



# Recent PandaX-II Results on Dark Matter Search and PandaX-4T Upgrade Plan

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**On behalf of PandaX Collaboration**

TAUP2017, Sudbury, 2017-07-24

# Outline

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- PandaX experiment
- PandaX-II operation and results
  - Calibration
  - WIMPs and Axion
- PandaX-4T upgrade plan
  - Design and outreach
- Outlook

# PandaX Collaboration

- **P**article **a**nd **A**strophysical **X**enon Experiments

- Formed in 2009,
- 12 Institutes, ~50 people

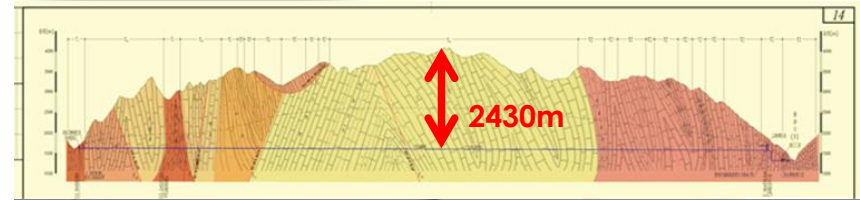
## Started in 2009

- 🇨🇳 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(2015-)

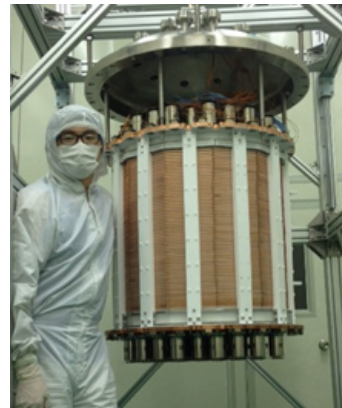


# CJPL and PandaX Experiment

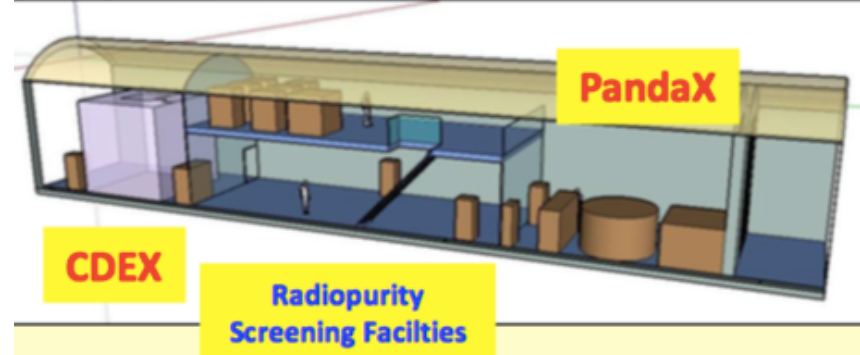
- China JinPing underground Laboratory (CJPL)
  - Deepest (6800 m.w.e )!
  - Horizontal access!
- PandaX-I 120kg (2009-2014)
- PandaX-II 500kg (2014-2018)



Phase I:  
120 kg DM  
2009-2014



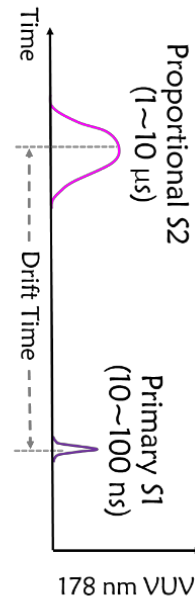
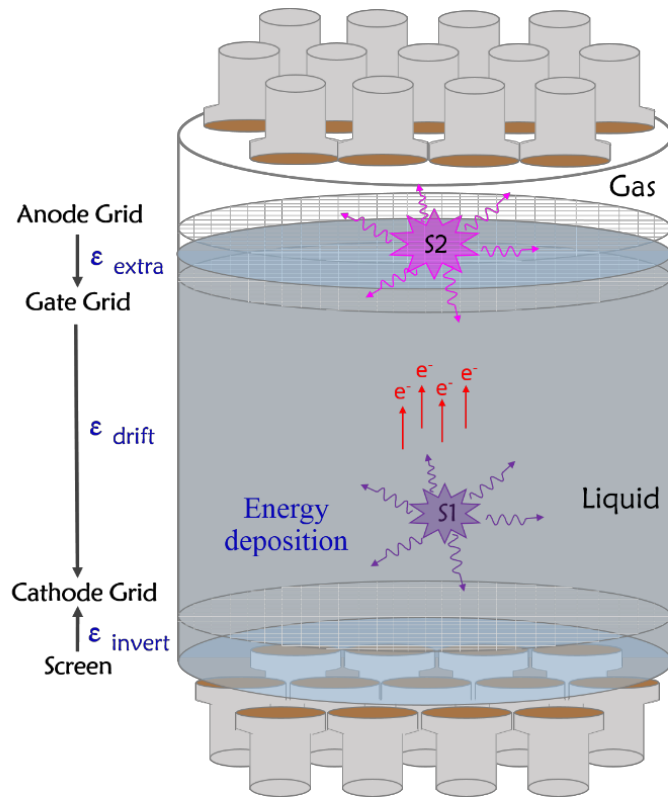
Phase II:  
500 kg DM  
2014-2018



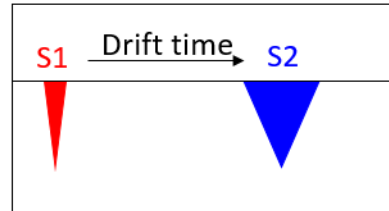


# PandaX-I/II: Dual-phase Xenon TPC

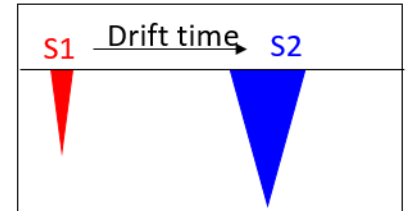
- Dark matter detection in Xenon detector
  - Incoming DM collide with Xenon atom
    - S1: scintillation light in LXe upon scattering
    - S2: scintillation light in GXe due to ionization electron
  - Reconstruct the collision energy and 3-D position



Dark matter: nuclear recoil (NR)

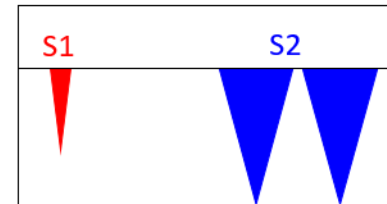


$\gamma$  background: electron recoil (ER)



