Laserbox as a user facility

and its use cases

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Detector Platform Retreat
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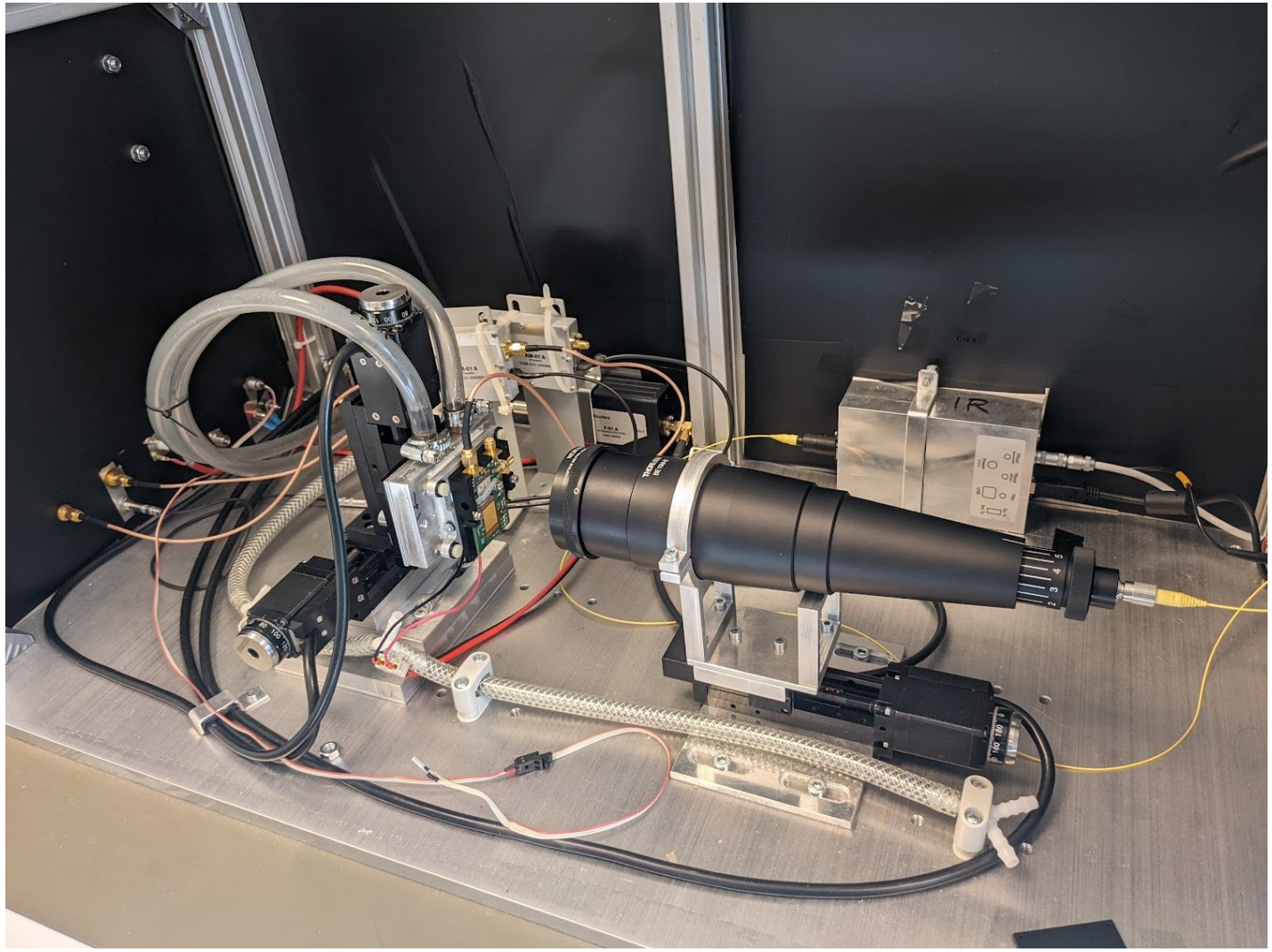
HELMHOLTZ

DESY.

