IBD selection and backgrounds in JUNO

**Mingyuan Wang** on behalf of **JUNO** Collaboration

Institute of High Energy Physics, CAS

mywang@ihep.ac.cn

Introduction

The Jiangmen Underground Neutrino Observatory (JUNO)

- Neutrino source

  Mainly reactor neutrino $\bar{\nu}_e$

  $\bar{\nu}_e + p \rightarrow e^+ + n$ (**Inverse beta decay**)

- Target substance

  20 kt liquid scintillator
  35.4-m-diameter sphere

- Physical goals

  - Neutrino mass ordering
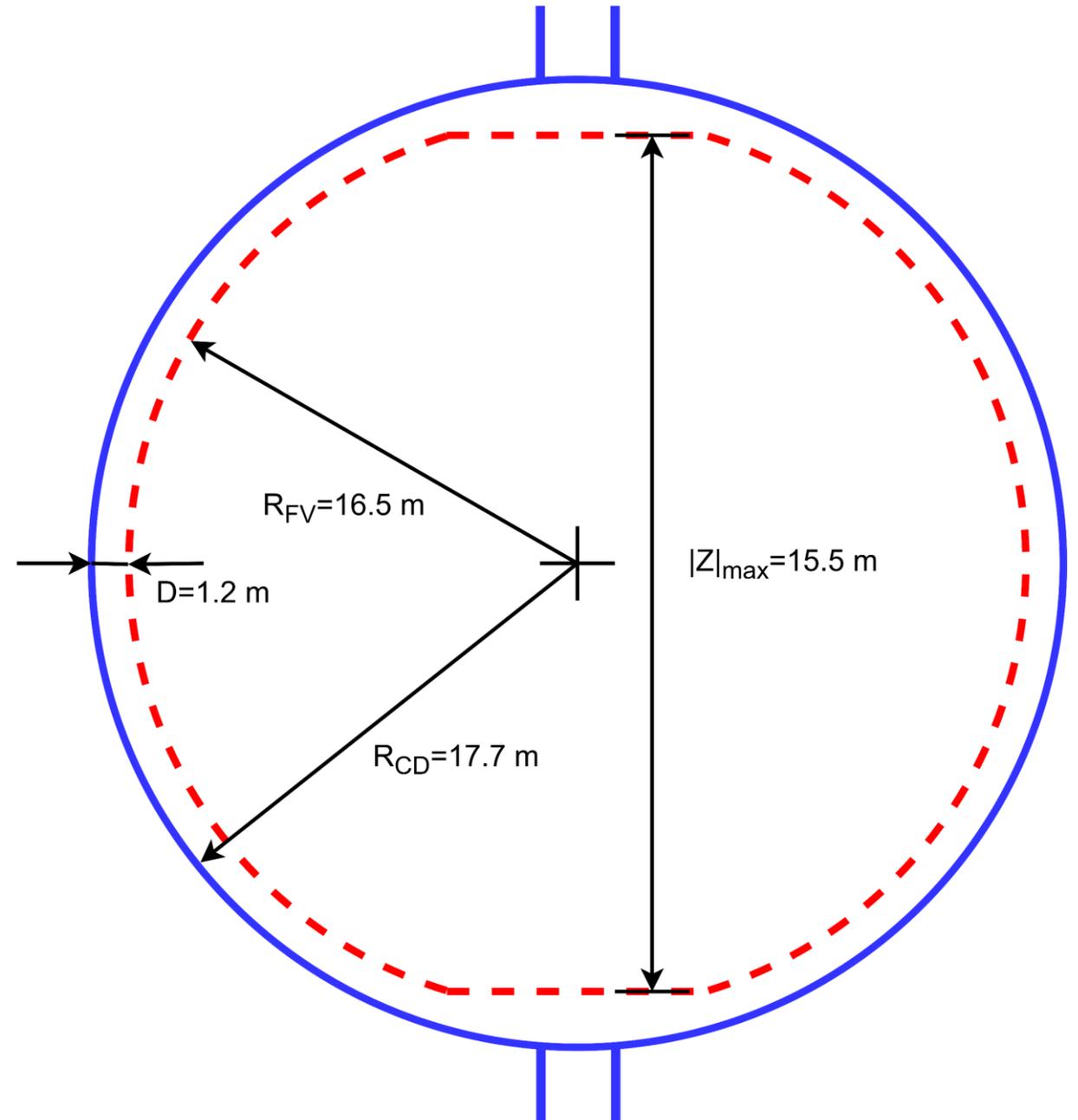 - Oscillation parameters
  - Other physics such as supernova neutrino
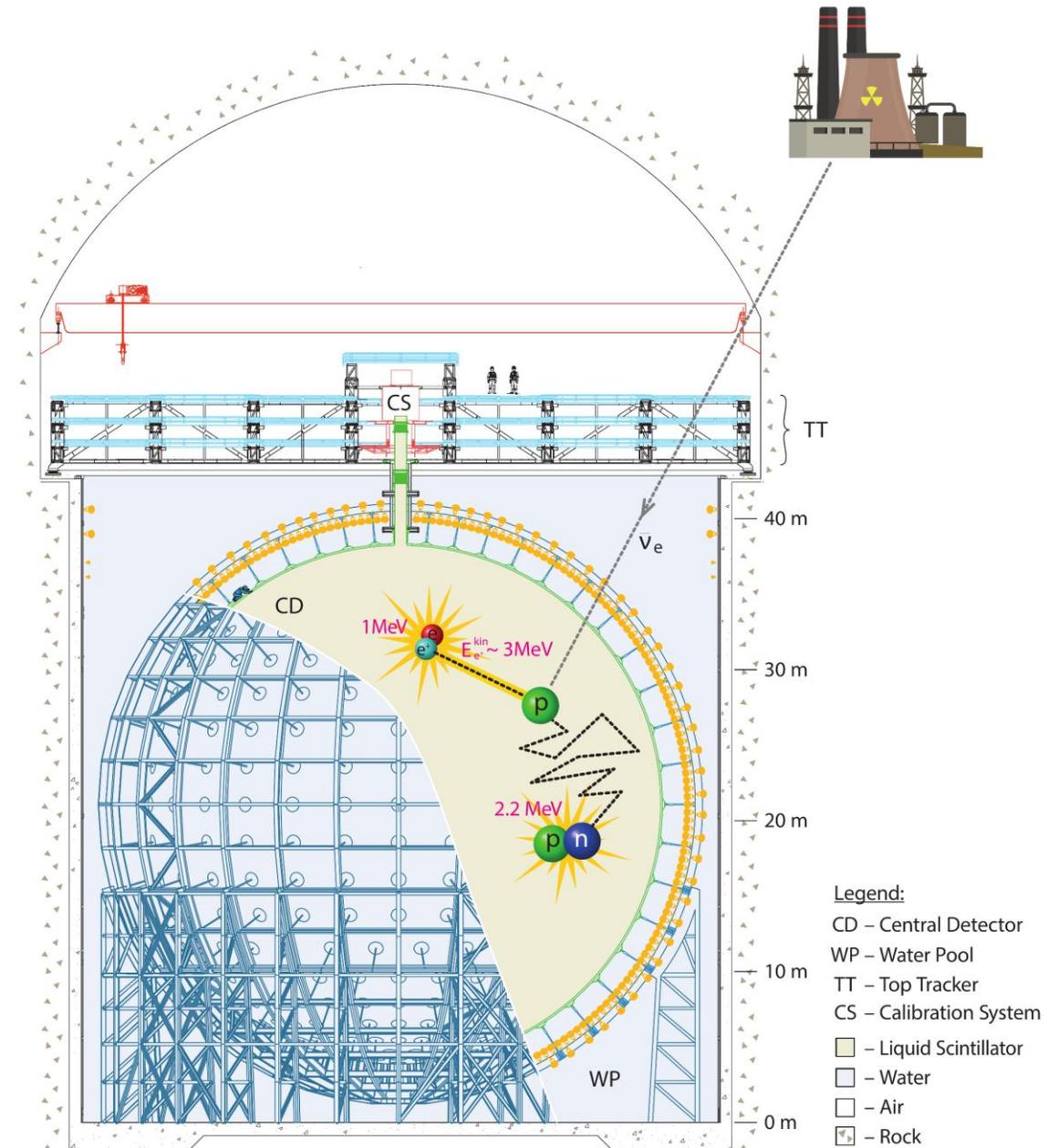
IBD selection strategy

1. ## Fiducial volume (FV)
   - Exclude signals beyond the FV
   - Suppress edge effects
     - Reject most of the external background
     - Better reconstruction performance
   - More subtle energy leakage

