First Results of 2023 Juelich B-field measurements

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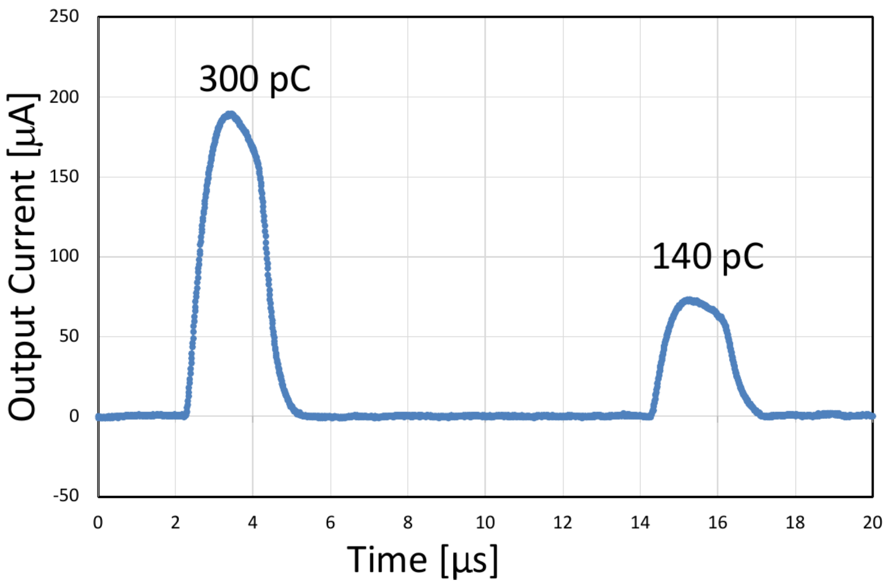
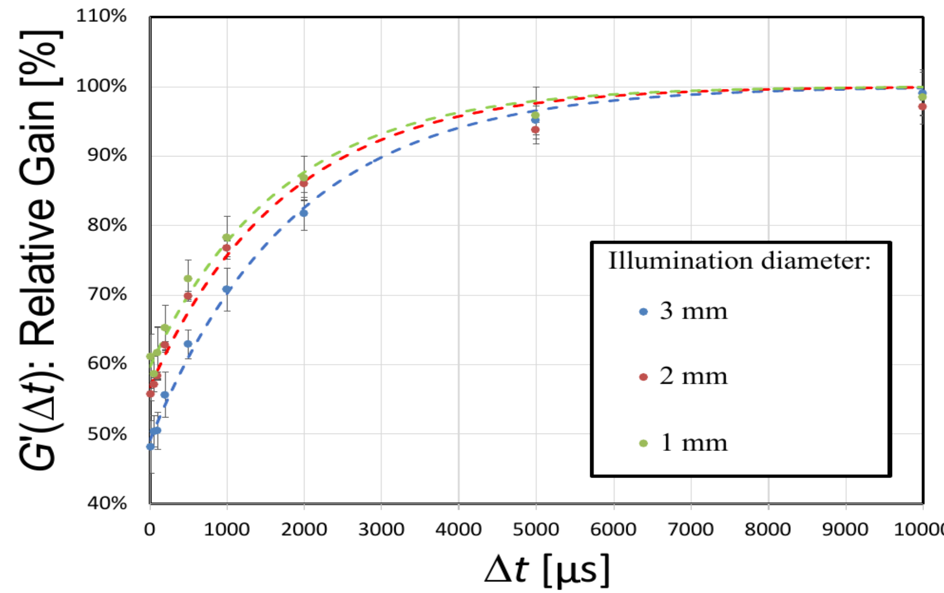
Gain-recovery time by the double-pulse method





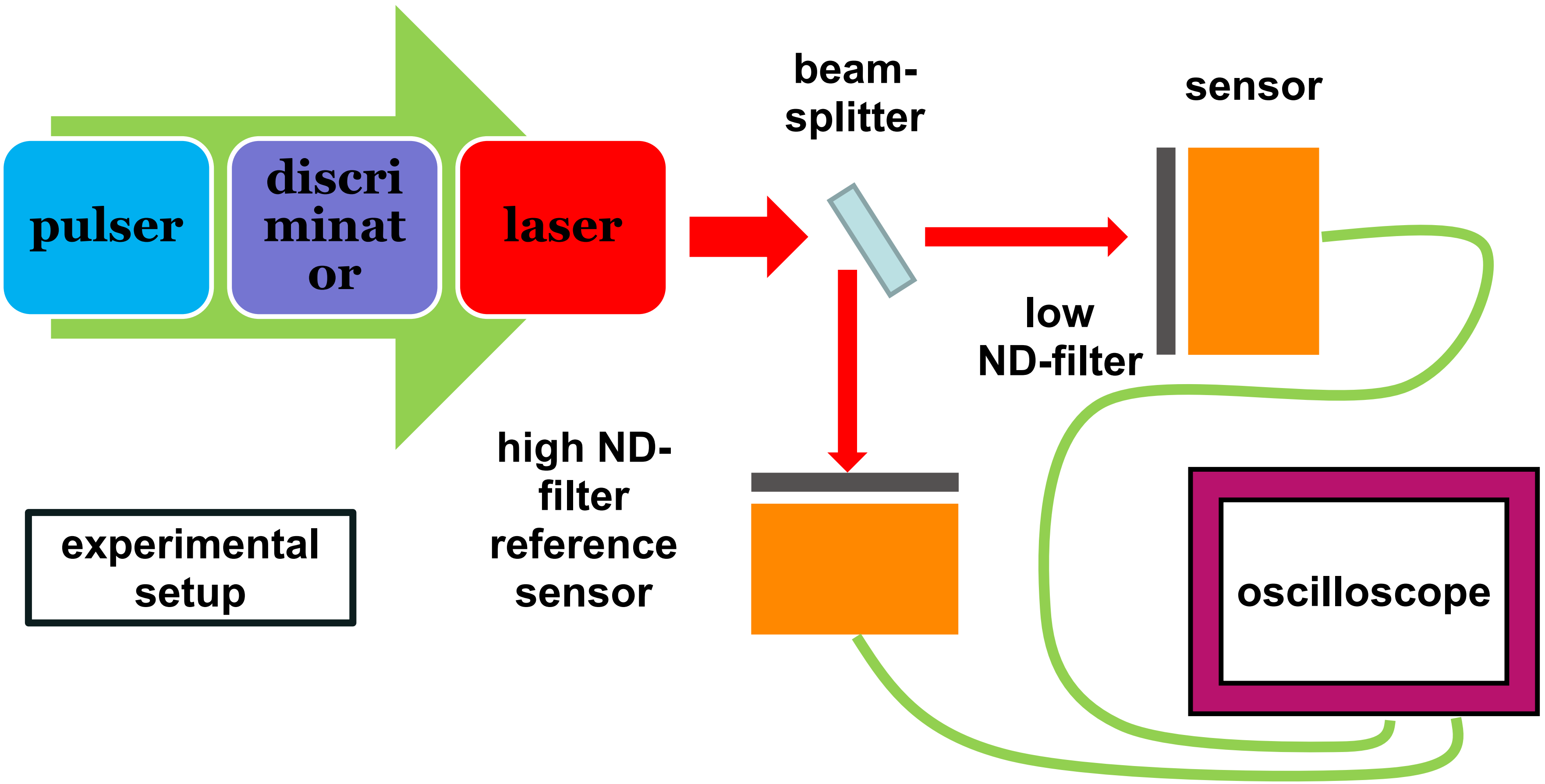
<u>**Result of the research group in Japan:**</u>

