Muon induced Li9/He8 and Fast-N & Muon-X BKG at Daya Bay

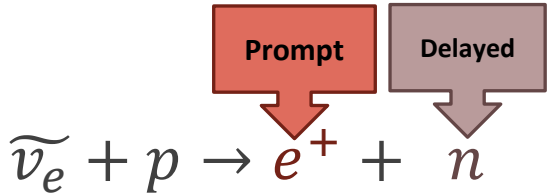
Wei Wei (魏巍)

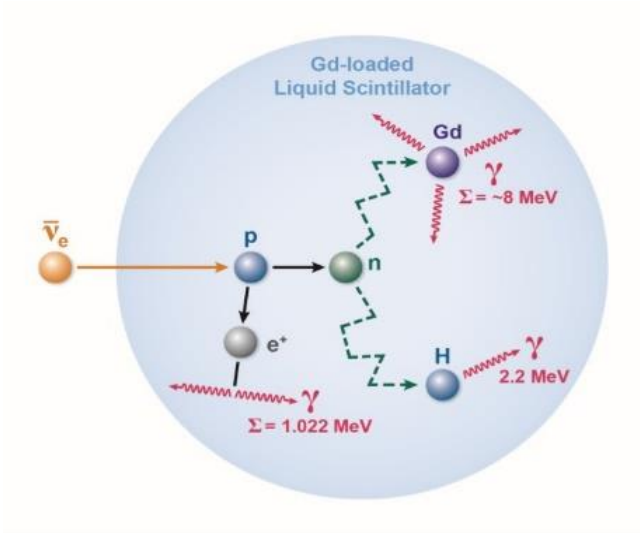
Shandong University

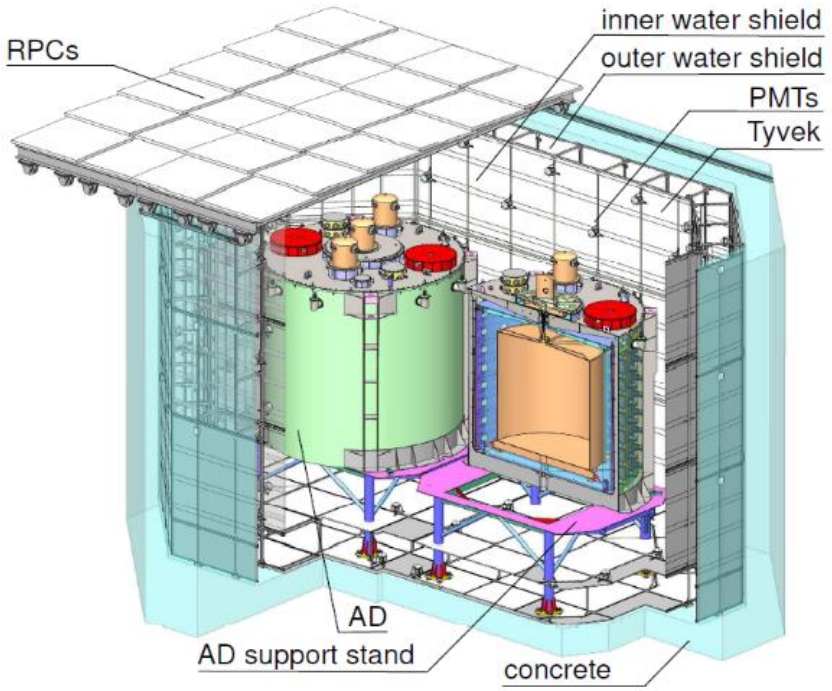
muyewei@mail.sdu.edu.cn

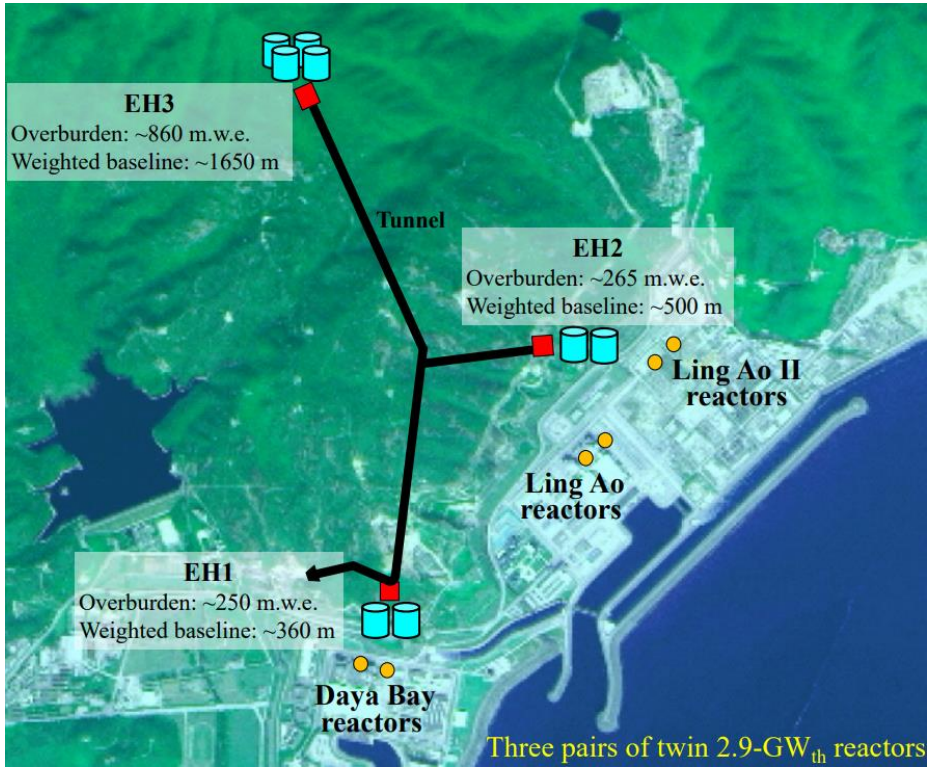
Daya Bay Reactor Anti-neutrino Experiment

Detect inverse β-decay reaction (IBD):









Muon induced backgrounds

1. **Li9/He8**
   - Origin: μ spallation with ^{12}C and create ^{9}Li / ^{8}He
