



李政道研究所
Tsung-Dao Lee Institute



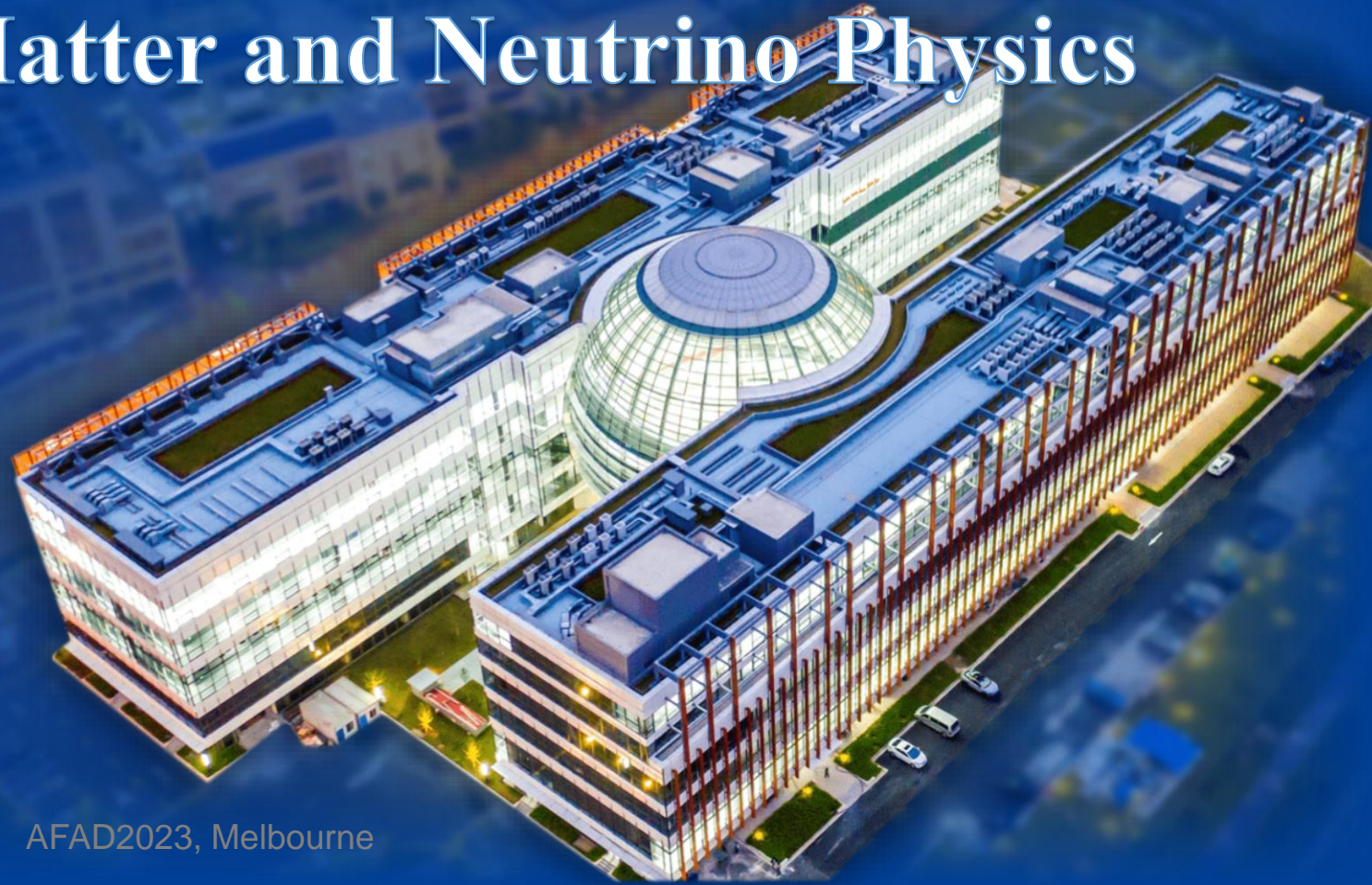
上海交通大學
SHANGHAI JIAO TONG UNIVERSITY

PandaX-4T - A Multi-Tonne Liquid Xenon Detector for Dark Matter and Neutrino Physics

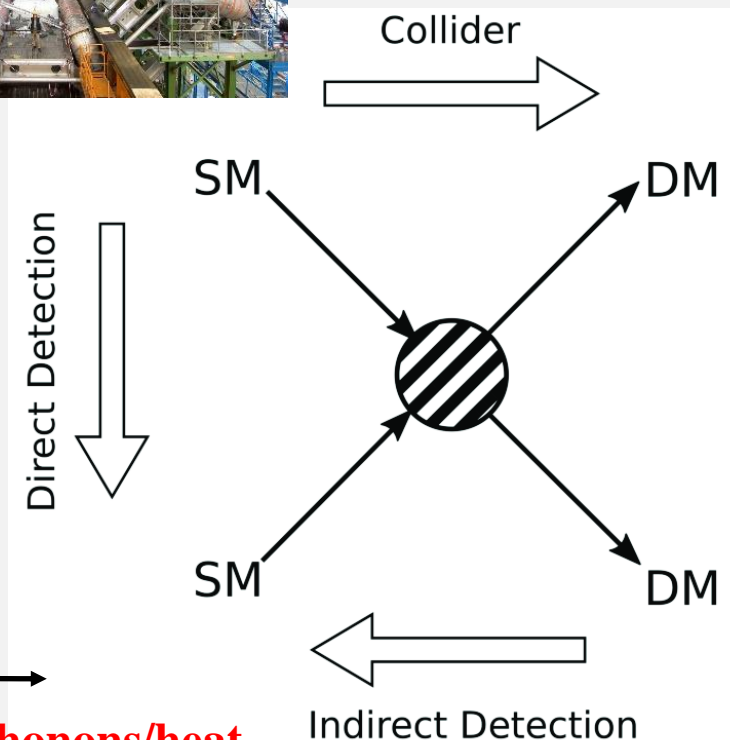
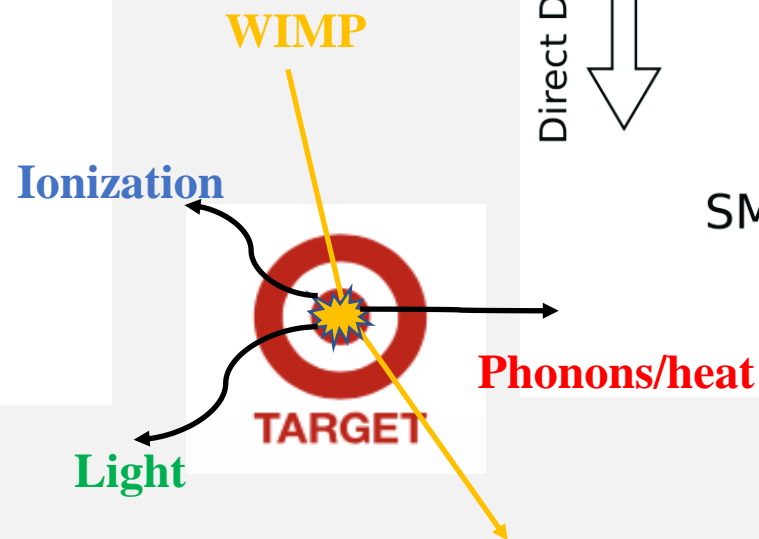
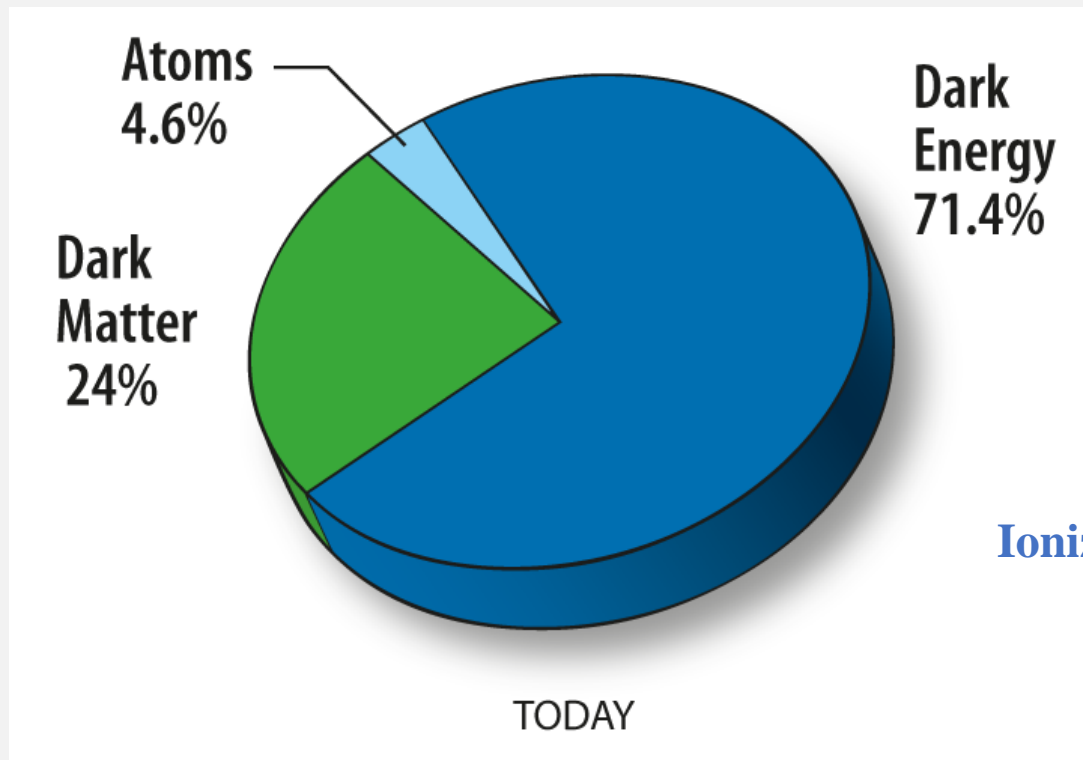
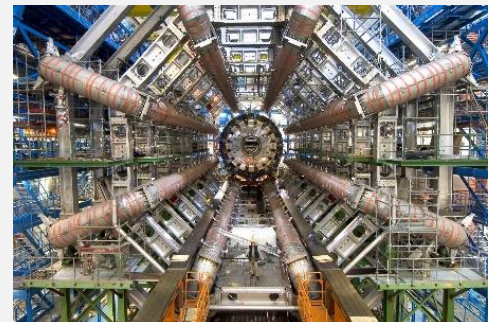
Xiangyi Cui (崔祥仪)

