

IMPLEMENTATION OF THE TRIGGER ALGORITHM FOR THE NEMO PROJECT

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We describe the implementation of trigger algorithm specifically tailored on the characteristics of the neutrino telescope NEMO. Extensive testing against realistic simulations shows that, by making use of the uncorrelated nature of the noise produced mainly by the decay of ^{40}K β -decay, this trigger is capable to discriminate among different types of muonic events.

1. Introduction

The NEMO (NEutrino Mediterranean Observatory) project aims at the deployment of a 1 km^3 underwater telescope specifically designed to investigate the properties of cosmic neutrinos having energies in the range 10^{19} and 10^{22} eV ^{1,2}. The neutrino component, unlike other components of the cosmic rays, preserves the direction of propagation over long distances and therefore it allows to identify the astrophysical counterparts responsible for its emission ³. The telescope will be deployed at about 3500 m of depth in the Central Mediterranean Sea, south of Capo Passero in Sicily. It will consist in an orderly grate of 5832 Photo Multiplier Tubes (PMT)⁴, organized in a grid of 9×9 towers (Fig. 1 a), each composed by 18 floors carrying 4 PMTs (Fig. 1 b). The PMTs used for the KM3 (Hamamatsu R7081SEL), will reveal the photons produced by Cherenkov effect^{5,6} and have a spectral response comprised between 350 and 550 nm .

The main difficulties encountered in the detection of the muonic events are related to the need to discriminate the true events from the strong background noise which, in the case of NEMO, is mainly due to the Cherenkov radiation by electrons released by the β -decay of the potassium-40:



We implemented a trigger software (which could also be implemented in firmware) which can reveal the presence of a muonic event also on a semi real

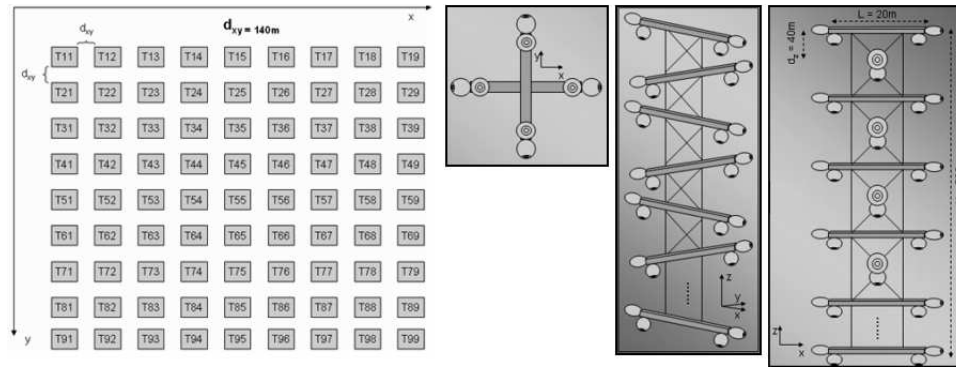
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Figure 1. NEMO telescope. Left panel: general layout. Right panel: structure of an individual tower (top and lateral views).

time basis, thus allowing to issue a target of opportunity alert to ground based and space borne instruments for follow-up observations. In what follows we shall shortly outline the main characteristics of such trigger and its performances as derived from the analysis of simulated data.

2. Trigger

The main idea behind the trigger is based on the statistic evidence that the PMTs event rate (number of times that a PMT turns on per unit of time) is larger for photo multiplier tubes turned on by muonic signals than for PMT's turned on by ^{40}K events.

From the data acquisition point of view, the NEMO data can be considered as a data stream where PMTs are sampled at regular intervals and the signal is set to 1 for PMTs which are turned on and to 0 for PMTs which are turned off. Each sampling epoch defines what we call a *datacube*, obtained by integrating the data stream over an arbitrarily chosen number of epochs. Therefore the implemented trigger makes use of three parameters which can be set by the operator accordingly to the needs of a specific experiment. Namely:

- (1) *sampling time*: time interval between two subsequent readings of the PMTs status (minimum value, 5 ns);
- (2) *number of datacubes checked or N*: parameter that characterizes the length of the data stream which needs to be checked in order to assess the significance of an event;
- (3) *threshold*: event rate threshold for the ^{40}K PMTs (minimum value, 1).

In each datacube the trigger eliminates PMTs with rates smaller than the assumed threshold but before eliminating it (as due to ^{40}K) the algorithm checks whether in the N datacubes the PMT does not turn on again.

3. Test on simulated data

In order to test the trigger, we used realistic (events + noise) simulations produced using the GEANT package⁷ as described in 8. The analysis of 126 events using 24 different combinations of the three above mentioned parameters⁸ lead to identify, as best compromise, the following instrumental setup:

- *sampling time* = 5 ns;
- *number of datacubes checked* = 5;
- *threshold* = 1.

The results are summarized in Fig. 2 which gives: (left panel) the raw status of the NEMO telescope, as integrated over the whole simulated event and (right panel) the location of the PMTs which are selected by the algorithm as triggered by real events. The darker dots represent the active PMTs (due to both muonic and/or ^{40}K event), while the lighter ones represent the inactive PMTs. The solid line gives instead the event trajectory as derived from the simulation. Obviously this knowledge is not in any way used by the trigger and is included only as a reference for visual inspection. It needs to be stressed that, as it will be further explained in 8, the efficiency of algorithm is very high, even for short track and or low energy signals.

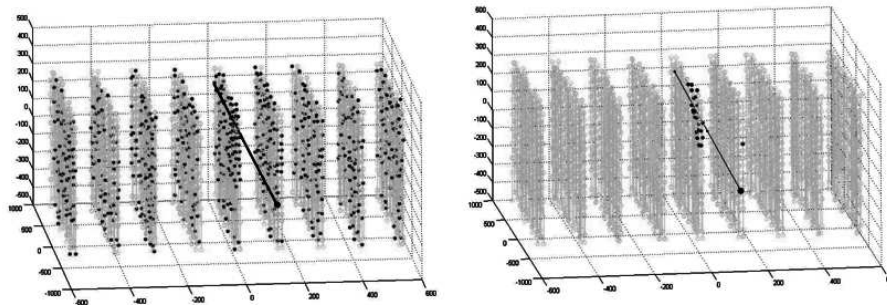


Figure 2. NEMO telescope. Left panel: the PMTs status integrated over the whole data stream. Right panel: the PMTs which survive the pruning performed by the trigger.

4. Future development

In December 2006, the NEMO project foresees the deployment at a depth of ca. 2000 m of a tower prototype consisting of 4 floors (NEMO phase 1). In this phase all devices and algorithms for detection and reconstruction, will be tested. We therefore plan to test the trigger on the single tower data in order to assess whether it can be implemented in the experiment pipeline. A further development aimed at

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better reconstructing the muon track will require the optimization of the algorithm with respect to the spatial correlation of the muonic signal.

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