CDEX Overview

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On behalf of CDEX Collaboration
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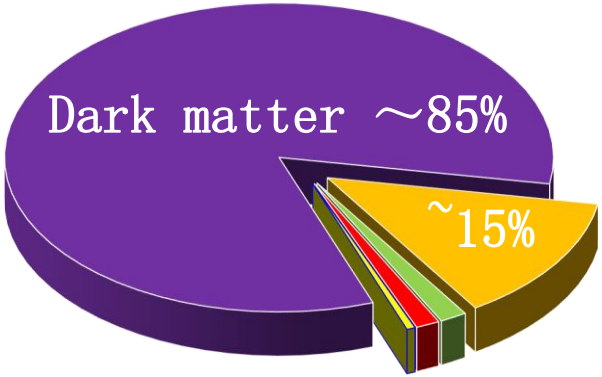
CJPL 中国锦屏地下实验室 China Jinping Underground Laboratory

NG-Ge experiment workshop @ Munich, April 25-27

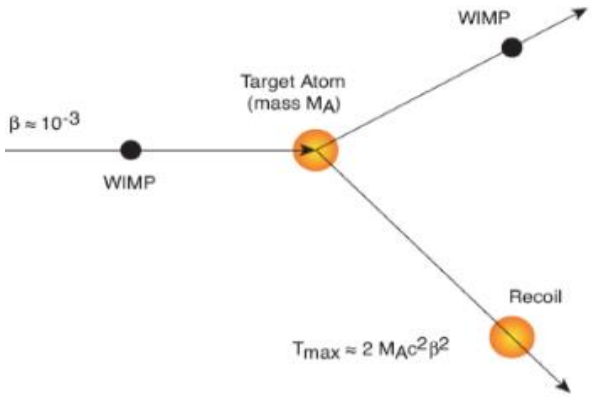
Outline：

- CDEX
- CDEX-10X
- Towards Ge-1T for DBD and DM
- Summary

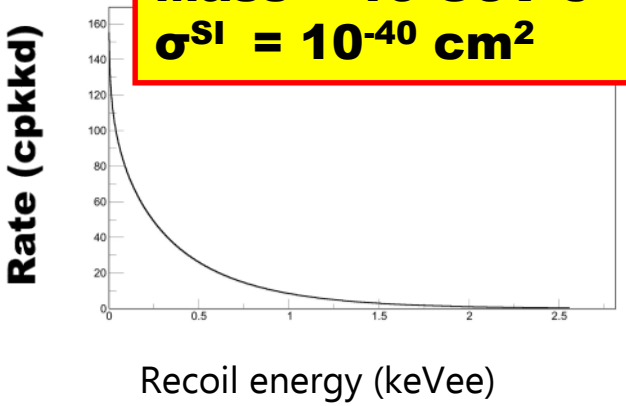
China Darkmatter Experiment (CDEX)



- **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

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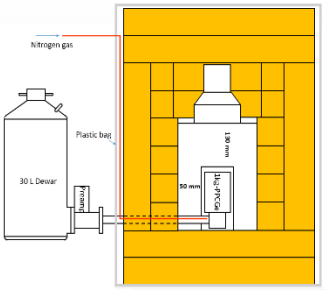
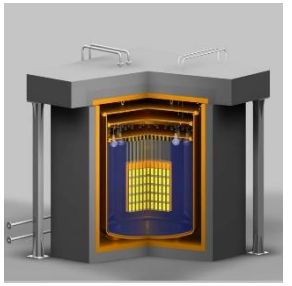
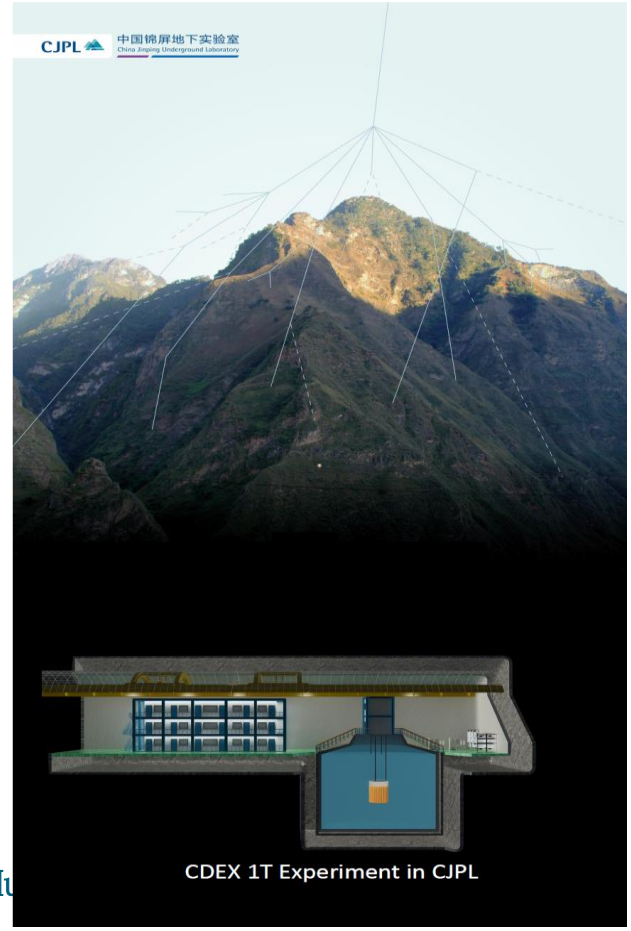
CDEX stages

