
BELLE2-NOTE-PL-2020-012
Version 1.0
July 23, 2020

# Search for an invisible $Z'$ in $e^+e^- \to \mu^+\mu^-$ + missing energy final states in early phase 3 data

The Belle II Collaboration

## Abstract

This note presents plots associated with the search for an invisible $Z'$ in $e^+e^- \to \mu^+\mu^-$ + missing energy final states targeting early phase 3 data. Plots include a distribution of the remaining backgrounds expected from simulation after event selection and a MVA classification. Furthermore we show the expected 90% $\mathrm{CL}_s$ upper limits obtained for different simulated analysis conditions for both the cross section $\sigma(\mathrm{e^+e^-} \to \mu^+\mu^-$ inv.) as well as the associated $Z'$ coupling constant in the framework of an $L_\mu - L_\tau$ theory.

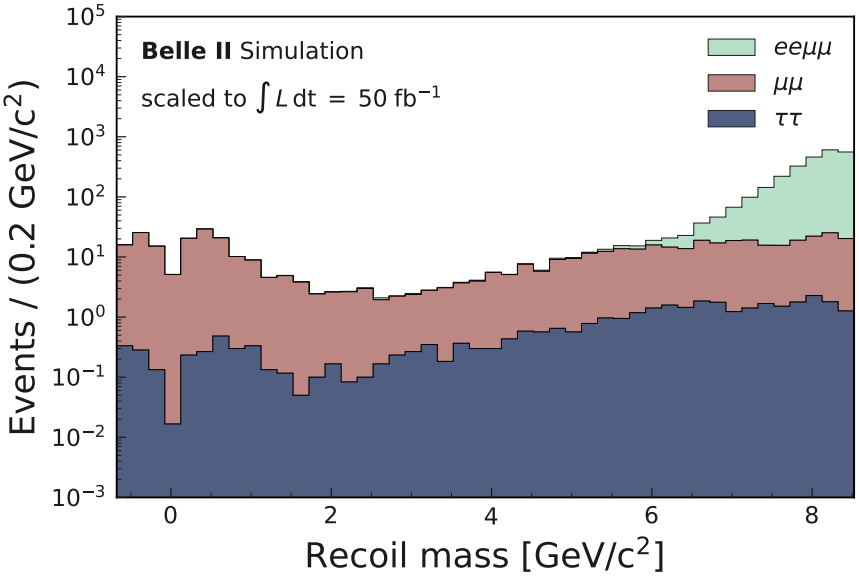


FIG. 1: Expected background in bins of recoil mass after all selections and further background suppression using a multi-layer perceptron. Only the relevant backgrounds with a non negligible number of remaining events are shown. The histograms are scaled to represent a total integrated luminosity of 50 $\text{fb}^{-1}$.

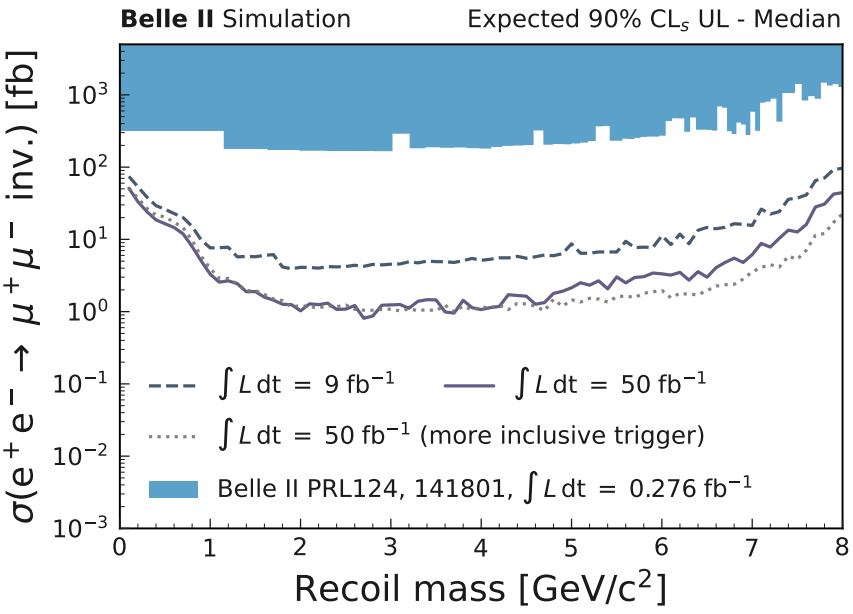


FIG. 2: Expected 90% CL$_s$ UL on the cross section superimposed with the current 90% CL UL set from Belle II 2018 data (PhysRevLett.124.141801, 2020), assuming a branching fraction for Z' $\to$ invisible of 1. The upper limits are shown for different assumed luminosities (9 fb$^{-1}$ and 50 fb$^{-1}$) where for the 50 fb$^{-1}$ case the effect of using a more inclusive trigger is compared. The trigger efficiency used is based on an internal study (BELLE2-NOTE-TE-2020-014). The limits are obtained with a toy Monte Carlo study by counting in recoil mass windows. Not all systematic effects are considered but a preliminary conservative systematic uncertainty on the background (20%) and signal (10%) was assigned.

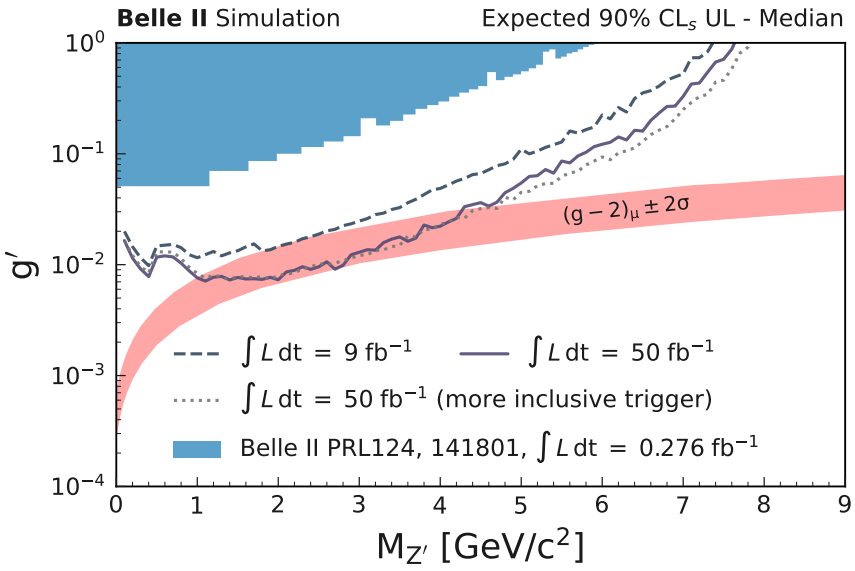


FIG. 3: Expected 90% CL$_s$ UL on the $Z'$ coupling constant $g'$ superimposed with the current 90% CL UL set from Belle II 2018 data (PhysRevLett.124.141801, 2020), assuming a branching fraction for Z' $\rightarrow$ invisible of 1. The upper limits are shown for different assumed luminosities (9 fb$^{-1}$ and 50 fb$^{-1}$) where for the 50 fb$^{-1}$ case the effect of using a more inclusive trigger is compared. The trigger efficiency used is based on an internal study (BELLE2-NOTE-TE-2020-014). The limits are obtained with a toy Monte Carlo study by counting in recoil mass windows. Not all systematic effects are considered but a preliminary conservative systematic uncertainty on background (20%) and signal (10%) was assigned.