Left: waveform acquired by averaging 100 waveforms at Δt =10 ns, illumination area 3 mm in diameter.

Right: relative gain over the time interval Δt between both pulses →<u>Our goal:</u> comparable curve

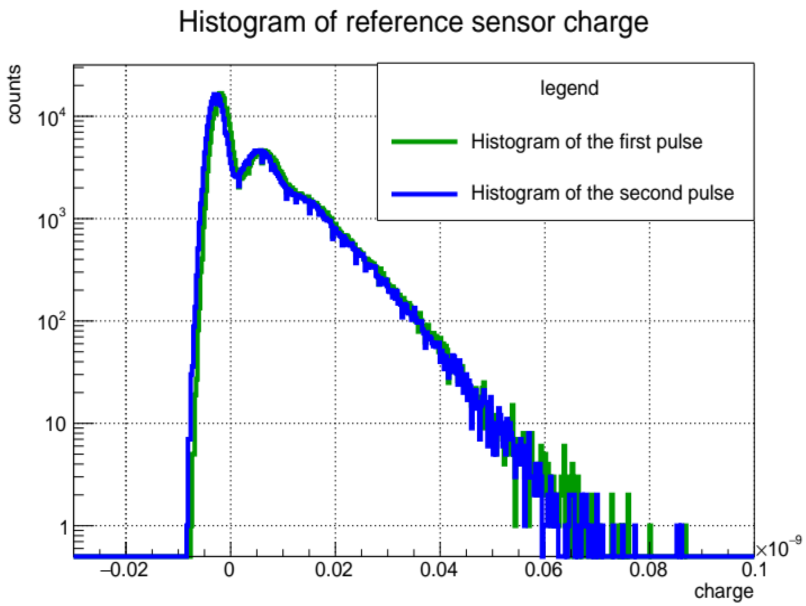
Kobayashi, Hiroshi, et al. https://doi.org/10.1016/j.nima.2023.168355

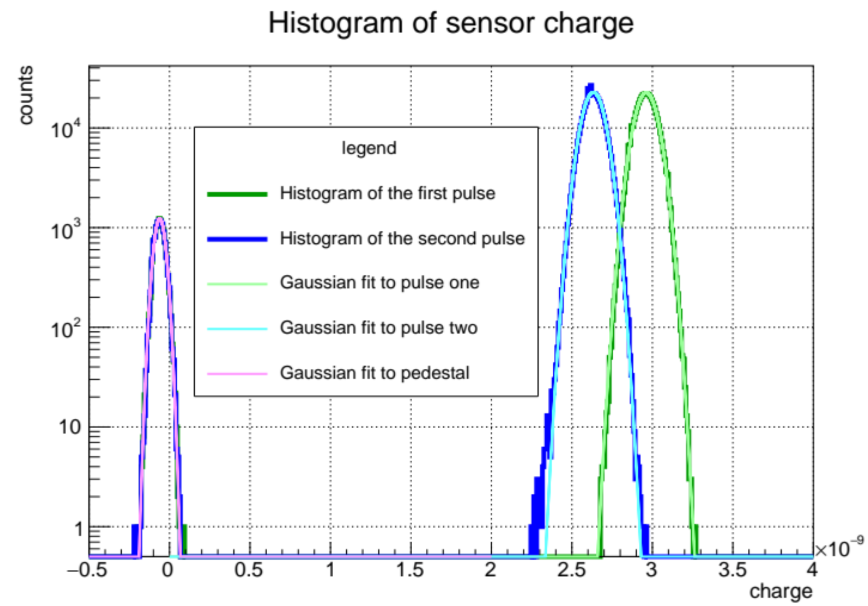
Gain-recovery time by the double-pulse method



experimental setup

Gain-recovery time by the double-pulse method





Left: Histogram of the reference sensor at a delay of 360 ns and ND filter of 4

⟶ laser pulsed correctly

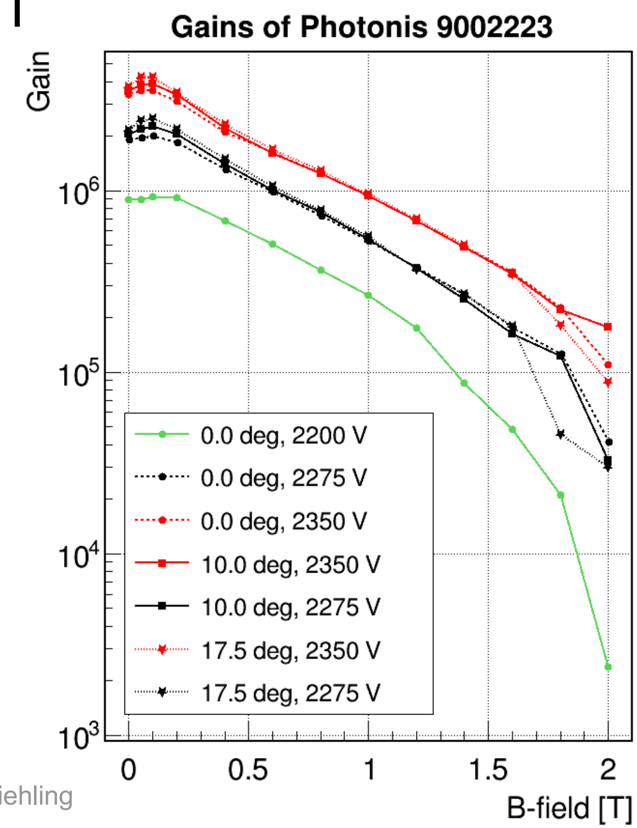
Right: Histogram of the sensor at a delay of 360 ns and ND filter of 0.6

