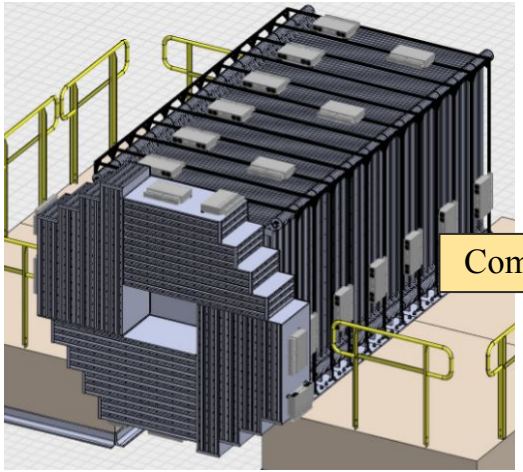

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Composed of

Scintillator bars with Counter-Mother-Board (CMB)

H. Herde, Partikeldagarna, 2024

HCal signal readout path

LDMX HCal

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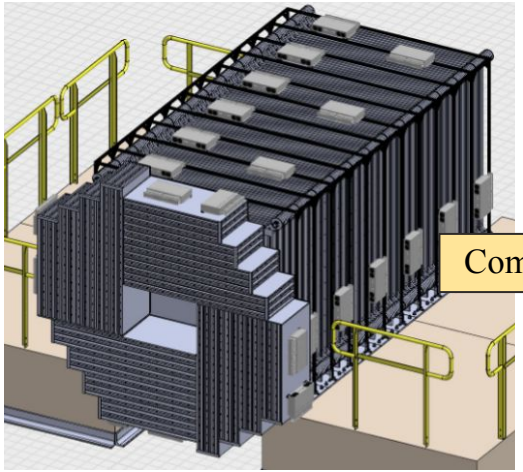

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H. Herde, Partikeldagarna, 2024

CMB with Silicon Photomultipliers (SiPMs)

Front panel with SiPMs visible

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HCal signal readout path

LDMX HCal

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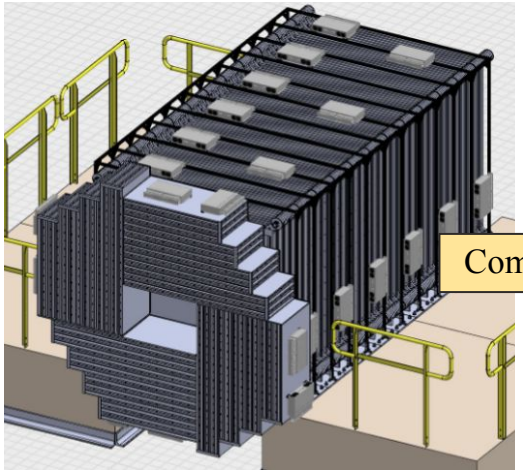
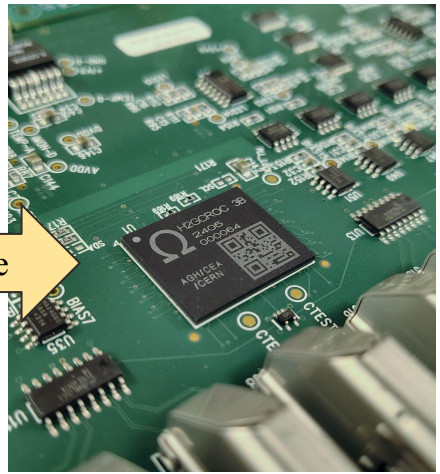
Readout electronics



Composed of

Cable



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H. Herde, Partikeldagarna, 2024

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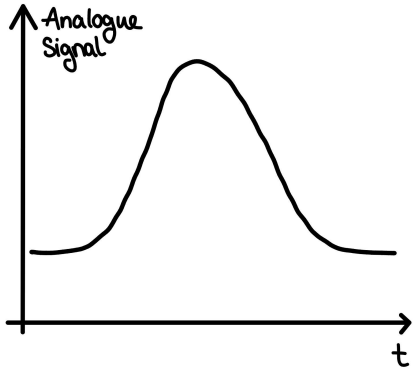

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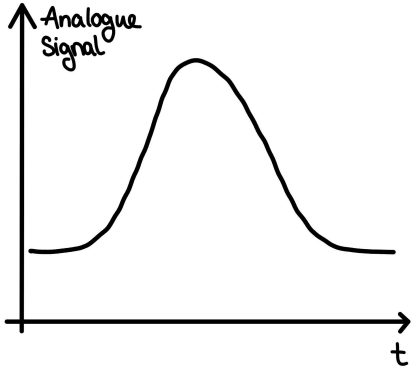

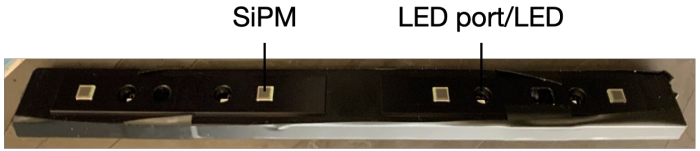

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H. Herde, Partikeldagarna, 2024

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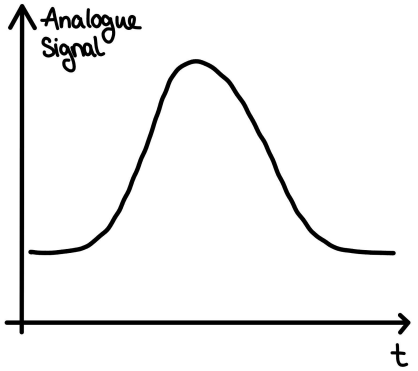

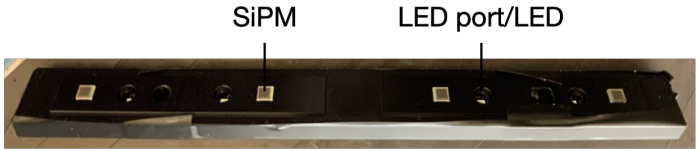

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H. Herde, Partikeldagarna, 2024

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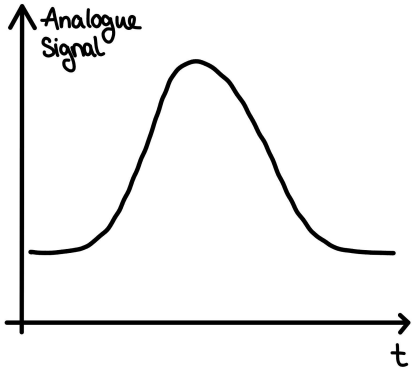
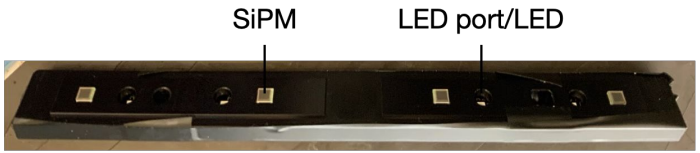
Our focus today





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H. Herde, Partikeldagarna, 2024

High Granularity Calorimeter ReadOut Chip (HGCROC)

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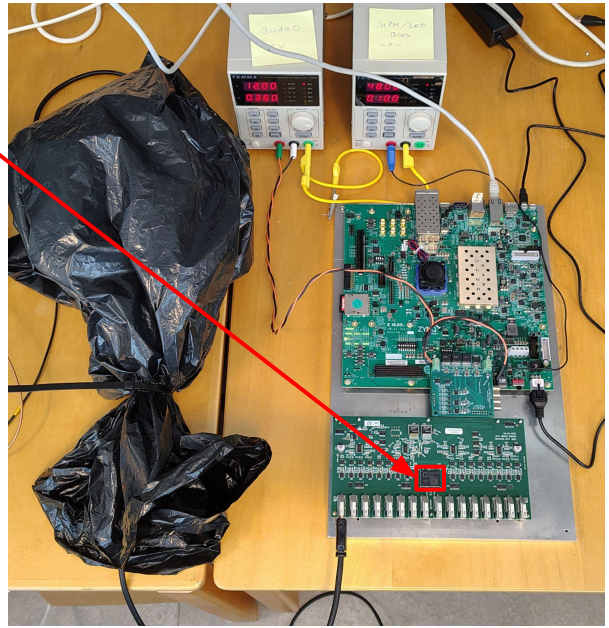
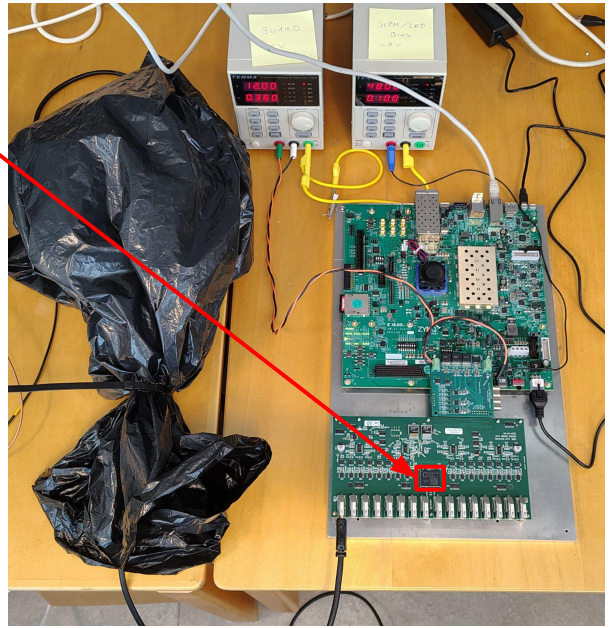


