CDF Note 7649

Study of $B_c^{\pm} \to \mathrm{J}/\psi + \mu^{\pm} + \mathrm{X}$ in Run II data

The CDF Collaboration
URL http://www-cdf.fnal.gov
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We have performed a search for $B_c^{\pm} \to \mathrm{J}/\psi + \mu^{\pm} + \mathrm{X}$ in 360 pb^{-1} of exclusive J/ψ data from Run II. We have identified and estimated several sources of background in the J/ψ+muon mass window of 4.0-6.0 GeV/c^2, including decay-in-flight and punch-through of pions, kaons and protons, tri-muons arising from the fragmentation of $b\bar{b}$ pairs, and fake J/ψ together with a third muon. Our J/ψ+muon sample of B$_c$ candidates has 106 events with a background of 46.0±7.3 events. The hypothesis that the observed sample can be accounted for by the background is rejected at the level of 5.2 standard deviations. The cross-section times branching ratio for $B_c^{\pm} \to \mathrm{J}/\psi + \mu^{\pm} + \nu$ relative to $B^{\pm} \to \mathrm{J}/\psi + \mathrm{K}^{\pm}$ is measured and found to be 0.245±0.045(stat.)±0.066(syst.)$^{+0.080}_{-0.032}$(life.) for the case where the B p$_T$ is greater than 6.0 GeV/c.

I. INTRODUCTION

This note summarizes the measurement of B$_c$ decays through $B_c^\pm \to \mathrm{J}/\psi + \mu^\pm + \nu$ and estimates the cross-section times branching ratio relative to $B^\pm \to \mathrm{J}/\psi + \mathrm{K}^\pm$ in $\bar{p}p$ collisions at $\sqrt{s} = 1.96$ TeV with the CDF detector at the Fermilab Tevatron. The measurement uses a sample J/ψ di-muon events that are subsequently matched with a third high quality muon. Our cross-section times branching ratio measurement for $B_c^\pm \to \mathrm{J}/\psi + \mu^\pm + \nu$ improves upon measurements made in CDF Run I.

The CDF detector is described in detail in [1]. The parts of the detector important to this analysis are: the SVX (silicon vertexer), the CMU, CMX and CMP (central muon, central muon extension and central muon upgrade detectors) and the COT (central outer tracker).

II. DATA SAMPLE & EVENT SELECTION

The $B_c^\pm \to \mathrm{J}/\psi + \mu^\pm + \nu$ analysis is based on 360 pb^{-1} of integrated luminosity collected using the CDFII detector from March 2002 to June 2004. The data were collected using a di-muon trigger that requires two muons each of which has a p$_T$ > 1.5 GeV/c^2.

A. J/ψ Selection

The di-muon dataset is skimmed for J/ψ events using the cuts listed in Table I. The resulting $\mu\mu$ mass distribution can be seen in Figure 1. We use the signal region of $|M(J/\psi) - 3.09687| < 0.05$ for our B$_c$ search and the sideband regions of $0.10 < |M(J/\psi) - 3.09687| < 0.20$ for background studies.

track	$p_T > 1.5$ GeV/c 3 or more Si $r - \phi$ hits 2 or more axial COT SL 2 or more stereo COT SL
CMU muon	$\chi^2 < 9$
CMX muon	$\chi^2 < 9$
opposite charge	$q_1 \cdot q_2$ = -1

TABLE I: The cuts applied to the J/ψ legs.

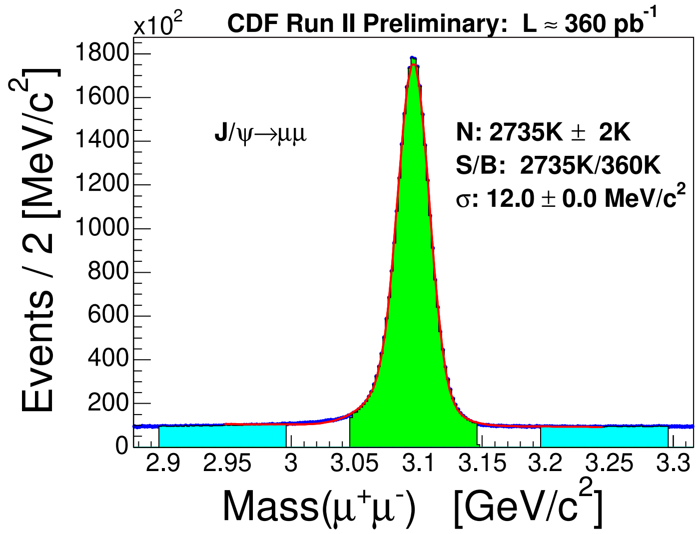

FIG. 1: Distribution of reconstructed mass for J/$\psi \to \mu^+\mu^-$ candidates with a double Gaussian and quadratic polynomial fit superimposed. The green area shows the mass window used in the J/ψ + track search , while the aqua areas show the sideband windows used in the fake J/ψ background calculation.

B. Third Track, Muon Selection

We select J/ψ+track and J/ψ + μ samples using the cut requirements outlined in Table II. The resulting mass distrubtions can be seen in Figure 2. Figure 3 shows the reconstructed J/ψ+K$^{\pm}$ mass which we use for our relative cross section times brancing ratio measurement. We expect our $B_c^{\pm} \rightarrow$ J/ψ + $\mu^{\pm}$ + ν signal to fall into the 4.0-6.0 GeV/c^2 three track mass region as can be seen by the reconstructed J/$\psi\mu$ mass for B$_c$ events generated using BGenerator and shown in Figure 4.

track quality	Si hits:$\geq$3, COT Ax/St hits:$\geq$25
J/ψ	within $\pm$50 MeV/c^2 around peak
third track	$p_T > 3.0$ GeV/c no track within 40 cm at CMU surface fiducial to CMUP
J/ψ + track vertex	J/ψ mass constrained $prob(\chi^2) > 1\%$ lifetime $c\tau > 60\mu$
kinematic	$\Delta\phi < \pi/2$
third muon	above quality requirements must be CMUP muon CMU $\chi^2_x < 9$
remove $B^+ \rightarrow$ J/ψK$^+$	$\lvert M(\mathrm{J}/\psi + \mathrm{K}) - \mathrm{M(B^+)}\rvert > 50$ MeV/c^2

TABLE II: Summary of the cuts used to create J/ψ+track and J/ψ+μ samples.

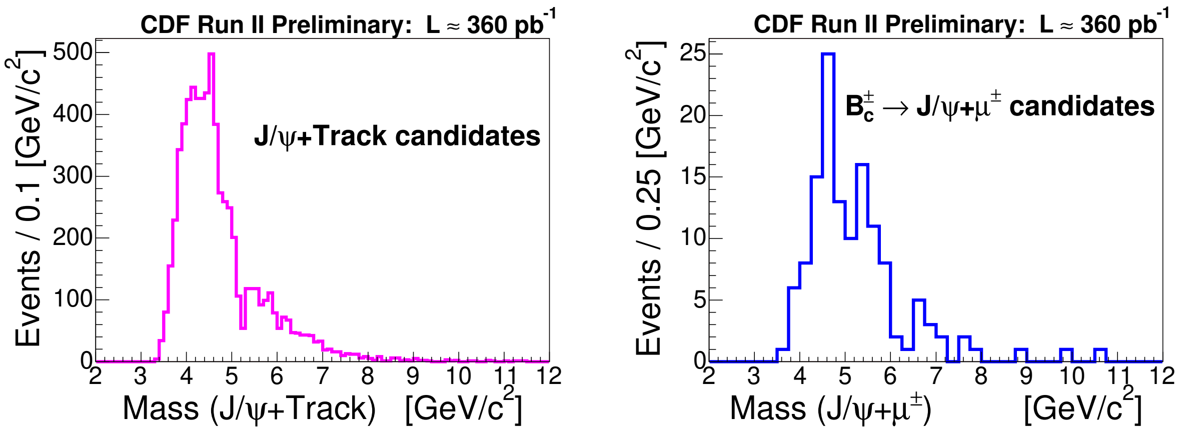

FIG. 2: Left: Three track mass for J/ψ+track sample. Right: Three track mass for J/ψ+μ sample.

