Position Sensitive TCT Measurements with 3D-stc detectors

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Motivation

TCT is a widely used to study pad detectors:
☺good signal to noise – fast current amplifiers (large signals, averaging)
☺not only charge, but also induced current pulses are measured
☺possibility to study motion of electrons and holes separately, emulation of m.i.p.

But studies of segmented devices require good position resolution of deposited charge (homogeneity of charge collection, charge sharing, CCE)
Test beam
☺minimum ionizing particles (known amount of generated charge)
☺use of telescope
☺multi-channel readout (although “only” charge sensitive)

We need best from both techniques!

Position sensitive multi channel TCT

Experimental Setup (I)

Key features of the setup:

•3 independent channels – fast current amplifiers 0.001MHz-2GHz
(study of charge sharing)

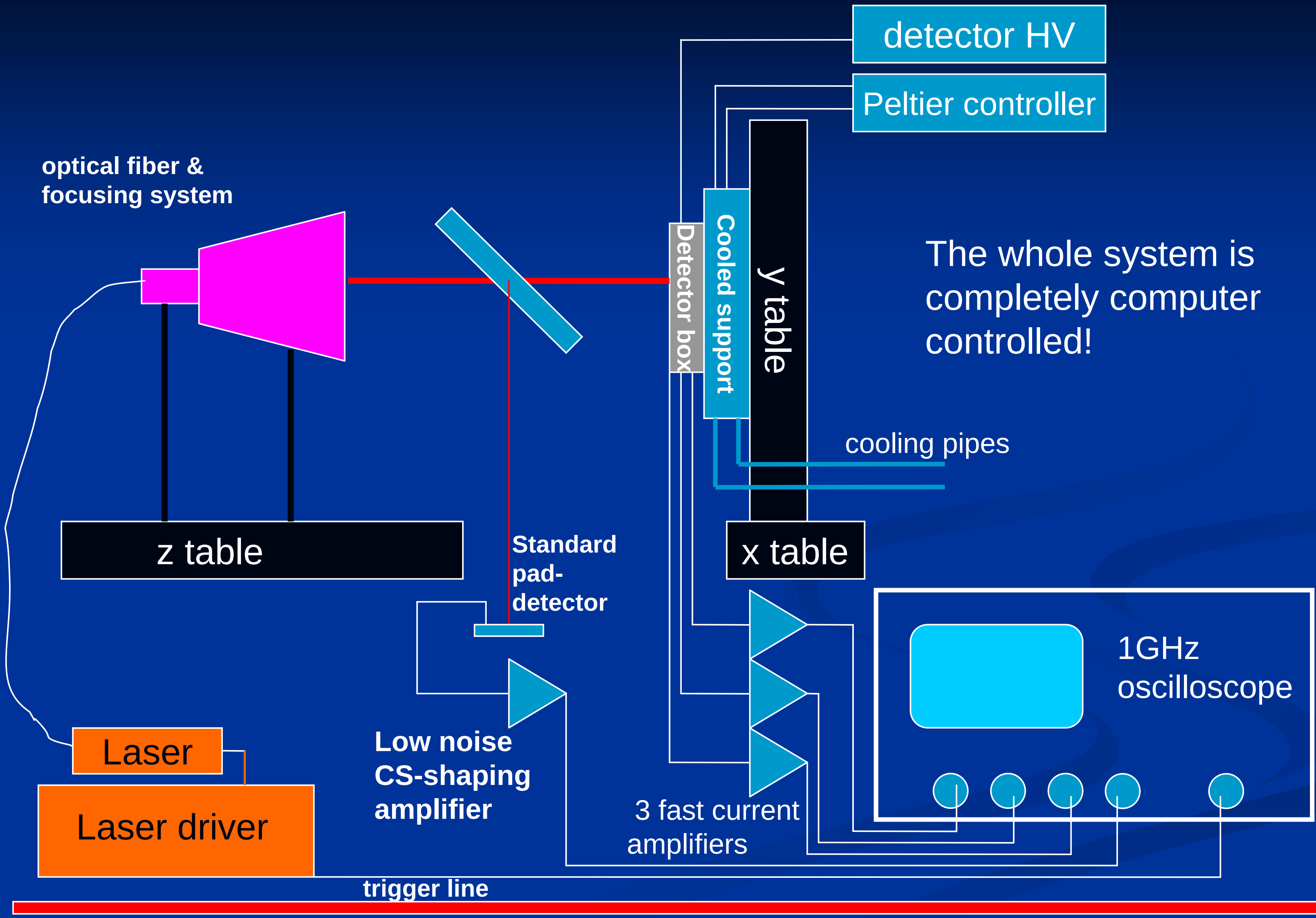
•Beam dimensions:
- •Red laser (small penetration depth) – spot diameter few μm
- •IR laser (m.i.p. simulation) – beam diameter in the silicon FWHM~7 μm

•Width of light pulses ~ 1ns , repetition rate 100 Hz
•Good time stability

•Large scanning range (few cm x cm) with submicron movement precision
•Peltier cooling (temperature controlled)
•Detectors mounted on printed AlN hybrid allowing complex electrode configuration of position sensitive detector and assuring good thermal conductivity

