Status Report: Multi-Channel TCT

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1. Introduction

Aim:

- **Determination of pulse shape of individual pixels with XFEL type irradiation.**
- **Experimental reference data for simulations (Weierstraß Institute Berlin + MPI Munich)**

Specifications XFEL-applications:

Photon fluxes: 10^0 - 10^4 γ/pixel/pulse (12 keV)

Properties of the charge cloud are not well understood for more deposited energy than mips.

Possible effects include:

- **Plasma effects: Distortion of pulses.**
- **Charge Cloud expansion: Charge sharing in neighboring pixels due to diffusion and electrostatic repulsion.**
- **Recombination losses: At very high charge carrier densities signal is lost due to electron-hole recombination.**

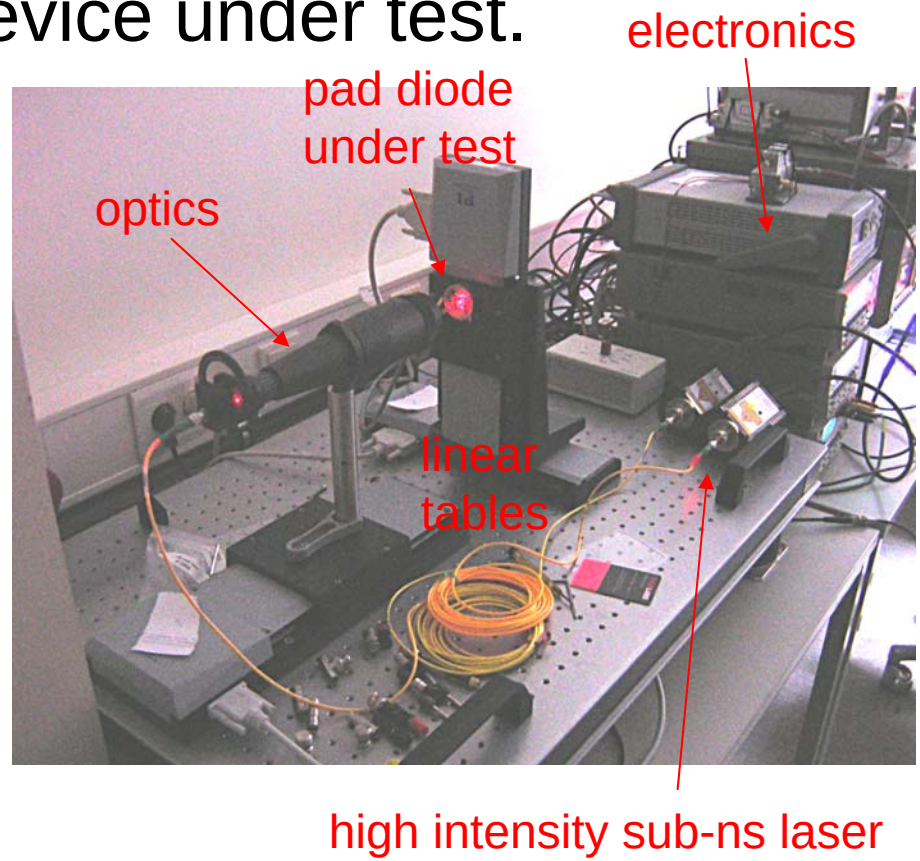
A Multi-Channel TCT setup allows to record pulse shapes and therefore study these effects in a structured device (strip or pixel detector)

2. Set-up and measurement techniques

TCT (Transient Current Technique) records the time-resolved current of the device under test.

⇒ Pulse shape

measured from:	property :
• Distortion of pulse shape	• Plasma effect
• Charge sharing of pixels (pulse on adjacent pixels)	• Charge cloud expansion
• Pulse height or integrated charge	• Recombination losses



