NEWS

Neutrinos make a splash in Italy

A long-awaited beam of neutrinos has finally made it from Switzerland to a laboratory 730 kilometres away in central Italy. The scientists involved hope the project, first sketched out 25 years ago, will address one of the big unsolved problems in particle physics. But it may yet be upstaged by the next generation of neutrino experiments.

The project, which was switched on this week, is a collaboration between the CERN particle-physics lab, near Geneva, and the Gran Sasso National Laboratory, located 1,400 metres underground in the region of Abruzzo and run by Italy's National Institute for Nuclear Physics (INFN). A flux of neutrinos — fundamental particles that are electrically neutral — is generated by an accelerator at CERN, and beamed towards the Italian lab. Neutrinos hardly interact with matter, so they travel underground through the rock in a straight line until they hit OPERA, a 1,800-tonne detector comprising emulsion films and lead plates that will stop a handful of them.

CERN

Massive project: the CERN particle-physics lab will beam neutrinos to Italy to see if they have mass.

Neutrinos are known to exist in three types, or 'flavours': muon, tau and electron. Since the late 1960s, researchers studying neutrinos reaching Earth from space have noticed that they seem to change flavour, or 'oscillate' as they travel. That is surprising because when their existence was first postulated in 1930, neutrinos were thought to have no mass; and quantum mechanics says the oscillations observed require some mass, albeit a small amount.

If neutrinos do have mass, tweaking today's standard model of the Universe to take account of it could help physicists get closer to a unified theory of fundamental forces. A neutrino with mass could also explain, at least in part, why the visible matter in the Universe forms such a tiny proportion of the total mass it is known to contain.

One way to settle the matter is to create neutrinos and fire them at distant detectors. By comparing the beam's composition at source and detector, it is possible to find out whether neutrinos oscillate along the way.

The first experiment of this kind was K2K in Japan (see 'A very lengthy business'). Between 1999 and 2004, it collected evidence that muon neutrinos — the easiest flavour to study — were disappearing between the source and final destination. A similar but more powerful experiment, MINOS, started in 2005 between Fermilab in Chicago and Soudan in Minnesota. In less than a year it saw three times as many events as K2K, and confirmed that muon neutrinos were disappearing.

OPERA is the third and most ambitious of these experiments: it can detect not just the absence of muon neutrinos, but the appearance of taus. "The others can only see if some neutrinos are missing and presume they have changed flavour," says INFN president, Roberto Petronzio. "We can see for the first time if new neutrinos appear." Next year, ICARUS, a more sensitive detector based on liquid argon, will join OPERA. Together, it is hoped the two experiments will provide definitive evidence for muon-to-tau oscillation, and determine the tau's mass.

"We can see for the first time if new neutrinos appear."

Although the oscillation model is now widely accepted, there are still big questions. First, researchers need to rank the three flavours in order of mass. Second, they want to see whether there is a fourth kind of neutrino, which doesn't interact with matter at all. Although this type of neutrino could not be observed directly, combining results from different experiments might reveal its existence.

Great reception

For the Italian physics community, the arrival of the first neutrinos satisfies a long-held dream. As long ago as the early 1980s, Petronzio recalls, "the INFN president drew a sketch for Italian senators showing a map of Italy and Switzerland, and a line connecting CERN and Gran Sasso". All the rooms in Gran Sasso are built so that they point to CERN.

Work on the neutrino beam got serious in the late 1990s, but funding problems slowed progress. CERN and the INFN were originally supposed to contribute equally. However, "in 2002, we decided not to have any scientific involvement in the project", recalls Jos Engelen, CERN's chief scientific officer. CERN now acts only as 'particle provider', a role he says the lab is still happy with.

Now it is finally running, OPERA may end up squeezed between old and new generations of neutrino experiments. In a few years, two new projects, NOvA in the United States and T2K in Japan, are due to start searching for the third flavour, the electron neutrino. "That is really the missing part of the picture," says Gary Barker, a physicist at the University of Warwick, UK, who is a member of the T2K group. "OPERA is a valuable experiment, but it will prove directly something MINOS has already shown indirectly."

Engelen says he is confident that the Italian experiment will provide precious results, but admits that CERN's long-term commitment is not yet confirmed. "CERN will provide the beam for the next five years, then a new agreement will be made depending on the results, both from OPERA and from the other experiments," he says. "Neutrino physics might not be among our priorities in the future." ■

Nicola Nosengo

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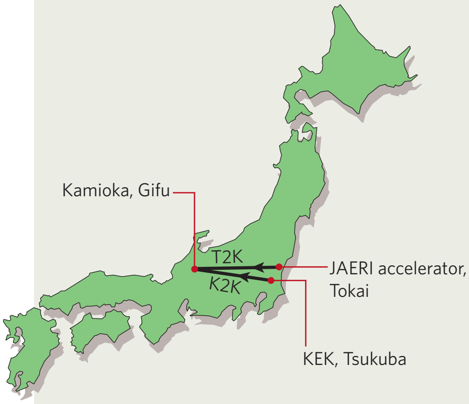
LINDEN RESEARCH

