



BELLE2-NOTE-PL-2019-015, PNNL-YYYYY

Approved Plots: Quarkonia in Early Phase 3 (Aug 01 2019)

Bryan Fulsom

Pacific Northwest National Laboratory

Joe Peetz

Florida State University

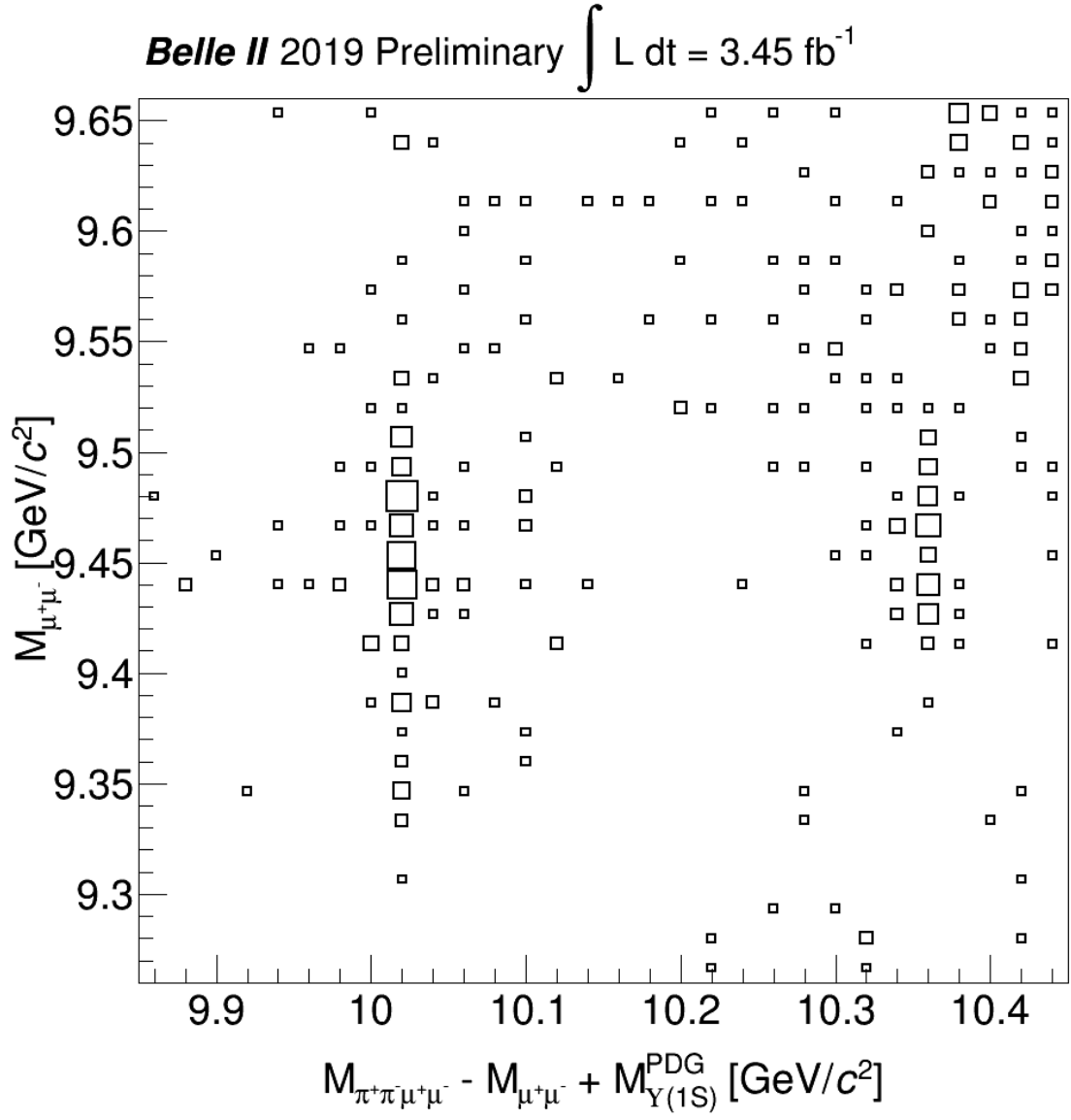


FIG. 1: Plot of $M_{\mu\mu}$ versus $\Delta M = M_{\pi^+\pi^-\mu^+\mu^-} - M_{\mu^+\mu^-} + M_{\Upsilon(1S)}^{PDG}$ for $\Upsilon(2S, 3S) \rightarrow \pi^+\pi^-\Upsilon(1S)$ decays produced by initial state radiation. To improve resolution, $M_{\mu^+\mu^-}$ is subtracted from the $M_{\pi^+\pi^-\mu^+\mu^-}$ invariant mass and replaced with the PDG value for $\Upsilon(1S)$. Signal events cluster near value of the $\Upsilon(1S)$ mass in $M_{\mu\mu}$, and near the value of $\Upsilon(2S, 3S)$ mass in ΔM .

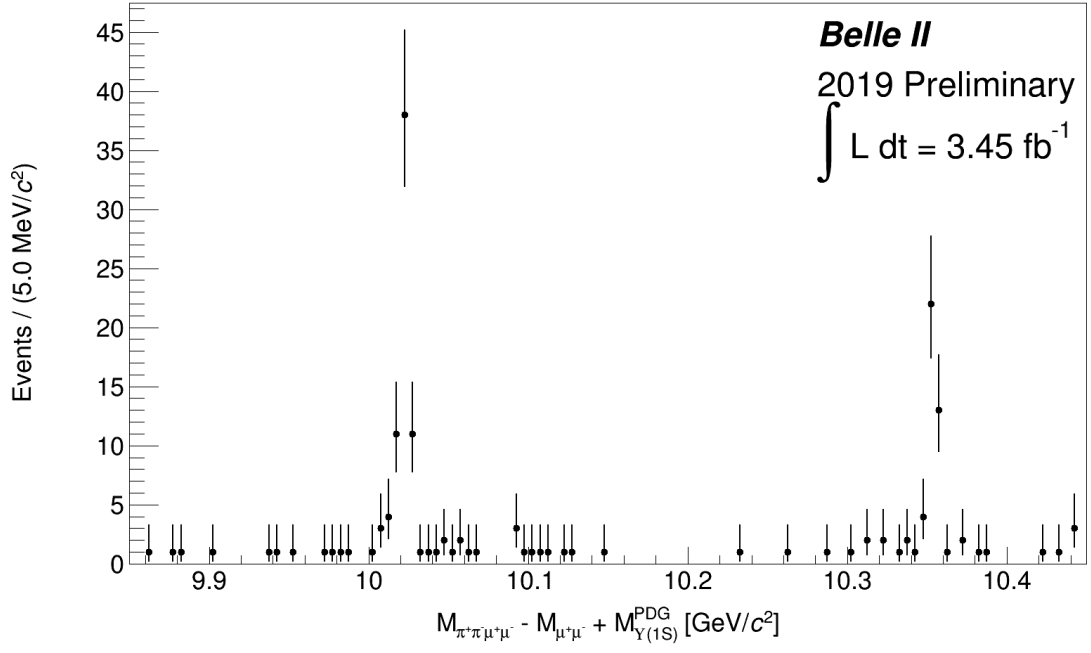


FIG. 2: Plot of $M_{\pi^+\pi^-\mu^+\mu^-} - M_{\mu^+\mu^-} + M_{\Upsilon(1S)}^{PDG}$ with a requirement of $|M_{\mu\mu} - M_{\Upsilon(1S)}^{PDG}| < 50 \text{ MeV}$. The peaks indicate $\Upsilon(2S)$ and $\Upsilon(3S)$ dipion decay signals.