III. BACKGROUNDS

Since we are searching for B$_c$ in a semi-leptonic decay channel, we are unable to reconstruct a sharp mass peak, and it is therefore important to accurately estimate background J/ψ+μ events. There are three sources of background events in our sample: fake muon events where a real J/ψ is matched with a track that fakes a muon (usually by decaying-in-flight or punching through to the muon chamber), $b\bar{b}$ events where the J/ψ comes from one b quark while the muon comes from another, and fake J/ψ events where the J/ψ background events are matched with third muons. We summarize our estimates of these backgrounds in the following sections.

A. Fake Muon Background

We estimate the fake muon background by applying fake muon probablilities to third tracks in our J/ψ+track sample. First we determine the particle composition of the third tracks by using dE/dx (energy loss) and TOF (time

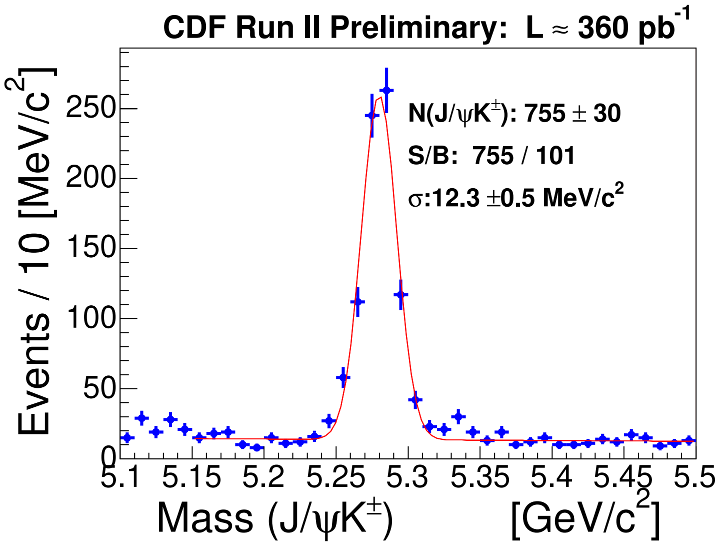

FIG. 3: Mass fit for $B^{\pm} \rightarrow J/\psi K^{\pm}$ events from the J/ψ+track sample

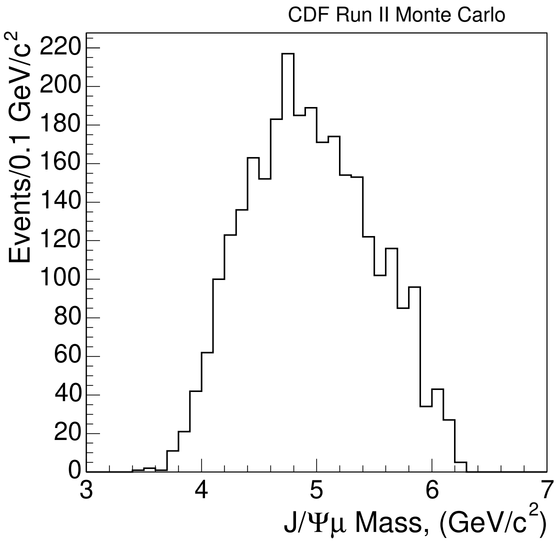

FIG. 4: Reconstructed $J/\psi+\mu$ mass for B_c events generated using BGenerator

of flight) measurements. The extraction of pion fractions using dE/dx can be seen in Figure 5. Kaons and protons are not seperated by dE/dx, so we used TOF (Figure 6) measurements in the 2.0-3.0 GeV/c momentum region to determine a proton fraction of 15% which we then extrapolate into the momentum region occupied by our third tracks. A summary of pion and kaon+proton fractions can be seen in Figure 7.

Having determined the third track particle composition we determine fake muon probablilites for the kaons, pions and protons that make up the third track sample. For kaons and pions we look at $D^{*+} \rightarrow D^0\pi^+ \rightarrow K^-\pi^+\pi^+$ decays where the pions and kaons from the D^0 decay are positively identified by the sign of the bachelor pion from the D^{*+} decay. We look for D^0 daughters that are identified as muons to determine our fake muon rate. The D^0 mass peaks before and after muon matching can be seen in Figure 8. For protons we place an upper limit on the fake muon rate by looking at $\Lambda \rightarrow p\pi$ decays where the proton is identified as the higher momentum particle. A summary of the fake rates can be seen in Figure 9.

We apply the particle fractions and fake muon rates to the the J/ψ+track sample. In the 4.0-6.0 GeV/c^2 mass window we see a predicted background of 16.3±2.9 events.

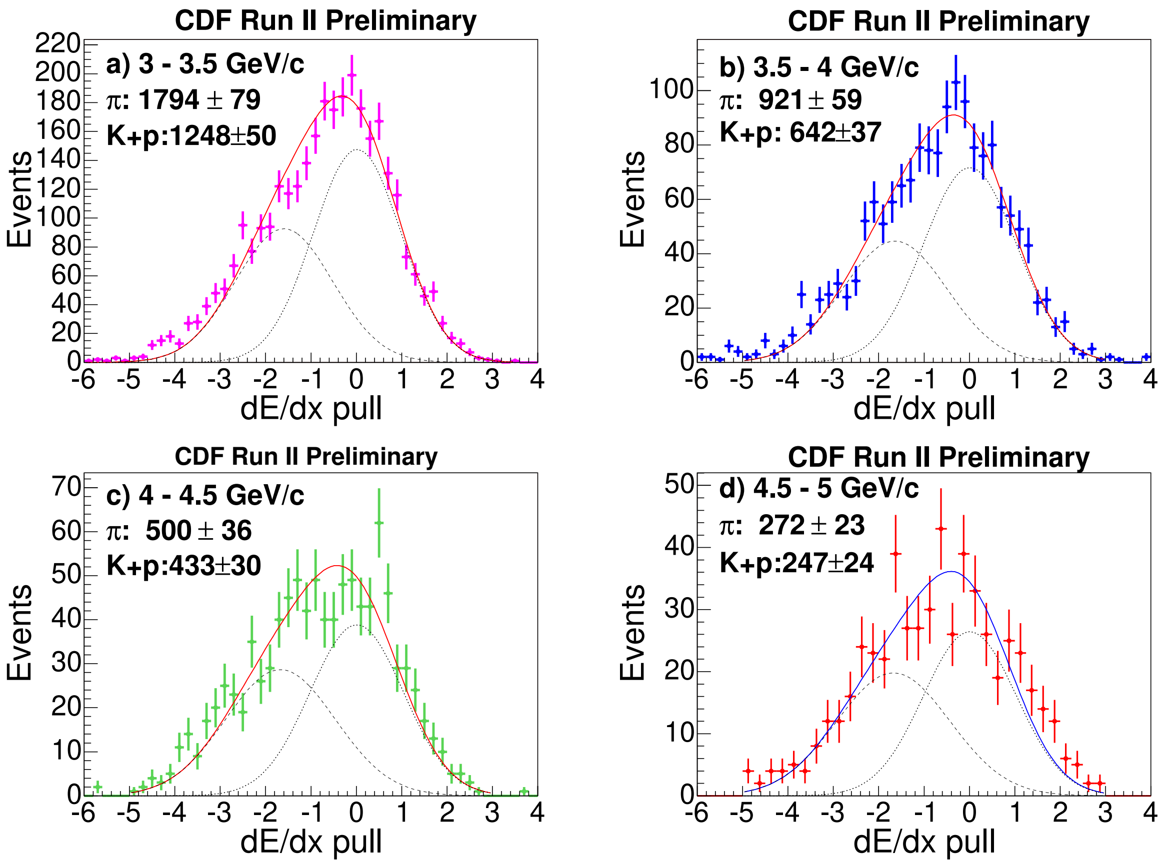

FIG. 5: The dE/dx significance distributions $\left(\frac{dE/dx - \langle dE/dx\rangle_\pi}{\sigma_\pi}\right)$ for 3-5 GeV/c momentum ranges of tracks in the $J/\psi + track$ sample.