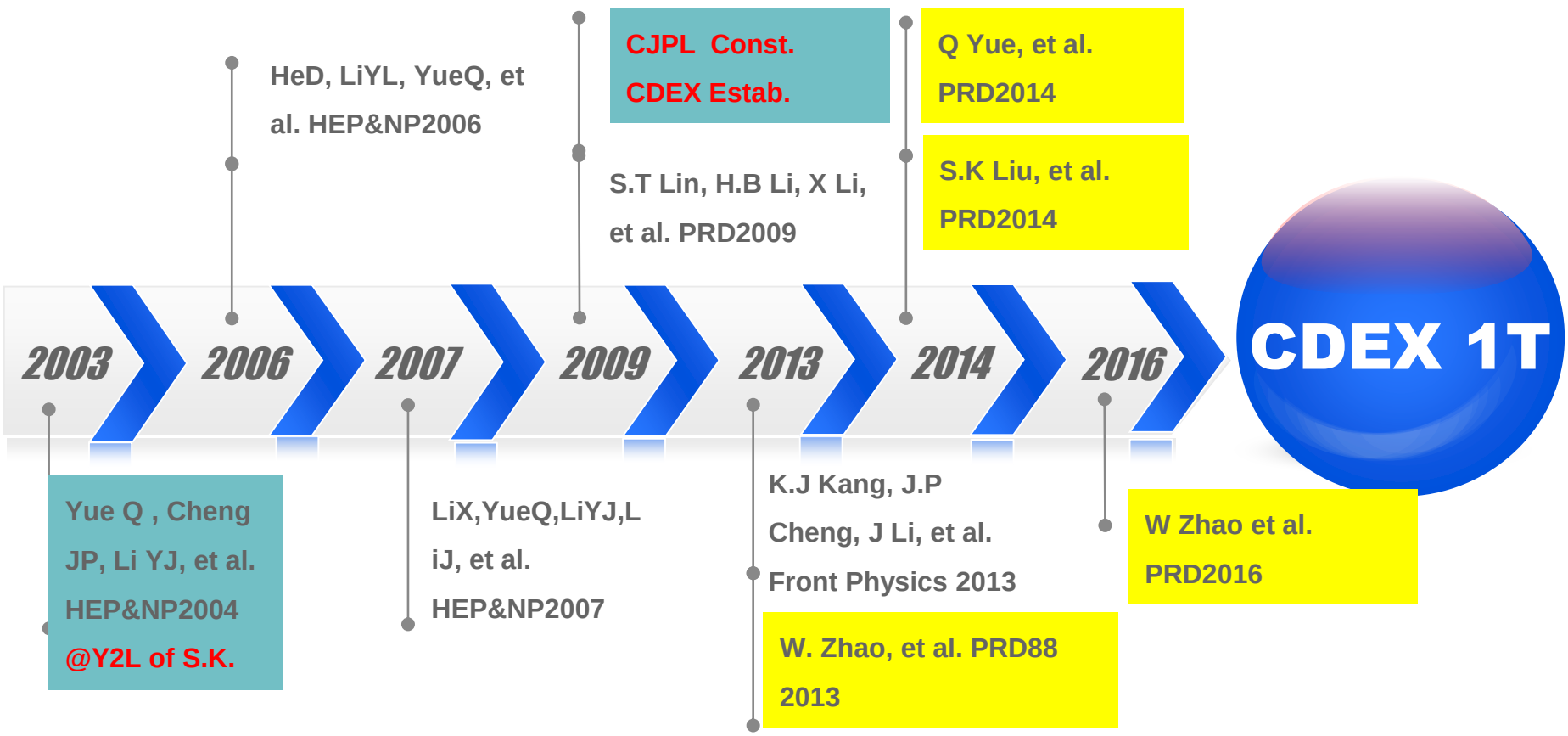
- CDEX-1: Development of large-mass prototype PCGe detector, data analysis methods, and its background understanding and suppression;
- CDEX-10: Performances of HPGe array detector system and its passive/active shielding systems;
- CDEX-10X: Fabrication of HPGe, Ge crystal growth and ULB-Cu;
- ……
- CDEX-1T: Multi-purpose experiment for dark matter and double beta decay.







CDEX History



- Supported by NSFC, MOST, Department Of Education of China

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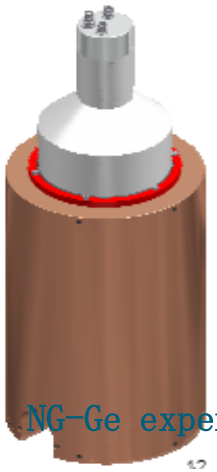
CDEX-1 experiment

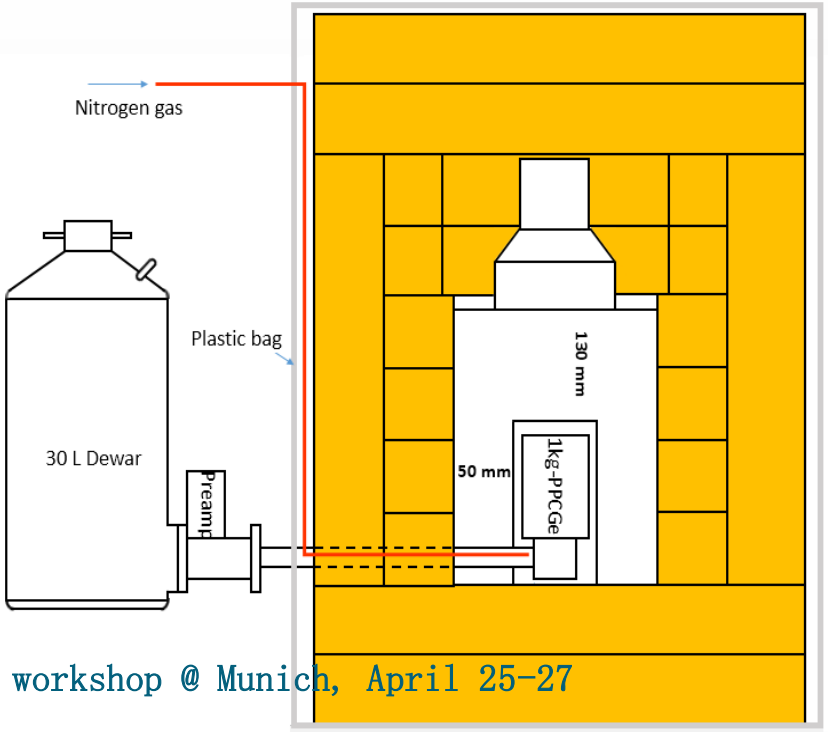
1. HPGe detector
   - ✓ Designed and studied the first 1kg-PPCGe (C1A) based on our simulation and experience from 2010 on.
     C1A: readout from both P+ point and N+ Li drift layer.
   - ✓ Upgrade to the second 1kg-PPCGe. C1B with lower Eth

