

Radiation Hardness Test of Silicon Sensors under Realistic Conditions at the Tübingen Van-de-Graaf Accelerator

Eduard Friske¹
on behalf of the CBM collaboration

¹Universität Tübingen

DPG Spring Meeting 2018

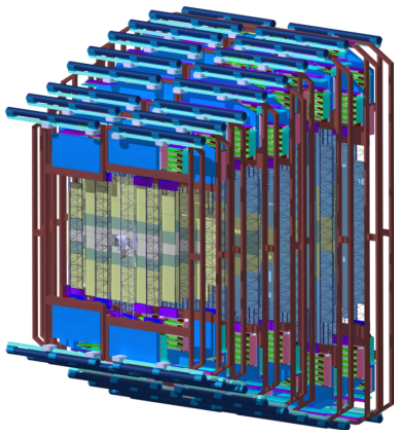


Outline

- 1 The STS within the CBM project
- 2 Radiation hardness
- 3 Experimental setup
- 4 Irradiation campaign
- 5 Results

The STS within the CBM project

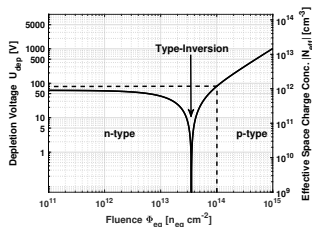
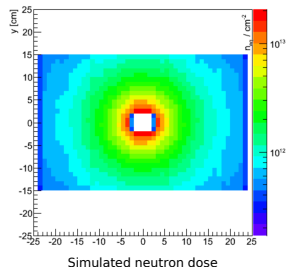
- Compressed Baryonic Matter (CBM):
study of nuclear matter at very high baryonic densities through heavy-ion collisions.
- Silicon Tracking System (STS):
central component, tracking collision products inside a magnetic field.
- ≈ 900 silicon strip detectors



Sensor irradiation

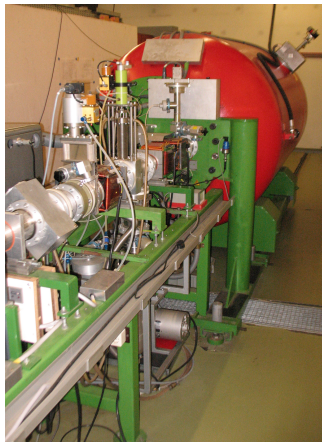
- expected total dose of up to $10^{13} \text{ n}_{\text{eq}}/\text{cm}^2$ for SIS 100
- high energy particles cause displacement damage
- partial reversion through annealing
- net lattice damage dependent on both dose and irradiation duration

⇒ change in electrical properties, degraded detector performance, type inversion



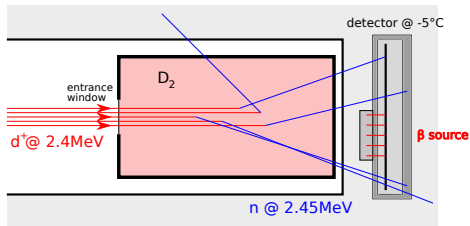
Irradiation tests at the Rosenau facility

- Van-de-Graaf accelerator, beam current in the μA range, decommissioned end of 2017
- up to $\approx 2.4 \text{ MeV}$ hydrogen, deuterium, . . . , carbon ions, ideal for neutron production via D-D fusion
- high availability, no other projects competing for beam time
- existing neutron monitoring equipment
- cryogenic gas cell to maximize neutron production in a compact volume
- online readout of 256 strips via Alibava readout system

