Measuring the Fluorescence Time Profile of the JUNO Liquid Scintillator using Gamma Radiation and a Pulsed Neutron Beam

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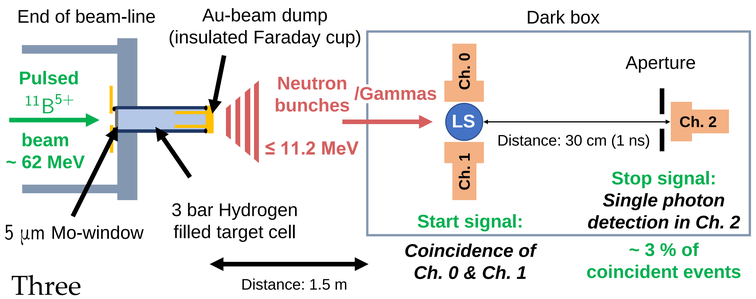
Motivation

Major science goals of the **Jiangmen Underground Neutrino Observatory (JUNO)** are the determination of the neutrino mass ordering and precise measurements of oscillation parameters but also the search for the proton decay and the detection of the diffuse supernova neutrino background.

- **Pulse shape discrimination (PSD)** performance of the **liquid scintillator (LS)** important to identify neutrino events from neutron-induced background events
- **Measuring the intrinsic fluorescence profile** of JUNO-like LSs using excitation by gammas inducing recoil electrons and neutrons inducing recoil protons

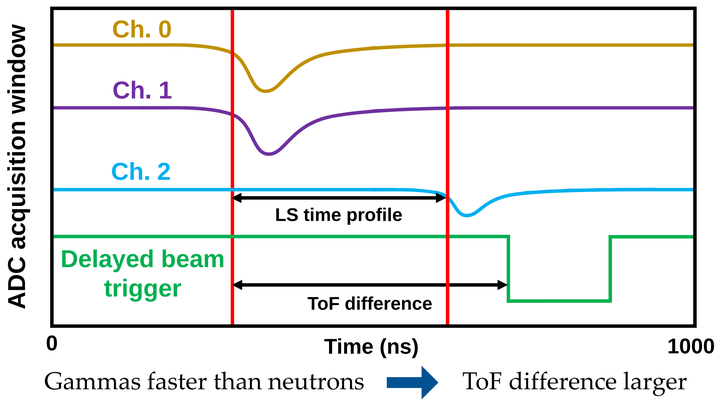
Results will e.g. improve Monte Carlo simulations such as predictions for event reconstruction or improve data analysis.

Experimental Setup



Three photomultiplier tubes of type ETL 9821 B

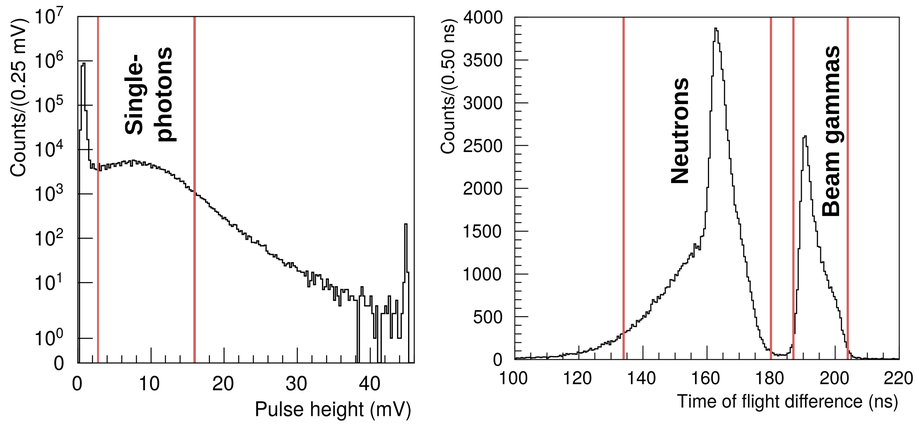
LS: Liquid scintillator vessel filled with
- LAB + 2.5 g/l PPO + 3 mg/l bisMSB
- LAB + 3.0 g/l PPO + 20 mg/l bisMSB



