TPA Laser Experiment on the MPW2 HVCMOS MAPS chip

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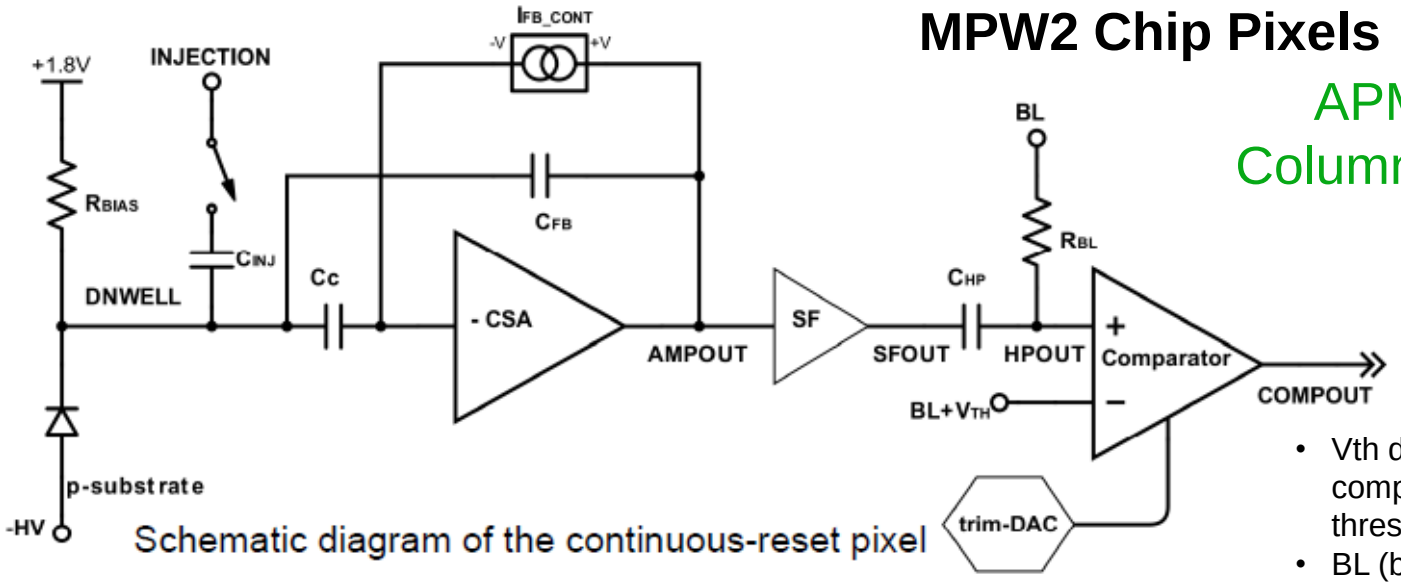
General Description

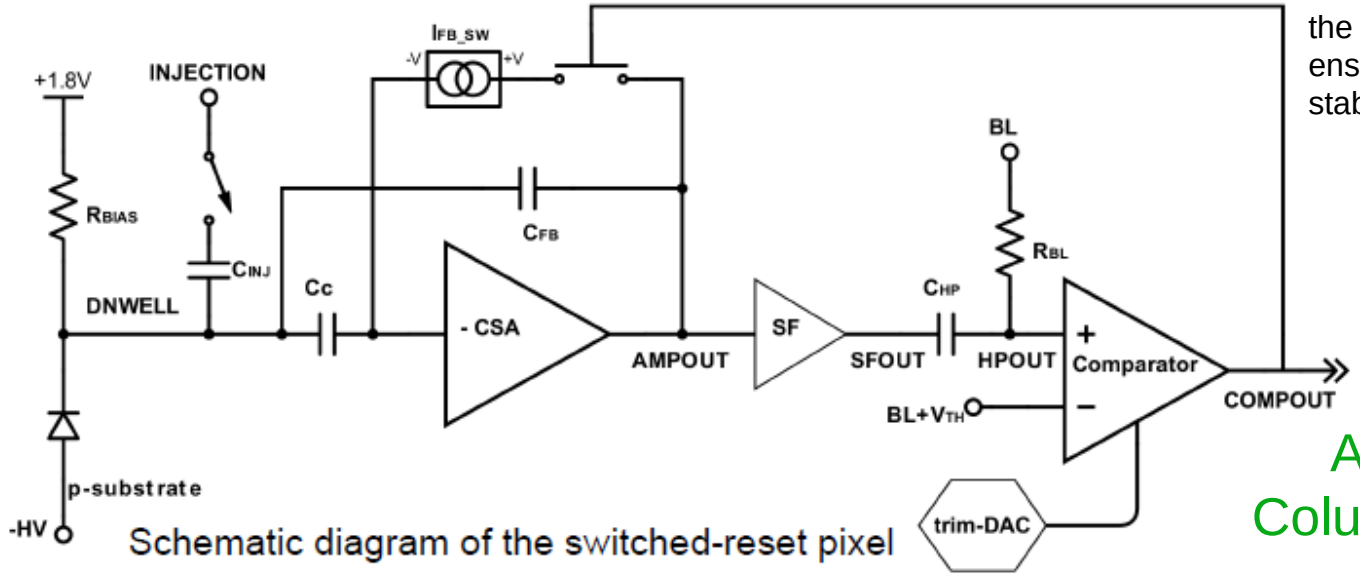
MPW2 Chip Pixels



Schematic diagram of the continuous-reset pixel

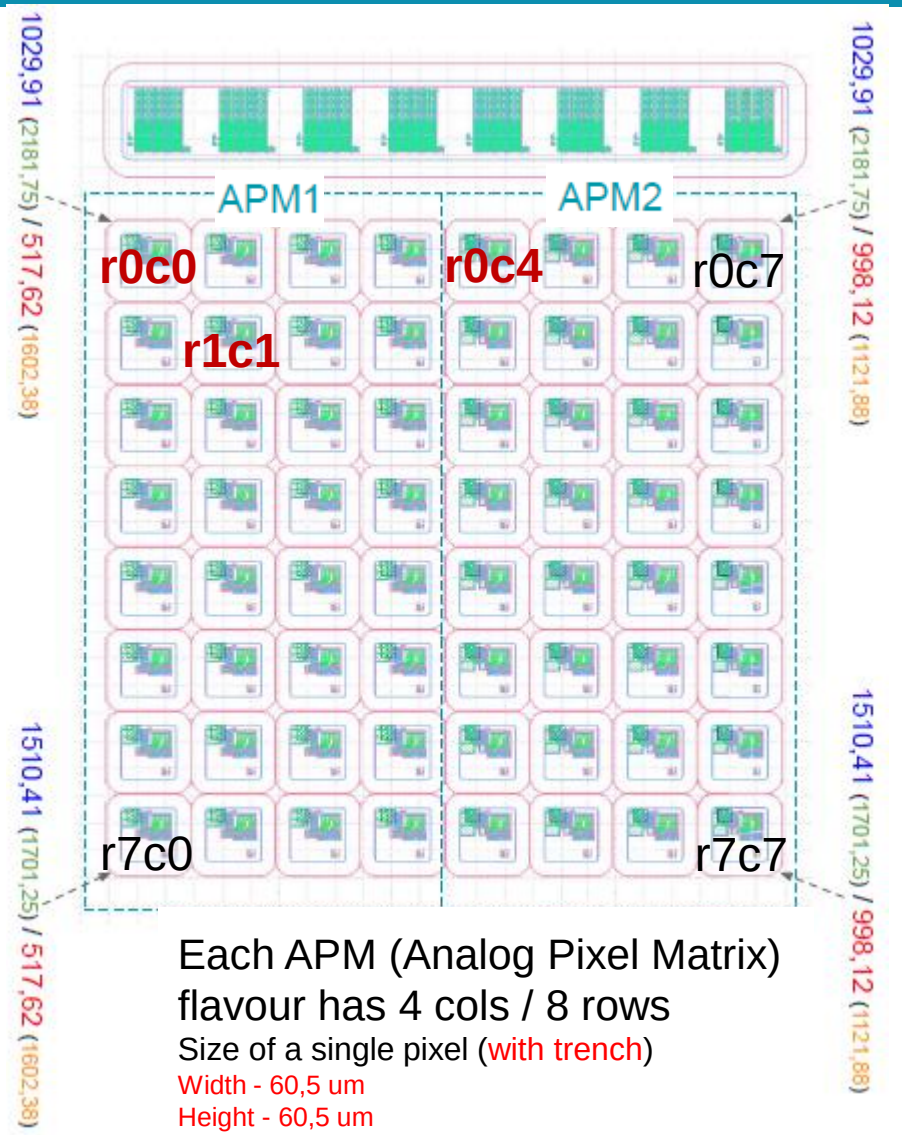
APM1
Columns 0-3

- Vth defines the comparator threshold
- BL (baseline) defines an offset to the analog output to ensure signal stability



