

Study of the HVCMOS detector

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2021/4/16



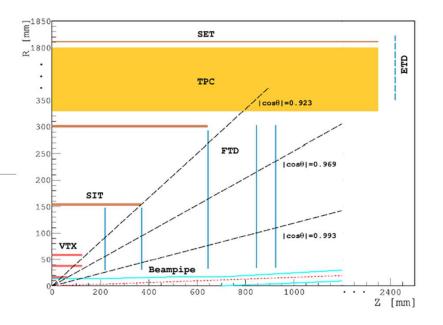
Content

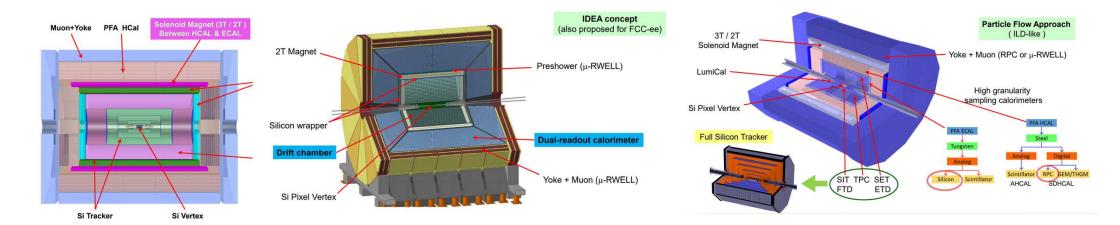
- Background: CEPC silicon tracker
- High Voltage CMOS detector
- A HV CMOS Chip:AtlasPIX3
- Test System: hardware and software
- Test Procedure: Test in the lab
- Radioactive Source Test
- Application: Test with beam
- Future Plan: Multi-Chip Module



Background

- CEPC Tracker:
 - outside of the VTX
 - TPC/DC + silicon or all-silicon concepts

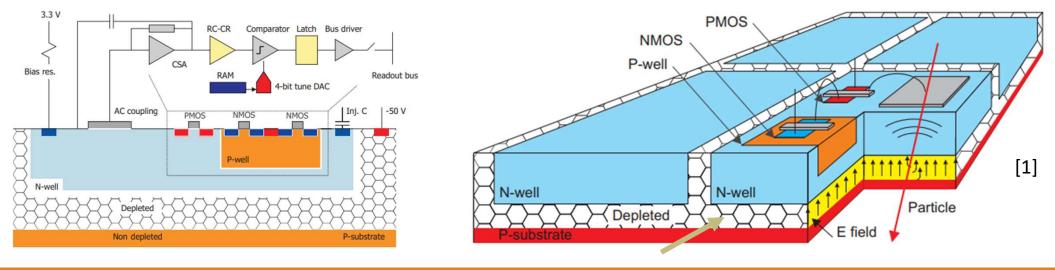


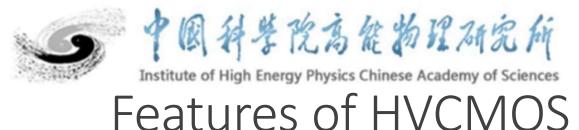




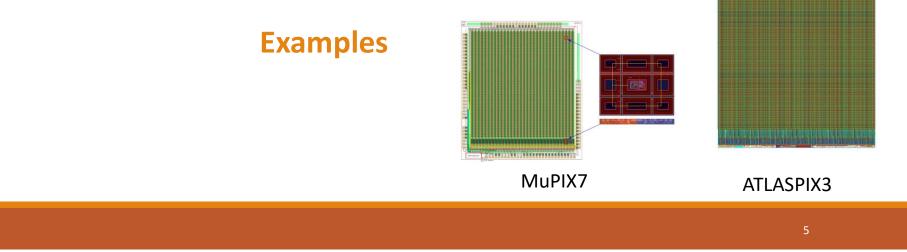
HV CMOS detector

- Detection based on the charge drift in the depleted zone of the reverse biased diode.
- Depleted zone thickness about 10µm(60V)
- Depleted area one magnitude lager than LV CMOS





- Good performance on efficiency(99.5%)
- Low noise(lower than 1Hz threshold above 50mV)
- Good time resolution(lower than 10ns)
- Fast charge collection
- Good radiation tolerance(High efficiency >98% at up to $2 \times 10^{15} n_{eq}/cm^2$)