2. NaI(Tl) used as anti-Compton detector
   - ✓ C1A without AC
   - ✓ C1A with NaI(Tl) AC
   - ✓ C1B with NaI(Tl) AC
   - ✓ C1 20g Ge + NaI(Tl)

1kg-PPCGe



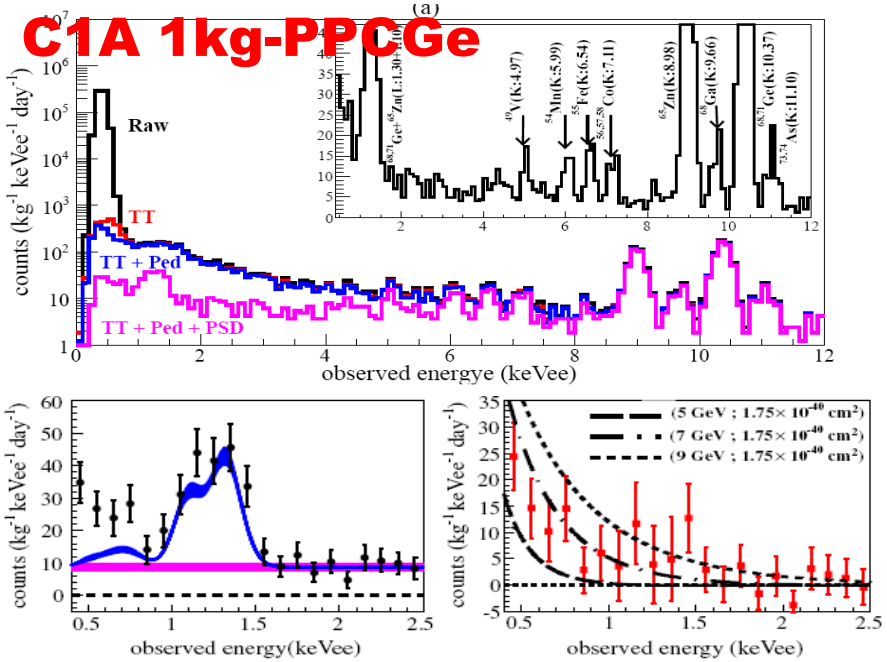
NaI(Tl)

