The PANDA MVD

Hans-Georg Zaunick
II. Physikalisches Institut, JLU Gießen
The FAIR Accelerator Facility

Darmstadt/Germany

GSI

SIS18

HESR

SIS100
SIS300

CBM

SuperFRS

NuSTAR

PANDA

FAIR

- Provides secondary ion and antiproton beams
- Parallel operation of many experiments
- High beam intensities and qualities

HESR

- High Energy Storage Ring
- Up to $10^{11}$ stored antiprotons
- Beam momentum: 1.5...15 GeV/c
The PANDA Detector @ FAIR

- Very broad physics program:
  - Hadron spectroscopy
  - In-medium effects
  - Hypernuclear physics
  → Focus on charmed hadrons

- 4π acceptance
- High spatial and momentum resolution
- No hardware trigger

19 Mar 2014  HG Zaunick  DPG Spring
The Micro-Vertex Detector

- 2 barrel pixel layers
- 4 pixel disks
- 2 barrel strip layers
- 2 mixed disks
- 2 optional forward wheels (@40 & 60 cm)
**Vertex Finding**

Open charm: e.g. $\bar{p}p \rightarrow D^+D^- \rightarrow K\pi^+\pi^K\pi\pi$

**PANDARoot** Simulations with detailed detector descriptions

- **Reco $D^+$ mass**
  - $\sigma_{Rec} = 25.1 \text{ MeV}/c^2$
  - $\sigma_{Vtx} = 24.5 \text{ MeV}/c^2$
  - $\sigma_{4C} = 5.8 \text{ MeV}/c^2$

- **Reco $D^+$ decay length**
  - $ct = 119.7 \pm 0.8 \mu m$

- **$D^0(K^+\pi^-)$**

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**HK 59.2, Fri, 14:30**

Elisabetta Prencipe

**HK 23.6, Tue, 18:15**

Andreas Pitka
Epitaxial silicon pixel sensors

- Several thicknesses evaluated, 100 µm chosen for PANDA
- 100 x 100 µm² pixel array
- Full qualification of prototypes done
- Full size PANDA geometry

NIMA 594 (2008) p.29
Pixel Subdetector - Modules

INFN Torino

DPG Spring Meeting, Frankfurt
Pixel Subdetector - Front-end

ToPix v2

- Torino Pixel Readout Chip, current version V3
- 2 x 128 + 2 x 32 double columns
- Size 4 x 4.5 mm²
- Complete pixel cells with full column architecture, end-of-column logic and buffers
- Fully tested in lab and beam setups
- Next prototype ToPix v4 submitted, lab tests pending

INFN Torino

ToPix v3

NIMA 596 (2008) p.96
Strip Subdetector - Setup

- **Barrel sensors**
  - Readout chip: 128 strips
  - Stereo angle: 90°
  - Chip size: 2 × 2
  - Chip size: 2 × 4
  - Strip pitch: $d_{\text{pitch}} = 1.30 \, \mu\text{m}$

- **Disk sensor**
  - Top edge: 4 chip width
  - Stereo angle: 15°
  - Strip pitch: $d_{\text{pitch}} = 67.5 \, \mu\text{m}$

- **Strip barrel layer**
  - Front view

- **Strip disk**
  - Along beam axis
Strip Subdetector – Barrel Stave

Actual Stave design

- CFRP (2* pre-peg 90° /0° mm, ~0,2 mm )
- Foam (Rohacell unpressed =2 mm)
- POCO HTC ~ 2,8 x ~ 10 mm (scheduled)
- Tube Do=2 mm Di=1.8 Material: MP35m (1.4571)
- Chip design: 4,2 *5-6mm² ~1,8W/cm² MDC~12*12 mm²
- 30 pairs of cables (from 0,1-0,4 mm)
Strip Subdetector – Barrel Stave
Strip Subdetector – Barrel Stave

Folding of PCB around stave to connect n-side and p-side r/o

HK 34.6 (this session) Tommaso Quagli
Strip Subdetector - Forward Disks

- 2 x 24 trapezoidal sensors
- 2 separate disks divided into 4 segments
Strip Subdetector - Forward Disks

Strip pitch: 67.5 µm
No. of channels: 512 (both sides)
Assembly
Assembly
Cooling

<table>
<thead>
<tr>
<th></th>
<th>In</th>
<th>Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrel 3</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Barrel 4</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Disk 5 &amp; 6</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>31</strong></td>
<td><strong>31</strong></td>
</tr>
</tbody>
</table>

