Cryogenics and Xenon handling system for the PandaX-4T dark matter experiment

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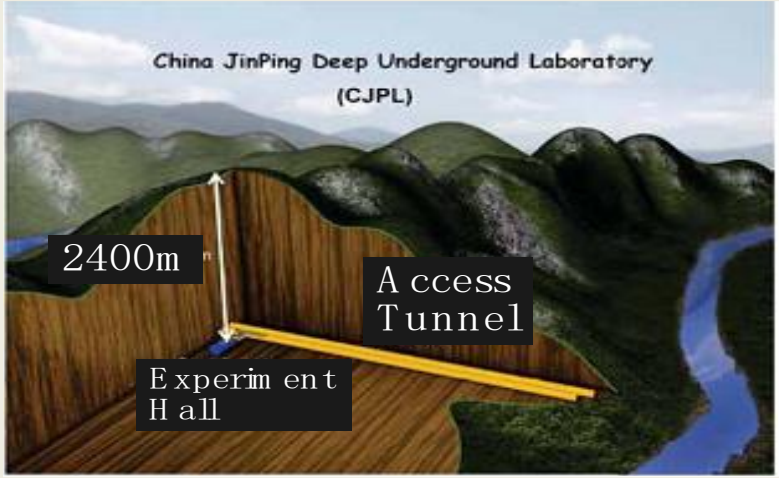
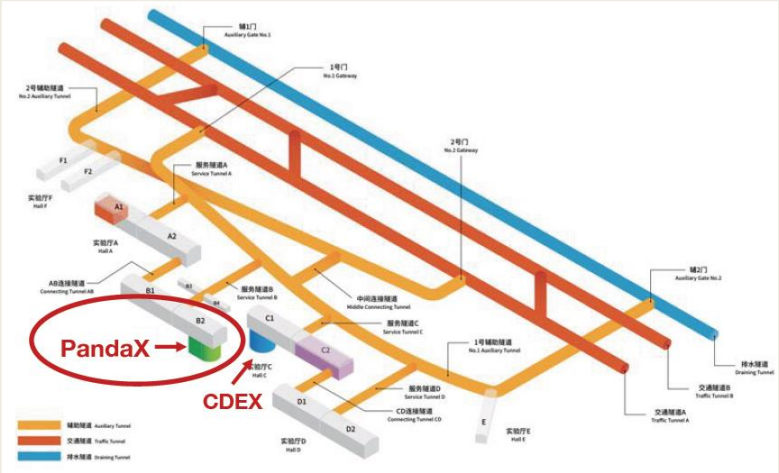
Outline

1. Introduction
2. Layout in lab and installation
3. Results of the commissioning
4. Summary

1 Introduction

- Dark matter experiment PandaX-4T is operated at B2 hall of CJPL-II.
- Liquid Xenon: ~ 6 ton.
- **A new cryogenics and gas handling system is needed**.





1.1 国内外液氙实验的制冷塔

意大利格兰萨索国家实验室

XENON1T(~3吨液氙)和
XENONnT(~**8吨液氙**)

制冷机：**2*PC150 （2*200W）**
液氮制冷：液氮盘管（~300W）

总功率：~700W（精控**400W**）

制冷机成熟

精控制冷功率偏小，功耗高

中国锦屏地下实验室（1期）

PandaX-I (~500公斤) 和PandaX-II(~1吨液氙）

制冷机：**1台（PC150）**
液氮制冷：液氮盘管（~300W）

总功率：480（**精控180W**）

制冷机成熟

精控制冷功率偏小，功耗高

美国桑福德地下实验室

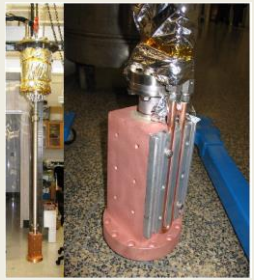
LUX(~370公斤液氙）和
LZ(~**10吨液氙**)

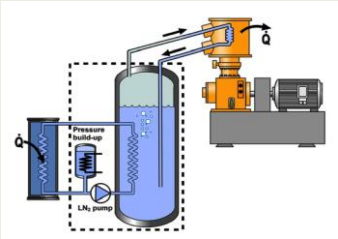
制冷机：无
制冷：液氮-虹吸管（200W~1000W）

总功率：**~1000W（精控）**

结构简单，无机械运动

精控制冷功率高，功耗低





1.2 国内外液氙实验的氙气处理

意大利格兰萨索国家实验室

XENON1T(~3吨液氙)和XENONnT(~**8吨液氙**)

