Status and prospects of CDEX

Qian Yue
Tsinghua University
On behalf of CDEX Collaboration
Sept. 7, 2015

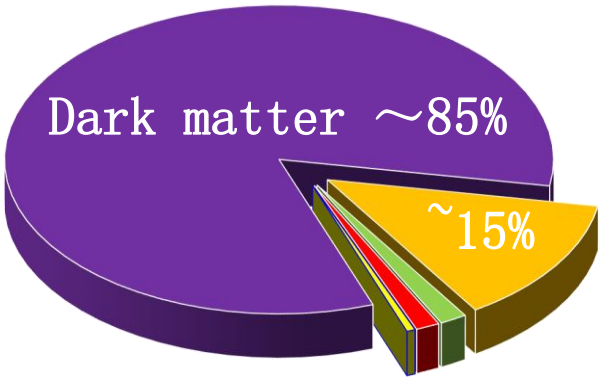
CJPL 中国锦屏地下实验室 China Jinping Underground Laboratory

TAUP 2015 @ Torino

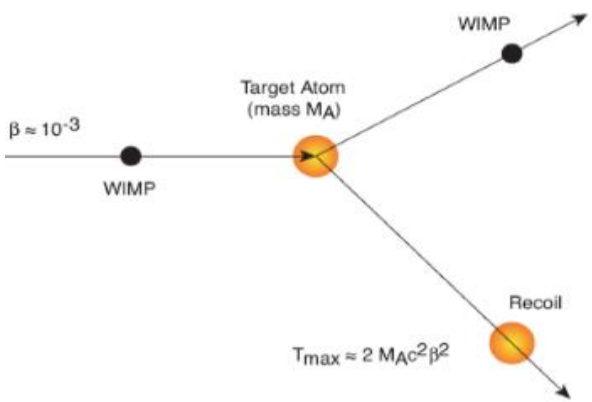
Outline：

- CDEX experiment introduction
- CDEX-1 results and CDEX-10 status
- CDEX-200 experiment plan
- Summary

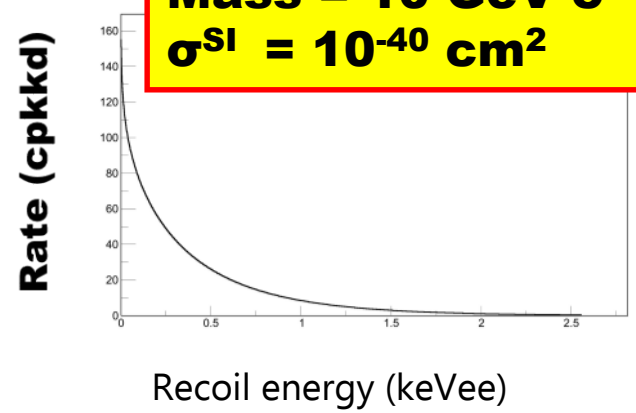
China Darkmatter Experiment (CDEX)



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



Target : Ge
Mass = 10 GeV·c^{-2}
σ^{SI} = 10^{-40} cm^2



Point-contact HPGe detector (PCGe) :
✓Low energy threshold (~ 100eVee)
✓Very good energy resolution
✓Easy to scale up

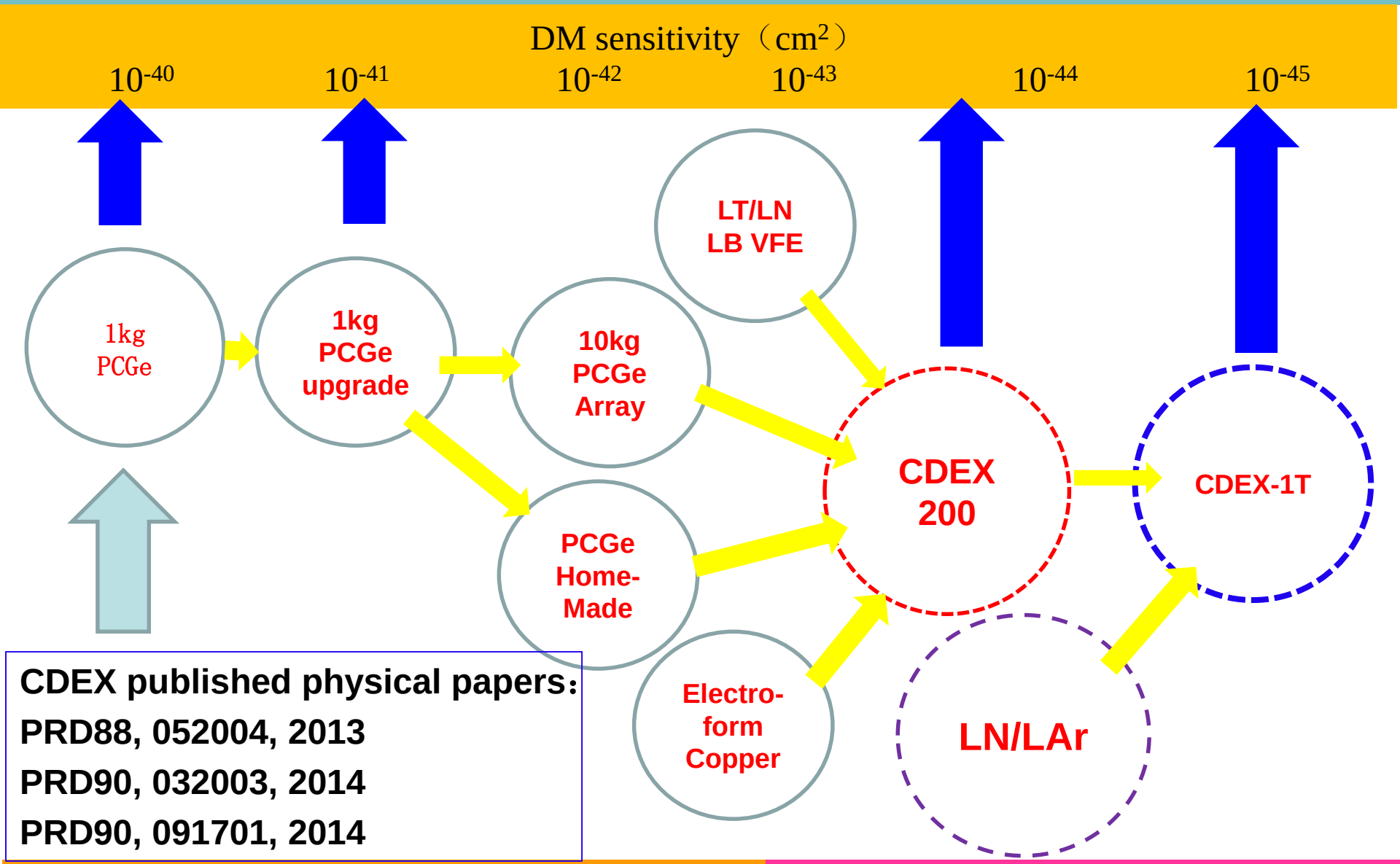
CDEX target:
Direct detection of low mass dark matter with tonne-scale PCGe array!

CDEX: China Dark matter EXperiment

Established in 2009.

