

PandaX Purification System and Cryogenic Distillation System

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On behalf of PandaX Collaboration

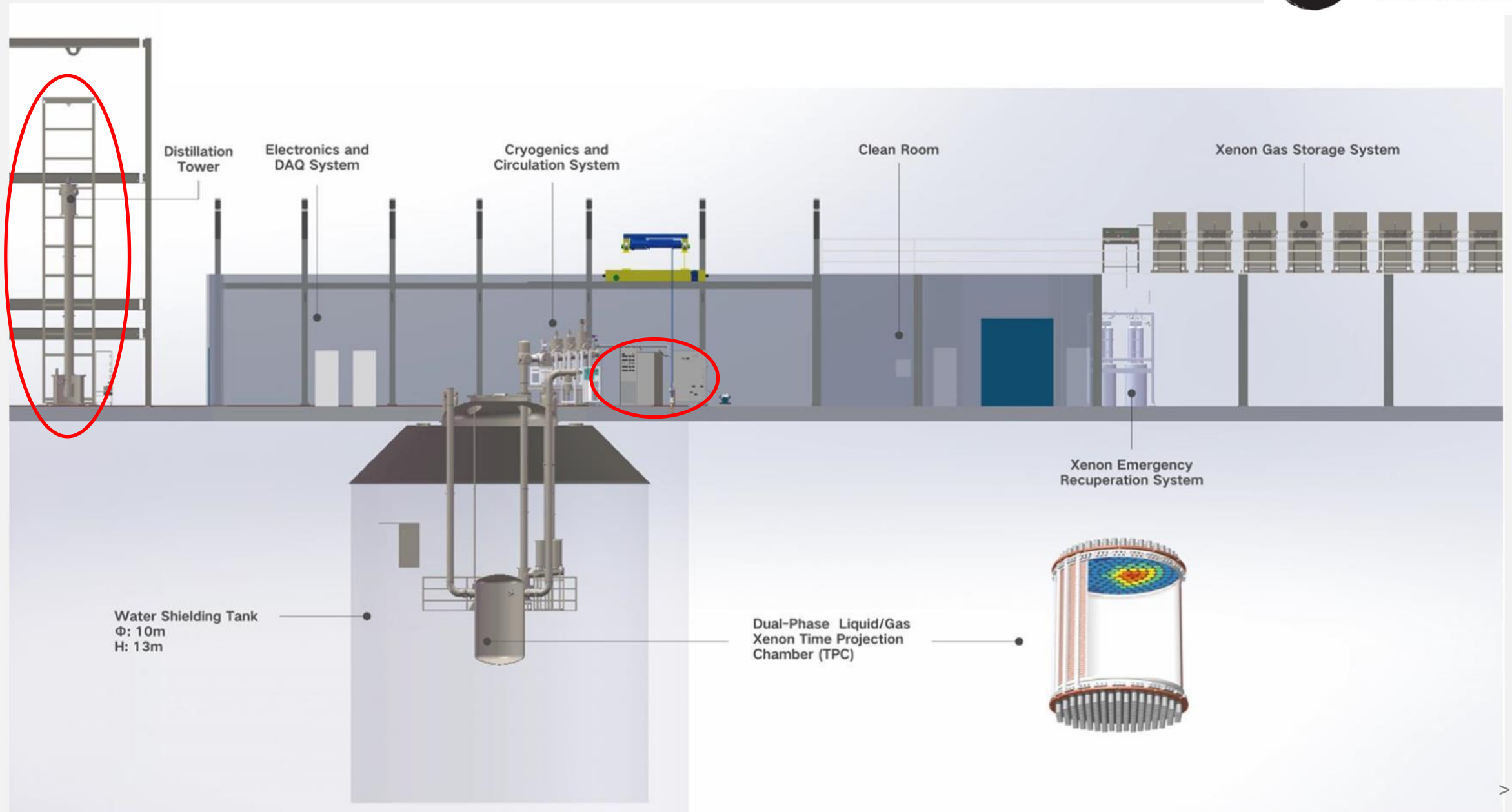


