

Application of Germanium Detector in fundamental research

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On behalf of CDEX Collaboration
June. 2 , 2012

CJPL 

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

Outline:

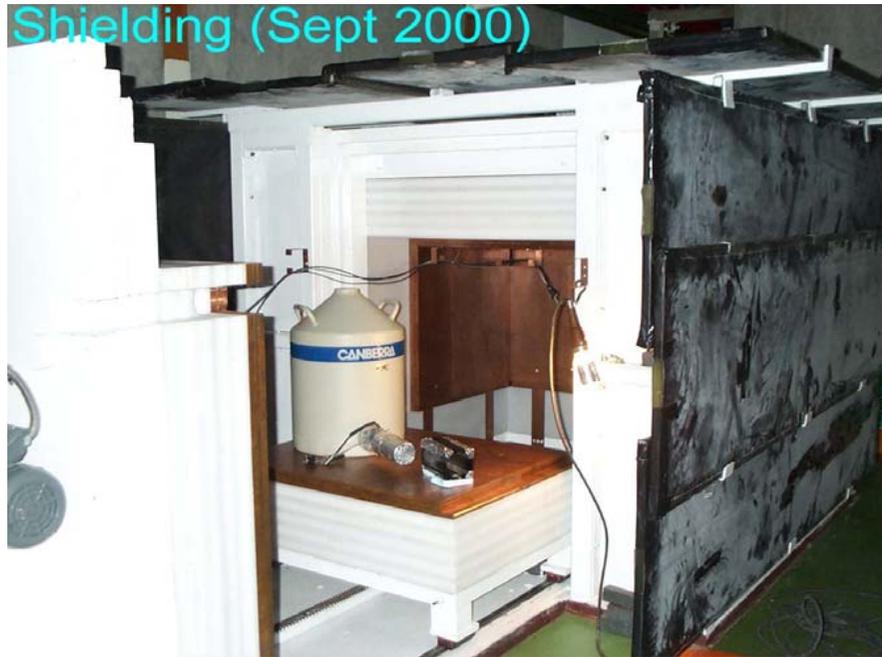
- HPGe detector and its application
- New development of Ge detector
- CDEX Collaboration and CJPL
- Recent status of CDEX
- Summary

The general application of HPGe detector

- Isotope identification;
- Radioactivity measurement;
- X-ray analysis;
- Low background measurement;
-



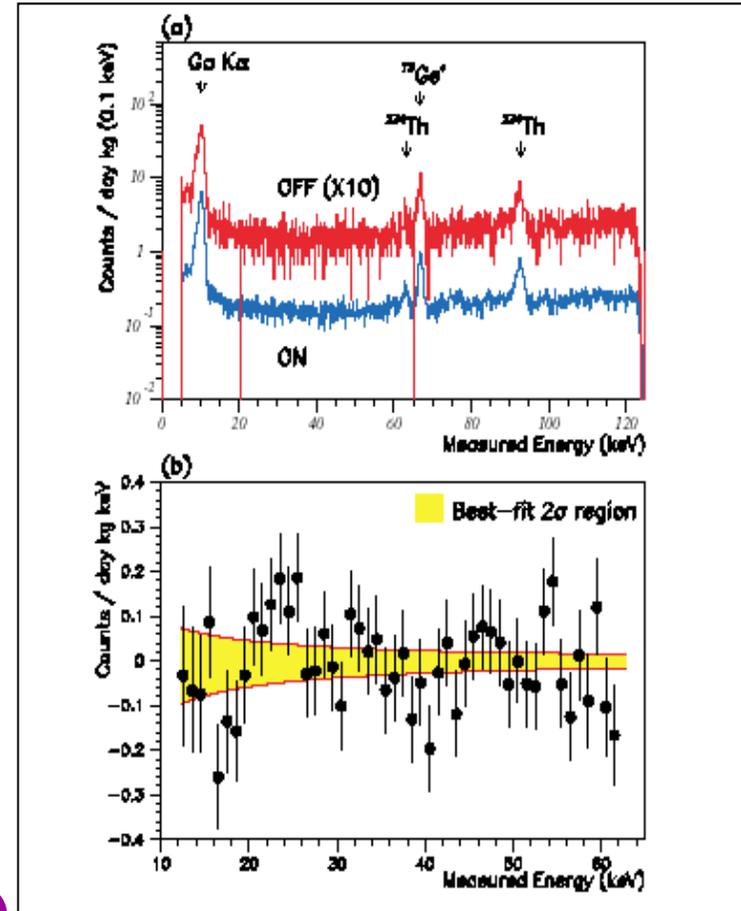
Reactor neutrino research by TEXONO group



➤ **TEXONO Group: SM $\sigma(\nu_e)$**

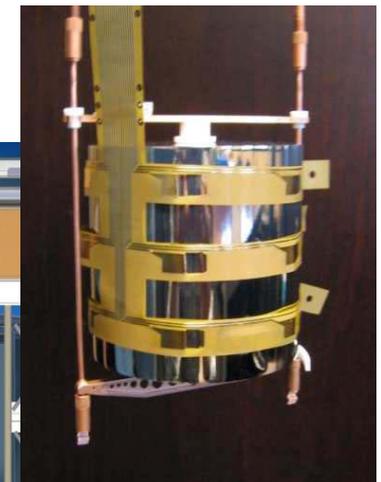
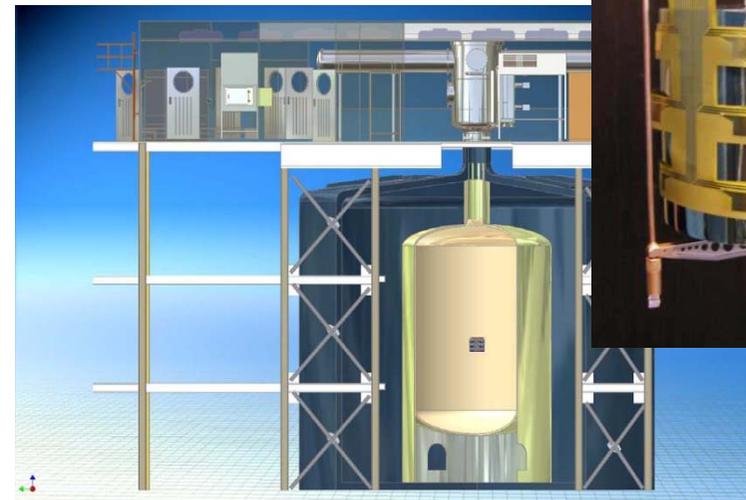
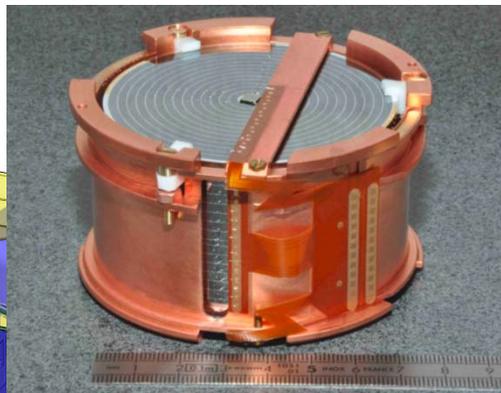
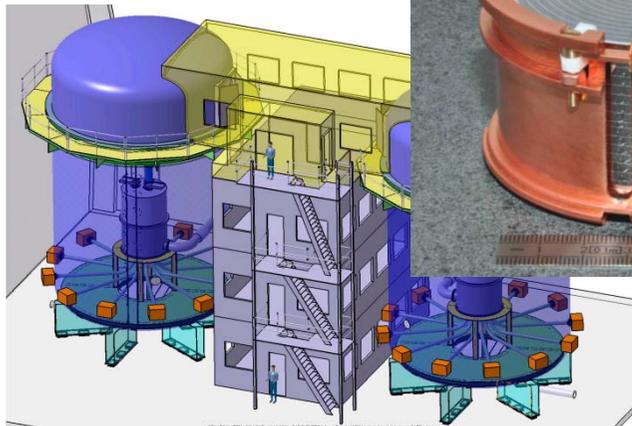
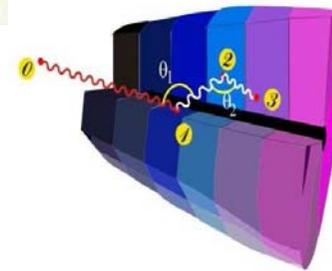
➤ **Limit: [PRL 90, 2003]**

