Studies of b-quark fragmentation

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Motivation

b-quark fragmentation can be studied at e^+e^- colliders using $x_b = E_{b\text{-hadron}} / E_{beam}$ distribution:

- Test fragmentation models (mainly non-pert. part)
  - Large b mass ⇒ b energy prior to hadronization from pQCD
  - Hadronization effects phenomenologically modelled
- $\sigma\langle x_b \rangle$ is used to assign systematic uncertainties in many other heavy flavour measurements
  - $\langle x_b \rangle$ allows the comparison of different measurements, while fitted model parameters strongly depend on perturbative part
  - A model independent measurement of $\langle x_b \rangle$ is therefore an important issue for b physics

New Preliminary Results

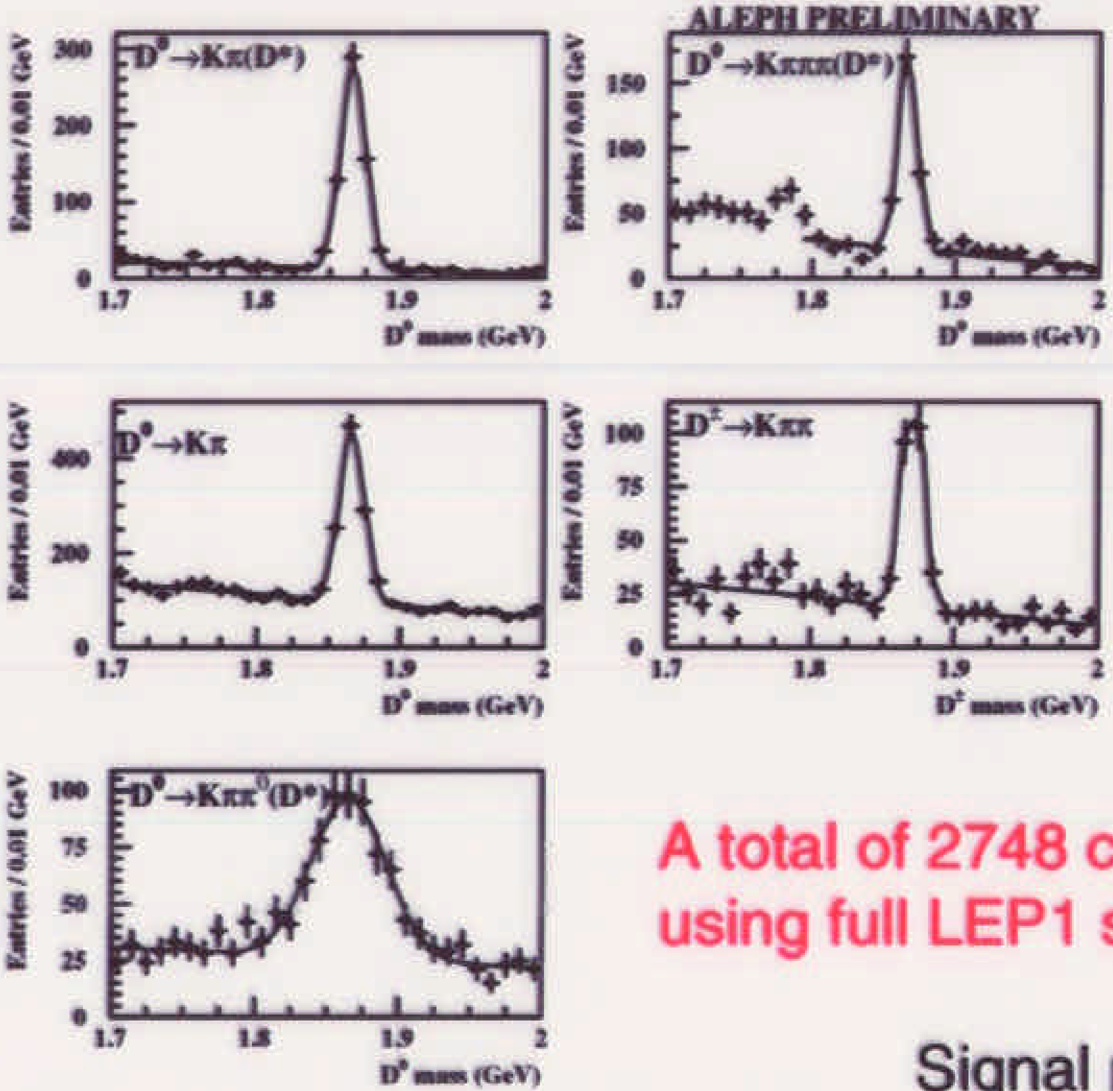
ALEPH (abstract 173)

