Institut
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Ljubljana, Slovenija

New TPA-TCT system at Jozef Stefan Institute (JSI)

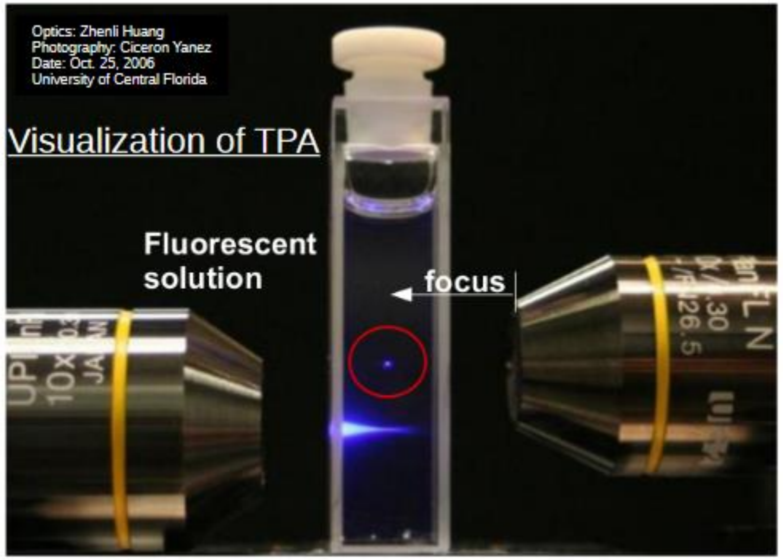
38th RD50 Workshop, online, 23. 06. 2021

Bojan Hiti, F9, Jožef Stefan Institute (JSI)

Reminder: Two Photon Absorption TCT

Two Photon Absorption - TCT

Single Photon Absorption
Continuous energy deposition along beam direction



Two Photon Absorption

Absorption only at focal point

M. Wiehe,
35th RD50 Workshop

Confine photons in
time (femto-second laser)
and in **space (microfocusing)**
for Two Photon Absorption

- 12th of March 2013, first TPA-TCT measurement at SGIker facility of UPV, Bilbao
- November 2014: Presentation of TPA-TCT at 25th CERN RD50 workshop
- 2013 – 2017: TPA-TCT measurements at UPV, Bilbao

1) NIMA Vol 845, 11 February 2017, Pages 69-71
https://doi.org/10.1016/j.nima.2016.05.070
2) Journal of Instrumentation, Volume 12, January 2017
http://iopscience.iop.org/article/10.1088/1748-0221/12/01/C01038