$$\mu_{\nu}(\nu_e) < 1.3 \times 10^{-10} \mu_B \quad (90\% \text{ CL})$$



New development of Ge detector

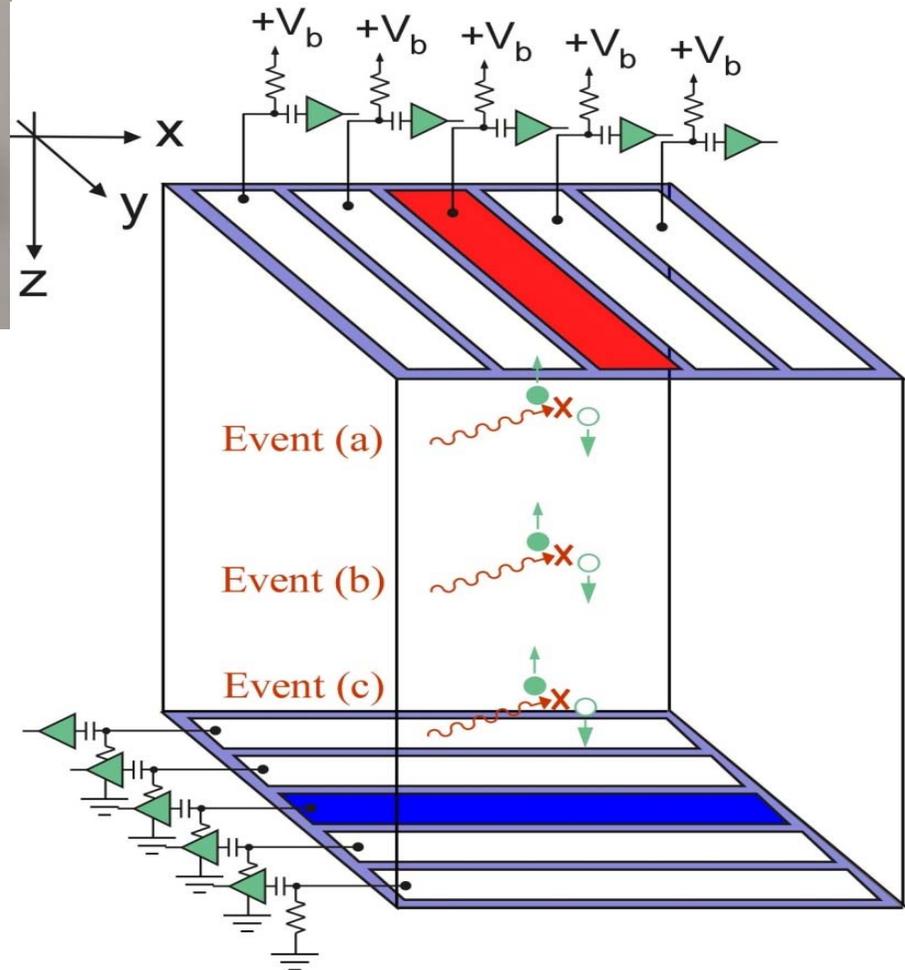
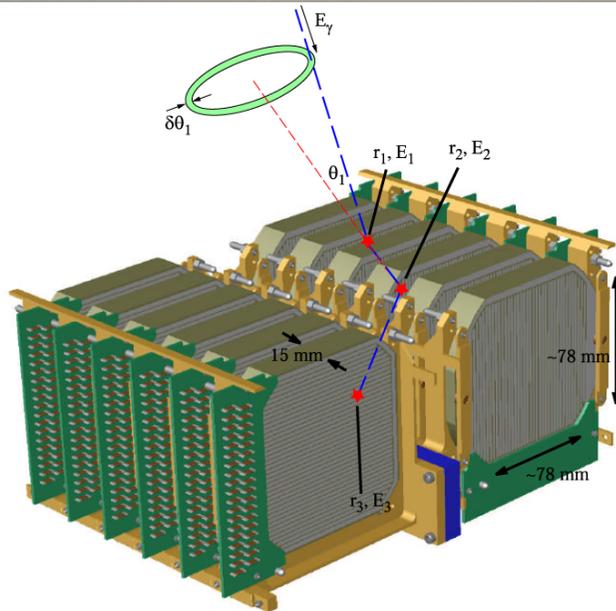
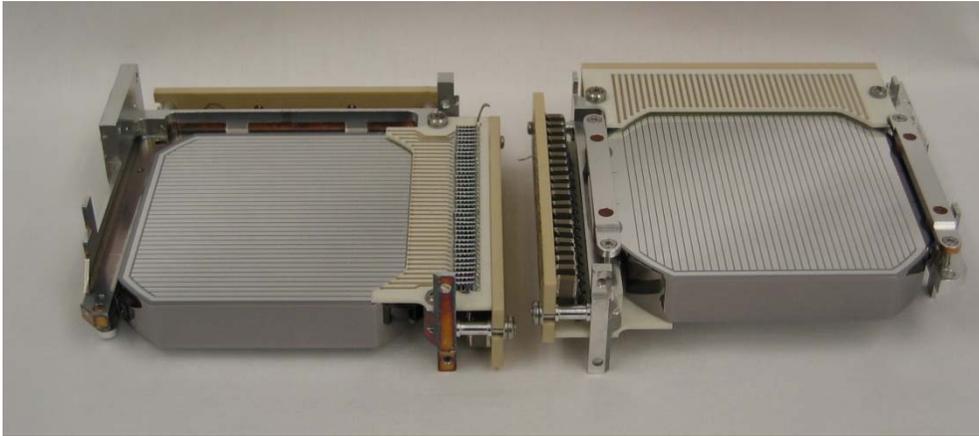
- Segmented Ge detector;



New development of Ge detector

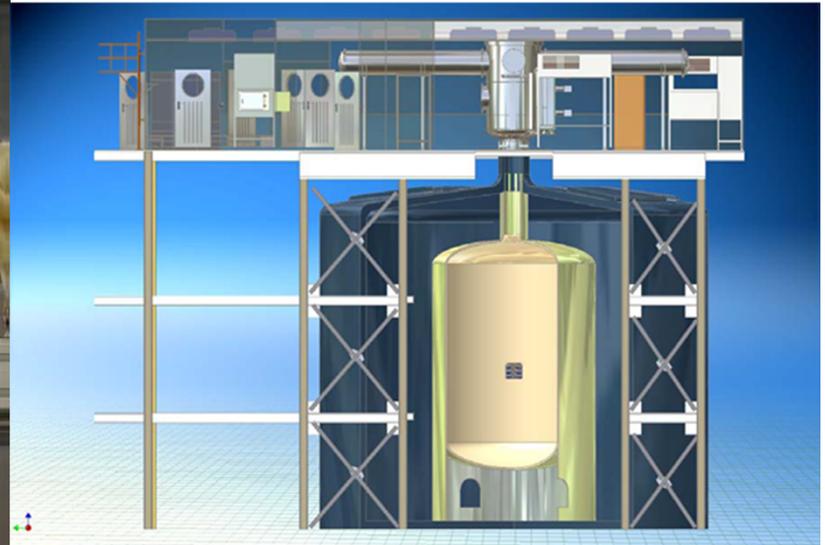
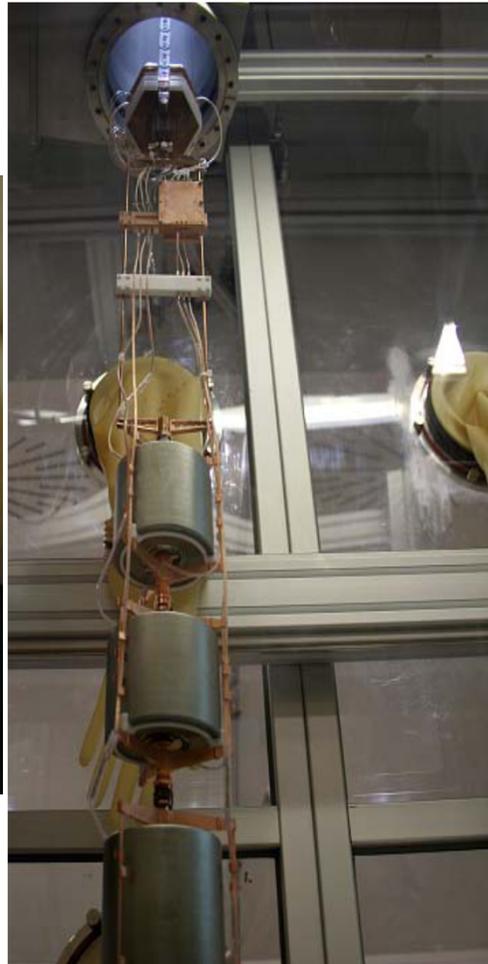
- Strip Ge detector;

Nuclear Compton Telescope



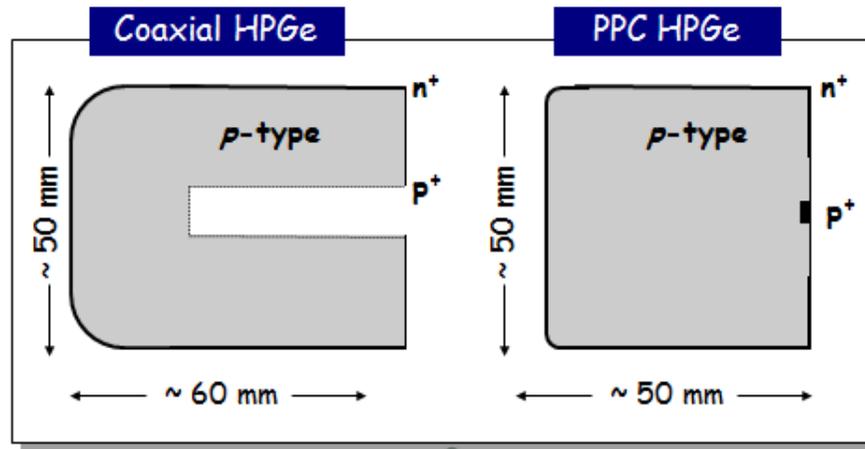
New development of Ge detector

- BEGe detector;



New development of Ge detector

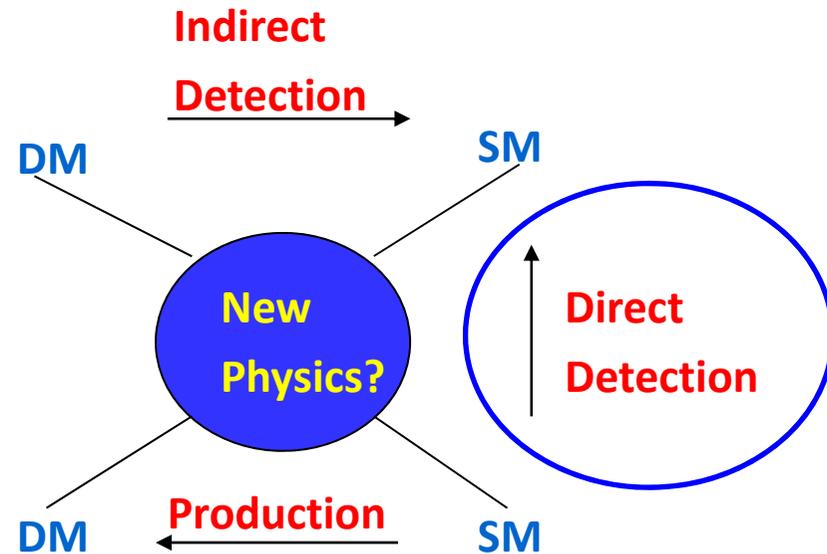
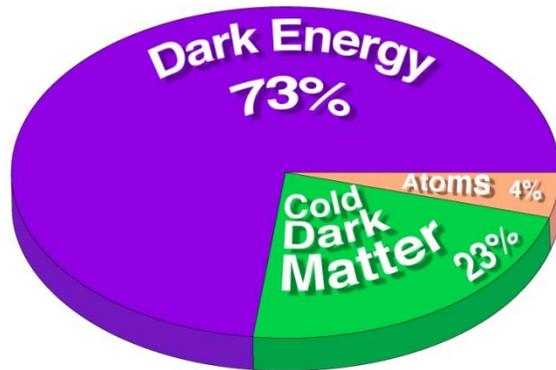
- Point-contact HPGe detector



- First developed in the 1980s as large volume, low noise HPGe detectors;
- Recently “rediscovered” for neutrino detection, dark matter search:
MAJORANA, GERDA, CoGeNT, CDEX,...