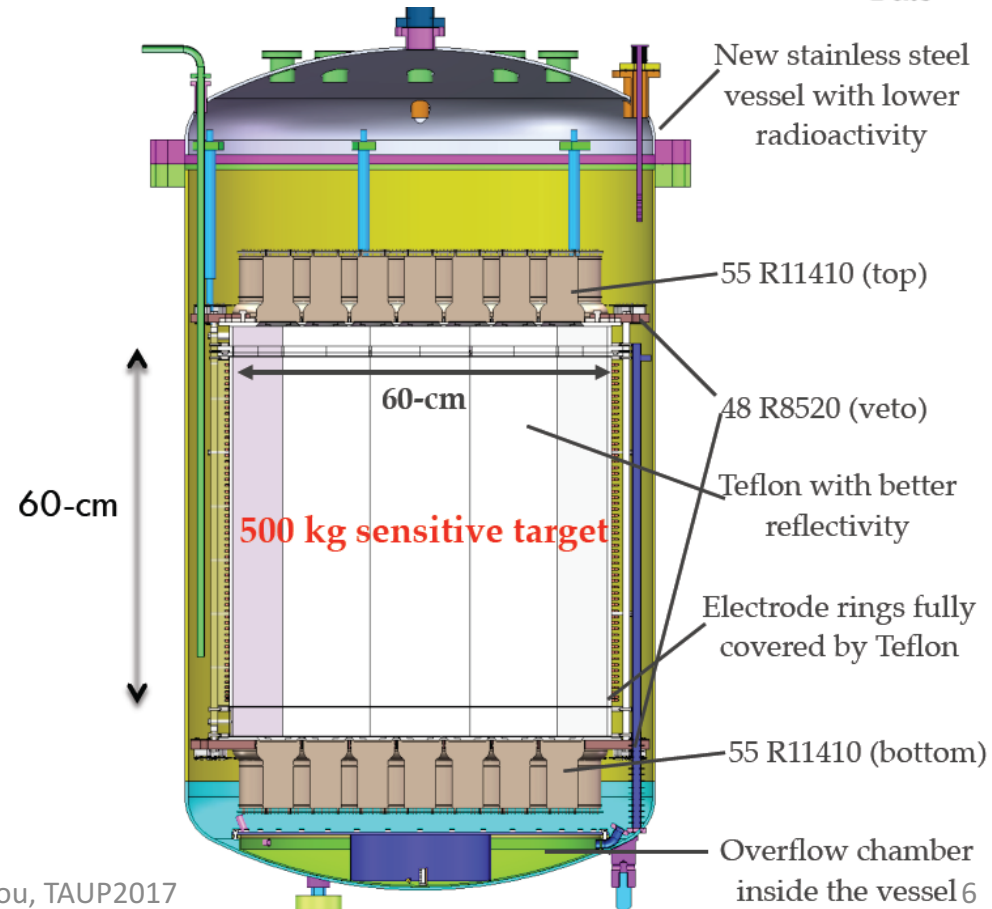
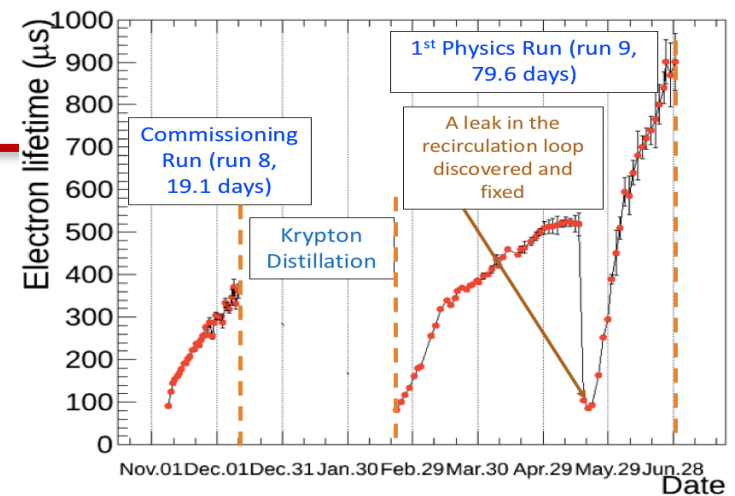
$$(S2/S1)_{NR} \ll (S2/S1)_{ER}$$

Multi-site scattering background (ER or NR)



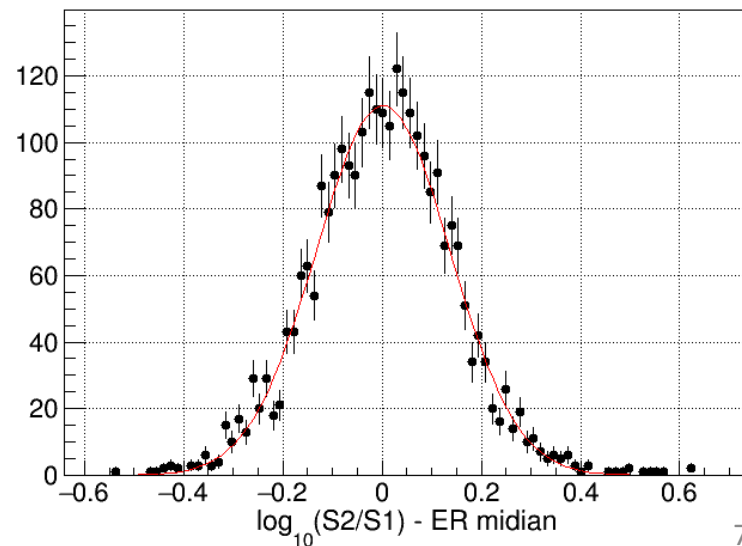
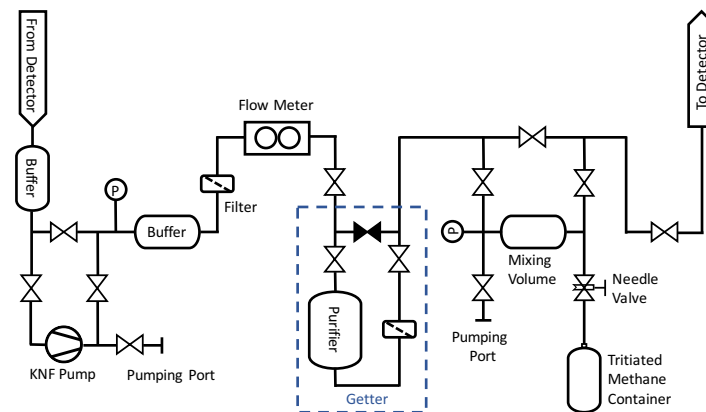
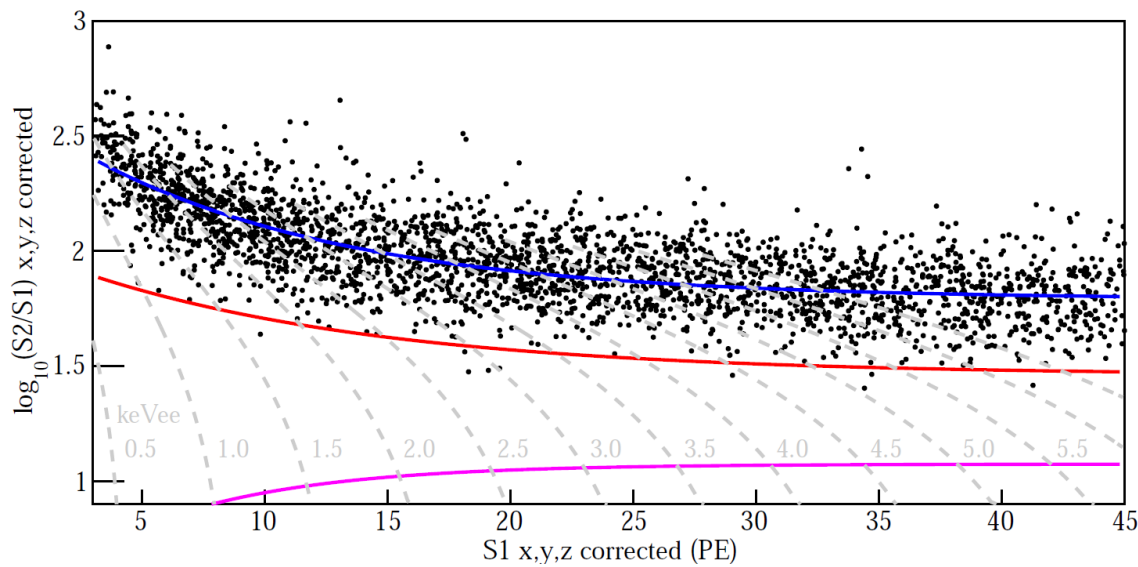
# PandaX-II 500kg

