A trigger ASIC for the Cherenkov Telescope Array

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Obertrubach, 06.10.2016

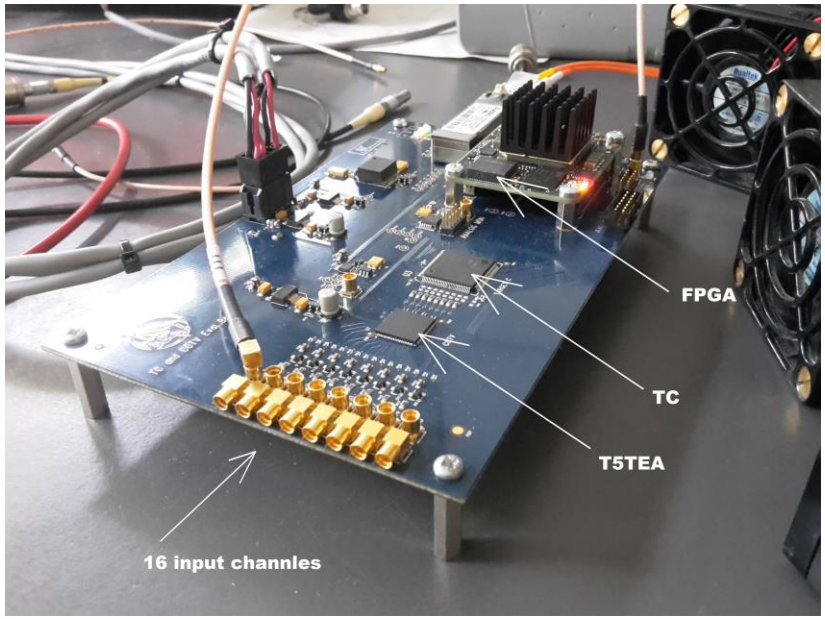
cherenkov telescope array

ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG

Outlook

- What are cosmic rays?
- How can they be detected?
- The Cherenkov Telescope Array
- TARGET / T5TEA
- Summary and Outlook



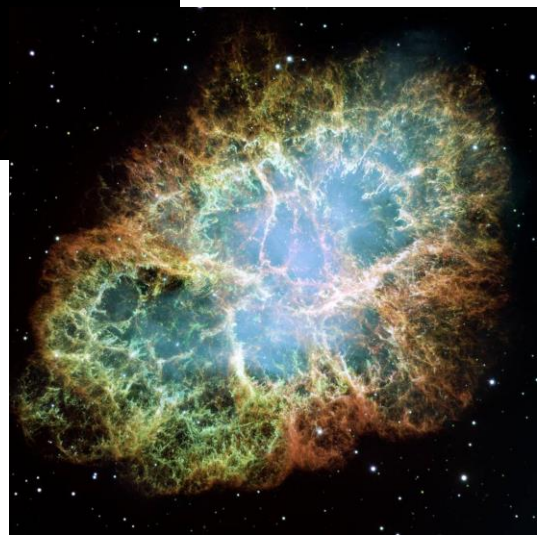
Evaluation board with T5TEA, TC and an FPGA

What are cosmic rays?

- First discovery by Viktor F. Hess in 1912

- Sources:
  - **A**ctive **G**alactic **N**uclei
  - **S**uper**N**ova **R**emnants
  - **P**ulsar **W**ind **N**ebulae
  - **G**amma **R**ay **B**ursts
  - Dark Matter annihilation??

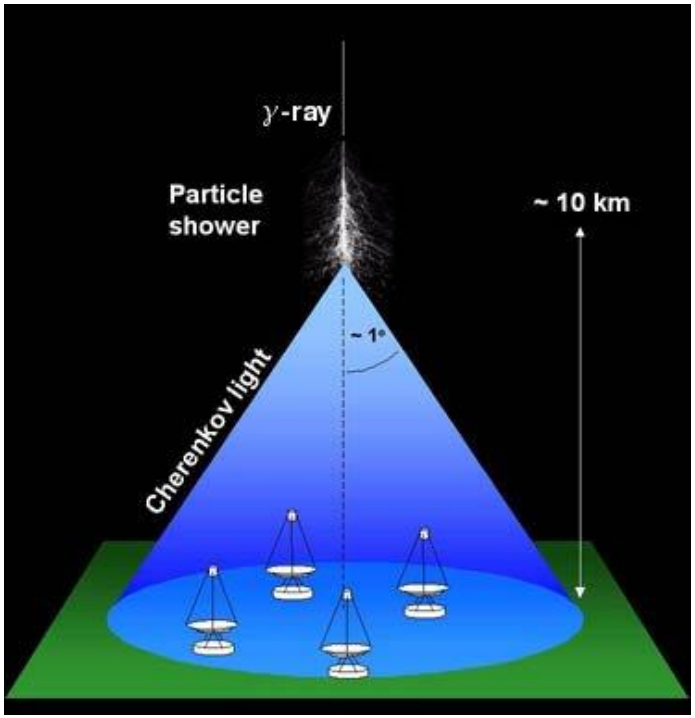
AGN (NASA)



Crab nebula (NASA)

How can they be detected?

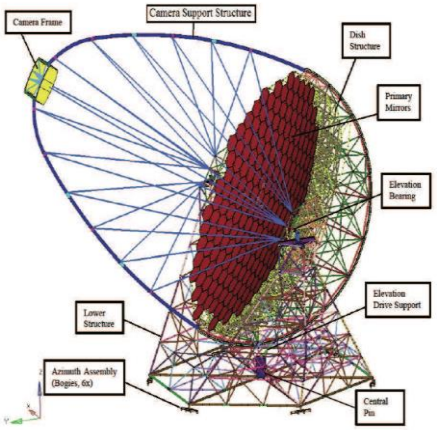
- In the atmosphere: hadronic and e.m. cascades
- In vicinity of source: gamma rays → particle shower
- Particles faster than local speed of light → Cherenkov radiation



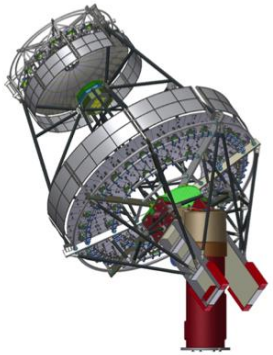
Emitted Cherenkov cone (Durham University)

