The Inclusive B Lifetime using Run II Data at CDF

Text for the blessed web page – CDF note 6023

The CDF Collaboration

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Abstract

We describe an inclusive B lifetime measurement using the J/ψ trigger sample in the central muon system only. We measure the inclusive B lifetime to be

$$\begin{aligned} c\tau_B &= 458 \pm 10 \text{ (stat)} \pm 11 \text{ (syst) } \mu\text{m} \qquad \text{corresponding to} \\ \tau_B &= 1.526 \pm 0.034 \text{ (stat)} \pm 0.035 \text{ (syst) ps} \end{aligned}$$

The alignment and the related resolution function so far dominate the systematic error. The largest systematic error identified in Run I has been significantly reduced, however, by choosing the selection cuts carefully.

The J/ψ meson is one of the standard candles used for all types of calibrations of the CDF detector and of physics analyses. In this spirit we also use this sample to measure the resolution function, which gives us access not only to the inclusive B lifetime but to the exclusive lifetimes of certain B meson decays as well.

1 Description

We measure the average lifetime of the b-hadrons using the decays b-hadron $\rightarrow J/\psi + X$ and $J/\psi \rightarrow \mu^+\mu^-$. The data sample is collected with the di-muon trigger based on muons measured in the central muon system (CMU), and includes approximately 28,132 J/ψ mesons after all selection criteria have been applied.

In order to measure the b-hadron lifetime the decay length of the b-hadrons must be measured. Because the b-hadron is not fully reconstructed its decay length is not completely determined. We therefore approximate the b-hadron decay length using the $\beta\gamma$ of the J/ψ and improve the approximation using a Monte Carlo study.

A proper understanding of the decay length resolution function is critical to understanding and properly modeling the decay length distribution of the J/ψ sample. Because J/ψ mesons are also produced in the proton anti–proton collision, a large fraction of the sample consists of the irreducible background of these so–called *prompt* J/ψ. The prompt J/ψ provide an excellent sample with which to study the resolution function.

A careful study of the systematic uncertainties of this measurement is undertaken. The primary contributions to the uncertainty are due to the model of the resolution function and the Monte Carlo correction for the b-hadron decay length. The remaining uncertainty comes from the imperfect model of the background and the imperfect alignment of the silicon vertex detector.

The inclusive b-hadron lifetime is measured to be 458 ± 10 (stat) ± 11 (syst) μm. This is in excellent agreement with both the Run I PRD value of $460 \pm 4^{+10}_{-9}$ μm and the PDG value of 469 ± 4 μm.

2 Blessed Numbers

This section summarizes the numbers which are blessed for this analysis.

The inclusive b-hadron lifetime is measured to be

$$\begin{aligned} c\tau_B &= 458 \pm 10 \text{ (stat)} \pm 11 \text{ (syst) } \mu\text{m} \qquad \text{corresponding to} \\ \tau_B &= 1.526 \pm 0.034 \text{ (stat)} \pm 0.035 \text{ (syst) ps} \end{aligned}$$

The systematic uncertainties for the measurement are found to be

Description	Uncertainty (%)
F correction factor	$\pm$ 1.1
Resolution function	$\pm$ 1.5
Alignment	$\pm$ 0.7
Background parameterization	$\pm$ 1.1
Total	$\pm$ 2.3

Lastly, the fraction of prompt J/ψ for the sample used in this analysis is measured to be 83%.

3 Blessed Figures

The following figures have been blessed for the inclusive lifetime measurement. See note 6023 for details.