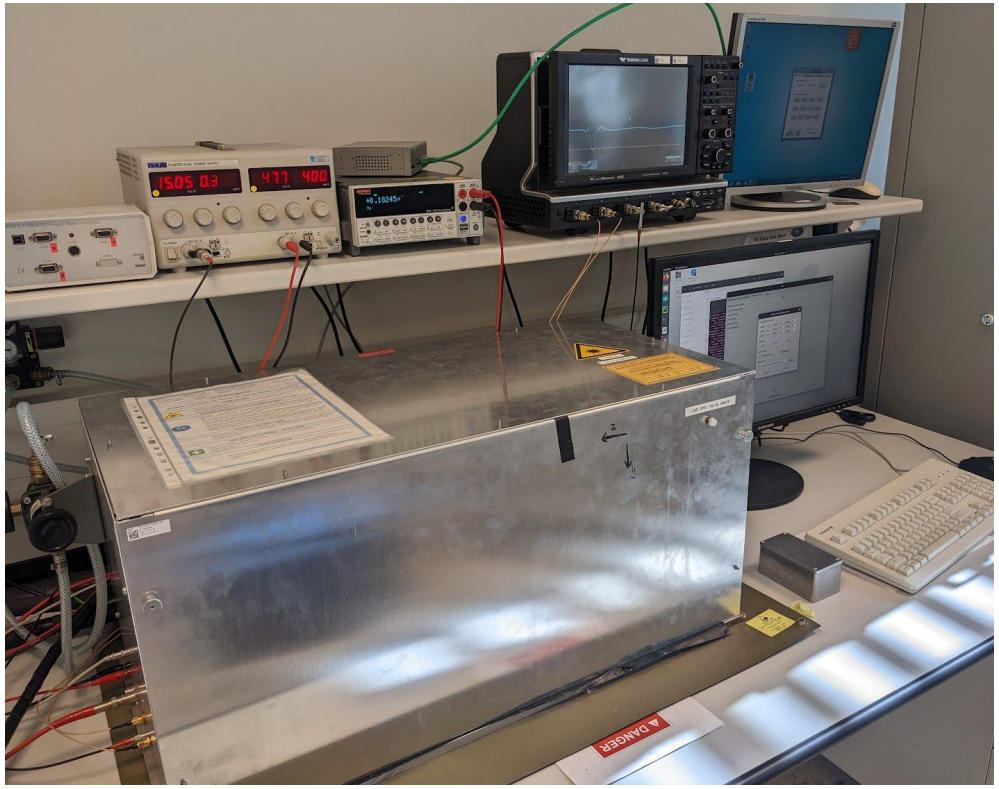
The setup

What the laserbox is

and how it came to be



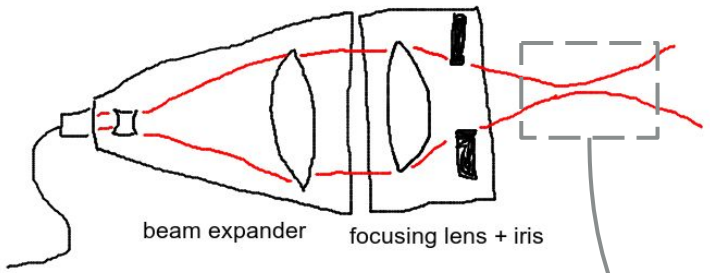
particulars, *advanced measurement systems*



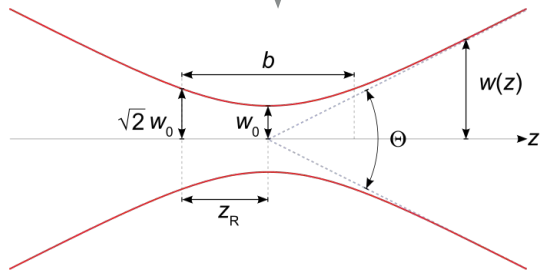
Injection lasers

Pulsed lasers are a common tool for charge injection:

- micrometer aim precision
- high repetition rate (up to MHz)
- tunable intensity



Focusing lens (sketch)



Silicon vs. different wavelengths:

Near infrared
pen.depth O(1 mm)
= *m.i.p passage*

Red
pen.depth O(1 μm)
= *heavy particle absorption*

Our laser heads:

Particulars IR 1064 nm
pulse duration ~ **2 ns**
charge injection up to 1000 m.i.p. equiv.

Particulars RED 660 nm
pulse duration ~ **2 ns**
charge injection up to 1000 m.i.p. equiv.

PiLas RED 672 nm
pulse duration ~ **50 ps**
trigger jitter < **5 ps**

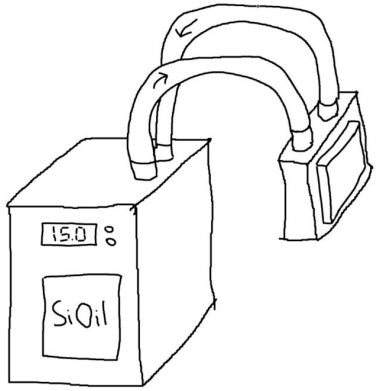
Best beam waist achieved: **~10 um**
(measured with knife-edge)

