Practical advices for using TCT (mostly for Particulars setups)

G. Kramberger
Jožef Stefan Institute & Particulars

Beam monitoring

Why beam monitoring?

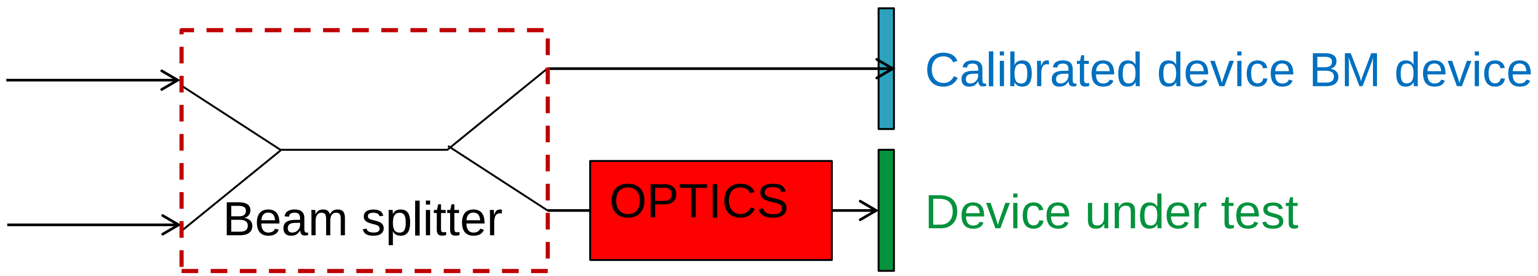
- Charge measurements
  - ensure that density of generated carriers doesn't influence the field (avoid plasma effect, excessive recombination …)
    - red laser (660 nm) is more problematic as the deposited volume is small when focused : in V~3.14*7 μm*3 μm~ 70 μm^3 around 1M e-h pairs , which yields: 1.42•10^{16} cm^{-3} >> Neff (note that laser is not infinitely fast)
    - Infrared (1064 nm) it is rarely the case that N_{e-h} influences the signal (larger beam and above all much longer penetration depth)
  - absolute scale of measured signal
    - In a calibrated system one should be able to measure the absolute difference in collected charge even if the intensity of the laser changes between two samples - CCE measurements
- Correct for laser instabilities
  - Variation of temperature
    - Over a longer period the laser power may fluctuate due to temperature changes (large ΔT). This is usually not significant, but it can be observed and corrected for.
  - operation of the laser at the edge of characteristics
    - lasers driven to the limits of width/amplitude/repetition they can be unstable

Implementation – types of beam monitor

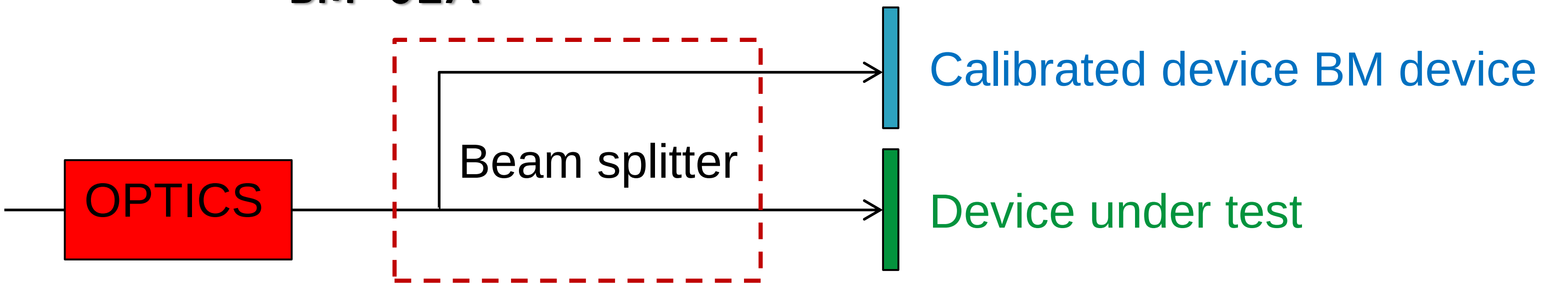
We have developed two different systems

- fiber split system (BM-01A)
- in-beam system   (BM-02A)