The Cherenkov Telescope Array

- Next-generation IACT with improved sensitivity and angular resolution w.r.t. H.E.S.S. (5) , MAGIC (2) or VERITAS (4)
- Arrays in North (~20) and South (~100) to cover whole sky
- Three different sizes: LST, MST and SST



Rousselle, 2015



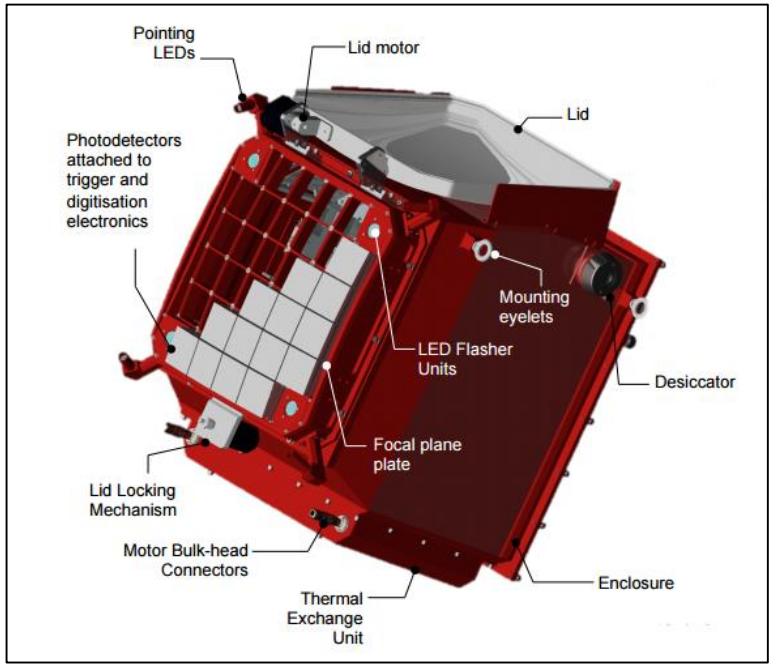
Hassan, 2015

Montaruli, 2015

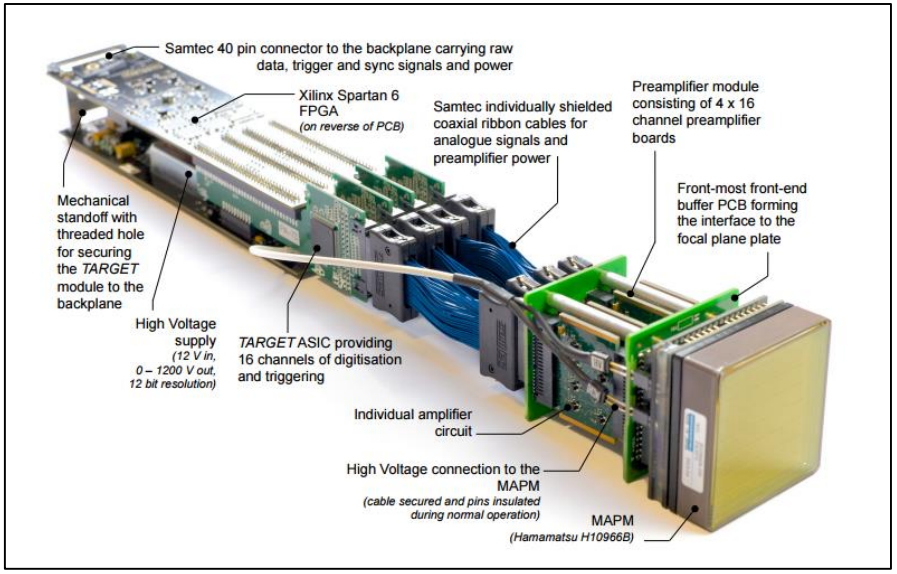
Telescope

Prototype GCT (CTA Hompage)