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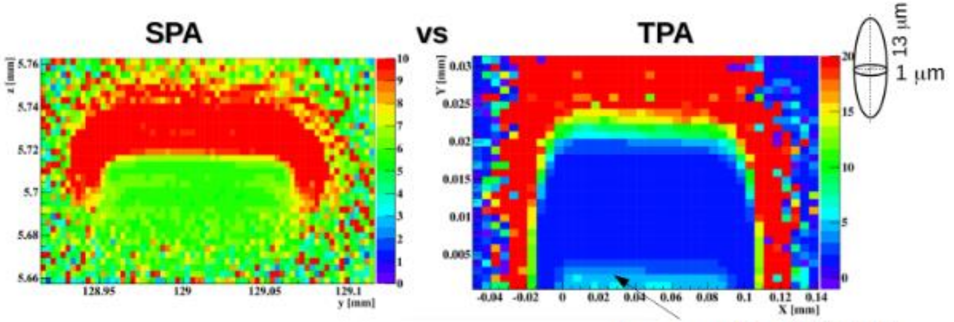
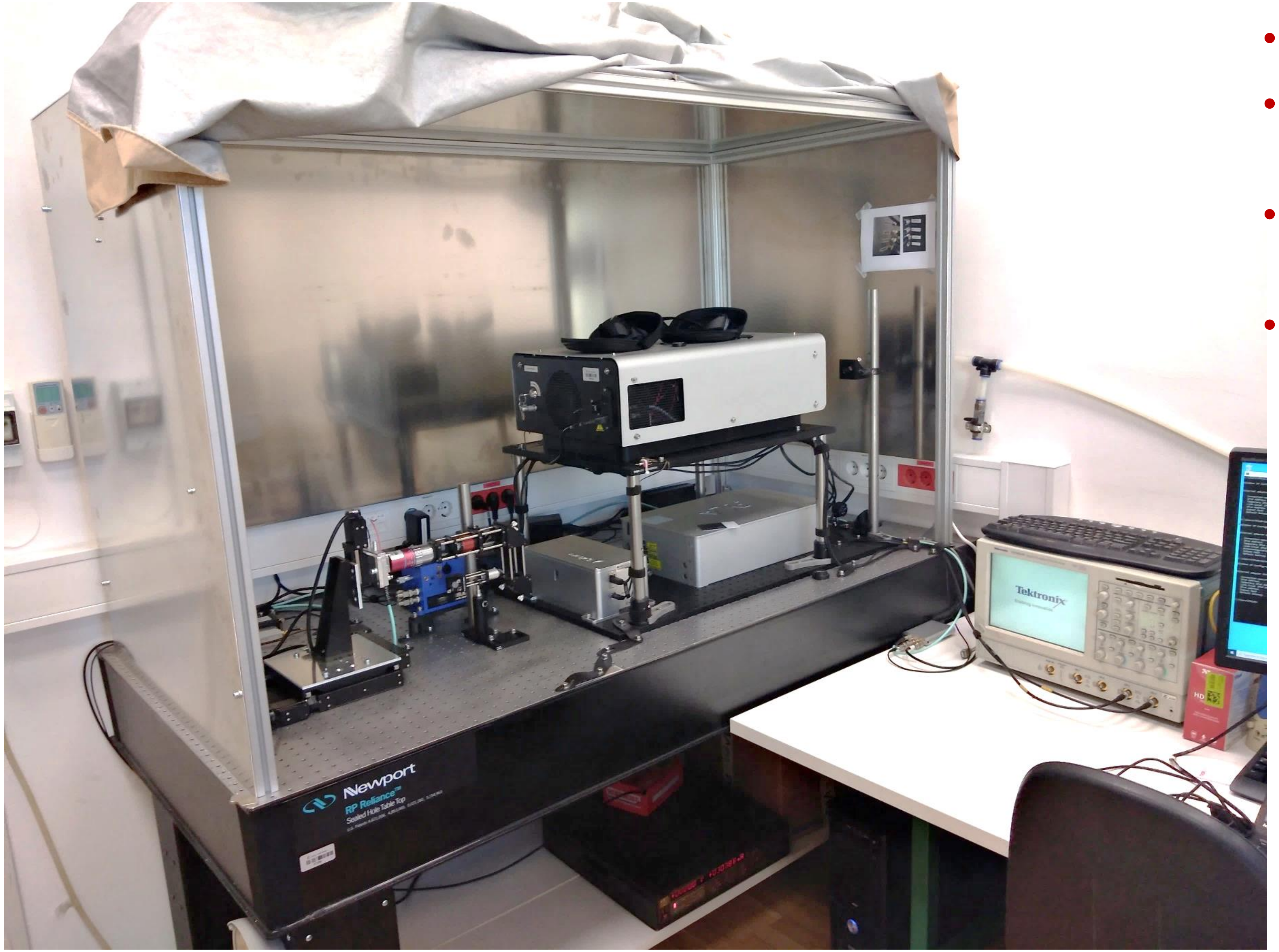
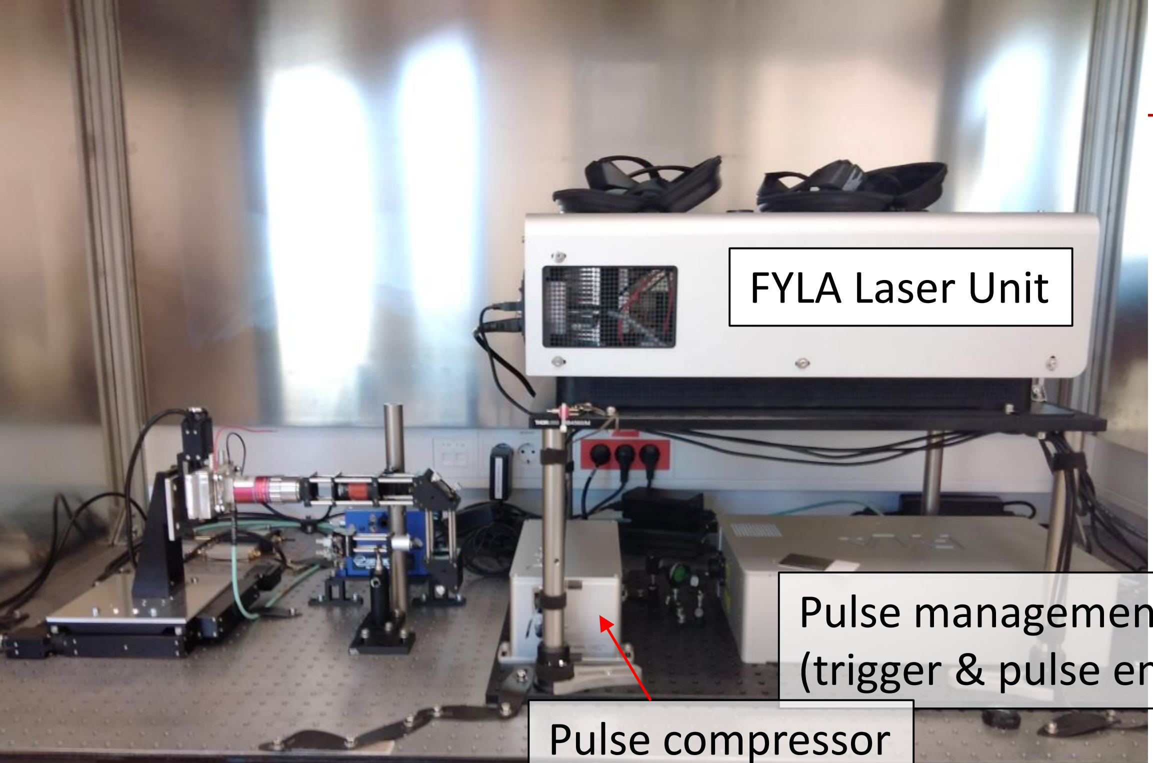