Schematic diagram of the switched-reset pixel

APM2
Columns 4-7



Each APM (Analog Pixel Matrix) flavour has 4 cols / 8 rows

Size of a single pixel (with trench)

Width - 60,5 um

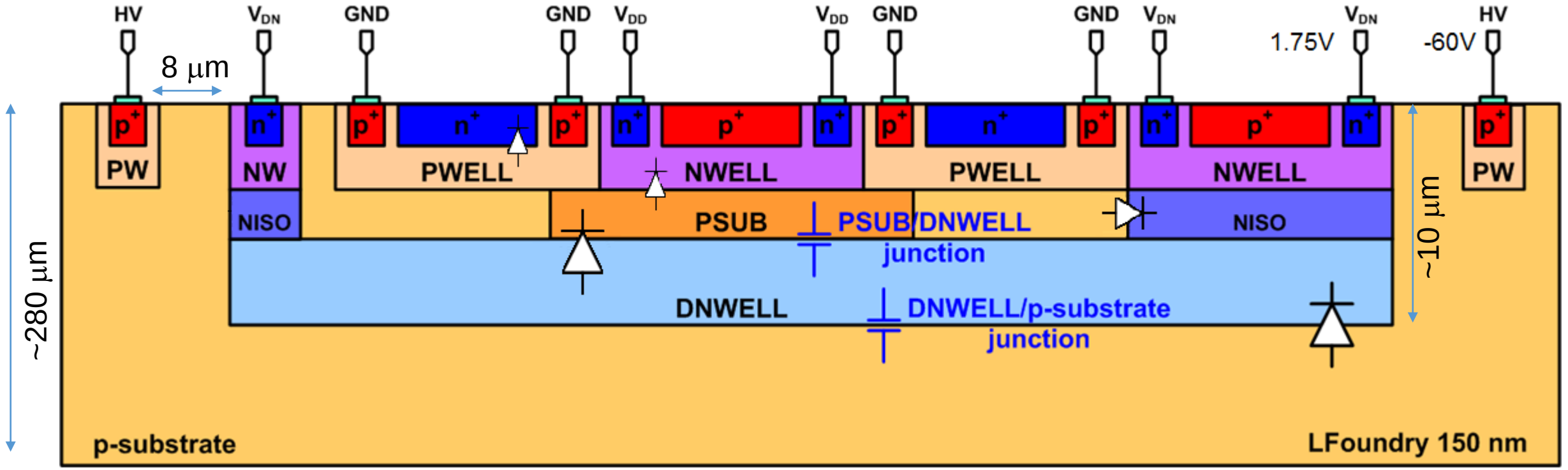
Height - 60,5 um

Size of a single pixel (without trench)

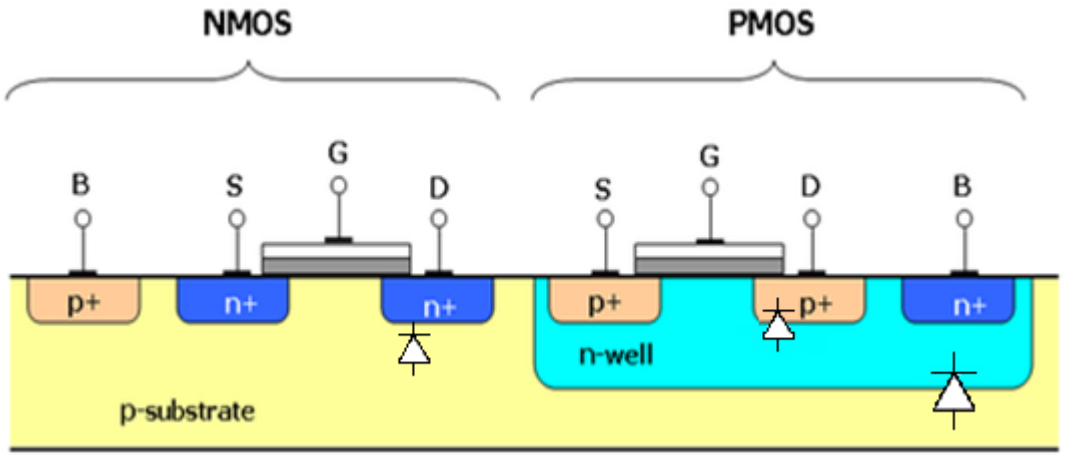
Width - 39,68 um $Trench_W$ - 20,3 um

Height - 39,68 um $Trench_H$ - 20,3 um

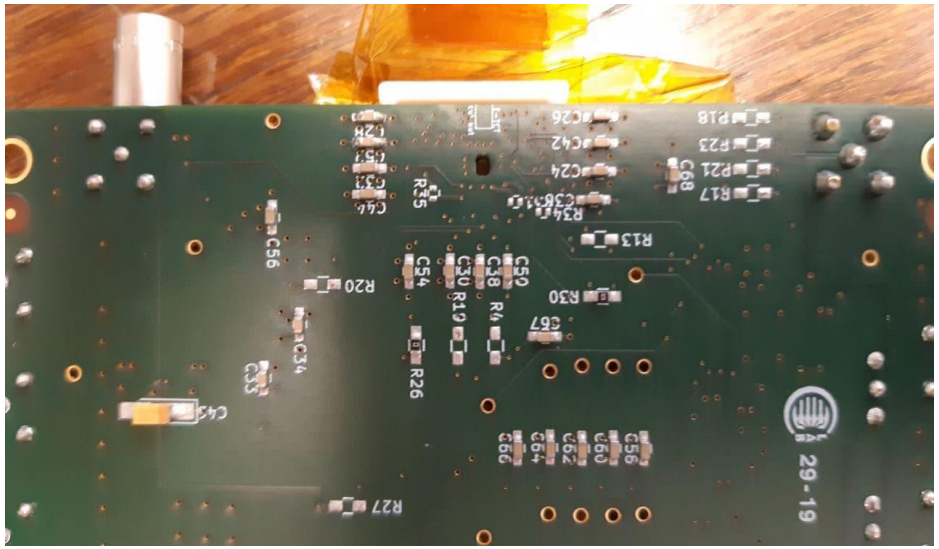
General Description



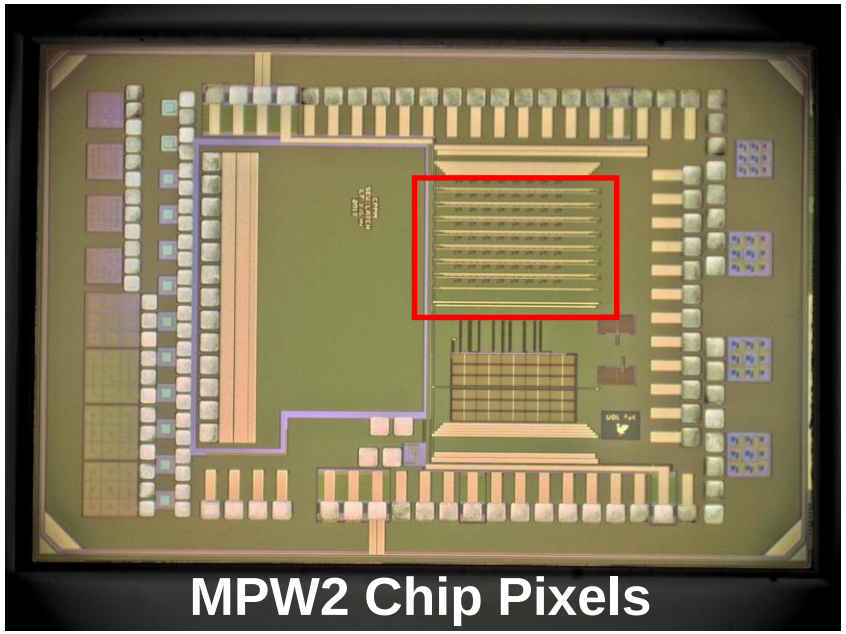
The experiment purpose is to get signals from the chip under femtosecond TPA laser excitation at different chip depths (z-scan mode). The hope is to get signals from every pixel layer in order to clasify them as proper detections (dnwell-psubs diode), parasitic detections (other inter-layers reverse biased pn diodes) or single event effects (laser voxel in the electronics zone, near to the die Surface, signal produced by the pn isolating diodes between the diffusion and the embedding well)