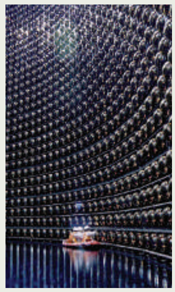
A very lengthy business



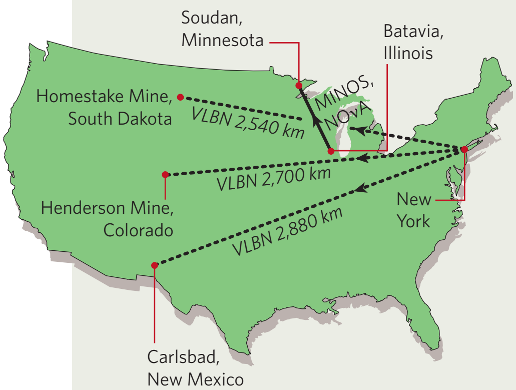
JAPAN

K2K 250 km
The first 'long-baseline' experiment, running from 1999 to 2005. Designed to confirm the neutrino oscillations reported by the Super-Kamiokande (pictured) experiment studying atmospheric neutrinos. By comparing neutrino events at the source and at the far detector, scientists could spot the disappearance of muon neutrinos, and infer their oscillation.

T2K 295 km
Due to begin in 2009, this experiment will look for electron neutrinos in a beam that initially consists of muon neutrinos after it has travelled 295 km underground. The beam is more intense than existing ones, which should maximize the probability of oscillations occurring.



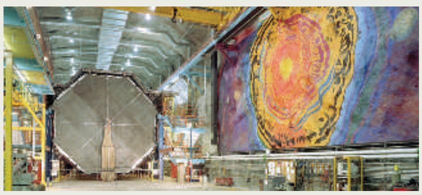
SUPER-K DETECTOR



VLBN >2,000 km
Proposed by Brookhaven National Laboratory and at a preliminary study stage, the VLBN project aims to use a beam more than 2,000 km long (potential routes shown). It might even detect the same particles oscillating more than once along their route.

UNITED STATES

MINOS 720 km
A beam three times longer than K2K, with higher intensity and energy, enables MINOS (pictured) to detect more events. It generates neutrinos from protons accelerated at Fermilab. The experiment looks for the disappearance of muon neutrinos, and in March 2006 it reported significant evidence of their oscillation.

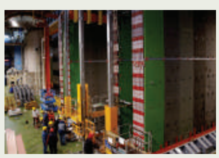


FERMILAB

NOνA 720 km
Scheduled to begin operation in 2011, NOνA will use the same beamline as MINOS, but will have its detectors located off the beamline axis. This yields a narrow-band beam with less background noise, increasing the chance of detecting muon-to-electron oscillation.

EUROPE

CNGS 730 km
Two experiments, OPERA (pictured) and ICARUS, will analyse the neutrino beam coming from CERN using different detectors that for the first time will be able to detect the appearance of tau neutrinos, and not only muon neutrinos disappearing.



LNGS

Warning flag for ethics boards

You're sitting on a university's ethics panel. A proposed experiment into the neurobiology of social behaviour comes up for approval. Subjects' brains will be scanned while they perform a series of tasks. Some of the participants have a history of disturbed social behaviour; one task involves viewing violent images. On completion, participants are simply asked to leave the laboratory. Would you give the experiment a green light?

If you're not sure, don't worry: neither are many real ethical review boards. When Canadian researchers asked their country's boards to rule on the protocol described above, they found a startling lack of conformity. All the boards that responded seemed to use similar ethical norms when judging the project, but thirty rejected it, ten approved it with qualifications, and three waved it through unconditionally (J. de Champlain and J. Patenaude *J. Med. Ethics* 32, 530–534; 2006).

"Everyone knows institutional review boards make very different decisions," says Joan Sieber, a psychologist at California State University, East Bay, who helps to train board members. She argues that it would be unrealistic to expect all boards to reach the same decision, but that the range of answers given shows that ethical norms are being applied in worryingly different ways. "This shows that something needs to be done."

The Canadian study is the work of Johane de Champlain and Johane Patenaude from the University of Sherbrooke in Quebec. The pair say they wanted to examine the belief that "considerable divergence" exists between review boards. In their experiment, each board knew that the protocol it was viewing was fictional, but was told to handle the proposal as it would any other.

Some boards worried that the consent form did not tell participants they would be viewing violent images. Another complained that the rationale for the study — to gather neurobiological knowledge that would inform "the direction in which we wish to see society develop" — reminded them of the "atrocious eugenics movement in the late nineteenth century". Two boards also noted that the rationale was not made clear in the consent forms.

Sieber says review boards need to be more rigorous in their risk assessments and decisions, and says they should call in outside experts where necessary. She adds, however, that a more common problem with institutional review boards is not a willingness to allow dubious studies, but an overly cautious approach that comes from ignorance of the experimental methods involved. ■

Jim Giles