Letter of Interest: Prospects of Vector boson scattering at future colliders

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Abstract: Vector boson scattering processes provide key insights into the breaking of the electroweak symmetry. The quartic gauge couplings can be probed at colliders via studies of vector boson scattering processes and via tri-boson production. Benchmark studies of VBS processes are proposed for comparative analysis of model parameter sensitivity for different multi-TeV lepton and high-energy hadron collider options.

1 Introduction

The electroweak (EW) sector of the Standard Model (SM) predicts self-interactions between W and Z gauge bosons through triple and quartic gauge couplings. The scattering of longitudinally polarized W and Z bosons is a particularly compelling probe of the SM, as its tree-level amplitudes would violate unitarity at high energies without precise cancellations from quartic gauge couplings and Higgs-boson contributions; thus, the study of VBS processes provides key insight into the quartic gauge couplings as well as the Higgs sector. Modifications of the VBS production cross sections are predicted in models of physics beyond the standard model (SM), for example through changes to the Higgs boson couplings to gauge bosons. The possible presence of anomalous triple and quartic gauge couplings could result in an excess of events with respect to the SM predictions.

We propose to perform a comparative study of future collider options for beyond standard model physics potential of the VBS processes in the high-energy regime. Future high-energy hadron colliders as well as circular multi-TeV $\mu^+\mu^-$ and linear e^+e^- machines can be considered for the benchmark studies. The center-of-mass energies and luminosities of the different collider options considered for the studies will be agreed with the Snowmass community.

- A future high energy hadron-collider operating at $\sqrt{s} = 100$ TeV, such as FCC-hh or SppC would provide powerful means to probe VBS processes. An example of recent study is given in Ref. [1].
- A multi-TeV muon collider is a high-luminosity, vector-boson collider machine. A recent study of the cross sections for the VBS processes and for a number of new physics processes is given in Ref. [2].

- A multi-TeV e^+e^- machine provides a clean environment to study VBS processes. An example of studies for different center-of-mass energy options motivated by the extension of the ILC project and the staging scenario of the CLIC project is given in Ref. [3].

The aim of this work is to use the the WW and WZ production to study the model parameter sensitivity for different collider options to relevant effective field theory (EFT) framework dimension-6 and dimension-8 operators. A unitarization procedure should be included to benchmark the different collider options. Production of singly (doubly) charged Higgs bosons via vector-boson fusion that decay to W and Z bosons in extended Higgs sectors with additional SU(2) isotriplet scalars, such as the Georgi–Machacek model (GM) [4] will also be used to benchmark the different collider options.

2 Roadmap to a unified VBS study

1. Adopt the collider/detector scenarios endorsed by Snowmass community.
2. Agree on model parameter benchmarks (EFT dimension-6, dimension-8, GM model).
3. Explore the space of generator and collider process scenarios for model parameter sensitivity.
4. Introduce increasing experimental realism in detector performance and backgrounds.
5. Introduce increasing theoretical realism in signal and irreducible background estimation.
6. Provide comparative analysis of model parameter sensitivity.

References

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