- **Engineering Run**
  - From the beginning of 2015
- **Commissioning Run (Run8)**
  - 2015.11.22 - 12.14 (19.1 days)
  - With high Kr background
- **Physics Run (Run9)**
  - 2016.03.09 - 06.30 (79.6 days)
  - First low background run, re-distillation to remove Kr
- **Running now**
  - Under good condition



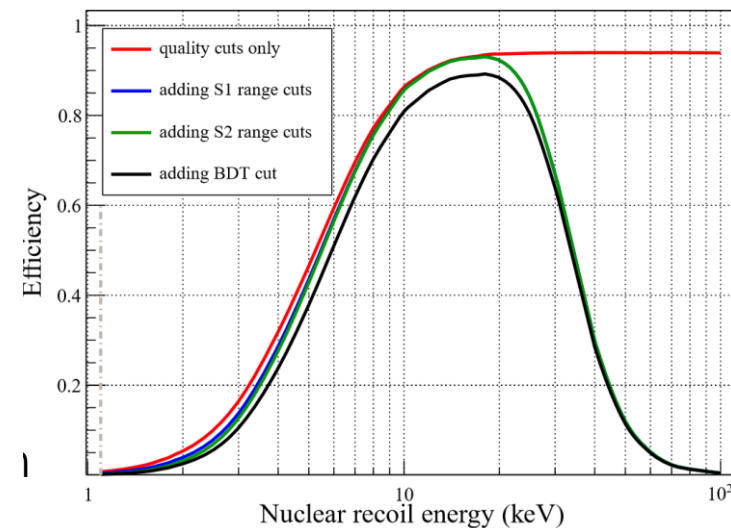
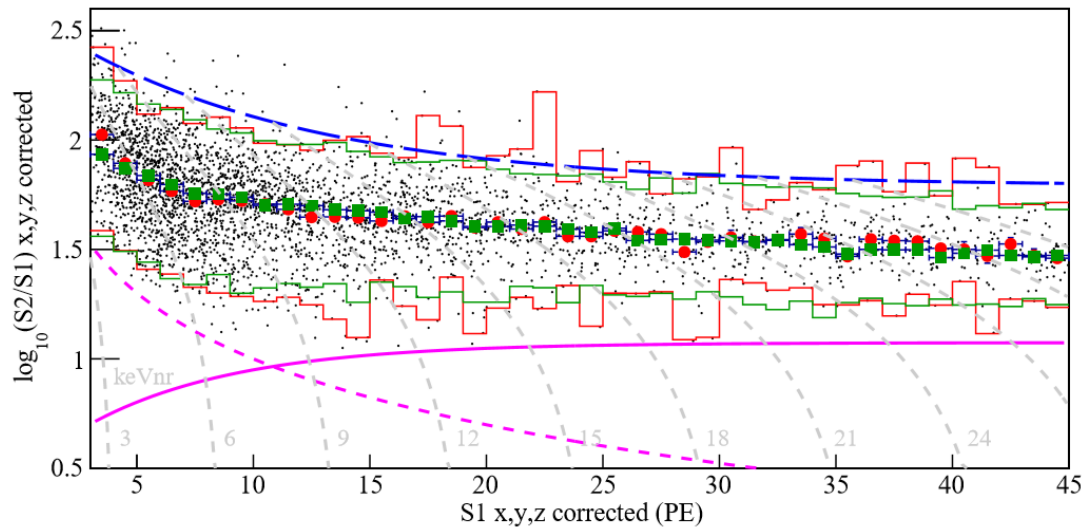
# ER Calibration

- 18.0 hours of **tritium CH<sub>3</sub>T** data taken, with  $\sim 2800$  low energy ER events collected
- 9 events leaked below NR median,  $(0.32 \pm 0.11)\%$
- Consistent with Gaussian expectation



# NR Calibration

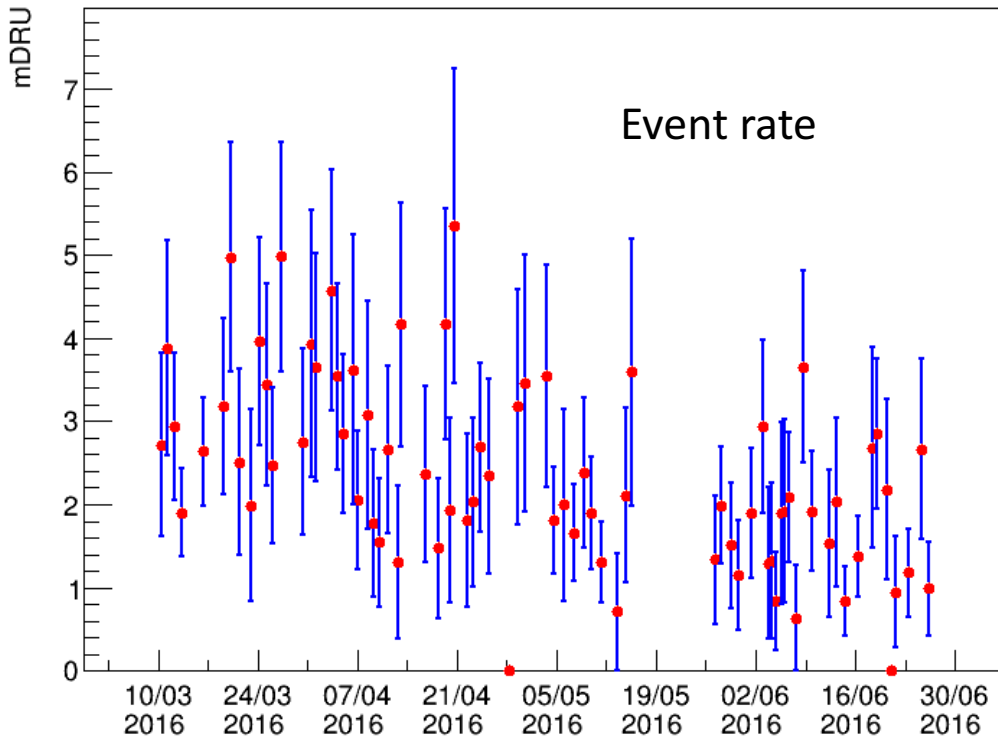
- 162.4 hours of **AmBe** data taken, with  $\sim 3400$  low energy single scatter NR events collected
- NR median curve and NR detection efficiency determined



