The latest progress of CDEX experiment

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Tsinghua University
On behalf of CDEX Collaboration
Oct. 24 , 2013

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

New Perspectives in Dark matter
Oct 22-25, 2013

Outline：

- China Jinping Underground Laboratory (CJPL)

CJPL; CJPL-II

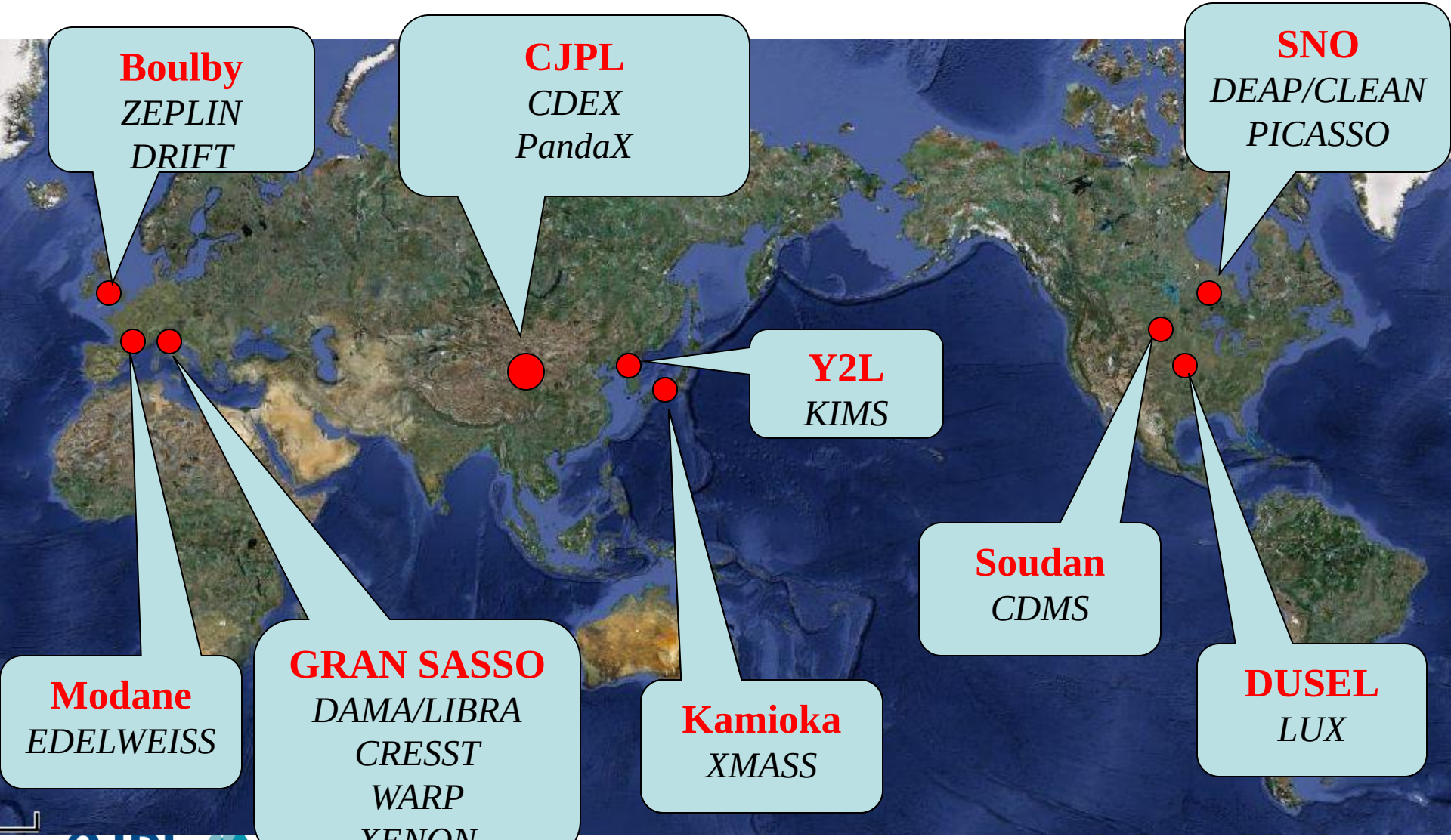
- China Dark Matter Experiment (CDEX) & Status

CDEX-1; CDEX-10; CDEX-1T

- Summary

CJPL

International Main Undergound Laboratories



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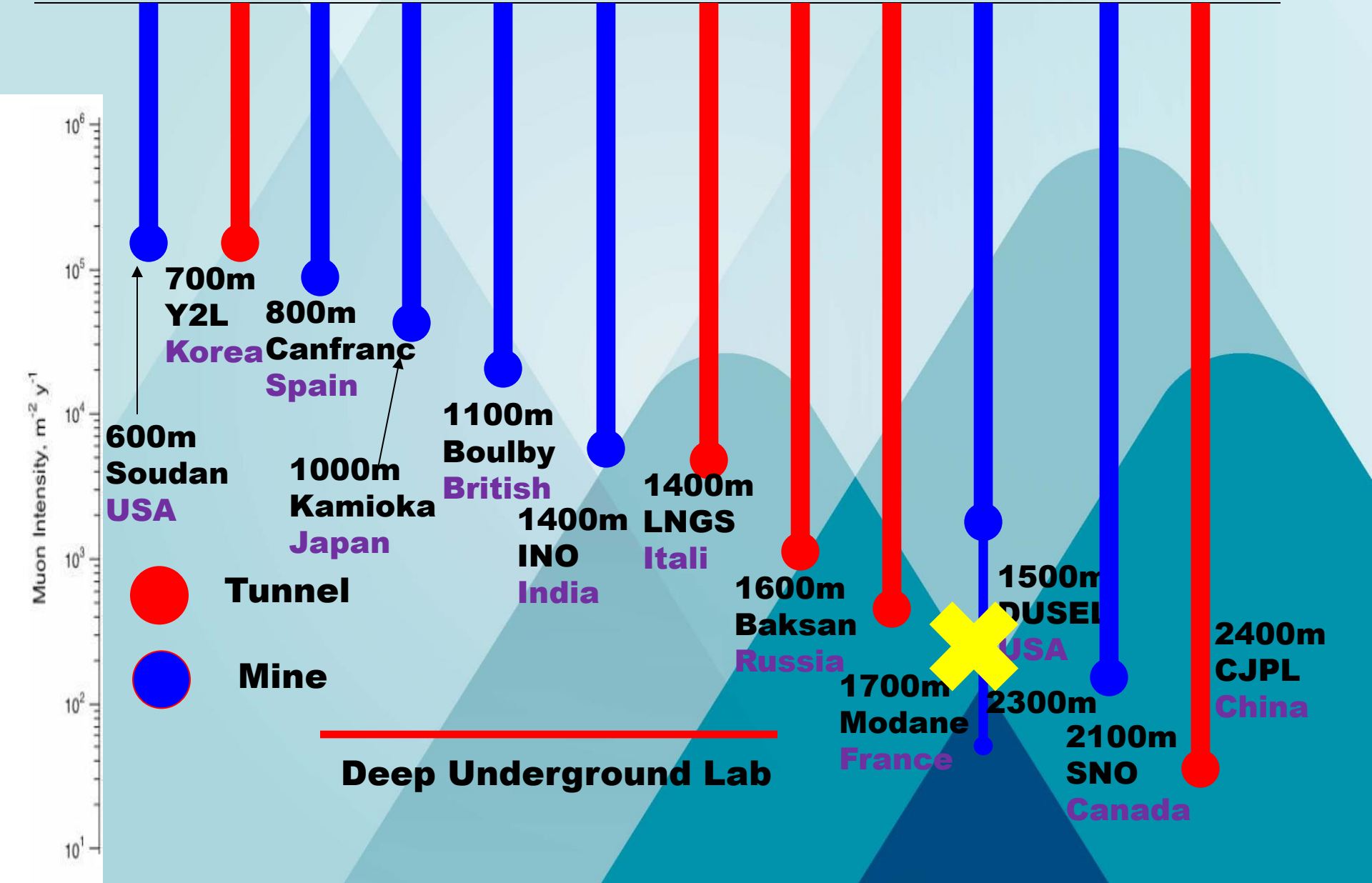
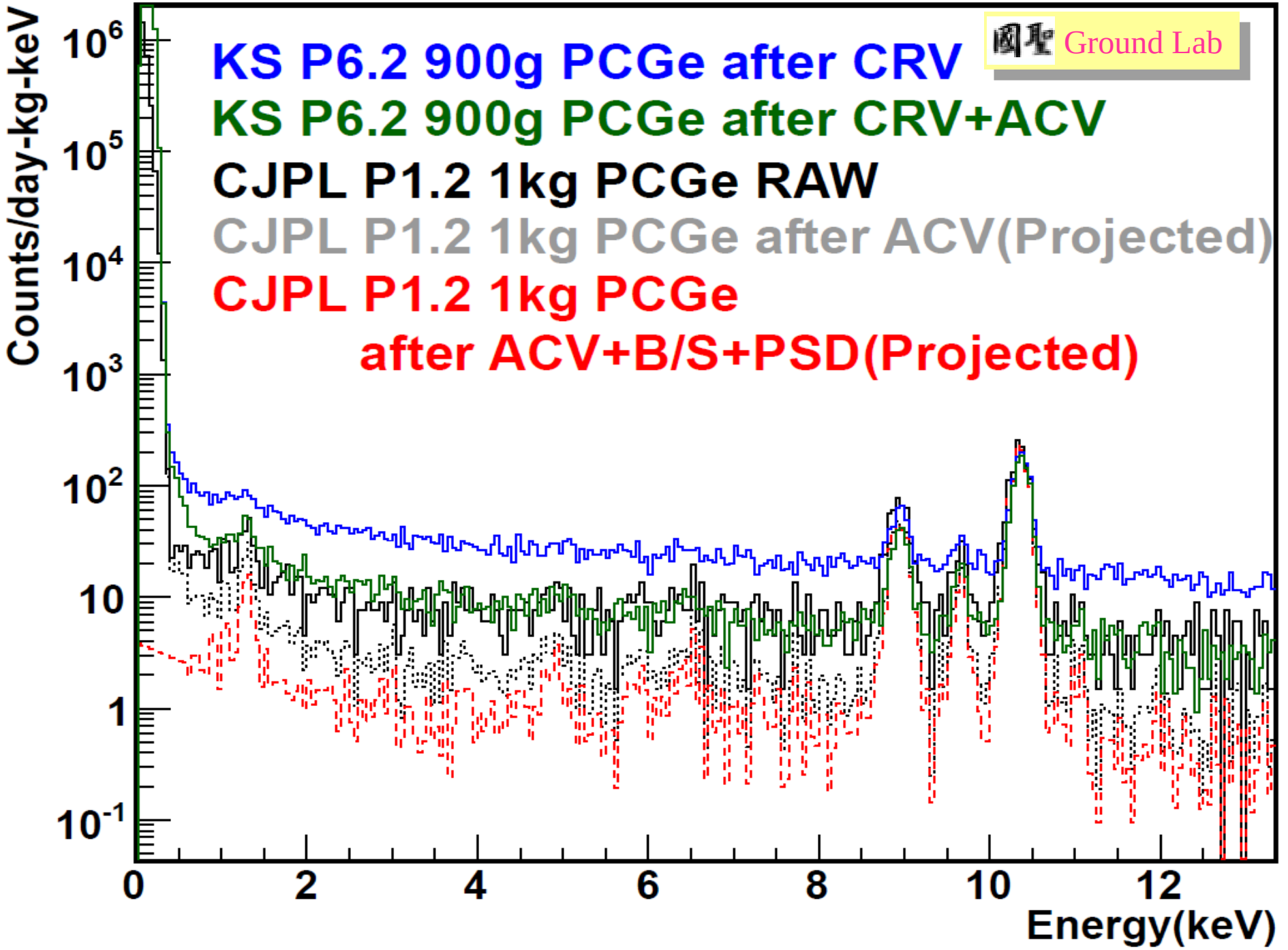
Two Direction Developments

- **Enhance Detection Efficiency**
  - increase detector target mass kg-ton-kt
  - reduce detector energy threshold 10keV-1keV-100eV
- **Suppress Backgrounds**
  - shield cosmic ray better
  - passive shield with Pb、Cu、PE…
  - active shield with LS
  - develop high efficiency signal discrimination

UL in the world(rock overburden)




KS P6.2 900g PCGe after CRV
KS P6.2 900g PCGe after CRV+ACV
CJPL P1.2 1kg PCGe RAW
CJPL P1.2 1kg PCGe after ACV(Projected)
CJPL P1.2 1kg PCGe
after ACV+B/S+PSD(Projected)
國聖 Ground Lab
Counts/day-kg-keV
Energy(keV)
10^6
10^5
10^4
10^3
10^2
10
1
10^-1
0
2
4
6
8
10
12

Yalong River and Jinping Mountain

Lasts >1500km in SiChuan Province

~150km

Tunnel

Jinping1st
3.6MkW

Jinping 2nd
4.8MkW

Seven parallel tunnels:
one drainage tunnel
two transport tunnels 2008
four headrace tunnels

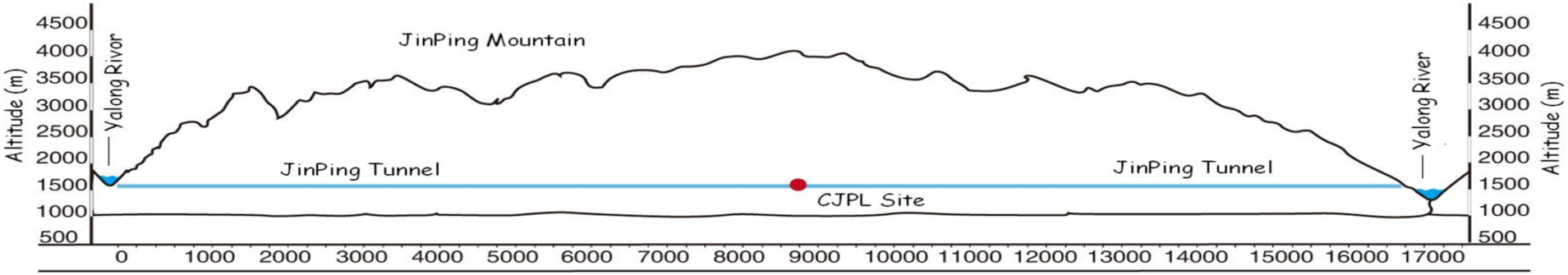
120km

30min from Chengdu
By Air

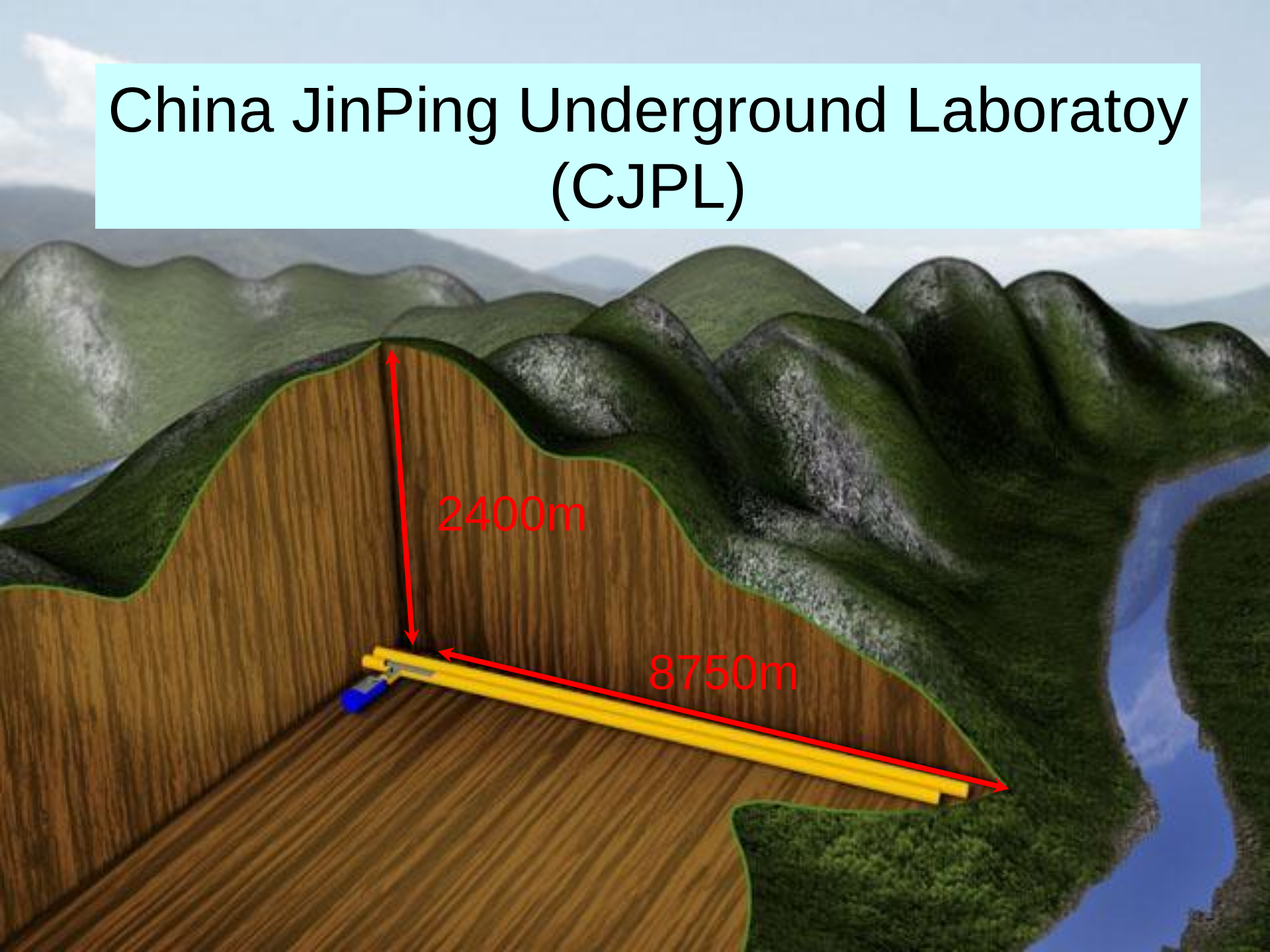
XiChang

CJPL site


CHINA
Sichuan Province
YaLongRiver
Jinping tunnels
Jinsha River
YaLong River
Jinsha River
Jinsha River
N
Yunnan Province