XENON1T: 气态提纯，~55 slpm，2*hot Getter(PS4)+3*Qdrive+1/2管路
XENONnT：气态提纯保留，采用磁力驱动泵，并增加液氙提纯系统（2L/m）

中国锦屏地下实验室（1期）

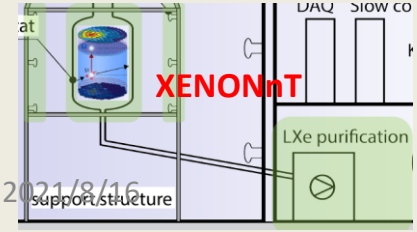
PandaX-I(~500公斤液氙) 和PandaX-II(~1吨液氙）

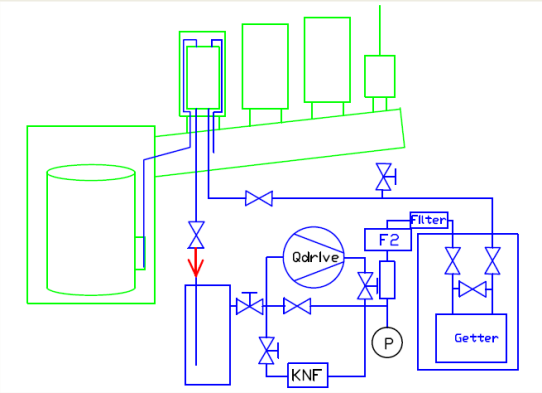
PandaX-I(II)：气态提纯，~55slpm，2*hotGetter(PS4)+2*KNF+1/2管路。

美国桑福德地下实验室

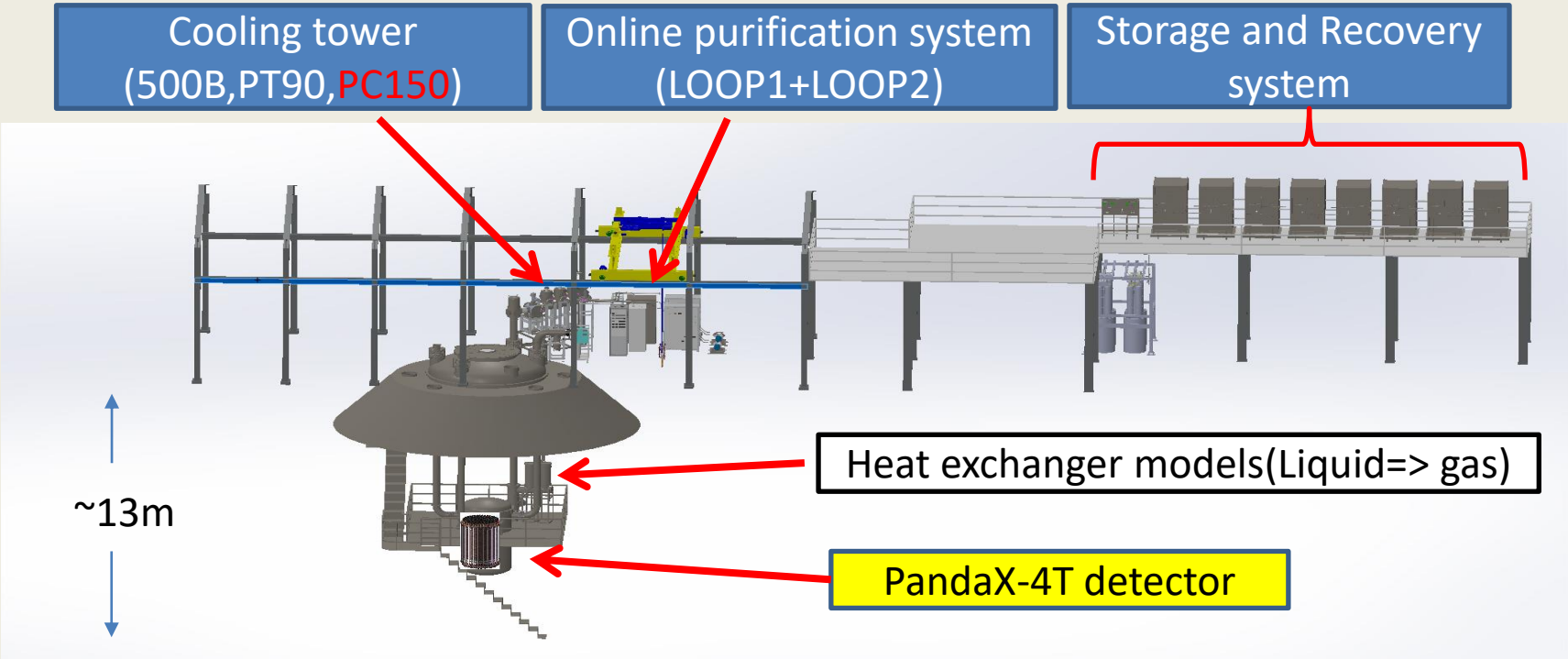
LUX(~370公斤液氙）和LZ(~**10吨液氙**)

