Neutron Irradiation for P-type Sensors. Detector Characterization with ALIBAVA system

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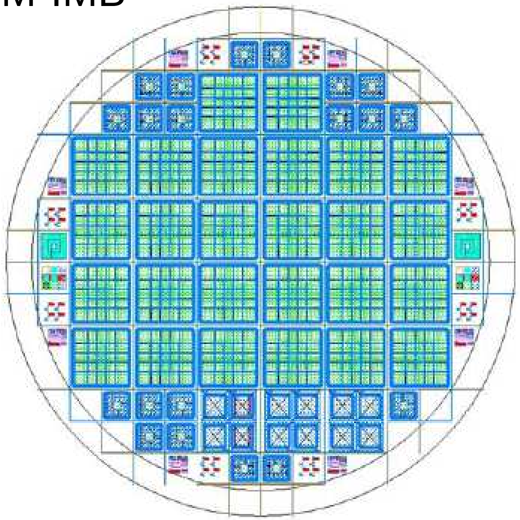
Outline

I. Fabrication process
II. P-type μstrip detectors irradiated with neutrons
III. Setup (ALIBAVA system)
IV. Detectors (IV-QV)
V. Microdischarges
VI. Summary

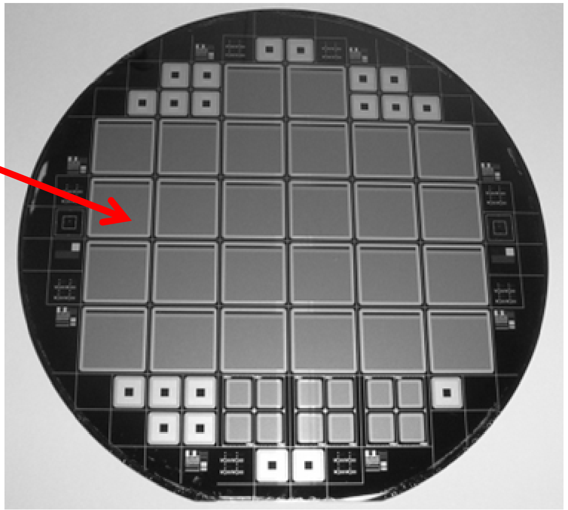
I. Fabrication Process

- Detectors have been fabricated in the Clean Room facility of CNM-IMB



- Rd50 Mask
  - Designed by the RD50 Collaboration
  - Double side processing
  - One metal layer
- Structures
  - 26 microstrips detectors
    - Polysilicon biasing resistors
    - Capacitive coupling
    - P-spray insulation
    - No p-stops
  - 20 pad detectors
  - 12 pixel detectors
  - 8 test structure sets

microstrips detectors used for this work

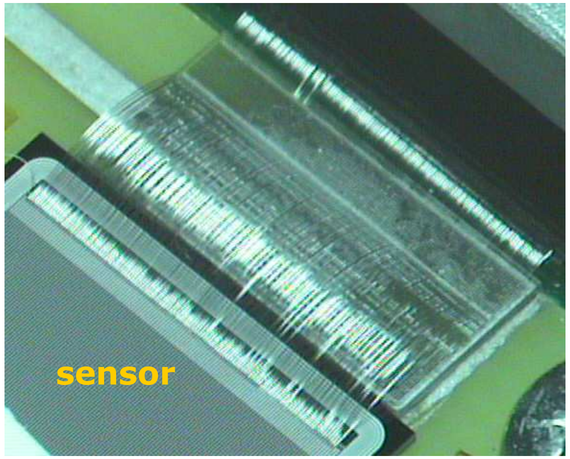


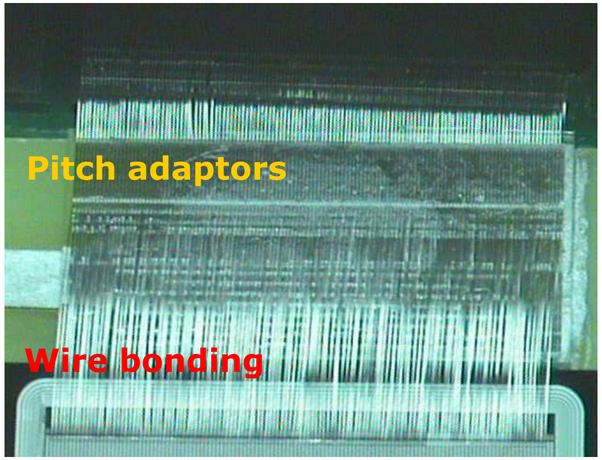
II. P-type μstrip detectors irradiated with neutrons

- Area: 1x1 cm^2
- 130 strips, width: 32 μm
- Pitch: 80 μm
- Thickness: 300 μm
- Multiple guard ring
- Surface isolation: p-spray

- FZ, MCz substrates to evaluate
- 1 MeV equivalent neutron irradiation at TRIGA nuclear reactor in Ljubljana, Slovenia.
- No annealing (except while wire bonding,~2h)

