Integration of the $\bar{P}$ANDA Micro-Vertex-Detector Barrel Staves

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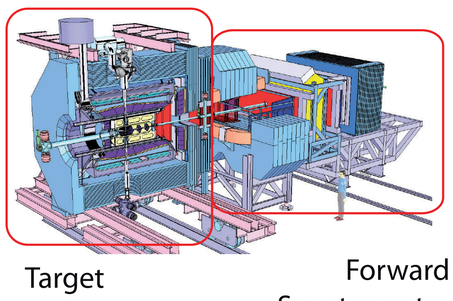
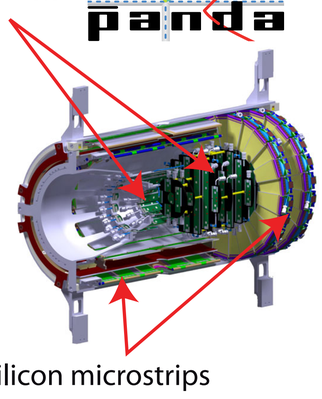
The $\bar{P}$ANDA Experiment

- 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}



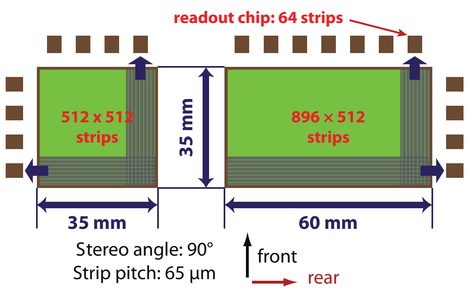
The Micro-Vertex-Detector

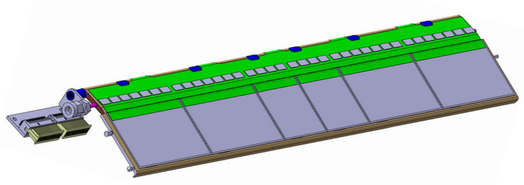
- 4 concentric barrels and 6 forward disks
- Vertex reconstruction for primary and secondary vertices
- Improvement of momentum resolution and PID
- Requirements:
  - trigger-less readout with high rate capability
  - good time resolution and low material budget
  - high radiation tolerance

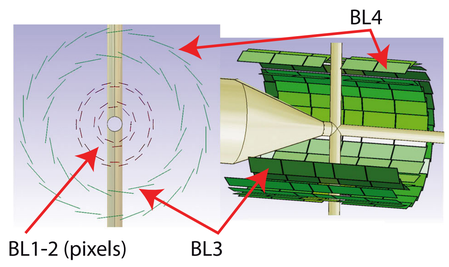


Double-Sided Silicon Microstrip Staves

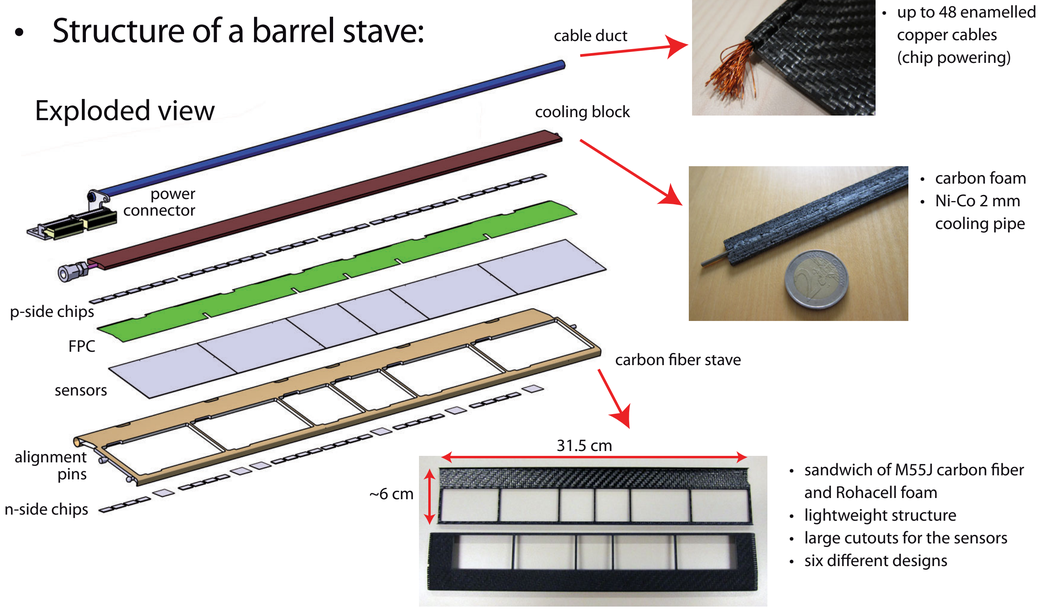
- Rectangular and square strip sensors
- Arranged in linear staves
- Two concentric strip barrels:
  - BL3: R = 92 mm, L = 278 mm
    20 staves (4 - 5 sensors)
  - BL4: R = 125 mm, L = 312 mm
    26 staves (5 - 6 sensors)
  - special staves on top and bottom
- Complete stave from BL4:

