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

R. Mumford, J. Pursley, M. Martin, M. Schmidt, S. Behari, P. Maksimovic
Johns Hopkins University
D. Litvinsev
FNAL

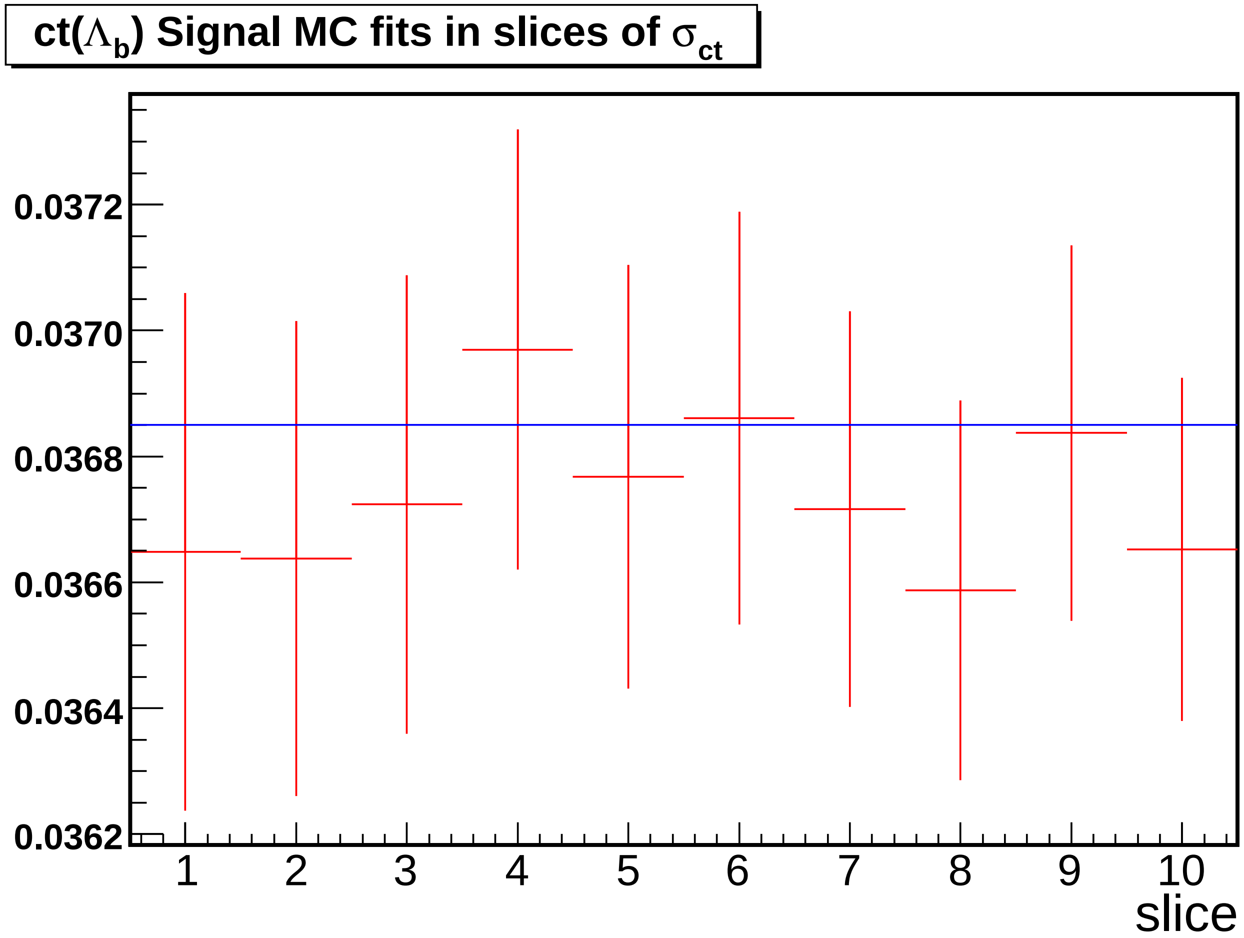
November 6, 2007

Talk Outline

- Lifetime fit in slices of σ_{ct}
- Lifetime fit in trigger slices
- Signal Monte Carlo review
- Baseline version of the lifetime fit
- Conclusion and Outlook

Lifetime Fit in σ_{ct} Slices

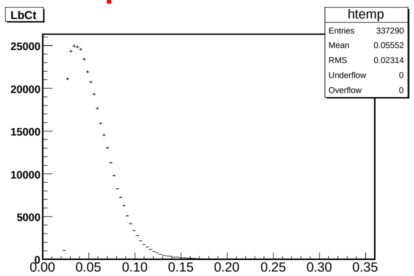
In August, we were cutting our $\sim 330k$ event Signal MC into 10 σ_{ct} slices.
A separate SVT efficiency was calculated for each slice.
MC fits in each σ_{ct} slice agreed w/ the generated Λ_b^0 lifetime $(368.5\mu m)$.



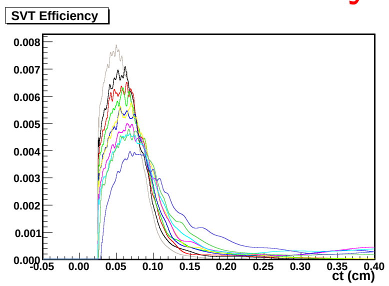
Lifetime Fit in σ_{ct} Slices II

When fitting the entire MC sample,
the efficiency slice was chosen dynamically based on σ_{ct} of the event.