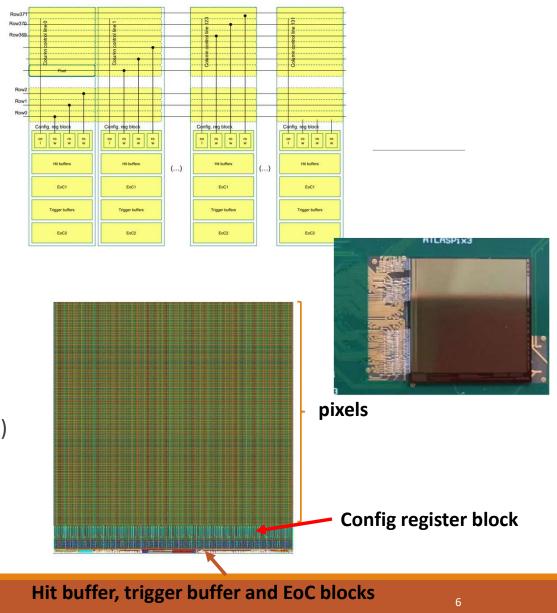


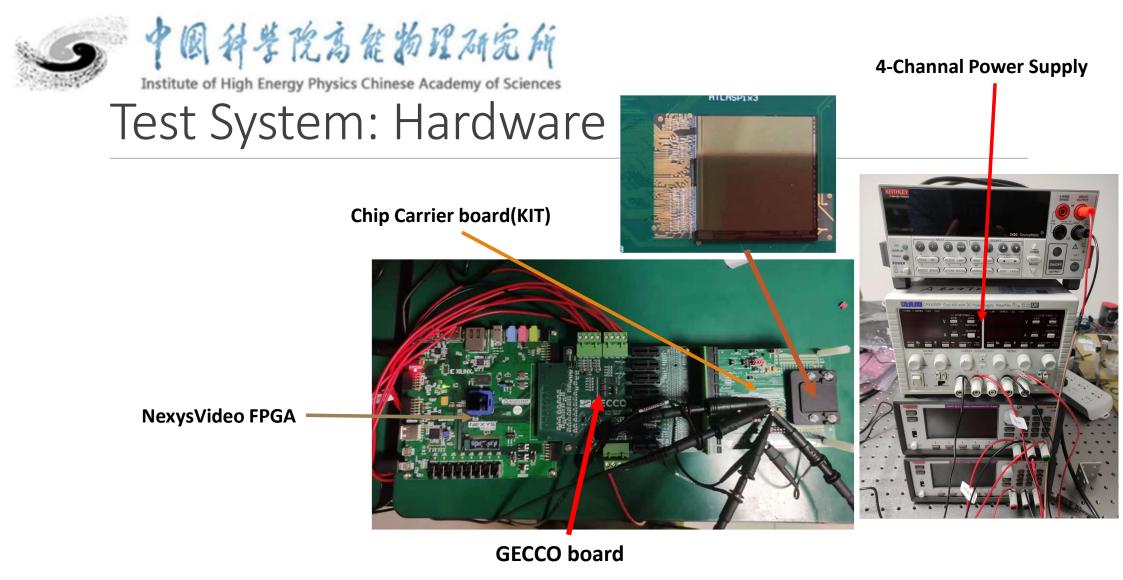


ATLASPIX3

- •372col×132row
- •150imes50 μ m per pixel
- •About 2cm imes 2cm in total
- •TSI 180 nm process on 200 Ω cm substrate
- •High efficiency 99.5%
- •High radiation tolerance

(High efficiency >98% at up to $2 \times 10^{15} n_{eq}/cm^2$)







Test Software

- Vivado(Configure Firmware):
 - Compile&Configure Firmware(Rudolf,KIT)
- DAQ Software(Rudolf,KIT):
 - Connect with the FPGA board
 - Configure Chip registers
 - Fast Readout Test
 - Scan S-curve(Check Threshold)
 - Trimming the chip(Adjust Threshold)