Altitude (m)
4500
4000
3500
3000
2500
2000
1500
1000
500
Yalong Rivor
JinPing Mountain
JinPing Tunnel
JinPing Tunnel
CJPL Site
Yalong River
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
16000
17000

China JinPing Underground Laboratoy (CJPL)



China Jinping Underground Laboratory

Ground laboratory building, office, dormitory, apartments, restaurants, hotel and sport facilities are near the entrance of the tunnel.

Tsinghua University,

have collaborated

with Yalong River company

to construct and run CJPL

6 m×6 m

Dec 12, 2010

CJPL

Logistic Condition of this UL

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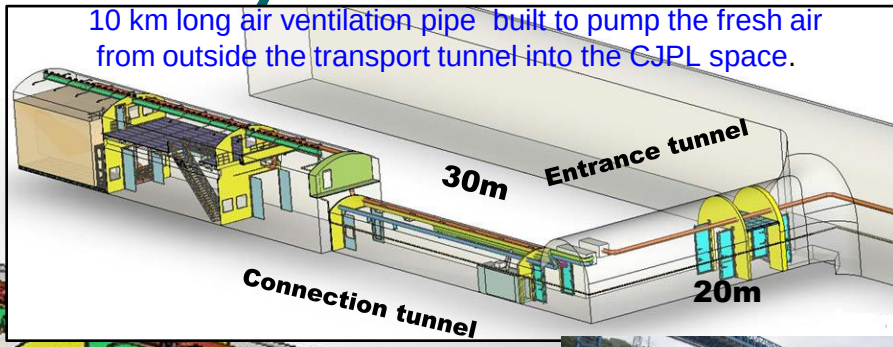
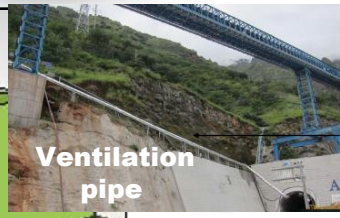
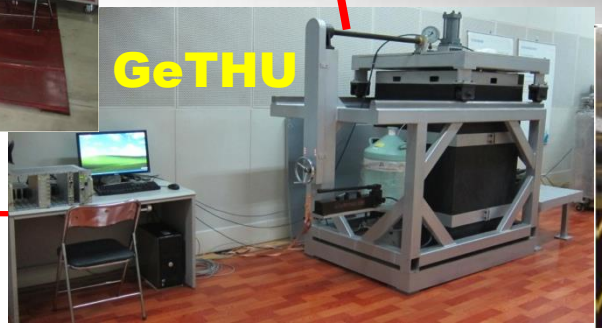
CJPL internal layout

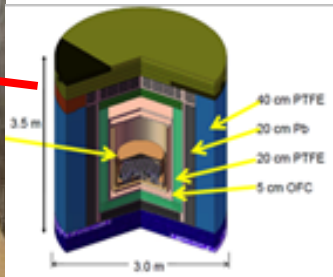
Wall is covered by a layer of air-proof resin to separate it from the rock

10 km long air ventilation pipe built to pump the fresh air from outside the transport tunnel into the CJPL space.









- Main Hall:6.5*7.5*40m
- Total Volume~4000m^3

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CJPL background facility

low background germanium spectrometer

CJPL Rock Background

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

The radioactivity of surrounding environment at CJPL

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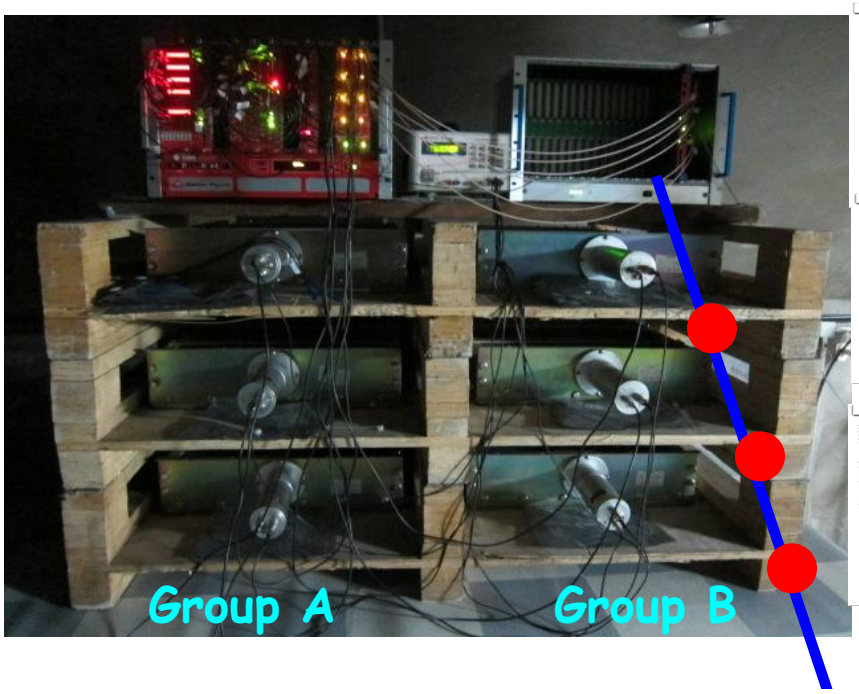
Radon ~ **100 Bq/m³ no ventilation**

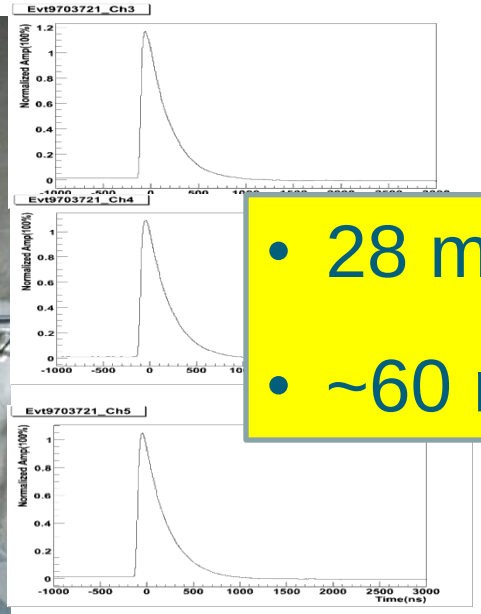
50 Bq/m³ ventilation

System is flushed by boiling N_2 from the cooling dewar to further reduce radon

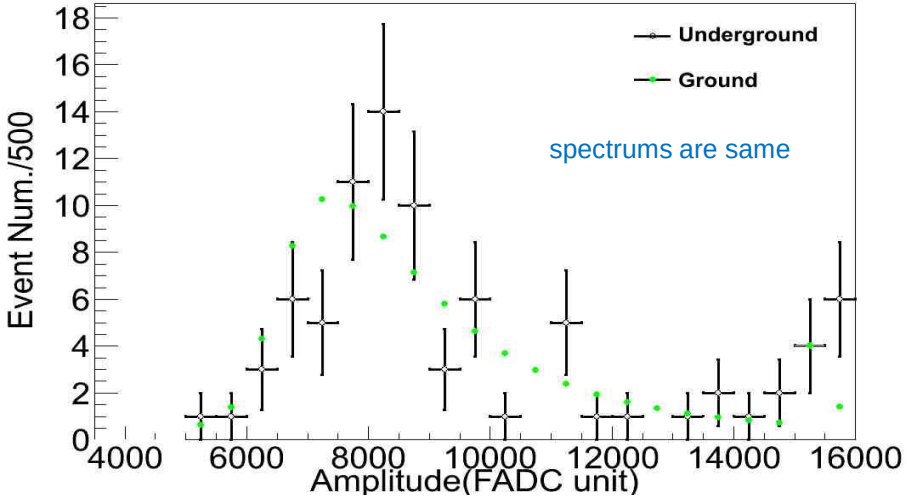
Muon flux @ CJPL

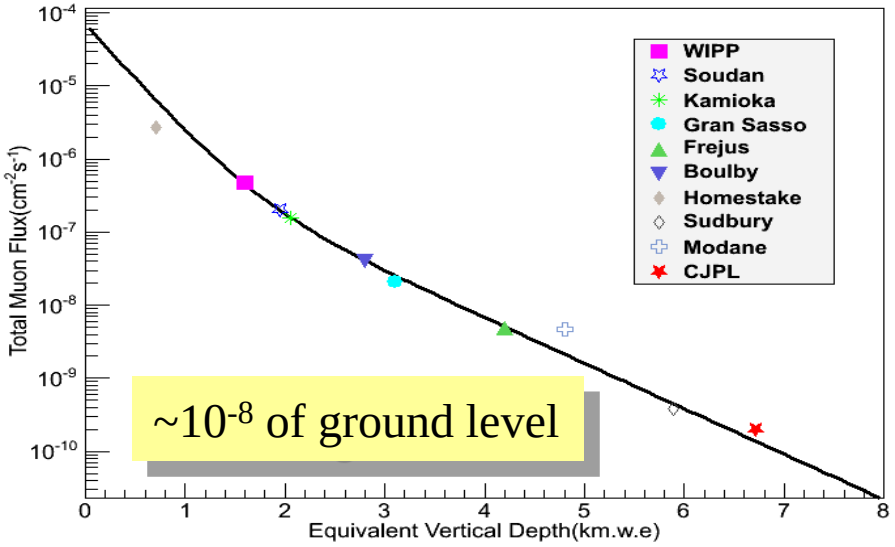
- plastic scintillators is 1 m×0.5 m×0.05 m
- 6 pieces divided into two group



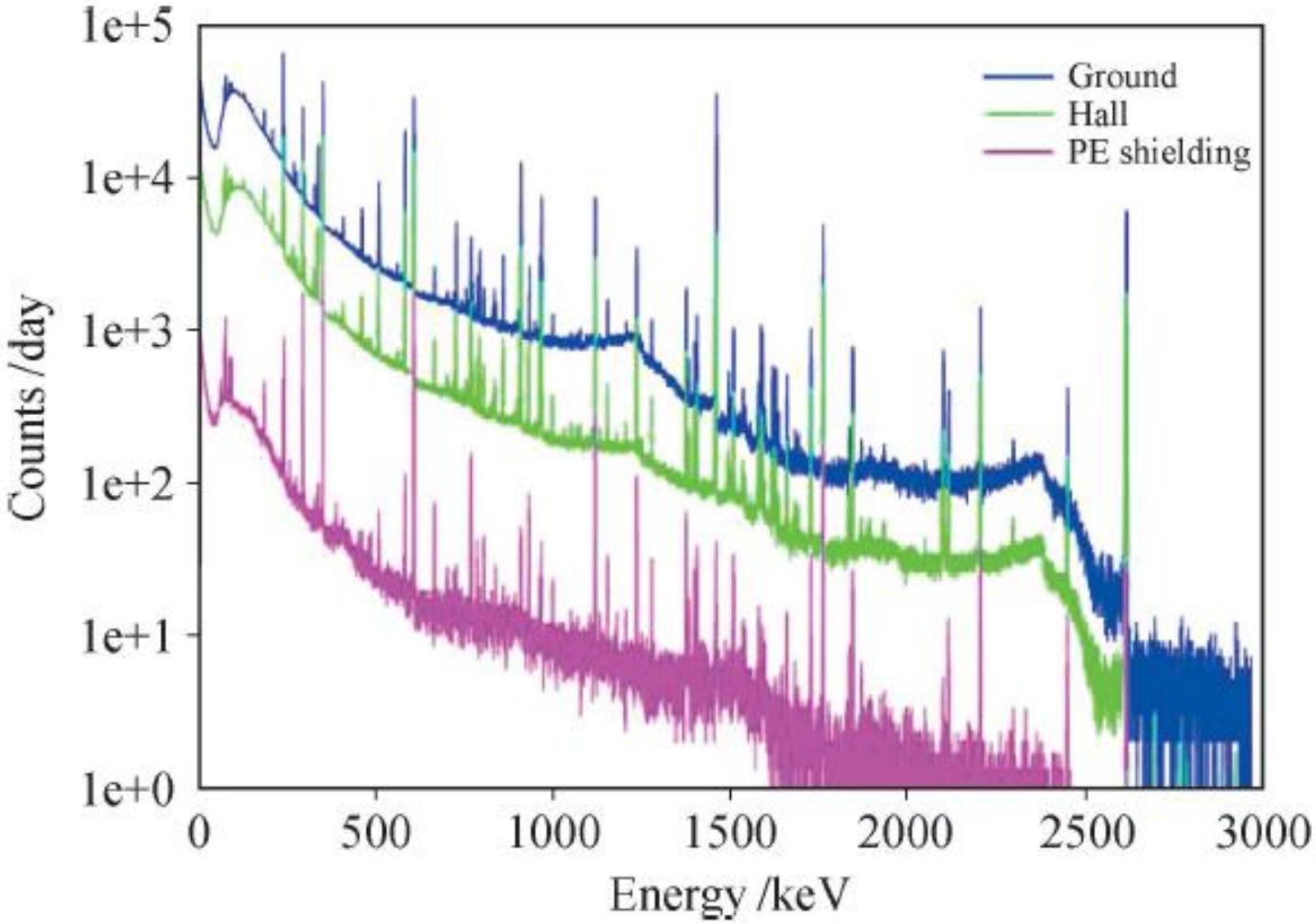


- 28 muons / 171 day;
- ~60 muon/year/m^2;





In-situ gamma spectra by a portable gamma spectroscoper



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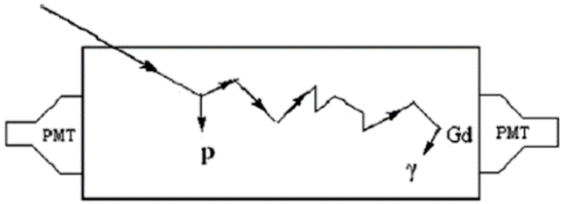
Fast neutron flux measurement in CJPL