   - Prompt & Delayed signal: $\beta - n\ cascade\ decay$ of ^{9}Li / ^{8}He
2. **Fast-N**
   - Origin: Muon collided with nucleus from surrounding rocks / AD unit
   - Prompt signal: Recoil proton
   - Delayed signal: Neutron capture.
3. **Muon-X**
   - Origin: Muon enter AD and pair with singles
   - Prompt signal： Escape vetoed Muon
   - Delayed signal (possible cases)：
     1. Muon retrigger
     2. Micheal electron
     3. Spallation neutron capture on Hydrogen

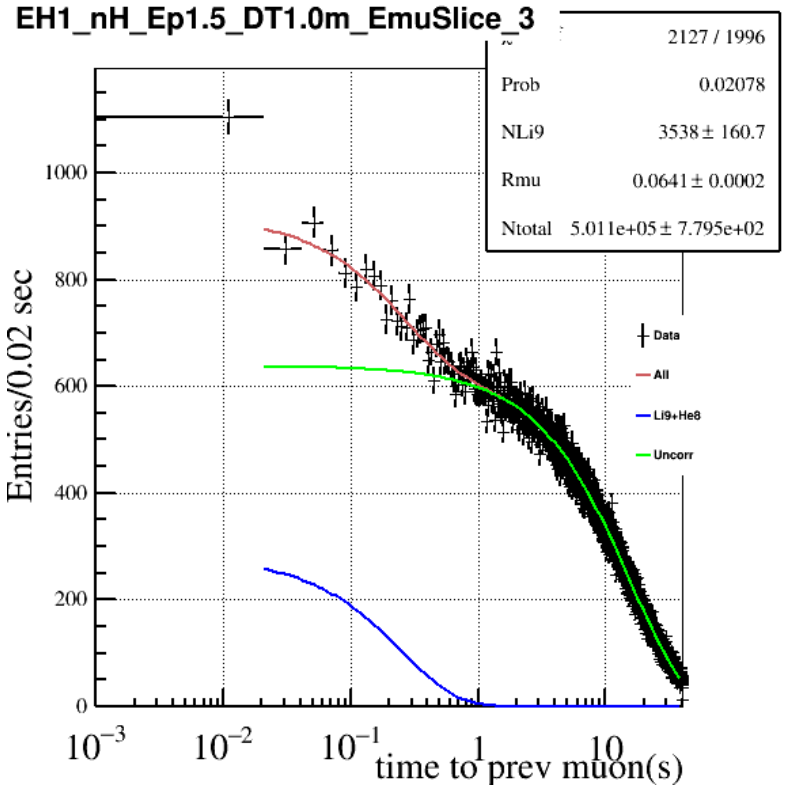
Degradation performance of water pool PMT