Wire bonding

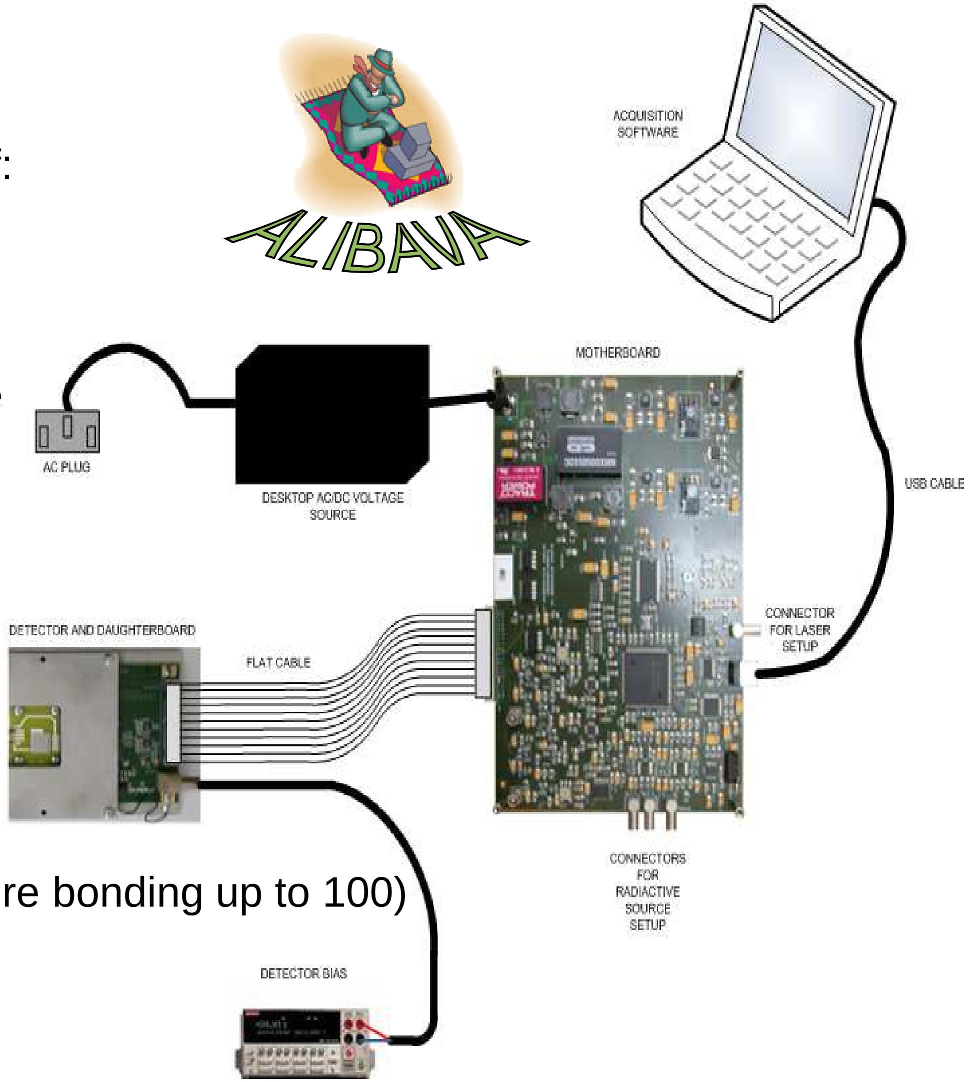




FLUENCES
$1X10^{14}$ n/cm^2
$3x10^{14}$ n/cm^2
$1x10^{15}$ n/cm^2
$3x10^{15}$ n/cm^2
$8x10^{15}$ n/cm^2

III. ALIBAVA system

- Compact and portable system consisting of:
  - Mother Board (MB):
    - Controls the hardware part
    - Processes de trigger signals and the analogue data
    - Communicates with a PC via USB
  - Daughter Board (DB)
    - Two Beetle chips in parallel mode
    - 256 input channels (128 per chip)
    - 3 types of pitch adaptors (multiple wire bonding up to 100)

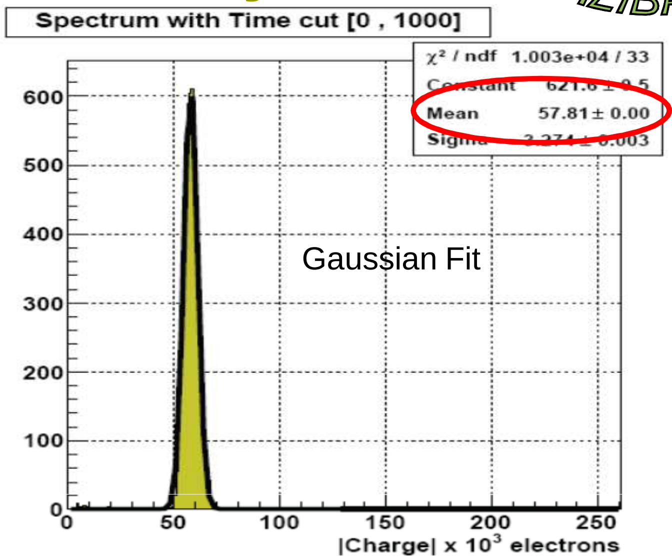


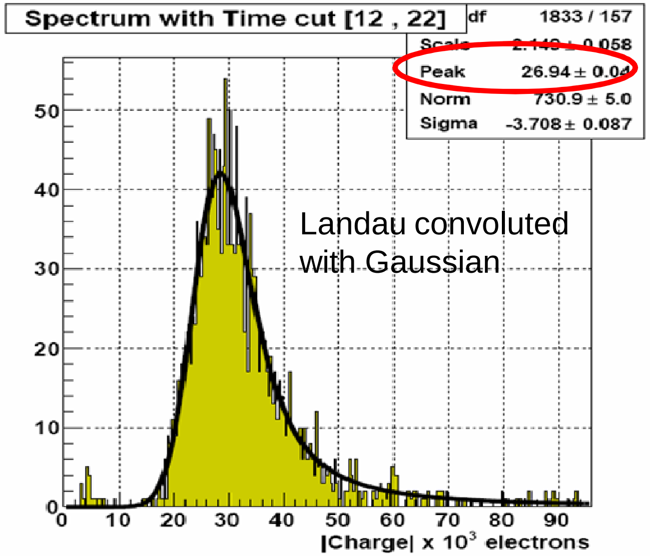
III. How to use the ALIBAVA system

- Laser measurements:
  - Laser synchronization (laser delay in ns)
  - Laser run and data analysis (calibration and pedestals applied)

- Radioactive source (^{90}Sr) measurements:
  - Final Collected Charge-Bias Voltage curves made with the laser setup. Measurements with the beta setup are only necessary for a few bias voltage. They are used to calibrate the laser beam.
  - Trigger configuration (one or two PM's, threshold ...)