Camera and camera-module



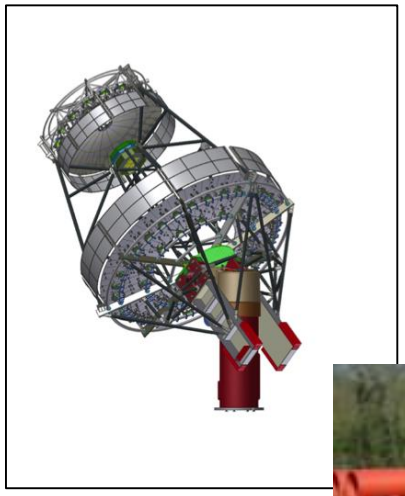
De Franco, 2015



De Franco, 2015

TARGET

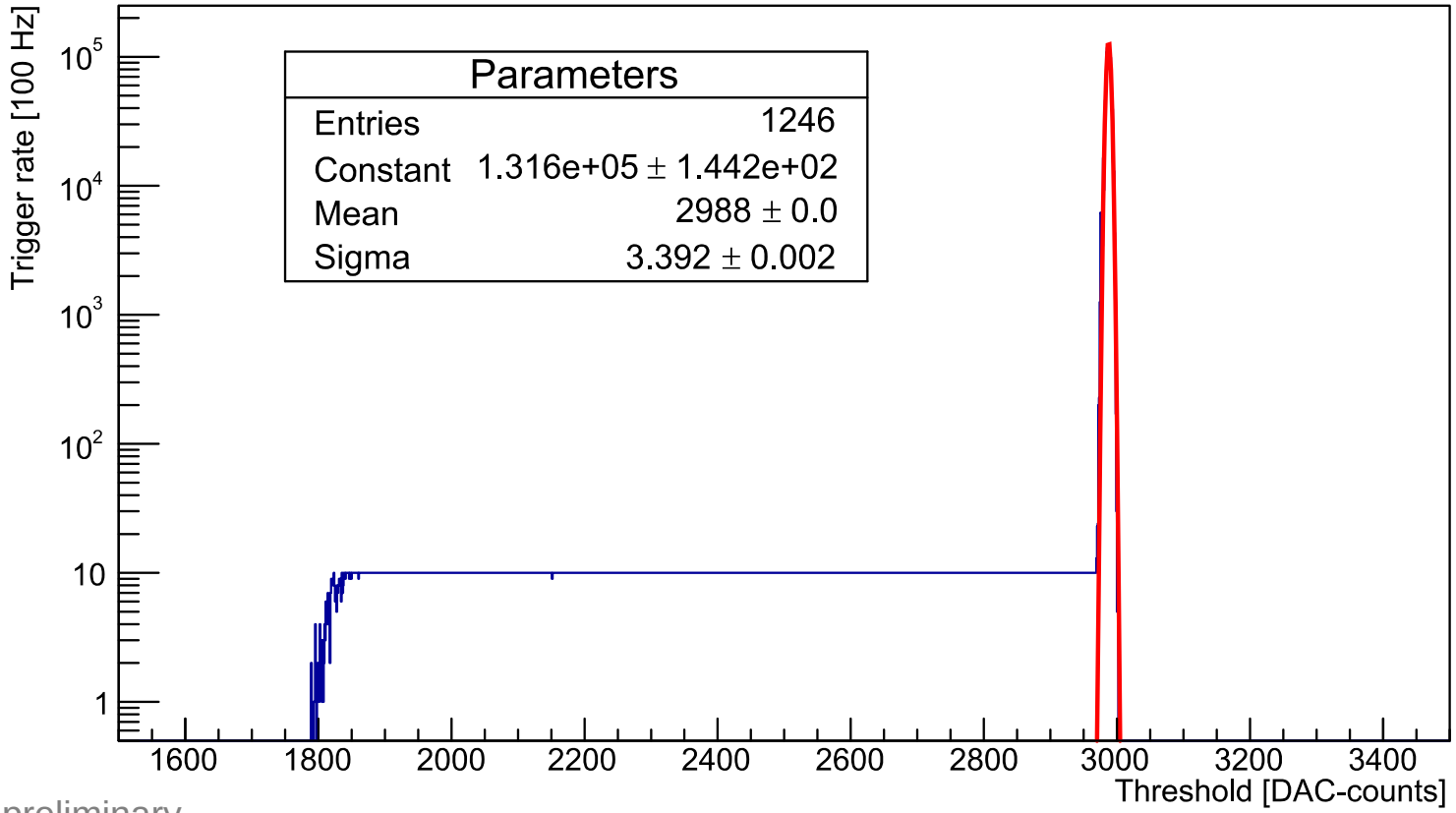
- Newest generation: T5TEA (self-trigger) and TC (sampling, digitization, read out)
- 16 channels at low cost (~20 $)
- Used in some MSTs and SSTs



