Time of Flight (ToF) Studies in SBND Experiment

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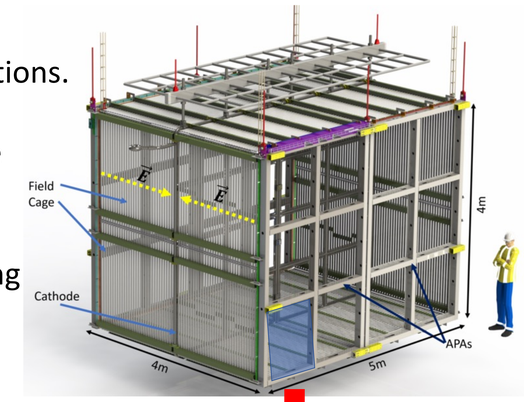
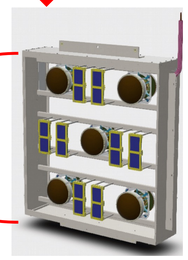
SBND Experiment

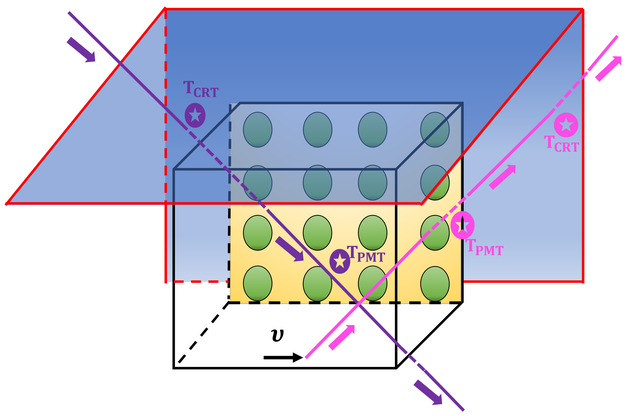
- Uses LArTPC technology to visualize particle interactions.
- Main objectives include confirming or ruling out the existence of eV-mass scale sterile neutrinos over 5σ confidence level, performing **υ-Ar** cross section measurements, BSM searches and R&D for upcoming LArTPC experiments.
- Equipped with advanced light detection system consisting of PMTs, Xarapucas and light reflecting foils, capable of reconstructing particle interactions at a few nano seconds precision.
- CRT system provides full ~4π converage in identifying cosmics, consists of 7 planes each made up of scintillating modules.





SBND Photon Detection System (PDS) box

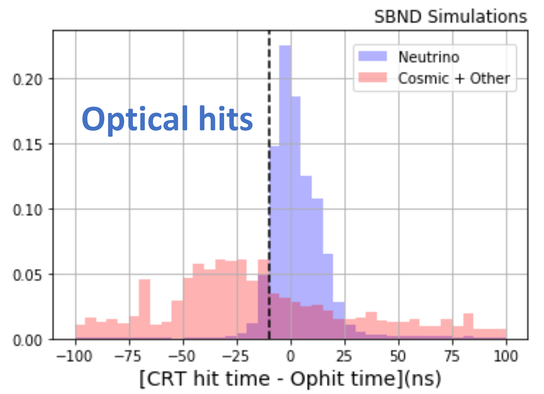
Use of ToF in Separating Intime Cosmics Vs Neutrino Tracks

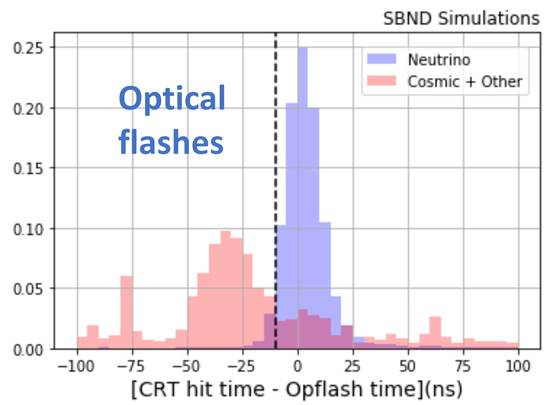


- $T_{CRT} - T_{PMT} > 0$ (υ-tracks)

  $T_{CRT} - T_{PMT} < 0$ (Cosmics)

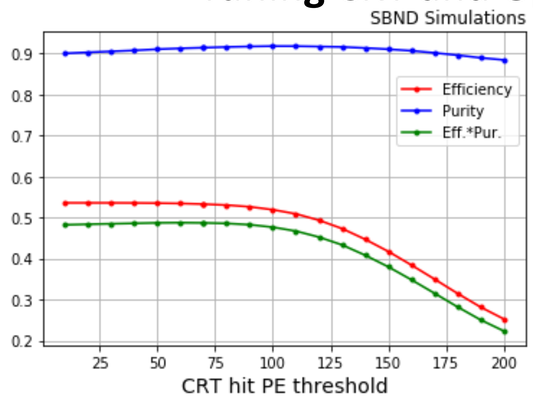
- Looked for CRT hits, which are inside BNB beam window (1.6 μs) and coupled with the largest optical flash (optical hit) with in a 100 ns **conincidence time winow** w.r.t CRT hit time to calculate ToF value.

