



B_c lifetime measurement in fully reconstructed channel $B_c \rightarrow J/\psi + \pi$ at CDF

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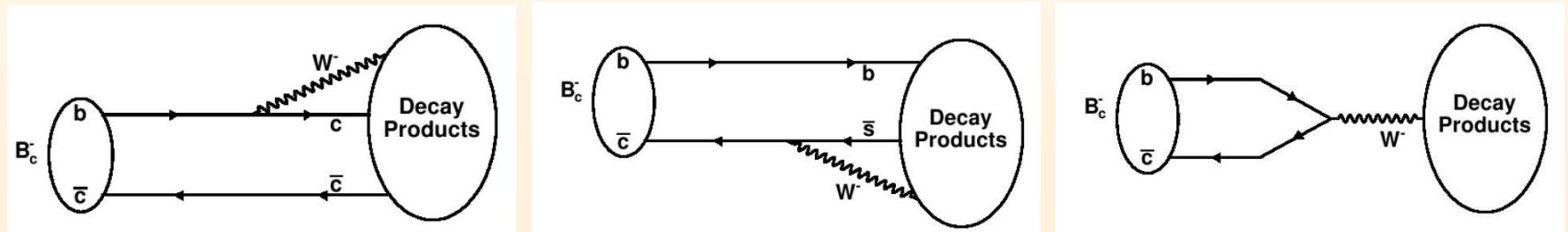
for the CDF Collaboration

Heavy Quarkonium 2011, GSI, Darmstadt, Germany



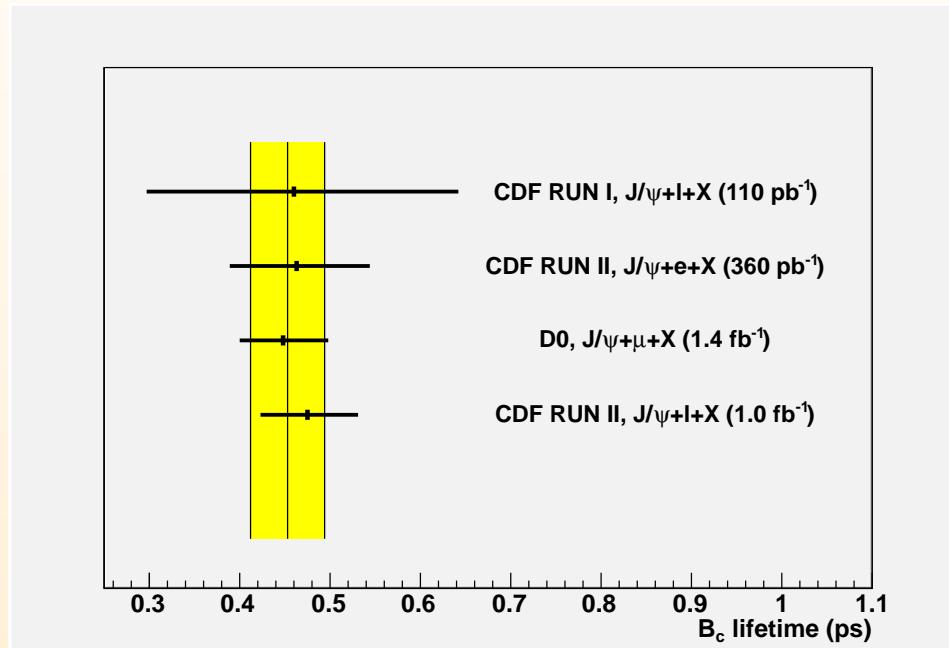
Motivation

- B_c meson is an heavy charged meson consisting of a b and a c quark.
- Could decay through either quark, or annihilate to a W boson.



- ◊ Each process can contribute to the total decay width.
- Most theory predict the lifetime to be $0.4 \sim 0.7$ ps.
 - ◊ Only $\sim 1/3$ of light B mesons such as B^+ , B^0 or B_s^0 .
 - ◊ precise measurement needed to test the theory.

