

IFAE 2012 - Ferrara 11-13 Aprile

# Hybrid Pixels for the $\bar{P}$ ANDA Micro-Vertex Detector

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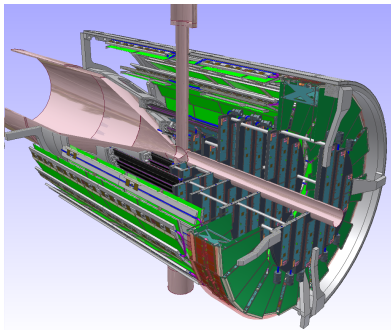


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# The Micro Vertex Detector

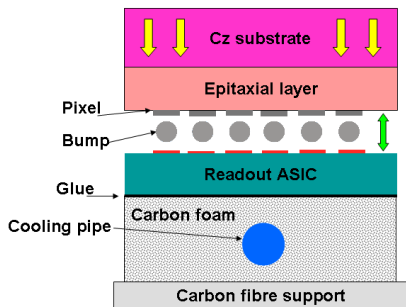


- Maximum Radius 15 cm
- Dimension along z:  $\pm 23$  cm

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

- Spatial resolution  $< 100 \mu\text{m}$
- Momentum resolution  
 $\delta p/p \sim 1\%$
- 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  $dE/dx$

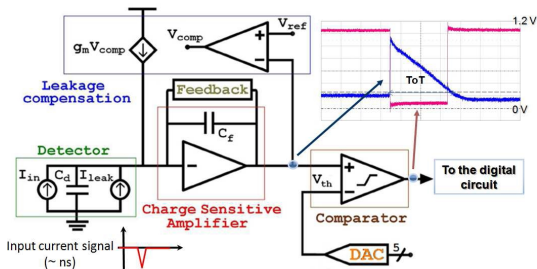
# MVD Hybrid Pixels



## Sensor R&D

- 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:  $100\mu m \times 100\mu m$
- 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:  $\leq 0.032$  fC

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

# First Beam Test

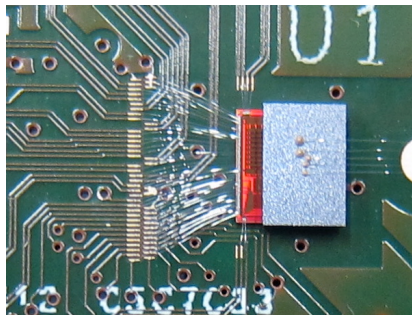
2.7 GeV/c protons @ COSY Synchrotron  
of Forschungszentrum Jülich

## Sensors

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

## Electronics

- ToPix3 Prototype
- Testing Board
- Xilinx Evaluation board + FPGA (Virtex6)



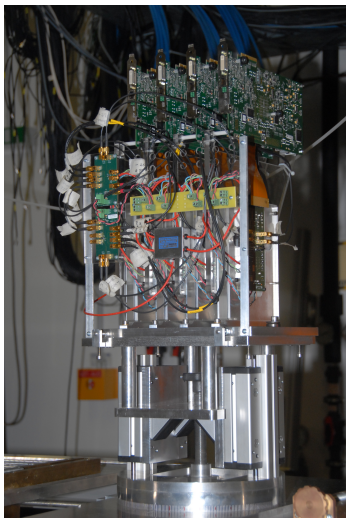
# First Beam Test

## Setup

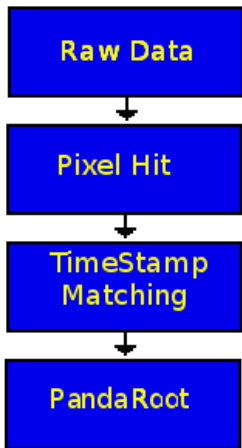
- 640 pixels each plane  $3.2 \times 2 \text{ mm}^2$
- Distance between 2 sensor surface 6 cm
- Total length  $\sim 20 \text{ cm}$
- 50 MHz clock

## Raw Data

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

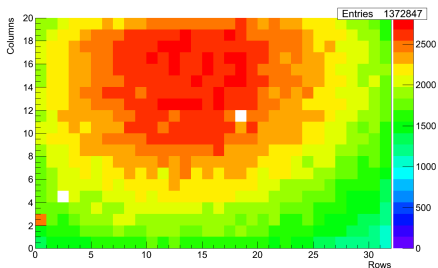
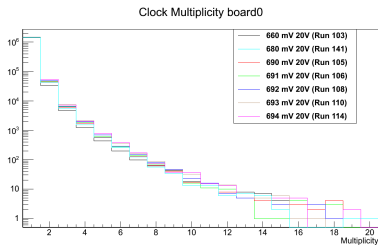


