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Moments for positivity: using Drell-Yan data to test positivity bounds and reverse-engineer new physics

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Moments of the leptonic angular distribution in the Drell-Yan process have recently been shown to be sensitive probes of a specific class of dimension-8, four-fermion operators in the Standard Model Effective Field Theory, involving a pair of quarks and leptons. The same operators are also subject to positivity bounds, when requiring the associated (unknown) UV completion to obey basic principles of quantum field theory. We perform a phenomenological study to quantify the sensitivity of the high-luminosity LHC to this set of operators and, by extension, the positivity bounds. We further extend the angular basis of moments and consider double differential information to improve the ability to disentangle the different operators, leading to a sensitivity to new physics scales up to 3 TeV. We use this information to explore the violation of positivity at the LHC as a way to test the underlying principles of quantum field theory. Finally, we present a case study which combines our results with information from other (current and prospective) experiments, as well as the positivity cone to infer the properties of possible tree-level UV completions. The data lead to robust, model-independent lower bounds on the $M/g^{-}\sqrt{}$ combination of the particle mass and coupling, for states that couple to right-handed leptons and/or up quarks.

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