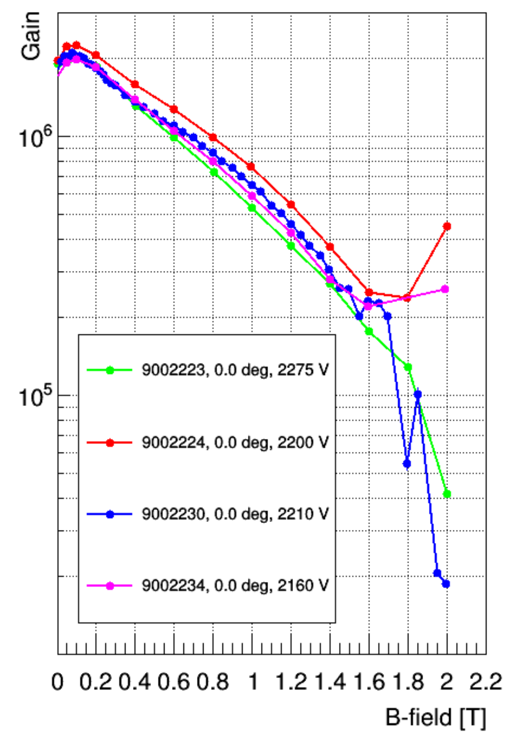
⟶ Relative Gain = 87%

Experiment still in early stage, more data will be taken in the next weeks

gain curves in magnetic field

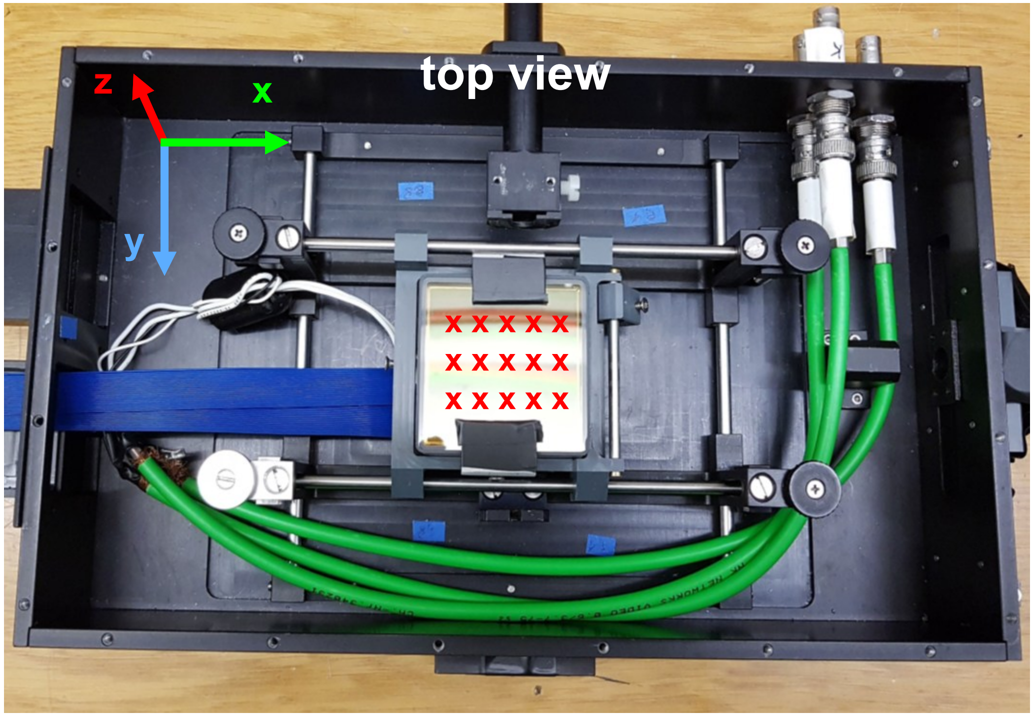
- measurement of gain for different magnetic fields, voltages and tilting angles
- at least 1 sensor per batch measured, only 4 shown
- last points: gain too low for fit
- factor ~3 gain loss at 1T
- all tilting angles look similar
- all tubes look similar

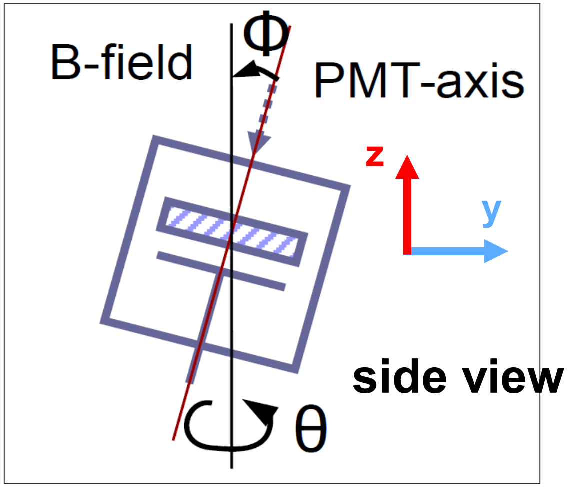




shifts of charge cloud centroid in B-field

- Measurement:
  - tilting of the tube in yz plane around x axis, scanning in y direction, B-field in z direction, E-Field along yz plane

