

China Jinping Underground Laboratory (CJPL): Status and prospects

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CJPL

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

Outline

1. History and characteristics of CJPL-I
2. Research activities at CJPL-I
3. Construction progress and plan of CJPL-II
4. Summary

1. History and Characteristics of CJPL-I



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China Jinping Underground Laboratory

Jinping hydropower station

- **Yalong river meets Jinping Mountain**
 - Jinping river bend: 150km long
 - 1st power plant: 305m high arch dam
 - 2nd power plant: natural 310m level difference from west to east side
- **Jinping traffic tunnel**
 - 17.5km long x 2
 - Overburden max. 2400m, 73% of length >1500m.
 - Finished on Aug. 8, 2008



Jinping traffic tunnel

Inside of tunnel



Jinping Mountain

~2400m

Half length~8km

Jinping traffic tunnel

Ideal site
for an underground laboratory!

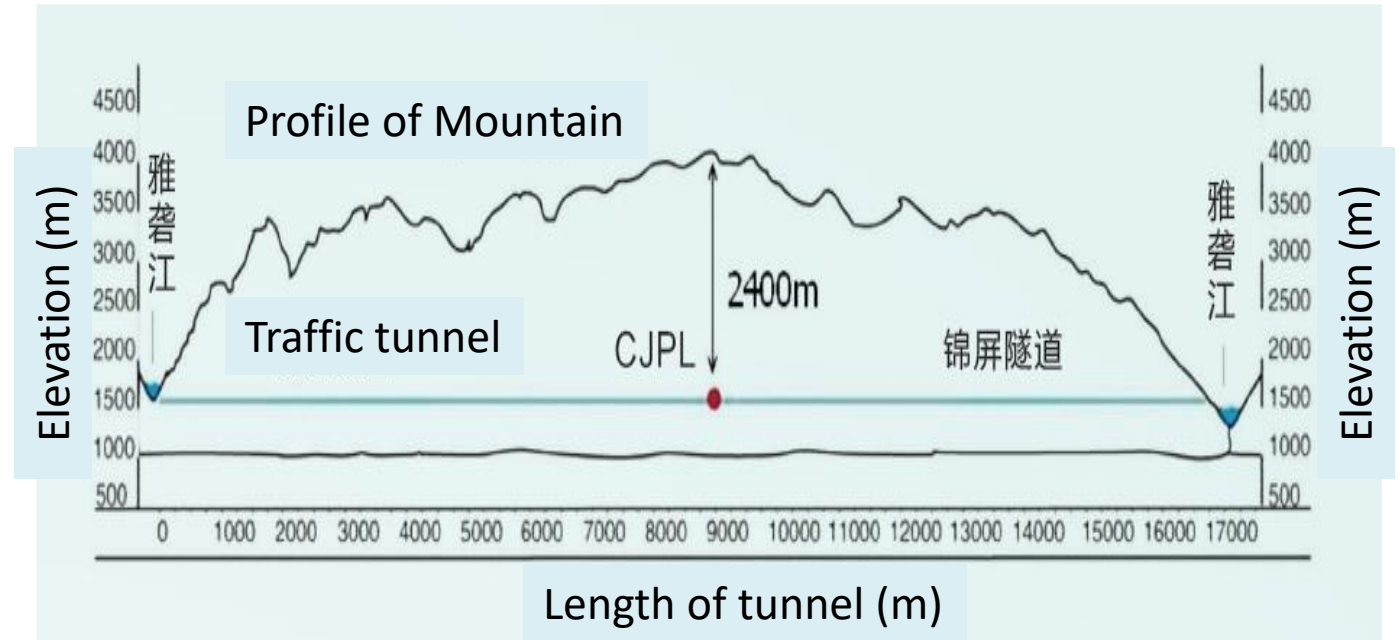
Yalong river



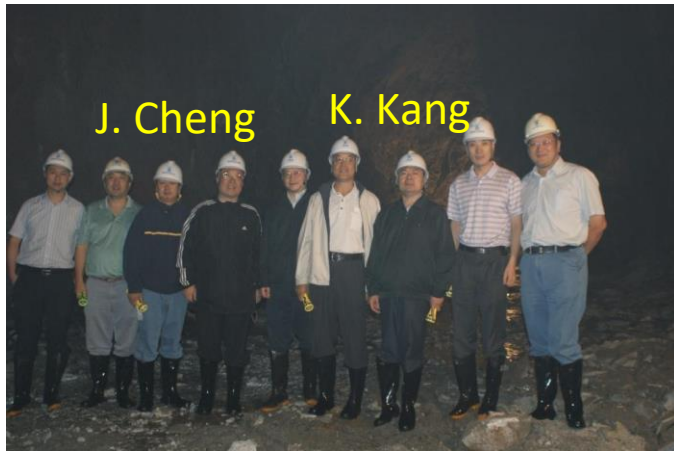
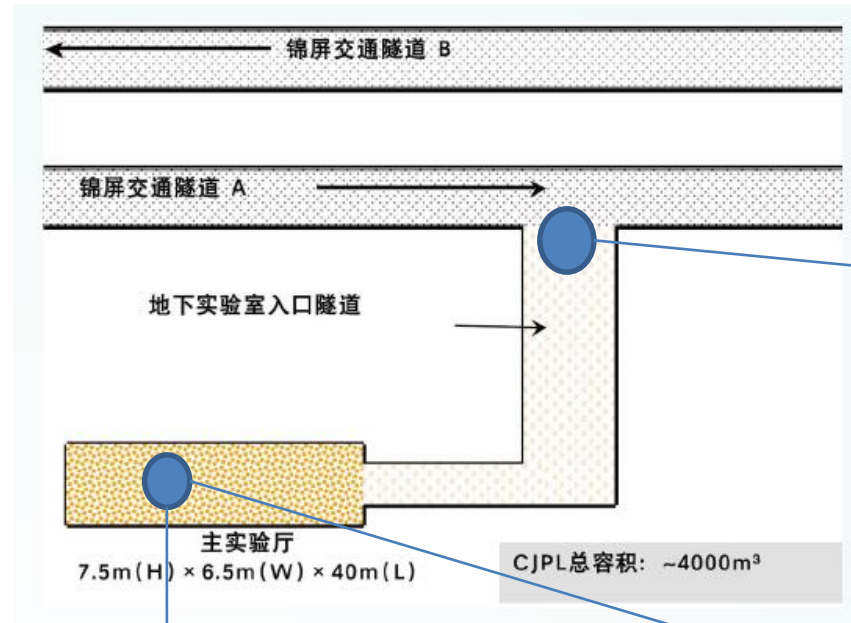
East entrance to tunnel

Beginning of CJPL

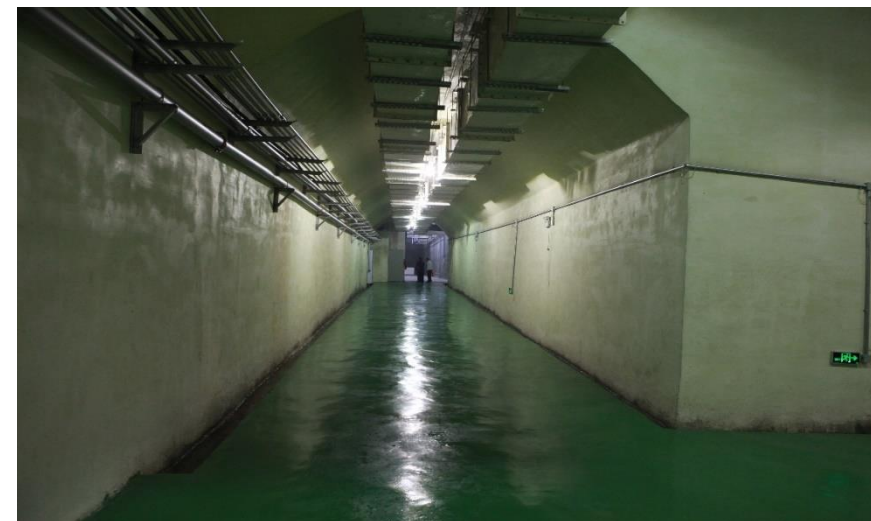
- Agreement between THU and EHDC in **May 2009**



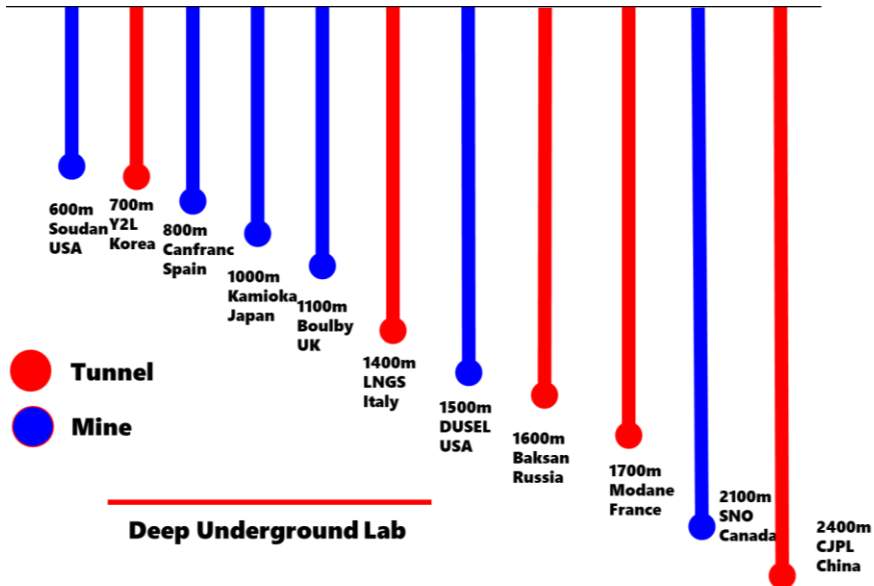
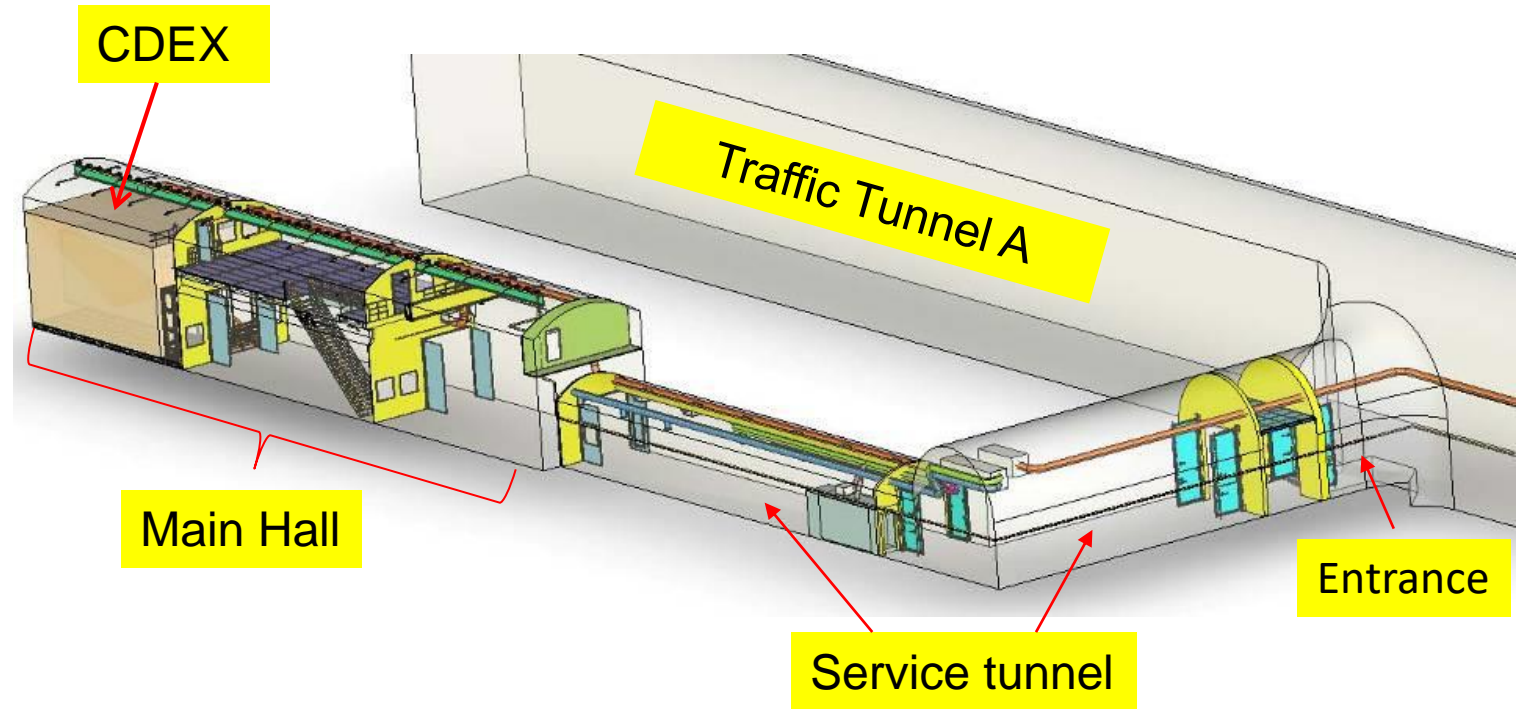
Site selection of CJPL-I in Aug. 2009



