

Ge and Dark Matter Searches:

CDEX, present and future

-Ge detectors at LN temperature

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On behalf of CDEX Collaboration

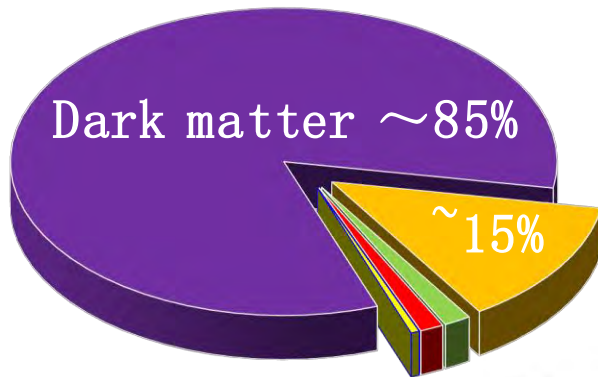
Oct. 19, 2015

(Materials Provided by Prof. Qian Yue)

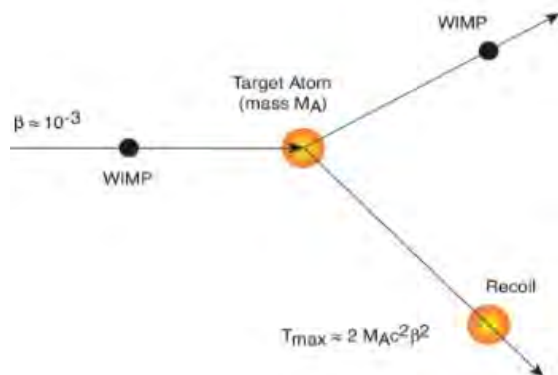
Outline:

- Introduction (Physics , Programs, Collaboration)
- Results of CDEX-1 ($5g \times 4$, 1 kg)
- Status and plans of CDEX-10
- Projects : CDEX-200
- Summary & Outlook

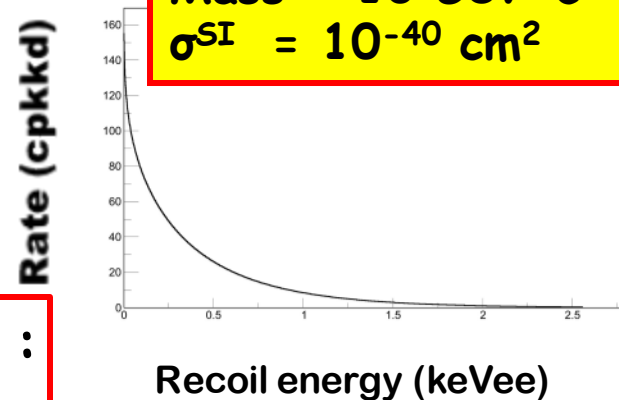
Direct WIMPs detection



- Nature of dark matter unknown.
- WIMPs is one kind of well motivated candidate.



Target : Ge
 Mass = $10 \text{ GeV} \cdot c^{-2}$
 $\sigma^{\text{SI}} = 10^{-40} \text{ cm}^2$



Point-contact HPGe detector (PCGe) :

- ✓ Low energy threshold ($\sim 100 \text{ eVee}$)
- ✓ Very good energy resolution
- ✓ Easy to scale up

CDEX target:

Direct detection of low mass WIMPs with a tonne-scale PCGe array!

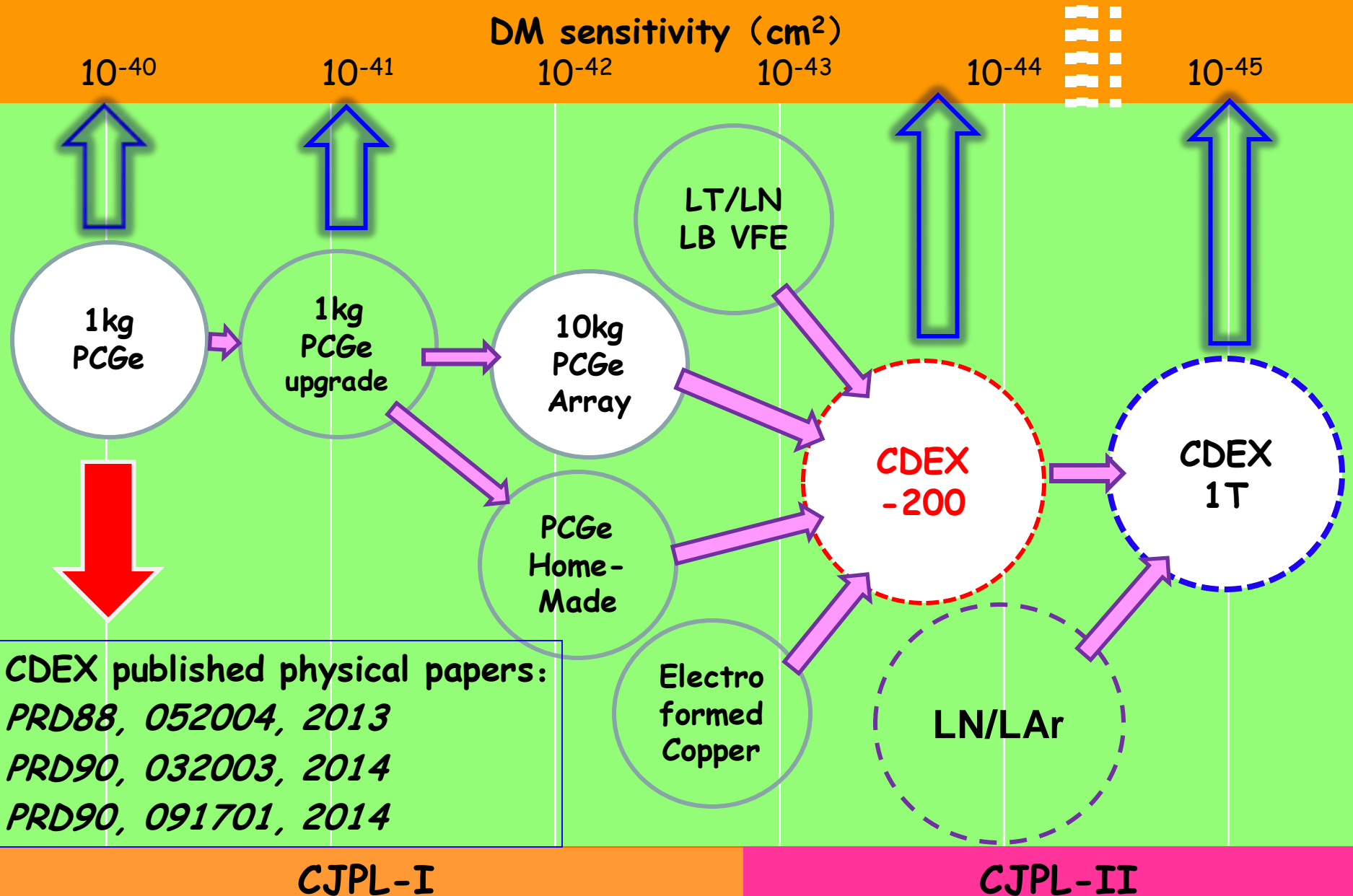
CDEX: China Dark matter EXperiment



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

CDEX's plan

Sino-German GDT @ Ringberg Castle



CDEX-1 Phase

Sino-German GDT @ Ringberg Castle

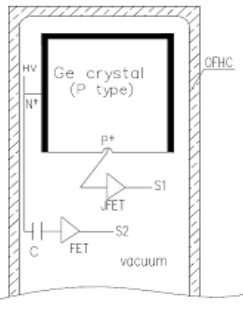
1. HPGe technology

- ✓ Designed the first one single module 1kg-scale p-type point-contact Ge detector (1kg-PPCGe) **C1A from 2011**
- ✓ Improved the second 1kg-PPCGe **C1B from 2014**

