Measurement of the B^- and $\bar{B}^0$ Meson Lifetimes Using Semileptonic Decays with Single Lepton Datasets in CDF Run II

(CDF 7458)

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— Blessing —

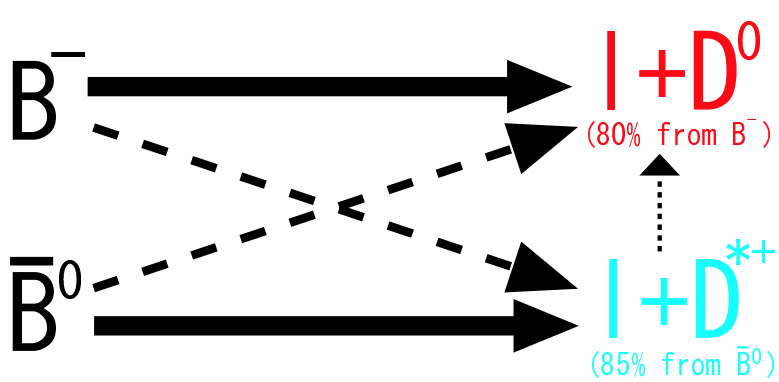
1. Analysis overview
2. Questions and answers
3. Plots and numbers to bless

Analysis overview

We measure the B^- and $\bar{B}^0$ meson lifetimes and their ratio using semileptonic decays,
$B^-/\bar{B}^0 \to \ell^- \bar{\nu} D^0 X (\ell^- = e^-$ or $\mu^-)$, $D^0 \to K^- \pi^+$.

Feature of this analysis:

- 8 GeV lepton trigger datasets are used.
- Large branching fraction, minimal trigger bias.
- 260 pb^{-1} used in total, electron trigger is dynamically prescaled.
- Charge correlation is useful to identify the B signal ($Q_\ell = Q_K$).
- Decay chains are somewhat complicated, but can be disentangled by separating $\ell^- D^{*+}$ candidates.



Analysis outline

1. Select a lepton (e or μ) from 8 GeV lepton datasets
2. Reconstruct $D^0 \to K^-\pi^+$ around the lepton
3. Find $D^{*+} \to D^0\pi_s^+$ candidates, and split them from the $\ell^- D^0$ sample
4. Reconstruct $\bar{B} \to \ell^-\bar{\nu}D^0X$ decay vertex in xy plane, and calculate B pseudo decay time
5. Correct missing momentum (K factor)
   - $p_T(B)$ can not be reconstructed due to some missing particles (neutrino, particles from $D^{*,**}$)
   - Correct it using MC
6. Model combinatorial background shape
   - use $D^0(D^{*+})$ mass sideband
7. Determine resolution scale factor
8. Estimate physics backgrounds
   - Prompt charm background
   - Bottom background
9. Estimate sample composition
   - Need to know $B^-/\bar{B}^0$ composition in each $\ell^- D^0$ and $\ell^- D^{*+}$ sample
10. Extract the lifetimes using unbinned likelihood fit
11. Estimate systematic uncertainties

Questions & Answers

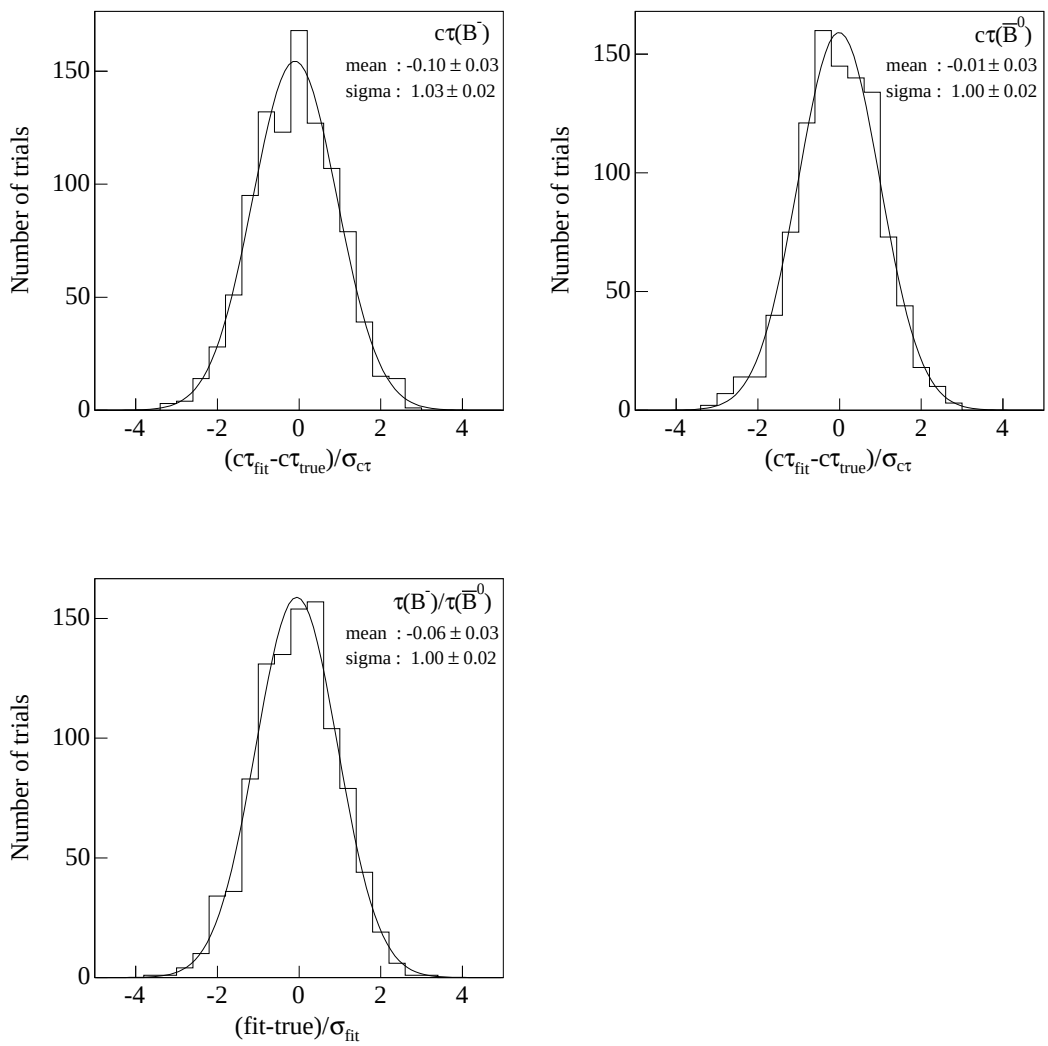
— 22 questions —

Question 1

Q1 : Please provide the pull distributions for the lifetime fitter.

A : These are the plots from toy monte carlo study.

- **1000 trials**
- **Input lifetime :** $c\tau(B^-) = 460\mu$**m,** $c\tau(\bar{B}^0) = 500\mu$**m**
- **Sample composition :** $g_-(D^0) =$ **0.8,** $g_-(D^{*+}) =$ **0.15**
- **Fit uncertainties :** B^-**...**10.0μ**m,** B^0**...**12.7μ**m,** $\tau(B^-)/\tau(\bar{B}^0)$**...**$0.044$



Question 2

Q2 : Why do you use a quality cut of 20 (16) axial (stereo) COT hits. This quality cut was designed for the 4.8.4 production release and is rather tighter than recommended for production release 5.3.1.

A : It is indeed my mistake. We agree we should use the standard cut, but effect to the lifetime fit is found to be very small. We quickly looked how the number of events in the signal region and signal fractions are changed. Here we show a numbers for muon+D0 sample.

- **WITH old number of COT hits cut:**
  Num. of events : 21971
  f_{sig} **: 0.425** $\pm$ **0.004**
- **WITHOUT old number of COT hits cut:**
  Num. of events : 22158
  f_{sig} **: 0.424** $\pm$ **0.004**

As these numbers indicate, the effect is very small. I briefly checked the effect to the lifetime fit results, and saw very little changes (less than 1μ**m changes of lifetimes).**

Question 3 - 4

Q3 : The muon track-stub matching cuts are tighter than normally used. What is the motivation for these cuts? Could you present evidence that these cuts substantially reduce backgrounds?

A : the tight track-stub matching were defined to achieve the best $S/\sqrt{N}$. Following are the numbers under normal and our muon cuts, for the $\mu^- D^0$ sample.

- **normal cut (χ^2_x(CMU,CMP) $<$ 9,χ^2_z(CMU) $<$ 12)**
  f_{sig} = 0.408 $\pm$ 0.004
  $S/\sqrt{N}$ = 82.3
- **tight cut (χ^2_x(CMU,CMP) $<$ 6,χ^2_z(CMU) $<$ 5)**
  f_{sig} = 0.425 $\pm$ 0.004
  $S/\sqrt{N}$ = 83.1

The f_{sig} and $S/\sqrt{N}$ are improved slightly by tighter mu ID cuts.

Q4 : Do you match the leptons to the trigger information?

A : We do not confirm that the lepton is the trigger lepton. Since we apply tighter cuts offline than the trigger cuts, we think it should be OK.

Question 5 - 7

Q5 : How did you choose the signal and sideband regions?

A : The signal region is taken to be $\pm$ 20 MeV for D^0 sample (30 MeV for D^{*+}) from the fitted $M(D^0) = 1.865$ GeV. The sideband regions are the same as in the Run I semileptonic lifetime analysis.

Q6 : Could you give details on whether you refitted the tracks, and whether you used L00 hits.

A : We refit the lepton, K, π tracks but not the π_s tracks. We drop only L00 hits at the refitting.

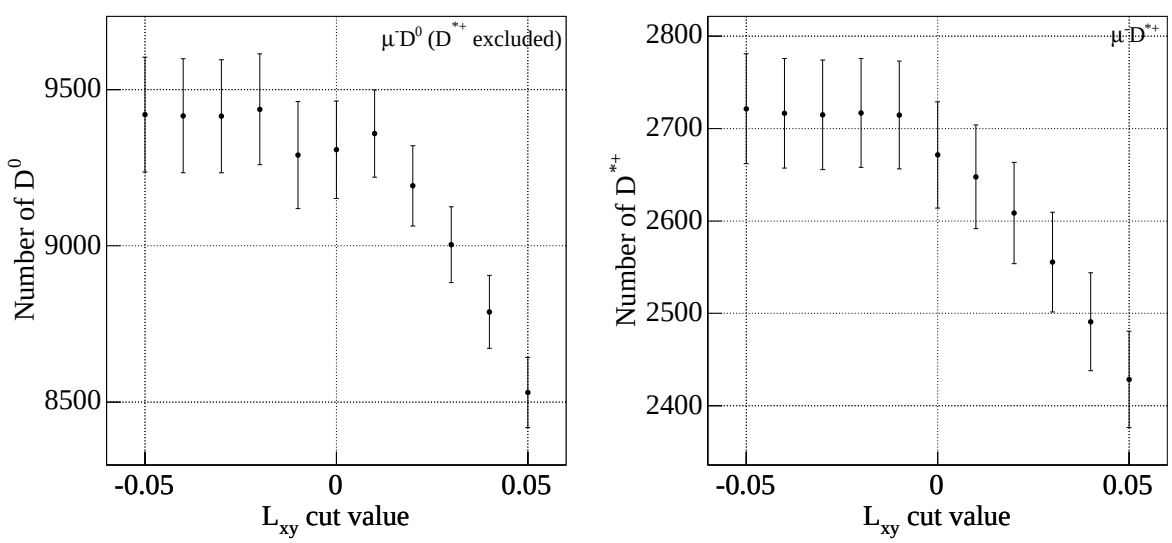
Q7 : I guess you use neither L00 nor EBE primary vertex, are you planning to use them?

A : As you said we use neither L00 nor EBE vertex. The first motivation of this analysis is to repeat the Run I analysis to understand the short lifetimes. So we used same configuration where the short lifetime was seen. But now we think that the short lifetime problem is solved in 8 GeV analysis, thus we might switch to use the L00 and EBE vertex, maybe before the publication.

Question 8

Q8 : You apply some loose cuts on the $L_{xy}(D^0 - P.V.)$. Are you sure you don't introduce any bias in the lifetime? I guess it should be something small, but maybe it's there.

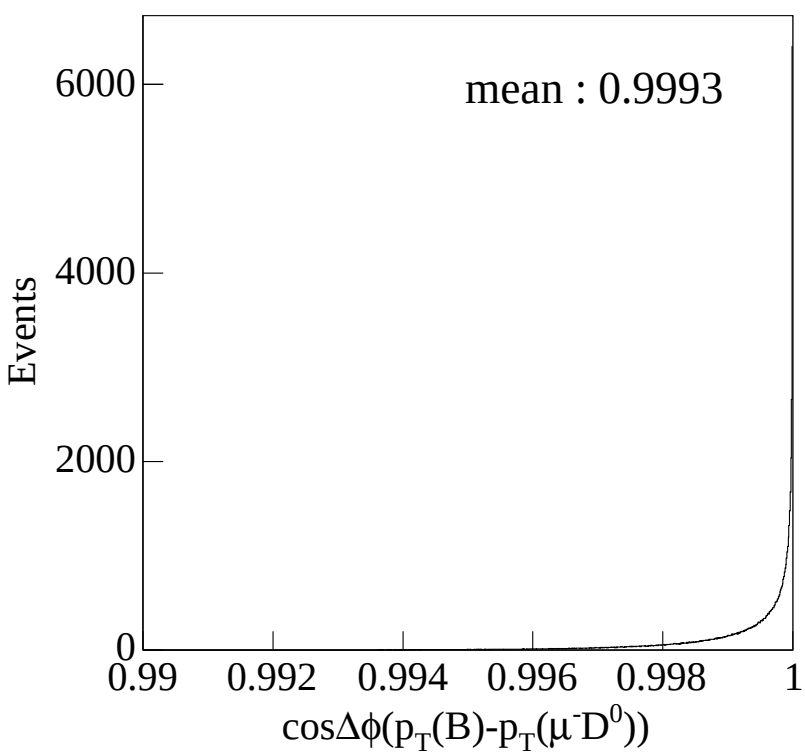
A : As plots below indicate, the effect of $L_{xy} > 0$ cut is small, but indeed it exist. We fit the full simulation sample with and without $L_{xy} > 0$ cut, and see about 2μm changes in the lifetimes. These numbers are assigned as systematic uncertainties.