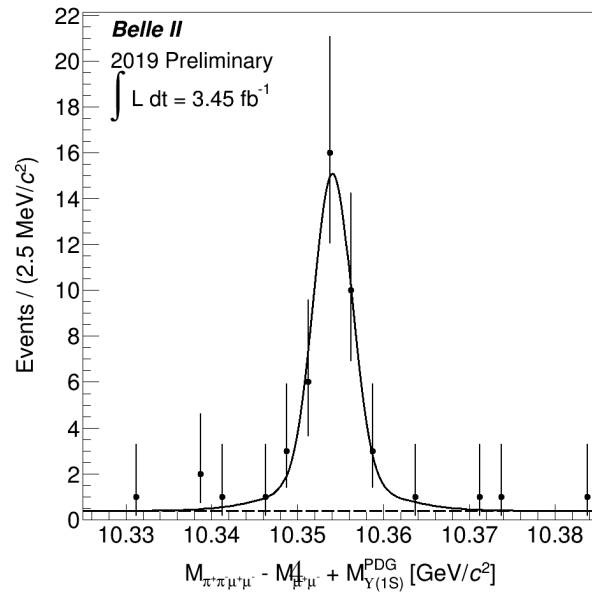
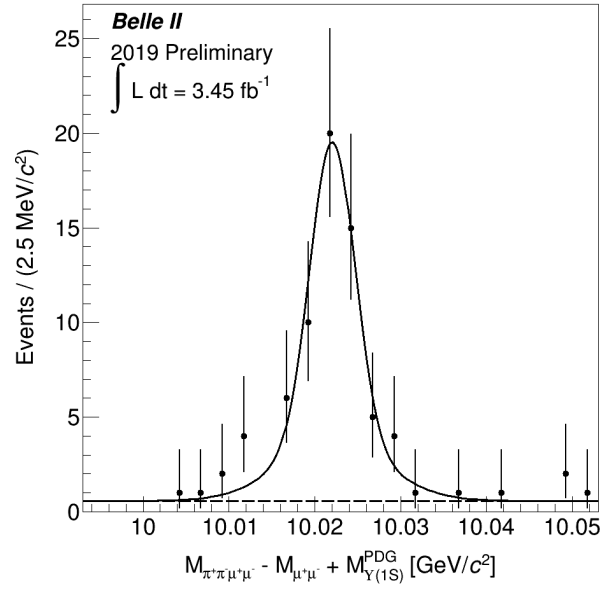
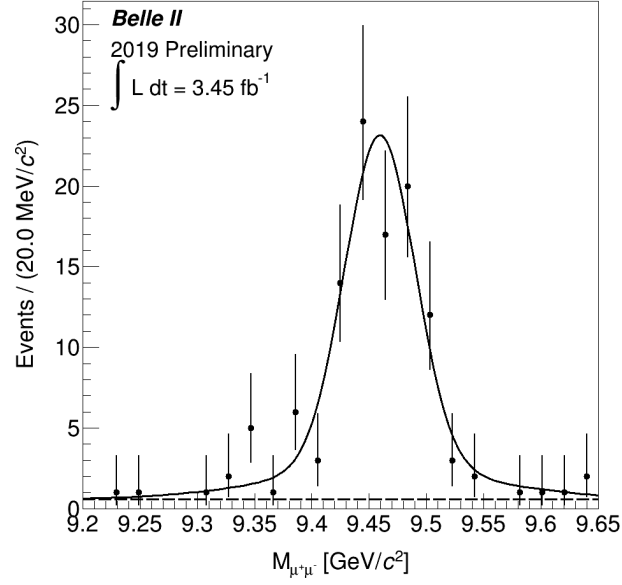


FIG. 3: Fitted plots of $M_{\mu\mu}$ ($\Upsilon(1S)$, top) with $|\Delta M - M_{\Upsilon(2S,3S)}^{PDG}| < 5 \text{ MeV}$, and $M_{\pi^+\pi^-\mu^+\mu^-} - M_{\mu^+\mu^-} + M_{\Upsilon(1S)}^{PDG}$ ($\Upsilon(2S)$, center, $\Upsilon(3S)$, bottom) with $|M_{\mu\mu} - M_{\Upsilon(1S)}^{PDG}| < 50 \text{ MeV}$. Points with error bars indicate data, the solid line represents the total fit, and the dashed line represents the fitted background.