On behalf of the PandaX Collaboration

AFAD2023, Melbourne



Dark Matter Direct Detection

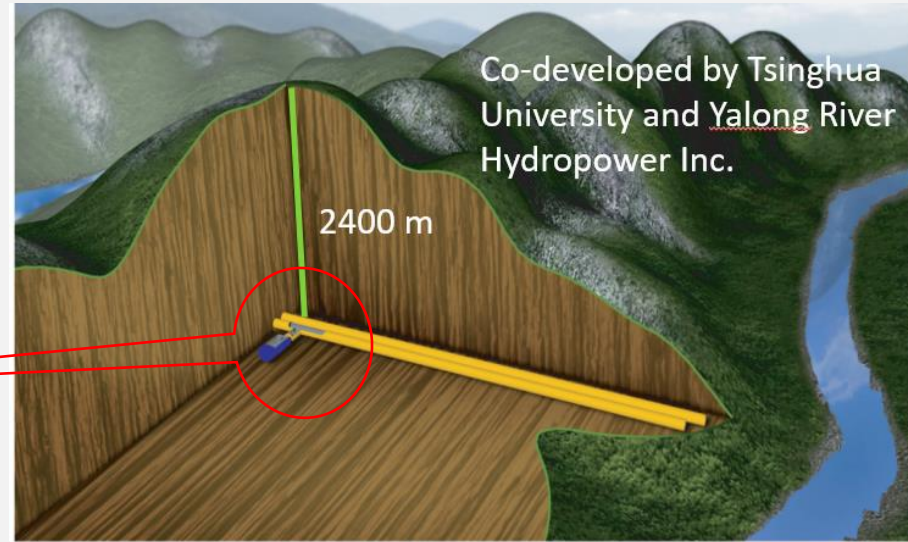
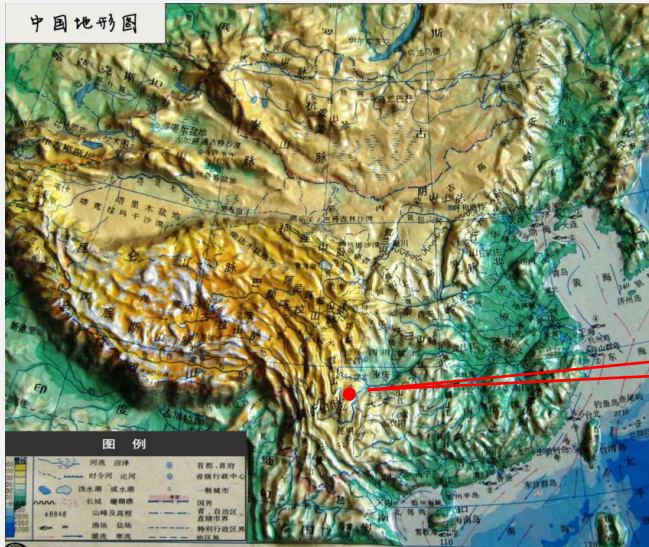


PandaX Collaboration

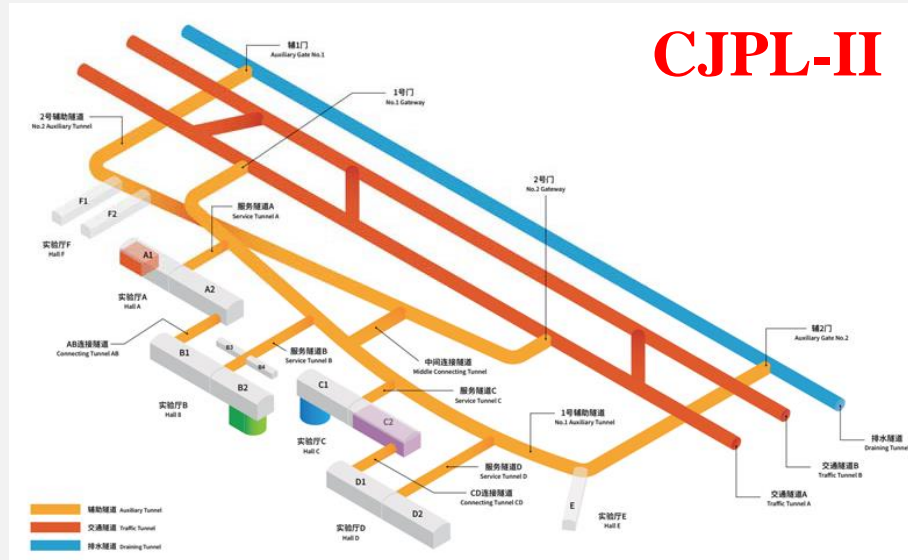
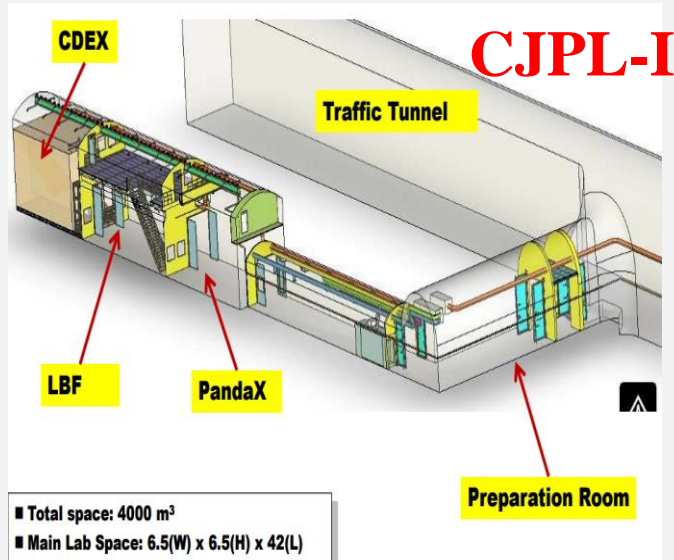


AFAD2023, Melbourne

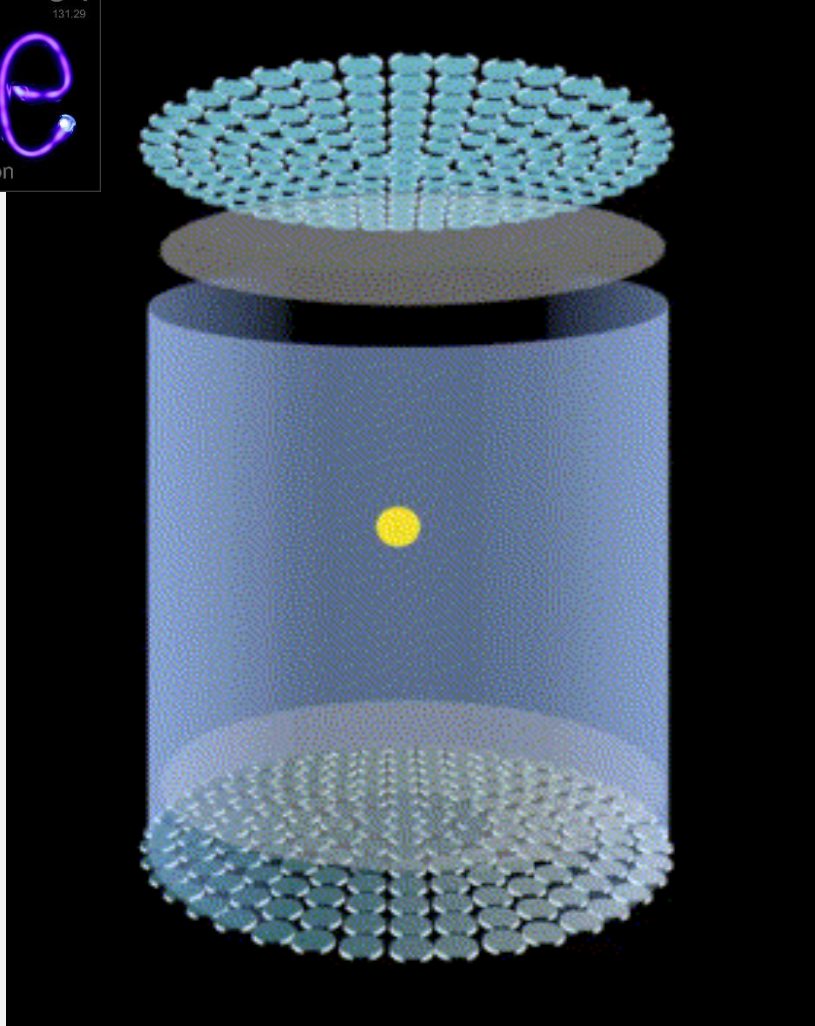
China JinPing Underground Laboratory – CJPL



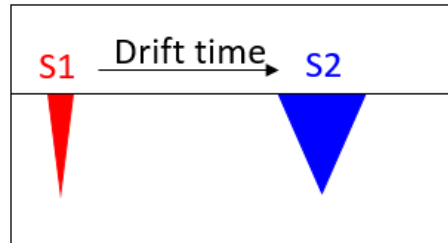
- Deepest (6800 m.w.e)
- Horizontal access
- Muon rate: 1 count/week/m²



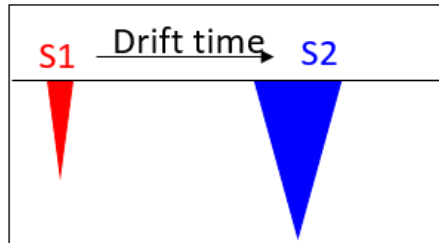
Dual Phase Liquid Xenon TPC



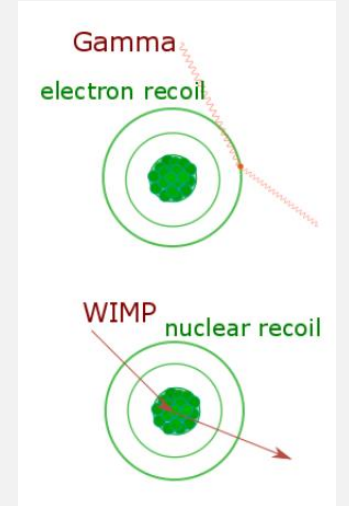
Dark matter: nuclear recoil (NR)