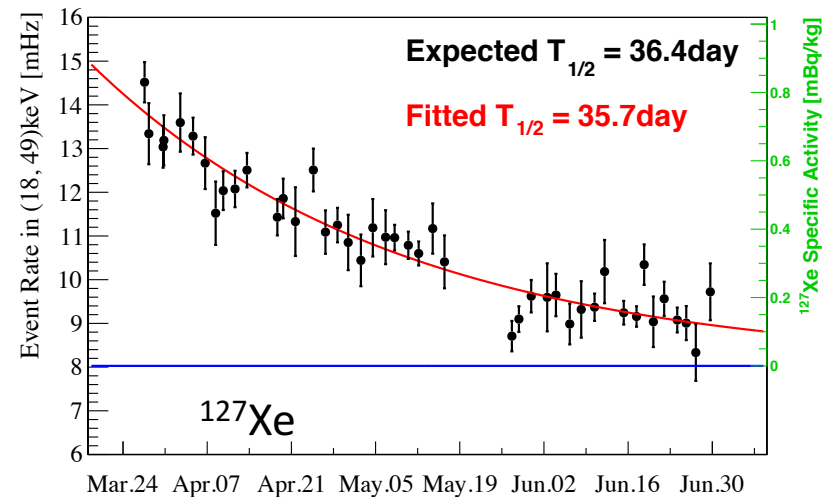
- NR efficiency obtained by data/MC ratio
- $S1 [3, 45] \text{ PE}, S2 [100_{\text{raw}}, 10000_{\text{corr}}] \text{ PE}$
- Adopted  $1.1 \text{ keV}_{\text{nr}}$  threshold

# Low-energy Rate

- Event selected in the fiducial volume with energy < 10 keVee
- ~ 2 mDRU in the FV on average
- Decrease over time due to  $^{127}\text{Xe}$  decay



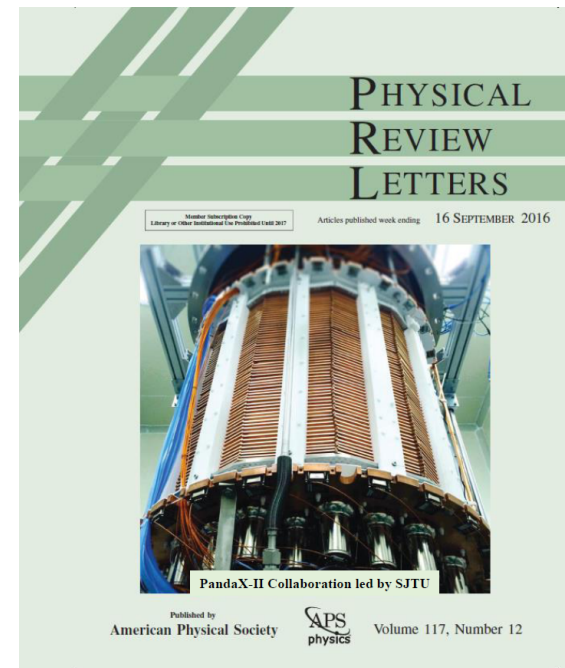
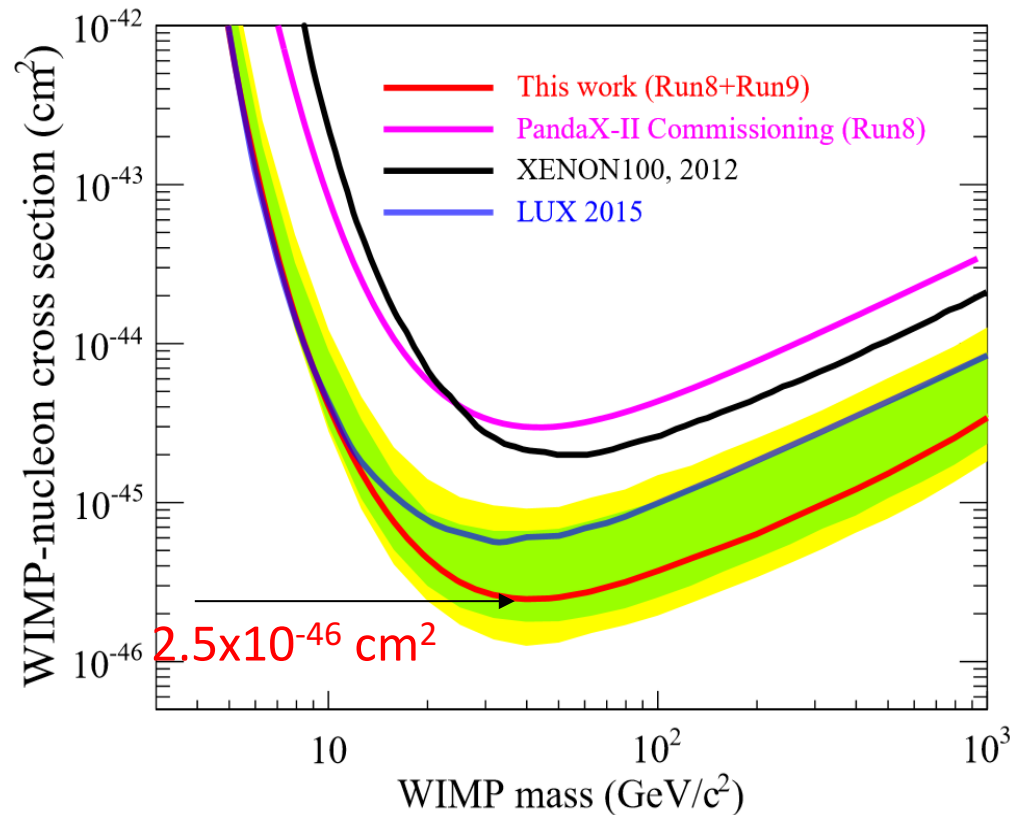
Item	Run 8 (mDRU)	Run 9 (mDRU)
$^{85}\text{Kr}$	11.7	1.19
$^{127}\text{Xe}$	0	0.42
$^{222}\text{Rn}$	0.06	0.13
$^{220}\text{Rn}$	0.02	0.01
Detector material ER	0.20	0.20
Total	12.0	1.95