Utilities

essentials and quality-of-life features

Translation stages
to aim and focus the laser

- remote-controlled positioners for x, y, z
- sub-micron precision

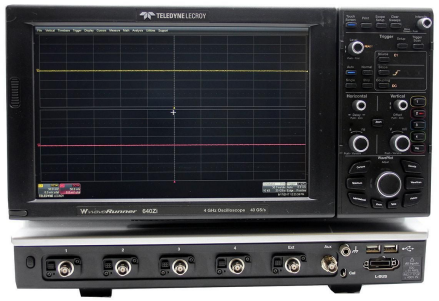


Cooling to keep it cool

- Chiller (SiOil)
- Peltier cell
- Dry air

High voltage source to bias the DUT

- Keithley 2410
- What else could it be

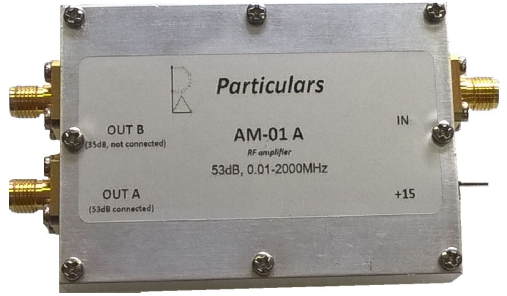


Oscilloscope for everything

- LeCroy WR640Zi

Optical reference for precision timing measurements and debugging

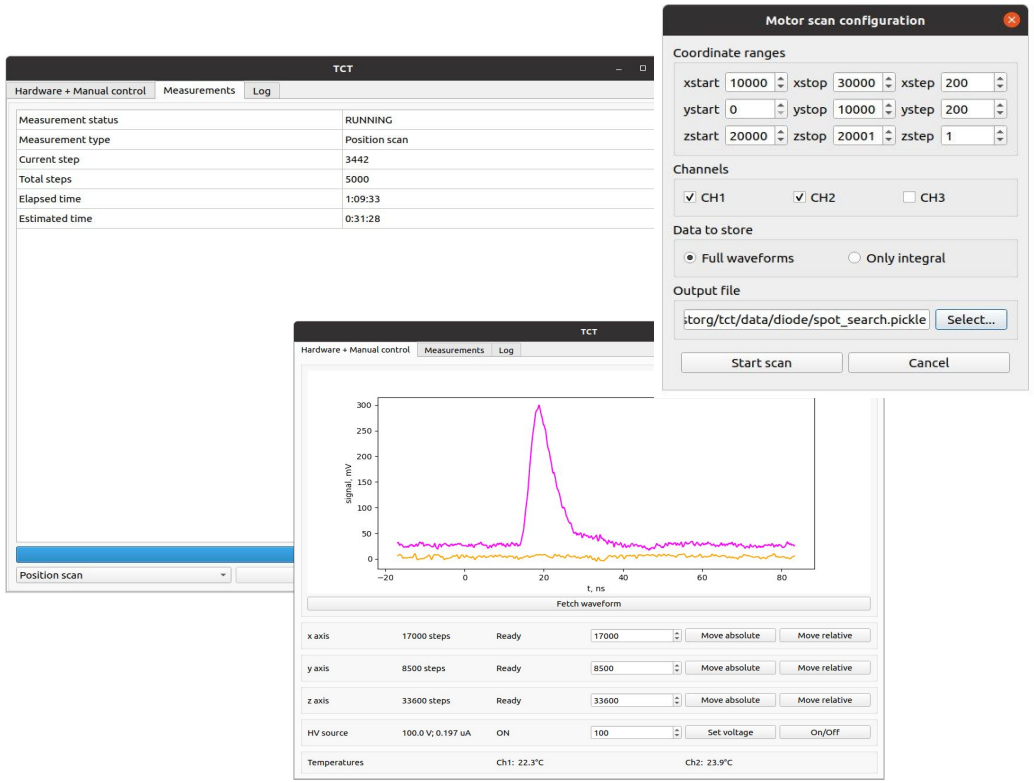
- InGaAs sensor
- fast response (~70 ps)



Analog readout to get waveforms from silicon sensors

- High-gain high-bandwidth amplifiers
- Bias-T's

Control and automation



GUI interface on the control PC

my_measurement_script.py

```
from tct_remote_client import TCTClient

my_tct = TCTClient('ip.add.re.ss')

my_tct.do_this()

for(...):
    my_tct.do_that()
```