PANDA X
PARTICLE AND ASTROPHYSICAL XENON TPC

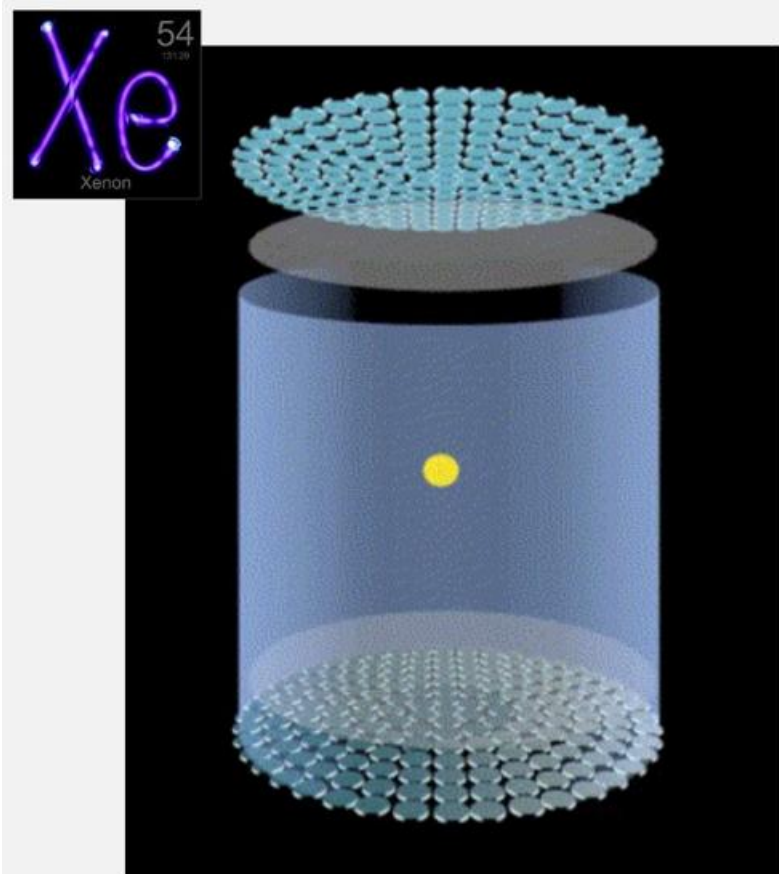
● PandaX Collaboration



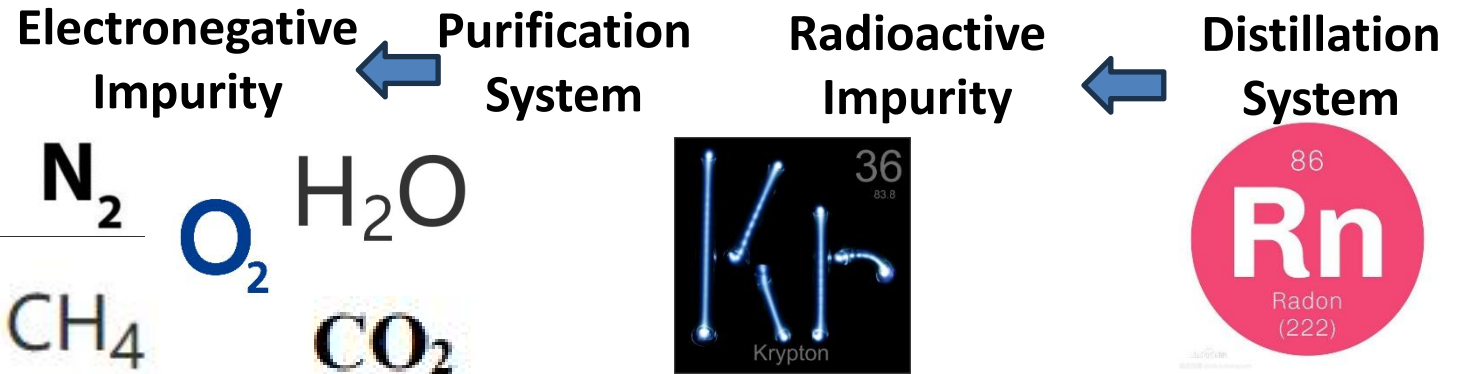
