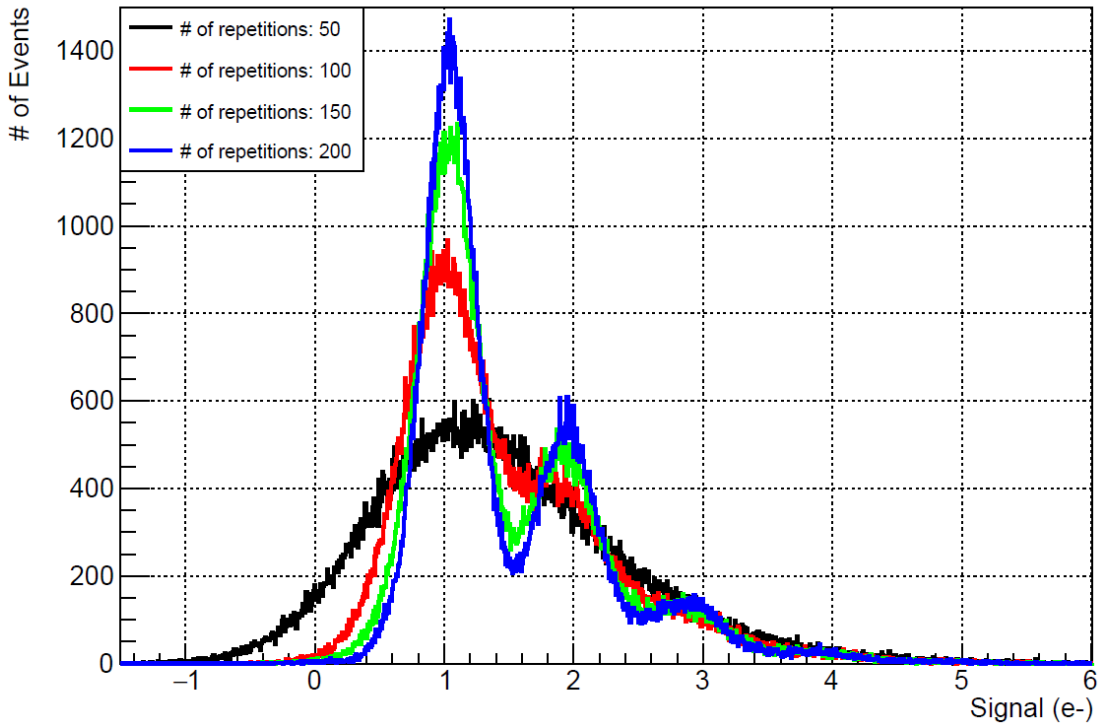


DANAE

Light dark matter searches with RNDR-DEPFET detectors

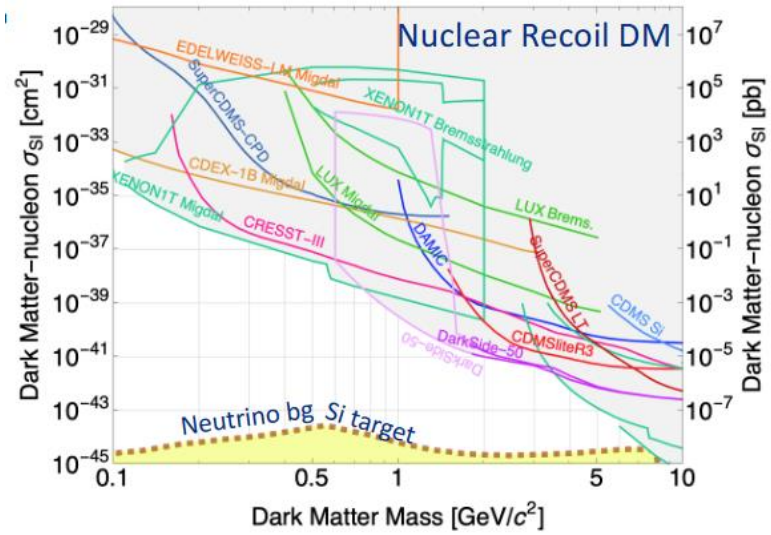
HEPHY/FHWN

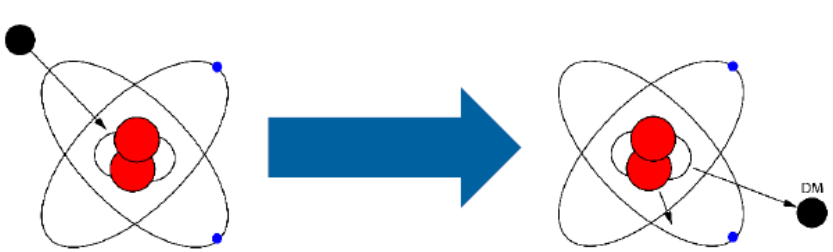
I. Introduction: Light dark matter

Classical approach

- Motivated by SUSY, Lee-Weinberg bound
- Particle mass: above 1 GeV/c^2
- Main event signature: nuclear recoils