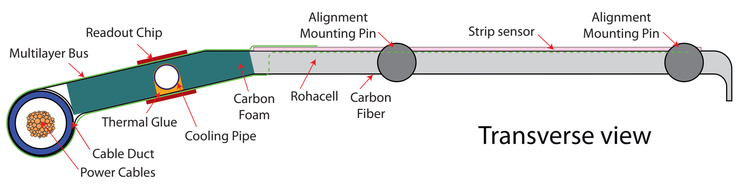




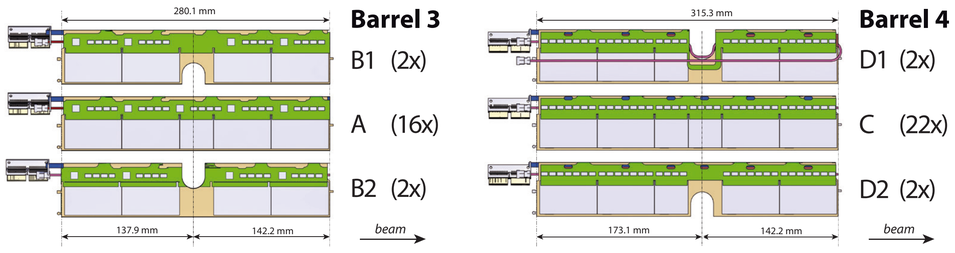


- Structure of a barrel stave:

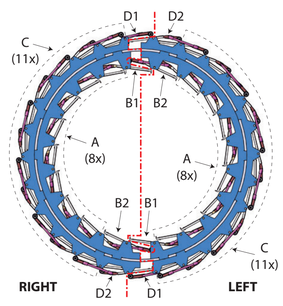




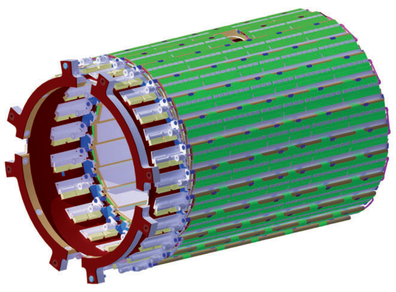
Design of the strip barrels



Six different stave designs



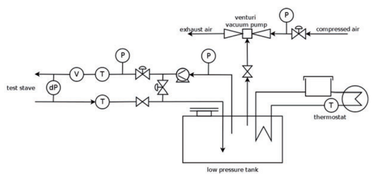
Cylindrical common support and disposition of the staves



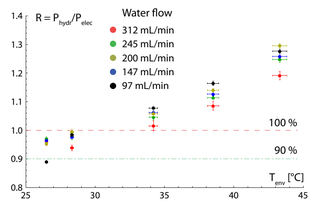
CAD view of the two strip barrels

Stave Cooling System

- Water at 18°C as coolant
- Underpressure operation to avoid leaks
- Equipped stave prototype:
  - 66 chips simulated with resistors
  - total dissipated power 17 W
  - one sensor glued and wire bonded
  - Flexible Printed Circuit implemented
- Experimental setup:
  - underpressure hydraulic circuit
  - temperatures measured with IR camera
- Performed studies varying:
  - environment temperature
  - chip power
  - water flow

