Different Charge Multiplication after proton and neutron irradiaton

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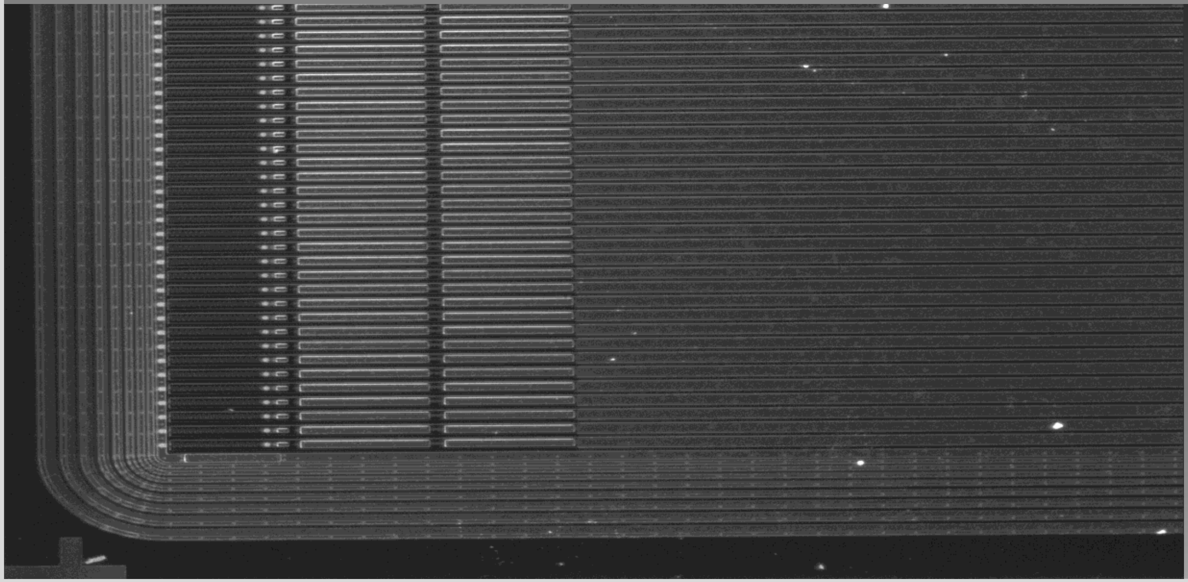
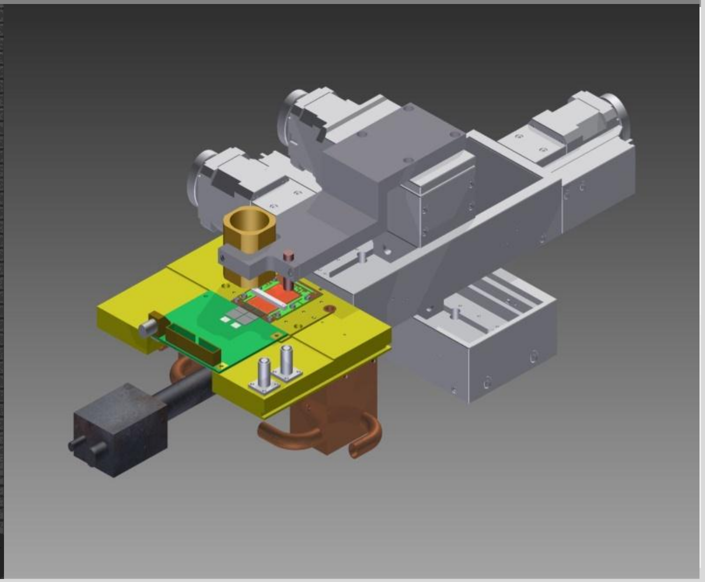
Lokman Altan, T. Barvich, F. Bögelspacher, W. de Boer, A. Dierlamm, Robert Eber,
K.-H. Hoffmann, A. Nürnberg, P. Steck

Institut für Experimentelle Kernphysik





Overview

- **Introduction**
  - **Overview of sensor properties**

- **Comparison between neutron and proton irradiation**
  - **CCE**
  - **Signal to noise ratio**
  - **Leakage current**

- **Comparison between sensors with standard processing and sensors with double implant energy**

- **Summary**

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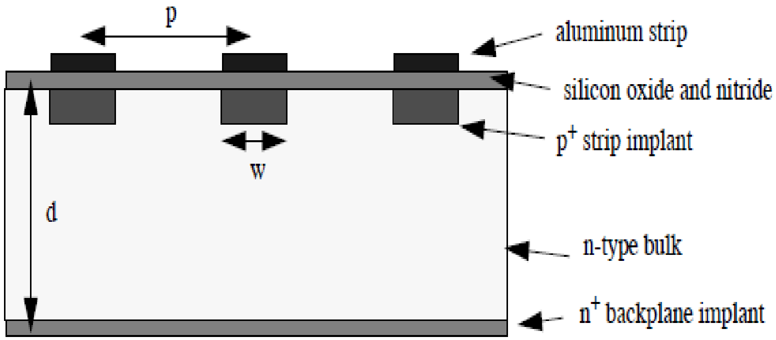
Institut für Experimentelle Kernphysik, KIT

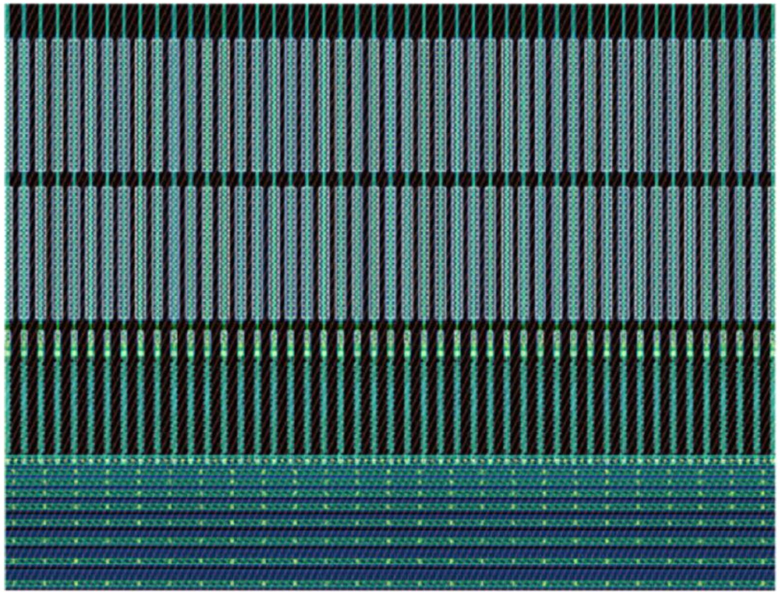
RD50 CM-Sensors: Properties

- P-type sensors
- 2 geometries
  - Depth d = 305 µm
  - Pitch p = 80 µm, width w = 6 µm
    pitch p = 80 µm, width w = 60 µm
  - Width/pitch w/p = 0.075 and w/p = 0.75
  - Active area: 10.18 mm x 11.76 mm