# SI WIMP

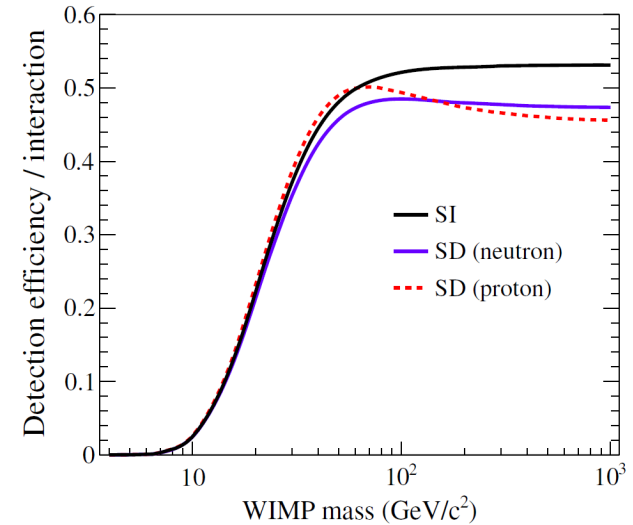
- Spin-independent WIMP-nucleon scattering
- $3.3 \times 10^4$  kg-day exposure
- constraints at  $2.5 \times 10^{-46}$   $\text{cm}^2$  for 40 GeV WIMP



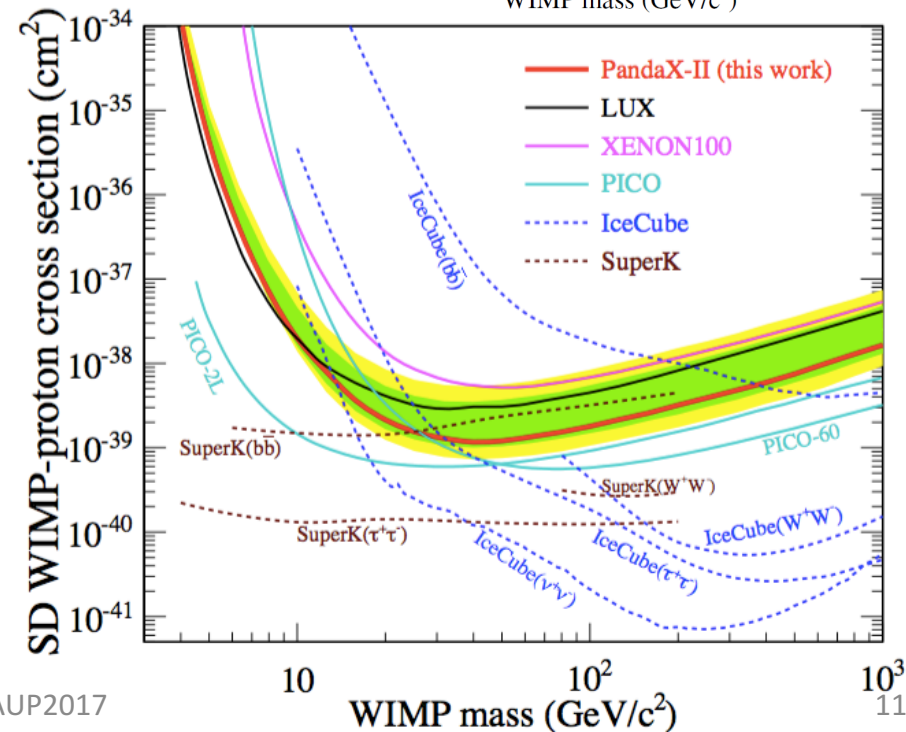
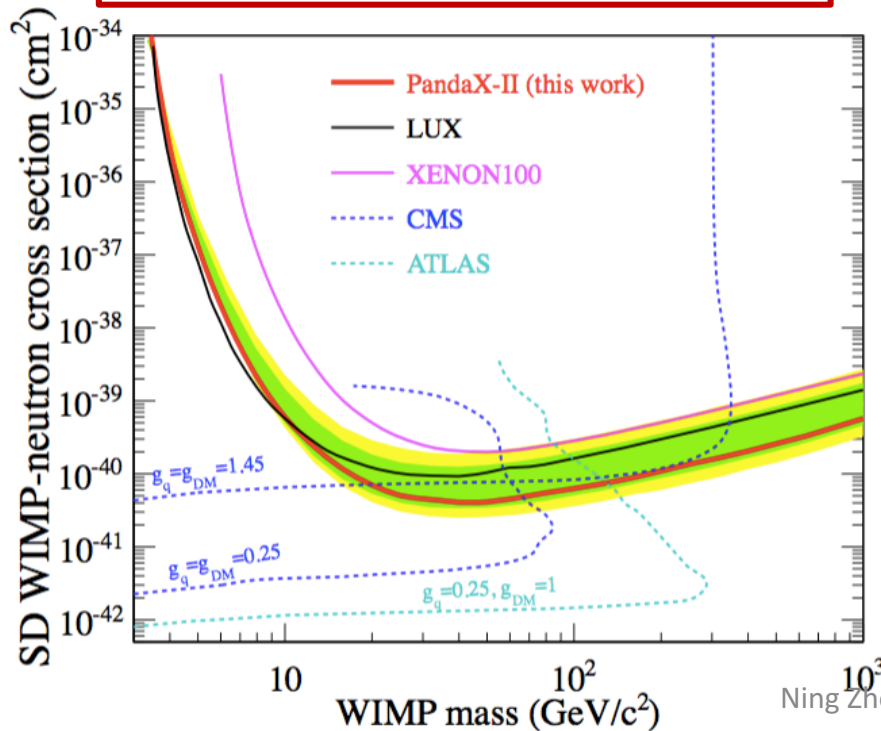
**Phys. Rev. Lett. 117, 121303 (2016)**

# SD WIMP

- Spin-dependent WIMP-nucleon scattering
- $3.3 \times 10^4$  kg-day exposure
- Constraints at  $4.1 \times 10^{-41}$  cm<sup>2</sup> on WIMP-neutron for 40 GeV WIMP