Li9/He8 Estimation

Time to previous μ distributions of IBD and Li/He are different.

$$f(t) = N_{^9Li+^8He}\left[r \cdot \lambda_{^9Li} \cdot e^{-t\lambda_{^9Li}} + (1-r) \cdot \lambda_{^8He} \cdot e^{-t\lambda_{^8He}}\right] + N_{IBD\ cand} \cdot R_\mu \cdot e^{-tR_\mu}$$

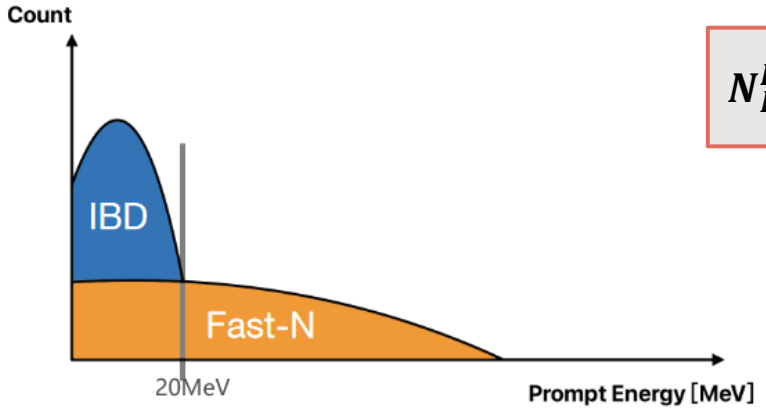
- $N_{^9Li+^8He}$ is the number of ^9Li and ^8He event



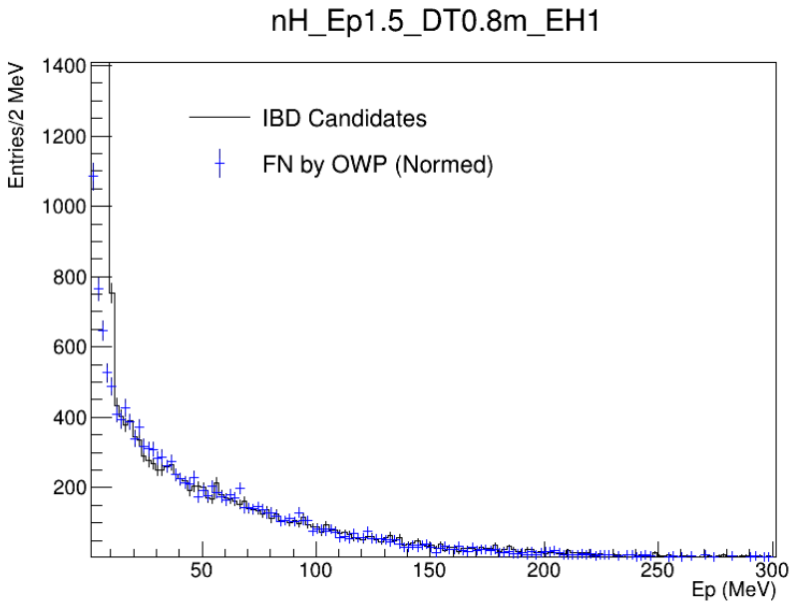
Fast-N Estimation

1. **Extended IBD sample**
   - LE: 1.5-12MeV, IBD + Fast-N
   - HE: >12 MeV, pure Fast-N
2. **OWP Fast-N sample**
   - LE: pure Fast-N
   - HE: pure Fast-N

(normalized by Extended IBD sample HE)



