



Lastest progress on the PandaX-4T and PandaX-20 experiment

Xiangyi Cui *on behalf of the PandaX collaboration*

2026/07/16



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PandaX - Particle and Astrophysical Xenon Experiments



- 16 institutions, >100 collaborators
- Located at CJPL, deepest with 2400m overburden

PandaX initiated



2009

PandaX-I
120 kg



2010-2014

PandaX-II
580 kg



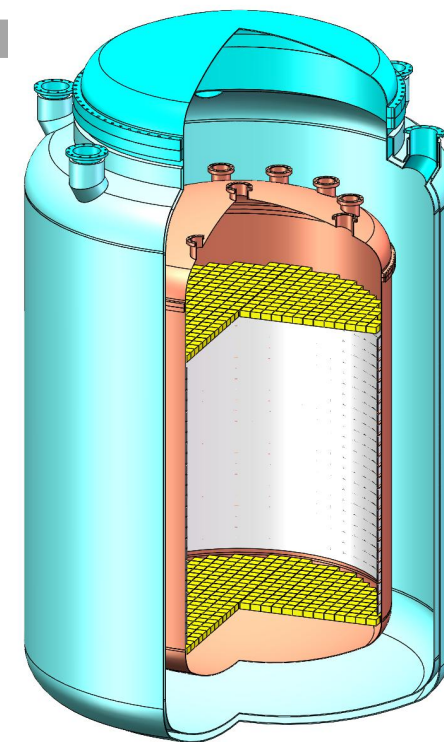
2015-2019

PandaX-4T
3.7 tonne



2020-2026

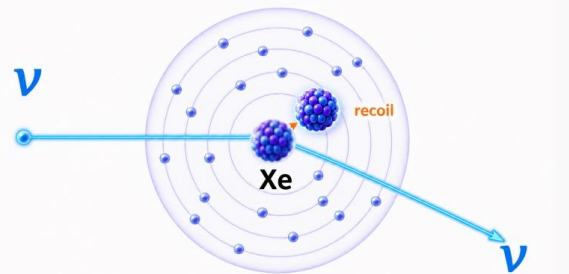
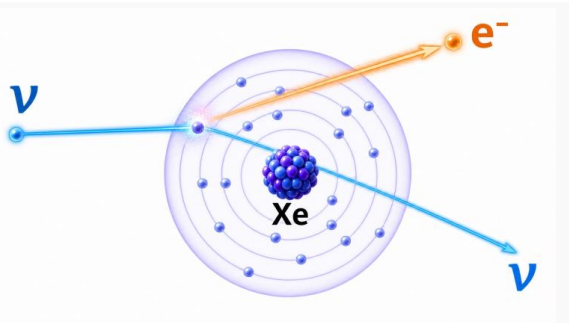
PandaX-xT
20 tonne -> 47 tonne



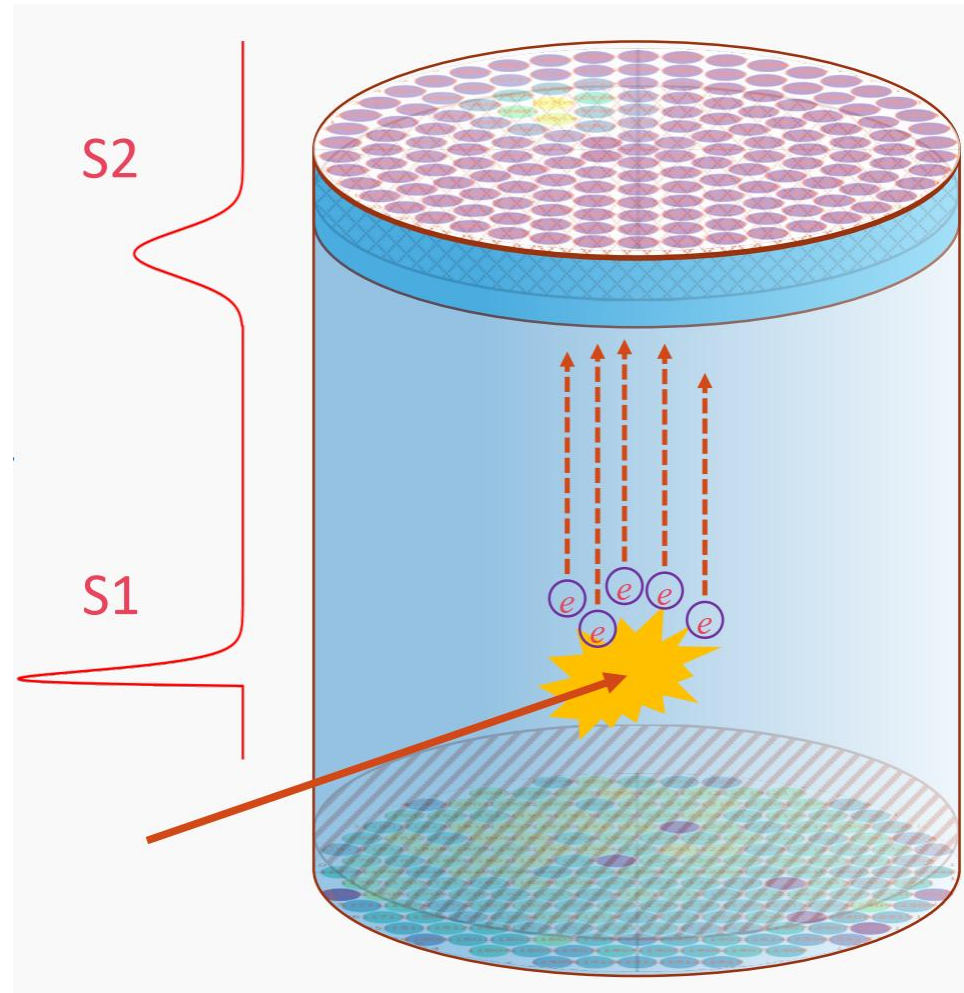
2027-

Dual phase xenon time projection chamber

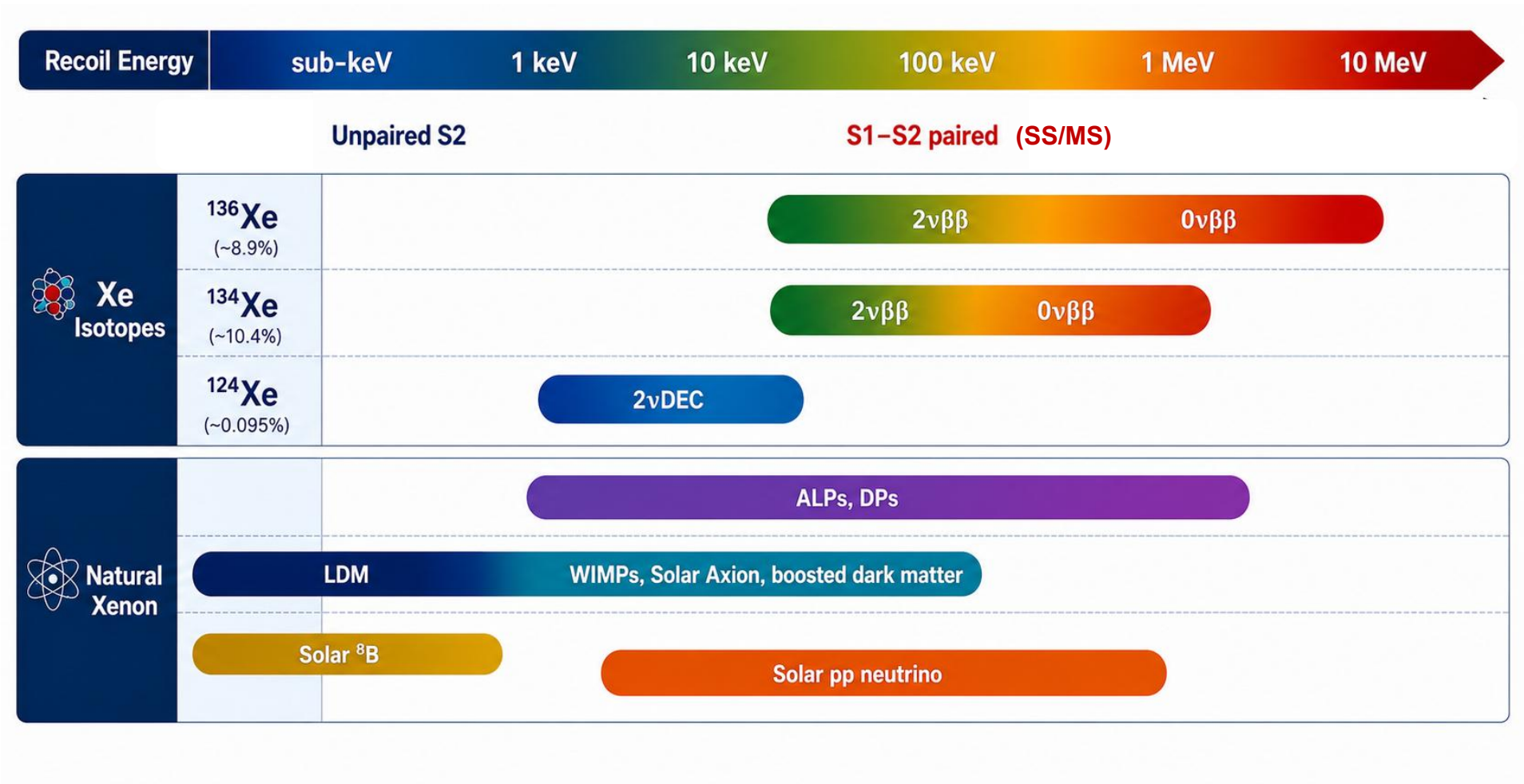
ER



NR

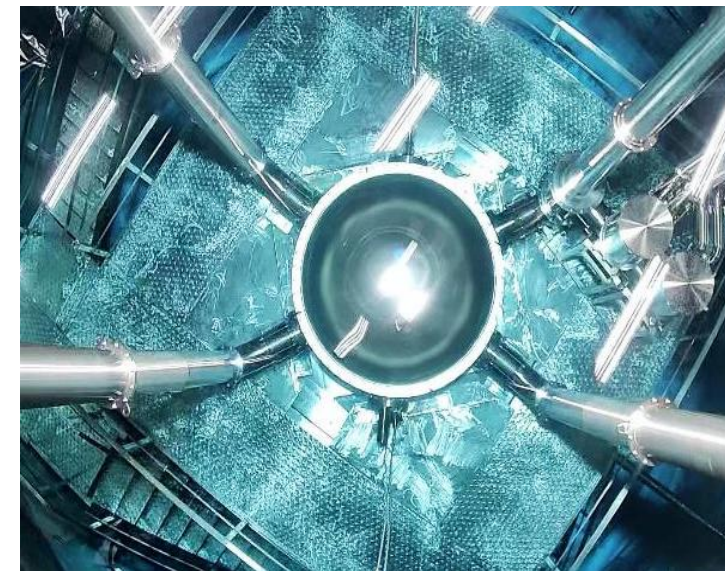


- Prompt scintillation signal (*S1*) followed by drift electron signal (*S2*)
- Measured the 3D position, energy and time
 - *S2/S1* ratio for the *ER* and *NR* discrimination
 - Ability for the Single-Site (*SS*) or Multi-Site (*MS*) event tagging



Timeline of PandaX-4T data taking

2020/11 -	Commissioning (<i>Run0</i>) 95 days
2021/07 -	Tritium removal
2021/11 -	Physics Run (<i>Run1</i>) 165 days
2022/09 -	CJPL B2 hall renovation
2023/12 -	Physics Run (<i>Run2</i>)
2024/01 -	Physics Run (<i>Run2</i>)
2026/04	
Current Status	Shut down at Apr. 15th