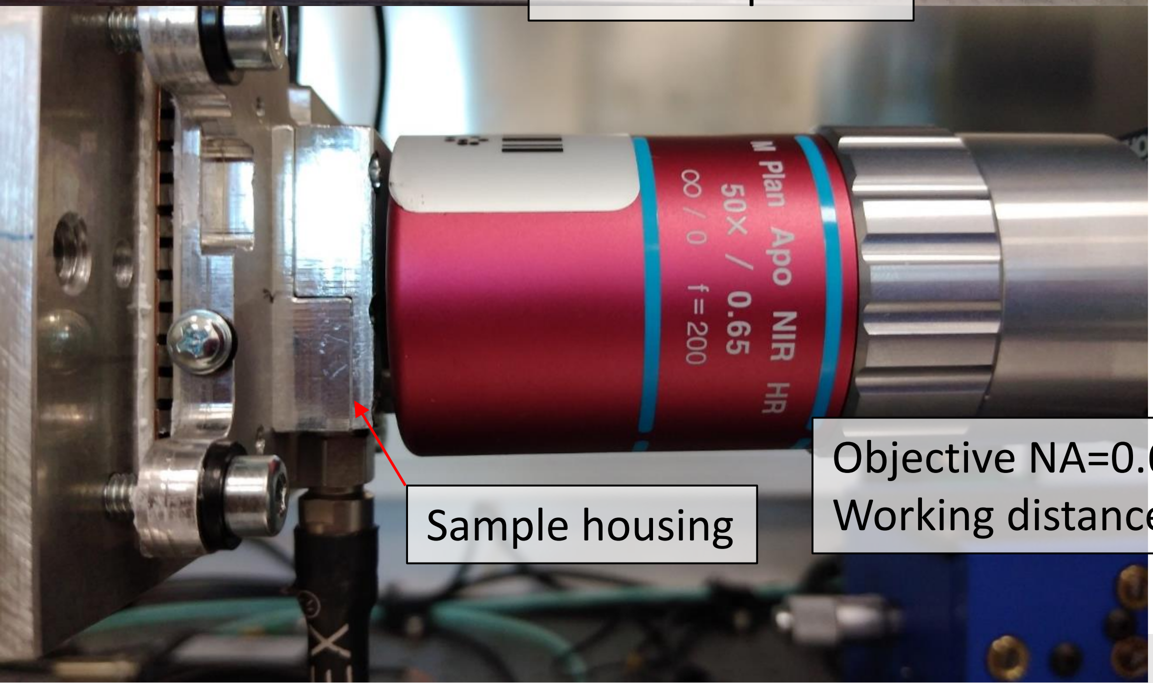
deep n-well in HVCMOS
Not resolved in SPA-TCT

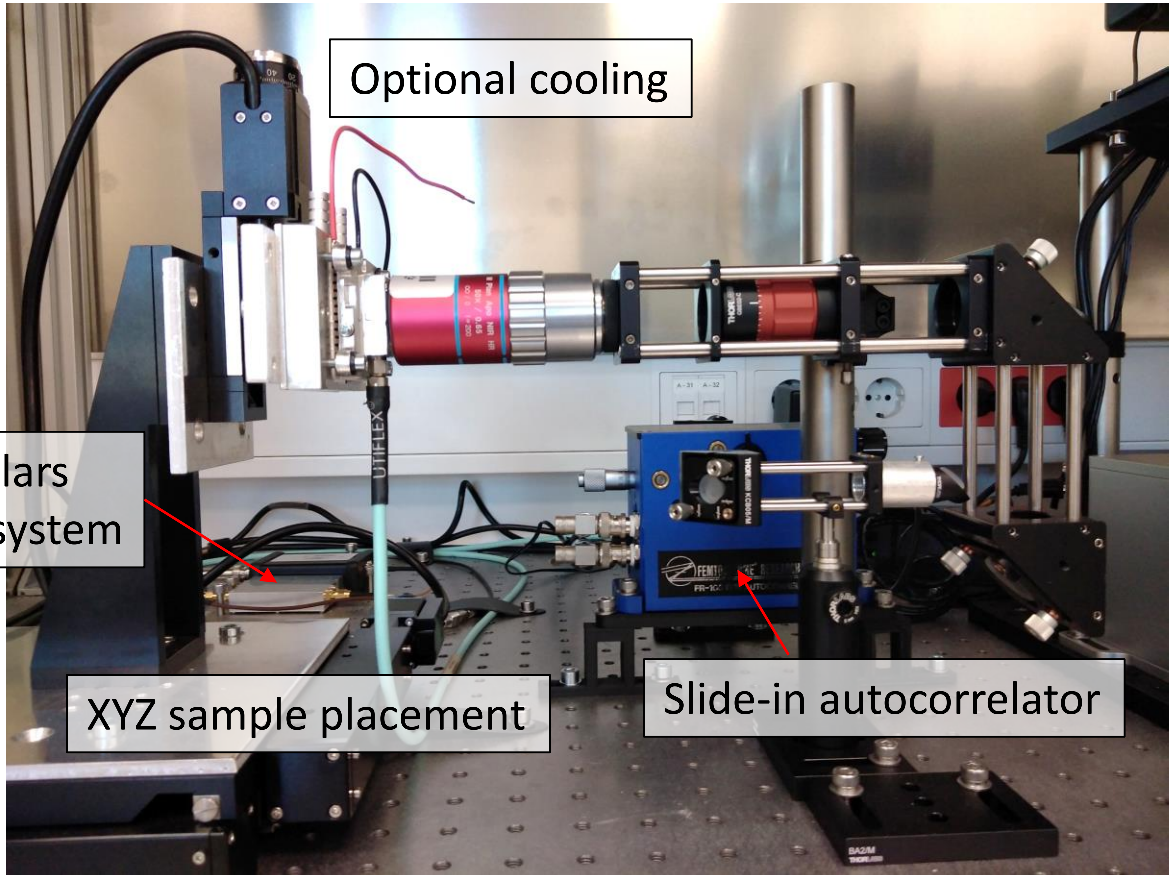
Ljubljana TPA-TCT setup



- New TPA-TCT system built at JSI
- Based on FYLA LFC 1500X fs laser (λ=1550 nm)
- Readout electronics and DAQ based on standard Particulars TCT
- First TPA signals observed in May 2021