Question 9

Q9 : I am confused by the formula of the B decay length $L_B = \vec{V}_B \cdot \vec{p}_T(\ell D^0)/|\vec{p}_T(\ell D^0)|$. By projecting the B decay distance along the lepton-D0 direction, you are in effect introducing a factor of $cos(\Delta\phi)$ where $\Delta\phi$ is the angle between the B direction and the lepton-D0 direction. I think that this factor is not corrected for anywhere else.

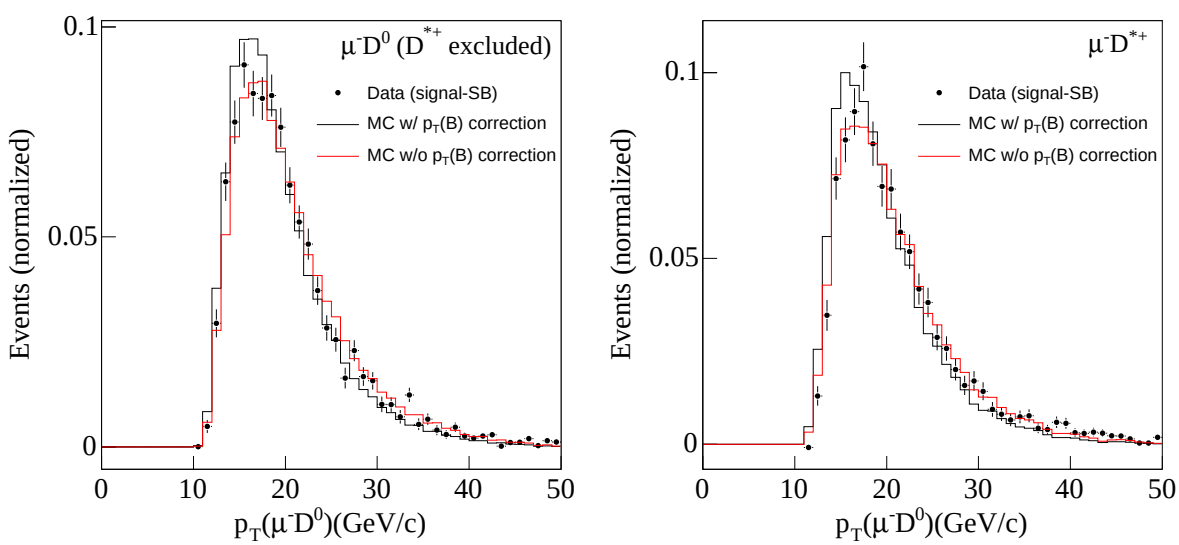
A : As pointed, K factor does not correct for the effect of the opening angle between B and lepton-D0 flight directions. I made a plot which shows the opening angle. This plot indicates that the opening angle effect is negligible.



Question 10

Q10 : For the B monte carlo samples, do you have a plot of the $p_T(\ell^- D^0)$ before and after the reweighting using the J/ψ samples? And compare it also to data?

A : These plots are the $p_T(\mu^- D^0)$ plots with and without the $p_T(B)$ spectrum correction, and real muon data. In the plots there is no evidence that the correction makes the $p_T(\mu^- D^0)$ distribution to match with the data, but the shapes of these distributions depend on sample composition and decay model used in the monte carlo. Besides there is 10% of physics background (charm, bottom) contaminations in the data distributions. Thus we can not have any conclusion with these plots. Anyway, imcompleteness with the $p_T(B)$ correction is imcorporated in the systematic uncertainties.



Question 11 - 12

Q11 : Did you make a trigger simulation with your B monte carlo samples?

A : For the full simulation sample, we do apply the trigger simulation. After the trigger simulation, we require an 8 GeV lepton trigger bit.

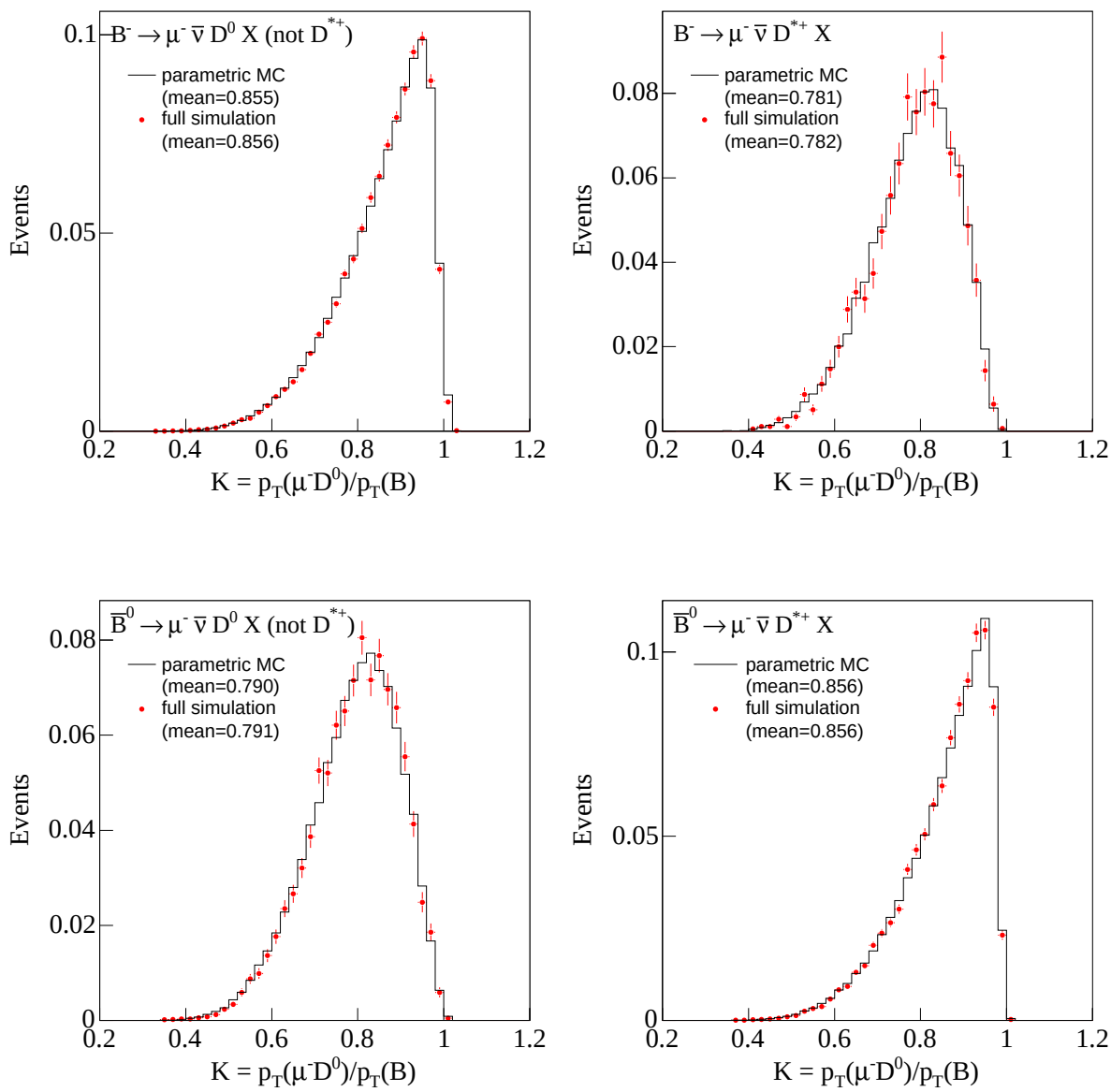
Q12 : Why do you use QQ for the decay model? EvtGen has the more recent ISGW2 functions implemented.

A : One motivation to start the 8GeV lifetime analysis was, to repeat the Run I lifetime analysis, because we did not solve the short lifetime problem with the lepton+SVT samples. So, we start with QQ, which is used in Run I. Since any sources of uncertainties caused by the monte carlo are evaluated in the systematic uncertainties, we think using QQ is OK.

Question 13

Q13 : Can you demonstrate that the K factors agree between the parametric and full simulation samples for the muons?

A : Here are the comparison. The differences between the parametric and full simulation are negligible ($\leq$0.1% on mean value)



Question 14

Q14 : To measure the resolution scale factor, you use loose lepton ID cuts to select a sample of tracks that is enhanced in prompt tracks. At least for the muon sample tracks that pass loose lepton ID cuts are likely to include decays in flight where the kink could be in the COT or silicon. These tracks will have mis-estimated track parameters and will produce a scale factor that is not necessarily appropriate for real leptons. I don't think this is a good way to determine the scale factor. You might consider using the electron scale factor for both.

A : We agree that the low quality muons contain lots of decay-in-flight muons. But for the electron case, it may be possible that electron ID cuts give a bias to the opening angle of lepton-D0, and change the scale factor. In any case the difference in the scale factor is small (difference is 0.07 between muon and electron), and the effect to thelifetime is negligible.

As another test, if we use our standard muon ID cuts to measure the scale factor, the scale factor do not changed (1.52). If we use very tight muin ID cuts ($\chi^2_{x,z}$(CMU), χ^2_x(CMP) < 1.5, Iso/$p_T(D^0) < 1.5$), the scale factor is still almost consistent with the 1.52 .

Question 15

Q15 : For the charm background, Currently you state that you don't understand difference between the electron and muon charm background fraction, but hypothesize that it may be due to the tightness of the lepton ID cuts. It should be possible to investigate this by trying looser lepton ID cuts and comparing the expected rates of fake leptons using other analysis that have studies this issue as input.

A : One thing we do know is that the fake rates are higher for muons than for electrons for $p_T > 8$ GeV/c. So I am not surprised that there is a difference in the measured prompt BG rates. This is a qualitative statement, and perhaps the observed difference may be a bit worrisome. However, the errors are not small, and in fact they are not inconsistent.
We looked at the charm fraction with some different lepton ID cuts.

- **looser muon ID**
  $f_c(D^0) = 8.7 \pm 1.3$ %, $f_c(D^{*+}) = 6.1 \pm 1.5$ %
- **tighter muon ID**
  $f_c(D^0) = 5.2 \pm 1.5$ %, $f_c(D^{*+}) = 6.4 \pm 1.7$ %
- **looser electron ID (in fact it is not so loose)**
  $f_c(D^0) = -4.5 \pm 2.0$ %, $f_c(D^{*+}) = 1.3 \pm 2.0$ %
- **tighter electron ID**
  $f_c(D^0) = -3.1 \pm 2.2$ %, $f_c(D^{*+}) = -0.6 \pm 2.5$ %

Since ucnertainties are large, we think it is difficult to say something from these numbers.

Question 16

Q16 : In the bottom background estimation, you assume the lepton ID efficiency for hadrons as 1%. How do you get it?

A : Actually the number of order 1% is from experience in Run I. In Run II there are some studies about fake muon. For example in $D^0 \to \mu\mu$ analysis (CDF6273), the misID probability is estimated to be about 2-4% in the region $p_T(\mu)$ = 8 - 15 GeV. We apply tighter muon ID cuts than their analysis, so the misID rate would be smaller. For the electron, we know that the fake rate is lower than the muon dataset because we have better S/N in the electron dataset than the muon. Anyway, if the misID probability exceeds 1%, it would not be a large number and still negligible.

Question 17

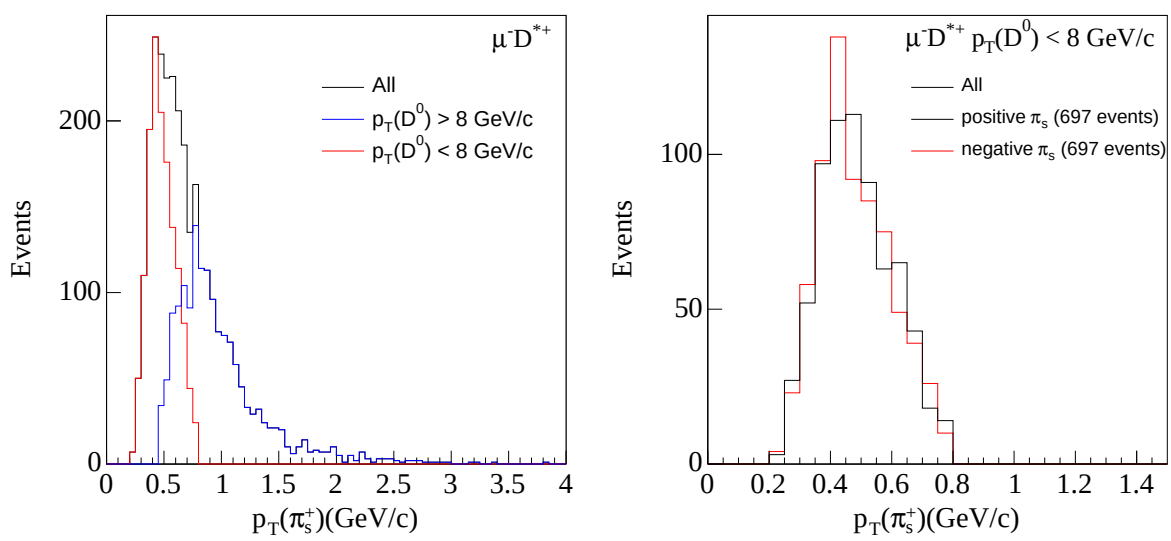
Q17 : For the pythia ccbar/bbbar MC samples, you don't apply detector simulation. But how can you give any relative efficiency of the physics backgrounds with respect to the signal?.

A : Basically we agree to apply full simulation to the ccbar/bbbar MC. But for this time we have limited time and pythia bbbar MC events. Currently we think cutting on the generator-level information would be OK. For example in the K factor calculation, the parametric and full simulation samples give almost consistent distributions. We might think about detailed study using full detector simulation before publication. It takes much CPU times, but the results are not expected to change so much.