High Granularity Calorimeter ReadOut Chip (HGCROC)

- Sourced from CMS at CERN



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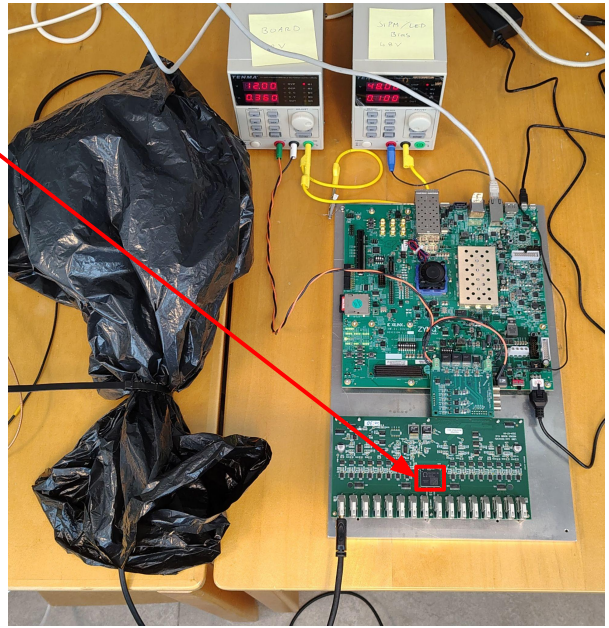
High Granularity Calorimeter ReadOut Chip (HGCROC)

- Sourced from CMS at CERN
- 72 channels, 64 connected to SiPMs



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High Granularity Calorimeter ReadOut Chip (HGCROC)

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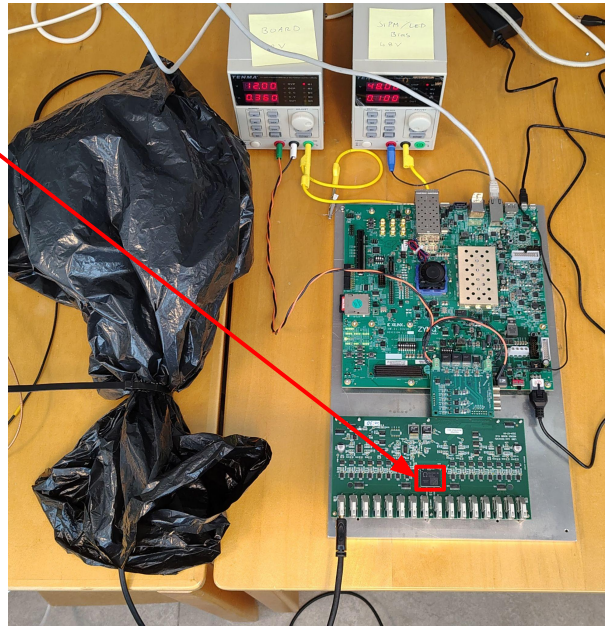

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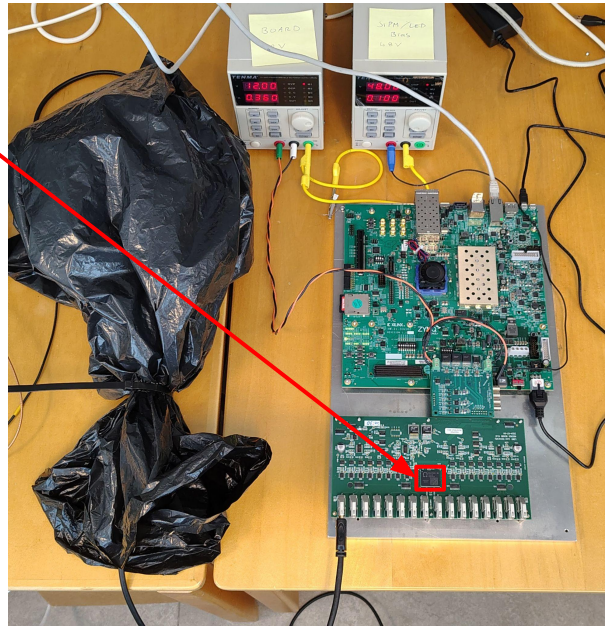
Internal charge injections

External LED flashing



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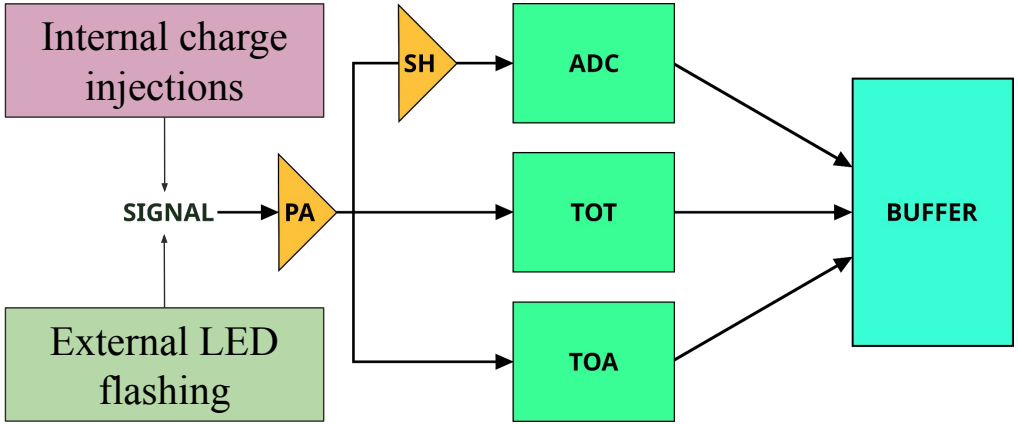

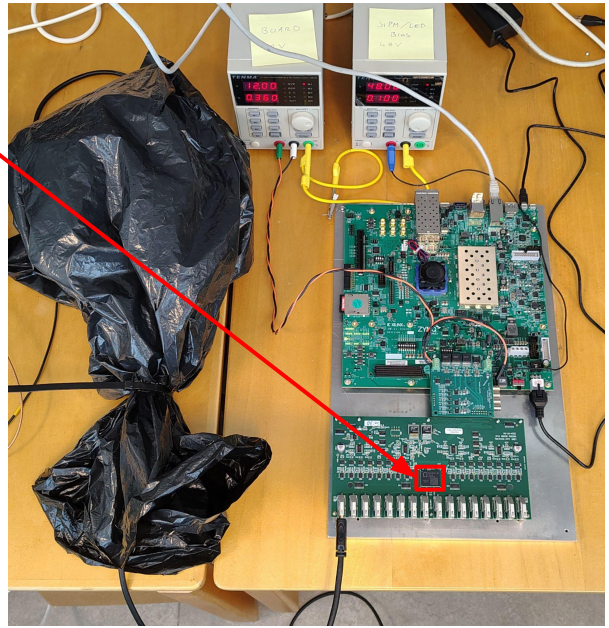

A. Pettersson, V. Hehl, Partikeldagarna, 2025

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Analogue-to-Digital Converter (ADC)

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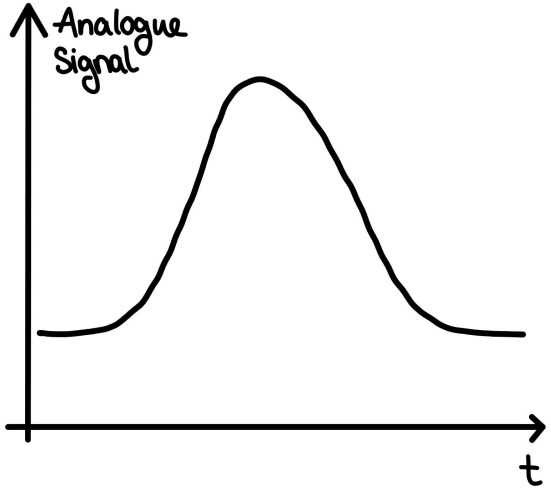

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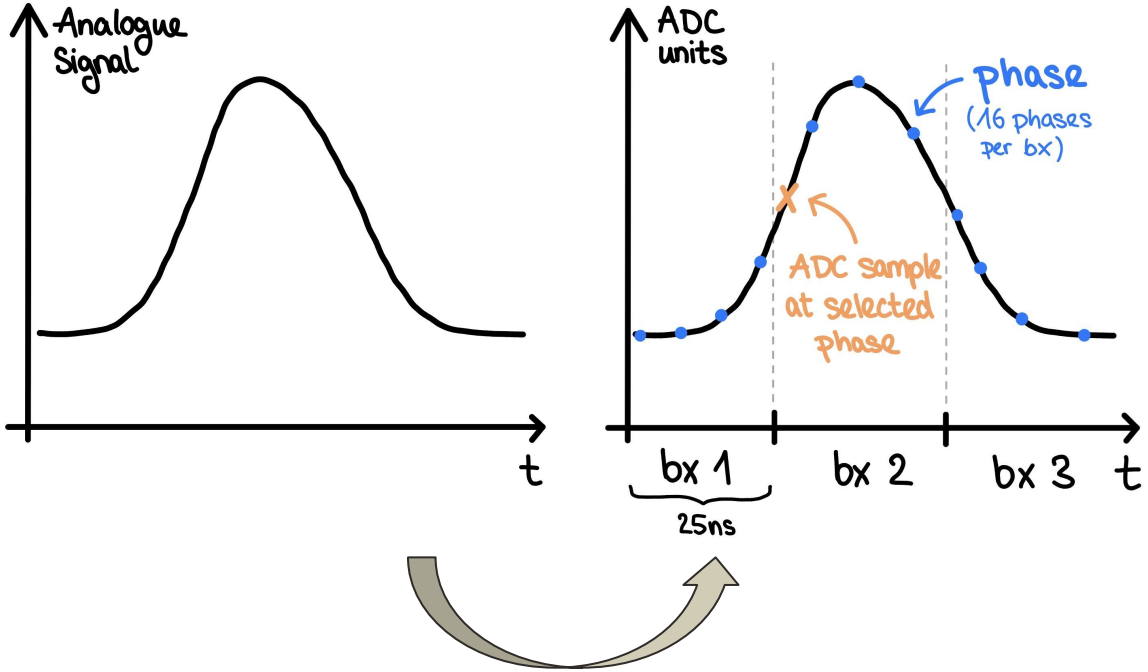