BM-01A

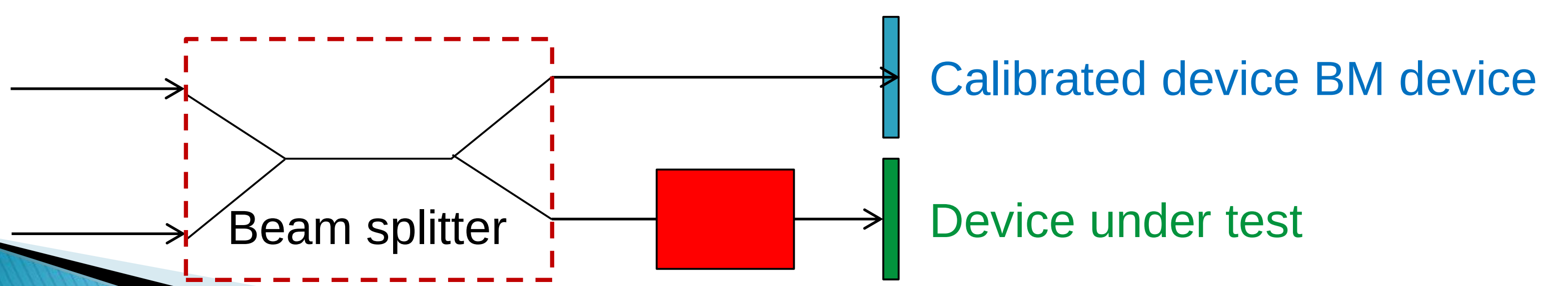


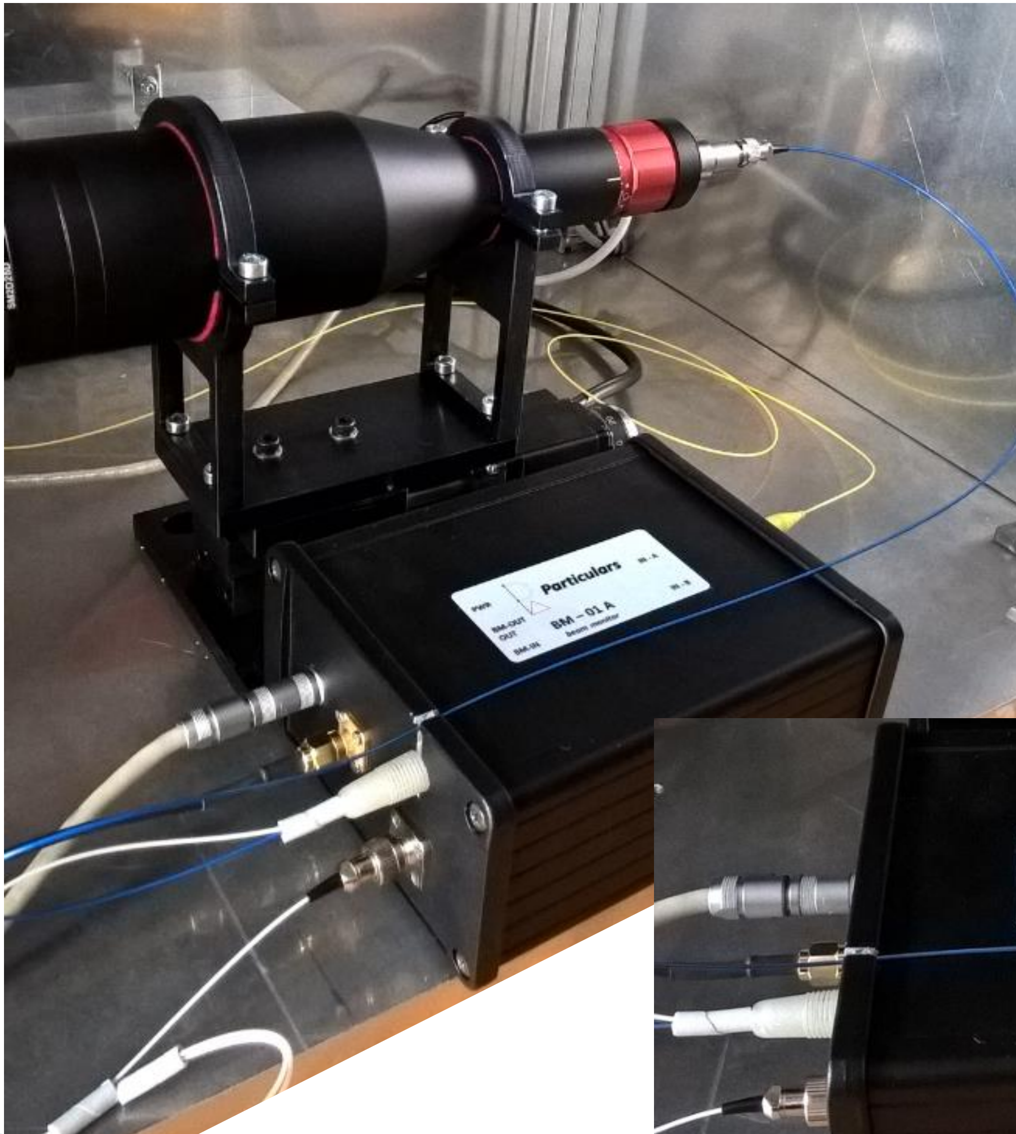
BM-02A



Fibre-split system (BM-01A)

- Fibre-split system advantages:
  - Two inputs – many options for advanced tests
    - DC+ pulsed light – operation of detectors in presence of high concentration of non-equilibrium carriers
    - Two pulse response – response of detector within several ns (usually not possible with conventional lasers)
  - Simple mounting
  - Calibrated device can be a commercial fast photodiode connected to amplifier circuitry – wide spectral sensitivity
- Fibre-split system drawbacks:
  - Adjusted to a single wavelength (for now we have 1064 nm version)
  - Requires calibration for each optics setting (using NDF, iris …changes the calibration)
  - Prone to insertion losses – large degradation of amplitude (~10x)

