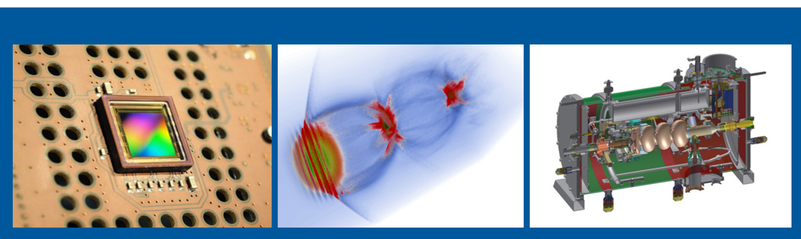
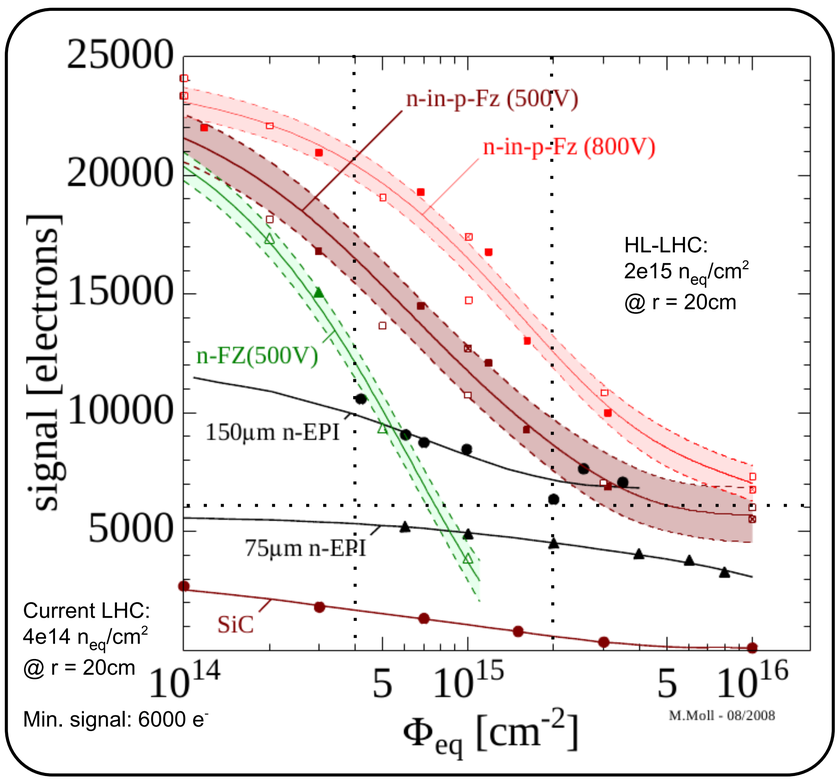
Programme Matter and Technologies

Radiation-Hard Silicon Sensors for the High Luminosity LHC

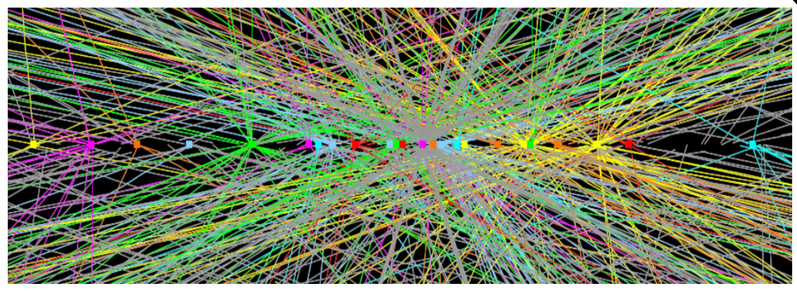


Thomas Eichhorn (DESY)

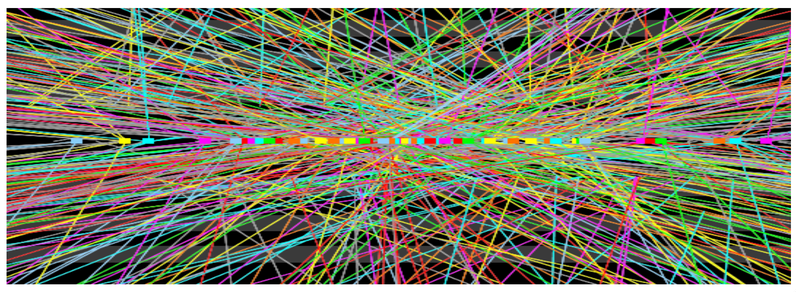


High Luminosity-LHC from 2023:
→ Increase luminosity by a factor of 5
→ Even harsher radiation environment

Trackers for the HL-LHC experiment need upgrade to maintain current performance:
→ Improve granularity to keep low detector occupancy
→ Develop radiation-hard sensors