2. Active shielding technology: NaI(Tl) used as anti-Compton detector

- ✓ C1A 1kg-PPCGe run
- ✓ C1 20g Ge + NaI(Tl) run
- ✓ C1A 1kg-PPCGe + NaI(Tl) run

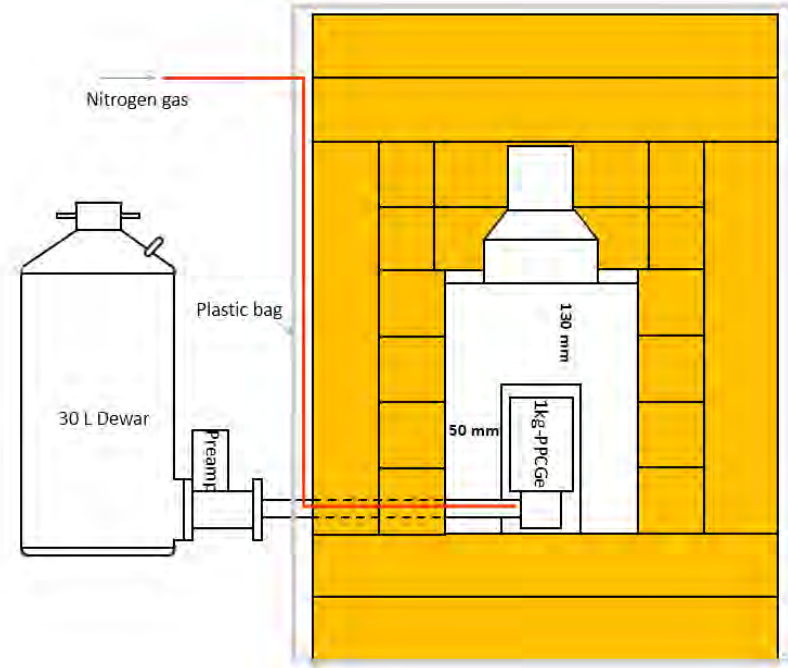
C0 from 2011



1kg-PPCGe



NaI(Tl)



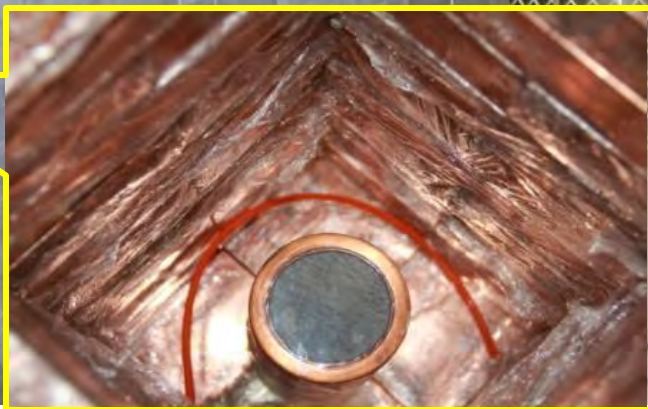
CDEX-1

1kg PCGe



20cm OFHC Copper+20cm Lead

20g ULEGe

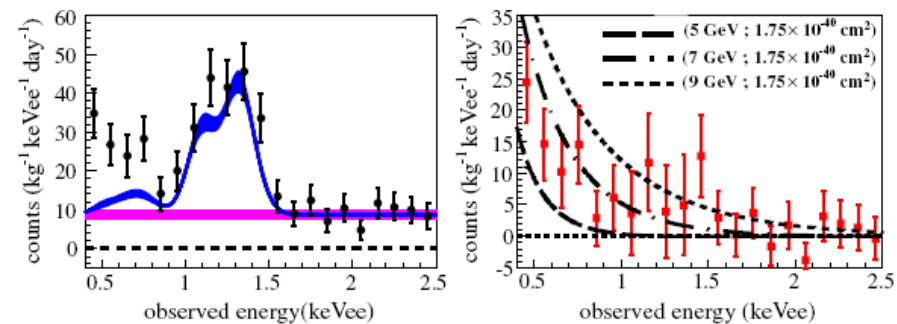
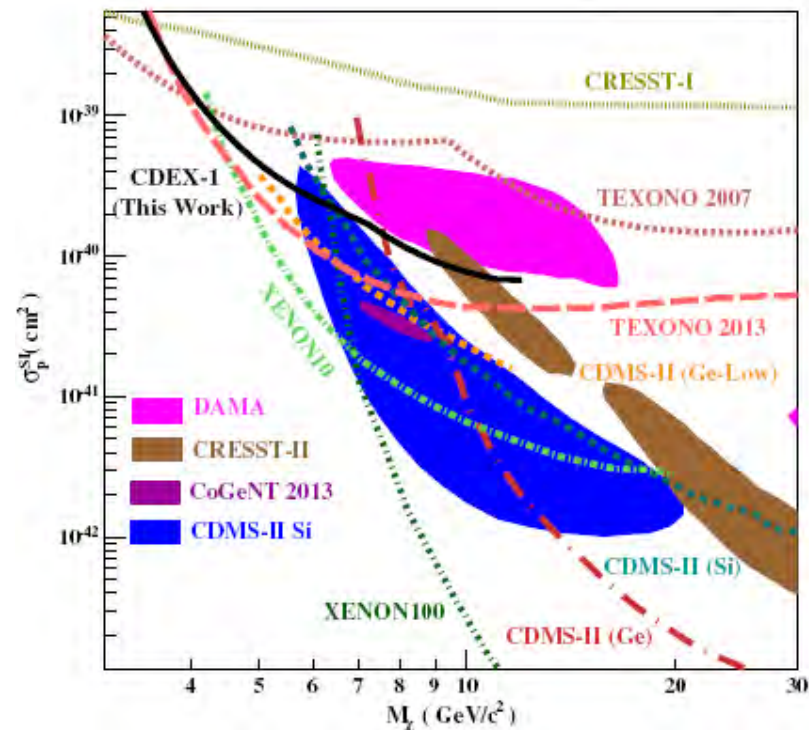
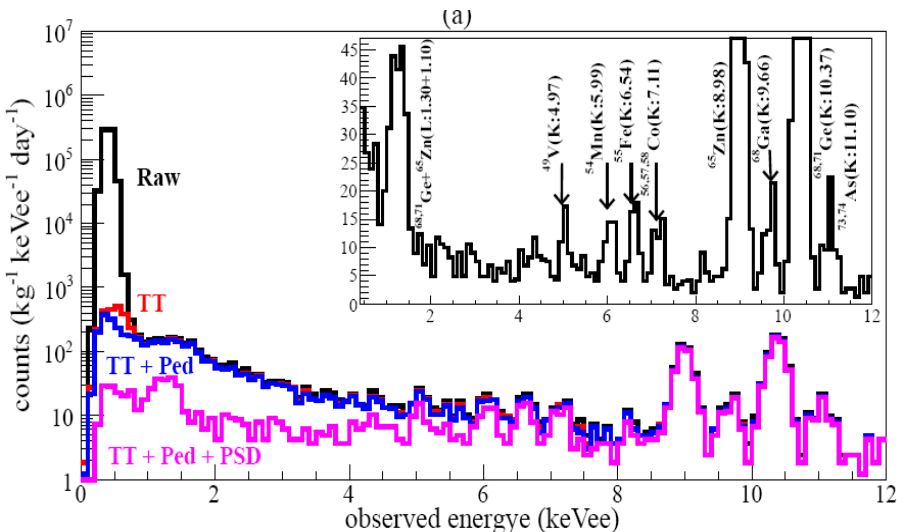


The NaI(Tl) served as AC enclosed both Ge detectors later.