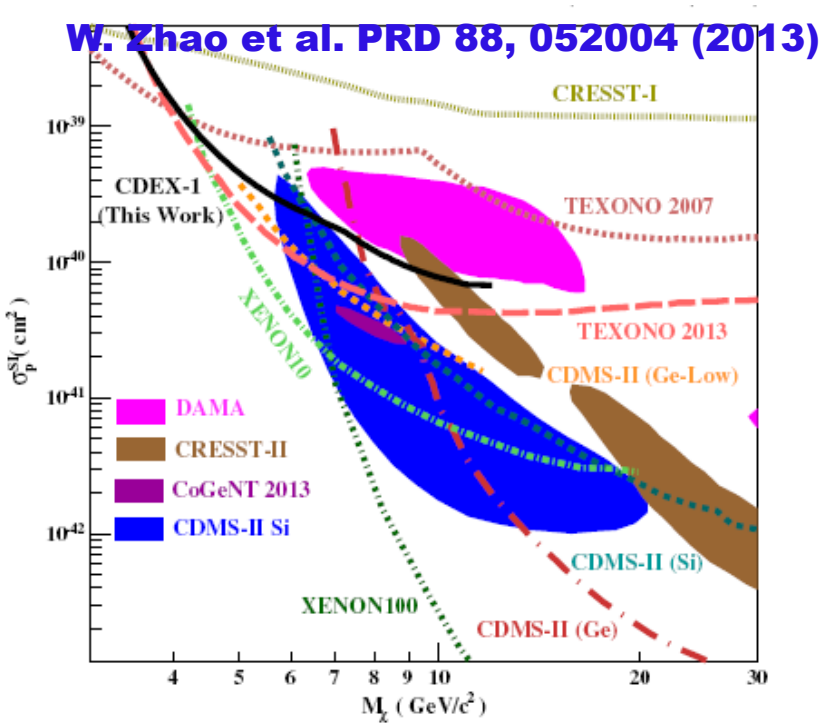


CDEX in CJPL-I

CDEX-1

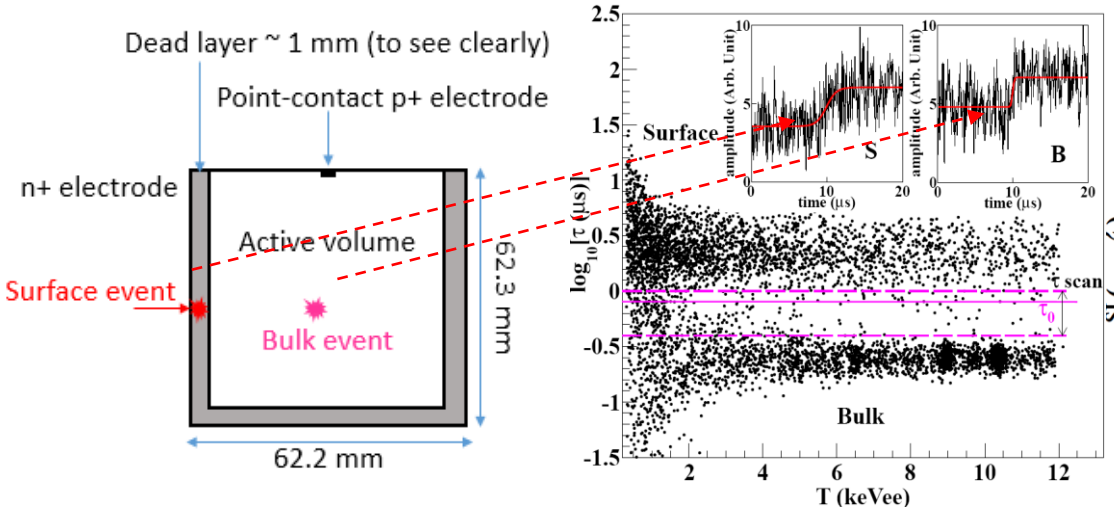
CDEX-1A experiment

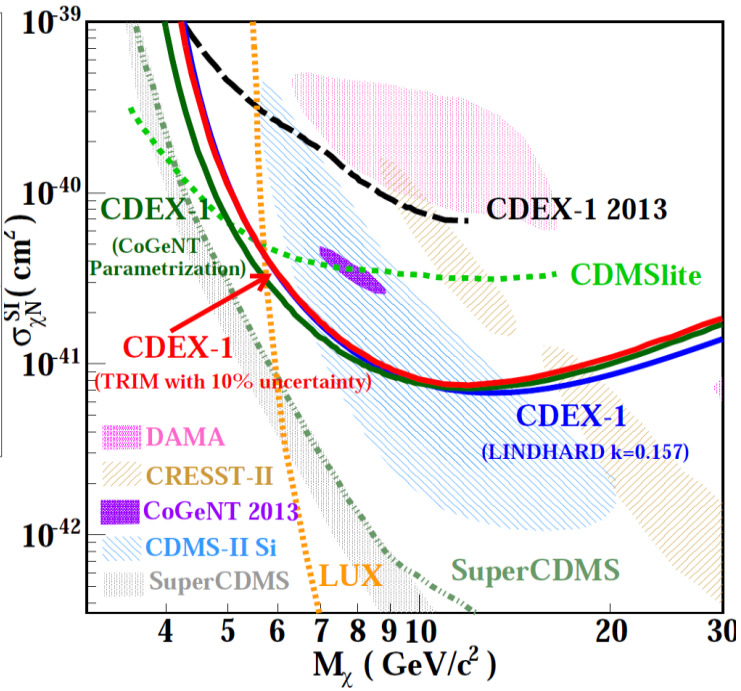




- ✓ Ge crystal mass: 994g
- ✓ Energy threshold ~400eV
- ✓ Background level @ 3-5keV: ~10cpkkd
- ✓ K/L X-ray peaks from cosmogenic nuclei identified.
- ✓ The first large pPCGe design by CDEX successful;
- ✓ The first dark matter physical result from China.

CDEX-1A upgrade





- **Bulk/Surf Discrimination**
- **C1A 1kg-PPCGe + NaI(Tl)**

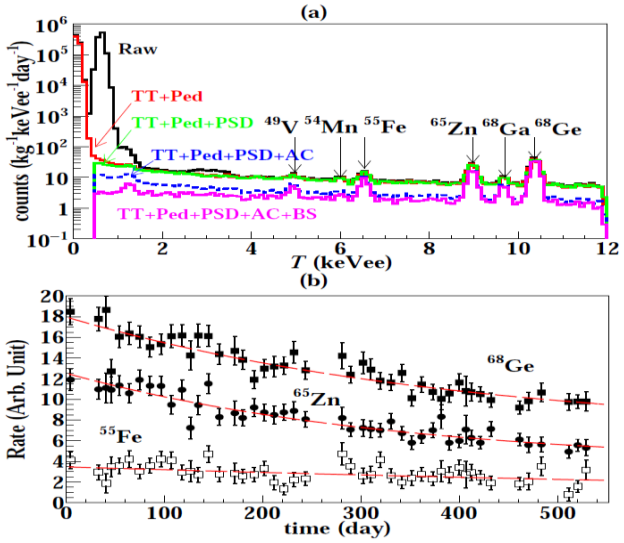
Q.Yue et al., PRD 90(RC) 091701,2014

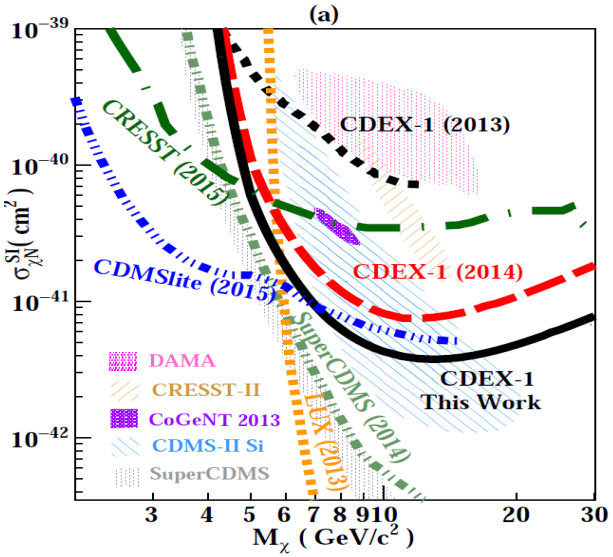
- ✓ B/S disc. to get rid of the Surface events with slow rise-time and partial charge collection;
- ✓ 1/3 background lower with/without AC detector;
- ✓ The best sensitivity by PCGe and Exclude the regions favored by CoGeNT.

