Neutron Radiation induced Effects in 4H-SiC p-in-n Diodes

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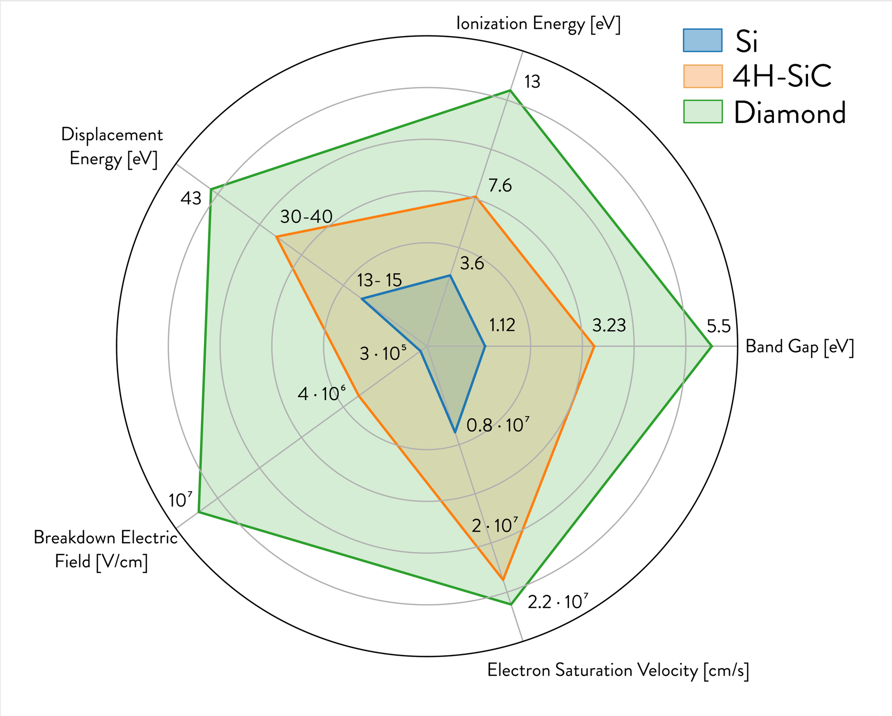
4H Silicon Carbide (SiC)

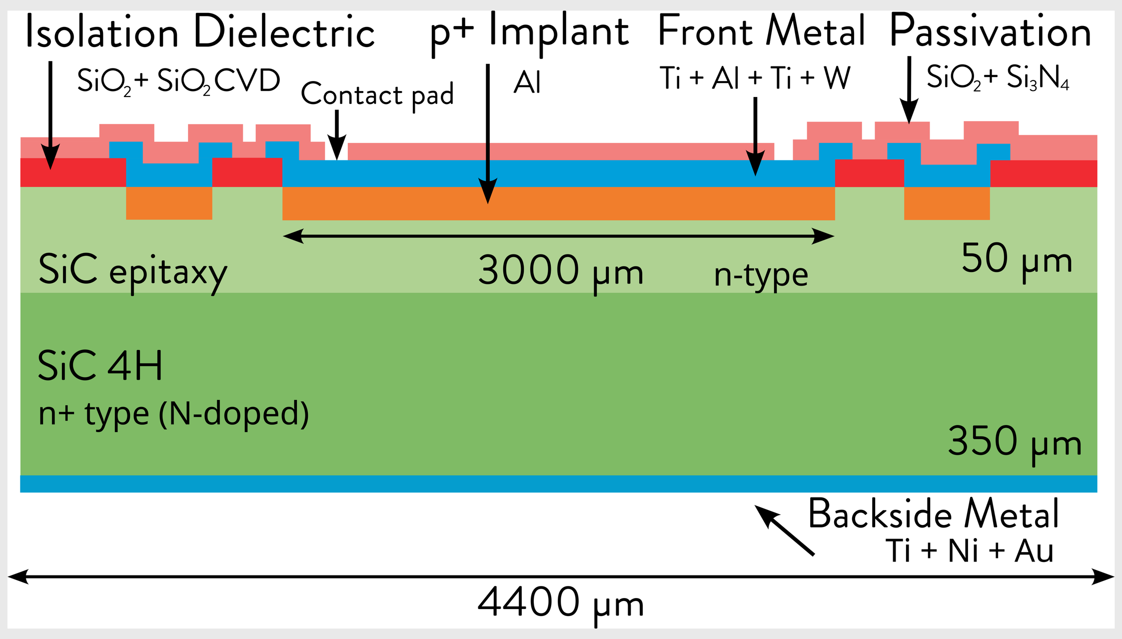
Extreme fluences at future colliders ($> 1 \cdot 10^{16}$ n_{eq}/cm^2) [1]