   - Efficiency ~**80.6**%

2. Veto

3. Pairing and multiplicity cut

$R_{FV}=16.5$ m

$D=1.2$ m

$R_{CD}=17.7$ m

$|Z|_{max}=15.5$ m

IBD selection strategy
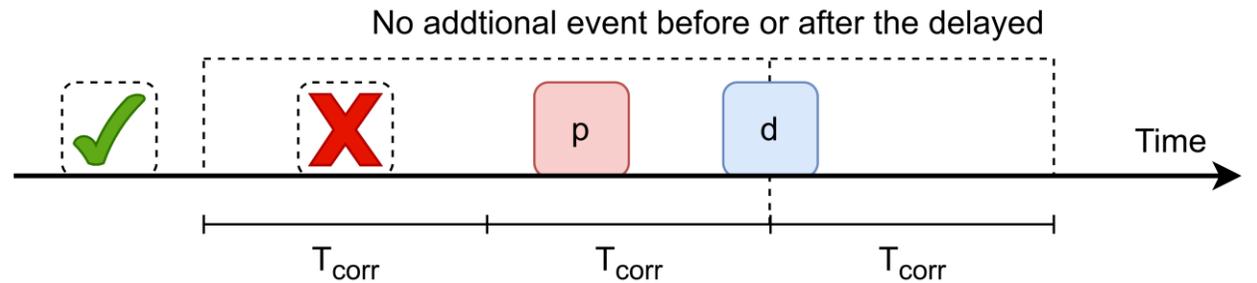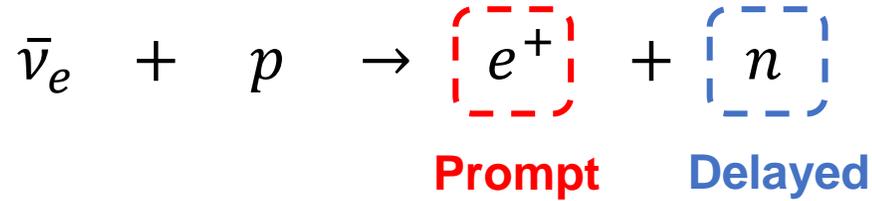
1. Fiducial volume

2. Veto

    1. Muon veto (5 ms)

       Remove muon-induced secondary particles

       Remove afterpulses

    2. Spallation neutron veto (4 m, 1.2 s)

       Veto long-lived cosmogenic isotopes

       (eg. ^{9}Li/^{8}He)

