

# The physics results from CDEX 1

*lijin*  
*THU/IHEP*  
*CDEX Collaboration*



中国锦屏地下实验室  
China Jinping Underground Laboratory

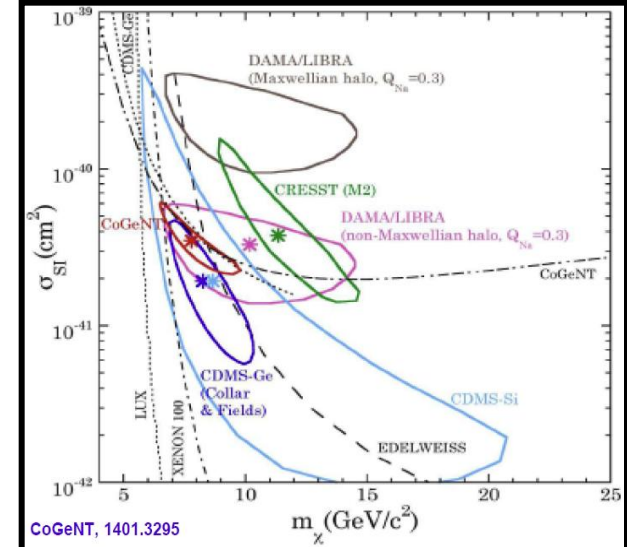
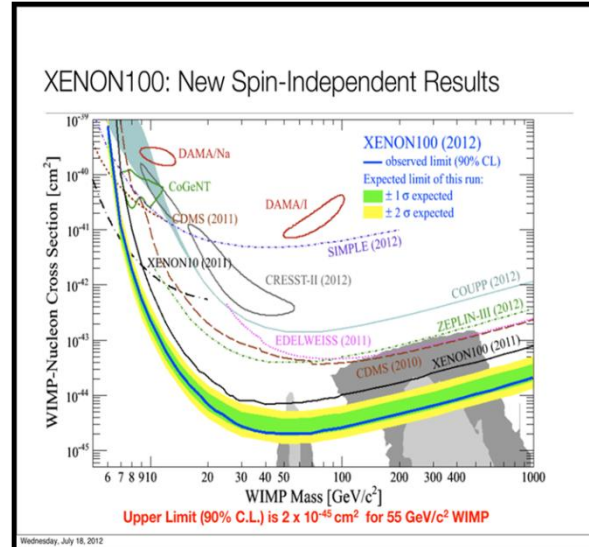
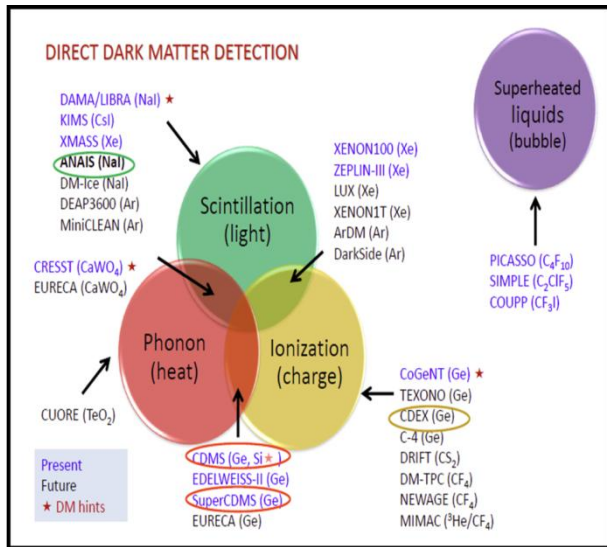
FCPPL2015 USTC 2015

# Outline

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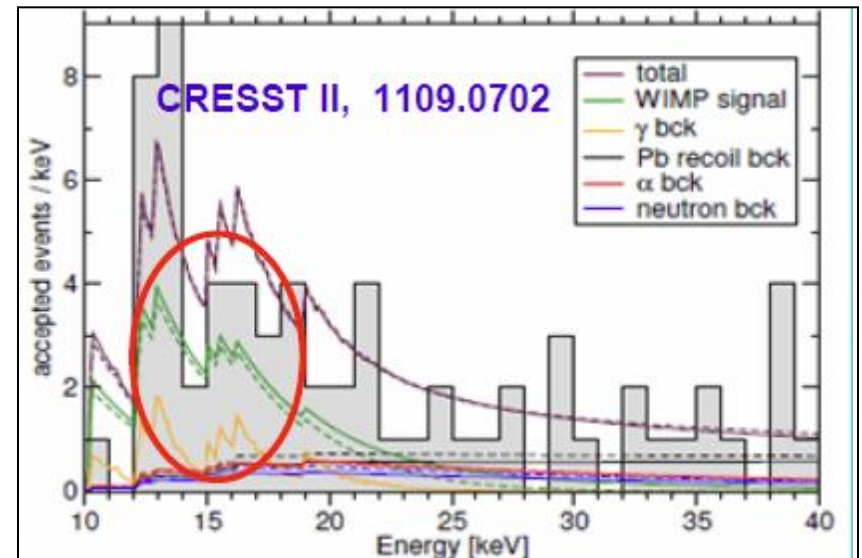
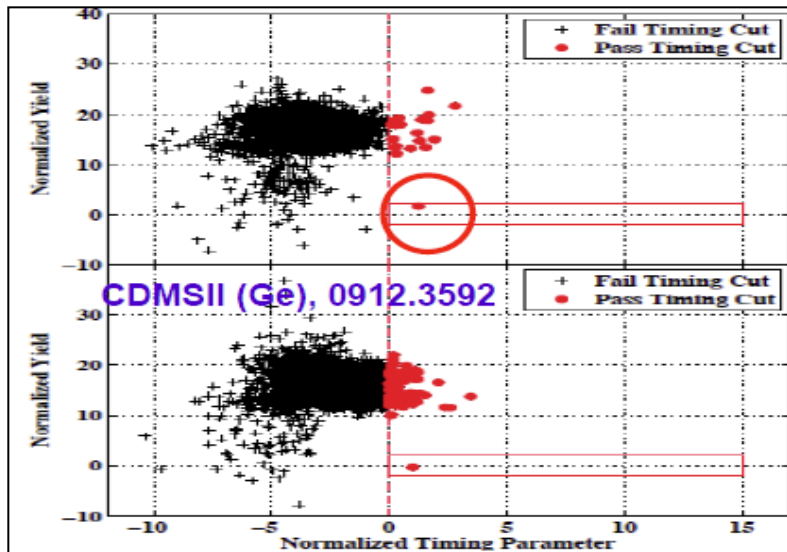
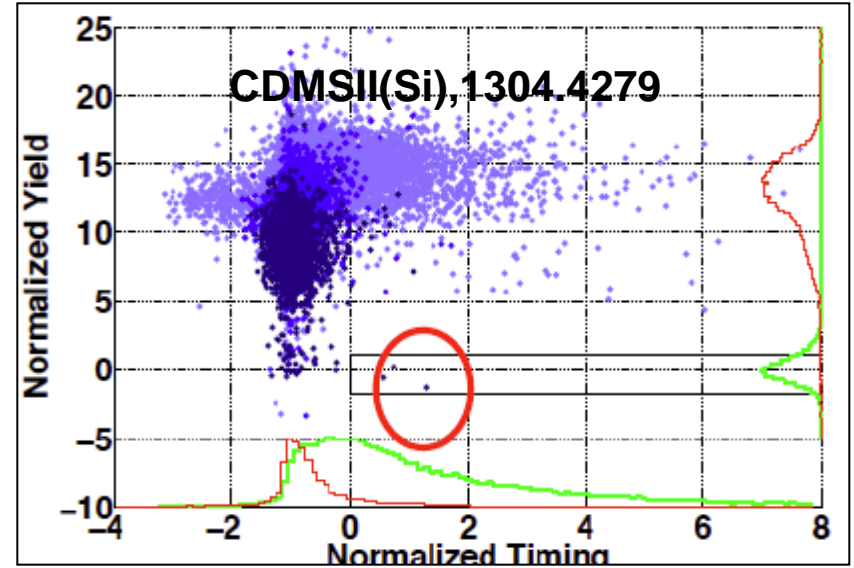
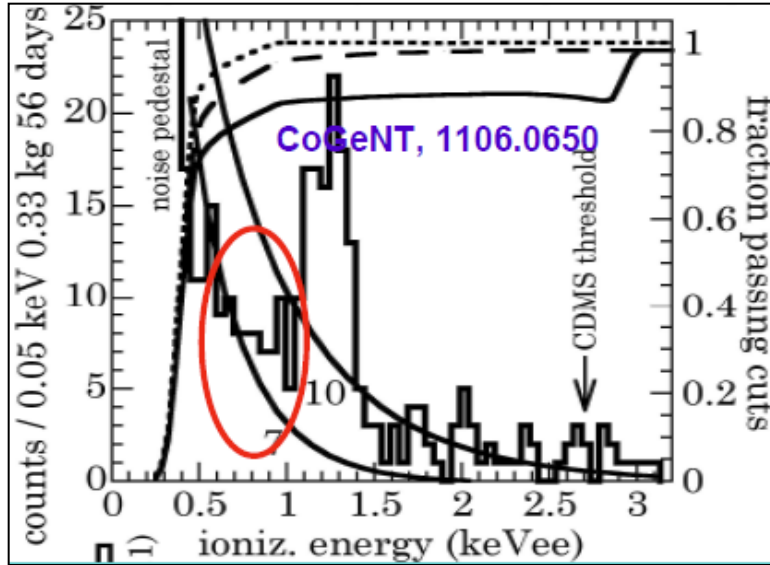
- What is CDEX-1 detector
- How to Search for WIMPs events
- What is the Physics result
- The next step of CDEX

# Direct Search for WIMPs



- **DAMA , CoGeNT ,CRESST-II ,CDMS(Si) found anomalous excess of unidentified events and has been interpreted as signature of light WIMPs**
- **But the null results from XENON ,TEXONO ,LUX,...**
- **CDEX use same detector as CoGeNT used to Search for WIMPs in low mass region at CJPL**

