

# The recent status and prospect of China Jinping Underground Laboratory

Tsinghua University

Prof. Jianmin Li

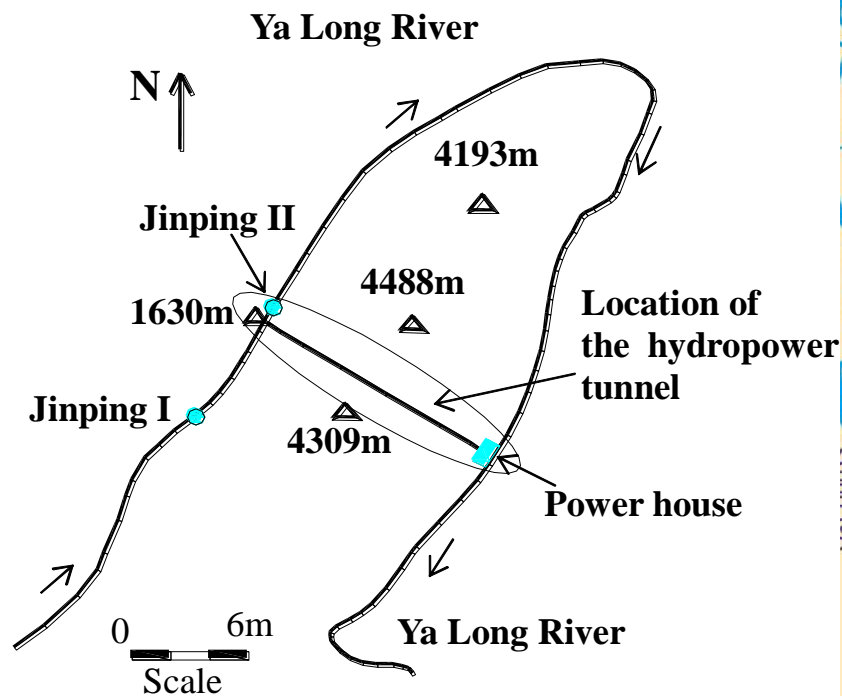


中国锦屏地下实验室  
China Jinping Underground Laboratory

# Contents

- I. CJPL Introduction
- II. CJPL-I Status
- III. CJPL-II Status and Future
- IV. Research Projects in CJPL-II
- V. Summary

# CJPL Site



Sichuan Province

Jinping tunnels

**Yalong River Hydropower Development Company** started to develop the hydro-energy for the entire river since 1990s.

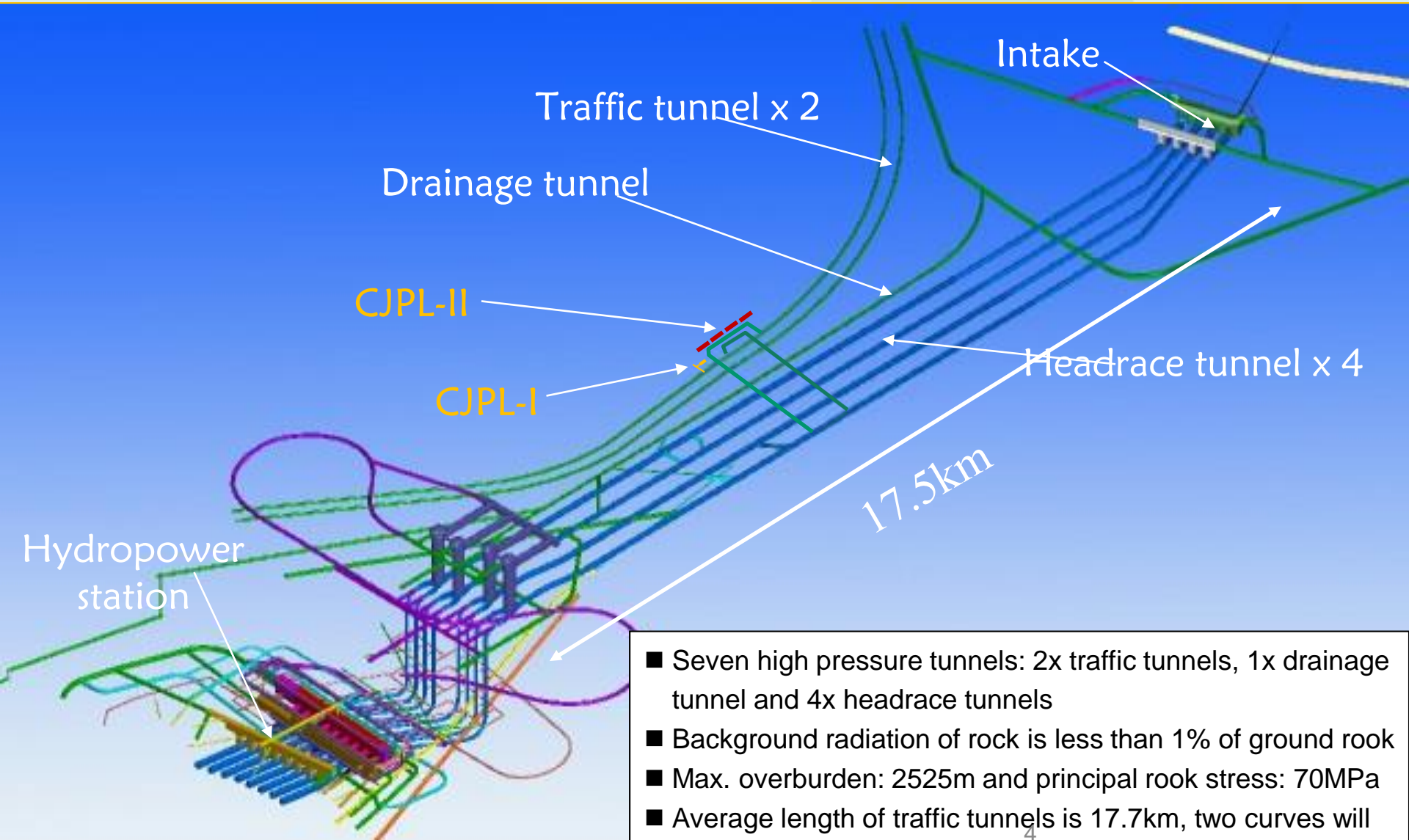


中国锦屏地  
China Jinping Undergro

Yunnan Province



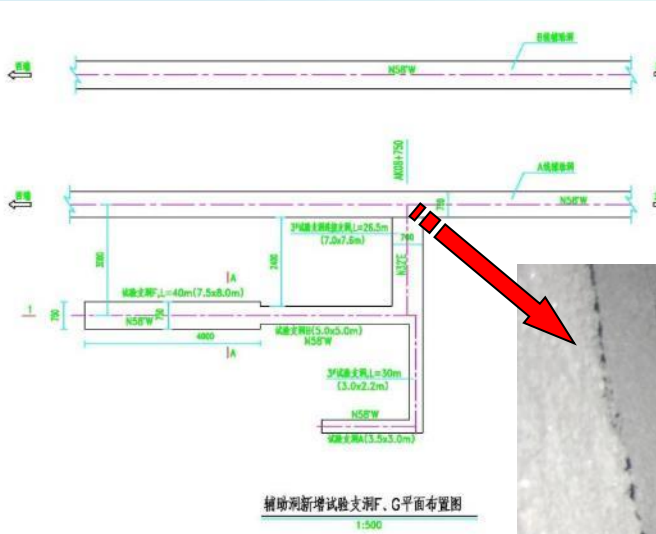
# CJPL Site and Jinping-II Hydropower Station



