

B^+ and B^0 Meson Lifetimes Status and Prospects

- Quick review of Decay Length method
- Motivation for looking at Impact Parameter method
- Impact Parameter fit results
- Combining the two analyses
- Estimate of errors once VXD-only tracks are used
- Plans for summer conferences

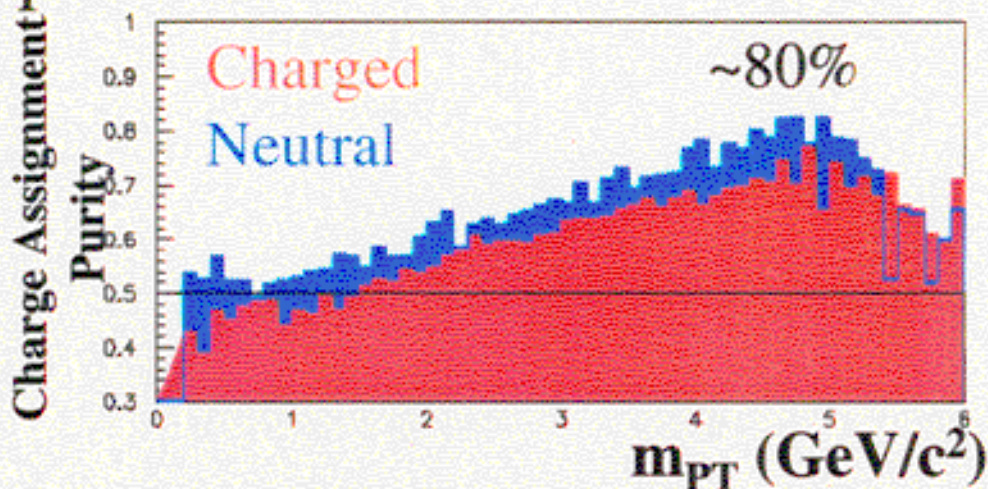
B^+ / B^0 Analysis Outline

- Reconstruct decay point of B mesons using ZVTOP & calculate decay length from IP
- Divide sample into “ B^0 ” and “ B^+ ” samples
- Use M_{PT} , Q_{VTX} , and $A_{FB}(\cos\theta)$ to improve purity of samples
- Determine lifetime by fitting MC to the Data decay length distributions
- Calculate Systematics

Charge Purity Enhancements

- Weight events based upon mass and charge:

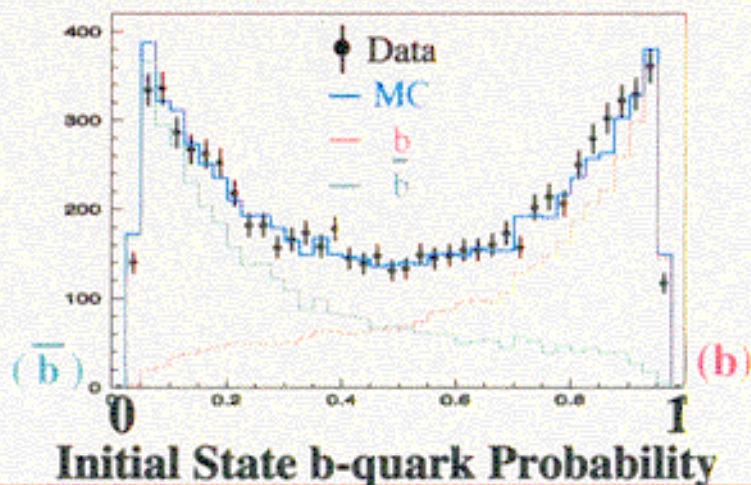
The higher the mass of the topological vertex, the more likely that all of the tracks have been attached, so the more likely that the charge assignment is correct



- Weight events based upon hemisphere flavor tag info (charged B mesons only):

b quark $\rightarrow B^-$

~~$\rightarrow B^+$~~



Lifetime Systematics (97-98 Decay Length Analysis)

Physics Systematics (selected subset)		$\Delta\tau_{B^+}$ (ps)	$\Delta\tau_{B^0}$ (ps)	$\Delta\tau_{B^+}/\tau_{B^+}$
B frag.	$.714 \pm .008$.025	.030	.004
X_E shape		.011	.009	<.003
B(B \rightarrow DD)	$.18 \pm .05$.015	.014	.016
b baryon fraction	$.072 \pm .040$.004	.017	.008
B_s^0 lifetime	$1.49 \pm .06$	<.003	.014	.009
TOTAL (all systs, including trking & detector)		0.033	0.044	0.026

← needs more study

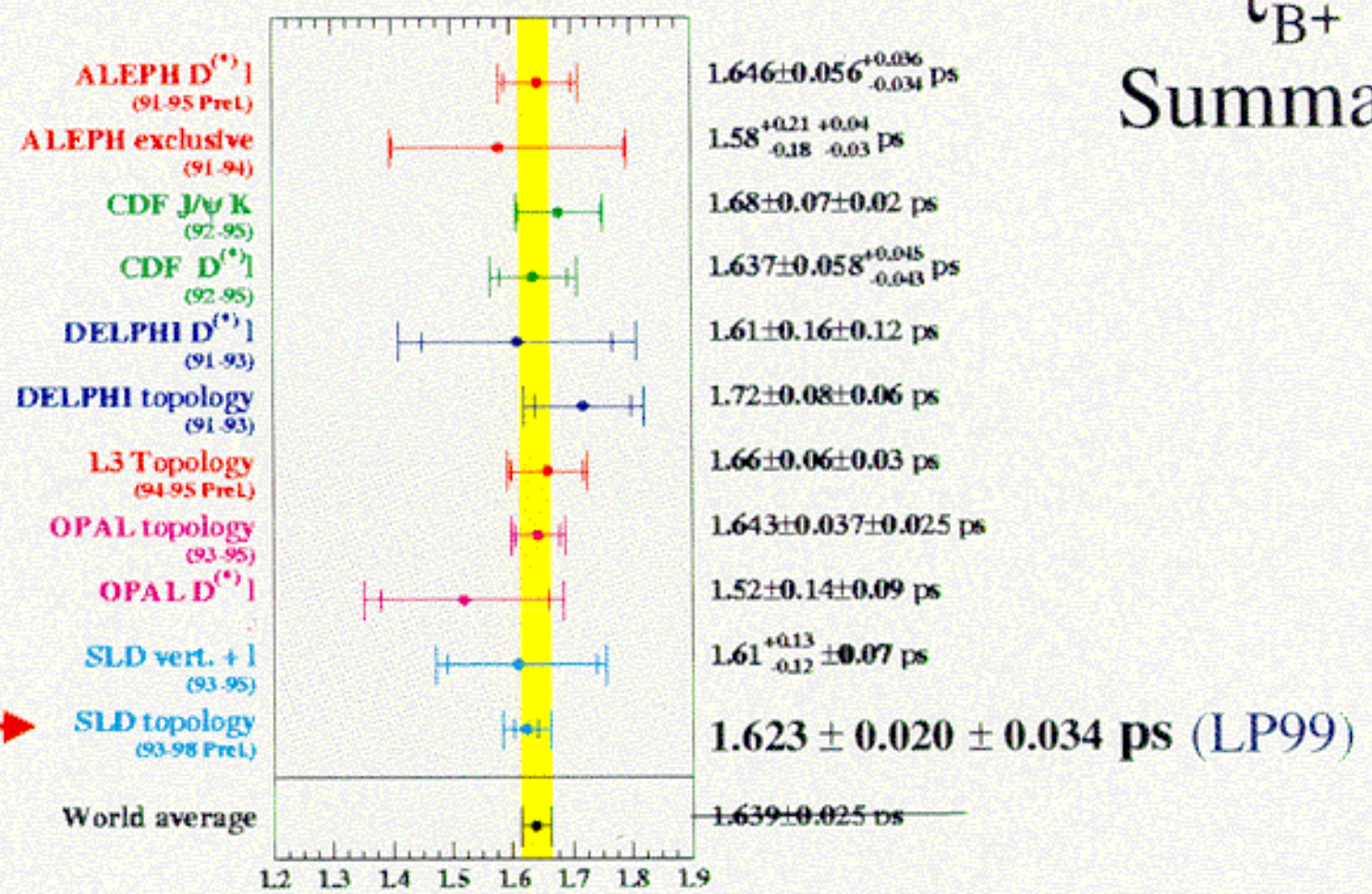
Dan Dong!!



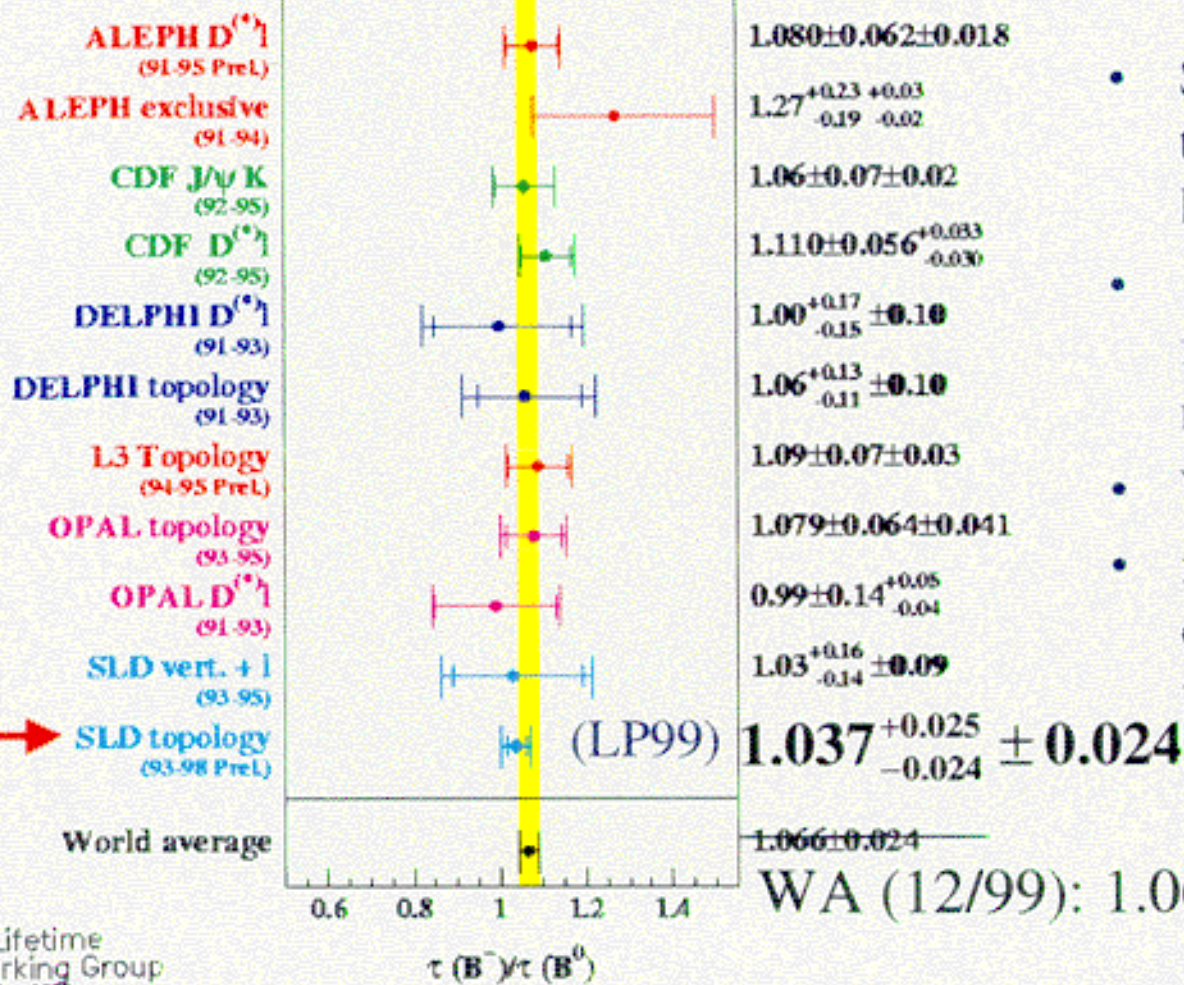
- b fragmentation systematics dominant for individual lifetimes

τ_{B^+}

Summary

WA (12/99): 1.656 ± 0.025 psB Lifetime Working Group
November 1999

τ_{B^+} / τ_{B^0} Summary



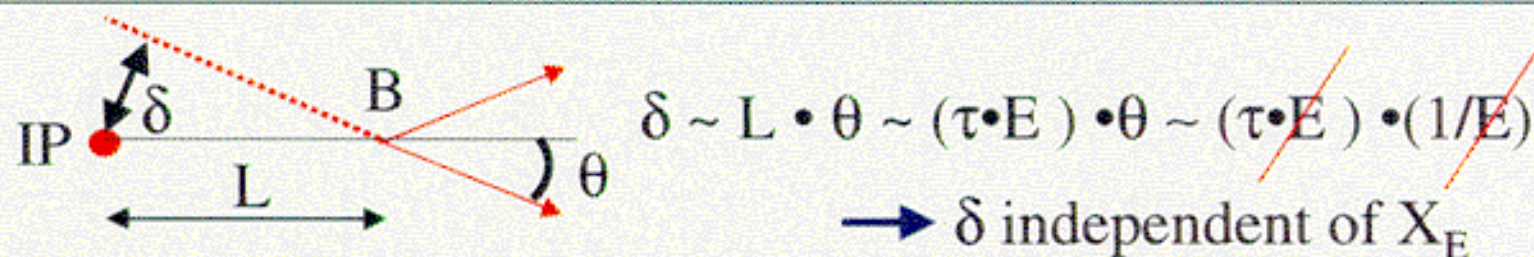
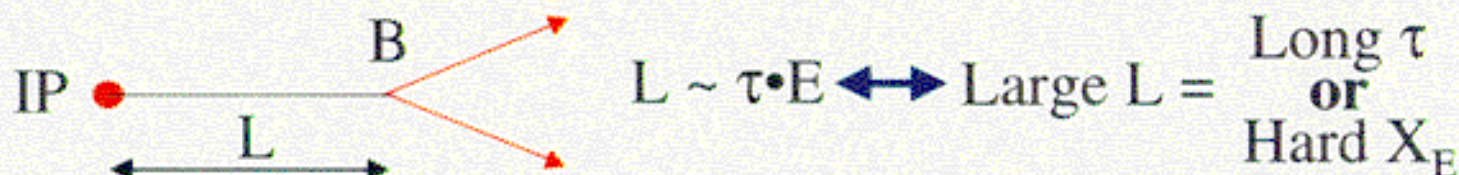
- SLD Measurement still the most precise for lifetimes & ratio
- $\tau_{B^+} / \tau_{B^0} \sim 1 \sigma$ deviation from naive spectator model prediction
- World sees 2.8 σ dev.
- need greater precision to discriminate between theoretical predictions

Crosschecks

Very important - results are most precise for now, but will be “checked” in < 1 yr by BaBar & few years down the road by CDF/D0

- τ as a function of
 - decay length cuts (min,max)
 - $\cos \theta, \phi$ regions
- error magnitude checks (**work in progress (still)**)
 - errors scale from previous results
 - Data errors agree with MC predictions
 - examining MC pulls, etc.

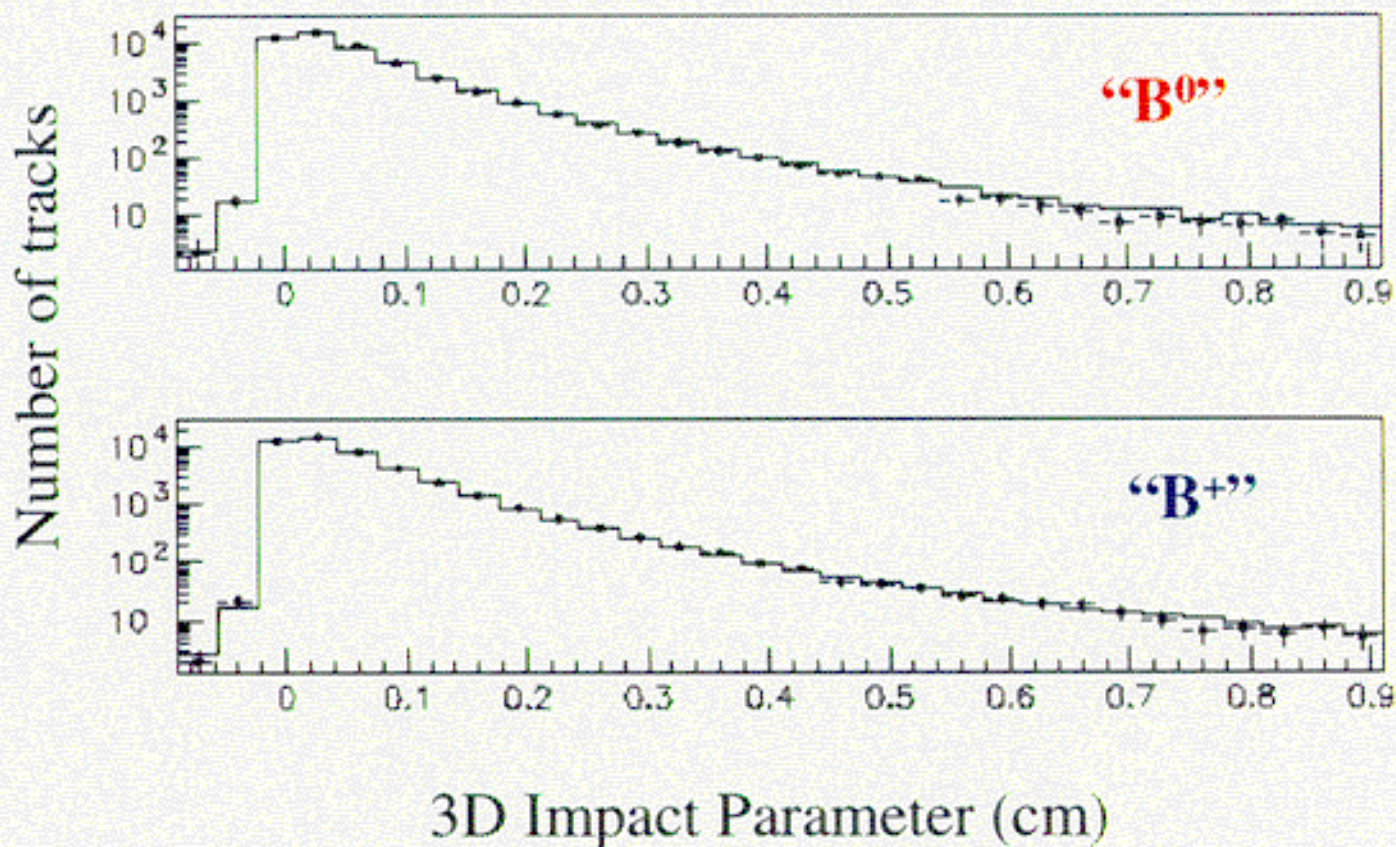
Can we use a variable that is less sensitive to X_E ?



Analysis
Outline:

- As before, find ZVTOP vertices
- As before, divide sample into charged & neutral
- As before, enhance B^\pm purity using A_{FB} , M_{PT} , etc.
- Use the Average of the **3D Impact Parameters** of the Vertex Tracks with respect to the IP

How does the Impact Parameter distribution look?

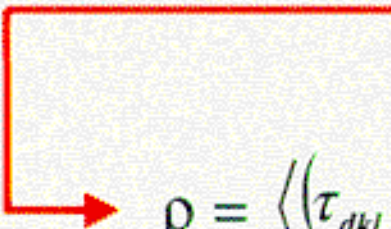


Reasonably good agreement!

Instead, look @ Average of the 3D impact parameters
for the tracks in the vertex

(nice thing: 1 entry/evt; less dependence on B-decay model)

	τ_{B^+} * (\pm stat) psec	τ_{B^0} (\pm stat) psec	τ_{B^+}/τ_{B^0} (\pm stat)	Total χ^2 (76 dof)
Decay Length	$1.660 \pm .024$	$1.577 \pm .024$	$1.052 \pm .027$	80
Ave. of 3D impact Parameters	$1.638 \pm .025$	$1.547 \pm .027$	$1.057 \pm .032$	79
Degree of correlation with dkl analysis	65.1%	74.0%	75.1%	



$$\rho = \frac{\langle (\tau_{dkl} - \overline{\tau_{dkl}})(\tau_{b3} - \overline{\tau_{b3}}) \rangle}{\sigma_{dkl} \sigma_{b3}}$$

* @ $\chi_E \approx .70$

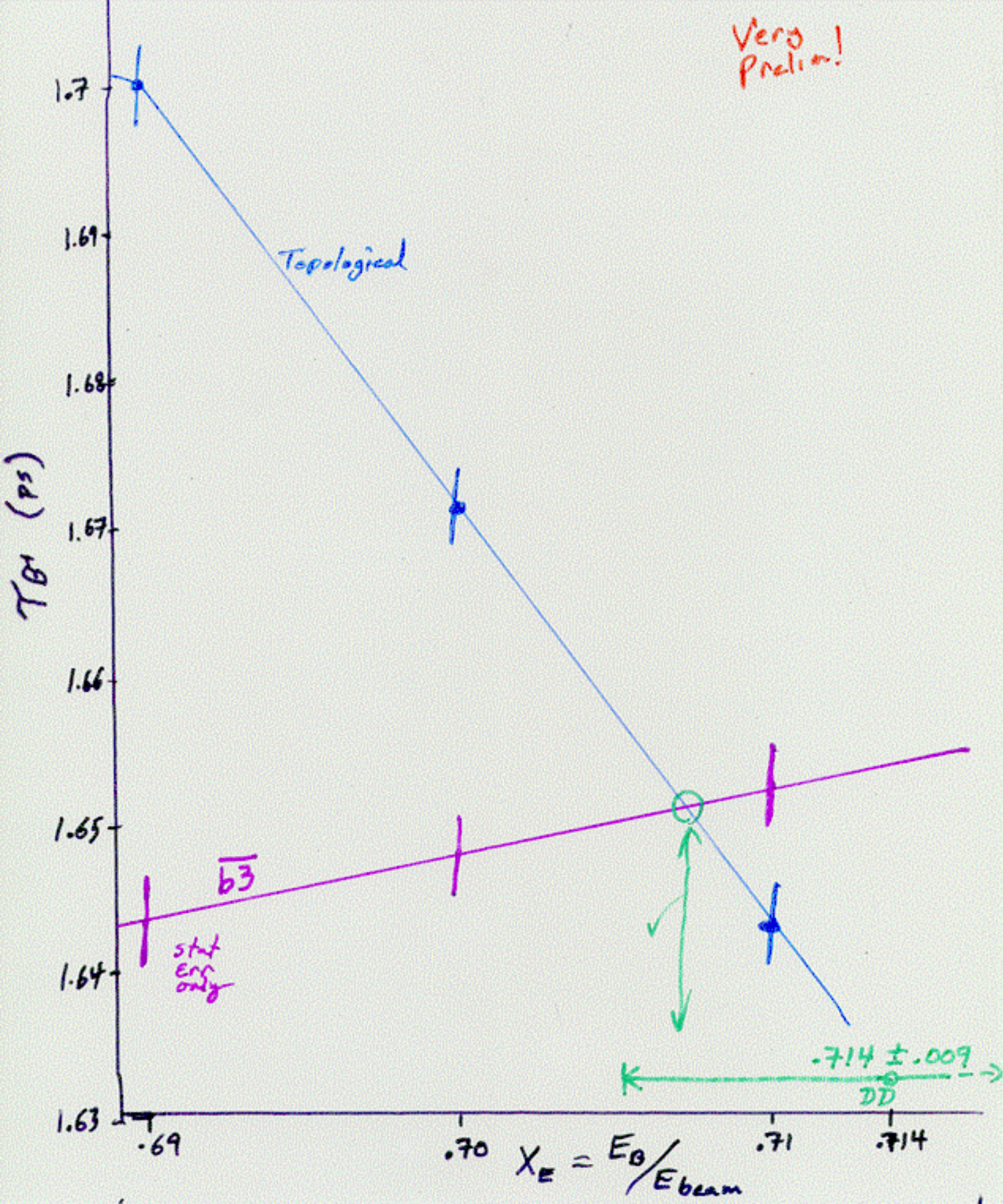
Lifetime Systematics (97-98 Ave. b3 Analysis)

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b baryon fraction	$.072 \pm .040$.004 .010	.017 .009	.008 .010	
B_s^0 lifetime	$1.49 \pm .06$	<.003	.014.015	.009	.010
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But, others now much more important!

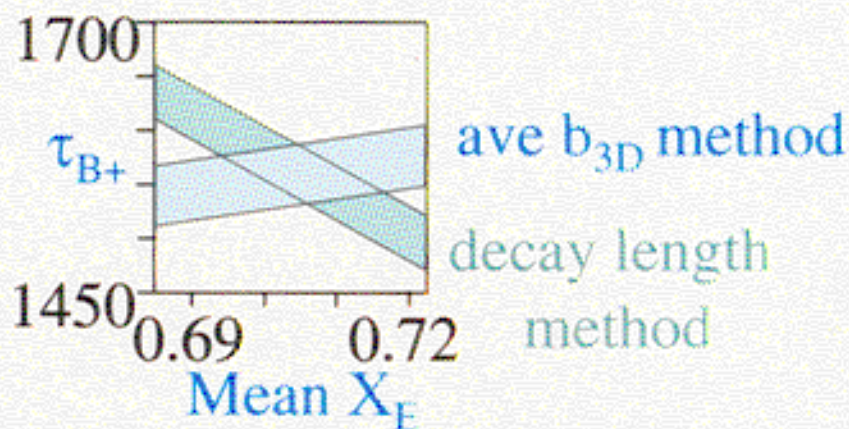
e.g. B decay multi: 0.019 0.013 0.019
(used to be negligible)

Very Precise!



We *may* want to combine methods, but since data is the same, we must worry about *correlations*:

Trial #1: treat it like an intersecting track problem



Prob. Dist.:

$$P(x, y) = \left(\frac{1}{2\pi\sigma_1\sigma_2} \frac{1}{\sqrt{1-\rho^2}} \right) \times \exp \left[-\frac{1}{2} \frac{1}{1-\rho^2} \cdot \left(\left[\frac{y - y_1(x)}{\sigma_1} \right]^2 + \left[\frac{y - y_2(x)}{\sigma_2} \right]^2 - \frac{2\rho(y - y_1(x))(y - y_2(x))}{\sigma_1\sigma_2} \right) \right]$$

Bottom Line: *Didn't Work!*

Instead, using same prescription as earlier lifetime analysis (93-95), when we first combined the topological vertexing analysis with the ~~lepton~~ ^{semilep.} analysis:

e.g. $\tau_{B^+} = 1.60 \pm .11 \pm .06 \text{ ps}$ (semilep) Overall Err
.13

$= 1.69 \pm .06 \pm .06 \text{ ps}$ (topo.) .085

If No correl., $\tau_{B^+} = 1.66 \pm .07$ (weighted ave.)

$P_{\text{stat}} = \underline{.051}$ $P_{\text{sys}} = \begin{cases} 1 & \text{For Common} \\ 0 & \text{Everything else} \end{cases}$

Examples of common systs: trking ϵ , det resol \rightarrow

matrix $E = \begin{pmatrix} \sigma_{\text{semil.}}^2 & \text{cov.} \\ \text{cov.} & \sigma_{\text{topo}}^2 \end{pmatrix}$ j cov = $P_{\text{stat}} \sigma_{\text{stat.}}^{\text{semil.}}$ $\sigma_{\text{stat.}}^{\text{topo}} + \cancel{P_{\text{stat}}} \sigma_{\text{common sys}}^{\text{semil.}}$ $\sigma_{\text{common sys}}^{\text{topo}}$

weight matrix $\alpha = E^{-1}U / \tilde{U}E^{-1}U = \begin{pmatrix} .235 \\ .765 \end{pmatrix}$ semilep.
topological *

From Lyons et al.
NIMA 270 (1988)
p. 110.

→ $\langle \tau_{B^+} \rangle = .235 \times \tau_{B^+}^{\text{semilep}} + .765 \times \tau_{B^+}^{\text{topo}}$

$\sigma^2 = \tilde{\alpha} E \alpha$

$= 1.67 \pm .079$

* would be if completely uncorrelated $\begin{pmatrix} .30 \\ .70 \end{pmatrix}$

For these two analyses, we have

$$\tau_{B^+} (\text{@ } X_E = .714)$$

Total Err

decay l.
topo.

$$1.633 \pm .025 \pm .033^* \text{ ps} \quad .041 \text{ ps}$$

$\sqrt{b_3}$

$$1.652 \pm .026 \pm .028^{*+} \text{ ps} \quad \underline{\underline{.038 \text{ ps}}}$$

$$P_{\text{stat}} = .651$$

~~Red~~ common systs!

$$E^{-1} = \frac{1}{|E|} \begin{pmatrix} (.038)^2 & -\text{cov.} \\ -\text{cov.} & (.041)^2 \end{pmatrix} ; \text{ cov } \underline{\text{large}}$$

$$= \begin{pmatrix} 2355.2 & -2197.4 \\ -2197.4 & 2741.9 \end{pmatrix}$$

$$\Rightarrow \alpha = \begin{pmatrix} .228 \leftarrow \text{decay l.} \\ .772 \leftarrow \sqrt{b_3} \end{pmatrix} !$$

$$\Rightarrow \tau_{B^+} = 1.647 \pm .038 \text{ ps}$$

\Rightarrow pre-prelim!! \leftarrow

$$(12/99 \text{ WA: } 1.656 \pm .025)$$

How much better might the τ results get...

- ...if we use Dan Dong's X_E ($\sim .709 \pm .006$)?
 - For LP99, we used $\sigma_{X_E} = \pm .008$
 - $\tau_{B^+} = 1.613 \pm .023 \pm .034 \cdot \frac{.025}{.039}$ psec
 - $\tau_{B^0} = 1.565 \pm .024 \pm .044 \cdot \frac{.025}{.039}$ psec
 - $R = 1.030 \pm .028 \pm .026$ **stays the same**
- ...if we combine the two analyses?
 - $\rho \sim 0.7$, so *maybe* stat error reduces $\sigma \rightarrow \sqrt{\rho}\sigma \rightarrow .85\sigma$
 - $\sigma_{\text{STAT}}(B^+) \rightarrow .020$ *(but systs prob. won't reduce as much as above)*
 - $\sigma_{\text{STAT}}(B^0) \rightarrow .020$
- ...if we use VXD-only tracks?
 - From T. Wright: tag purity goes from $\sim .79\%$ to $\sim .82\%$
 - so A.P. = |2P-1| goes from 0.58 to .64 (10% improvement)
 - $\sigma_{\text{STAT}}(B^+ \& B^0) \rightarrow .020 \rightarrow .018$

So.....

$$\tau_{B^+} = 1.613 \pm .018 \pm .030 \text{ psec}$$
$$\tau_{B^0} = 1.365 \pm .018 \pm .042 \text{ psec}$$
$$R = 1.030 \pm .021 \pm .026$$

or.....

Really, Really Preliminary!

$$\sigma_{\tau} / \tau(B^+) = 2.5\% \rightarrow 2.1\%$$

$$\sigma_{\tau} / \tau(B^0) = 3.2\% \rightarrow 2.9\%$$

$$\sigma_R / R = 3.7\% \rightarrow 3.2\%$$

Plans & Goals

- For Valencia conference (**Hyperons, Charm and Beauty Hadrons; late June**), we want to release “almost final” results for 1996-98 data
 - combination of dkl and ave. b3 analyses
 - using VXD-only tracks
 - using best estimate of X_E
 - completed physics note
- **Results must freeze by mid-June**
- Publication plans: draft 0 will be B-lifetime PRL using 1993-95 data

Plans & Goals

- By the end of the **summer**, Dan and I want to release final results for 1996-98 data
 - combine dkl and ave. b3 analyses? *(to determine X_E)?*
 - Nope** → crosscheck only
 - using VXD-only tracks
 - using best estimate of X_E
- Publication plans: draft 0 will be B-lifetime PRL using 1993-95 data