Separation of Scintillation and Cherenkov Lights in Linear Alkyl Benzene⋆

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⋆ Li Mohan, Guo Ziyi, et al. *Separation of scintillation and Cherenkov lights in linear alkyl benzene*[J]. NIM A, 2016, 830:303-308.

Outline

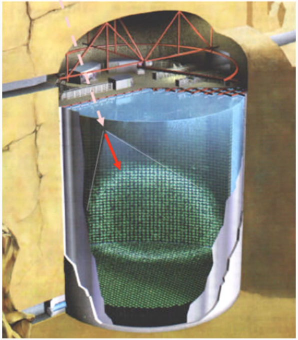
1. Introduction
2. Experiment Method
3. Experiment Result
4. Conclusion

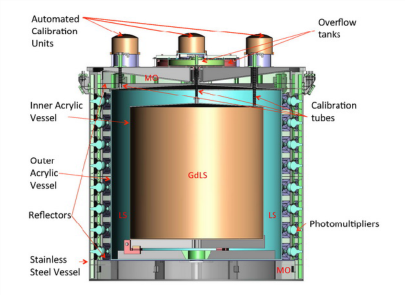
Introduction

Neutrino Detector

A typical neutrino detector comprises the target medium and photomultipliers.

Netrinos react with the target medium, and we observe the Cherenkov light or scintillation emitted by the secondary particles.

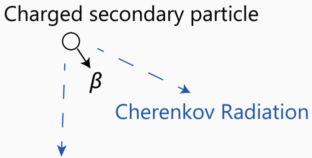




Neutrino Detector

Currently, two viable options for detector materials:

- Water/Heavy water:

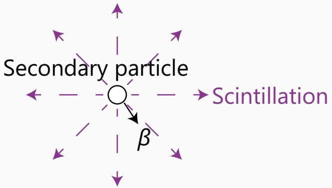


✓ Measuring both energy and direction.

✗ Poor light yield and resolution.

✗ High detection threshold.

- Liquid scintillator:



✓ Low detection threshold

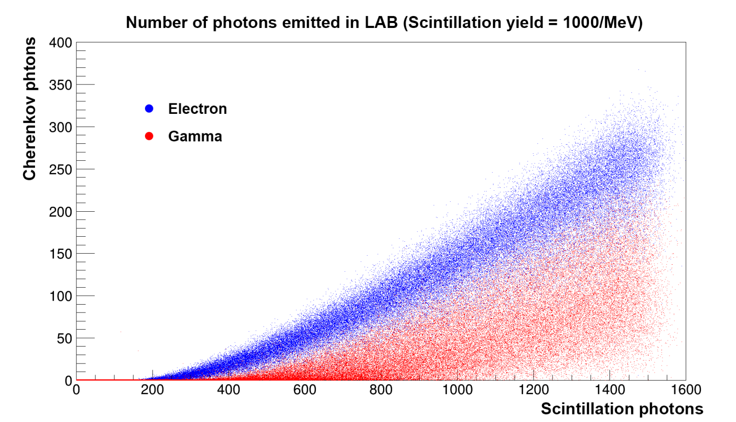
✓ High energy resolution.

✗ Inefficient in other aspects.

Neutrino Detector

Detecting Cherenkov light and scintillation simultaneously
$\rightarrow$ Low threshold, both direction measurement and high energy resolution

In addition: identify different particles, suppress background.



Water-based liquid scintillator

Water-based liquid scintillator (WbLS) can achieve the goal.

Linear alkyl benzene (LAB) is one important ingredient of both liquid scintillator and WbLS*.

In our experiment, we

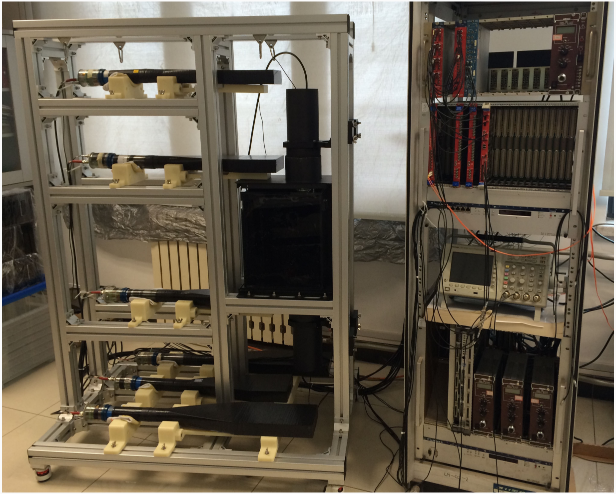
- Test the separation of Cherenkov and scintillation lights by the waveform.
- Measure the time profile of LAB sample
- Measure the scintillation light yield of the LAB sample

