Investigating the effect of processing and isolation layout design parameters of IP region in segmented LGAD on electric field and charge multiplication

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MOTIVATION

We saw strong spikes in proximaty of p-stops in Type 10 LGAD from Ti-LGAD batch and we wanted to test the effect of wider IP distance and wider distance between p-stops (also wider larger distance between p-stop and JTE).

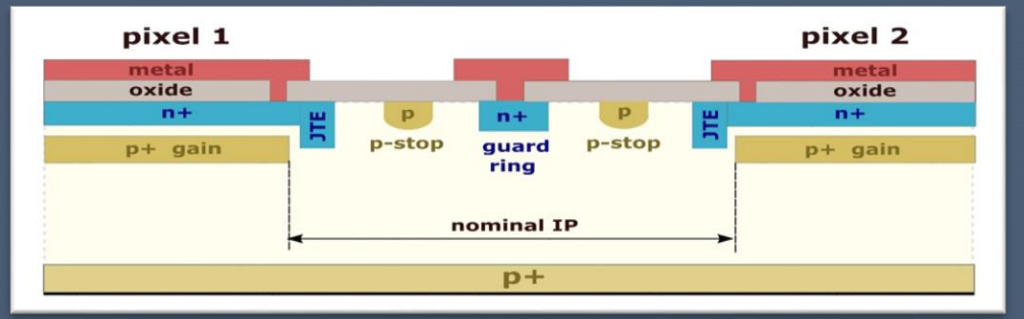
- *Gordana"s talk*

Reminder: TYPE 10: 2 p-stops + bias ring between p-stops

The way we did it:

- Type 10 UFSD from the TI-LGAD batch
- **UFSD 4.0 prototype.**

Type 10



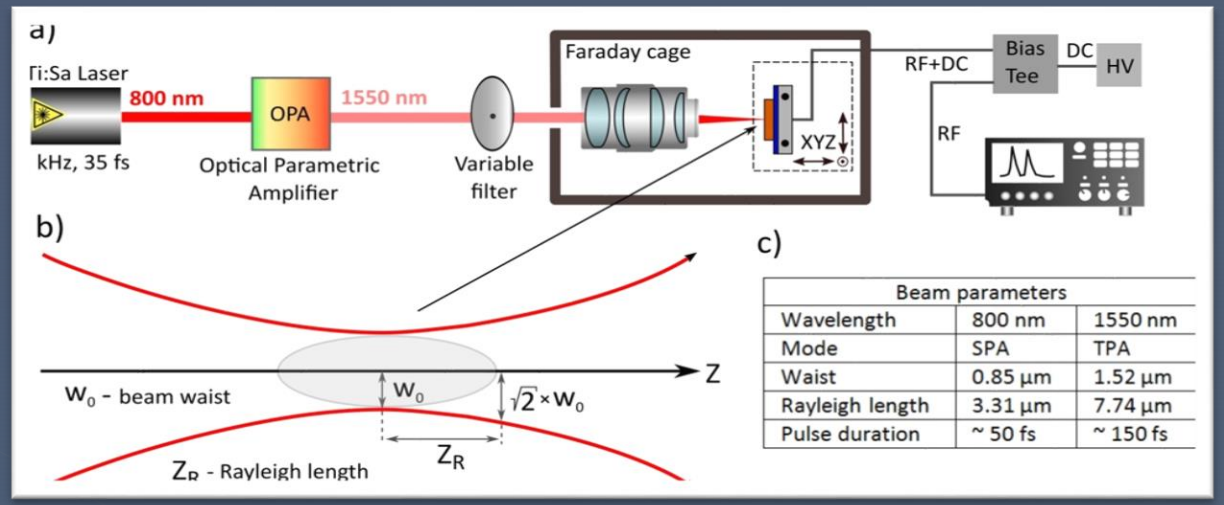
Research Methodology

TCT technique
Designed and developed at the laser facility ELI Beamlines, ELI ERIC in Prague

- SPA & TPA
- Fs-laser, 1KHz
- OPA system (for TPA)
- XYZ tables
- IR laser (800 nm basic wavelength) with beam focusing
- HV on backplane

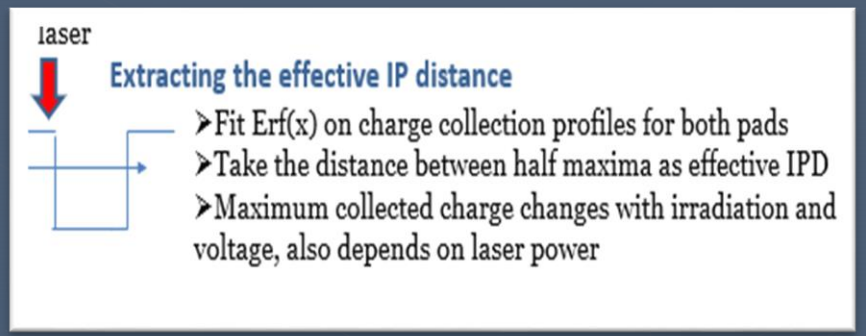
Operating conditions

- **Cooling : -25°C**
- Insulation cap
- Closed environment



Beam parameters		
Wavelength	800 nm	1550 nm
Mode	SPA	TPA
Waist	0.85 µm	1.52 µm
Rayleigh length	3.31 µm	7.74 µm
Pulse duration	~ 50 fs	~ 150 fs

Gordana Laštovička-Medin, et al., "Femtosecond laser studies of the Single Event Effects in Low Gain Avalanche Detectors and PINs at ELI Beamlines.", NIM A: Accelerators, Spectrometers, Detectors and Associated Equipment, Vol. 1041 (2022): pp:167321; https://doi.org/10.1016/j.nima.2022.167321

