Different groups have different ways of setting the plasma oscillating: Hogan's team at SLAC uses pulses of electrons, for example. AWAKE will be the first to use pulses of protons, which have some big advantages.

Because protons have greater mass than electrons, each proton pulse penetrates further into the plasma, setting up a longer series of charged regions, which in turn provides greater acceleration per pulse. A proton machine is also compatible with the LHC, which accelerates and collides protons.

For now, AWAKE will use the proton bunches that feed the LHC to test whether protons can generate the electric fields necessary to accelerate particles in plasma.

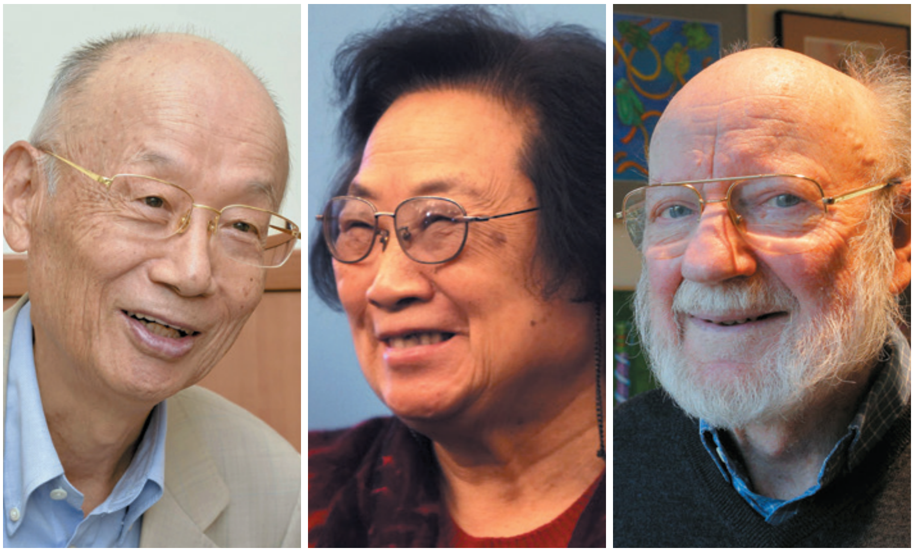
The latest investment from CERN — worth 2.6 million Swiss francs (US$2.7 million), from the total of 21.4 million Swiss francs so far committed to the experiment — is intended to allow AWAKE to test the concept before the end of 2018, when CERN is scheduled to shut down its accelerators for an upgrade. Success will depend on whether these proton bunches, which are long relative to what is needed to create plasma waves, can be efficiently chopped up into short pulses.

"The fact that CERN has decided this is an important field to get involved in is a bit of validation for this community."

Eventually, it might be possible to inject the much-higher-energy protons that have been accelerated by the LHC into a plasma wakefield machine for further acceleration. Hogan estimates that a machine just a few kilometres long could produce electrons with 6 times the energy of those that would be produced by the next planned conventional accelerator, the 31-kilometre-long International Linear Collider.

Despite such promise, plasma accelerators are decades from practical use because, to do better than existing accelerators, they must also match them in efficiency — supplying focused, accelerated particles at high rates as well as high energies, says Walker. Still, he adds, "right now, this is the only thing I see that might work".

The technology might also be useful elsewhere. Wakefield-accelerated electrons could drive X-ray free-electron lasers, which probe matter using powerful bursts of light that are short enough to capture the motions of molecules. These are currently kilometres long — but using wakefield technology might allow them to fit into labs or hospital basements. "I think this is more realistic as a potential application," says Walker, "and I would say a mandatory first step before the plunge into trying to achieve high-energy-physics experiments." ■



THE YOMIURI SHIMBUN VIA AP IMAGES, REUTERS/STRINGER, REUTERS/BRIAN SNYDER

Satoshi Ōmura, Youyou Tu and William C. Campbell share the Nobel Prize in Physiology or Medicine.

MEDICINE

China celebrates first Nobel

Pharmacologist shares prize for work on parasitic infections.

BY EWEN CALLAWAY & DAVID CYRANOSKI

For the first time, a researcher based in China has won the ultimate status symbol in science — a Nobel prize.

