KORAY SIMSEK

# H2M TOT MEASUREMENTS

UNIVERSITÄT BONN

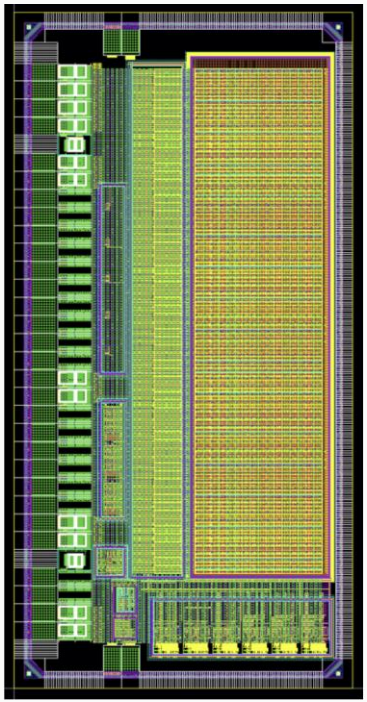
# TANGERINE

DESY.

- Towards Next Generation Silicon Detectors
- Design, Simulation and Testing of silicon detectors for future lepton collider experiments
- Present study focuses on monolithic sensors based on 65-nm CMOS imaging technology → low power consumption, small capacitance (large STN)

# GOALS

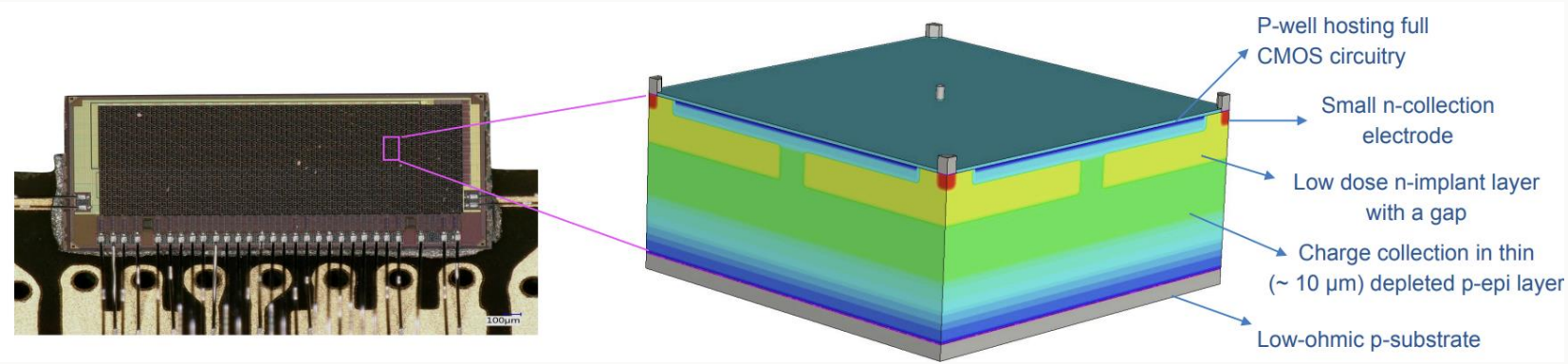
- H2M chip has different characteristics, that need to be determined
  - Feedback for designers & compare to simulations
- Threshold calibration with a source (DAC to $e^-$)



@I. Kremastiotis (CERN EP-ESE-ME), on behalf of the H2M design teams at CERN, DESY and IFAE - H2M reference manual - 03.04.23

# H2M (HYBRID TO MONOLITHIC) TESTCHIP

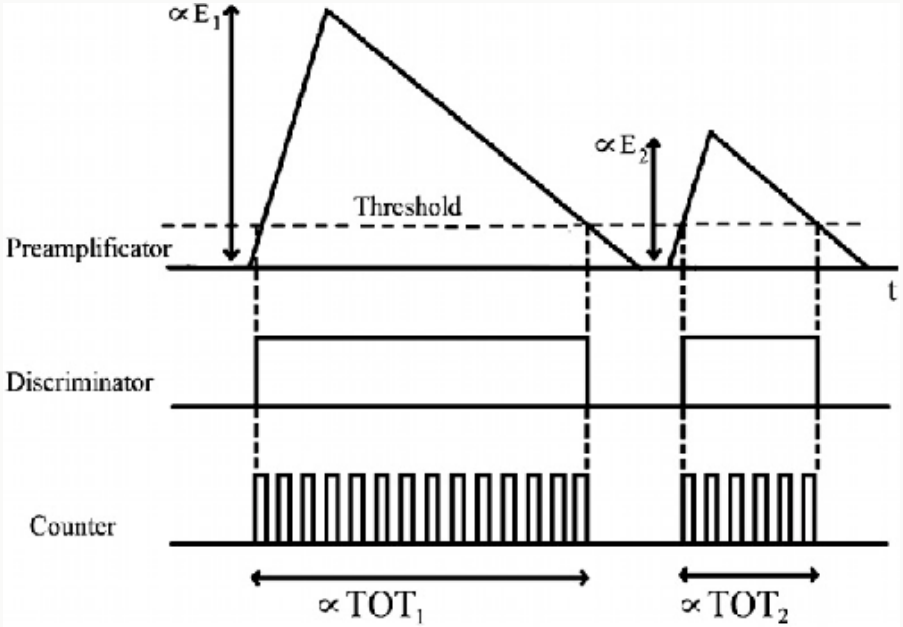
- Hybrid pixel detector architecture into a monolithic chip
- 64×16 pixel matrix with a 35µm pixel pitch
- 4 acquisition modes, in this studies ToT mode used




