The Detector

The experimental apparatus is made up of two "supermodules", each formed by a target followed by a muon spectrometer.
The targets consist of 58 walls containing over 150,000 bricks, where the neutrino interactions occur. The walls are interleaved with layers of Target Trackers, detectors that electronically track the event, permitting the determination in real time of the position. The measurement of the position of the neutrino interaction allows the identification of the brick in which the interaction occurred. That brick can be extracted using the BMS and, after developing the photographic emulsions, can be analyzed using automated microscopes. While the events concerning muon neutrinos are relatively frequent (about 30 per day), only a few tau neutrino events are foreseen each year.

SPECTROMETER

The magnetic spectrometer for muons consists of iron layers (in green) 5 cm thick and magnetized by a coil driven by direct current. These are alternated with particle detectors. The measure of the curvature of the trajectory of the particle, induced by the magnetic field, allows the determination of its energy.

TARGET TRACKERS

The detector planes of the target are interleaved with the parallel planes that hold the bricks. These detectors, consisting of plastic scintillator strips whose signals are carried by optical fibers to sensors, provide the x and y coordinates allowing the localization in space of the event in real time.

About 150,000 bricks are mounted on 58 parallel walls, 7m x 7m. Each brick, 10,2cm x 12,7cm x 7,5cm and weighing about 8 kg, is made up of 56 layers of lead foil interleaved with 57 layers of nuclear emulsions. The nuclear emulsions give the detector a spatial resolution of several microns, necessary to reveal the production of the tau lepton, which is the characteristic signature of the tau neutrino interaction.

BRICK

BAM

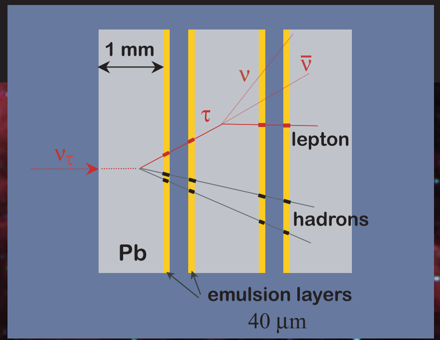
The Brick Assembly Machine is the robotized system capable of producing bricks automatically. More than 150,000 bricks have been produced over one year.

BMS

The Brick Manipulator System is the automatic system that inserts and removes the bricks from the target walls.

Due to the large number of emulsions to analyze, automated systems for the analysis have been prepared. These consist of computerized microscopes, mechanized with sub-micrometric precision and high scanning speed. Several laboratories dedicated to the scanning of the emulsions have been set up at LNGS as well as at other participating institutes in Europe and in Japan.

Microscopes and emulsions



Neutrinos, having no electric charge, can be detected only through the particle tracks left by their interactions in the experimental apparatus. In particular, the tau neutrino produces, besides other particles (hadrons), the tau particle (or tau lepton). The tau particle has an extremely short lifetime and travels less than 1 mm before decaying into a lepton (electron or muon) and other neutrinos. The characteristic of the event is that it contains a track with a kink, that is, a track that deviates suddenly at a vertex.

NEUTRINOS

Neutrino oscillation

The neutrino is a neutral particle with very small mass. In nature there are three different types of neutrinos: the electron neutrino (ν_e), the muon neutrino (ν_μ) and the tau neutrino (ν_τ), associated respectively to the electron, to the muon and to the tau particle. Subject only to the weak and gravitational forces, neutrinos interact rarely with matter, making their detection very difficult.

According to a theory elaborated by Bruno Pontecorvo at the end of the 50's, neutrinos have the property to transform themselves from one type to another while travelling through space or matter, giving way to the oscillation phenomenon. The demonstration that neutrinos oscillate indicates the presence of a non zero mass for the neutrinos, different for every type.

