TCT setup at FH E-lab.

It has received an overhaul and now works.

Disclaimer: everything is preliminary.

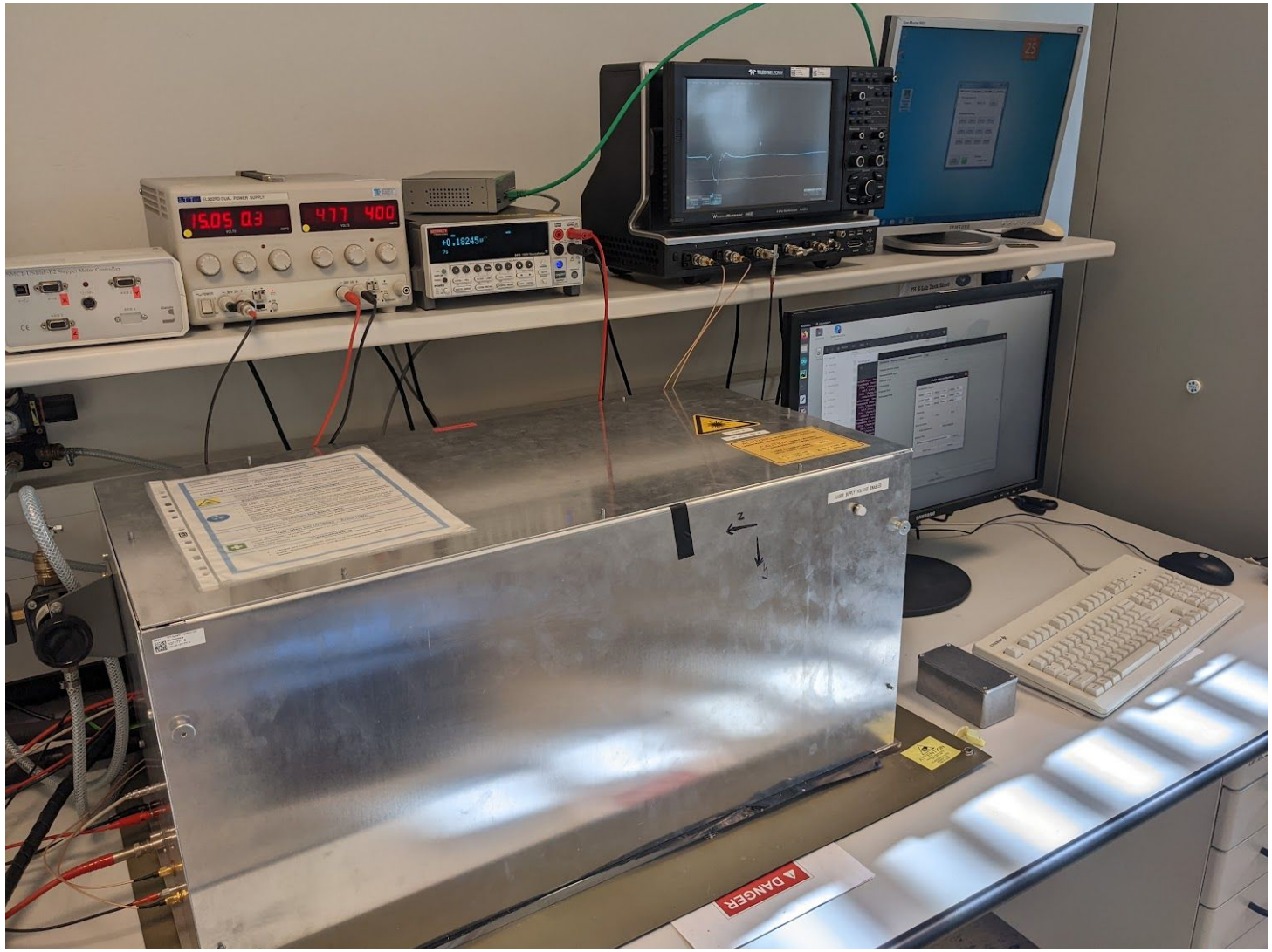
Daniil Rastorguev
SiDet meeting
25.10.2022

HELMHOLTZ

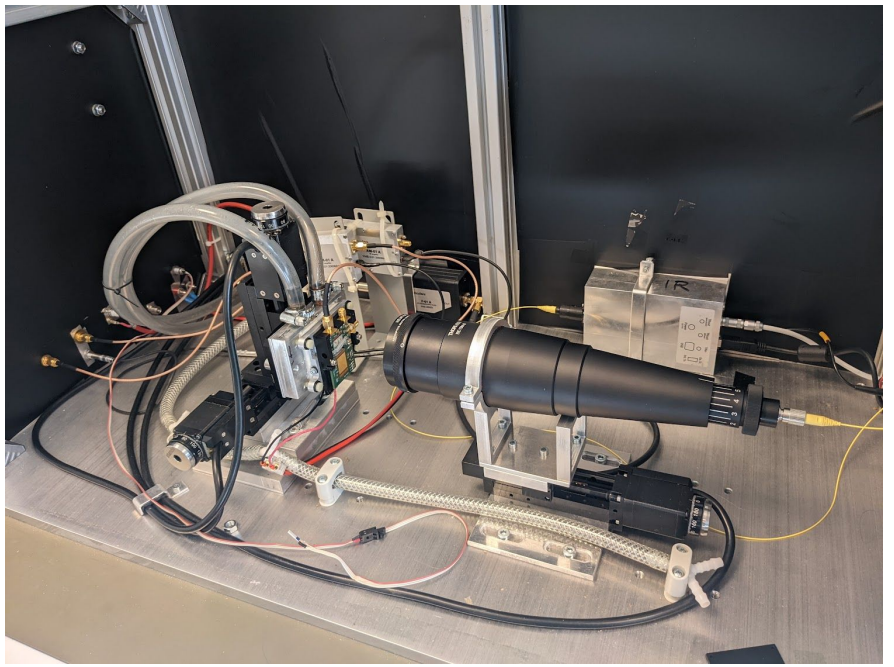
DESY.

