A CCE and TCT Study on low resistivity MCz p-on-n detectors

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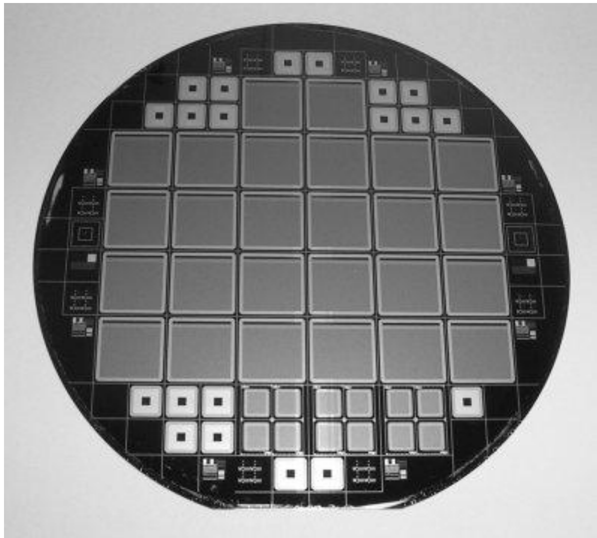
16th RD50 workshop, Barcellona, 31 May-2 June 2010

Studied structures

- Common RD50 4” production at CNM
-MCz p-on-n, 500 Ω·cm (design resistivity)
- 300 µm thickness, 80 µm strip pitch
- Actual resistivity: ~200 Ω·cm
- AC coupled strips
- P-spray insulation



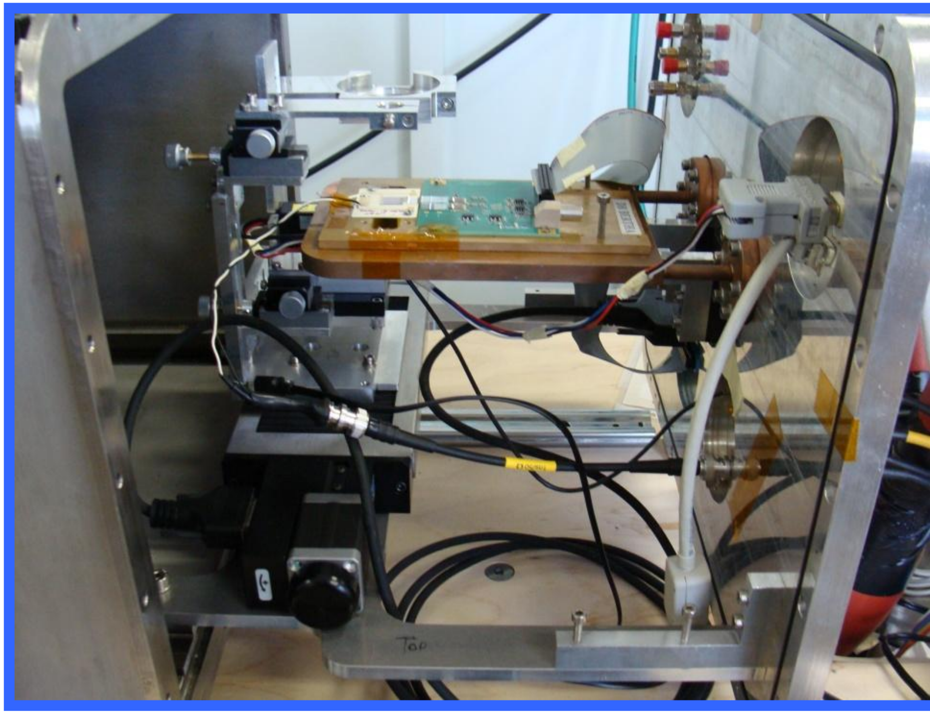
-Previous studies on detectors from the same production batch (different materials)

- G. Pellegrini – 10th RD50 workshop
- U. Soldevila – 14th RD50 workshop

Irradiation:
1 MeV neutrons – Ljubljana, March 2007, (1e14, 3e14, 1e15, 3e15, 8e15 n/cm^2)
24 GeV/c protons – CERN, 2009 (1.6e14, 4.8e14, 1.6e15, 4.8e15, 1.3e16 p/cm^2)