PandaX-4T Overview



● PandaX-4T background

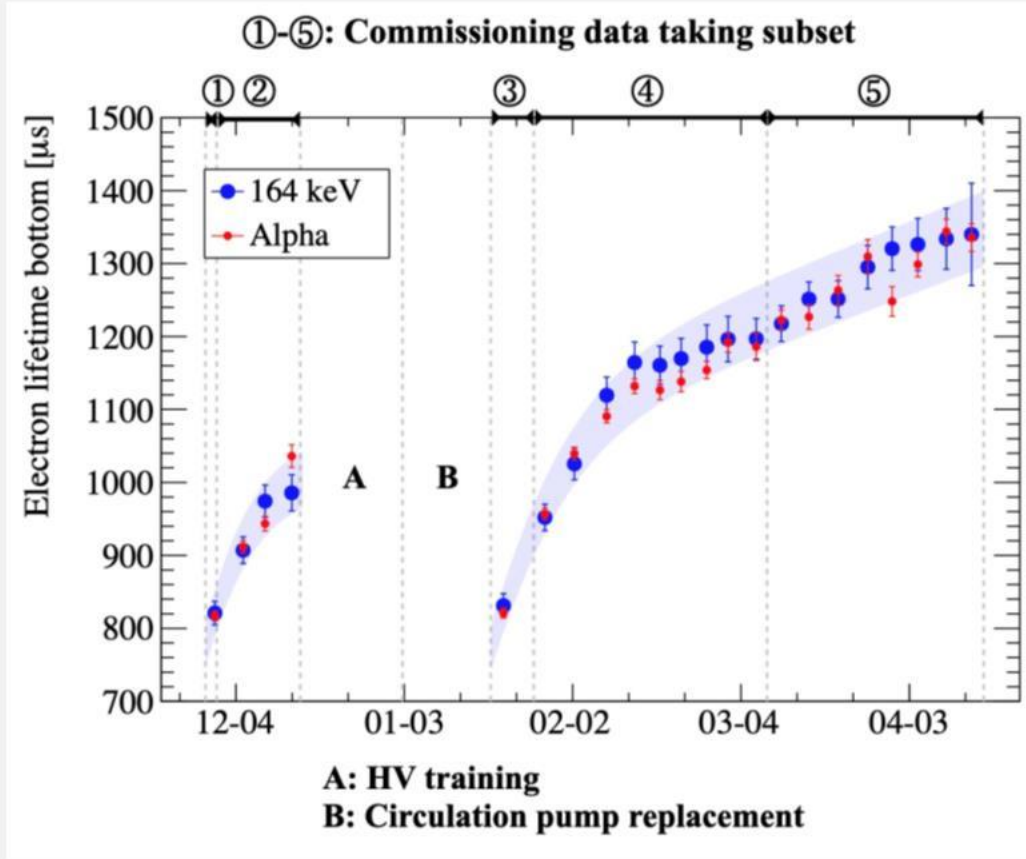


- Purity liquid xenon target, high light & charge yield;
- Low background leads high sensitivity