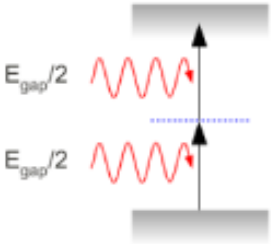
General Description

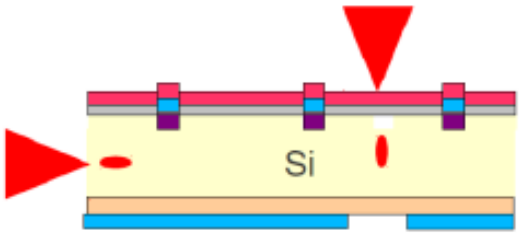


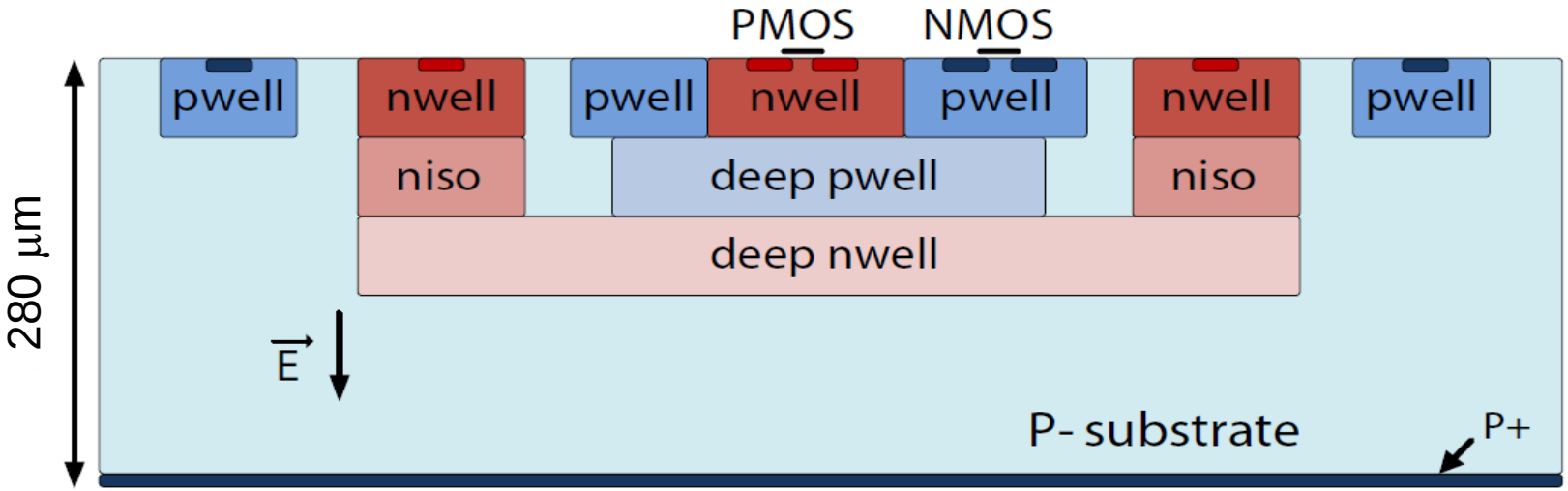
The MPW2 card has a window to the MPW2 chip, designed for backside laser illumination. At 1550 nm, 400 fs, the silicon is transparent below a light intensity threshold so the photoionization (light absorption) happens only around the focus point (voxel volume). A z-scan means to precisely position the voxel volumen along different die depths, also moving the beam along the pixel area. That way any particular volume can be excited to generate a signal in the collecting electrodes.



8x8 active pixel matrix
60x60 μm^2 pixel size
1.9 kΩ-cm substrate resistivity
no backside metallization