Trivia

A mystery box has arrived

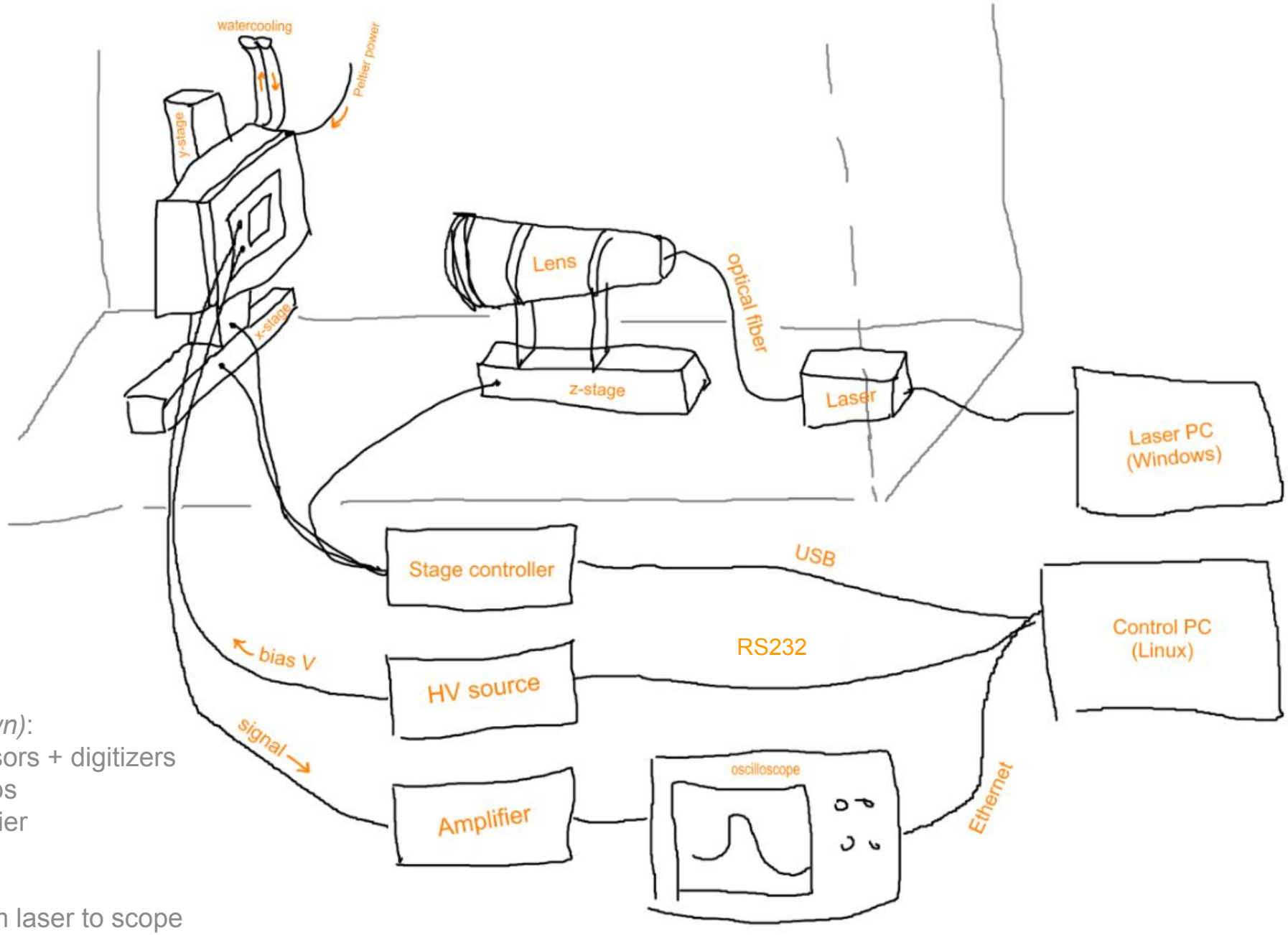


particulars, *advanced measurement systems*



Trivia

Setup layout



There is also *(not shown)*:

- temperature sensors + digitizers
- LV power for amps
- LV power for Peltier
- HV filter
- Bias-T (optional)
- trigger signal from laser to scope