FYLA Laser Unit
Pulse management module
(trigger & pulse energy)
Pulse compressor

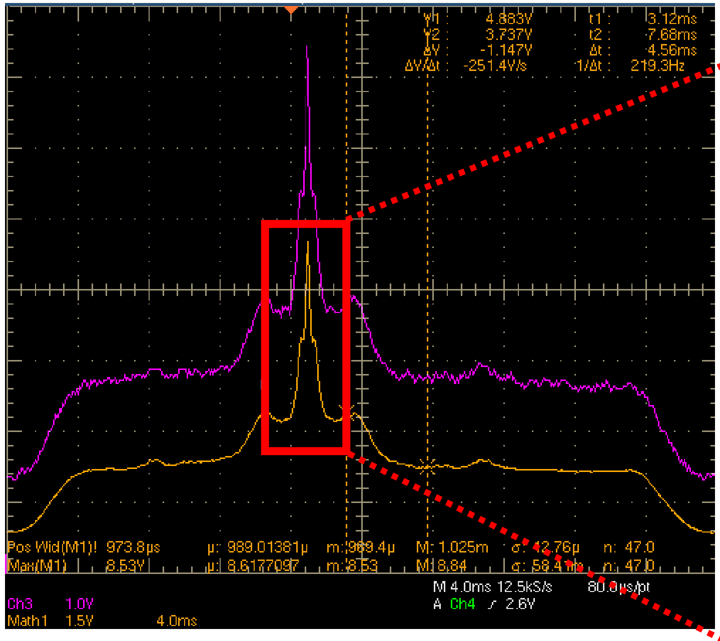

Plan Apo NIR HR
50× / 0.65
∞ / 0 f = 200
Sample housing
Objective NA=0.65,
Working distance 10 mm


Optional cooling
Particulars
readout system
XYZ sample placement
Slide-in autocorrelator