China Dark matter Experiment (CDEX)

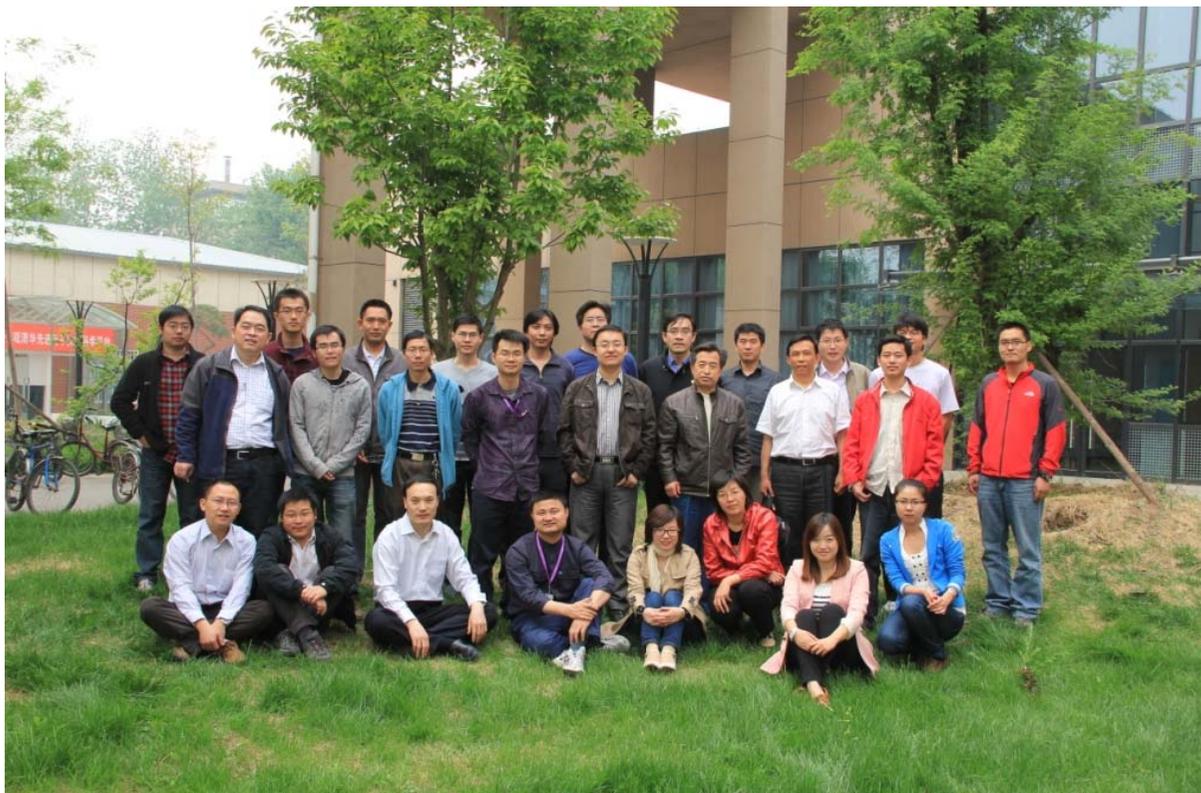


CDEX Target:

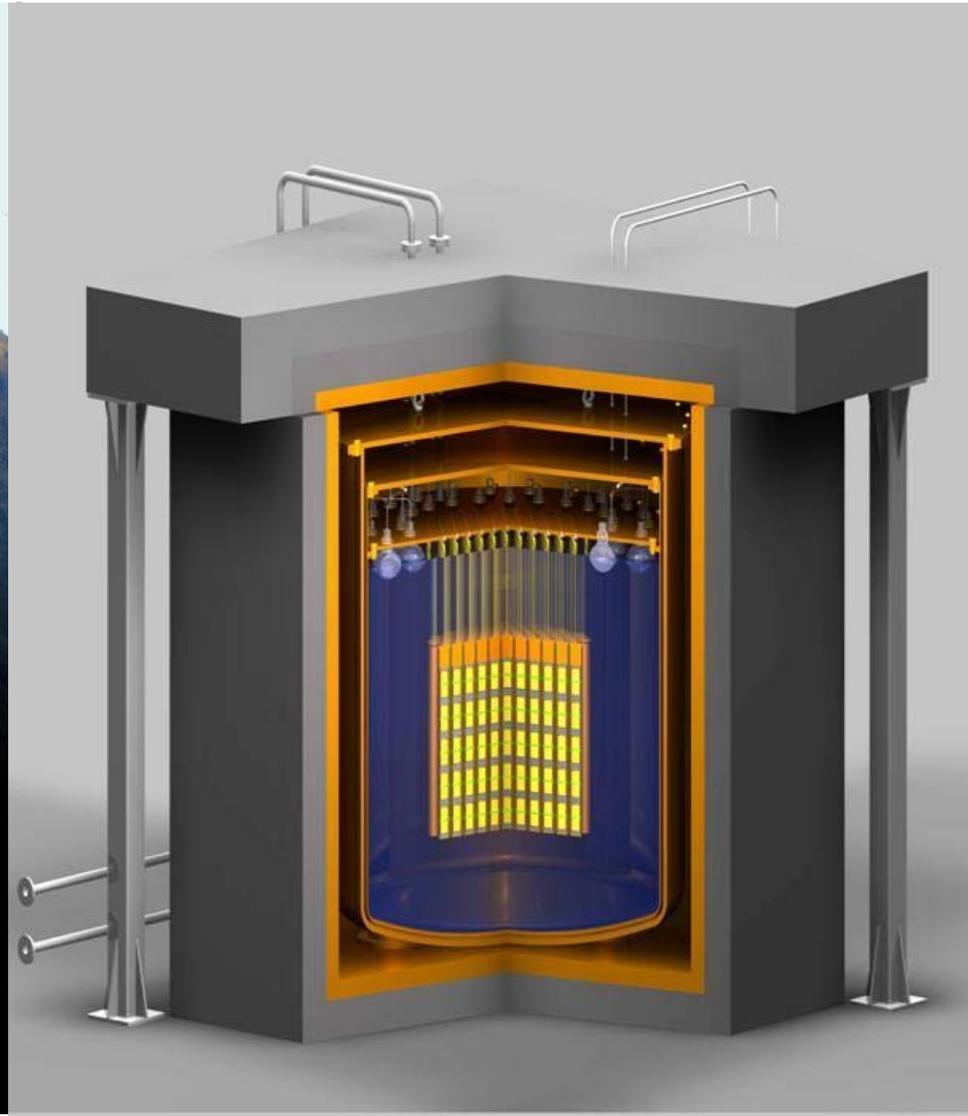
Direct detection of cold dark matter with Ton-scale Point-Contact Germanium (PCGe) array detectors with ultra-low energy threshold(<300eV).

China Darkmatter EXperiment (CDEX)

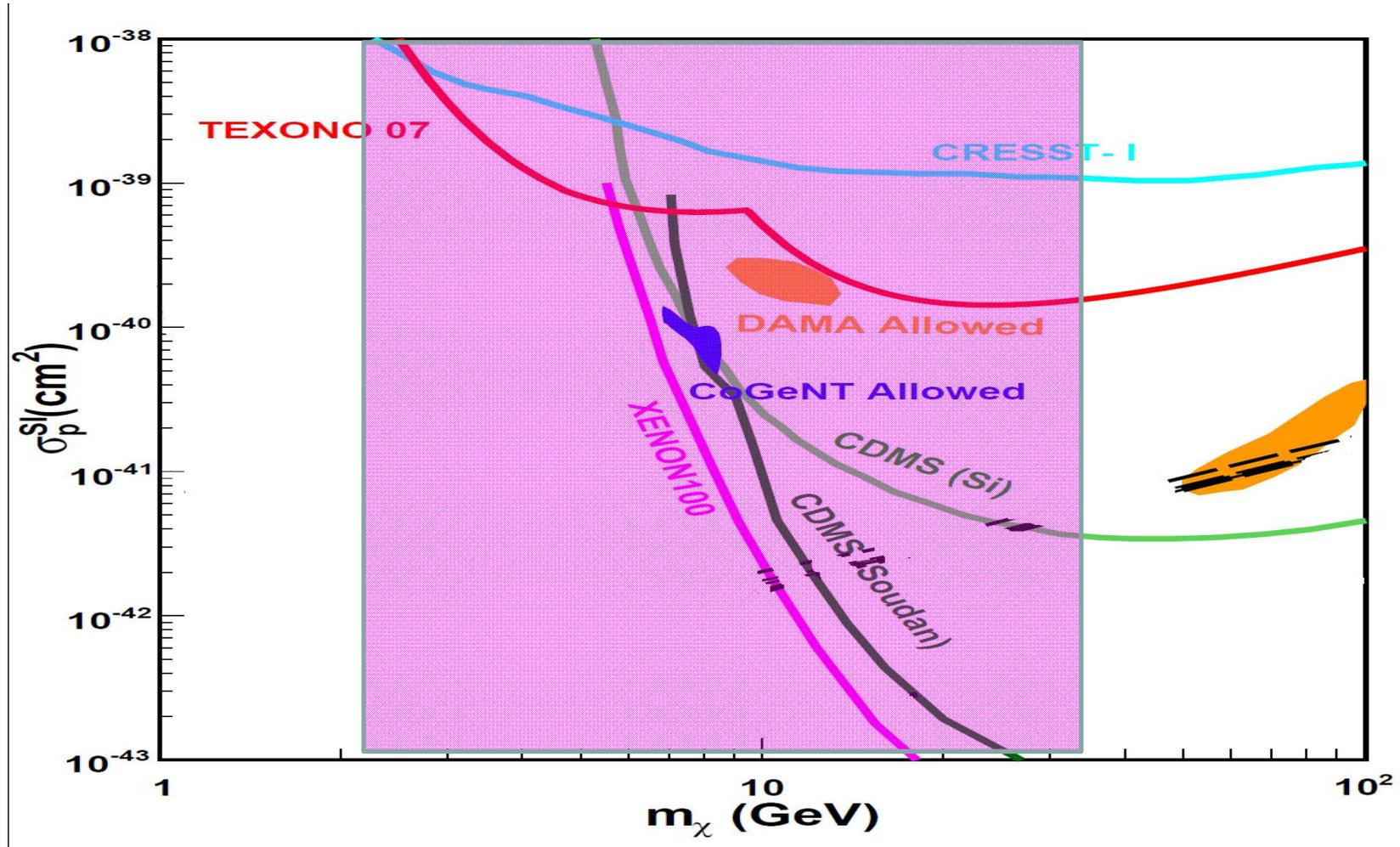
- Tsinghua University, THU
- Sichuan University, SCU
- Nankai University, NKU
- China Institute of Atomic Energy, CIAE
- Ertan Hydropower Company, EHDC
- Collaborate with TEXONO and KIMS group.