γ background: electron recoil (ER)



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



- Purity liquid xenon target, high light & charge yield;
- Good ER/NR separation by S1&S2;
- 3D reconstruction reject external background;

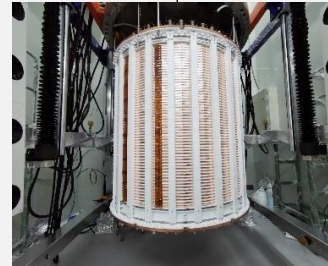
Collaboration formed



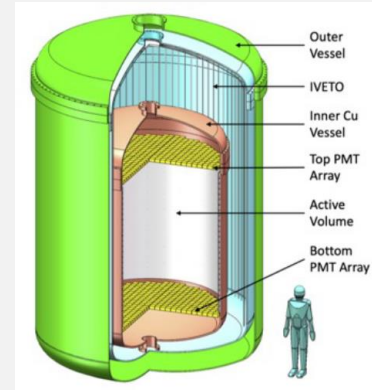
PandaX-II, 580 kg operation



PandaX-4T Commissioning



Ongoing



PandaX-xT



2009.3

2014.5-10

2016.7-2019.7

2019.8

2021.4

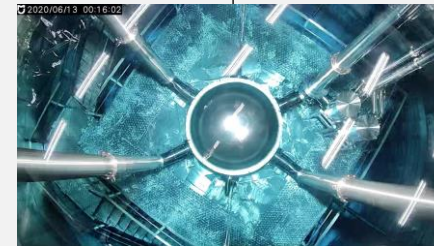
2021.11



PandaX-I, 120 kg operation

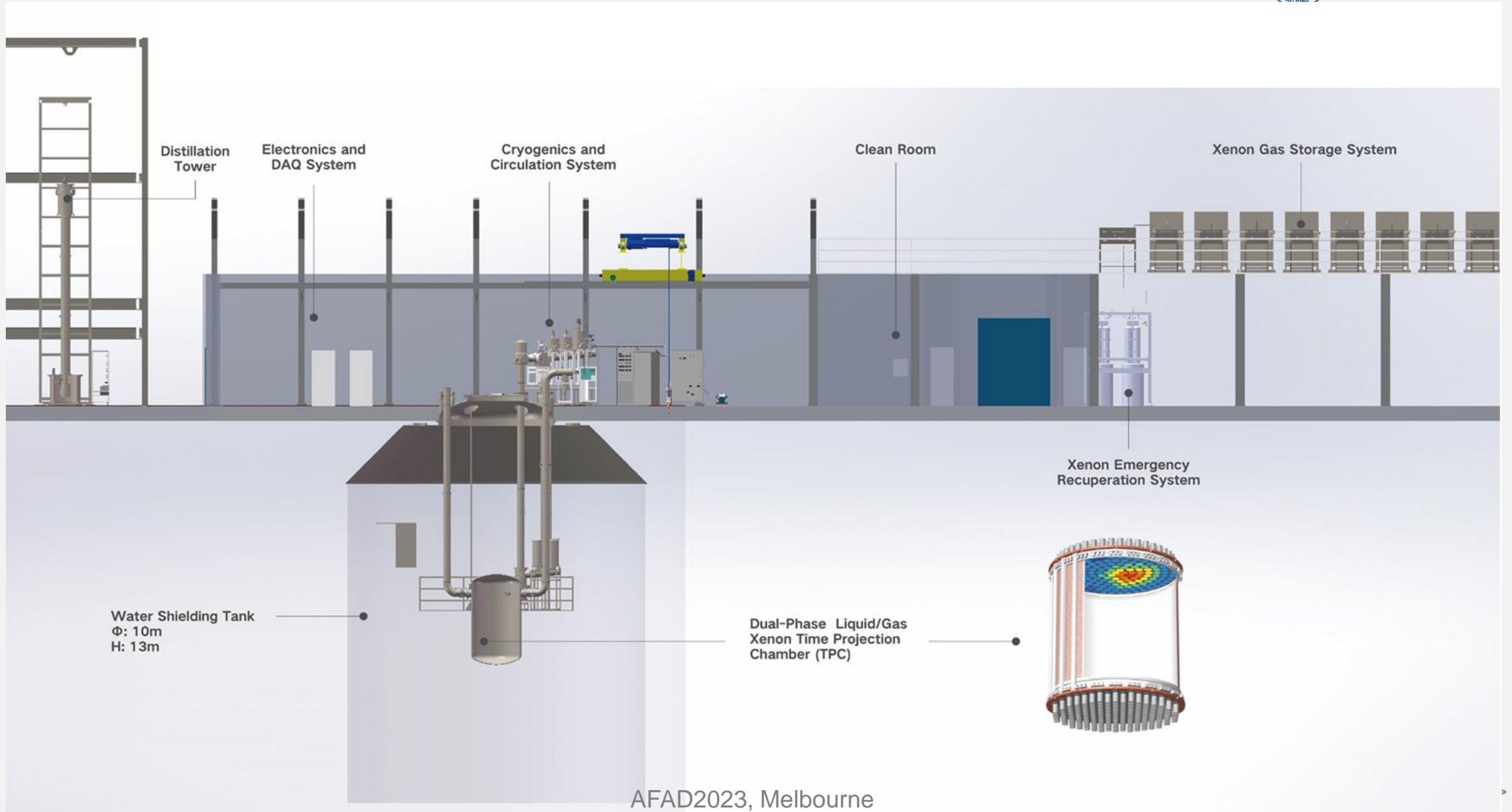


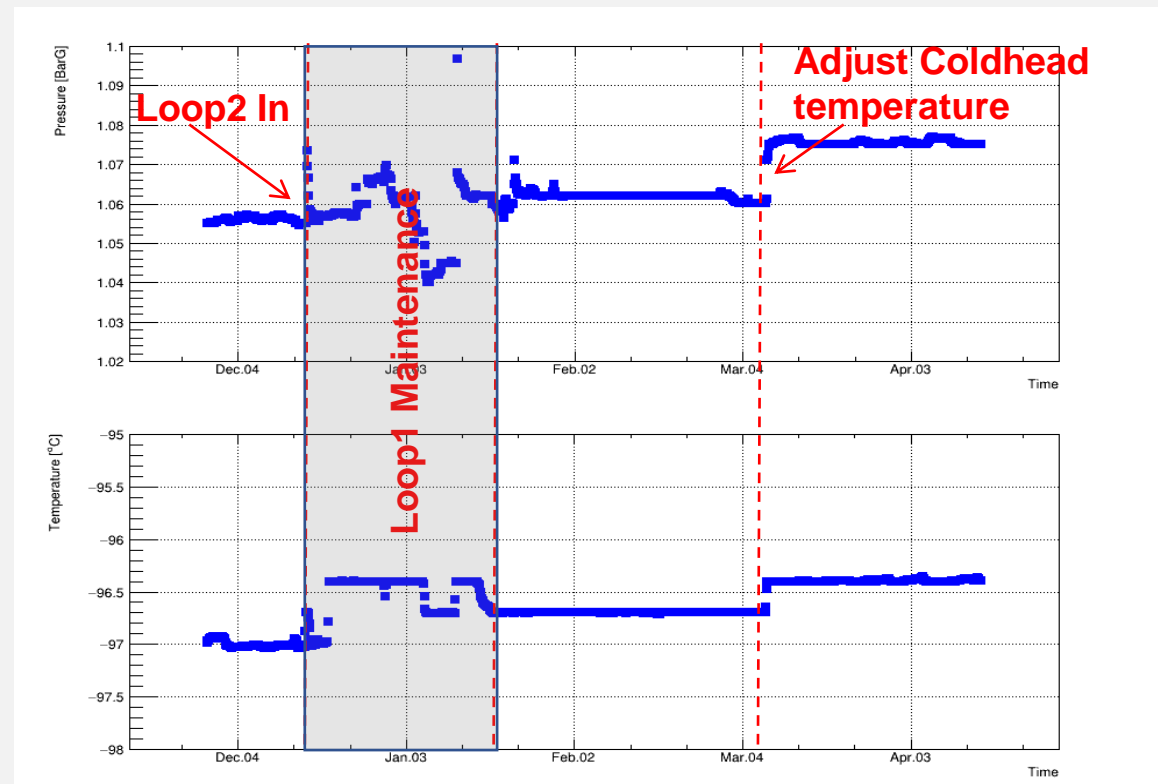
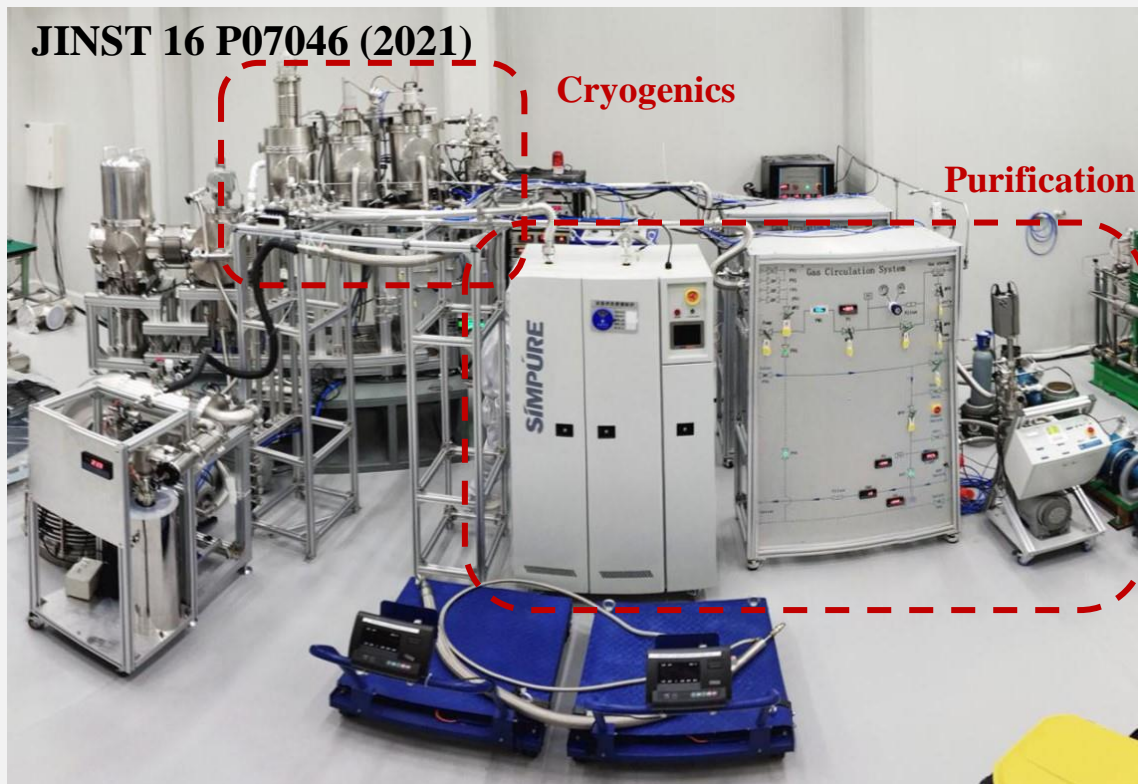
PandaX-4T moved to CJPL-II



