

Study of the interactions between neutrinos and the Earth for the Near Detector of T2K

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Outline

- Presentation of the Problem
- Description of Simulation
- Analysis of variables
- Conclusions
- New Goals

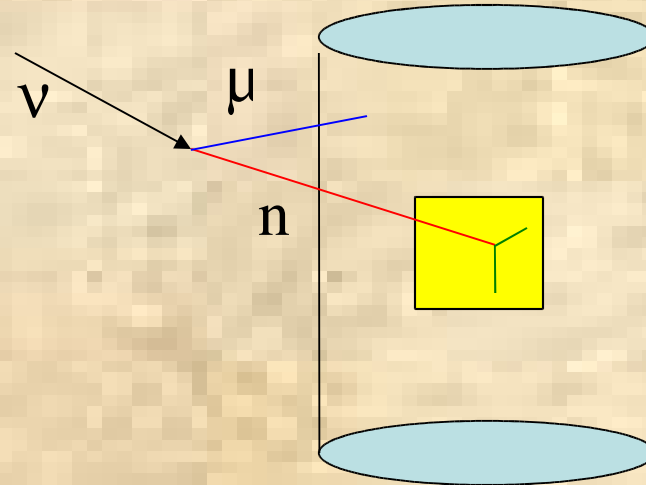
Presentation of the Problem

- Interactions of neutrinos with Soil generate neutrons that enter in the Scintillator

