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

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FIG. 1: Plot of $M_{\mu\mu}$ versus $\Delta M = M_{\pi^+\mu^-\mu^+} - M_{\mu^+\mu^-} + M_{\Upsilon(1S)}^{PDG}$ 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 $M_{\pi^+\mu^-\mu^+}$ 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 $\Delta M$. 
FIG. 2: Plot of $M_{\pi^+\pi^-\mu^+\mu^-} - M_{\mu^+\mu^-} + M^{PDG}_{\Upsilon(1S)}$ with a requirement of $|M_{\mu\mu} - M^{PDG}_{\Upsilon(1S)}| < 50$ MeV. The peaks indicate $\Upsilon(2S)$ and $\Upsilon(3S)$ dipion decay signals.
FIG. 3: Fitted plots of $M_{\mu\mu}$ ($\Upsilon(1S)$, top) with $|\Delta M - M_{\Upsilon(2S,3S)}^{PDG}| < 5$ MeV, and $M_{\pi^+\pi^-\mu^+\mu^-} - M_{\mu^+\mu^-} + M_{\Upsilon(1S)}^{PDG}$ ($\Upsilon(2S)$, center, $\Upsilon(3S)$, bottom) with $|M_{\mu\mu} - M_{\Upsilon(1S)}^{PDG}| < 50$ 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 $\Delta M$, 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 $R_2 < 0.3$, $p_{\mu^+\mu^-} < 4.25$ GeV/$c$, and greater than 4 tracks in the event. $\text{muonID} > 0.8$ is applied to both reconstructed muons. Peaks are seen for $J/\psi$ and $\psi(2S)$ decays. The points with error bars represent data.
FIG. 6: Fits of inclusive charmonium decays to $\mu\mu$: $J/\psi$ (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. $\text{muonID} > 0.8$ 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.