Hassan, 2015

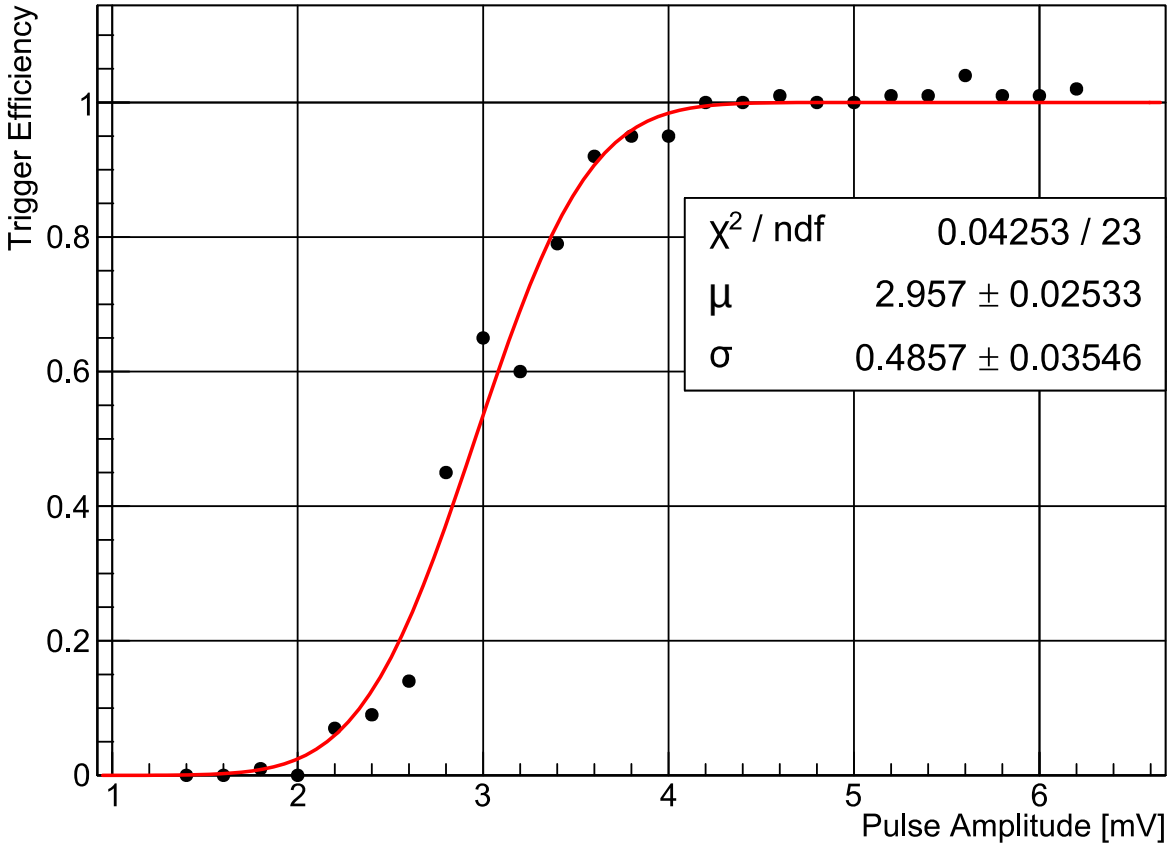
Montaruli, 2015

Trigger ASIC T5TEA



preliminary

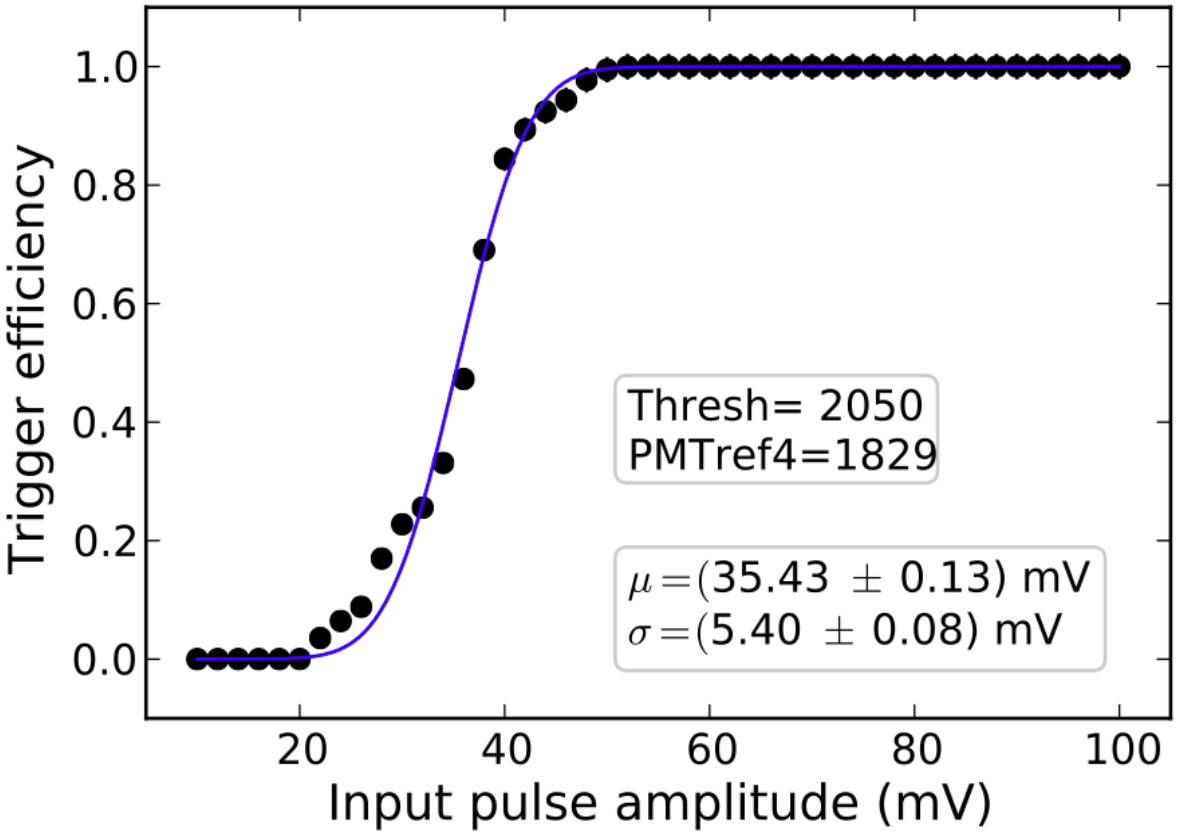
Trigger efficiency



preliminary

- **Fit: Gaussian error function with**
  μ: threshold (50% efficiency)
  σ: spread (noise)
