Snowmass LOI Les Houches Wishlist: placeholder

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1 Introduction

One of the legacies of the Les Houches workshops has been the precision standard model wishlist [1, 2]. This is an attempt to (1) summarize the start of the art for higher order QCD and EW calculations and (2) to determine the calculations needed for the full exploitation of the full-luminosity LHC. This list includes calculations that may not necessarily be accessible with current-day techniques, but that can be obtained in a reasonable time frame, given sufficient theoretical effort. The justification for the effort is the expected statistical and systematic precision of the relevant experimental measurements, and the importance of better theoretical predictions for those measurements.

Given the longer-term nature of the wishlist (2040), it seems natural to fit it into the Snowmass21 framework, by extending the scope to physics expected at a 33 or 100 TeV collider. This can also be considered the extension of the work conducted in Snowmass13 [3]. The higher energies allow for an extension of the kinematic reach, for example, for a high p_T Higgs boson to a region where new physics effects may become evident. Cross sections below the kinematic edge may reach a 1% or better precision. Scales well above the W/Z boson mass will result in the importance of higher order EW corrections, as well as combined QCD+EW corrections. QCD calculations at N^3LO will require PDFs at a similar order, as well as a combined QCD+EW evolution of these PDFs. The treatment of W/Z bosons, as well as top quarks, as partons present in the proton may become necessary.

Another future accelerator that will require increased theoretical precision is the Electron-Ion-Collier (EIC), where higher-order $\alpha_s(m_Z)$ and electroweak corrections will have to be well-understood. Data taken at the EIC will also have the potential to provide more precise PDF information, both at $x \gtrsim 10^{-4}$ as well as high x, that will be crucial for precision predictions at a 33 or 100 TeV collider. The greater objective is to generalize beyond 1-D distributions, so further theoretical effort is required to develop factorization theorems, especially for robust extraction and interpretation of multi-dimensional distributions like TMDs and GPDs.

In this LOI, we propose a coherent program between Les Houches 2021 and Snowmass21 to explore the higher-order calculations needed for 33/100 TeV and a projection of the technical capabilities available by that time. Experience at 13 TeV, and that expected at the HL-LHC, will be crucial in this extrapolation. The calculations needed will depend not only on the experimental errors expected, but the impact of higher order corrections at these higher energies.

References

[1] *Les Houches 2017: Physics at TeV Colliders Standard Model Working Group Report*, 3 2018.

[2] S. Amoroso et al. Les Houches 2019: Physics at TeV Colliders: Standard Model Working Group Report. In *11th Les Houches Workshop on Physics at TeV Colliders: PhysTeV Les Houches*, 3 2020.

[3] J.M. Campbell et al. Working Group Report: Quantum Chromodynamics. In *Community Summer Study 2013: Snowmass on the Mississippi*, 10 2013.