



中国锦屏地下实验室
China Jinping Underground Laboratory
清华大学·雅砻江流域水电开发有限公司



清华大学
Tsinghua University



Introduction of CJPL and its low background facilities

Wenhan Dai (dai-wh@tsinghua.edu.cn)
Department of Engineering Physics
Tsinghua University

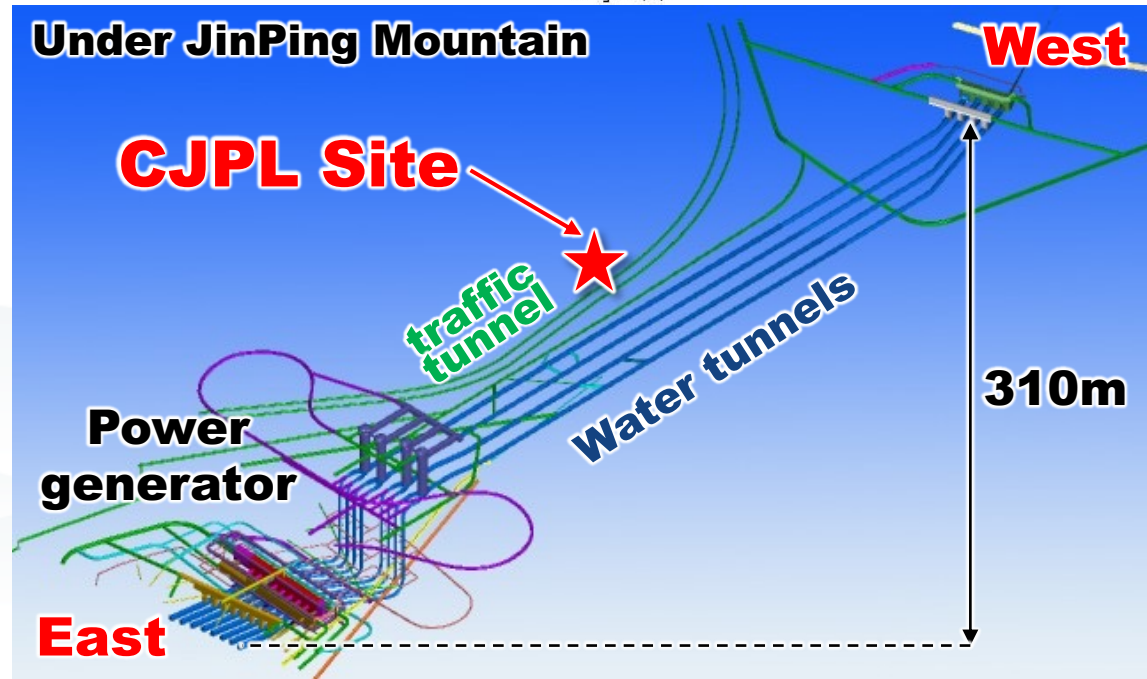
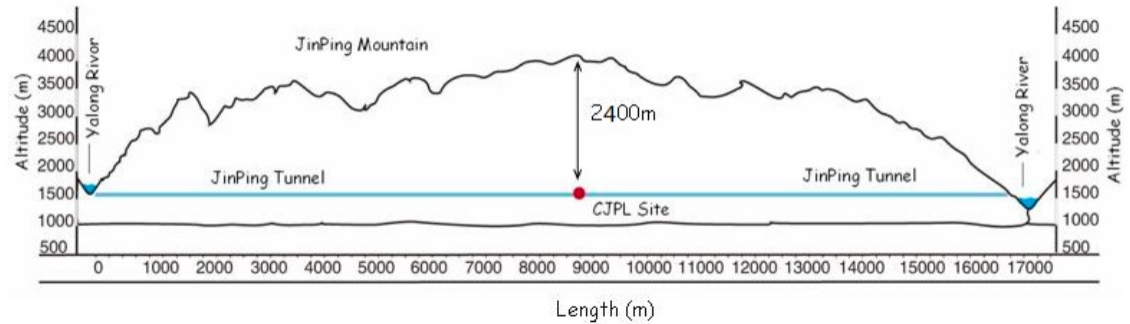
2026/09/21

Low Radioactivity Techniques (LRT2026)

Deep Underground Lab Worldwide

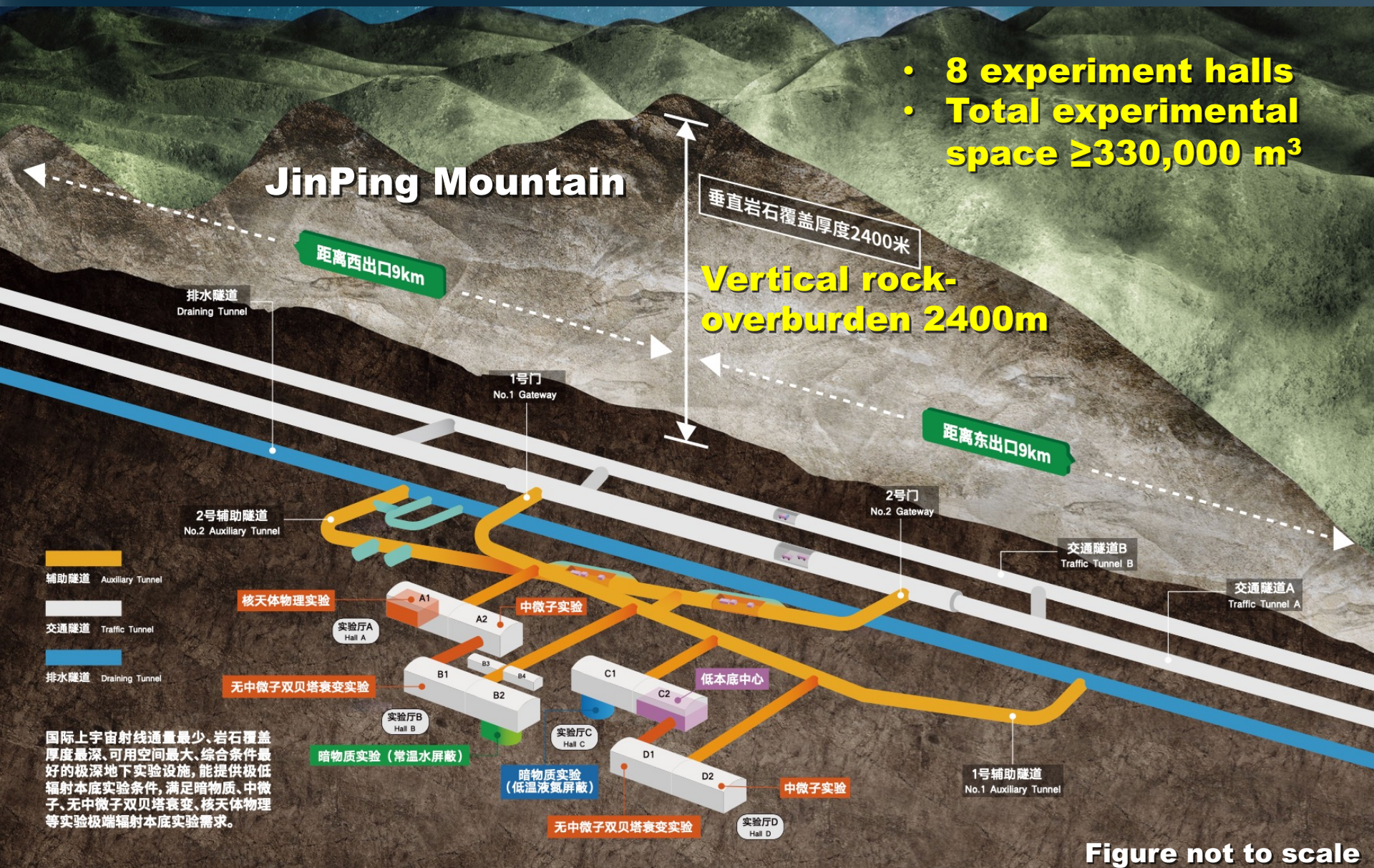


China JinPing Underground Lab(CJPL)



Yalong river hydropower development company
dig tunnels under Jinping Mountain to generate power

Deep Underground and ultra-low Radiation background Facility for frontier physics experiments (DURF)



JinPing Tunnel View

West Tunnel Entrance



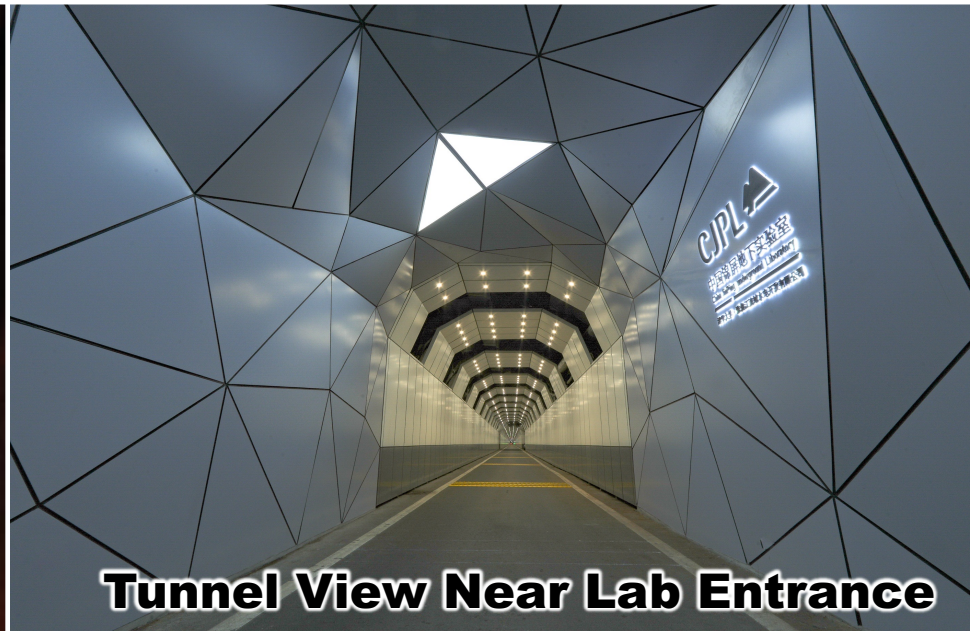
Inside Lab



17.5 km Tunnel



Tunnel View Near Lab Entrance



Experiment Hall

Hall-A1



Hall-B2



Hall-C1



Service Tunnel



Muon flux at CJPL

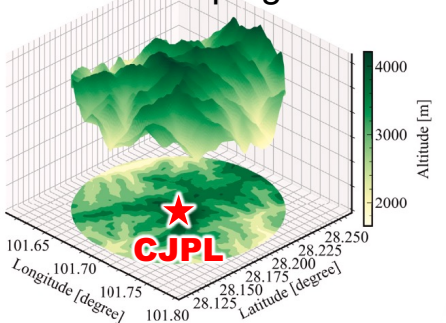
Measured μ -flux at CJPL:

$$3.03 \pm 0.24(\text{stat}) \pm 0.18(\text{sys}) \times 10^{-10} \text{ cm}^{-2} \text{ s}^{-1}$$