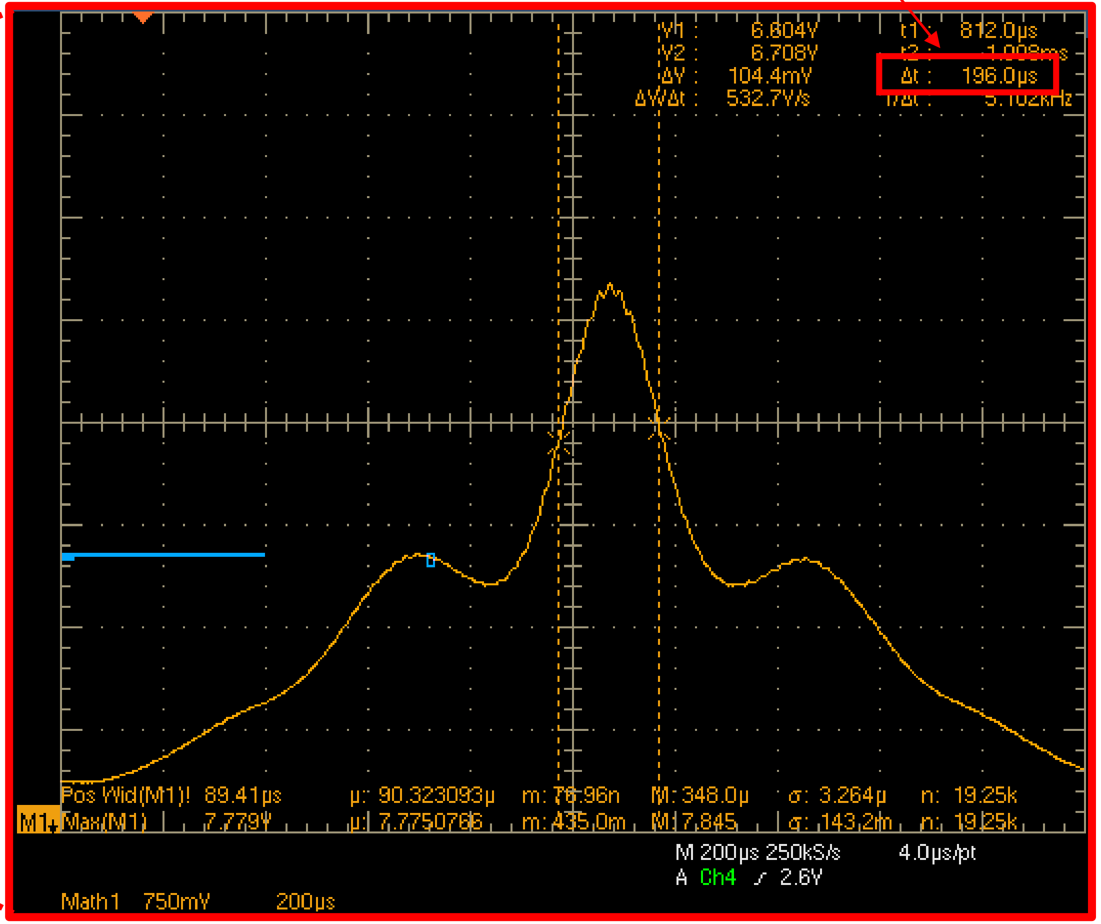
TPA laser pulse: Time domain

- Measurement of laser pulse duration with an autocorrelator

Autocorrelator output



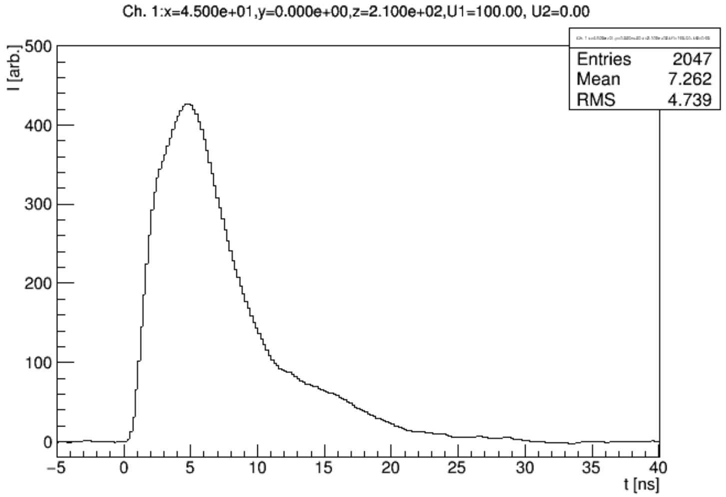
Pulse width (FWHM)
0.196 ms x 1600 fs/ms = 310 fs

