PandaX液氙暗物质实验

刘江来

上海交通大学

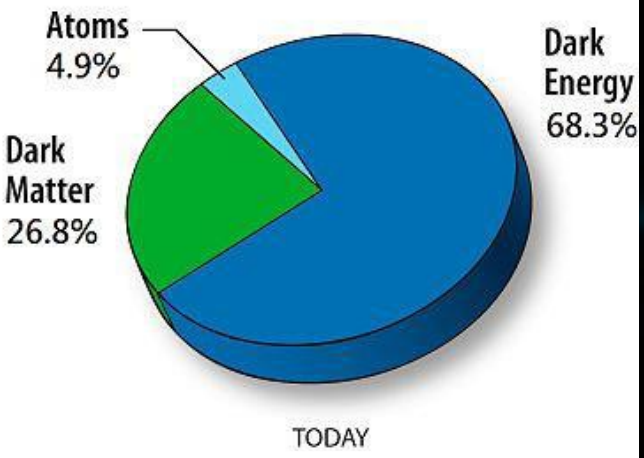
上海市粒子物理宇宙学重点实验室

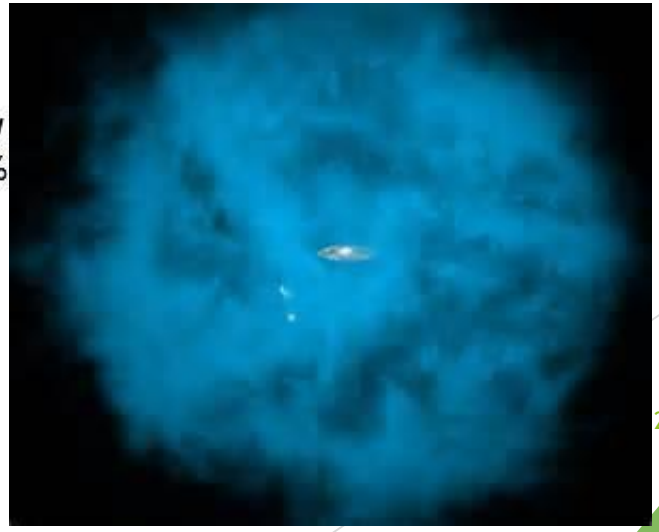
On Behalf of the PANDA X Collaboration

NED' 2014， 兰州，8月13日

What is dark matter?

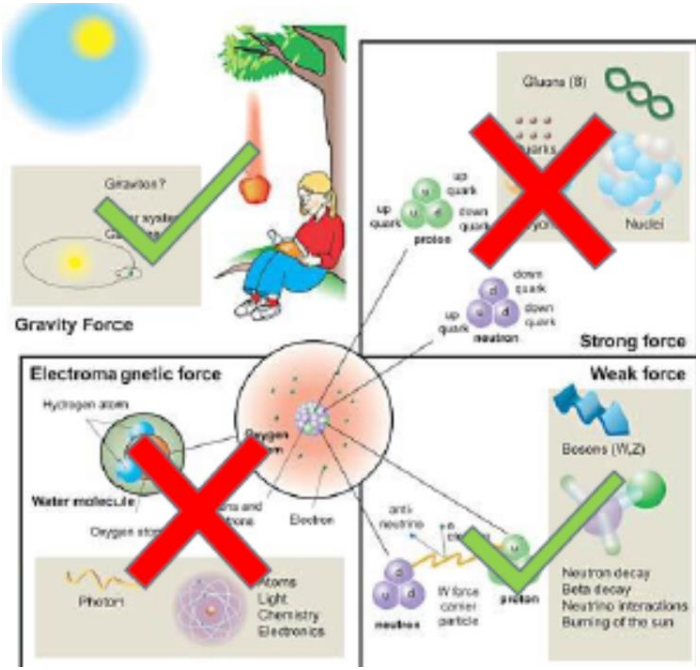
- Based on many different astronomical observations, the normal visible matter makes up 5% of the energy of the universe, the rest of 27% is dark matter (the particle properties of which are unknown), and 68% is dark energy
- Dark matter accrete under gravity and form a halo around our galaxy

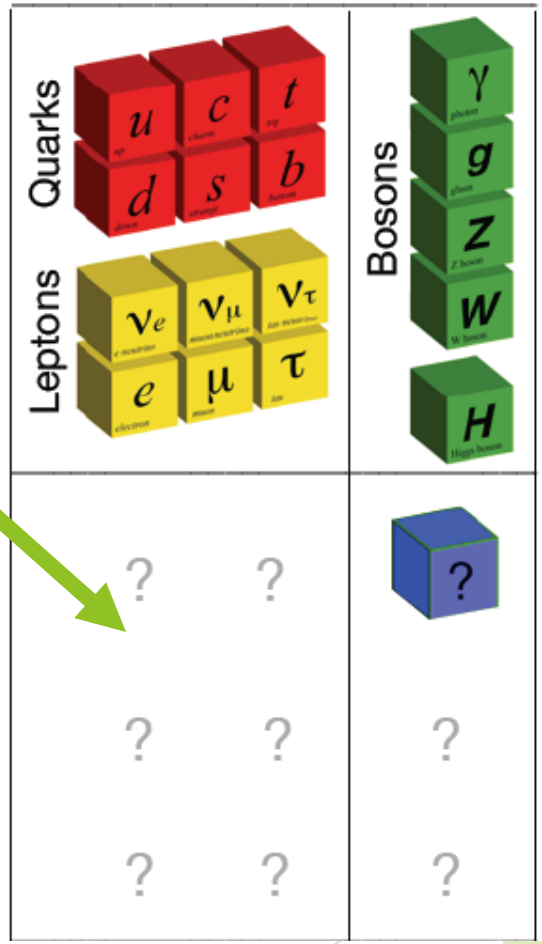




What do we “know”

- No EM and strong interactions
- Very long lived (half-life longer than the age of the universe)
- Most popular: weakly-interacting-massive-particle





Dark matter “beam”

- Solar system moves in the galaxy (DM halo) with a speed of 220 km/s
- Everyday we are in the dark matter shower, with 10^8 hitting our body every second
- “Beam” is always on!

How to detect dark matter

- Search invisible via scattering reaction, e.g.

$$\bar{\nu}_e + p \rightarrow e^+ + n$$

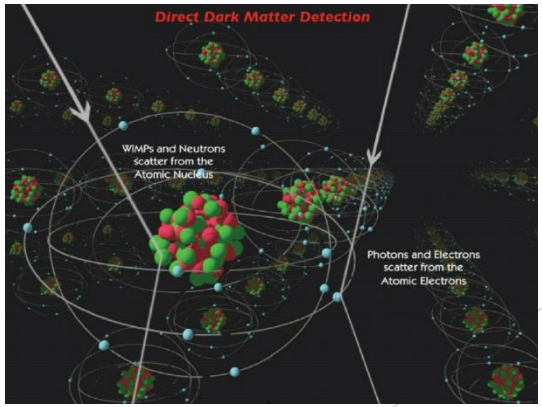
Detection of the Free Neutrino*

F. Reines and C. L. Cowan, Jr.
Los Alamos Scientific Laboratory, University of California, Los Alamos, New Mexico

(Received July 9, 1953; revised manuscript received September 14, 1953)

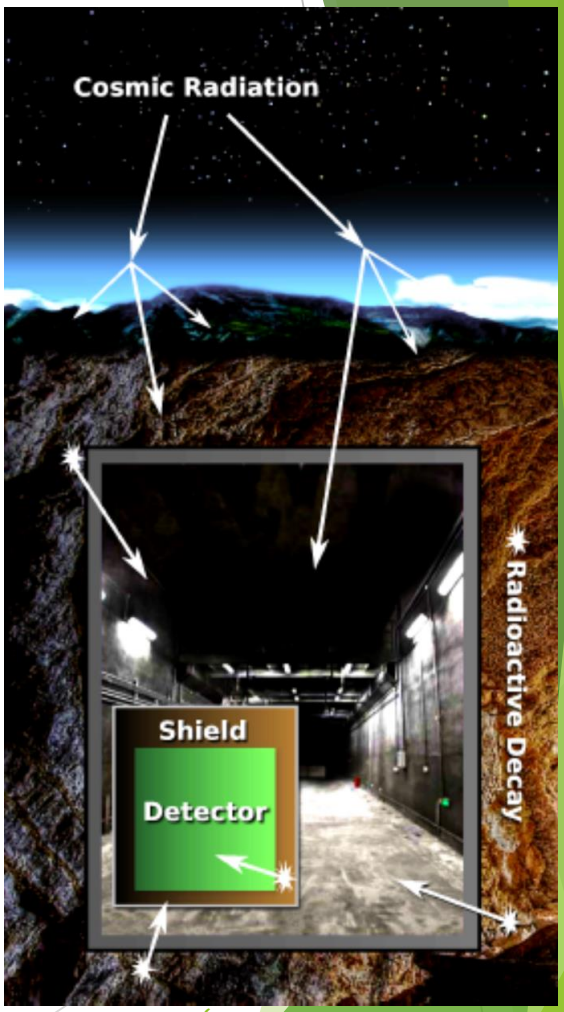
Pile up (three runs totaling 10 000 seconds): 2.55±0.15 delayed counts/min.
Pile down (three runs totaling 6000 seconds): 2.14±0.13 delayed counts/min.
Difference due to the pile: 0.41±0.20 delayed count/min.

- DM direct detection: wait for DM interacting atomic nucleus in the detector, and detect its recoil



Tough to see dark matter

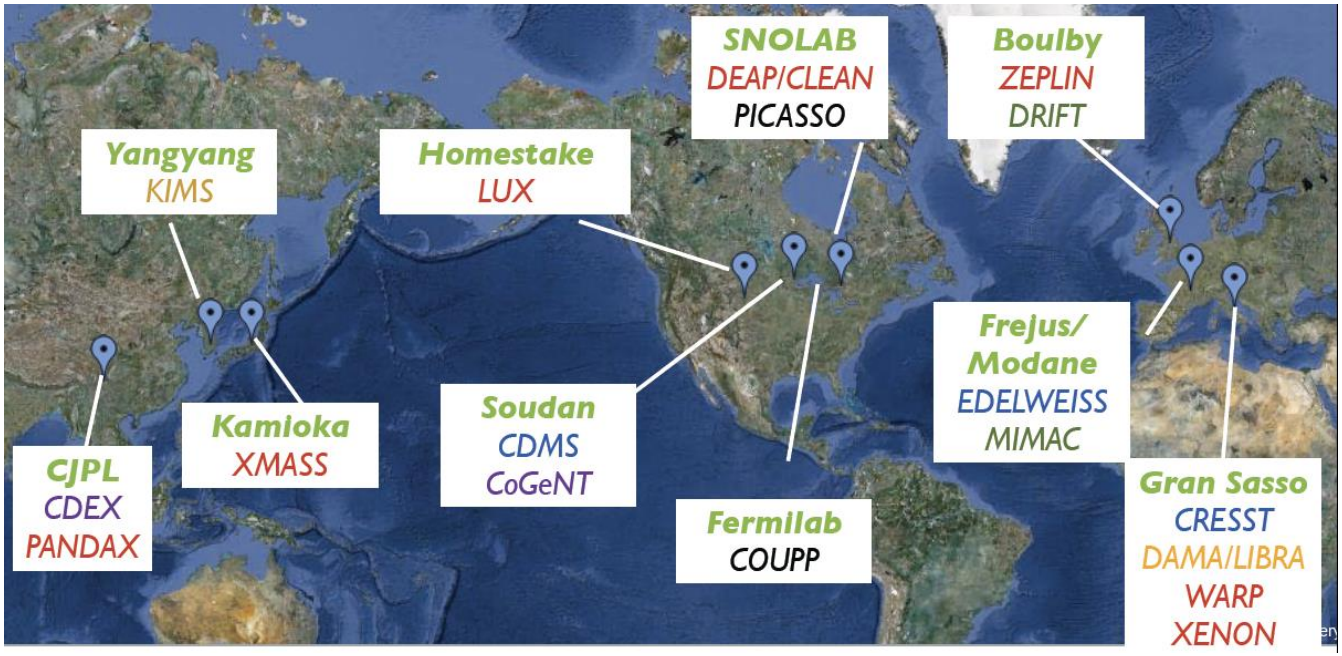
- Our body has 10^{30} atoms
- Every second there are 10^{8} dark matter passing through us
- Less <1 nucleus is hit per day!
- But our body is hit 10^{8}/day by environmental background radiation!
- Hide detector in deep underground lab, and put massive shield



