Status and prospects of CJPL

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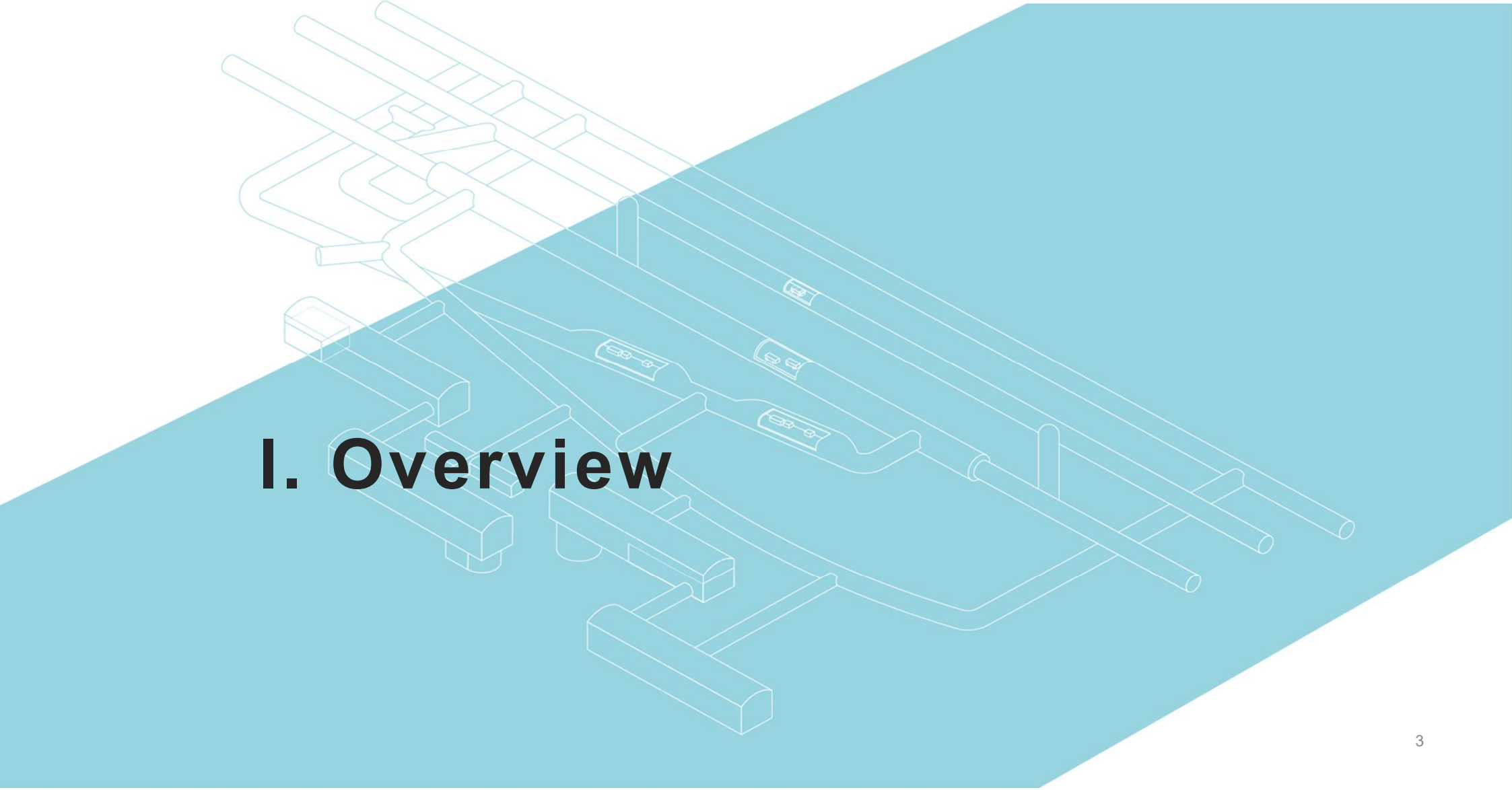
SNOLAB Future Projects Workshop

清華大學 Tsinghua University

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

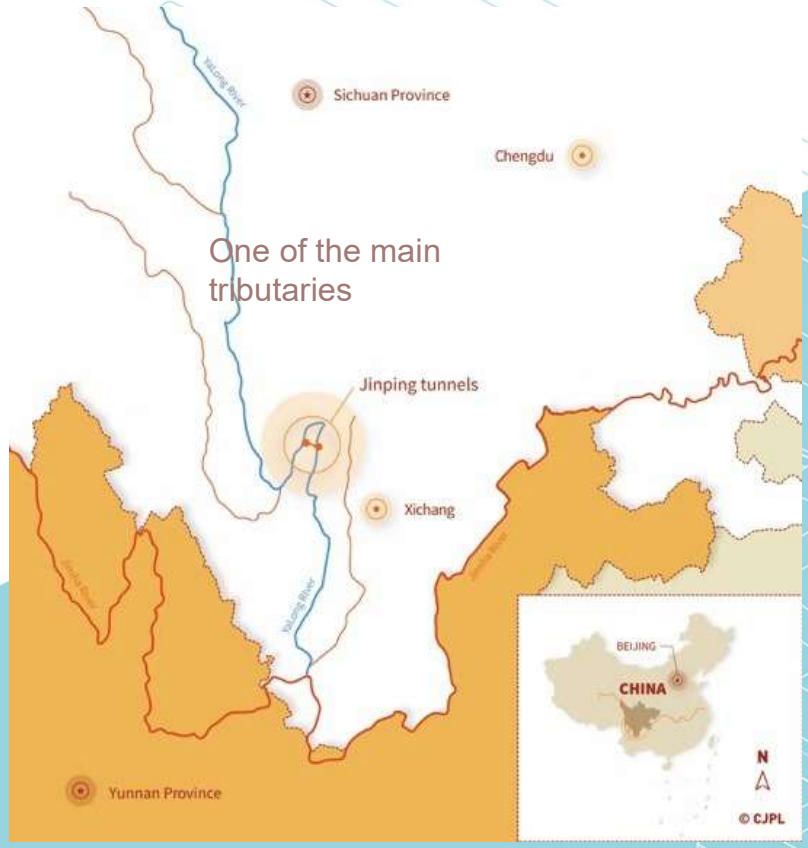
国投 SDIC | 雅砻江水电 YALONG HYDRO

Contents



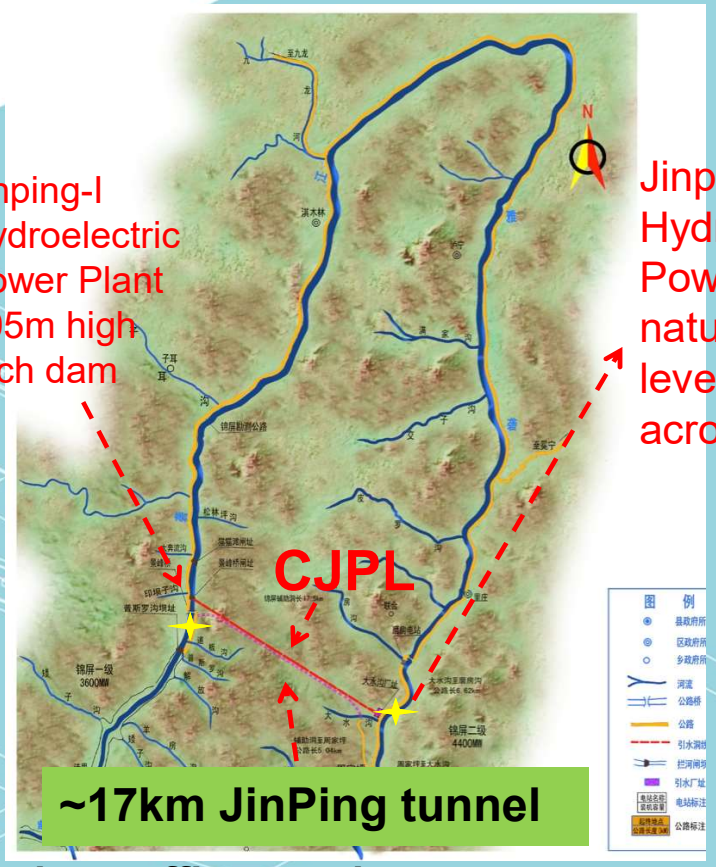
I. Overview

Jinping Hydroelectric Power Plants



Yalong river meets Jinping Mountain:

- The largest tributary of Jinsha River
- Jinping river bend：150km long



Jinping traffic tunnel

- 17.5km long x 2
- **Overburden**: max. 2400m, 73% of length >1500m.
- Finished on Aug. 8, 2008

Tunnel Layout inside Jinping Mountain

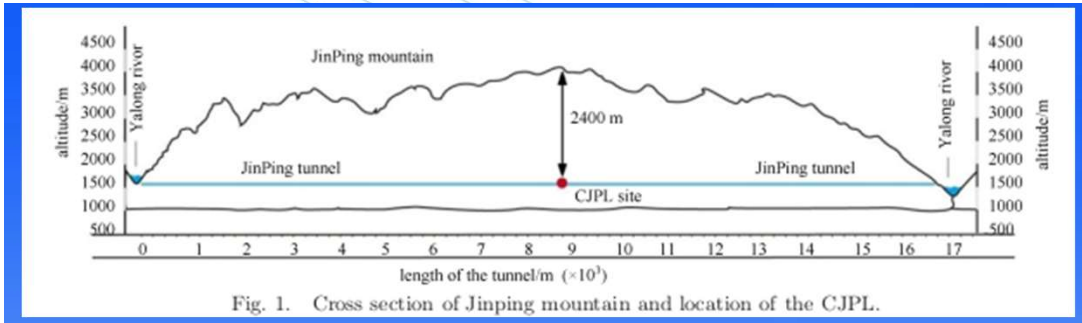


Fig. 1. Cross section of Jinping mountain and location of the CJPL.