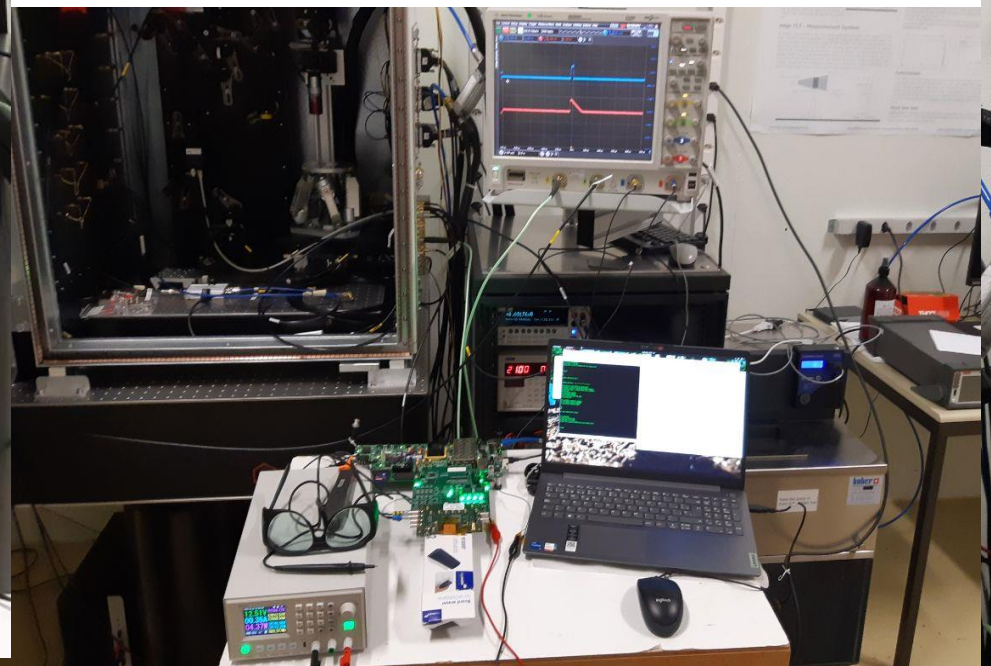


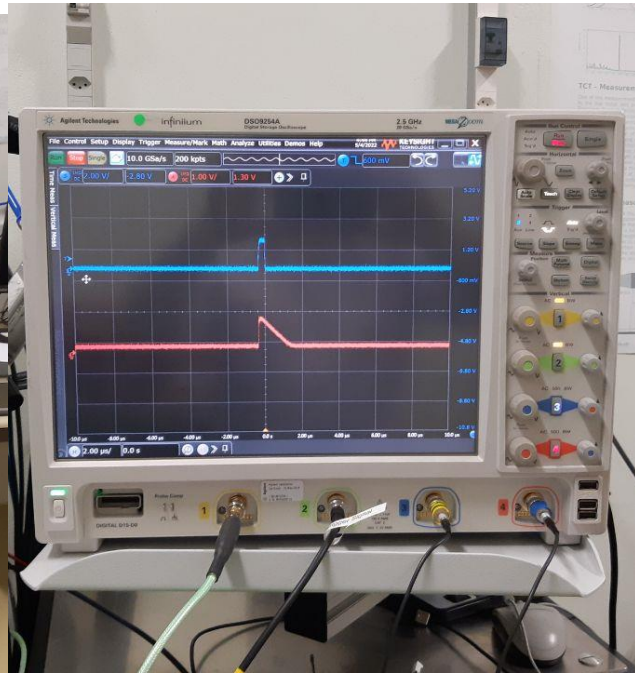




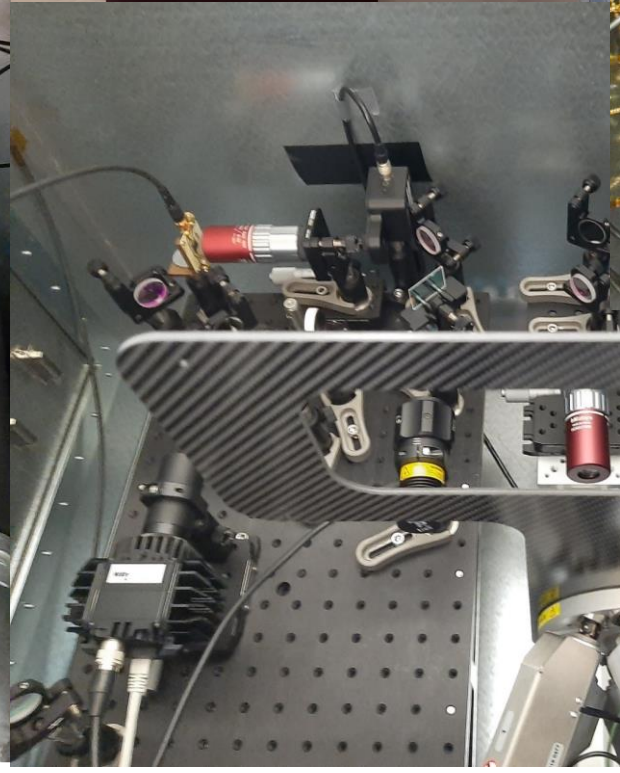
General Description

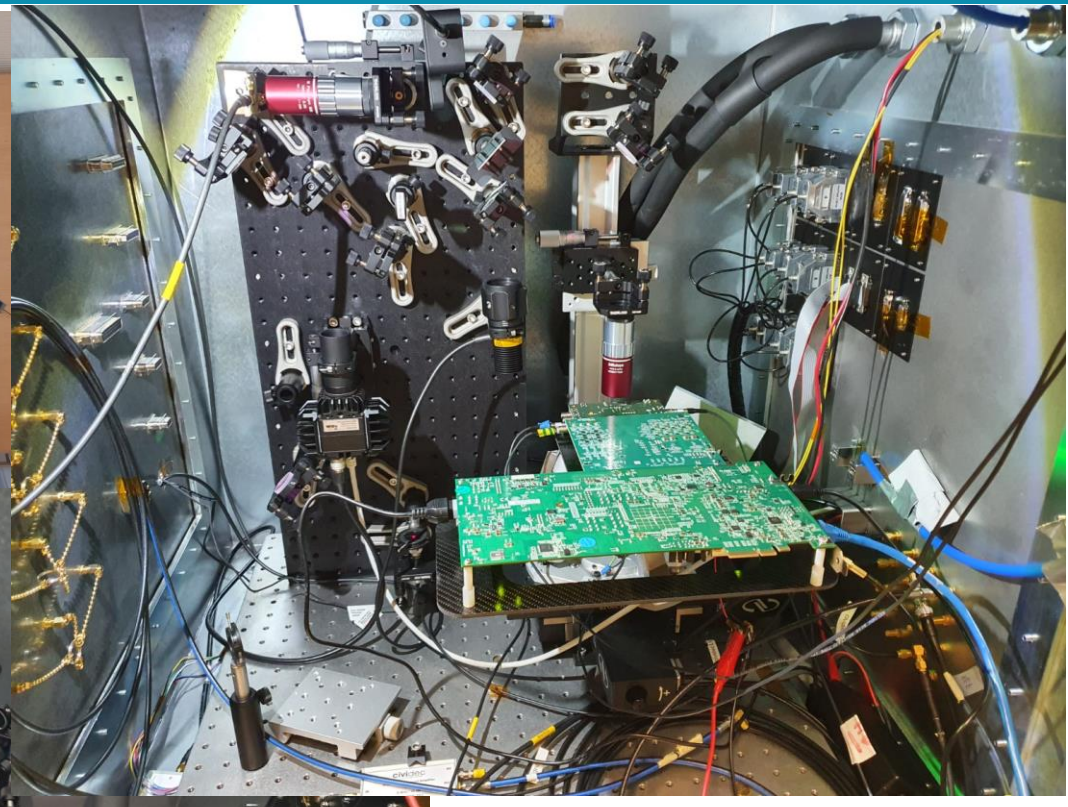
SSD Laser for TPA
1550 nm, ~400 fs, magnetoacustic pulse picker (selectable single shots). Different depths by focusing, different XY positions by a hexa-pod platform, EMI isolated, batiment 28 basement@CERN





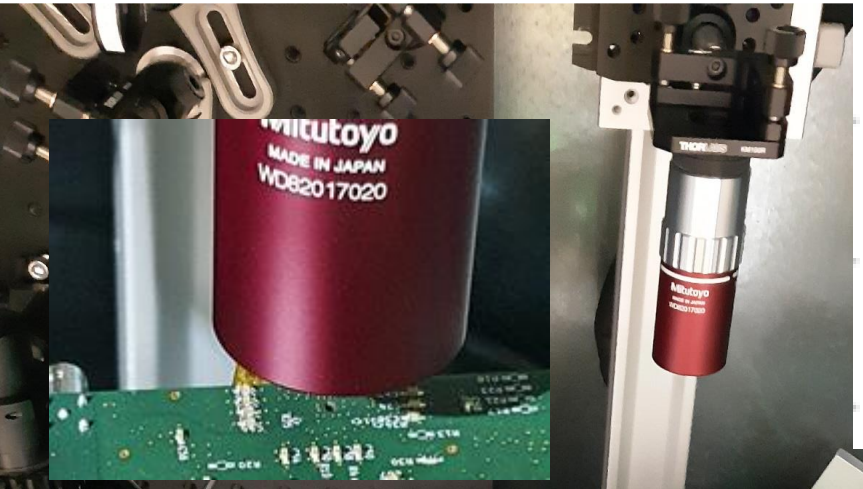
General Description

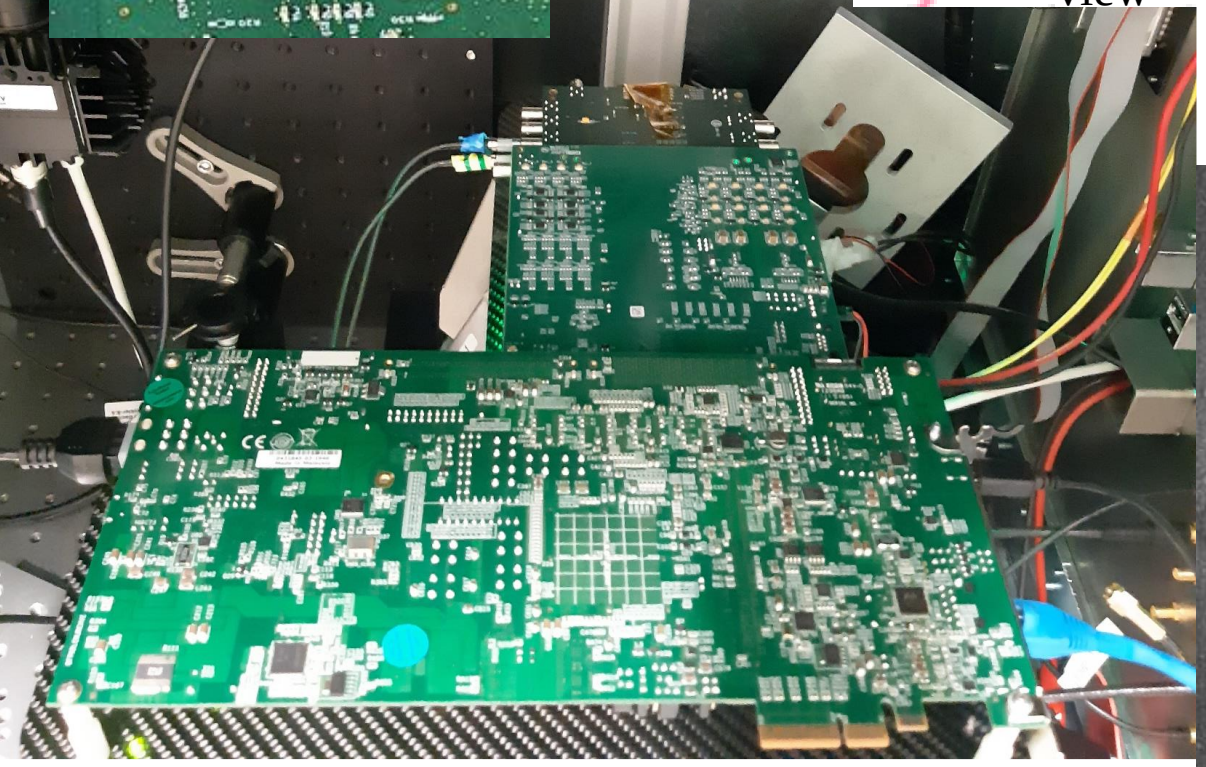


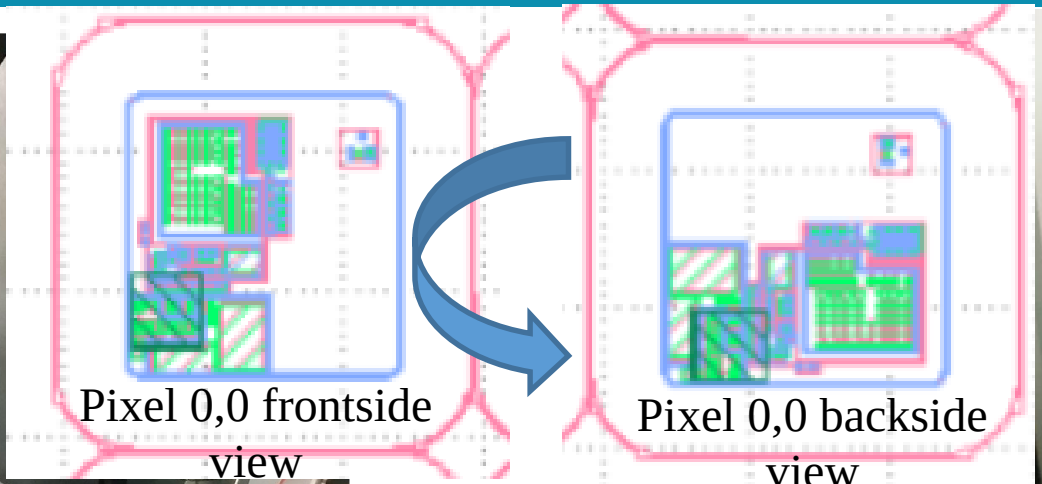


MPW2 + Caribou + FPGA in the setup, mounted on a costume made rigid carbon fibre holder manufactured by Ruddy Constanzi (SSD, CERN)

Locating the target (backside shot)

