Minutes and manual from Edge-TCT Workshop at DESY, 5-6, Oct. 2015

Topic: The first TCT workshop covering TCT and edge-TCT. The idea is to have talks and hands-on sessions based on the particulars TCT-systems (http://www.particulars.si/). Several groups are setting up such a system and start working with it. In the 1,5 day workshop, we would like to collect knowledge and experience, aiming for successful and efficient application of the systems. It will consist of few talks and technical sessions in the lab. Therefore the amount of participants is limited. More details on the topics can be found on the agenda.

Indico page: https://indico.desy.de/conferenceDisplay.py?confId=12934

Session 1: Introduction to setup and preparation of measurements

- **Hardware description: Particulars system** https://indico.desy.de/getFile.py/access?contribId=3&sessionId=1&resId=0&materialId=slides&confId=12934
  - Discussion:
    - Laser controlled through logic gate firing on delayed versions of the same signal: Control for pulse length, giving intensity, Control for frequency and pattern, pump and probe
    - System spot size: 10-12 in 1060nm, 6-8 for 640nm, smaller spots need coherent sources, no pigtailed lasers…
    - Different Peltier systems for -20/-60°C temperature reach
      Temperature controller block soon available from Particulars, could also do with an Arduino (two PT100, one peltier to control)
    - 1kV certified Bias-Ts seem to be missing on the market
    - Iris size 9mm
    - cold setup by placing styrofoam box around and use peltier
    - *Complaint about movements without control, computer on and seemingly moving the stages, only one reported case*

- **Hardware description: CERN system** https://indico.desy.de/getFile.py/access?contribId=19&sessionId=1&resId=0&materialId=slides&confId=12934
  - Discussion:
    - System has two Lasers: Visible (red) for front and backside illumination with 10% monitoring, 50/50 split between front and back and beam blockers
      Infrared for Front/Back and e-TCT, 10% monitoring split, 50/50 for e-TCT and TCT, 50/50 for front and back, all with shutters
    - stable running after 2 hours stabilisation
    - Temperature controller is commercial, software is available, see link in Christians talk (Slide 8)
    - Thermal PCBs for management (Ask if available through CERN, price)
    - CERN PCB-shop has manufactured PCBs, material was bought by C. Gallrapp at CERN, might be available
    - Iris size 14mm
    - *Biasing of neighbouring channels important to measure realistic characteristic of sample*
    - *Deconvolution to be discussed*

- **Beam monitoring:**
  - Discussion:
    - Why do beam monitoring? Protection from high density effects: Plasma effect, excessive recombination, get absolute charge scale and understand laser instabilities Operation at the edge of operational parameter space needs monitoring
    - Two different systems for splitting the laser light into DUT and monitoring device, fibre based and beam-splitter based – BM-01A, Fibre beam splitter has two inputs, useful, BM-02A, Beam splitter can sit after the optics, sees the same thing exactly, as the DU
    - Repition/two-pulse response can be checked with two lasers mounted to fibre, can only work at the same wavelength, i.e. 1060 atm.
    - Beam splitter based is much closer to DUT in chain, less calibration constants
    - where is light lost in beam splitter: 50 % in splitter
  - *Questions:*
    - *How do you calibrate? Manually… In Gregors case using a comparison with 241Am*
    - *Polarisation in the Fibre? Gregor says there is no problem with Polarisation, checked by moving the Fibre*
    - *Reflection from the Beam Monitor back into the optics causing different monitoring values? Calibration should include this…*
    - *Temperature control or correction in the Laser? Control, i.e. measurement and software correction*
    - *Changes in Reflectivity of the DUT can not be picked up? Currently not, maybe worth looking at Back-reflection from the device*

- **PCBs and mounts for different sensors: diode, strip sensors**
  https://indico.desy.de/getFile.py/access?
  contribId=4&sessionId=1&resId=0&materialId=slides&confId=12934
  - Discussion:
    - DESY pcb available to be used with Gregors Setup, cost is about 5-10 Euros per PCB, from Rogers material
    - Questions: *Thermal Performance questions: Thermal vias? Insulate the housing, rather than trying to get a non-conducting PCB*
      Bias filtering circuit included
      Temperature/Voltage dependence of Bias circuit is questioned – unmeasured by Hendrik as of now