- 2 processings
  - 150keV implantation energy
  - 300keV implantation energy

- 2 irradiations
  - Irradiation with protons in Karlsruhe
  - Irradiation with neutrons in Ljubljana
  - Same fluence $5*10^{15}$ n_{eq}/cm^2



Measurement Results
different width/pitch - ratio

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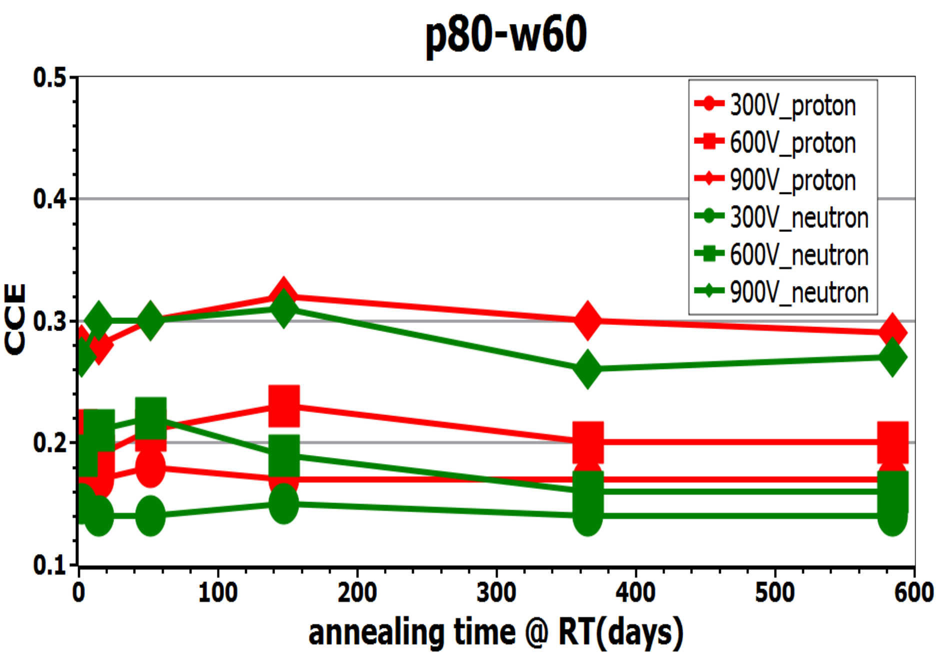
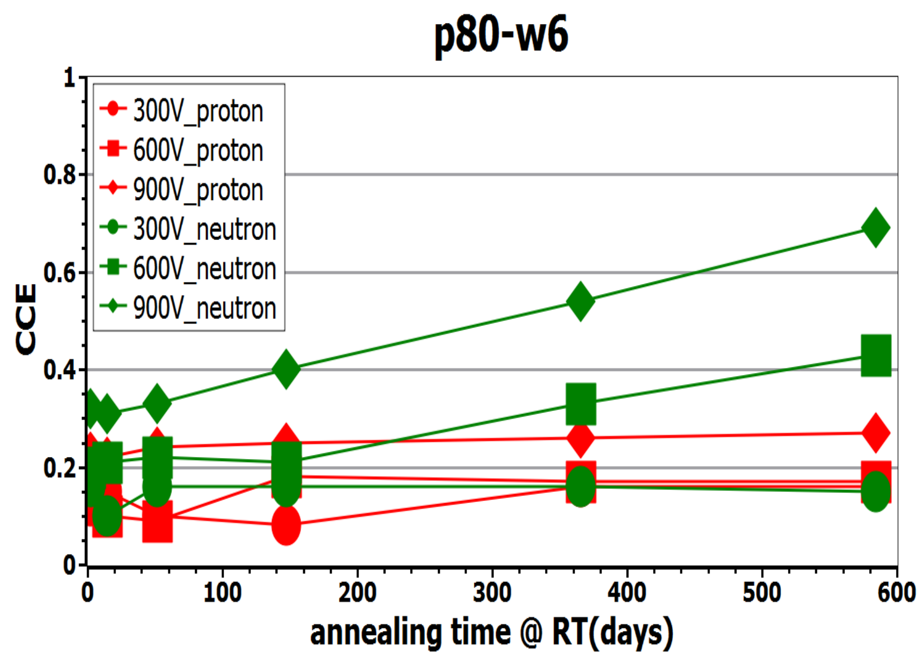
Institut für Experimentelle Kernphysik, KIT

Comparison between proton and neutron irradiation (CCE)





Broad implants show usual annealing behaviour

- Beneficial annealing up to 150d
- Reverse annealing later

Narrow implants show difference between protons and neutrons: more CCE after neutron irradiation
Charge multiplication?

