Abstract

The aim of the OPERA experiment is to provide a “smoking-gun” proof of neutrino oscillations, through the detection of the appearance signal of ν_τ’s in an initially pure ν_μ beam. The beam is produced at CERN, 732 Km far from the detector, which is located underground in the Gran Sasso laboratory.

The evidence of the appearance signal will be provided by the detection of the daughter particles produced in the decay of the τ lepton. A micro-metric spatial resolution is needed in order to measure and study the topology of the ν_τ-induced events. With this goal, nuclear emulsions, the highest resolution tracking detector, were chosen to be the core of the OPERA apparatus.

The analysis of the large amount of nuclear emulsions used in the OPERA experiment has required the development of a new generation of fast automatic microscopes, featuring a scanning speed more than one order of magnitude higher than in past emulsion-based experiments. The long R&D carried out by the Collaboration has given rise to two new systems: the European Scanning System (ESS) and the Japanese S-UTS.

The work presented in this thesis has been carried out in one of the laboratories involved in the OPERA emulsion scanning, hosted at the University of Salerno, and during a 6 month’s stay at the IPNL (Institut de Physique Nucleaire de Lyon).

As for emulsion data-taking, several bricks from the 2008, 2009 and 2010 OPERA runs were scanned in Salerno and about 250 ν_μ-induced events were located. For the events triggered in the 2008 run, a kinematical analysis was performed, by developing a new likelihood-based software, able to estimate the momentum of the particles traversing the emulsion sheets through multiple Coulomb scattering. The algorithm was also tested on a set of Monte-Carlo data and a set of pion tracks collected during the 2003, 2004 and 2007 test beam campaigns at CERN. The 2008 run sample was used also to perform the hadron interaction search and the data collected were merged with those from other laboratories to estimate the background to the hadronic decay channel.

The kinematical analysis of the $\tau \rightarrow h$ decay channel is the subject of the second part of this thesis, developed while staying at the IPNL. The study on the quantities used to discriminate the signal and the background was accomplished by using simulated data. The kinematical cuts suggested by the OPERA Proposal were reviewed and the efficiencies obtained by applying these cuts were re-computed. In addition, another set of discriminating variables are suggested and their background suppression power is explored. Such estimators are proposed to be the subject of further work in the years to come.