Commissioning of a Two-Photon Absorption laser setup

Two-Photon Absorption Transient-Current Technique

Carmel Neuburger[1]
Supervisors: Marcos Fernandez[2], Michael Moll[1]

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CERN EP-DT summer students DT seminar 20, August 2019


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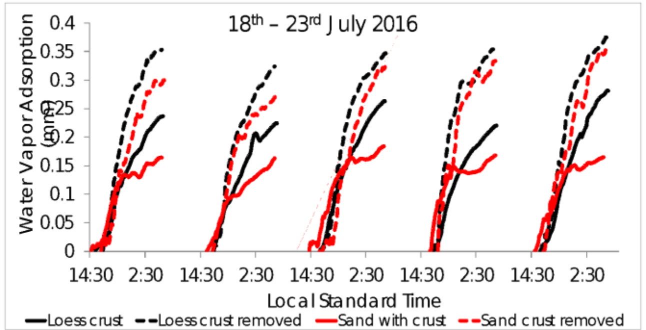
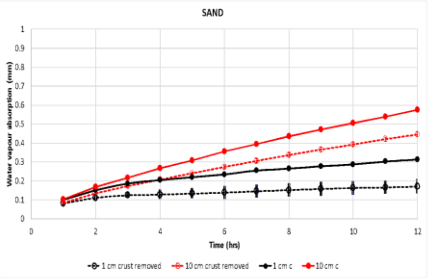
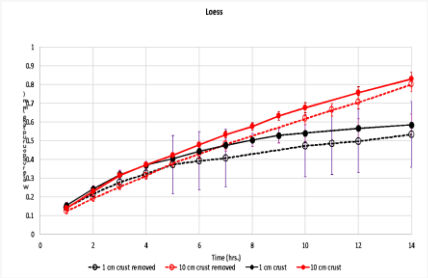
אוניברסיטת בן-גוריון בנגב
המכונים לחקר המדבר ע"ש
יעקב בלאושטיין
BEN-GURION UNIVERSITY OF THE NEGEV
THE JACOB BLAUSTEIN
INSTITUTES FOR DESERT RESEARCH



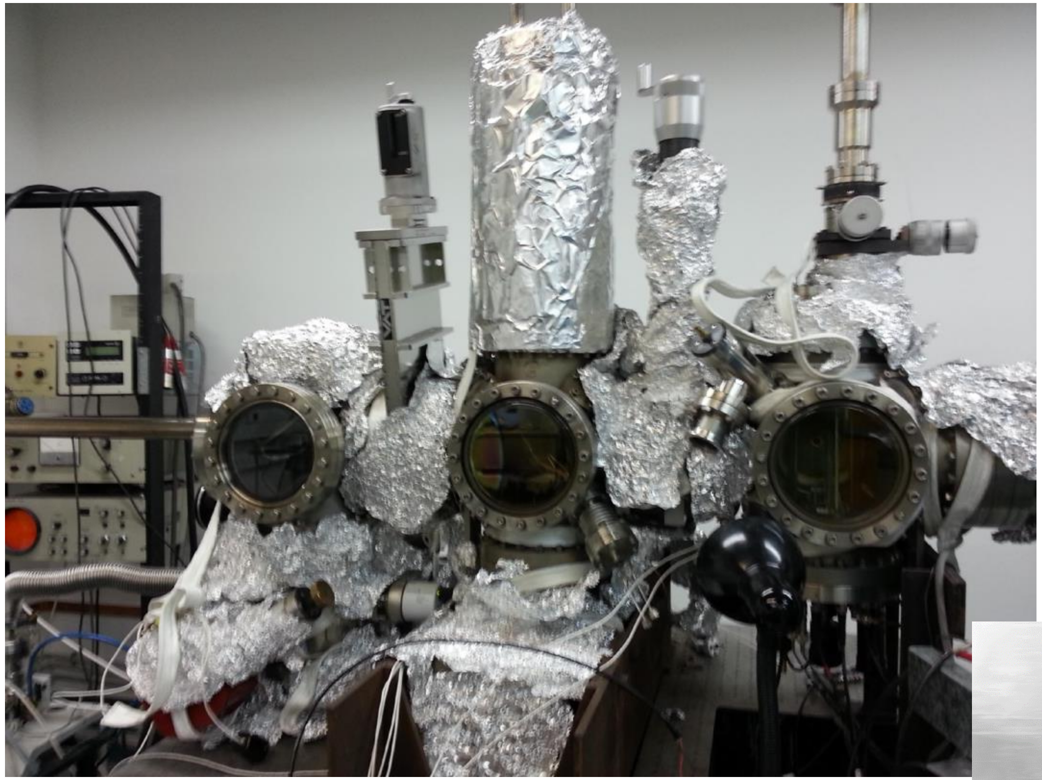
18th – 23rd July 2016
Water Vapor Adsorption (mm)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
14:30 2:30 14:30 2:30 14:30 2:30 14:30 2:30 14:30 2:30
Local Standard Time
Loess crust
Loess crust removed
Sand with crust
Sand crust removed



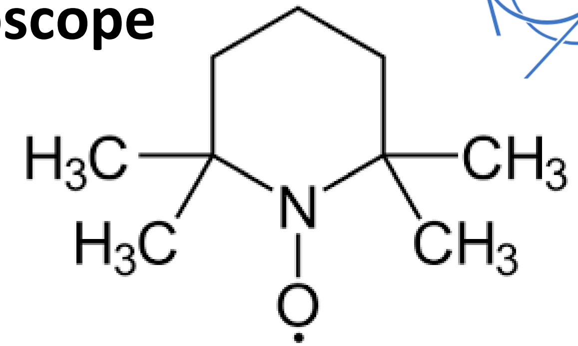
SAND
Water vapour absorption (mm)
Time (hrs)
1 cm crust removed
10 cm crust removed
1 cm c
10 cm c