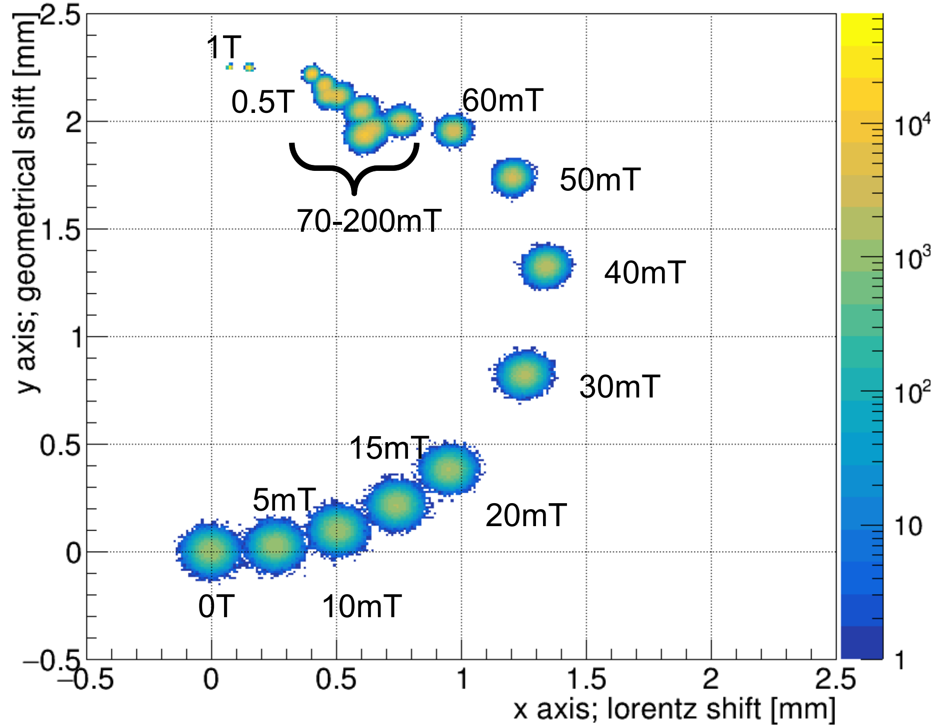


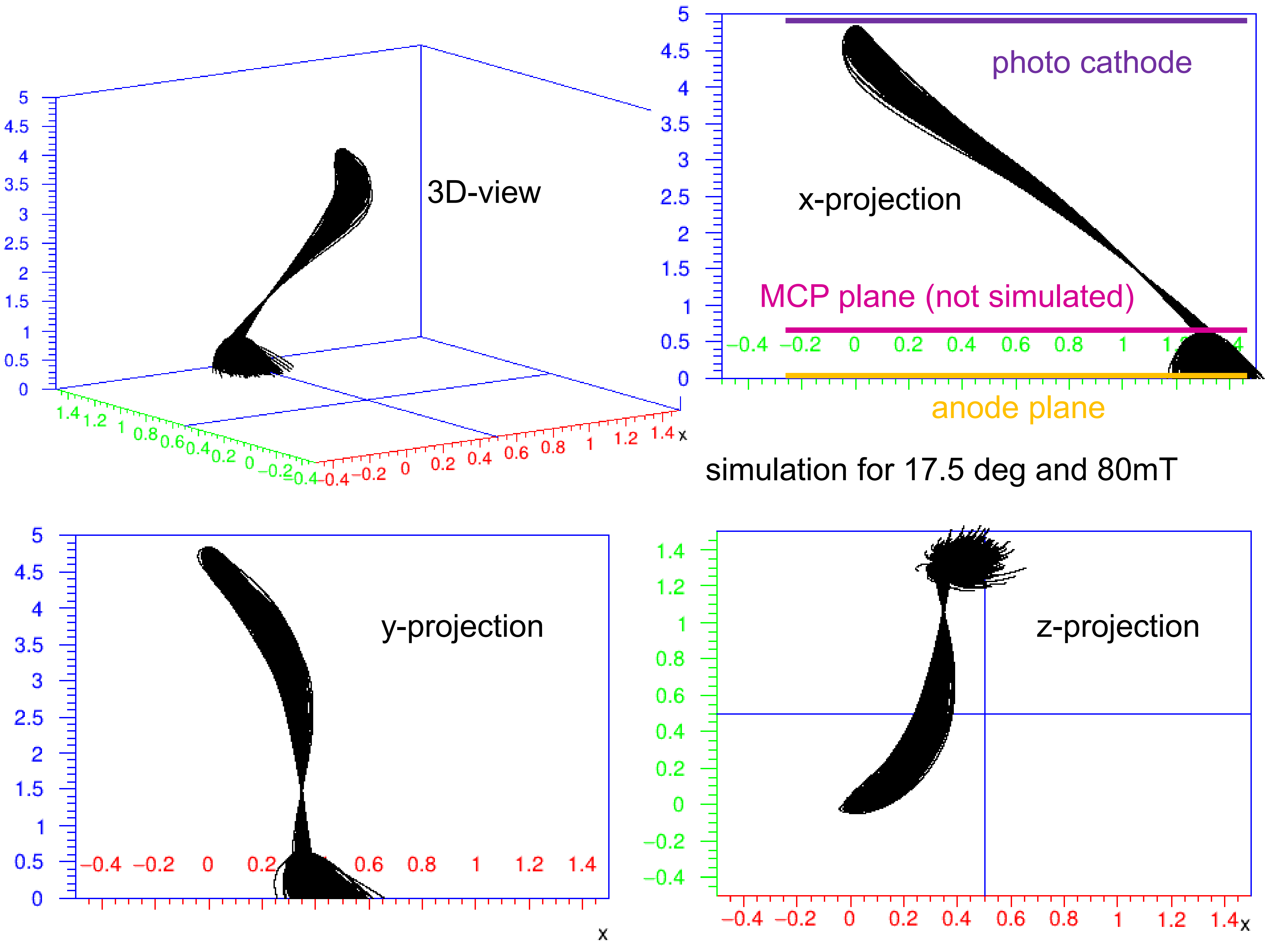


Simulation of charge cloud centroid in B-Field

- **geometrical shift** of charge cloud in **y** direction
  - electrons will follow B-field direction, depends on tilt angle, saturates at certain B-field strength
- **lorentz shift** of charge cloud in **x** direction
  - electrons experience Lorentz force perpendicular to E- and B-field depending on **B-field strength & tilt angle** (higher Φ increases $E_\perp$ component)