$$\nu + N \rightarrow n + X$$

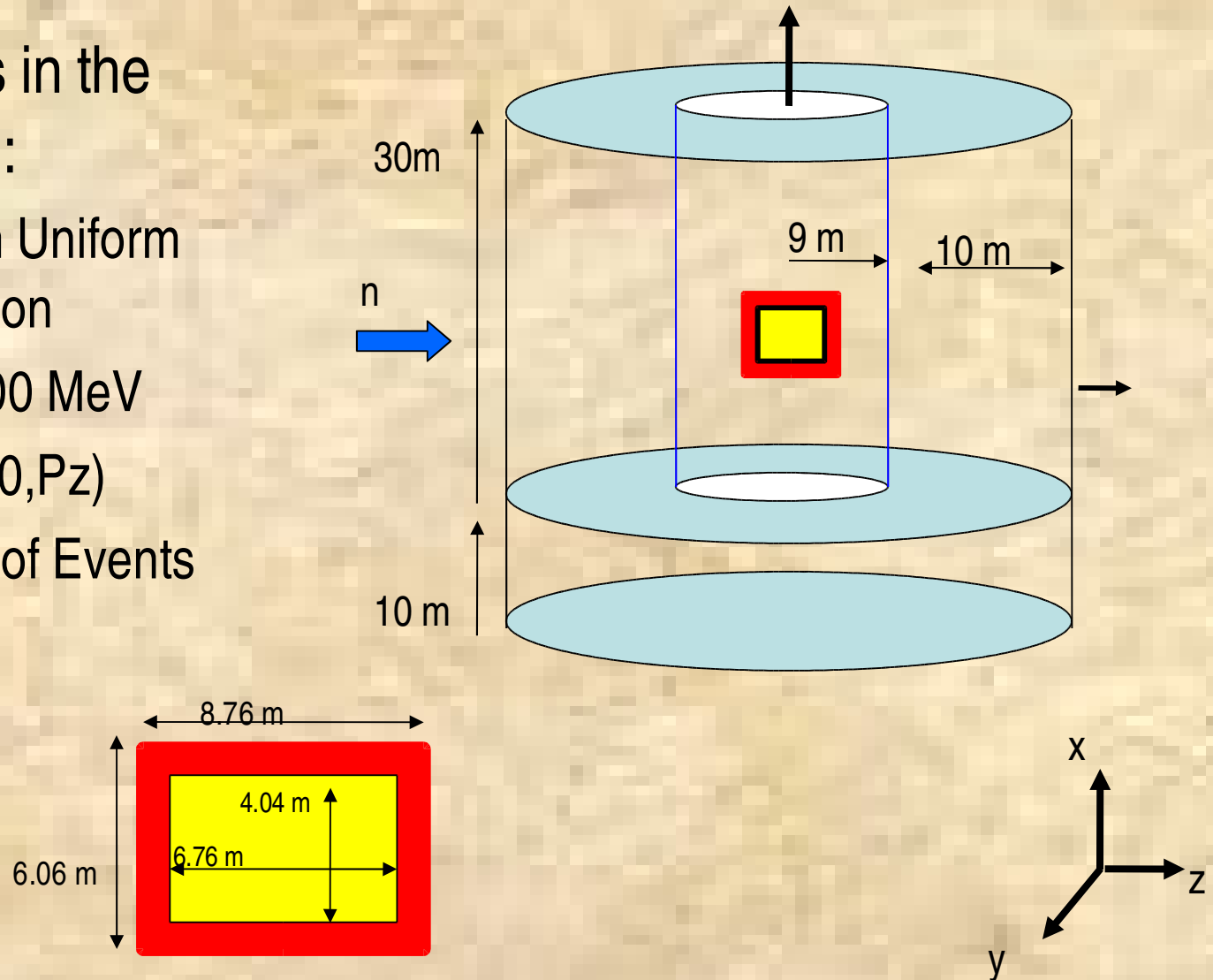
$$E(\nu) = 600 \text{ MeV}$$

Background Problems?



Description of Simulation

- Conditions in the Simulation:
 - Random Uniform distribution
 - $K(n) = 400 \text{ MeV}$
 - $P(n) = (0, 0, P_z)$
 - 1 Milion of Events

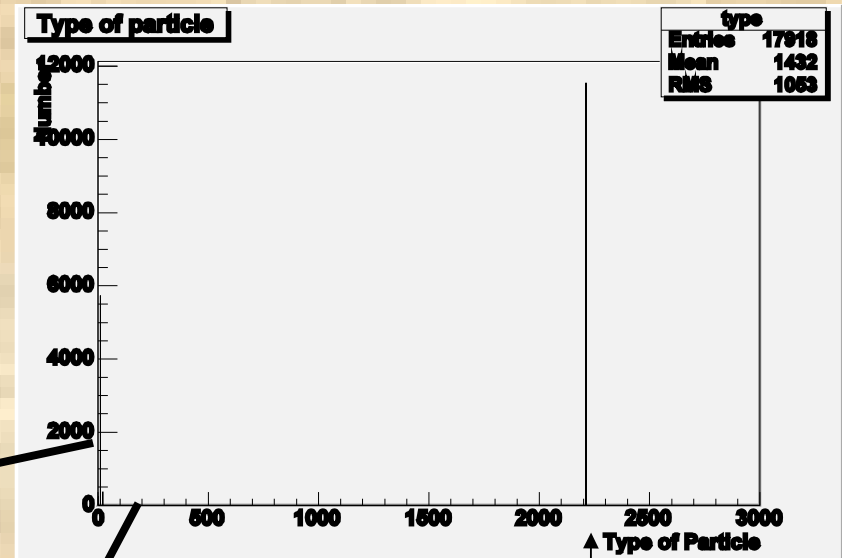


Analysis of variables

- Particles generated.
- Production vertex.
- Energy spectra for different particles.
- Distance crossed for each particle in Scintillator.
- Production time.
- Study of the distance for the EM cascade.

Particles generated

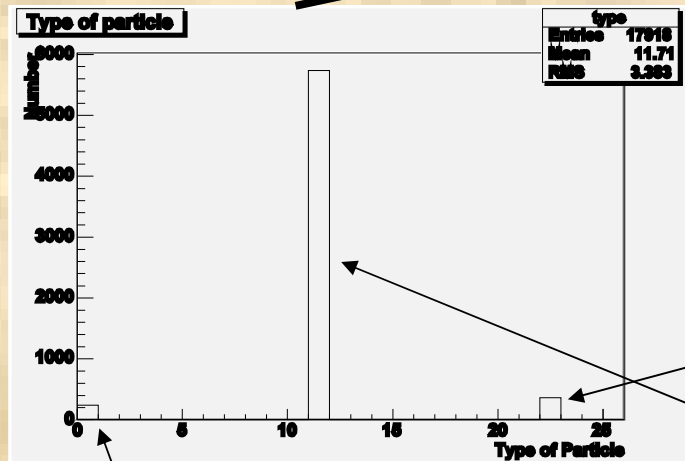
- Number of Events: **1 Million**
- Particles in the Scintillator: **17918**