PandaX-4T Run1

PandaX-4T Overview

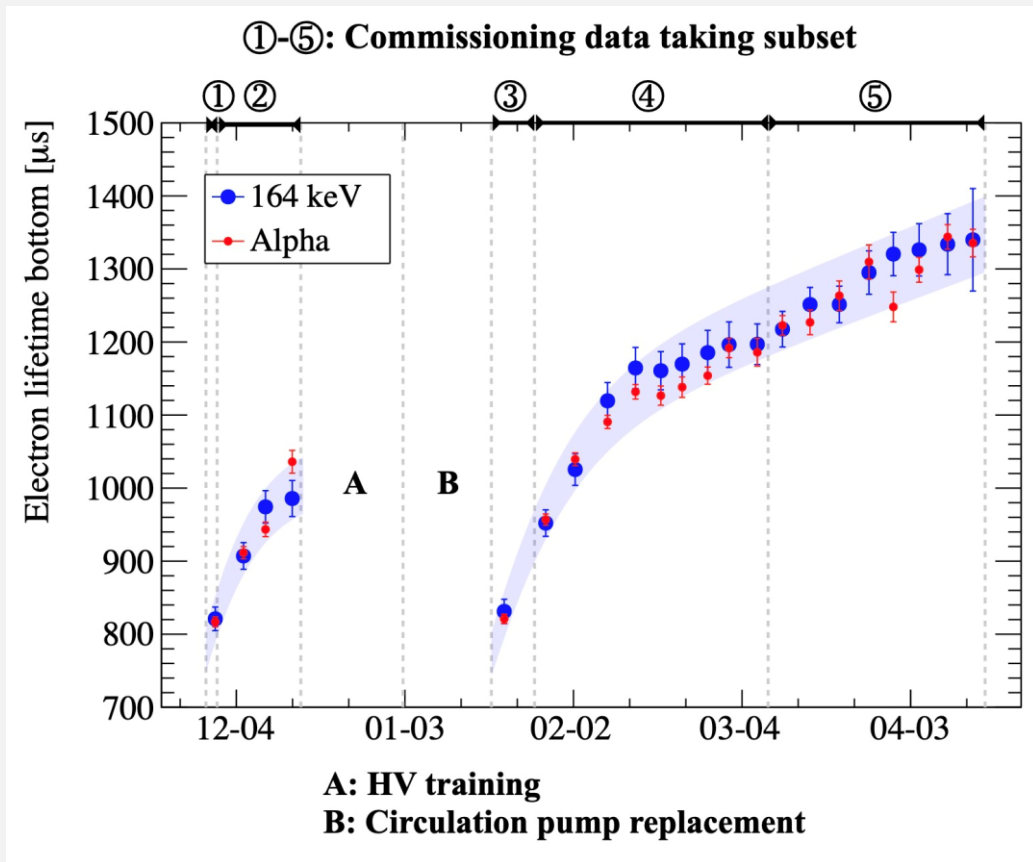




Parameters	Heating load (No purification)	Maximum Cooling Power	Filling/Recuperation flow rate	Outer Vacuum
Value	~50 W	~580 W	~1 ton/day	<2E-4 Pa

Purification system

NEXT



Ref. the maximum drift time $\sim 840 \mu\text{s}$

- Low Outgassing
- High flow rate

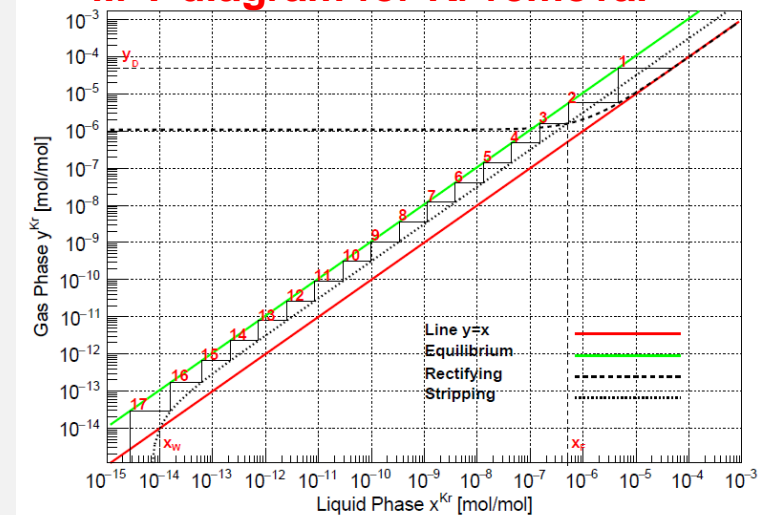
Distillation System



Structured packing



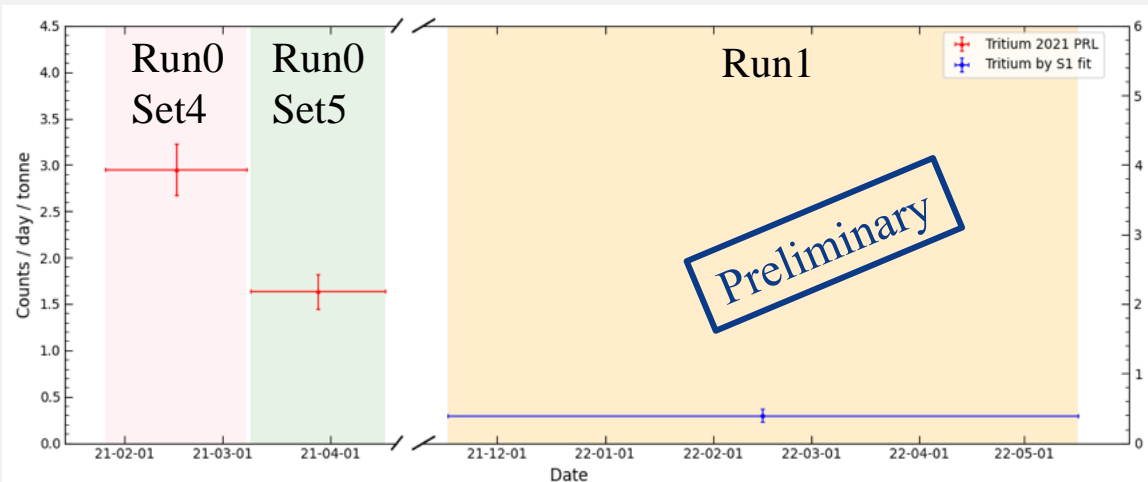
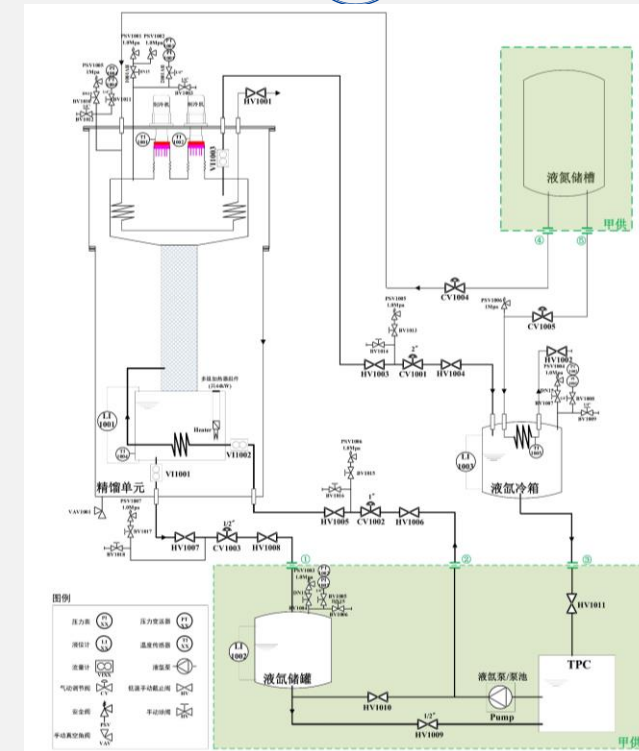
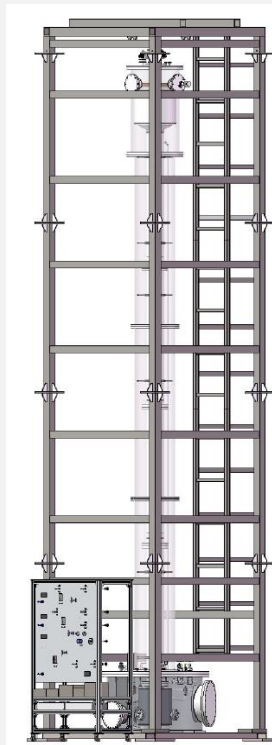
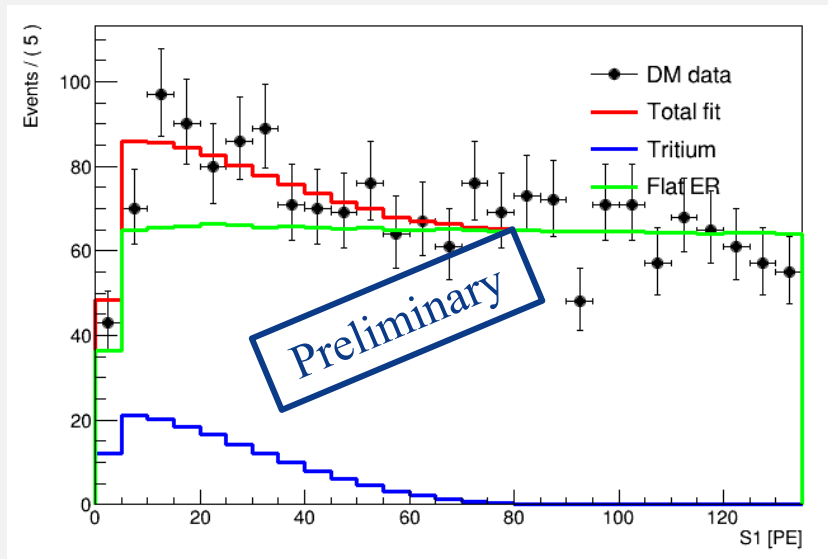
M-T diagram for Kr removal