Gammas faster than neutrons → ToF difference larger

Data Analysis

Reduce noise events, select single photon events, and use Time-of-Flight (**ToF**) measurements to discriminate neutron events from gamma events



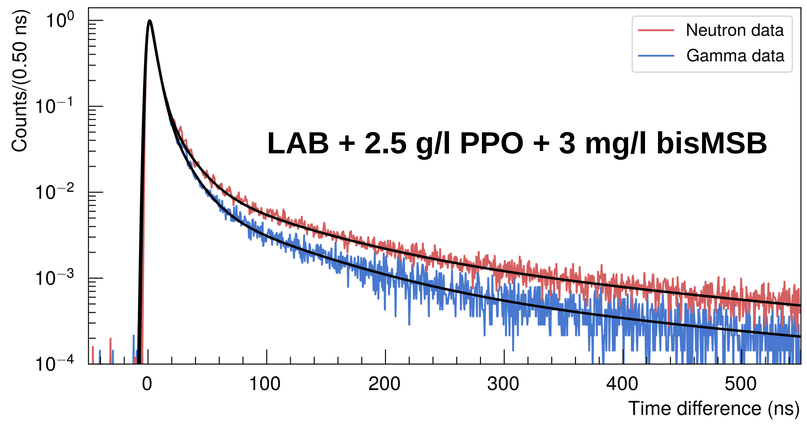
Pulse height spectrum of Ch. 2 and ToF spectrum of one data run

Preliminary Results

Modeling the probability density function (***PDF***) of the fluorescence time profile as the sum of four exponential decay distributions **convolved** with a Gaussian distribution to account for the detector resolution

$$PDF = \frac{1}{\sqrt{2\pi\ \sigma^2}} \exp\left(-\frac{(t-\mu)^2}{2\ \sigma^2}\right) * \sum_{i=1}^{4} \frac{n_i}{\tau_i} \times \exp\left(-\frac{t}{\tau_i}\right)$$

Binned maximum likelihood fit using the *RooFit* toolkit and *Minuit*



Conclusions and Future Work

Measured the fluorescence time profiles of two JUNO-like LSs during two beam-times at the MLL laboratory

- Time profiles show potential to separate neutron events from gamma events via PSD
- Preliminary fit values:

	Weights (%)				Decay-times (ns)				(ns)
	n_1	n_2	n_3	n_4	τ_1	τ_2	τ_3	τ_4	σ
	LAB + 2.5 g/l PPO + 3 mg/l bisMSB								
Neutrons	61.4 ±4.3	23.2 ±1.7	9.0 ±0.5	6.4 ±0.5	4.5 ±0.3	15.7 ±1.5	76.2 ±7.6	367 ±39	1.7 ±0.2
Beam gammas	70.7 ±6.0	20.5 ±2.5	6.0 ±0.4	2.8 ±0.4	4.6 ±0.4	15.1 ±1.9	76.1 ±10	397 ±91	1.9 ±0.1
	LAB + 3.0 g/l PPO + 20 mg/l bisMSB								
Neutrons	59.6 ±3.9	25.0 ±1.6	8.9 ±0.4	6.5 ±0.4	4.3 ±0.3	15.2 ±1.2	71.9 ±6.2	309 ±23	1.6 ±0.1
Beam gammas	70.5 ±5.1	21.0 ±2.3	5.9 ±0.4	2.6 ±0.4	4.4 ±0.4	15.1 ±1.5	73.1 ±6.4	341 ±44	1.8 ±0.2

- Finalizing analysis and writing a paper
- Study LS reponse depending on the PPO concentration using gamma sources
- Study of other LS samples such as **water-based LSs**
- Beam-time at the CN accelerator at the Legnaro National Laboratories **(proposal accepted)**

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