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Analysis of Monte Carlo events for ICARUS PMT trigger studies

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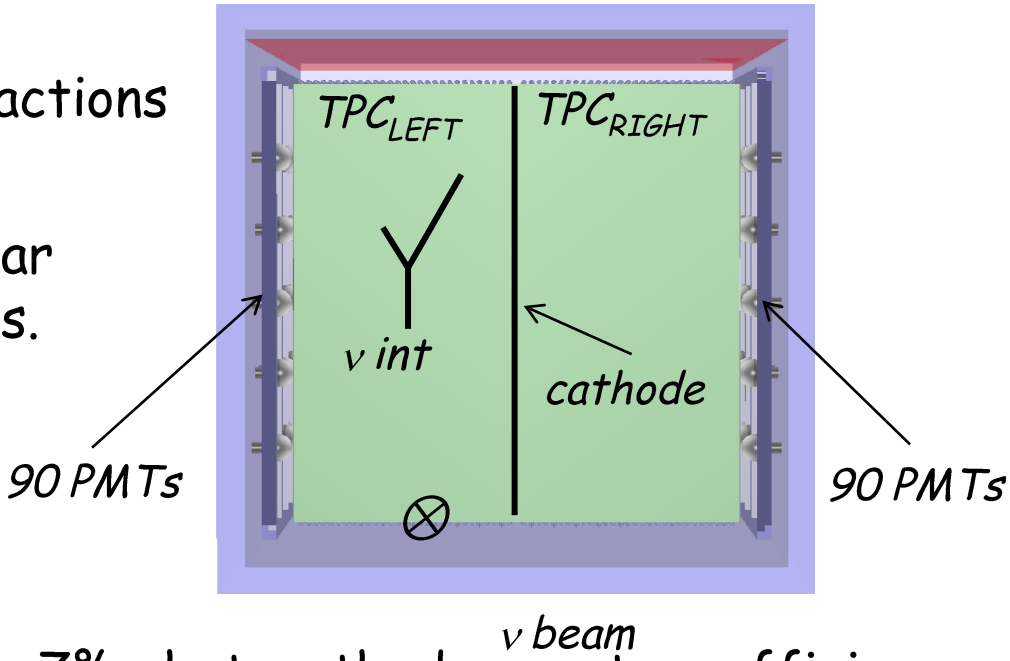
Introduction

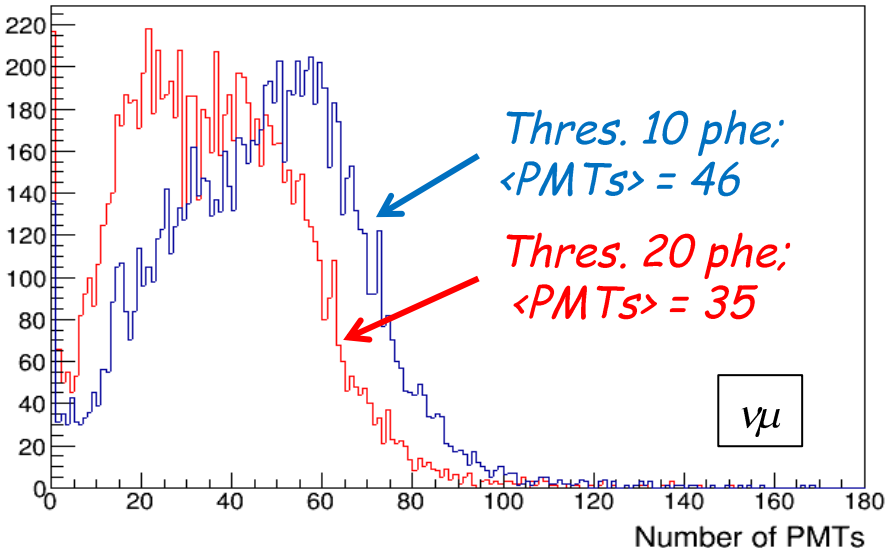
First study dedicated to the ICARUS trigger performance was carried out by analyzing events simulated with LArsoft:

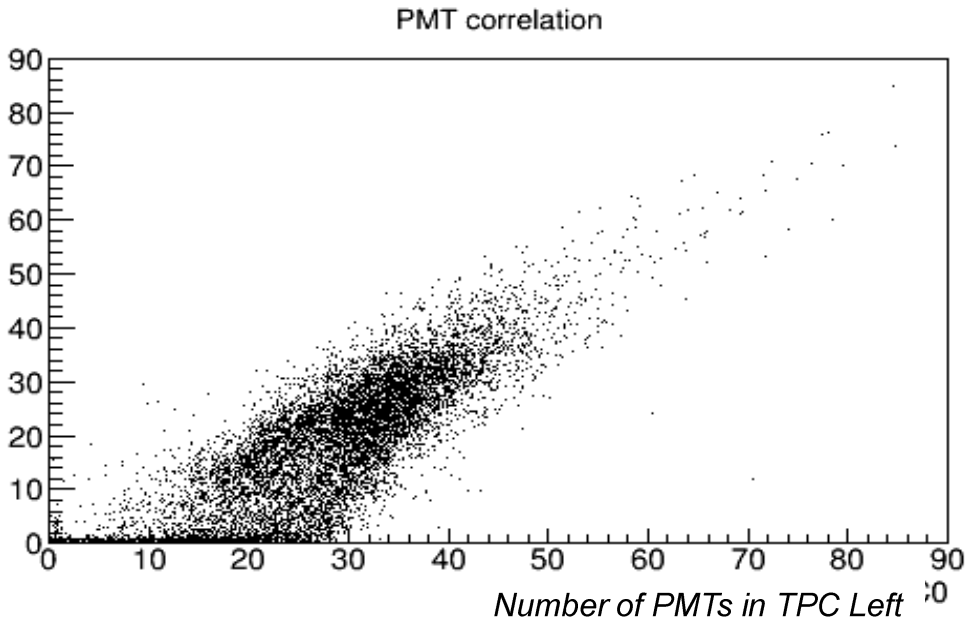
- BNB $\nu\mu$ and νe: both CC and NC interactions occurring in the TPC_{LEFT}
- crossing muons with energy and angular distribution similar to the cosmic rays.



- The scintillation light signal reaching each PMT is computed as a function of the track position inside the detector.
- In the conversion to photoelectrons a 7% photocathode quantum efficiency is applied together with a random smearing according to Poisson statistics. To mime the saturation, the signal is limited to 400 phe.
- Time propagation of the scintillation light is determined as a function of the PMT distance from the position where photons are generated.
- Only **fast component** of the light is considered for a first prompt level trigger.

Total number of PMTs vs threshold



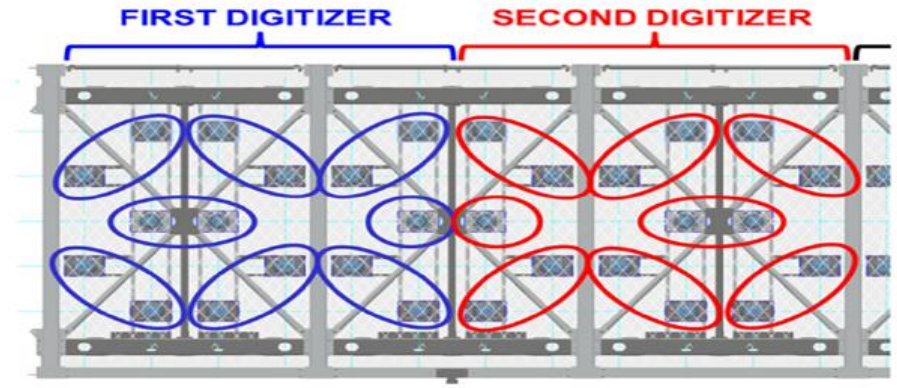


- *On average, for BNB νμ interactions, ≈46 PMTs out of the total 180 inside a T300 are fired above a 10 phe threshold:*
  - *28 in the chamber where interaction occurs (TPC_{LEFT});*
  - *20 on the adjacent one (TPC_{RIGHT}), behind the semi-transparent cathode.*
- *Similar results hold also for νe interactions, with a larger average PMT multiplicity (<PMTs> = 52 for 10 phe threshold).*

