

The Micro-Vertex Detector for the $\bar{\text{P}}\text{ANDA}$ experiment

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on behalf of the $\bar{\text{P}}\text{ANDA}$ MVD group
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FAIRNESS 2012

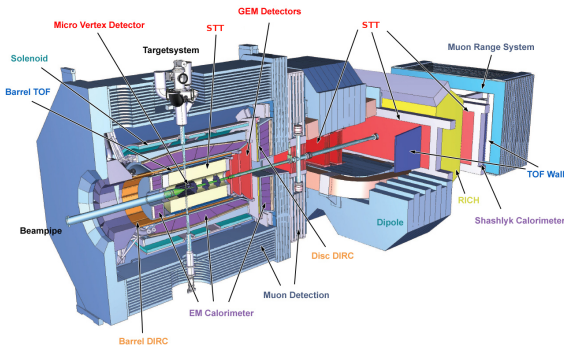
Hersonissos, Greece - Sept. 3-8 2012

Outlines

- $\overline{\text{P}}\text{ANDA}$ Physics and Experimental Setup
- The Micro Vertex Detector
 - Detector Layout
 - Hybrid Pixel
 - Double-Sided Micro-Strip
 - MC Simulation and Physics Performance
- The First Hybrid Pixel Beam Test

$\overline{\text{PANDA}}$ Physics and Experimental Setup

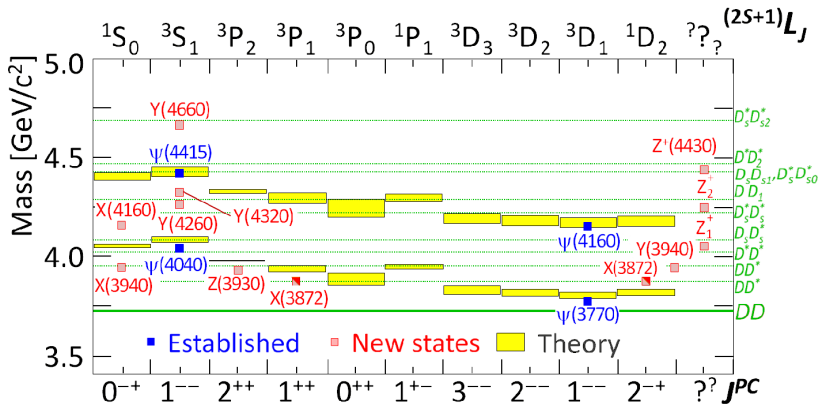
$\overline{\text{PANDA}}$ is one of the experiments of the new FAIR facility at GSI.
Antiproton beam will be available with a beam momentum
from 1.5 up to 15 GeV/c in HESR.



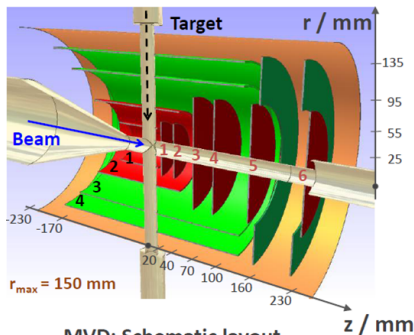
Physics Goals

- Hadron spectroscopy
- Gluonic excitations
- Charm in nuclei
- Hypernuclei
- CP violation