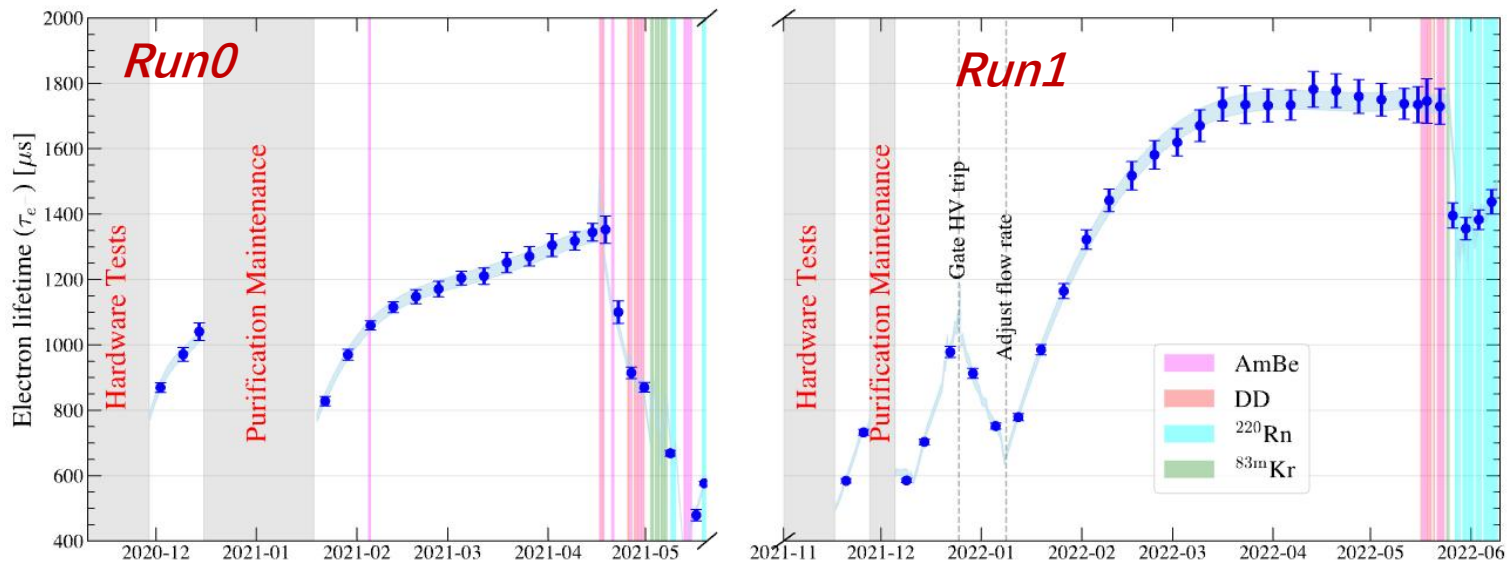
- 5.6-tonne LXe in total
- 169 top / 199 bottom 3-inch PMTs
- Ultrapure water shielding with VETO system

Run0&Run1 physics data



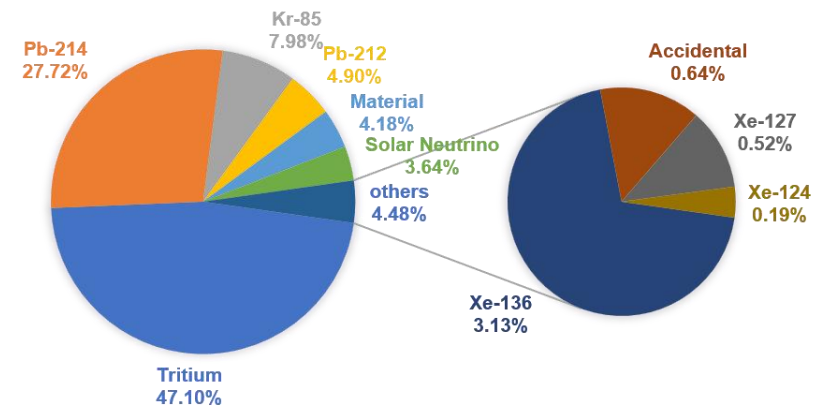
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Electron lifetime evolution

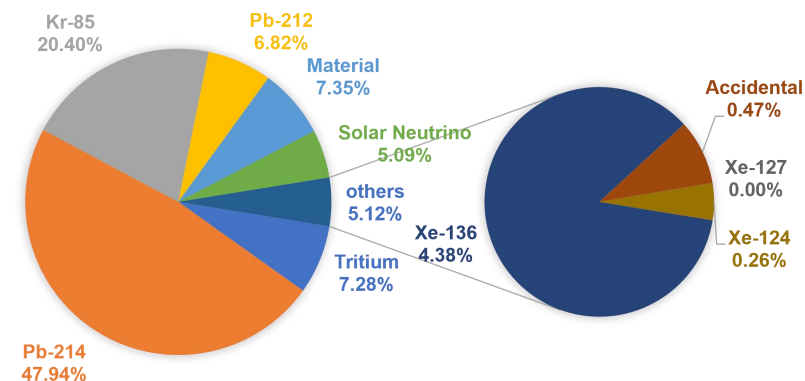


- Tritium dominate in *Run0*
- After the tritium removal, ^{214}Pb and ^{85}Kr are the dominant BKG components in *Run1*

Run0



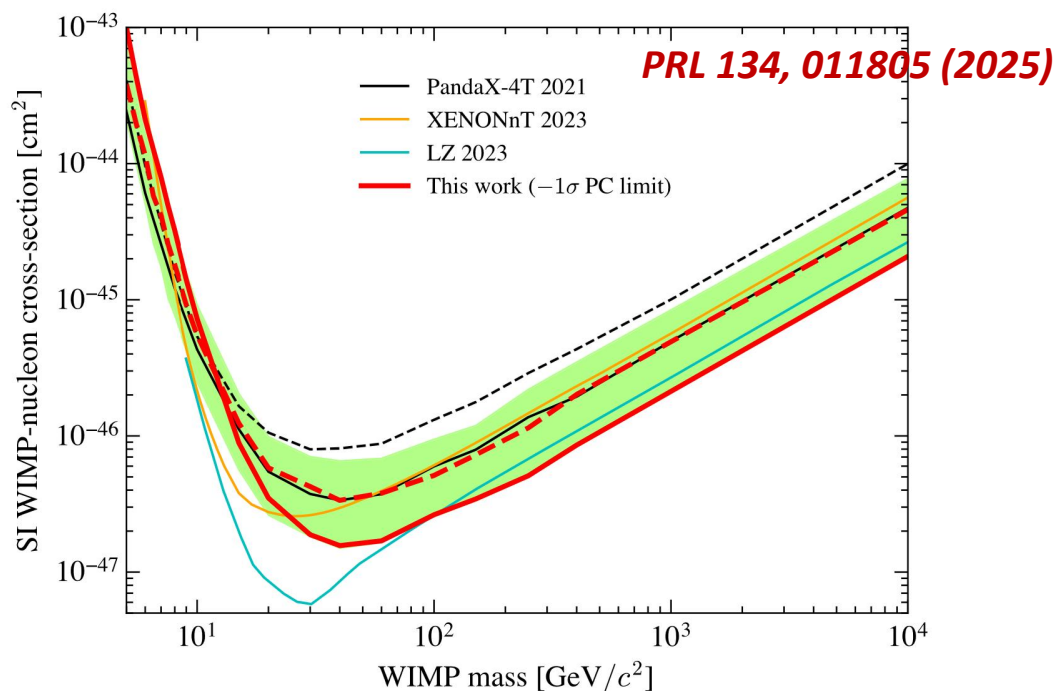
Run1



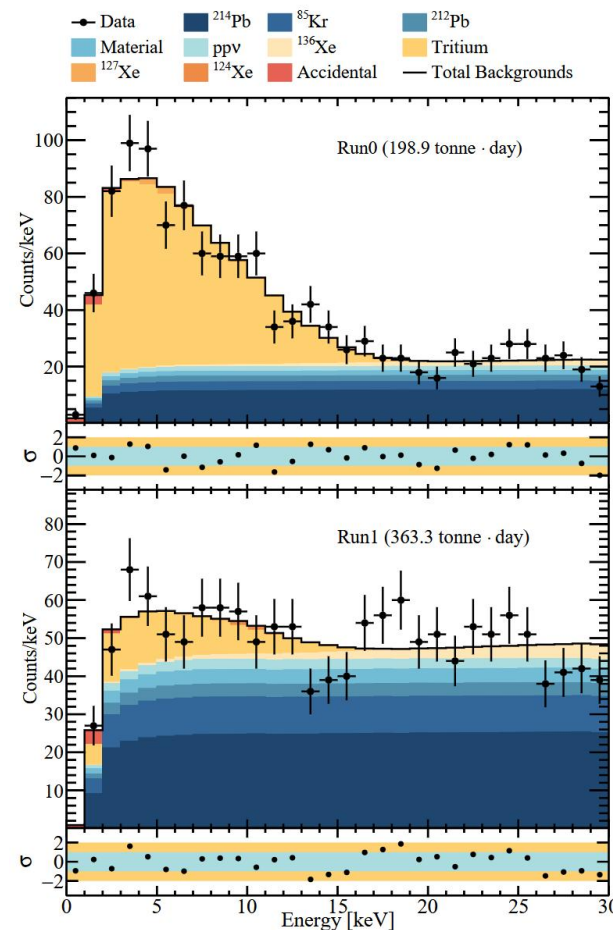
ROI: $S1 > 2\text{PE}$, $E_{\text{rec}} < 30\text{keV}$, ER 99.5% acceptance

O(10keV) - WIMP, Axion

- Total **1.54 tonne*year** exposure with *Run0&Run1*
- *ROI* for WIMPs search: $S1 \sim [2, 135] \text{ PE}$, $S2 \sim [120, 20000] \text{ PE}$
- Excluded value of **$1.6 \times 10^{-47} \text{ cm}^2$** at **40 GeV/ c^2**

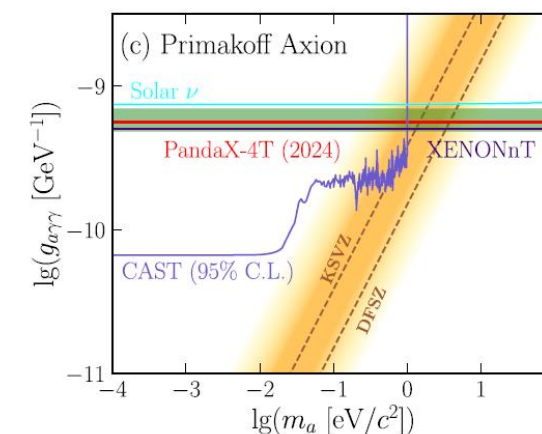
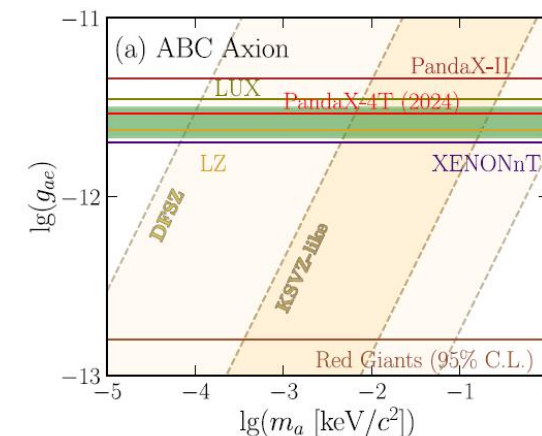


PRL 134, 041001 (2025)



- **<30 keV_{ee}** data are studied, consistent with the bkg-only model with a p value of 0.16
- For Solar axion, ALPs, Solar boosted DM, Cosmic ray boosted DM, etc.

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PRL 133, 191001 (2024)



Top Panel: Solar ^8B ν flux constraints

The top panel shows constraints on the Solar ^8B ν flux in units of $\times 10^6 \text{cm}^{-2} \text{s}^{-1}$. The x-axis ranges from 0 to 25. The y-axis represents the flux. The constraints are as follows:

- B16-GS98 prediction:** A blue vertical line with error bars at approximately 5.5.
- XENON1T:** A black horizontal line with error bars at approximately 13.5.
- PandaX-4T (2023):** A green horizontal line with error bars at approximately 8.5.
- PandaX-4T (paired & US2 combined):** A red horizontal line with error bars at approximately 8.5.

