Position sensitive TCT studies of irradiated 3D sct sensors

(preliminary results)

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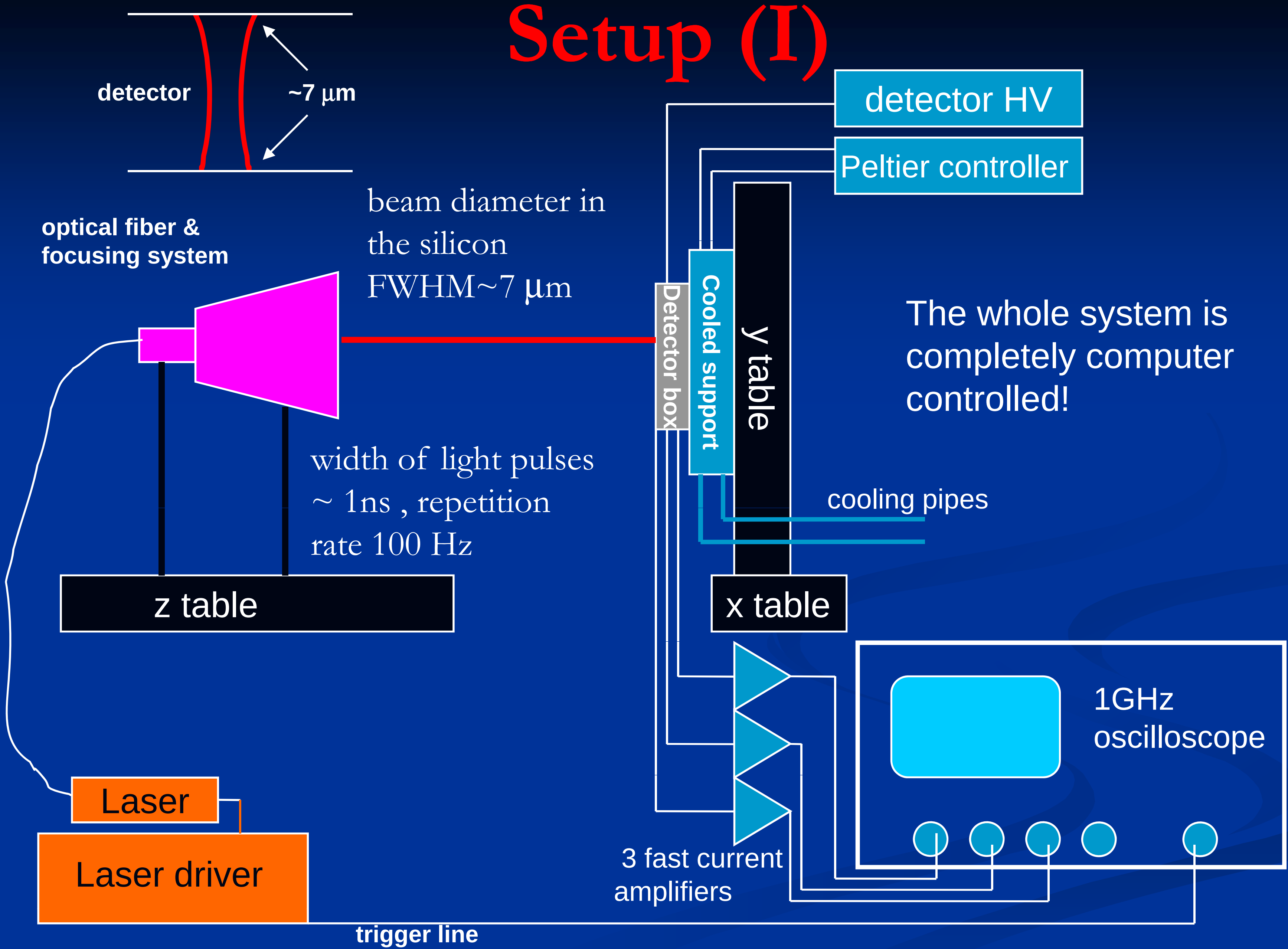
Motivation

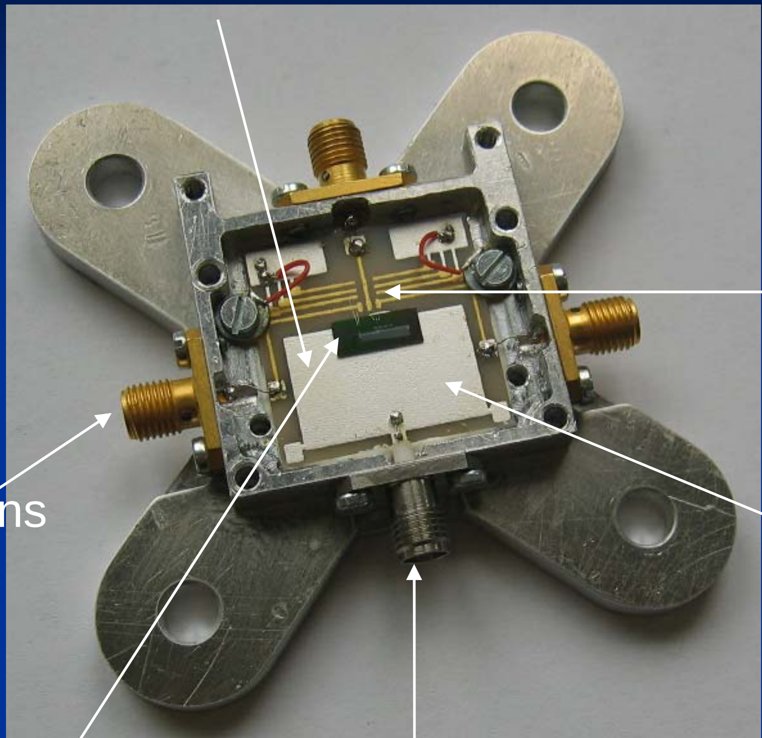
- Are the 3D-sct radiation hard?
  - According to simulations no!
  - How the charge collection depends on bias?
  - How is charge shared over the columns?
  - How homogeneus is the response over the detector?
- Get experience to routinly operate the setup …

Setup (I)



The whole system is completely computer controlled!

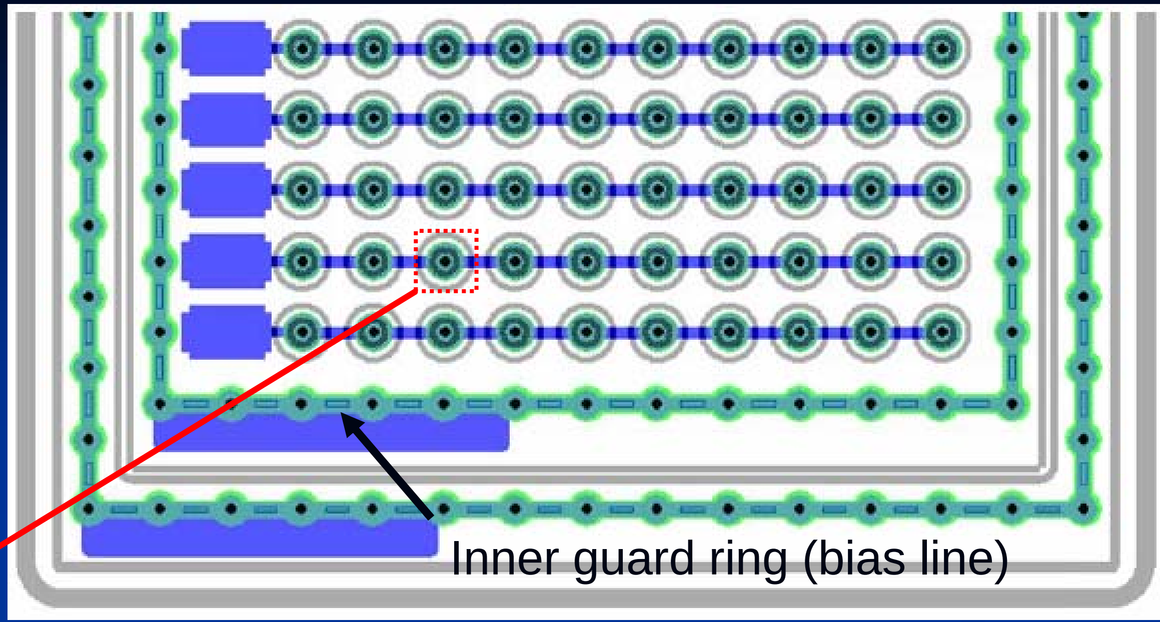
Setup (II)