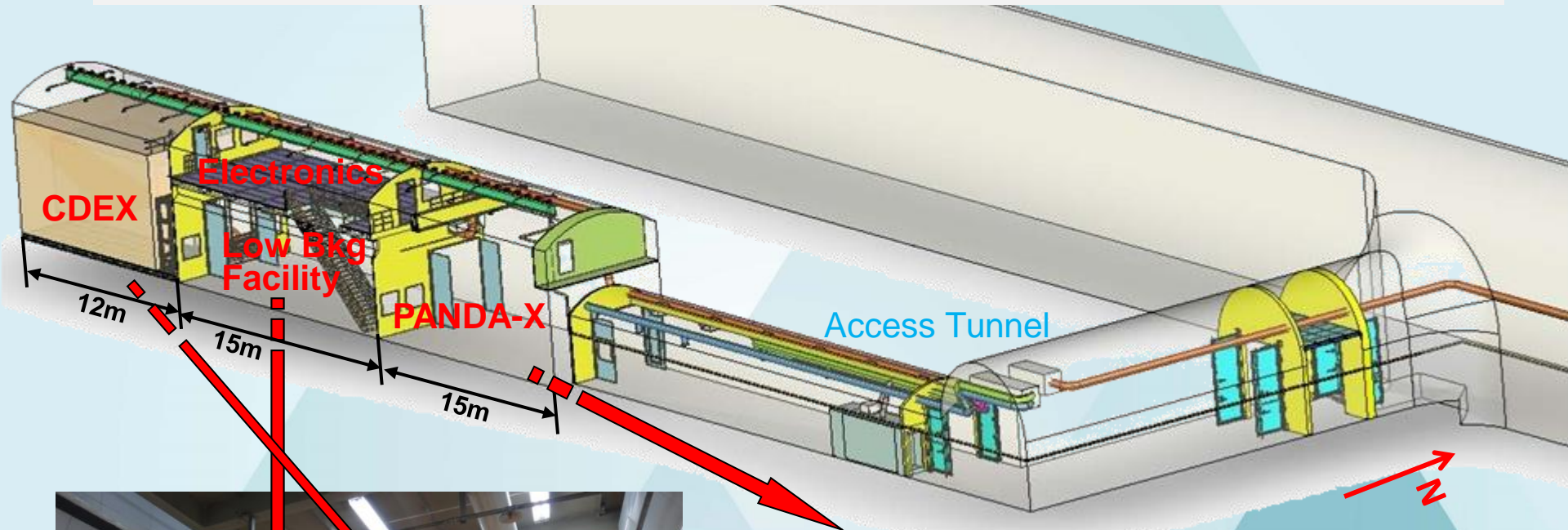
- Seven high pressure tunnels: 2x traffic tunnels, 1x drainage tunnel and 4x headrace tunnels
- Background radiation of rock is less than 1% of ground rock
- Max. overburden: 2525m and principal rock stress: 70MPa
- Average length of traffic tunnels is 17.7km, two curves will be helpful for comic radiation shielding.



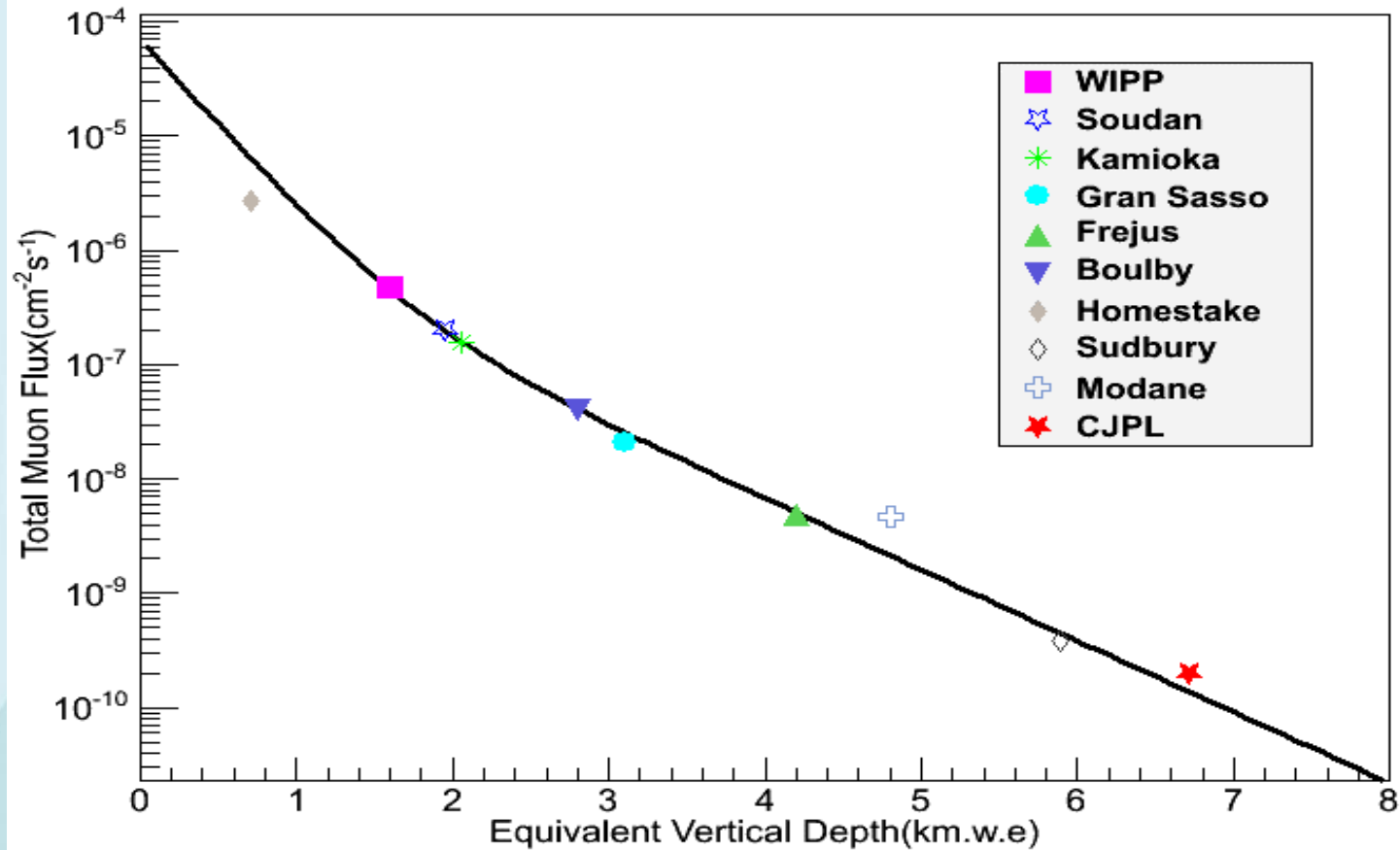
# Dig the tunnel for CJPL-I, July 2009



# CJPL-I – Dark Matter Experiment



# Radiation Environment in CJPL-I



Humidity: 37%; Temperature: 21°C。  
Rn average:  $34 \pm 7 \text{ Bq/m}^3$  ( $2.6 \times 10^{-1} \mu\text{J/m}^3$ )

# CJPL : laboratory with low background radiation

## Convenient traffic condition

Large equipment can be transported into the lab by truck

Staffs and visitor can get into the lab by car

## The deepest lab by rock cover in the world

Equal ~7000m water shielding

Low background cosmic radiation ( $<70$  counts/m<sup>2</sup>.y)

## Low background radiation

The underground lab with rock (marble) cover condition of low background radiation

No high-energy radiation isotopes in the background radiation, easy for shielding