Protons: 11549 (65%)

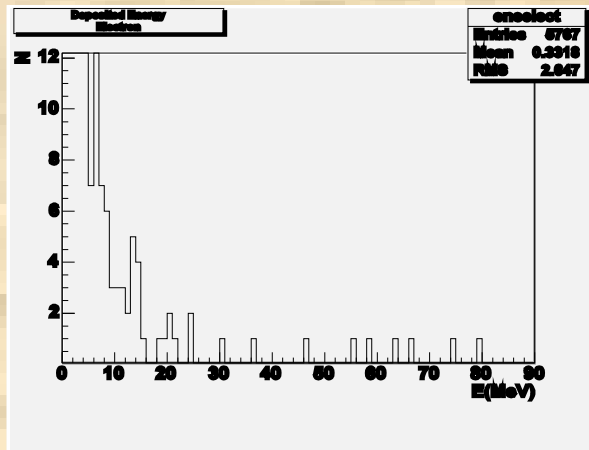
Photons: 362 (2%)

Electrons: 5767 (32%)



Deuterium: 240 (1%)

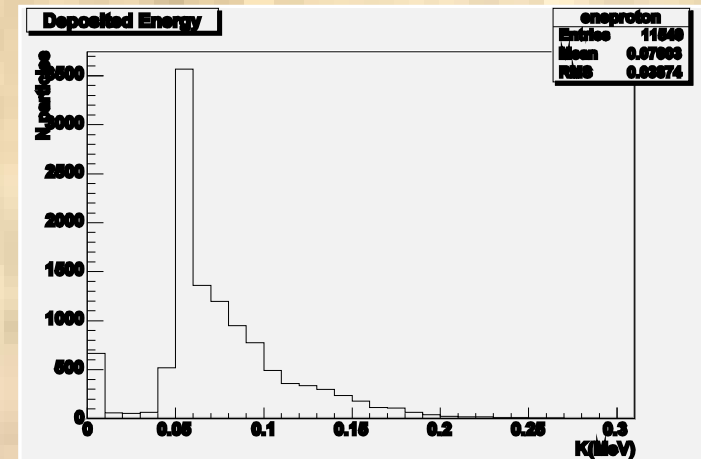
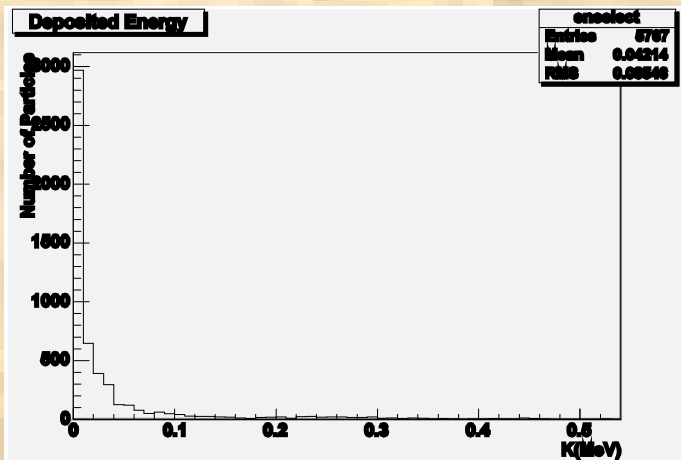
Energy spectra for the different particles in Scintillator