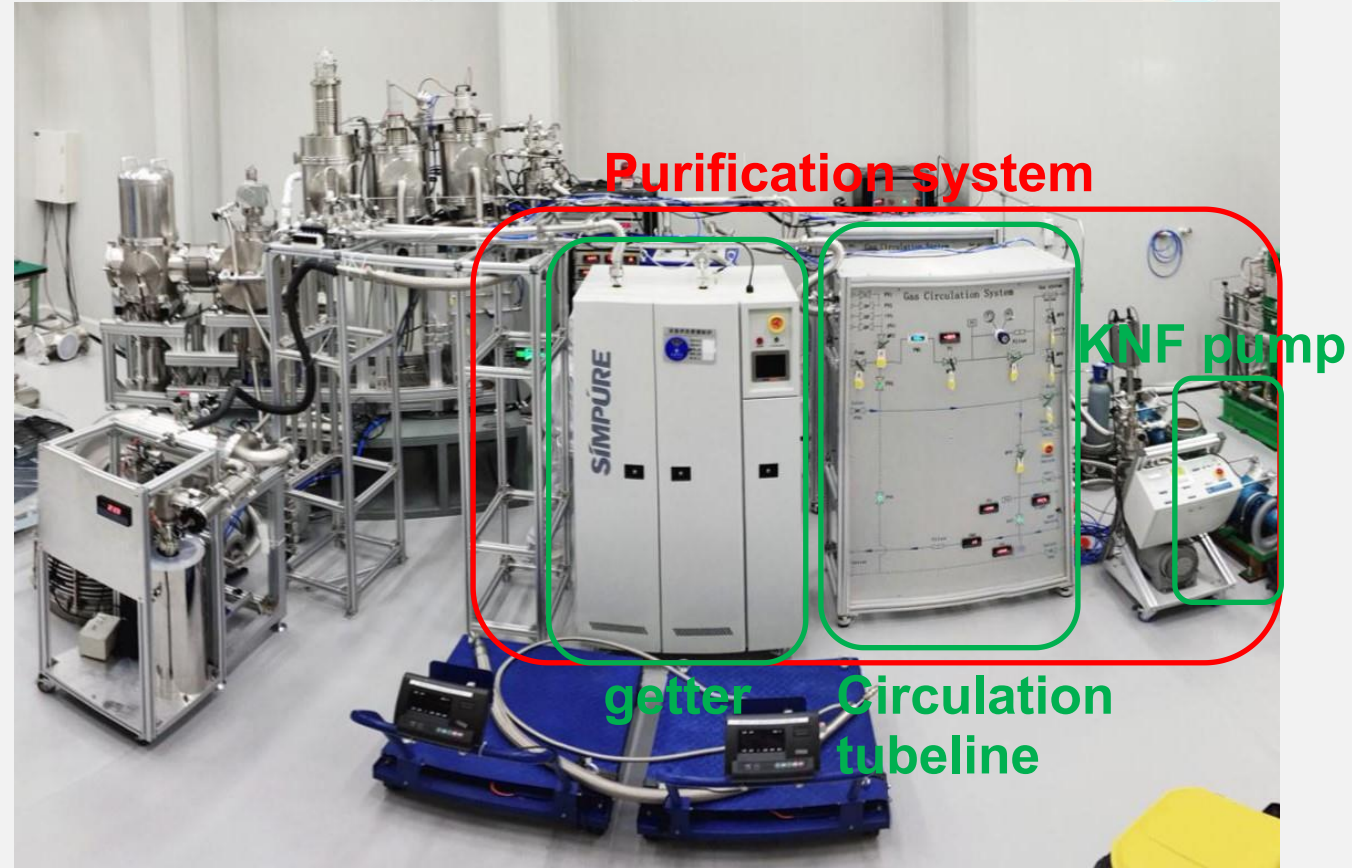


- Absorb photon to effect detector sensitivity
- Detector requirement: ~1ppb
- Krypton-85 (Beta decay half-life of 10 years)
- Even small amounts could effect detector sensitivity
- Detector requirement: Kr<1ppt
- Radon-222 generated from the decay of uranium and thorium inside the detector
- Minuscule amount could effect detector sensitivity
- Detector requirement: Rn ~uBq/kg level