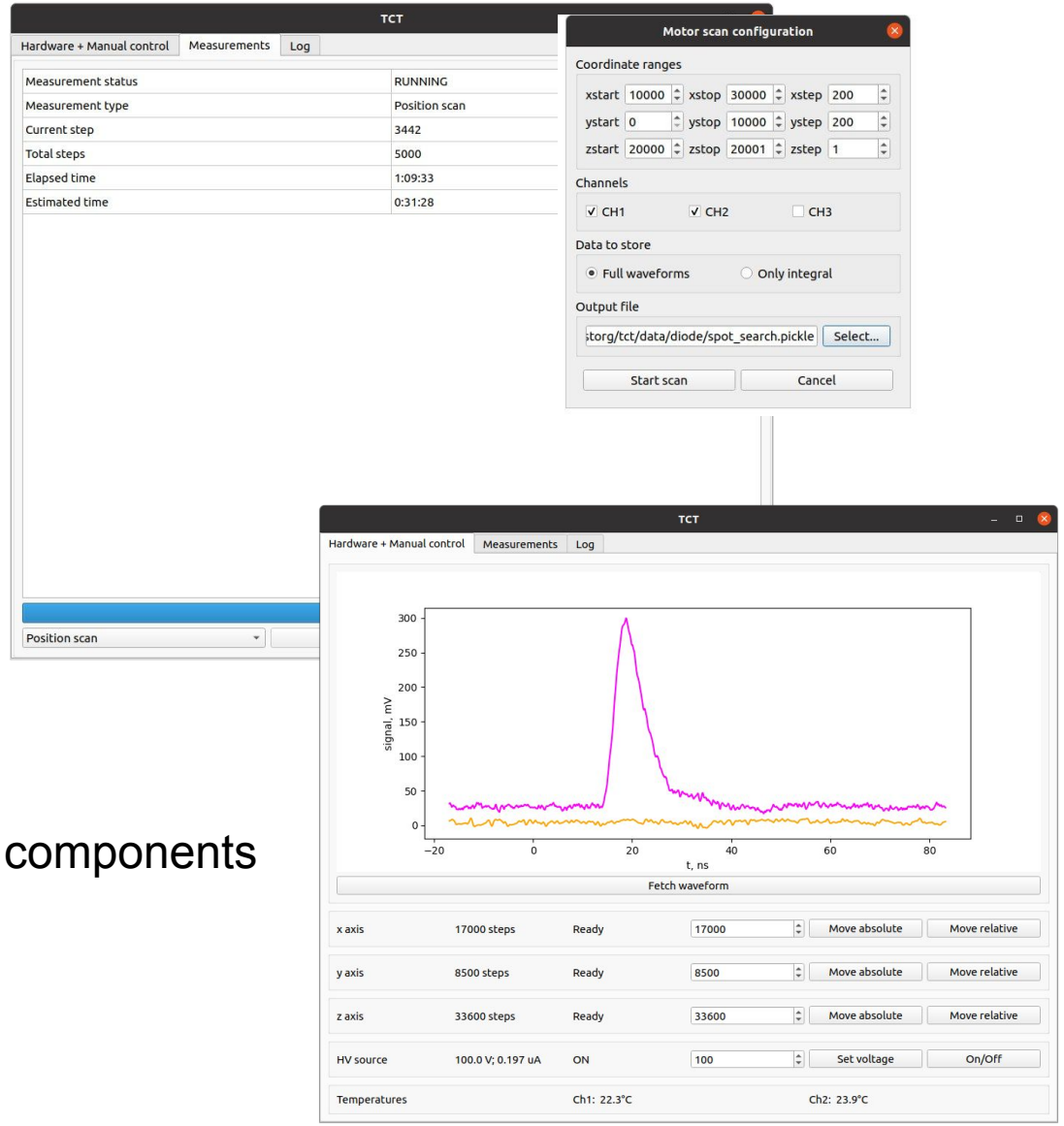
Setup upgrade

Hardware:

- Installed oscilloscope and HV source
- Replaced motor controller
- Fixed liquid cooling
- Installed temperature sensors
- Working on *Caribou-based* detectors support

Software:

- Configured a new Linux PC to run the setup
- Implemented remote control and automation for essential components
- Designed a simple GUI control+DAQ utility



Setup specifications

Readout

Oscilloscope (LeCroy WR640Zi):

4 GHz bandwidth, up to 40 GS/s, 12-bit

Amplifiers 2x (Particulars):

2 GHz, 53 dB

Bias-T (Particulars):

2 GHz

Setup specifications

Positioning

3-axis controller (Standa 8SMC5)

Positioning stages (3x Standa 8MT30-50):

- 50 mm travel
- 1.25 um step
- 1/256 microstep

Setup specifications

Cooling

Liquid cooling (Huber H1):

- runs on Si oil
- is in principle capable of below-zero temps

Peltier element

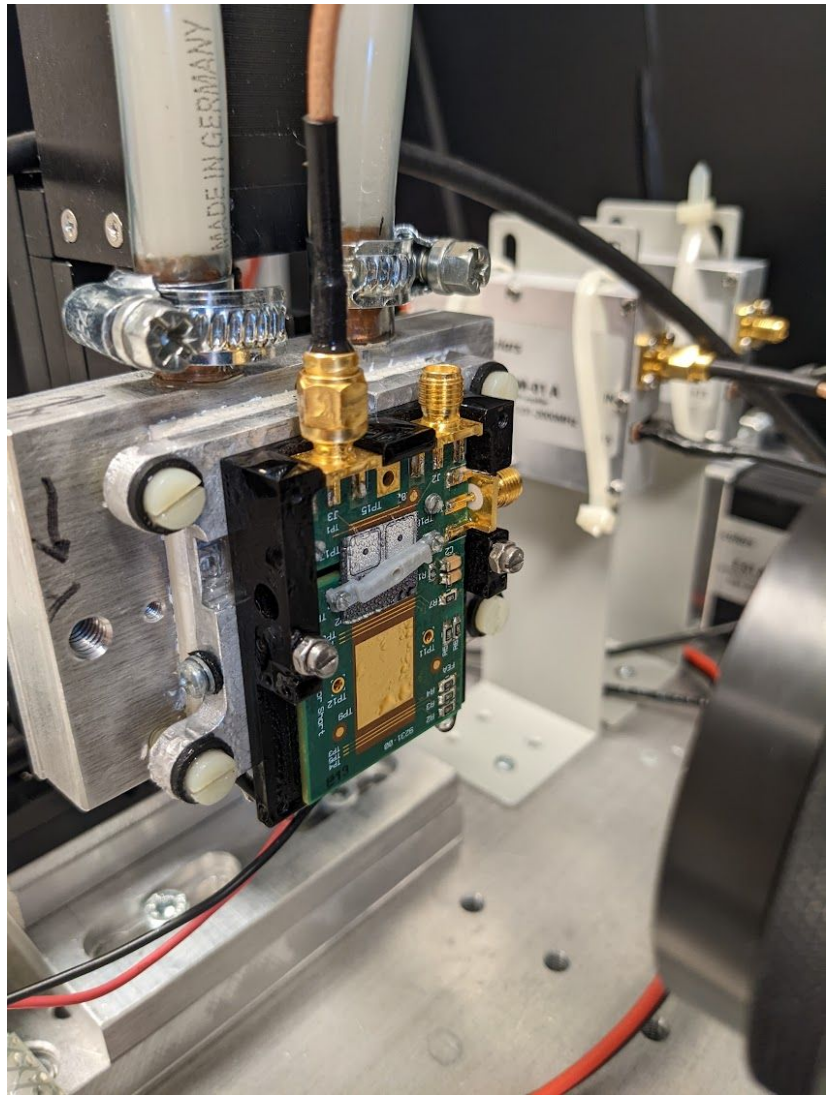
very cool

Dry air supply

to compensate for being situated in Hamburg

Temperature sensors:

- 2x PT1000 RTD's
- Arduino + 2x external digitizers

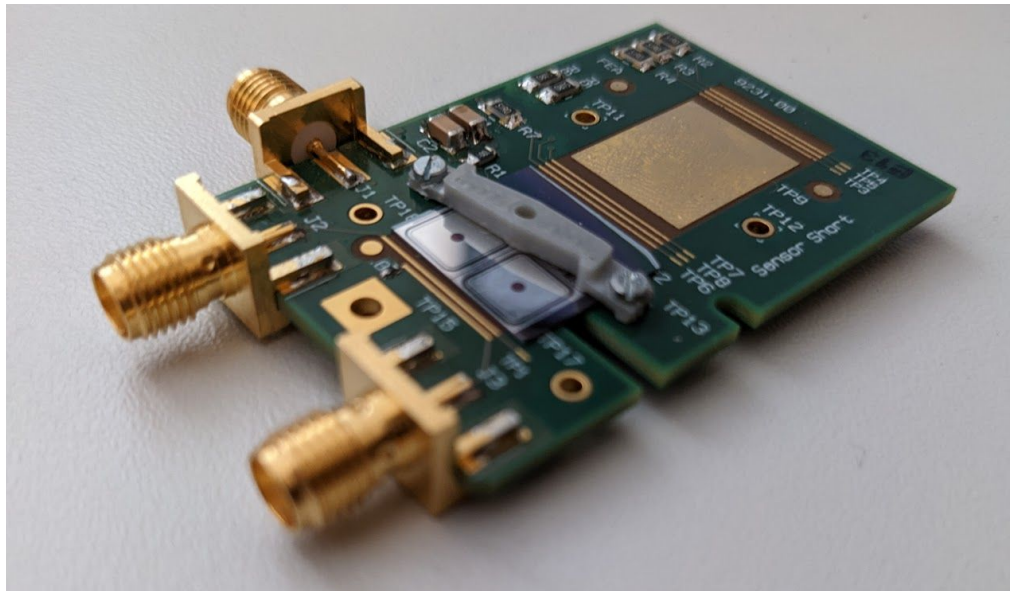


This happens if one forgets we're in Hamburg

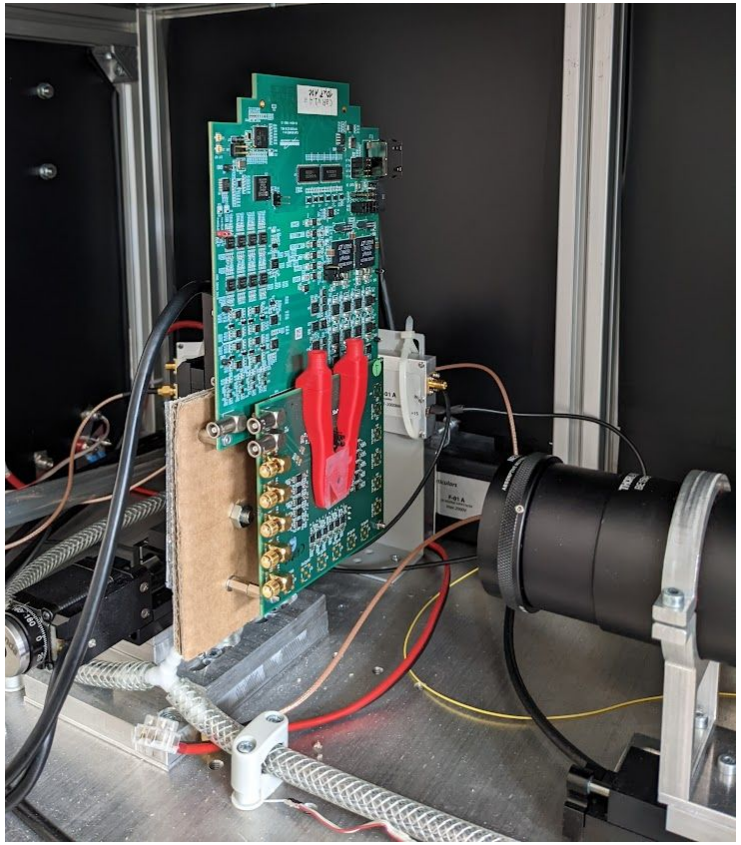
Setup specifications

How to measure my sensor with it

Option #1: TCT PCB for wafer pieces



Option #2: CaRBoard



Carboard on a cardboard haha (it's a prototype)
Now we have actual mounts

Setup specifications

Lasers

Generic equipment by Particulars

Two exchangeable lasers:

- 640 nm (~3 um absorption length in Si)
- 1064 nm (~1 mm absorption length in Si)

Pulsed drivers:

- 100 mW peak power
- adjustable (kinda) pulse duration
- adjustable repetition rate

Introduction

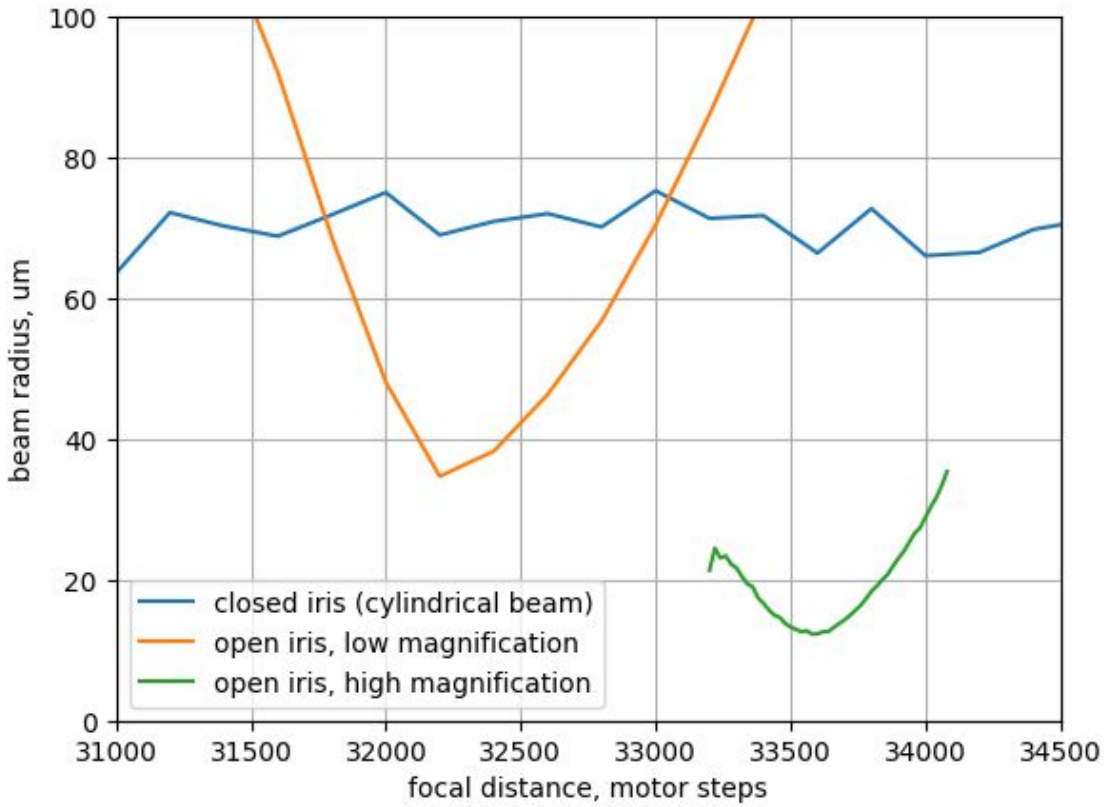
Particulars lasers are very compact and lightweight since they combine the laser head and driver in the single housing. They were designed for Transient Current Technique, but their applicability is far broader. They offer short pulses (350-4000 ps) with pulses energy corresponding to creation of e-h pairs in silicon equivalent to up to 1000 m.i.p. The lasers can be triggered internally triggers or externally. Internal triggering can be simple with a fixed frequency or a pattern of pulses can be programed with trigger(s) provided independently of the laser/driver pulses.