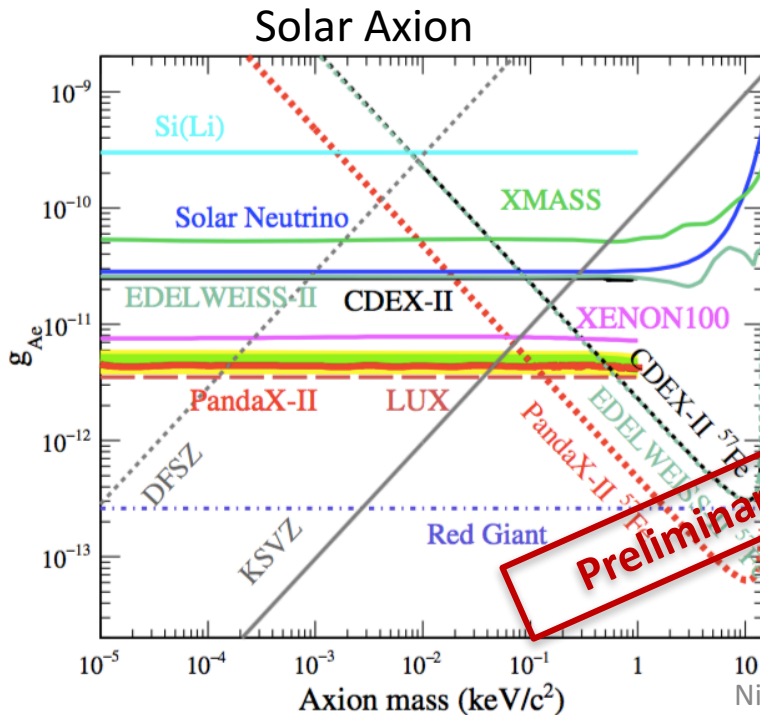
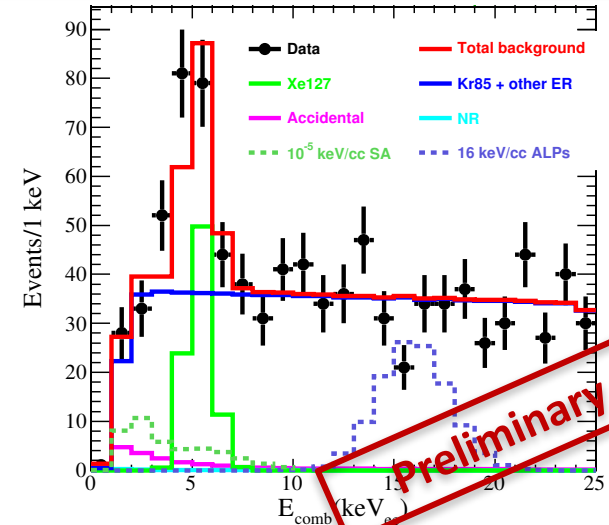


**Phys. Rev. Lett. 118, 071301 (2017)**

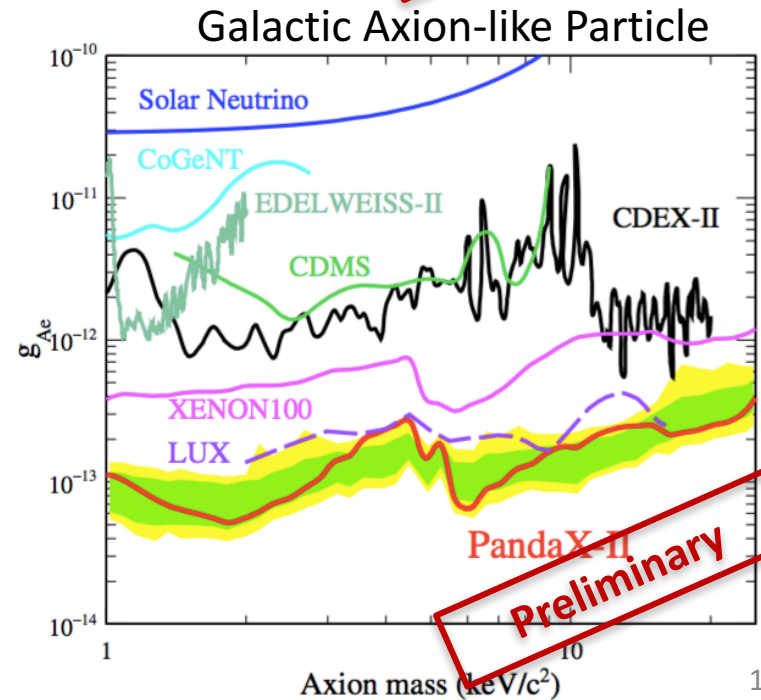


# Axion

- Solar Axion and Axion-like Particles
- ER signal,  $E < 25 \text{ keV}_{ee}$
- Leading upper limits are set, paper is being prepared.



Ning Zhou, TAUP2017



# PandaX – in Future

- PandaX-4T for DM search
- PandaX-III for 0vbb search [See Ke Han's talk](#)

