TCT measurements with strip detectors

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Introduction:

- TCT with focused IR laser light - Position Sensitive TCT

  - see the talk by G. Kramberger at RD50 meeting in Prague 2006:
    http://indico.cern.ch/getFile.py/access?contribId=41&sessionId=10&resId=1&materialId=slides&confId=1242

- focused IR laser light (λ = 1060 nm) directed on the surface of strip detectors

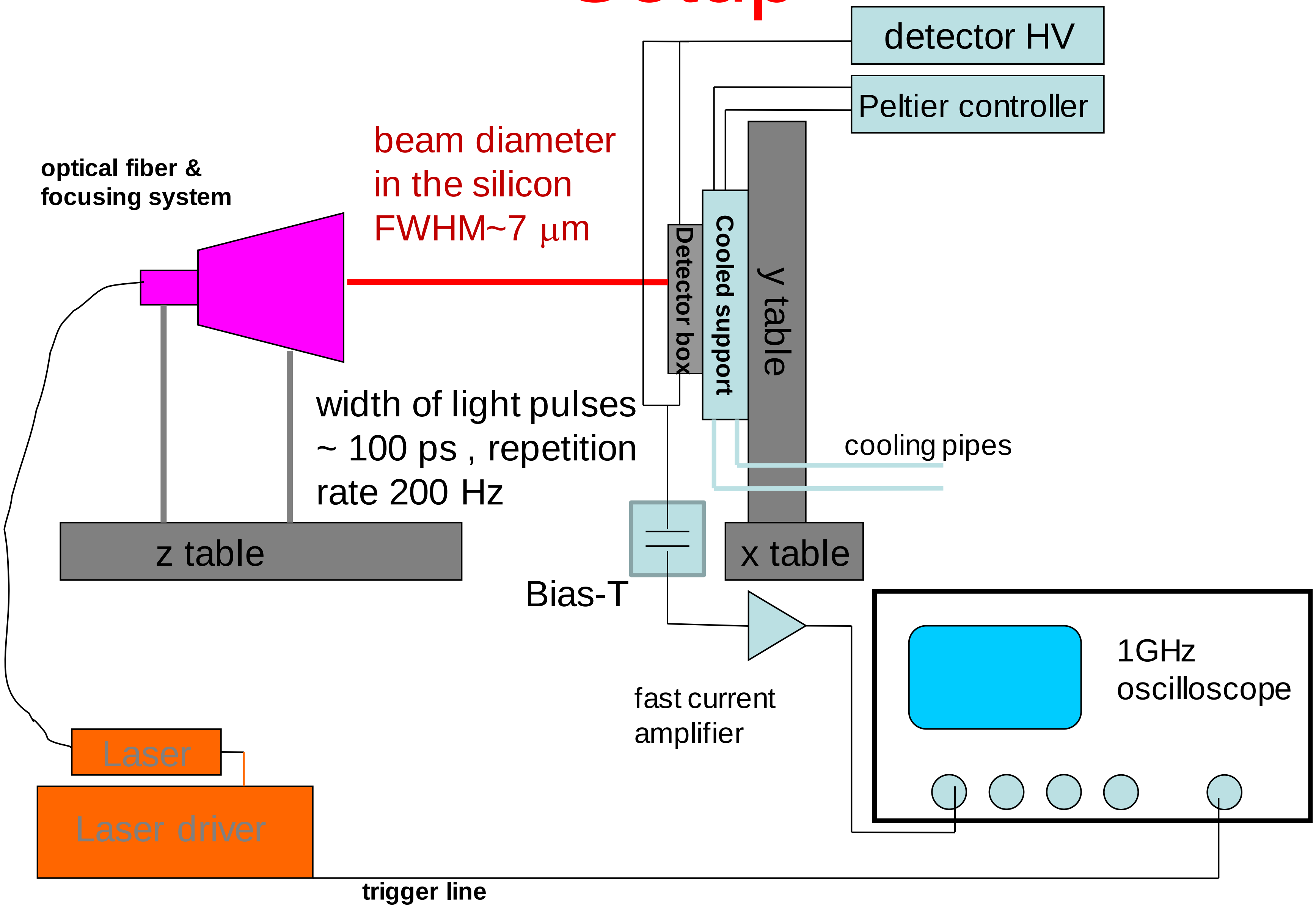
- Hamamatsu ATLAS07 mini strip detectors irradiated with neutrons in Ljubljana

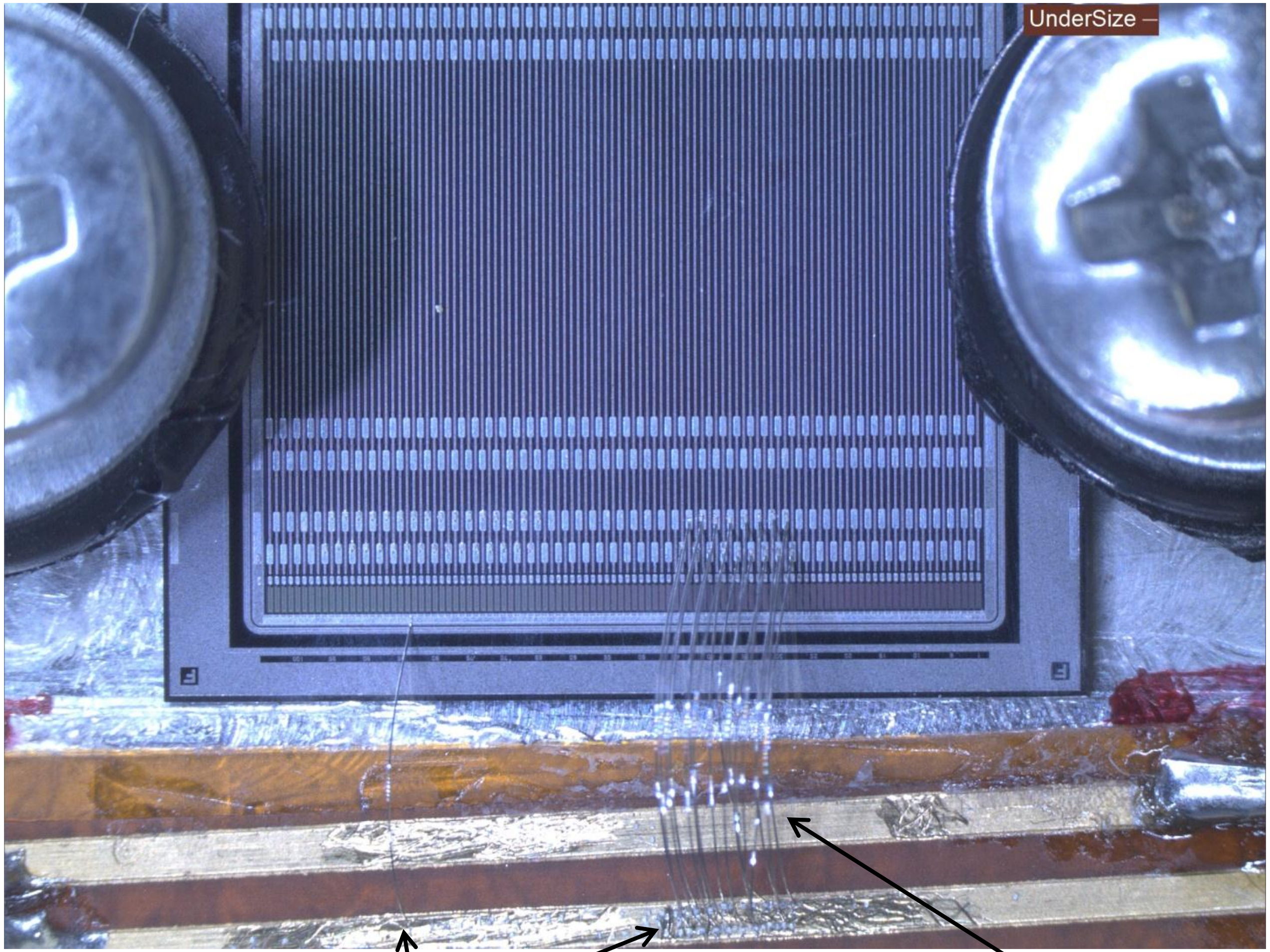
- p-type, FZ, 320 µm thick, 1x1 cm^2 , produced by Hamamatsu
  - strip pitch: 74.5 µm
  - implant width: 16 µm
  - metal width: 22 µm
  - all zone 3

- detectors irradiated to $2\cdot10^{14}$, $5\cdot10^{14}$, $1\cdot10^{15}$ and $5\cdot10^{15}$ n/cm^2
- $2\cdot10^{14}$ annealed 80 minutes, others 84 hours at 60 C!!
- measurements made at T = - 20 C

Motivation: check the uniformitiy of response at high bias voltages

Setup


detector HV
Peltier controller
optical fiber &
focusing system
beam diameter
in the silicon
FWHM~7 μm
Detector box
Cooled support
y table
width of light pulses
~ 100 ps , repetition
rate 200 Hz
cooling pipes
z table
x table
Bias-T
fast current
amplifier
1GHz
oscilloscope
Laser
Laser driver
trigger line