Key features of our M-TCT setup

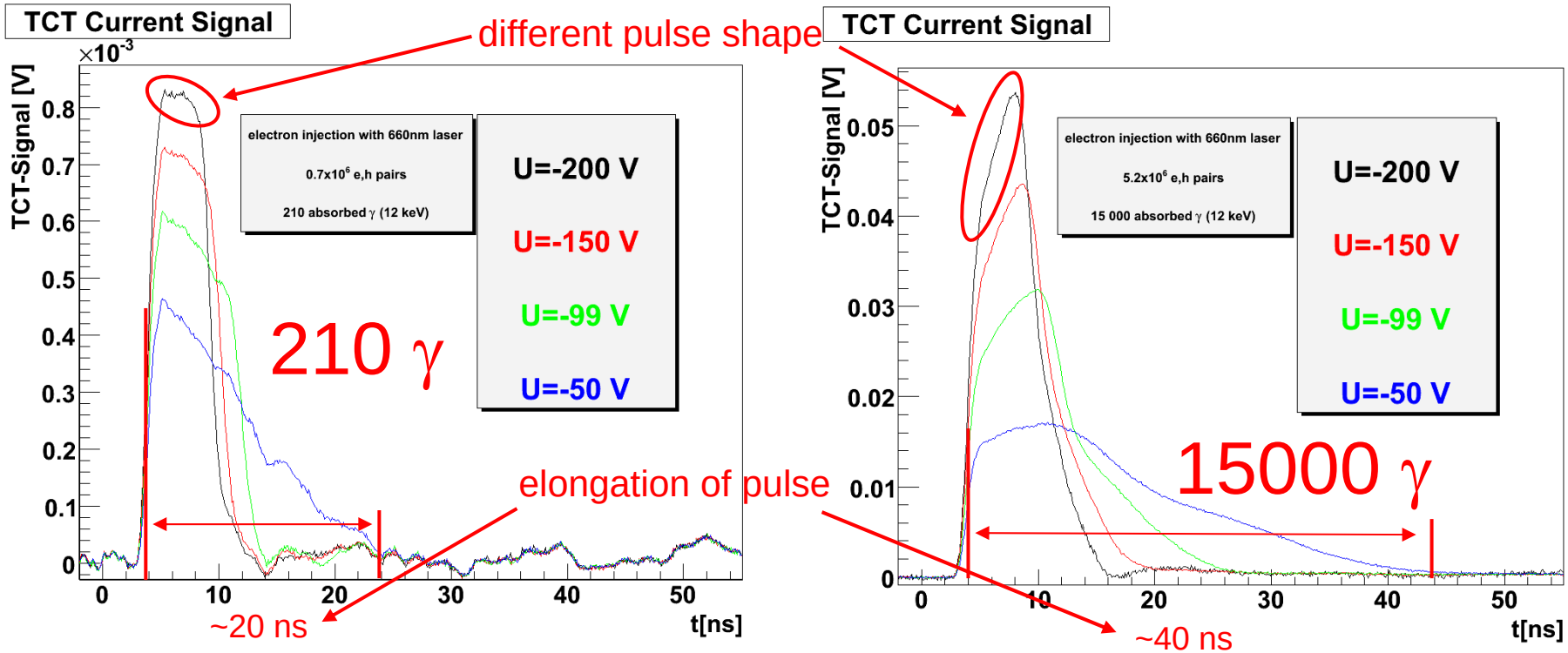
- Red and IR lasers with short pulses (~100 ps)*
- high dynamic range of injection $\hat{=} 10^0 - 10^4$ γ(12keV) and electronics (8 orders of magnitude due to use of attenuators and amplifiers)
- small spotsize of ~17µm (FWHM)
- position steps of 0.1 µm
- so far 4 readout channels (expandable)
- temperature control (20°C to -10°C)
- space for device of 13x26 mm^2