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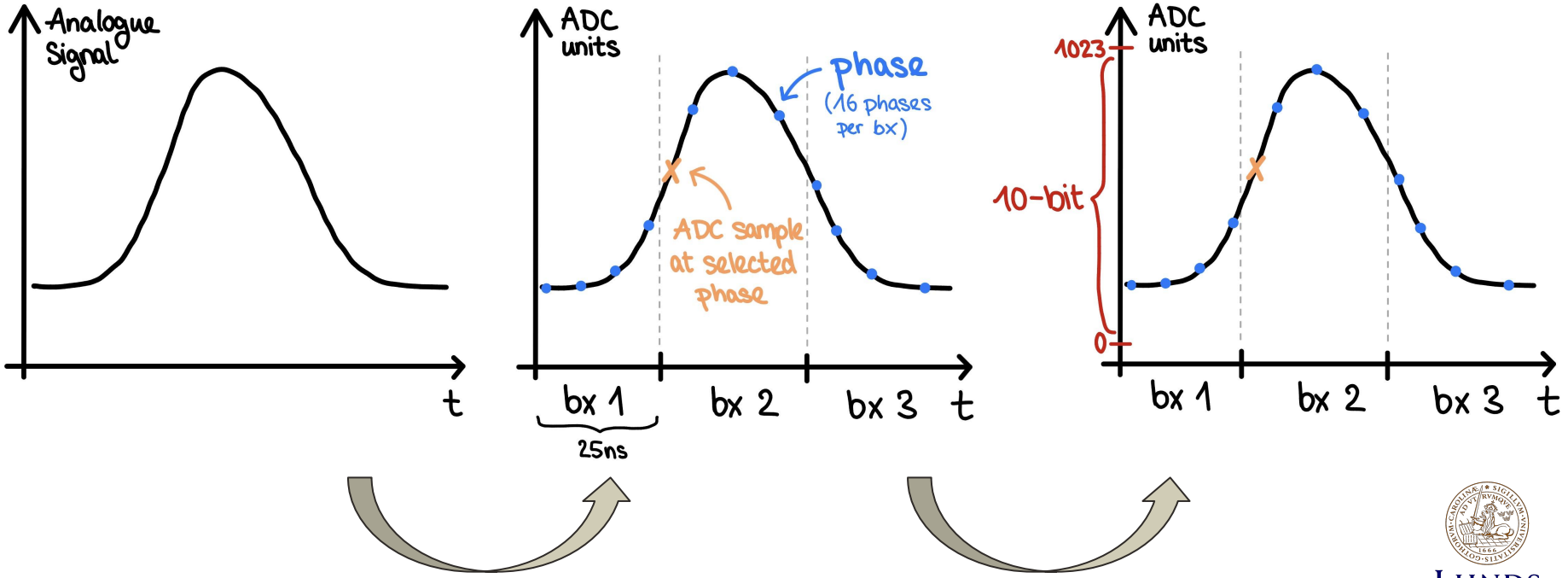

Time Of Arrival (TOA) and Time Over Threshold (TOT)

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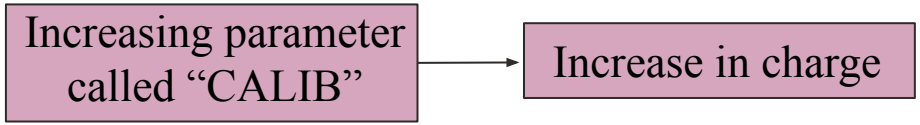
Increasing parameter called “CALIB”

Time Of Arrival (TOA) and Time Over Threshold (TOT)



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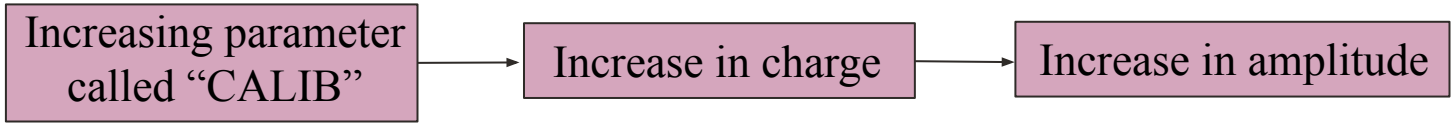
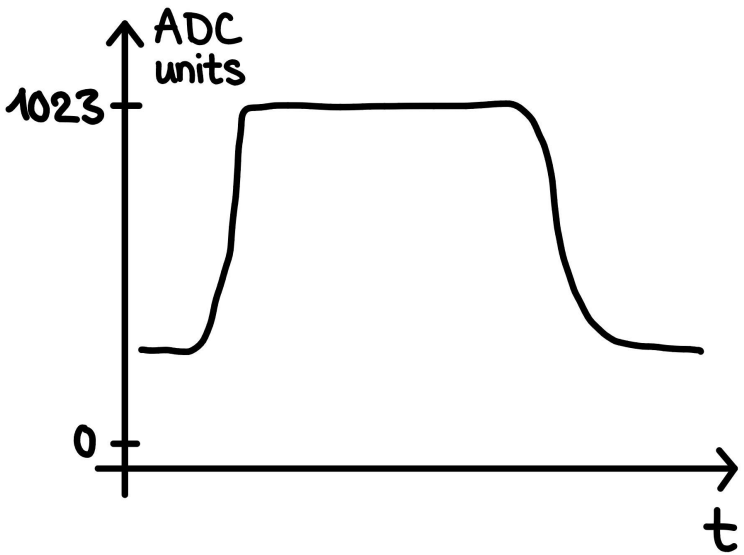


Time Of Arrival (TOA) and Time Over Threshold (TOT)

Increasing parameter called “CALIB” → Increase in charge → Increase in amplitude



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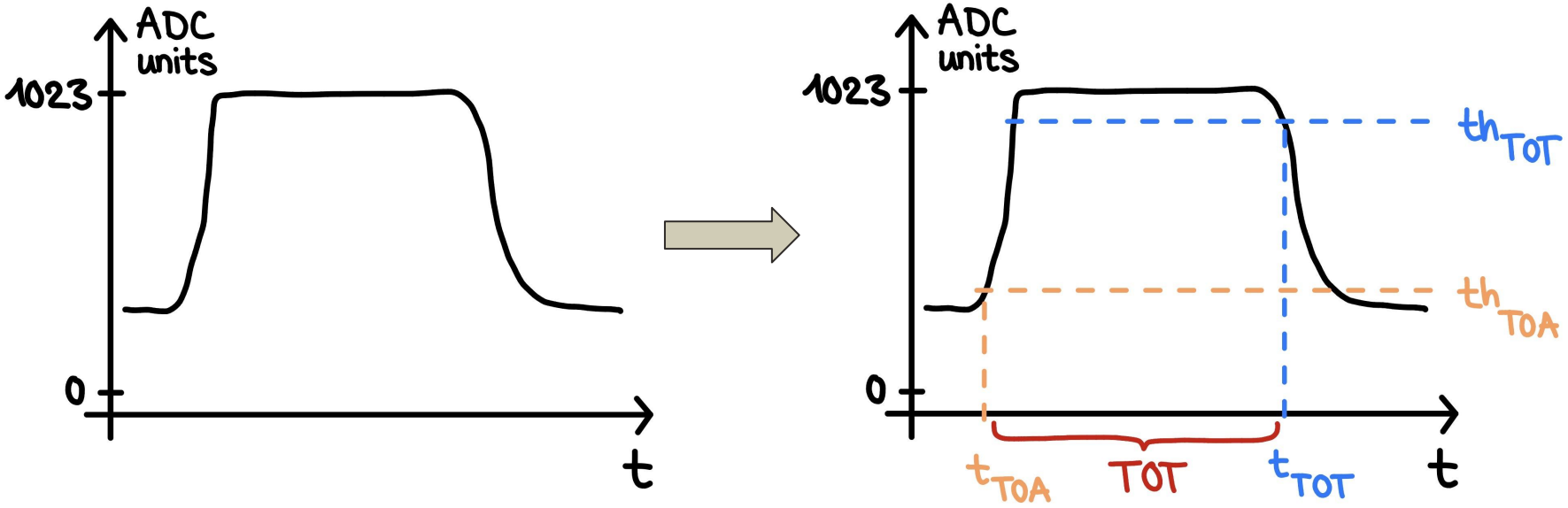

