Performance studies of Micromegas Detectors with Pad-Readout

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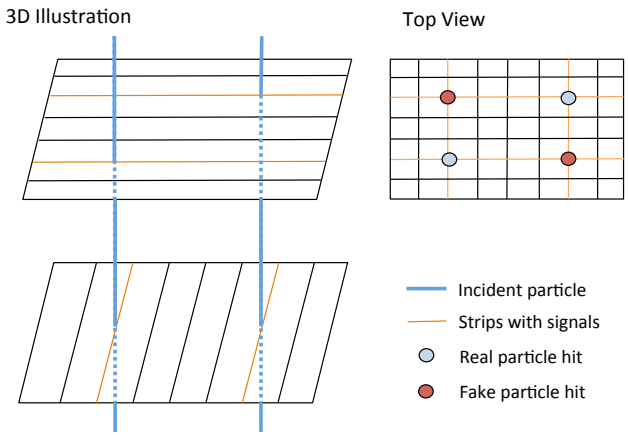
Outline

Motivation

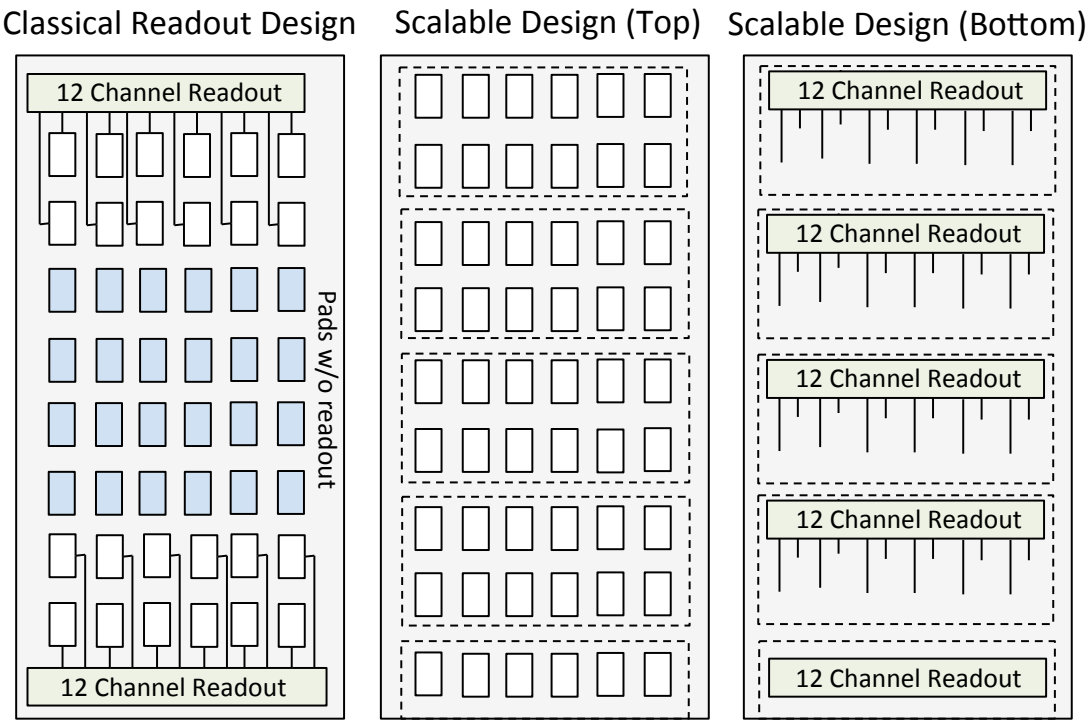
Ambiguities

- high rates lead to ambiguities in hit association in different layers of the chamber
  $\rightarrow$ Pad readout structure to solve ambiguities



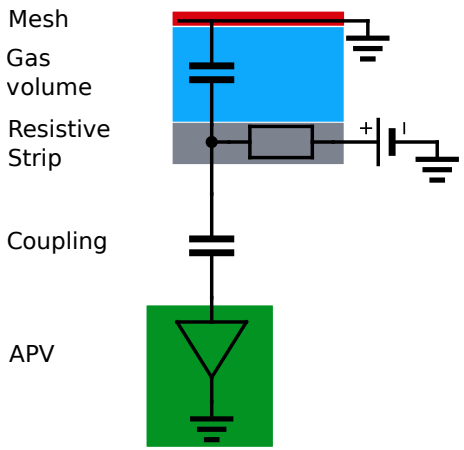
Design of the Pad Detectors

- 10*10 cm active area
- 500 pads in 20*25 grid
- pad size: 5*4 mm^2
- distance between pads: 300 μm
- readout connection on backside to allow scalable design



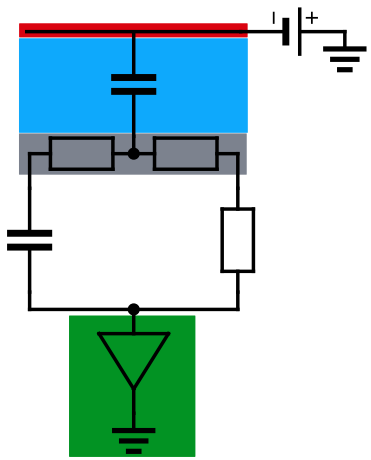
Couplings in the Pad Detectors

Capacitive Coupling (CC)



- standard capacitive coupling between resistive layer and readout layer
- charge spreads over resistive layer

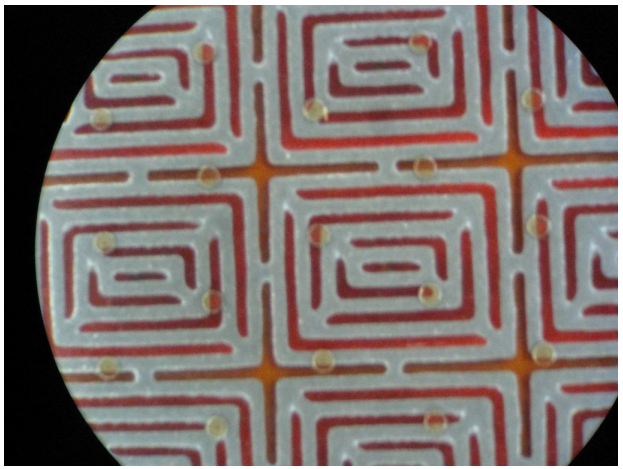
Resistive Coupling (RC)



- resistive coupling between resistive layer and readout layer
- independent grounding of each resistive pad over readout layer

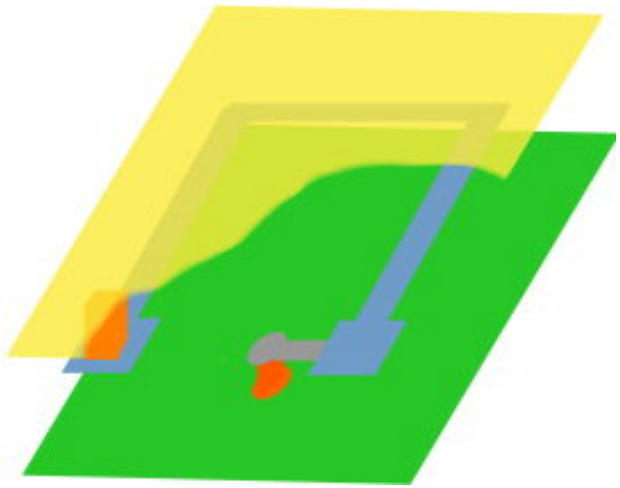
Realization of the Pad Detectors

Capacitive Coupling



- resisitive layer in maze shape to reduce charge spread between pads

Resistive Coupling

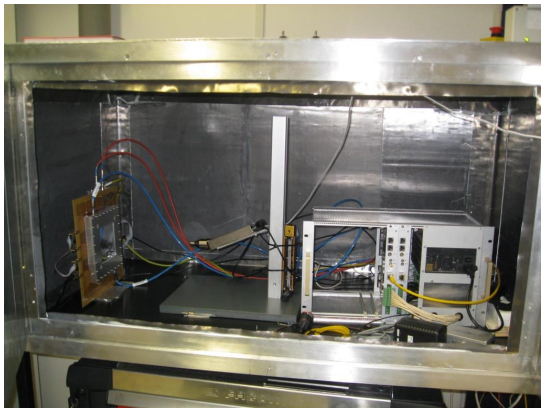


- intermediate resistive layer as connection between resistive pad (yellow) and readout pad (green)

Measurements

Setup

- Ar:$C0_2$ (93:7) with 3 l/h
- readout: APV25 with SRC and mmdaq
- source: Amptek Mini X-Ray tube



Voltage Scan

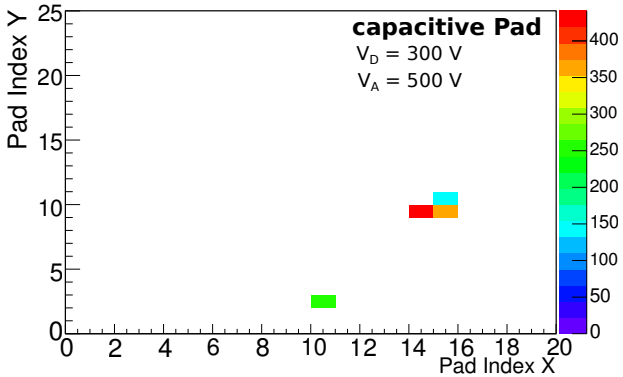
- drift voltage: 100 V, 200 V, 300 V, 400 V
- amplification voltage:
  - capacitive pad: 475 V, 500 V, 525 V
  - resistive pad: 450 V, 475 V, 500 V

