Dark Matter Direct Detection Experiments in China

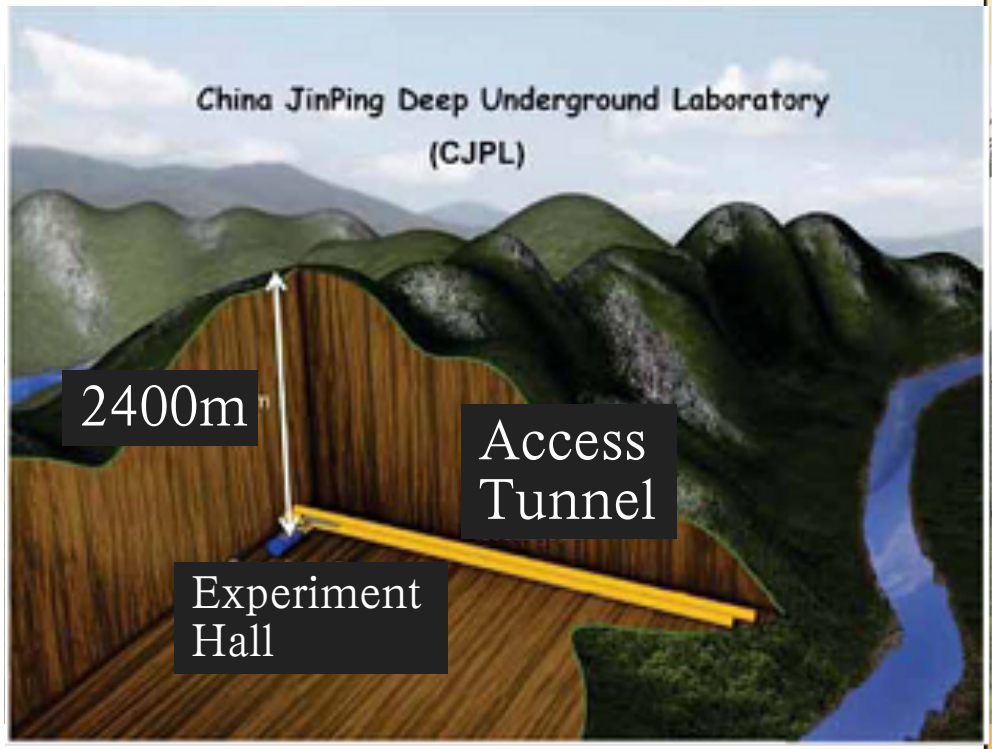
Kaixuan Ni

Shanghai Jiao Tong University

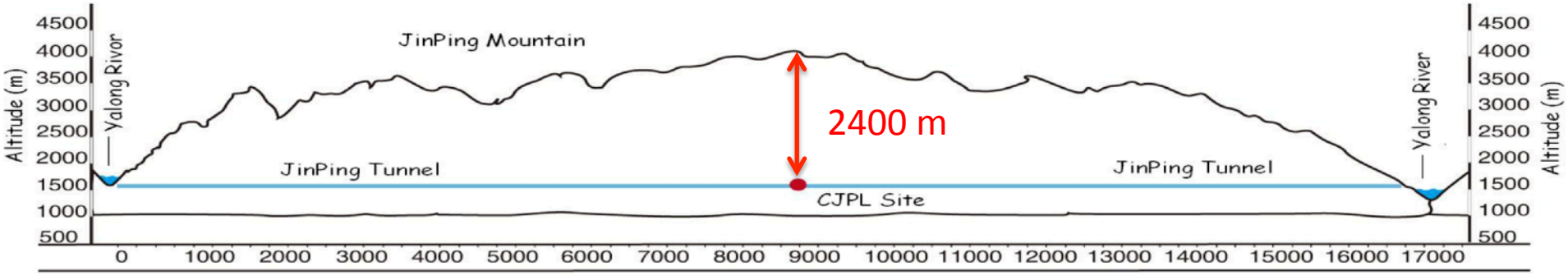
A brief history of DM direct detection in China…

- 1992-1996: Beijing (IHEP)-Roma-Saclay collaboration to search for dark matter using NaI detectors
- 1990's: IHEP joined the DAMA (NaI) experiment
- 2000's: Tsinghua University (THU) and IHEP joined KIMS (CsI) and TEXONO (Ge) experiments
- 2009: Shanghai Jiao Tong University (SJTU) joined XENON100 (LXe) experiment
- 2011: IHEP joined the DarkSide (LAr) experiment
- 2009-now: Development of the China Jinping underground laboratory (**CJPL**) by THU and Yalong River Company
- 2010-now: Two experiments, **CDEX** (Ge, led by THU) and **PandaX** (LXe, led by SJTU), being developed at CJPL
- 2010-now: R&D for new target detectors, including **CINDMS** (CsI) by IHEP.

CJPL site

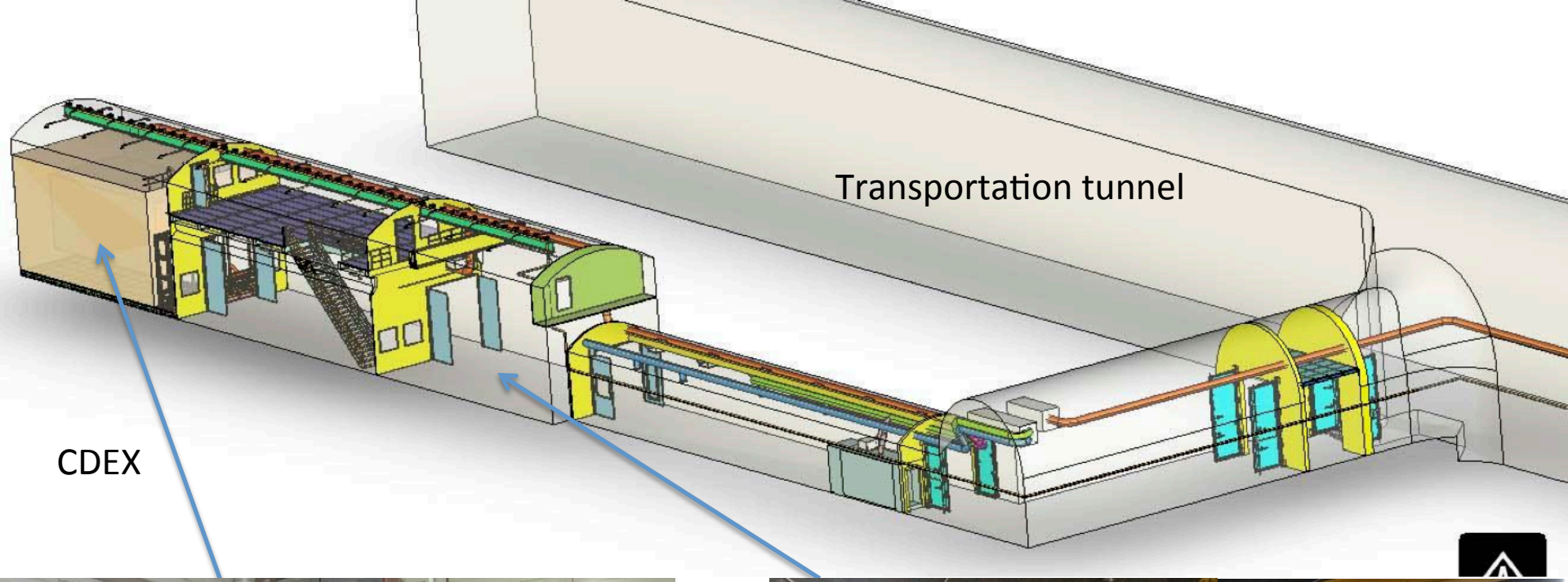

China JinPing Deep Underground Laboratory
(CJPL)
2400m
Access Tunnel
Experiment Hall


CHINA
Sichuan Province
YaLongRiver
Jinsha River
Jinping tunnels
YaLong River
Jinsha River
Jinsha River
N
Yunnan Province


Altitude (m)
4500
4000
3500
3000
2500
2000
1500
1000
500
Yalong River
JinPing Mountain
2400 m
JinPing Tunnel
JinPing Tunnel
CJPL Site
Yalong River
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
16000
17000

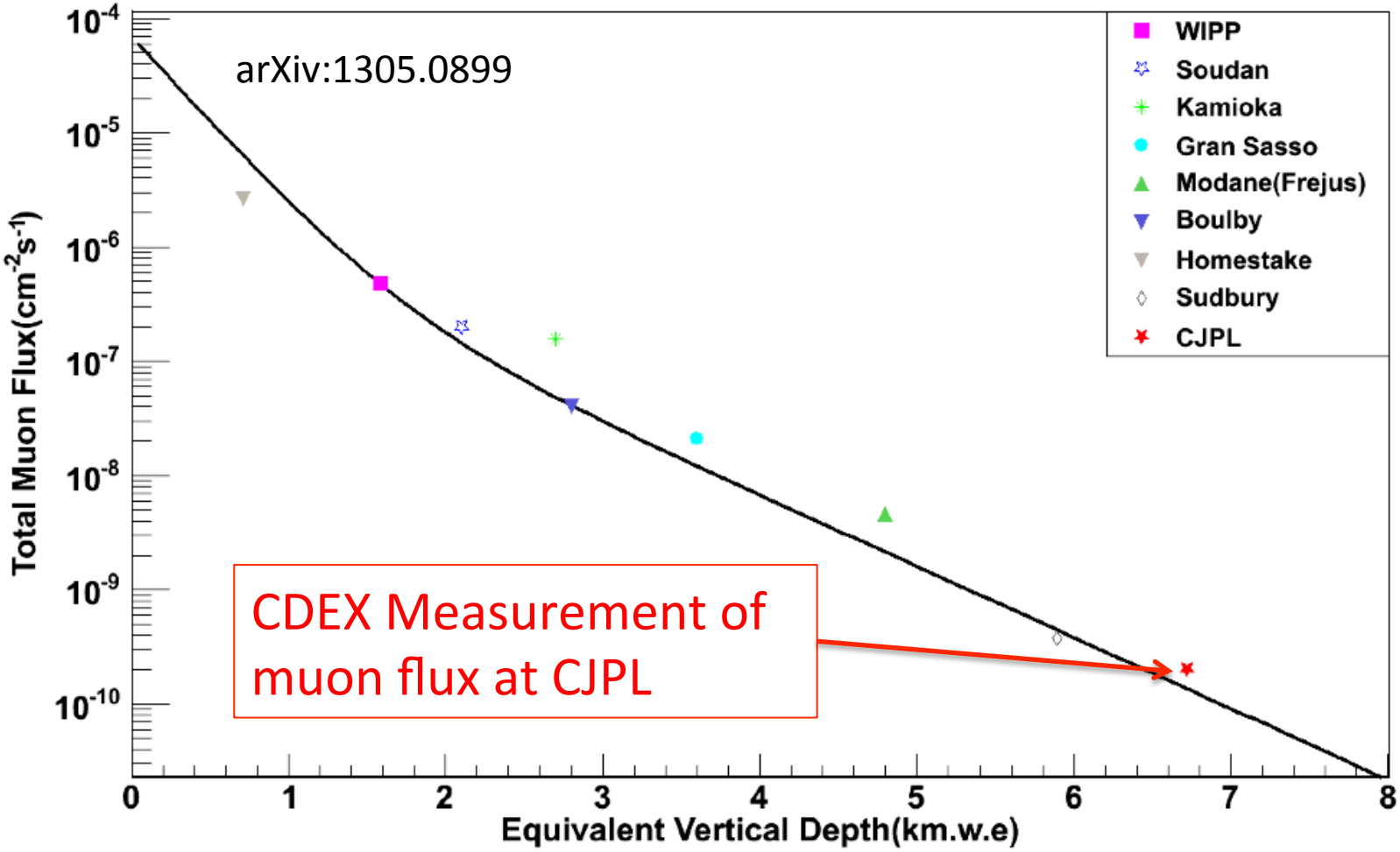
Excavated through on Aug.8, 2008, Jinping tunnel is the world's second deepest transportation tunnel.