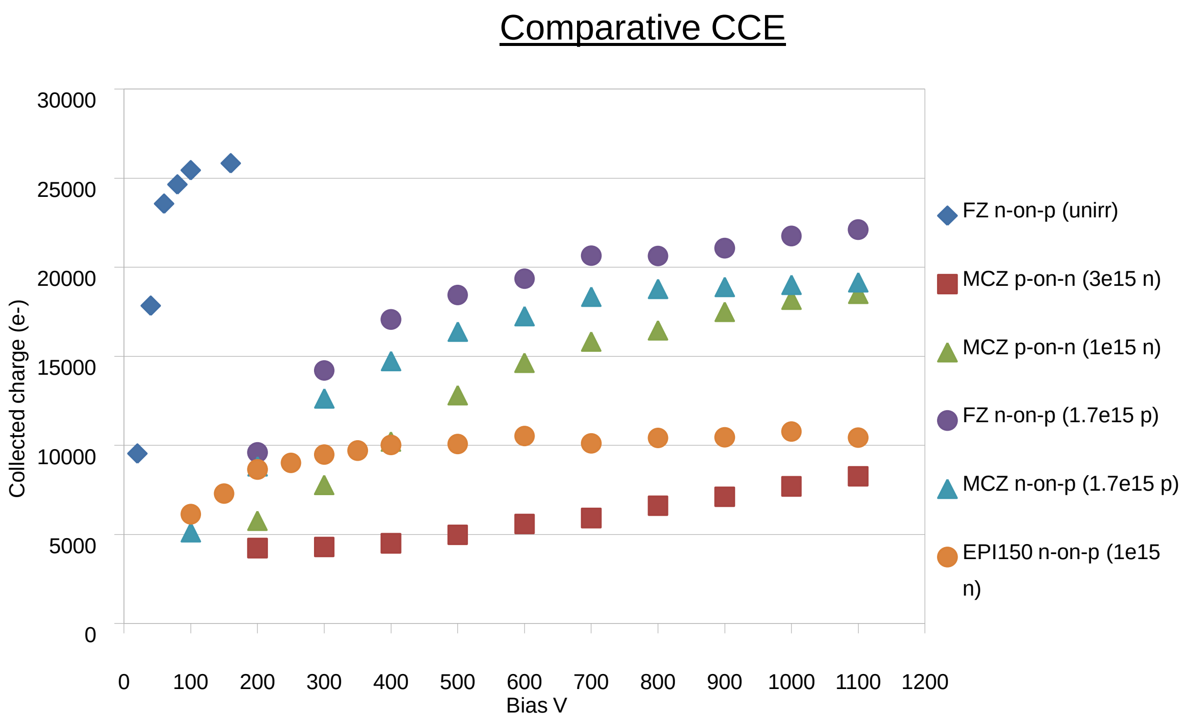
CCE setup

- Alibava based setup
- 3.6 MBq ^{90}Sr source
- - 20±0.5 temperature (provided with closed circuit silicon-oil cooling)
- Single scintillator triggering (collimation provided by small cross section of the scintillator)
- Plastic moderator, stopping slow electrons (not MIPS)
- Alibava DAQ 0.1.5 custom modified for bias voltage scans (E. del Castillo, 15th RD50 workshop)
- Custom version of the analysis root macros



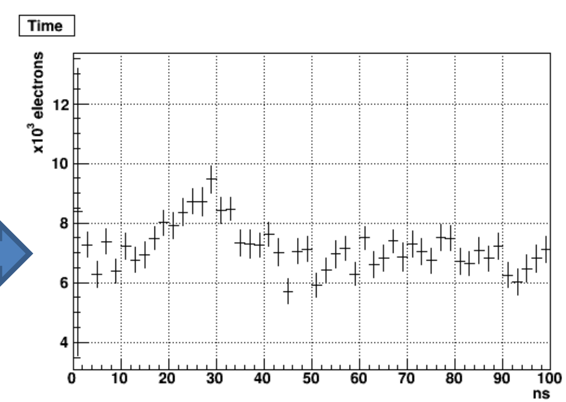
CCE measurements (revised)

(results already shown at the 15th RD50 workshop, some other detectors measured with the same setup shown for comparison)

