understanding of how an aerogel material invented in his lab can soak up as much as eight times its weight in oil from water surfaces and then be wrung out for reuse. He hopes the cost of the material can be lowered, so that the technology can be used during the next big spill and for cleaning up routine spills at refineries and marinas. In another case, researchers at the University of Central Florida received a $67 000 grant to develop a chemical process they hope will turn fly ash, a waste product from coal burning, into a low-cost, recyclable oil absorbent.

David Kramer

China, others dig more and deeper underground labs

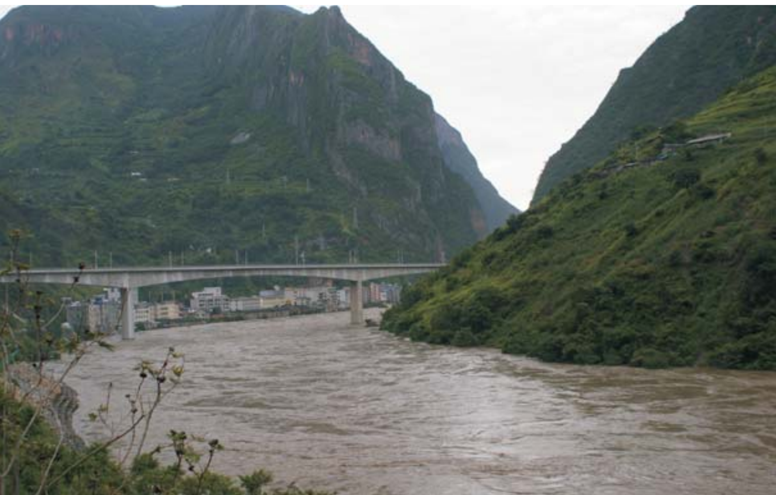
From tiny to gargantuan, experiments are in the works to exploit the shielding from cosmic rays that being deep underground offers.

Initial experimental plans are modest, but with its drive-in access and extreme depth, the new China Jinping Deep Underground Laboratory (CJPL) has the potential to become a major international player. China is plunging into the vibrant global scene of underground labs with a small dark-matter experiment set to start collecting data this fall.

"Underground science is really booming," says André Rubbia, the ETH Zürich physicist who chairs LAGUNA, a study of European underground sites for a megaton long-baseline neutrino experiment. "With bigger and bigger accelerators more difficult to build and finance, physicists realize that there is a huge amount of science to be done underground—in a low-background environment—that is complementary to the high-energy frontier," he says. Physicists go underground to block cosmic rays from experiments that look for neutrinos, dark matter, proton decay, double beta decay, and the like. Underground sites are also attracting projects in other areas, including geology, electronics, gravity waves, biology, and engineering.

Small but fast

The CJPL grew rapidly from an idea to reality: In mid-2008 scientists got wind that the Ertan Hydropower Development Co



QIAN YUE

A new underground lab (below) in China will be the world's deepest research site, located in Jinping mountain (left) of Sichuan Province.

SNOLAB

The deepest underground lab for now is the recently completed SNOLAB in Canada. One of several new experimental halls will host two dark-matter search experiments that are set to be installed in the next two years.

was going ahead with a decades-old idea for a power plant in Jinping mountain in Sichuan province. The company is building dams at two sites on the Yalong river, which hugs the mountain, and is connecting the sites with seven 17.5-km-long tunnels. A few months later, in May 2009, an agreement was in place to excavate lab space next to one of the two transportation tunnels the company was digging.

"It was very exciting to find a good place to set up our own lab," says CJPL physics chief Qian Yue of the engineering physics department at Tsinghua University in Beijing. "We have been involved in the dark-matter search for almost 10 years. But there is no special underground lab in China. We have worked at a relatively shallow underground lab in [South] Korea."

The CJPL has about 2500 meters of rock shielding, making it the world's deepest underground lab. The required depth depends on a given experiment's need to be shielded from cosmic rays.

Tsinghua University, Ertan, and China's ministry of education paid the roughly $5 million to dig out the lab and install ventilation, internet access, and other infrastructure. The initial experiment hall is about 40 m long by 6.5 m wide and 7.5 m high. The China Dark Matter Experiment (CDEX) is moving into the lab and starting to take data this month.

The CDEX is a collaboration of about 30 scientists, led by groups at Tsinghua and at Taiwan's Academia Sinica. Incident dark matter will cause germanium nuclei in the detector to recoil; the associated ionization of germanium atoms can be detected when the ions and electrons drift in an electric field. The detector will start out tiny, at 20 grams, but the CDEX plans to upgrade to 1 kg by the end of this year, and eventually to one ton.

"We will start by testing the detector at the new site," says Yue. The germanium detector was used previously in Taiwan, where it was installed near a nuclear power plant to detect reactor neutrinos. Until now, dark-matter detectors have focused on higher energies, in the range of 10–1000 GeV, he adds. The CDEX will be one of the first dark-matter detectors sensitive below 10 GeV.

Background brainstorming

Xiangdong Ji, who splits his time between the University of Maryland, College Park and Shanghai Jiao Tong University (SJTU), is leading what is likely to be the CJPL's second experiment, also hunting for dark matter. The experiment will be based on a small, 25-kg xenon detector that Ji and colleagues plan to install in the lab next year. The team is still discussing "how this new opportunity interfaces with the goal of a one-ton xenon detector," says Ji, referring to the international XENON Dark Matter Project, of which he is a member. It could be research and development for the larger project or for another ton-scale experiment in collaboration with XENON, he says.