# “Evidence” of WIMP



# CDEX collaboration

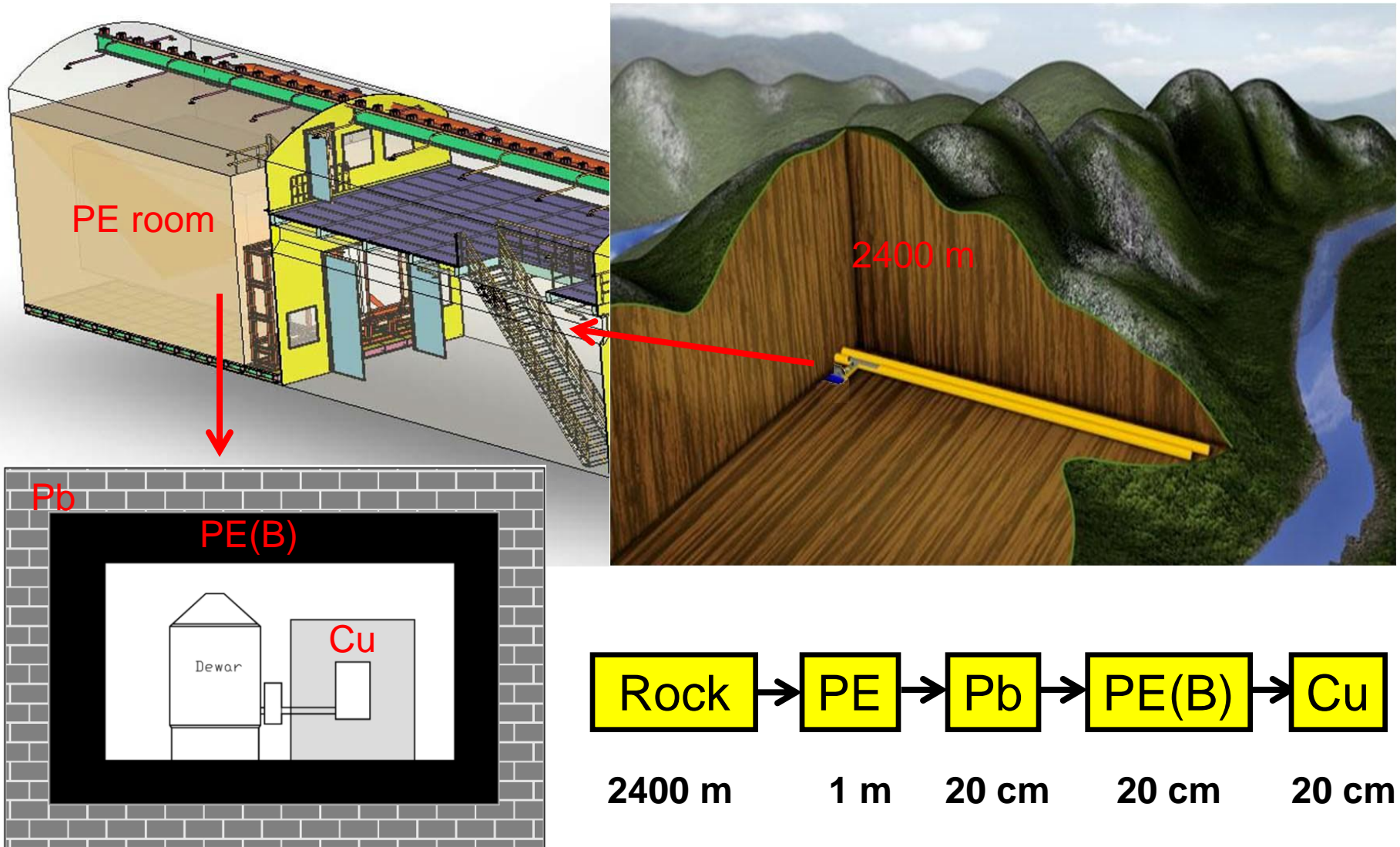
- Tsinghua University, THU
- Sichuan University, SCU
- Nankai University, NKU
- China Institute of Atomic Energy, CIAE
- Ertan Hydropower Company, EHDC
- Collaborate with **TEXONO** and **KIMS** group.



Focus on the searching for WIMPs at low mass region



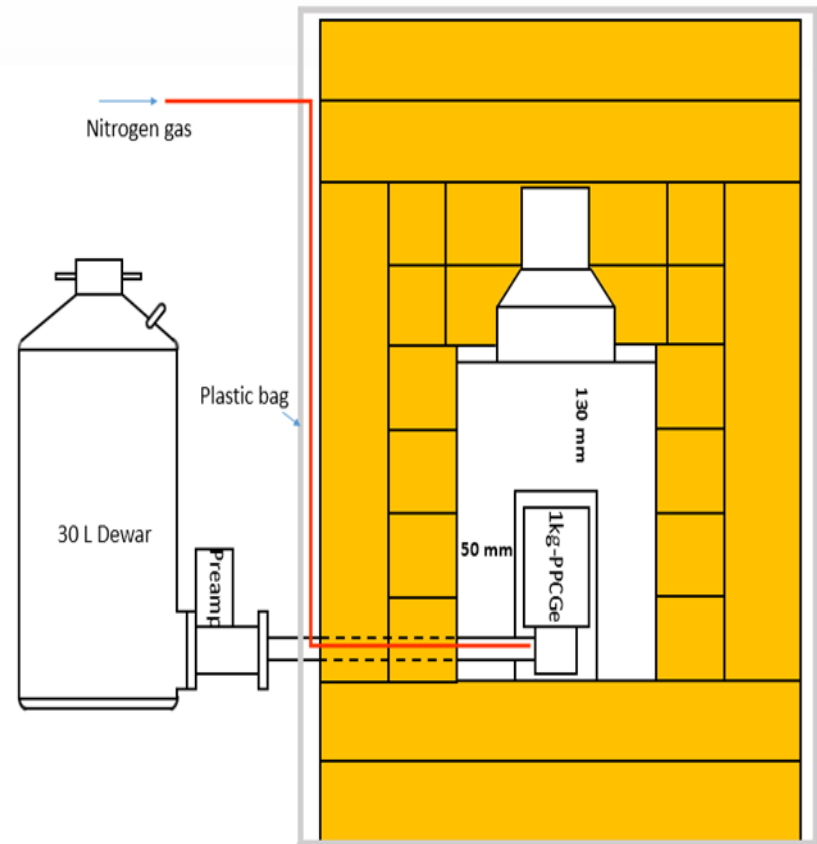
# CDEX System Setup at CJPL and Shielding



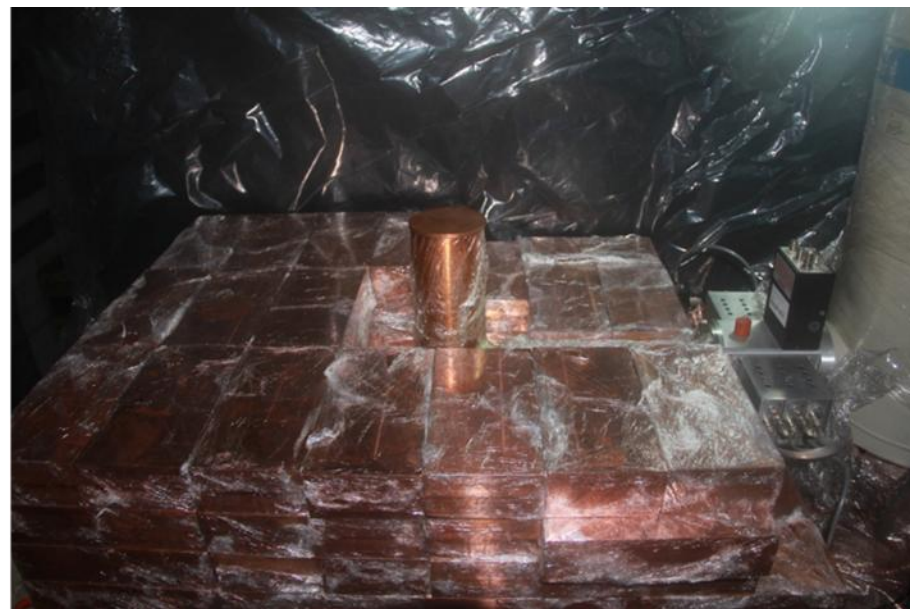
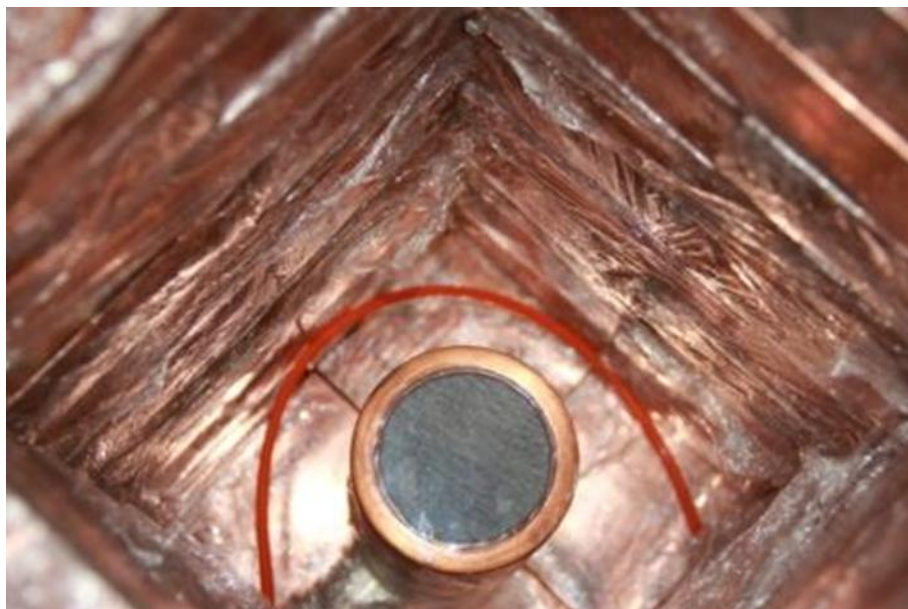
# CDEX -1 Detectors

## 1kg-PPCGe

- Crystal Mass: ~ 1k g
- Dead Layer: ~ 1.0mm
- Fiducial Mass: ~ 905 g
- **P-type Crystal**
- **P<sup>+</sup> Contact: central, ~1mm, ~1pF**
- Pulsed Optical Feedback Preamplifier
- N<sup>+</sup> Contact: outer, HV module
- Resistive Feedback Preamplifier
- HV: +3500 V
- Cryostat: 1.5 mm OFHC
- Dewar : 30L