West inlet

CJPL-II

CJPL-I

2 traffic tunnels
(Jinping Tunnel)

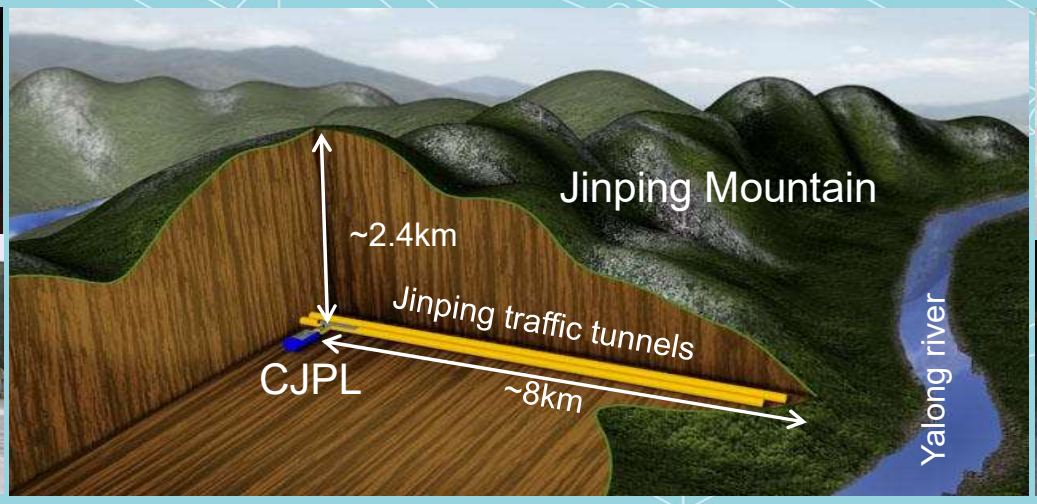
Drain tunnel

power generator

4 hydraulic tunnels for electric power generator

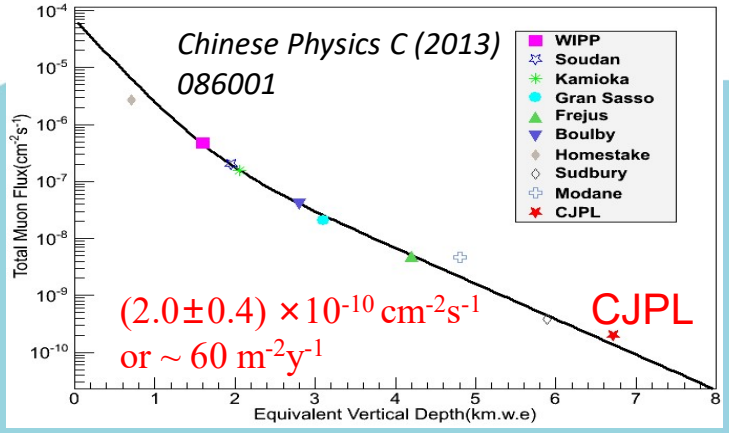
China JinPing Underground Laboratory(CJPL)

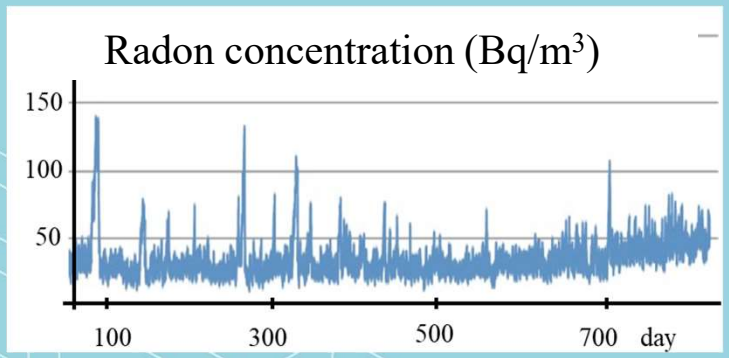
- THU-EHDC cooperation on a new underground lab started in May 2009
- CJPL-I site selected in Aug. 2009
- Rock sampling and in-situ measurement to study environmental radioactivity
- An ideal site for an underground laboratory



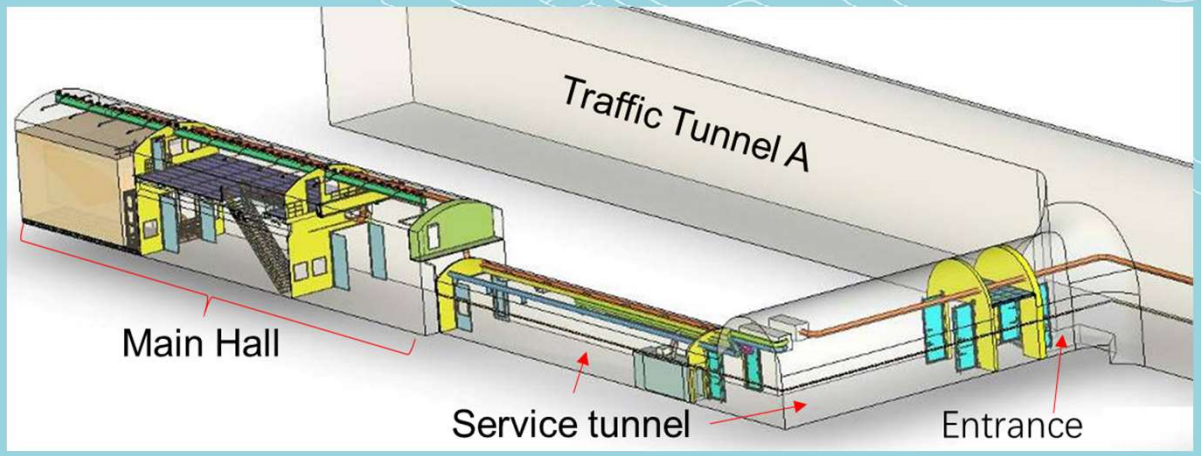
CJPL Features

- Deepest underground lab with 2400m rock overburden
- CJPL-I opened on Dec. 12, 2010
- Total space: ~4000 m^3
- Main Hall: 6.5m(W) × 6.5m(H) × 42m(L)
- Low muon flux and environmental background





Thermal n flux ~ 4×10^{-6} $cm^{-2}s^{-1}$
Fast n flux ~ 1.5×10^{-7} $cm^{-2}s^{-1}$

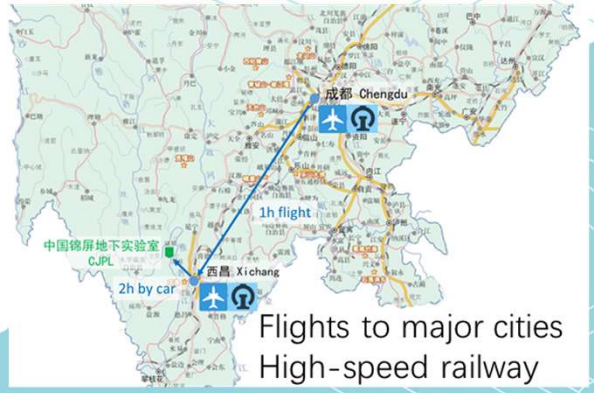


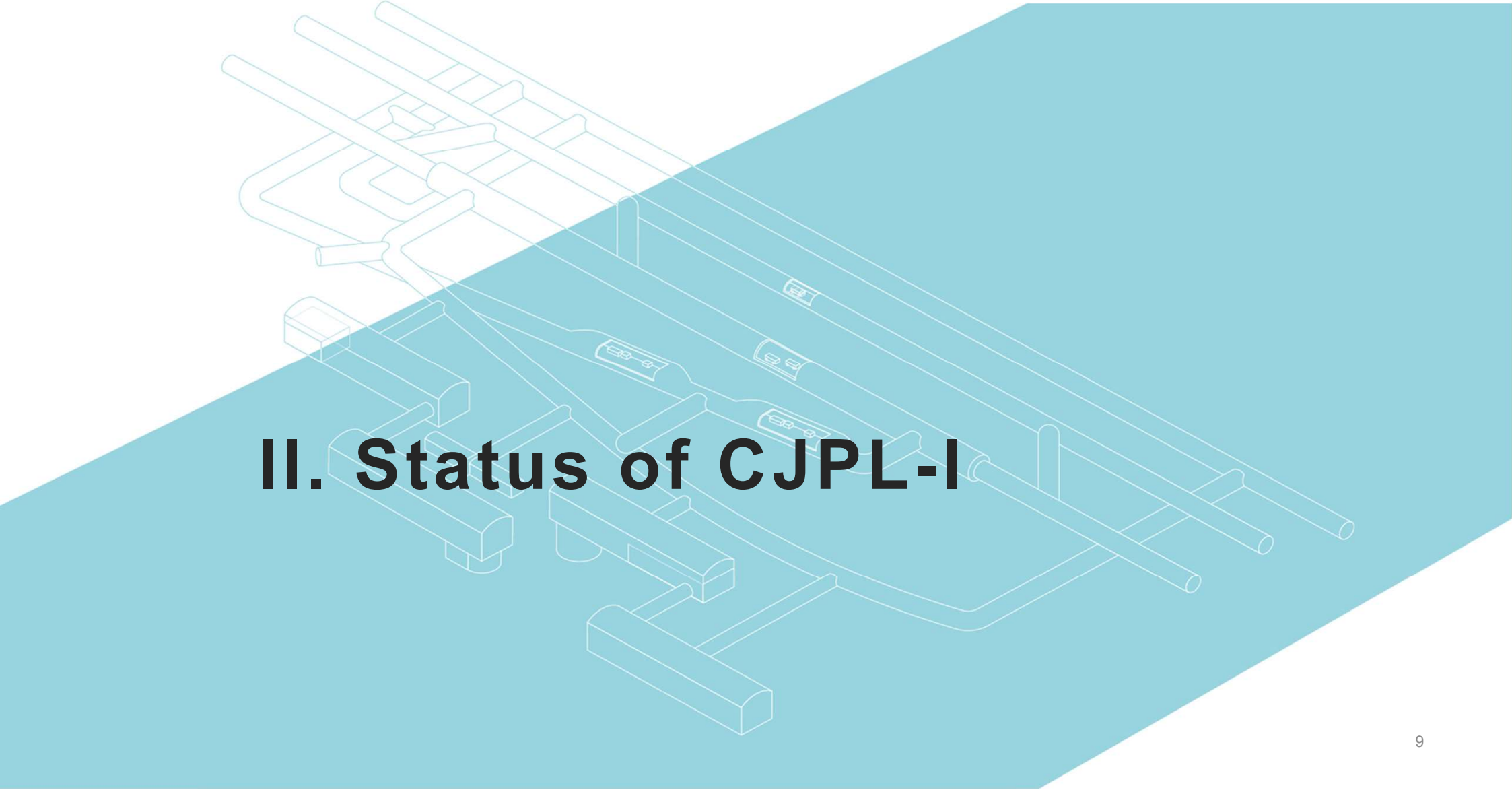
Rock sample(Marble) measured by Ge detector

(Unit : Bq/kg)	K-40	Ra-226 (609keV)	Th-232 (911keV)
Rock Sample	< 1.1	1.8±0.2	< 0.27
Ground Level(Beijing)	~600	~25	~50

Logistics of CJPL

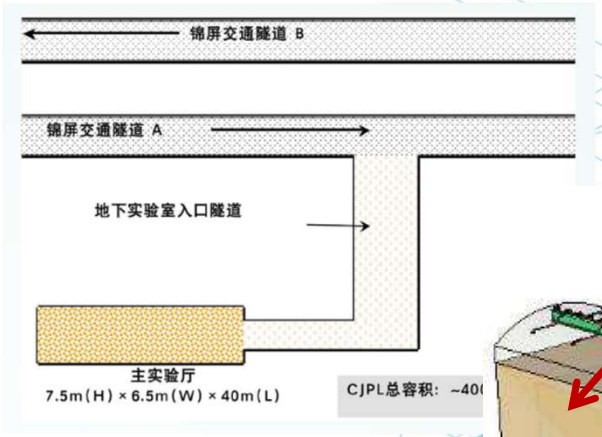
- Comprehensively supported by Yalong river company
- Convenient & Comfortable for researchers