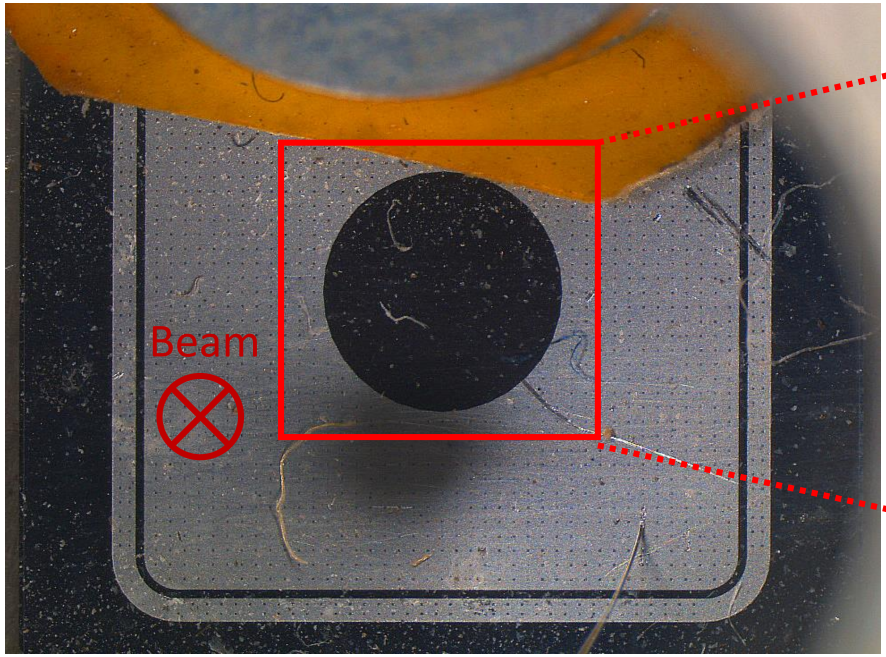


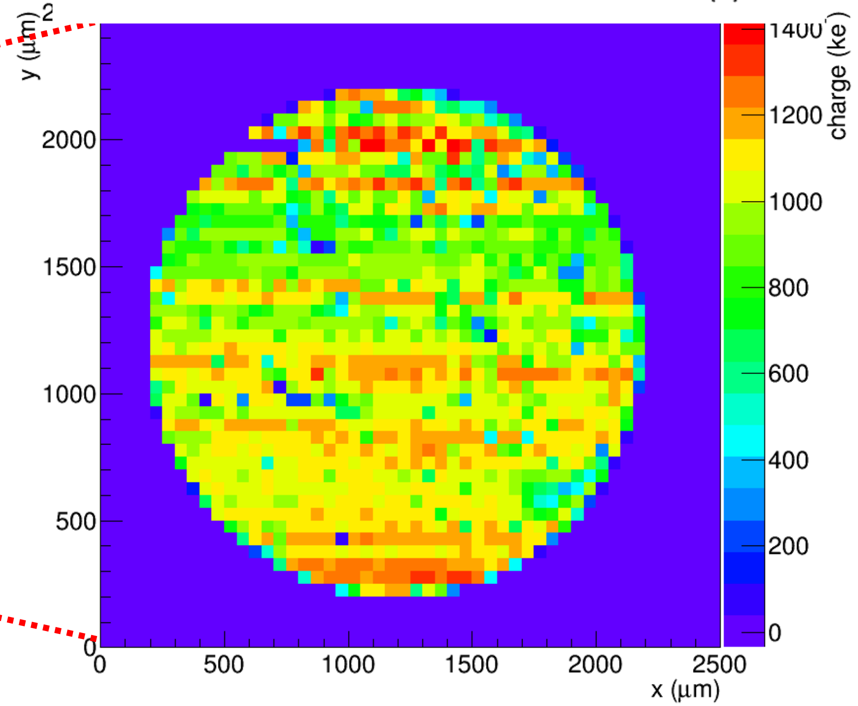
Pulse duration ≈ 300 fs

First TPA-TCT measurements

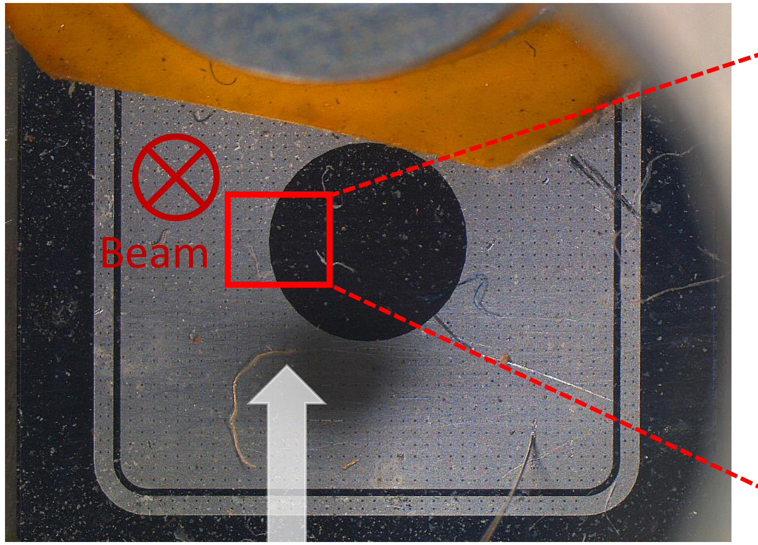
- Sample:
  - 6 x 6 mm p-in-n pad diode, metalization opening 2 mm
  - Thickness 300 µm, 10 kΩ·cm, unirradiated
- Charge = time integral (50 ns) of TCT-pulse
- Amplifier output calibrated with Am^{241} alpha source (5.4 MeV)



