

EUROPEAN ORGANISATION FOR NUCLEAR RESEARCH (CERN)



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Supplemental Material for: Search for heavy neutral leptons in decays of W bosons using a dilepton displaced vertex in $\sqrt{s} = 13$ TeV pp collisions with the ATLAS detector

The ATLAS Collaboration

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In this supplemental material, we present Feynman diagrams for lepton number violating processes targeted in this analysis, as well as background distributions showing the validation of opposite-sign (OS) and same-sign (SS) vertices and the correlation between displaced vertex mass (m_{DV}) and radius (r_{DV}).

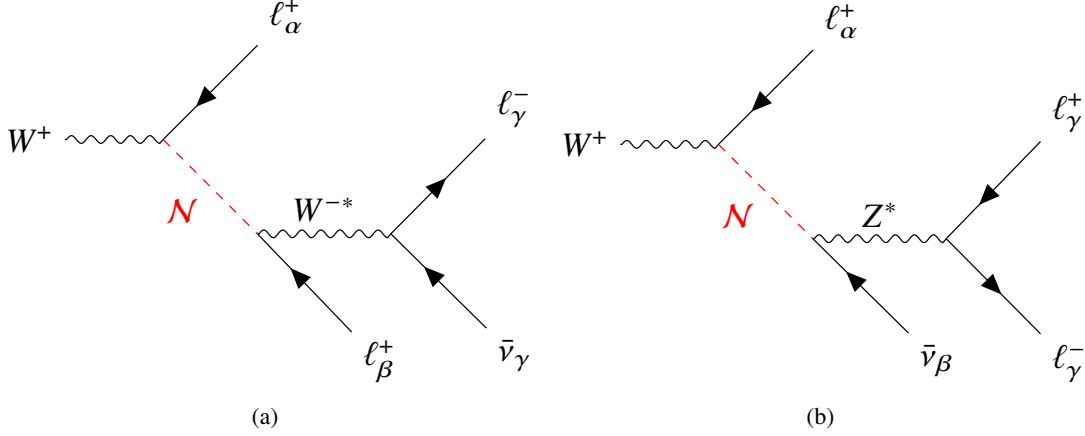


Figure 1: Feynman diagrams for the HNL production and decay modes targeted in this analysis. Only lepton number violating processes are shown. The flavors of the leptons in the diagrams, labeled by α , β , and γ , are either muons or electrons. If the charged leptons in the HNL decay have the same flavor, then both the diagrams with the virtual W (a) and virtual Z (b) contribute to the process. Equivalent processes are also valid for an initial state W^- boson.

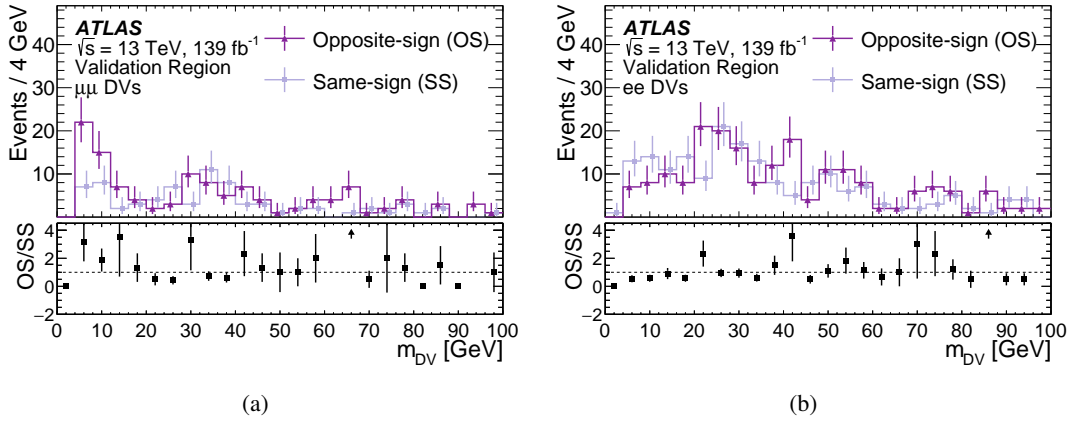


Figure 2: The m_{DV} distributions of OS and SS DVs in the validation region, for (a) $\mu\mu$ and (b) ee DVs. These demonstrate that the SS and OS DV distributions generally agree well, in line with the assumption that the dominant residual background for the search is that of random-crossing vertices, which is then estimated by a data-driven method. The disagreements which are visible here in part result from the remaining nonrandom-crossing backgrounds and these are accounted for with a systematic uncertainty. The markers are offset from the central positions for visualization purposes.

