Contributions to the Development of the PANDA MVD Strip Detector

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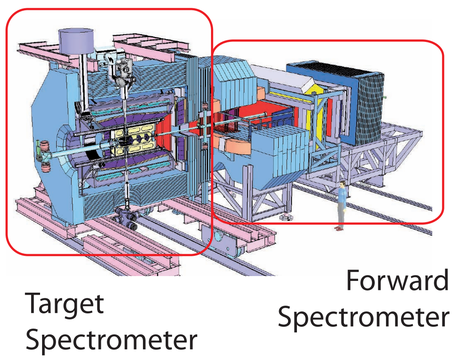
532. Wilhelm and Else Heraeus-Seminar, Bad Honnef

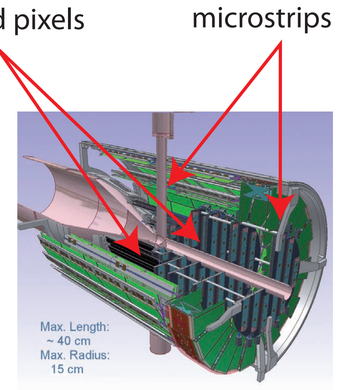
The PANDA Experiment

- Fixed target experiment
- Almost 4π acceptance
- Cooled antiproton beam using electron and stochastic cooling
- Proton or heavy nuclear target
- Momentum from 1.5 up to 15 GeV/c
- Peak luminosity of $2 \cdot 10^{32}$ cm^{-2} s^{-1}



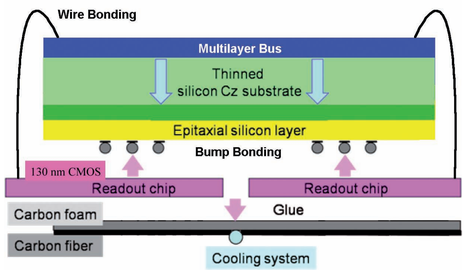
The Micro-Vertex-Detector

- 4 concentric barrels and 6 forward disks
- Vertex reconstruction for primary and secondary vertices
- Improvement of momentum resolution and PID
- Requirements:
  - trigger-less readout with high rate capability
  - good time resolution and low material budget
  - high radiation tolerance

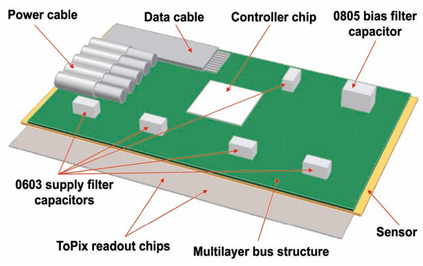


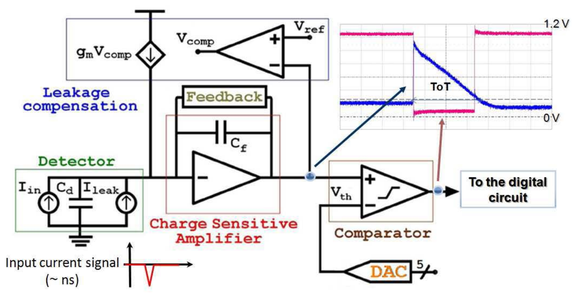
Hybrid Pixel Detectors

- Developed at INFN, Torino
- Sandwich of sensor, front-end chip and mechanical support (carbon fiber and carbon foam) with embedded cooling system
- Sensor: epitaxial 100 µm silicon layer on a thinned CZ substrate
- Pixel size 100x100 µm^2
- Front-end connected via bump bonding

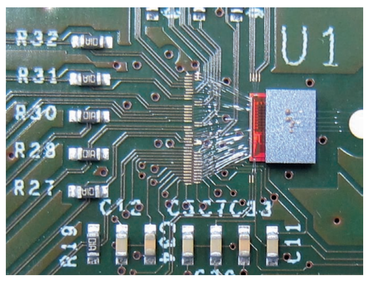


Front-end chip: ToPix ASIC
- matrix of 116x110 pixel cells
- self-triggered
- dE/dx measurement via ToT technique with 12-bit resolution
- time resolution 6.45 ns (1.9 ns rms)
- input range up to 50 fC
- noise floor < 0.032 fC
- power density < 800 mW/cm^2
- maximum data rate ~450 Mbit/s
- total ionizing dose < 100 kGy