- uses semi-exclusive reconstruction of $B \to D^{(*)} \ell \nu X$
- updates the preliminary result submitted to 2000 Winter conferences

SLD (abstract 690)

- uses inclusive b reconstruction from b-decay vertex
- updates to full statistics 1996-98 previously published result (PRL 84:4300-4304, 2000)

ALEPH selection



Five $B \to D^{(*)} \ell \nu X$ channels

- ❑ Lepton $p_\perp > 1$ GeV/c
- ❑ Loose momentum cuts on D tracks
- ❑ Good D and $D\ell$ vertices
- ❑ Kaon dE/dx

A total of 2748 candidates reconstructed using full LEP1 statistics (4M hadronic Z)

Signal purity: 63-90 %

B energy reconstruction

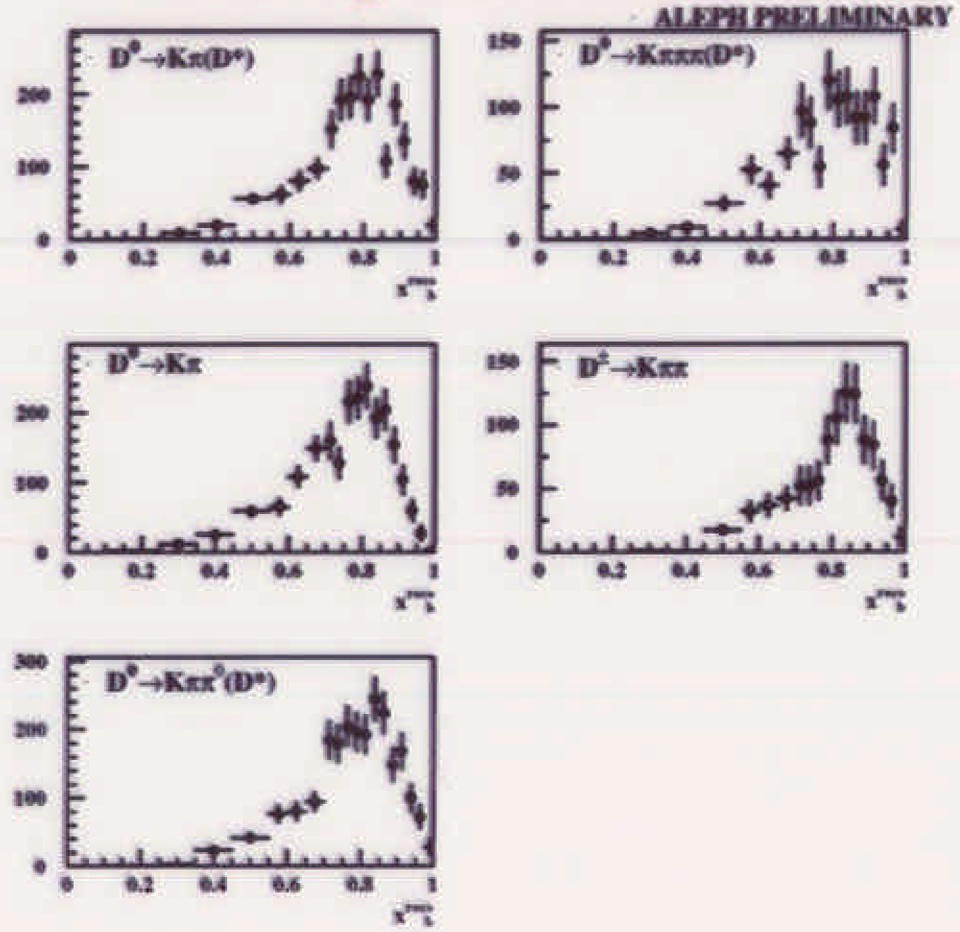
- Neutrino momentum estimated from c.m. energy constraint:

$$E_\nu = E_{tot}^{hemi} - E_{vis}^{hemi}$$

$$E_{tot}^{hemi} = E_{beam} + \frac{m_{same}^2 - m_{oppo}^2}{4E_{beam}}$$

- x_B resolution:
  - 0.04 in core (50-60%)
  - 0.10 in tails (50-40%)

Raw x_B distributions



$\langle x_B \rangle$ extraction

- Raw x_B distribution must be corrected for:

  Acceptance

  Detector resolution

  Missing pions from D^{**} and D^{0*} decays

➔ x_B of the weakly decaying B meson

Missing pions from B resonances decays

- Fraction of B^{**}: $f(B^{**})=0.279 \pm 0.059$

➔ x_B of the leading B meson

$\langle x_B \rangle$ extraction (2)

- Model dependent:
  - JETSET 7.4 + fragmentation model
  - Fit fragmentation model parameter to raw x_b distribution