@Sara Ruiz Daza – The H2M Testchip – Vertex Detector Discussion Meeting (6-5-24)

# TOT METHOD

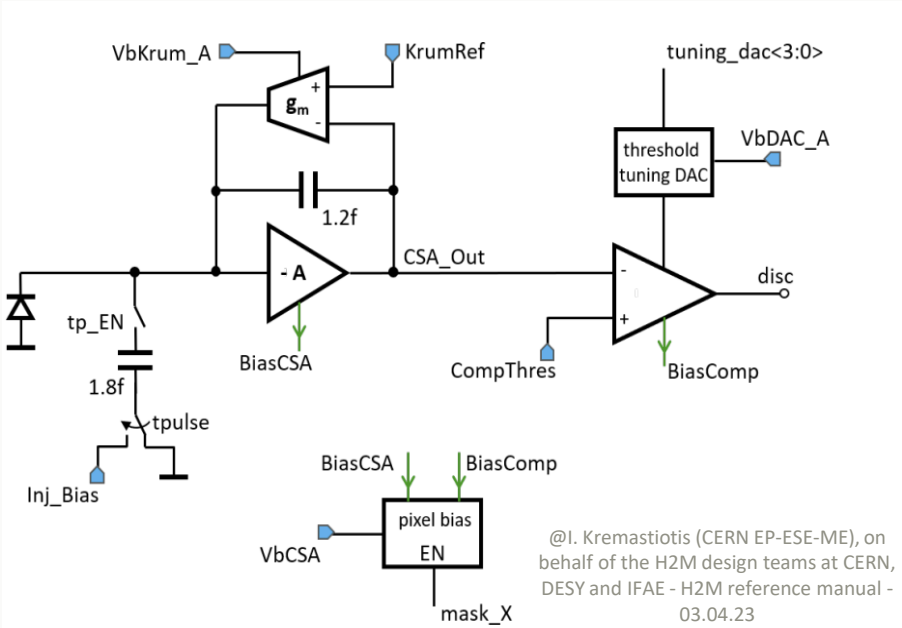
- Analog signal converted into digital pulse at discriminator
- ToT: time the signal is above the set threshold
- Higher Threshold ⟹ lower ToT
- H2M: 100MHz Clock ⟹ 1 ToT ≙ 10ns




@Esposito, Michela & Mettivier, G. & Russo, P. (2011). 14 C autoradiography with an energy-sensitive silicon pixel detector. Physics in medicine and biology. 56. 1947-65. 10.1088/0031-9155/56/7/003.

# KRUMMENACHER CURRENT

- Krummenacher feedback in the CSA in the AFE
- Power consumption
- Configure CSA output slope gradient
- Pile up reduction

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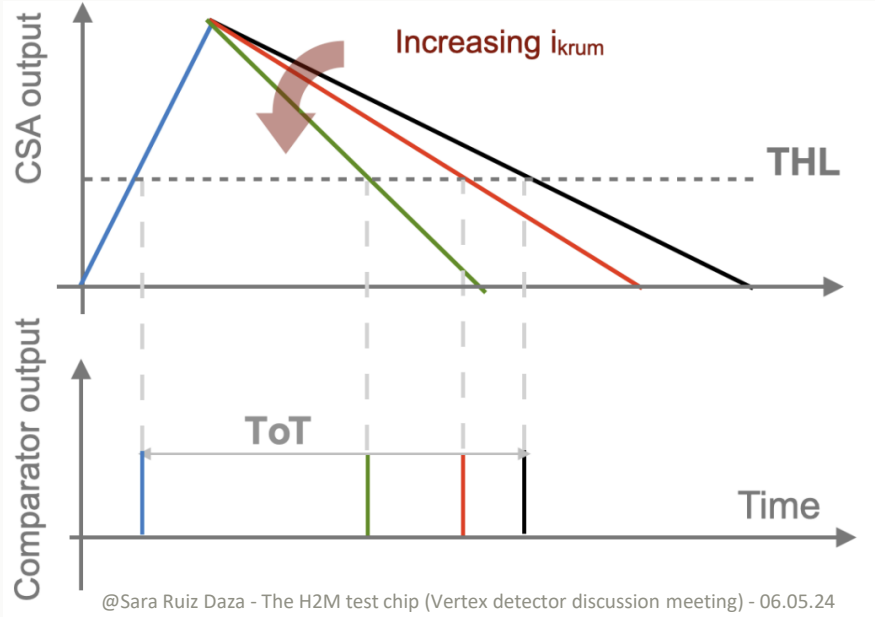