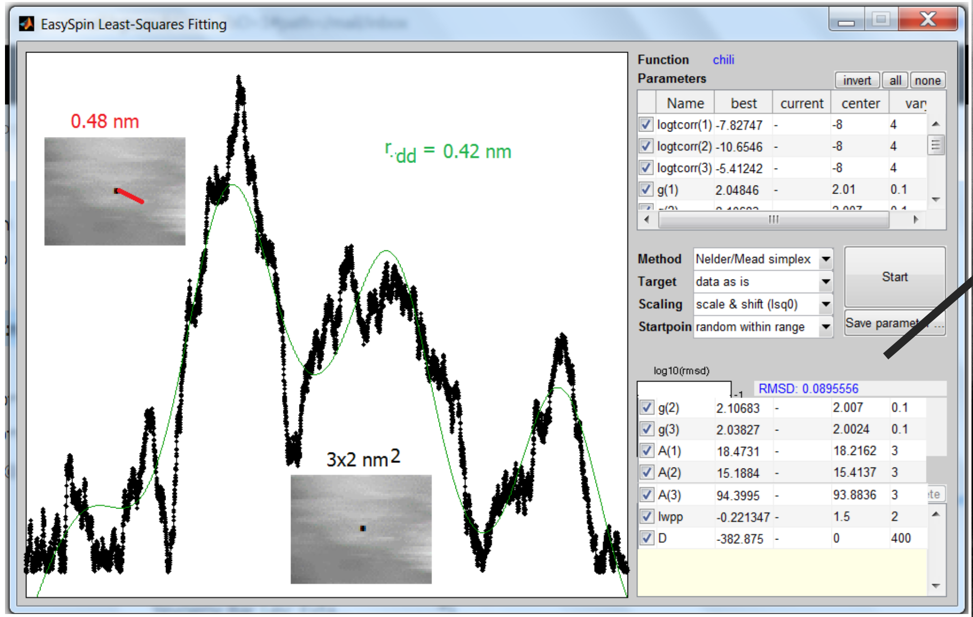


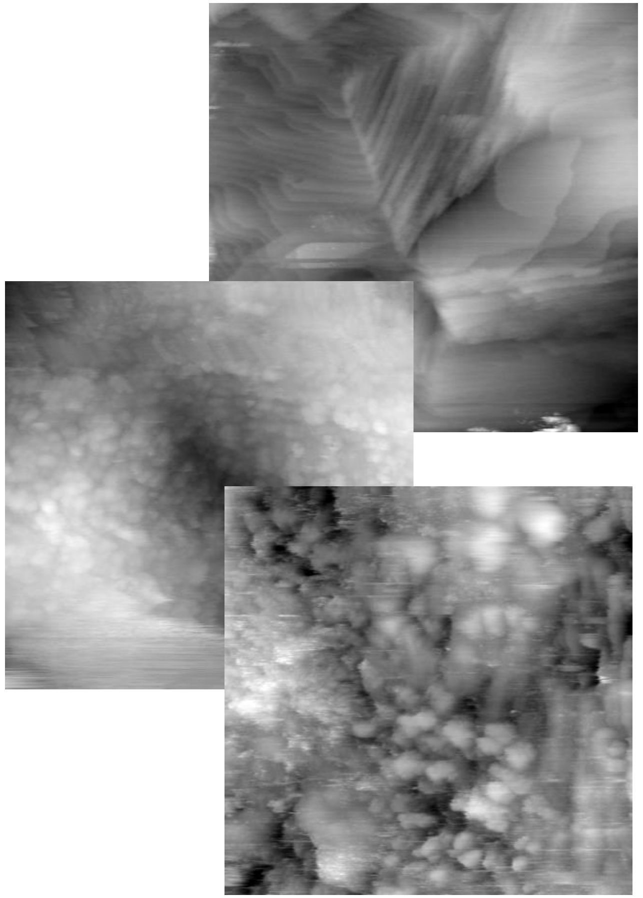
Loess
Time (hrs.)
1 cm crust removed
10 cm crust removed
1 cm crust
10 cm crust



