# Neutrinos found to switch to elusive 'tau' flavour

**Experiment that once claimed faster-than-light observation achieves its original goal.**

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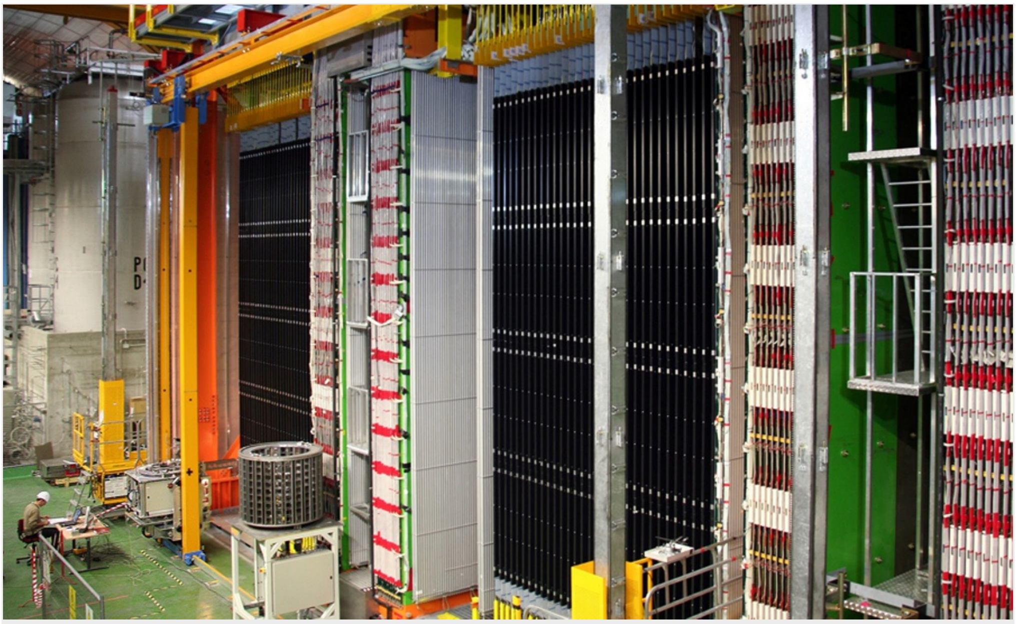

CNRS Photothèque/IPNL/ILLE, Bernard

The Gran Sasso particle-physics laboratory is located underground in central Italy.

Using a beam shot through the Earth's crust, physicists have found the first direct proof of a metamorphosis between two of the three known types of neutrinos — those known as 'muon' and 'tau' flavours of the elementary particles.

The experiment, OPERA (Oscillation Project with Emulsion-tracking Apparatus) at the Gran Sasso underground lab in central Italy, made headlines in 2011 after it announced that it had detected neutrinos travelling faster than light, in apparent violation of Einstein's special theory of relativity. Although that claim later proved false, when researchers discovered several potential sources of error in their measurements, the OPERA collaboration announced on 15 June that it has now achieved its original goal of observing the switch in neutrino flavours.

"It was an extremely difficult measurement that no one had done before," says Marco Pallavicini, a neutrino physicist at the University of Genoa, Italy, who is not a member of the OPERA collaboration.

There are three known types, or flavours, of neutrino: electron, muon and tau. The particles' names allude to the fact that on the rare occasions, when neutrinos interact with protons or neutrons, they variously produce electrons, muons or tau leptons.

Scientists had long suspected that neutrinos can transform from one flavour to another. Several previous experiments that used known sources of particular types of neutrino have detected fewer neutrinos than would be expected if the particles did not change flavour.

In July 2013, the T2K experiment in Japan saw the first direct evidence of the appearance of a different flavour[1] — rather than just the disappearance of the original one. It detected electron neutrinos in a beam originally made of muon neutrinos.

**Hidden target**

Between 2008 and 2012, a beam of muon neutrinos was shot from CERN, Europe's particle physics lab near Geneva, Switzerland, to the base of the Gran Sasso massif, 730 kilometres to the southeast, where the Italian lab is carved inside the rock.

By the time the neutrinos arrived at Gran Sasso, some of the muon neutrinos had turned into tau neutrinos. When these hit the lead targets inside the OPERA detector, they produced tau leptons, the latest results show.

The leptons decay in just one-trillionth of a second, says Giovanni De Lellis, a physicist at the University of Naples who is the OPERA spokesperson. “Even though it travels at nearly the speed of light, [the tau lepton] only runs for less than a millimetre,” he says.

OPERA detected the short-lived particles with an array of 150,000 'bricks', each of which weighs about 8 kilograms and contains 57 stacked emulsion plates. This set-up has 110,000 square metres of surface area, so researchers set up an automated system to search the plates for microscopic streaks that would signal the brief presence of tau leptons.

In partial results announced last year[2], the OPERA collaboration counted four probable tau lepton sightings, not quite enough to claim a success according to the stringent discovery criteria of particle physics. But the physicists have now found a fifth tau lepton, enough for the experiment to be declared successful.

“The result could not be taken for granted,” he says. Once the CERN beam was shut off, De Lellis and his team were limited to searching through existing data, and finding five events took a bit of luck, he admits. “It could have been six — or four, or three.”

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## References

1. Abe, K. *et al*. *Phys. Rev. Lett.* **112**, 061802 (2014).
2. Agafonova, N. *et al*. *Prog. Theor. Exp. Phys.* http://dx.doi.org/10.1093/ptep/ptu132 (2014).