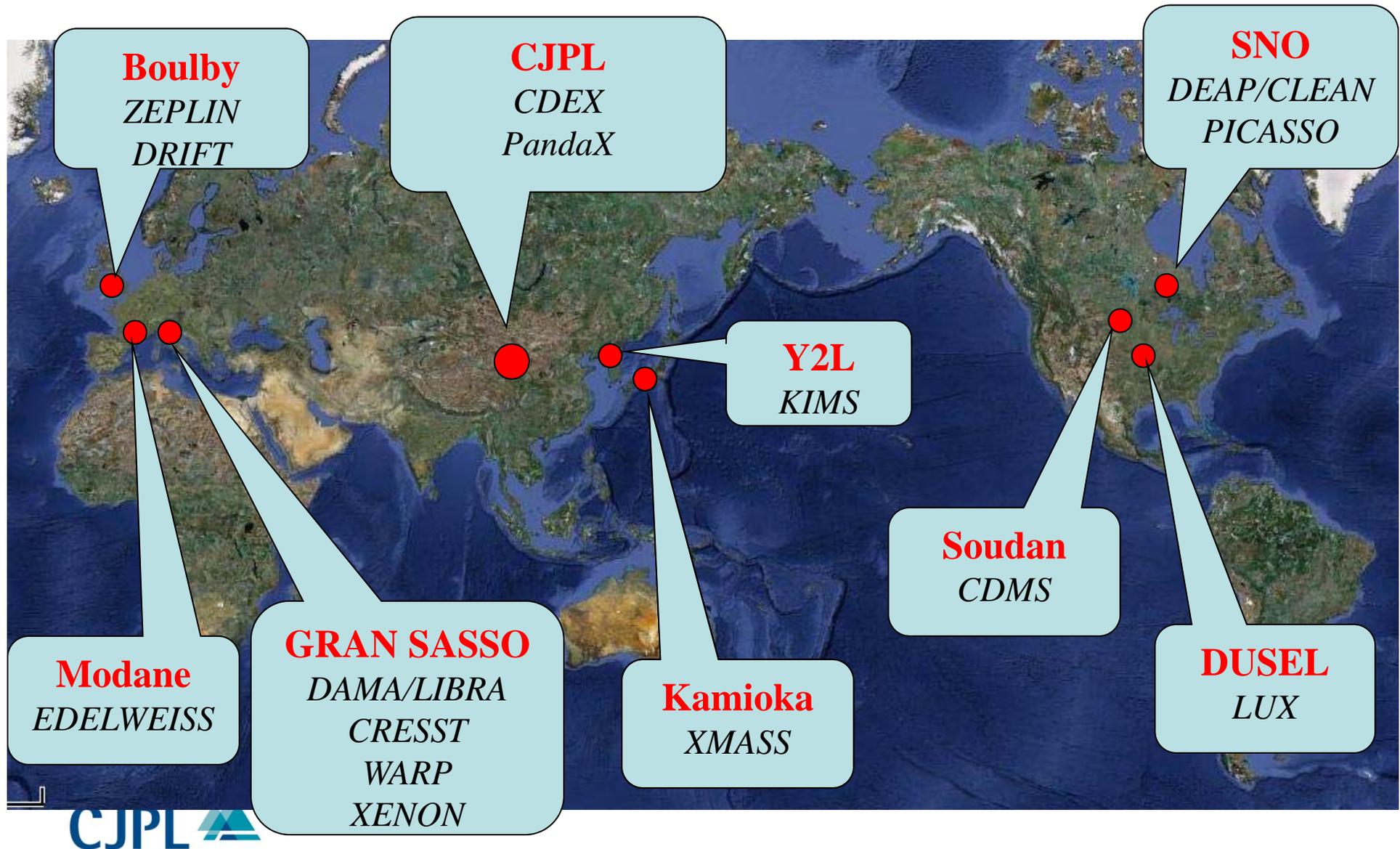
CDEX Experiment



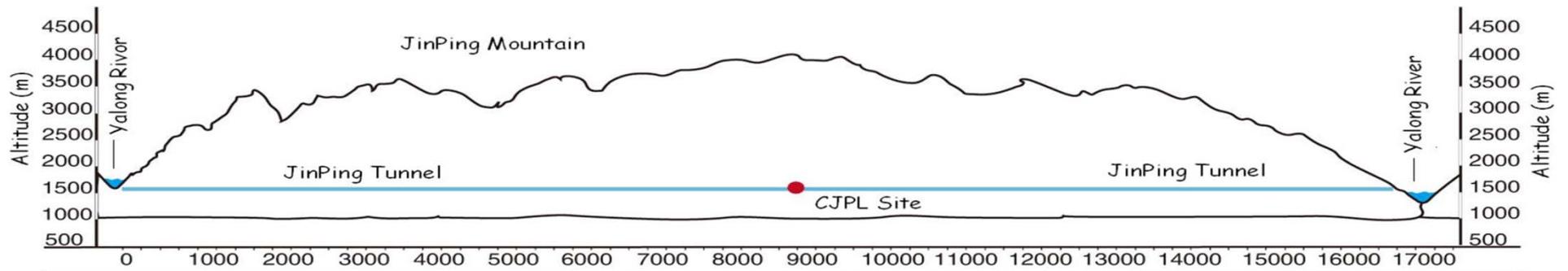
CDEX physics goals



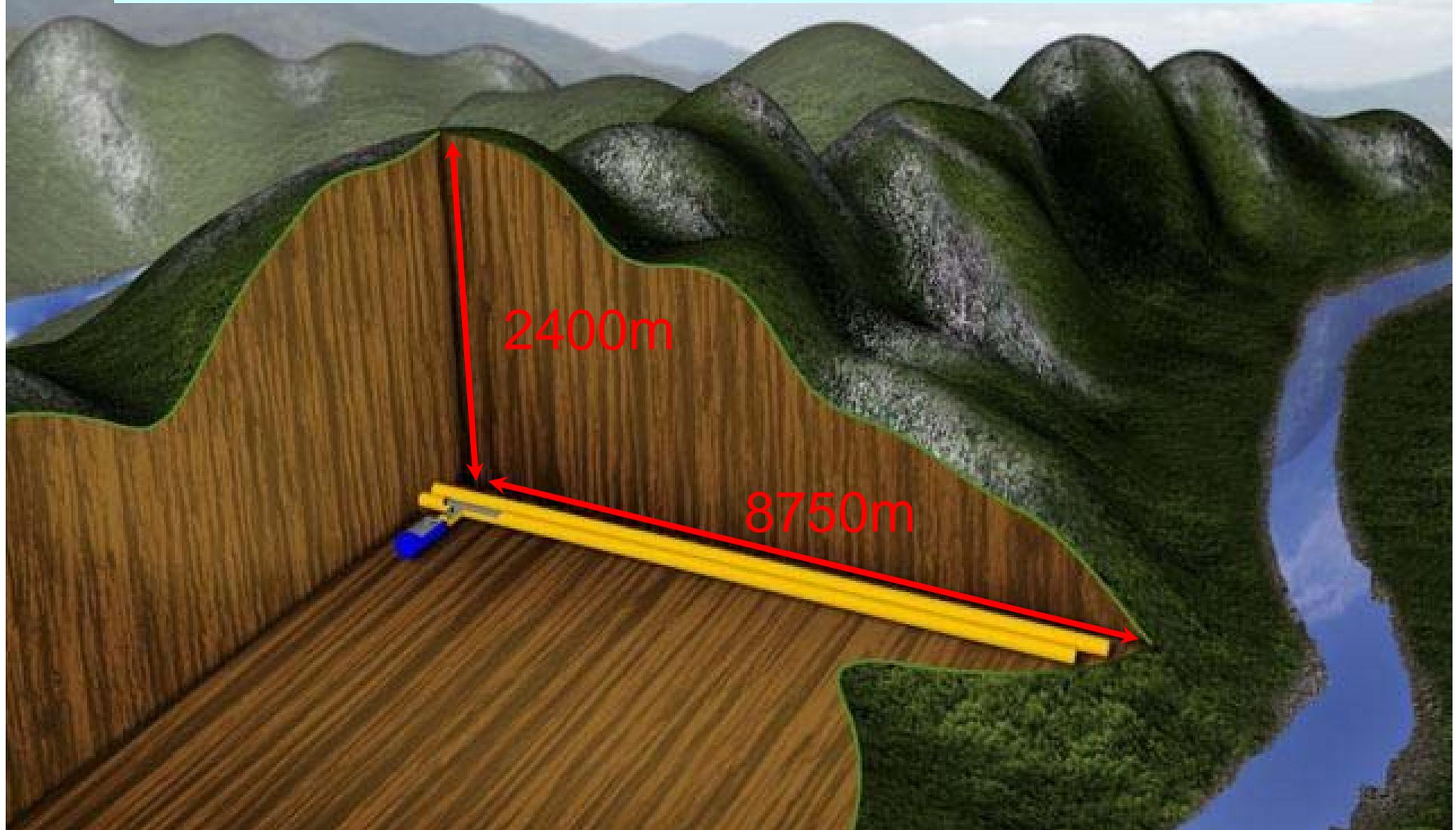
International Main Underground Laboratories



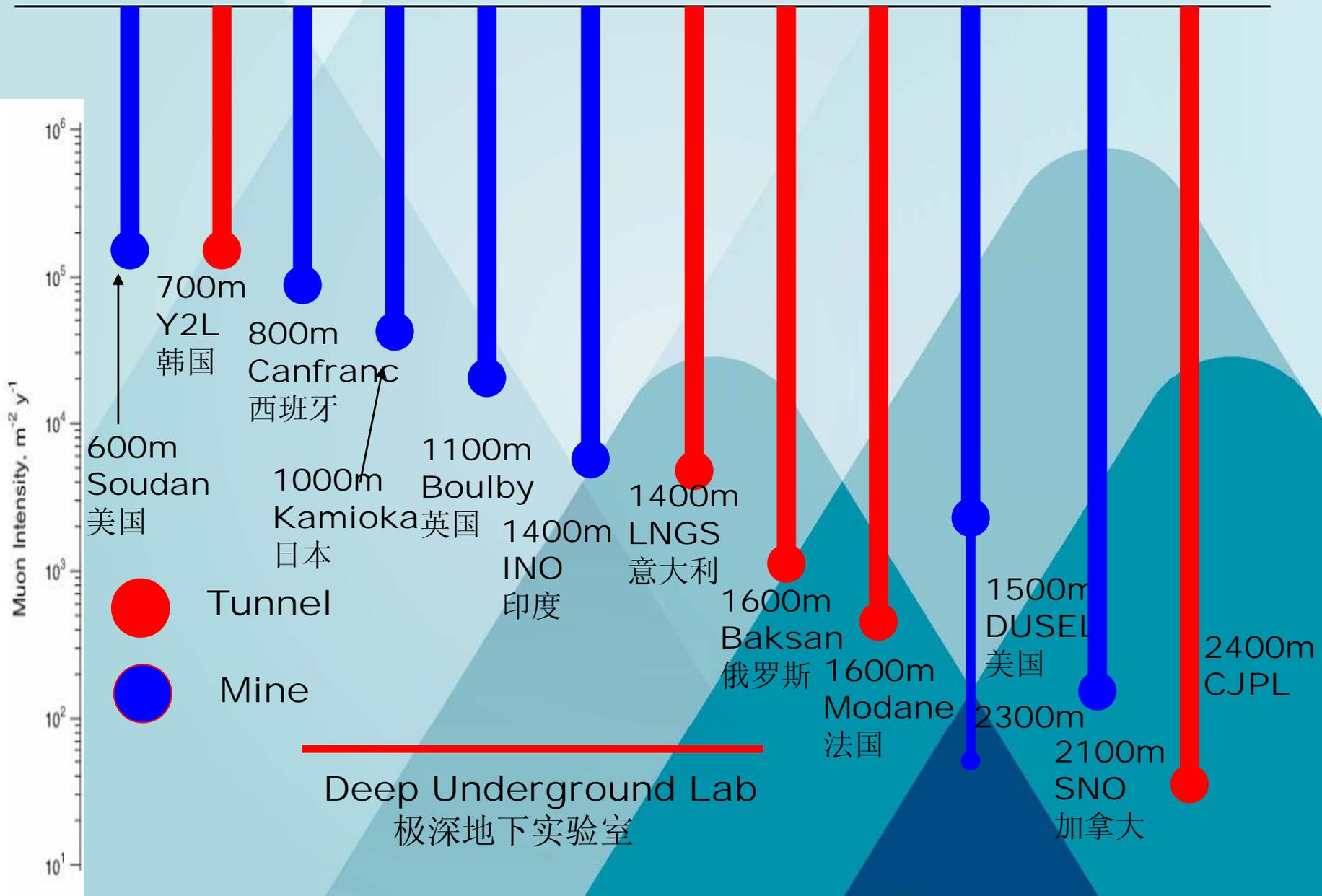
CJPL site



China JinPing Underground Laboratory (CJPL)



