Status and prospects of the China Dark Matter Experiment

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Abstract. The China Dark Matter Experiment (CDEX) pursues direct searches of light Weakly Interacting Massive Particles (WIMPs) at the China Jinping Underground Laboratory (CJPL), which is the deepest operating laboratory for astroparticle research in the world. Results from a prototype CDEX-0 20 g germanium detector array and CDEX-1 994 g pPCGe (p-type Point Contact Germanium) detector are reported. The new result from CDEX-1 pPCGe excludes the CoGeNT-2013 allowed region with an identical detector technique. CDEX-10 with a PCGe array of 10 kg target mass range enclosed in a liquid argon anti-Compton detector is being constructed and tested. The CDEX program evolves into the targets of "CDEX-1T Experiment". The CDEX-1T experiment will be located in CJPL-II which is under construction and will be finished by the end of 2016.

1. Introduction

There is compelling evidence that about one-quarter of the energy density of the Universe is made up of Dark Matter, the identification and study of which are among the most important goals in basic research [1]. WIMPs is a most favoured candidate for Dark Matter. Some earlier experiments have produced intriguing results which can be interpreted as positive signatures of WIMPs with relatively light mass of a few GeV [2-5], in disagreement to other experiments which yielded negative results [6-10]. The issue remains controversial and generates intense interest.

The CDEX [11] pursues formally the direct detection of light WIMPs from 2009 on, after more than five-year pre-study at Tsinghua University, towards the goal of a ton-scale germanium detector array. As illustrated schematically in Figure 1, the CDEX experiment is performed in the China Jinping Underground Laboratory (CJPL) [12] which is the deepest operating laboratory for astroparticle research in the world, with more than 2400m of rock overburden, attenuating the cosmic-rays background by more than a factor of $10^8$ to the level of about 60 m$^{-2}$ y$^{-1}$ [13].
Figure 1. Schematic diagram of the CDEX-1 experiment conducted in the China Jinping Underground Laboratory.

Figure 2. Schematic diagram of the CDEX-1 experiment, including PCGe and NaI(Tl) detectors and copper shielding.

The CDEX experiment is led by Tsinghua University, with collaborating partners from Sichuan University, Nankai University, China Institute of Atomic Energy, Yalong River Hydropower Development Company, as well as the TEXONO Collaboration. As the phase-I experiment by CDEX collaboration, CDEX-1 deploys state-of-the-art ultra-low-background point-contact 1kg-mass germanium detectors with sub-keV sensitivities [14]. This germanium detector is enclosed by NaI(Tl) crystal scintillator plus copper blocks and placed inside a poly-ethylene housing, as shown in figure 2. These can highly suppress the gamma background and neutron radiations from outside. In addition, the inner space of the copper is purged by nitrogen gas to reduce the influence of the radioactive radon gas.

2. The current status of CDEX

Ultra-low energy threshold germanium detectors were identified [15] as effective means to probe the light WIMPs and motivated by the development of point-contact germanium detectors. The generic “benchmark” goals in terms of detector performance are: (1) modular target mass of order of 1 kg and total mass up to 10kg; (2) detector sensitivities reaching to the range of 100 eV; (3) background at the range of $1 \text{ kg}^{-1} \text{ keV}^{-1} \text{ day}^{-1} (\text{cpk})$.

Results on light WIMPs from the CDEX-0 and CDEX-1 employed a germanium detector array with a total mass of 20 g and a crystal mass of 994g pPCGe detector respectively had been published [16,17]. The latest results from CDEX-1 experiment with the 994g pPCGe detector having two crucial features incorporated including the presence of an anti-Compton detector and surface event suppression were recently reported and shown in Figure 3 [18]. All events above the analysis threshold of 475 eVee can be quantitatively accounted for with the understood background channels. An order of magnitude improvement over the previous CDEX results is achieved. In particular, the CoGeNT-2013 allowed region is excluded based on identical detector technique. It provides direct comparisons without the uncertainties due to model dependence introduced via the choice of astrophysical and nuclear parameters.
3. Prospects of CDEX
The CDEX-1 experiment continues to accumulate data at CJPL. Research programs are pursued to further reduce the physics threshold via hardware and software efforts. Time modulation of the data will be studied. The CDEX-10 experiment with a PCGe array of 10 kg target mass range enclosed in an active liquid argon anti-Compton detector is being constructed. Feasibility studies towards scale-up to ton-scale experiment are being pursued.

The CDEX program evolves into the targets of "CDEX-1T Experiment" with ton-scale germanium detector arrays, which will compose of thousands of kg-mass prototype germanium detectors. The detector arrays will be submerged in liquid argon for cooling and active shielding. The conceptual drawing is shown in Figure 4. This Facility will further contribute to the studies of Dark Matter and Neutrinoless Double Beta Decay. It will be located in one of the four halls with dimensions of $14m(W) \times 14m(H) \times 65(L)$ in CJPL-II which will be completed by the end of 2016.
Figure 4 Conceptual drawing of the future CDEX-1T facility

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