Question 18

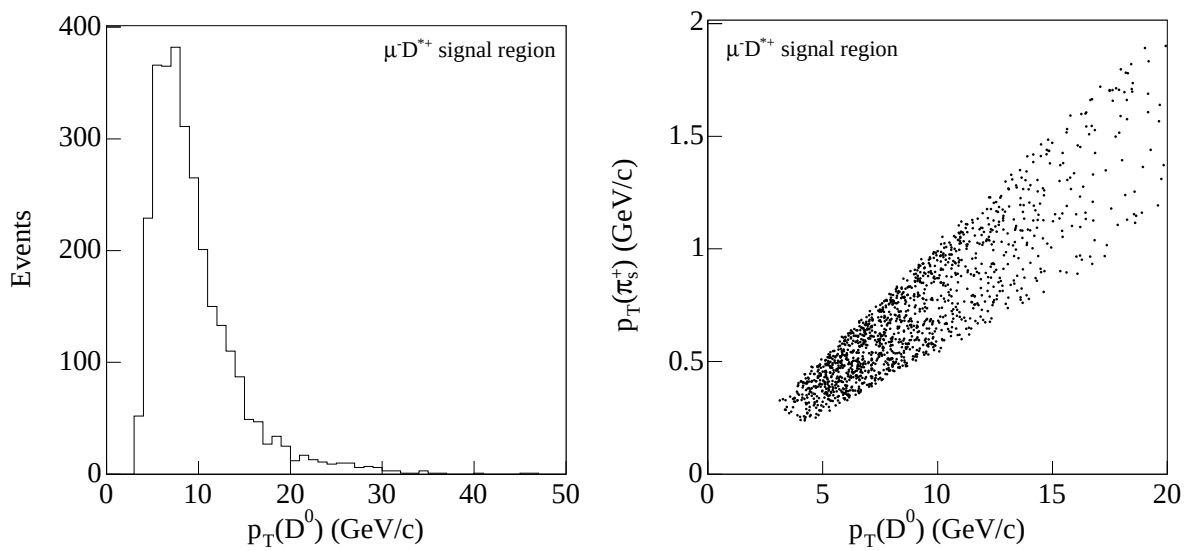
Q18 : I'd like to see the slow pion p_T distributions for the $p_T(D^0) > 8$ and < 8 GeV regions. To account for a 70% vs >99% difference in slow pion reconstruction efficiency, the slow pion p_T must be very low. Also if the soft pion p_T is that low you might be able to observe a charge asymmetry. This difference in efficiency might be lower if more typical COT hit quality cuts are used.

A : These are the slow pion p_T distributions. We see that the slow pion p_T is very low in $p_T(D^0) < 8$ GeV region, but can not see the charge asymmetry.



Question 18 (cont'd)

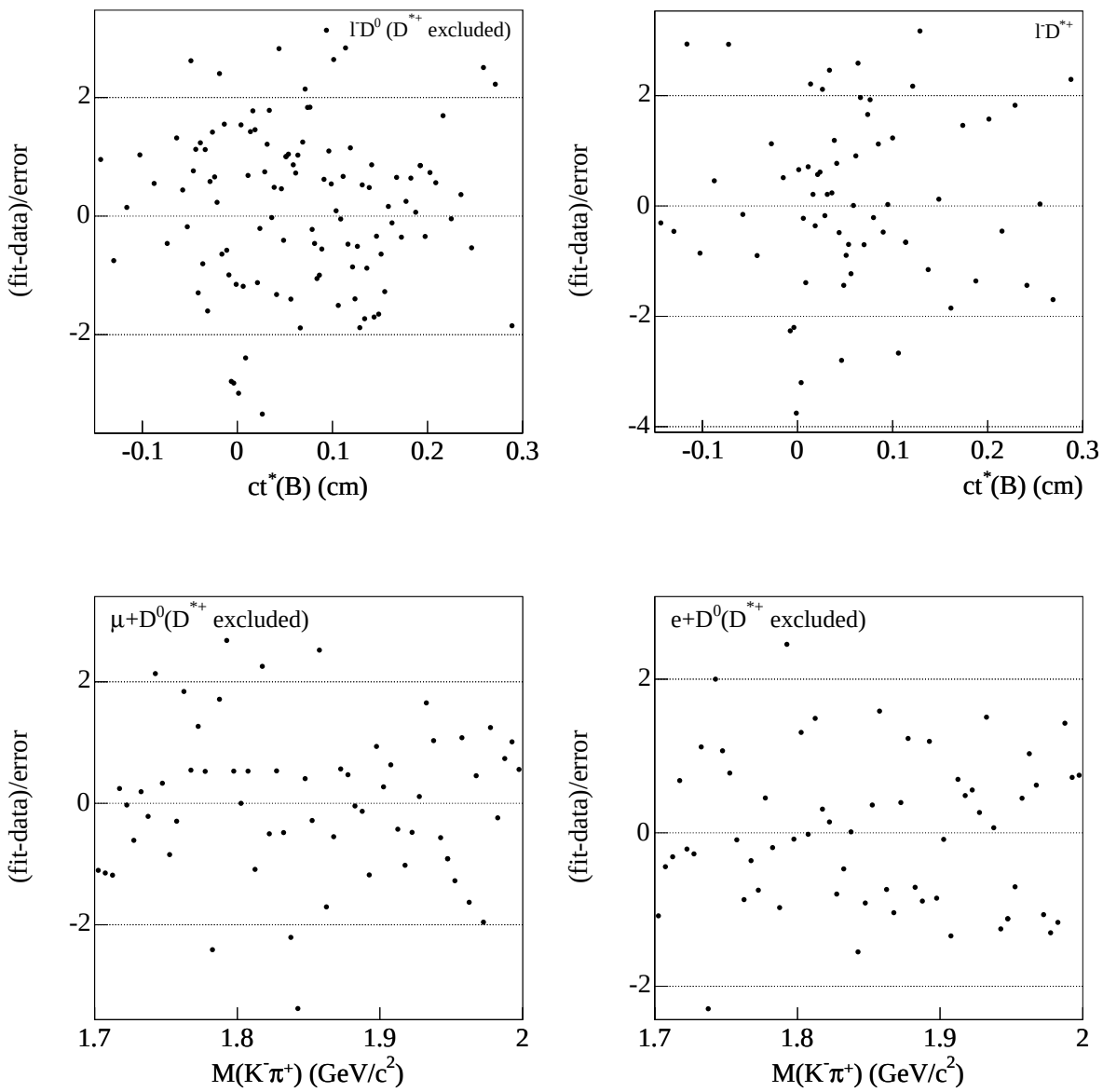
A (cont'd) : You can note that the Q value is very small in the decay and there is a strong correlation between the momenta of the D^0 meson and the slow pion (below plots). If p_T of D^0 becomes below 7 or 8 GeV/c, the slow pion spectrum starts to sneak into the region below 0.5 GeV/c, where you know the COT tracking becomes inefficient. So we do not really hope to recover those lost tracks, and they become a source of $\bar{B}^0$ decays leaking to the lepton-D^0 channel. What we can do and should do is to estimate the inefficiency accurately, and thus the effect of the leakage. Also, note that the main cross talk comes from the D^{**} decays, not from the slow pion inefficiency.



Question 19

Q19 : Please provide residual plots for your mass and lifetime fits.

A : Here are the plots for combined lifetime fit, and D^0 mass fit both for muon and electron.



Question 20

Q20 : About p_T spectrum correction with B monte carlo: I'd like to see the B pt distributions used for this systematic check. The range of alpha values seems rather large and the systematic accessed is very large. I would not very the B pt spectrum by more the errors on the measured spectrum from our published analysis.

A : Our rationale for the range of the parameter alpha is as follows. The original b-quark p_T spectrum comes from the NDE calculation, which is the best available theory and thus we should respect. The Run-II data (B hadron spectrum) seem to differ from the spectrum calculated starting from NDE. Then we should take the difference as the range in evaluating possible systematic effects. Fortunately, the effect cancels in the lifetime ratio.

Q (again) : I think we have fairly conclusively demonstrated that the NDE spectrum, as it's calculated in our MC generators, is incorrect. Also studies done in exclusive modes of the B^+, B^0 and B_s have shown good agreement with the inclusive spectrum we have published. Therefore, I think it incorrect to compare to the NDE spectrum and assign a systematic error. As I stated this uncertainly should be based on the errors reported in our published cross section measurements.

Question 20 (cont'd)

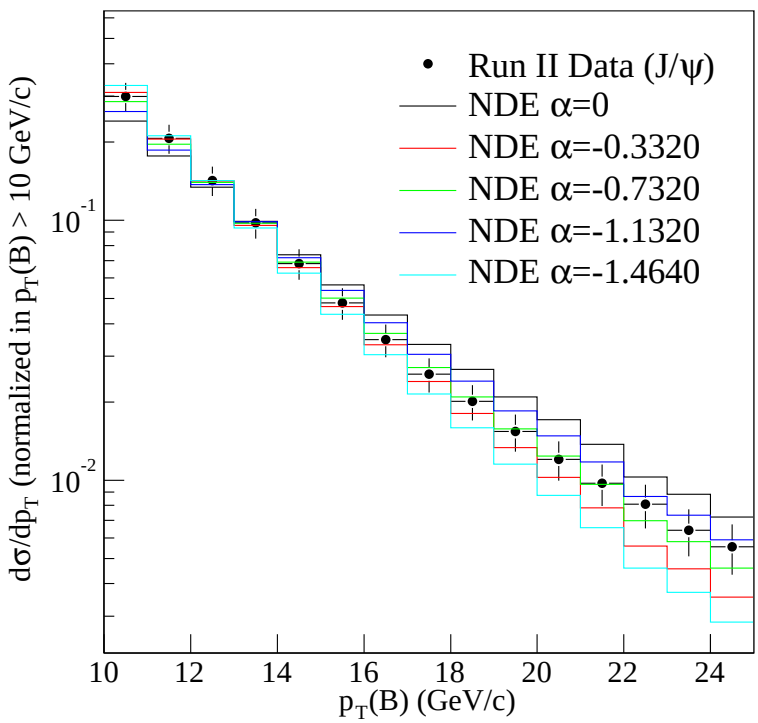
A : Corrected $p_T(B) =$ **NDE** $\cdot\, p_T^{-\alpha}, \quad \alpha = -0.7320$

Current range for systematics estimation is

$\alpha = 0 \sim -1.4640.$

We agree that using this range may be an over estimation.

Thus we examine somewhat narrower range $\alpha = -0.7320 \pm 0.4.$



Comparison of the systematics under two configurations:

α **region**	$c\tau(B^-)$ **(**μ**m)**	$c\tau(\bar{B}^0)$ **(**μ**m)**
-0.7320 ± 0.7320 **(current)**	± 6.1	± 5.3
-0.7320 ± 0.4	± 3.3	± 2.9

Which one we should take?

Question 21

Q21 : About systematic uncertainty from resolution scale factor: The variation used for the scale factor also seems very large ($s = 1 \sim 2$) and results in a large systematic error. A very conservative choice would be to use the typical value for lower pt analysis (around 1.3) as a lower bound and 1.7 as an upper bound - though this would still likely be an overestimate.

A : Our rationale is that the scale factor should have come out to be 1.0 if we had understood the detector. Therefore, the difference from 1.0 is the range we should consider for an evaluation of systematics.

Q21 (again): We believe we qualitatively understand the behavior and magnitude of the scale factor. In our track fit we assign errors for the silicon hits based on the measured resolution from data. This resolution represents the core of the distribution. The distribution has tails from known sources such as delta ray production. Toy MC studies have shown that if you perform track fits on sets of hits with errors that are sampled from the core and tails of the distribution you end up with scale factors such as those we observe.

Question 21(cont'd)

A : We examine the Matt's suggestion to evaluate the systematics
(change scale factor in the region $1.3 \sim 1.7$).

s region	$c\tau(B^-)$ (μm)	$c\tau(\bar{B}^0)$ (μm)	$\tau(B^-)/\tau(\bar{B}^0)$
$1 \sim 2$ (current)	± 9.5	± 5.3	± 0.008
$1.3 \sim 1.7$ (suggested)	± 3.6	± 1.9	± 0.003

Again, which one we should take?

Symmary of systematics with Question 20 & 21

	$c\tau(B^-)$	$c\tau(\bar{B}^0)$	$\tau(B^-)/\tau(\bar{B}^0)$
$p_T(B)$ spectrum (current)	± 6.1	± 5.3	-
$p_T(B)$ spectrum (suggested)	± 3.3	± 2.9	-
scale factor (current)	± 9.5	± 5.3	± 0.008
scale factor (suggested)	± 3.6	± 1.9	± 0.003
Other systematics	$^{+7.0}_{-6.0}$	± 15.3	$^{+0.041}_{-0.038}$
Total (current)	$^{+13.3}_{-12.8}$	± 17.0	$^{+0.041}_{-0.039}$
Total (suggested)	$^{+8.6}_{-7.8}$	± 15.7	$^{+0.041}_{-0.039}$

In the table unit of $c\tau$ is μm.