Electron Spin Resonance of single molecules using a scanning tunnel microscope







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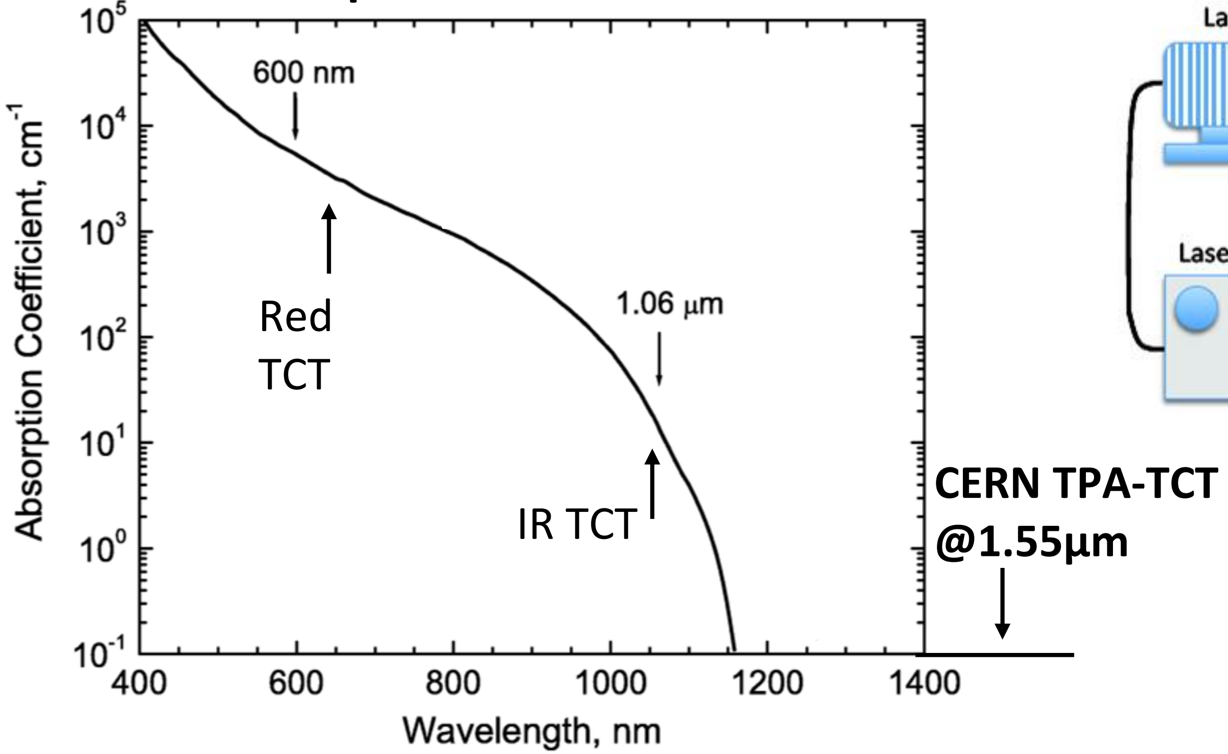
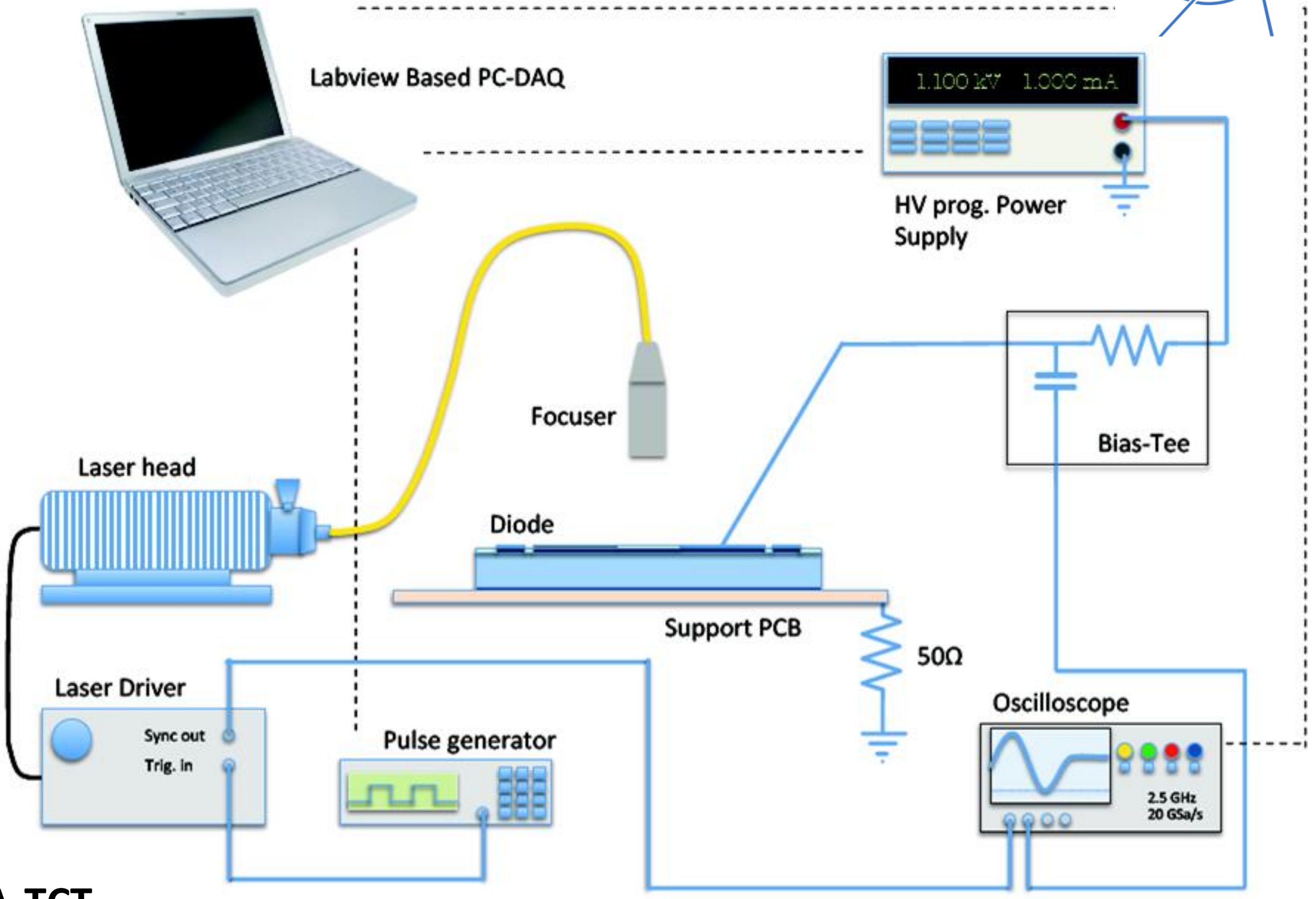
TCT

TCT=**T**ransient **C**urrent **T**echnique
Laser characterization technique: light injected in a detector -> induced current studied.

Workhorse for characterization of Si detectors within RD50 collaboration.

Linear absorption coefficient of silicon





Two Photon Absorption

TPA provides spatial resolution along the beam propagation direction.