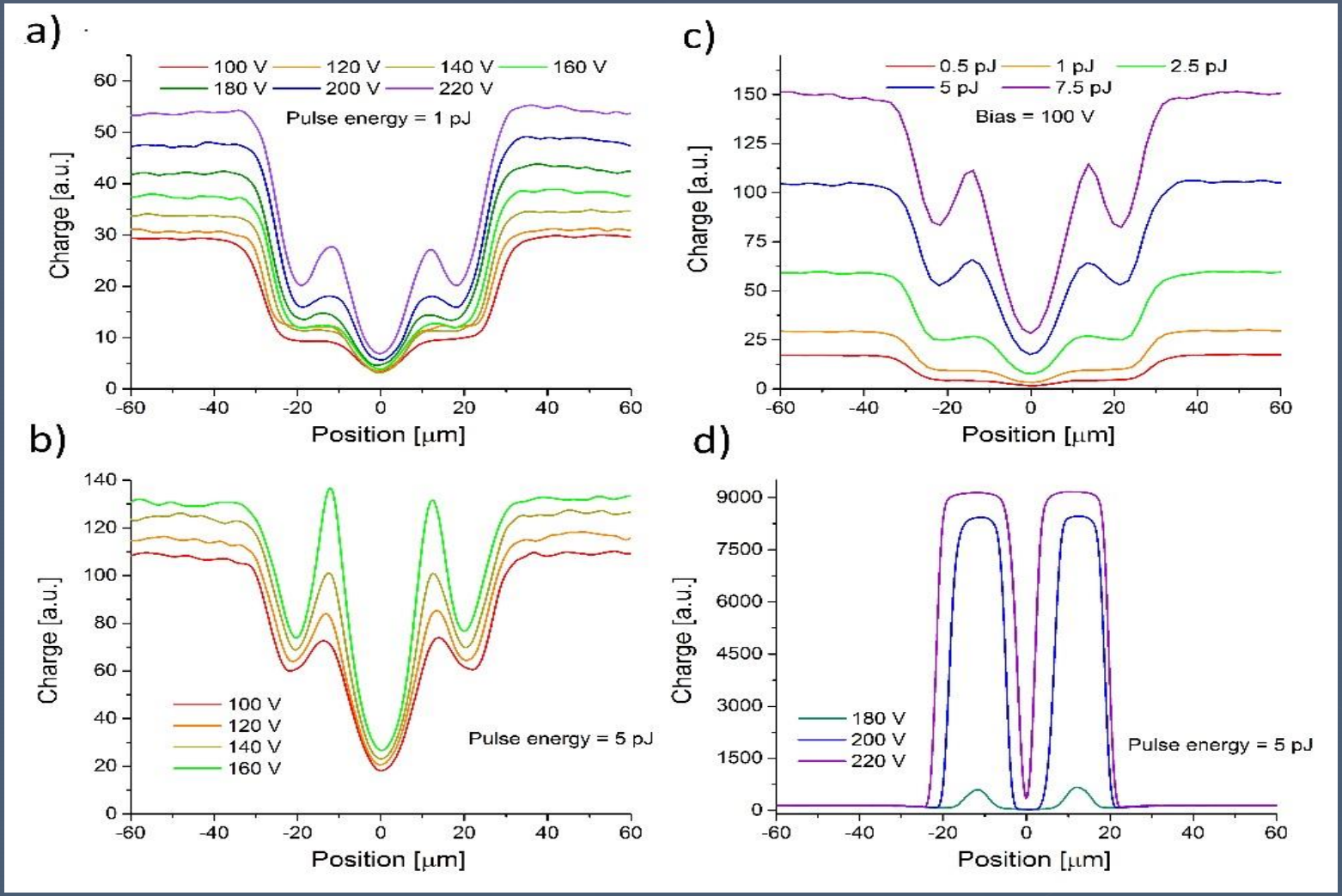


In this talk we used only SPA experiment at 800 nm
Room temperature, No amplifier
Bias range: 100-180 V (above 180 signal unstable)
Power range: 1-5 pJ (plus a few example data for 0.2 pJ)

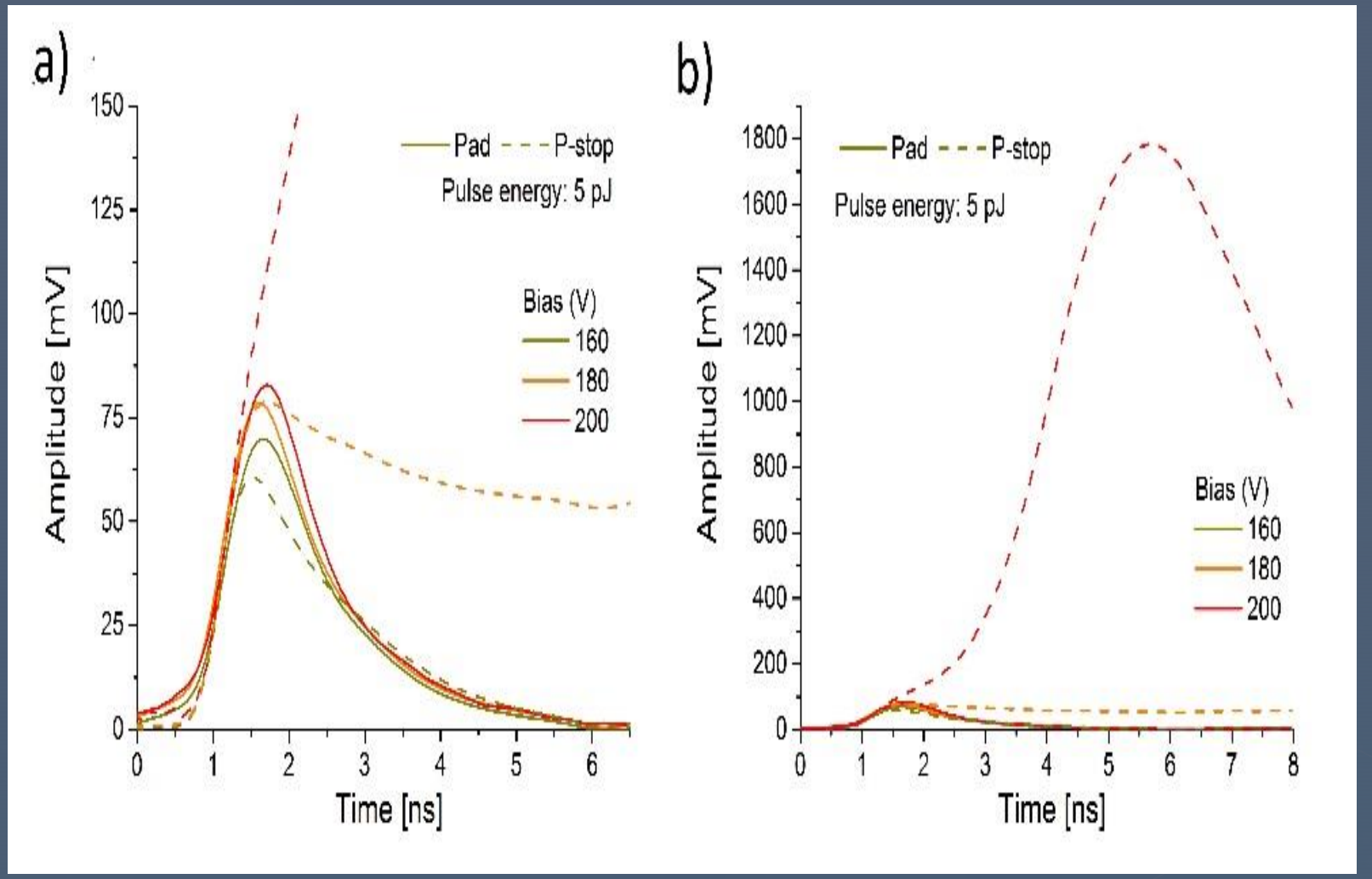
Reminder: UFSD TYPE 10 FROM Ti-LGAD PRODUCTION

