$\Lambda_b^0 \to \Lambda_c^+ \pi^-$ Lifetime Measurement

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Talk Outline

- Trigger Code Cross-Checks: Update
- Realistic Λ_b^0 Monte Carlo Cross-Checks
- Systematic: Lc lifetime
- Systematic: Efficiency for B^0 Background
- Fit result on Amanda's $B^0 \to D^* \pi$ sample

Trigger Code Fit Cross-Check

- The Λ_b^0 signal MC sample is divided into 6 trigger code samples.
- Fits are run separately on each Trigger Code.

$$\Lambda_b^0 \to \Lambda_c \pi_2; \Lambda_c \to pK\pi_1$$

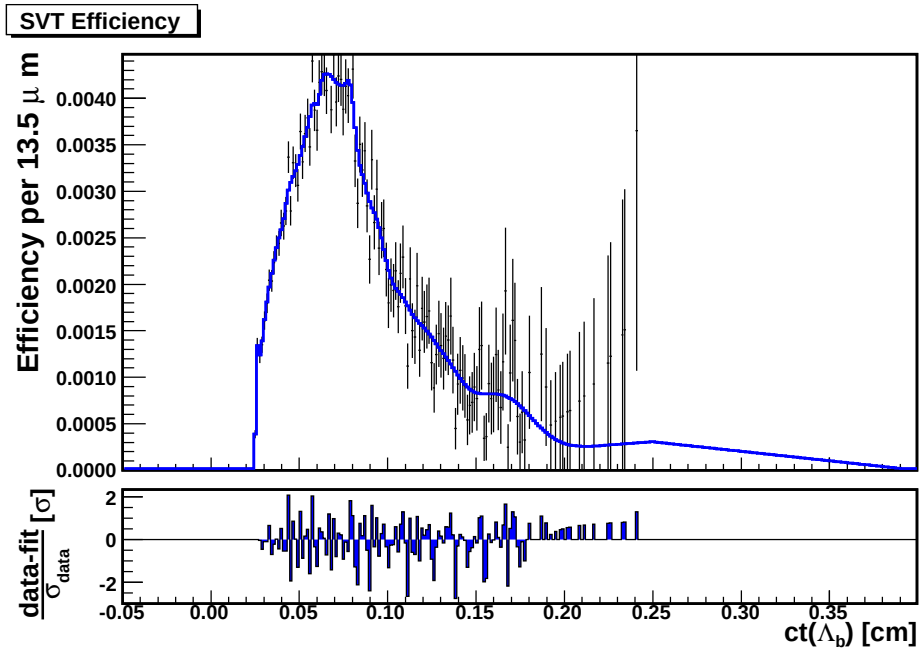
Code	Description	Nevts
1	pK	$26,071$
8	$p\pi_1$	$237,704$
9	$p\pi_1 + pK$	$29,206$
16	$\pi_1\pi_2$	$17,711$
24	$p\pi_1 + \pi_1\pi_2$	$17,398$
99	All other combinations	$10,402$

This is a good check because:

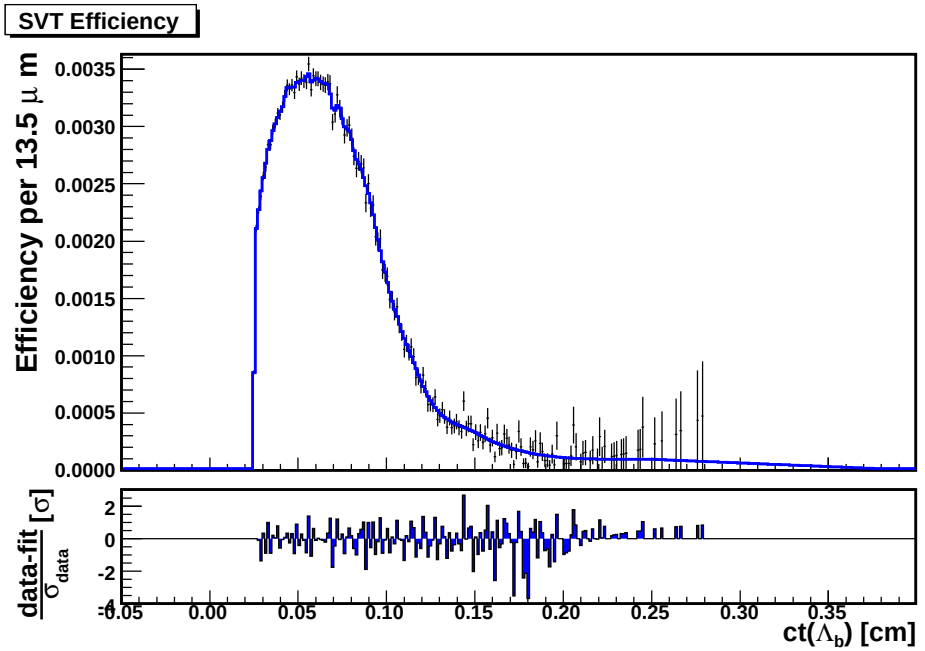
- the kinematics of each trigger code are very different.
- it exercises our method.

Efficiencies by TrigCode I

Efficiencies are calculated using the same, `RooKeysPdf` histogram smoothing method for each Trigger Code.

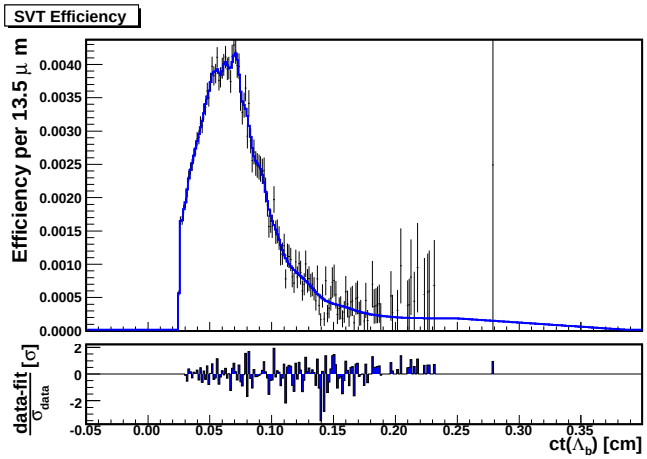


TrigCode=1 (pK)