Construction progress of CJPL-I



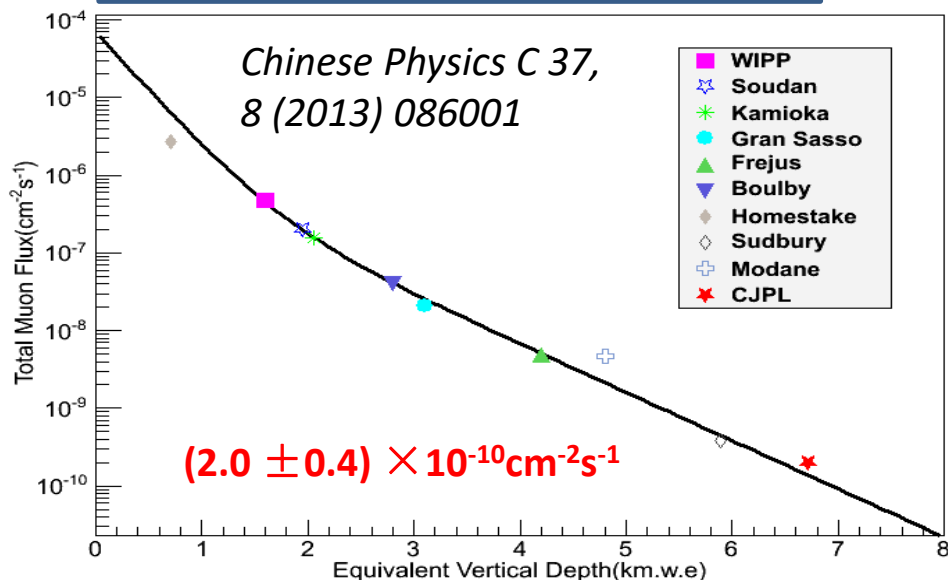
CJPL-I opened in Dec. 12, 2010



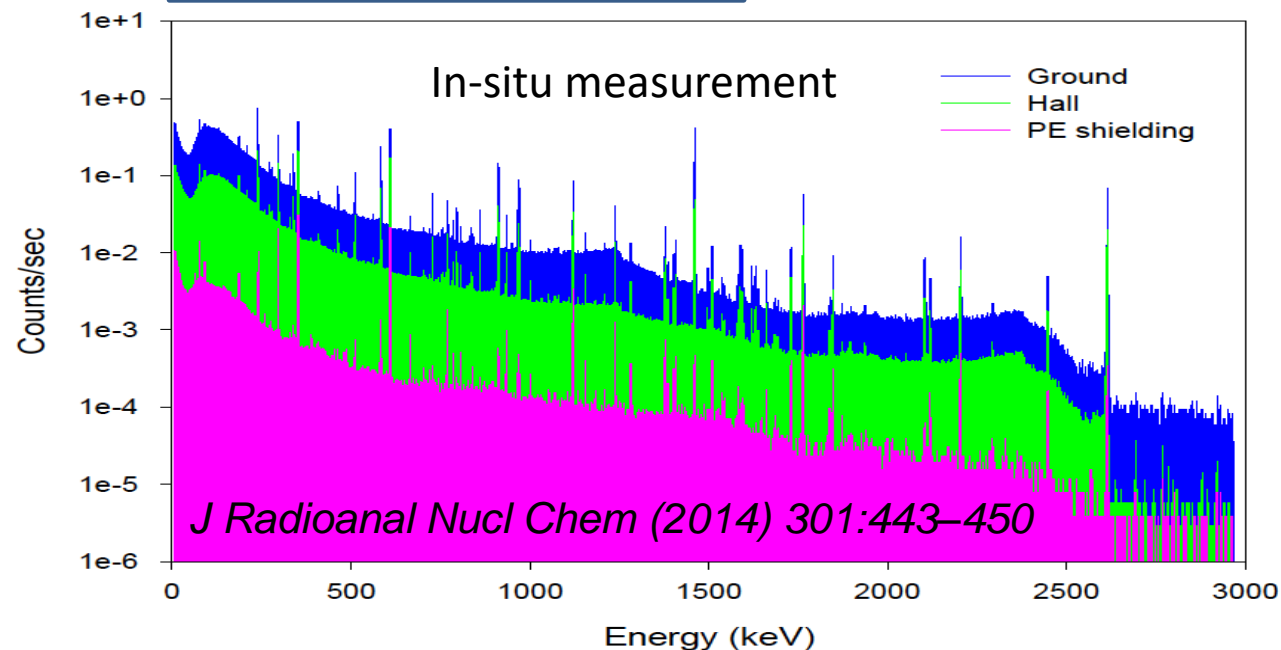
- Total space: $\sim 4000 \text{ m}^3$
- Main Hall: $6.5\text{m(W)} \times 6.5\text{m(H)} \times 42\text{m(L)}$

Characteristics of CJPL-I

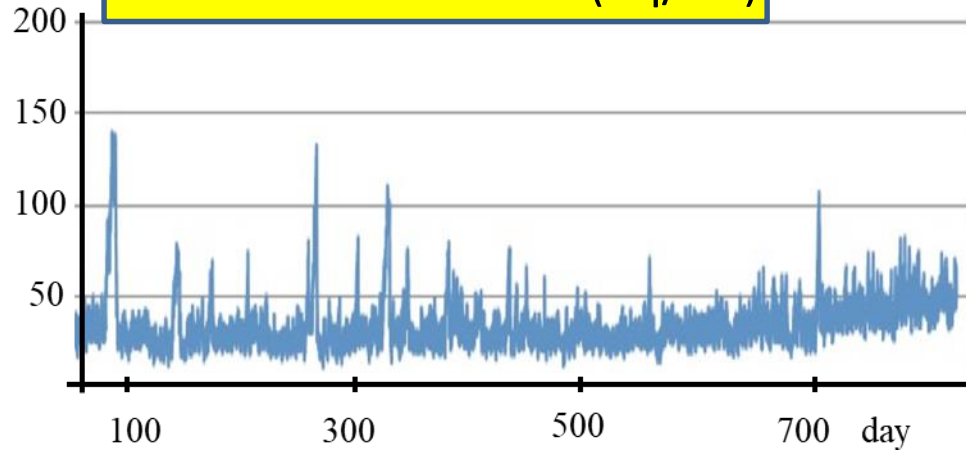
Muon flux ~ 60 muons/year/m²



Gamma ray background



Radon concentration (Bq/m³)

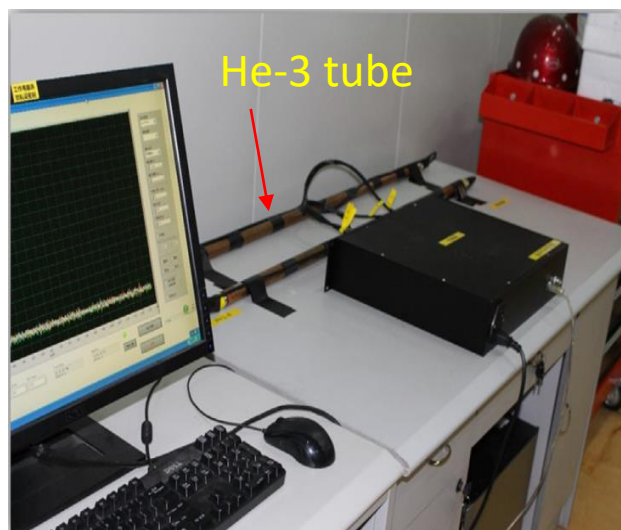


Sample(Marble) measurement
by gamma ray spectrometry

(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

Neutron background measurement

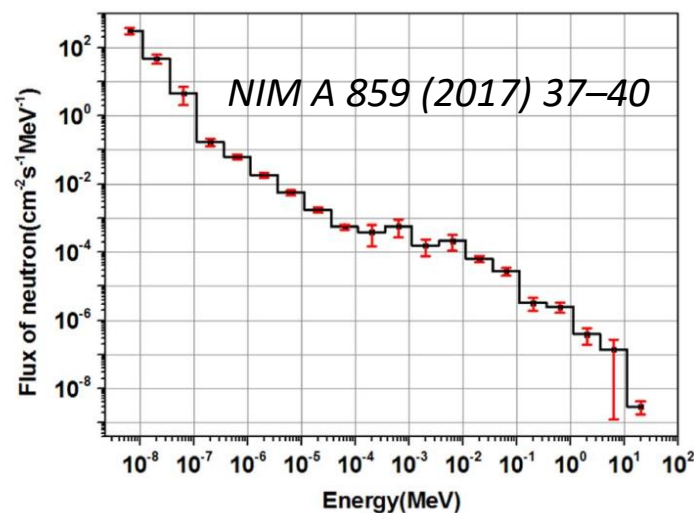
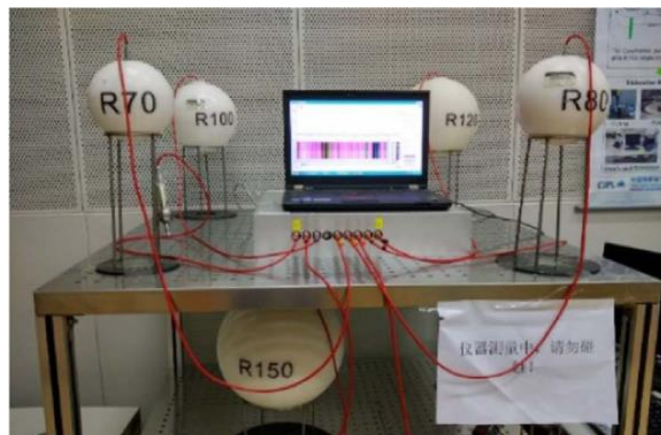
Thermal neutron flux:
by He-3 detector