- Normalization to 24ke$^-$ (in order to compare with other measurements)





IV. Detectors

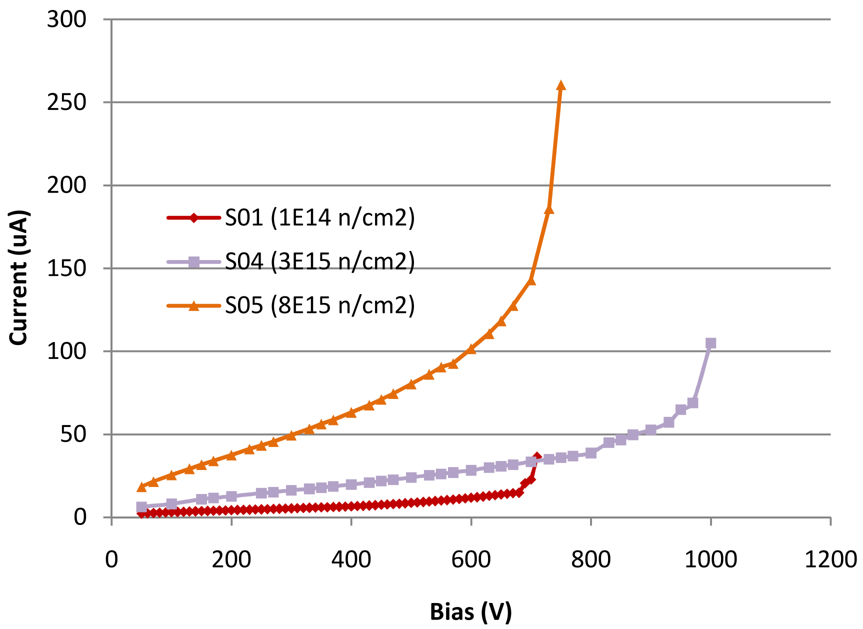
- We have measured three different wafers
  - Two with n-on-p sensors
  - One with n-on-n sensor to compare
- Each wafer has sensors irradiated with neutrons at different doses

Type	Wafer	Non-irradiated	10^{14}(n/cm^2)	3x10^{14}(n/cm^2)	10^{15}(n/cm^2)
n-on-n FZ	W17	S24	S01	S02	S03
n-on-p FZ	W04	S08	S01	S02 ✕	S03
n-on-p MCZ	W10	S21 ✕	~~S15~~	~~S16~~	~~S17~~

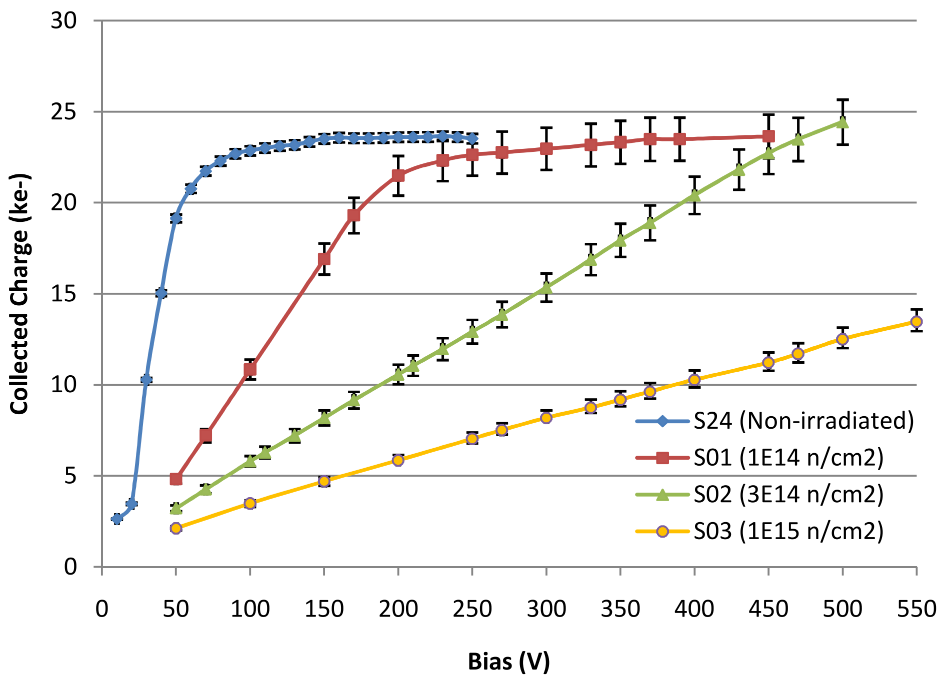
- ✕ : we could not read out any signal
- ----- : we could not normalise the measurements with the corresponding non irradiated sensor

IV. Detectors: Wafer 17 (n-on-n FZ)

(-25ºC)