● PandaX-4T Purification system



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



Two loops
Max flow rate: 150 SLPM in total

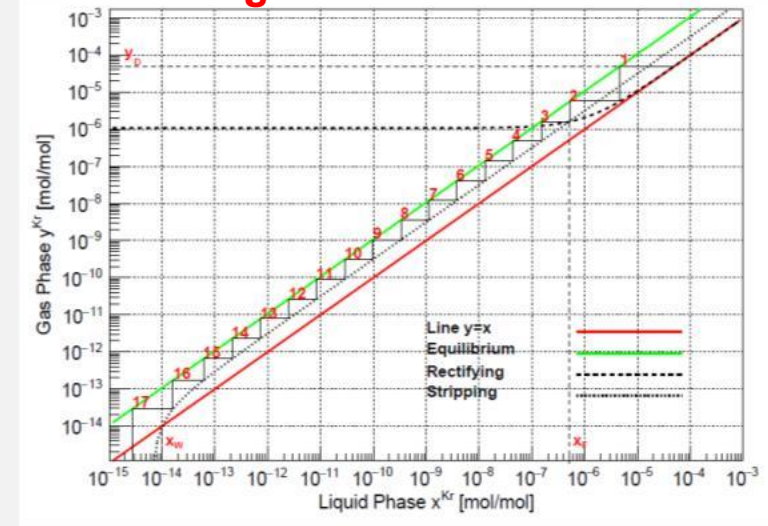
● PandaX-4T Distillation System