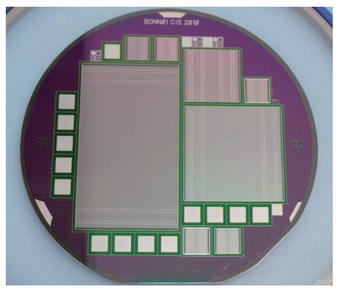
Analog cell schematic of ToPix v3

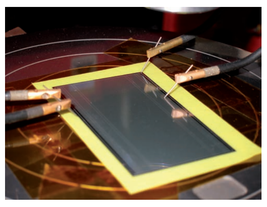


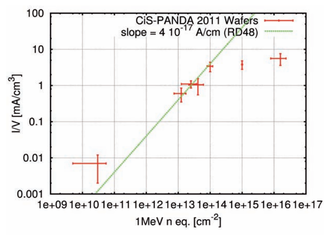
ToPix v3 bump-bonded to an epitaxial sensor

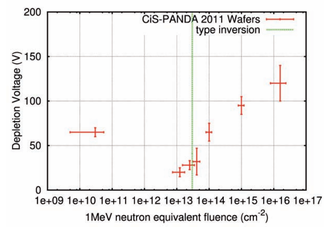
Double-Sided Silicon Microstrip Sensors

- Manufactured by CiS, Erfurt (Germany)
- Main features:
  - substrate: FZ Si (n), thickness 285 ± 10 µm
  - resistivity: 2.3 ... 5.0 kΩ · cm
  - stereo angle 90°; AC and DC coupled readout
  - punch-through biasing; p-spray isolation
  - 65/50 µm pitch
- Single strip capacitances:
  - p-side (L=33.32 mm): (9.8 ± 0.2) pF
  - n-side (L=58.28 mm): (17.1 ± 0.4) pF
- Sensor tests with probe station and with fixed-contact probe card
- Radiation hardness studies performed with neutrons and protons

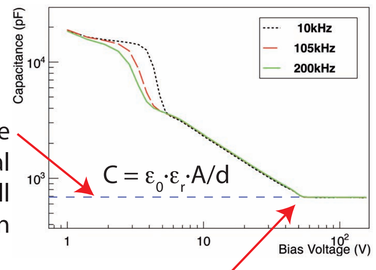






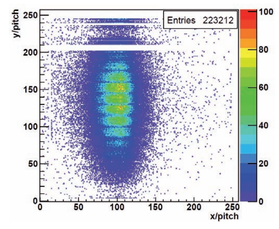


leakage current and depletion voltage for different fluences



Sensor capacitance matches geometrical capacitance at full depletion

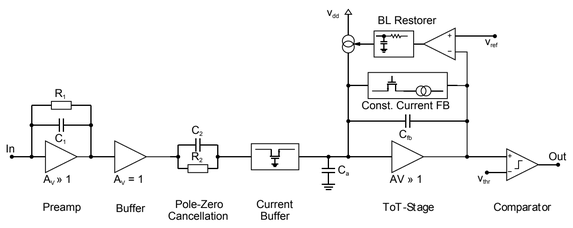
Full depletion voltage

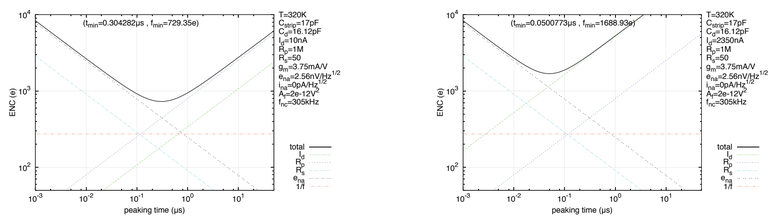


beam spot observed during CERN beam time

Strip Electronics

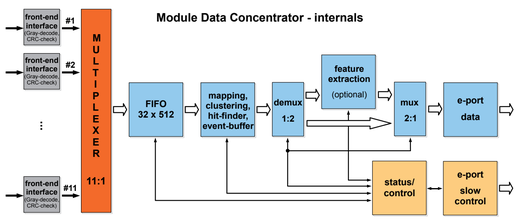
- Front-end development:
  - ASIC design at INFN, Torino
  - self-triggering
  - fully digital output
  - precise time resolution (~100 ps) with TDCs adapted from the TOFPET chip