Calibration procedure: Pedestal alignment

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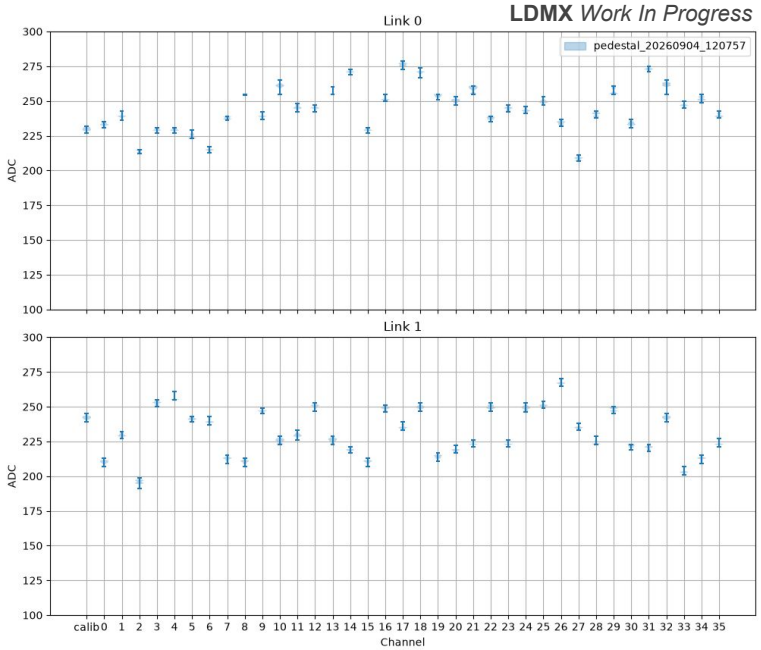
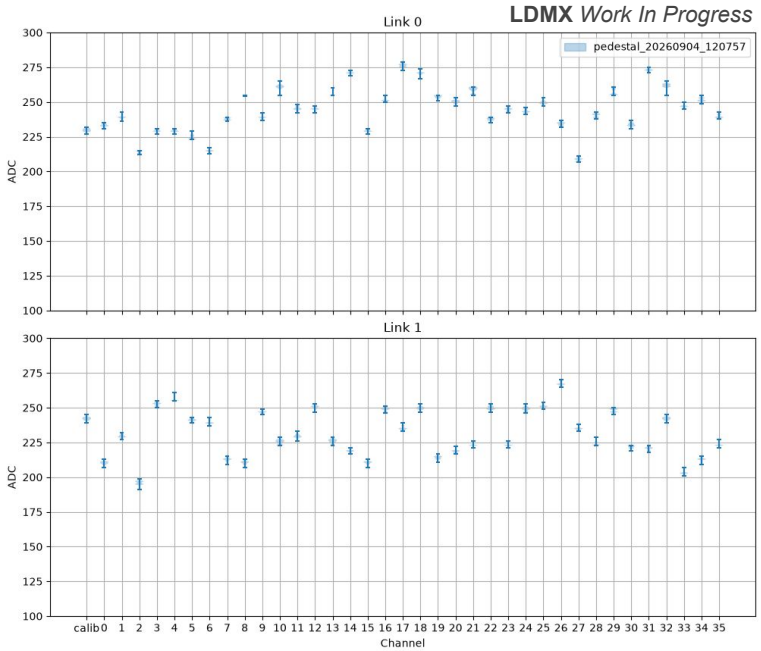
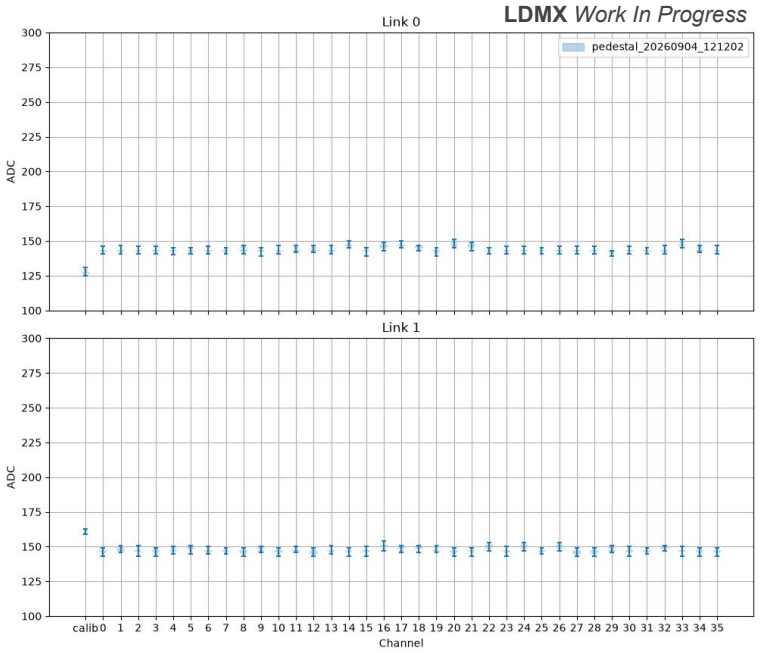


Before levelling

Calibration procedure: Pedestal alignment





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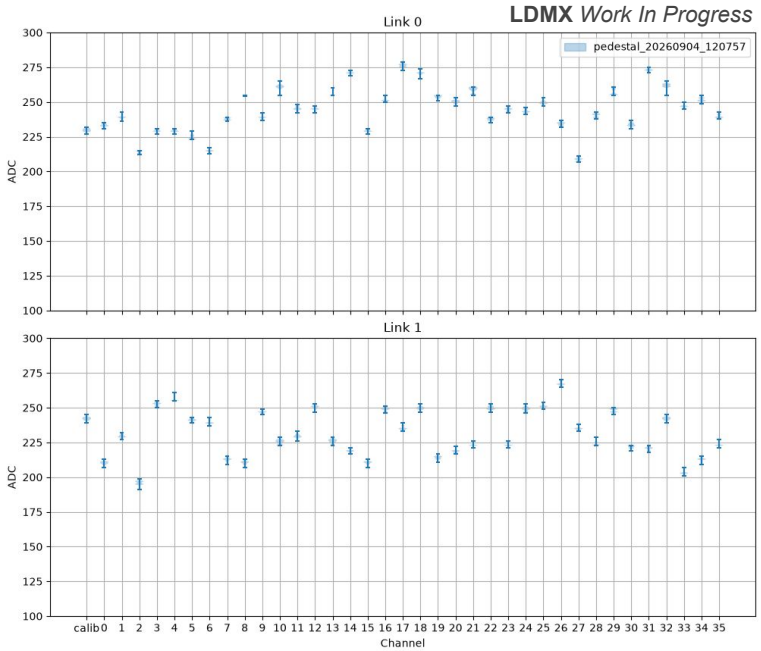
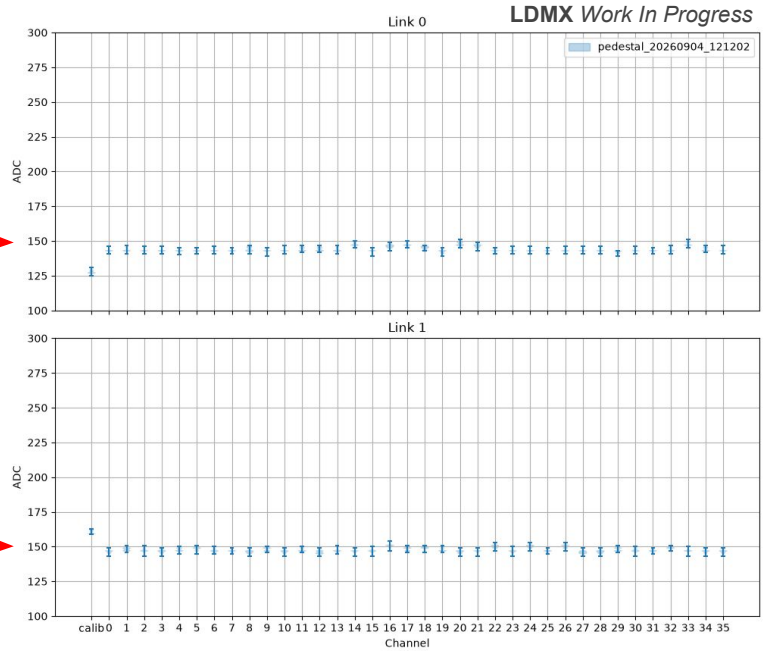


Target threshold



Before levelling

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Calibration procedure: Configure the TOA and TOT

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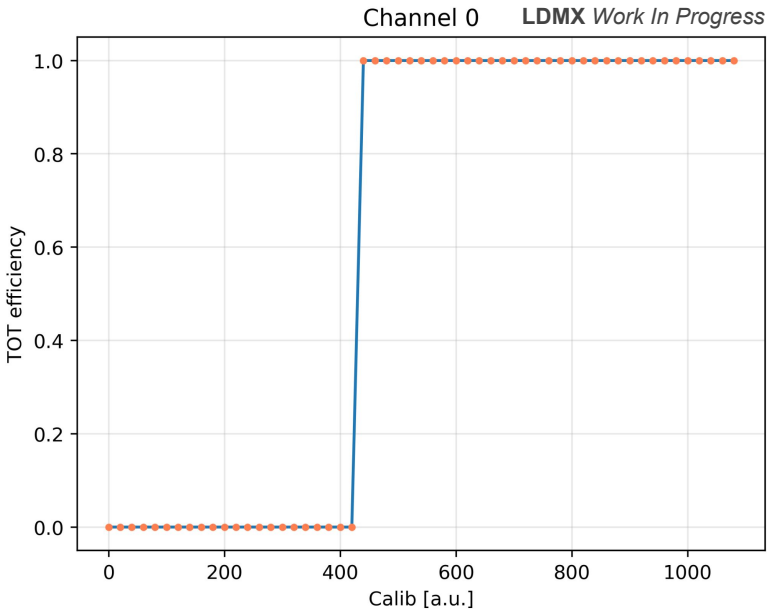