- Experiments: large scale, no discoveries

[L. Hsu, ICHEP 2020]

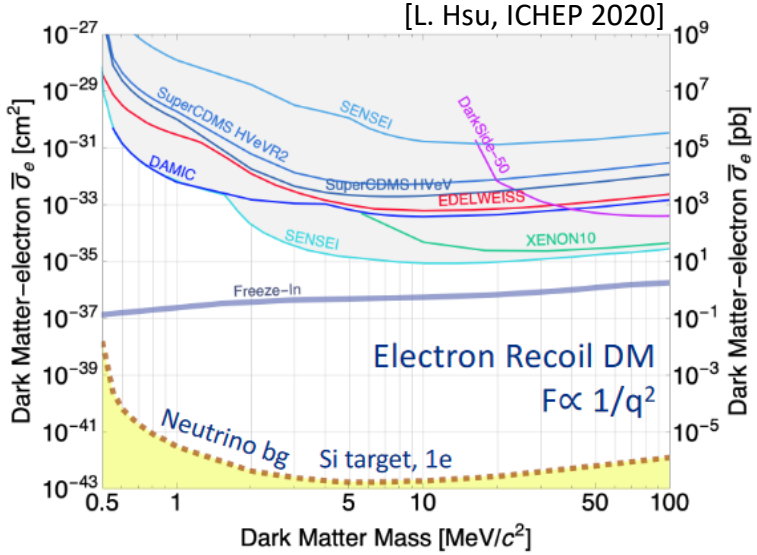


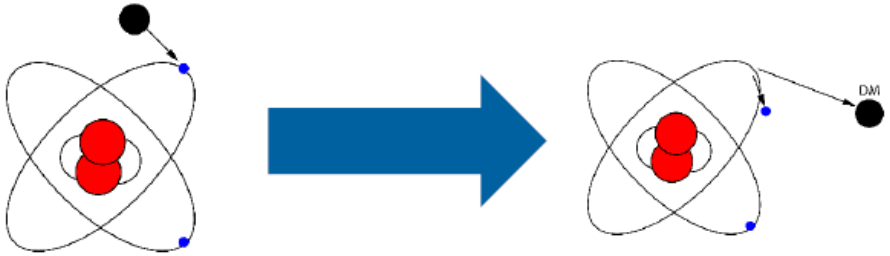


Light dark matter approach

- Motivated by dark sector, ELDER, SIMP
- Particle mass: above 100 keV/c^2
- Main event signature: electron recoils
- Moderate sensitive mass needed

[L. Hsu, ICHEP 2020]