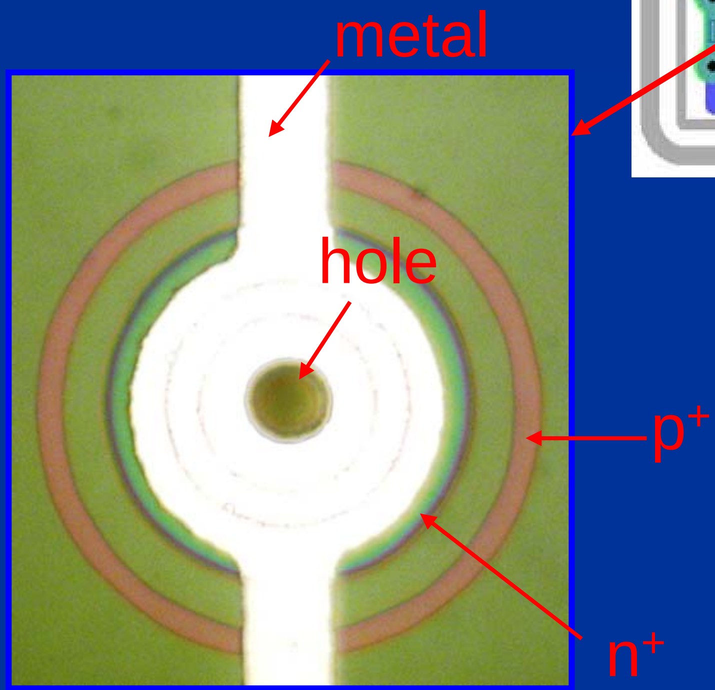


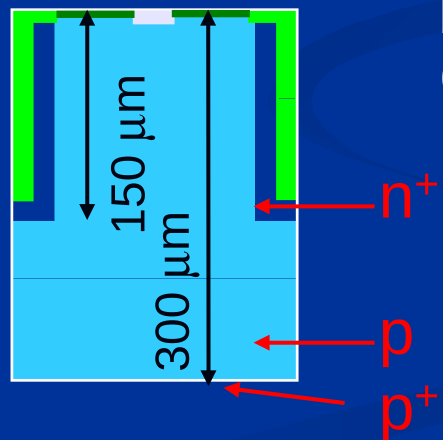
- scanning steps used: 2.5x2.5 μm
- the light intensity is reproducible to better than 20% between different measurements
- operation T=10^{o}C
- IR laser used

Samples

3D-stc DC coupled detector
(64 x 10 columns)
80 μm pitch
80 μm between holes
10 μm hole diameter

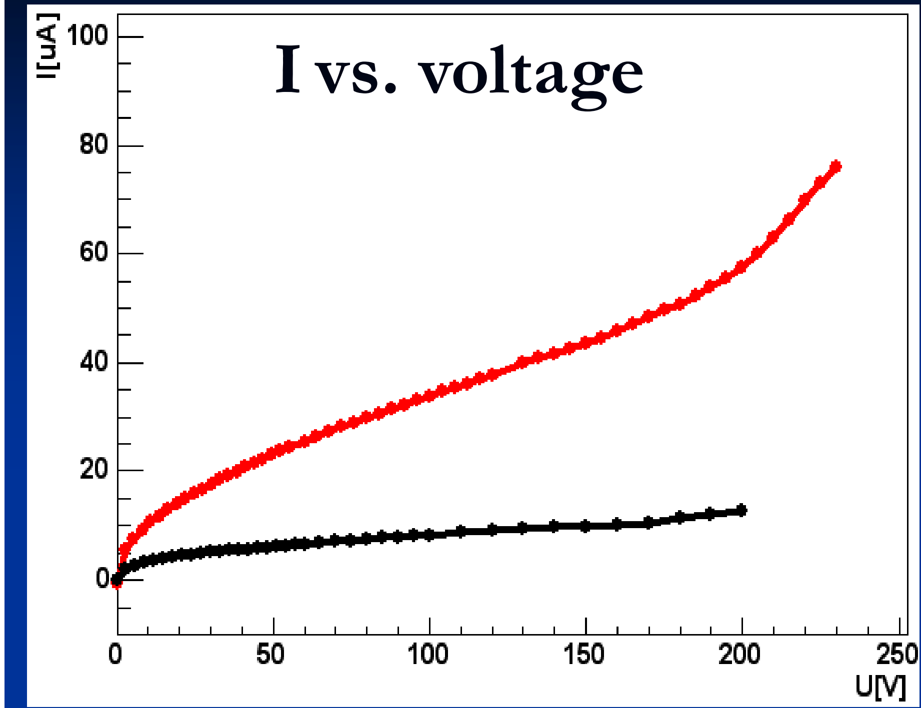


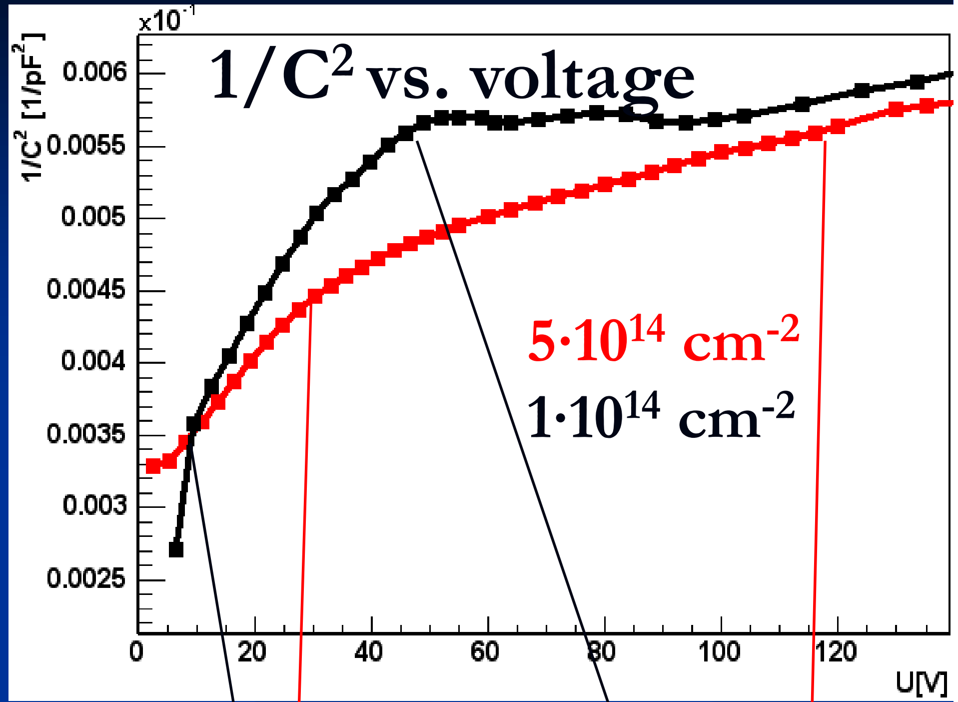


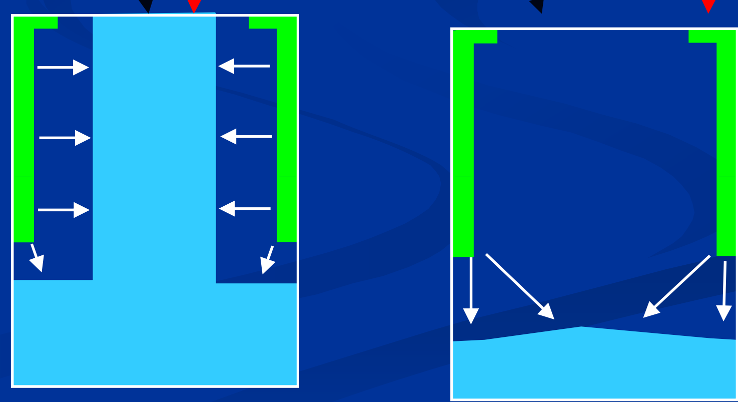


•3 adjacent channels were bonded to the electronics (impact on weighting field)

CV and IV







The voltages chosen in the TCT studies up to 200V

- 1st kink in CV is lateral depletion
- 2nd kink in the CV when V_{fd} is reached