LUX：气态提纯，~29 slpm.
LZ：气态提纯，~500slpm（计划），
2*PDC金属隔膜泵+2*hotGetter(PS5（450度）)





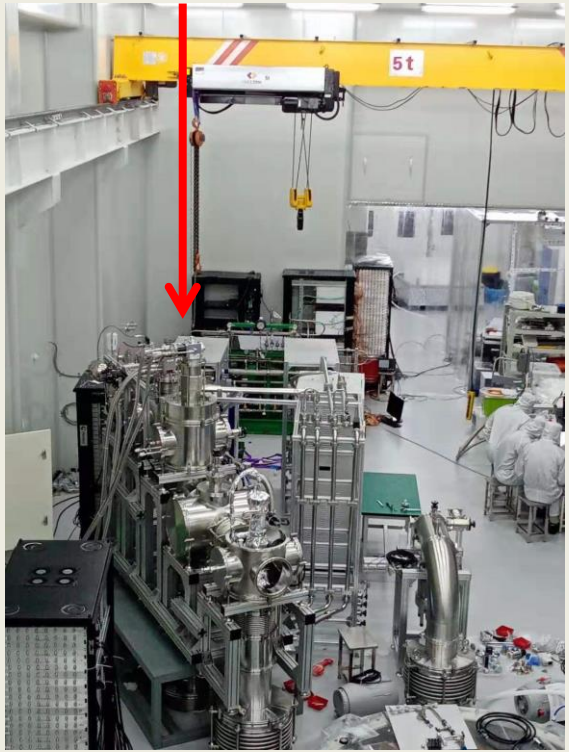
2.1 Layout of Cry. and gas handling system of PandaX-4T in lab