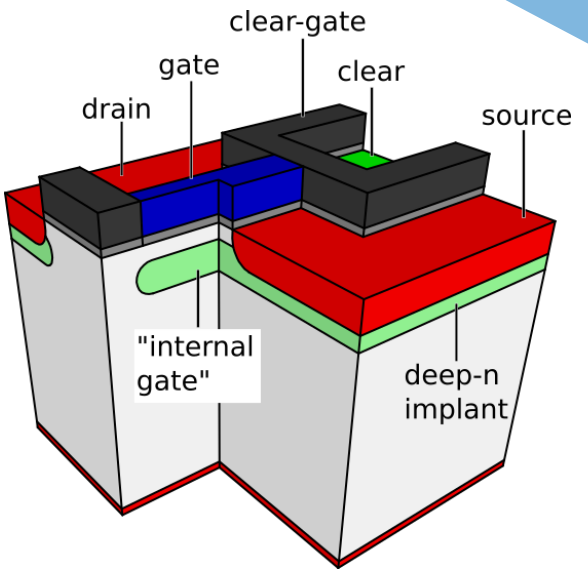




II. DANAE: RNDR-DEPFETs

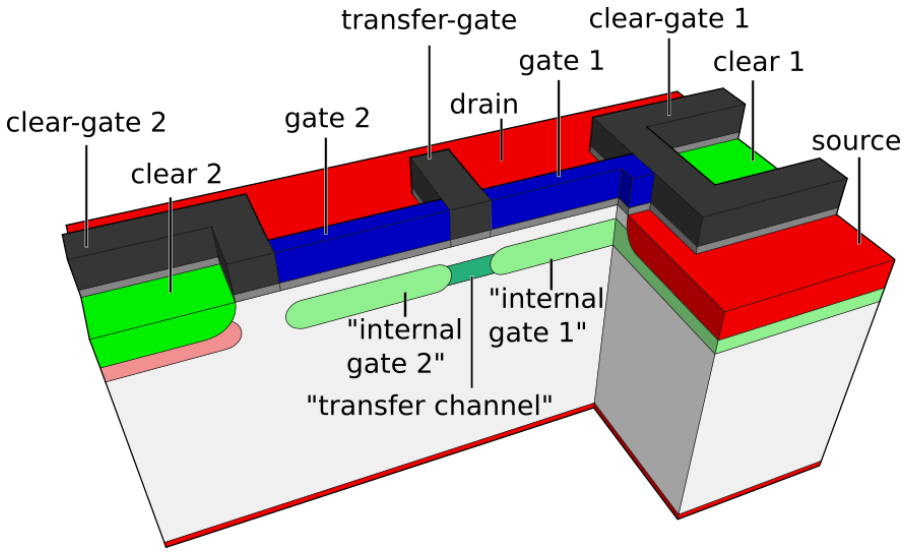
DEPFET detectors

- Technology established in astrophysics (Bepi-Columbo, ATHENA) and particle physics (Belle)
- DEPFET principle:
  - Side wards fully depleted bulk
  - e^- are collected in internal gate
  - conductivity of transistor channel is proportional to number of e^-
  - e^- are removed by the clear contact

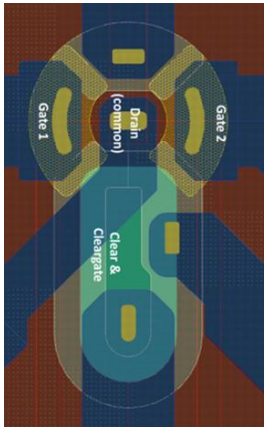


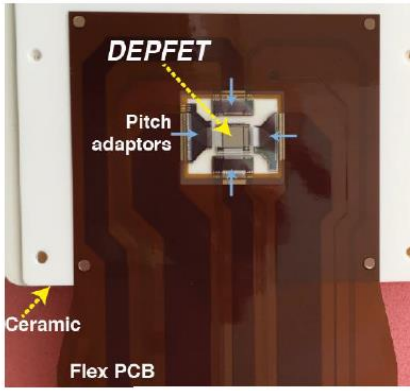
RNDR-DEPFET detectors

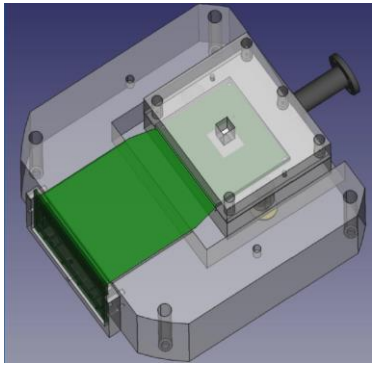
- Instead of removing the e^-, they are shifted to a second internal gate
- Repetitive independent (n) readout cycles of same signal
- Reduction of noise by $1/\sqrt{n}$