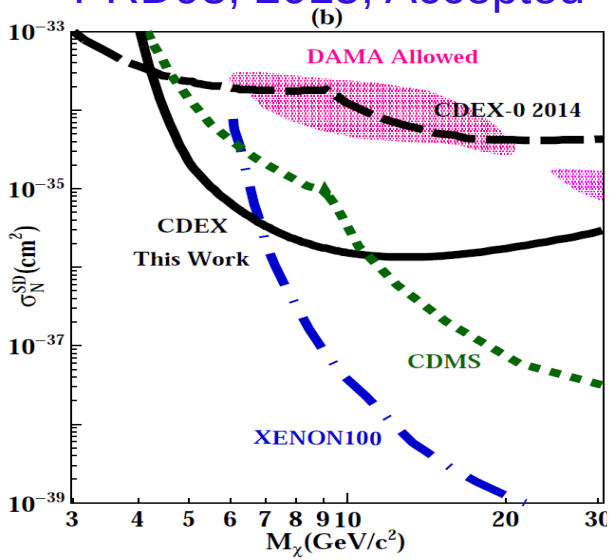
CDEX-1A 2016 results

- CDEX-1A run > 500 day, totally ~336 d·kg dataset;
- Flat background level decay from ~10 to ~3 cpkkd;
- Based on the decay of K/L x-ray peaks from the cosmogenic nuclei, the crystal history may be traced;
- ~2 times more sensitive than 2014 SI result and best sensitivity at 4-7 GeV region for SD;
- AM analysis with >1 year data going on.