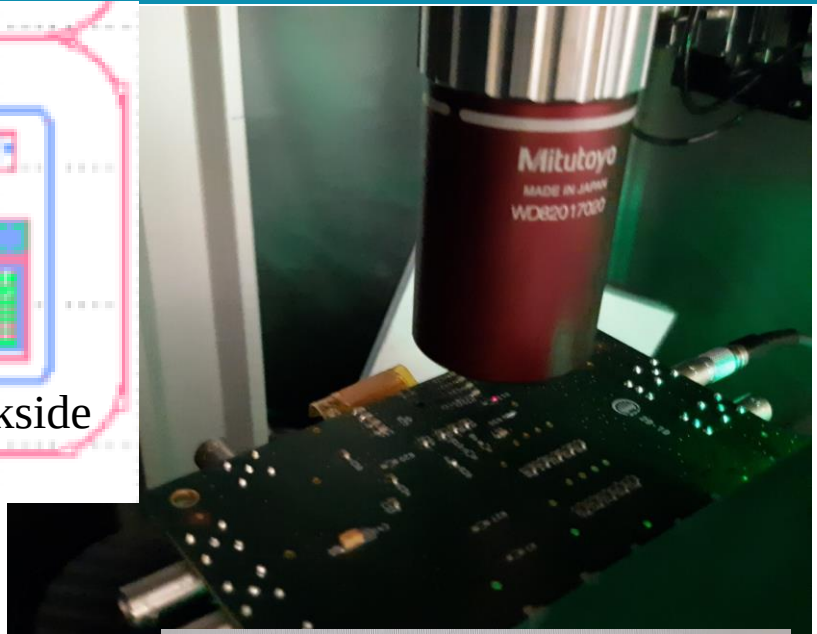




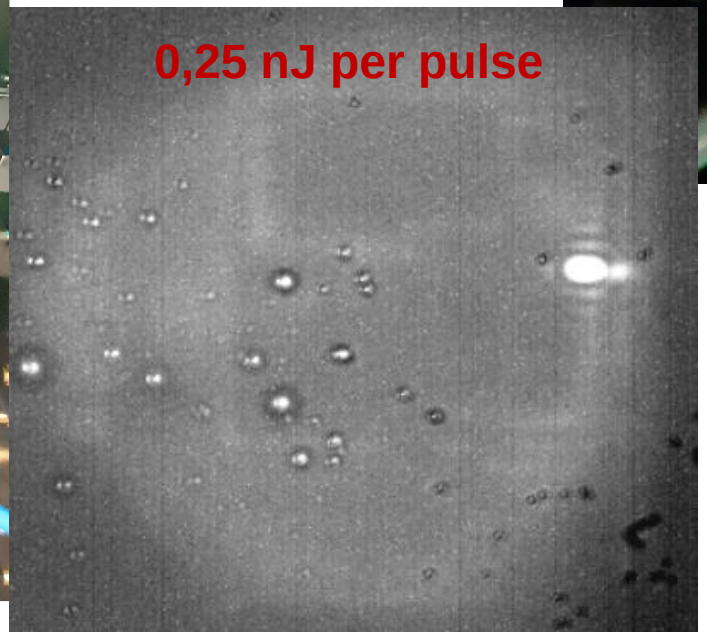


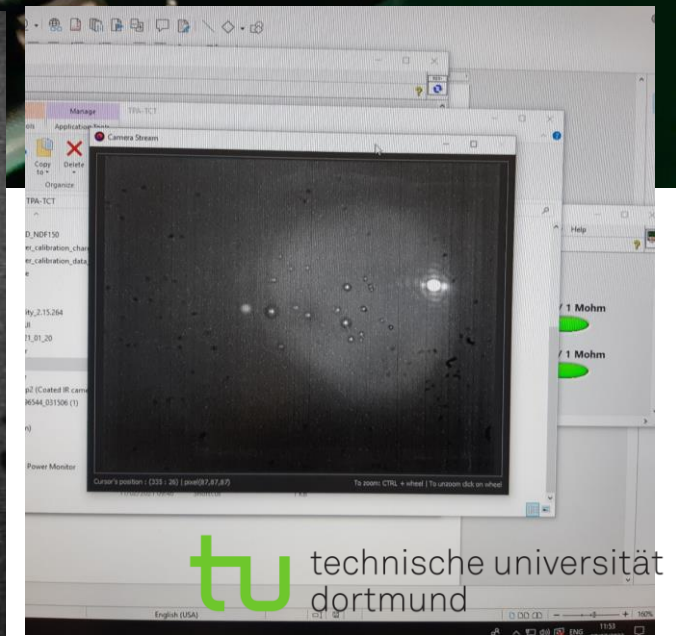
Pixel 0,0 frontside view

Pixel 0,0 backside view

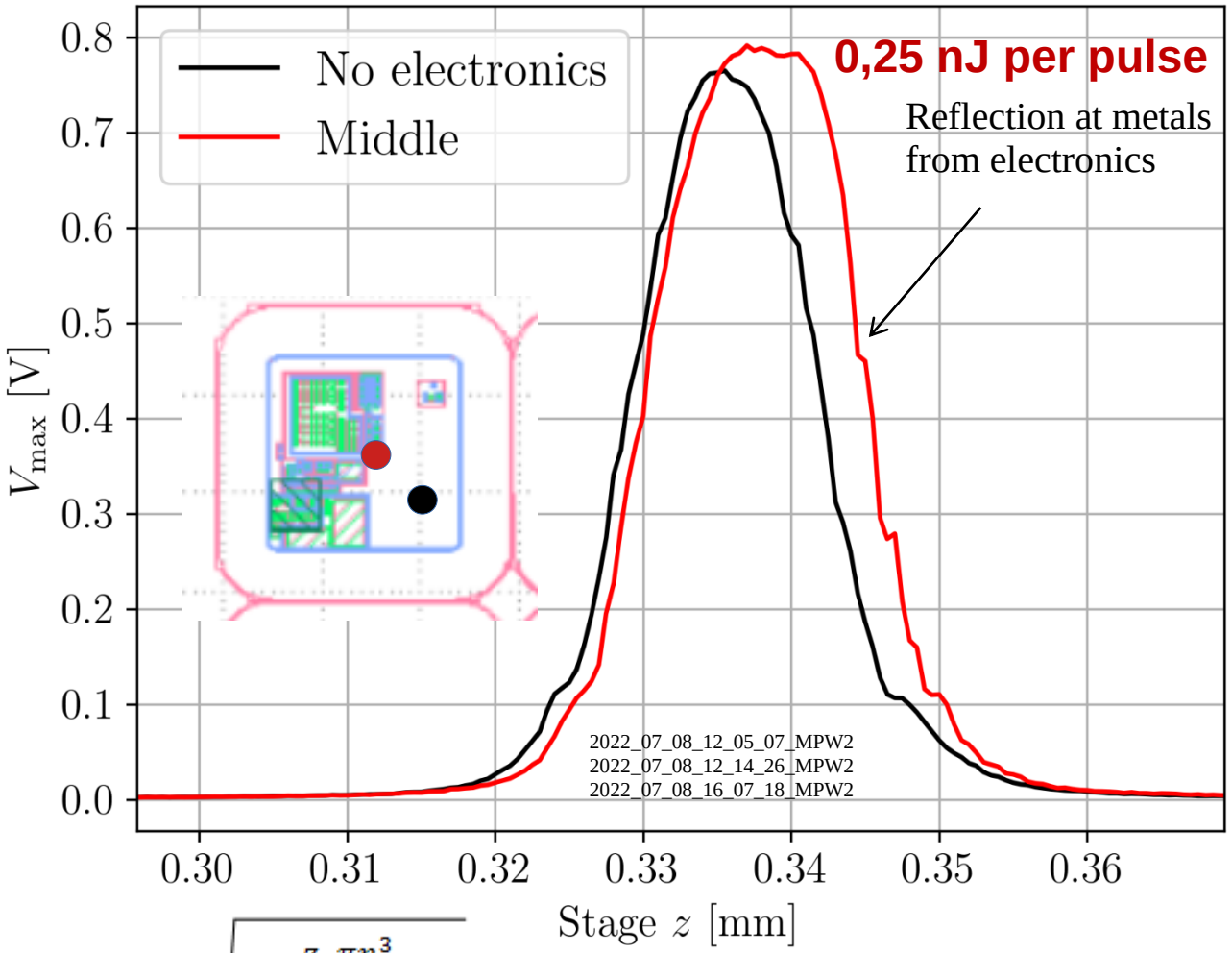


Pixel 0,0 under the IR microscope (backside)





Pixel 0,0 (APM1)