First result from CDEX-1

C1A 1kg-PPCGe

W. Zhao et al., Phys. Rev. D 88, 052004 (2013)

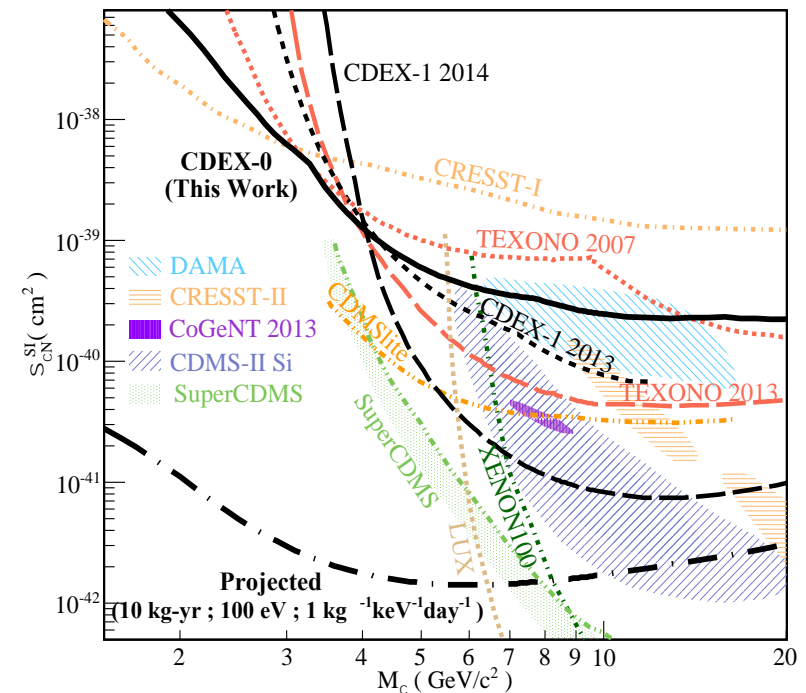
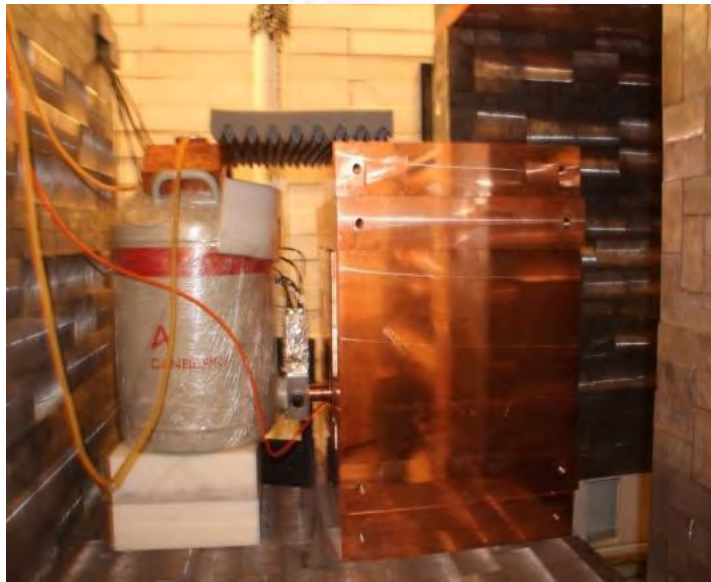
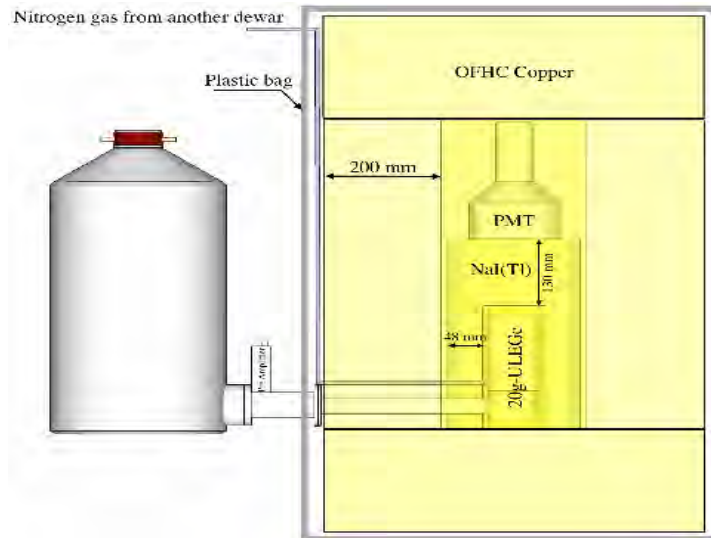


~400 eV threshold was achieved

- The lowest energy threshold for ~1kg-scale PCGe detector. Detail analysis given by *W Zhao's talk*.
- The first dark matter physical result from China!

Results from a 5g*4 array detector

CDEX-0 5g*4 + AC detector



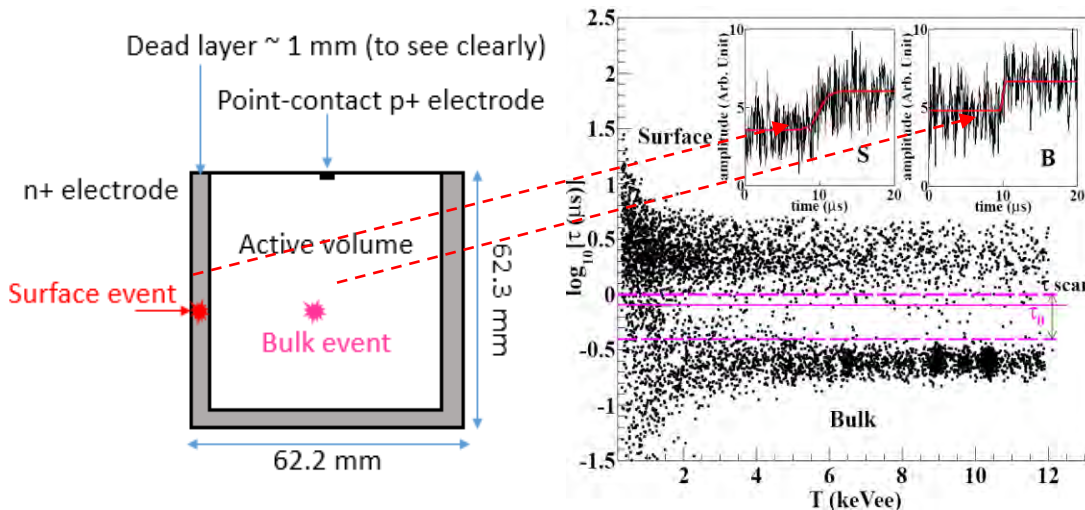
PRD90, 032003, 2014

Highlight:

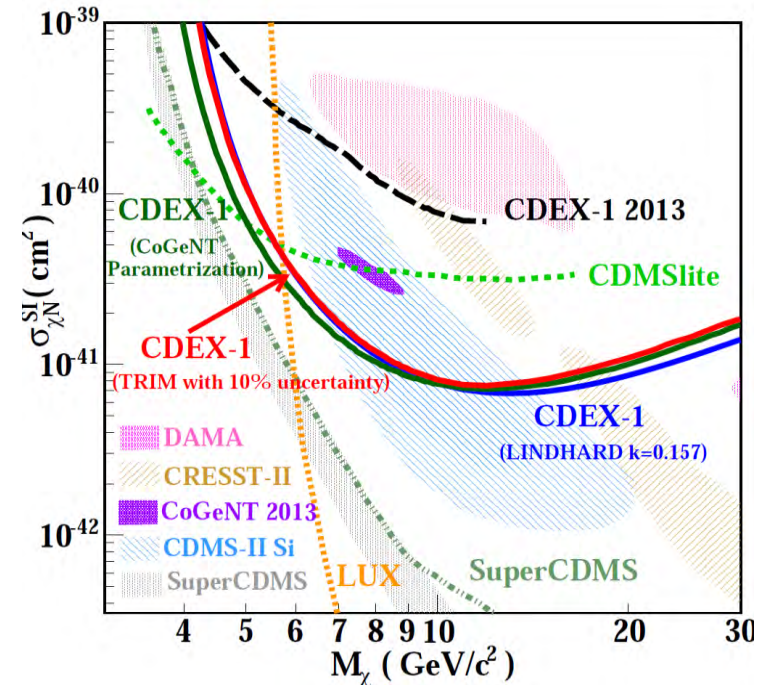
- ✓ **177eV** lowest ionization energy threshold
- ✓ Good direction to lower energy threshold further

CDEX-1: AC Compton & surface/bulk incorporated

C1A 1kg-PPCGe + NaI(Tl)



Bulk/Surf Discrimination



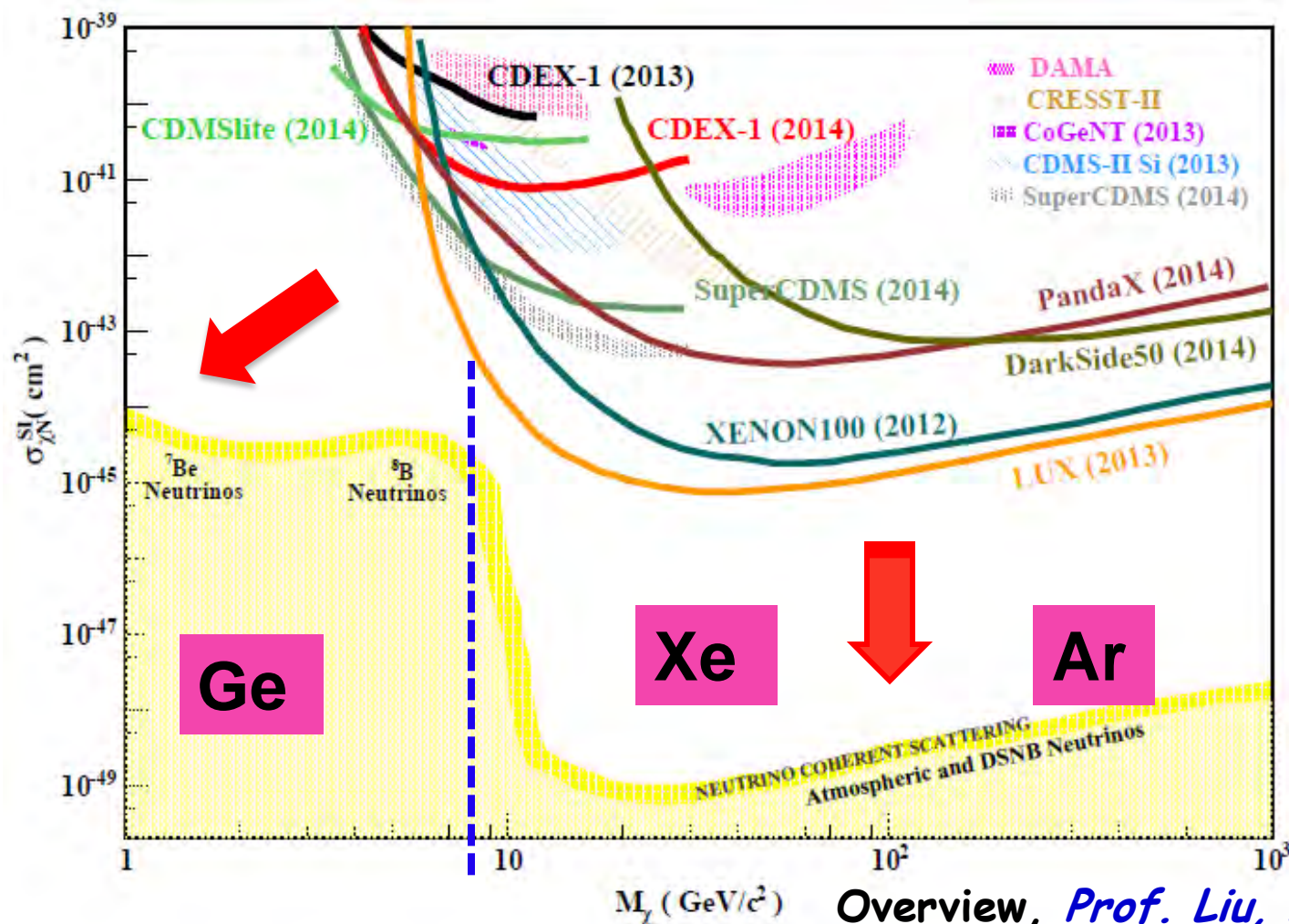
Q. Yue et al., PRD 90(RC) 091701 2014

- ✓ The regions favored by CoGeNT has been probed and excluded. Provided the interpretations of differentiation for bulk and surface events .

C1B *Yang, LiTao's talk.*

The development of direct WIMPs searches in China

- ✓ NO definite WIMP evidences both at *low* and *high* mass regions;
- ✓ Generic parameter spaces yet not observed;
- ✓ CDEX will focus on the low mass WIMP search.

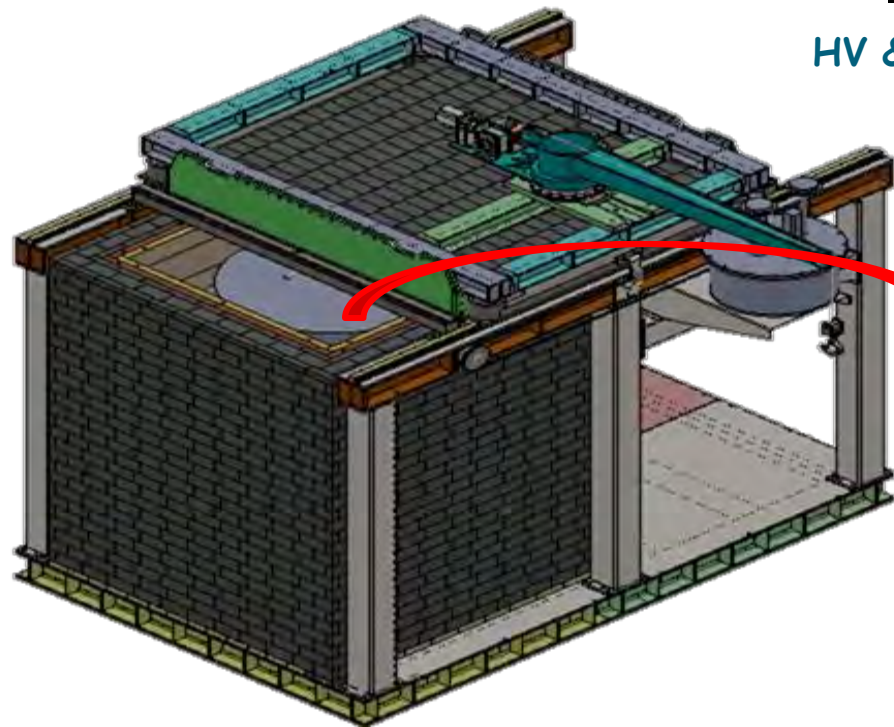
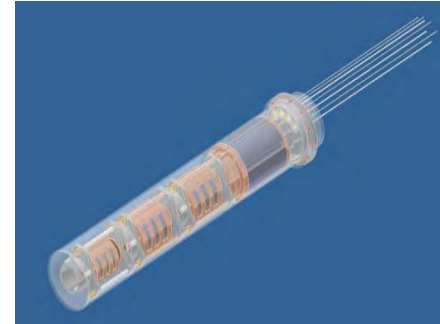