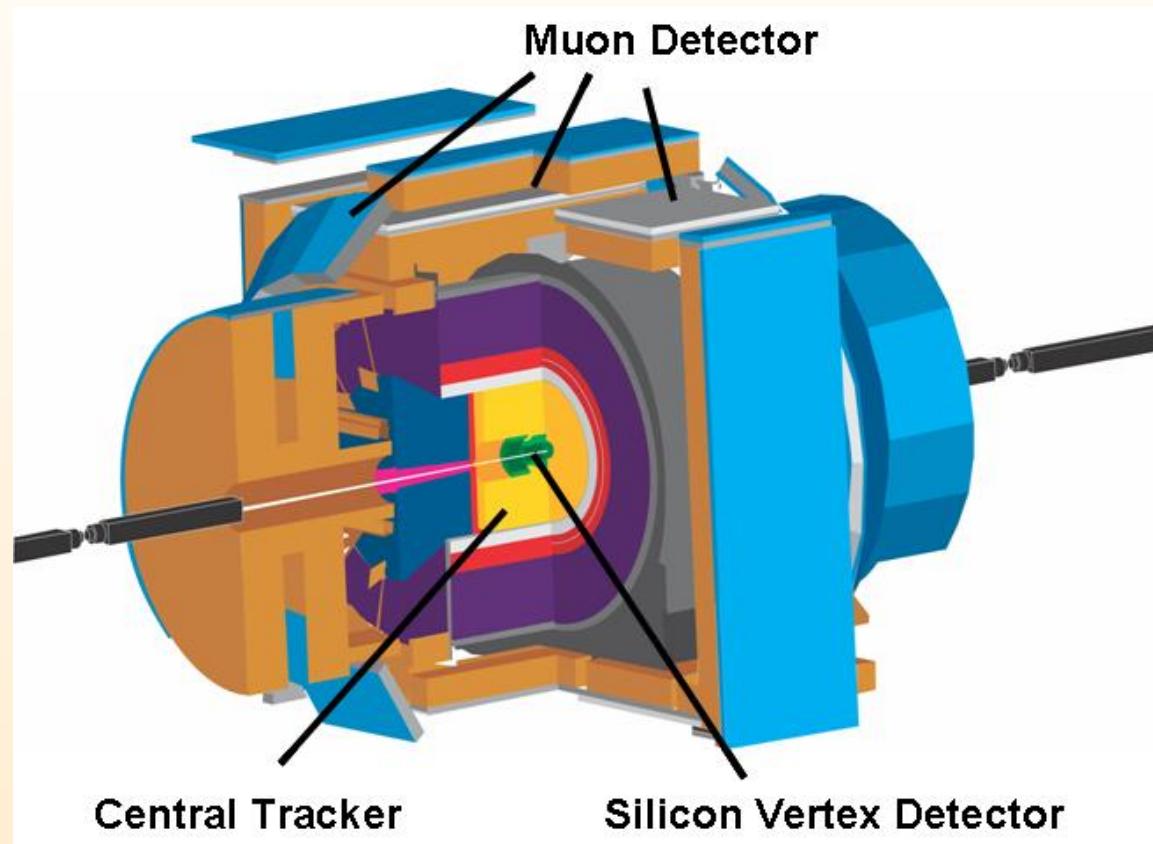
- Lifetime has been measured by CDF and D0 using semileptonic decay $B_c \rightarrow J/\psi + l + X$.
 - ◊ large branching fraction, but has a missing neutrino.



- Fully reconstructed $B_c \rightarrow J/\psi + \pi$ decay first observed at CDF.
 - ◊ With 2.4 fb^{-1} , mass was measured as : $6275.6 \pm 2.9 \pm 2.5 \text{ MeV}/c^2$.
(PRL 100.182002.2008)
- Now with 6.7 fb^{-1} luminosity, the lifetime is also measured in this decay channel.



CDF Detector



- Silicon Detector precise vertex position.
- Central Tracker momentum of charged particles.
- Muon Detector muon identification.

