E687 Meeting
Fermilab, USA
Jan. 18th 1996

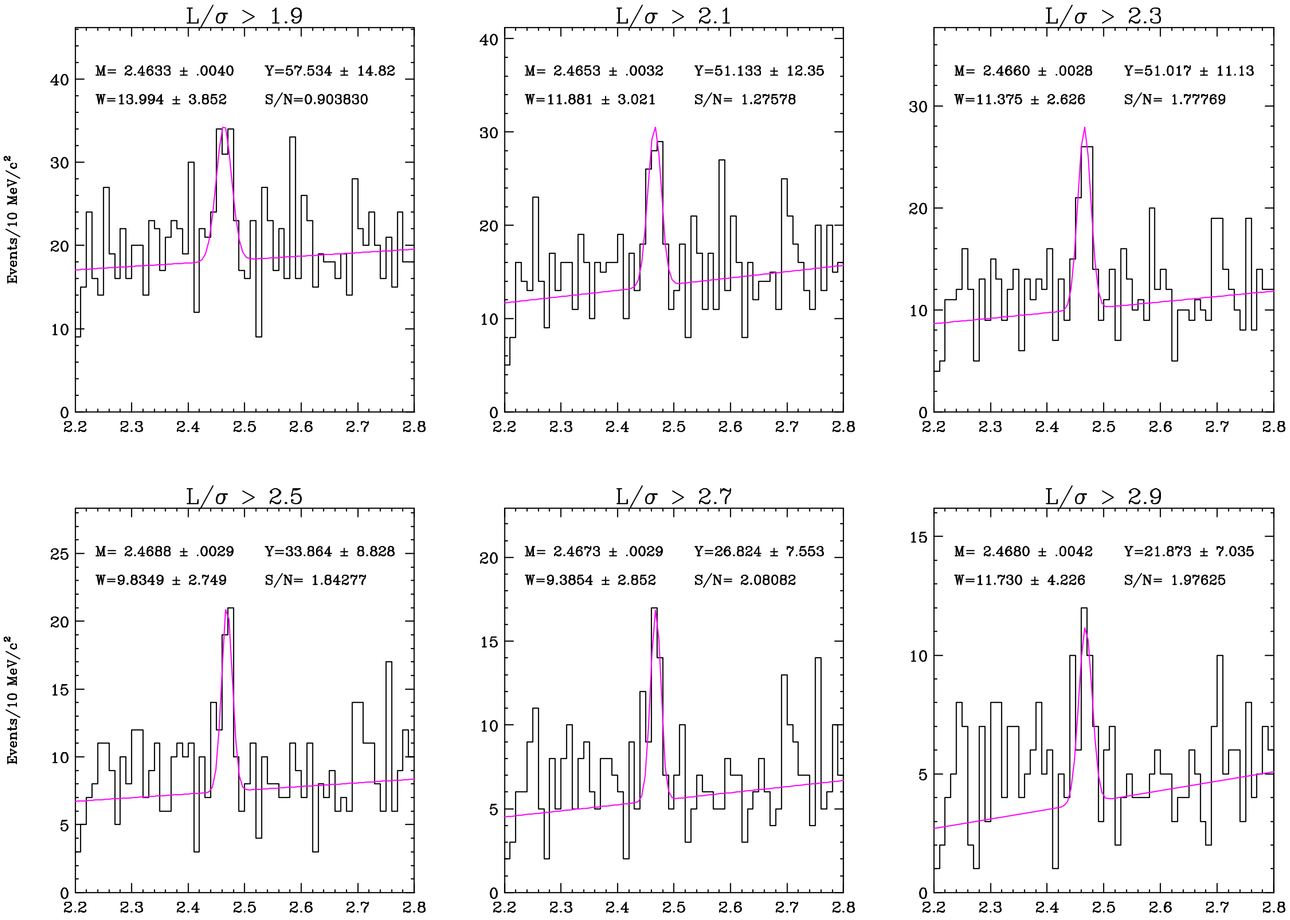
# A $\Xi_c^+$ Lifetime Measurement for $\Xi_c^+ \to \Sigma^+ K^- \pi^+$

## Analysis Cuts

- 1.3 M events sample of $\Xi_c^+ \to \Sigma^+ K^- \pi^+$ with $\Sigma^+ \to p\pi^0$
- Protons $\sim$ p or k/p
- Kink Z position $\sim$ between upstream of M1 magnet and downstream of SSD system
- Kaon $\sim$ k, k/p, or k/p/$\pi$ (if P $>$ 60 GeV/c)
- Pion $\sim$ not e, not k, not p and not k/p ambiguous
- All daughter pions and kaons $\sim$ singly linked
- $P(\Sigma^+ K^- \pi^+) > 40$ GeV/c
- The primary vertex should be within the target volume and the secondary vertex is required to be upstream of the TR1 counter.
- CLD $>$ 6% and CLP $>$ 1%
- CL1 $<$ 85% and CL2 $<$ 6%
- $\delta$ m weighting method with $\delta m = 40$ MeV/$c^2$ to avoid double counting the events which are two fold ambiguous

# $\Xi_c^+ \to \Sigma^+ K^- \pi^+$ Signals

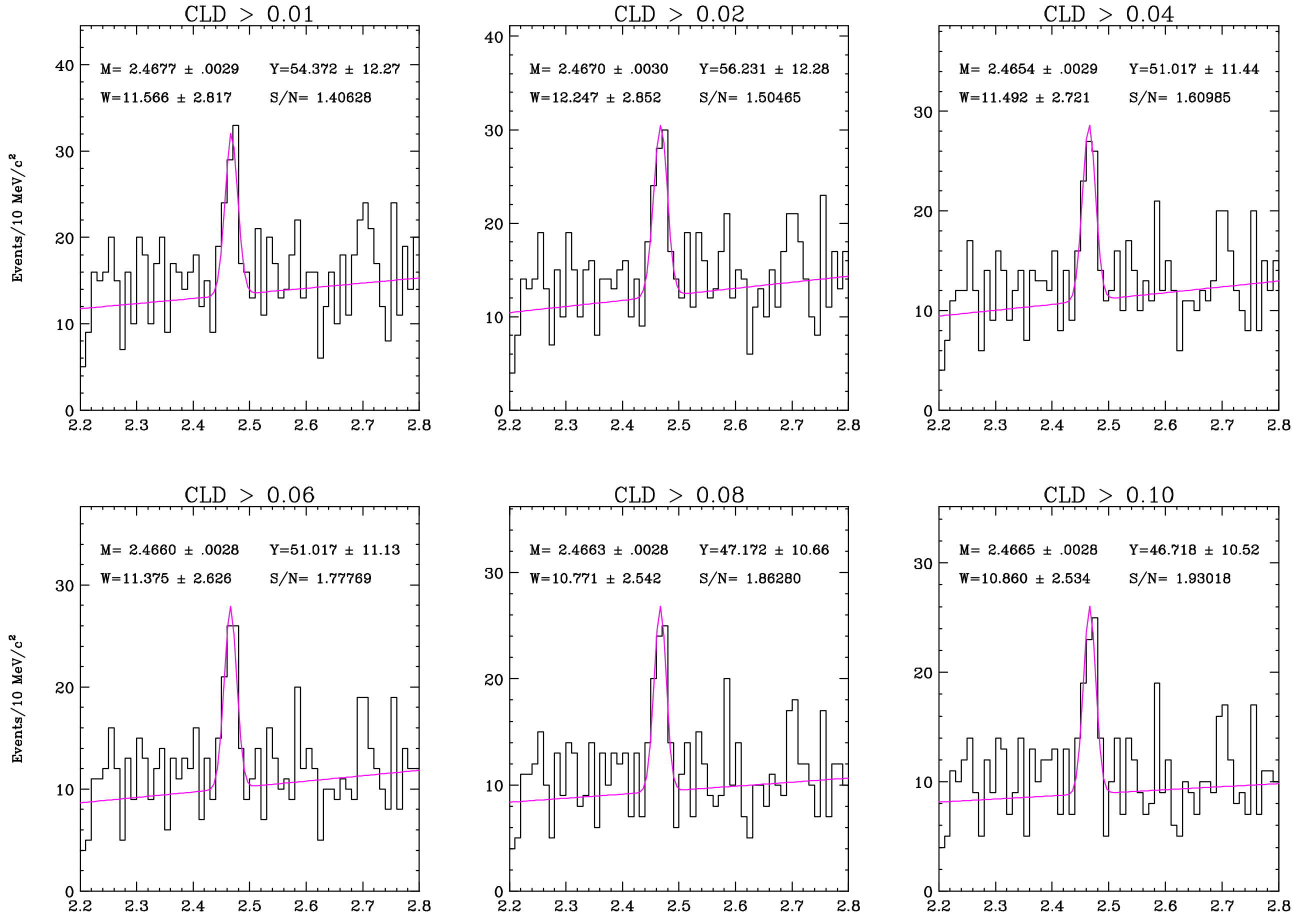
- $M(\Sigma^+ K^- \pi^+)$ plots for a range of $L/\sigma$ with the cuts




- Fit with linear backgrounds and Gaussian signals using a bin likelihood method
- The mass measurement for $L/\sigma > 2.3$ is $2466.0 \pm 2.8$ MeV/c$^2$, in good agreement with the current world average of $2465.9 \pm 1.4$ MeV/c$^2$. The previous E687 measurement is $2464.4 \pm 2.4$ MeV/c$^2$ using 30 events of $\Xi_c^+ \to \Xi^- \pi^+ \pi^+$.
- The fitted yield, width for $L/\sigma > 2.3$ are $51.8 \pm 11.5$ events and $11.3 \pm 2.6$ MeV/c$^2$ respectively.

# Signal Stability against CLD Cut

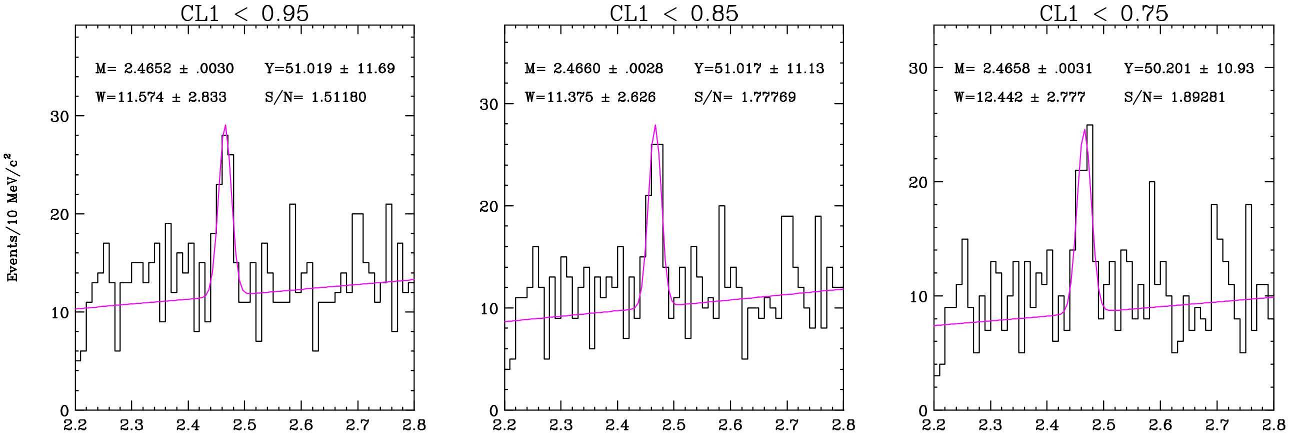
- $M(\Sigma^+K^-\pi^+)$ plots for a range of CLD when $L/\sigma > 2.3$



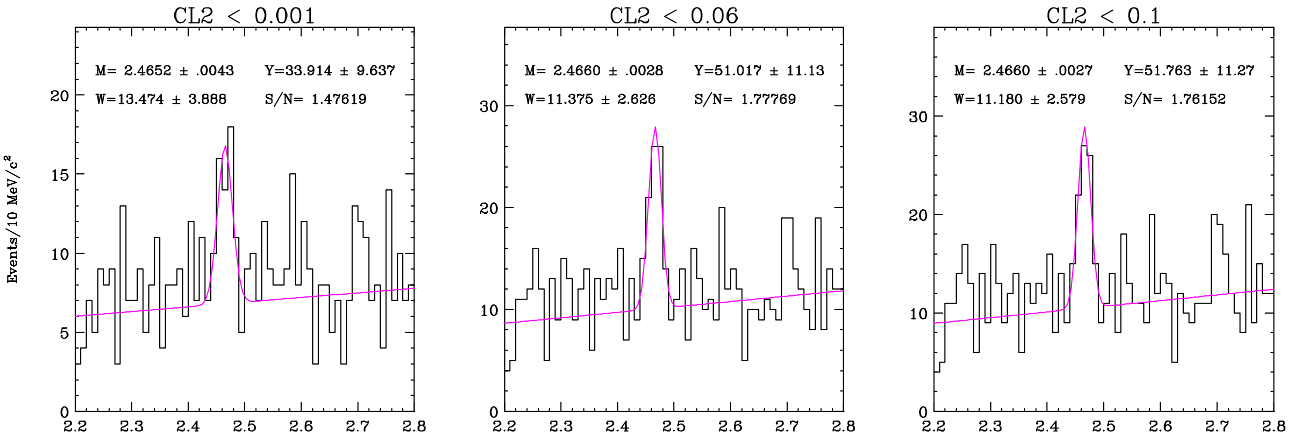

- The signal is very stable against CLD variations. We chose CLD $> 0.06$ on the basis of good S/N and yield.

## Signal Stability against CL1 and CL2

- $M(\Sigma^+K^-\pi^+)$ plots for a range of CL1 when $L/\sigma > 2.3$



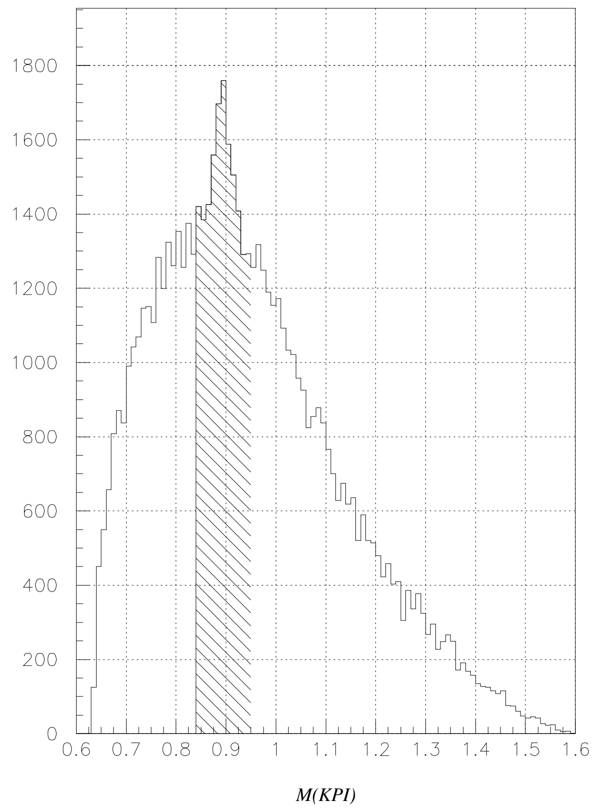

- $M(\Sigma^+K^-\pi^+)$ plots for a range of CL2 when $L/\sigma > 2.3$



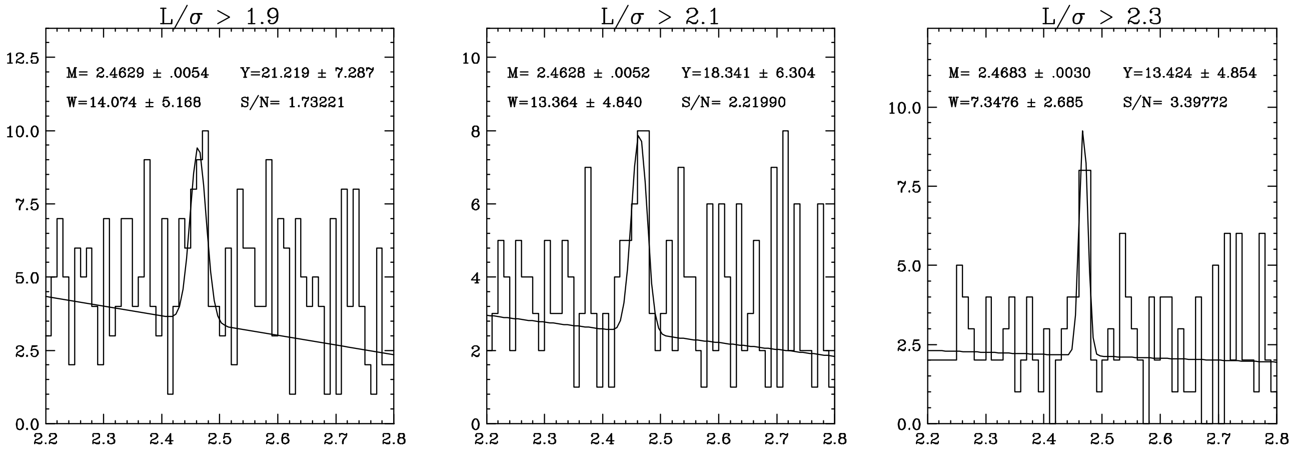

- **The signal is stable against a wide range of CL1 and CL2 variations. We chose CL1 $<$ 0.85 and CL2 $<$ 0.06 on the basis of good S/N and yield.**

# Resonant State

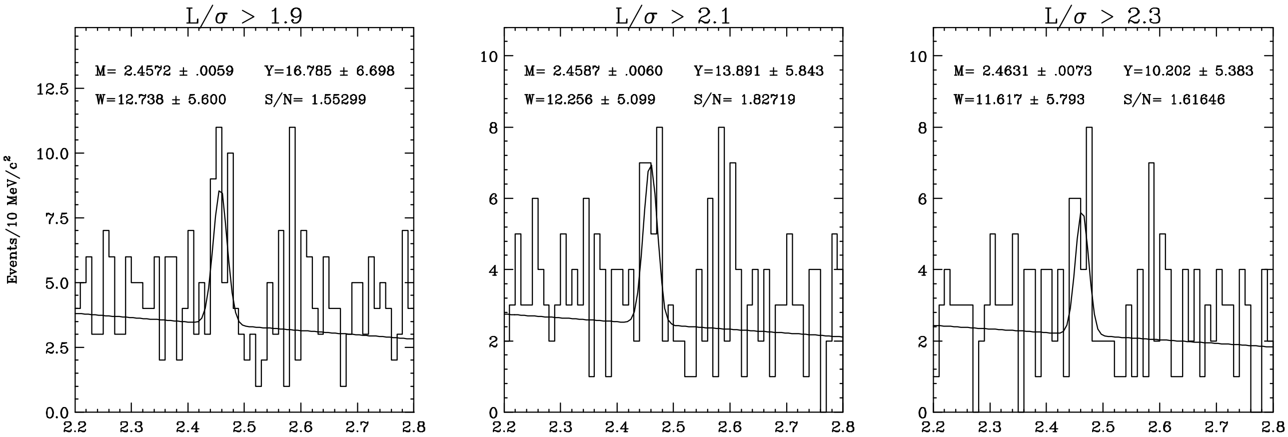
- We investigated the size of the resonant contribution $\Xi_c^+ \to \Sigma^+ \overline{K^{*0}}(892)$ by requiring $|M(K^-\pi^+) - 0.8961| < 0.05$ GeV/$c^2$.
  - $M(K^-\pi^+)$ with $|M(K^-\pi^+) - 0.8961| < 0.05$ GeV/$c^2$ shaded for the data sample



- $\mathbf{M(\Sigma^+K^-\pi^+)}$ **with** $\mathbf{|M(K^-\pi^+) - 0.8961| < 0.05\ GeV/c^2}$**.**




- $\mathbf{M(\Sigma^+K^-\pi^+)}$ **with sidebands of** $\mathbf{M(K^-\pi^+)}$



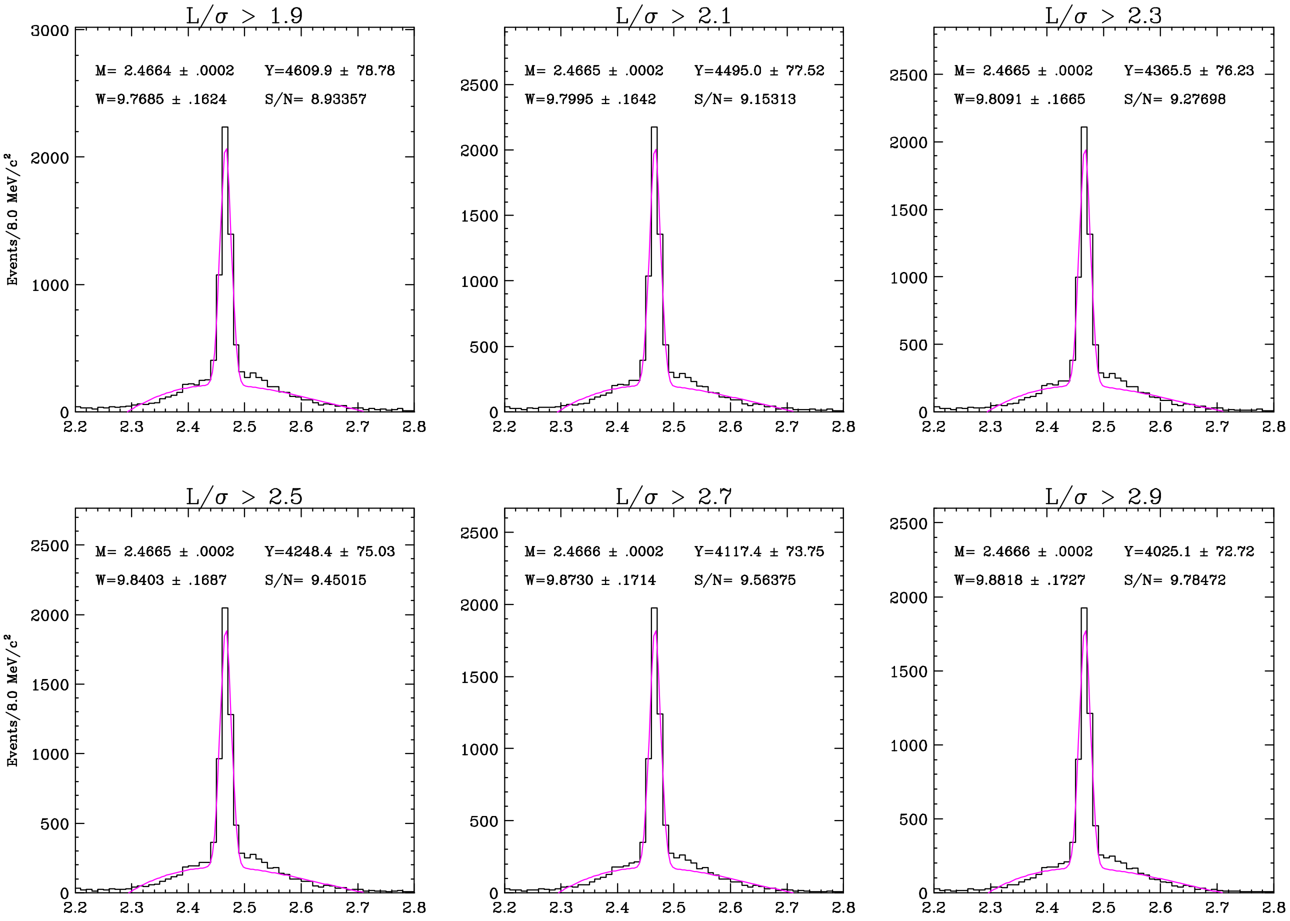

- **There is no significant contribution of the** $\mathbf{\Xi_c^+ \to \Sigma^+\overline{K^{*0}}(892)}$ **resonance mode in the signal.**

# MC Study

- About 2 M events for the following decay topology : $\gamma g \rightarrow \Xi_c^+ \bar{C} \rightarrow \Sigma^+ K^- \pi^+ \rightarrow p \pi^0 K^- \pi^+$ using the SROGUE with LUND73

- 2465.9 MeV/$c^2$ ('96 PDG world average) and 0.41 ps (the E687 $\Xi_C^+$ lifetime measurement) as the initial input values of $\Xi_c^+$ mass and lifetime respectively.

- $M(\Sigma^+ K^- \pi^+)$ plots for the MC sample, using the same cuts as for data sample

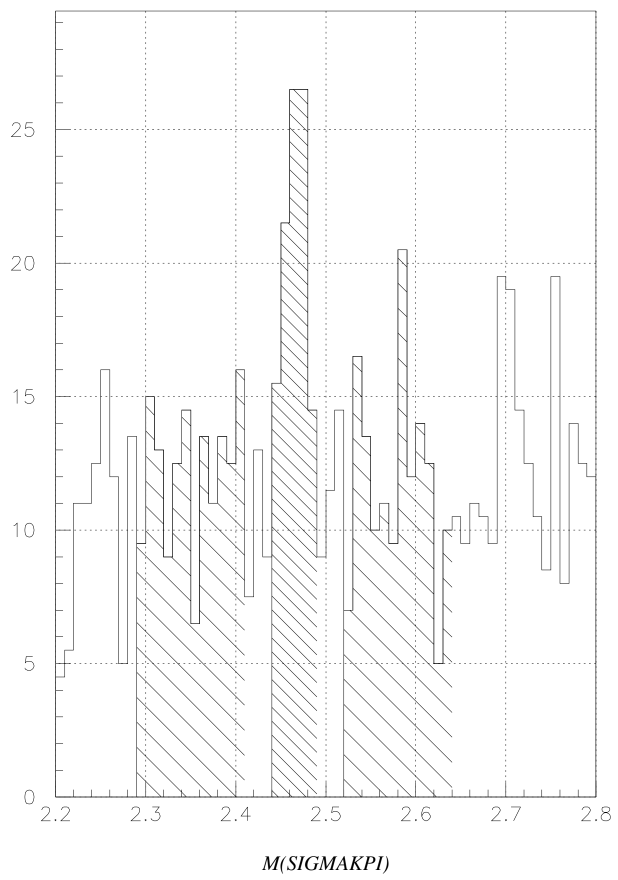



- Almost no shift between the input mass and the fitted mass in MC

- The signal widths of MC and data are consistent with each other.

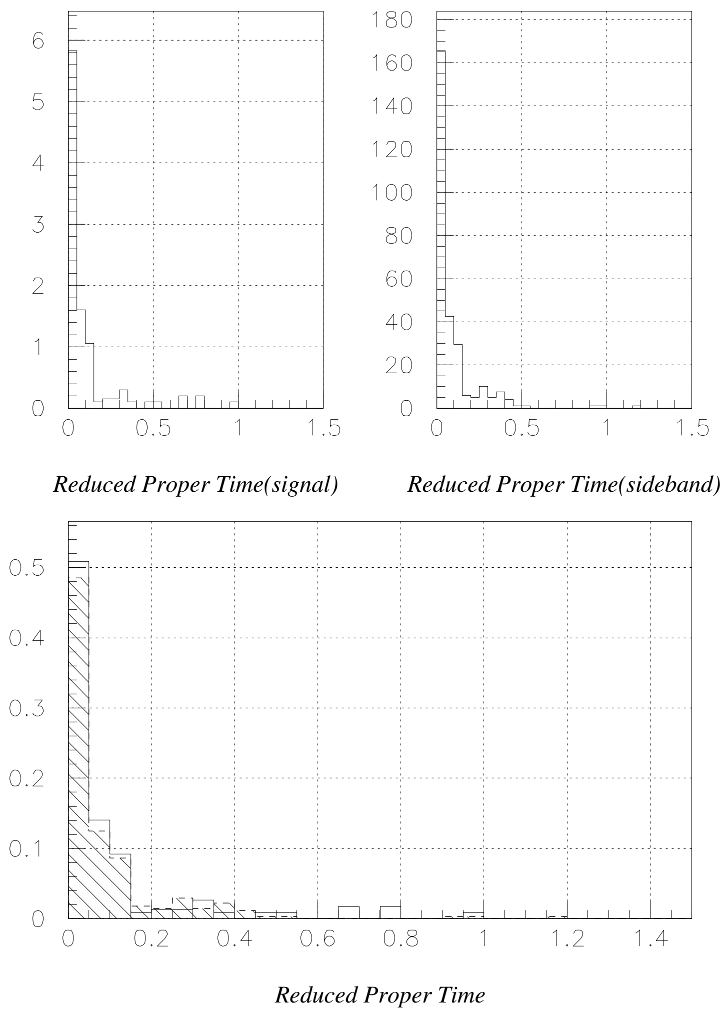
# Reduced Proper Time

- **Reduced proper time $t' = t - \mathcal{N}\sigma_L \frac{m}{p} = \frac{m}{p}(L - \mathcal{N}\sigma_L)$**
  **t is the proper time ($t = \frac{mL}{p}$).**
  **$\mathcal{N}$ is the vertex separation cut( $L/\sigma_L > \mathcal{N}$ ).**
- **Two reduced proper time plots $\sim$ signal region reduced proper time plot and sidebands reduced proper time plot**
- **Signal region $\sim$ within $\pm 2\sigma$ of the measured $\Xi_c^+$ mass**
  **Sidebands $\sim$ $5\sigma$ away from the measured $\Xi_c^+$ mass and $10\sigma$ wide**
  **$\sigma$ $\sim$ the measured width of the signal**
- **$\Xi_c^+$ mass plot when $L/\sigma_L > 2.3$, showing signal (densely hatched) and sideband (sparsely hatched) regions**



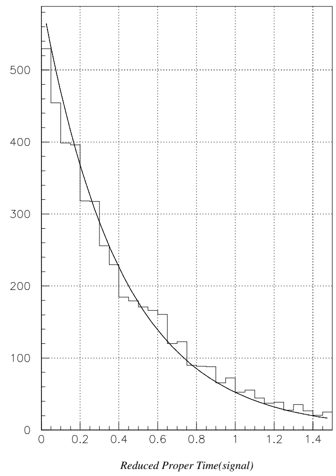
# Reduced Proper Time (continued)

- **The reduced proper time plots for the signal region (upper left), the sideband regions (upper right) and the reduced proper time plot for the signal region (lower histogram) and sideband regions (lower hatched) normalized by the number of entries when $\mathbf{L/\sigma_L > 2.3}$. Thirty reduced proper time bins are used to span the range from 0 to 1.5 ps.**

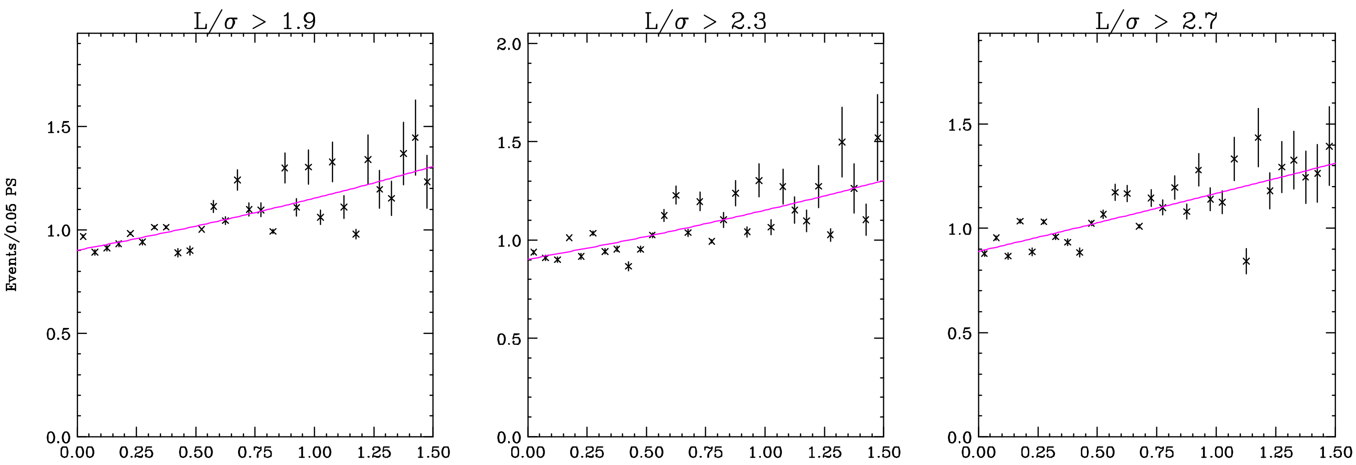


# MC Correction Function

- The modulation function $\sim$ dividing the reconstructed, reduced proper time distribution, with all cuts applied, by a perfect exponential
- The reconstructed distribution (the points) with a perfect exponential superimposed (the curve) for the $\Xi_c^+$ signal from MC when $L/\sigma_L > 2.3$




- The actual $f(t')$ distributions (the points) for various $L/\sigma_L$ cuts with second order polynomial fits (the curves) superimposed

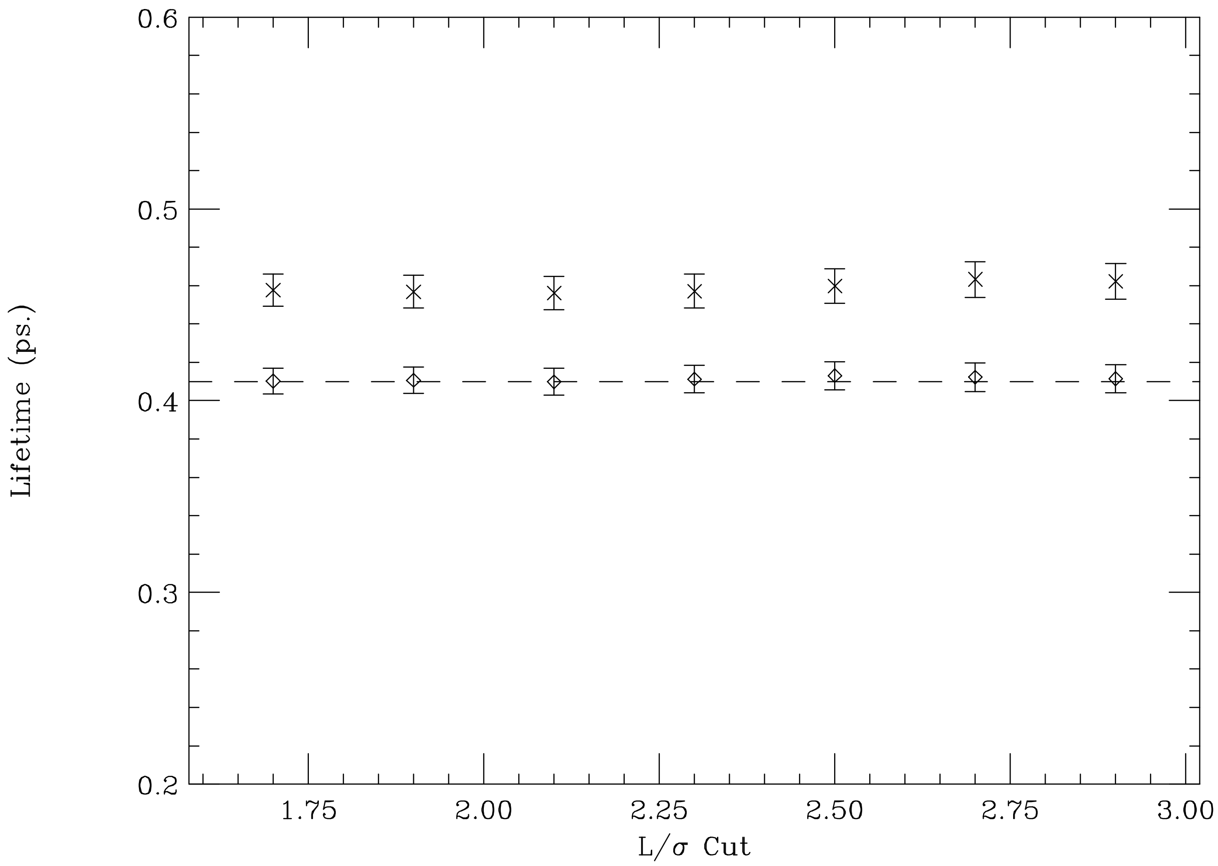


# MC Lifetime Fit

- **Binned maximum likelihood method, where the predicted number of events in a reduced proper time bin is**

$$n_i = S\frac{f(t_i')\exp(-t_i'/\tau)}{\sum_i f(t_i')\exp(-t_i'/\tau)} + B\frac{b_i}{\sum_i b_i}$$

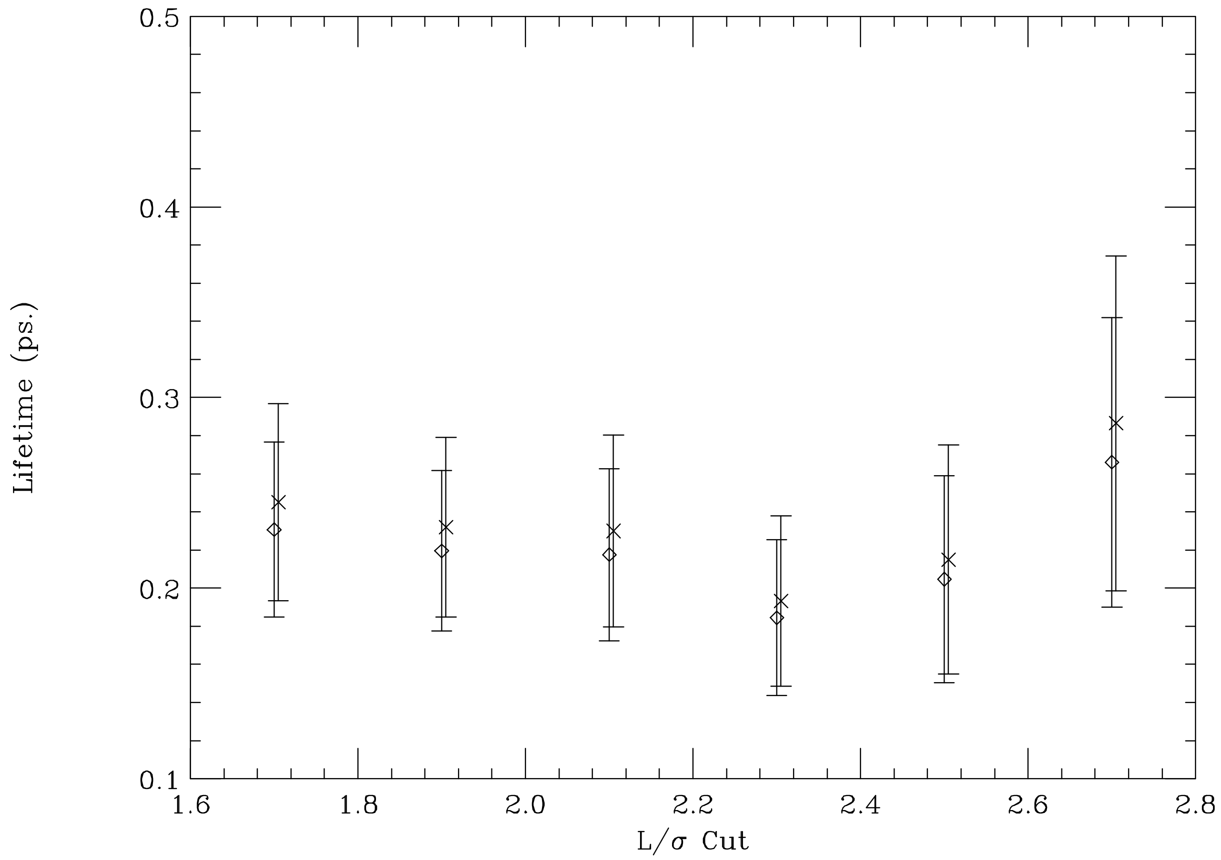
- **The fit parameters are $\tau$ and B.**
- **MC lifetime fit results as a function of $L/\sigma_L$ cuts ( cross = no $f(t')$, diamond = $f(t')$ included, and dashed line = input lifetime value)**




- **Our fitting program and the MC correction function $f(t')$ look working well.**

# Data Lifetime Fit

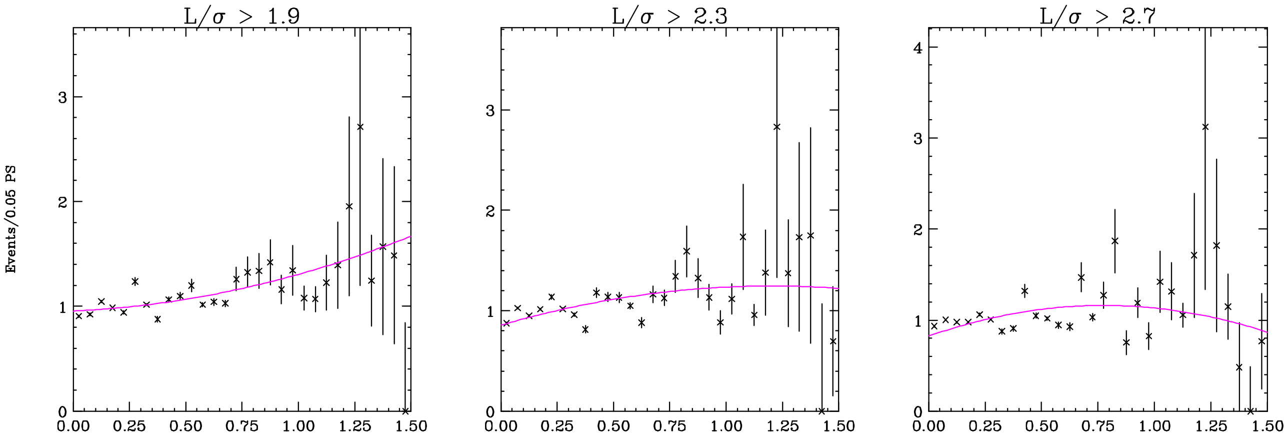
- **Data lifetime fit results as a function of $L/\sigma_L$ cuts ( cross = no $f(t')$, diamond = $f(t')$ included)**



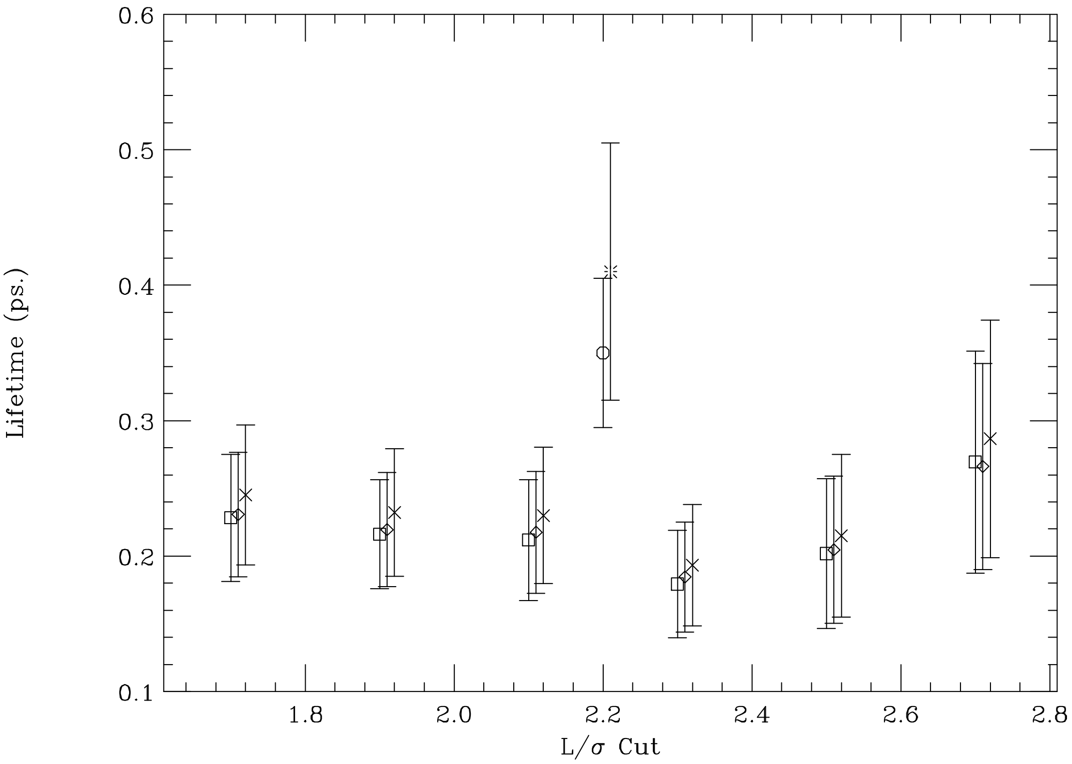

- **Since the fitted lifetimes are significantly different from the MC input lifetime, new $f(t')$ needs to be generated using the new lifetime results.**
- **Another 1.5 M MC events with the input $\Xi_c^+$ lifetime of 0.215 ps**

# Data Lifetime Fit (continued)

- The new $f(t')$ distributions (the points) for various $L/\sigma_L$ cuts with second order polynomial fits (the curves) superimposed

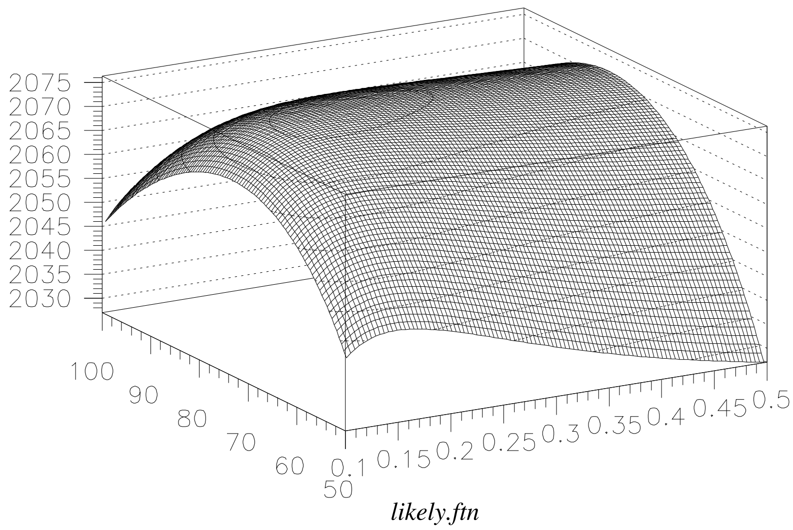



- Data lifetime fit results as a function of $L/\sigma_L$ cuts ( cross = no $f(t')$, diamond = 0.41 ps $f(t')$ included, square= 0.215 ps $f(t')$ included, circle = PDG world average, and asterisk = E687 measurement)

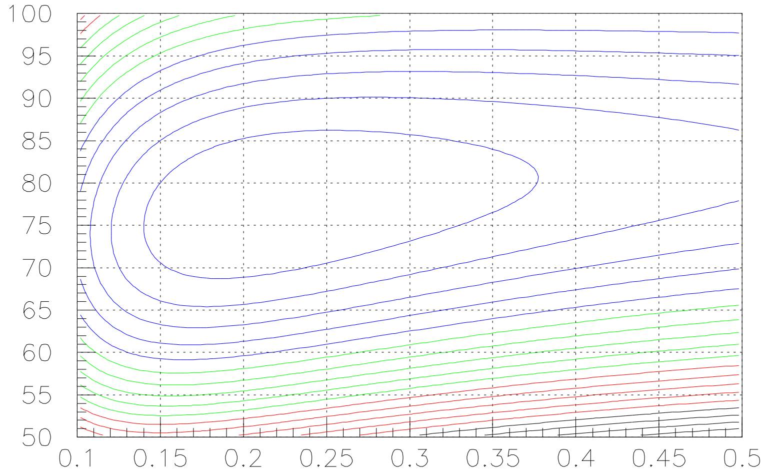


# Log Likelihood Distribution

- $\ln \mathcal{L}$ distribution when $L/\sigma_L > 2.1$ as a function of $\tau$ and B
  The fitted values are $\tau = 0.0212$ ps and $B = 77.2$.



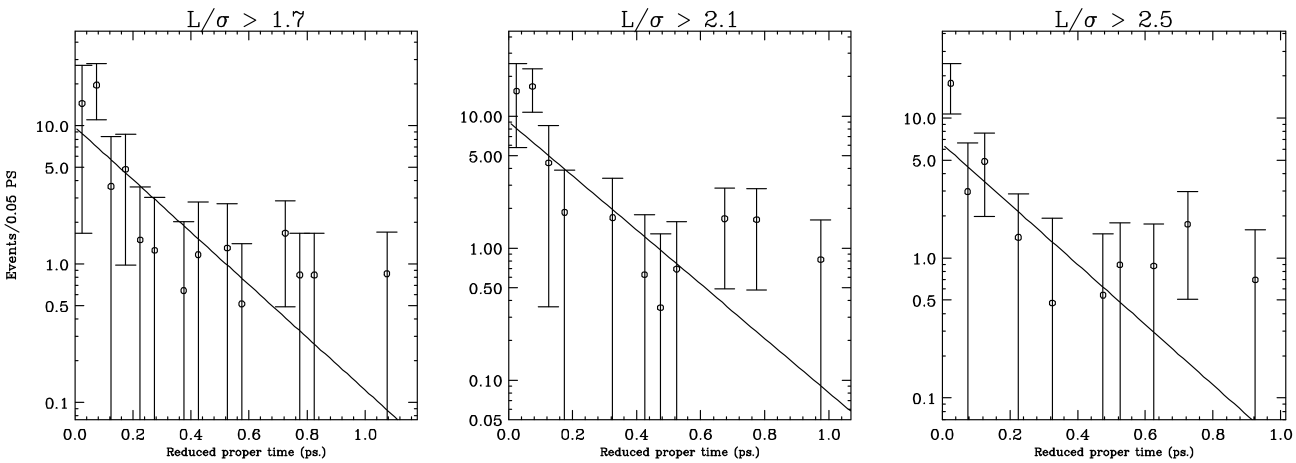

*likely.ftn*




*likely.ftn*

# Completely Corrected Reduced Proper Time Plots

- **Background subtracted, MC corrected, reduced proper time distributions for various $L/\sigma_L$ cuts**



# Discussion

- **The lifetime is measured to be 2 $\sim$ 3 $\sigma$ lower then the current world average and the previous E687 measurement.**
- **G. Bonomi is working on $\Xi_c^+ \rightarrow \Sigma^+ k^- \pi^+$ mode with $\Sigma^+ \rightarrow n\pi^+$. We are waiting for the results he will obtain from the decay mode.**