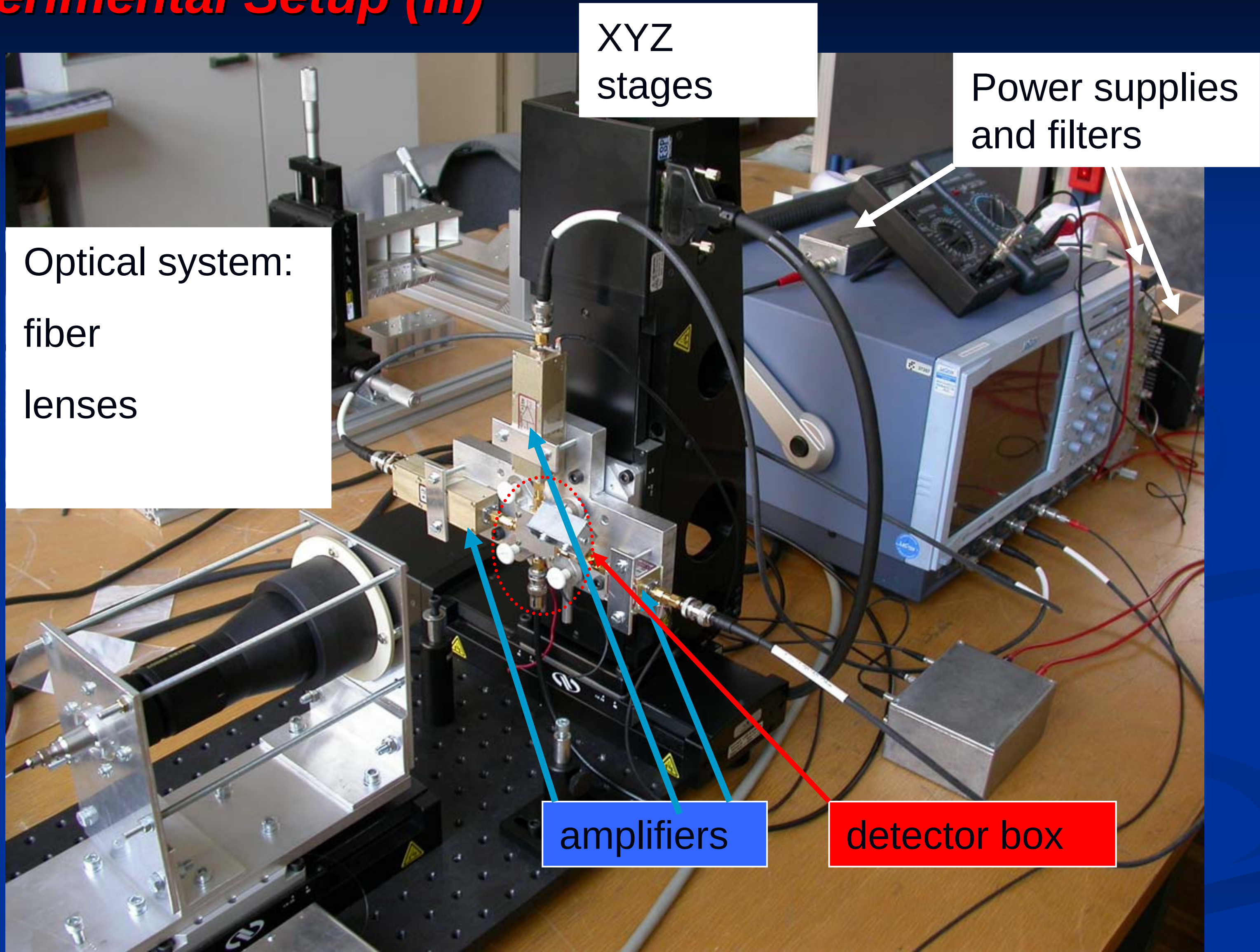
Easy mounting of detectors and possibility of performing fast and automatic tests!

Experimental Setup (II)

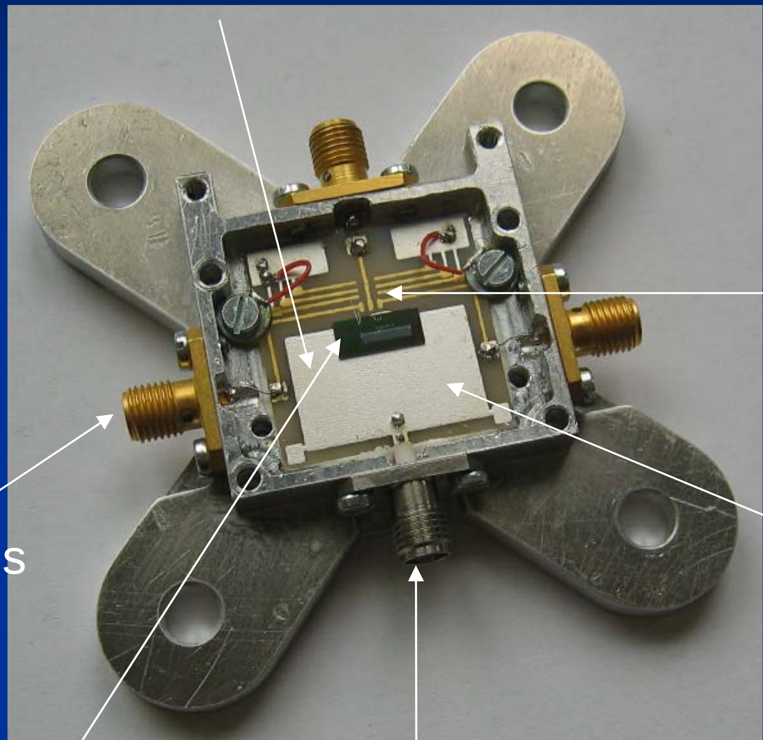


The whole system is completely computer controlled!

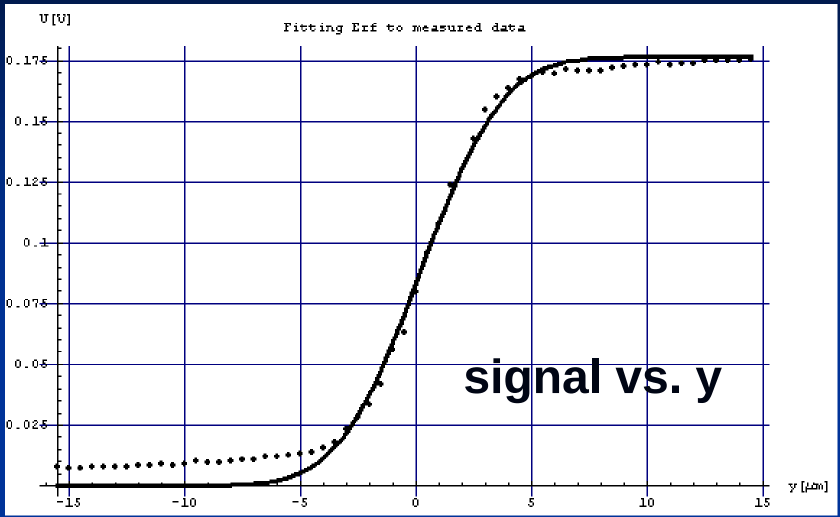
Experimental Setup (III)