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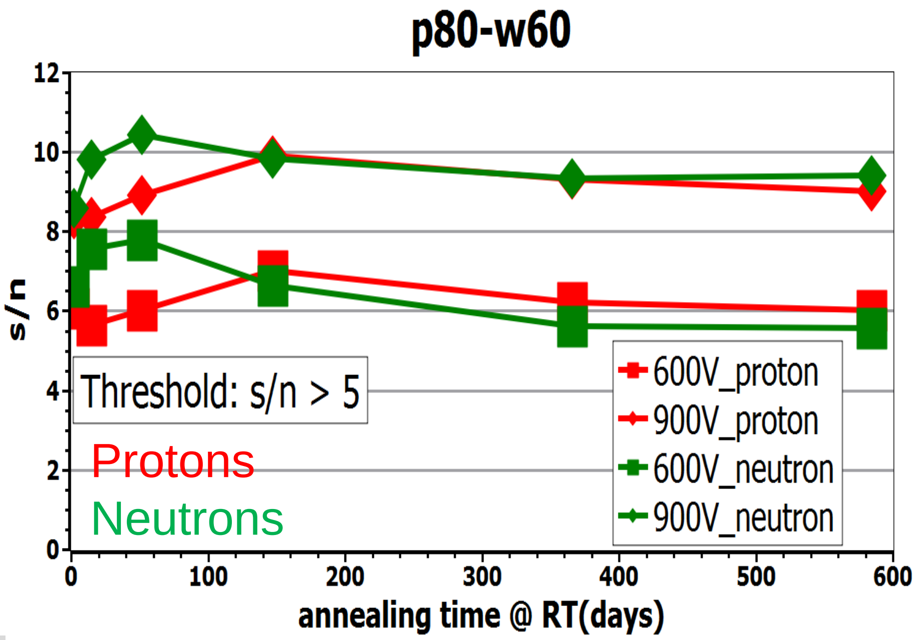
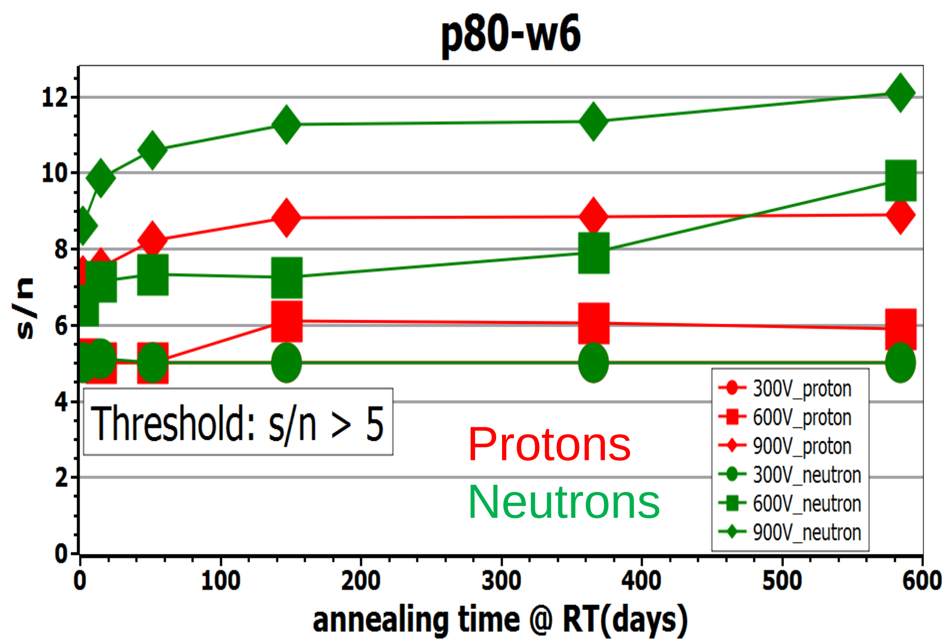
Signal to Noise (s/n)





- **s/n for proton irradiation independent of width**
- **s/n for neutron irradiation 25% larger for narrow strips**

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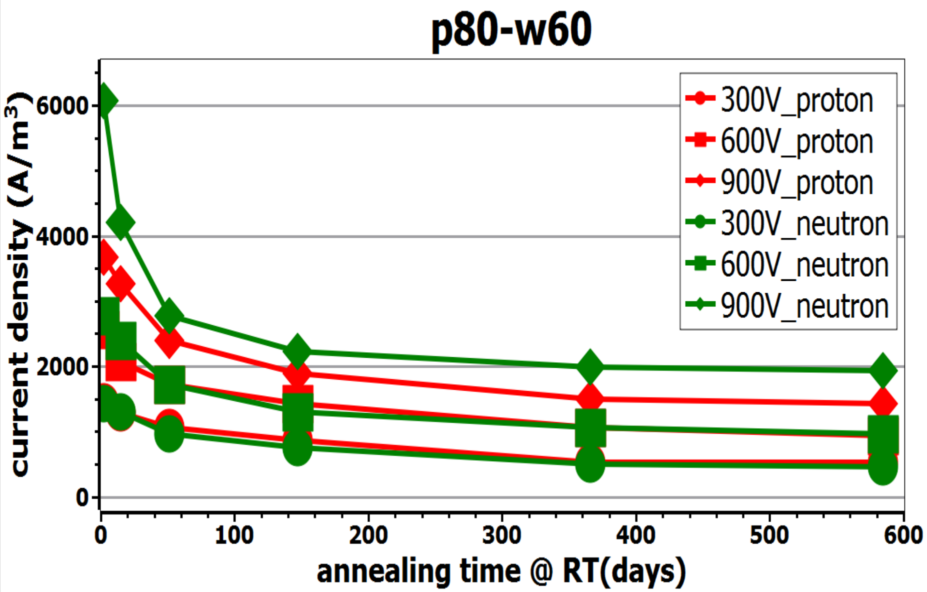
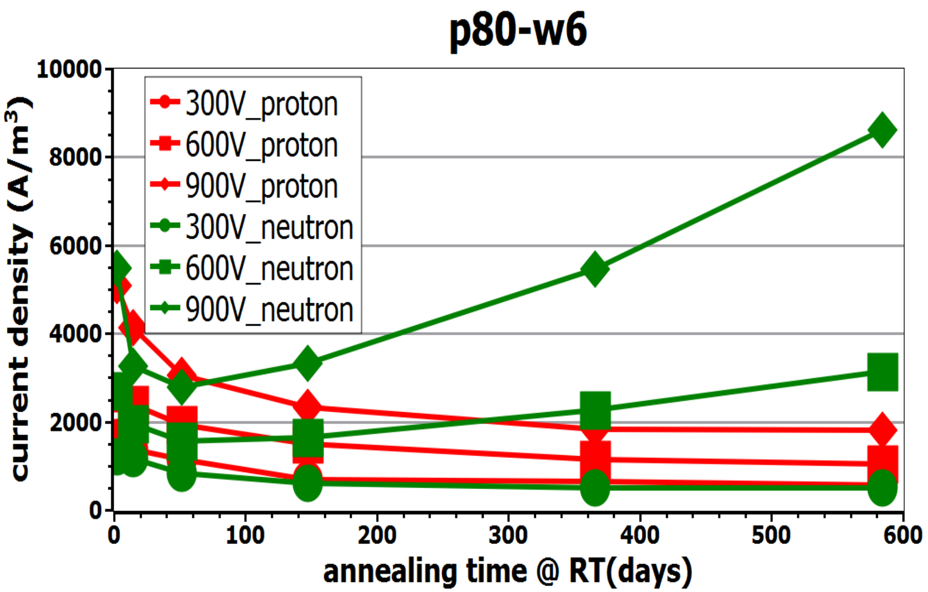
Leakage current