Non typical "UFSD" with 2 p-stops + bias; IP = 49 µm

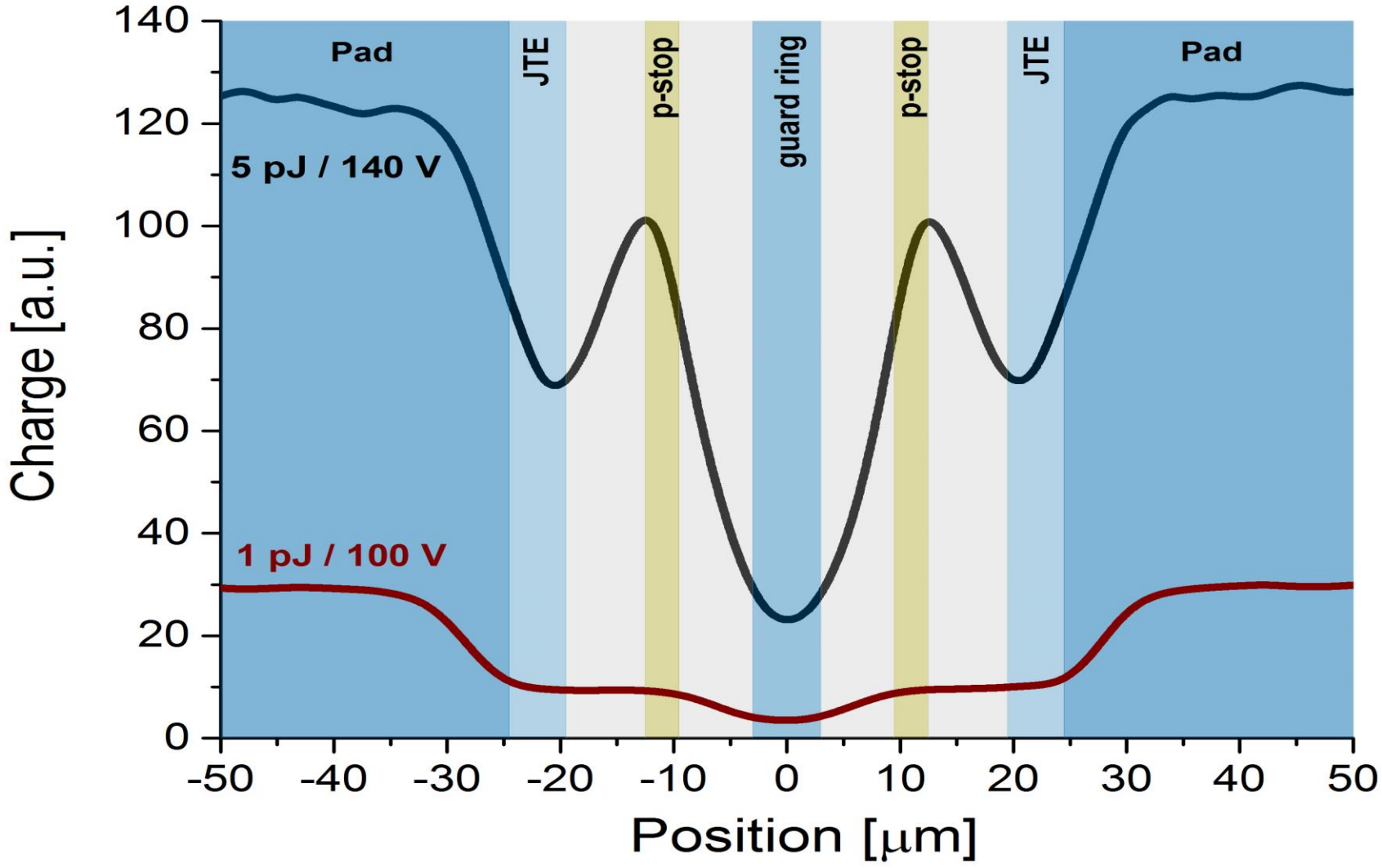
X profile



Waveforms:


a)
Amplitude [mV]
Time [ns]
Pad
P-stop
Pulse energy: 5 pJ
Bias (V)
160
180
200
b)
Amplitude [mV]
Time [ns]
Pad
P-stop
Pulse energy: 5 pJ
Bias (V)
160
180
200

Resolved structure:

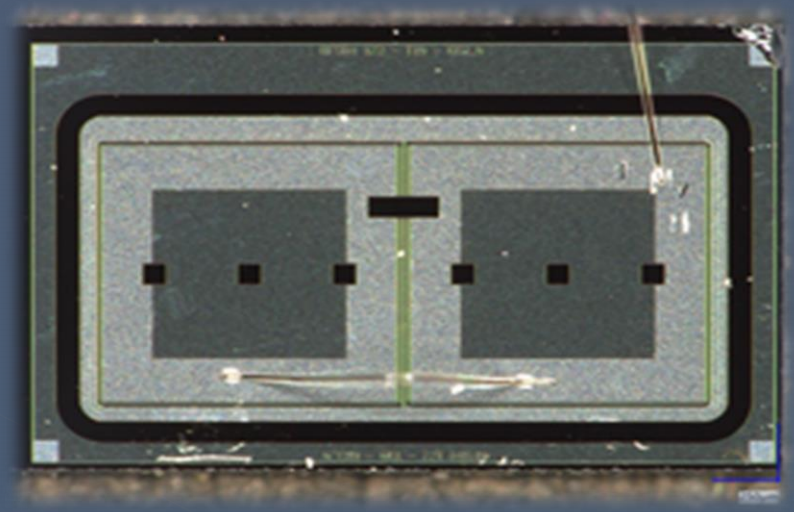


UFSD4 W18 T10 GR3_0

Description of sensor:

UFSD4: UFSD4 represents the version or generation of the UFSD sensor. It indicates that this particular sensor is from the fourth generation of UFSD sensors. Each generation may have improvements or modifications compared to previous versions, such as enhanced performance, optimized design, or updated fabrication processes.

GR3_0: "GR3_0" represents the guard ring structure used in the UFSD sensor. The guard ring is an additional structure around the active area of the sensor that helps reduce the impact of edge effects, charge diffusion, or cross-talk between adjacent sensing elements. The specific details of the guard ring structure may vary based on the design and fabrication process used.



T10: Type 10 already explained

EXPERIMENTAL RESULTS

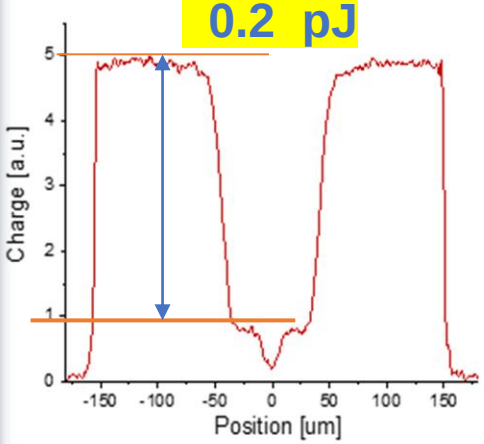
Constant parameter: Bias **100V**

Scaning over laser power from 0.2pJ o 5 pJ

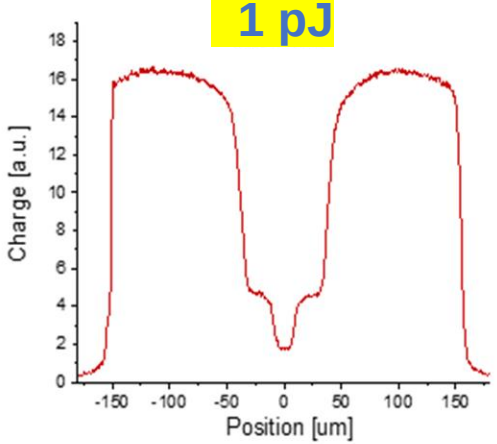
MESSAGE: Spikes previously observed in IP region are significantly reduced

Full X-profiles at 100 V

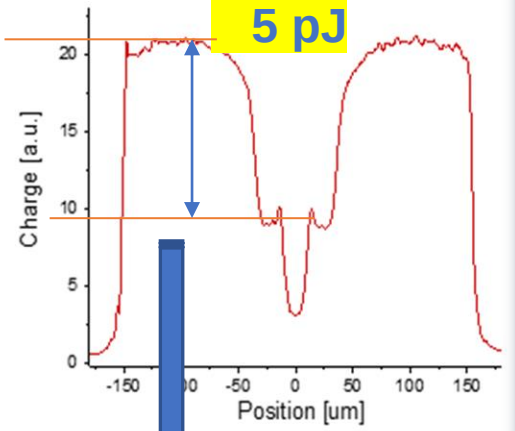
0.2 pJ



1 pJ

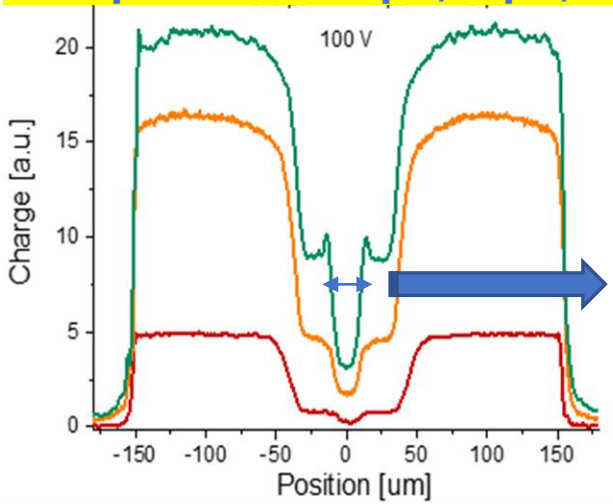


5 pJ



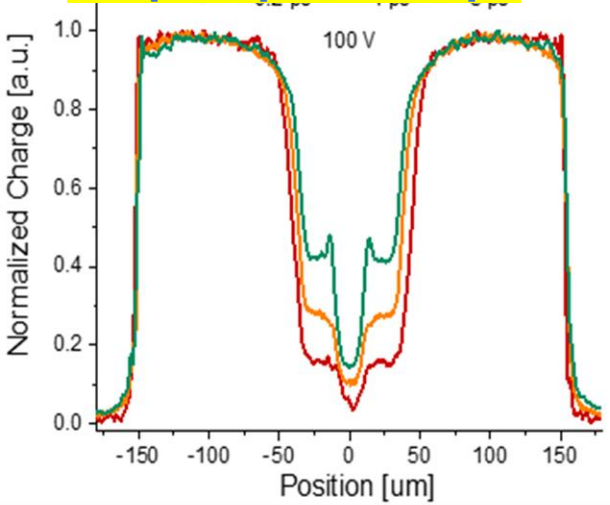
One can deduce information about change in gain.