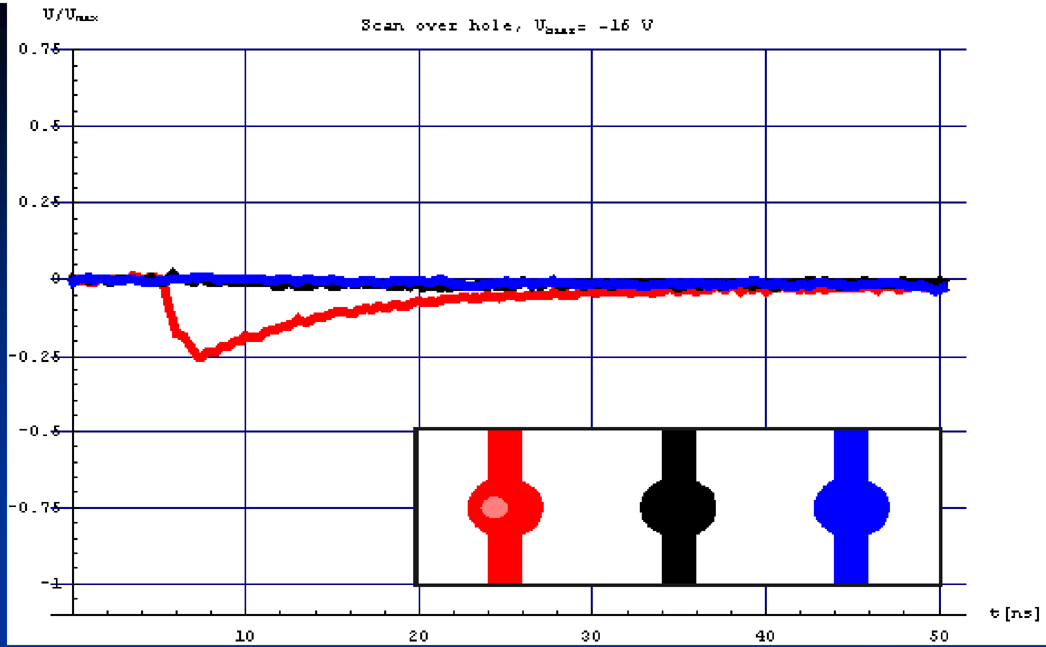
Not-irradiated: U_1~10V, U_2>50V
Φ_{eq}=10^{14} n cm^{-2} : U_1~10V, U_2=50V
Φ_{eq}=5·10^{14} n cm^{-2} : U_1~40V, U_2~200V

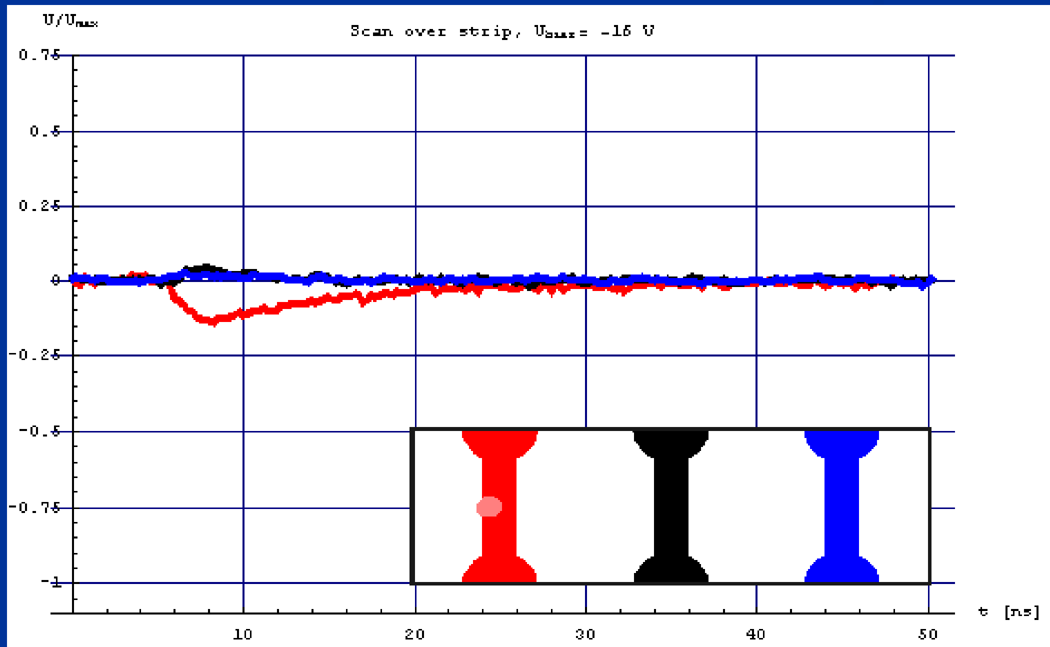
Induced current (I)

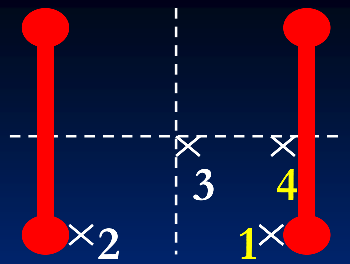
•U=16 V>lateral depletion voltage
•All 3 channels are shown (colors)

Note:
•Much larger signal induced on neighbors than in planar detectors
•Unlike in the planar detectors the position of the highest induced current varies with impact position (for few ns)
•Long tail due to slow drift of holes towards the backplane

•Slight difference between side strips and central strip is caused by the different weighting field (other strips are not bonded)

