

Machine Learning Method on Reactor IBD Selection

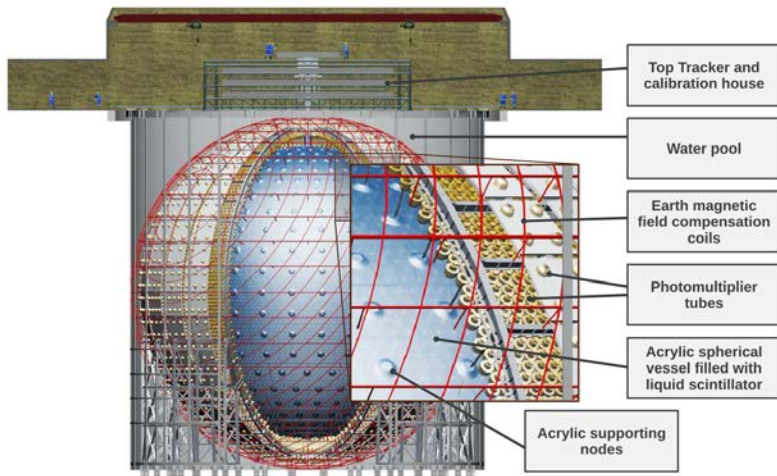
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第十四届全国粒子物理学术会议

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Motivation



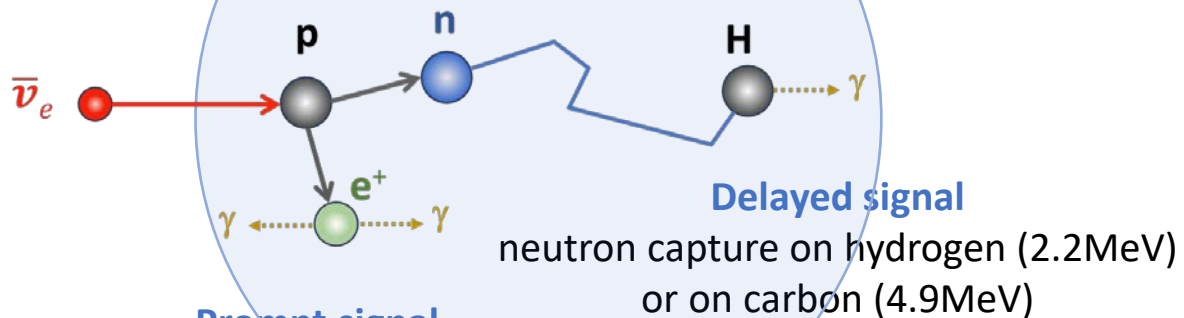
The Jiangmen Underground Neutrino Observatory (JUNO)

- 20 kt liquid scintillator target
- Energy resolution $< 3\%$ @ 1 MeV
- To measure neutrino oscillation parameters to sub-percent precision
- To determine the **neutrino mass ordering** (sign of Δm^2_{32}) independently of the CP phase δ and the θ_{23} octant

IBD selection

Correlated IBD signal suppress uncorrelated background, but still some background can mimic IBD signal.

Inverse beta decay (IBD) reaction:



Prompt signal

two annihilation photons ($2 \times 0.511\text{MeV}$) + deposited kinetic energy

why Machine Learning to do IBD selection?

- In traditional way, multiplicity cut requires neither event in or near IBD pair, which resulting in IBD signal lost.
- In traditional way, box cut criteria cause some IBD pair be discarded