Data-acquisition: ADC time-scans

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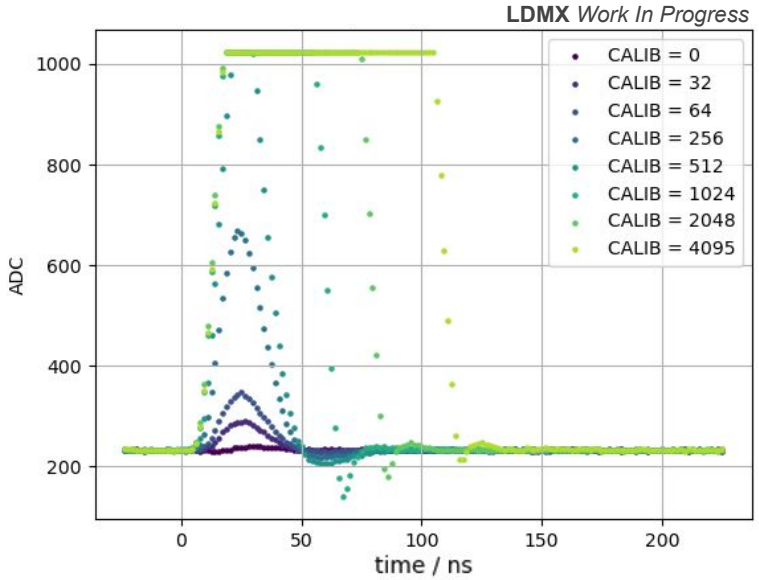
ADC values over time for one channel



A. Pettersson, V. Hehl, Partikeldagarna, 2025

Internal charge injections

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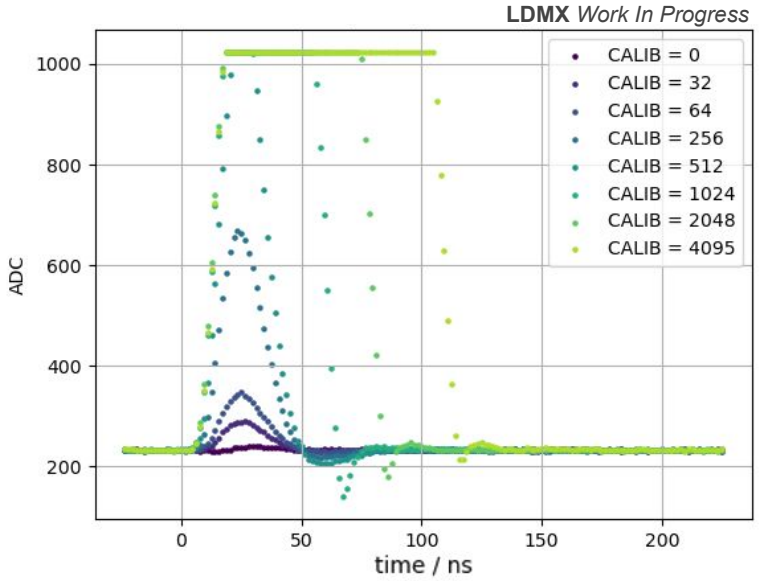
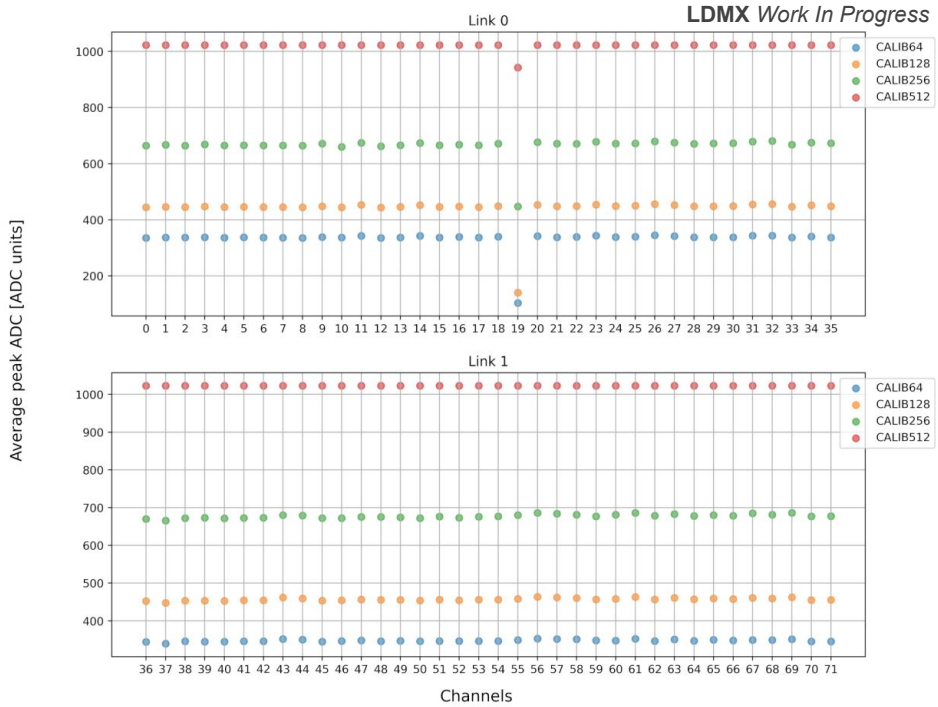


A. Pettersson, V. Hehl, Partikeldagarna, 2025

Average peak ADC over all channels



B. Rozmarynowicz: *LDMX HCal read-out chip board characterization and diagnostics.* Master thesis, 2026.

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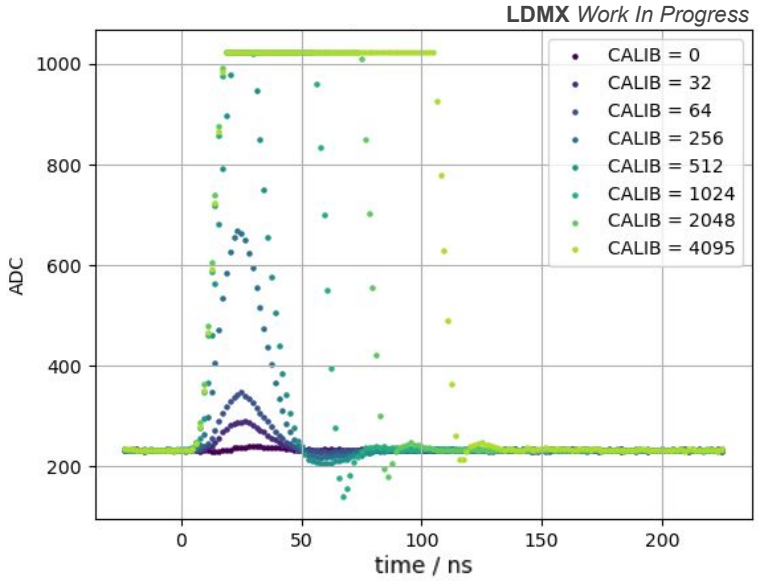

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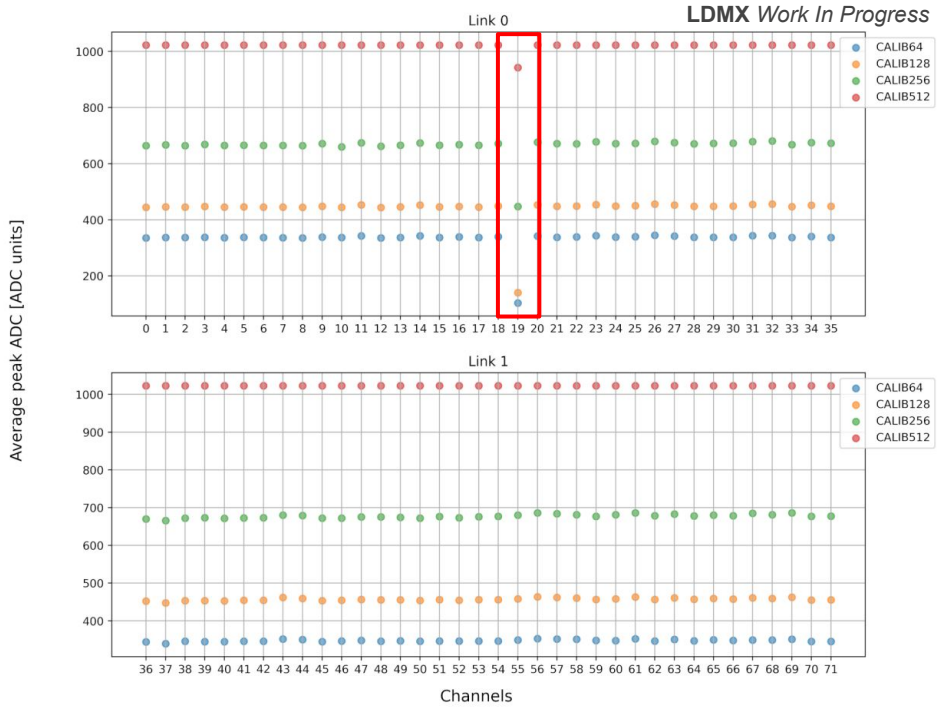

