The Search for the dark vector boson

Hidden sector or dark sector states appear in many extensions to the Standard Model, to provide a particulate candidate for dark matter in universe or to explain astrophysical observations such the as positron excess observed in the cosmic radiation flux. A hidden or dark sector can be introduced with an additional U(1)d dark gauge symmetry. The presence of the dark sector could be experimentally inferred at colliders as deviations from the SM-predicted rates of Drell-Yan (DY) events, from Higgs boson decays through exotic intermediate states, or other processes which may depart from the SM predictions. The discovery of the Higgs boson during Run 1 of the Large Hadron Collider opens a new and rich experimental program based on the Higgs Portal. This discovery route uses couplings to the dark sector at the Higgs level, which were not experimentally accessible before. These searches include the study of possible exotic decays: $H \rightarrow Z\ Z_d \rightarrow 4l$ and $H \rightarrow Z_d\ Z_d \rightarrow 4l$. Here Z_d is a dark vector boson. We have experience of this search from the Run 1 period of the LHC using the ATLAS detector at CERN. These results showed (tantalizingly) two signal events where none were expected, so that in the strict criteria of High Energy Physics, the result was not yet statistically significant. The Run 1 analysis for 8 TeV collision energy is further developed in Run 2 with 13 TeV collision energy, to expand the search area, take advantage of higher statistics, a higher Higgs production cross section, and substantially better performance of the ATLAS detector. As things evolved, the search now further broadened and includes allow the mass of the originating boson (the dark Higgs) to vary away from the SM value. This allows the search for the dark vector boson to also explore higher masses (instead of limiting the dark boson to 60 GeV as Run1 and Run2). This extended search is efficient and could include a more general class of models, with the constraint of the SM Higgs portal lifted. This contribution reviews the results for Run1 and Run2 and also presents the extension of this analysis to the heavy scalar case.