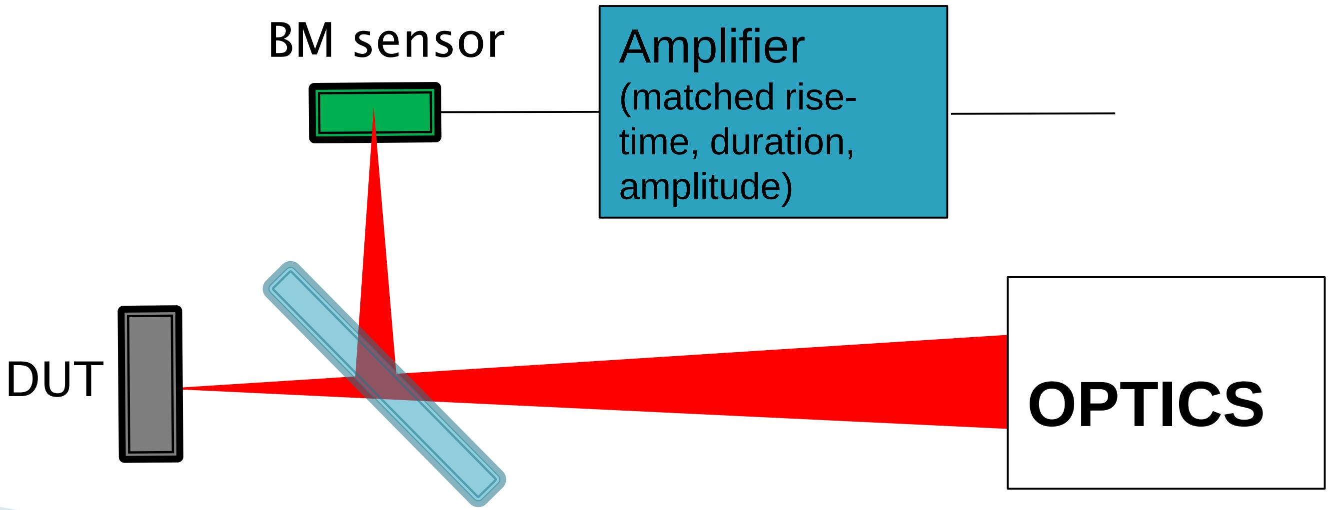




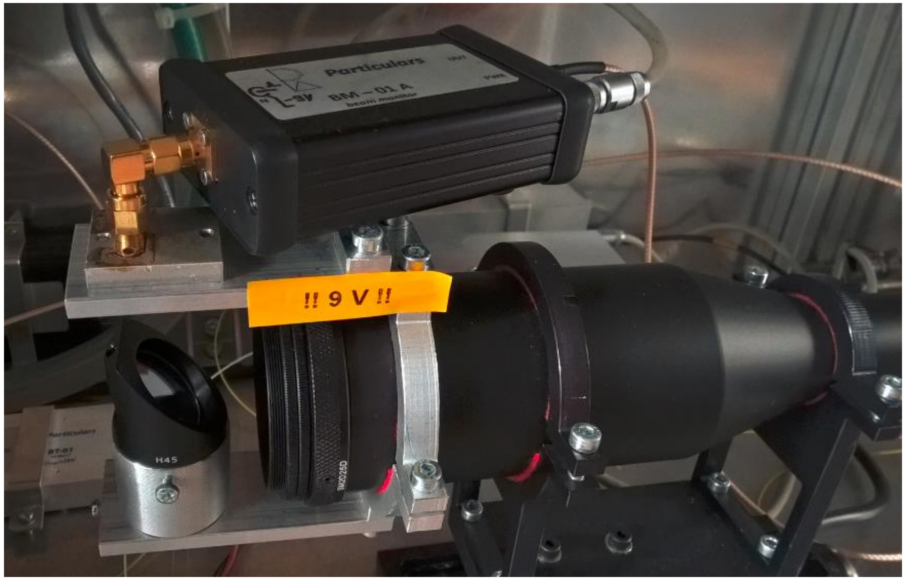

PWR
Particulars
IN - A
BM-OUT
OUT
BM – 01 A
IN - B
BM-IN
beam monitor

In-beam system (BM-02A)

- In-beam system advantages:
  - Mounted in-front of the optics – "transparent to" optics setting (iris, filter)
  - A single beam monitor for all wavelengths
  - Less losses of light – basically corresponds to mirror split ratio
- In-beam system drawbacks:
  - Requires special diodes (non-commercial) with large enough sensitive area.
  - Problem with polarization non-maintaining fibers -> ratio of split light depends on the fiber routing… – difficult to make absolute calibration.