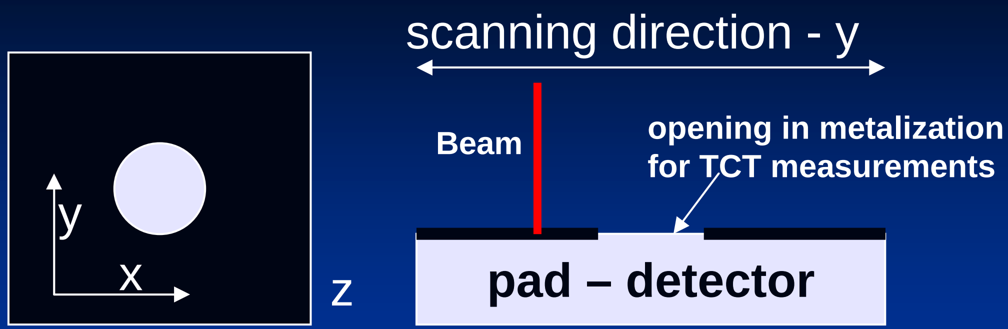


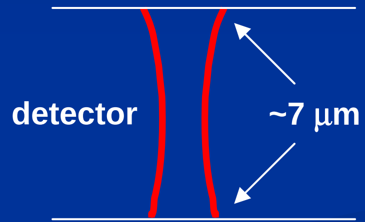
Experimental Setup (III)

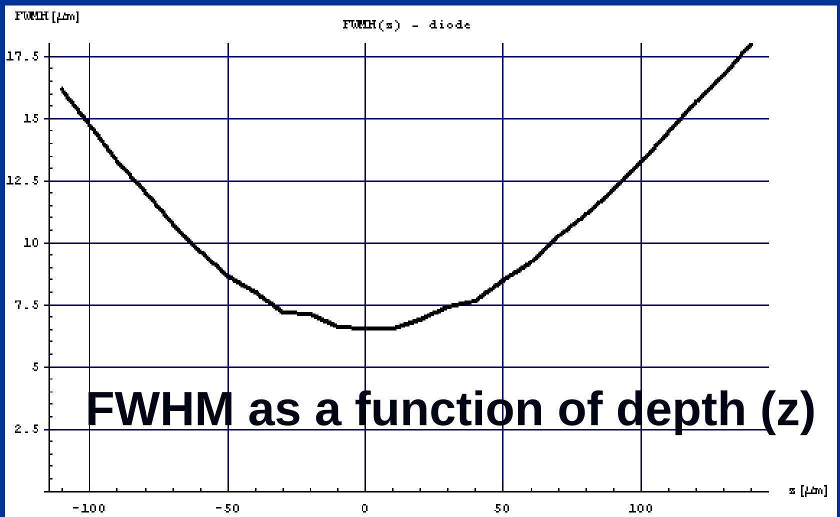


Experimental Setup (IV)





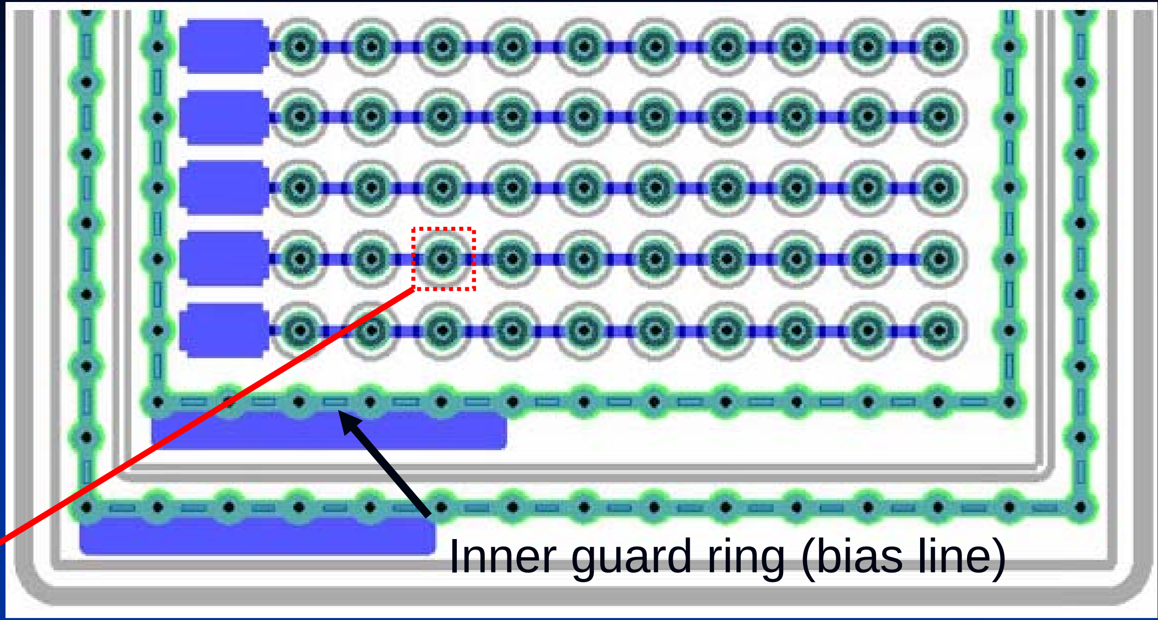


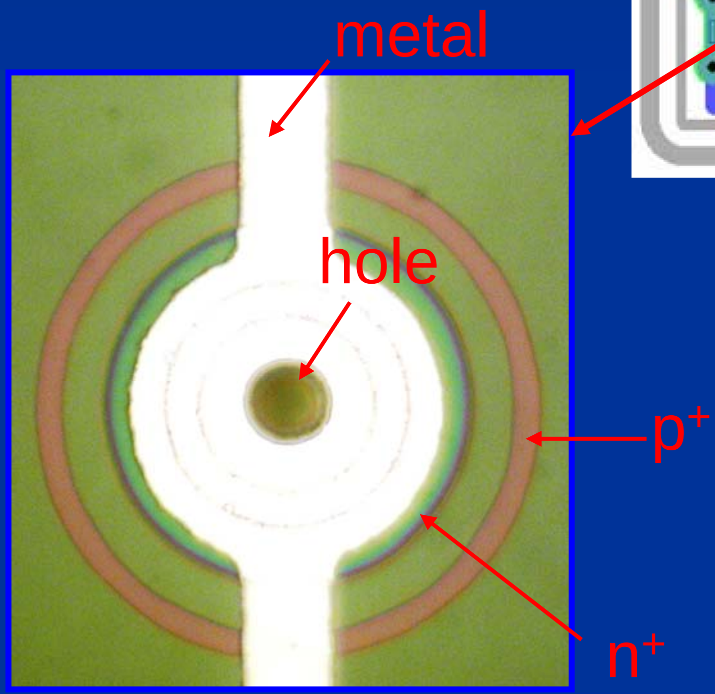


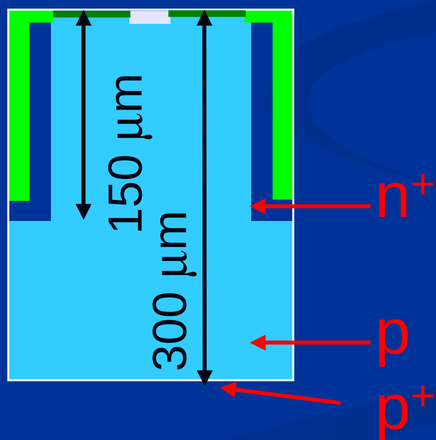
- FWHM obtained from fitting the error function to induced current peak
- The minimum FWHM is around 6 µm
- Beam has a circular shape (same results for x and y)
- For each detector the minimum can be (was) found with the width of the signal on metalized strip

Detector (I)

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)
  - Electric field has a saddle in the inter-column region
  - Electrons drift to columns
  - Holes drift to bachplane

(for details see N. Zorzi talk at 2nd Trento Workshop)

Detector (II)

What do we want to measure?

•Shape of the induced current as a function of position and voltage!

•Homogeneity of induced charge as a function of integration time

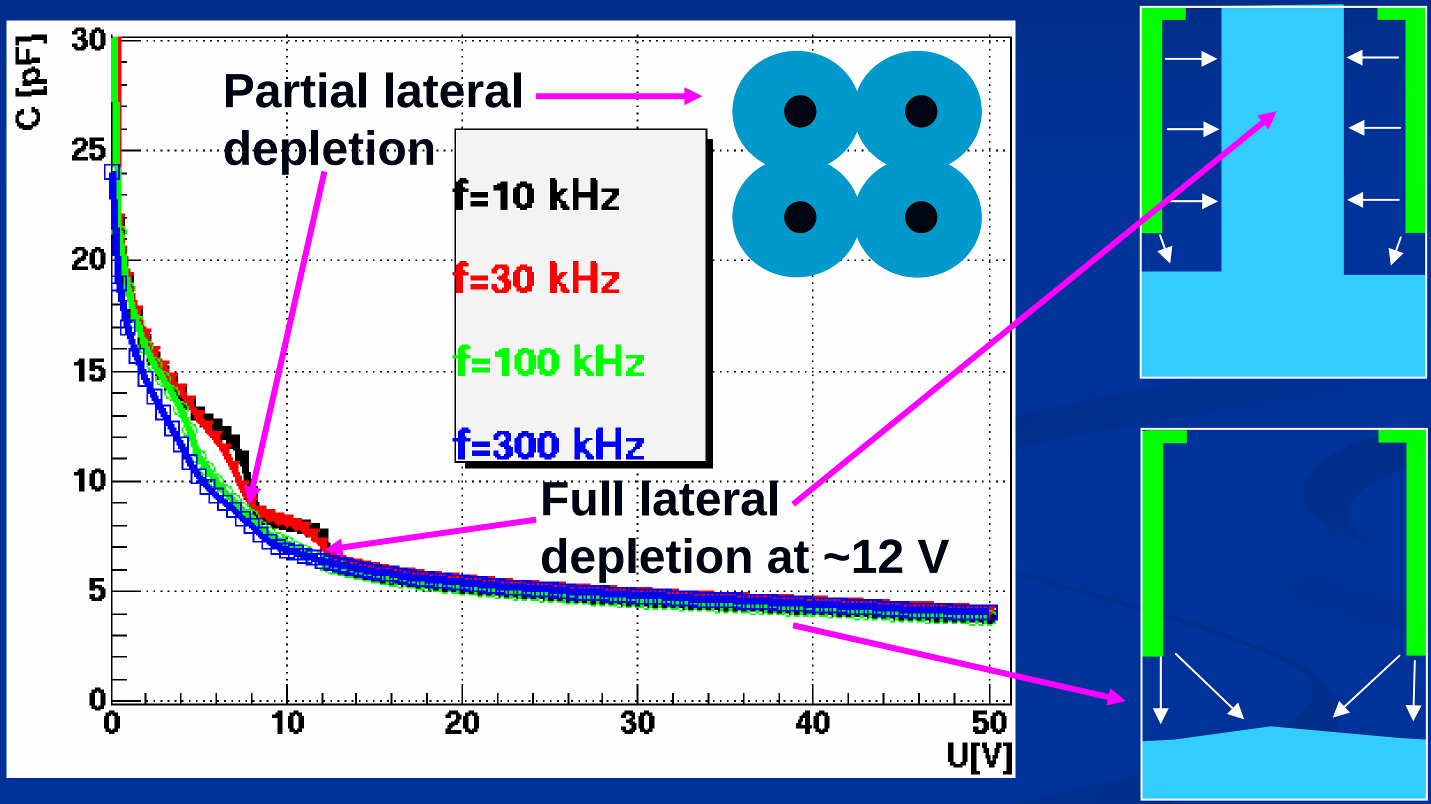
•Charge sharing (pulses on neighbors)

•Possible special features of the detectors

Needless to say that there is large amount of data available from one scan!

Detectors (III)

Strip leakage current < 5 pA
Strips to back plane capacitance (CV measurements):



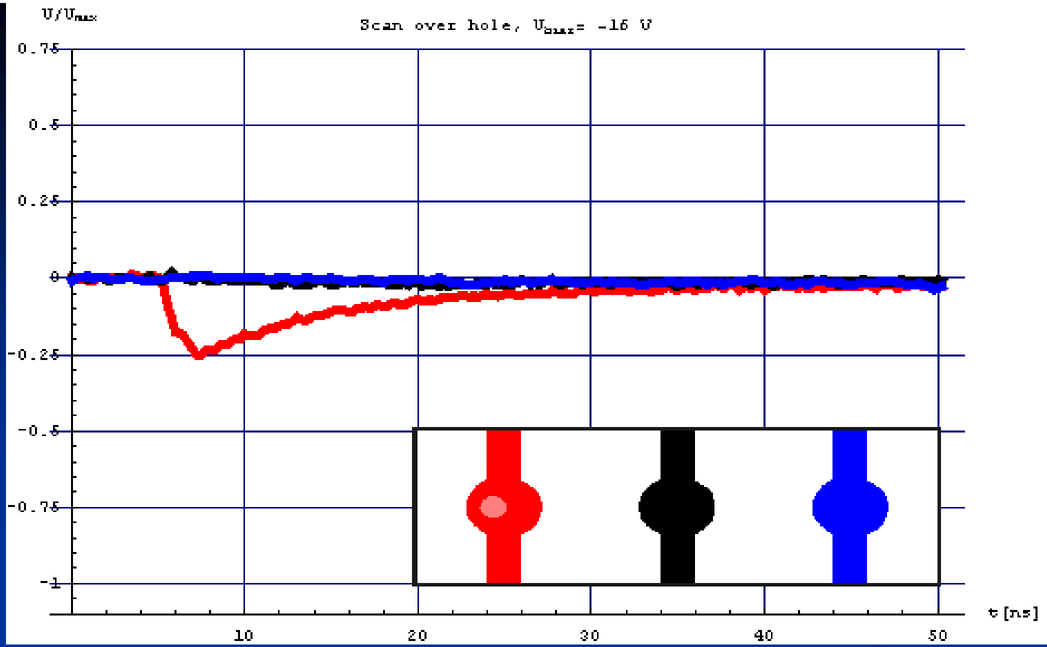
Induced current (I)

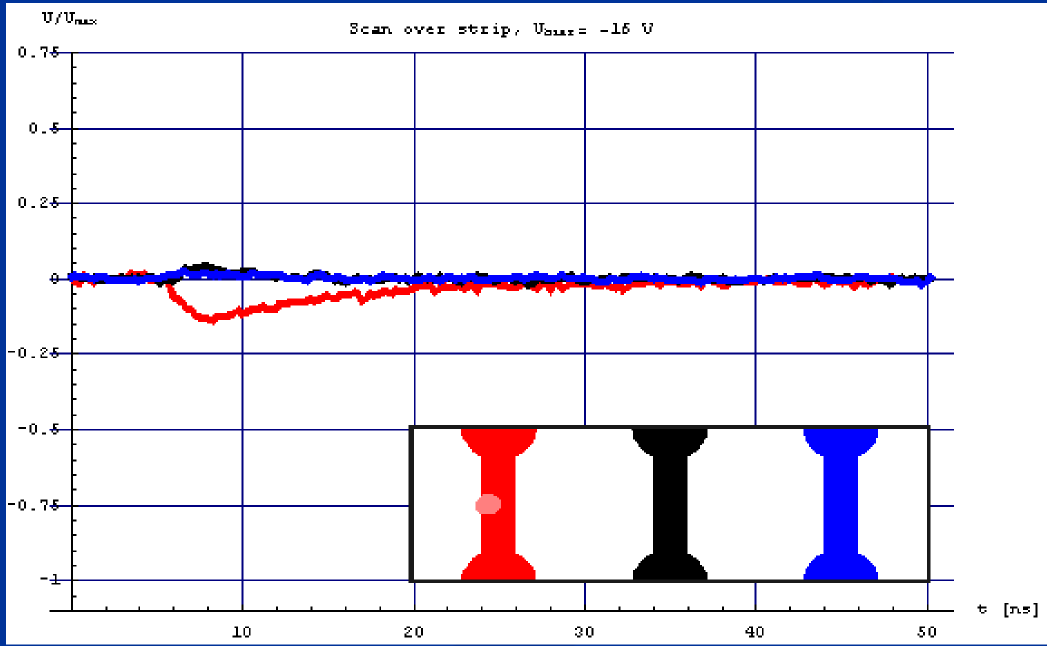
- U=16 V>lateral depletion voltage
- All 3 channels are shown (colors)

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

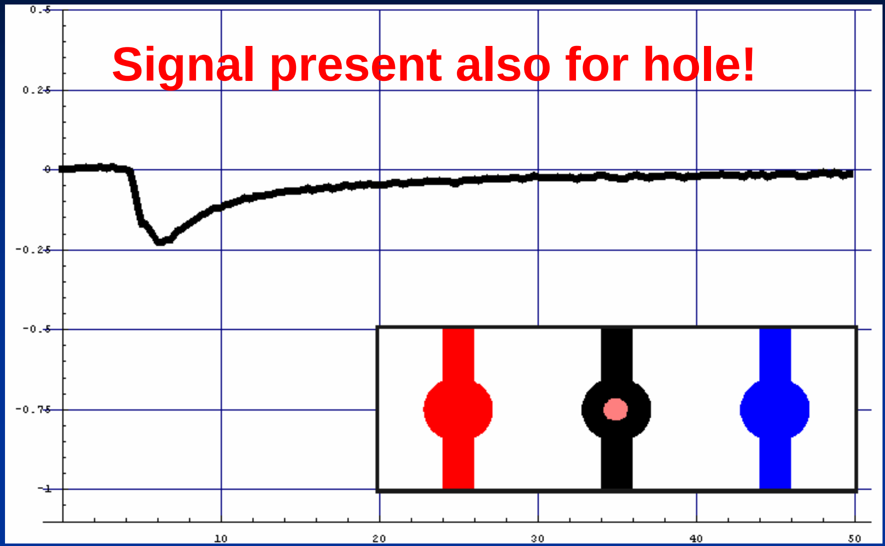
- Slight difference between side strips and central strip is caused by the different weighting field (other strips are not bonded)

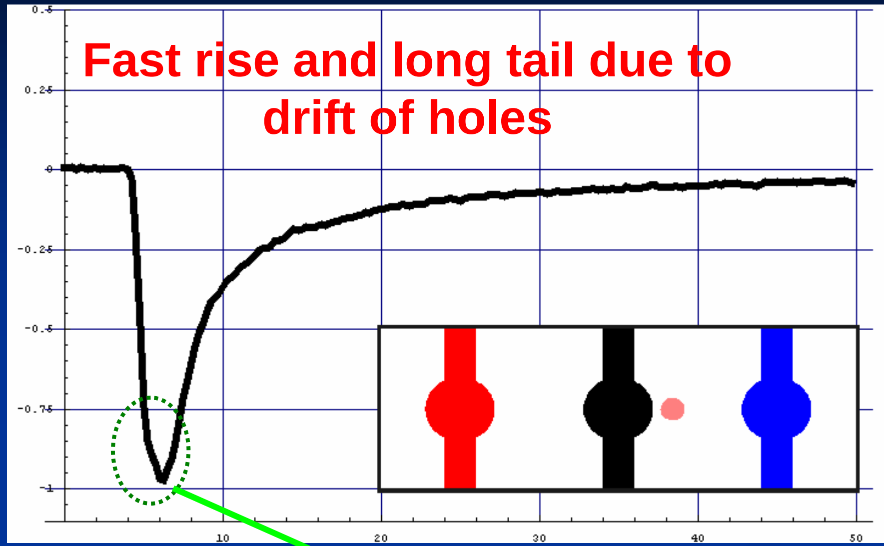




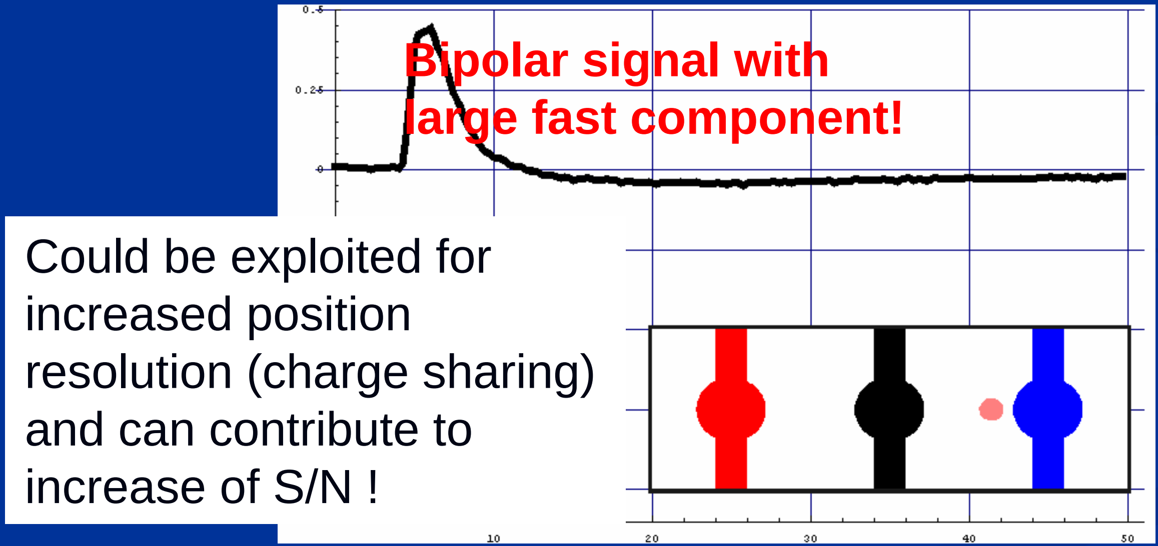
Induced current (III)

U=16 V (laterally depleted)!





Drift of electrons to higher weighting potential region



Could be exploited for increased position resolution (charge sharing) and can contribute to increase of S/N !

Induced current (IV)

