Status and Prospects of a Deep Underground Laboratory in China

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Abstract. An excellent candidate location for a deep underground laboratory with more than 2500 m of rock overburden has been identified at Sichuan Province in China. It can be accessed through a road tunnel of length 17.5 km, and is supported by services and amenities near the entrance provided by the local Ertan Hydropower Plant. The particle physics community in China is actively pursuing the construction of an underground laboratory at this location, under the leadership of Tsinghua University. Memorandum has been signed with Ertan Hydropower Plant which permits access to and construction of the underground laboratory — China Jinping Deep Underground Laboratory (CJPL). The basic features of this underground site, as well as the status and schedules of the construction of the first laboratory cavern are presented. The immediate goal is to have the first experiment operational in 2010, deploying an Ultra-Low-Energy Germanium detector for WIMP dark matter searches, with emphasis on the mass range of 1-10 GeV. The conceptual design of the experiment, as well as the future plans and prospects of the laboratory, will be surveyed.

1. Introduction

The essence of dark matter direct detection is to survey possible parameter space for the most popular dark matter candidate WIMP (Weakly interactive massive particles) and has been a subject of intense. in particle physics, astrophysics and cosmology. The experimental approach is to study the recoil nuclei scattered off by an incident WIMP particle inside an active detector. The experiments require ultra-low background techniques to suppress background events, similar to those of double beta decay experiment, neutrino experiment, proton decay experiment, and so on.

Low background experiments require very good laboratory to reduce the background event rates which come mainly from the cosmic-ray muons, ambient radioactivity, as well as the internal backgrounds and the detector noise. The radioactive background from the ambient radioactive isotopes can be shielded with passive and/or active shielding system. The high energy muons, however, can penetrate the shielding system and interact with the detector, though this channel can be vetoed by an active veto system. Background due to cosmic-ray induced neutron and long-lived radioactive isotopes generated by the interactions of the incident muons with the materials in the vicinity of the detector are the most difficult to shield. So it will be important to find it is essential to perform dark matter experiments at underground laboratories where the muon flux is greatly reduced by the huge rock overburden.

There are many underground laboratories established or under construction in the world including the LNGS in Italy, Subdury in Canada, Modane in France, DUSEL in USA, and so on [1]. In this
paper, we will give an introduction to a forthcoming deep underground laboratory in China which will have the deepest rock overburden and convenient conditions for work and lives. This deep underground laboratory is named China Jinping Deep Underground Laboratory (CJPL).

2. The condition of the CJPL

The Yalong River in Sichuan province, southwest China, changes its course due to the Jinping Mountain, creating a great river bend with length more than 200 km. Ertan Hydropower Company will build two hydropower plants at each side of the Jinping Mountain. Two parallel tunnels have been dug to pass through the Jinping Mountain for transportation and hydropower plant construction as shown in Figure 1. A total of seven tunnels will be constructed including four headrace tunnels, one drainage tunnel, on top of the two transport tunnels where construction was completed in August 2008 [2]. The length of these two transport tunnels is 17.5km and the cross-section is about 6m*6m. The underground laboratory will be constructed in the central portion of one of two Jinping tunnels. The detailed position of CJPL is shown in Figure 2. The minimal rock overburden is more than 2500km.

The construction of CJPL will be done in stages as shown in Figure 3. In Phase-I, a hall with dimension of 6m×6m×40 will be established for dark matter search experiment by the end of 2009. This Hall A can be accessed by a right-angled tunnel which is 60 m in length and will be served by a second engineering laboratory (Hall B) before the end of 2009. At the same time, several tunnels have been constructed for the geological exploration to evaluate the construction of huge cavity for large-scale experiments in the future. Construction of the power supply, ventilation and drainage systems will be completed in the middle of 2010. The tunnel laboratory area is equipped with 3G wireless network and fiber access to broad-band internet. Apartments, restaurants, hotel and sport facilities are available at the tunnel entrance.

3. The dark matter experiment at CJPL

By the end of 2009, the construction of Phase-I of CJPL infrastructure will be finished as Hall-A with dimension of 6m×6m×40m plus concrete coverage. The first experimental program will start to install its shielding system and main detector for dark matter search. More than 30 scientists from
China have established a collaboration (China Dark matter EXperiment, CDEX) to conduct the experiment with the TEXONO [2] and KIMS collaborations. This experiment will use Ultra-Low-Energy High Purity Germanium (ULE-HPGe) detector as the target detector for WIMP search [4,5]. The complex shielding system covering the main ULE-HPGe detector includes, from inside out, 10 cm of copper, 10 cm of steel frame, 5 cm of plastic scintillator, 20 cm boron-loaded polythene, 20 cm of lead and 1 m of water as shown in Figure 4. Water and boron-loaded polythene are served as neutron decelerator and absorber. Lead and copper layers are served as gamma shielding and plastic scintillator is used as cosmic-ray veto detector. The steel frame is the supporting structure. The internal space with dimension of 1.5m(w)×2m(h)×2m(L) will be served as the main detector space, where the HPGe detector array will be located.

![Figure 4](image1.png)  Schematic layout of the detector space system and its shielding. The coverage is 4π, but only one face is shown.

The layout of the Ultra-Low-Energy High Purity Germanium (ULE-HPGe) detector and its active shielding system is shown in Figure 5. The HPGe detector array is surrounded by the cryostat. Outside the cryostat, the CsI(Tl) crystal detector serves as the active shielding for cosmic-ray muon and gamma background. The copper layer is used to shield the gamma background from the preamplifiers and the Dewar bottle which contains liquid nitrogen for Ge crystal cooling. The ULE-HPGe detector can achieve an energy threshold of less than 300eV and is sensitive to low-mass WIMP detection, especially for WIMP with mass less than 10GeV[3]. The Phase-I experiments will include WIMP searches using ULE-HPGe as well as Point-Contact Germanium detectors with mass will up to 500g.

4. Summary and Prospects
An underground laboratory named CJPL with minimal rock overburden of 2500m will be constructed in China and one of the experimental halls will be ready by the end of 2009. The first experiment for dark matter search with 500g ULE-HPGe will be run in the CJPL. Upgrades of the target mass of the ULE-HPGe detector to the scale of ~100 kg scale can be considered in the future, based on the results and experience of Phase-I.

References
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