

A large, detailed wireframe model of a particle detector, likely a heavy-ion detector. It shows a complex, multi-layered structure with a large, roughly circular central region and several smaller, curved sections extending outwards. The model is rendered in a light gray color, highlighting the intricate geometry of the detector components.

Characterisation of the HitDetection Analogue Front End

Holger Flemming

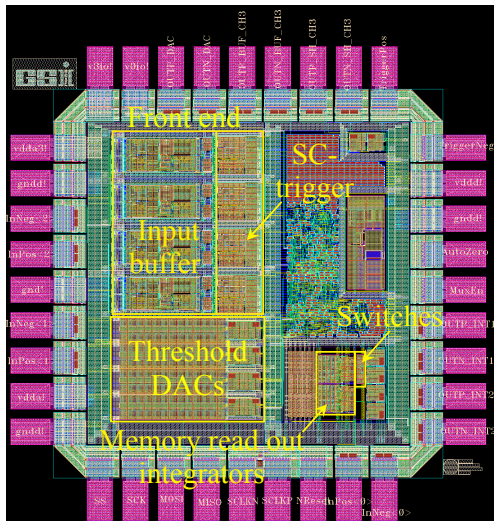
GSI Helmholtzzentrum für Schwerionenforschung GmbH
Experiment Electronics Department

28.10.2020

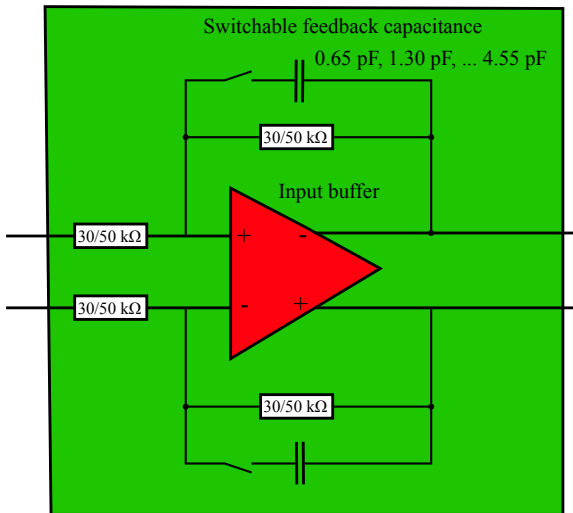
Outline

- 1 Input Buffer
 - Frequency Response
 - Input Buffer Noise
 - Dynamic Range
- 2 Trigger Unit
 - Leading Edge Discriminator Mode
 - Differential / Switched Capacitor Mode
- 3 Summary and Outlook

Test Chip

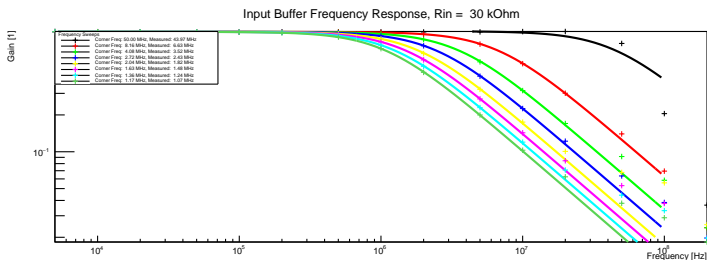
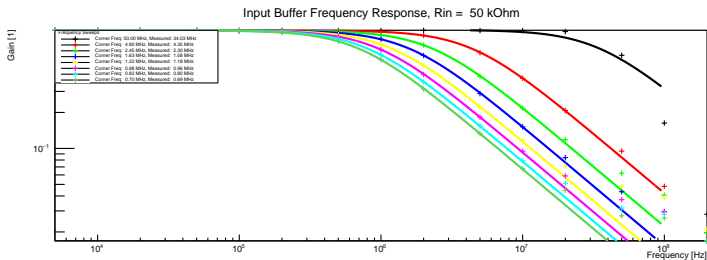