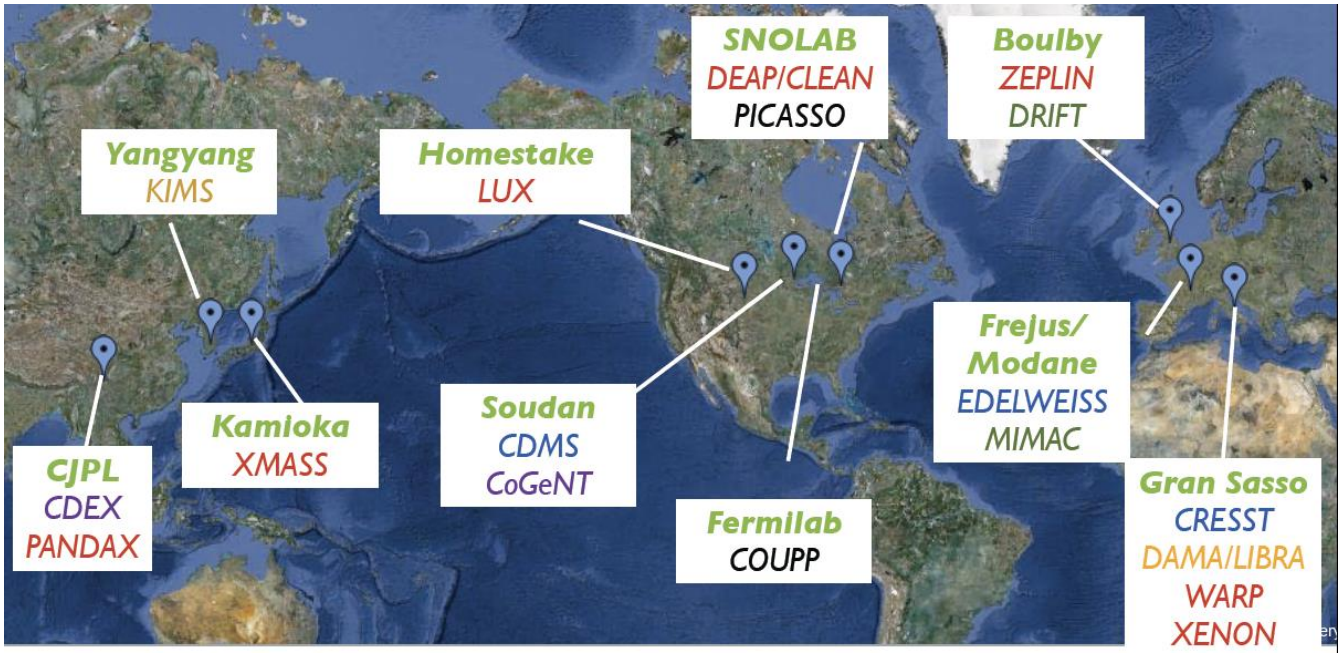
Global competition

- COUPP, PICASSO, XENON,CoGENT,DEAP/CLEAN, ZEPLIN, DRIFT, LUX, KIMS, XMASS, CDMS, WARP, EDELWEISS, MIMAC…

Global competition

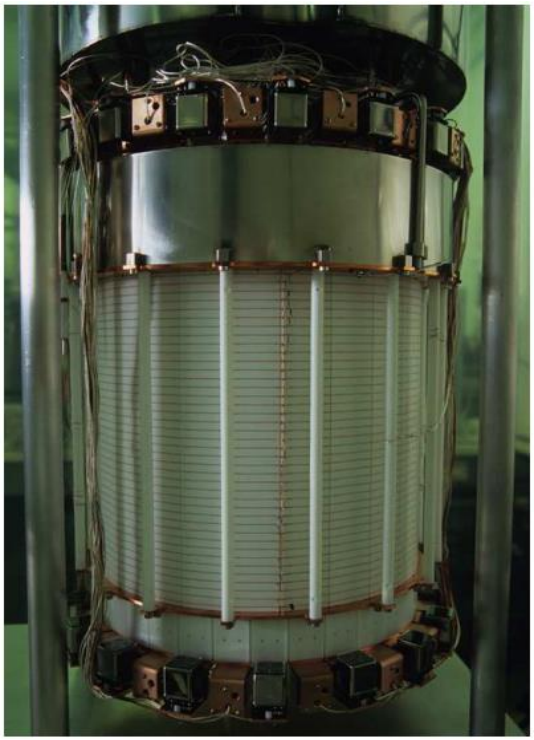


Global competition



- Leading technology: noble gas and semi-conductor

XENON experiments



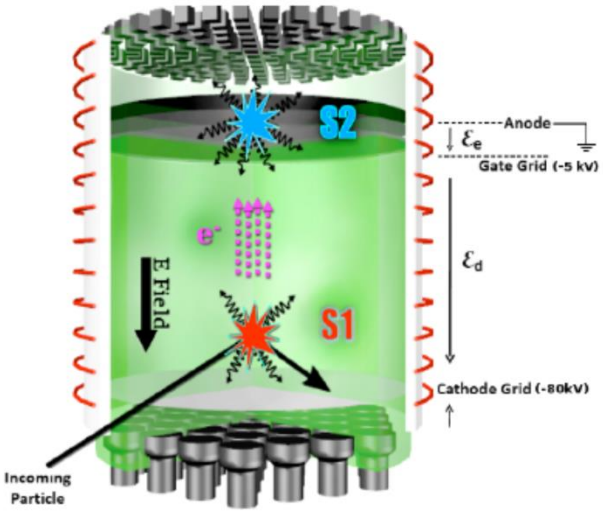
XENON100, 60 kg, completed 2012, Gran Sasso
XENON1T in preparation

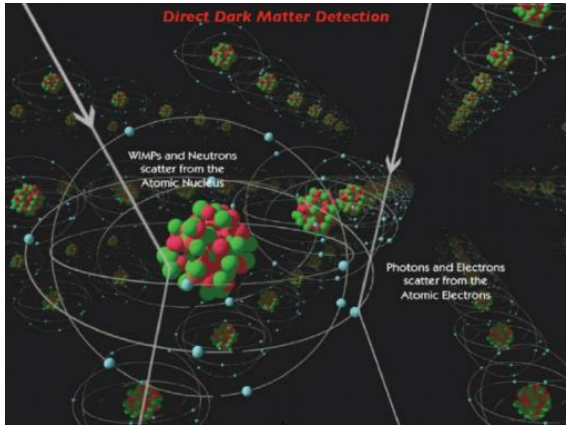
LUX, 250 kg, running, Sanford Lab
LZ(multi-ton) in preparation

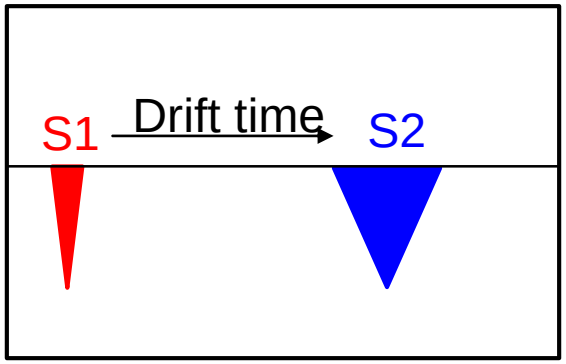
Xe advantages

- Low radioactive isotopes
- Good scintillation yield
- Powerful self-shielding
- Relatively easy to scale up
- “easy” cryogenics
- Dual phase TPC for signal reconstruction
- Good background discrimination
- …

Dual phase Xenon detector

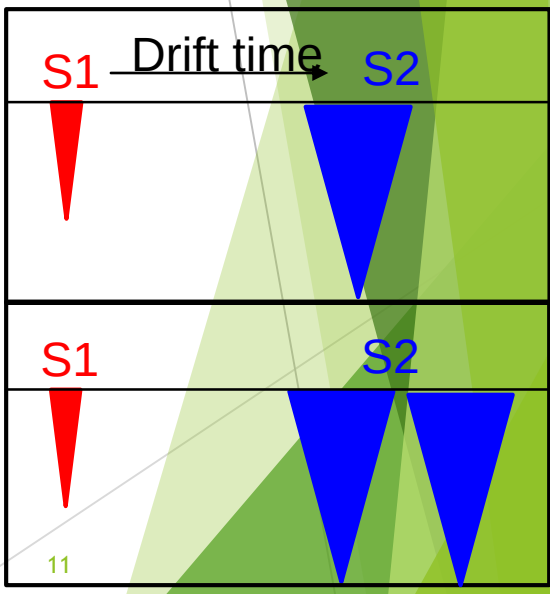






Dark matter: nuclear recoil (NR)

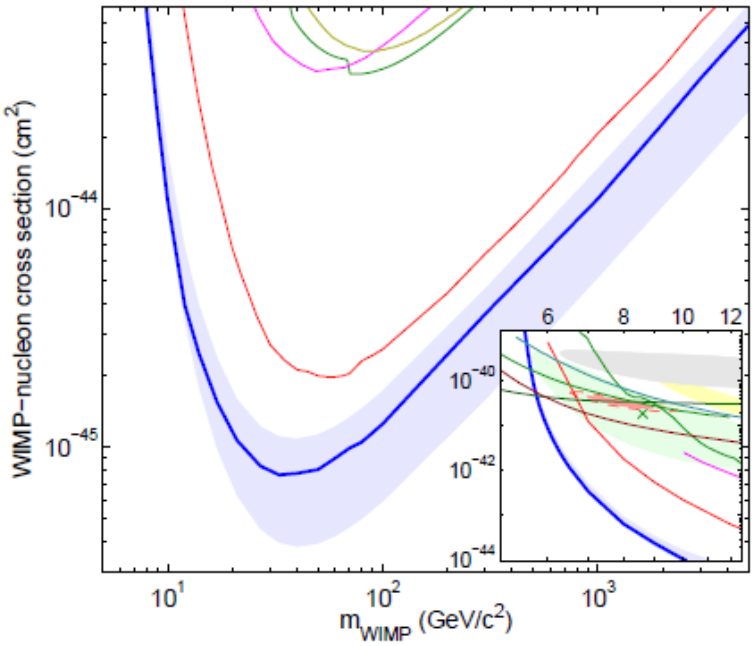
$(S2/S1)_{NR} << (S2/S1)_{ER}$



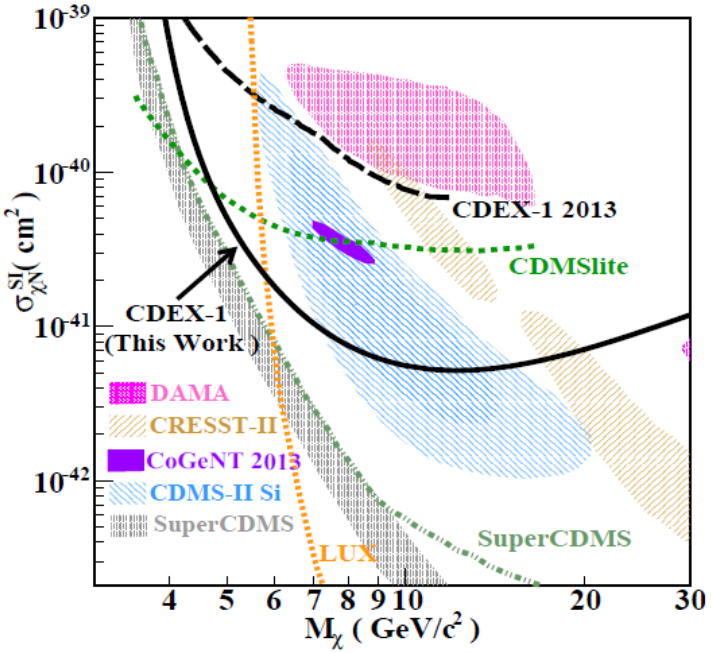
Gamma background: electron recoil (ER)