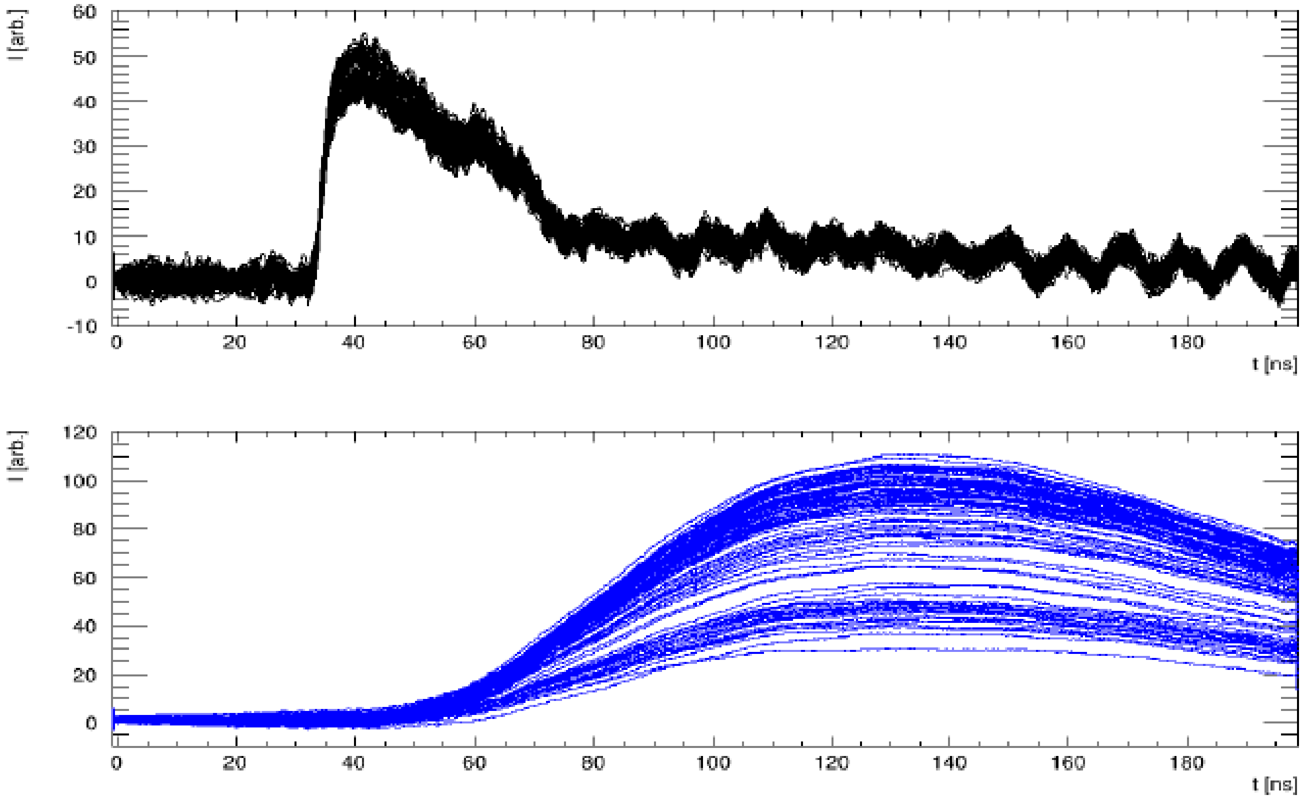



Particulars
N
OUT
BM – 01 A
beam monitor
PWR
H45


Particulars
BM – 01 A
beam monitor
!! 9 V !!
H45

BM + DUT

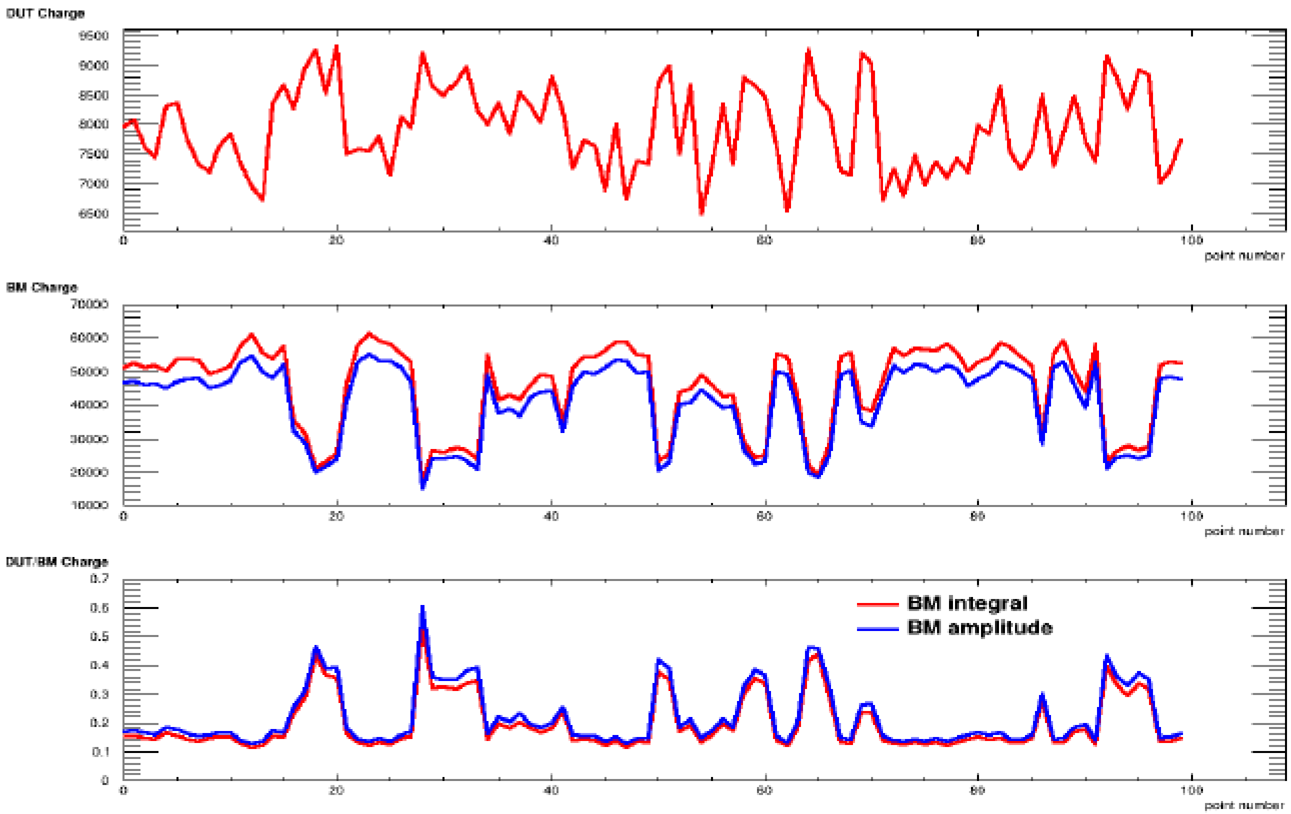
Acquiring data while touching the optical fiber



Both signals in the BM and in the DUT were quite small but the DUT was hit in the center
20ns to100ns as time interval for charge integration in the DUT

BM + DUT

Acquiring data while touching the optical fiber

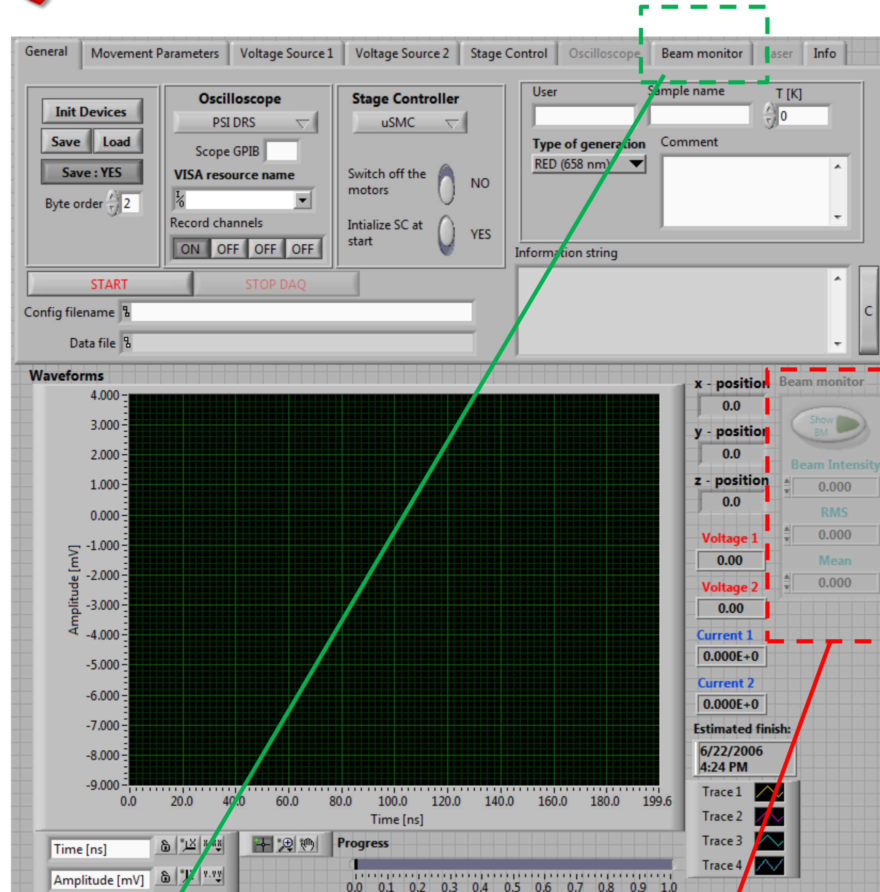


There is anti-correlation between the charge collected by the BM and the one collected by the DUT diode
The signal on the BM was smaller when the bending radius of the optical fiber was shorter