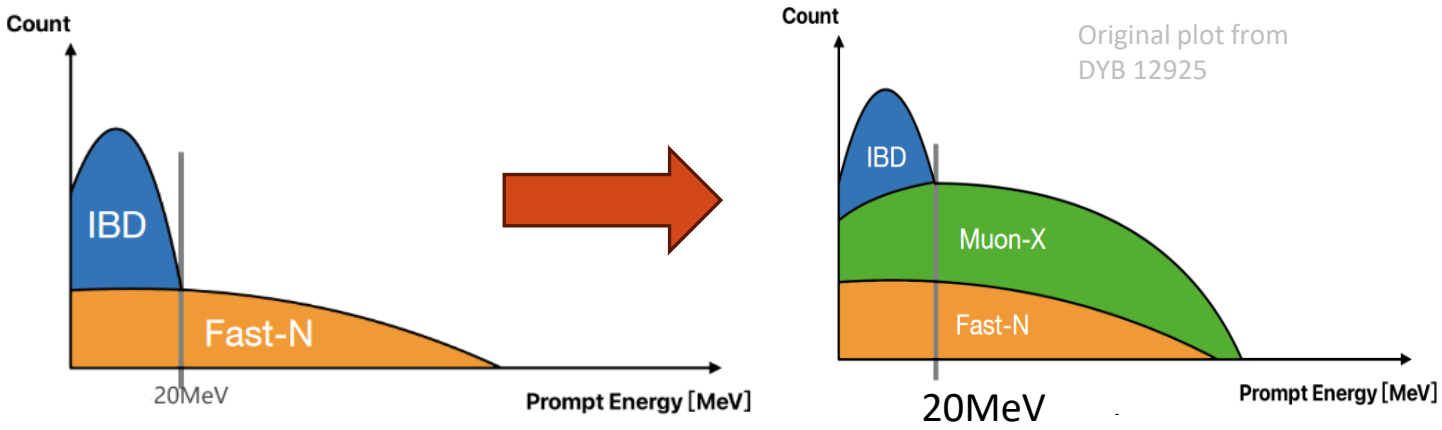
$$N_{FastN}^{LE} = N_{OWP\_LE} \times \frac{N_{IBD\_FN}^{HE}}{N_{OWP\_FN}^{HE}}$$

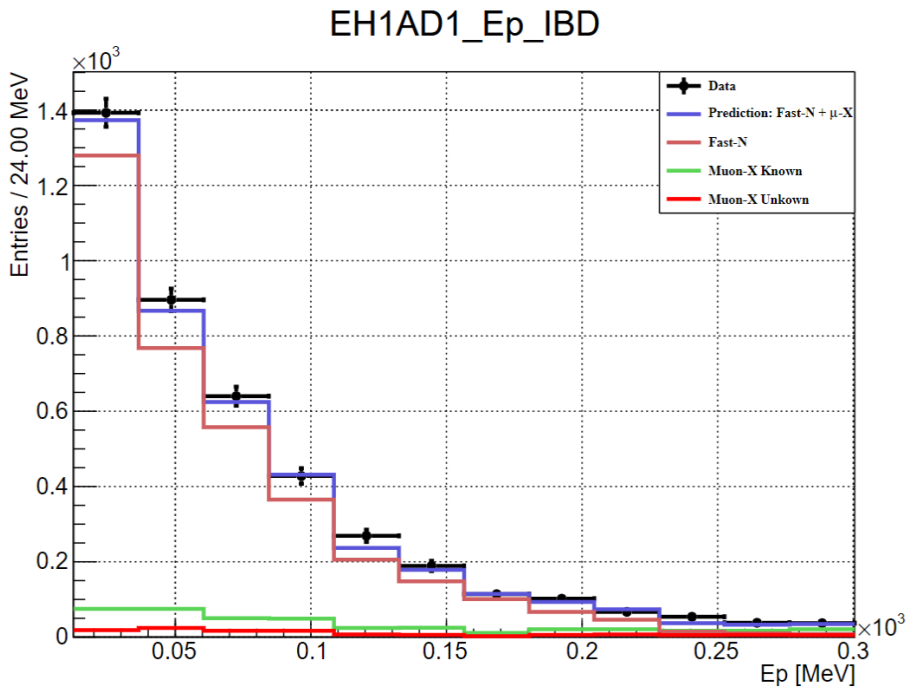


Muon-X Estimation

Looser muon selection criteria to select samples:

1. **OWS2 sample**
   - $nHit > 15 \rightarrow [8\ or\ 9,15]$
2. **IWS sample**
   - $nHit > 12 \rightarrow [7,12]$





Summary

1. Introduced the background estimation of Li9/He8 and Fast-N & Muon-X

2. P17B (1958 days data) nH results can be found in arXiv:2406.01007v1

3. Full Dataset nH results are nearly finished.

Thanks!

