Improving Two-Neutron Detection Efficiency on the NEBULA Detector using XGBoost Algorithm

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（On behalf of SAMURAI18 collaboration）

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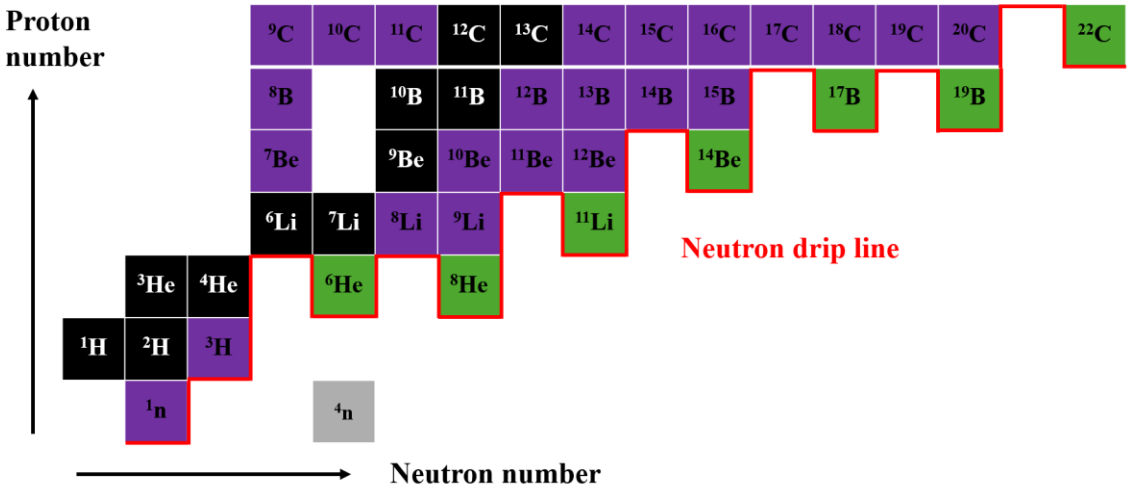
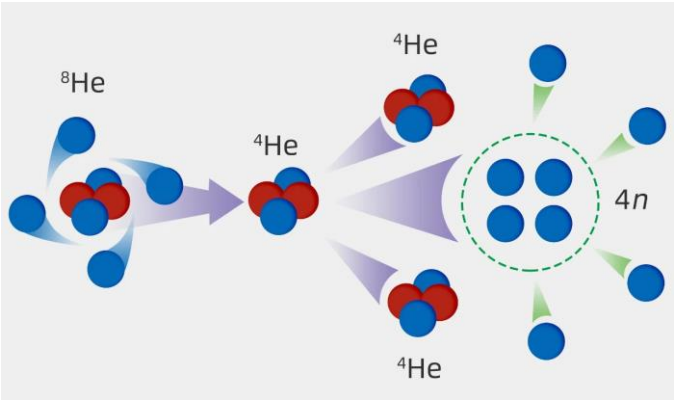
Background: multi-neutron detection is very important in nuclear physics

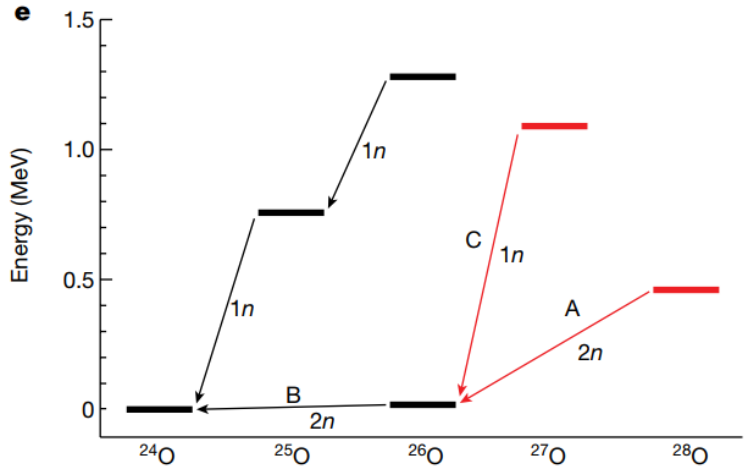


- In the field of nuclear physics, **multi-neutron detection** plays a critical role in revealing specific nuclear properties around neutron drip line
  - Neutron drip line: The boundary beyond which atomic nuclei are unbound
  - Invariant method: All decay products are required
  - Multi-neutron decay: Many drip line nuclei or resonances have more than one decay neutron