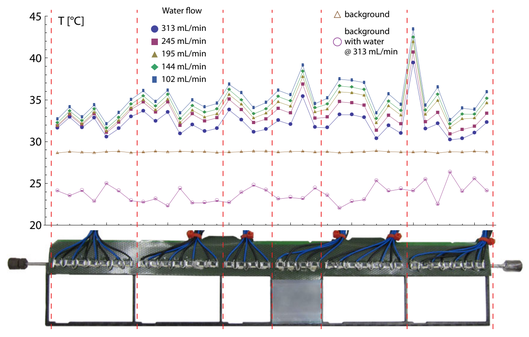


Cooling system test setup



Ratio between hydraulic power removed by the water and electric power dissipated on the stave

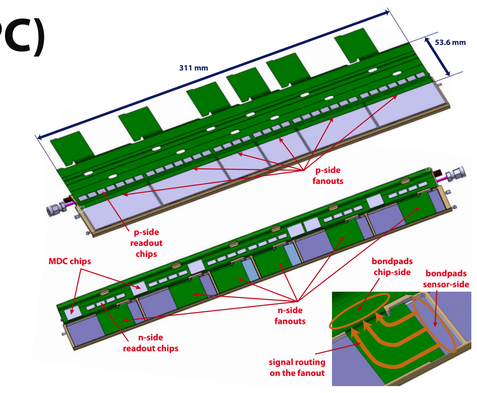
Typical IR image of the stave during the cooling test

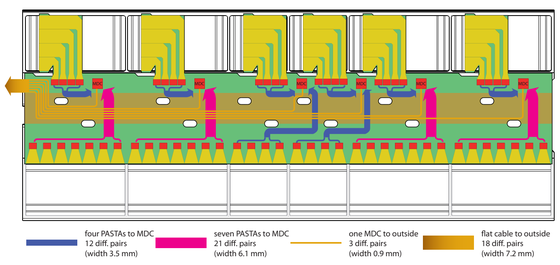


Temperature profile along the stave at different water flows (T_{env} = 28.5°C), plus background profiles

Flexible Printed Circuit (FPC)

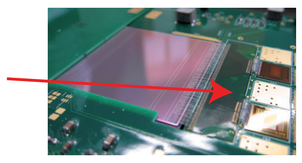
- Pitch adaptation from 130 µm (sensor) to 63 µm (chip)
- 2-layer design
- Interconnection between chips
- Power and data distribution
- up to 24 power domains



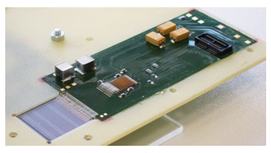


- foldable around the stave
- n-side fanouts implemented on foldable flaps
- up to 12 openings to access the cable duct

- First prototype series:
  - flexible pitch adapters
    - 2-layer, 50 µm thick flex
    - 50 µm laser-drilled vias
  - one-chip carrier boards
    - 2-layer, 100 µm thick flex
    - integrated sensor-chip fanout structure

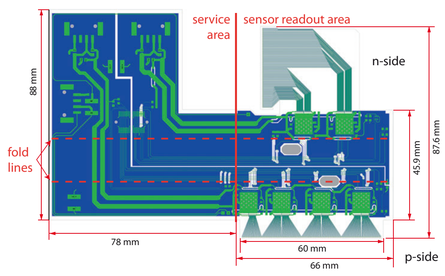


Flexible pitch adapter prototype on rigid PCB



Chip carrier board module with one sensor

- Next series of designs:
  - multi-chip carrier board
    - same technology of pitch adapters
    - full one-sensor design with six chips
    - sensor readout area foldable and compatible with final design
  - new pitch adapters and cables



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