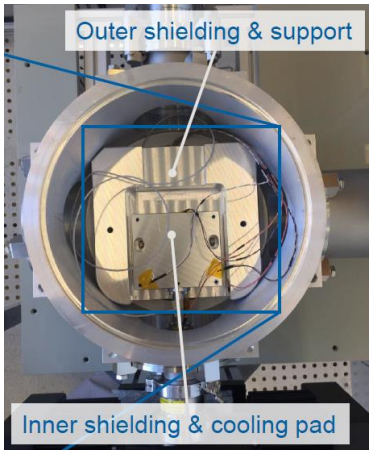


II. DANAE: RNDR-DEPFETs



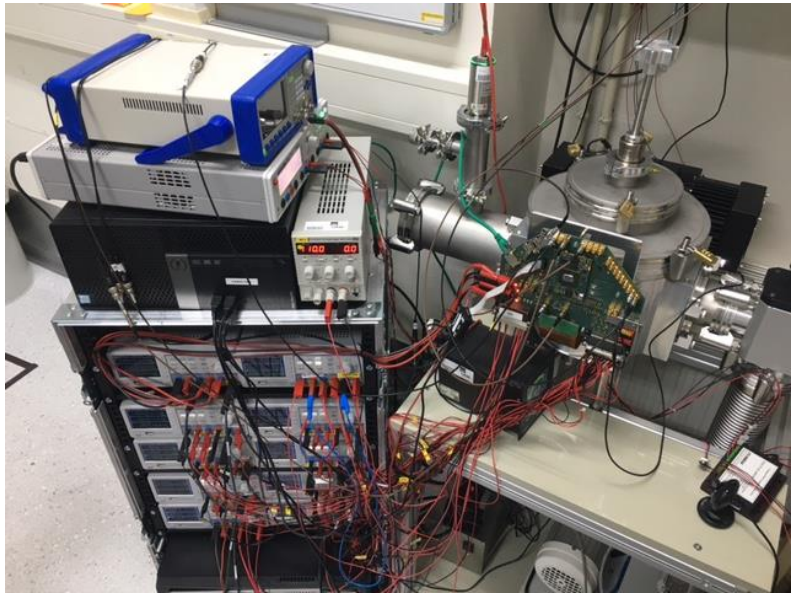






DANAE prototype Setup

- 64x64 RNDR-DEPFET pixels a 50x50 μm^2
- Sensor glued on carrier ceramic and wire bonded to flexible PCB
- Sensor mounted in inner and outer Al shielding block with separated front end electronic
- Inner block connected to Stirling cooler, placed in vacuum chamber