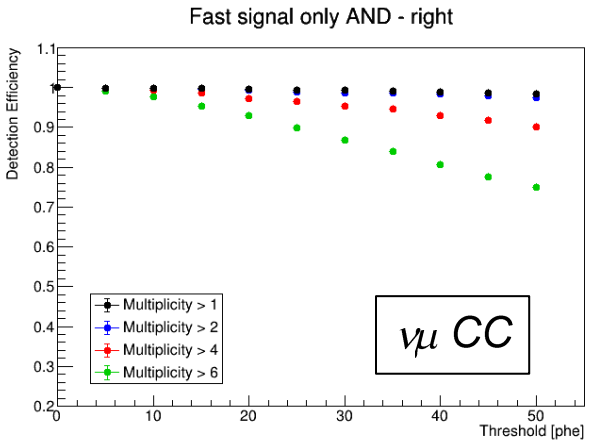
Trigger efficiency studies

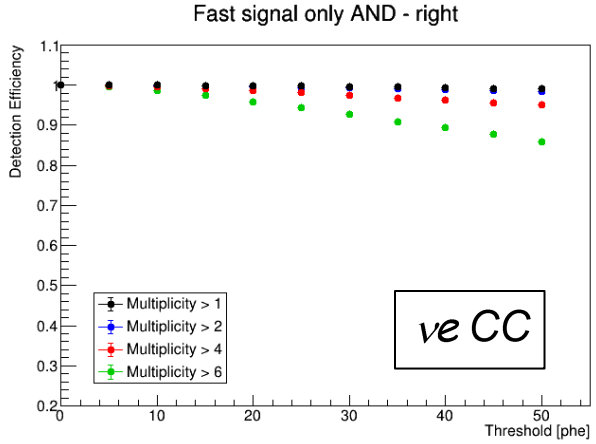
- A trigger study has been carried out to emulate the PMT granularity of discriminated signals provided by the available electronics.

- The ICARUS CAEN boards generate either the OR or the AND of the discriminated signals for each pair of adjacent channels.



Coupling scheme of adjacent PMTs





Multiplicity	Thres.(phe)	Eff.
6	10	0.98
4	20	0.98

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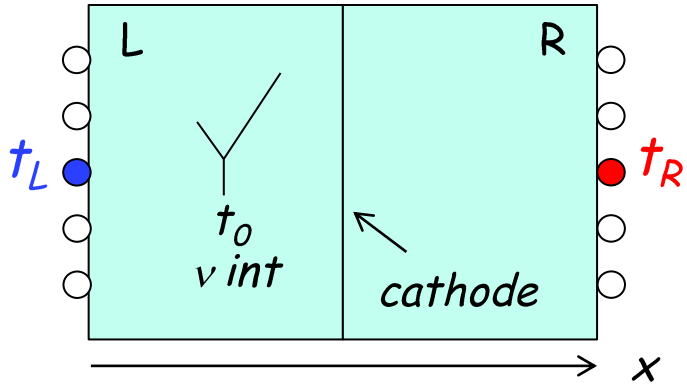
This MC study suggests possible combinations of PMT multiplicities and threshold to get an almost optimal efficiency.

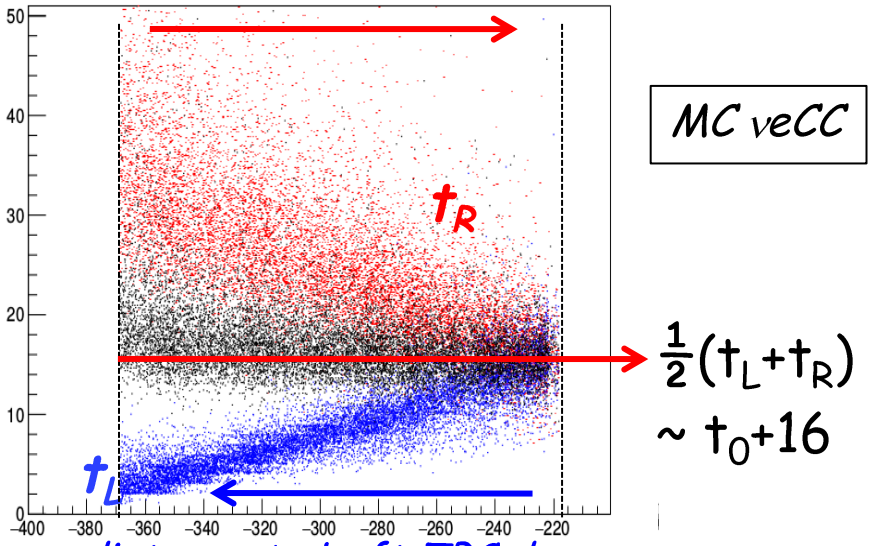
PMT timing for event filtering: transverse resolution

- In order to select genuine ν interactions the acquired events can be filtered out by reconstructing quasi-online the PMT signals, determining signal pulse height and timing at ns level.
- The precise timing of neutrino interaction will depend on position of the vertex interaction along both the transverse (drift) *x* and longitudinal *z* directions.
  - Light propagation from track to PMTs introduces a delay between t_0 time of ν interaction and the first hit PMT in Left, Right TPCs t_L, t_R which increases with track distance from PMTs:



ν interaction in Left TPC

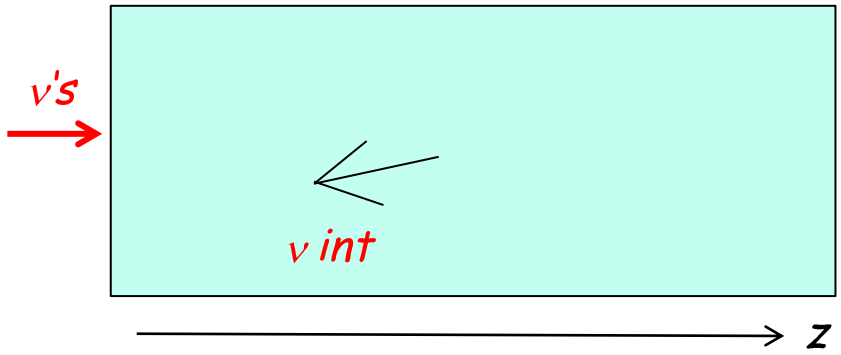
→ $(t_L+t_R)/2$ provides a 1st evaluation of t_0 ν interaction independent from ν vertex position with σ ~2.4 ns



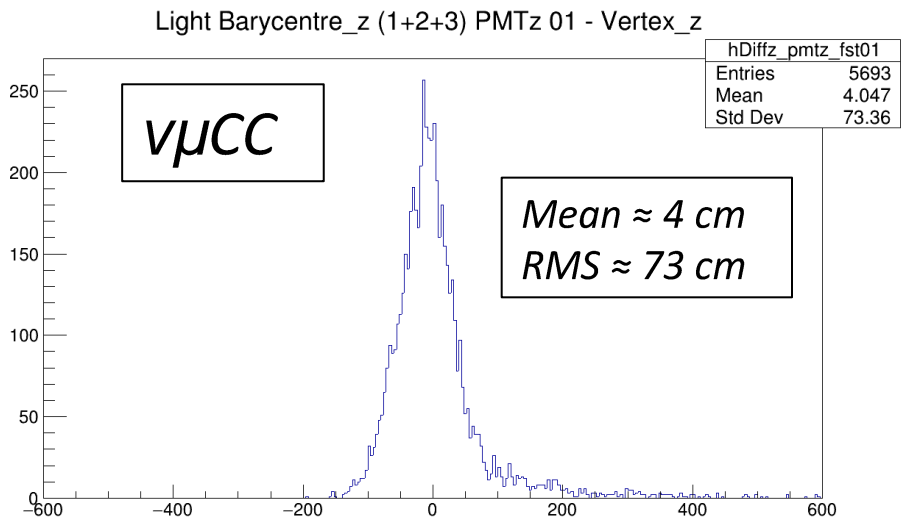
Scint. light propagation delay

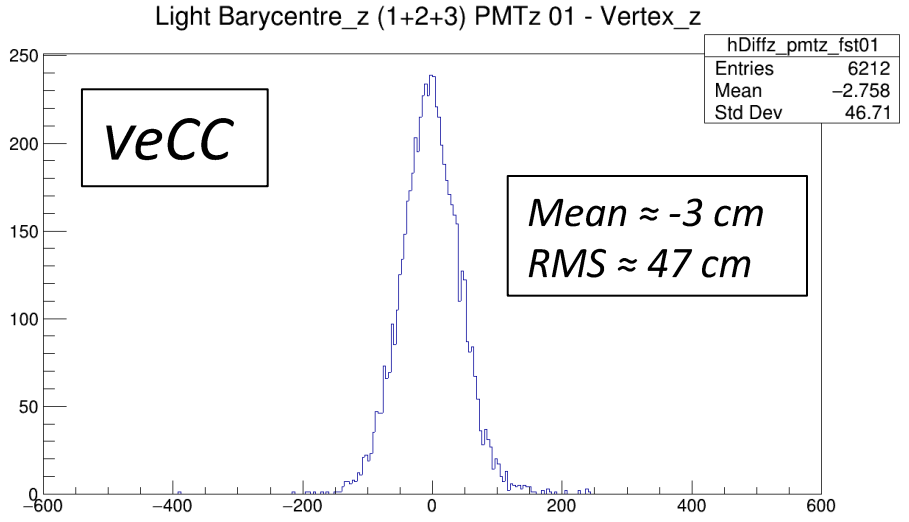
PMT timing for event filtering: longitudinal resolution

- First attempt to determine the position of ν interaction along the beam direction by using the hit PMT signals alone.



- *Best RMS resolutions have been obtained for νμCC and νeCC by evaluating of the difference between the true neutrino vertex position along the beam direction and barycentre of first hit PMTs.*





Corresponding to few ns time resolution.