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

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Introduction

Production

- The high mass of the quarks allows Pertubative QCD predictions.
- Fragmentation process $\bar{b} \to B_c + \bar{c}$ dominates production.
- The mass of the B_c is predicted by nonrelativistic potential models to be in the range of $6.194 - 6.292$ GeV/c^2.

Decay and Lifetime

- The B_c can decay via one of three weak interactions:
  - Decay of the $\bar{b}$ quark
  - Decay of the c quark
  - $\bar{b}c$ annihilation
- Predicted lifetimes vary from 0.4 ps to 1.34 ps.

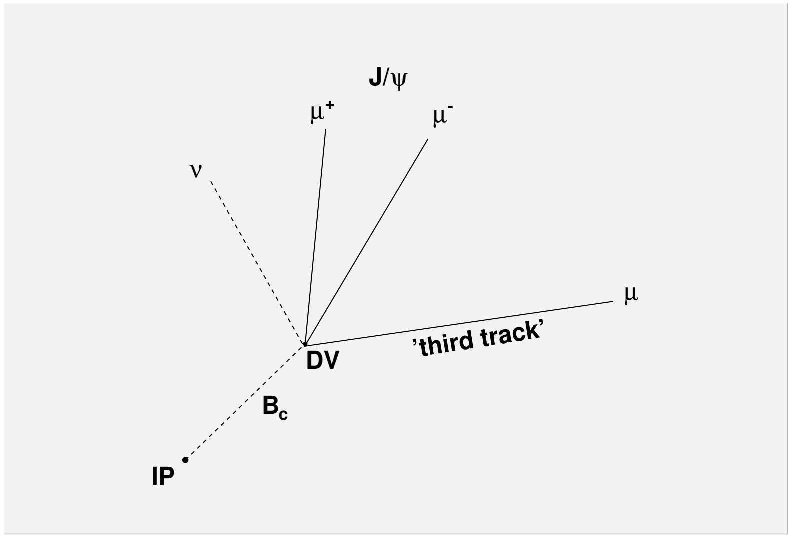
Past Measurements:

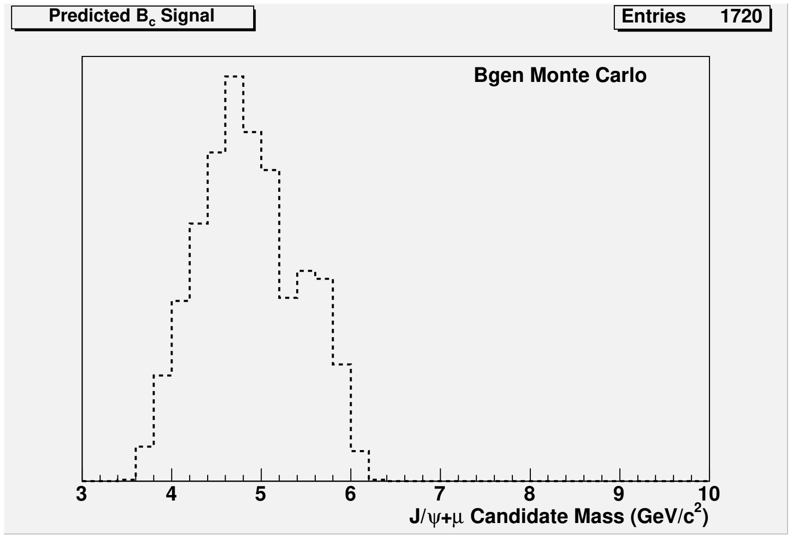
- CDF measured B_c lifetime and mass in Run I in the combined μ and e channels.
- OPAL observed 2 $B_c \to \mathrm{J}/\psi\pi^+$ events, with a background of 0.63 ± 0.2
- The LEP experiments have set limits on various branching ratios.