Bottom Panel: DM mass vs cross-section constraints

The bottom panel shows constraints on the dark matter mass (DM mass [GeV]) versus the cross-section (σ [cm 2]) for three different interaction types:

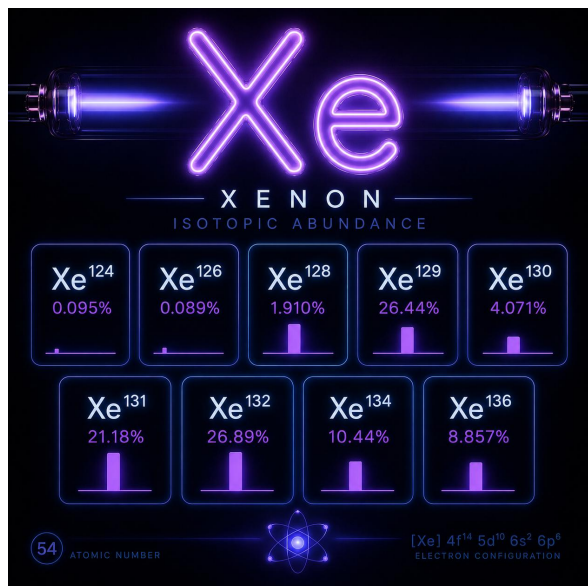
- Spin-independent:** The leftmost plot shows constraints for spin-independent interactions. The x-axis ranges from 2 to 6 GeV, and the y-axis ranges from 10^{-44} to 10^{-41} cm 2 . Constraints include XENON1T (S2-only), XENON1T (S1-only), LUX (2017), PandaX-4T (S2-only), PandaX-4T (S1-only), and PandaX-4T (This work).
- Spin-dependent (neutron-only):** The middle plot shows constraints for spin-dependent (neutron-only) interactions. The x-axis ranges from 2 to 6 GeV, and the y-axis ranges from 10^{-44} to 10^{-41} cm 2 . Constraints include XENON1T (S2-only), XENON1T (S1-only), LUX (2017), PandaX-4T (S2-only), PandaX-4T (S1-only), and PandaX-4T (This work).
- Spin-dependent (proton-only):** The rightmost plot shows constraints for spin-dependent (proton-only) interactions. The x-axis ranges from 2 to 6 GeV, and the y-axis ranges from 10^{-40} to 10^{-34} cm 2 . Constraints include PandaX-II, PandaX-4T (This work), and PICO.

Legend for Bottom Panel:

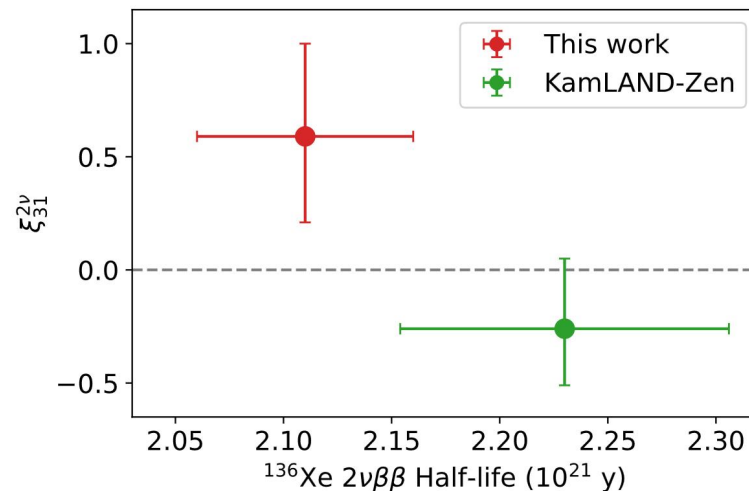
- $\pm 1\sigma$:** Shaded green regions.
- 90% C.L. upper limit:** Solid blue lines.

- With unpaired $S2$ ($US2$), the energy range down to 0.04 keV_{ee}
- First indicate Solar B8 Neutrino “fog” with $S1$ - $S2$ & $US2$ data
- Push the sensitivity much lower for the GeV-region of DM

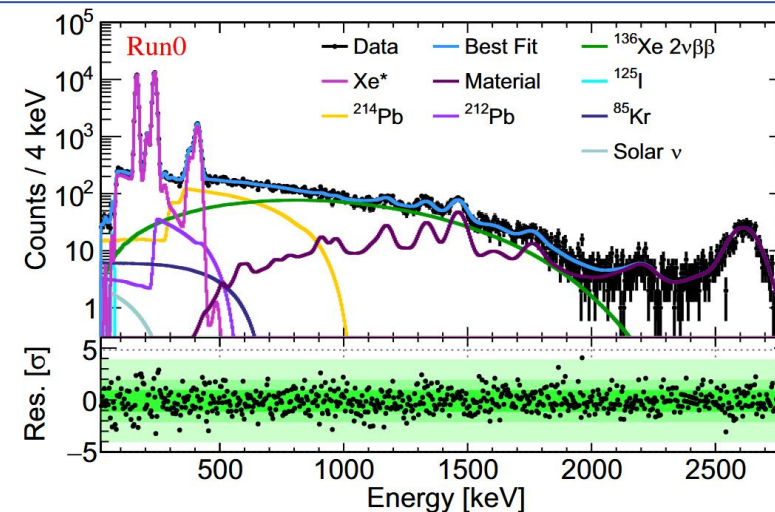
To MeV range - Rich neutrino physics



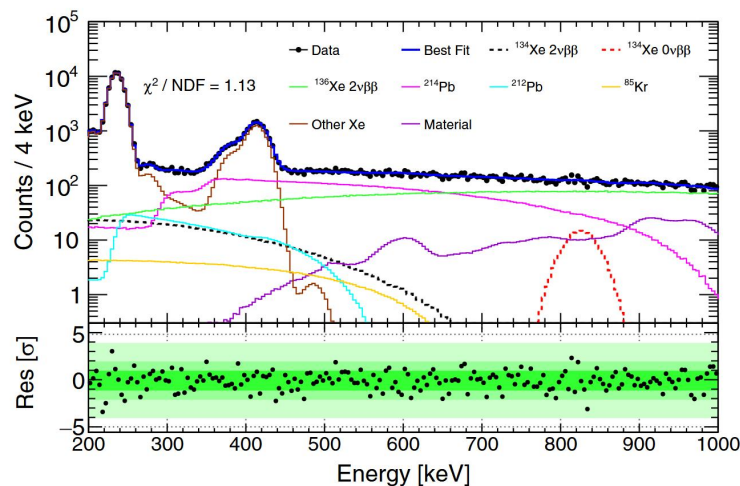
$^{136}\text{Xe } 2\nu\beta\beta$ *PRL 136, 162501 (2026)*



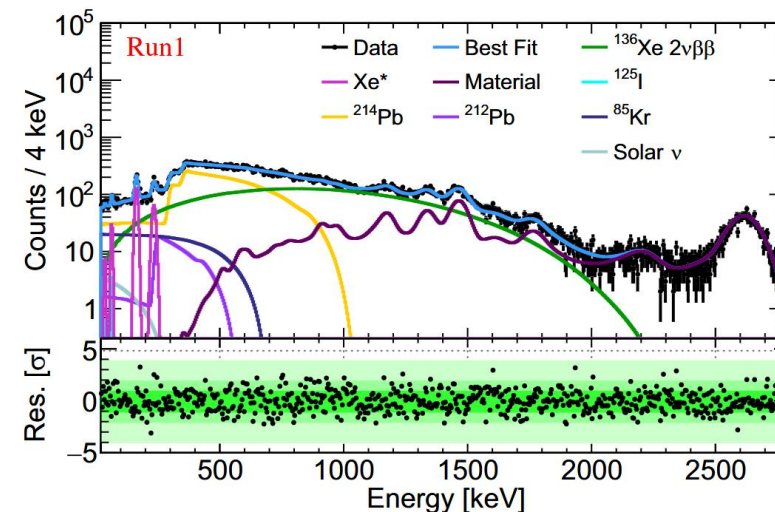
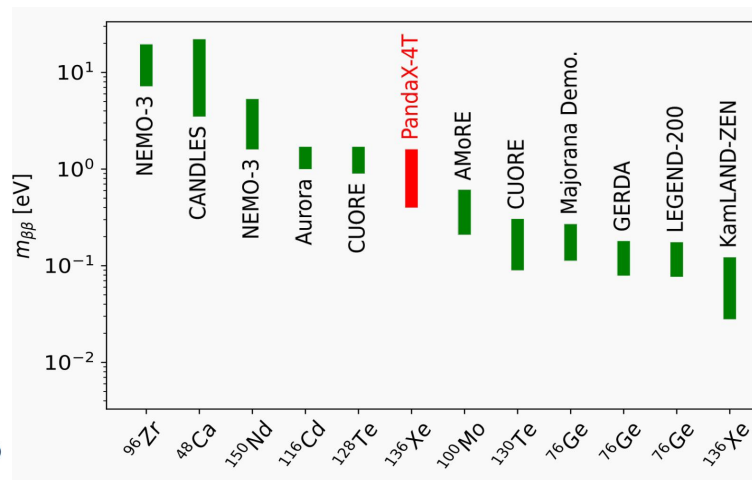
Data spectra and the fit for the $^{136}\text{Xe } 2\nu\beta\beta$ half-life



$^{134}\text{Xe } 2\nu\beta\beta/0\nu\beta\beta$ *PRL 132, 152502 (2024)*



$^{136}\text{Xe } 0\nu\beta\beta$ *Sci. Bul. 70, 1779 (2025)*

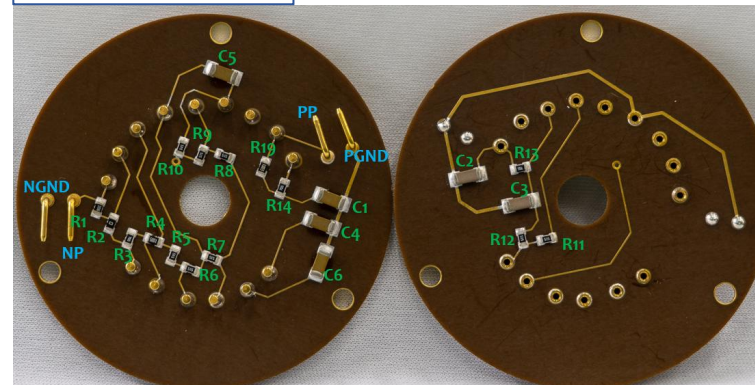


Run2 improvements

- Upgraded PMT base improve the linearity in MeV energy range
- A wide range of calibration techniques applied, ^{37}Ar , pulse DD, DT, ^{125}Xe etc.
- New custom 14-bit 500MS/s digitizers

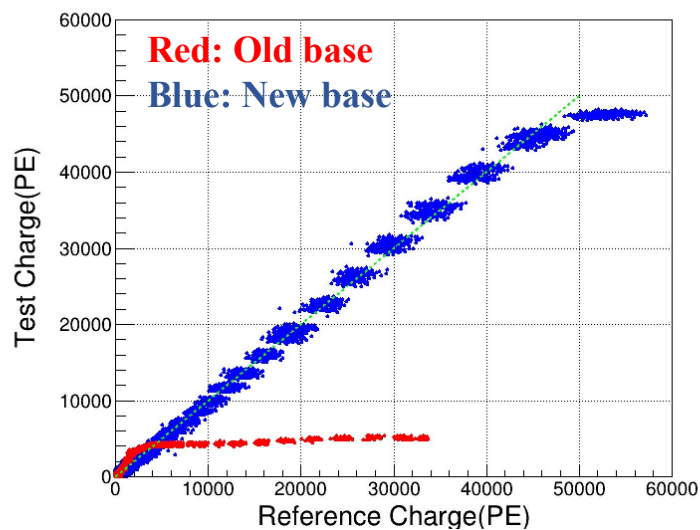
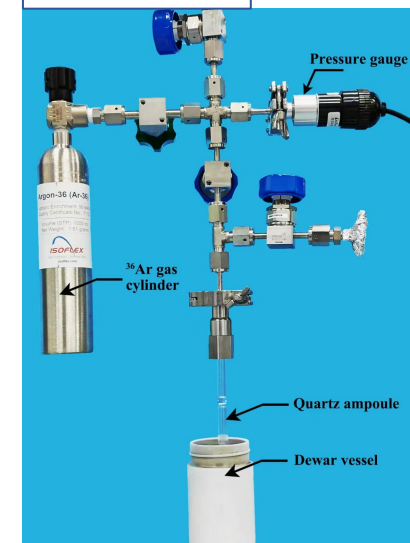
more details see Jiamin Wang's talk
07/17 11:03AM