@Sara Ruiz Daza - The H2M test chip (Vertex detector discussion meeting) - 06.05.24

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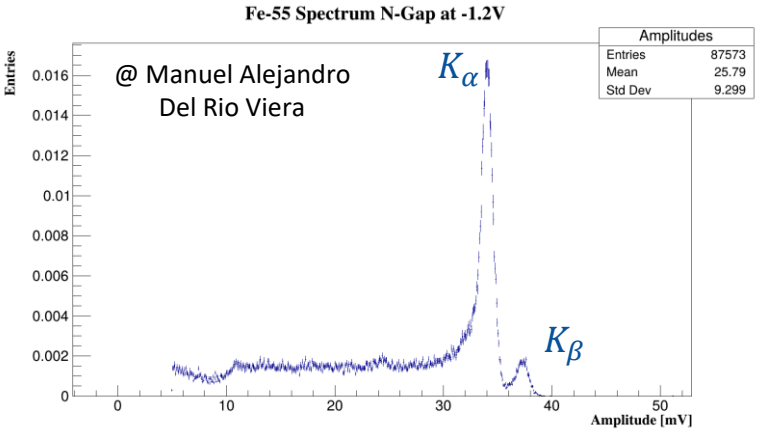
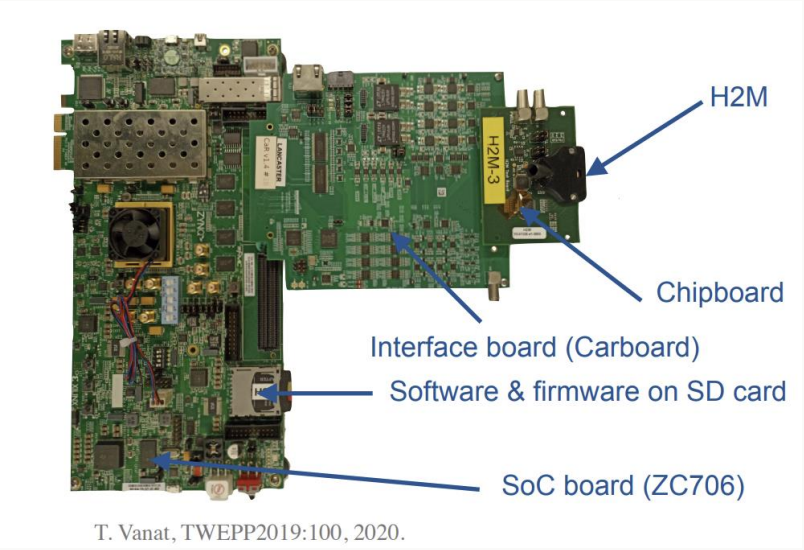
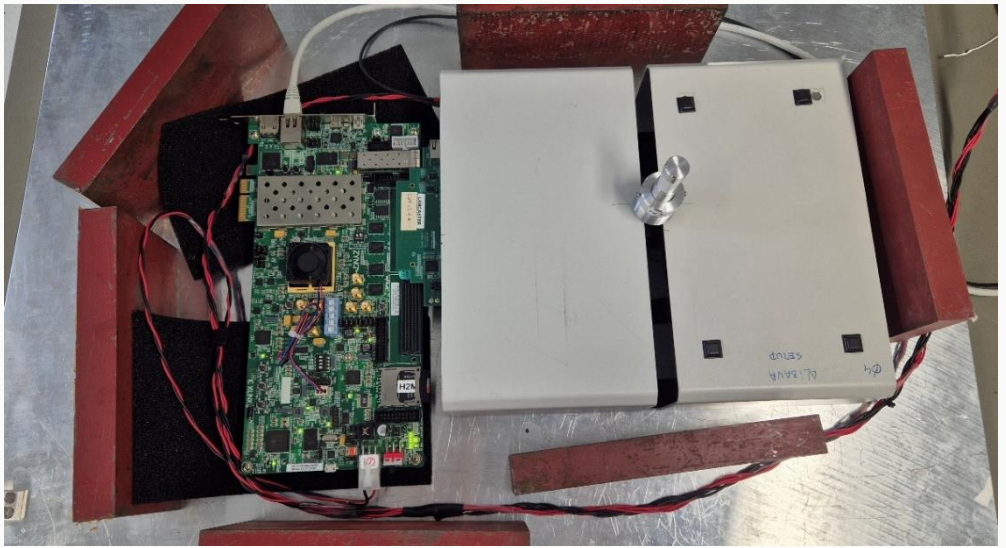
# SETUP

