Characterization of P-type Silicon Detectors Irradiated with Neutrons

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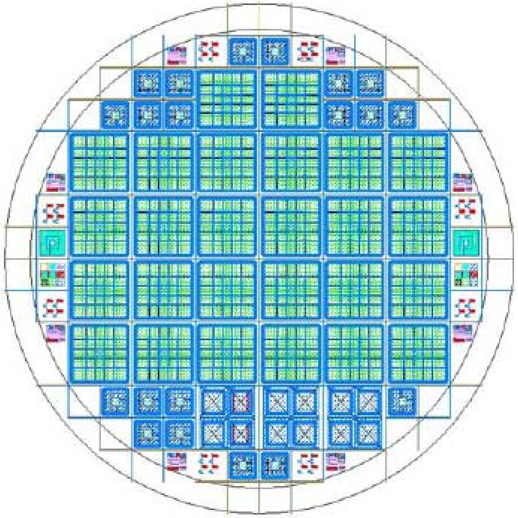
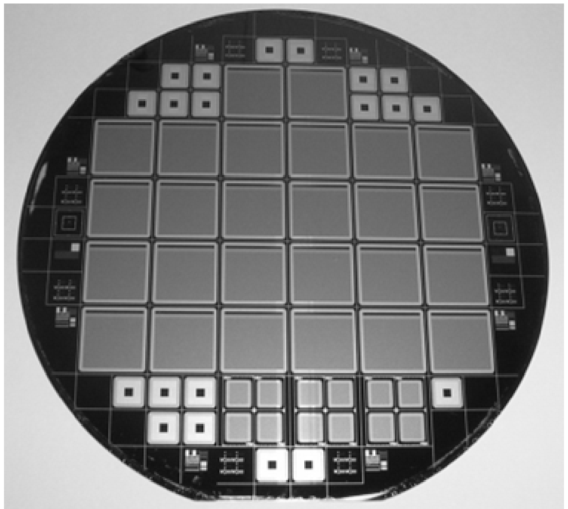
Outline

I. Fabrication process
II. P-type μstrip detectors irradiated with neutrons
III. Setup (Laser & Radiactive Source)
IV. I-V results
V. Q-V results
VI. Summary and Outlook

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



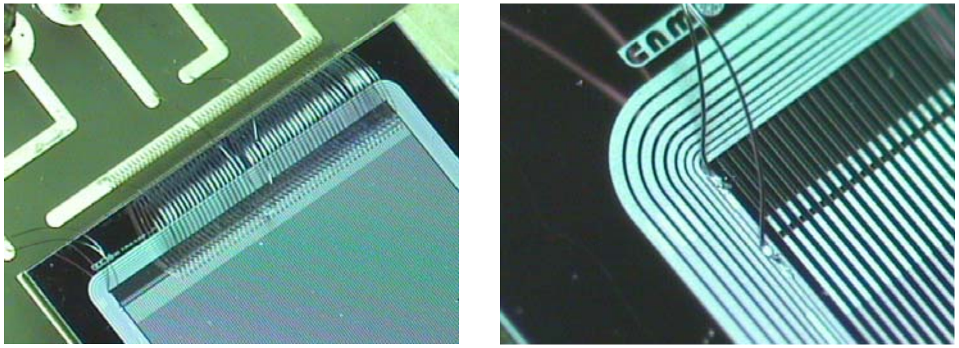


II. P-type μstrip detectors irradiated with neutrons

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

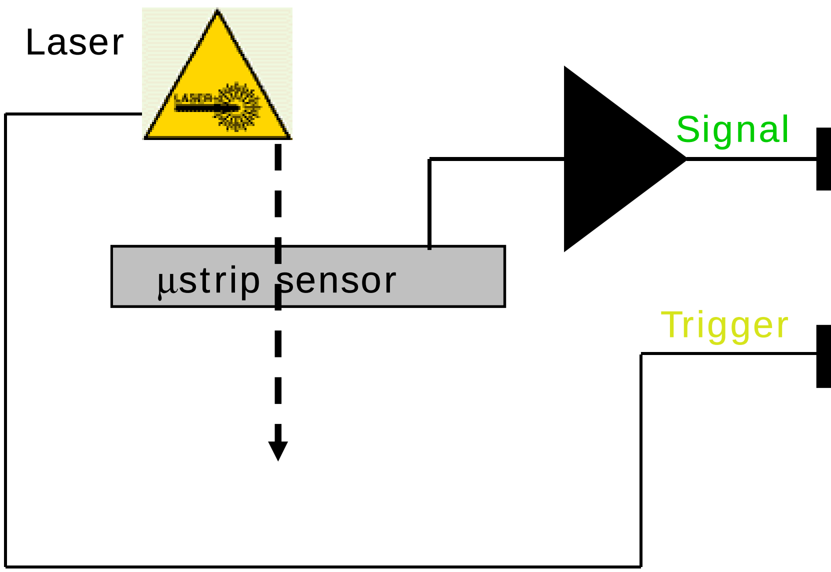
- DOFZ, MCz substrates to evaluate
- 1 MeV equivalent neutron irradiation at TRIGA nuclear reactor in Ljubljana, Slovenia.
- No annealing