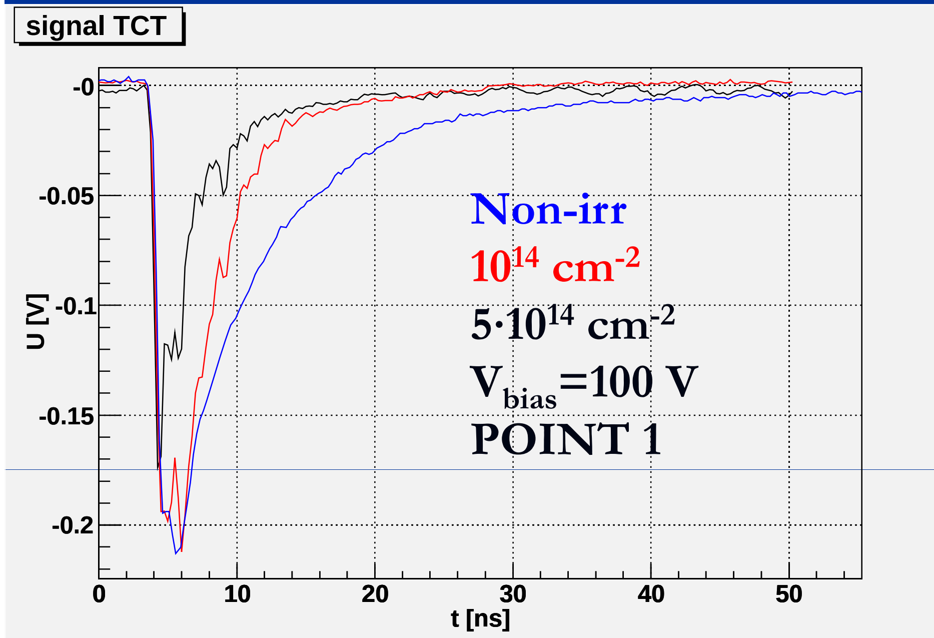


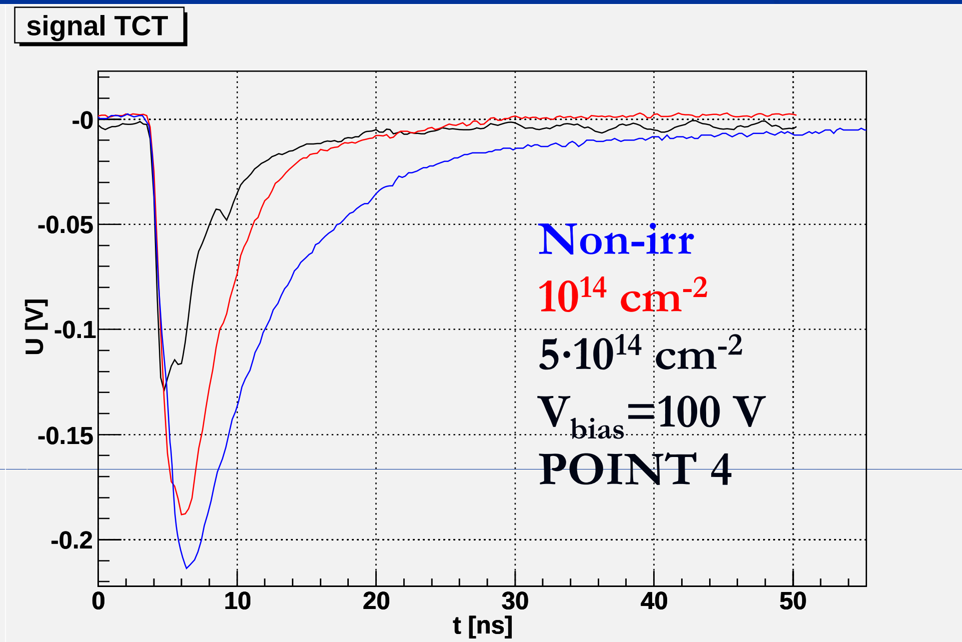


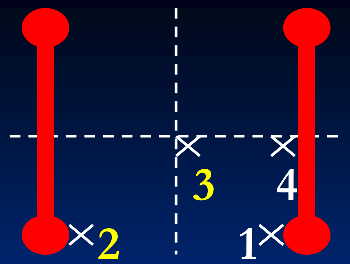


Signals (different Φ_{eq} at 100 V)

- (1) significant decrease of the signal trapping:
  - similar amplitude (coming from electron drift)
  - much smaller tail (coming from hole drift)
- (4) similar signal shapes as for (1), but somewhat different amplitudes
- not fully depleted detector for high fluence



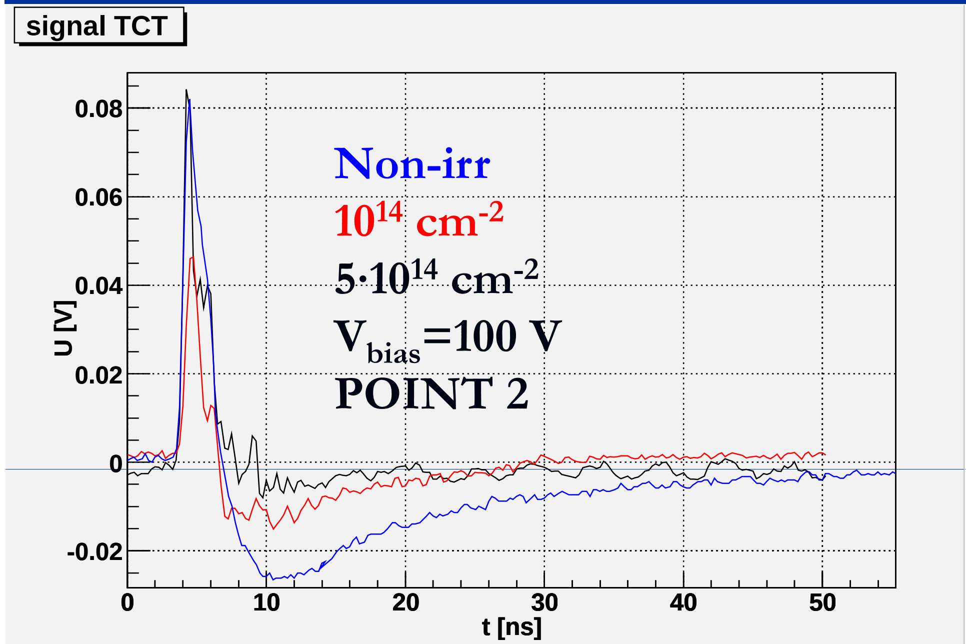


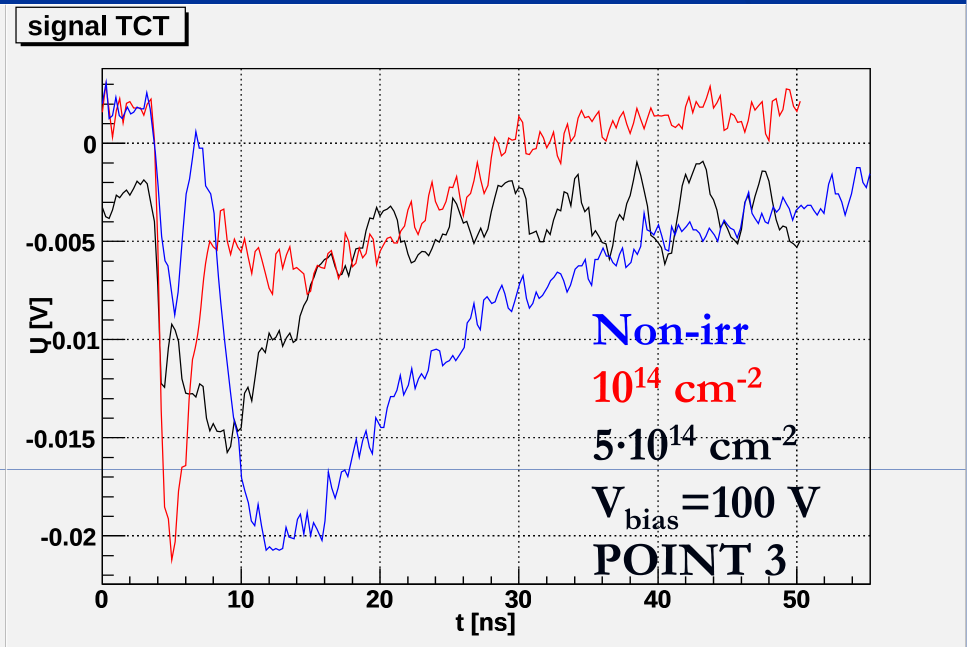


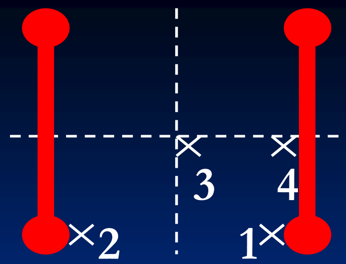
Signals (different Φ_{eq} at 100 V)

(2) first part due to electron drift + hole drift to the electrode (opposite sign) and than long tail (same sign) due to drift of holes in the mid-strip plane – large decrease of the signal

- (3) broad signal (small) – one can separate electrons from holes
- (3) at high fluence the picture is less clear due to small signal