## Facilities

Stable electric power and communication supply

Good condition for Logistics services

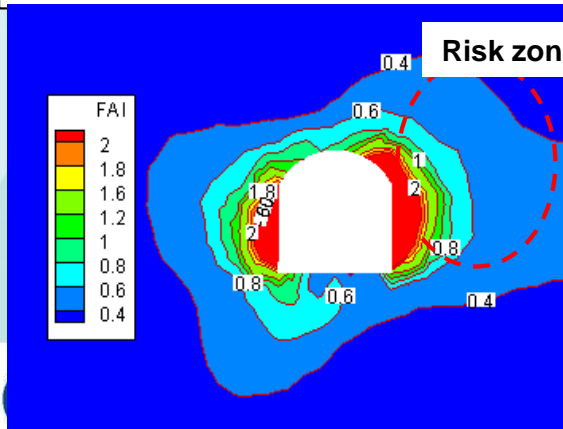
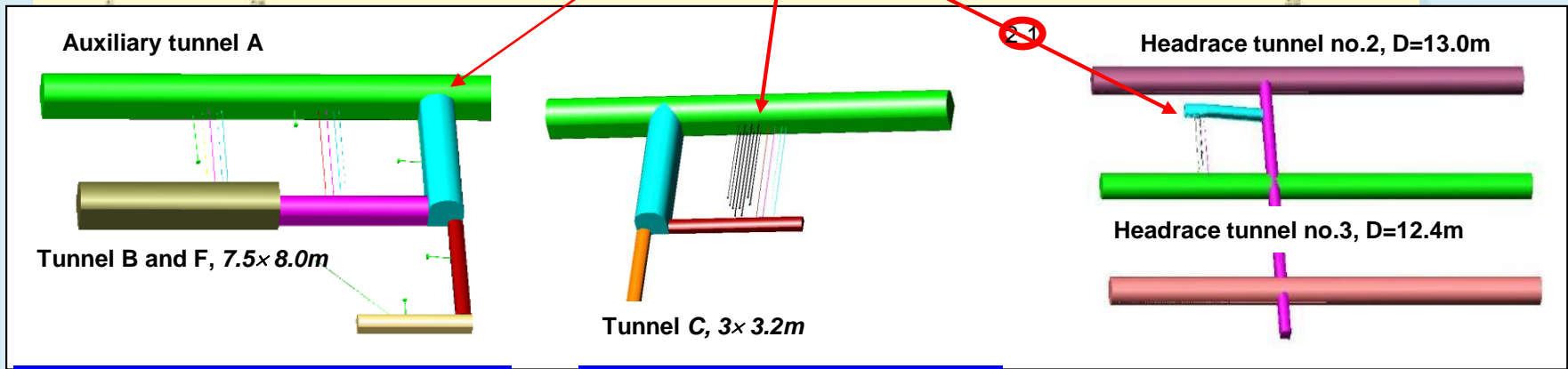
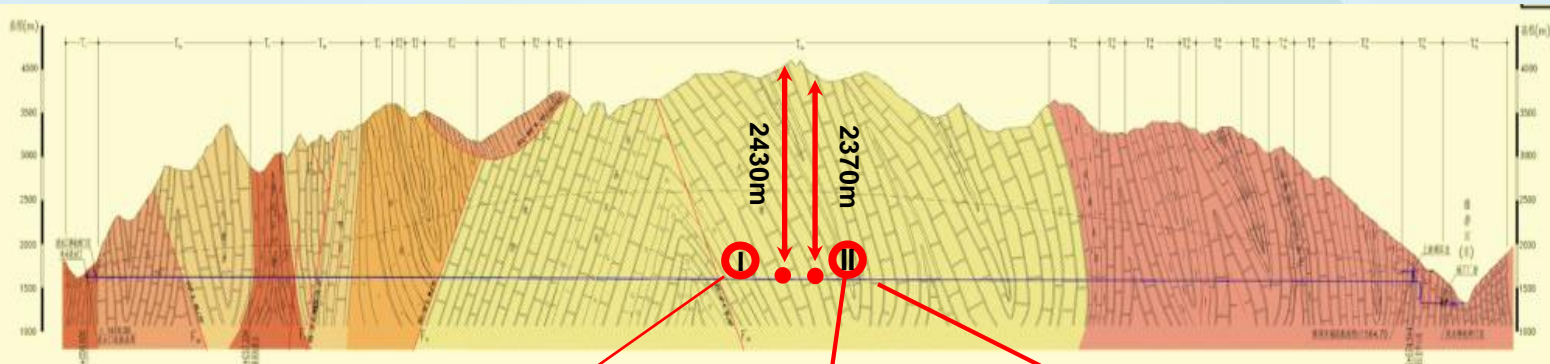
Professional engineering staff



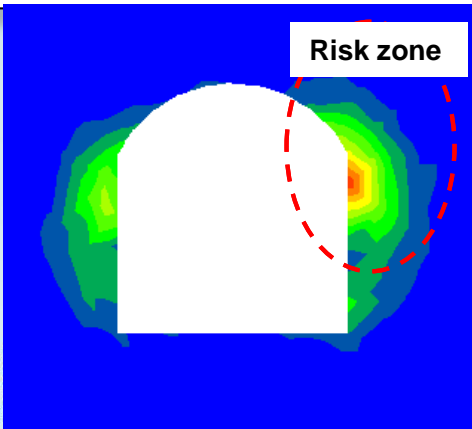
中国锦屏地下实验室  
China Jinping Underground Laboratory



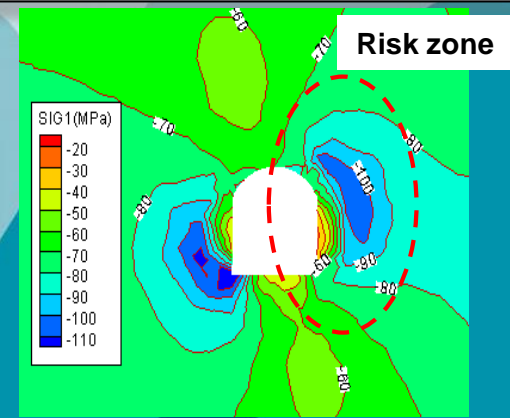
# ● Evolution of Surrounding Rock



Distribution of failure approach index(FAI)