1. Set Threshold near to baseline to get ToT values from noise
2. Fe55 source approx. 2h $\pm$ 15 min measurement time



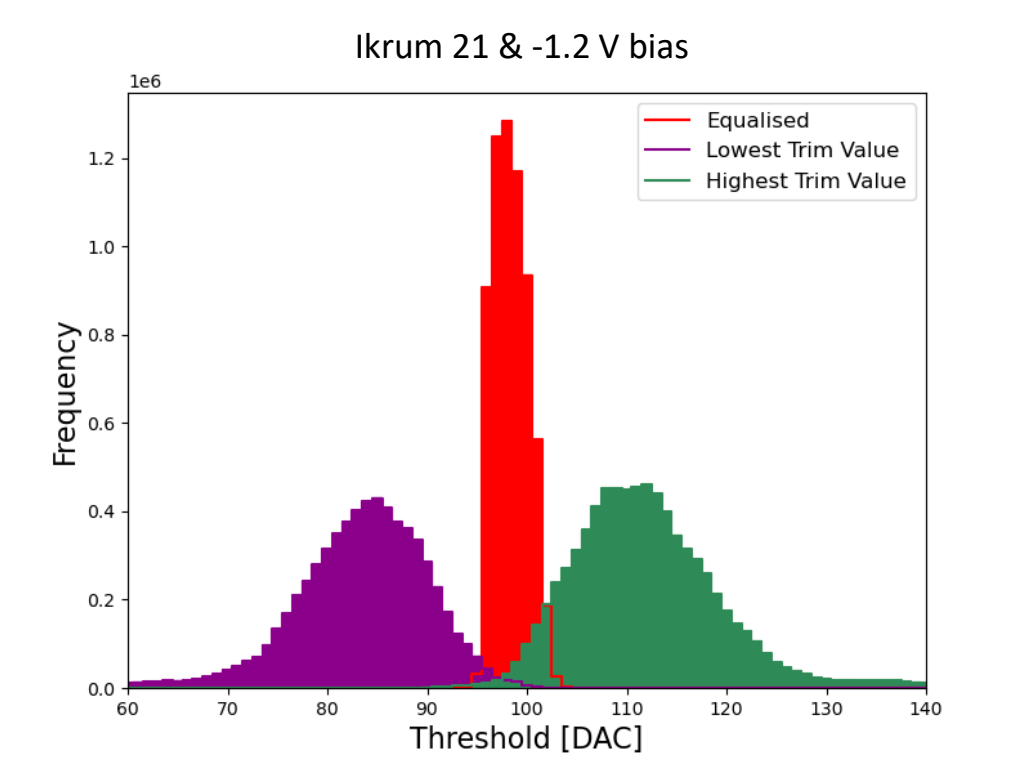



T. Vanat, TWEPP2019:100, 2020.

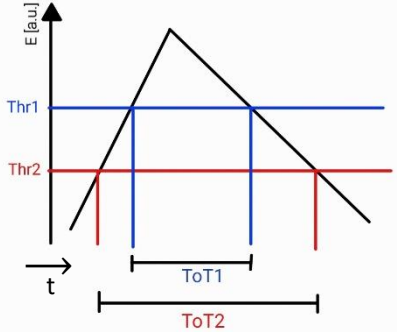


# TRIMMING

- Pixel threshold tuning needed for different bias voltages and Krummenacher currents
- Correct pixel-to-pixel differences in baseline level to get a narrow threshold dispersion
- 4-bit in pixel trimming DAC for threshold mismatch compensation

