$\Lambda_b^0 \to \Lambda_c^+ \pi^-$ Lifetime Bias Hunting

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

June 26, 2007

Summary of Previous Presentation

- Solved efficiency fn. induced instability
- Implemented smoothed histogram efficiency
- Fit framework validated on B^0 cross-check mode
- Signal MC fit pulls and NLL scan both look good
- $-4\mu m$ bias in Λ_b^0 Signal MC fit
- Suspect ct, σ_{ct} correlation as cause of bias

This presentation will focus on recent efforts to solve the $-4\mu m$ bias.

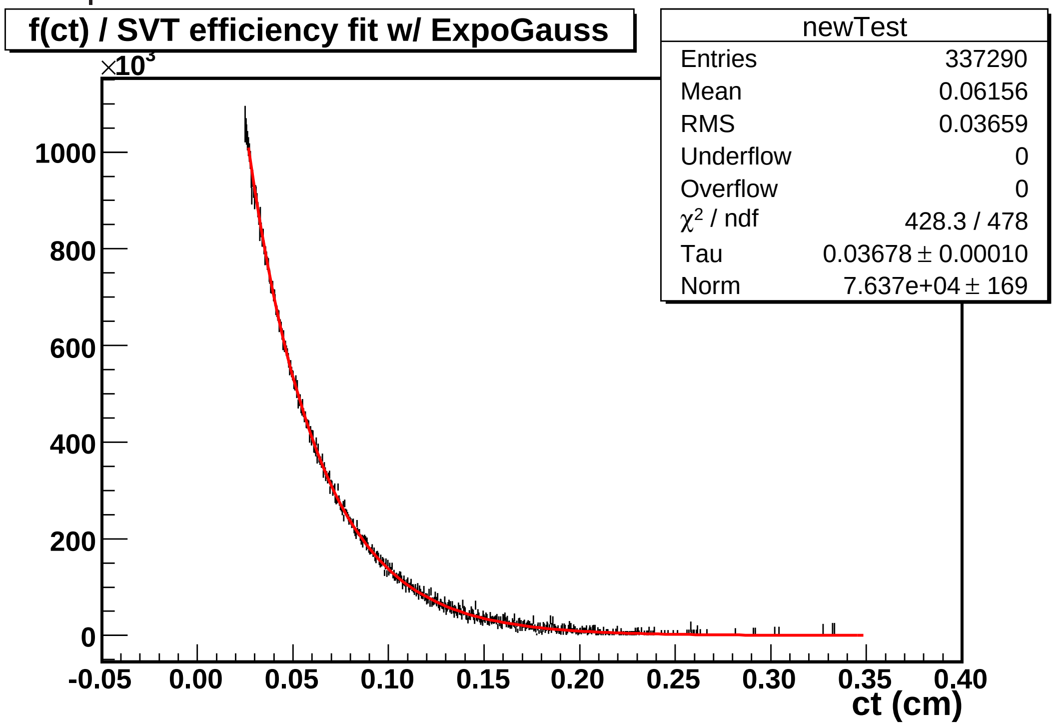
Stand-Alone ROOT Fit

To hunt for bias, we developed a very simple fit.

$$f(ct) = \frac{1}{c\tau} e^{-ct'/c\tau} \otimes R(ct, ct') \epsilon_{TTT}(ct)$$

$$\frac{f(ct)}{\epsilon_{TTT}(ct)} = \frac{1}{c\tau} e^{-ct'/c\tau} \otimes R(ct, ct')$$

$\Leftarrow$ Expected Λ_b^0 lifetime distribution



SA fit gets the right answer:

$ct(\Lambda_b^0) = 367.8 \pm 1.0\mu m$

$(ct_{MC}(\Lambda_b^0) = 368.5\mu m)$

Efficiency Function... (again)

$$\epsilon_{TTT}(ct) = \frac{Histo^{TTT}_{smooth}(ct)}{\sum_i exp(ct^i, ct^{MC}) \otimes Gauss(\sigma_{ct})}$$

Numerator: Smoothed histogram filled with all MC events that pass trigger and analysis cuts.