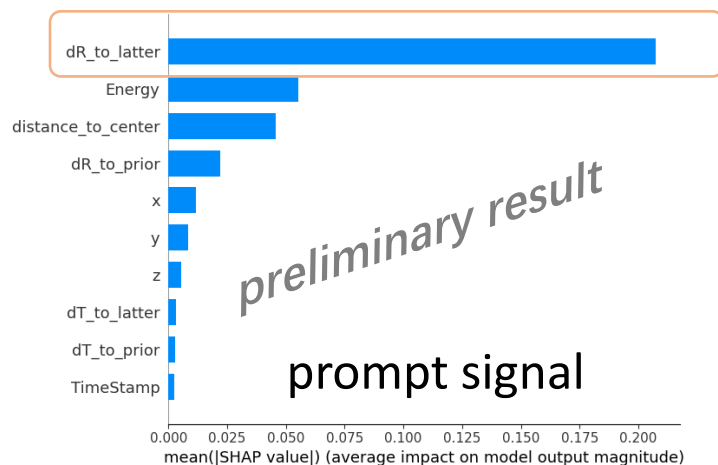
Method

Try **RNN** method to select IBD signal from accidentals background

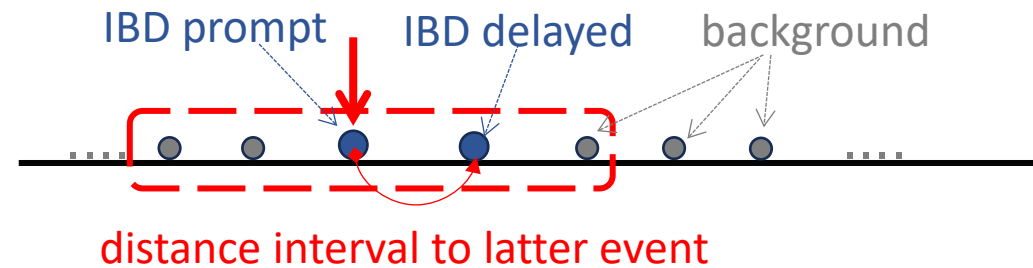
every event has

- **10 parameters:** vertex (x, y, z) , $r, t, E, (\Delta r, \Delta t)$ of current event and adjacent previous and following event
- **a tag:** prompt signal of IBD, delayed signal of IBD, radioactive element (triple classification)

◆ To understand how parameters influence the event classification, and which parameters are more important in classification, the **SHAP** method is used



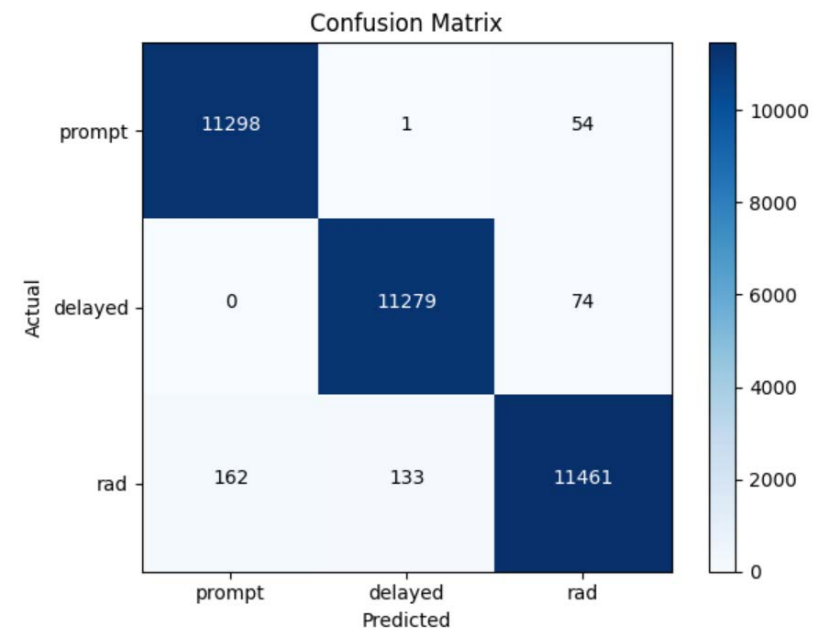
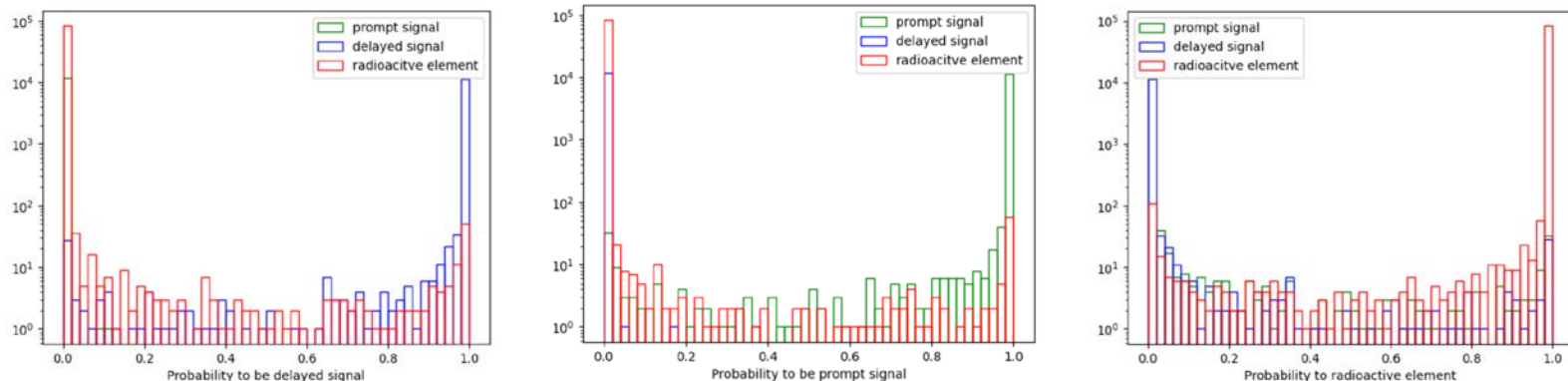
Take prompt signal class as an example.