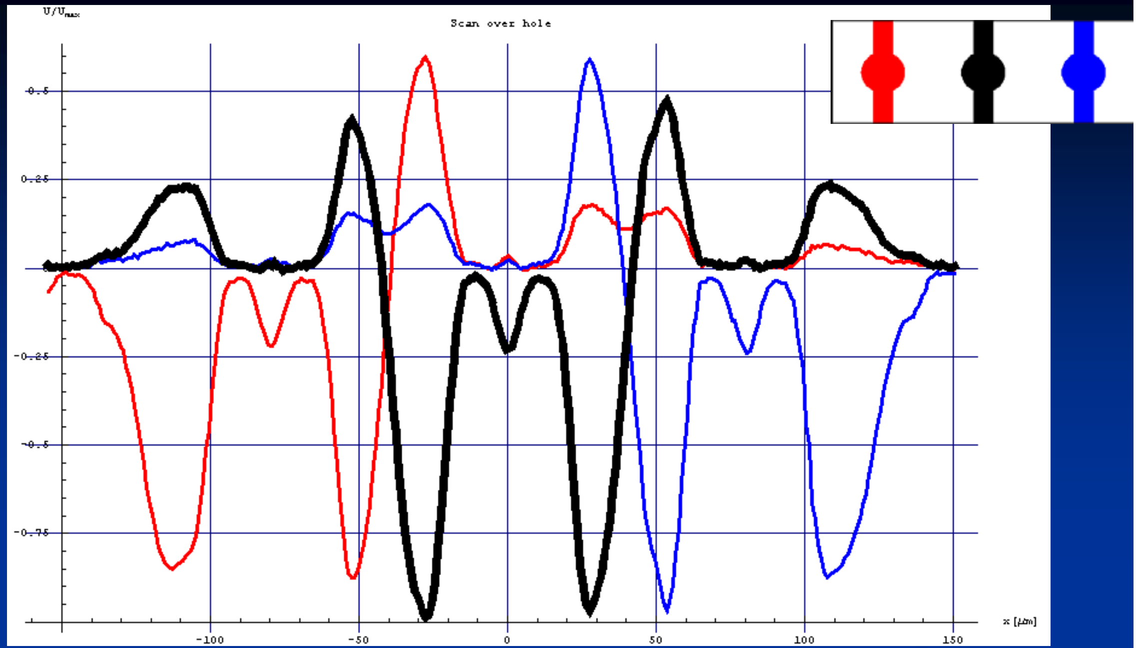
Peak of induced current vs. impact position for all 3 channels

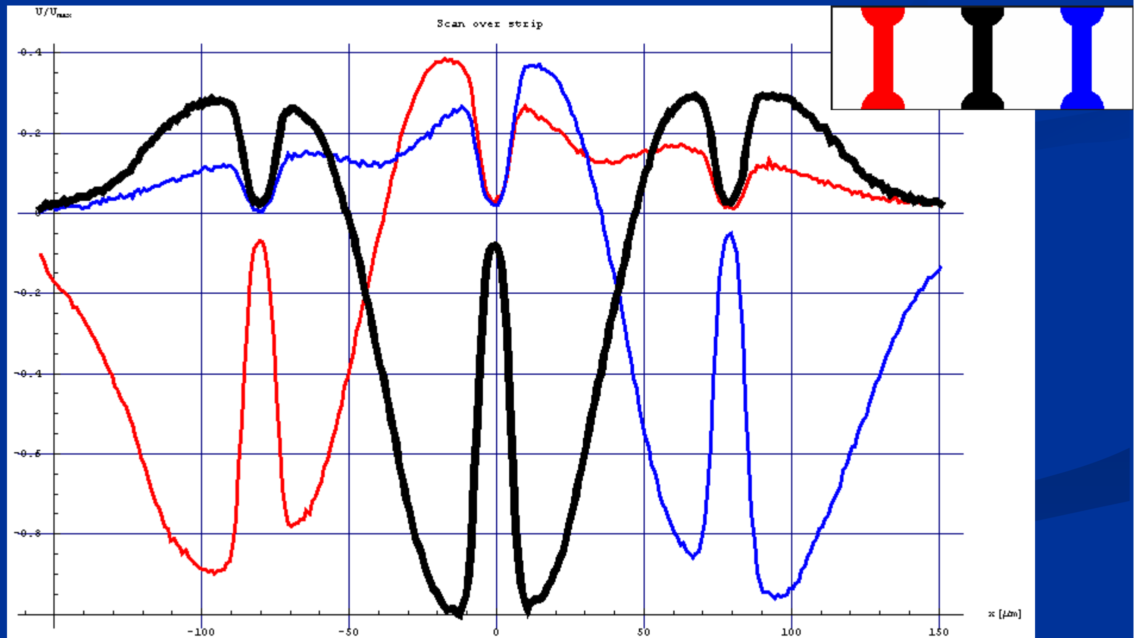
Note:

- The dips are due to metalized surfaces (reflection of the light)

- If short integration times (~12 ns) are used these signals would be proportional to induced charge

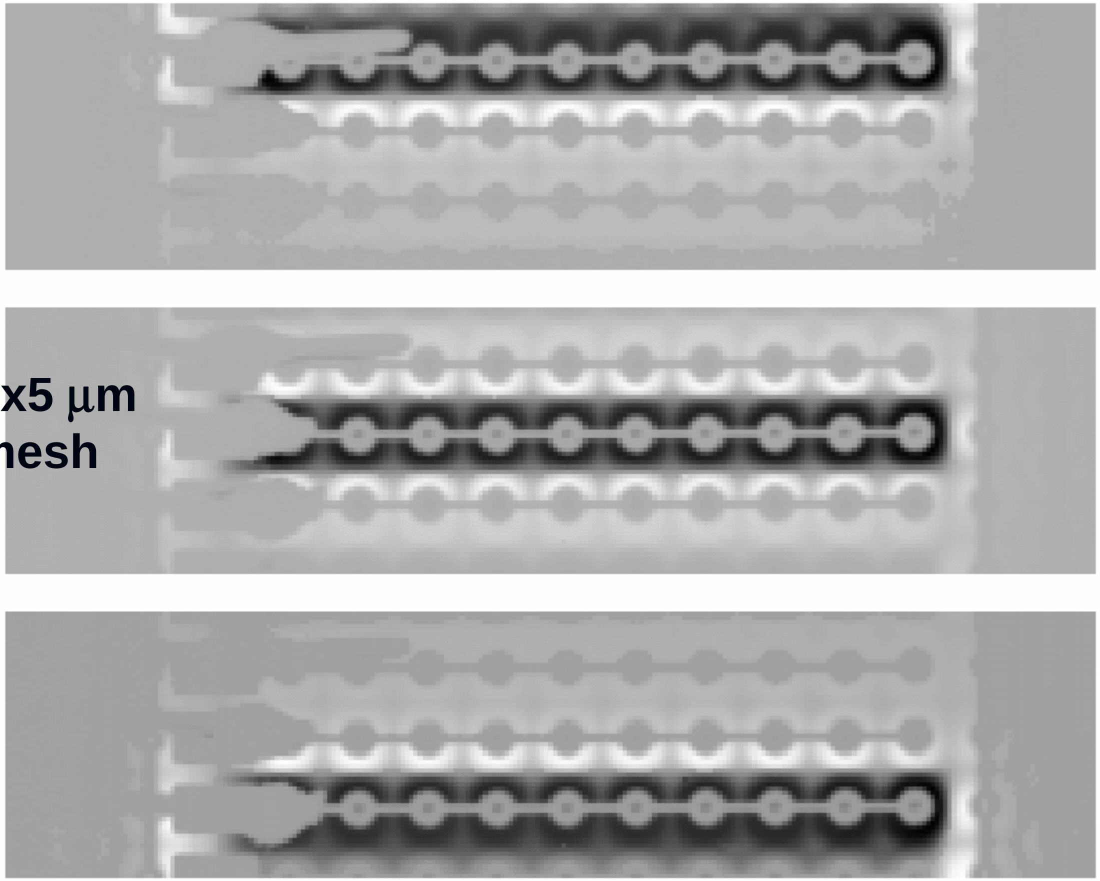
- Peaks in induced current point to the maximum of the weighting potential along the impact track.