Comparison: 0.2pJ, 1 pJ, 5 pJ

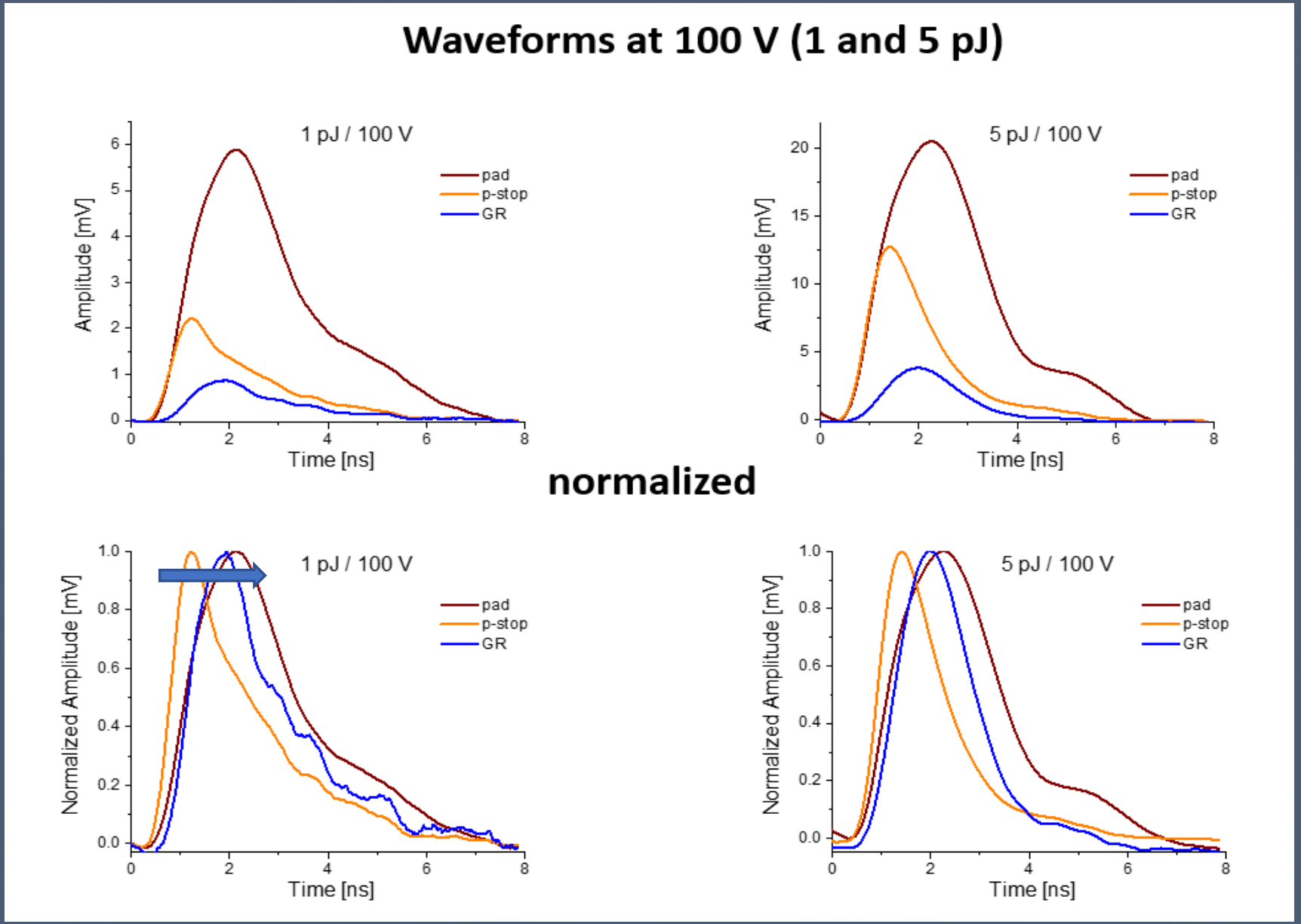


One can deduce information about width bias ring (20 µm)