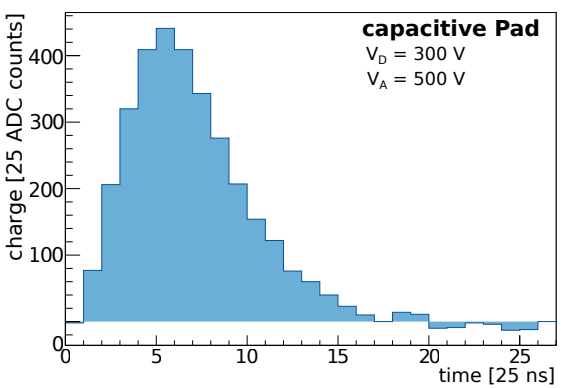
High Rate Test

- current in x-ray tube: 5 μA, 50 μA, 100 μA, 150 μA, 200 μA

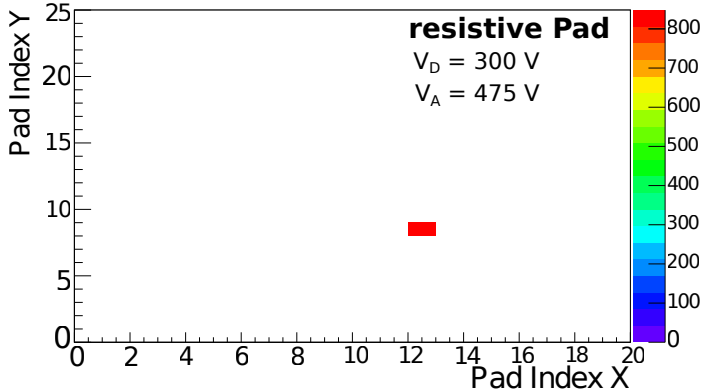
Signal Shape

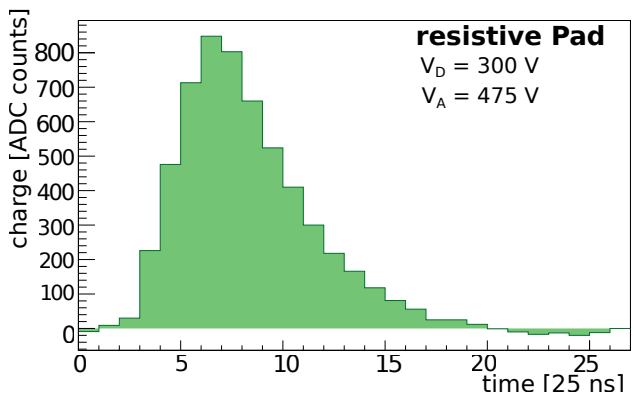
capacitive coupling





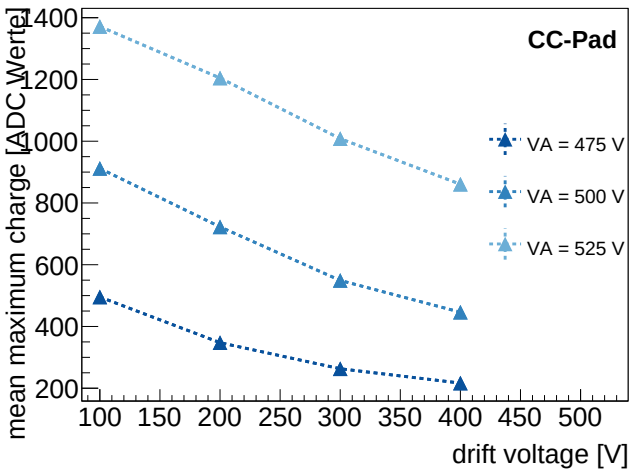
resistive coupling



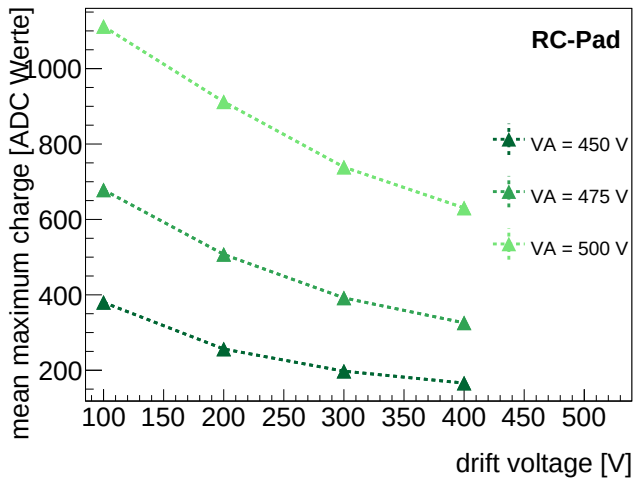


Voltage Scan - Maximum Charge

capacitive coupling



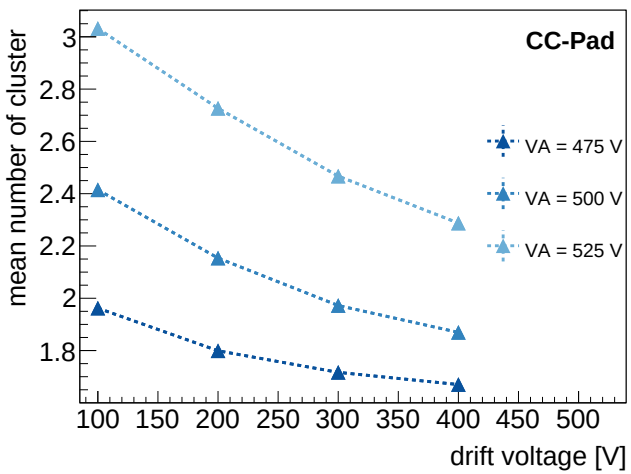
resistive coupling



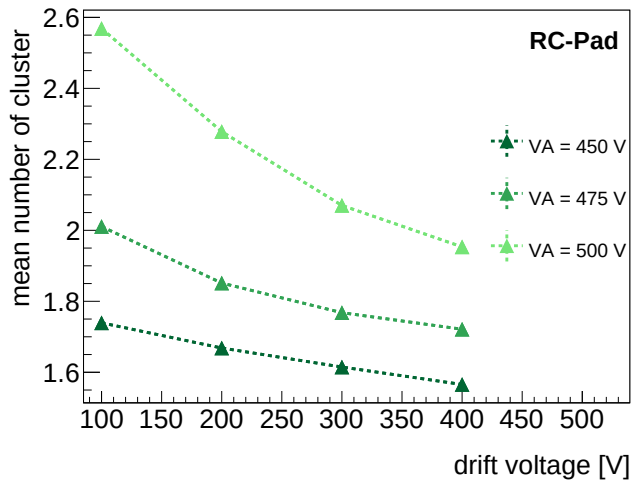
- rise of charge with amplification voltage
- drop of charge with rise of drift voltage $\rightarrow$ reduced mesh transparency
- higher charge in capacitive coupled detector

Voltage Scan - Number of Cluster

capacitive coupling



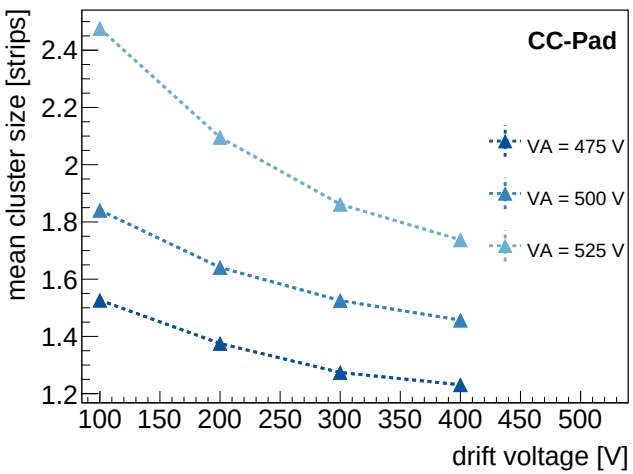
resistive coupling



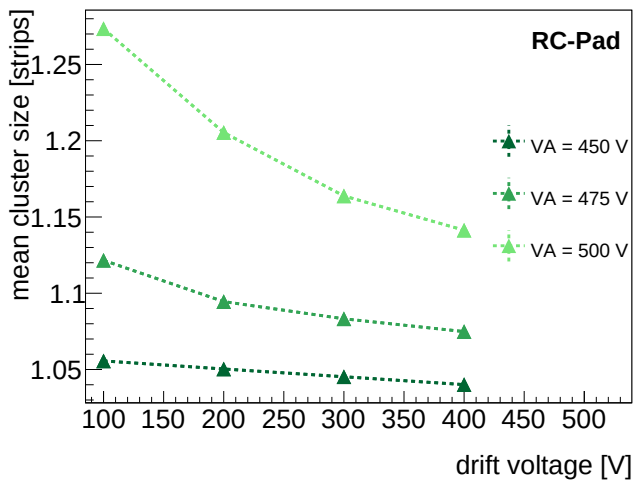
- less cluster for smaller charge
- difference in number of cluster between both detectors correlated with difference in charge

Voltage Scan - Cluster Size

capacitive coupling



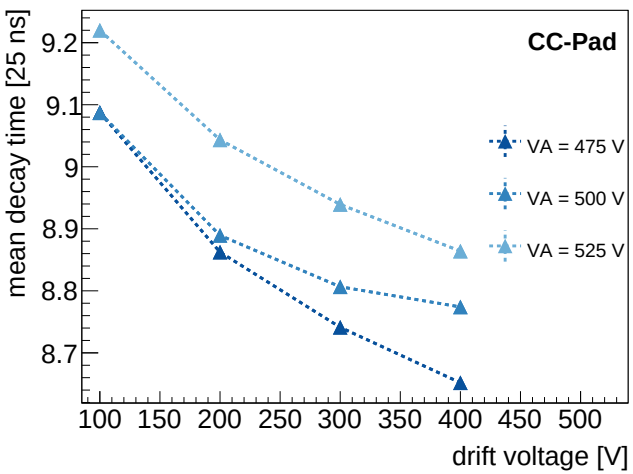
resistive coupling



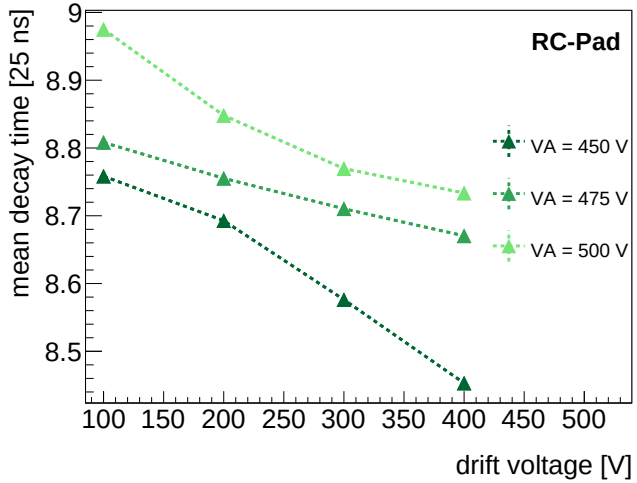
- rise of cluster size with maximum charge
- larger cluster size in capacitive coupled detector $\rightarrow$ spread in resistive layer