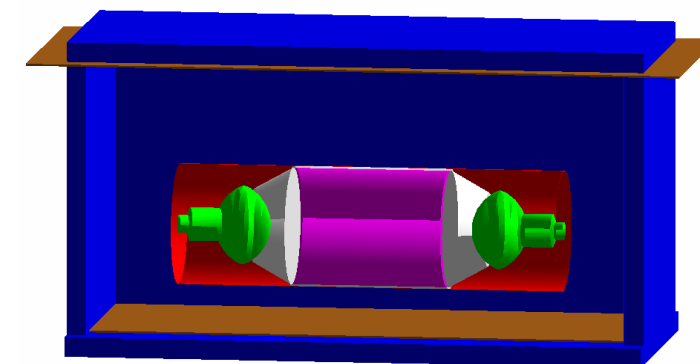
$(4.00 \pm 0.08) \times 10^{-6} \text{ n/cm}^2/\text{s}(\text{Thermal})$

NIM A 804 (2015) 108–112

Neutron spectrum
by Bonner multi-sphere spectrometer



Fast neutron flux:
by liquid scintillation detector



$0.15 \times 10^{-6} \text{ n/cm}^2/\text{s}(1\text{-}10\text{MeV})$

Logistics of CJPL

High way from Xichang airport to CJPL



Office building



Sports



Direct access to underground by car or truck



Hotel



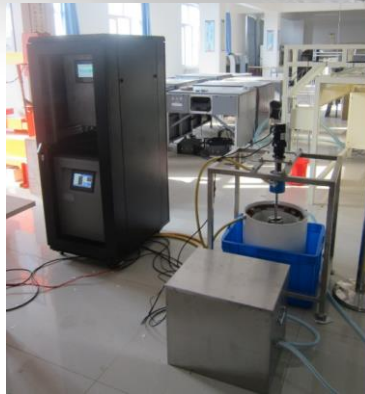
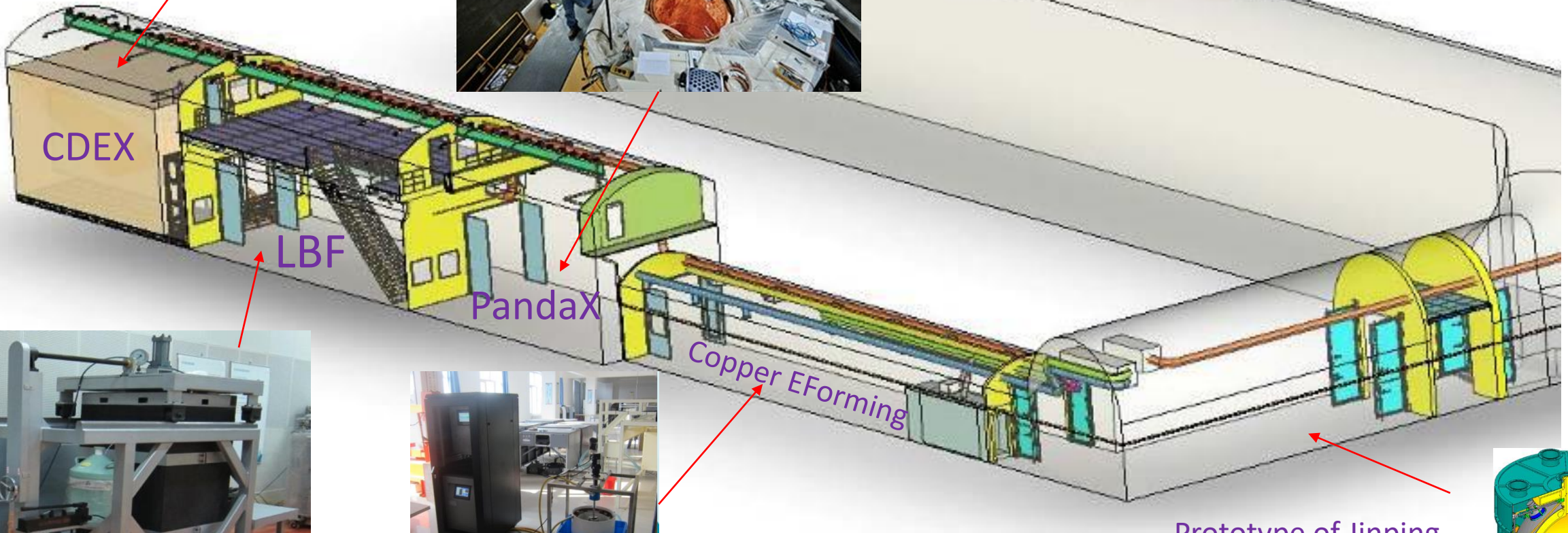
Auditorium

2. Research activities at CJPL-I

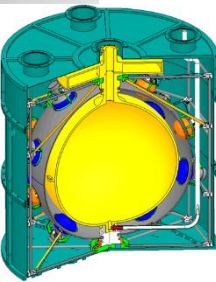


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Layout of CJPL-I



Prototype of Jinping
neutrino experiment
Details in Z. Wang's talk



CDEX: China Dark matter EXperiment

- Collaboration Established in 2009, members from:
 - Tsinghua University, THU;
 - Sichuan University, SCU;
 - Nankai University, NKU;
 - China Institute of Atomic Energy, CIAE;
 - Yalong River Hydropower Company;
- Collaborating with TEXONO and KIMS group.



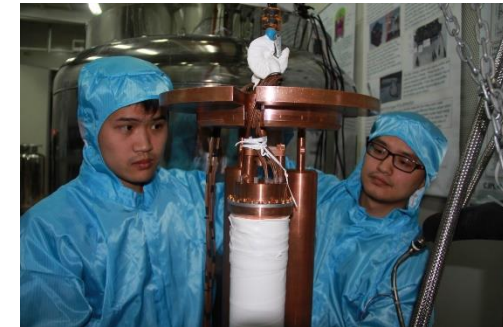
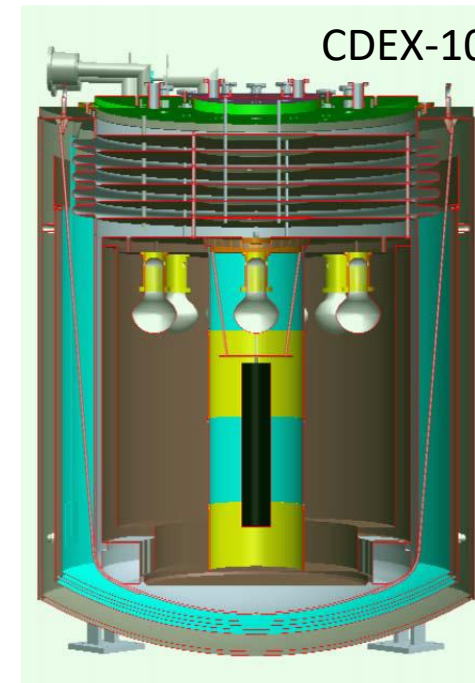
CDEX evolution

- CDEX-1: Development of HPGe detector, its background understanding and the studies of its performances based on 1kg-scale-mass HPGe detector.

Energy threshold:

CDEX-1: 400eV \rightarrow CDEX-10: <300eV;

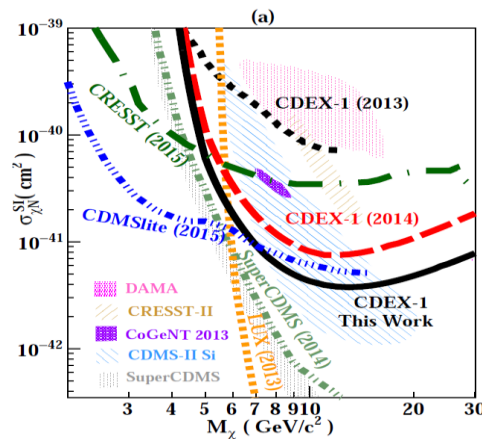
- CDEX-10: Performances of HPGe array detector system and its passive/active shielding systems.
- CDEX-10X: Fabrication of HPGe detector and Germanium crystal growth by CDEX.



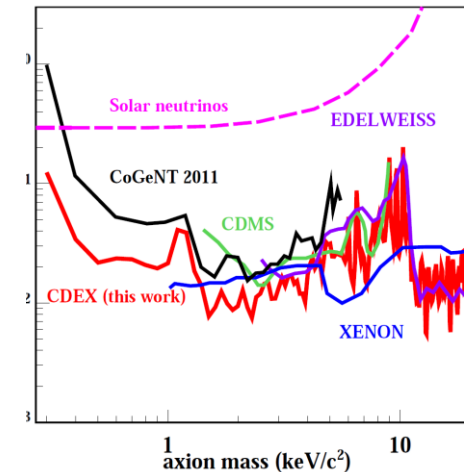
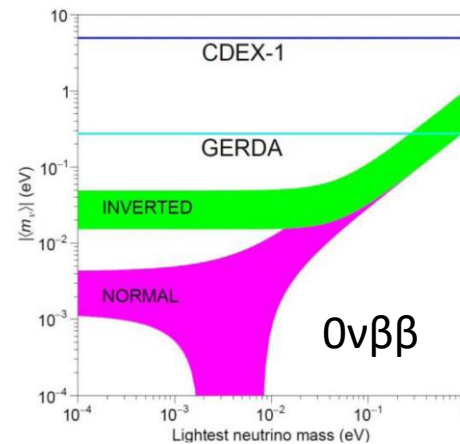
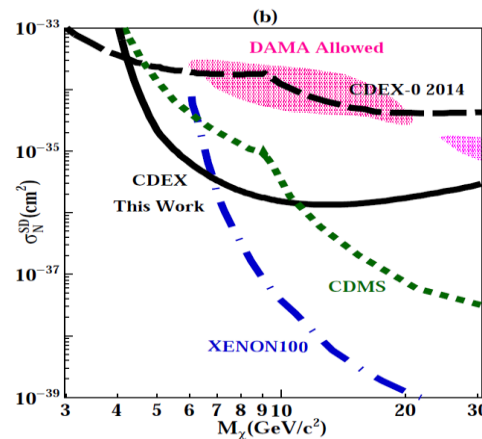
CDEX-1 results

- From 2012 on, CDEX-1A (> 700d), CDEX-1B (> 400d);
- Serial physical results published, CoGeNT region excluded definitely with identical technique;
- Axion dark matter results accepted by PRD;
- $0\nu\beta\beta$ results distributed based on CDEX-1A data;
- AM results under preparation;

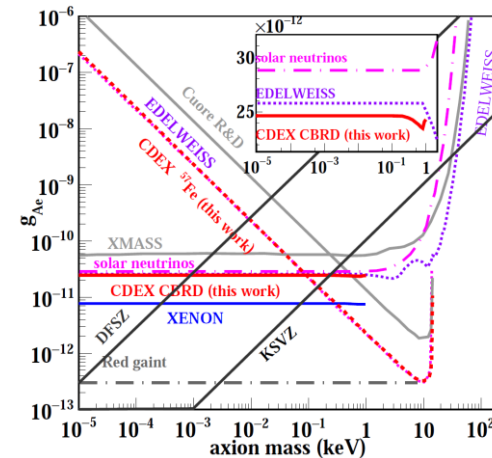
PRD88, 052004 (2013); PRD90, 032003 (2014); PRD90(R), 091701 (2014); PRD93, 092003 (2016);
arXiv: 1610.07521, accepted by PRD;
arXiv: 1703.01877