Wire bonding

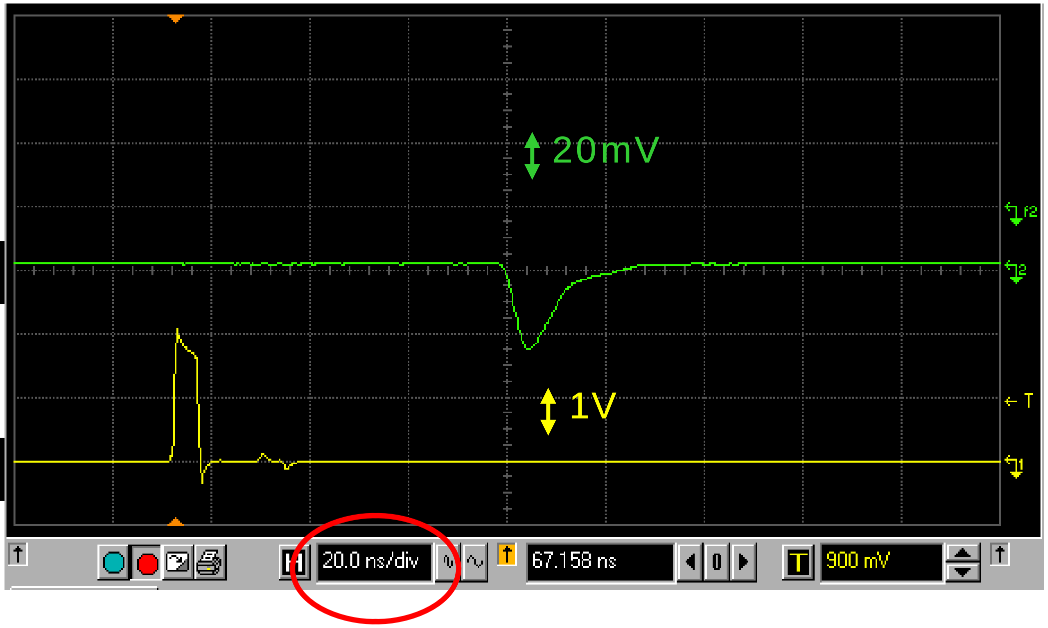


FLUENCES
$1X10^{14}$ n/cm^2
$3x10^{14}$ n/cm^2
$1x10^{15}$ n/cm^2
$3x10^{15}$ n/cm^2
$8x10^{15}$ n/cm^2

III. Laser Setup



Real signal viewed at 70V in the scope



Horizontal scale

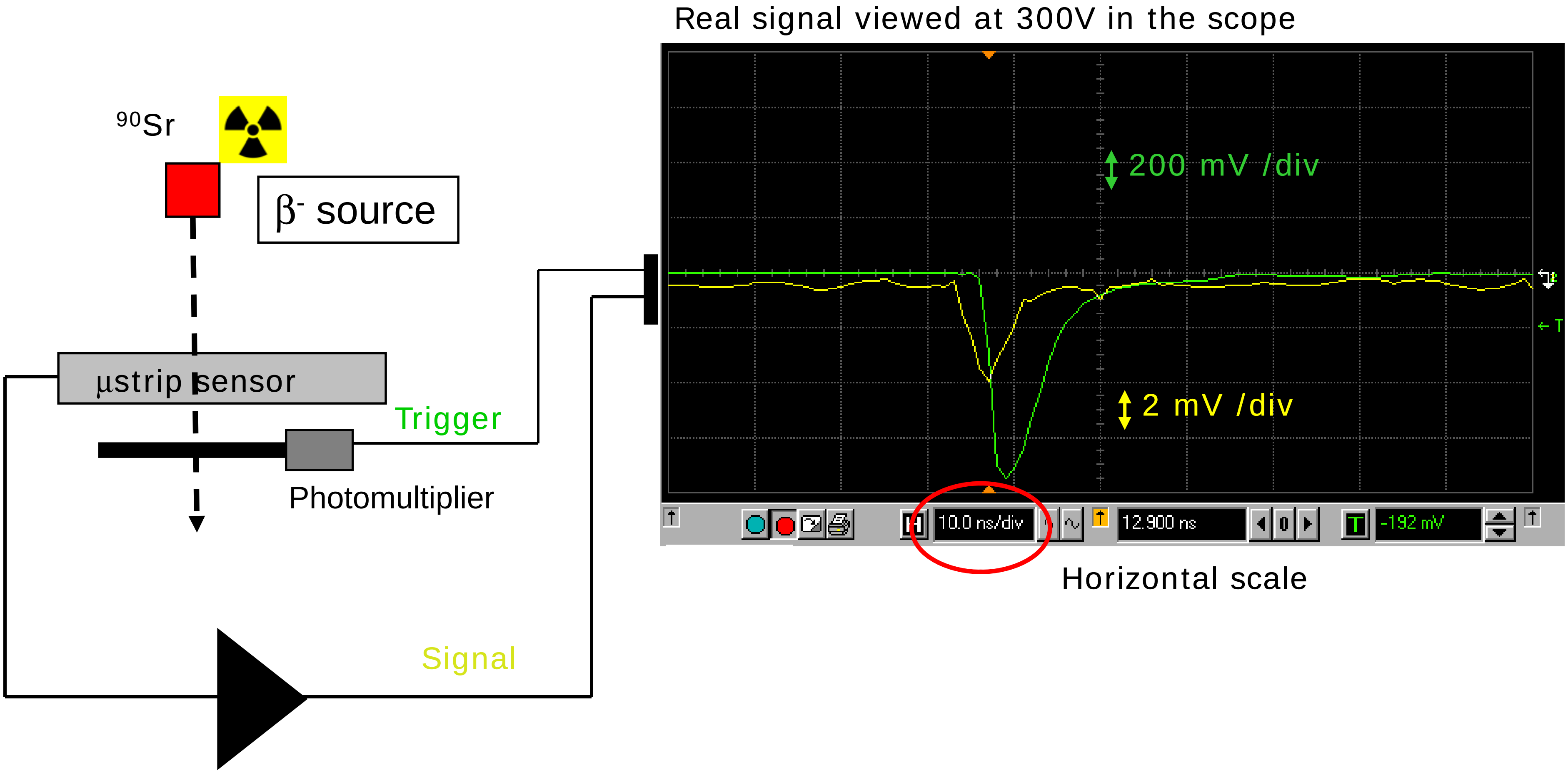
- Laser light is generated by exciting a laser source with an external pulsed signal