Sample

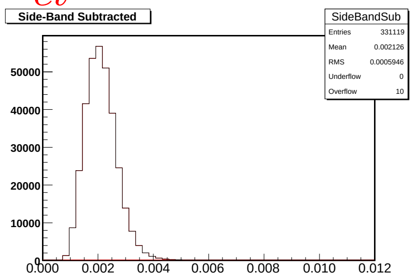


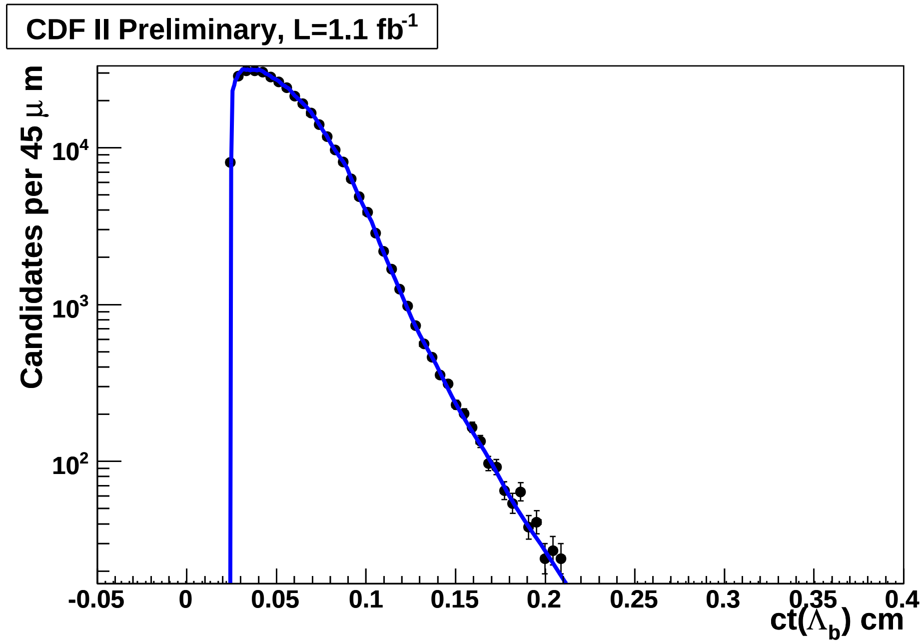
Sliced Efficiency



$\Rightarrow$

σ_{ct} Distribution





$ct(\Lambda_b^0) = 367.2 \pm 1.0\mu m$

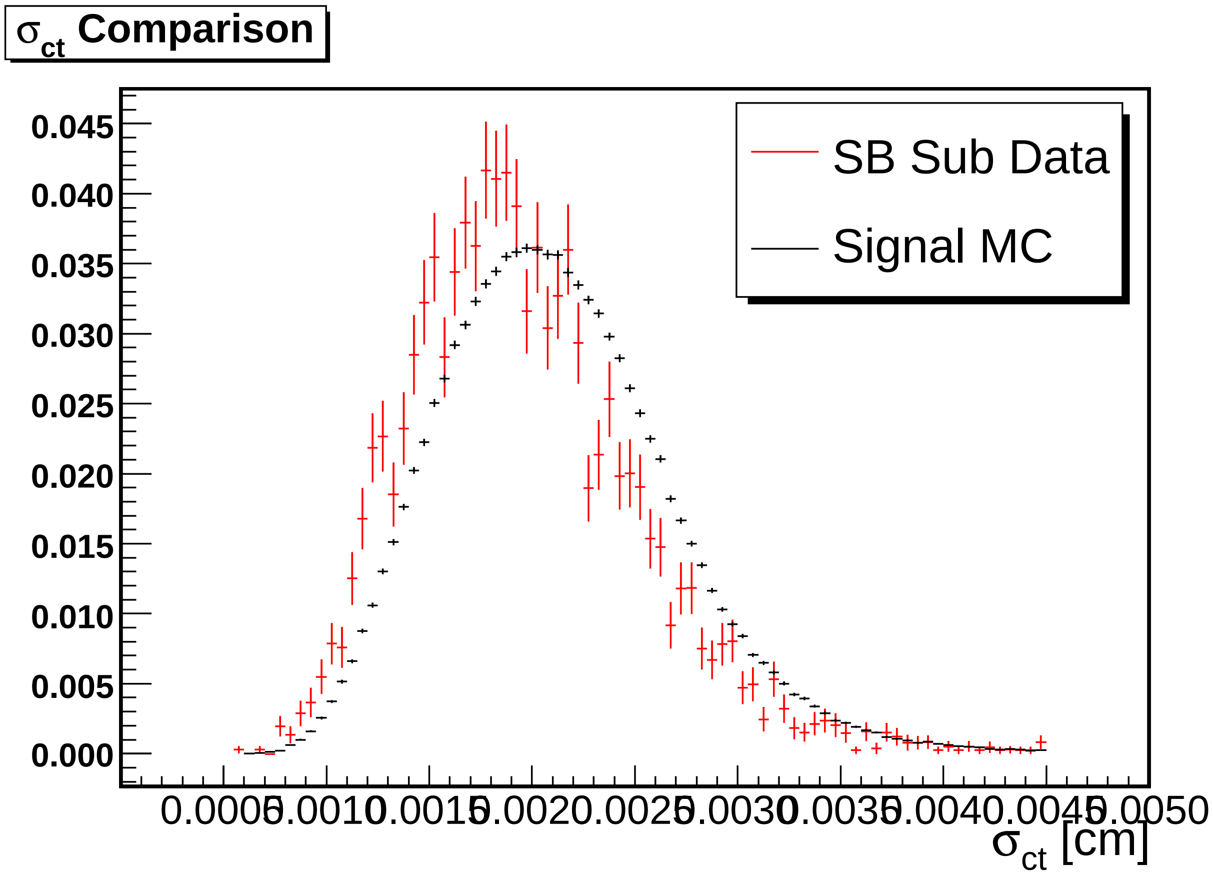
Consistent w/ Generated and Stand-Alone lifetime.

Method works great in MC.

Complications with σ_{ct} Slice Fits

Problems arise when moving from realistic MC to fitting the blinded data.

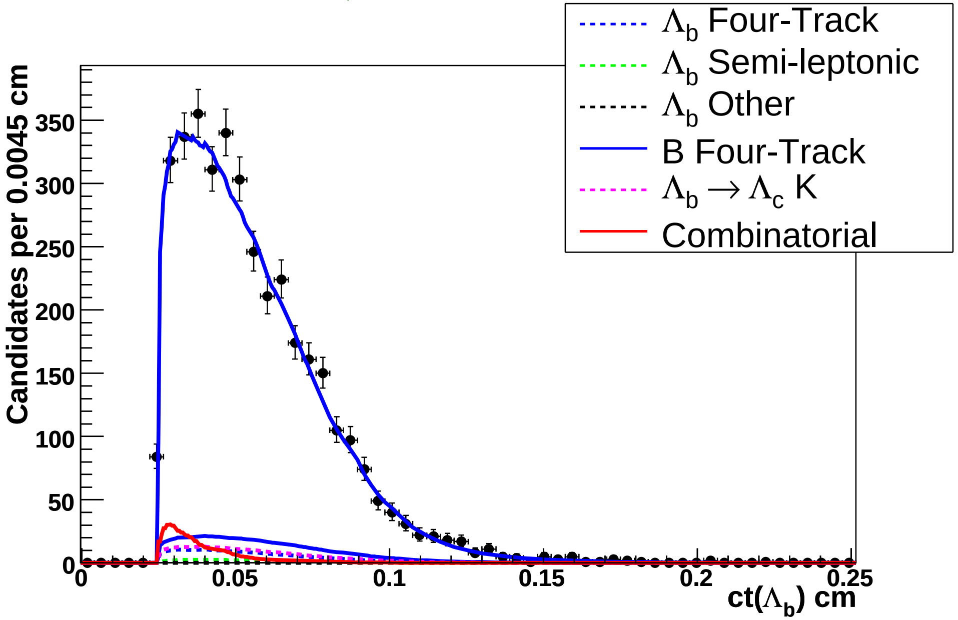
How to map the σ_{ct}? What value do we use for σ_{ct} scale factor?