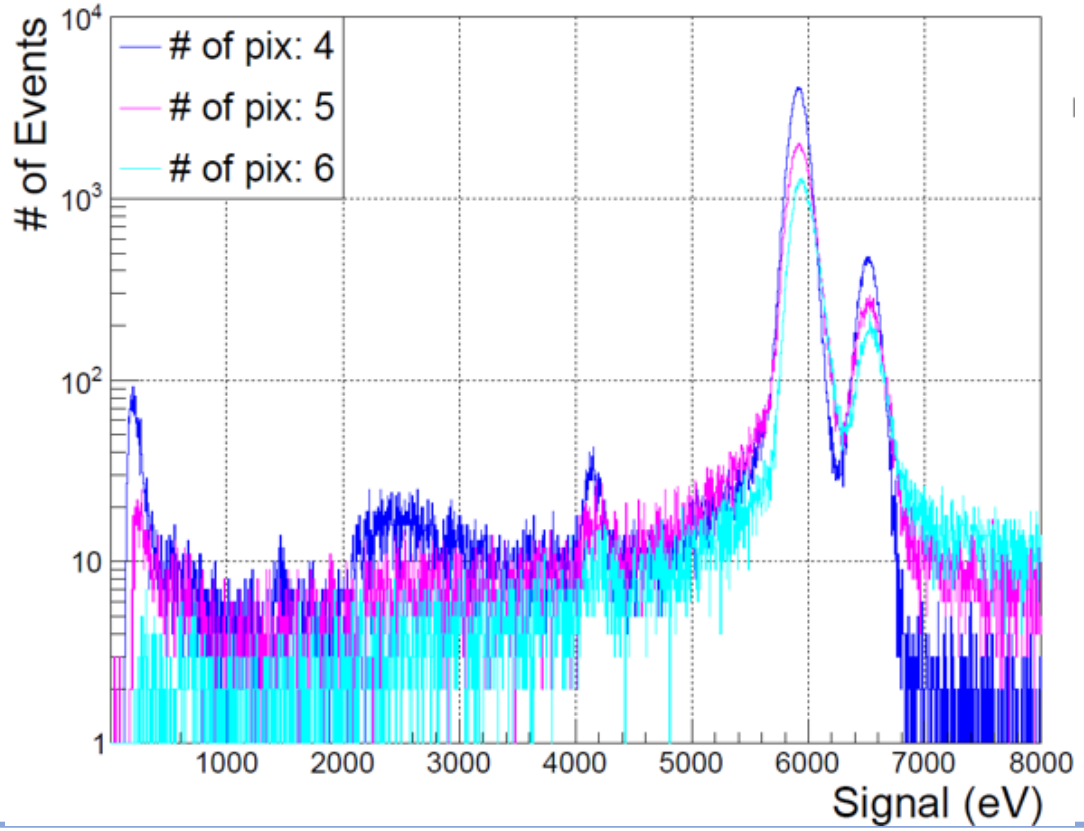
Updates:
Detector R&D

III. DANAE: Performance – ^{55}Fe

Detector performance and calibration

- ^{55}Fe spectrum recorded with
  - Calibration on 6 keV lines
  - Recombination of events
  - Relevant for background rejection of detectors

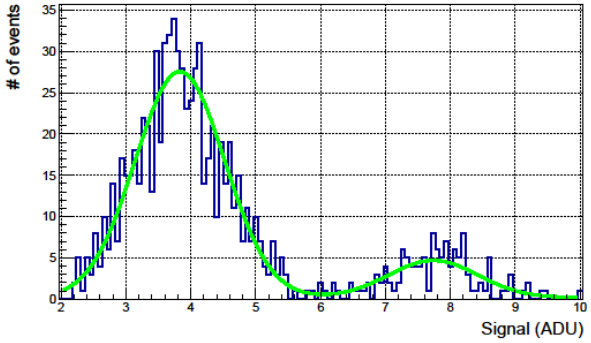
Published [doi.org/10.1117/12.2629248]