Remote control over network

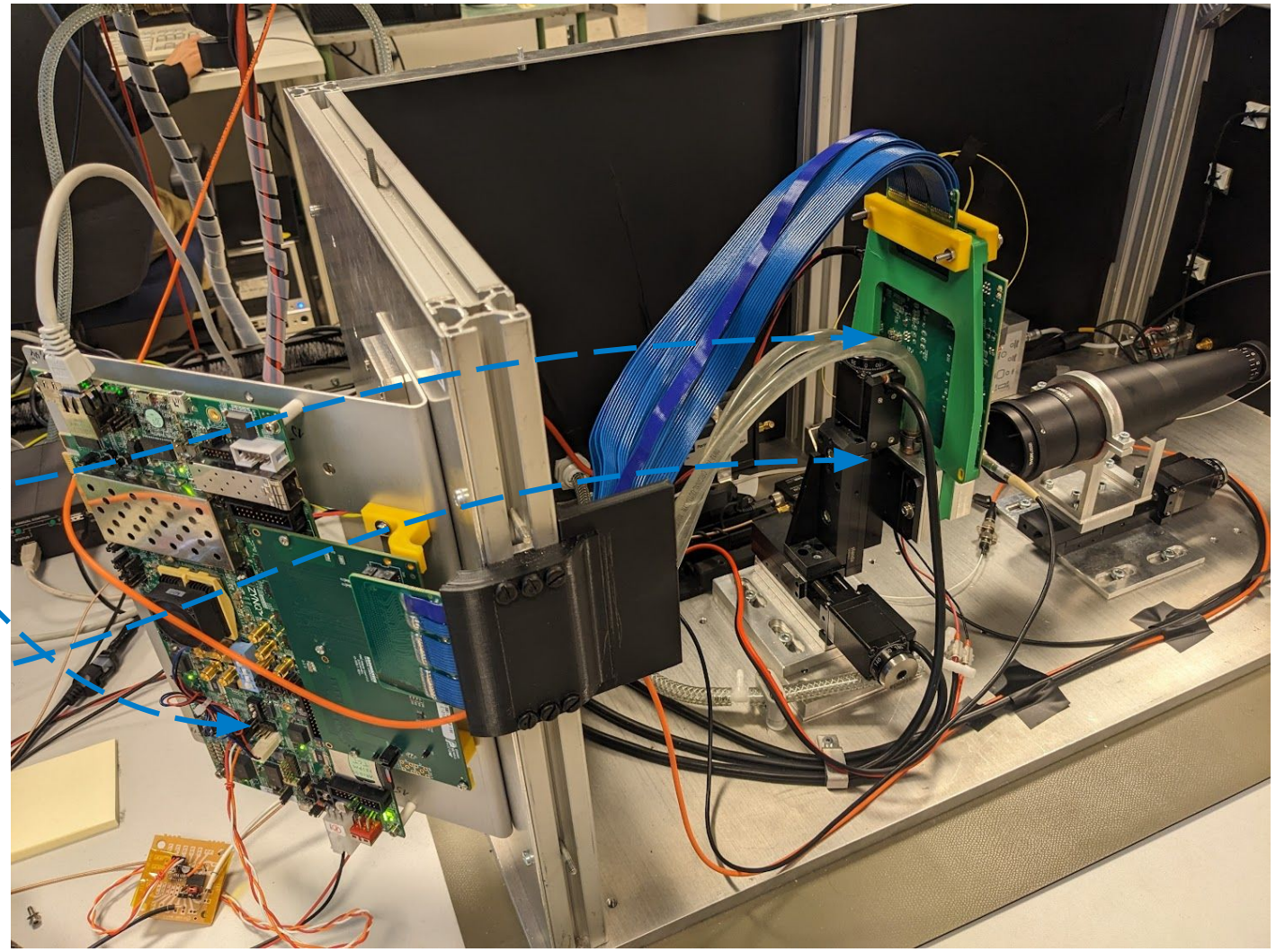
Caribou integration

it was an engineering challenge

SoC + FPGA
runs DAQ
handles data

CaR board
low-level DUT interfaces

Chip carrier board
DUT
nothing else (almost)



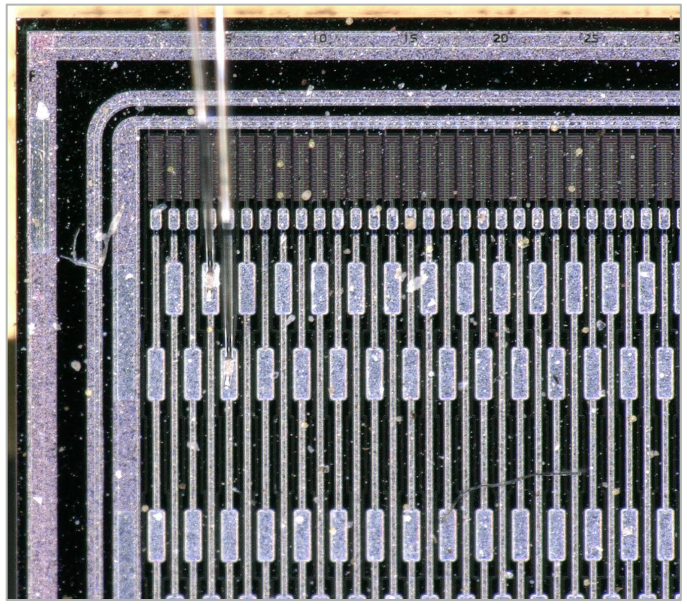
Detector integrated with Caribou => plug and play!

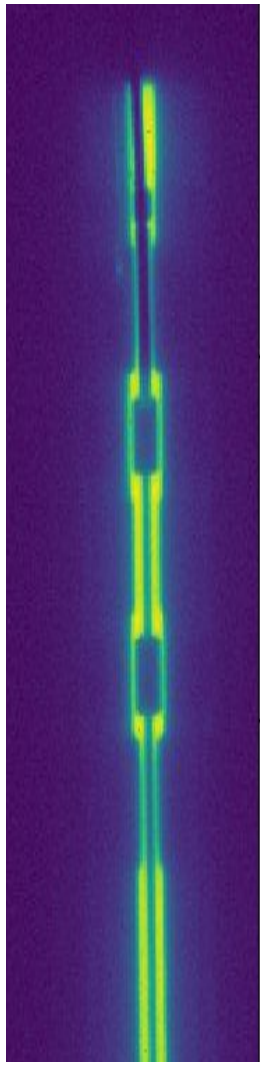
What can we do with it?