A comparison of the σ_{ct} distributions from data and MC.

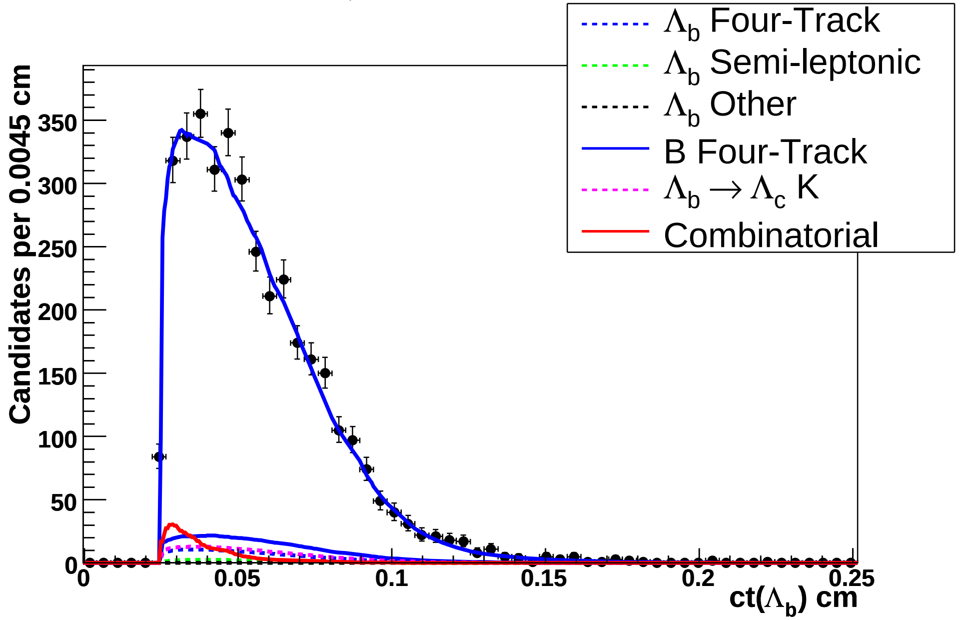
Abandoning σ_{ct} Slice Fits

Blinded Data w/ single SVT efficiency



$c\tau(\Lambda_b^0) = 390.1 \pm 10.5\mu m$

Blinded Data w/ Efficiency in σ_{ct} Slices



$c\tau(\Lambda_b^0) = 409.4 \pm 11.9\mu m$

Small changes in σ_{ct} scale factor result in large lifetime shifts.

Because there is no way for us to measure the σ_{ct} scale factor, mapping the slices in σ_{ct} between data and MC artificially increases our sensitivity to getting the scale factor correct.

Because of this, we abandoned the idea of fitting in σ_{ct} slices.

A New Approach

Instead of σ_{ct} slice fits, we tried another method.

- Match MC kinematics to data: ($i.e.$ fit Λ_c Dalitz structure, Λ_b^0 polarization, etc.)
- Fit Λ_b^0 lifetime in slices of Trigger Type.

Trigger Type flags which combination of tracks fires the TTT and is critically depending on the kinematics of the event.

Matching MC to Data: Λ_c Dalitz

Realized that our old signal MC included only $\Lambda_c \rightarrow pK^*$ and $\Lambda_c \rightarrow \Delta^{++}K$ Dalitz modes.

2 missing Dalitz modes were generated and added to our existing MC sample.

- $\Lambda_c \rightarrow pK^*$ ($\sim 22.6\%$)
- $\Lambda_c \rightarrow \Delta^{++}K$ ($\sim 12.2\%$)
- $\Lambda_c \rightarrow \Lambda(1520)\pi$ ($\sim 25.5\%$)
- $\Lambda_c \rightarrow pK\pi$ ($\sim 39.7\%$)

(Dalitz modes are weighted to match PDG values)