Excavation and renovation of the CJPL underground lab (6x6x40 m^3) for two experiments (CDEX/PandaX)


Transportation tunnel
CDEX

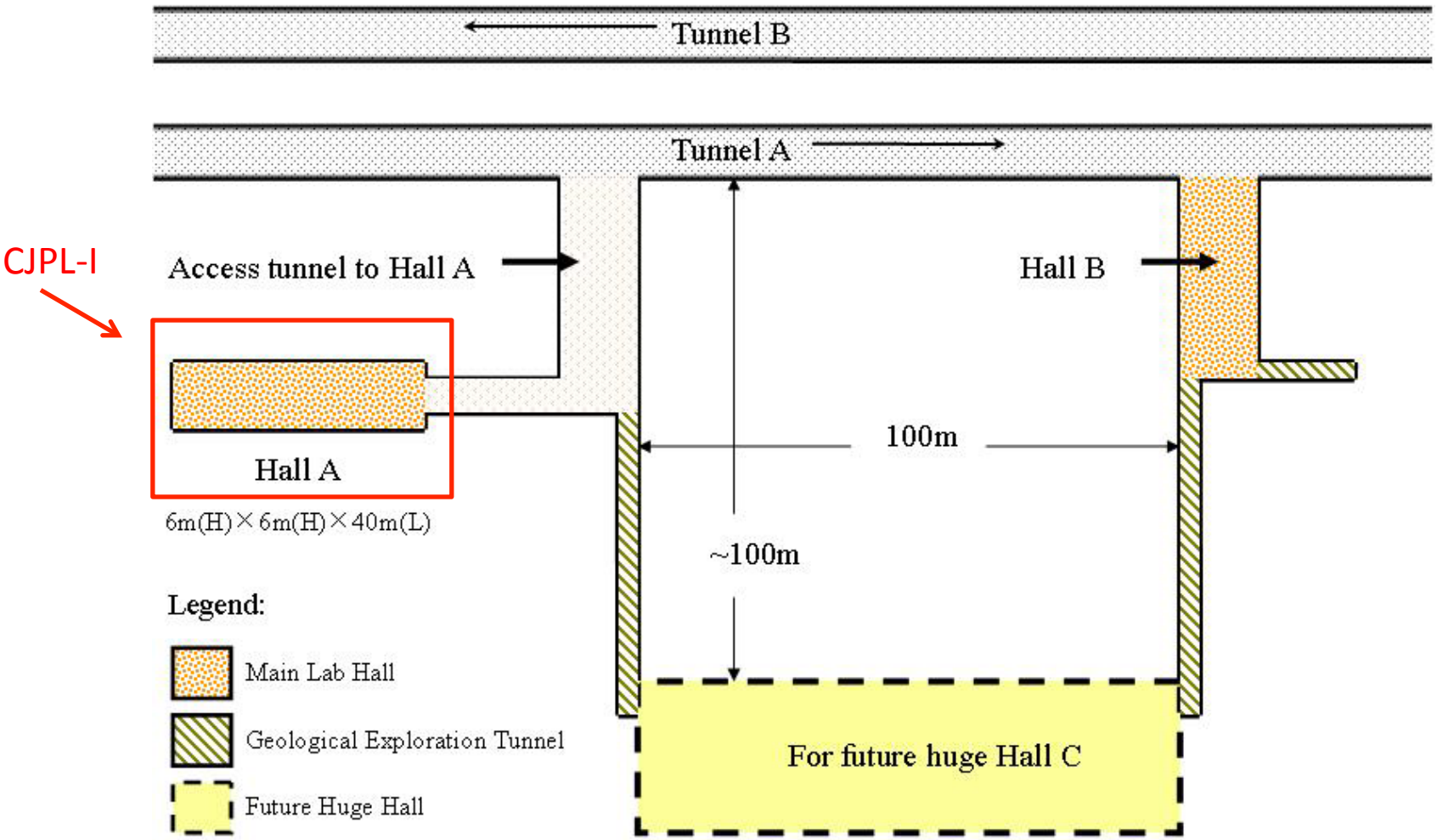

CDEX-1 实验
1kg ULEGe
20g PCGe
20cm OFHC Copper
+20cm Lead


5t
PandaX
2012 04 24



- *CJPL muon flux: 2.0 x 10^{-10} cm^{-2} s^{-1} (~60 m^{-2} yr^{-1})*
- *A factor of 100 lower compared to the muon flux at Gran Sasso*

Future plans (CJPL-II)



CJPL-II: x20 more space than CJPL-1, 12mx12mx50mxN, under design and plan to be finished by 2015.

2013
TAUP
Asilomar
September 8-13

A Town Meeting for the 2nd-phase Development of the China Jinping Underground Laboratory

The town meeting for discussing the second phase development of the China Jinping Underground Laboratory has been moved to Asilomar to allow better coordination with TAUP2013. The meeting will begin at 9:00am on Sunday, September 8, the "arrival day" for TAUP participants, and continue until 5:00pm. Thus those attending TAUP who would also like to participate in the Town Meeting can do so by arranging one additional night in Asilomar; TAUP attendees who arrive in Asilomar on September 8 are also welcome to participate for a partial day. There is no registration fee. Basic information is below:

Date: Sept 8, 2013

Venue: Asilomar, CA, USA (Coordinated with TAUP2013)

Organization Committee: Jianmin Li (Chair, Tsinghua University, China)

Xiangdong Ji (U. Maryland/Shanghai Jiao Tong University, China)

Wick Haxton (LBNL & UC Berkeley, USA)

Joe Wang (LBNL, USA)

CDEX: China Dark matter EXperiment

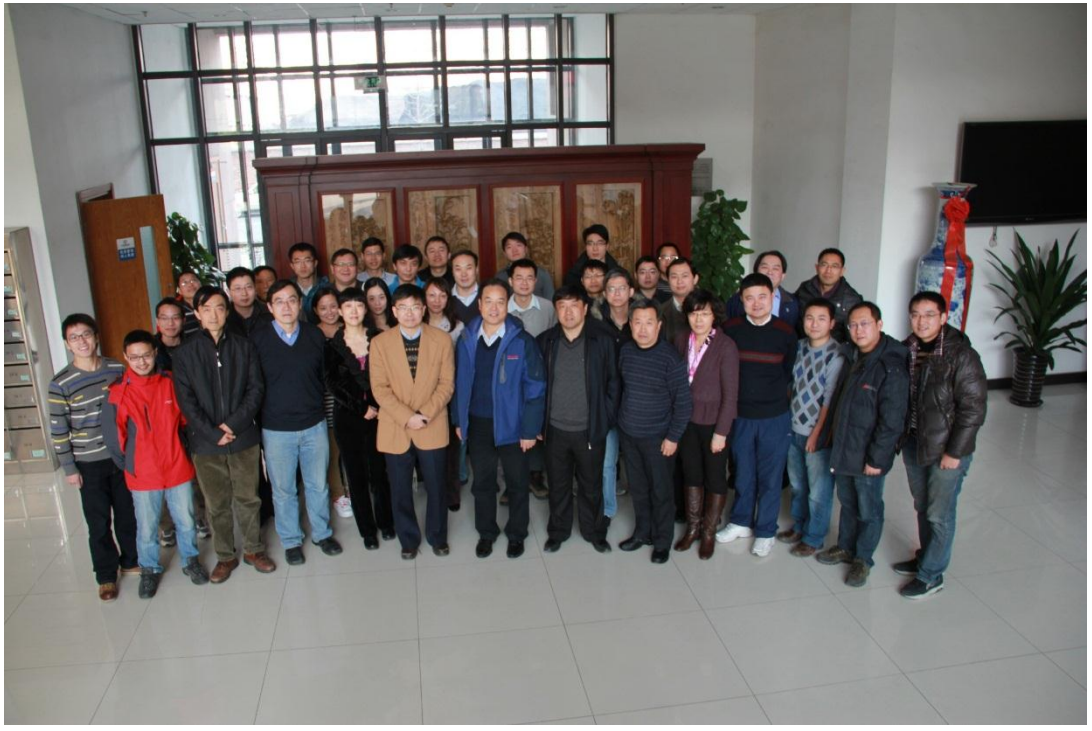
CDEX target:

Direct detection of cold dark matter with Ton-scale Point-Contact Germanium (PCGe) array detectors with ultra-low energy threshold (<300 eV).

slides from Qian Yue (THU)

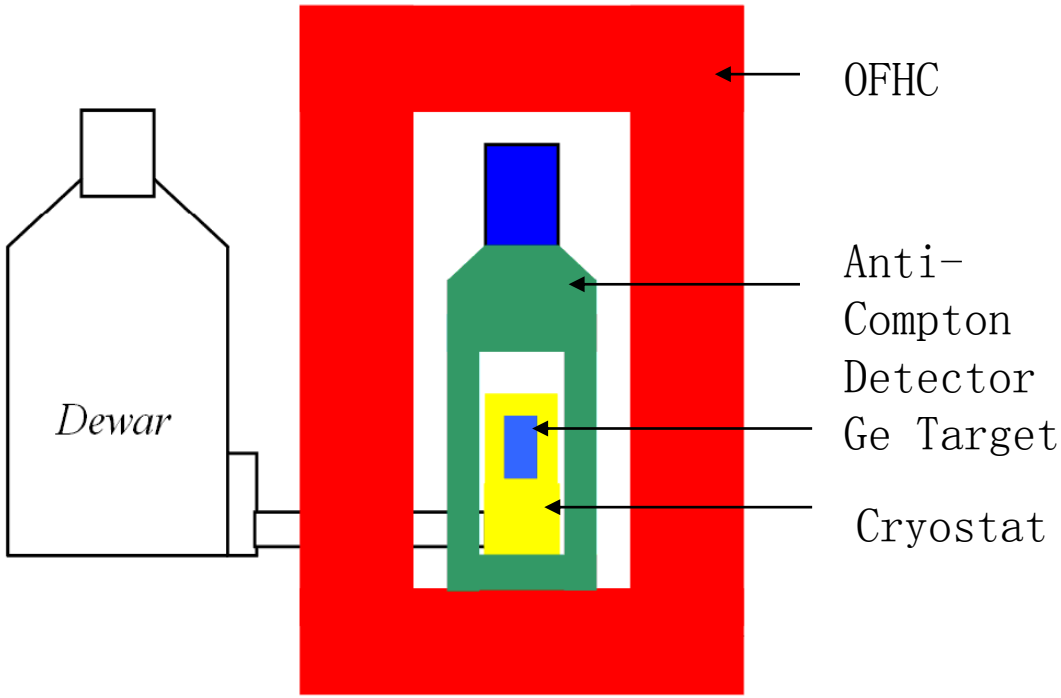
China Darkmatter EXperiment (CDEX)
Established in 2009

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



CDEX-1kg @ CJPL

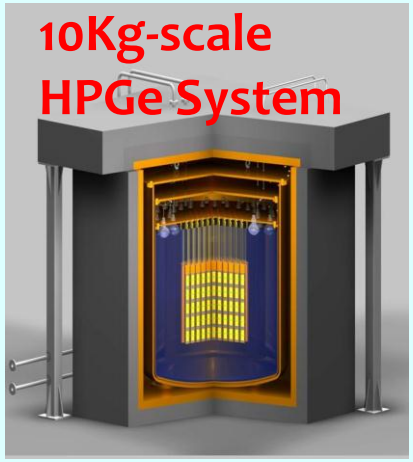
- ✓ Point-contact Ge array detector with ultra-low energy threshold (~300eV or less).
- ✓ Mass of Ge target: 20g, 1000g.
- ✓ Further ultra-pure crystal serve as active shielding and anti-compton detector.