New PMT base

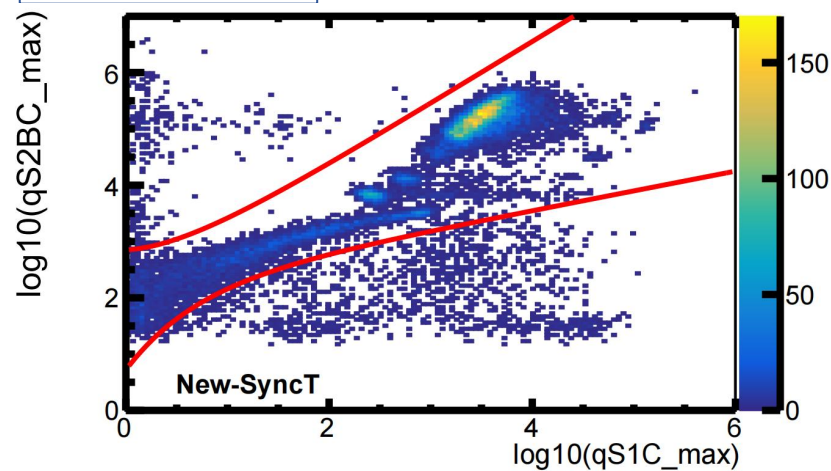


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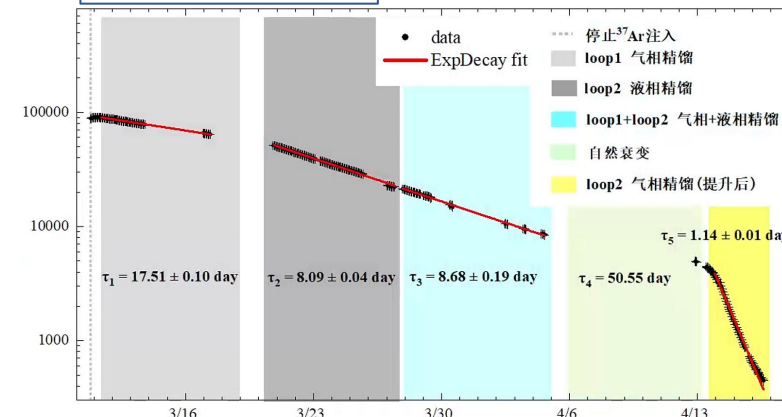
^{37}Ar source



Pulse DD signal



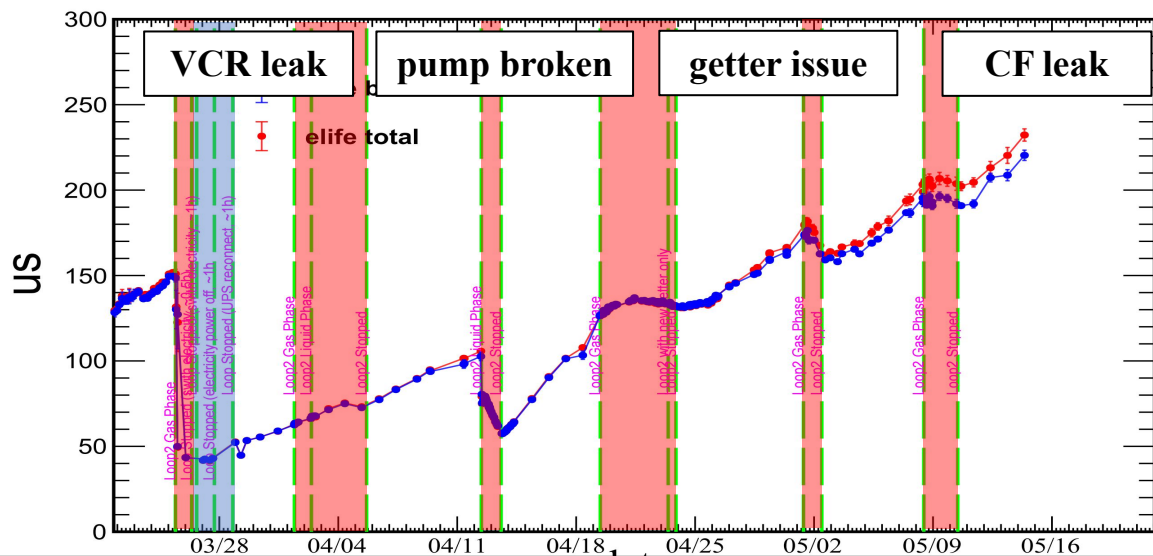
^{37}Ar evolution



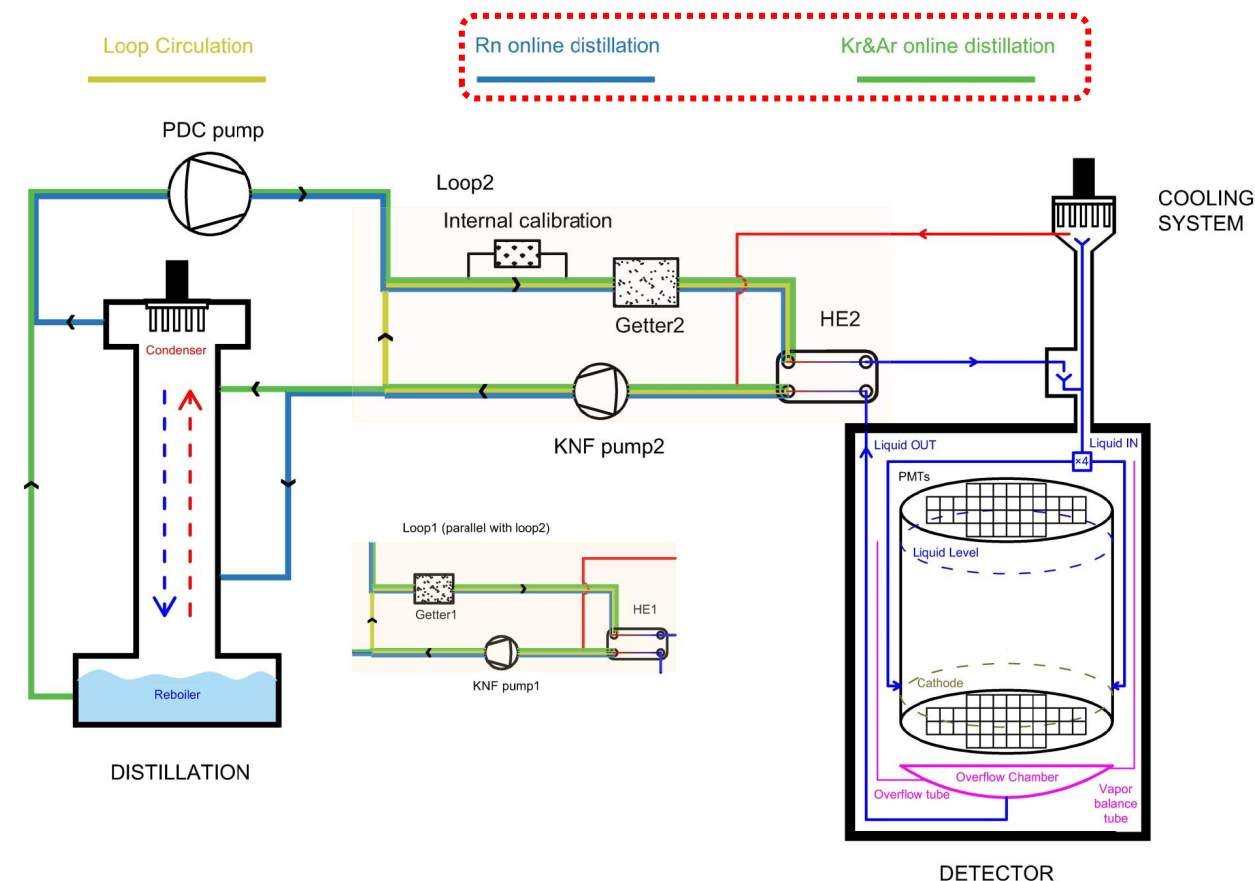
Resume data taking in *Run2*



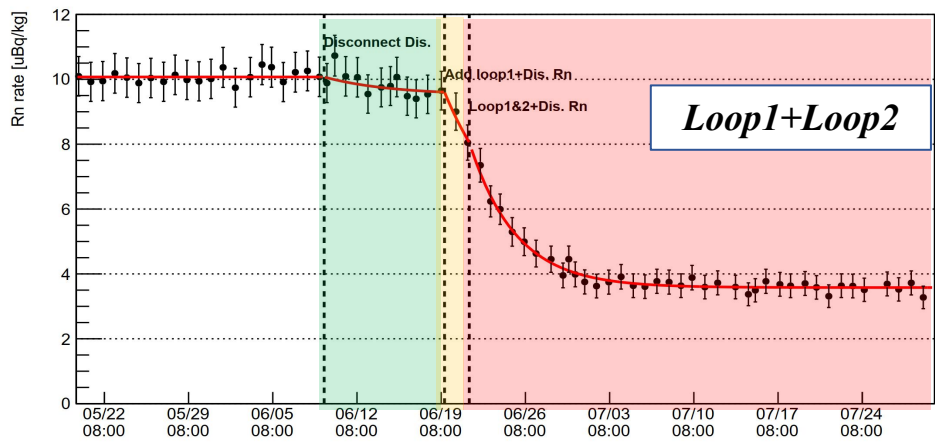
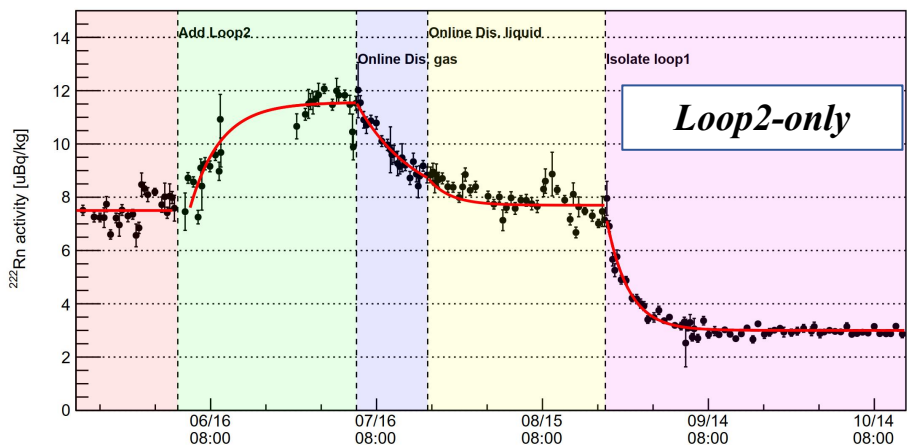
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- At the beginning of *Run2*, e-lifetime struggle for about 3 months (GXe/LXe pur., replace bellows, etc.)
- Online Rn distillation process to suppress ^{222}Rn
 - Loop2-only, down to 2.9 uBq/kg with 40 slpm
 - Loop1+Loop2, down to 3.6 uBq/kg with 60 slpm

