Progress report and future plan of the PandaX experiment

Report at the CJPL International Advisory Committee meeting

PandaX Collaboration, Dec. 2018

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. Since the last IAC meeting in 2016, the PandaX-II experiment has been operated for two more years. The near future PandaX program will focus on the following three main directions:

1. Systematics and technical studies using PandaX-II detector;
2. Develop and operate a 4-ton scale multi-purpose liquid xenon experiment, PandaX-4T, to push further the dark matter search;
3. Develop and operate a 200-kg (upgradable to ton-scale) high pressure gas TPC (HpgTPC), PandaX-III, to search for NLDBD in ^{136}Xe.

PandaX-II: science and systematics studies

In Nov. 2017, PandaX collaboration published a new result on the spin-independent WIMP-nucleon scattering from 54-ton-day exposure data (Run 9+Run10), providing the most stringent constraints to WIMP-nucleon spin-independent (SI) interaction for WIMP mass above 100 GeV at that time [1]. Searches for other WIMP candidates and interactions were performed and world-leading results were obtained, including spin-dependent interactions [2], axions [3], inelastic scattering [4], light mediator interactions [5] and EFT models [6]. We will continue produce scientific results based on the data.

From operational side, PandaX-II experiment has been running stably. In 2017 and 2018, we have collected about 50% more dark matter exposure than the sum of the released data sets (Run 9 and Run 10).

The focus for our remaining data taking is to perform systematic studies using the PandaX-II detector. They include novel means of ER/NR calibrations, upgrade of trigger/electronics system, ways to improve the energy linearity and resolution at higher energies for the NLDBD signals, etc. These studies will provide critical technical guidance to the future multi-ton scale experiment.

Next phase DM experiment: PandaX-4T

We are developing a proposal of PandaX-xT, with the ultimate target of reaching the so-called neutrino-floor at a sensitivity to ~$10^{-49}$$cm^2$ for the spin-independent WIMP-nucleon cross section [7].

For the immediate next phase, we have completed the R&D and design work of the PandaX-4T detector with a sensitive target of 4-ton liquid xenon. Simulations show that the sensitivity of PandaX-4T could reach $10^{-47}$$cm^2$ from a 6-ton-year exposure [8]. PandaX-4T contains a TPC with a diameter of 1.2 m and a height of 2 m. A prototype of the TPC has been completed and passed functionality tests. There will be 368 3-inch PMTs from Hamamatsu to read the 178nm VUV light signal. New trigger and electronics system are designed and will be tested on PandaX-II. The PandaX-4T experiment needs to handle around 6-ton of liquid xenon. We are collaborating with the industry on the cryogenics, storage, filling and recuperation systems.

The PandaX-4T detector will be housed in a large ultrapure water pool in CJPL-II Hall B2. The inner part of the experimental hall is a clean room of class 10000. Construction of the ultrapure water tank for PandaX-4T is ongoing and is expected to be completed early in 2019. Other infrastructure, for example the clean room, ultrapure water supply, fresh air and stable electrical power, etc., is expected to be ready in the fall of 2019, after which the assembly of the PandaX-4T detector can start.

The PandaX-III experiment

NLDBD, if observed, would confirm that a neutrino is its own anti-particle and provide insights in the origin of tiny neutrino masses. It is generally agreed that the next goal of the worldwide NLDBD experiments shall be to determine the nature of neutrinos when the neutrino mass spectrum has the inverted hierarchy (e.g. 2015 US nuclear science long-range plan).

To search for NLDBD, PandaX-III project is using ^{136}Xe HpgTPC with the ability of identifying the event topology to discriminate signal from background. Details of the PandaX-III project can be found in its conceptual design report [9].

The R&D of the first HpgTPC with 200 kg of 90% enriched ^{136}Xe has been moving forward in the past two years. A prototype HpgTPC with 20 kg is being constructed with 7 Microbulk Micromegas readout modules [10]. Through calibration studies, a 2.2%

energy resolution (FWHM) is being expected at the NLDBD Q-value. To identify the event topology, machine learning through convoluted neural network algorithm was developed for PandaX-III detector with better signal/background discrimination power than the traditional method [11]. The next step is to construct and to deploy the 200-kg HpgTPC to CJPL-II.

Collaboration: The PandaX collaboration is led by SJTU, and includes researchers from Peking University, Shandong University, Nankai University, Shanghai Institute of Applied Physics, University of Science & Technology of China, China Institute of Atomic Energy, Sun Yat-Sen University, Yalong Hydropower Company, University of Maryland, Lawrence Berkeley Lab, Alternative Energies & Atomic Energy Commission of France, University of Zaragoza, and Suranaree University of Technology. PandaX-II, PandaX-xT and PandaX-III are all sub-collaborations within PandaX. There is a significant personnel-overlap among the three groups and full information is shared.

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