Input Buffer



Input Buffer

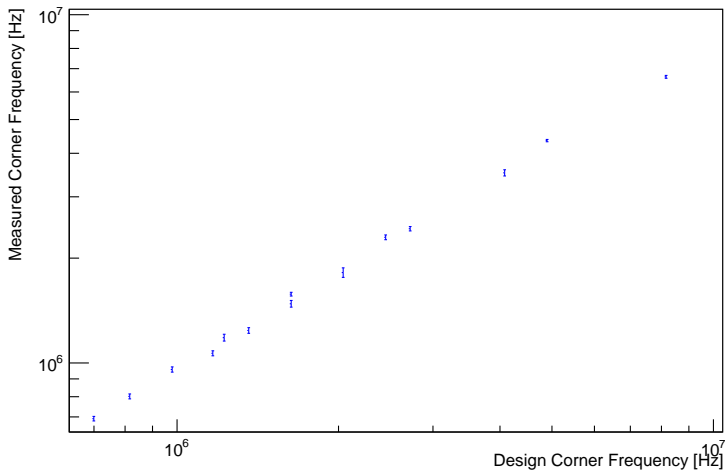
Frequency Response



Input Buffer

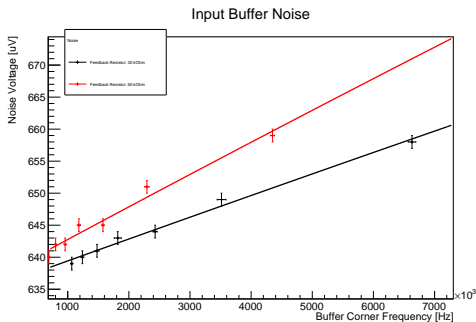
Frequency Response

Corner Frequencies vs. Design Values



Input Buffer

Input Buffer Noise



Fit function: $\bar{U}_n = \sqrt{\bar{U}_P^2 + b \cdot \rho_n^2}$

50 kΩ:

$$\bar{U}_P = 637.6(7) \mu\text{V}$$

$$\rho_n = 81.14(257) \text{ nV}/\sqrt{\text{Hz}}$$

30 kΩ:

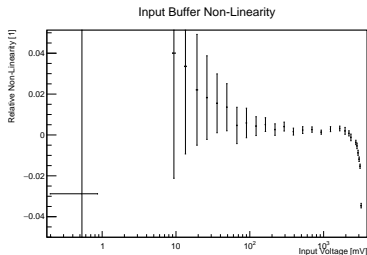
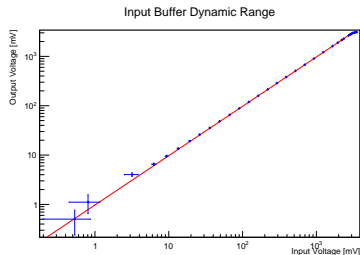
$$\bar{U}_P = 636.0(7) \mu\text{V}$$

$$\rho_n = 66.25(209) \text{ nV}/\sqrt{\text{Hz}}$$

Terminated probe:
621 µV

Input Buffer

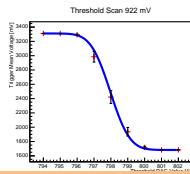
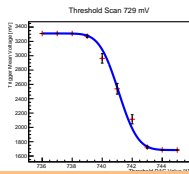
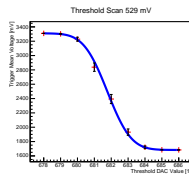
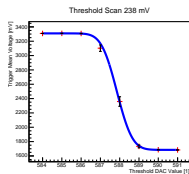
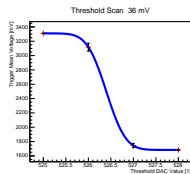
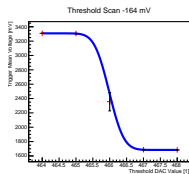
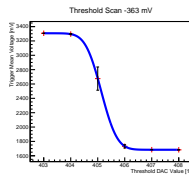
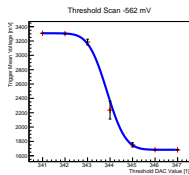
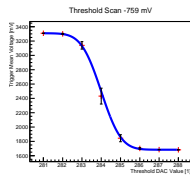
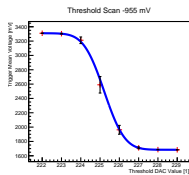
Dynamic Range



- Measured with 50 kHz sine signal
- Dynamic range $> \pm 1$ V
- Linearity < 1 % in the range from 0.1 V to 1 V