Induced current (IV) – whole detector scan

Peak of the induced current is plotted -> roughly corresponds to collection speed!



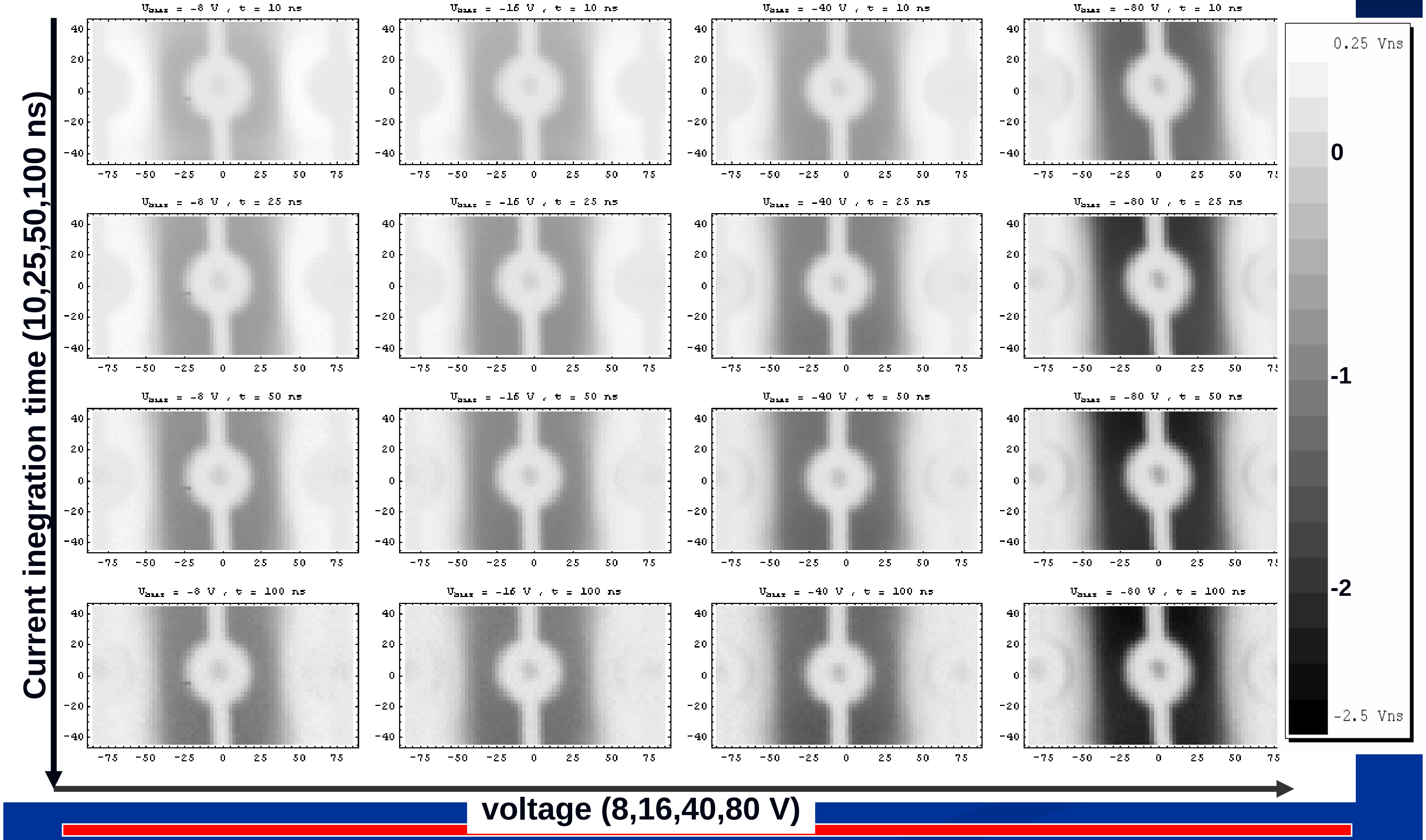
5x5 μm mesh

•Regions of large peak ~ fast collection are close to holes as expected

•Note the impact of not grounded (floating for fast signals) strips to left and right strip!

Charge collection (I) - Integral of current at different voltages and integration times

x,y represent beam position, color represents the induced charge



Conclusions

- PS-TCT system was set-up and is performing very well - a useful tool to study any position sensitive silicon detector!
- 3D-stc detectors were studied with IR light pulses:
    - current pulses as a function of position were determined
    - charge collection and charge sharing
    - timing

Future plans

- Beam splitter will be installed to enable not only relative measurement in terms of collected charge but also absolute measurements
- There are other detector geometries and types (AC coupled) will be tested
- A large irradiation campaign will be started to determine the radiation hardness of these detectors