China Jinping Underground Laboratory and experiments inside

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Mar. 28, 2017

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

Outline：

- Physics based on UL
- China Jinping Underground Laboratory (CJPL)
- Experiments in CJPL-I
- CJPL-II and planned experiments inside
- Summary

CJPL

Physics based on UL

- Dark matter direct detection:
- Neutrino physics: Double beta decay, Solar neutrino, Geo-neutrino, Supernova neutrino……
- Astroparticle physics: Hydrostatic stellar evolution, ……
- Deep underground rock mechanics, seismology and geophysics,……
- Biology;
- ……

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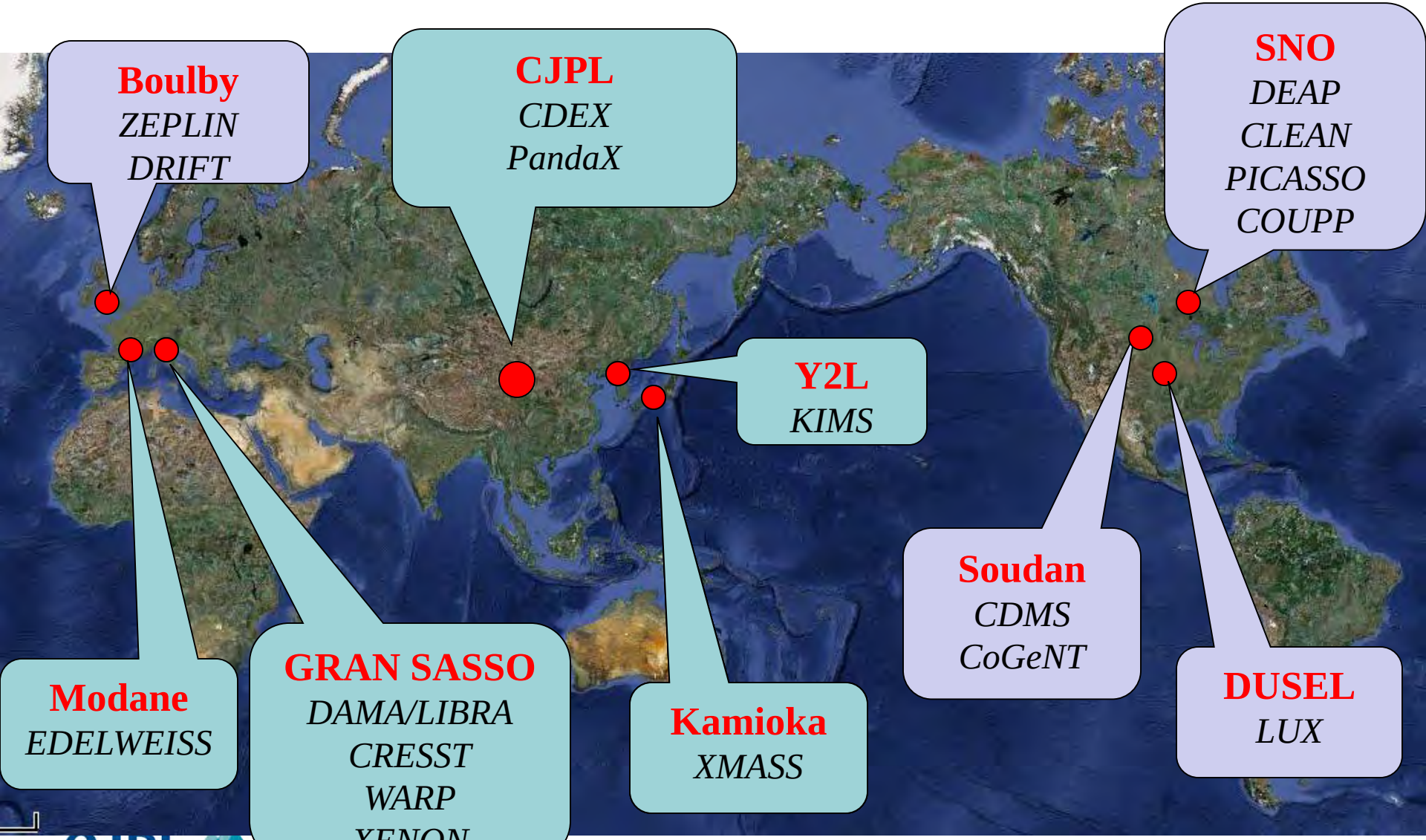
International Main Undergound Laboratories



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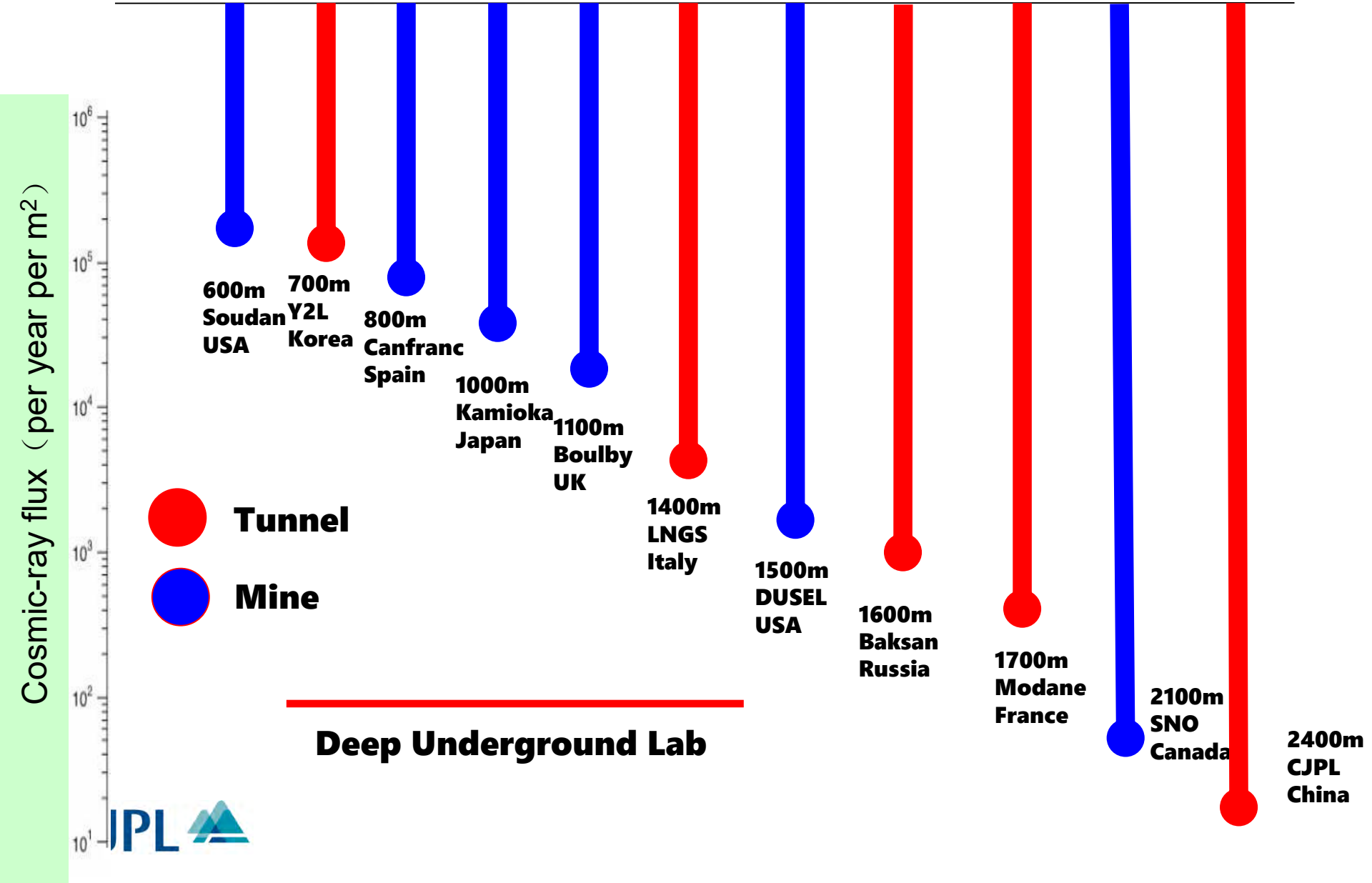
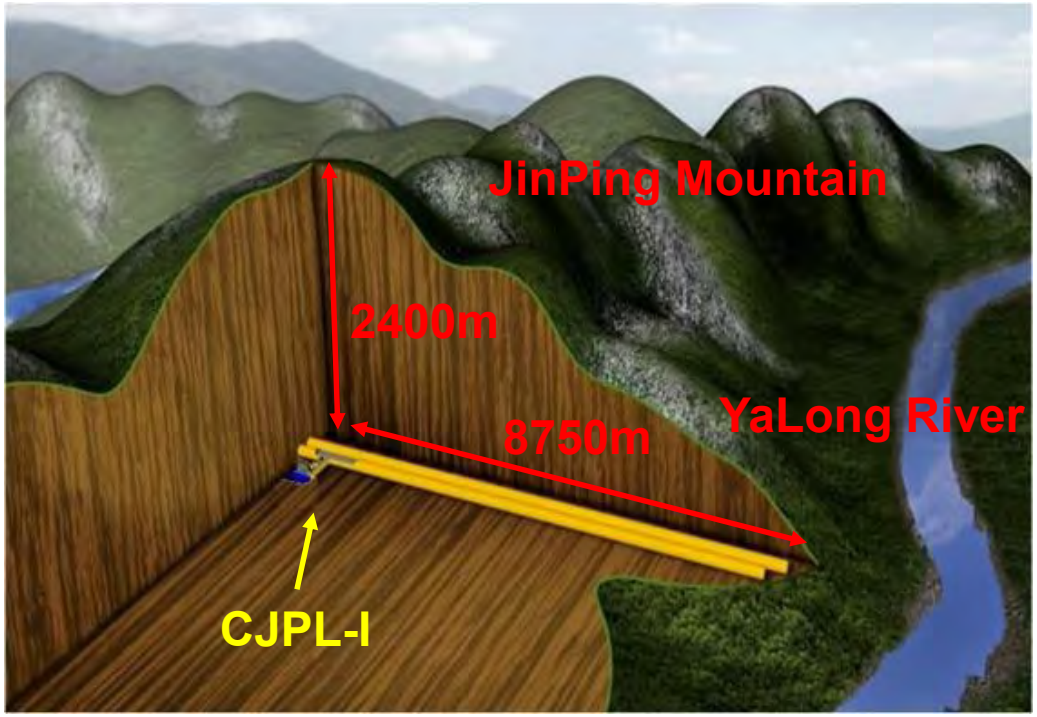
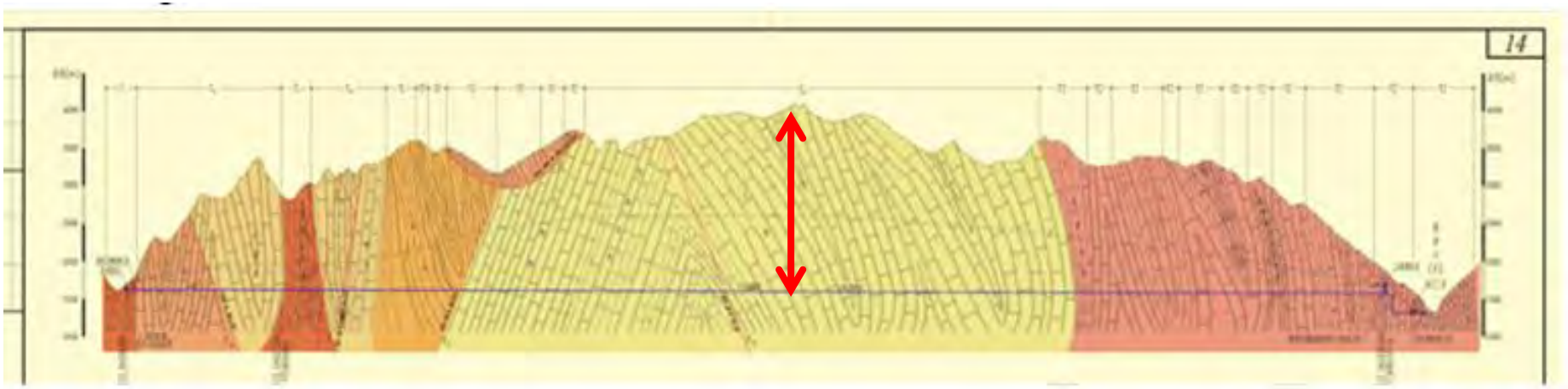
Rock overburden of main international UL