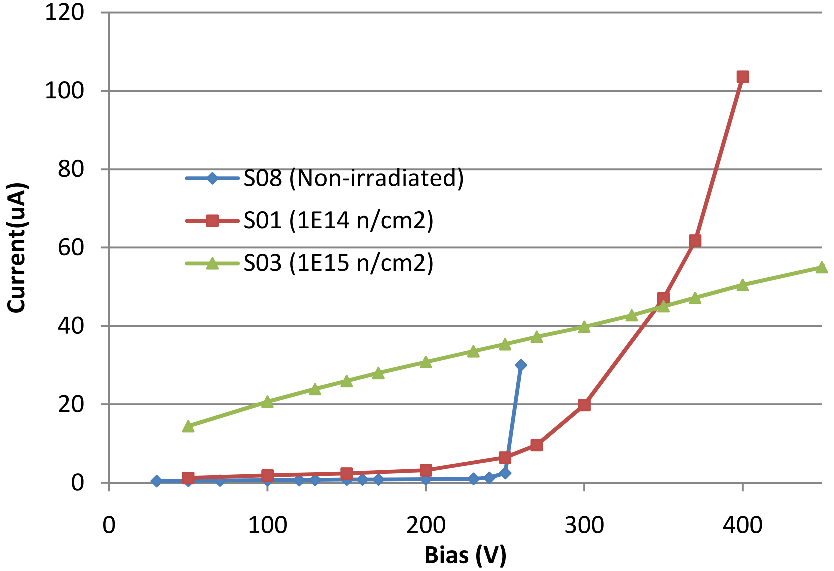
IV Curves



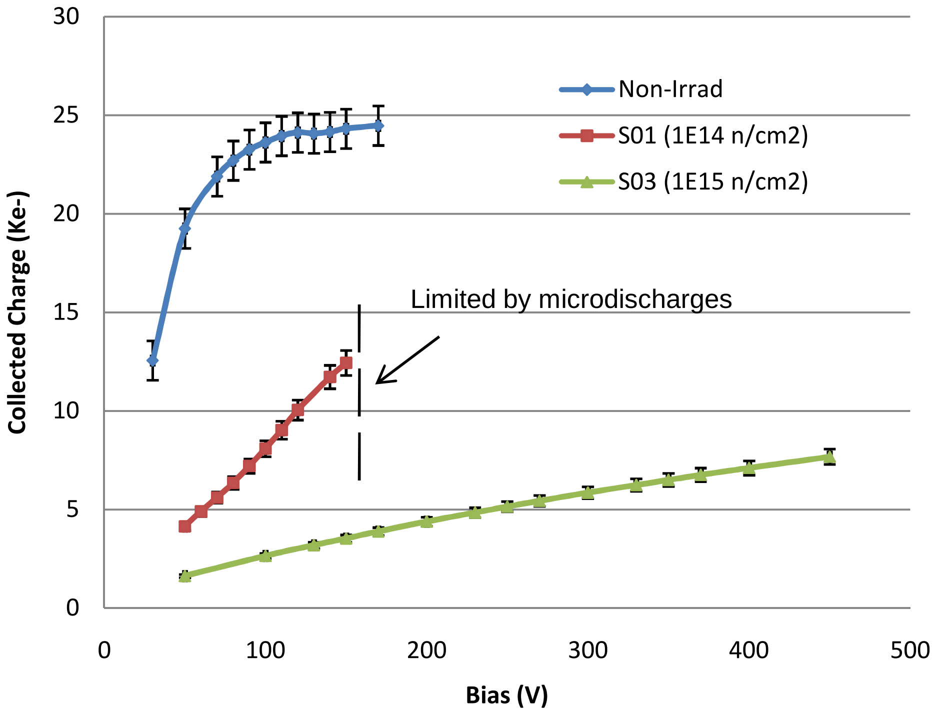
QV Curves

IV. Detectors: Wafer 04 (n-on-p FZ)

(-25ºC)