- 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 plan



CDEX published physical papers:

PRD88, 052004, 2013

PRD90, 032003, 2014

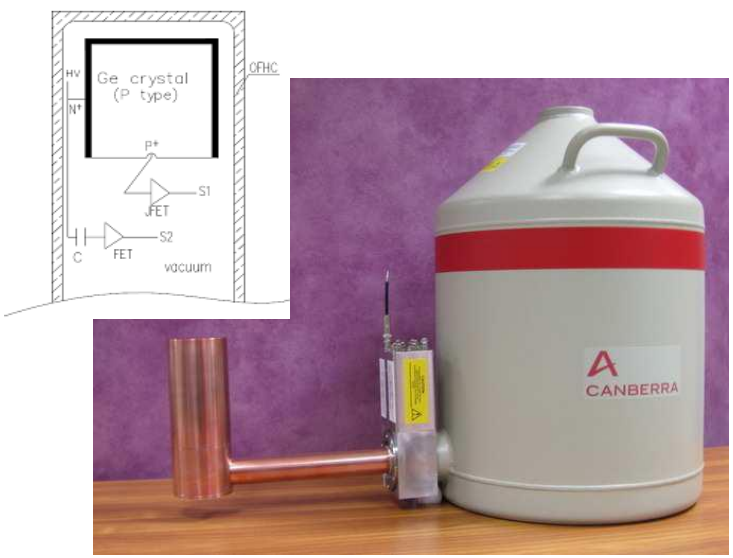
PRD90, 091701, 2014

CJPL-I

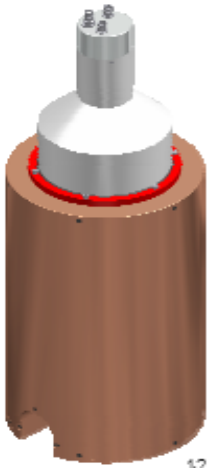
CJPL-II

CDEX-1 experiment

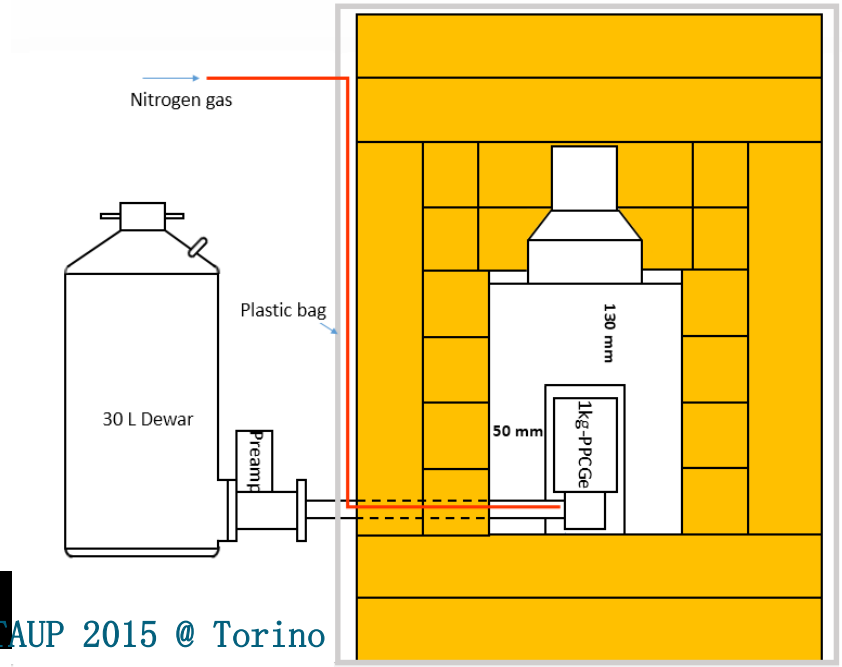
1. HPGe technology
   - ✓ Designed the first one single module 1kg-scale p-type point-contact Ge detector (1kg-PPCGe) C1A from 2011
   - ✓ Improved the second 1kg-PPCGe C1B from 2014
2. Active shielding technology: NaI(Tl) used as anti-Compton detector
   - ✓ C1A 1kg-PPCGe run
   - ✓ C1 20g Ge + NaI(Tl) run C0 from 2011
   - ✓ C1A 1kg-PPCGe + NaI(Tl) run



1kg-PPCGe



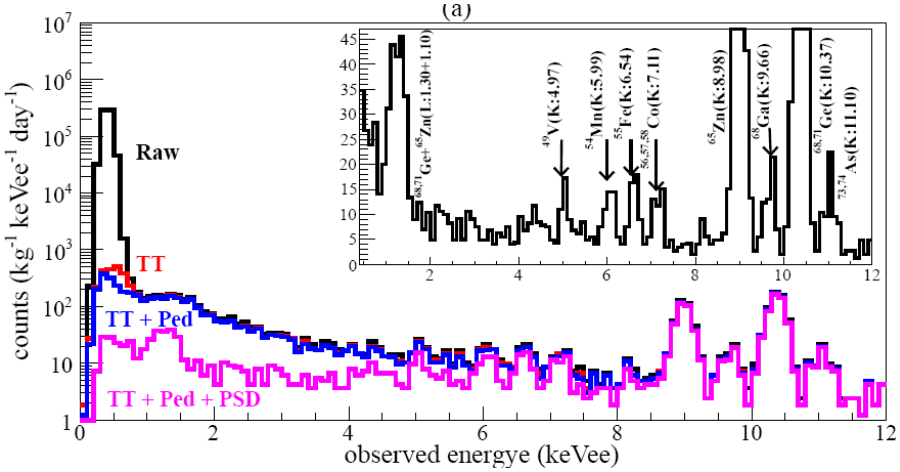
NaI(Tl)