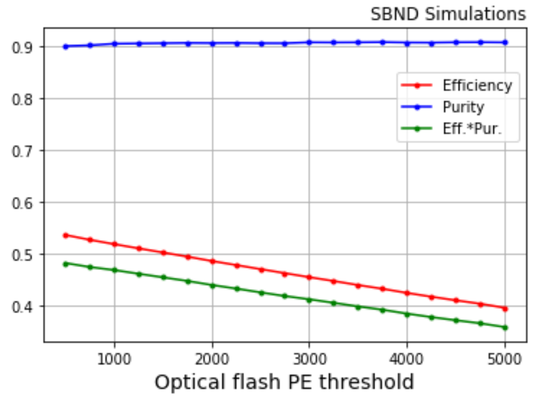




Chris Hilgenberg first performed these ToF studies in ICARUS.
Ref: https://mountainscholar.org/handle/10217/219579

Tuning CRT and Optical Flash PE Thresholds



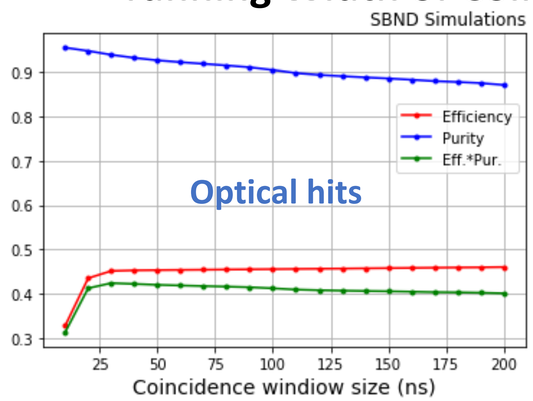


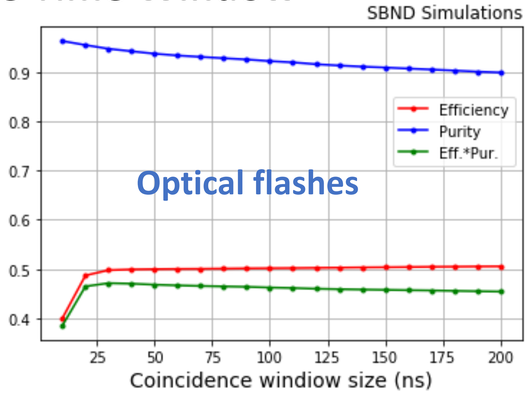
$$\text{Eff.} = \frac{\#\ \text{of}\ \upsilon\ \text{tracks tagged by TOF metric}}{\#\ \upsilon\ \text{tracks leaving cryostat}}$$

$$\text{Pur.} = \frac{\#\ \text{of}\ \upsilon\ \text{tracks TOF} > 10}{\#\ \text{of all tracks TOF} > 10}$$

- Identified threshold values on CRT PE and optical flash (hit) PE which maximize performance of ToF metric (**100 PE** on CRT hit PE, **100 PE** on optical hit, **1000 PE** on optical flashes).

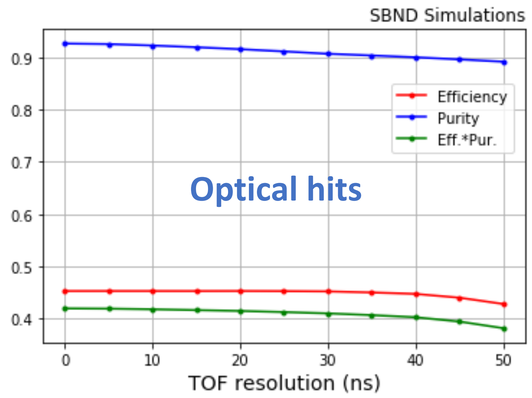
Tunning Width of Coincidence Time Window

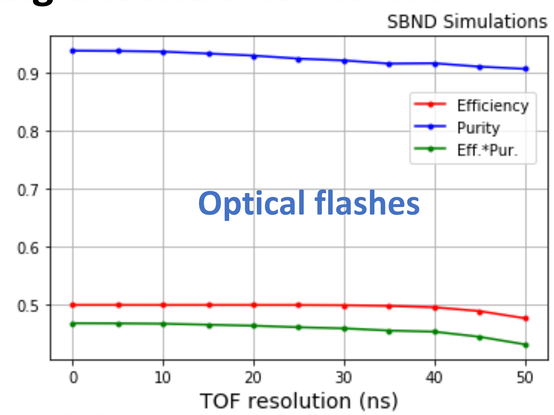




- Optimized the width of the coincidence time window to gain higher efficiency for ToF metric (**50 ns**).

Impact of PMT and CRT Timing uncertainties on ToF





- Smeared the ToF distributions to evaluate the impact of timing uncertainties.

Results

- After optimizing parameters, ToF metric reached **50% (65%)** efficiency and **93% (57%)** purity in tagging υ-tracks (cosmics).