Voltage Scan - Decay Time

capacitive coupling

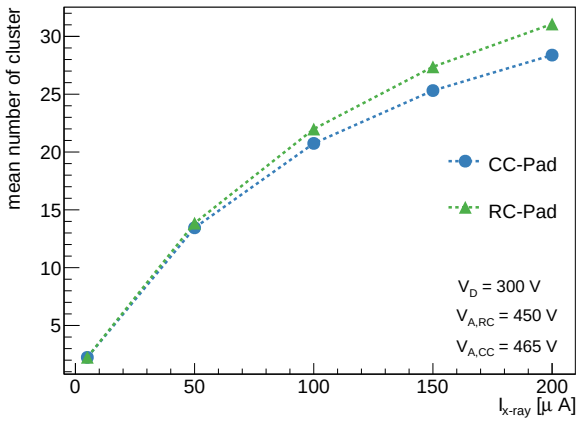


resistive coupling

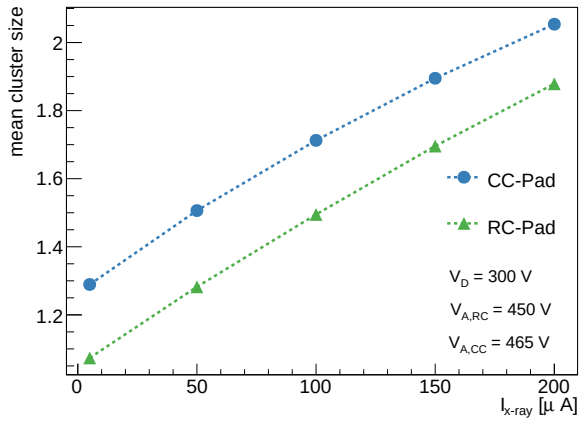


- correlation of decay time with maximum charge
- less difference for last two drift voltages

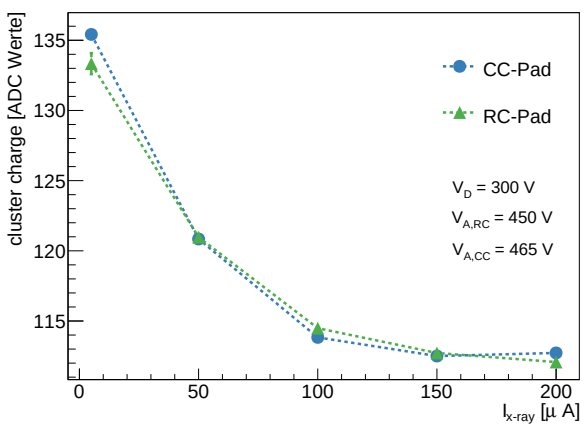
High Rate Test



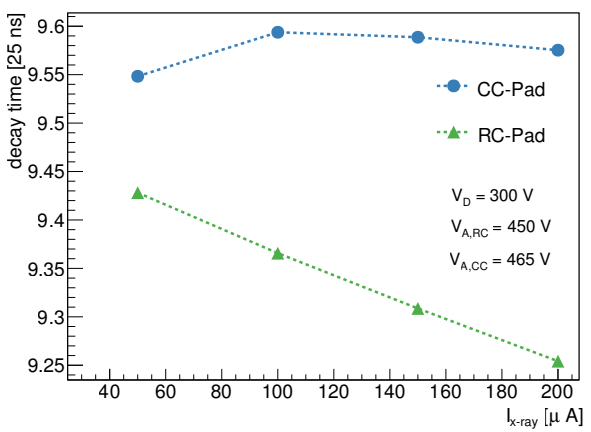
(a) number of cluster



(b) cluster size



(c) cluster charge

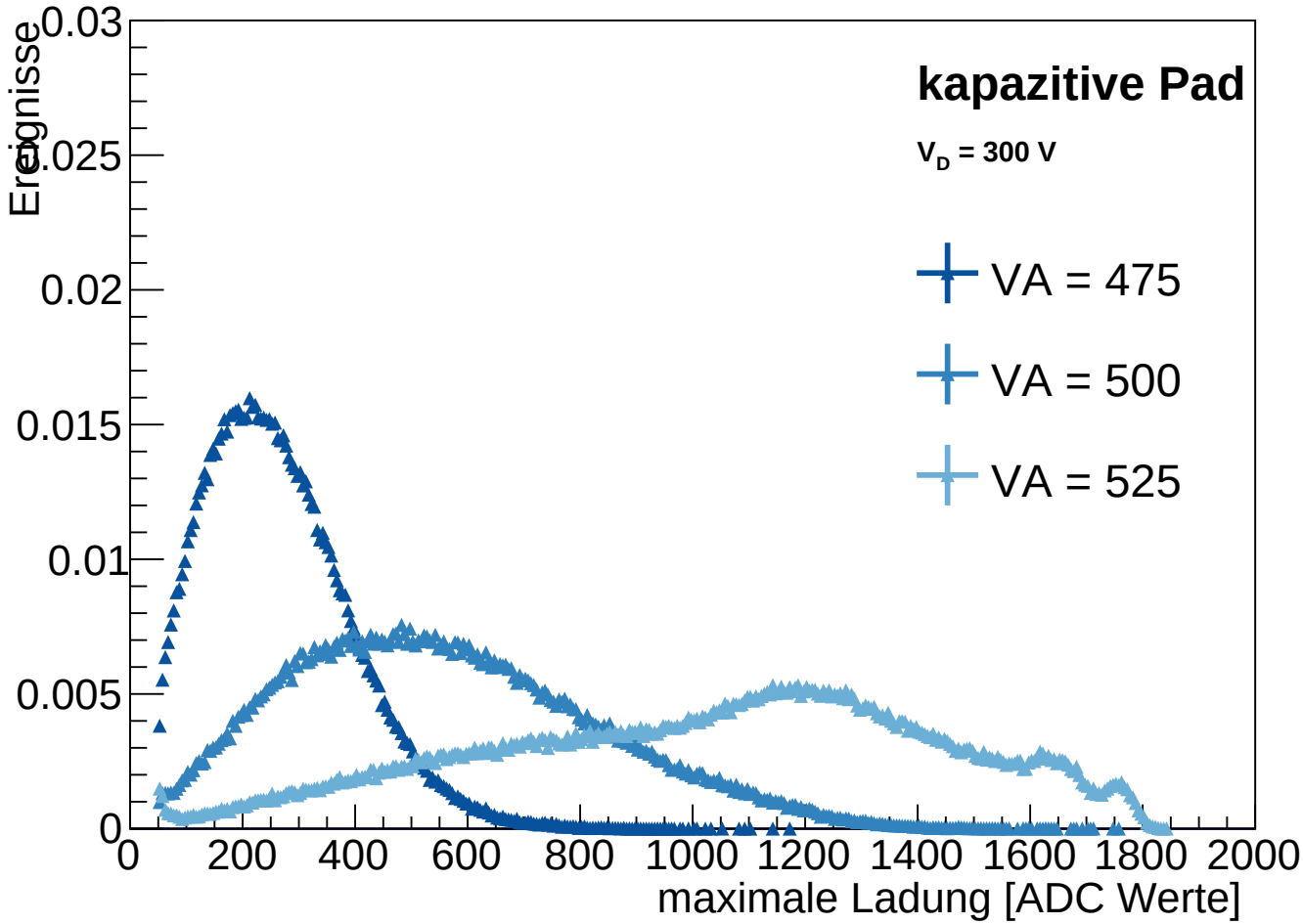


(d) decay time

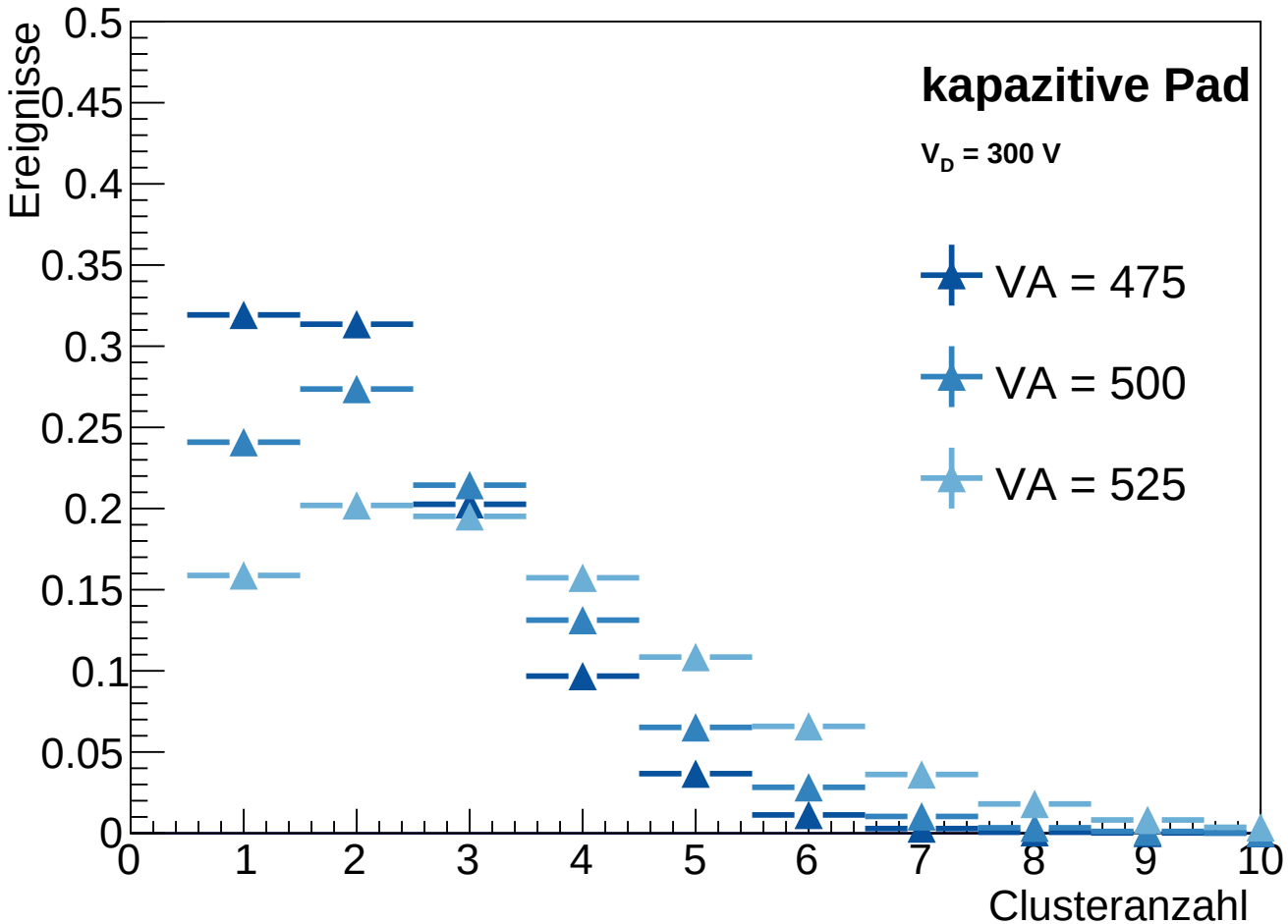
Conclusion

- ideal drift voltage for high rate usage: 300 V
- amplification voltage has to be adjusted to incident radiation
- smaller cluster size in resistive detector $\rightarrow$ no charge spread in decoupled resistive layer
- better high rate capability of resistive detector:
  - faster decay time
  - more stable cluster reconstruction