Pile-up collisions per event:
Today: 40
HL-LHC: 140



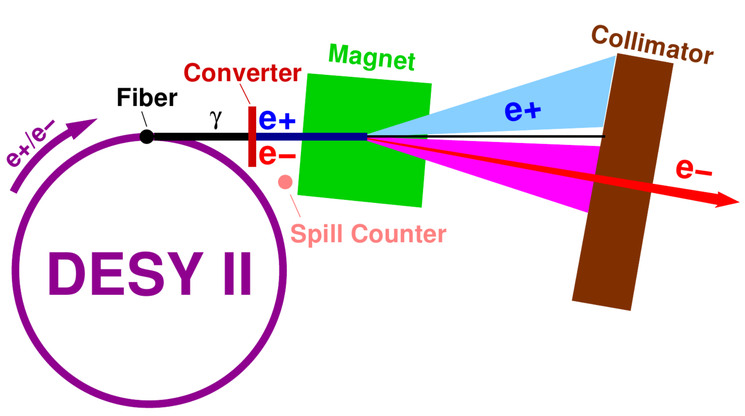
Is epitaxially grown silicon a radiation-hard sensor material?

Investigate new technologies with different development tools:
→ Sensor irradiations
→ Laboratory and test beam measurements with pixel telescopes
→ TCAD simulations of test structures

Can the expected radiation damage effects in silicon be simulated?

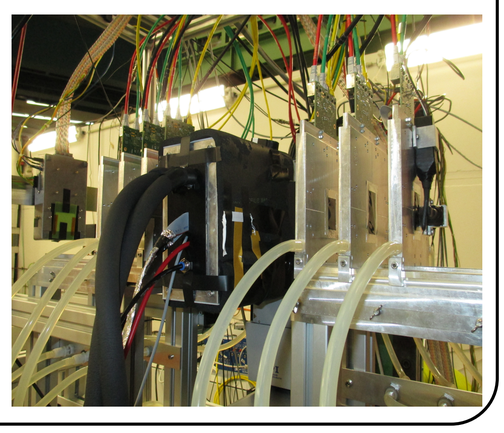
Test beam measurements:

Excellent DESY infrastructure available:
→ 6 GeV e^+/e^- test beam facility

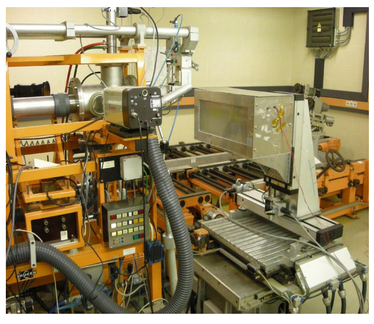


→ Pixel telescopes with µm tracking resolution:

evaluate and test sensor performance in the beam



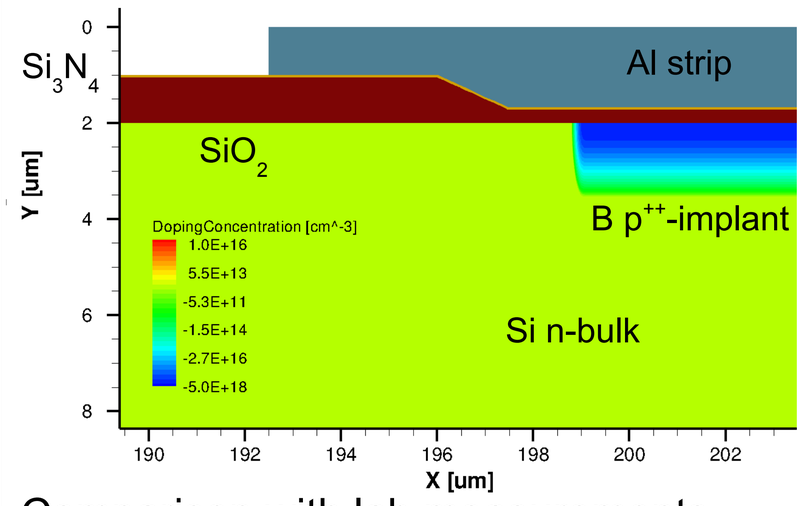
Karlsruhe Irradiation Center:
→ 25 MeV protons from Zyklotron AG



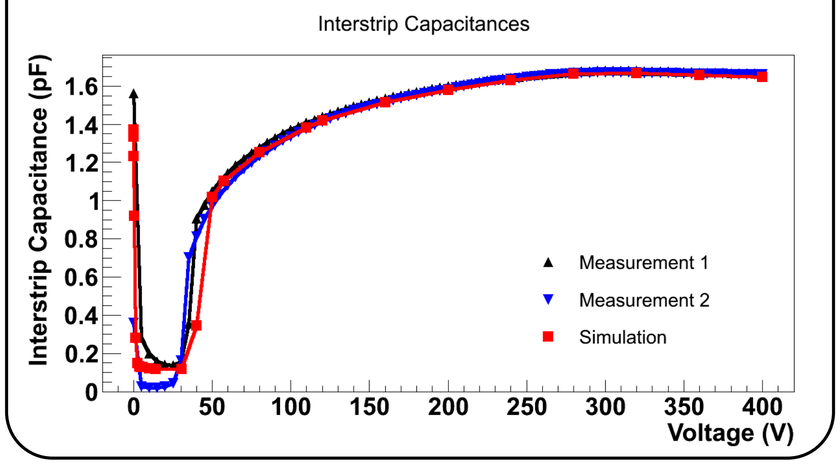
Other irradiation centers:
→ CERN (23 GeV p)
→ Los Alamos (800 MeV p)
→ Ljubljana (1 MeV n)