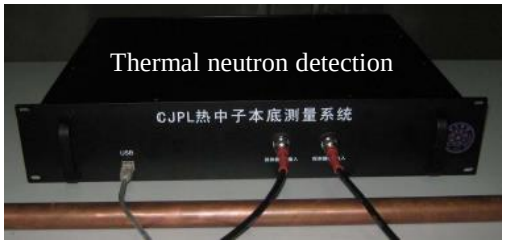
Geant4 Monte Carlo simulation:

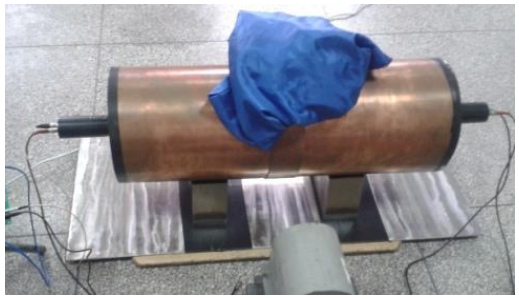
Neutrons from Rock ~ 3.129 × 10−12 cpd

neutrons from concrete layer ~ 6.490 × 10−10 cpd;

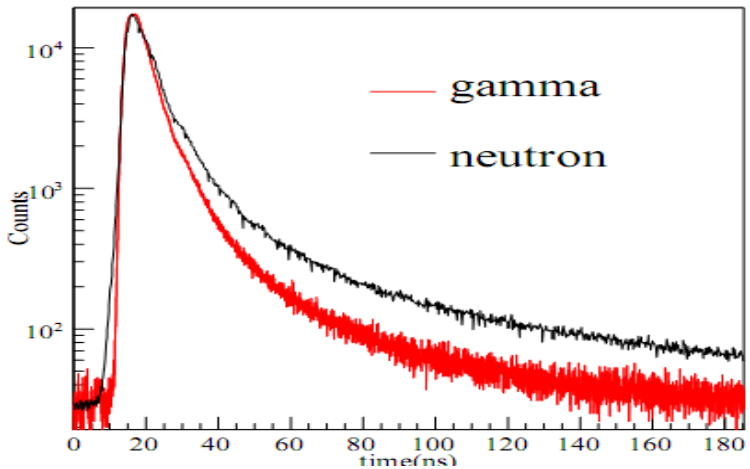
(Gd-load LS detector)

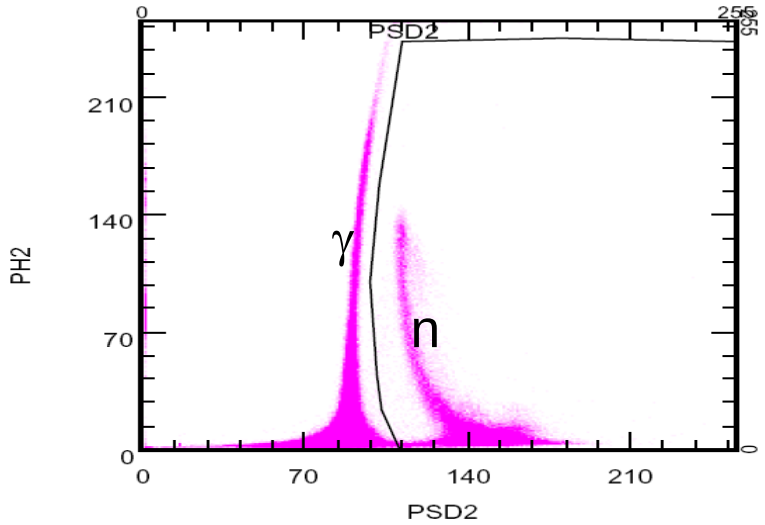






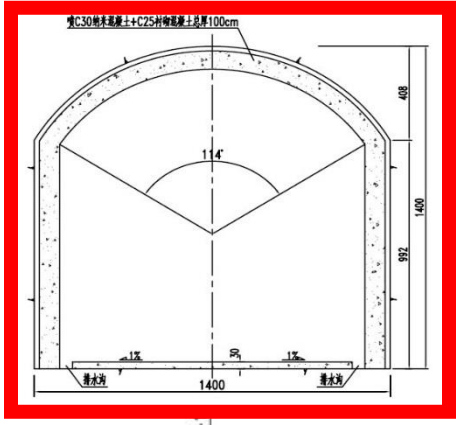
	Hall	PE shielding
Thermal Neutron Rate	~30 cpd	< 1 cpd
Thermal Neutron Flux	4.34 x10^{-6} n/cm^2/s	< 1.45 x10^{-7} n/cm^2/s

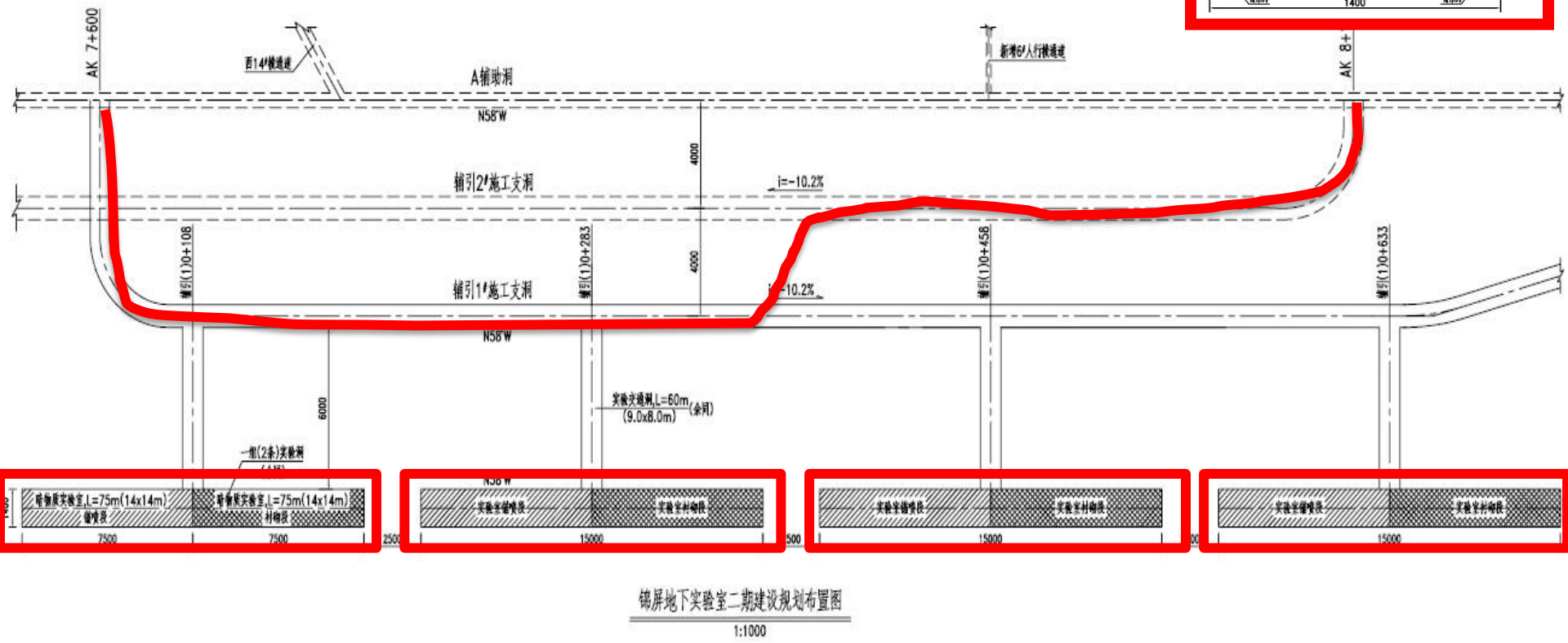




CJPL Future： CJPL-II

Total volume $10^5 m^3$米





锦屏地下实验室二期建设规划布置图

1:1000

Four12m*12m*150m rooms, to be finished in 2015。

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CDEX – Status - Membership

- Tsinghua University
- SiChuan University
- Nankai University
- China Institute of Atomic Energy
- Ertan Hydropower Development Company

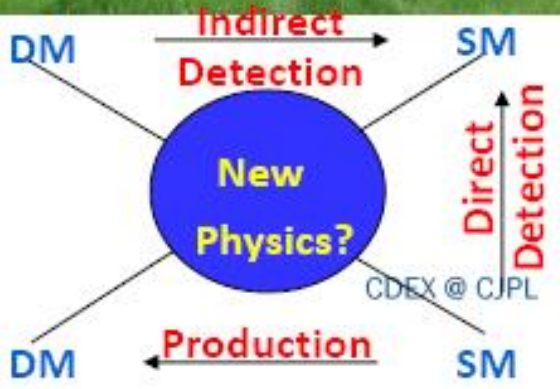
Yalong River Company

CDEX Target:

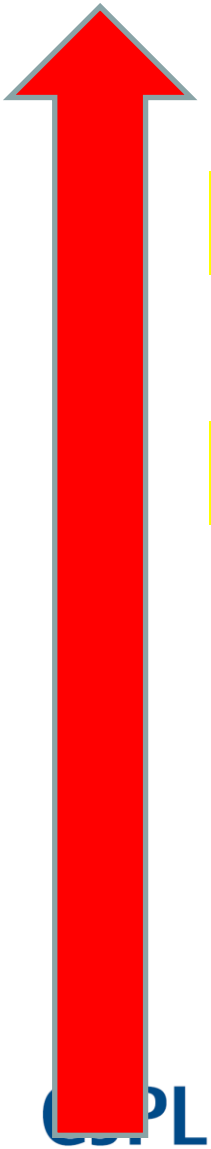
Direct Search of Cold Dark Matter with O(10 kg) Ge detectors of Sub-keV Energy Sensitivity.

Goal: O(0.1cpkkd), < 300eV

CJPL



Before and after CDEX born



2015: Design of CDEX-1T (based on new CJPL space)

2014: CDEX-10 10kg Ge array + LAr shielding

2013: CDEX-1 preliminary result(without B/S and ACV)

2011: CDEX-1 Detector test and data taking

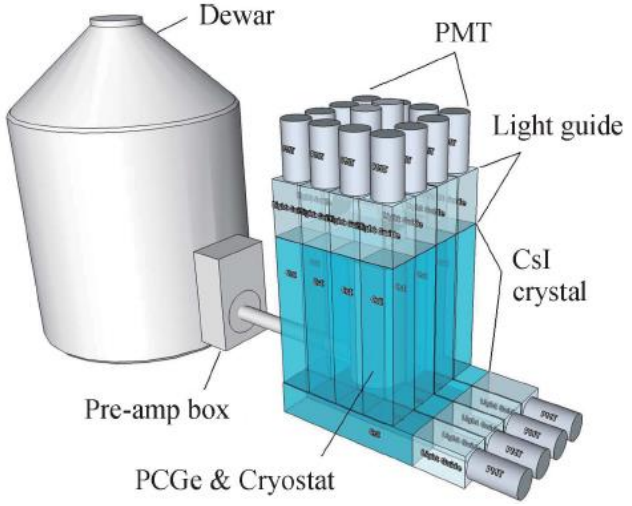
2010: CJPL run; CDEX-1 20g Array +1kg PPCGe

2009: CJPL planed; CDEX was born

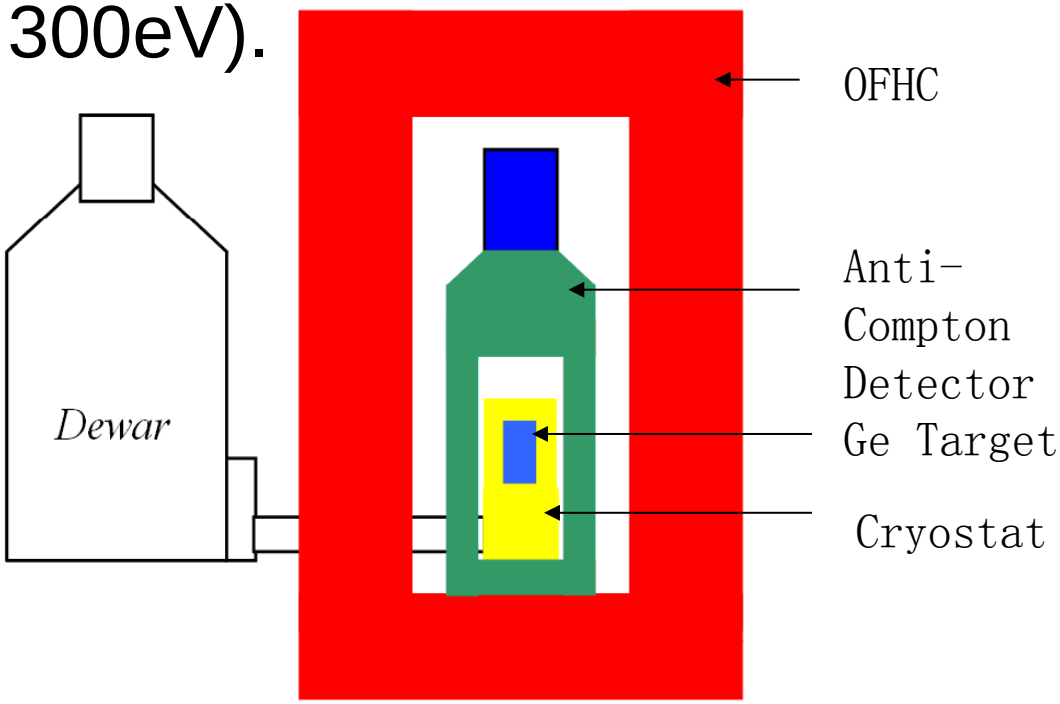
2005: 5g Ge det. run in Y2L, S. Korea

2003: Join in TEXONO and KIMS

CDEX-1kg @ CJPL



- ✓ Mass of Ge target: 20g, 1000g.
- ✓ Point-contact Ge detector with ultra-low energy threshold (< 300eV).
- ✓ Further ultra-pure crystal serve as active shielding and anti-compton detector.