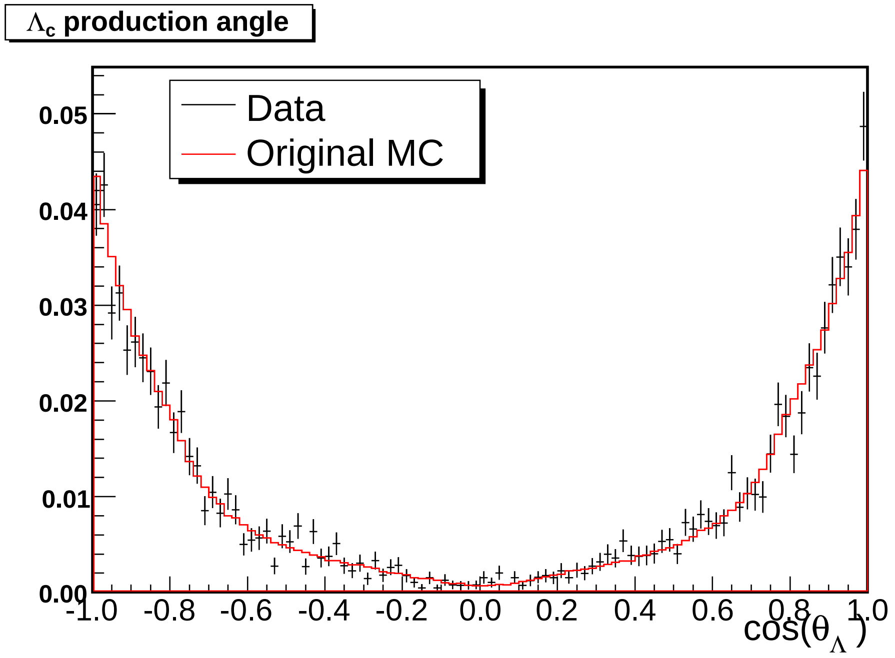
Matching MC to Data: Λ_b^0 Polarization

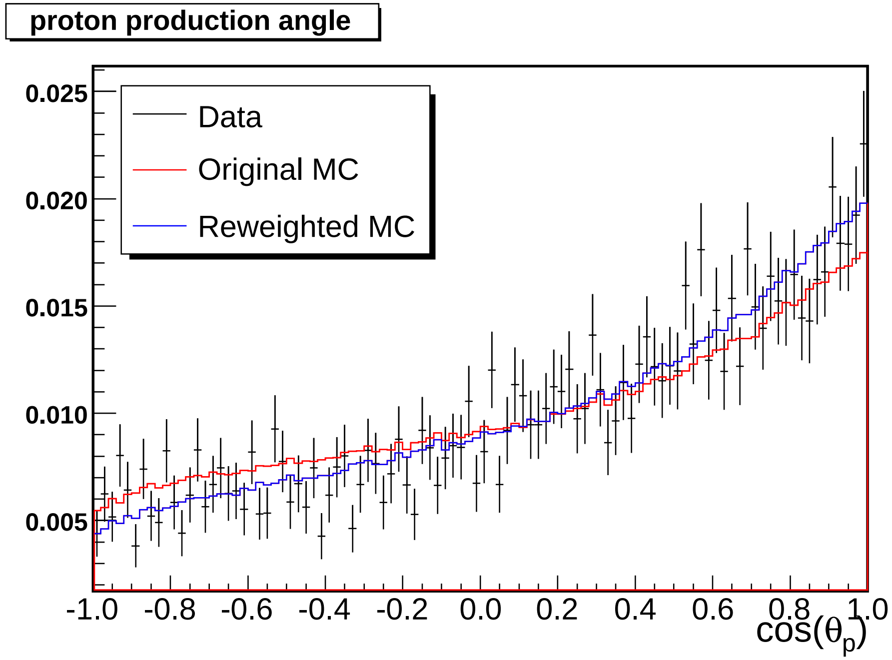
The basic variables for our polarization parameterization are two angles;

$cos(\theta_{\Lambda_c})$: Angle between Λ_b^0 production (beam direction) and the Λ_c momentum in Λ_b^0 rest frame.

$cos(\theta_p)$: Angle between Λ_c momentum in Λ_b^0 rest frame and the p momentum in the Λ_c rest frame.

$cos(\theta_{\Lambda_c})$ distribution matches well. $cos(\theta_p)$ is re-weighted to match data.





$cos(\theta_{\Lambda_c})$ $cos(\theta_p)$

Matching MC to Data:Trigger Code

Pairs of stable tracks are tested for Two Track Trigger satisfaction.

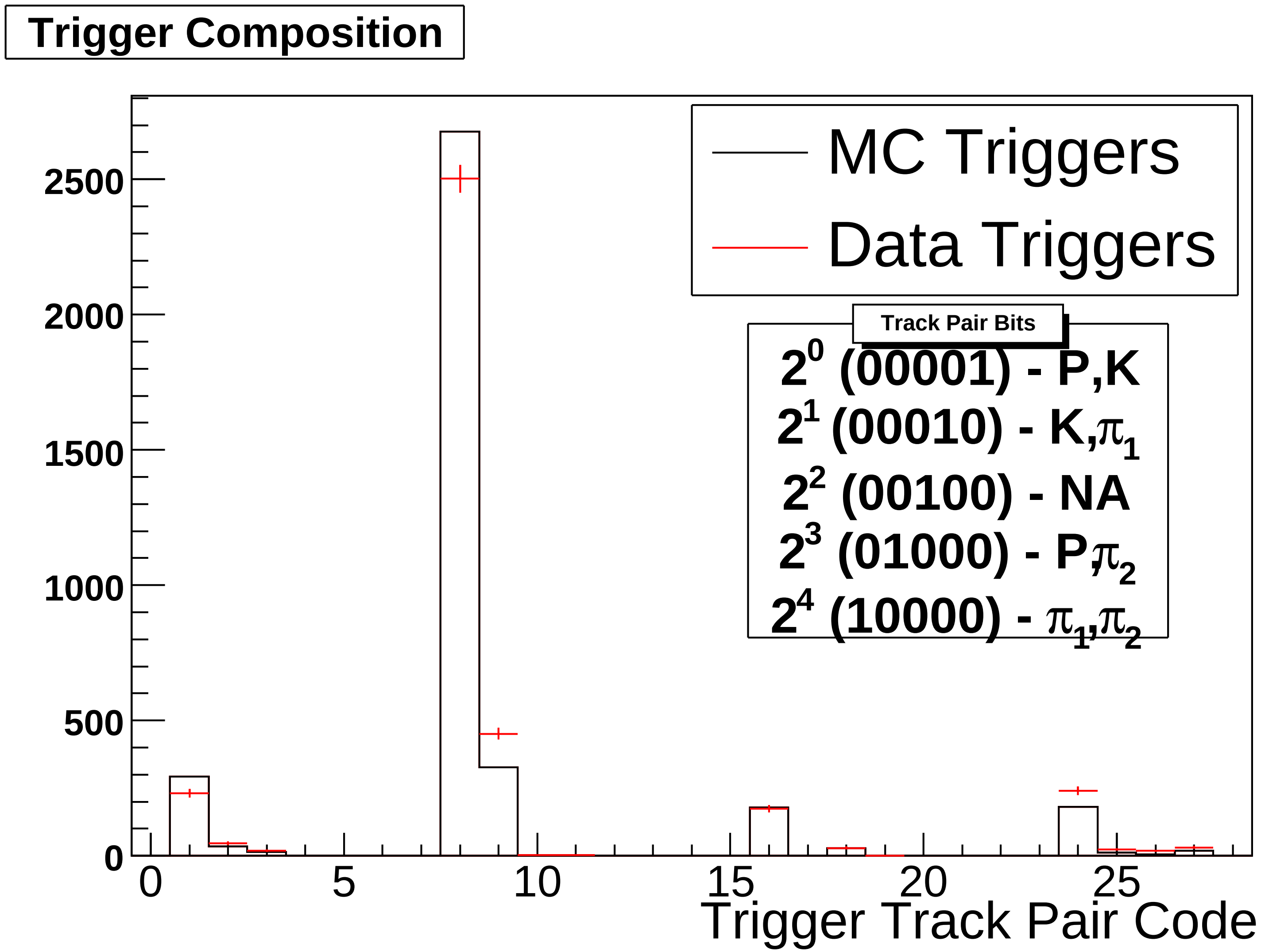
Labeling Convention: $\Lambda_b^0 \to \Lambda_c \pi_2; \Lambda_c \to pK\pi_1$

Code	Bits	Description	Nevts
1	00001	pK	$26,071$
2	00010	$K\pi_1$	$3,216$
3	00011	$pK + K\pi_1$	$1,428$
8	01000	$p\pi_1$	$237,704$
9	01001	$p\pi_1 + pK$	$29,206$
10	01010	$p\pi_1 + K\pi_1$	60
11	01011	$p\pi_1 + pK + K\pi_1$	164
16	10000	$\pi_1\pi_2$	$17,711$
17	10001	$\pi_1\pi_2 + pK$	17
18	10010	$\pi_1\pi_2 + K\pi_1$	2454
19	10011	$\pi_1\pi_2 + pK + K\pi_1$	16
24	11000	$p\pi_1 + \pi_1\pi_2$	$17,398$
25	11001	$p\pi_1 + \pi_1\pi_2 + pK$	$1,212$
26	11010	$p\pi_1 + \pi_1\pi_2 + K\pi_1$	533
27	11011	$p\pi_1 + \pi_1\pi_2 + pK + K\pi_1$	$1,664$

