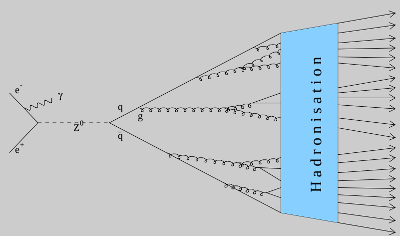
Kristian Harder

Inclusive Analysis of

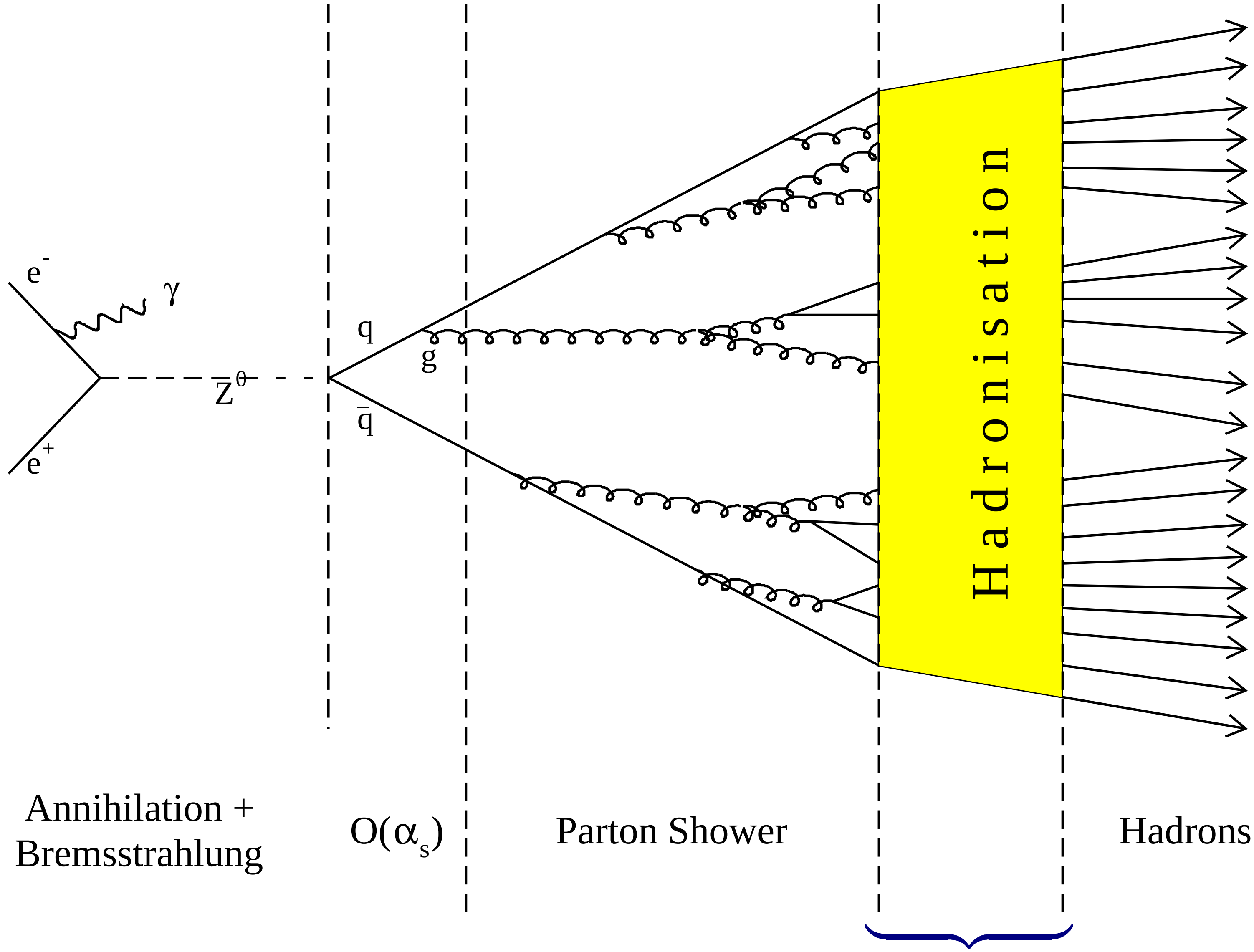


b Hadronization

in Z Decays at OPAL

This talk sponsored by

Production of b hadrons in Z-decays



non-perturbative! far from being understood, only phenomenological descriptions

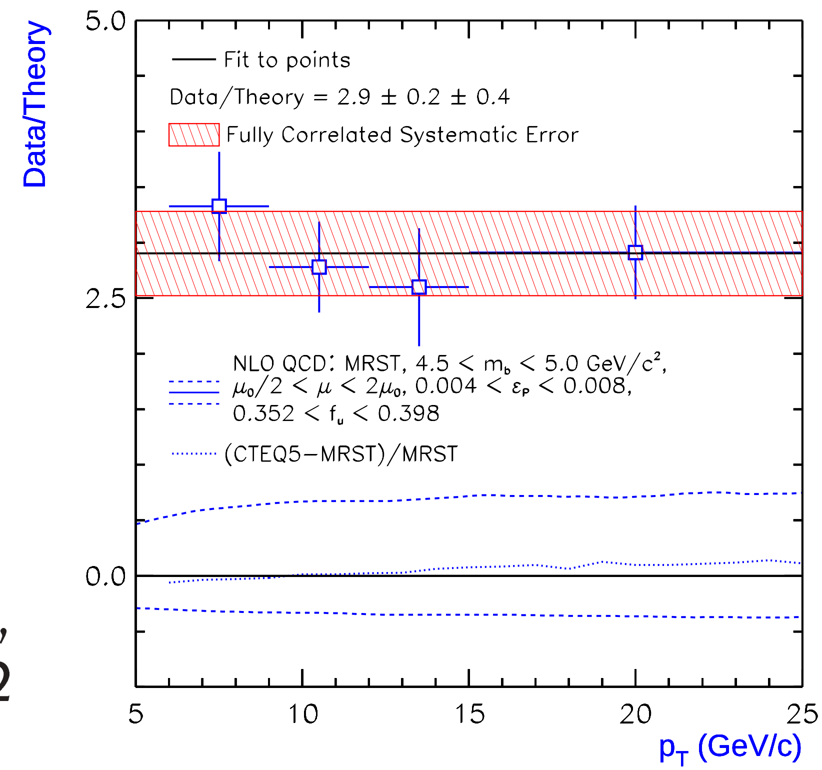
picture by A. Leins

WHY should we investigate b hadronization?

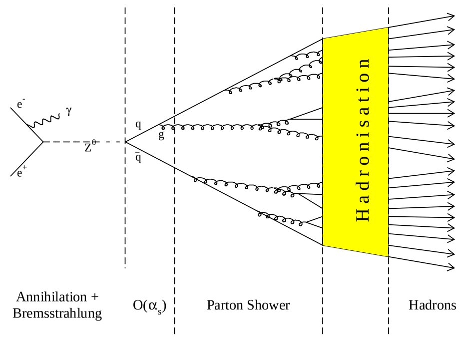
- new insights into non-perturbative QCD?
- reduction of important systematic uncertainties

Example:
CDF B^+ cross-section measurements possibly affected by hadronization mismodeling!

CDF Collaboration,
Phys. Rev. D65:052005,2002



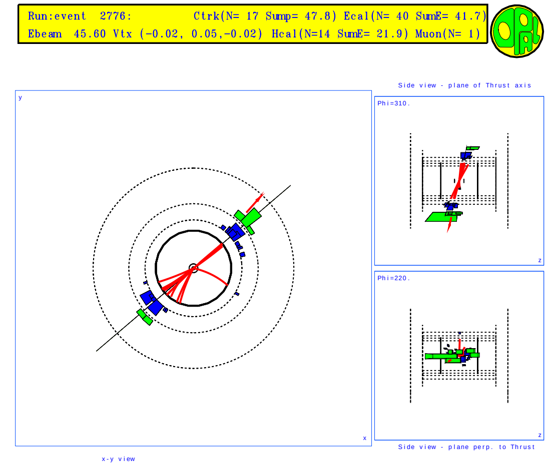
HOW should we investigate b hadronization?



No experimental separation between perturbative and non-perturbative part
$\rightarrow$ have to measure both together

- Measure energy distribution of weakly decaying B hadrons!
- Compare to Monte Carlo simulation using specific hadronization model, fit parameters to optimize agreement
- Give model-independent description of B hadron energy spectrum