(2 V and 1 MHz rate)

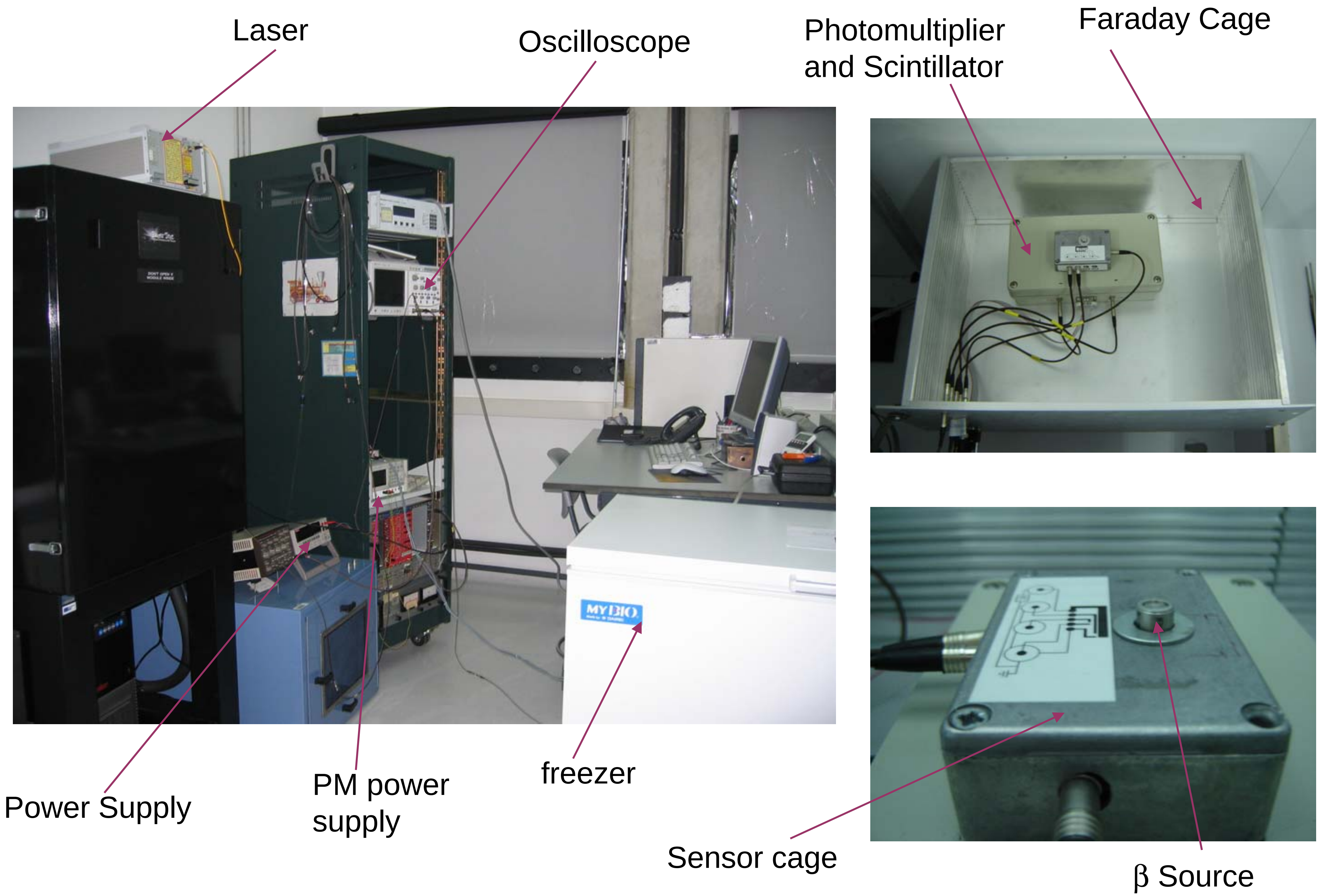
Laser properties:

