Development of Silicon Strip Sensors and Radiation Hardness Studies for the PANDA MVD

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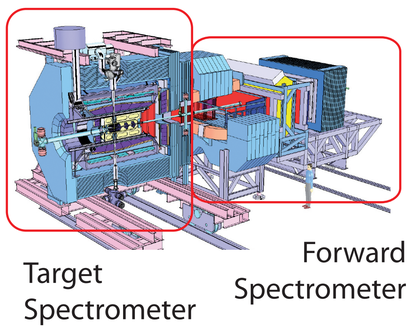
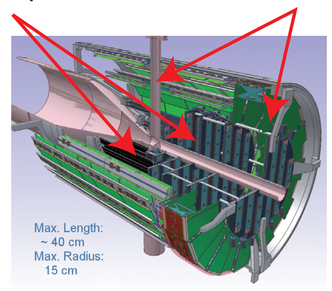
The PANDA Experiment

- Fixed target experiment at the future FAIR facility
- Antiproton beam: momentum 1.5 GeV/c to 15 GeV/c



The Micro-Vertex-Detector

- high resolution (~100µm) vertexing
- fast, triggerless readout
- high radiation tolerance
- 4 concentric barrels and 6 forward disks

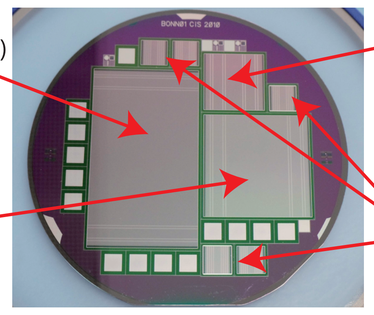


Double-Sided Silicon Microstrip Sensors

- First full-size prototype run produced in 2011 by CiS, Germany
- Main features:
  - substrate: FZ Si (n)
  - resistivity: 2.3 ... 5.0 kΩ · cm
  - stereo angle 90°
  - punch-through biasing
  - thickness: 285 ± 10 µm
  - p-spray isolation
  - AC and DC coupled readout

S1 (PANDA rectangular sensor)
65µm pitch
896x512 strips
active area 58x33 cm²

S2 (PANDA squared sensor)
65µm pitch
512x512 strips
active area 33x33 mm²



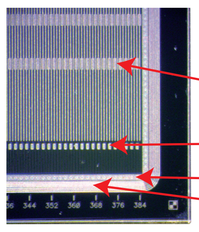
S3
50µm pitch
384x384 strips
active area 19x19 mm²

S4 ("Baby")
65µm pitch
128x128strips
active area 8x8 mm²

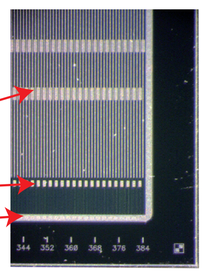
4" wafer with sensor prototypes and additional test structures

corners of the strip sensors:

- AC pads
- DC pads
- bias ring
- guard rings



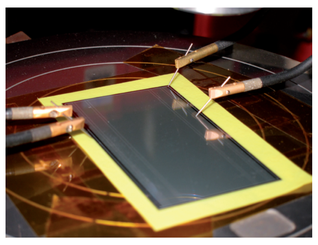
p-side



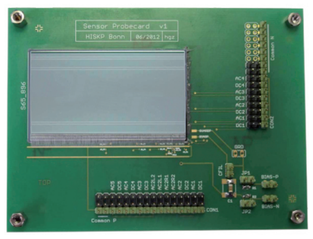
n-side

Measurement Setup

- Two setups available:

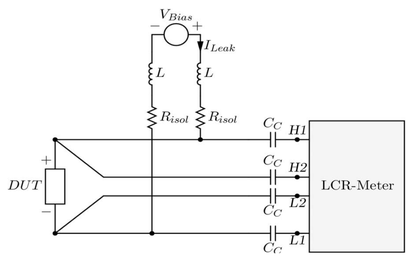


Probe station (adjustable needles)



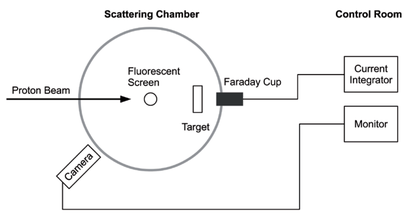
Fixed-contact probe card (wire bonding)

- PC-controlled LCR meter and voltage source
- DUT connected via a biasing box

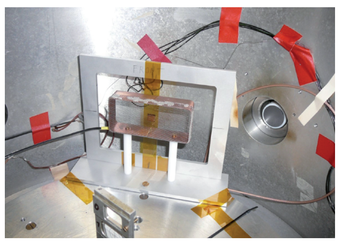


Radiation Hardness Studies

- Irradiations of the S4 sensors with protons at HISKP in Bonn
- Additional neutron irradiations with a source and a reactor
- Annealing at 60 °C for 80 minutes