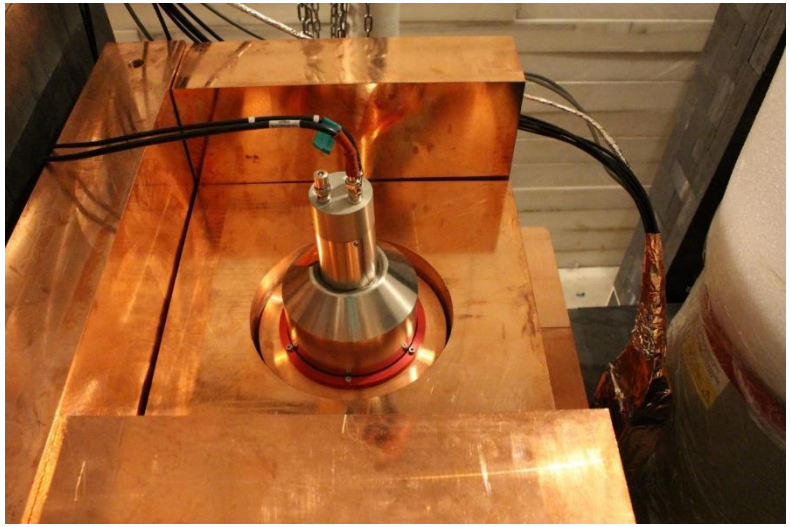
PRD93, 2015, Accepted

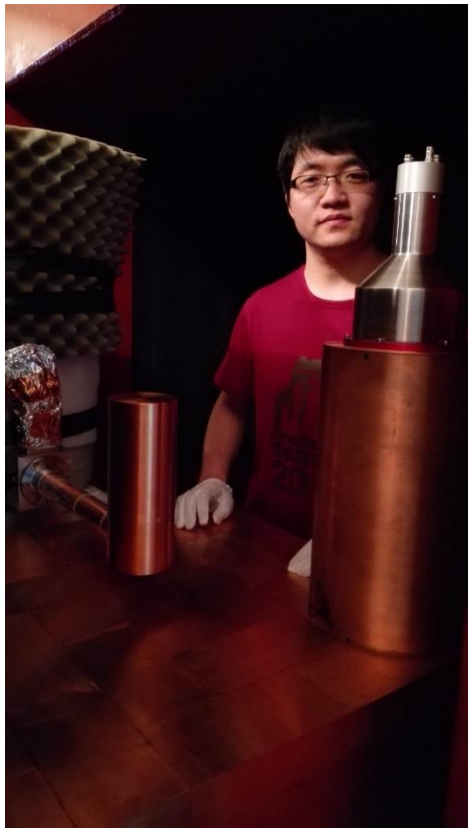






CDEX-1B experiment

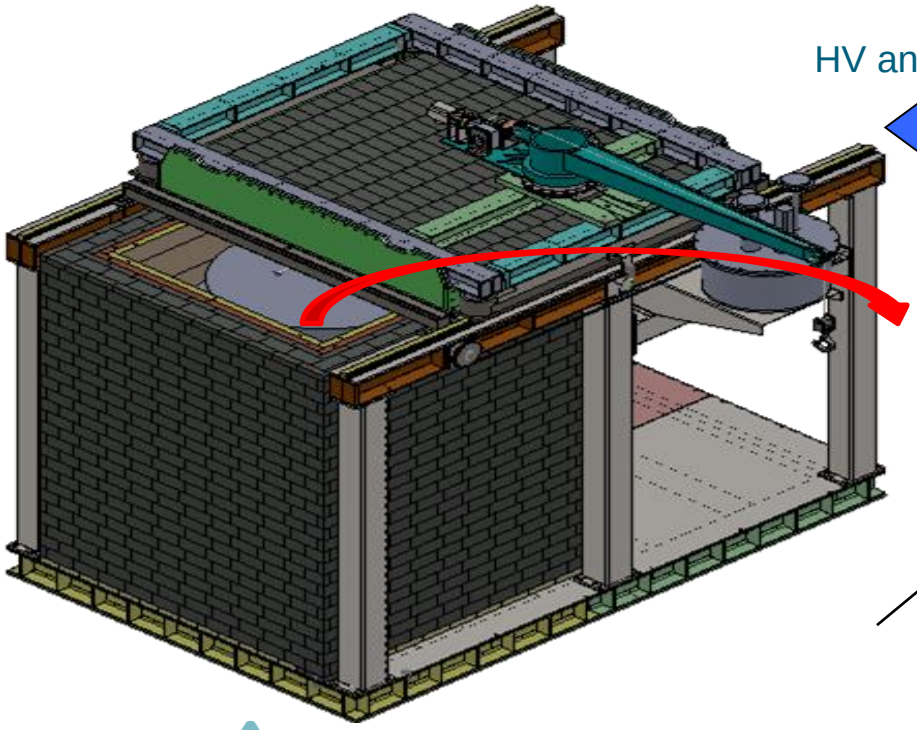




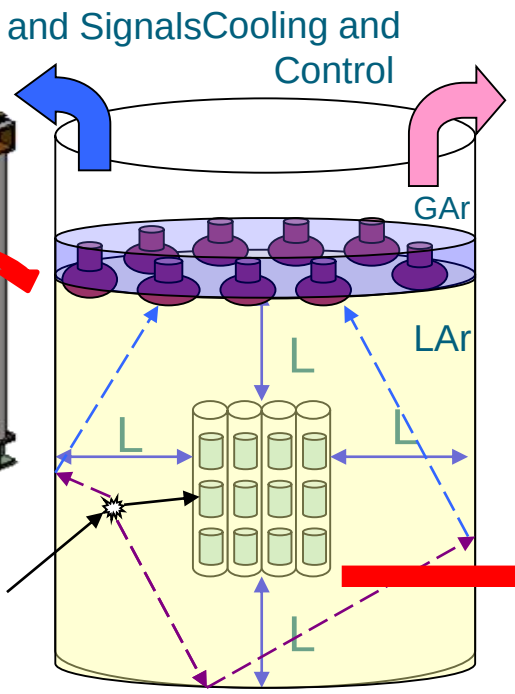
- ✓ Upgrade based on C1A
- ✓ Ge crystal mass: 1008g
- ✓ Energy threshold <300eV
- ✓ Background level @ 3~5keV: 2~3cpkkd
- ✓ K/L X-ray peaks from cosmogenic nuclei identified
- ✓ The first physical result under preparation

CDEX-10 experiment

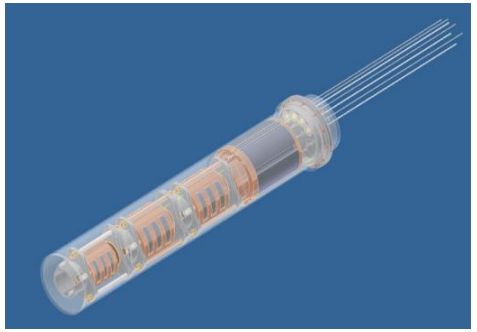
- An important stage towards tonne-scale Ge experiment;
- PCGe array with lower energy threshold：<300eV;
- Design and study of the PCGe array detector;
- Feasibility of LAr anti-Compton detector.



CDEX-10 experimental setup



10kg-PCGe + LAr



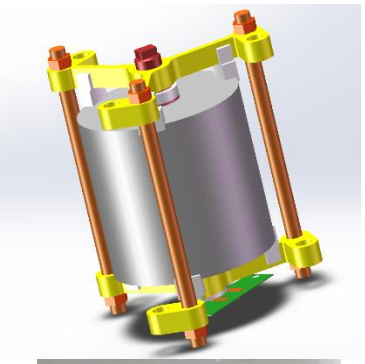
3-PCGe element

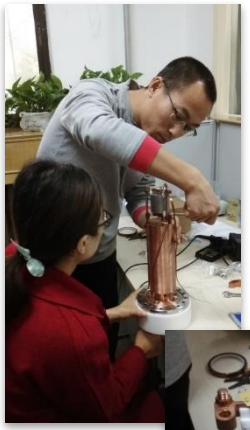
CDEX-10 Array detectors

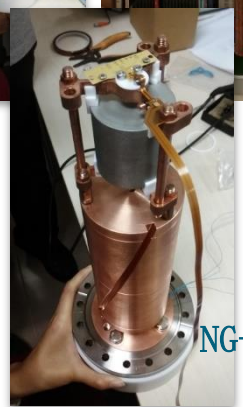
Totally 10kg PPCGe + 0.5kg NPCGe under testing and run at CJPL!

CDEX-10X

- ✓ Two 0.5kg PCGe with <350eV under preparation first；
- ✓ Totally new design by CDEX and background control with pure cable, VFE substrate and structure materials；
- ✓ Two PreAMP types: JFET and ASIC;
- ✓ ULB-Cu production in CJPL this year.