Denominator: For each event that enters the histogram at the numerator, we add to the content of each bin of a second histogram.

- σ_{ct} is the uncertainty on ct of the event we are considering
- ct^i is the ct corresponding to the center of the i th bin
- $ExpoGauss$ is the NORMALIZED distribution given by the convolution of an exponential (with lifetime $c\tau_{MC}$) with a Gaussian resolution function centered in zero and with width $= \sigma_{ct}$.

Missing Mass Cut in Eff. Dist.

I discovered a missing mass cut in the calculation of the efficiency distribution.

This mass cut is responsible for nearly $1\mu m$ of bias.

$$m \in [5.565, 5.67] \sim 331,000 events$$

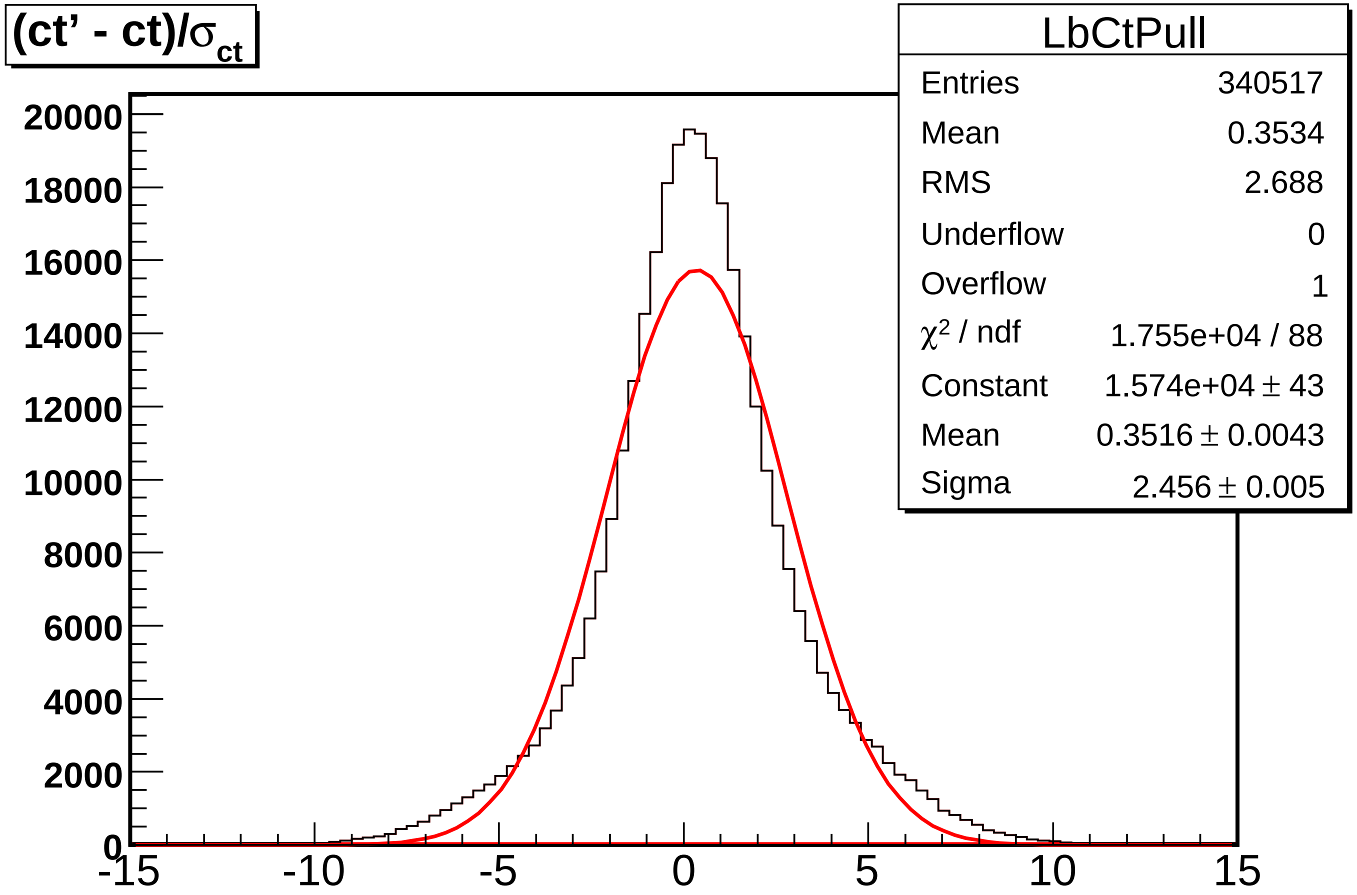
$$m! \in [5.565, 5.67] \sim 6,000 events$$