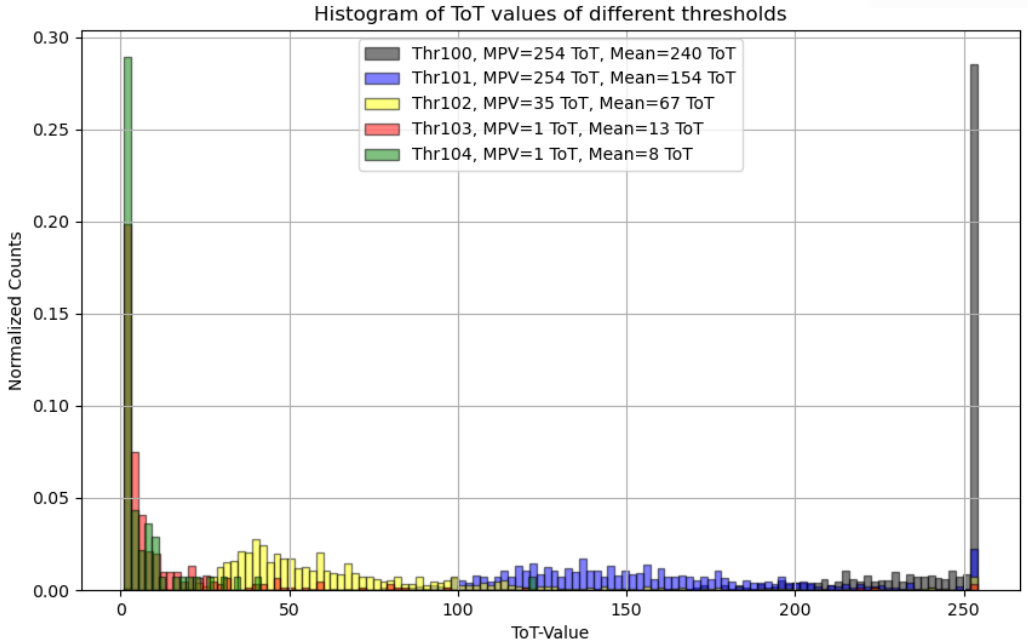


# TOT MEASUREMENT WITH NOISE



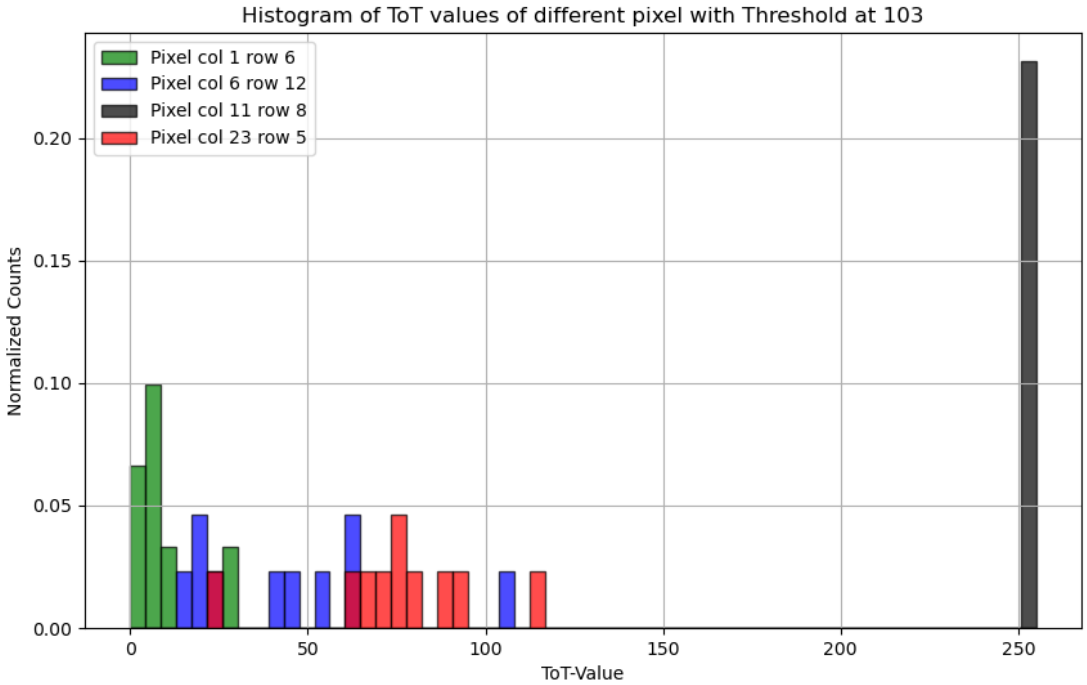

- 8-bit global threshold DAC
- Smaller threshold

  ⟹higher ToT
- Baseline at 99 DAC
- Out of noise at 110 DAC
  - concluded from 30 min long measurement



# SEPARATE PIXEL TOT WITH NOISE

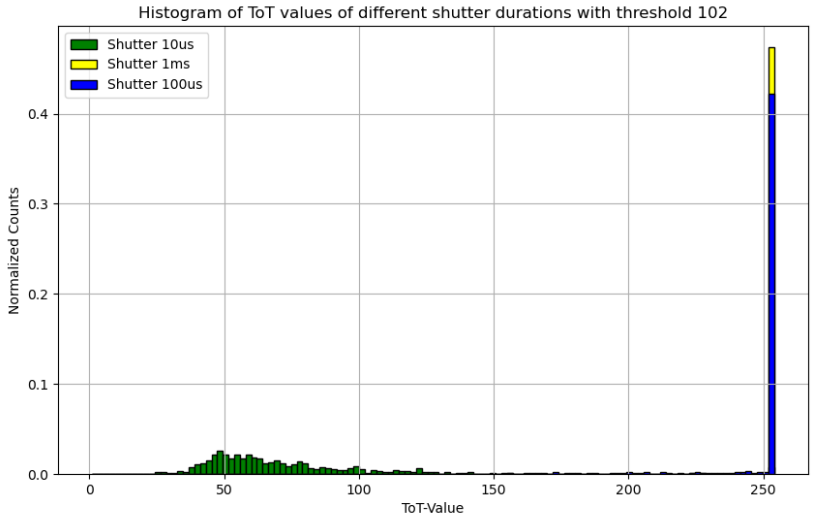