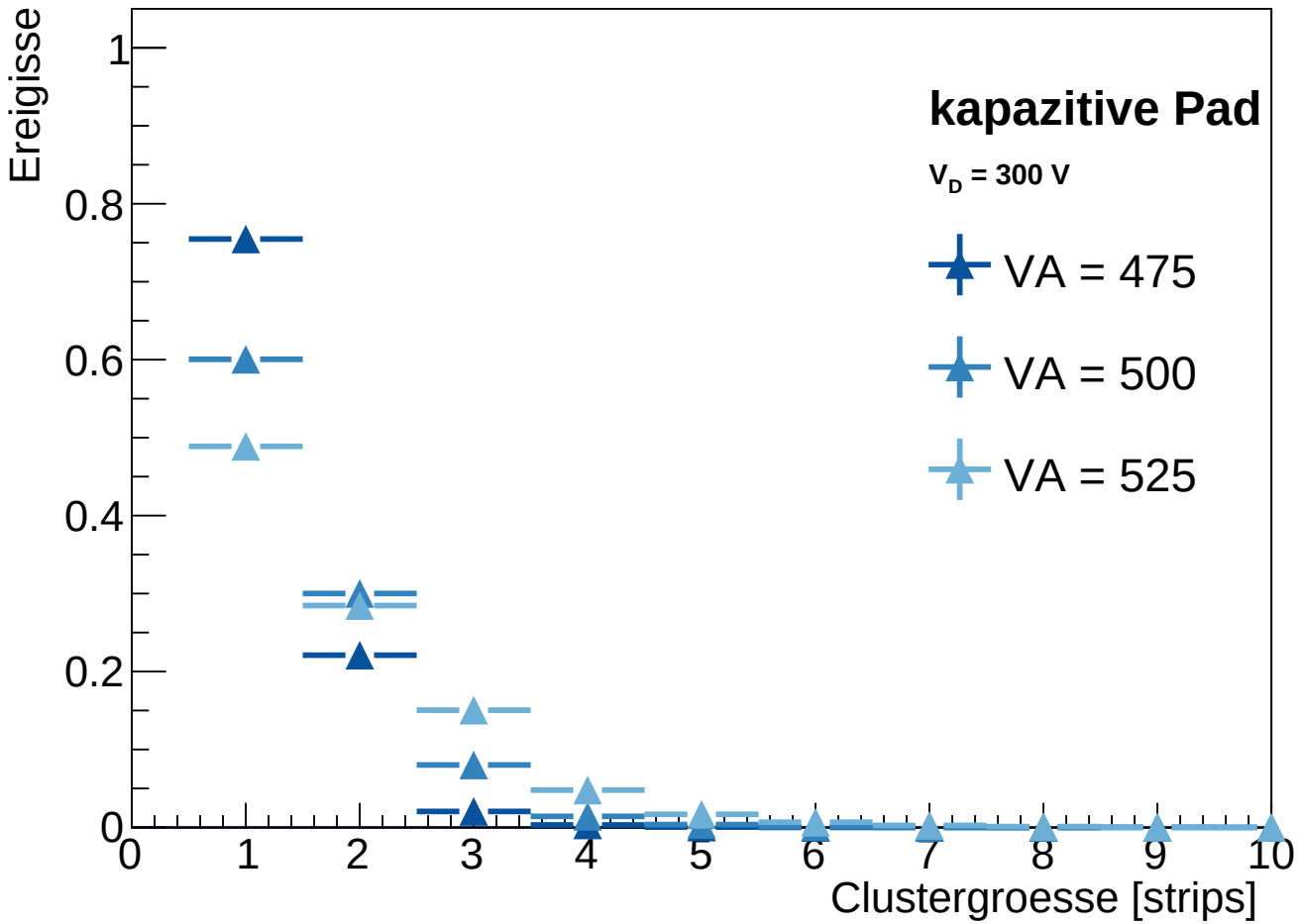
CC-Pad - Voltage Scan - Max. Charge



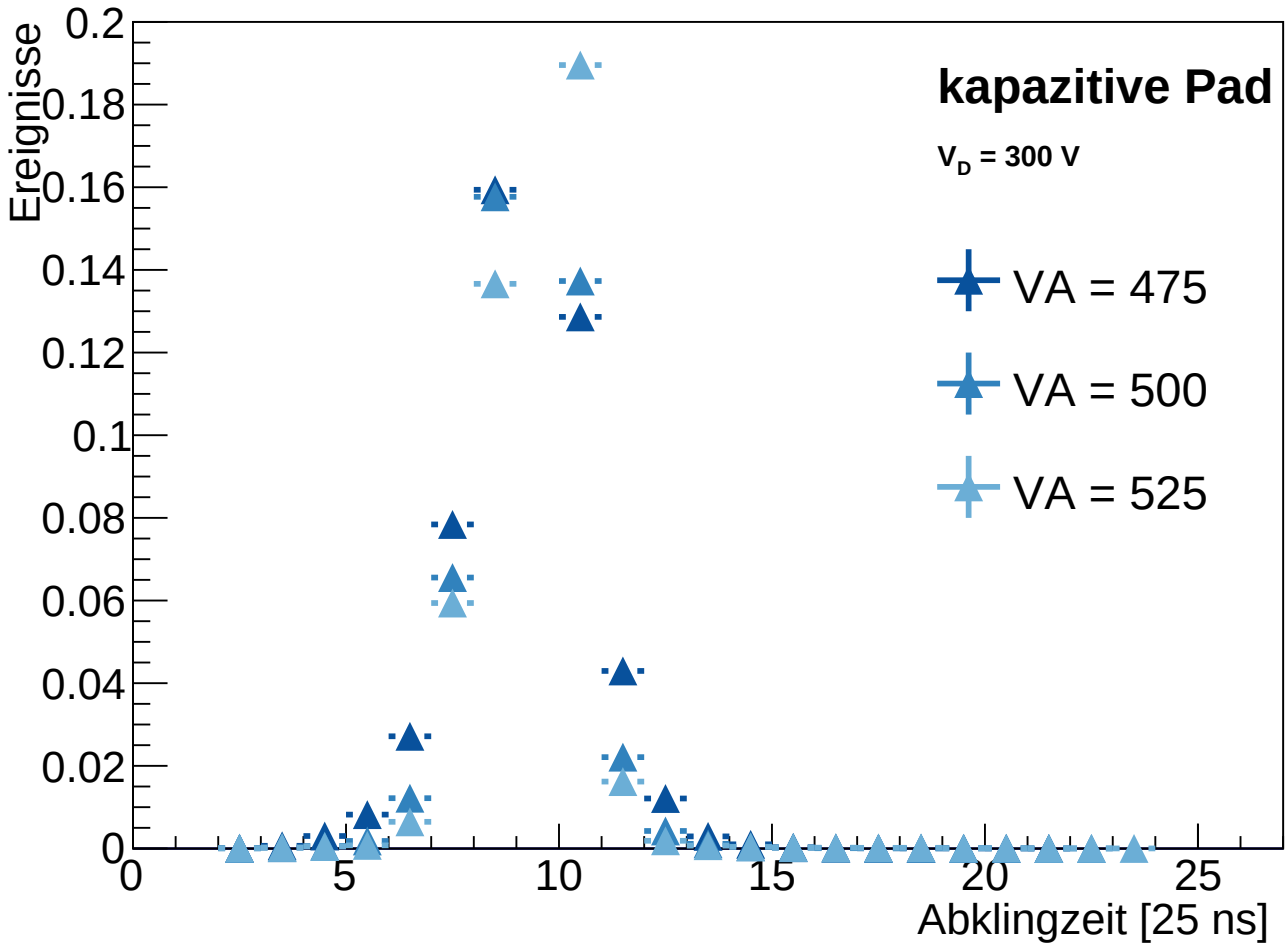
CC-Pad - Voltage Scan - Cluster Number



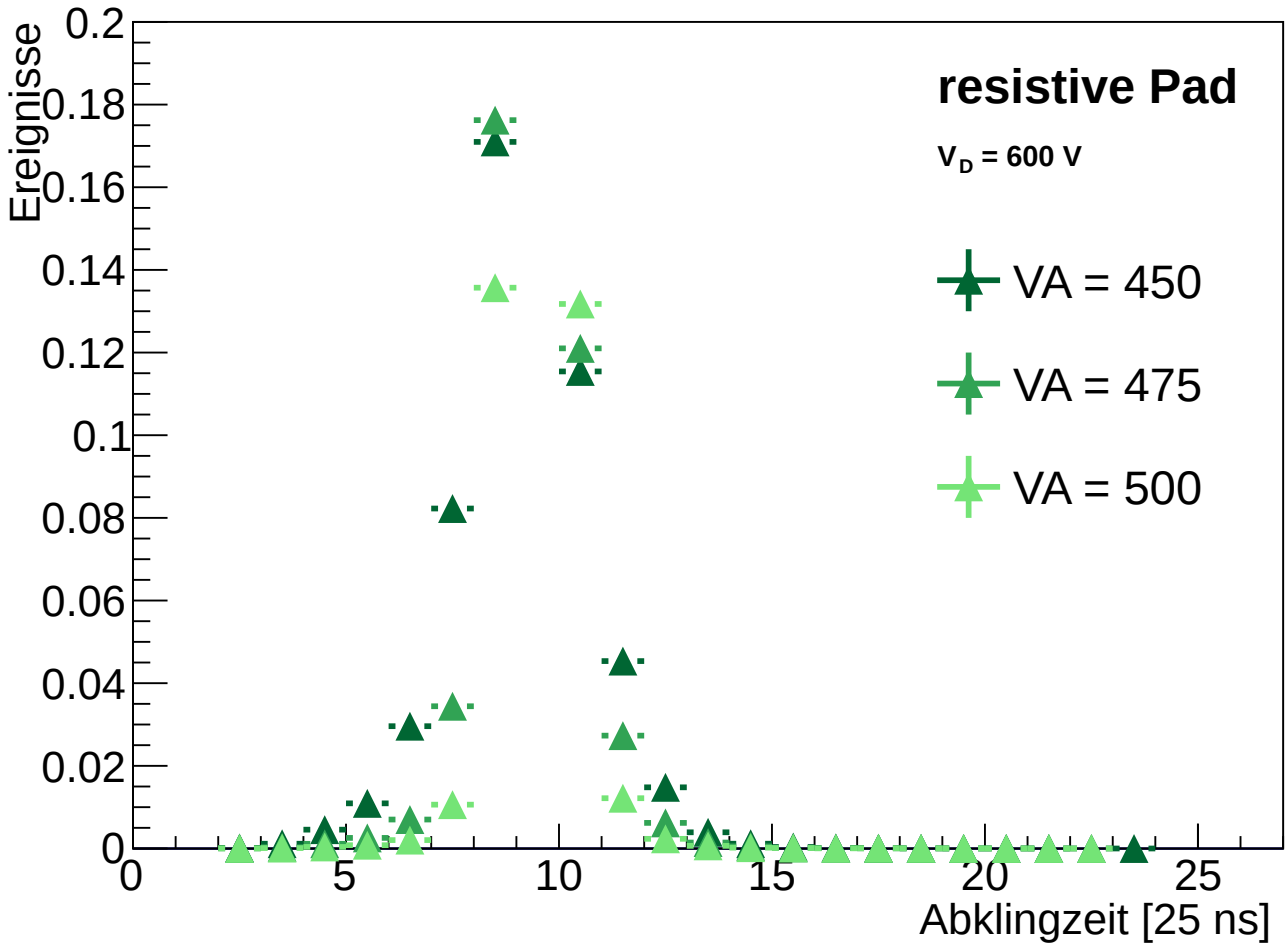