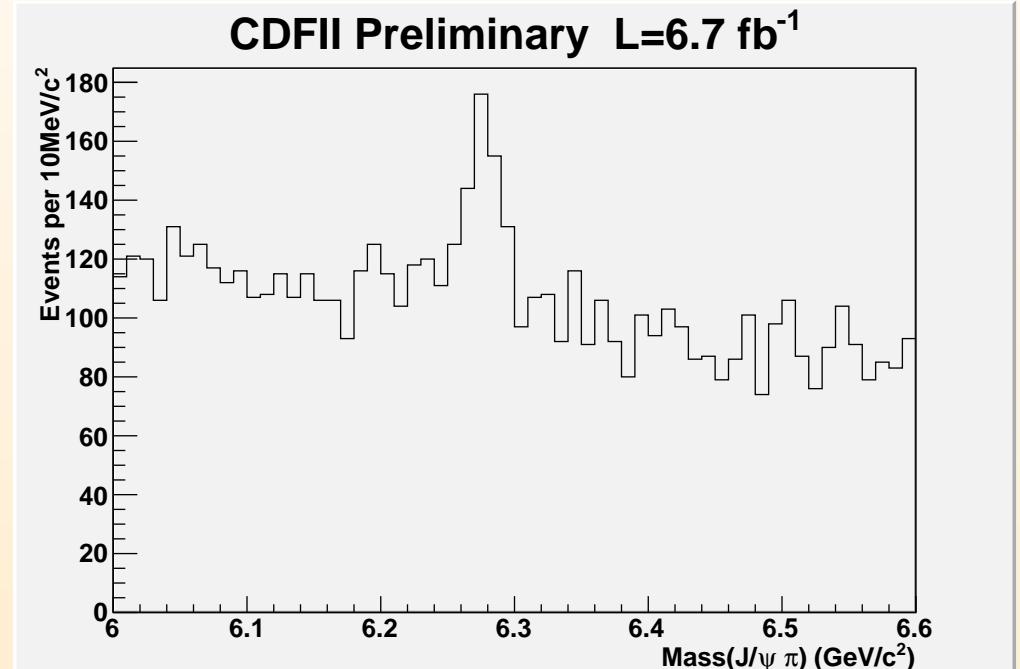


Event Selection

Use 6.7 fb^{-1} dataset, with selections that give better S/N

Event Selection

- $\text{Pt}(\pi) > 2.0 \text{ GeV}/c$
- $\text{Pt}(B) > 6.5 \text{ GeV}/c$
- $\text{Prob}(\chi^2) > 0.001$
- $|ip(B)| \text{ WRT PV} < 2 \sigma$
- $c\tau > 80 \mu\text{m}$
- $\sigma(c\tau) < \max(65-3*\text{Pt}(B), 35) \mu\text{m}$
- Pointing angle $\beta_t < 0.2$
- Isolation > 0.6
- $\sigma(M_B) < 40 \text{ MeV}/c^2$
- $|M_{\mu\mu} - M_{J/\psi}| < 80 \text{ MeV}/c^2$