- ToT difference between pixels with same threshold
- Need ToT calibration for every pixel

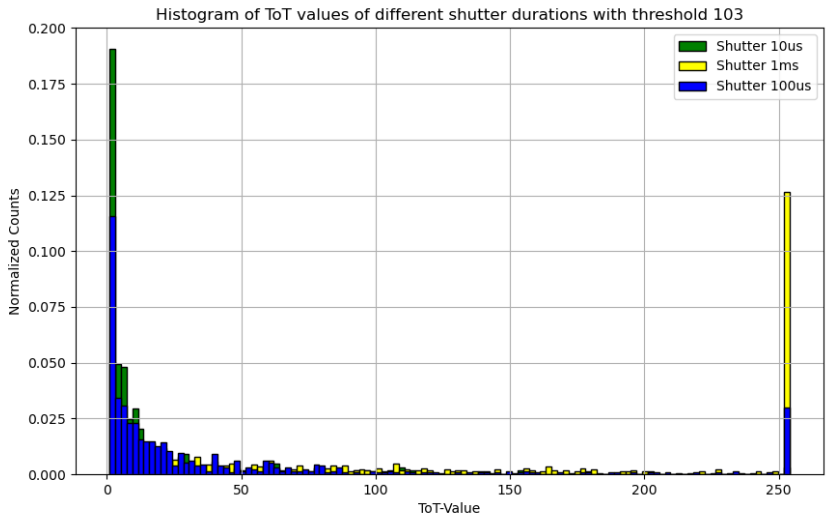


# SHUTTER DURATION

@ Sara Ruiz Daza & Naomi Davis

- Select reasonable shutter duration for source measurement (1ms)
- Longer shutter gets higher ToT values ⇒ noise and other signals sums up