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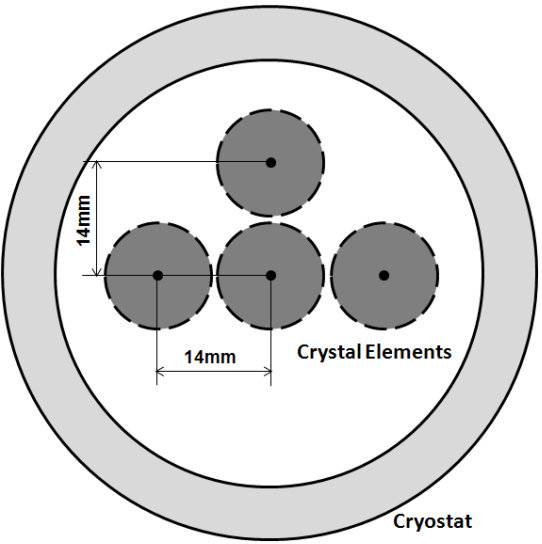
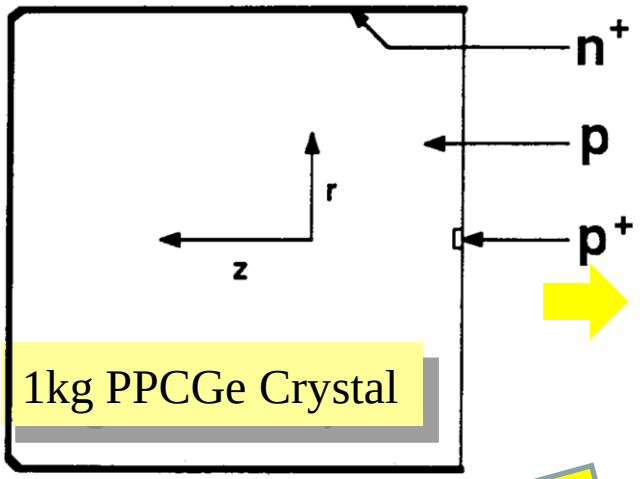
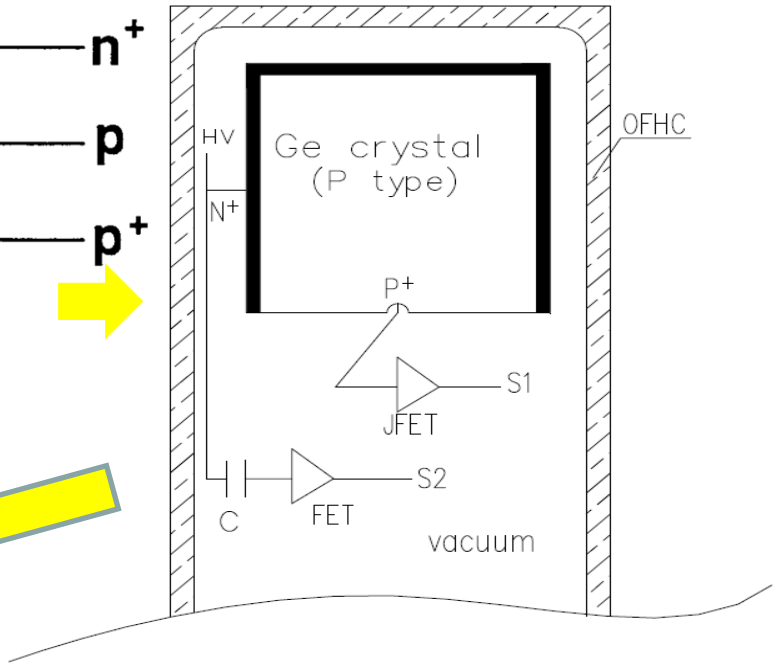
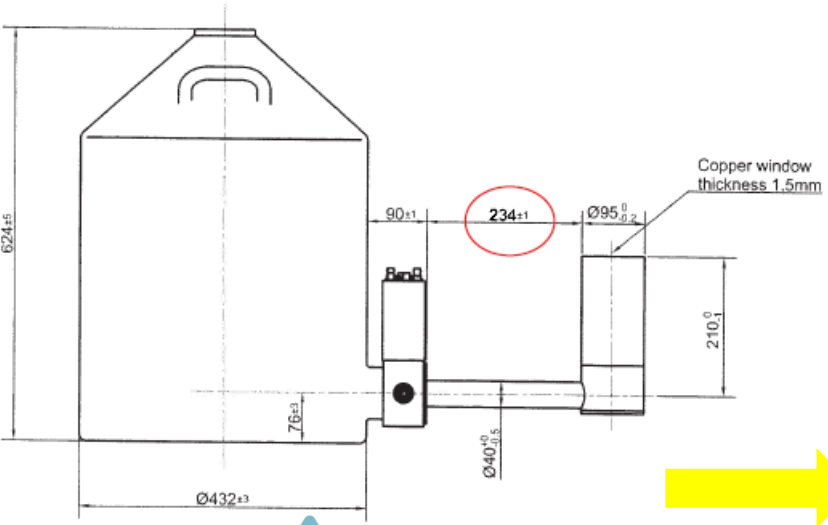


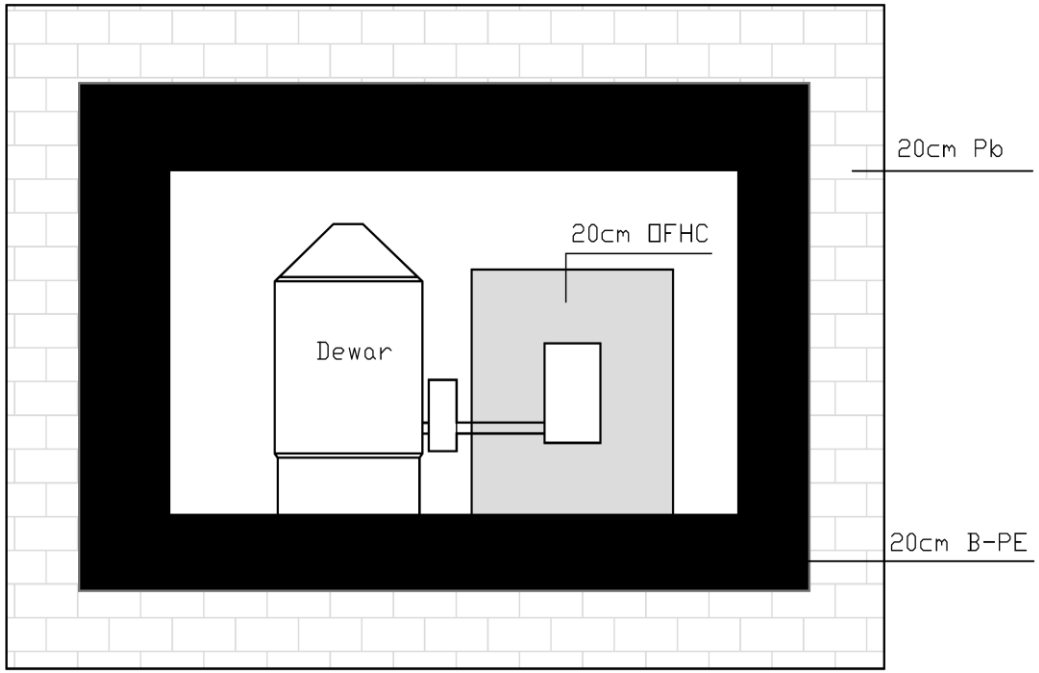


1kg PPCGe Crystal



20g PPCGe Crystal





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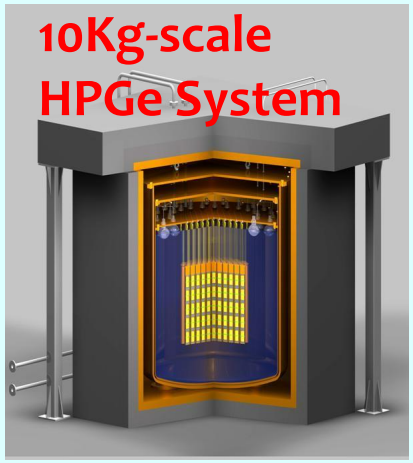
CDEX-1 Shielding System

PE shielding room



CDEX-1 Shielding system

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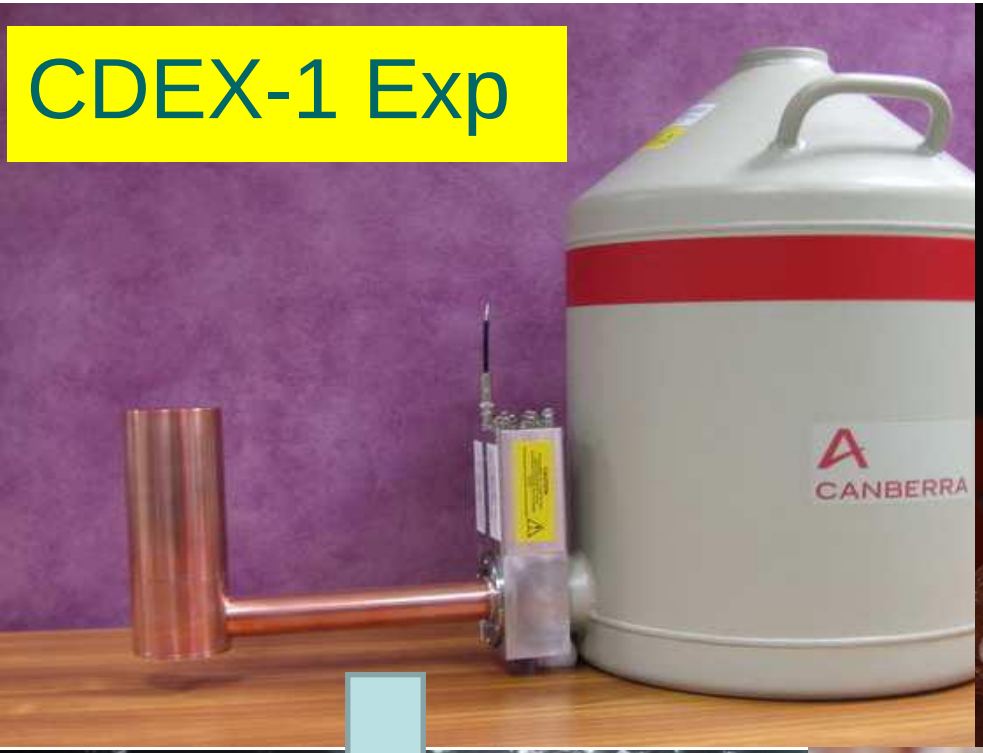
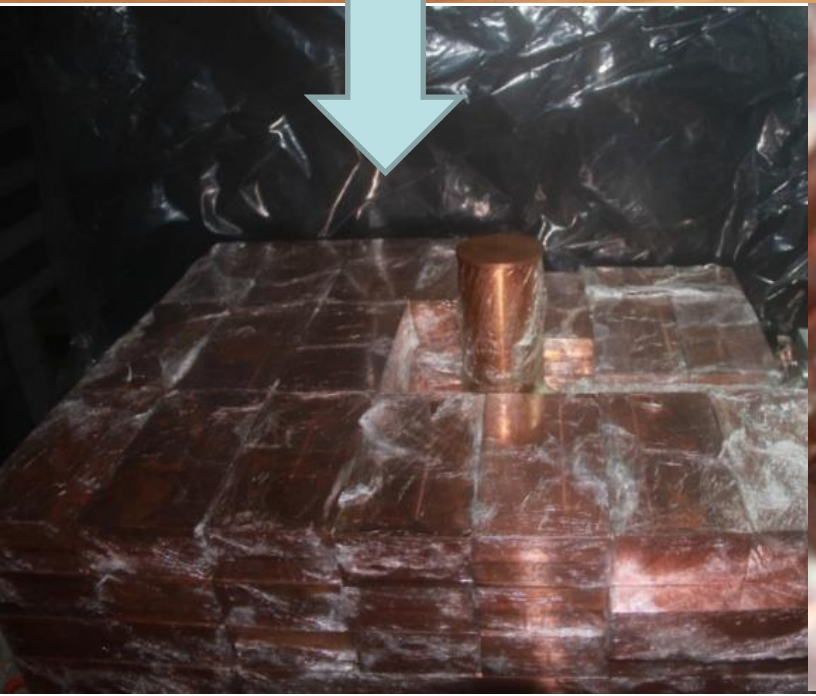
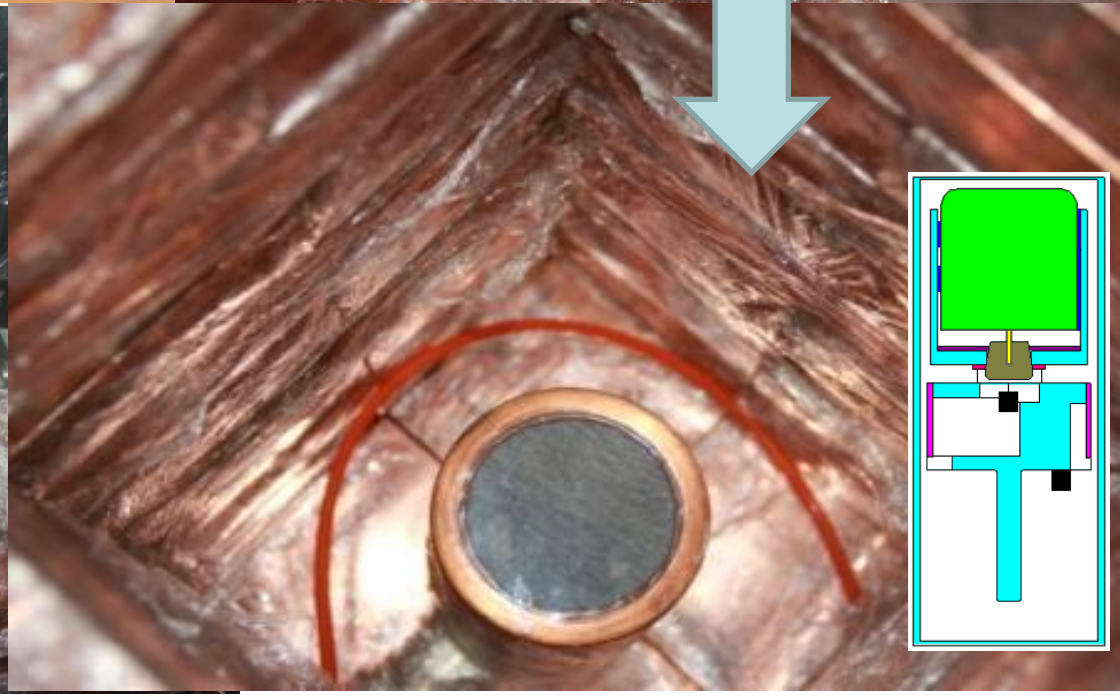
CDEX-1 Exp
1kg ULEGe
20g PCGe
20cm OFHC Copper
+20cm Lead