Analysis Strategy

Our signature is a J/ψ and another μ sharing a common displaced vertex. We require:

- Hits from our silicon tracker for a good vertex
- $prob(\chi^2) > 1\%$ for vertex
- lifetime $c\tau > 60\ \mu$m
- the J/ψ and the third track to be in same hemisphere ($\Delta\theta < \pi/2$)
- $p_t > 3.0$ GeV/c for third track (good muon)

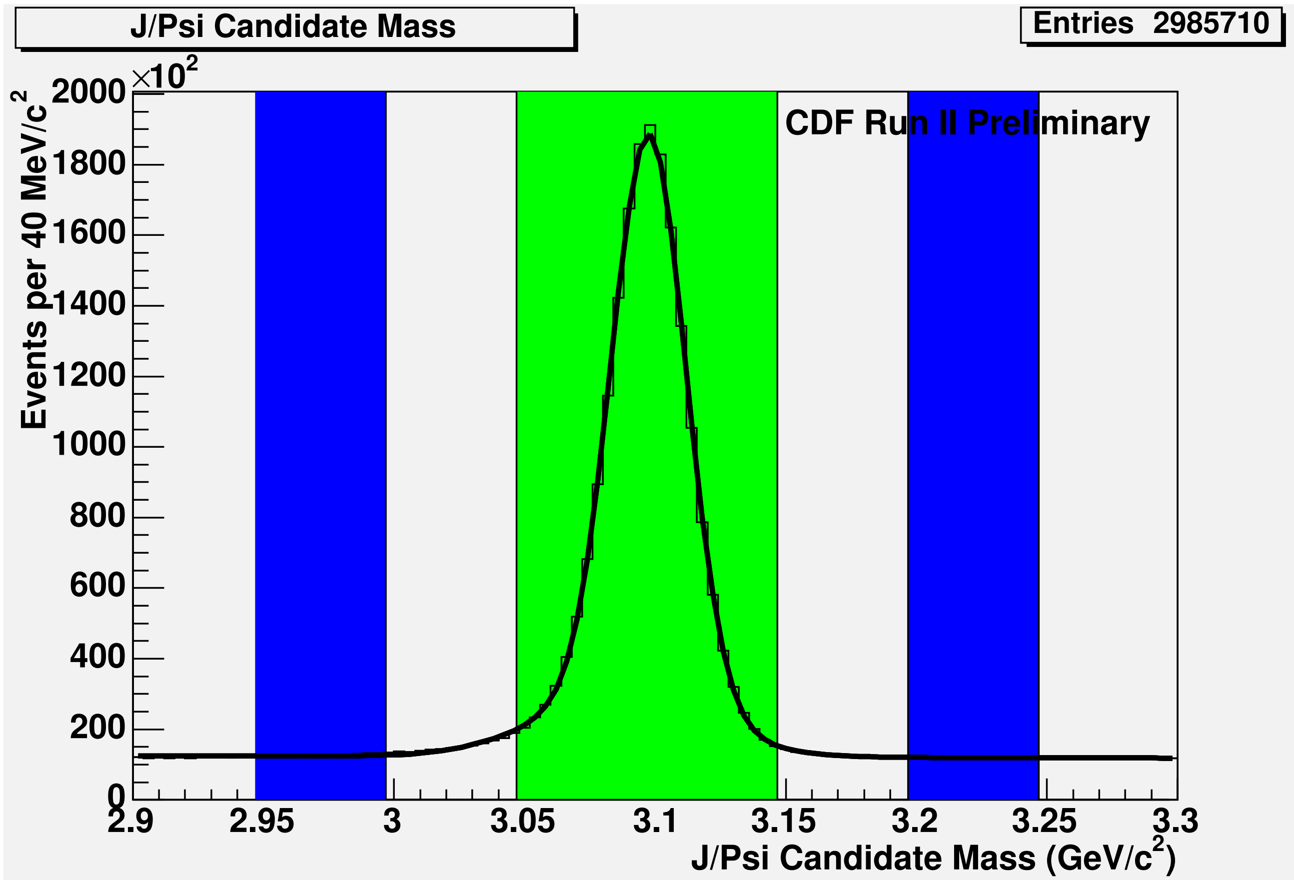




We cannot fully resolve the B_c in this decay mode. Our signal region is from $4.0-6.0$ GeV/c^2, excluding the $B^{\pm} \rightarrow J/\psi + K^{\pm}$ mass ± 50 MeV around PDG value.

