# A low cost scanning TCT
## (un update)

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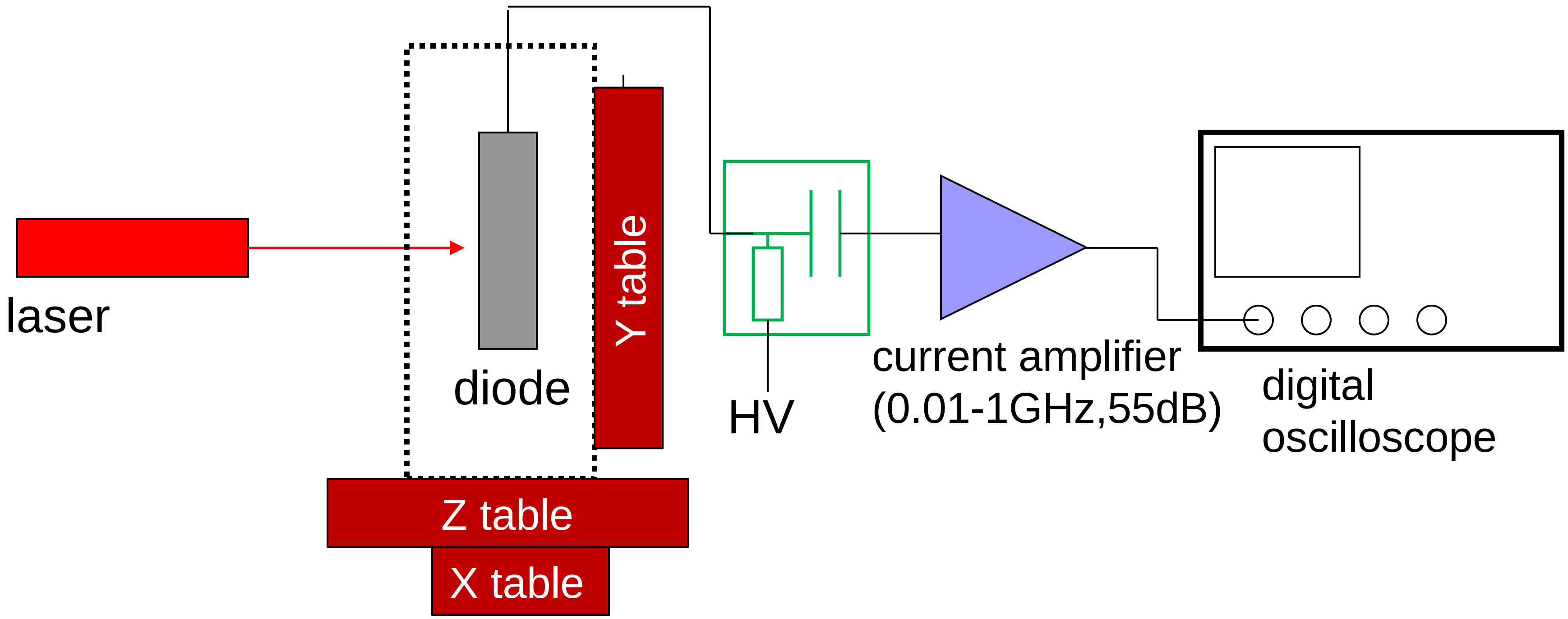
# Motivation

- Equiping Faculty of Physics of Univeristy of Ljubljana with TCT setup for undergraduate student practicum exercise
- Scanning-TCT for investigation of other semiconductors
- A lot of experience in TCT → some limitations/problems/ inconveniences with commercial products …
  - Amplifiers:
    - frequent break down of commonly used MITEQ-AMP
    - need for very large gain – to get the amount of generated e-h pairs as small as possible to avoid plasma effects ( $n_{e-h}$~$N_{eff}$)
      - Conventional TCT with focused short wavelength lasers
      - Edge-TCT, PS-TCT where beam is focused to few μm
    - to get reasonably priced device for multi-channel setups, where the price of around 1000$/piece can lead to substantial costs
  - Bias-T
    - Limited HV performance
    - Limited bandwidth
    - No integration Bias-T/amplifier (particularly useful if space is an issue)
  - Lasers
    - low cost/simple design
    - programmable laser pulse pattern