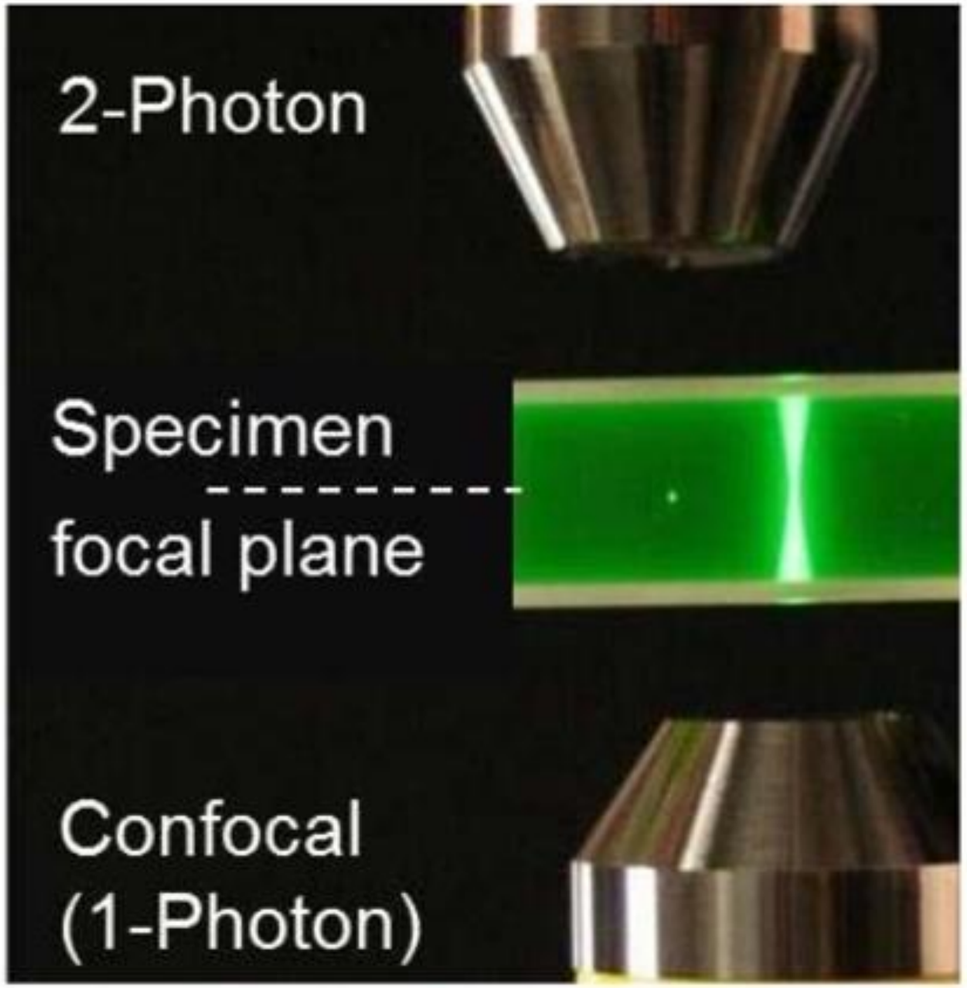
Before TPA, there was no spatial resolution along the beam propagation direction. With TPA, the laser probe is “point-like” (3D ellipsoid ∼1x1x10 μm³)

$$\frac{dN(r,z)}{dt} = \frac{\alpha I(r,z)}{\hbar\omega} + \frac{\beta I^2(r,z)}{2\hbar\omega}$$

Linear absorption

N = density of free carriers [1/cm³]

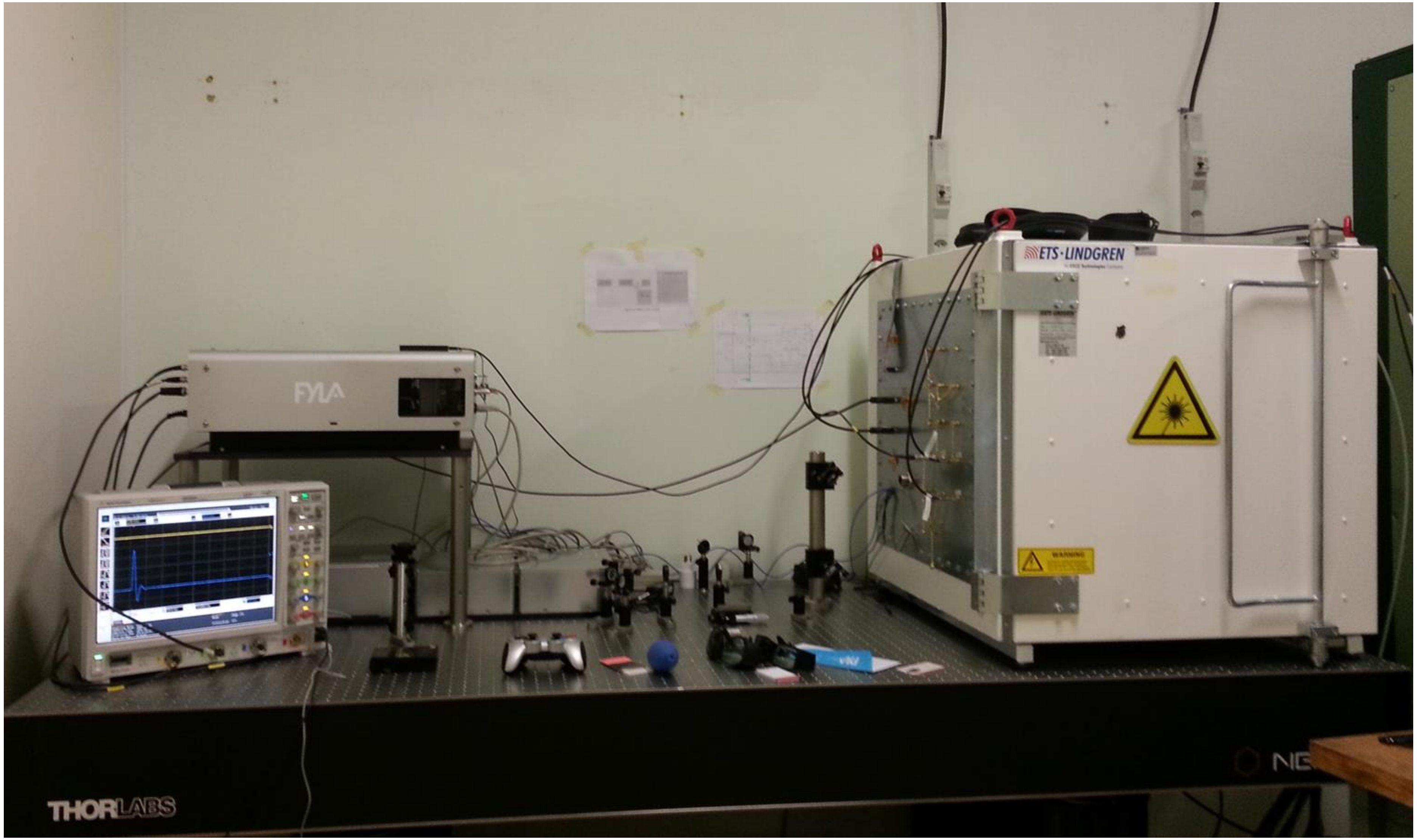
I = pulse irradiance [J/cm²]