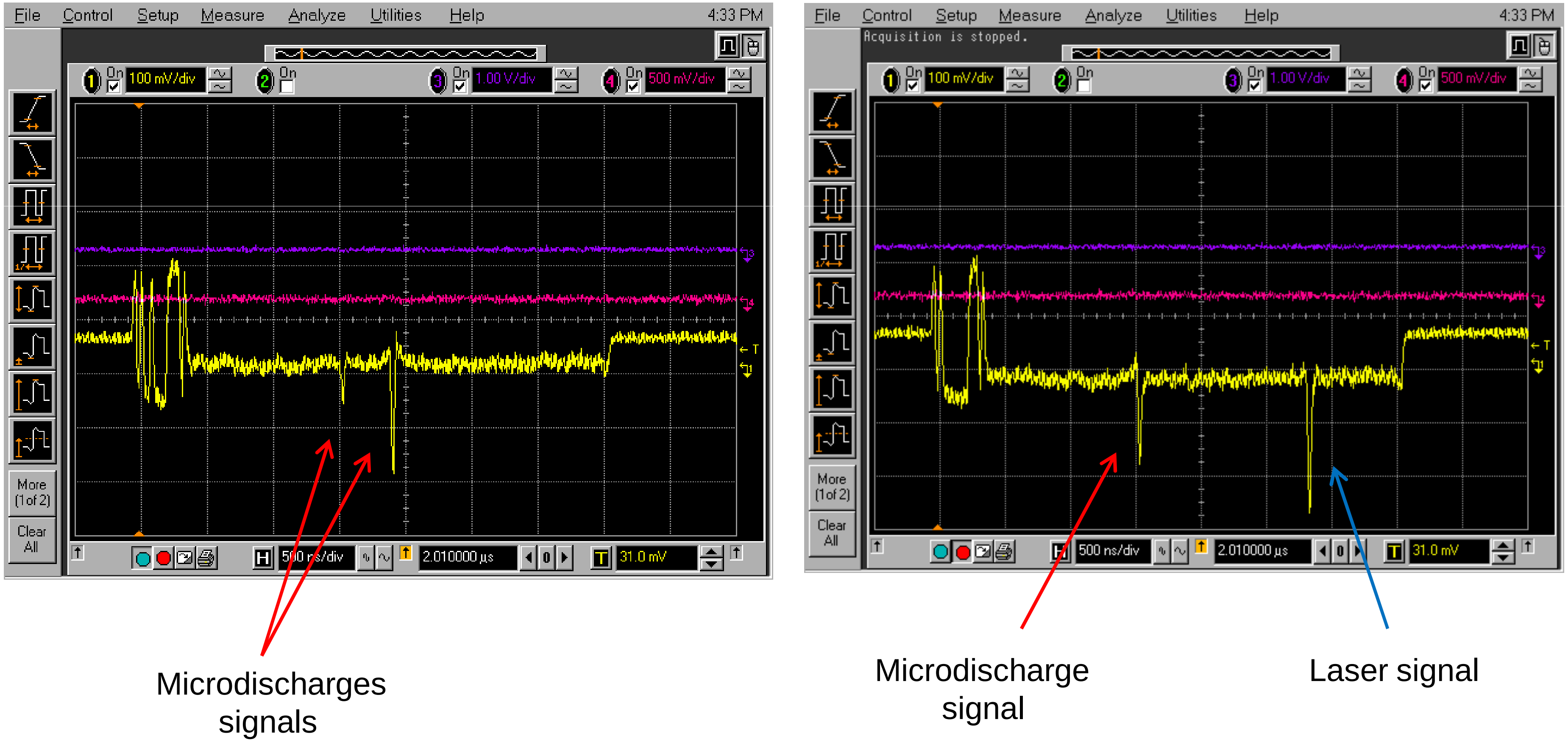
IV Curves



QV Curves

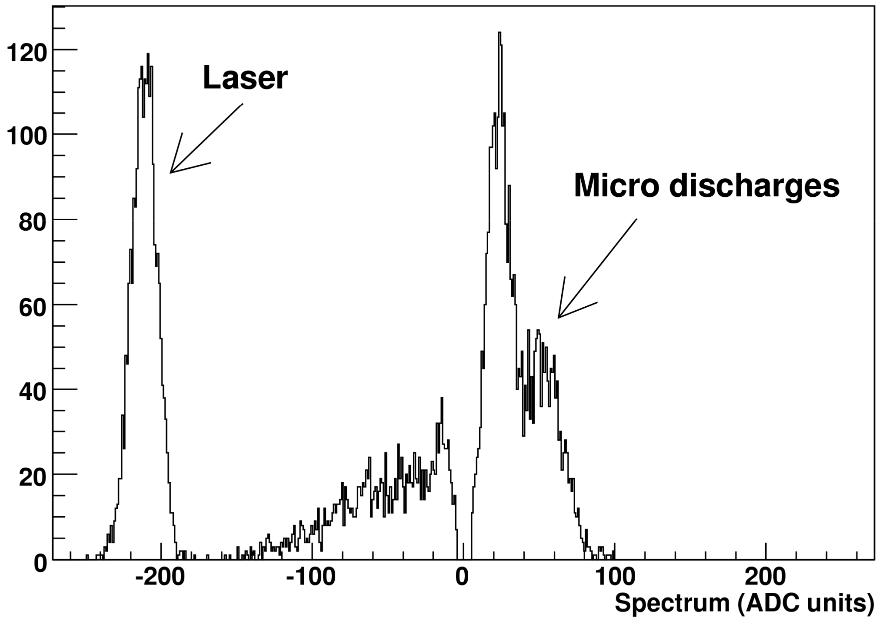
V. Microdischarges

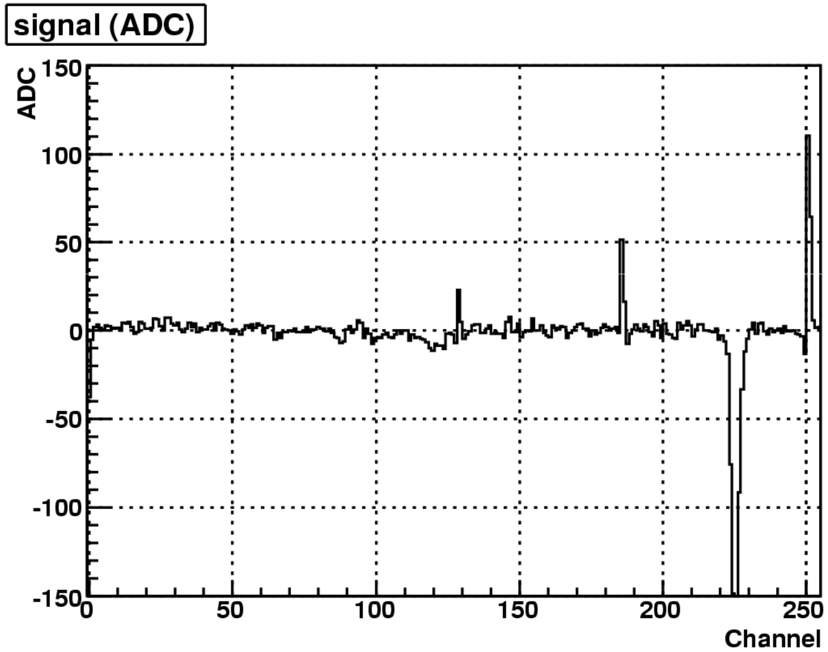
- Microdischarges have been observed in these detectors during the measurements in our setup
- They appear as high signal peaks.



V. Microdischarges

- Microdischarges can represent a problem for the beetle chip. They can burn it.
- They can have both polarities.