CC-Pad - Voltage Scan - Cluster Size



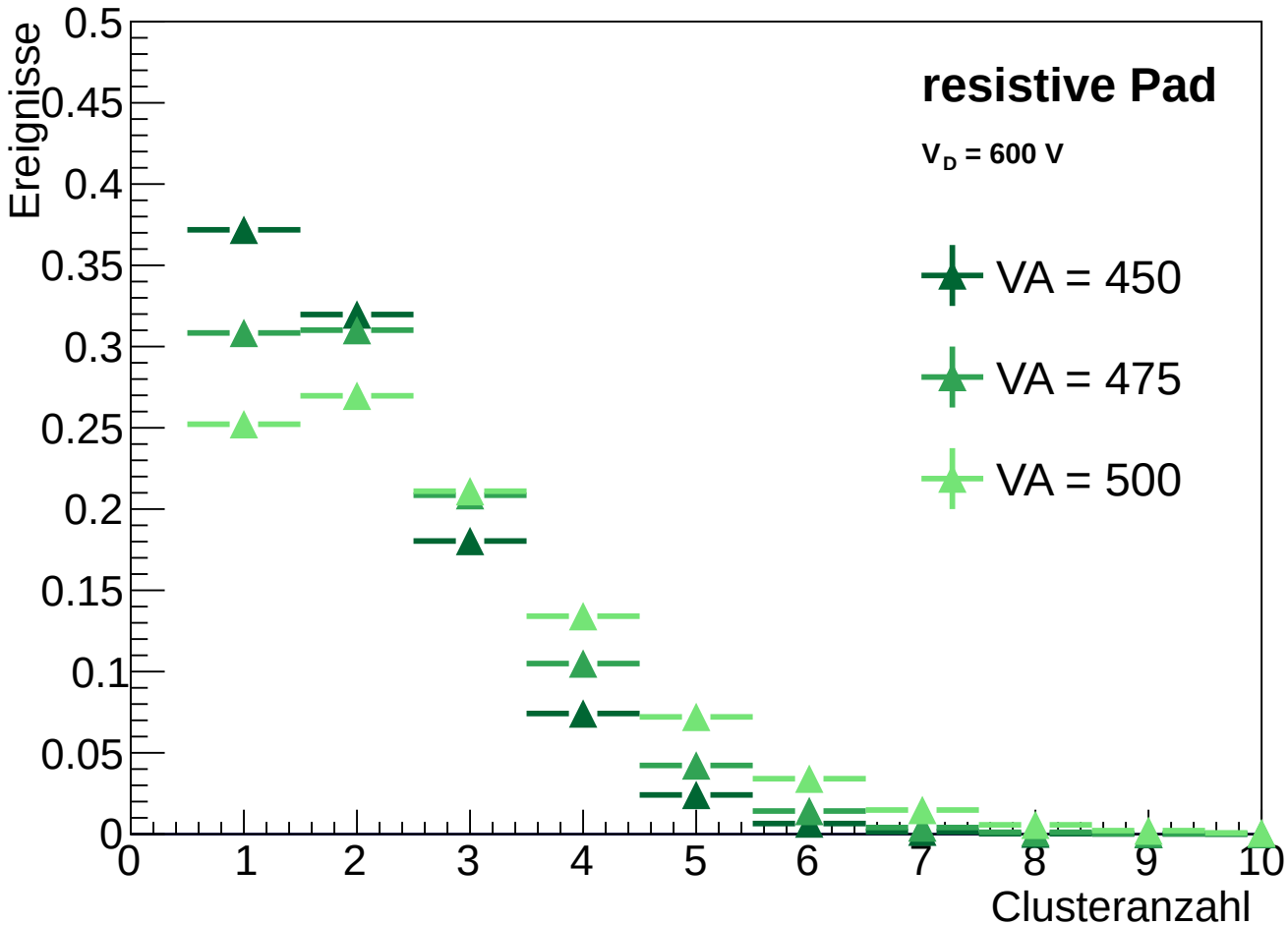
CC-Pad - Voltage Scan - Decay Time



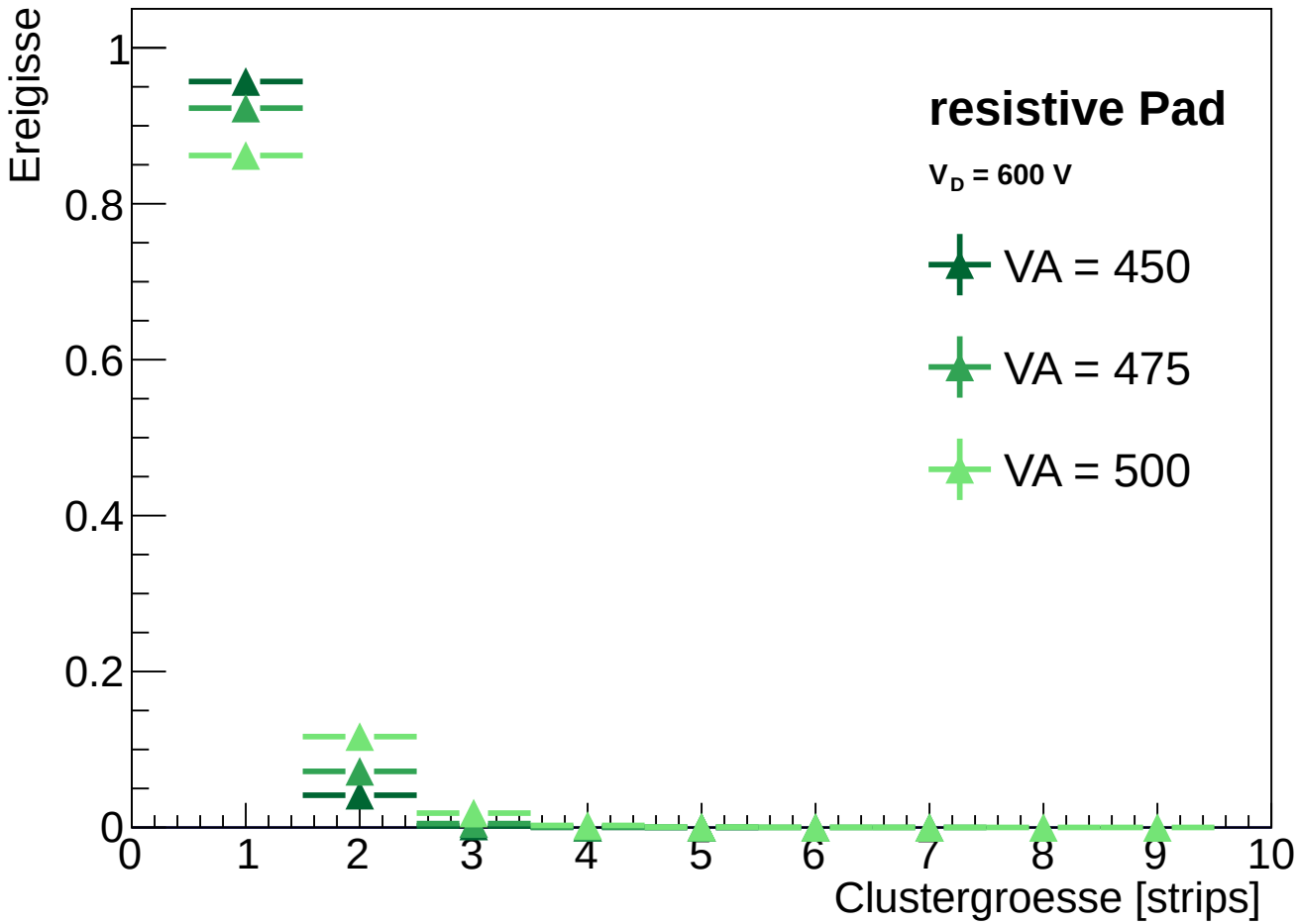
RC-Pad - Voltage Scan - Decay Max. Charge