Surrounding strips and
bias ring connected to HV supply

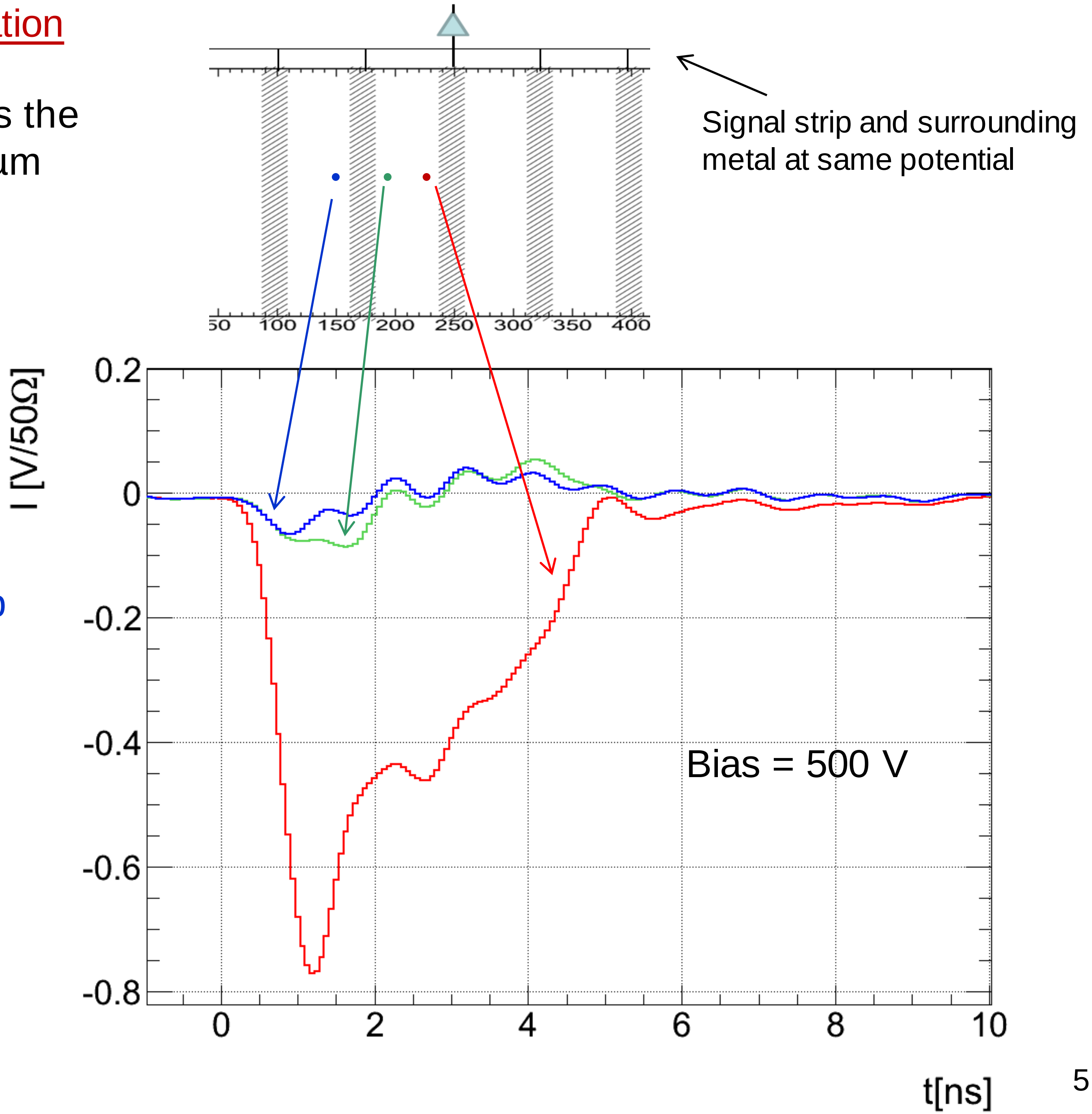
One strip connected to HV
and to amplifier via Bias-T

Metal: connected to same potential (HV supply)!
➔ weighting field as when connected to multi-channel readout chip!

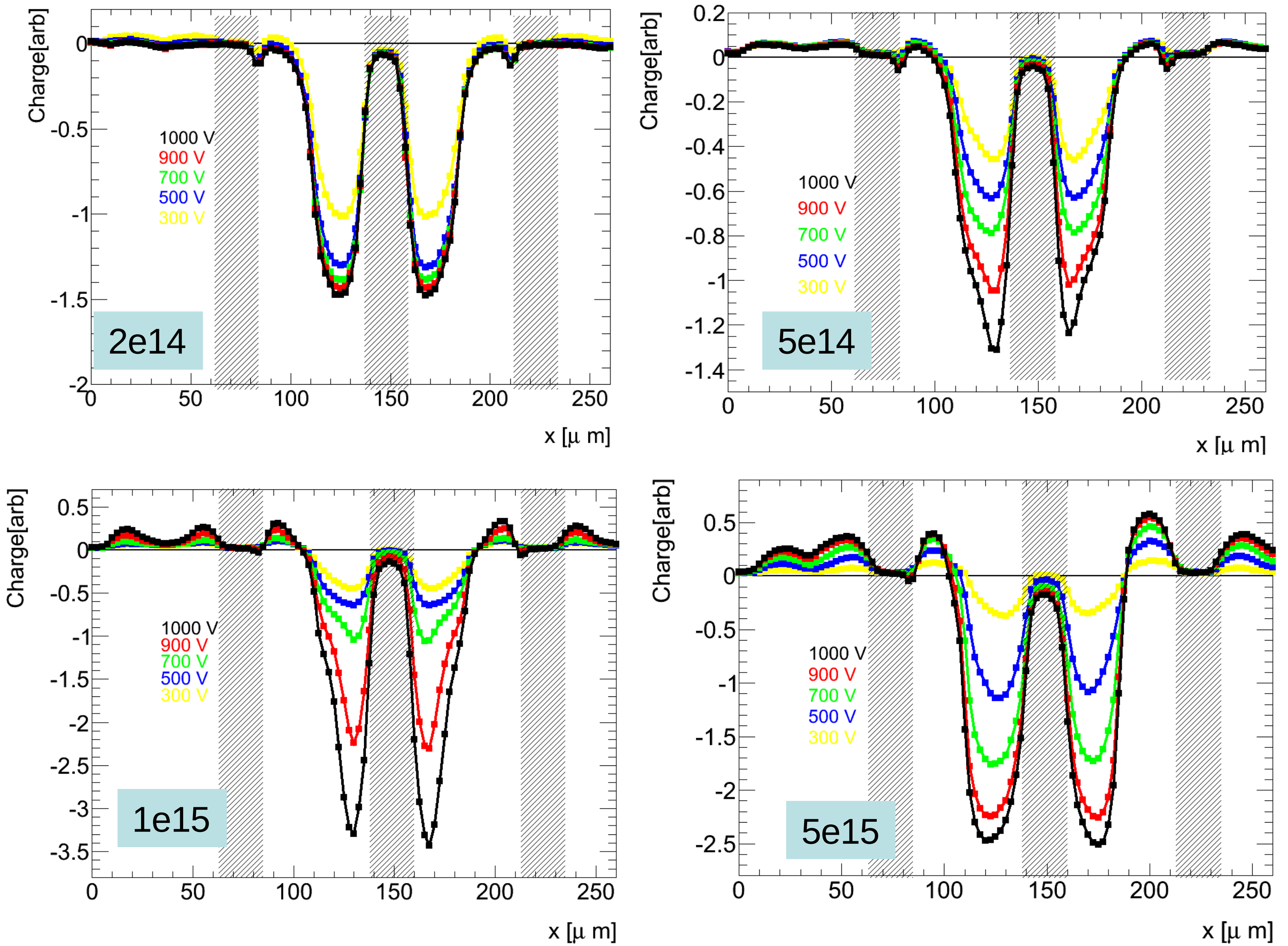
Detector before irradiation

- scan laser spot across the the surface, step 2.5 μm

Examples of signals induced on readout strip by laser beam at different locations:



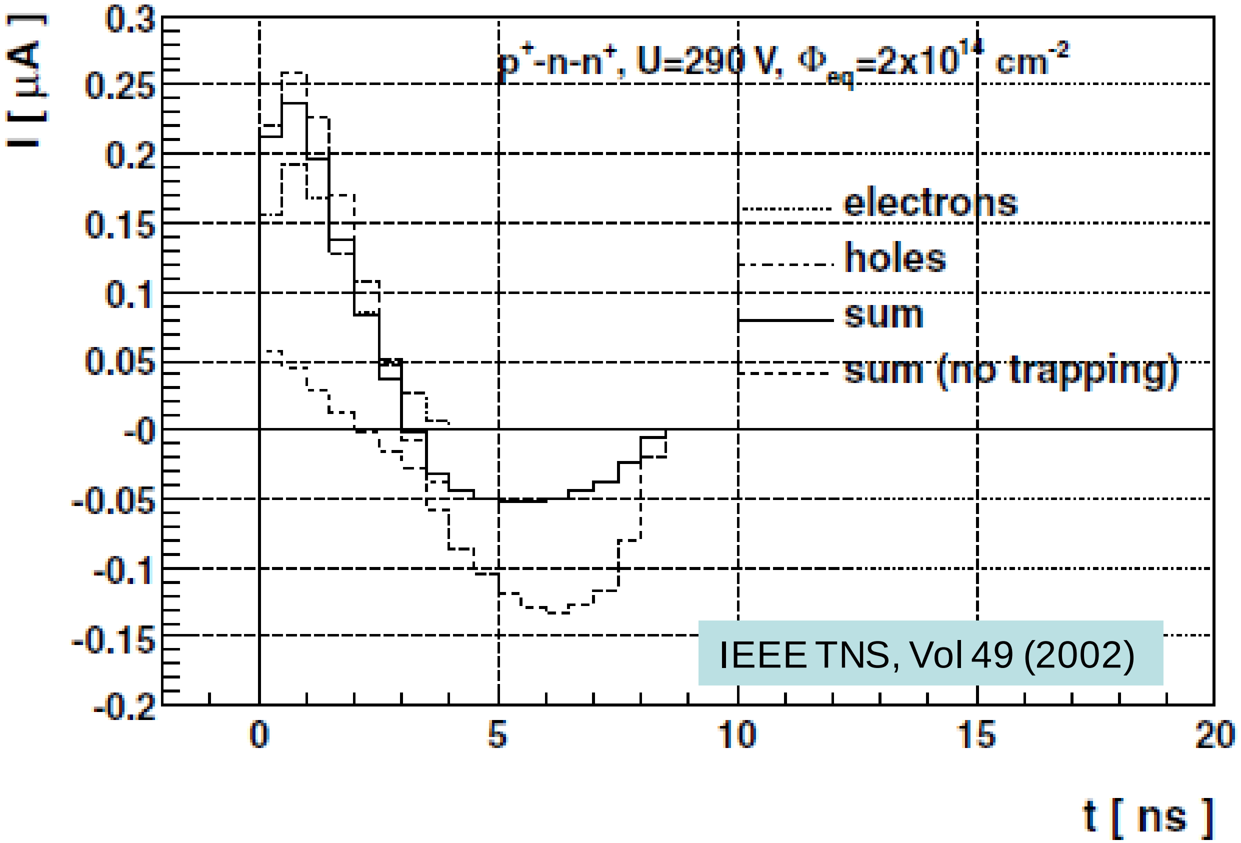
Charge vs. x for irradiated detectors



In irradiated detectors non zero signal expected on neighbour strip

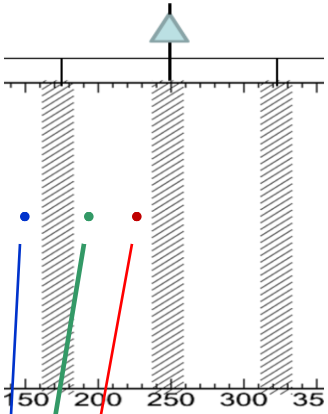
- G. Kramberger et al., *Influence of trapping on silicon micro-strip design and performance*, IEEE TNS, Vol 49 (2002) p1717
- G. Kramberger, D. Contarato, *Simulation of signal in irradiated silicon pixel detectors,* NIMA511 (2003) p 82