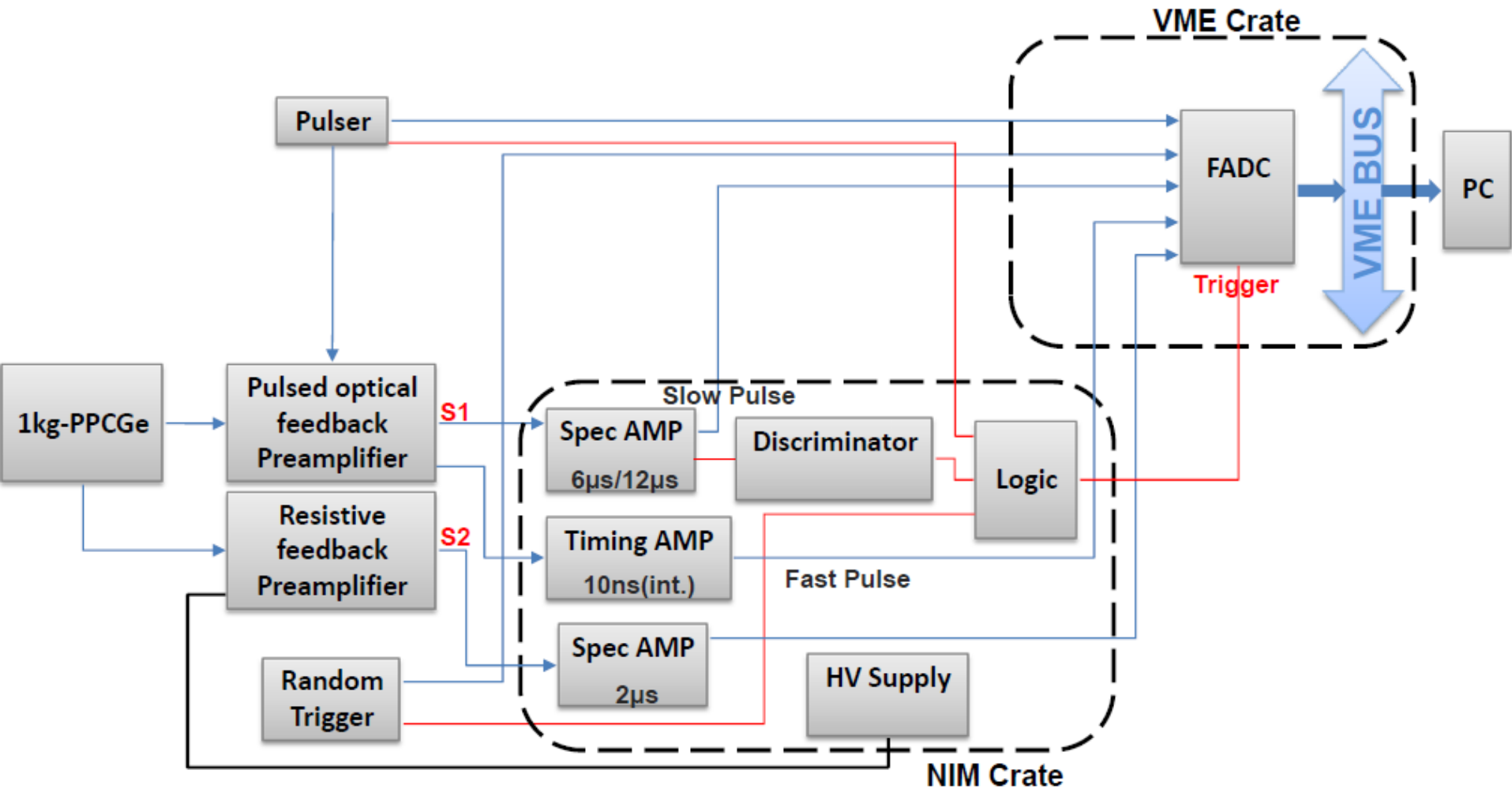


# CDEX-1 Dark Matter Experimental Device





# CDEX-1 Electronics and DAQ



# CDEX 1 Performance: Linearity/Resolution

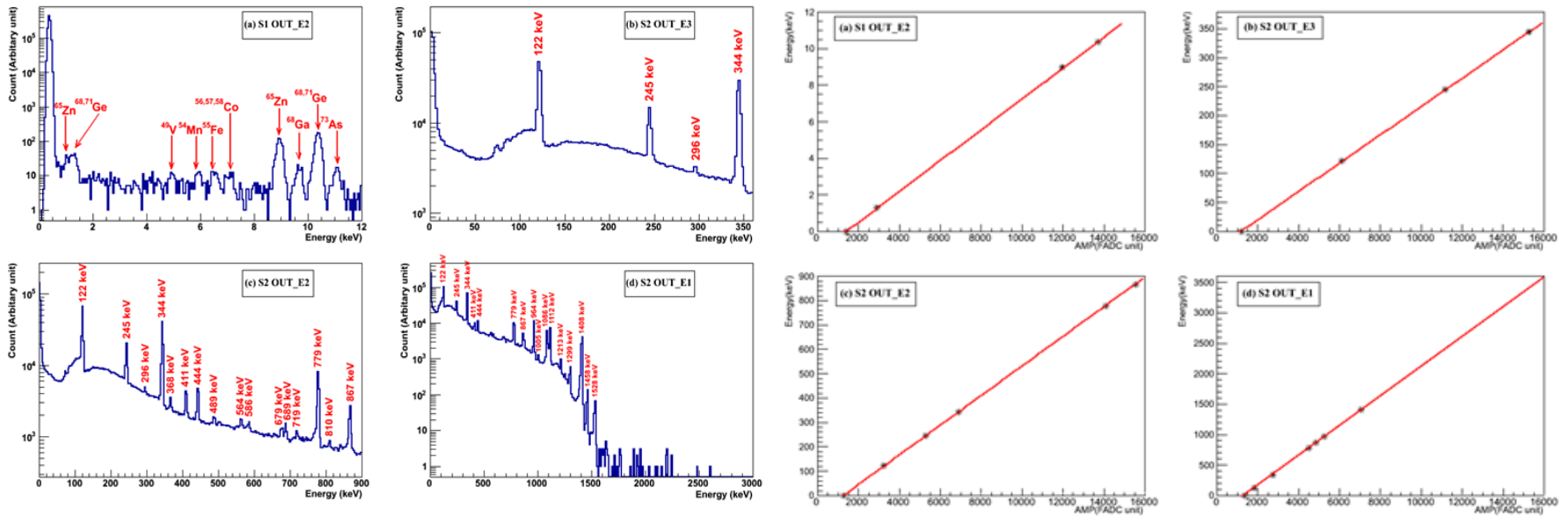


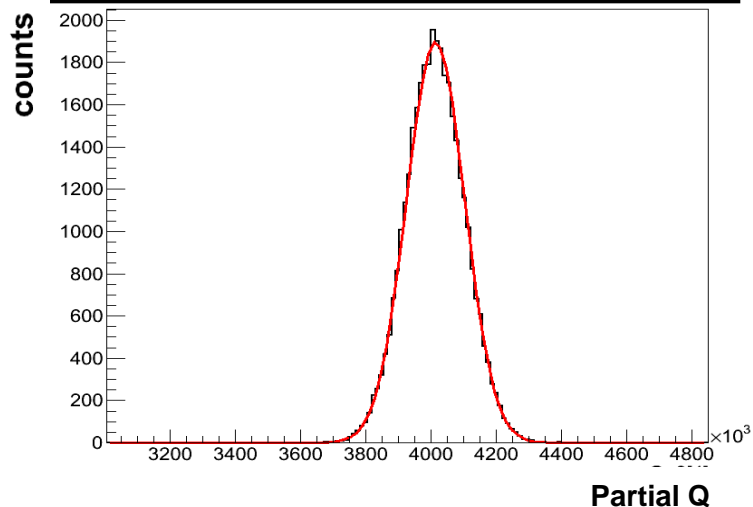
Table 1 The energies and life time of K shell X-rays and L shell X-rays for different atoms.

Atomic species	K-shell (keV)	L-shell (keV)	Lifetime (day)
<sup>73</sup> As	11.10	1.414	80.30
<sup>71</sup> Ge	10.37	1.298	11.43
<sup>68</sup> Ge	10.37	1.298	270.8
<sup>68</sup> Ga	9.66	1.194	67.63
<sup>65</sup> Zn	8.98	1.096	244.3
<sup>56</sup> Ni	7.71	0.926	6.077/5.9
<sup>56,57,58</sup> Co	7.11	0.846	77.27 <sup>56</sup> , 271.8 <sup>57</sup> , 70.86 <sup>58</sup> ,
<sup>55</sup> Fe	6.54	0.769	997.1
<sup>54</sup> Mn	5.99	0.695	312.3
<sup>51</sup> Cr	5.46	0.628	27.70
<sup>49</sup> V	4.97	0.564	330

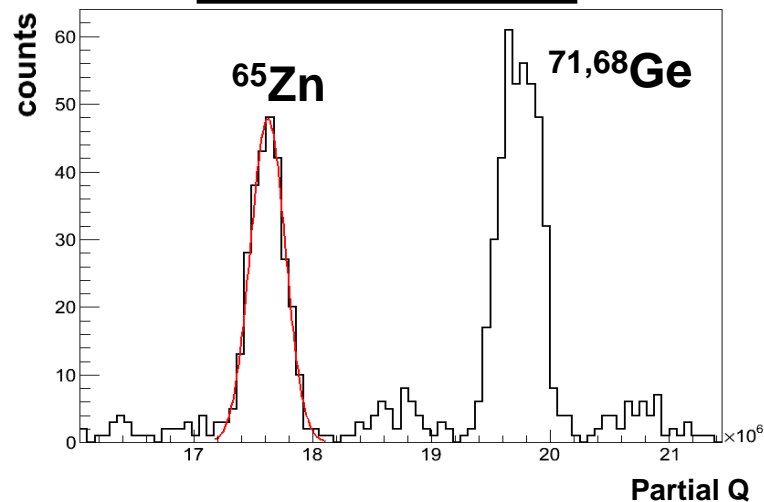
Cosmogenic radioactive isotopes

# Linearity/Resolution in **low energy region**

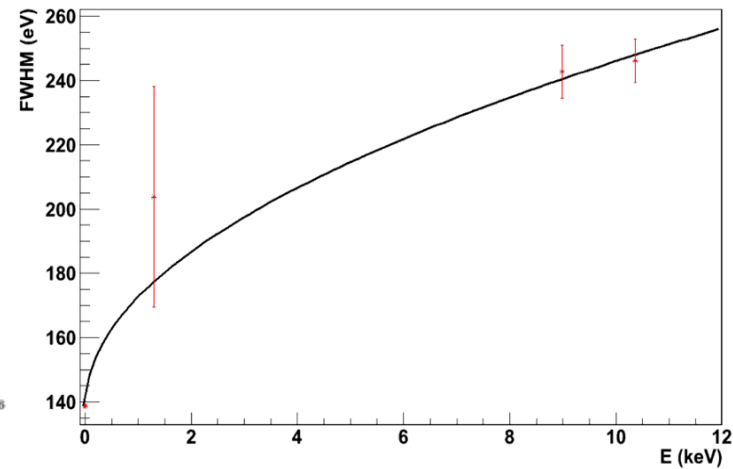
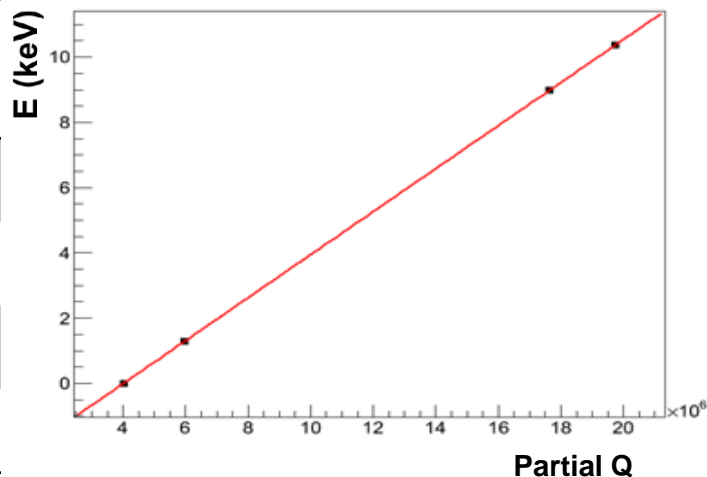
Random Events as energy 0