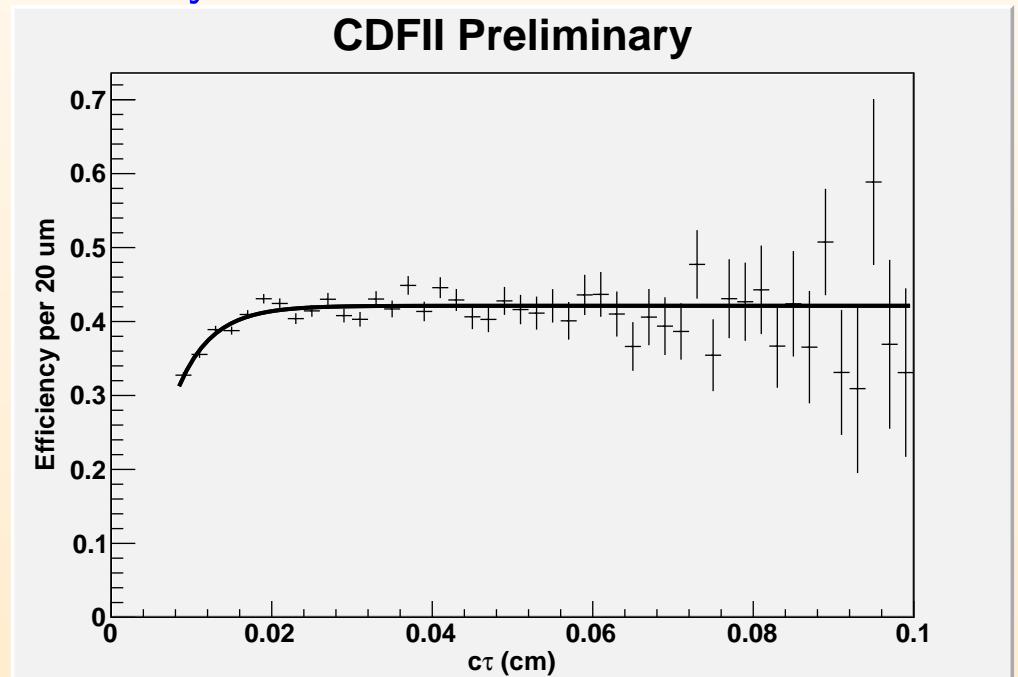
Selection Efficiency

Use 6.7 fb^{-1} dataset, with selections that give better S/N

Event Selection

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But MC suggests efficiency depends on decay time ...

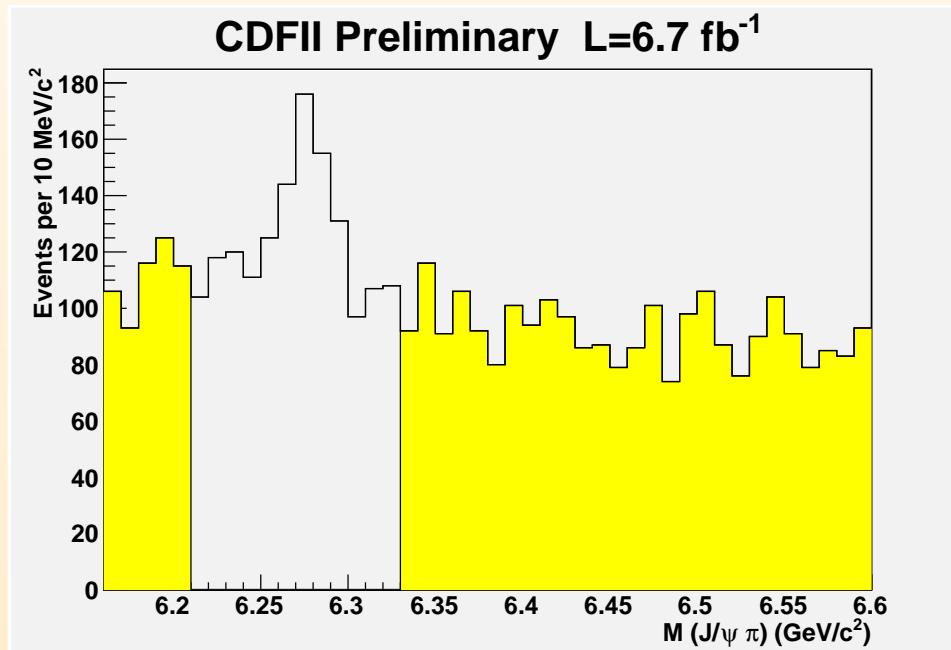




Likelihood Function



$$L = \prod_i [f_s \cdot M_s(m_i) \cdot T_s(c\tau_i) + (1 - f_s) \cdot M_b(m_i) \cdot T_b(c\tau_i)]$$



$M_s(m_i)$: Gaussian distribution for signal mass.

$T_s(c\tau_i)$: exponential convoluted with resolution, multiplied by efficiency for signal decay time.

$M_b(m_i)$: linear function for background mass.

