China Jin-Ping Deep Underground Laboratory: Status and Plan

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Introduction

One of the prominent results of 20th century is establishment of several evidences for the existence of dark matter (DM). DM constitutes most of the universe matter content and yet it is elusive because of its weak interaction strength and due to tremendous detection challenges.

Standard model of particles does not provide any DM candidate. But, the natural extension of standard model such as Supersymmetry, Universal extra dimension and little Higgs model provides several DM candidates. Weakly Interacting Massive Particles (WIMP, χ) are the most favorite candidates [1].

The experimental efforts on WIMP's can be broadly classified into three categories, namely: Accelerator searches (in this approach environment similar to time scale of big-bang are obtained and signal for WIMP's are searched), Indirect detection (In this approach, the self-annihilating by products are observed) and Direct detection (In this approach, WIMP interaction with target nucleus are observed). These experiments focus on WIMP's with mass of 1GeV–1TeV because these WIMP's posses required relic density and below 1GeV are largely ignored because of detector energy threshold constrains.

The experiments being performed at China Jin-Ping Deep Underground Laboratory (CJPL) falls under direct detection experiment. The status, plans and how the DM experimental challenges are being overcome will be presented.

CJPL Laboratory

The CJPL [2] laboratory bears Jin-ping mountain rock overburden of >2400m with tunnel drive-in access. It is located at southwest Sichuan, China, reachable from the provincial international airport at Chengdu via a 50 min flight to Xichang followed by a 90 min drive on a private two-lane motorway. The laboratory is owned by the Ertan Hydropower Development Company and managed by Tsinghua University, China.

The excavation and construction of an experimental hall of size 6.5 m X 6.5 m X 40 m with 50cm of concrete lining was completed in summer 2010. By the end of 2011, ventilation system, high-speed internet connection and the necessary surface infrastructures was installed.

There are intense efforts at CJPL to characterize the background. Measurements are being performed on the ambient radioactivity as well as fast and thermal neutron fluxes. The preliminary CJPL rock background result of ^{40}K, ^{226}Ra (609keV) and ^{232}Th (911keV) is better than 1.1, 1.8±0.2 and < 0.27, respectively. The background of similar elements at ground level in Beijing is around 600, 25 and 50, respectively.

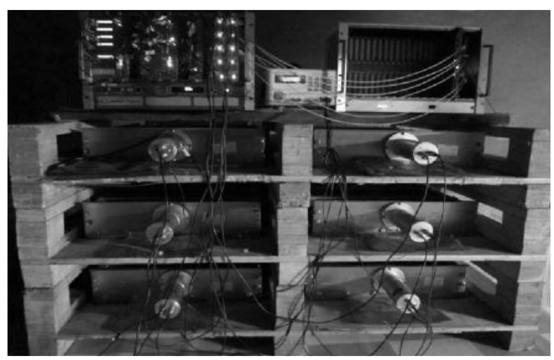

Fig. 1: Cosmic ray test stand.

Cosmic ray test stand of six plastic scintillation detectors as shown in Fig. 1 is taking cosmic ray muon data in 3-fold coincidence. 28 cosmic ray muons are observed in 178 days at the rate of 6 muons per m^2 per month and comparative results are shown in Fig. 2 that is similar to the expected one [3].

A very low radon background is observed at experimental site and various other experiments are being performed to understand neutron, gamma-ray etc. backgrounds.

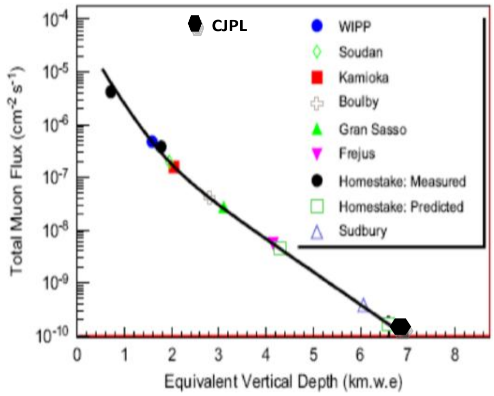

FIG. 2: Total cosmic ray muon flux at CJPL along with other underground labs.

To overcome experimental challenge concern with low energy threshold, Ge detection technology is being employed. TEXONO-CDEX is acquiring data with a kilogram p^+ - Point Contact Germanium detector (PCGe) [3] surrounded by moderate passive shielding comprising of boron loaded polyethylene, low activity Pb and OFHC Cu is shown in Fig.3.

FIG. 3: PCGe detector with moderate passive shielding material.

Prospects and Outlook

The Phase I of experimental operation is being implemented. In the later phases, research and development towards enhancing target mass of the order of 10 kg and ton scale is under consideration. The schematic layout of 10 kg experiment is shown in Fig. 4 and is scheduled to be achieved by the end of 2015.

Exclusion plot for spin independent-nucleus interaction cross-section as a function of mass is shown in Fig. 5. The plot contains worldwide limits and CJPL projected sensitivities obtained by considering 1cpkkd background level, 100 eV detection threshold and 1kg target mass. The project sensitivity demonstrates the best world's best limit in the low mass dark matter.

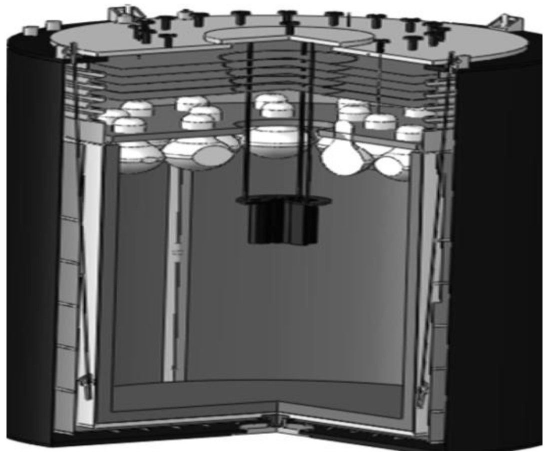

FIG. 4: Schematic layout of 10 kg detector set up.

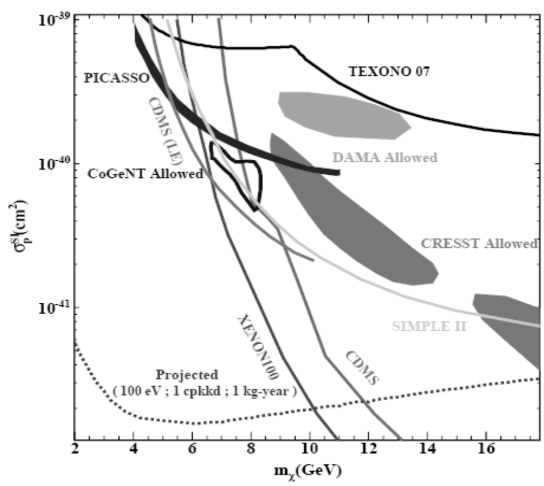

FIG. 5: Exclusion plot of spin-independent χN cross section verses WIMP mass.

CJPL is thus the deepest operating underground laboratory in the world with favorable conditions to perform DM studies. The details of experimental configuration and adopted analysis procedures will be presented.

References

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