Internal X-rays

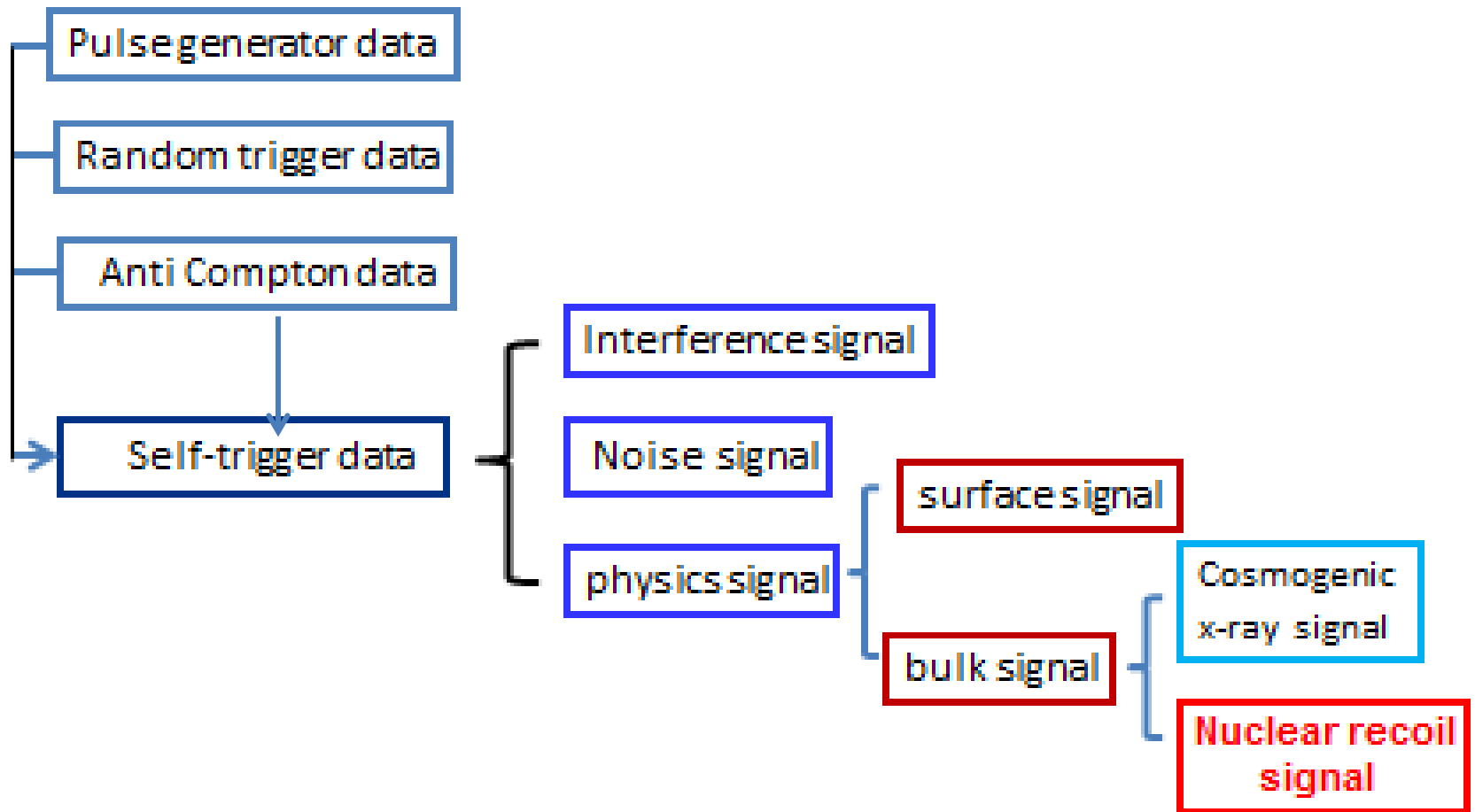


X-ray	Energy (keV)
RT	0
<sup>68,71</sup> Ge	1.2977(LX)
<sup>65</sup> Zn	8.98(KX)
<sup>68,71</sup> Ge	10.37(KX)



# Data Analysis Process

Events selection and Efficiency correction



TT cut , PSD cut , Q range cut , shaping time relation .rise time cut ....

# Event Selection Steps

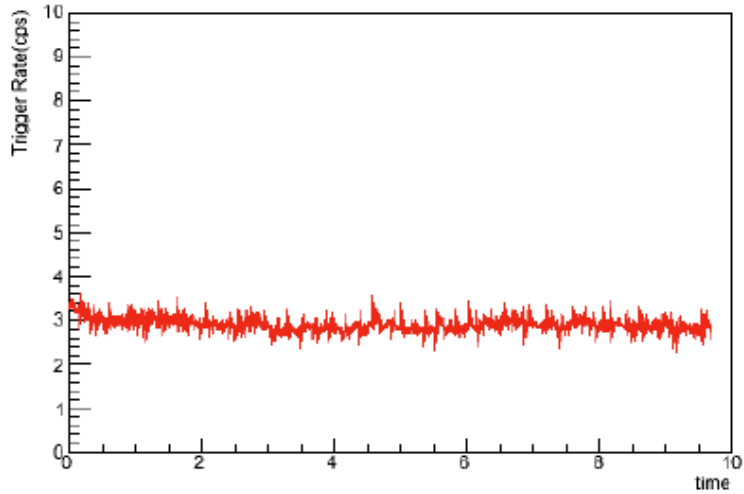
**WIMP induced interactions : single events , same pulse shape  
Very low energy range , continuum of energy spectrum**

- **Data Quality Check**
  - **Timing Selection**
  - **Anti-Compton selection**
  - **Physics events and Noise selection by PSD**
  - **Bulk/surface events Selection (B/S cut)**
  - **Efficiency correction**
  - **Deduction of L-shell X-ray contribution from K-shell**
  - **Driving Upper limits on the cross section as a function of WIMPs Mass**
- } **Basic Cut**