Stand-Alone fit results:	
Efficiency w/o Mass Cut ($m \in [4.8, 7.0]$)	$366.6 \pm 1.0\mu m$
Efficiency with Mass Cut ($m \in [5.565, 5.670]$)	$367.5 \pm 1.0\mu m$
RooFit Framework fit results:	
Efficiency w/o Mass Cut ($m \in [4.8, 7.0]$)	$364.5 \pm 1.0\mu m$
Efficiency with Mass Cut ($m \in [5.565, 5.670]$)	$365.1 \pm 1.0\mu m$

Resolution Function

We have been modeling the resolution with a Gaussian.

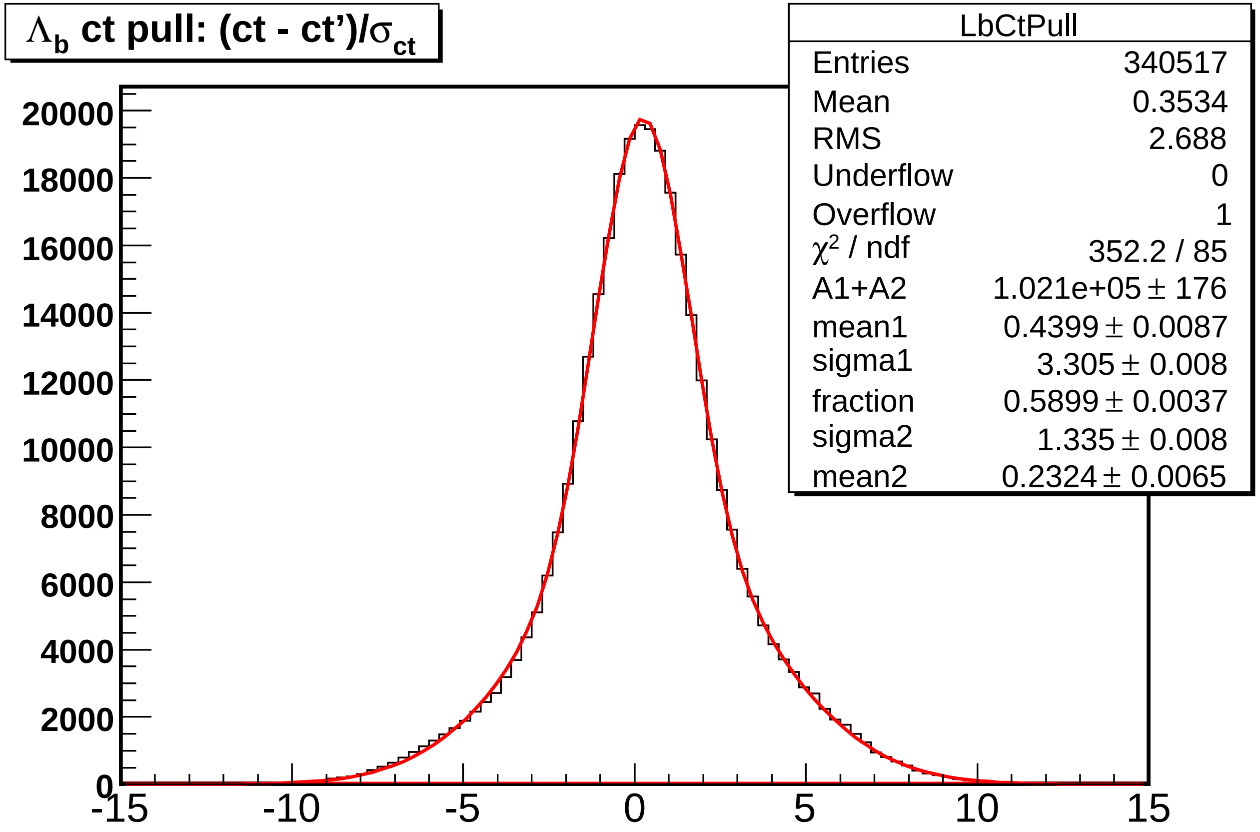
It is clear from the $ct(\Lambda_b^0)$ pull that this is not the best model.



