Integration of the strip detector of the PANDA Micro Vertex Detector

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International Conference on Science and Technology for FAIR in Europe 2014, Worms
October 15th, 2014
The PANDA Experiment

- Fixed target experiment at FAIR, Darmstadt
- Antiproton beam with $p = 1.5 - 15$ GeV/c and hydrogen or nuclear target
- Maximum luminosity $2 \cdot 10^{32}$ cm$^{-2}$ s$^{-1}$; interaction rate $2 \cdot 10^7$ s$^{-1}$
- Continuous, triggerless readout

**Physics program:**
- High precision charmonium spectroscopy
- Search for hybrids and glueballs
- Study of exotic states ($X, Y, Z$)
- Nucleon structure
- Hyper-nuclear physics
The Micro Vertex Detector

• Vertex reconstruction with high spatial (<100 µm) and time (<6 ns) resolution
• High rate capability (2 \cdot 10^7 pbar-p ann./s) and triggerless readout
• Low material budget (<10% radiation length overall) and high radiation tolerance
• Hybrid pixels and double-sided silicon strip detectors
Strip Disks – Design Concept

- Trapezoidal sensors, 285 µm thick
- Stereo angle: 15°
- Strip pitch: 45 µm; readout every second channel
- 768 strips per side
- 2 disks at z = 172 and 232 mm, 24 sensors per disk
- Adjacent sensors overlap to avoid dead zones

- Coverage: 0.07 m²
  (12% of the full MVD)
- 37k channels
- 288 readout chips
Cooling performance studied with FEM analysis.

Complex procedure for assembly:
- Wire bonding is performed on both sides, while module is kept flat
- The frame is slid on the sensor
- The module is bent in the final shape
Strip Disks – Module Design

- The 6 modules on a quarter are glued to the support and to the cooling pipe
- The MDC support is added
- Wire bonding is performed on the 6 MDCs
Strip Barrels – Design Concept

- Rectangular (512 × 896 channels) and squared (512 × 512 channels) sensors
- Stereo angle: 90°, strip pitch 65 µm
- Readout every second strip
- Two barrels at r = 92 and 125 mm
- 4 – 6 sensors on each of the 46 staves (248 sensors in total)

- Coverage: 0.422 m²
  (70% of the full MVD)
- 162k channels
- ~2500 readout chips
- ~700 W power consumption
- Barrel 3: 20 staves 28 cm long
- Barrel 4: 26 staves 31 cm long
Strip Module – Stave Design II

- Sandwich structure of carbon fiber (200 µm) and foam (2 mm)
- Up to 18 W dissipated on one stave → active water cooling
- Embedded cooling pipe in nickel-cobalt alloy (2 mm diameter, 80 µm wall thickness)
- Carbon foam (POCO HTC) in the area around the cooling pipe
Strip Module – Stave Prototypes I

- Design in collaboration with ZEA-1, Jülich
- Large cutouts for the sensors
- Special design for top/bottom staves around the target pipe
- 6 different designs in total

31.3 cm

- Thermal tests to validate the cooling system are ongoing

~6 cm
Strip Module – Stave Prototypes II

Cooling pipe embedded in the carbon foam

Reduced size stave with carbon foam and pipe

Reduced size stave with cable channel hosting 60 enameled copper wires with diameter between 0.15 and 0.55 mm
Strip Barrels – Mechanical Integration

Complete half-detector

Global frame

Strip barrels support
Strip Module – Hybrid Bus I

Readout short strips

Readout long strips
Strip Module – Hybrid Bus I

Readout short strips

• Connects the sensor and the front-end chips, adapting the pitch
• Distributes I/O signals and power to the chips

Readout long strips

Proposal for the full hybrid layout
First prototypes with flexible technology: flex pitch-adapters

**Laser microvias diam. 50 µm**

- **Varnish 15 µm**
- **Cu 12 µm**
- **Kapton 25 µm**
- **Cu 12 µm**
- **duPont Pyralux Cu-Kapton-Cu laminate 49 µm**

**Ver. 1:** varnish 15 µm

**Ver. 2:** Kapton coverlay 25 µm

**Flex pitch-adaptor prototype**
Strip Module – Hybrid Bus III

- Reduced-scale prototype with APV25 readout chip produced

Laser microvias
diam. 200-650 µm

APV25 readout chip
transition board
high density data cable

Bonding pads for the sensor
Pad for 1 APV readout chip
Sensor biasing connectors
Pitch adapter

Cu 12 µm
Kapton 50 µm
Cu 12 µm
Varnish 15 µm

Thinflex A-2003AD
Cu-Kapton-Cu laminate 74 µm

S3 double-sided microstrip sensor
APV power supply connectors
Summary & Outlook

• The general design of the PANDA MVD is finalized.

• Development and validation of components is ongoing:
  • Carbon fiber stave prototypes under study;
  • Flex pitch adapters and small-scale PCB produced and tested successfully.

• Next steps:
  • Design and test of a full-scale hybrid;
  • Validation of the stave cooling system;
  • Study of the assembly procedures and tools.
Thank you for your attention!
Strip Barrels – Powering

- DC-DC powering operating in B=2T
- 4 power domains per sensor
- up to 50 power supply cables per strip barrel stave (up to 4 m long)
- ~1200 converters for barrels + disks (+600 for pixel detector)
- MVD services routing is a crucial issue

FEASTMP converter (CERN development)