For the lifetime fit,
Decide to split sample into 6 categories:

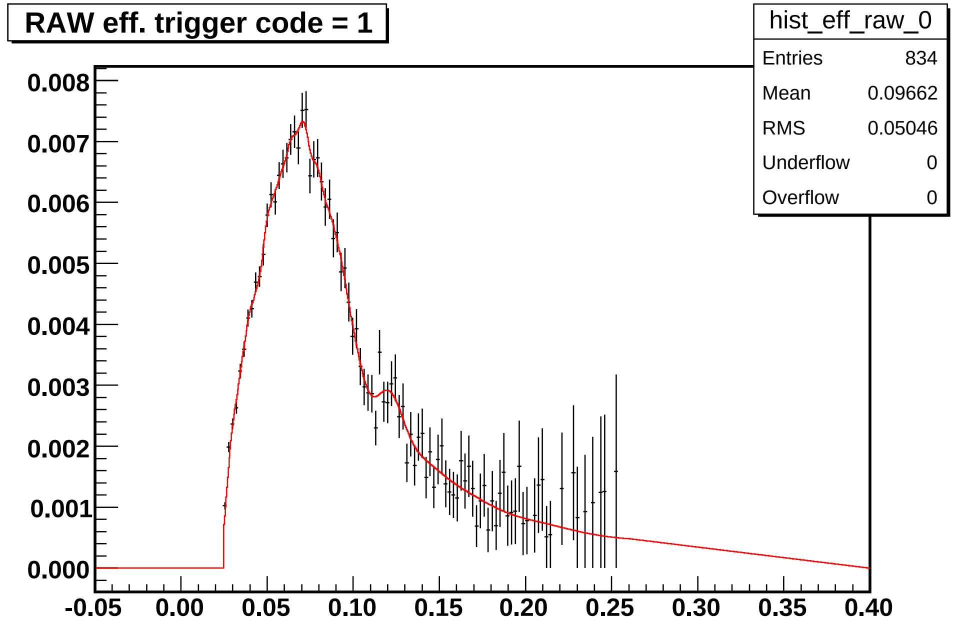
Code	Description	Nevts
1	pK	$26,071$
8	$p\pi_1$	$237,704$
9	$p\pi_1 + pK$	$29,206$
16	$\pi_1\pi_2$	$17,711$
24	$p\pi_1 + \pi_1\pi_2$	$17,398$
99	All other combinations	$10,402$

Monte Carlo vs. Data Trigger Codes

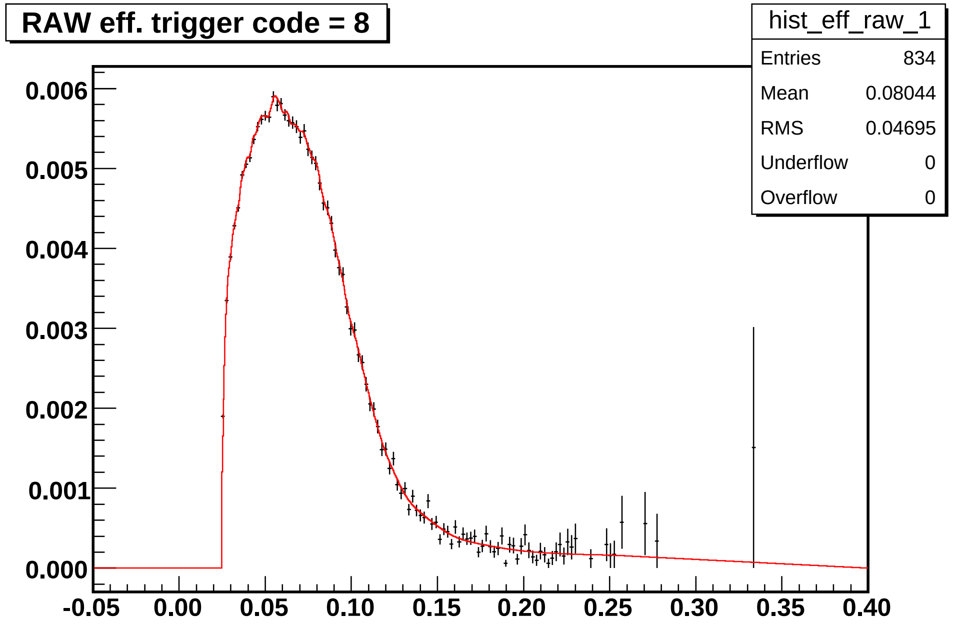


Efficiencies by TrigCode I

For each of the 6 Trigger Codes, efficiencies are calculated.
We use the same, `RooKeysPdf` histogram smoothing method that we've been using all along to generate the efficiencies.

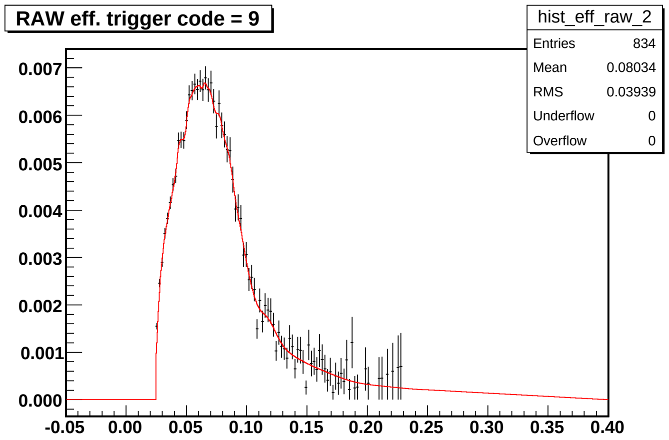


TrigCode=1 (pK)

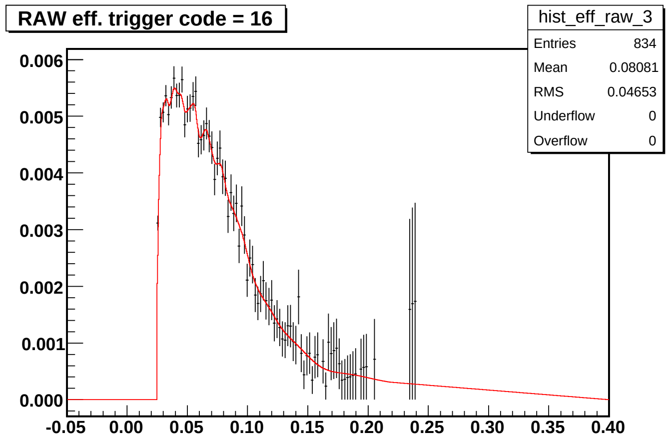


TrigCode=8 ($p\pi_1$)