Cooling Manifolds

Water cycle Barrel

¼ Disk Counter flow exchanger

Barrel & Disk 62 feedthroughs
Strip Subdetector - Sensors

<table>
<thead>
<tr>
<th>Strip</th>
<th>P-side/n-side strips</th>
<th>Pitch/Width</th>
<th>Active Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>896/512</td>
<td>65/30 µm</td>
<td>58.275×33.315 mm²</td>
</tr>
<tr>
<td>S2</td>
<td>512/512</td>
<td>65/30 µm</td>
<td>33.315×33.315 mm²</td>
</tr>
<tr>
<td>S3</td>
<td>384/384</td>
<td>50/20 µm</td>
<td>19.230×19.230 mm²</td>
</tr>
<tr>
<td>S4</td>
<td>128/128</td>
<td>65/30 µm</td>
<td>8.355×8.355 mm²</td>
</tr>
</tbody>
</table>

Punch-Through Biased

Poly-Si Biased
Cleanroom Facility (ISO class 6)

**JLU Gießen**

Semi-automatic wedge wire Bonder

Automatic Prober
Sensor Probing and Prototype Assembly

Many sensor characterization capabilities available

“Probecard”: fixed sensor assembly with all strips bonded to common lines (top and bottom)

Probe Station

Wafer diode test fixture
Handle on depletion behavior of sensors

\[ D = \tan \delta = \frac{\Re Z}{\Im Z} = \frac{1}{\omega C_R p} \]
Radiation Hardness Studies

Pixel barrels/disks

2GeV

15GeV

Strip barrels/disks

@ 15GeV

pp DPM calculations (T. Stockmanns)
Radiation Hardness Studies

Irradiation with 14 MeV Protons (Isochrone Cyclotron Bonn)

Typical profile of hadronic lattice damage
Prototypes

Flex-PA and squared sensor assembled on a test board and successfully tested at SPS, CERN (September 2012)

3.5x3.5cm² PANDA fullsize sensor S2 (@130µm r/o)

APV25 Front-ends
Prototypes

- **Laser microvias**: diam. 200-650 µm
- **Varnish 15 µm**
  - **Cu 12 µm**
  - **Kapton 50 µm**
- **Cu-Kapton-Cu laminate 74 µm**
- **Thinflex A-2003AD**
- **Bonding pads for the sensor**
- **Pad for 1 APV readout chip**
- **High density data connector**

19 Mar 2014  HG Zaunick

DPG Spring Meeting, Frankfurt
Prototypes
Prototypes

Successfully tested in Beams @ COSY

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Poster HK 46.91
Strip Frontend

- Design of new selftriggered FE based on ToPIX pixel FE and TOFPET ASIC started in 2013
- Modified analog stage, simplified single column buffer logic
- ToT+HiRes TDC stage for amplitude measurement
- Dual threshold

Analog Chain

Time-to-Amplitude Converter + Wilkinson ADC

HK 34.7 (this session) Valentino Di Pietro
HK 6.1 Mon, 14:00 Alberto Riccardi
Module Data Concentrator

- On-module ASIC
- Multiplexes all FEs of one sensor
- Feature extraction: cluster finding, cluster correlation
- Manages slow-control + calibration of all attached FEs
- Fast GBT e-link for data out + config in

FH Südwestfalen Iserlohn
Infrastructure - Readout

→ **Thin Al-cables**
- Thin kapton carrier
- Aluminum strips, 18 diff. pairs
- For data transmission out of the MVD
- Connect FEs/MDC to GBT receiver
- 320 Mbit/s serial links

→ **GBT Project**
- E-link interface to on-detector node
- Optical link to the off-detector side
### Numbers

- **Number of sensors:** 176 (pixel) 296 (strip)
- **Number of FEs:** 810 (pixel) 3112 (strip)
- **Number of channels:** 10.3 M (pixel) 200k (strip)
- **Number of DC-DC:** ~800 (pixel) 1480 (strip)
- **Active area (m²):** 0.106 (pixel) 0.494 (strip)
- **Cables off MVD:** 1584 (disks) 3592 (barrels) 614 (GBT) 5790 (total)
- **Cable cross section:** 21835 mm² (total)
- **Power dissipation:** ca. 2 kW (pixel) 800 W (strips) (~0.5kW in cables)