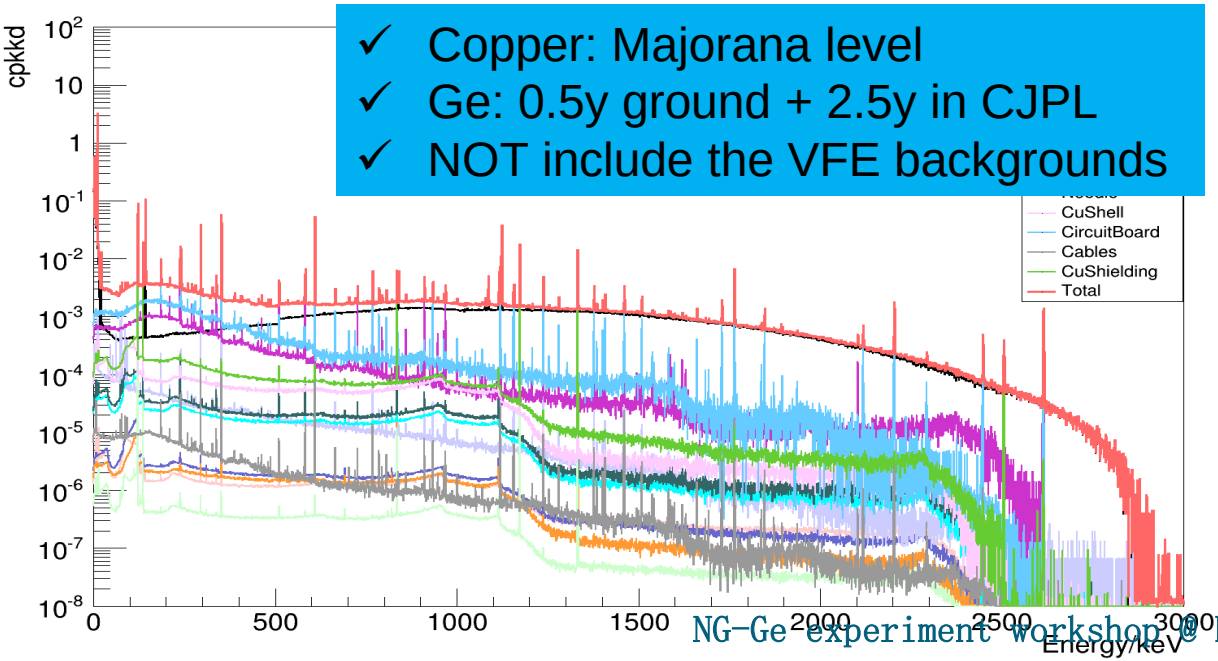

CDEX-10X

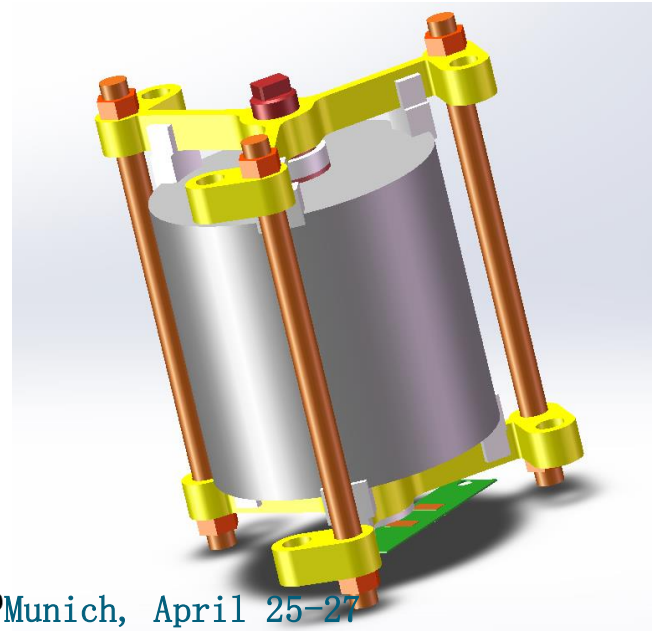
Dark Matter Direction:

- ✓ On track now;
- ✓ DM Sensitivity: ~ 10^{-43} cm^2, 10~20 times improved;
- ✓ Technical Target:
  - PCGe with Eth<200eV;
  - H-3 spectrum measurement;
  - Expected Background Level: 0.1cpkkd;

CDEX-10X background @ 2MeV

- $^{68}Ge \rightarrow {}^{68}Ga$(Half life: 67.7min,EC and β+) background contribution up to 2.9MeV;
- CDEX PCGe: ^{68}Ga 7.3 cpkty @ 2MeV, compared with DBD Background requirement: <0.1 cpkty (GERDA-I level:~10cpkty);
- Enrichment (^{68}Ge) and UG crystal growth + detector fabrication (^{60}Co) and UG Copper production (^{60}Co, Th+U) very important.