Induced signal from MIP impact on neighbour strip:

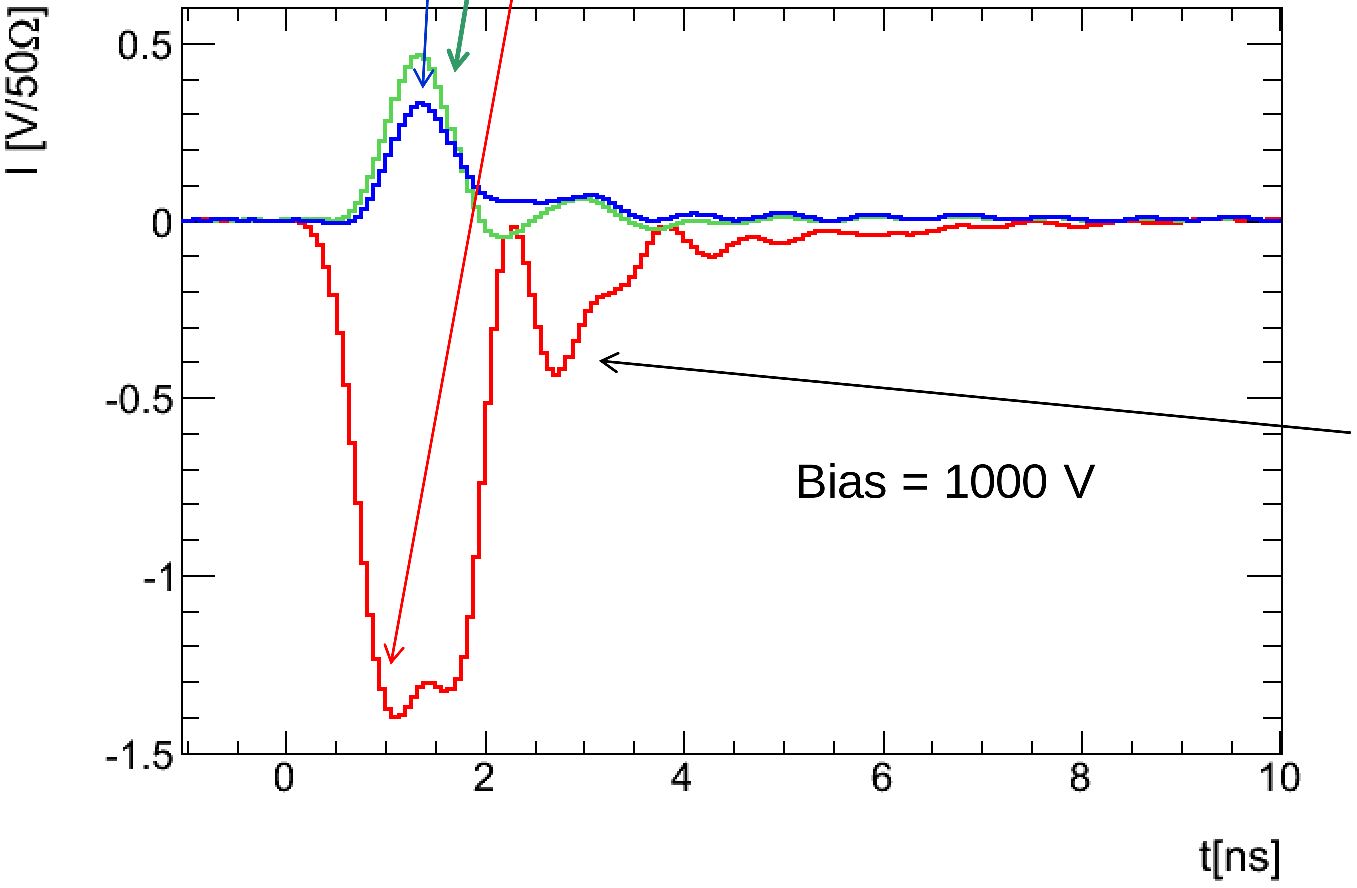


→ Because of trapping integrals of induced signal not 0!

$\Phi = 5 \cdot 10^{15}$ n/cm^2

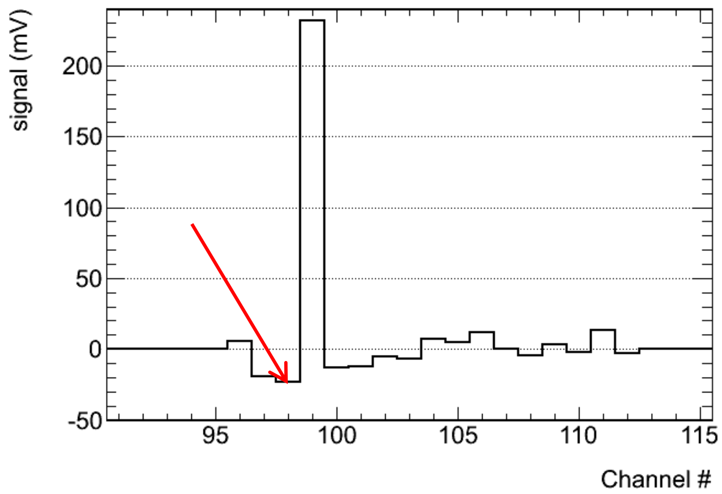


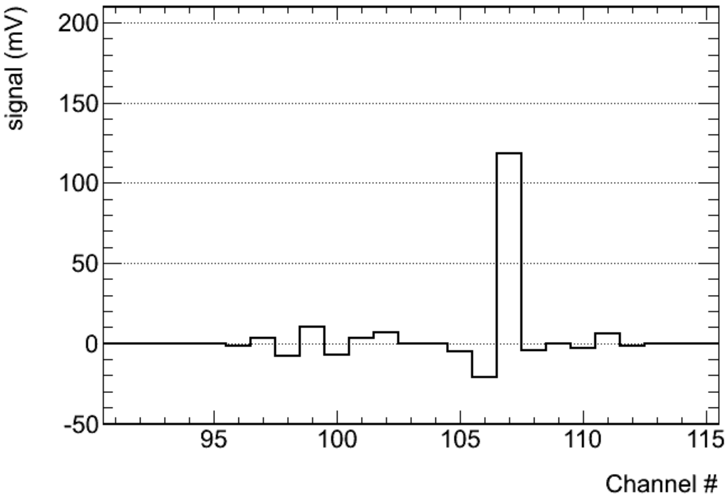
- if carriers move in different direction with respect to signal strip
  → polarity of induced current changes

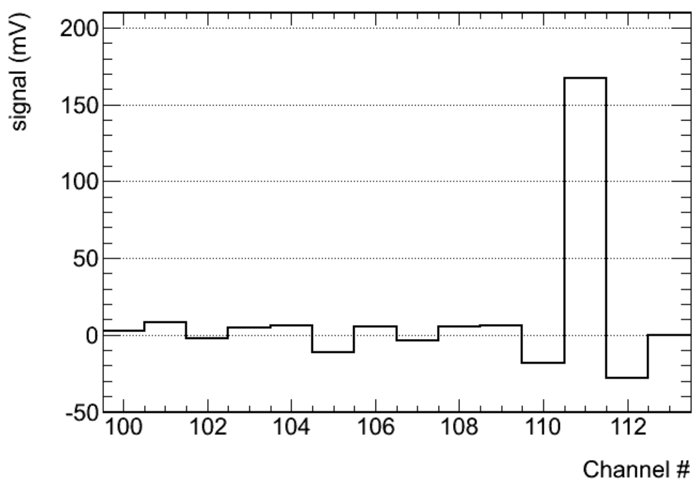


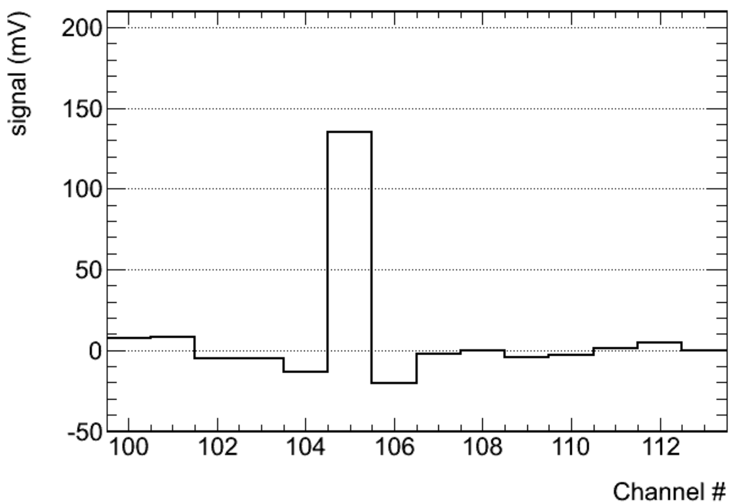
• examples of events measured with SCT128, ^{90}Sr, Φ = 5e15, Bias = 1400 V