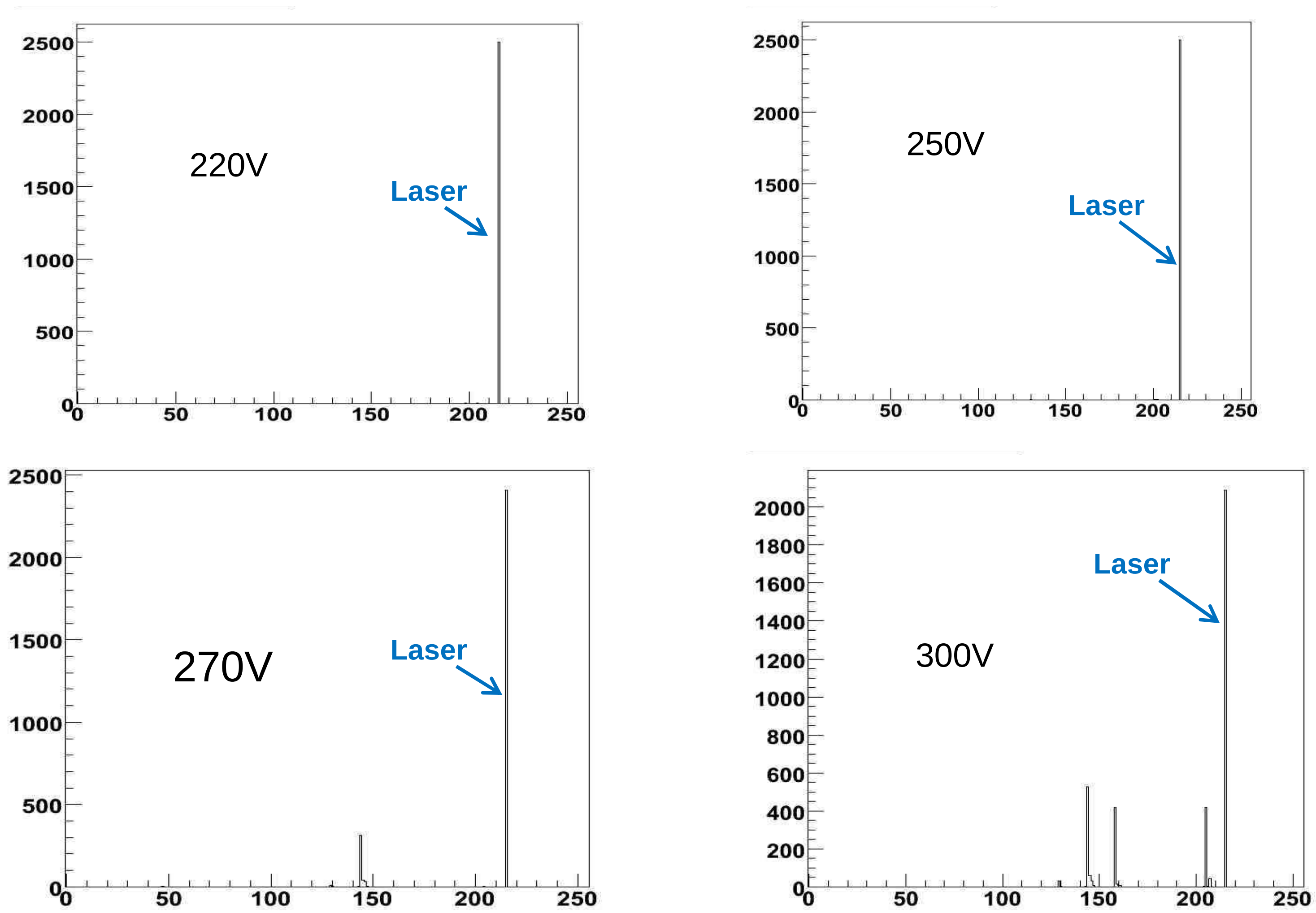




V. Microdischarges

S02-W04 (irradiated 3x10E14)