➢ **Four-neutron resonance states [1]**



➢ **First observation of ^{28}O [2]**

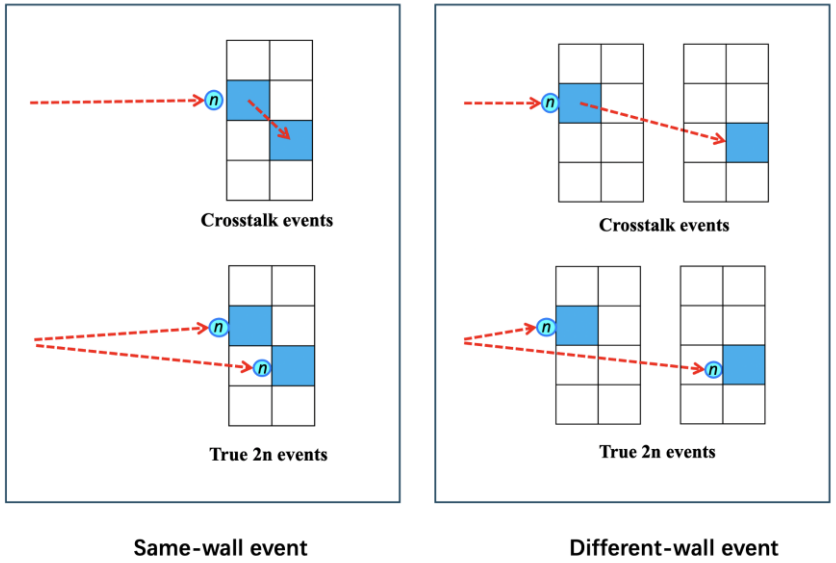


1) Duer, M., Aumann, T. et al. Nature 606, 678–682 (2022).
2) Kondo, Y., Achouri et al. Nature 620, 965–970 (2023).

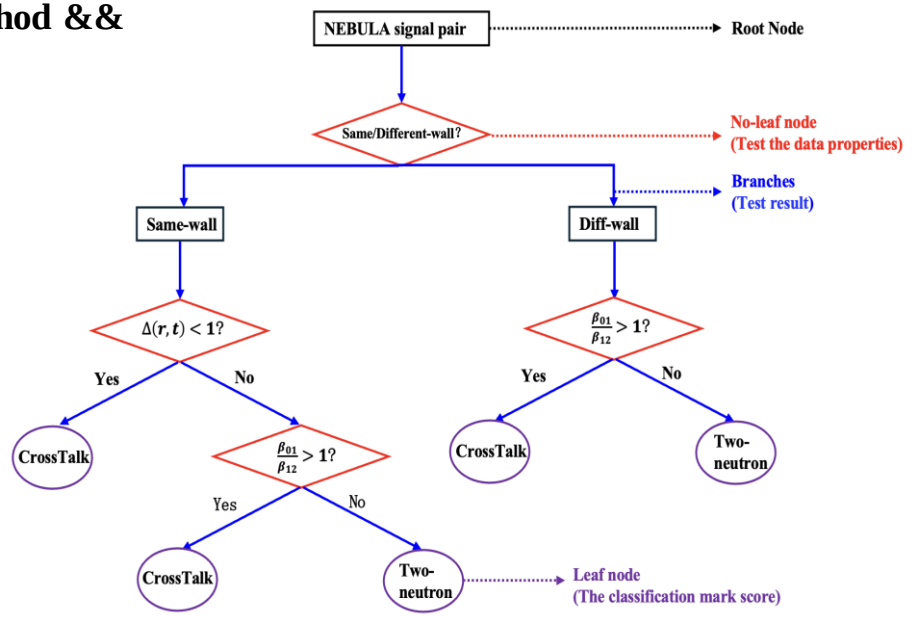
CrossTalk events and XGBoost method

➢ CrossTalk events

- Space-time separation
- Causality condition

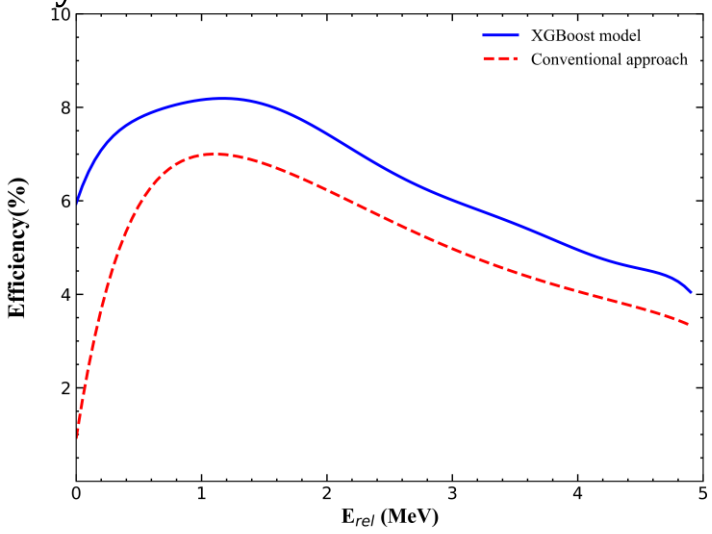


➢ Conventional method && Decision tree



➢ Two-neutron Efficiency curve

- Within a smaller relative energy range, the detection efficiency for two-neutron is significantly improved.
- This performance is very helpful for enhancing the detection of multi neutrons.



➢ Different numbers of features

- Using the same number of features as conventional methods, XGBoost methods do not have obvious advantages.
- After adding other features including relative energy, XGBoost demonstrates its ability to classify in high-dimensional spaces..