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Expectation:

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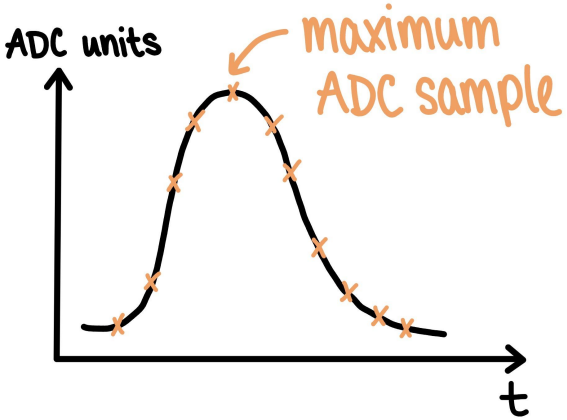
Expectation:

- Peak ADC against CALIB: linear



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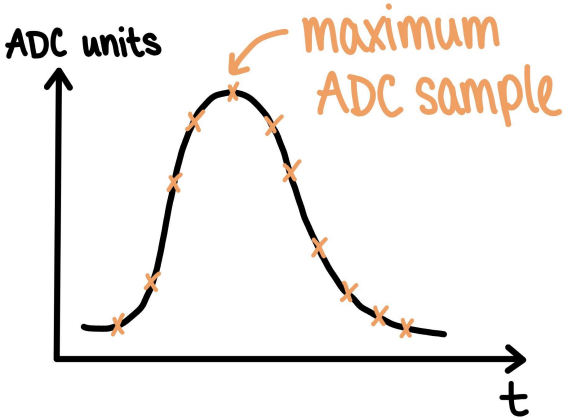

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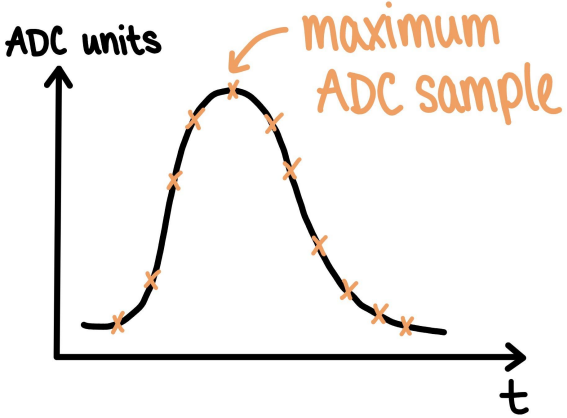
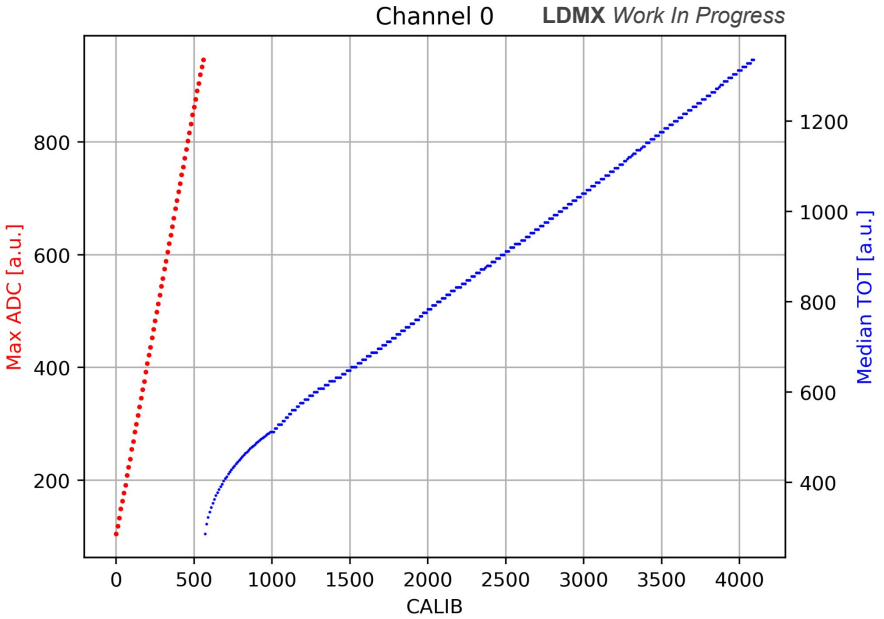




External LED flashing

Testing of CMBs and quadbars via LED flashing

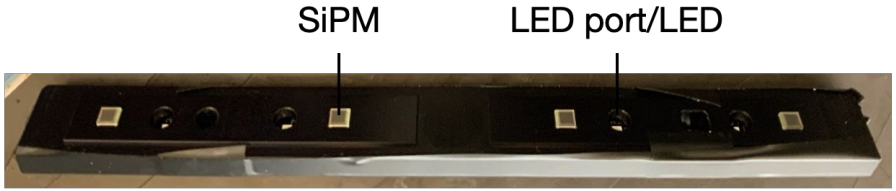
Testing of CMBs and quadbars via LED flashing

- 4 LEDs on each CMB

Front panel with SiPMs visible

Testing of CMBs and quadbars via LED flashing

- 4 LEDs on each CMB
- CMB enclosed in light-tight box



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Testing of CMBs and quadbars via LED flashing

- 4 LEDs on each CMB
- CMB enclosed in light-tight box
- Flash LEDs into SiPMs

Front panel with SiPMs visible

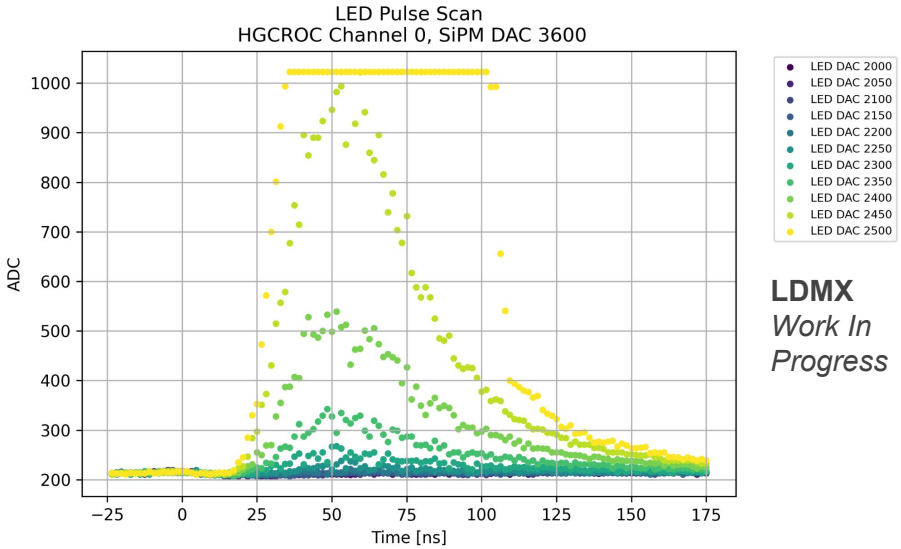
LED flashing

LED flashing

- Varying applied voltage flashes LEDs

LED flashing

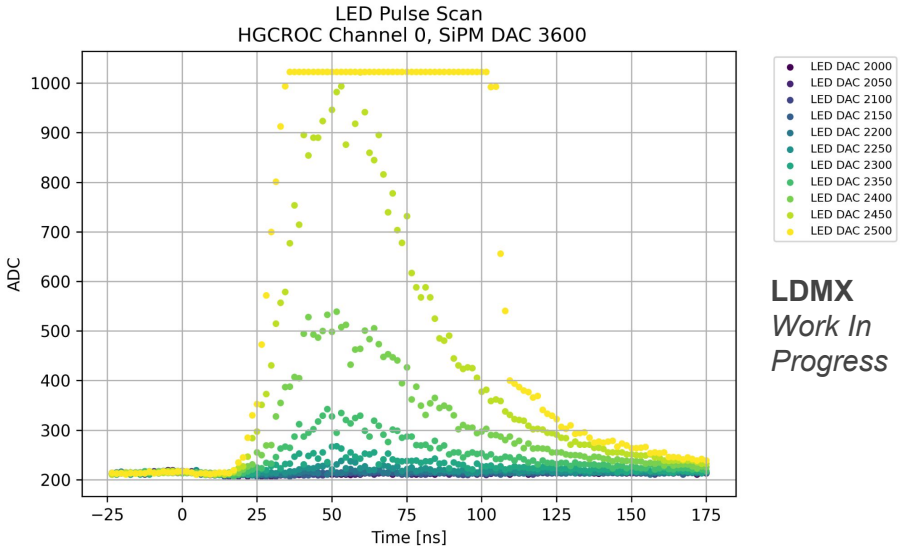
- Varying applied voltage flashes LEDs
- Timescan of the pulses



LDMX
Work In Progress

LED flashing

- Varying applied voltage flashes LEDs
- Timescan of the pulses
- Outlook:What happens if we connect CMB to the scintillator bar?