# TCT experimental setup - general

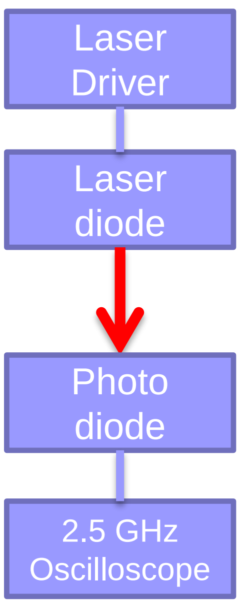



The main difference between conventional and scanning TCT is:

- focusing system
- moving tables

# Laser (I)

- The driver is general for almost any kind of laser diode:
  - Max current pulse 350 mA (the current is tuned to laser)
  - Repetition rate from 0 to 150 MHz – depends on the laser diode
- So far we tested
  - 670 nm (open) , 935 and 1064 nm (fiber coupled)
- Laser power should be regulated by using neutral density filter (absorber)





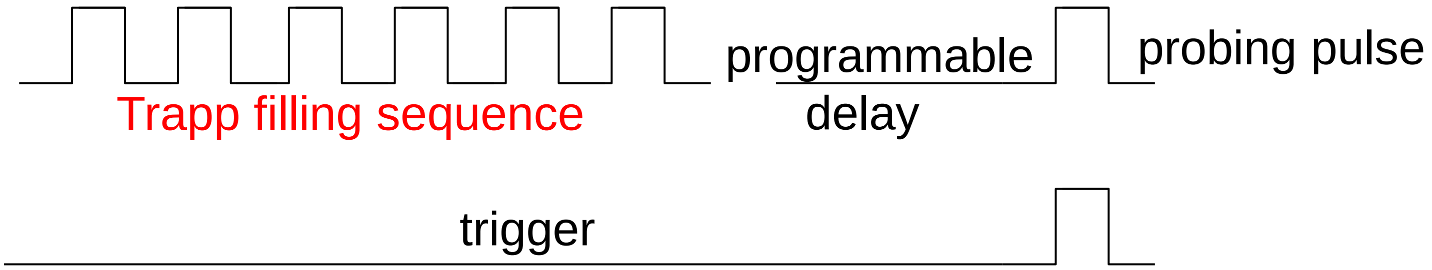
Parameters of the laser as measured with photodiode (**real parameters are probably better**)

- FWHM <= 350 ps
- Rise time (10-90%) ~150 ps

# Laser (II)

- Trigger in (from pulse generator) /out
- Computer (via USB) controlled light sequences.
  - any bit pattern of (1024 deep) can be programed like a sequence which can be repeated with selected frequency
  - the width of the laser pulse is programmable