Charmonia and Charmonium-like system



The Micro-Vertex Detector



Layout

- 6 Forward Disks
- 4 Barrels

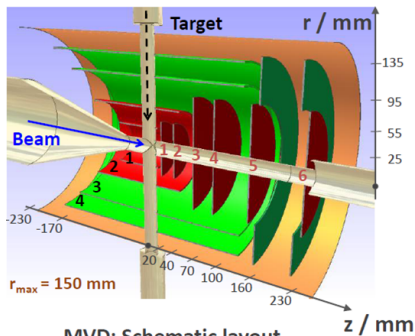
Geometrical Constraint

- Maximum Radius: 15 cm
- Dimension along z : ± 23 cm

Readout Channels

- $\sim 10^7$ Hybrid Pixels
- $\sim 2 \cdot 10^5$ Double-Side Microstrips

The Micro-Vertex Detector

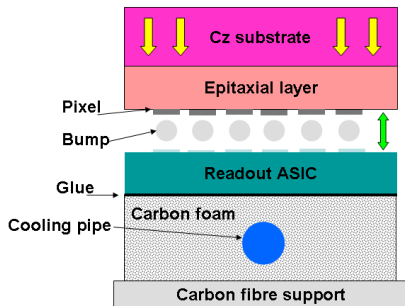


MVD: Schematic layout

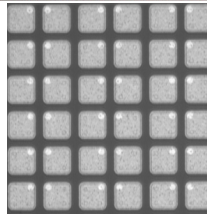
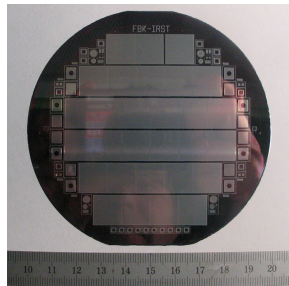
Requirements

- Spatial resolution $< 100 \mu\text{m}$
- Momentum resolution
 $\delta p/p \sim 2\%$
- Time resolution $\leq 10 \text{ ns}$
- High rate capability
- No hardware trigger
- Radiation tolerance
 $\sim 10^{14} \text{ n}_{1\text{MeV eq}}\text{cm}^{-2}$
- Low material budget
- PID by dE/dx

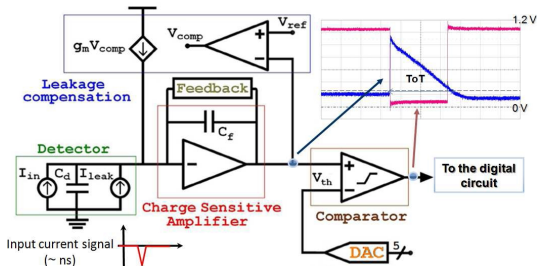
MVD Hybrid Pixels



- Epitaxial Silicon Material
- $100\mu\text{m} \times 100\mu\text{m} \times 100\mu\text{m}$
- $\rho_{\text{epi}} \sim \text{k } \Omega \cdot \text{cm}$
- $\rho_{\text{Cz}} \sim 20\text{-}50 \text{ m } \Omega \cdot \text{cm}$



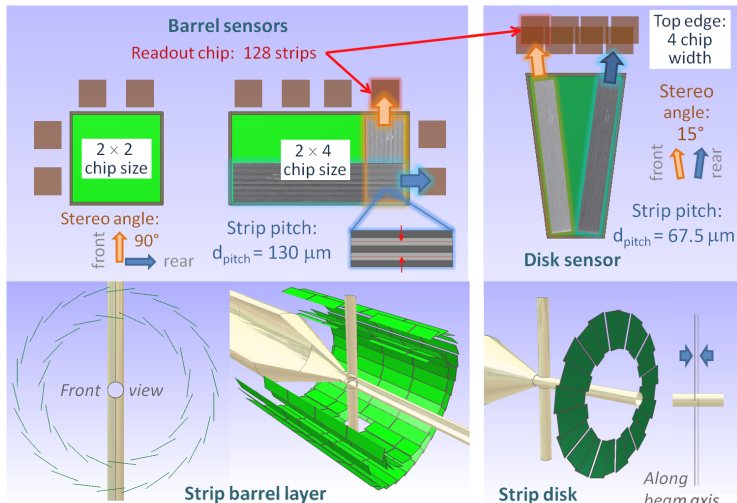
MVD Hybrid Pixels - ToPix3



- Pixel Size: $100\mu\text{m} \times 100\mu\text{m}$
- Self Trigger Capability
- Chip Size: 11.6 mm x 14.8 mm
- ToT for dE/dx Measurement
- Input Range: up to 50 fC
- Noise Floor: ≤ 0.032 fC