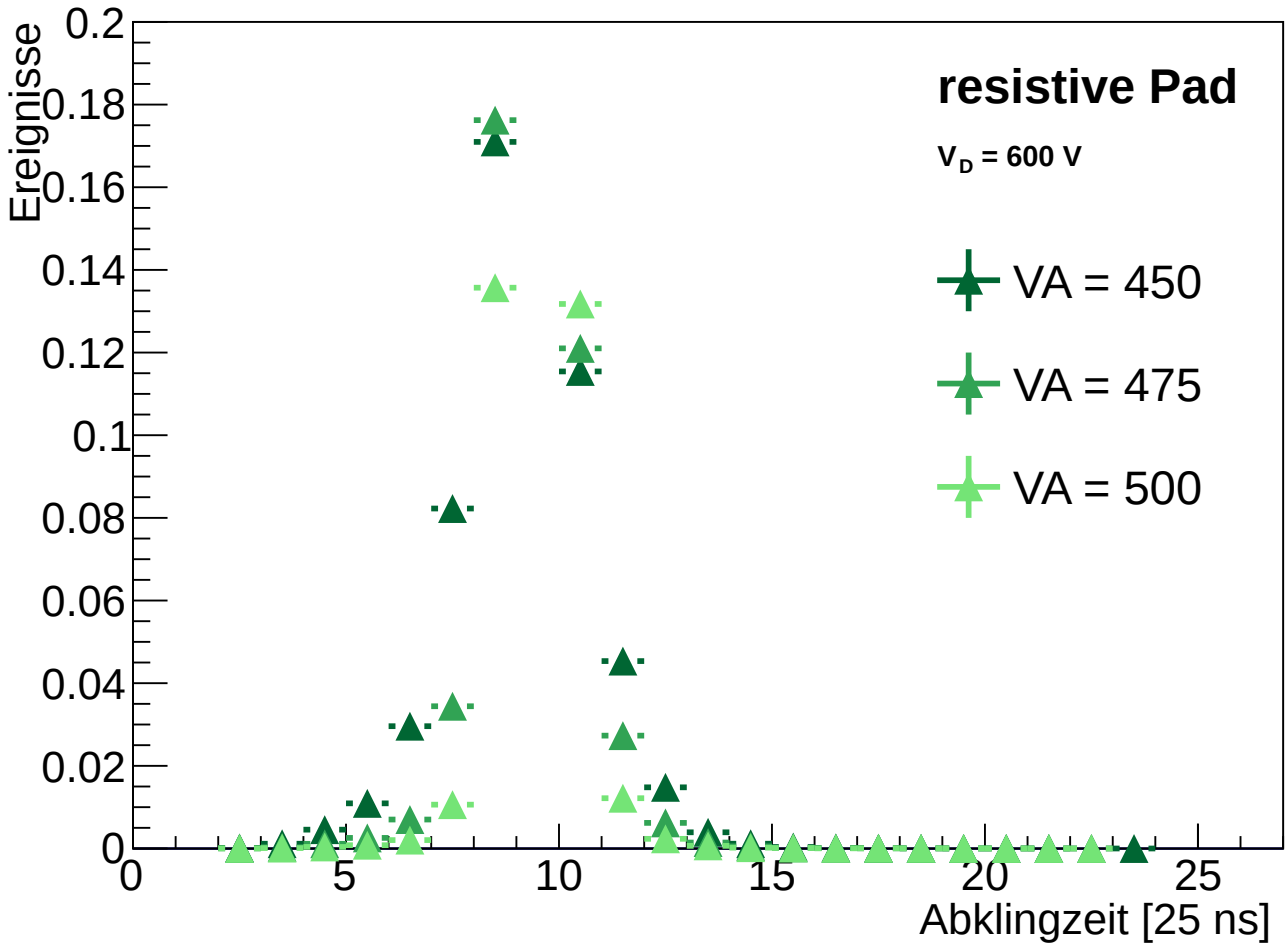
RC-Pad - Voltage Scan - Cluster Number



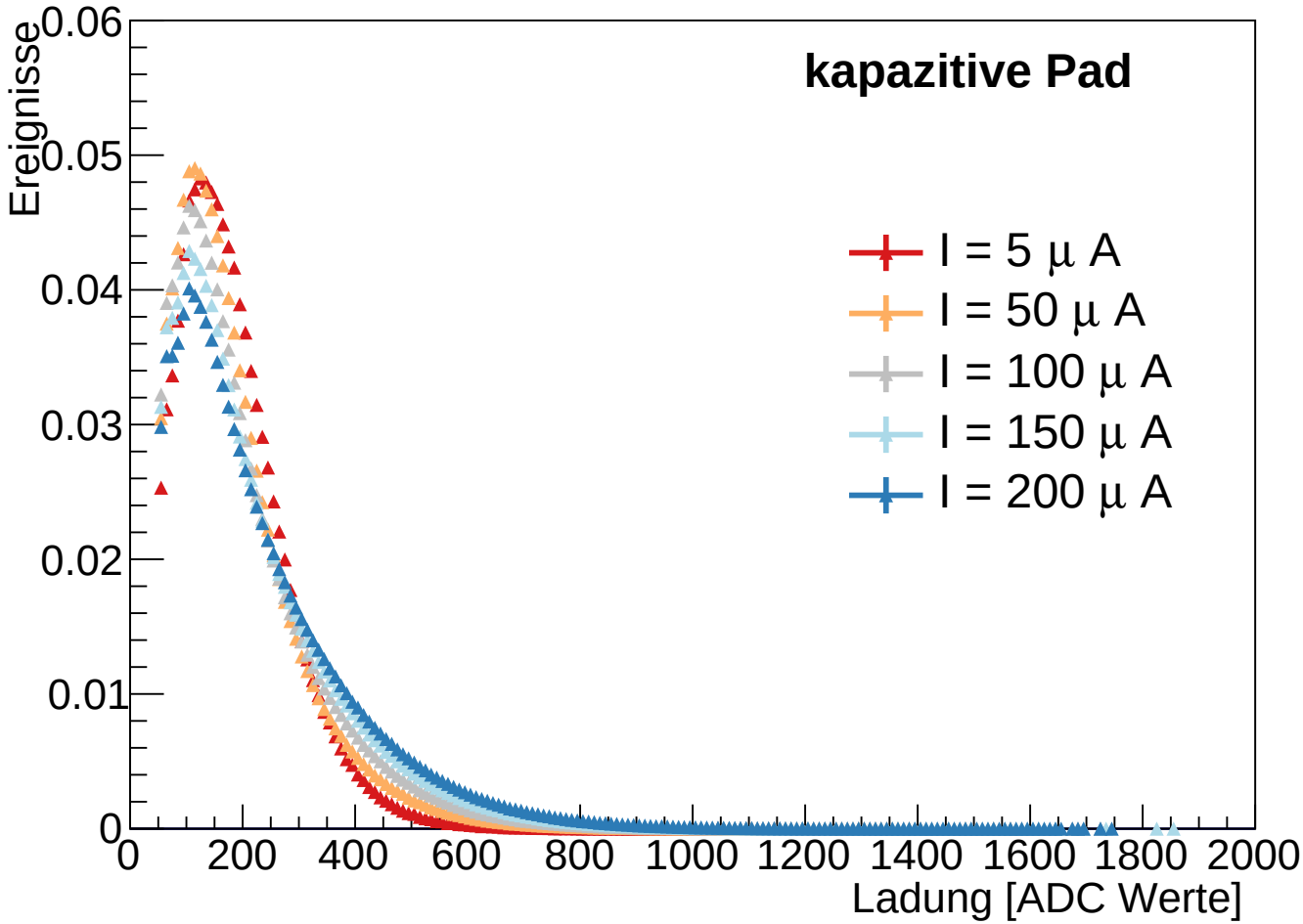
RC-Pad - Voltage Scan - Cluster Size



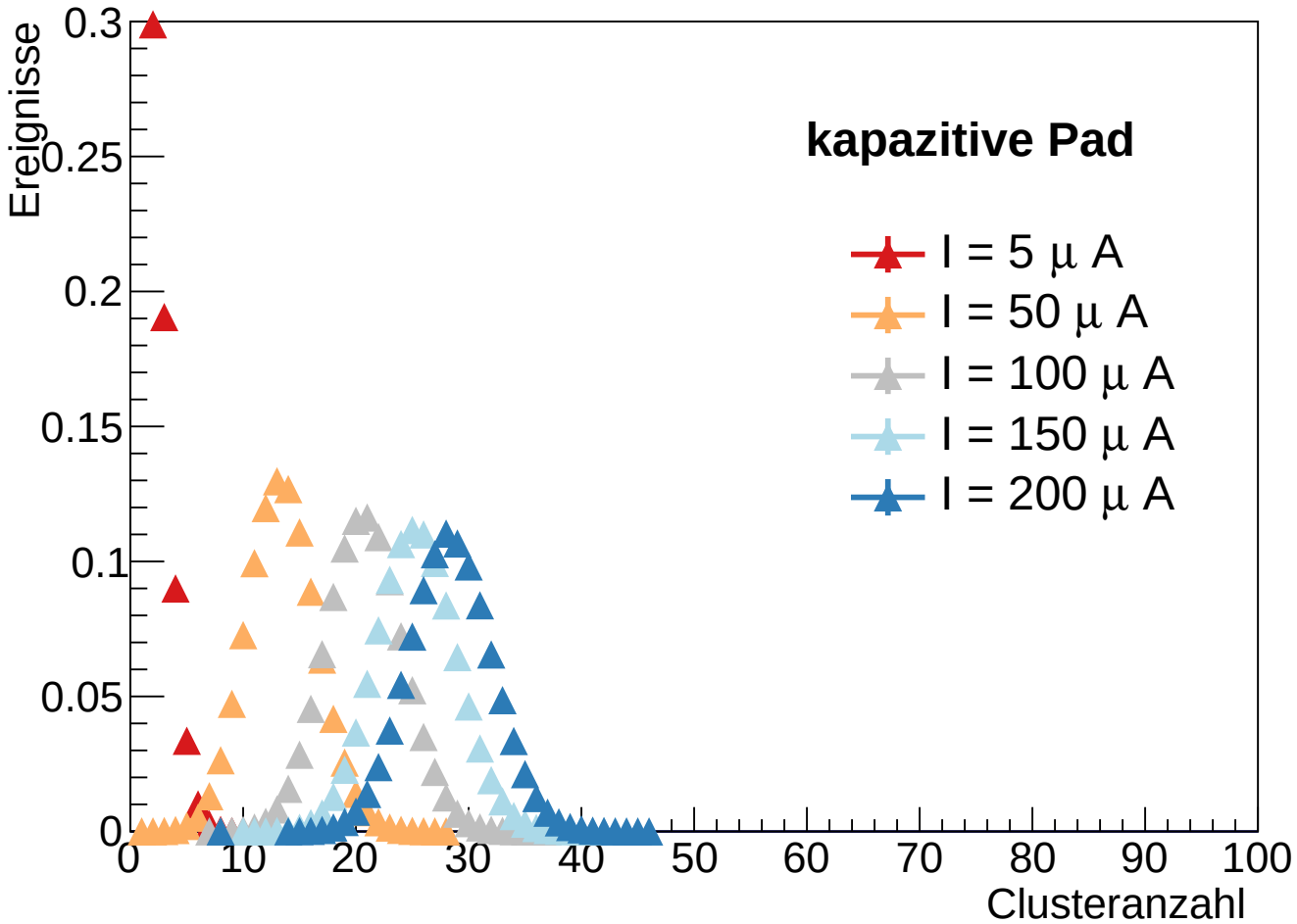
RC-Pad - Voltage Scan - Decay Time