Question 22

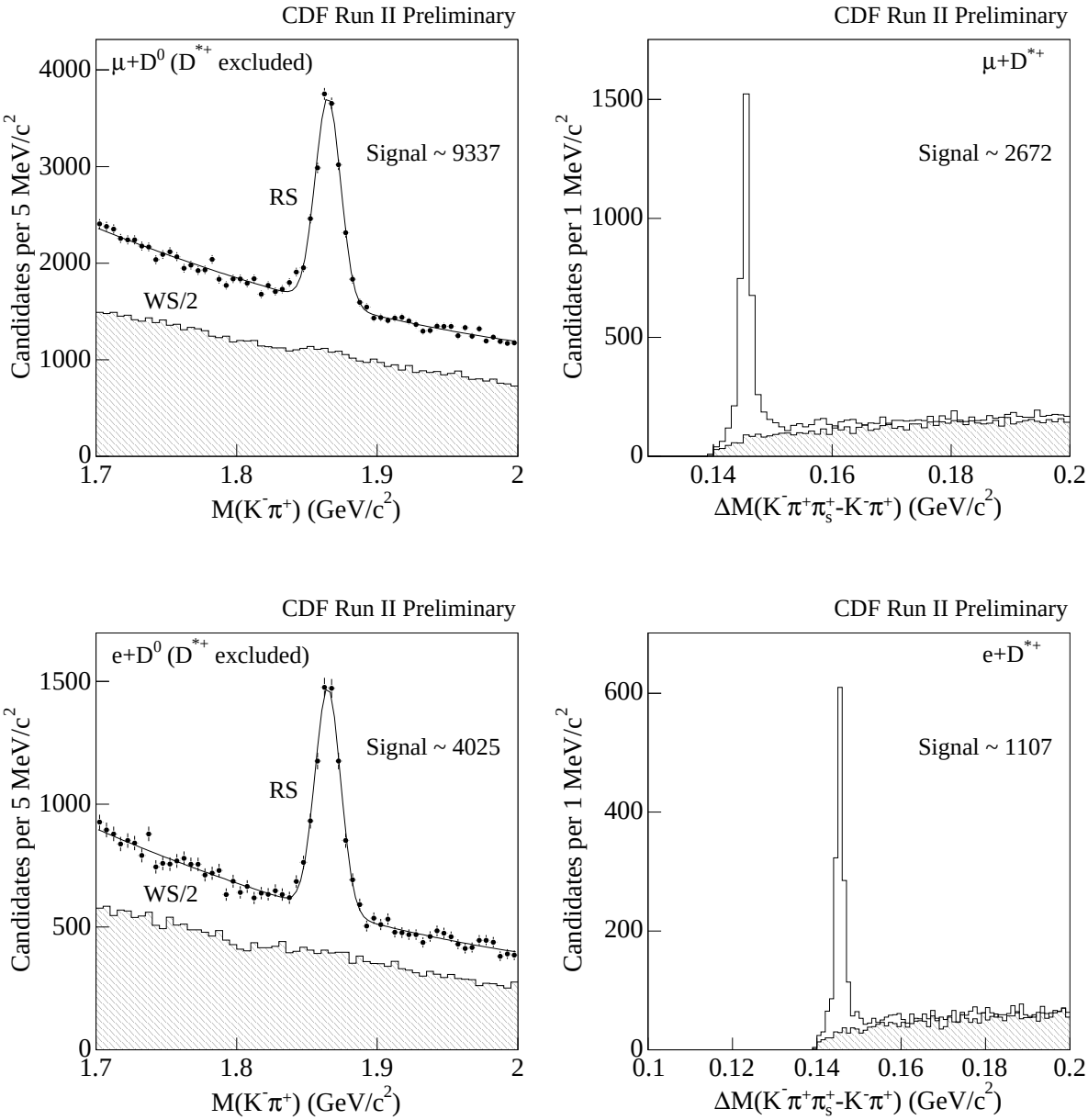
Q22 : Can you justify your alignment systematic error of 2 μm?

A : Actually the number 2 μm is taken from the Run II lifetime analysis with J/ψ modes. We think systematics from the alignment are not so different among these analyses.

Plots and numbers we ask to bless

— 22 slides —

D^0, D^{*+} mass plots



D^0, D^{*+} yields, signal fractions

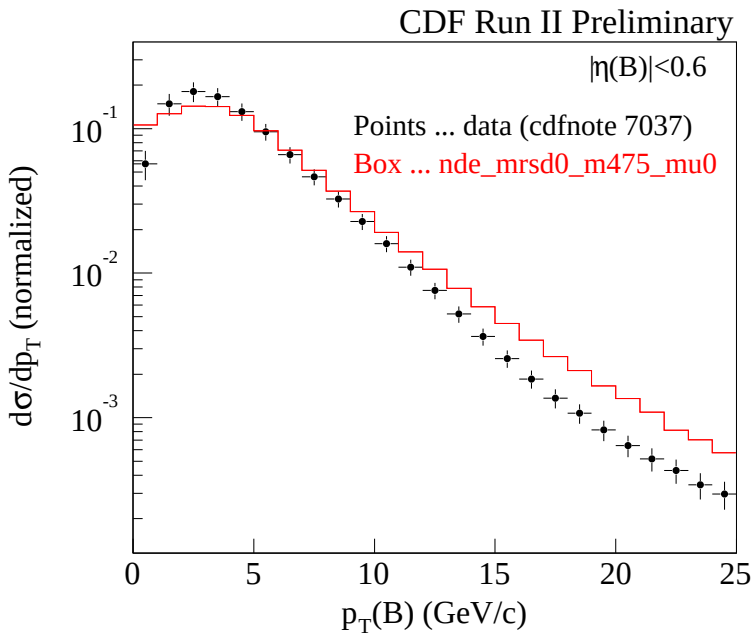
Sample	$M(K^-\pi^+)$ range (GeV/c^2)	ΔM range (GeV/c^2)	Events	Signal fraction
$\mu^- D^0$	1.845 - 1.885	0.142 - 0.148 (veto)	21971	0.425 $\pm$ 0.004
$\mu^- D^{*+}$	1.835 - 1.895	0.144 - 0.147	2947	0.907 $\pm$ 0.007
$e^- D^0$	1.845 - 1.885	0.142 - 0.148 (veto)	8539	0.471 $\pm$ 0.007
$e^- D^{*+}$	1.835 - 1.895	0.144 - 0.147	1219	0.908 $\pm$ 0.010

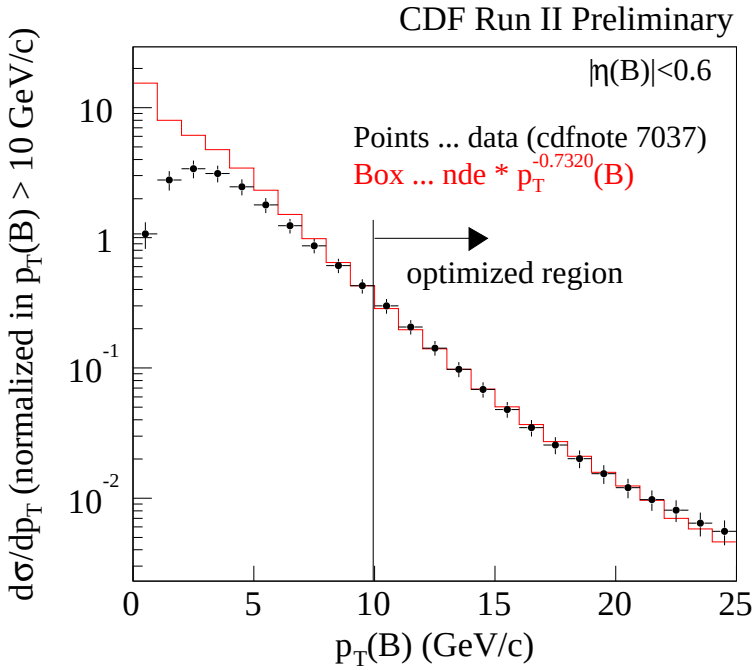
Summary of signal region definitions and yields.

Sample	$M(K^-\pi^+)$ range (GeV/c^2)	ΔM range (GeV/c^2)	Events
$\mu^- D^0$	1.74-1.79, 1.94-1.99	0.142 - 0.148 (veto)	32763
$\mu^- D^{*+}$	1.835 - 1.895	0.15 - 0.2	7658
$e^- D^0$	1.74-1.79, 1.94-1.99	0.142 - 0.148 (veto)	11868
$e^- D^{*+}$	1.835 - 1.895	0.15 - 0.2	2922

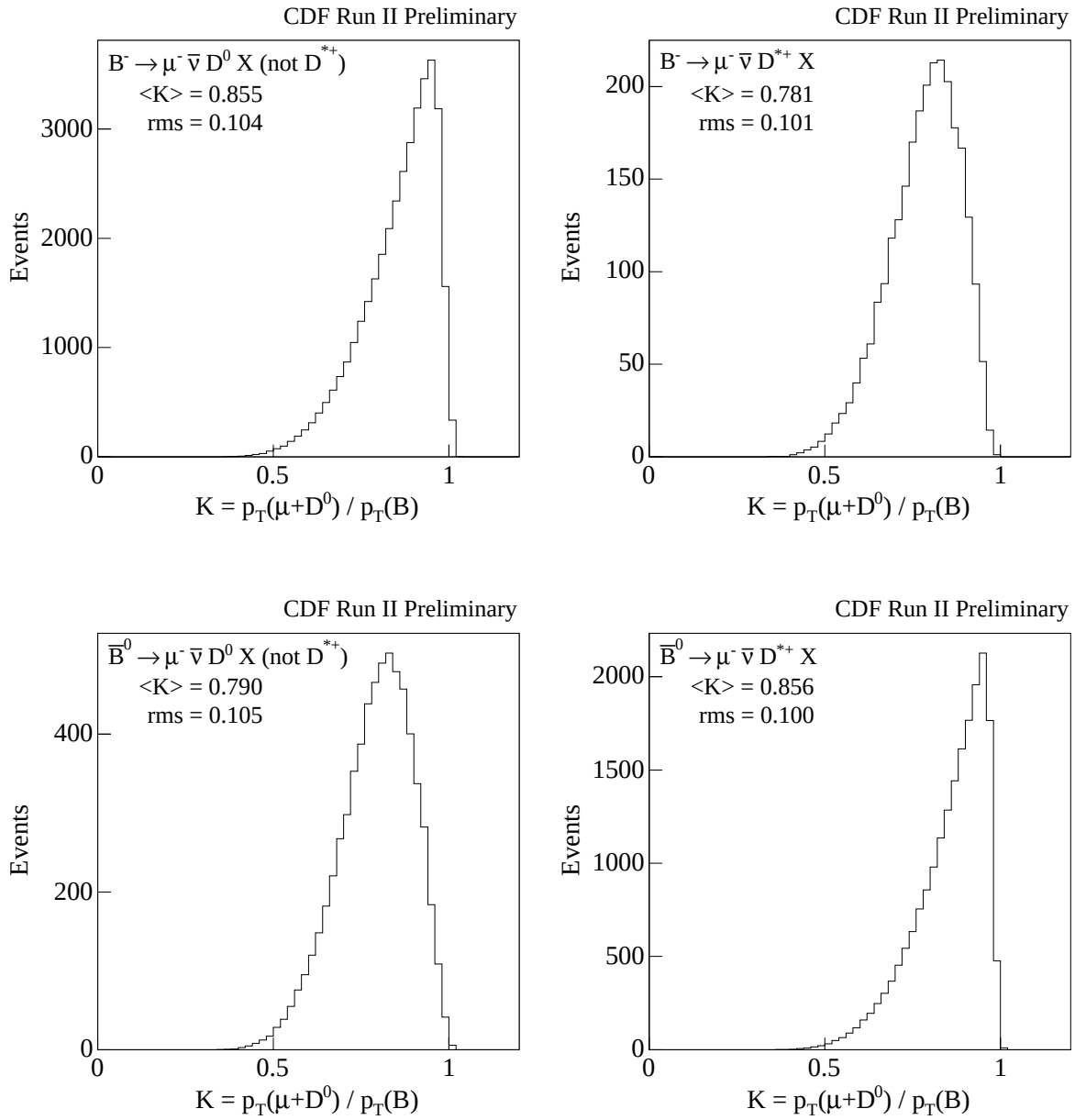
Summary of sideband region definitions and yields.