CDEX-1 Shielding System

PE shielding room

10Kg-scale HPGe System

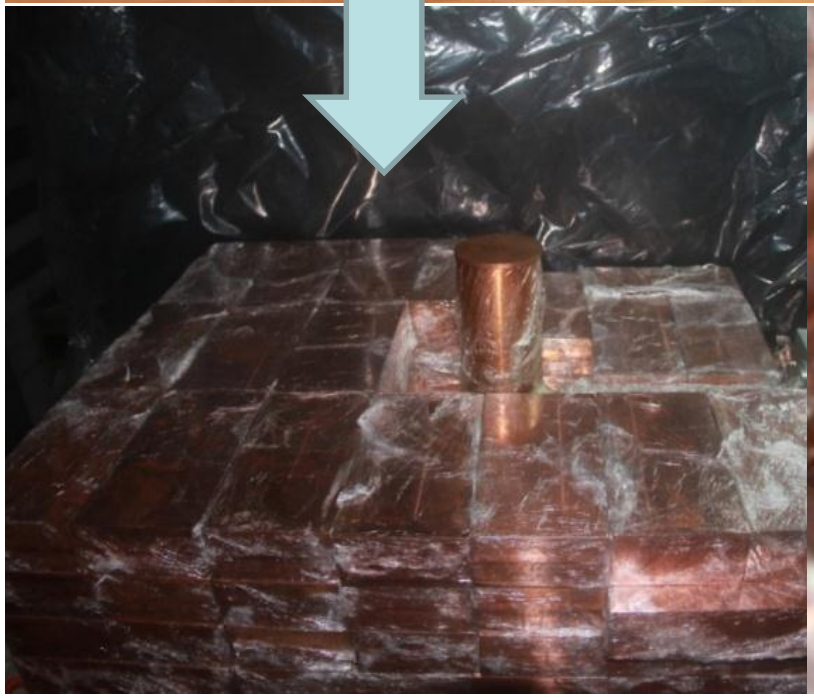


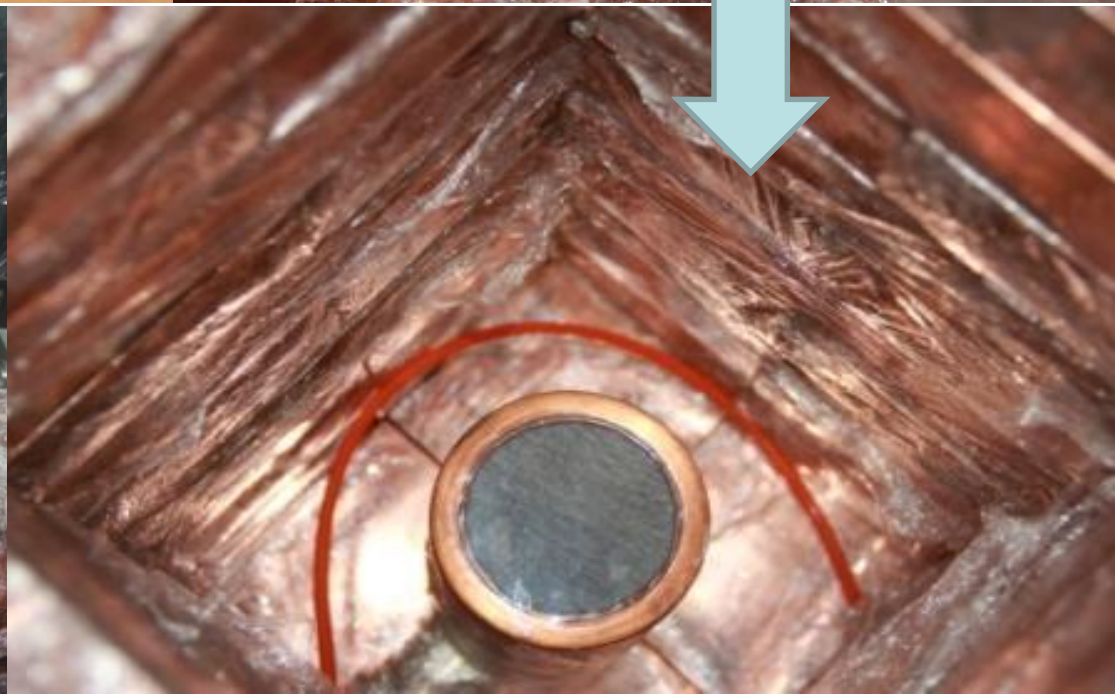
CDEX-1 Shielding system

CJPL

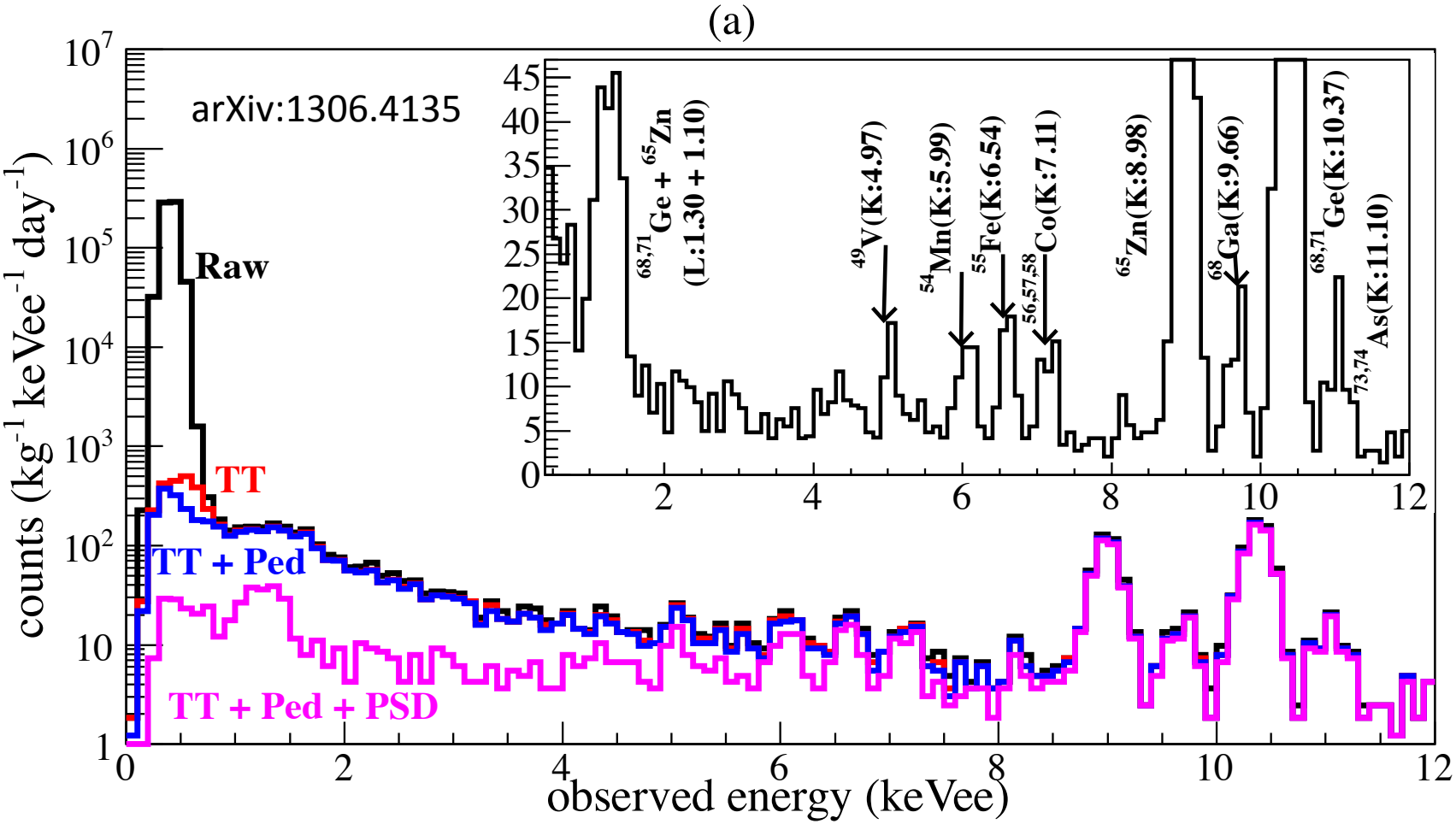

CDEX-1 实验
1kg ULEGe
20g PCGe
20cm OFHC Copper
+20cm Lead

CDEX-1 实验



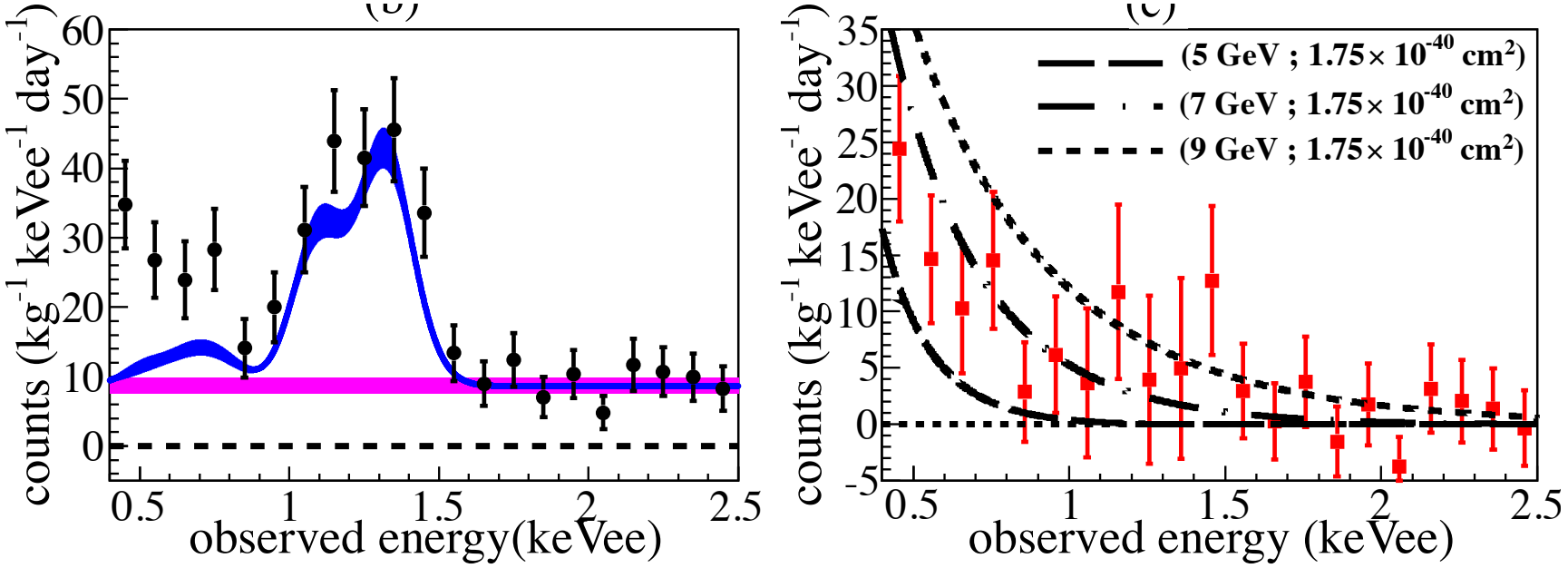


First dark matter search data from CDEX-1: background dominated by cosmogenic radioisotopes, such as ^{68,71}Ge and are clearly visible.

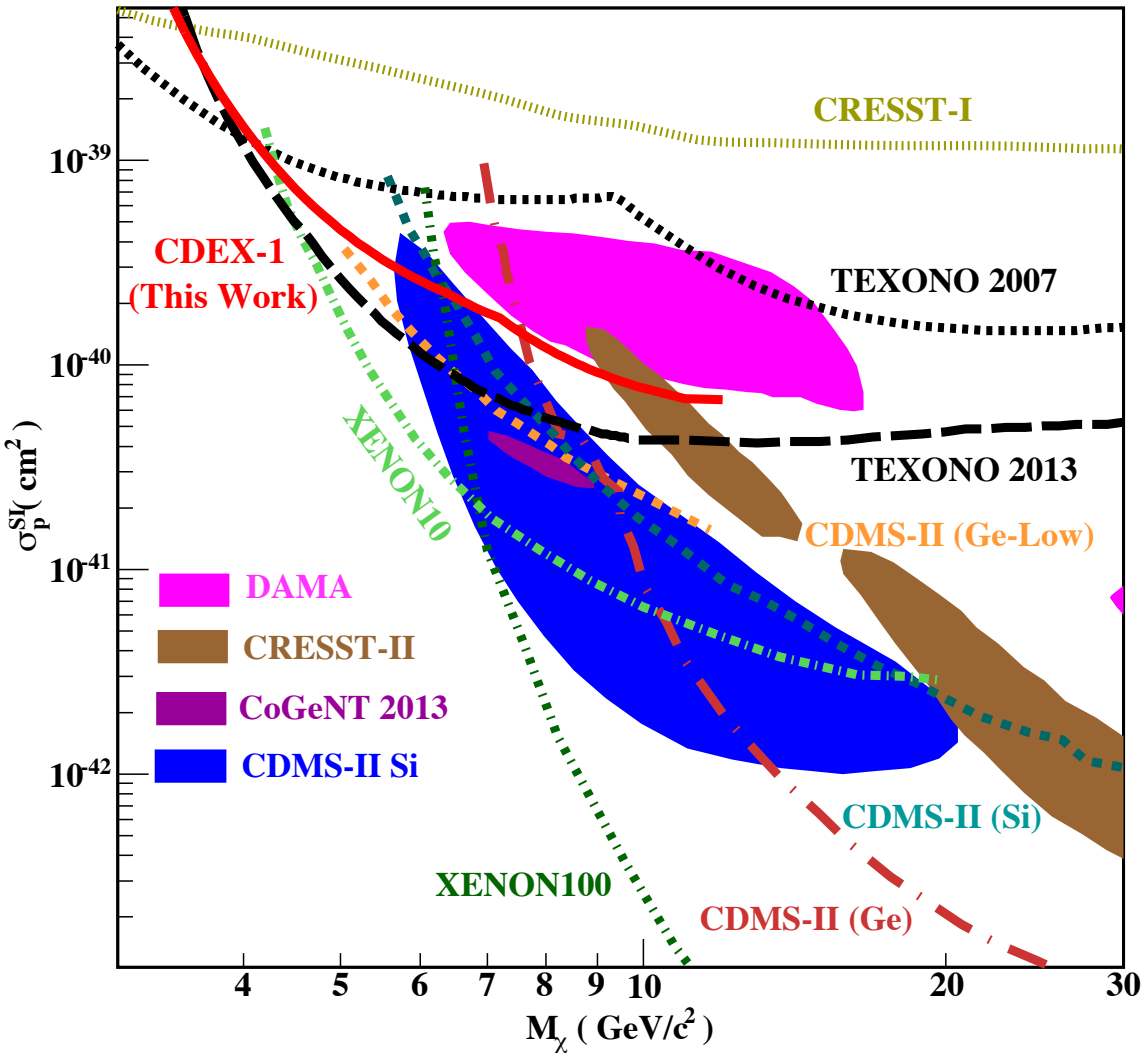


14.6 kg-day exposure
400 eVee threshold
No anti-compton veto
No bulk/surface background discrimination

At the low energy (0.4-2.4 keVee), the L-shell contribution from the cosmogenic radio-isotopes are subtracted for WIMP analysis.



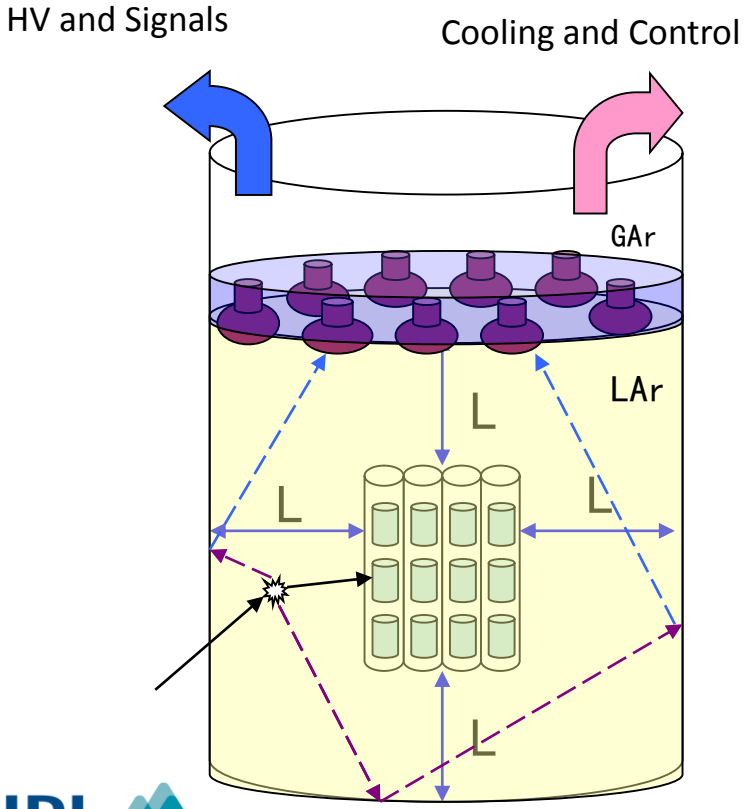
First CDEX limit reported based on the above data (arXiv:1306.4135)