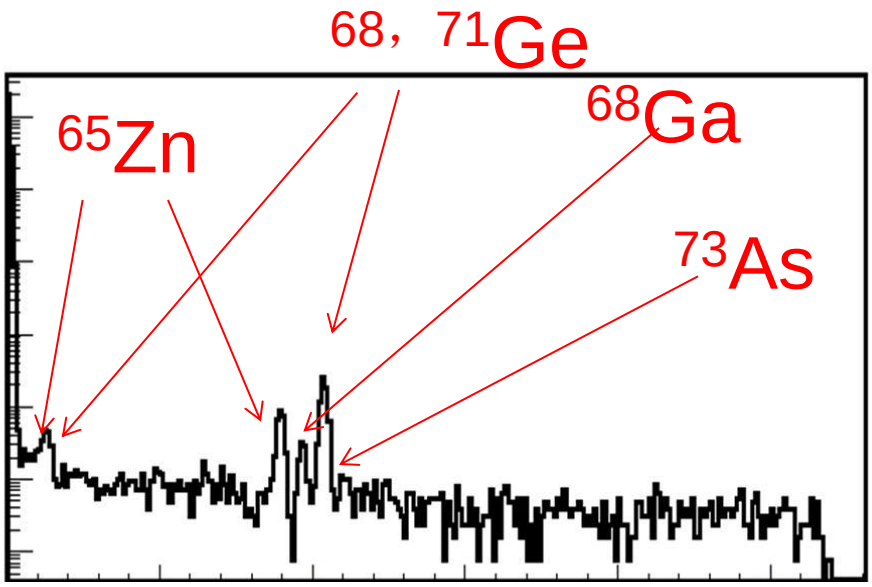
CDEX-1 Exp



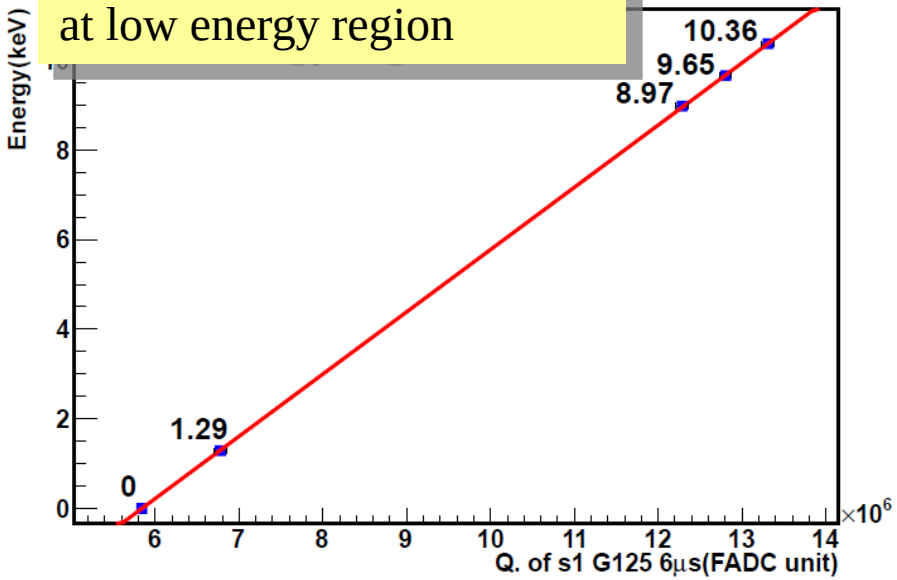


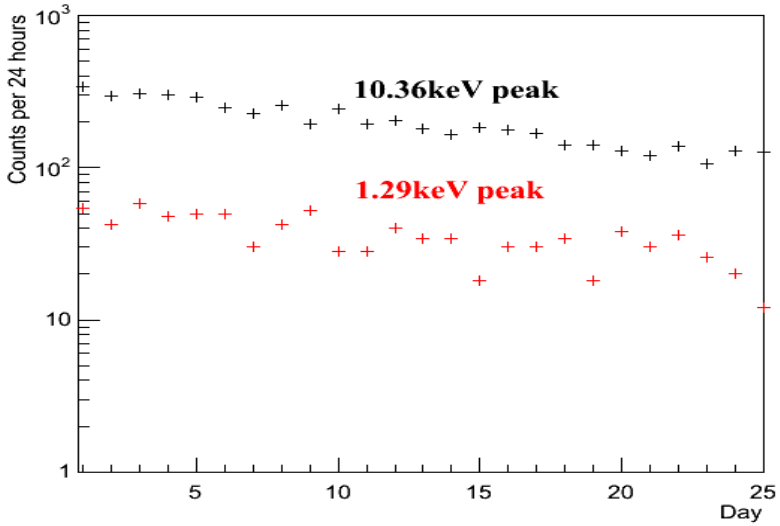


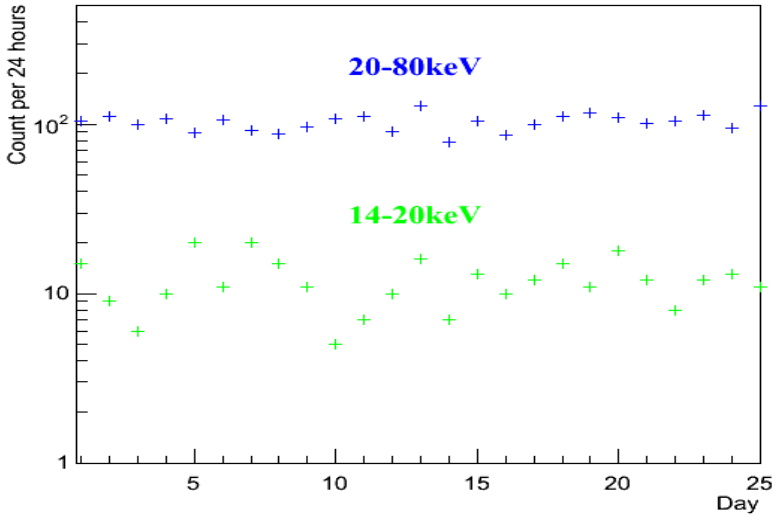
Background understand of PCGe detector



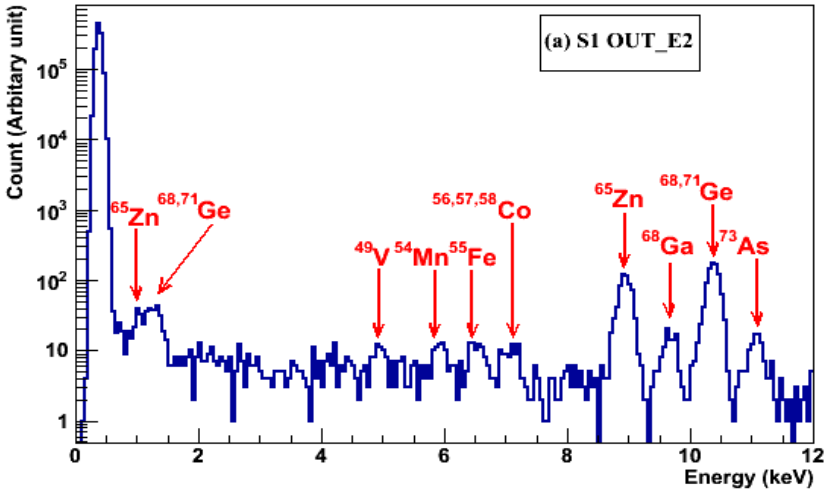
1kg PCGe energy spectrum at low energy region

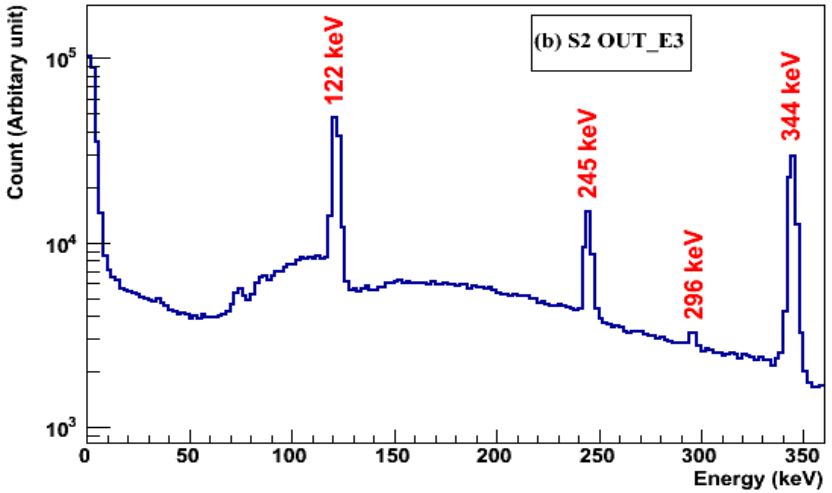


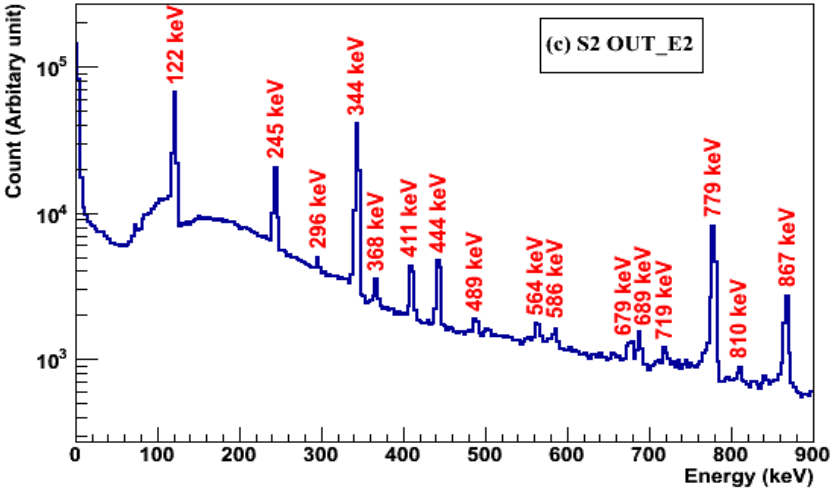


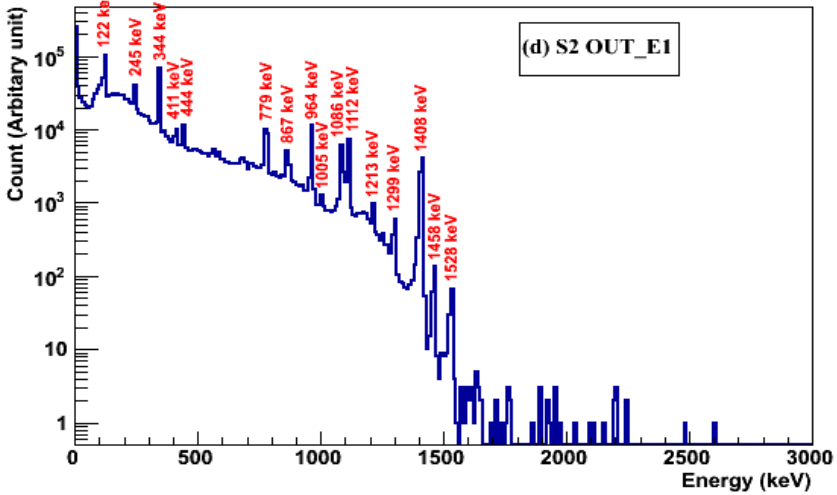


1kg-Ge Background spectrum

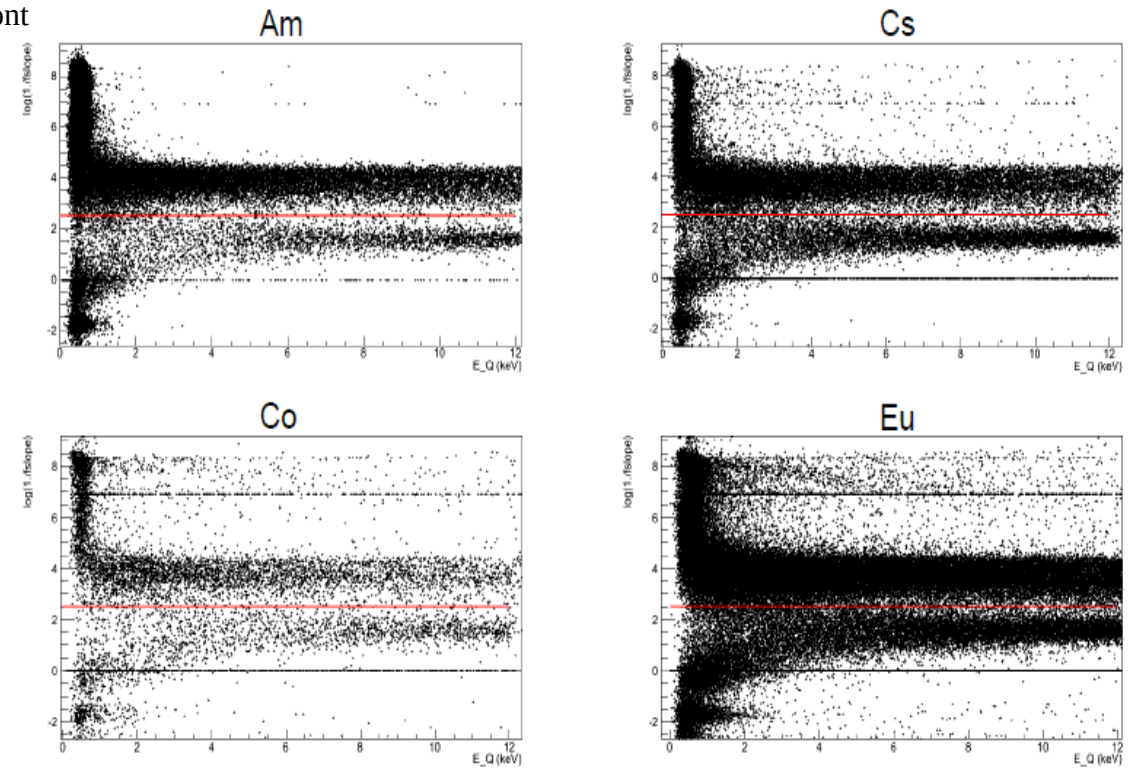








Bulk/surface discrimination



- Finished simulation

$d_{\text{front}} = d_{\text{side}} =$

0.0～1.5 mm

d=0.5 mm, m=955g
d=0.78mm, m=933g
d=1.16mm, m=905g

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PHYSICAL REVIEW D 88, 052004 (2013)

First results on low-mass WIMPs from the CDEX-1 experiment at the China Jinping underground laboratory

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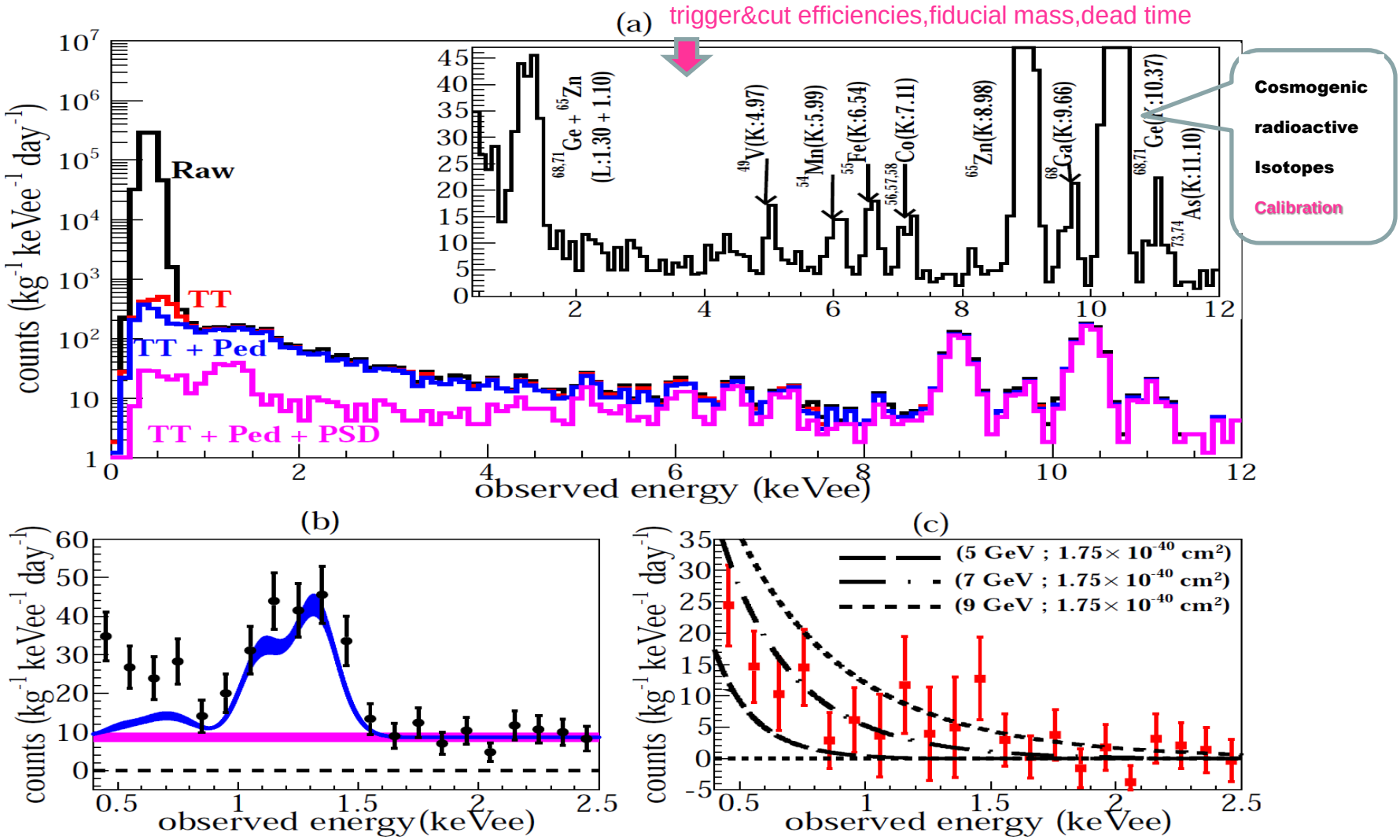
(Received 18 June 2013; published 9 September 2013)

The China Dark Matter Experiment Collaboration reports the first experimental limit on weakly interacting massive particles (WIMPs) dark matter from 14.6 kg-days of data taken with a 905 g p-type point-contact germanium detector at the China Jinping underground laboratory where the rock overburden is more than 2400 m. The energy threshold achieved was 400 eVee. According to the 14.6 kg-day live data, we placed the limit of $\sigma_{\chi N} = 1.75 \times 10^{-40}$ cm^2 at a 90% confidence level on the spin-independent cross section at a WIMP mass of 7 GeV before differentiating bulk signals from the surface backgrounds.

DOI: 10.1103/PhysRevD.88.052004 PACS numbers: 95.35.+d, 29.40.Wk

TT: time intervals between the event and its nearest prior and post-inhibit signals.