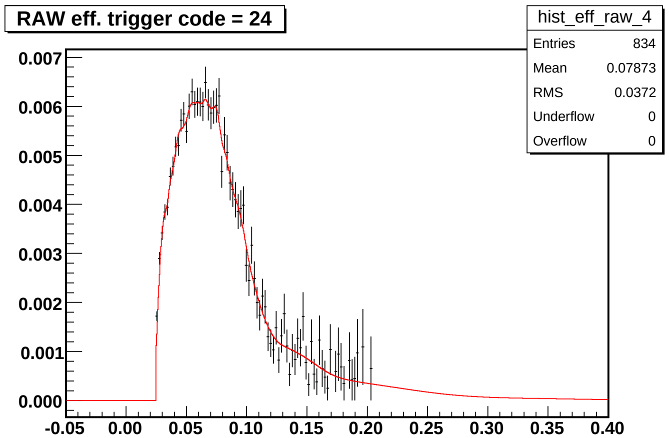
Efficiencies by TrigCode II



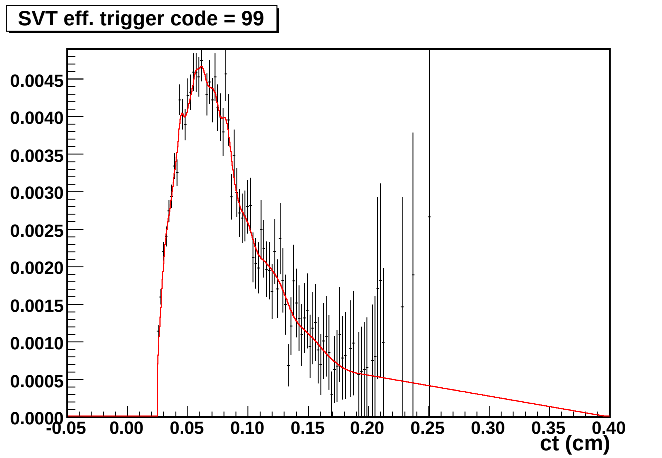
TrigCode=9 $(p\pi_1 + pK)$



TrigCode=16 $(\pi_1\pi_2)$



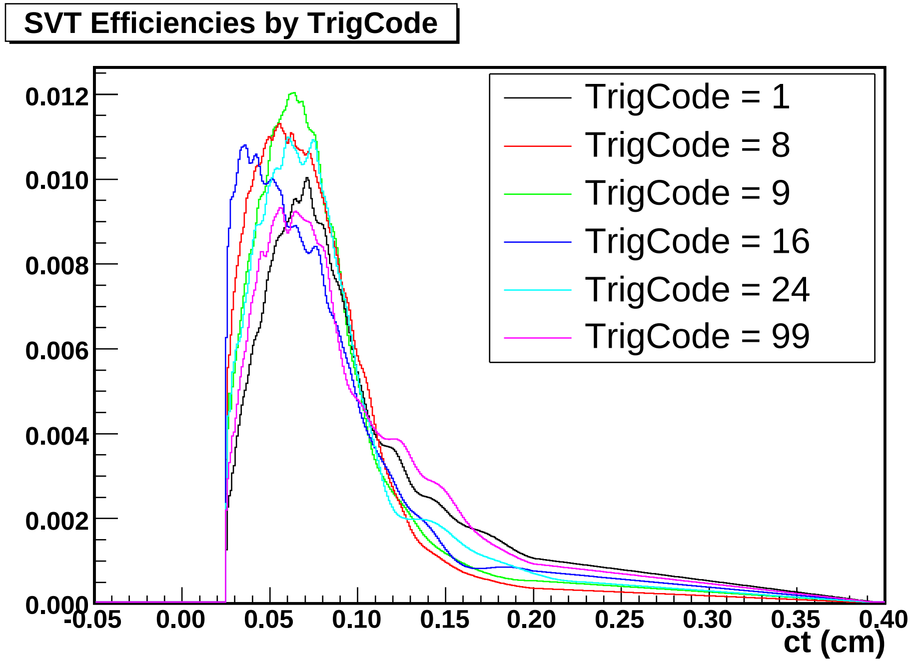
TrigCode=24 $(p\pi_1 + \pi_1\pi_2)$



TrigCode=99 (All Other)

Fitting Λ_b^0 Lifetime with Trigger Codes

Efficiencies are dynamically chosen based on the TrigCode of each event.



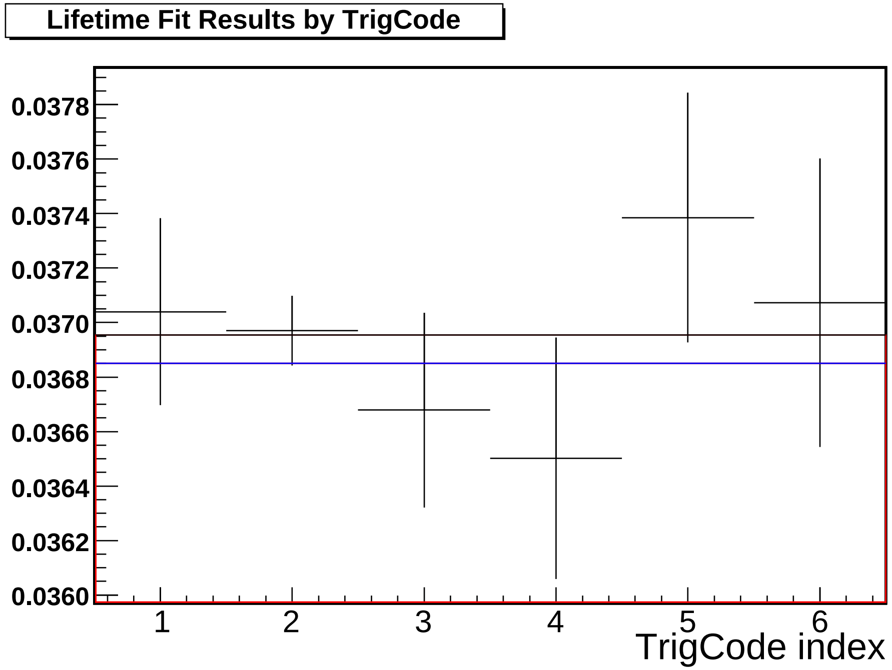
Punzi term is now a 2-D histogram in terms of TrigCode and σ_{ct}. The likelihood looks like this;

$$\mathcal{L}(ct, \sigma_{ct}) = P(ct|\sigma_{ct}, T) \cdot P(\sigma_{ct}, T)$$

The corresponding σ_{ct}distribution is also dynamically chosen.