- **Able to trigger at a single photoelectron (3-4 mV per p.e.)**

Trigger efficiency T5



Albert, 2016

- **Fit: Gaussian error function with**
  μ: threshold (50% efficiency)
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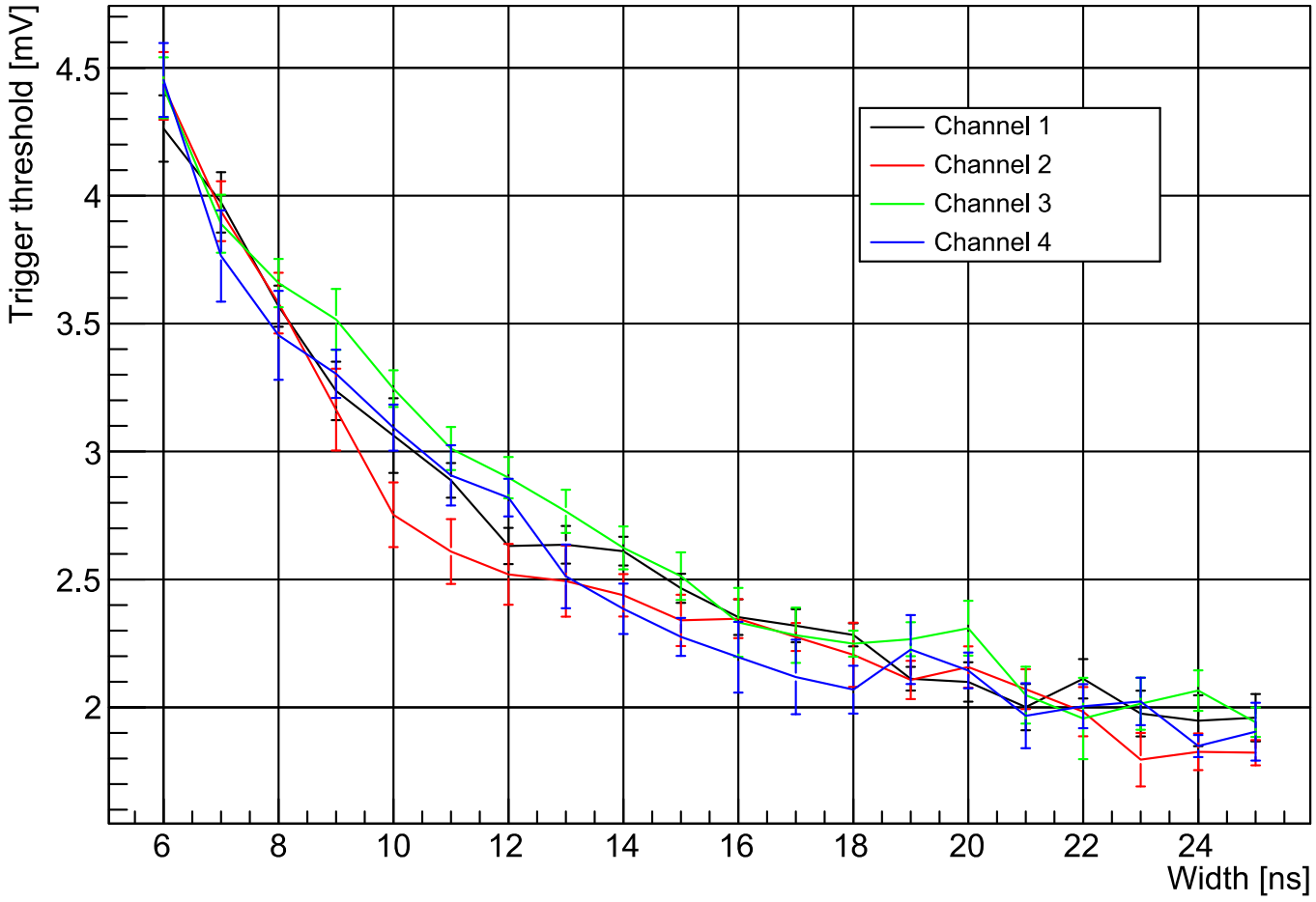
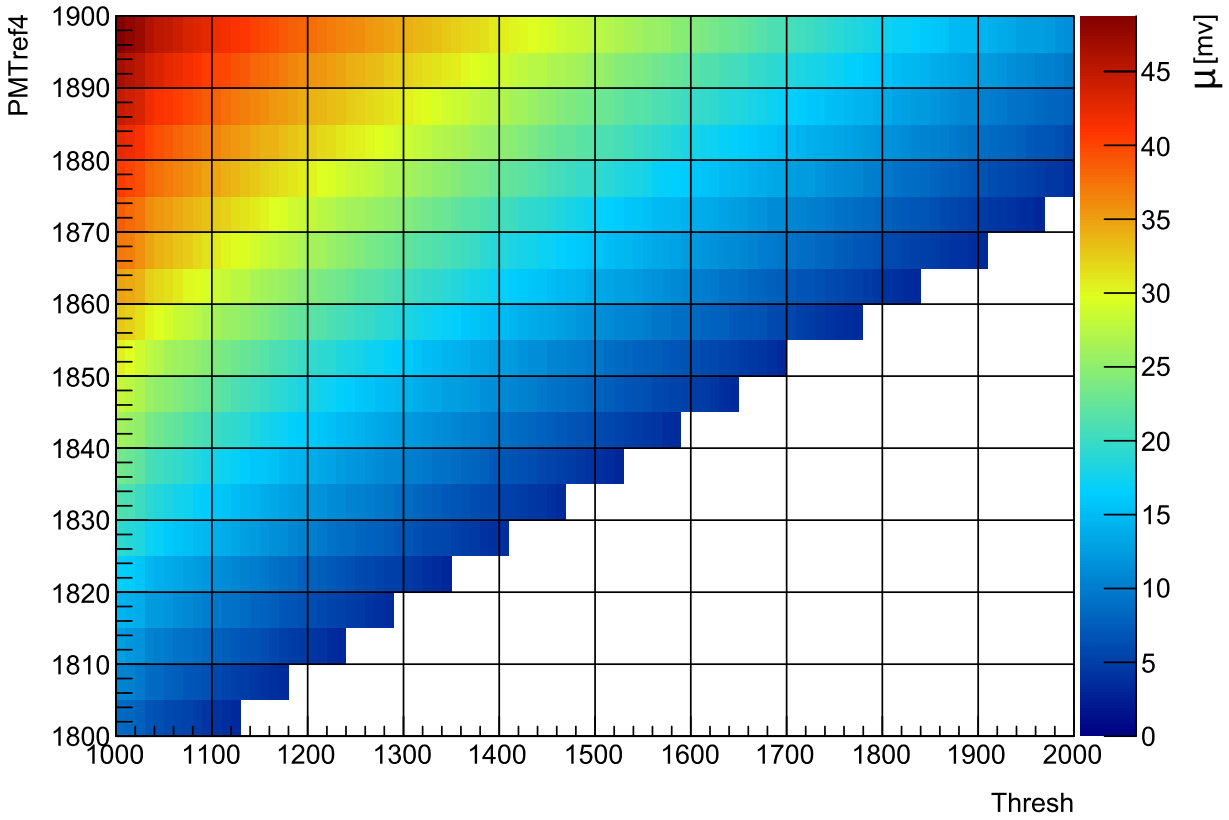
Input pulse width