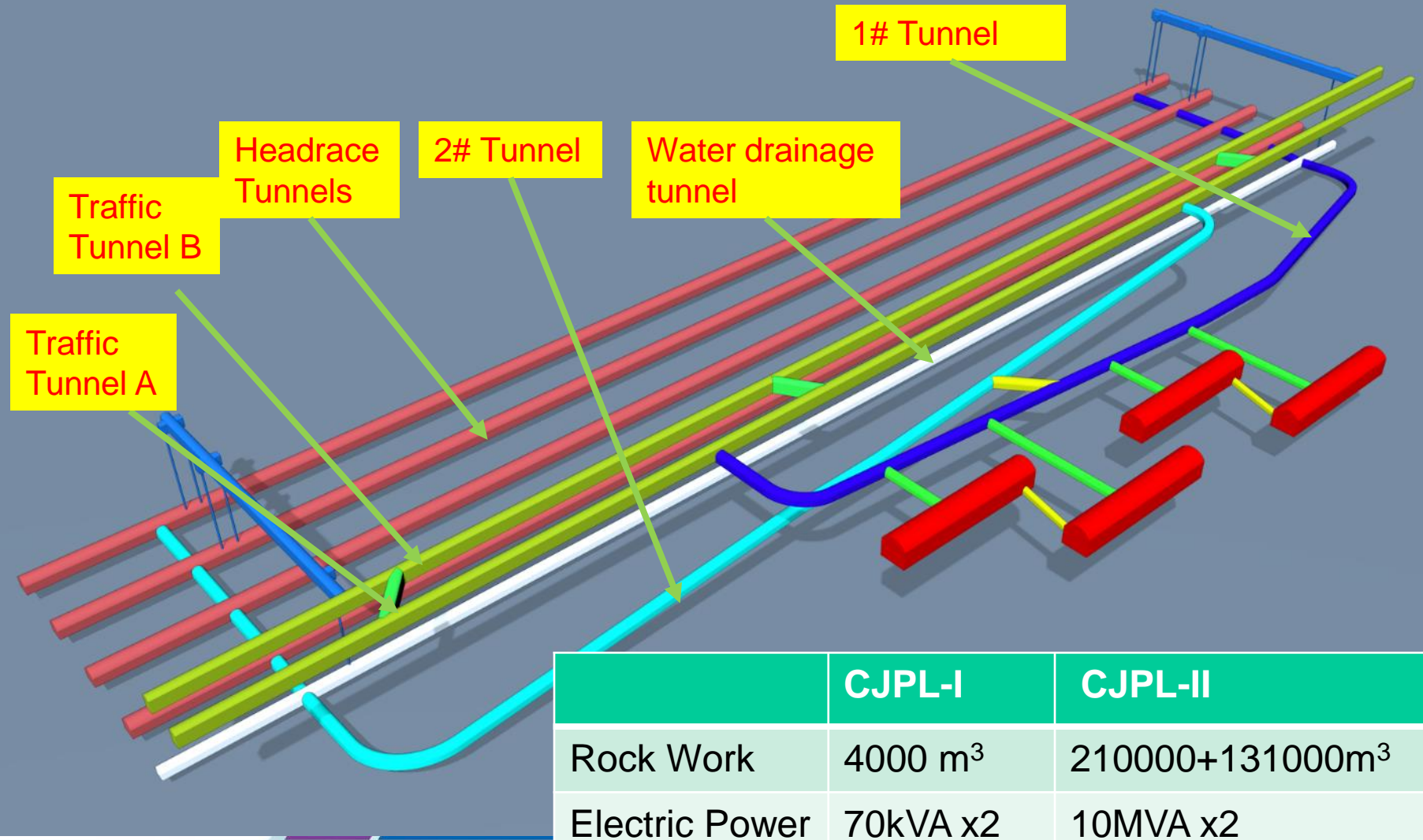


Distribution of local energy released rate (LERR)



Distribution of the maximum principal stress

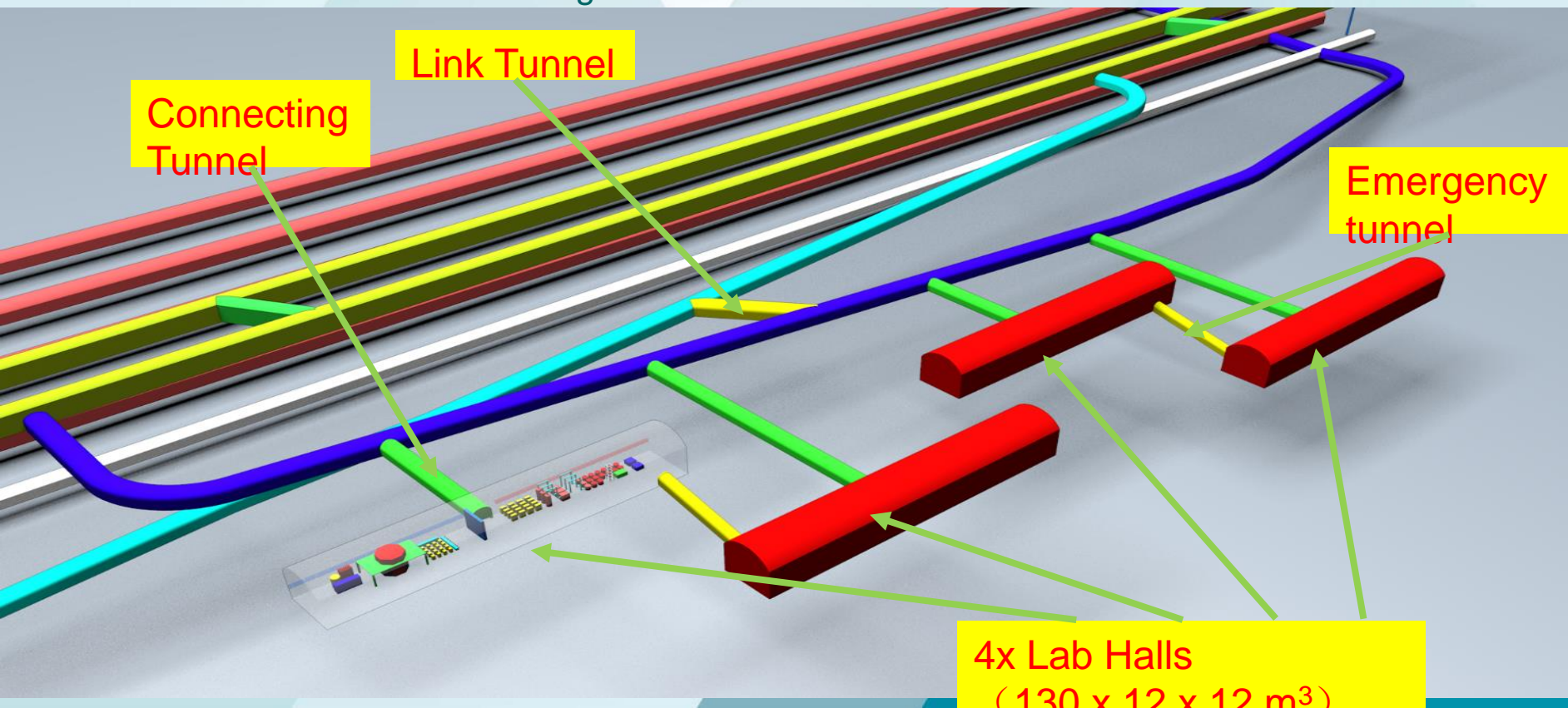
# Preliminary Design of CJPL-II



	CJPL-I	CJPL-II
Rock Work	4000 m <sup>3</sup>	210000+131000m <sup>3</sup>
Electric Power	70kVA x2	10MVA x2
Fresh Air	2400 m <sup>3</sup> /h	15000 x3 m <sup>3</sup> /h

# Preliminary Design of CJPL-II

- A Link Tunnel between 1# & 2# tunnels, size is  $7\text{m} \times 7\text{m}$ , slope of 1%
- 4 Connecting tunnels to link 1# tunnel to 1-4# lab halls separately, size is  $8.2\text{m} \times 8.2\text{m}$ . Slope of 1# and 2# Connecting tunnels is 1%, and Slope of 2# and 4# Connecting tunnel is 4.5% .
- 2 emergency tunnels between 1# lab and 2# lab , and 3# lab and 4# lab. The inner size is  $5\text{m} \times 5\text{m}$ .
- $2 \times 2$  doors in the entry of 1# tunnel, 2# tunnel from traffic tunnel A. 2 doors between 1# tunnel and water drainage tunnel. Some fire doors between tunnels.





# Preliminary Design of CJPL-II

- Requirement of lab hall:
  - The length of each lab hall is 130, size is  $14\text{m} \times 14\text{m}$ , slope is less than 0.3%. Drainage ditches are on the both side.