Integration in the DAQ

Beam monitor is integrated in the PSTCT software since V1.61

- a free channel is required in your DRS/oscilloscope
- DAQ uses charge/peak from BM to get the laser intensity (more complex analysis possible)
- It writes the BM value (charge/peak) to the file in the same way as other data in front of the waveforms (x,y,z,U1,U2,I1,I2…)
- The BM channel can be monitored/not stored during data taking
- V1.1 of TCTAnalyse is required for analysis/loading of the data

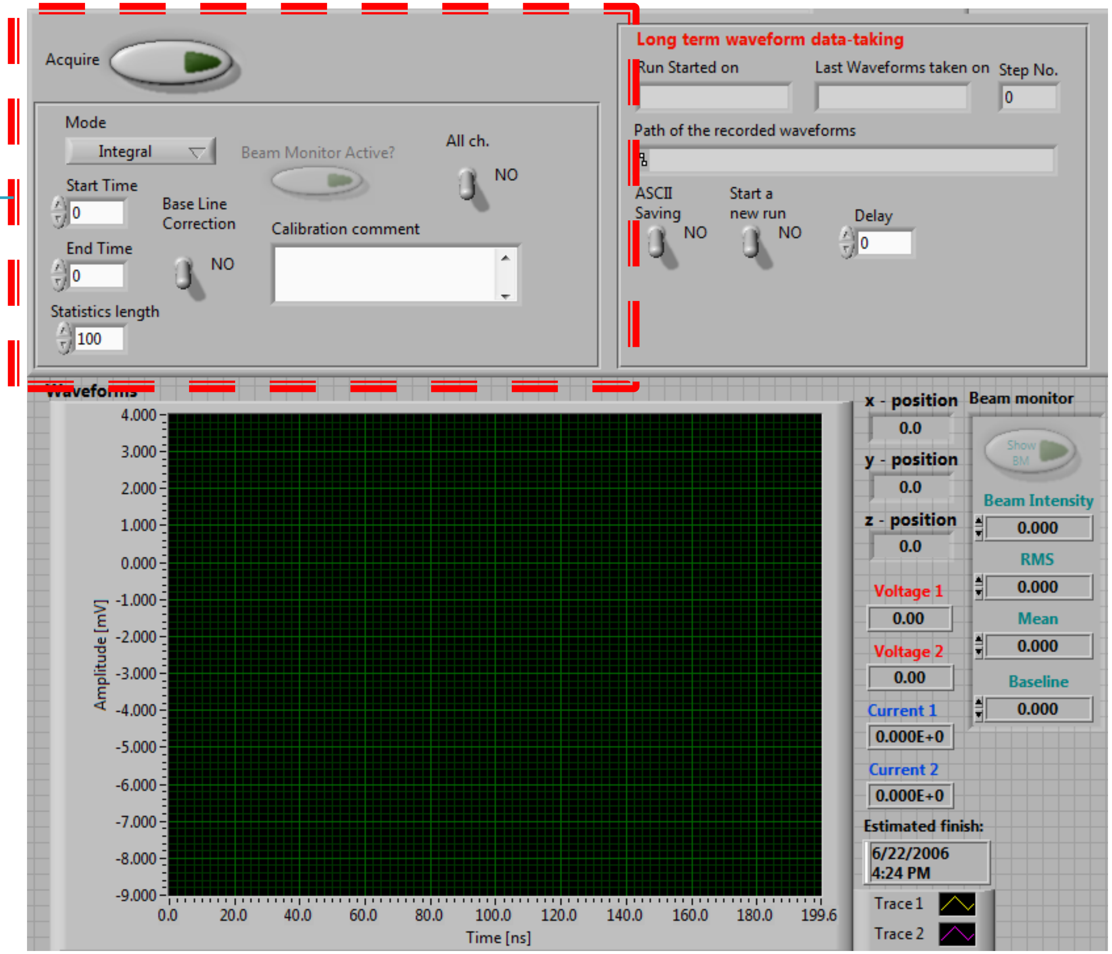


Shows current value of BM and Some statistics over last N of events

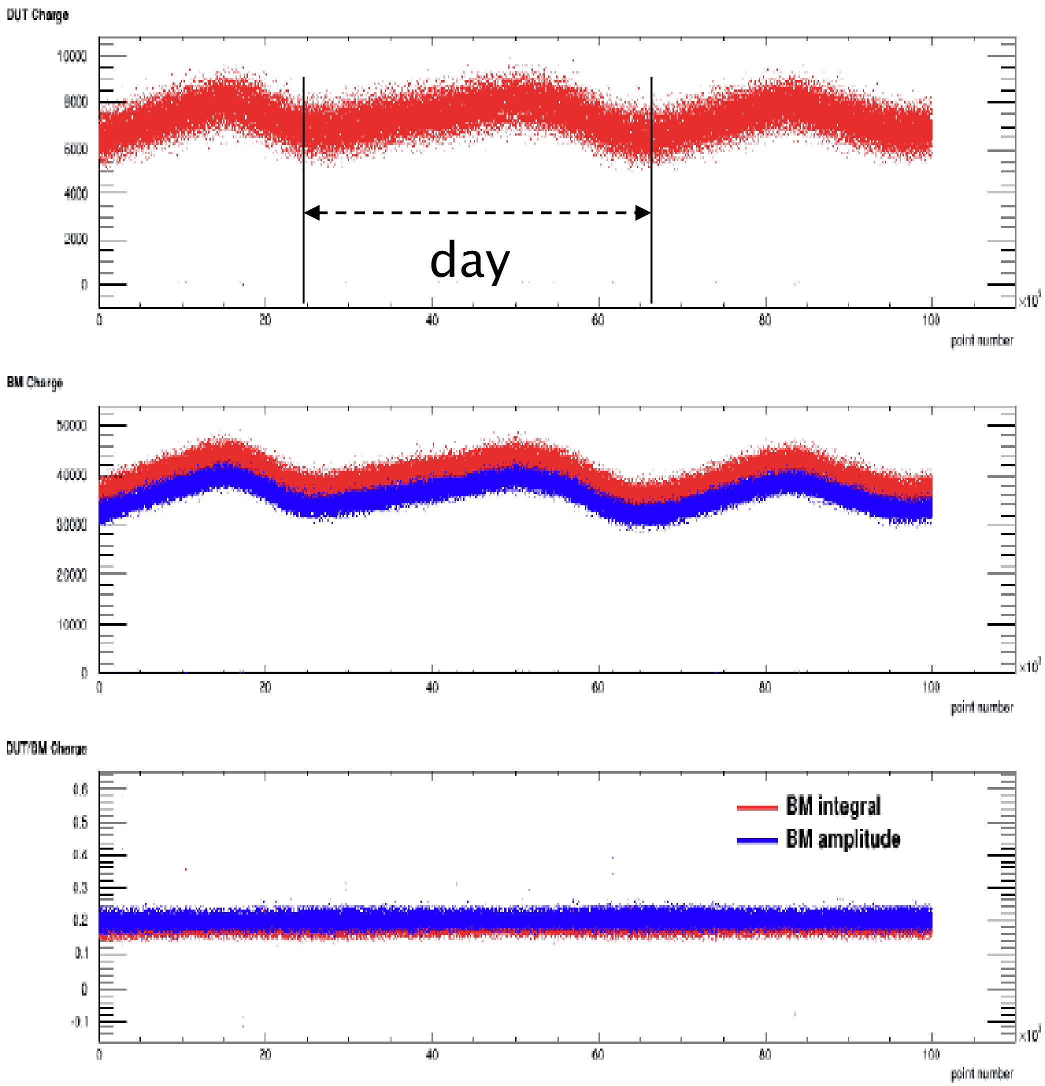
Settings tab for the BM

Integration in the DAQ

- One can select time interval
- Statistics on precision
- Mode: integral/amplitude



Example of use



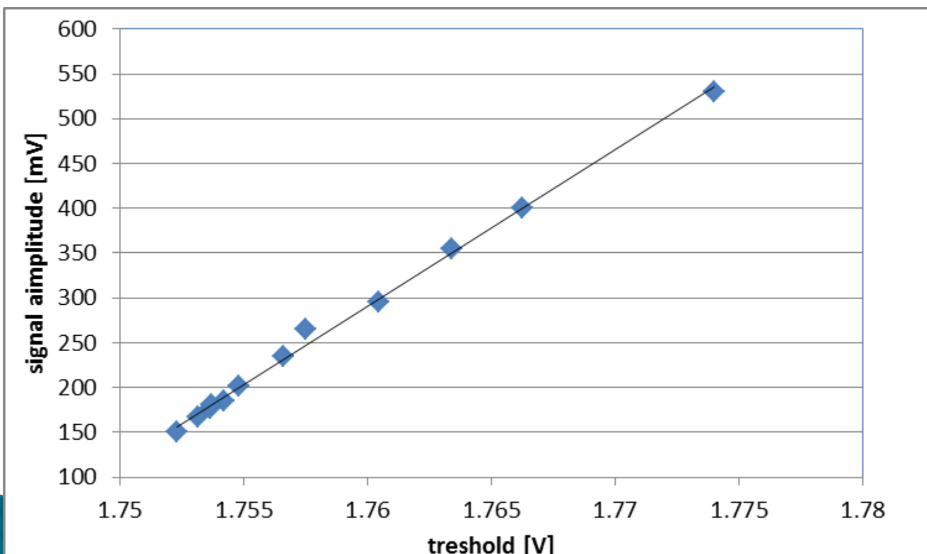