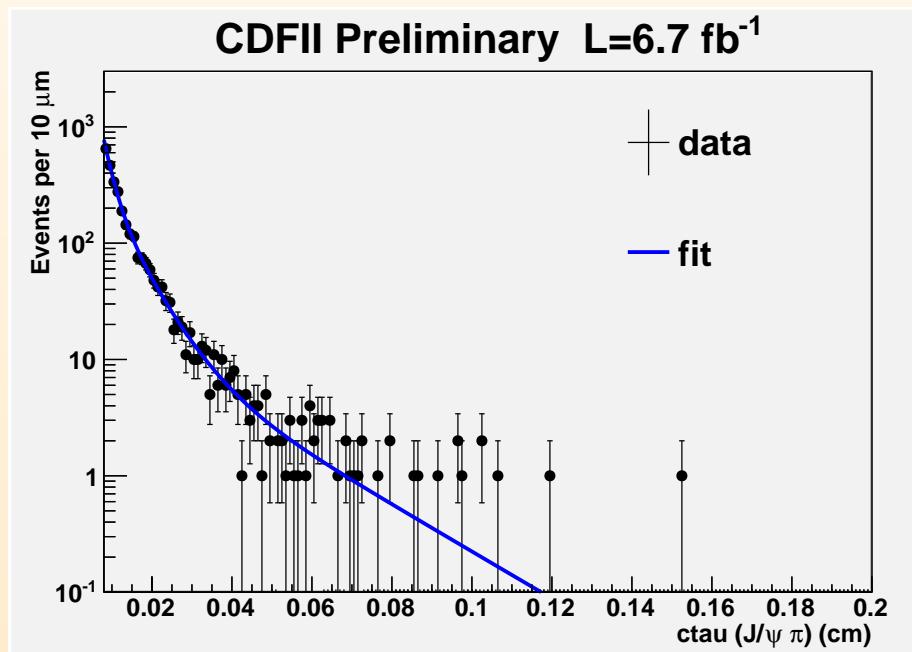
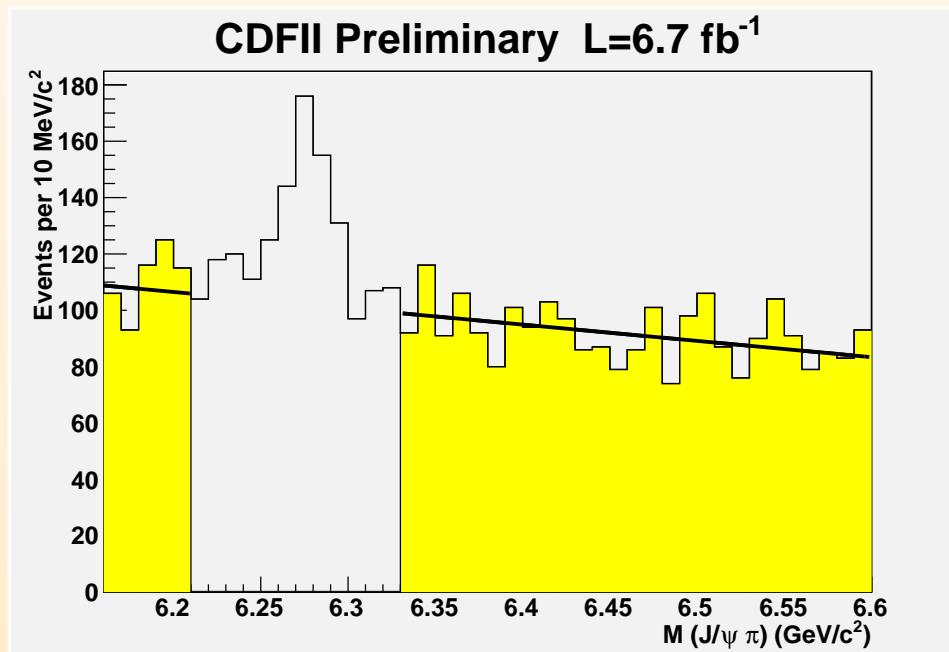
$T_b(c\tau_i)$: combination of 3 exponentials for background decay time.