CDEX-1 low energy spectra



CJPL

Calculated L-shell background from ratios of K-shell to L-shell x-ray events

γ background with statistical error band

B/S~2-3

Dead layer

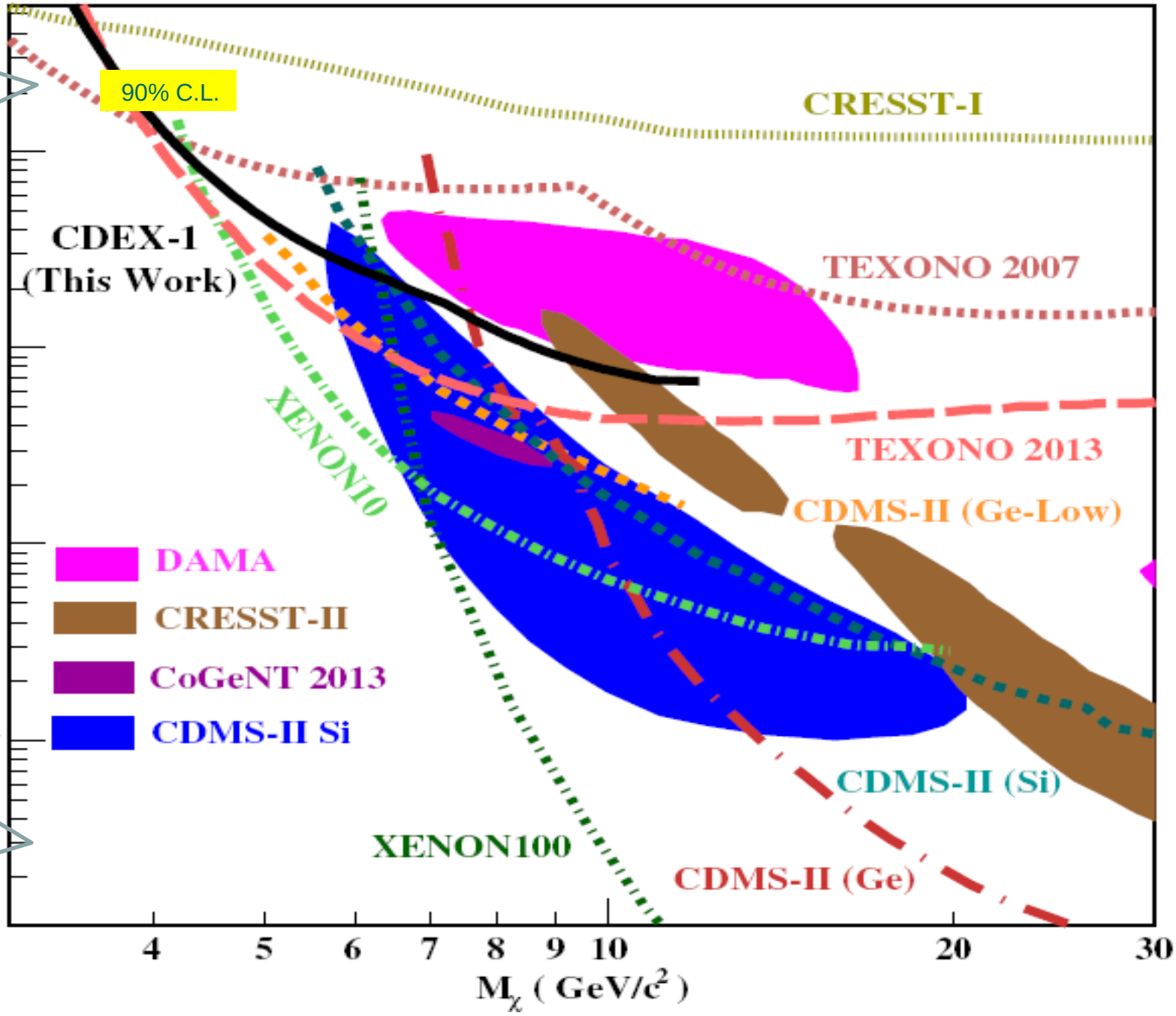
1.16mm ?

More data for

redidual

spectrum

AC detector?



20gGe + AC

6 month data

Data taking

& analysis

Publish in

Next month

1kg no AC

New result

this month

1kg +AC

C.L

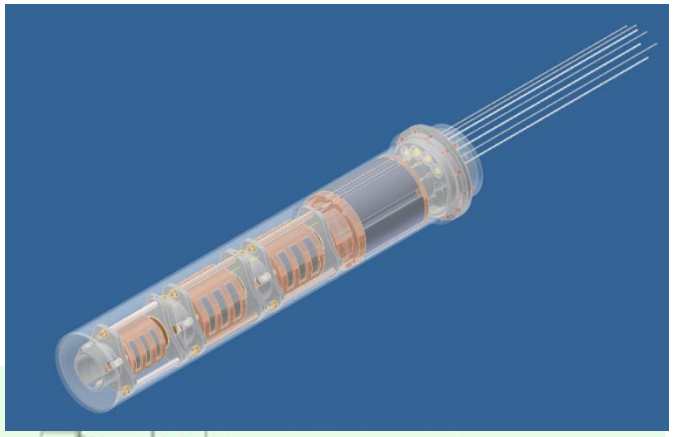
CDEX-10kg Experiment

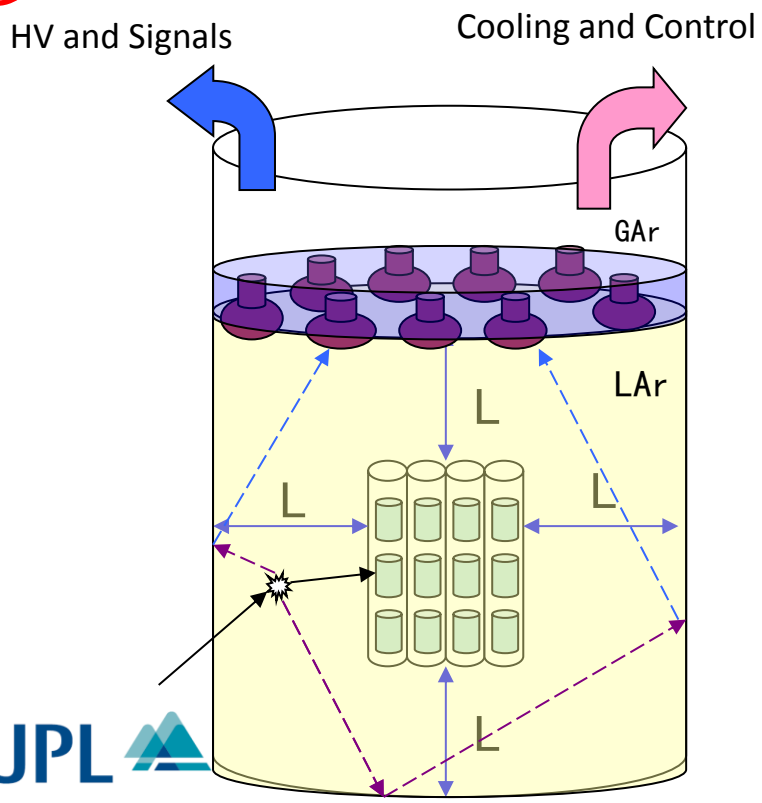
Ge: Encapsuled into copper vacuum tube.

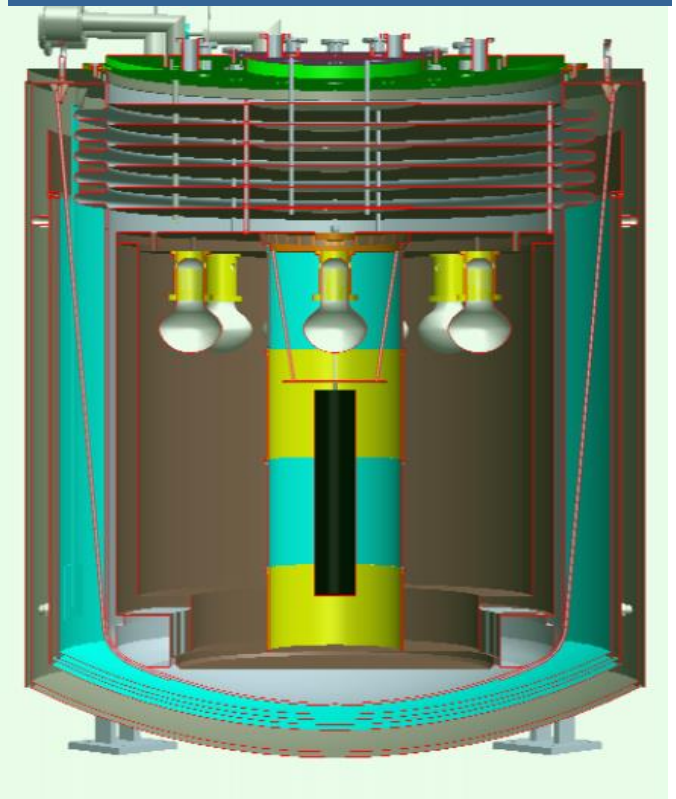
LAr: Passive shielding +Active shielding.

PMT: Detecting ~420nm light

WLS: Transfering 128nm light to~420nm light.