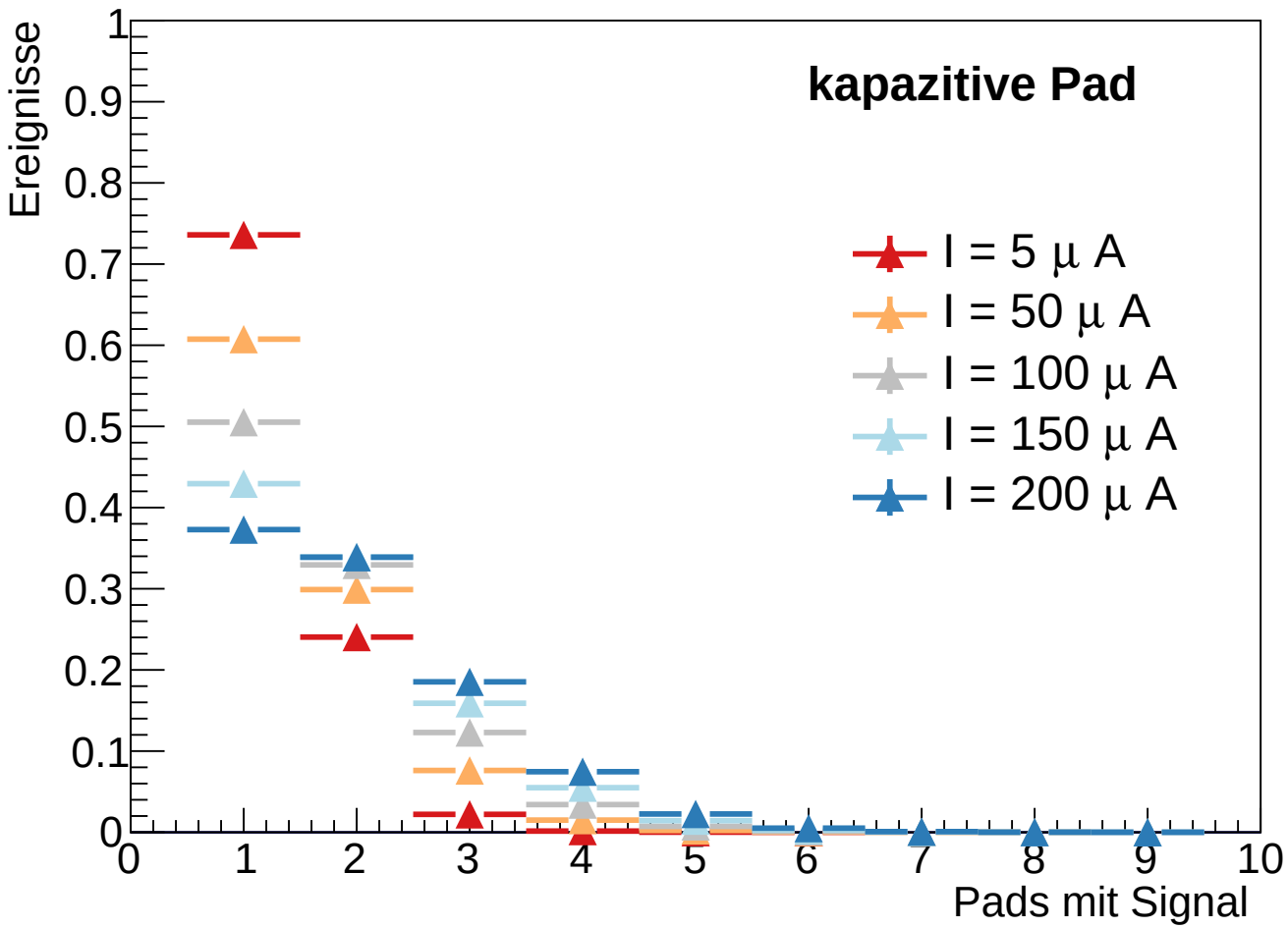
CC-Pad - High Rate - Max. Charge



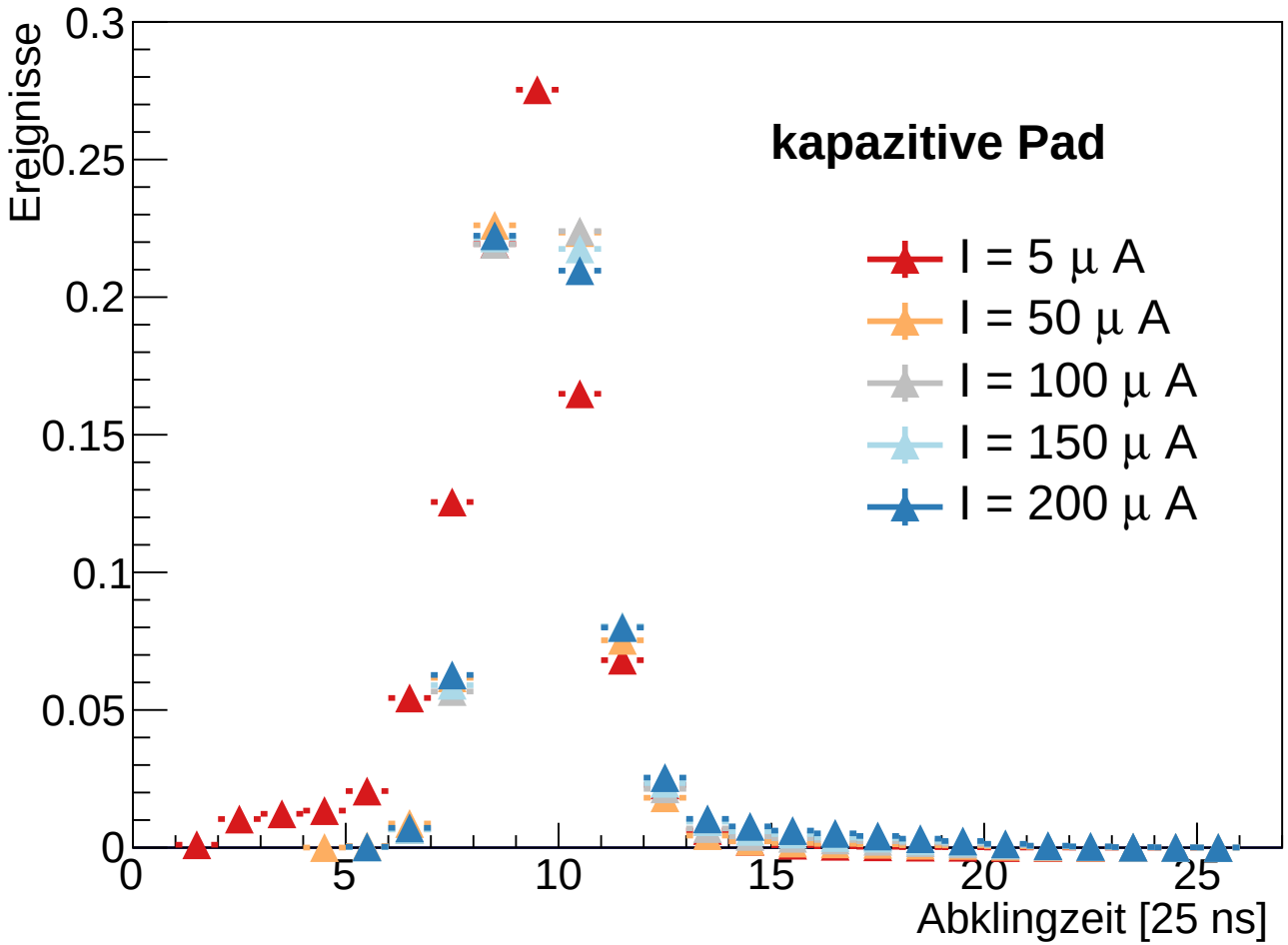
CC-Pad - High Rate - Cluster Number



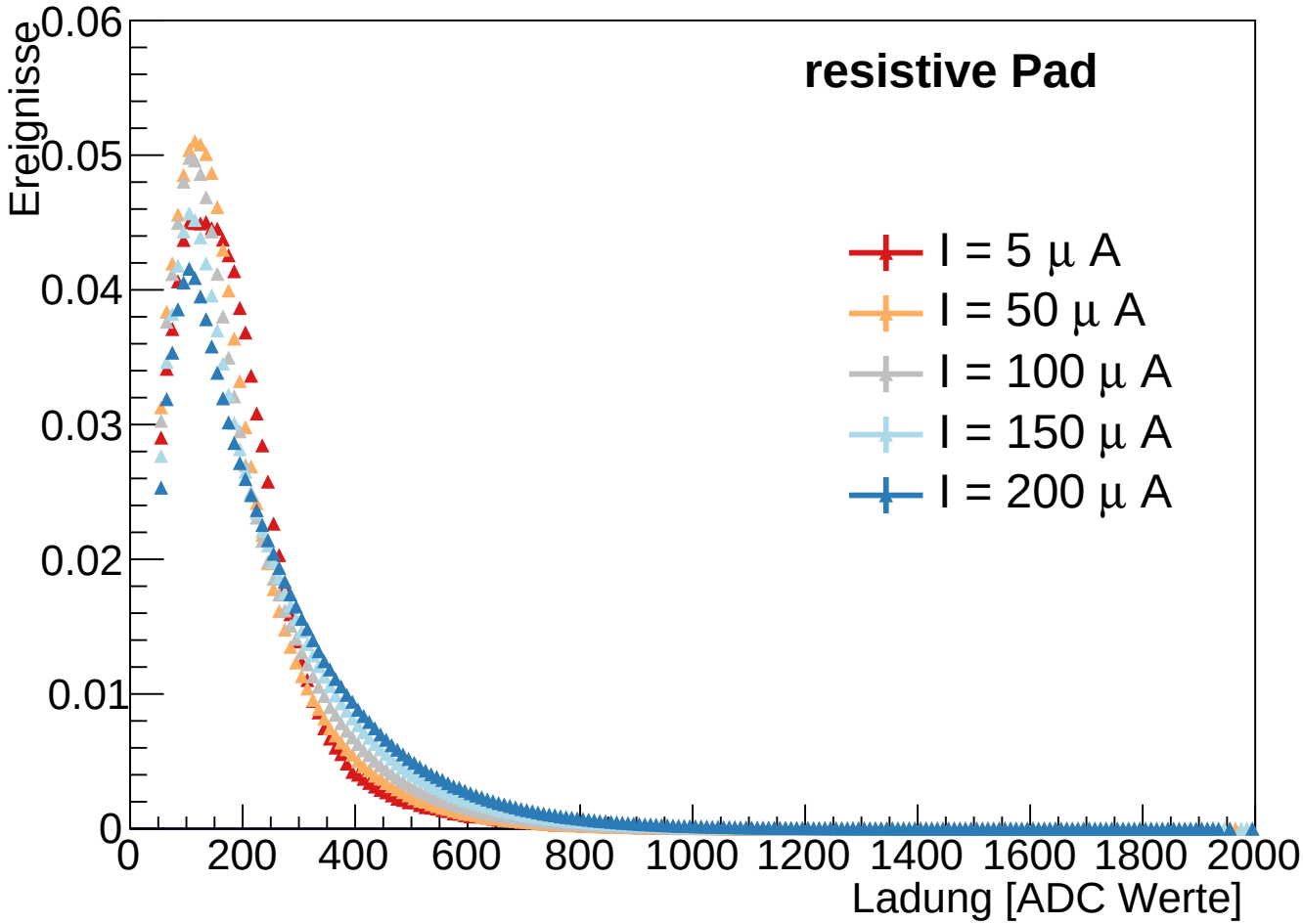
CC-Pad - High Rate - Cluster Size