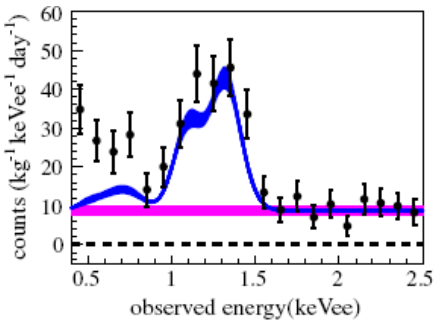


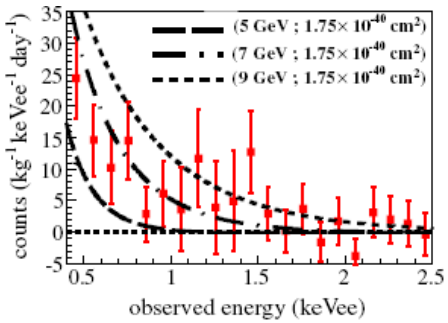
CDEX-1

CDEX-1 experiment

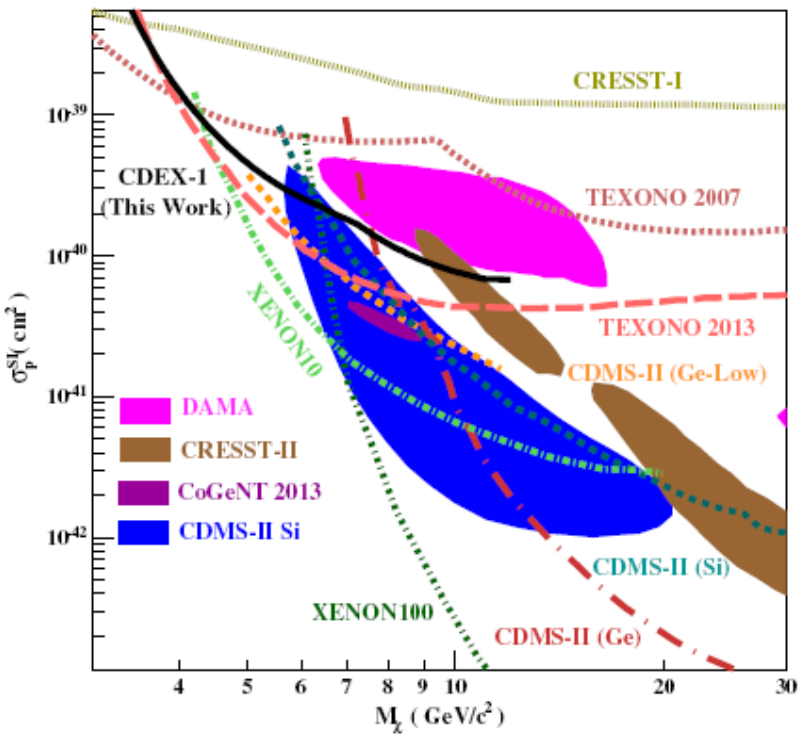
C1A 1kg-PPCGe







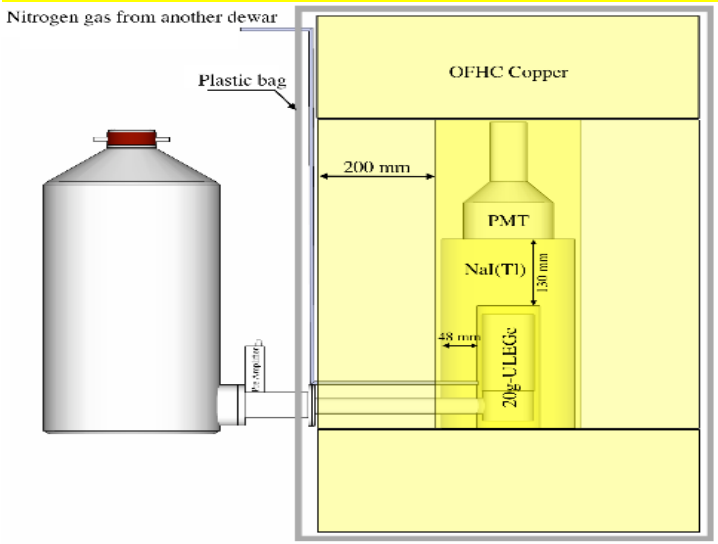
W. Zhao et al., Phys. Rev. D 88, 052004 (2013);

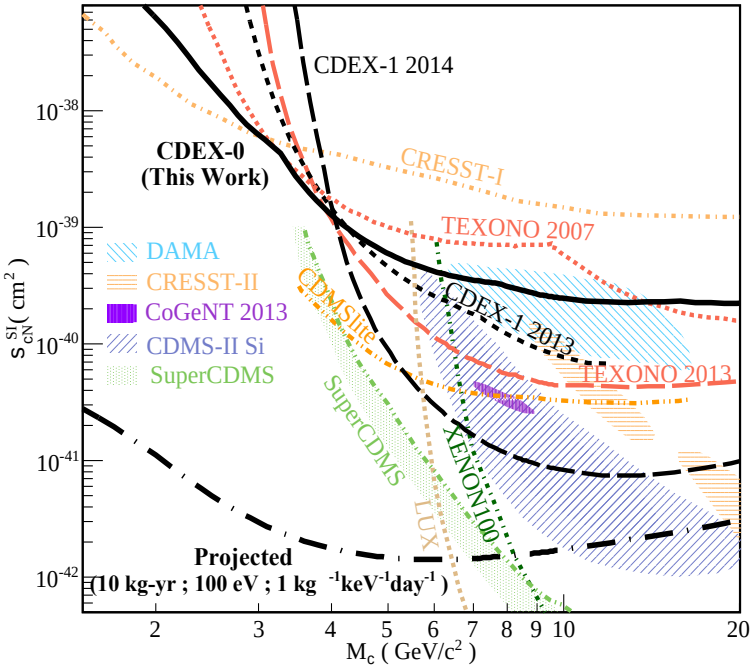


- The lowest energy threshold for ~1kg-scale PCGe detector: 400eV
- The first dark matter physical result from China!

CDEX-1 result from 20g Array detector

CDEX-1 5g*4 +AC detector



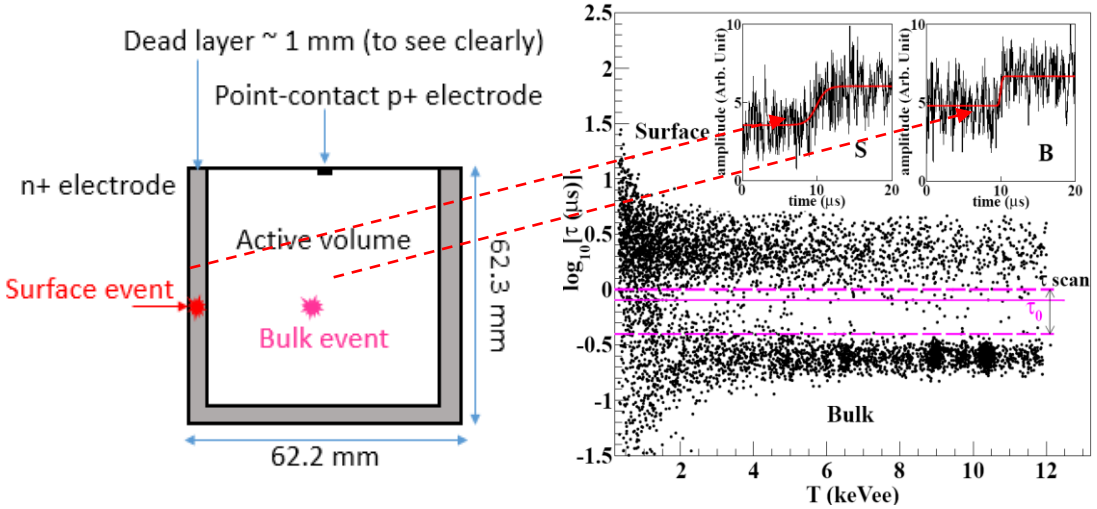


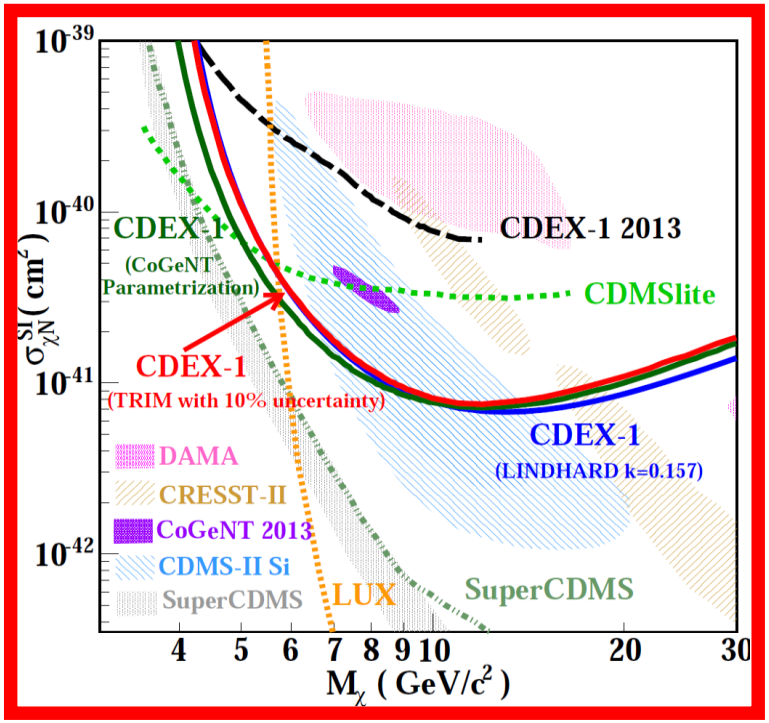
PRD90,032003,2014

Highlight:

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

CDEX-1 result in 2014





- **Bulk/Surf Discrimination**
- **C1A + NaI(Tl) AC**

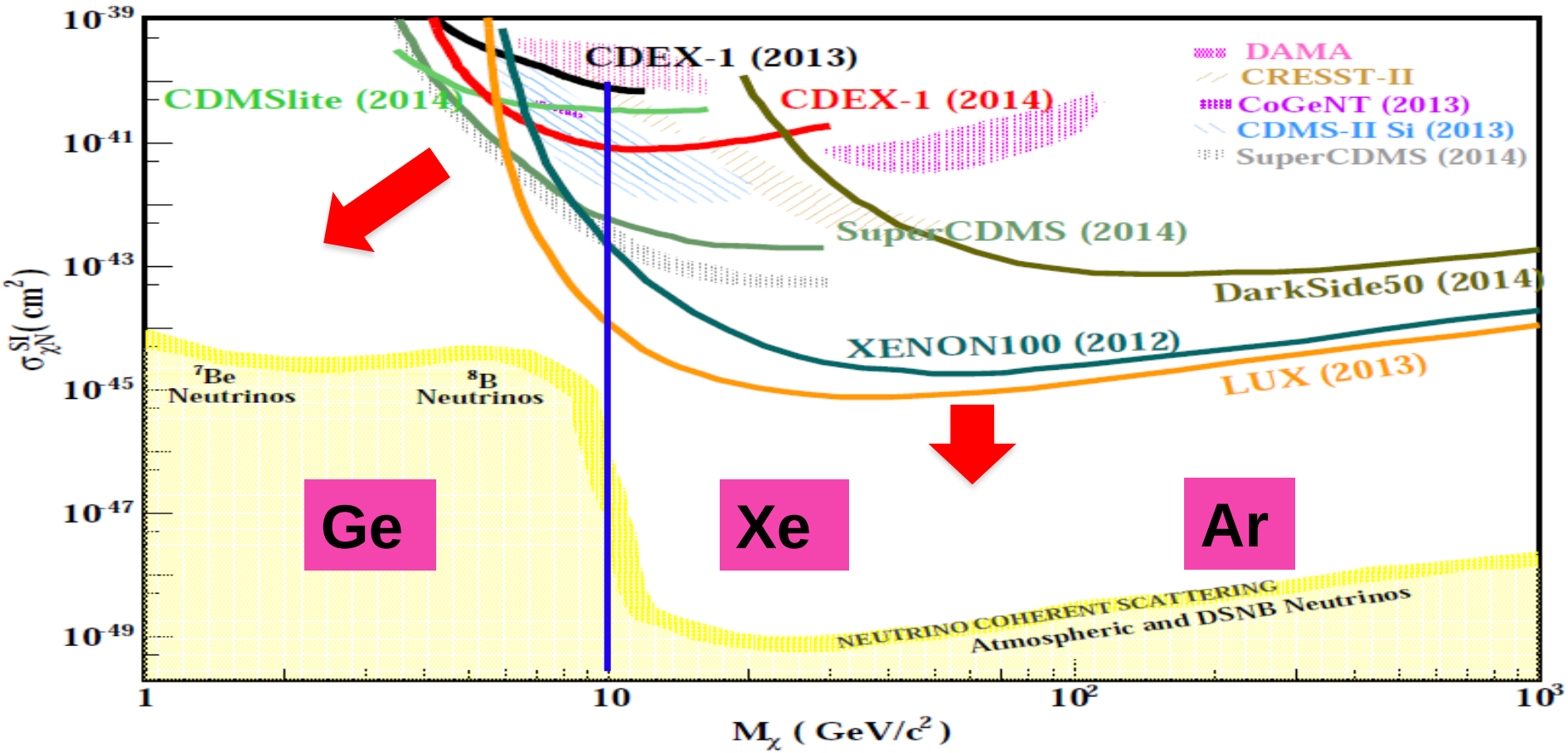
Q.Yue et al., PRD 90(RC) 091701

✓The best sensitivity by PCGe in the world;

✓Exclude the regions favored by CoGeNT.

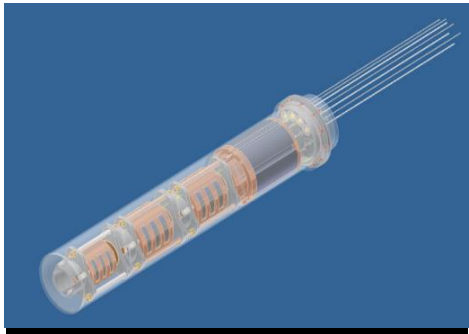
The development of DM experiment

- Have no definite DM evidences in the low mass and high mass regions;
- Have spaces need to be scanned;
- CDEX will focus on the low mass DM search.

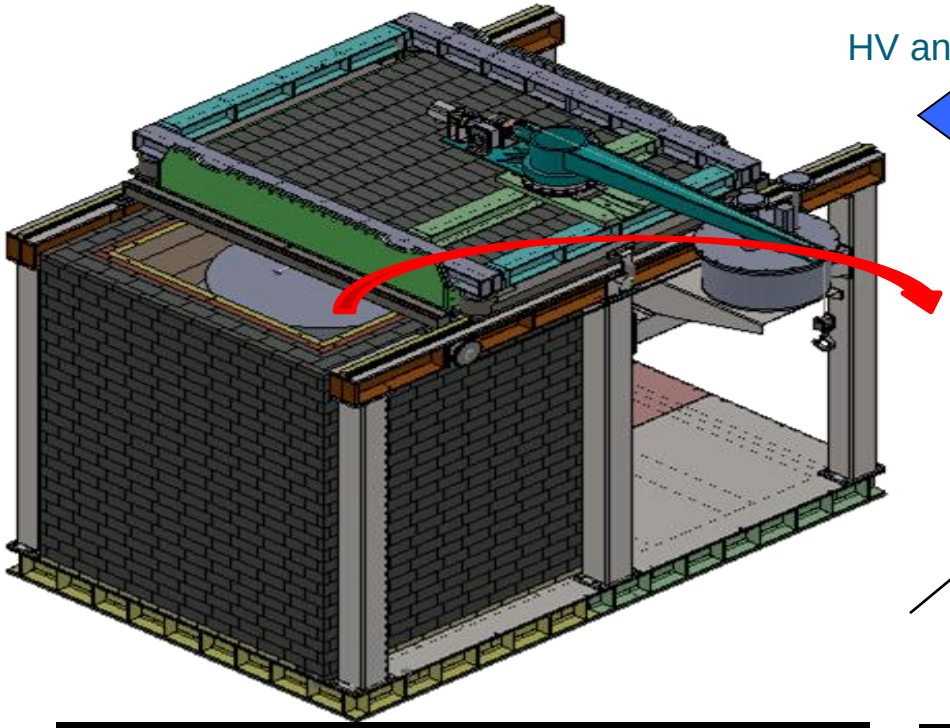


CDEX-10 experiment

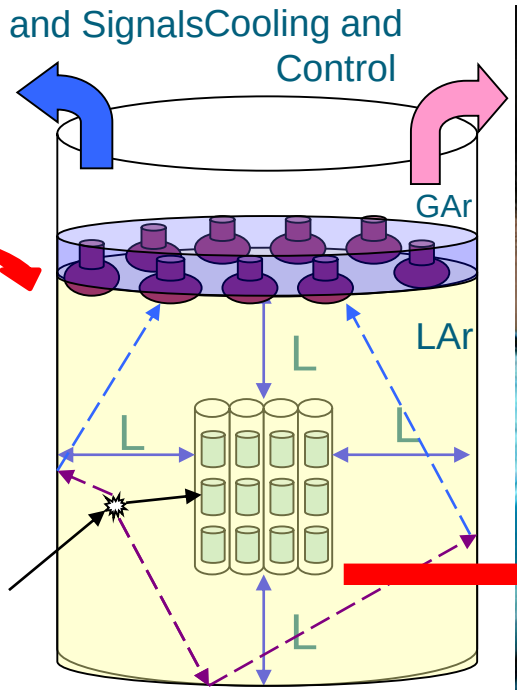
- The important stage towards large-scale Ge experiment!
- Performance study of the Ge array detector
- Feasibility study of LAr Anti-Compton detector