CDEX-10 experiment

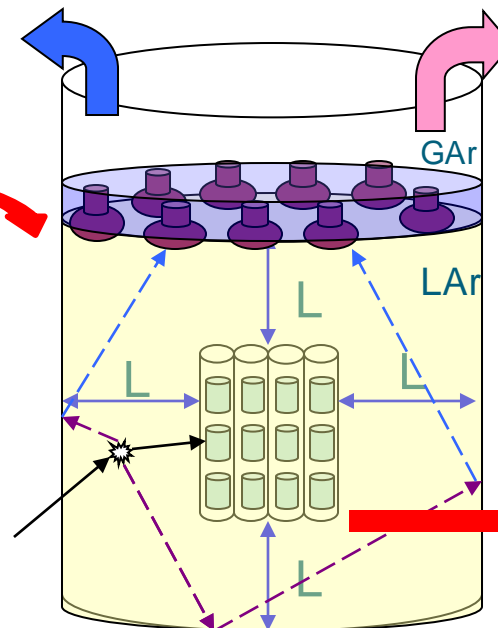
- The important stage towards large-scale Ge experiment.
- Study on the performance of the Ge array detector
- **Feasibility test** of LAr Anti-Compton detector

10kg-PCGe + LAr

3-PCGe element

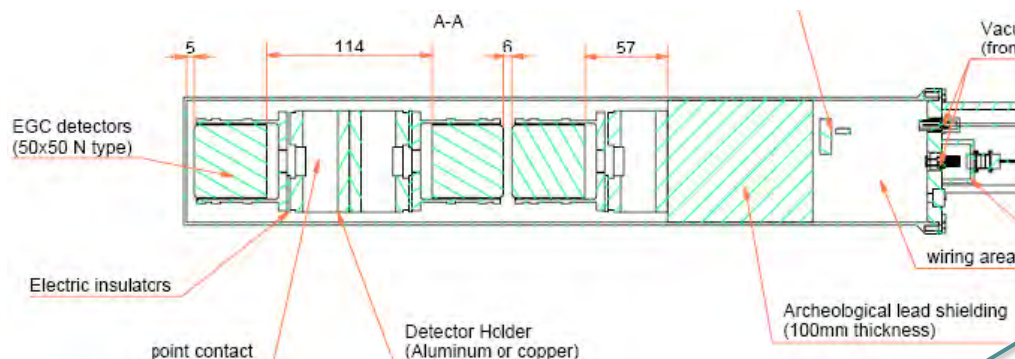


HV & Signals Cooling & Control



Schematics of shielding & mechanics house

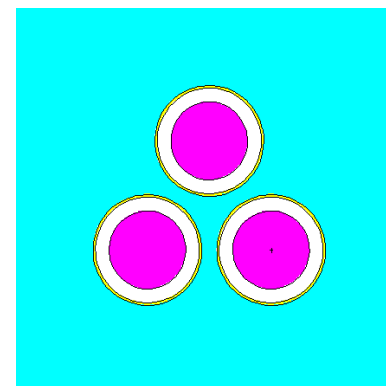
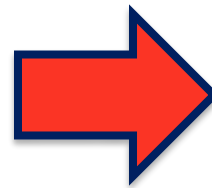
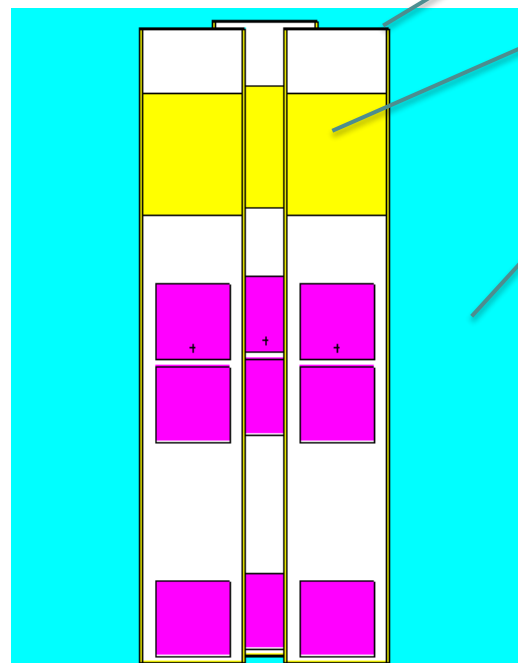
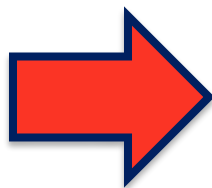
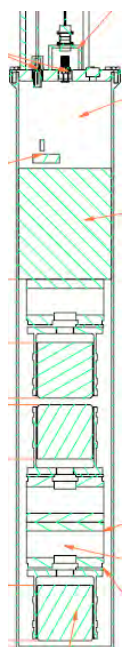
PPCGe array detector



Cu 2mm

Pb + Cu 10mm

HPGe



Three 3kg PPCGe detector

The fine-tune & tests of cryogenic system for CDEX-10



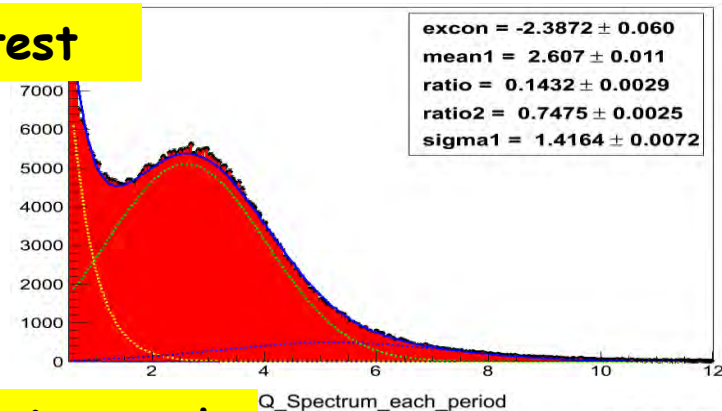
The performance of the Prototype LAr detector

