

STATISTICAL ANALYSIS OF THE TRIGGER ALGORITHM FOR THE NEMO PROJECT

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We discuss the performances of a trigger implemented for the planned neutrino telescope NEMO. This trigger seems capable to discriminate between the signal and the strong background introduced by atmospheric muons and by the β decay of the ^{40}K nuclei present in the water. The performances of the trigger, as evaluated on simulated data are analyzed in detail.

1. Introduction

The NEMO (NEutrino Mediterranean Observatory) telescope is designed to reveal high and ultra-high energy neutrinos produced by a variety of astrophysical sources ^{1,2}. More in particular, the telescope will use a 1 km^3 array of PMTs to detect the Cherenkov light emitted by muons produced by a charged current interaction of ultra high energy neutrinos. The data analysis is made extremely difficult by the presence of a strong optical background, introduced mainly by atmospheric neutrinos and by the β -decay of the unstable nuclei of ^{40}K . Elsewhere in this proceedings ³ we have discussed the structure and the optimization of the trigger in some detail, here we shall instead focus on the evaluation of its performances.

2. Performances of the trigger algorithm

As a first step, our analysis required the optimization of the algorithm in terms of its three free parameters, namely: sampling time, number of datacubes checked, threshold (for further details see ³). In absence of real data, we made extensive use of data simulated with the Montecarlo package described in ⁴ and, more in particular, we used a set of 1824 simulated events (muon+ ^{40}K) plus 1200 data containing only the ^{40}K noise to be used as a reference. (Table 1),

We then defined two different criteria, the so called Absolute Criterion (C_{abs}), and Relative Criterion (C_{rel}), which provide complementary information.

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Table 1. Values of the parameters used for the optimization of the trigger.

Sampling Time (ns)	Number of Datacubes checked	Threshold
5	5-10-20-40	1
25	2-3-4-5-6-7-8	1
50	2-3-4	1
100	1-2	1-2
300	1-2	1-2-3

2.1. Absolute Criterion

In C_{abs} , the relative efficiency of the trigger is the sum, conveniently normalized, of two terms. The first one is defined as the ratio between the number of reconstructed signal PMTs ($N_{PMT}\mu_{ric}$) and the total number of PMTs ($N_{PMT}\mu_{tot}$) which accordingly to the simulation should have been turned on by the muonic event. The second term takes instead into account the relative contribution of PMTs activated by ^{40}K events ($N_{PMT}K_{ric}$) which are erroneously attributed to the muonic signal:

$$C_{abs} = \frac{100}{2} \left[\frac{N_{PMT}\mu_{ric}}{N_{PMT}\mu_{tot}} + \left(1 - \frac{N_{PMT}K_{ric}}{N_{PMT}\mu_{ric} + N_{PMT}K_{ric}} \right) \right] \quad (1)$$

2.2. Relative Criterion

C_{rel} generalizes the performances of the algorithm, weighing the absolute performances against the ratio between the number of PMTs which are recognized as being activated by the muon event and the total number of PMTs activated in the simulated event ($N_{PMT}\mu_{tot} + N_{PMT}K_{tot}$). It needs to be stressed that even though this term does not depend on the output of the algorithm, it estimates the dependence of the performances of the trigger on the specific features of the considered event. The relative efficiency for C_{rel} is then calculated by adding to C_{abs} a term providing the ratio between the number of PMTs activated by muon and the totality of PMTs which are turned on by the event. This term gives higher weight to the positive feedbacks of the algorithm in the case of short tracks (few PMTs are activated):

$$C_{rel} = \frac{100}{2.999} \left[\frac{2}{100} C_{abs} + \left(1 - \frac{N_{PMT}\mu_{tot}}{N_{PMT}\mu_{tot} + N_{PMT}K_{tot}} \right) \right] \quad (2)$$

3. Parameters setting

By applying the analysis criteria just described, we derived the values of C_{abs} and C_{rel} for the different configurations listed in Table 1. The best combination of parameters is the one that offered the best compromise among three factors: i) the capability to reveal tracks; ii) the efficiency in terms of number of PMTs correctly

recognized as turned on by events; iii) the threshold which needs to be kept as low as possible. It turns out that such combination is given by:

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

4. Results of statistics

Using the above derived triplet of parameters, we estimated the relative efficiency of the trigger in terms of its capability of: i) identifying that an event has affected a given datastream (Fig. 1) and, ii) how many PMTs are correctly recognized as turned on by muons (Fig. 2).

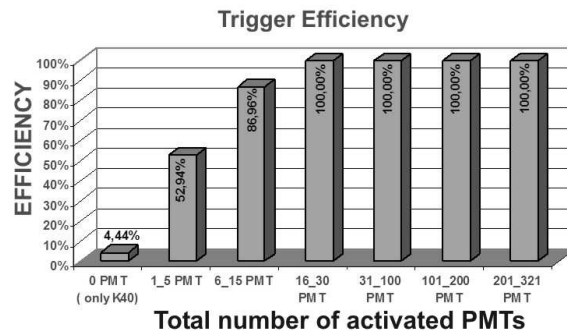


Figure 1. Efficiency of the trigger for identifying muonic events.

As it can be seen in Fig. 1 (axis y gives the efficiency of revealing the presence of an event and the axis x is divided into intervals which indicate the minimum and the maximum number of PMTs activated by a muon in different events), the trigger performs well also for short or low energy events. In fact in the first interval (0 PMTs, i.e. only ^{40}K), in the 95.56% of cases, the trigger flags the absence of muon, giving spurious detections only in 4.44% of cases. In the second interval (1-5 PMTs) the trigger flags the presence of muon in the 52.94% of cases, and its efficiency increases with the number of PMTs activated, reaching 100% above 16 PMTs.

In Fig. 2 we show the "reconstruction" performance of the trigger, i.e. how many PMTs activated by a muon correctly identified with respect to the total number of PMTs turned on. Also in this case the algorithm provides good performances since it is capable to reconstruct a minimum of about 33% PMTs for very low energy events up to about 78% PMTs for high energy ones.

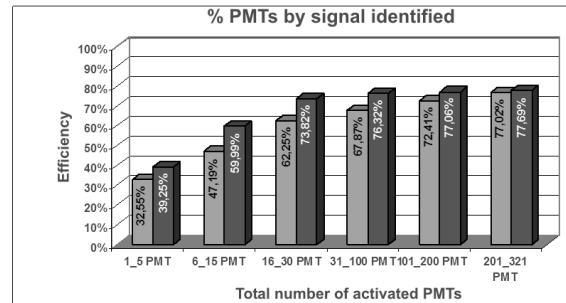
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Figure 2. Efficiency of the trigger for identifying PMTs activated by muonic events.

5. Future development

In the framework of the NEMO project we foresee the implementation and testing of the trigger on the real data which will soon be acquired by the prototype tower (4 floors and 16 PMTs) currently under deployment and to start its testing on data simulated to match the characteristics of the first NEMO tower (18 floors and 72 PMTs) which will be deployed in a few years.

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