4H-SiC advantages [2]:
- Low leakage currents
- Fast signals
- Insensitive to light

Drawbacks:
- Epi thickness / resistivity
- High ionization energy [3]



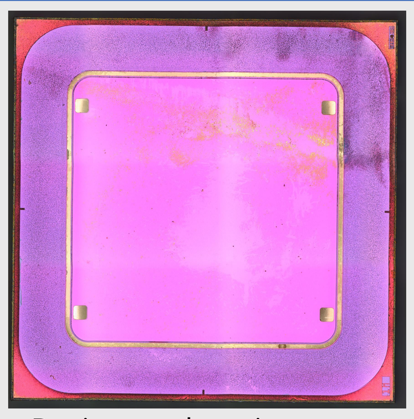
Samples + Readout



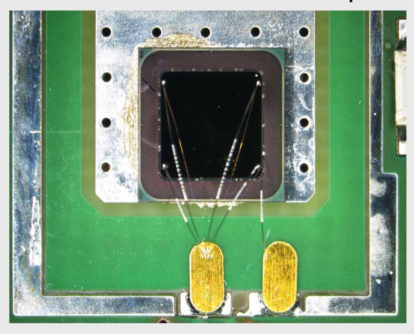
- Charge sensitive (CSA) : Cividec Cx-L
- Transimpedance amplifier (TIA) : UCSC LGAD Board [5]

- Planar diode
- 50 µm epi
- 3 x 3 mm^2 area
- $1.5 \cdot 10^{14}$ cm^{-3} N_{eff}
- V_{dep} : 325V

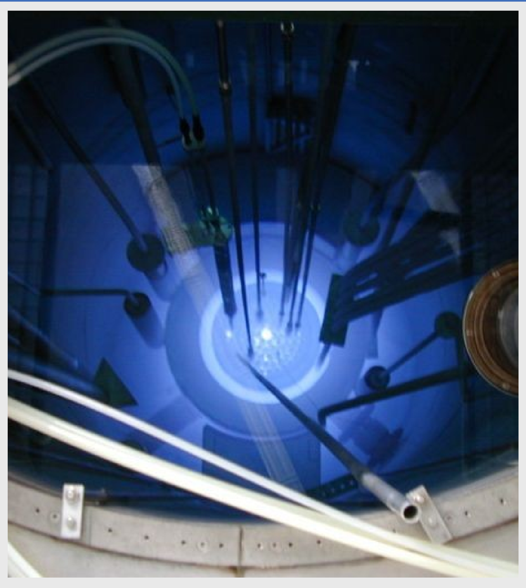
Run 13575 of IMB-CNM-CSIC Barcelona [4]