ATLAS12 strips

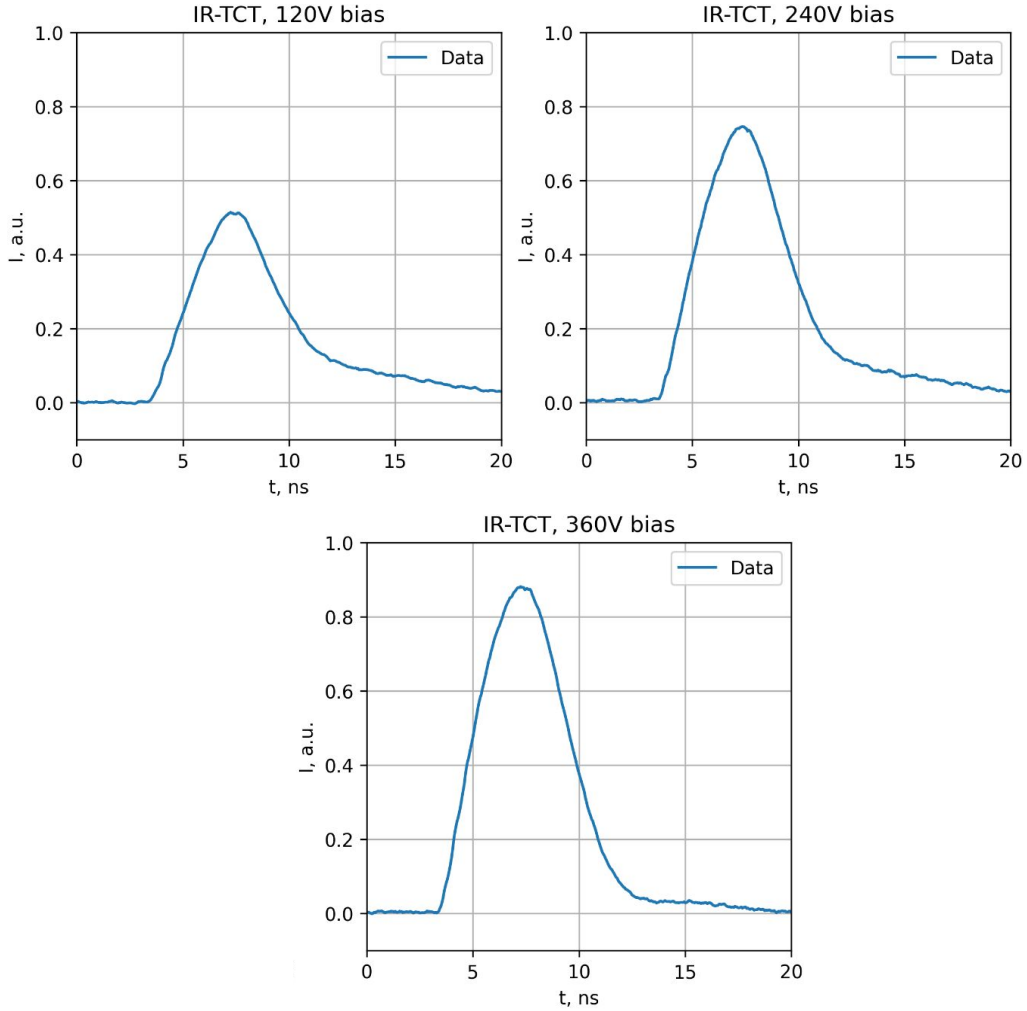
TCT on a conventional passive sensor

- Infrared laser from the front
- Acquire waveforms with an oscilloscope through an external amplifier
- Study waveform dependency on sensor parameters (here: V_{bias})
- Repeat for different injection positions = get a 2D map of a desired quantity





Strip 2D sensitivity map

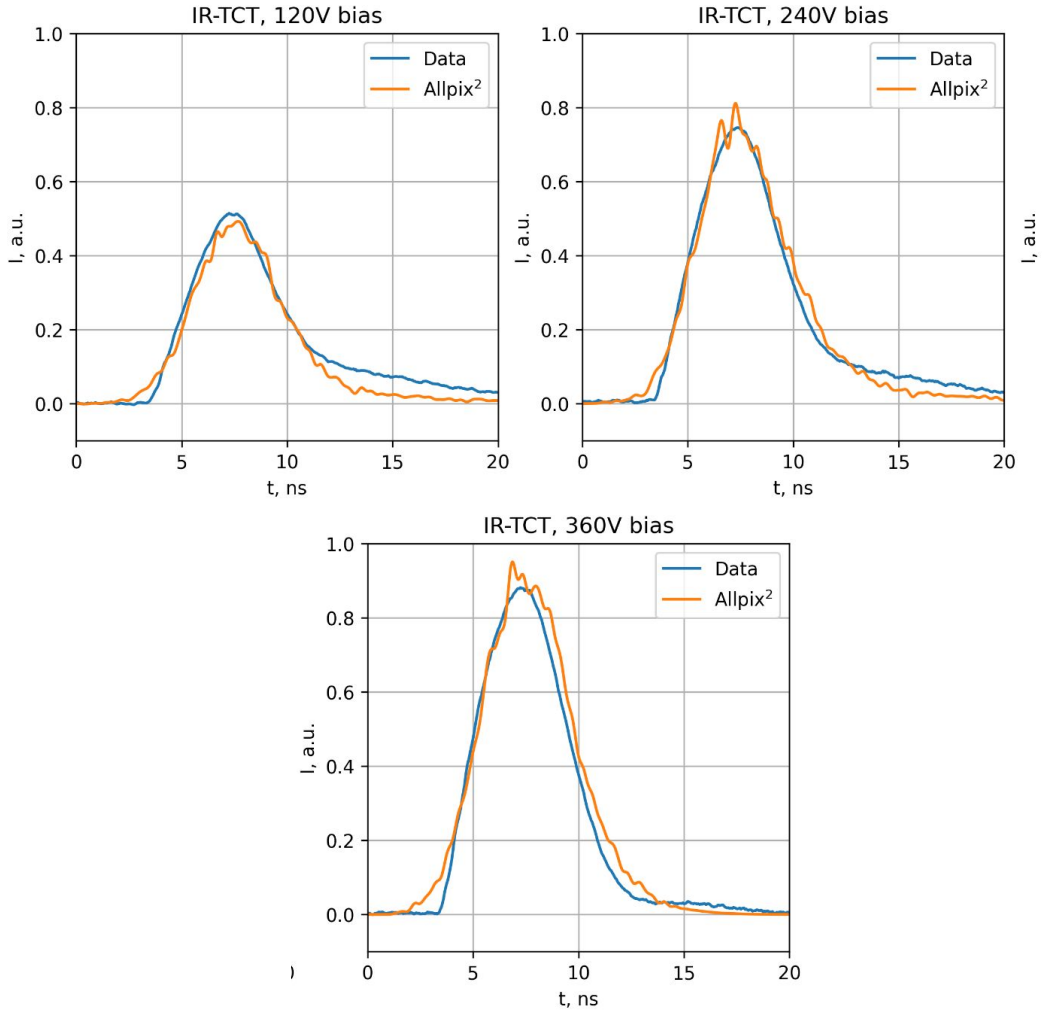


Waveforms!