China Jinping Underground Laboratory





Convenient transportation

Highway+Special road access by car from nearest Xichang airport, cost 2h.

Direct flight from many main city to Xichang.

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Logistic Condition of CJPL

Meeting Rooms

several meeting rooms(20-50 persons)

one large hall (300 persons)

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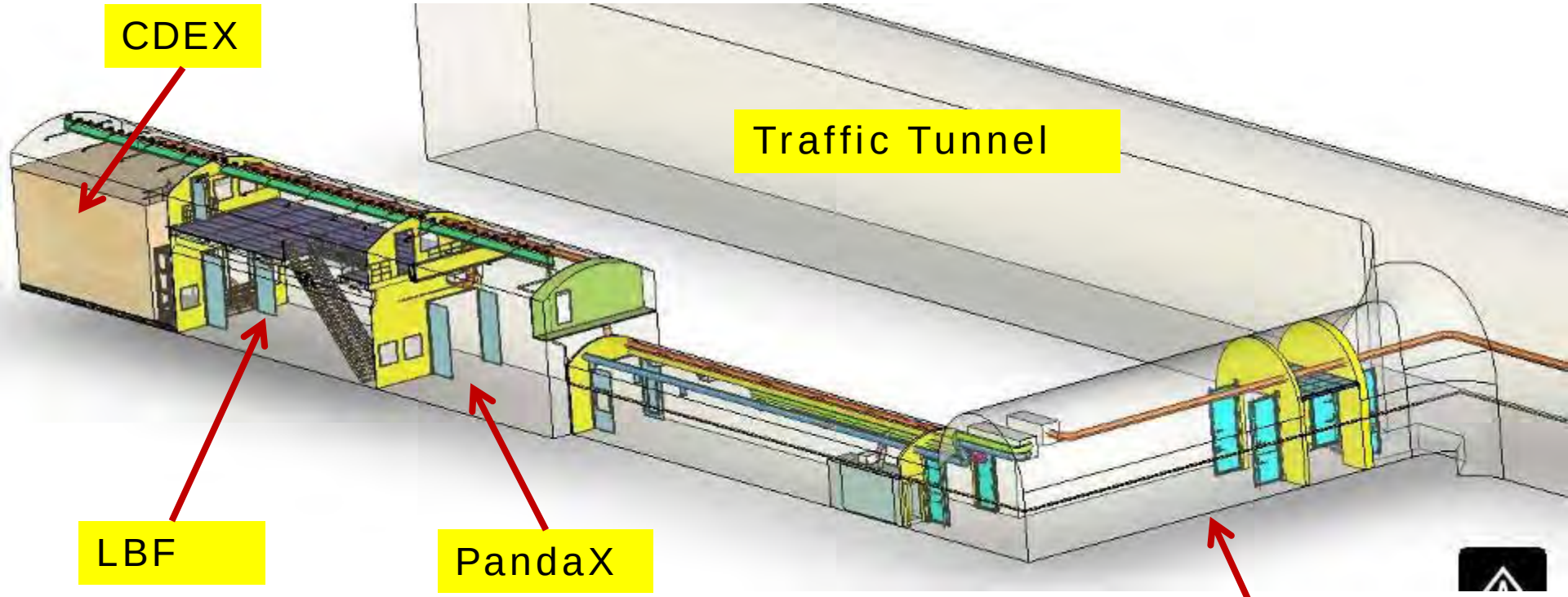
Layout of CJPL-I



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

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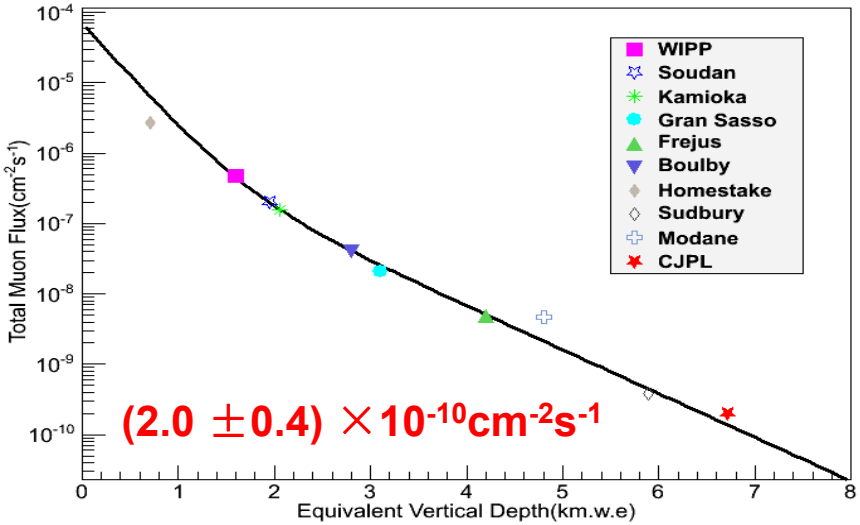
Background Measurement of CJPL-I

Ref: Chinese Physics C 37, 8 (2013) 086001

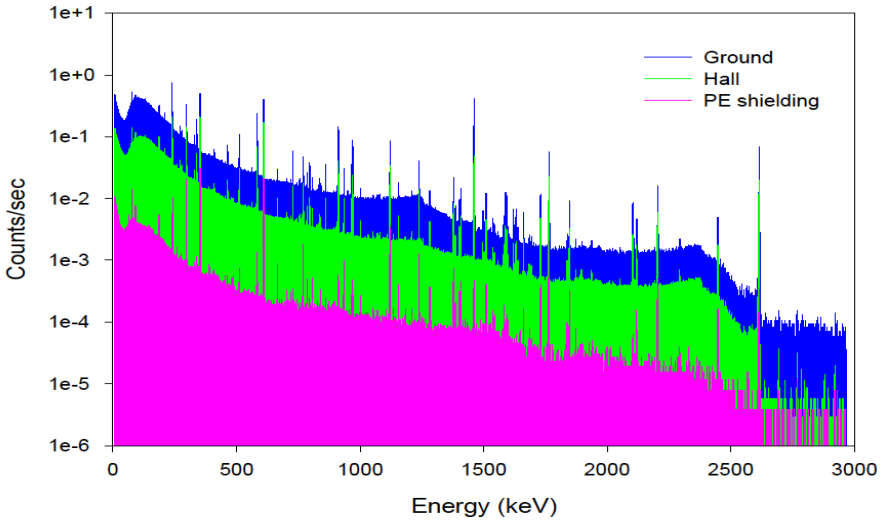
Muon flux ~ 60 muons/year/m^2



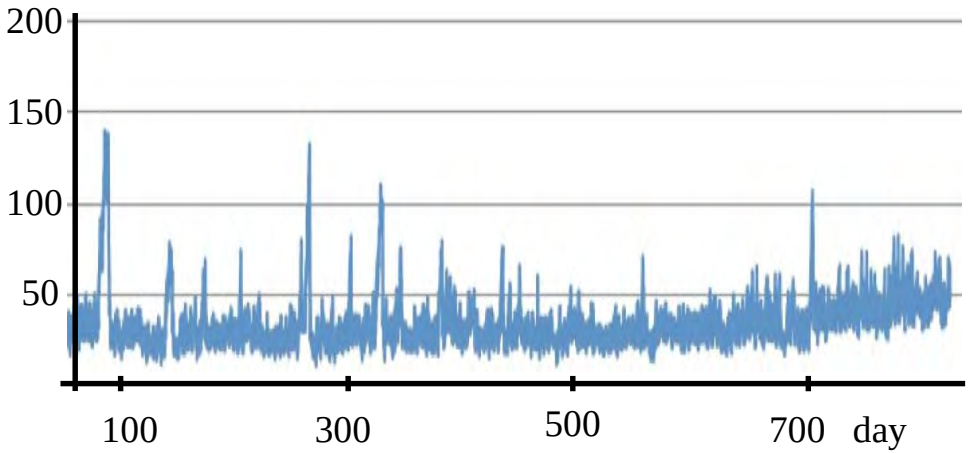
Rock background

(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

Gamma ray flux in CJPL



Radon Monitoring (Bq/m3)