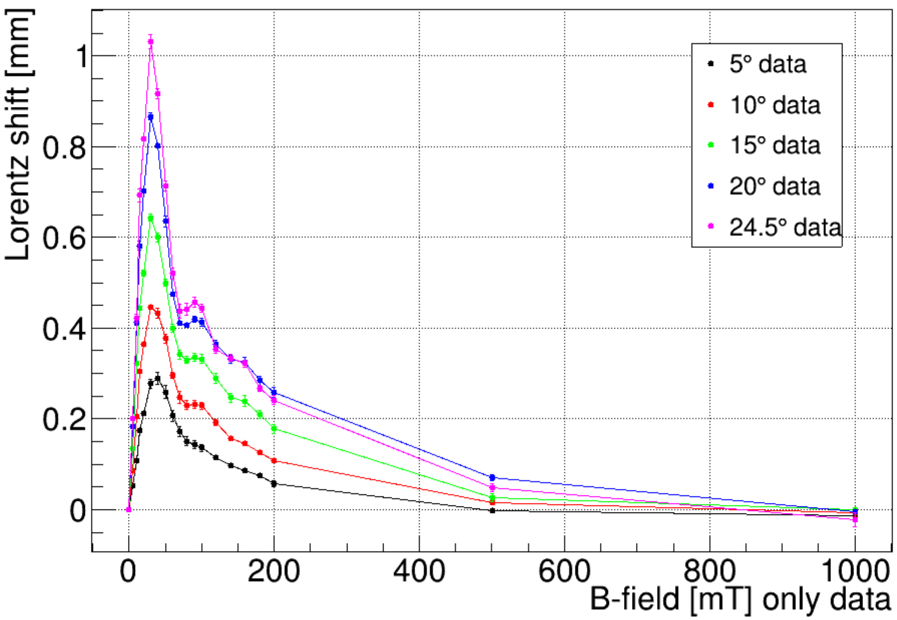
simulated hit positions @ 25deg tilt angle

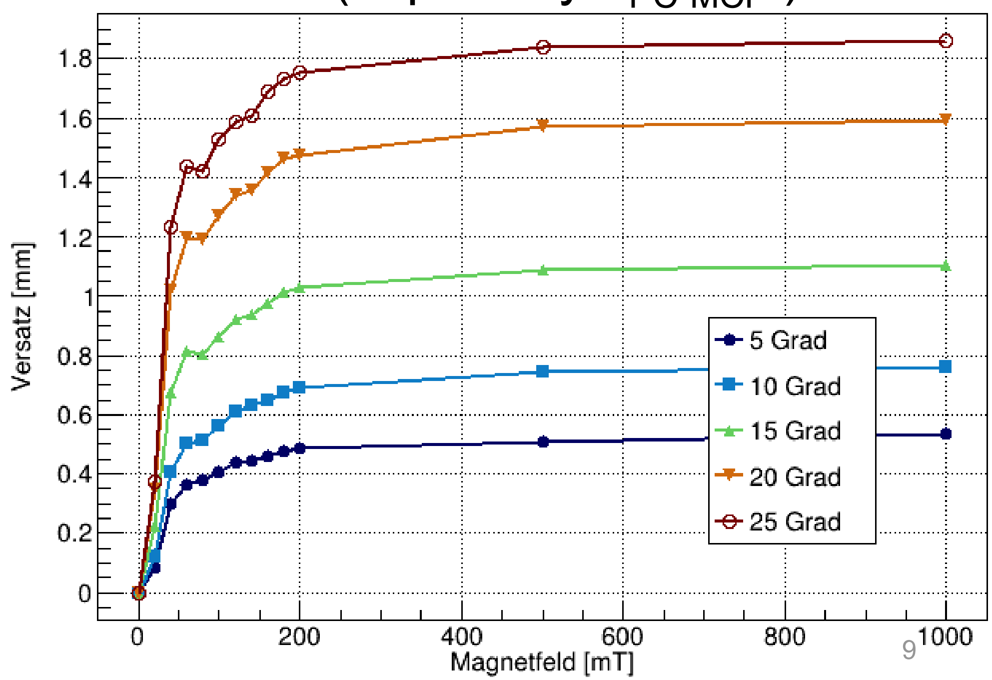



3D-view
x-projection
photo cathode
MCP plane (not simulated)
anode plane
simulation for 17.5 deg and 80mT
y-projection
z-projection
x

shifts of charge cloud centroid in B-field

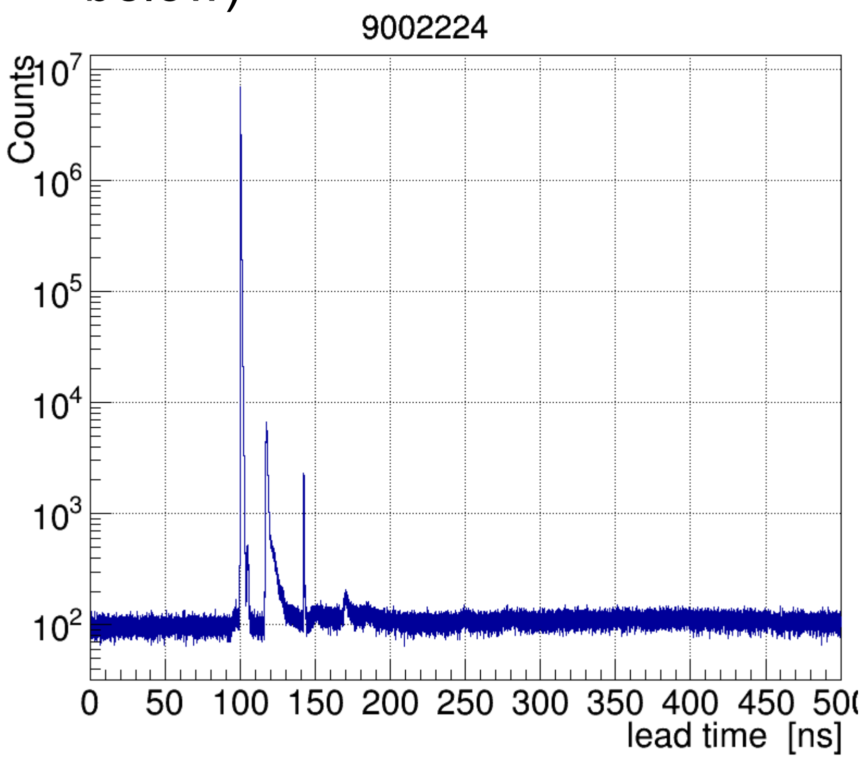
- measurement of Photonis 946P541 (3x100 pixels)
- **lorentz shift** and **geometrical shift** shown for different tilting angles below
- **lorentz shift** peaks at ~40mT and goes back to almost zero
- **geometrical shift** saturation starts at a few hundred mT, as expected
  - at 25° tilt angle, saturation at ~ 1.8 mm shift → 3 – 4 pixels shift for EDD
  - also at 15° tilt angle & 1 T B-field ~mm shift → geometrical shift not negligible for Barrel DIRC
- both depend on the inner dimensions of the tube (especially $d_{PC\text{-}MCP}$!)