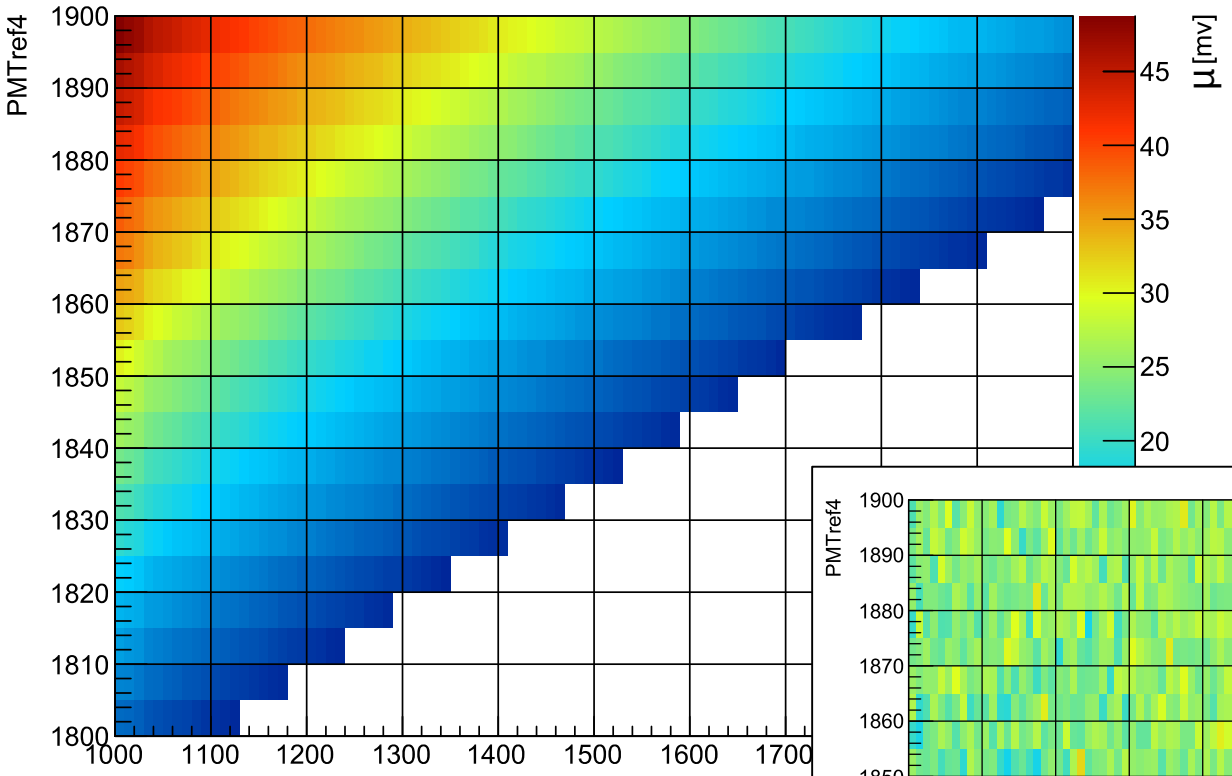
preliminary

Parameter scan



preliminary

Parameter scan



preliminary

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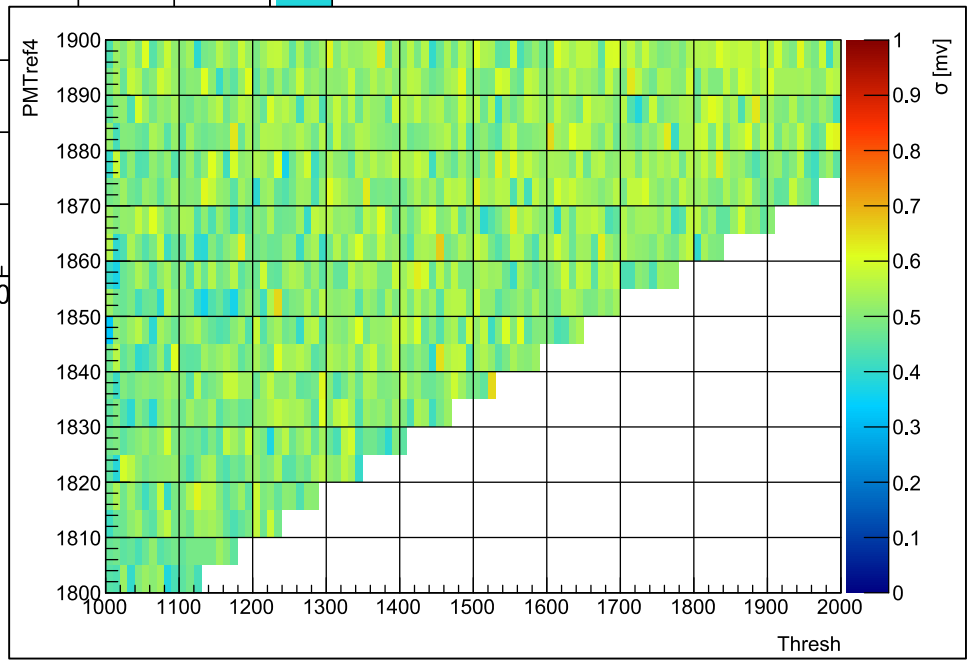
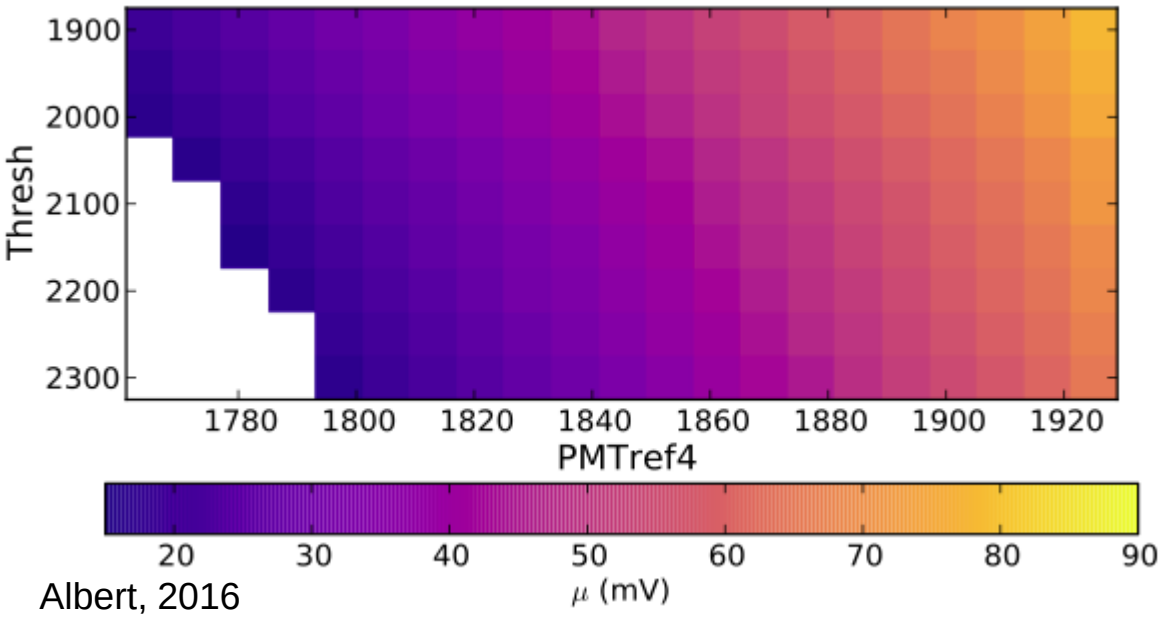
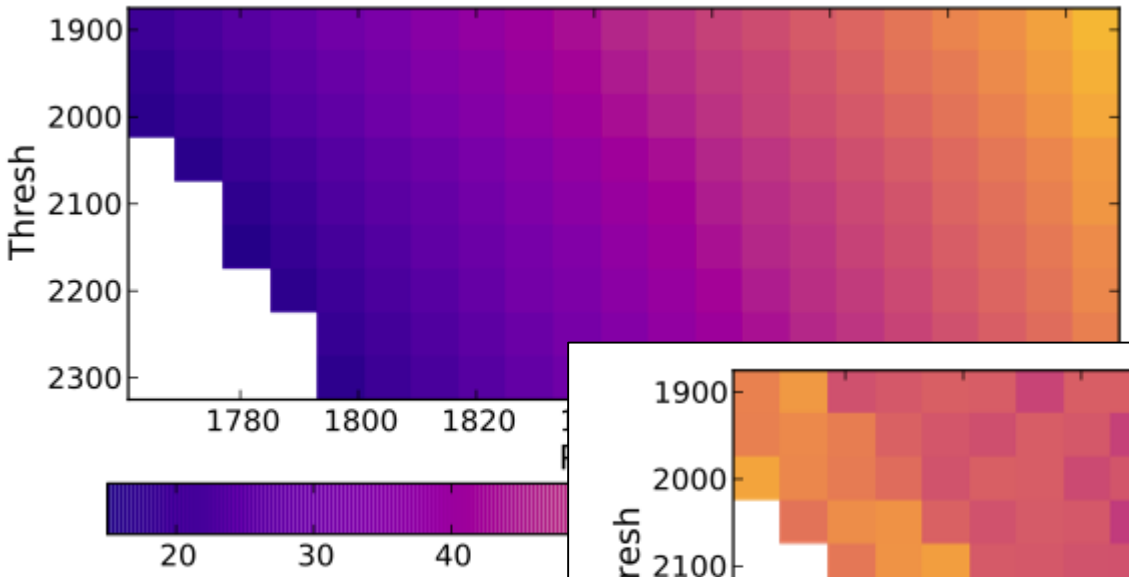