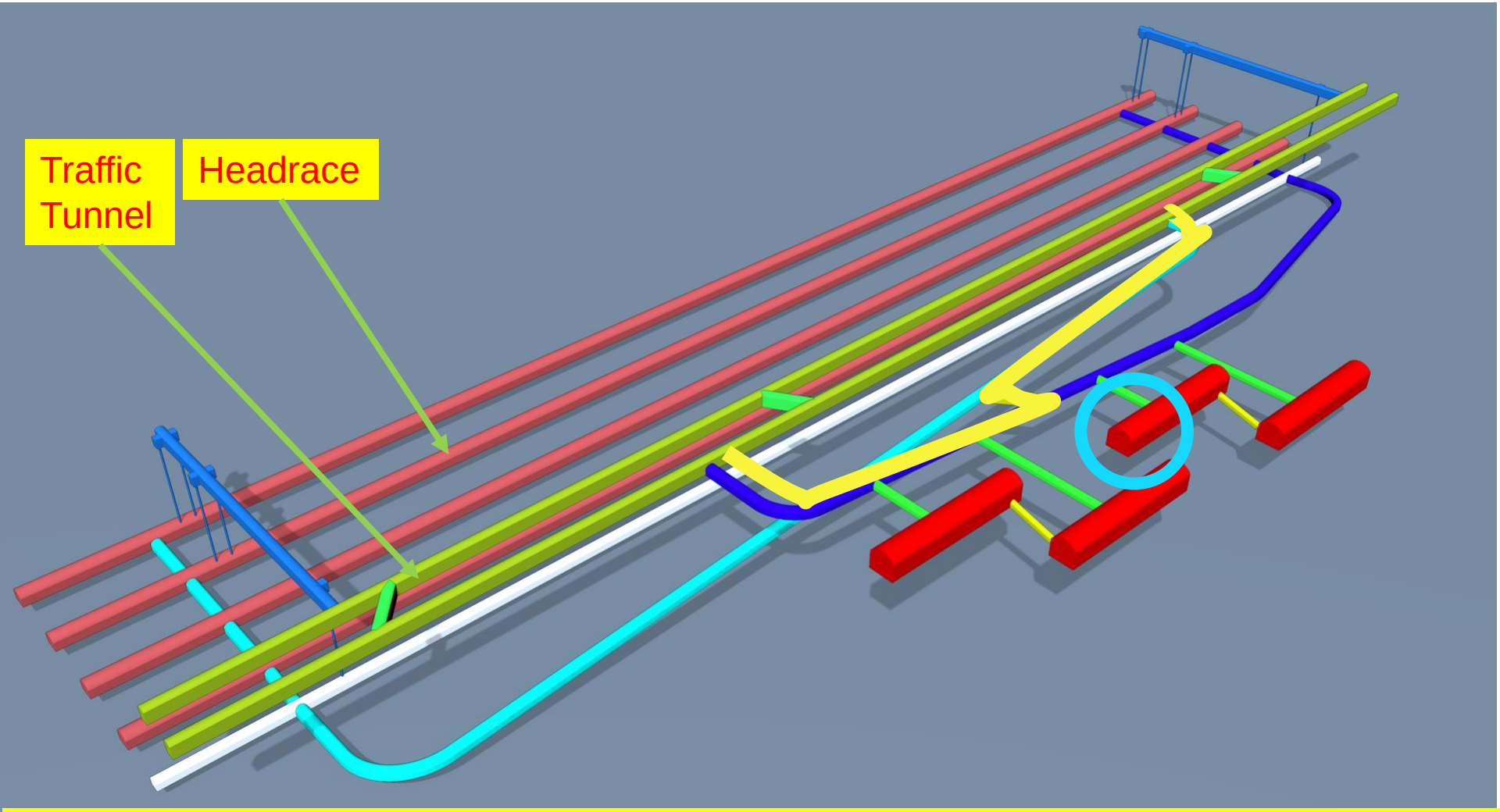


Key technologies towards Ge-1T DBD+DM

- Double Beta Decay (high priority beyond CDEX-10X):
  - Ge purification and Ge crystal growth
  - HPGe detector fabrication
  - Ultra-low background VFE
  - Ge enrichment
  - Ultra-pure copper for structure and cables
  - Large-volume UG space
  - HPGe background simulation platform
  - ……

Prof. Li Yulan's talk!

CDEX in CJPL-II



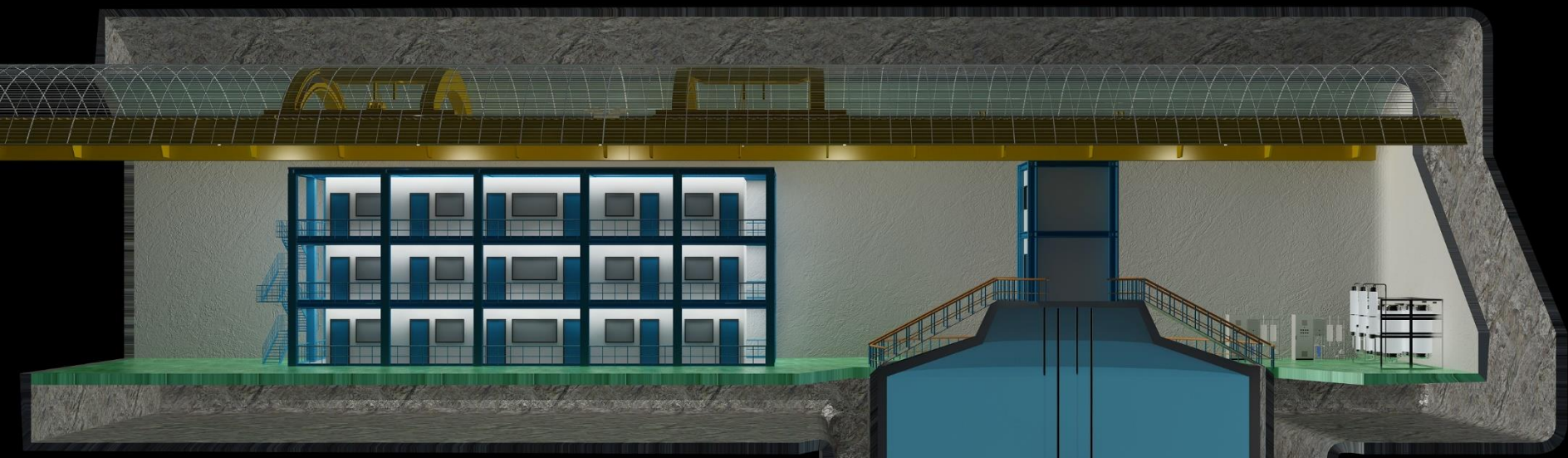
- **Four 14m*14m*130m main halls**
- **Total Volume： ~300K m³**

CJPL-II Rock excavation for four general hall ready last November!

Astroparticle Physics group-JUNA start to design their our facilities from March, 2016.

CJPL

CDEX-1T Multi-purpose experiment



- The pit (ϕ18m×D18m) ready!
- LN2：ϕ13m × H13m;

If this pit is not suitable for a new DBD Exp., new special space could be constructed with quite small cost comparing with the Ge-1T DBD experiment fund scale!

International Collaboration

- HPGe technologies development for basic research supported by Sino-Germany research center;
- International collaboration needed for Ge-1T DBD.

2013 symposium @ Tubingen

2015 symposium @ Munich

2014 symposium @ Beijing

Summary

- CDEX has achieved competitive DM physical results from 2013 on. CDEX results disfavored CoGeNT region with identical detector technique and lower energy threshold.
- CDEX-10 with 10kg array detector testing in CJPL. CDEX DM experiment on track now based on CDEX-10X.
- Ge-1T DBD experiment will have high priority in CDEX next stage. The key technologies towards Ge-1T DBD+DM pursued;
- CJPL-II ready now with large space special for DBD. An international Ge-1T DBD exp. based on CJPL is highly welcome. CDEX and China are open for this.
- CDEX plan to host an international Ge meeting in 2017 and invite you join and visit CJPL-II at that time.