*Yeh Minfang, Hans S, Beriguete W, et al. A new water-based liquid scintillator and potential applications[J]. NIM A, 2011, 660(660):51-56.

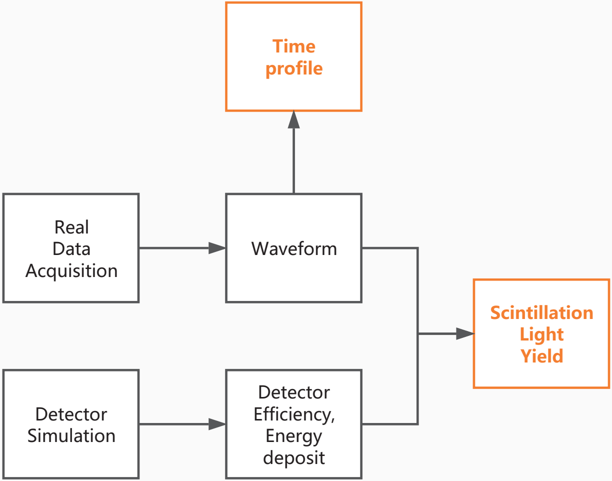
Experiment Method

Apparatus

We design a detector to observe the Cherenkov and scintillation lights of vertically incident muons in an LAB sample.



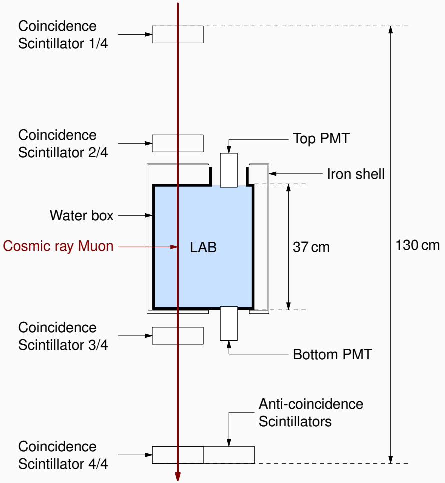
Experiment Method



Signal waveform

Once a single vertically-going muon fly into the detector,

- 4 coincidence scintillators: trigger
- 2 anti-coincidence scintillators: no trigger
- Top PMT: scintillation
- Bottom PMT: both the Cherenkov light and scintillation



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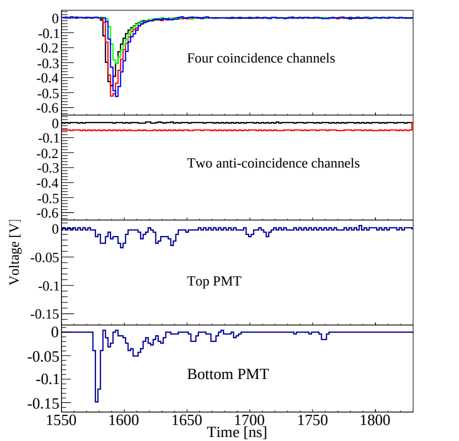
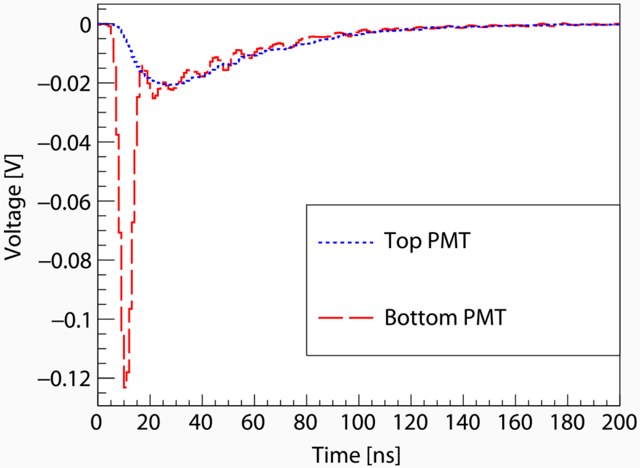