Direct detection: global picture

LUX 2013 , PRL 112, 091303 (2014)

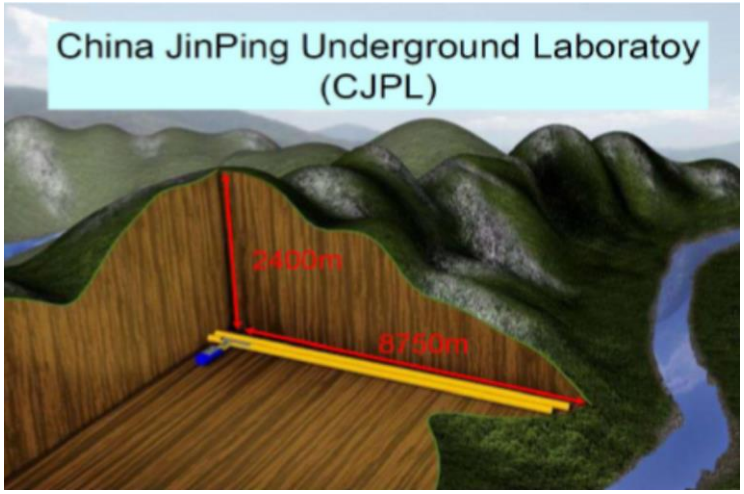


CDEX 2014, arXiv:1404.4946



- Many experiments
- Quite some contradictory claims
- Xenon experiments carve into the “mainstream” supersymmetry theory predictions, still say no

China Jinping Underground Laboratory



- Tsinghua university and Ertan Hydropower Company co-developed world's deepest underground lab, the China Jinping Underground Lab (CJPL), with an overburden of 2400 m
- Generation I Dark Matter Experiments: CDEX (Germanium) and PandaX (Xenon)

PandaX collaboration

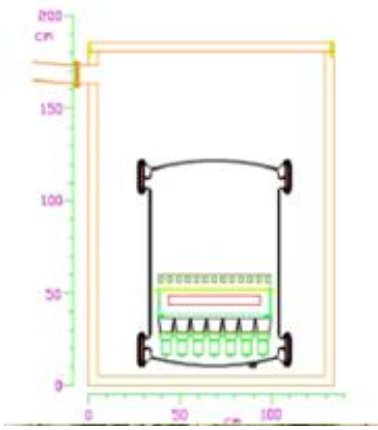
- Started in 2009
  - 上海交通大学 (Shanghai Jiao Tong University)
  - 中科院上海应用物理研究所 (Shanghai Inst. of Applied Physics)
  - 山东大学 (Shandong University)
  - 北京大学 (Peking University)
  - University of Michigan
  - University of Maryland
  - Ertan Hydro Power Co.

PandaX collaboration

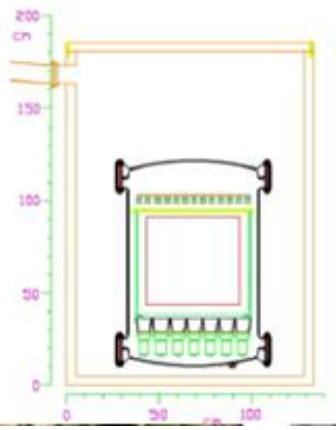
PandaX Road Map

- PandaX = Particle AND Astrophysical Xenon Detector
- Goal: XENON100 as initial target, develop a ton-scale Xenon dark matter detector in three stages, and use the same detector to search for Xe136 neutrinoless double beta decay

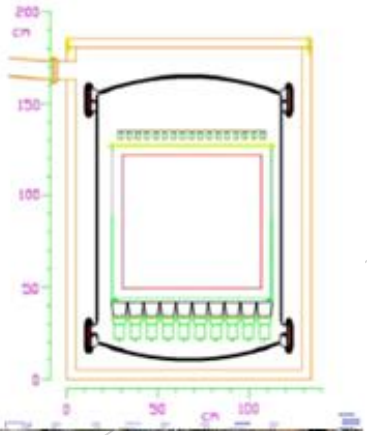
Phase I 125 kg



Phase II 500 kg



Phase III 1.5 ton?



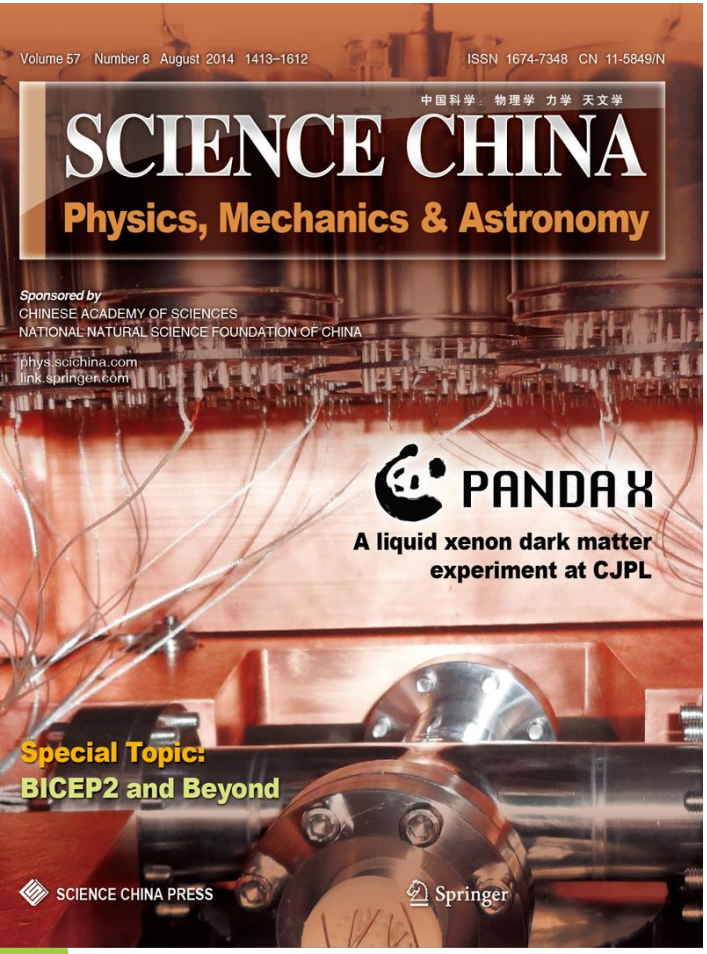
Milestones

Aug. 16, 2012, apparatus arriving CJPL

Mar. 2013：Commissioning

Mar. 2014: Physics data taking

PandaX Technical Paper



SCIENCE CHINA
Physics, Mechanics & Astronomy

• Article •
Progress of Projects Supported by NSFC

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PandaX: a liquid xenon dark matter experiment at CJPL†

CAO XiGuang[4], CHEN Xun[1], CHEN YunHua[8], CUI XiangYi[1], FANG DeQing[4], FU ChangBo[4], GIBONI Karl L.[1], GONG HaoWei[1], GUO GuoDong[1], HE Ming[1], HU Jie[1], HUANG XingTao[3], JI XiangDong[1,6,7*], JU YongLin[2], LI ShaoLi[1], LIN Qing[1], LIU HuaXuan[2], LIU JiangLai[1], LIU Xiang[1], LORENZON Wolfgang[5], MA YuGang[4], MAO YaJun[6], NI KaiXuan[1], PUSHKIN Kirill[1,5], REN XiangXiang[3], SCHUBNELL Michael[5], SHEN ManBing[8], SHI YuJie[1], STEPHENSON Scott[5], TAN AnDi[7], TARLÉ Greg[5], WANG HongWei[4], WANG JiMing[8], WANG Meng[3], WANG XuMing[1], WANG Zhou[2], WEI YueHuan[1], WU ShiYong[8], XIAO MengJiao[1], XIAO Xiang[1], XIE PengWei[1], YE Tao[1], YOU YingHui[8], ZEN XiongHui[8], ZHANG Hua[2], ZHANG Tao[1], ZHAO HaiYing[1], ZHAO Li[1], ZHOU XiaoPeng[6] & ZHU ZhongHua[8]

[1] *The Institute of Nuclear and Particle Physics, Astronomy and Cosmology (INPAC) and Department of Physics and Astronomy, Shanghai Jiao Tong University, Shanghai 200240, China;*
[2] *School of Mechanical Engineering, Shanghai Jiao Tong University, Shanghai 200240, China;*
[3] *School of Physics and Key Laboratory of Particle Physics and Particle Irradiation (MOE), Shandong University, Jinan 250100, China;*
[4] *Shanghai Institute of Applied Physics, Shanghai 201800, China;*
[5] *Department of Physics, University of Michigan, Ann Arbor, MI, 48109, USA;*
[6] *School of Physics, Peking University, Beijing 100080, China;*
[7] *Department of Physics, University of Maryland, College Park, MD, 20742, USA;*
[8] *Yalong River Hydropower Development Company, Ltd., Chengdu 610051, China*

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PandaX is a large liquid-xenon detector experiment usable for direct dark-matter detection and ^{136}Xe double-beta decay search. The central vessel was designed to accommodate a staged target volume increase from initially 120 kg (stage I) to 0.5 t (stage II) and eventually to a multi-ton scale. The experiment is located in the Jinping Deep-Underground Laboratory in Sichuan, China. The detector operates in dual-phase mode, allowing detection of both prompt scintillation, and ionization charge through proportional scintillation. In this paper a detailed description of the stage I detector design and performance as well as results established during the commissioning phase are presented.

dark matter, liquid xenon detector, underground experiment, time projection chamber