Resolution Function cont'd

The resolution pull is fit much better with a double Gaussian.

$$f(x) = f \cdot Gauss(\bar{x_1}, \sigma_1) + (1 - f) \cdot Gauss(\bar{x_2}, \sigma_2)$$



We have large pollution from the broad tails.

Expo 2 Gauss Resolution

Based on the ct pulls, we need a better resolution function.

$$ExpoGauss \rightarrow Expo2Gauss = f \cdot ExpoGauss(\sigma \cdot sf_1) + (1 - f) \cdot ExpoGauss(\sigma \cdot sf_2)$$

The relative fraction is obtained from the fit
The width of each Gaussian is set by a scale factor;

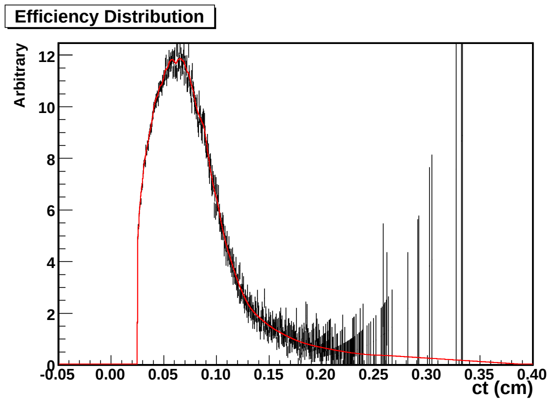
$$\begin{aligned} sf_1 &= 3.3 \\ sf_2 &= 1.4 \end{aligned}$$

Summary of the fit results

Fit	**ExpoGauss**	**Expo2Gauss**
Stand-Alone	$367.5 \pm 1\mu m$	$367.3 \pm 1\mu m$
Unbinned RooFit	$365.1 \pm 1\mu m$	$365.1 \pm 1\mu m$

