Proposal

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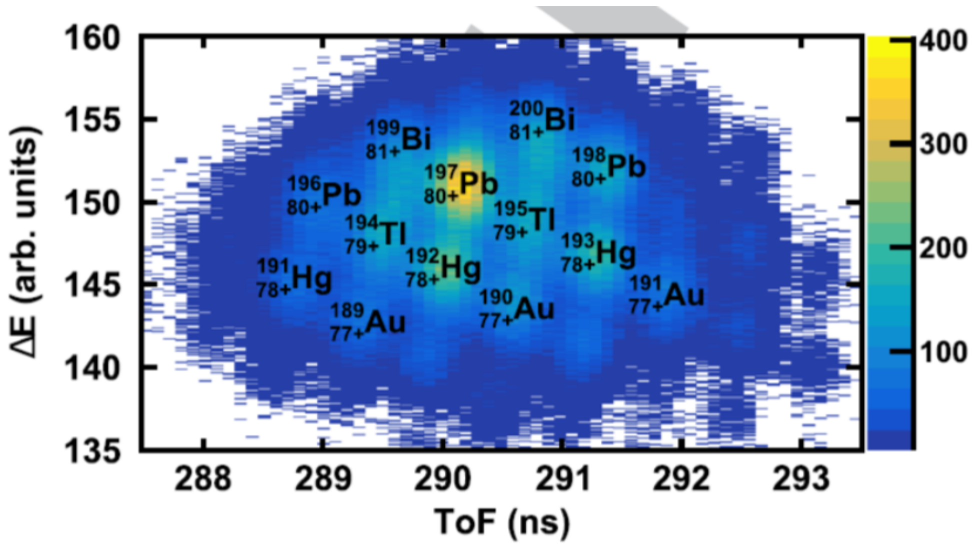
Problem description:

We have an Active-Target Time Projection Chamber (AT-TPC) detector, which consists of a gas chamber (the detector gas is at the same time the target material), a source of magnetic and electric fields, and the pad plane on which particles are detected. The plate consists of 10240 triangular electrodes, which are responsible for particle detection. The composition of the gas is ^{4}He, while the beam itself is made up of radioactive isotopes.Figure 1 shows the beam composition for the data of interest for this project. The beam was created via a fission reaction and sent to the AT-TPC, where it underwent reactions with the ^{4}He gas. This data was collected recently using the AT-TPC at the Facility for Rare Isotope Beams in Michigan, USA.

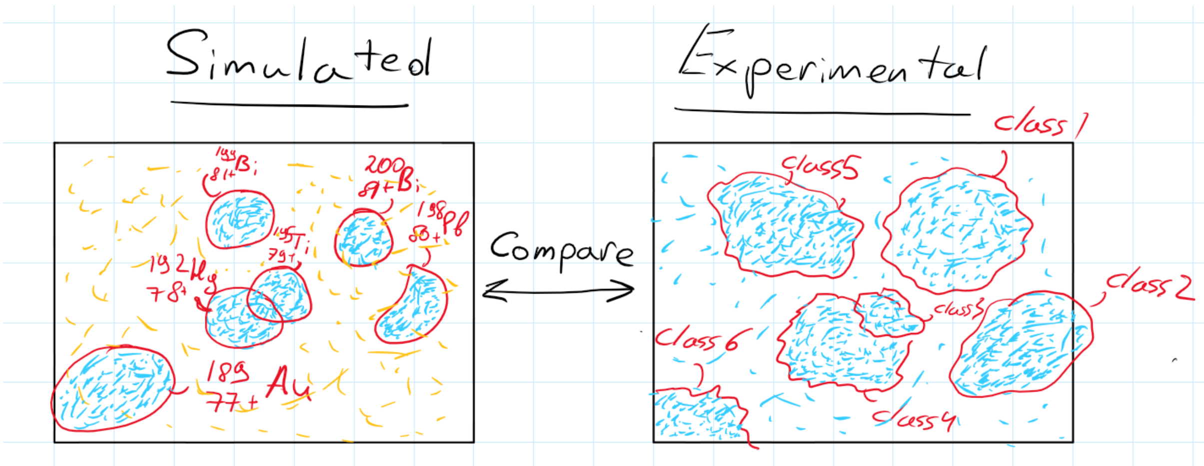


(Fig.1 *The PID plot of secondary beam isotopes*)

The task is to extract information from the data that we receive on the detector, such as information about energy and angles, as well as the classification of events to identify particles (which we have, looking at the composition of the beam, a considerable amount).

Suggested Solution Method:

The first task is to use simulated data that corresponds to the actual experiment, namely: to simulate the flow of radioactive isotopes and its passage through 4He gas, and collides with the target. Thus, we will obtain a certain distribution of initial particles on the target. Next, we start working with our experimental data, namely, we will build a PointNet architecture and train a model to identify events and tracks within the events.. Next, we simply compare the received perturbations from simulation and experiment, and draw conclusions based on this. The figure below demonstrates this approach.



(Fig.2 Schematic representation of simulated data (left) and experimental data after processing with PointNet (right). The yellow dots in the picture on the left are artificially created noise.)

This approach, in its certain variation, has already been used, for example, in the work [1].

Why do I propose to use PointNet in this paper? Because this model can take in a cloud of unordered points, and at the output gives classification of either the entire point cloud or for each point, depending on the details of the architecture.
The PointNet architecture has been shown to successfully classify point cloud objects such as tables and airplanes, and shows promise for this learning task.

Deliverables:

- ***4-th week:*** First event classification on simulated data, using architecture PointNet
- ***8-th week:*** Applying the model to experimental data
- ***12-th week:*** Final implementation and preparation for distribution

TimeLine:

Duration	***Task***
2 weeks	*Become familiar with PointNet and process data*
2 weeks	Modify PointNet for our simulated data and do first event classification
2 weeks	Tune event classification model, modify architecture for track classification
2 weeks	*Tune track classification and apply models to experimental data*
2 weeks	*Tune models for experimental data (may require building noise rejection models)*
2 weeks	*Final implementation and preparation for distribution.*

References

[1] J. Bradt, D. Bazin, F. Abu-Nimeh, T. Ahn, Y. Ayyad, S.B. Novo, L. Carpenter, M. Cortesi, M. Kuchera, W. Lynch, W. Mittig, S. Rost, N. Watwood, J. Yurkon, Commissioning of the active-target time projection chamber, Nucl. Instrum. Methods Phys. Res. A 875 (2017) 65–79

[2] - Machine learning methods for track classification in the AT-TPC M.P. Kuchera a,∗ , R. Ramanujan b , J.Z. Taylor a , R.R. Strauss b , D. Bazin c , J. Bradt c , Ruiming Chen; Nuclear Inst. and Methods in Physics Research, A940 (2019) 156-167

[3] - Unsupervised learning for identifying events in active target experiments R. Solli a,b,∗ , D. Bazin c , M. Hjorth-Jensen c,d , M.P. Kuchera e , R.R. Straussf; Nuclear Inst. and Methods in Physics Research, A 1010 (2021) 165461

[4] - PointNet: Deep Learning on Point Sets for 3D Classification and Segmentation Charles R. Qi Hao Su* Kaichun Mo Leonidas J. Guibas Stanford University (2017)*

[5] - PointNet++: Deep Hierarchical Feature Learning on Point Sets in a Metric Space Charles R. Qi Li Yi Hao Su Leonidas J. Guibas Stanford University (2017)