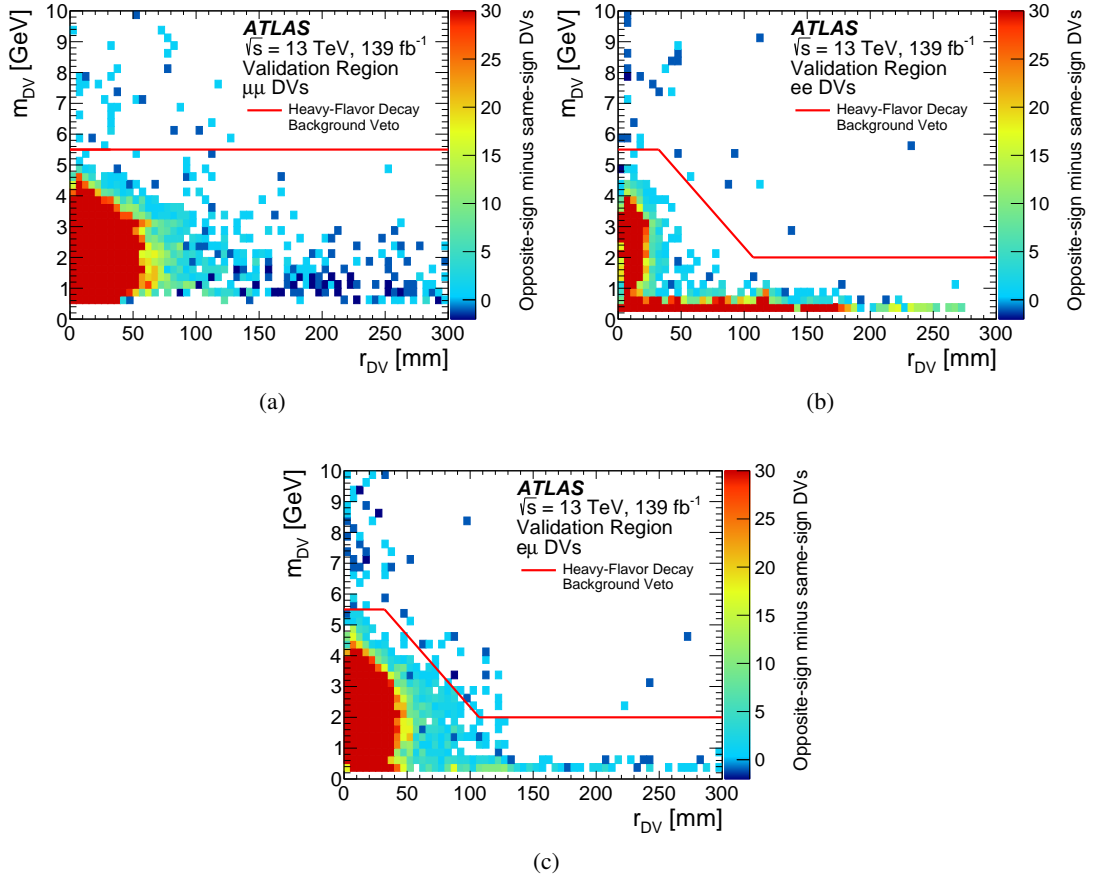


Figure 3: The two-dimensional distribution of m_{DV} and r_{DV} . Shown is the difference between the OS- and SS-vertex distributions. The vertices used in the selection are from the validation region, in which events containing prompt leptons are vetoed. The z -axis maximum is set to 30 to provide a scale that distinguishes between small positive (more OS- than SS-DVs) and small negative (more SS- than OS-DVs) entries. The solid red line represents the DV selection that is applied in each channel to remove background from heavy-flavor decays. The larger reconstruction efficiency for $\mu\mu$ DVs results in a number of displaced metastable heavy-flavor decays. For this reason, the $r_{DV}-m_{DV}$ correlation selection, which is applied in the ee and $e\mu$ channels, is not sufficient to remove heavy-flavor $\mu\mu$ decays. Instead, an $m_{DV} > 5.5$ GeV selection is applied in channels with $\mu\mu$ DVs.