PACS number(s): 95.35.+d, 14.80.Ly, 29.40.-n, 95.55.Vj

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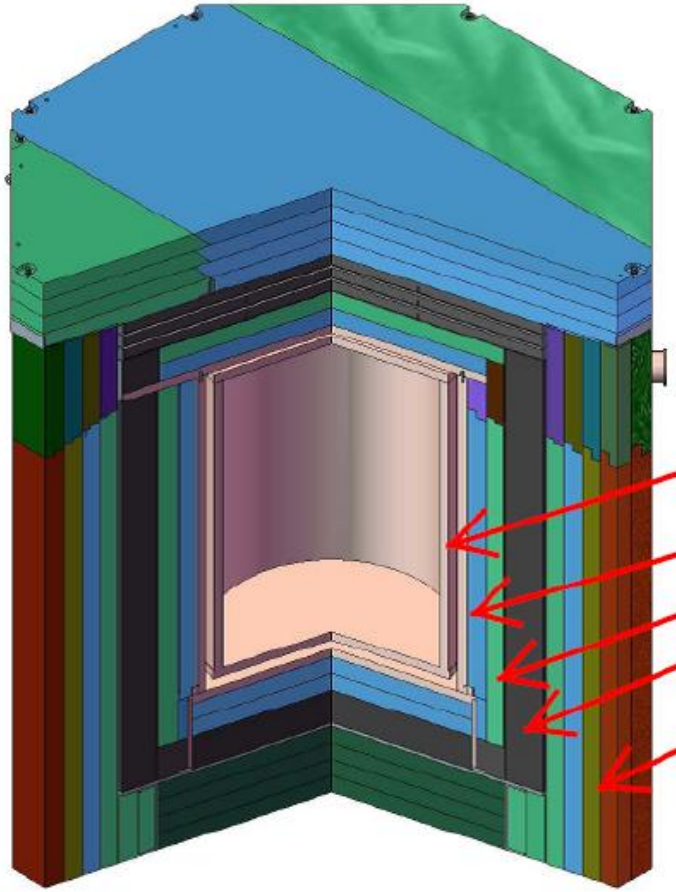
*Corresponding author (email: xdji@sjtu.edu.cn; xji@umd.edu)
†Contributed by JI XiangDong (Associate Editor-in-Chief)

External shielding



Vacuum Vessel

inner diameter 1240mm

inner height 1750mm

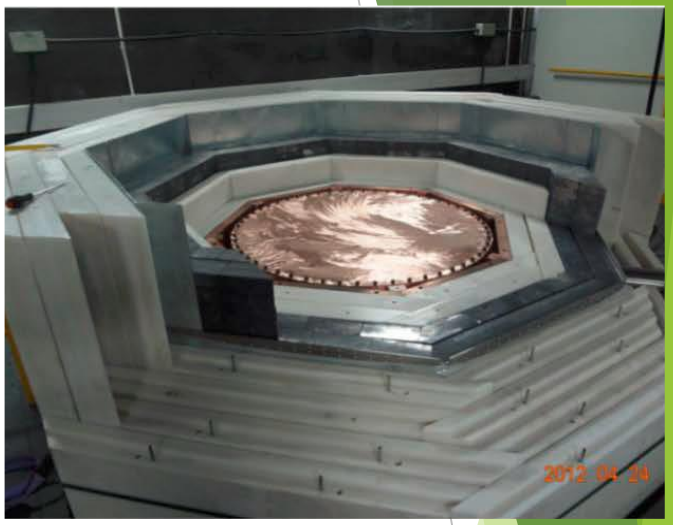
50mm Cu Vessel

50mm Cu

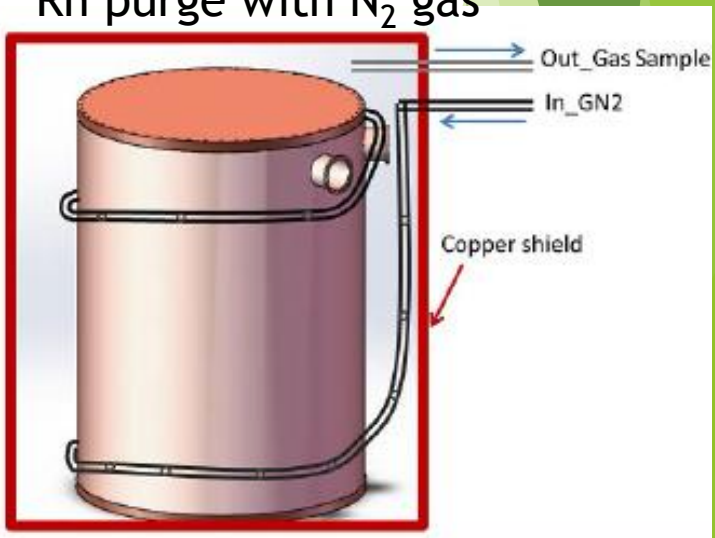
200mm inner PE

200mm Pb

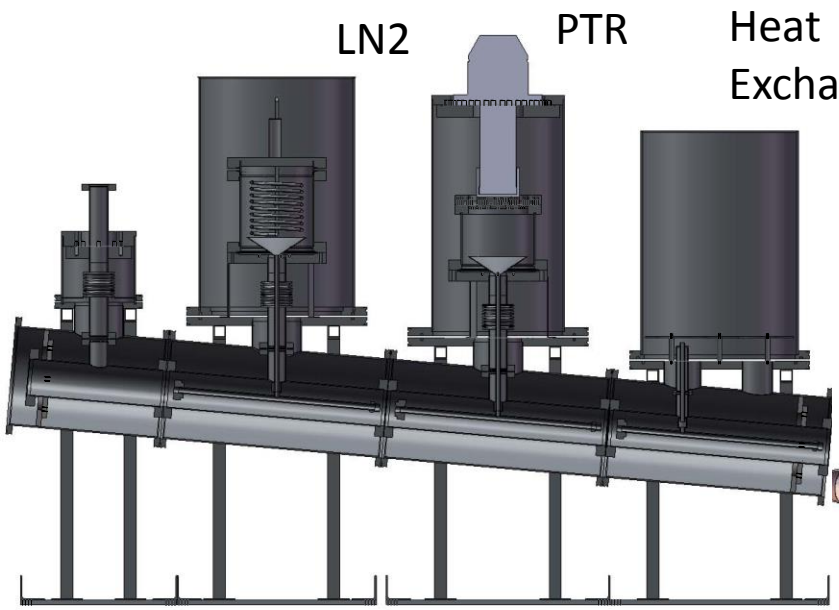
400mm outer PE



Rn purge with N_2 gas



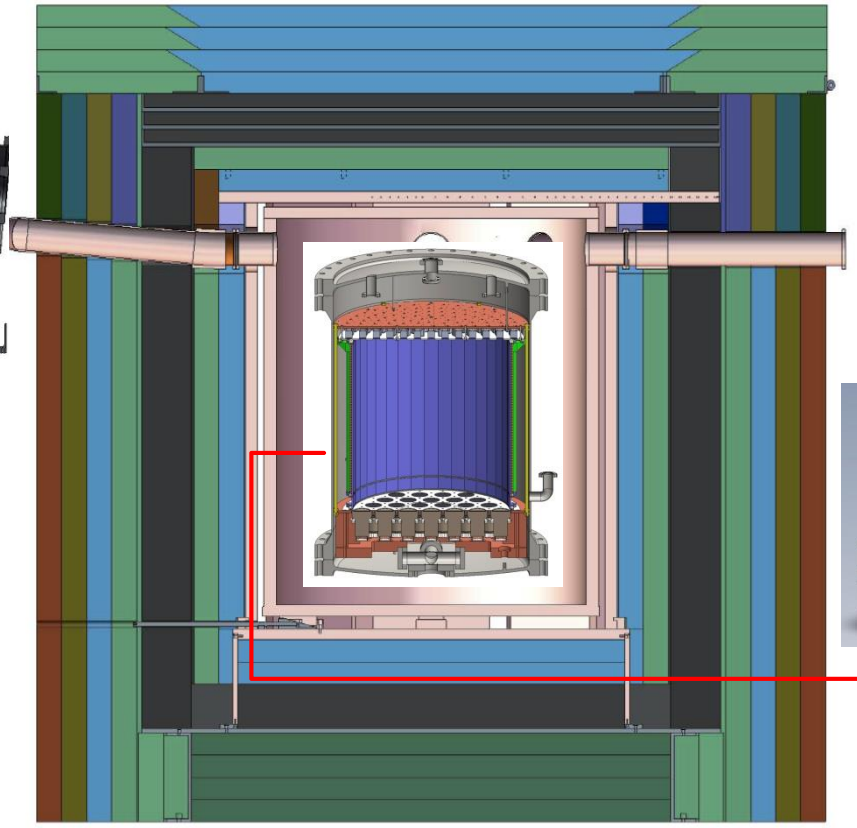
Cryogenic system

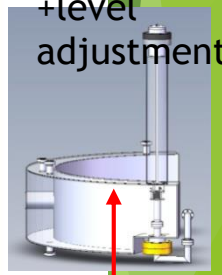


Cryogenic System

Shield

Cavity size:
1.8 m x 1.2 m





Cryogenics system

Gas handing

Control panel

Cooling bus

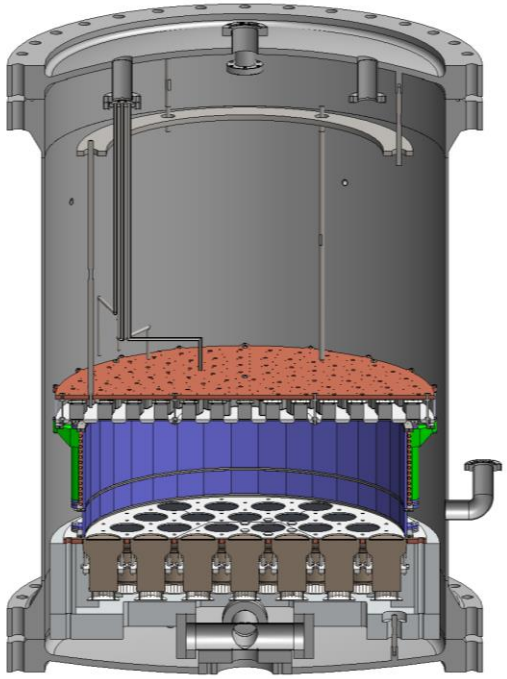
LN2-cooled sorption pump

Stage-I TPC design

TPC radius: 30 cm
Drifting length: 15 cm

Total Xe mass: ~ 400 kg
Sensitive Target Xe mass: 125 kg
Fiducial volume Xe mass: 25 kg

Top PMT Array (R8520): 143
Bottom PMT Array (R11410-MOD): 37

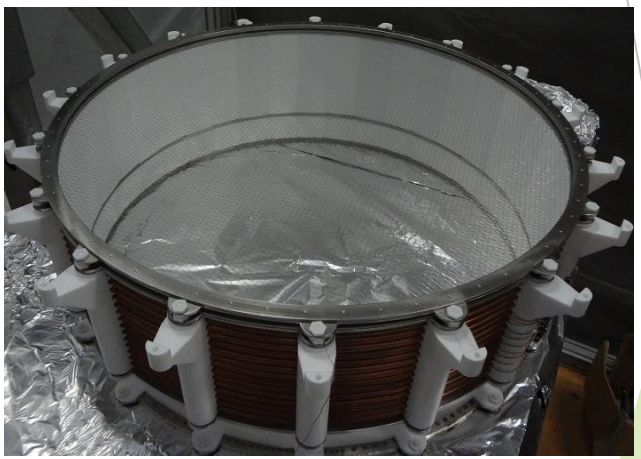


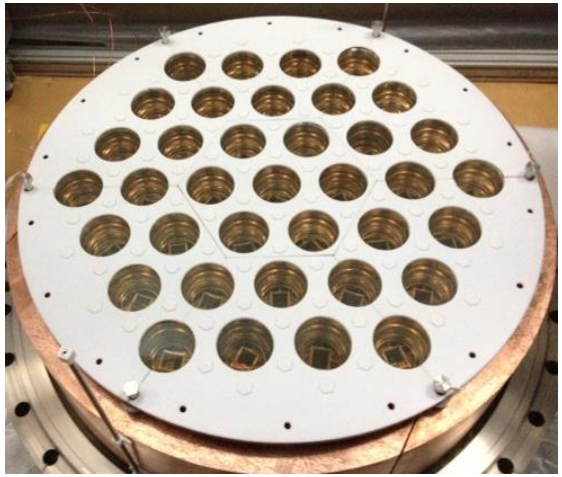
Key advantage: light collection efficiency