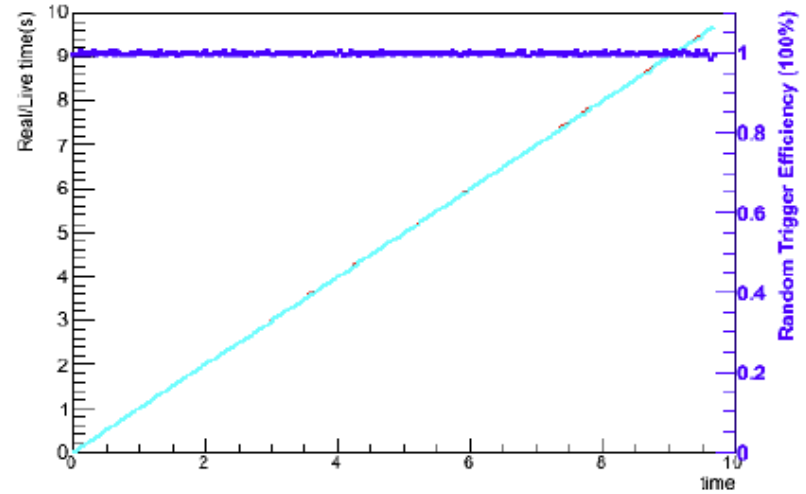
# Data Analysis : Data Quality Check

20140115 dataset

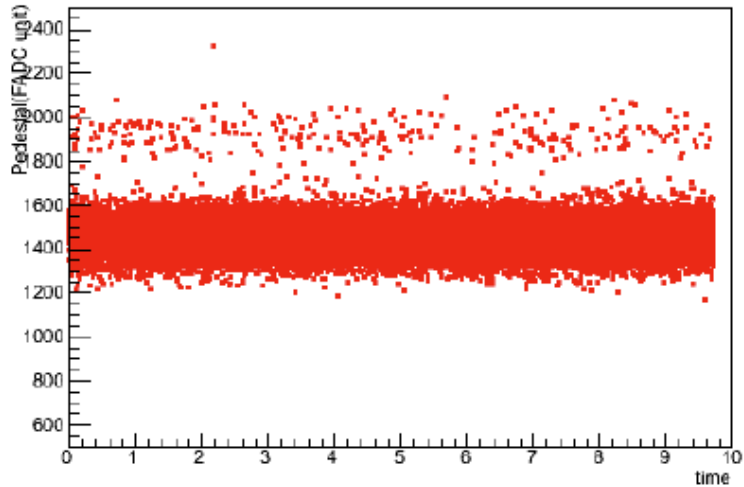
Trigger Rate per 1/4 run



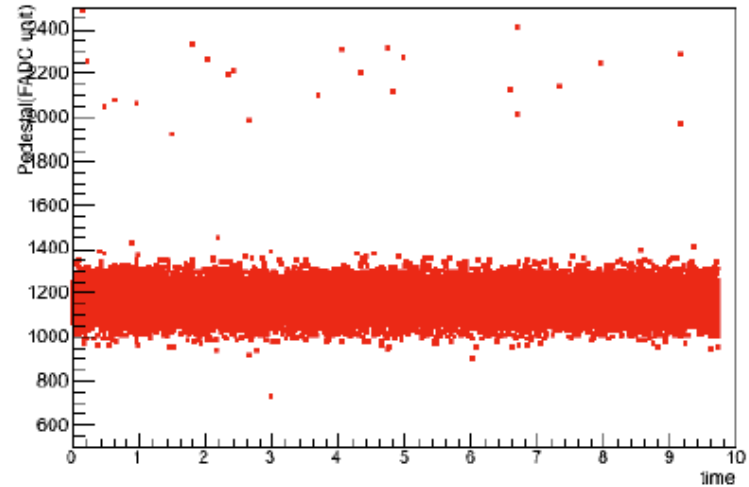
Real/Live time per run



Ped of Ch0



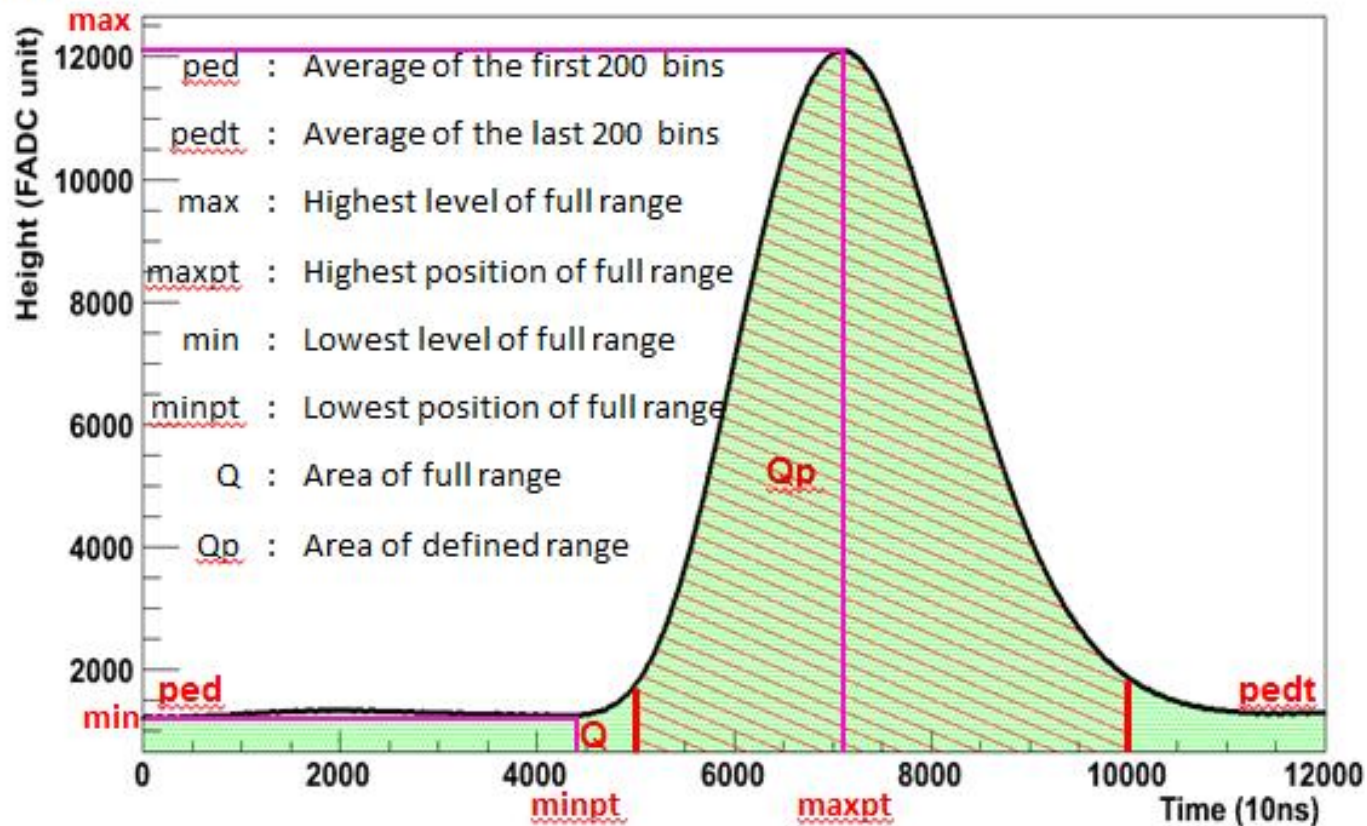
Ped of Ch1



# Data Analysis : Ped & PSD Selection Cuts

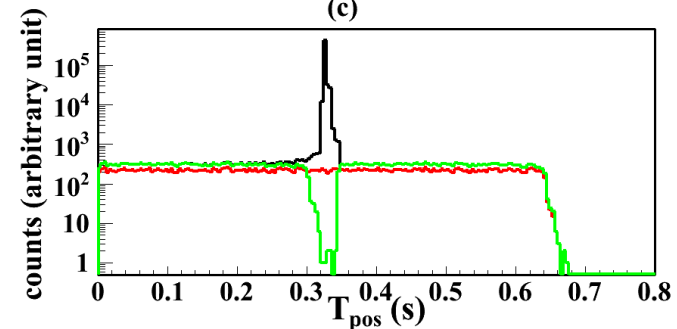
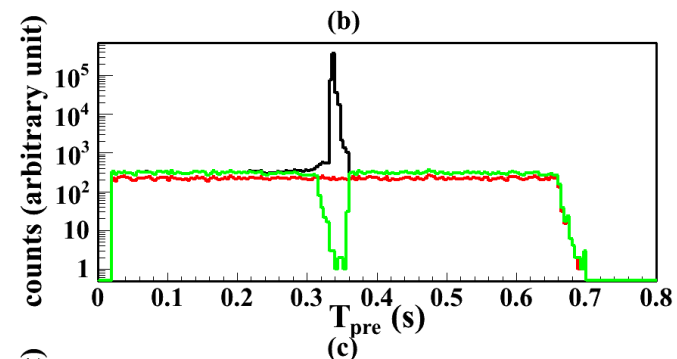
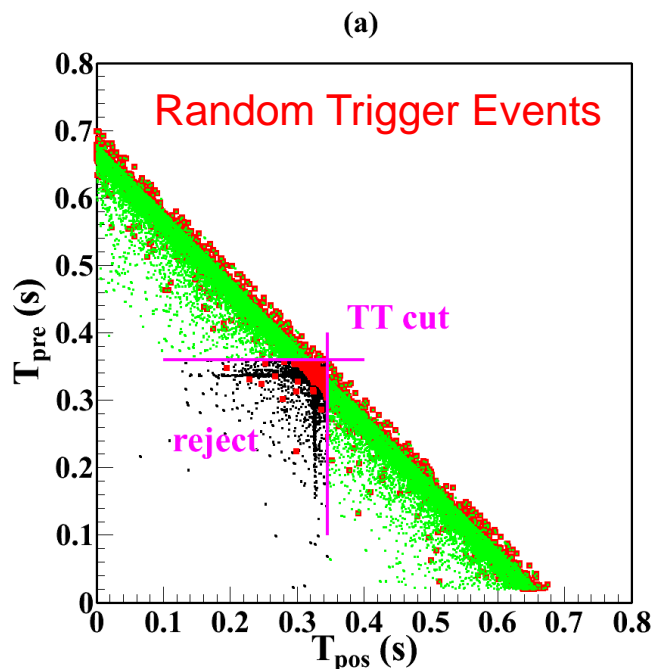
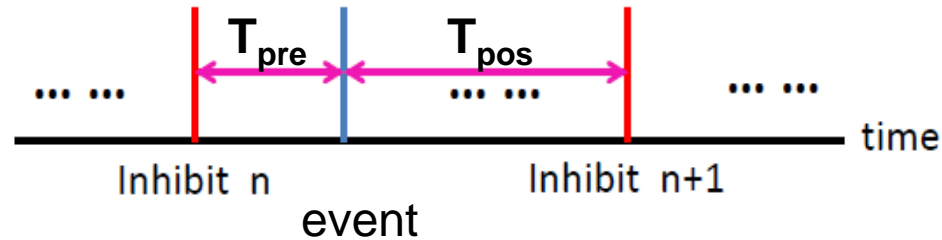
Parameters related to pulse shape defined for one event.

