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Multi-Purpose Machine Learning Models for TPCs

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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. 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. In this talk, I will summarize results from various approaches to build a foundation model for TPCs. To build our initial models, we used data from the Active-Target Time Projection Chamber (AT-TPC) and the GADGET II detector, both at the Facility for Rare Isotope Beams at Michigan State University.

We tuned these models on a suite of downstream tasks such as of counting the number of reaction products for events in the ^{22}Mg $+\alpha$ experiment, also using the AT-TPC at FRIB. For this task, 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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