Stage-I TPC design

Top PMT array

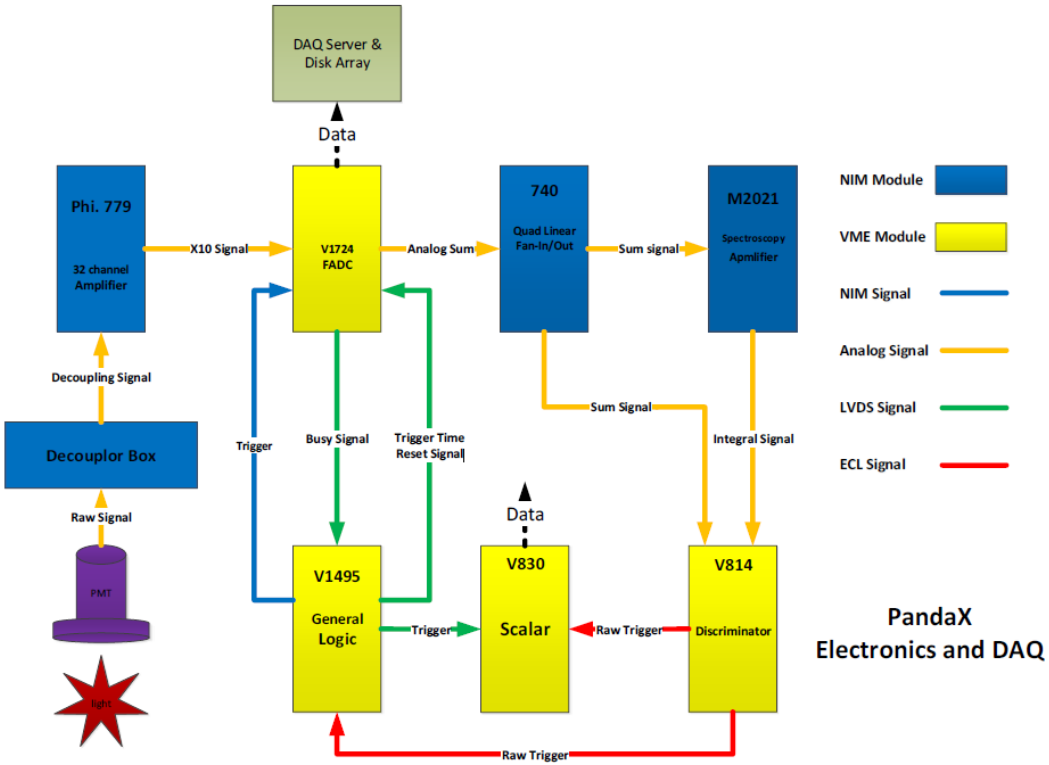
TPC Field cage



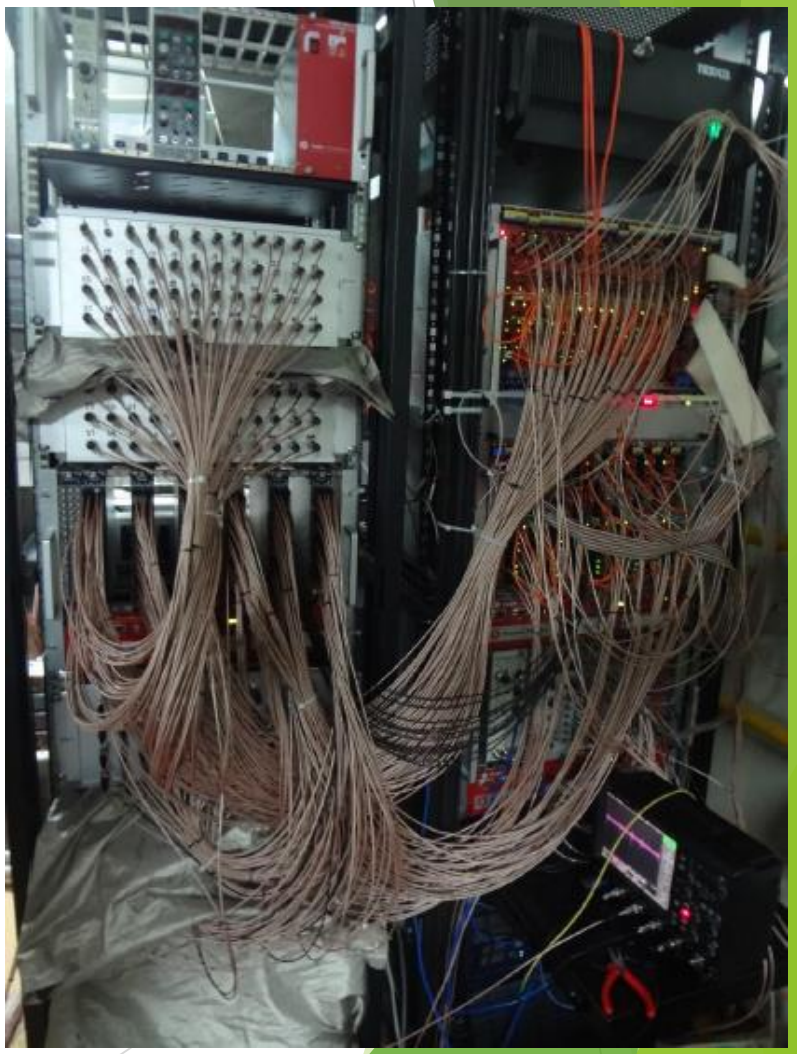


Bottom PMT array

Electronics/DAQ



PandaX Electronics and DAQ



nature international weekly journal of science

Dark-matter hunt gets deep

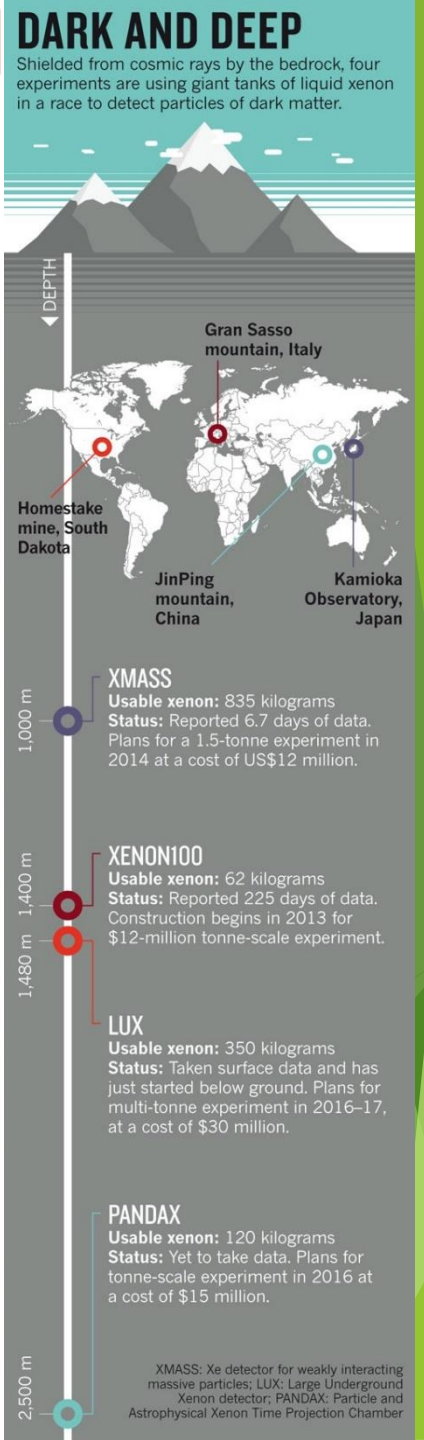
China launches world's deepest particle-physics experiment — but it joins a crowded field.

Eugenie Samuel Reich

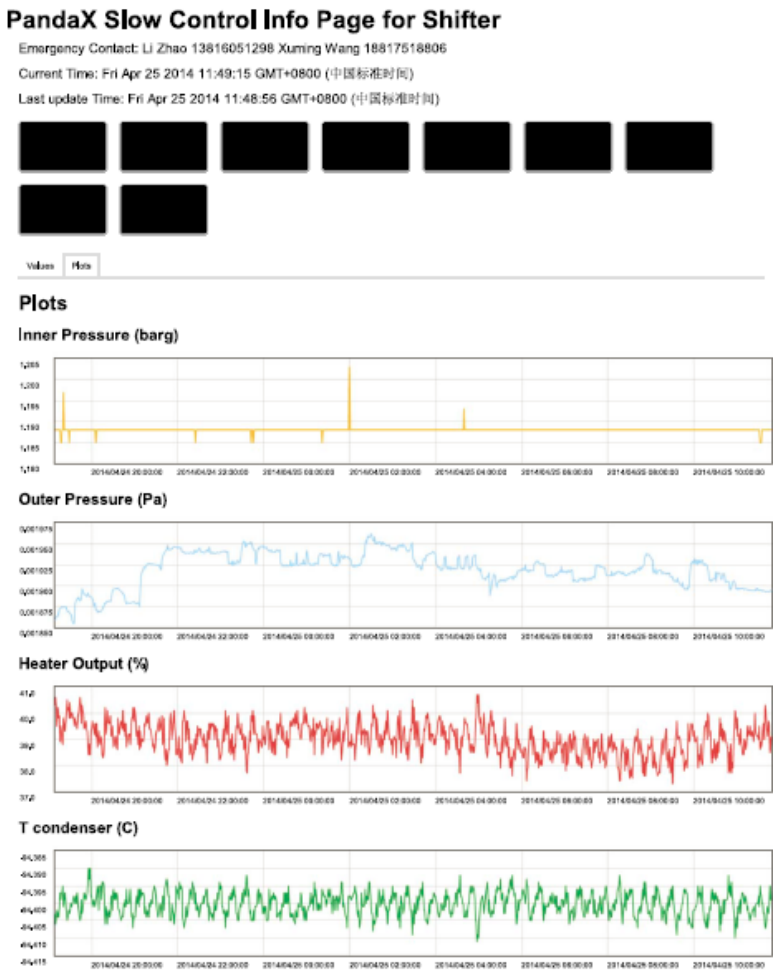
20 February 2013 | Corrected: 21 February 2013

