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Deep Learning Models for Jet Tagging

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Jet tagging, a classification task crucial for new physics searches at the LHC, has been evolved by deep learning. This work presents a comparative study of two state-of-the-art architectures, ParticleNet (a dynamic graph neural network) and Particle Transformer (ParT), which operate on permutation-invariant particle cloud representations of jets. We present a comparative analysis across different model architectures, dataset sizes, and feature subsets to evaluate the impact of these parameter variations on model performance for this classification task. We find that comprehensive feature engineering, incorporating low-level detector information such as track displacement parameters, is the most critical factor, elevating discovery potential by over 300\% for heavy-flavor jets. The model architecture is the second decisive factor; global attention of ParT mechanism yields a significant advantage, increasing the average discovery potential by 60\% over the locally-constrained ParticleNet. The synergy between rich, physics-informed features and powerful, globally-aware architectures is therefore paramount for maximizing scientific reach in high-energy physics.

Author: RIAÑO REYES, Diana Catalina (Universidad Nacional de Colombia)

Co-author: SANDOVAL USME, Carlos (Universidad Nacional de Colombia)

Presenter: RIAÑO REYES, Diana Catalina (Universidad Nacional de Colombia)

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