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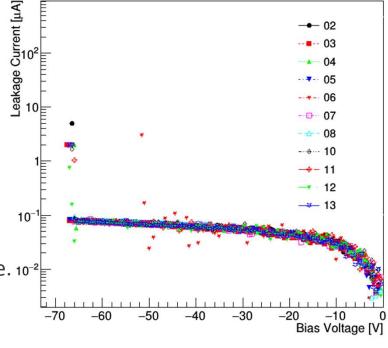
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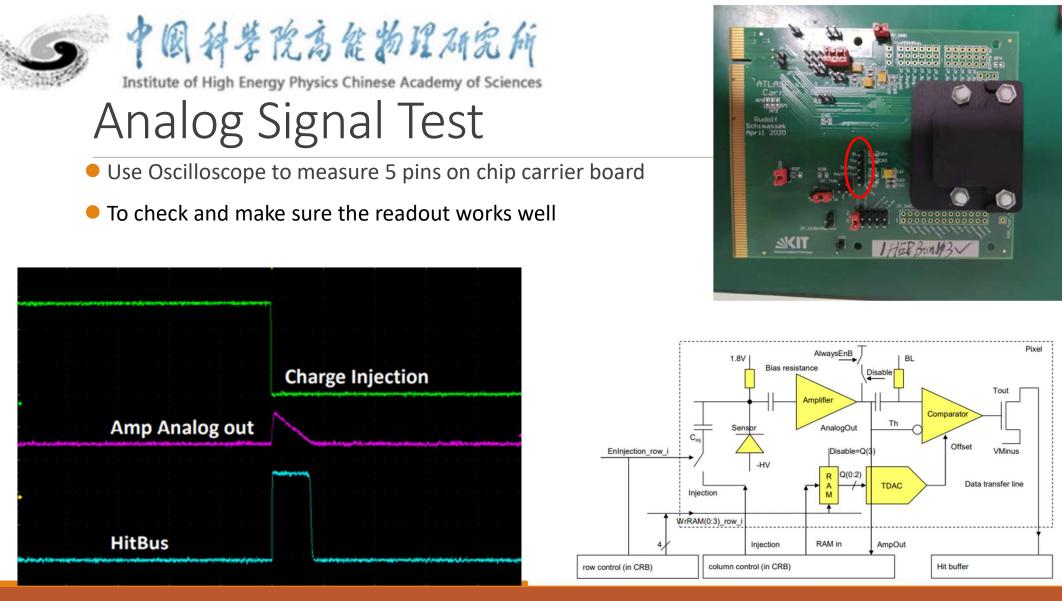
Test in lab: HV Bias Voltage Test

Change HV Voltage and get an IV curve

- To check the HV leakage current & Breakdown voltage
 - Break voltage at about -65V
 - Leakage current: about 50nA@-20V at room temperature. 10⁻²



IV curve of several chips

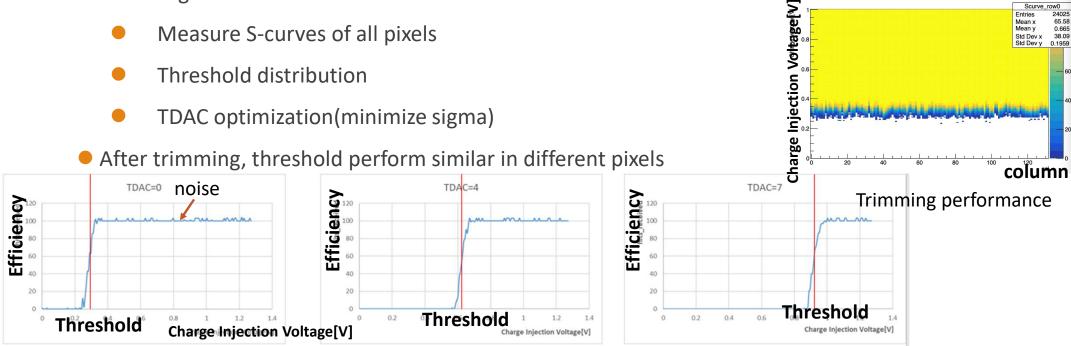




Trimming Test

- Threshold : S-curve(Efficiency 0%->100%)
- Trimming Procedure :
 - Measure S-curves of all pixels
 - Threshold distribution
 - TDAC optimization(minimize sigma)





Entries

Mean Mean y

Std Dev x Std Dev w

collumn

Scurve row0 24025

65.58

0.665

38.09 0.1959

Entries Mean x

Mean y

Std Dev x Std Dev y

22177 65.09

0.7685 37.89 0.141

Charge Injection Voltage[V]

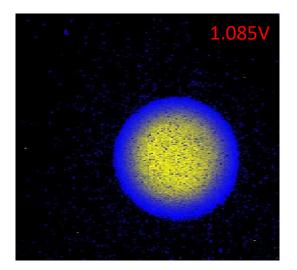
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Radioactive Source Test: Fe55 (5.9keV EC)

To calibrate the Threshold with Energy

Tape the source at the back side of the chip(with collimation)



Calibrate the Fe55 5.9keV with threshold 1.085V



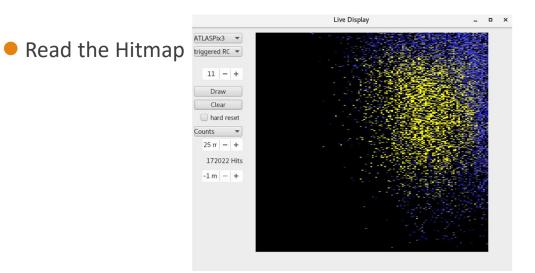
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Institute of High Energy Physics Chinese Academy of Sciences Radioactive Source Test: Sr90 ($546 \text{keV}, \beta$ -)