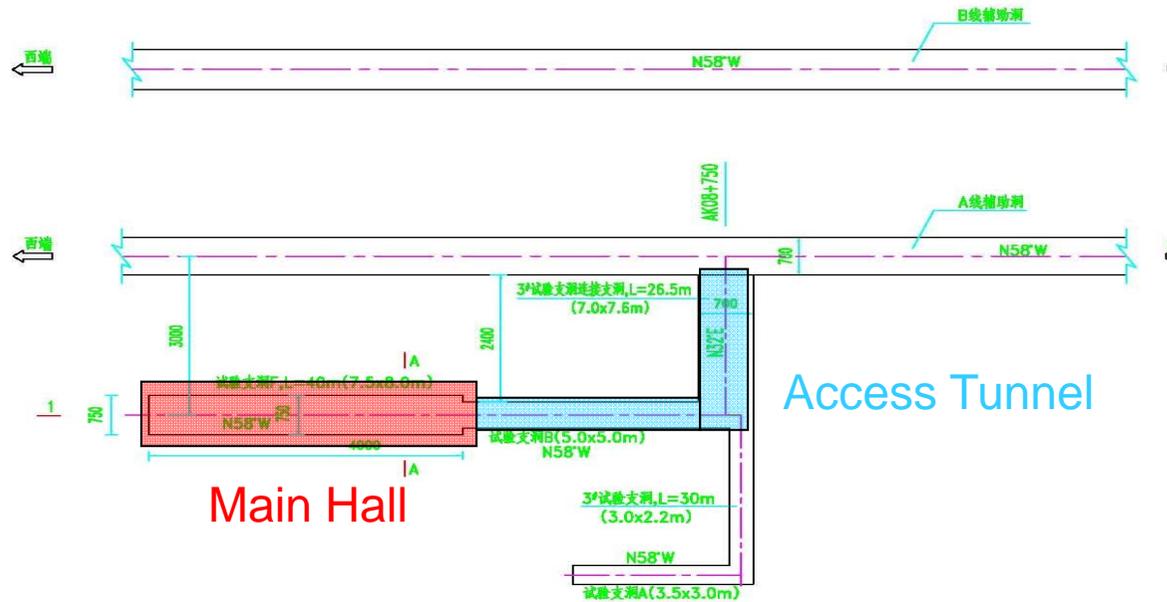
UL in the world (rock overburden)



CJPL Rock Background

(Unit: Bq/kg)	K-40	Ra-226 (609keV)	Th-232 (911keV)
JinPing Rock Sample	< 1. 1	$1.8 \pm 0. 2$	< 0. 27
Beijing Normal Ground Level	~600	~25	~50

The Layout of CJPL-I



辅助洞新增试验支洞F、G平面布置图

1:500

- Main hall: 6.5*6.5*40m
- Total Volume: ~4000m³

The Gate of CJPL in June 2010



Dec. 12, 2010 Opening Ceremony



CJPL logo and structure



CJPL (directed by Prof. Jianping Cheng)

- Physics division
- Engineer division
- Service division

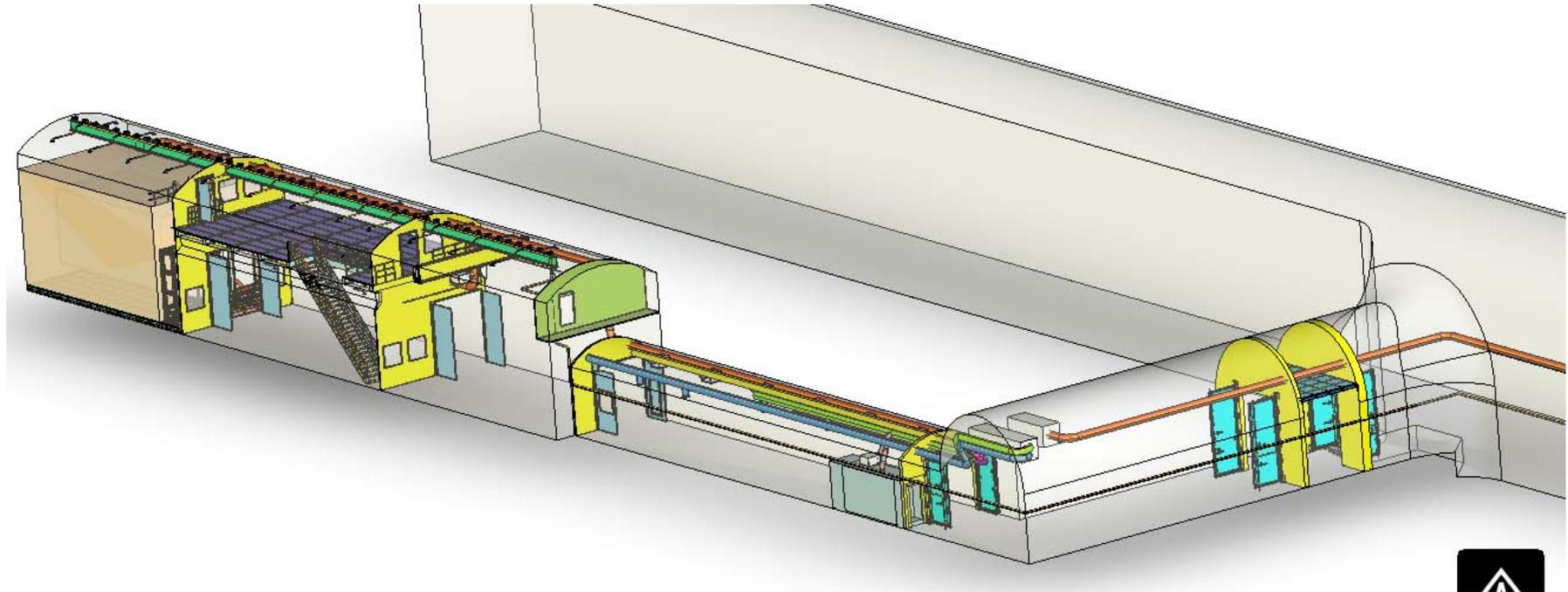
Inside of CJPL in 2010



Ventilation Upgrade in 2011

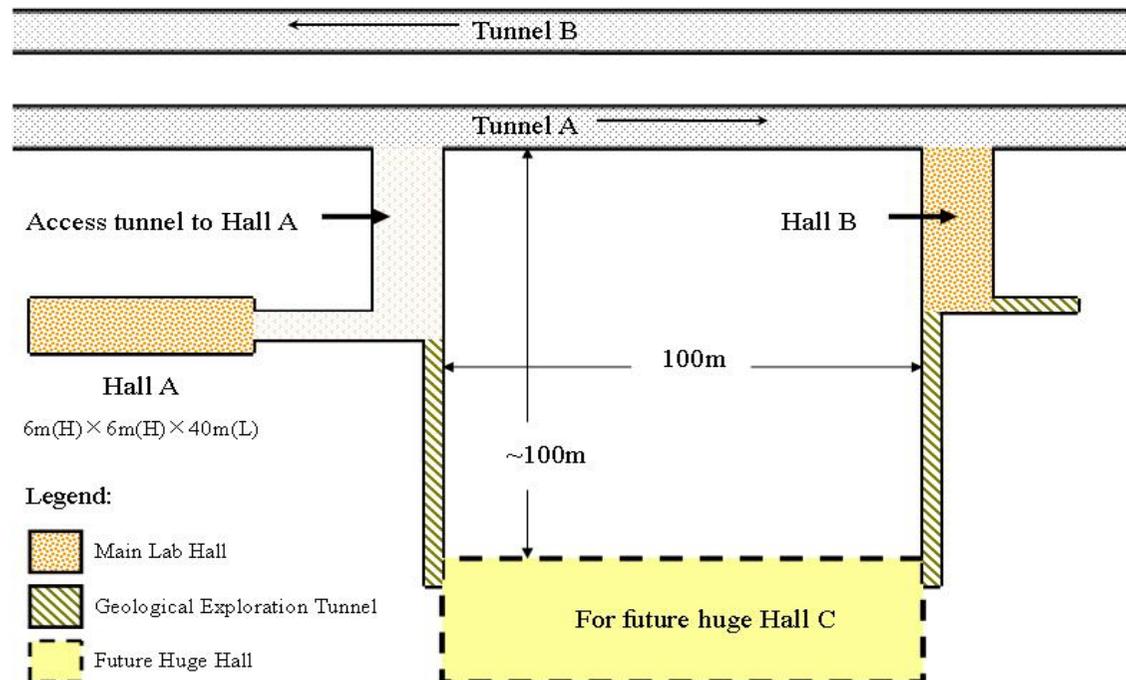


CJPL internal layout



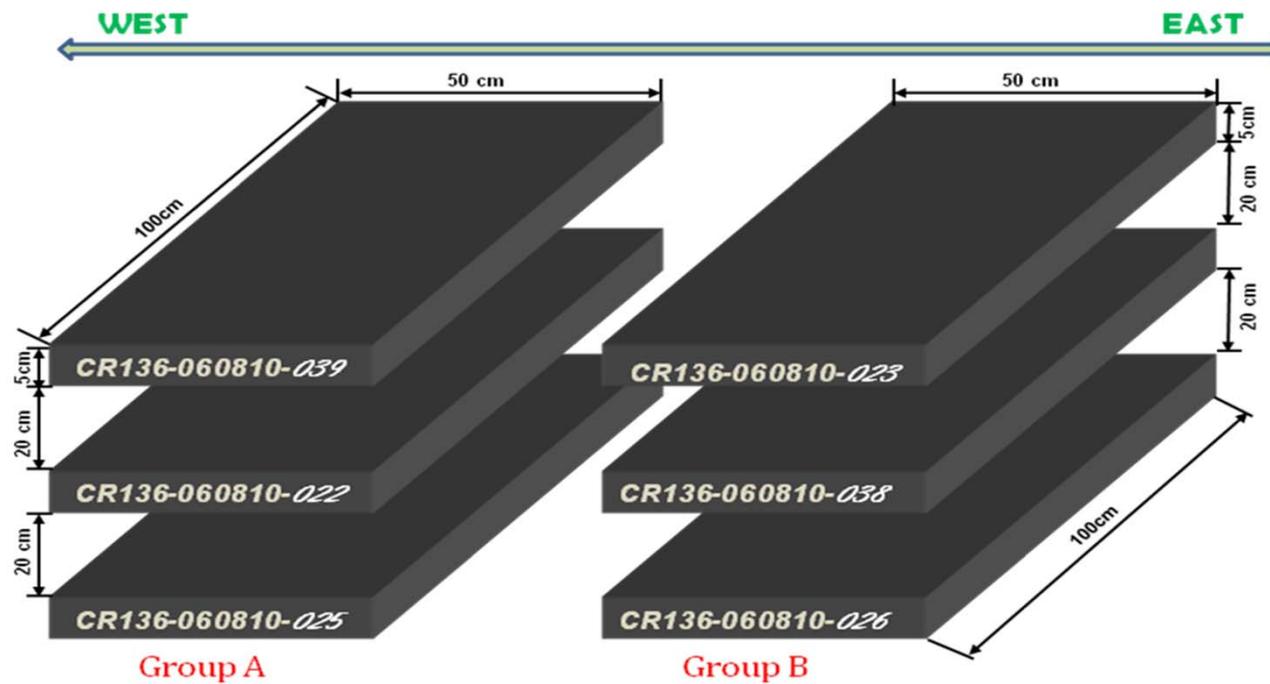
CJPL Future Plan

- CJPL has large space for future development;
- The shapes of the possible caves can be flexible;
- The new CJPL space can be constructed in 2-3 years.
- The potential experimental project are welcome;