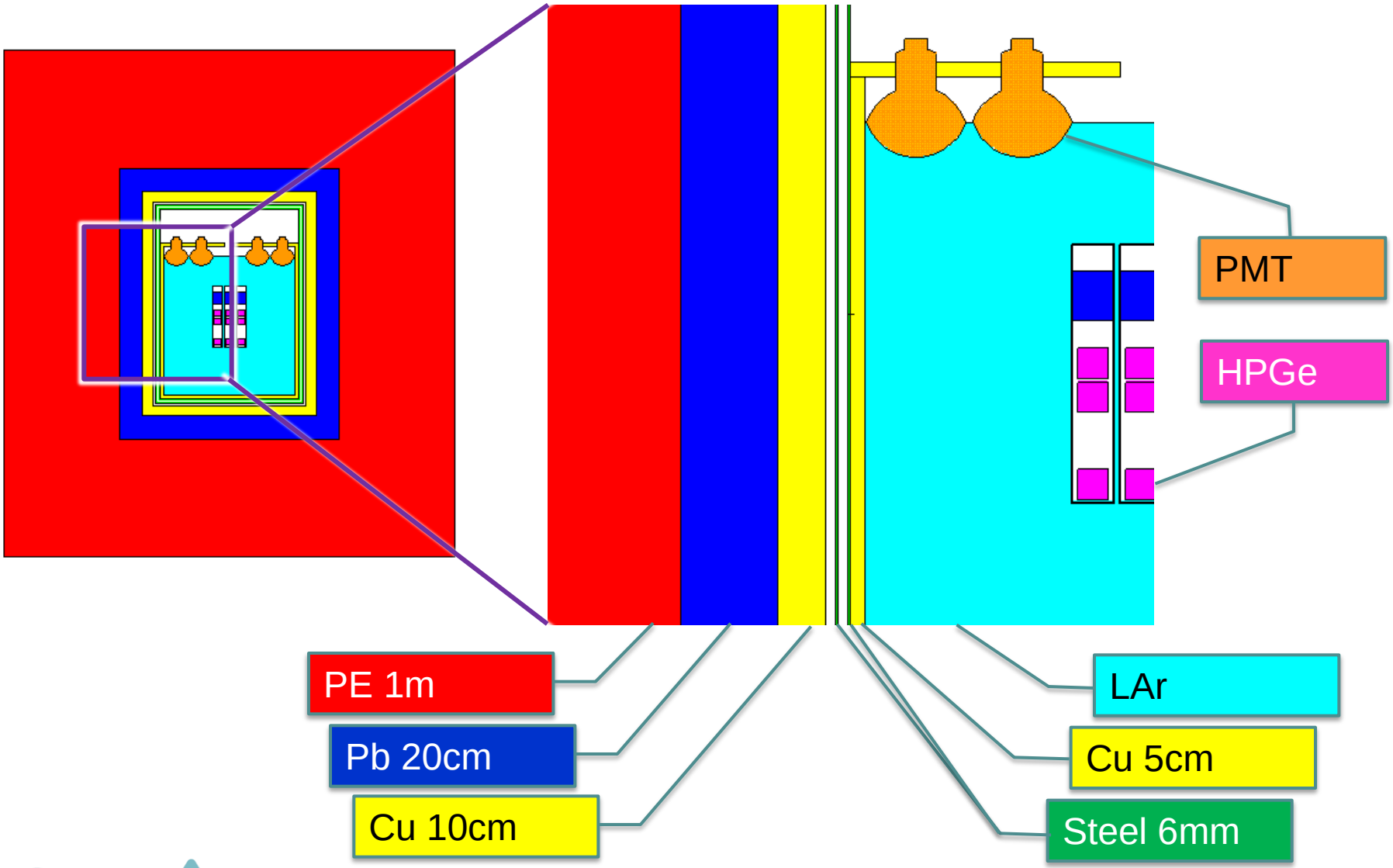






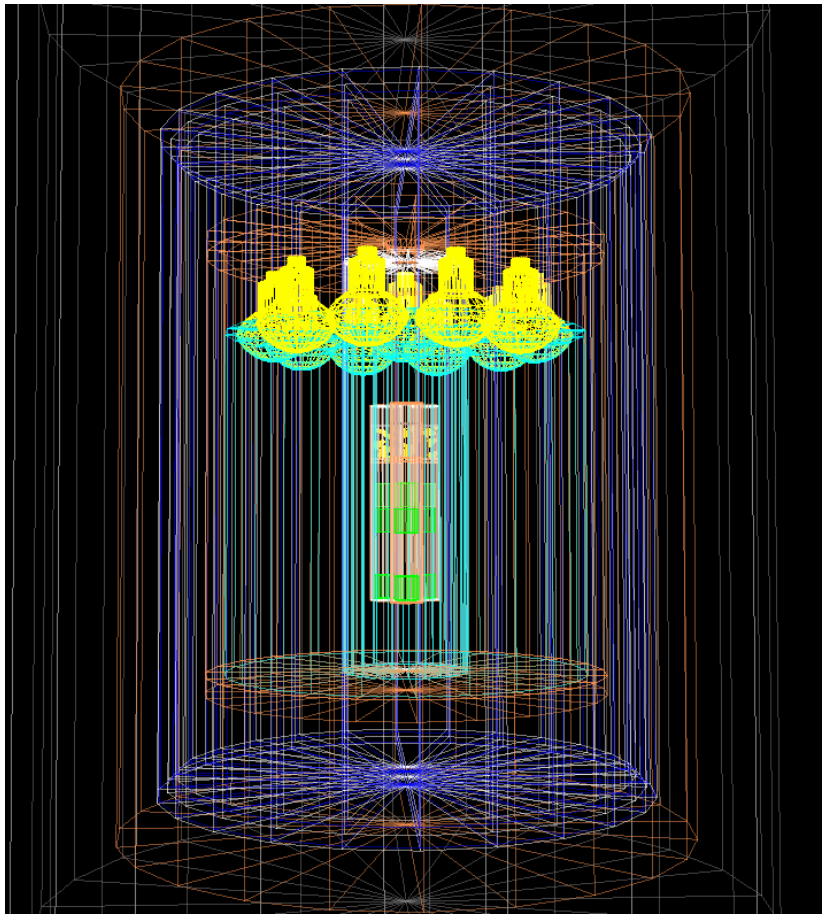
CJPL

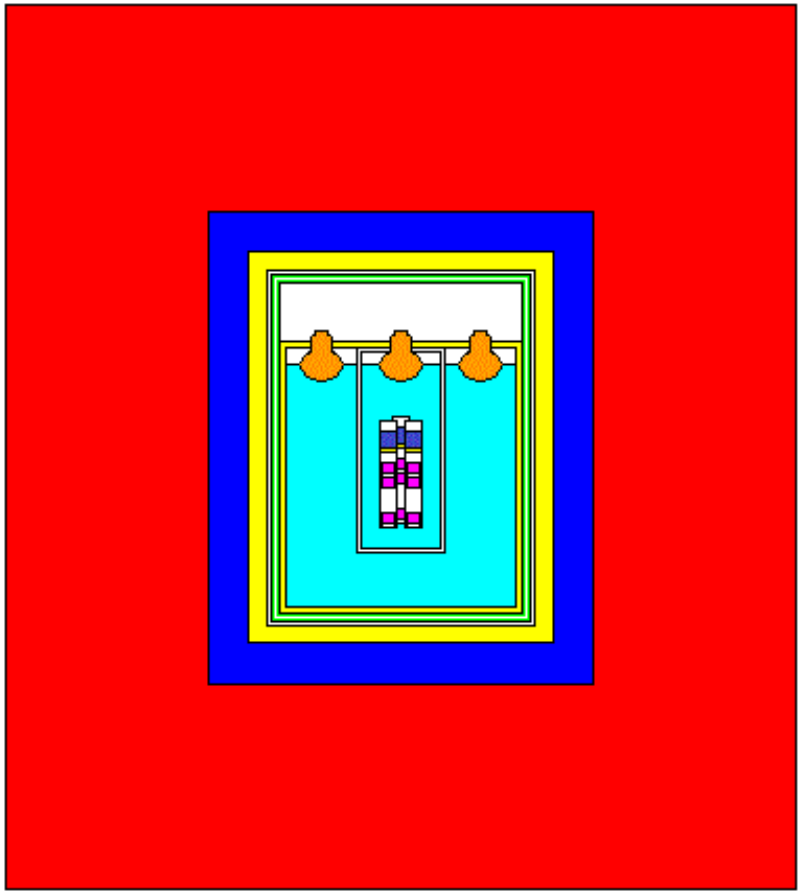
CDEX shielding system



CJPL

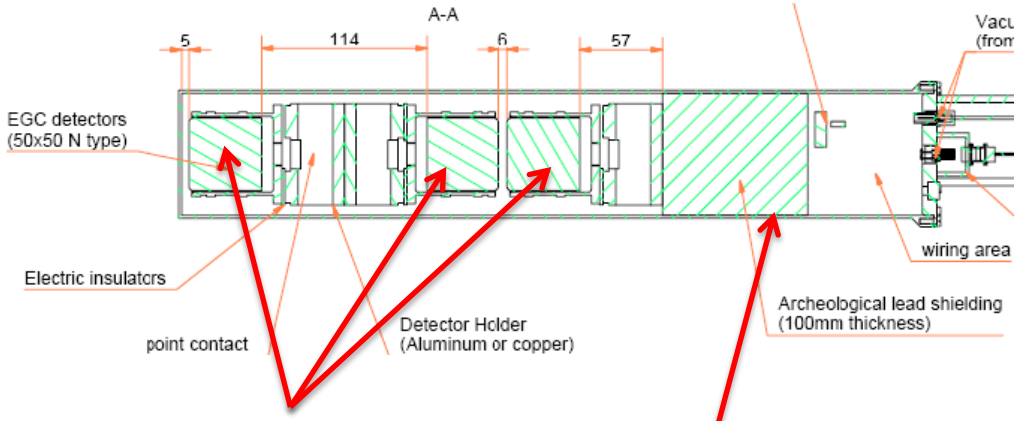
CDEX-10 simulation



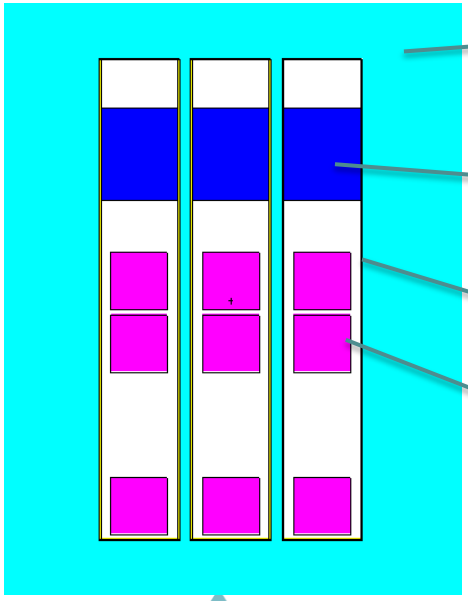


CJPL

PCGe detector



HPGe crystal

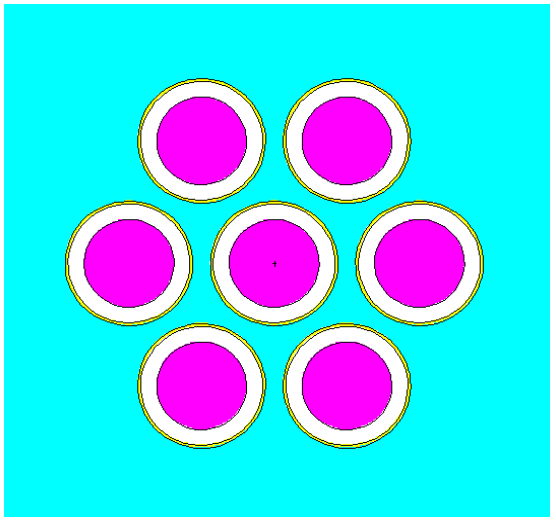


LAr

9mmLead + 1mm

Cu 2mm

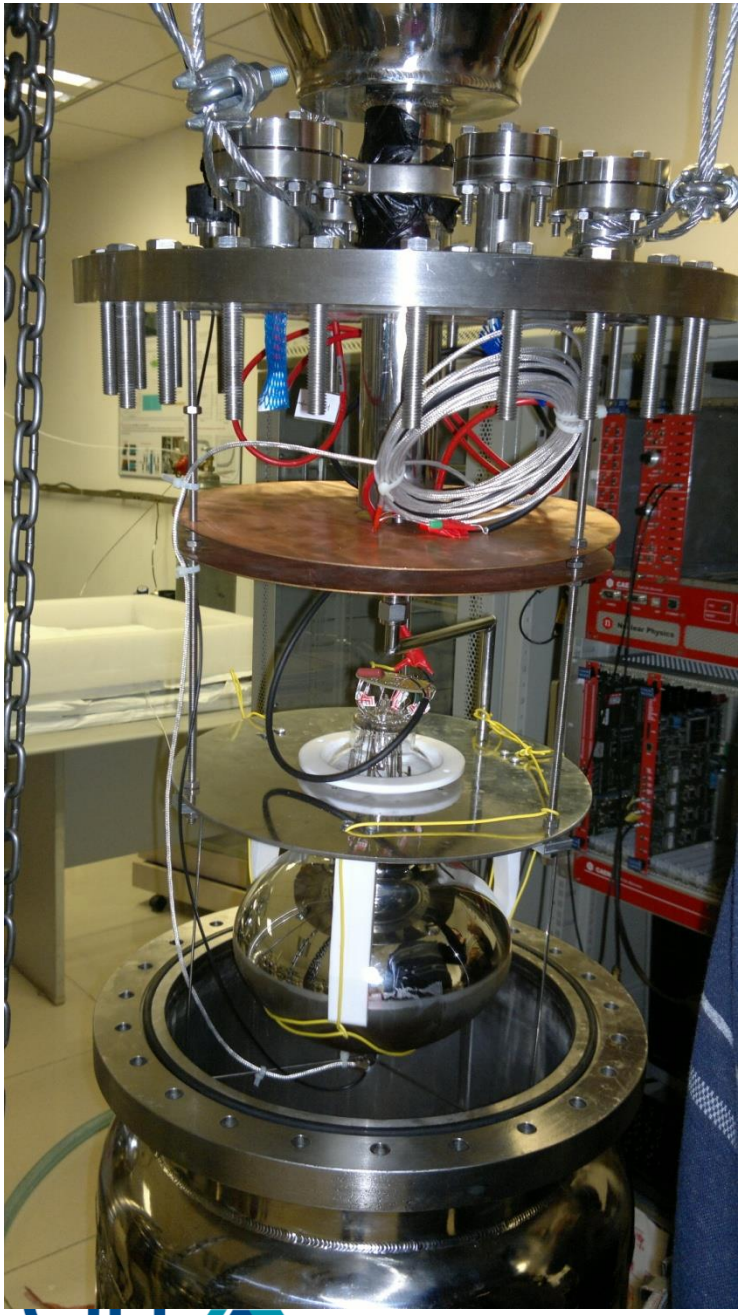
HPGe (1kg)