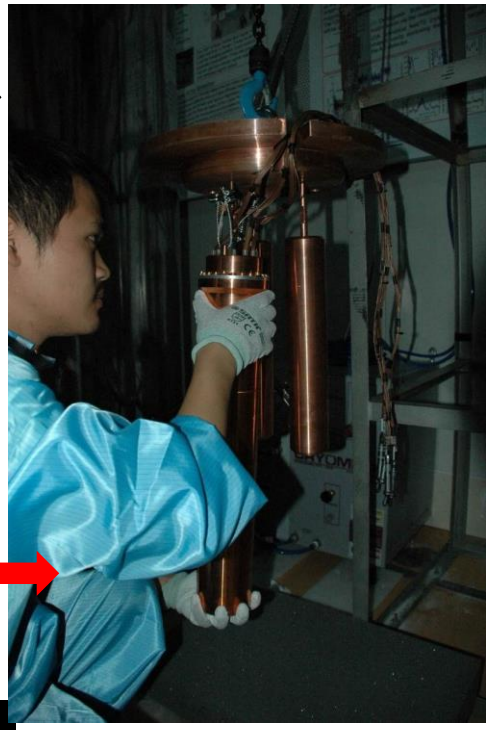
3-PCGe element



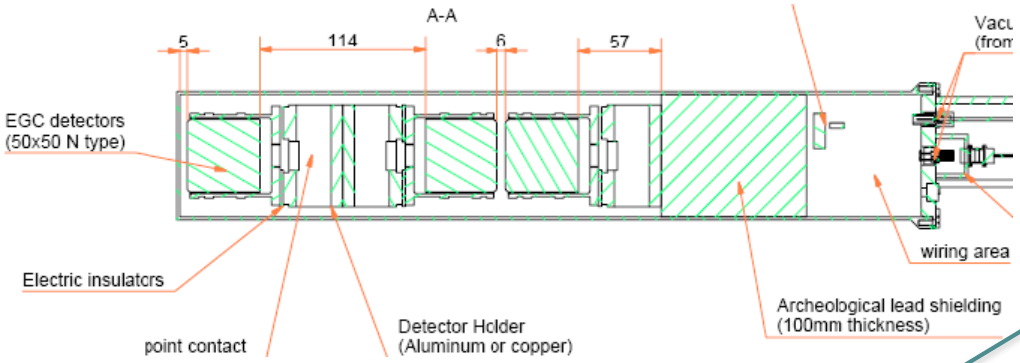
CDEX-10 experimental setup

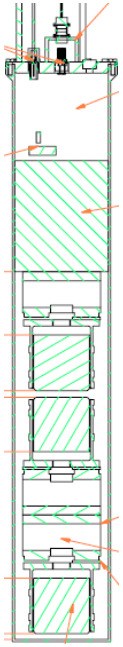


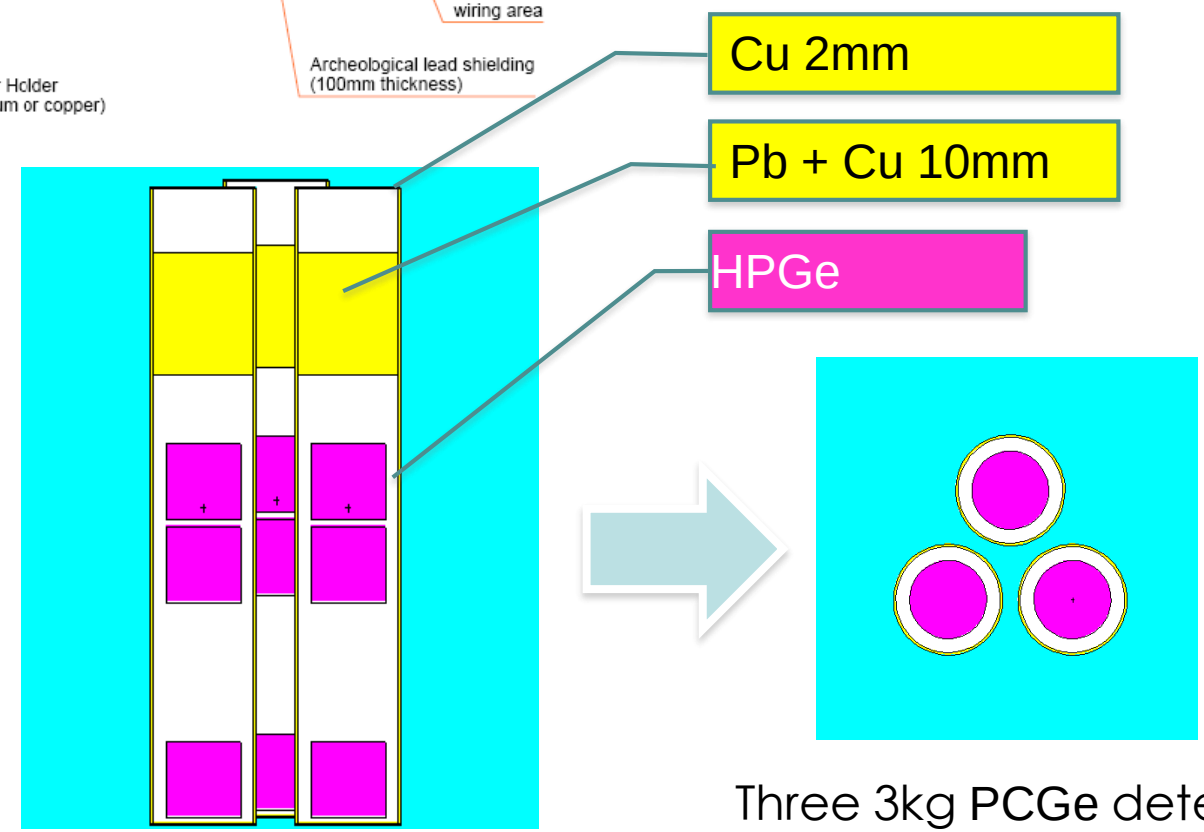
10kg PCGe + LAr



PPCGe array detector







Three 3kg PCGe detector

The performance test of Ge array in CDEX-10

- Two 3kg PCGe Array detectors tested in CJPL;
- The energy thresholds and backgrounds are quite good for dark matter experiment;
- The first results planed by the end of this year.

Key technologies towards CDEX-200(1T)

- Ge purification and Ge crystal growth
- HPGe detector fabrication
- Ultra-low background VFE
- Ultra-pure copper for structures and cables
- Large-volume cooling tank
- ……

CDEX-1T –Ge crystal growth

Zone refining machine

Czochralski machine

Cutting & Polishing

Crystal growth

- ✓ The requirement for making P-type Ge detector
  - ✓ Impurity density: $<3*10^{10}$ cm^{-3}
  - ✓ Dislocation: <5000 cm^{-2}

Achieved

- ✓ Impurity density: $\sim 5*10^{10}$ cm^{-3}
- ✓ The dislocation: ~ 5000 cm^{-2} in the center