Structured packing



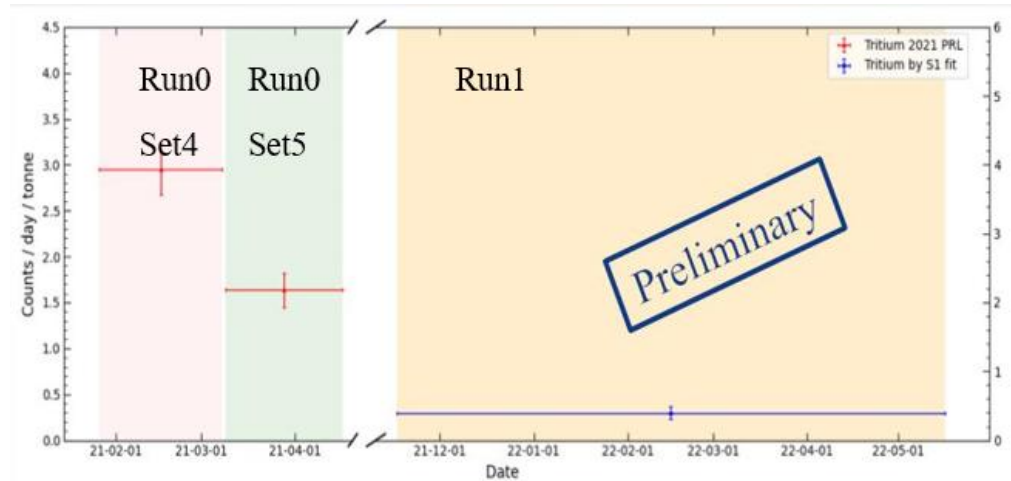
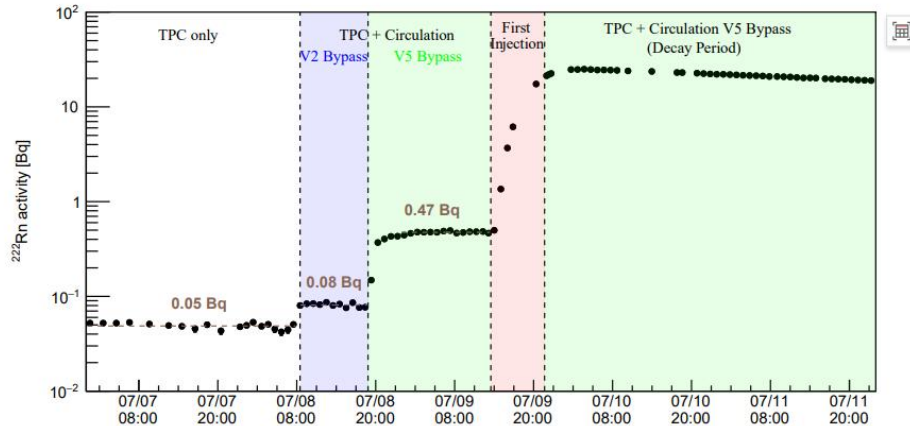
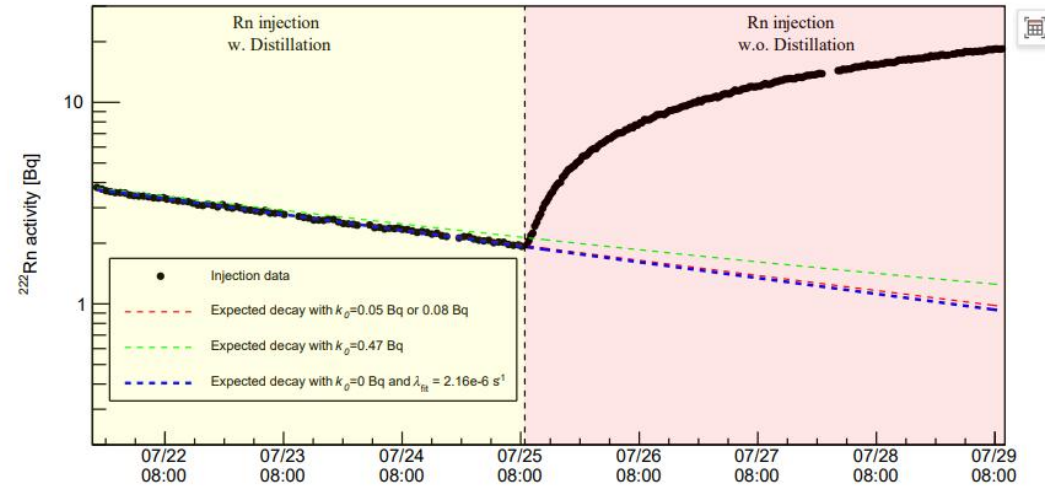
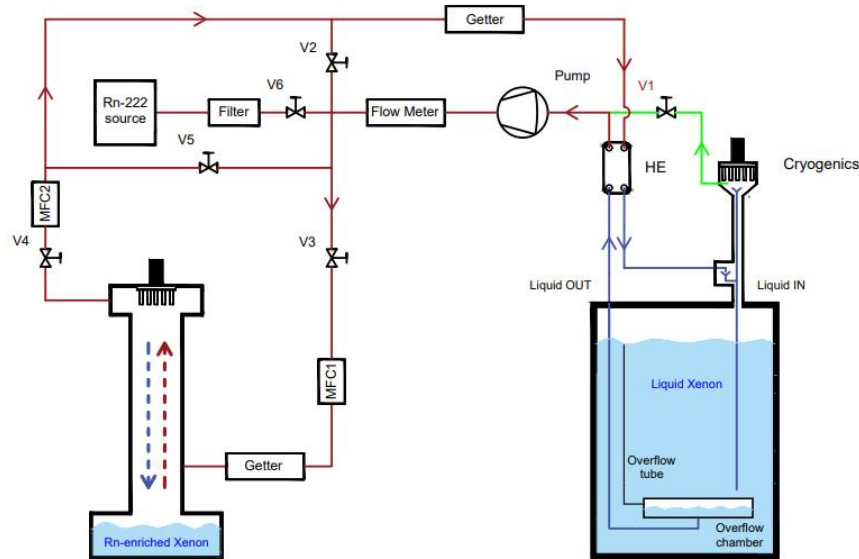
M-T diagram for Kr removal