Summary and Outlook

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- Created standardized calibration and data acquisition procedure
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- Coming soon: LED flashing tests

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Thank you for your attention!

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Backup slides

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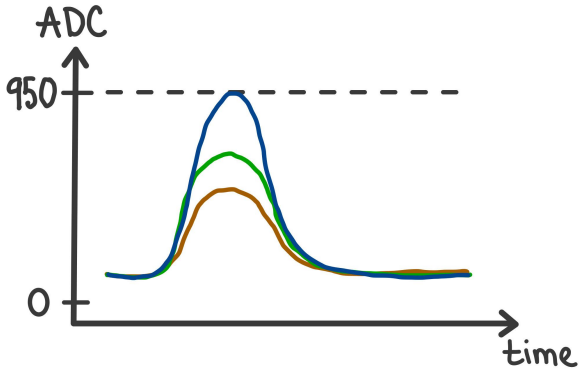
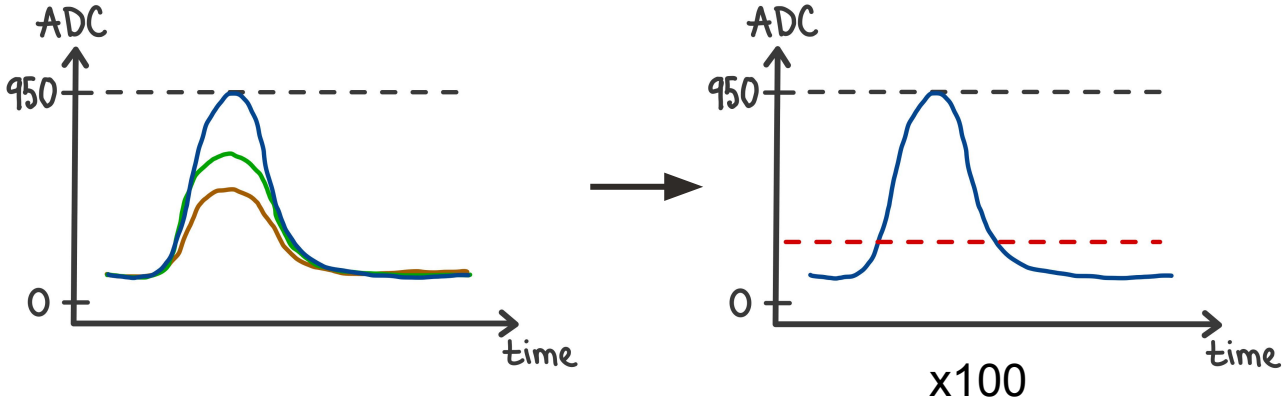
Calibration: How to set the TOT threshold



1. Find the correct `CALIB`

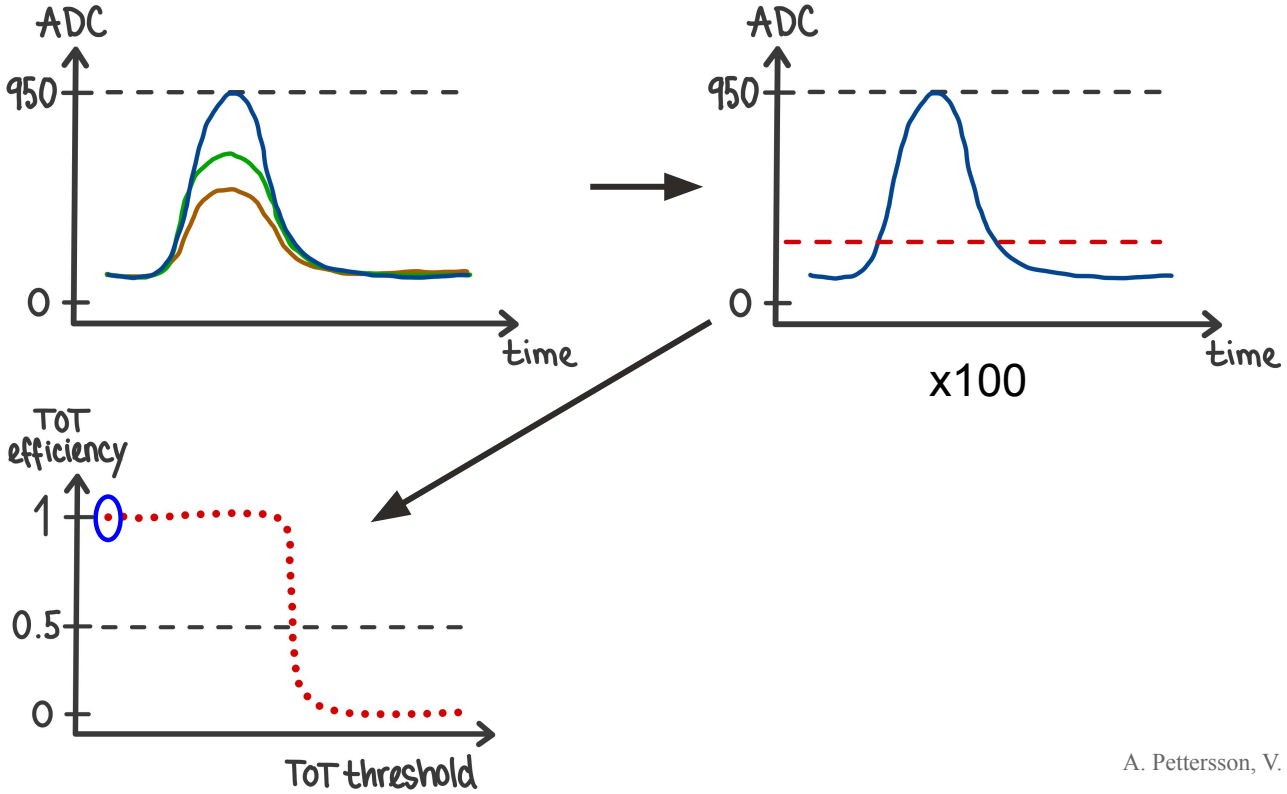
Calibration: How to set the TOT threshold



