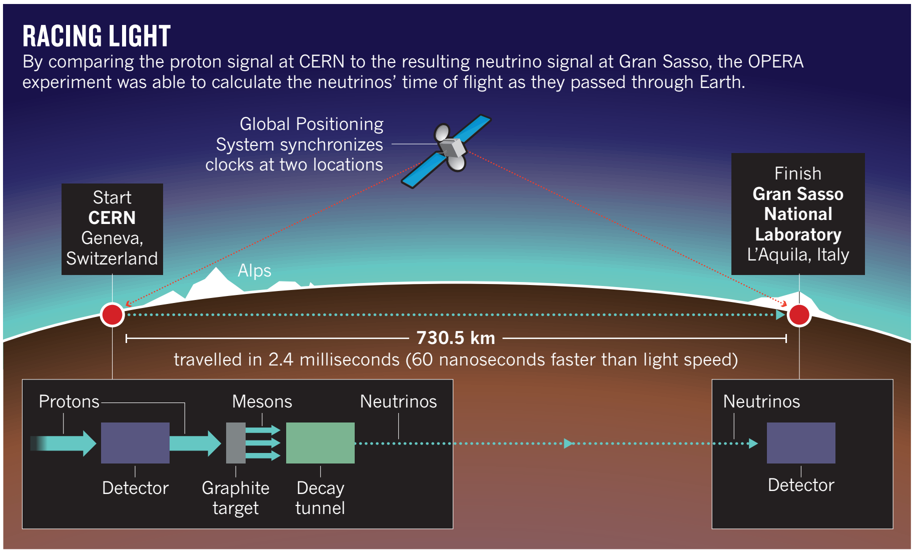

PARTICLE PHYSICS

Speedy neutrinos challenge physicists

Experiment under scrutiny as teams prepare to test claim that particles can beat light speed.

BY EUGENIE SAMUEL REICH

The joke begins with the barman saying: "I'm sorry, we don't serve neutrinos." Then the punch line: a neutrino walks into a bar.

Such causality-bending humour has been rife on the Internet in the past week, following the news that an experiment at the Gran Sasso National Laboratory near L'Aquila, Italy, has apparently clocked neutrinos exceeding the speed of light as they travelled 730 kilometres from their source at CERN, Europe's particle-physics laboratory near Geneva, Switzerland.

The finding by the OPERA (Oscillation Project with Emulsion-tracking Apparatus) collaboration, released on 22 September, has the media abuzz with talk of a century's worth of physics upended, starting with Albert Einstein's special theory of relativity. This sets the velocity of light as the inviolable and unattainable limit for matter in motion, and links it to deeper aspects of reality, such as causality.

Physicists, for the most part, suspect that an unknown systematic error lies behind OPERA's startling result. But nothing obvious has emerged, and many see the experiment as a tour de force because of its high precision. "It is quite a complicated experiment but they did a professional job," says Rob Plunkett, co-spokesman for the MINOS (Main Injector Neutrino Oscillation Search) experiment at Fermilab in Batavia, Illinois, which is likely to investigate the claim.

OPERA was switched on in 2006 to study the peculiar ability of the fleeting, nearly massless neutrinos to 'oscillate' from one type to others as they travel. It was later adapted to measure neutrino velocity to a higher precision than any previous experiment. A crucial aspect of this was the pioneering use of the Global Positioning System (GPS) to establish a time reference at both ends of the neutrino's flight path. Another was the careful timing of particles through different stages of the experimental apparatus, using a pair of ultra-high-accuracy caesium clocks to determine sources of delay.

In March 2011, the group was shocked to discover that its data suggested neutrinos were arriving 60 nanoseconds faster than light would do over the equivalent distance. "After six months of cross-checking we decided to go public," says Dario Autiero of the Institute of Nuclear Physics in Lyons (IPNL), France, who is the physics coordinator for OPERA. Most members of the collaboration agreed with the decision, but physicist Caren Hagner of the German Electron Synchrotron (DESY) in Hamburg was among those who declined to put their name to the result. In her case, she says, it was not because of any specific problem, but because she would have liked to spend more time checking the finding.

The release of the team's data on the arXiv server (The OPERA Collaboration, preprint at http://arxiv.org/abs/1109.4897; 2011) and in a presentation (see go.nature.com/kl4jah) now have the neutrino community looking for sources of error that might explain the result. Two elements of the experiment receiving particular scrutiny include the GPS-synchronization system and the profile of the proton beam that generates the neutrinos as a by-product of colliding with a target. Experimenters determined the flight time by comparing the shape of the proton signal at CERN to that of the neutrino signal received at Gran Sasso (see 'Racing light').

Two other collaborations are looking to check the OPERA result independently. Neither can yet time neutrinos to the same level of precision; however, an upgrade is already planned for MINOS, which sends a beam of muon neutrinos from Fermilab to the Soudan mine in Minnesota — roughly the same distance as from CERN to Gran Sasso.

Japan's T2K experiment, which sends neutrinos 295 kilometres from an accelerator in Tokai to the Super-Kamiokande detector in Kamioka, was shut down after the earthquake on 11 March. Scientists there are also discussing an upgrade to check OPERA's result, says co-spokesman Chang Kee Jung.

The upgrades would take more than a year to implement. In the meantime, researchers with both the T2K and MINOS collaborations are taking a second look at their existing data to see whether they are consistent with OPERA's result. Plunkett says that the MINOS group might have an answer within a few months. And even if the speed of light remains unbroken, a move to more accurate timing will bolster experiments in the long run. ■

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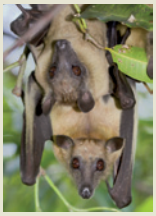

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