Other researchers say they are brainstorming for experiments they may do in the CJPL. Changgen Yang, a physicist at the Institute for High Energy Physics in Beijing, says he is looking at what is already going on in the world "so we can join the interesting underground lab." And, he adds, people keen to use the new lab include not only particle and astroparticle physicists, but also those studying geophysics and soil mechanics.

Underground renaissance

The Modane Underground Laboratory (LSM), located in the French side of a tunnel that connects France and Italy, is perhaps the site that most resembles the CJPL. The LSM is fairly deep (1700 m) and like the CJPL has the advantage of horizontal access. Having hosted physics experiments for 30 years, the LSM could now be expanded by piggybacking on the digging of a second tunnel, which is under way in response to roadway accidents that led to deadly fires. With the new egress tunnel set to be completed in 2012, various local and national French agencies are expected to decide by next spring whether to fund the proposed lab expansion. The idea is to increase the current 3500-m^3 lab space by more than 12-fold, possibly to as much as 60 000 m^3, says director Fabrice Piquemal. "I am optimistic about getting funding. Everybody agrees it's a unique opportunity." The bigger lab would have room for new experiments, but it would still be much smaller than Italy's Gran Sasso National Laboratory, which is tucked under an average of 1400 m of rock and is the world's biggest and fullest underground lab.

With 2000 meters of rock overburden, the deepest currently operating lab is Canada's SNOLAB. Over the past couple of years it was transformed from a single experiment to a multi-hall laboratory, with the entire space maintained as a clean room. Located in an active nickel mine, SNOLAB has hoist, or vertical, access. A double beta decay experiment, SNO+, inherits the largest cavern and much of the hardware from the lab's original solar neutrino experiment, the Sudbury Neutrino Observatory (see PHYSICS TODAY, January 2010, page 20). Several dark-matter and other experiments have begun moving in, and, because the expansion is recent, the lab still has space available. That is rare, says director Nigel Smith.

The Deep Underground Science and Engineering Laboratory (DUSEL) that US scientists have been working to set up in Lead, South Dakota, would eventually be on a par with the CJPL in terms of depth. (See PHYSICS TODAY, January 2008, page 40.) A couple of experiments are moving into a shallower part of the former gold mine (about 1500 m deep) as part of a state-run initiative. And a preliminary design for the full DUSEL (with lab space at depths approaching 2500 m) will be submitted to NSF next spring. The push for a US underground lab is "gaining tremendous momentum," says DUSEL principal investigator Kevin Lesko of the University of California, Berkeley. "If we count up the US scientists involved in underground science, it's easy to get to 700, and once you get action to go forward, that number will grow."

Other underground lab projects include a proposed expansion of the Kamioka Observatory in Japan and this fall's opening of the expanded Canfranc Underground Laboratory in Spain—now the second largest underground lab in Europe after Gran Sasso. For its megaton detector, the LAGUNA study is looking in seven countries—Italy (not Gran Sasso), Finland, France, Poland, Romania, Spain, and the UK. "We will recommend the best European sites at the end of the year," says Rubbia. After that, scientists in the US, Europe, and Asia will work together on the project since, in all likelihood, no more than one such billion-dollar-class facility will be built.

China has not expressed interest in hosting such a large experiment, but it might some day. Although the CJPL is small for now, there is much talk and excitement about its future. Says Henry Wong, a CDEX member from the Academia Sinica, "Growing is a safe statement. But how fast and how big is not known." At this point, he says, there are discussions, plans, and lobbying, but nothing more concrete than interest. "The key ingredients look promising. And in China, if there is a good science project, and local and international interest, they can get resources," says Wong.

Toni Feder

Physics olympiad meets in Croatia

A greater open-endedness to the questions in the 41st International Physics Olympiad marked a return to a tradition that rewards competitors for creativity and originality, says US team coach Paul Stanley of Beloit College in Wisconsin. A previous trend toward a more guided "cookbook approach" came about because it made grading easier, he adds.

Some 370 high-school students from 80 countries participated this year in the olympiad, held 17–25 July in Zagreb, Croatia. Despite the more challenging exam format, the team from China shone as it has for years. Yichao Yu earned the top overall score, the top score in the theoretical section, and recognition for the most original solution, and all five Chinese competitors won gold medals. The teams from Taiwan and Thailand also took home all golds. Hungary's Zoltán Jéhn scored the highest in the experimental part of the competition.

Some teams that have traditionally done very well slipped a bit, including those from the US, Japan, Iran, India, and Russia, notes Stanley. Still, all five US competitors won medals. Daniel Li of Fairfax, Virginia, garnered a gold; Eric Spieglan of Lisle, Illinois, and Anand Oza of North Potomac, Maryland, won silvers; and Jenny Lu of Southbury, Connecticut, and David Field of Andover, Massachussetts, won bronzes.

The theoretical questions this year concerned the height for efficient burning in a chimney; image charges; and binding energy, fission energy, and other calculations for atomic nuclei. The experimental tasks involved measuring forces between a ring and a rod magnet and determining bending rigidity and Young's modulus using a flexible foil.

Next year's physics olympiad will be held in Bangkok, Thailand.

Toni Feder

PAUL STANLEY

The US high schoolers who competed in this year's physics olympiad in Zagreb were, from left, Anand Oza, David Field, Dan Li, Jenny Lu, and Eric Spieglan.