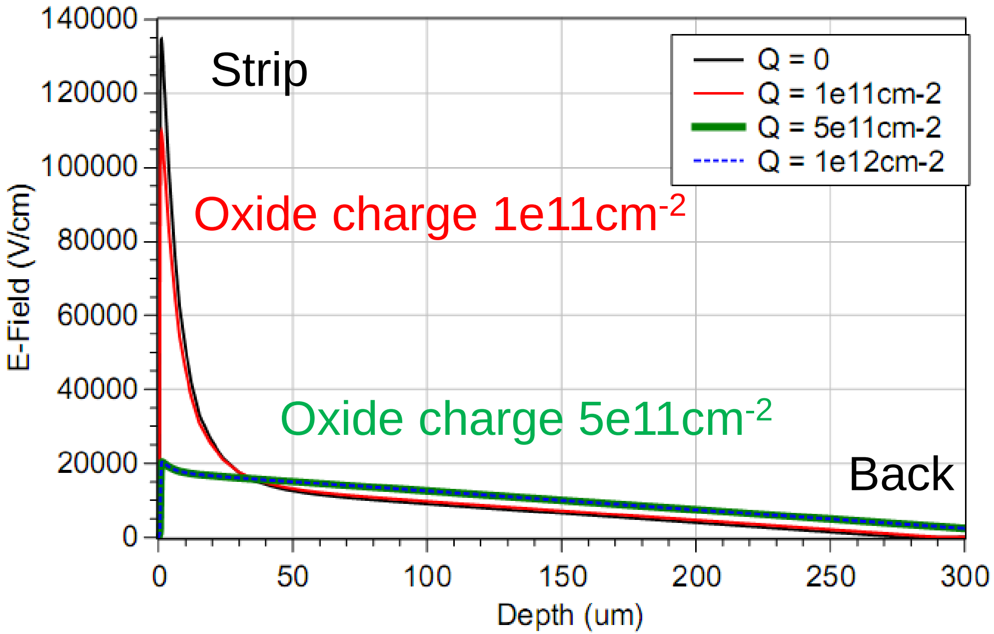




- **Decrease of current after annealing, both for neutrons and protons**
- **Increase of current after annealing for neutron irradiation**

Possible explanation for difference between protons and neutrons

- Proton irradiation generates positive charge in the oxide / interface between silicon and oxide
- Neutron irradiation doesn't create much oxide / interface charge
- Preliminary simulation with interface charge shows:
  - Electric field decreases at the strip with increasing interface charge



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Institut für Experimentelle Kernphysik, KIT