DM



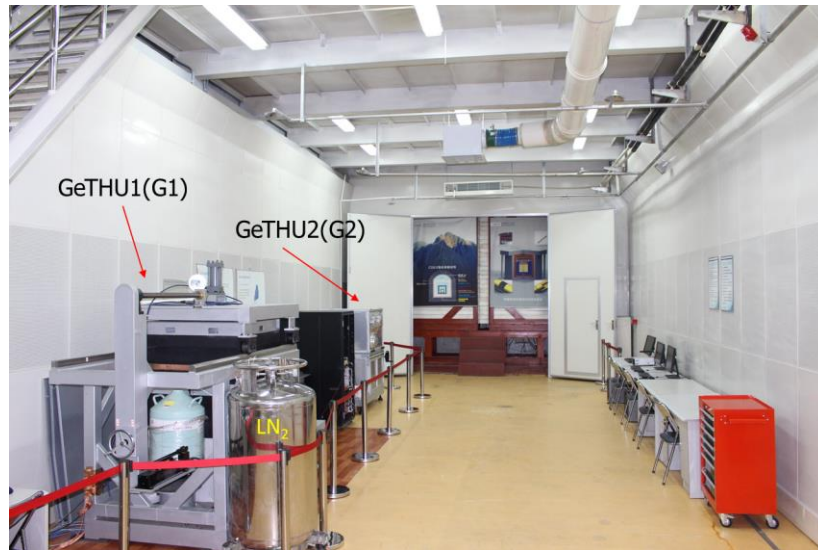
Axion-electron couplings
with solar axions



Axion-electron couplings
with dark matter axions

Low background gamma ray spectrometry

- Material screening and environmental sample measurement
- GeTHU1: N type HPGe, 0.9kg crystal, 0.29cpm/kg_{Ge}(40~2700keV)
- GeTHU2: BEGe with glove box, compact system



Main hall of CJPL-I



GeTHU1



GeTHU2

3. Construction progress of CJPL-II



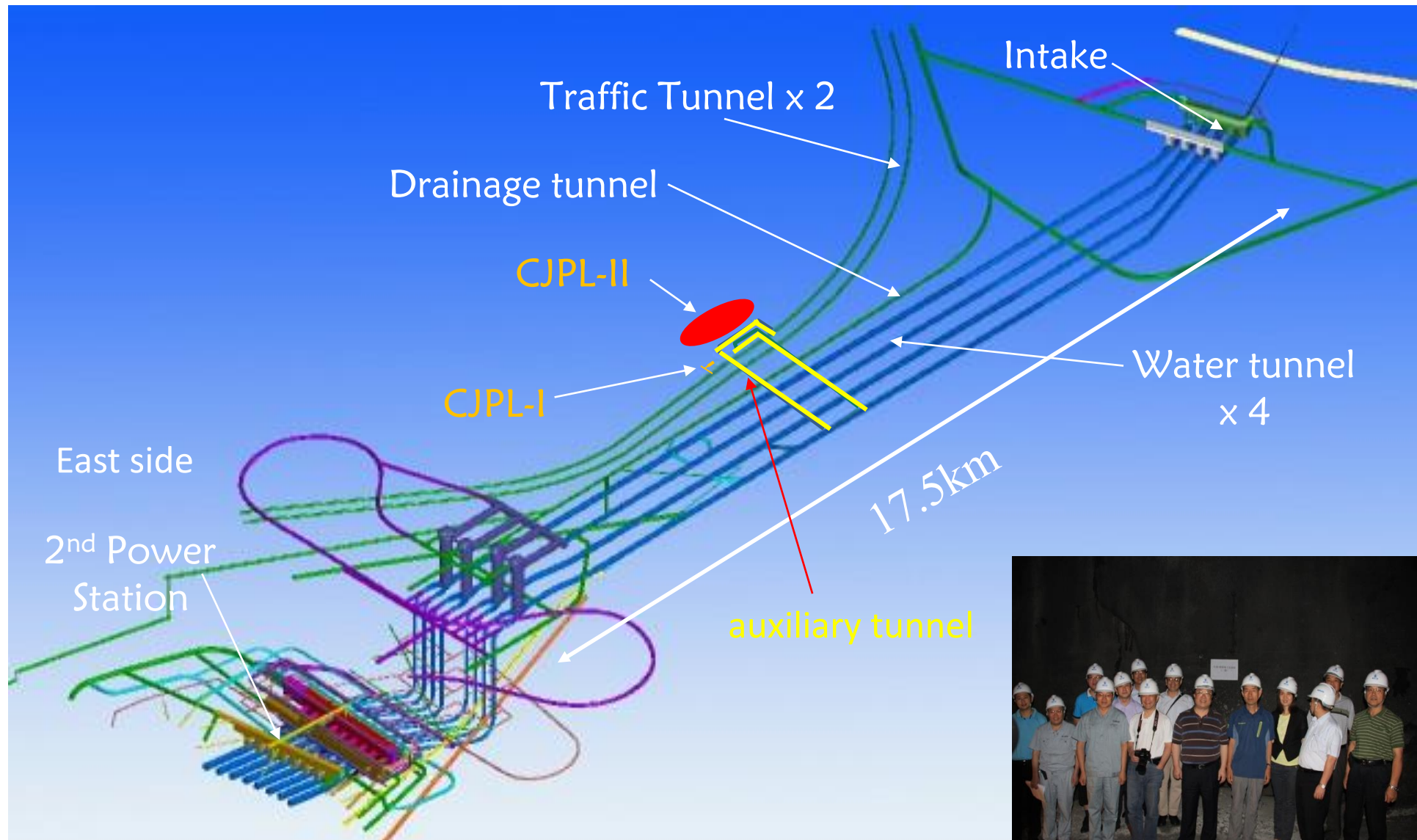
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CJPL-II project

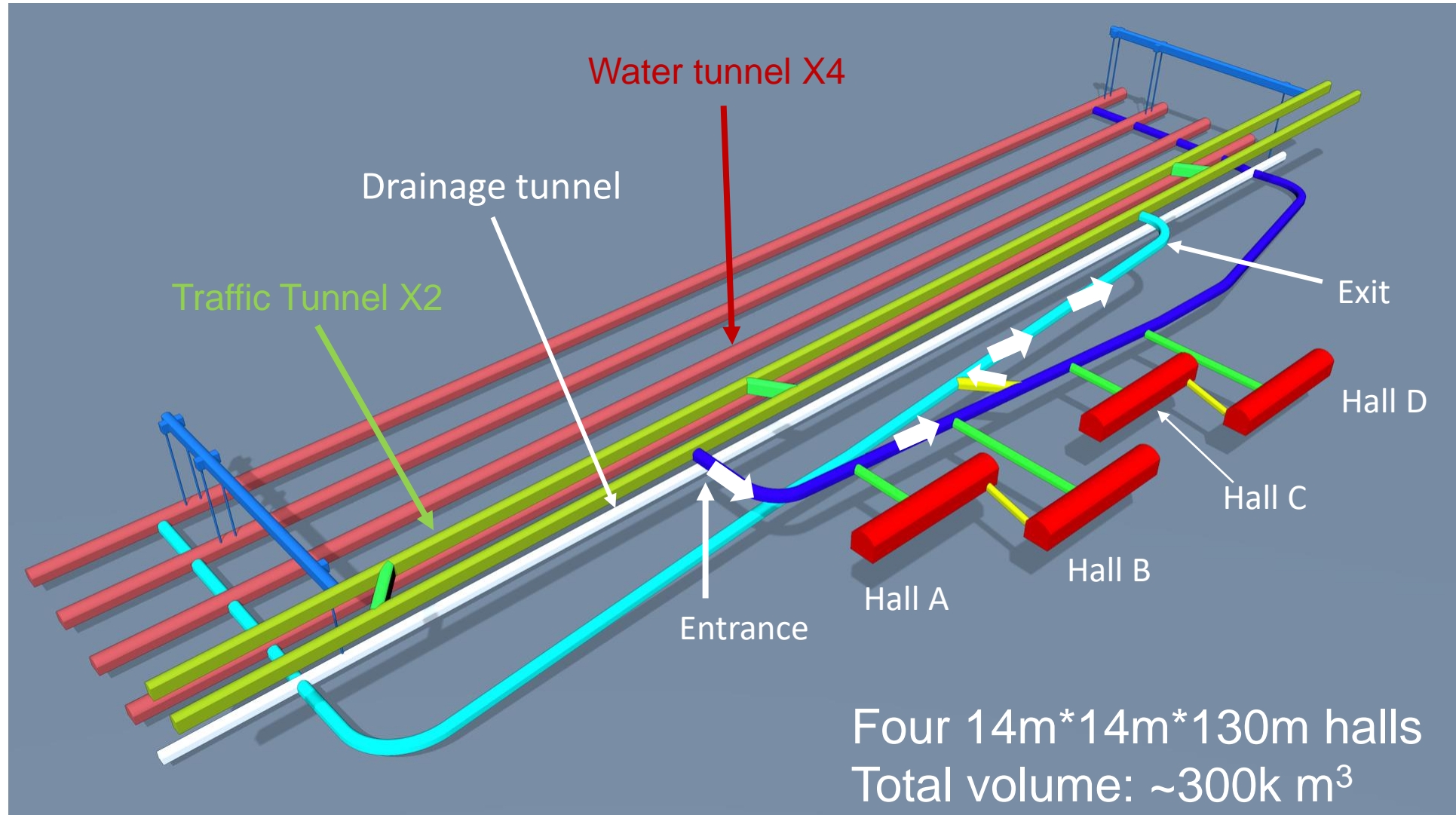
- CJPL-I: **almost full Vs. more requirements**
- THU + YL Hydro Company started to consider CJPL phase-II construction for time saving and money saving in 2013.
- **Urgency**: The dam and tunnel for hydropower plant finished in 2014. Expert construction team and tools would leave from JP tunnel.
- **Decision**: 2 auxiliary tunnels (km-long) refilled for long-term safety or reused by other project?
- Agreement on extension to CJPL in **Aug. 2014!**
- CJPL-II was born.



Site selection of CJPL-II



Design of CJPL-II



Construction of CJPL-II started on Nov. 25, 2014



PHYSICS

China supersizes its underground physics lab

Planned expansion could pave way for “ultimate dark matter experiment”

By Dennis Normile

The world's deepest physics laboratory is about to become one of its largest.

WIMPs exist, they should occasionally travel unmolested through the mountain and collide with a xenon nucleus, producing a flash of light. In the other experimental hall, the

other labs indicating that WIMPs are likely to have very little mass.

For an initial effort, the results are “pretty decent,” says Wick Haxton, a theorist at the

Construction progress

- Dec. 2015: The rock excavation of all halls completed.
- May 2016: Expansion of two pits finished.
- Dec. 2016: Installation of ventilation system started.