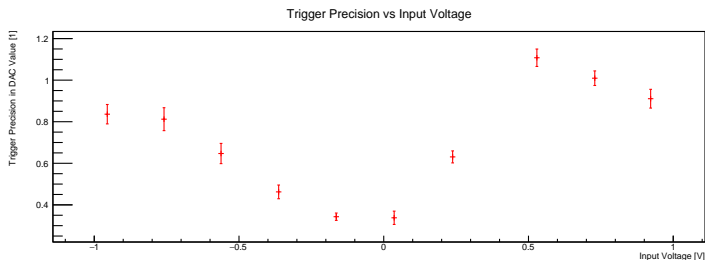
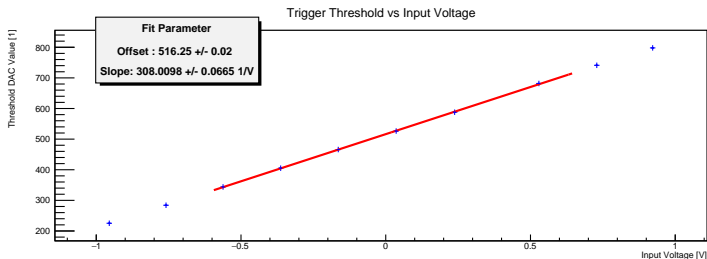
Trigger Unit

Leading Edge Discriminator Mode



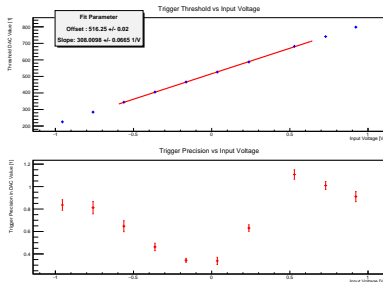
Trigger Unit

Leading Edge Discriminator Mode



Trigger Unit

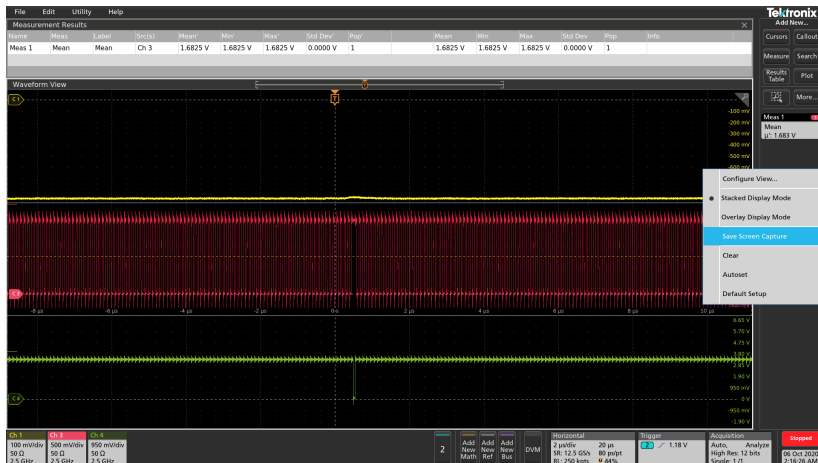
Leading Edge Discriminator Mode



- DAC-Slope:
3.2466(7) mV
- $M = 200$, High Gain
Mode ($\times 16$)
 $\alpha = 0.158 \text{ MeV mV}^{-1}$
- 1 DAC-Step $\hat{=} 0.51 \text{ MeV}$

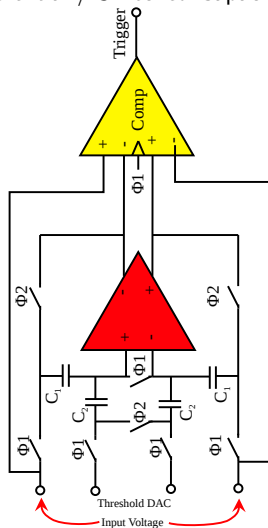
Trigger Unit

Leading Edge Discriminator Mode



Trigger Unit

Differential / Switched Capacitor Mode



- Φ_1
 - Storing input voltage in C_1
 - Storing threshold voltage in C_2
- Φ_2
 - Switching C_1 into feedback
 - Transferring charge from C_2 to C_1
 - Output voltage:

$$U_{in} - C_2/C_1 U_{thres}$$
 - Used as comparator threshold
- Leading edge of Φ_1
 - Taking comparator decision