Data Selection

We use a skim of dimuon-triggered events. The total luminosity for the data is 180 pb^{-1}.



J/ψ mass plot showing J/ψ mass window (green) and sidebands (blue) used for fake J/ψ background calculation.

The Backgrounds

As the B_c is not fully reconstructed, understanding the background is of greatest importance. The B_c is rare, but the J/ψ is plentiful. There is potential for a lot of background.

- Fake third μ
  - A real J/ψ in coincidence with another track
  - The track - a π or K, decays in-flight or punches through to muon chambers
  - This is the major background
- $B\bar{B}$
  - One B meson decays to give a J/ψ, the other gives a real μ
  - The unlikeliness of the J/ψ and μ forming a good vertex makes this a small background
- Fake J/ψ
  - We have some contribution of the dimuon continuum underneath our J/ψ peak
  - Again, the fake J/ψ must form a good vertex with another μ, real or fake
  - This is also a small background

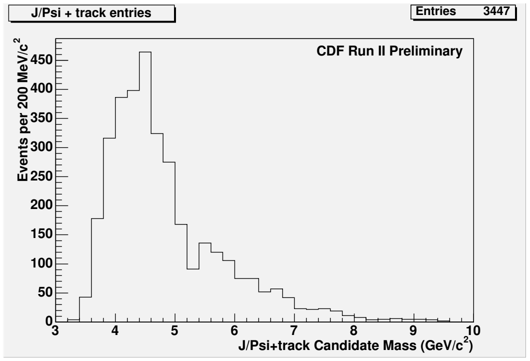
We use data, when possible, to determine backgrounds.

Fake Third μ Background

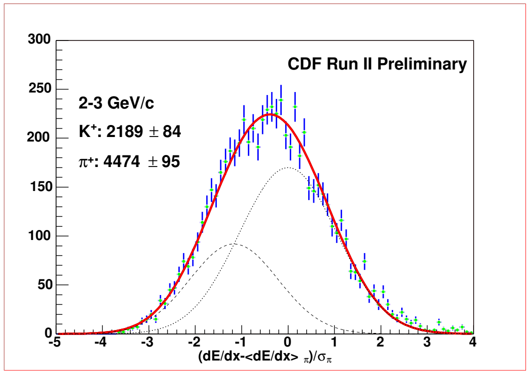
We start with the J/ψ + track distribution and apply the scaling

$$Prob(track \to \mu) = F_\pi(p) * P_\pi(p_t) + F_K(p) * P_K(p_t)$$

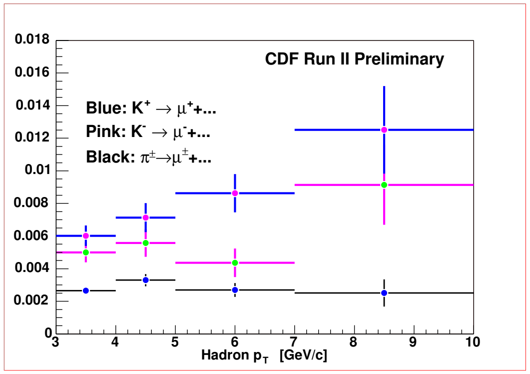
where $F_{\pi,K}(p)$ is the fraction of π, K tracks and $P_{\pi,K}(p_t)$ is the fake μ rate for π, K.



We fit a dE/dx pull distribution to determine π and K fractions for the sample.