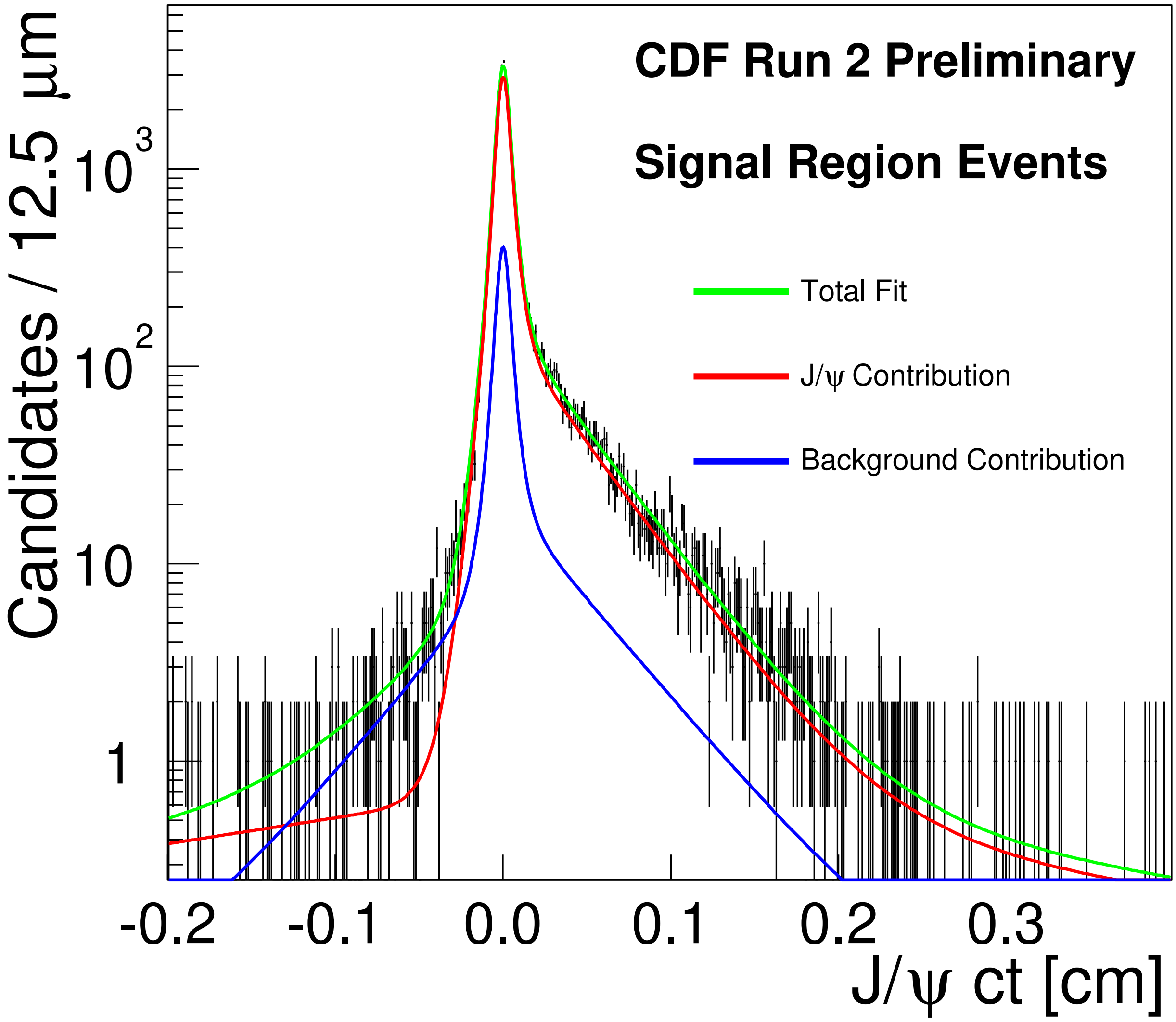

Figure 1: Fit results projected onto the data in the signal region.

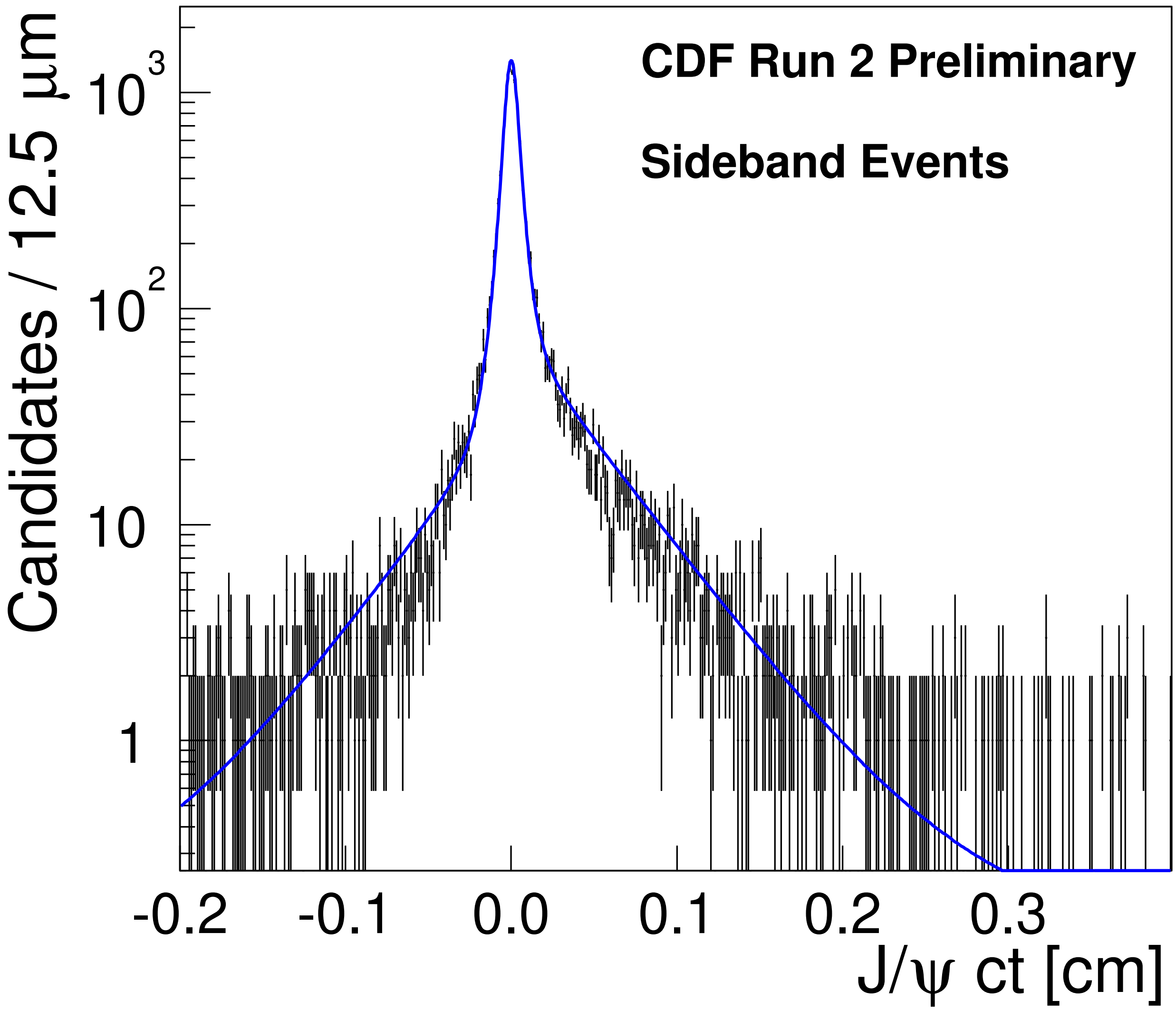

Figure 2: Fit results projected onto the data in the sideband regions.