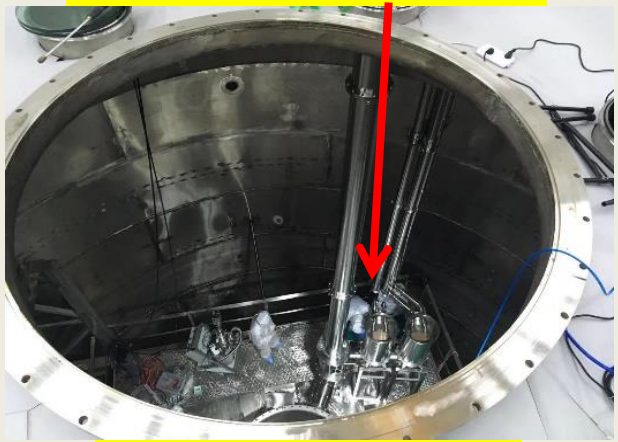
2.2 Installation and tests

Before installation

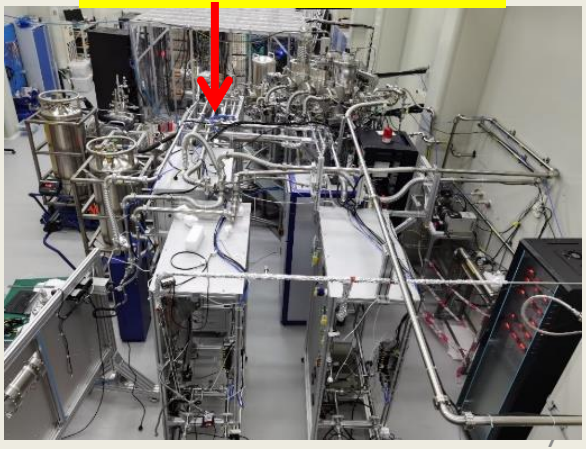
Cooling tower



Heat exchanger in water tank



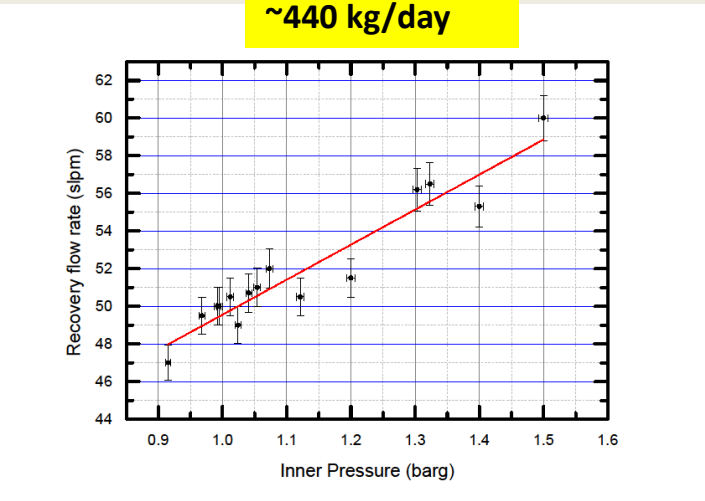
Online purification



2.3 Installation and tests

Emergency: Xenon Recuperation by LN2

~440 kg/day

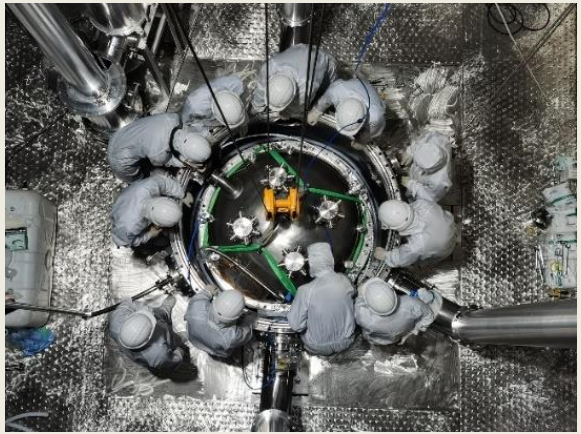


Storage system of 6 tons Xenon (8*16, 128 bottles,40L)

2.4 Installation for commissioning

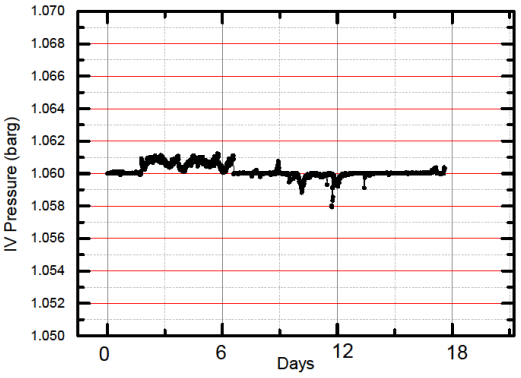
Low temperature tests of IV(-70C) for 3 times as positive pressure

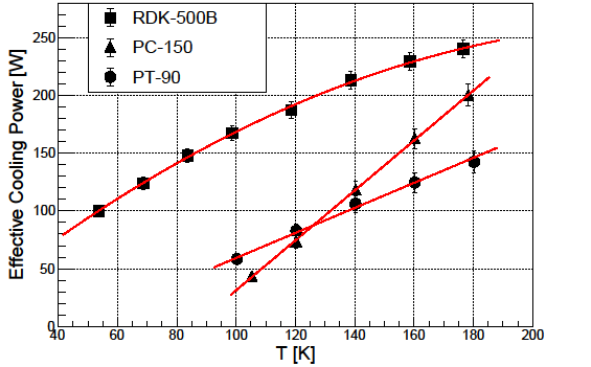
Inner vessel is being put in outer vacuum vessel, which is in water tank.