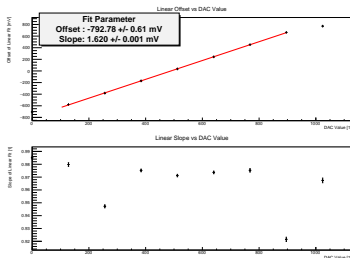
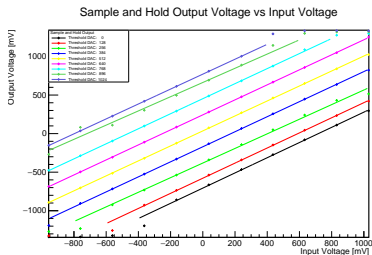
$$U_{in}(t) > U_{in}(t - \Delta t) - \frac{C_2}{C_1} U_{Thres}$$

$$\Rightarrow \frac{\Delta U_{in}}{\Delta t} < \frac{C_2}{C_1} U_{Thres}$$

Trigger Unit

Differential / Switched Capacitor Mode

Test of Sample and Hold Stage



- DAC dependency in comparison to DAC slope:

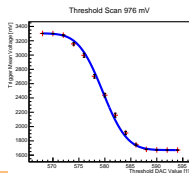
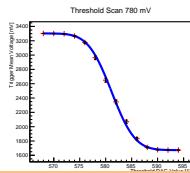
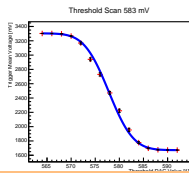
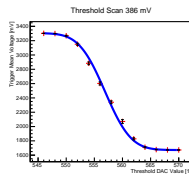
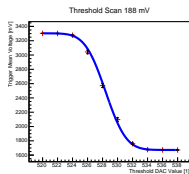
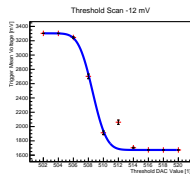
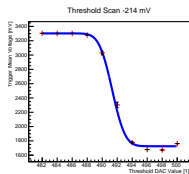
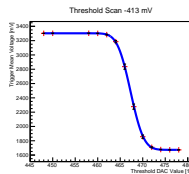
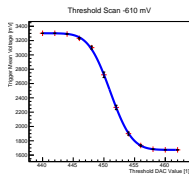
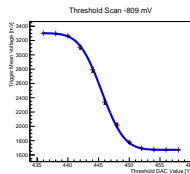
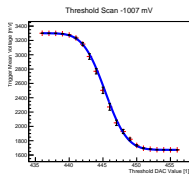
$$3.2466(7) \text{ mV} / 1.620(1) \text{ mV} = 2.004(1)$$

Design Value: 2

- Sample and hold gain < 1

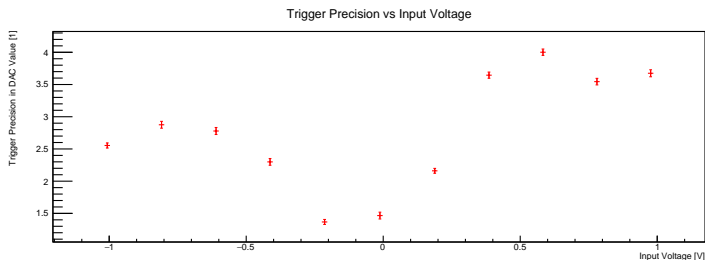
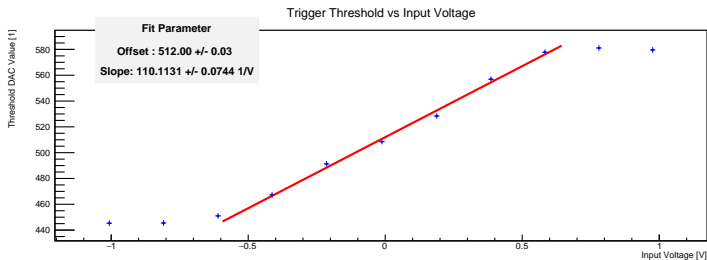
Trigger Unit