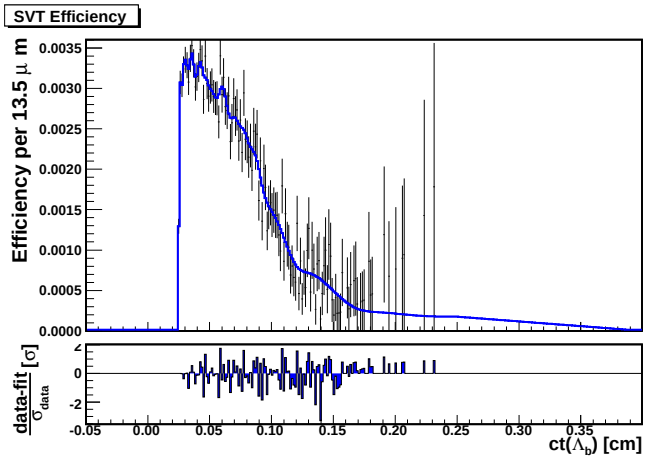


TrigCode=8 ($p\pi_1$)

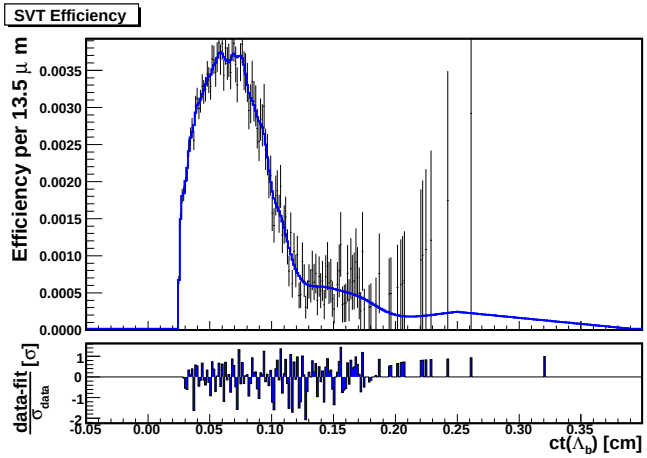
Efficiencies by TrigCode II



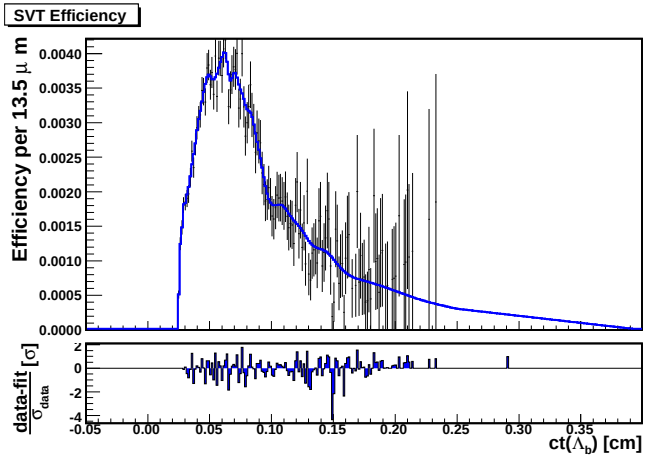
TrigCode=9 ($p\pi_1 + pK$)



TrigCode=16 ($\pi_1\pi_2$)



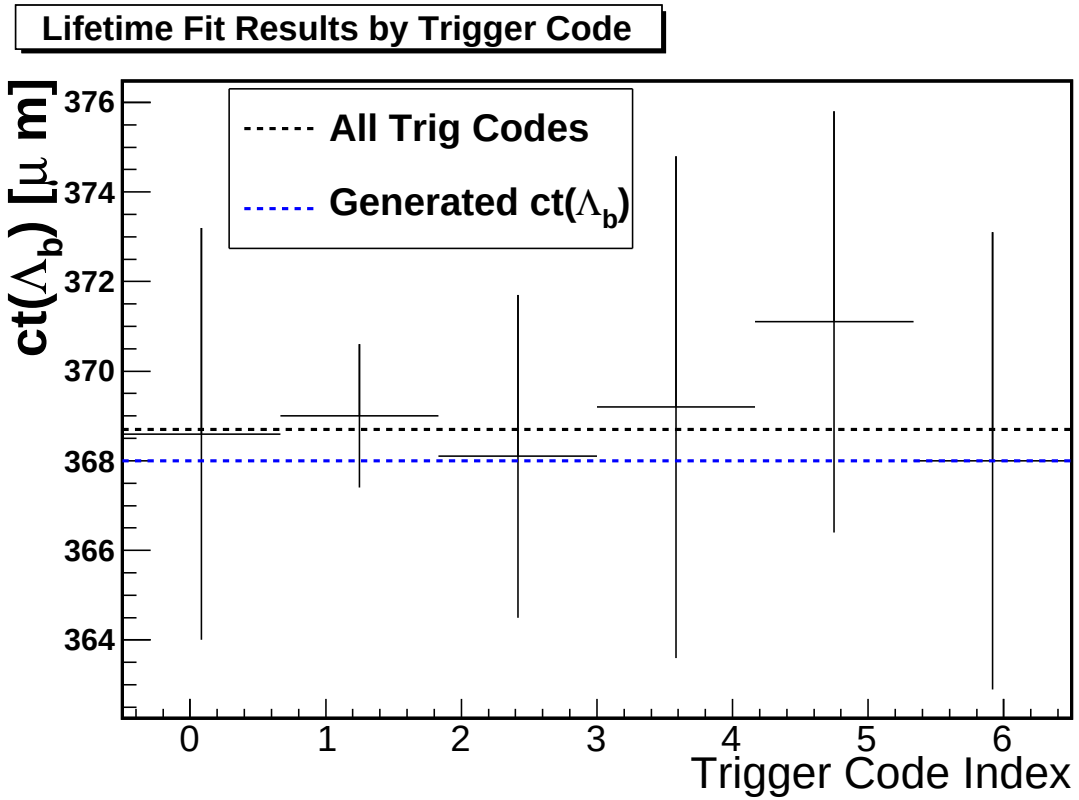
TrigCode=24 ($p\pi_1 + \pi_1\pi_2$)



TrigCode=99 (All Other)

TrigCode Slice Λ_b^0 Lifetime Result

Per-slice(points) TrigCode, Λ_b^0 lifetime fit results all agree with generated value (blue).



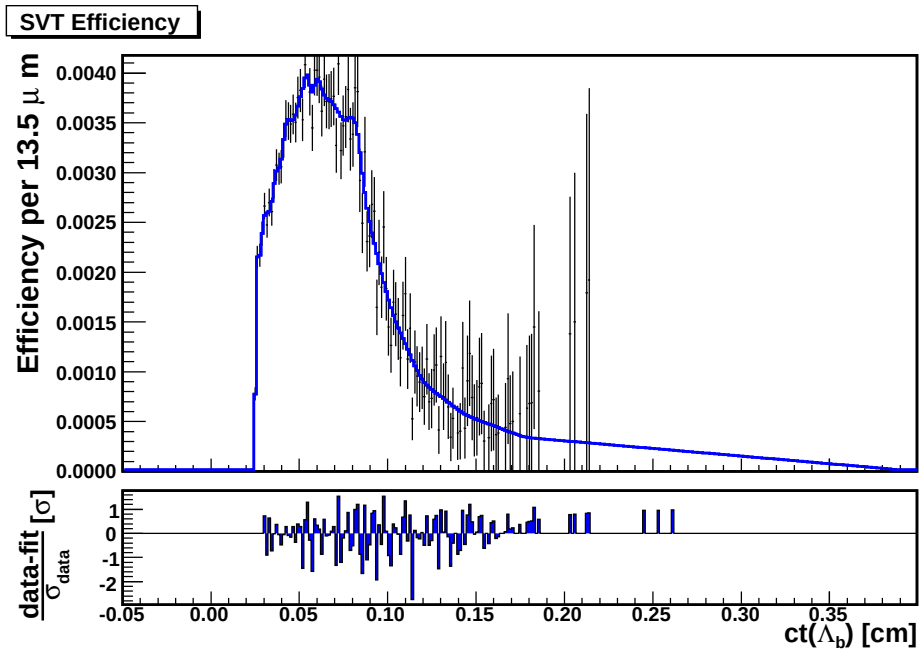
- Fit produces the correct lifetime in ALL trigger code sub-samples.
- SVT generation is robust; able to handle many kinematic situations.
- Combined efficiency from re-weighted MC should also describe the kinematics of data well.

Realistic MC Cross-Check

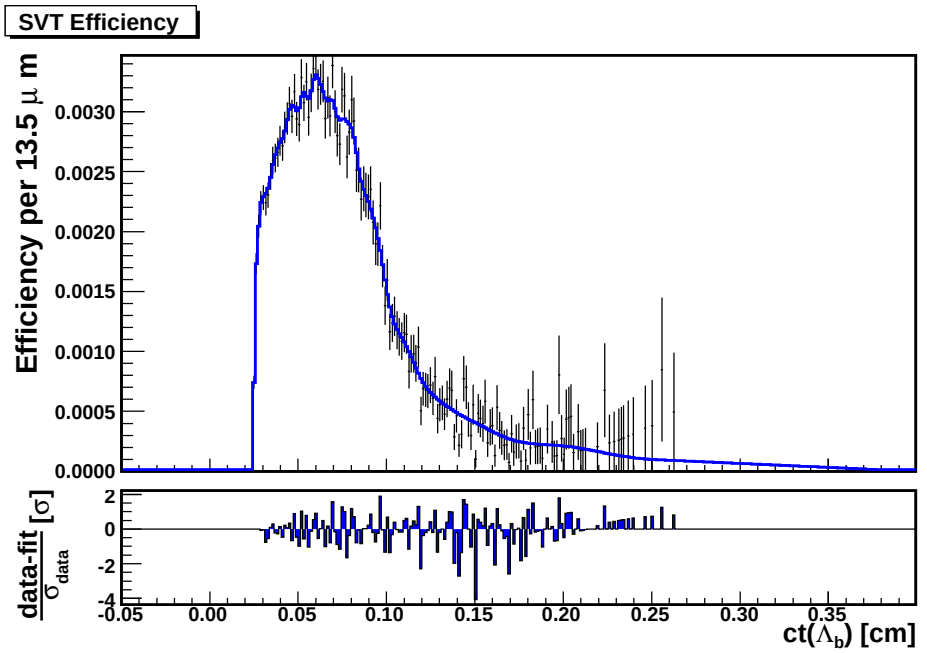
Three realistic MC samples, with different $c\tau'(\Lambda_b^0)$

$c\tau'(\Lambda_b^0)$	**Events (after cuts and re-weighting)**
325μm	$12,000$
368μm	$280,000$
500μm	$15,000$

As an additional cross-check of our method, efficiencies are generated from each of these three samples.



325μm



500μm

Realistic MC Cross-Check II

The 9 efficiency/data fit combinations are performed to probe the sensitivity of the fit to the lifetime used to generate the efficiency.

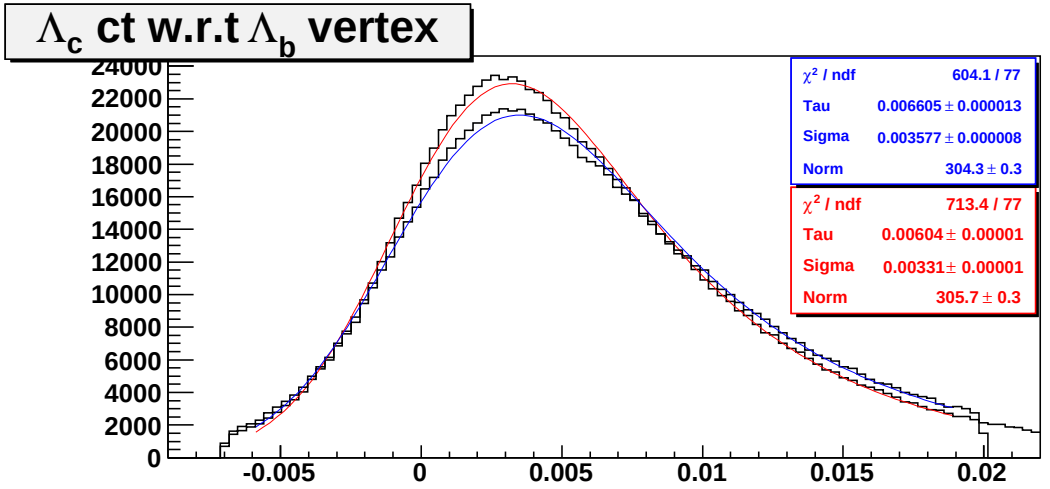
Input Sample	Fit Model	Fit Result
$325\mu\mathrm{m}$	$325\mu\mathrm{m}$	$326.5 \pm 4.4\mu\mathrm{m}$
	$368\mu\mathrm{m}$	$335.7 \pm 4.7\mu\mathrm{m}$
	$500\mu\mathrm{m}$	$337.7 \pm 4.7\mu\mathrm{m}$
$368\mu\mathrm{m}$	$325\mu\mathrm{m}$	$357.0 \pm 1.2\mu\mathrm{m}$
	$368\mu\mathrm{m}$	$368.7 \pm 1.2\mu\mathrm{m}$
	$500\mu\mathrm{m}$	$370.6 \pm 1.3\mu\mathrm{m}$
$500\mu\mathrm{m}$	$325\mu\mathrm{m}$	$473.0 \pm 6.0\mu\mathrm{m}$
	$368\mu\mathrm{m}$	$501.3 \pm 7.0\mu\mathrm{m}$
	$500\mu\mathrm{m}$	$501.5 \pm 6.9\mu\mathrm{m}$

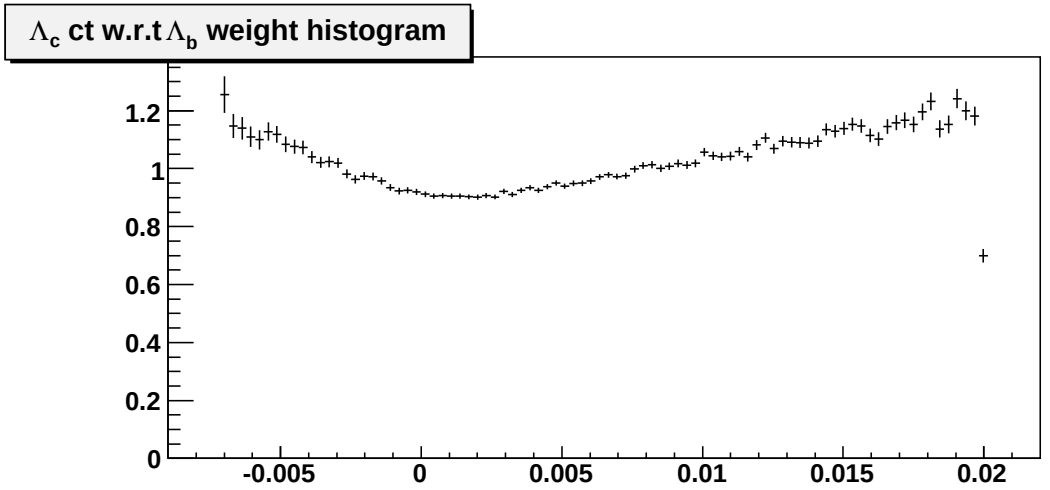
- $368\mu\mathrm{m}$ and $500\mu\mathrm{m}$ samples agree very well with one another.
- $325\mu\mathrm{m}$ is self-consistent, but doesn't fit the other samples well.
- This same effect is reproduced with Toy MC.
- $325\mu\mathrm{m}$ is near very low end of allowed $ct(\Lambda_b^0)$; effect of a boundary limit?

Systematic: Lc lifetime

- $c\tau_{gen}(\Lambda_c) = 60\mu\mathrm{m}$.
- The Λ_c lifetime is extracted from our Λ_b^0 signal MC sample by fitting Λ_b^0 daughter ct distribution to an ExpoGauss.
- Numerically modify this Λ_c lifetime distribution to a new lifetime, $c\tau_{rew}(\Lambda_c) = 66\mu\mathrm{m}$.
- Re-weight our sample to the new distribution.

The re-weighted MC results in a shift of $< 1\mu\mathrm{m}$ in the $c\tau(\Lambda_b^0)$ fit. This systematic is negligible.



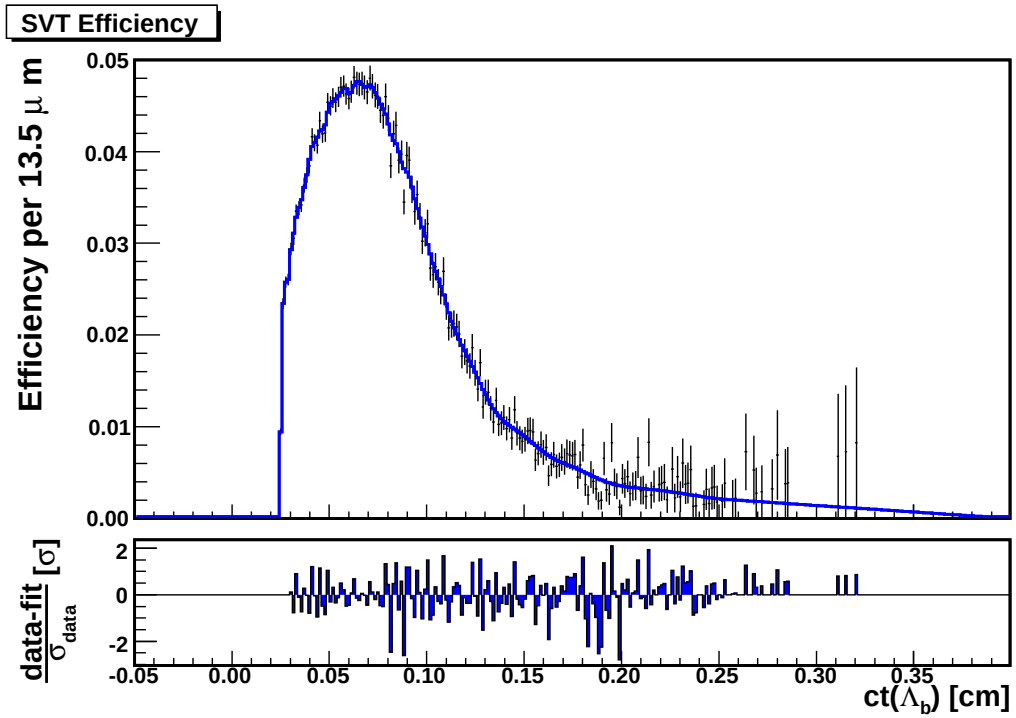


Systematic: Efficiency for B^0 Background

- When we started the analysis, we assumed that the B^0 efficiency would be very similar to that of the Λ_b^0.
- Trigger Code study and Diego's question regarding the Λ_c lifetime made us re-visit this assumption.
  - Λ_c lifetime systematic is negligible
  - But D^+ has a much longer lifetime
- It turns out that the error due to this assumption is not small.
- Instead of taking this as a systematic, we now include a separate B^0 efficiency by default.

Generating the B^0 Background Efficiency

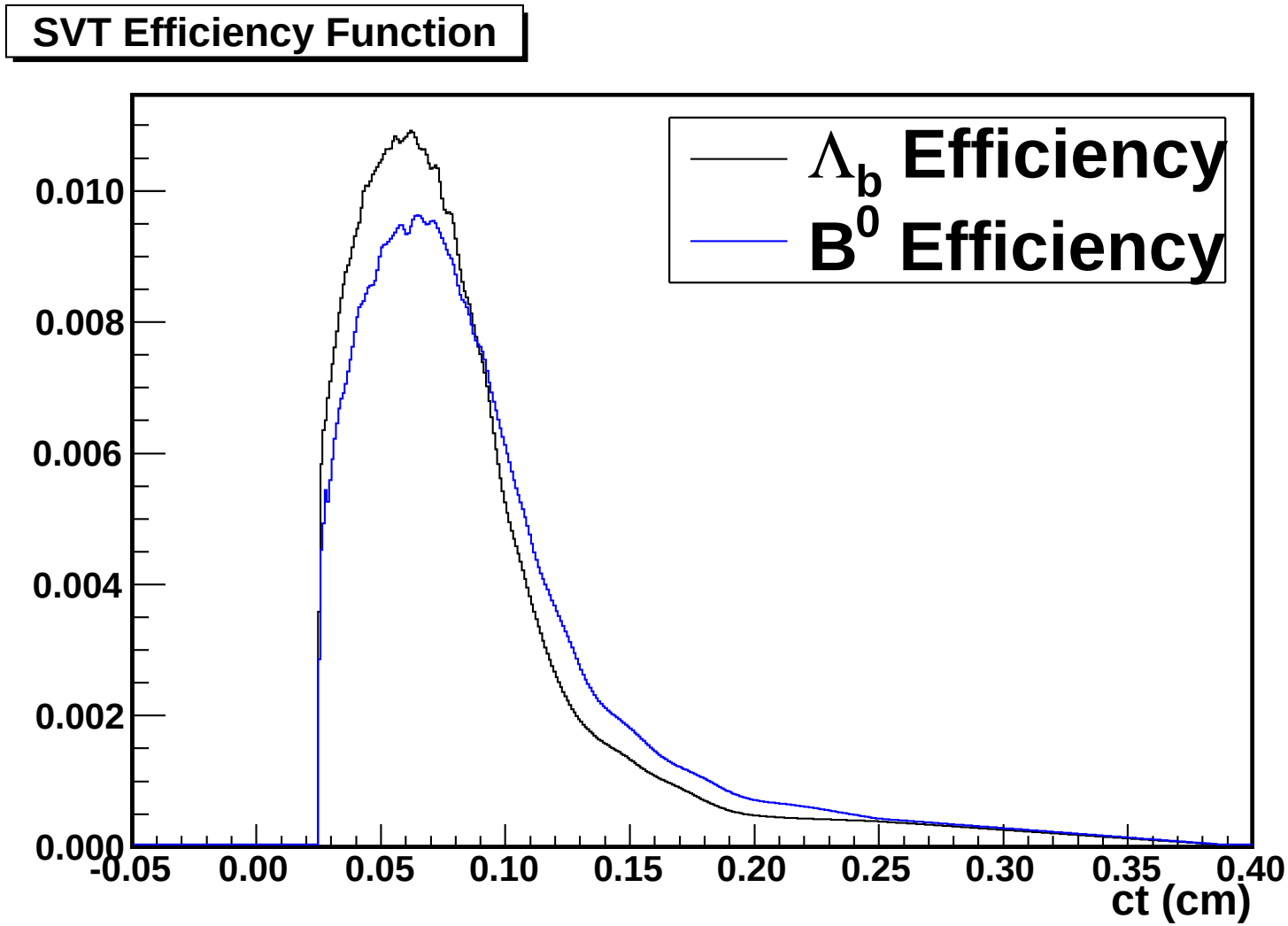
- JHU/LBL $B^0 \to D^+\pi^-$ sample.
- Reconstruct $\Lambda_b^0 \to \Lambda_c^+\pi^-$ in this sample w/o Λ_c mass constraints and very loose Λ_c mass cuts to maximize the statistics ($\sim 140k$).
- Generate the efficiency the same way that we do for Λ_b^0, but use the lifetime of the B^0.



Fit Normalizations

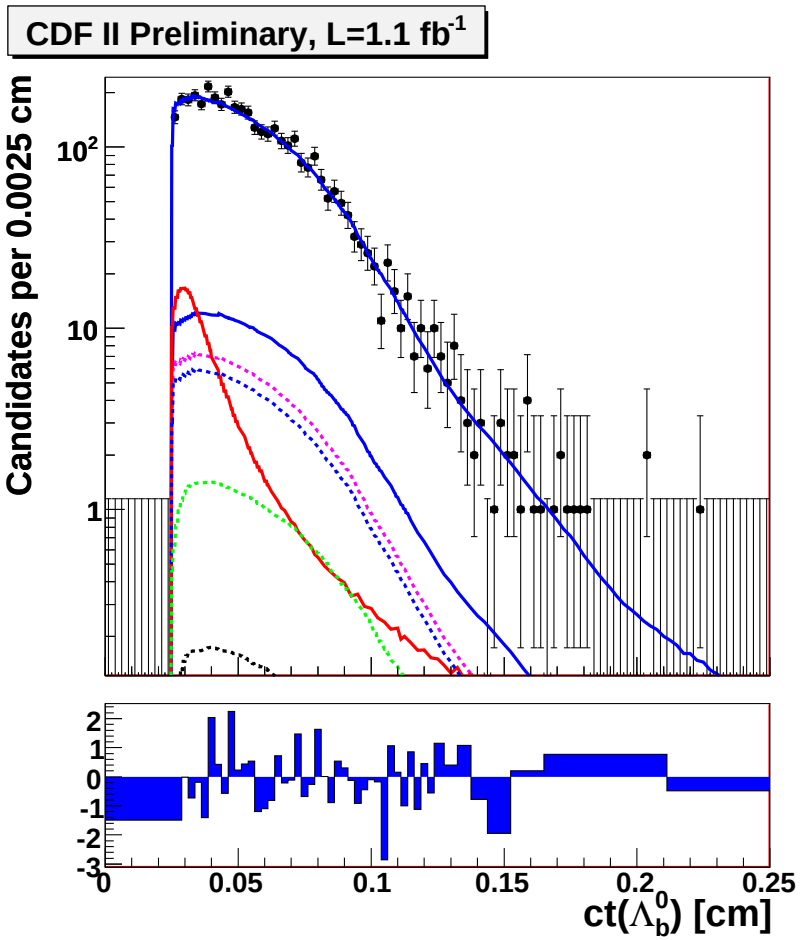
i	Component	Norm $[\mu m]$
1	N_LbLcPi	2904.9 ± 57.9
2	N_B4Track	250.5 ± 15.4
3	N_LbLcK	138.6 ± 15.9
4	N_CmbBkg	116.2 ± 5.0
5	N_Lb4Track	113.7 ± 15.9
6	N_LbSemi	27.0 ± 7.8
7	N_BOther	7.2 ± 6.8

Default Efficiency Compared to B^0 Efficiency

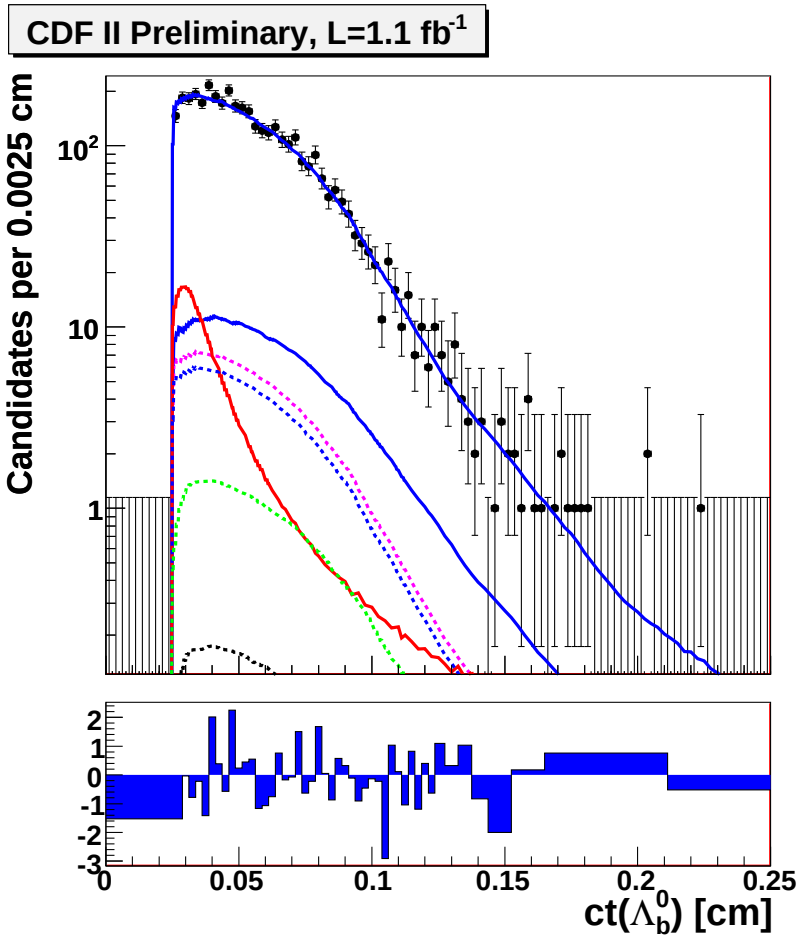


Fit Result Using the B^0 Efficiency

Description	Blind $c\tau(\Lambda_b^0)$	EDM
Old Baseline	$437.0 \pm 14.0 \mu\mathrm{m}$	1.71621×10^{-8}
w/ B^0 Efficiency	$429.4 \pm 13.8 \mu\mathrm{m}$	2.46679×10^{-8}



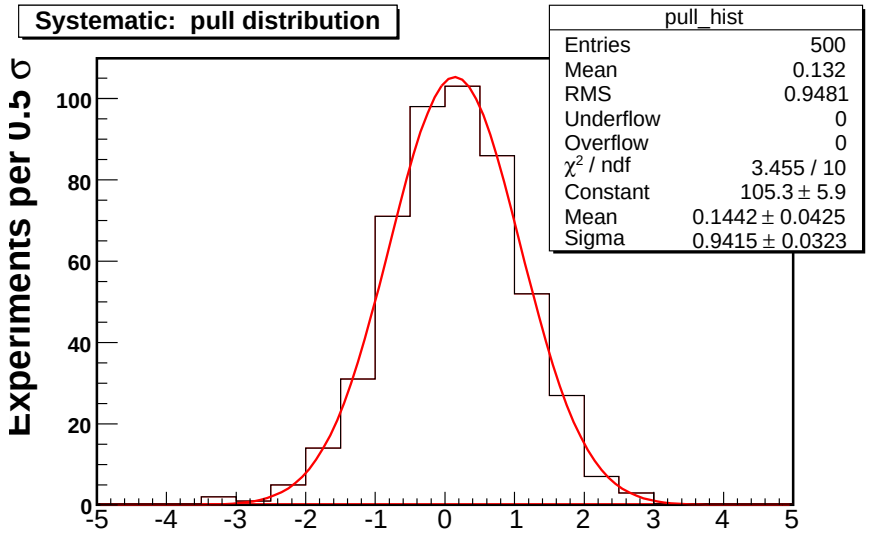
Old Baseline Projection



w/ B^0 Eff. Projection

Fit Result Using the B^0 Efficiency

- Inclusion of B^0 efficiency changes the fit result by $\sim 8\mu\mathrm{m}$.
- Our new baseline fit includes this efficiency for B^0.
- Systematic on shape of B^0 efficiency shape.
  - Generate from the same $B^0 \to D^+\pi^-$ MC sample.
  - Mass-constrain Λ_c .
  - Generate the $rigged$ efficiency w/ ~ 9000 events.



Sample	Rigged ct	Result	Δ
Rigged B^0 Eff.	$428.5\mu m$	$431.2\mu m$	$-2.7\mu\mathrm{m}$
		Quoted Systematic:	$2.7\mu m$

Systematic: Signal Normalizations

Of all the systematics, the normalizations from the mass fit are expected to be most sensitive to the addition of an efficiency for B^0.

This systematic was re-evaluated using the new fit. The error increased $\sim 30\%$.

Sample	Rigged ct	Result	Old Δ	Δ
SignalNorms_1	$428.5\mu m$	$430.1\mu m$	$-1.7\mu m$	-1.6
SignalNorms_2	$427.5\mu m$	$430.5\mu m$	$-2.3\mu m$	-3.0
SignalNorms_3	$429.2\mu m$	$429.9\mu m$	$-0.5\mu m$	-0.7
SignalNorms_4	$429.7\mu m$	$431.5\mu m$	$-0.9\mu m$	-1.8
SignalNorms_5	$429.4\mu m$	$431.6\mu m$	$-0.6\mu m$	-2.2
		Quoted Systematic:	$2.3\mu m$	3.0μm

Systematic: Signal Normalizations

The Final List of Systematics.

Systematic	Status
Alignment	$2.0\mu m$ (cdfnote 8524)
SVT-SVX d0 correlation	$1.0\mu m$ (cdfnote 7386)
Λ_c Dalitz structure	$9.0\mu m$
Data-MC comparison:TrigCode re-weighting	$4.3\mu m$
Λ_b^0 polarization	$3.4\mu m$
Sample Composition	$3.0\mu m$
Fluctuating B^0 Efficiency	2.7μm
Data-MC comparison:$pt(\Lambda_b^0)$ spectrum	$2.3\mu m$
Combinatorial ct distribution	$1.7\mu m$
ct background (B τ-parameter)	$1.2\mu m$
Global scale factor	$1.0\mu m$
Fitter bias	negligible
σ_{ct} binning	negligible
Λ_c lifetime	negligible

$$ct(\Lambda_b^0) = XXX.X \pm 13.8(stat.) \pm 11.9(syst.)\mu m$$

$B^0 \to D^{*-}\pi^+$ Cross-Check Fit

Originally asked to compare with the PDG lifetime.

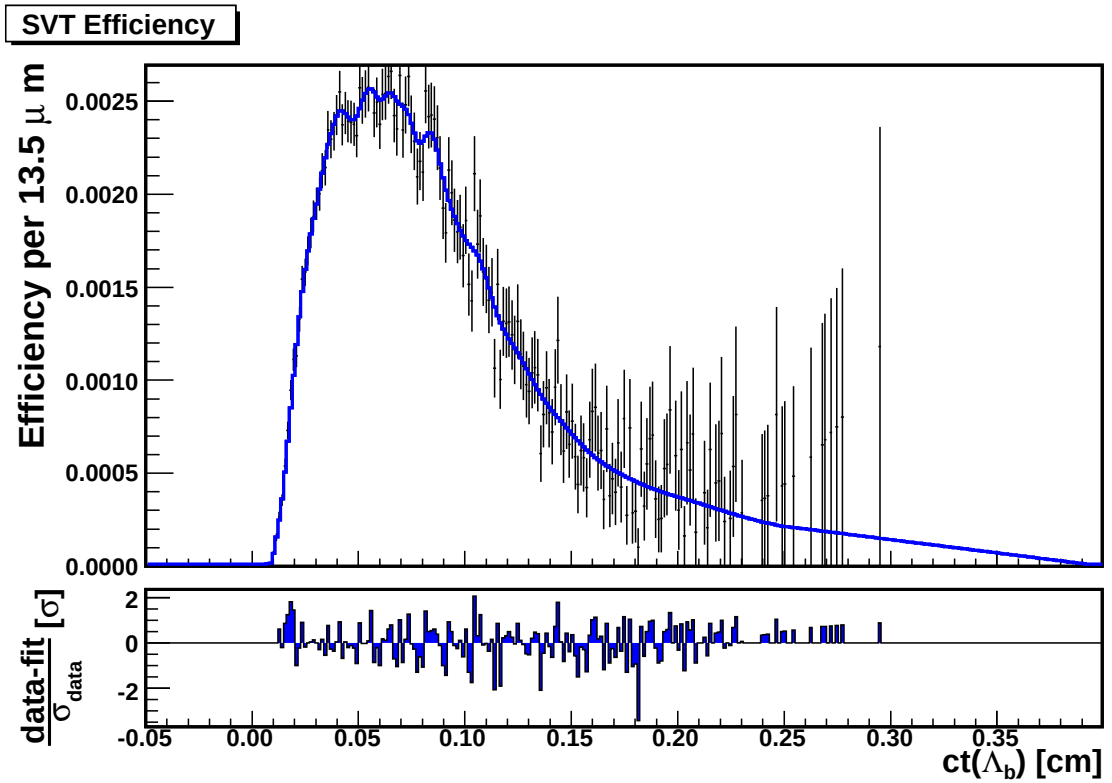
Amanda and LBL people graciously supplied their data and Monte Carlo samples.

Data:

- `0d,0h,0i` data.
- $\sim$ $16,500$ FR and PR candidates.

MC:

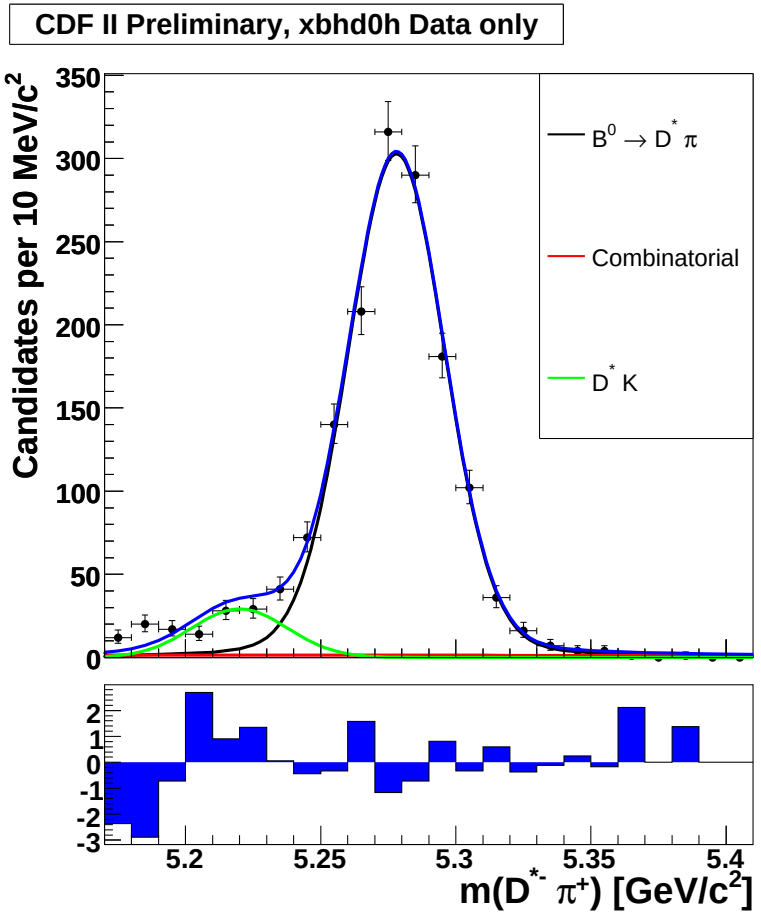
- B-generator, signal-only sample.
- $\sim$ $23,300k$ events (after Amanda's re-weighting).



$B^0 \to D^{*-}\pi^+$ Fit Description

- Our cross-check started as a simple check of our framework.
- Only 3 components (compared to Amanda's 6)
- Signal, $B^0 \to D^{*-}K^+$, and Combinatorial.
- f_{us}: The fractions from our simple fit.
- f_{Amanda}: Amanda's FR fractions.
- f'_{us}: Amanda's fractions reduced to our three components.

Norm	f_{us}	f_{Amanda}	f'_{us}
$B^0 \to D^*\pi$	0.9053	0.9063	0.9063
$B^0 \to D^*K$	0.0898	0.0670	0.0750
$B^0 \to D^*\rho$	NA	0.0015	NA
$B^0 Other$	NA	0.0064	NA
B^+	NA	0.0036	NA
real D	0.0049	0.0151	0.0187



$B^0 \to D^{*-}\pi^+$ Fit Results

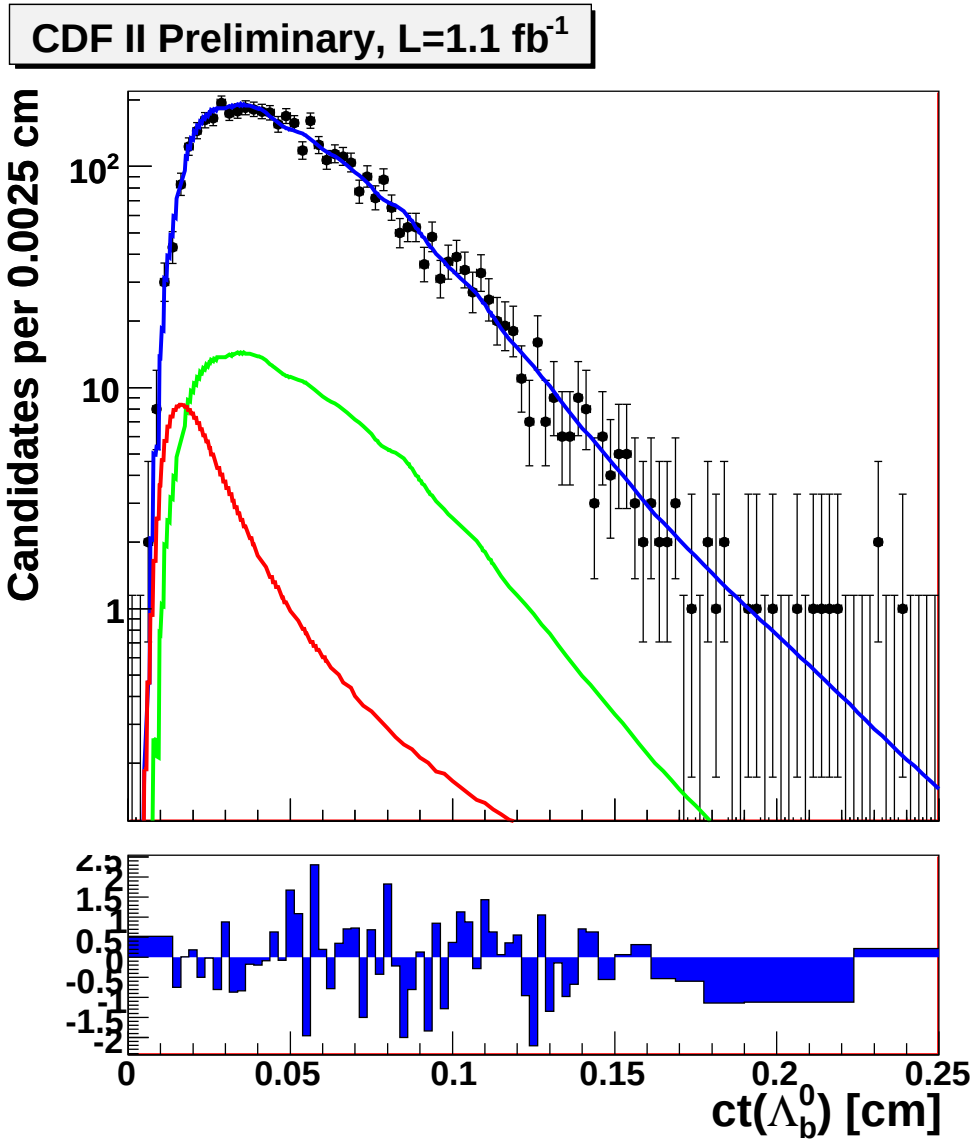
Monte Carlo:

$c\tau_{gen}(B^0)[\mu\mathrm{m}]$	$c\tau_{fit}(B^0)[\mu\mathrm{m}]$
464	$458um \pm 4.6$

Data:

Fit	$c\tau(B^0)[\mu\mathrm{m}]$
Amanda's FR Fit	442.8 ± 12.8
Using f_{us} Norms	434.0 ± 9.9
Using f'_{us} Norms	440.3 ± 9.9

- Our result agrees well with Amanda's FR result.
- Yet another cross-check that our fit is working well.
- This cross-check is complete.



Conclusion

- Trigger Code and realistic MC cross-checks build confidence in our technique. Nearly all of these fits produce results that are expected.
- Evaluated the Λ_c lifetime systematic; found it to be negligible.
- Efficiency for B^0 Background turns out to be a big deal.
- Baseline fit has been modified to include the B^0 efficiency.
- Systematic for B^0 efficiency has been evaluated.
- All of the systematics are now done.
- Fit result on Amanda's $B^0 \to D^*\pi$ sample has been updated and is very compatible with Amanda's result.
- The note (8578) will be updated by the end of this week
- We'd like to proceed with the blessing as soon as possible.