1. Find the correct `CALIB`

2. Scan TOT threshold parameter.

Calibration: How to set the TOT threshold

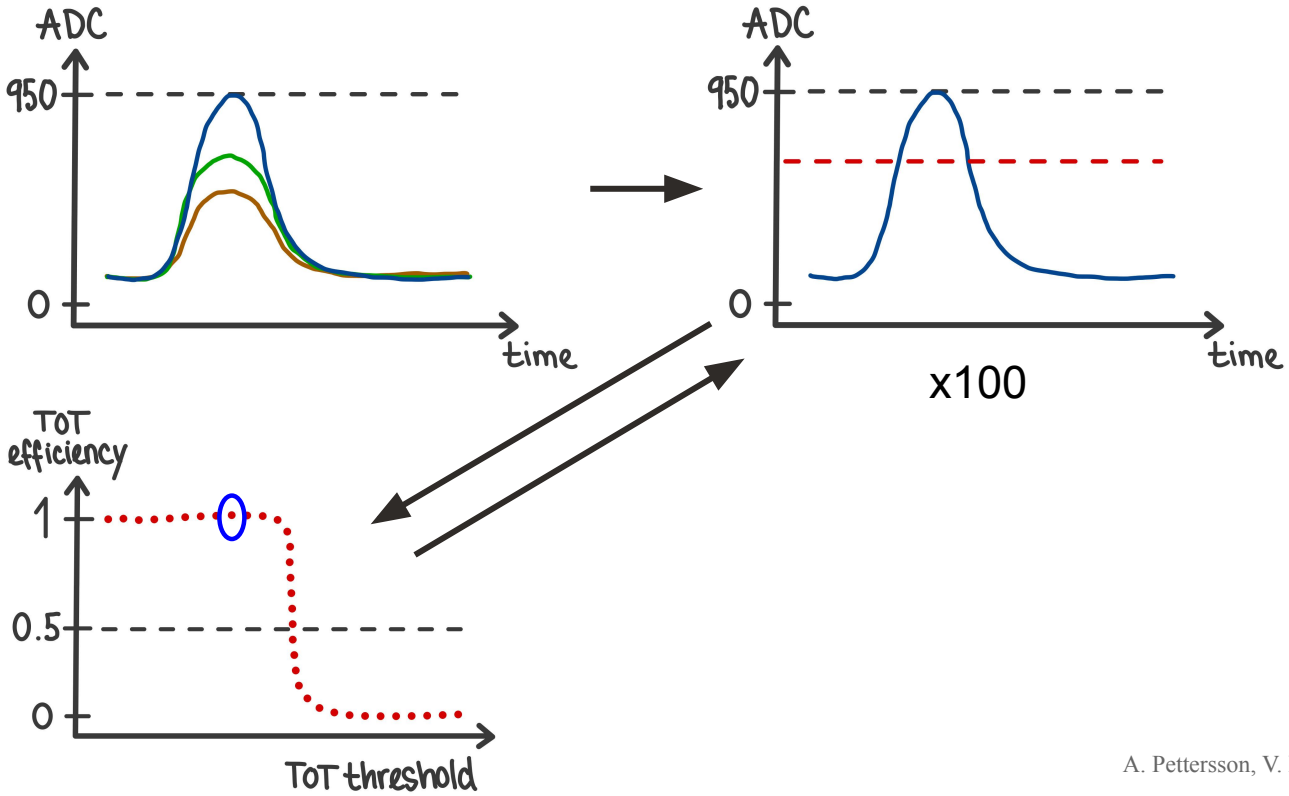


1. Find the correct `CALIB`

2. Scan TOT threshold parameter.

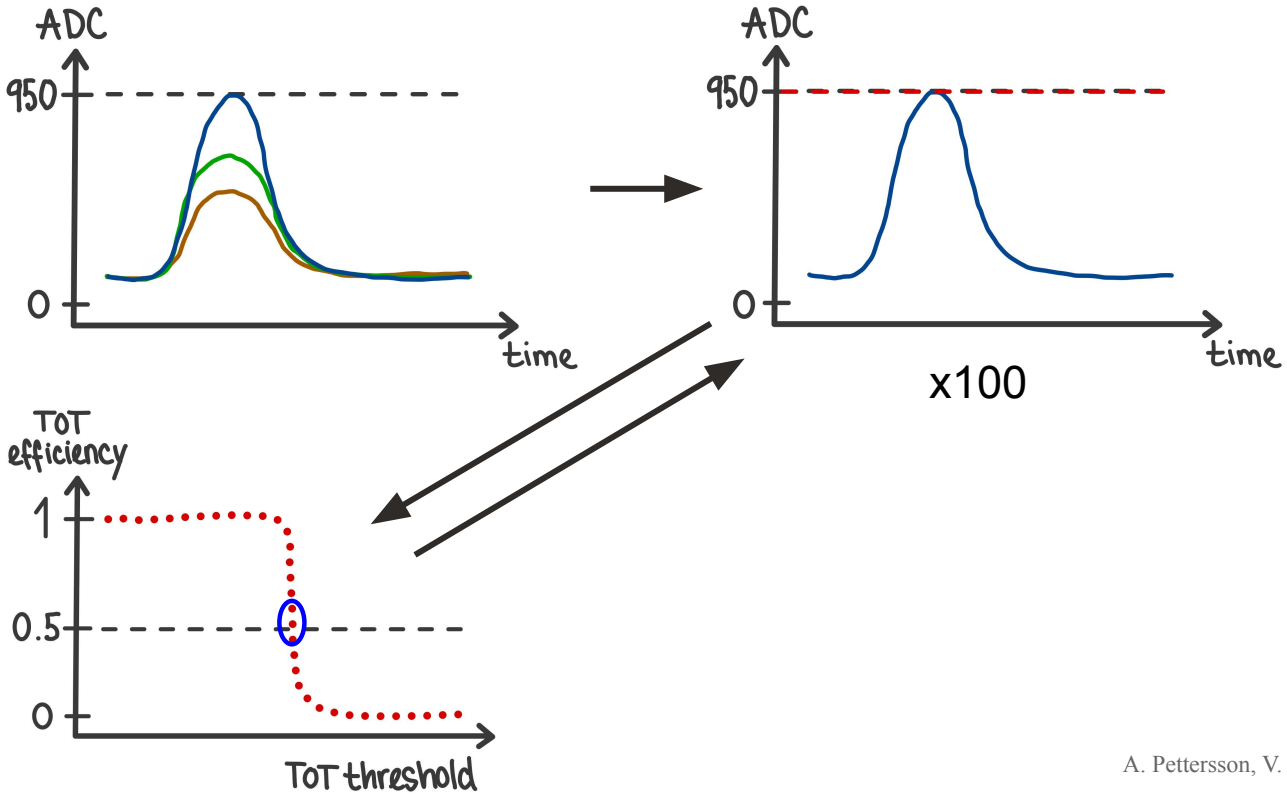
3. Calculate the TOT efficiency.

Calibration: How to set the TOT threshold



1. Find the correct `CALIB`
2. Scan TOT threshold parameter.
3. Calculate the TOT efficiency.
4. Iterate steps 2 & 3 until a TOT threshold with 50% efficiency is found.

Calibration: How to set the TOT threshold



1. Find the correct `CALIB`

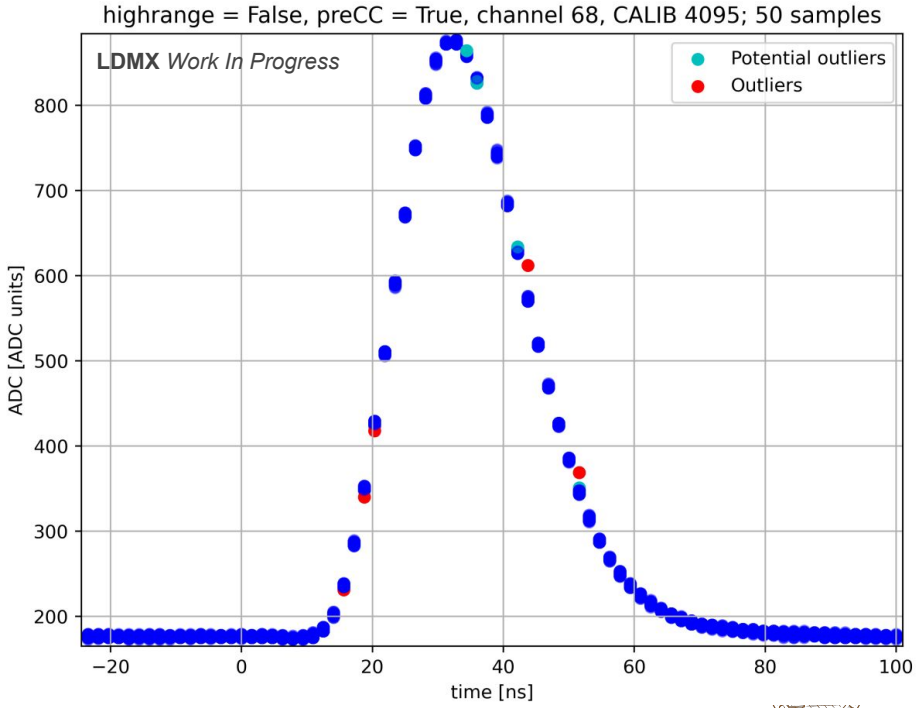
2. Scan TOT threshold parameter.

3. Calculate the TOT efficiency.

4. Iterate steps 2 & 3 until a TOT threshold with 50% efficiency is found.

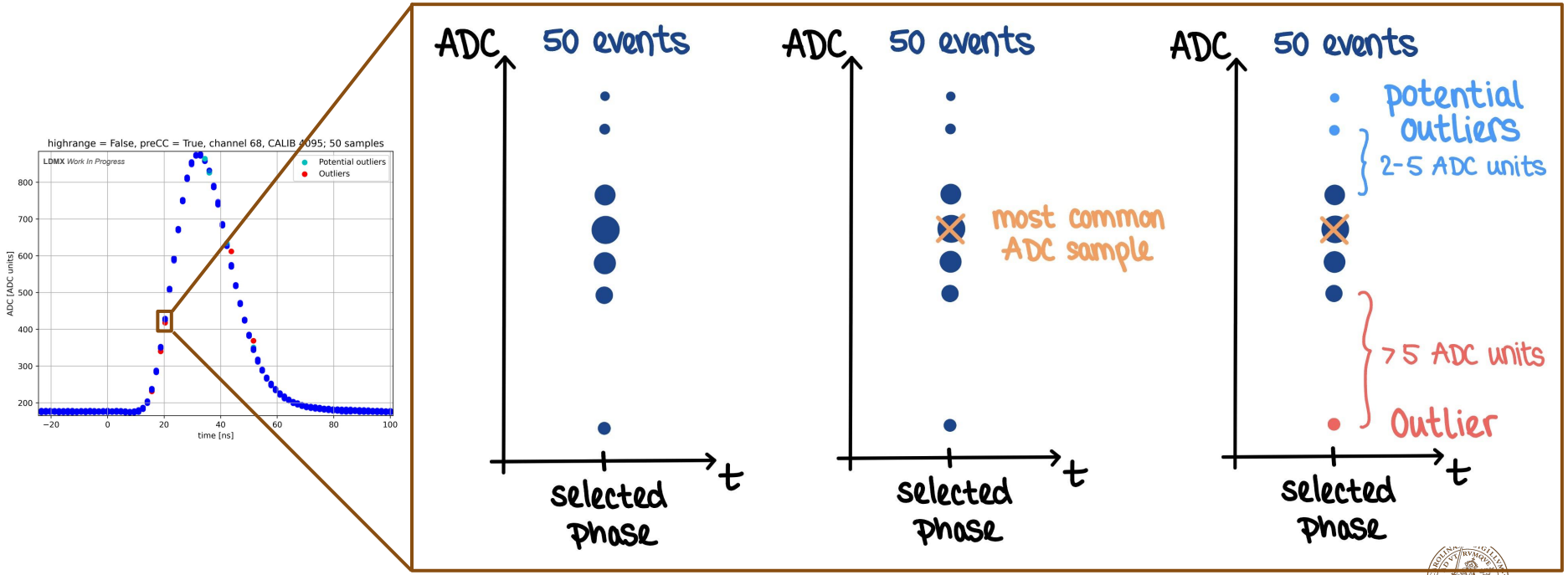
Sample-clustering Identification Algorithm

- Aforementioned and other metrics did not always spot e.g. “outliers”
- Outliers = Samples that lie outside expected pulse shape



B. Rozmarynowicz: *LDMX HCal read-out chip board characterization and diagnostics.* Master thesis, 2026.

Sample-clustering Identification Algorithm



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