Different processings

Comparison between 150keV and 300keV implantation energy

Neutron irradiation to $F = 5 \cdot 10^{15}\ n_{eq}/cm^2$

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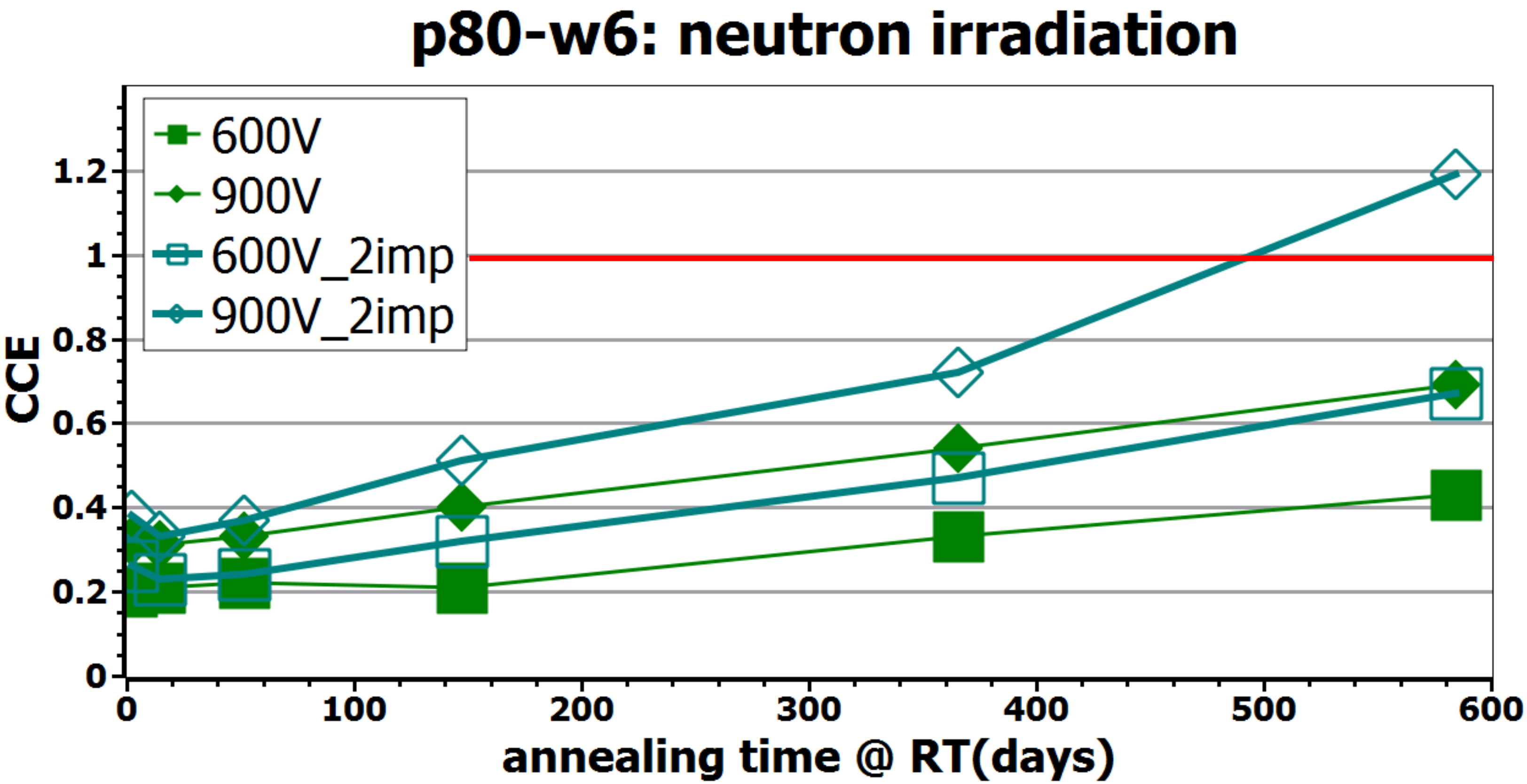
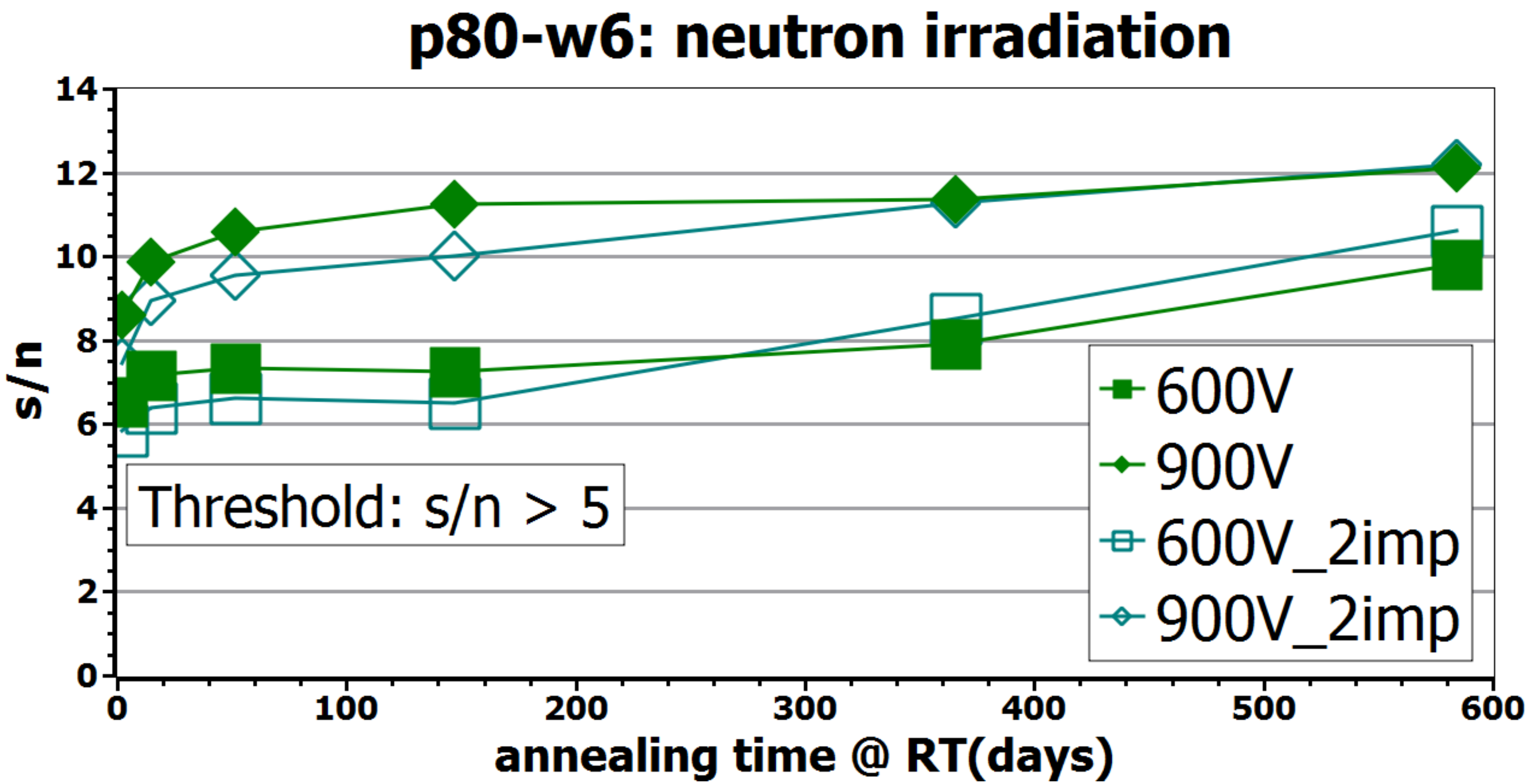
Comparison of implantation energy (CCE)



- **Doubling implantation energy almost doubles CCE**
  Charge Multiplication

Comparison of implantation energy (s/n)



- **Implantation energy does not influence s/n**

Summary

- **Only narrow implants show charge multiplication after neutron irradiation**
- **No charge multiplication after proton irradiation**
- **Possible explanation: more space charge in oxide after proton irradation reduces electric field**
- **Larger implantation energy increases charge multiplication**

Thank you for your attention.