Differential / Switched Capacitor Mode



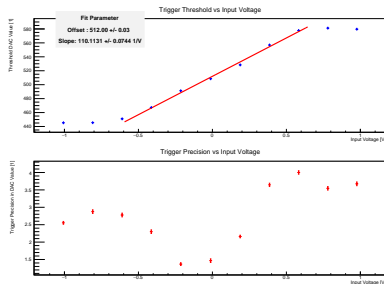
Trigger Unit

Differential / Switched Capacitor Mode



Trigger Unit

Differential / Switched Capacitor Mode

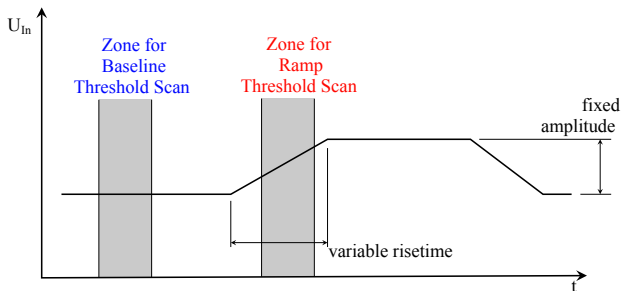


- Suppression of proportional Trigger contribution ≈ 6
 - S&H-Gain < 1
 - DC dependent comparator offset
- Trigger Noise:
 - Measured in DAC counts, DAC voltage divided by 2!
 - $V(t)$ compared with $V(t + \Delta t) \Rightarrow$ input voltage noise $\times \sqrt{2}$

Trigger Unit

Differential / Switched Capacitor Mode

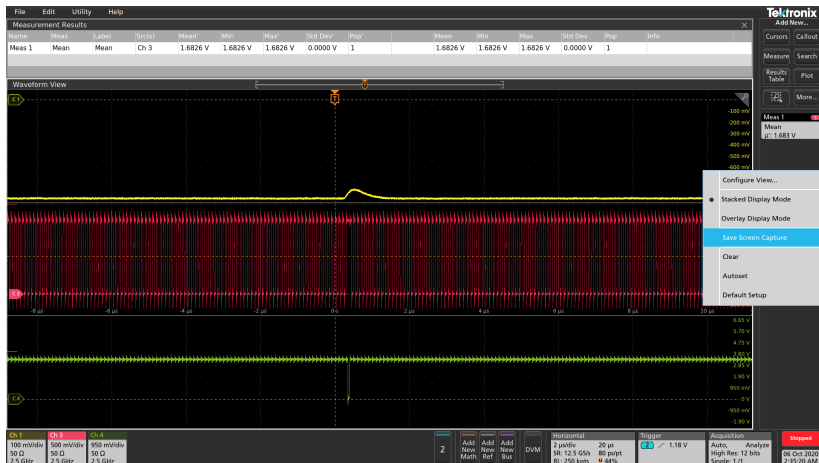
Determining Input Signal Slope Dependency of Trigger



- Measurement was done
- Linear threshold distance dependency on slope observed
- Slope was not consistent to used clock cycle \Rightarrow Has to be checked!

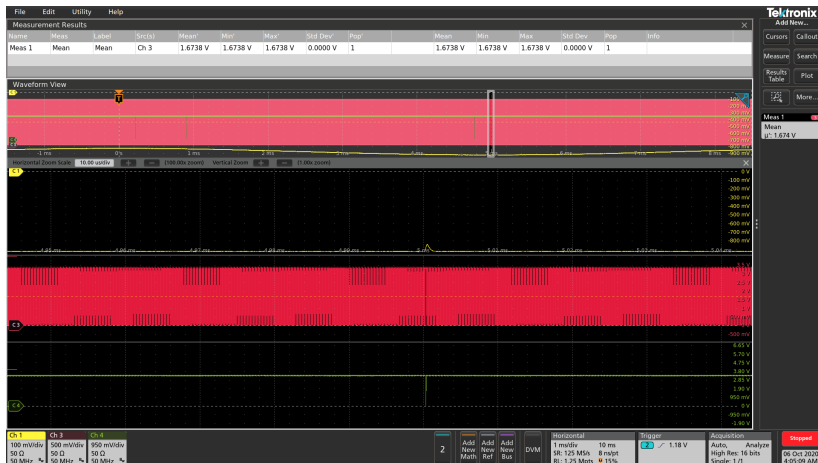
Trigger Unit

Differential / Switched Capacitor Mode



Trigger Unit

Differential / Switched Capacitor Mode



Summary and Outlook

- Input buffer works fine
- Trigger in leading edge discriminator mode works fine
- Trigger in switched capacitor mode works
 - Proportional suppression not as expected
 - Larger trigger noise (by principle)
 - Parameter characterisation has to be checked
- In case of low frequency noise / pick-up switched capacitor mode can be helpful otherwise LED mode with better noise performance
- Submission of 16 channel prototype on December 14th

Thank you