$p_T(B)$ spectra used for monte carlo

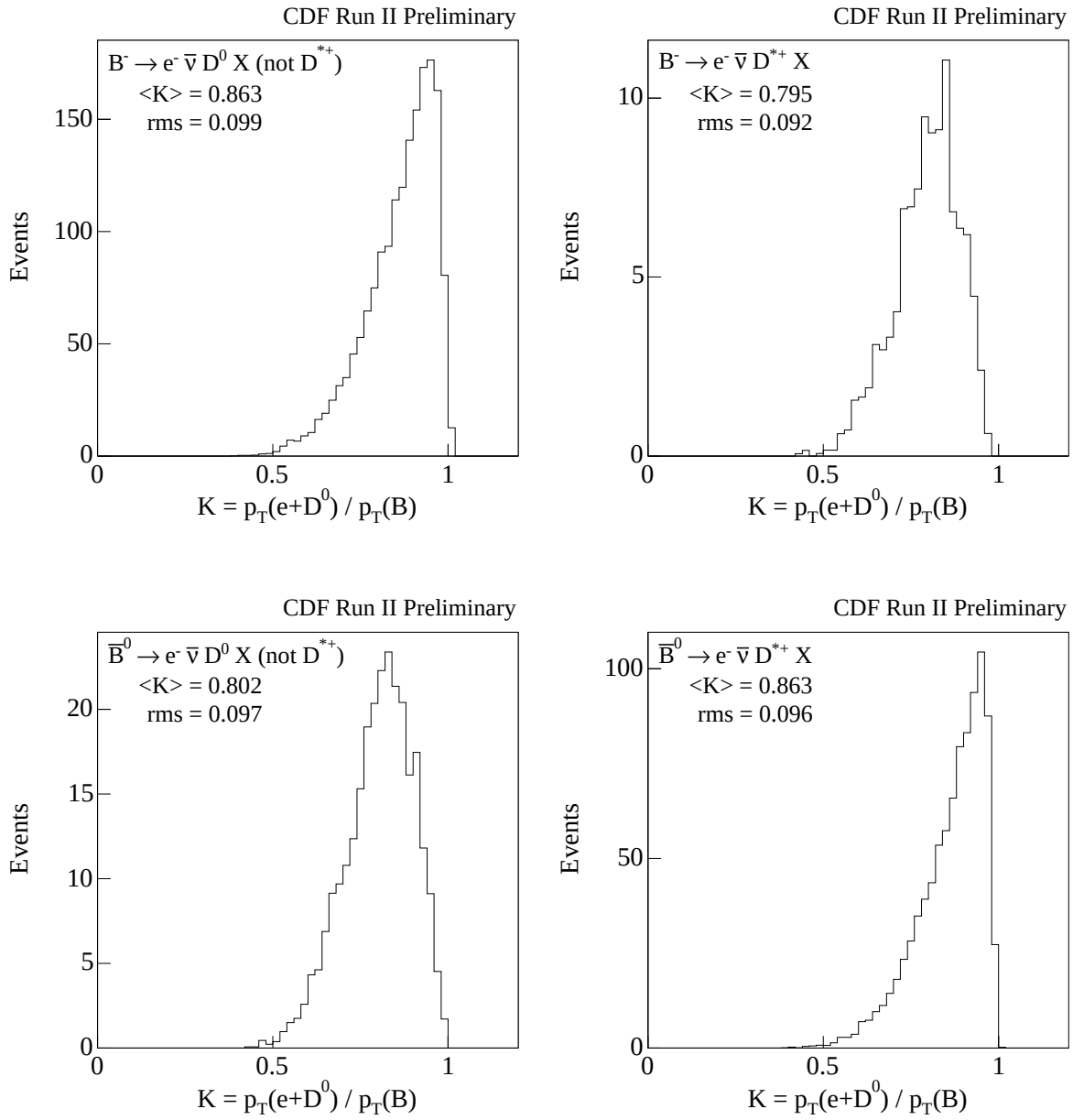




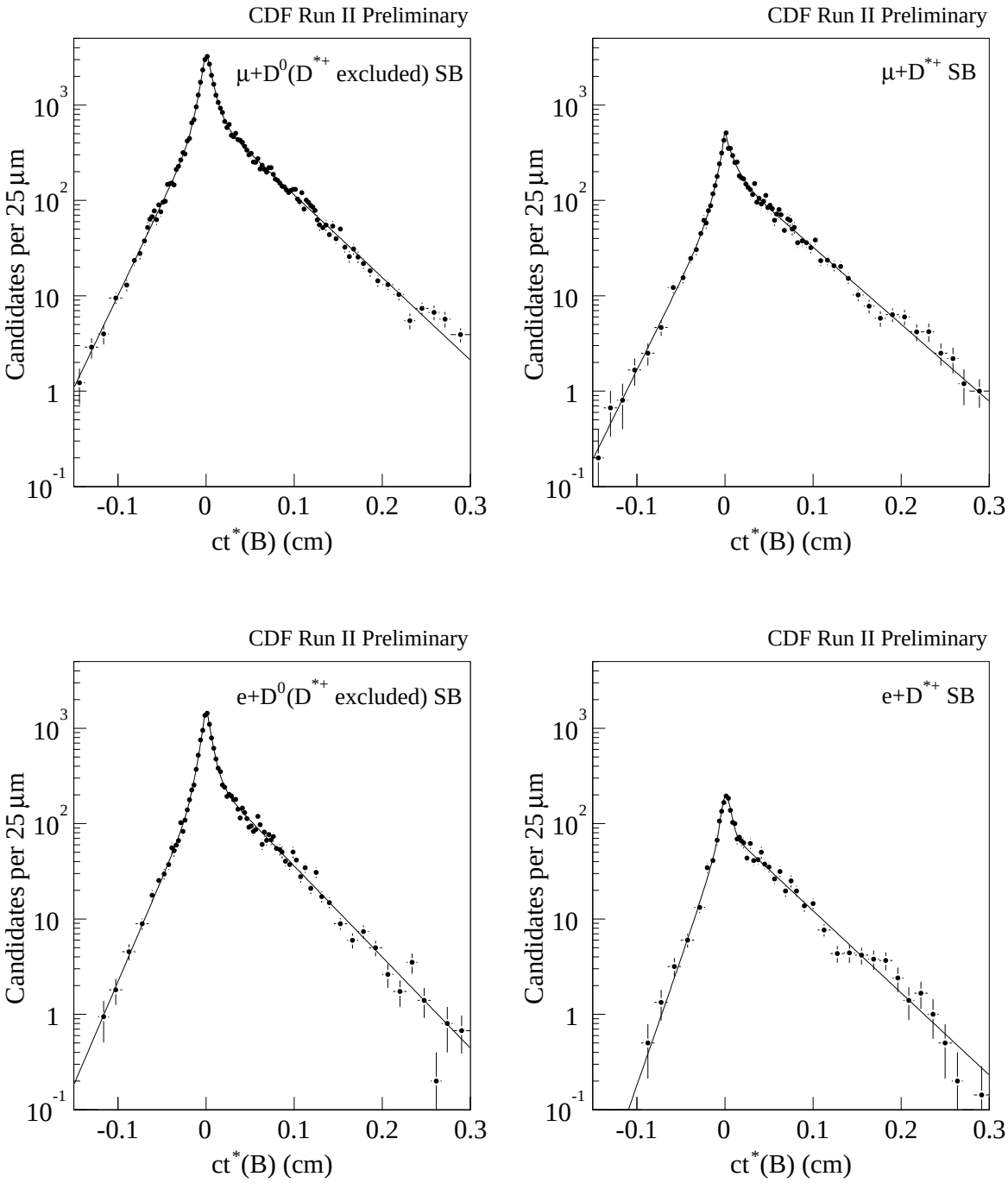
K factor distributions for muon



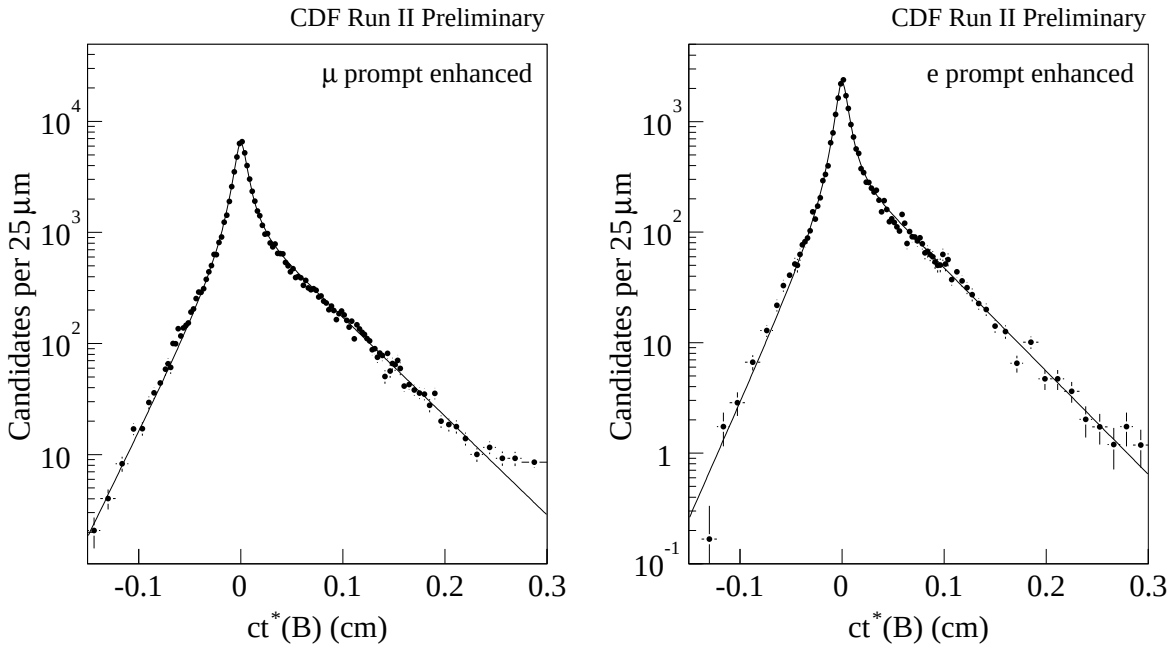
K factor distributions for electron



ct^* shapes of sideband events



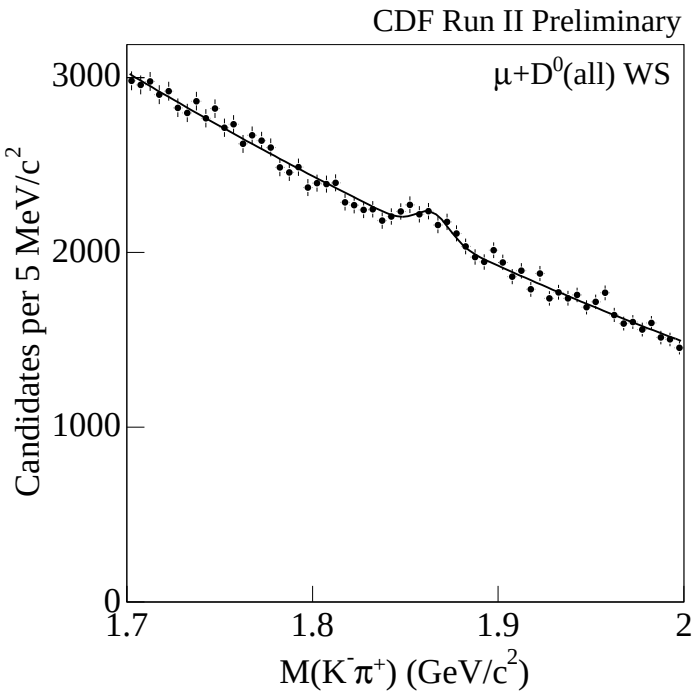
Resolution scale factor determination

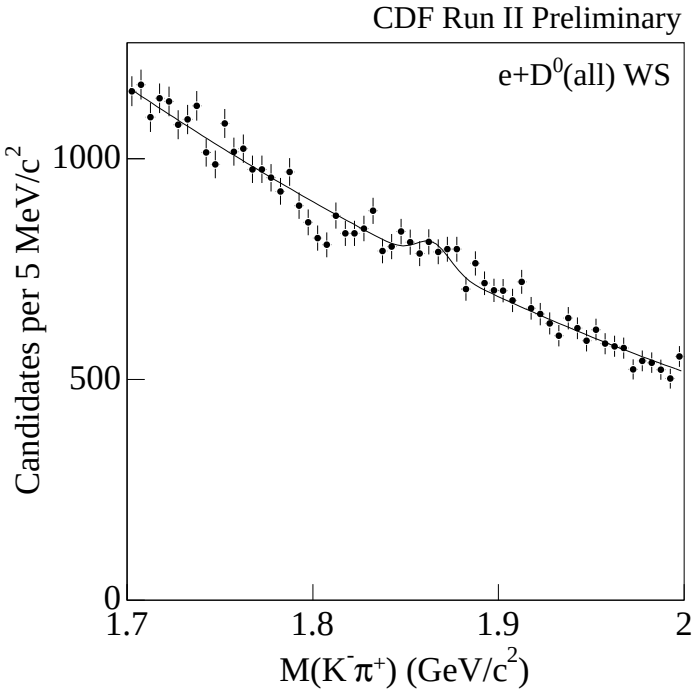


The Resolution scale factor

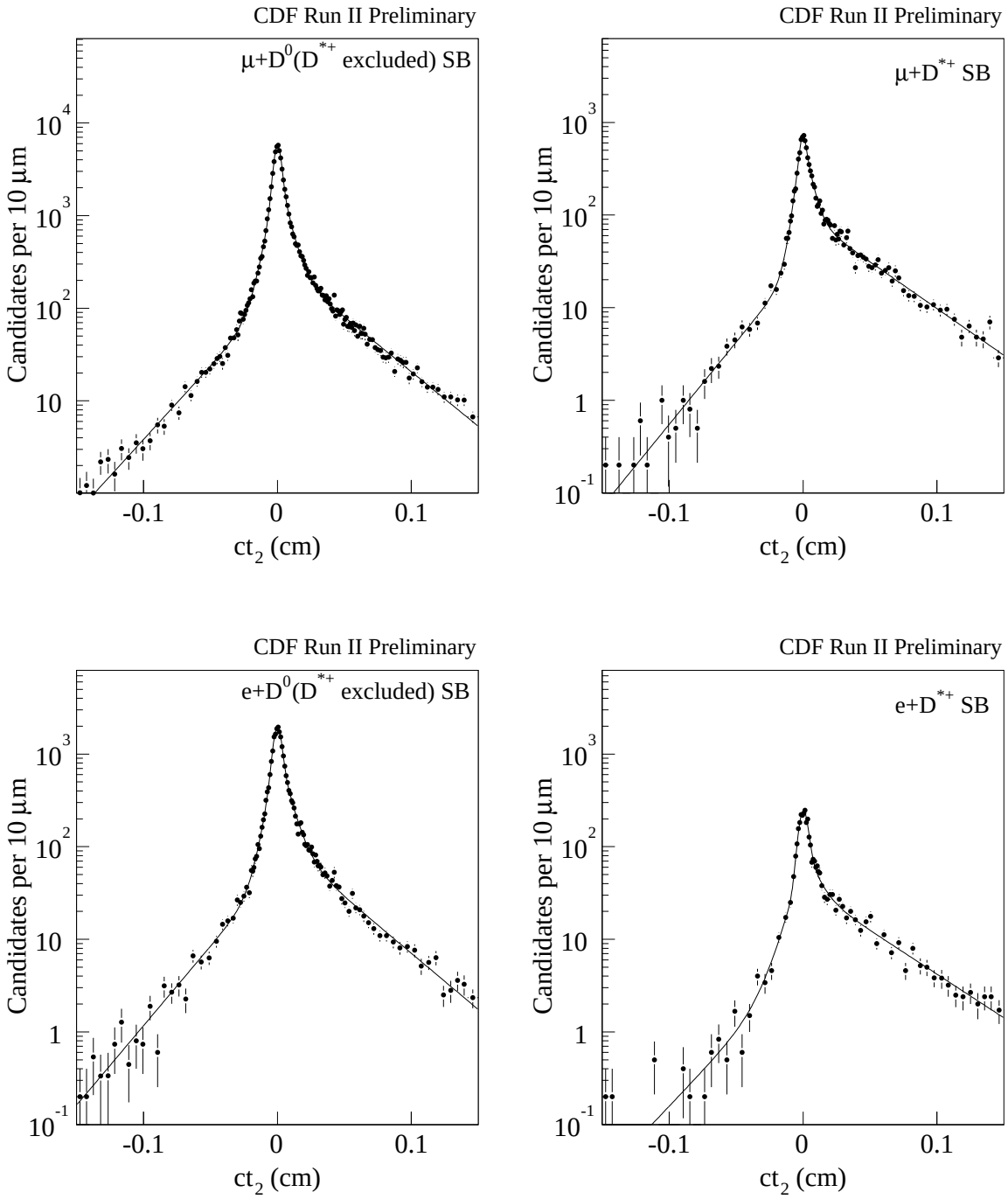
$$s = \begin{cases} 1.52 \pm 0.01 & \text{for } \mu \text{ dataset} \\ 1.45 \pm 0.02 & \text{for } e \text{ dataset} \end{cases}$$