Devices under microscope

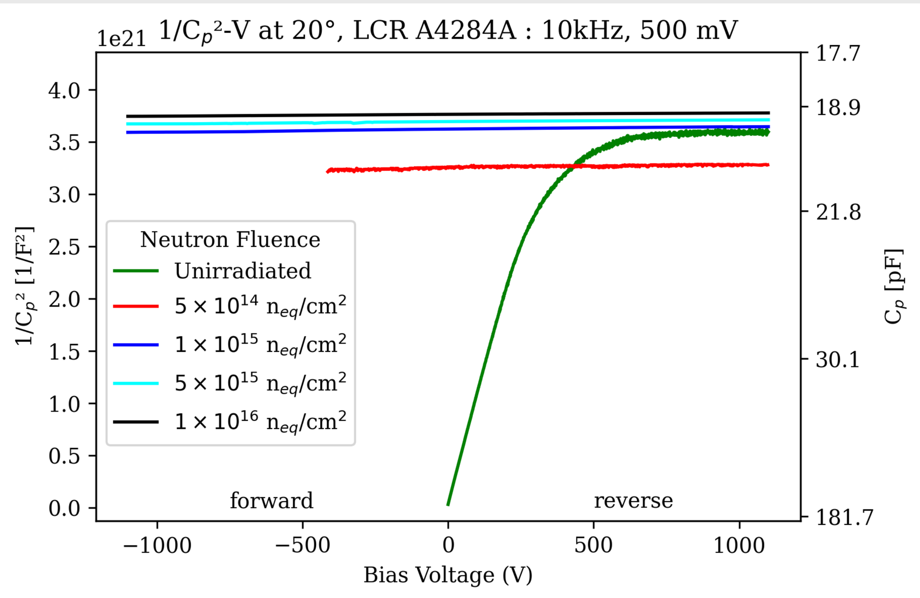


Irradiation + Electrical Characterization

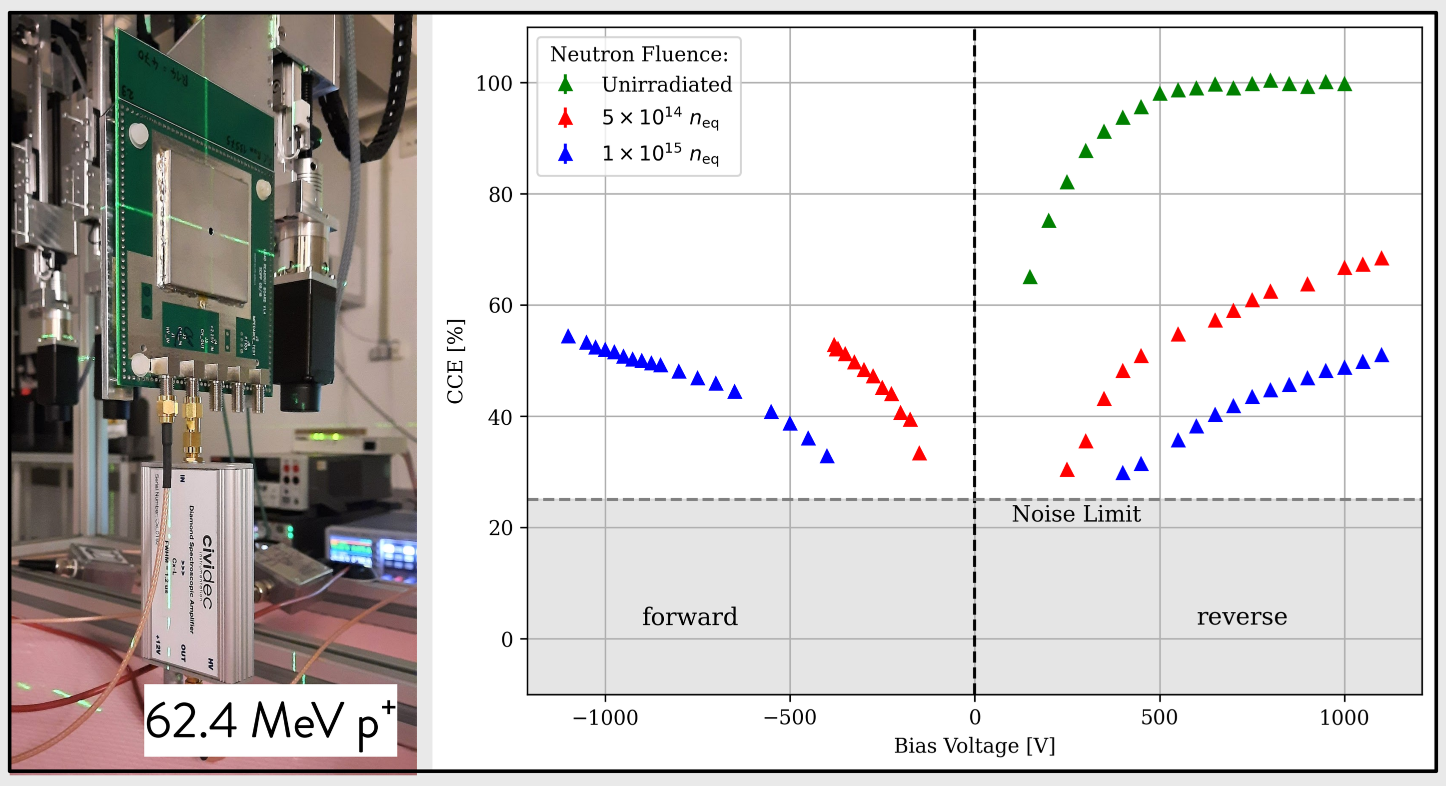


ATI Triga Mark II reactor in Vienna [5]

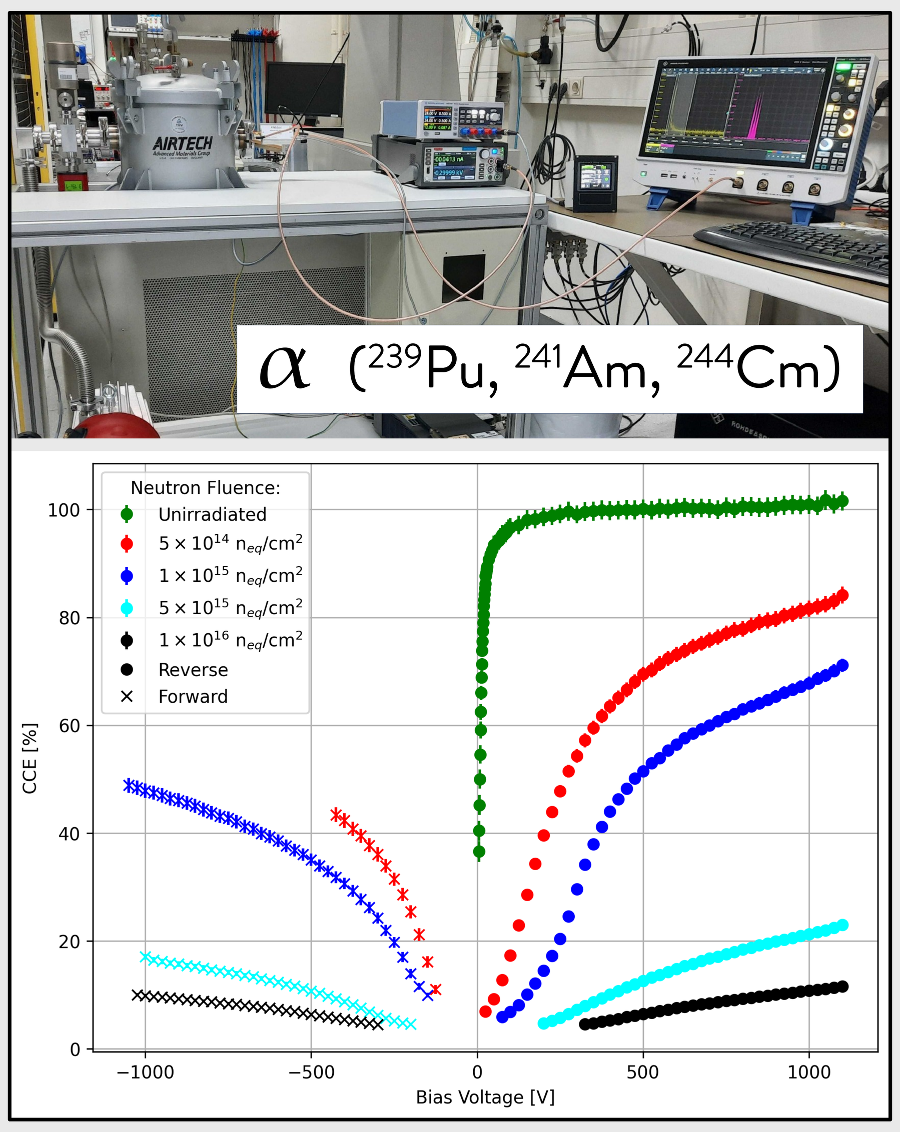
Neutron Irradiation at ATI Vienna, fluences up to $1 \cdot 10^{16}$ n_{eq}/cm^2 [6]
- Electric rectification characteristics lost [7]
- $I_{leak} < 10$ pA up to 1.2 kV
- Flat $1/C^2$ curve
- Further studies needed to identify and model defects



