Simulation of the detector with Magnet

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November 18, 2004

1 Introduction

For this study,we have taken into account the interactions of the neutrinos with magnet and so we have simulated neutrons generated around the magnet.

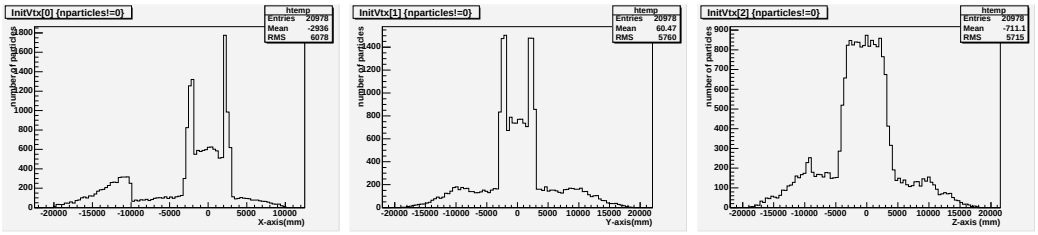
2 Process type

For 1 million events, we have obtained 20978 events that generate particles inside of the scintillator. A 98.1% of these are leptons and hadrons,and a 1.9% have only hadron.

The number of particles generated are 107933.The type of particles are electrons, protons and photons (these are due to energy threshold and so we will not consider them in the study).We have 26.4% of protons,69.3% of electrons and the rest are photons.

3 Initial Vertex

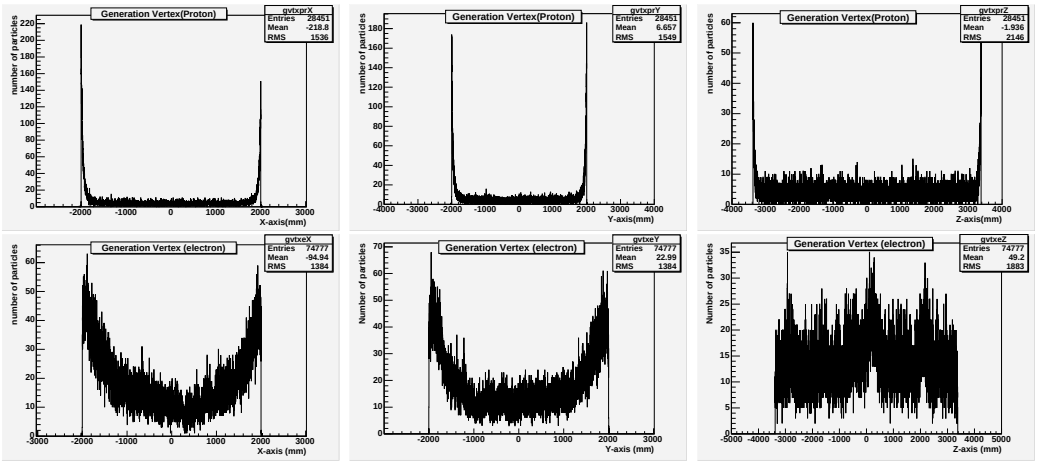
In this section, we have analyzed the production position of the neutrons which generate particles that enter in the scintillator.The graphics below represents the initial vertex of the neutrons for the different axis of the detector.In general, we can see that almost all the neutrons are created in the magnet.



Initial vertex of the neutrons that generate particles inside of the Scintillator.In the left plot,we can observe the soil ground at 10 m and the walls of the magnet.

4 Production Vertex

The production vertex is the position where the particle, that will enter in the scintillator, is created.In the graphics below, we see that all particles have their vertexes inside the scintillator (remember that the dimensios of the scintillator are x=4m,y=4m and z=6.75m).

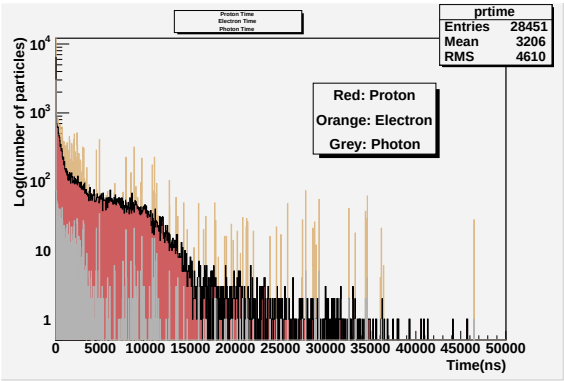


Production vertex for protons (upper figures) and for electrons (lower figure) in the x,y and z axis.

The difference between upper and lower graphics is due to the fact that the lower graphics,that correspond to electrons,also contain secondary electrons created inside the scintillator.

5 Production Time

The production time is the interval of time between the neutron generation and the detection particle.



Production Time for the different particles.

We can see that the times are between 5 and 10 microseconds.