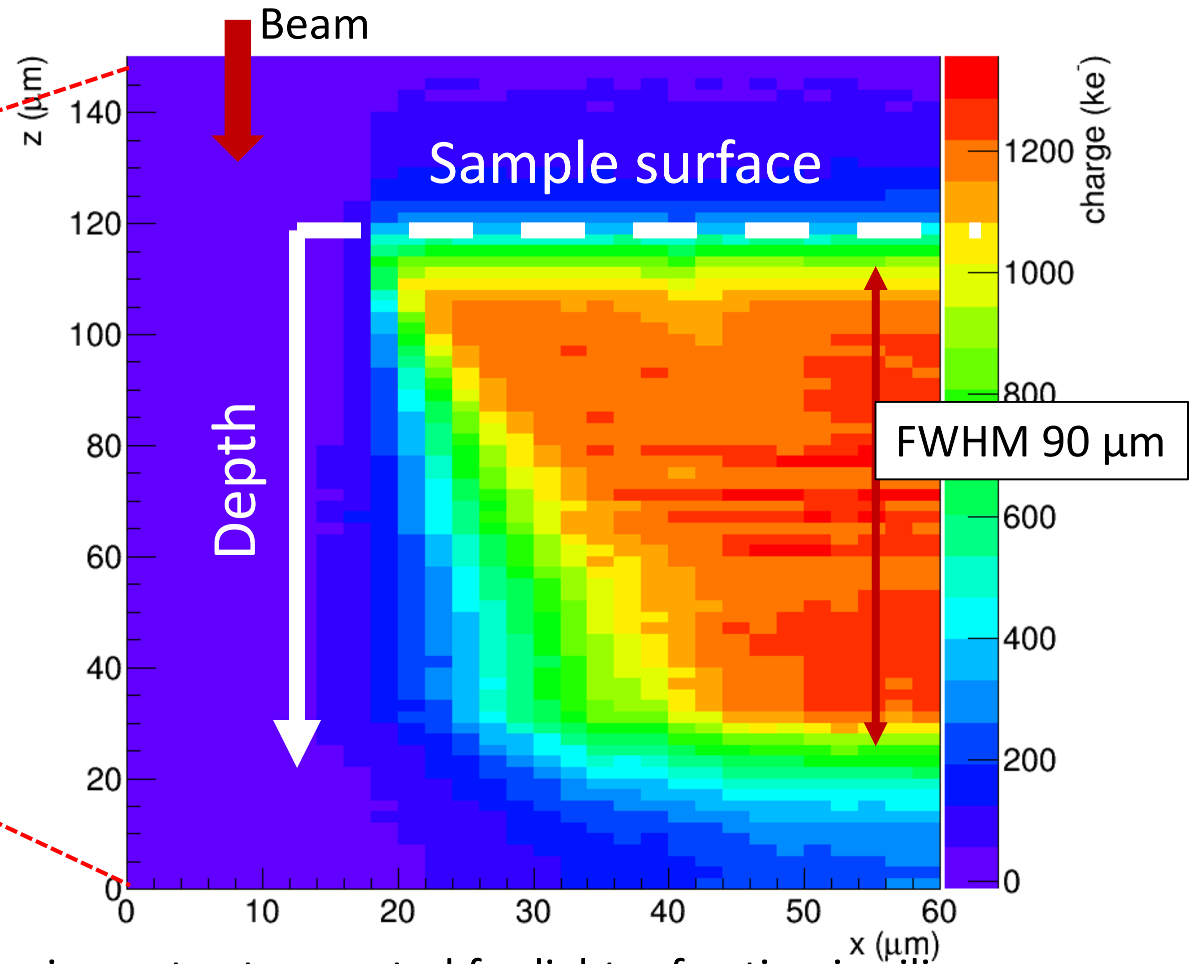




First TPA-TCT measurements



Direction of projection



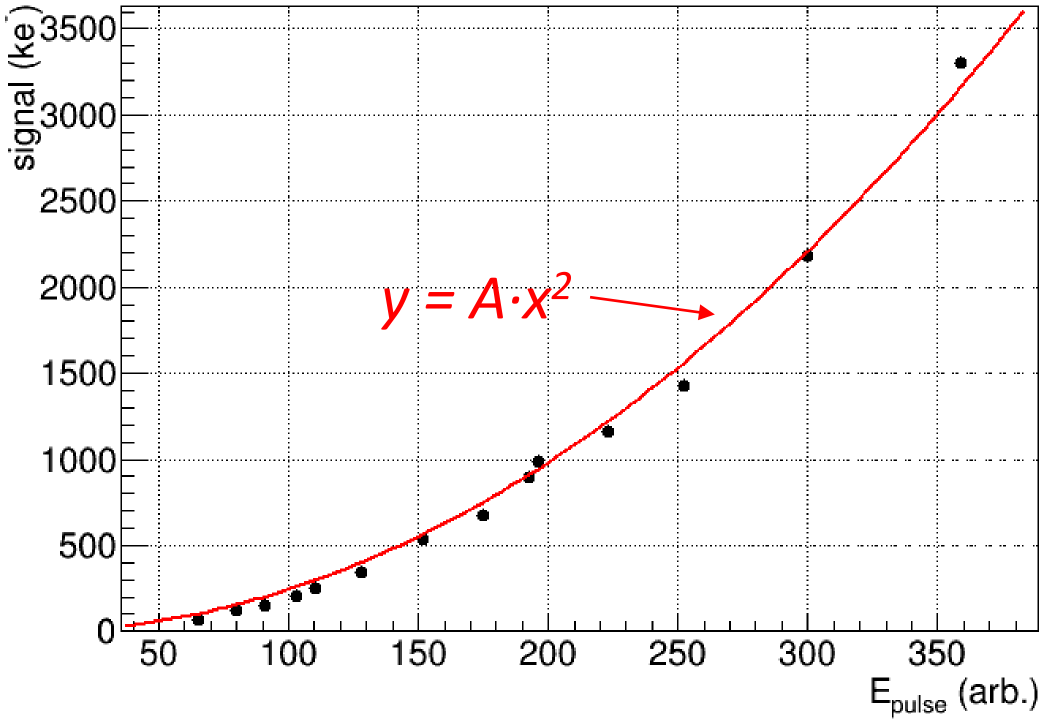
z-dimension not yet corrected for light refraction in silicon
→ Analysis ongoing

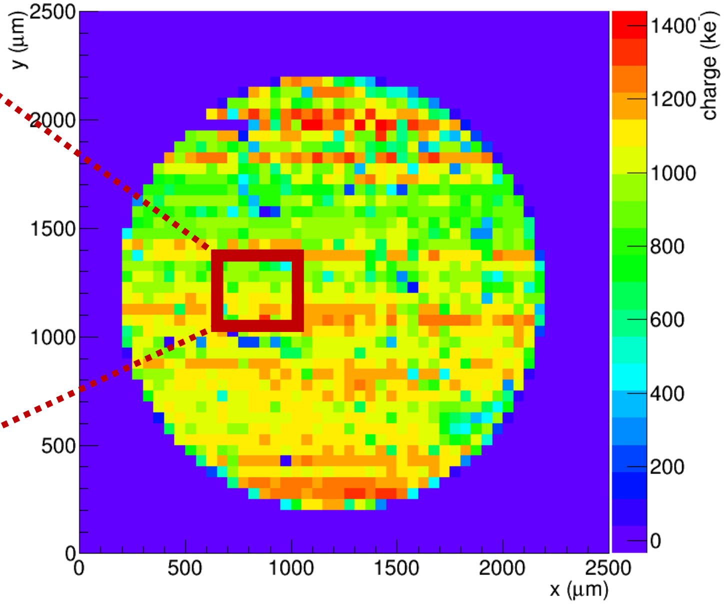
FWHM x n_{Si} = 90 µm x 3.4 = 306 µm
→ compatible with device thickness

Dependence of signal size on pulse energy

- Varying laser power at fixed point in the sample
- Charge carrier generation equation: $$\frac{\mathrm{d}N(r,z)}{\mathrm{d}t} = \frac{\alpha I(r,z)}{\hbar\omega} + \frac{\beta_2 I^2(r,z)}{2\hbar\omega}$$