These are pretty much all the specs that are in laser manual

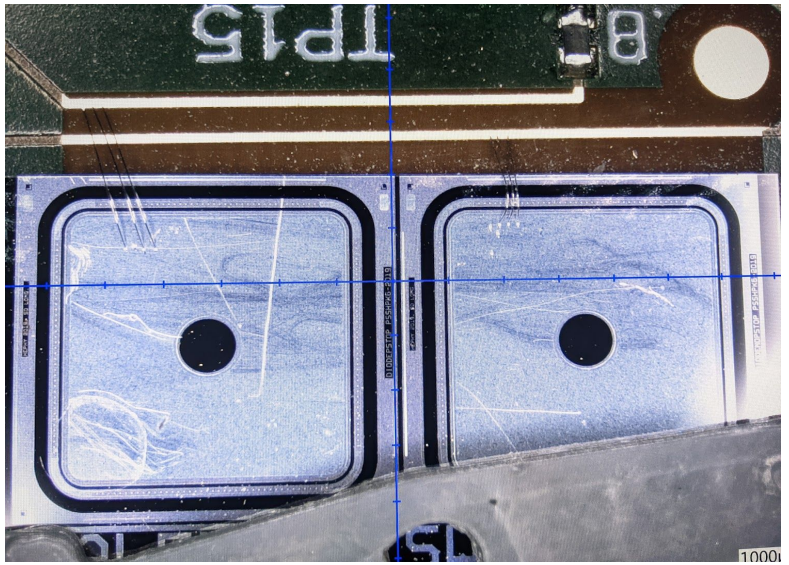
Laser pulse shape (from some other manual)

Laser tests

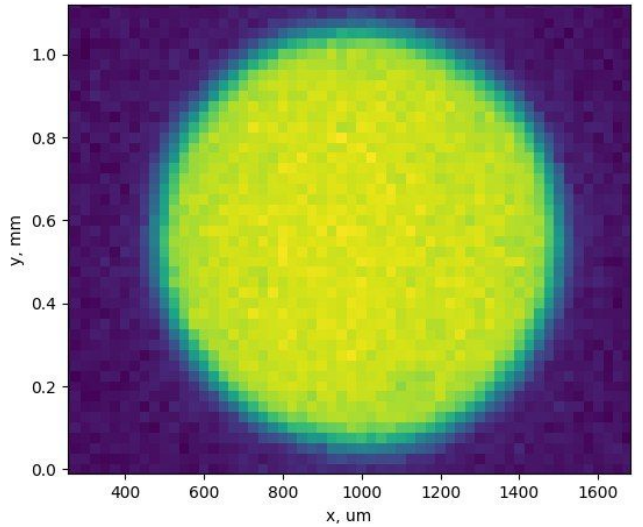
Spot size



The best beam radius achieved is **~12 um**



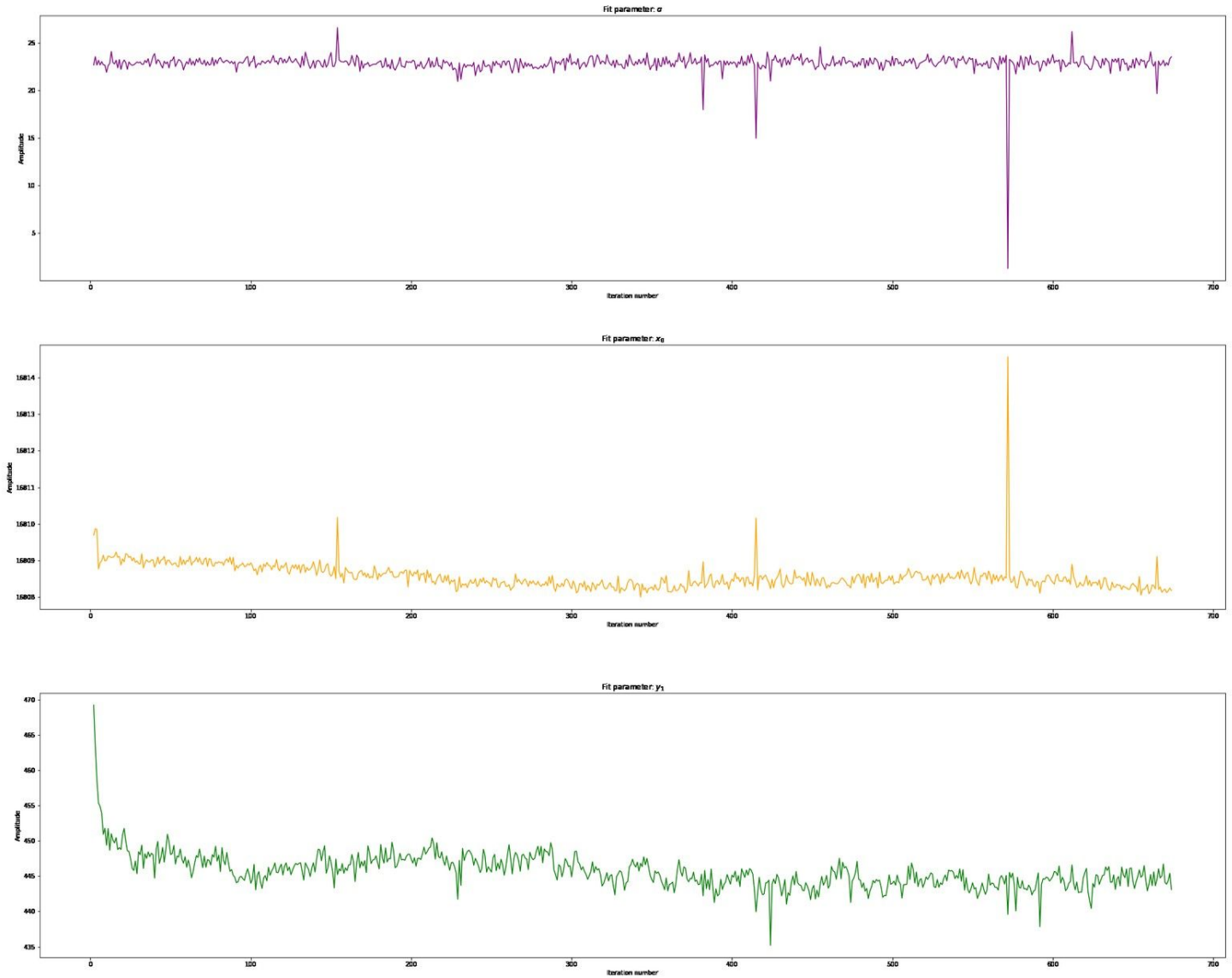
Test structure: Si diodes with metallization layer