- **DAQ + Software operation for particulars**
  - Discussion:
    - LabVIEW DAQ has to be delivered compiled, as there are IP restrictions, *Windows only, same for the CERN system*
    - TCTAnalyse to run analyses on recorded Data
    - *Question on Acquisition speed: O(s) per measurement point with DRS, depending heavily on Scope*

**Session 2: Lab session on DAQ & focus for preparation of scans and sensor preparation**

- **Sensor preparation for edge, backside illumination**
  https://indico.desy.de/getFile.py/access?
  contribId=21&sessionId=1&resId=0&materialId=slides&confId=12934

  ○ Discussion/Questions

    ▪ Polishing with diamond tape (3um) and diamond paste (1/10th um)

    ▪ Usually good to polish the whole edge, rather than being selective, manual polishing takes about 15 min for experienced user (coarse with diamond paper + fine polishing with q-tip and paste)

    ▪ Ethanol preferred for cleaning, IPA leaves traces

    ▪ Online check of the surface with microscope -> take care of the focusing

    ▪ Take care not to produce an angle relative to the surface or rounding of the polished edge for manual polishing.

    ▪ Backside preparation: mask of kapton firmly applied

    ▪ *Llubljana uses a rotating table with the sensor in resin -> better handle of the* flatness of the surface (90 degree relative to surface); more effort

    ▪ NaOH for etching, apply some drops with swab, wait for cloudy pattern visible, rinse with DI water and ethanol

    ▪ *Questions about the optical inspection procedure, coarse resolution microscope is problematic to understand the polishing quality*

    ▪ *Have people tried optical gel? No*

    ▪ Left figure before, right after polishing
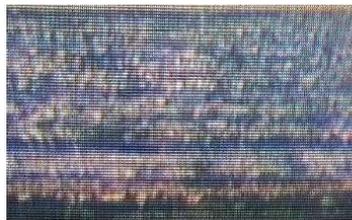
    ▪ Bad polishing can lead to results like this:
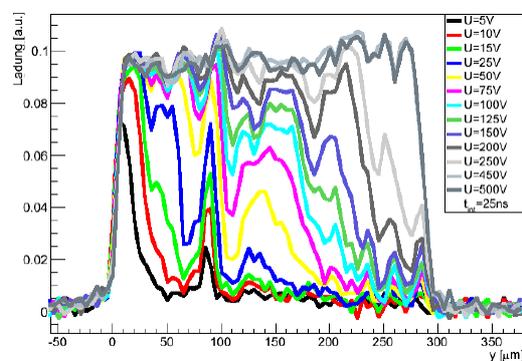
- **Focus finding**
  - Doing a scan over the edge of a sensor for different optical distances
  - scans result is in an errorfunction, fits provide FWHM of the errorfunctions and therefore the laser diameter
  - More information about the focusscans and the analysis for it can be found on the particulars webpage

- **Edge-TCT setup from particulars (as installed at DESY lab)**
  - Setup:
    - The detector is mounted in edge-positon within the setup
    - the signal strip (5th from the edge, AC-readout) is connected over an amplifier to the readout (DRS or oscilloscop)
    - deplet the sensor by connecting the voltage source to the backplane and the biasring
    - if the biasvoltage is applied to the signalstrip a bias-T is used to seperate voltage and signal
    - the two strips next to the signal strip on each side, are connected to the same potential as the biasring (AC-readout)
    - between the voltage source and the detector/bias-T a HV-filter is installed
    - the laser is connected over a fiber cable to the optical system, which collimates the laserbeam on the detector
    - between laser and optical system a beam splitter may be used to measure the laserpower with an oscilloscope
    - for cooling a peltier element is used together with an PID-controller (PR 59)
    - a chiller is used as a heat sink
  - Tips for operation:
    - in the case of an overshoot of the signal, using a longer cable (delay) between the detector and the amplifier delays the overshoot so it can be easily separated from the signal
    - everything should be terminated over an Impedance of 50 Ohm
    - each cable should be shielded if possible (SMA better than Lemo)