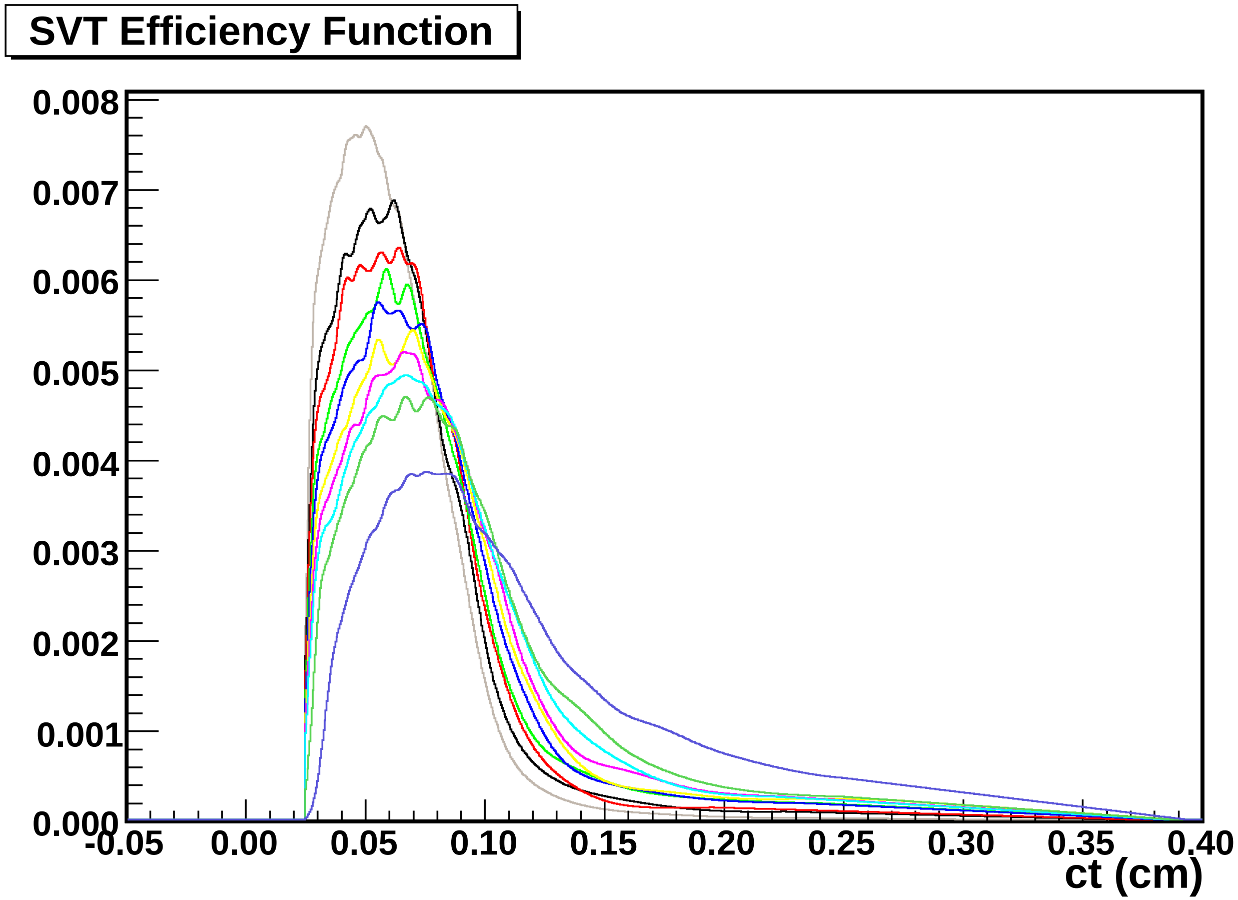
Efficiency in slices of σ_{ct}

We are also exploring the effect of the ct,σ_{ct} correlation that I presented last time.



