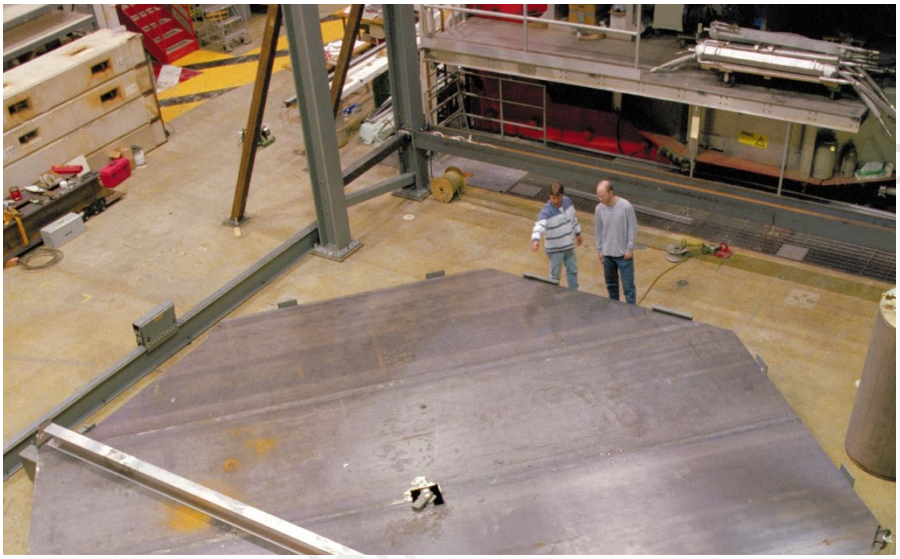
Neutrino study 'needs transatlantic effort'



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US neutrino detector should remain part of national effort, say Europeans.

[WASHINGTON] US particle physicists are trying to persuade their European rivals to join them in a joint effort to study neutrinos.

Experiments involving neutrinos are extraordinarily difficult, say the physicists who spend their lives scrutinizing these virtually undetectable particles. It therefore makes sense for rival teams to adopt different experimental approaches. But US neutrino scientists are left wondering why cash-strapped high-energy physics programmes on both sides of the Atlantic are pursuing separate, but highly similar, projects to measure the mass of a neutrino.

Both proposed projects will harness protons from accelerators to generate beams of muon neutrinos, which they will send underground, at an angle of inclination of around 5 degrees, towards massive detectors 750 km away. This will establish how many of the muon neutrinos 'oscillate' (into tau neutrinos) during the journey.

One project would send the neutrinos from Fermilab in Illinois to northern Minnesota, while the other would start its beam at CERN, the European Laboratory for Particle Physics in Geneva, and observe the result at the Gran Sasso Laboratory near Rome.

Oscillation between any two of the three classes of neutrino — electron, muon and tau —would indicate that they have mass. This would require the modification of the prevalent theory of particle physics, the Standard Model, which holds that the neutrino is massless.

Oscillation of neutrinos generated naturally in the atmosphere, as they pass through the Earth, was recently observed at the SuperKamiokande experiment in Japan (see *Nature* **391,** 123; 1998). An experiment to generate neutrinos at KEK, the Japanese particle accelerator, and direct them underground to the Kamiokande detector 250 km away, will begin in January. The United States and Europe are both planning similar but more powerful experiments, with more energetic neutrinos sent over a longer distance, in a bid to confirm and measure their mass.

The US project, Neutrinos at the Main Injector (NUMI), has been approved by the Department of Energy, and construction of its $76 million neutrino beamline is commencing at Fermilab. The beam will send muon neutrons through a 'near' detector at Fermilab to a 'far' one 730 km away at Soudan, Minnesota, down a disused iron mine. The experimental side of the project, known as the Main Injector Oscillation Search (MINOS), will cost a further $60 million.

European plans for a similar project have been around for years, and room to construct a suitably inclined neutrino beamline is built into the design of CERN's new Large Hadron Collider. "Everyone agrees it's a great idea but we're not sure where to find the money," says John Ellis, head of the theory group at CERN.

Although CERN can provide no cash, the Italian National Institute for Nuclear Physics (INFN) has committed 60 per cent of the $50 million it would cost to build the beamline in Switzerland, and additional money for ICARUS, the detector at the INFN Gran Sasso Laboratory.

Most proposals received so far for the Gran Sasso experiment are from Italian groups, says Luigi di Lella, head of the NOMAD neutrino experiment at CERN. At a workshop in Amsterdam this week, its supporters will seek to broaden its appeal beyond Italy. "We hope other institutes will join in, and that other countries will share in the cost of the beam," says di Lella.

But US physicists will encourage Europeans to join them instead, and perhaps to use whatever money they can raise to add an experiment of their own using the NUMI beam.

Stan Wojcicki, a professor of physics at Stanford University in California and a spokesman for MINOS, says that European neutrino scientists should join the US project, which already has UK and Russian collaborators. "I think it makes perfect sense," he says. "The Europeans clearly feel they'd have more impact if an experiment was done in Europe, but there is a shortage of money everywhere."

European scientists should consider making moves to collaborate immediately, rather than "waiting in the wings" while Gran Sasso seeks full funding, he says. "Unfortunately the right time for them to join [MINOS] is now: in two or three years, things will be cast in stone."

Supporters of the European experiment are not convinced of the justification for a single international experiment. The costs are simply not high enough, says Enzo Iarocco, president of INFN. Iarocco and other supporters of the Gran Sasso plan also say that, because neutrino physics is so subtle, it is scientifically preferable to have two systems, as a check. Iarocco also points out that Gran Sasso is "a unique facility, designed 15 years ago to have its underground laboratory orientated in the direction of CERN — precisely to catch the neutrino beam it hoped would one day be sent".

The US group counters that the European proposal is too weak to compete effectively. Robert Bernstein, one of the MINOS team, says he believes in a "let a thousand flowers bloom" approach to neutrino experiments — but not in this case. He says MINOS will detect 38,000 events a year when it starts operating in 2002, whereas ICARUS will open later and detect fewer than 2,000 events. With both a near and a far detector, MINOS will be able to count muon neutrinos at both ends of the journey, as well as looking for tau neutrinos at the end. The European proposal has only a far detector, although options for a near detector will be discussed at Amsterdam.

But a CERN spokesman says the two experiments are equivalent but not directly comparable, because the larger flux of neutrinos achieved by MINOS is compensated by the higher energy of the ICARUS beam.

Other physicists at Fermilab, which is heavily involved in the $450 million contribution to the Large Hadron Collider (see *Nature* **394,** 611; 1998), say Europe should help with NUMI in reciprocation. But agencies on both sides of the Atlantic believe that no such reciprocation is due on a project of NUMI's modest size.

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