Hall



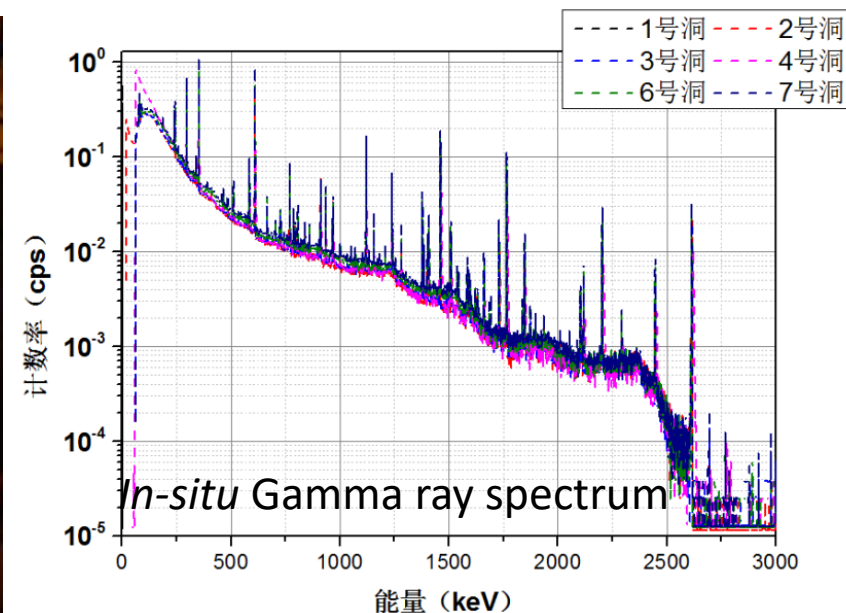
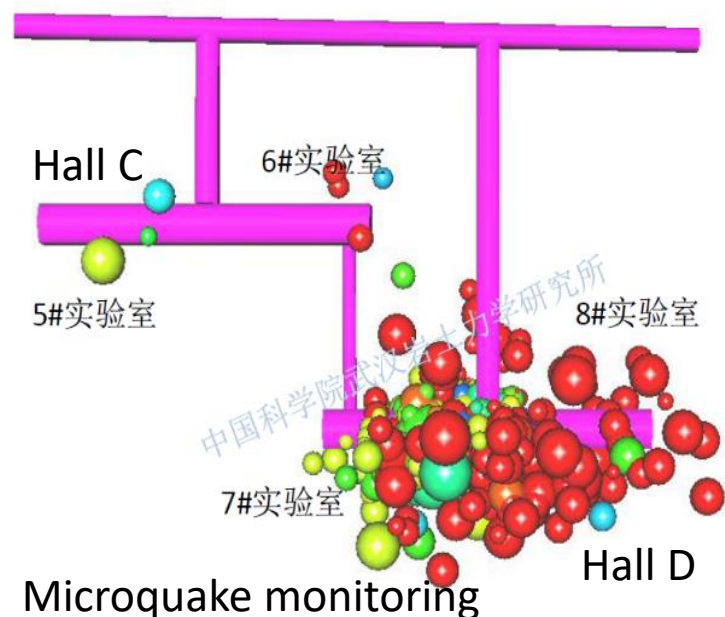
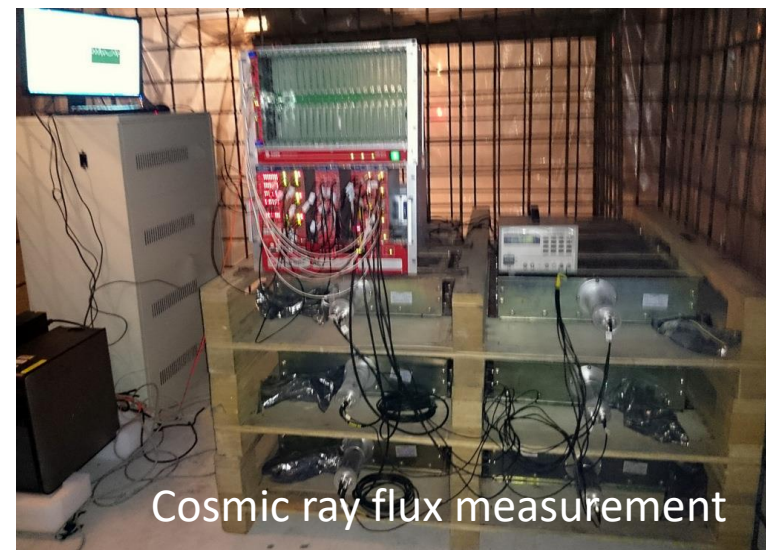
Pit for CDEX-1T(in front)



Ventilation pipes

Recent Status

- Ventilation system being installed.
- Environmental parameters measurement
 - Rock mechanics
 - Radon concentration
 - γ , n background



CJPL-II plan

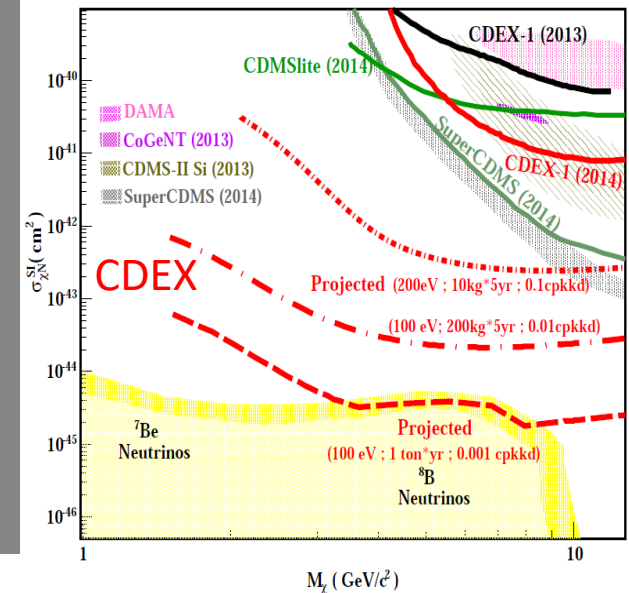
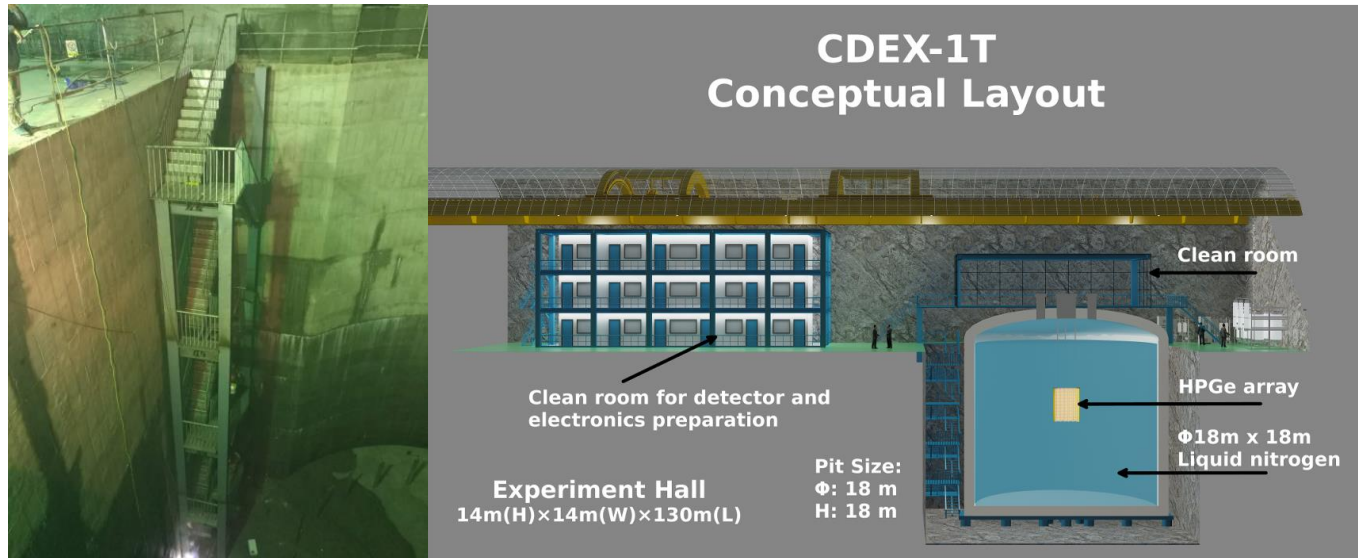


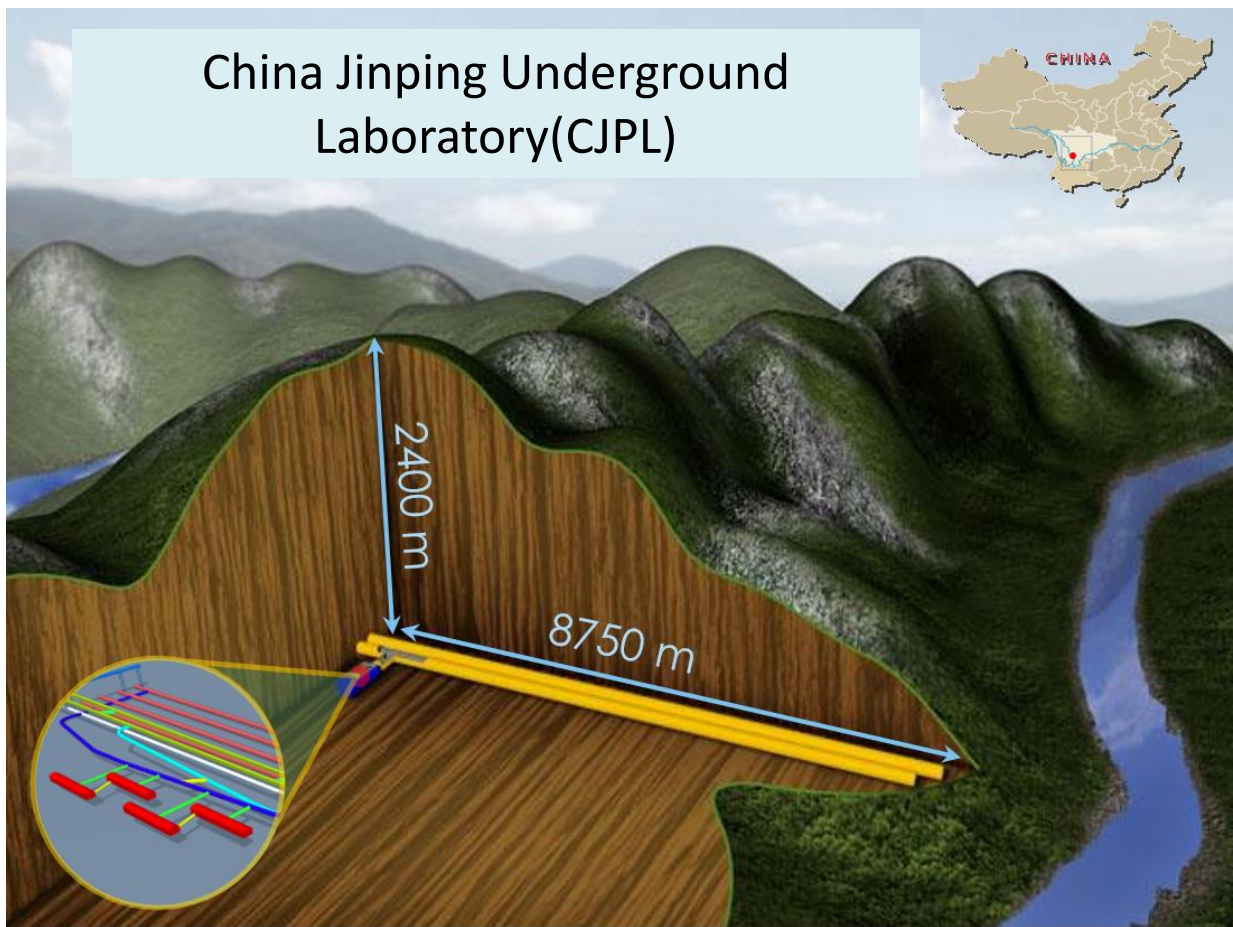
- CJPL was selected to be a candidate project of National Major S&T infrastructure of China in 2016.
- Proposal being prepared and possibly approved in the end of 2017.
- Possible users:
 - CDEX-1T(DM, $0\nu\beta\beta$), PandaX-1T, LAr DM., CUPID-China.
 - Nuclear astroparticle physics
 - Solar neutrino experiment
 - Rock mechanics experiment
 -
- Service
 - Low background counting
 - Ultra pure copper
 - popularization of science