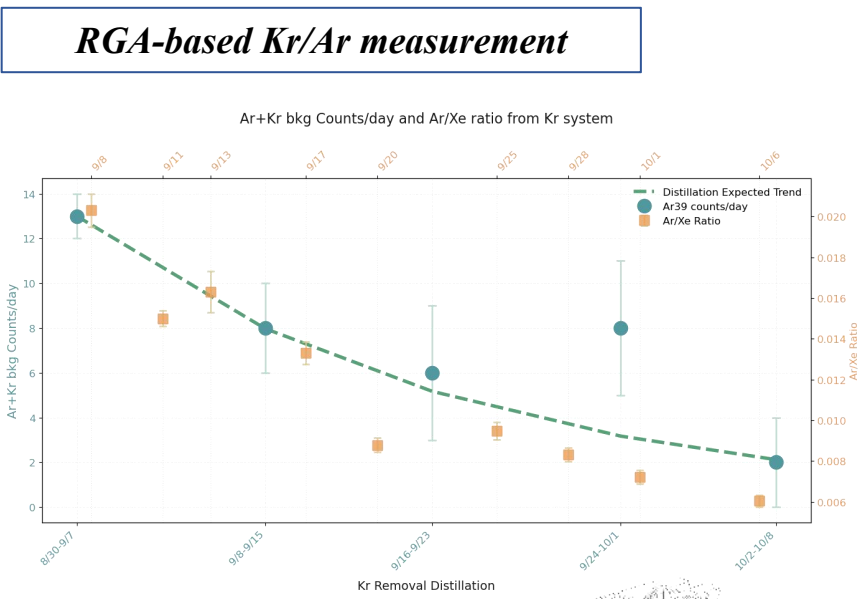


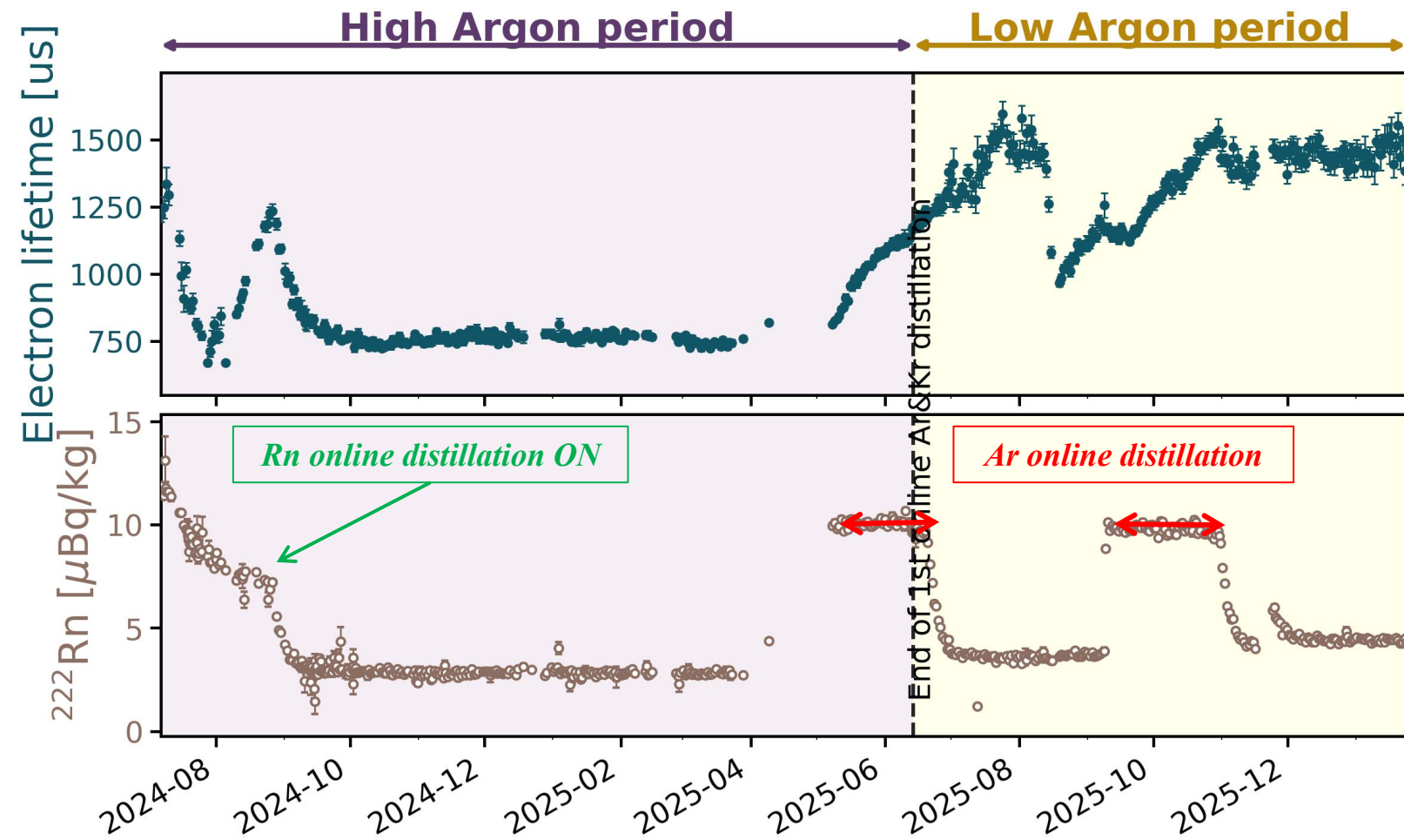
Online Distillation for Rn&Ar



Rn source [uBq/kg]	Before Dis.	After Dis.
TPC		0.98
Loop1	3.05	1.35
Loop2	0.99	3.07
Distillation		0.56

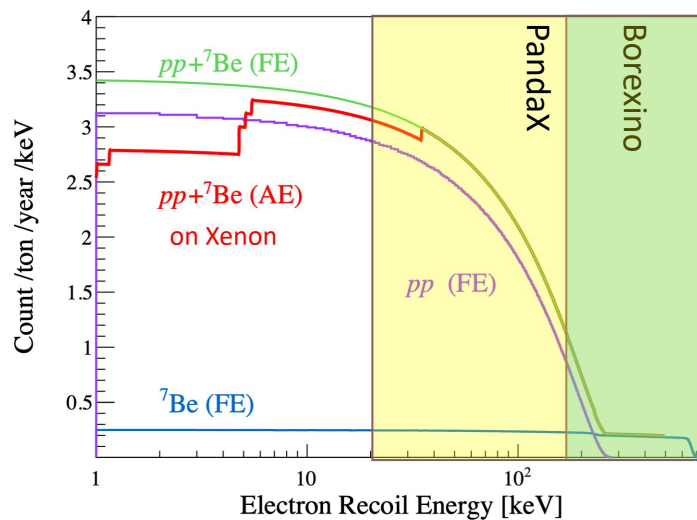
- **Rn** emanation rate from different part is obtained
- ³⁹Ar elevated in *Run2*, two online Ar distillation applied, reduce from 0.74 to 0.10 uBq/kg



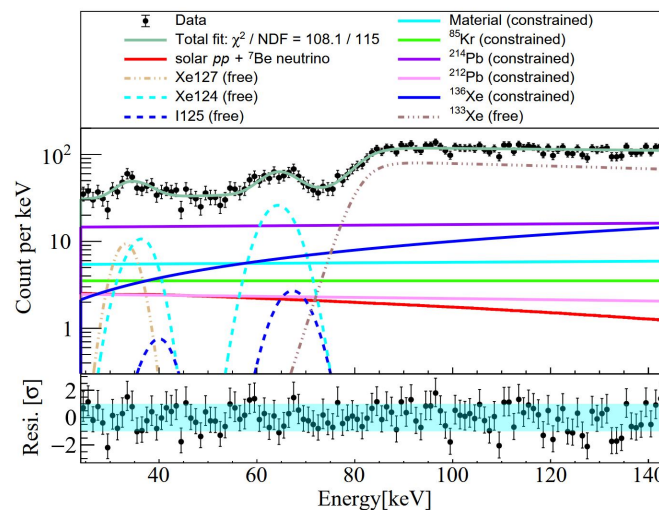


Solar pp neutrino

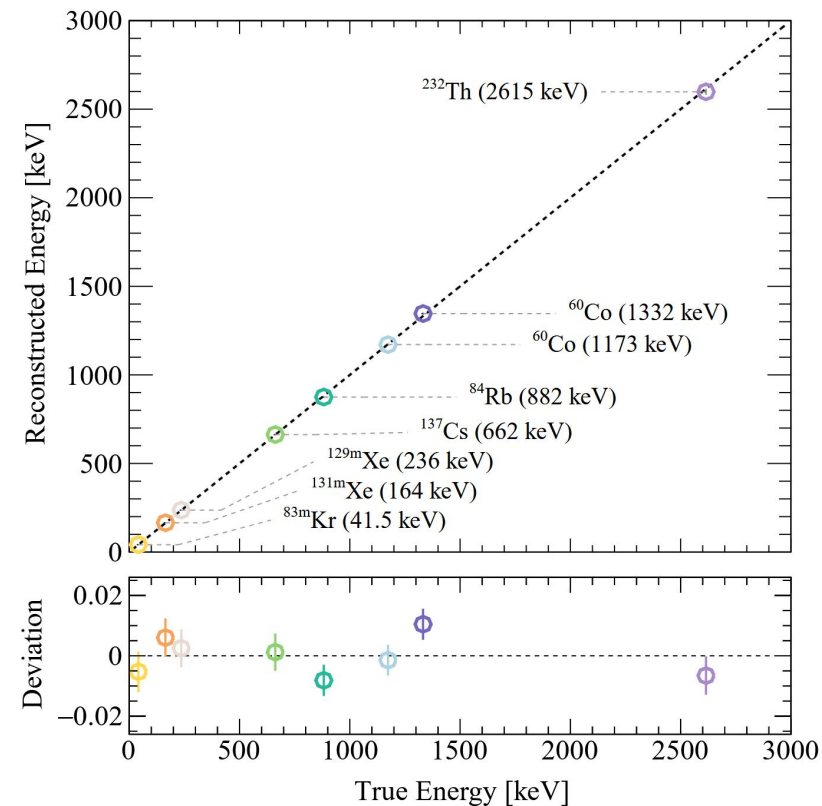
- With low energy threshold, PandaX provide complementary approach for the solar pp flux measurement (Borexino, > 165 keV)
- In *Run2*, the unified data production from keV to MeV



Run0 Data, CPC 48, 091001 (2024)



Run2: Rec. Energy vs. True Energy

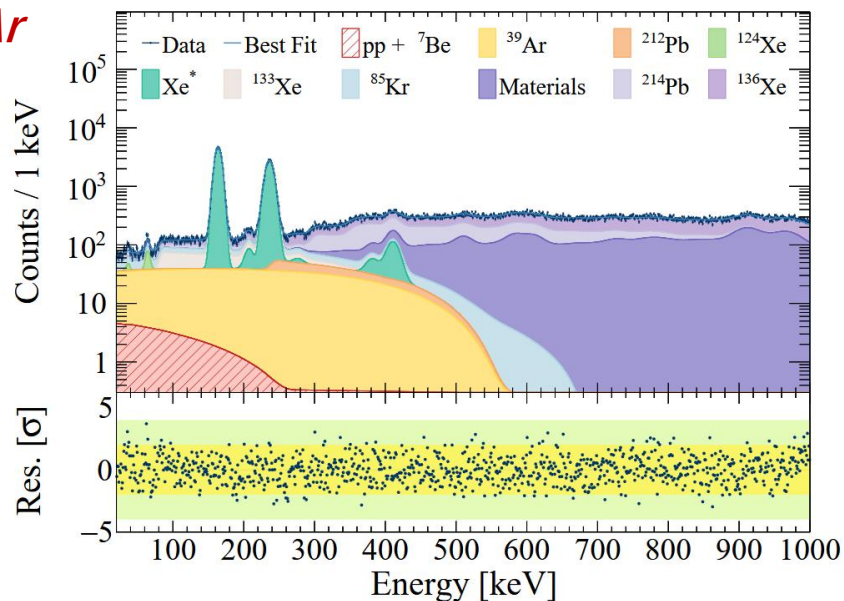


Solar pp neutrino - background model

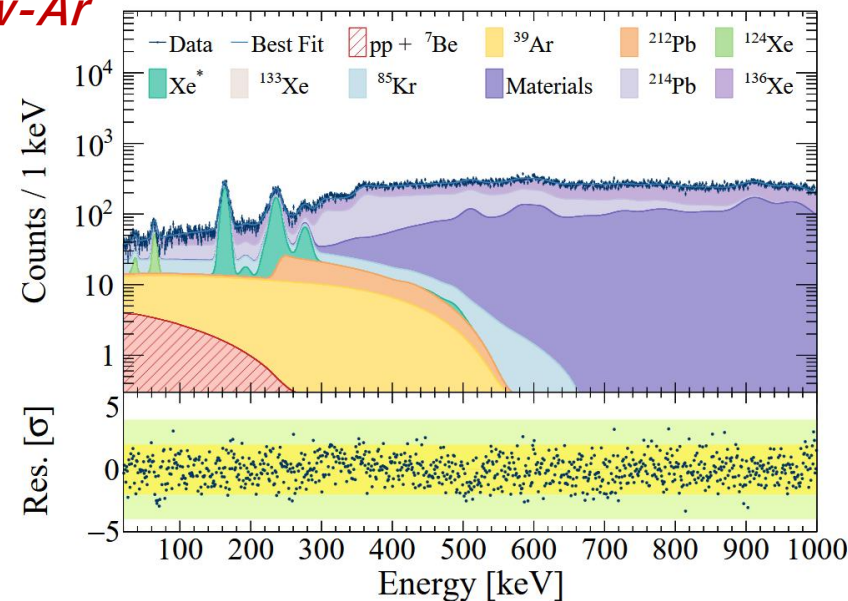
see Zhixing Gao's talk
07/17 11:53AM

- **Background Model:**
 - Internal β : ^{39}Ar from assay monitoring, ^{85}Kr from delayed coincidences, $^{214,212}\text{Pb}$ from α -tagged decay-chain activity
 - External γ from detector materials: MS spectral fit for U/Th/K/Co
 - Xe* nuclides: temporal evolution: ^{136}Xe $2\nu\beta\beta$: PandaX-4T measurement
- Blind analysis applied and simultaneous fit of the High-Ar and Low-Ar spectra in *Run2*