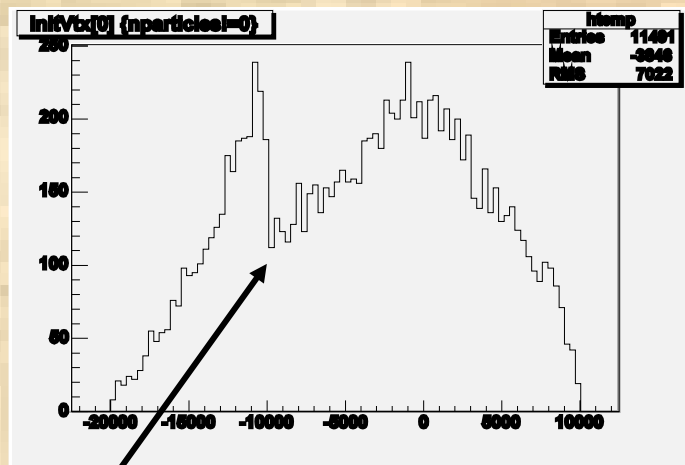
Electrons



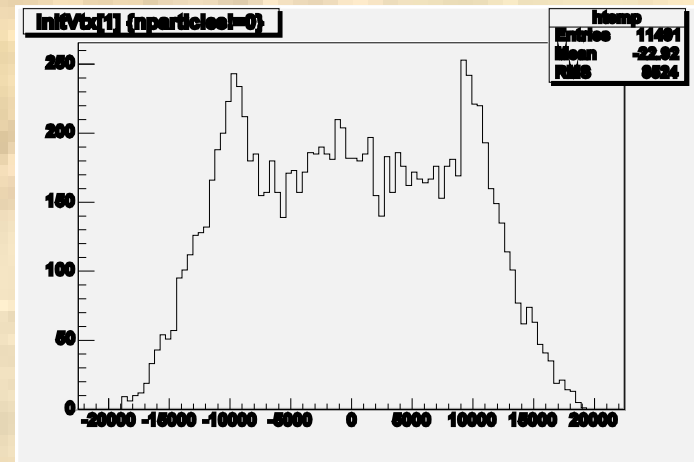
Protons



Production Vertex



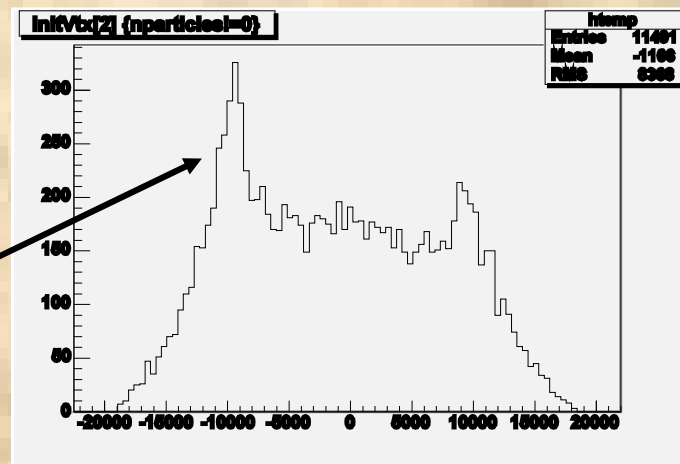
X-axis



Y-axis

SoilGround

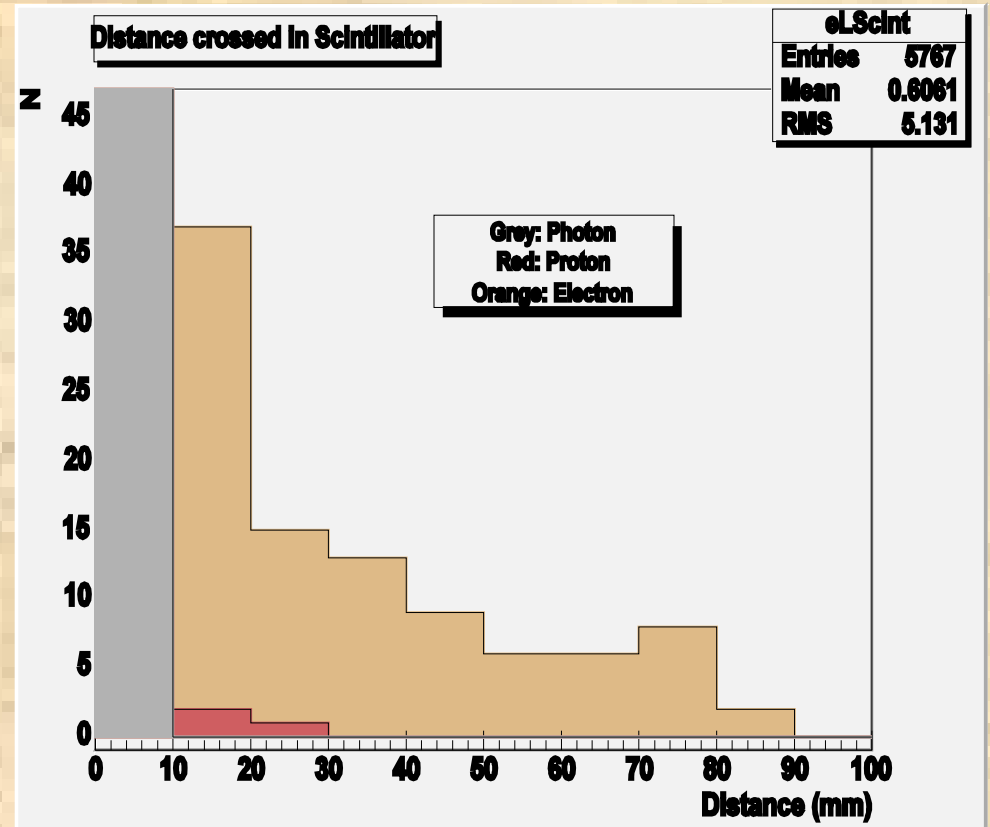
Asymmetric due to
Z momentum of the
neutrons