Parameter scan – T5



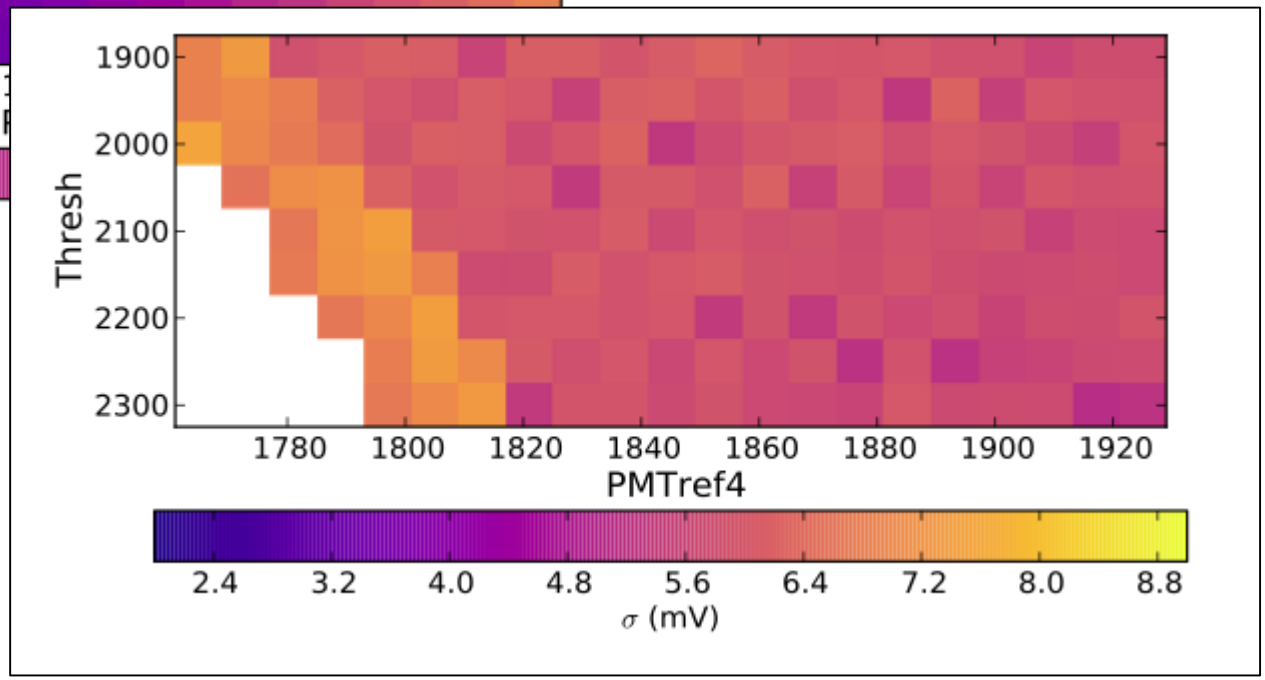
Albert, 2016

Parameter scan – T5

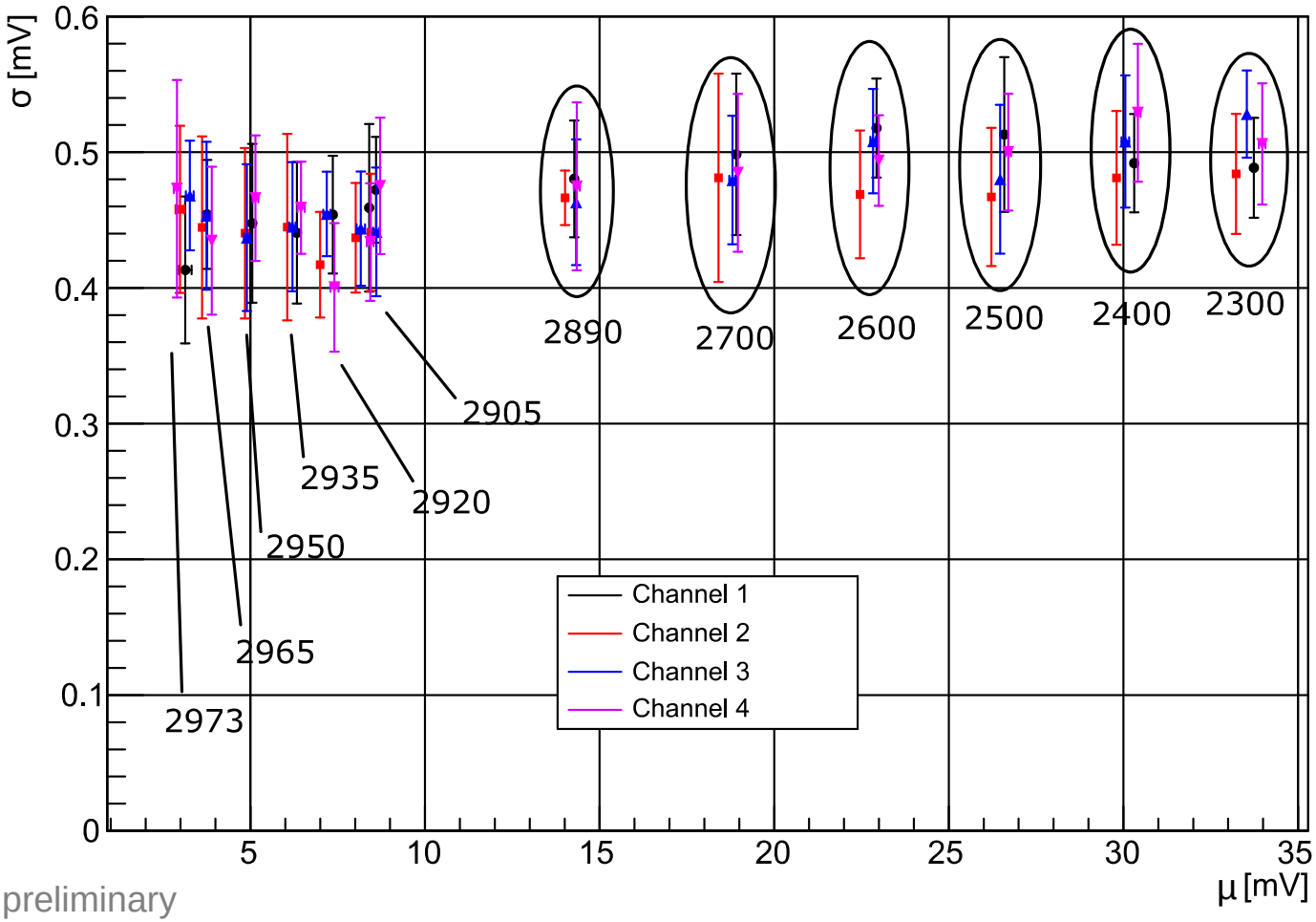


Albert, 2016

Albert, 2016



Noise measurement



preliminary

Summary and Outlook

Summary

- T5TEA way better than former ASIC T5 and meets requirements
- T5TEA is able to trigger at ~3 mV (10 ns FWHM, 5.4 ns edge time, 50 Ω load impedance setting) with noise of 0.5 mV
- The wider the pulse the lower the threshold

Outlook

- Parameter scan through all parameters
- Measurements with whole read out chain (buffer board and shaper) and later whole camera
- Temperature dependence

TARGET Group Erlangen

Prof. Dr. Stefan Funk