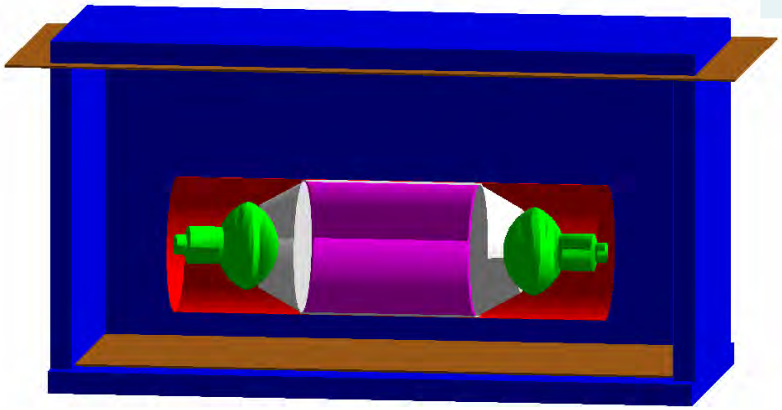


Neutron flux Measurement of CJPL-I

Fast neutron detector

Fast neutron flux compare with other UL

Underground laboratory	Fast neutron flux n/cm^2/s	Energy range	Depth (m)
YangYang	4.17×10^{-6}	1-10MeV	700
Canfranc	0.41×10^{-6}	1-10MeV	800
Gran Sasso	0.42×10^{-6}	1-10MeV	1400
Boulby	1.72×10^{-6}	>0.5MeV	1100
Modane	0.40×10^{-6}	2-6MeV	1780
CJPL Hall	0.15×10^{-6}	1-10MeV	2400
CJPL Poly-room	4.27×10^{-9}	1-10MeV	2400



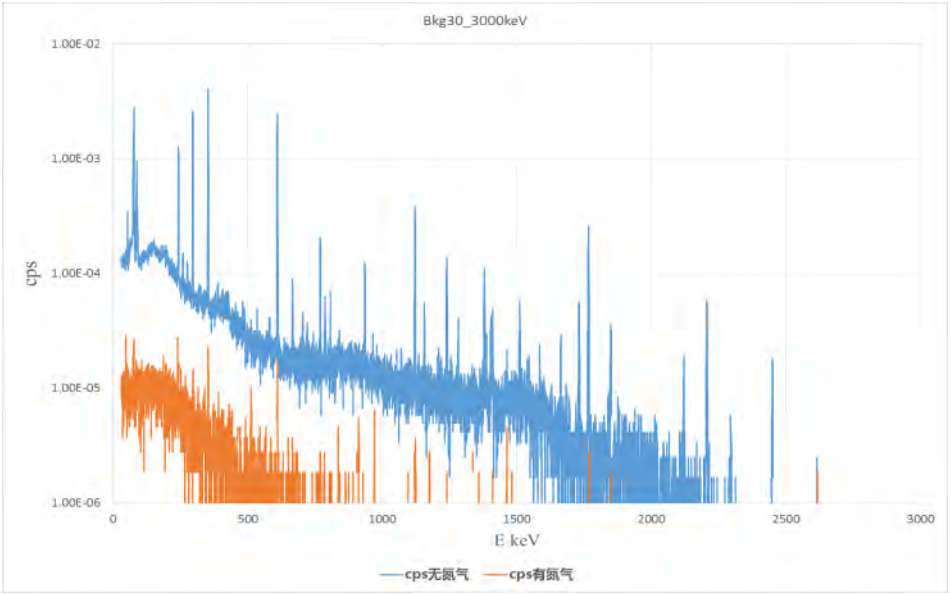
Fast neutron detector (simulation)

Thermal neutron measurement

Thermal neutron flux: < **4.4 x10^{-6} n/cm^2/s**

LBF in CJPL

Low background Facility Sensitivity：<1.0 mBq/kg



CJPL and Modane collaborate to measure the samples and improve the sensitivity of the low background facility.

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China Jinping Underground Laboratory (CJPL)

- Setup and run by THU and EHDC
- Deepest laboratory in the world
  - ~2400m rock overburden (6720 m.w.e)
  - Muon-induced background is negligible (~60muons/yr/m^2)
- Low natural radioactivity in the laboratory
  - Marble stone with the lowest natural radioactivity
- Horizontal access to the laboratory
  - Large facilities directly transported to CJPL by truck
  - Personnel access by car
  - 20min from ground site to underground lab
- Environmental T: <18℃, save much power

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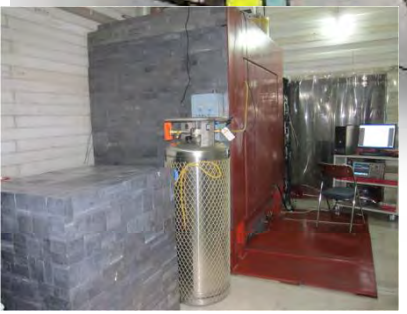
Recent experiments in CJPL

LBF



CDEX

PandaX

Jinping neutrino Experiment

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CDEX: China Dark matter EXperiment

Established in 2009，

70 ~ 80 members：

- Tsinghua University, THU
- Sichuan University, SCU
- Nankai University, NKU
- China Institute of Atomic Energy, CIAE
- Yalong River Hydropower Company, EHDC
- Collaborate with TEXONO and KIMS group.

part members of the CDEX collaboration

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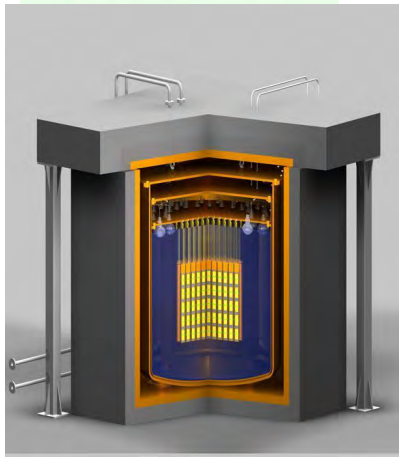
CDEX development stages

- CDEX-1: Development of HPGe detector, its background understanding and the studies of its performances based on 1kg-scale-mass HPGe detector.
- 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-1T: Multi-purpose experiment for dark matter and double beta decay.



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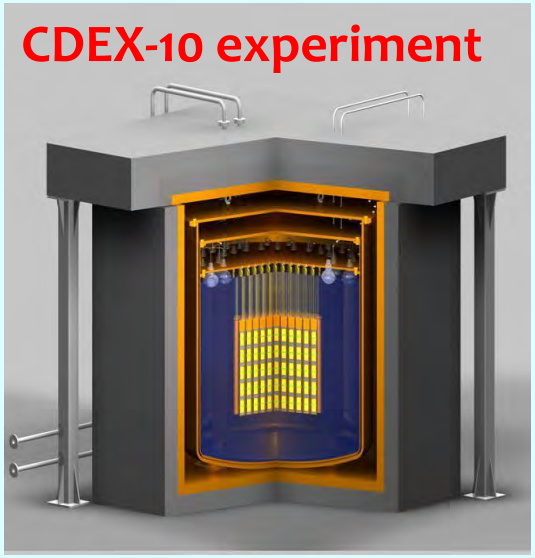
CDEX-1

PE room

CDEX-10 experiment



CDEX-1

Gate

CDEX-10 Ge experiment

PCGe array with lower energy threshold : CDEX-1: 400eV → CDEX-10: <300eV;

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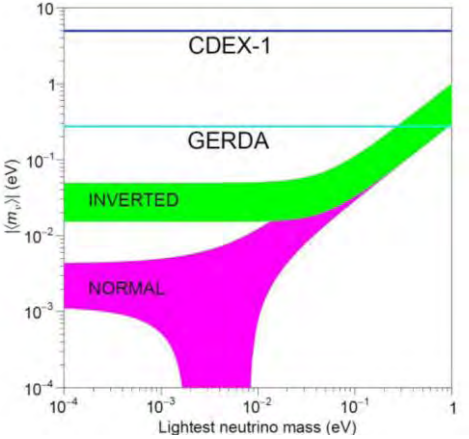
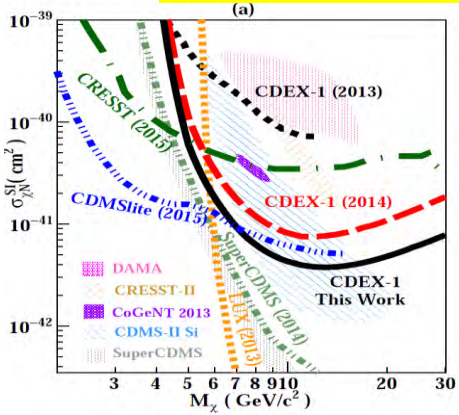
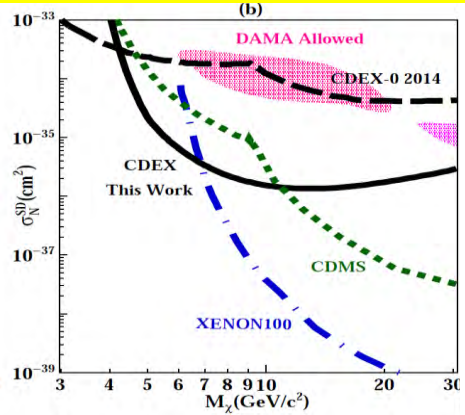
CDEX-1 results

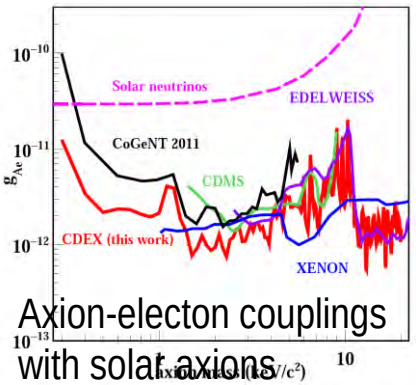
- From 2012 on, CDEX-1A (> 700d), CDEX-1B (> 400d);
- Series physical results published，CoGeNT region excluded definitely with identical technique;
- Axion dark matter results accepted by PRD;
- DBD results distributed based on CDEX-1A data;
- AM results under preparation;