Pharmacologist Youyou Tu, who led a Beijing team that discovered the key malaria drug artemisinin in the late 1960s and 1970s, was awarded the 2015 Nobel Prize in Physiology or Medicine on 5 October. Two microbiologists, William C. Campbell at Drew University in Madison, New Jersey, and Satoshi Ōmura at Kitasato University in Japan, shared the award for their development — also in the 1970s — of therapies against parasitic roundworms.

"This certainly is fantastic news for China. We expect more to come in the future," says Wei Yang, president of the nation's main research-funding agency, the National Natural Science Foundation of China. Lan Xue, an innovation-studies specialist at Tsinghua University in Beijing, says that he was inundated with messages about the prize. "People will be celebrating, but I hope they also take a sober look, because there are lots of things to learn from this award," he says.

Young scientists in China today are told to go overseas to do good research and to churn out publications in internationally recognized journals, Xue notes. Yet Tu has never worked outside China, and has not racked up major publications. "Tu doesn't fit into any of the trends today, and yet she gets the Nobel because of the originality of her work. It couldn't have been a better choice in terms of the lessons it offers Chinese scientists," Xue says.

MALARIA BREAKTHROUGH

Tu's prizewinning research, at the China Academy of Chinese Medical Sciences in Beijing, originated from a government push in 1967 to discover new therapies for malaria. At the time, the main treatments — chloroquine and the older quinine — were proving increasingly ineffective. Tu and her team screened more than 2,000 Chinese herbal remedies to search for drugs with antimalarial activity. An extract from the wormwood plant *Artemisia annua* proved especially effective, and by 1972, the researchers had isolated chemically pure artemisinin.

"I'm very happy about this. She totally deserves it," says Yi Rao, a neuroscientist at Peking University in Beijing who has researched the discovery of artemisinin. But there has been some controversy over credit for the discovery, Rao points out, so Tu has never won a major award in China. She has not been elected to either of China's major academies — neither the Chinese Academy of Sciences nor the Chinese Academy of Engineering.

"Though other people were involved, Tu

was clearly the undisputed leader," says Rao. "But she's never been given fair recognition within China."

Artemisinin has "saved possibly millions of lives", says Stephen Ward at the Liverpool School of Tropical Medicine, UK. And the work of Campbell and Ōmura, who together discovered a class of compounds known as avermectins that kill parasitic roundworms that cause infections such as river blindness and lymphatic filariasis, has protected millions from disease, he adds.

Working in Japan, Ōmura isolated strains of a group of soil bacteria called *Streptomyces* that were known to have antimicrobial properties. In 1974, he pulled a promising organism out of soil near a golf course and sent it, along with others, to a team led by Campbell at the Merck Institute for Therapeutic Research in Rahway, New Jersey. (Ōmura's institute had signed a research partnership with Merck in 1973.)

Campbell's team isolated avermectins from the bacterial cultures and tweaked the structure of one of the most promising compounds to develop it into a drug — ivermectin. In 1987, Merck announced that it would donate the drug to anyone who needed it for treatment of onchocerciasis (also known as river blindness). A decade later, the firm began giving away the drug to treat lymphatic filariasis. Each year, Merck gives away some 270 million treatments of the drug, according to the Mectizan Donation Program in Decatur, Georgia.

Ward notes that the Nobel this year highlights the global acceptance of the importance of parasitic infections and of neglected tropical diseases in general. "It may refocus us on the idea that the immense diversity of products out there in the natural world is a great starting point for drug discovery," he says. ■