## Slow Pulse



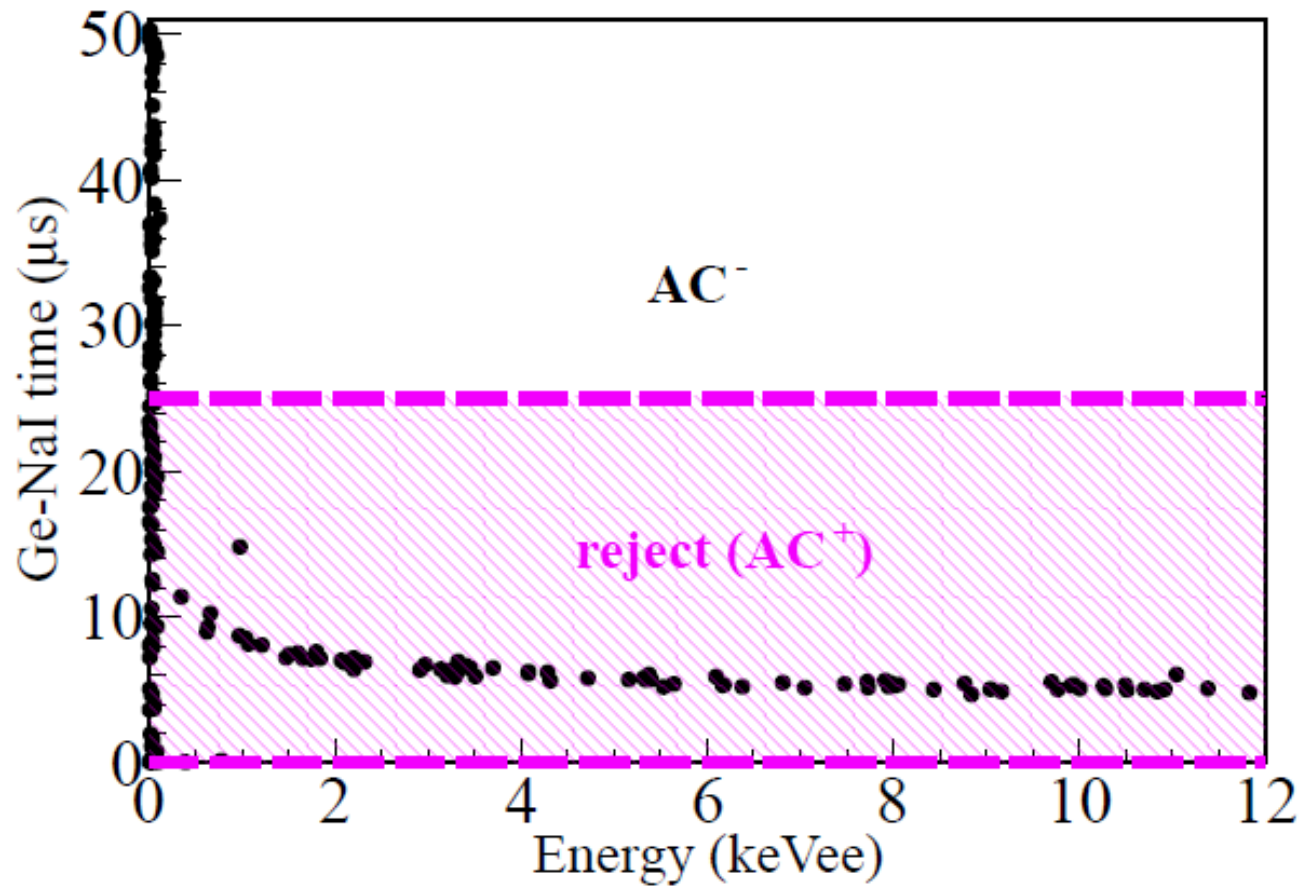
# Data Analysis : Selection — TT Cut

Timing information of one event, energy independence

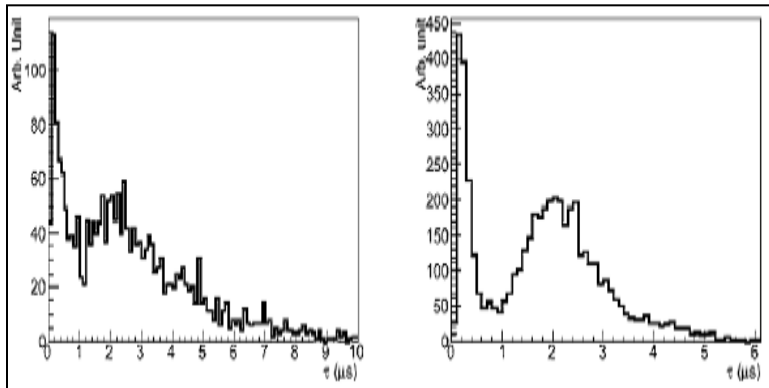
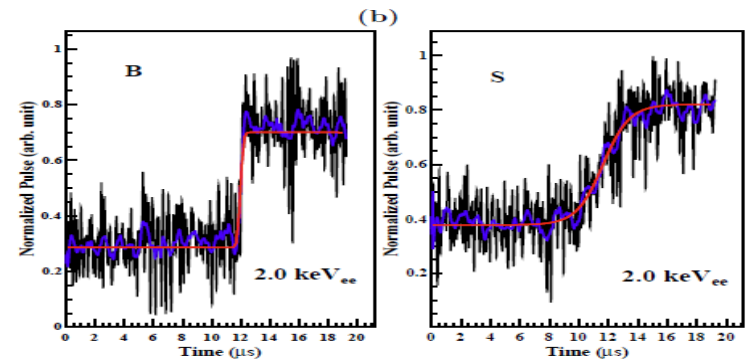
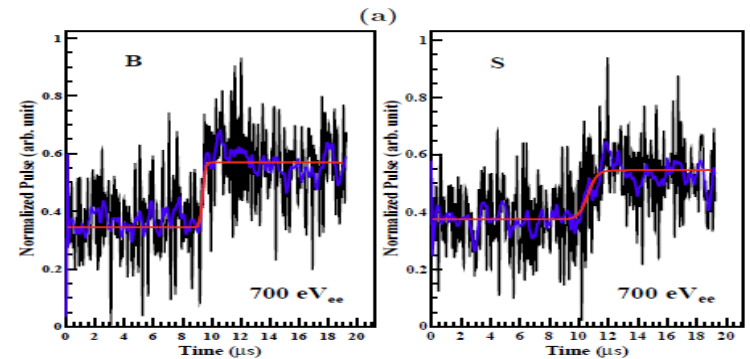
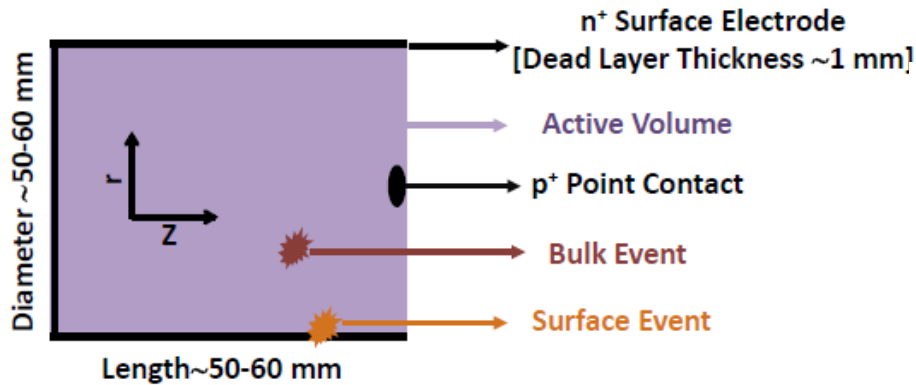




# Rejection by Anti Compton NaI(Tl) (Ge-NaI timing)



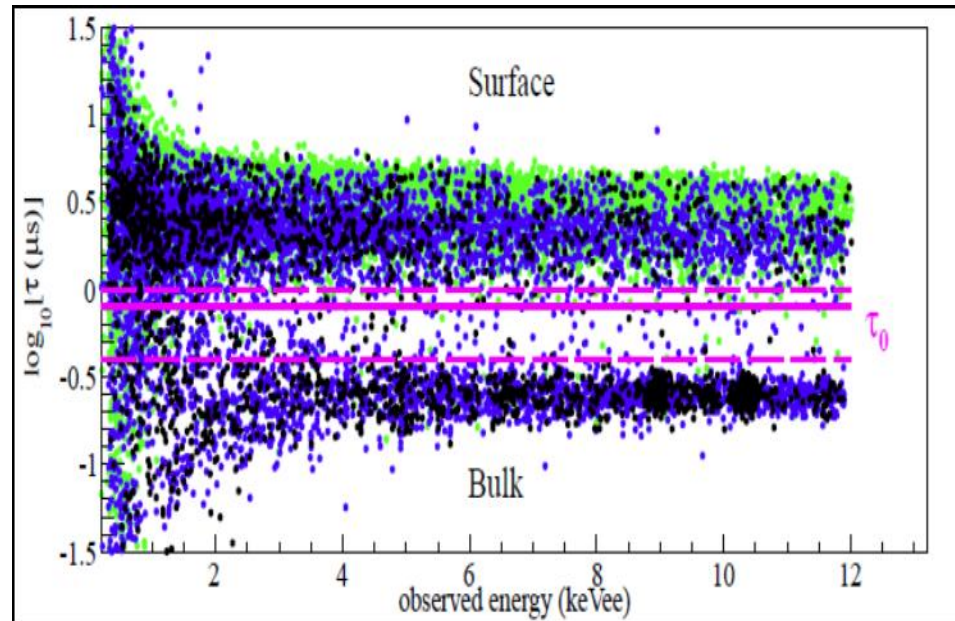
# Bulk and Surface Events



0.5–0.6 keV

2–3 keV

# B/ S event selection



$$B = \varepsilon_{BS} \cdot B_0 + (1 - \lambda_{BS}) \cdot S_0$$

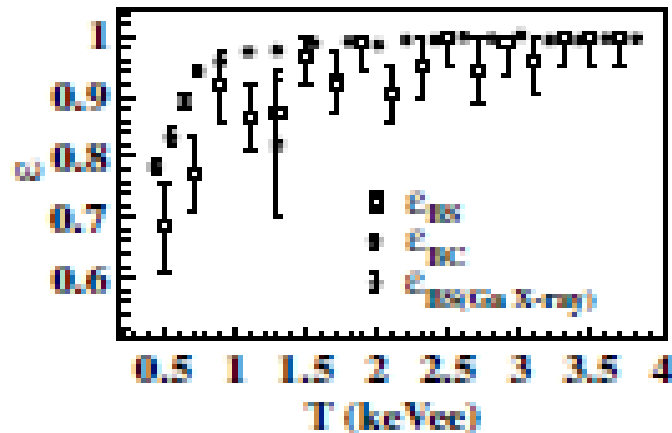
$$S = (1 - \varepsilon_{BS}) \cdot B_0 + \lambda_{BS} \cdot S_0$$

# Efficiency Correction

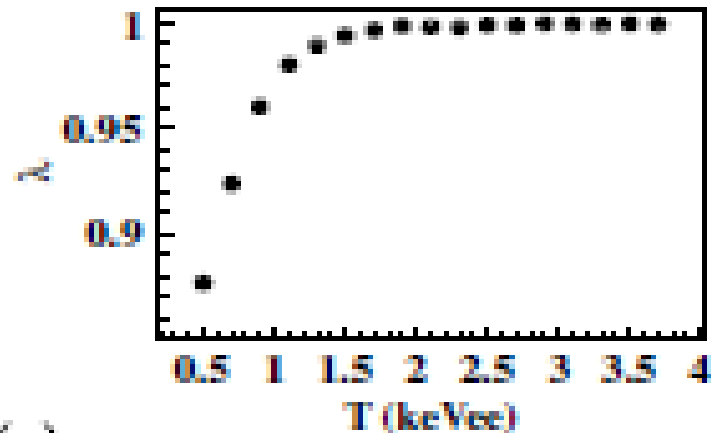
Efficiency calculation method:

- ✓ Energy-independent Cuts — **Random Trigger Events**  
TT Cut : 92.5% , Ped Cut : 96.2%.
- ✓ Energy- dependent Cuts — **Source Sample Events**  
 $^{241}\text{Am}$  Source Sample and  $^{137}\text{Cs}$  Source Sample give the consistent results, bin-by-bin combined the results.
- ✓ Trigger efficiency — **Pulsar Events**