TrigCode Slice Λ_b^0 Lifetime Results

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



However, we have decided to abandon the fit in TrigCode slices because;

- The statistics in our data sample ($\sim 3,000$ events) doesn't support a fit sliced in terms of TrigCode (sample is $\sim 80\%$ TrigCode=8)
- The overall fit improvement does not justify the increased fit complexity.

New Baseline Λ_b^0 Lifetime Fit

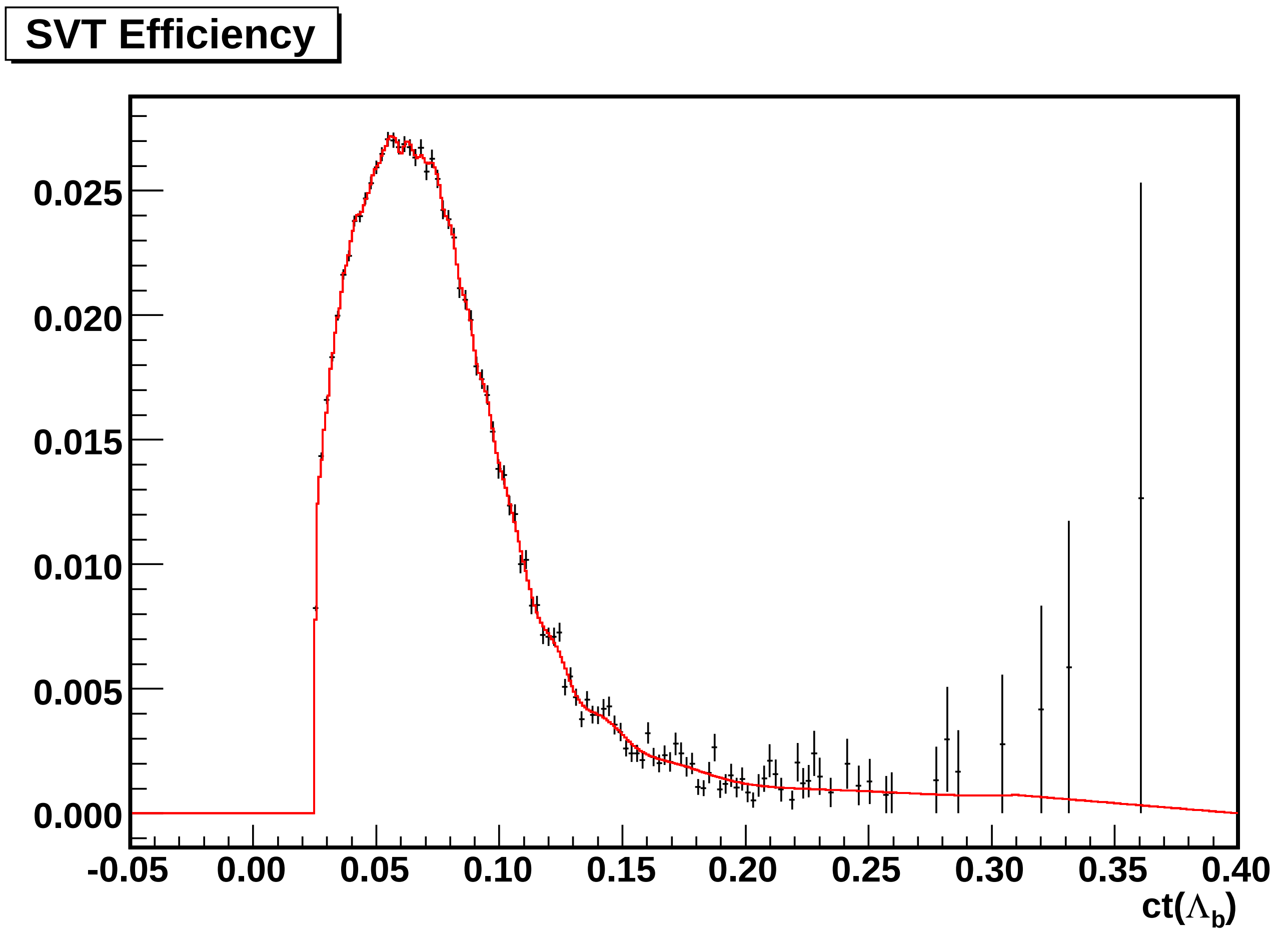
For our "new" baseline Λ_b^0 lifetime fit
We return to fit technology that we were using several months ago.

- MC re-weighted in Dalitz, Polarization, and TrigCode.
- monolithic SVT efficiency based on the re-weighted MC.
- 1-D, side-band subtracted, σ_{ct} Punzi term.

Baseline SVT Efficiency

Generated from signal MC sample re-weighted in Λ_c Dalitz (to PDG fractions), Polarization (from Data), and TrigCode (from Data).

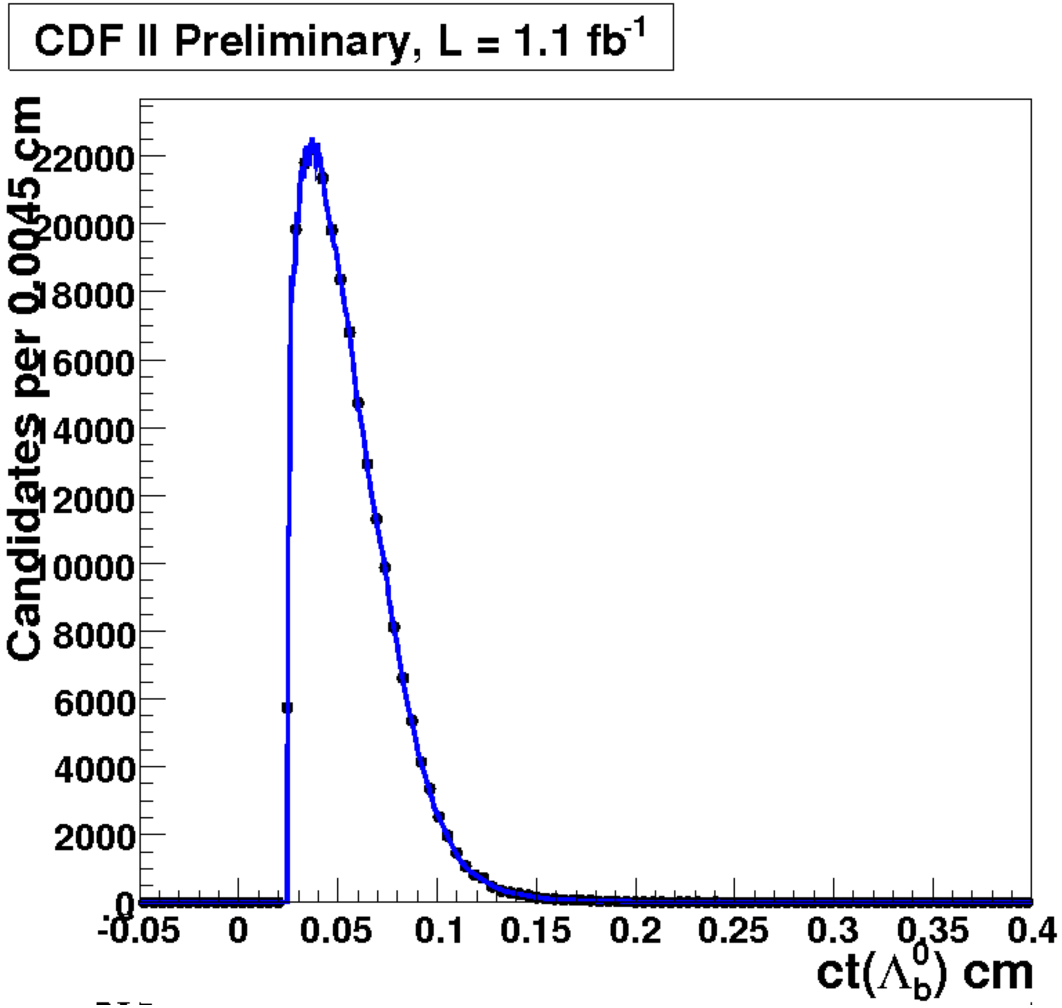
Signal MC sample of $\sim 234,000$ events used to compute efficiency.