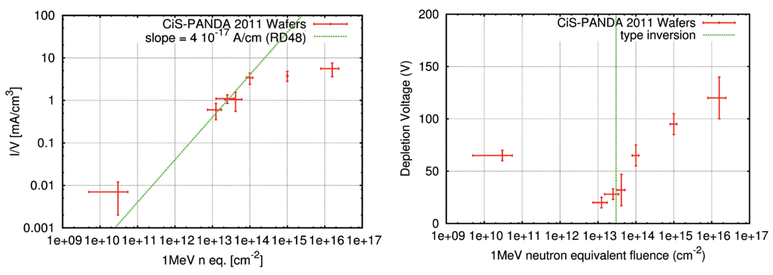


Schematic of the irradiation setup



Sensor in the irradiation chamber at the cyclotron at HISKP in Bonn

- Global sensor parameters are evaluated after irradiation
- Equivalent neutron fluence calculated with the NIEL hypothesis

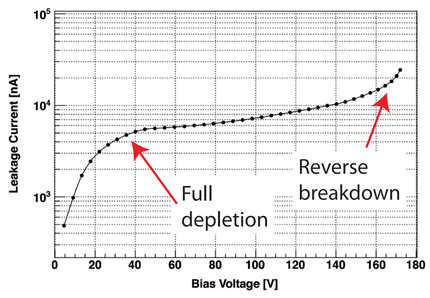


Variation of leakage current and depletion voltage with the equivalent fluence

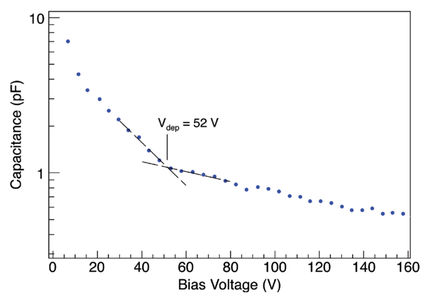
Measurement Results

Evaluation of the main parameters of an S1 sensor:

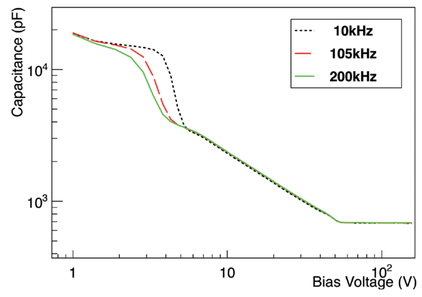
- Leakage current
- Full depletion voltage
- Capacitances
  - Bulk capacitance
  - Interstrip capacitance
  - Stray capacitance
  - Coupling capacitance (AC pad to DC pad)



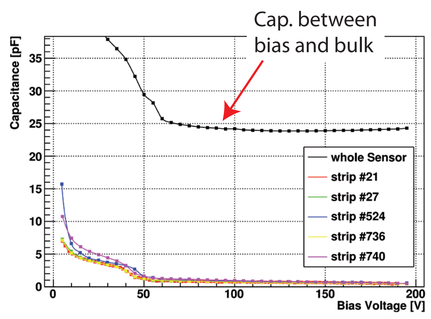
Leakage current



Full depletion voltage extracted from C/V characteristic of the stray capacitance of a strip



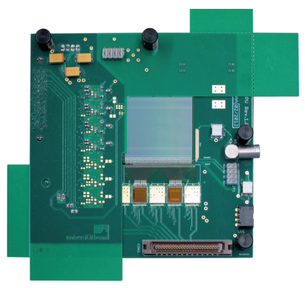
Bulk capacitance (all n-side strips to all p-side strips)

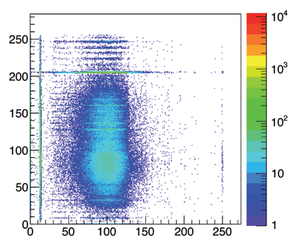


Stray capacitance (strip-implant to bulk)

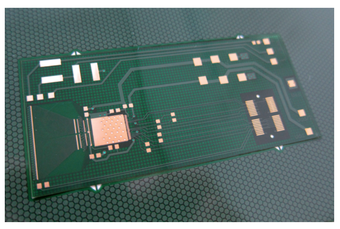
Conclusions

- Static characterization of the sensors completed
- Support PCBs with APV25-S1 readout chips produced
- In-beam tests in progress





- Flexible hybrid support with integrated fanout and pitch adapter structure under study



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