High-Ar



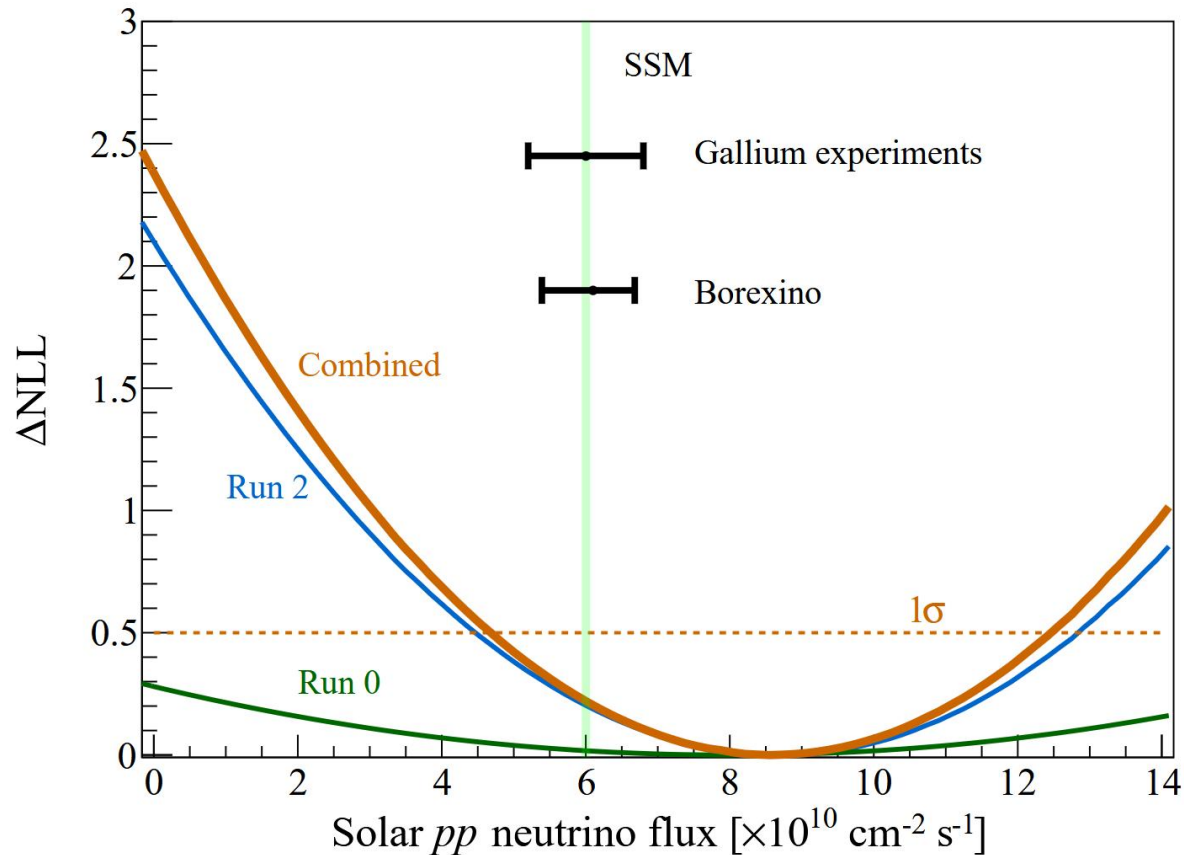
Low-Ar



Solar pp neutrino - new data

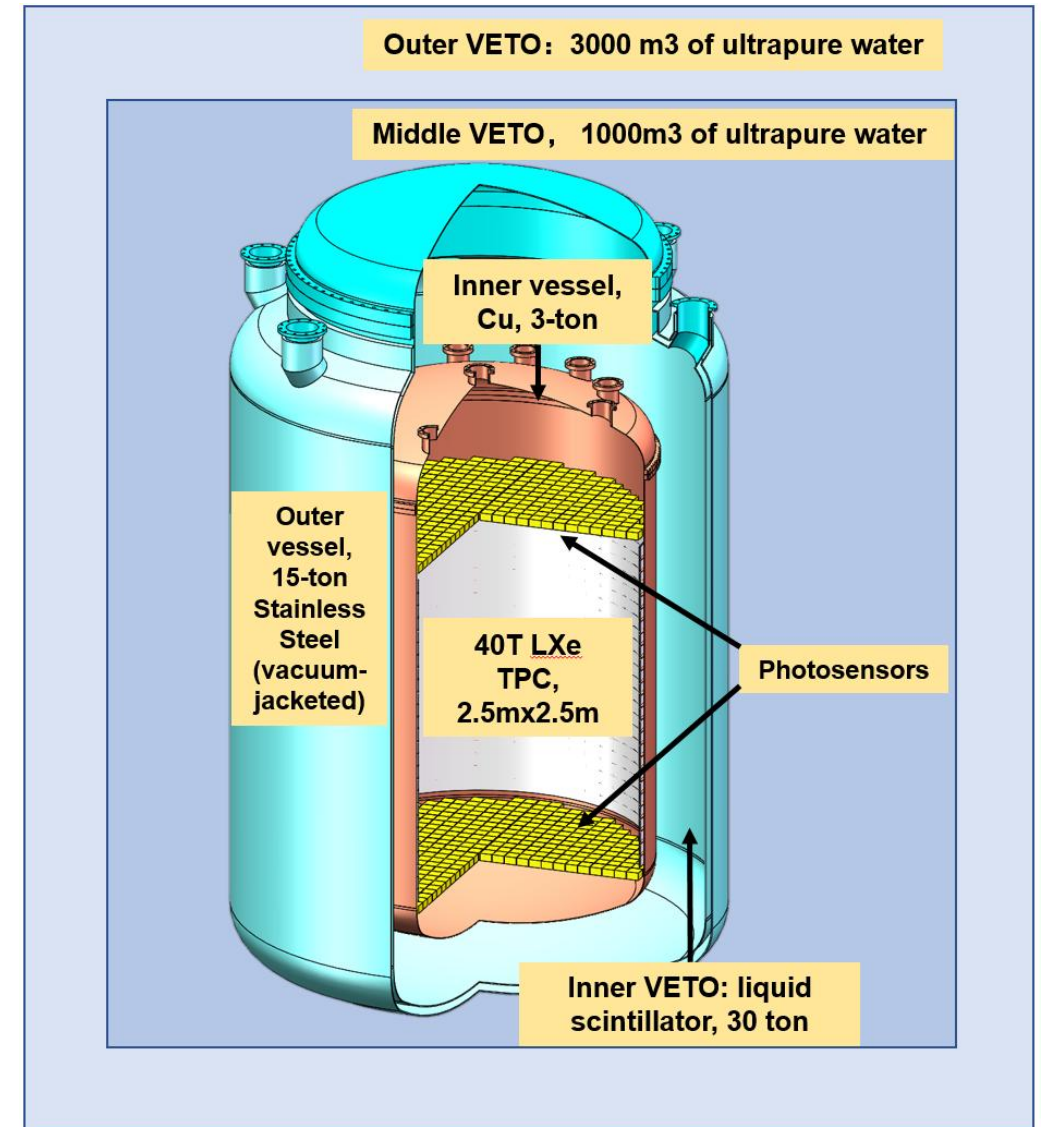
see Zhixing Gao's talk
07/17 11:53AM

Arxiv: 2607.02405

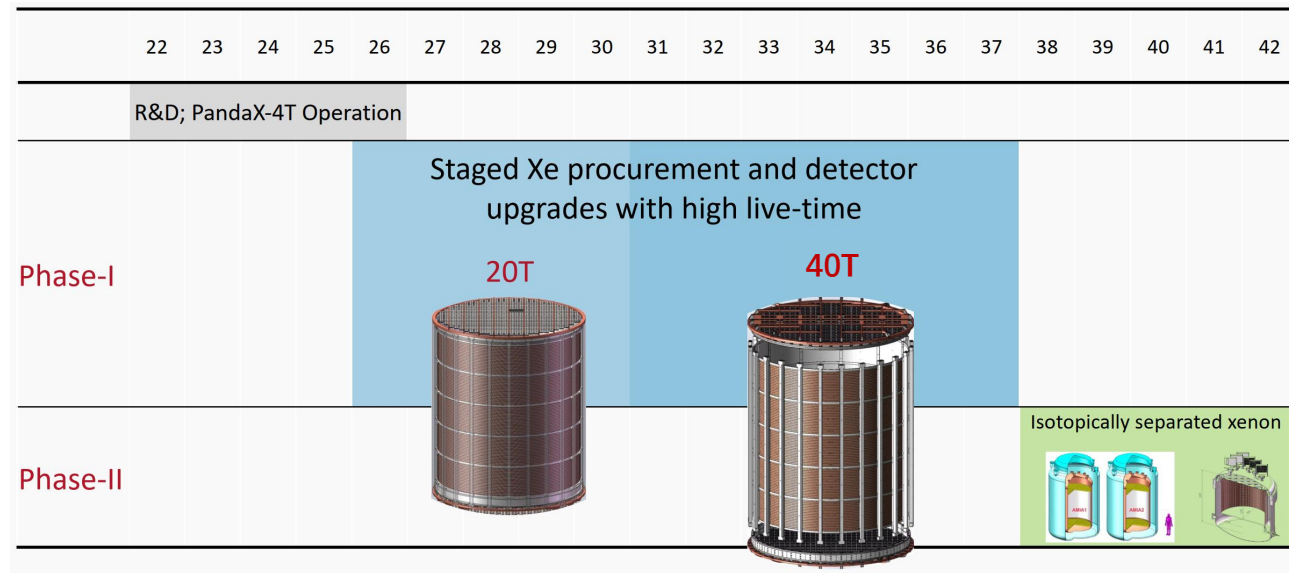


- Using PandaX-4T data, the first positive indication of a non-zero solar pp neutrino flux below 165 keV
- Measured pp flux is $(8.5 \pm 3.5) \times 10^{10} \text{ cm}^{-2} \text{ s}^{-1}$, consistent with the SSM prediction

- **Staged plan**, eventually 40-tonne sensitive volume
 - TPC: 2.5 m in diameter and height
 - Cold LS veto right outside Cu vessel
 - Ultrapure water as veto and shielding
- First stage, **PandaX-20T** with 17-tonne sensitive mass

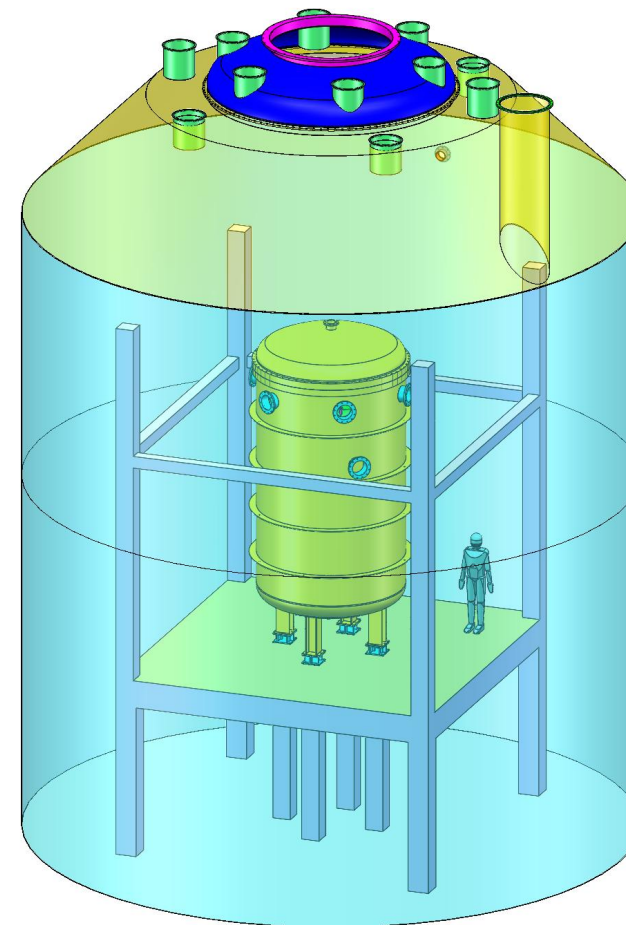


First stage - PandaX-20T



➤ First stage PandaX-20T:

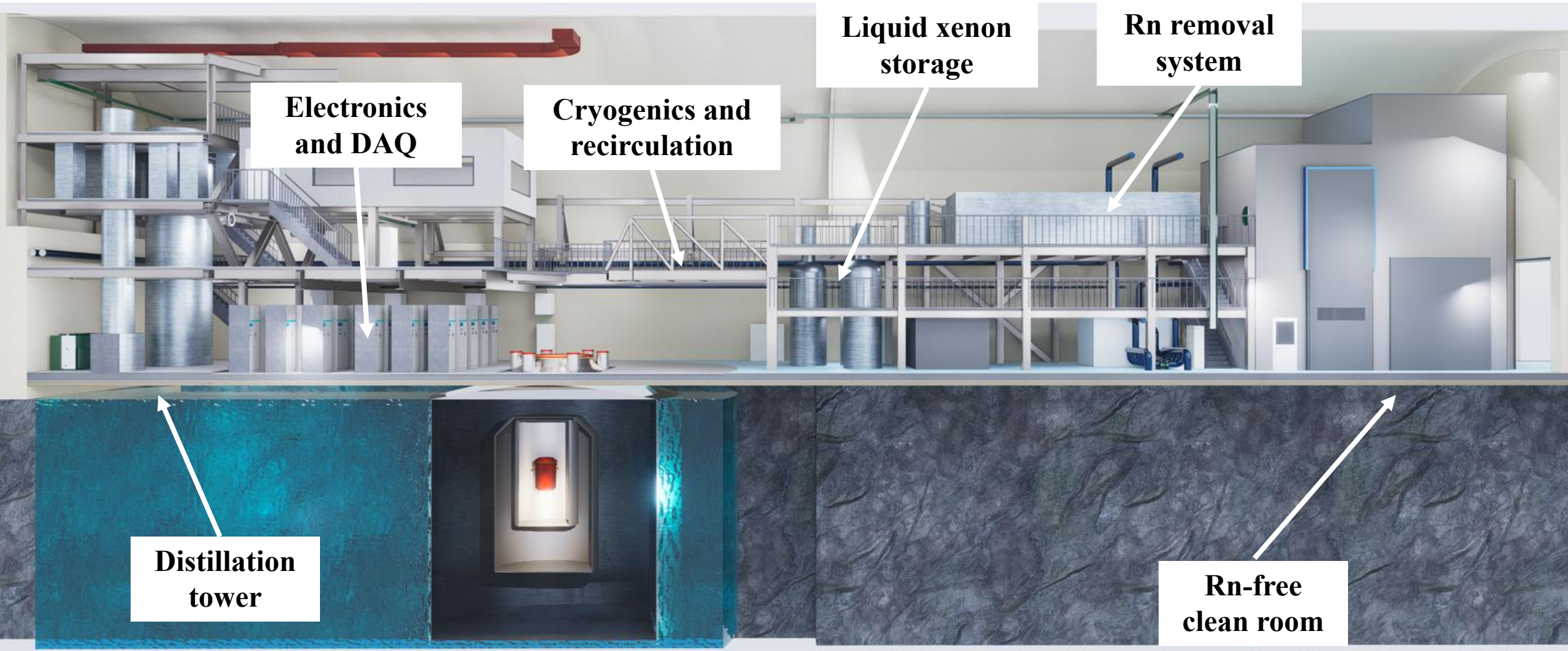
- Titanium cryostat
- Room-temperature LS veto outside Titanium cryostat
- Cryogenics, LXe storage, Kr & Rn distillation tower, etc. for the final-stage xT



CJPL-II layout



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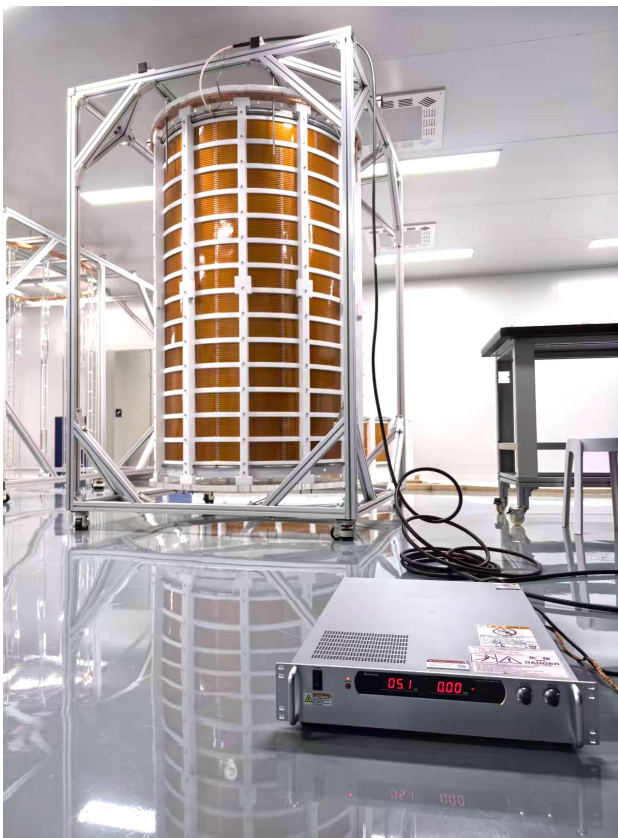


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[illegible]

- Flexible PCB shaping ring
- Mesh grid for Gate eletrode, 200 um wire, 5 mm pitch
- Wire grid for the Cathode electrode, same wire



PandaX-20T PMT array

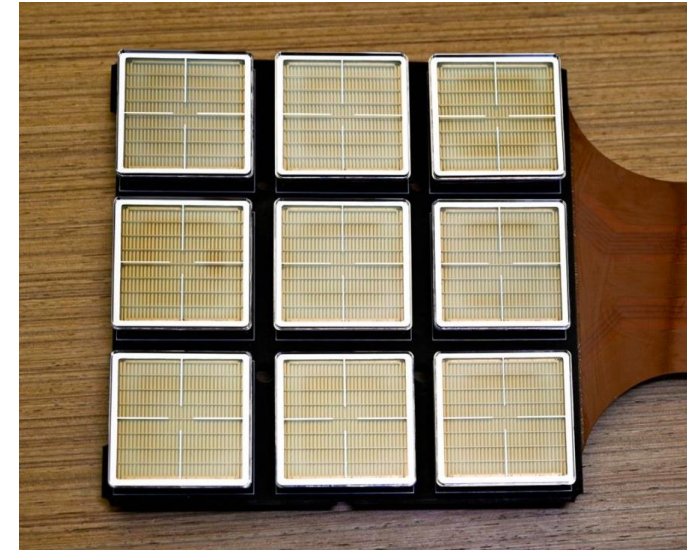
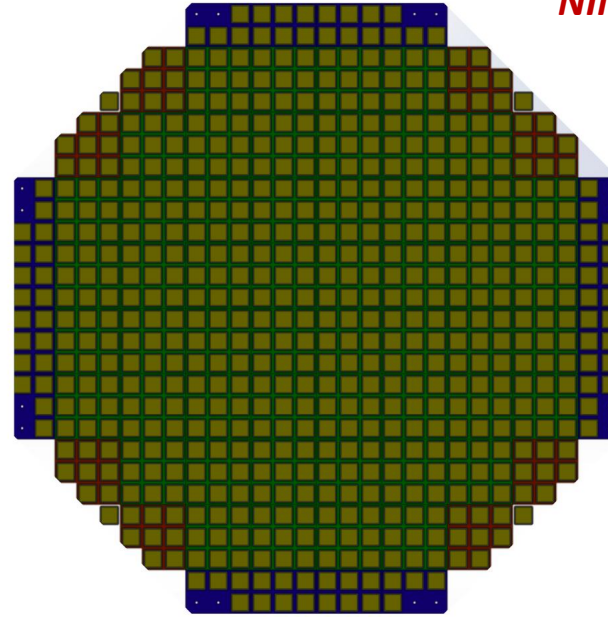


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NIMA 1073, 170290 (2025)

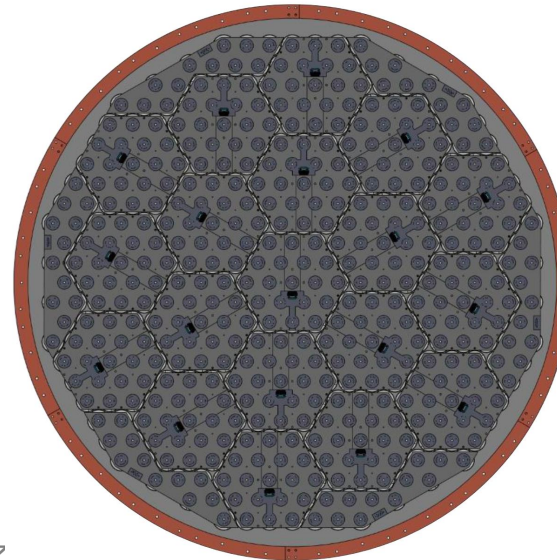
- **Top PMT array:**

- 616 2-inch multi-anode PMTs (**R12699**)
- Development with Hamamatsu for low-radioactivity version (U / Th / K = 0.002 / 0.003 / 1.4 mBq/cm²)
- Flexible-Rigid PCB (FRP) boards for integrated HV/signal readout lines with base

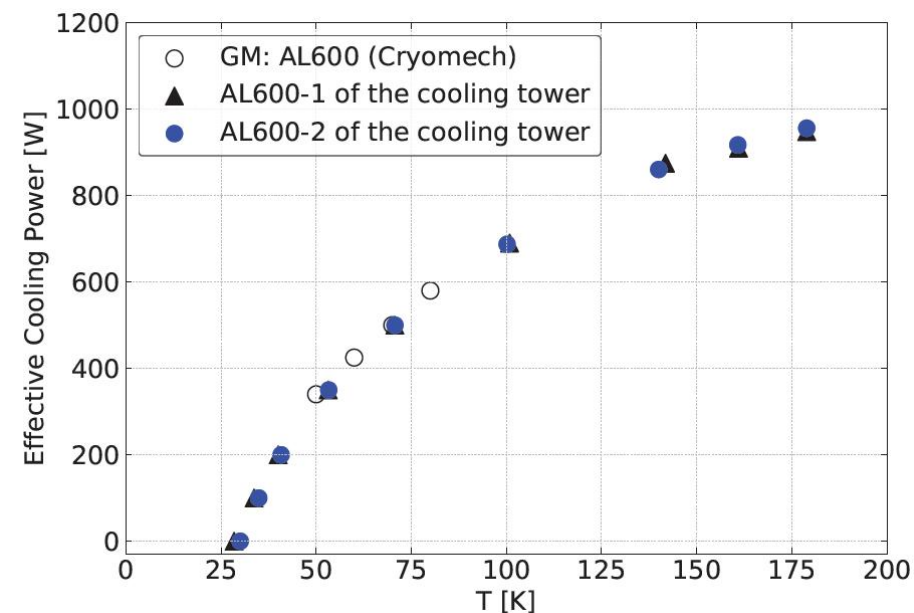


- **Bottom PMT array:**

- 433 3-inch PMTs (**R11410**)
- Mainly 19 PMT tiles
- Flexible PCB bases



PandaX-20T Cryogenic system



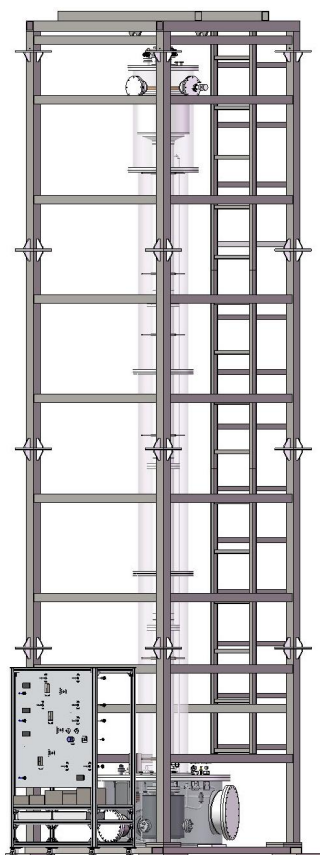
- 1.9 kW cooling power with two cryocoolers (AL600 Cryomech)
- LN2 emergency cooling power >1500 W @178K

PandaX-20T Distillation system

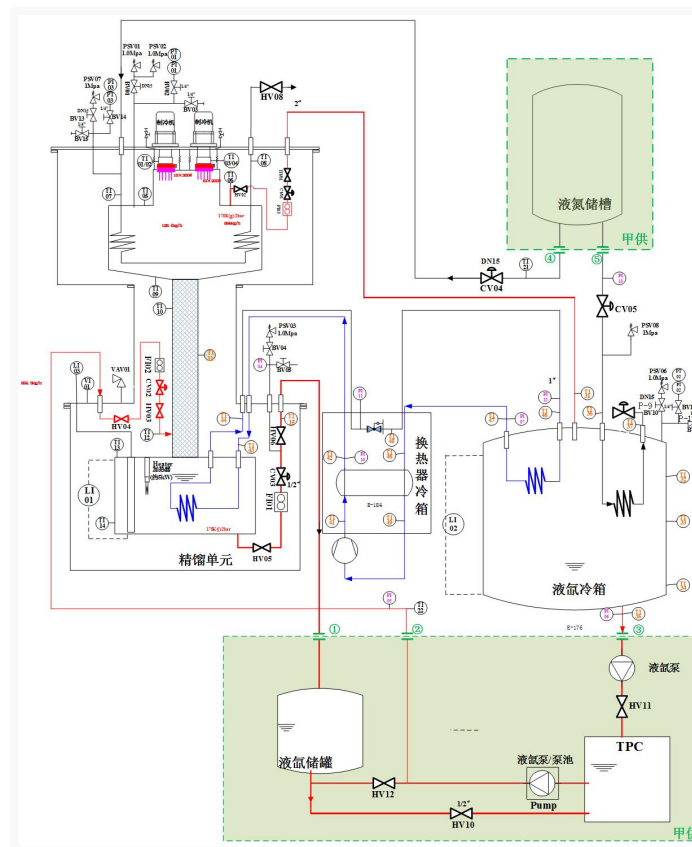
see Kangkang Zhao's talk
07/16 2:30PM



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- Kr distillation tower: 30 kg/hour
- Target Kr concentration in Xe: 0.01 ppt