* Red laser λ=660nm => 3µm absorption length

IR laser λ=1052nm => 900µm absorption length

3. First results from single-channel measurements

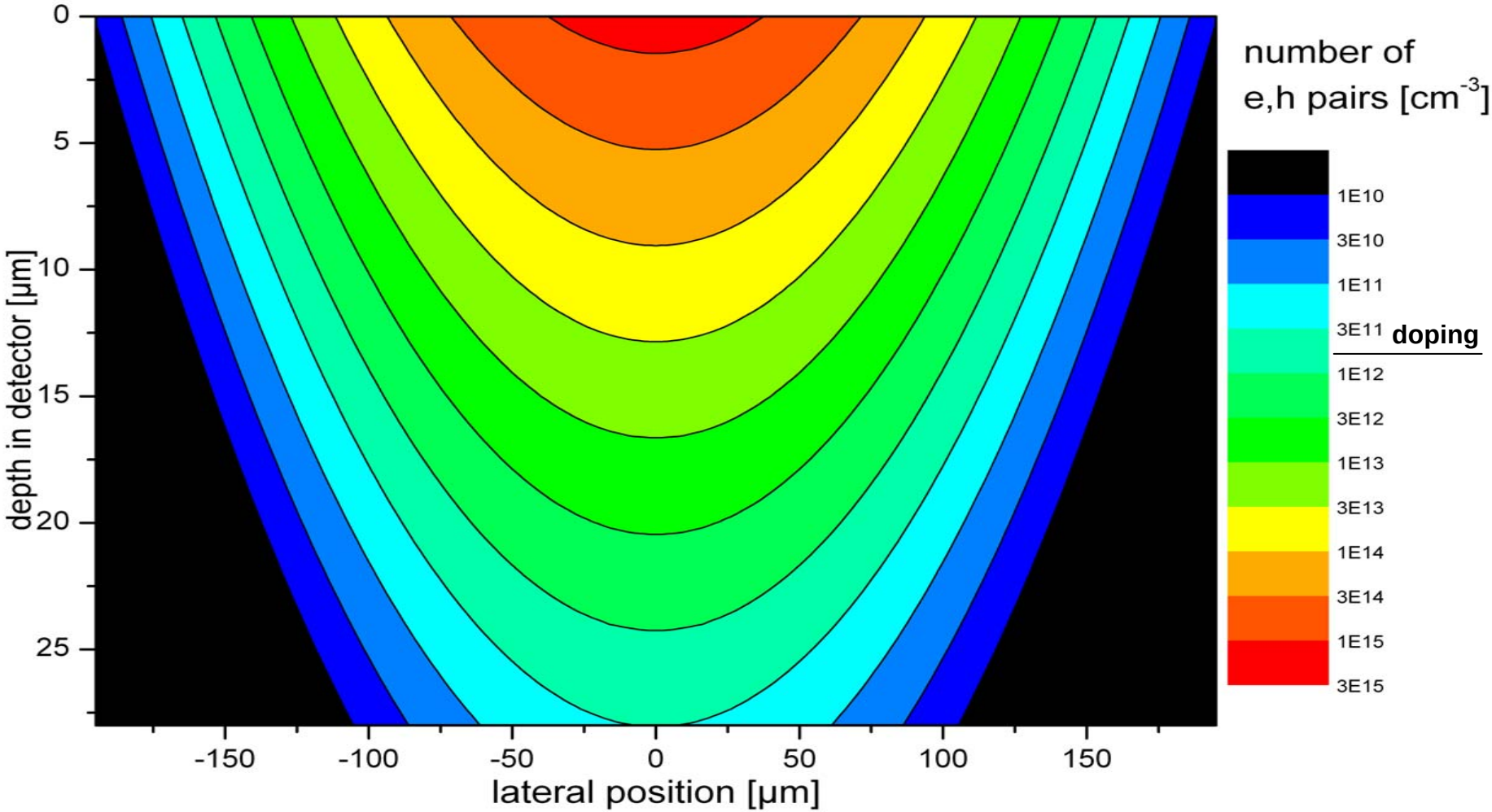
- Low (210 absorbed 12 keV γ) and high (1.5×10^4 absorbed 12 keV γ) electron injection with 660nm laser
- Pulse distortion clearly visible



CG1233 FZ-n-Si 280 µm, N_{eff}= 8×10^{11} cm^{-3}, U_{dep} = 48.5 V, C_{dep} = 9.5 pF, ρ= 5.3 kΩcm