LAr System - Prof. Ming Zeng's talk

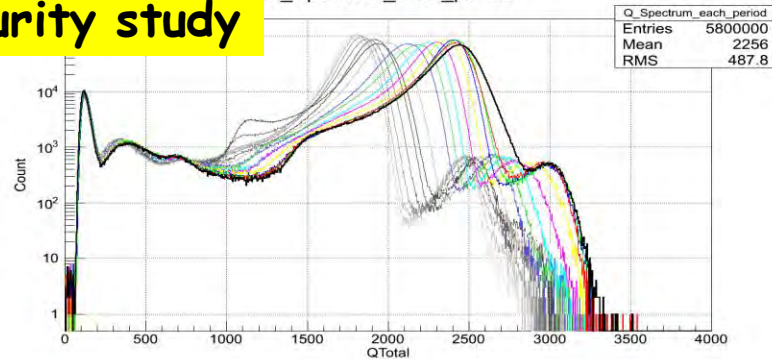
Prototype Ar detector



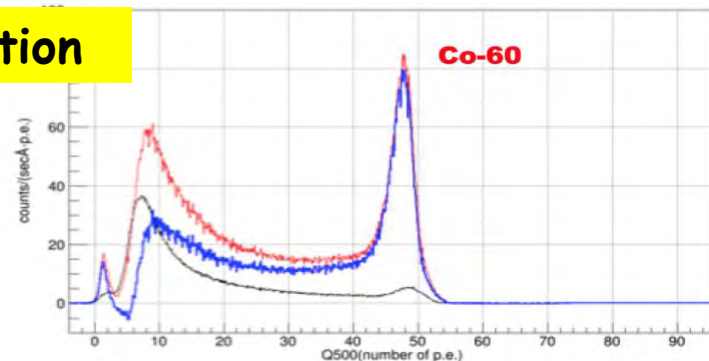
PMT test



Ar impurity study

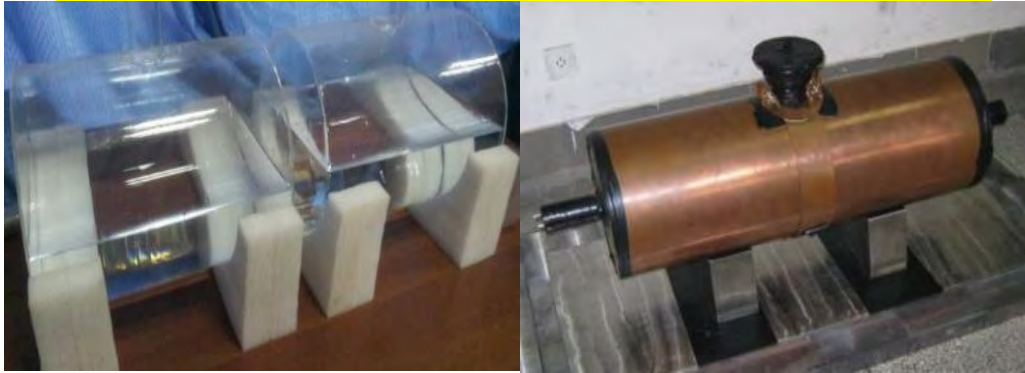


Calibration



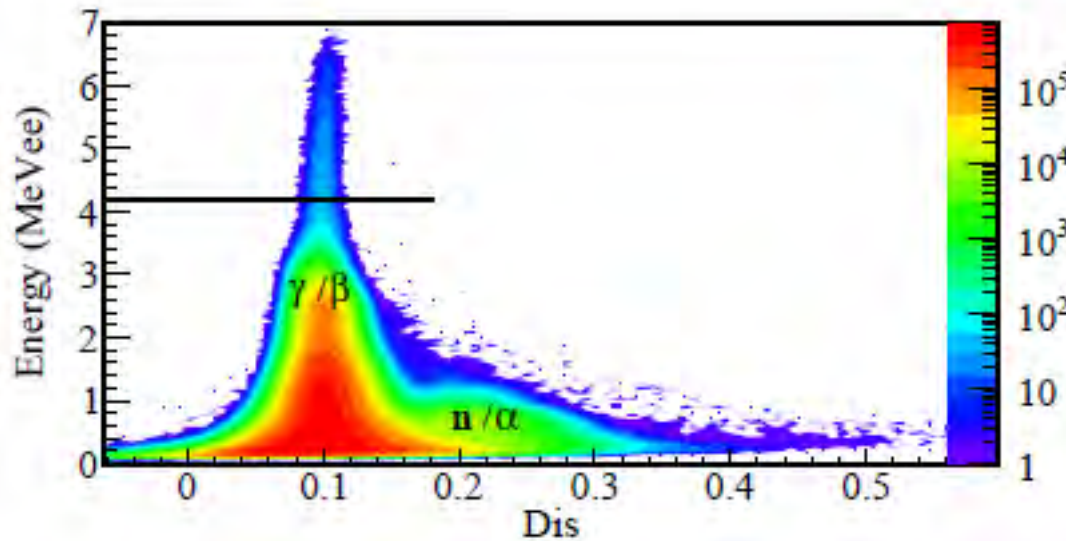
Neutron Background measurement at CJPL

Liquid Scintillator doped Gd



LS detector with Gd

- Good γ/n discrimination
- Fast-slow coincident to enhance the sensitivities and avoid the contamination of Th/U.
- Detector Calibration : *Li Wang's talk*
- Fast neutron BKG : *Qiang Du's talk.*



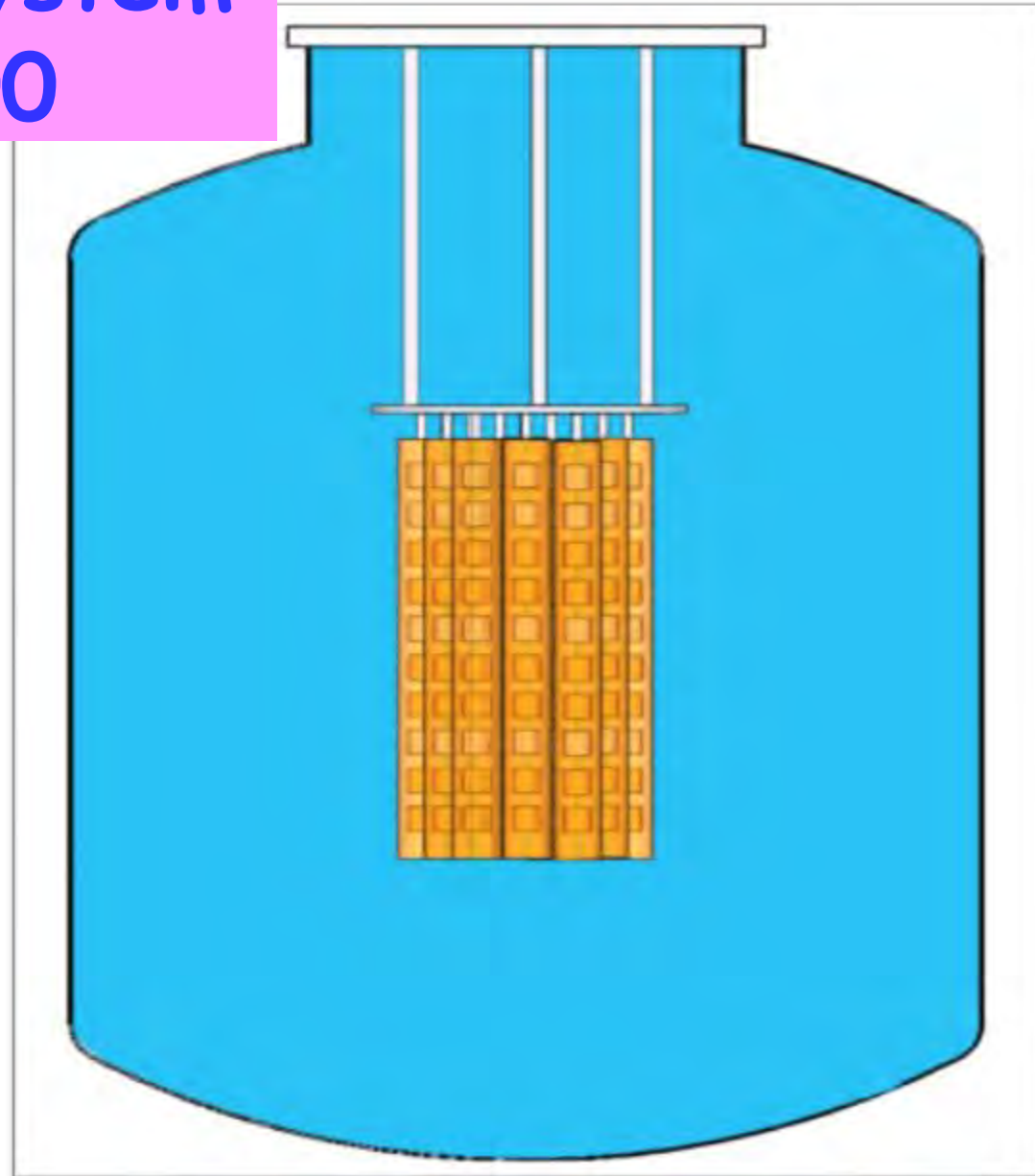
Key technologies towards CDEX-200(1T)