Normalized distribution: 0.2 pJ, 1pJ and 5 pJ

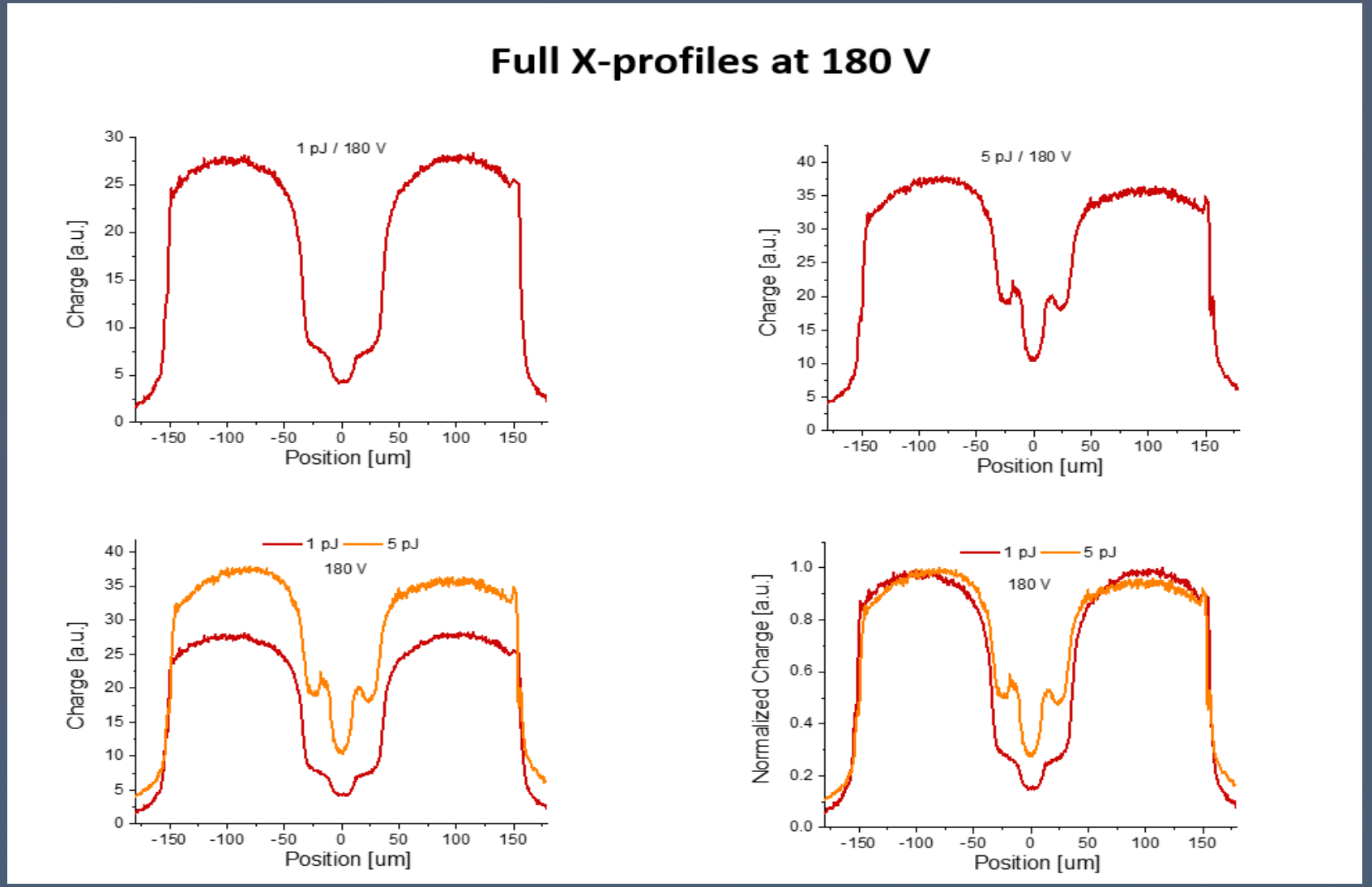


- Plasma effect clarly seen for pad signal in waveform

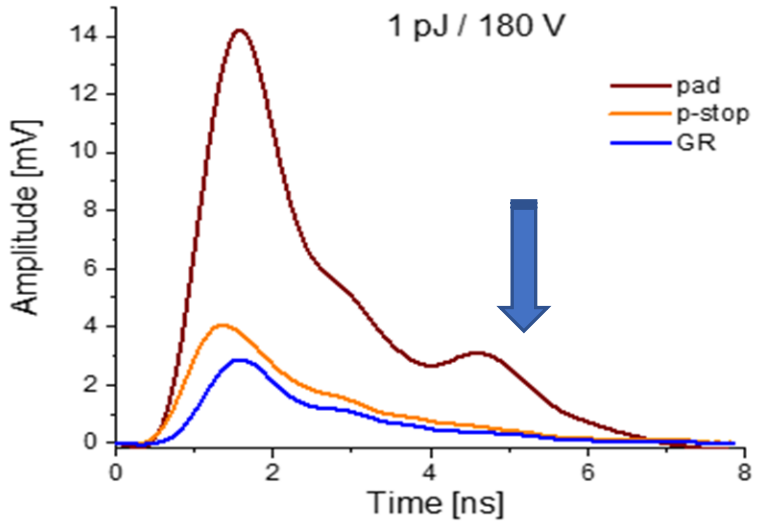


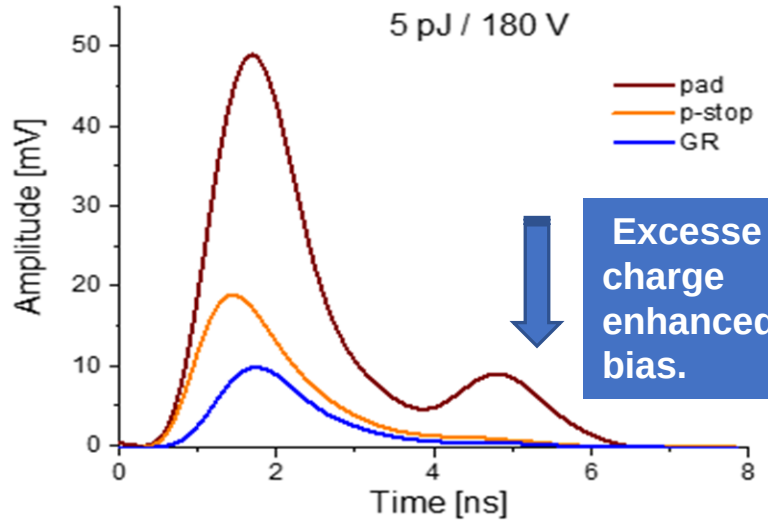
Constant parameter:
Bias **180V**

Scaning over laser power from 0.2pJ to 5 pJ



Waveforms at 180 V (1 and 5 pJ)