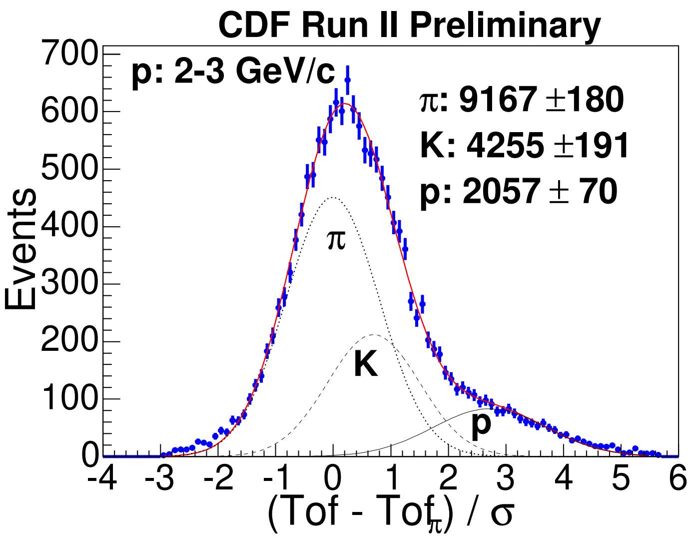

FIG. 6: Tof pull distribution for the tracks from $J/\psi + track$ sample. This data is evidence for a combined $p/\bar{p}$ contribution of $\sim 15\%$.

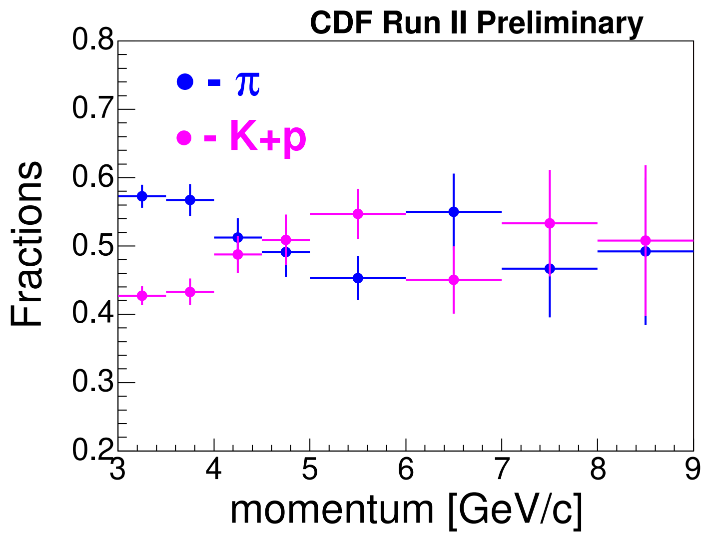

FIG. 7: The fractions of π and combined $(K+p)$ particles on the J/ψ + track sample within 3-9 GeV/c region. F_π is derived from the fit and $F_{(K+p)} = 1 - F_\pi$. For further analysis we assign that $F_{p/\bar{p}}$=0.15±0.04, $F_K = 1 - F_\pi - F_{p/\bar{p}}$.

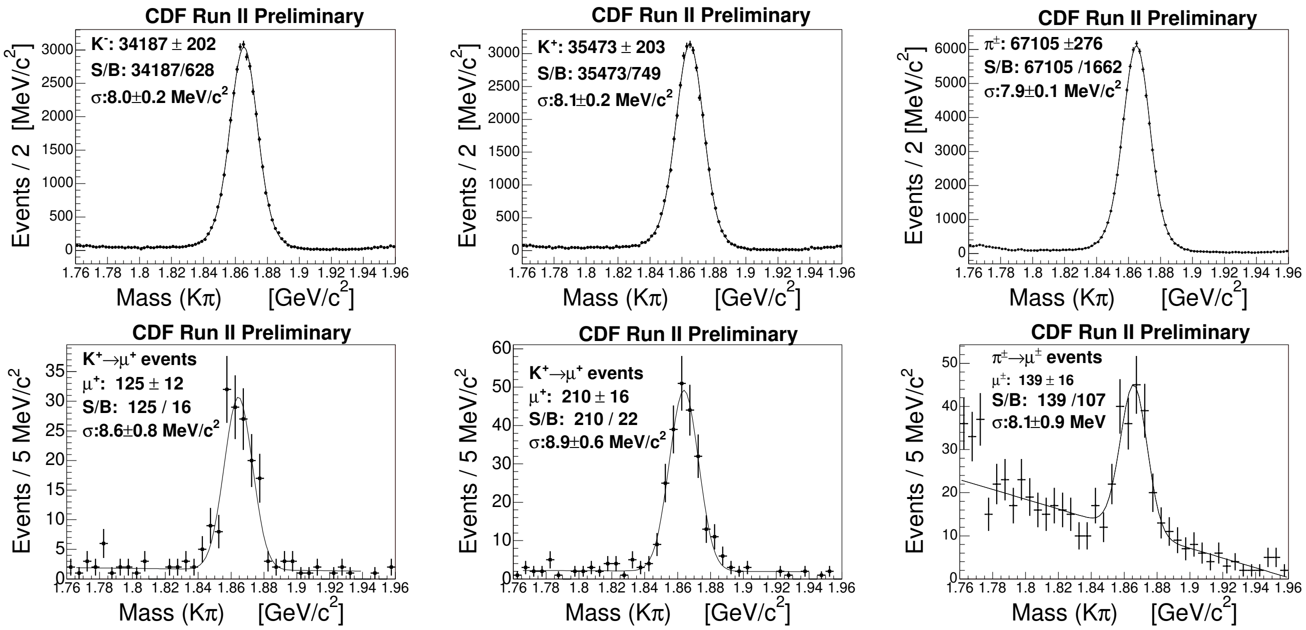

FIG. 8: Top Left: D^0 mass distribution for K$^-$ legs. Top Center: D^0 mass distribution for K$^+$ legs. Top Right: D^0 mass distribution for $\pi^\pm$ legs. Bottom Left: D^0 mass distribution for K$^-$ legs identified as muons. Bottom Center: D^0 mass distribution for K$^+$ legs identified as muons. Bottom Right: D^0 mass distribution for $\pi^\pm$ legs identifed as muons.

B. $b\bar{b}$ Background

We estimate the $b\bar{b}$ background using a Pythia Monte Carlo sample of $p\bar{p} \to b\bar{b}$ events and normalize to data using the $B^\pm \to$ J/ψ + K$^\pm$ mass peak. A large source of systematic error in the Pythia prediction is uncertainty of the relative cross sections for different QCD processes that produce $b\bar{b}$. The Pythia Monte Carlo produces $b\bar{b}$ by the following highest order QCD processes: flavor creation (FC) where two quarks or gluons annihilate to produce $b\bar{b}$, flavor excitation (FE) where a b quark from a $b\bar{b}$ pair in the sea scatters off of a parton, and gluon splitting (GS) where a gluon scatters and then splits to a $b\bar{b}$ pair. We study the Pythia sample's agreement with data by fitting the $\Delta\phi$ distribution for unvertexed J/$\psi\mu$ events in Pythia to data while allowing the relative fractions of FC, FE and GS in Pythia to float.

