## EW gauge boson 3/4-body rare decay at the LHC

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We investigate the W boson's exotic decay channel,  $W \rightarrow \ell \ell \ell \ell \nu$ , at the LHC. Although the four-body final states suppress the decay branching ratio, the large production of W bosons makes detecting and precisely measuring this decay probability entirely feasible. Our simulation study indicates that this tiny branching ratio can be measured with sub-percent precision at the HL-LHC. This decay channel can also constrain Standard Model extensions. Using the  $L_{\mu} - L_{\tau}$  model as a benchmark, we find that the current bound on the gauge coupling for Z' mass in the range of [4, 75] GeV can be significantly improved.

Additionally, the branching ratio of the radiative Z decay,  $Z \rightarrow \mu^+ \mu^- \gamma$ , has not been revisited since its initial measurement at LEP (only an upper bound). This simple 3-body decay channel can be measured within subpercentage level at the LHC and can uniquely constrain on axion-like particles (couple to muon) within [5, 85] GeV.

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