Next generation of CDEX

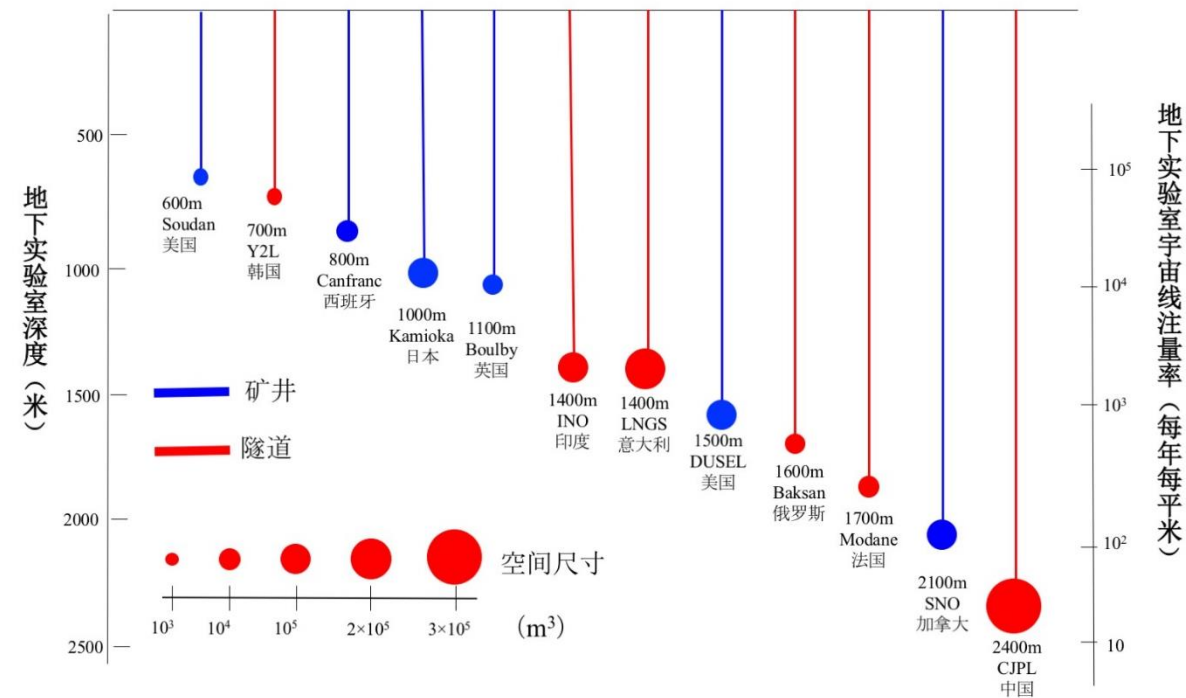
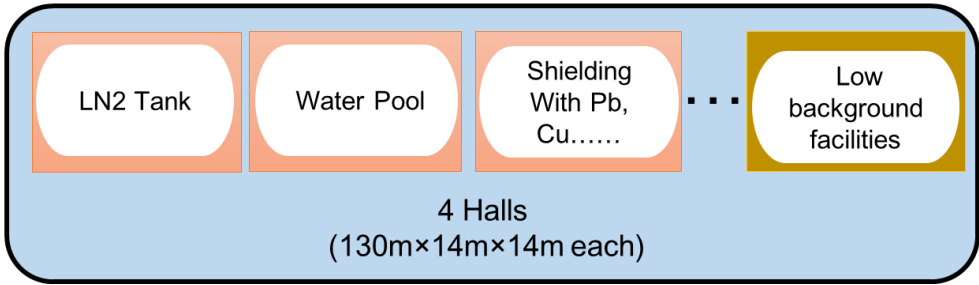
- Toward a ton-scale PCGe array with LN_2 shielding & cooling system for DM and $0\nu\beta\beta$.
- Key technologies
 - Ge purification and Ge crystal growth, Ge detector fabrication.
 - Ultra-low background VFE, Ultra-pure copper for structure and cables.
 - Large-volume cooling tank.





Ground

Underground



4. Summary

Summary

- CJPL, deepest UL now, promotes DM experiments in China contributing important results to physics.
- CJPL-II, deepest & largest UL soon, under setup.
- CJPL as a candidate of National infrastructure of China under review.
- Several experiments, including DM/ $0\nu\beta\beta$ /Neutrino/Astroparticle, applying for space in CJPL-II.
- Possible users from all over the world are welcome.

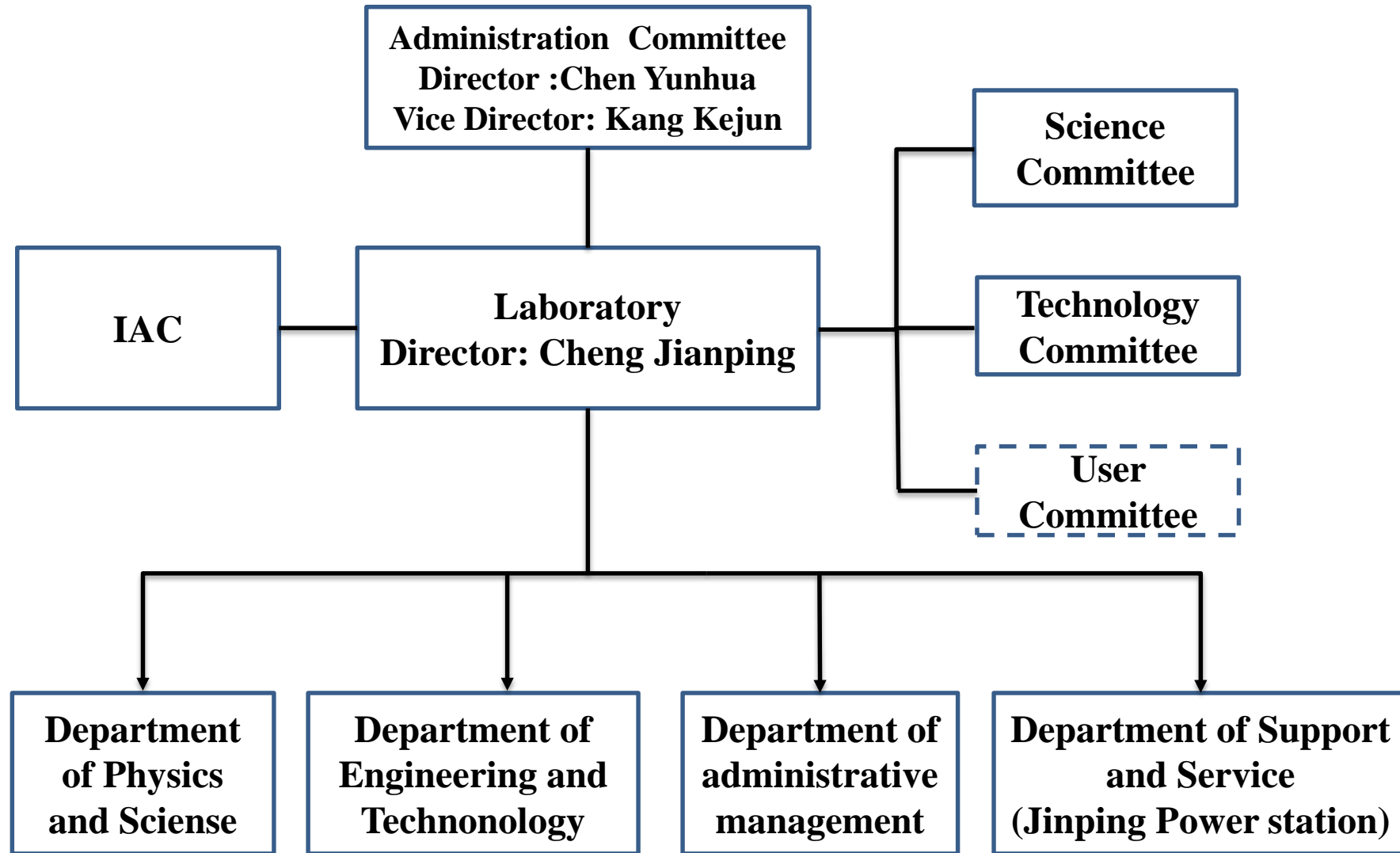
Thanks for your attention
Welcome to CJPL

Backup



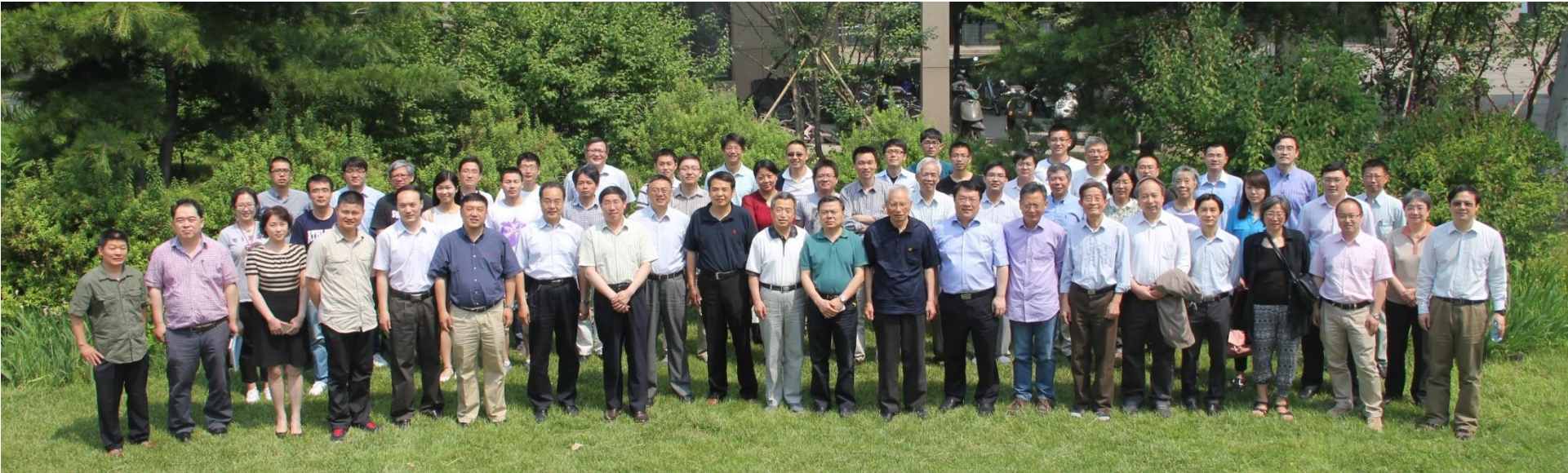
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Organization Structure of CJPL



Symposiums on CJPL Physics

- DM experiment
- Double beta decay exp.
- Solar neutrino exp.
- Astroparticle physics exp.
- Rock mechanics exp.



CJPL International Advisory Committee

Elena Aprile, Alessandro Bettini, John Ellis(chair), Derek Elsworth, Gilles Gerbier, Wick Haxton, Nigel Smith, Yoichiro Suzuki;
CJPL-IAC meeting :2014.11/2016.12





