

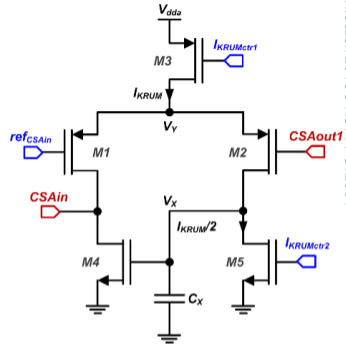


Universität Hamburg

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Annika Vauth  
21 July 2020

# CSA implementation in Allpix-Squared digitisation



Kieczek 2016 JINST11 C12001



# Motivation

Would like timing for Allpix<sup>2</sup> simulation

- ▶ Implement a new digitizer:
- ▶ Charge Sensitive Amplifier (CSA) with Krummenacher feedback

→ CSADigitizer module



# Transfer function

Idea for CSA implementation:

Transfer function from [Kleczek 2016 JINST11 C12001]

$$H(s) = \frac{R_f}{((1 + \tau_f s) * (1 + \tau_r s))},$$

with  $\tau_f = R_f C_f$ , rise time constant  $\tau_r = \frac{C_{det} * C_{out}}{g_m * C_f}$

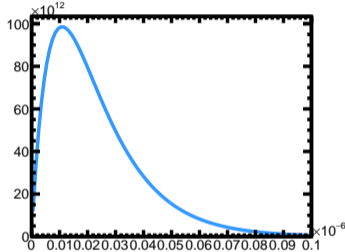
Impulse response:  $\mathcal{L}^{-1}(K)$  (thanks to Wolfram Alpha)

*InverseLaplaceTransform*[ $R / ((1 + as)(1 + sb))$ ,  $s, t$ ] =  $(1 / ((a - b)E^{(t/a)}) - 1 / ((a - b)E^{(t/b)}))R$

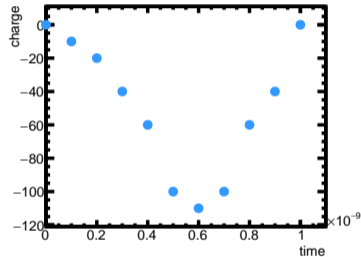
→ convolution of impulse response with charge pulse

# Example with simple dummy pulse

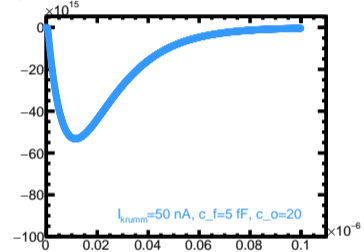
impulse response



pulse

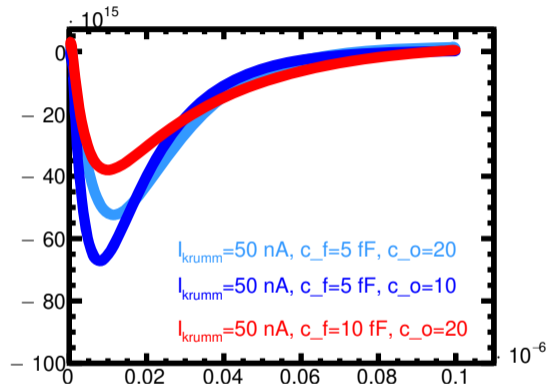
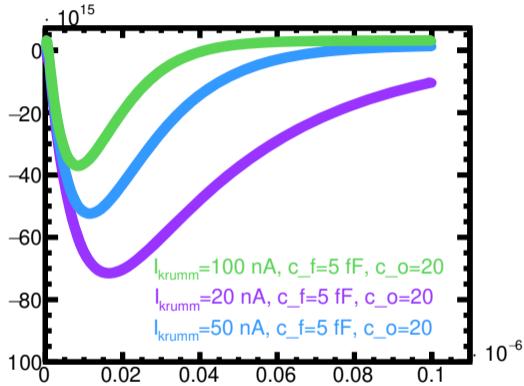