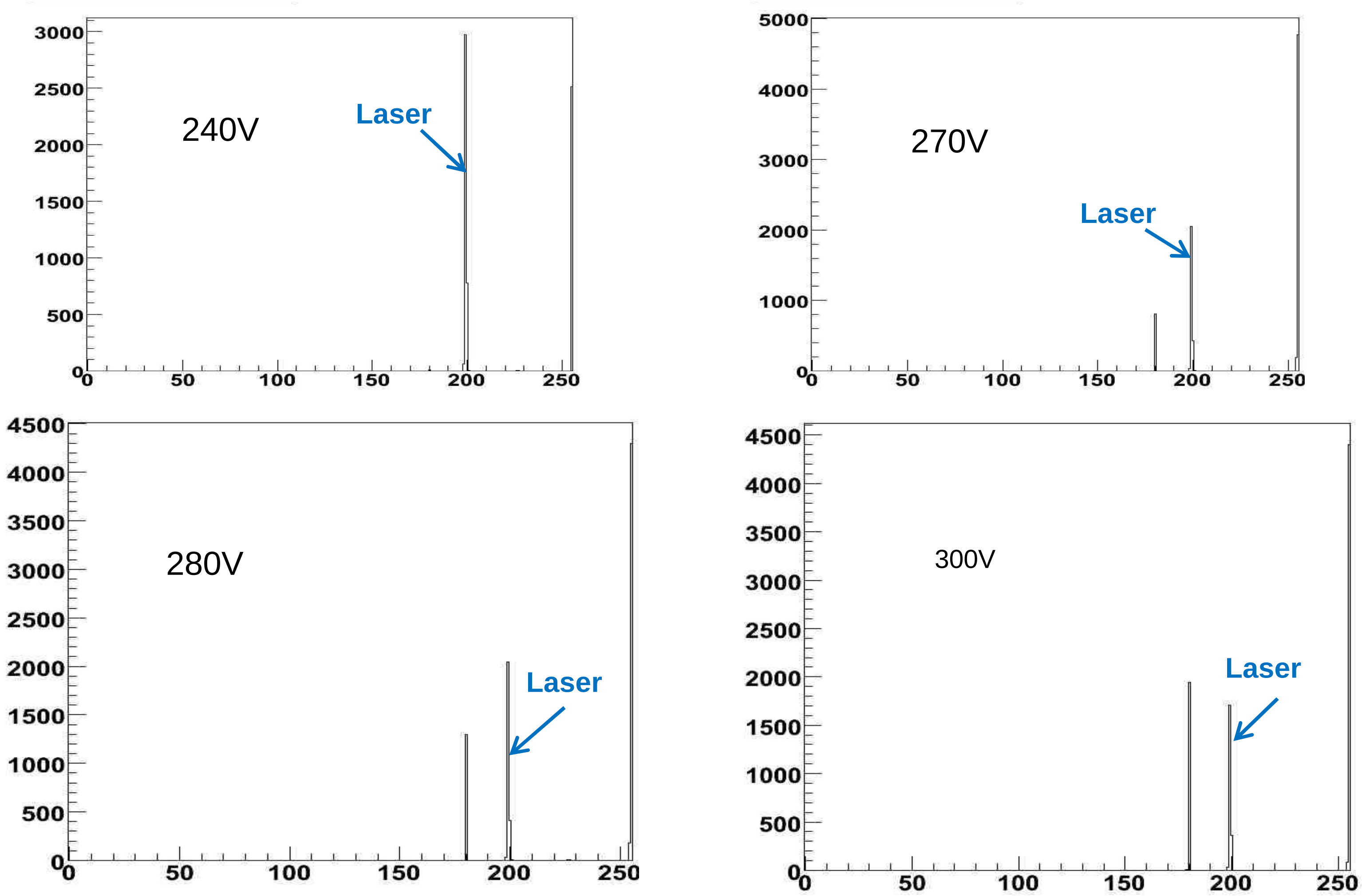
Hit Map



V. Microdischarges

S24-W17 (non-irradiated)

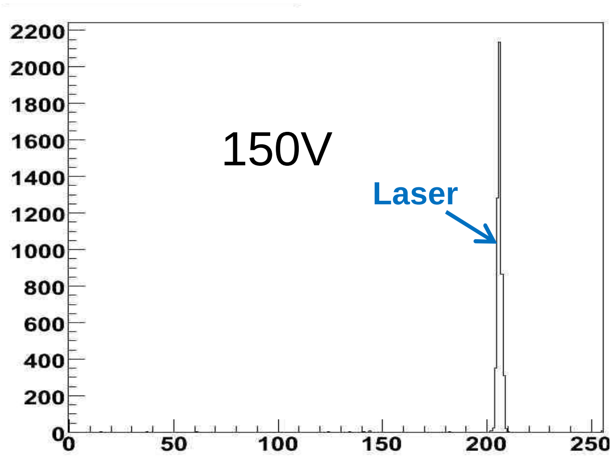
Hit Map

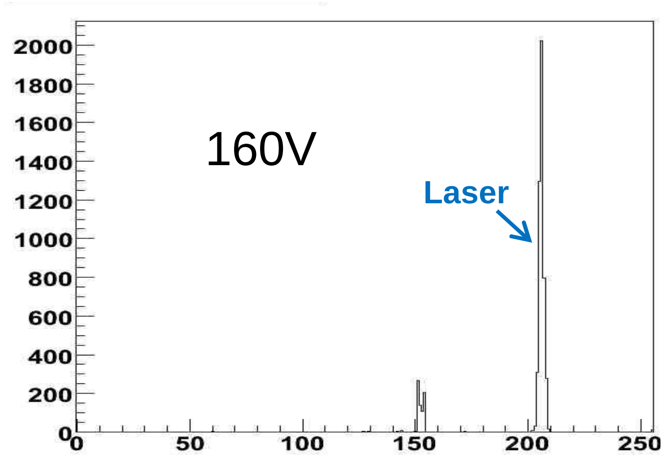


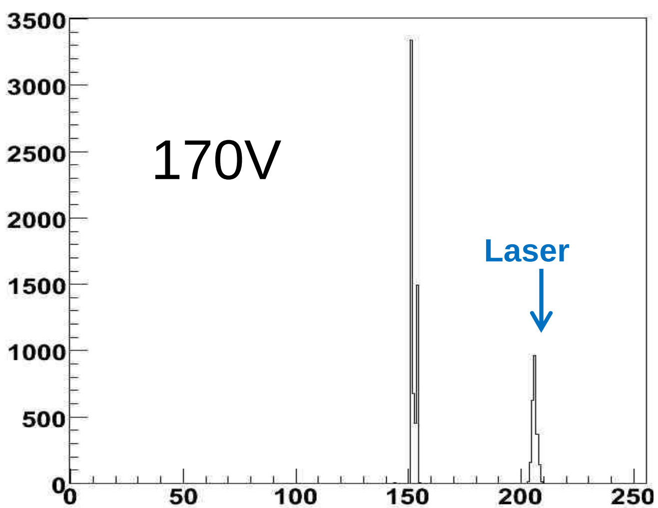
V. Microdischarges

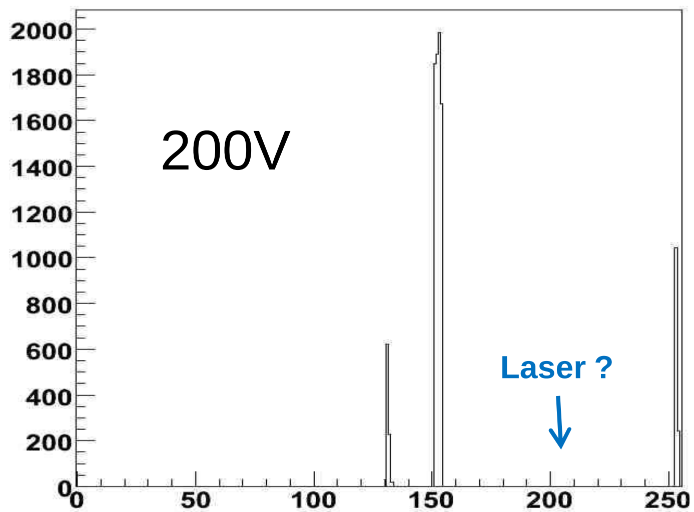
S08-W04 (non-irradiated)