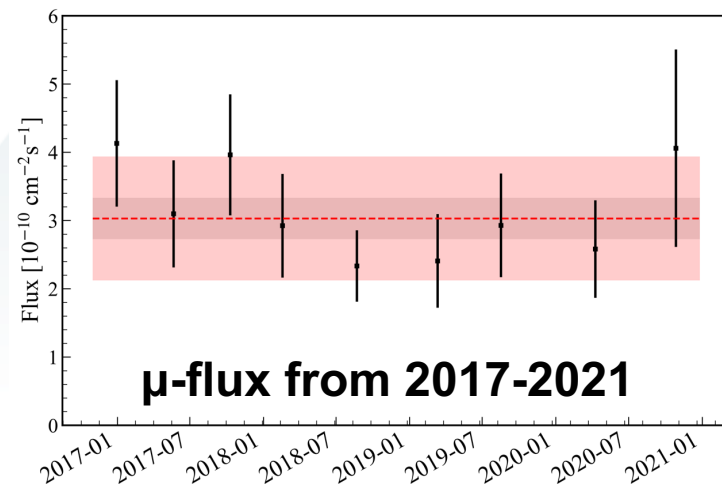
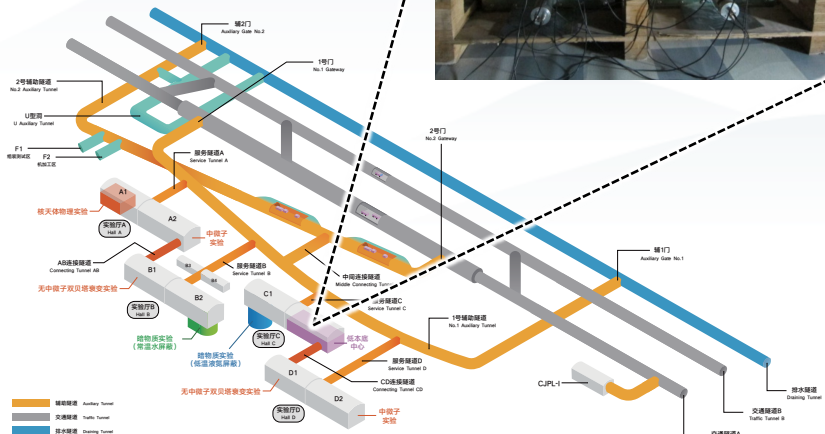
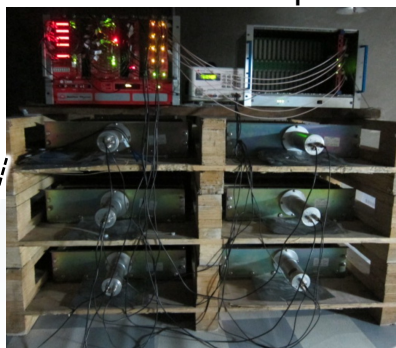
$$= 95.5 \pm 7.6(\text{stat}) \pm 5.6(\text{sys}) \text{ m}^{-2} \text{ yr}^{-1}$$

Astro. Phys. 172, 103147, (2025)

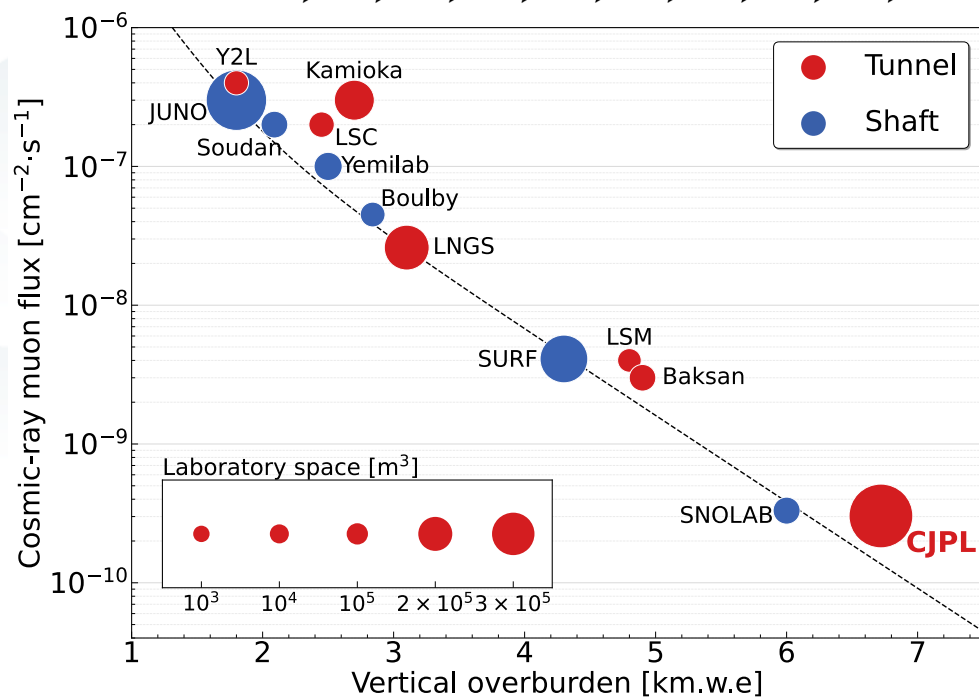
Model of Jinping mountain



plastic scintillator muon telescope

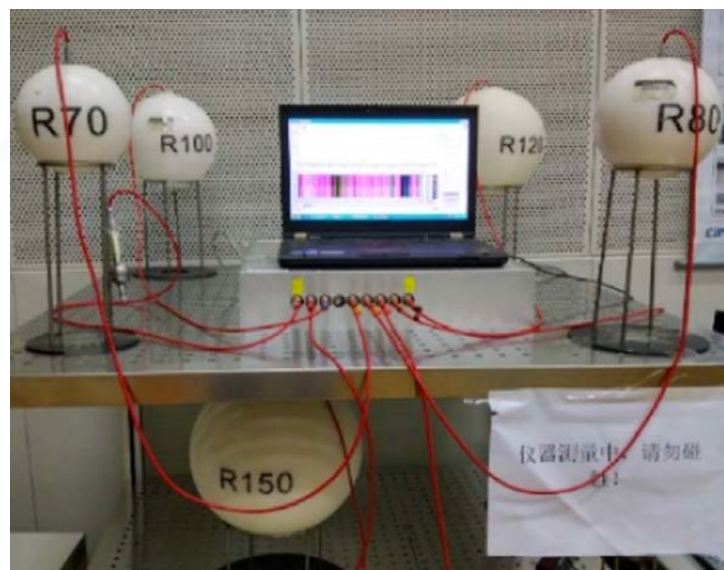


μ -flux from 2017-2021



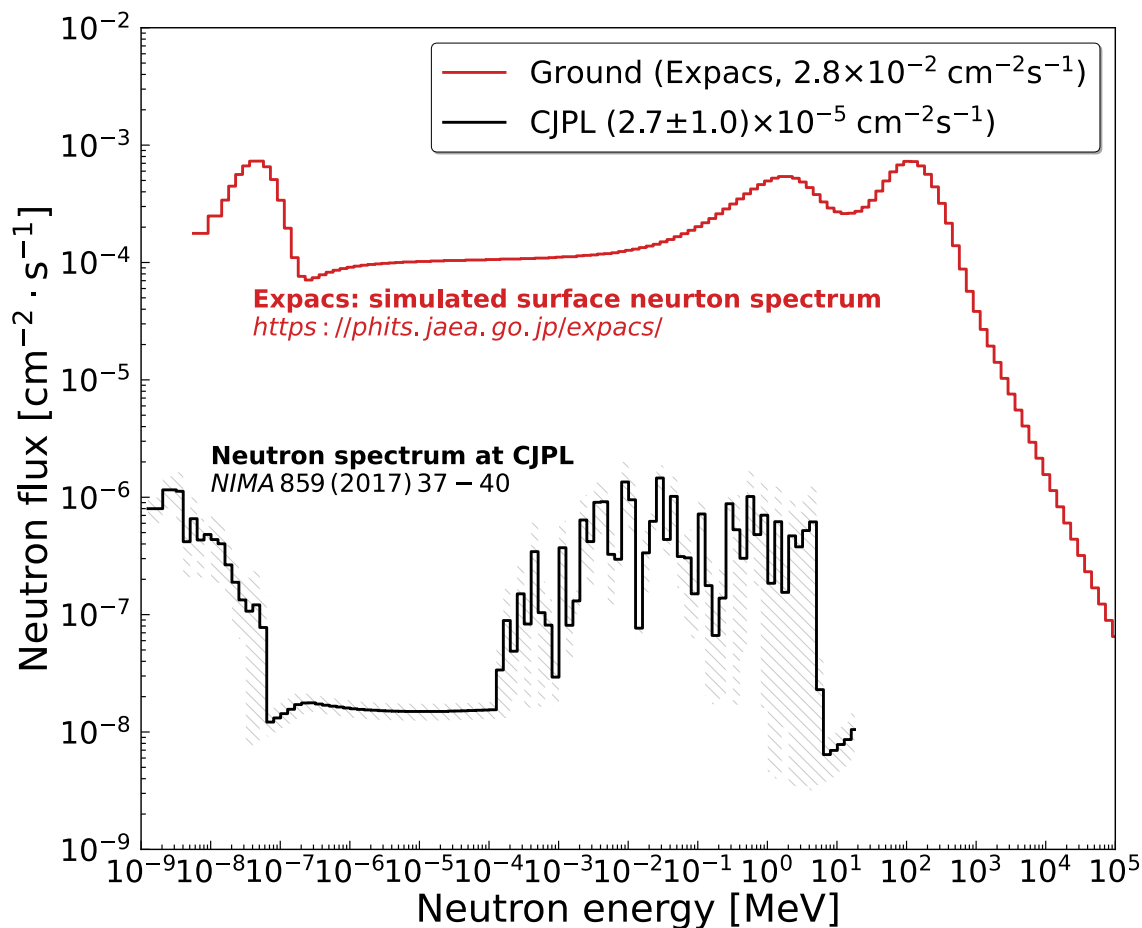
Neutron flux at CJPL

**CJPL total neutron flux $\sim(2.7\pm0.1)\times10^{-5} \text{ cm}^{-2}\text{s}^{-1}$
~1000 times lower than ground level**



