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The WASA-FRS hypernuclear experiment and developments of machine learning analyses with graph neural network

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The WASA-FRS hypernuclear experiment has been performed at GSI in 2022 for measuring the lifetimes of hypertriton and ${}^{4}_{\Lambda}\mathrm{H}$ and for confirming whether or not a neutral charged bound state of a Λ hyperon and two neutrons, $nn\Lambda$, can exist. Hypernuclei of interest were produced by the induced reaction with ${}^{6}\mathrm{Li}$ and ${}^{12}\mathrm{C}$ projectiles at $1.96\,A\,\mathrm{GeV}$ on a fixed diamond target with a thickness of $9.87\,\mathrm{g/cm^2}$. Produced hypernuclei are identified by reconstructing invariant mass with detection of π^- by the WASA detector and of residual nuclei by the FRS. Their lifetimes are measured from their decay lengths and kinematics.

Since induced reactions of heavy-ion beams produce a large number of particles in the forward direction, which induce large combinatorial background, track finding in the WASA detector is one of key issues in this experiment. To overcome this difficulty, we have developed a track finding algorithm with machine learning techniques employing the graph neural network (GNN) by using data with Monte Carlo simulations. It is a powerful neural network model for deducing the connection between data nodes. Additionally, analyses with the GNN demonstrate an ability to estimate the momentum and charge of particles from the given track associations.

The current status of the analysis of the WASA-FRS hypernuclear experiment and the developments of the GNN analyses will be discussed.

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