OPERA: Electronic Detectors

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Abstract
OPERA is an hybrid detector for the ν_τ appearance search in a direct way, and the Electronic Detectors (ED) have the crucial role of triggerring for the neutrino events and of localizing such an interaction inside the target.
Another very important task of the ED is to identify the muon since only a correct matching of such a track with a track in the emulsion connected to the vertex of the event allows to reduce the charm background to the desired level.
The ED, fully working since 2006, consist of a target tracker (scintillator strips) and a spectrometer (RPC and drift tubes). The different sub-detectors are described in the poster, as well as their performance both on Monte Carlo (MC) and real data.

1 Introduction

The main motivation for the OPERA [1] experiment was given by the atmospheric muon neutrino disappearance. The goal is the direct observation of the $\nu_\mu \rightarrow \nu_\tau$ transition in an appearance mode, in the oscillation parameter region determined first by the Super-Kamiokande results [2, 3] and then improved by K2K [4] and MINOS [5] experiments.
Given the distance of 730 km between the neutrino source (at CERN) and the detector (in the Gran Sasso underground laboratory), the CNGS beam was designed in order to maximize the number of ν_τ charged current interactions detectable at Gran Sasso and the best performance is achieved with the selected average neutrino energy of the CNGS beam of about 17 GeV.
With the CERN SPS accelerator operating in a shared mode, 4.5×10^{19} protons on target (p.o.t.) can be delivered per year, and 2900/kton/year ν_μ charged current interactions are expected at Gran Sasso. If the $\nu_\mu \leftrightarrow \nu_\tau$ oscillation hypothesis is confirmed, the number of τ's produced via charged current interaction at Gran Sasso should be of the order of 17/kton/year (before detection efficiency is considered) for Δm^2=2.4×10^{-3} eV^2 at full mixing.

In the following sections the Electronic Detectors will be described as well as some preliminary comparison between MC and data based on the full 2008 statistics and part of the 2009 sample.

2 Electronic Detectors

OPERA is an hybrid detector made up of Electronic Detectors (ED) and emulsions, divided into two identical supermodules. In each supermodule, the ED consist of a Target Tracker (TT) and a spectrometer, as it can be seen in Fig.1.

2.1 Target Tracker

The main goals of the Target Tracker are the trigger on the neutrino events and the location of the interaction inside the target.

It is composed, in each super-module, by 31 walls (each wall is made of a X and Y projection plane) of plastic scintillator strips. Each strip (6.86 m long, 2.63 cm wide and 1 cm thick) is made of polystyrene with 2% of p-Terphenyl and 0.02% of POPOP, and it has a wavelength shifting fiber glued in a groove in the middle. The fibers are connected, at both ends, in groups of 64 to multi-anode Hamamatsu PMTs for a total of 63488 electronic channels.

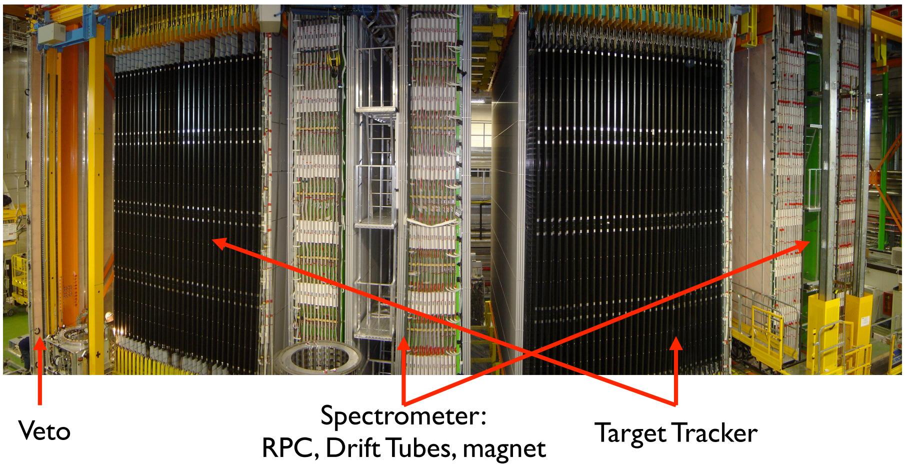

Fig. 1: The OPERA detector in Hall B at LNGS.

