Contribution ID: **20** Type: **not specified**

Autonomous New-Physics Discovery from Foundational Embeddings of SMEFT

Saturday 8 November 2025 15:45 (15 minutes)

Representing hadronic parton distribution functions (PDFs) through flexible, high-fidelity parameterizations remains a long-standing goal of particle physics phenomenology. One crucial goal is to quantitatively connect experiments'sensitivity to underlying theory assumptions, including a broad array of BSM and SMEFT scenarios, to the properties of the PDFs'flavor and x-dependence. We explore this problem by encoding many SMEFT scenarios in contrastive embedding spaces generated from simulated events. Within this space we apply evidence-based uncertainty quantification techniques to disentangle data (aleatoric) and knowledge (epistemic) uncertainty while identifying out of distribution samples. Equivalently important is the ability to exclude particular classes of theories, such as standard model-only physics scenarios, which we do through the identification of theory "superclasses."I will present the latest progress in building these embedding spaces unifying dozens of SMEFT variants, demonstrating how model discrimination and anomaly detection naturally emerge alongside generation and classification tasks with uncertainty quantification.

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Session Classification: Regular Sessions