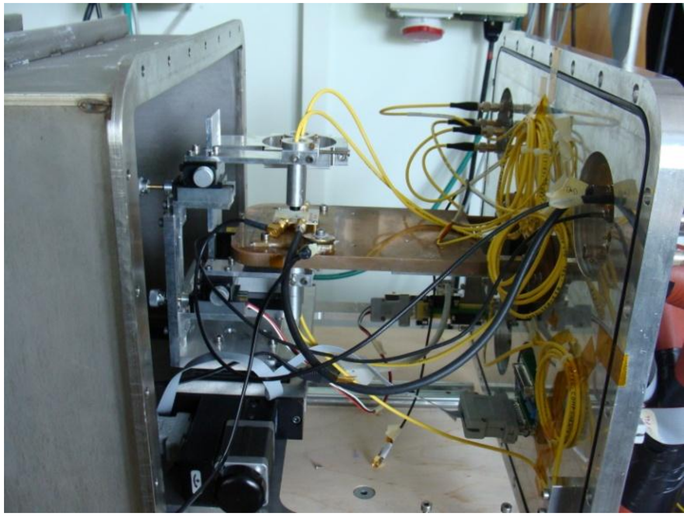


- Good charge collection efficiency for low resistivity MCz p-on-n
- Signal still visible and measurable after 3e15 n/cm^2
- It was not possible to measure other neutron fluences (1e14, 3e14, 8e15) and all the proton fluences due to the onset of huge microdischarges

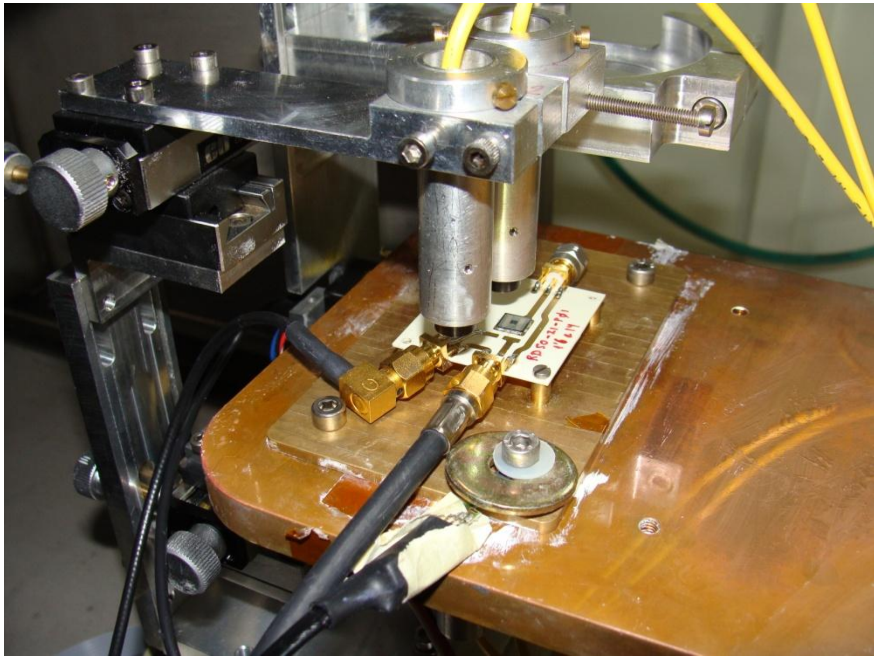
Problem previously attributed to Alibava (baseline shift in the signal at the point of "eating up" the signal) was finally correctly associated to the averaging on microdischarges!