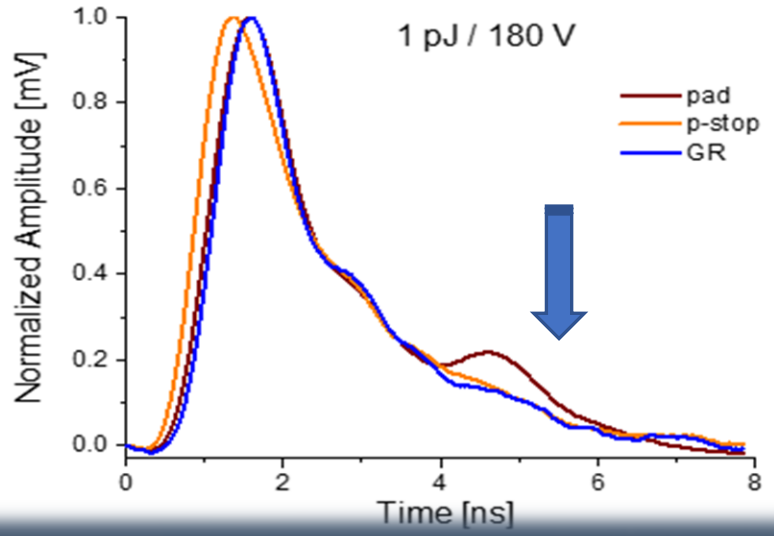


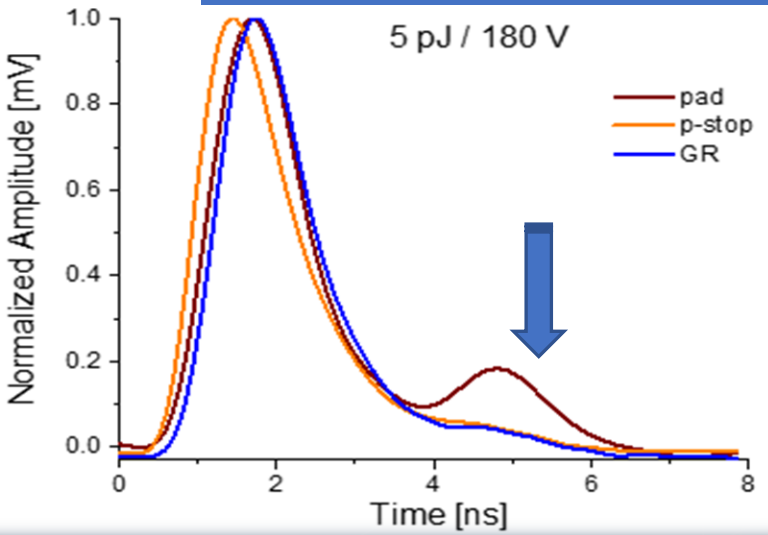


Excesse of charge enhanced by bias.

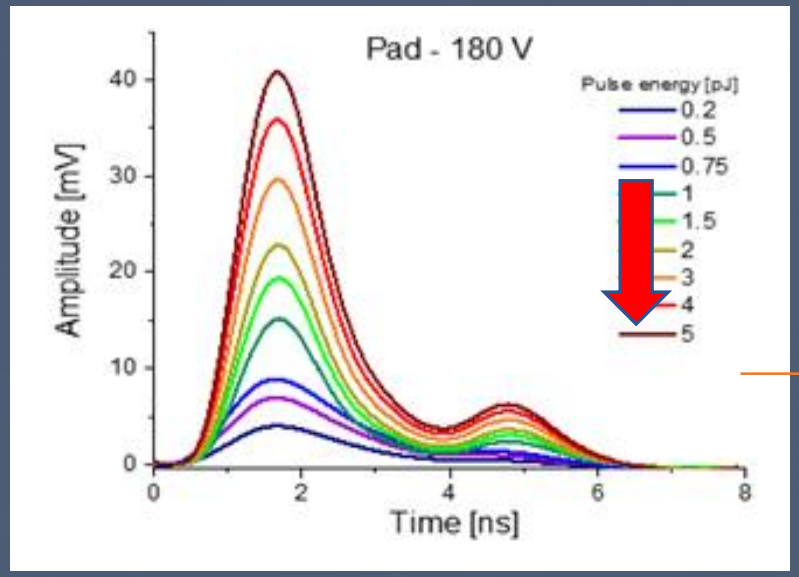
normalized

Could it be explained by the pronolged signal showing enhanced charge nultiplication?