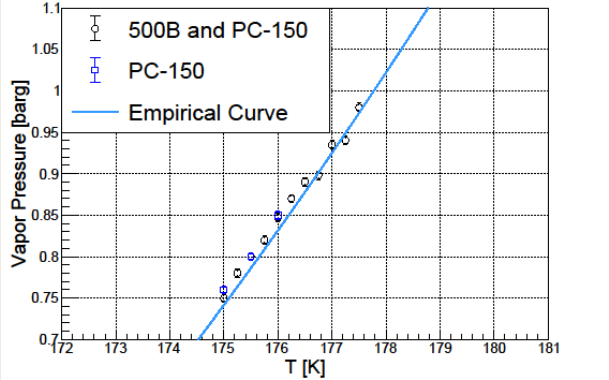


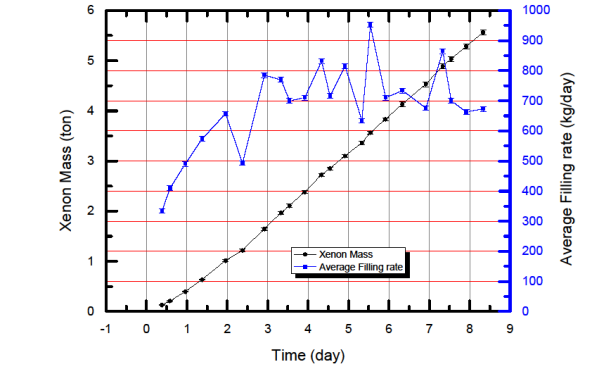
3.1 Some results of Cooling Bus

1. Total cooling power with 3 coldheads: ~**580W@178K**;
2. Multiple coldheads **can cooperate**, P-T function is the same for one or Two coldheads;
3. It is the **first time to successfully liquify about 6 tons** at CJPL-II in 9 days with a help of LN2.(~700kg/day)
3. **Outer vacuum:~E-4Pa; heat load of IV: ~96W.**
4. **Inner pressure is stable: <0.002bar.**





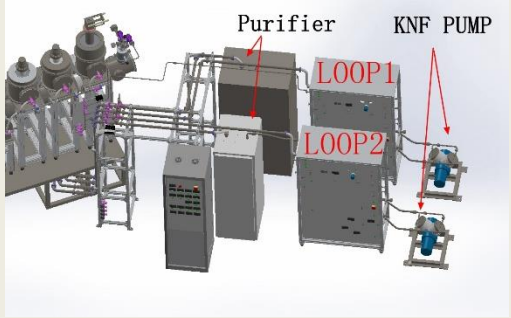




3.2 Some results of online purification

LOOP1:

1) **Purifier**: PS5-MGT50-R-909 (big);
2) Xenon gas(cooling tower): ~5 slpm;
3) Xenon liquid (overflower chamber): ~**120 slpm**;



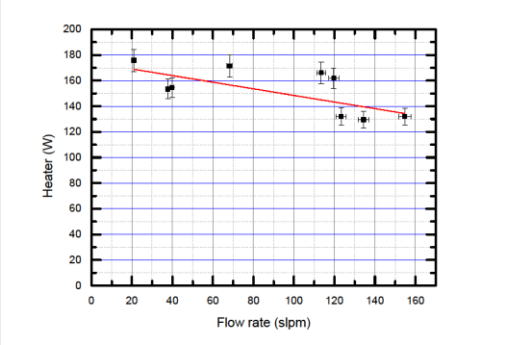
LOOP2:

1) **Purifier**: PS4-MT50-R (small);
2) Xenon gas(cooling tower) : ~5 slpm;
3) Xenon liquid (overflower chamber): ~ **35 slpm**;

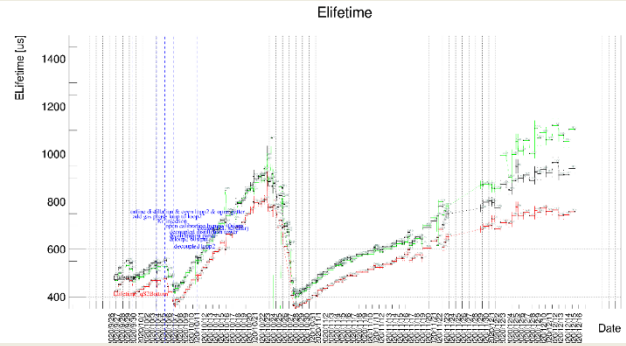
For others:

1) Gas calibration; 2) online distillation.

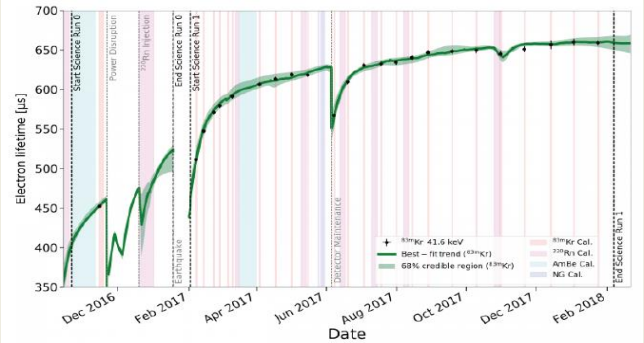
Efficiency of Heat exchangers: 97.5+-0.5%



PandaX-4T（~6 tons）, 3 months, Max-elifetime: ~1000 us



XENON1T（~3 tons）, ~1year, Max-elifetime: ~650 us



4 Summary

1) A **new Cryogenics and gas handling** system has been set up for a new dark matter experiment **PandaX-4T at CJPL-II**;
2) Total cooling power with 3 coldheads: **~580W@178K;**
3) Total purification flow ratio: **~155 slpm@6T**.
4) It can support the operation of the detector with ~6T liquid xenon.

Thanks a lot for your attention