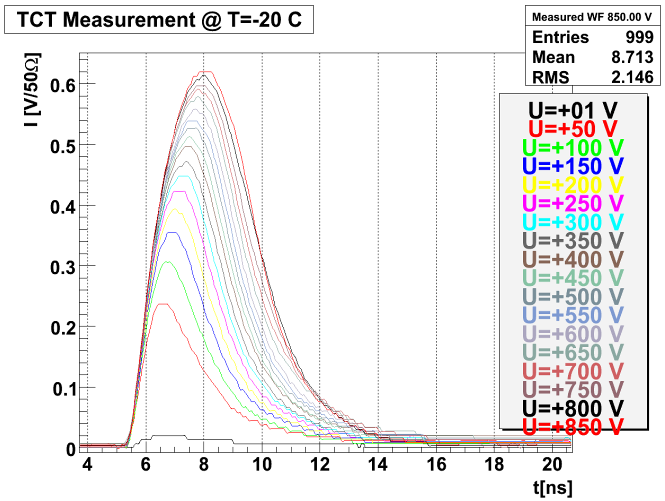
TCT setup



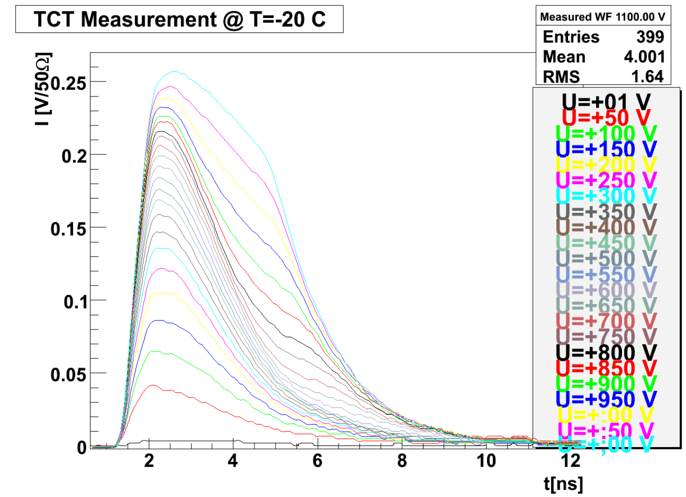
- Cooling to -20±0.5 C
- Red (665 nm) and Infrared (1060 nm) laser illumation
- FWHM pulse width 80 ps
- Miteq 1.5 GHz 44 dB low noise amplifier
- Agilent 2.5 GHz oscilloscope
- Detector bonded on thermally conductive PCB
- Front biasing, decoupling with 12 GHz BW Bias-Tee
- Laser delivery system with 4 focusers (front/back, red/IR)
- Humidity controlled: dry air atmosphere with dew point < -50C



Red TCT pulses – Neutrons (1/2)



1e14 n/cm^2



1e15 n/cm^2

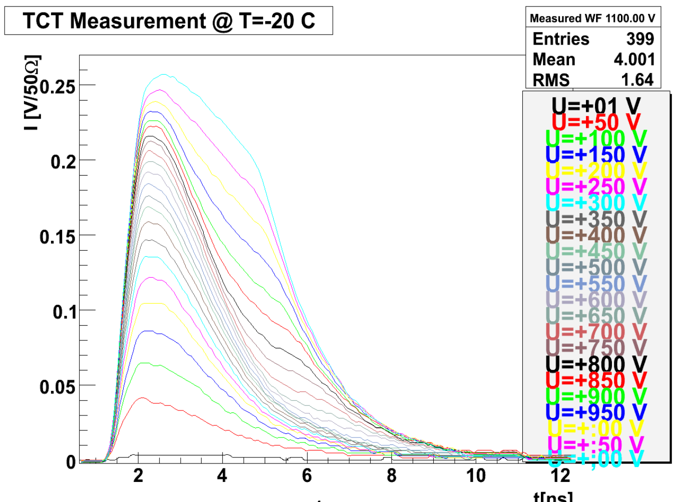
Major MDs issues @ > 850 V!

Maximum applicable voltage: 850 V
The peak is shifting in time with higher voltages – not due to plasma effects (tested at lower laser powers)

Double peak – Only fully depleted detector (see
In this case there is no peak shift with bias voltage, as well as no microdischarges. Is there any correlation?

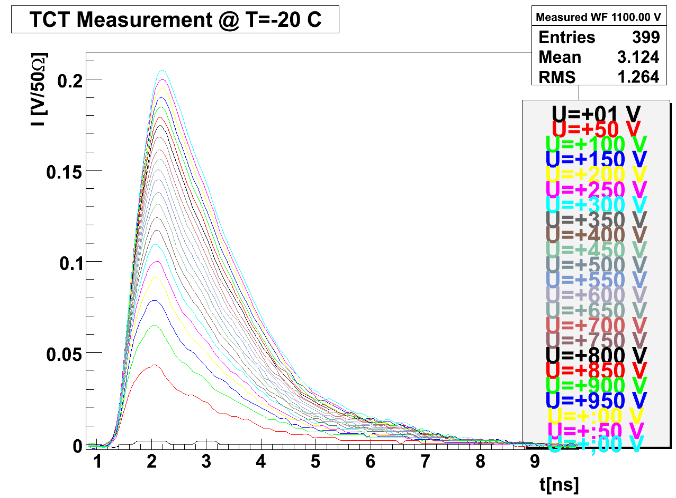
Extimated τeff,e=3.3 ns

Red TCT pulses – Neutrons (2/2)