    - Livetime & Geometric Efficiency $\sim\mathbf{93.6}\%$

3. Pairing and multiplicity cut

Muon veto
full detector, 5 ms

R=4 m

Neutron
capture

Possible
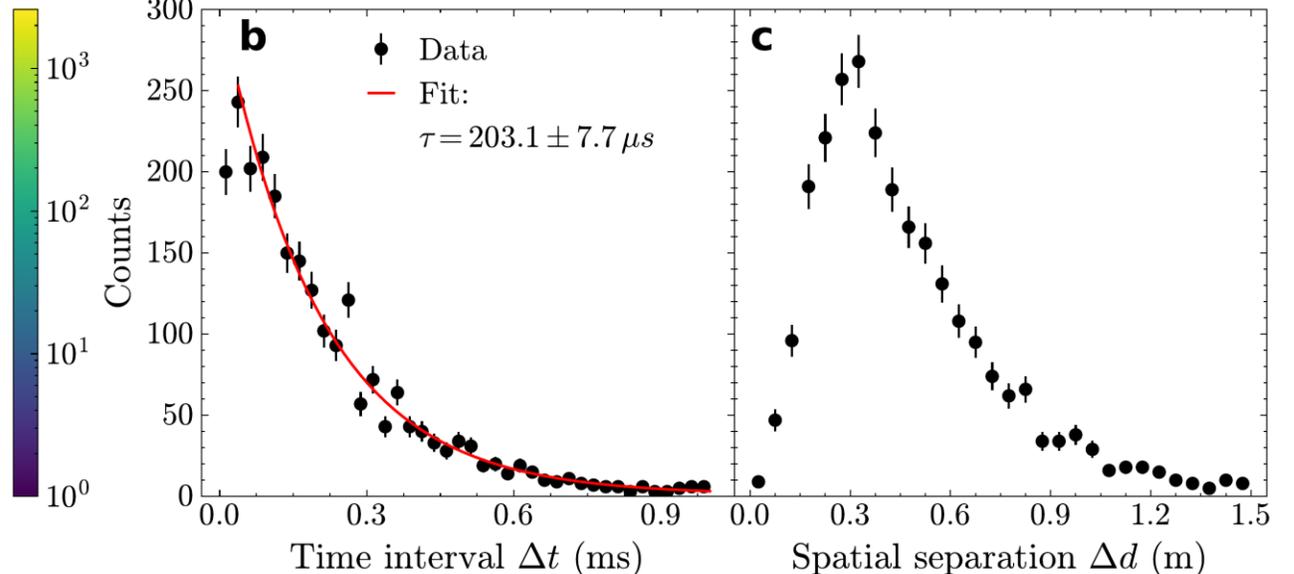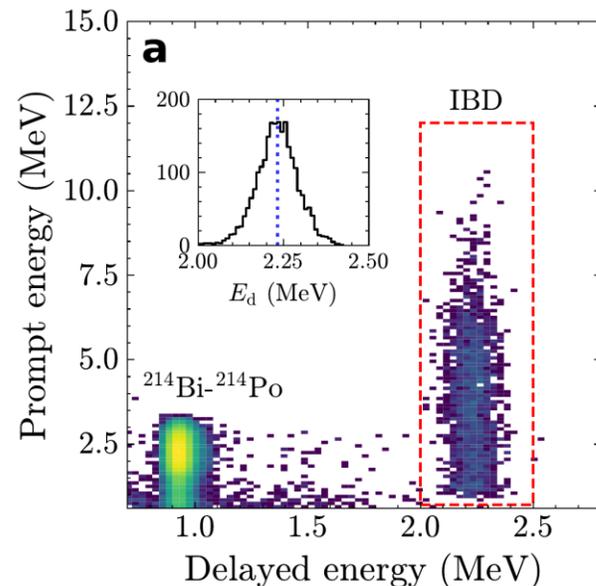isotopes