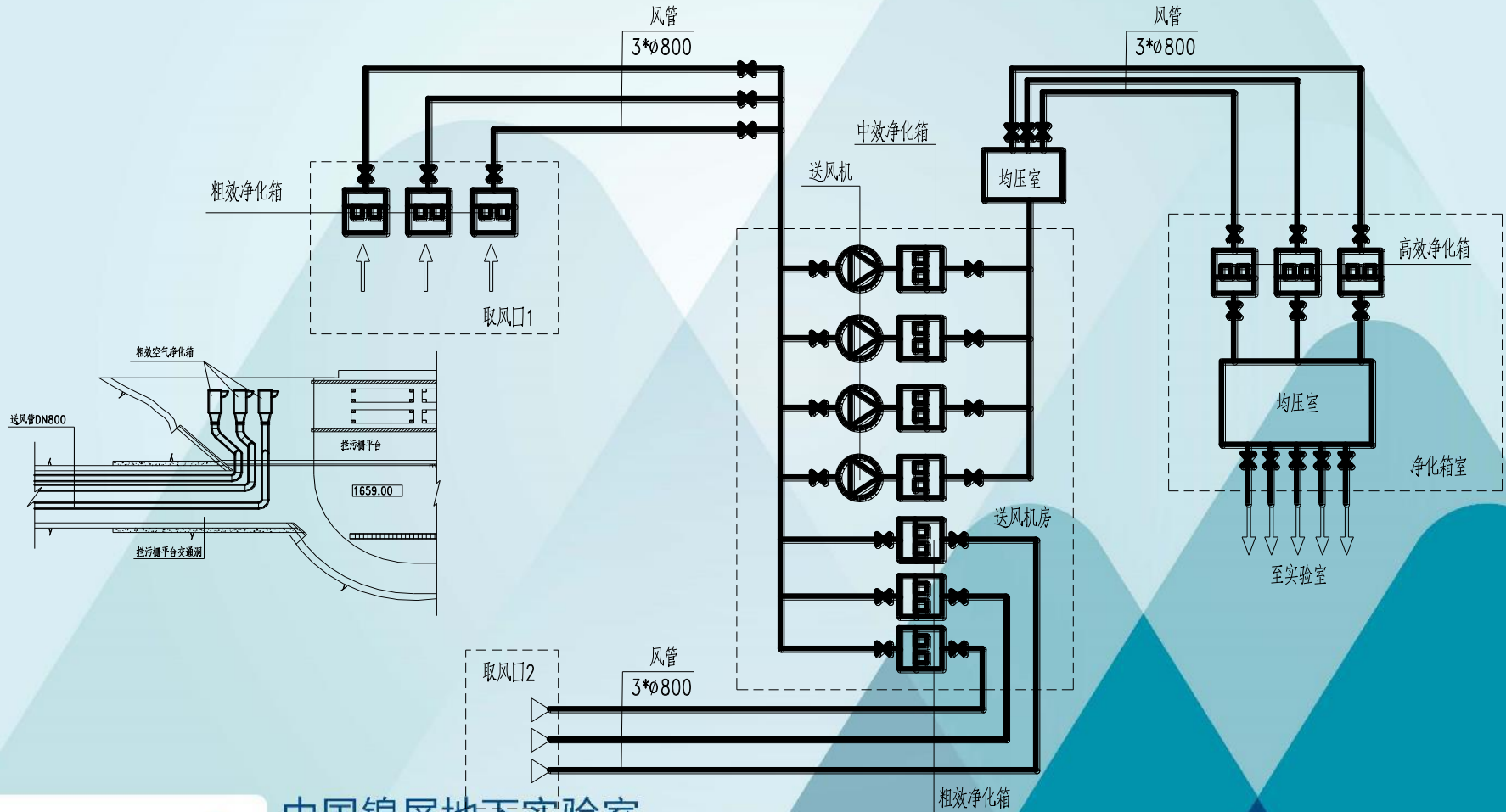
钢材估量表				
编号	规格	单重 Kg/m或Kg/m <sup>2</sup>	长度/面积 m或m <sup>2</sup>	总重 Kg
1	H350X250X10X16	87.8	2815	247160
2	H550X350X10X16	128.6	9	1160
3	H400X300X10X16	104.2	5	520
4	H500X350X10X16	124.6	242	30150
5	H600X500X10X16	170.2	16.5	2810
6	HN100X50X5X7	8.9	610	5430
7	HN200X100X5.5X8	20.5	260	5330
8	2L63X6	11.5	610	7015
9	2L50X6	9	105	945
10	2L90X6	16.7	5	85
11	L63X6	5.8	14500	84100
12	吊车轨道	43	260	11180
13	节点板			47505
	总重			443390

注：1. 钢丝网用量不包括在总重内

2. 钢丝网采用丝径为4mm，孔径为30mm，面积约4736m<sup>2</sup>



# Ventilating System



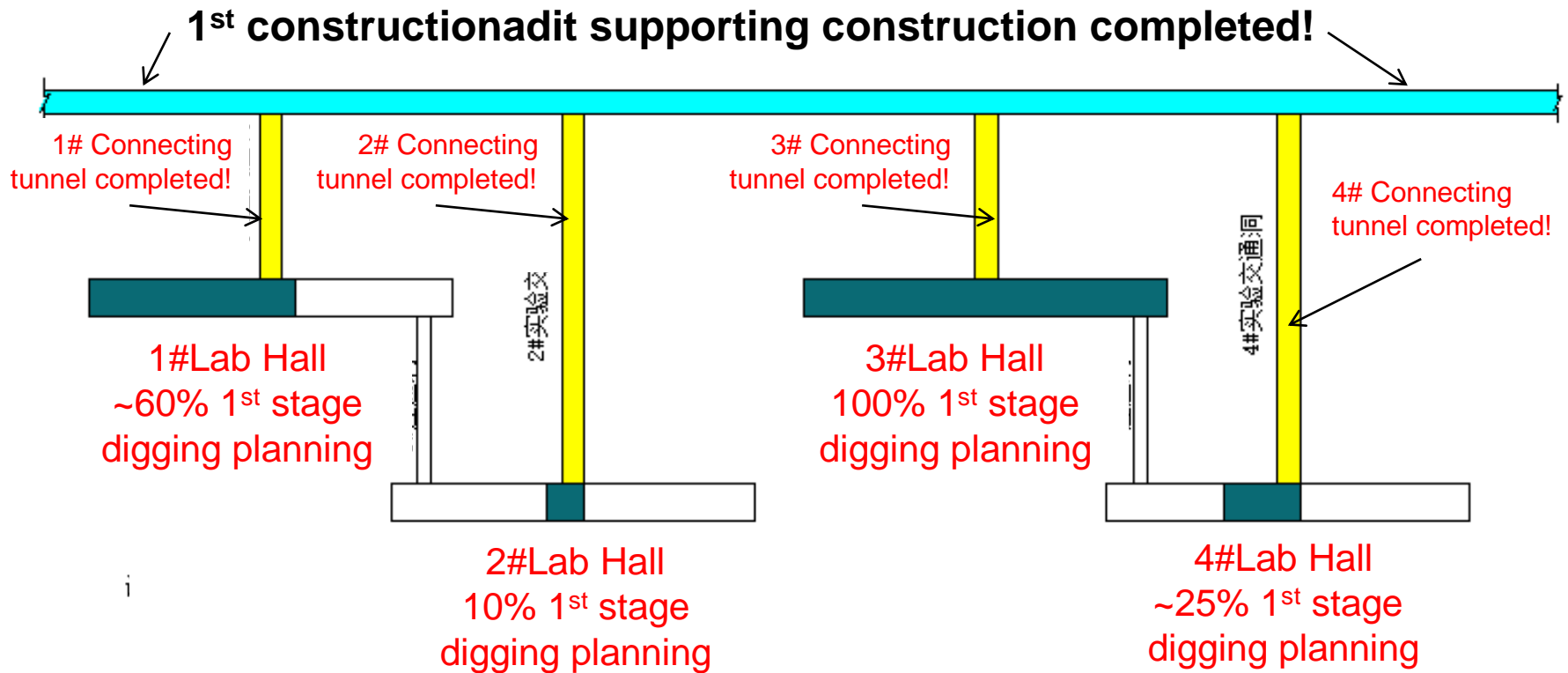
# Render Picture of Tunnel



# CJPL-II Construction site , Dec 2014



# CJPL-II Construction Complete Schedule



Upon to the end of April 2015



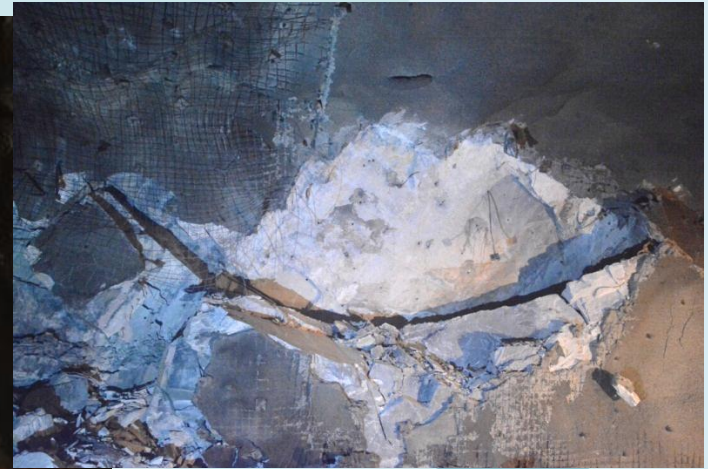
# Rock burst and collapse during Construction