3e15 n/cm^2

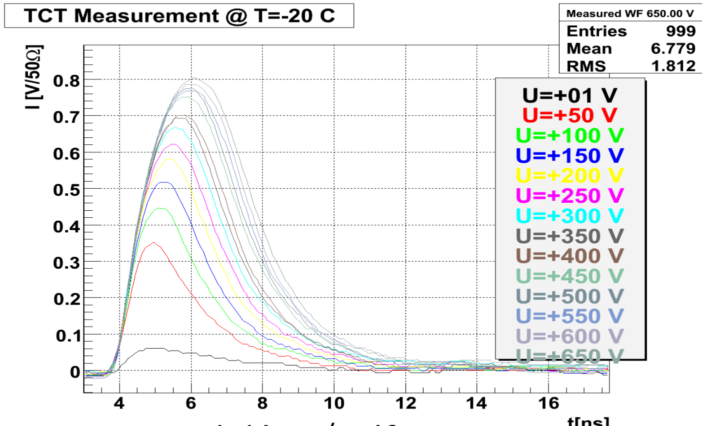
No microdischarge, double peak, still no peak shift



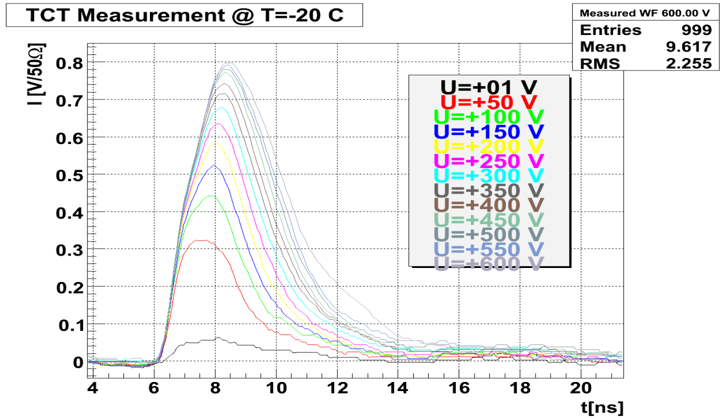
8e15 n/cm^2

Detector not fully depleted

Red TCT pulses – Protons



1e14 neq/cm^2

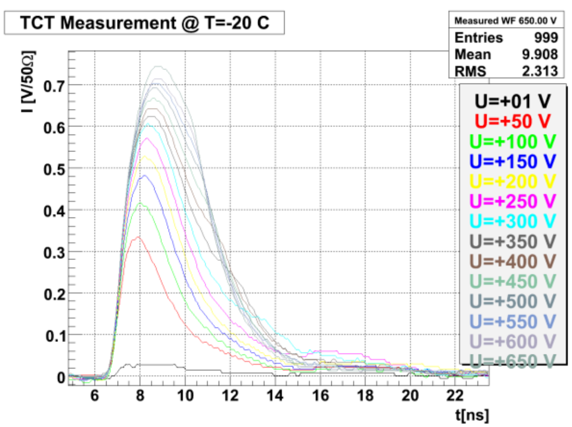


3e14 neq/cm^2

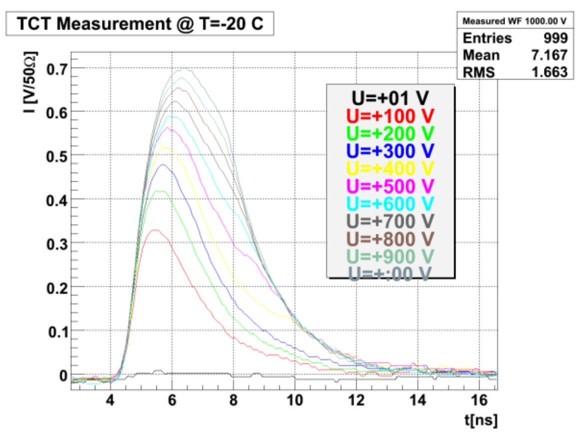
All measurements heavily affected by MD.