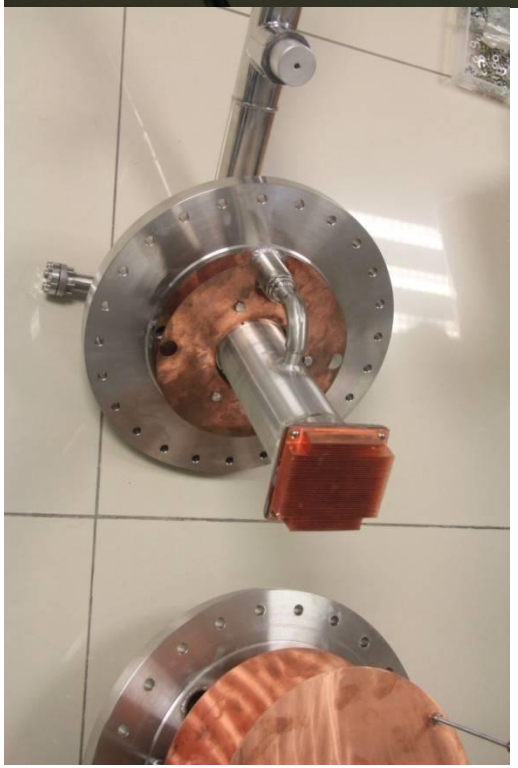
CJPL

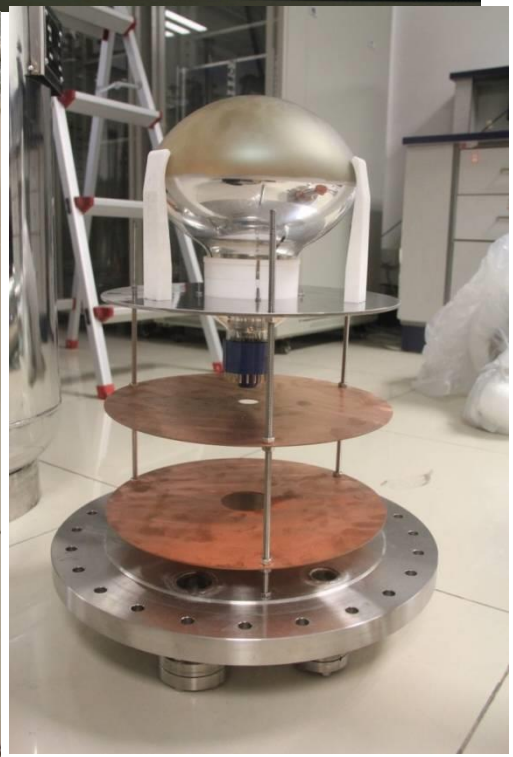
LAr AC detector

CJPL

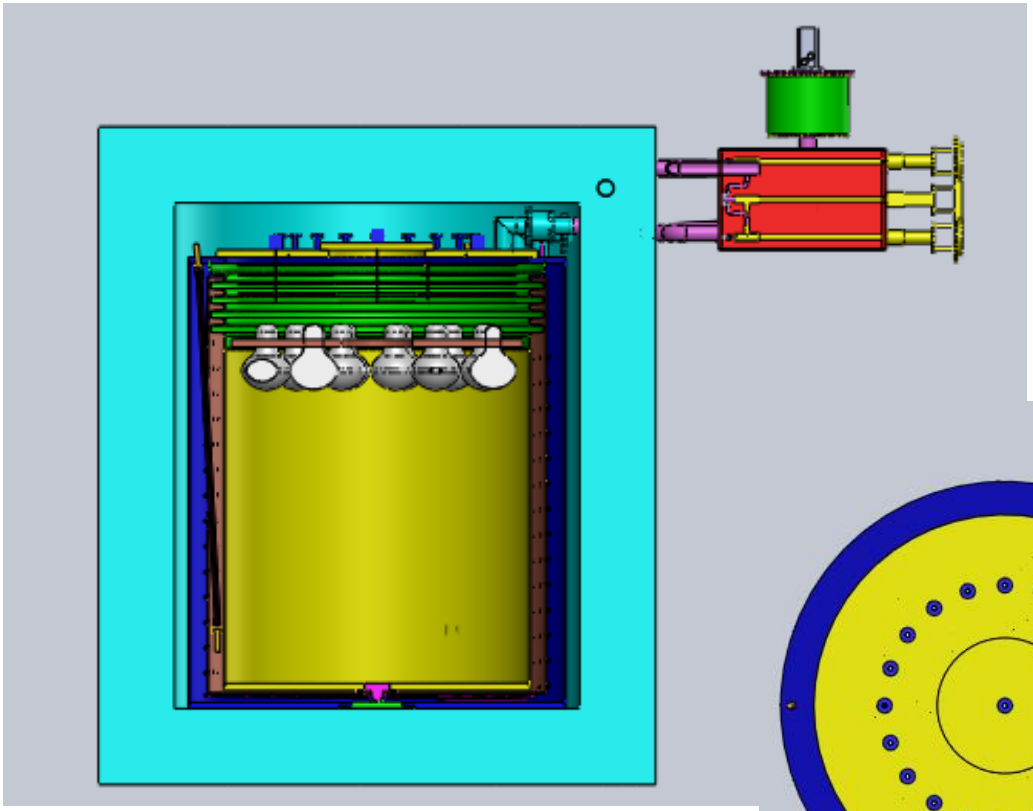


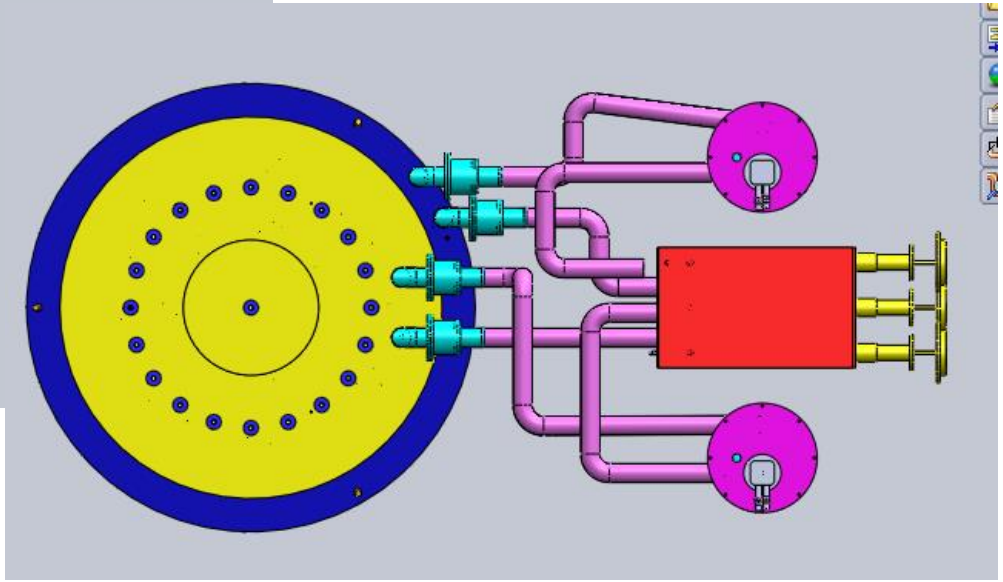

XMZ604
智能显示仪
J1
J2
COM
197.9
SET





CDEX-10 LAr AC system



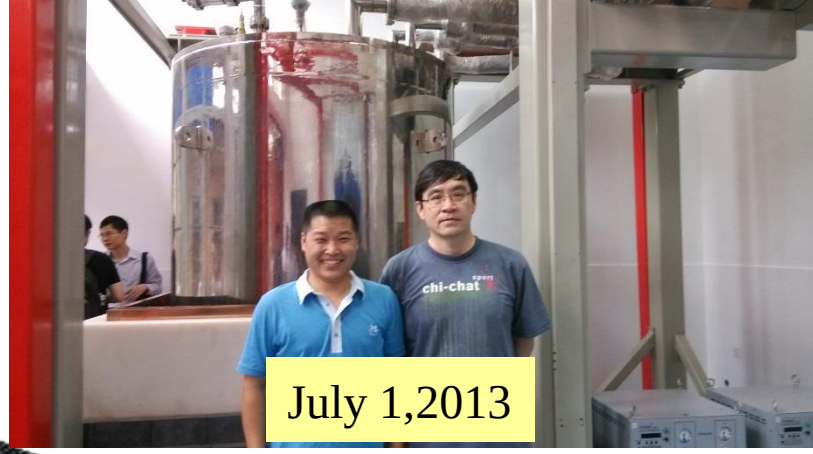


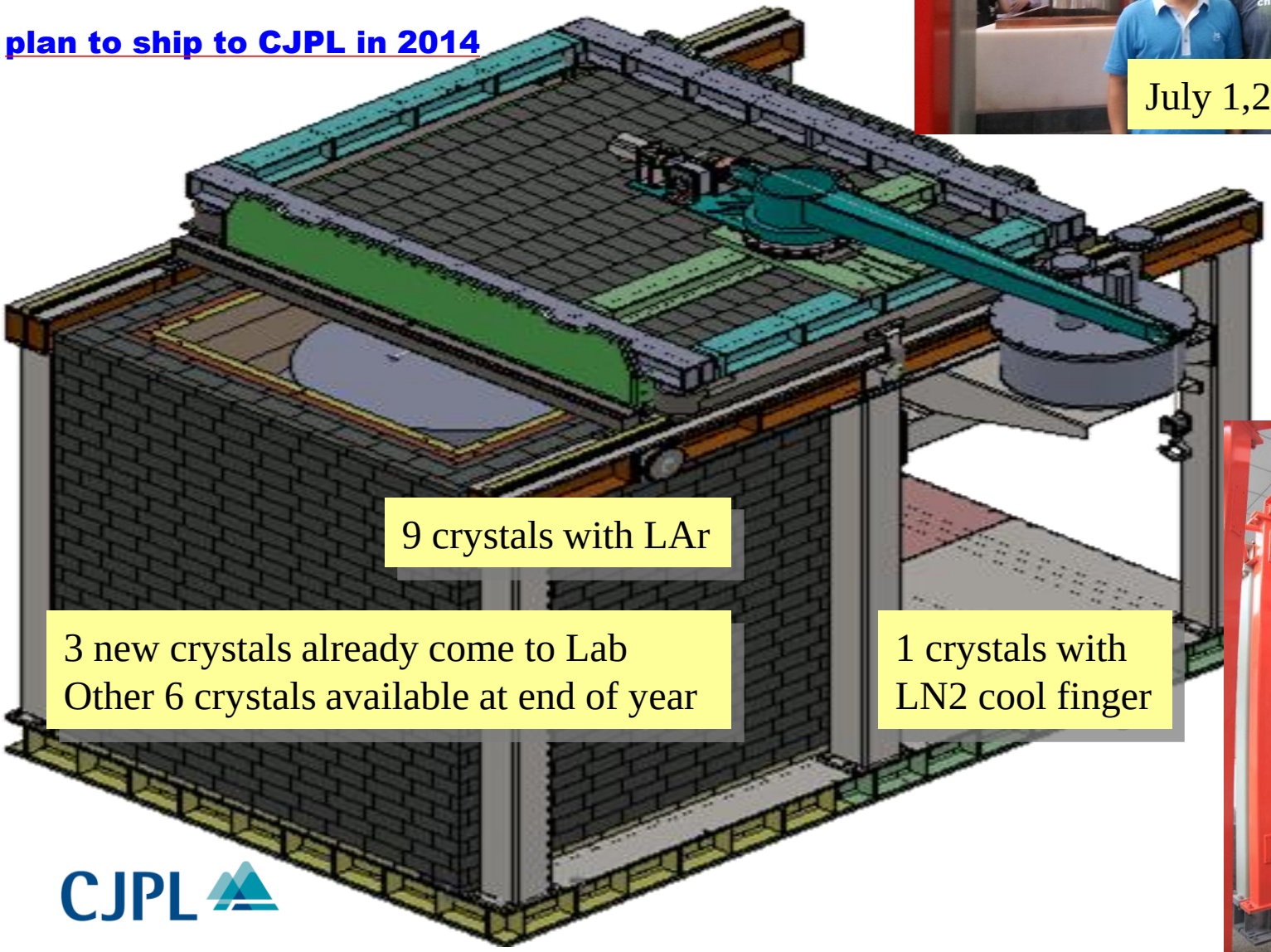
CJPL

CDEX-10 Layout

Ground testing at SCU starts from this May

plan to ship to CJPL in 2014



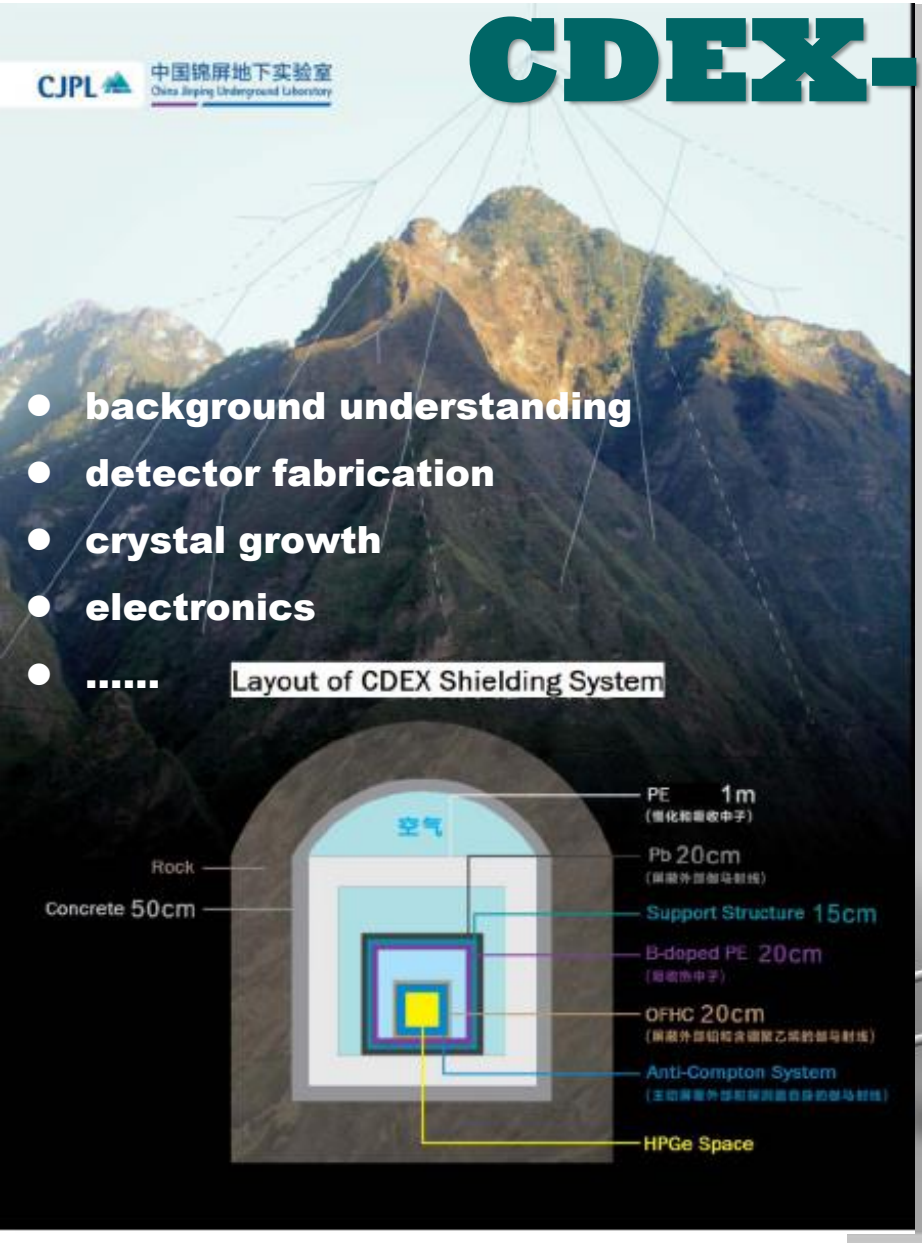


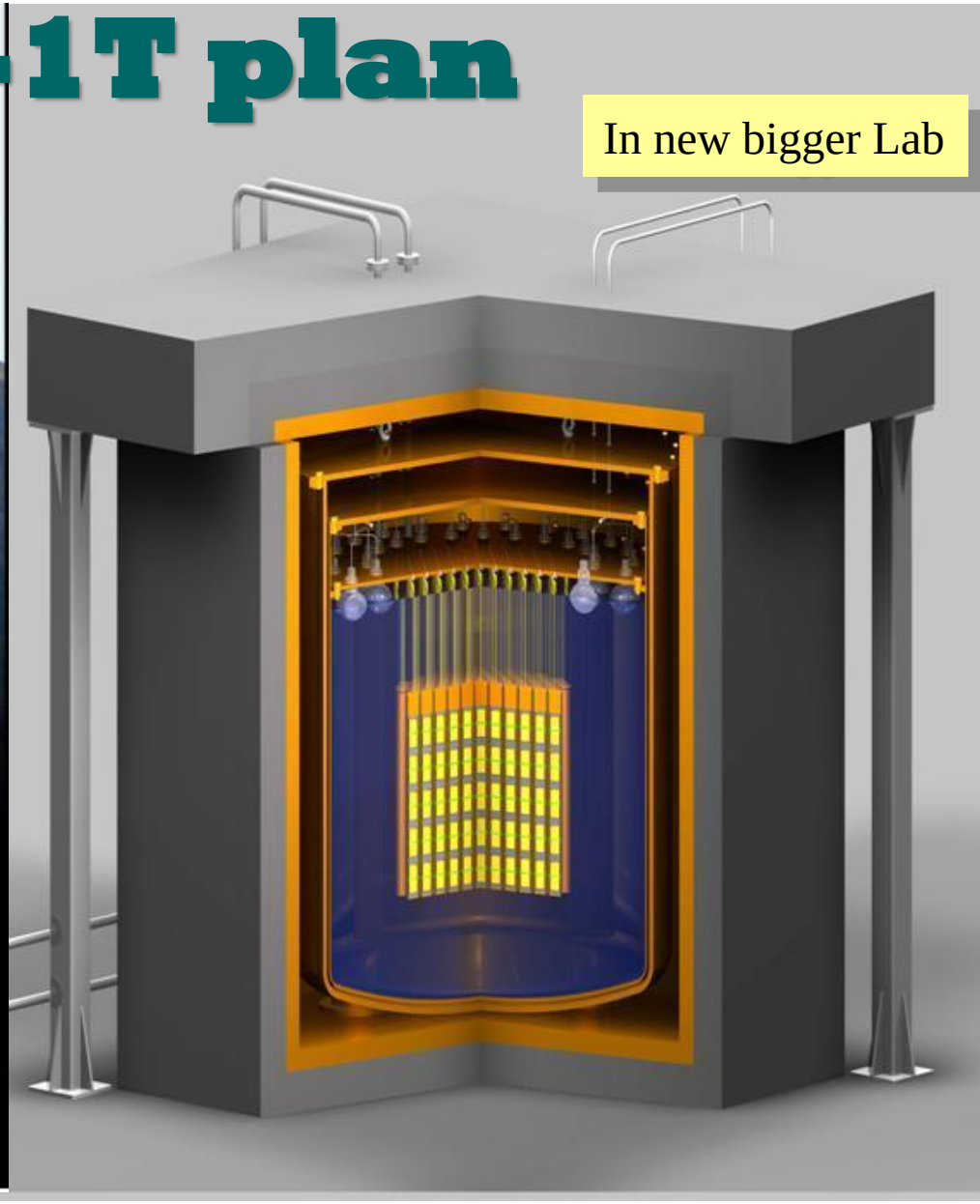
CJPL

CDEX-1T plan

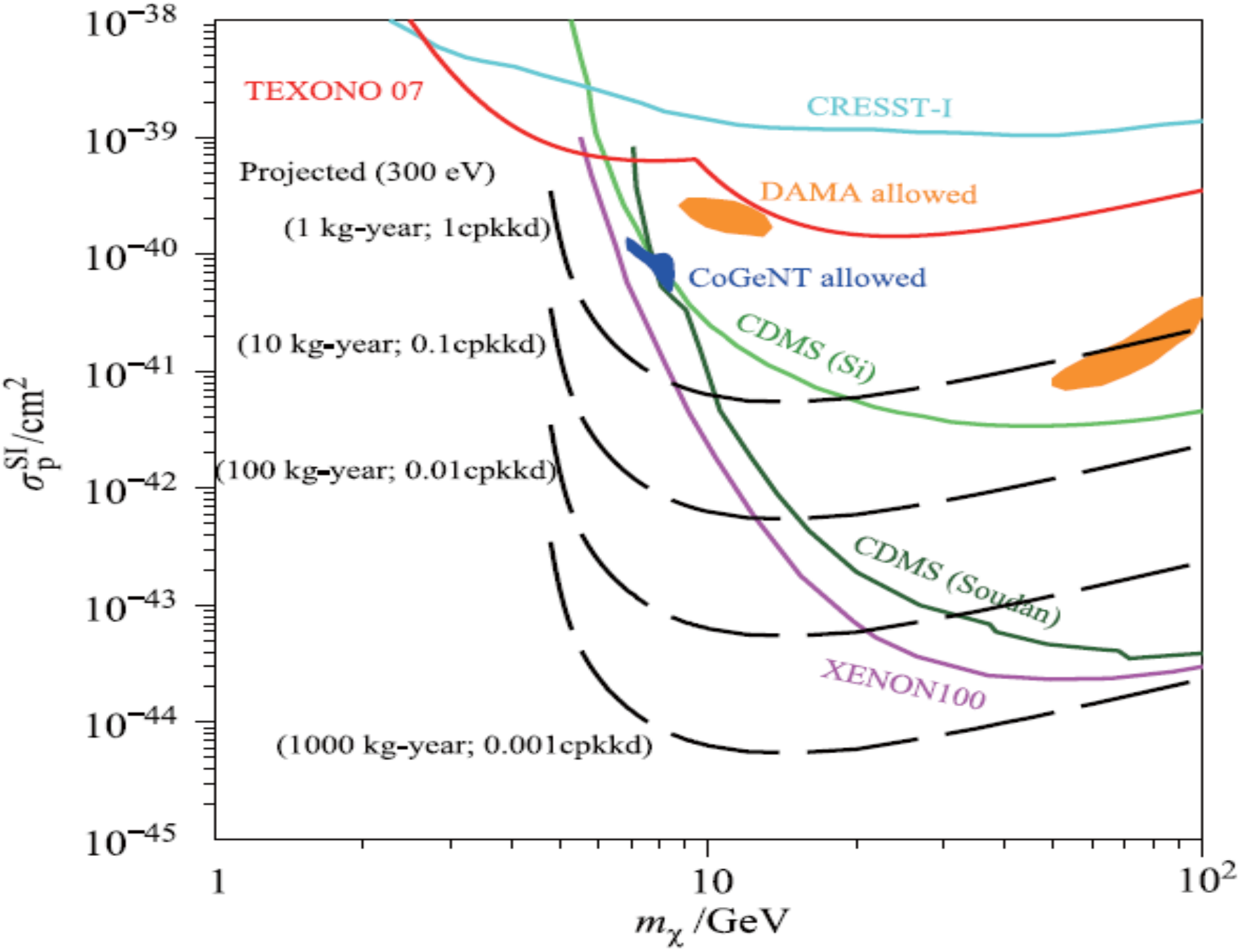
In new bigger Lab

- background understanding
- detector fabrication
- crystal growth
- electronics
- ……





CJPL


TEXONO 07
CRESST-I
Projected (300 eV)
(1 kg-year; 1cpkkd)
DAMA allowed
CoGeNT allowed
(10 kg-year; 0.1cpkkd)
CDMS (Si)
(100 kg-year; 0.01cpkkd)
CDMS (Soudan)
XENON100
(1000 kg-year; 0.001cpkkd)
10^{-38}
10^{-39}
10^{-40}
10^{-41}
10^{-42}
10^{-43}
10^{-44}
10^{-45}
σ_p^{SI}/cm^2
1
10
10^2
m_χ /GeV

Summary

- CJPL with deepest rock overburden in the world run now. CJPL-II with 20 times space under design.
- CDEX has started CDEX-1 experiment, and a first physics result is already published.
- CDEX-10 (PCGe+Lar AC) already start ground testing at SCU from this May and plan to ship to CJPL in 2014.
- CDEX-1T related technologies has been exploited by CDEX including background understanding, detector fabrication, crystal growth, electronics and so on.

CJPL

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

Thank you for your attention!