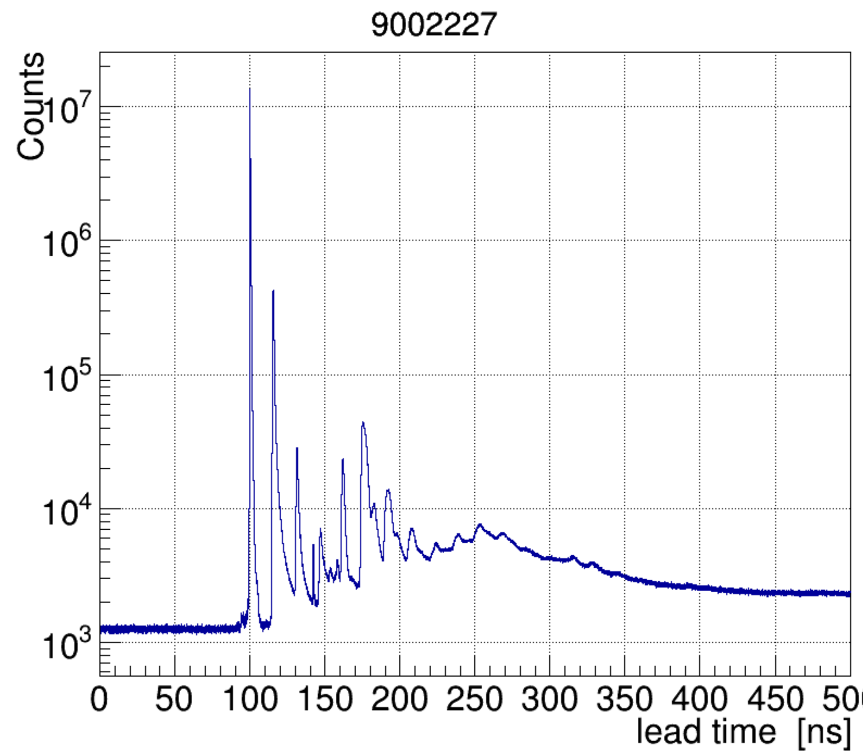




Afterpulsing of 9002224 and 9002227

- afterpulse ratio = probability of creating a feedback ion which produces an additional delayed signal
- probably bad impact on the lifetime → should be low
- looks very different for different tubes (see TRB-measurements below)

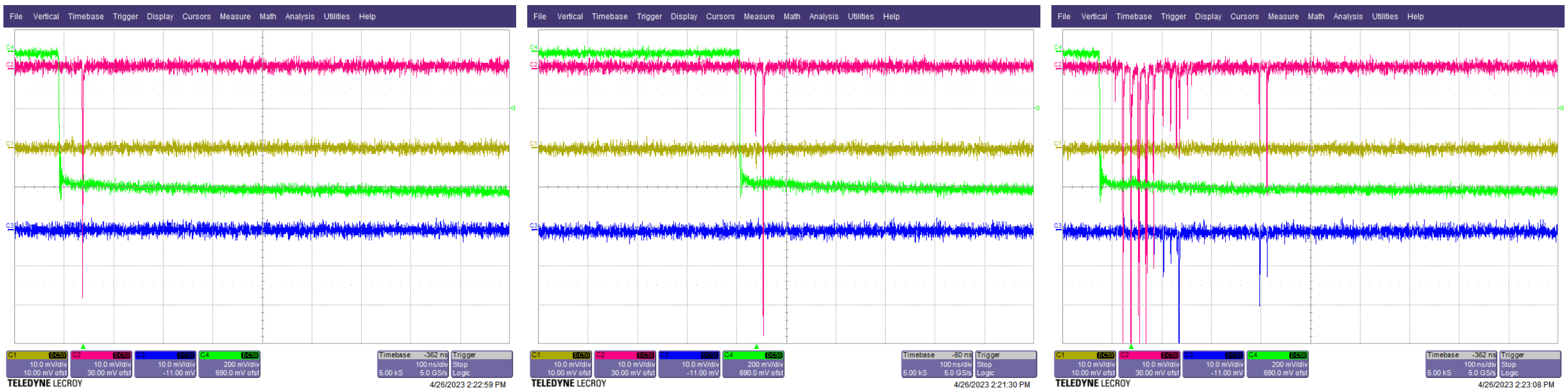




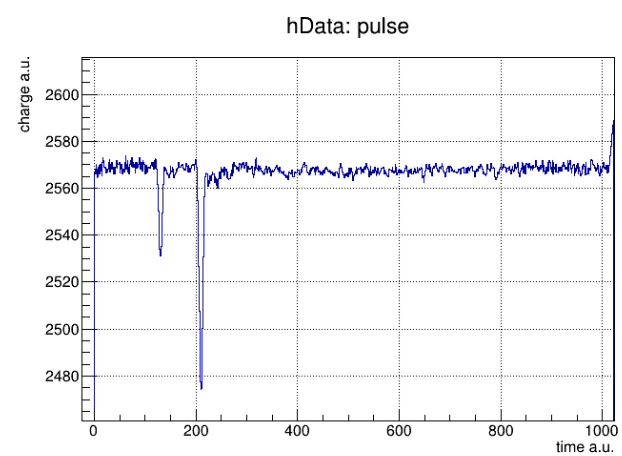
Comparison of 9002224 and 9002227 afterpulsing

- further investigation on very high afterpulsing of 9002227

scope screenshots of a normal (a little high) signal, a normal + afterpulse and multiple afterpulses