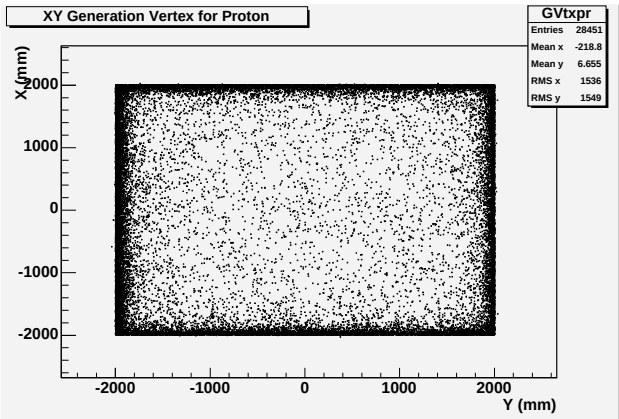
6 Protons in the scintillator

This section studies the total energy deposited in the scintillator,the generation vertex and the length crossed in the scintillator. We consider the total energy as:

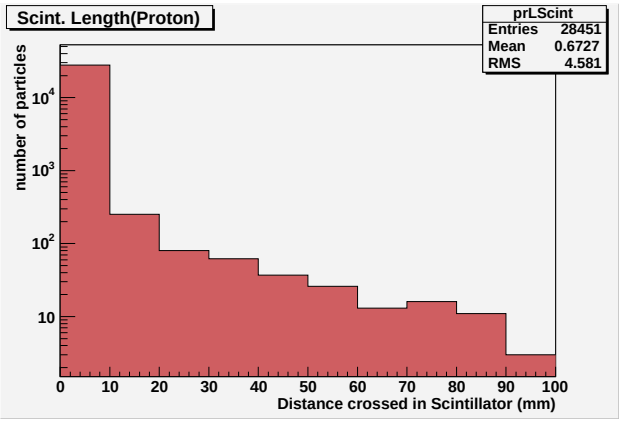
$$\mathrm{E}_t = P + M; \ (1)$$

where P is the total momentum deposited by the particle until it stops, and M is the mass of the particle deposited when the particle stops.

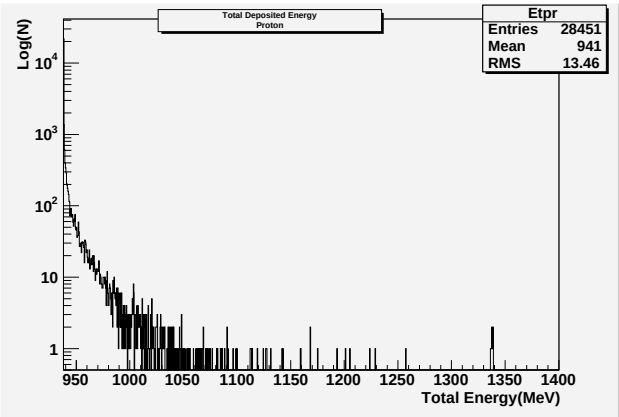
The first figure represents a trasversal section of the system (the system are the cylindrical soil,the magnet and the scintillator).Almost all the protons have their vertexes near the walls of the scintillator, the position where the density of protons is bigger is approximate 200 mm of the walls.
The second figure represents the motion of the protons in the scintillator, with maximum length of 50 mm.And in the third figure, the energy spectrum is represented.The energies are of the order of MeV.



Trasversal section,XY axis, of the scintillator.



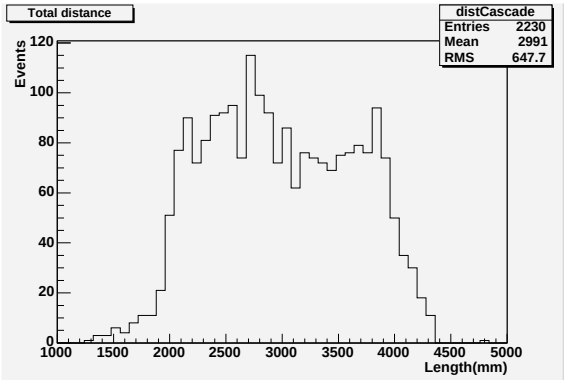
Length of a single proton in scintillator.



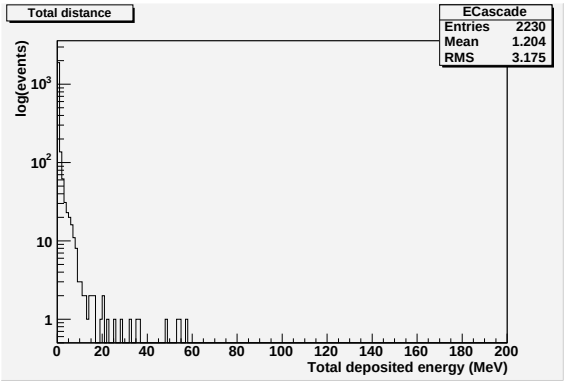
Energy spectrum for proton.

7 EM cascade in the scintillator

The EM cascades are produced in the scintillator and so we have analyzed the lengths of the EM cascades for the different events and the total energies deposited in the scintillator.The results obtained indicate that the lengths have between 2 and 4 meters and the energies are of the order of MeV(see the figure below).



Lengths of electromagnetic cascades for the different events.



Total deposited energy for the EM cascades.

8 Conclusions

In this study we can reach two important conclusions.The first is the case of the protons in scintillator.For these particles, we could consider a section of approximally 210 mm around the inner walls of the scintillator, as a strong factor of background, and veto the analysis of the data.Therefore we can eliminate this problem.
The other conclusion is the EM cascade.We now know that the EM cascades

have lengths between 2 and 4 meters and deposite energy of the order of MeV, is it relevant in the measurements?