Most probable explanation arising to comparison with neutrons:

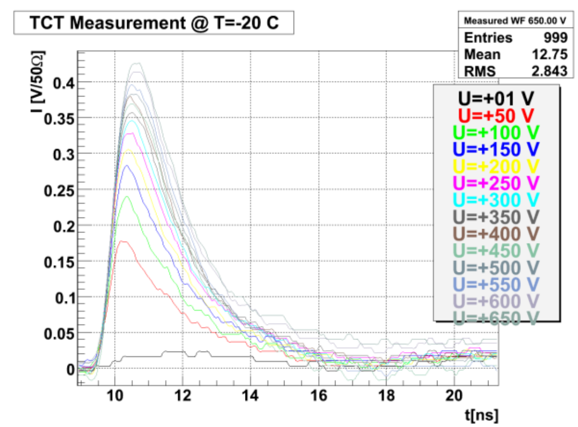
Very high Vdep-> Very high fields -> MD



5e14 neq/cm^2



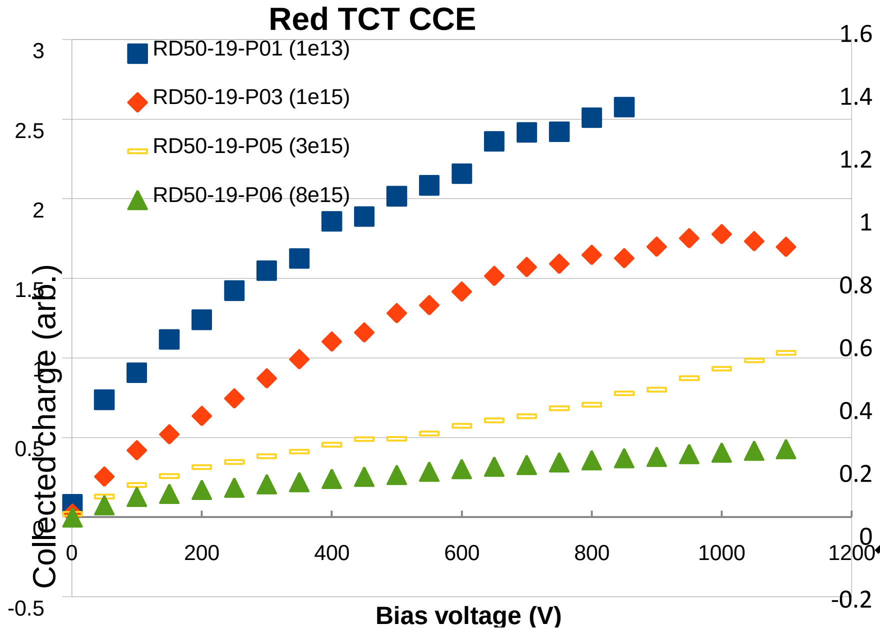
1e15 neq/cm^2

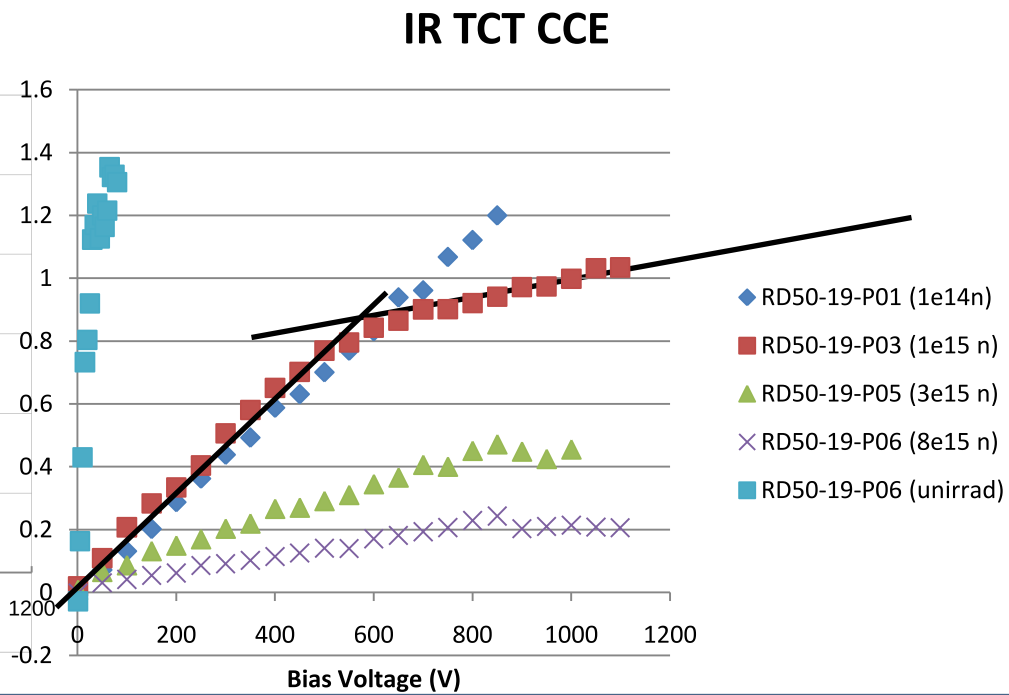


3e15 neq/cm^2

Laser CCE (neutrons)