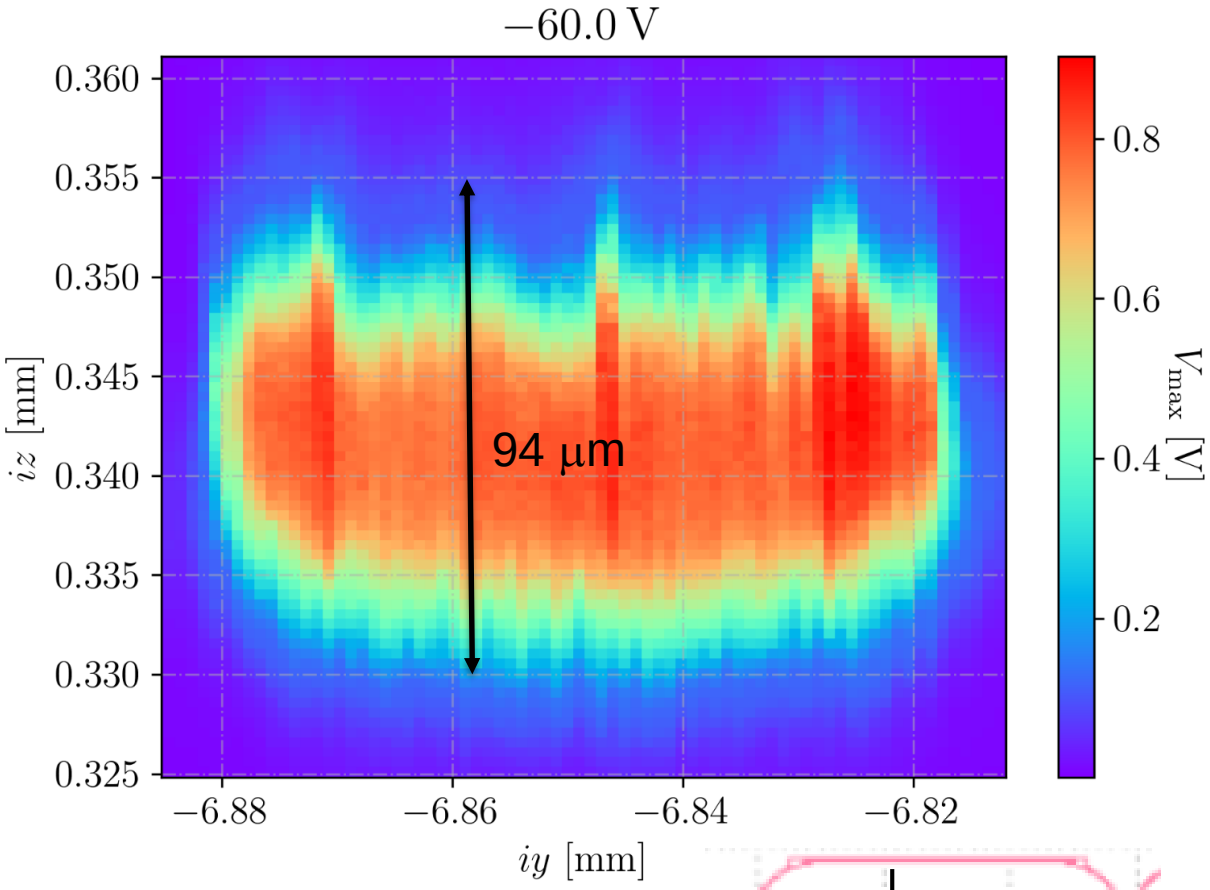


$$z_{Si} = z_{stage} \cdot \sqrt{\frac{z_R \pi n_{Si}^3}{z_R \pi n - \lambda n^2 + \lambda}}$$

$$w_0 = 1.5\ \mu m \quad z_R = \frac{\pi w_0^2 n_{Si}}{\lambda}$$

z-scale corrected for refraction on Air-Silicon interface factor 3.77 on the stage measurements

Moritz Wiehe et al., TNS 68(2) 2021

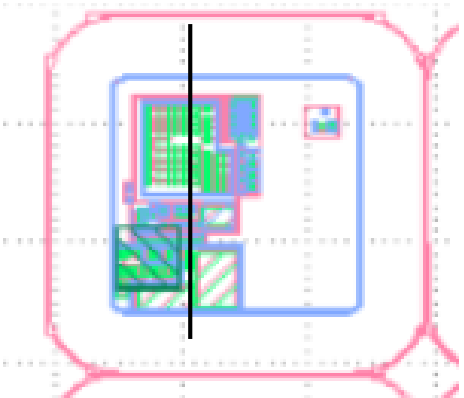


YZ-Scan across the electronics

0µm top side

-49µm middle side

-94µm bottom side



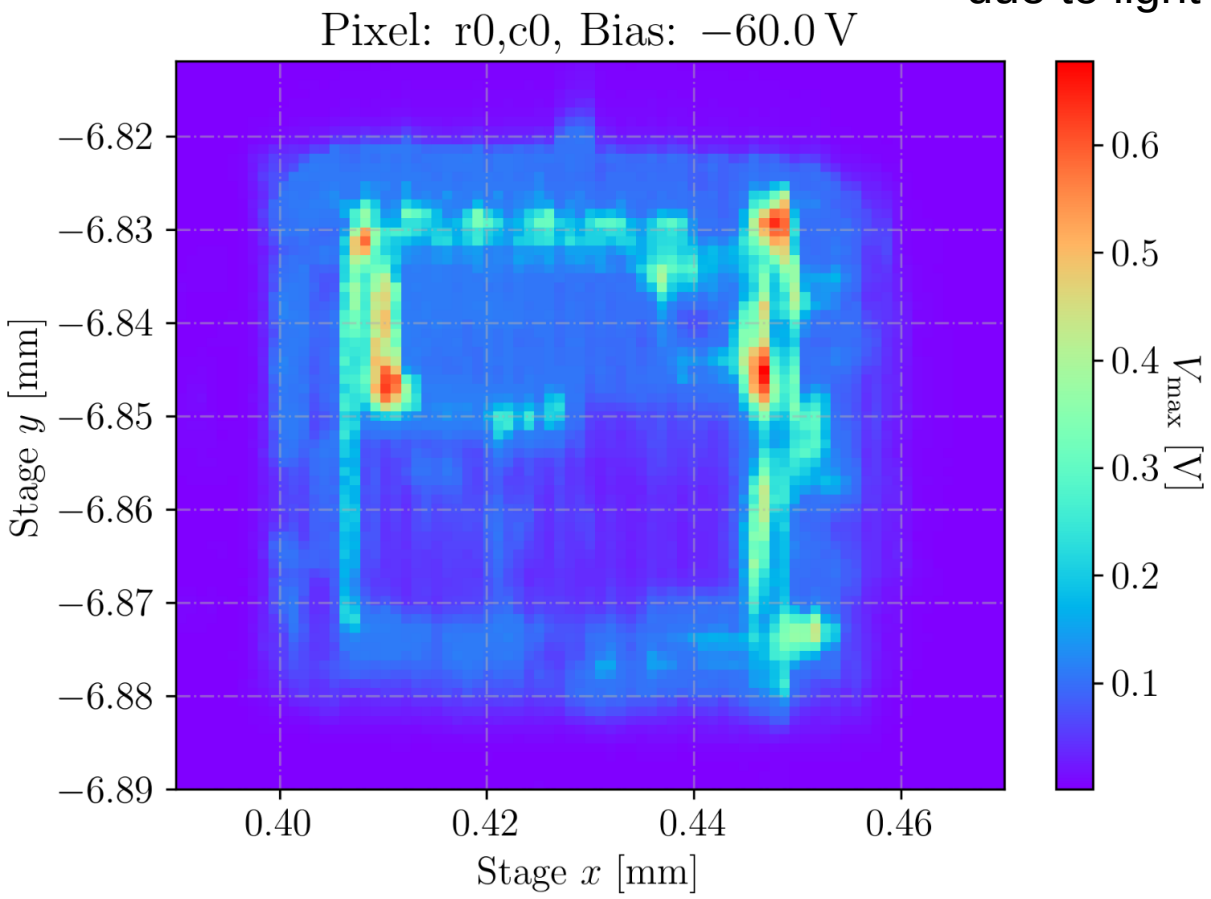
Pixel 0,0 (APM1)