- λ=1060 nm (Near Infrared)
- Laser energy of photons=1.170 eV

III. Radiactive Source Setup

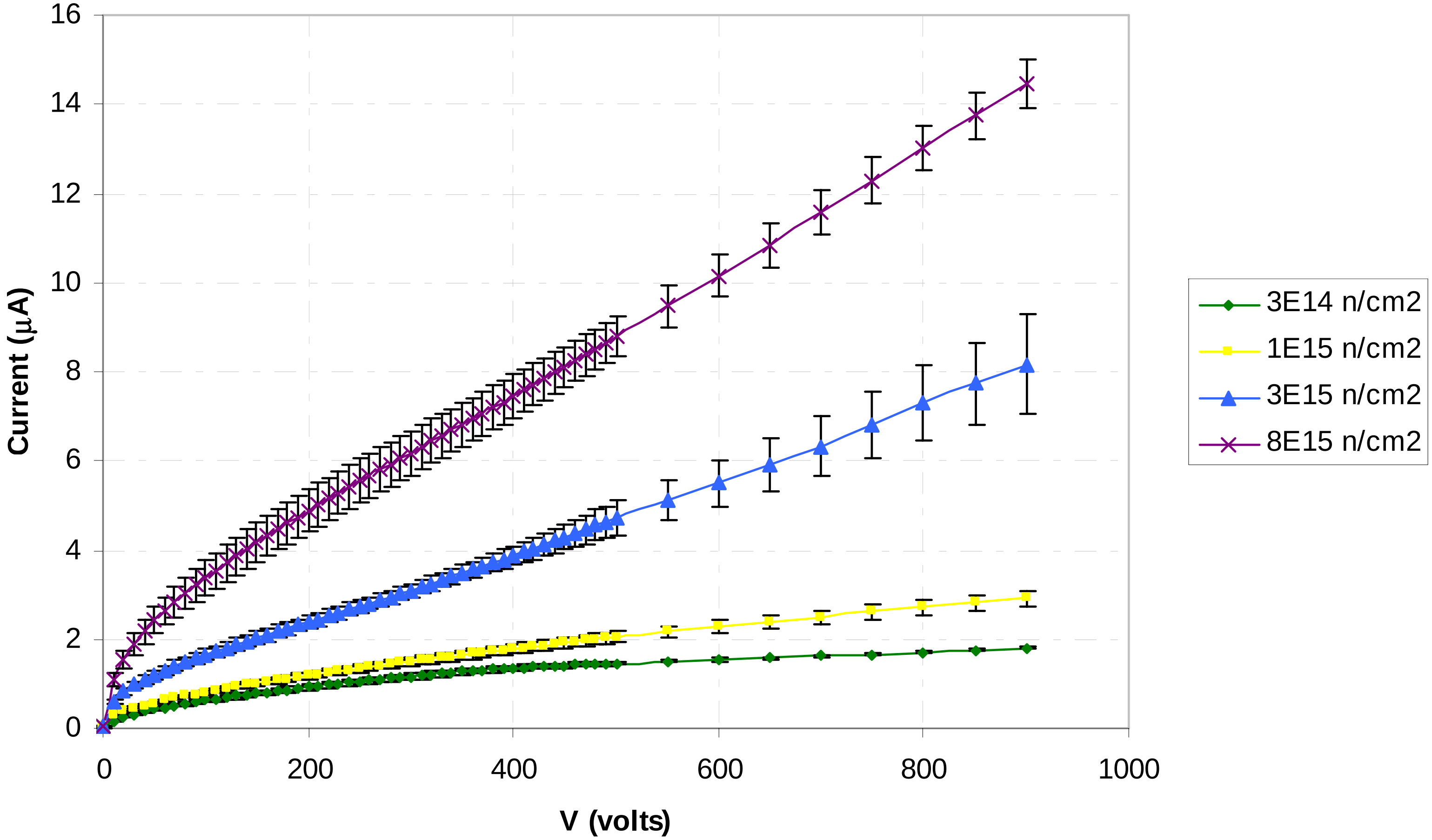


β Measurements are used to calibrate the laser measurements


Laser
Oscilloscope
Photomultiplier and Scintillator
Faraday Cage
Power Supply
PM power supply
freezer
Sensor cage
β Source