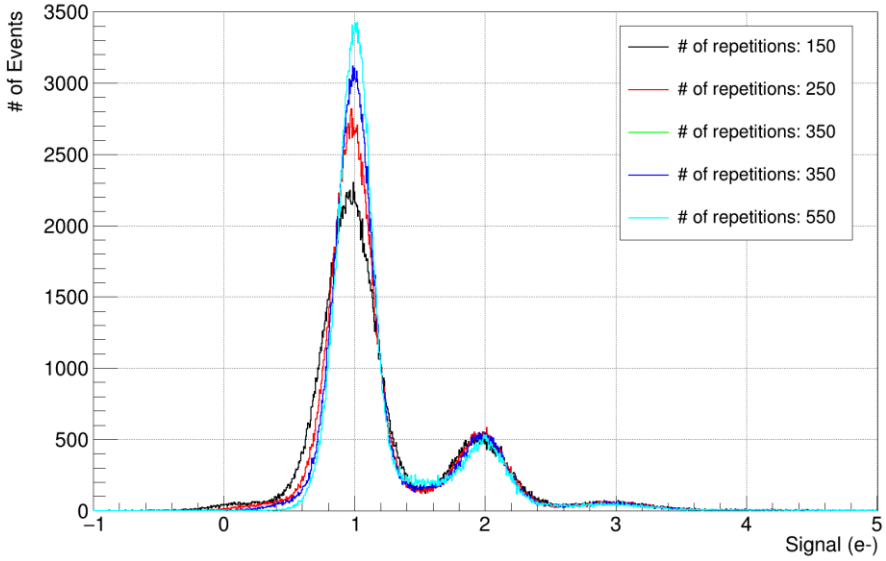


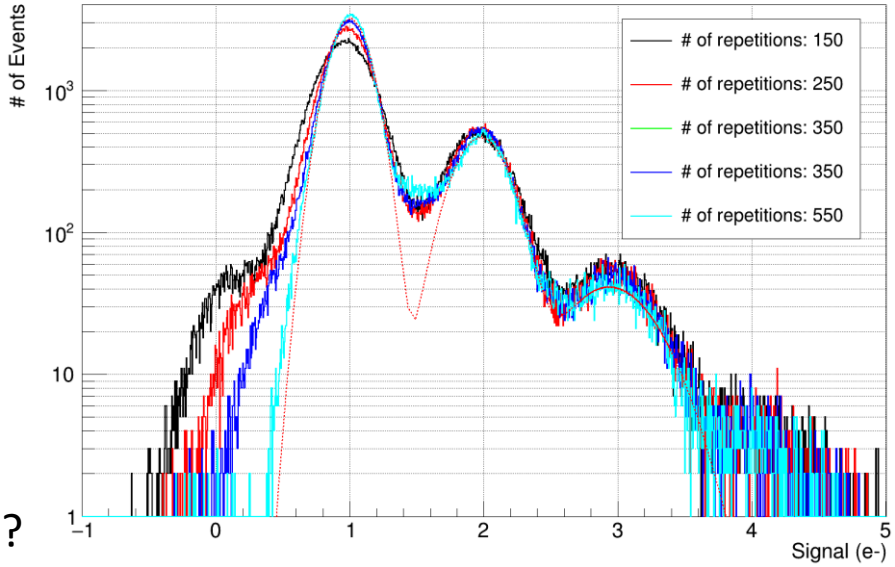
III. DANAE: Performance – LED

Calibrated spectra of LED

- Calibration with LED and pixel wise gaussian fit on single electron peaks
- Spectra for different number of averaged repetitions (up to 600)
- Signal peak: Noise or width of peak decreases as expected with increasing repetitions
- Valley: Due to charge loss and generation (“Misfit” during repetitions) valley worsens with increasing repetitions





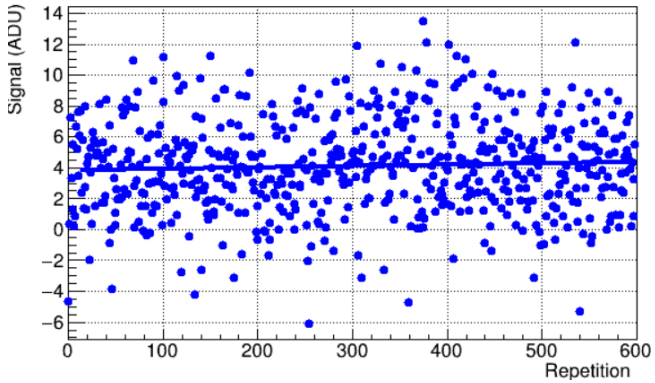


➔ How to find lost or generated electrons?