Hit Map





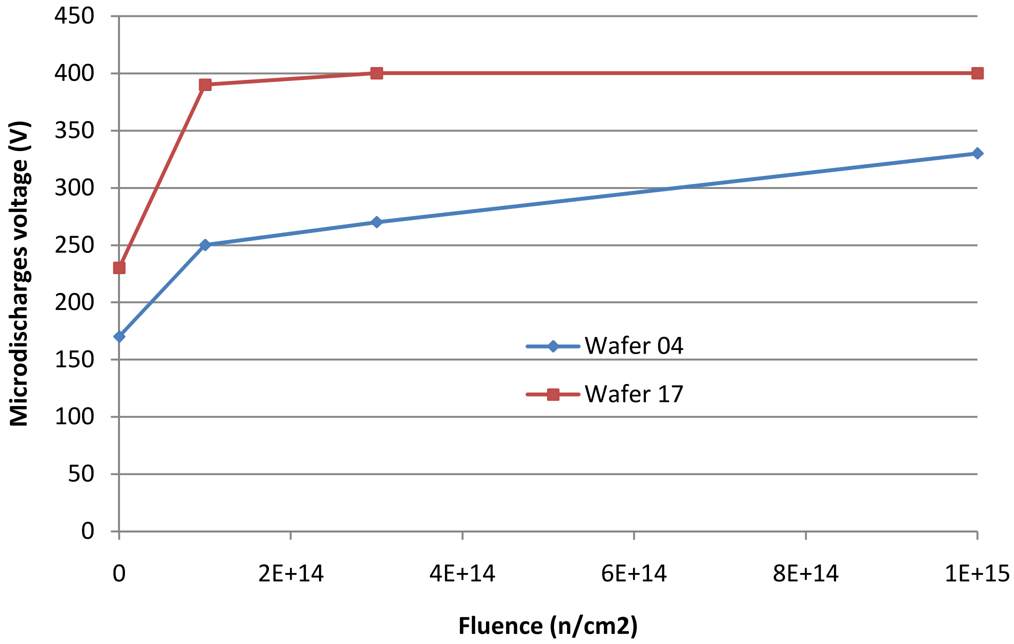




V. Microdischarges

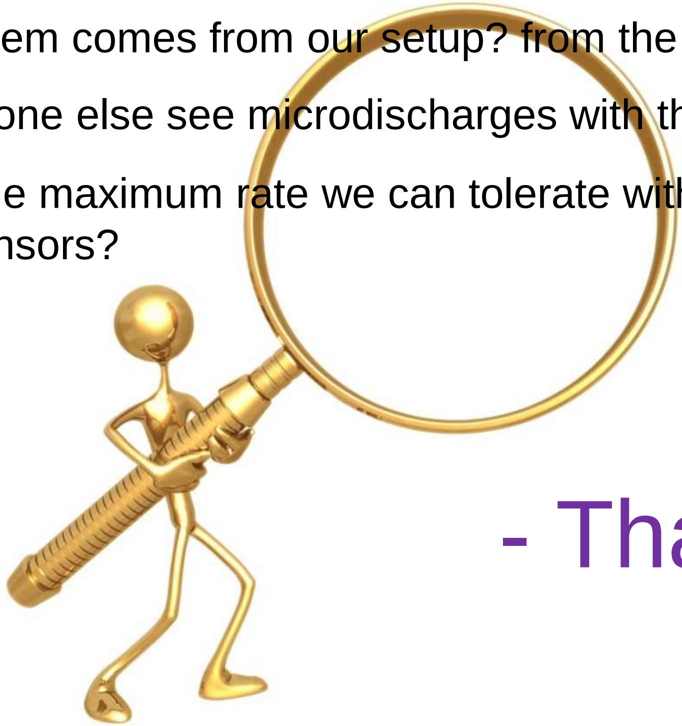
- At higher fluences, the microdischarges appear later

Microdischarge Voltage (V)		
Fluence (n/cm2)	**Wafer 04** (n-on-p FZ)	**Wafer 17** (n-on-n FZ)
0	170	230
$1x10^{14}$	250	390
$3x10^{14}$	270	400
$1x10^{15}$	330	400



VI. Summary

- N-on-N and N-on-P microstrip silicon sensors have been measured and characterized in terms of their neutron radiation damage with the ALIBAVA system.
- Measurements limited by massive microdischarges
  - We need to understand Microdischarges
  - This problem comes from our setup? from the detectors?
  - Does anyone else see microdischarges with these kind of sensors?
  - What is the maximum rate we can tolerate without worrying about electronics and/or sensors?



- Thank you -

- Backup -

III. How to use the ALIBAVA system

- Correction factors:
  - Comparison between collected charge by radiation source and laser

$$Rsrc = \frac{\text{Collected Charge (source setup)}}{\text{Collected Charge (laser setup)}}$$

(Non-irradiated sensor)

  - Normalization of the radioactive source's peak at 24.000 electrons

$$R_{24} = \frac{24}{Q_{mean}\text{ (source setup)}}$$

(Non-irradiated sensor)

  - Temperature dependence: Use calibration at 20ºC and gain correction factor (only applied to irradiated sensors)

$$R_{cal} = \frac{Q_{outside}\text{ (source setup)}}{Q_{inside}\text{ (source setup)}}$$

(Non-irradiated sensor)

- For laser data with irradiated detectors: $\mathbf{Q_{corrected} = R_{24} \times Rcal \times Rsrc \times Q_{cal}}$
  - Q_{cal} is the collected charge in electrons with the calibration (ADC/electrons conversion)