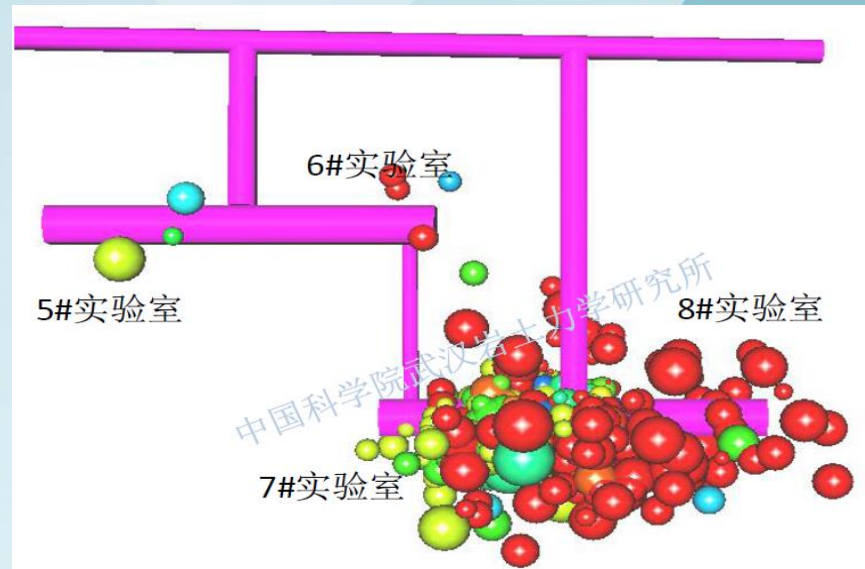
Dealing with the collapse



rock burst of 1000m<sup>3</sup> in May-9



rock burst of 600m<sup>3</sup> in Aug-23



# Variable rock structure under anticline environment in the same area



Lab in the middle of an anticline structure

- Hard intact — original rock mass
- Alteration fractured — original rock mass
- Change of rock mass structure due to cavern excavation (High stress released or redistributed)



Alteration fractured zone in 2# access tunnel



Rock altered into mud





Rock condition of Hall 2#



原岩结构大部分完全破坏



Rock condition of Hall 3#



Rock condition of Hall 1#

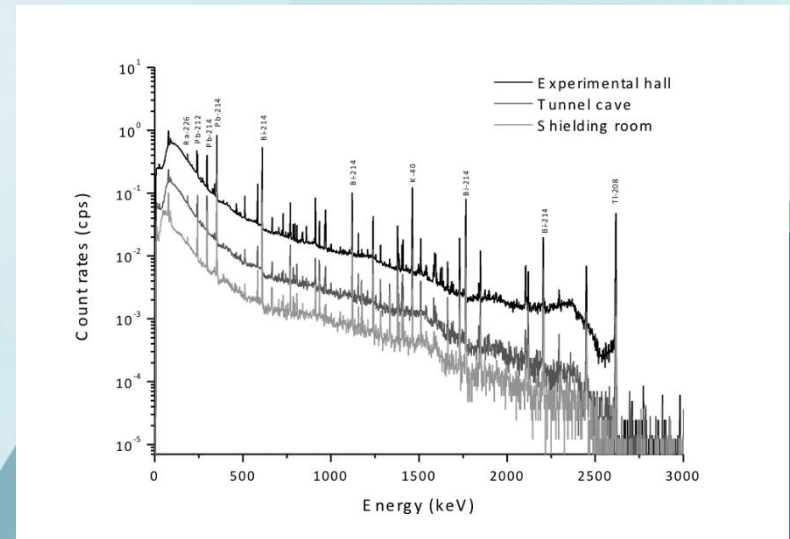
# CJPL-II Radioactivity Background Control



some coal ash from electric power plant and some nano-additive were as concrete building material during the tunnel construction.

Comparison of radionuclides concentration(Bq/kg)

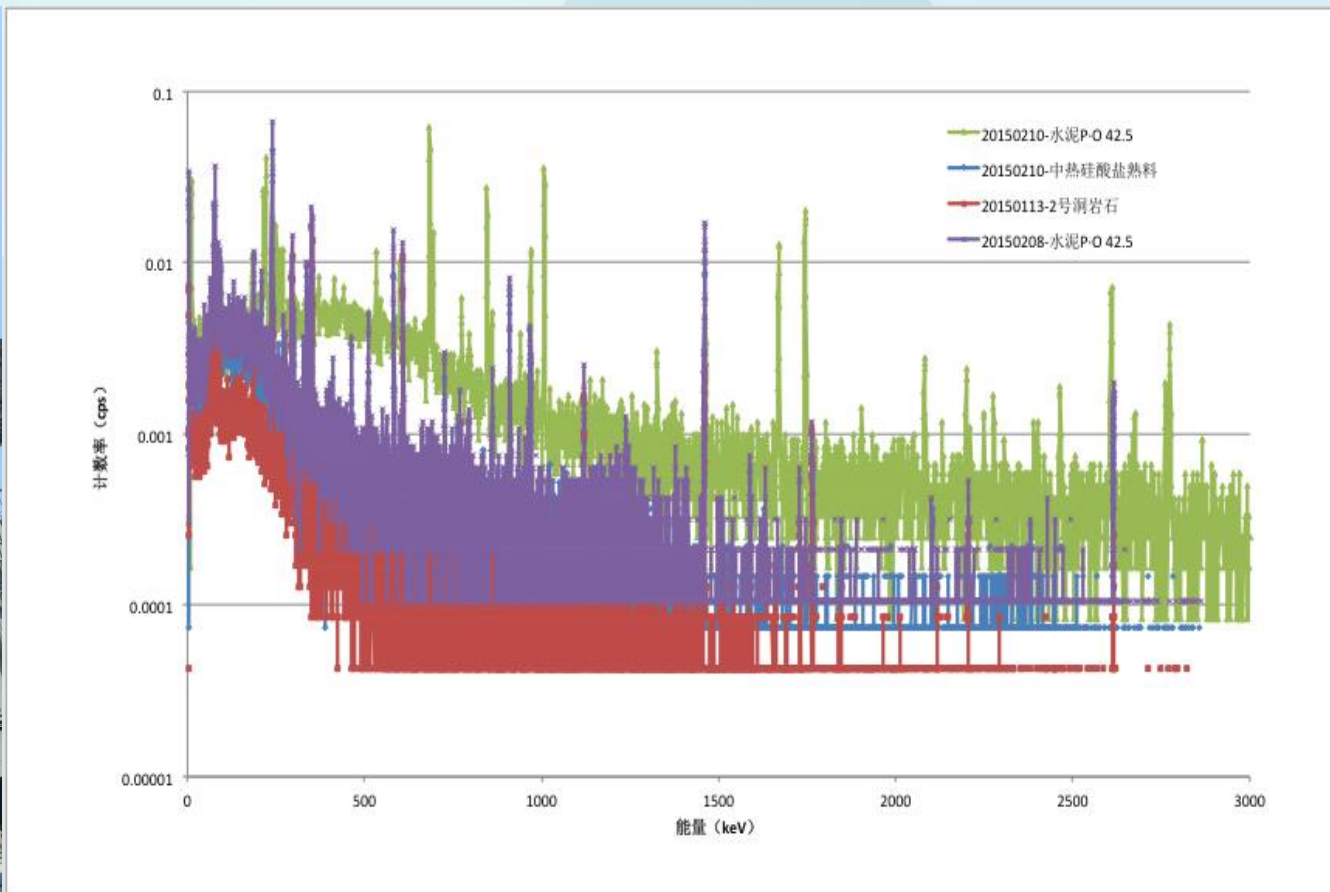
Radionuclide	Coal Ash	Rock
$^{238}\text{U}$	$123.92 \pm 37.18$	$12.45 \pm 3.11$
$^{232}\text{Th}$	$118.6 \pm 23.79$	$0.41 \pm 0.03$
$^{40}\text{K}$	$356.73 \pm 71.35$	$9.84 \pm 2.46$