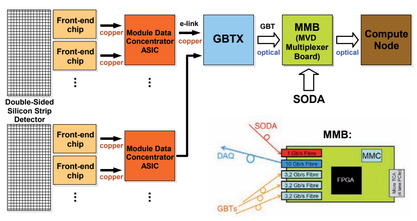


calculation of baseline noise obtained with current preamplifier-cascode design without (left) and with full irradiation (right) expected at PANDA end-of-lifetime radiation dose of $5 \cdot 10^{13}$ $n_{eq} \cdot cm^{-2}$

- Module Data Concentrator at stave level
  - ASIC design at FH-SWF, Iserlohn
  - decoding of front-end data
  - mapping, clustering
  - slow control functions
  - interfacing DAQ via serial GBT e-links



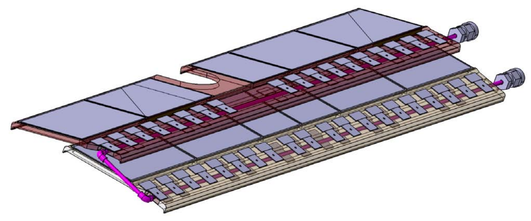
Schematic of the Module Data Concentrator

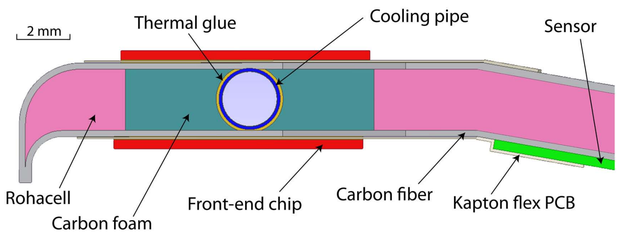


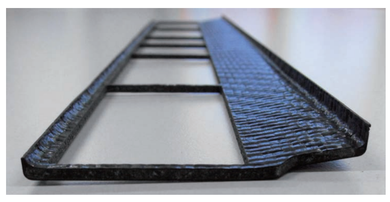
DAQ chain of the PANDA MVD

Strip Mechanics and Hybridization

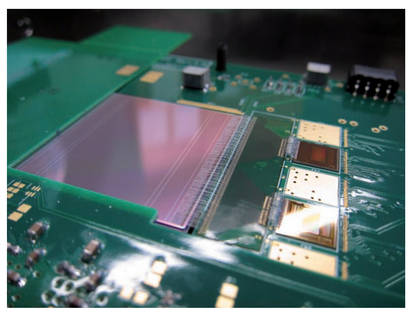
- Barrel stave mechanical design:
  - sandwich of carbon fibers (M55J) and Rohacell
  - embedded cooling pipe and POCO HTC carbon foam under the chips

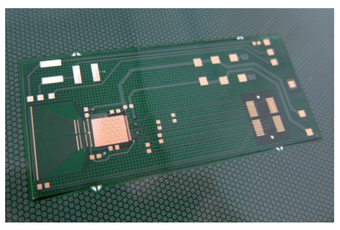


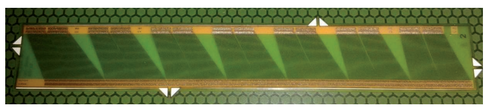




- Hybridization design:
  - flex pitch-adapter on a rigid PCB
    - 2-layer flex PCB
    - 50 µm laser-drilled blind vias
    - 25 µm kapton substrate + 2x12 µm copper layers
    - successfully produced and tested
  - fully integrated flex board
    - 2-layer flex PCB, ~100 µm total thickness
    - sensor-chips fanout structure
    - first prototype (1 sensor, 1 chip) under test







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