Signal waveform

Average waveforms of the top and bottom PMTs*



Detector Simulation

From the simulation result of the apparatus, we can

- Understand the collected data
- Estimate the efficiency of scintillation light detection. Shown in the table
- Estimate the energy deposit in the detector

	Top PMT	Bottom PMT
Cherenkov	$(0.21 \pm 0.14) \times 10^{-4}$	$(6.32 \pm 0.70) \times 10^{-4}$
Scintillation	$(2.74 \pm 0.33) \times 10^{-4}$	$(2.73 \pm 0.33) \times 10^{-4}$

The uncertainly comes from the uncertainly of apparatus parameters:

- Quenching effect
- Reflectivity of optical surfaces
- Quantum and collection efficiency of PMTs
- Attenuation length of LAB

Experiment Result

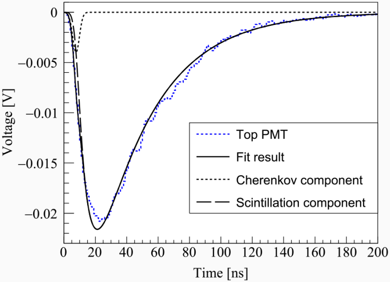
Time Profile

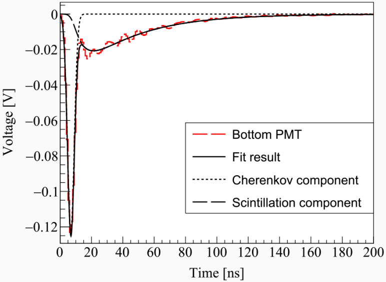
The average pulse shape of the scintillation light is interpreted as

$$n(t) = \frac{\tau_r + \tau_d}{\tau_d^2} \left(1 - \mathrm{e}^{-t/\tau_r}\right) \cdot \mathrm{e}^{-t/\tau_d}$$

The top and bottom waveforms were fitted with

$$f(t) = (A_C \cdot \delta(t) + A_S \cdot n(t)) \otimes \mathrm{Gaus}(t)$$





Fitting result: $\tau_r = (7.7 \pm 3.0)$ **ns**, $\tau_d = (36.6 \pm 2.4)$ **ns**

Scintillation light yield

After calibrating the gain of the PMTs, we can obtain the number measured photoelectrons (PEs) by the charge on PMTs.

	PEs on Top PMT	PEs on Bottom PMT
Cherenkov	0.33 ± 0.33	10.7 ± 0.4
Scintillation	17.6 ± 0.6	17.7 ± 0.6

The scintillation light yield L of the LAB was calculated with the following relation

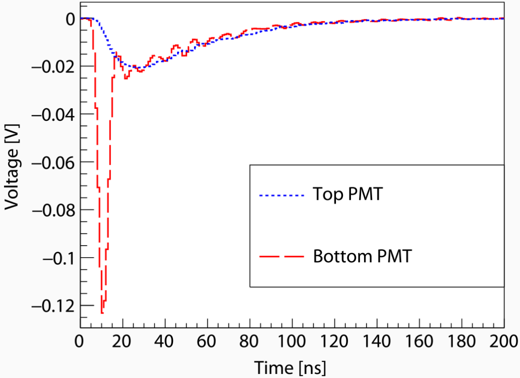
$$L = \frac{D}{\varepsilon E}$$

D - Number of measured photoelectrons on the top PMT due to scintillation
ε - Detection efficiency of scintillation light
E - Total visible energy deposit estimated with the simulation.

The scintillation light yield was measured to be $(1.01 \pm 0.12) \times 10^3$ **photons/MeV**.

Conclusion

Conclusion



- The Cherenkov and scintillation light of LAB **can be separated by the waveform**.
- The rising time constant of LAB was measured to be (7.7 ± 3.0) **ns**, and the decay time constant (36.6 ± 2.4) **ns**.
- The scintillation light yield of LAB was measured to be $(1.01 \pm 0.12) \times 10^3$ **photons/MeV**.

Thanks

Enjoy dinner!