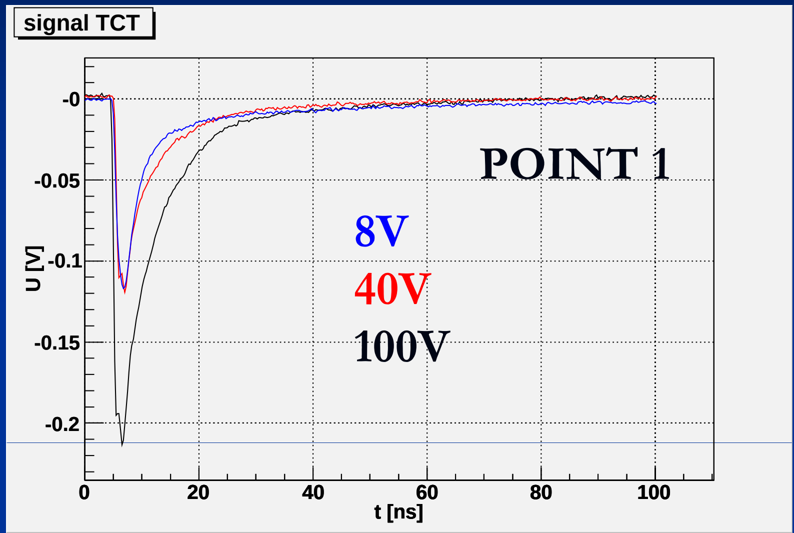


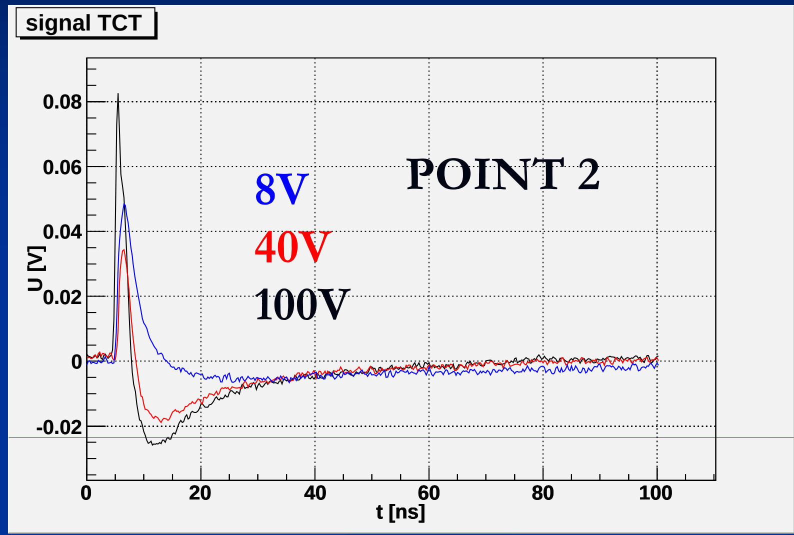


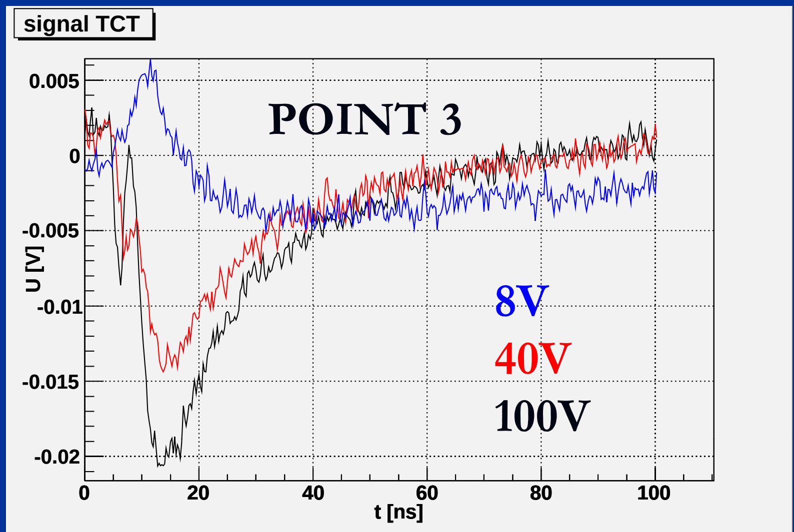


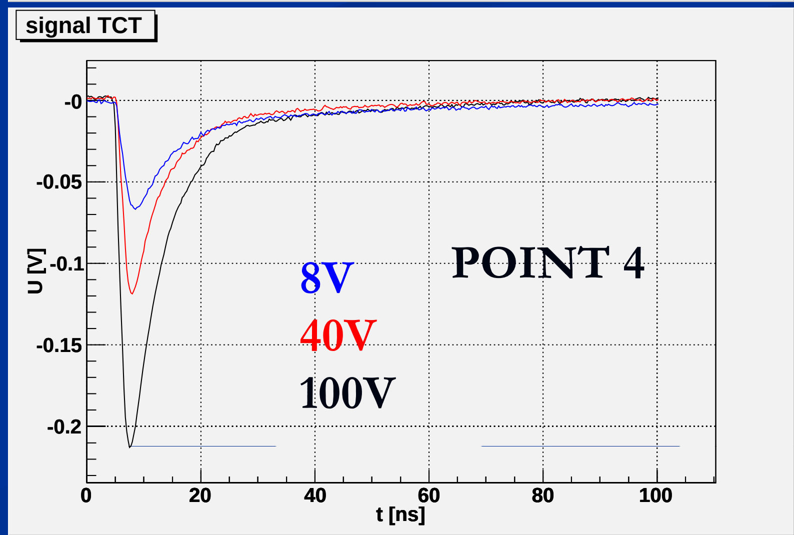
Signals (same Φ_{eq}=nirr.)

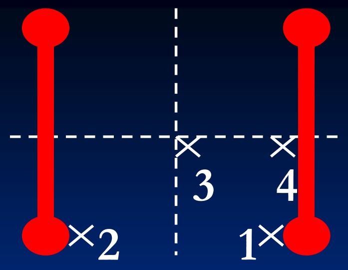
- not fully depleted at 8 V (P1,P4)
- same signal for 40 V (P1,P4) – depleted detector in the intercolumn region





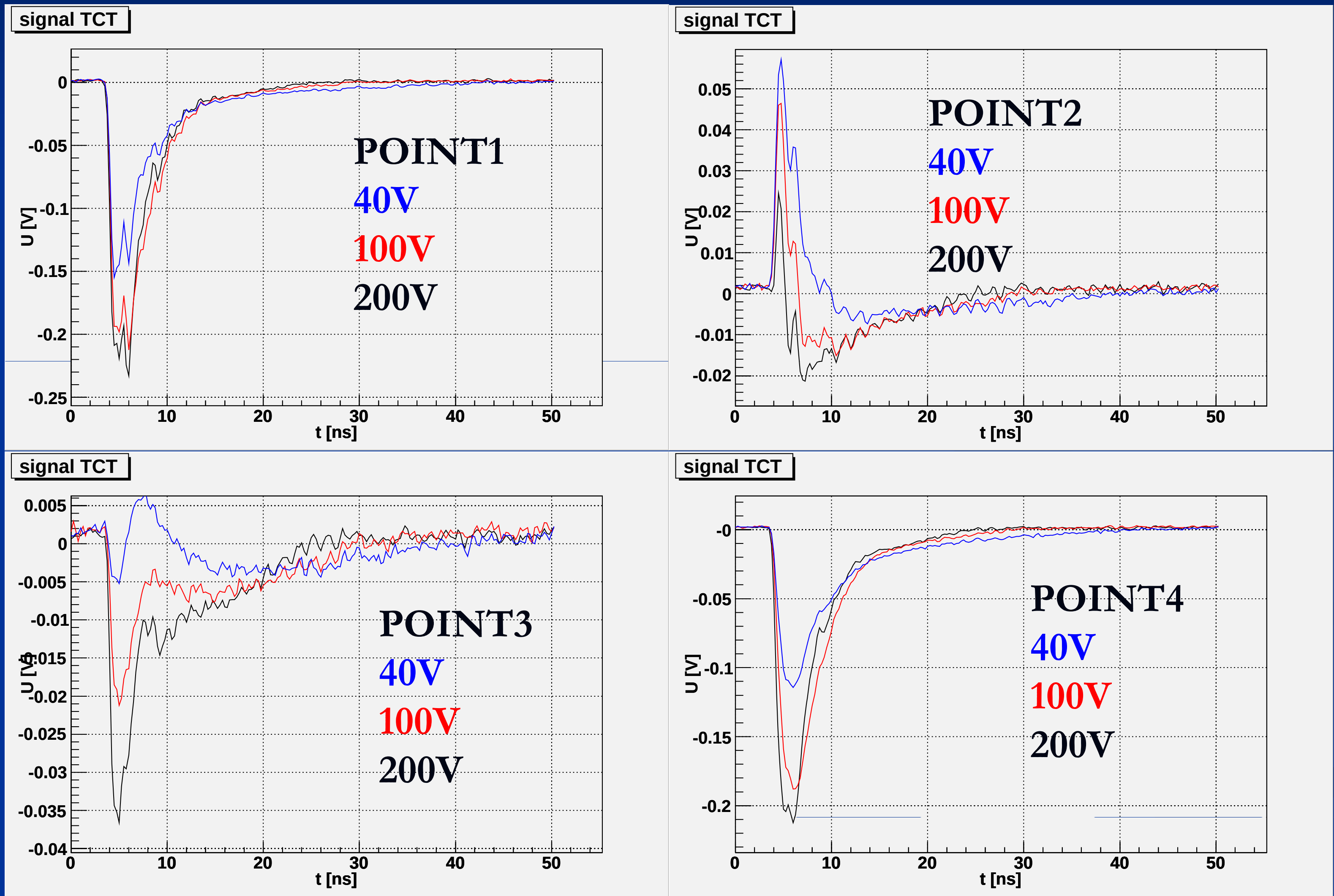


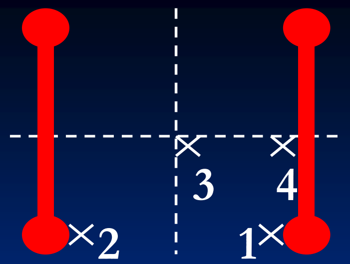




Signals (same $\Phi_{eq}=10^{14}$ cm^{-2})