- Temperature oscillations in the lab (IFAE) cause variation of signal in DUT
- The same oscillation is measured in BM with exactly the same pattern
- When corrected for variation the signal stability is very good within 3%!

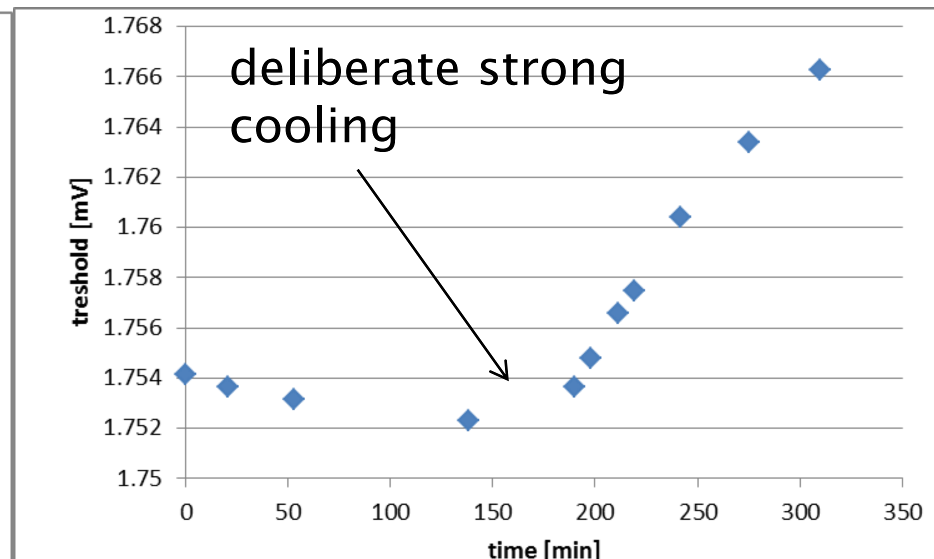
Temperature dependence of laser output

Gain of the laser depends on the temperature:

- the reason is in one of the driver stages the transistor for voltage regulation has a temperature dependent leakage which translates in to shift of threshold for current pulse
- some drivers have very small T effect/none, but some have sizeable T effect in non thermally stabilized laboratory
- Recent lasers have a compensation circuitry that mitigates the effect
- If you have an older laser which is operated in thermally not stable environment the stabilization circuitry can be added