arXiv:1303.0925

CDEX-10kg Experiment

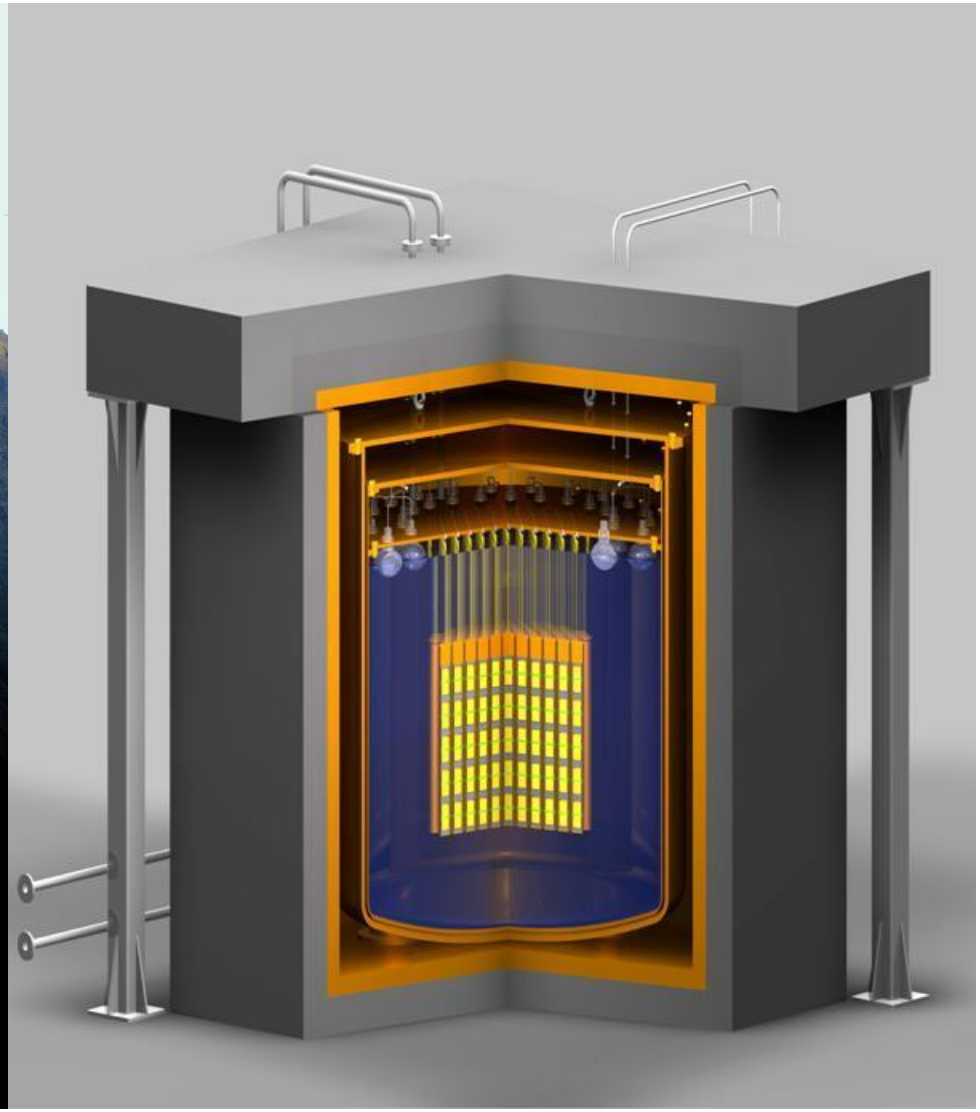
LAr: Passive shielding +Active shielding.
Ge: Encapsuled into copper vacuum tube.
WLS: Transfering 128nm light to~420nm light.



CJPL

CDEX-1T plan


CJPL
中国锦屏地下实验室
China Jinping Underground Laboratory
CDEX整体屏蔽结构
空气
岩石
混凝土 50cm
聚乙烯 1m
(慢化和吸收中子)
铅 20cm
(屏蔽外部伽马射线)
支撑结构 15cm
含硼聚乙烯 20cm
(吸收热中子)
高纯无氧铜 10cm
(屏蔽外部铅和含硼聚乙烯的伽马射线)
反符合探测系统
(主动屏蔽外部和探测器自身的伽马射线)
高纯锗探测器
工作空间



PandaX: **P**article **AND** **A**strophysical **X**enon experiment

The goal is to build a large-mass two-phase xenon detector with ultra-low background for dark matter and neutrino-less double beta decay searches.

The initial experiment is optimized for scintillation light detection to enhance the sensitivity to low mass WIMPs, while has the capacity to upgrade to a ton-scale experiment.

Slides from K. Ni "status of the PandaX experiment" at 9th PATRAS workshop

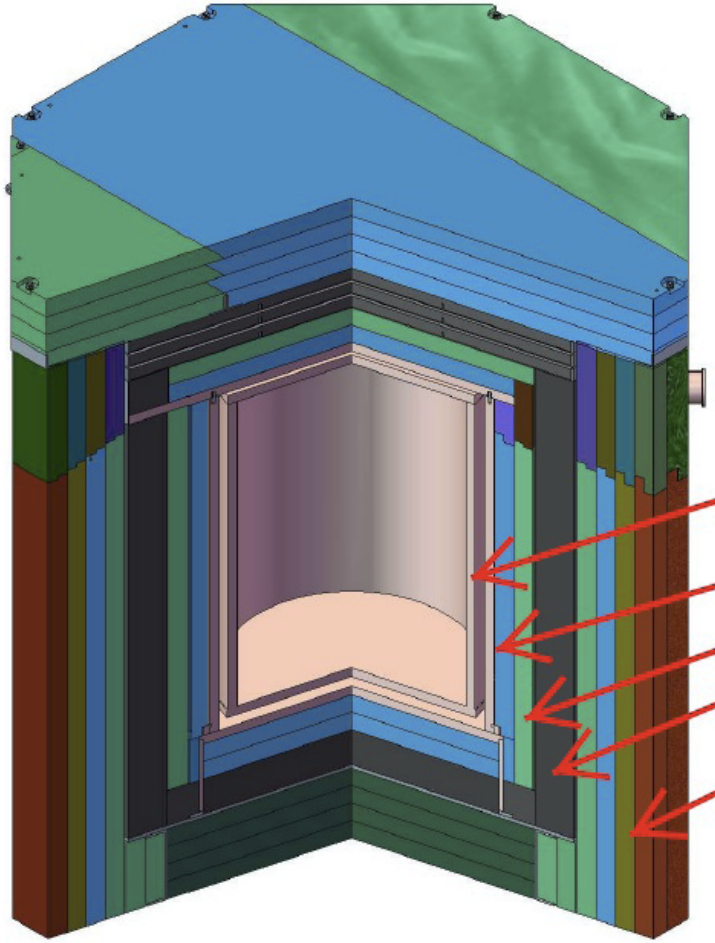
PANDA X at CJPL

Shanghai Jiao Tong University
Shanghai Institute of Applied Physics
Shandong University
Peking University
Yalong River Hydropower Development Company

University of Michigan
University of Maryland

http://pandax.org

Passive shield, which can accommodate a ton-scale detector, is built for PandaX.



Vacuum Vessel

inner diameter 1240mm

inner height 1750mm

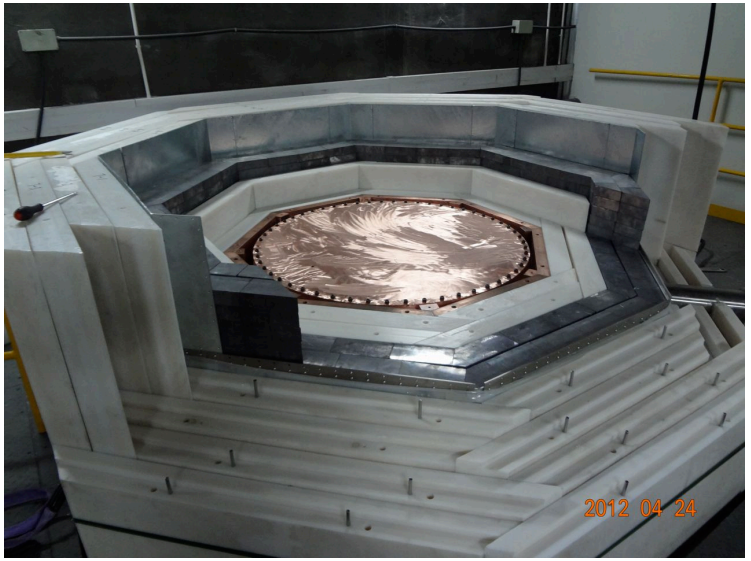
50mm Cu Vessel

50mm Cu

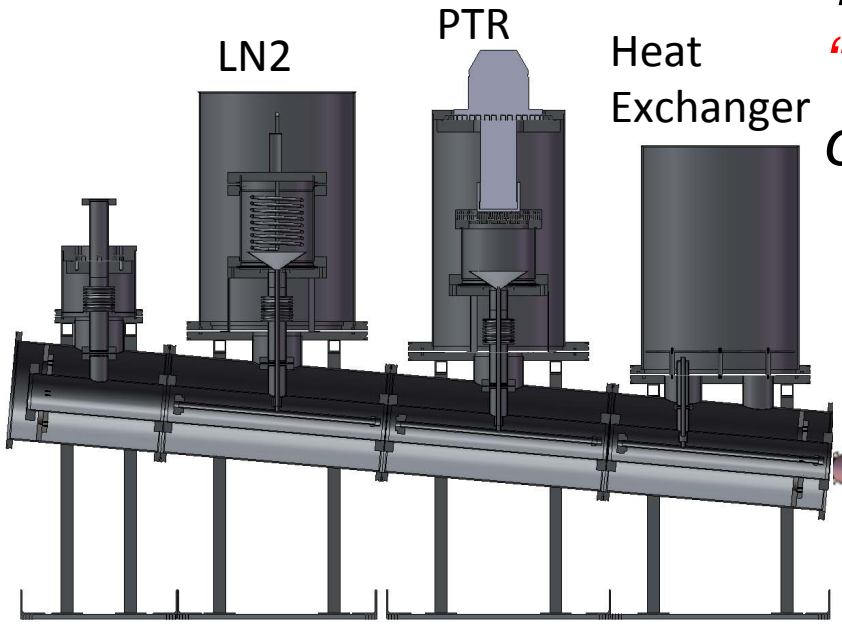
200mm inner PE

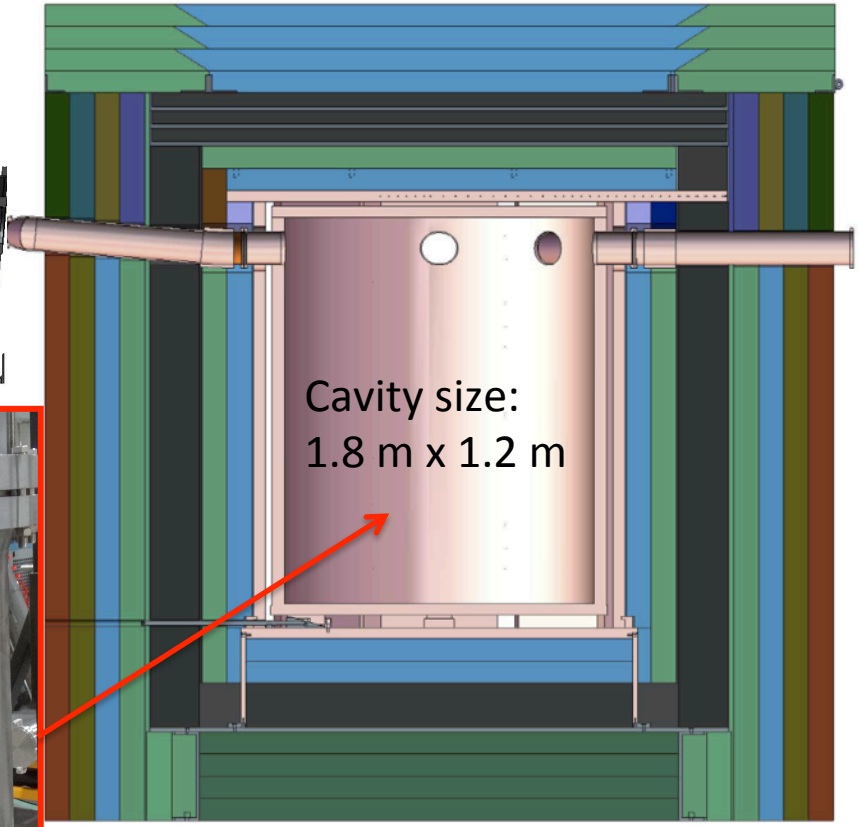
200mm Pb

400mm outer PE



The cryogenic system "cooling bus" is located at outside of the shield .