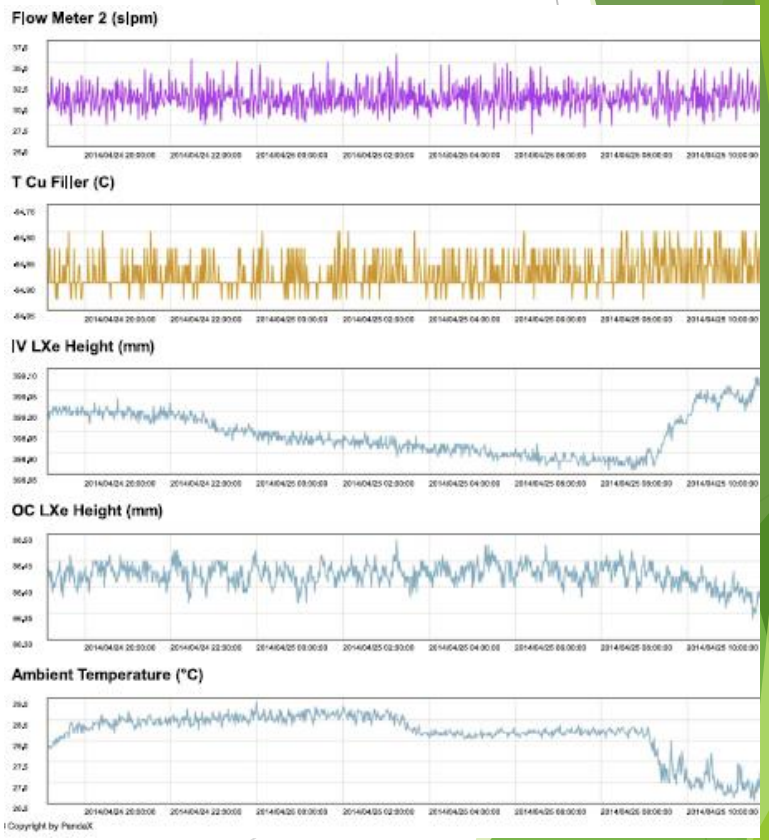
NATURE | NEWS

Ongoing experiments in Italy, the United States and Japan are now being joined by a fourth in China, called PandaX (see 'Dark and deep'). Installed in the deepest laboratory in the world, 2,500 metres under the marble mountain of JinPing in Sichuan province, PandaX will this year begin monitoring 120 kilograms of xenon. The team hopes to scale the tank up to 1 tonne by 2016, which would mean that the experiment had developed more quickly than any other dark-matter search. "We want to demonstrate that world-class research in dark matter is possible in China," says Xiangdong Ji, a physicist at Shanghai Jiao Tong University in China and a spokesman for PandaX.

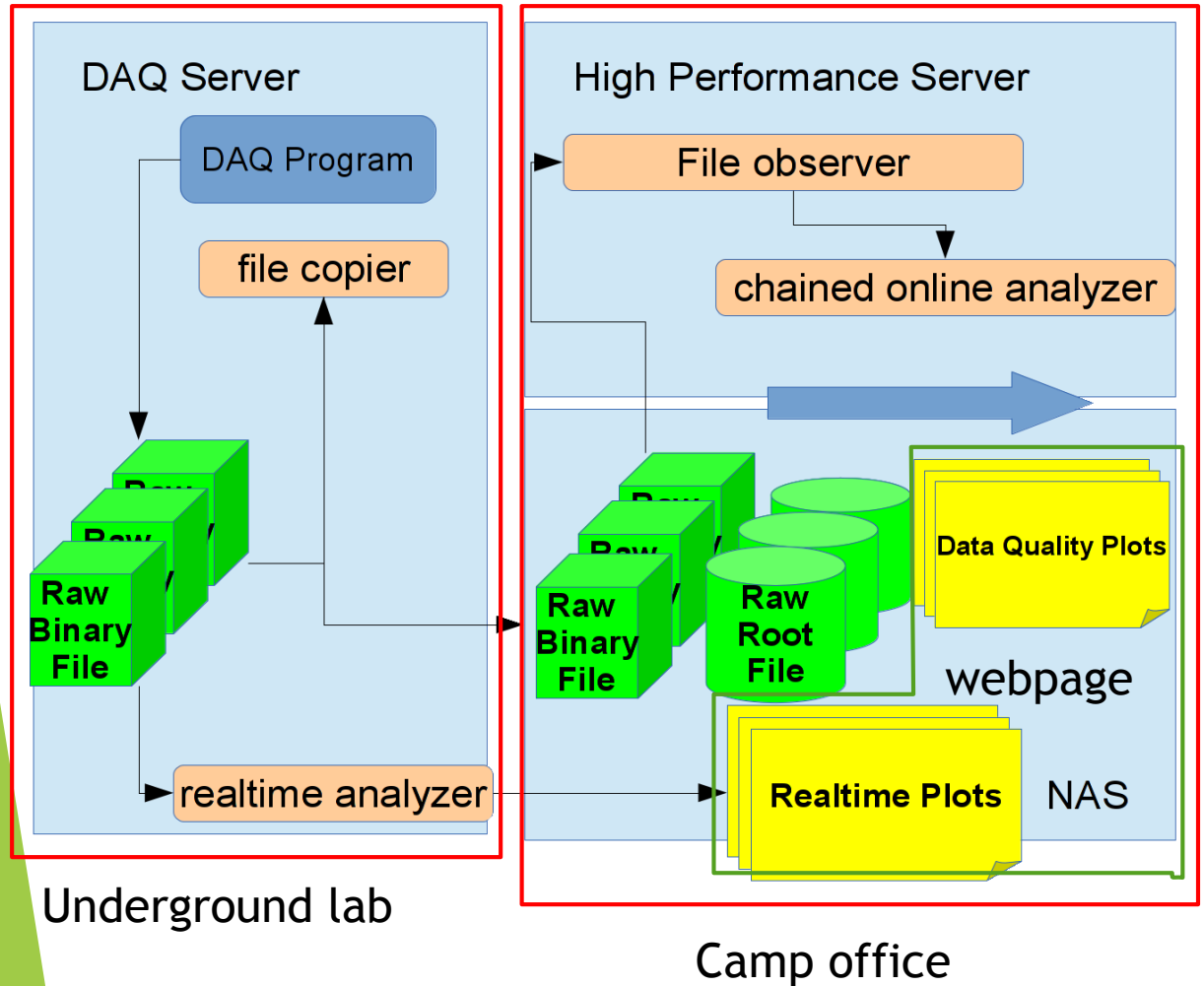


Cryogenics performance: generally stable



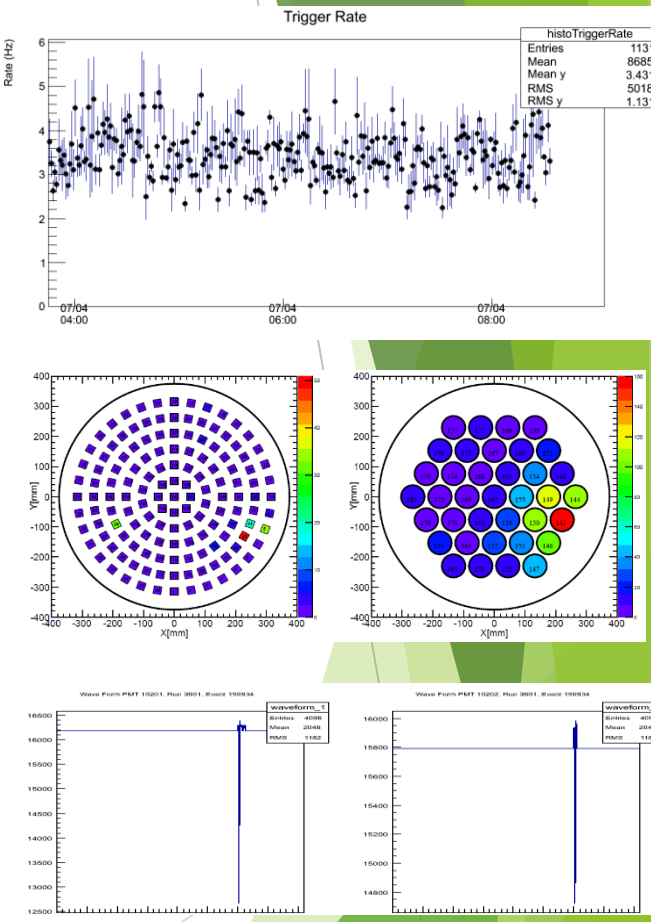


Online data monitoring



Underground lab

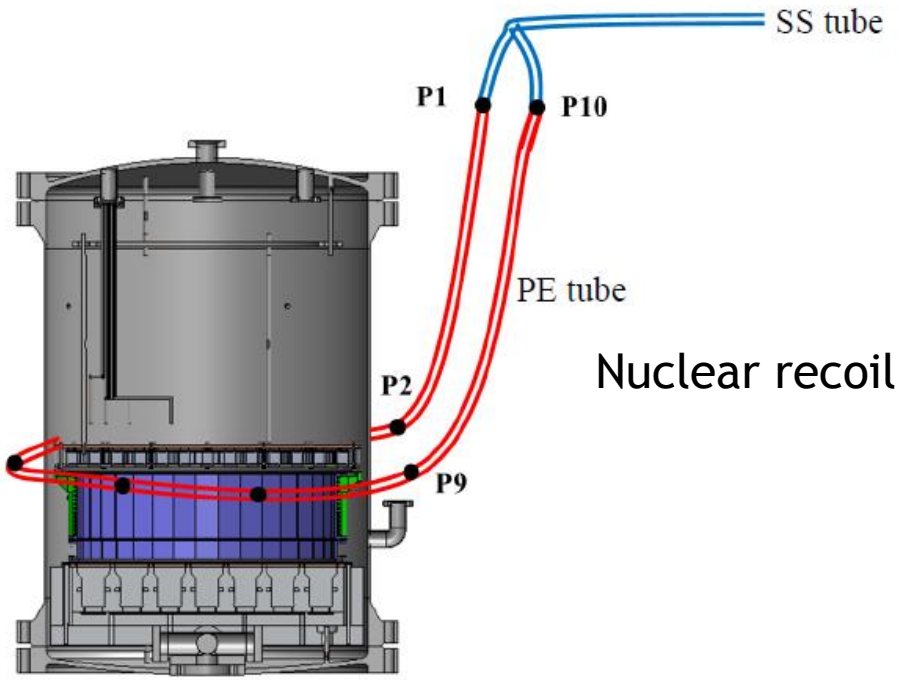
Camp office



Electronics performance

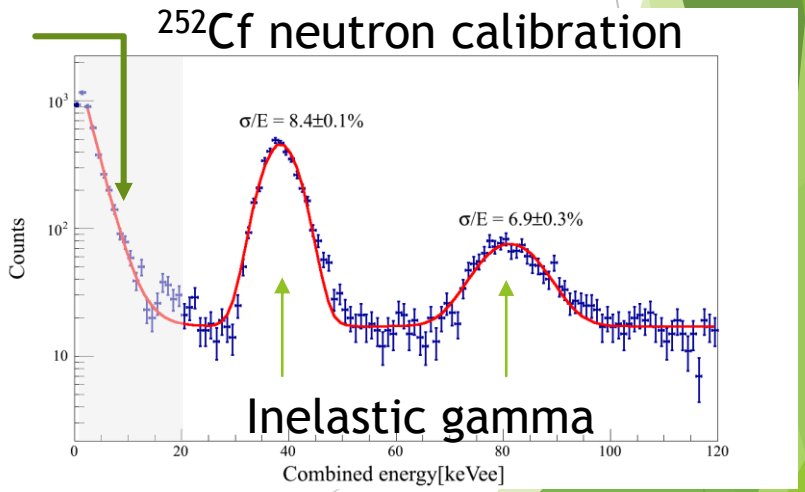
Calibration data

Can put either a gamma or neutron source through the tube to calibrate the detector response