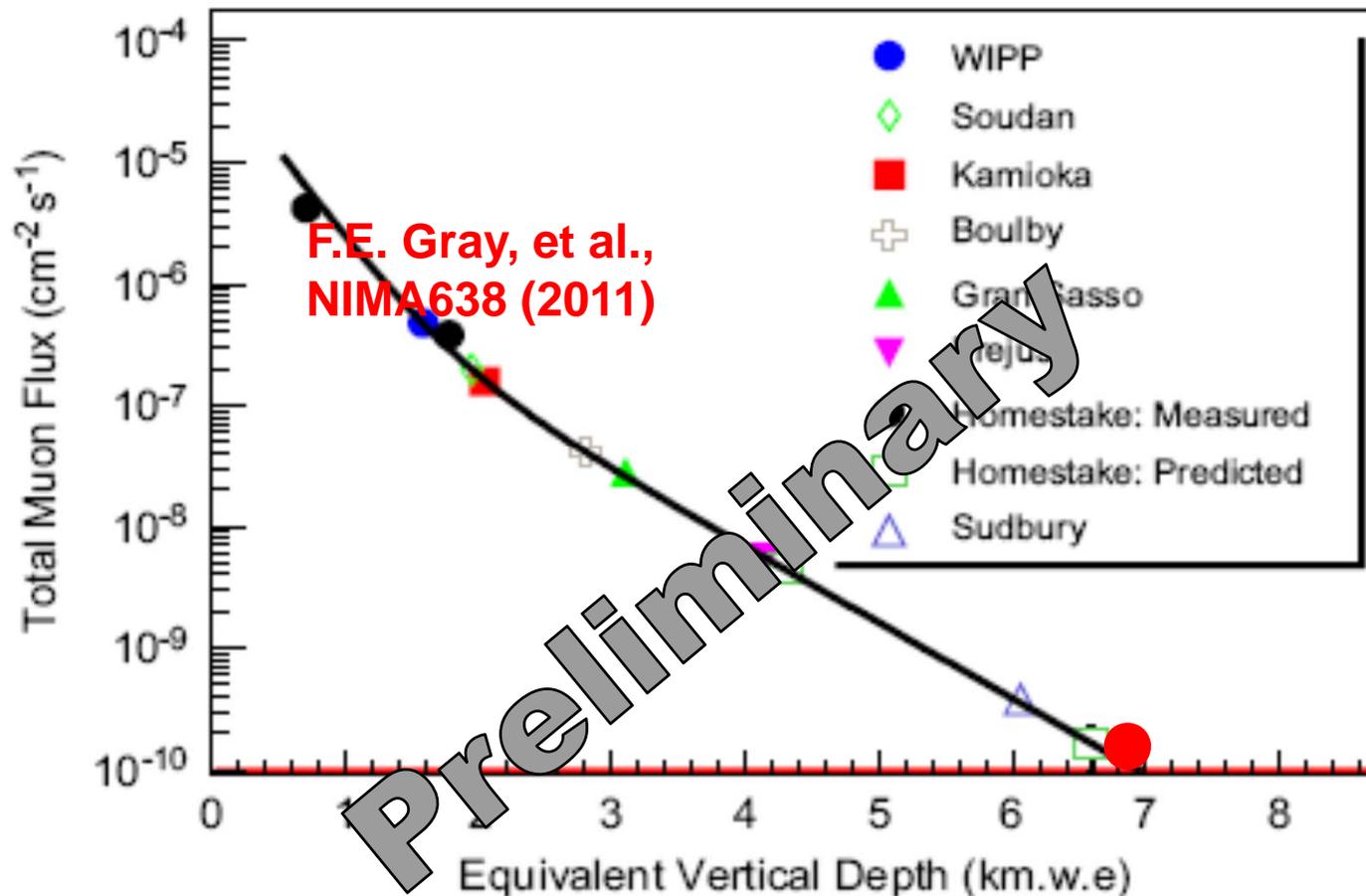


CJPL Muon flux measurement

- Plastic Scintillators: 100cm × 50cm × 5cm;
- 6 pieces divided into two group.