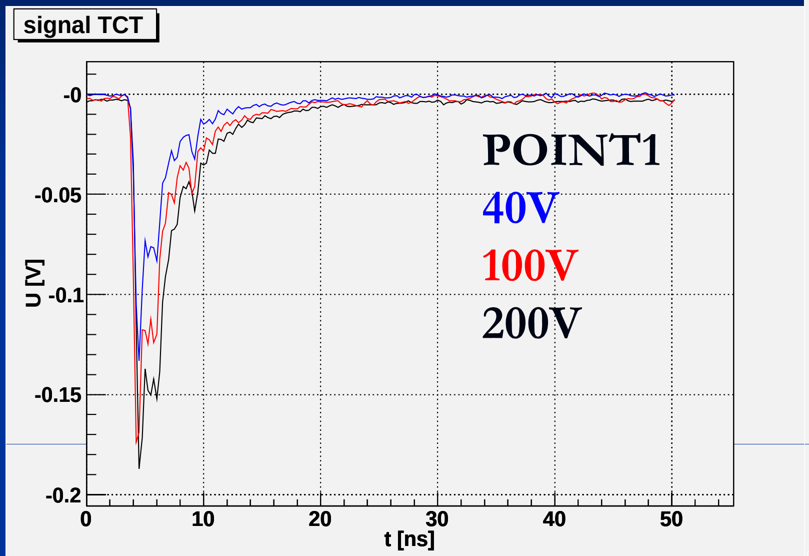
- 40 V is not enough to fully deplete the sensor
- 100 V and 200 V are identical except POINT3 (mid-region)
- Tail in POINT2 is reduced

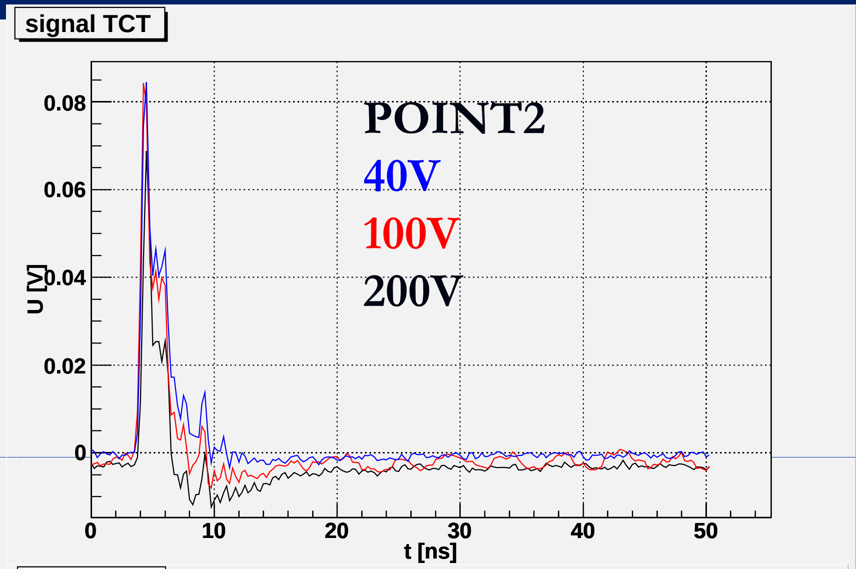


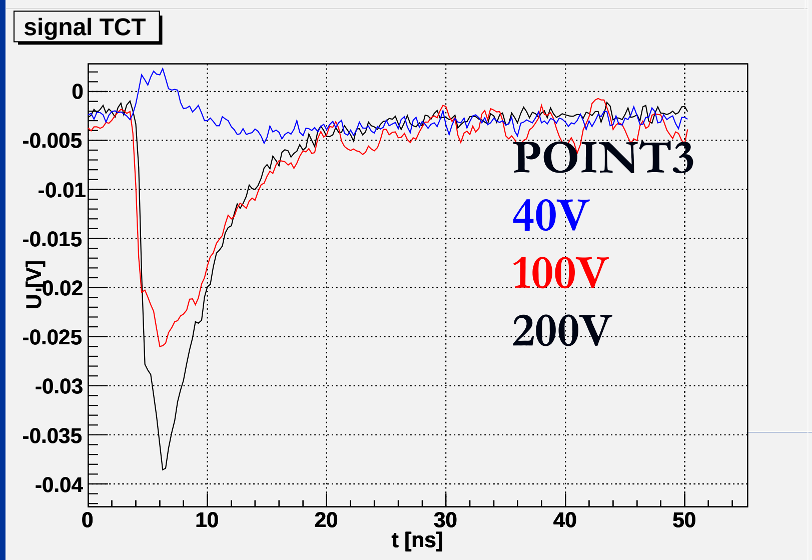


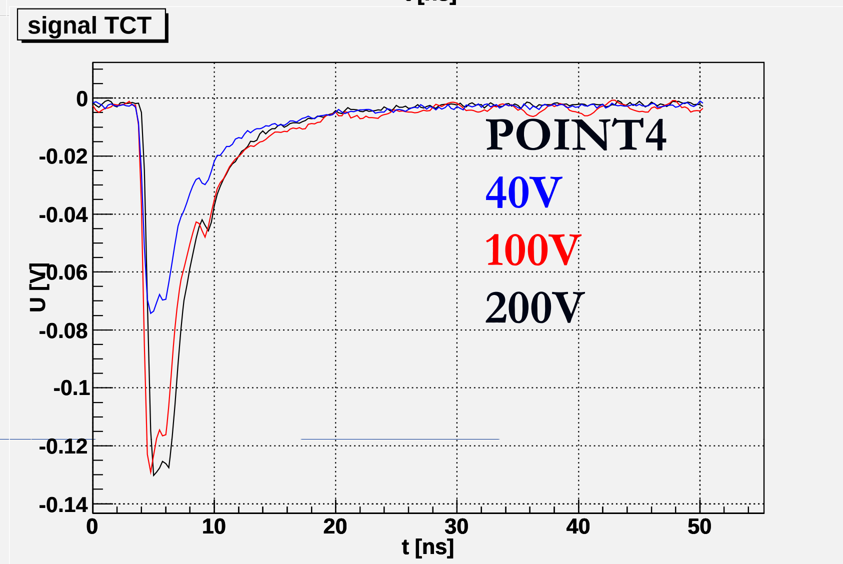
Singals (same $\Phi_{eq}=5\cdot10^{14}$ cm^{-2})

- 100 V and 200 V have same shapes with slightly lower signal for 100V
- Almost no tail in POINT2







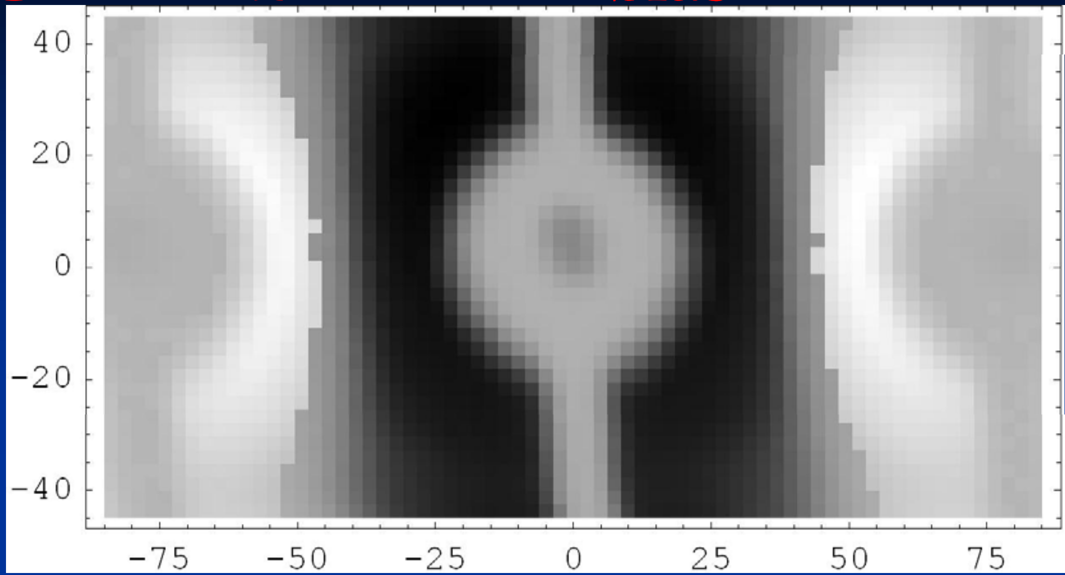


Signal speed (V_{bias}=100 V)

black ↑ 1 (arb.)