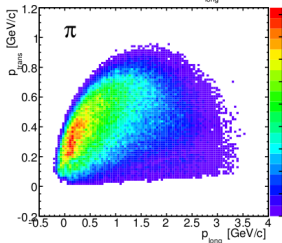
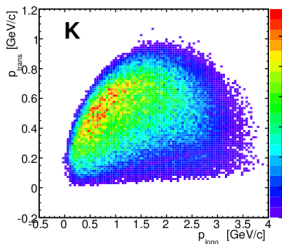
- Clock Frequency: 155.52 MHz
- Time Resolution: 6.45 ns
- Power Budget: $< 800 \text{ mW/cm}^2$
- Max Rate cm^{-2} : $6 \cdot 10^6$ Hits/s
- TID: $\leq 100 \text{ kGy}$
- Serial Output

Strip Sensor Geometry

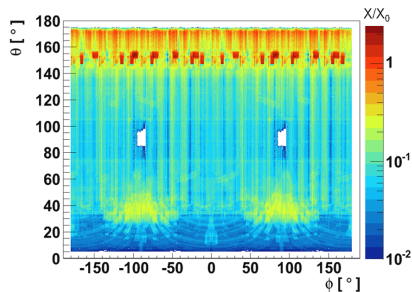


Material Budget

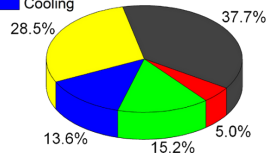
$$\bar{p}p \rightarrow D^+ D^- \rightarrow K^- \pi^+ \pi^+ K^+ \pi^- \pi^-$$



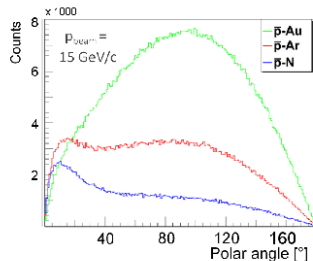
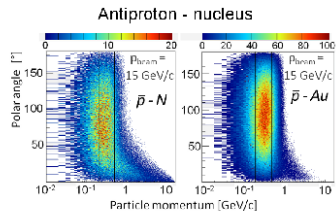
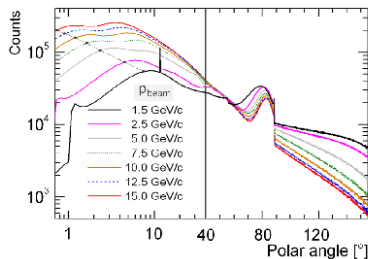
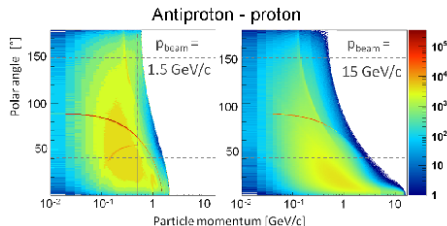
R. Jakel, PhD thesis, TU Dresden, 2009



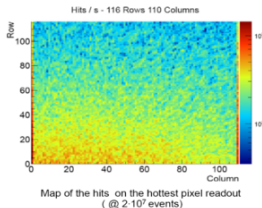
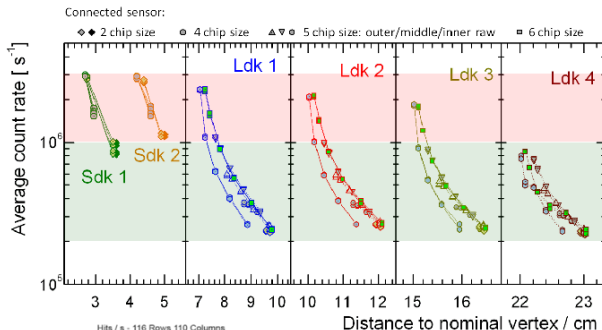
- Electronics
- Sensor
- Cooling
- Support
- Cabling



Rate Study



Rate Study



Data load from MVD
(@ $2 \cdot 10^7$ ann/s) ~ 38 Gb/s

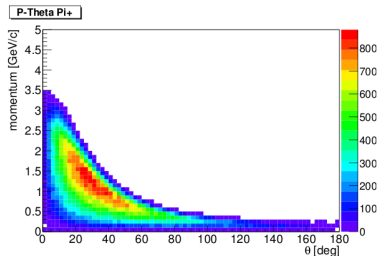
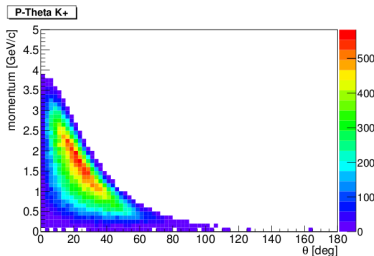
Physics Performance

$$\bar{p}p \rightarrow \psi(3770) \rightarrow D^+ D^- \rightarrow K^- \pi^+ \pi^+ K^+ \pi^- \pi^-$$

$(p_{\bar{p}} = 6.5788 \text{ GeV}/c)$

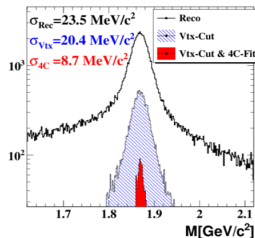
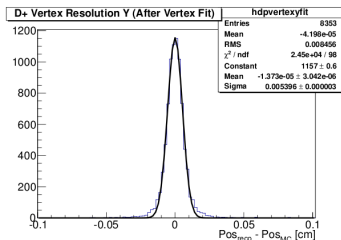
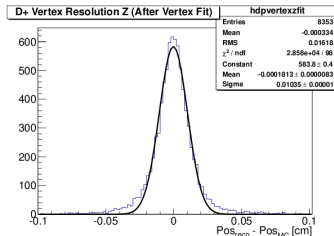
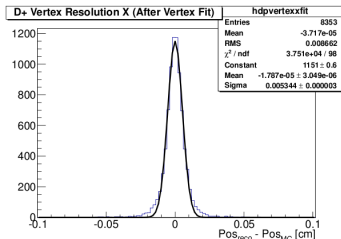
- Secondary Vertex (short decay length)
- Large Number of Ejectiles

- $\Delta m_{D(\text{cand})} < 750 \text{ MeV}/c^2$
- Vertex Fit $\rightarrow \chi^2$ selection



(Figures from: STT-TDR: arXiv:physics.ins-det/1205.5441v2)

Physics Performance



(Figures from: STT-TDR: arXiv:physics.ins-det/1205.5441v2)

First Hybrid Pixel Beam Test

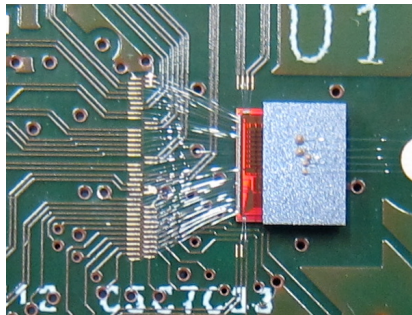
2.7 GeV/c protons @ COSY Synchrotron
of Forschungszentrum Jülich

Sensors

- Produced @ FBK (Trento)
- Bump Bonding @ IZM (Berlin)
- $100\mu\text{m}$ Active Epitaxial Layer
- $525\mu\text{m}$ Passive CZ Substrate

Electronics

- ToPix3 Prototype
- Testing Board
- Xilinx Evaluation board + Virtex 6FPGA



PANDA-MVD: Addendum to the TDR

First Hybrid Pixel Beam Test

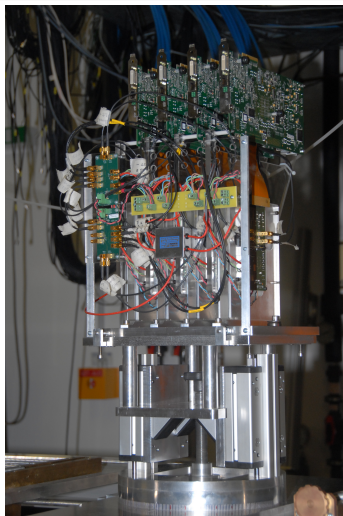
Setup

- 640 pixels each plane $3.2 \times 2 \text{ mm}^2$
- Distance between 2 sensor surface 6 cm
- Total length $\sim 20 \text{ cm}$
- 50 MHz clock

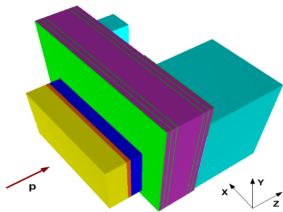
Raw Data

- Column & Row Information
- 44 bits Timestamp
- 12 bits Leading & Trailing Edge (Gray Encoded)

PANDA-MVD: Addendum to the TDR



First Hybrid Pixel Beam Test



COMPONENTS	THICKNESS [cm]	MATERIAL
PixelPassive	0.0525	Si
PixelActive	0.0100	Si
Chip	0.0300	Si
PCB	0.1630	Cu+FR4
Capacitor Big	0.2018	Fused Si+Cu
Capacitor Small	0.0958	Fused Si+Cu

	X/X_0	
Number of planes	$x > 0$	$x < 0$
1 pixel	$\sim 5\%$	$\sim 6.6\%$
4 pixel	$\sim 20\%$	$\sim 26.6\%$

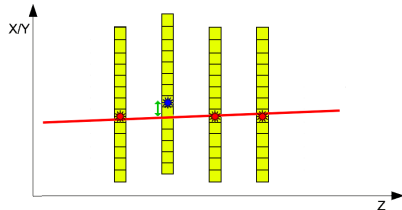
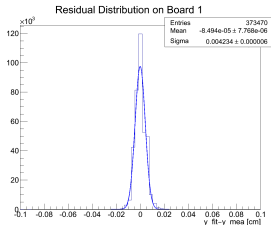
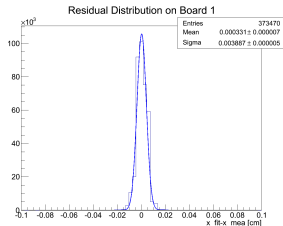
```

*****
*      Row      * data0.fTi *
*****
*          0 * 167300227 *
*          1 * 167300226 *
*          2 * 167299186 *
*          3 * 167299986 *
*          4 * 167298360 *
*          5 * 167298360 *
*          6 * 167301046 *
*          7 * 167301045 *
*          8 * 167298095 *
*          9 * 167298359 *
*         10 * 167298359 *
*         11 * 167298894 *
*         12 * 167298359 *
*         13 * 167298359 *
*         14 * 167298359 *
*         15 * 167297481 *
*         16 * 167297480 *
*         17 * 167297480 *
*         18 * 167298893 *
*         19 * 167297362 *

```

PANDA-MVD: Addendum to the TDR

First Hybrid Pixel Beam Test



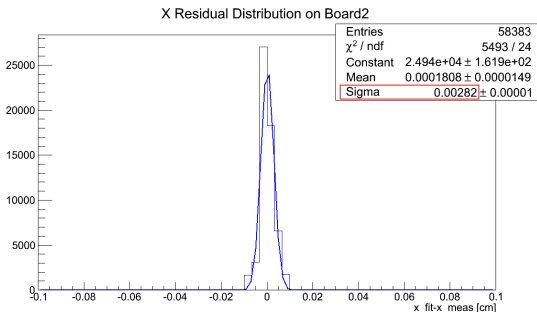
Pixel Plane	σ_x [μm]	σ_y [μm]
0	65	62
1	39	42
2	45	45
3	73	53

$$\sigma_{\text{track}} = \frac{\sqrt[4]{\sigma_0^2 * \sigma_1^2 * \sigma_2^2 * \sigma_3^2}}{\sqrt{4}} \rightarrow \sigma_x = \sigma_y \simeq 27 \mu\text{m}$$

PANDA-MVD: Addendum to the TDR

First Preliminary Results from CERN Beam Test

- 100 μm Epi Sensor + 20 μm Cz substrate
- π @ 10 GeV/c



- MVD Layout Design :-)
- R&D Developments :-)
- MC Performance :-)
- Beam Test Results :-)

Thanks for your attention!

All the material, if not otherwise specified, comes from the MVD-TDR:
[arXiv:physics.ins-det/1207.6581v2](https://arxiv.org/abs/physics.ins-det/1207.6581v2)