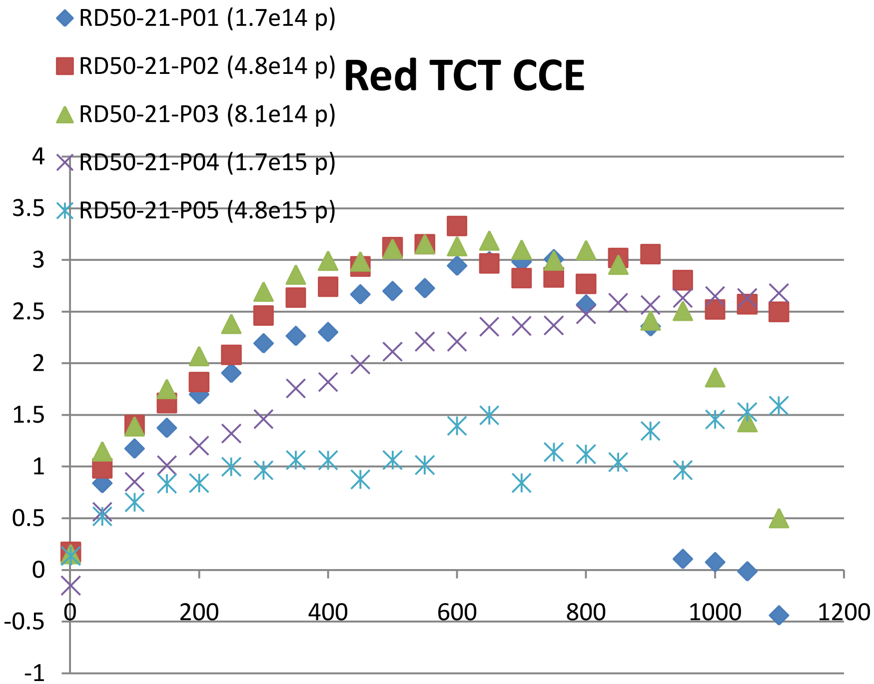
- CCE through TCT (both red and infrared) was performed on neutron irradiated samples (not possible on proton irradiated due to microdischarges)
- Calibration check of the laser was obtained by re-measuring the first diode of the set and verifying repeatedly that the height of the pulse was kept