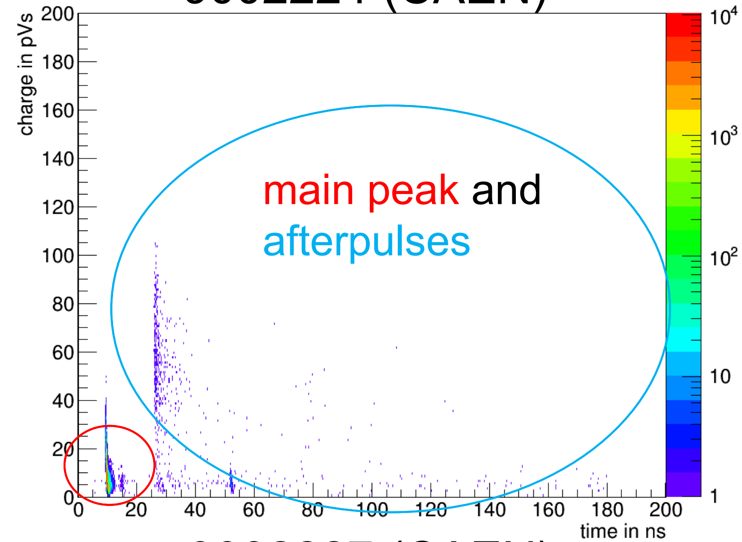
- non-bipolar pulses → indicates real afterpulses and no (electronic) crosstalk
- measuring waveforms with CAEN DT5742-digitizer
- analysis of pulse arrival time and charge



Comparison of 9002224 and 9002227 afterpulsing

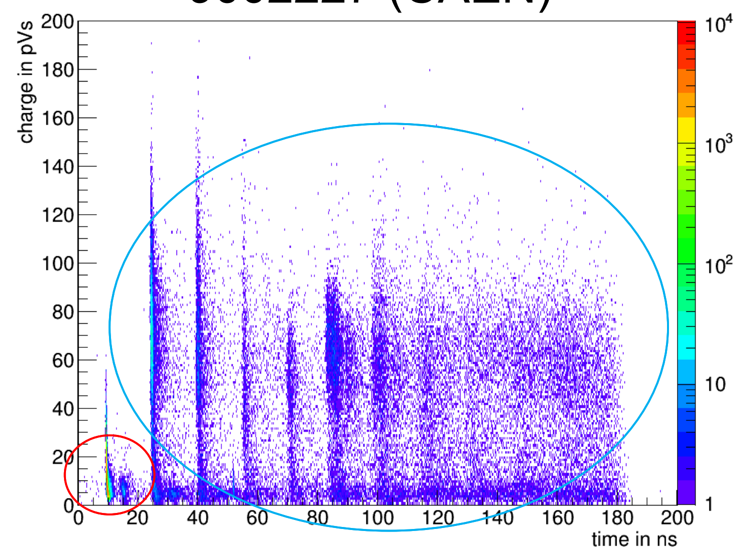
- illumination at one single position, readout of one complete row (CAEN) or complete sensor (TRB)
- charge vs arrival time of illuminated pixel for ~1e6 gain and 0T for 9002224 and 9002227 (CAEN)

9002224 (CAEN)



- a lot more entries for 9002227
- afterpulses: higher charge than main peak
- afterpulses have a chance of creating another feedback ion (and again and again) → equidistant stripes (~15 ns in this case)

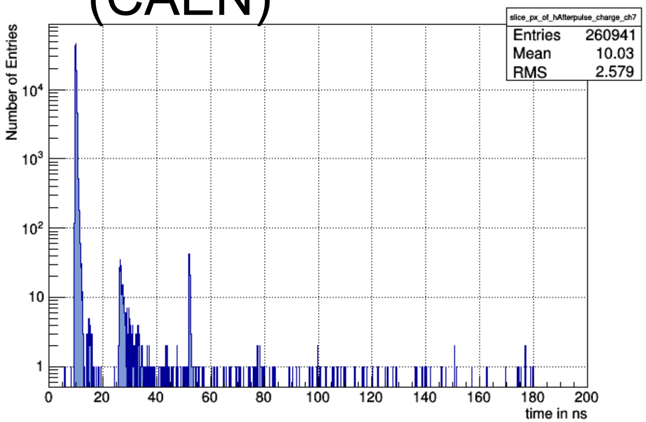
9002227 (CAEN)

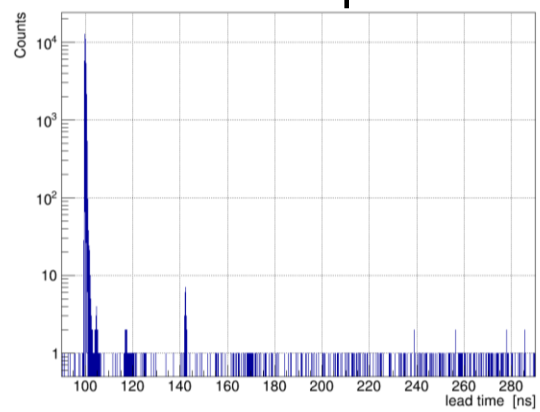


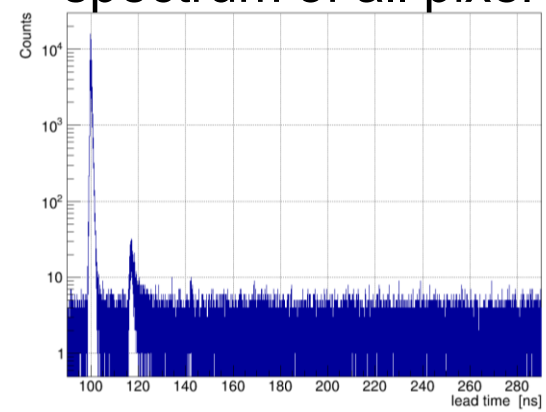
Comparison of 9002224 and 9002227 afterpulsing

projection to x-axis (CAEN) | TRB afterpulse spectrum of illuminated pixel | TRB afterpulse spectrum of all pixel