ATLAS12 strips

TCT on a conventional passive sensor

Check out **DepositionLaserModule** in **Allpix Squared**!
Monte-Carlo simulation of pulsed laser charge injection



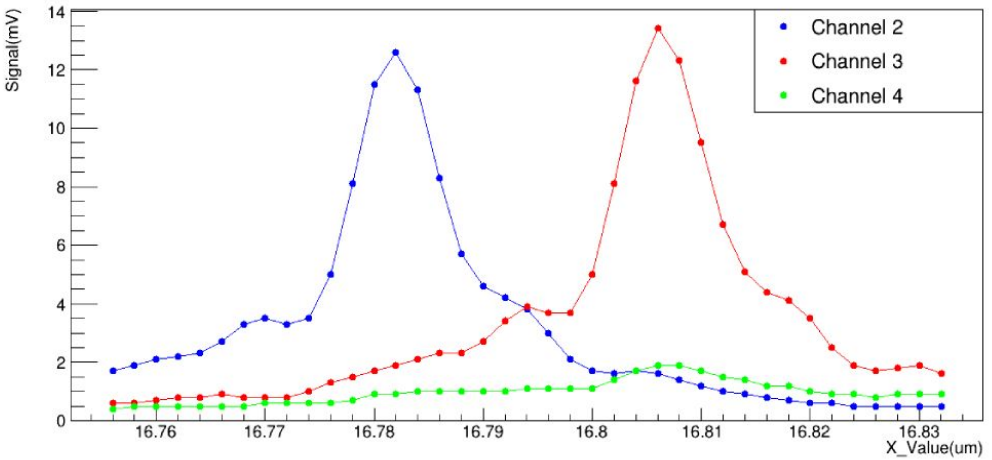
Waveforms!