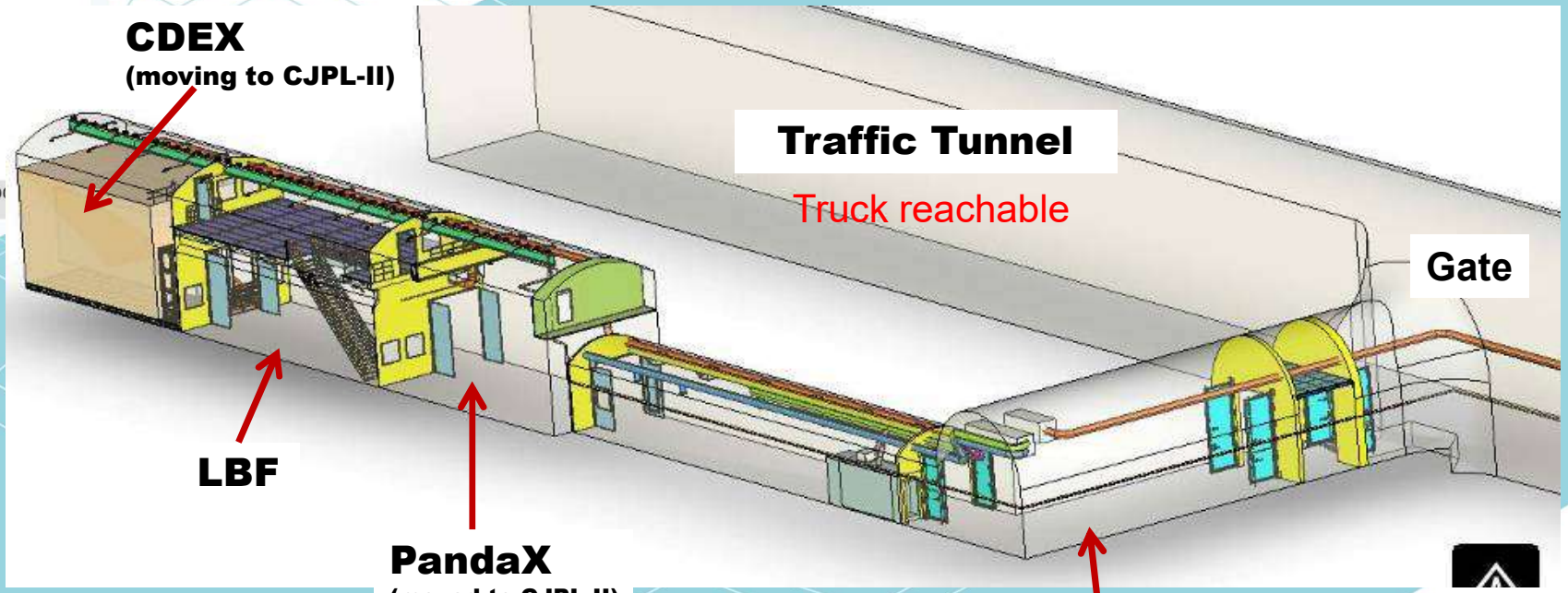




II. Status of CJPL-I

Layout of CJPL-I





Jinping Neutrino Exp.
(1 ton prototype)

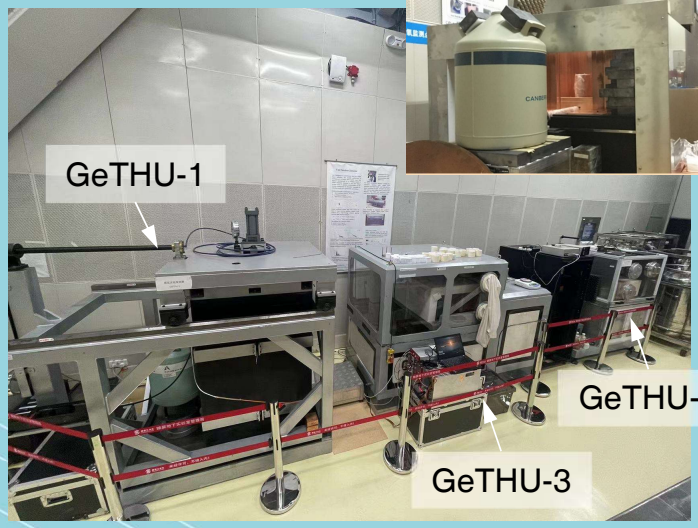
- **Total space: 4000 m^3**
- **Main Lab Space: 6.5(W) x 6.5(H) x 42(L)**

Experiments in CJPL-I

CDEX

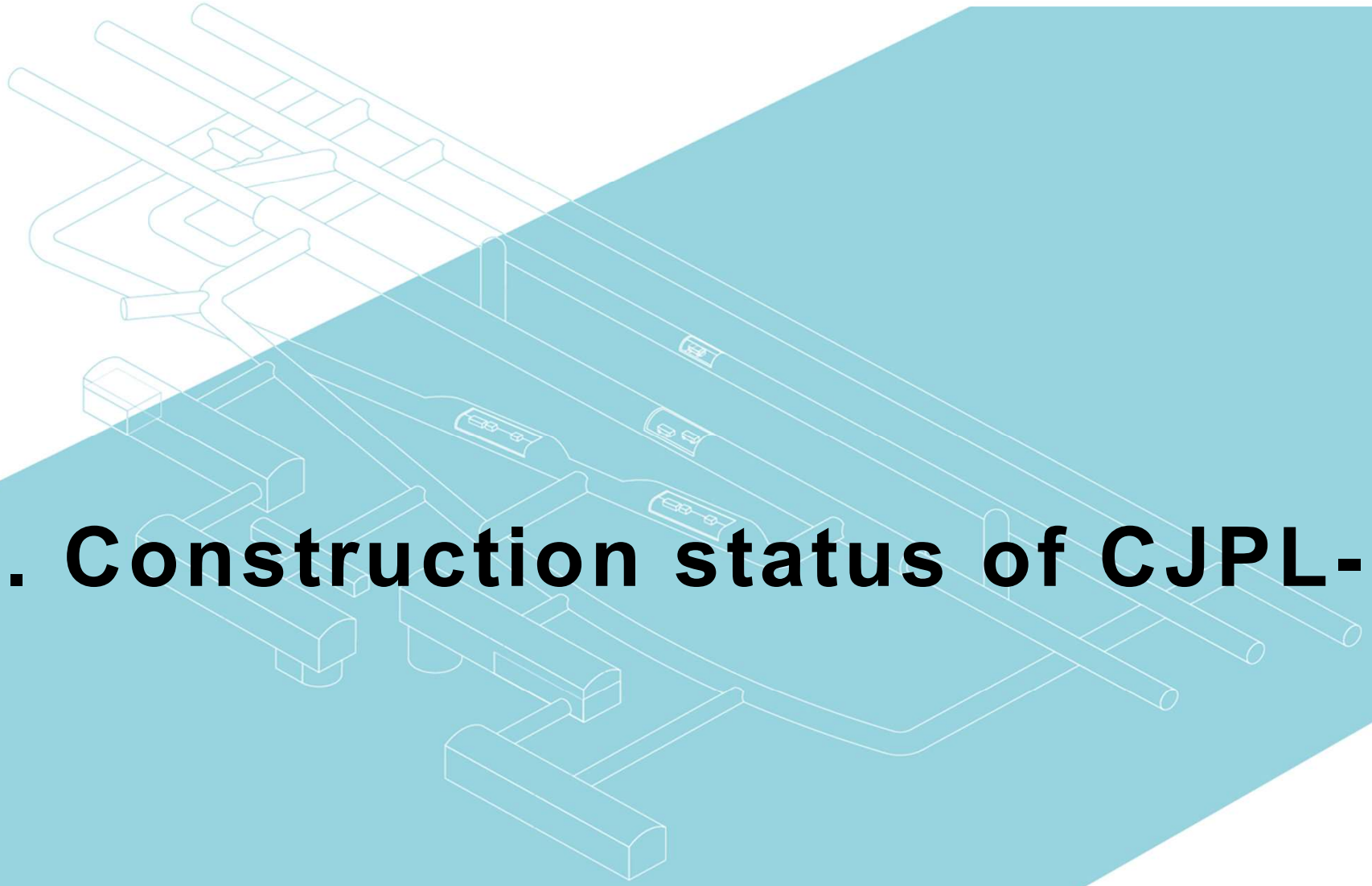
PandaX

Jinping neutrino Exp.



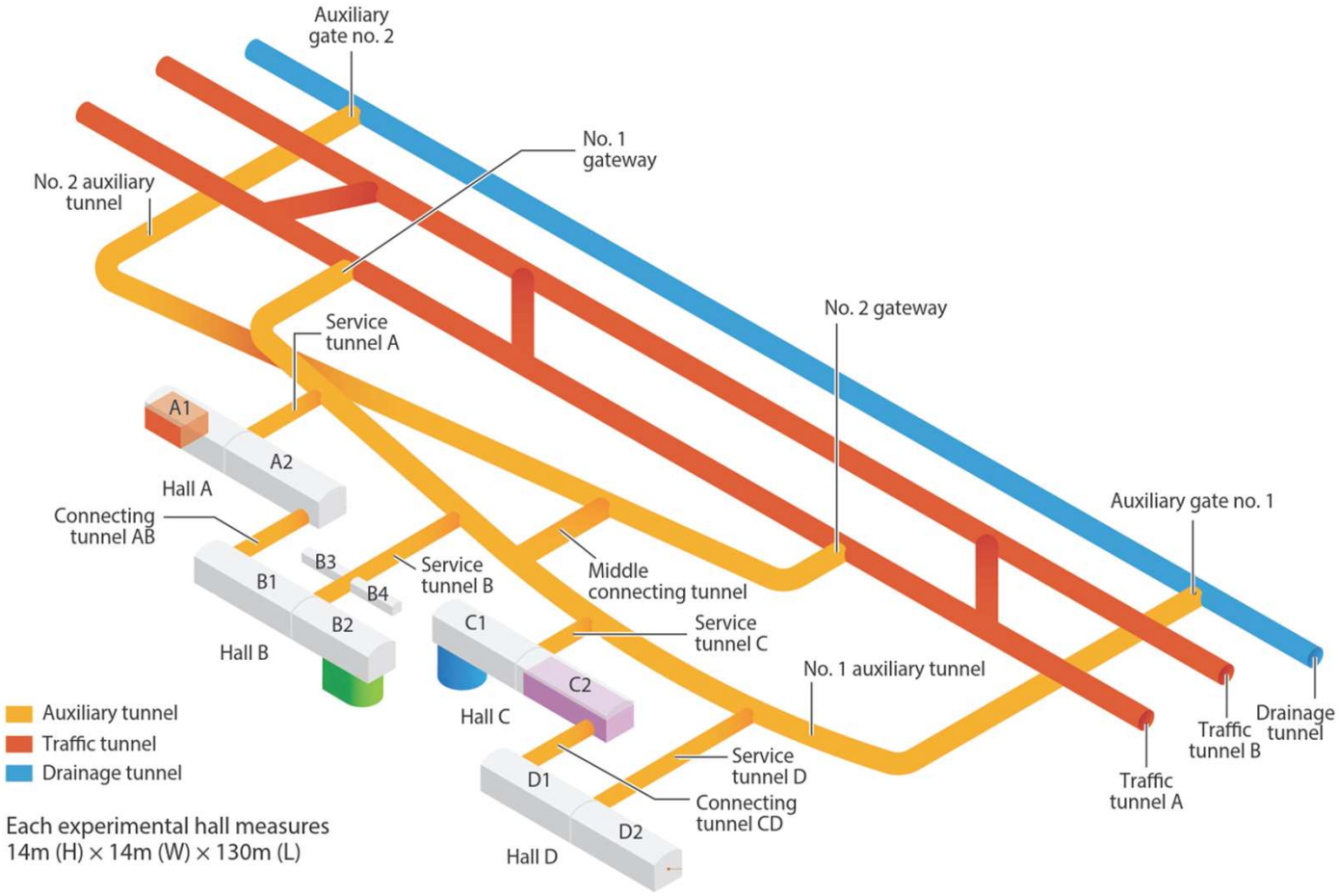
Low-background γ spectrometers

- Physics experiments
  - 2 dark matter experiments: CDEX, PandaX (now at CJPL-II)
  - 1 neutrino experiment: Jinping Neutrino Exp. (1 ton prototype)
- Low background counting facility
  - 4 low-background γ-ray Ge spectrometers: GeTHU1/2/3/4