Injection profile for FWHM 100 µm

Charge carrier density after injection with 660nm laser



4. Data from neon ion beam at GSI

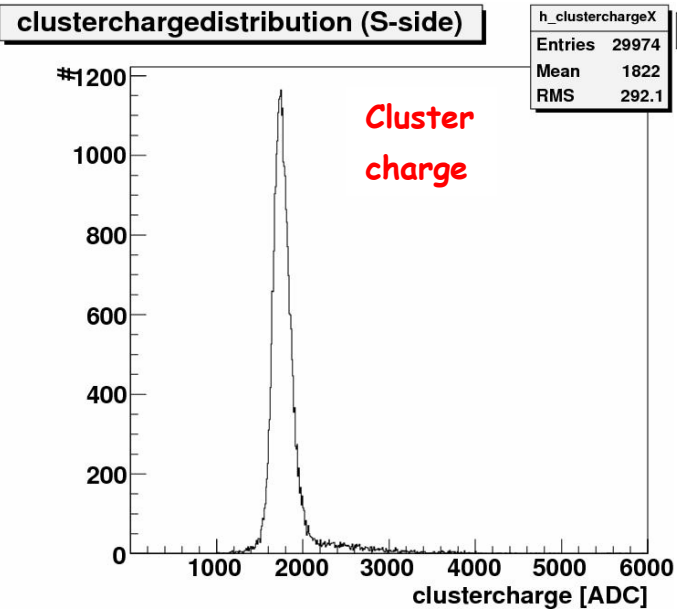
Goal: Experimental verification of charge collection in silicon at large charge carrier densities: Can use heavy ions instead of high intensity γ's: Large dE/dx due to Z^2-dependence in Bethe-Bloch Formula.

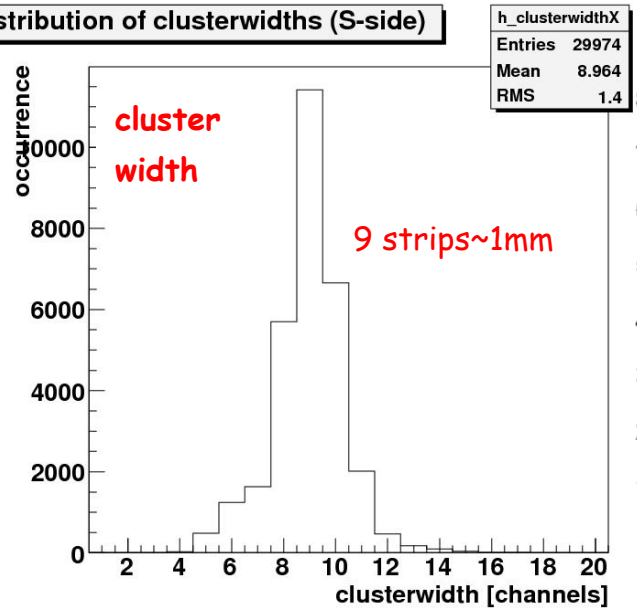
Ongoing analysis of data from test beam at GSI by UHH students.

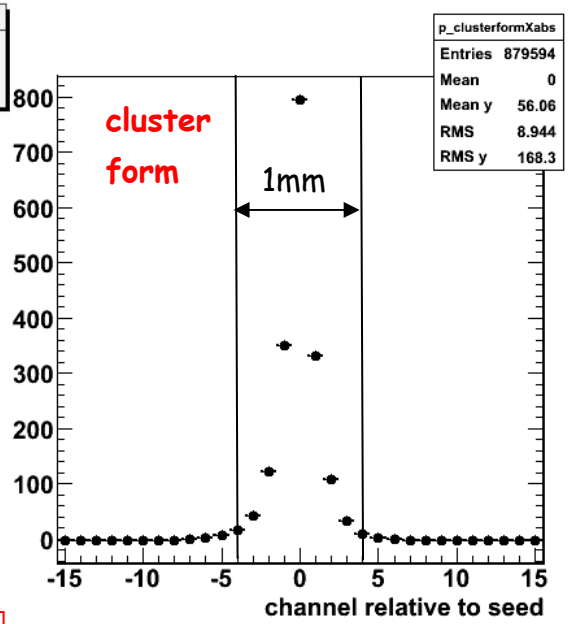
Some preliminary results (for Neon: Z=10):

S-side:

r/o pitch 110 μm







Next steps:

- Understand proton-signal (also present).
- Analysis of data taken with other ions to investigate Z-dependence: B (Z=5), C (Z=6), Mg (Z=12), P (Z=15) and Ar (Z=18).

5. Conclusion and next steps

- single channel TCT setup running
- pulse distortion clearly visible for high energy injection -> plasma effects present
- so far no evidence for recombination losses (sensitivity of setup ???)
- ion data (p,Ne,…) under analysis
- multi-TCT under preparation
  -> aim for autumn
- study of test devices (strip and pixel)
- comparison to simulations