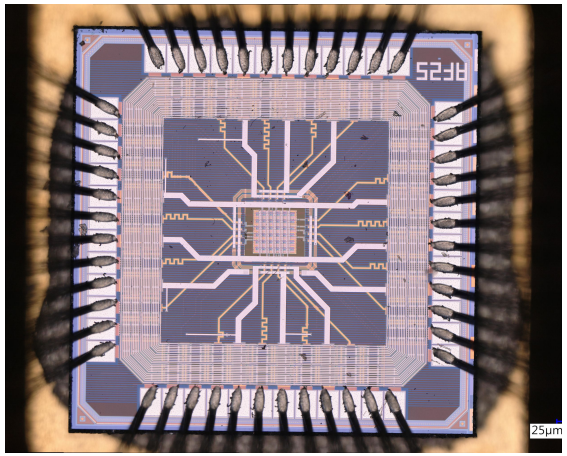
Tangerine APTS

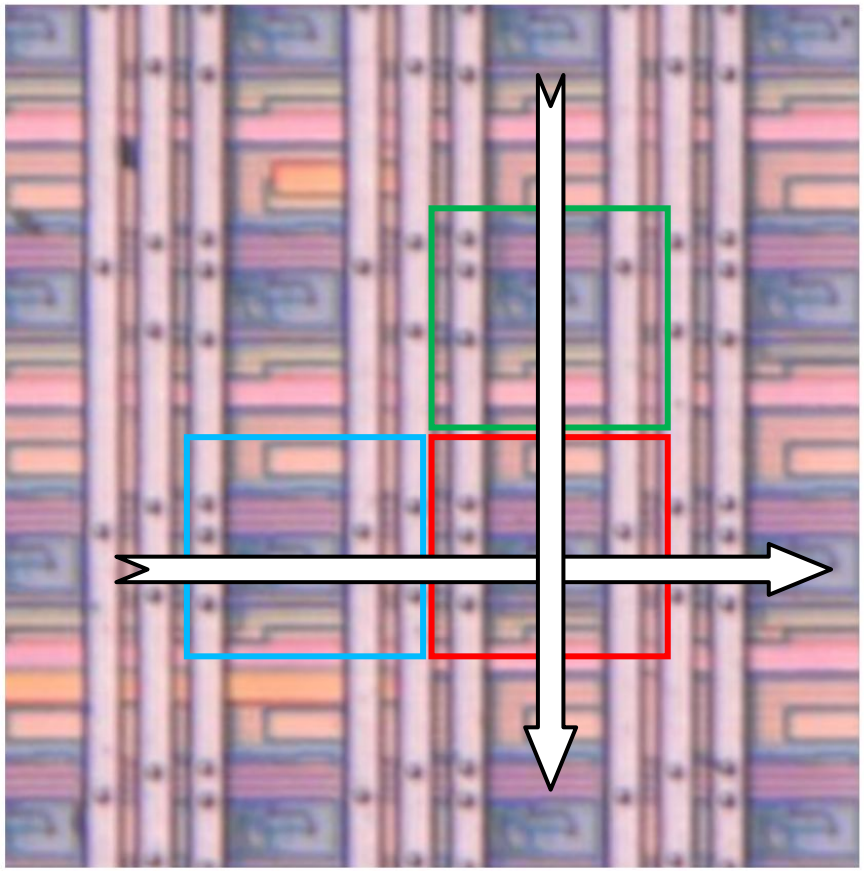
TCT on a passive CMOS sensor

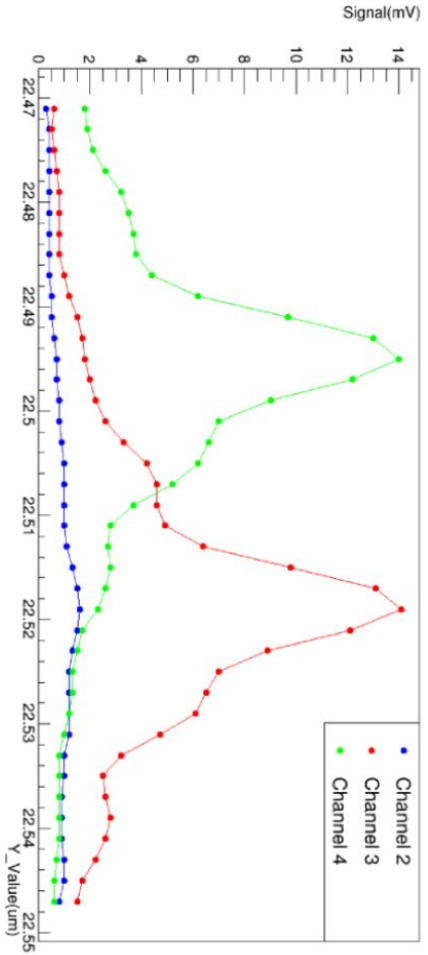
Work in progress
Courtesy of Gianpiero V.

- Infrared laser from the front
- 1D laser scan
- Need to get light in between metal traces
- Intensity tuned to ~1 m.i.p.
- Waveform readout with an oscilloscope
- Analyse pulse amplitude vs. laser position







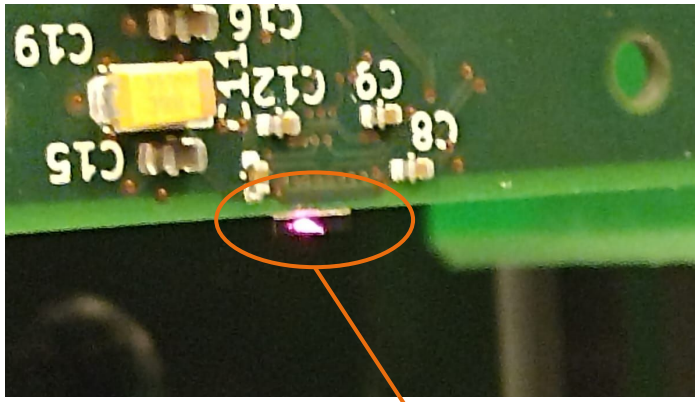


H2M MAPS

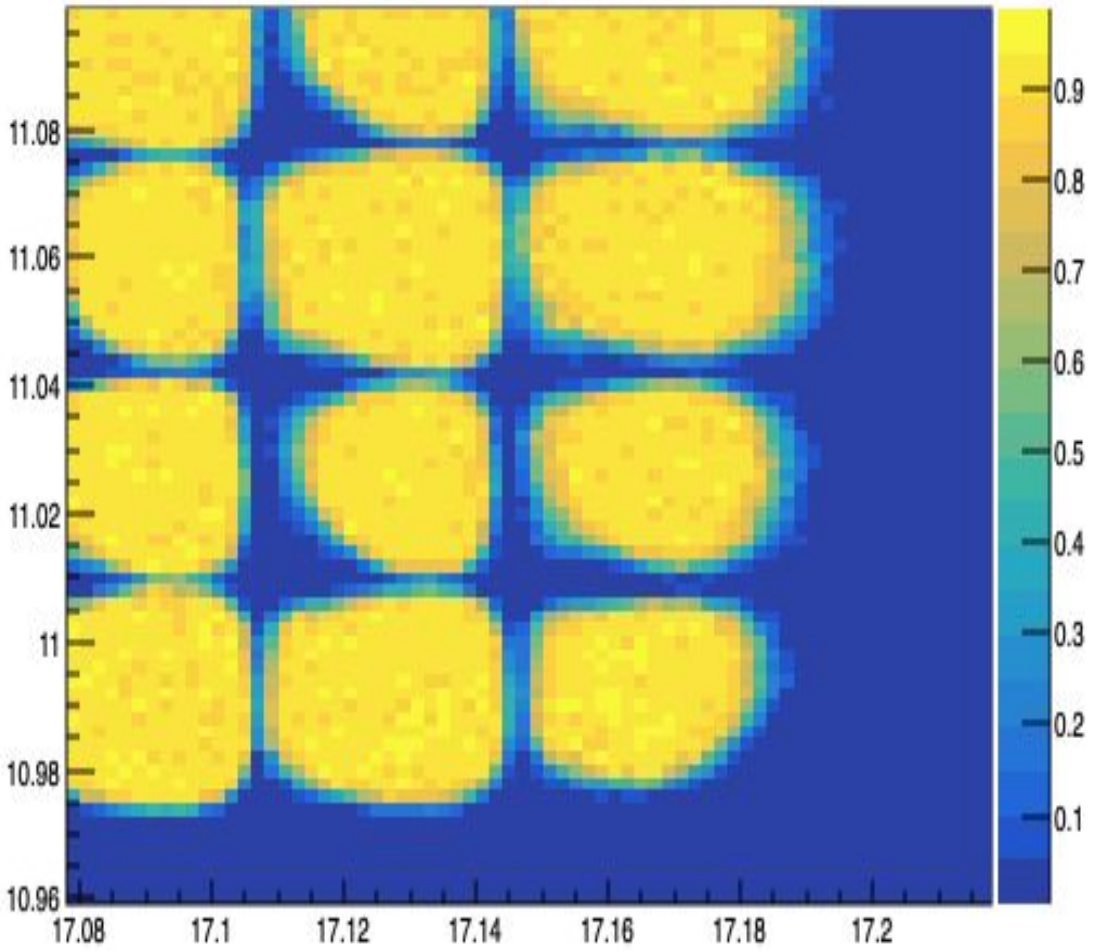
Injection studies on a monolithic CMOS detector

Work in progress
Courtesy of Sara R.D.