III. Construction status of CJPL-II

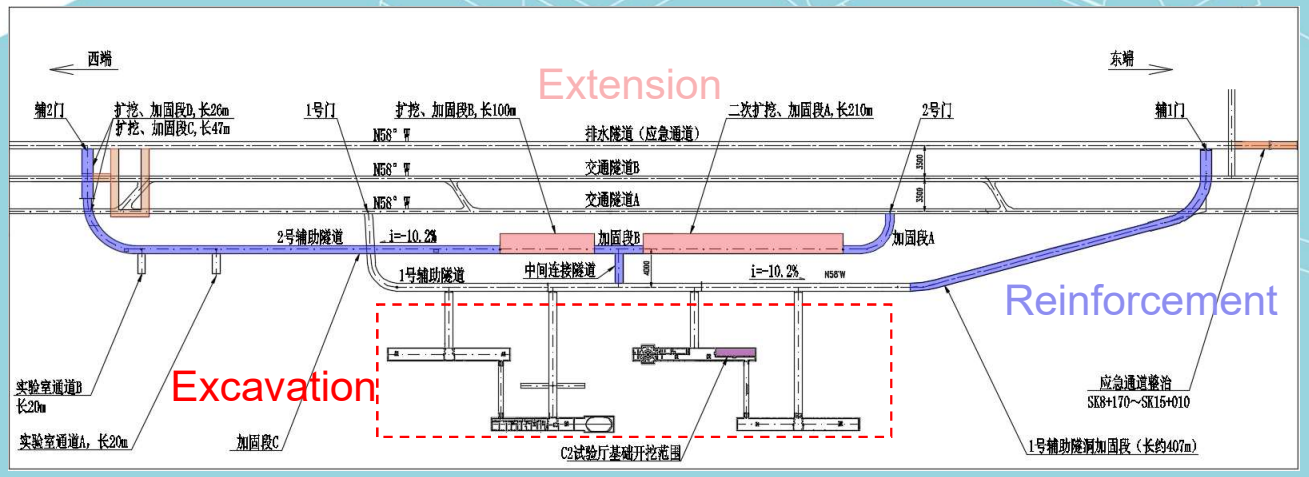
Deep Underground and ultra-low Radiation background Facility for frontier physics experiments(DURF) in CJPL-II



- Proposal approved in 2019
- Construction started in Dec. 2020
- Civil engineering finished late 2023
- Equipment being installed
- 4 experiment halls (A-D), total space of >300,000 m^3
- To be the deepest and largest underground lab worldwide

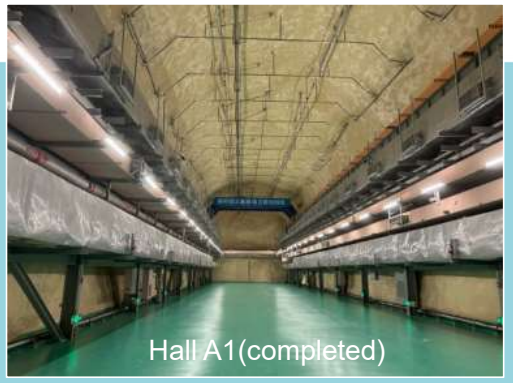
Civil engineering of CJPL-II

- Experimental hall excavation finished in 2016
- Cavern extension and reinforcement completed in Jan. 2020

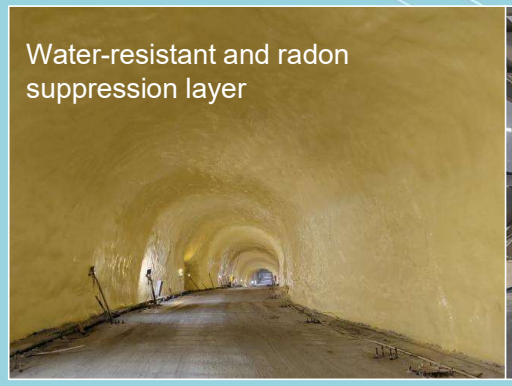


Civil engineering of CJPL-II

- **Water-resistant and radon suppression**
- **PE/LN/Water shielding facilities**
- **Steel structure**
- **Mechanical and electrical installation**


Hall A1(completed)

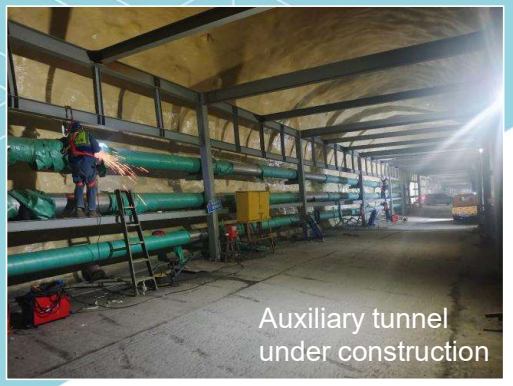

Auxiliary tunnel (completed)


Water-resistant and radon suppression layer


Steel structure and ventilation pipes

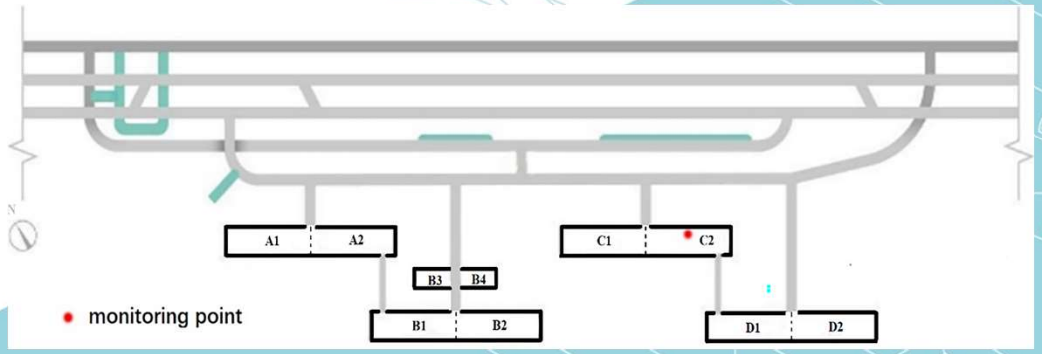

PE shielding room @ Hall C2

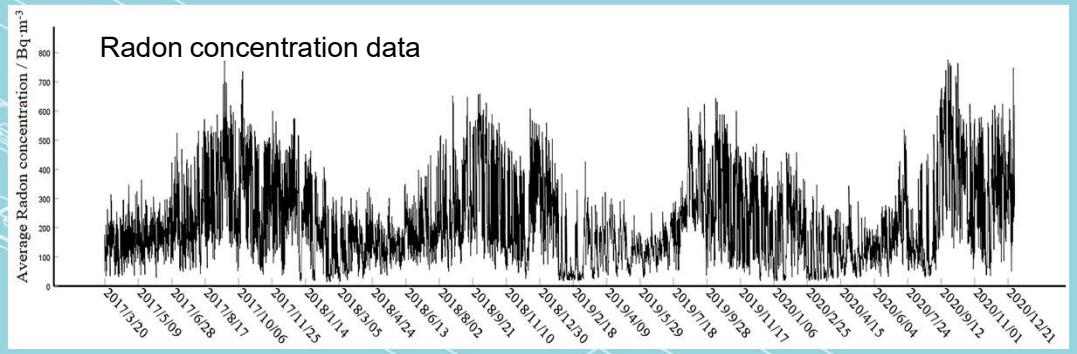
聚乙烯屏蔽舱舱体建设完成形象


Auxiliary tunnel under construction

Key Project: Water-resistant and radon suppression

- Monitoring Rn-222 in Hall-C2 in bare caverns
  - Rn-222 concentration in 14~776 Bq/m^3 (average 201 Bq/m^3)
  - Data fitting demonstrates a Rn-222 variation cycle of 12.7 month



