Green light for the neutrino beam from Cern to Gran Sasso

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The delivery of the neutrino beam (Cngs) from Cern and the beginning of a new generation of experiments were officially celebrated today at Infn (Italian National Institute for Nuclear Physics) National Laboratories of Gran Sasso with the participation of Fabio Mussi, Minister of Universities and Research.

The Cngs beam and the experimental devices constructed in the Gran Sasso Laboratories to study neutrino interactions are part of a project aimed at shedding light on the mysterious phenomenon of the oscillation of these particles.

Neutrinos are continuously produced in nuclear reactions within the stars, and they are the most abundant particles in the Universe after photons. Our planet is constantly traversed by their flux: each second, 60 billion neutrinos go through a fingertip. They interact so weakly with other particles that they can go through any form of matter without leaving a trace. This peculiarity makes neutrinos so elusive that a great care is required in the design of experiments to study them. Neutrinos are divided into three families: electron, muon and tau. Experimental evidence obtained through both cosmic and man-made neutrinos shows that they can oscillate from one type into another. This important phenomenon implies that each type of neutrino has a mass, and that the masses of the three types are different.

“The existence of a mass for these particles sheds light on some of the most important problems of modern physics,” explains Roberto

Petronzio, Infn President. “For example, the existence of neutrino mass could help to explain the so-called asymmetry between matter and antimatter, that is to say the prevalence of matter in the Universe, in spite of the nearly perfect similarity of their fundamental interactions”.

By virtue of the oscillation phenomenon, a beam of neutrinos that is initially homogeneous, detected after some time, would contain within it another kind of neutrino. Experiments at the Gran Sasso Laboratories, which use the neutrino beam from Cern, will be able to demonstrate in particular the transformation of muon neutrinos into tau neutrinos, a phenomenon never so far observed. Only muon neutrinos will be produced at Cern, but after 2,5 milliseconds, when the beam arrives at Gran Sasso after having covered about 730 kilometers at the speed of light, a very small number of tau neutrinos are expected to be detected by the researchers. According to some theoretical calculations, among many thousands of billions of muon neutrinos arriving at Gran Sasso, only about 15 tau neutrinos will be identified.

At Cern, neutrinos are generated from collisions of an accelerated beam of protons with a target. When protons hit the target, particles called pions and kaons are produced. They quickly decay, giving rise to neutrinos. Unlike charged particles, neutrinos are not sensitive to the electromagnetic fields usually used by physicists to change the trajectories of particle beams. Neutrinos can pass through matter without interacting with it; they keep the same direction of motion they have from their “birth”. Hence, as soon as they are produced, they maintain a straight path, passing through the earth’s crust. For this reason, it is extremely important that from the very beginning the beam points exactly towards the laboratories at Gran Sasso.

At Gran Sasso two experiments will be waiting for the neutrinos from Cern: Opera, and, eventually, Icarus, the latter still under construction. Opera is an enormous detector weighing 1.800 tons, made up of photographic plates interleaved with lead layers. The very few tau neutrinos produced from neutrino oscillation, interacting with the lead layers, will generate very short-lived charged particles (called tau leptons) whose decay products will leave marks in the photographic emulsions. The reconstruction of these traces will allow experimenters to identify the tau lepton and so detect the presence of tau neutrinos in the beam. The Icarus apparatus will instead use a detector of 600 tons of liquid argon. The products of the interaction among neutrinos and argon atoms will be registered by a series of sophisticated sensors plunged into the liquid itself. The experiments are located at the Gran Sasso Laboratories where they are sheltered by 1.440 metres of rock, a very powerful screen against the cosmic rays produced in the atmosphere by primary cosmic radiation. These cosmic rays consist of a storm of charged particles that constantly hit our soil. Without the protection of rock, the “noise” from cosmic rays would drown out the very weak signal of the few interactions of neutrinos in the detectors.

Cngs experiments are an integral part of the strategy for particle physics conceived by the Cern Council for the next ten years, expressed in a series of guidelines approved last 14 July in Lisbon.

Source: Istituto Nazionale di Fisica Nucleare (INFN)