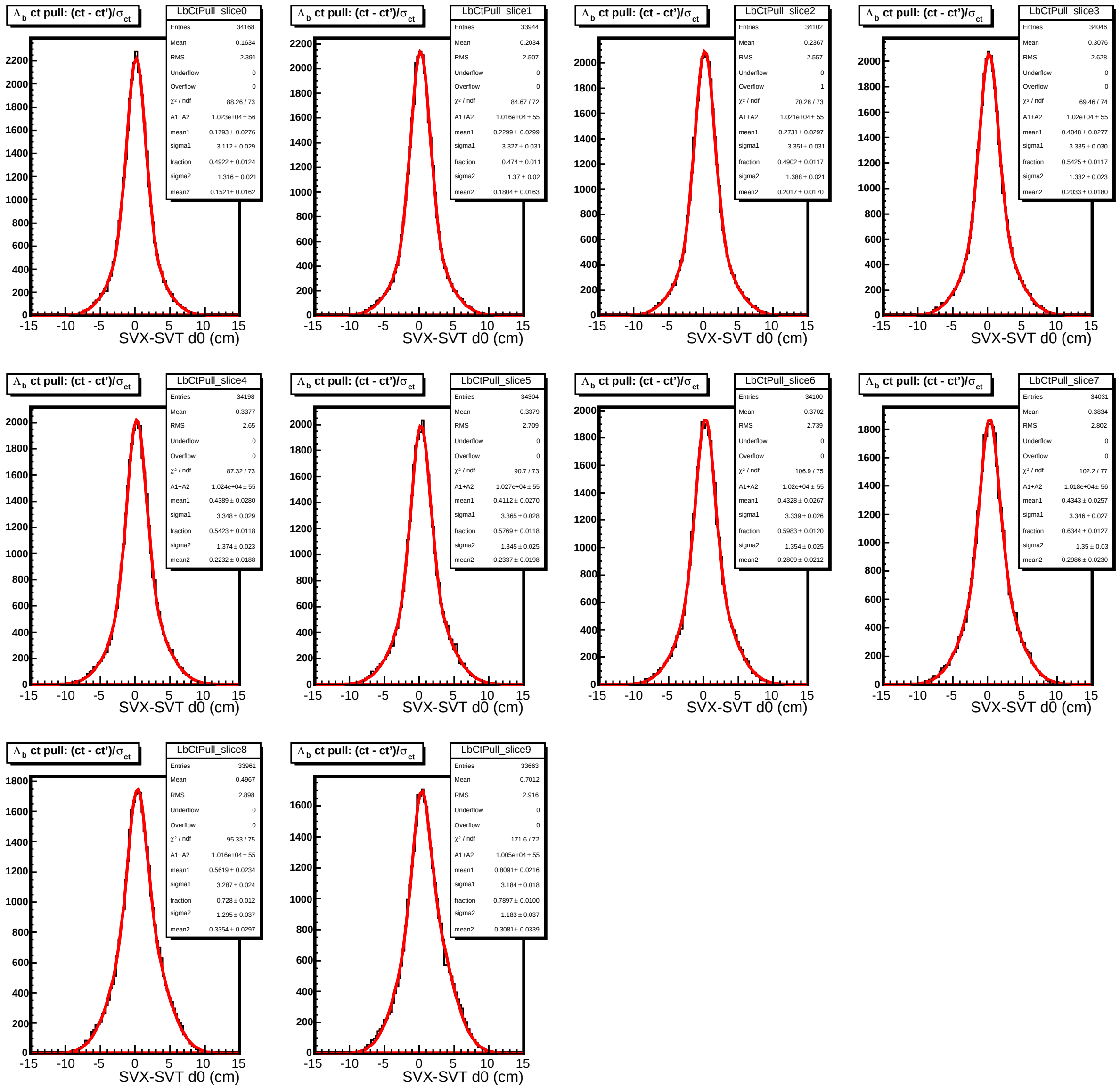
Replace this efficiency...

...with one chopped in σ_{ct} slices.



3-slice ExpoGauss fit $\rightarrow 365.3\mu m$. 10-slice ExpoGauss fit $\rightarrow 362.4\mu m$