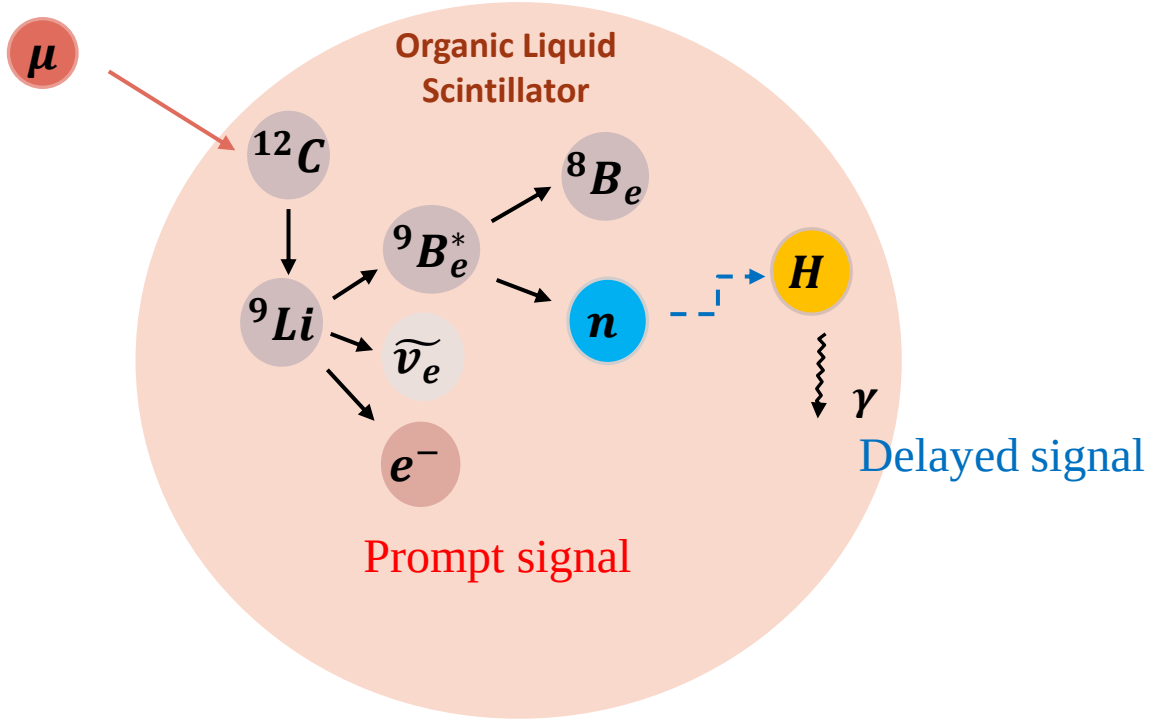
Backup

Li9/He8 Background

- $^{9}Li \xrightarrow{49.5\%} {}^{9}B_e^* + e^- + \bar{\nu}_e, \begin{cases} {}^{9}B_e^* \rightarrow {}^{8}B_e + n \\ {}^{9}B_e^* \rightarrow {}^{5}H_e + \alpha, {}^{5}H_e \rightarrow \alpha + n \end{cases}$
- $^{8}H_e \xrightarrow{16.1\%} {}^{8}L_i + e^- + \bar{\nu}_e, \begin{cases} {}^{8}L_i \rightarrow {}^{7}L_i + n \\ {}^{8}L_i \rightarrow {}^{6}L_i + 2n \\ {}^{8}L_i \rightarrow {}^{4}H_e + {}^{3}H + n \end{cases}$