**Neutron flux in CJPL
measured by a Bonner
multi-sphere spectrometer**

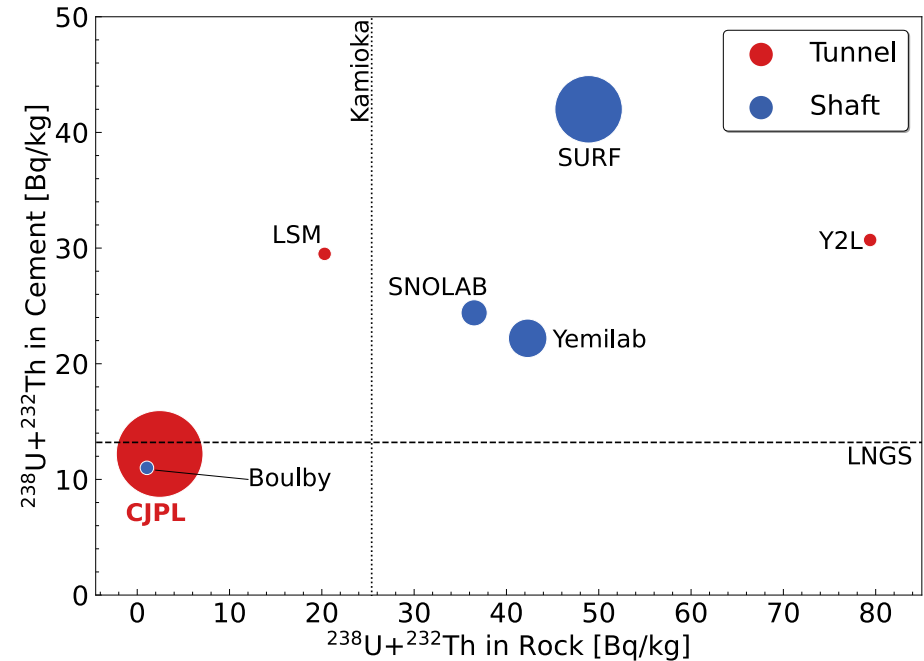
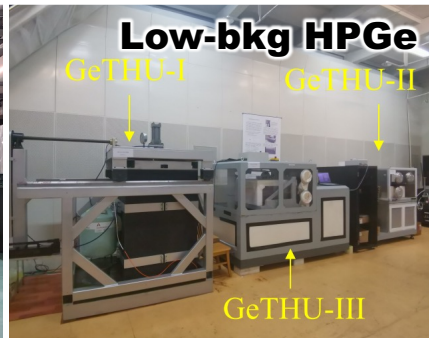
Nucl. Instrum. Meth. A. 2017, 859, 37–40



U, Th in Cement and Rock

Low background rock @JinPing mountain

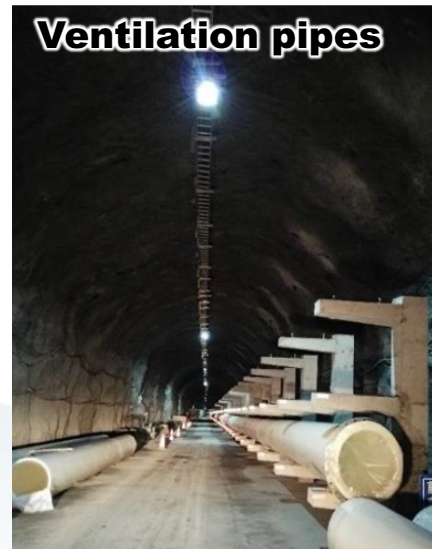
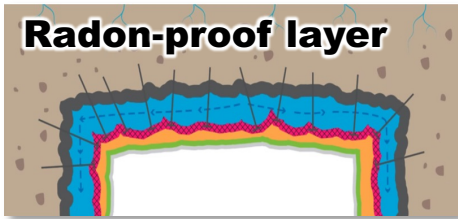
Special made low background cement (U,Th~6 Bq/kg)



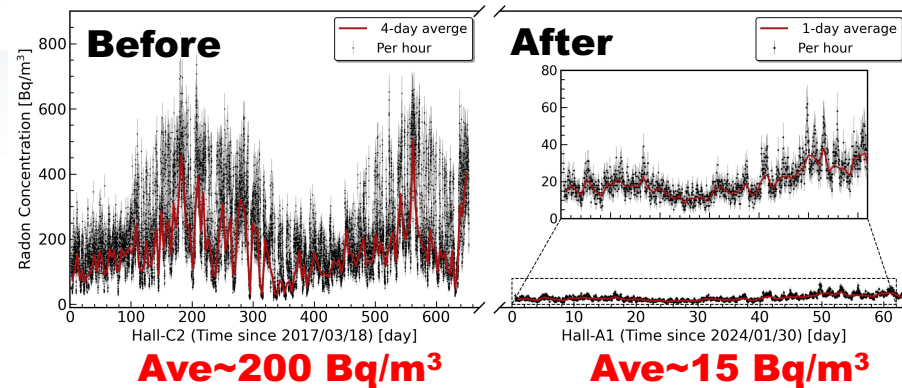
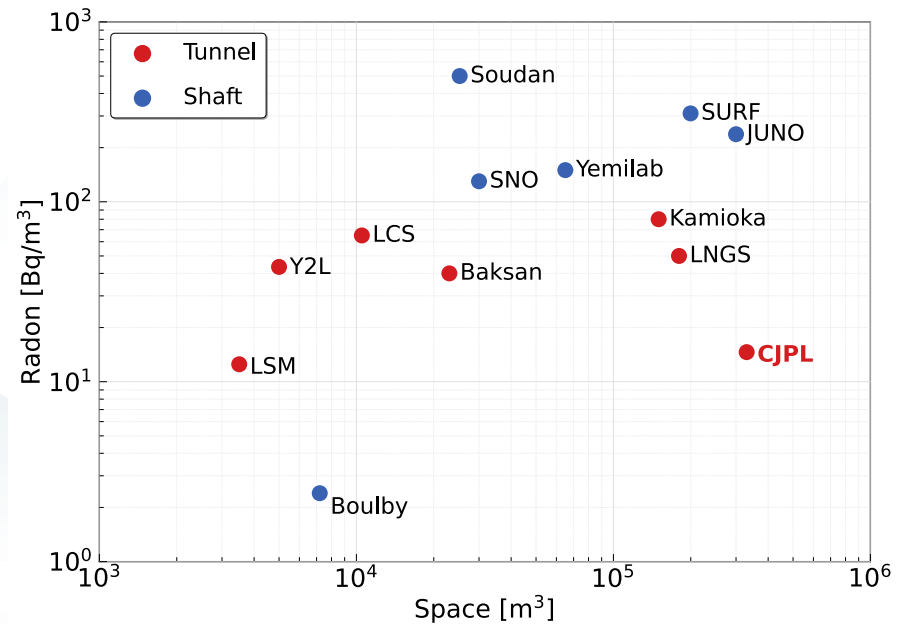
Item	detector	Radioactivity [Bq/kg]		
		U-238	Th-232	K-40
Rock	In-situ HPGe	3.69	0.52	4.28
Cement	In-situ HPGe	5.8 ± 0.06	6.7 ± 0.03	148.9 ± 1.70

Radon at CJPL

Low Radon($\sim 15 \text{ Bq/m}^3$) for Large space($>300,000 \text{ m}^3$)



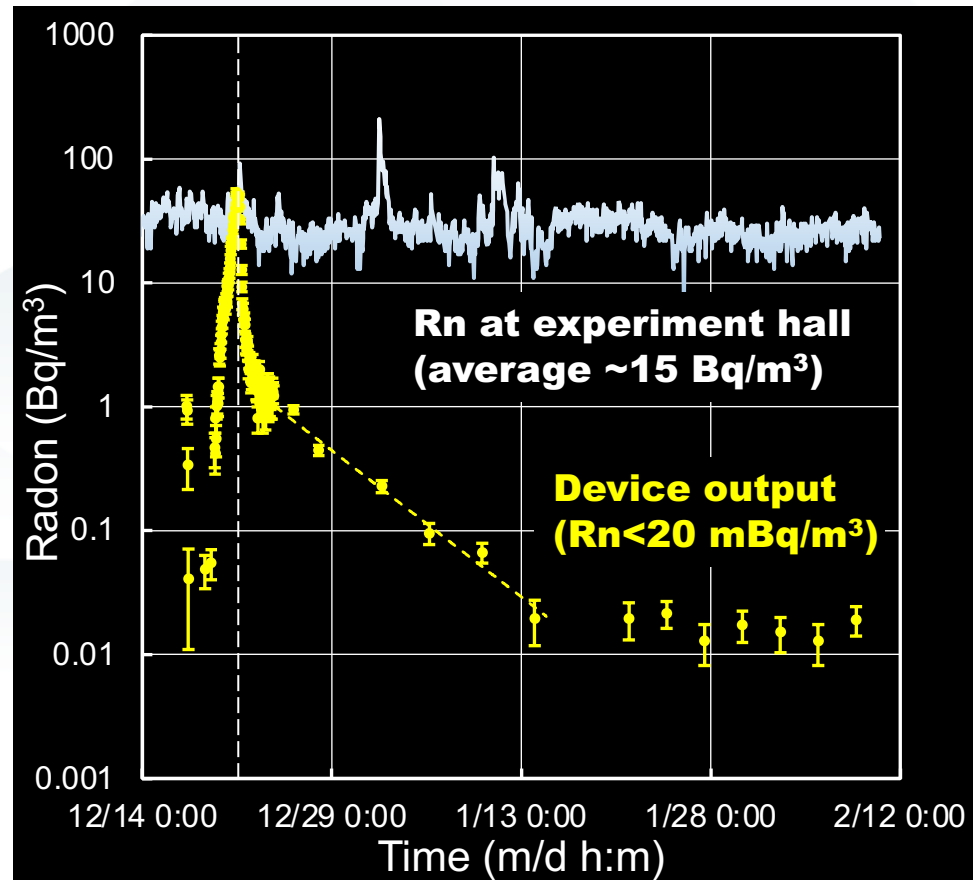
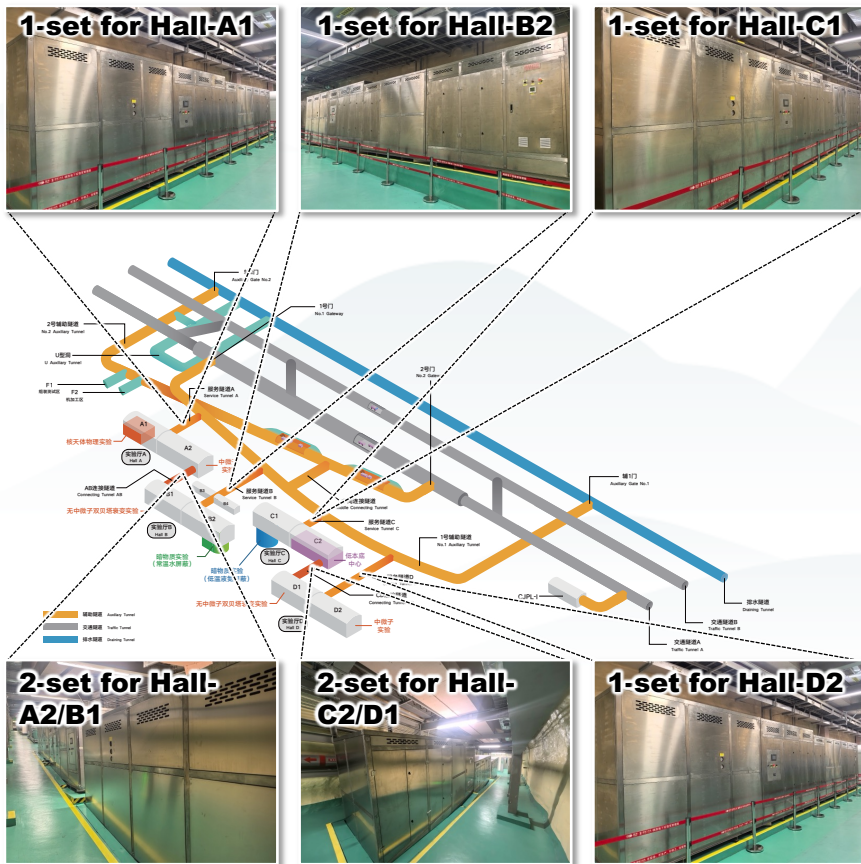
- 45,000 m^3/h ventilation via low-bkg pressurized pipes
- All experiment area in positive pressure
- Radon-proof layer cover all surfaces, **Rn emission $< 0.1 \text{ mBq/m}^2/\text{s}$**