Measured in fully depleted p-n sample of standard thickness with IR laser





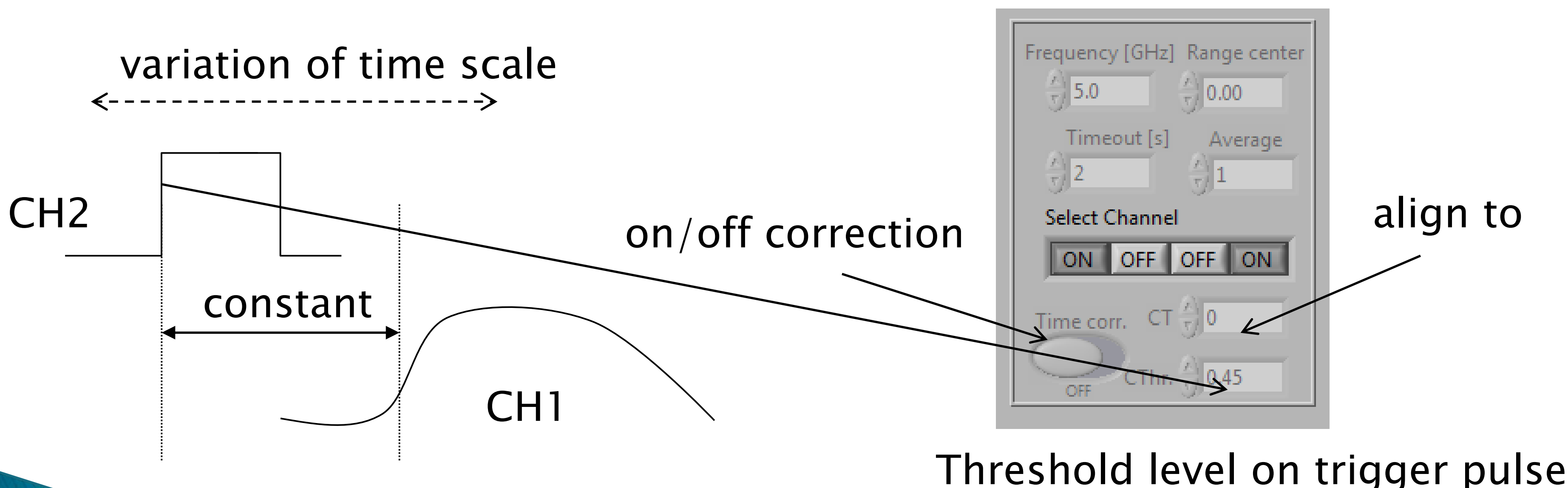
Beam locator

- Finding a small structure of ~100x100 μm^2 with a beam of infrared light for e.g. Edge-TCT measurements is a problem – those who have tried know it – scanning of larger area with high power is very time consuming
- The visible light is a far more appropriate to hit small cell sizes. So the XY position of the spot is determined by red laser and then the fiber is changed to IR laser.
- If you don't have a red fiber coupled laser, a beam locator – fiber coupled red CW laser is an option (cheap solution).
  - It is biased by standard Laser PS
  - Uses a laser diode and multi mode (50 μm core) laser fiber

You will be able to see it in lab tests.

DRS and correct averaging

- If you use DRS with very short signals make sure that you make timing correction
  - Depending on the time of arrival of trigger wrt to DRS cell number the whole time scale can shift for up to 2 ns left and right -> when averaging is done the signal is smeared
  - In timing correction the signal is aligned to the trigger pulse, which allows for good “average”



PCBs for TCT

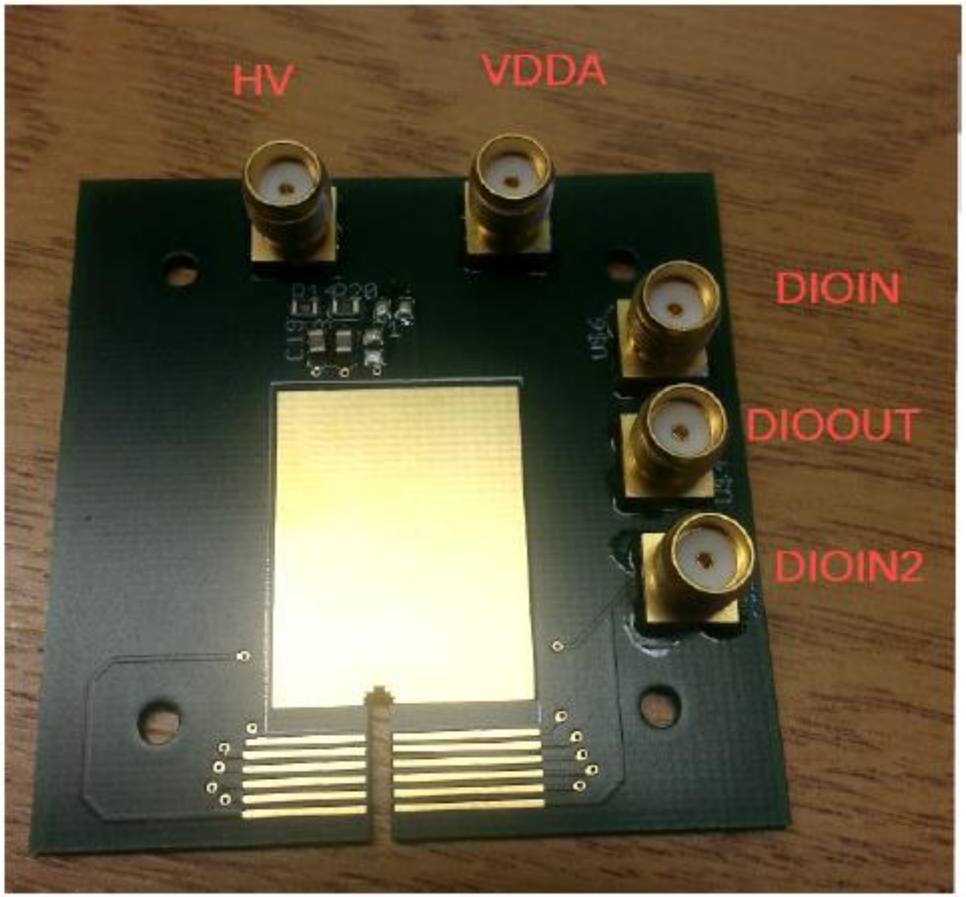
- There are specific designs for each application, but are usually versatile enough to be used for different sensors
  - DESY board (general purpose)
  - Liverpool H35
  - SCIPP board
  - JSI
  - …

- But:
  - Cooling is a problem through PCB
  - Do we need a general purpose circuit on Al_2O_3 or AlN ceramics that can effectively cooled?
  - Would it be required to have a common pool of PCB designs?