Robert Eber
Institut für Experimentelle Kernphysik, KIT

BACKUP

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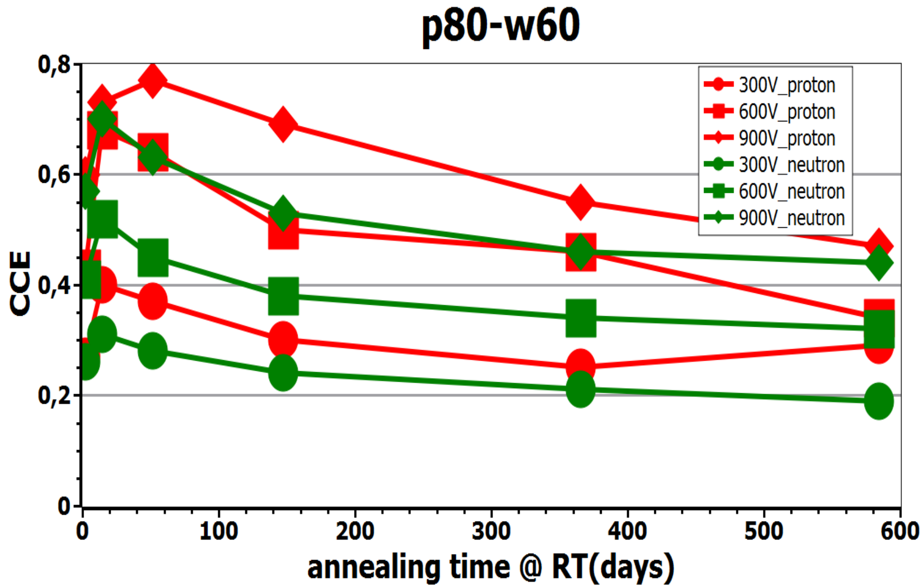
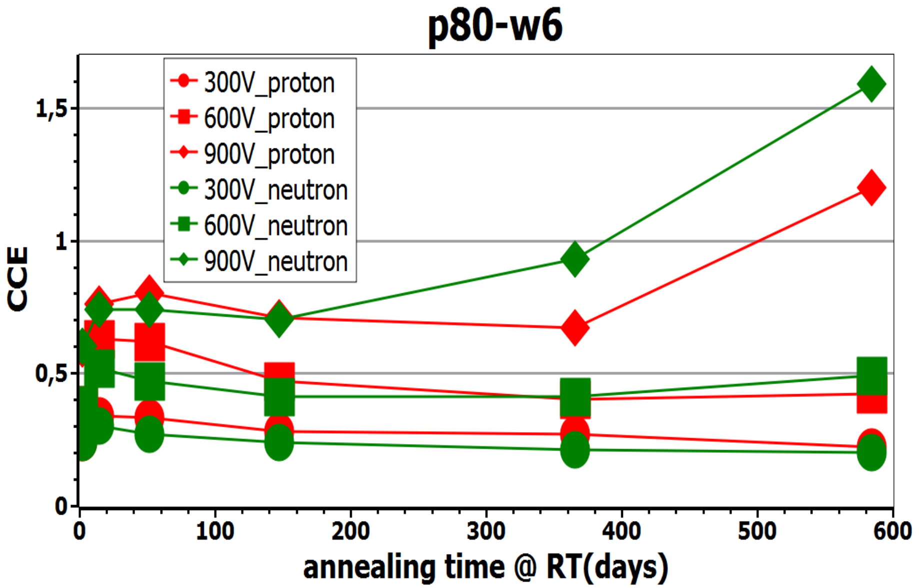
Institut für Experimentelle Kernphysik, KIT

CCE @ F= $1*10^{15}\ n_{eq}/cm^2$





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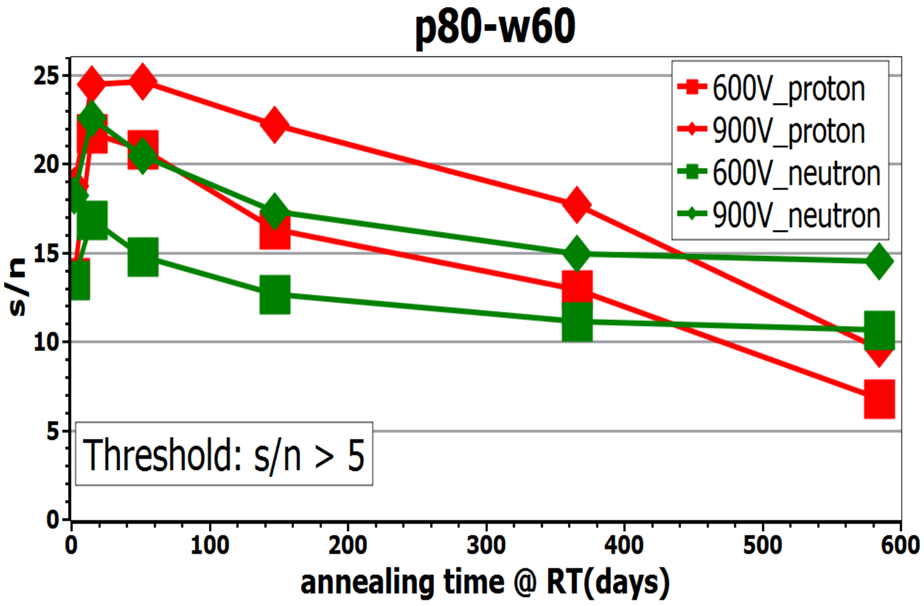
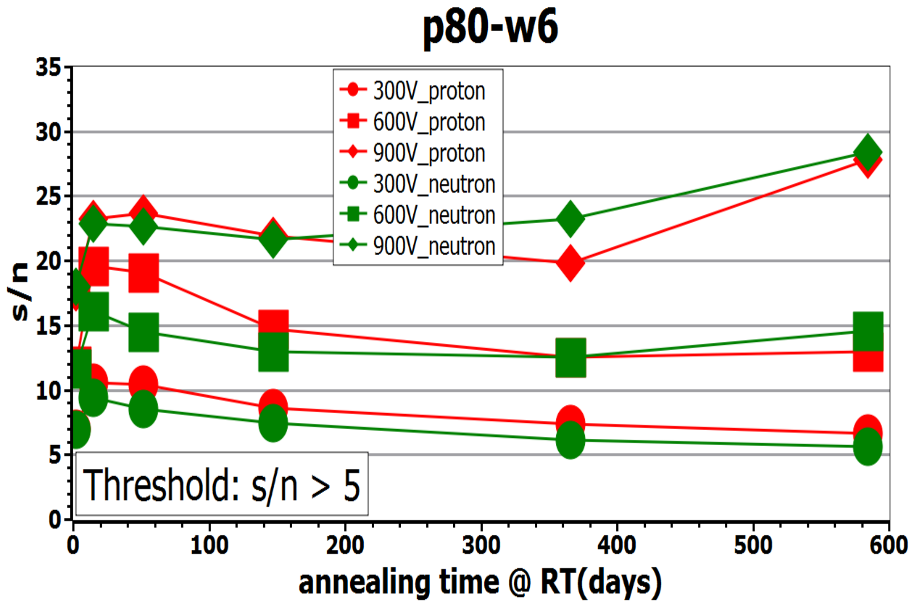
s/n @ F= $1*10^{15}$ n_{eq}/cm^2