Z-axis

Distance crossed by each Particle

- The Electrons are the particles which cross more distance in Scintillator, approx. 1 cm!
- It is for one only particle, but in electromagnetic cascade?



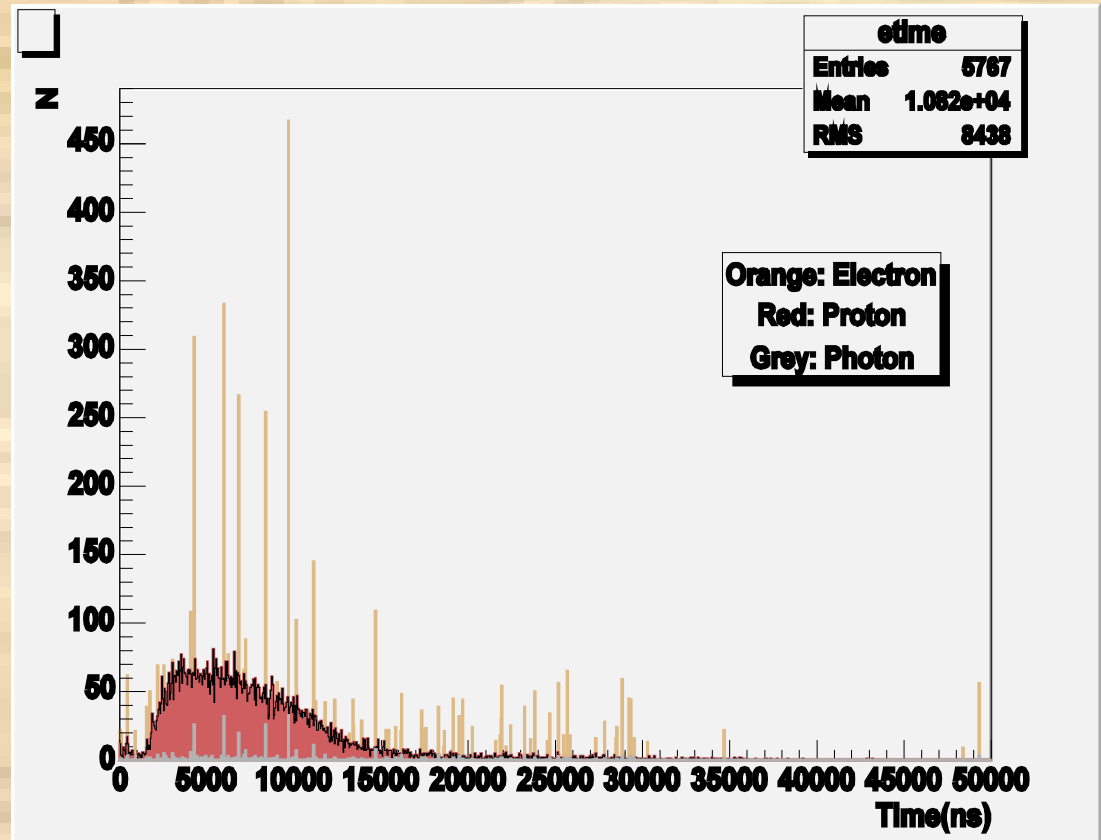
Production Time

-Production Time: Time interval from the neutron generation to the particle (produced by this neutron) is detected in Scintillator.

Remarkable Aspects:

1-A continuous time spectrum for proton.