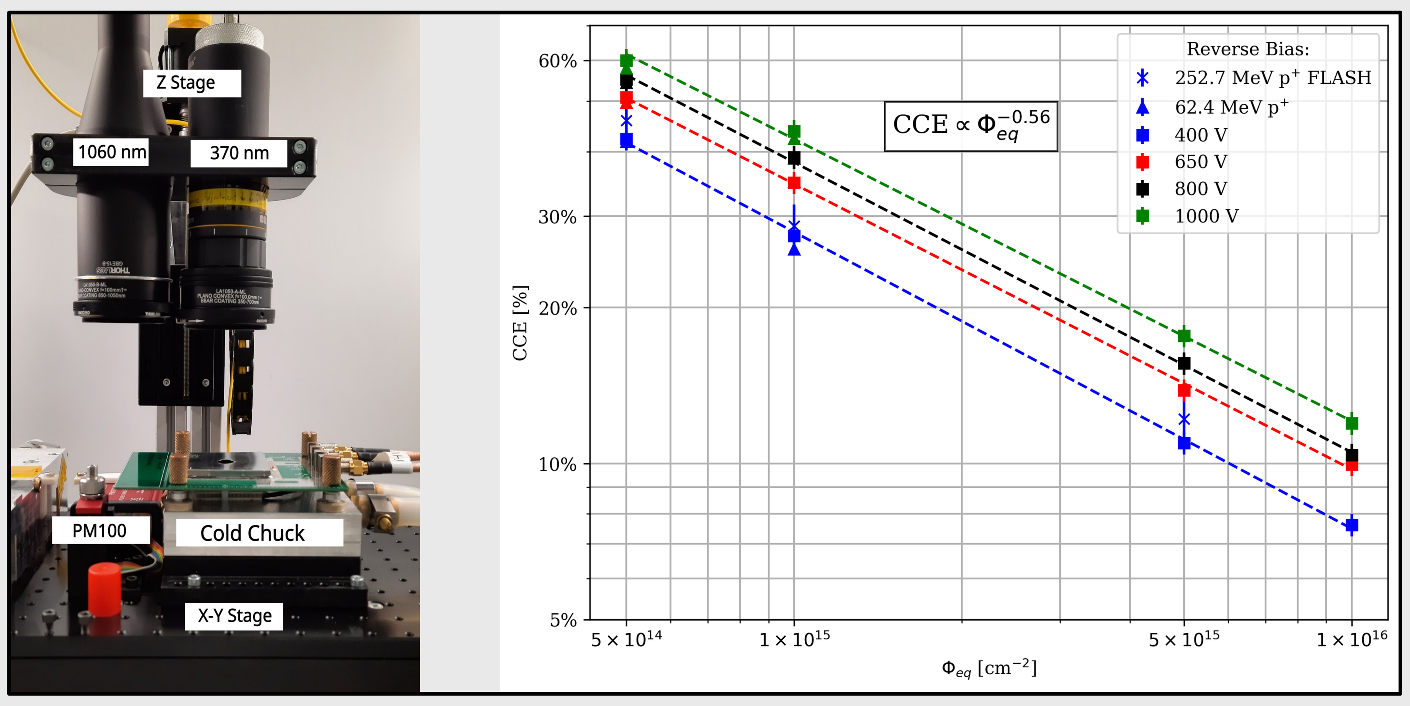
Charge Collection Efficiency (α, p^+, UV-TCT)



- Proton beam at MedAustron
- 62.4 MeV p^+ (5 MIP eqv.) detected up to fluences of $1 \cdot 10^{15}$ n_{eq}/cm^2, in reverse and forward bias
- CCE still improving at high voltages
- HV limited by readout electronics and detector passivation
- Highest fluences: limitations by sensor thickness and electronics