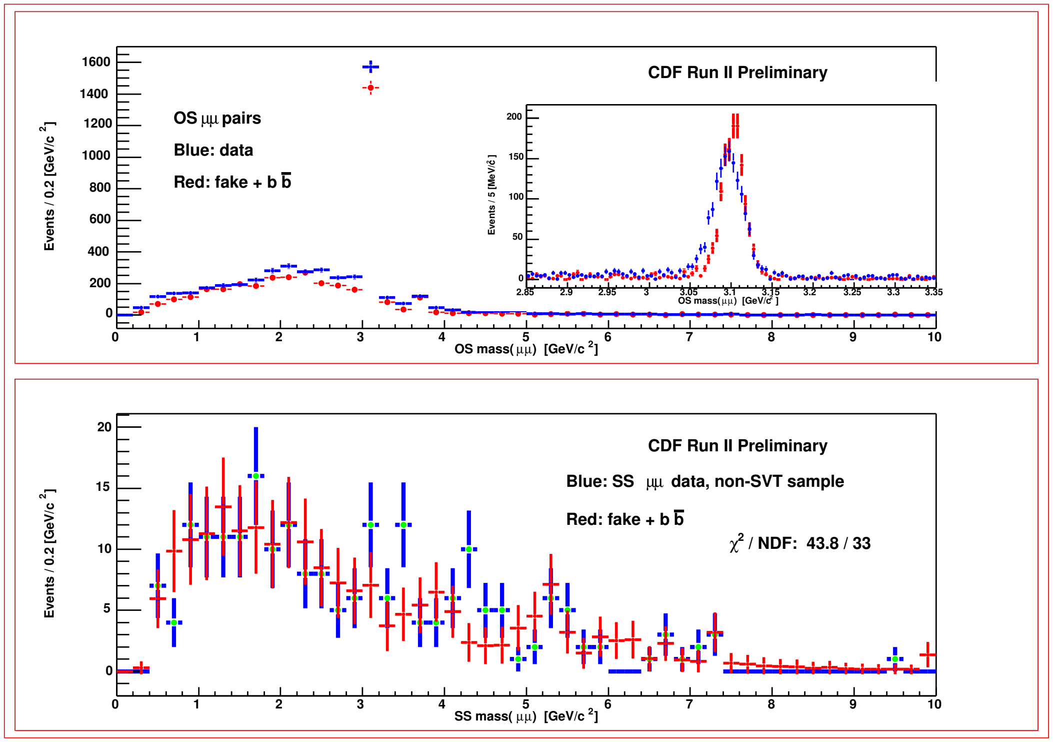
We use $D^* \to D^0\pi \to K\pi\pi$ to obtain pure π and K track samples. We determine how often the π, K is reconstructed as a μ. The probabilities range from 0.2% to 1.2%.



Fake Third μ Validation

We have validated the methodology for the fake third μ background with an independent dataset that is pure background.

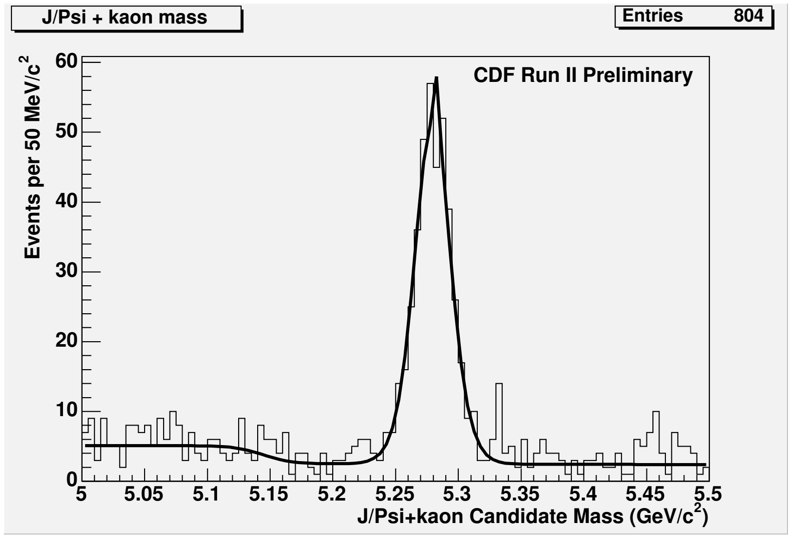
- We use a $\mu + track$ triggered sample, and compare the distribution when $track = \mu$ is required with our prediction.



Dimuon mass distributions for the $\mu + track$ sample, requiring $track = \mu$, with $B\bar{B}$ contribution added to fake μ prediction overlaid. The same sign (SS) sample is a pure background.

