Figure 3: Relative $\eta_c$ to $J/\psi$ differential production cross-sections for (left) prompt production and (right) production in $b$-hadron inclusive decays. The uncertainties are statistical, systematic, and due to the $\eta_c \rightarrow p\overline{p}$ and $J/\psi \rightarrow p\overline{p}$ branching fractions, respectively. For the relative prompt production cross-section, the result of a fit with a linear function is overlaid.

Figure 4: Differential production cross-sections of $\eta_c$ (red rectangles) and $J/\psi$ (blue circles) for (left) prompt production and (right) production in $b$-hadron inclusive decays. The uncertainties for $\eta_c$ production are statistical, systematic, and due to the $\eta_c \rightarrow p\overline{p}$ and $J/\psi \rightarrow p\overline{p}$ branching fractions and $J/\psi$ production cross-section. For the prompt production cross-sections, the results of fits with an exponential function are overlaid. The $p_T$ values of the data points correspond to the average values of the fit function over the bins.

applied for the entire data sample to measure the $\eta_c$ mass relative to the well-known $J/\psi$ mass.

Proton and antiproton candidates are required to have good track-fit quality, to be incompatible with originating from any PV, and to have a transverse momentum greater than 1.0 GeV. The proton-antiproton system is required to have a vertex with a good fit quality, a large significance, $\chi^2_{FD} > 81$, of the distance between this vertex and any PV, and to have a transverse momentum greater than 5.5 GeV. The contamination of the selected sample from $J/\psi$ and $\eta_c$ prompt production is estimated to be below 0.1%.

The mass difference $\Delta M_{J/\psi, \eta_c}$ is extracted from an extended maximum-likelihood fit to the $M_{p\overline{p}}$ distribution. The signal and background components are modelled in the same way as described in Sect. 4. The fit provides a good description of the $p\overline{p}$ invariant-mass