➔ large positive signals accompanied by negative signals on neighbour channels





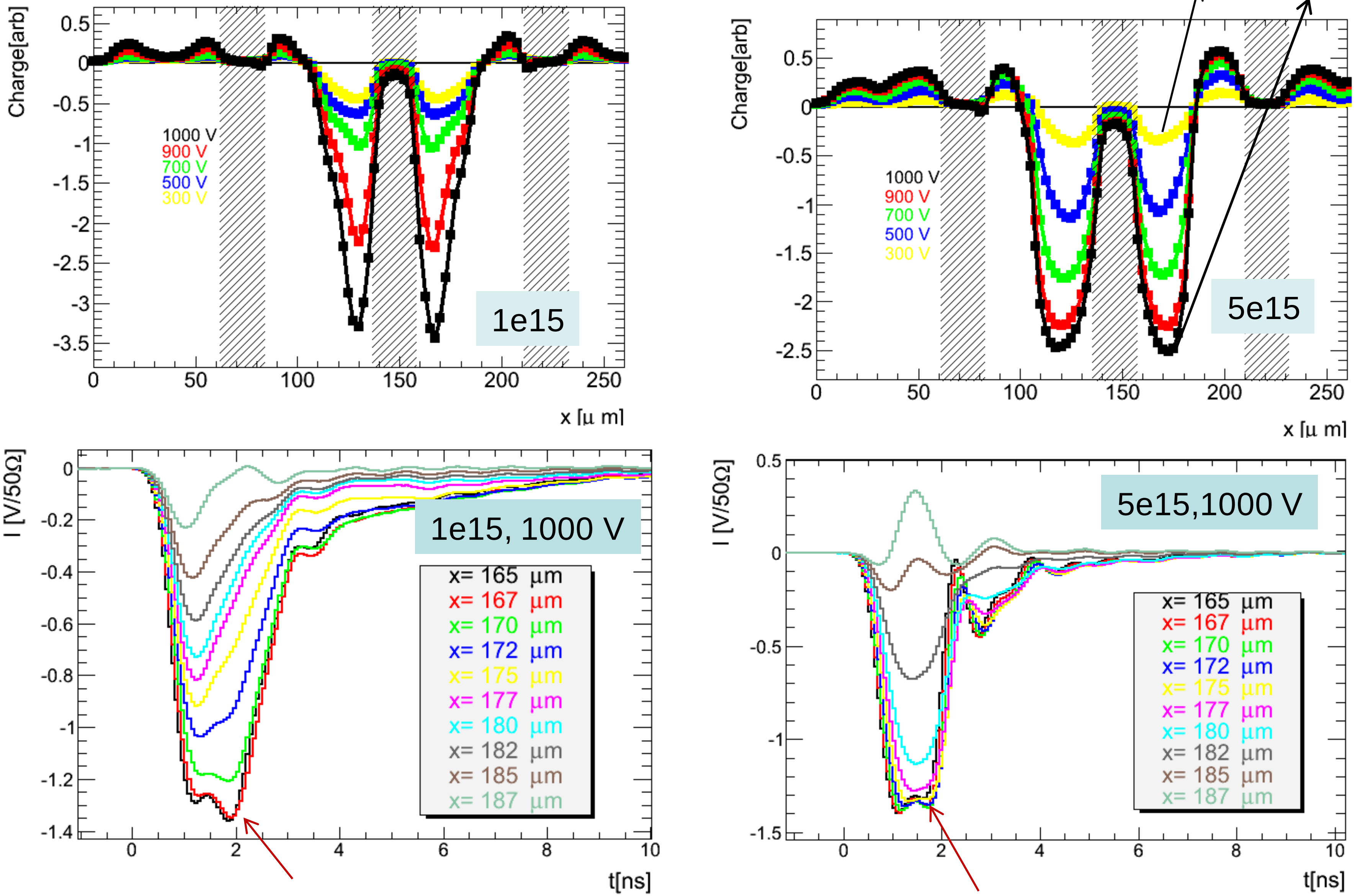




Multiplication sign: the second peak in induced current pulse

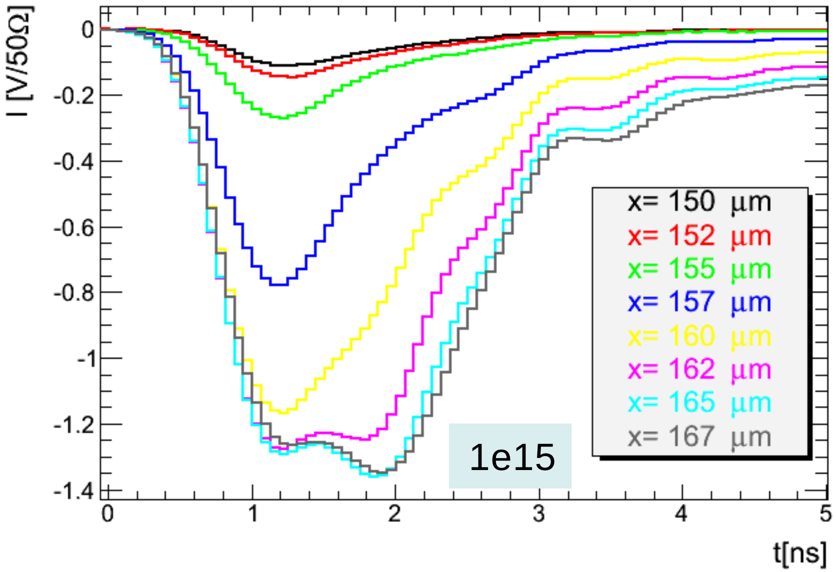
→ in detector irradiated to $5\cdot10^{15}$ region of high charge wider

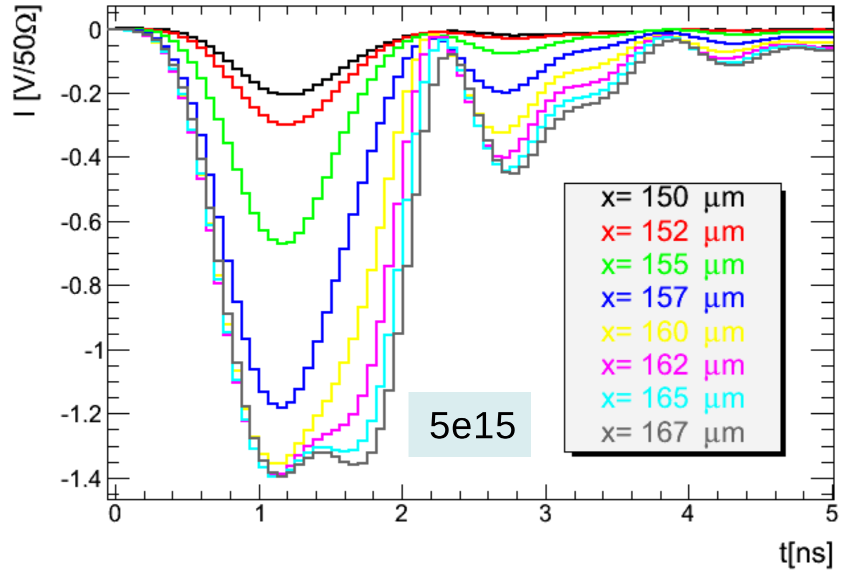
Max. moves for ~ 5 µm 300-1000 V



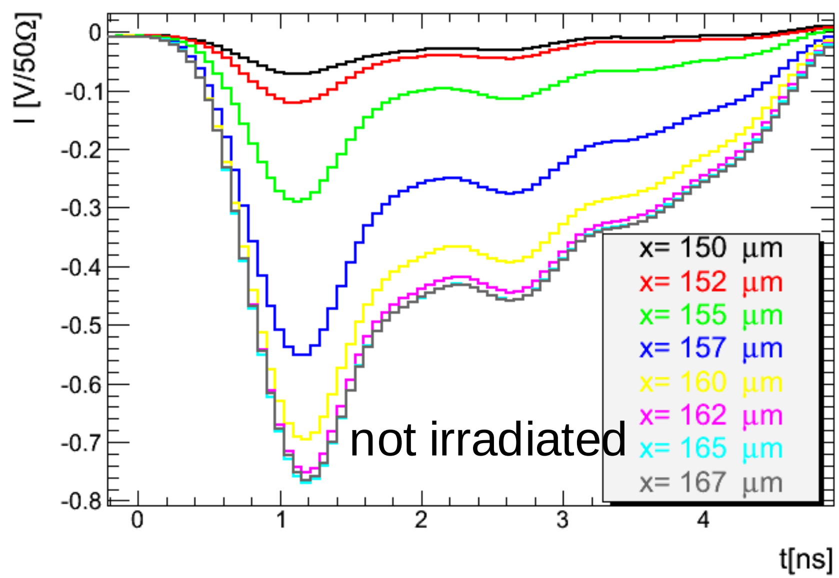
- pulses for laser spot between the metal and the peak