- Distillation method for the LXe intrinsic background Kr&Rn removal;
- $\sim 10^6$ reduction factor for Kr removal with 10 kg/h;
- Reversed operation mode working for Rn removal;

Distillation

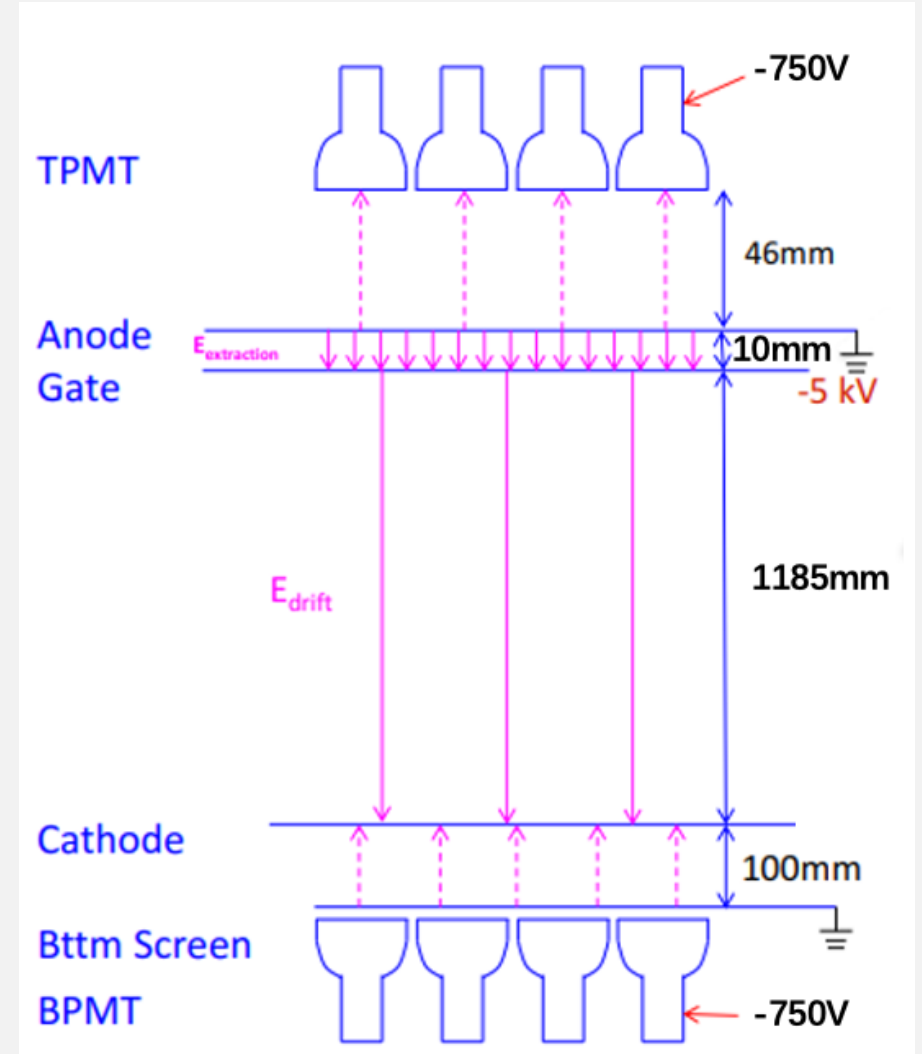
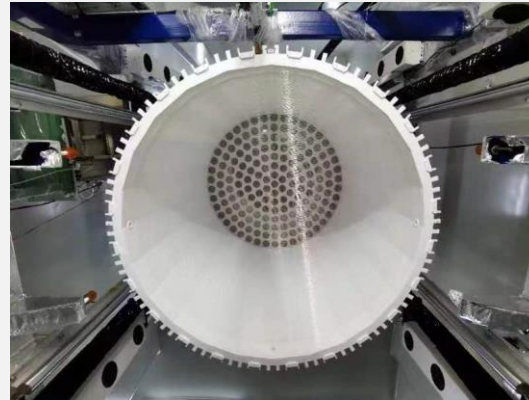
NEXT



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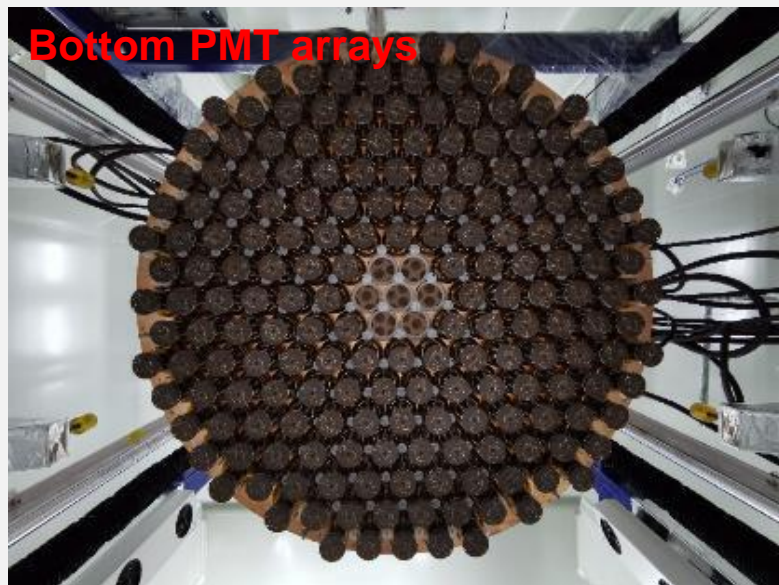
		PandaX-4T	Upgraded
Flow rate	Kr	10	30
	Rn	56.5	856
Reduction factor	Kr	10^6	10^8
	Rn	2.2	4.4

TPC conditions

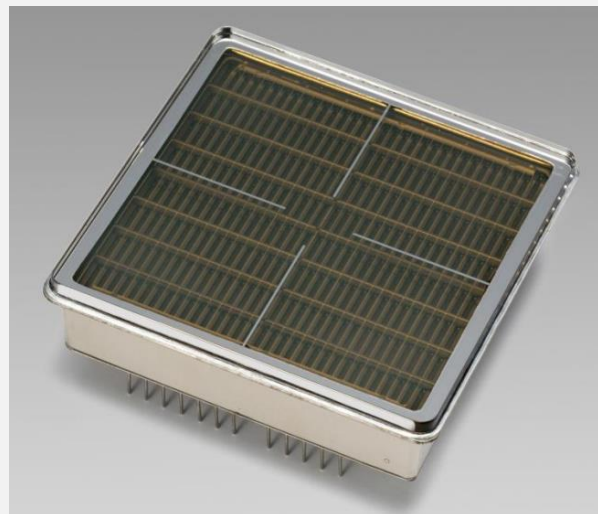


	Set1	Set2	Set3	Set4	Set5
Gate(kV)	-4.9	-5	-5	-5	-5
Cathode (kV)	-20	-18.6	-18	-16	-16

● PMT Arrays



NEXT

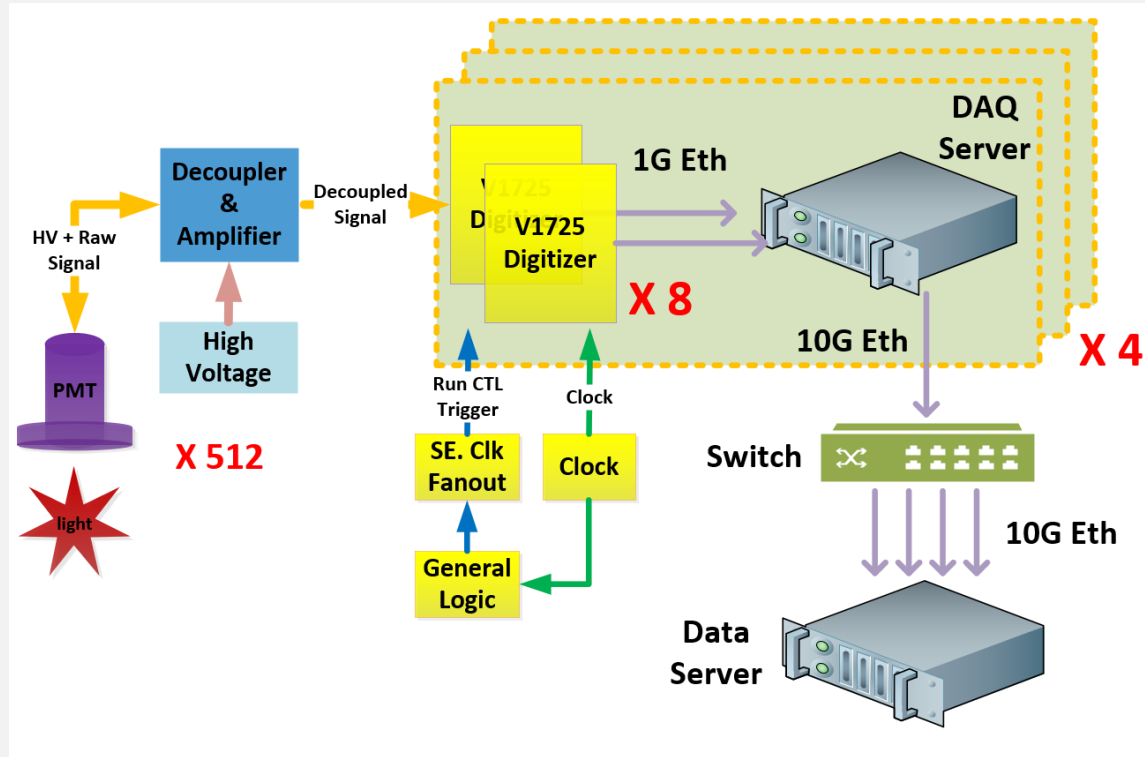


- R12699 2-inch PMTs with 4 independent anode readout;
- Better time response for better waveform build;
- Lower radioactivity;