Λ_b^0 Lifetime Result: Signal MC Fit

Fitting the same realistic MC sample used to generate the efficiency.

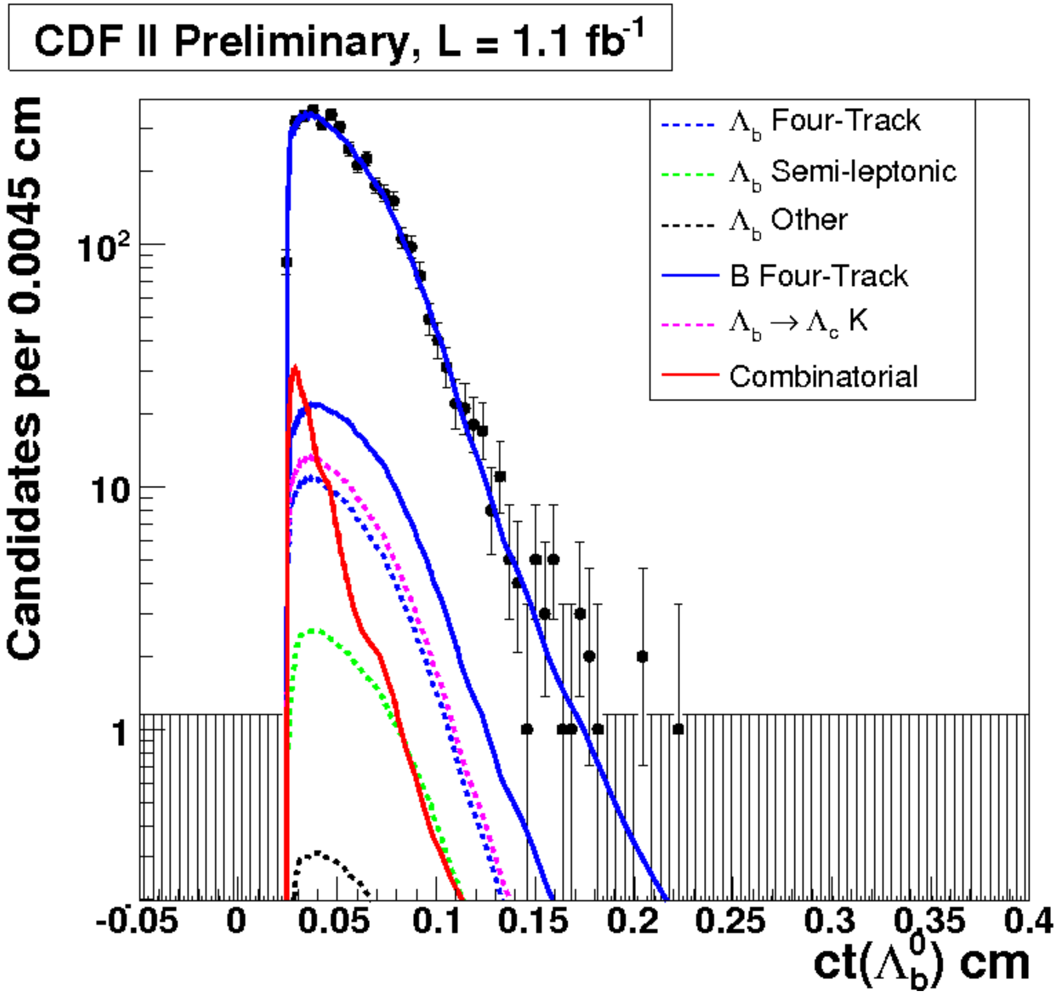
$$c\tau(\Lambda_b^0) = 369.8 \pm 1.2\mu m$$



Λ_b^0 Lifetime Result: Blinded Data Fit

Fit results on blinded data.

$c\tau(\Lambda_b^0) = XXX.X \pm 11.4\mu m$



Systematics

We have converged on our baseline fit.

Most of the systematics have been setup before, but will need to be re-evaluated with the new baseline fit.

Systematic	Status
Alignment	$2\mu m$ (`cdfnote 8524`)
SVT-SVX d0 correlation	$1\mu m$ (`cdfnote 7386`)
Fitter bias	Setup (negligible)
Sample Composition	Setup ($4\mu m$)
Λ_c Dalitz structure	Setup ($4\mu m$)
ct background (B τ-parameter)	Setup ($< 1\mu m$)
Global scale factor	Setup (negligible)
ct parameterization	Setup (negligible)
Combinatorial ct distribution	Setup (negligible)
σ_{ct} binning	Setup (negligible)
Λ_b^0 polarization	Setup ($1\mu m$)
Data-MC comparison:$pt(\Lambda_b^0)$ spectrum	To Do
Data-MC comparison:TrigCode re-weighting	To Do
Primary Vertices	To Do

Conclusion and Outlook

- We have abandoned lifetime fit in σ_{ct} slices.
- We have developed (and abandoned) a lifetime fit in trigger code slices.
- We have settled on our Baseline fit.
- We expect $11.4\mu m$ statistical error on our result.
- We are evaluating the systematic errors.
- We plan to pre-bless ASAP.