# First Beam Test - Analysis Framework



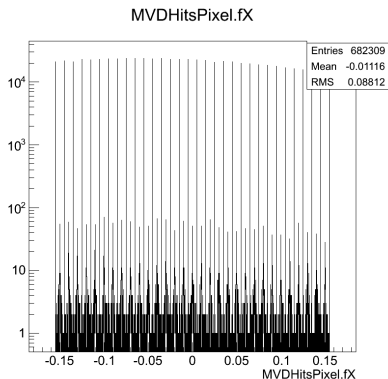
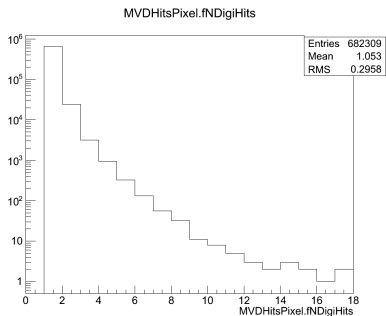
```
*****
* Row * data0.fT1 *
*****
* 0 * 167300227 *
* 1 * 167300226 *
* 2 * 167299186 *
* 3 * 167299986 *
* 4 * 167298360 *
* 5 * 167298360 *
* 6 * 167301046 *
* 7 * 167301045 *
* 8 * 167298095 *
* 9 * 167298359 *
* 10 * 167298359 *
* 11 * 167298894 *
* 12 * 167298359 *
* 13 * 167298359 *
* 14 * 167298359 *
* 15 * 167297481 *
```

# First Beam Test - What can we see?

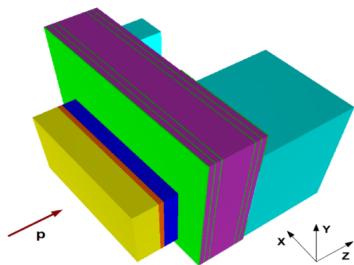




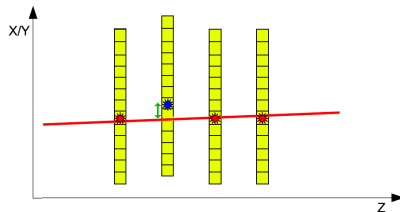
# First Beam Test - What can we see?



# First Beam Test - Montecarlo Results



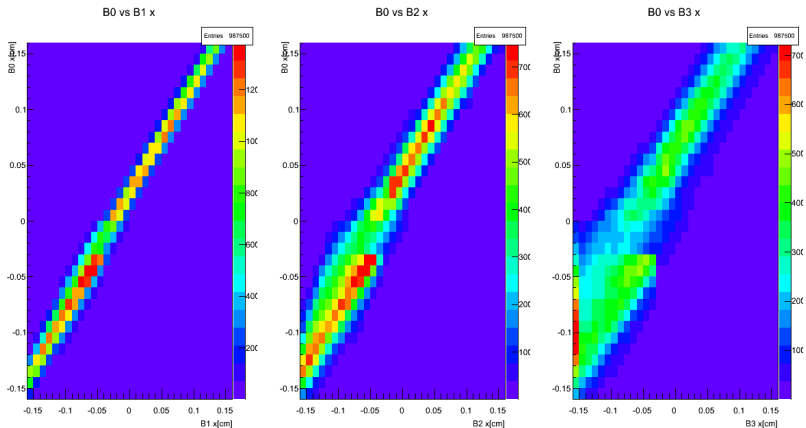
COMPONENTS	THICKNESS [cm]	MATERIAL
PixelPassive	0.0525	Si
PixelActive	0.0100	Si
Chip	0.0300	Si
PCB	0.1630	Cu+FR4
Capacitor Big	0.2018	Fused Si+Cu
Capacitor Small	0.0958	Fused Si+Cu



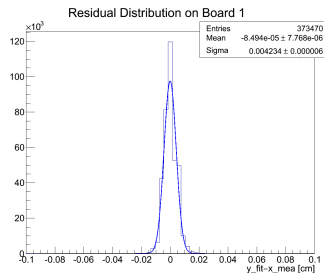
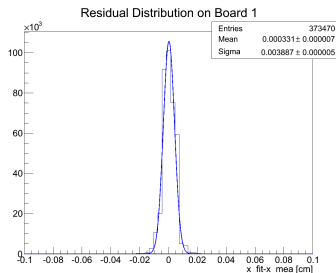
Region	Board	$\sigma_x$ [ $\mu\text{m}$ ]	$\sigma_y$ [ $\mu\text{m}$ ]	$\sigma_{\text{track } x}$ [ $\mu\text{m}$ ]	$\sigma_{\text{track } y}$ [ $\mu\text{m}$ ]
ALL	0	59.13	71.69	26.09	26.9
	1	44.35	43.48		
	2	43.15	38.08		
	3	65.49	70.58		
X<0	0	68.42	74.5	26.94	27.23
	1	40.32	40.74		
	2	42.3	40.25		
	3	72.18	72		
X>0	0	59.27	63.38	22.87	24.21
	1	34.33	36.59		
	2	36.51	37.18		
	3	58.94	63.8		

$$\sigma_{\text{track}} = \frac{\sqrt[4]{\sigma_0 * \sigma_1 * \sigma_2 * \sigma_3}}{\sqrt{4}}$$

# First Beam Test - Hits Correlation



# First Beam Test - Alignment Results



Pixel Plane	$\sigma_x$ [ $\mu\text{m}$ ]	$\sigma_y$ [ $\mu\text{m}$ ]
0	65	62
1	39	42
2	45	45
3	73	53

$$\sigma_{\text{track}} = \frac{\sqrt[4]{\sigma_0 * \sigma_1 * \sigma_2 * \sigma_3}}{\sqrt{4}}$$

$$\sigma_x = \sigma_y \simeq 27 \mu\text{m}$$

## Conclusions

The preliminary analysis of the first triggerless pixel readout prototype under beam shows satisfactory results.  
Further analysis are ongoing.

Thanks for the attention!