CJPL cosmic ray flux



CJPL cosmic ray flux : $\sim 2 \times 10^{-10} \text{ cm}^{-2} \text{ s}^{-1}$

Low background facility

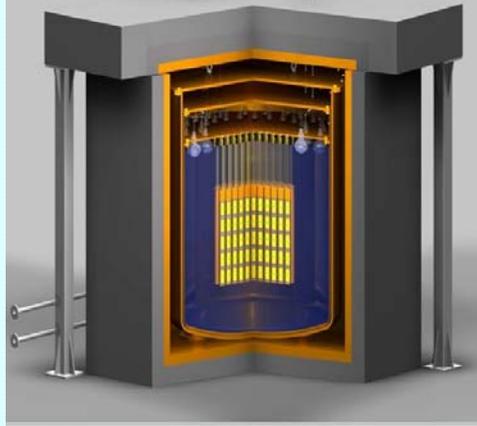


Recent status of CDEX

CDEX-1kg & 10kg Shielding system

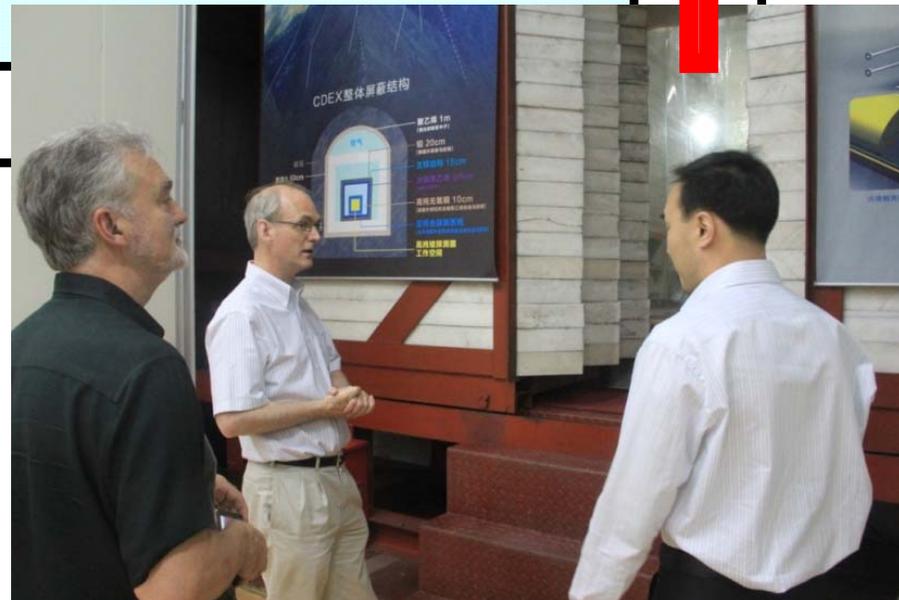
PE shielding room

10Kg-scale
HPGe System

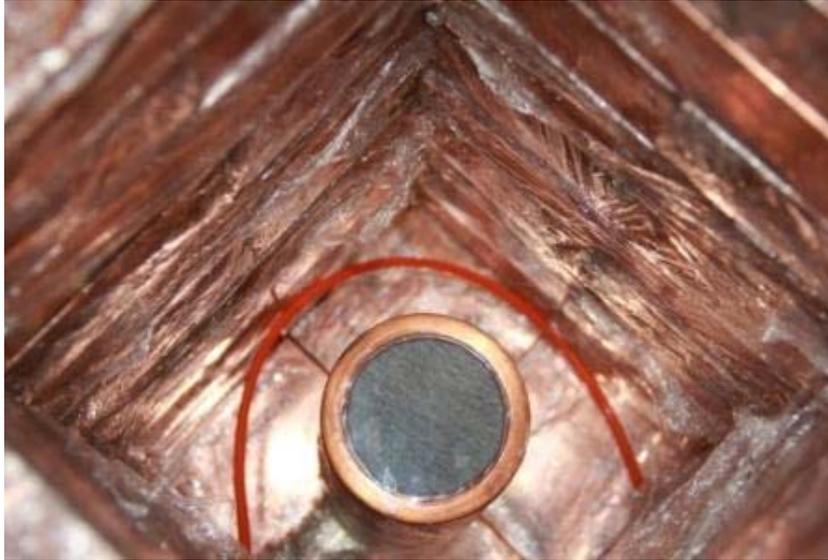


Lead, Copper
Shielding for
1Kg-scale
HPGe detector

Gate



CDEX-1kg scale HPGe detector



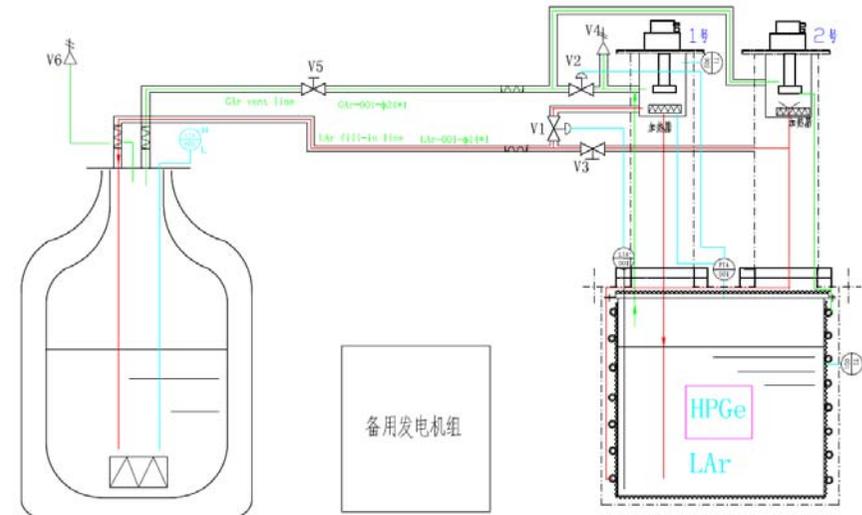
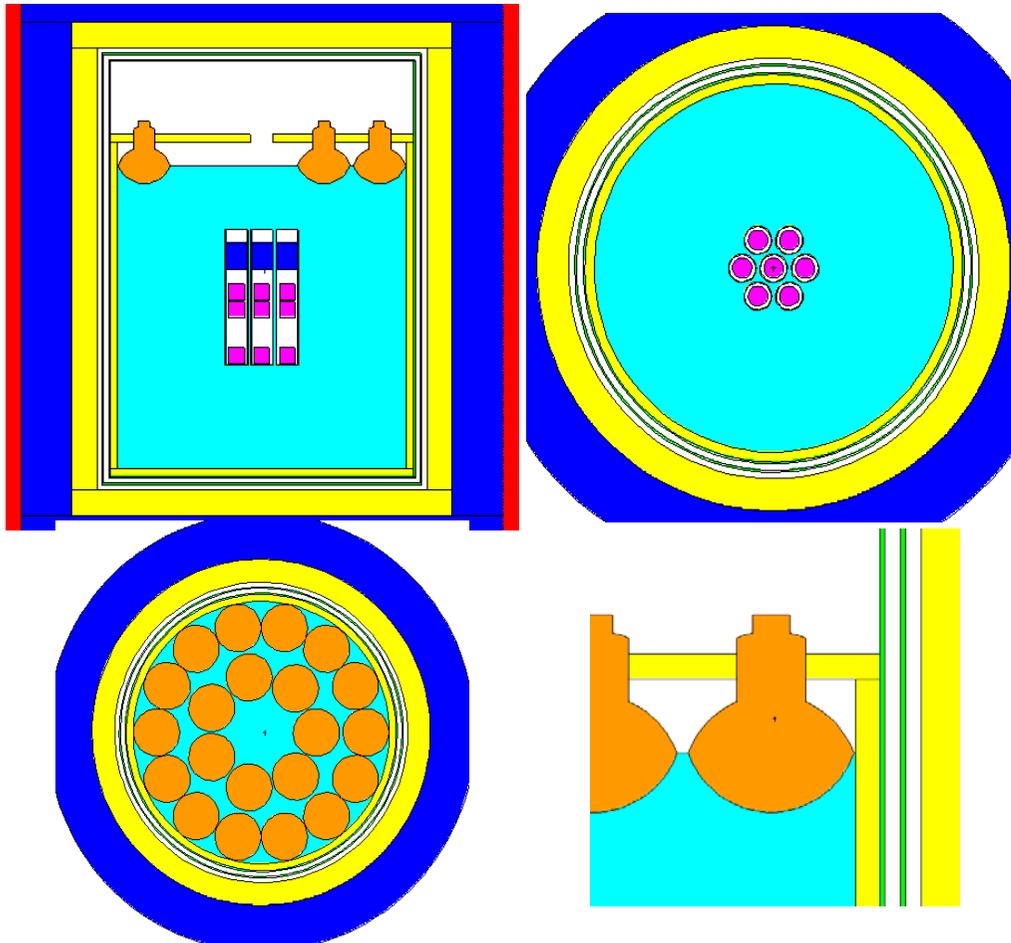
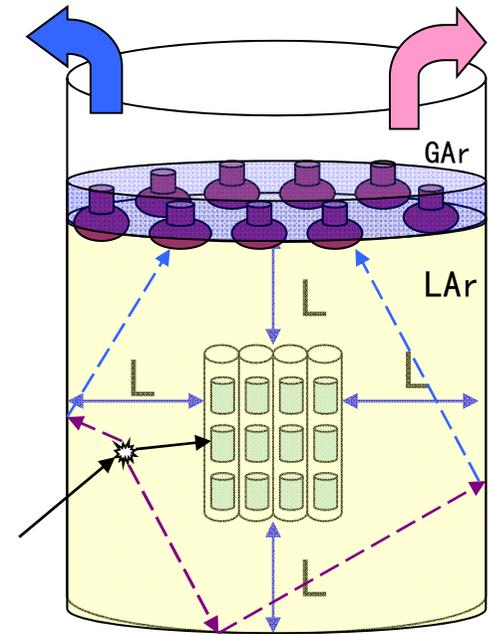
- 20g HPGe running now!
- 1kg PCGe detector testing!



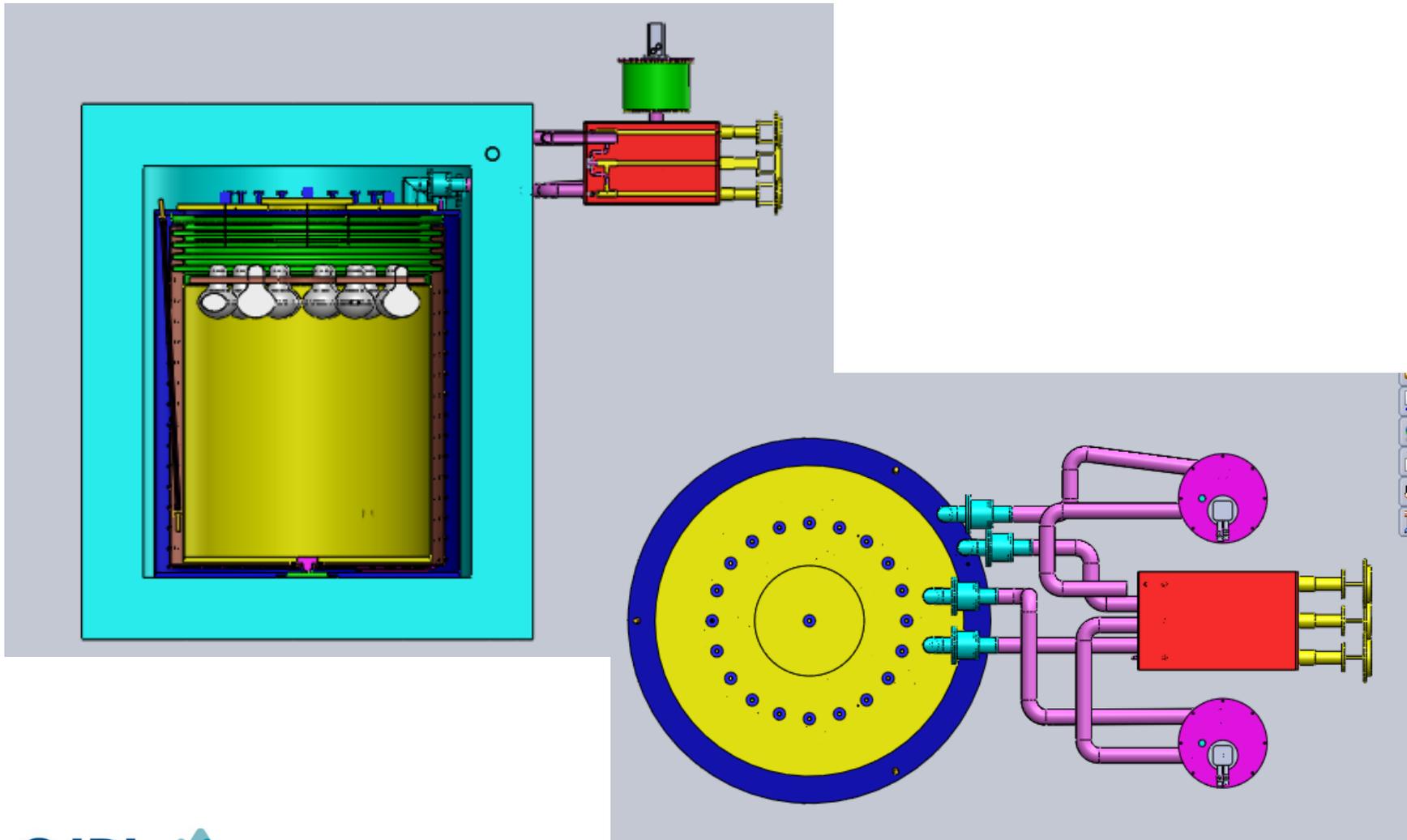
CDEX-10kg

LAr: Cooling + Passive shielding + Active shielding.
 Ge: Encapsulated into Cu vacuum tube for cooling.
 Ge: Three PCGe in one tube.
 WLS: Transferring 128nm light to ~420nm light.

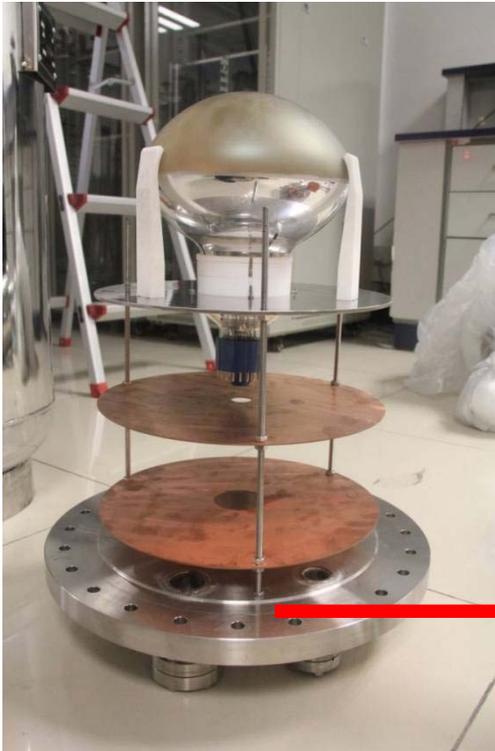
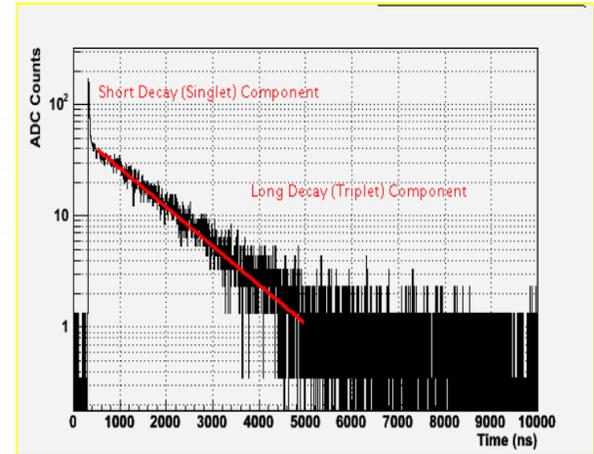
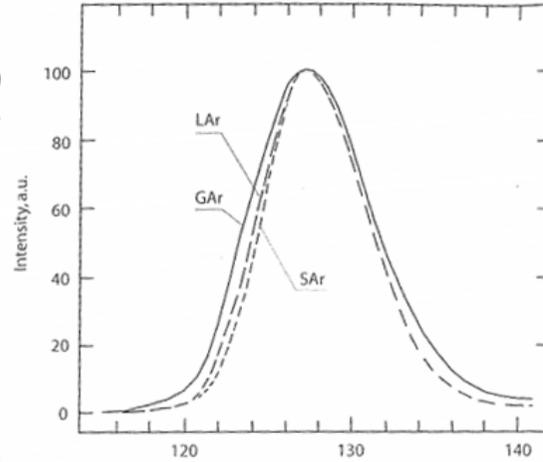
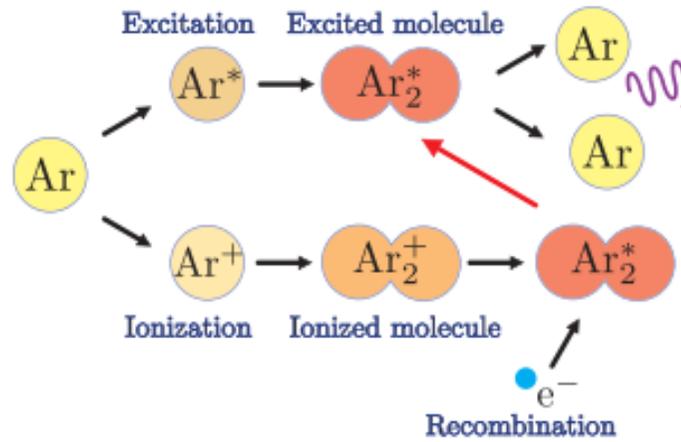
HV and Signals Cooling and Control



