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Accelerating resonance discovery via signature-oriented pre-training

The search for high-mass resonances is central to the LHC experiments, serving as a direct probe for physics beyond the standard model (SM). As the quest for discovering new resonances intensifies, there has been increasing focus on model-agnostic search strategies. While these methods are renowned for their universality, they often fall short in sensitivity when distinguishing potential signals from background processes, compared with those model-specific searches that benefit from advanced jet taggers designed for dedicated final states. In response, this study introduces "Sophon", a groundbreaking approach that leverages signature-oriented pre-training for high-mass resonance observation. First, we pre-train a large jet model on over a hundred jet final-state signatures for a multi-class classification task, allowing it to capture a comprehensive representation of large-radius jets. This model is then utilized to detect anomalous signatures abundant at certain mass regions through a weakly-supervised learning approach. Our methodology's efficacy is validated through a holistic scan of the mass spectrum, successfully uncovering the resonance structures of known SM particles. Furthermore, "Sophon"shows a significant increase in sensitivity over previous methods. By benchmarking its performance against the optimal model-specific search strategy, we highlight its ability to expedite the detection of unknown particles within the LHC's energy range.

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