III. DANAE: Performance – LED

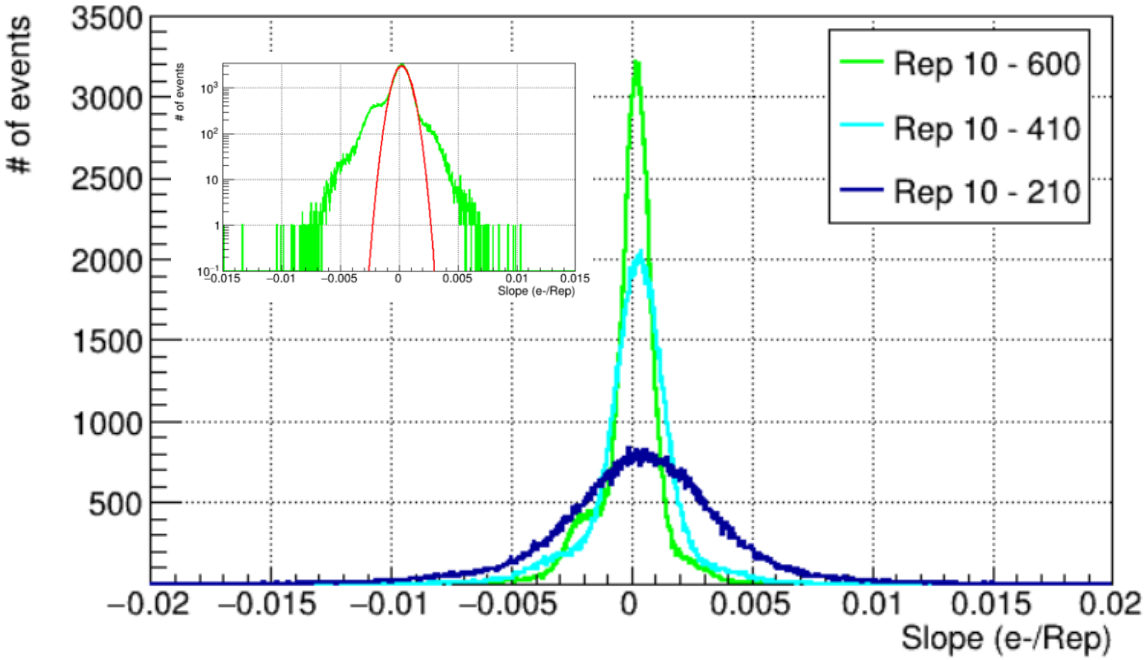
Inspection of single readings in events

- Perform linear fit on single readings versus the number of repetitions
- Assign a slope value to every event and put into histogram



What to learn from slopes?

- Sufficient large number of repetitions -> distribution with pos. and neg. shoulders evolves
- Deviation from gauss shape -> identify events
- First shoulder one electrons second two, etc.

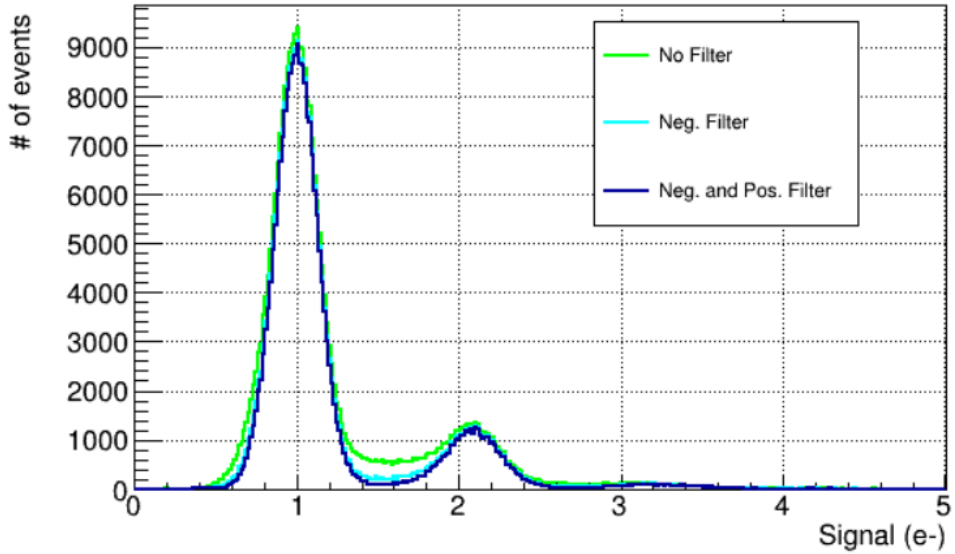


➔ Verify assumption and use this result at calibrated spectrum

III. DANAE: Performance – LED

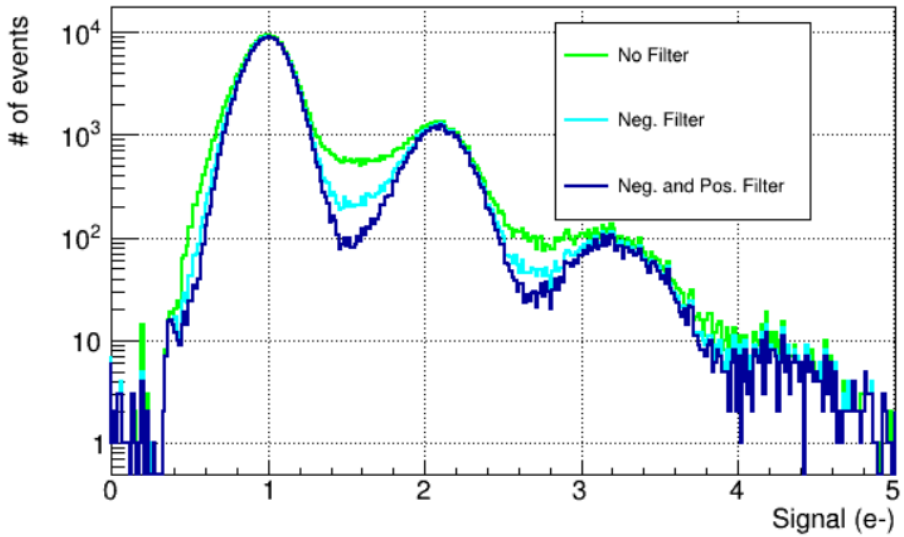
Corrected calibrated spectrum

- Gaussian fit on slopes after 600 repetitions
- Filter events with 2.5 sigma below (negative) or above (positive) mean of gaussian fit
- Discard events in calibrated spectrum
  - Peak height and width hardly affected
  - Valley significantly improved, peak approaches to gaussian shape