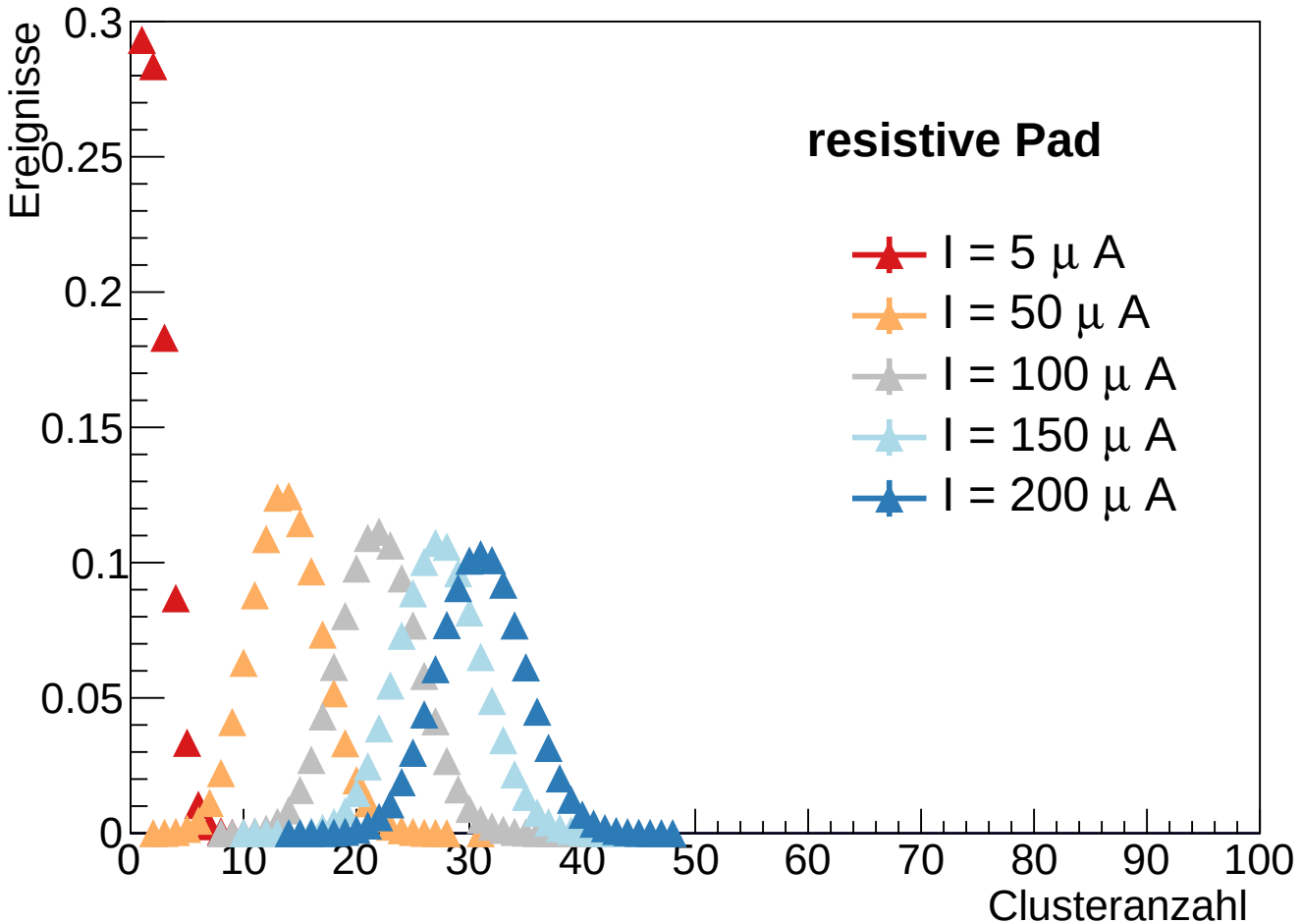
CC-Pad - High Rate - Decay Time



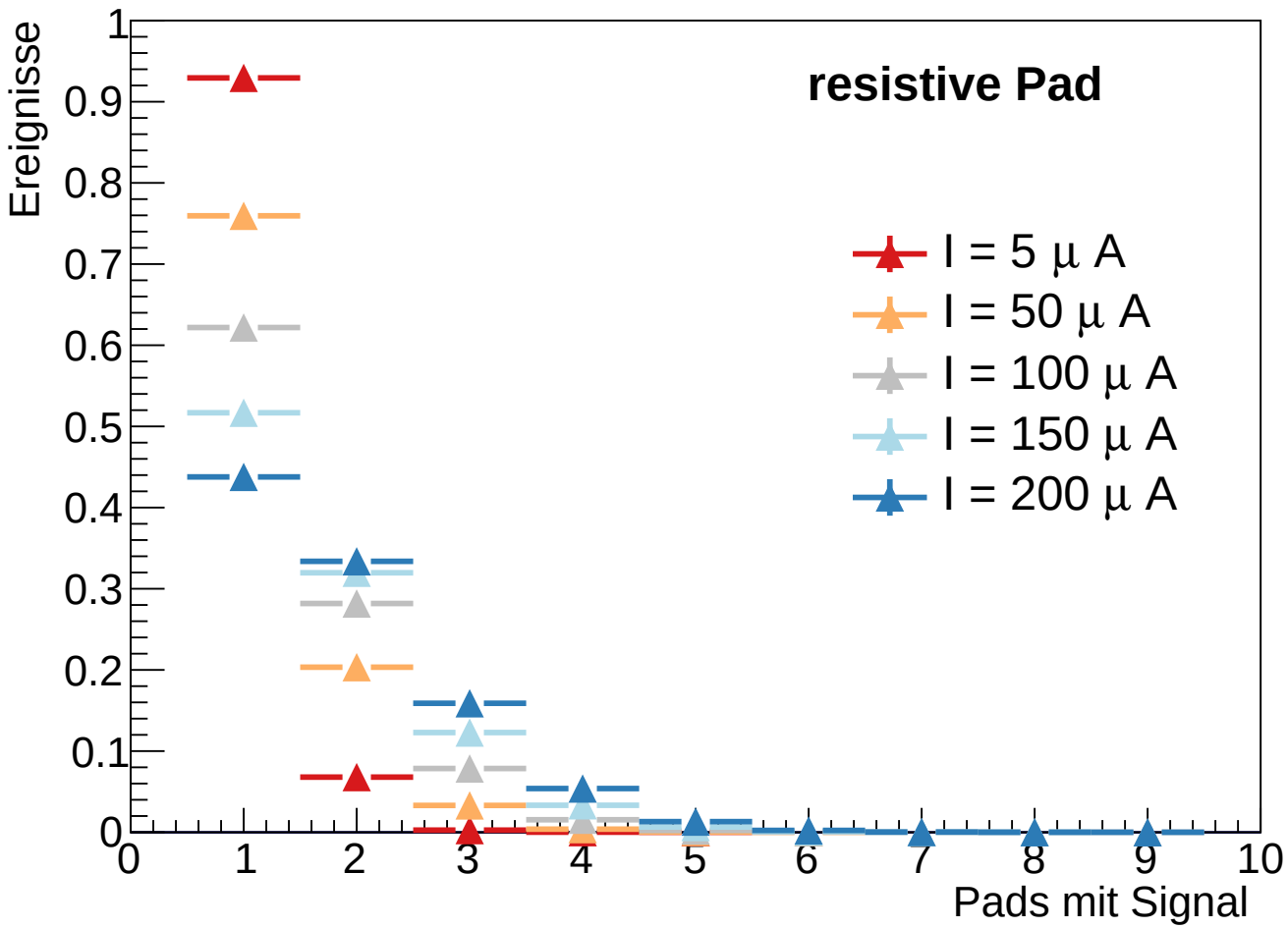
RC-Pad - High Rate - Decay Max. Charge



RC-Pad - High Rate - Cluster Number



RC-Pad - High Rate - Cluster Size



RC-Pad - High Rate - Decay Time