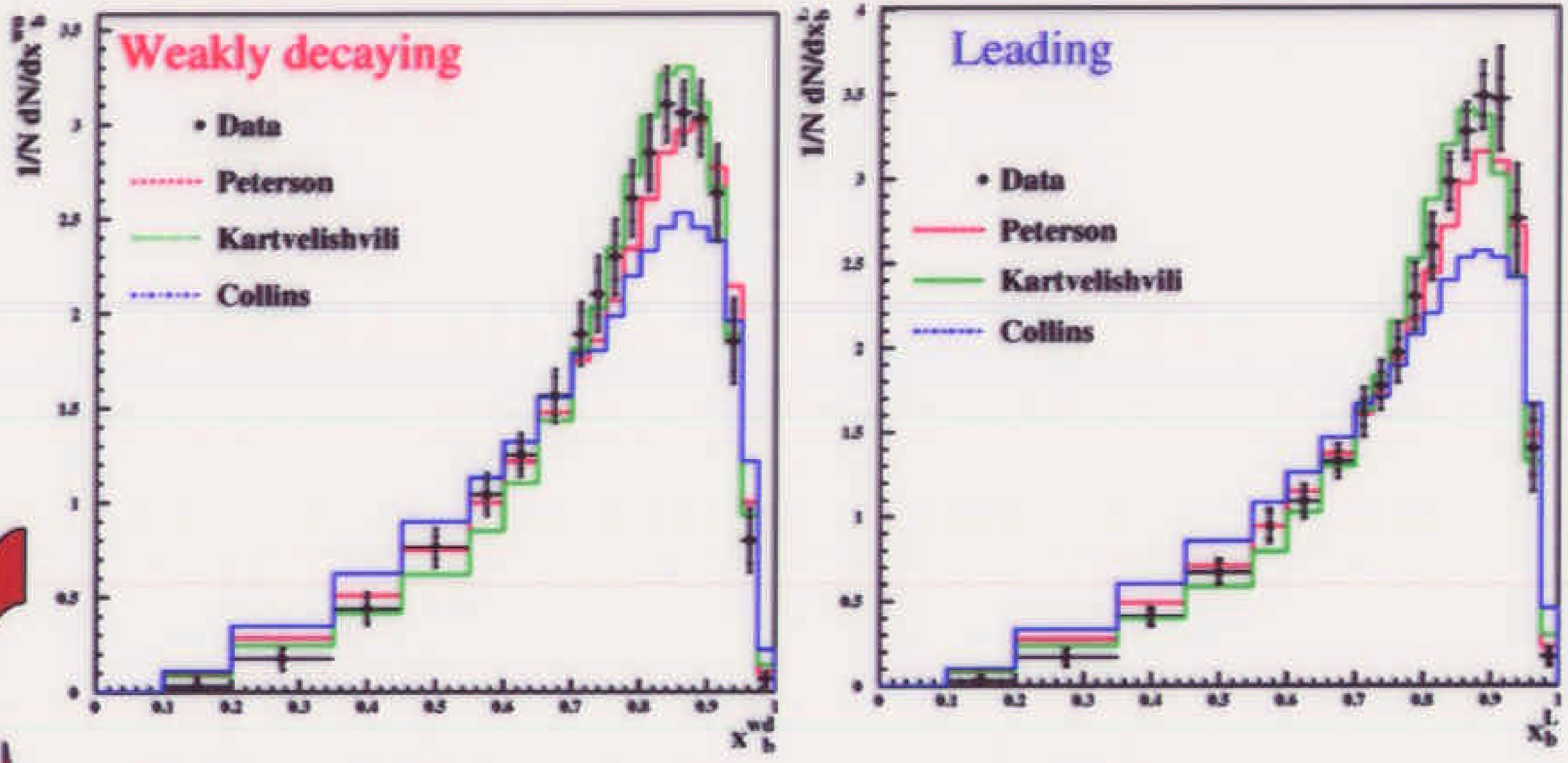
Model	$\langle x_B(L) \rangle$	χ^2/N_{DOF}
Peterson	0.733±0.004±0.005	116/94
Kartvelishvili	0.746±0.004±0.007	97/94
Collins	0.712±0.005±0.005	164/94

- Model independent:
  - Channel-by-channel acceptance corrections ε and resolution matrix *G* from MC simulation using a starting *D(x)*
  - Calculate *D(x)* from data:

$$D(x_b^{true}) = \varepsilon^{-1}(x_b^{true}) \cdot G(x_b^{true}, x_b^{reco}) \cdot D^{data}(x_b^{reco})$$

  - Use new *D(x)* to calculate ε and *G* again (iterative procedure)

Model independent results



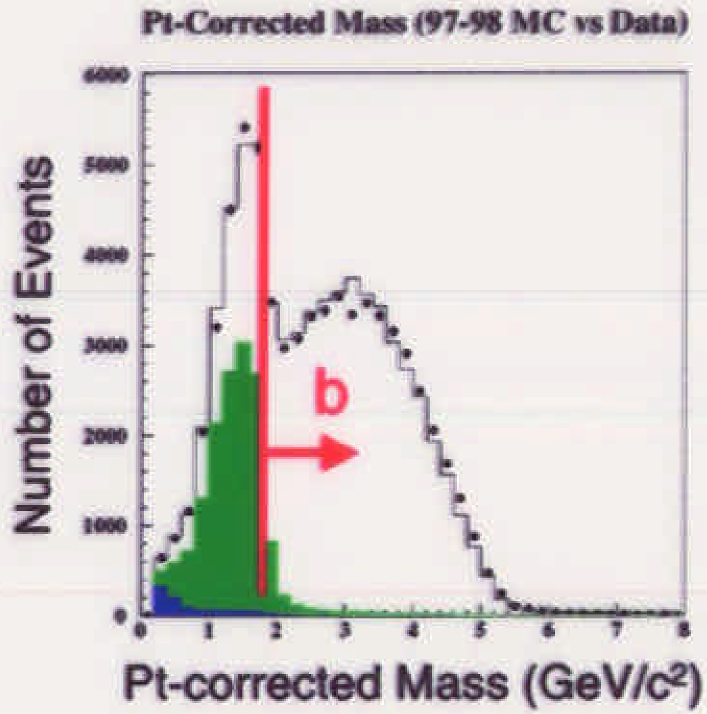
$\langle x_B(wd)\rangle = 0.7304 \pm 0.0062\ (stat) \pm 0.0058\ (syst)$

$\langle x_B(L)\rangle = 0.7499 \pm 0.0065(stat) \pm 0.0069(syst)$

SLD b-hadron selection

- Topological vertex algorithm assigns charged tracks to secondary vertex
  $\Rightarrow \varepsilon_b \approx 92\%, P_b \approx 98\%$
- b flight direction estimated from PV and SV positions
- Missing P_T used to correct vertex mass:

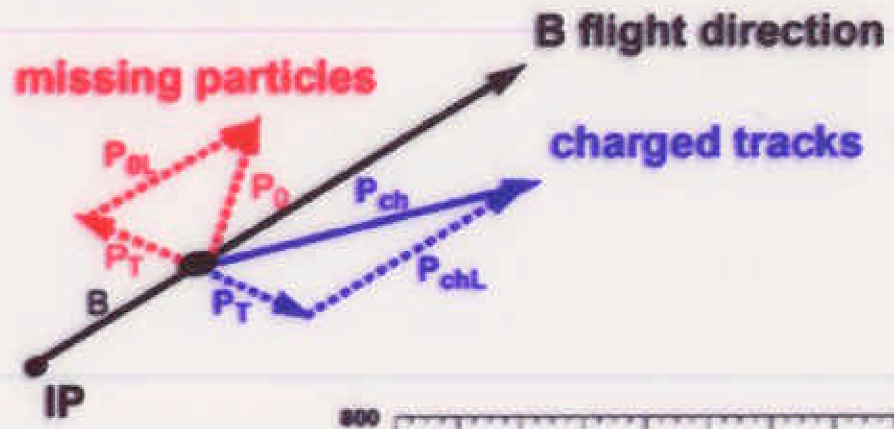
$$M = \sqrt{M_{ch}^2 + P_T^2} + |P_T|$$



High purity b sample

$\varepsilon_b \approx 44\%, P \approx 98\%$

b-hadron energy



Missing energy:

$$E_0 = \sqrt{M_0^2 + P_{0L}^2 + P_T^2}$$

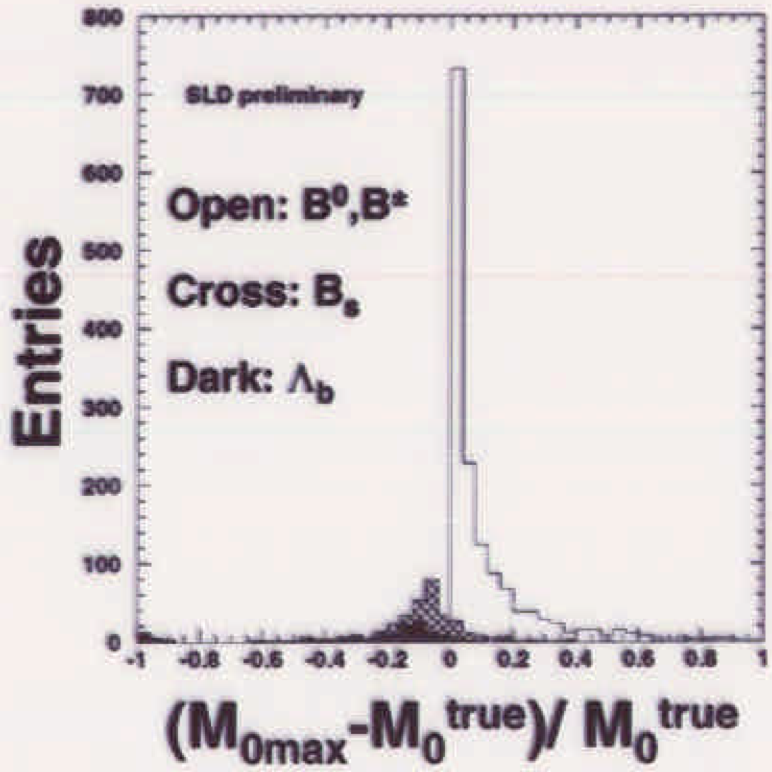
Missing mass constrained by:

$$M_0^2 \le M_{0\max}^2 = M_B^2 - 2M_B\sqrt{M_{ch}^2 + P_T^2} + M_{ch}^2$$

Equality holds for $P'_{0L} = 0$ in b rest frame

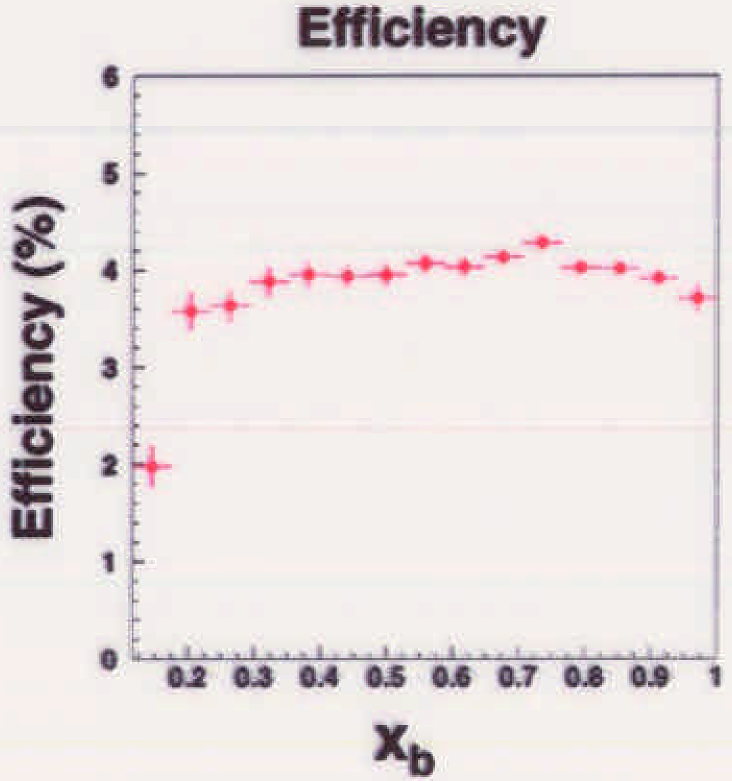
But $P'_{0L} << P_T$ more probable because of phase space

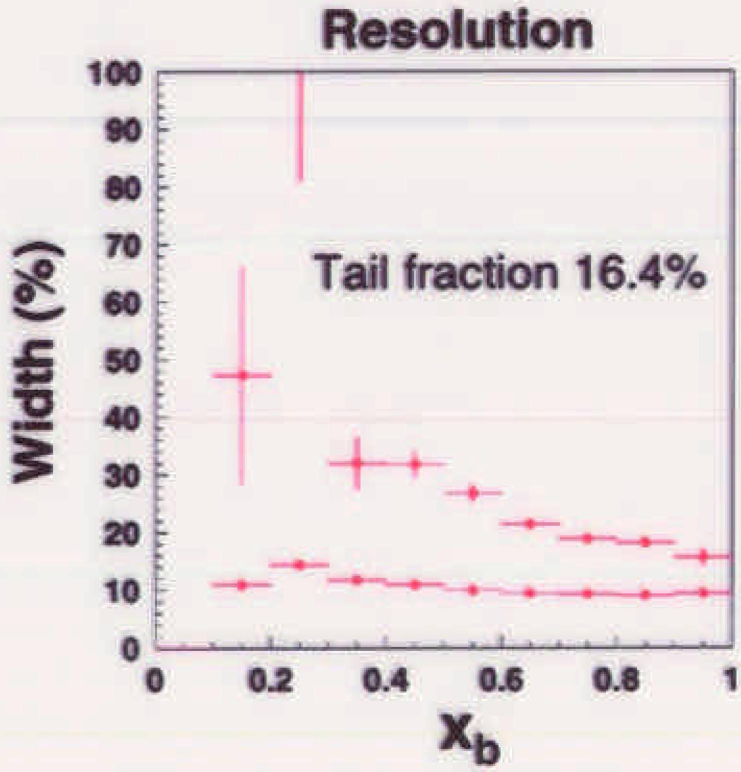
$$M_0^2 \approx M_{0\max}^2$$



b-hadron energy (2)

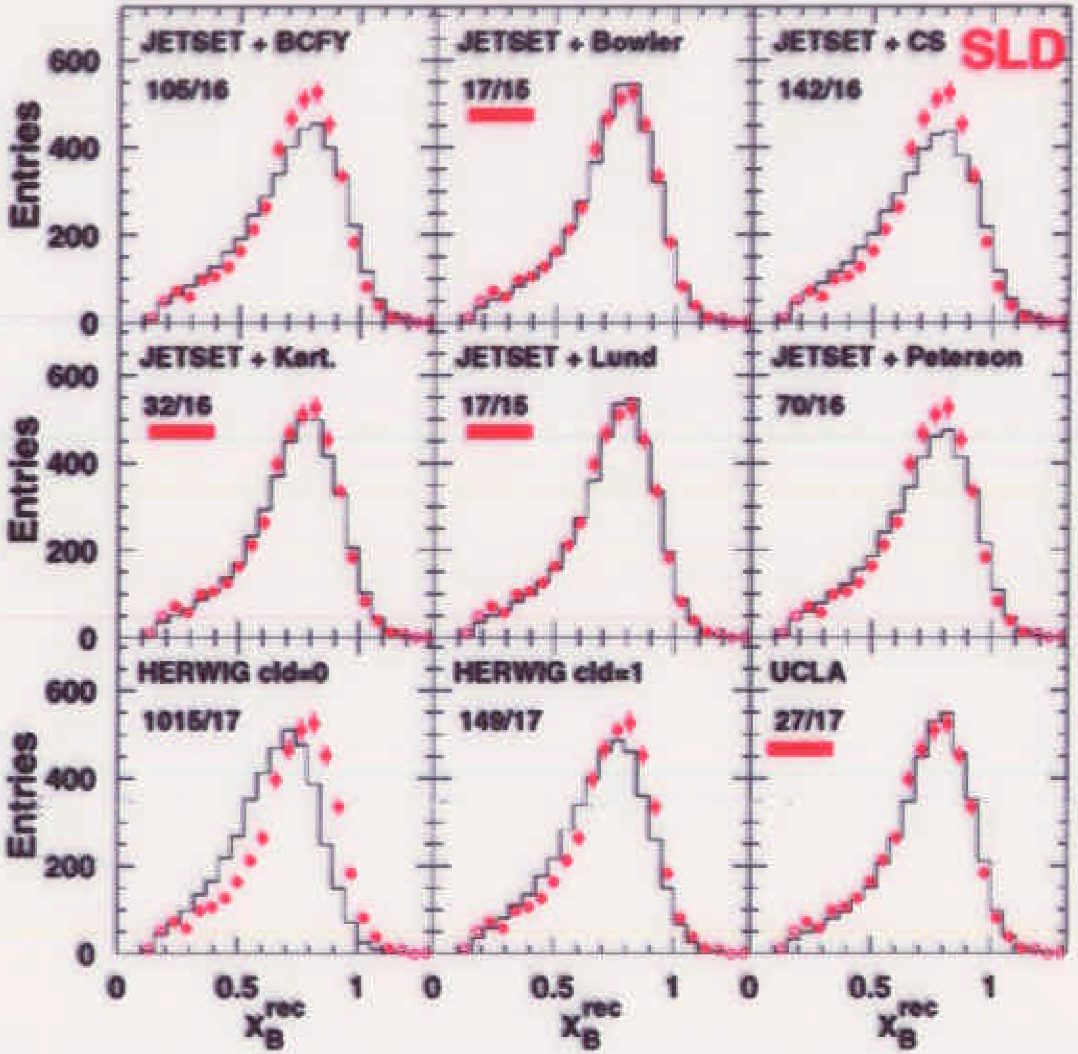
- Using $M_0 = M_{0max}$, $M_B^2 = E_B^2 - P_B^2$ can be solved for P_{0L}
- Resolution is better for low M_{0max} $\Rightarrow$ $-1 < M_{0max} < f(x_b^{rec})$





4164 candidates for 97-98 data (1920 for 96-97)

Test of fragmentation models



Good description of data by:

JETSET + Bowler

JETSET + LUND

JETSET + Kartevelishvili

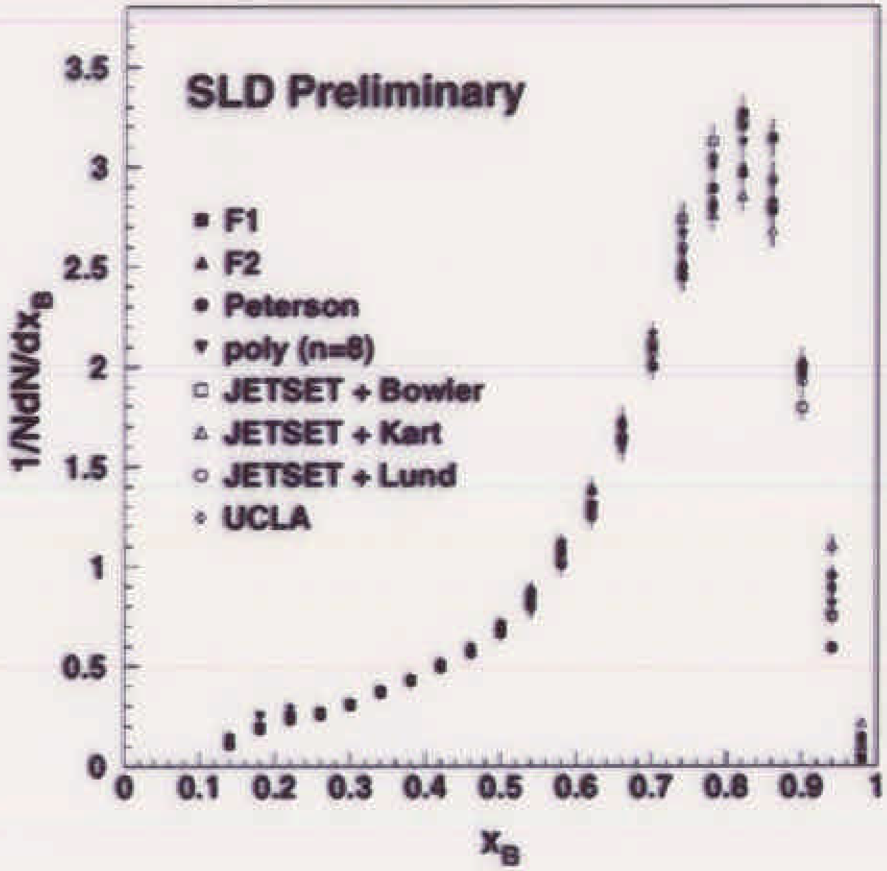
UCLA

SLD result

Unfolding performed using
the 4 consistent models

+

4 functional forms consistent
with x_b distribution

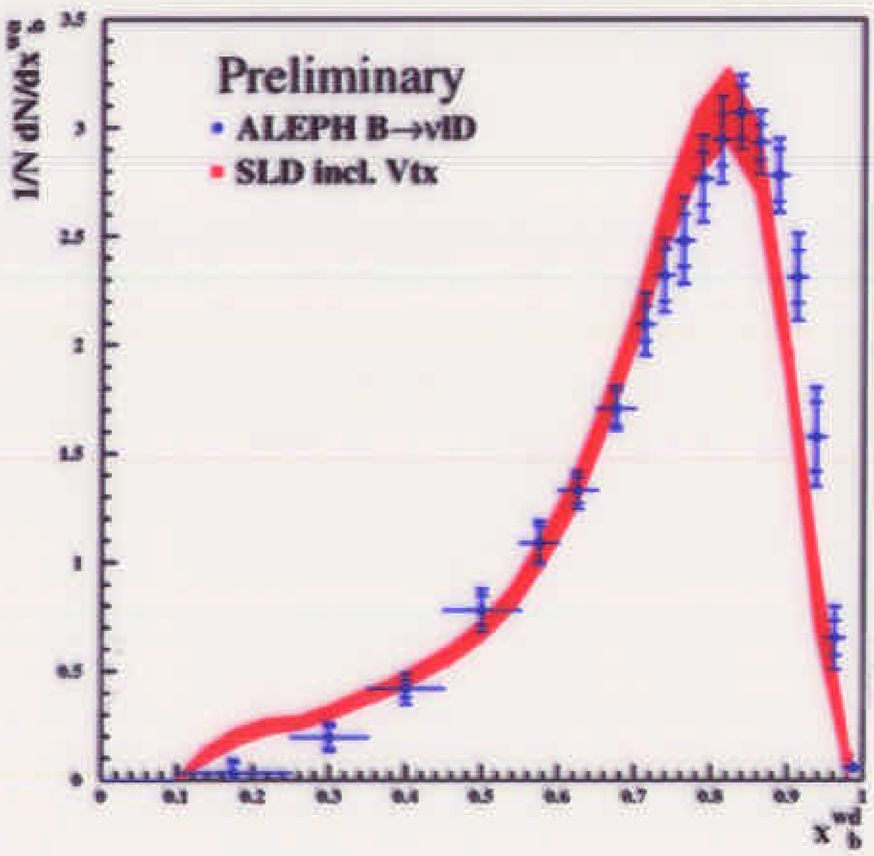


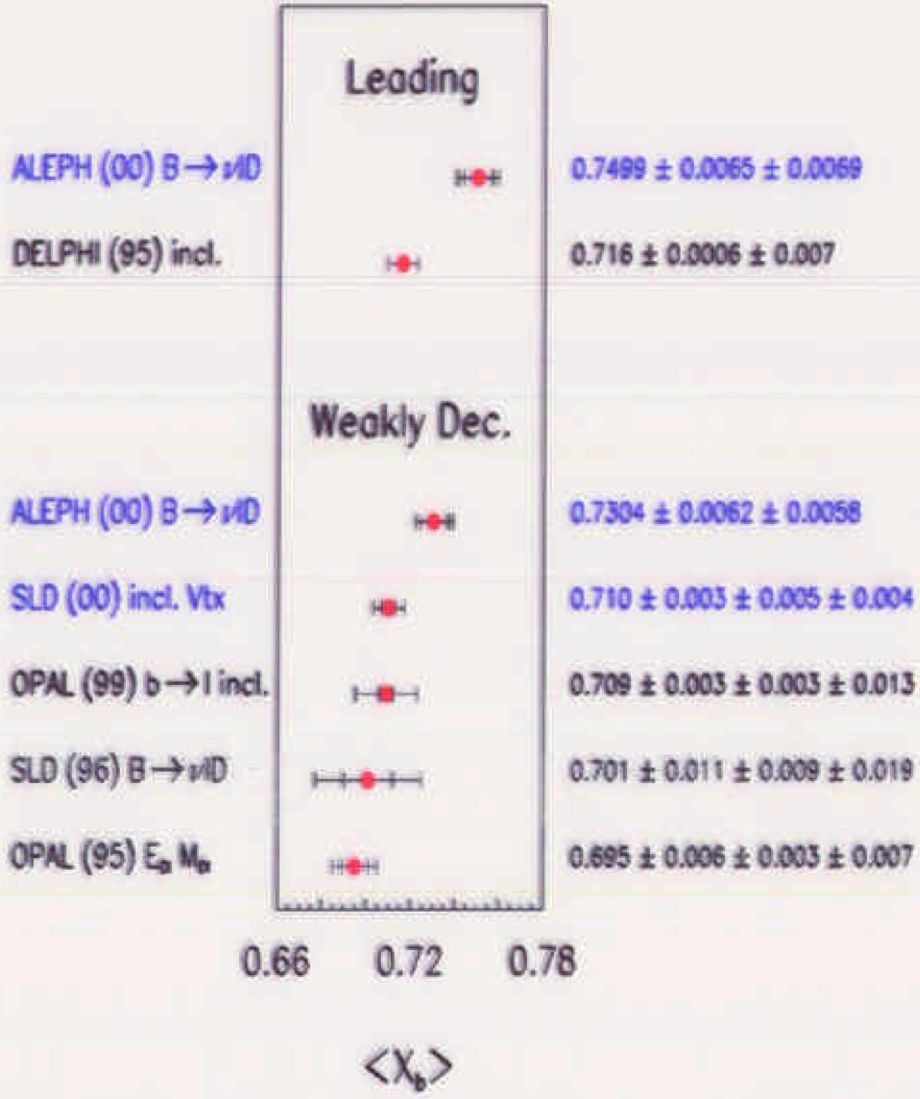
$\langle x_b(wd) \rangle = 0.710 \pm 0.003$ (stat) ± 0.005 (syst) ± 0.004 (model)

Systematic error dominated by p_t resolution uncertainty

Summary

Unfolded distributions for w.d. B's





Conclusions

Two new preliminary analyses of x_b spectrum:

- Improved sensitivity to distinguish between fragmentation models

- New measurements of $\langle x_b \rangle$:

ALEPH

$\langle x_B(wd) \rangle = 0.7304 \pm 0.0062$ (stat) ± 0.0058 (syst)

SLD

$\langle x_b(wd) \rangle = 0.710 \pm 0.003$ (stat) ± 0.005 (syst) ± 0.004 (model)

These two results are slightly inconsistent, but do the they really measure the same thing?