Radon at CJPL

8 low-temperature radon adsorption devices

- low-bkg active carbon ($Ra-226 < 1$ Bq/kg)
- Rn suppression factor > 1000 ($Rn < 20$ mBq/m³), Flow > 220 m³/h



Shielding Facilities at CJPL

Combined shielding

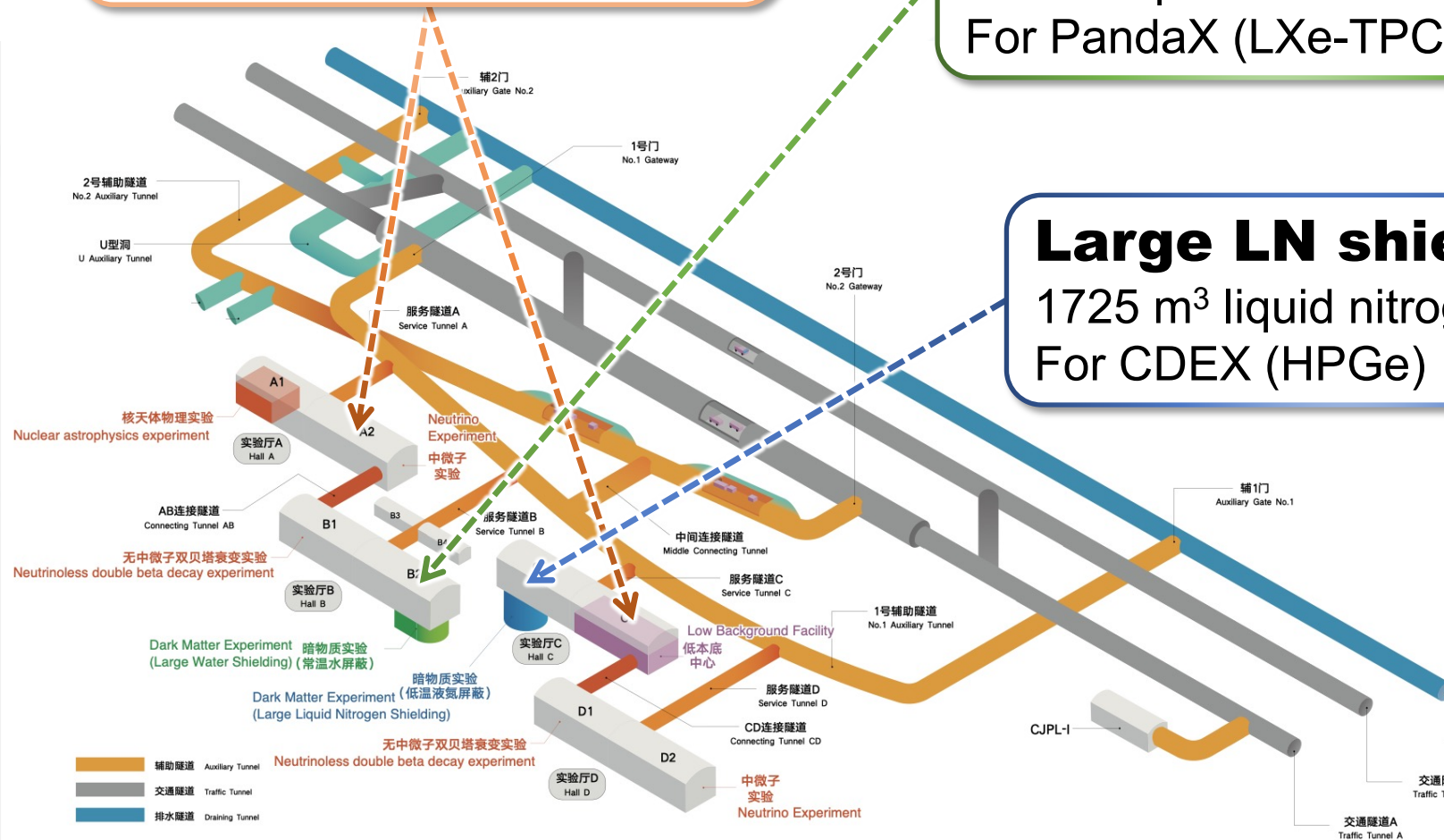
Copper + Lead + Polyethylene
Space: $2 \times 2 \times 2 \text{ m}^3$ / $1 \times 1 \times 1 \text{ m}^3$

Large H₂O shielding

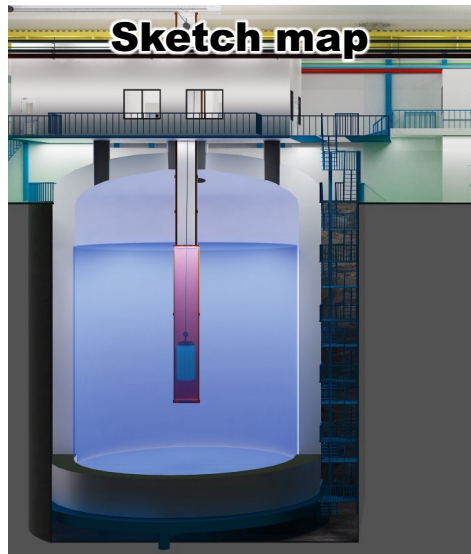
4500 m³ pure water
For PandaX (LXe-TPC)

Large LN shielding

1725 m³ liquid nitrogen
For CDEX (HPGe)

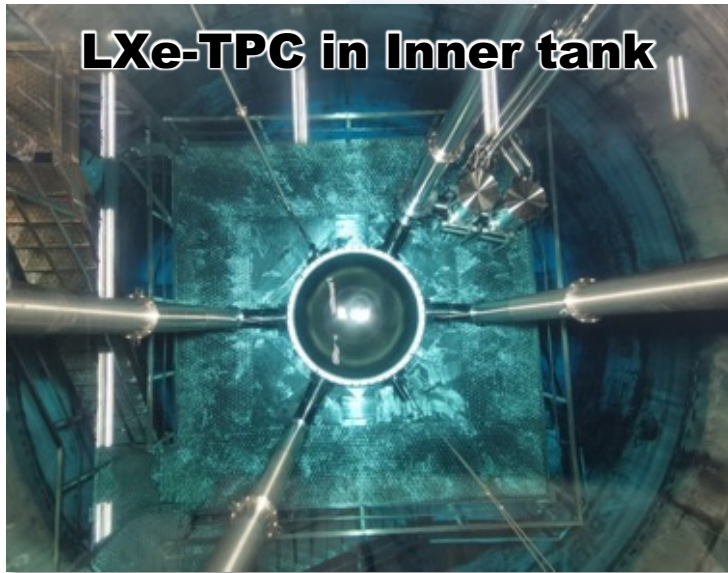
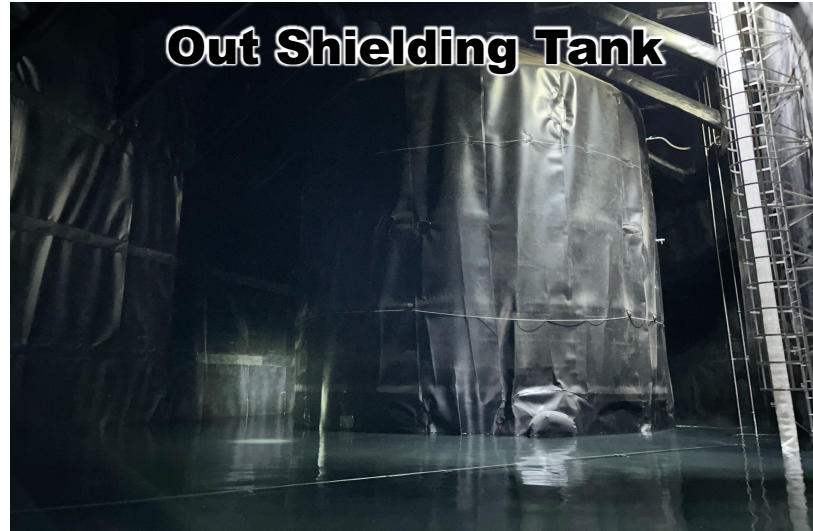
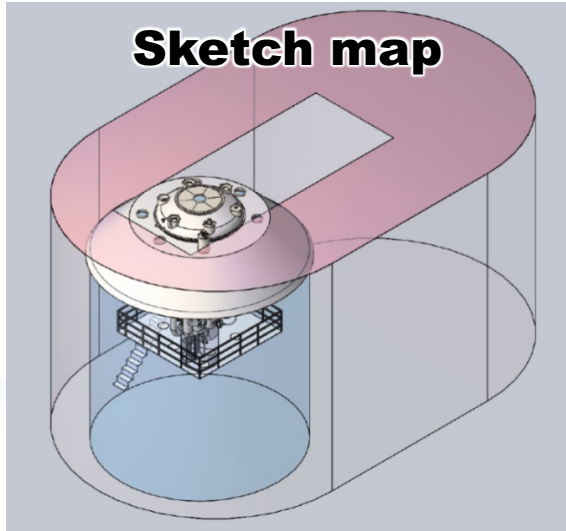