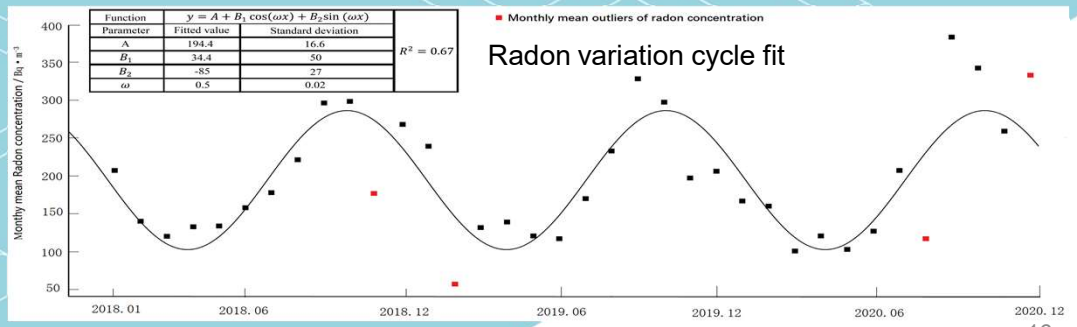


Det: Alpha-GUARD PQ2000

Loc: CJPL-II hall-C2

Date: 2017.3-2021.1

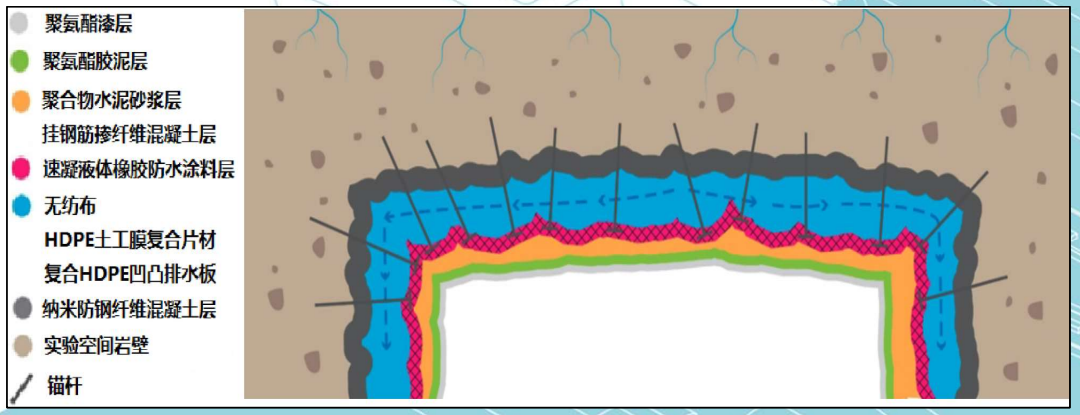
Mea-time: 60 min/point



Key Project: Water-resistant and radon suppression

☐ Water-Resistant and Radon Suppression (WRRS) layer

- A dedicated engineering using multi-layer protection against water and radon

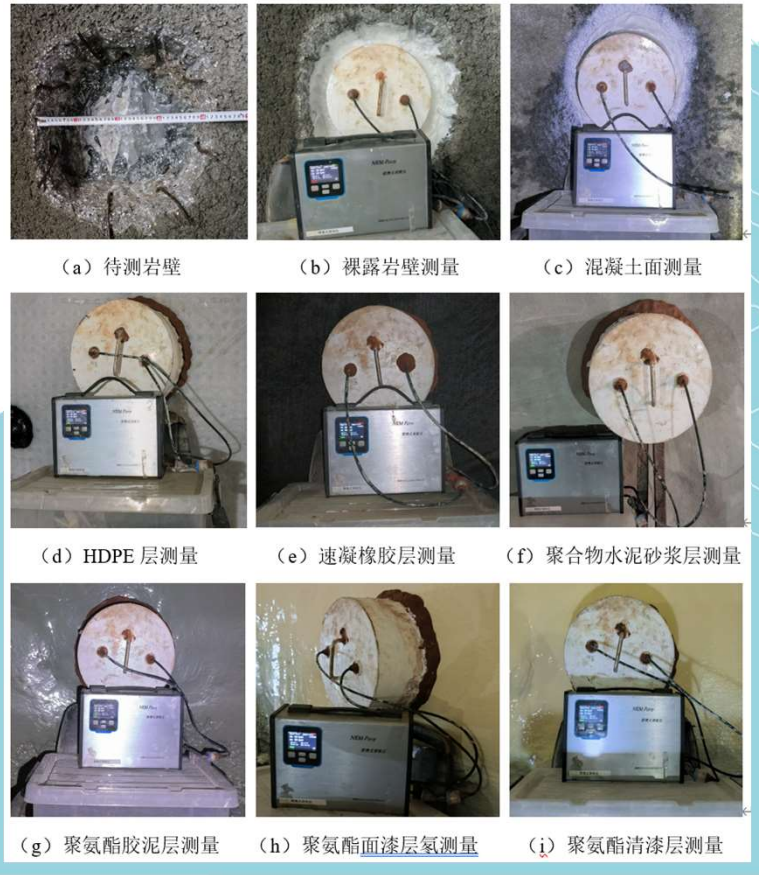


Features of the WRRS layer

- ➢ Preventing water and radon permeating from the rock simultaneously
- ➢ Covering the full-space of each experiment hall (walls and floor)
- ➢ Using low-background materials in WRRS
- ➢ 7 layers, 9 processing, dozens of materials

Key Project: water-resistant and radon suppression

- Radon suppression power of the WRRS layers < 0.1 mBq/m²/s
  - After WRRS, radon exhalation reduced to less than 1% of its initial value



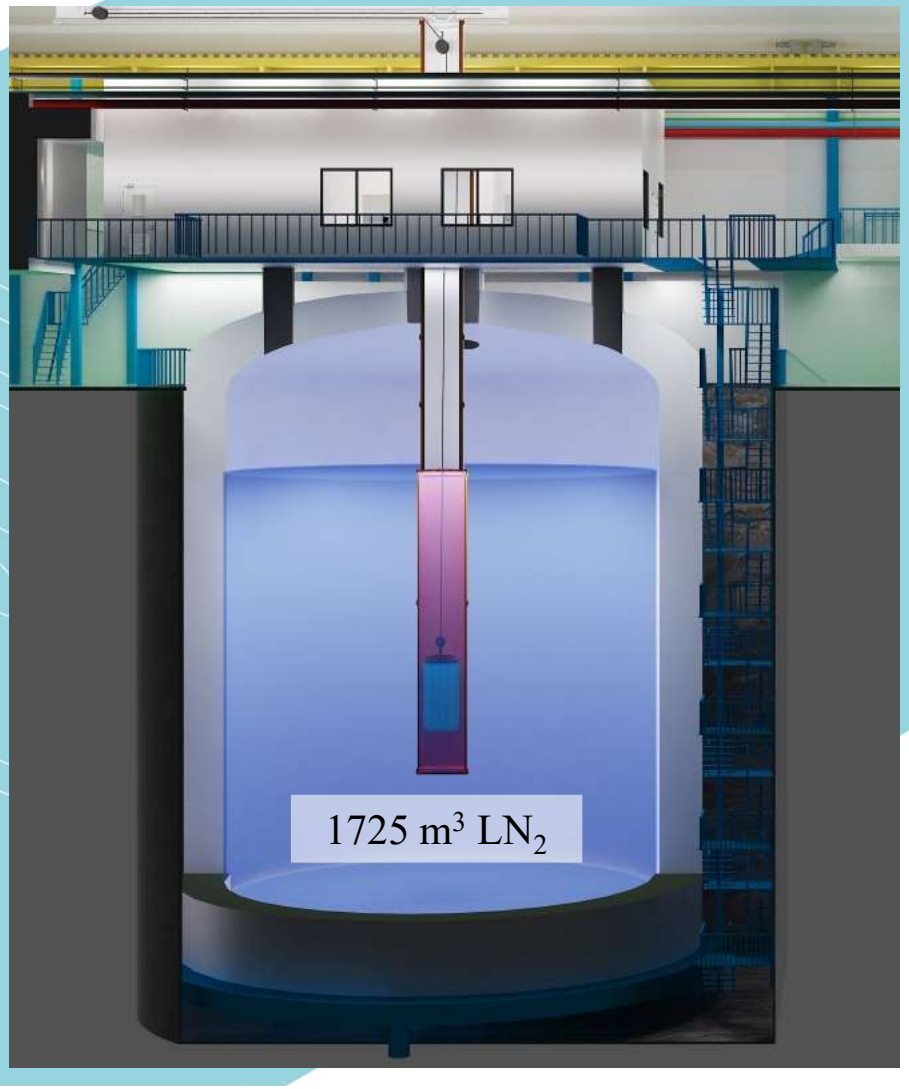
WRRS layers	Radon exhalation rate ($mBq \cdot m^{-2} \cdot s^{-1}$)		
	Value	Error	Detection limit
Rock (before WRRS)	6.99	0.331	0.239
Concrete	3.23	0.171	0.058
HDPE	0.09	0.057	0.075
Accelerated rubber layer	-	-	0.075
Concrete-polymer-cement	0.14	0.092	0.087
Polyurethane cement	-	-	0.080
Polyurethane top-coat	-	-	0.077
Polyurethane varnish	-	-	0.072

Key Project: Large Nitrogen vessel shielding

- Large LN tank completed
- Clean room under construction
- LN volume: Φ13m×H13m, ~1725 m^3
- LN being filled and to be finished in June