- Can be detected at higher Threshold
- Use a collimation to have a circle shape
- Tape to the back side of the chip





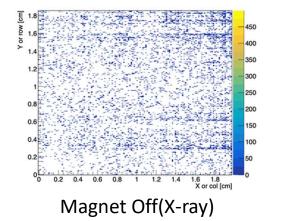




Application : Test with Electron beam

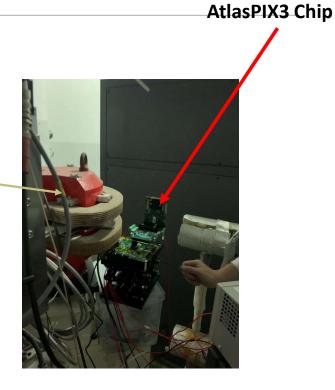
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- Detect the Electron and X-ray in the beam
- Electron and X-ray(>6.9keV) can be detected
- When Magnet on, the electron beam will turn



(Disable electron)

Beam direction



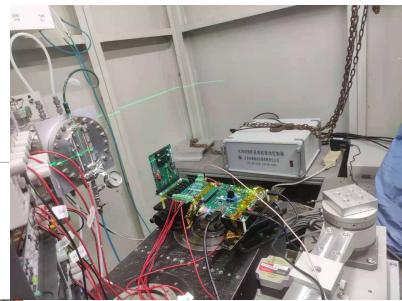
• When Magnet off, there are still hits, which are recognized as X-ray.

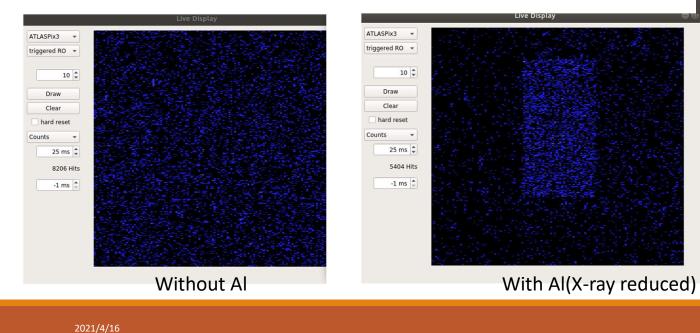




Test with synchrotron X-ray

- Beam open a little rectangle window/shutter
- An Aluminum foil can be placed to shield the X-ray
- Al shield X-ray, electron obvious at the rectangle





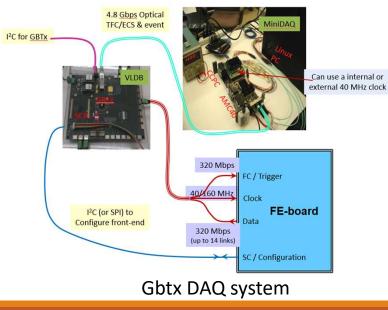


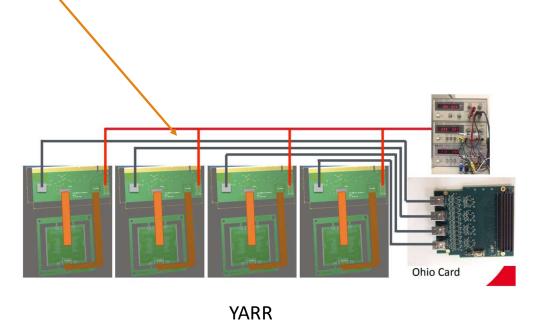
Future Plan

Multi-chip Module readout test:

YARR(Yet A Rapid Readout)(H .Fox Wednesday afternoon's report)

DAQ system based on GBTx(LHCb)





Summary

- HV CMOS silicon tracker simple introduction
- ATLASPix3 tested in lab and works well
- Test with radioactive source Fe55 and Sr90
- Application with electron beam and synchrotron radiation
- Future plan: multi-chip module readout

Thanks for your attention!



Thanks!

backups

GECCO – The Concept

- GEneric Configuration and COntrol System
- It is a collection of
 - hardware
 - firmware
 - software

for testing ASICs

- central element: the GECCO board
- Design Goals:
 - versatile for application with different chips
 - easy change of sample
 - enable hands-free debugging
 - economic





Test Process: Power Supply

Basically, it needs 7-channal power supply.

•While using on-board regulaters, only 4-channal power supply.

• To save space , use less power supply