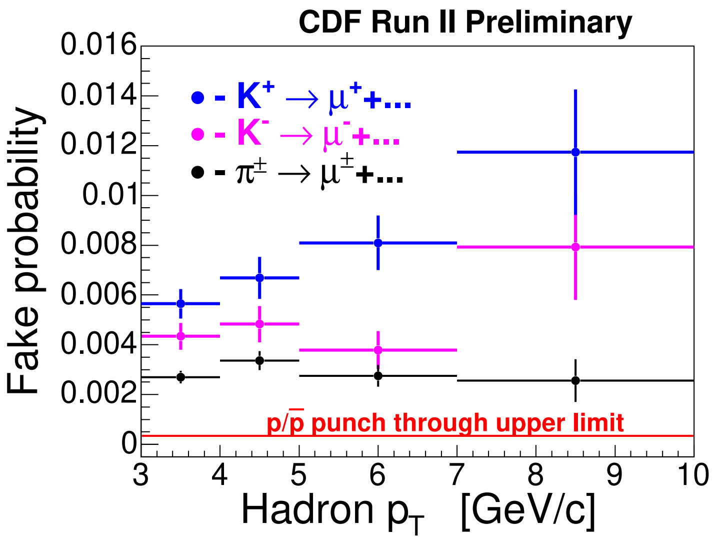

FIG. 9: Summary of fake muon probablilites

Before fitting the Pythia $\Delta\phi$ distributions to data we fit individual $\Delta\phi$ templates for FC, FE and GS which can be seen in Figure 10. The unvertexed $J/\psi\mu$ also contains contributions from fake muon, fake J/ψ, fake muon + fake J/ψ and $B_c \rightarrow J/\psi\mu$ events. We fit templates for these additional sources and estimate the size of their contributions (except for B_c). The templates can be seen in Figure 11.

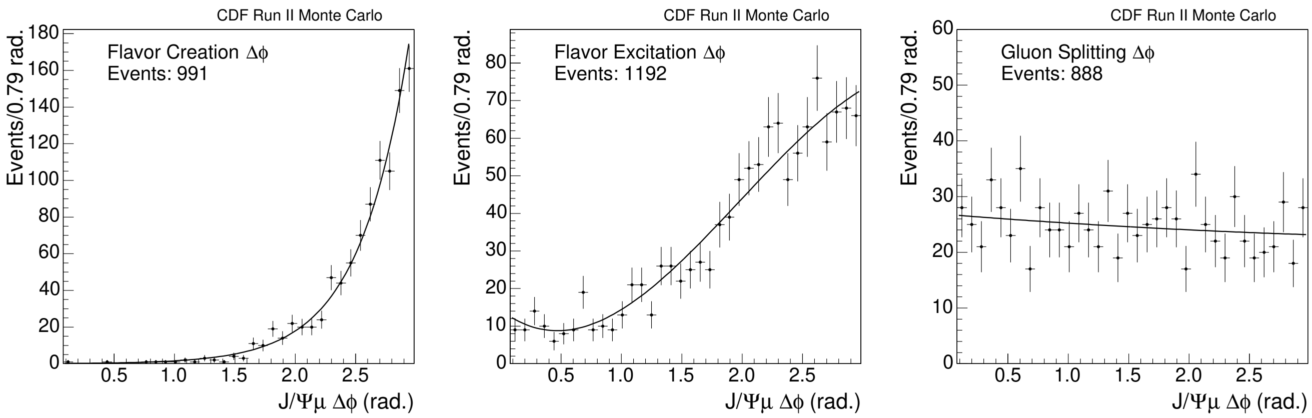

FIG. 10: $J/\psi\mu$ $\Delta\phi$ distributions and template fits for Pythia QCD processes. Left: Flavor creation. Center: Flavor Excitation. Right Gluon Splitting.

Fitting the $\Delta\phi$ templates to data, we see the fit results shown in Figure 12 and extract scale factors for FC, FE and GS which can be seen in Table III. All three scale factors are consistent with 1, so we use the default Pythia sample to estimate the $b\bar{b}$ background. We estimate the sytematic uncertainty using the uncertainties from our $\Delta\phi$ study. We predict a $b\bar{b}$ background of 12.7±1.7(stat.)±5.7(syst.) in the 4.0-6.0 GeV/c^2 mass window.

QCD Process	Default Pythia Fractions (Generator)	Default Pythia Fractions ($J/\psi + \mu$)	Fit Fractions ($J/\psi + \mu$)	Scale Factors
Flavor creation (FC)	26.0%	32.3%	$29.1 \pm 6.6\%$	0.90 ± 0.21
Flavor excitation (FE)	52.2%	38.9%	$31.5 \pm 14.2\%$	0.81 ± 0.37
Gluon splitting (GS)	21.8%	29.0%	$39.5 \pm 11.2\%$	1.36 ± 0.39

TABLE III: Pythia QCD process fractions before $\Delta\phi$ fitting and fractions and scale factors after fitting.

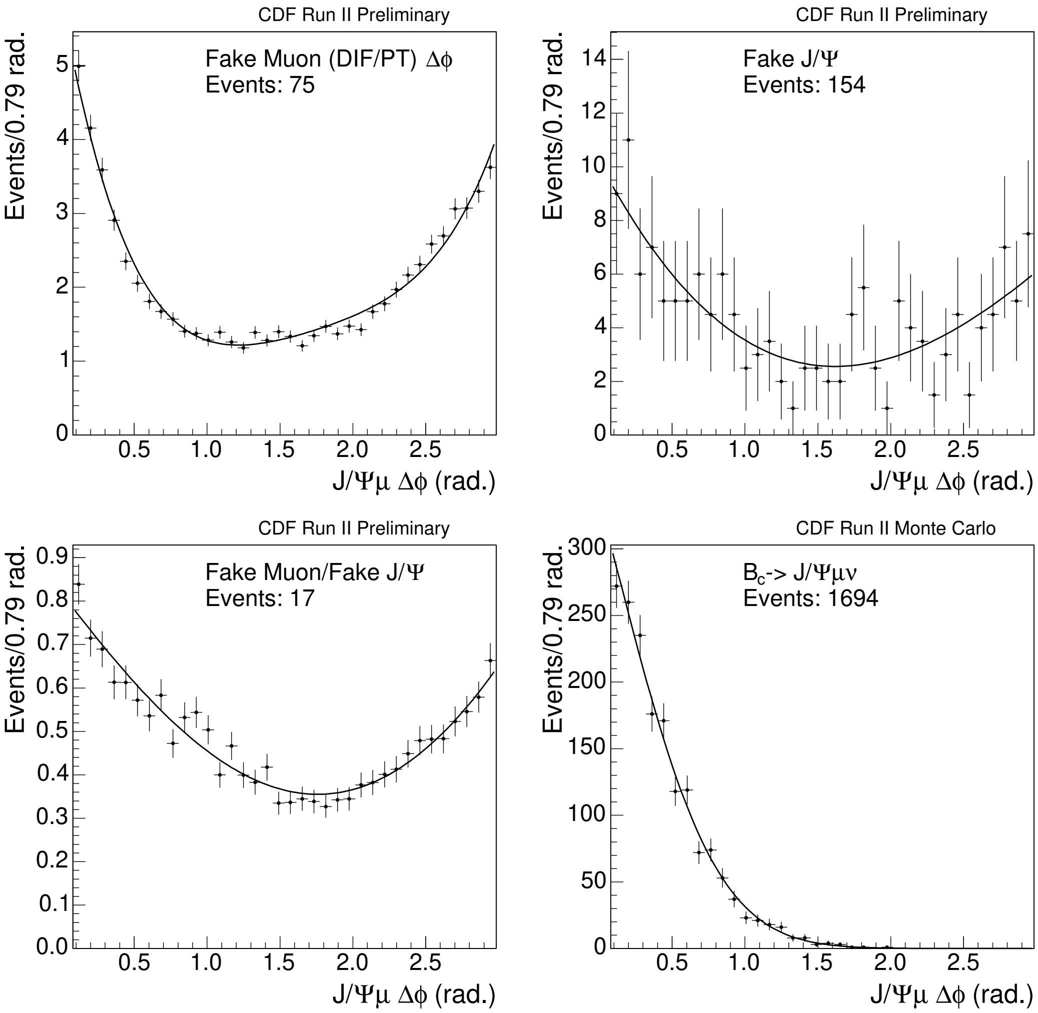

FIG. 11: $\Delta\phi$ distributions for other sources of J/$\psi\mu$ and template fits. Top Left: Fake muon. Top Right: Fake J/ψ. Bottom Left: Fake muon + Fake J/ψ. Bottom Right: $B_c \to$J/$\psi\mu$.