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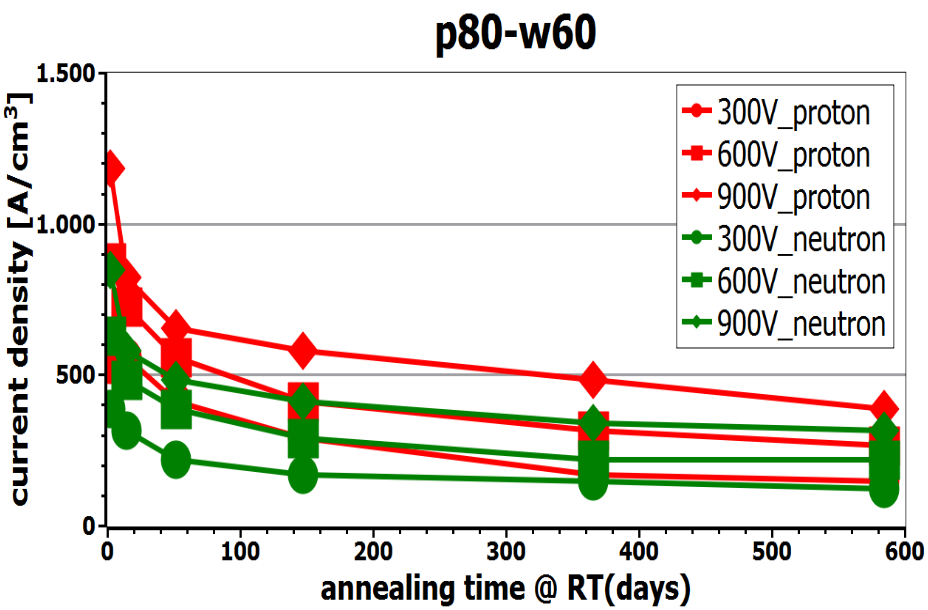
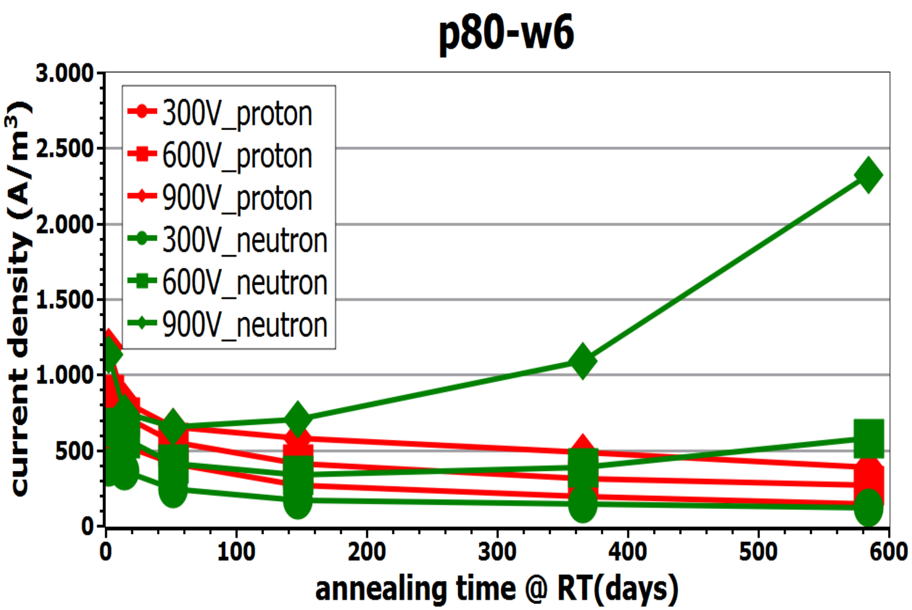
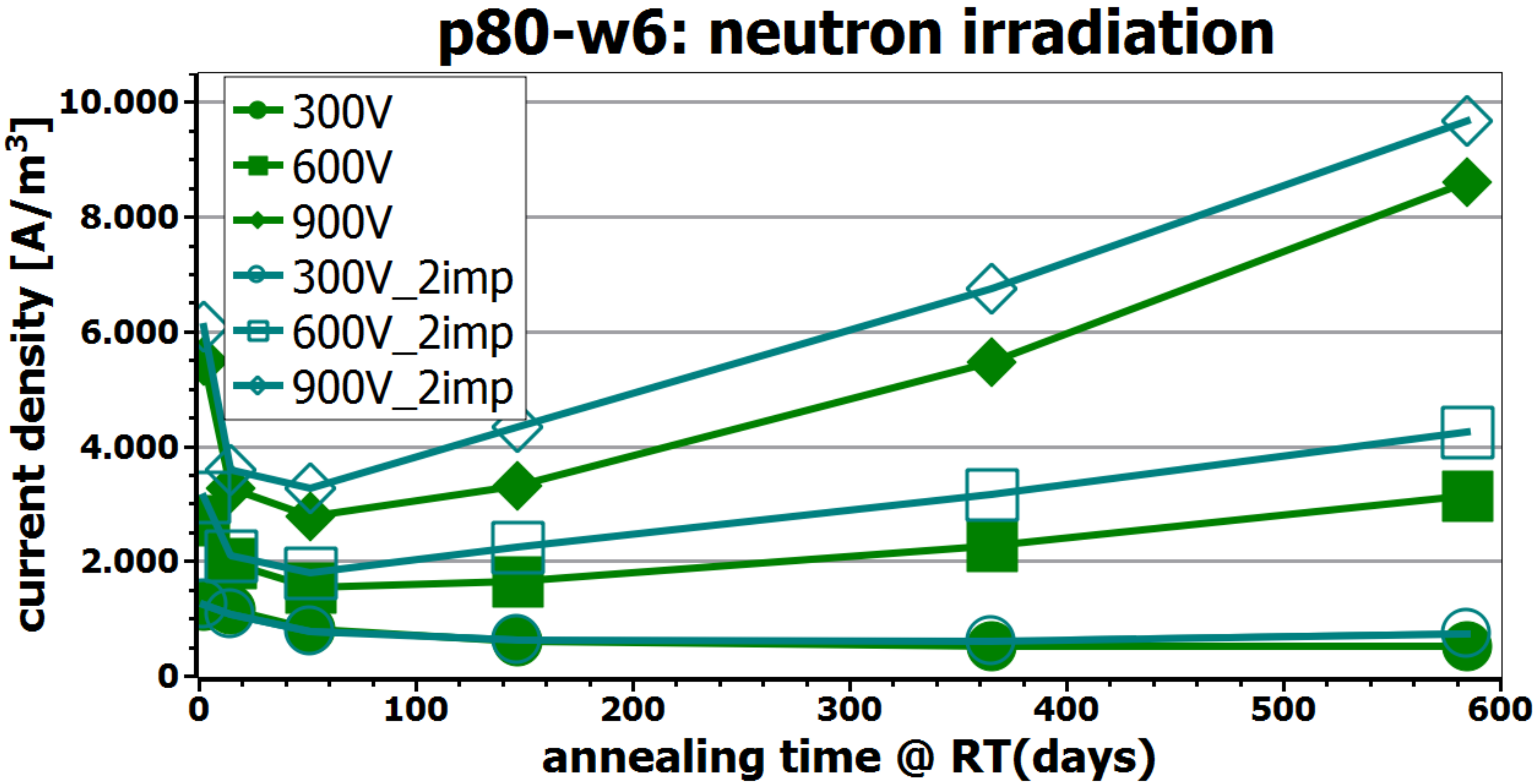
Leakage current @ F= $1*10^{15}$ n_{eq}/cm^2