Graph



simple toy code for testing:  
convolution of impulse response with code

# Example with simple dummy pulse

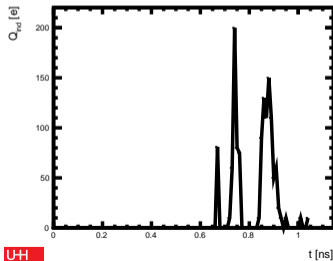


simple toy code for testing:  
different  $I_{Krumm}$  ; different feedback/output capacities

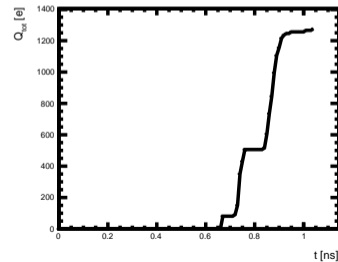
# Implementation in Allpix<sup>2</sup>

- ▶ convolution of impulse response with charge pulse  
→ voltage pulse
- ▶ addition of noise - simple normal distribution
- ▶ ToT logic: check when pulse crosses threshold

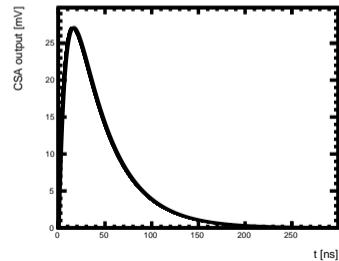
Induced charge in pixel (21,22),  $Q_{\text{tot}} = 1276$  e



Accumulated induced charge in pixel (21,22),  $Q_{\text{tot}} = 1276$  e



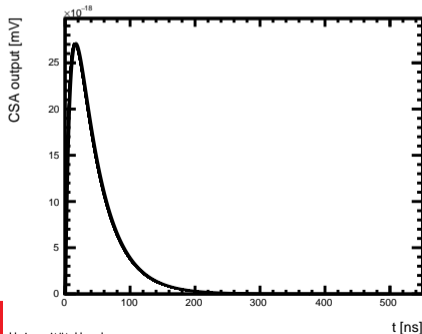
Amplifier signal in pixel (21,22)



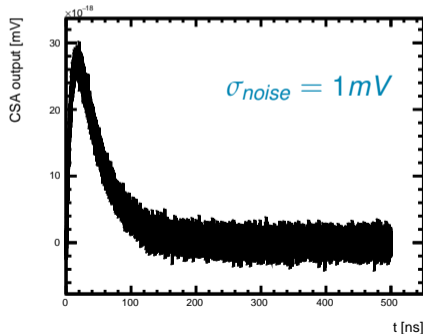
# Implementation in Allpix<sup>2</sup>

- ▶ convolution of impulse response with charge pulse  
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Amplifier signal in pixel (21,22)



Amplifier signal with added noise in pixel (21,22)



# General Parameters

- ▶ **model** Choice between different CSA models. Currently implemented are two parametrisations of the circuit from [Kleczek], 'simple' and 'csa'.
- ▶ **feedback\_capacitance** The feedback capacity to the amplifier circuit
- ▶ **amp\_time\_window** The length of time the amplifier output is registered
- ▶ **sigma\_noise** Standard deviation of the Gaussian-distributed noise added to the output signal
- ▶ **threshold** Threshold for TOT/TOA logic, for considering the output signal as a hit
- ▶ **output\_tot** Determines if the output of this module is Time-over-Threshold. Otherwise, the pulse integral is stored instead.
- ▶ **output\_plots** [**output\_pulsegraphs**] Enable output histograms: raw pixel charge, time of arrival, time over threshold, pixel charge vs tot [*pulse graphs for each pixel and event*].



# Specific Parameters

Parameters for the `simple` model:

- ▶ **rise\_time\_constant** Rise time constant of CSA output.
- ▶ **feedback\_time\_constant** Feedback time constant of CSA output.

