# Validation of the GNN tracking at Belle II

Jonas Lotz
*University of Bonn*

A novel end-to-end multi-track reconstruction algorithm based on a graph neural network (GNN) architecture was developed for the Belle II collaboration [1]. That work demonstrates substantial improvements in key performance metrics such as tracking efficiency, with particularly strong gains for tracks originating from displaced vertices. In addition, different hit-to-track association provides an opportunity for improved event clean-up, which may be particularly useful for missing-energy decays. In this presentation, building on this development, the applicability of this GNN-based tracking algorithm in the context of searches for $B^0 \to K^0_S \nu\bar{\nu}$ decays is studied. I focus on validating the algorithm against established tracking methods and assessing potential benefits for rare decay searches.

I compare four track-finder configurations across five beam-background conditions, ranging from no background to five times the nominal rate at the target luminosity, with every configuration run on the same simulated events. Performance is assessed both per track and along the full analysis selection.

The track-finding gain grows with increasing beam background, at the cost of a roughly doubled clone rate. Propagated through the complete selection, however, this gain does not reach the physics result, but is lost at $K^0_S$ selection. Restricted to candidates built from the same true pions in both configurations, the GNN reconstructs them from fewer CDC hits, with a correspondingly poorer $K^0_S$ vertex fit.

Finally I discuss the implications for the analysis and for the training of the finder.

## References

[1] L. Reuter *et al.*, *End-to-End Multi-track Reconstruction Using Graph Neural Networks at Belle II*, Comput. Softw. Big Sci. **9**, 6 (2025), arXiv:2411.13596, doi:10.1007/s41781-025-00135-6.