Session 3: Theoretical background of measurements and analysis software

- **Theoretical background for measurements** https://indico.desy.de/getFile.py/access?contribId=8&sessionId=3&resId=0&materialId=slides&confId=12934
  - Questions:
    - Why HV on frontside: It was easier for us to connect
    - Ramo potential for strip measuremenst not important? Yes, but slide 13 e.g. was done with IR laser and integrated so cancels out. Much more difficult if you want to try to understand field in this configuration

- **Simulation from Torino** https://indico.desy.de/getFile.py/access?contribId=25&sessionId=3&resId=1&materialId=slides&confId=12934 https://indico.desy.de/getFile.py/access?contribId=25&sessionId=3&resId=0&materialId=slides&confId=12934

  - slides are shown and the program demonstrated

  - Questions:

    - Is it 2D? Yes

    - easy to use, allows 10% precision

    - Can you include p-stops? Don't know if it is the right tool. p-stops float, this is not easily implemented - voltages are set and given. For more difficult things, TCAD is used.

- **Simulation from LjubljanaDiscussion** https://indico.desy.de/getFile.py/access?contribId=26&sessionId=3&resId=0&materialId=slides&confId=12934

- **Simulation with TRACS** https://indico.desy.de/getFile.py/access?contribId=29&sessionId=3&resId=0&materialId=slides&confId=12934

  - Discussion

    - Also a program at HH university. Should try to compile literature data for attenuation and multiplication, possibly merge programs. "Natural" idea, ancient code already from Krakow. Comment do we try to merge?

→ Conclusion on simulations: simulate benchmark points to compare the simulations. Results will be presented at the RD50 workshop https://indico.cern.ch/event/456679/overview

Aiming for placing comparision on RD50 webpage (what is in each tool, methods) and constrain models.

- **Common Code** https://indico.desy.de/getFile.py/access?contribId=10&sessionId=3&resId=0&materialId=slides&confId=12934

  - Comment: Main difference mentioned by GK and MFG: "interactive" approach not possible. However, functions implemented in ROOT can be loaded as library and used from within Hendrik's framework.

  - People interested in code but so far no real developers found

  - In particulars functions as cint and in framework from Hendrik as macros available

  - pay attention in common code: compare to other code otherwise common bugs.

  - particulars has binary readout file

  - Send any code you want to have included to Hendrik Janssen (hendrik.jansen@desy.de)

Session 4: Lab session for measurement, edge pulse and readout

- **Readout boards: DRS4 vs. Oscilloscope** https://indico.desy.de/getFile.py/access?contribId=15&sessionId=5&resId=0&materialId=slides&confId=12934

  - Discussion on whether DRS4 bandwidth is sufficient for very thin detectors/short pulses. Suggestion to do the example measurement again with diodes with smaller capacitance

  - When using oscilloscope: wait 200ms after movement of stage

  - DRS problematic sind thin detectors need 20 GSPS

  - for timing measurements a scope is needed

  - Caen has a board with 8 GSPS for 5kEuro

  - DRS4 is good for a few active channels, similar board from STRUCK available

Summary: Do's and Dont's

- https://indico.desy.de/getFile.py/access?contribId=17&sessionId=4&resId=0&materialId=slides&confId=12934

- Discussion:

  - Don't look into the laser! You can do it once

  - Clean the sensor, more than clean, super clean

  - Be sure to initialize your device

  - Move the x-y stage without power, don't do it

  - Use the bias-T whenever possible. However, even if a Bias-T is used, damage can occur to the amplifier.

  - Connect the neighboring strips, 2 on each side

  - PCB: get matching impedance!! Ask an engineer in case of dear need

  - Don't do too many steps in voltage steps, there are problems in the analysis package

  - In edge scan, don't use the first strip, but further in.

  - Temperature VI controller will be included in particulars software

  - Don't use Lemo cable for signal. Use SMA. Even for low voltages Lemo should be avoided. Additionally cables must be properly shielded, otherwise every time one is changed an alteration in the noise is observed.

  - Be careful of laser cables and pick-ups. Put the laser far from the set-up if you can.

Suggestions

  - If you have any questions, ask them in the forum: http://www.particulars.si/Forum/index.php

  - Add PID vi to particulars system

Thanks to all attendees for contributions, minutes and discussions!