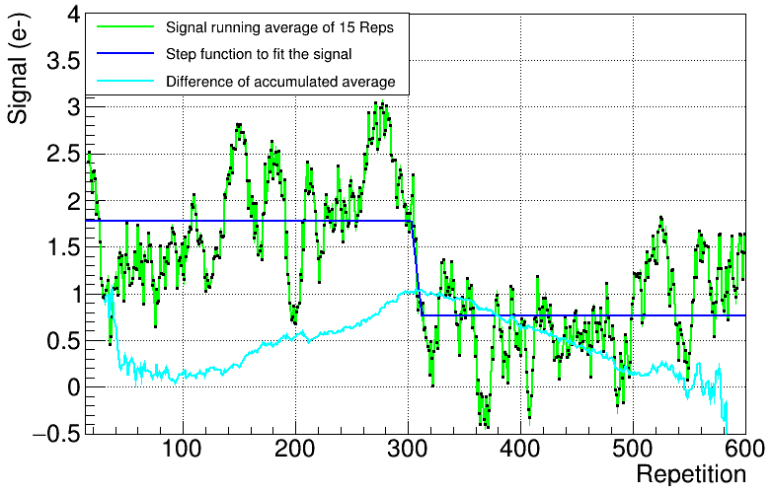
➔ How to handle discarded events?

Published [preprint: scipost_202211_00018v2]

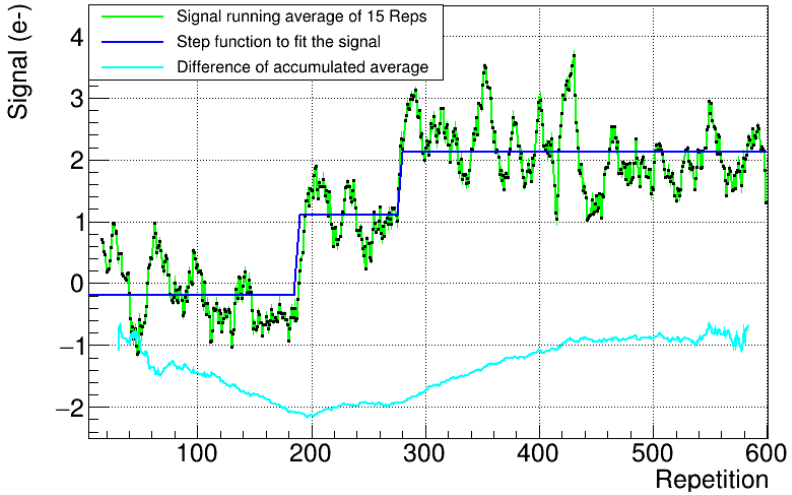


III. DANAE: Performance – LED

Discarded misfits or electron loss events



- Identify event with slope **below** 3 sigma (loss)
- Initial signal of 2 electrons reduced to 1 electron
- Automatized step function fit, single electron detected with time resolution (appr. 300 µs)



- Identify event slope **above** 5 sigma (generation)
- Initial signal of 0 electrons increased by 2
- Searched for two separated arriving electrons

- Updates:
  - Identify lost or generated electrons during the readout process
  - Dark current generation still needs to be understood with new samples and advanced analysis

- Funding: FWF till 07/2024

- Conferences:
  - 24th International Workshop on DEPFET Detectors and Applications (Munich, GER)
  - SPIE Astronomical Telescopes + Instrumentation 2022 (Montreal, CAN)
  - IDM Identification of Dark Matter 2022 (Vienna, AUT)
  - MPG Halbleiterlabor Project Review 2022 (Ringberg, GER)

- Members:
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  - H. Kluck (HEPHY), J. Schieck (HEPHY), J. Ninkovic (HLL), J. Treis (HLL)

Thank you for the attention