Large LN Shielding



- For CDEX experiment (HPGe)
- Volume $\Phi 13\text{m} \times \text{H}13\text{m} \sim 1725 \text{ m}^3$
- $>6\text{m}$ LN shielding at center
- LN filling started at Dec. 2024 and completed at Jun. 2025
- **Environmental BG $<10^{-5}$ cpkkd @2MeV after shielding (simulation)**

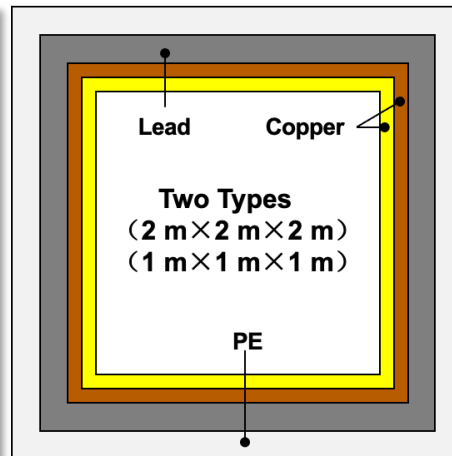
Large Water Shielding



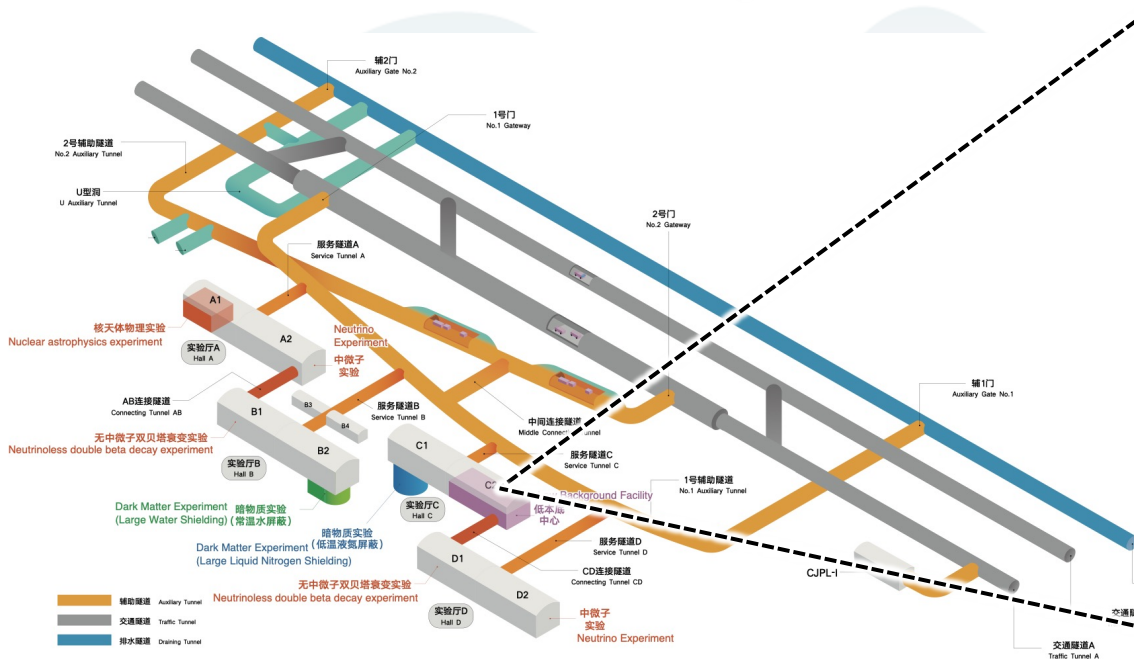
- For PandaX (LXe-TPC)
- 4500 m³ pure water
- **Environmental BG**
<10⁻⁴ cpkkd @2MeV
after shielding
(simulation)

Combined Shielding

- **Cu 20cm**
(U,Th<20μBq/kg)
- **Pb 20cm**
(U,Th<20mBq/kg)
- **PE 20cm/100cm**
(U,Th<50mBq/kg)



Environmental BG < 10⁻³ cpkkd @ 2MeV

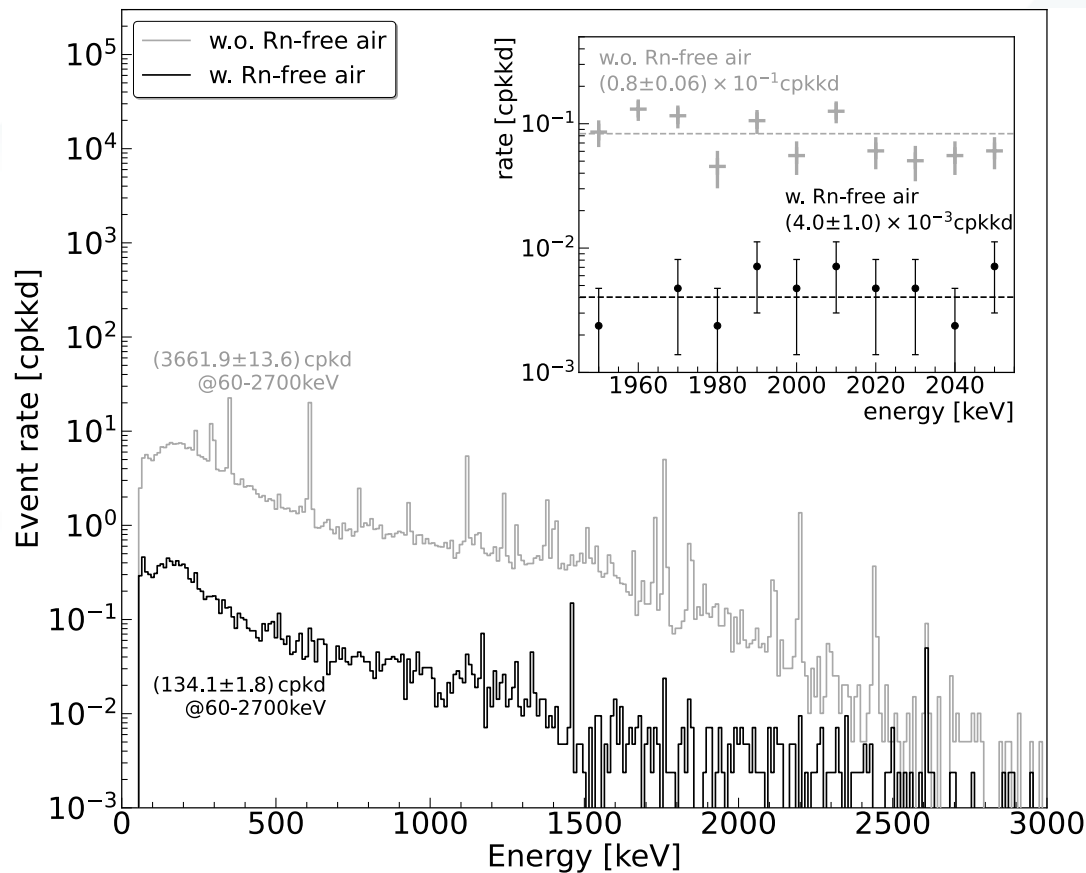


Background in Combined Shielding

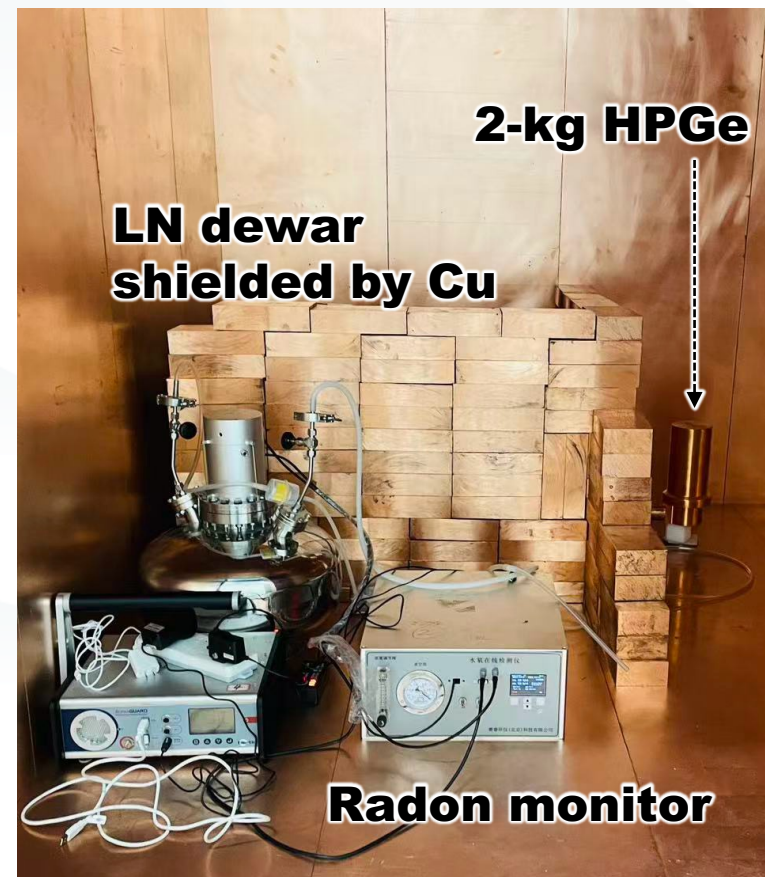
Environmental background

➤ **Geant4: 5×10^{-4} cpkkd @2MeV for HPGe**

➤ **Measurement with HPGe: BG $< 4 \times 10^{-3}$ cpkkd @2MeV**



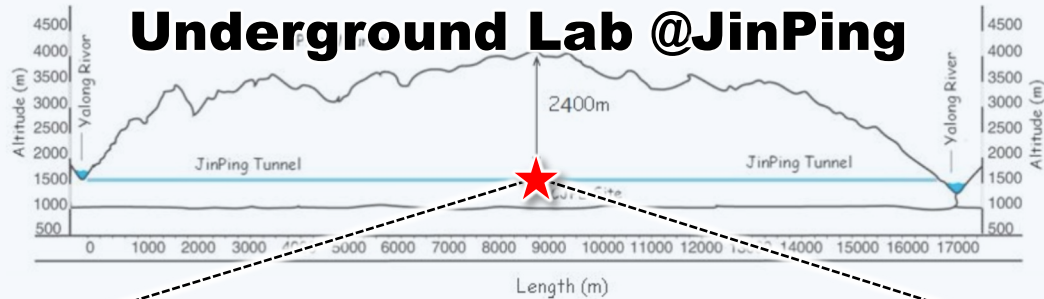
Background spectra measured by a HPGe detector