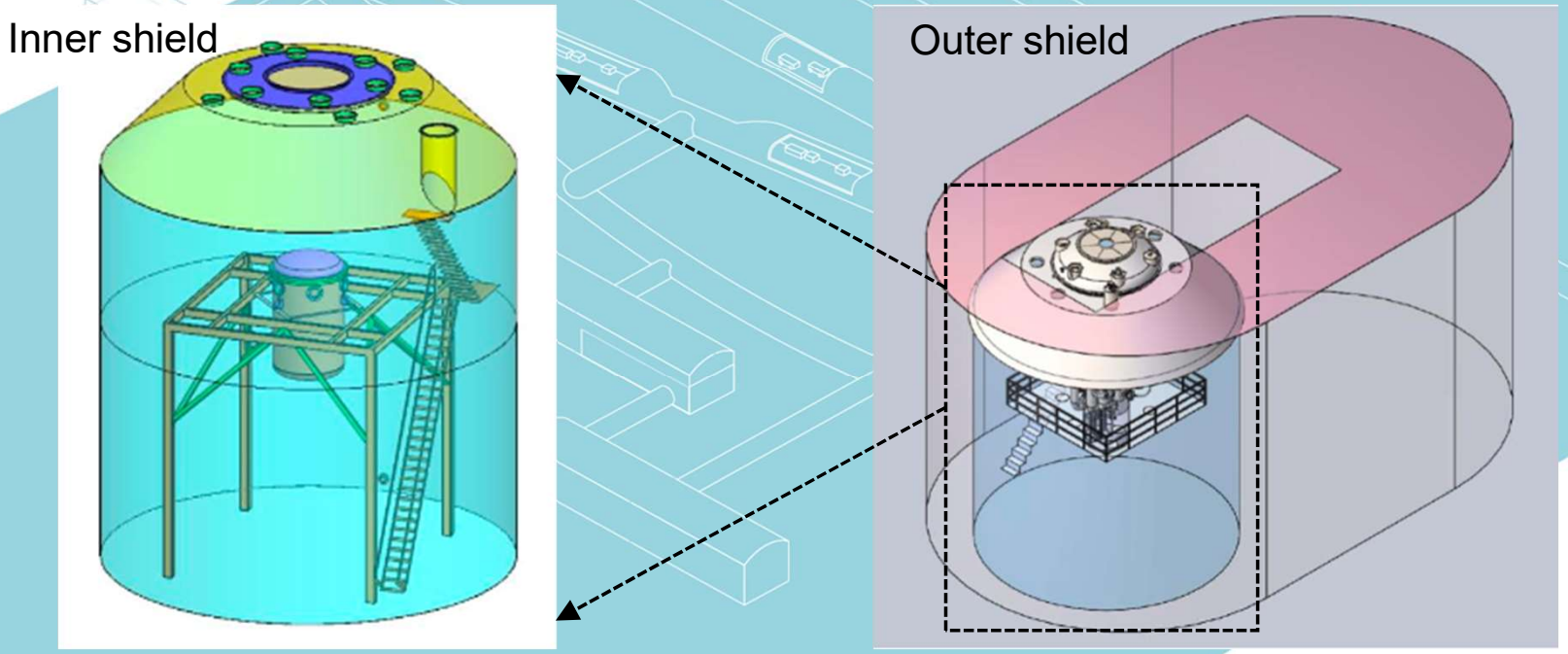

Pit in Hall C1


1725 m^3 LN tank in Hall C1



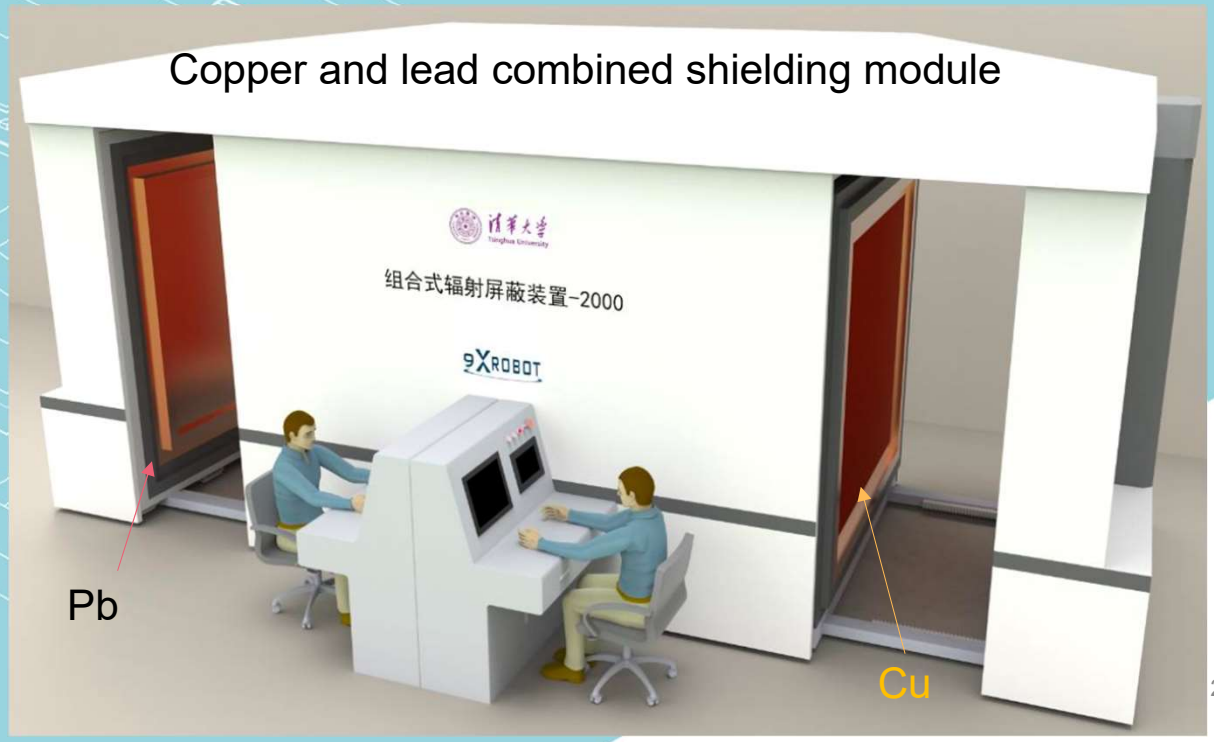
Key Project: Large pure water tank shielding

- Located in Hall-B2
- Outer shield (4500 m^3 water) and inner shield (1000 m^3 water)
- 12 L low-level radon measurement device completed



Key Project: Combined shielding module

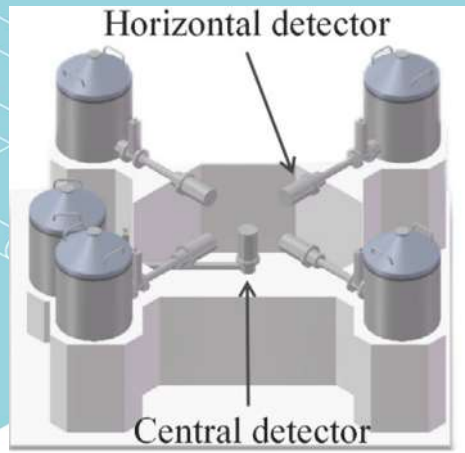
- Multi-purpose shielding combined by PE, Copper, and Lead
  - PE room completed
  - Inner copper and lead combined shielding module under construction



Key Project: Ultra-low-background γ spectrometers

- mBq/kg spectrometers (GeTHU)
  - Extension of current GeTHU-1/2/3/4
  - Detection limit: ~ mBq/kg scale
  - Total 15 HPGe γ spectrometers
    - 10 customized + 5 home-made Ge detectors

- μBq/kg spectrometers (ARGUS)
  - Detection limit: ~ μBq/kg
  - 5 customized LB Ge detectors
  - Low-background shielding



Applied Radiation and Isotopes 220 (2025) 111748

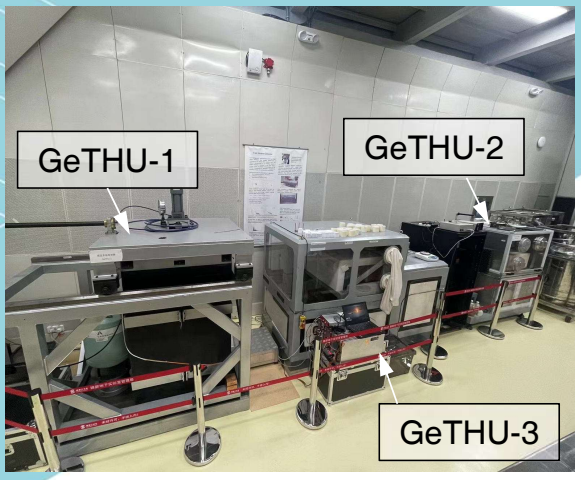
Key Project: Low-background material selection

- Measurement and selection of construction materials
  - Samples are randomly selected at the construction site and measured at GeTHU gamma-spectrometers
  - 2703 samples, 24359 h in total until Sept. 30, 2023
  - Collaborating with manufacturers to get low-background cement


Cement sampling


Measured Samples


Processing



Ground laboratory in Xichang

Experimental building(1-3F) Office building(5-6F)

Located in between Xichang airport and downtown

ICP-MS room

Experimental hall

Labs for sample treatment

IV. Experiment proposals of CJPL-II

- CDEX、PandaX
- JUNA
- Jinping Neutrino Program
- CUPID-China、NvDEX
- GeoDEX、 IC SER Exp.

CDEX

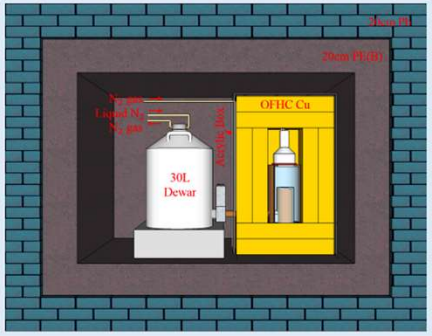
- Founded in 2009, 11 institutions, more than 100 people now
- Focused on Dark Matter detection and Ge-76 0νββ search using HPGe technology

2009-2016	2016-2020	2021-	Planed

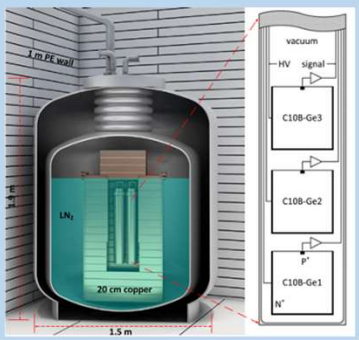
CDEX-1

CDEX-1A
- DM: χ-N (SI/SD)
- Axion & Axion-like DM
- CDEX first ovββ result

CDEX-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 (0νββ)

CDEX-1T (0νββ, DM...)

CJPL-I | CJPL-II

PandaX

- Started in 2009, consists of dozens of Universities and research Institutions
- Increasing LXe detector mass for DM and neutrino studies
- Next step: PandaX-xT

PandaX

Phase-I
120 kg

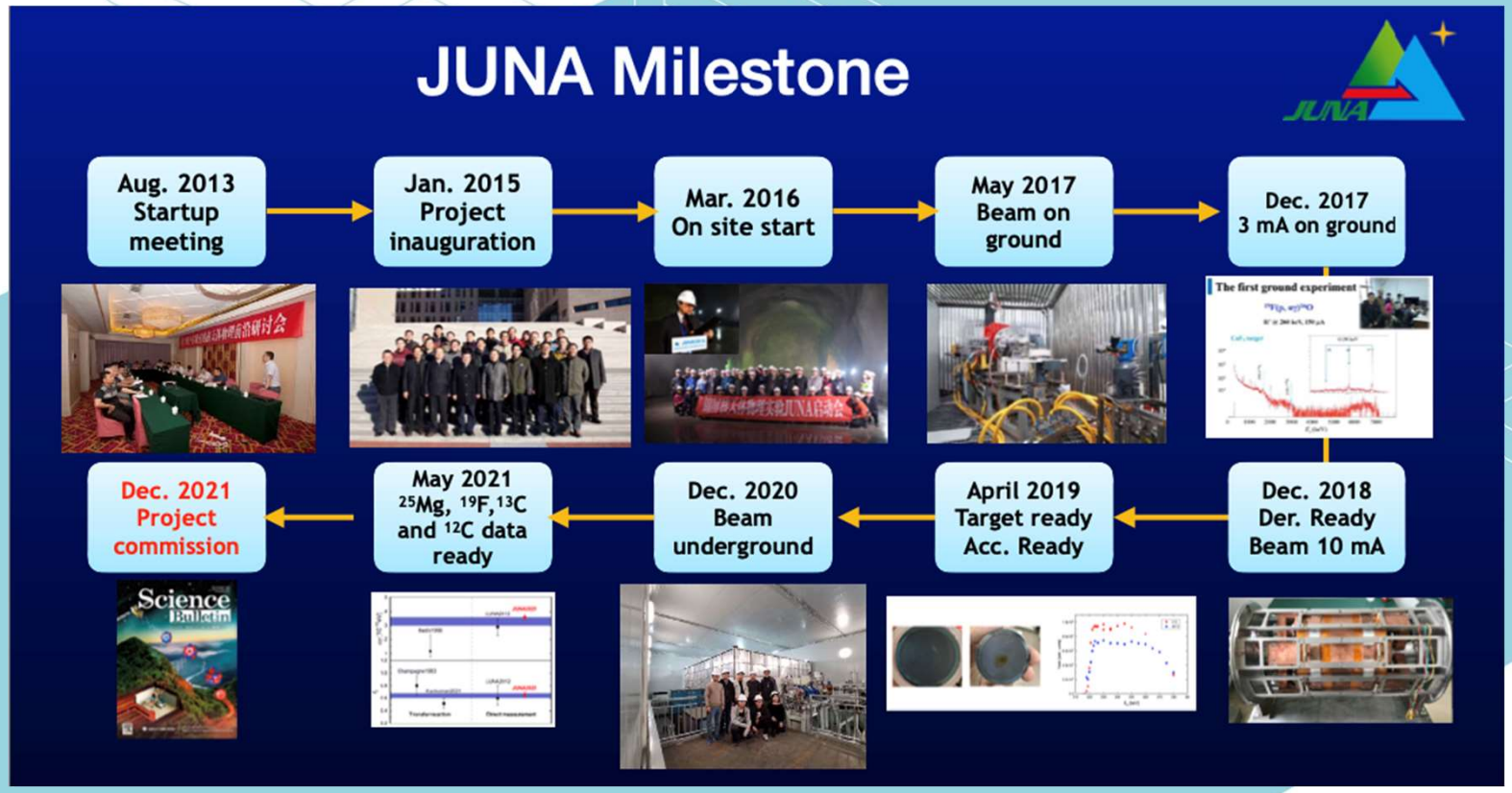
Phase-II
580 kg

PandaX-4T
3.7 ton

2009 | 2010-2014 | 2015-2019 | 2020-

Jinping Underground Nuclear Astrophysics experiment

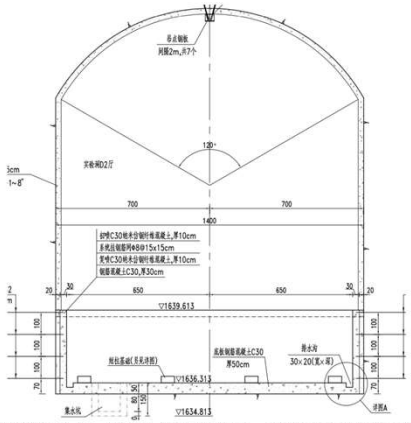
- Started in 2013, 7 Universities and research Institutions
- Goals: Nuclear astrophysics study using underground accelerator
- Next phase: Super JUNA