- 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
- Product Kr concentration ~ 0.52 ppt

● PandaX-4T Distillation System

- Rn Reduction of the distillation tower >190
- Tritium Reduction ~ 3



● PandaX-xT Requirements

- Dark Matter: 1keV~10keV
- Electron life time: 7ms → electronegative impurity concentration: <1ppb
- Kr Concentration: 2nBq/kg(10^{-14} mol/mol)
- Rn Concentration: $0.5\mu\text{Bq/kg}$ (5×10^{-26} mol/mol)

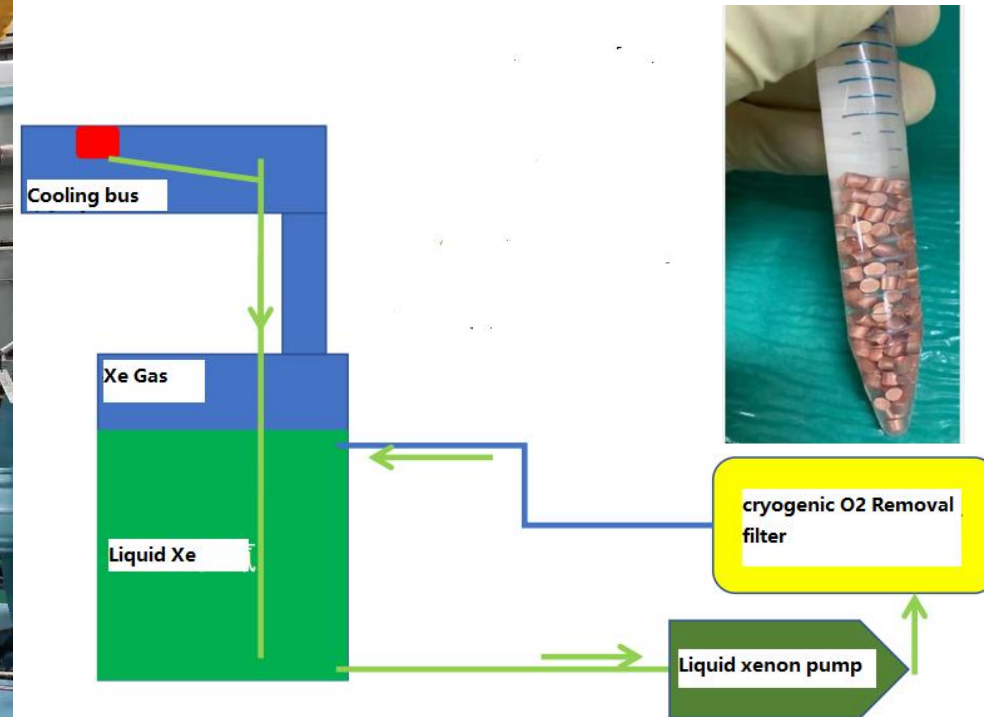
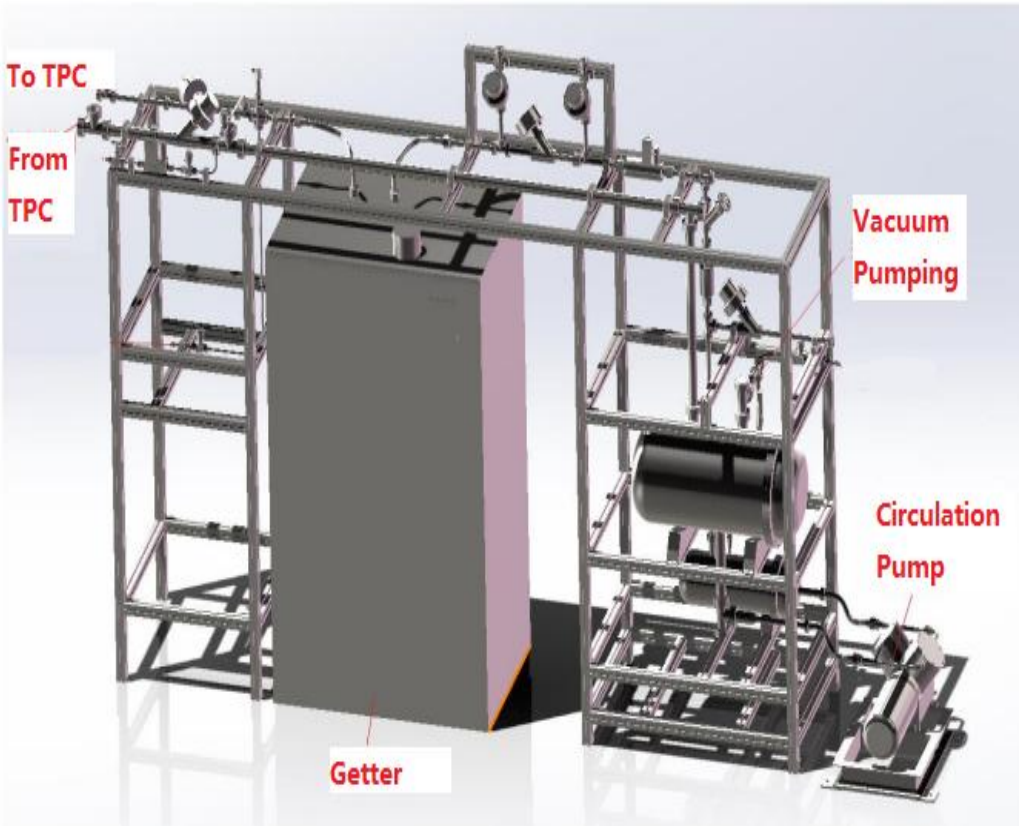
Purification System