Experiment set-up

Radioactivity analysis facilities

Underground Lab @JinPing



2 sets
low-Background LS

Low-BG
LS-Det

ARGUS

ARGUS
~10.0 $\mu\text{Bq/kg}$

GeTHU (mBq/kg):

- 3 sets in CJPL-I
- 15 sets in CJPL-II

GeTHU

GeTHU-1

GeTHU-2

GeTHU-3

GeTHU-1/2/3
@CJPL-I

Ground Lab @Xichang

- ~4000m² space
- ~5km to airport
- ~200km to UL (3-hr drive)

2 sets,
XIA UltraLo-1800

UltraLo-1800

2 sets,
Element-XR ICPMS

ICPMS

Ground auxiliary Lab

ARGUS: 5-detector γ -spectrometer

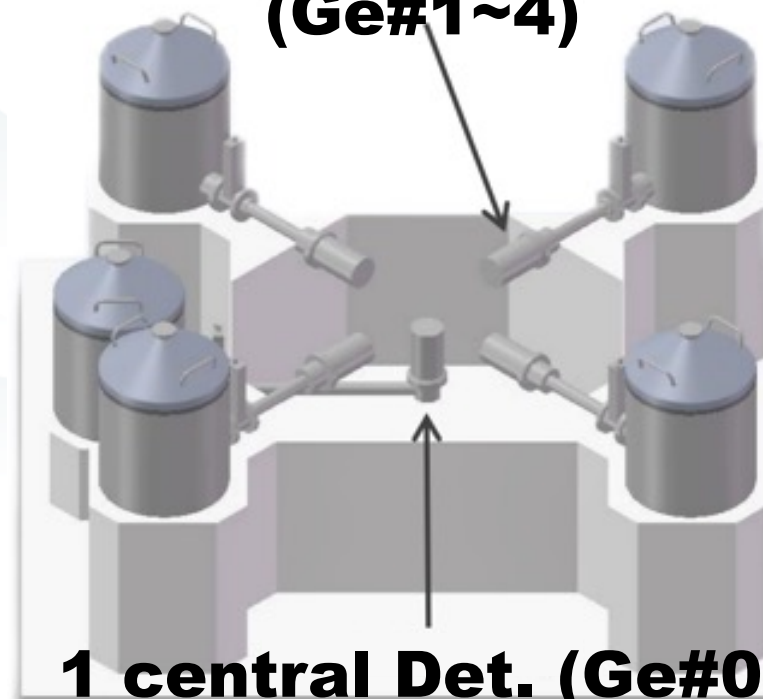
HPGe Det.	Ge#0	Ge#1	Ge#2	Ge#3	Ge#4
Ge Mass	2.4 kg	2.2 kg	2.2 kg	2.2 kg	2.2 kg
Rel. efficiency	120%	100%	100%	100%	100%
BG@60-2700keV	90.9 cpkd	166.6 cpkd	103.8 cpkd	145.4 cpkd	182.7 cpkd

cpkd: cts/kg/day

Shield: 20cm Cu + 20cm Pb + 1m PE



**4 horizontal Det.
(Ge#1~4)**



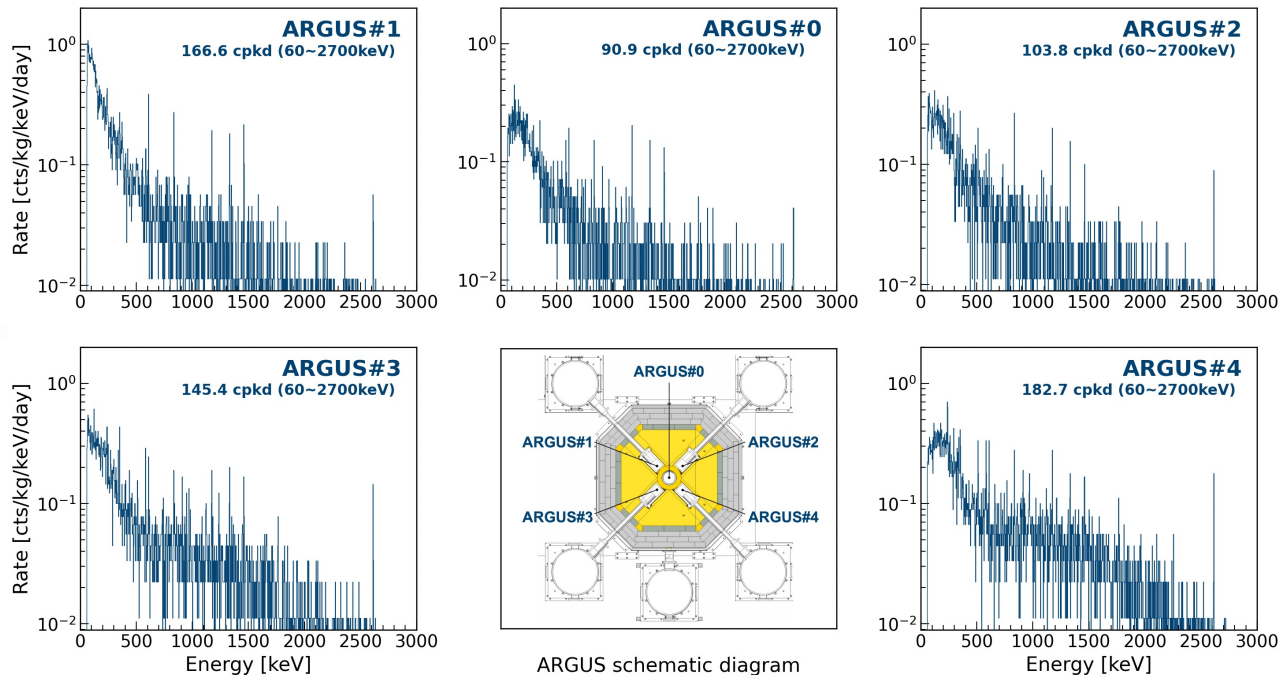
1 central Det. (Ge#0)

ARGUS: 5-detector γ -spectrometer

Minimum detection activity (MDA)

- Copper sample (Maline cup) + 100-day measurement
- MDA of Bi-214(U-238) $\sim 50 \mu\text{Bq/kg}$
- MDA of Cs-137 $\sim 20 \mu\text{Bq/kg}$

90-day background spectra



Research Activities at CJPL

JUNA

Jinping Underground Nuclear
Astrophysics experiment

CUPID-CJPL

Mo-100 $0\nu\beta\beta$ via LMO
scintillation bolometer

And more: ICSER

Integrated Circuit Soft
Error Research

JPDUQIE

Underground Quantum
Qubit experiment

...