Jinping Neutrino Program

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

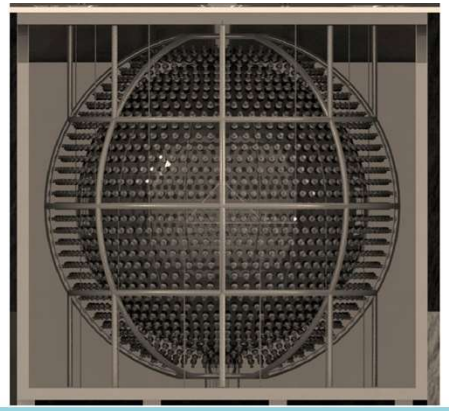
Pit for 500 ton Neutrino Observatory at Hall D2

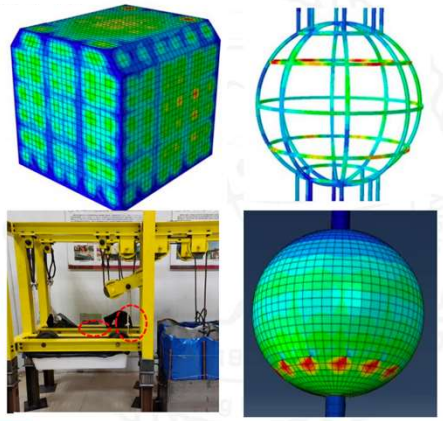


实验设备基坑设计图（华东设计院）

实验设备基坑，长16米，宽14米，深3.8米，开挖工作完成（水电5局）

Neutrino detector design





CUPID-CJPL: ^{100}Mo-based bolometric exp. for 0νββ search

Crystal testing
(2021-2022)
6-12 natural crystals

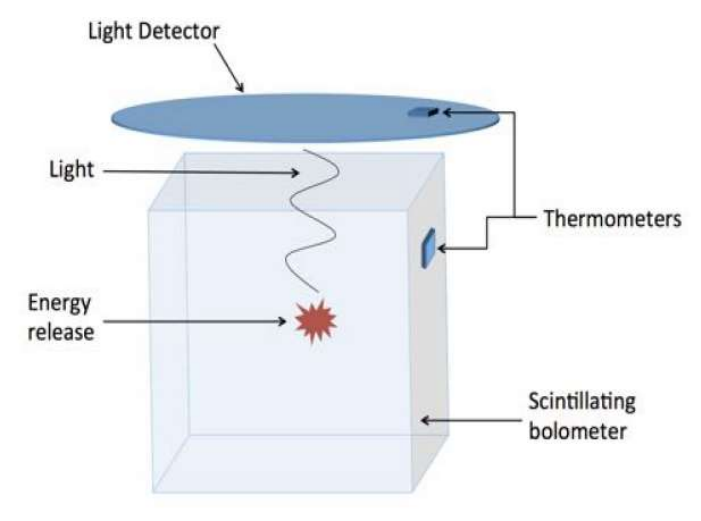
CUPID-CJPL demonstrator
(2022-2025)
10 kg, 36 enriched crystals

CUPID-CJPL-200/1T
(2025+)
>1000 enriched crystals

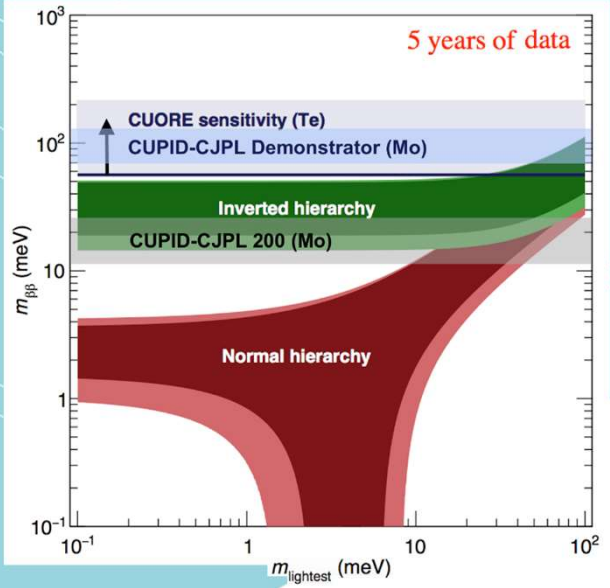
CUPID-China

- Fudan University*
- Beijing Normal University*
- Shanghai Institute of Applied Physics
- Shanghai Institute of Ceramics
- Shanghai JiaoTong University*
- Tsinghua University
- University of Science and Technology of China*
- Ningbo University

*officially joined international CUPID

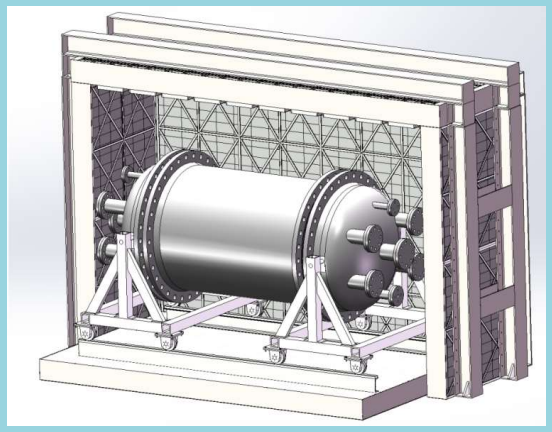


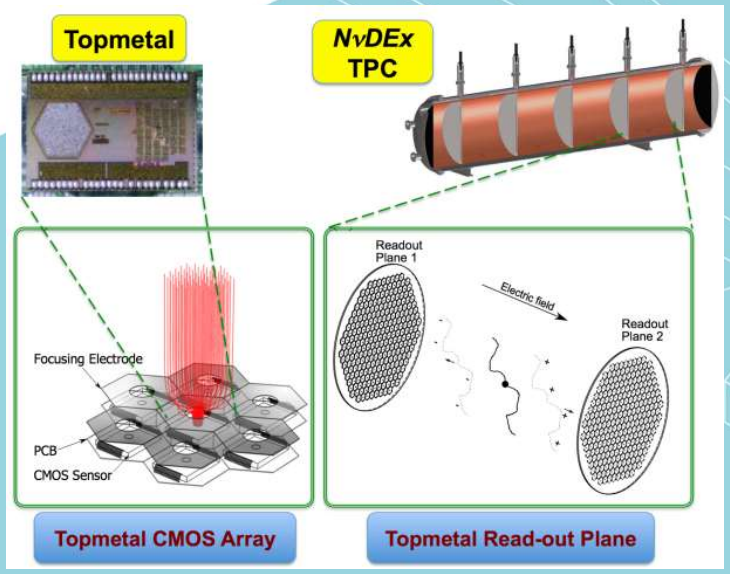
From Long Ma, Fudan U.

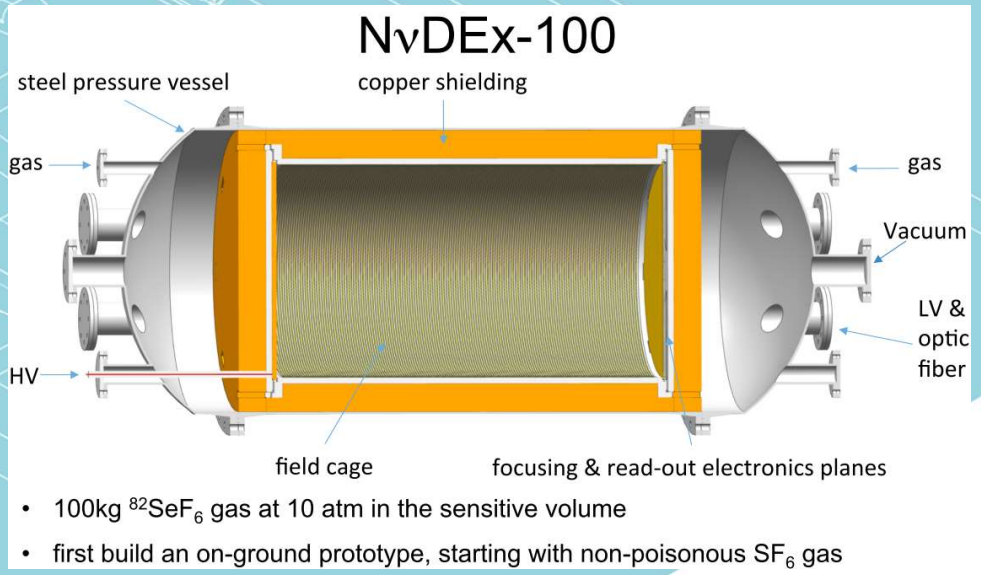


NvDEx for ^{82}Se 0νββ search

- High pressure $^{82}SeF_6$ Gas TPC
- Direct read-out by top-metal CMOS sensors
- Prototype detector being built and tested above ground