Spallation neutron veto
4 m, 1.2 s

Muon
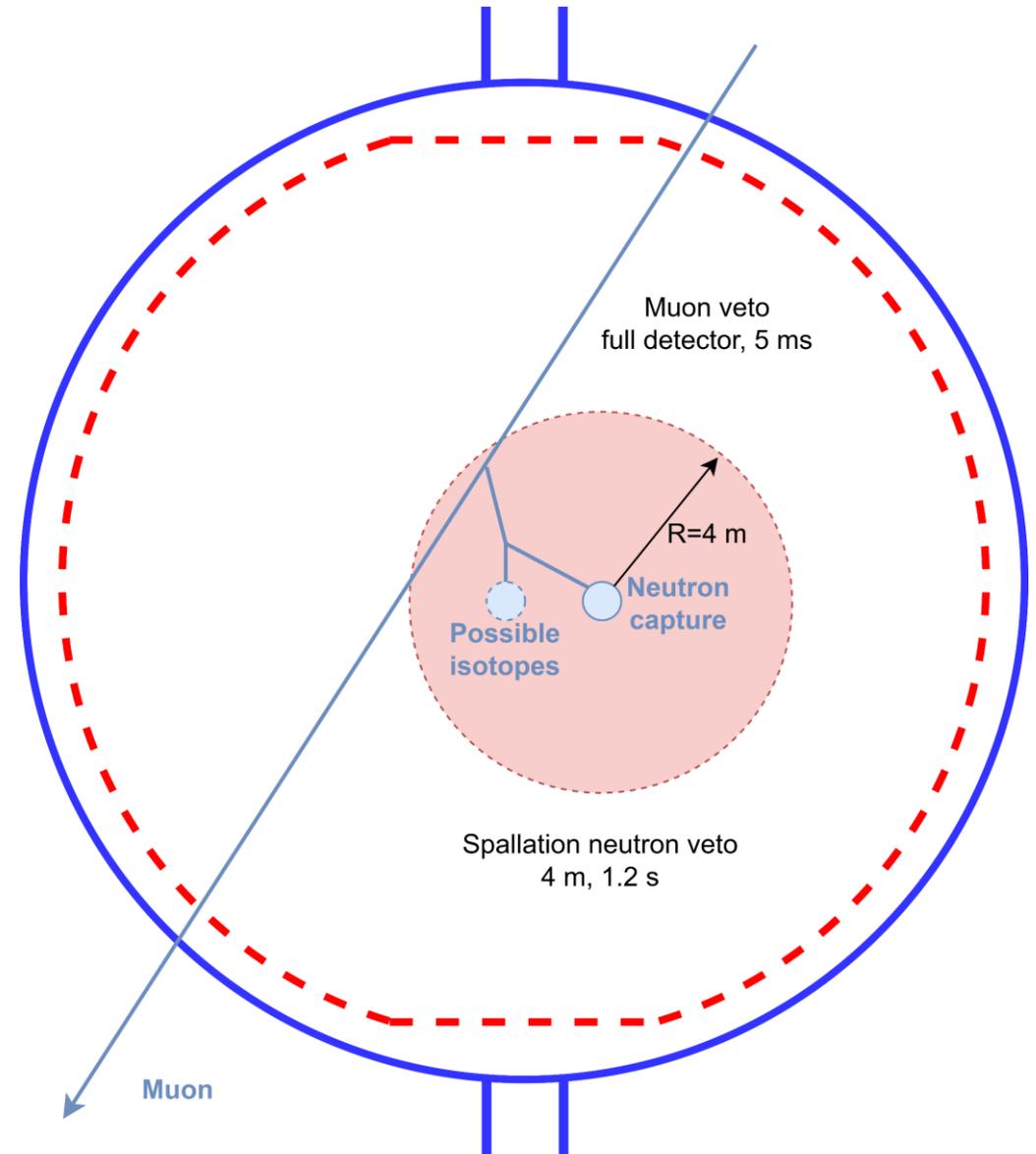
IBD selection strategy

1. Fiducial volume
2. Veto
3. Pairing and multiplicity cut
   - Exclude single events
   - Improve SNR
   - Efficiency ~$95.1\% \times 97.4\%$

**Strategy**

$$\bar{\nu}_e \quad + \quad p \quad \rightarrow \quad \boxed{e^+} \quad + \quad \boxed{n}$$

Prompt   **Delayed**

No addtional event before or after the delayed

T_{corr} T_{corr} T_{corr} Time

Result

Fit: $\tau = 203.1 \pm 7.7\,\mu s$

Residual backgrounds

1. Cosmogenic isotope ^{9}Li/^{8}He
   - The most important background in current analysis, $\sim\mathbf{4.4\ cpd}$
   - Suppressed by **spallation neutron veto**
   - Will be further suppressed by a track-based veto around reconstructed muon trajectories

$$^{9}\text{Li} \rightarrow {}^{9}\text{Be}^{*} + e^{-} + \bar{\nu}$$
$$\hookrightarrow n + \alpha + \alpha$$