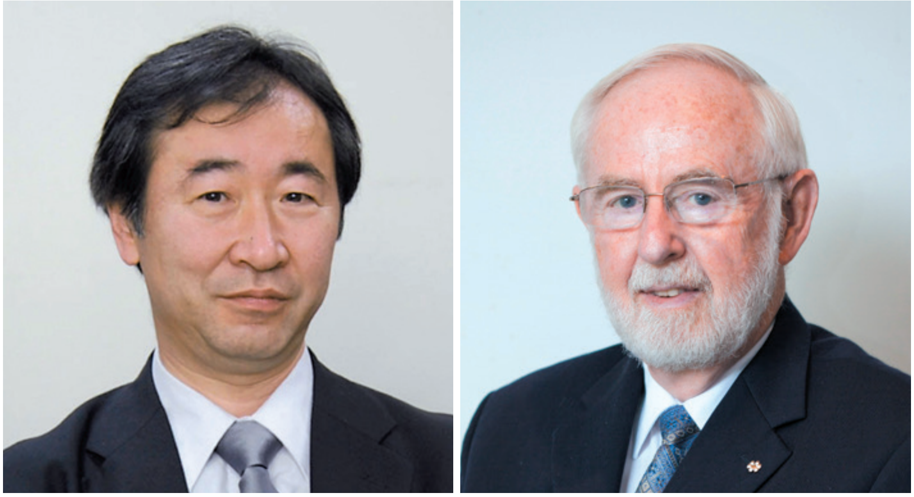
Additional reporting by **Alison Abbott**.

NOBEL PRIZE

Neutrino flip wins physics prize

Physicists share Nobel for solving puzzle about the subatomic particles' changing identities.

BY ELIZABETH GIBNEY & DAVIDE CASTELVECCHI



REUTERS/KYODO N

Takaaki Kajita and Arthur McDonald share the 2015 Nobel Prize in Physics.

Two researchers who helped to demonstrate that neutrinos oscillate between types, or 'flavours', as they travel — which proved that the elusive particles have mass — have won this year's Nobel Prize in Physics.

Takaaki Kajita at the University of Tokyo and Arthur McDonald at Queen's University in Kingston, Canada, share the prize for their discoveries with teams at two deep, underground neutrino detectors — Kajita at the Super-Kamiokande neutrino detector in Hida, Japan, and McDonald at the Sudbury Neutrino Observatory in Canada.

The standard model of particle physics — the current best explanation of the Universe's particles and forces — struggles to explain why neutrinos have mass. So the two teams' discoveries, in 1998 and 2001, spurred a wave of new experiments seeking to pin down the neutrino's properties. "Other than the Higgs boson, I'd say this is the biggest discovery in particle physics in the last 30 years," says Daniel Hooper, a theoretical physicist at the University of Chicago in Illinois.

Neutrinos come in three flavours: electron, muon and tau, names that relate to the sister particle they are produced with. They are more abundant than any other particle in the Universe except for the photon: each second, billions of them stream through every square centimetre of Earth. But they interact so weakly with other matter that remarkably little is known about them.

The first hint that neutrinos were stranger than expected came in the 1960s. But an experiment at the Homestake gold mine in South Dakota threw up a mystery: it detected fewer electron-type neutrinos streaming from the Sun than theorists had predicted. (Alongside Masatoshi Koshiba of the University of Tokyo, Raymond Davis, who led the Homestake experiment, later shared half of the 2002 Nobel Prize in Physics for developing techniques to detect such neutrinos from space.)

Kajita's group began unravelling this conundrum in 1998, when it reported that neutrinos might change flavours as they travel. Muon neutrinos created in collisions between cosmic rays and Earth's atmosphere seemed to disappear on their way to the Super-Kamiokande detector, a steel tank filled with pure water located in a zinc mine.

Conclusively proving this, however, meant not just spotting 'disappearing' neutrinos, but showing that they had turned into other flavours. The Sudbury team, using a tank of water in a nickel mine more than 2,000 metres beneath Earth's surface, announced in 2001 that neutrinos oscillated between flavours as they travelled from the Sun to Earth.

The discovery has profound implications. Rather than the three neutrino flavours having no mass, or indeed any fixed masses, physicists now reason that neutrinos must be made from mixtures — or quantum superpositions — of three different mass states, which change in proportion as the particles travel. Pinning down the neutrino properties and their antimatter counterpart, antineutrinos, could lead to an understanding of physics beyond the standard model, says André Rubbia, a neutrino physicist at the Swiss Federal Institute of Technology in Zurich.

"We believe that differences in the way neutrinos and antineutrinos oscillate, for example, is the best possible explanation we have for why the Universe is today dominated by matter and not antimatter," says Rubbia. ■