- Infrared laser from backside
- 2D laser scan
- Intensity tuned to ~1 m.i.p.
- Digital readout via Caribou



The chip is a small notch, sticking out of the PCB
(illuminated with a red laser to aim)



Efficiency map of one of the matrix corners

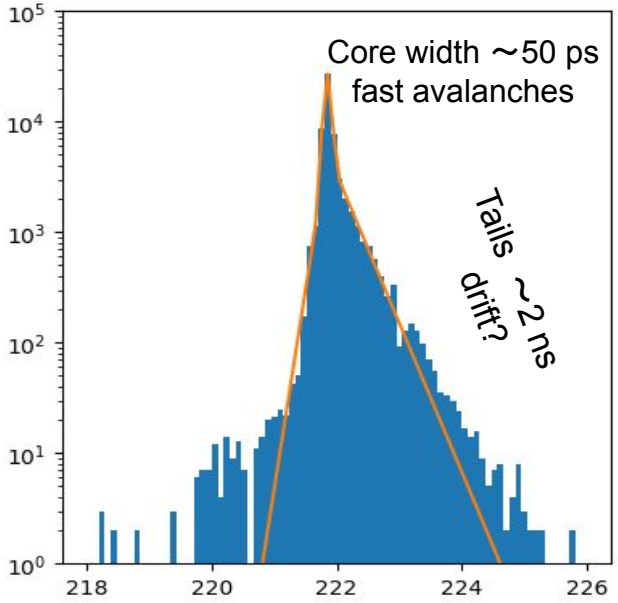
- Uneven efficiency patterns are a sensor design issue
- Results are in accordance with the test beam data
- Laserbox allows to collect high statistics in a given ROI

Digital SiPM

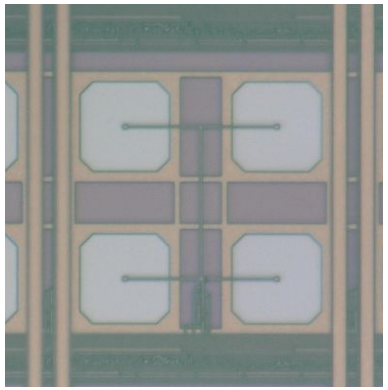
Timing performance of a single-photon sensor

Work in progress

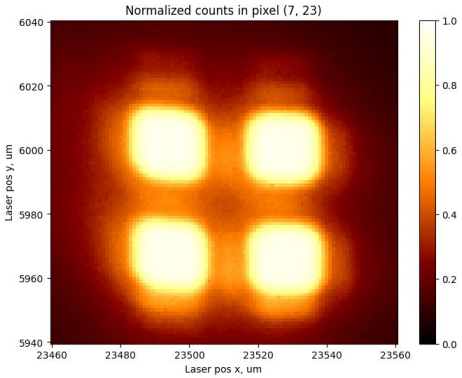
- Picosecond(-ish) red laser
- Intensity tuned to a minimum
- Digital readout via Caribou
- Record timestamps distribution for different laser positions



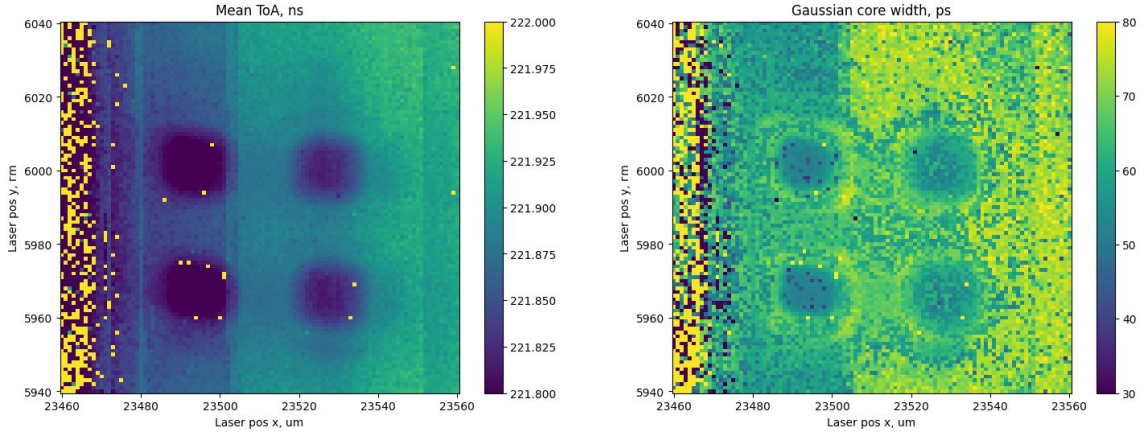
Structure of time residuals



One dSiPM pixel (4 sub-pixels)



In-pixel efficiency map



Mean (left) and RMS (right) of the fast timing component

- Consistent timing resolution of ~50 ps at SPAD centers
- Timing resolution degrades towards SPAD edges
- Results are in accordance with the test beam data

Conclusions

Laserbox is a flexible **testbench** for silicon sensors

- Range of lasers and other hardware
- Quick setup (if your device works with Caribou)
- Precise charge injection at high statistics

Application domain similar to test beams

- Possibility to cross-check TB results
- TB-like characterizations at lower costs

That's it!

Discussion?