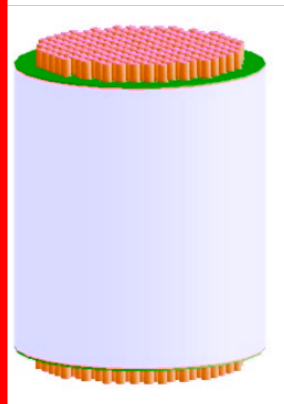


**PandaX-I:** 120 kg  
DM experiment  
2009-2014

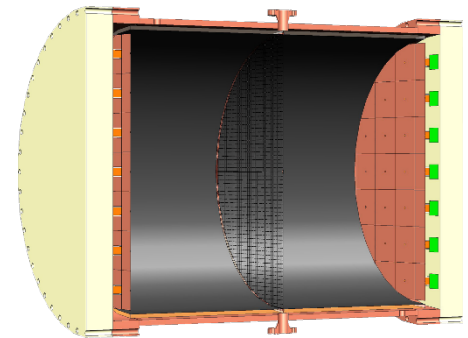


**PandaX-II:** 500 kg  
DM experiment  
2014-2018

CJPL-I



**PandaX-xT:**  
multi-ton (~4-T)  
DM experiment  
Future



**PandaX-III:** 200 kg to  
1 ton HP gas  $^{136}\text{Xe}$   
0vDBD experiment  
Future

CJPL-II

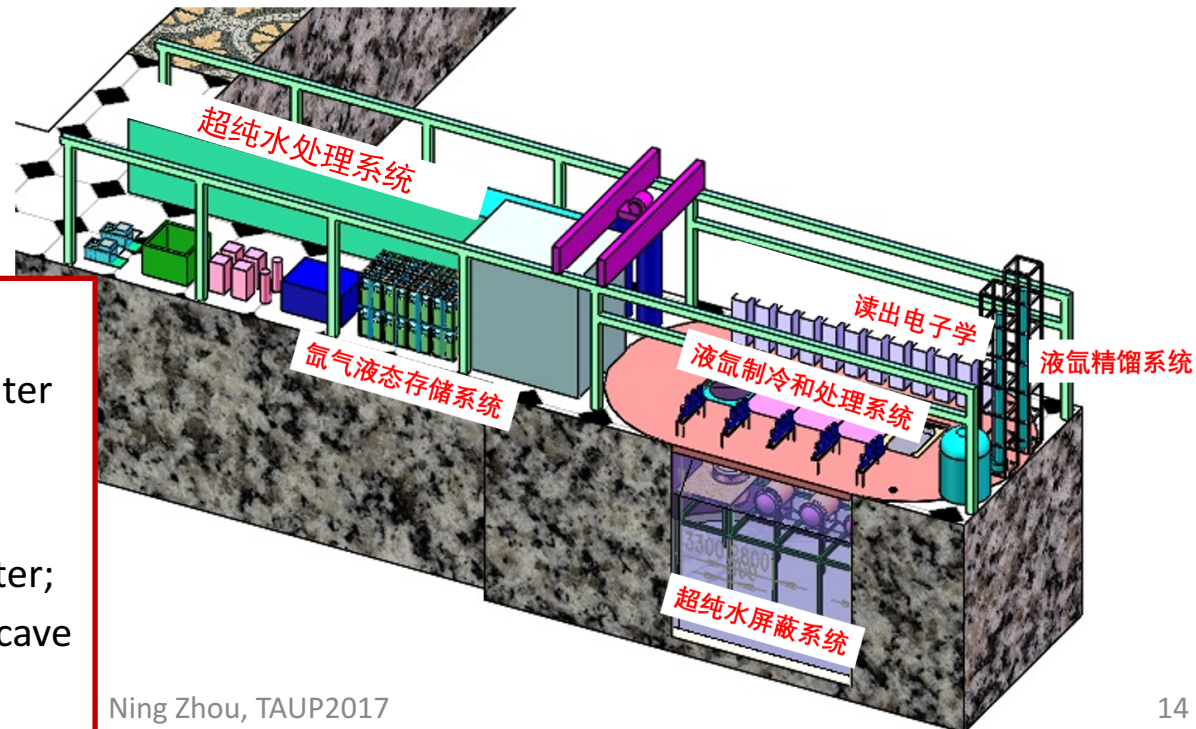


# New Experiment Hall at CJPL-II

- Height 14m
- Width 14m
- Length 65m
- Water tank, depth of 13m



Water Pool

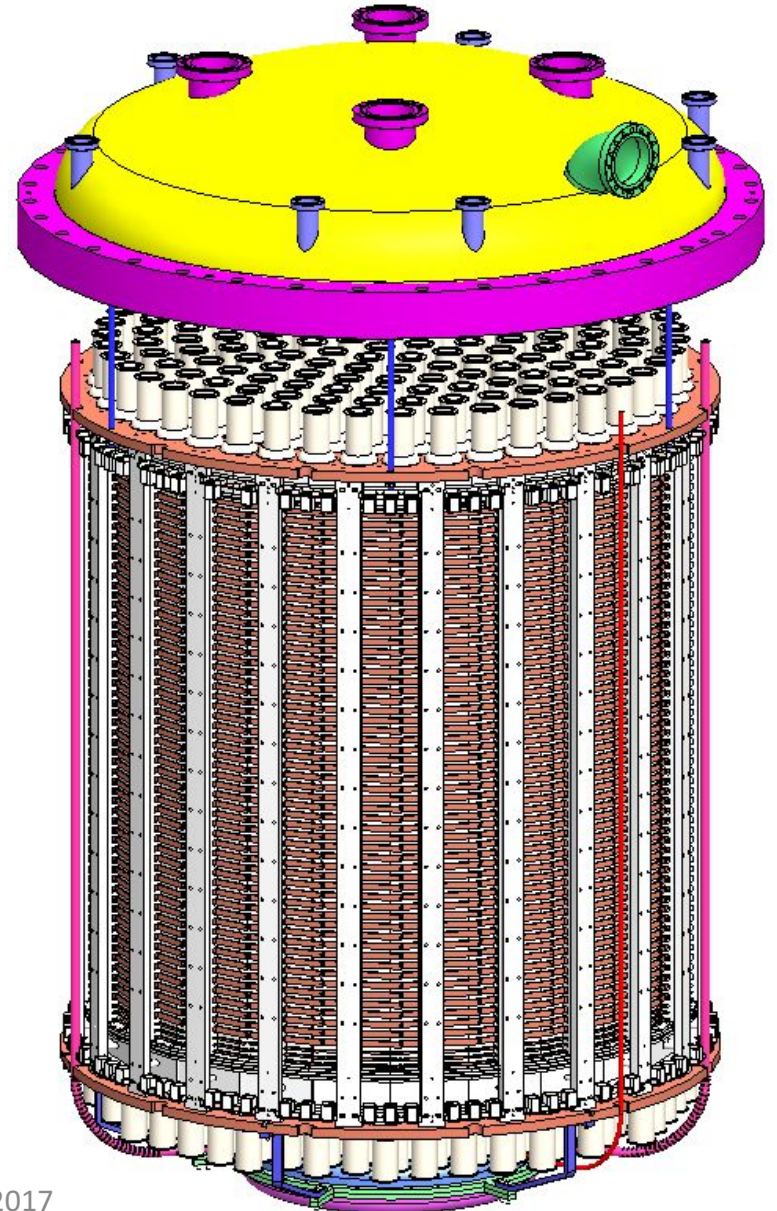
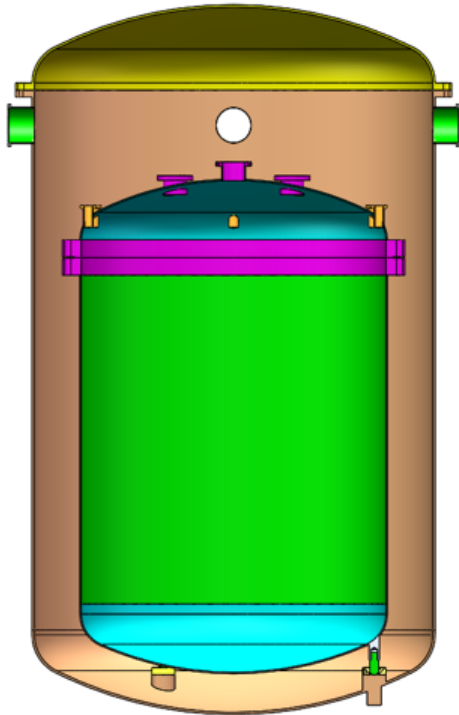


- Water Shielding
  - 5000Ton pure water
  - U/Th  $<10^{-14}$  g/g
- Rn ctrl.
  - $<1\text{mBq/m}^3$  in water;
  - $\sim 10\text{Bq/m}^3$  in the cave
- Fresh air