**Need to control the raw material of concrete!**



# CJPL-II Radioactivity Background Control



customized Moderate  
heat cement

gamma spectrum of different cement by GeTHU  
--green: ordinary cement (20150210)(~4 times)  
--blue: moderate heat cement(<1.5times)  
--red: rock sample(base line);  
--purple: ordinary cement (20150208)(3-4time)



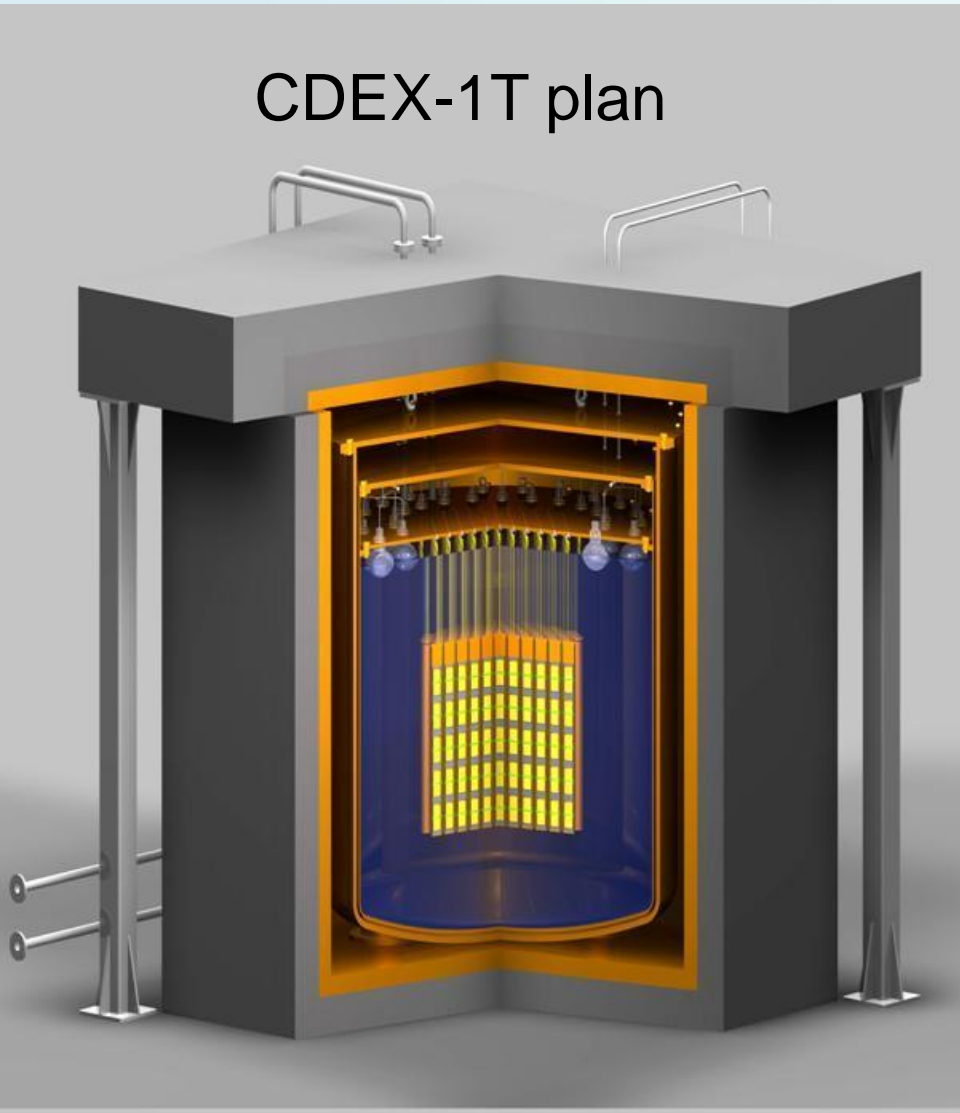
中国锦屏地下实验室  
China Jinping Underground Laboratory



# Planned Research Projects in CJPL-II

# Point Contact Germanium Array Dark Matter Experiment in CJPL

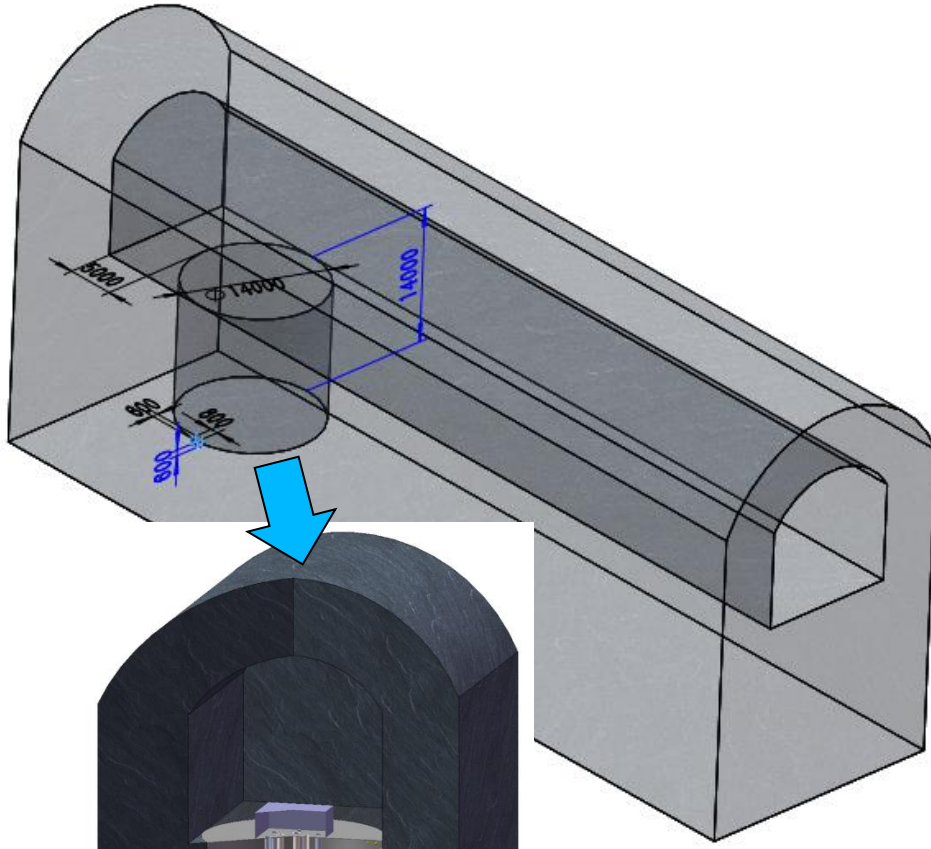
CDEX-1T plan



- **CDEX has started CDEX-1 experiment, and the first physical results has been published, two new results submitted to PRL and PRD.**
- **CDEX-10 (PCGe+Lar AC ) is testing at ground laboratory and plan to ship to CJPL in 2015.**
- **CDEX-1T multi-purpose experiment: Related technologies has been exploited including background understanding, detector fabrication, crystal growth, electronics and so on.**



