

Probing Inert Scalar Dark Matter via Vector Boson Fusion at a Future Muon Collider

The Inert Doublet Model (IDM) and Inert Triplet Model (ITM) feature a neutral scalar dark matter candidate along with inert charged scalars. In the ITM, the charged scalars exhibit a compressed mass spectrum, while in the IDM, the mass splittings among scalar components arise from electroweak symmetry breaking. Recent constraints from direct and indirect dark matter searches push these models toward the TeV scale, making their production challenging at current and future LHC runs. However, a future Muon Collider provides a promising alternative via Vector Boson Fusion (VBF), which significantly enhances the production cross-section. In the ITM, the compressed mass spectrum leads to disappearing track signatures from long-lived charged scalars, whereas the IDM predominantly exhibits missing transverse momentum. Both models yield energetic forward muons from VBF, a distinctive feature at a Muon Collider. We analyze these signatures and present discovery prospects based on luminosity projections.

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