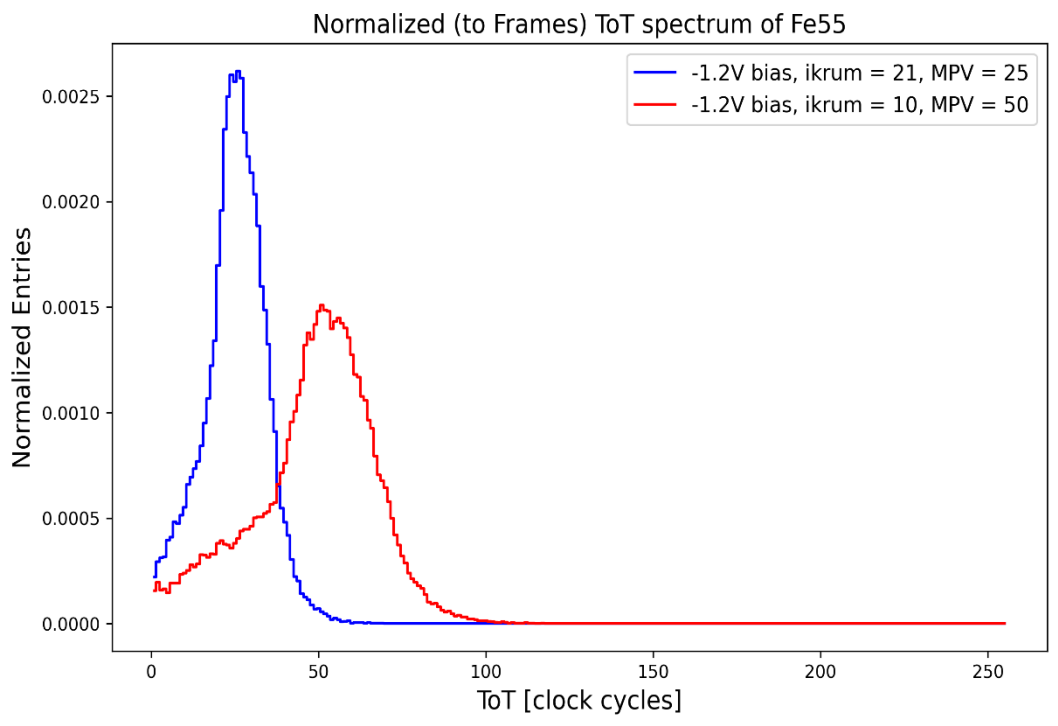


# DIFFERENT KRUMMENACHER FEEDBACK

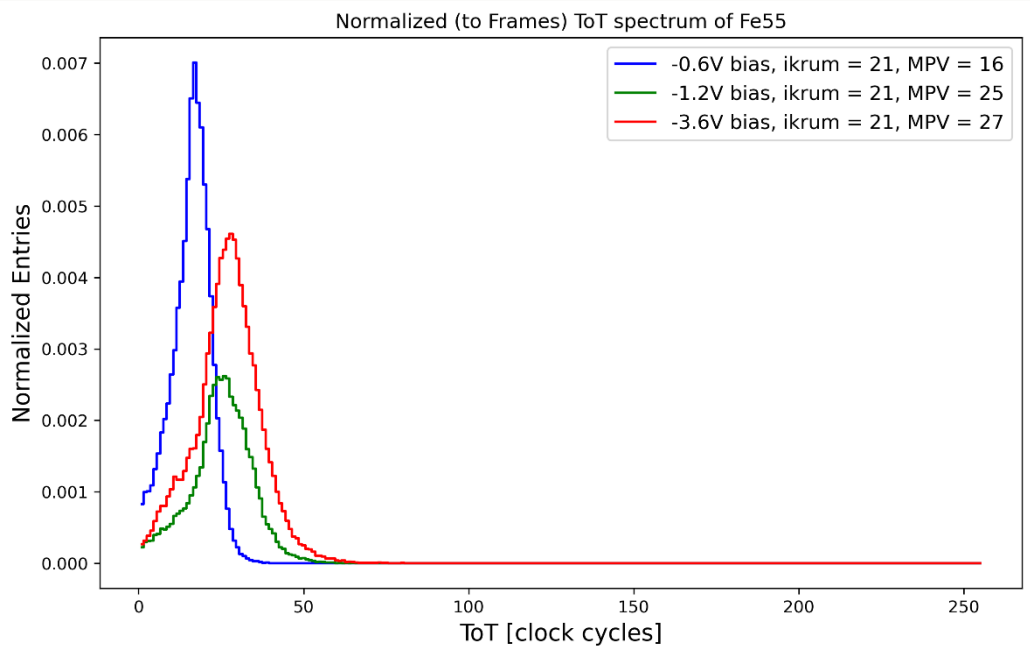
@ Sara Ruiz Daza & Naomi Davis

- Expect $K_\alpha$ peak at 140 DAC
- Set threshold to 120 DAC to be out of noise
- Higher ikrum → lower ToT
- $Q = \frac{E_{K\alpha}}{3.65\ eV/e} \approx 1600\ e^-$
  - With $E_{K_\alpha}$ = 5.89 keV for Fe55
- $K_\beta$ peak not visible due pixel-to-pixel variations



# DIFFERENT BIAS

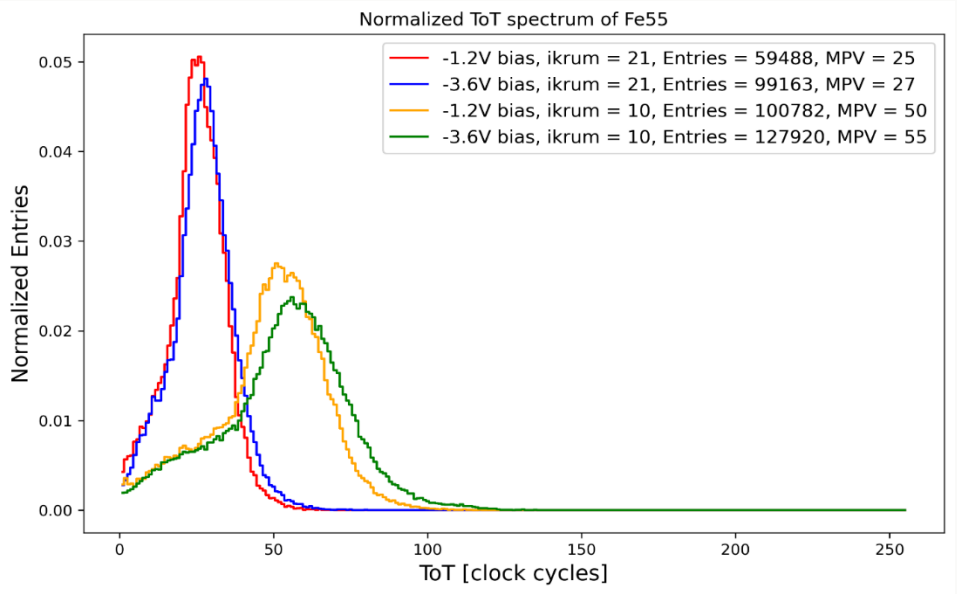
- Higher bias → higher ToT
- Increase depletion for faster charge collection (ballistic deficit)
- Capacitance between electrode and depletion zone changes
- H2M nearly fully depleted with -1.2V bias
  - Small difference of peak ToT value between -1.2V and -3.6V bias

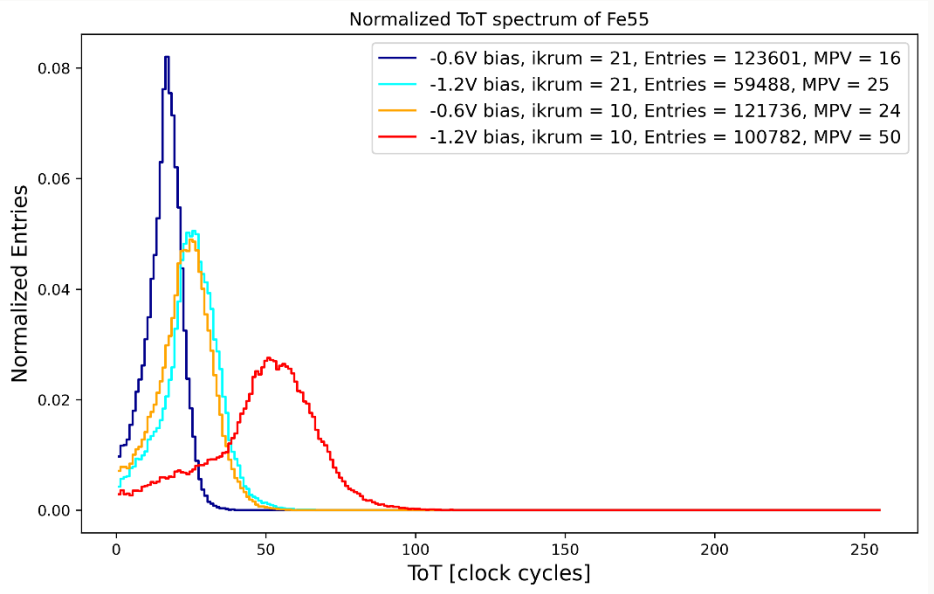



@ Sara Ruiz Daza & Naomi Davis

# COMPARISON OF ALL MEASUREMENTS

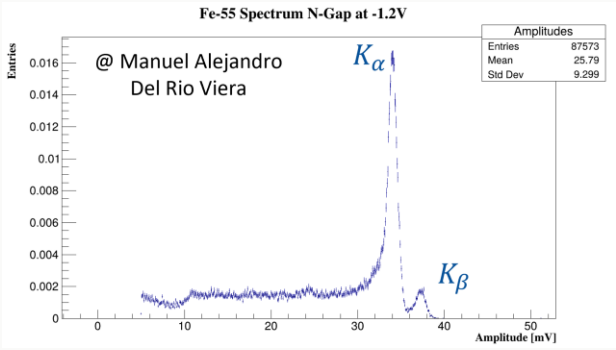
- Normalized to number of entries



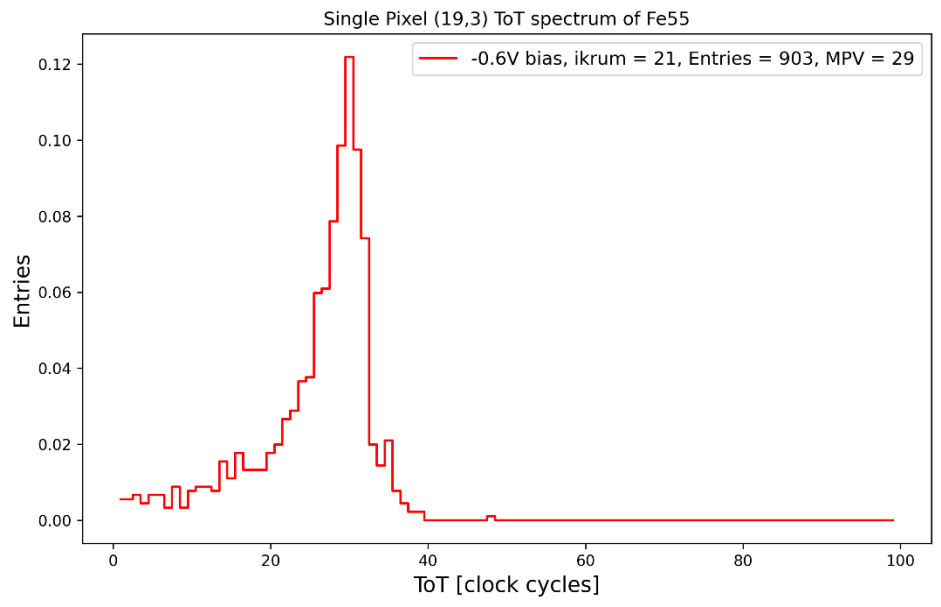



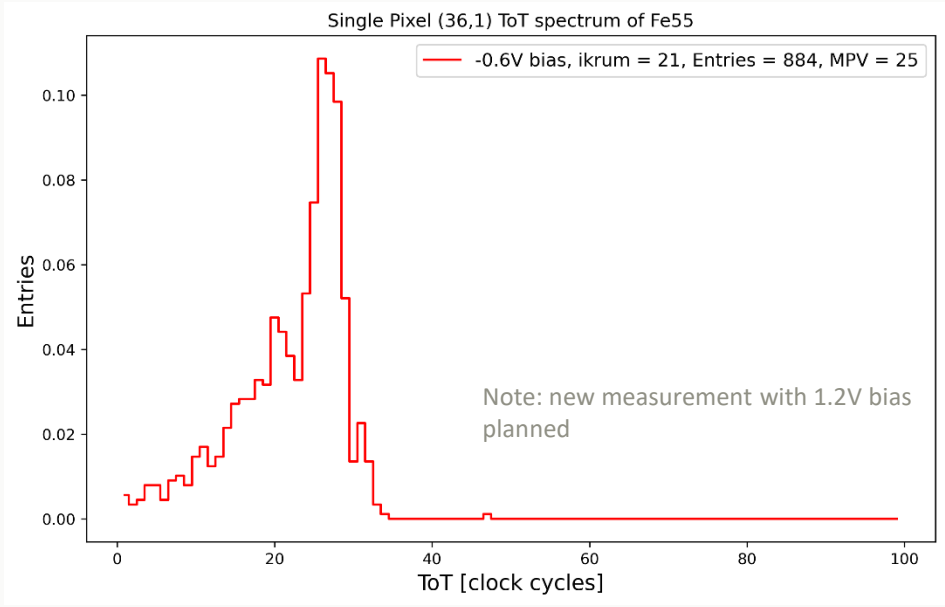

@ Sara Ruiz Daza & Naomi Davis

# SINGLE PIXEL SOURCE TOT PLOTS




- Overnight measurement with Fe55, ~10 hours
- Need ToT calibration to know where to expect $K_\beta$ - peak



# SUMMARY AND OUTLOOK

- Baseline of H2M at 99 DAC, out of Threshold at ~110 DAC
- Higher ikrum results in lower ToT and higher bias in higher ToT
- Pixel-to-Pixel ToT variations

## Outlook

- Source Threshold measurement for charge calibration
- Injection pulse ToT measurements for In-pixel ToT calibration