## Study of PC-HPGe detector for dark matter search

#### Yulan Li CDEX collaboration



### Outline

- What's a PC-HPGe detector?
- What we have done?
- Conclusion



## **Point-contact HPGe detector**

- First developed in the late 1980s as large volume, low noise HPGe detectors
  - ~ 1 pF capacitance
  - ~ 300 eV noise threshold







- Recently "rediscovered" for neutrino detection, dark matter search, etc.
  - MAJORANA, GERDA, CoGeNT, CDEX,...



#### **Charge Collection & Signal Induction**

• Charge collection and signal induction characteristics can be used to separate single- and multi-site events



## **Pulse Shape**



Very useful for background suppression:

•WIMP interaction is eminently single-site type.

•A large fraction of background is not.

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## What We Have Done

- Laboratory set-up
- Crystal processing
- Pre-amplifier design
  - JFET based
  - CMOS based
- Cryostats design
- Simulation study



#### **Laboratory Set-up**

Clean room



• Wet Lab





• Machine-shop





#### **Crystal Processing**

• Typical Processing Technology is used (so far)





#### **Detector Performance(1)**



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#### **Detector Performance(2)**



#### **Pre-amplifier Study: J-FET based**





## **Performance: J-FET based**

Resistor Feedback

Pulse-reset feedback



• For detail, please see Zhu Weibin's talk this afternoon



#### Performance: CMOS ASIC based





• For detail, please see Deng Zhi's talk this afternoon



## **Cryostat Design**

- Traditional design:
  - not optimized for pointcontact configuration
- New design:
  - Point-contact probe
  - Scalable for different sizes of crystal
  - Low background material:
    - Quartz substrate for J-FET bonding







## **Simulation Study**





### **Simulation: Electric Field**





## **Simulation: Capacitance**

Detector Configuration			Capacitance pF	
			By Theory Calculation	By Maxwell simulation
Planar ( $\phi$ =5mm, H=8.5mm			1.31	1.3
<b>Open-ended Co-axial</b> (R <sub>i</sub> =25mm, R <sub>o</sub> =50mm, H=50mm)			64.18	64.5
Point- Contact Detector	Crystal Size	Point Contact Size (Depth = 1mm)		
	φ=50 mm, H=50mm	φ=1 mm		0.72
		φ=2 mm		1.11
	φ=40 mm, H=40mm	φ=1 mm		0.72
		φ=2 mm		1.11
	φ=50 mm, H=50mm	φ=1 mm		0.73
		φ=2 mm		1.13



#### **Simulation: Depletion characteristics**



#### **Simulation: Charge Collection**





## **Simulation: Signal Induction**



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## Conclusion

- We are at the very beginning;
- Some preliminary results are achieved;
- Next step:
  - Further understanding
  - Larger size
  - Better performance
    - New processing technology
      - Passivation: Amorphous germanium sputtering
    - Amorphous-Ge R<sub>f</sub>
    - Digital signal processing
  - Low radiation background material selection.

#### Ends

#### Many Thanks for Your Attention!!

# Thanks the authors from whom I "stole" slices/pictures for this talk.



## **CDEX & PC-HPGe**

- CDEX @ CJPL proposed to use to Point Contact HPGe detector to detect WIMP directly, because of its:
  - Low capacitance > low threshold
  - Pulse shape analysis > discrimination between SSE and MSE
  - High purity material> low background
  - Module availability > good for manufacture, test, installation, maintenance, ready for extension to larger volume
  - High density, small volume > good for shielding