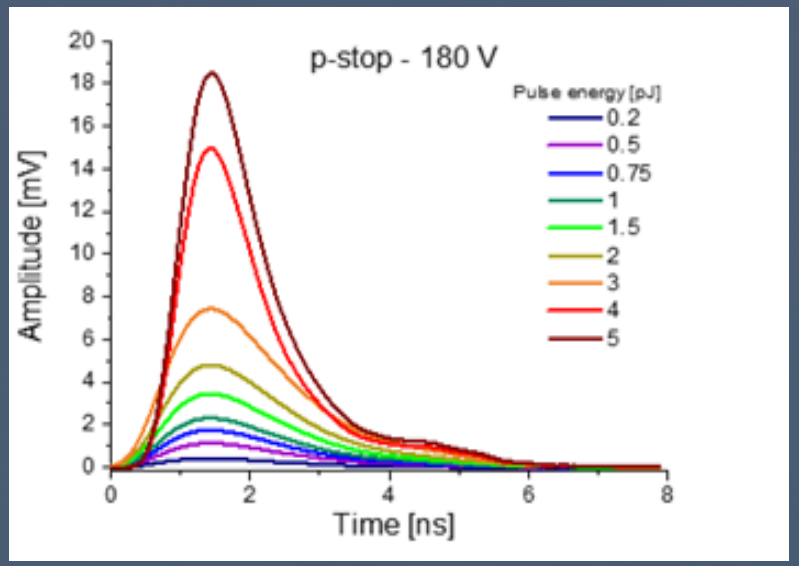




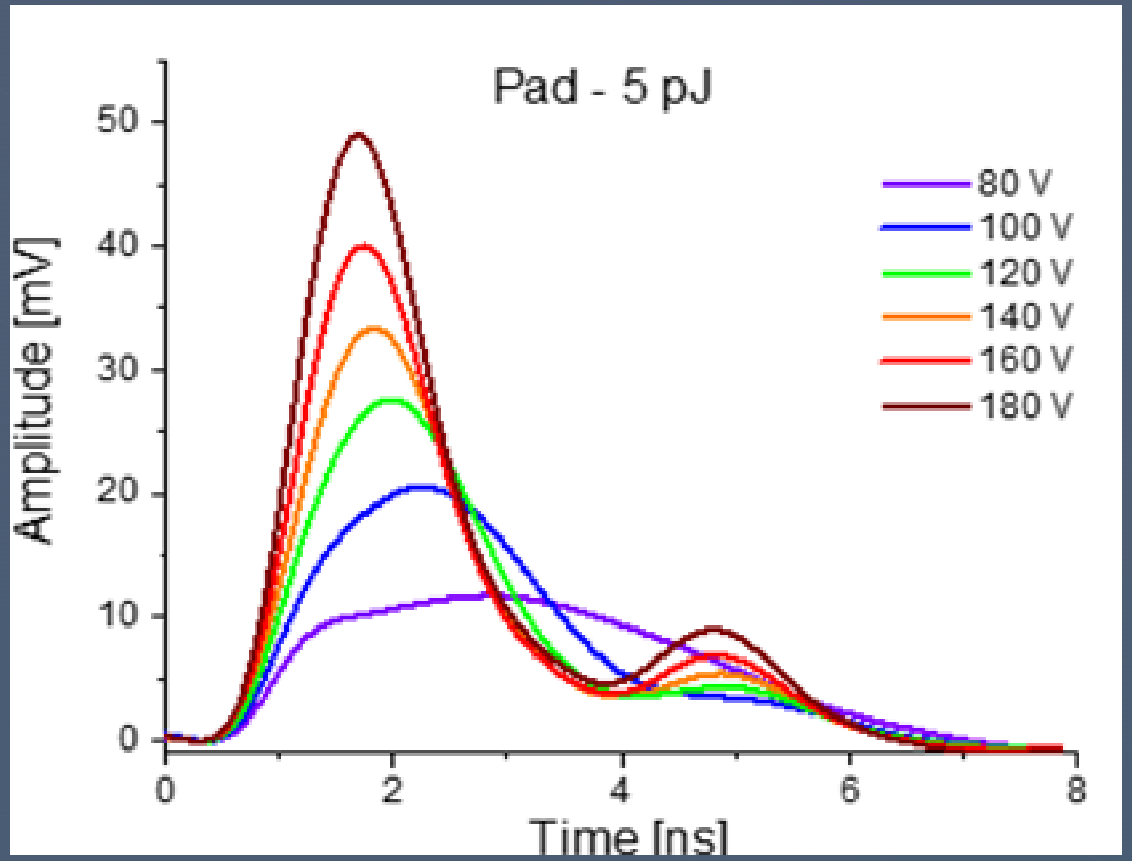
Waveforms for different laser intensities at fixed biasof 180 V



prolonged signal showing enhanced charge multiplication?

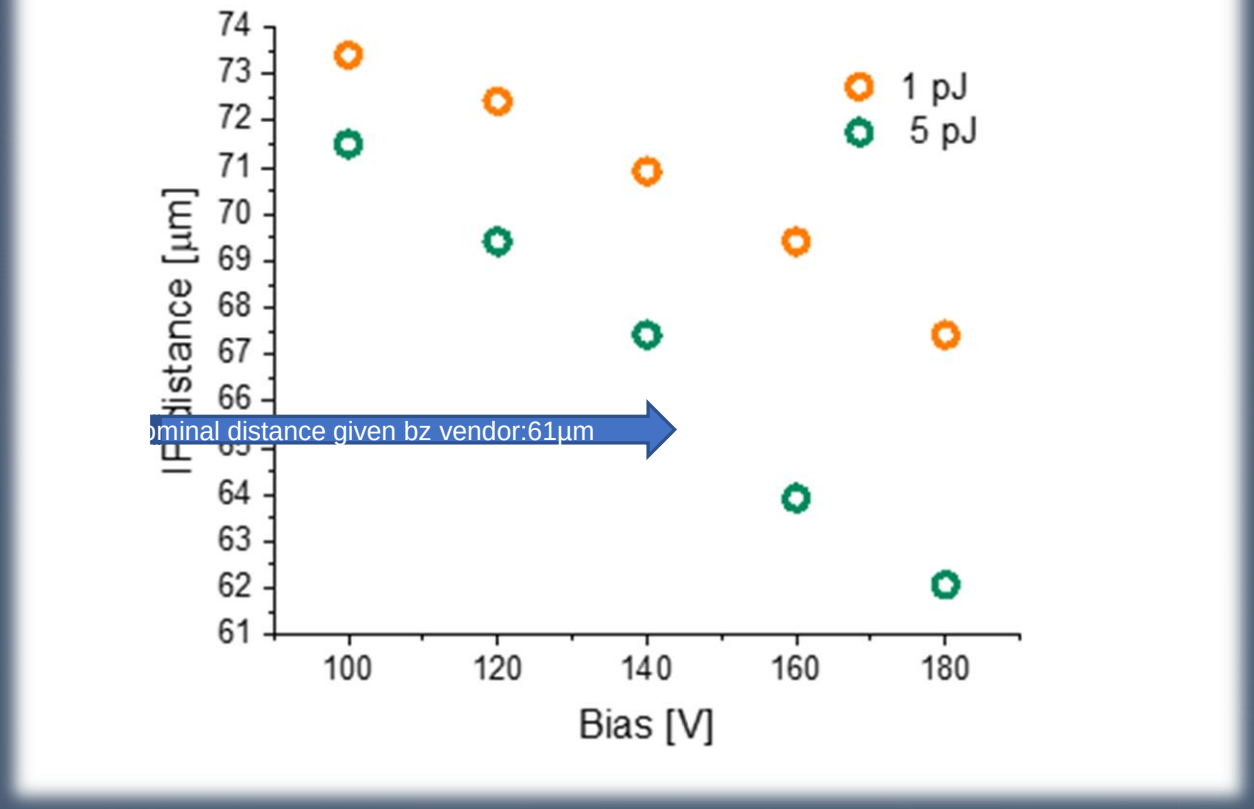


- **Waveforms for different bias voltages at fixed laser intensity of 5pJ**



IP distance vs. Bias voltage

- Study with higher laser power showing lower interpad distance
  - Higher laser intensity artificiallly producing the lower interpad distance



Conclusion

- We saw strong spikes in proximaty of p-stops in Type 10 LGAD from Ti-LGAD batch and we wanted to test the effect of wider IP distance and wider distance between p-stops (also wider larger distance between p-stop and JTE).
- Notably, both samples exhibit a similar X-profile with a well-defined position of the bias ring.
- However, while the spikes observed in the proximity of p-stops are significantly amplified in the case of the Type 10 LGAD sensors from the TI-LGAD batch, in the UFSD 4.0 Type 10 sensors the spikes are absent, except when enhanced laser power is used.

THANK YOU