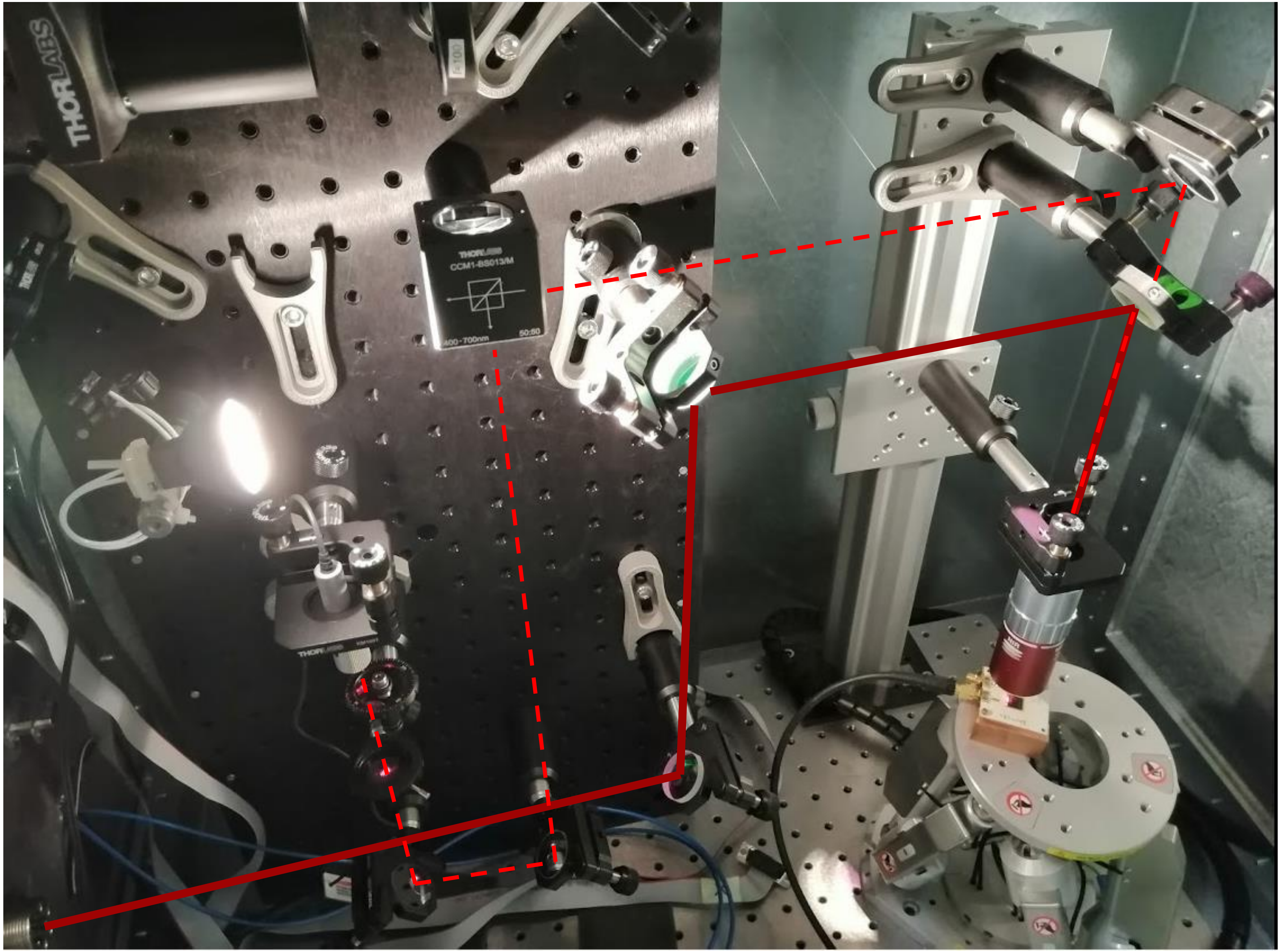


Photography: Ciceron Yanez, University of Central Florida

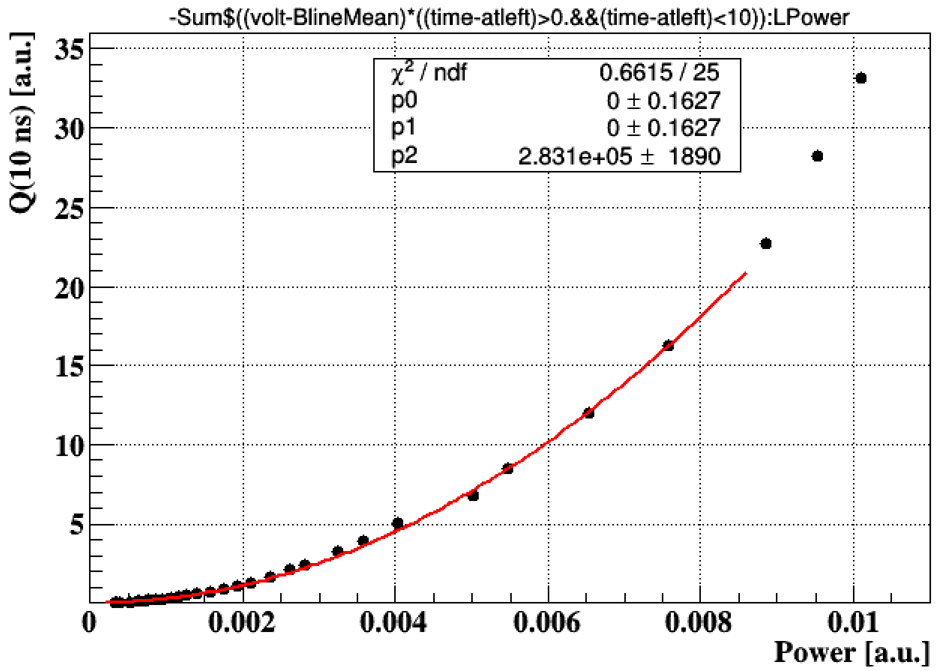
TPA-TCT uses a laser operating in Two Photon Absorption and uses TCT analysis techniques
TPA needs high irradiance -> it happens only at the focus (x100) of the microscope objective

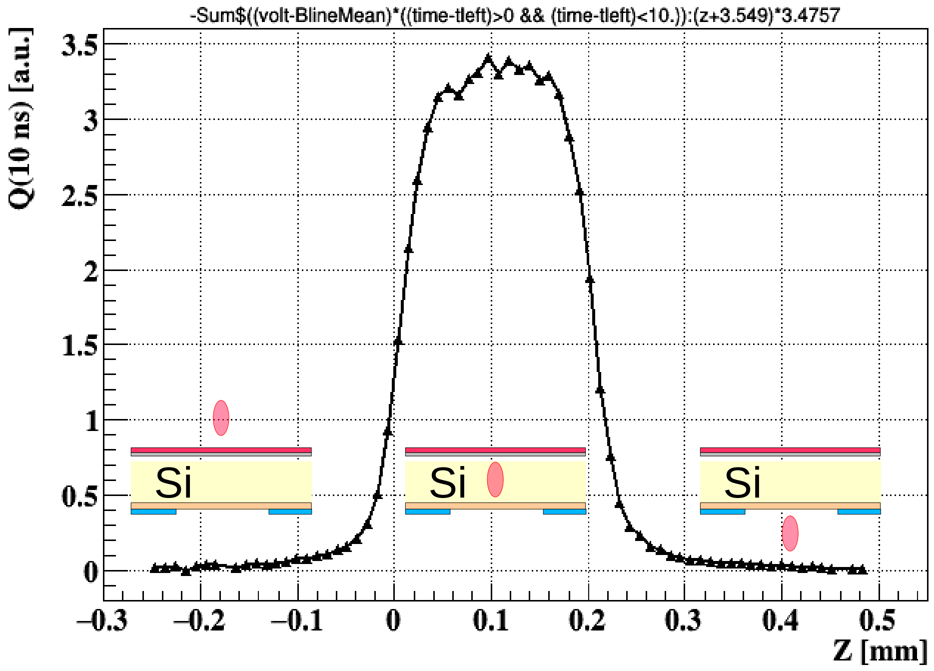