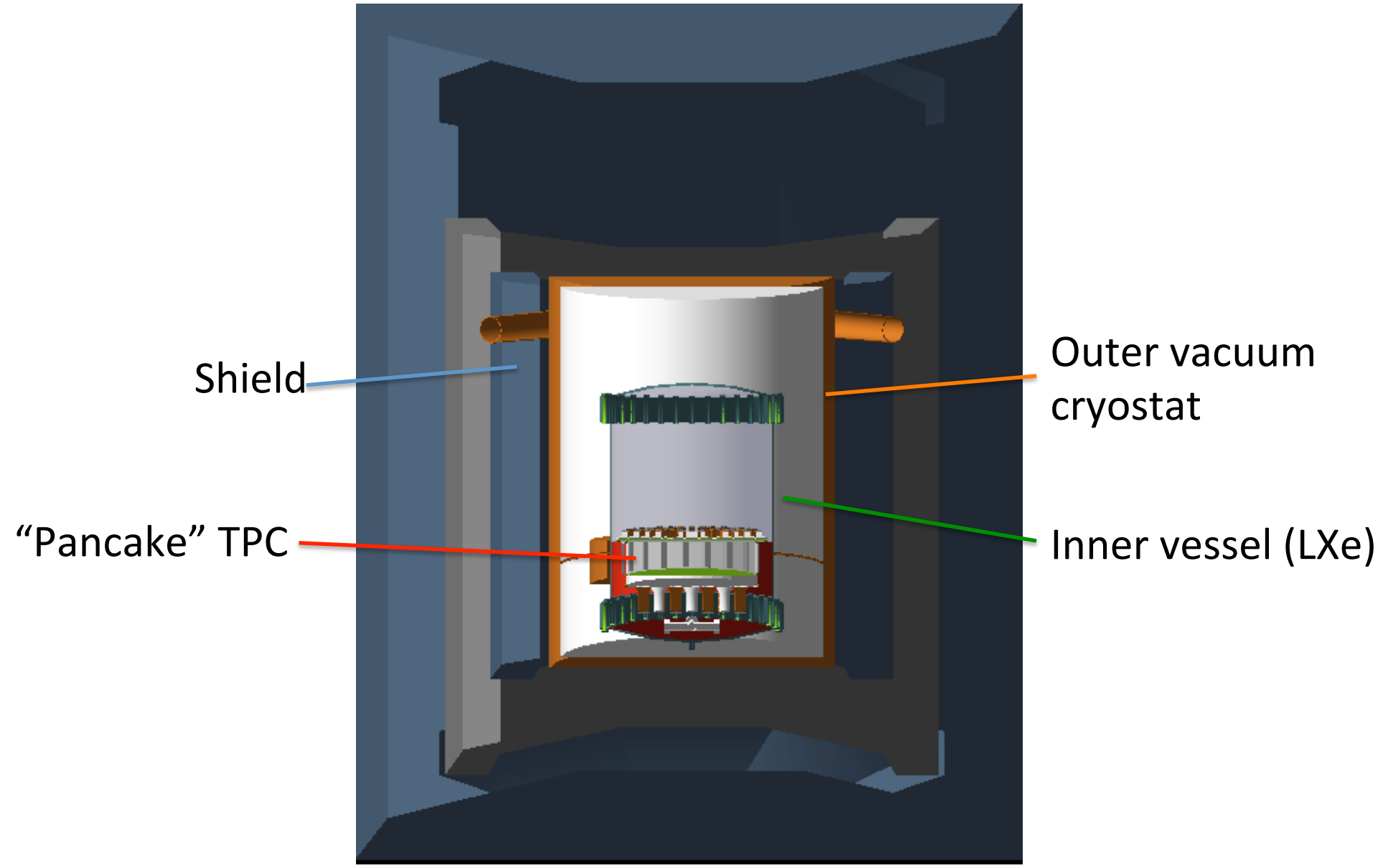




An inner liquid xenon vessel with a "weir" structure to control the liquid level.

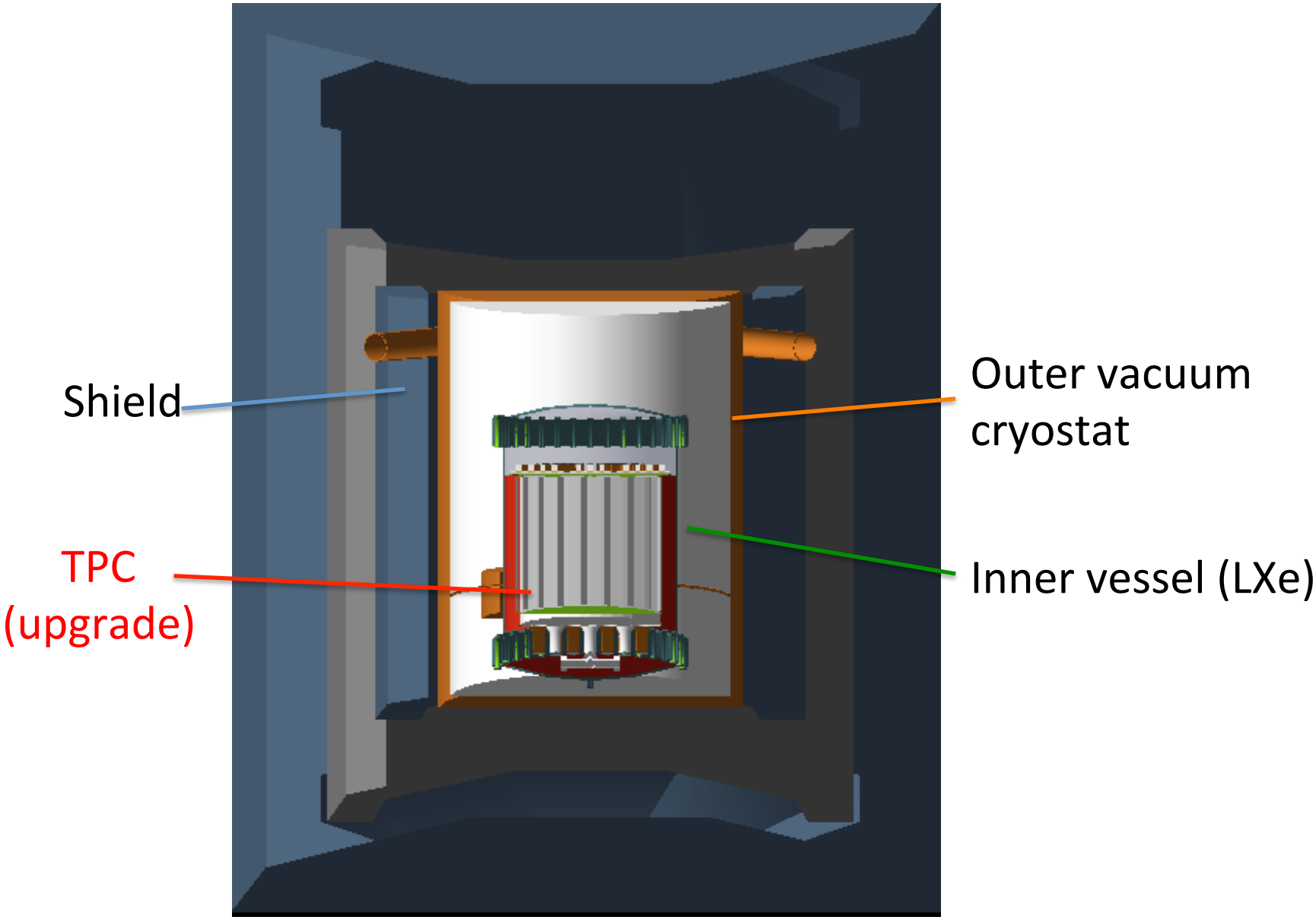

Vacuum Pump
Heat Exchanger
PTR
LN2
Purification Getter

PandaX will progress through three stages.



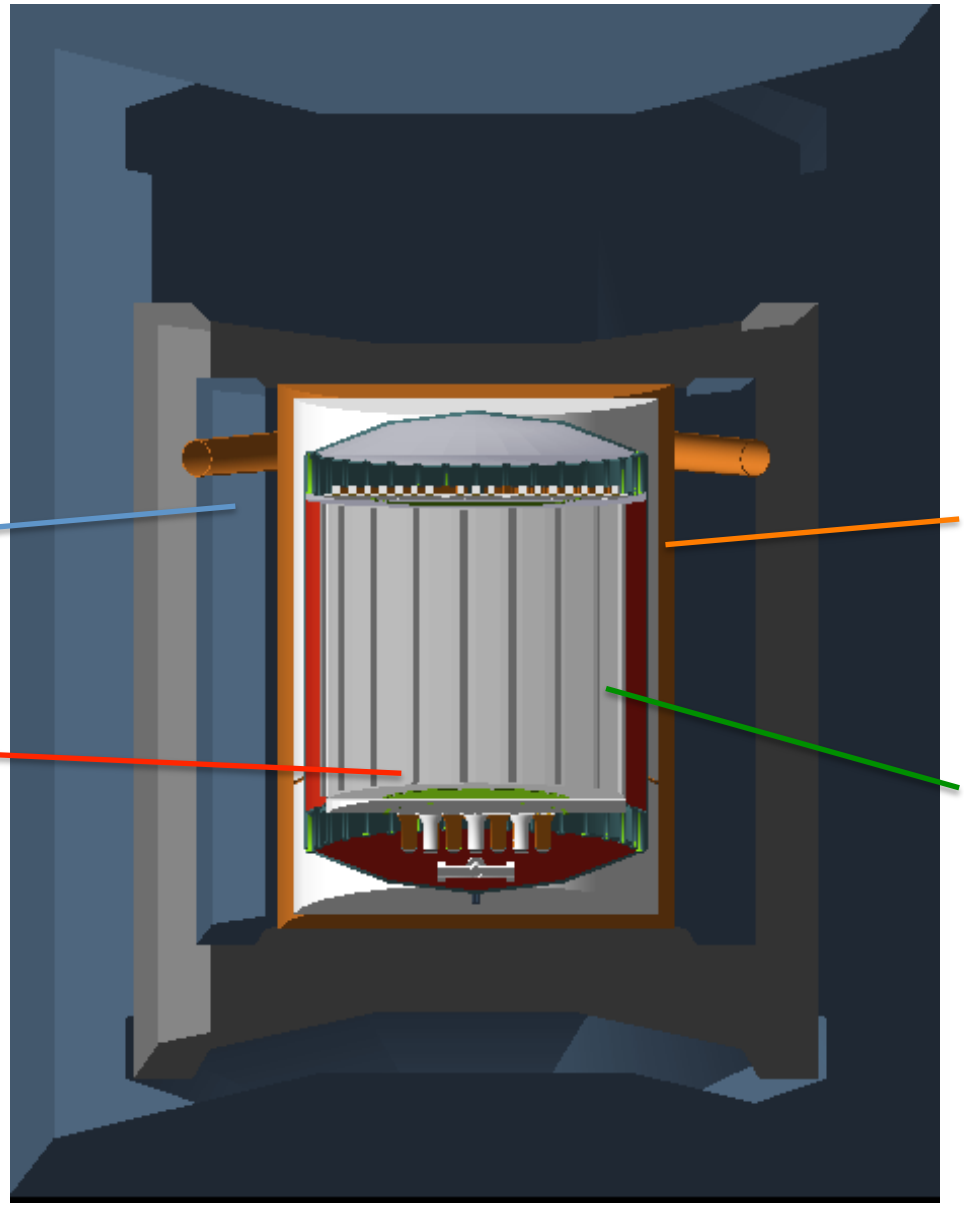
Stage-1a (125 kg target)

PandaX will progress through three stages.



Stage-1b (500 kg target)

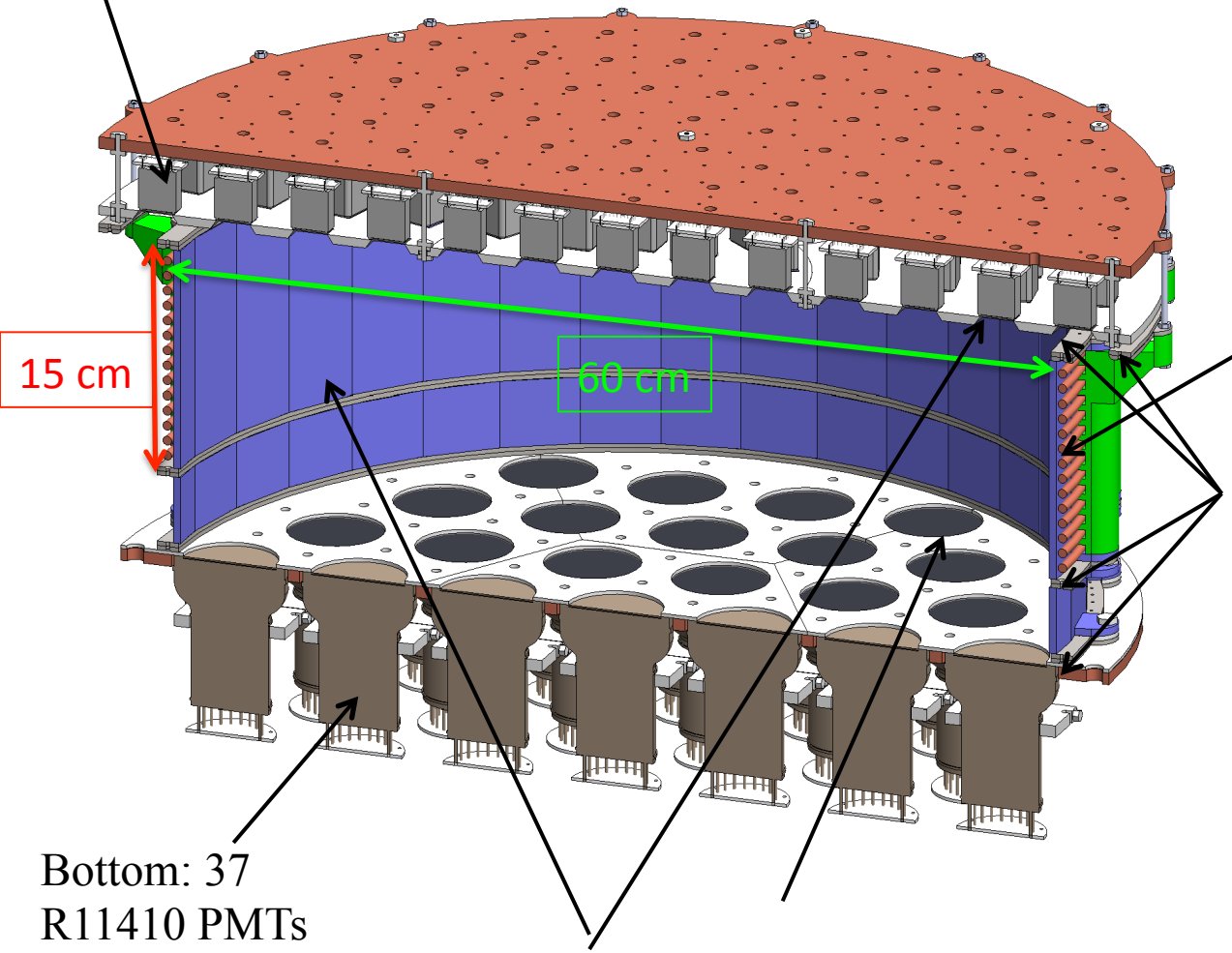
PandaX will progress through three stages.