- Ge purification & Ge crystal growth
- **HPGe** detector fabrication
Prof. Yulan Li's talk
- Pre-amplifier electronics
ASIC - Prof. Zhi Deng's talk; Feng Liu's talk
- Ultra-low background VFE (**$0\nu\beta\beta$**)
Prof. Zhi Deng's talk
- Techniques on electroformed copper
Prof. Hao Ma's talk
- Large-volume cooling tank in **CJPL-II**
CJPL-II Prof. Zhi Zeng's talk; QuingDong Hu's talk
- *Feedback-adjustment...*

Tentative idea for the Cryogenic system of CDEX-200

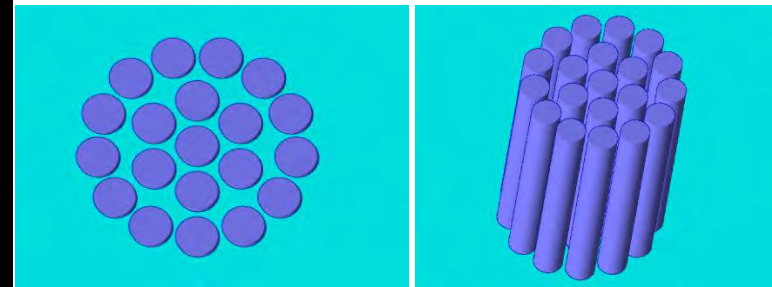
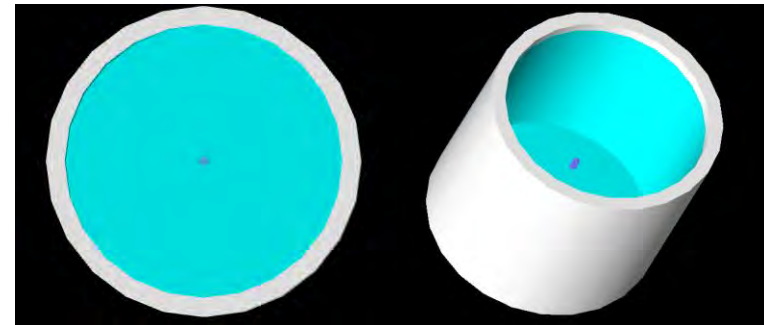
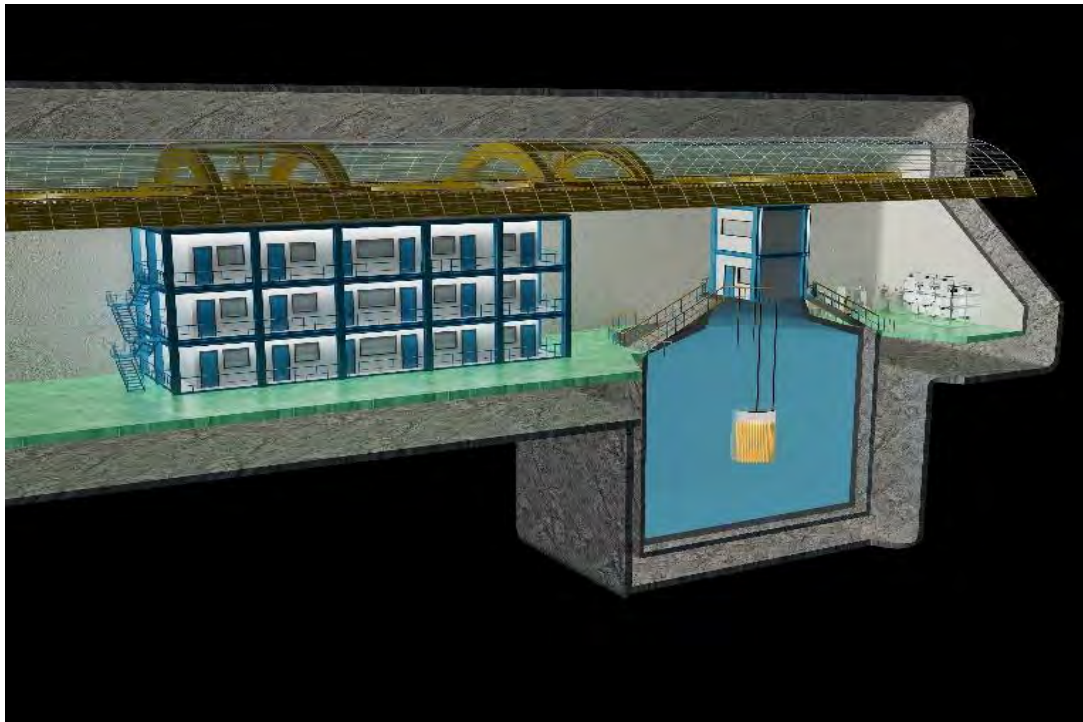
Sino-German GDT @ Ringberg Castle