D^0 peaks in WS events

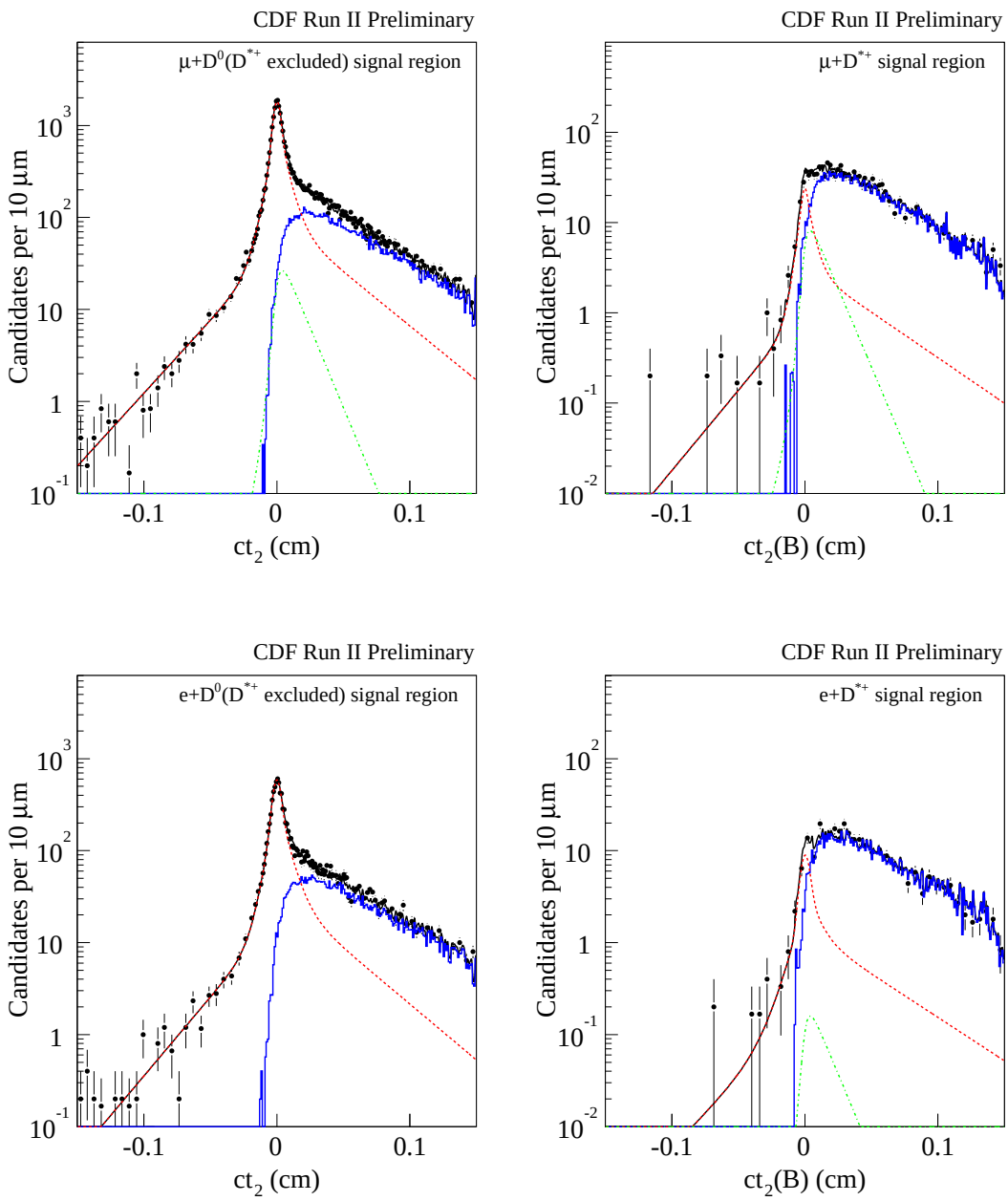




ct_2 shapes for sideband events



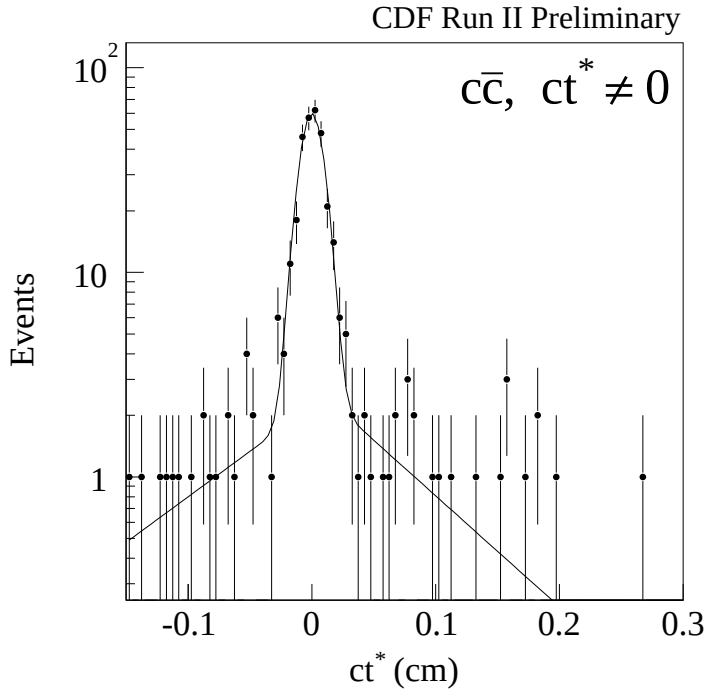
Determination of charm background fraction



The charm background fraction (after $L_{xy} > 0$ cut)

$$f_c = \begin{cases} 5.7 \pm 1.2\ \% & \text{for } \mu^- D^0 \\ 5.8 \pm 1.3\ \% & \text{for } \mu^- D^{*+} \\ 0.0\ ^{+2.0}_{-0.0}\ \% & \text{for } e^- D^0 \\ 0.3\ ^{+1.9}_{-0.3}\ \% & \text{for } e^- D^{*+} \end{cases}$$

ct^* shape of non-zero lifetime charm backgrounds



Bottom backgrounds

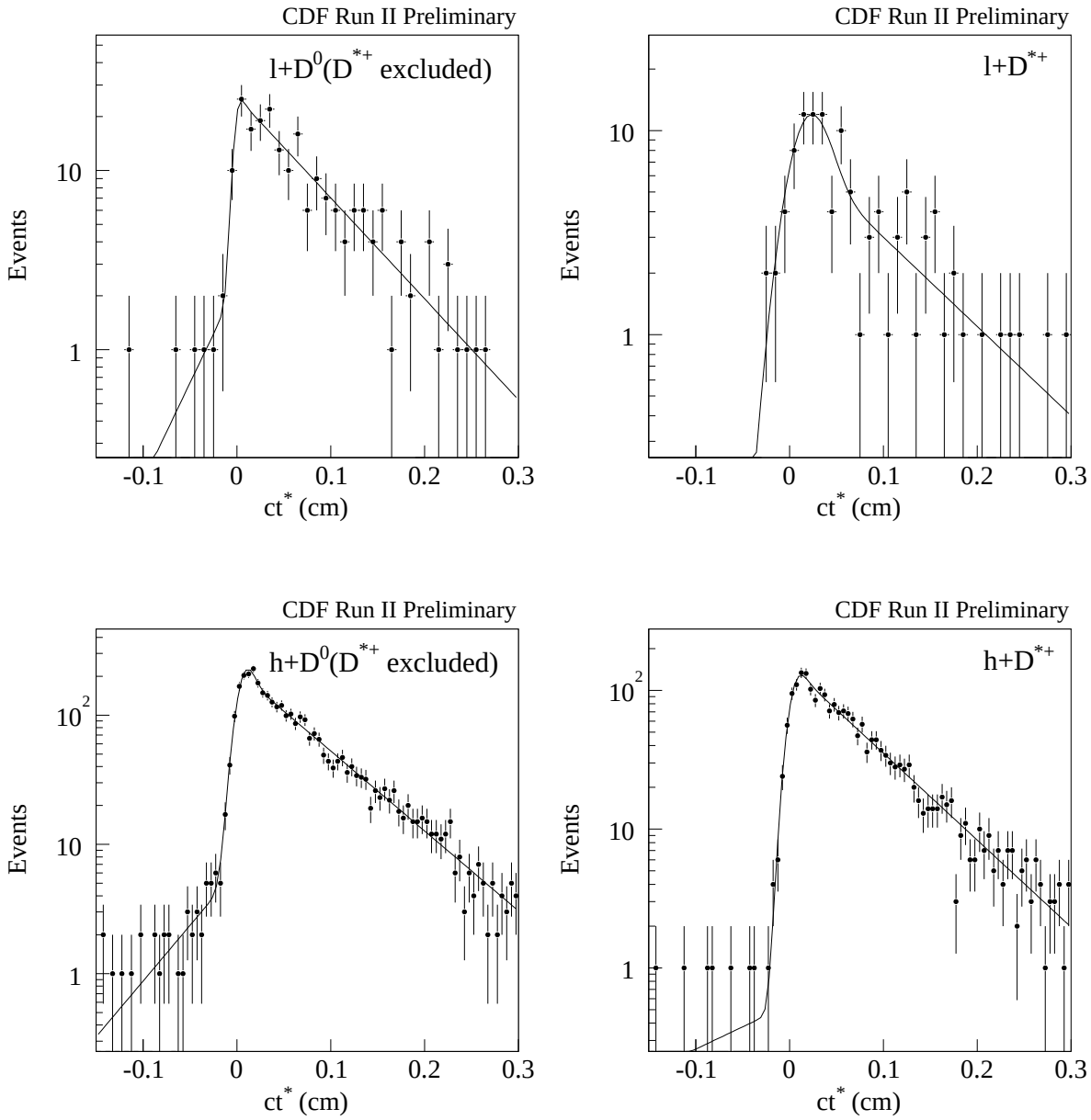
Breakdown of the $b\bar{b} \to \ell^- D^0$ MC processes (by Pythia + QQ, no detector simulation):

process	$\ell^- D^0$(D^{*+} excluded)	$\ell^- D^{*+}$
Semileptonic $\ell^- D^0$	**5226**	**2702**
non-semileptonic $\ell^- D^0$	**217**	**108**
$\bar{B}_s^0 \to \ell^- \bar{\nu} D_s^{**+}, D_s^{**+} \to D^0 X$	84	50
$\bar{B} \to \tau^- \bar{\nu} D^0, \tau^- \to \ell^- \bar{\nu}$	52	27
$\bar{B} \to D^0 D_s^- X, D_s^- \to \ell^- X'$	46	8
$\bar{B} \to D^0 D_s^- X, D_s^- \to \tau^- X', \tau^- \to \ell^- X''$	18	5
$\bar{B} \to D \bar{D} X \to \ell^- D^0 X'$	7	6
$b\bar{b}, b \to D^0 X, \bar{b} \to \ell^+ X'$, ($b$ or $\bar{b}$ oscillates and give RS)	6	8
$b\bar{b}, b \to D^0 X, \bar{b} \to \bar{c} \to \ell^- X'$	2	1
others	2	3
hadron+D^0	**3371**	**2138**
single $b \to h^- D^0$	3308	2117
$b\bar{b} \to h^- D^0$	63	21

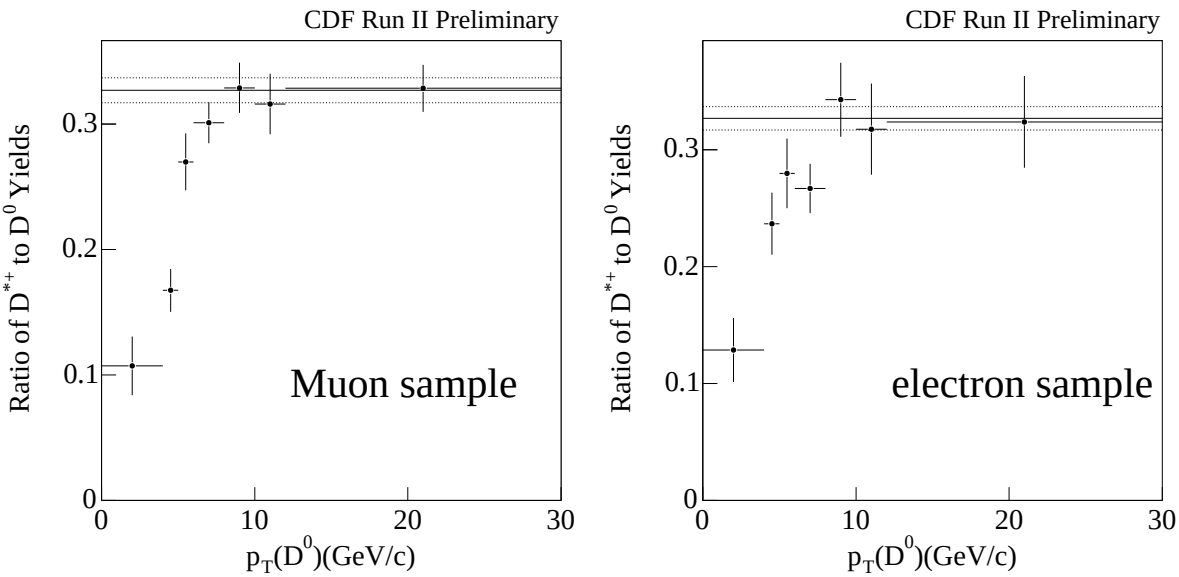
The bottom background fraction

$$f_b = \frac{N_b}{N_{D^0}} = \begin{cases} 3.8 \pm 0.3\% & \text{for } \mu + D^0(D^{*+} \text{ excluded}) \\ 3.6 \pm 0.4\% & \text{for } \mu + D^{*+} \\ 4.0 \pm 0.3\% & \text{for } e + D^0(D^{*+} \text{ excluded}) \\ 3.8 \pm 0.4\% & \text{for } e + D^{*+} \end{cases}$$

ct^* shapes of the bottom backgrounds



Ratio of D^{*+}/D^0) yields and π_s^+ reconstruction efficiency



Dataset	$p_T(D^0)$ region	D^{*+}/D^0 ratio	$\epsilon(\pi_s)$
Muon	< 8 GeV/c	0.221 ± 0.010	0.673 ± 0.037
	> 8 GeV/c	0.326 ± 0.012	$0.993\ ^{+0.007}_{-0.049}$
Electron	< 8 GeV/c	0.232 ± 0.013	0.707 ± 0.046
	> 8 GeV/c	0.330 ± 0.021	$1.000\ ^{+0.000}_{-0.067}$

Summary of the slow pion reconstruction efficiency in each D^0 transverse momentum region.