Stage-2 (2.5 ton target)

Stage-1a: "pancake" TPC

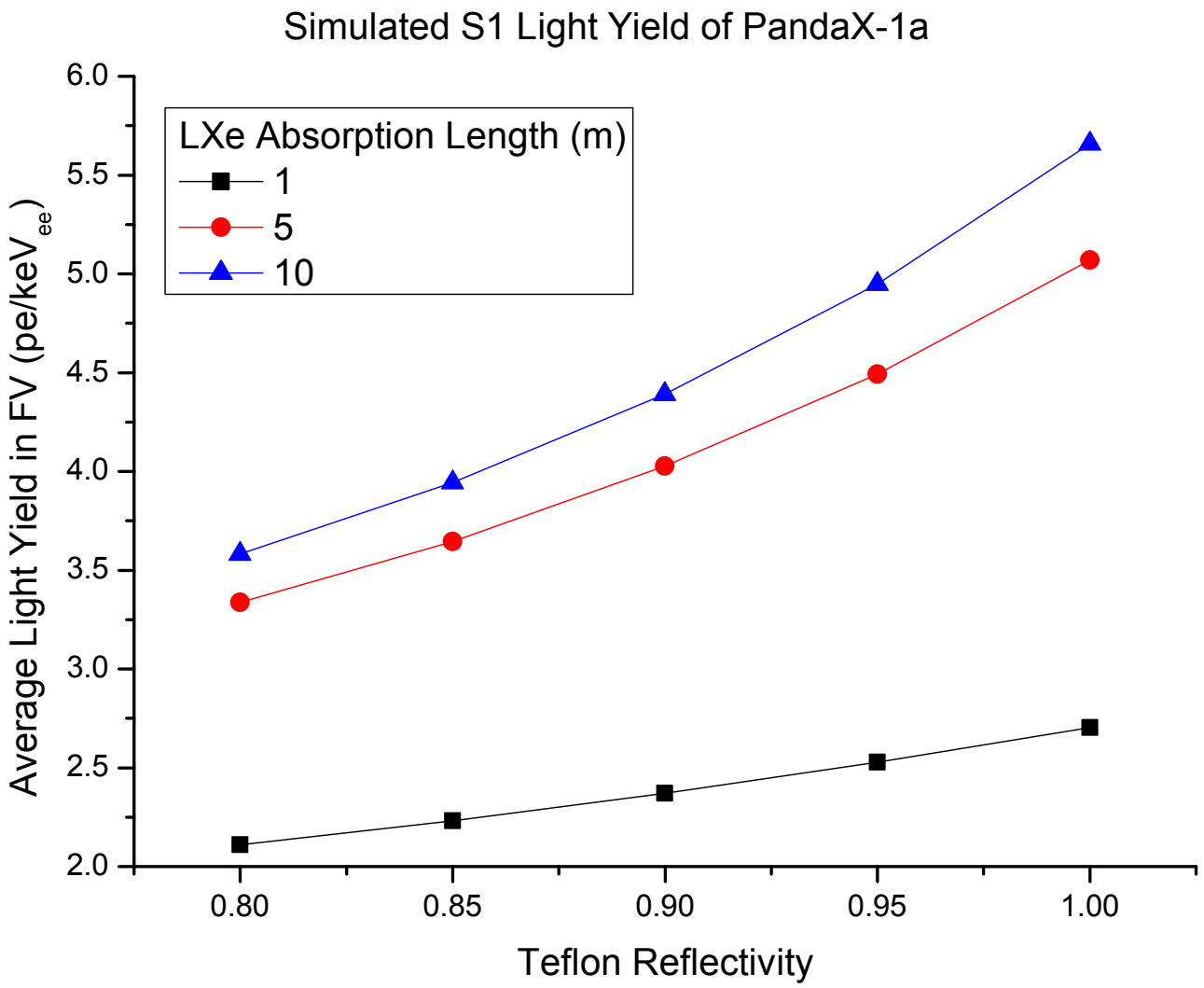
Top: 143
R8520 PMTs



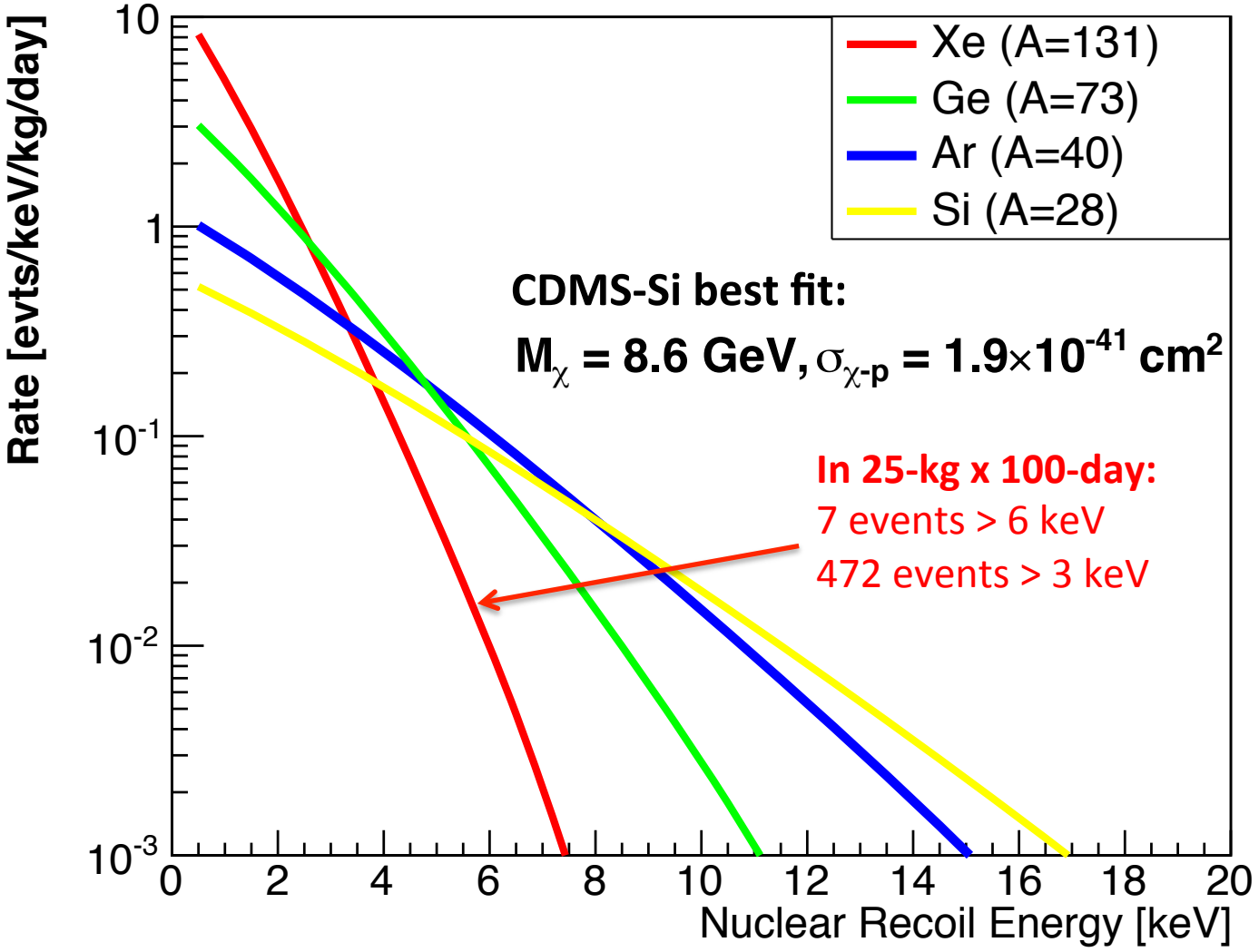
Bottom: 37
R11410 PMTs

Teflon reflector

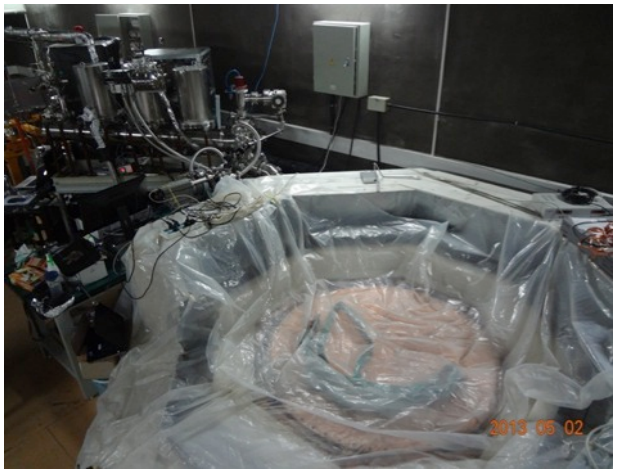
We expect to get 3.3~5.7 pe/keVee for 122 keV gammas at 1 kV/cm with at least 5 m of absorption length.

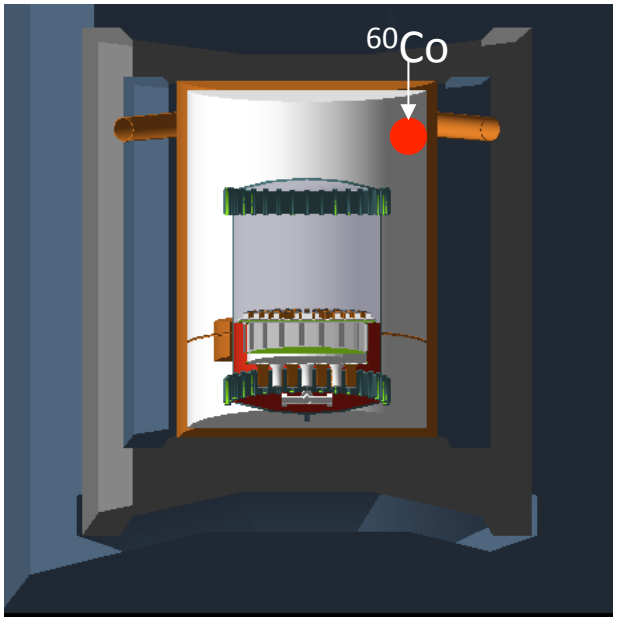


Expected event rate for “light WIMPs”.

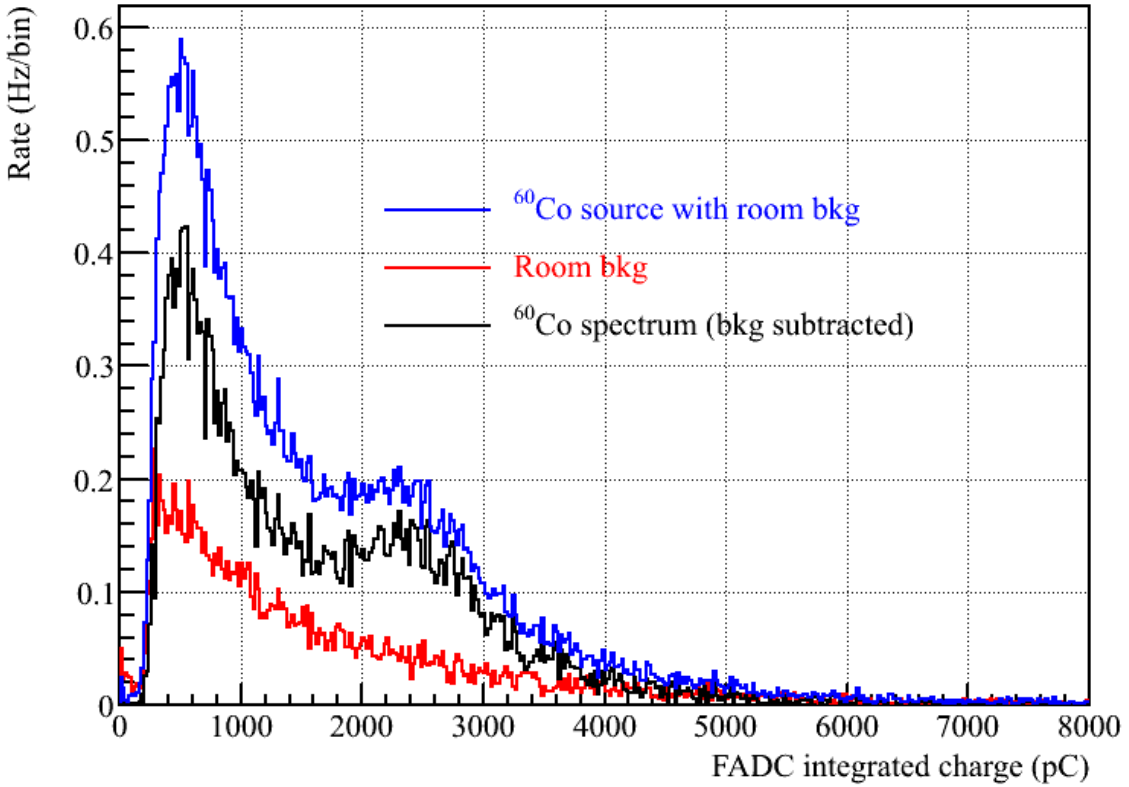


First liquid xenon test run at CJPL (Apr-May, 2013)