Sensitivity area

Laser tests

Stability

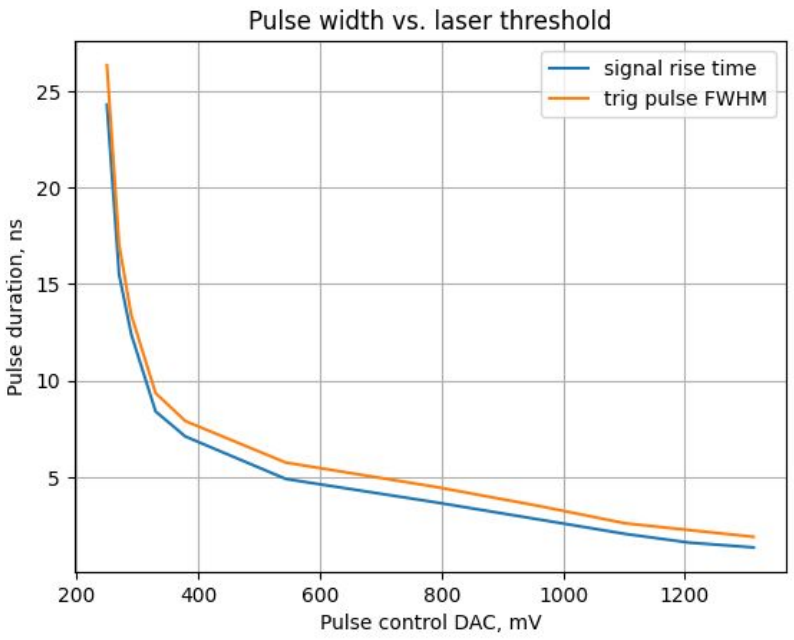


Knife-edge repeated for 15 h (almost 700 iterations)
by Marianna G. the summie

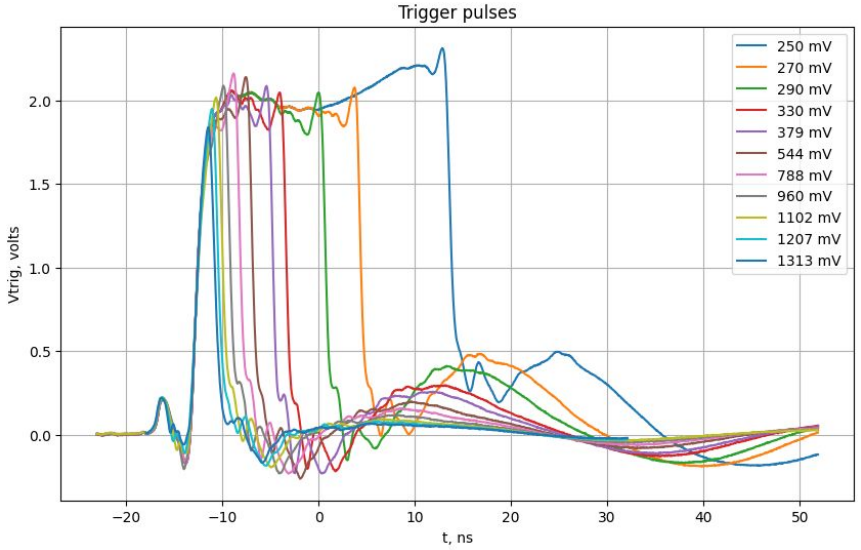
Top row: spot size
Middle row: spot position *x*
Bottom row: intensity

