

Smart Gradient-Based Optimization of HEP Analyses

Tuesday, October 28, 2025 4:30 PM (50 minutes)

Automatic differentiation, the technique behind modern deep learning, can be applied more broadly in High Energy Physics (HEP) to make entire analysis pipelines differentiable. This enables direct optimization of analysis choices such as selection thresholds, binning strategies, and systematic treatments by propagating gradients through the statistical analysis chain.

This talk will introduce automatic differentiation for HEP, explaining how it works and how its usefulness extends beyond deep learning. We will highlight the potential and challenges of writing differentiable pipelines in the Scikit-HEP ecosystem, while utilising tools such as JAX and evermore. We will also outline ongoing developments in differentiable particle reconstruction and identification algorithms, placing them in the broader vision of an end-to-end differentiable pipeline.

The second half will be a tutorial on building differentiable statistical analyses with **GRAEP** (Gradient-based End-to-End Physics Analysis). We will show how to implement selections, construct differentiable histograms, and perform likelihood inference within a gradient-enabled environment. Examples will demonstrate how gradients can be used to optimize analysis parameters and streamline exploration of strategies compared to traditional approaches.

All code and examples will be openly available on GitHub for participants to try out after the session.

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