	PandaX-4T	Upgraded
Purification speed [SLPM]	150	500
Electron drift time [ms]	0.84	7

Distillation System

		PandaX-4T	Upgraded
Flow rate [kg/h]	Kr	10	30
	Rn	56.5	856
Reduction factor	Kr	10^6	10^8
	Rn	2.2for 4t	4.4for30t

● PandaX-xT Purification system



Gas xenon purification system

- Flow rate: 500SLPM
- Expected electron Lifetime: 4ms

- PDC metal diaphragm pump
- Low outgassing
- Flow rate ~200SLPM

Liquid xenon purification system

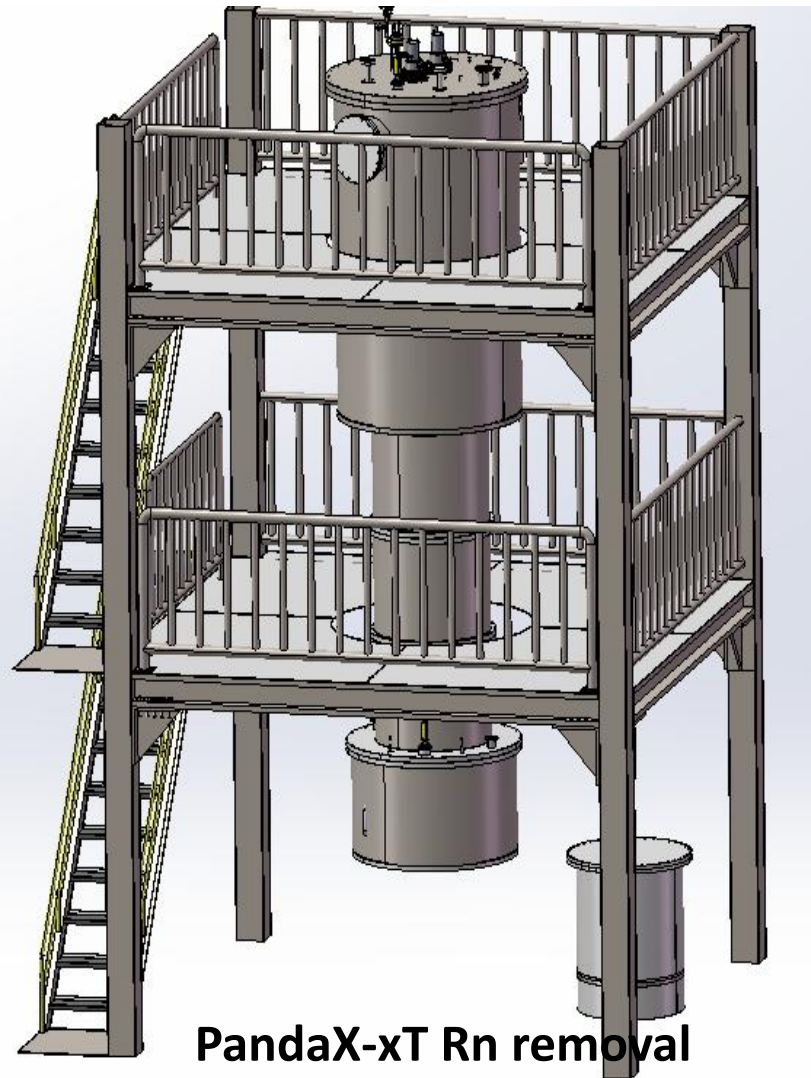
- Flow rate: 2LPM
- Expected electron Lifetime: 7ms

● PandaX-xT Distillation System



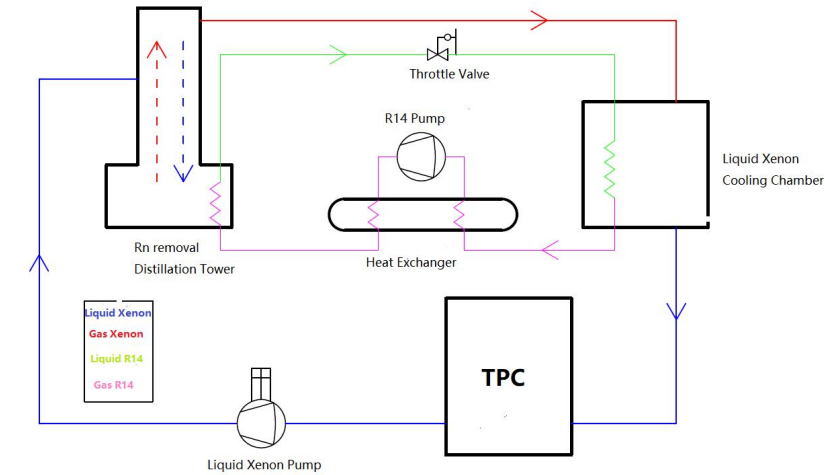
PandaX-xT Kr removal distillation system

- Flow rate: 30kg/h
- Expected Kr reduction: 10^8



PandaX-xT Rn removal distillation system

- Flow rate: 856kg/h (liquid 5lpm)
- Expected Rn reduction in TPC: 4.4 for 30t



PandaX-xT Rn removal distillation flow chart

- Cooling power recycle: 22kW
- Low temperature refrigerant throttling refrigeration circulation
- Carbon tetrafluoride: R14

● Summary and outlook



- PandaX-4T is one of the new generation multi-tonne xenon experiments (operation until 2025);
- PandaX-4T purification system flow rate is 150SLPM max in parallel, the max drift time 840 μ s
- PandaX-xT purification system flow rate is 500SLPM max, the liquid purification circulation is added, the drift time of 7ms is expected
- PandaX-4T distillation system Kr reduction 10^6 with 10kg/h, Rn reduction 2.2 with 56.5kg/h for 4t xenon
- PandaX-xT distillation system Kr reduction 10^8 with 30kg/h, Rn reduction 4.4 with 856kg/h for 30t xenon

The background features a traditional Chinese architectural style. At the top, a dark, multi-tiered tiled roof with ornate ridges is visible. Below the roof, a large, rectangular decorative plaque is mounted on a light-colored wall. The plaque has a gold-colored border with intricate patterns and contains several large, stylized Chinese characters in gold calligraphy. The overall scene is softly lit, giving it a warm and elegant appearance.

Thank You !