- 169 top + 199 bottom R11410-23 3-inch PMTs, with the average gain of 5.5×10^6 ;
- LED calibration every week;

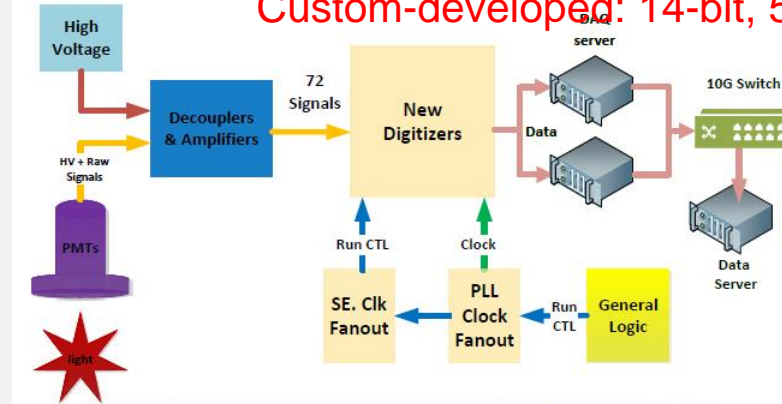
		R11410	R12699
Time Response [ns]	Rise Time	5.5	1.2
	Transit Time	46	5.9
Radioactivity [mBq/pc]	Co-60	1.16±0.72	0.00±0.04
	Th-232	4.33±2.16	0.13±0.17
	U-238	26.29±16.90	0.00±0.62

NEXT



- V1725 Digitizer, 250 MS/s;
- Self-trigger mode: read out pulses above 20 ADC (~ 1/3 PE);

Custom-developed: 14-bit, 500MS/s



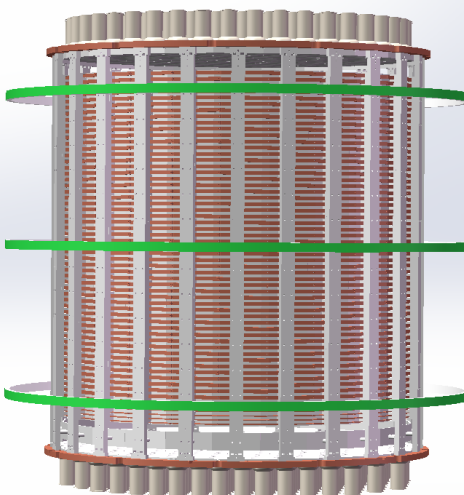
- Higher sampling rate;
- Accept out-trigger mode;

● Calibration

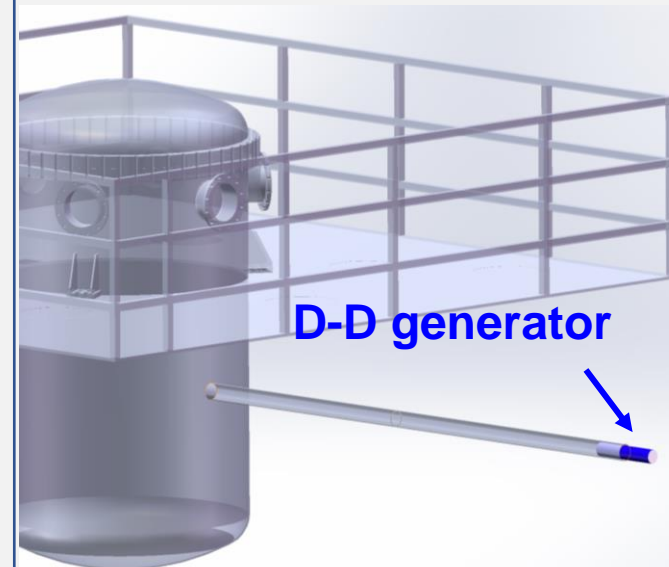
Gaseous source injection panel



Calibration tubes



D-D generator



Calibration source

$^{83m}\text{Kr}/^{220}\text{Rn}$

$^{241}\text{Am-Be}$

D-D neutron

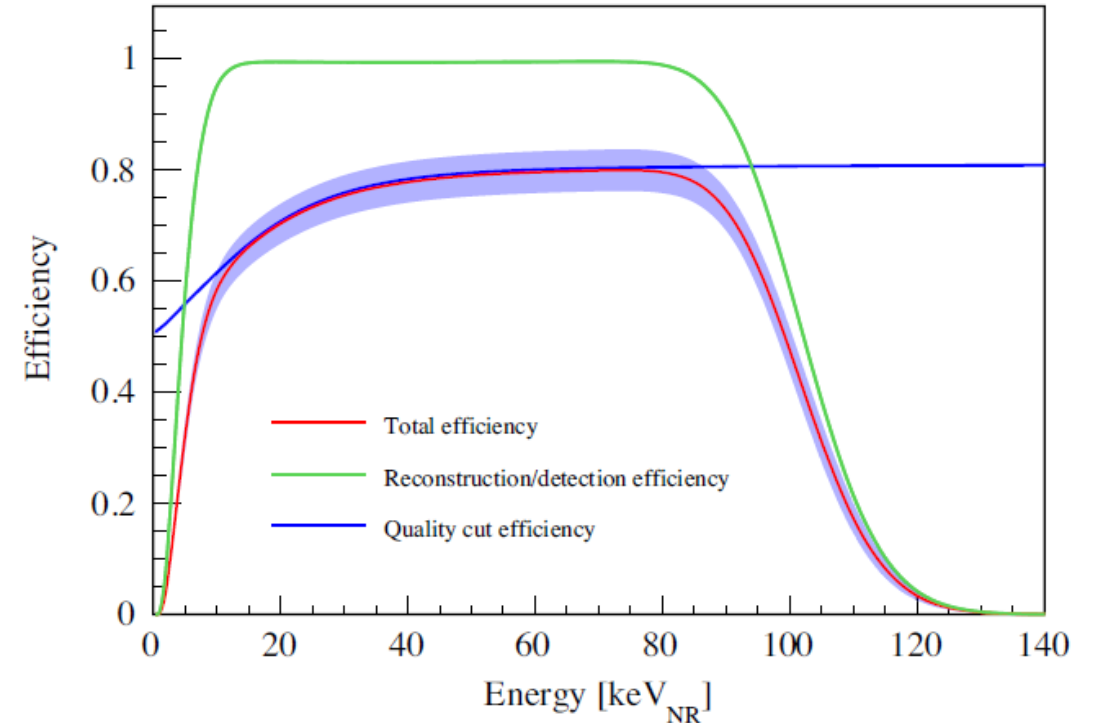
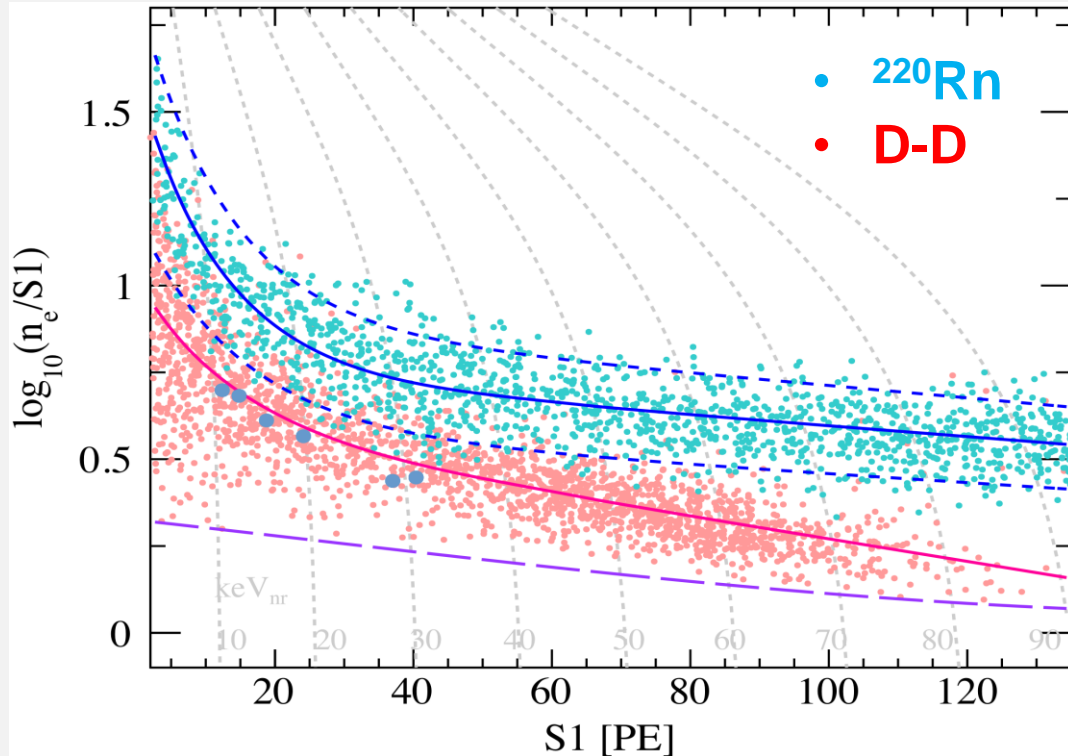
Position