Sideband Fit

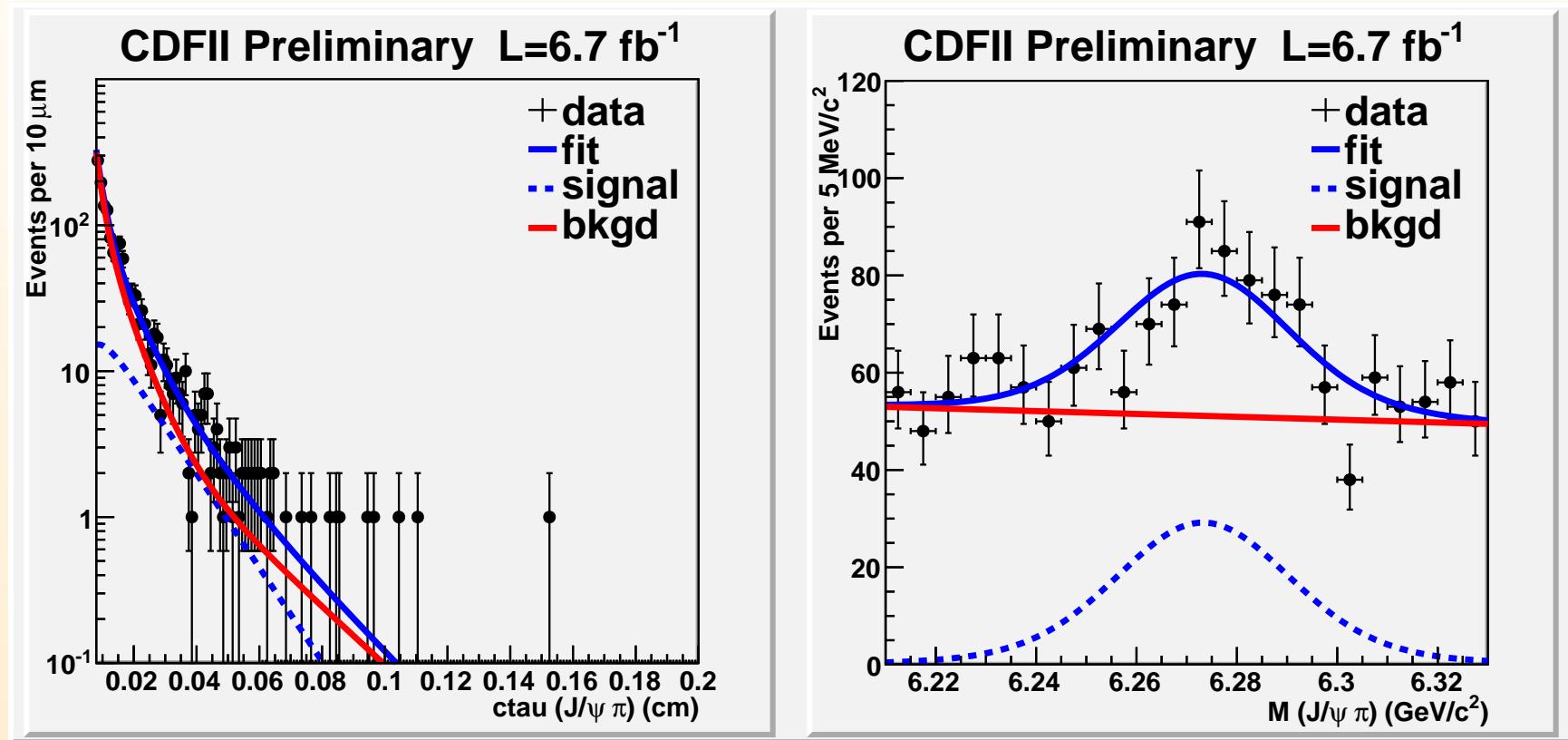


$$L = \prod_i [f_s \cdot M_s(m_i) \cdot T_s(c\tau_i) + (1 - f_s) \cdot M_b(m_i) \cdot T_b(c\tau_i)]$$