→ second peak appears at ~162 um, laser spot ~ 6 µm away from the edge of metal



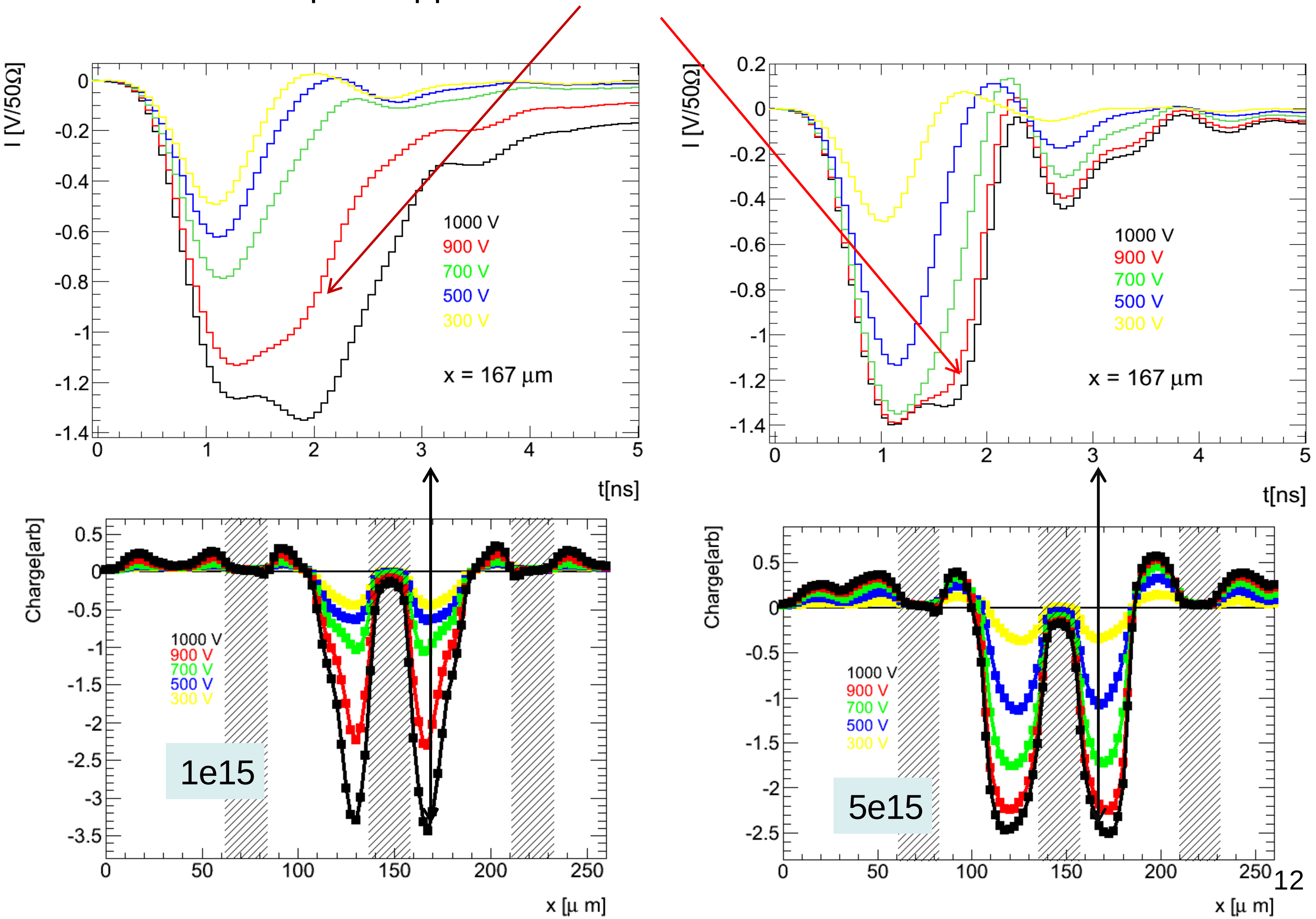


- signal starts to increase when laser spot at ~ 152 µm
  ➔ edge of metal at ~ 156 µm
- whole spot on silicon at ~ 160 µm
- second peak (multiplication) appears when center of laser spot at ~ 162 µm



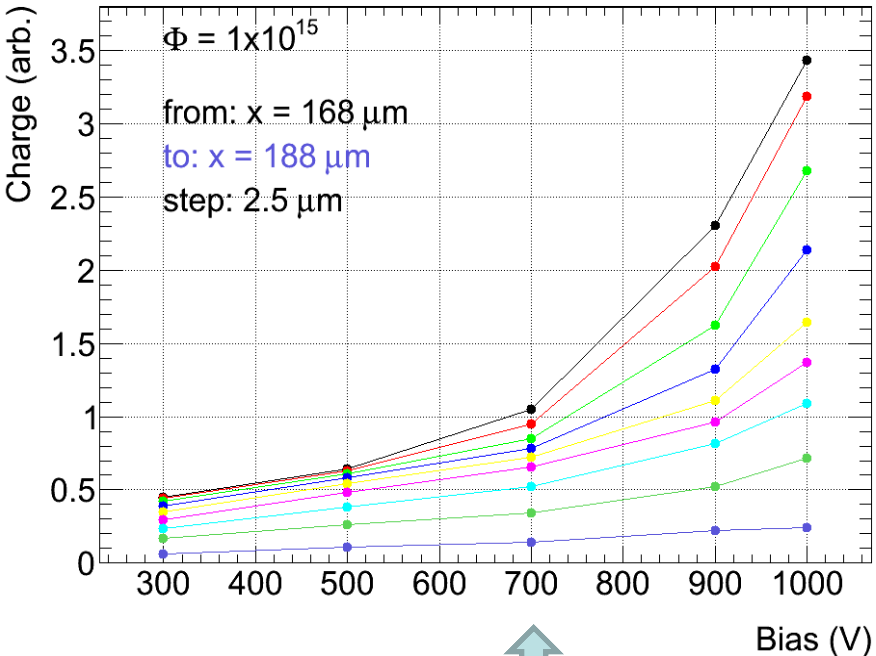
Pulses at the peak of collected charge

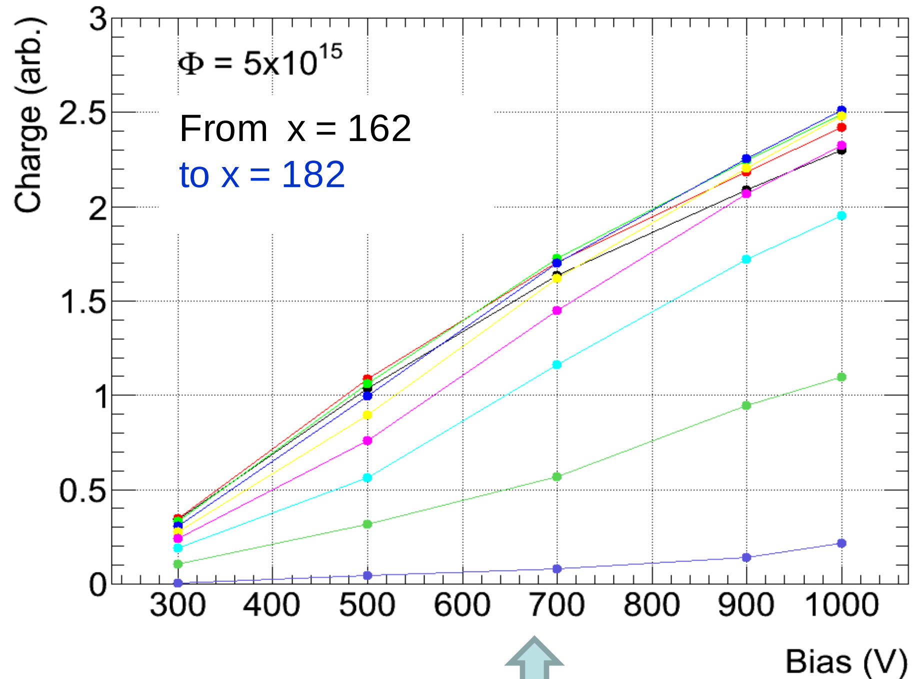
→ clear second peak appears at ~ 900 V

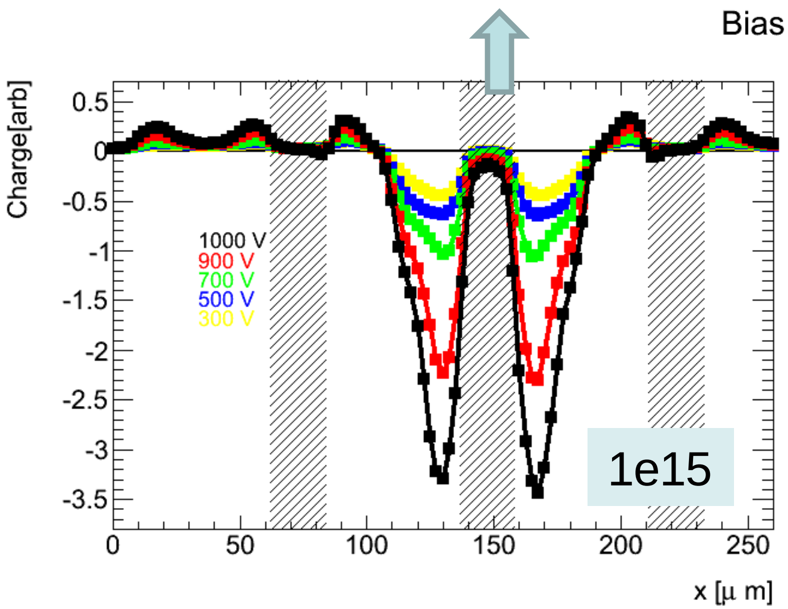


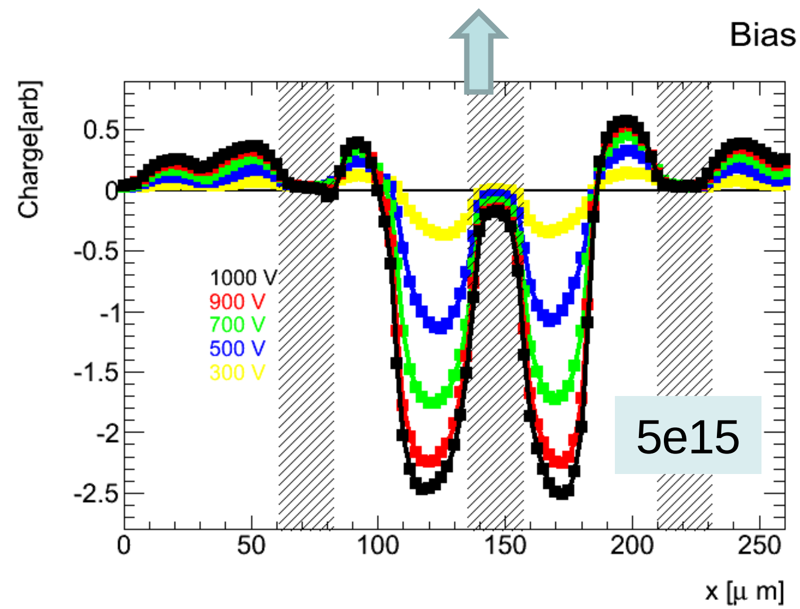
Charge vs. bias voltage measured at different impact point x

- each colour different x: black 168 µm, blue 188 µm (for 1e15)
  → steep rise of collected charge with bias voltage at peak location (168 um) for 1e15