Prompt signal

Delayed signal



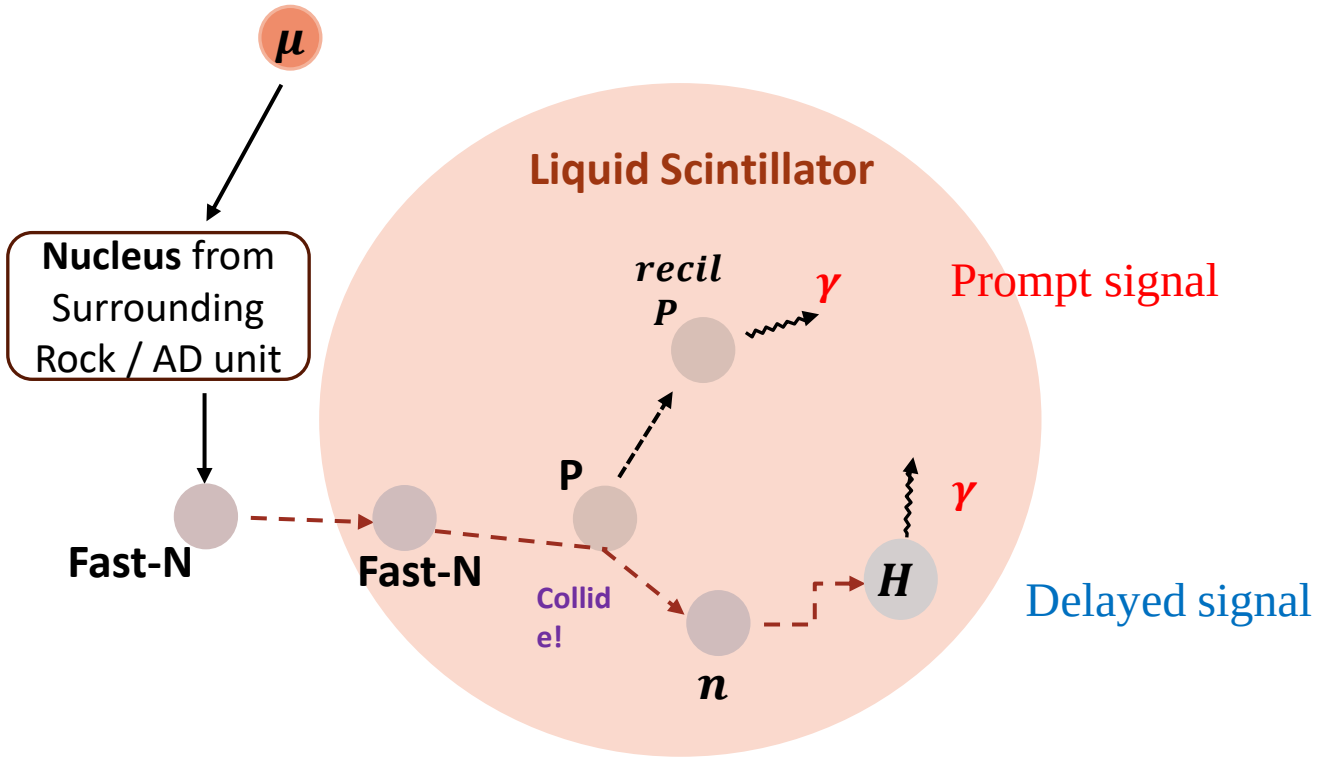
- $\tau_{^{9}Li} = 2.572 \times 10^5 \mu s$
- $\tau_{^{8}He} = 1.717 \times 10^5 \mu s$

$>$ μ_{AD} veto window $= 800 \mu s$

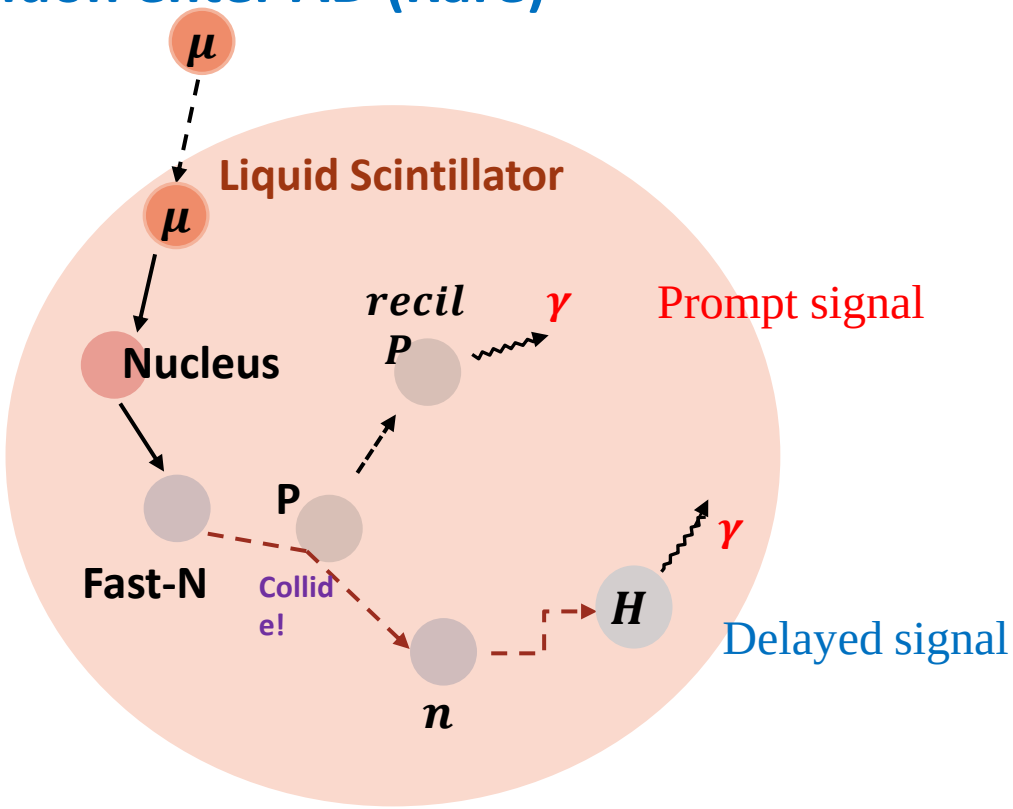
Not vetoed by Muon veto cut!