Delayed   **Prompt**
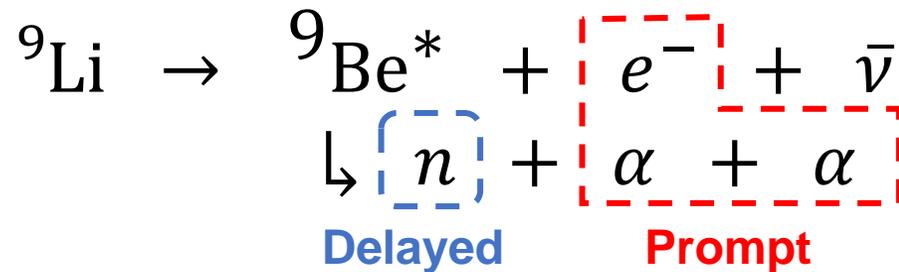
2. $^{214}\text{Bi} - {}^{214}\text{Po}$ related
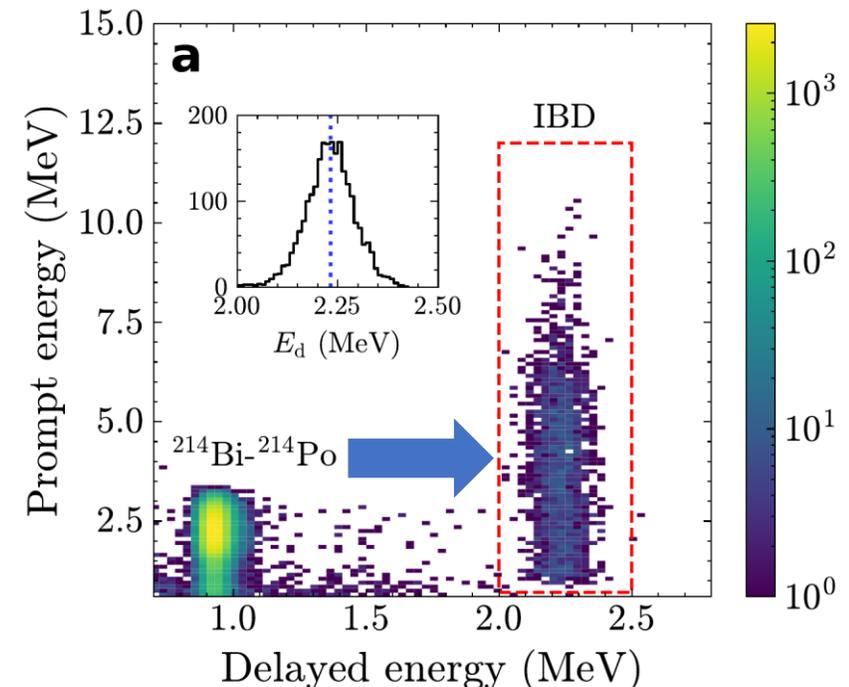
3. ......
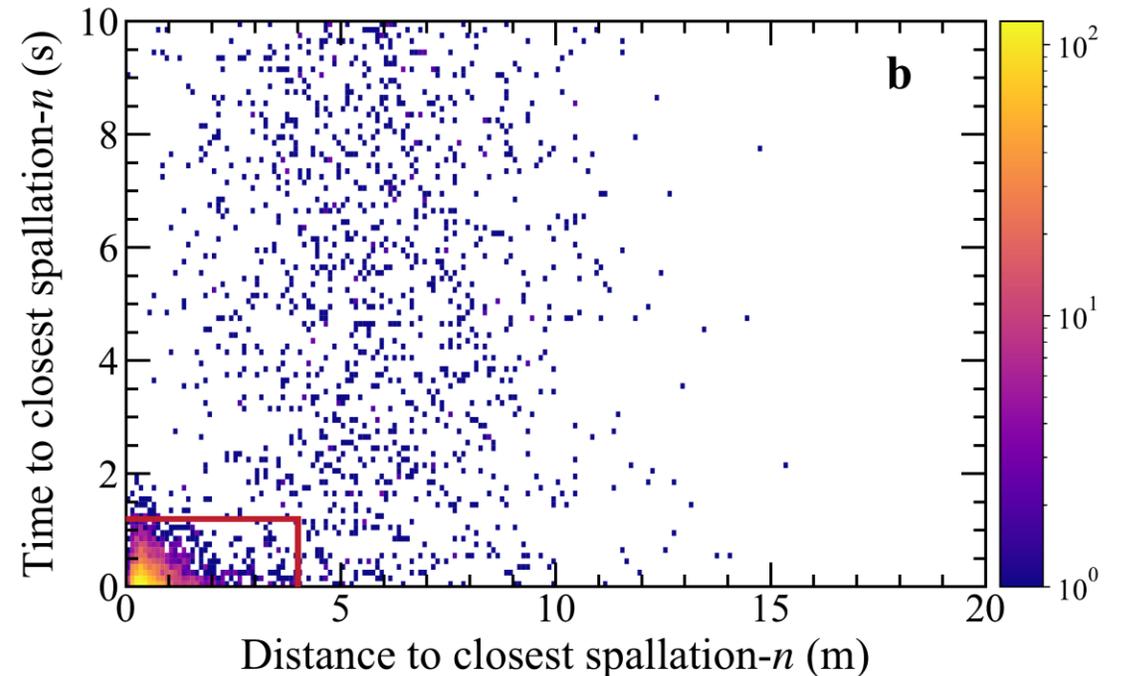
Residual backgrounds