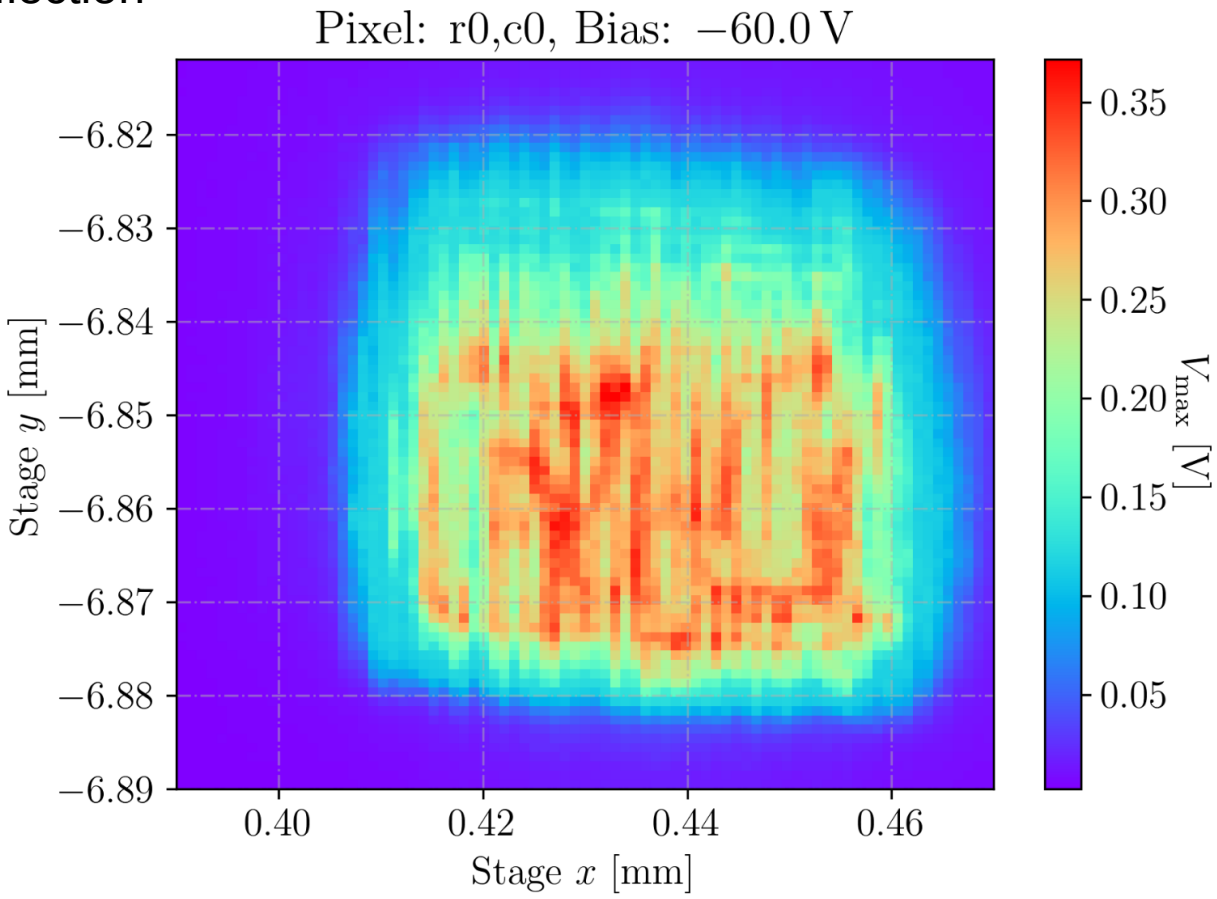
2022_07_08_14_40_24_MPW2
2022_07_11_12_34_21_MPW2

XY-Scan with focus at the top side electronics (±3µm) :

Metal layers on the DNWell implant gives bigger signal due to light reflection

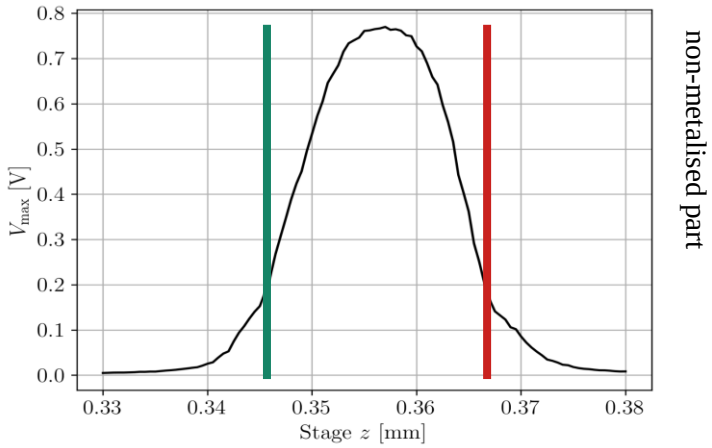
XY-Scan with focus at the back side (-94±3µm) :





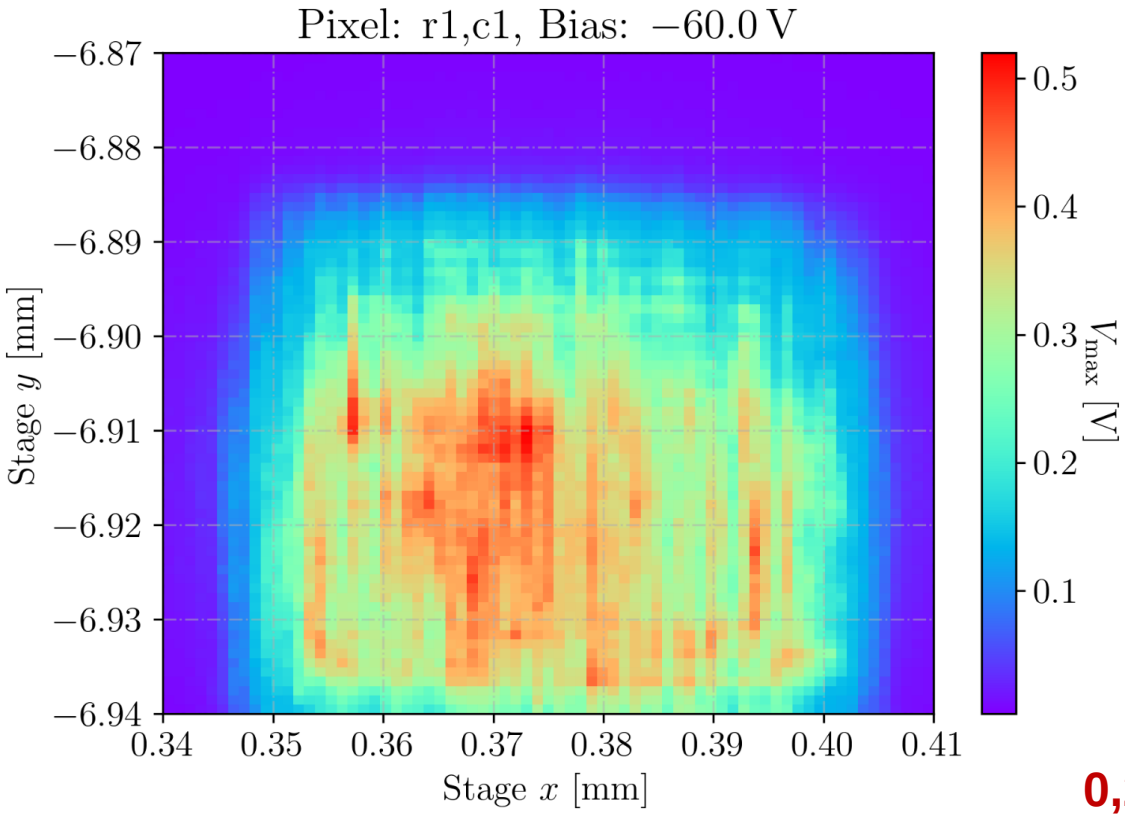
0,25 nJ per pulse

Pixel 1,1 (APM1)

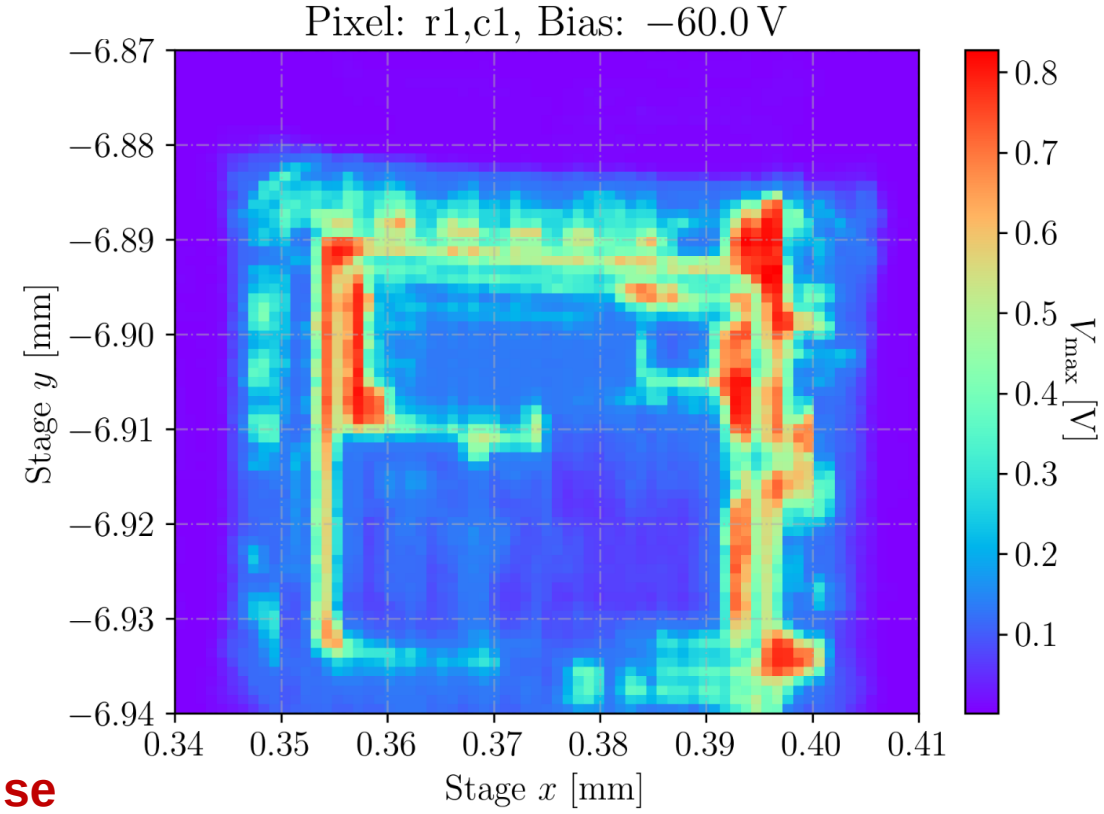


2022_07_11_16_53_15_MPW2
2022_07_11_17_14_49_MPW2
2022_07_11_19_31_19_MPW2

XY-Scan with focus at the back side (-94 µm with ±3µm):