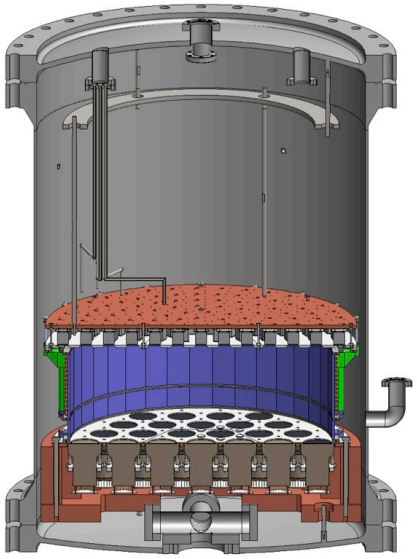




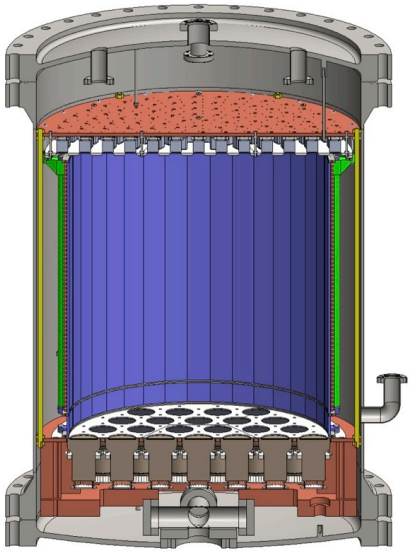
- *>400 kg liquid xenon was filled into the detector and maintained stably during the test run.*
- *Achieved 35 SLPM circulation speed through the purification getter.*
- *Bottom PMT array operational to observe the first light in liquid xenon from background and source.*



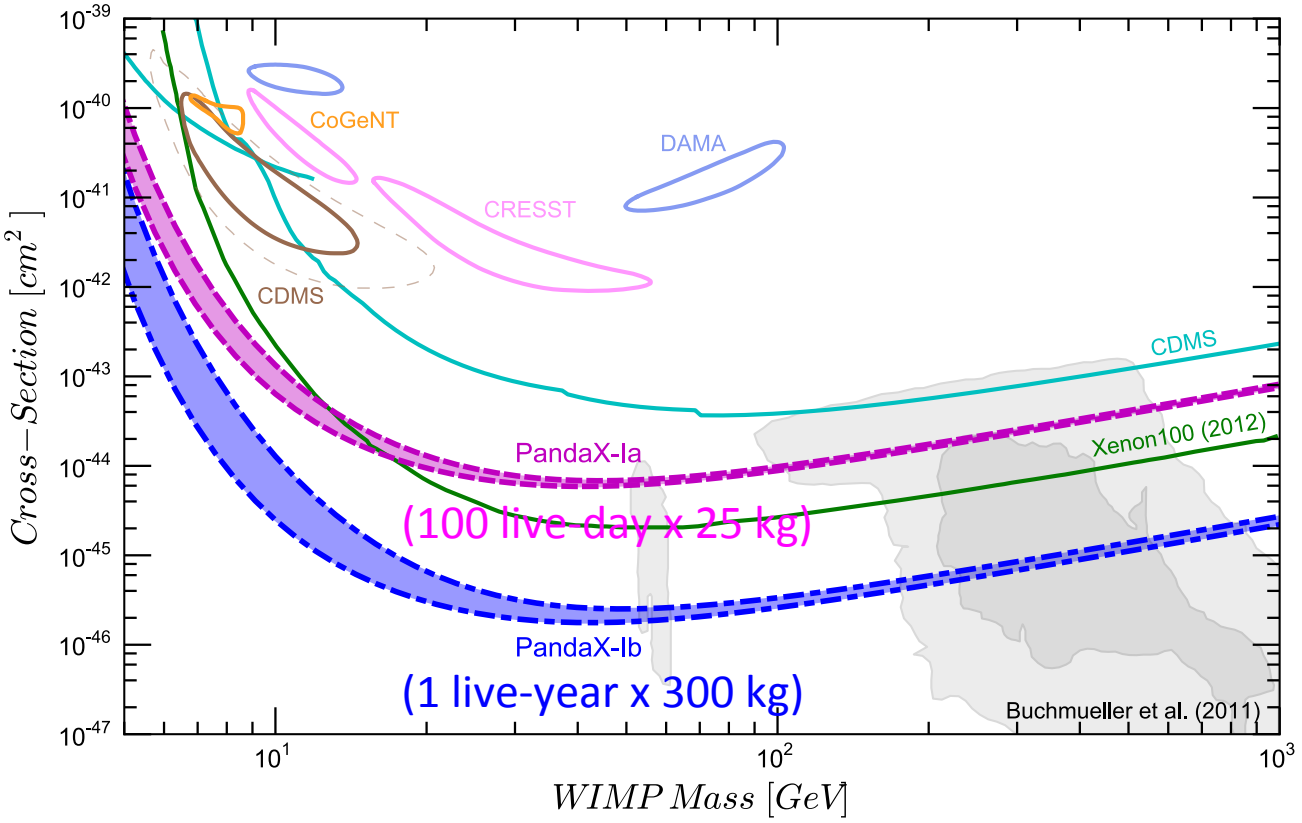
Projected sensitivity for PandaX-1a and PandaX-1b detectors.



PandaX-1a



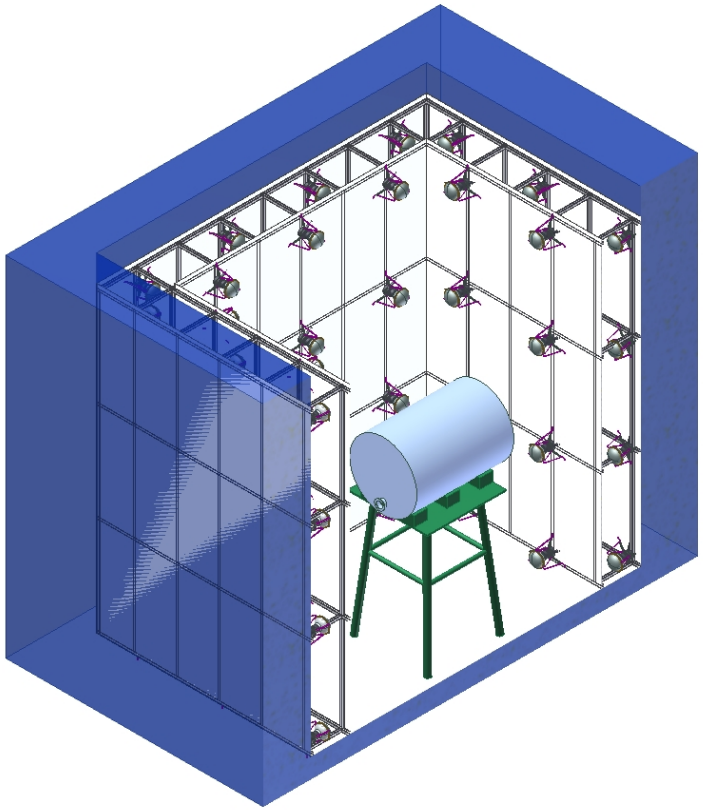
PandaX-1b

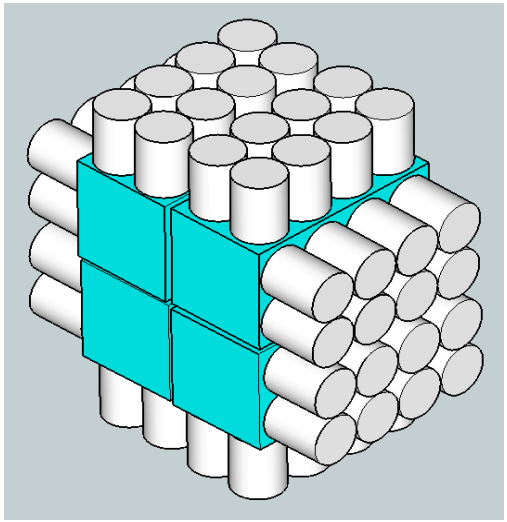


CsI(Na) Dark Matter Search Experiment

CINDMS

Detector conceptual design





Target: CsI(Na) dual light emitting crystal

Gamma background rejection based on pulse-shape discrimination

Slides from Xilei Sun (IHEP)

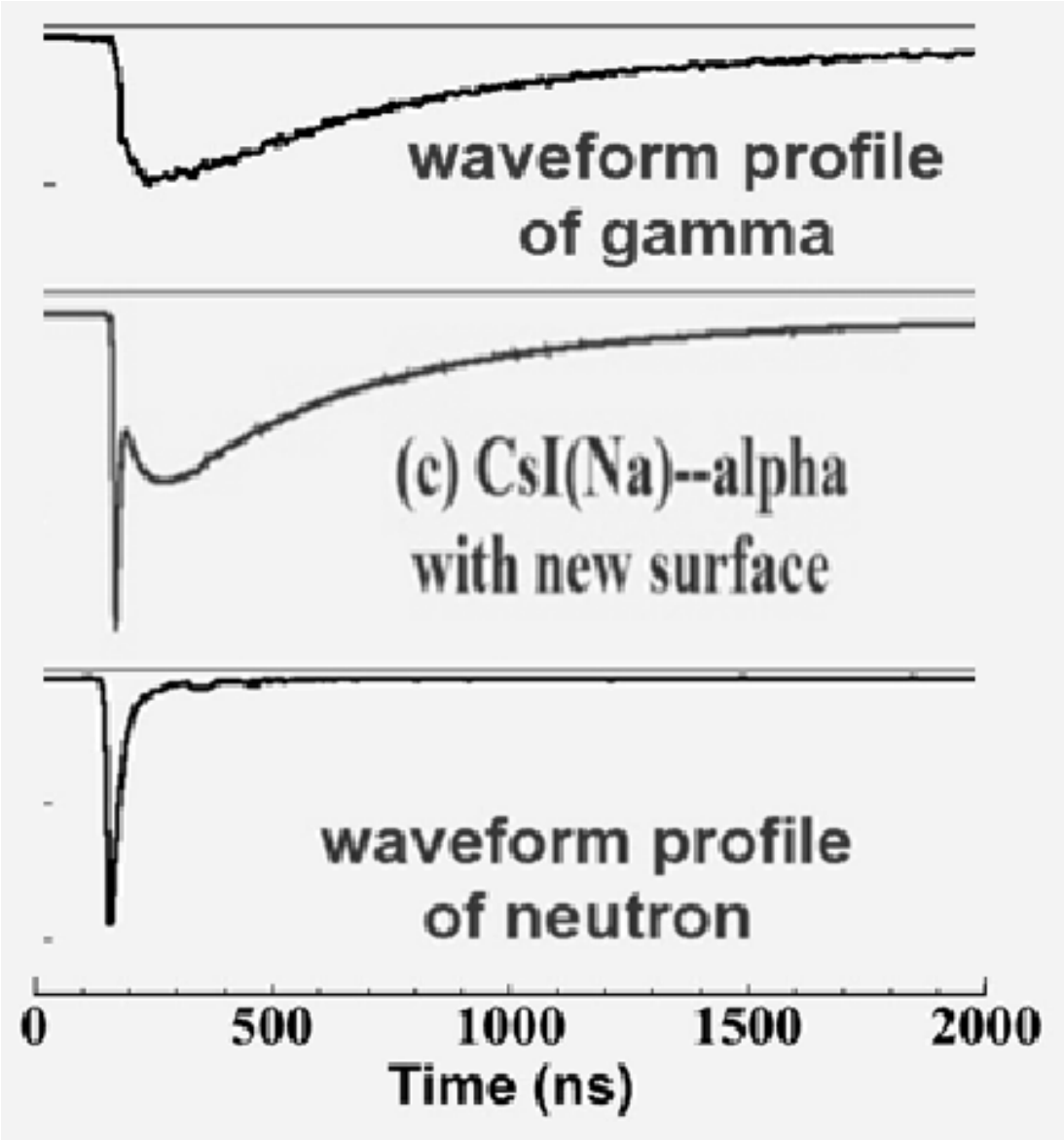
The Ratio of light emitting from Na^+ and pure CsI is different for NR and ERs.

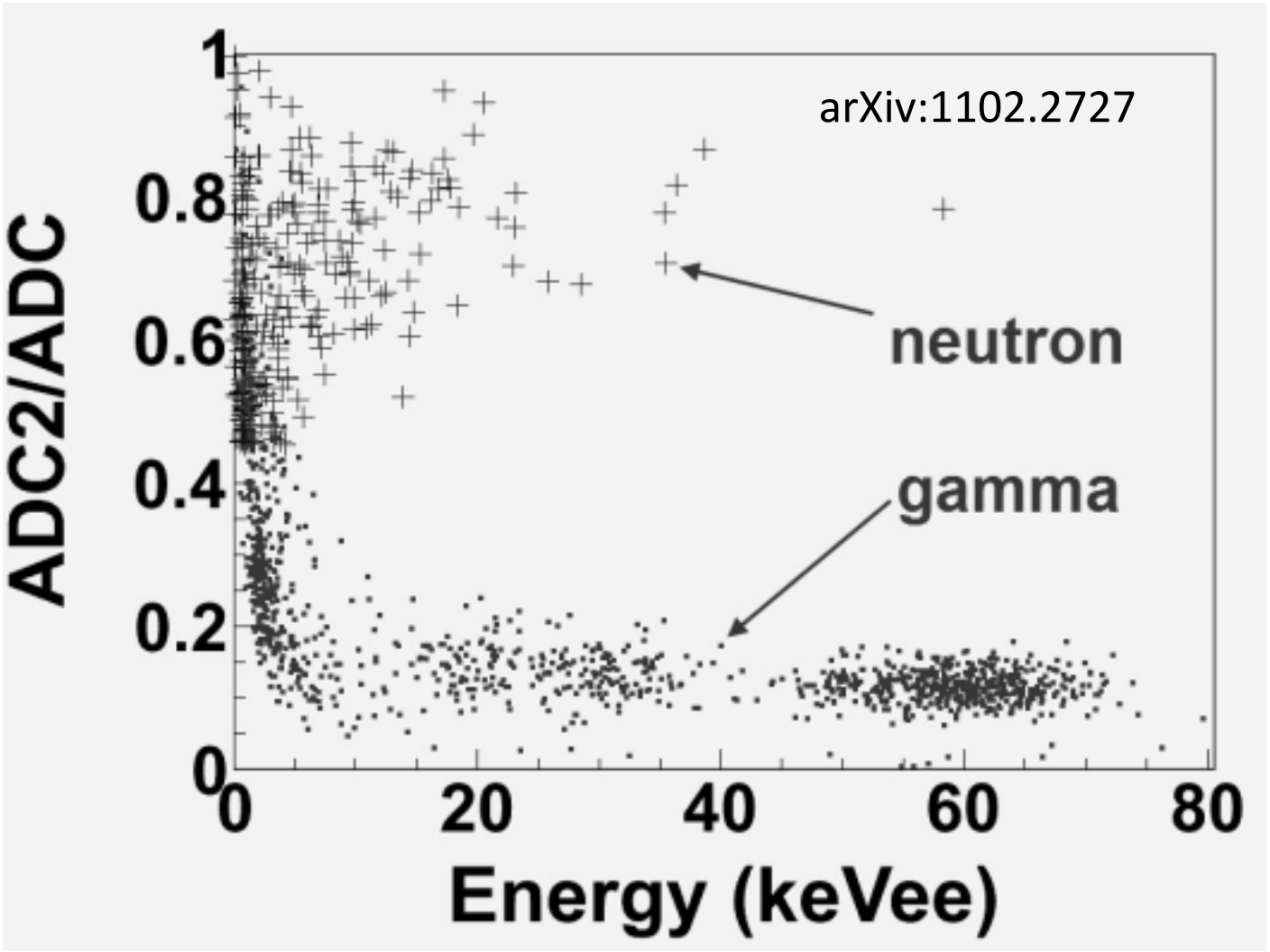
Na^+ light: slow and high yield
CsI light: fast and low yield

Average spacing of doped Na ions is 77Å

electron recoils cover more Na due to large range ~ n*1000Å

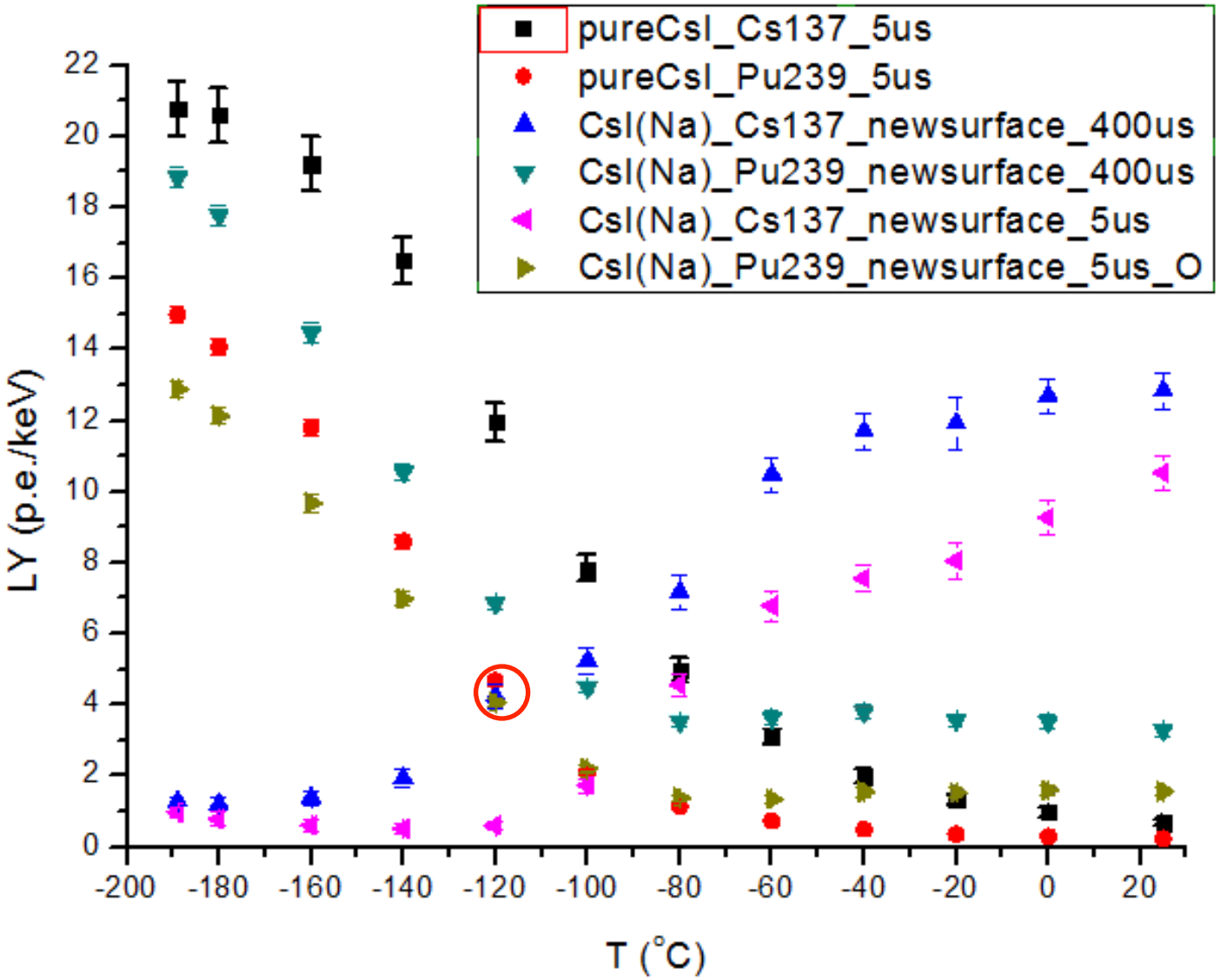
Nuclear recoils cover less Na due to small range ~ n*100Å



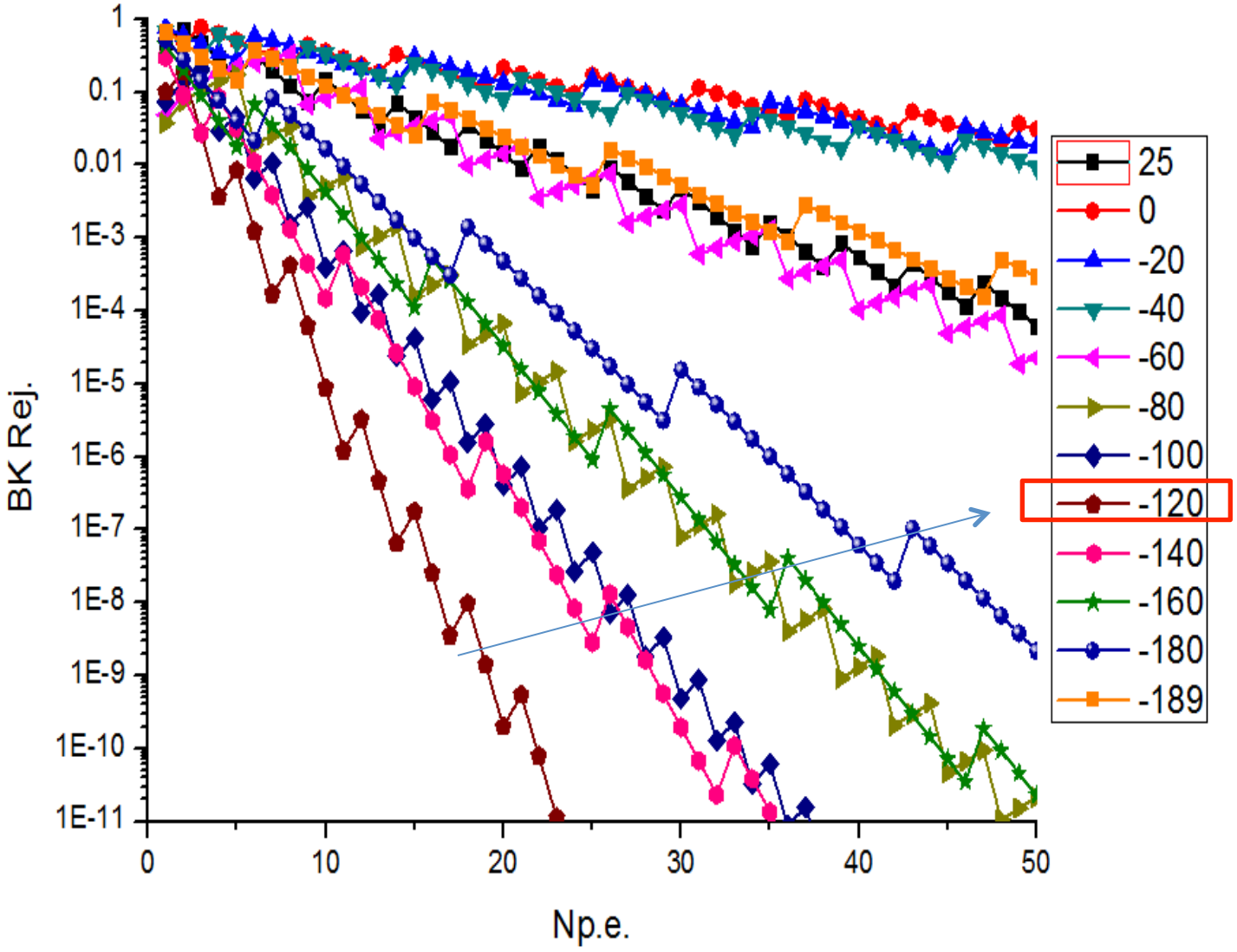


Problem: scintillation efficiency of pure CsI is very low at room temperature

The light yield pure CsI increases as temperature decreases.



Optimized ER background rejection power at around -120 °C



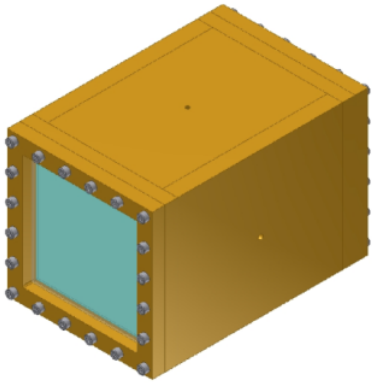
Plans of CINDMS

2013-2014: verification of the technology

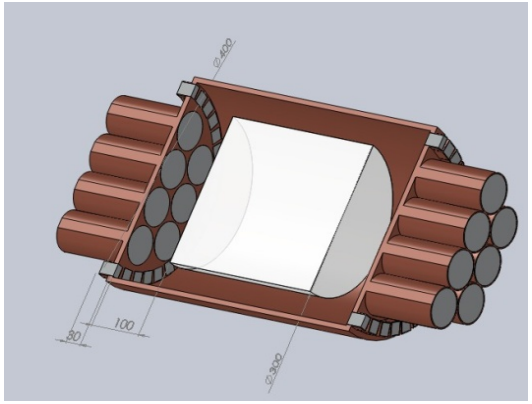
• funded by IHEP for the first 40-kg module to be installed at Daya Bay underground laboratory

• using ultra-pure water for extraction and recrystallization to produce ultralow background CsI(Na) crystals

2015 : ton-scale experiment



Copper Vacuum chamber



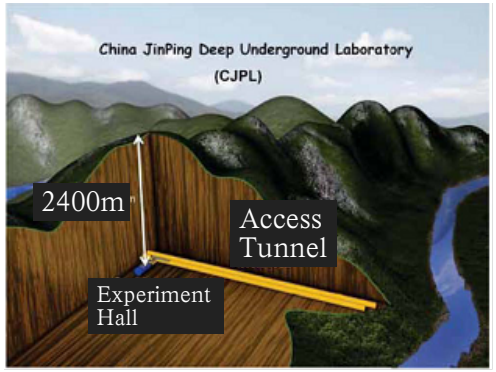
Active shield with LXe

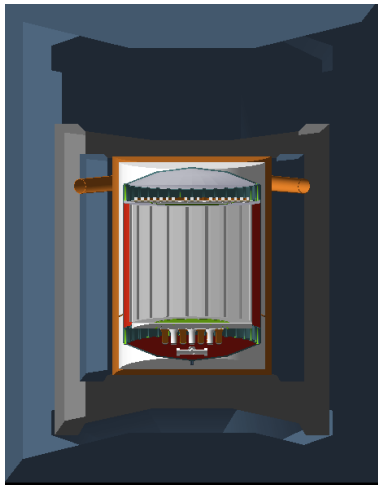
Summary

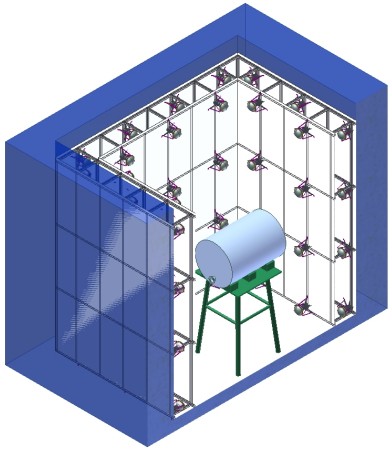
CDEX and PandaX are being constructed towards ton-scale dark matter experiments at CJPL.

New techniques, such as CINDMS, are being developed to join the dark matter search.

CJPL provides the deepest underground environment for dark matter search. CJPL-II will host multi-target multi-ton scale experiments.







Thanks the above collaborations for their latest updates presented in this talk!