The number of photo-electrons measured when a m.i.p. crosses the strip in the middle of its length (where the signal is minimal) is more than 5, which allows for a very high trigger efficiency (more than 99%). The trigger for a neutrino event is defined asking for at least 2 XY coincidences in the TT with a threshold of 1 photo-electron, in time with the CNGS clock.

A schematic picture of the TT working principle can be seen in Fig.2. For further details see Ref. [6].

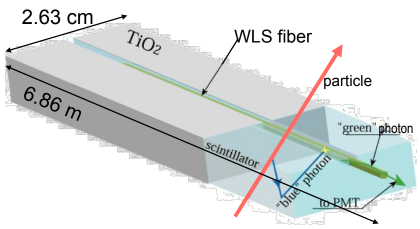

Fig. 2: Working principle of the Target Tracker.

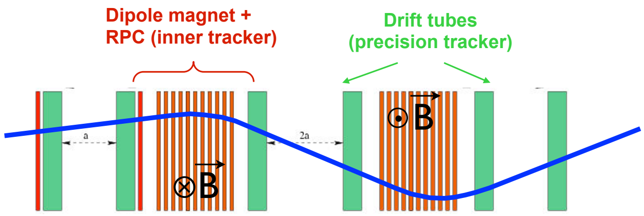

Fig. 3: Working principle of the spectrometer.

2.2 Spectrometer

The goal of the spectrometer is the momentum measurement and the charge discrimination. In particular it is used to measure and identify muons in order to reduce the charm background.

The 1.5 tesla magnetic field is provided by a dipole magnet instrumented with an inner tracker made of Resistive Plate Chambers and complemented by a precision tracker composed by pairs of Drift Tubes stations. The performance of the spectrometer has been fully evaluated and the following figures have been estimated:

– A charge misidentification between 0.1% and 0.3%.
– A precision on the momentum measurement (Δp/p) for momenta lower than 50 GeV/c of $\sim$ 20%.
– A muon identification (together with TT information) of $\sim$ 95%.

A schematic picture of the spectrometer working principle can be seen in Fig.3. For further details see Ref. [7, 8].

3 Data/MC comparison

The ED have been working since 2006, in 2007 the first physics run was performed and in 2008 we had the first run with high statistics. Using the data collected in 2008 and part of the data of the present run (2009), studies on the comparison between data and Monte Carlo have been performed, both on the muon and on the hadronic shower.

An excellent agreement has been found on the muon reconstruction, both for the track length and the muon momentum (see Fig. 4).

For the hadronic energy deposition we have a good agreement (see Fig. 5), however it seems that in real data there is a slightly higher energy deposition. There are several hints that point to a slight underestimation of the hadronic activity in the Monte Carlo and tests are currently ongoing in order to understand this difference.

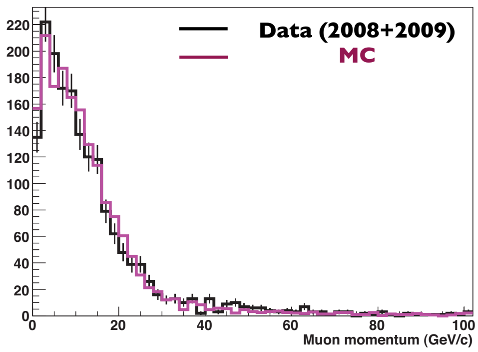

Fig. 4: Data/MC comparison for muon momentum reconstruction.

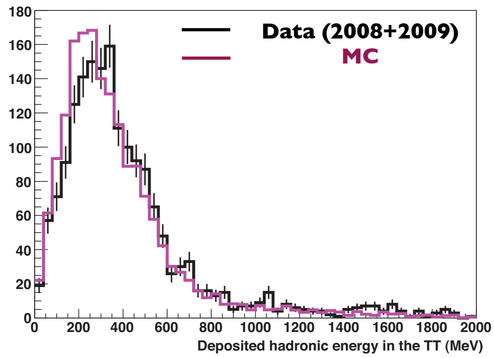

Fig. 5: Data/MC comparison for hadronic energy deposition in TT.

4 Conclusions

The OPERA experiment is fully completed and it is taking data since 2007. Enough statistics has been collected for a detailed comparison of data and Monte Carlo as far as the ED are concerned, showing that a good understanding of the detector response has been reached. Few thousands of neutrino interaction have been collected so far (see Ref. [9, 10]) and we hope to see the first τ event soon.

References

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