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

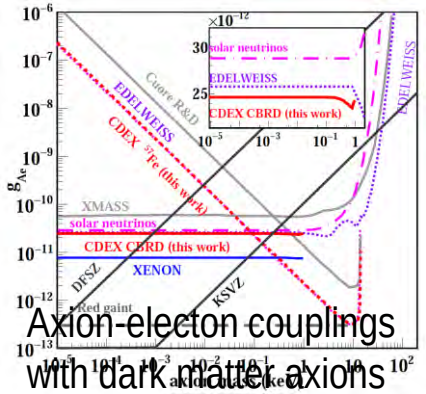








Axion-electon couplings with solar axions



Axion-electon couplings with dark matter axions

PandaX

Started in 2009, ~50 people

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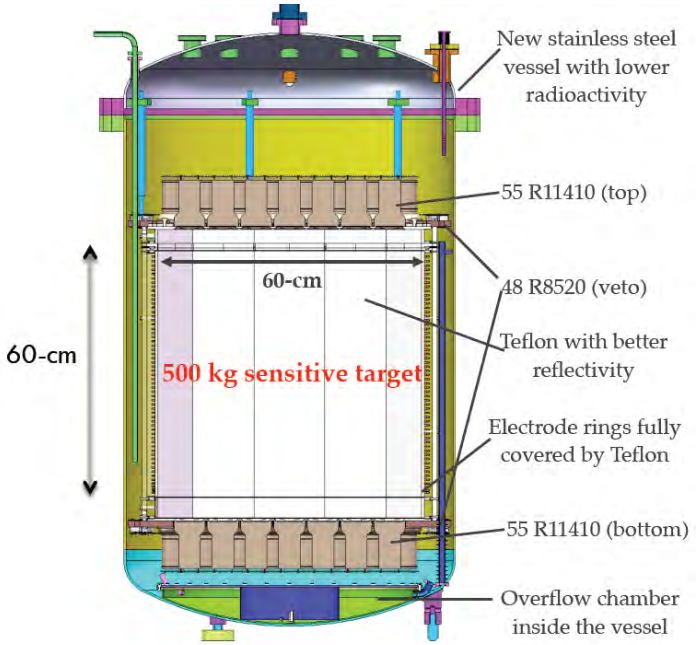
- Shanghai Jiao Tong University (2009-)
- Peking University (2009-)
- Shandong University (2009-)
- Shanghai Institute of Applied Physics, CAS (2009-)
- University of Science & Technology of China (2015-)
- China Institute of Atomic Energy (2015-)
- Sun Yat-Sen University (2015-)
- Yalong Hydropower Company (2009-)
- University of Maryland (2009-)
- Alternative Energies & Atomic Energy Commission (2015-)
- University of Zaragoza (2015-)
- Suranaree University of Technology(2016-)

PandaX apparatus



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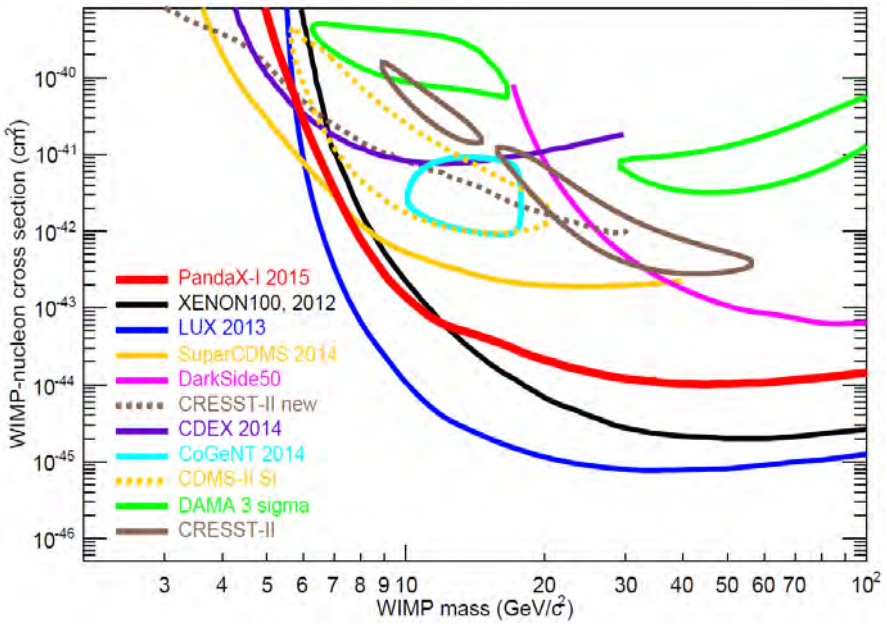
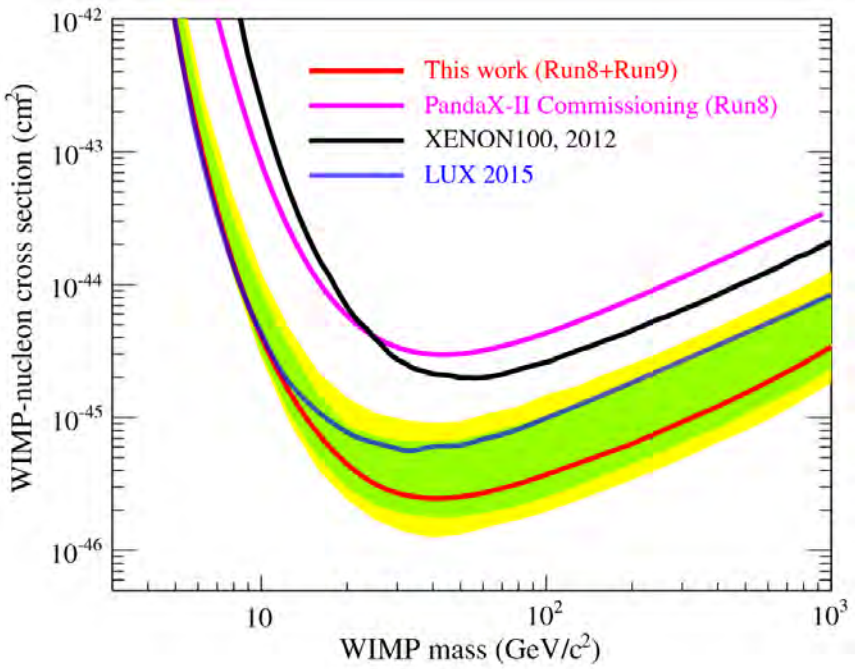
PandaX results



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



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

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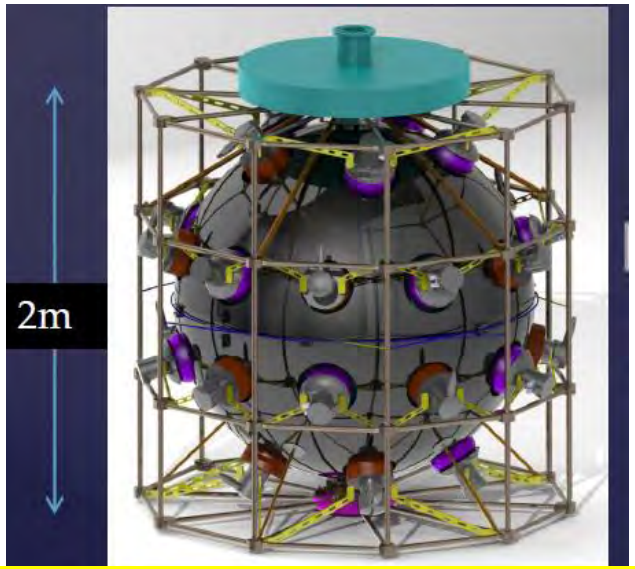
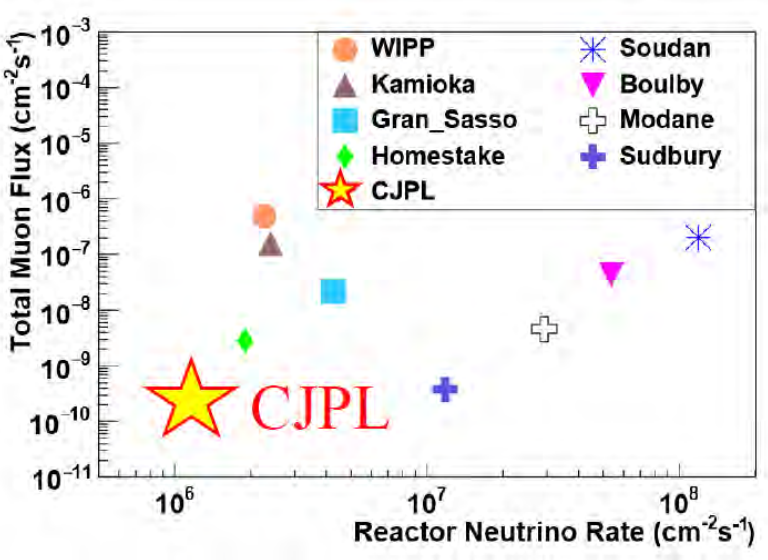
Jinping Neutrino Experiment

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



1-ton detector installed



CJPL-II PROJECT

The dam and tunnel for YL hydropower plant finished in 2014, Time to decide km-long auxiliary tunnels refilled for long-term safety or reused by other project. Expert engineering team and tools would leave from JP tunnel;

THU + YL Hydro Company started to consider CJPL phase-II construction for time saving and money saving in 2013.

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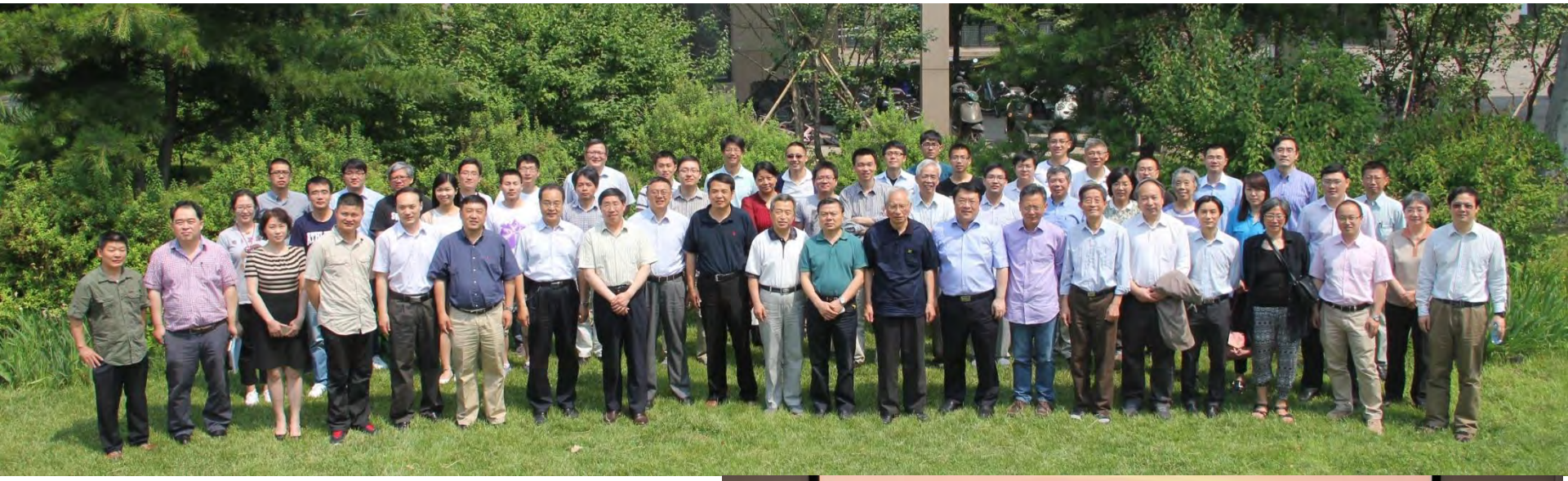
Symposiums on CJPL Physics



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

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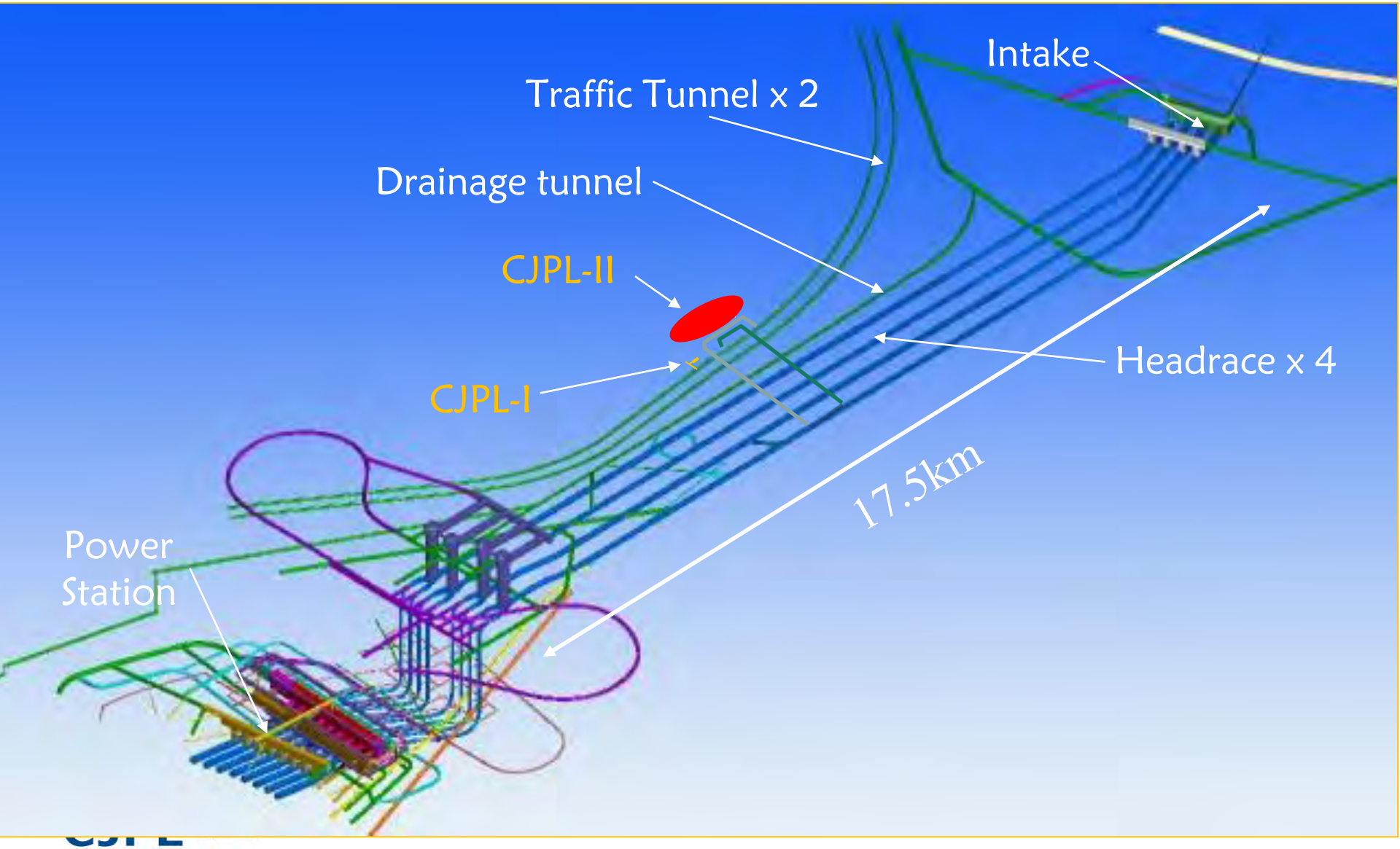
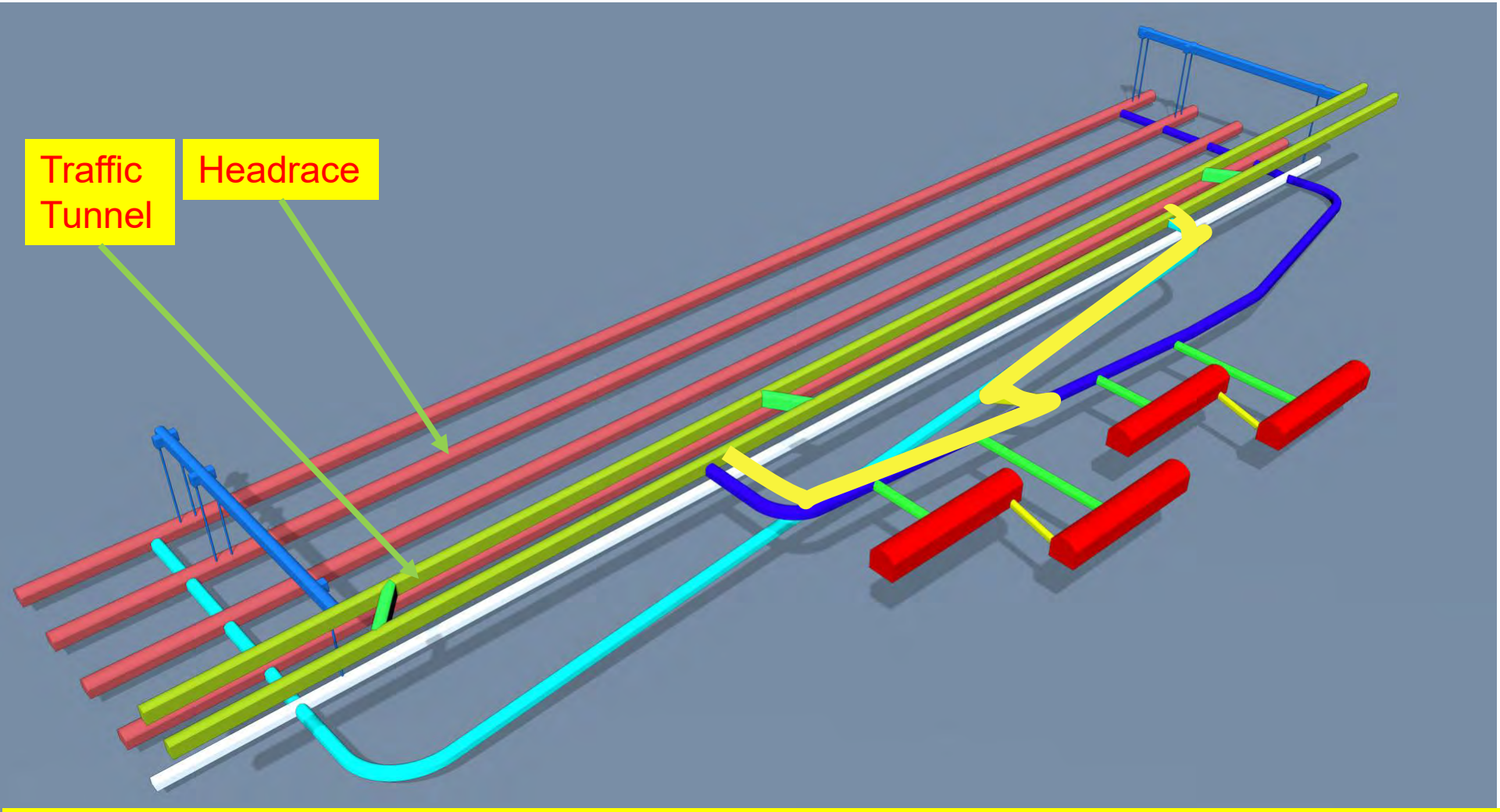
CJPL International Advisory Committee

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

CJPL in Jinping tunnels



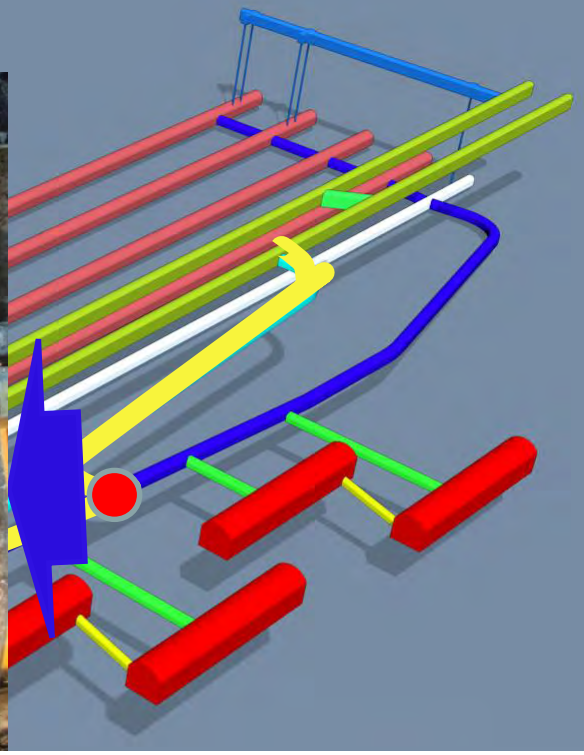
CDEX in CJPL-II



- **Four 14m*14m*130m main halls**
- **Total Volume： ~300K m³**

CJPL-II

2014.11.25



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, of light. In the other experimental hall, the

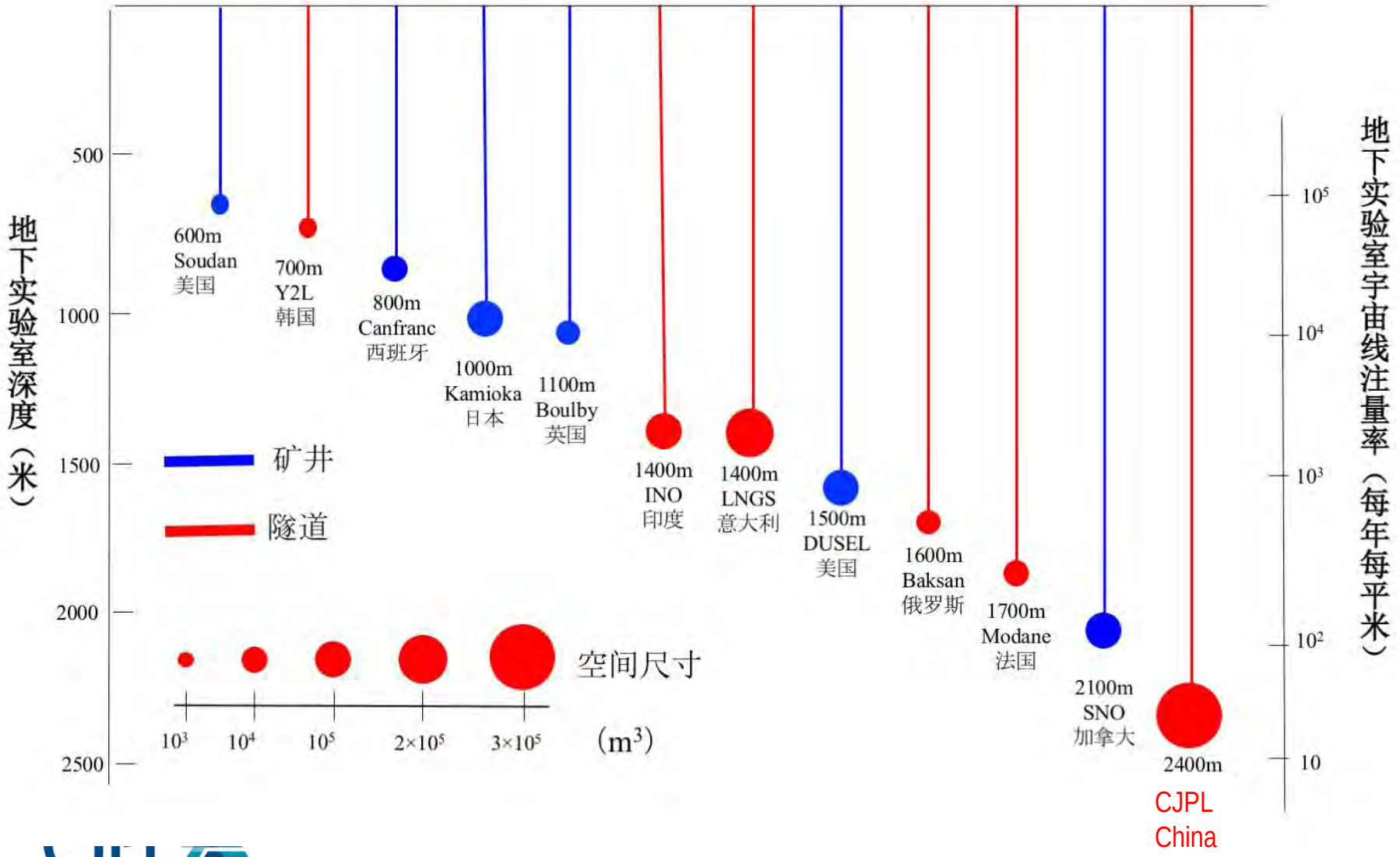
other labs indicating that WIMPs are likely to have very little mass

Science, Nov. 30, 2014

Status of CJPL-II

- **Dec. 2015:** The rock excavations of all the main halls are completed;
- **May. 2016:** Expansion of two sites have been OK;
- **Dec. 2016:** Ventilation system start to install.

ULs in the world(rock overburden)



CJPL
China

CJPL-II plan

Main Hall

Internal traffic tunnel

Ground Campus

CJPL be candidate project of national major S&T infrastructure of China in 2016.

CJPL-II possible users

- CDEX-1T (Ge DM+DBD Exp.)
- PandaX-1T (Xe DM Exp.)
- LAr dark matter experiment
- Nuclear astroparticle physics
- Solar neutrino experiment
- rock mechanics
- CUPID-China(NLDBD)
- ……

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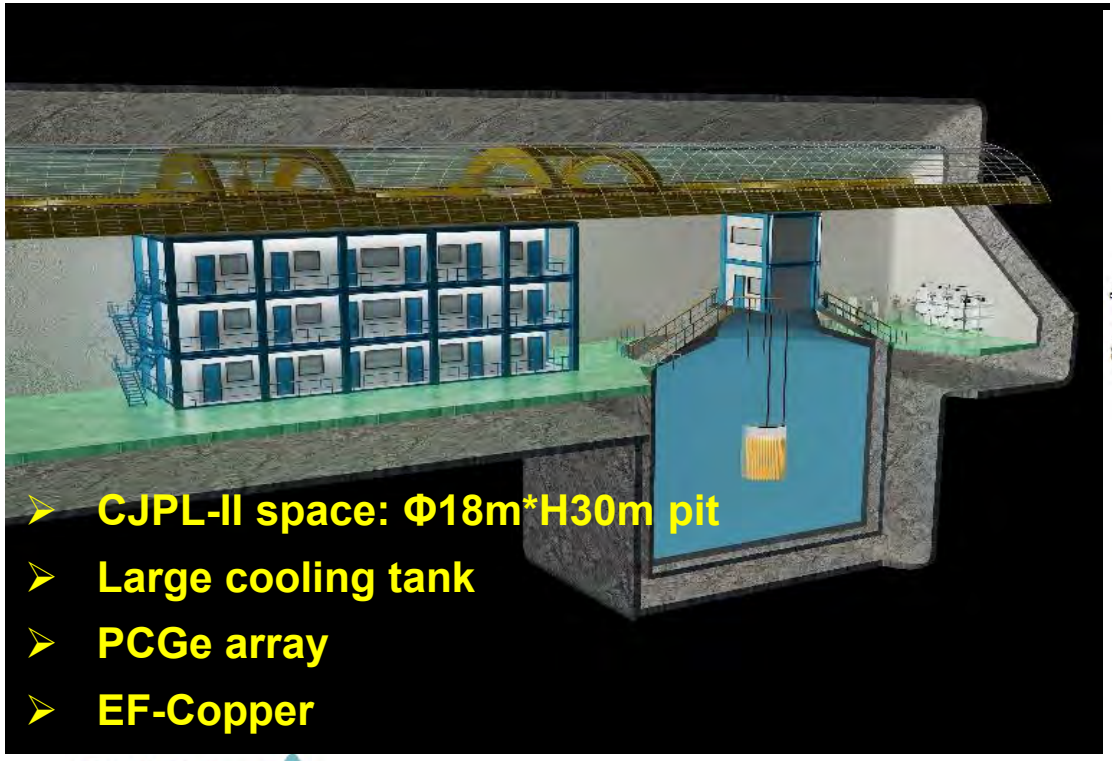
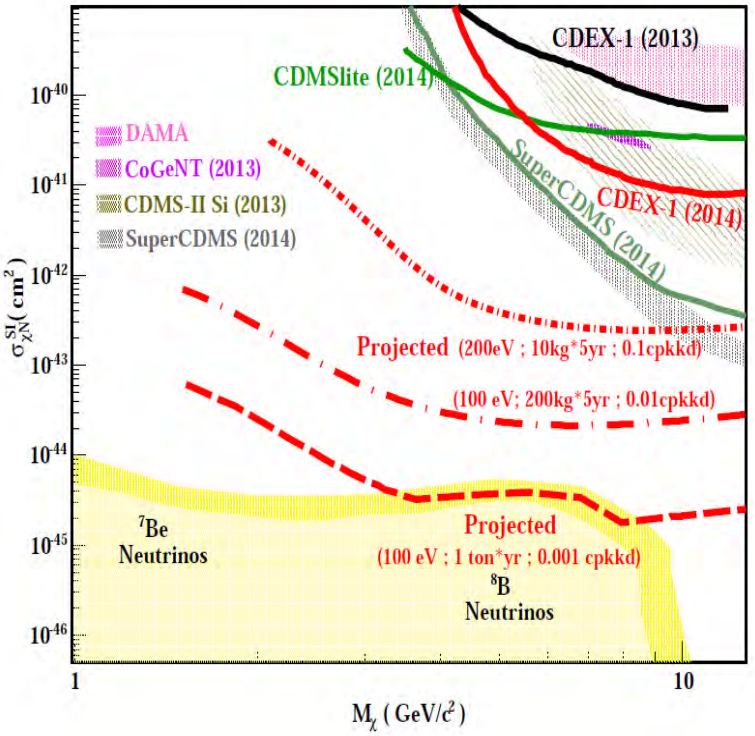
CDEX future projects at CJPL-II

- A ton-scale Ge detector composed of the PCGe detector and LN shielding and cooling system in the CJPL-II
- Both Dark matter and Double Beta Decay





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CDEX-1T in CJPL-II

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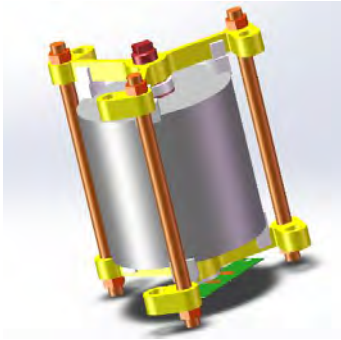
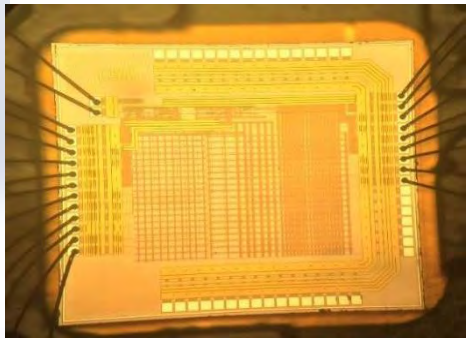
CDEX-1T Key technologies

- Ge purification and Ge crystal growth
- HPGe detector fabrication
- Ultra-low background VFE
- Ultra-pure copper for structure and cables
- Large-volume cooling tank



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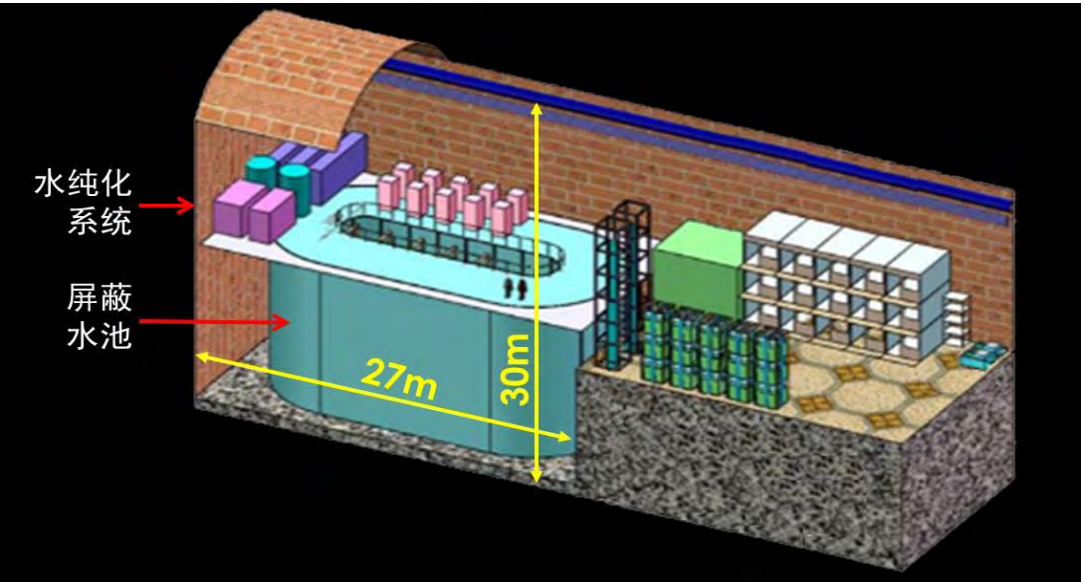
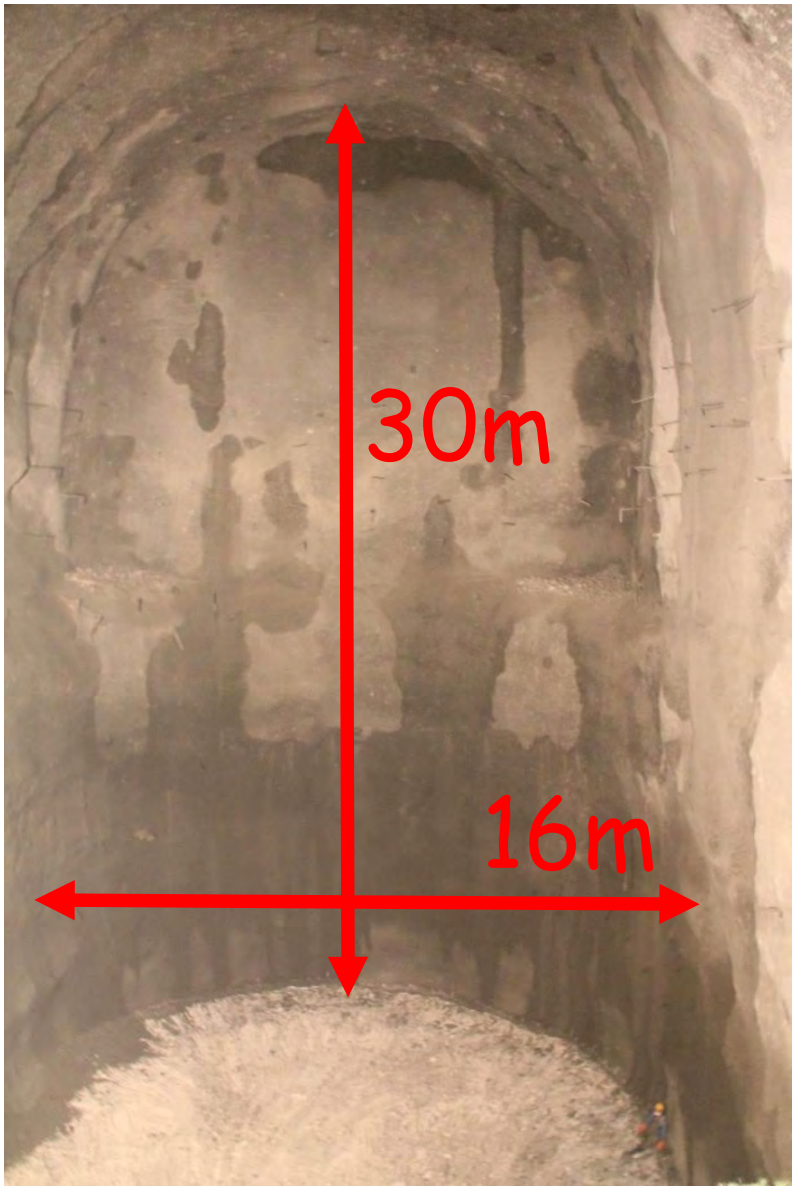
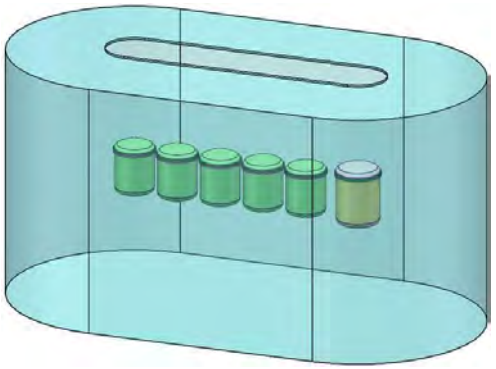
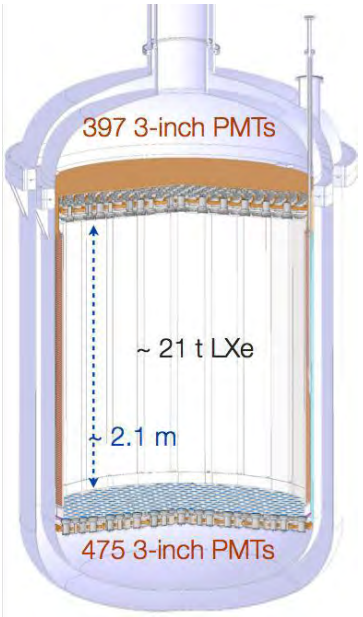
PandaX in CJPL-II

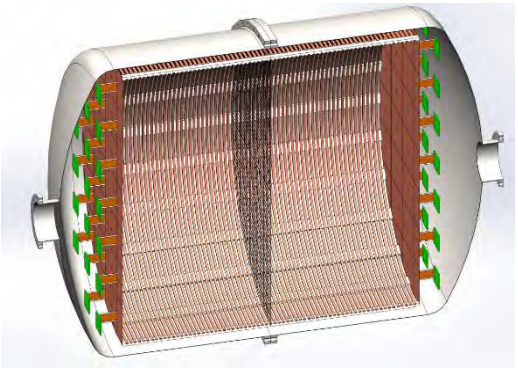




Liquid Xeon Darkmatter Experiment-PANDAX in CJPL-II







- One 20-40T LXe DM detector;
- Five 200kg HP(10-15bar) Xe136 gas TPC

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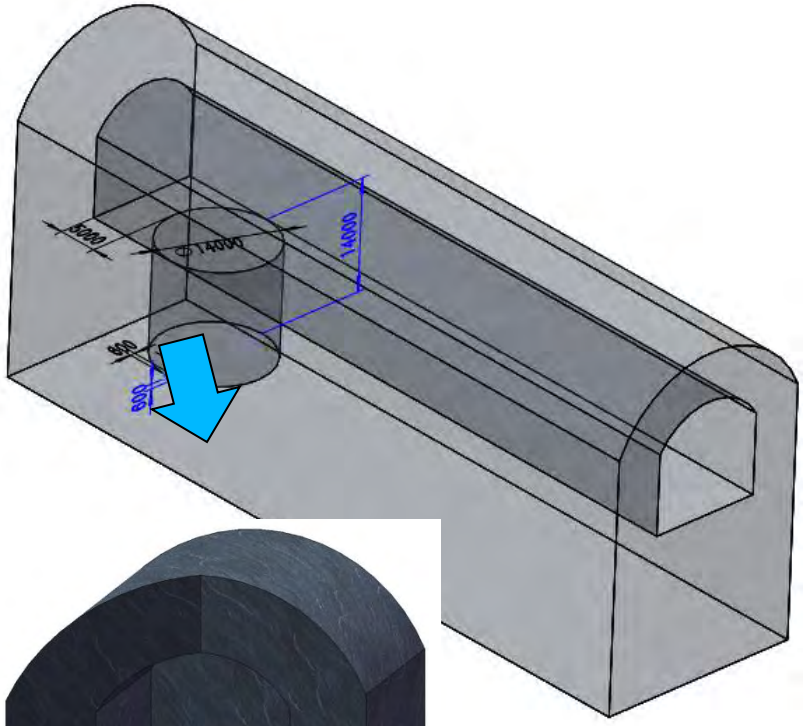
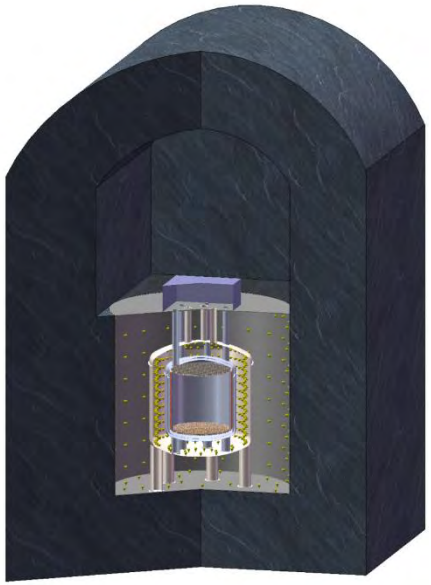
Liquid Argon Dark Matter Experiment in CJPL-II