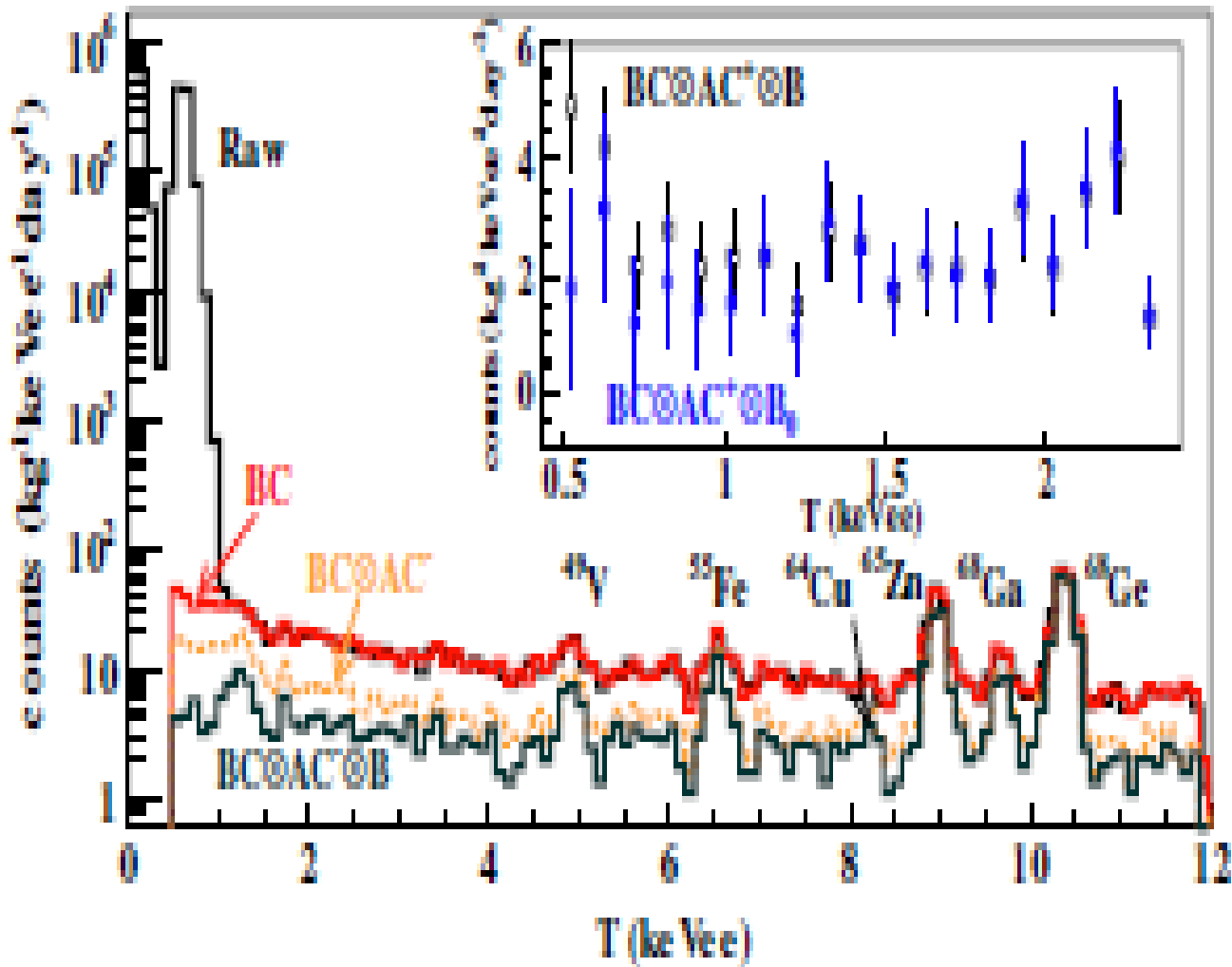
(b)



(c)



# Measured Energy Spectra

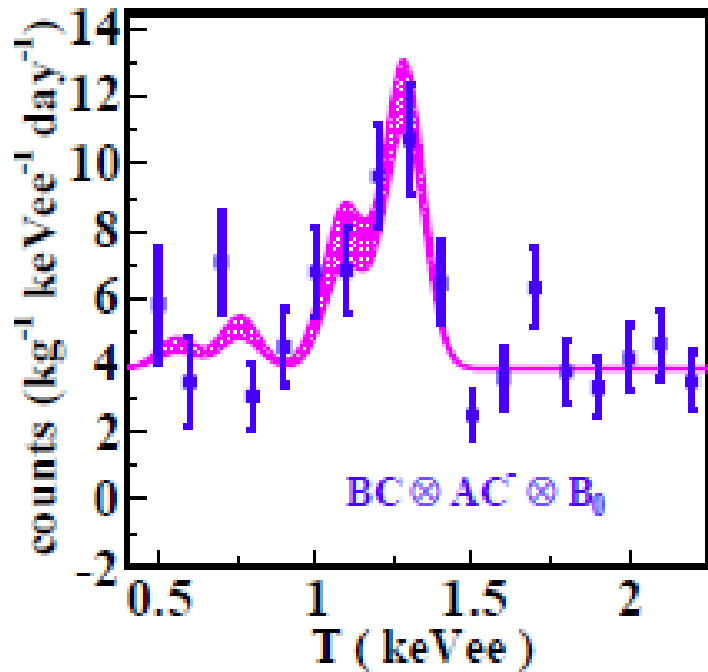


Basic selection BC

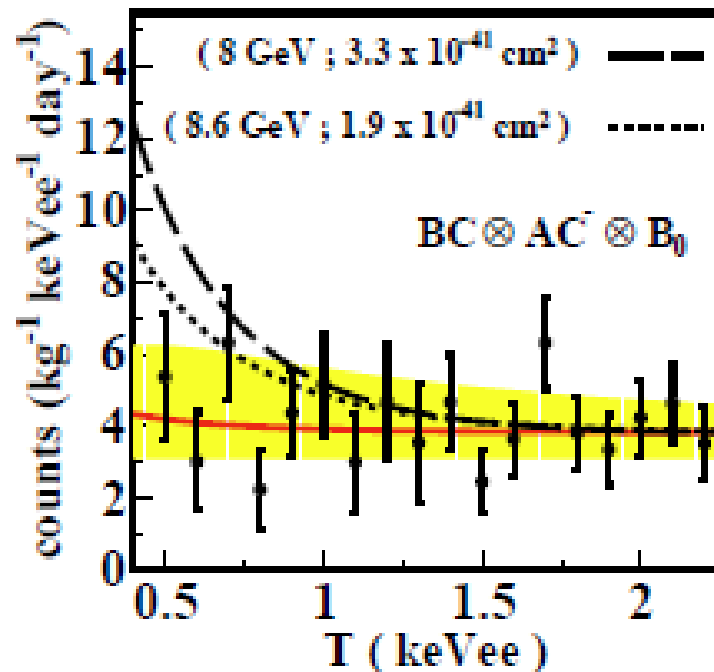
Anti-coincidence  
Selection AC<sup>-</sup>

B/S Correction

# Energy Spectrum in low energy region

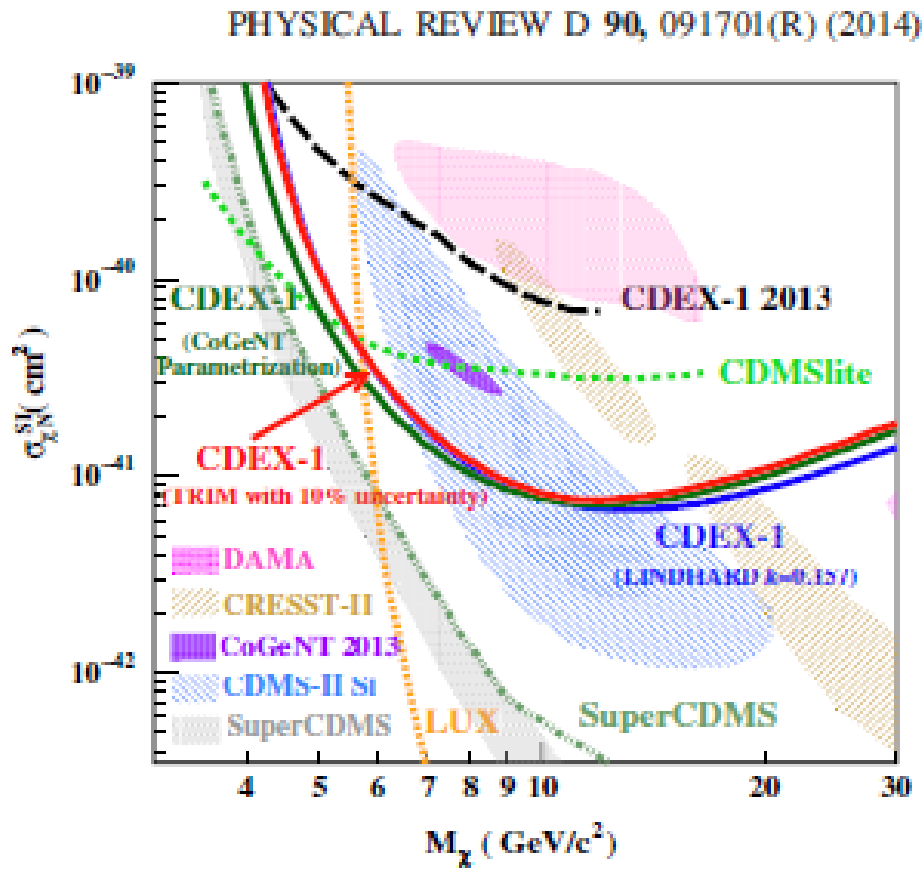


The L-X peaks predicted by  
K-X intensity And subtracted



Residual spectrum with best fit  
And 2-RMS uncertainty  
WIMP signal + flat background

# Physics result :Exclusion Plot

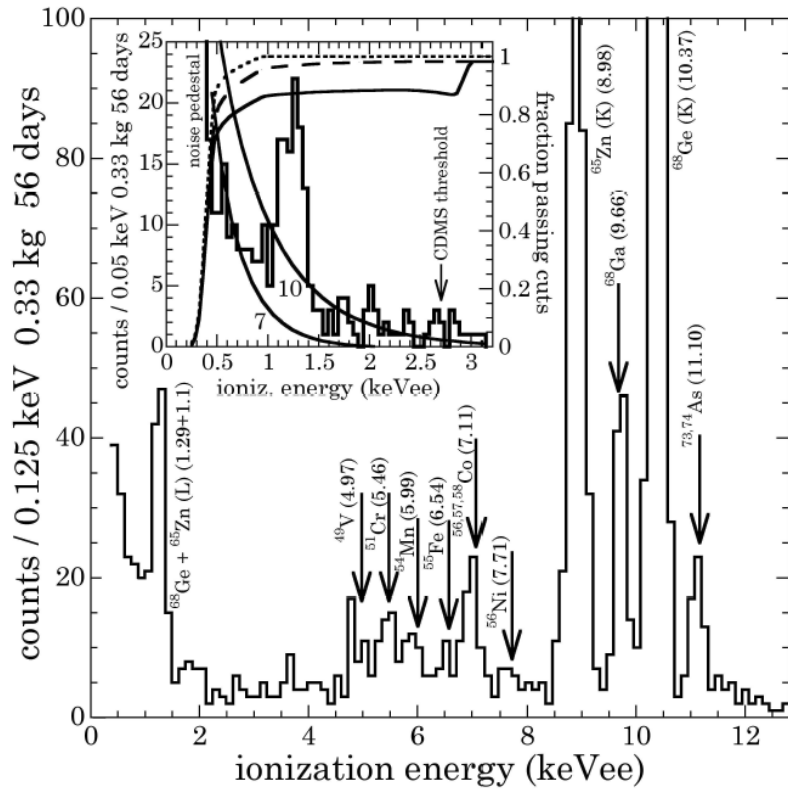


- input parameters:  
standard WIMP halo assumption,  
conventional astrophysics mode
- Local density  $0.3 \text{ GeV cm}^{-3}$ ;
- Maxwellian velocity distribution with  
 $220 \text{ km/s}$ ,
- escape velocity  $544 \text{ km/s}$ ), energy  
resolution
- The quench factor in Ge
- The minimum  $\chi^2$  method used to  
residual spectrum with two free  
parameters ( $\sigma_{\chi^{\text{SI}}}^{\text{SI}}$ , flat background)