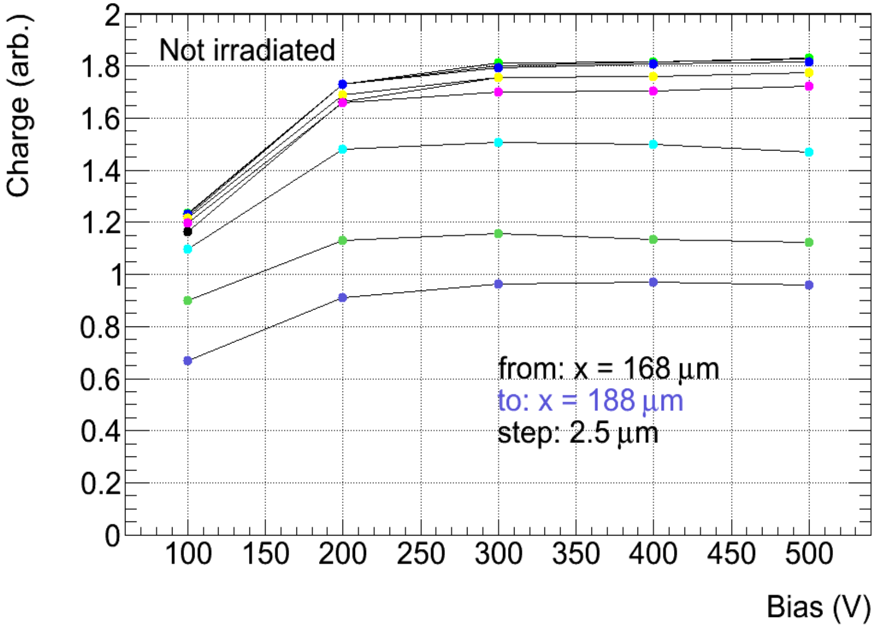


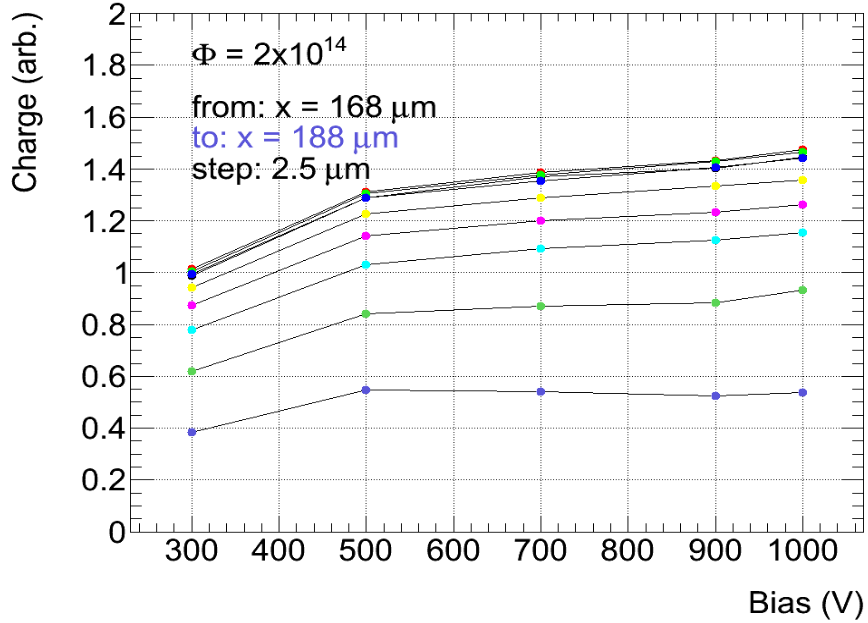


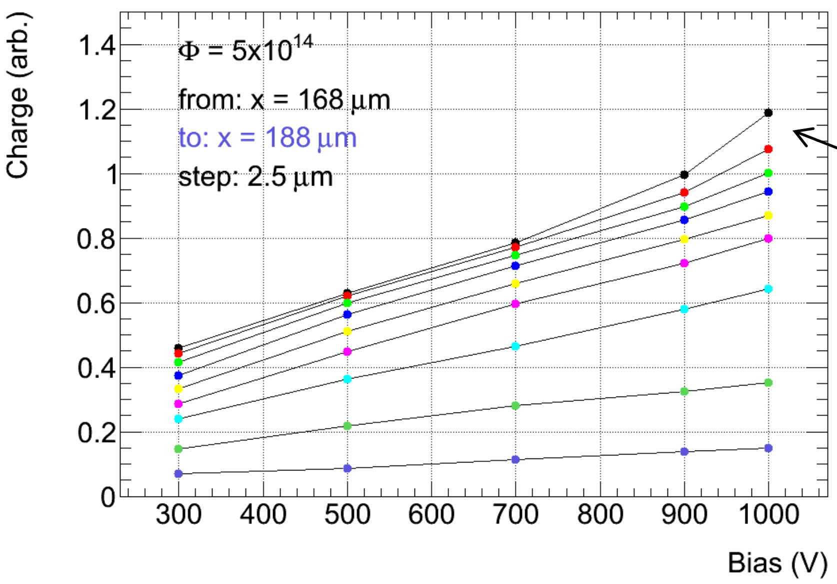


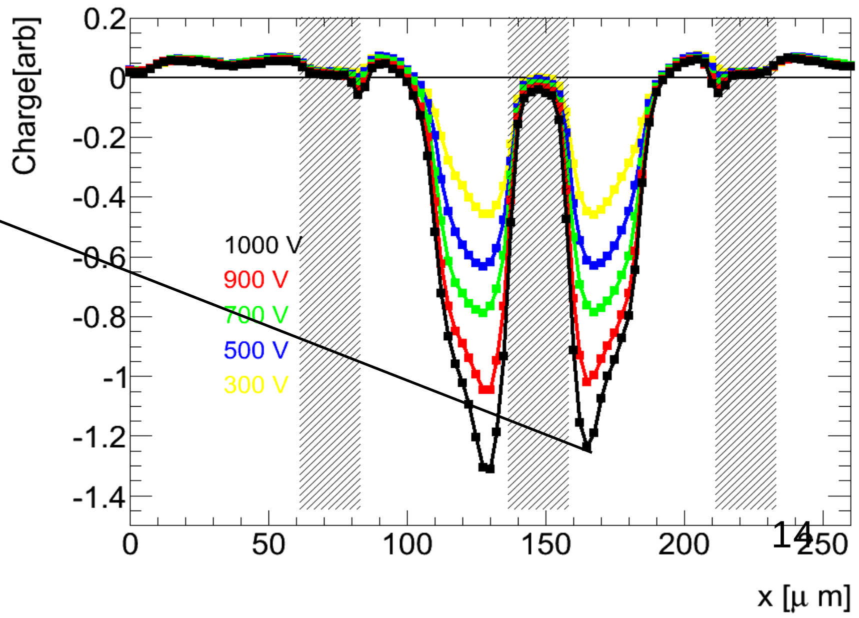


• other fluences



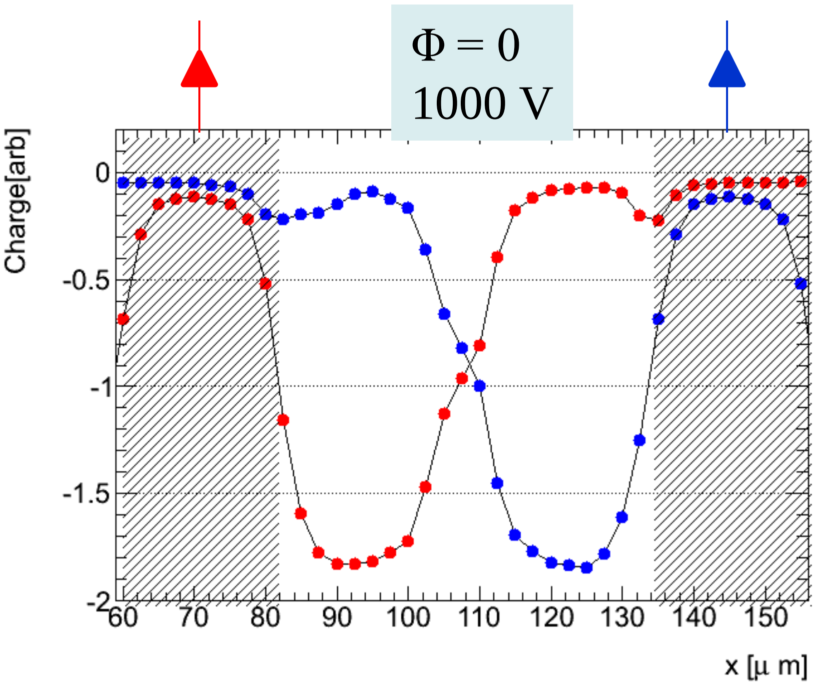




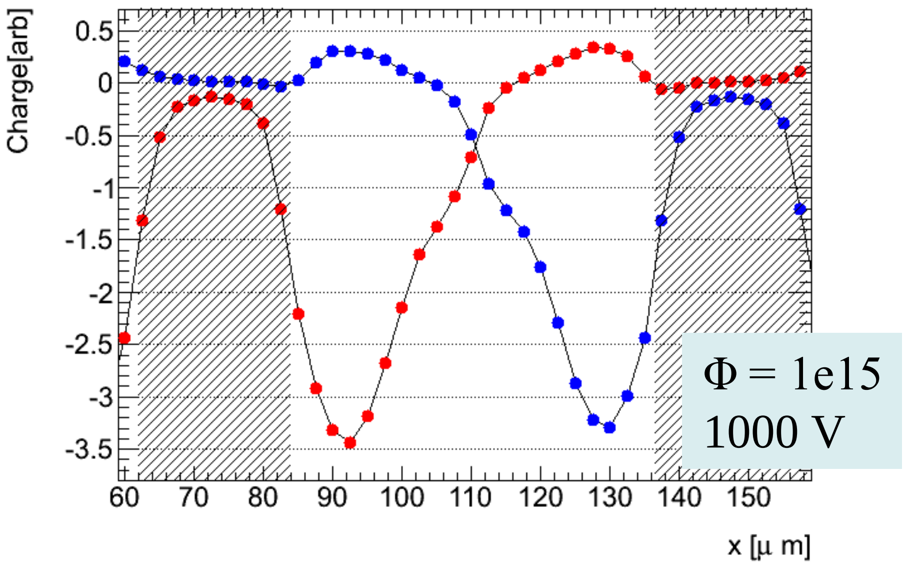


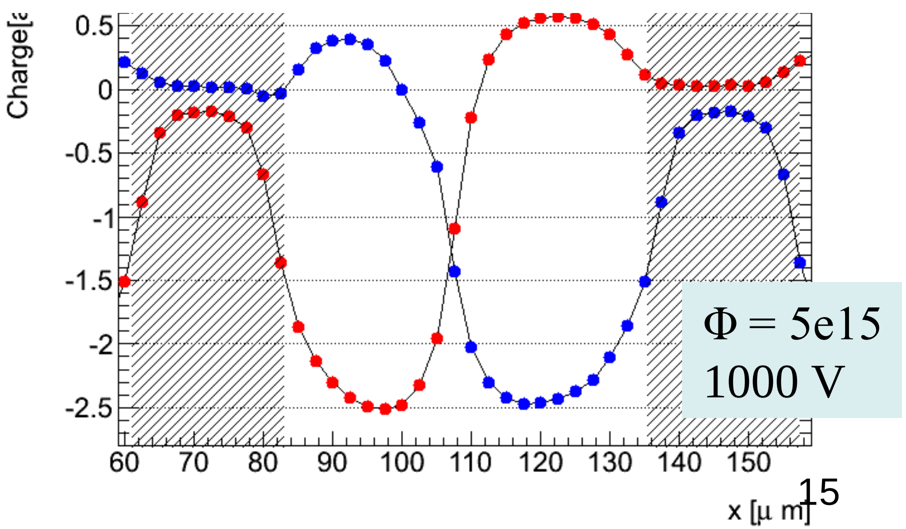
Effect of non-uniform response on tracking efficiency

- binary electronics: it depends on the threshold if non-uniformity affects the efficiency
  → more non-uniform after 1e15 than 5e15



Red: values measured on the right of the blue strip shifted





Summary

- preliminary results of measurements with focused IR laser beam directed on the surface of heavily irradiated strip detectors

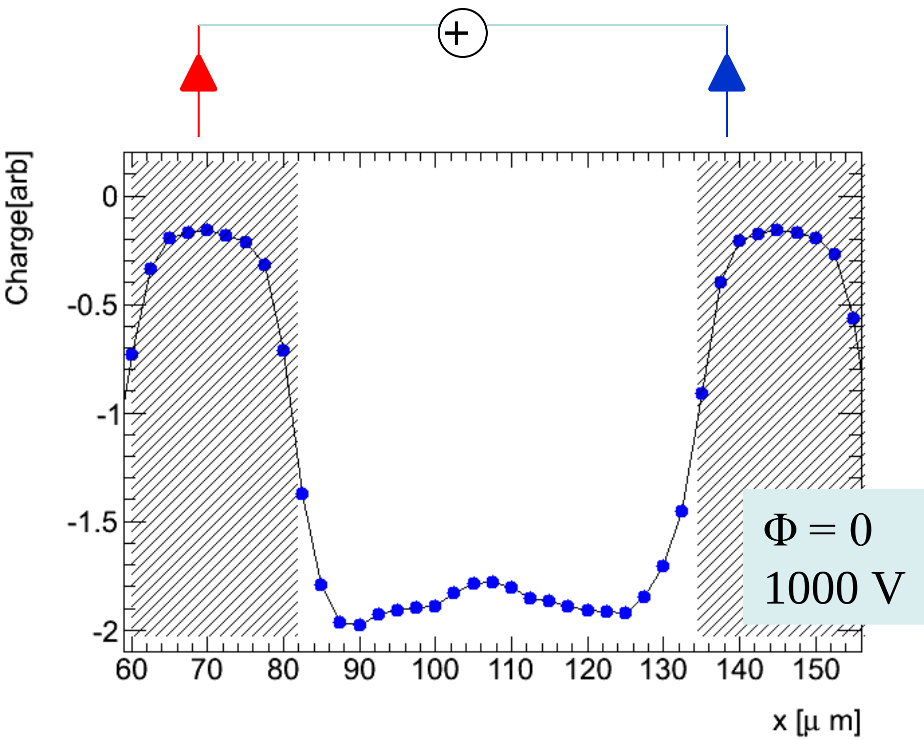
- signal of opposite polarity induced on the neighbor strip
  → expected because of trapping
  → observed also in events measured with SCT128 chip (^{90}Sr)

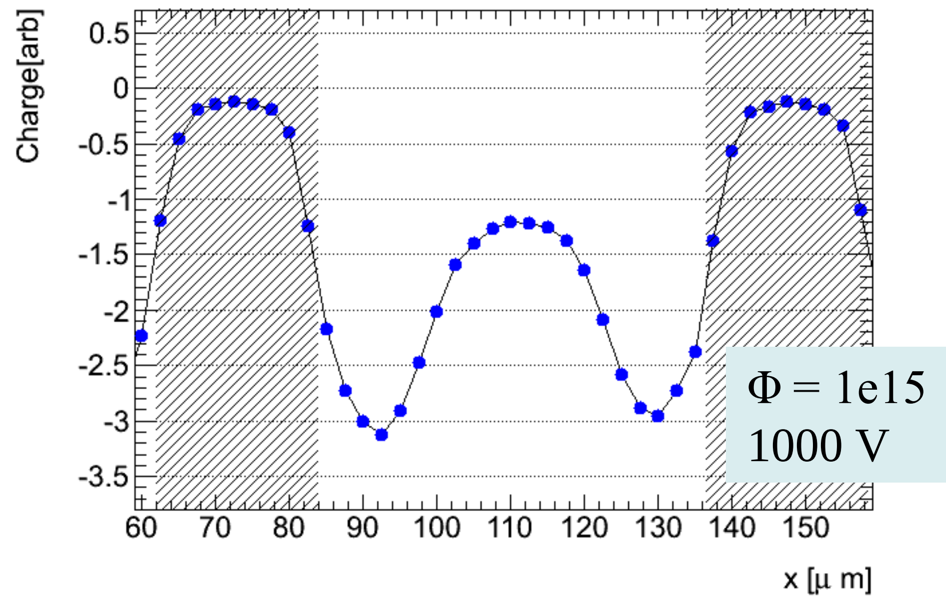
- multiplication seen in TCT signals: second peak in induced current
  → takes some time that electrons reach the region of high field
    → movement of charge created in multiplication is seen as the second peak

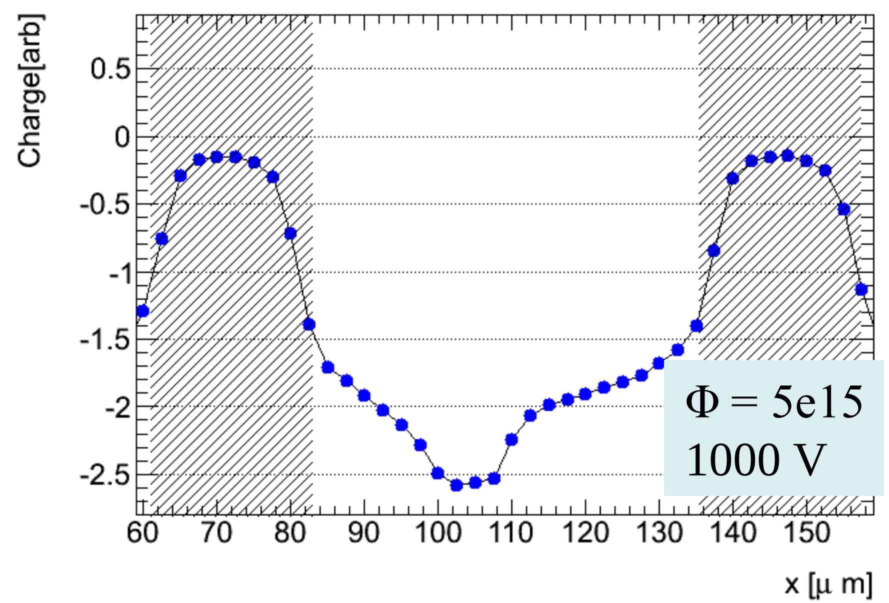
- significant multiplication seen in detector irradiated to 10^{15} n/cm^2 in narrow region
  → narrower than in the detector irradiated to $5 \cdot 10^{15}$ n/cm^2

- response of detectors across the surface
  → more uniform for detector irradiated to $5 \cdot 10^{15}$ n/cm^2 than to 10^{15} n/cm^2