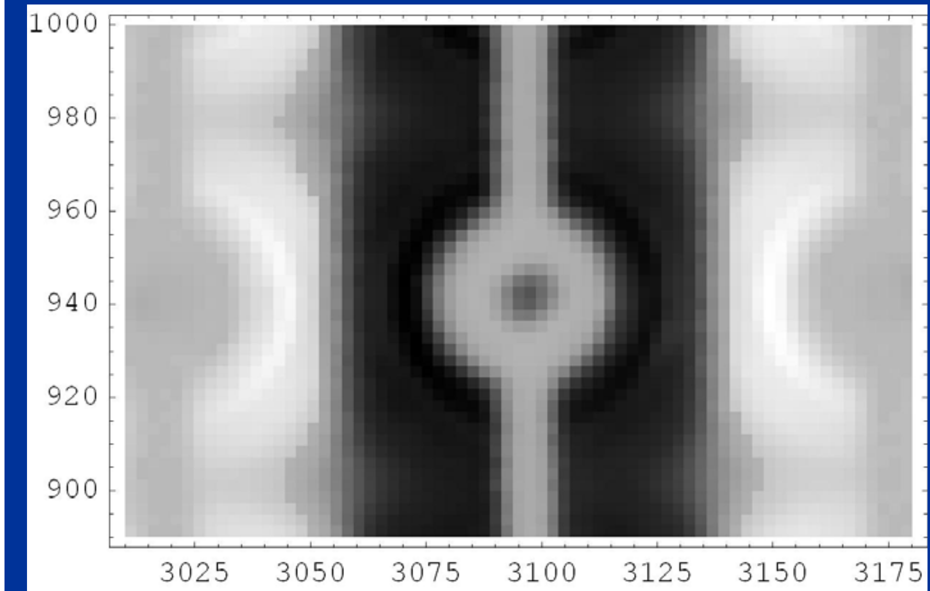
gray 0

white ↓ -1

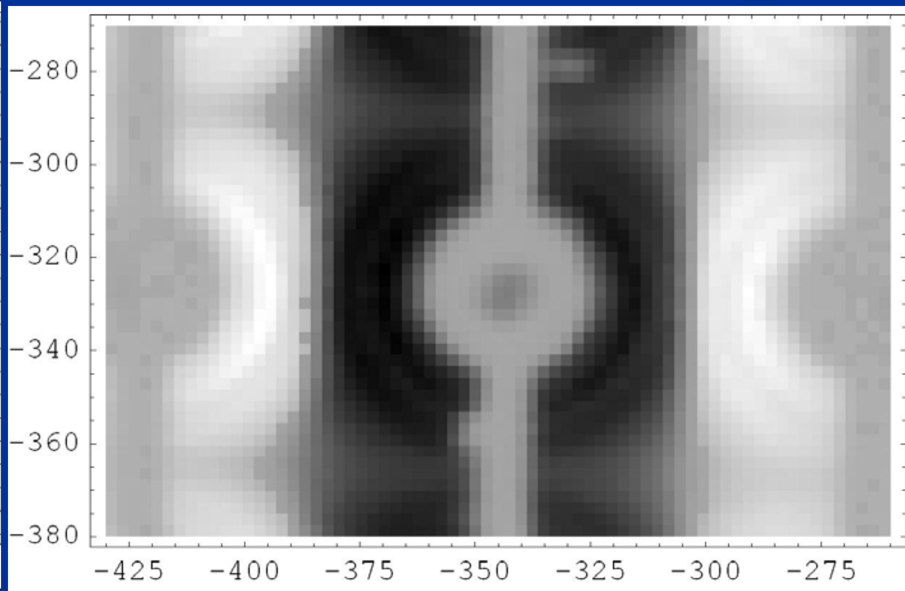


Φ_{eq}=nirr.

- Induced current peak is shown for the region of 2 cells!
- Signal for the center strip
- Plots normalized to +/-1 for each fluence separately, but comparable