$B\bar{B}$ Background

- Pythia generation of all QCD to get proper B correlation.
- B mesons with $\bar{b}$ quarks forced into $\mathrm{J}/\psi \to \mu^+\mu^-$ decay, other particles decay normally.
- Third muon verified with MC truth info.
- Only third muons with parentage other than π, K considered.
- Scale MC sample using $B^\pm \to \mathrm{J}/\psi + \mathrm{K}^\pm$ peak to normalize.
- The total contribution is $\mathcal{O}(1)$ events.



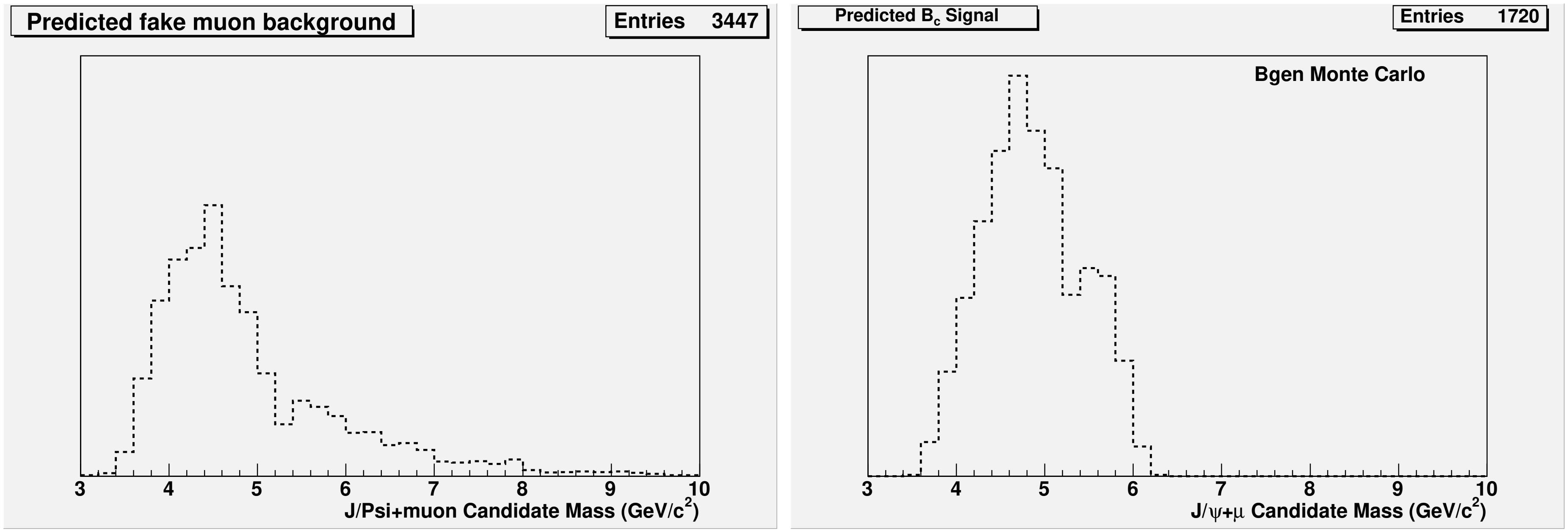
$B^\pm \to \mathrm{J}/\psi + \mathrm{K}^\pm$ peak from data using all valid analysis cuts.

Fake J/ψ Background

- Dilepton continuum is the source of fake J/ψ.
- We take two 50 MeV sidebands of J/ψ and pass the events through the entire analysis, omitting χ^2 cut on J/ψ + track fit.
- Surviving events must be scaled to account for effect of χ^2.
- We use the data to determine this scale factor.
- The total contribution is $\mathcal{O}(1)$ events.