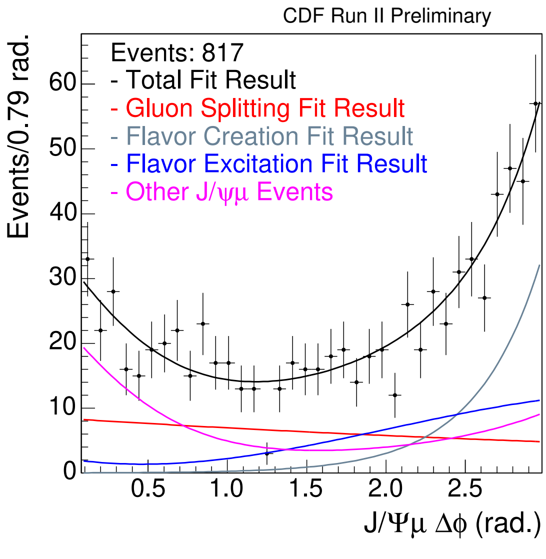

FIG. 12: Results fitting J/$\psi\mu$ $\Delta\phi$ distributions from Pythia to data.

C. Fake J/ψ Background

To estimate the fake J/ψ background we look at the sidebands of the J/ψ mass distribution and match a third muon to events that fall into the sideband regions. Figure 13 shows the J/ψ mass distribution for events matched with a third muon for both the signal and sideband regions. Using the sideband regions we estimate the Fake J/ψ background to be 19.0±3.0 events for the 4.0-6.0 GeV/c^2 mass region.

We also must account for double counting of events that contain both a fake J/ψ and a fake muon. We do this by appling our fake muon rates to J/ψ sideband events matched with a third track. We estimate this double counting to be 2.0±0.5 events in the 4.0-6.0 GeV/c^2 mass region.

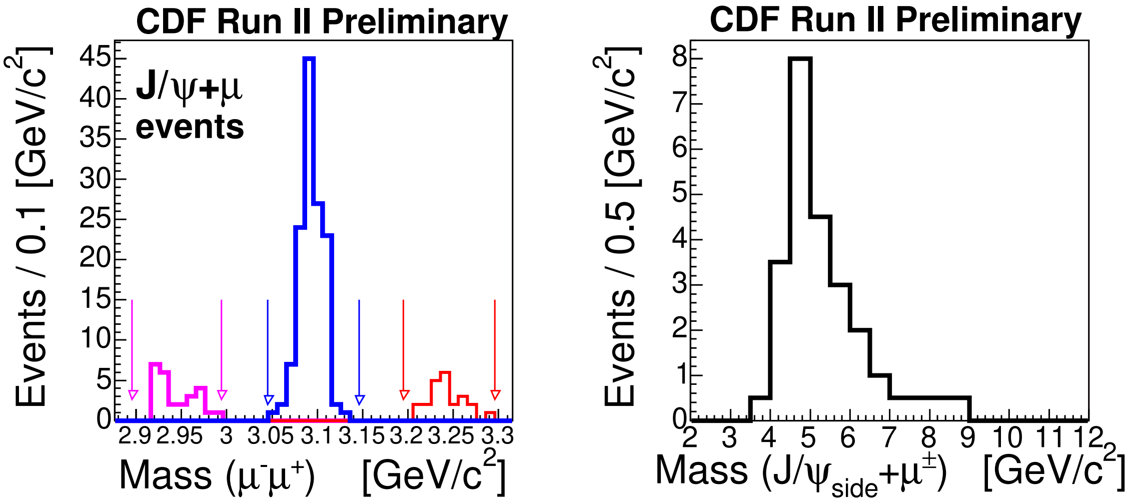

FIG. 13: Left: J/ψ mass distribution for signal and sideband events matched with third muon. Right: J/ψ mass distribution for fake J/ψ events.

IV. RELATIVE EFFICIENCY FOR CROSS-SECTION CALCULATION

To estimate the $B_c^\pm \to \mathrm{J}/\psi + \mu^\pm + \nu$ cross-section time branching ratio relative to $B^\pm \to \mathrm{J}/\psi + \mathrm{K}^\pm$ we must first calculate the efficiencies to recontruct both $B_c^\pm \to \mathrm{J}/\psi + \mu^\pm + \nu$ and $B^\pm \to \mathrm{J}/\psi + \mathrm{K}^\pm$ events in our analysis chain. Table IV summarizes the efficiences for our analysis cuts on $B_c^\pm \to \mathrm{J}/\psi + \mu^\pm + \nu$ and $B^\pm \to \mathrm{J}/\psi + \mathrm{K}^\pm$. We define a relative efficiency, $\epsilon_{rel} = \frac{\epsilon_B}{\epsilon_{B_c}}$. Table V summarizes the corrections we make to ϵ_{rel} and the sources of systematic error. Applying the corrections we estimate ϵ_{rel}=3.29±0.11(stat.)±0.81(syst.)$\pm^{1.08}_{0.43}$(life.).

cut	$B^\pm \to \mathrm{J}/\psi + \mathrm{K}^\pm$	$B_c^\pm \to \mathrm{J}/\psi + \mu^\pm$
J/ψ within ±50 MeV/c^2	0.948	0.901
$prob(\chi^2) > 1\%$	0.917	0.909
life time $c\tau > 60\mu m$	0.885	0.641
hemisphere cut	1.000	0.978
has $p_T > 3.0$ GeV/c	0.591	0.448
is fiducial	0.456	0.449
is isolated	0.884	0.859
total MC events	185878	819575
J/$\psi \to \mu^+\mu^-$ reconstructed	39474	163532
events in signal region	1806	2494
total cut efficiency	0.0457	0.0153

TABLE IV: The selection cut efficiencies.

Error source, Correction and Uncertainty for ϵ_{rel}		
MC statistics	none	3.1%
Production spectrum	none	23.5%
Detector simulation	1.031	2.5%
XFT efficiency	none	7.0%
Trigger simulation	1.013	1.2%
Total	1.044	±3.1%(stat.)±24.7%(syst.)

TABLE V: Errors and corrections associated with the $B^{\pm} \to \mathrm{J}/\psi + \mathrm{K}^{\pm}$ and $B_c^{\pm} \to \mathrm{J}/\psi + \mu^{\pm}$ efficiency calculations. The errors and corrections are for the quantity $\epsilon_{rel} = \epsilon_B/\epsilon_{B_c}$

Mass window	$3.0 - 4.0$ GeV/c^2	$4.0 - 6.0$ GeV/c^2 (signal)	$6.0 - 10.0$ GeV/c^2
B_c candidates in mass window	7 ± 2.4	106 ± 10.3	19 ± 4.2
Fake muon background	3.9±0.7	16.3±2.9	2.2±0.4
BB background	$0.6 \pm 0.4 \pm 0.1$	$12.7 \pm 1.7 \pm 5.7$	$6.0 \pm 1.1 \pm 1.8$
Fake J/ψ background	0.5 ± 0.5	19.0 ± 3.0	5.0 ± 1.7
Fake μ from $(J/\psi_{side} + Trk)$	0.3±0.1	2.0±0.5	0.7±0.2
Total Background	4.7±0.9	46.0±7.3	12.5±2.7
Events above background	2.5±2.8	60.0±12.6	6.5±5.1

TABLE VI: Summary of background estimates and data for J/$\psi\mu$ mass windows

V. SUMMARY OF SYSTEMATIC UNCERTAINTIES

Our primary source of systematic uncertainty in the background estimate comes from the uncertainties in the fractional cross sections for FC, FE and GS in the Pythia sample that we use to estimate the $b\bar{b}$ background. This leads to an uncertainty of 5.7 events. The fake muon estimate contains systematic uncertainties from two major sources: the estimate of the proton fraction in the third track sample and the affect of decay-in-flight events that move out of the D^0 peak on the fake muon rates. These sources account for a systematic error of 2.1 events in the fake muon estimate. The fake J/Ψ background estimate's error is dominated by the statistical uncertianty of the small sample of sideband J/Ψ events that get matched with a muon.