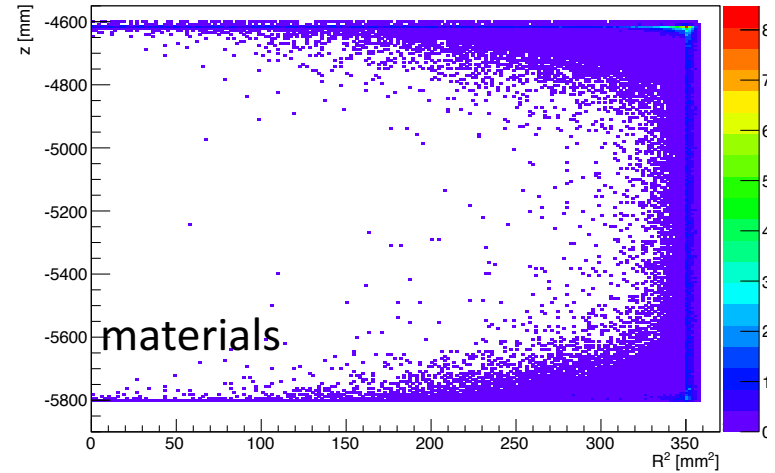
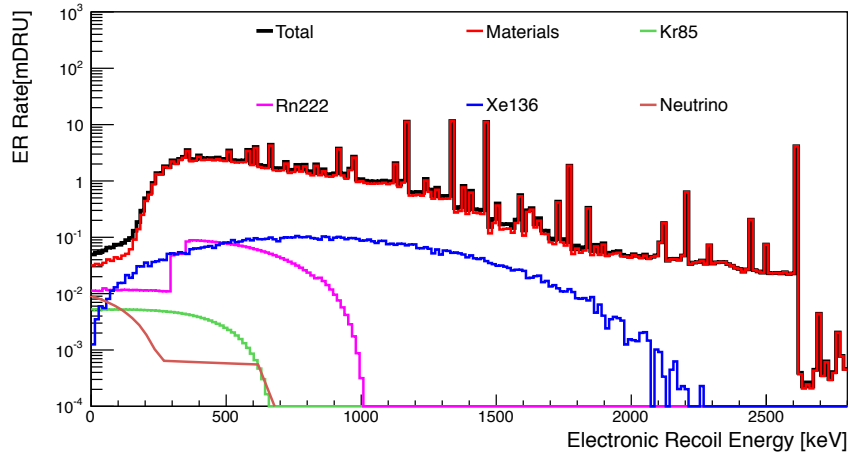
# PandaX-4T

- Drift region:  $\Phi \sim 1.2\text{m}$ ,  $H \sim 1.2\text{m}$ 
  - Xenon in sensitive region  $\sim 4\text{ton}$
  - $\sim 400$  3" PMTs
  - Skin detector for vetoing



# Background Simulation

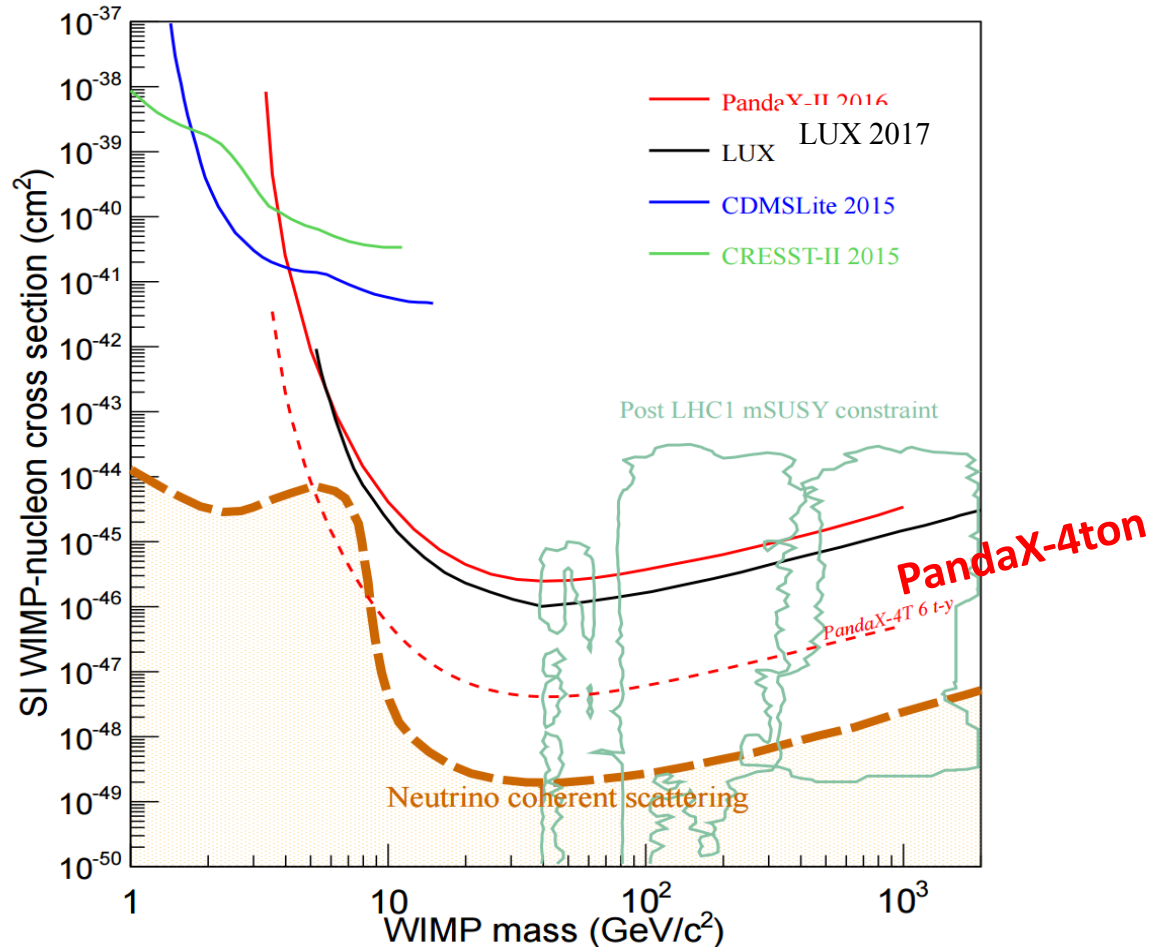
- Background from materials,  $^{222}\text{Rn}$ ,  $^{85}\text{Kr}$ ,  $^{136}\text{Xe}$  and neutrino



Background for DM search [0, 10 keV $_{ee}$ ]	mDRU
Electronic Recoil: materials	0.020
Electronic Recoil: $^{222}\text{Rn}$	0.011 (1 $\mu\text{Bq/kg}$ )
Electronic Recoil: $^{85}\text{Kr}$	0.005 (0.1 ppt)
Electronic Recoil: $^{136}\text{Xe}$	0.002
Electronic Recoil: Solar Neutrino	0.009
Total Electronic Recoil	0.047
Total Nucleus Recoil	$3 \times 10^{-4}$

# Expected Sensitivity

- With exposure of 6 ton-year, DM SI sensitivity could reach  $\sim 10^{-47} \text{cm}^2$



# Summary and Outlook

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- PandaX experiment with 500kg Xenon has reached the world frontier of dark matter direct detection.
  - Limits on SI and SD WIMP-nucleon cross sections were obtained.
  - Limits on solar axion and Galactic ALP were set recently.
  - PandaX-II continues data-taking smoothly.
- We are under preparation to the future PandaX-4T program.
- **Thank you!**