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Efficient bin by bin profile likelihood minimization for precision measurements

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The High-Luminosity LHC era will deliver unprecedented data volumes, enabling measurements on fine-grained multidimensional histograms containing millions of bins with thousands of events each. Achieving ultimate precision requires modeling thousands of systematic uncertainty sources, creating computational challenges for likelihood minimization and parameter extraction. Fast minimization is crucial for efficient analysis development.

We present a novel tensorflow-based tool that leverages optimized parallelization on CPUs and GPUs for this task. Our implementation interfaces with boost histograms, supporting flexible likelihood configurations with symmetrization options to establish Gaussian approximations. The minimization utilizes automatic differentiation to compute (quasi) second-order derivatives, yielding robust and efficient results. We further provide analytic proof of deterministic solutions within linear approximation limits.

Our tool distinctly focuses on measuring physical observables rather than intrinsic parameters, disentangling likelihood parameterization from quantities of interest and creating a more intuitive, less error prone user experience. Comprehensive benchmarking demonstrates excellent scaling with increased threading and reveals significant efficiency gaps when compared to commonly used frameworks in the field. These performance differences highlight the need for continued development of optimized statistical tools for high-energy physics analyses.

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