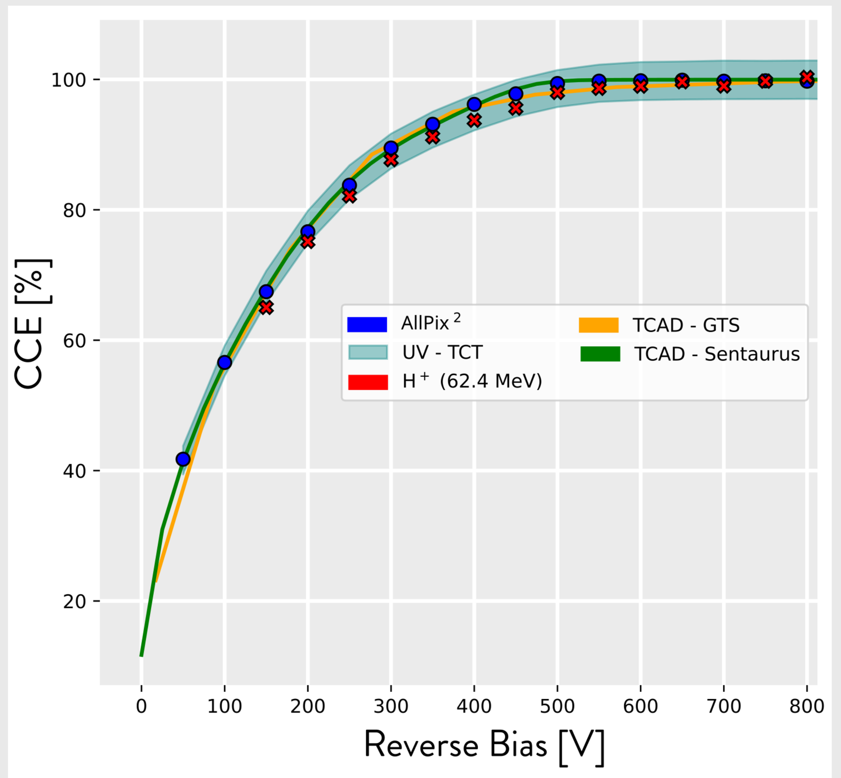


- Using α's and TCT : Signals collected up $1 \cdot 10^{16}$ n_{eq}/cm^2
- Setup improved over previous studies [7, 10, 11]
- Up to 10% CCE at $1 \cdot 10^{16}$ n_{eq}/cm^2
- CCE follows $\Phi_{eq}^{-0.56}$ dependency



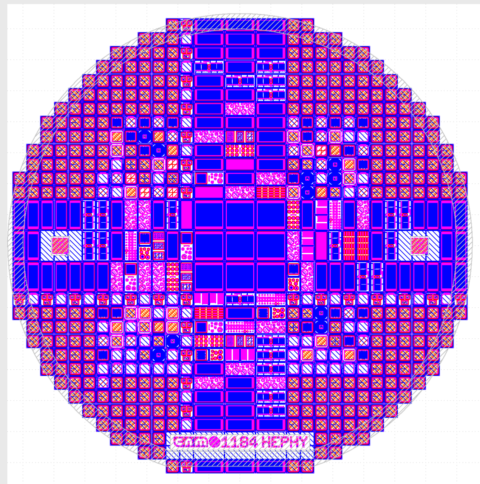
TCAD + Simulations

- Device simulation using TCAD, Synopsys Sentaurus and Global TCAD Solutions [8]
- GTS: Collaboration to implement 4H-SiC [9]
- Convergence and material parameters were studied
- Doping profile extracted from C-V measurements
- Very good agreement for CCE curves
- Radiation damage models to be proposed and tested



Outlook

- SiC Low Gain Avalanche Diode (LGAD)
  - Highly doped gain layer → Impact Ionization
  - Large Signals
  - Better timing than Si possible [12]
- Medical Applications
  - Ion Imaging [13]
  - FLASH dosimetry / Microdosimetry [14]
- New Run upcoming! in preparation for LGADs [15]



Wafer layout of new production

References

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