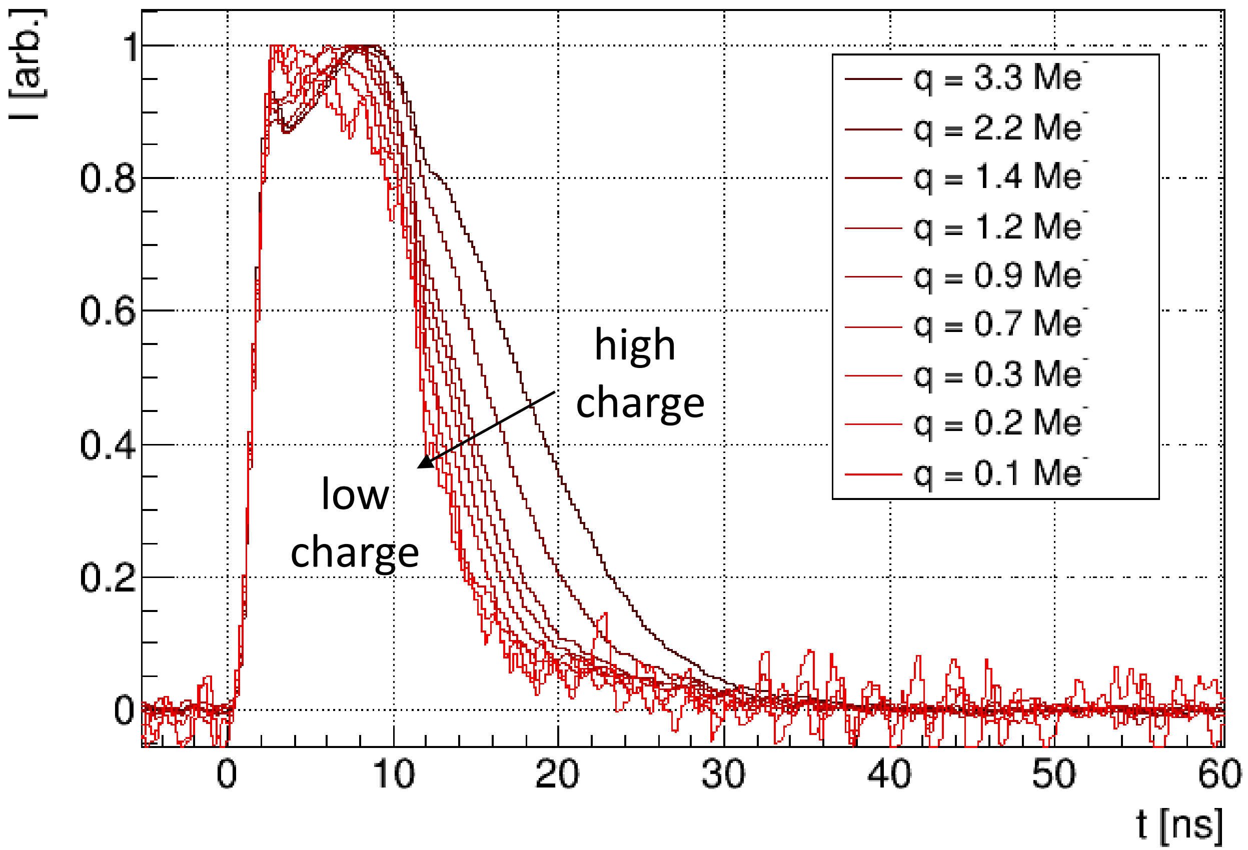
SPA TPA





Signal size ∝ *(Irradiance)*^{2} – **Proof of TPA**

Signal shape vs. pulse energy



- TCT signals at different pulse energies normalized to the same height
- Onset of plasma effect at > 2 Me- injected charge (E-field screening → elongated pulse)

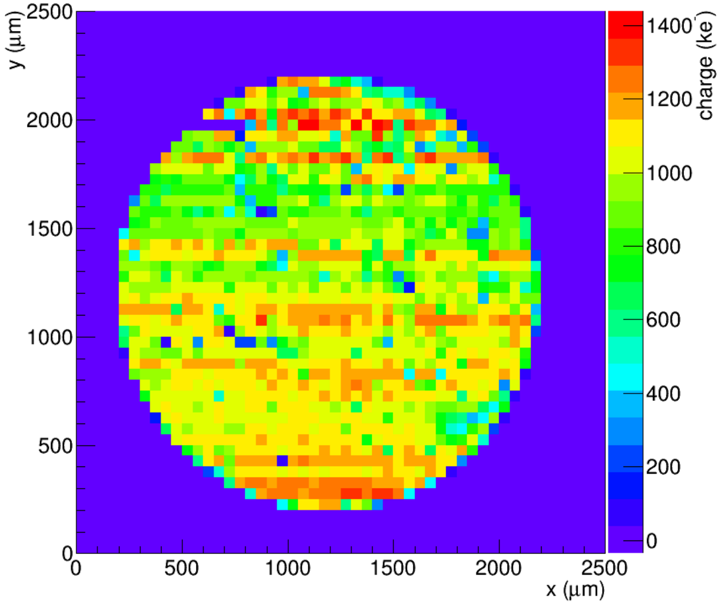
SEU studies potential

- LGAD mortality studies require charge of the order of 30M e-h pairs
  - Can it be done with TPA?
- Maximized signals cannot be measured directly (amplifier saturation)
- Beam intensity measurement with power meter (before entering objective) – (PM100D + S401C), pulse rate 4 MHz
- Pulse energy is selected with adjustable neutral density filter → should not change pulse shape

Beam power	3.5 mW
Charge	≈ 1M e-h

Maximize pulse energy →

Beam power	28 mW (*8x Irradiance*)
Charge (expected)	**≈ 1M e-h *x* 8^2 */ Losses(?)* ~ 30M e-h**



Maximal signals in the range of 30M e-h pairs seem to be achievable

Summary

- New TPA-TCT system under commissioning at JSI
- First measurements demonstrated operation in TPA mode
- Beam characterization ongoing
- In future tests with irradiated sample
- Plan to investigate SEU test capabilities