CDEX Lab for HPGe detector fabrication

- Clean room

Vacuum Coating Machine

Magnetron Sputtering Device

- Wet Lab

- Machine-shop

Crystal Processing

- Typical Processing Technology is used

Mechanical Preparation

↓

Lithium Diffusion

↓

Wet Lab

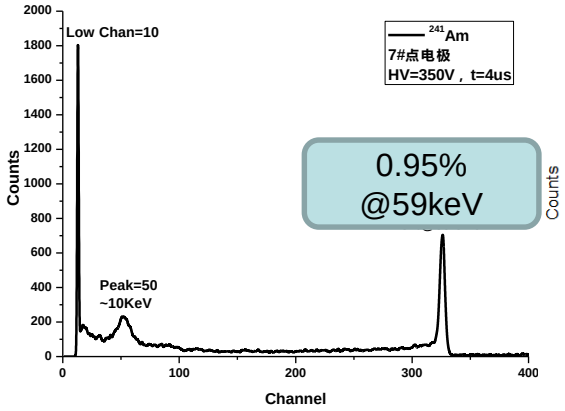
↓

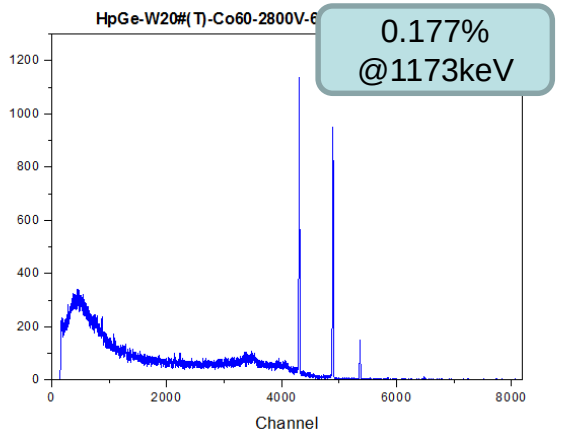
Boron Implant

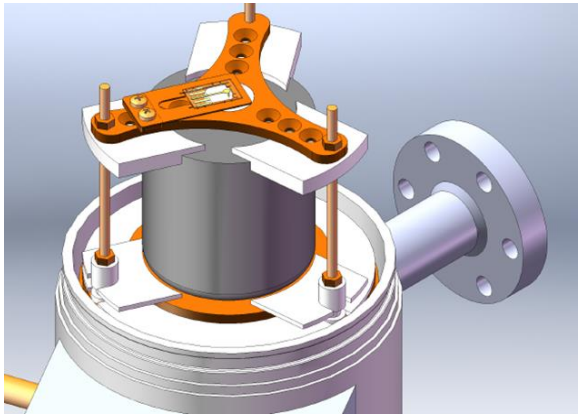
Boron Implant Accelerator

HPGe detector fabrication

- 500g point-contact Ge detector has been done successfuly, comparable to the commercial product in energy resolution
- Next plan: PCGe R&D with ultra-low energy threshold and background used for dark matter experiment

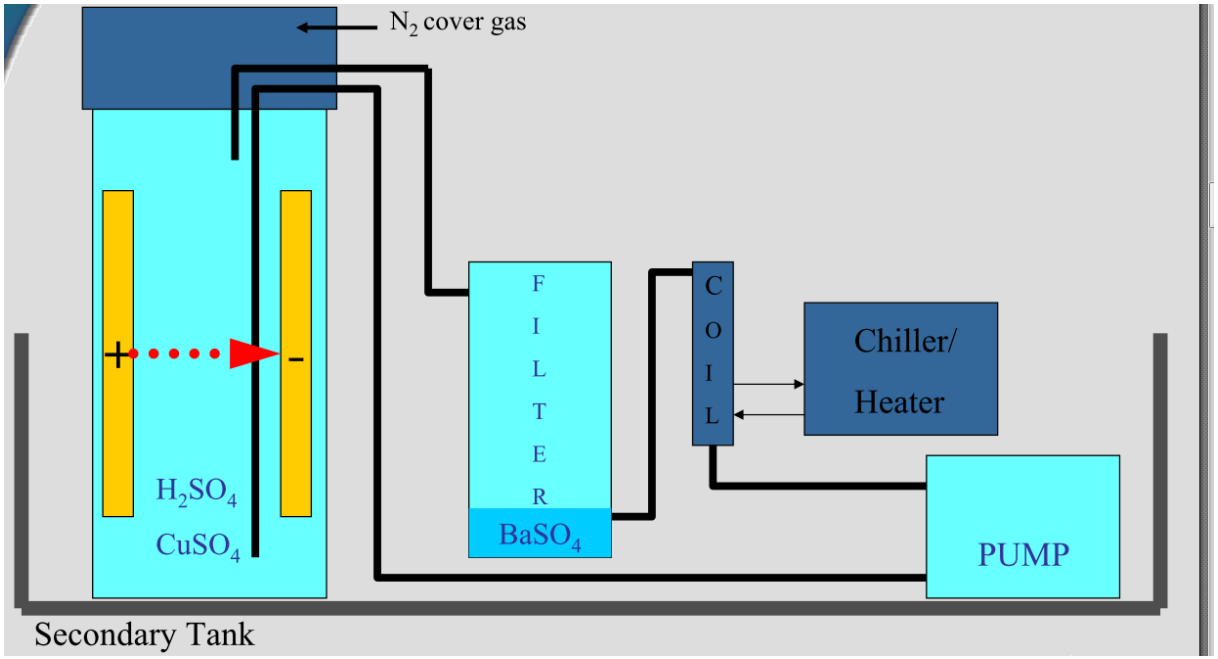






CJPL Electro-form Copper

- Electro-form Copper produced in CJPL for CDEX ;
- The Copper background now:
  Th:~44.66 μBq/kg、U:~149 μBq/kg
- Our target in 5 years:
  Th<0.06 μBq/kg、U<0.17 μBq/kg (lower 1000 times)