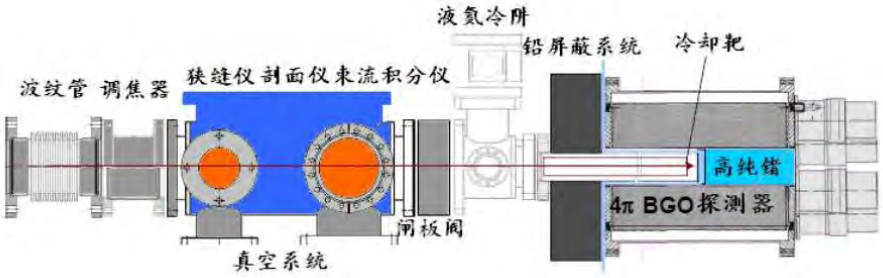




Construction of Detector in CJPL-II

- **Outer sector (14x14x14m^3): Water Cerenkov detector**
- **Middle sector in SS tank (9x9x9m^3): Liquid scintillator detector for neutron veto**
- **Inner sector (6x6x6m^3): Two phase TPC with Underground Ar**

JINPING Underground Nuclear Astrophysics (JUNA) Experiment



JUNA Accelerator concept design

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.

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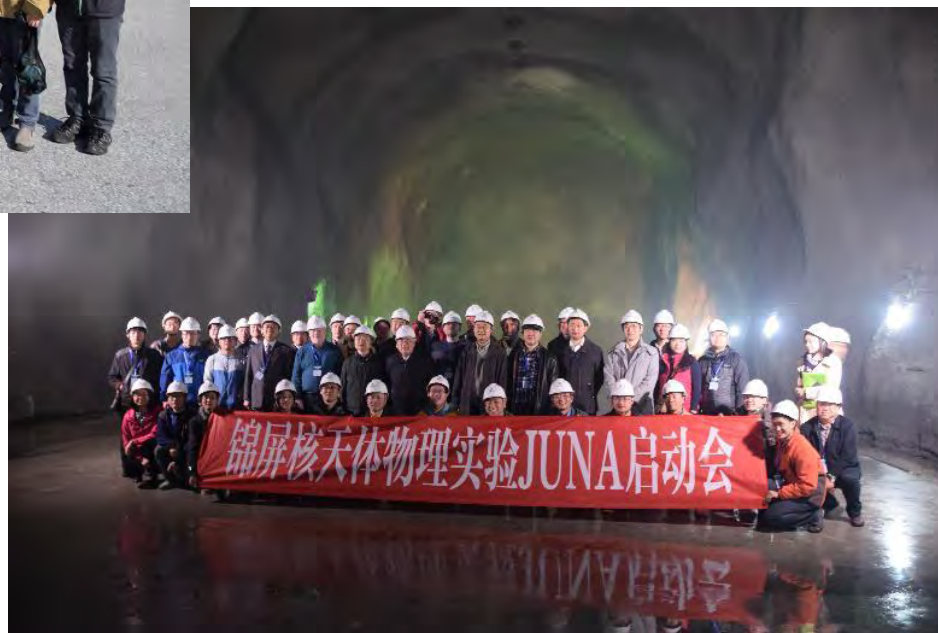
JUNA Astroparticle experiment



March 1st, 2016@CJPL-II

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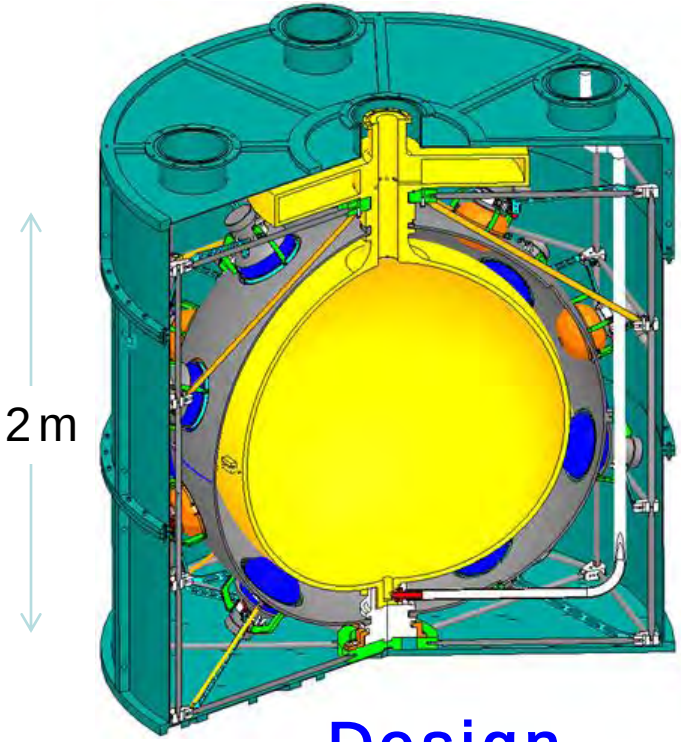
Jinping Neutrino Experiment

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



Design

Fabrication

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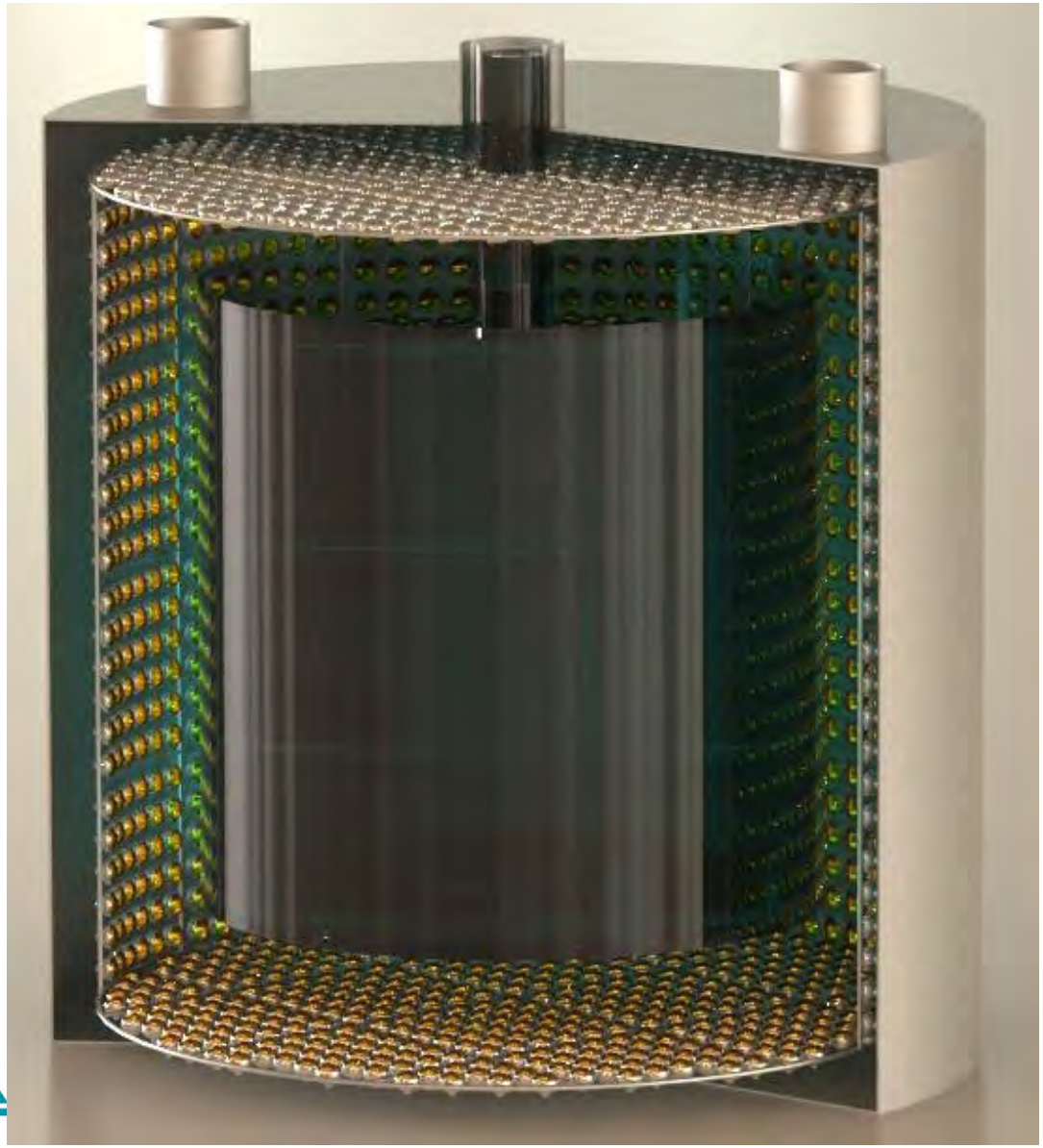
Jinping Neutrino Experiment
Kilo-Ton scale from 2020



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Summary

- CJPL with deepest rock overburden in the world run now; Two DM experiments run in and published important physical results.
- CJPL-II with deepest rock overburden, largest space in the world under setup;
- Several experiments applying CJPL-II space including: DM, DBD, Neutrino, Astroparticle;
- The possible users of CJPL-II in the world are welcome.

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Thank you!

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