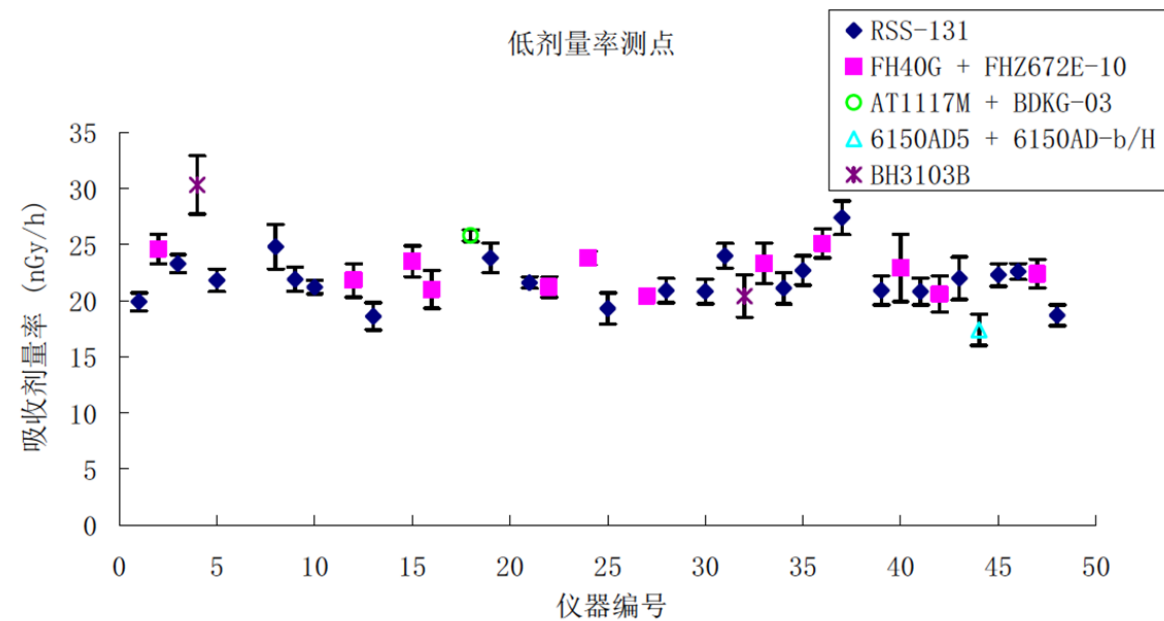
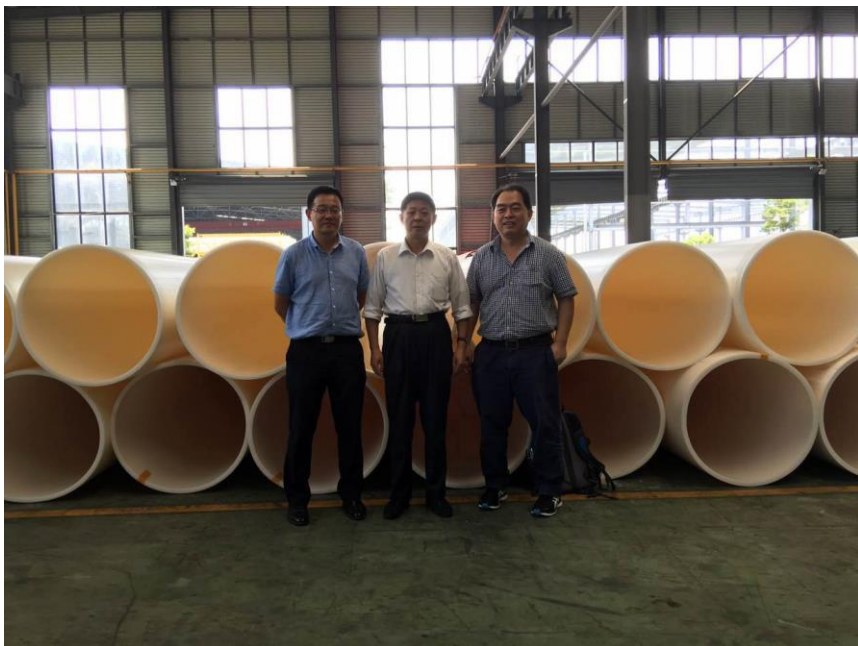


图 5 低剂量率测点吸收剂量率结果

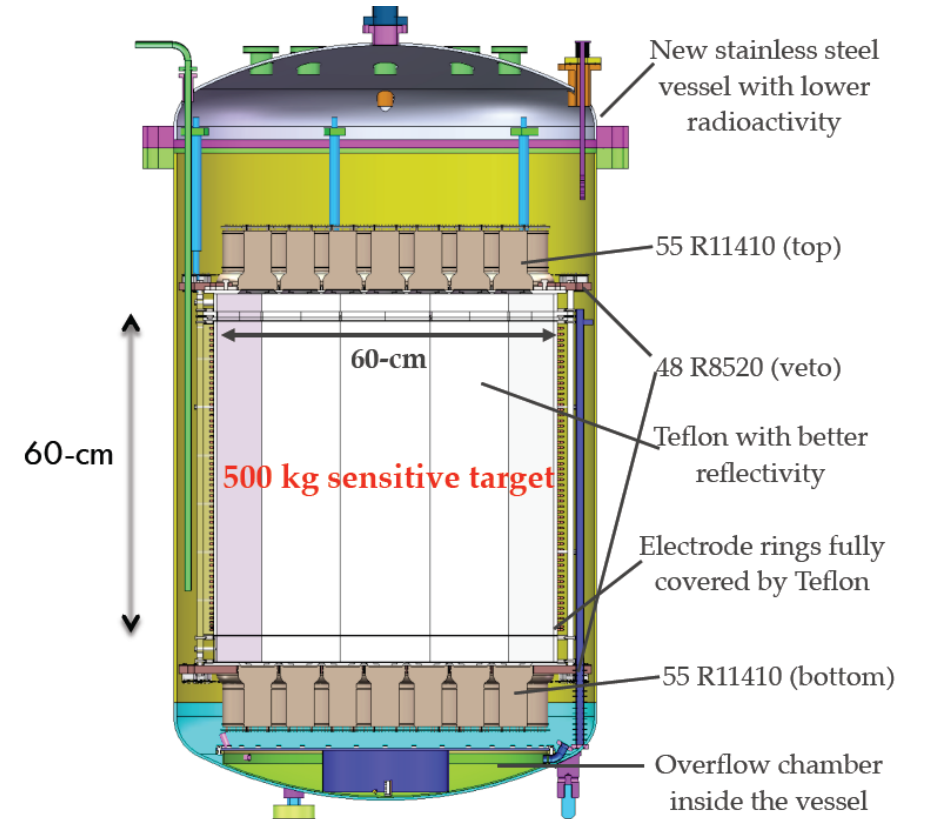
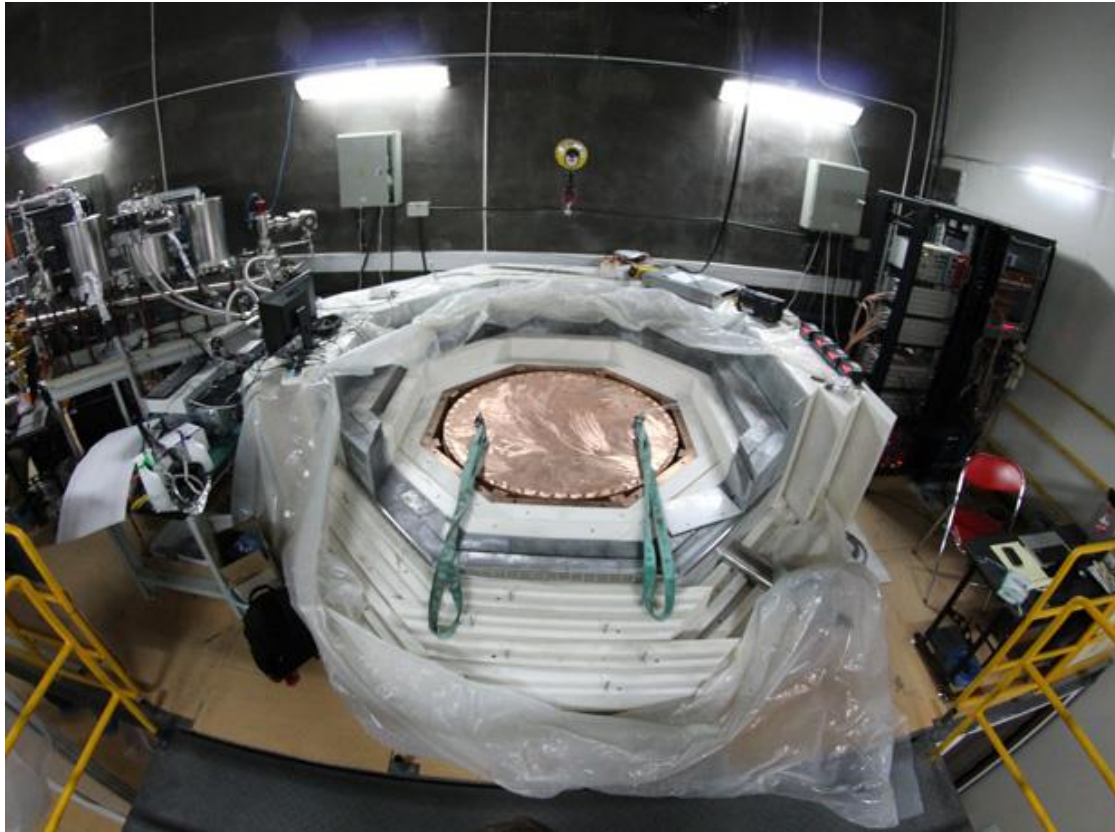
PandaX



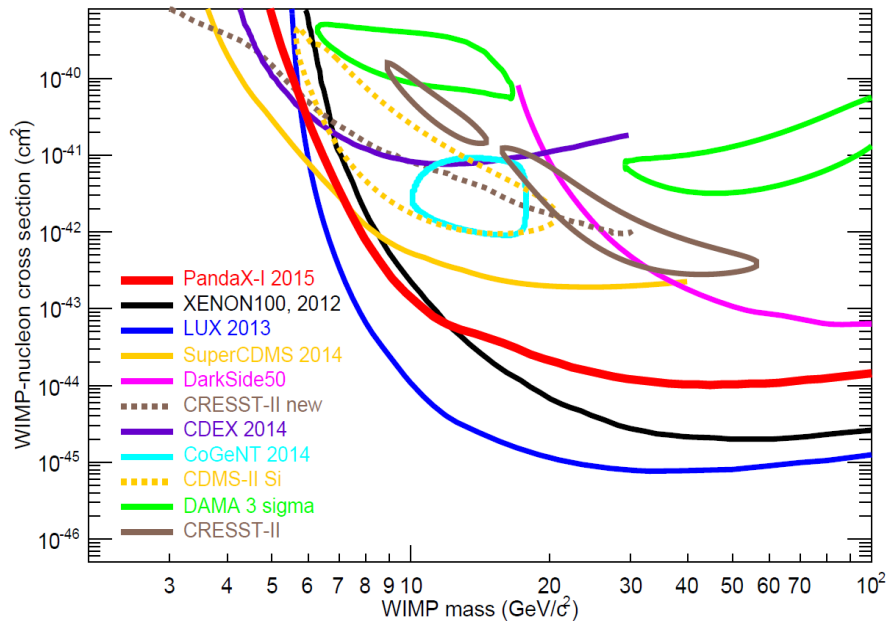
Started in 2009, ~50 people

- 🇨🇳 Shanghai Jiao Tong University (2009–)
- 🇨🇳 Peking University (2009–)
- 🇨🇳 Shandong University (2009–)
- 🇨🇳 Shanghai Institute of Applied Physics, CAS (2009–)
- 🇨🇳 University of Science & Technology of China (2015–)
- 🇨🇳 China Institute of Atomic Energy (2015–)
- 🇨🇳 Sun Yat-Sen University (2015–)
- 🇨🇳 Yalong Hydropower Company (2009–)
- 🇺🇸 University of Maryland (2009–)
- 🇫🇷 Alternative Energies & Atomic Energy Commission (2015–)
- 🇪🇸 University of Zaragoza (2015–)
- 🇹🇭 Suranaree University of Technology (2016–)