PandaX

DM & $0\nu\beta\beta$ via LXe-TPC

CDEX

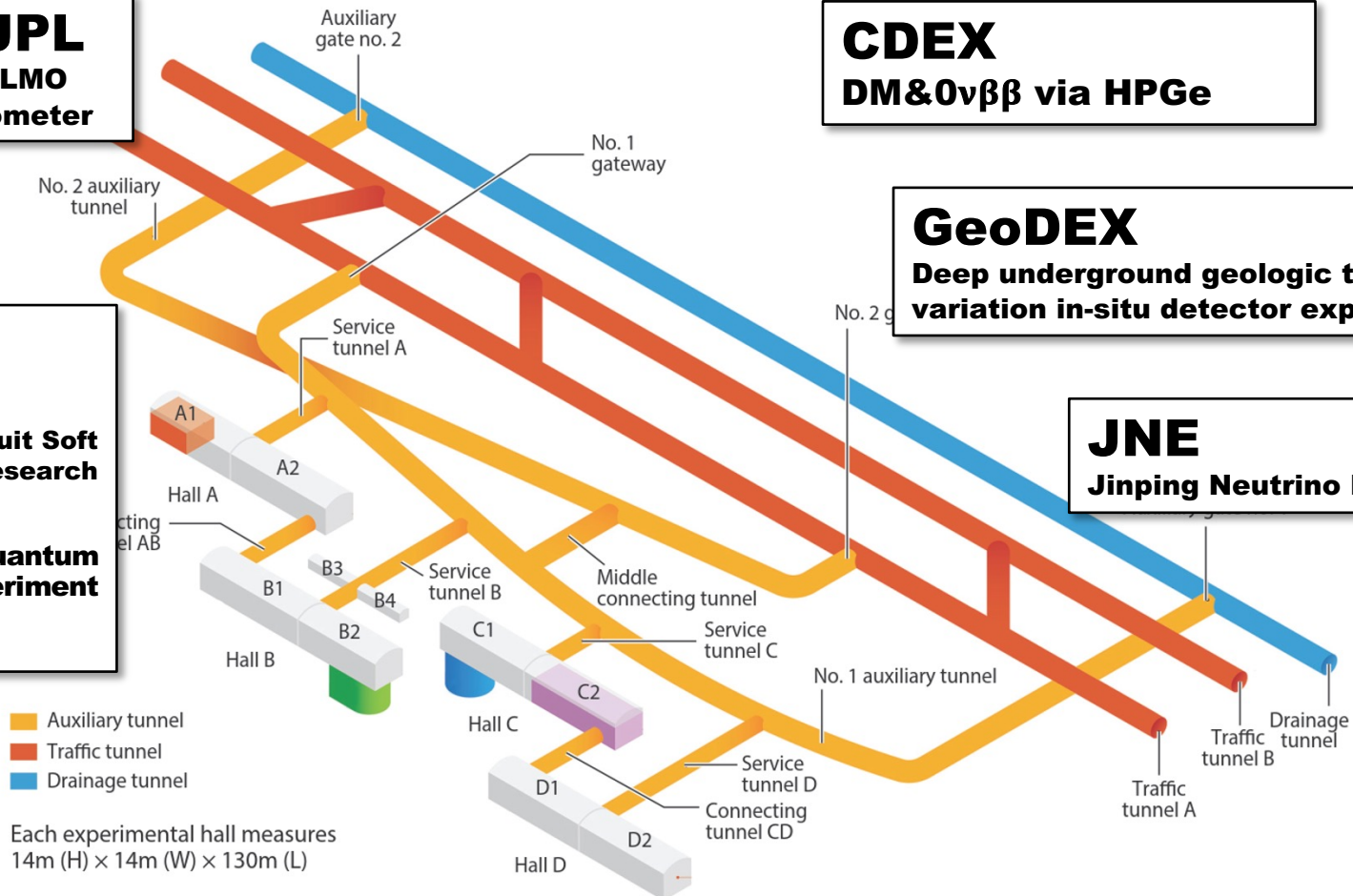
DM & $0\nu\beta\beta$ via HPGe

GeoDEX

Deep underground geologic time
variation in-situ detector experiment

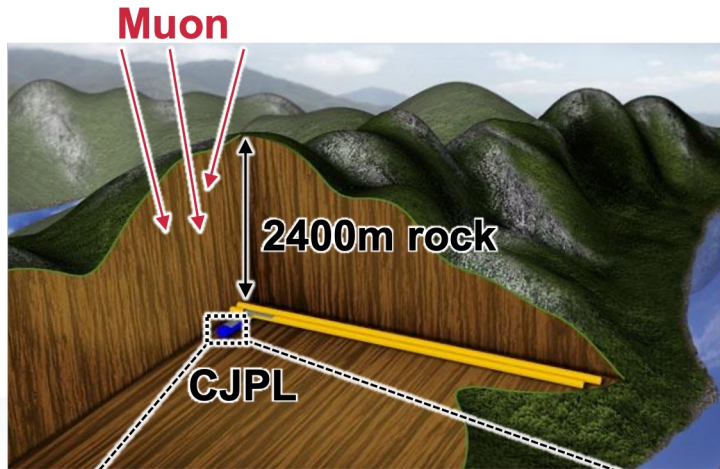
JNE

Jinping Neutrino Program



JPDUQIE

JinPing Deep Underground Quantum Instrument Experiment



Operate shielded superconducting quantum qubits in CJPL



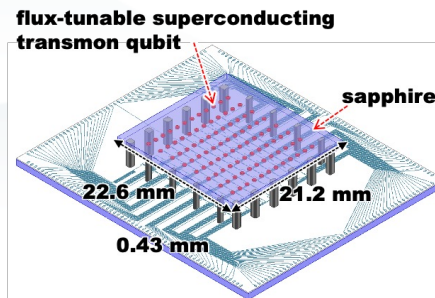
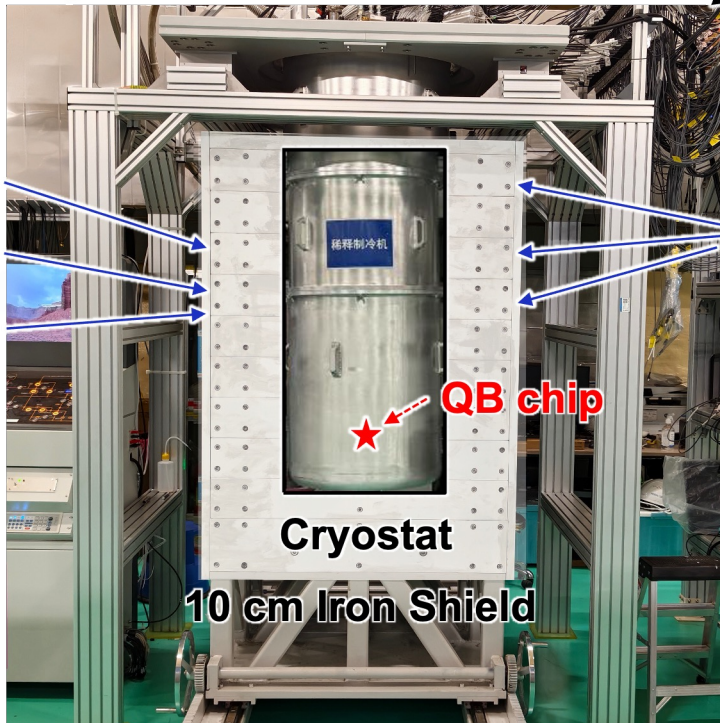
北京量子信息科学研究院
Beijing Academy of Quantum Information Sciences



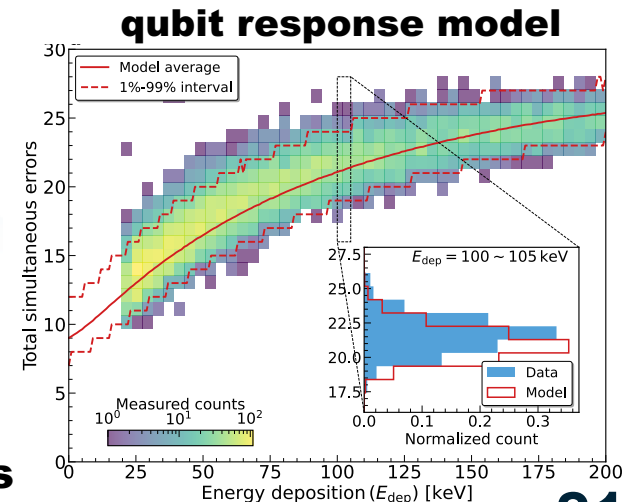
中国锦屏地下实验室
China Jinping Underground Laboratory
清华大学·雅砻江流域水电开发有限公司

Environment	Ground	CJPL	CJPL + shield
Correlated error rate	~100 mHz	~60 mHz	~5 mHz

Study qubit response to radiation and origins of residual errors in a cosmic-ray-free environment



**96-qubit system
with 28 good qubits**



Welcome to CJPL!

<http://cpl.tsinghua.edu.cn>



CJPL 

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

清华大学·雅砻江流域水电开发有限公司

锦屏大设施 A1 厅

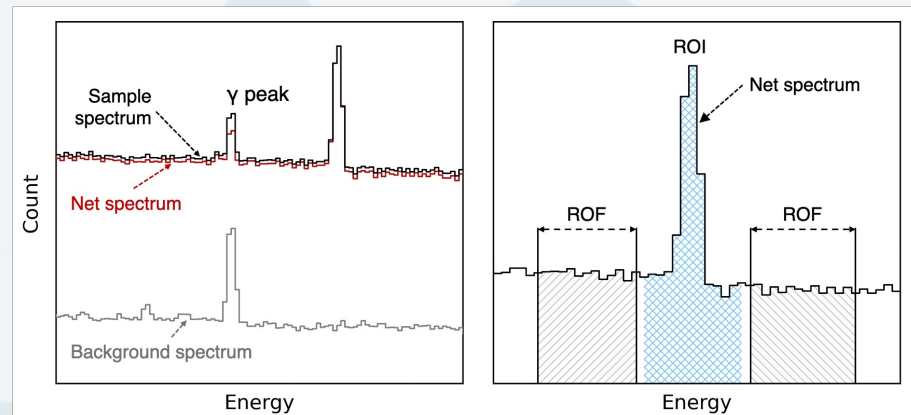
ARGUS data analysis

Single Detector Analysis

Calculate isotope activity (A) by characteristic gamma peaks via a net peak area method

$$A = \frac{1}{I_\gamma \cdot \varepsilon \cdot t_s}, \quad \hat{S} = C_g - C_b \frac{t_s}{t_b} - \frac{ROI}{ROF} \left[C_{g,c} - C_{b,c} \frac{t_s}{t_b} \right]$$

$$\sigma_{\hat{S}}^2 = C_g + C_b \left(\frac{t_s}{t_b} \right)^2 + \left(\frac{ROI}{ROF} \right)^2 \left[C_{s,c} + C_{b,c} \frac{t_s}{t_b} + C_{b,c} \left(\frac{t_s}{t_b} \right)^2 \right]$$

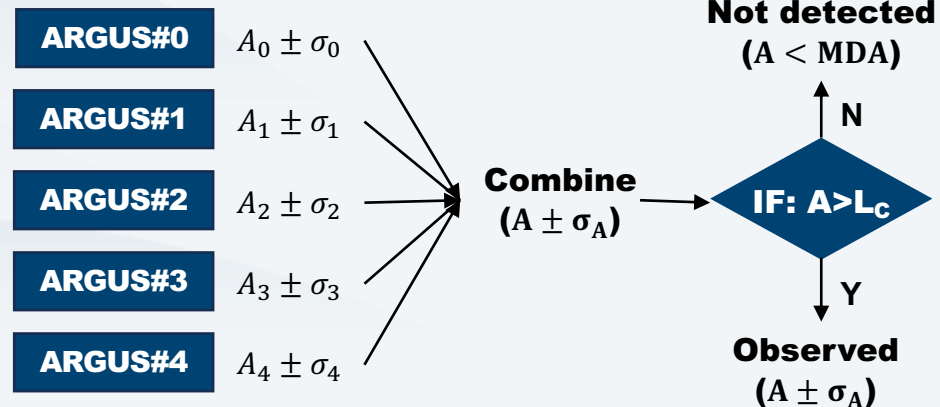


Multi-Detector Analysis

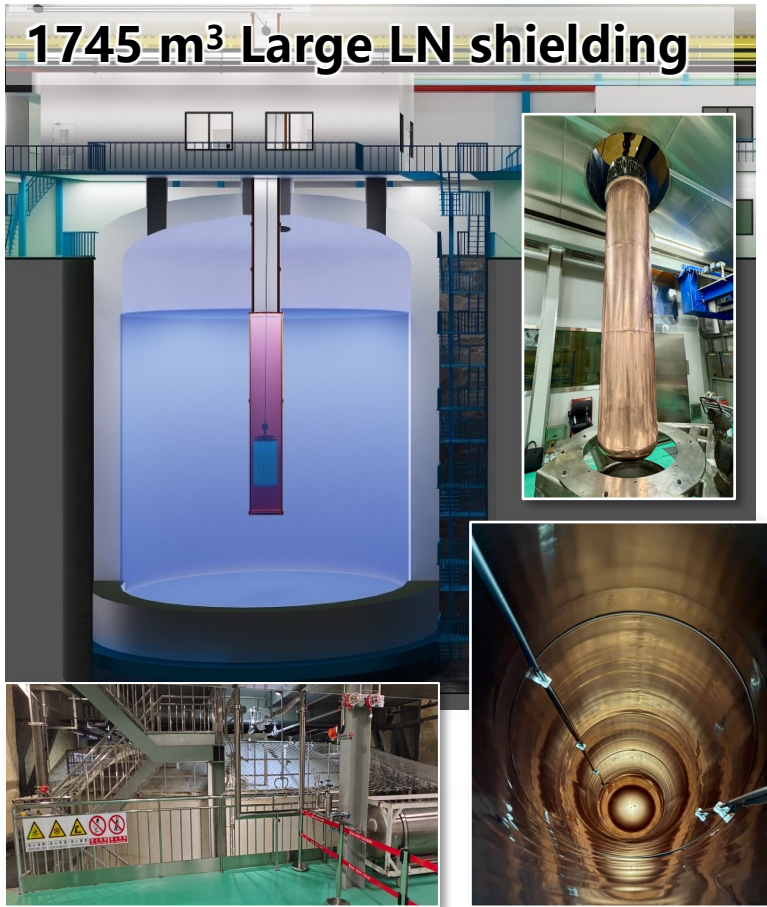
Combine activity results from 5 detectors by a weighted summarization via a global fit