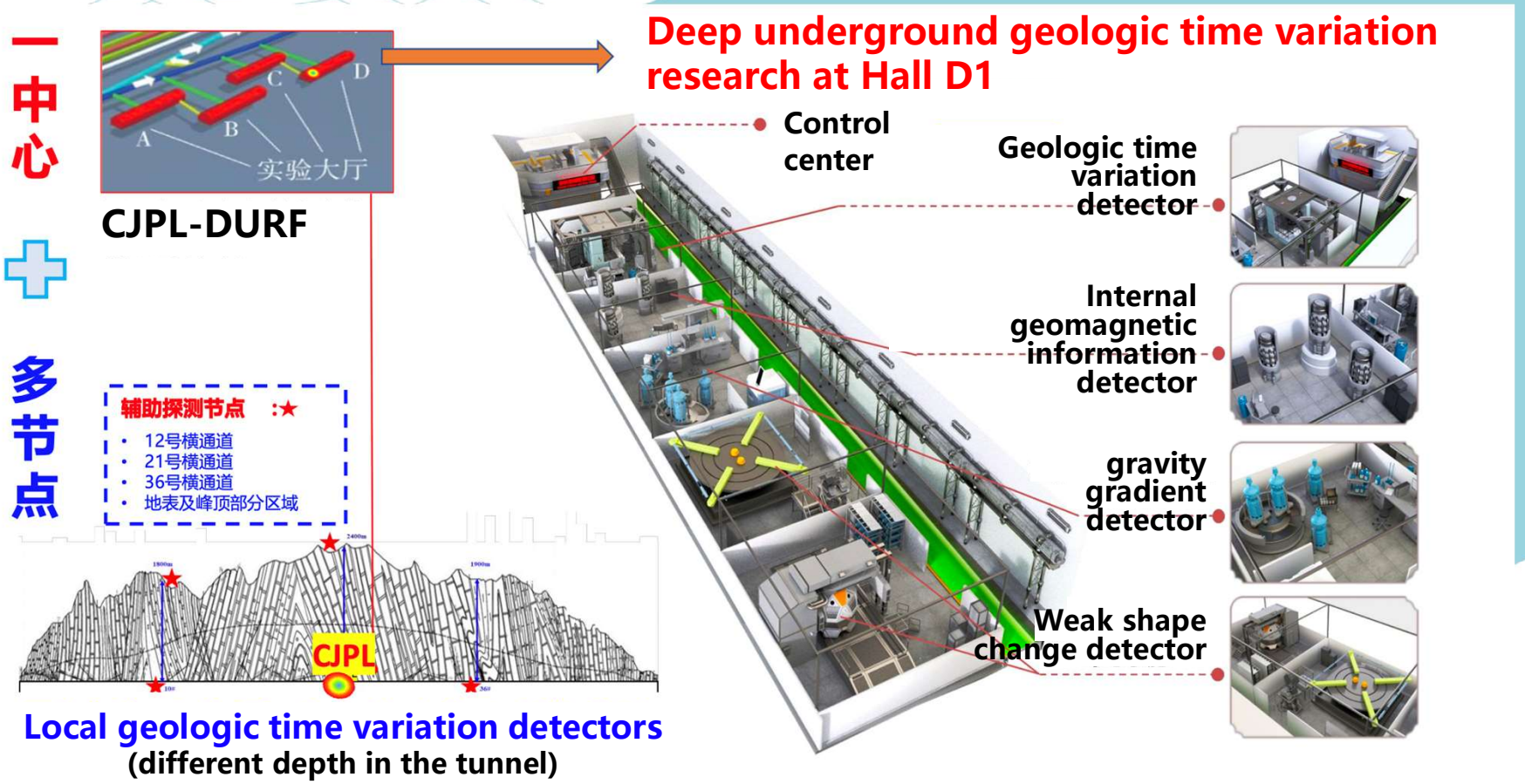




From Hao Qiu, IMP, CAS

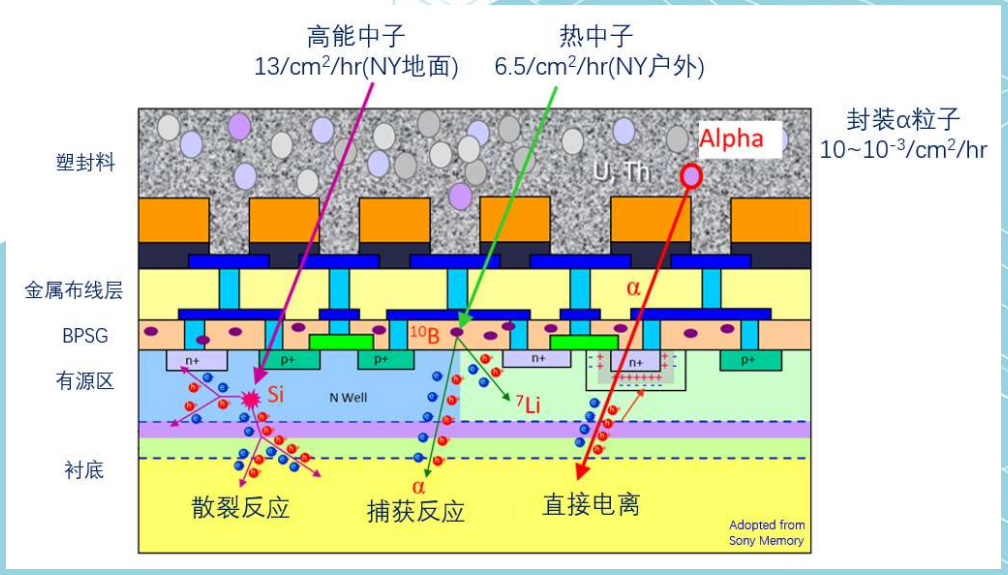
GeoDEX

- Deep underground geologic time variation in-situ detector experiment



IC SER: deep underground Integrated Circuit Soft Error Research

- Radioisotopes in IC could cause soft error (SE) by emitting alpha particles
- Study the SE rate in CJPL to prevent interference from atmospheric neutrons
- Compare test data in CJPL and Lhasa to acquire “Golden data” for IC SE rate

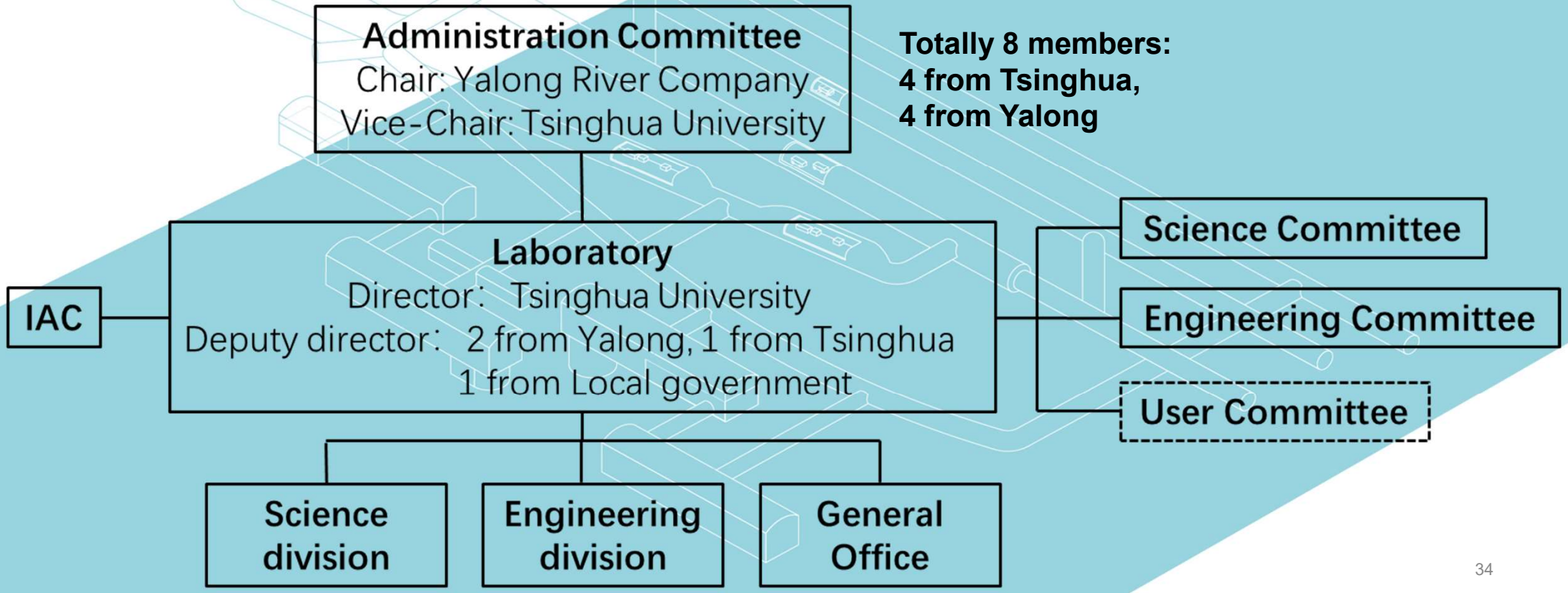


Test at Lhasa
- 6651 hr

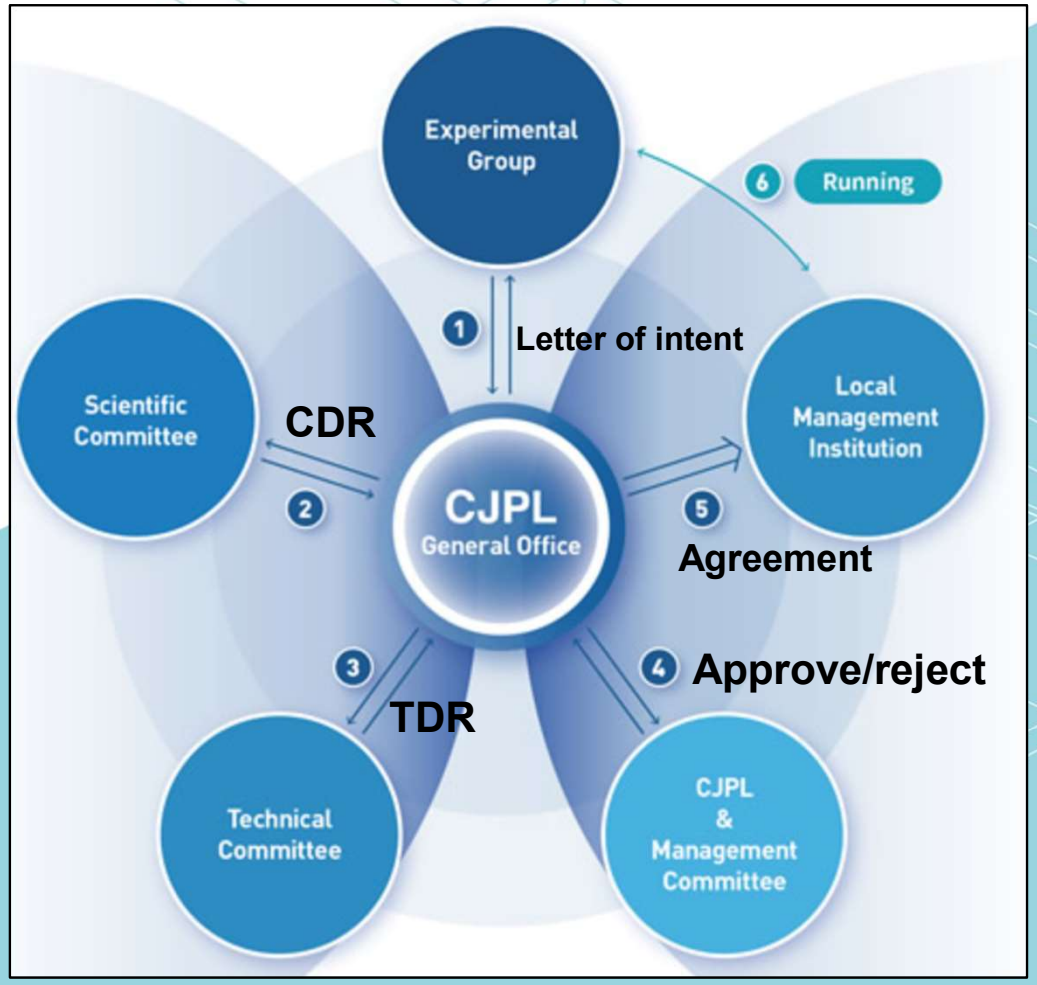
Test at CJPL-I
- 6000 hr

V. CJPL Management structure

News: An entity (Jinping Underground Science Center) will be established soon to operate CJPL in Xichang city.



Experiment Approval Process



Welcome researchers worldwide to submit your proposals

VI. Summary

- CJPL-II will be the deepest (2400m rock) and largest (>300,000 m^3 space) underground Lab worldwide
- Civil engineering of CJPL-II completed
- CJPL-II plans to start operation at the end of 2025
- The water-resistant and radon suppression in CJPL-II controls radon exhalation rate to less than 0.1 $mBq/m^2/s$
- Construction materials are measured and selected to control their background
- Cavern safety monitoring system ensures the safe and smooth operation of CJPL-II

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Contact: cjpl@tsinghua.edu.cn

Welcome to CJPL!

Welcome to join in TAUP 2025!

https://hep.tsinghua.edu.cn/taup