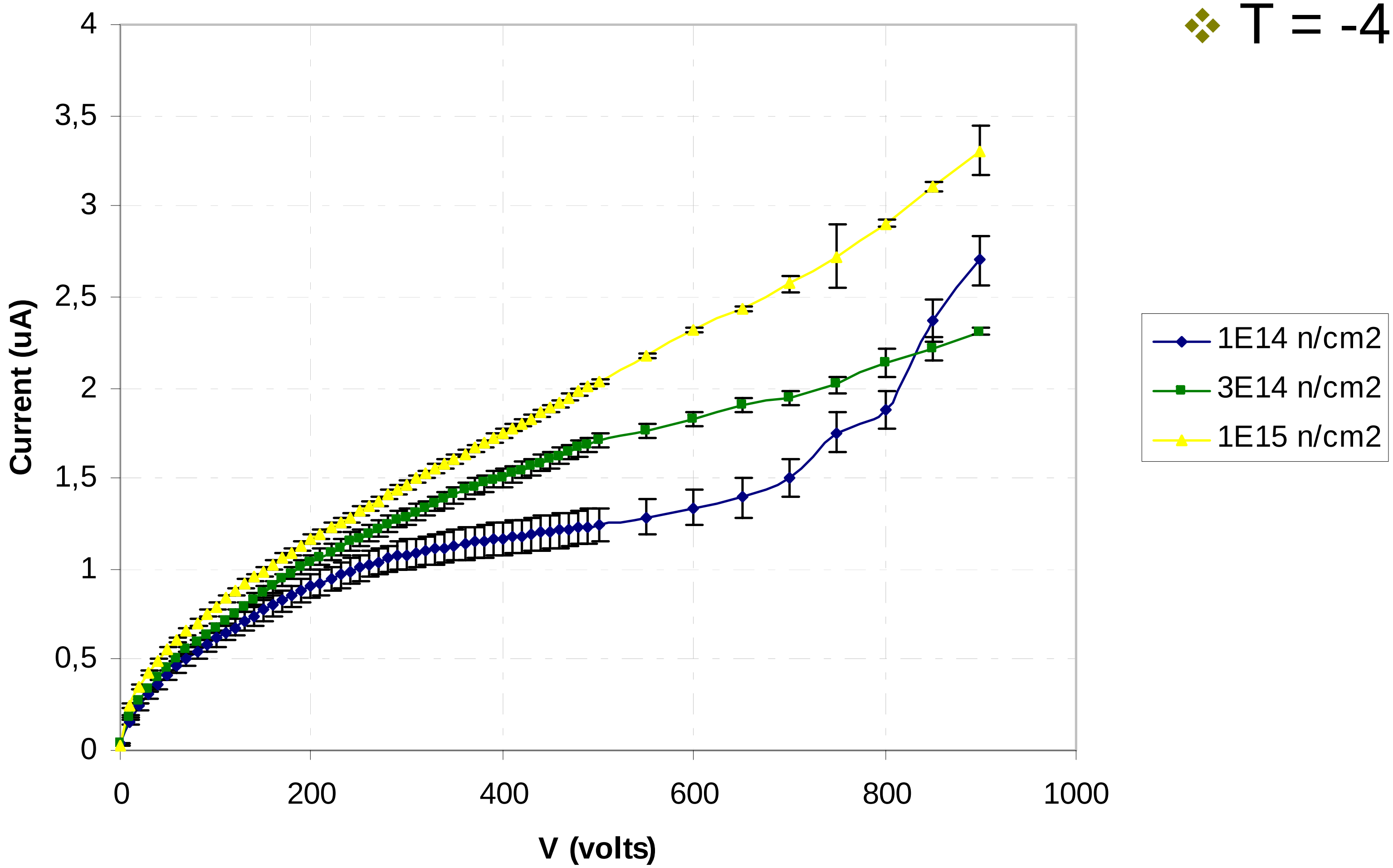
IV. Current vs Voltage: DOFZ

- T = -40^{o}C



For the sensor irradiated with 1x10^{14} n/cm^{2} we observed an extremely early break