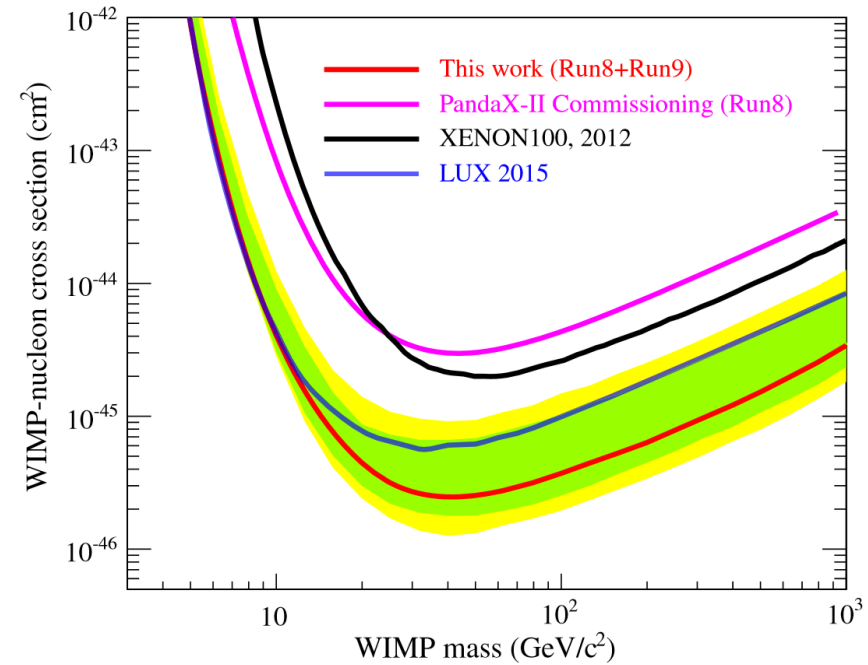
PandaX apparatus



PandaX results

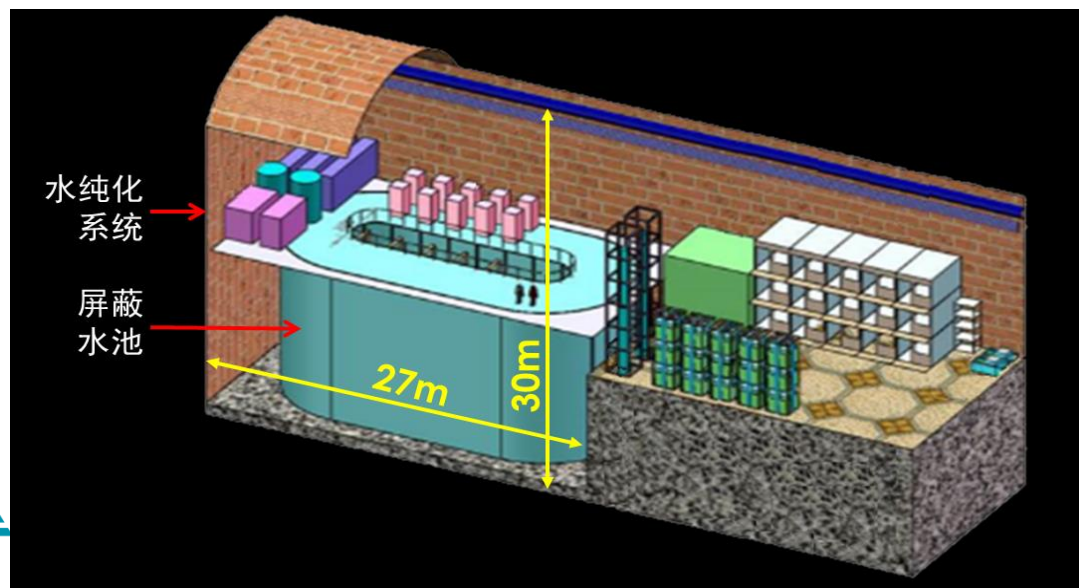


Phys. Rev. D **92**, 052004(2015)



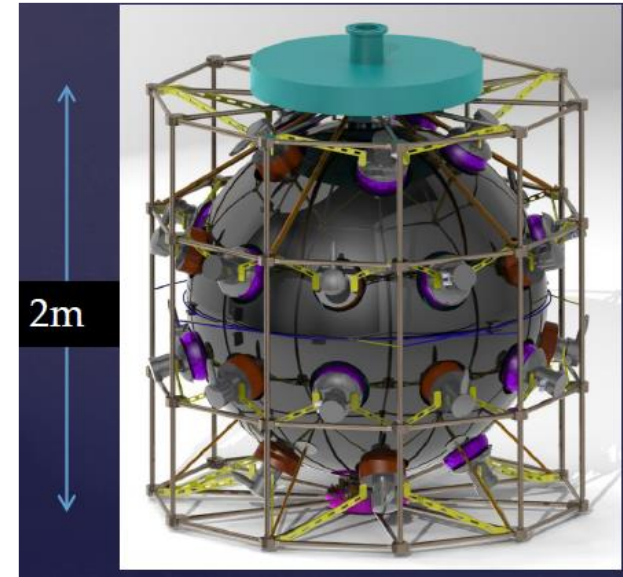
Phys. Rev. Lett **117**, 121303(2016)

PandaX in CJPL-II

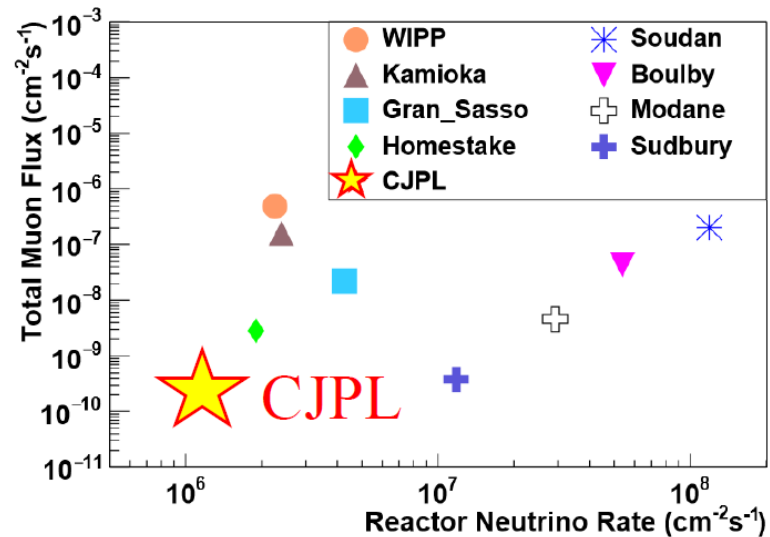


Jinping Neutrino Experiment

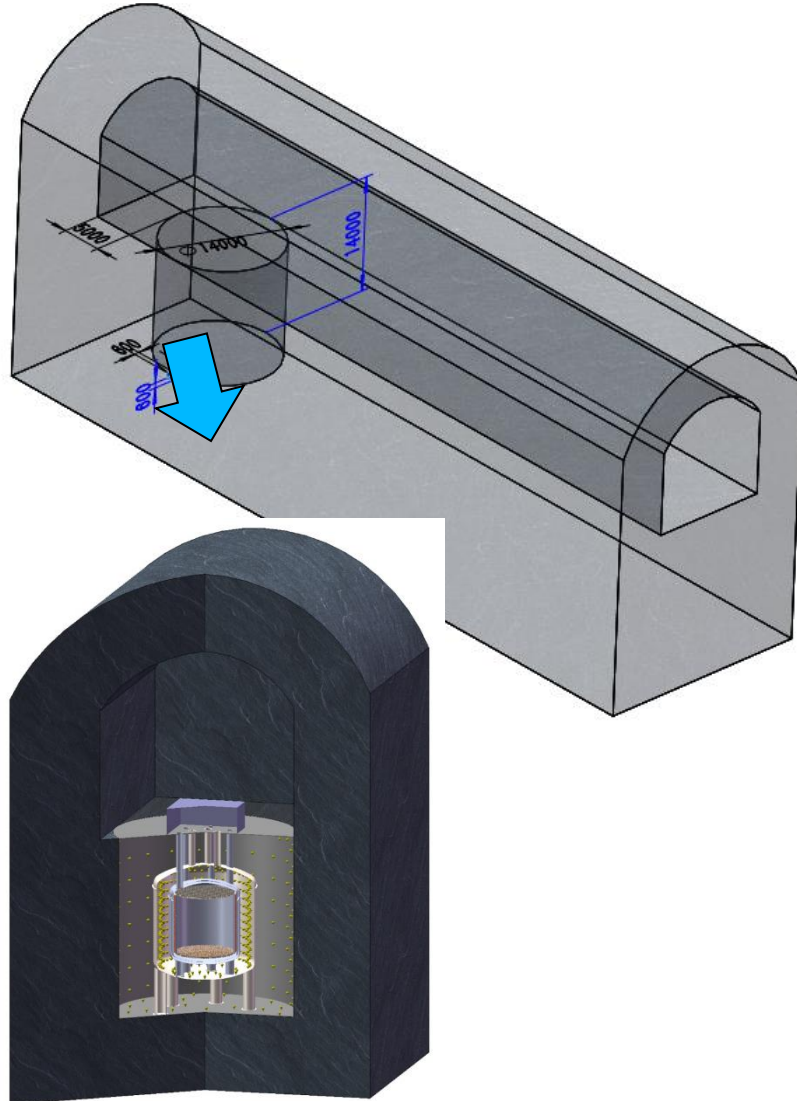
- Solar Neutrino;
- Discover CNO neutrino and address metallicity problem;
- Geoneutrino: flux, U/Th ν spectra
- SuperNova neutrino.....



1-ton detector installed



Liquid Argon Dark Matter Experiment in CJPL-II



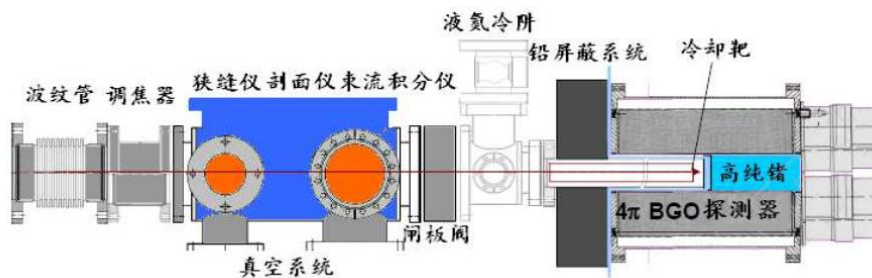
Construction of Detector in CJPL-II

- 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

JINPING Underground Nuclear Astrophysics (JUNA) Experiment



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

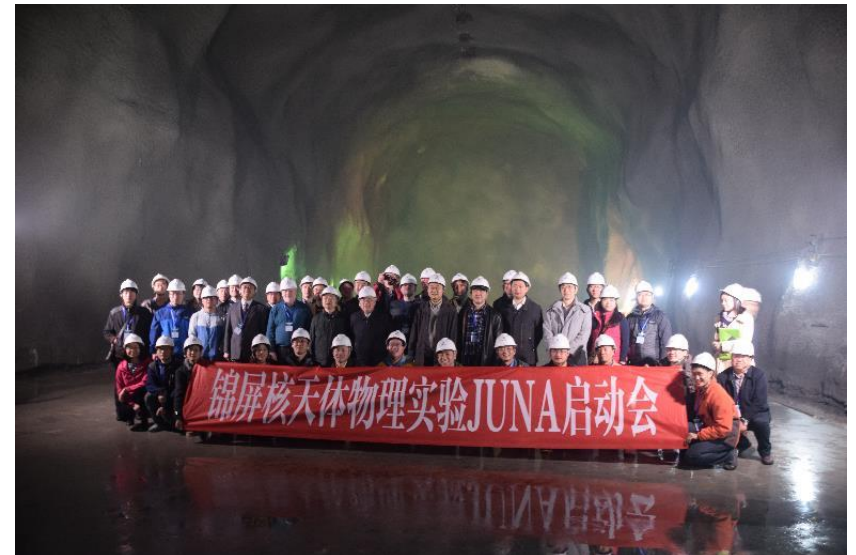


JUNA Accelerator concept design

JUNA Astroparticle experiment



March 1st, 2016 @CJPL-II



Jinping Neutrino Experiment

1-ton Prototype of Jinping Neutrino Experiment

Physics goals:

1. Detector design and fabrication
2. Measure fast neutron background
3. Test detection material: water, LS, and slow LS

Schedule:

1. Deliver the main body in 2016/12
2. Full assembly by 2017/03
3. Take data in 2017-2018