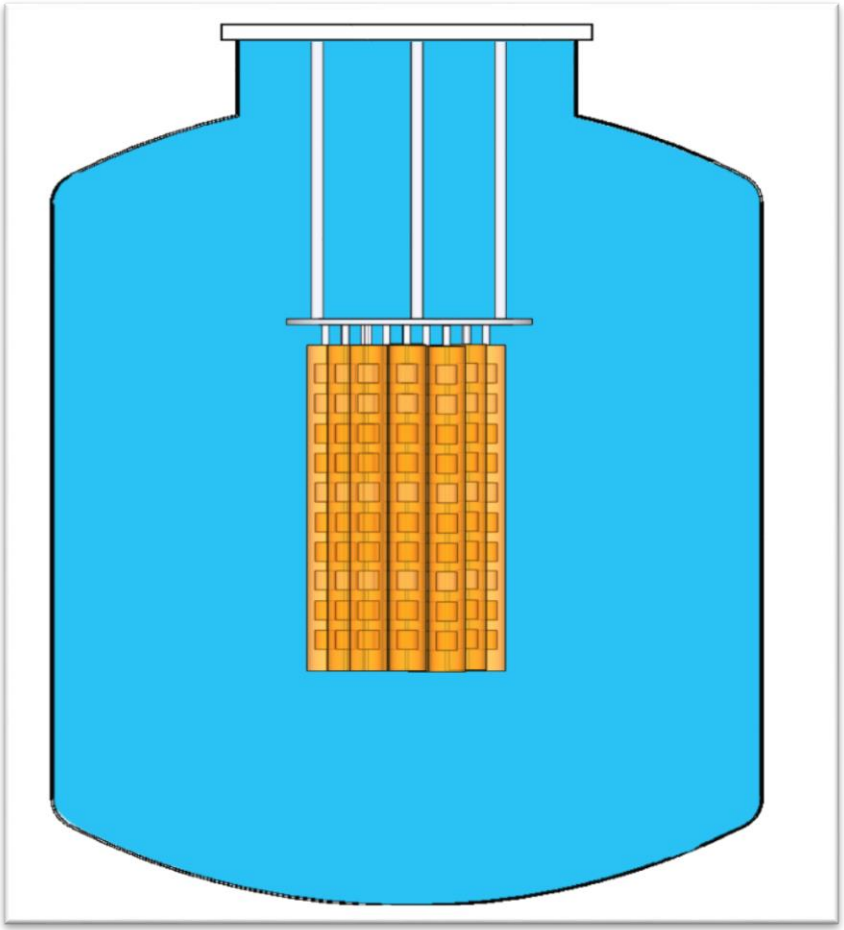
Cooperation on Ge detector development

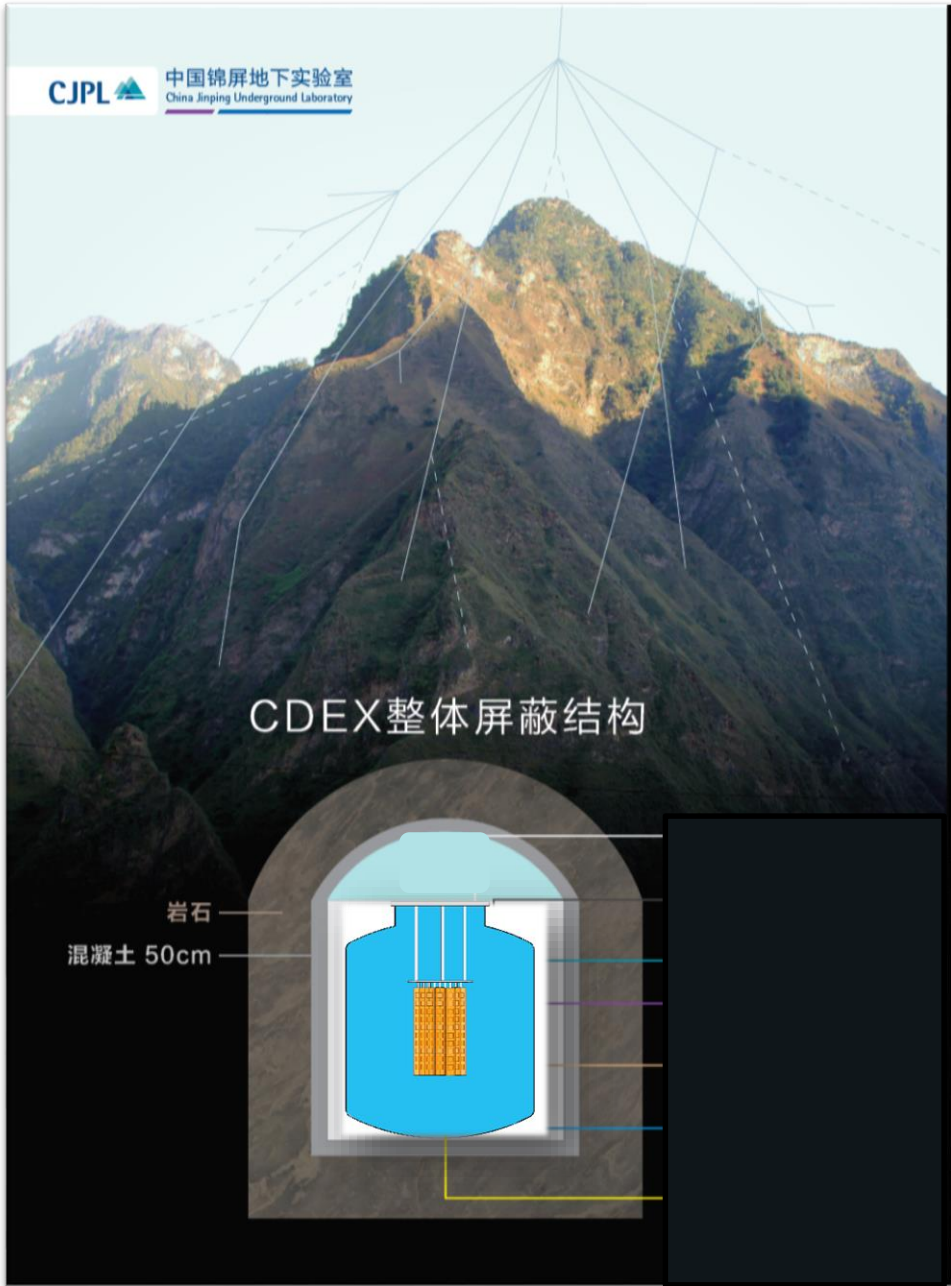
Ge meeting @ Munich on March, 2013

Ge meeting @ THU, Beijing on May, 2014

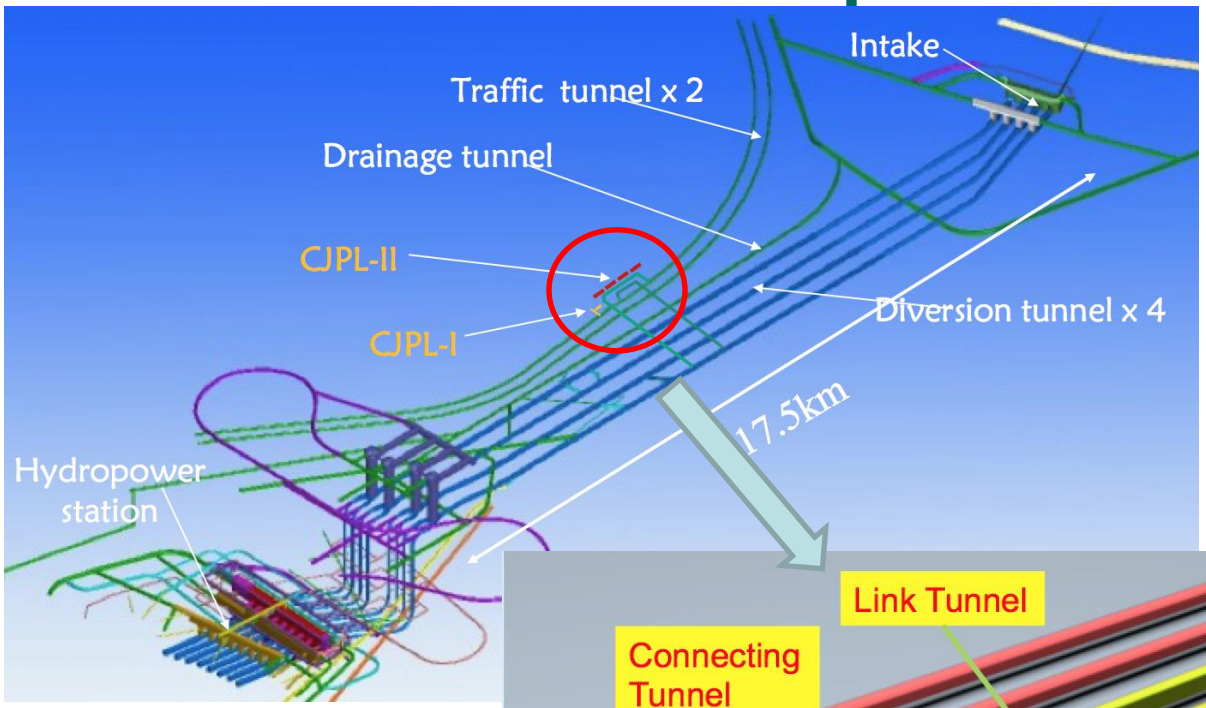
CDEX-200

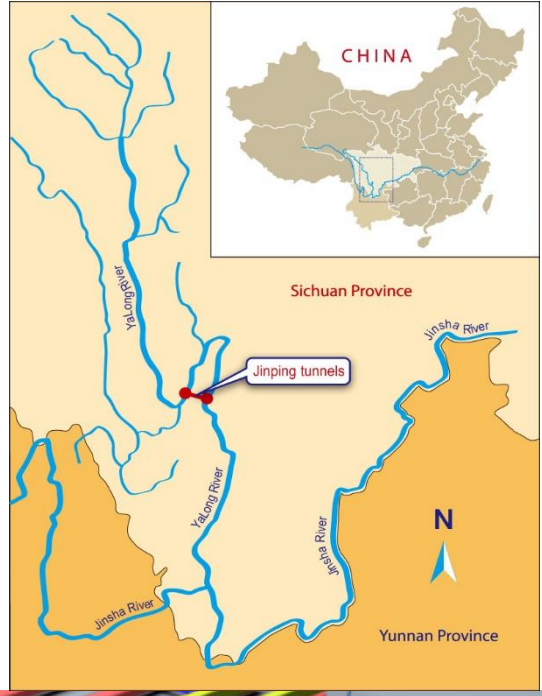
CDEX-200 with LN2 cooling system

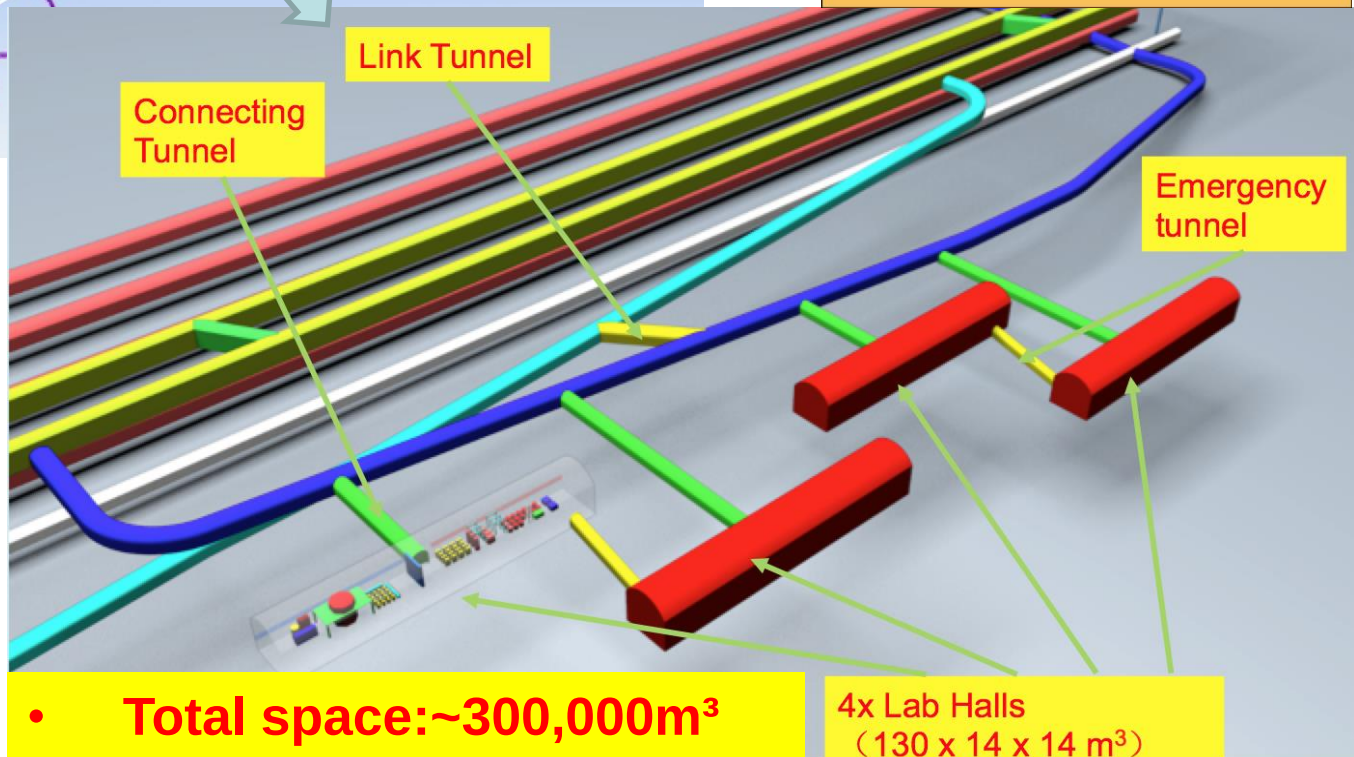




CJPL-II development





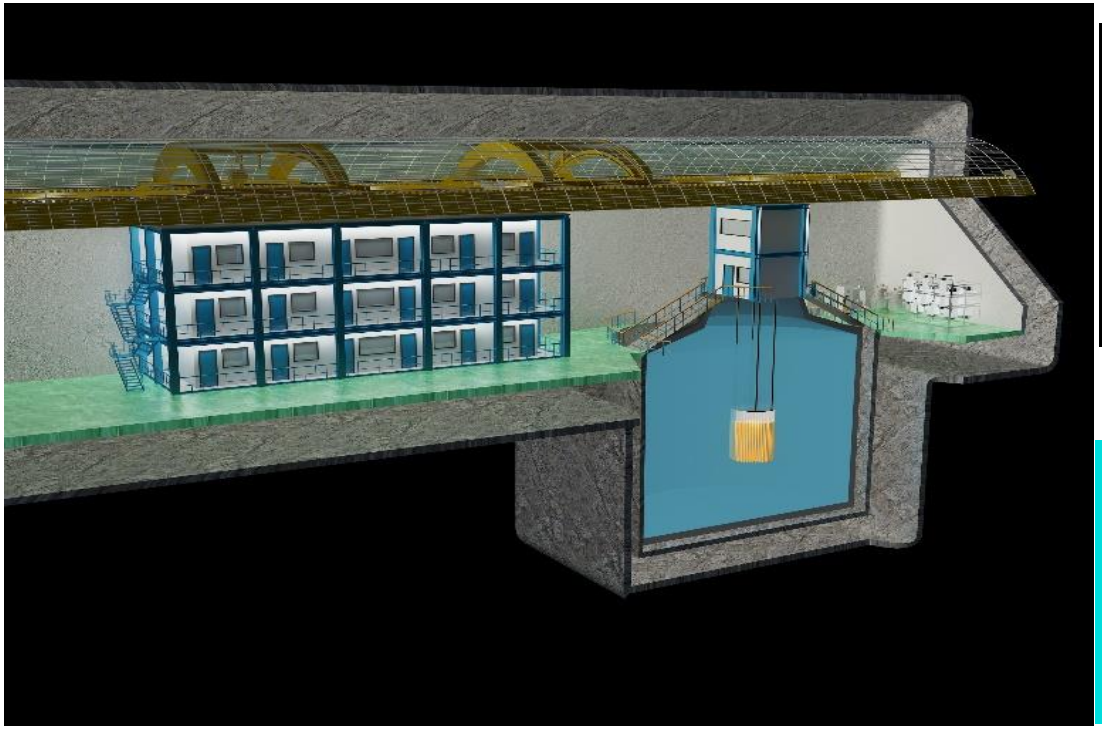


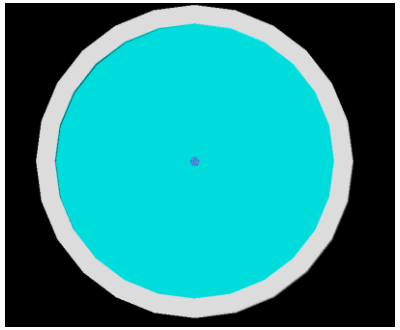
- **Total space:~300,000m³**

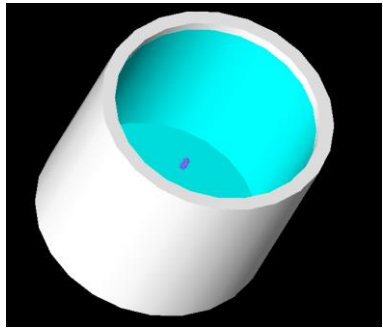
CJPL

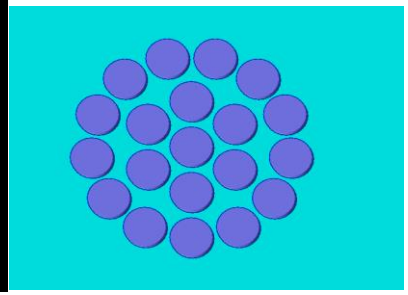
CDEX-200 space in CJPL-II

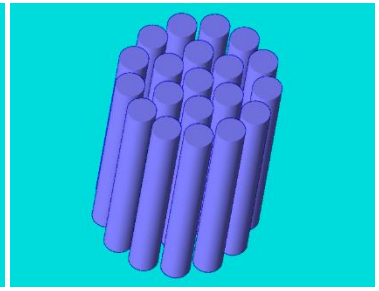
- The LN2 cooling and passive shielding system：
  Goal: Background from outside of Ge < 10^{-4}cpkkd
- The CDEX new space: ϕ18m * 30m;
- CDEX-200 space ready in 2016.











Summary

- CDEX-1@CJPL has started to run detectors from 2011.
- DM physical results have been published in 2013 and submitted in 2014.
- The 2014y CDEX-1 exclusive curve has disfavored CoGeNT region with identical detector technique and lower energy threshold. New results is coming.
- CDEX-10 with 10kg array detector tested in CJPL and commissioning next month.
- CDEX-200 (2016-2020) preparing the space and key technologies.

Thank you !