UNIVERSITY OF LIVERPOOL

H35DEMO TCT Board

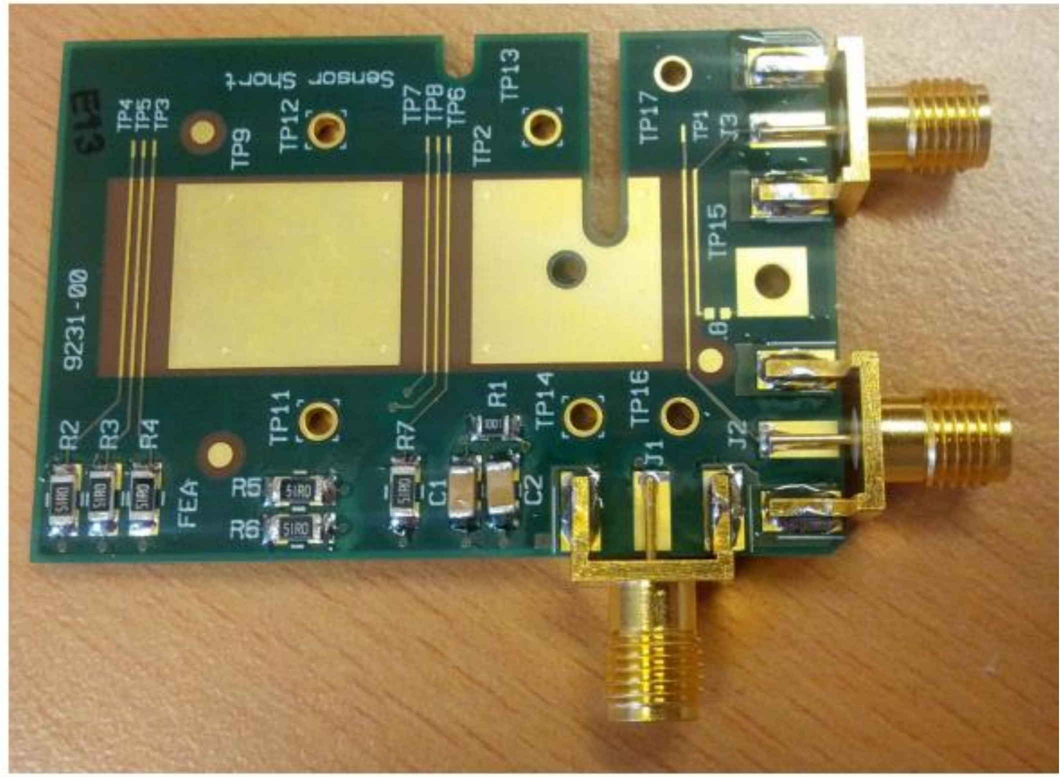
6 Layer board with separate planes for all signals to reduce noise



- PCB fits onto Particulars support plate for cooling (holes match threads)
- 1.27mm (0.05”) wide slit for edge-TCT

- Designed at DESY
- For Top/Bottom/Edge-TCT
- Usual sensor size:
  10 mm x 10 mm
- Up to 30 mm x 10 mm
- Filtered HV from J1
- Two signals
- Hold-down clamp
  → No glue needed
- Mount for measurement
  and bonding

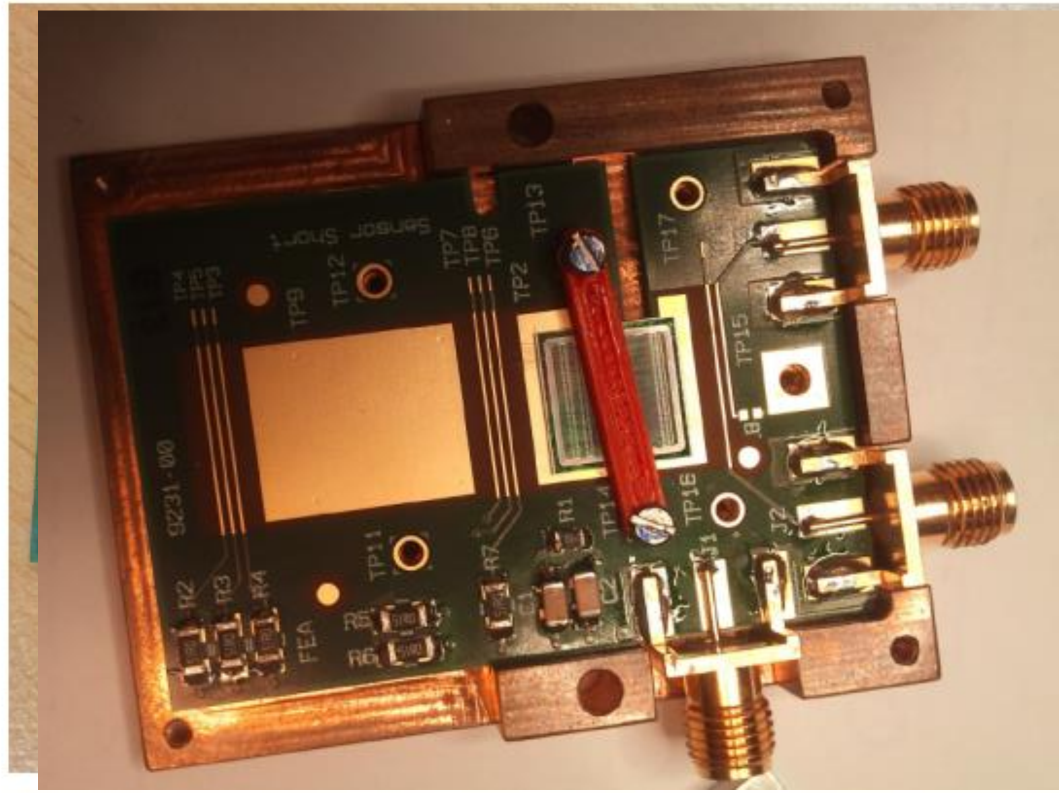
Very good impedance mathing – no ringing



06.10.15 | 1st TCT workshop 2015 | Hendrik Jansen 2

- Designed at DESY
- For Top/Bottom/Edge-TCT
- Usual sensor size:
  10 mm x 10 mm
- Up to 30 mm x 10 mm
- Filtered HV from J1
- Two signals
- Hold-down clamp
  → No glue needed
- Mount for measurement
  and bonding

Very good impedance mathing – no ringing



06.10.15 | 1st TCT workshop 2015 | Hendrik Jansen 2