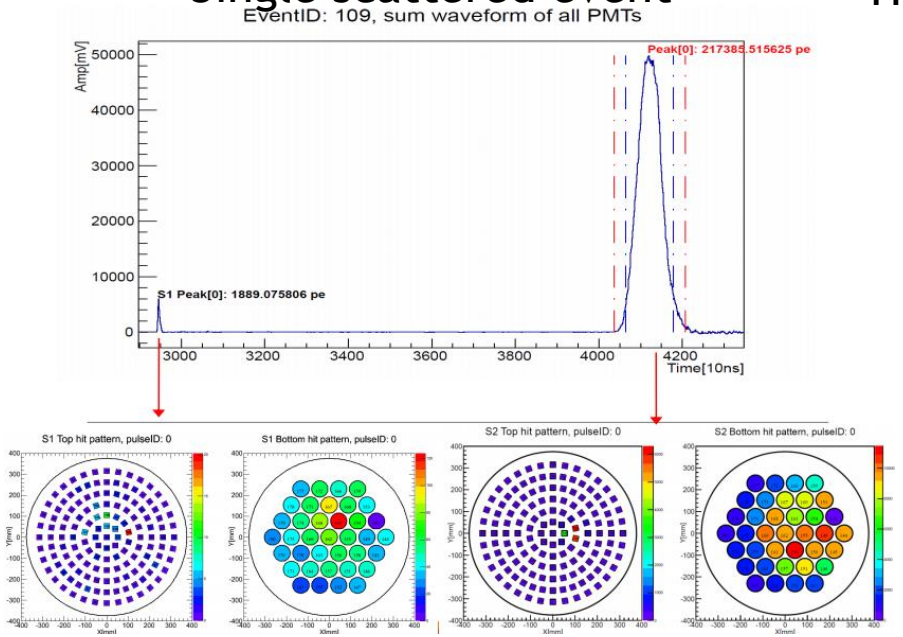
Nuclear recoil

^{252}Cf neutron calibration

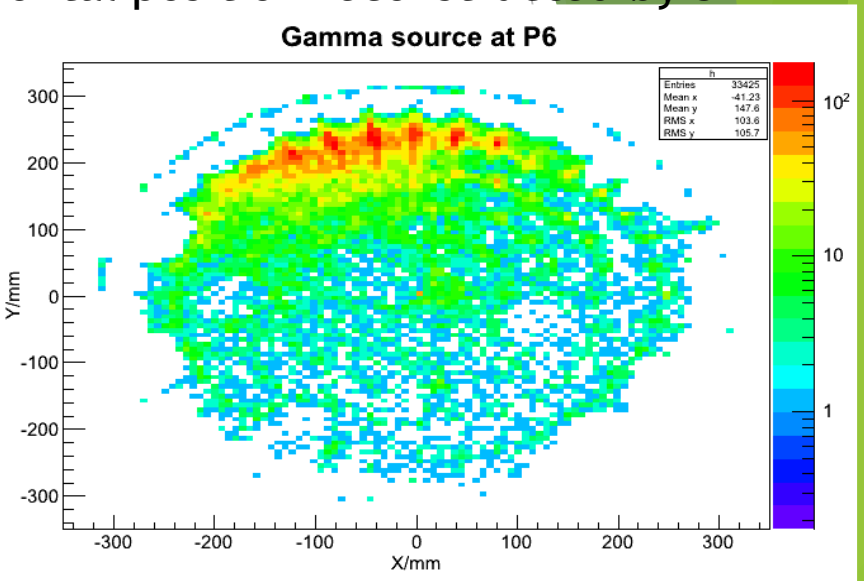


Event reconstruction

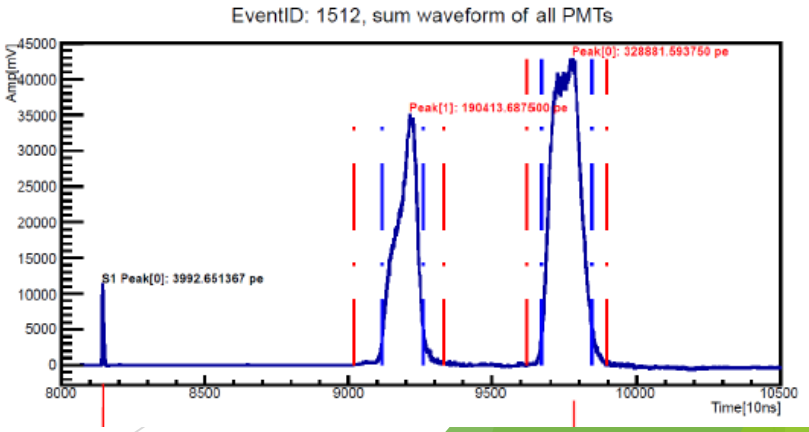
Single scattered event



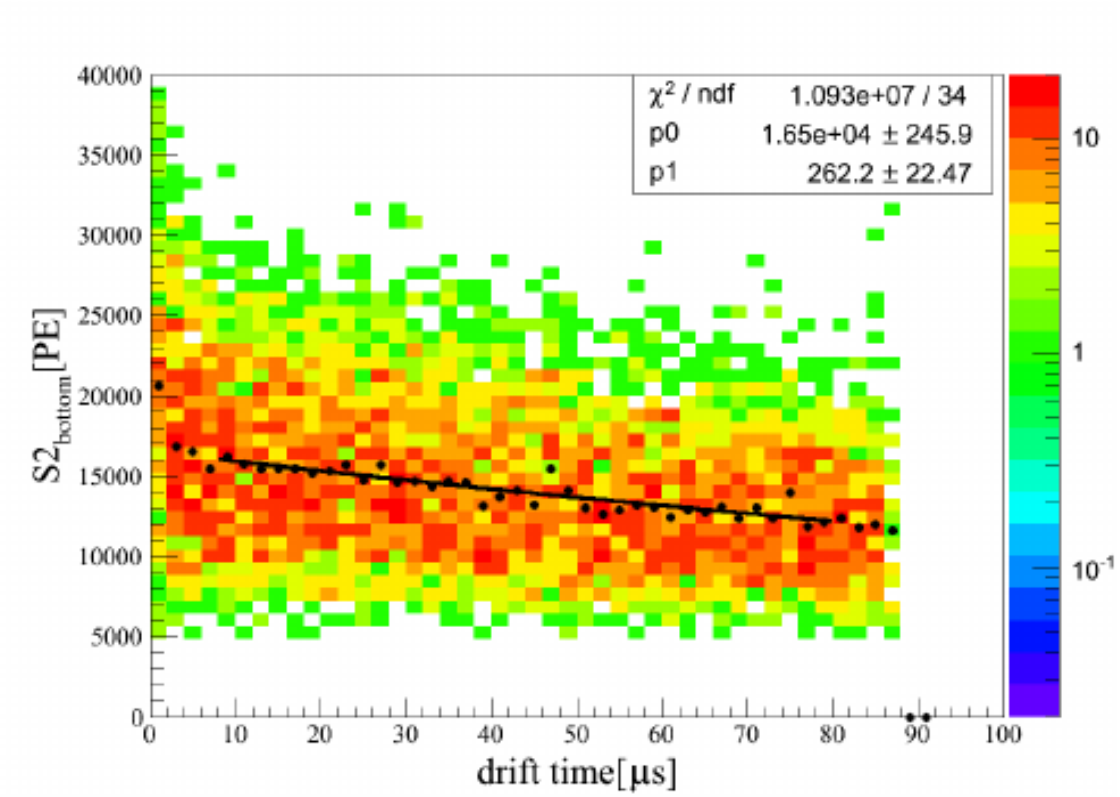
Horizontal position reconstructed by S2



Double scattered background event

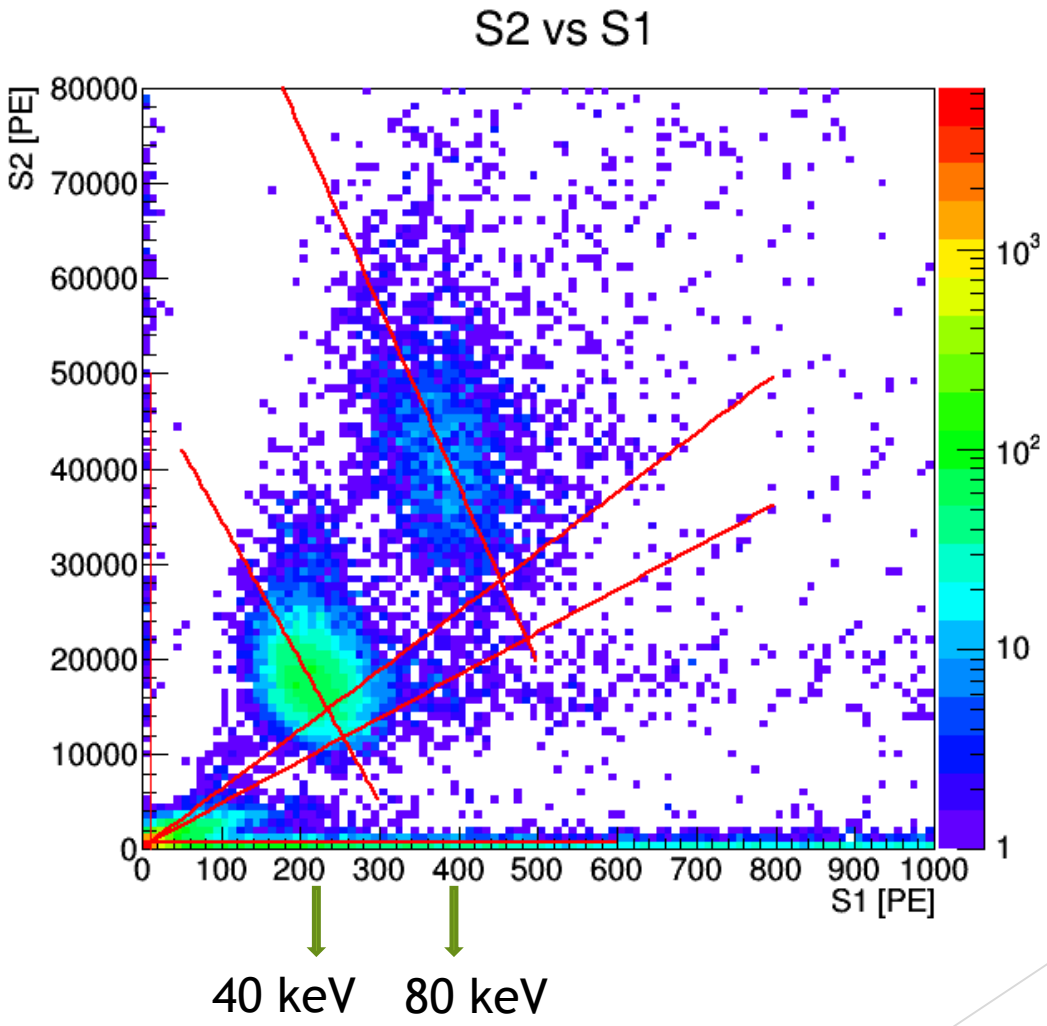


Electron lifetime



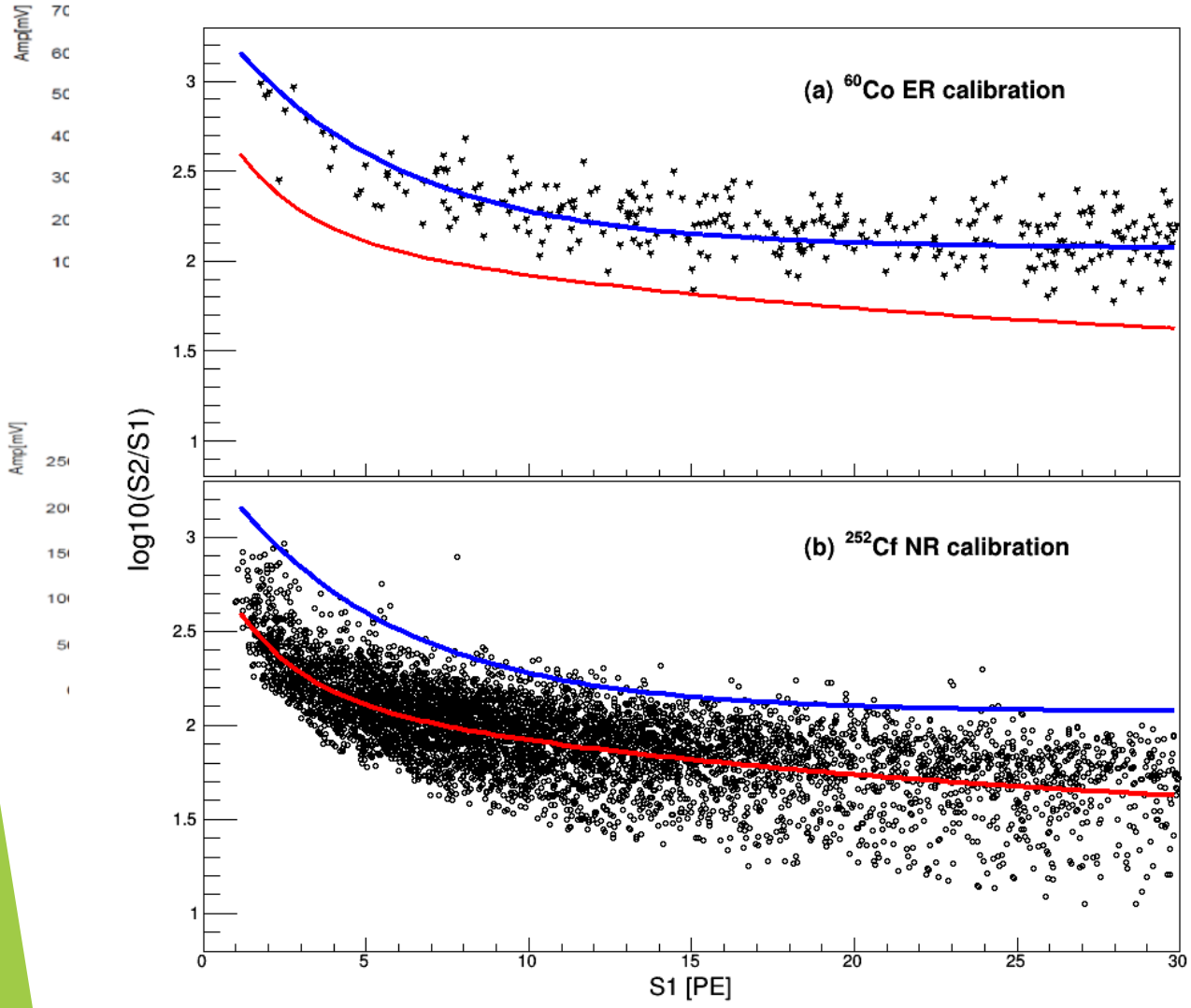
- Electrons can be “eaten” by impurities during drifting
- Measured lifetime: average 260 us or 442 mm (max drift length 150 mm)

Anti-correlation between scintillation and charge signals



Energy scale set by the measured light collection efficiency: 10.5(4)%

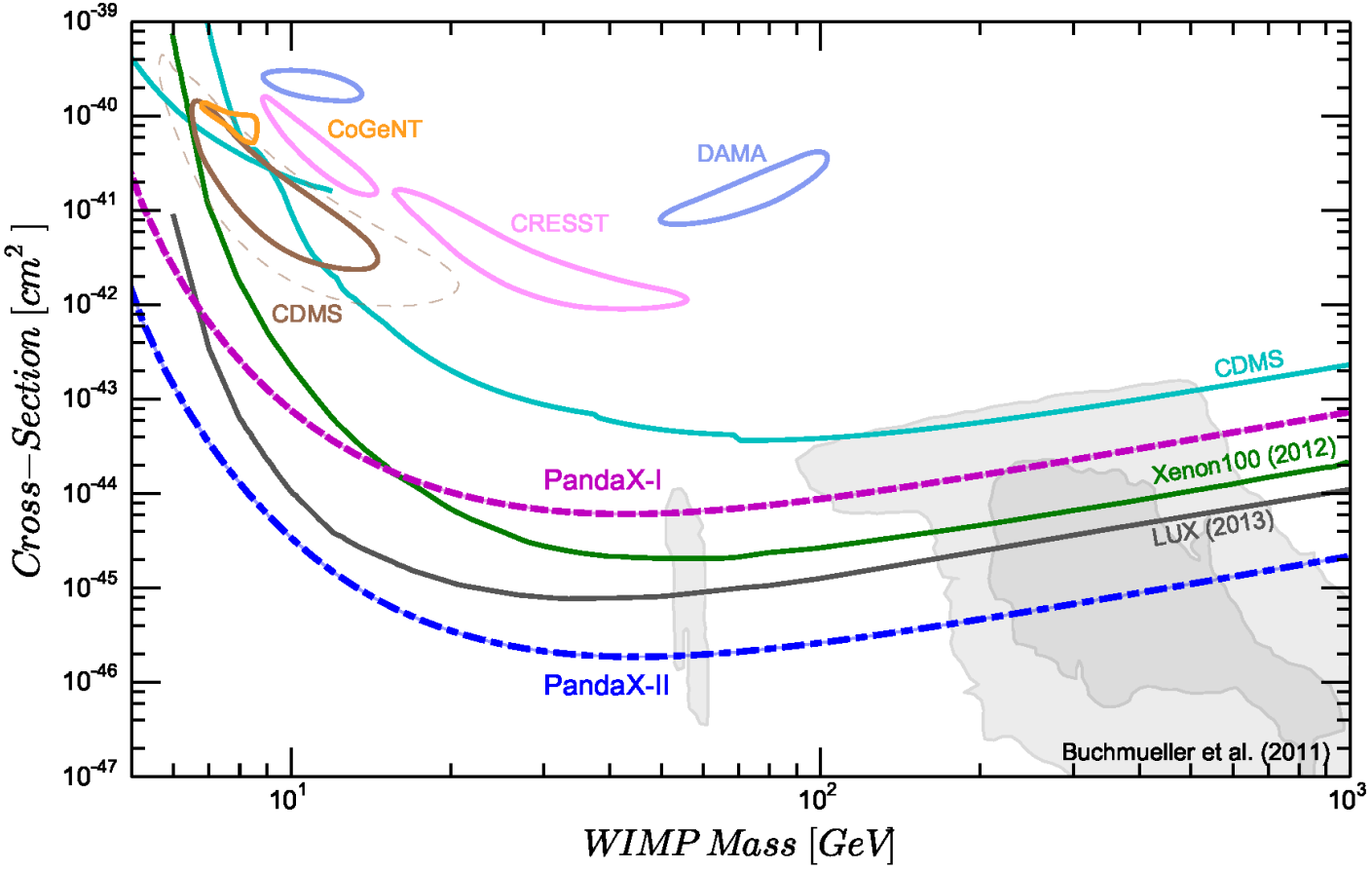