Laser development funded by CERN - Knowledge Transfer program
Laser developed with the company FYLA, Spain
Setup assembled by Moritz Wiehe (CERN doctoral student funded by Gentner program)




THORLABS
THORLABS
CCM1-BS013/M
400 - 700nm
50:50

Proof of TPA





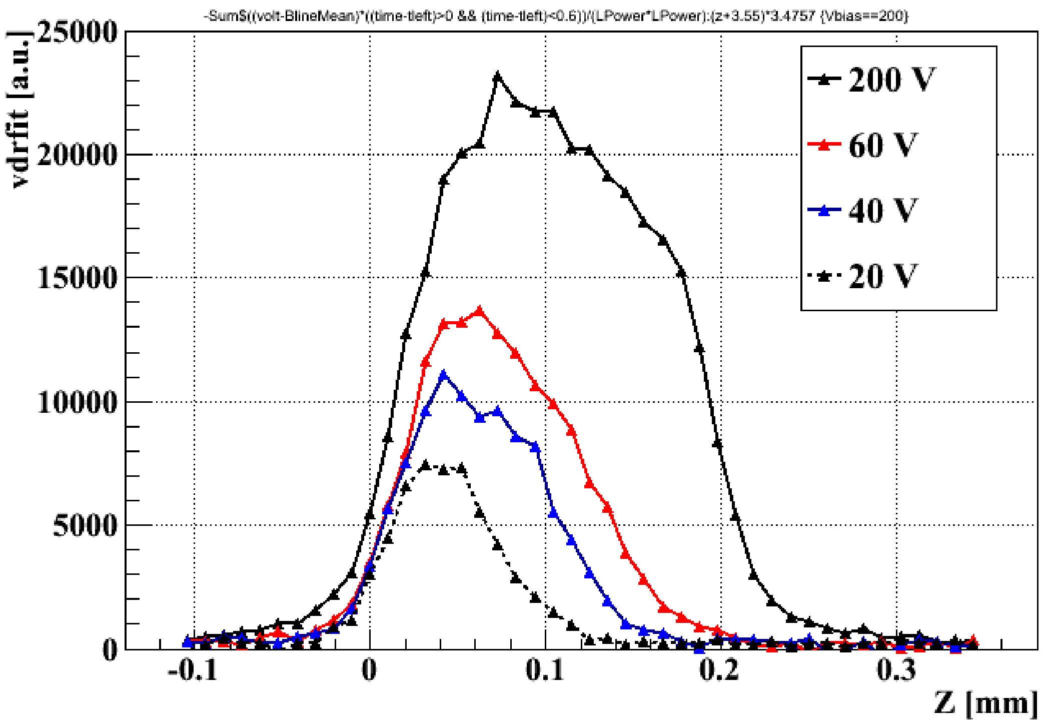
1) Quadratic relation between collected signal (in Si) and laser power

