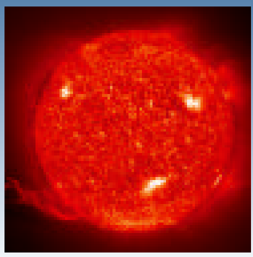
Neutrino Physics

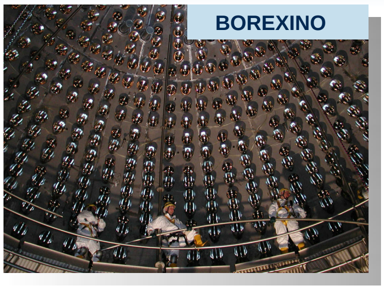


Neutrinos are elementary, neutral, weakly interacting particles. A complete knowledge of their properties would give us fundamental information in many fields of physical research. Neutrinos come in three different “flavors” (electron, muon and tau neutrinos) that, according to the theory of the so-called “Standard Model”, cannot convert (or “oscillate”) into each other if one describes them as massless particles. Recently, experiments searching for “neutrino oscillations” have provided evidence for neutrino mass and mixing of flavor states.

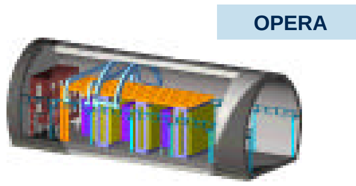
Neutrino sources can be divided into two classes: natural sources (Sun, cosmic rays, Supernovae, radioactive materials, Big-Bang) and artificial sources (mainly nuclear reactors and particle accelerators). A few of these sources are studied intensively at the LNGS.

Atmospheric neutrinos. When cosmic rays penetrate the atmosphere, they interact with atoms and produce a great deal of secondary particles, among which there are a lot of neutrinos and antineutrinos (mostly electron and muon neutrinos). The MACRO experiment, decommissioned in 2000, has found, together with the Japanese SUPERKAMIOKANDE, the evidence of atmospheric neutrino oscillations. It was composed of three sub-detectors: liquid scintillation counters, limited streamer tubes and nuclear track detectors.

Supernova neutrinos. Neutrinos produced by all the other stars but the Sun reach the Earth with a weak intensity, due to the enormous distance that separates us from the stars; thus it’s almost impossible to disentangle them from solar neutrinos. One can distinguish only neutrinos generated by the explosion of supernovae, very massive stars (M > 8 solar masses) that terminate their life with an extraordinary explosion. The LVD experiment, constituted by 1,000 tons of liquid scintillator, is able to observe neutrinos originating from stellar collapses. The frequency of supernovae in our Galaxy is about one every 30 years.



Solar Neutrinos. The most powerful natural source of neutrinos on Earth is the Sun. Neutrinos, produced inside the Sun by the nuclear fusion reactions, leave the center of the star and reach the Earth traveling for a long distance (about 150 million kilometers) in less then 8 minutes. Studying the energy and the number of solar neutrinos, physicists can understand the physical processes that make the Sun work. GNO (30 tons Gallium based radiochemical experiment) and BOREXINO (a stainless steel sphere filled with liquid scintillator) in the near future, are two important experiments that measure solar neutrino properties.



Long baseline experiments. The beam, produced at the CERN, will consist of only muon-type neutrinos. Neutrinos will pass undisturbed underground arriving to their destination, the Gran Sasso National Laboratory (LNGS), 730 km away from CERN. LNGS is currently preparing to house huge detectors, ICARUS (liquid argon detector) and OPERA (emulsion detector), specially designed to detect the rare tau-neutrinos created by "oscillation" from muon-neutrinos on the way between CERN and LNGS.