The sources of systematic uncertainty for our relative cross-section times branching ratio estimate are contained within the relative efficiency ϵ_{rel} for reconstructing $B^{\pm} \to \mathrm{J}/\psi + \mathrm{K}^{\pm}$ and $B_c^{\pm} \to \mathrm{J}/\psi + \mu^{\pm}$. Table V summarizes the uncertainties for ϵ_{rel} with the largest source coming from the uncertainty in the spectrum of B$_c$ events. Another large source of uncertainty in ϵ_{rel} is the B$_c$ lifetime which was measured in Run I to be $0.46^{+0.18}_{-0.16}$ ps [2].

VI. RESULTS

Figure 14 shows the J/$\psi\mu$ mass distrubutions for the the backgrounds, and the observed events. We observe a clear a signal above background, which is summarized in Table VI. In the 4.0-6.0 GeV/c^2 mass region we see 60.0±12.6 events above background. This corresponds to a significance of 5.2σ.

We estimate the relative cross-section times branching ration using the following formula:

$$\frac{\sigma(B_c^{\pm}) * BR(B_c^{\pm} \to J/\psi\mu^{\pm}\nu)}{\sigma(B^{\pm}) * BR(B^{\pm} \to J/\psi K^{\pm})} = \frac{N_{B_c}}{N_B}\epsilon_{rel}$$

We calculate ϵ_{rel}, N_{B_c} and N_B for the two cases: $p_T(B) > 4.0\ GeV/c$ and $p_T(B) > 6.0\ GeV/c$. The results of the calculations for these two cases can be seen in Table VII.

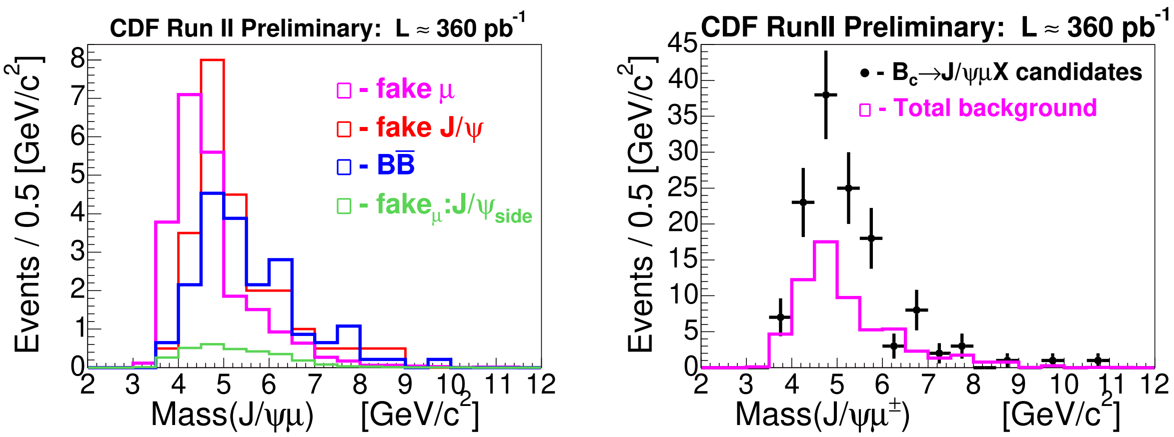

FIG. 14: Left: J/ψ+μ mass for background estimates. Right: J/ψ+μ mass for total background and data.

	$p_T(B)$ >0 GeV/c	$p_T(B)$ >4 GeV/c	$p_T(B)$ >6 GeV/c
B_c candidates	106 ± 10.3	104 ± 10.2	89 ± 9.4
$B^{\pm} \rightarrow \mathrm{J}/\psi + \mathrm{K}^{\pm}$	755 ± 30	755 ± 30	709 ± 28
Fake muon background	16.3±2.9	16.1±2.9	14.1±2.6
BB background	$12.7 \pm 1.7 \pm 5.7$	$12.7 \pm 1.7 \pm 5.7$	$8.4 \pm 1.1 \pm 3.7$
Fake J/ψ background	19.0 ± 3.0	18.0 ± 3.0	15.0 ± 2.7
Fake μ from $(J/\psi_{side} + Trk)$	2.0±0.5	1.9±0.5	1.4±0.3
Total Background	46.0±7.3	44.9±7.3	36.1±5.4
Events above background	60.0±12.6	59.1±12.5	52.9±10.8
$\frac{\epsilon_{B^+}}{\epsilon_{B_c}}$	$\frac{0.0457}{0.0153} = 2.99$	$\frac{0.0455}{0.0151} = 3.01$	$\frac{0.0417}{0.0134} = 3.11$
ϵ_{rel} (corrected)	$3.16 \pm 0.10 \pm 0.78 \pm^{1.04}_{0.42}$	$3.18 \pm 0.10 \pm 0.79 \pm^{1.04}_{0.42}$	$3.29 \pm 0.11 \pm 0.81 \pm^{1.08}_{0.43}$
$\frac{\sigma(B_c) \cdot BR(B_c \rightarrow \mathrm{J}/\psi\mu\mathrm{X})}{\sigma(B^+) \cdot BR(B^+ \rightarrow \mathrm{J}/\psi\mathrm{K}^+)}$		$0.249 \pm 0.045 \pm 0.069 \pm^{0.082}_{0.033}$	$0.245 \pm 0.045 \pm 0.066 \pm^{0.080}_{0.032}$

TABLE VII: Summary of cross-section calculations.

Acknowledgments

We thank the Fermilab staff and the technical staffs of the participating institutions for their vital contributions. This work was supported by the U.S. Department of Energy and National Science Foundation; the Italian Istituto Nazionale di Fisica Nucleare; the Ministry of Education, Culture, Sports, Science and Technology of Japan; the Natural Sciences and Engineering Research Council of Canada; the National Science Council of the Republic of China; the Swiss National Science Foundation; the A.P. Sloan Foundation; the Bundesministerium fuer Bildung und Forschung, Germany; the Korean Science and Engineering Foundation and the Korean Research Foundation; the Particle Physics and Astronomy Research Council and the Royal Society, UK; the Russian Foundation for Basic Research; the Comision Interministerial de Ciencia y Tecnologia, Spain; and in part by the European Community's Human Potential Programme under contract HPRN-CT-20002, Probe for New Physics.

[1] F. Abe, et al., Nucl. Instrum. Methods Phys. Res. A **271**, 387 (1988); D. Amidei, et al., Nucl. Instum. Methods Phys. Res. A **350**, 73 (1994); F. Abe, et al., Phys. Rev. D **52**, 4784 (1995); P. Azzi, et al., Nucl. Instrum. Methods Phys. Res. A **360**, 137 (1995); The CDFII Detector Technical Design Report, Fermilab-Pub-96/390-E

[2] F. Abe, et al., Observation of B_c mesons in $p\bar{p}$ collisons at $\sqrt{s} = 1.8\ TeV$, Phys. Rev. **D58**, 112004 (1998).