2) Carriers produced only when focus of laser is inside the detector. No signal collected outside
→ Spatial resolution along the beam demonstrated

$$\frac{\mathrm{d}N(r,z)}{\mathrm{d}t} = \frac{\beta I^2(r,z)}{2\hbar\omega} \Rightarrow \Delta N(r,z) = \frac{\beta I^2(r,z)}{2\hbar\omega}\Delta t$$

$Q \propto N$ $\quad P \propto I$

E-field mapping in top-TPA configuration

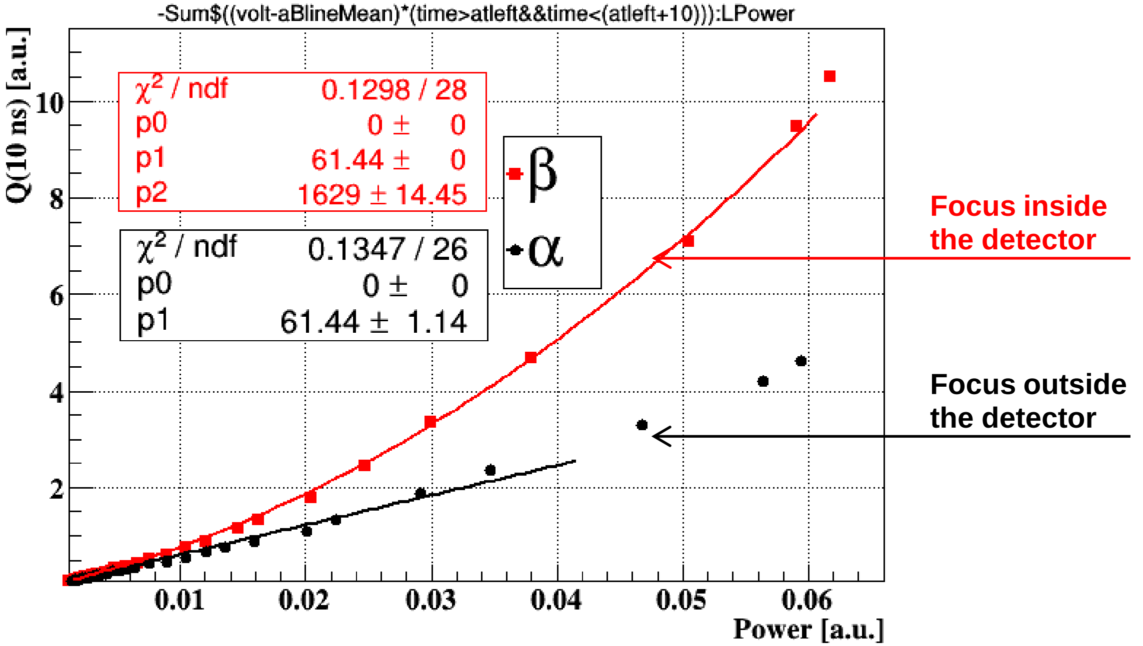


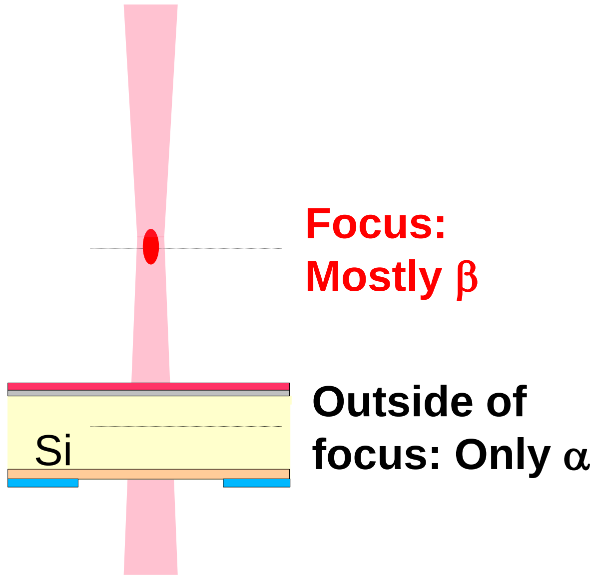
Voltage scan of HPK 200 μm thick detector
Shown E-field calculated as a function of depth
Detector (not irradiated) depletes from the front
Depletion width increases with voltage
This measurement can not be done with top/bottom SPA-TCT

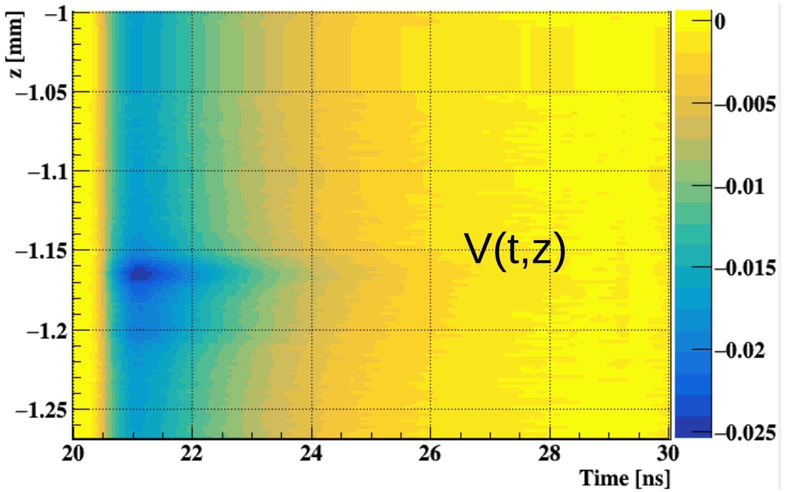
First measurement of irradiated diodes ($1.6x10^{16}\ n_{eq}/cm^2$)