ER/NR discrimination power



First dark matter run: May 26 to July 5

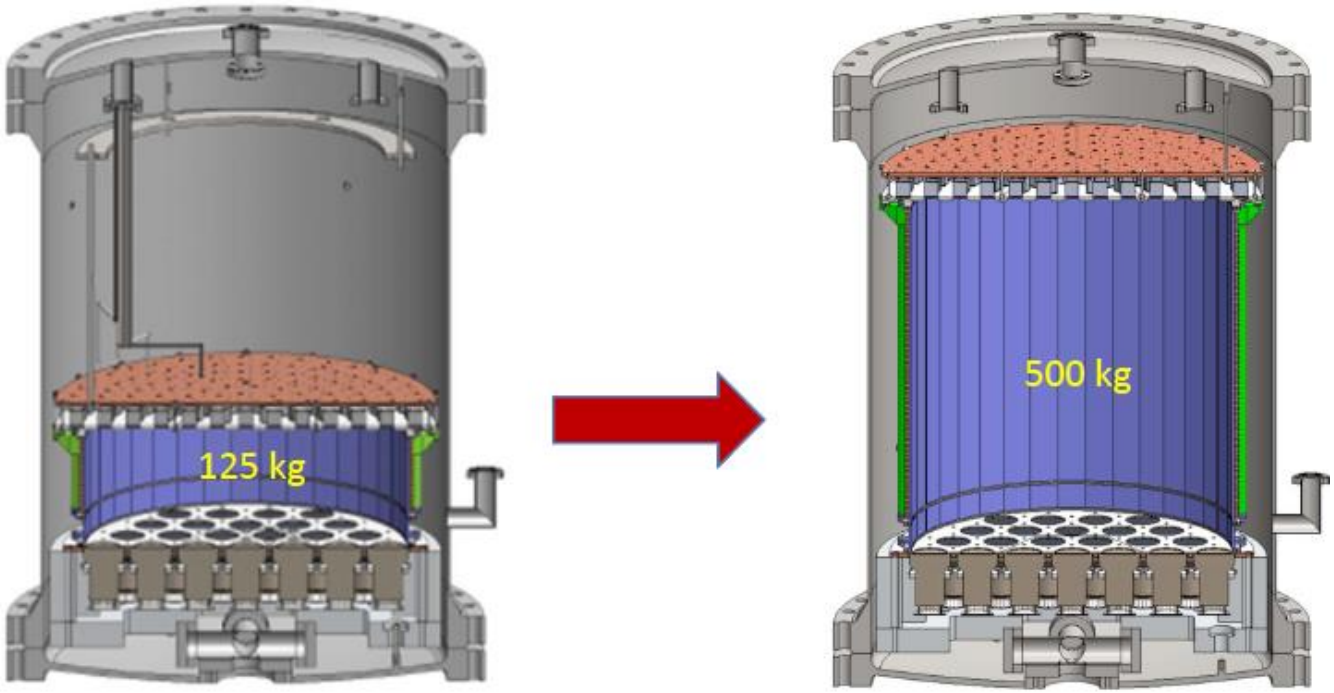
- 17.39 live-day of dark matter data
- Fiducial mass 37 kg
- Results release REALLY imminent

Sensitivity projection



1st physics results from PandaX-I VERY SOON

Next step



- Preparations in 2014-2015
- Sensitivity reach 2x10-46 cm2 at 50 GeV with 300 kg x 360 day

Summary

- PandaX made good progress last year, and currently we are taking phase I dark matter data
- We expect to have physics results VERY soon on 17 live-day of Phase I data
- We are preparing the PandaX II upgrade in parallel
- Stay tuned for more exciting news!
- PandaX electronics talk by 郭国栋 in 第二分会场 Session 6

谢谢您的关注和支持！