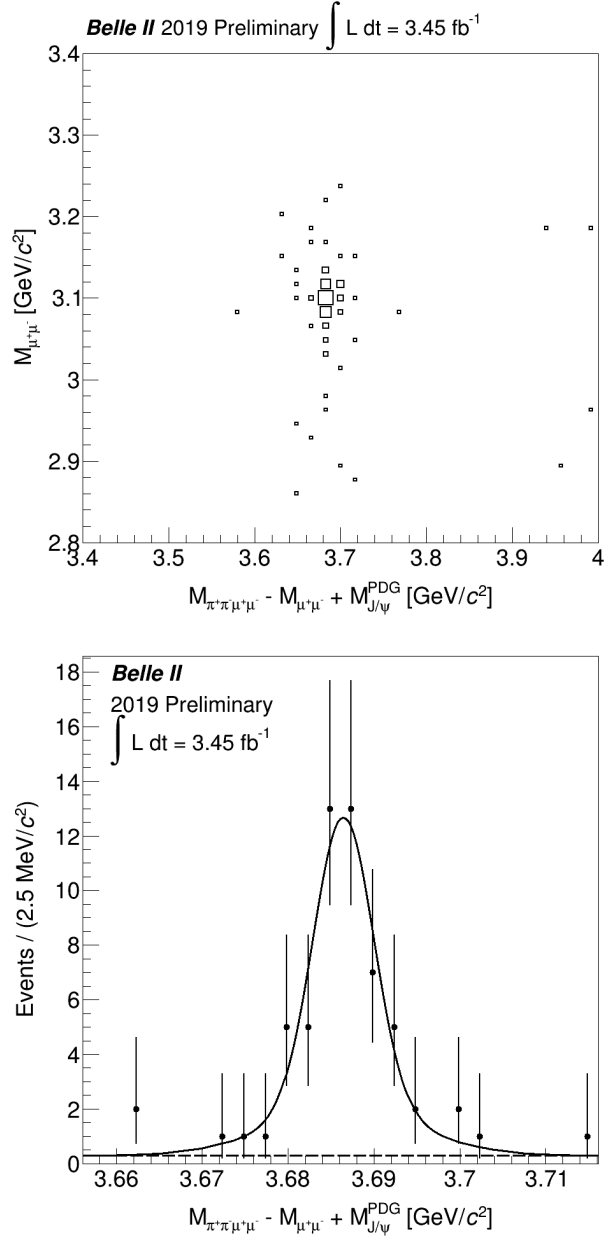


FIG. 4: Plot (top) of $M_{\mu\mu}$ versus $\Delta M = M_{\pi^+\pi^-\mu^+\mu^-} - M_{\mu^+\mu^-} + M_{J/\psi(1S)}^{PDG}$ and the fitted plot (bottom) of ΔM , for $\psi(2S) \rightarrow \pi^+\pi^-J/\psi(1S)$ decays produced from initial state radiation. Points represent data, the solid line represents the total fit, and the dotted line represents the fitted background.