CDEX-10 LAr AC system



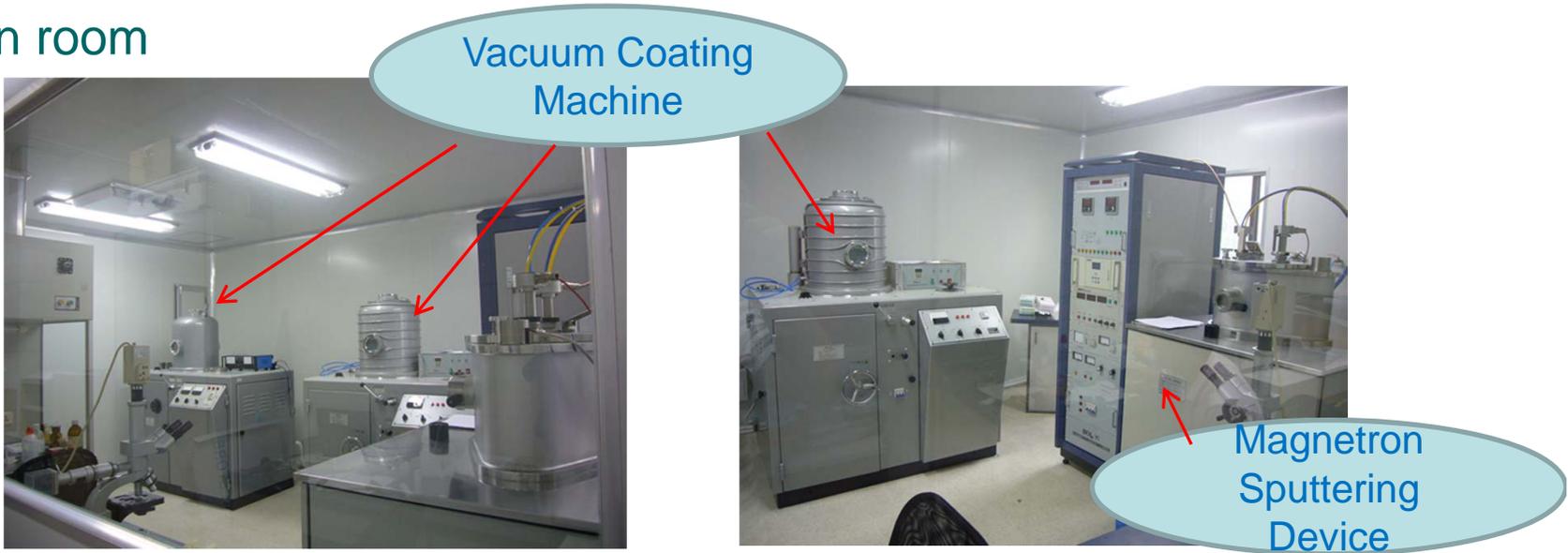
LAr AC detector



Ge detector fabrication in THU

Laboratory Set-up

- Clean room



- Wet Lab



- Machine-shop



Crystal Processing

- Typical Processing Technology is used (so far)

Mechanical Preparation



Lithium Diffusion



Wet Lab



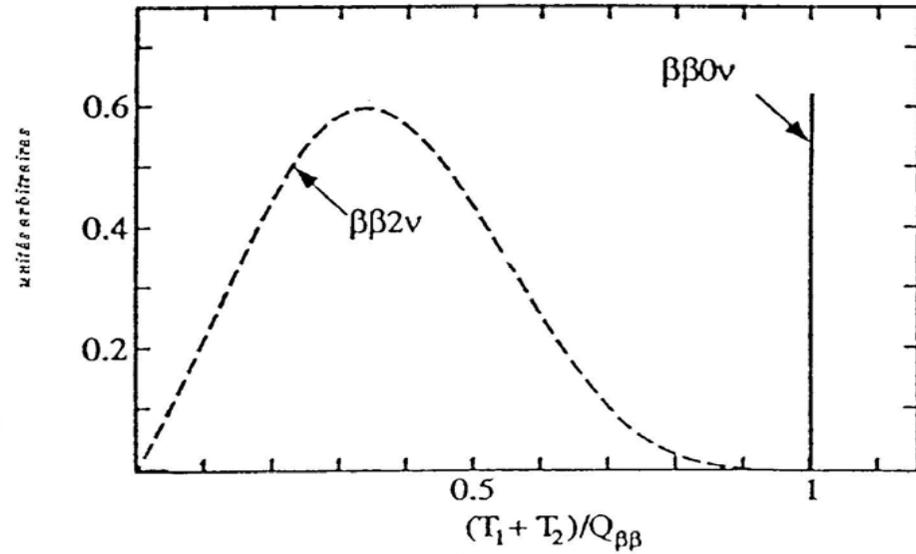
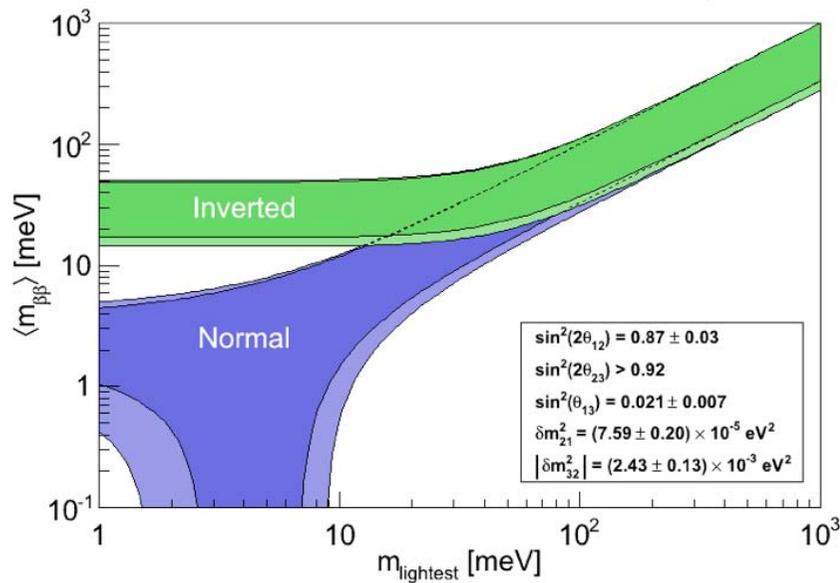
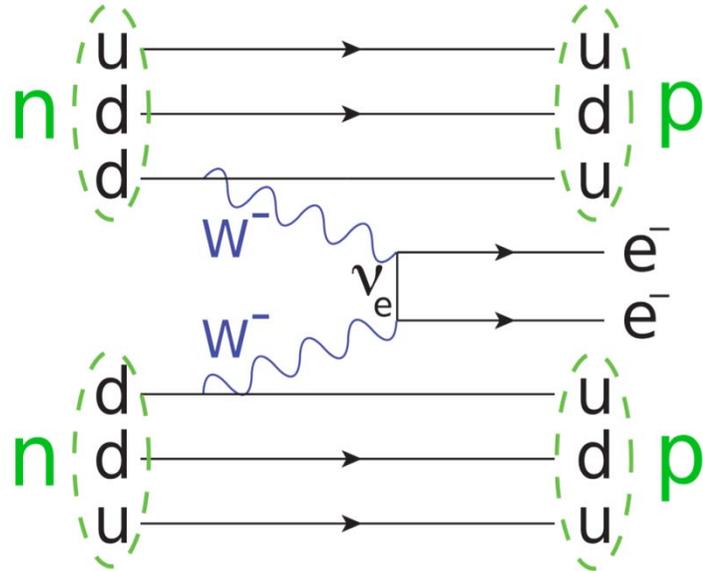
Boron Implant



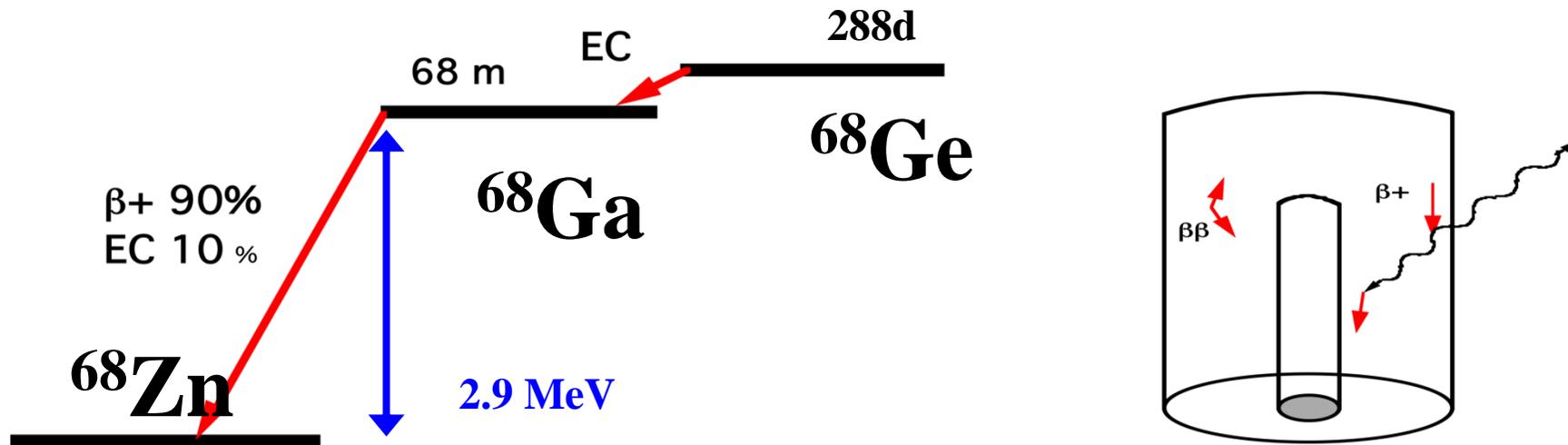
Boron Implant Accelerator



PCGe detector for DBD



Cosmogenic ^{68}Ge and ^{60}Co Ge detector example



^{68}Ge and ^{60}Co are the dangerous internal backgrounds

**For 60-kg enriched detector, initially
expect ~ 60 ^{68}Ge decays/day. $\tau_{1/2} = 288$ d**

Minimize exposure on surface during enrichment and fabrication
PSD, segmentation, time correlation cuts are effective at reducing these

Ge crystal growth @ underground laboratory



Summary

- New type of Ge detectors developed for particle physics;
- CJPL with deepest rock overburden in the world run now. Easy to expand to huge space in near future. Physical project considered seriously;
- CDEX: First DM exp in CJPL. 20g +1kg ULE-HPGe detector running; 10kg under engineering design, 1 ton PCGe +LAr AC in the future; THU has also started to fabricate Ge detector in order to lower the cost.
- It's natural for a ton-scale Ge array detector system to cover DM and DBD topics together. May just one ton-scale Ge detector system affordable in our world. Co-operation of scientists in the world is very important.



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Thank you!