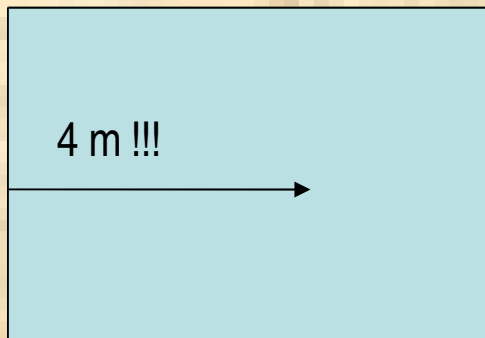
2-Coincidence in time between photons and electrons:EM Cascade.



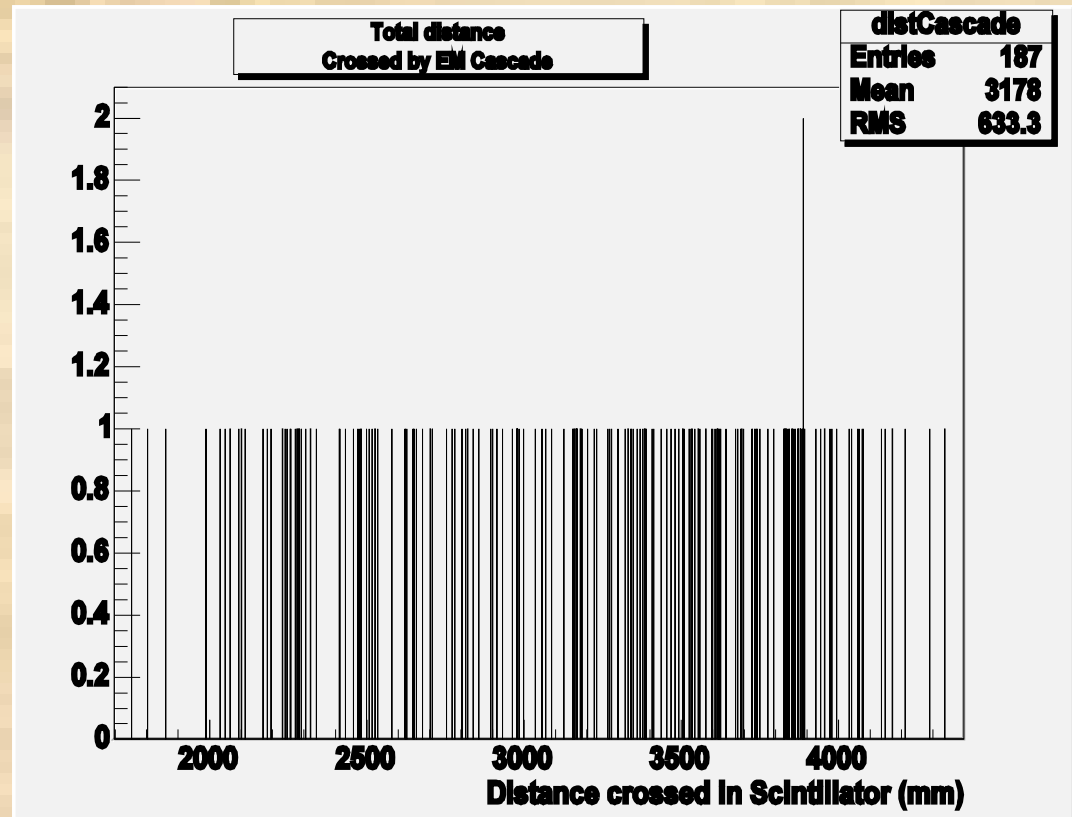
Characteristics times: 5 to 15 microseconds

Study of the distance for EM Cascade

- In X-axis we have the distance crossed in the Scintillator by the EM cascade.
- It is from 2 to 4 meters!!!



6.76m of Scintillator



Conclusions

- We know the range of times for these particles ($10\ \mu\text{s}$).
- We have 1% of particles inside the Scintillator for each 100 neutrons.
- The distances of Electromagnetic Cascades , generated inside the Scintillator, are between 2 and 4 meters.

New Goals

- Can it be the effect of the “skyshine”?
- We will do the same study for neutron energies of 200 and 600 MeV.
- And changing the neutrons for muons.

To be Continued

Thanks for your attention