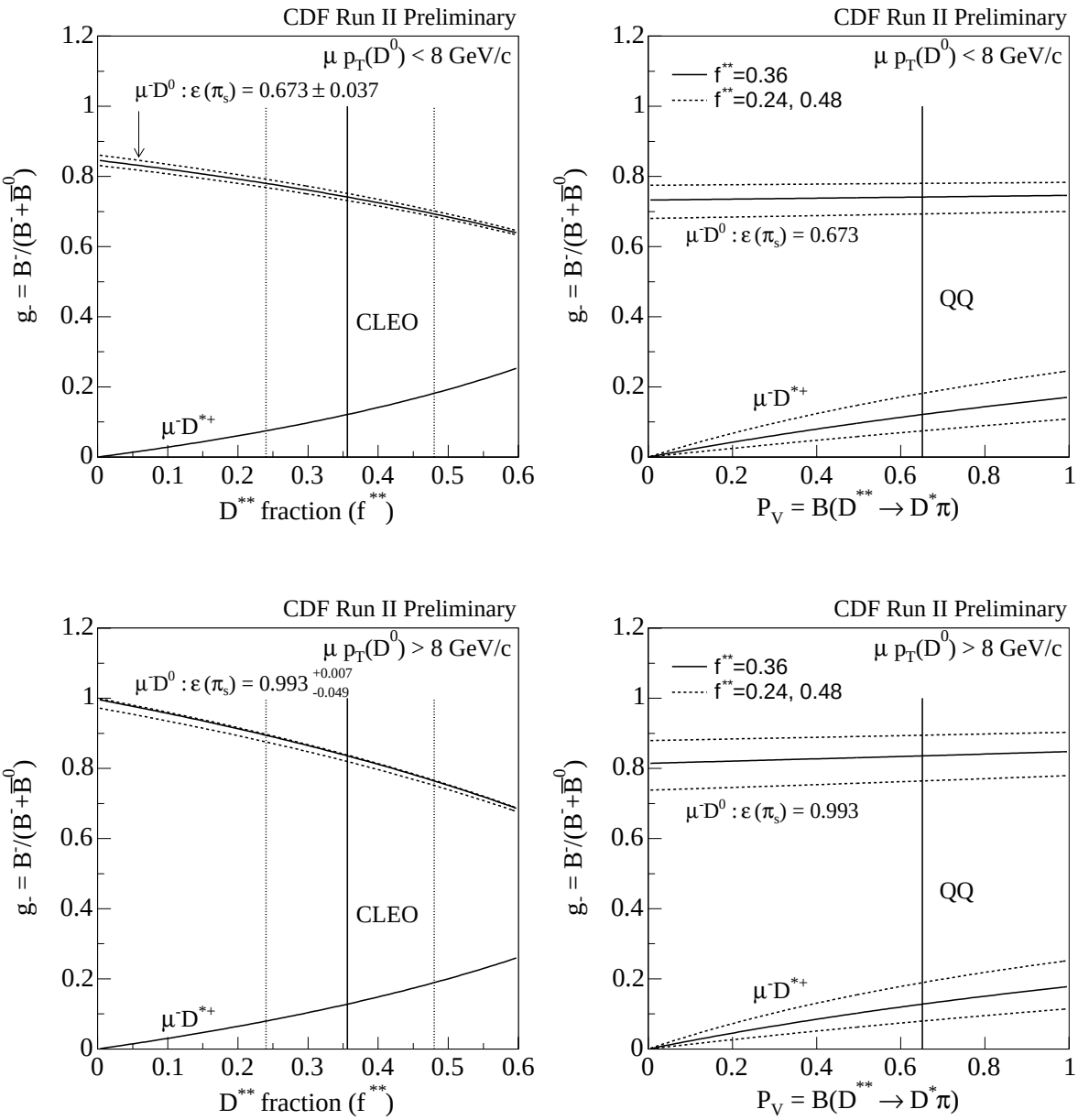
Dataset	$p_T(D^0)$ range	$\ell^- D^0$	$\ell^- D^{*+}$
Muon	< 8 GeV/c	0.741	0.121
	> 8 GeV/c	0.836	0.128
Electron	< 8 GeV/c	0.756	0.109
	> 8 GeV/c	0.870	0.107

Table of the g_- (B^- fraction) in each sample with $\tau(B^-)/\tau(\bar{B}^0) = 1$.

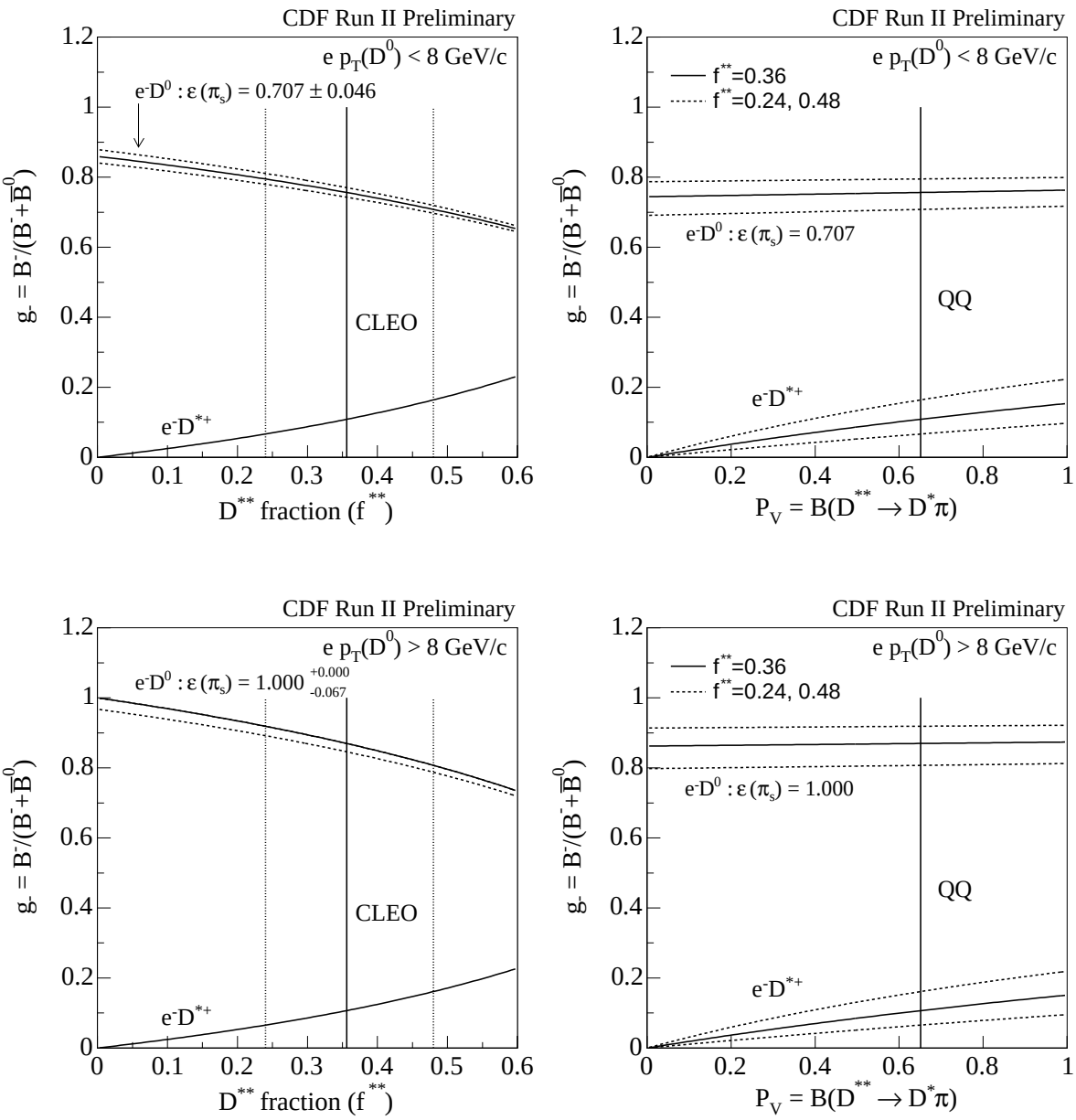
Changes of g_- as function of f^{**}, P_V for muon

$$f^{**} = \frac{\mathcal{B}(\bar{B} \to \ell^- \bar{\nu} D^{**})}{\mathcal{B}(\bar{B} \to \ell^- \bar{\nu} D X)}$$

$$P_V = \frac{\mathcal{B}(D^{**} \to D^* \pi)}{\mathcal{B}(D^{**} \to D^* \pi) + \mathcal{B}(D^{**} \to D \pi)}$$



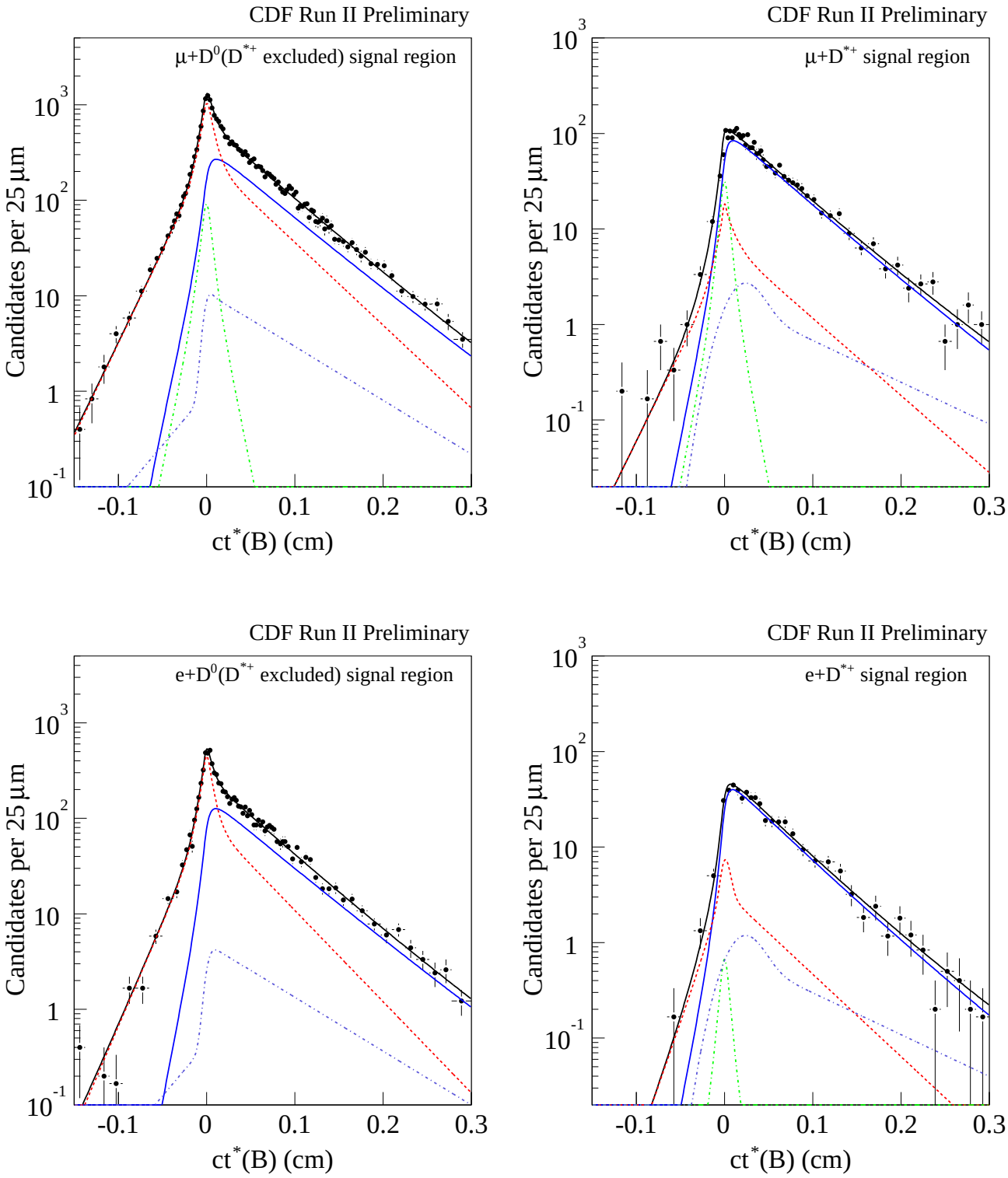
Changes of g_- as function of f^{**}, P_V for electron



Tables of the lifetime fit results under several conditions of the sample composition

f^{**}	P_V	$\epsilon(\pi_s)$				$c\tau$ (μm)		correl.	$\frac{\tau(B^-)}{\tau(\bar{B}^0)}$
		μ low	μ high	e low	e high	B^-	$\bar{B}^0$	coeff.	
0.24	0.65	0.673	0.993	0.707	1.000	495.0 ± 7.8	448.0 ± 10.0	−0.295	1.105 ± 0.034
0.36	0.65	0.673	0.993	0.707	1.000	495.6 ± 8.6	441.5 ± 10.9	−0.418	1.123 ± 0.040
0.48	0.65	0.673	0.993	0.707	1.000	498.1 ± 9.8	431.4 ± 12.7	−0.566	1.155 ± 0.051
0.36	0.22	0.673	0.993	0.707	1.000	494.2 ± 8.5	452.5 ± 9.7	−0.340	1.092 ± 0.035
0.36	1.00	0.673	0.993	0.707	1.000	496.3 ± 8.6	432.9 ± 12.0	−0.463	1.146 ± 0.045
0.36	0.65	0.636	0.944	0.661	0.933	495.7 ± 8.8	441.8 ± 11.0	−0.440	1.122 ± 0.041
0.36	0.65	0.710	1.000	0.753	1.000	495.0 ± 8.5	442.3 ± 11.0	−0.410	1.119 ± 0.040

Fit results for the muon, electron separate fit



Fit results for the electron, muon separate fit (cont'd)