Fast-N Background

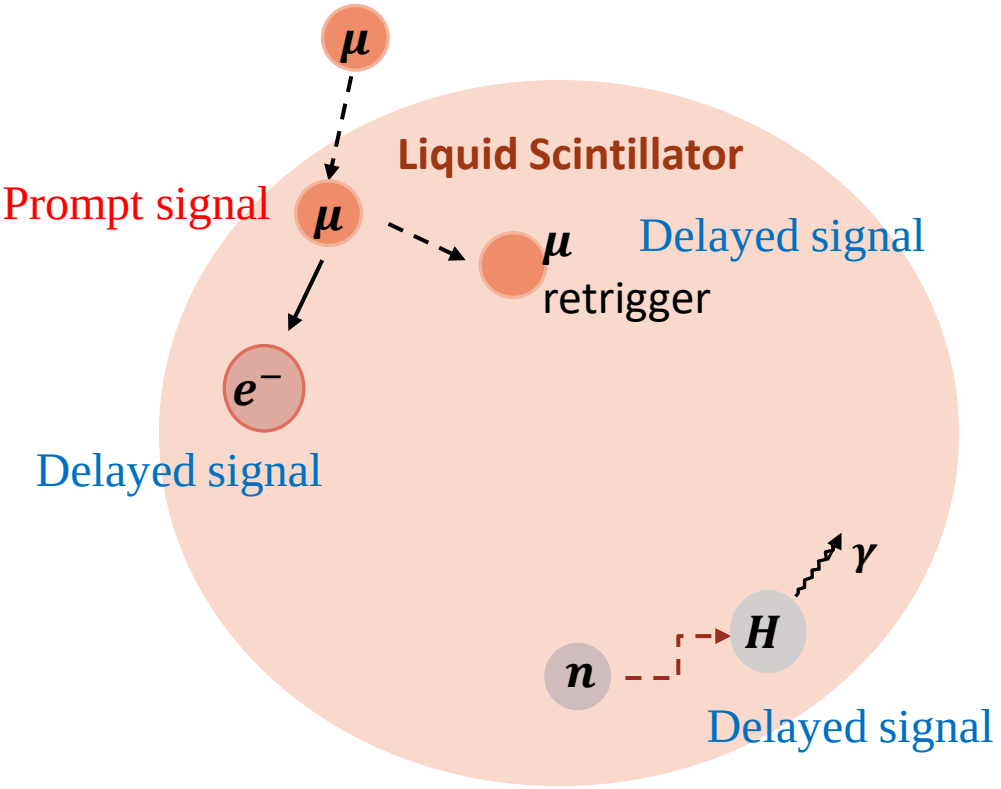
- **Muon not enter AD (Dominant)**



- **Muon enter AD (Rare)**



Muon-X Background



- Since 7AD period (2017-02-03), more μ can enter AD because of the degradation performance of water pool PMT

Prompt signal:

1. Escape vetoed Muon

Delayed signal (possible cases):

1. Muon retrigger
2. Micheal electron
3. Spallation neutron capture on Hydrogen