Injected from gas panel

Calibration tubes

Beam pipe

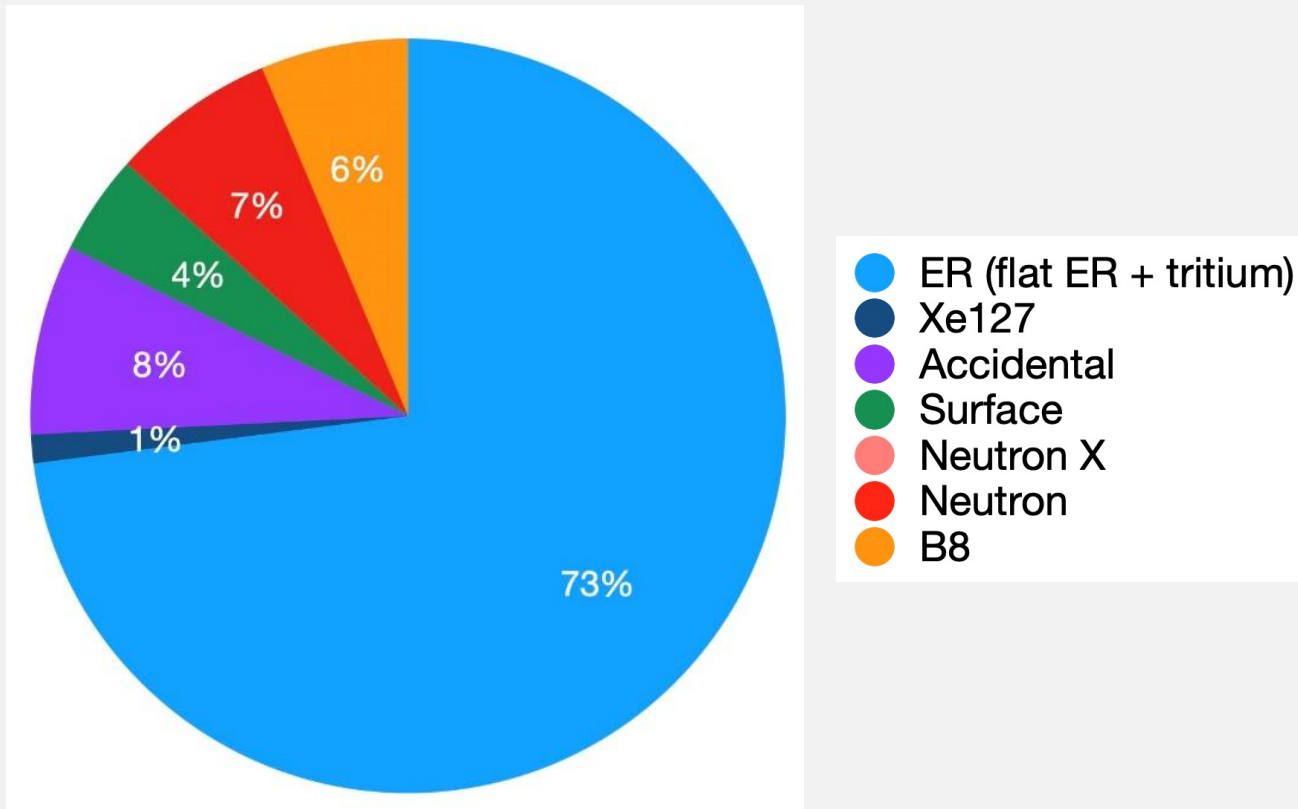
Detector Response



- ER leak ratio (below NR median curve) is $0.43\% \pm 0.18\%$;
- Efficiencies separately determined from ER or NR calibration data are all consistent;

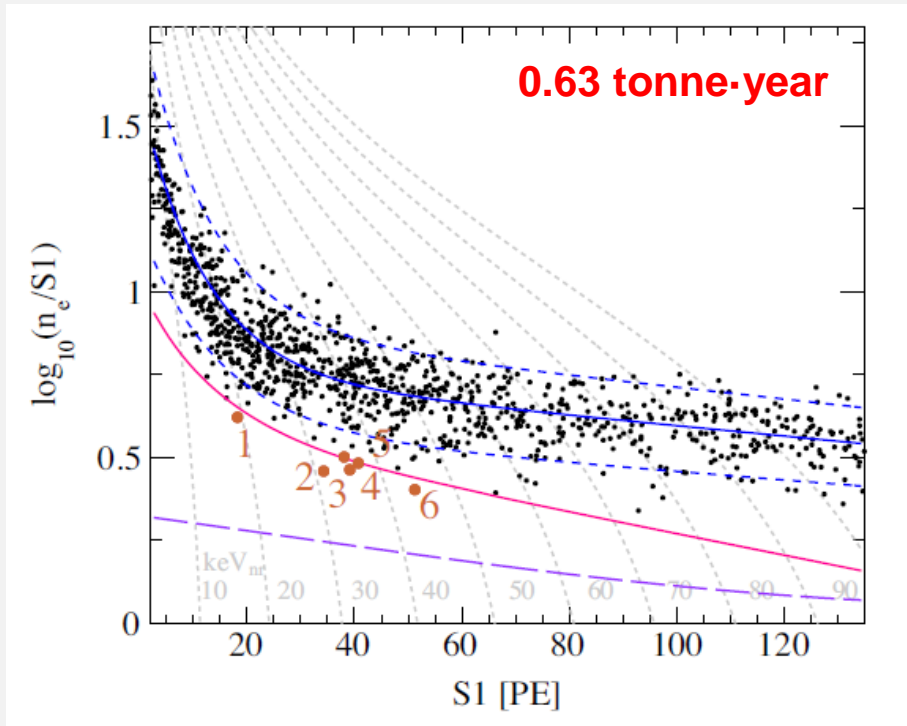
Background

Expected below-NR-median
events: 9.8 (0.6) evts

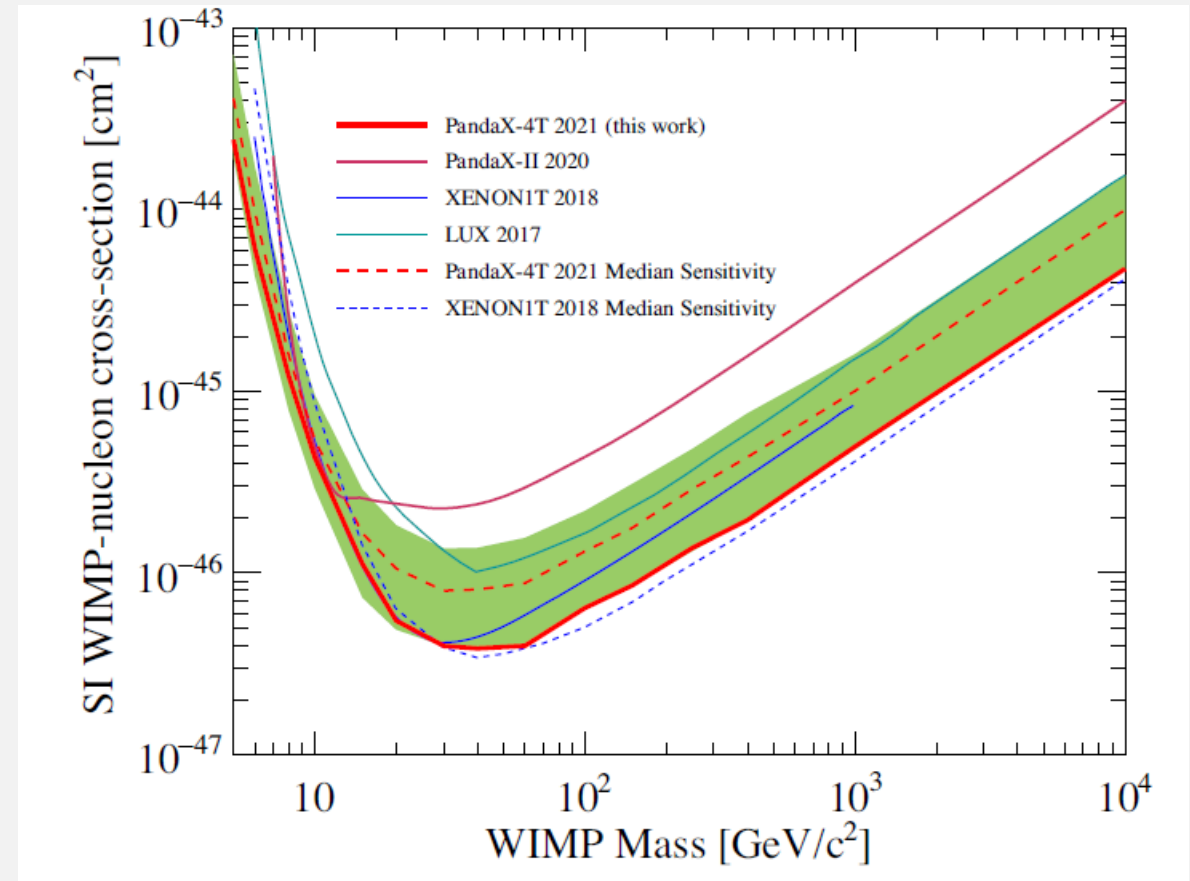


- ER (Rn+Kr+Material+Tritium) background dominated in the selection region;
- Background per unit target is improved from PandaX-II by 4 times (<10 keV);