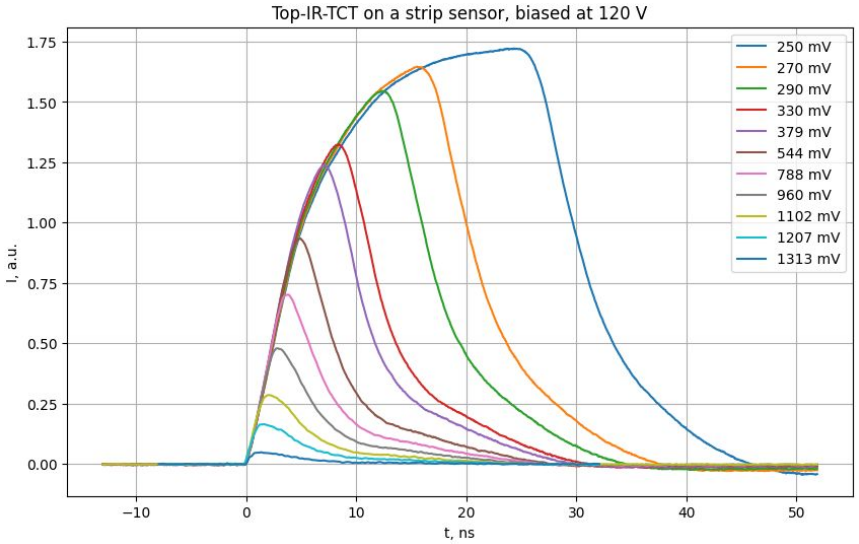
Laser tests

Pulse shape



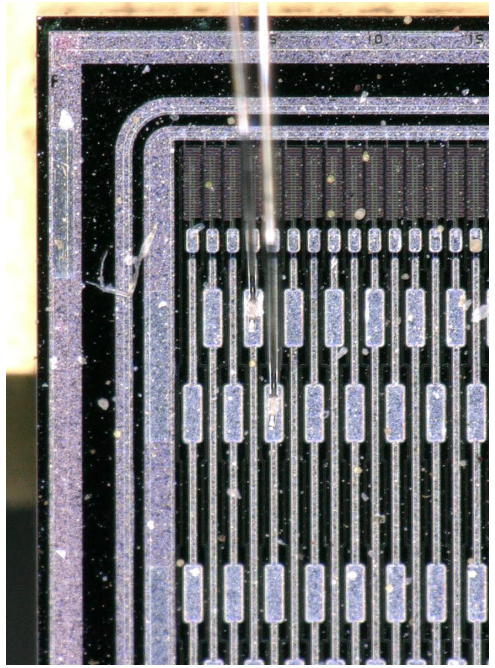
Shortest pulse achieved is **~1.5 ns**



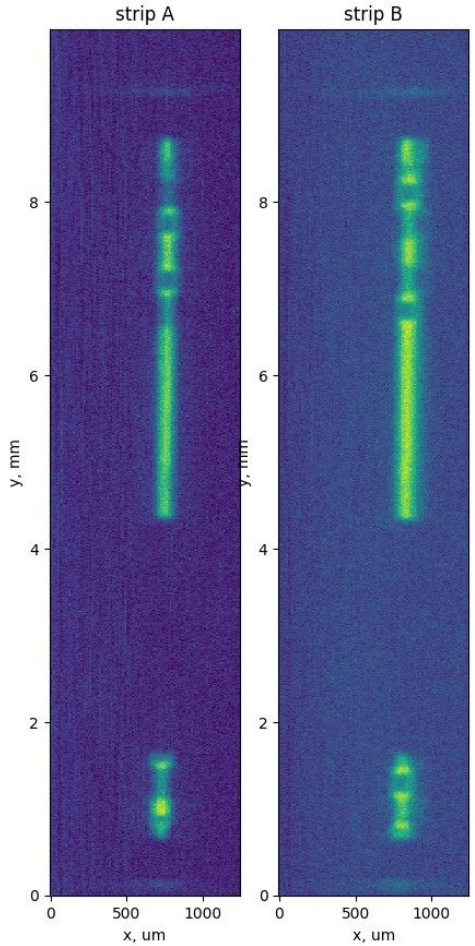


Spatial resolution showcase

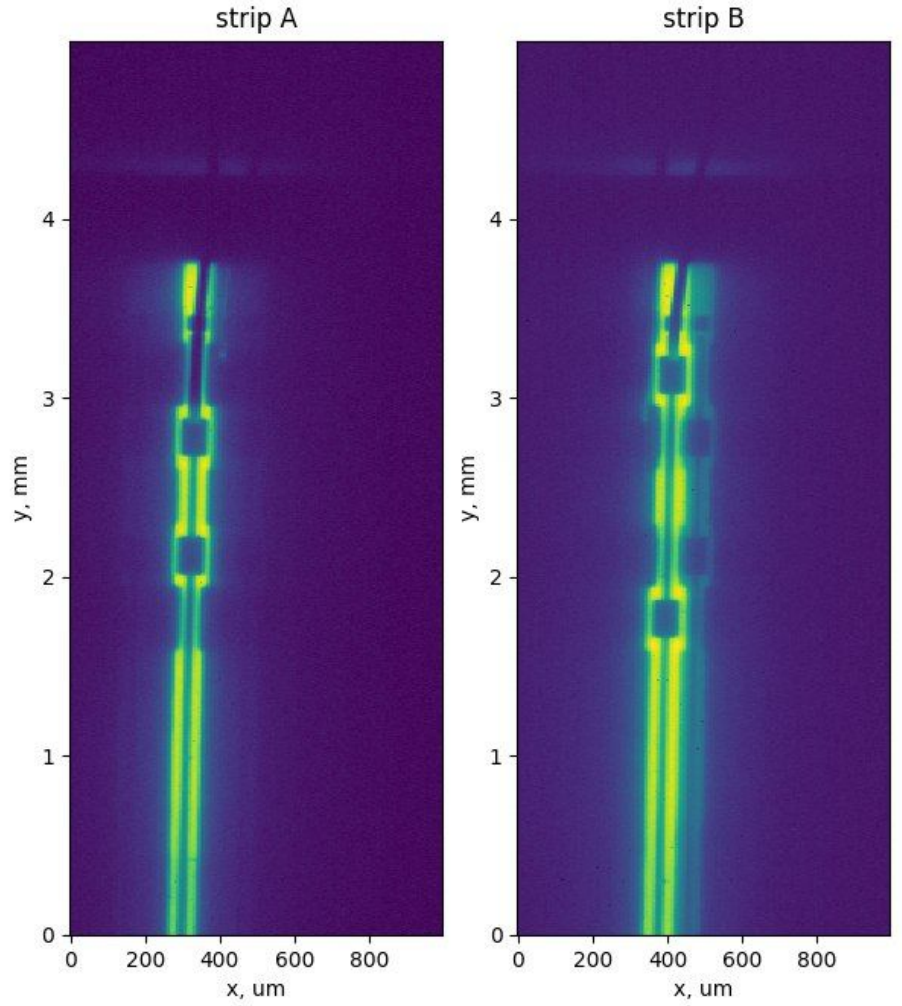
Sensitivity area scans on an ATLAS generic strip sensor



The sensor



60 um beam radius



12 um beam radius

TCT simulations.

Allpix^2 can nicely simulate build-up of transient currents,
but at the moment it has no option to simulate **interaction of laser pulses with silicon** sensors.

allpix::DepositionLaserModule is being developed to be able to carry out this part
The following process features are simulated:

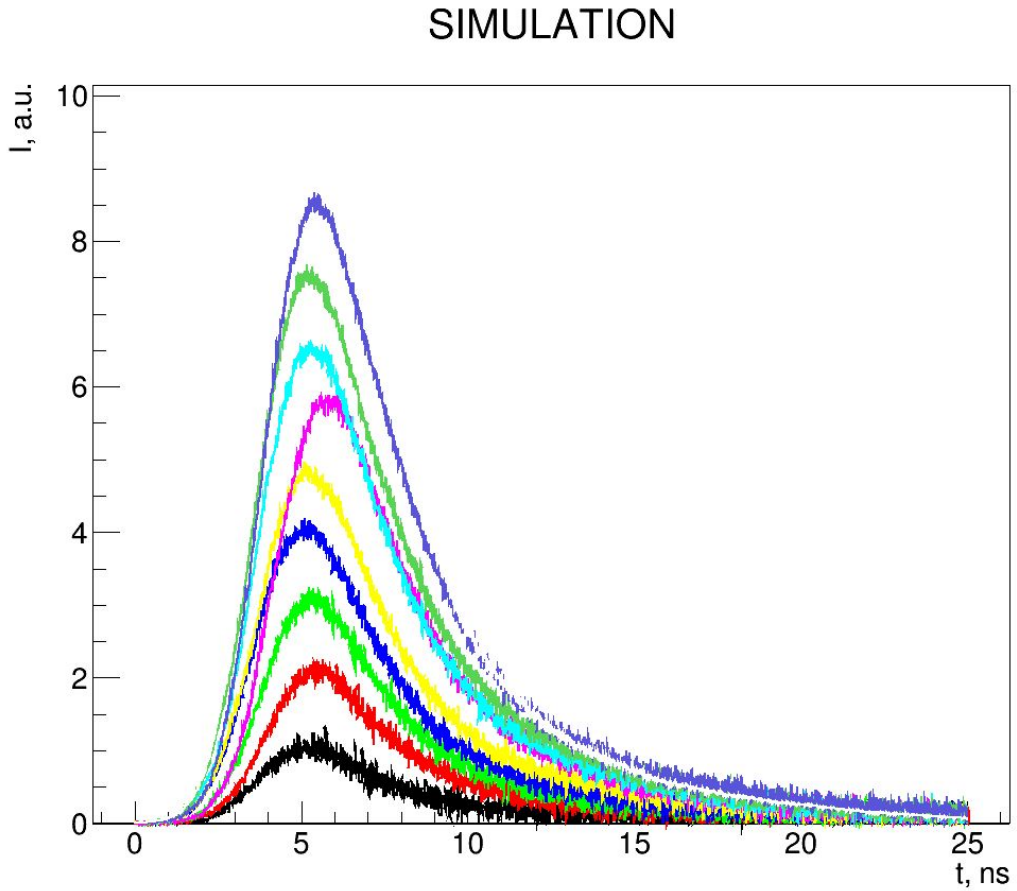
- *Somewhat* realistic geometry of the beam
- Temporal profile of the laser pulse
- Proper absorption depth, depending on laser wavelength

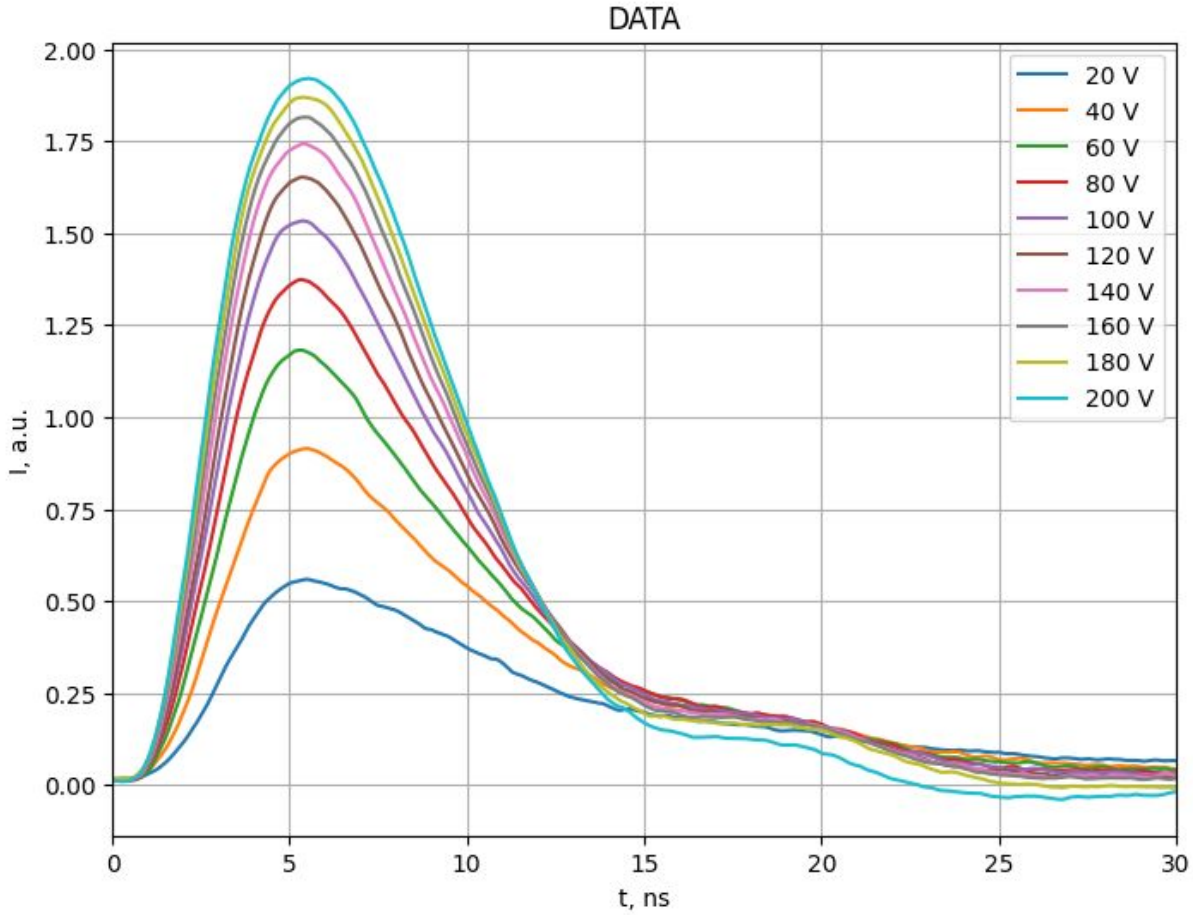
https://gitlab.cern.ch/drastorg/allpix-squared/-/tree/laser/src/modules/DepositionLaser

Example simulation

Simulation parameters are to be tuned

Preliminary





Analog detector response
Top geometry, IR laser on 300 um diode, bias up to 200 V with a step of 20 V

Outlook

Setup stuff to implement:

- Pulse shape monitoring (beam splitter + standalone InGaAs diode)
- CCD camera for aiming (either standalone or embedded in the optical system)
- Software integration with Caribou

Research stuff to try:

- Edge-TCT geometry
- APTS studies
- dSiPM studies

That’s it!