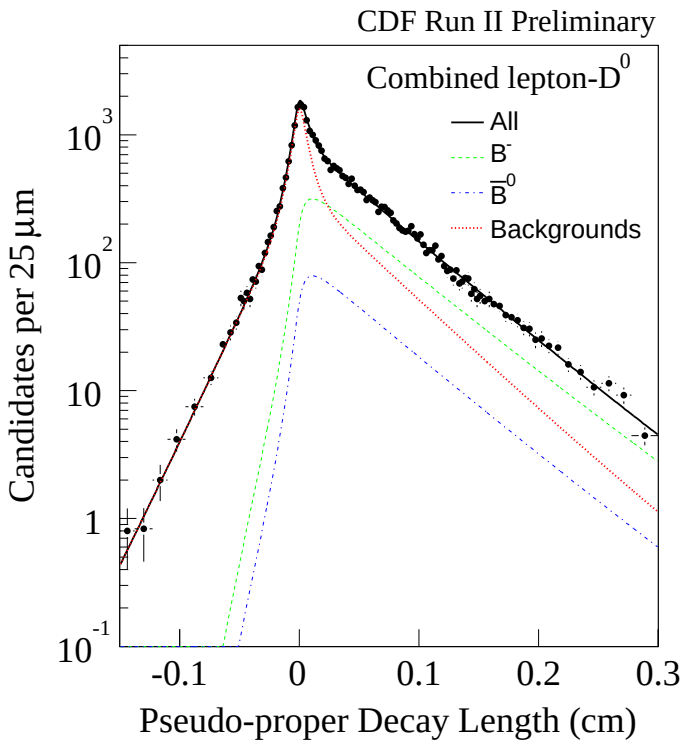
Fit results for the muon dataset:

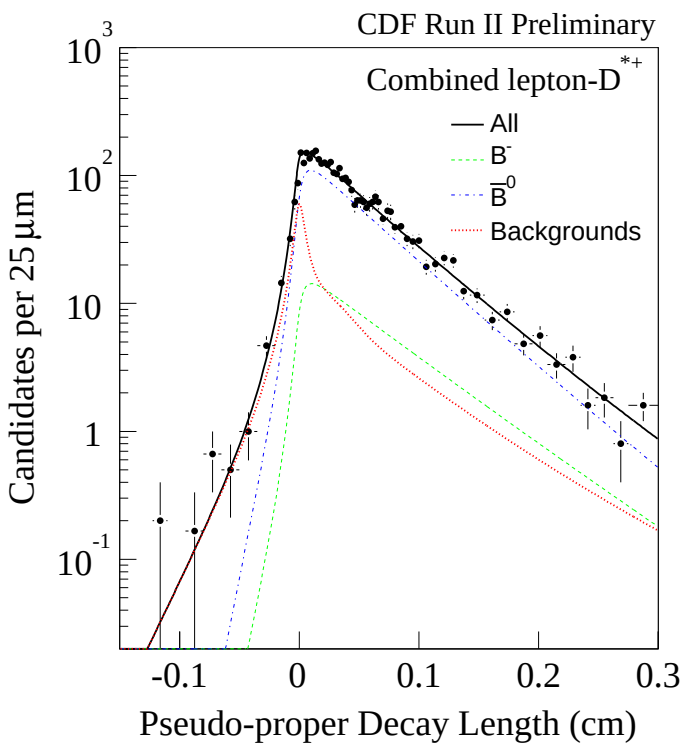
$$\begin{aligned} c\tau(B^-) &= 489.8 \pm 10.8\ \mu\text{m} \\ c\tau(\bar{B}^0) &= 453.6 \pm 13.6\ \mu\text{m} \\ \tau(B^-)/\tau(\bar{B}^0) &= 1.080 \pm 0.048 \end{aligned}$$

Fit results for the electron dataset:

$$\begin{aligned} c\tau(B^-) &= 504.7 \pm 13.9\ \mu\text{m} \\ c\tau(\bar{B}^0) &= 418.1 \pm 18.2\ \mu\text{m} \\ \tau(B^-)/\tau(\bar{B}^0) &= 1.207 \pm 0.072 \end{aligned}$$

Combined fit result





Lifetime fit result

Muon & electron combined fit results

(including systematics, red numbers are suggested systematics):

$$c\tau(B^-) = 495.6 \pm 8.6 \,^{+13.3}_{-12.8} \,(^{+8.6}_{-7.8})\ \mu\text{m}$$
$$c\tau(\bar{B}^0) = 441.5 \pm 10.9 \pm 17.0\ (\pm 15.7)\ \mu\text{m}$$

or

$$\tau(B^-) = 1.653 \pm 0.029 \,^{+0.044}_{-0.043} \,(^{+0.029}_{-0.026})\ \text{ps}$$
$$\tau(\bar{B}^0) = 1.473 \pm 0.036 \pm 0.057\ (\pm 0.052)\ \text{ps}$$

$$\tau(B^-)/\tau(\bar{B}^0) = 1.123 \pm 0.040 \,^{+0.041}_{-0.039}$$

Dataset	$\ell^- D^0$ (D^{*+} excluded)	$\ell^- D^{*+}$
e only	0.8562	0.1071
μ only	0.0484	0.8091
Combined	0.7538	0.0999

Fitting probabilities calculated from each fit result.

Dataset	$p_T(D^0)$ range	$\ell^- D^0$	$\ell^- D^{*+}$
Muon	< 8 GeV/c	0.763	0.134
	> 8 GeV/c	0.851	0.141
Electron	< 8 GeV/c	0.777	0.120
	> 8 GeV/c	0.882	0.118

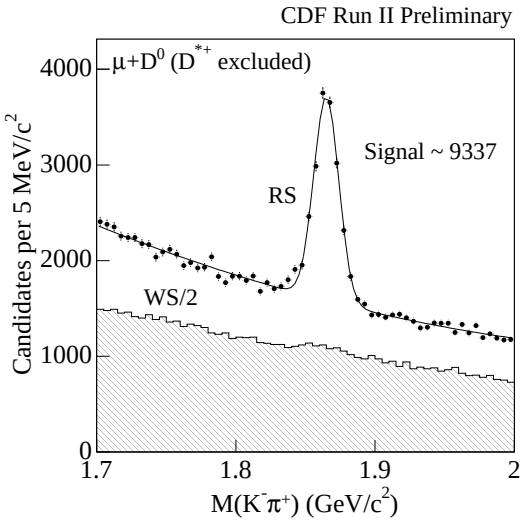
The g_- (B^- fraction) at the converged point of the combined fit.

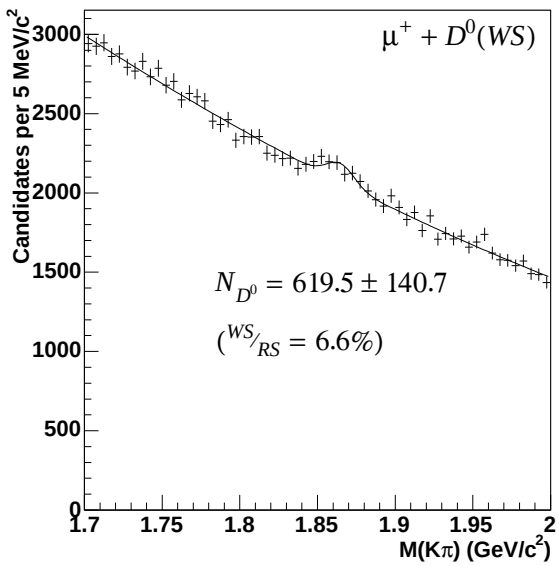
Systematic uncertainties

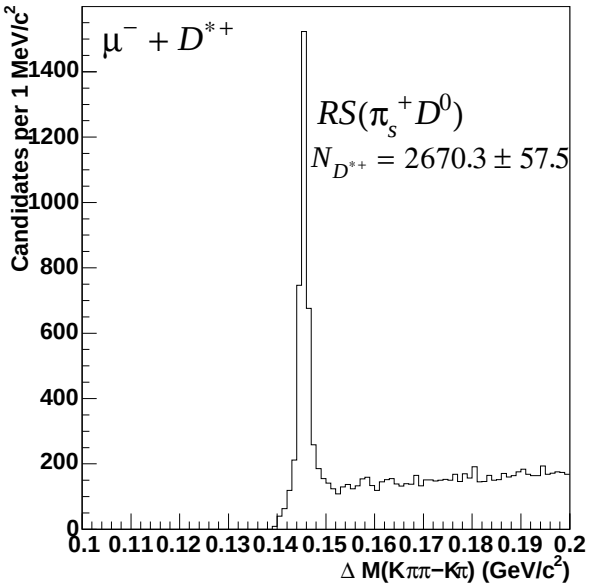
Source	Contribution to		
	$c\tau(B^-)(\mu\text{m})$	$c\tau(\bar{B}^0)(\mu\text{m})$	$\tau(B^-)/\tau(\bar{B}^0)$
Charm background			
Charm BG fraction (f_c)	$^{+3.7}_{-1.9}$	$^{+5.7}_{-3.7}$	$^{+0.006}_{-0.007}$
Charm BG shape ($\mathcal{F}_c$)	± 2.6	± 5.2	± 0.007
Bottom background			
Bottom BG fraction (f_b)	$^{+0.3}_{-0.9}$	$^{+0.7}_{-1.5}$	$^{+0.001}_{-0.002}$
Bottom BG shape ($\mathcal{F}_b$)	± 2.6	± 1.4	± 0.002
Sample composition (B^- vs $\bar{B}^0$)			
D^{**} fraction (f^{**})	$^{+2.5}_{-0.6}$	$^{+6.5}_{-10.1}$	$^{+0.032}_{-0.018}$
D^{**} composition (P_V)	$^{+0.7}_{-1.4}$	$^{+11.0}_{-8.6}$	$^{+0.023}_{-0.031}$
π_s^+ reconstruction	$^{+0.1}_{-0.6}$	$^{+0.8}_{-0.0}$	$^{+0.000}_{-0.004}$
K factor			
$p_T(B)$ spectrum	± 6.1	± 5.3	-
(suggested)	± 3.3	± 2.9	-
B decay model	± 1.0	± 1.3	-
Electron cuts	± 2.0	± 1.4	-
Signal fraction (f_{sig})	± 2.4	± 0.9	± 0.003
Resolution scale factor	± 9.5	± 5.3	± 0.008
(suggested)	± 3.6	± 1.9	± 0.003
Decay length cut	$^{+0.0}_{-1.8}$	$^{+0.0}_{-2.2}$	$^{+0.001}_{-0.000}$
Combinatorial BG shape	± 0.7	± 0.1	± 0.002
Detector alignment	± 2.0	± 2.0	-
Total	$^{+13.3}_{-12.8}$	$^{+17.0}_{-17.0}$	$^{+0.041}_{-0.039}$
(suggested)	$^{+8.6}_{-7.8}$	$^{+15.7}_{-15.7}$	$^{+0.041}_{-0.039}$

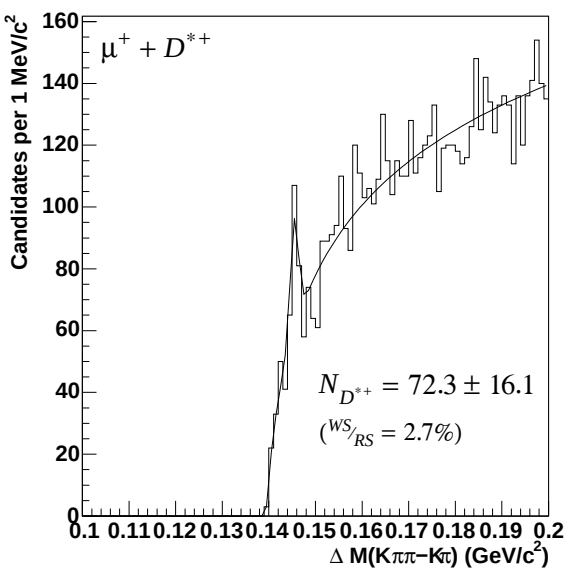
Backup slides

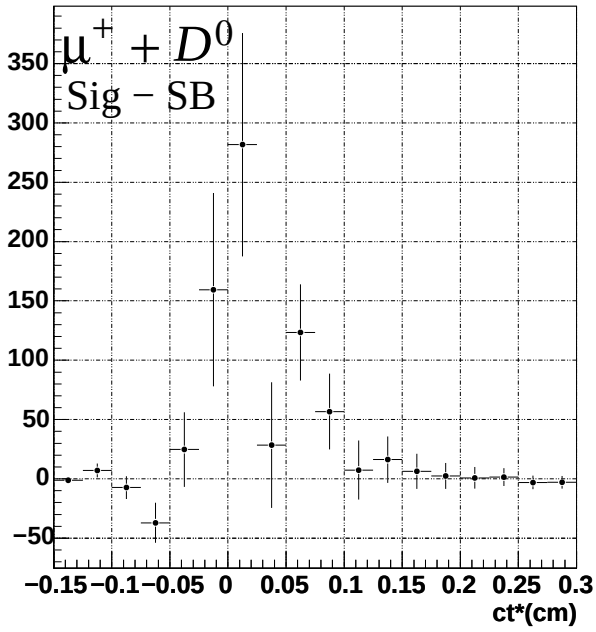
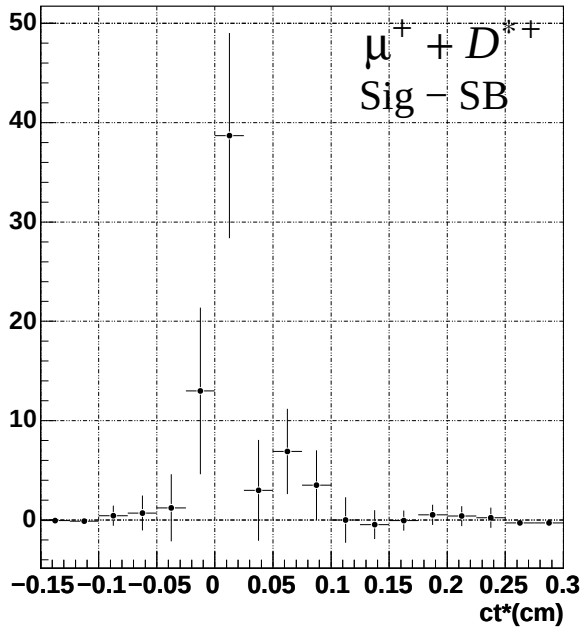
WS peak in wrong-sign μD^0 and μD^{*+}









ct^* shape of WS events

ct^* distributions for WS events, signal-SB plots: