Pixels in $\overline{\text{P}}$ANDA

1st Pixel Platform Workshop

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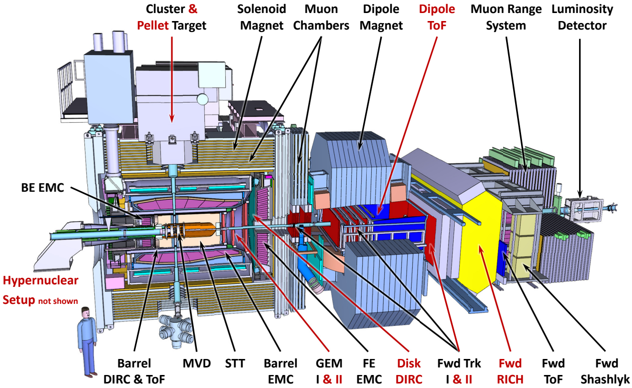
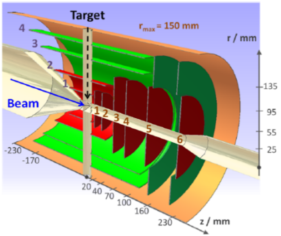
The $\overline{\mathrm{P}}$ANDA Detector



$\overline{\mathrm{P}}$ANDA physics program:

- Hadron spectroscopy
- Hadron structure
- Hadrons in medium
- Hypernuclear physics

Micro Vertex Detector



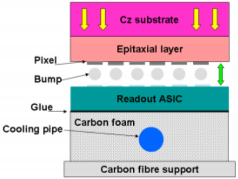
Barrel:

- Layer 1: radius 28 mm, Pixel Detector
- Layer 2: radius 53 mm, Pixel Detector
- Layer 3: radius 92 mm, Strip Detector
- Layer 4: radius 120 mm, Strip Detector

Forward:

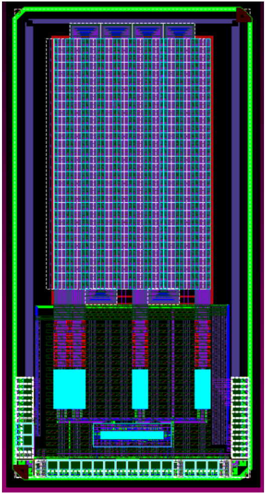
- Disks 1-2 : radius 37.5 mm, Pixels
- Disks 3-4 : radius 75 mm, Pixels
- Disks 5-6 : radius 130 mm, Pixels + Strips

Pixel Sensor for MVD



- 116×110 Pixels
- Pixel size" $100 \times 100\,\mu m^2$
- Active area: $11.4 \times 11.6\,mm^2$
- dE/dx measurement: ToT, 12bits dynamic range
- Time resolution: 6.25 ns (1.80 ns r.m.s.)

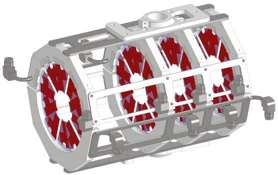
Readout ASIC: ToPiX v4

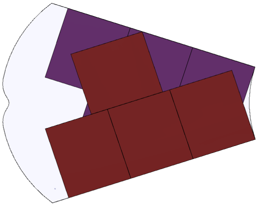


- Size: 3 mm $\times$ 6 mm
- CMOS 130 nm
- 640 pixel cells, 2 $\times$ 2 $\times$ 128 and 2 $\times$ 2 $\times$ 32 columns
- Hamming encoding and TMR pizel logic protection schemes
- Clock frequency 160 MHz
- SEU protected EoC
- Serial data output
- GBT-compatible SLVD I/O
- Project discontinued in $\sim$ 2014

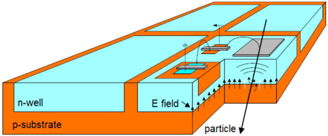
Luminosity Detector

- Reconstruct tracks of elastically scattered antiprotons to determine luminosity at IP
- Resolution limited by multiple scattering
  - ⇒ Low material budget
  - ⇒ Sensors in vacuum
- Four detector layers with 10 sensor modules each
- Aluminum holding structure with embedded stainless steel pipes for cooling

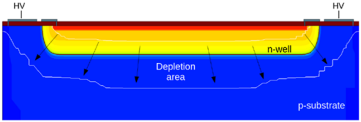




High Voltage Monolithic Active Pixel Sensor (HV-MAPS)

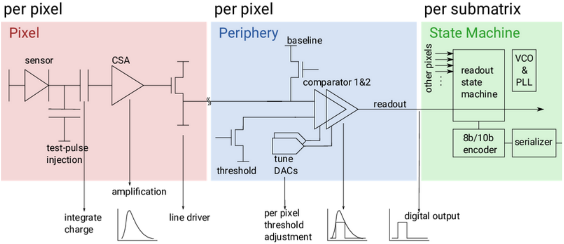


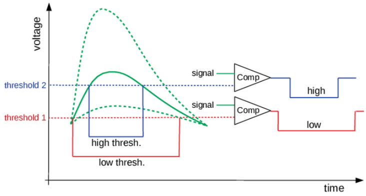
I. Perić, NIM A 582 (2007), 876 – 885



- Sensitive volume and readout electronics on same chip
- Pixels implemented as deep n-wells in a p-substrate
- 180 nm HVCMOS
- Depletion layer by applying high reverse bias voltage
- Fast charge collection via drift
- Depletion layer thickness: 10 – 15 µm
- Sensor thickness: $\sim$ 70 µm

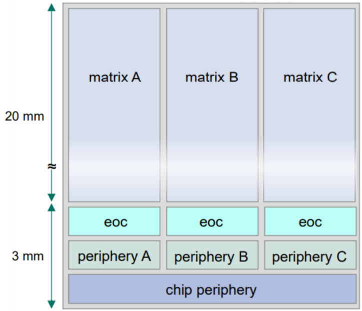
High Voltage Monolithic Active Pixel Sensor (HV-MAPS)





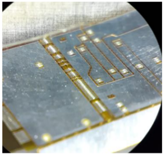
- 2 Thresholds
- Low thresholds locks timestamp
- High threshold “verifies” hit

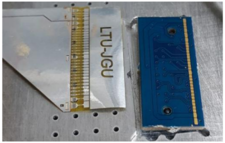
HV-MAPS in $\overline{\text{P}}$ANDA



	MuPix11	P2Pix
Pixels	256 × 250	244 × 240
Pixel size	$80 \times 80\,\mu m^2$	$84 \times 84\,\mu m^2$
Physical size	$20.7 \times 23.2\,mm^2$	$20.7 \times 22.6\,mm^2$
Active area	$20.0 \times 20.5\,mm^2$	
Comperators	Two in periphery	One in pixel cell

Flexcable Unit



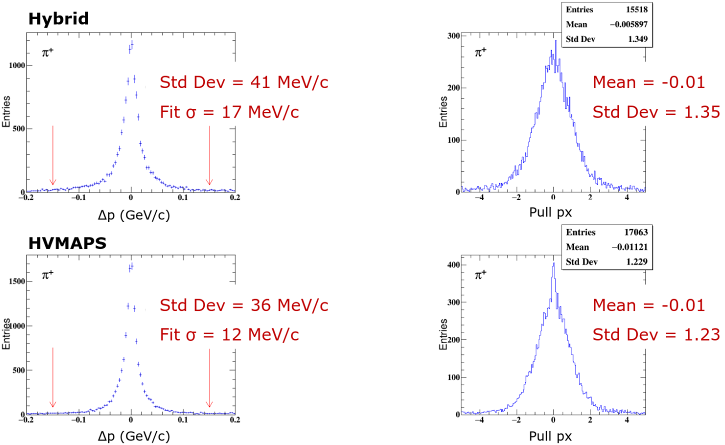


Aluminium flex cable from LTU in Ukraine
Lower material budget then copper ⇒ less scattering
Sensor and connector PCB tab bonded to cable

Simulation study of reaction channel $\bar{p}p \rightarrow D^+D^-$

- Investigate HV-MAPS as possible replacement
- Data set
  - $\bar{p}p \rightarrow D^+D^-$
    with $D^+ \rightarrow K^-\pi^+\pi^+$ and $D^- \rightarrow K^+\pi^-\pi^-$
  - $p_{\text{beam}} = 8.9\,\text{GeV}/c$
  - 10000 events
- Event selection
  - $n \geq 6$ charged tracks
  - Ideal PID algorithm
  - Truth match $(D/K/\pi)$ depending on stage

Momentum Resolution and Pulls

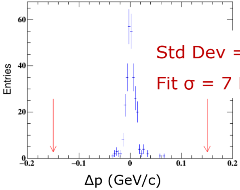


Resolution and Pulls (π^+) better for HV-MAPS

Resolutions for D^+

Momentum

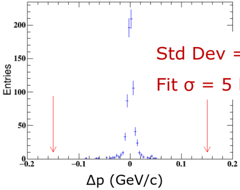
Hybrid



Std Dev = 11 MeV/c

Fit σ = 7 MeV/c

HVMAPS

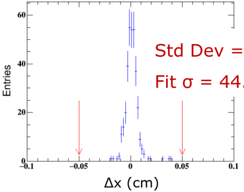


Std Dev = 10 MeV/c

Fit σ = 5 MeV/c

Vertex (x)

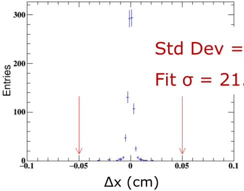
Hybrid



Std Dev = 50.5 μm

Fit σ = 44.1 μm

HVMAPS



Std Dev = 28.1 μm

Fit σ = 21.9 μm

Slight improvement in momentum resolution (10 %)
Factor 2 in vertex resolution

Summary

- Two different types of Pixel sensors in $\overline{\text{P}}$ANDA:
  HV-MAPs and hybrid Pixels
- Compared HV-MAPS and Hybrid Pixels in MVD:
  - Slightly less hits/clusters $< 1\,\%$ with HV-MAPS (in MVD)
  - More tracks with HV-MAPS ($\sim 10\,\%$)
  - HV-MAPS offer better momentum resolution of K and $\pi \sim 15\,\%$