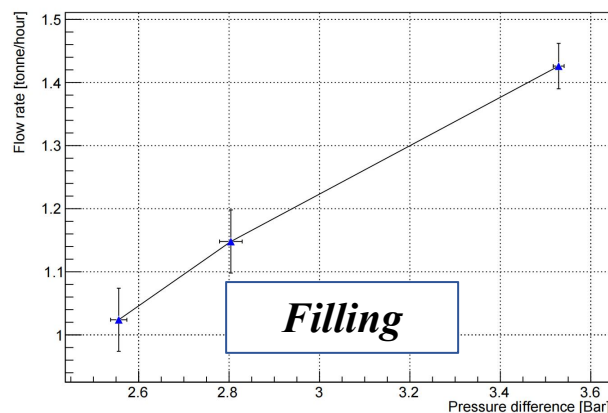
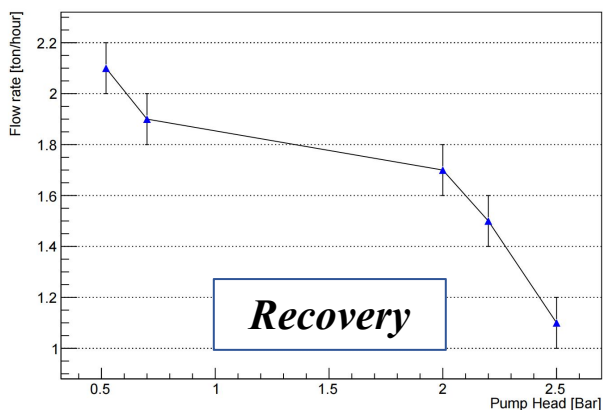
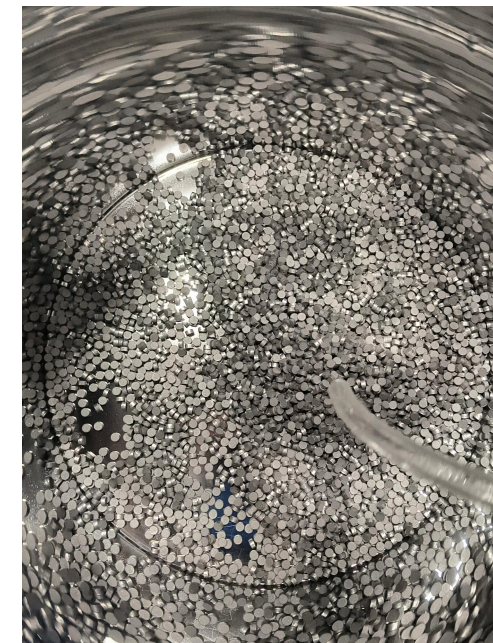
- Rn distillation tower: 850 kg/hour
- R14 cooling recovery system has achieved 20 kW cooling power
- Target Rn reduction factor: $\times 10$ ($^{222}\text{Rn} \sim 0.5 \mu\text{Bq/kg}$)

PandaX-20T LXe handling

LXe Storage and Transportation



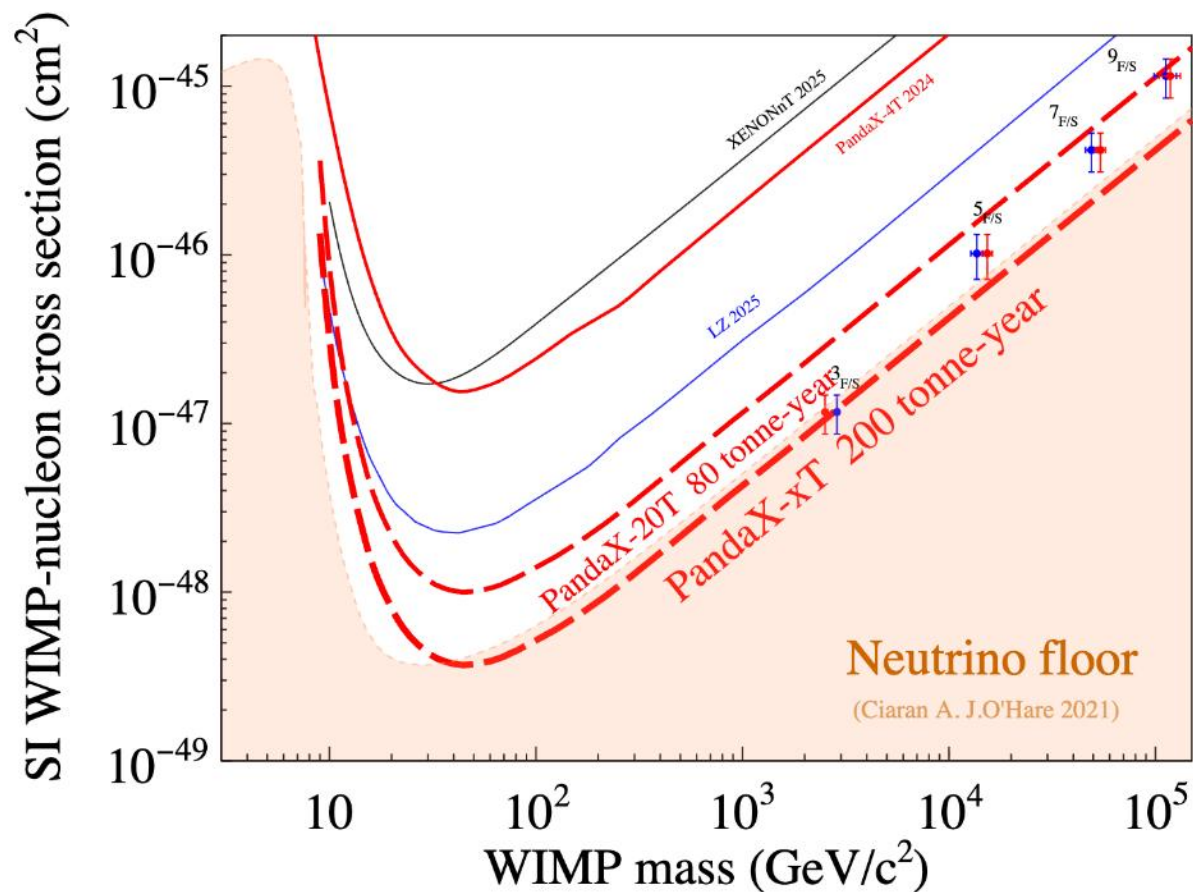
O_2 absorb materials



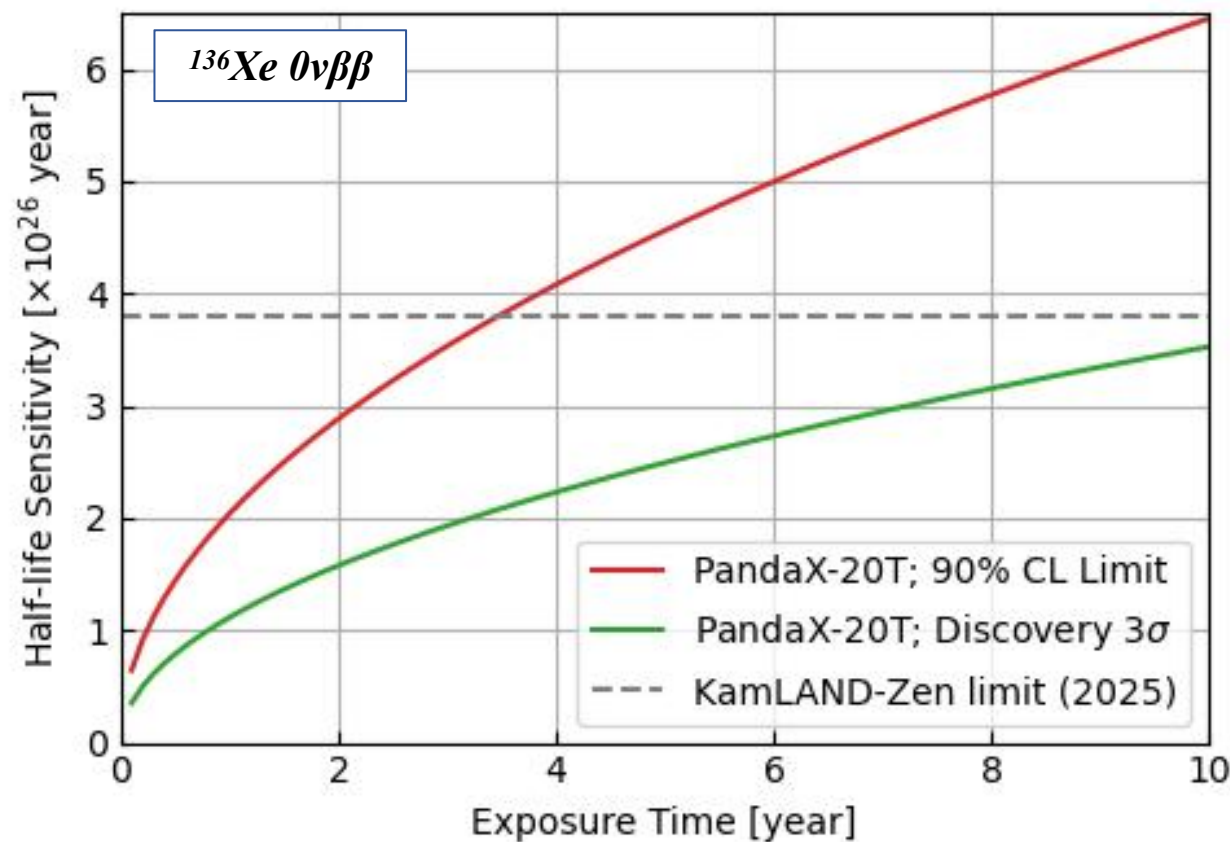
- **Storage and transportation:** $5 \times 6 \text{ m}^3$ center tanks for RT< storage, **>1.4 tonne/hour** transportation speed
- **LXe Purification:** **700 kg/hour** LXe flow, material selection for **Rn-free**, O_2 removal study with different materials

Sensitivity projection

FV 13 tonne, ROI 1-10 keVee, 99.7% ER rejection



FV 2.4 tonne natural Xe, 1% resolution @Q-value



Timeline of PandaX-20T

- Now: 4T has been dismantled, 20T Xenon transferred to CJPL
- 2026.6-12: PandaX-20T infrastructure construction
- 2027.1-6: PandaX-20T installation
- 2027.7-12: PandaX-20T commissioning
- 2028.1: PandaX-20T physics operation



- PandaX-4T has now completed the physics program
- About 700 live days of data has been collected
- Solar pp neutrino measured with new data and more physical analyses are ongoing
- PandaX-xT first stage - 20T is planned to get online in 2027; physics data in 2028

报告人	No.	Time	Title
周宁	343	07/16 10:30AM	Deep underground atmospheric neutrino and cosmic ray detector at CJPL
潘奕羽	291	07/16 2:20PM	PandaX-20T Photosensor System Design and Verification
赵康康	229	07/16 2:30PM	PandaX-20T超高纯氦氙/氩氙低温精馏塔
郭弈含	90	07/17 9:00AM	AURORA: A High Performance DAQ Framework for Next-Generation Rare-Event Search Experiments
王佳敏	194	07/17 11:03AM	Search for WIMPs with PandaX-4T Run2 Analysis
高智星	195	07/17 11:53AM	PandaX 实验太阳中微子研究进展
张敏祯	138	07/17 11:56AM	Search for solar 8B neutrinos and light dark matter with PandaX-4T
张思远	110	Poster	PandaX-20T 漂移区电场模拟及整形环优化设计



谢 谢