Additional Plots and Tables

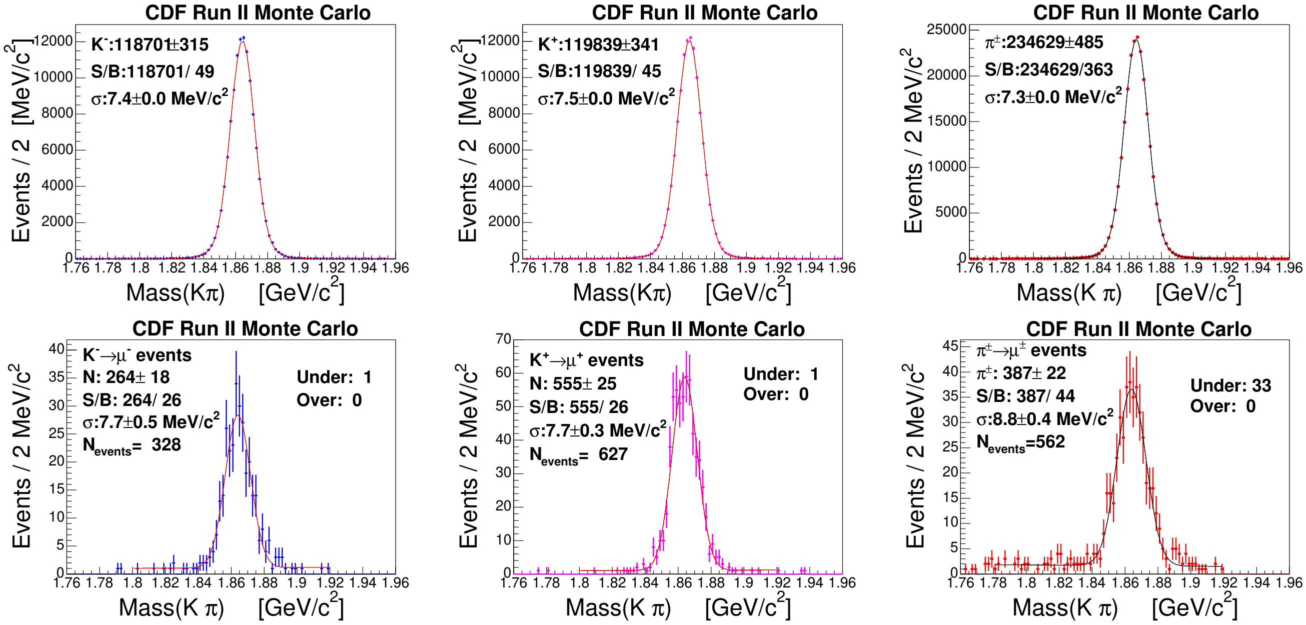

FIG. 15: D^0 distributions generated using BGenerator. Top Left: D^0 mass distribution for K^- legs. Top Center: D^0 mass distribution for K^+ legs. Top Right: D^0 mass distribution for $\pi^\pm$ legs. Bottom Left: D^0 mass distribution for K^- legs identified as muons. Bottom Center: D^0 mass distribution for K^+ legs identified as muons. Bottom Right: D^0 mass distribution for $\pi^\pm$ legs identifed as muons.

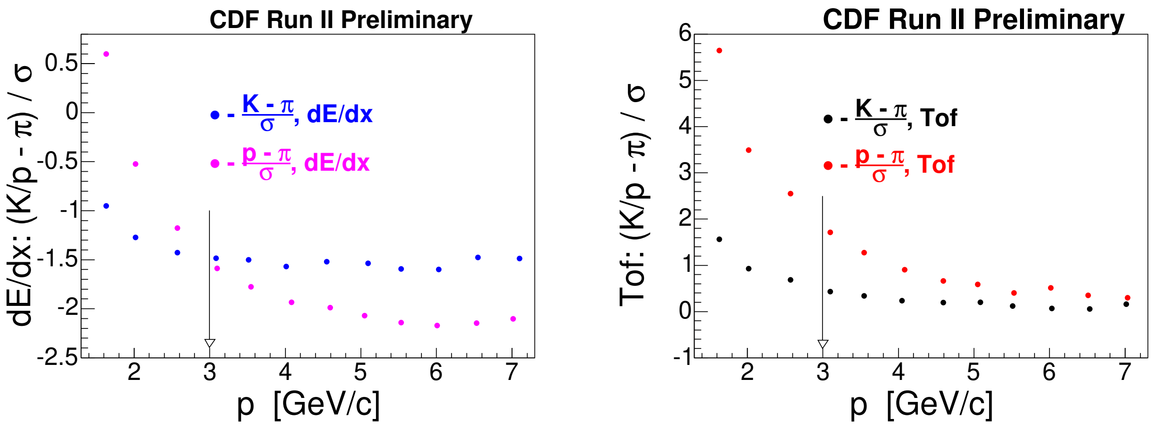

FIG. 16: Left: Pion, kaon and proton seperation in dE/dx as a function of momentum. Right: Pion, kaon and proton seperation in TOF as a function of momentum.

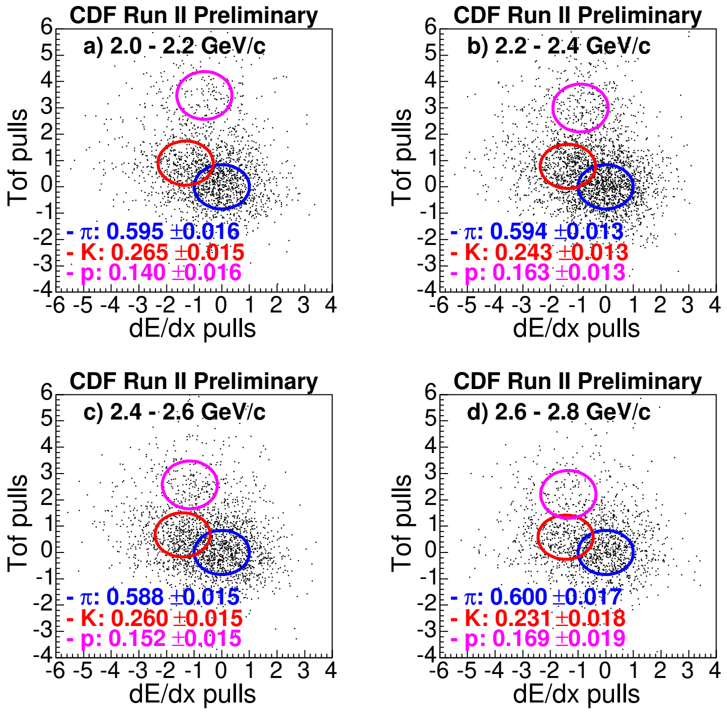

FIG. 17: The dE/dx vs Tof significance ditributions for the J/ψ + track sample within: a)2.0-2.2 GeV/c, b)2.2-2.4 GeV/c, c)2.4-2.6 GeV/c and d)2.6-2.8 GeV/c momentum regions.

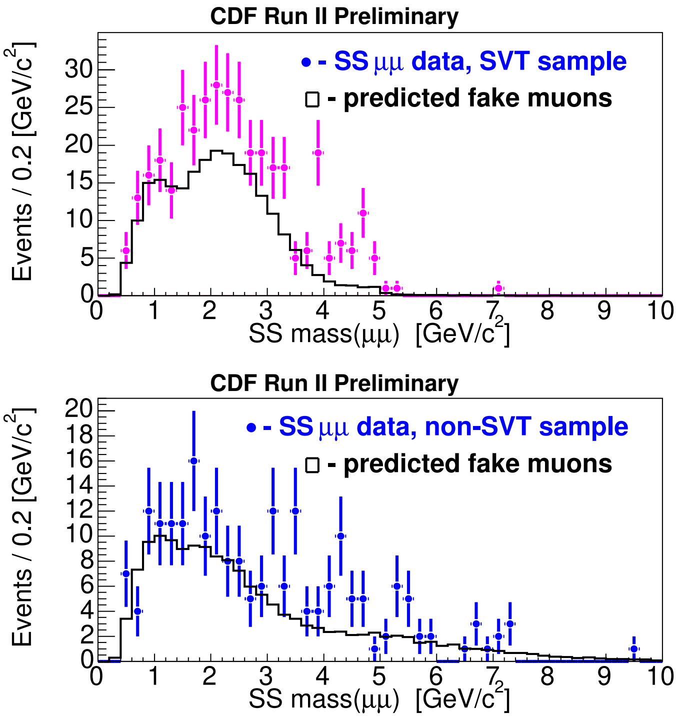

FIG. 18: Same sign muon mass distributions and the predicted fake muon distributions. Top: SVT tracks. Bottom: Non-SVT tracks.