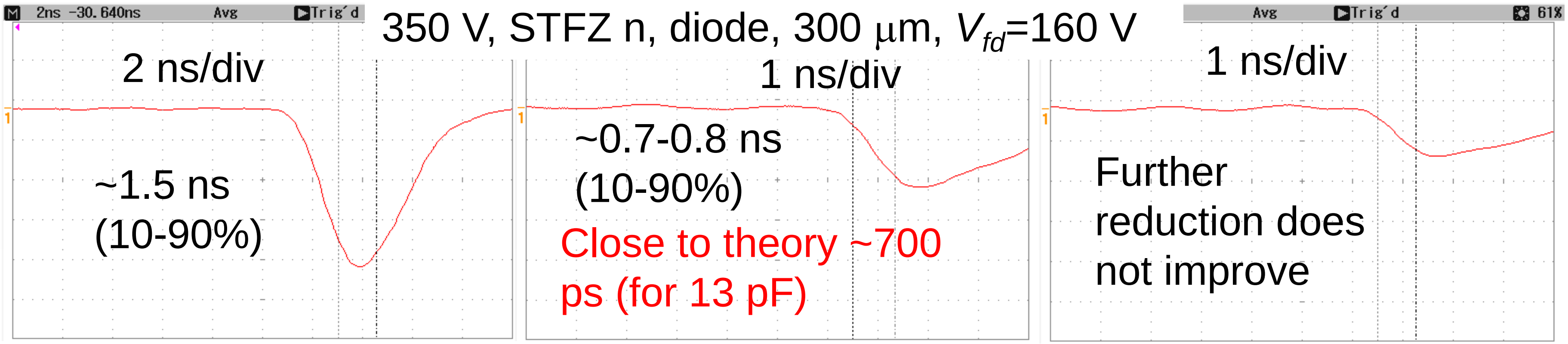
e.g. for studying of trap filling

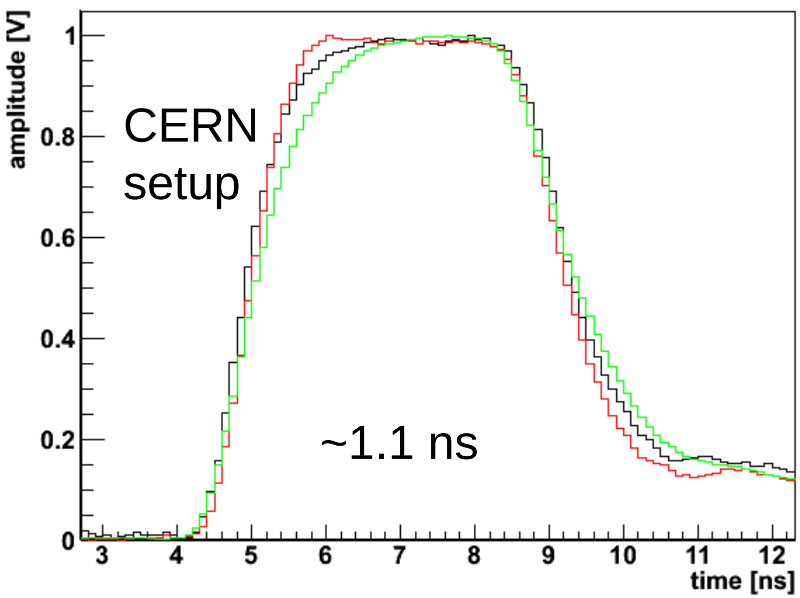


# Laser (III)

- The pulse widths can be tuned according to the application

350 V, STFZ n, diode, 300 µm, $V_{fd}$=160 V

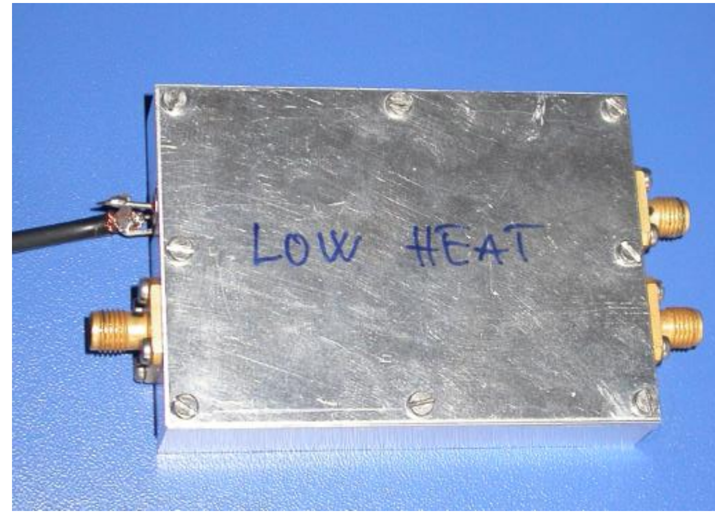


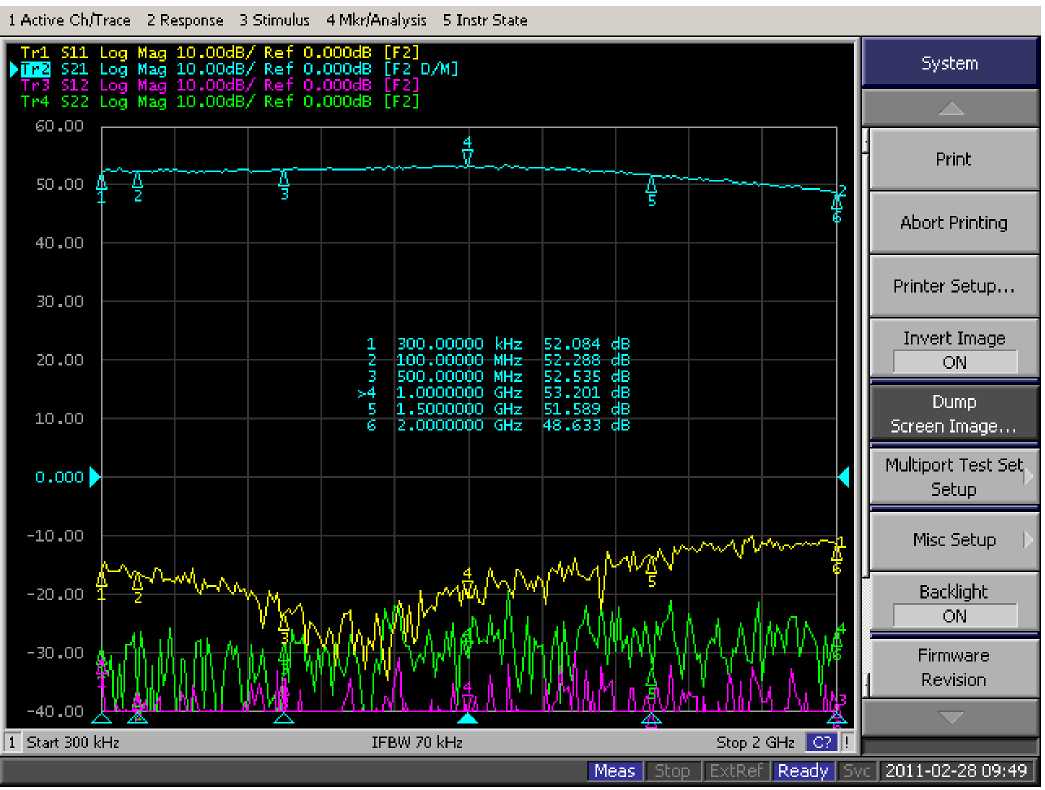




- n-type after 3e14 $cm^{-2}$, $V_{fd}$~200 V, 400 V, electron injection
- Plots normalized to 1 (maximum point)
- CERN laser (~100 ps) with three different amplifiers

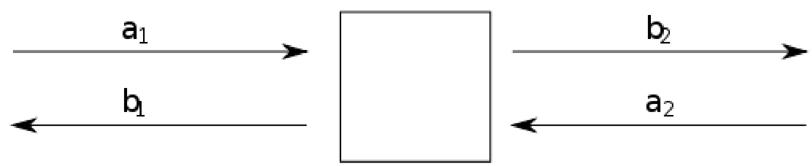