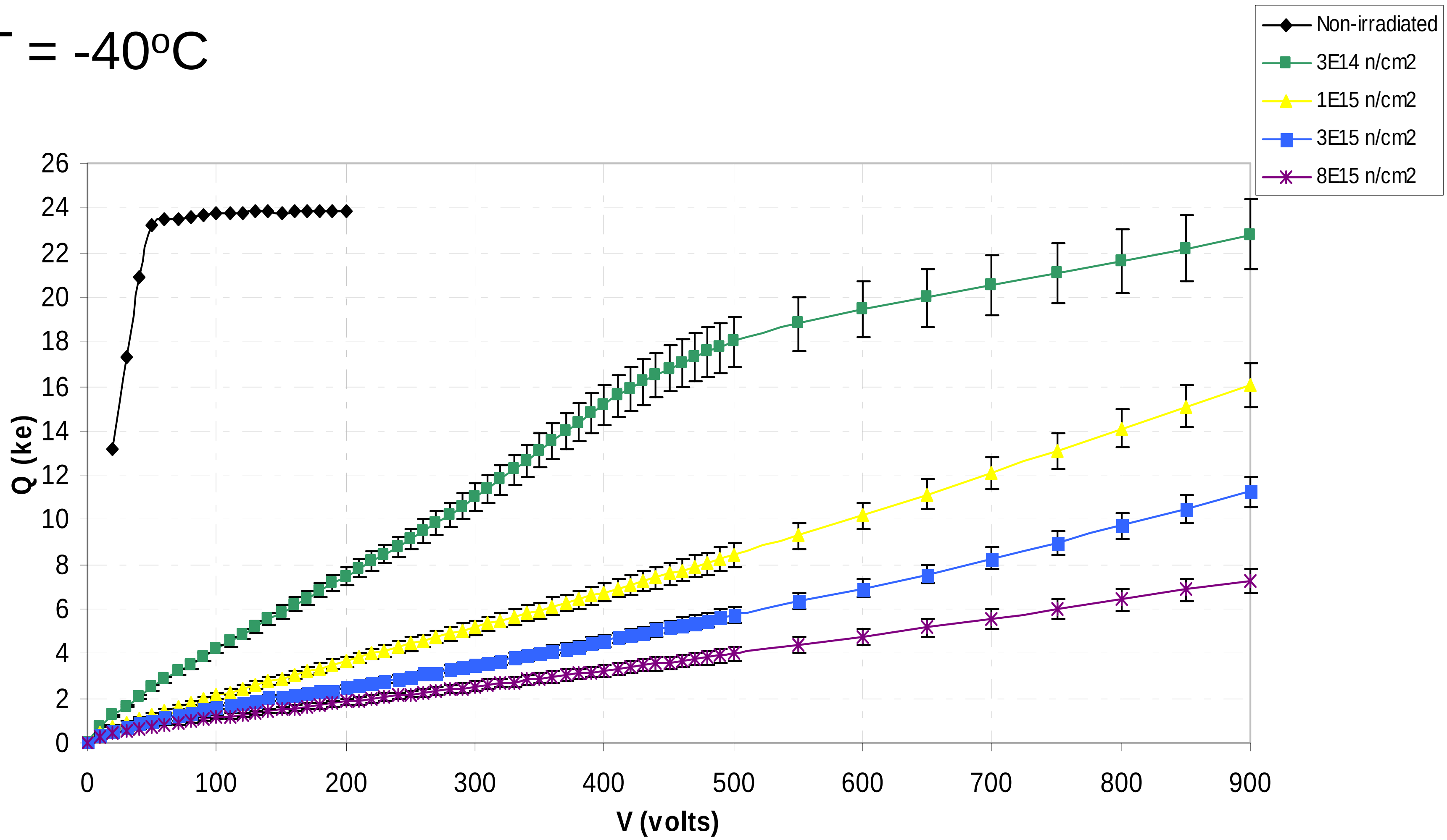
IV. Current vs Voltage: MCz



- T = -40°C

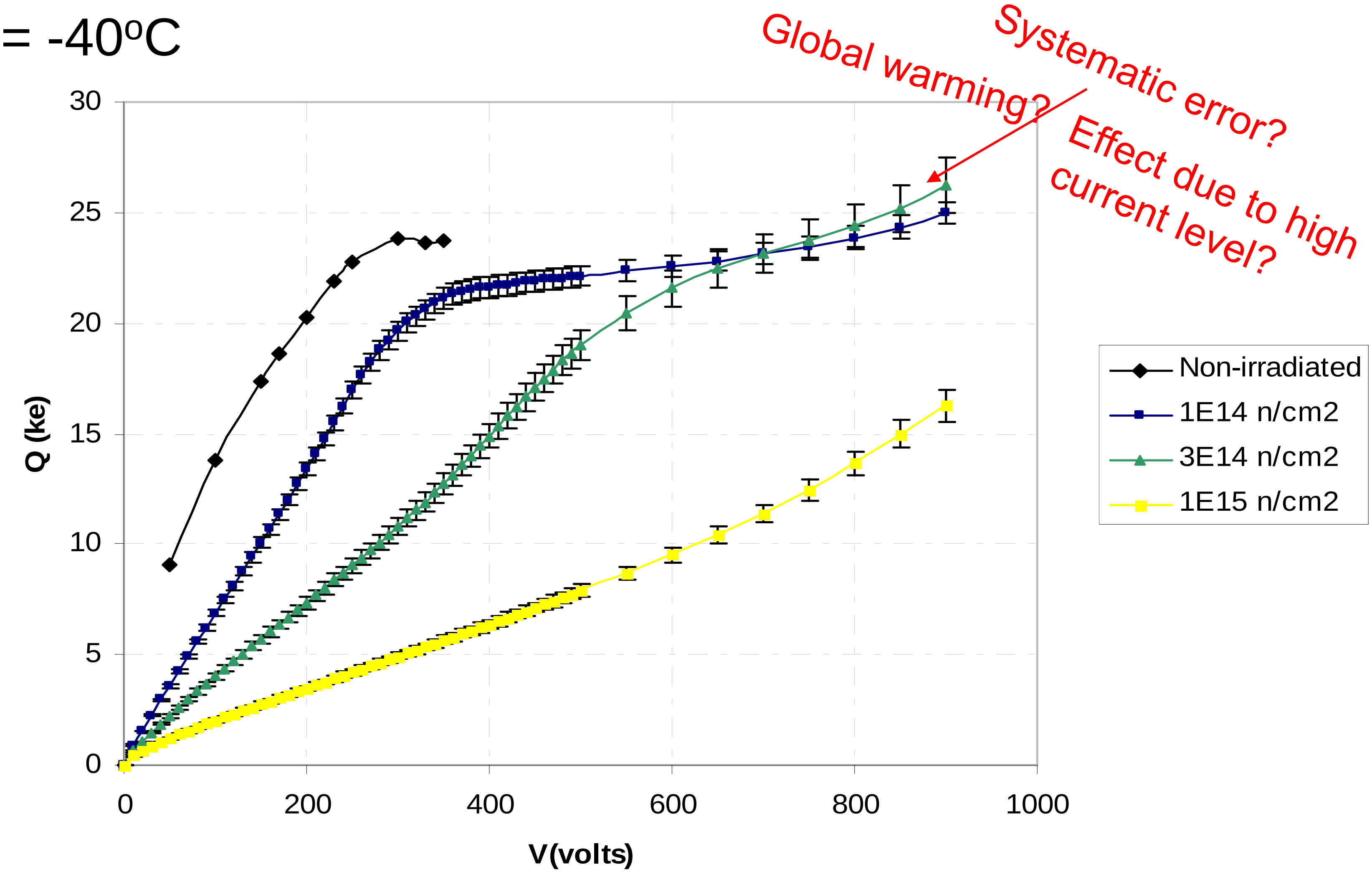
V. Charge vs Voltage: DOFZ

- T = -40°C



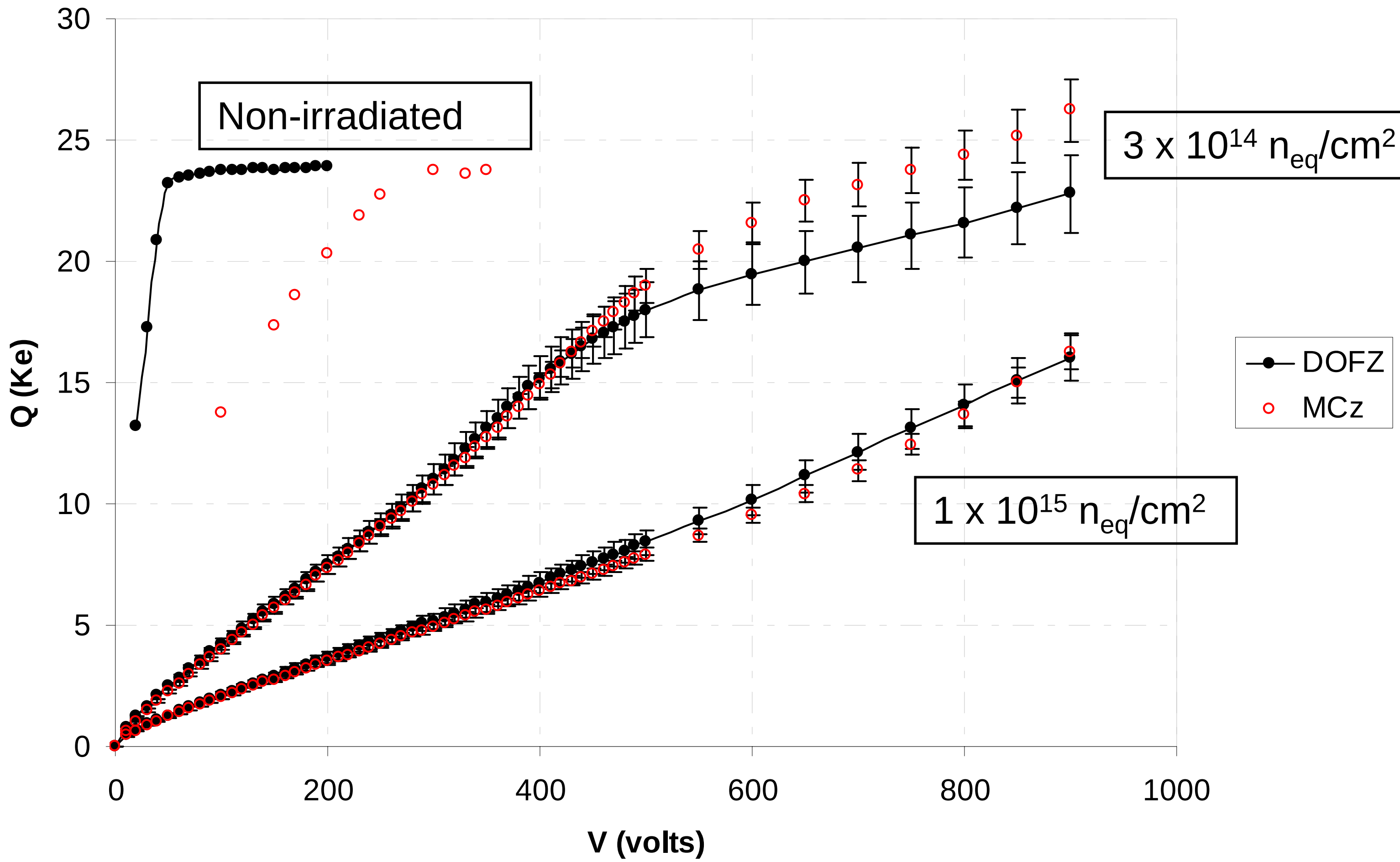
V. Charge vs Voltage: MCz

- T = -40ºC



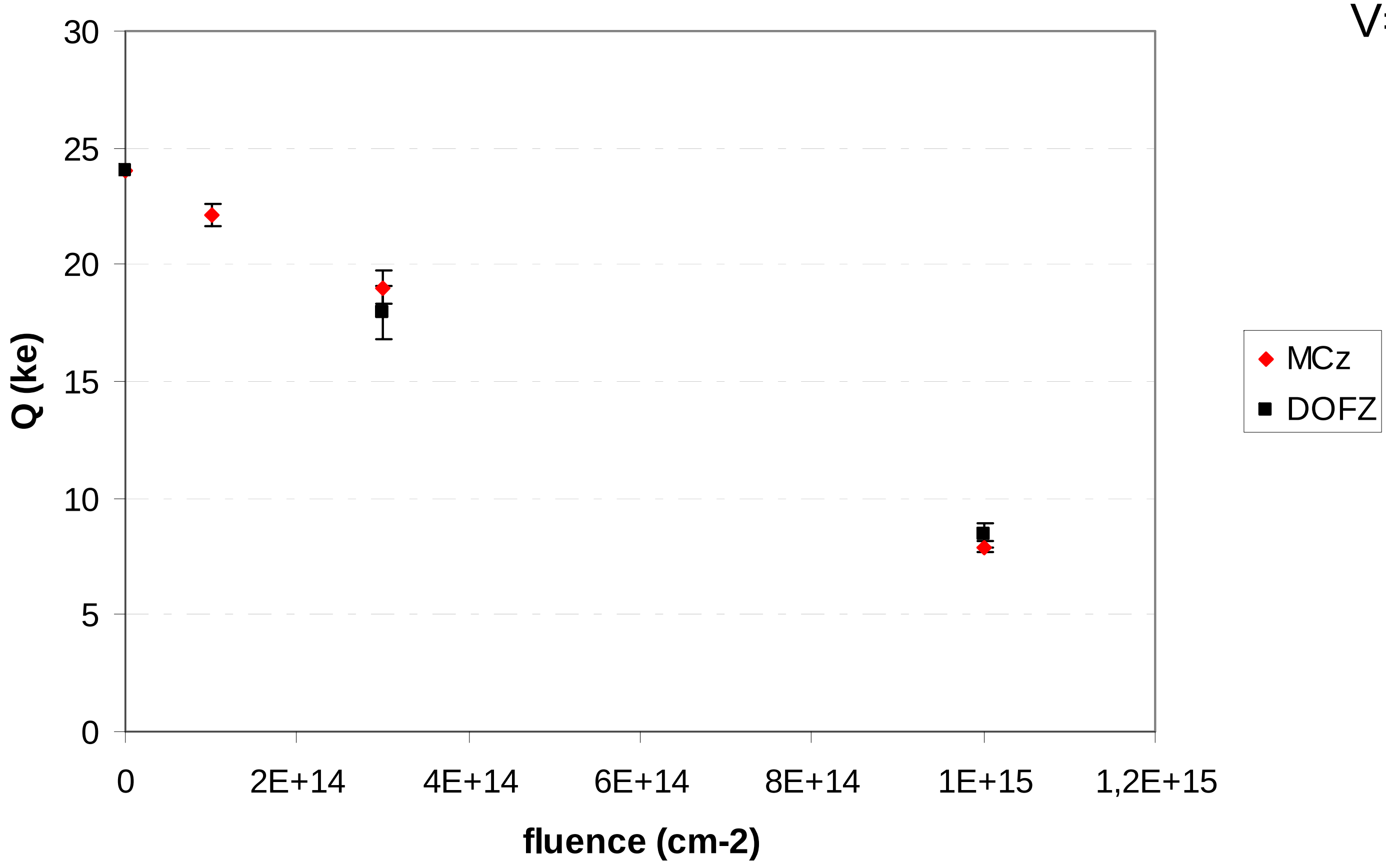
Neutron Irradiation:

Comparison DOFZ vs MCz substrates at the same fluences



Degradation after neutron irradiation: Q- Φ

V=500V



Collected charge is unaffected by the silicon substrate type

VI. Summary and Outlook

- P-type µstrip sensors have been fabricated in CNM-IMB and irradiated with neutrons at several fluences at the TRIGA Nuclear Reactor in Ljubljana.
- Detectors on alternative substrates (MCz, DOFZ) have been evaluated.
- Current and Collected charge vs Voltage measurements have been done.
- Even after the highest neutron fluence (equivalent to 10 years of the sLHC operation) the detectors are still operational.

For instance, at 8.0 10^{15} n/cm^2 ~7300 e- are collected at 900V.

- MCz charge collection at high bias voltages to be understood.
- The neutron radiation hardness does not depend on the substrate technology.
- Near future plans, ALIBAVA system will be used to performance the charge collection measurements and signal characterization.
- More neutron and proton irradiated detectores will be characterized in the coming months.