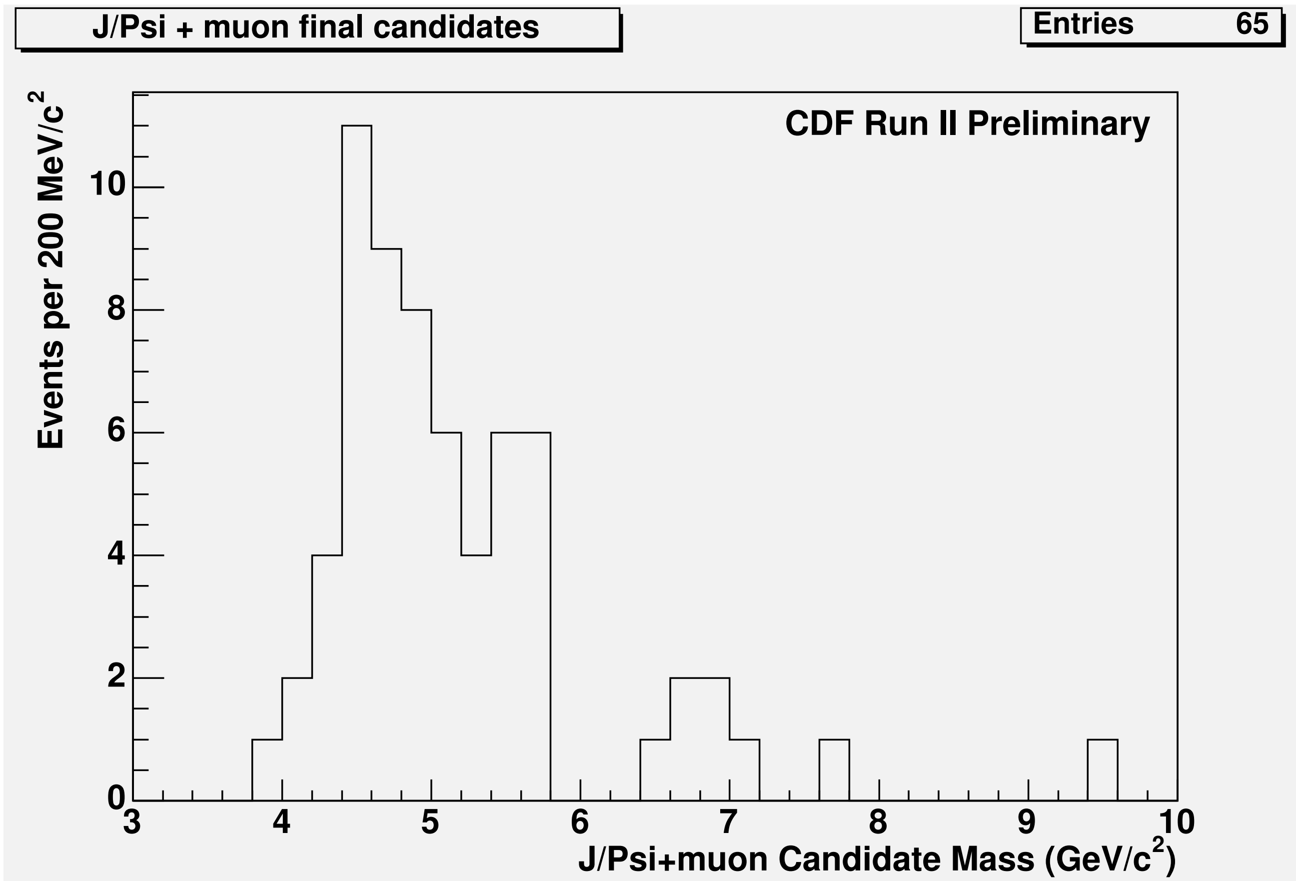
Background Summary

The final fake third μ contribution is $\mathcal{O}(10)$ events. We are finalizing some systematics so we can not quote the exact magnitude here. For comparison we show the expected shape of the B_c from MC.



Left: the shape of the predicted fake third μ background, magnitude TBD. Right: the shape of the predicted B_c signal from a Bgen MC.

A B_c Signal?



Final B_c candidates. J/ψ + muon mass after all cuts. The high mass events are explained by $B\bar{B}$ and fake J/ψ backgrounds, within uncertainties.

Conclusions

The dominant background in this study is from the decay-in-flight and punch-through of the third track which form the candidate tracks for the third muon. Although we believe that we are making correct estimates for this background there are a number of sources of systematic error (such as trigger bias effects in the analysis of the D^0 sample) which are still being considered. For this reason we are not prepared at this meeting to give a precise statement of the overall background in the signal region. Nonetheless, we fully expect that once our errors are finalized that a statistically significant signal in excess of four standard deviations for the inclusive B_c will emerge.