# Custom made amplifier

- Optional dual gain (higher gain)
- Bandwidth <<0.3-2000 MHz, the network analyser could not go below 300 kHz
- Small power consumption (+12 V) – initial problem with heating solved – good for use in thermally enclosed setups




What do the numbers on the plot mean?

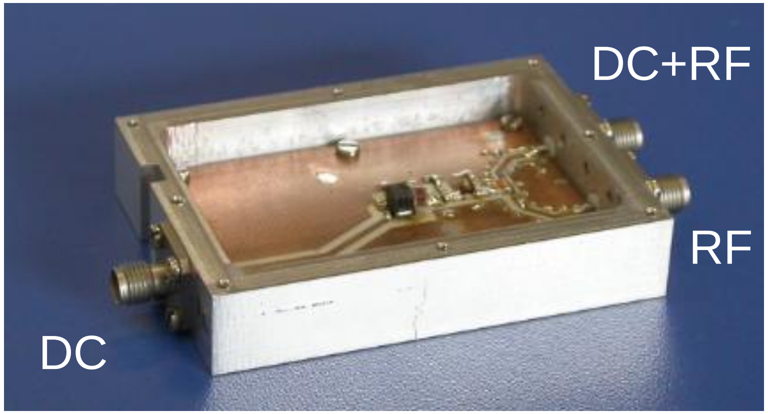



$$\begin{pmatrix} b_1 \\ b_2 \end{pmatrix} = \begin{pmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{pmatrix} \begin{pmatrix} a_1 \\ a_2 \end{pmatrix}$$