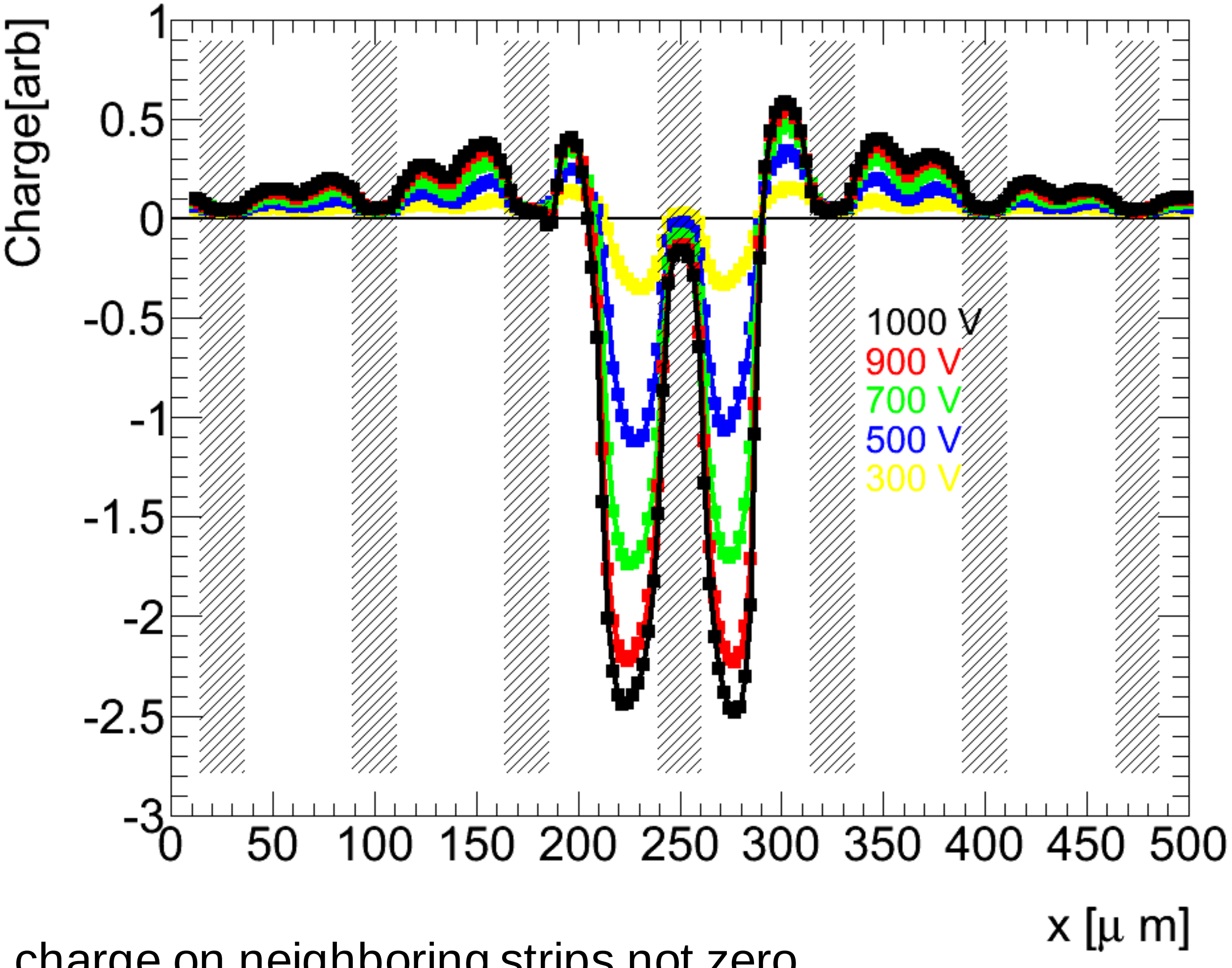
Sum of red and blue







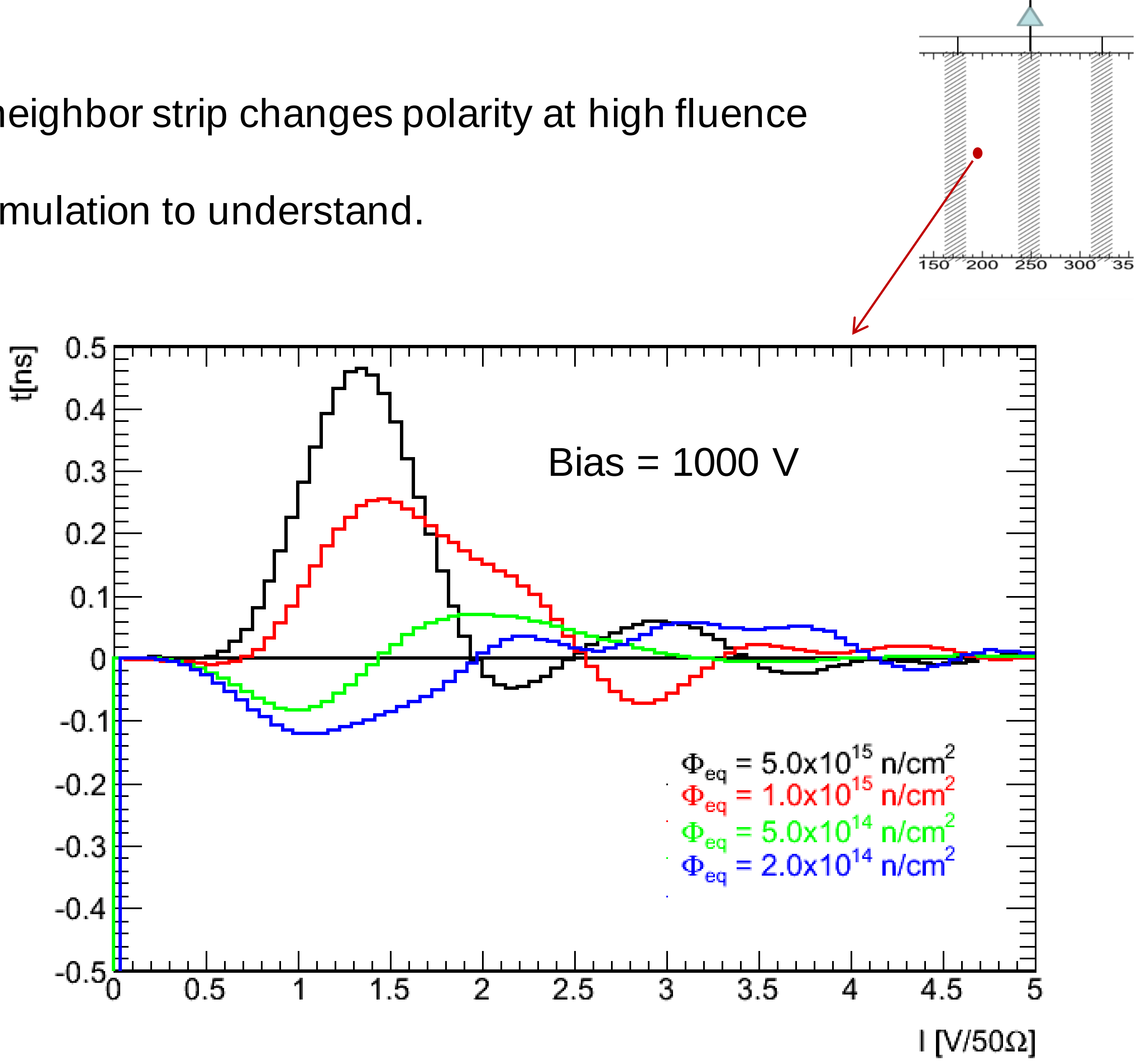
$\Phi = 5\cdot10^{15}$ n/cm^2



- charge on neighboring strips not zero
  → expected because of trapping

• pulse on neighbor strip changes polarity at high fluence

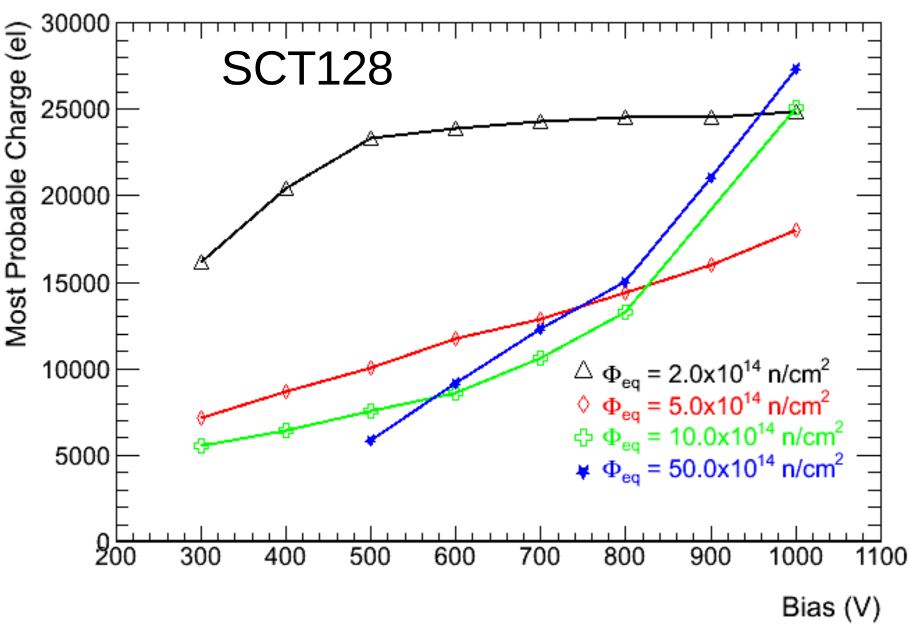
→ need simulation to understand.

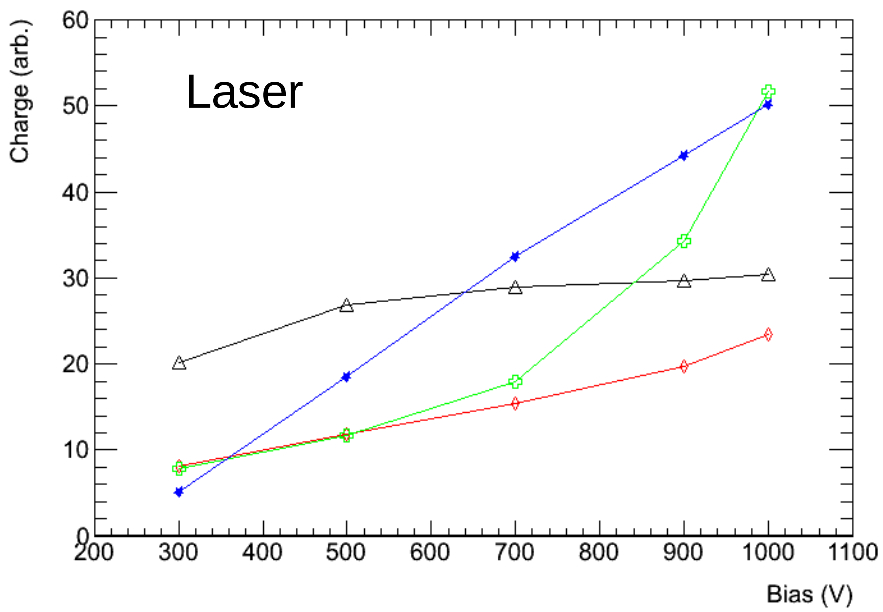


Compare SCT128 and TCT

- SCT128: charge measured with ^{90}Sr
- laser: average across high signal region

➔ laser → only shapes of curves can be compared, not values of charge





→shape for 5e15 (blue) for laser and SCT128 somewhat different, other look similar