Experimental Status of

of

Inclusive $|V_{cb}|$ Measurements

For the L3 Collaboration

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Outline

- Introduction
- Average B-lifetime Measurements
- Semileptonic Branching Ratio Status
- $|V_{cb}|$ measurement
- Conclusions

- Theoretical Basis for inclusive $|V_{\rm cb}|$ measurements:

$$\Gamma(B \to X_c l \nu) = \frac{G_F^2 m_b^5}{192\ \pi^3} |V_{\rm cb}|^2\ F_{\rm theo}$$

$$\delta\ F_{\rm theo} \simeq 10\% - 20\%$$

- Experimental Input Needed:

$$\Gamma(B \to X_c l \nu) = \frac{{\rm BR}(B \to X_c l \nu)}{\tau_B}$$

- Typical Experimental Uncertainties:

$$\frac{\delta\ {\rm B}_l}{{\rm B}_l} \simeq 3 - 5\%$$

$$\frac{\delta\ \tau_B}{\tau_B} \simeq 1.5 - 3\%$$

- Typical Discrepancies between measurements:

$$\frac{\delta\ {\rm B}_l}{{\rm B}_l} \simeq 5\%$$

$$\frac{\delta\ \tau_B}{\tau_B} \simeq 3\%$$

- Based on accurate microvertex detectors:

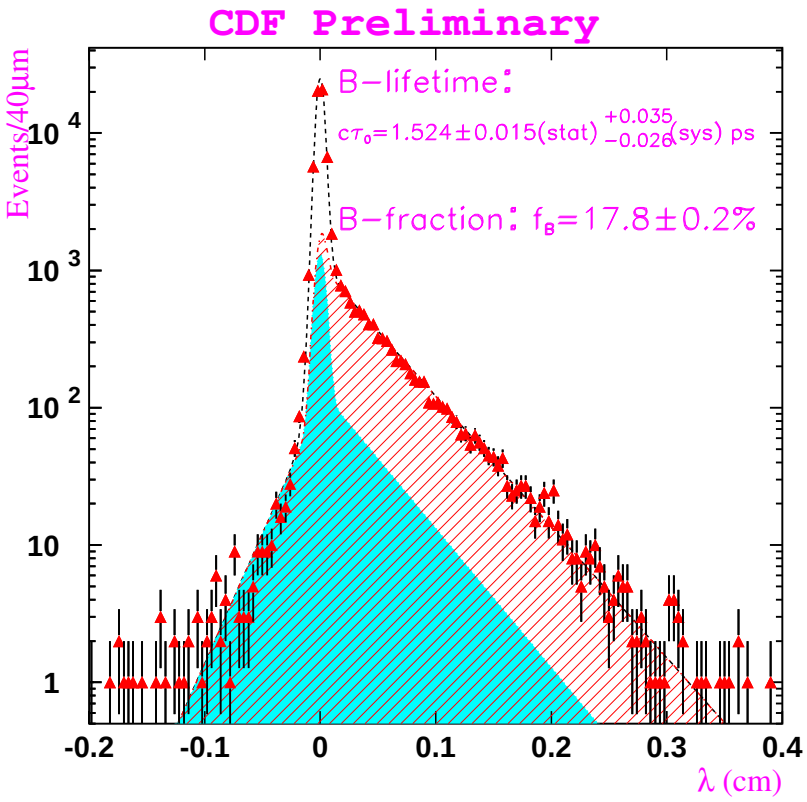
$$\delta(\delta_{\rm imp}) \lesssim 30\ \mu m$$

$$\delta(L) \lesssim 500\ \mu m$$

- Two methods:
  - Impact parameter distribution (leptons,all)
  - Decay length distribution (J/ψ, all)

- Two new measurements (L3, CDF)

J/ψ Decay Length Distribution

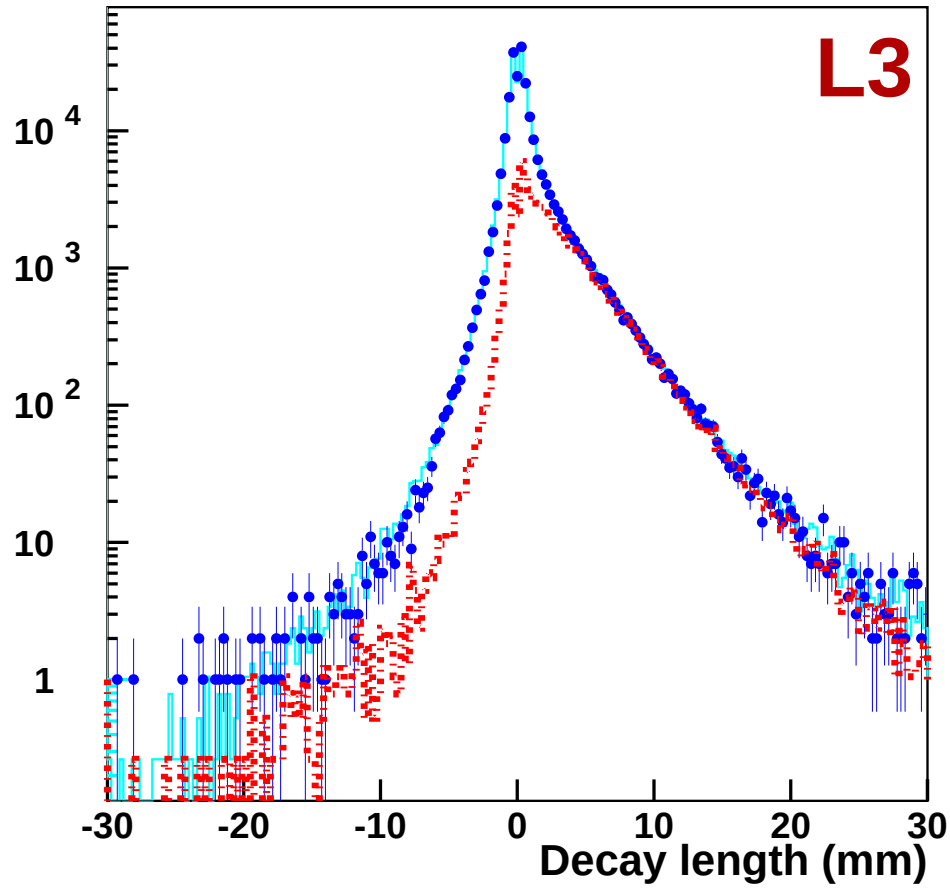


- Use of the SMD L3 detector
- Project all tracks onto the jet axis direction to build a secondary vertex
- Likelihood fit in the region 2 mm $< L <$ 30 mm

Error Source	$\Delta\tau_b$ (ps)
Statistical error	0.023
MC Statistics	0.010
Track Resolution	0.018
Jet direction resolution	0.004
D fraction in B decays	0.014
D lifetimes	0.002
B charged decay multiplicity	0.010
Fragmentation	0.032
B purity	0.009
Long-lived hadron decays	0.001
Total Systematics	0.043

L3 PRELIMINARY

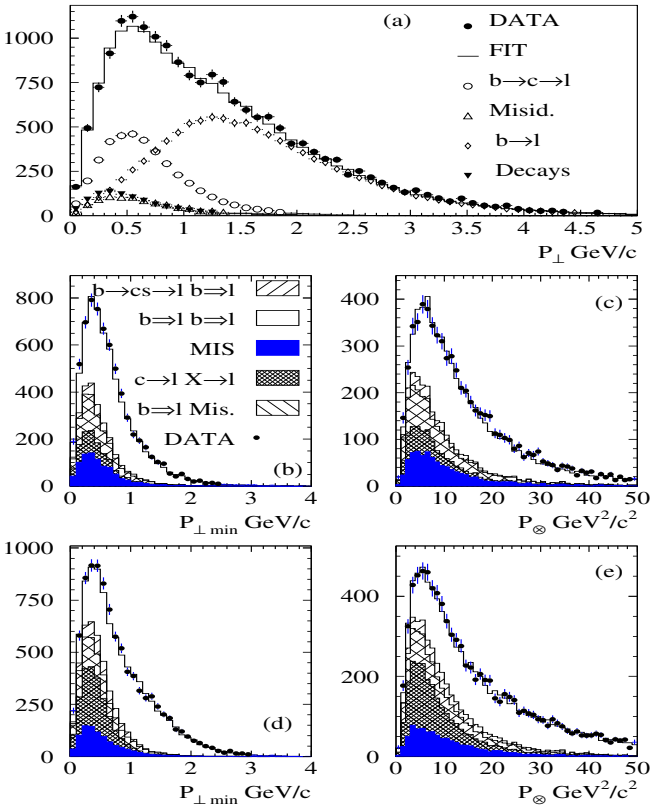
$\tau_b = 1.552 \pm 0.023 \pm 0.043$ ps



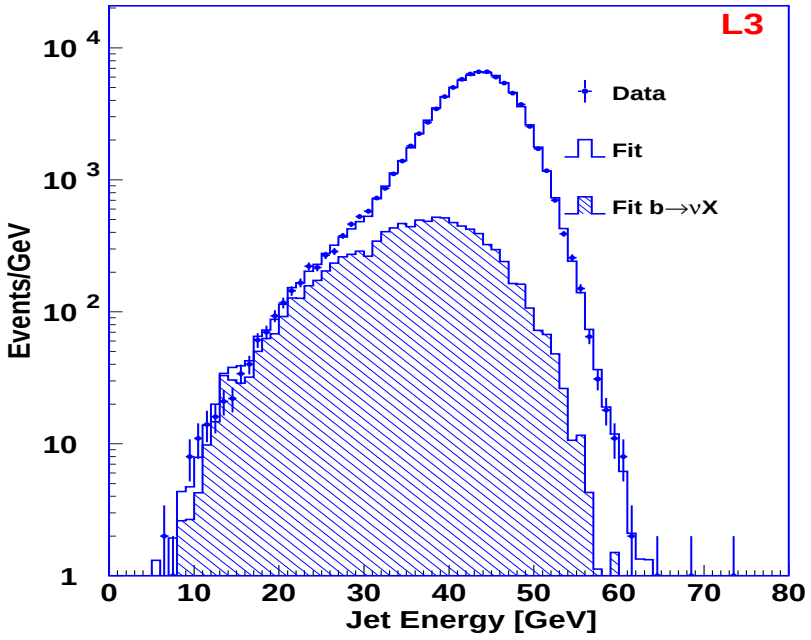
Experiment	Method	Data Set	τ_b (ps)
ALEPH	Lepton IP 3D	91-93	$1.533 \pm 0.013 \pm 0.022$
ALEPH	Dipole	91	$1.511 \pm 0.022 \pm 0.078$
CDF	J/ψ VTX	92-93 (Run 1a)	$1.46 \pm 0.06 \pm 0.06$
CDF	J/ψ VTX	94-95 (Run 1b)	$1.524 \pm 0.015^{+0.035}_{-0.026}$
DELPHI	All IP 2D	91-92	$1.542 \pm 0.021 \pm 0.045$
DELPHI	All VTX	91-93	$1.582 \pm 0.011 \pm 0.027$
L3	Lepton IP 2D	90-91	$1.535 \pm 0.035 \pm 0.028$
L3	All VTX	94	$1.552 \pm 0.023 \pm 0.043$
OPAL	Lepton IP 2D	90-91	$1.523 \pm 0.034 \pm 0.038$
SLD	All VTX	93	$1.564 \pm 0.030 \pm 0.037$
Average			1.55 ± 0.02

- Error dominated by physics effects:
  - Impact parameter: ℓ Decay Models and fragmentation
  - Decay Length: Fragmentation
- Inclusive decay length methods tend to higher τ_b values
- Physics effects are highly correlated
  - $\Delta\tau_b = 0.02$ ps could be the ultimate precision

- Measurements at the $\Upsilon(4S)$:
  - Use of kinematic and charge correlations in 2-lepton samples to avoid model dependence: ARGUS, CLEO
- Measurements at LEP:
  - Mainly based on fits to the p, p_t spectra of lepton candidates.
  - First attempts to understand to understand the model dependence: 2-lepton analyses, control samples, multiparameter fits.



L3 Br(b $\to \ell\nu$X) analysis



Br(b $\to \ell\nu$X)Measurements

Experiment	Method	Br(b $\to \ell\nu X$) (%)
ARGUS	2 ℓ	$9.6 \pm 0.5 \pm 0.4$
CLEO	2 ℓ	$10.49 \pm 0.17 \pm 0.43$
Υ(4S) Average		$10.40 \pm 0.16 \pm 0.30$
ALEPH	2 ℓ, p_t	$11.01 \pm 0.10 \pm 0.21^{+0.24}_{-0.17}$
DELPHI	Multiparameter fit	$11.06 \pm 0.39 \pm 0.19 \pm 0.12$ R_c
L3	Missing energy and tags	$10.68 \pm 0.11 \pm 0.46$
OPAL	Multiparameter fit	$10.5 \pm 0.6 \pm 0.5$
LEP Average	$< x_e >= 0.70$ used	$10.91 \pm 0.18 \pm 0.25(model)$

Br(b $\to \ell\nu$X)Measurements

- Differences between the Υ(4S) and the Z regions:
  - $R_b \Rightarrow$ Included in fits (LEP HF Group)
  - QCD effects $\Rightarrow$ Fragmentation and Gluon Radiation (L3 study)
  - Different hadron composition
- Br(b $\to \ell\nu$X) is decreasing at LEP

$|V_{cb}|$Measurement

- Positive Correlations between τ_b and Br(b $\to \ell\nu$X) due to fragmentation effects (not considered)
- Do not include B_s, Λ_b in τ_b at the Υ(4S)

Υ(4S) Result

$$|V_{cb}| = 0.0391 \pm 0.0007\ (exp) \pm 0.0030\ (theo)$$

LEP Result

$$|V_{cb}| = 0.0407 \pm 0.0006\ (exp) \pm 0.0030\ (theo)$$

- Experimental uncertainties in $|V_{cb}|$ are small compared to the theoretical error

- The inclusive τ_b measurement is already limited by systematics.

- $Br(b \to \ell\nu X)$ discrepancies between LEP and $\Upsilon(4S)$ are still existing, but smaller than before.

- Indication of possible problems in the modelling of the p_t spectra of leptons.