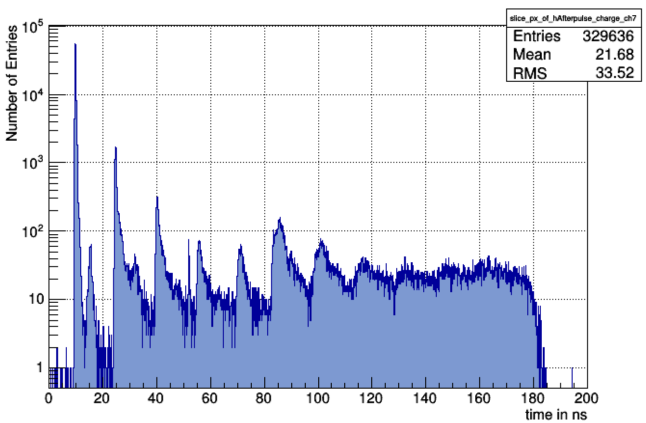
900 2224

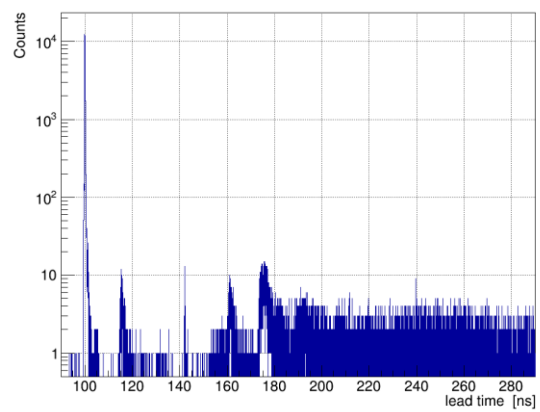


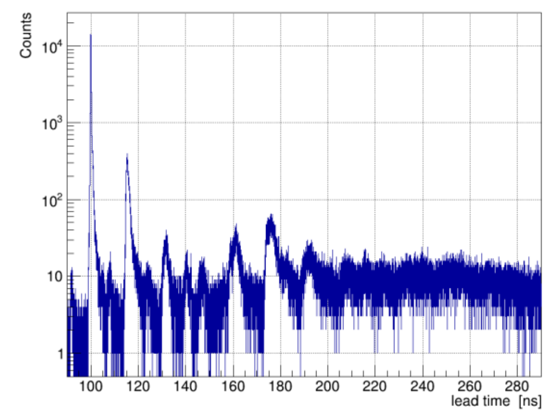




900 2227



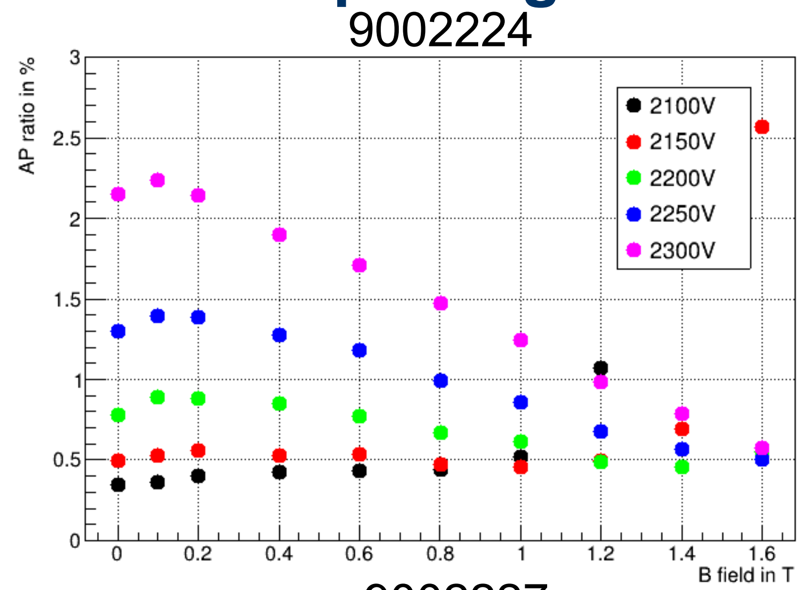


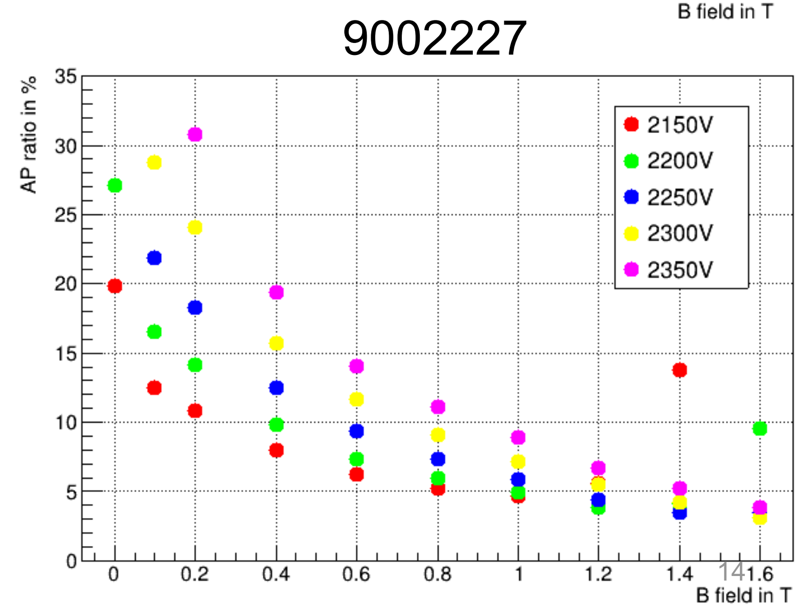


- same setup, but: TRB has 30 ns dead time after hit → 1 pixel spectrum not useful, better: use of all pixel but possibility of counting one afterpulse ion multiple times

Comparison of 9002224 and 9002227 afterpulsing

- afterpulse ratio (CAEN) for different magnetic fields and voltages
- missing first points for 9002227 are due to escalation
- „rising“ afterpulsing for high magnetic fields is due to threshold effect (main peak is below threshold, while afterpulses are still above)
- higher afterpulse ratio for higher voltage and smaller B-field
  → afterpulse ratio depends mainly on gain (not voltage!)





Summary

- first try of measuring the time constant of MCPs with the double pulse method
- gain in B-field looks as expected
- shifts in x- and y-direction in magnetic fields (Lorentz and geometrical) are now understood
- high afterpulse ratio of 9002227 caused by real afterpulses, not (electronic) crosstalk or backplane effects etc.
- there is still a lot of data from Jülich to be analyzed
  - voltage and magnetic field dependent AP-ratio with the TRB-system
  - convert voltage and magnetic field information to a gain information to get the gain dependent AP-ratio
  - cuts on neighboring pixels to look for crosstalk waveforms with the CAEN system
  - …

Thank you for your attention!

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