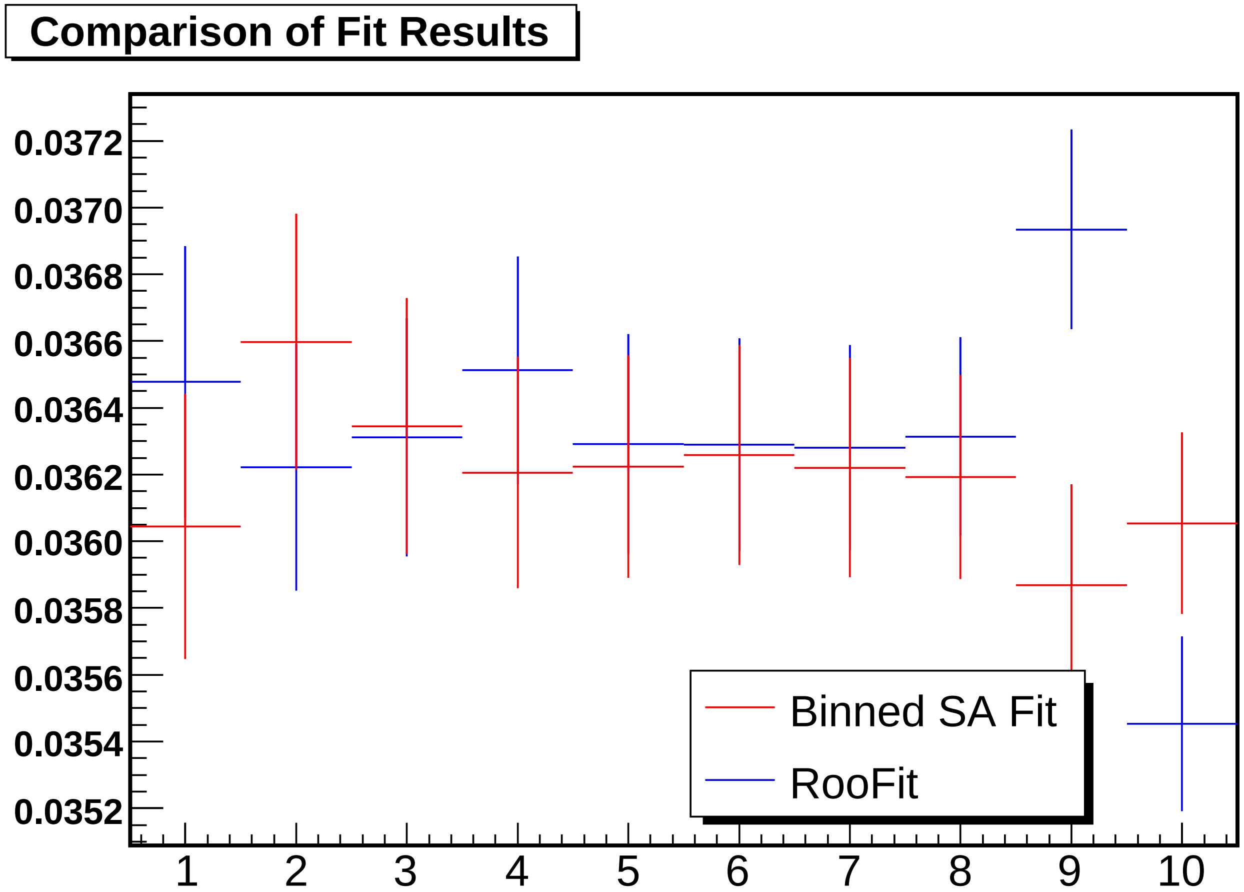
Resolution in slices of σ_{ct}



Fits in slices of σ_{ct}

Fitting with: $f \cdot ExpoGauss(sf_1 \cdot \sigma_{ct}) + (1 - f) \cdot ExpoGauss(sf_2 \cdot \sigma_{ct})$

Each slice is tuned to the fraction obtained from the ct pull fits.



Summary of Lifetime Results

Description	**SA ROOT Fit**	**Unbinned Fit**
True MC lifetime	$368.5\mu m$	
Result at last presentation	366.6 ± 1.0	364.4 ± 1.0
Mass cut in efficiency	367.5 ± 1.0	365.1 ± 1.0
Fit in 3 σ_{ct} slices	–	365.3 ± 1.0
Fit in 10 σ_{ct} slices	–	362.4 ± 1.0
Resolution model: Expo2Gauss	367.3 ± 1.0	365.1 ± 1.0
Ave. per-slice fit (10 slices)	362.0 ± 1.0	363.1 ± 1.0

Several improvements which we thought should help have been included.
The result is no closer to the true MC lifetime.