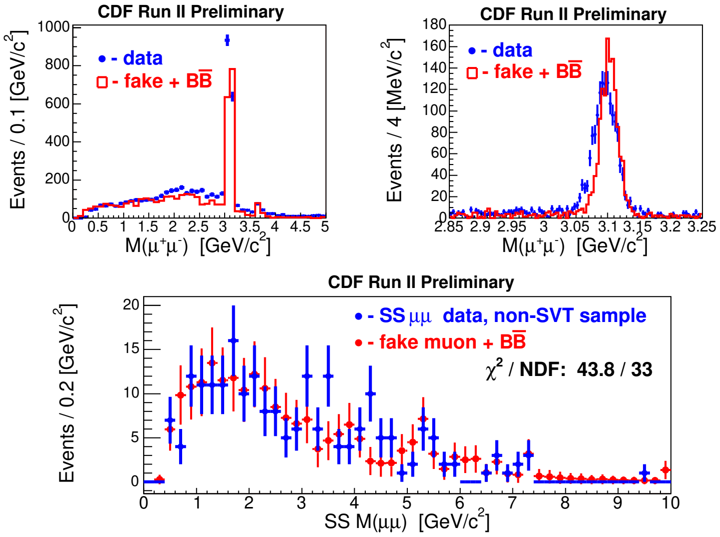

FIG. 19: Top Left: Predicted opposite sign $\mu\mu$ and data mass distributions. Top Right: Predicted opposite sign $\mu\mu$ and data mass distributions, J/ψ region. Bottom: Predicted same sign $\mu\mu$ and data mass distributions.

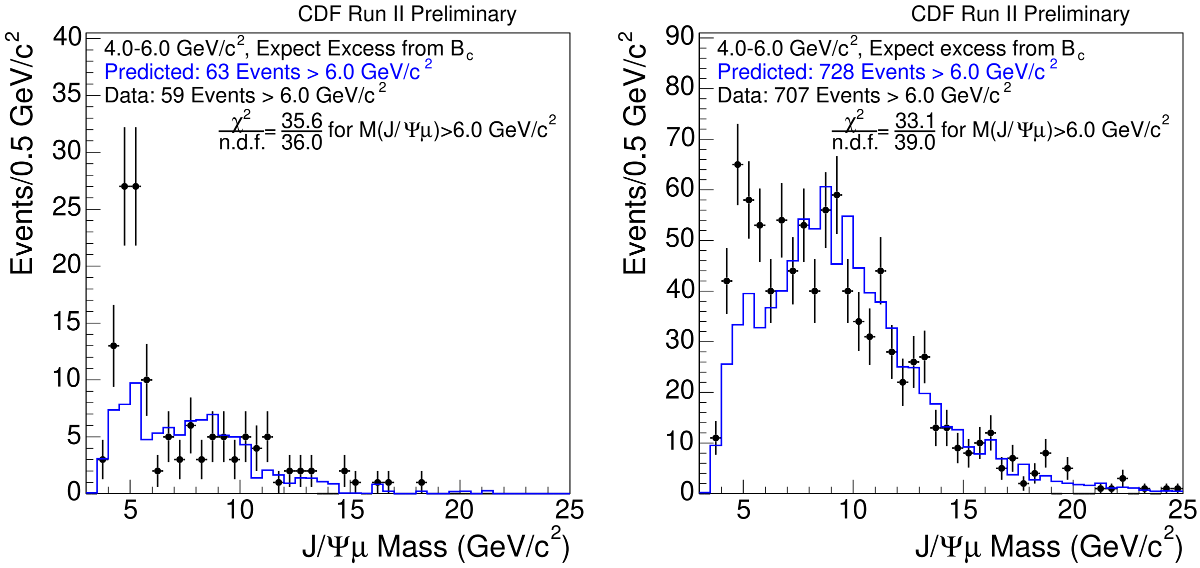

FIG. 20: J/$\psi\mu$ mass distributions for data and predicted backgrounds wiht $\Delta\phi$ requirements. Left: Vertexed events. Right: Unvertexed events.

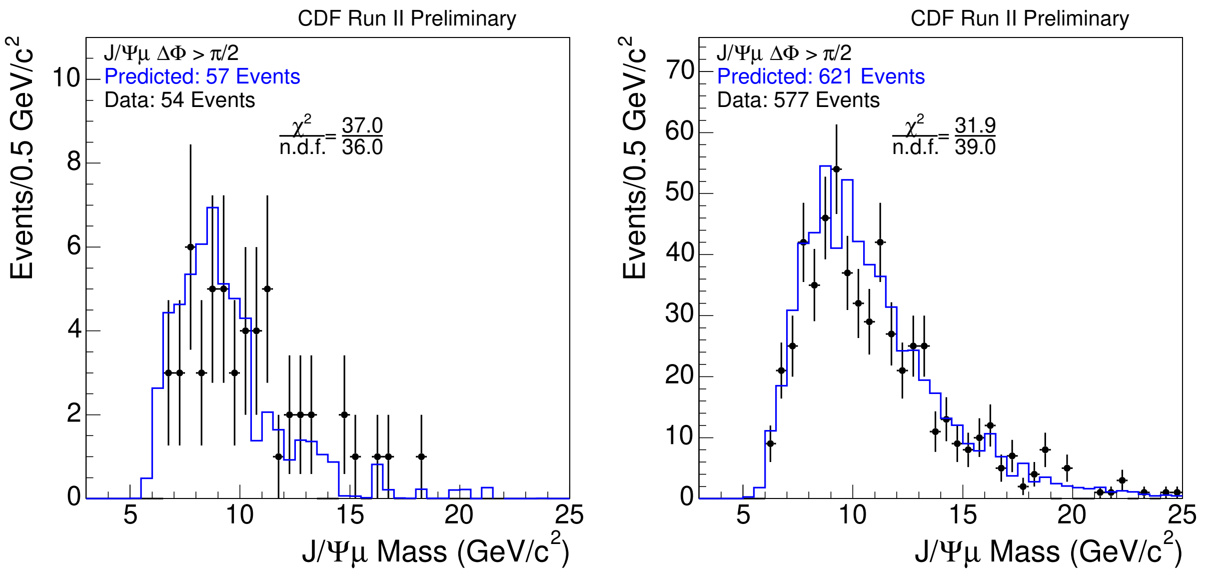

FIG. 21: $J/\psi\mu$ mass distributions for data and predicted backgrounds wiht $\Delta\phi > \frac{\pi}{2}$ requirement. Left: Vertexed events. Right: Unvertexed events.

Summary of Pythia *bb* background estimation for P_t> 3.0 GeV/c				
	$N_{Data}(B^{\pm})$	$N_{FC}(B^{\pm})$	$N_{FE}(B^{\pm})$	$N_{GS}(B^{\pm})$
B peak entries	755 ± 30	1293 ± 36	2688 ± 52	962 ± 31
		S_{FC}	S_{FE}	S_{GS}
Process dependent scale factors		0.90 ± 0.21	0.81 ± 0.37	1.36 ± 0.39
Mass window		A	B	C
Pythia *bb* background	N_{FC}	0	1	0
	N_{FE}	2	17	13
	N_{GS}	1	41	15
Predicted *bb* background (Scaling)*		$0.7 \pm 0.4 \pm 0.1$	$16.1 \pm 2.1 \pm 5.7$	$7.1 \pm 1.3 \pm 1.8$
Predicted *bb* background (No Scaling)		$0.6 \pm 0.4 \pm 0.1$	$12.7 \pm 1.7 \pm 5.7$	$6.0 \pm 1.1 \pm 1.8$

TABLE VIII: Summary of $b\bar{b}$ background estimation.
*The following formula is used to normalize to data, where C_{Norm} is a correction factor which allows us to normalize using the $B^{\pm}->J/\Psi K^{\pm}$ mass peaks in Pythia: $N_{b\bar{b}} = (N_{FC}S_{FC}+N_{FE}S_{FE}+N_{GS}S_{GS})\frac{N_{Data}(B^{\pm})}{(N_{FC}(B^{\pm})S_{FC}+N_{FE}(B^{\pm})S_{FE}+N_{GS}(B^{\pm})S_{GS})C_{Norm}}$