PHYSICS

China supersizes its underground physics lab

Planned expansion could pave way for "ultimate dark matter experiment"

By **Dennis Normile**

The world's deepest physics laboratory is about to become one of its largest. Early next year, workers will start carving four cavernous experiment halls along a tunnel through Jinping Mountain in China's Sichuan province. Once the science at the China Jinping Underground Laboratory (CJPL) is scaled up as well, "it will be a milestone for Chinese physics," says Nigel Smith, director of the underground SNOLAB in Sudbury, Canada.

Opened in December 2010, CJPL is the deepest facility of its kind, with 2400 meters of rock shielding it from background radiation (see chart). The lab so far has focused on the hunt for dark matter, the universe's postulated missing mass. More space will allow larger and more sensitive dark matter detectors and an expanded research agenda that will include a nuclear astrophysics accelerator to replicate the inner workings of stars. CJPL also hopes to branch out into observing neutrinos and studying exotic particle phenomena.

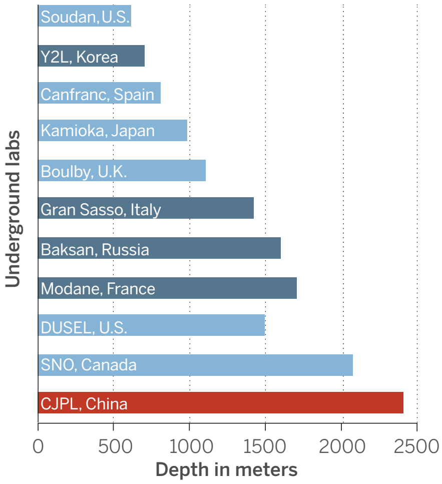
Deep underground labs elsewhere have a head start in all of these areas. This means the Chinese will have to choose research targets carefully based on "if and where they can do better" than existing experiments, says Alessandro Bettini, director of the Canfranc Underground Laboratory in Spain. Others have confidence in the Chinese quickly coming up to speed. "It's a highly competitive site [with] lots of potential," says John Ellis, a theorist at King's College London who chairs a new international advisory committee that visited the lab last month.

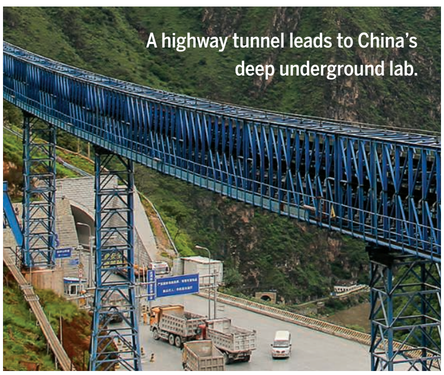
China's ascent in underground physics began serendipitously in August 2008, when Qian Yue, a physicist at Tsinghua University in Beijing, saw a TV report about access tunnels being bored through Jinping Mountain for a massive hydroelectric project. Tsinghua approached the Yalong River Hydropower Development Co. Ltd., which agreed to excavate two experiment halls totaling 4000 cubic meters along one of the tunnels (*Science*, 5 June 2009, p. 1246).

CJPL, run by Tsinghua, now hosts two dark matter experiments. The Particle and Astrophysical Xenon (PandaX) experiment uses a 37-kilogram liquid xenon target to watch for dark matter in the form of postulated weakly interacting massive particles (WIMPs). If WIMPs exist, they should occasionally travel unmolested through the mountain and collide with a xenon nucleus, producing a flash of light. In the other experimental hall, the China Dark Matter Experiment (CDEX) aims to catch the electrical signal produced if a WIMP bumps into a nucleus within a germanium crystal. "There is complementarity" between the two approaches, says Henry Wong, a physicist at Academia Sinica's Institute of Physics in Taipei and member of the CDEX collaboration. Xenon detectors should be better at distinguishing a WIMP signal from flashes sparked by some kinds of background radiation, whereas the more sensitive germanium detectors ought to be able to spot interactions involving lighter WIMPs. Although neither experiment has yet detected a WIMP, they both have helped confirm results from other labs indicating that WIMPs are likely to have very little mass.

Deep, dark labs

In the hunt for dark matter, deeper is better. Labs are built in mines (light blue) and tunnels (dark blue and red).





A highway tunnel leads to China's deep underground lab.

For an initial effort, the results are "pretty decent," says Wick Haxton, a theorist at the University of California, Berkeley. To boost its chances of sighting WIMPs and determining their mass, CJPL needs a larger volume of xenon, more germanium crystals, and better shielding. All of that requires more space. "If they significantly enlarge those experiments over the next couple years," Haxton says, "they could end up being very competitive."

CJPL is about to get the elbow room it needs. Before the hydropower construction work wraps up next year, crews will bore another four 130-meter-long experiment halls. When lined with concrete, each will be 13.2 meters wide with an arched ceiling 13.2 meters high. All told, the enlarged facility will have 120,000 cubic meters of research space, second only to Italy's Gran Sasso National Laboratory, which has 180,000 cubic meters. By piggybacking on the hydropower project, Tsinghua limited the expansion's cost to $50 million. Yue hopes to start experiments in the new halls by the end of 2016.

CDEX aims to boost its sensitivity by increasing its germanium target from 1 to 10 kilograms and by adding more elaborate shielding. The PandaX team is thinking much bigger. "We are interested in building the ultimate dark matter experiment: a 20-ton scale liquid xenon experiment," says Xiangdong Ji, a physicist at Shanghai Jiao Tong University and the University of Maryland, College Park. That would be several times larger than existing liquid xenon experiments. Realizing such a mammoth project, says Ji, who leads PandaX, could require teams worldwide to pool resources.

A new experiment planned for the expanded space is the Jinping Underground laboratory for Nuclear Astrophysics (JUNA). Its pièce de résistance would be a particle accelerator used to replicate the nuclear processes generating energy within stars and the synthesis of heavier elements from hydrogen and helium in the primordial universe. The rock shielding would reduce background noise, making it easier for researchers to detect rare and subtle signals. With a more powerful accelerator and a deeper location than other efforts, says project head Weiping Liu, a physicist at the China Institute of Atomic Energy in Beijing, "JUNA has the potential to take a favorable position among underground nuclear astrophysics labs." ■

PHOTO: CJPL