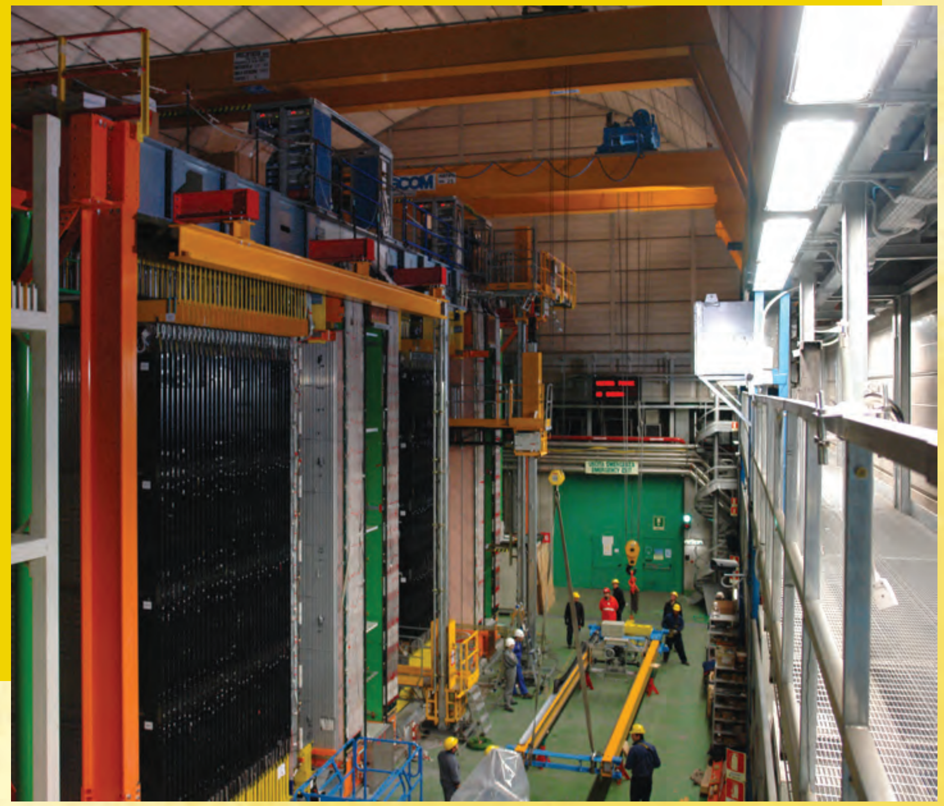
grafica Ciccone Francesca

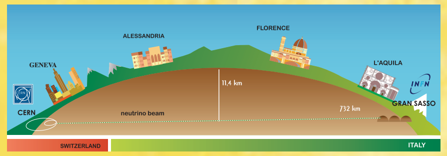
INFN

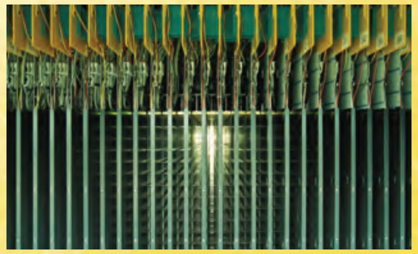
OPERA

Gran Sasso National Laboratory

Belgium, Bulgaria, Korea, Croatia, France, Germany, Japan, Israel, Italy, Russia, Switzerland, Tunisia, Turkey







OPERA – *Oscillation Project with Emulsion-tRacking Apparatus* is a large mass experiment located in Hall C of the Gran Sasso National Laboratory (LNGS).
The aim of the experiment is to detect the appearance of tau neutrinos in the beam of muon neutrinos that, generated at CERN in Geneva, reach the Gran Sasso Laboratory with a flux of several billions per day.

A beam of protons, with an energy of 400 GeV, produced in the CERN SPS accelerator, collides with a target of graphite to produce a secondary beam consisting partially of pions (π) and kaons (K), charged particles with short lifetimes. After having been focused and directed towards the Gran Sasso, the π+ and K+ decay, giving origin to neutrinos that maintain practically the same direction of the particles that generated them. The neutrino beam contains almost exclusively muon neutrinos with an average energy of 17.4 GeV and a contamination on the level of a few percent of anti-muon neutrinos, electron and anti-electron neutrinos.
The distance between CERN and the Gran Sasso Laboratory is about 730 km.