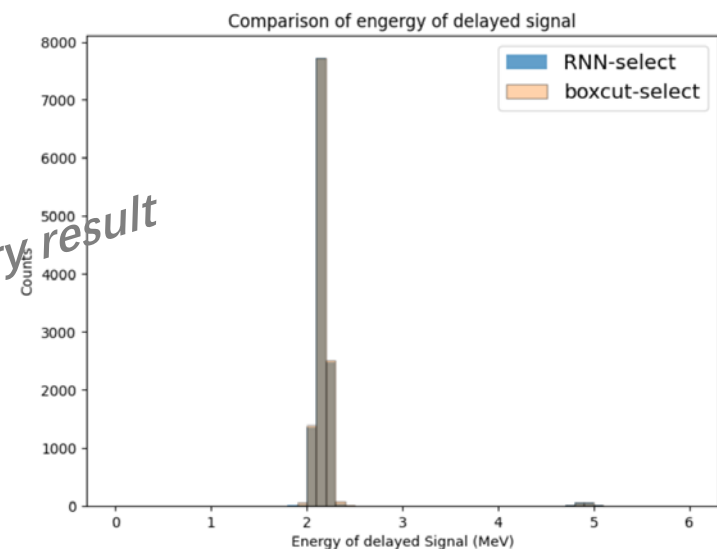
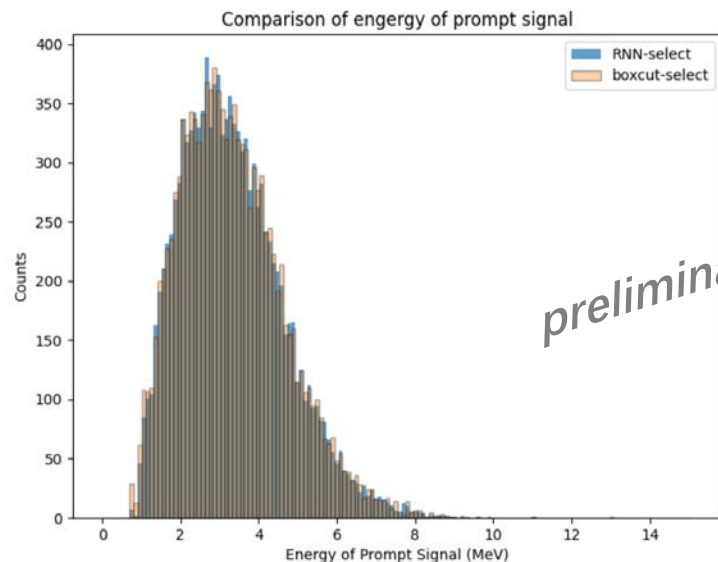
Distance interval is the most decisive parameter

Result

use ~ 250-day-time data as testing dataset



The selection result from two different methods (traditional method VS RNN method) can be compared event by event



preliminary result

Conclusion

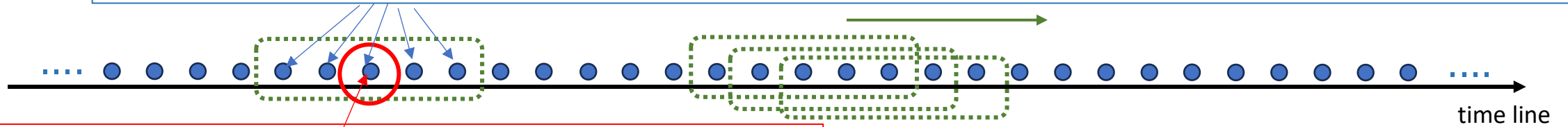
- RNN is well trained and is comparable with traditional IBD selection method
- RNN can help reserve more IBD signals.
- SHAP method helps to understand how parameters influence classification in RNN

Thanks for your attention!

back up

RNN (recurrent neural networks) structure:

every event still has 10 parameters (vertex (x, y, z) , r , t , E , $(\Delta r, \Delta t)$) of current event and adjacent previous and following event) to describe its energy, vertex, timestamp and its relationship with adjacent events



the event **in the center of sequence has a tag**, (prompt signal of IBD, delayed signal of IBD, radioactive element)