OPERA detects its fifth tau neutrino

16 June 2015, by Cian O'luanaigh

Aerial View of the CERN. Credit: CERN

The OPERA (Oscillation Project with Emulsion-tRacking Apparatus) experiment at the Italian National Institute for Nuclear Physics (INFN) at Gran Sasso in Italy has detected the fifth occurrence of a tau neutrino in the muon-neutrino beam from CERN. A particle that left CERN as a muon neutrino underwent "oscillation" during its 730-kilometre journey to Gran Sasso, arriving as a tau neutrino.

Researchers at Gran Sasso announced the result yesterday, naming it "5 sigma" on the scale that particle physicists use to describe the certainty of results. One sigma could be a random statistical fluctuation in the data, 3 sigma counts as evidence, but only a result of 5-sigma or more is ranked as a clear observation. By definition, the probability that a 5-sigma result is wrong is less than one in a million.

"The detection of a fifth tau neutrino is extremely important: We…can definitely report the discovery of the appearance of tau neutrinos in a muon neutrino beam," said spokesperson Giovanni De Lellis of INFN in Naples, Italy, on behalf of the international research team.

Three types or "flavours" of neutrino exist in nature: the electron neutrino, the muon neutrino and the tau neutrino. But it seems that neutrinos are the chameleons of the particle world: they can change from one flavour into another. This phenomenon, called "oscillation", occurs as neutrinos travel long distances through matter. The process is directly related to the neutrinos' tiny mass.

OPERA was designed to search for tau neutrinos in the muon-neutrino beam from CERN, which ran during 2006-2012; detecting tau neutrinos in this beam is proof that oscillation occurred during their particles' 730 km long flight.

CERN produced the neutrino beams for Gran Sasso by firing pulses of protons from the Super Proton Synchrotron (SPS) at a graphite target. The collisions created particles called pions and kaons, which were fed into a system of two magnetic lenses to focus the particles into a parallel beam in the direction of Gran Sasso. The pions and kaons then decayed into muons and muon neutrinos in a 1-kilometre long pipe underground. At the end of the pipe, a block of graphite and metal 18 metres thick absorbed protons as well as pions and kaons that did not decay. Muons were stopped by the rock beyond, but the muon neutrinos remained to streak through the rock on their journey to Italy. As they hardly interact at all with matter, the neutrinos could travel the 730 kilometres from CERN to Gran Sasso directly through the rocks of the Earth's crust. When they arrived at Gran Sasso, a small fraction of the incoming neutrinos interacted with the OPERA detector, which can determine which type of neutrino passed through.

After detecting the first few muon neutrinos produced at CERN in 2006, the experiment collected data from 2008 to the end of 2012. The first tau neutrino was observed in 2010. The second and third events were reported in 2012 and 2013 respectively, while the fourth one was published in 2014.

"The achievement reported yesterday was made possible thanks to the continuous effort of all the researchers involved in the project, to the excellent performance of the CERN neutrino beam and to the support of all the funding agencies", said De Lellis.

Scientists will continue to analyse the data collected, searching for other tau neutrinos produced from the oscillation of muon neutrinos. Technologies developed for the OPERA experiment will be used in forthcoming experiments in neutrino physics and other fields.

More information: operaweb.lngs.infn.it/

Provided by CERN

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