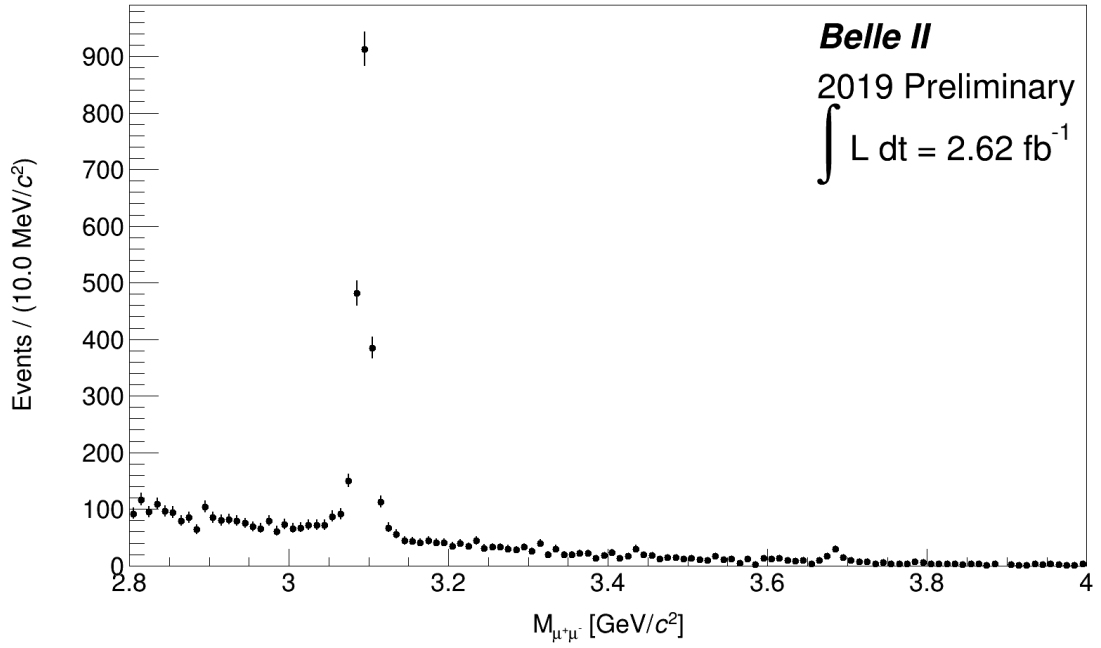


FIG. 5: Plot of inclusive charmonium decays to $\mu\mu$. Decays from B mesons are enhanced in this sample by requiring $R_2 < 0.3$, $p_{\mu^+\mu^-}^* < 4.25 \text{ GeV}/c$, and greater than 4 tracks in the event. $muonID > 0.8$ is applied to both reconstructed muons. Peaks are seen for J/ψ and $\psi(2S)$ decays. The points with error bars represent data.

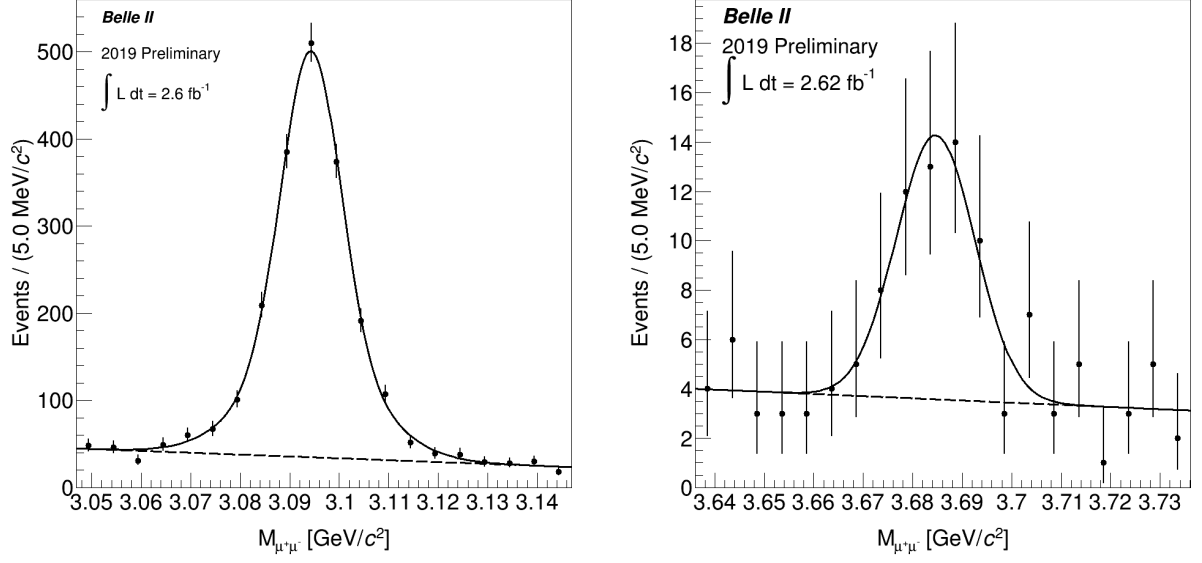


FIG. 6: Fits of inclusive charmonium decays to $\mu\mu$: J/ψ (left) and $\psi(2S)$ (right). Decays from B mesons are enhanced in this sample by requiring $R_2 < 0.3$, $p_{\mu^+\mu^-}^* < 4.25$ GeV/c, and greater than 4 tracks in the event. $muonID > 0.8$ is applied to both reconstructed muons. The points with error bars represent data, the solid line represents the total fit, and the dashed line represents the background fit.