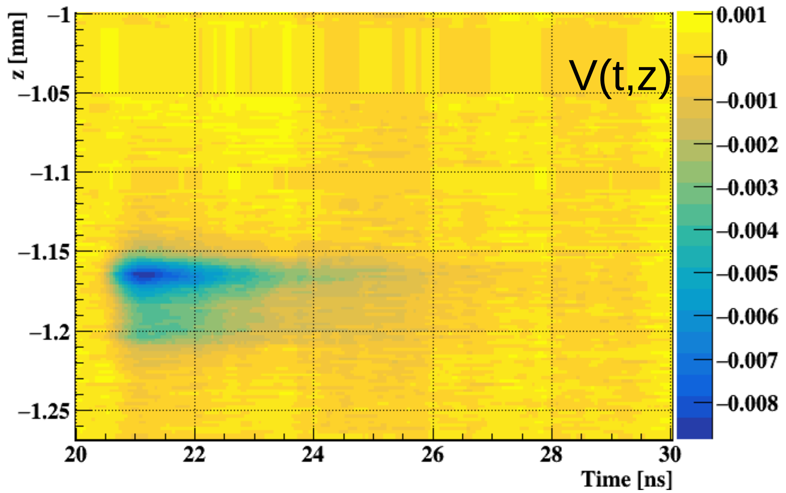
No cooling yet

$$\frac{dN(r,z)}{dt} = \frac{\alpha I(r,z)}{\hbar\omega} + \frac{\beta I^2(r,z)}{2\hbar\omega}$$







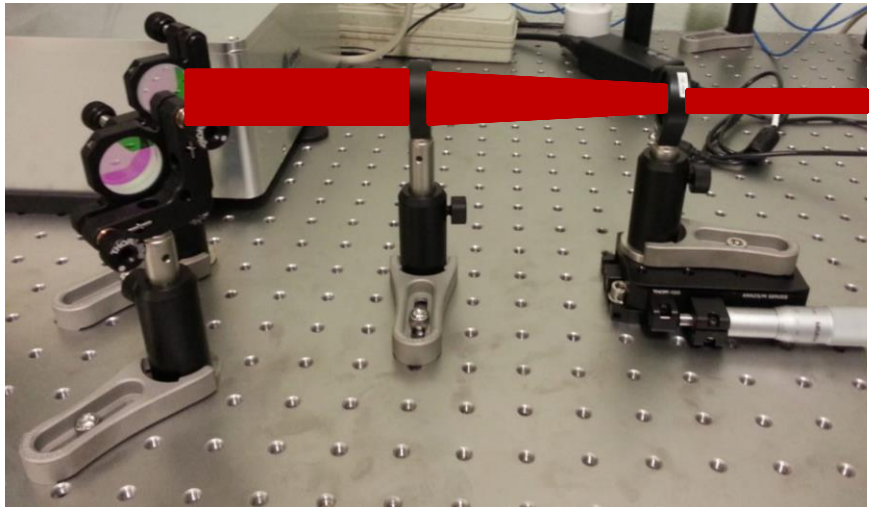


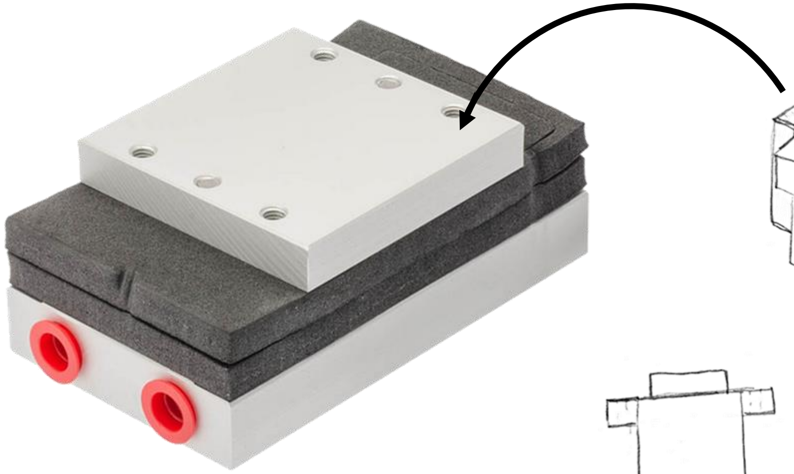
No spatial resolution along z

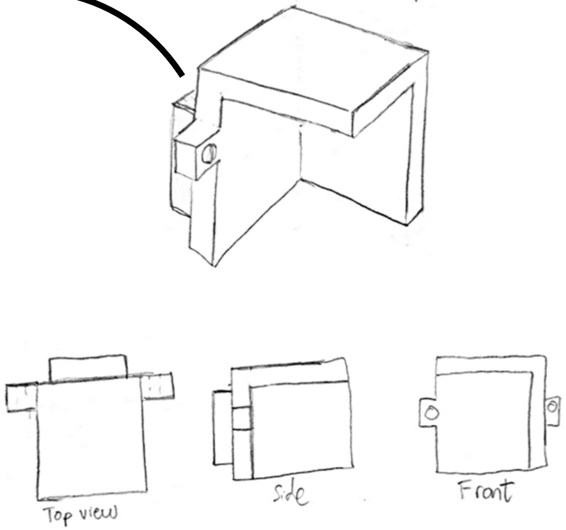
Spatial resolution recovered

Setup improvements

Addition of telescope for better coupling of the light to the microscope objective:







Creation of a cooling block sample holder compatible with edge/top injection

Missing:

- DAQ program (all measurements here were taken by hand :))
- Realization of cooling
- Edge-TPA measurements

Conclusions

First (and only) TPA-TCT compact setup in the world being commissioned at CERN (another TPA setup exists in Spain, but uses a 1 room-sized laser)

- We have verified that the chosen custom parameters we ordered were correct:
    - Enough power for measurements of both irradiated and non-irradiated detectors
- We have demonstrated TPA process in a diode (top injection)
- We are able to measure irradiated detectors with good SNR
- We are still developing some parts of the system: DAQ, cooling