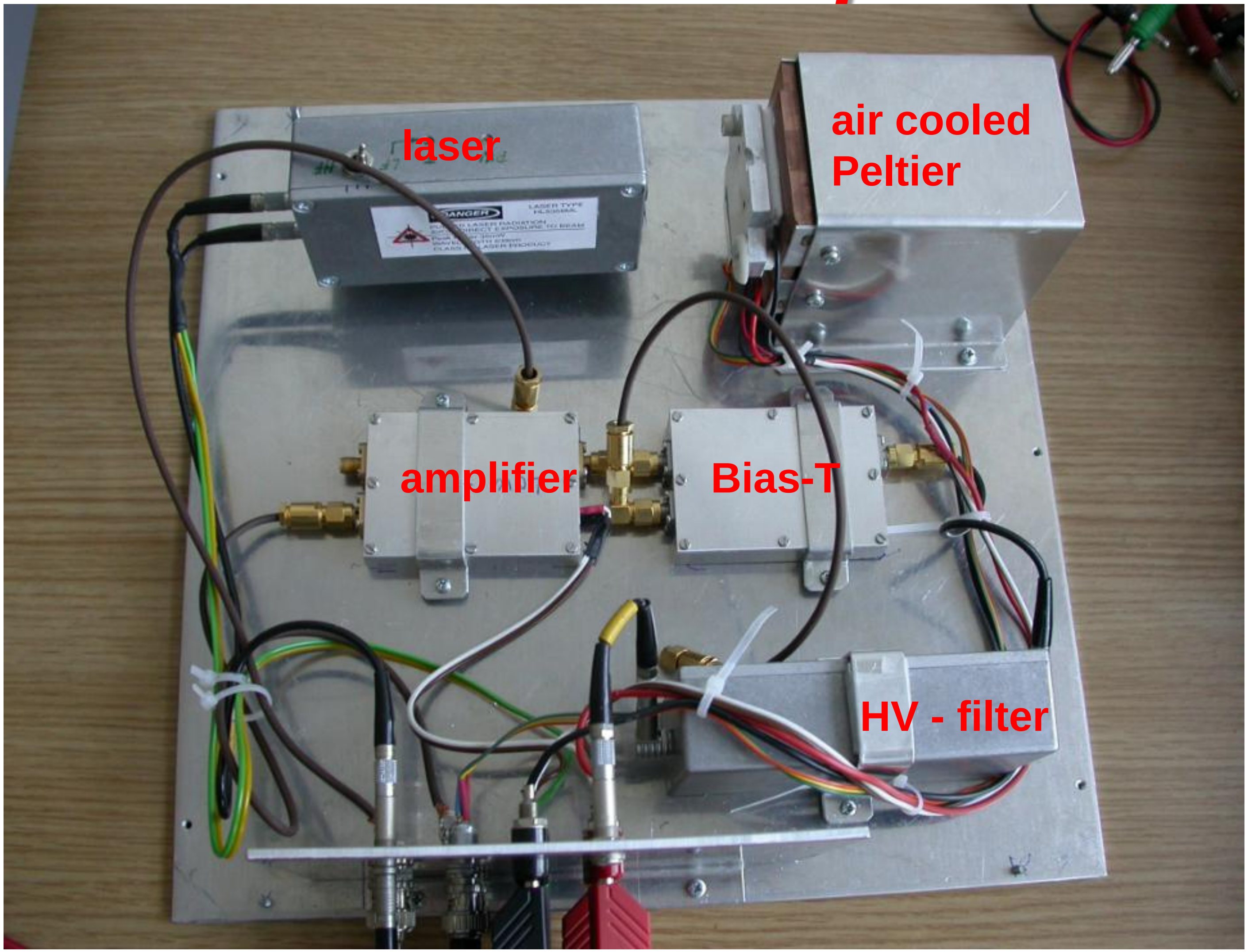
Gain of the amplifier

# Bias-T

- very few Bias-T for GHz range with HV capabilities. Most commonly used Picoseconds which has some limitations
  - limited to 1kV
  - Bandwidth limit at lower side is relatively high - 750 kHz
- custom made design can sustain high voltages up to 2.5 kV (currently tested up to 1100V)
- will/can be integrated in the same box as amplifier – compact design
- Problem: Bias-T sinks current (we are solving the problem now)