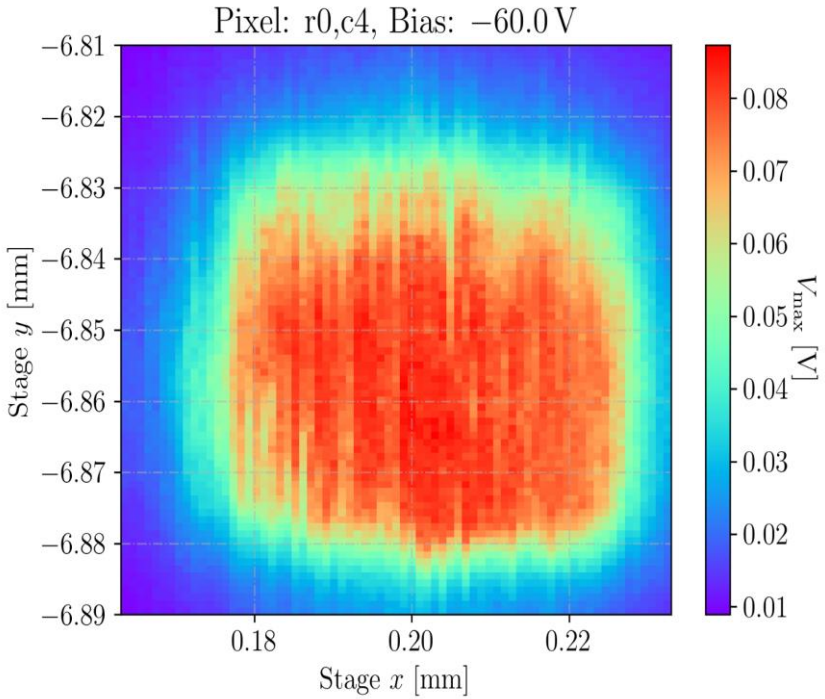
XY-Scan with focus at the top side electronics (±3µm) :

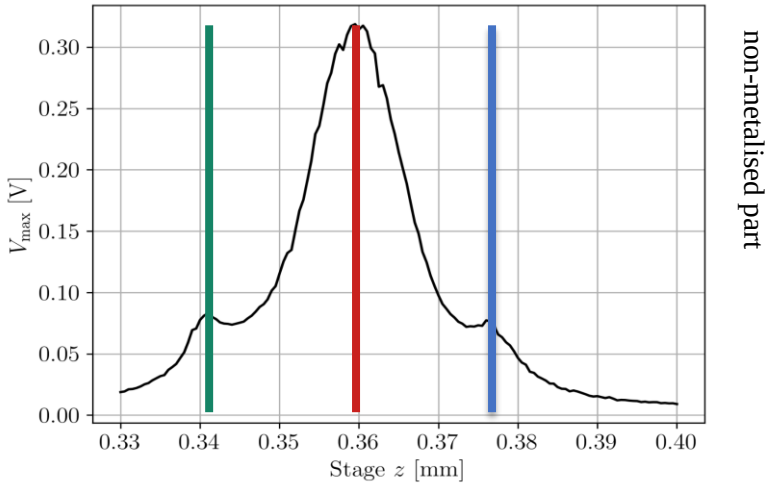


0,25 nJ per pulse

Pixel 0,4 (APM2)

XY-Scan with focus at the back side (-94 µm ±3µm):



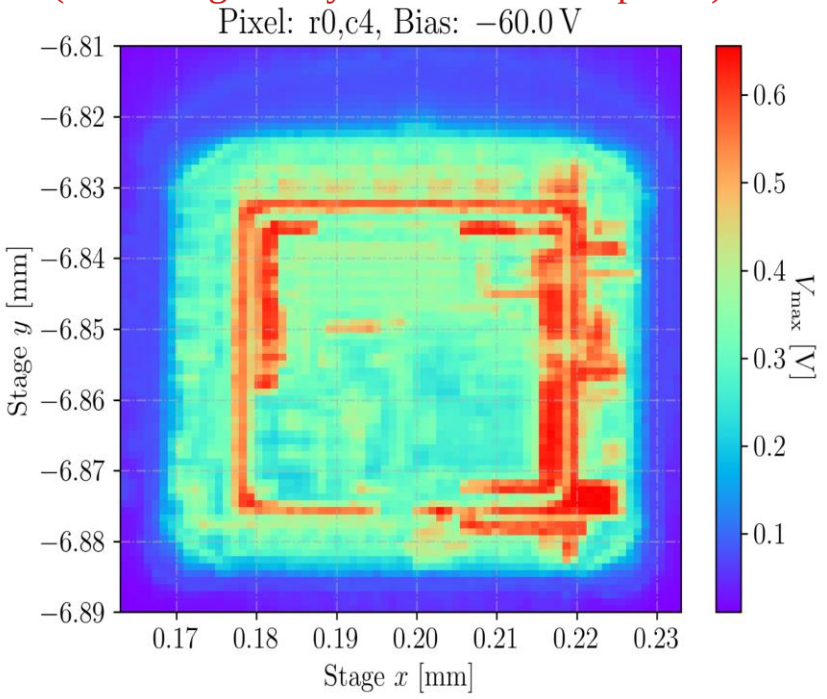


non-metalised part

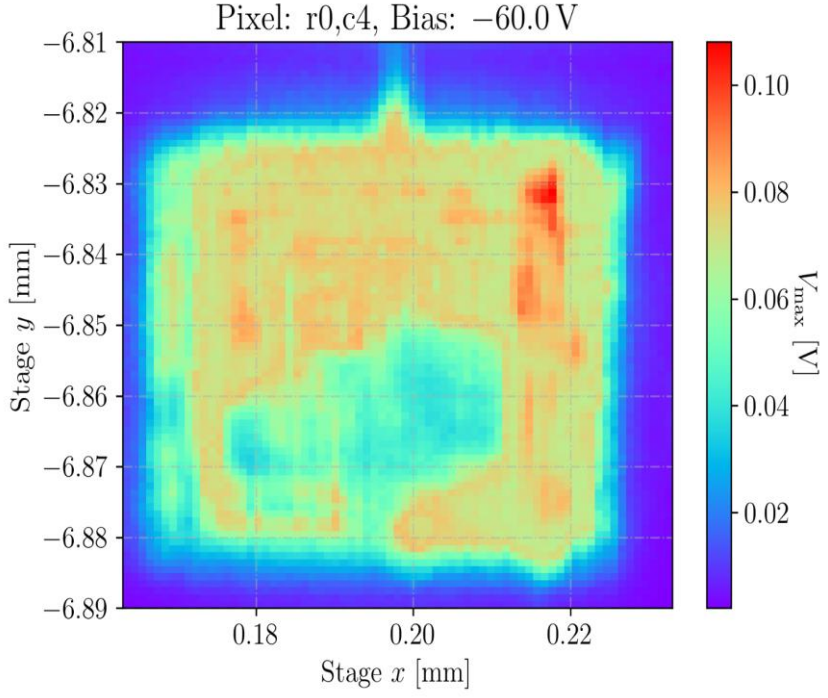
2022_07_13_10_00_30_MPW2
2022_07_13_10_21_42_MPW2
2022_07_13_11_35_35_MPW2
2022_07_13_13_54_27_MPW2

0,25 nJ per pulse

XY-Scan with focus at the middle (-49µm ±3µm):
(nwell ring clearly shown in the response)



XY-Scan with focus at the top side (±3µm) :



Conclusions

- TPA method can make detailed maps of the electric field, useful to determine the homogeneity of the field

It is specially appropriate for MAPS because of the in-pixel electronics interference

- ZY maps gives the depletion depth (and the depletion volumen)
- XY maps gives the CCE in the in-pixel detector volume
- Probably the best method for quality assesment and with no radiation damage
- Complementary to the proton microprobe technique, that can be considered the second testing technique for MAPS detectors before going to a full testbeam in a telescope

Thanks for your attention

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