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Grand Design of the Collider Space: How can AI and human work together to mine more physics from the LHC data?

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As the Large Hadron Collider (LHC) generates hundreds of petabytes of data and even more with its high-luminosity upgrade, particle physics is entering a new era of data-driven discovery where machine learning (ML) techniques play a pivotal role. Alongside numerous task-specific ML algorithms, recent works have introduced foundation models excelling across diverse applications. At the heart of these ML models, especially general-purpose ones, is a geometric representation space for collider events that encodes the essential physics. Key questions then arise: How can we probe and refine the representation space for theoretical insights?

This talk presents a first step towards the construction and analysis of a collider space. I will introduce two metric structures, one inspired by the mathematical theory of optimal transport and the other grounded in the physical phase space. Such explicitly-defined metrics enable comparisons with the representation space implicitly generated by an ML model. This paves the way to further dissect a model's internals and offers hope for discovering new physical laws directly from data.

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