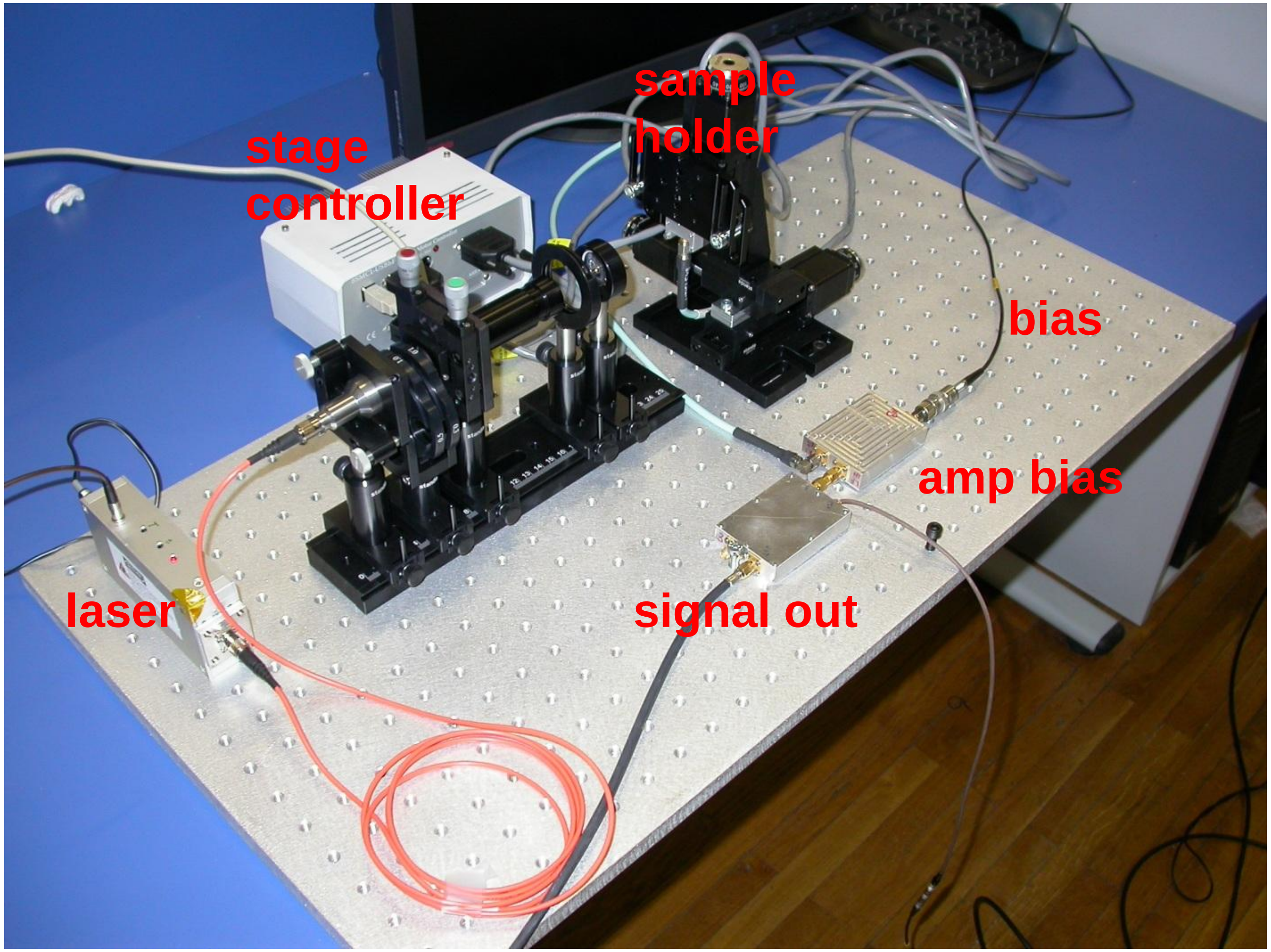



# Classical TCT setup




- red laser – not focused, open (not fiber coupled)
- temperature control via Peltier element [0-60ºC]
- lightweight and portable

# Scanning TCT setup




**Temperature control:**

- Water cooled Peltier element
- Pt-100 connected to T controller

**Mechanical properties:**

- ~1 μm resolution in x-y-z
- movement range 5 cm (focus range of Red/Infrared)
- table load 2 kg – tables are
- computer and manual control
- 40x40x40 $cm^3$

**Optical properties:**

- spot size ~2 μm (red), IR-1060 nm not determined yet
- laser fiber coupled
- Intensity variation – neutral density filter
- lenses optimized for IR/Red light

**Computer controlled:**

- USB – moving stages and laser

# If you are interested ...

- in anything (any piece ) shown please contact me or Marko.Zavrtanik@ijs.si
- in complete TCT-setups …
  - comes together with DAQ/Analysis software ☺
  - diode holder, bias voltage-filter …