Progress report and future plan of the PandaX experiment

PandaX Collaboration, Dec. 2021

The PandaX (particle and astrophysical xenon) observatory uses xenon as target and detector to search for WIMP particles as well as neutrinoless double beta decay (NLDBD) in ^{136}Xe. PandaX-4T experiment has started operation in 2021. The future PandaX program will focus on the following two main directions:

1. Develop PandaX-4T into a multi-purpose liquid xenon experiment, to push further the dark matter search and other physics topics;
2. Technological R&D and instrumental upgrade(s) to PandaX-4T towards a multi-ten-ton experiment (PandaX-xT) at CJPL

<u>PandaX-4T operation</u>

PandaX-4T (3.7 tonne sensitive LXe target) completed its commissioning data taking from Nov. 2020 to Apr. 2021, including 95.0 days of data taking. Due to two occasions of diaphragm pump failures, the run was separated into five different sets, but within each set the detector operation condition was stable. The detector response was studied with calibration using multiple methods, and no surprises were found. Two major background components, krypton, and radon, were suppressed to about 0.33 ppt and 5 μBq/kg, representing a factor of 20 and 6 improvements in comparison to PandaX-II. Some amount of tritium events is identified in the data. With spectral fit, the amount was estimated to be 5×10^{-24} mol/mol in xenon. The origin is likely due to some left-over tritium from PandaX-II end-of-run calibration. The temporal variation in the data indicates that gas circulation through hot getters may slowly reduce its concentration.

After the commissioning run, PandaX-4T undertook a tritium removal campaign. This activity has been intertwined with the construction in CJPL-II (currently in other areas of B2). We have signed an agreement with CJPL management to fully cooperate with the construction activities. It is expected that the B2 construction will commence in April 2022, by when we will take a halt on the current activity. The experimental activity will resume likely one year later.

<u>Scientific achievements</u>

The first results of PandaX-4T were released in July this year. With 0.63-tonne*year exposure, no signal excess was identified, so we produced a world leading dark matter-nucleon spin-independent exclusion, with a minimum cross section at 3.8×10^{-47} cm^2 at a WIMP mass of 40 GeV/c2. The paper【1】 has been accepted by Physical Review Letters as an Editor's Suggestion.

Being an ultralow background multi-tonne detector, we are actively expanding the physics reach of PandaX-4T in other areas, particularly in neutrino physics (neutrinoless double beta decay and solar neutrinos). Other scientific publication of the collaboration includes an ionization-only analysis on the PandaX-II data to search for low-mass WIMP-electron scattering 【2】, an improved search on self-interacting dark matter 【3】, and a detector response model of PandaX-II 【4】. The analysis activities are funded by an NSFC Major grant, with five universities involved (SJTU, USTC, SDU, SYSU, BUAA).

<u>Future R&D</u>

PandaX is also planning the next generation of experiment (PandaX-xT). The detector configuration will be decided in a few years based on the outcomes from the current generation of xenon experiments. However, most of the infrastructure for PandaX-4T can be reused. CJPL-II is also in the process of becoming a national major scientific facility (DURF), which will provide infrastructure and logistic support to future experiments.

PandaX collaboration is actively pursuing R&D on detector technologies of this new scale and background controls. Dedicated efforts include:

1) Funded through a MOST Major R&D grant, we are continually developing a 100-kg-scale high-pressure gaseous xenon TPC detector (PandaX-III), a pathfinder utilizing tracking calorimeter to search for the neutrinoless double beta decay in ^{136}Xe. All detector infrastructure, including a pressure vessel with 4 m^3 inner volume has been completed. We have made good progress with the thermal bonding Micromegas from USTC to form the charge readout plane. The first data taking with a fully instrumented 100-kg module will happen in spring next year.
2) Funded through the T. D. Lee institute, we are carrying out R&D in the following aspects: next generation LXe TPC, photosensors and readout, cryogenics, liquid xenon storage and circulation, background removal, and isotopic separation.

References

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【4】DETERMINATION OF RESPONSES OF LIQUID XENON TO LOW ENERGY ELECTRON AND NUCLEAR RECOILS USING A PANDAX-II DETECTOR, by PandaX-II Collaboration (Binbin Yan, Xun Chen*, Jianglai Liu* et al.), Chin. Phys. C 45 (2021) 7, 075001