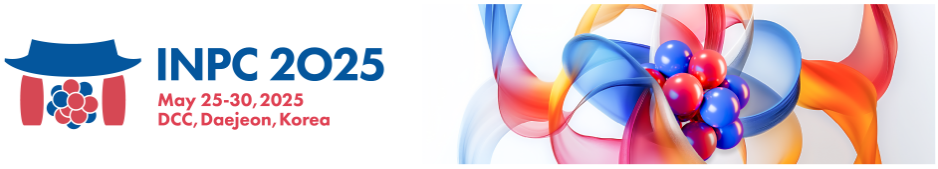

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A foundation model for TPC data

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This work centers on providing a multi-purpose deep learning model for time projection chamber detector systems that can be tuned for various tasks such as event identification, particle or track identification, and regression tasks. Time-projection chambers are used across various subfields of nuclear physics experiments to provide three-dimensional "images"of particle reactions or decays. Foundation models such as the GPT models, BERT, and DALL-E have shown impressive performance in text and image domains. Such models are built through large-scale training on self-supervised tasks. Similarly, we present results of using a point-cloud shuffling task to build our foundation model. To build this initial model, we used data from the $^{16}\mathrm{O} + \alpha$ and $^{16}\mathrm{C} + d$ experiments using the Active-Target Time Projection Chamber (AT-TPC) at the Facility for Rare Isotope Beams at Michigan State University. We then tuned this model on a downstream task of counting the number of reaction products for events in the $^{22}\mathrm{Mg} + \alpha$ experiment, also using the AT-TPC at FRIB. Data from the experiment used for the downstream task was not incorporated into the pretrained foundation model. We show that we can achieve an F1 score of .91 with only 250 labeled training events using our pretrained model, compared to an F1 score of .45 using 250 labeled training events for a model trained from randomly initialized weights. Similarly, we find that more than 2000 labeled events are needed to surpass an F1 score of .9 when training a model from scratch. We discuss current efforts in incorporating more data into our pretrained model and our efforts that build towards our future plans of incorporating data from other TPCs.

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