# Liquid Argon Dark Matter Experiment in CJPL-II



## Construction of Detector in CJPL-II

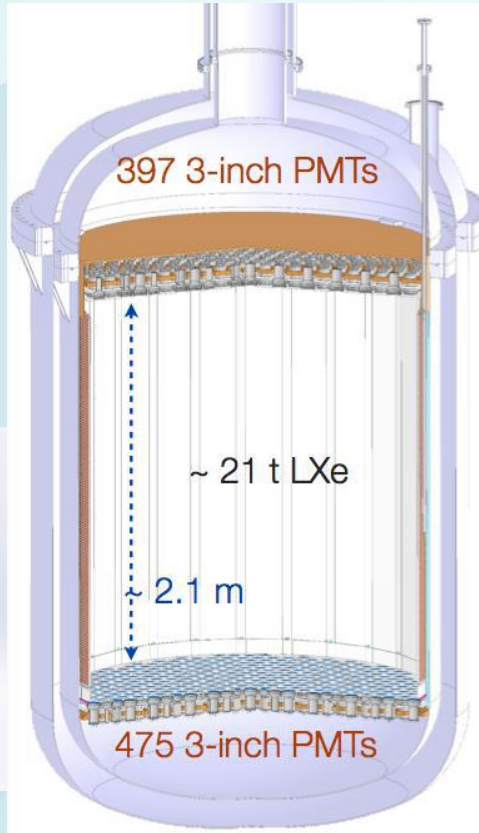
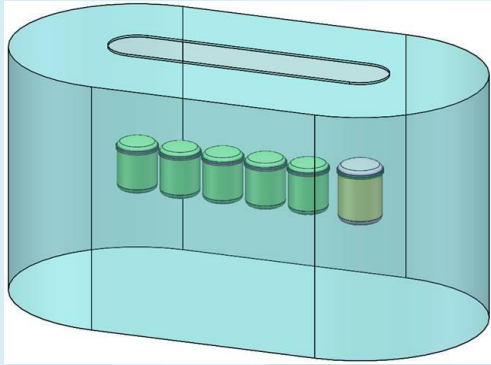
- Outer sector ( $14 \times 14 \times 14 \text{m}^3$ ): Water Cerenkov detector
- Middle sector in SS tank ( $9 \times 9 \times 9 \text{m}^3$ ): Liquid scintillator detector for neutron veto
- Inner sector ( $6 \times 6 \times 6 \text{m}^3$ ): Two phase TPC with Underground Ar

CJ

地下实验室  
Underground Laboratory



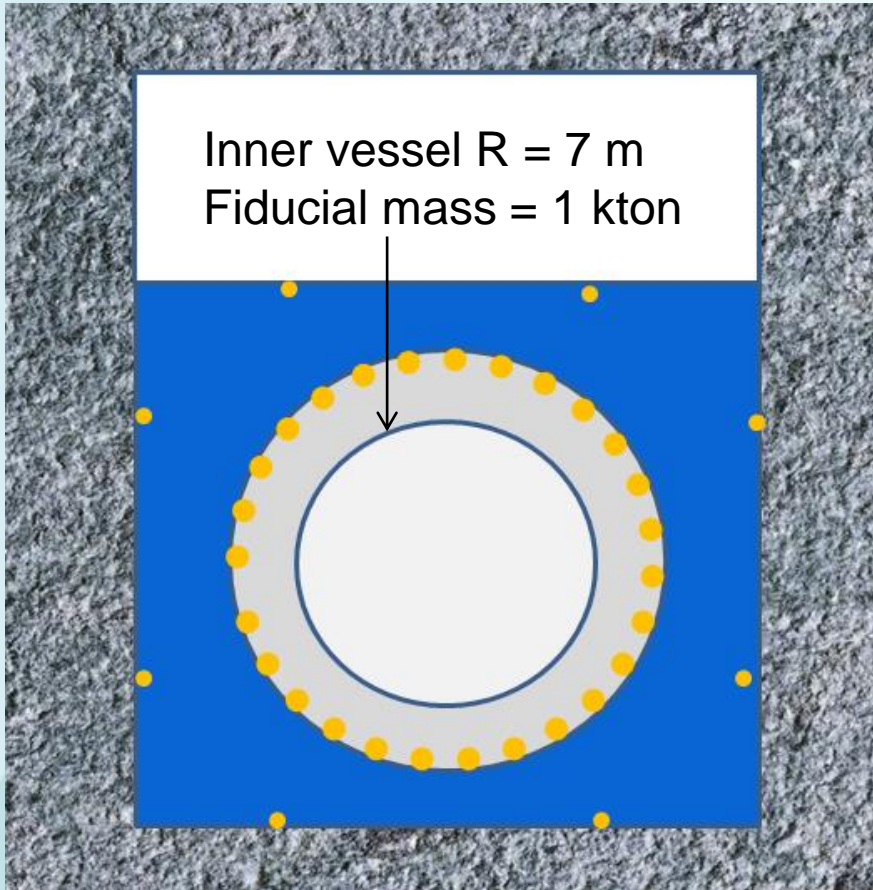
# Liquid Xenon Darkmatter Experiment-PANDAX in CJPL-II



PANDAX Develop a:

- high-energy resolution (0.5-3%FWHM)
- low-background ( $10^{-3}$  c/keV kg yr)
- large size (3~4 m<sup>3</sup>)
- high-pressure (10-15bar) Xe136 gas TPC

# Jinping Neutrino Experiment

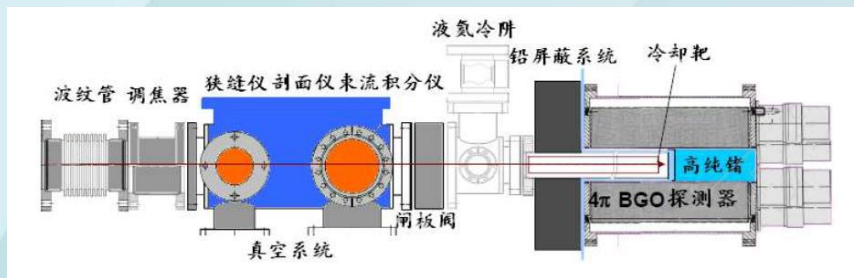


- Two modules 1k-ton water based scintillator detectors
- 1) Best neutrino lab in the world
  - 2) 24m in diameter, 35m in high
  - 3) Physics motivation
    - Solar neutrinos
    - Supernova neutrinos
    - Geo-neutrinos
    - Atmospheric & accelerator neutrinos

# JINPING Underground Nuclear Astrophysics ( JUNA ) Experiment



**JUNA experiment aims at direct measurement of  $(\alpha, \gamma)$ ,  $(\alpha, n)$  reactions in hydrostatic helium burning and  $(p, \gamma)$ ,  $(p, \alpha)$  reactions in hydrostatic hydrogen burning, and will provide key input of nuclear physics for understanding evolution of stars and origin of elements.**



JUNA Accelerator concept design



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

# V. Summary

- CJPL will be first-class underground laboratory in the world.
- CDEX and PANDAx experiments has been running in CJPL-I and the preliminary experiment results inspiring;
- CJPL-II are constructing currently, and would be finished in 2016. Some experiments have been proposed in CJPL-II.



# Thank !

## Welcome to CJPL

Prof. Jianmin Li

Email: [leejm@tsinghua.edu.cn](mailto:leejm@tsinghua.edu.cn)

Cell phone: +86-13911239065

Dept. of Engineering Physics

Tsinghua University



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