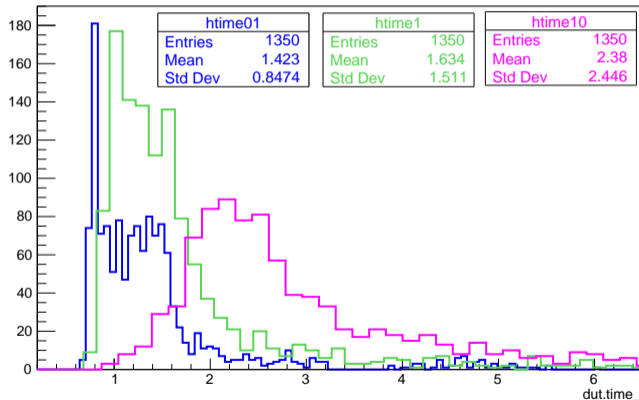
Parameters for the `csa` model:

- ▶ **krummenacher\_current** The feedback current setting of the CSA.
- ▶ **detector\_capacitance** The detector capacitance.
- ▶ **amp\_output\_capacitance** The capacitance at the amplifier output.
- ▶ **transconductance** The transconductance of the CSA feedback circuit.
- ▶ **temperature** Defaults to 293.15K.

# Example output: ToA

Time-of-Arrival for different thresholds (0.1mV , 1mV , 10mV)

dut.time\_ different thresholds

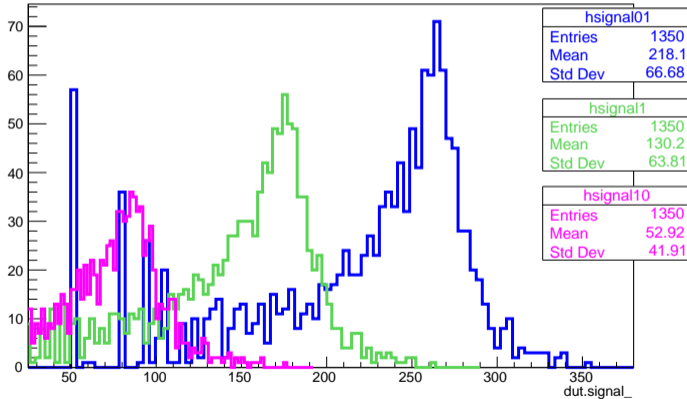


one sensor, otherwise default parameters

# Example output: ToT

Time-over-Threshold for different thresholds (0.1mV , 1mV , 10mV)

dut.signal\_ different thresholds

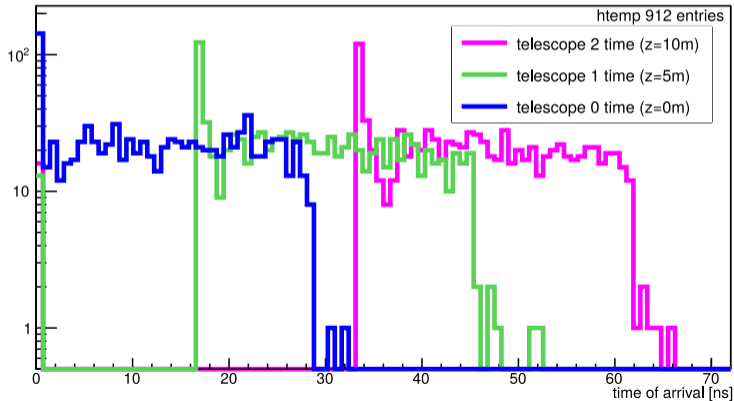


one sensor, otherwise default parameters

# Example output: Timing

Time-of-Arrival for **very** exaggerated setup:  
3 planes of Mimosa26, spaced 5 meter apart


TOA for three detector planes



# CSADigitizer Module: Status



Pull request made





Lots of helpful feedback from Simon




- thanks! 

Should become part of main branch soon.


## Csadigitizer #7



 Open **annkvth** wants to merge 32 commits into `allpix-squared:master` from `annkvth:csadigitizer` 


 Conversation **44**  Commits **32**  Checks **0**  Files changed **6**

 **annkvth** commented on May 28  

WIP: first draft of a digitizer emulating charge sensitive preamp with Kruppenacher feedback

 **Annika Vauth** added 2 commits on May 27

-  CSA digitizer branch, freshly rebased to upstream master 46d1d92
-  decided to only plot hits above threshold b341f17

 **simonspa** requested changes on Jun 2 [View changes](#)

**Backup: some more plots**

# ToT vs raw pixel charge