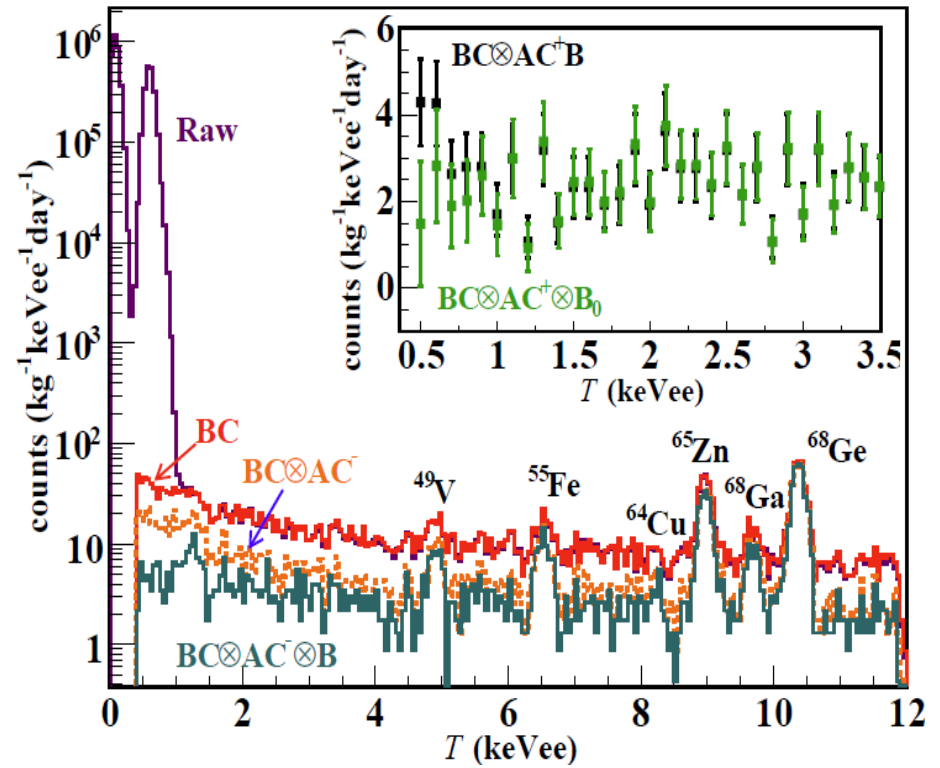
PHYSICAL REVIEW D 90, 091701(R) (2014)

# Measured Energy Spectrum Comparison

## CoGeNT & CDEX-1



CoGeNT



CDEX1



# Summary

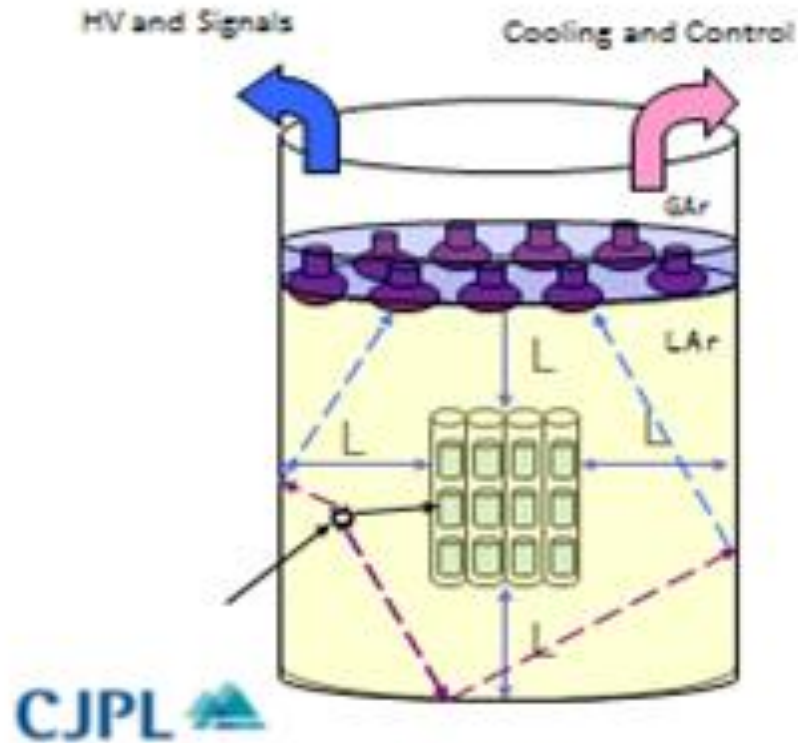
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- CDEX detectors CDEX1 with and without AC works well at CJPL
- Physics results of CDEX1 at low mass region are successful
- Next step of CDEX -CDEX10 will coming soon

<b>CDEX0</b>	<b>20g</b>	<b>AC NaI(Tl)</b>	172 eVee	0.784 kg-days
<b>CDEX1</b>	<b>1Kg</b>	<b>no AC</b>	400 eVee	14.6 kg-days
<b>CDEX1</b>	<b>1Kg</b>	<b>AC NaI(Tl)</b>	475 eVee	> 60 kg-days
<b>CDEX1 (new)</b>	<b>1Kg</b>	<b>AC NaI(Tl)</b>	<b>testing ;pre-data taking</b>	
<b>CDEX10</b>	<b>10kg</b>	<b>AC (LAr)</b>	<b>building</b>	

# CDEX 10 - Next step of CDEX

LAr: Passive shielding + Active shielding.  
Ge: Encapsulated into copper vacuum tube.  
WLS: Transferring 128nm light to ~420nm light



*Thanks for*

*your Attentions & comments ...*



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FCPPL2015 USTC 2015

# CDEX暗物质实验整体规划

暗物质实验灵敏度 ( $\text{cm}^2$ )

$10^{-40}$

$10^{-41}$

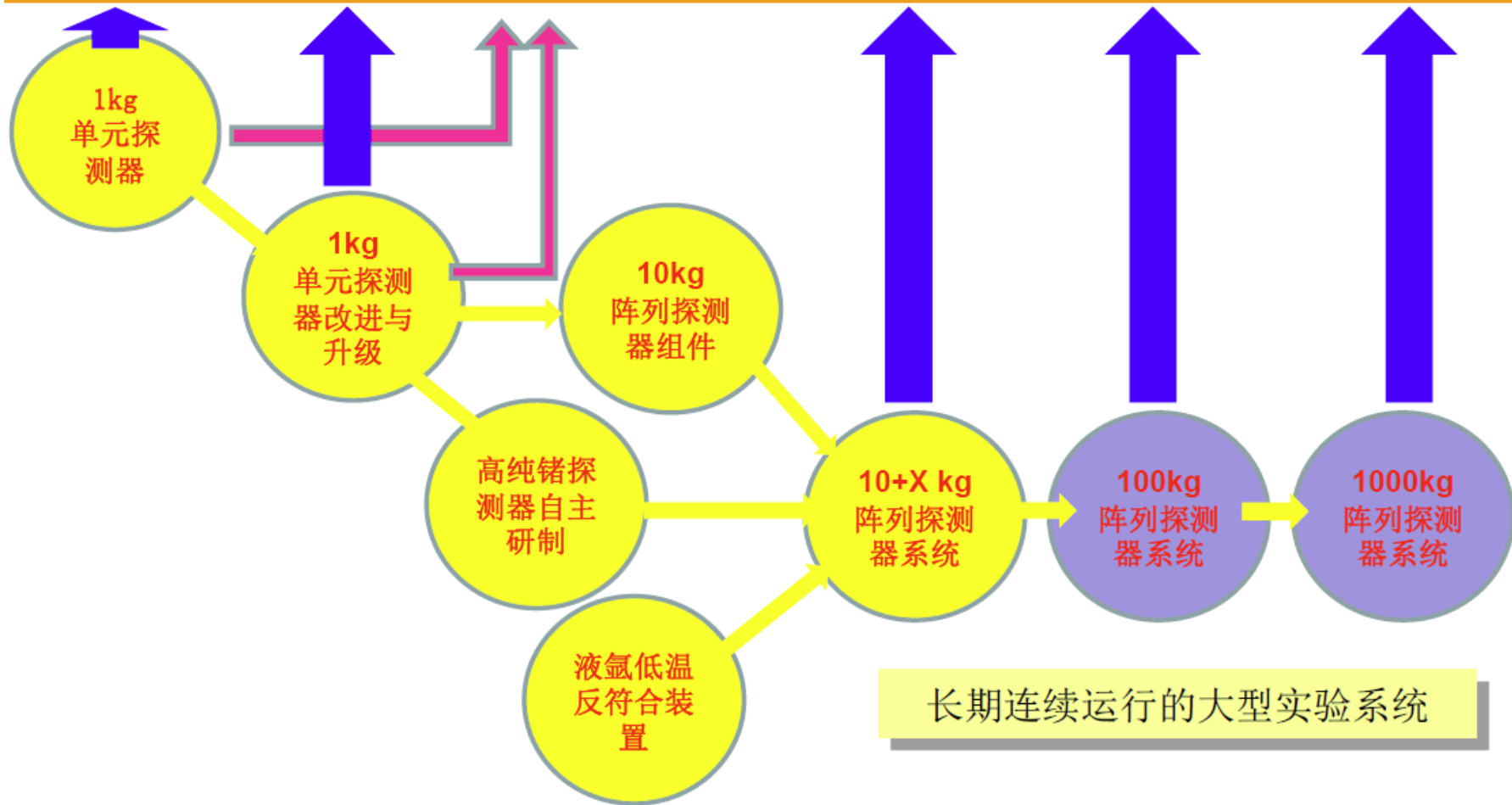
$10^{-42}$

$10^{-43}$

$10^{-44}$

$10^{-45}$

$10^{-46}$



CJPL-I

CJPL-II

# CDEX 10

## 10Kg PPC-Ge



李全 第15届中国核物理大会 2013 上海