$$\mathcal{L} = \prod_i \frac{1}{\sqrt{2\pi}\sigma_i} \exp\left(-\frac{(A_i - A)^2}{2\sigma_i^2}\right), \quad \frac{\partial \ln \mathcal{L}}{\partial A} = 0$$

$$A = \left(\sum_i \frac{A_i}{\sigma_i^2} \right) / \left(\sum_i \frac{1}{\sigma_i^2} \right), \quad \sigma_A^2 = 1 / \left(\sum_i \frac{1}{\sigma_i^2} \right)$$



1745 m³ Large LN shielding



- ❑ Founded in 2009, 10 institutions, more than 100 people now
- ❑ Search for Dark Matter and Ge-76 $0\nu\beta\beta$ via low-threshold HPGe detectors
- ❑ **Currently building the 50-kg DM detector in Large LN shielding in C2**

2009-2016	2016-2022	2021-	Planned
CDEX-1 DEX-1A DM: χ -N (SI/SD) Axion & Axion-like DM CDEX first $0\nu\beta\beta$ result DEX-1B DM: χ -N (SI/SD) DM: χ -N (Migdal Effect) DM: χ -N (AM) Axion & Axion-like DM	CDEX-10 - DM: χ-N (SI/SD) - DM: χ-N (EFT) - Solar dark photon - Dark photon DM - DM: CR boosted DM - DM: Exotic DM - DM: χ-e - DM: Evaporating PBHs	CDEX-50 (DM) CDEX-300 ($0\nu\beta\beta$)	CDEX-1T ($0\nu\beta\beta$, DM...)

PandaX

- Started in 2009, consists of dozens of Universities and research Institutions
- Increasing LXe detector mass for DM and neutrino studies
- Currently upgrading to PandaX-xT

PandaX



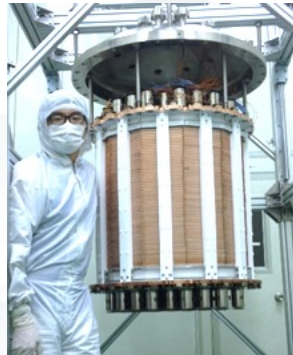
2009

Phase-I 120 kg



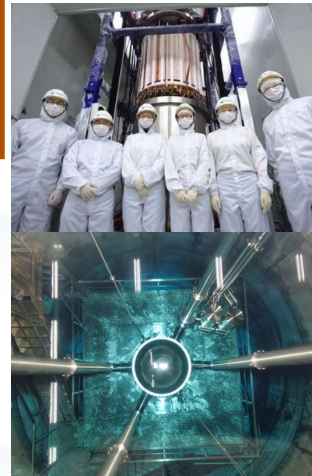
2010-2014

Phase-II 580 kg



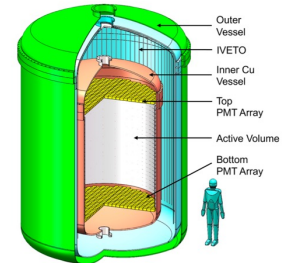
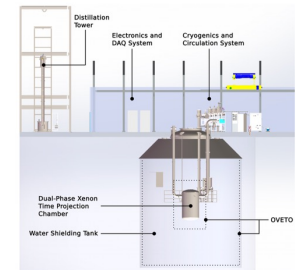
2015-2019

**PandaX-4T
3.7 ton**



2020-2026

PandaX-xT

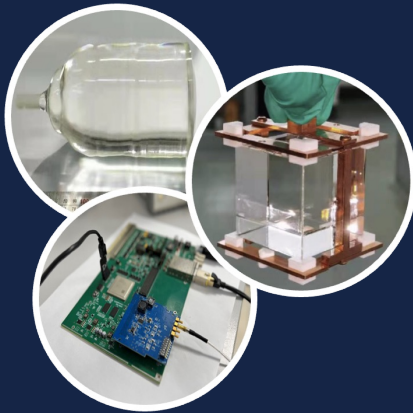


2026-

CUPID-CJPL

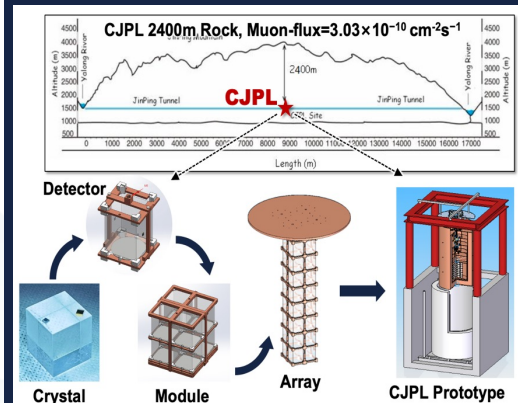
- Developing key technologies for a ton-scale Mo-100 $0\nu\beta\beta$ experiment
- Building a prototype facility in CJPL
- Design for the ton-scale experiment in CJPL.

Key technologies



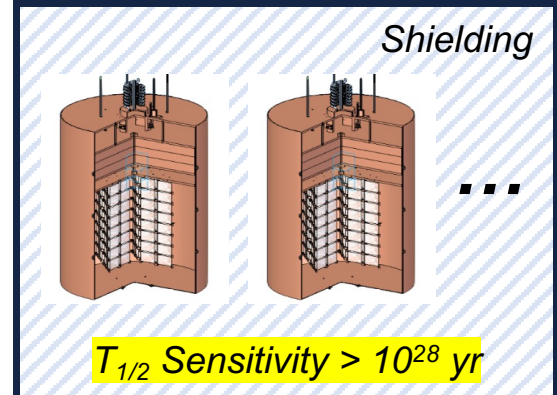
Crystal growth & Quality control
Detector & Electronics
Cryogenic system
Data collection & analysis...

Prototype @CJPL



LMO array at CJPL:
7-kg Mo (Mo-100 enrichment >95%)
Crystal size: $45 \times 45 \times 45 \text{ mm}^3$
Detector number: ~44

Ton-scale design



Test & QC for mass production
Modularized detector
Complex shielding
Background & sensitivity...

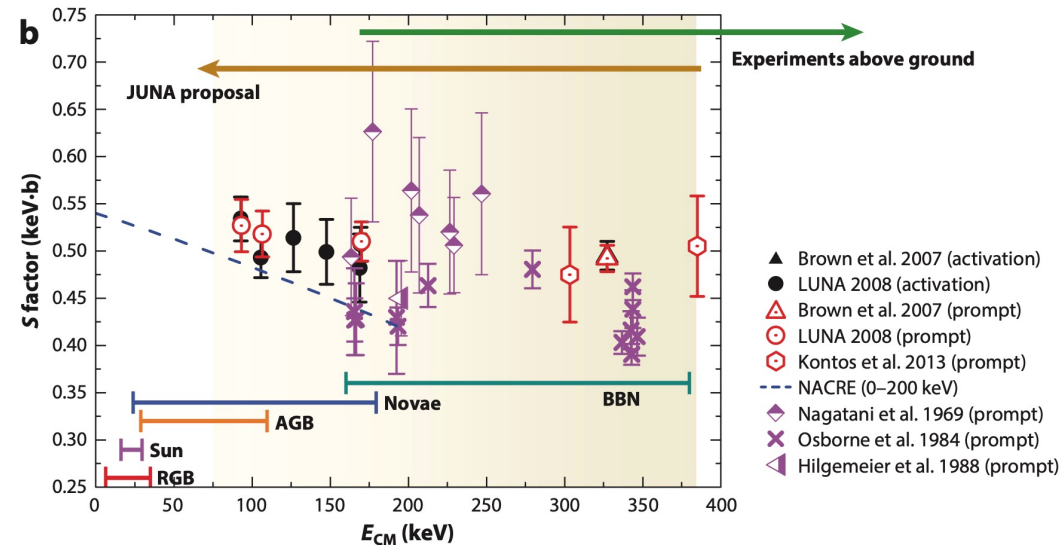
JUNA

Jinping Underground Nuclear Astrophysics experiment

- Started in 2013, 7 Universities and research Institutions
- Goals: Nuclear astrophysics study using underground accelerator
- Next phase: Super JUNA



JUNA platform
at CJPL-II Hall A1



Existing data and energy range planned to be covered by
JUNA Run2

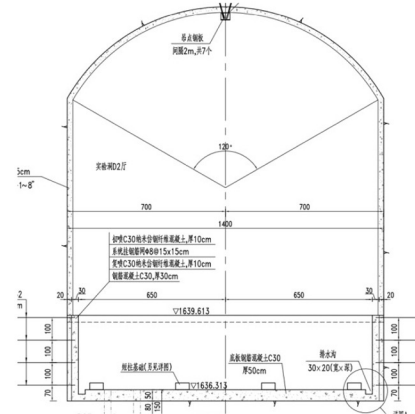
Jinping Neutrino Program



- Ever growing interest from the community.
- Active working group.
- Starting CDR draft: Welcome to join!



Pit for 500-ton Neutrino Observatory at Hall D2



Experiment pit Design



Excavation of Experiment pit

1-ton prototype at CJPEI



Neutrino detector design