1. Cosmogenic isotope

2. $^{214}Bi - ^{214}Po$ related

   - Energy region typically differs from IBD candidates
   - Alpha long tail in LS, caused by $\alpha-p$ scattering, elevating the visible energy into the delayed signal window with probability $\sim 10^{-4}$
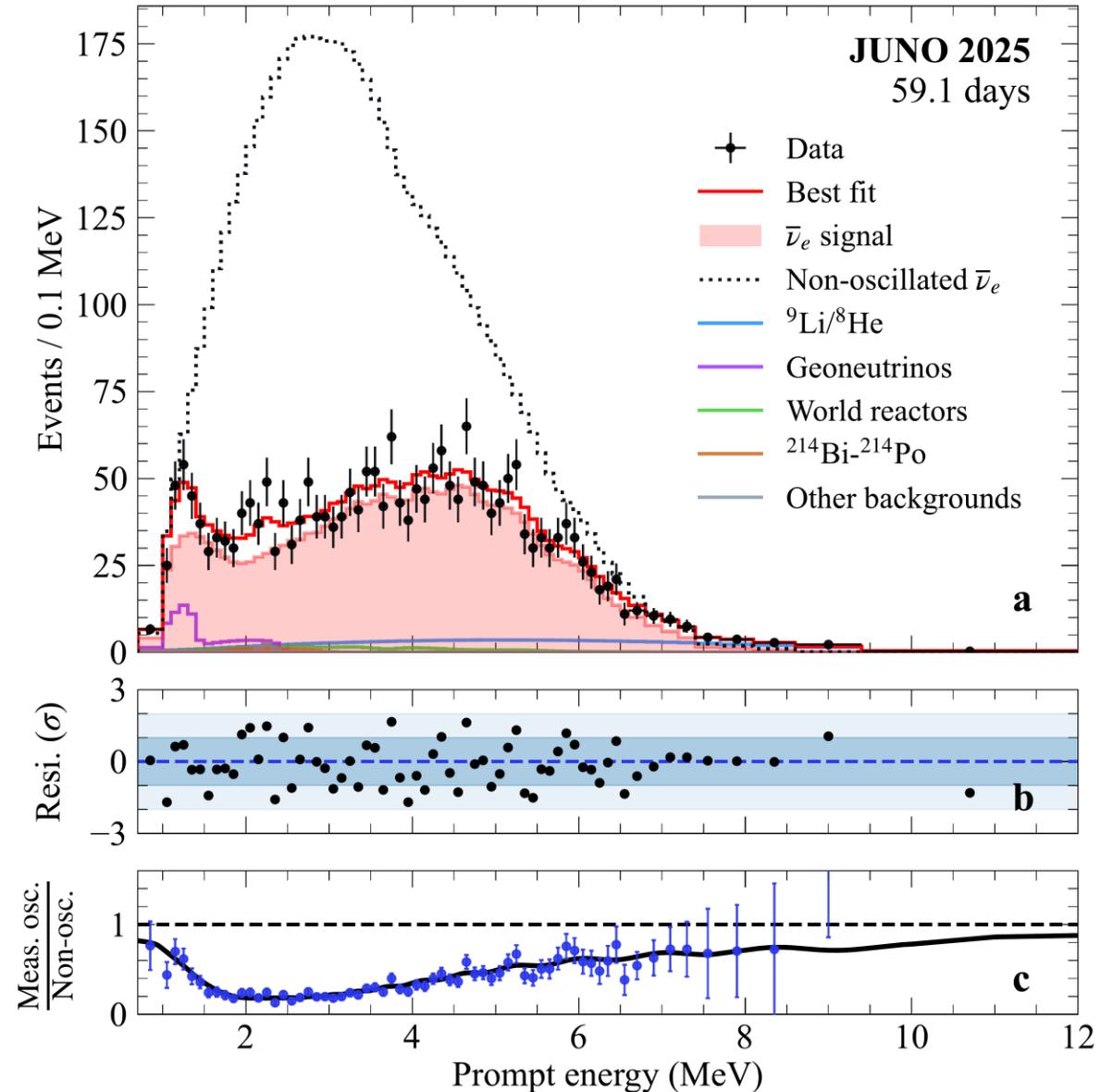
   - Rate ~ 0.18 cpd in **JUNO**
   - Also reported by **SNO+**

3. ……

Summary

- In the first measurement of reactor neutrino oscillations at JUNO, the overall selection efficiency is **69.9 ± 1.6%**

- **Fiducial volume**
  - Largest source of efficiency loss
  - Dominant to efficiency uncertainty
  - Will be improved by better vertex reconstruction

- Cosmogenic isotope $^9Li/^8He$
  - Primary background
  - Can be further suppressed by improved muon reconstruction

Thanks!