CDEX-200 with
LN₂ cooling system

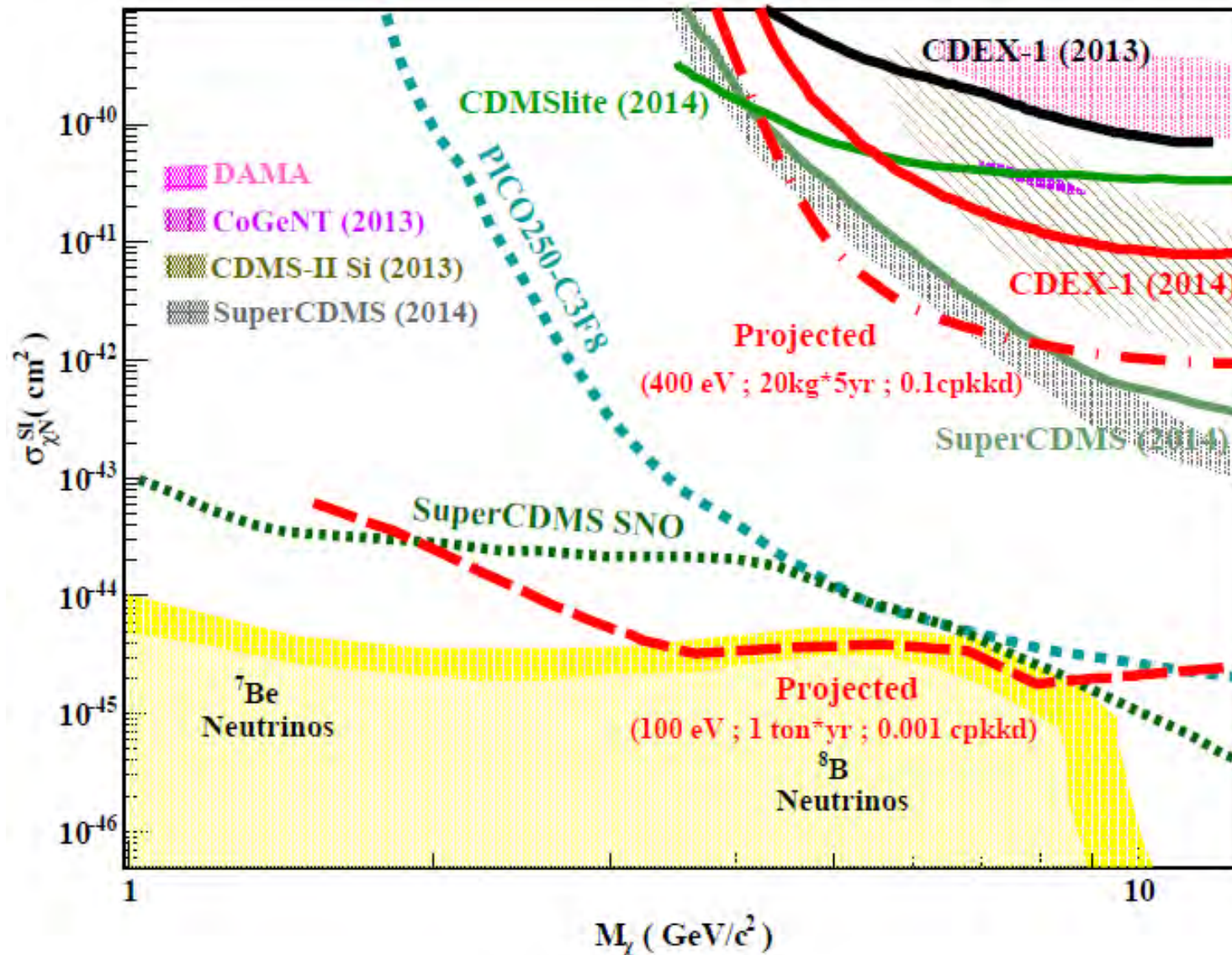


CDEX-200 : Space available in CJPL-II

- LN_2 as a cooling and passive shielding system
 - : Goal: Background from outside of Ge $< 10^{-3}\text{cpkkd}$
- New space for CDEX: $\phi 18\text{m} * 30\text{m}$;
- CDEX-200 space ready in 2016.



Projected sensitivities of CDEX



Summary & Outlook

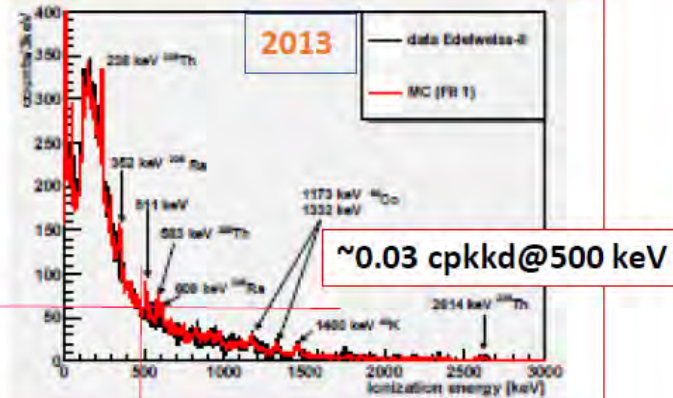
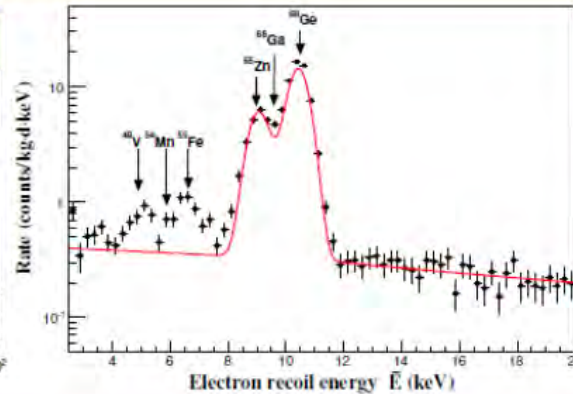
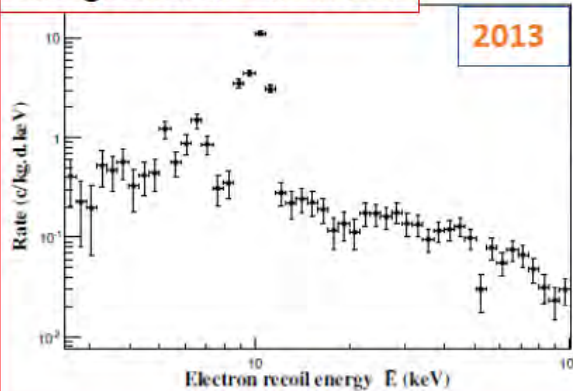
- CDEX-1@CJPL has been commissioned from 2011.
- Physical results from CDEX-0/1 have been achieved.
PRD-2013, PRD(R)2014.
- The regions favored by CoGeNT has been **probed and excluded with the identical detection**. Provided the interpretations of differentiation for **bulk and surface events**. New results is coming !!
- CDEX-10 with a 3 kg array detector(a string) tested and the rests are coming. The cryogenic system will be installed at CJPL in **Nov. 2015**.
- CDEX-200 (2016-2020) : **key technologies** and **facility arrangements** are on-going.

Thank you !

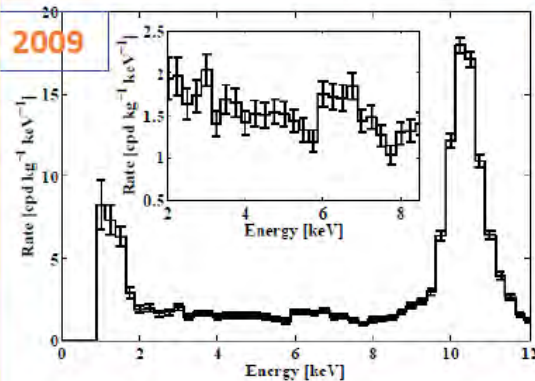
Sino-German GDT @ Ringberg Castle



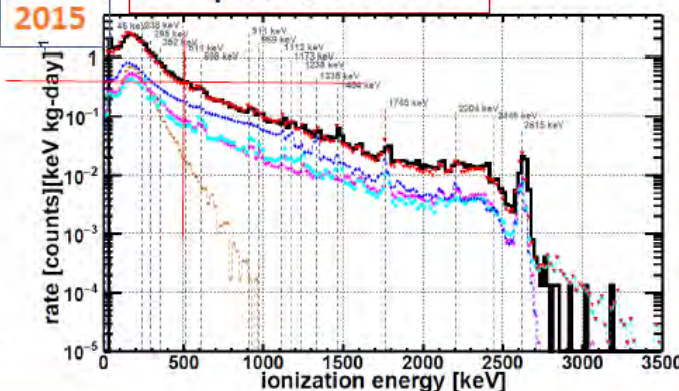
2013



2009



0.3 cpkkd @ 500 keV



Background for Gerda