Comparison of implantation energy (Leakage current)



- Increase in noise can be explained by current
- Higher current seen for high voltages at the 2imp-sensor

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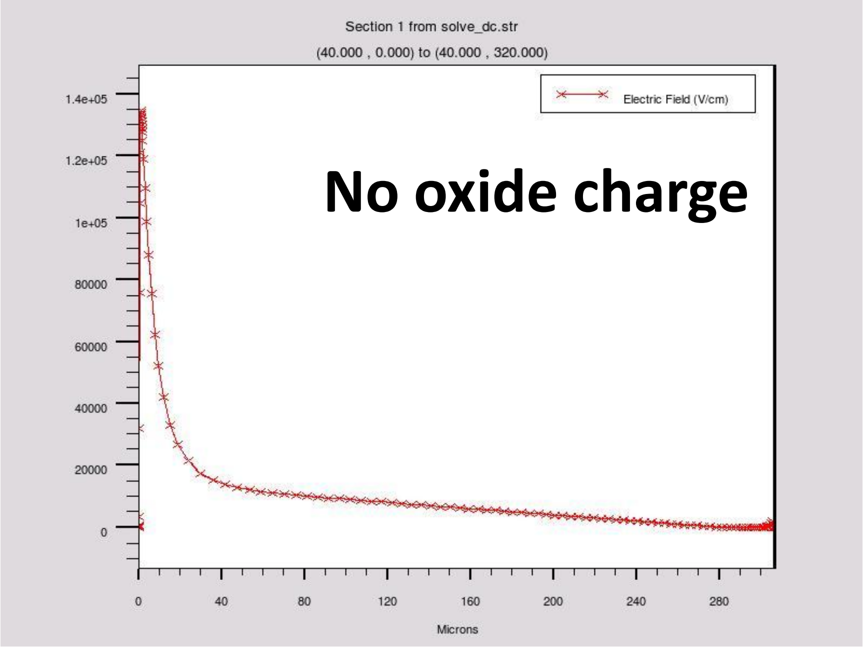
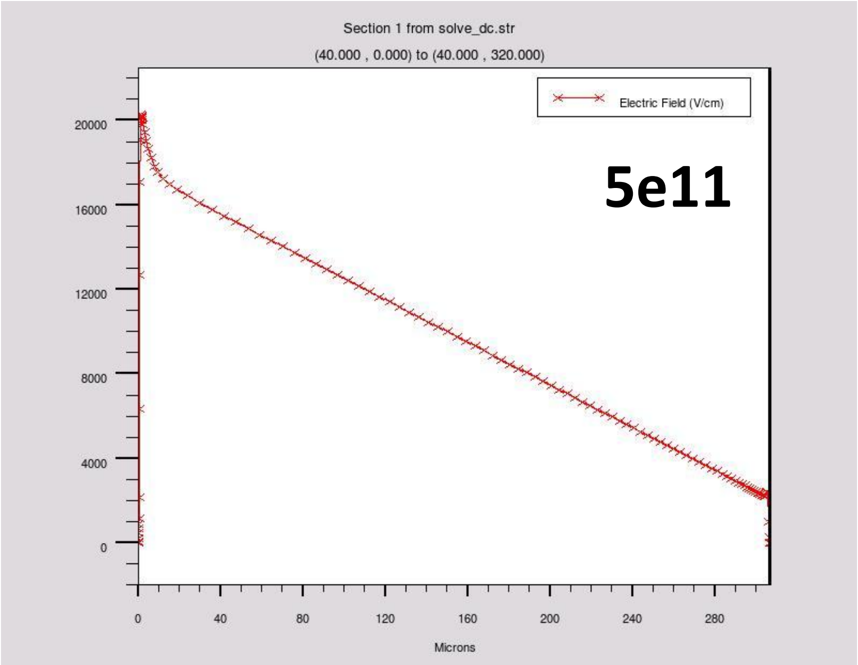
Institut für Experimentelle Kernphysik, KIT

Oxide Charge





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