Dr. Adrian Zink

David Jankowsky
PhD Student

Manuel Kraus
PhD Student

Peter Deiml
PhD Student

Thank you very much for your attention!

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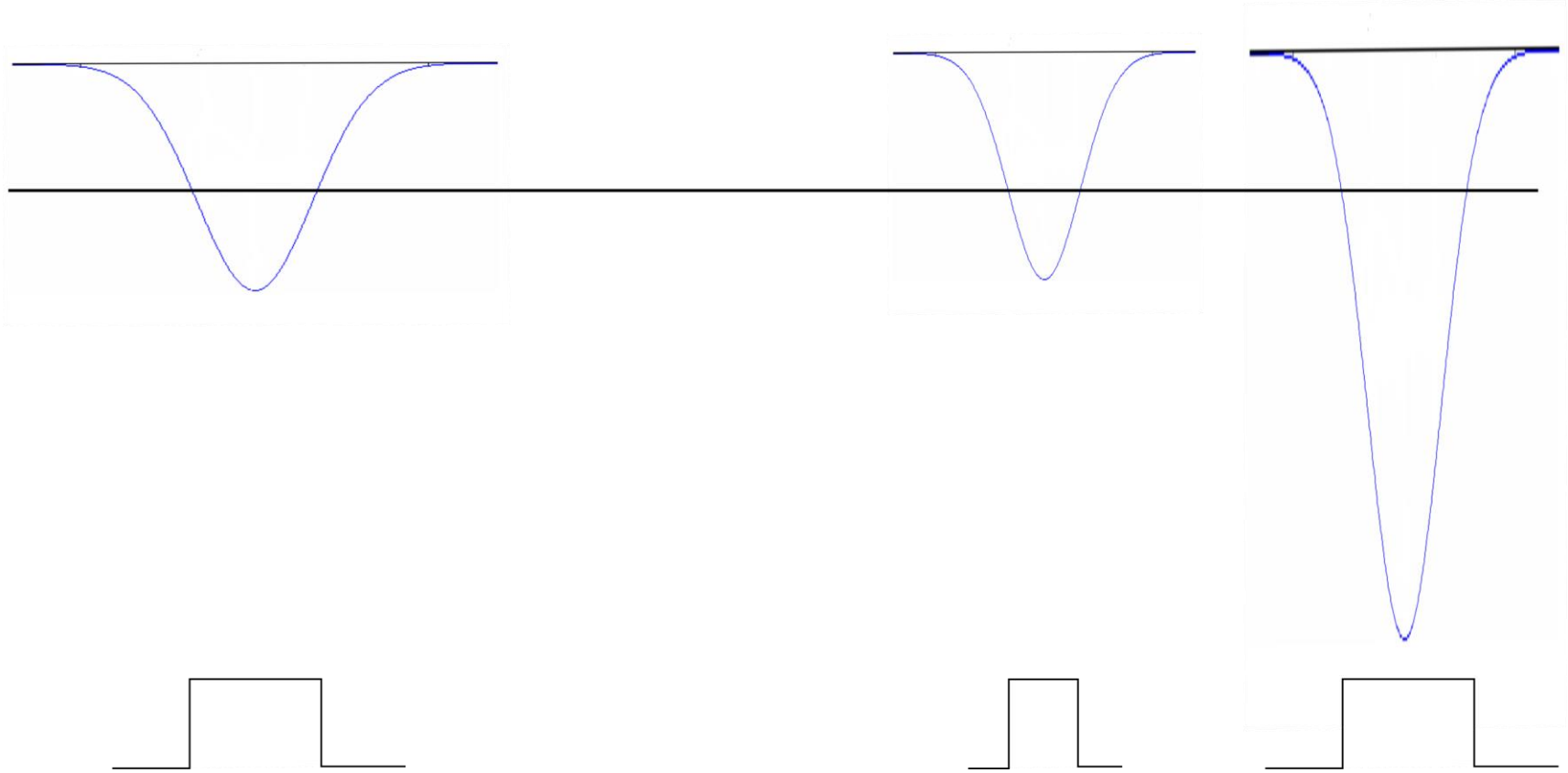
Input pulse width



G. Häfner, 2016 (modified)

TARGET

- Trigger path (T5TEA):
  - Four channels = one trigger group
  - Grouping, inverting and amplifying of signal
  - Comparator: compares set TRG_THRES with signal → FPGA

- Data path (TC):
  - Two arrays: sampling and storage
  - “Ping-pong fashion” of 32 cells
  - Read out: 512 Wilkinson ADCs with voltage ramp for all channels, stopped 12-bit counter corresponds to voltage held in capacitor