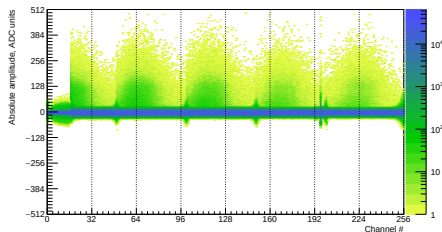


Rosenau accelerator

Setup



schematic view of gas target and sensor housing



sensor hitmap

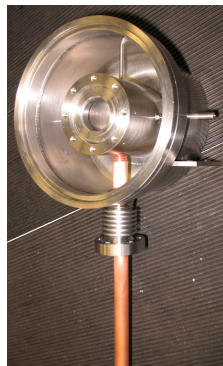
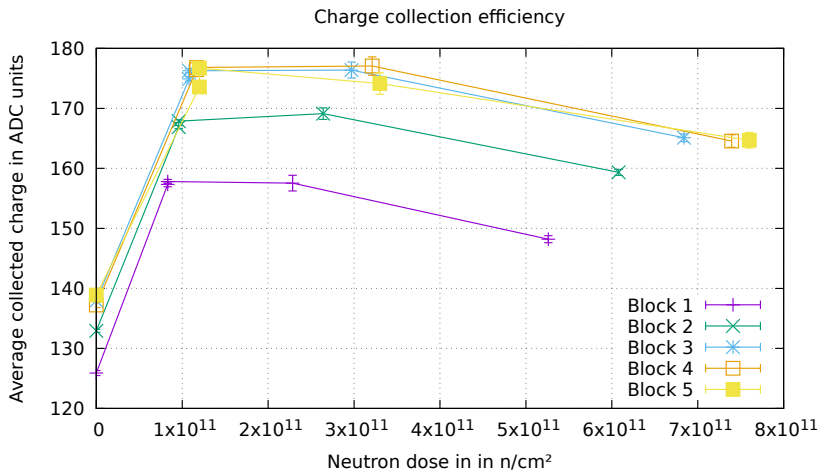
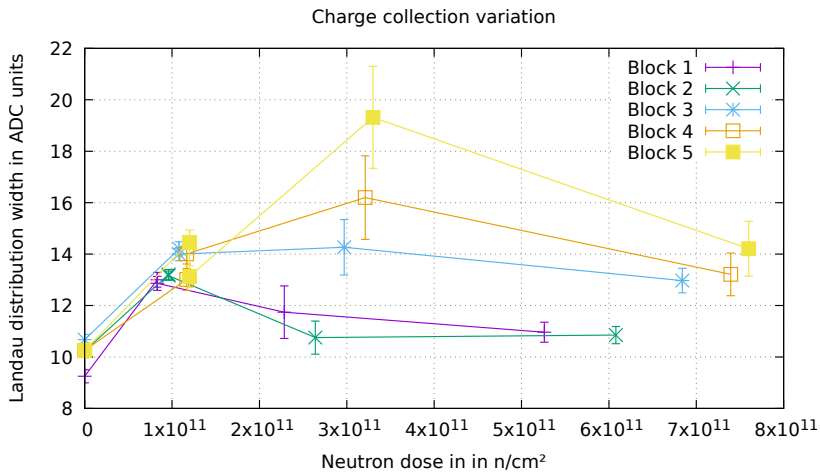


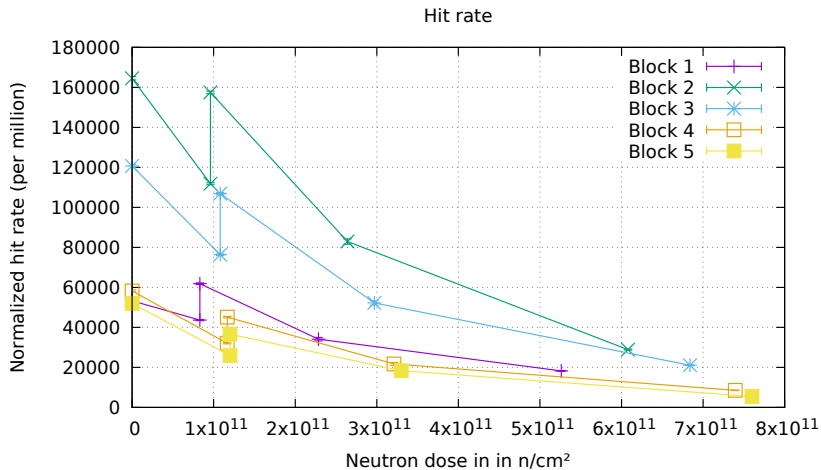
image of the gas target

Irradiation campaign

- irradiation campaign from October to mid December 2017
- estimated total dose at sensor center $7.6 \cdot 10^{11} \text{ n/cm}^2$ of the intended $10^{13} \text{ n}_{\text{eq}}/\text{cm}^2$
- sensor response measurements during beam downtimes
- sensor signal produced with collimated 2 MBq ^{90}Sr source
- plastic scintillator behind sensor as trigger







Results:

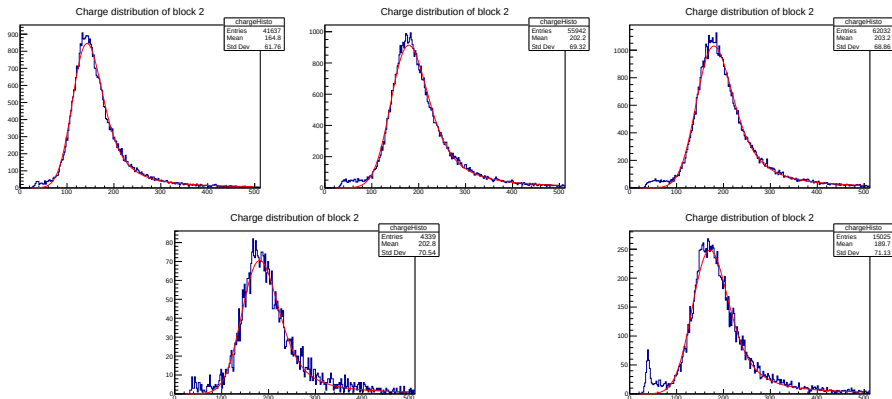
- slight signal quality drop with irradiation after initial improvement
- large drop in trigger efficiency
- increase in leakage current from $\approx 2\mu\text{A}$ to $25\mu\text{A}$

Steps to be done:

- better neutron dose error estimation:
 - neutron monitor data available
 - new calibration measurement of neutron monitor efficiency
 - simulations of setup geometry with higher statistics
- measurement with X-Ray source
 - complementary measurement with ionising radiation
 - existing setup can be used with modifications
- thorough electrical characterisation

Thank you for your attention!

Charge spectra



Charge cluster sizes