TCAD Structure Simulations:

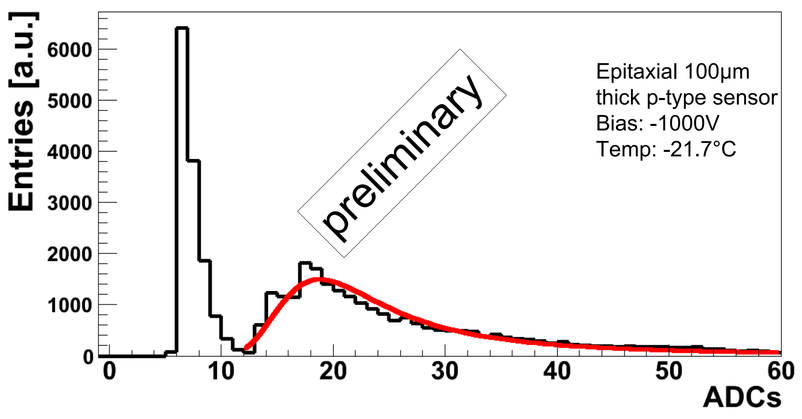
Reverse-engineer sensor structure



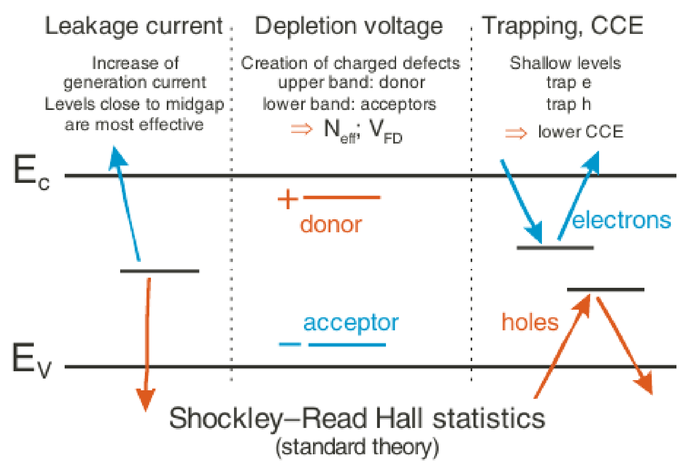
Comparison with lab measurements



Testbeam campaign in 2013/2014:
→ Investigate epitaxial mini sensors from a run at a potential vendor
→ Signal/noise levels after 3e15 n_{eq}/cm^2 proton irradiation:

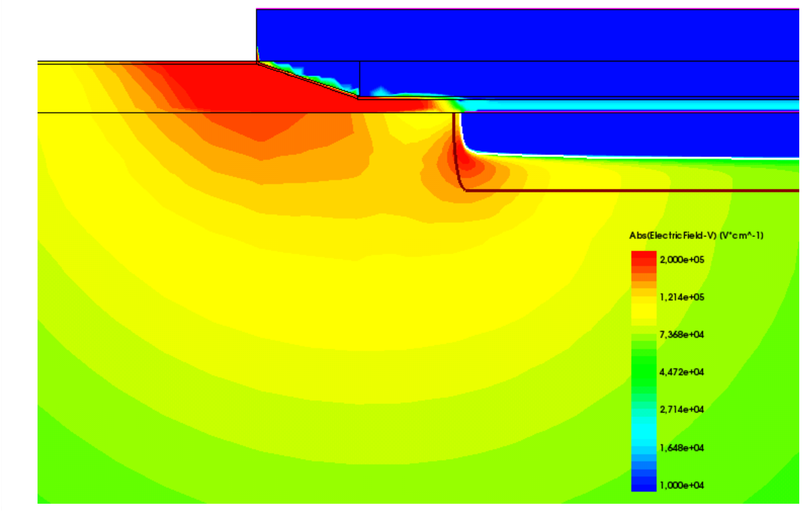


Bulk radiation damage:
→ acceptors and donors introduced



Model used implements one acceptor and one donor

Surface radiation damage creates charges at the Si – SiO_2 interface, leading to spikes in the electric field



DESY · JÜLICH Forschungszentrum · HI Jena Helmholtz Institute Jena · HIM Helmholtz Institute Mainz · GSI · HZB Helmholtz Zentrum Berlin · HZDR · KIT Karlsruhe Institute of Technology

HELMHOLTZ ASSOCIATION