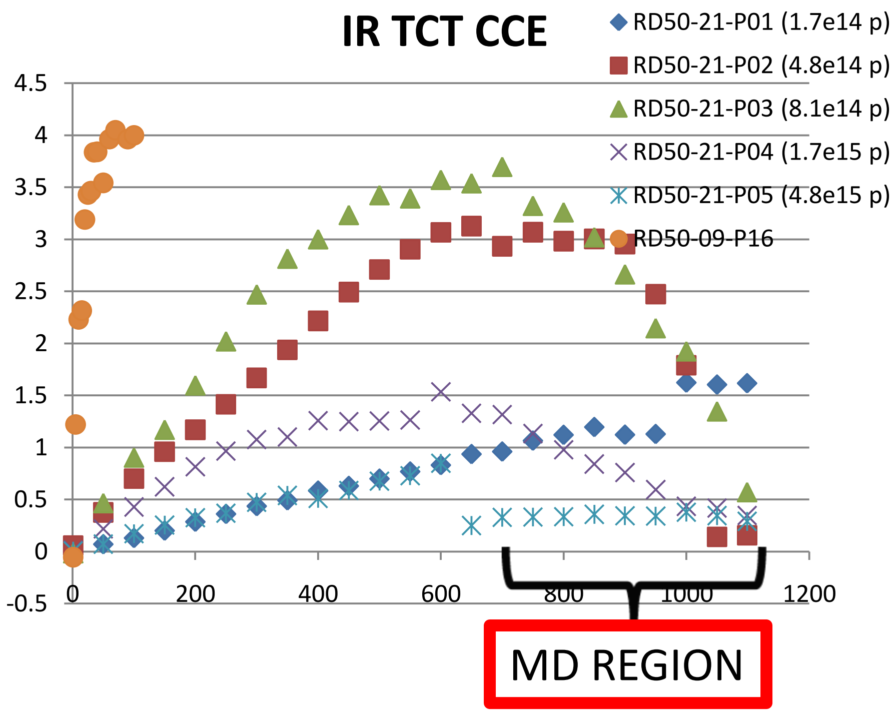




Laser CCE (protons)

- CCE through TCT (both red and infrared) was performed on neutron irradiated samples (not possible on proton irradiated due to microdischarges)
- Calibration of the laser was obtained by re-measuring the first diode of the set and verifying repeatedly that the height of the pulse was kept

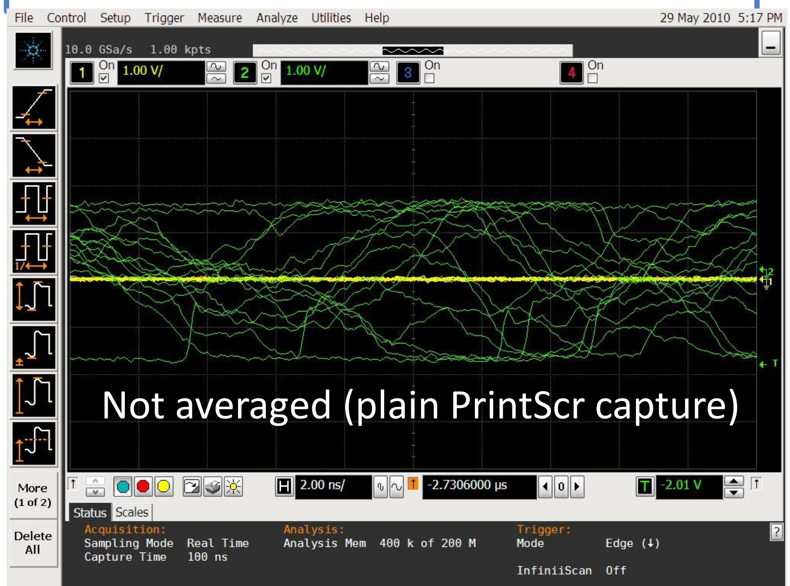




Microdischarges

Microdischarges were present to some extent in all the measured detectors (both strips and diodes), making some measurements impossible (i.e. most strip CCE's). The phenomenon was somehow correlated to high depletion voltages of the structures, getting less important at Vdep minima.

(Microdischarges in 1.7e14 p irradiated sample at 700 V)



Conclusions

- CCE and TCT measurements were performed on MCz-n low resistivity samples
- Charge collection efficiency properties were measured at 1e15 and 3e15 n/cm^2, showing good results (better than standard high resistivity FZ-n and MCz-n, almost comparable to p-type technologies @ 1e15.
- Measurements were affected in most cases by severe MDs inside the detectors, already observed on the same production batch in other materials (refer to U. Soldevila presentation – 14^{th} RD50 workshop) - processing issues?
- Apparently irradiation with neutrons at fluences of 1e15 and 3e15 improved the situation -> Are the MDs correlated to the radiation-induced increase in resistivity?