Final Result

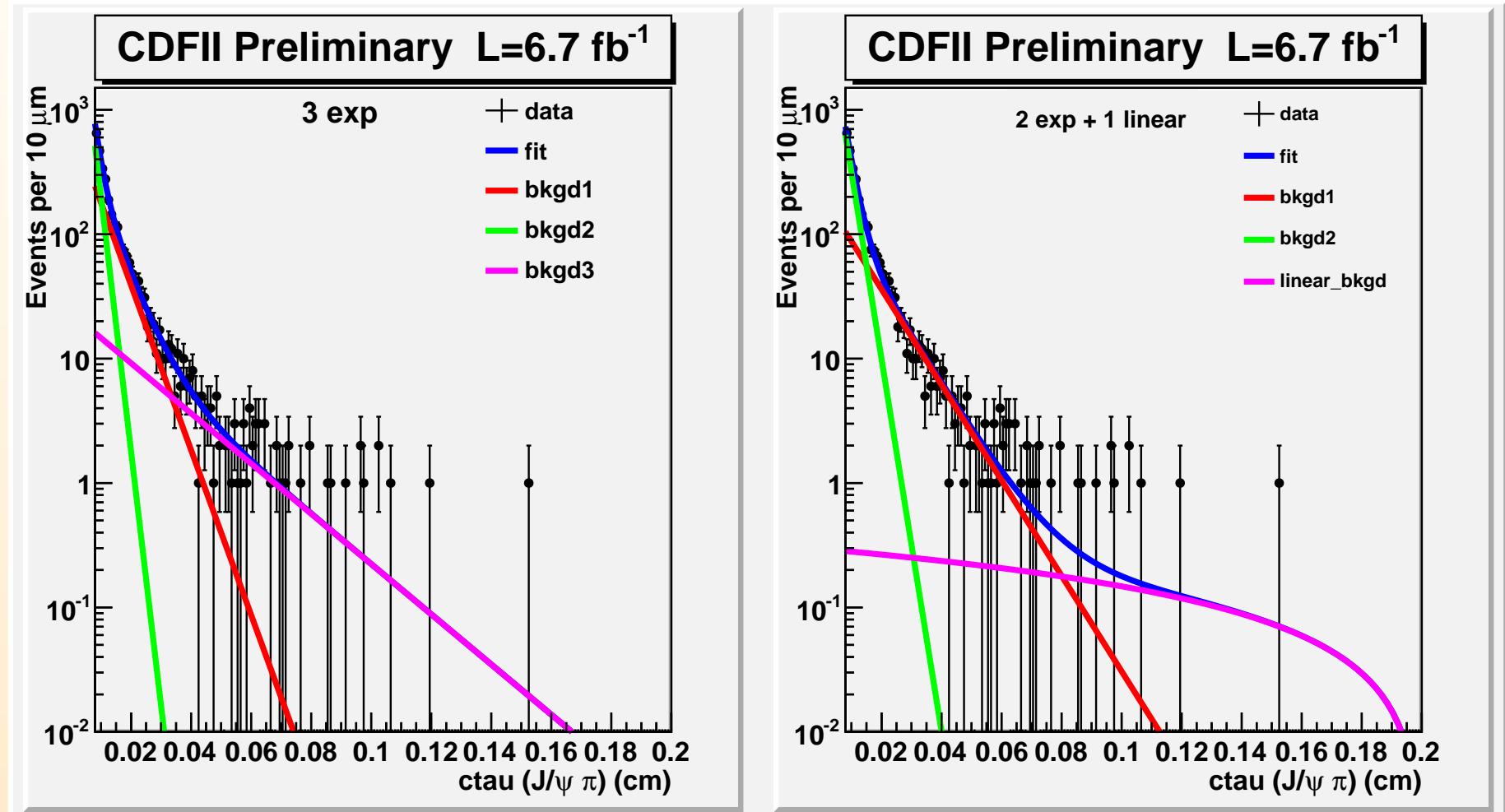


$$c\tau(B_c) = 136 \pm 14 \quad \mu\text{m}$$

$$\tau(B_c) = 0.452 \pm 0.048 \quad \text{ps}$$



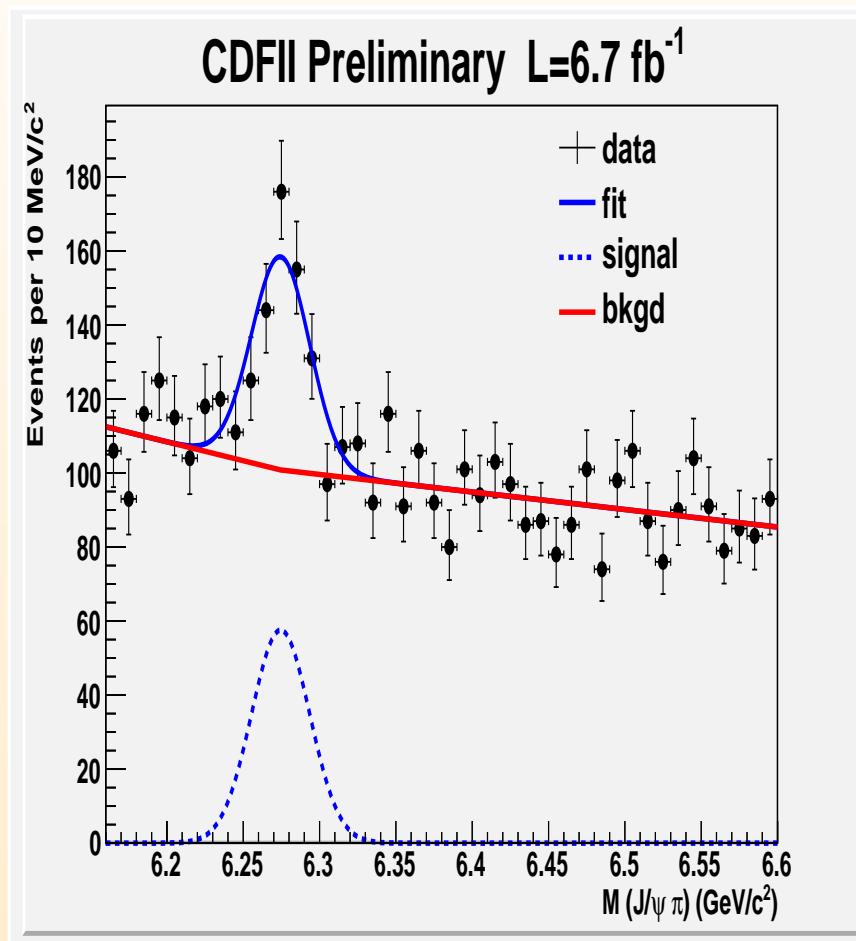
Systematics



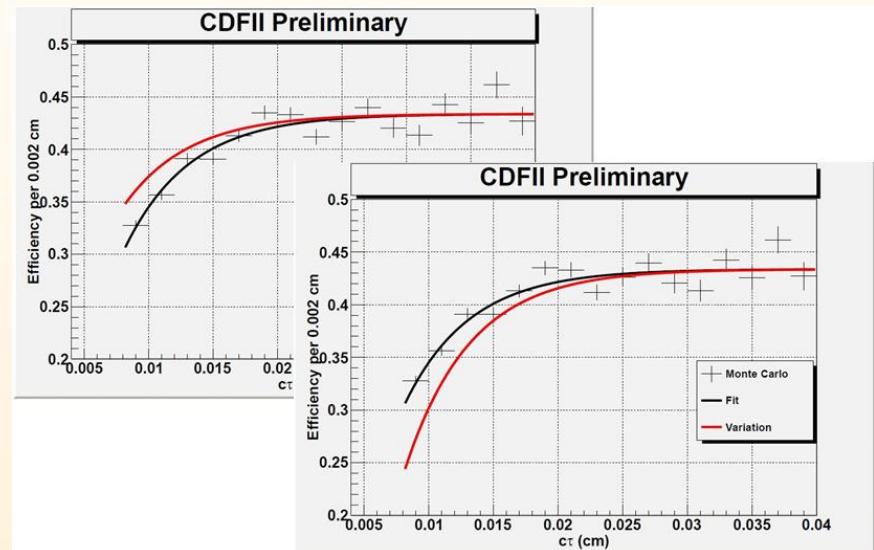
$4 \mu\text{m}$ variation from bkgd $c\tau$ model



Systematics (cont'd)



$5 \mu\text{m}$ variation from bkgd mass model



$3 \mu\text{m}$ variation from signal $c\tau$ model

| Systematic (in μm) | |
|--------------------------------|---|
| Calibration | 2 |
| Signal Mass Model | 1 |
| Signal Decay Time Model | 3 |
| Background Mass Model | 5 |
| Background Decay Time Model | 4 |
| Fitting Method | 1 |
| Other Test | 3 |
| Total | 8 |



Summary

- First B_c lifetime measurement in the channel $B_c \rightarrow J/\psi + \pi$.
- Consistent with previous measurements.

$$c\tau(B_c) = 136 \pm 14 \pm 8 \quad \mu\text{m}$$
$$\tau(B_c) = 0.452 \pm 0.048 \pm 0.027 \quad \text{ps}$$