PandaX-4T first commissioning Result - WIMPs



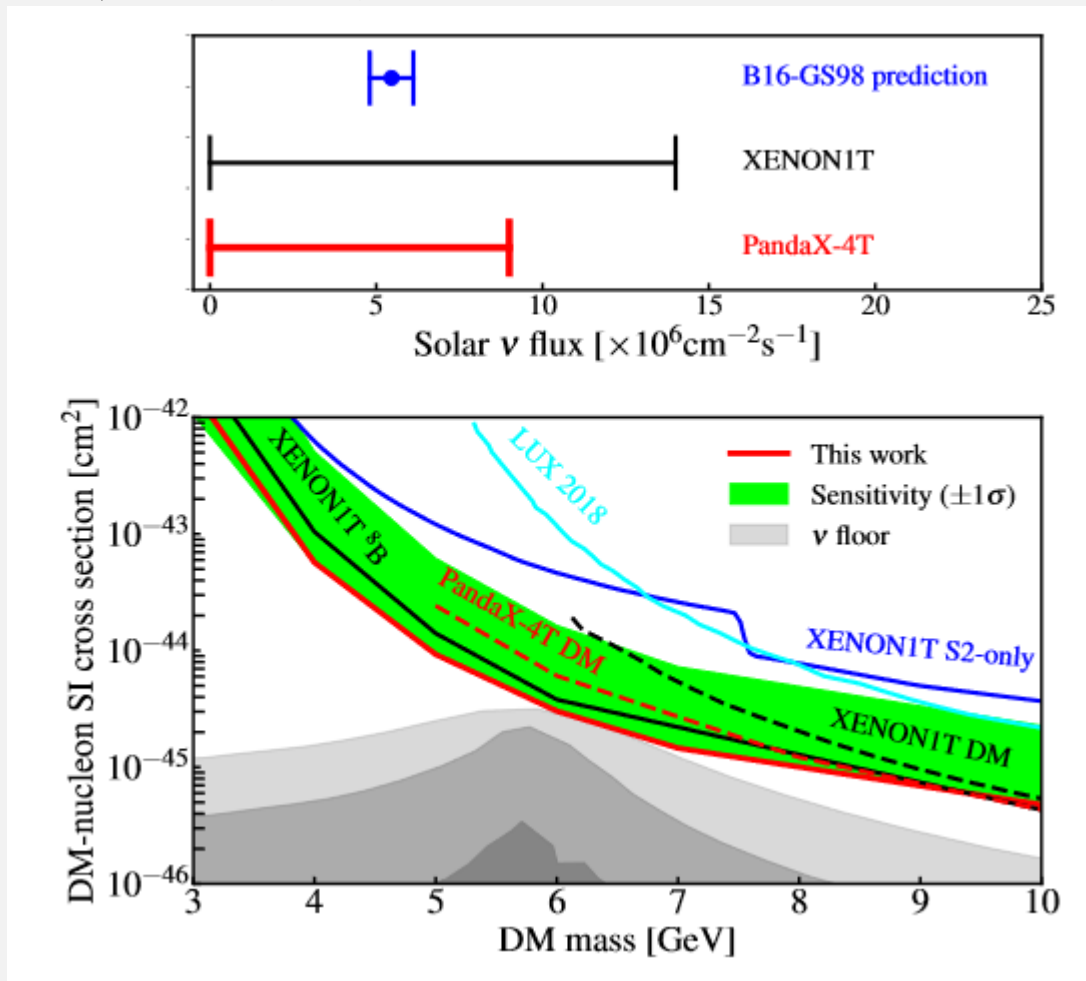
PRL 127, 261802 (2021)



- 1058 candidates (expected 1054 ± 39), 6 below NR median curve (expected 9.8 ± 0.6);
- Sensitivity improved from PandaX-II final analysis by 2.9 times (30 GeV/c²);

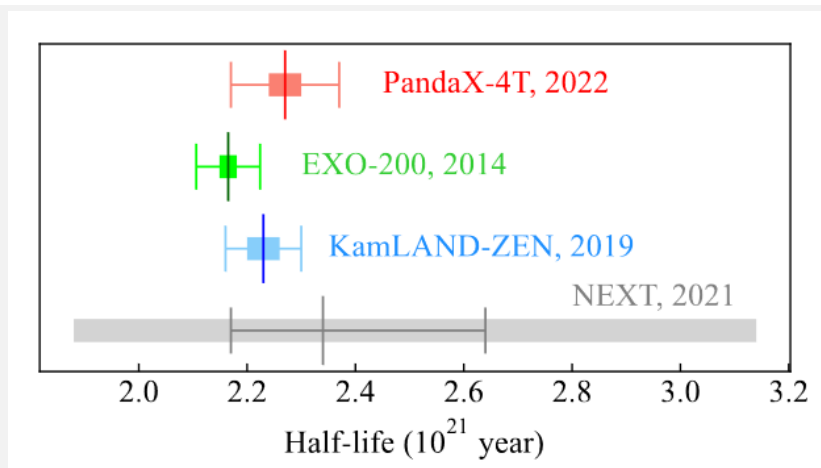
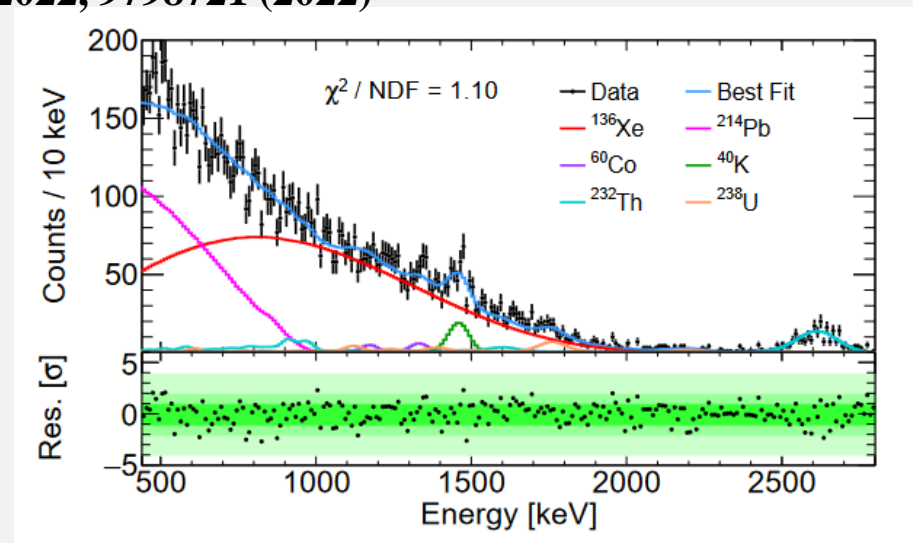
Solar Neutrino – ^8B

PRL 130, 021802 (2023)



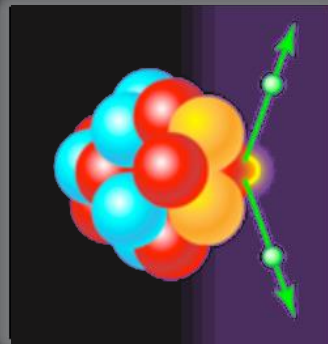
Neutrino double beta decay – ^{136}Xe

Research 2022, 9798721 (2022)

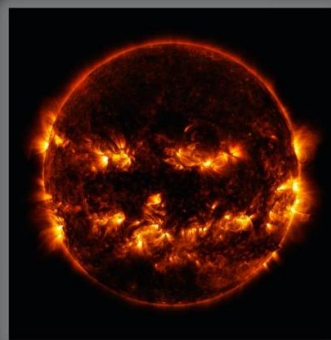


● NEXT - PandaX-xT

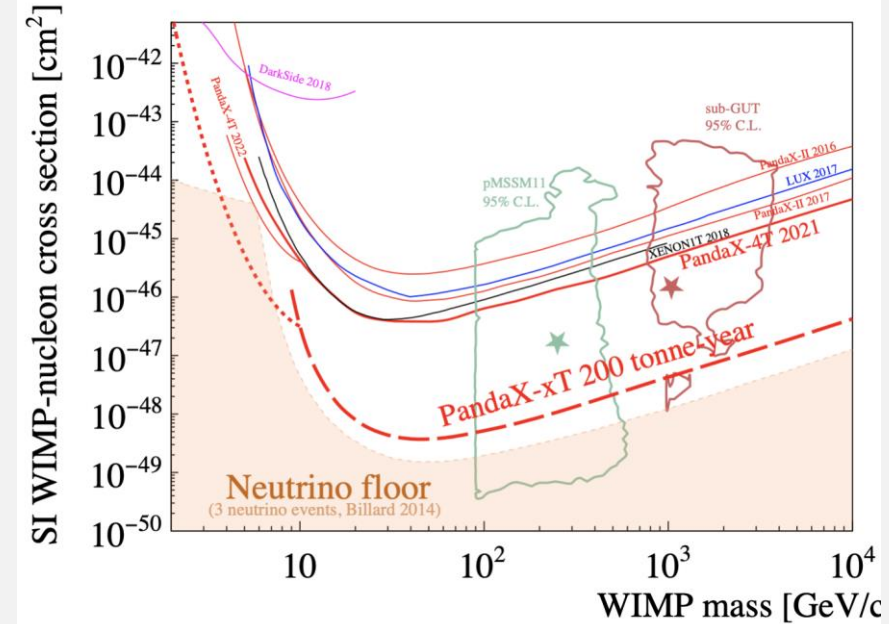
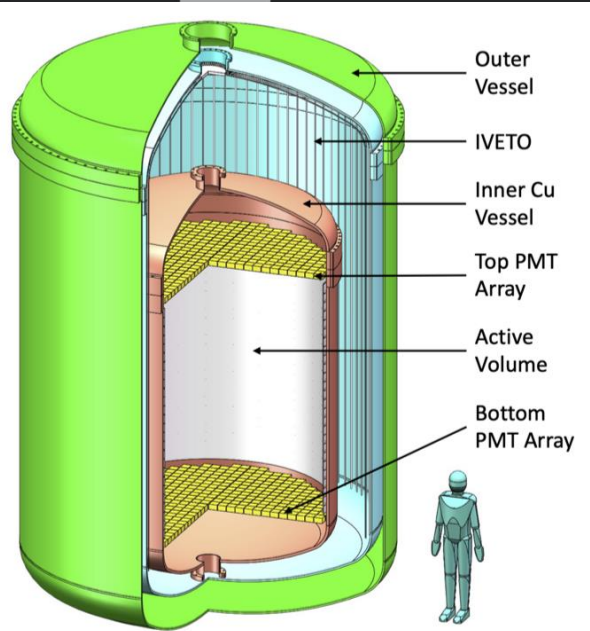
Dark Matter
1 keV – 10 keV



Majorana neutrino
> 2 MeV



Astrophysics neutrino < 300 keV



- With >30 tonne liquid xenon in the sensitive volume;
- Decisive test on WIMP and key test on Dirac/Majorana neutrino;

● Summary and outlook

- PandaX-4T is one of the new generation multi-tonne xenon experiments (operation until 2025);
- Intense searches for various types of physics, including DMs and neutrinos;
- In parallel, the collaboration is developing the plan for the next generation experiment at CJPL;
- Highly welcome new collaborators!



—— 谢谢! ——