$\Phi_{eq}=10^{14}$ cm^{-2}



$\Phi_{eq}=5\cdot10^{14}$ cm^{-2}

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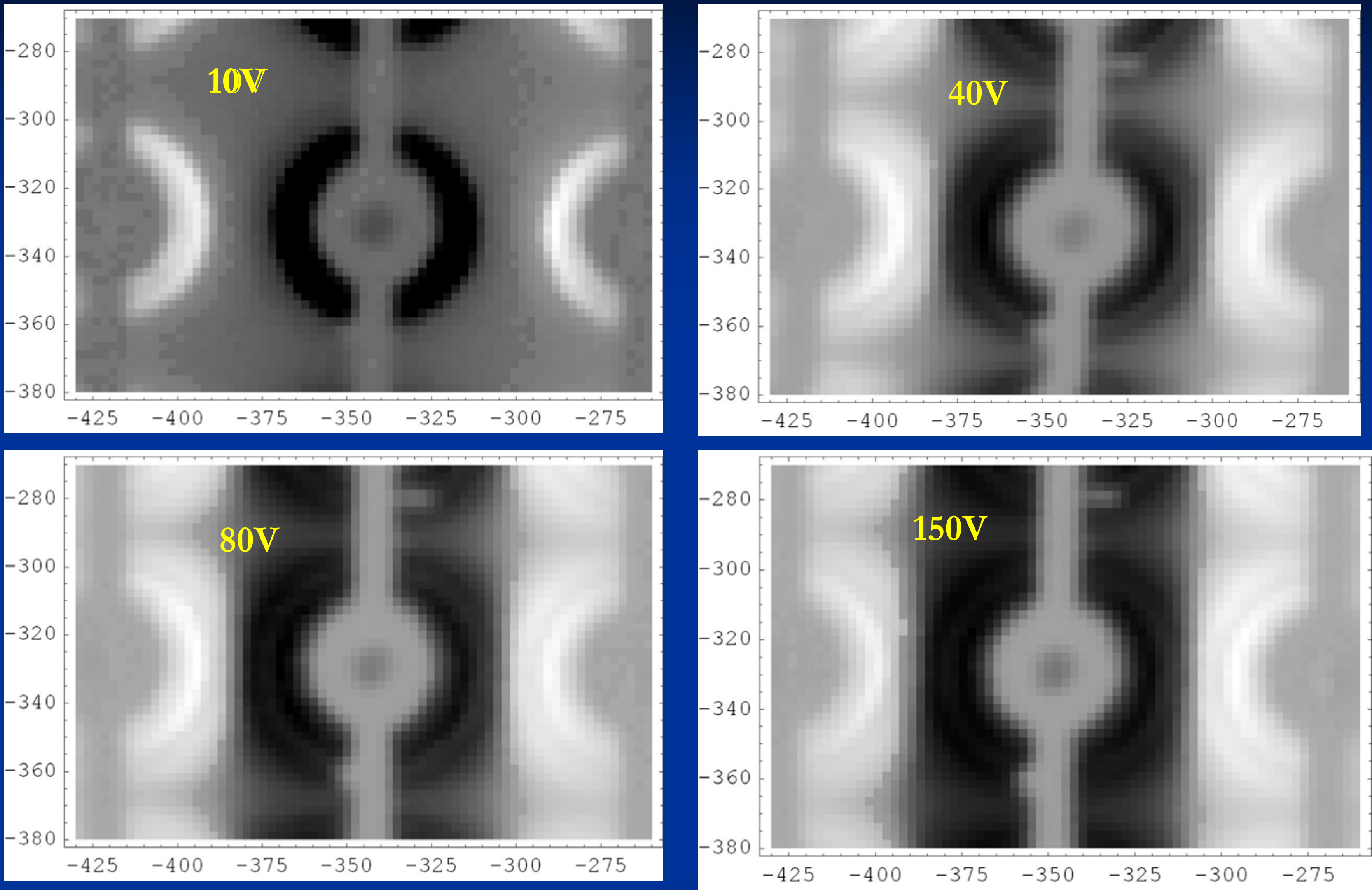
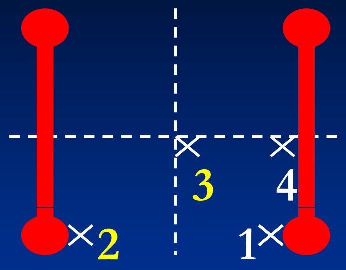
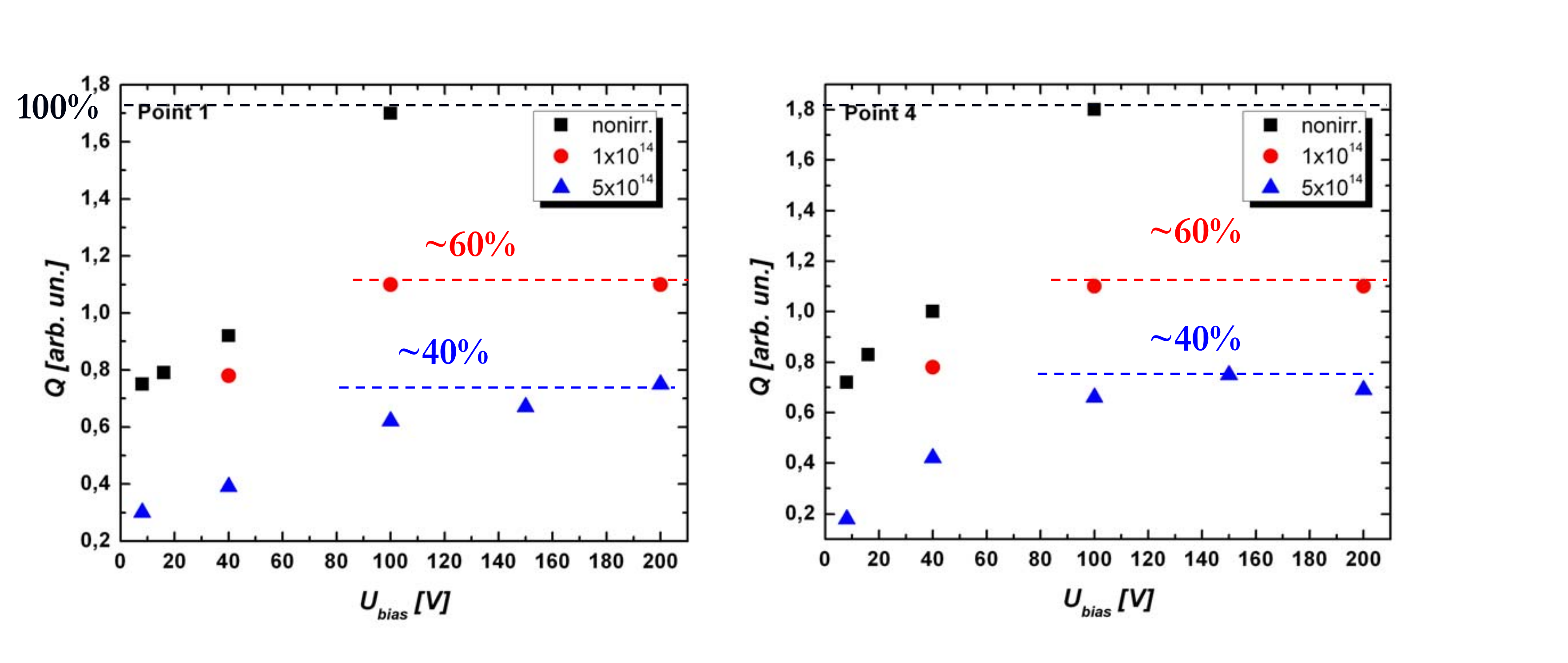
Signal speed ($\Phi_{eq}=5\cdot10^{14}\ cm^{-2}$)



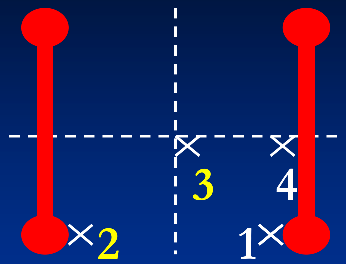
CCE (point 1,4)



- Q is the transient current integral in 25 ns!
- Significant loss of CCE also for P1 and P4 due to long drift of holes (ballistic deficit + hole trapping)
- Similar performance at P1 and P4

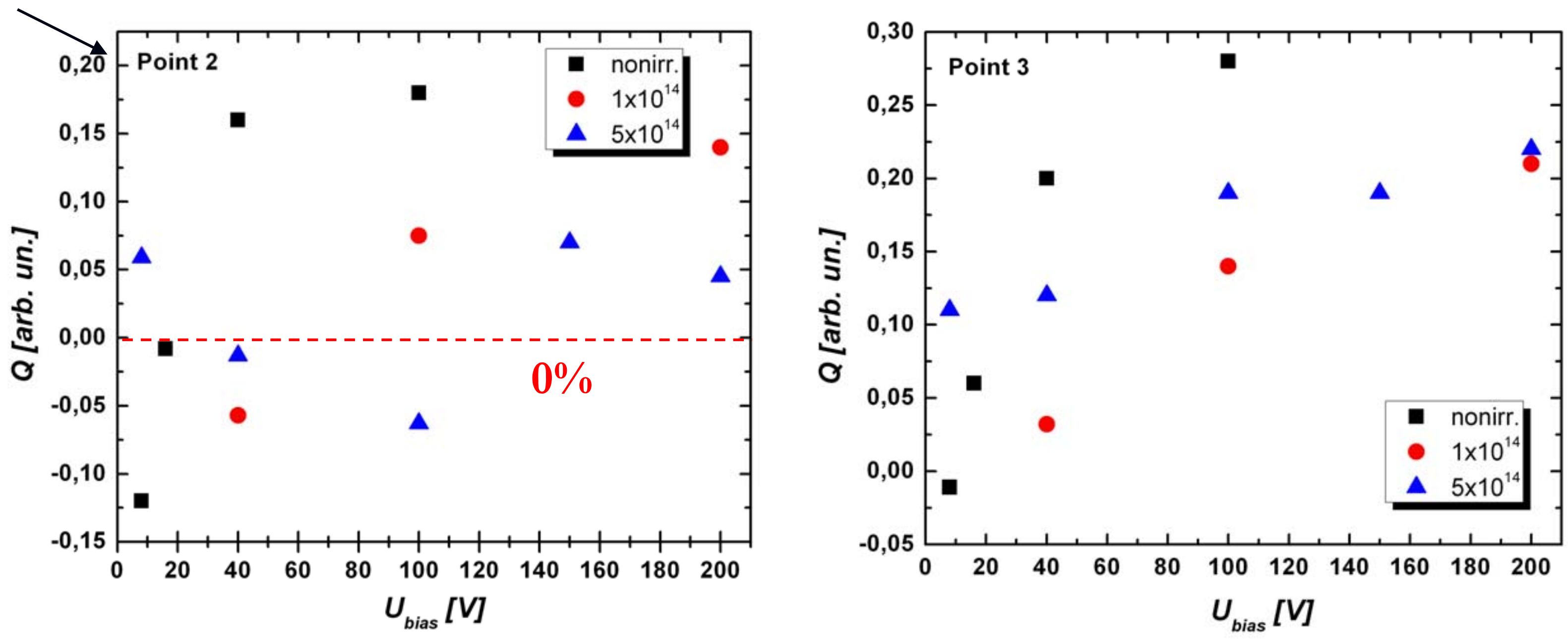


CCE (point 2,3)



- Significant loss of charge collection in the mid-strip region P3
- Significant charge sharing (of order of 10% for hits P2)
- Bias voltage helps to increase the charge (25 ns integration) P3
- In the mid-region (P3) the CCE is very poor

10% of the charge – ballistic deficit



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Conclusions

- As predicted (by designers) 3D-sct are not suitable for fast charge collection (25 ns) of irradiated sensors:
  - Ballistic deficit (slow hole drift)
  - Trapping of holes
- Very non-homogenous response (as expected) of the detector: the saddle in the E-field (mid-region), trapping effects

- The setup is working and can be used for all sorts of samples (2D, 3D) !

Looking forward to see the 3D-dct detectors!