Selection and reconstruction of B hadrons

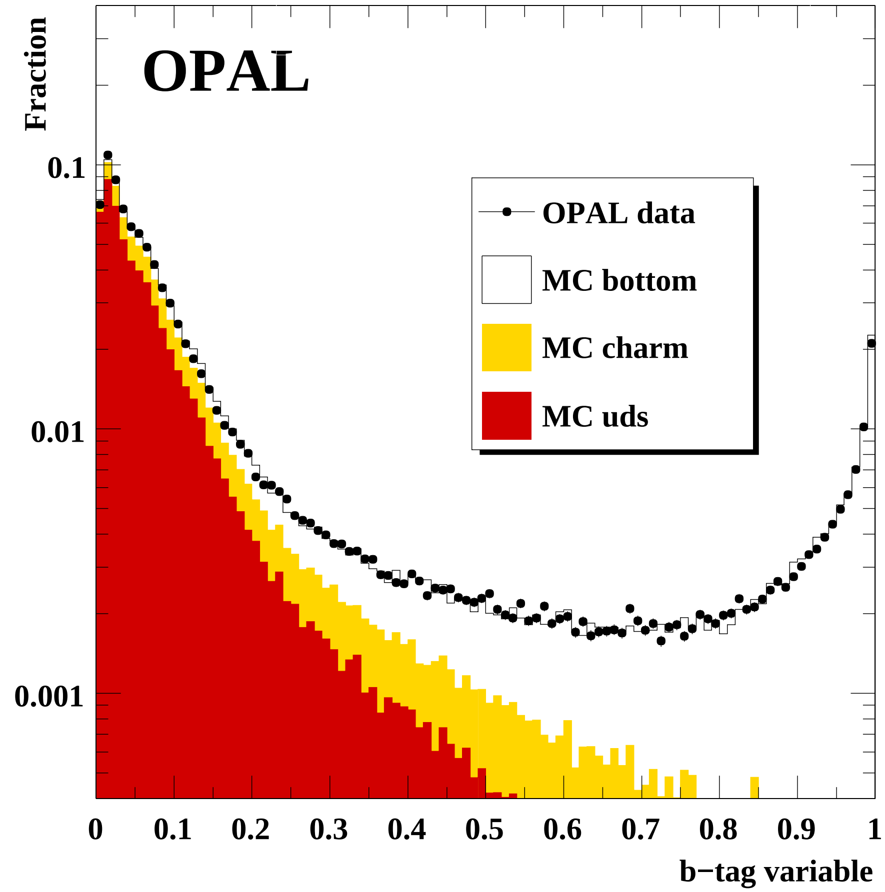


- selection of b jets
  (OPAL Higgs b tagger)

- reconstruction of B decay vertex

- selection of B hadron decay products
  artificial neural nets identify tracks and clusters from B decays

- estimation of the B hadron energy
  (see next slide)



reconstruction efficiency: 16%
background contamination: 4%
energy resolution ≈ 10%

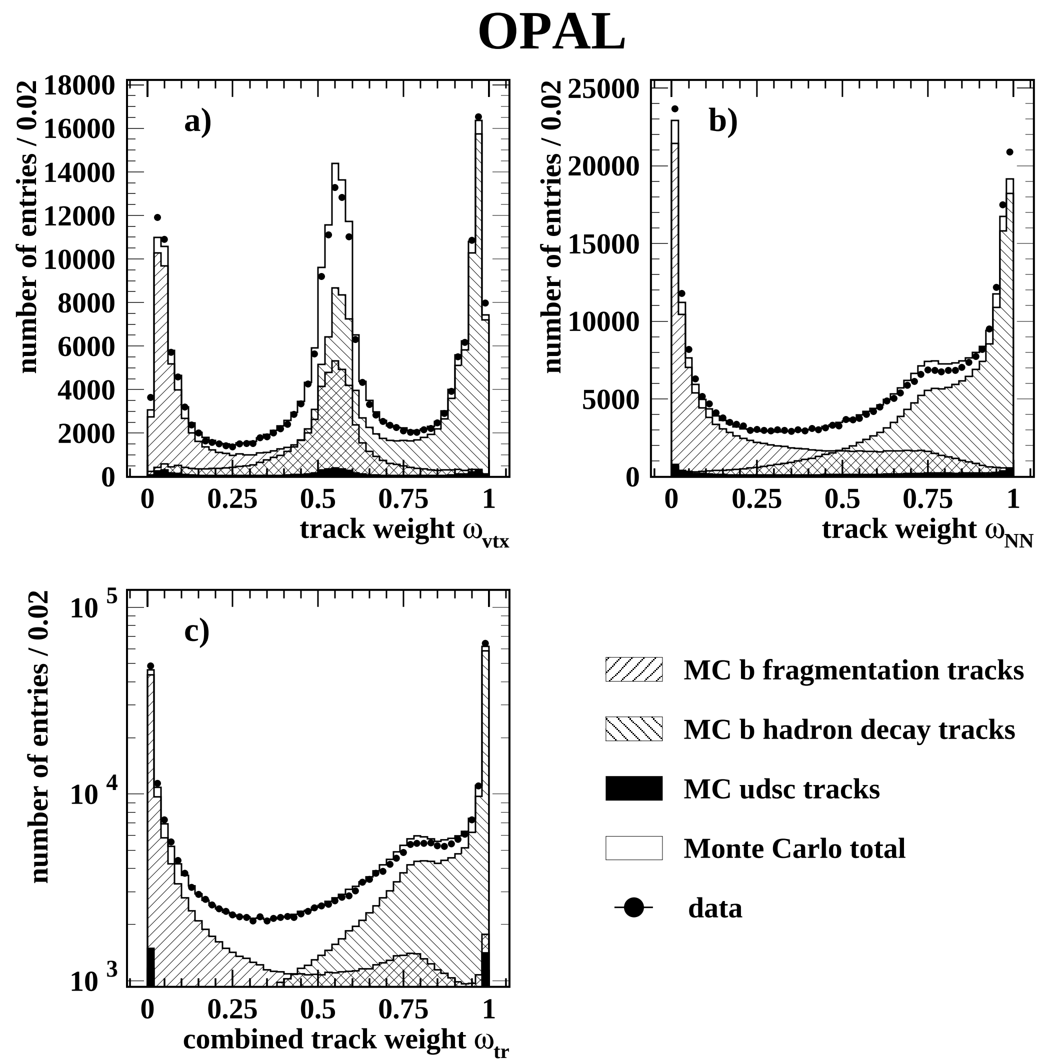
B hadron energy estimation

ideal case:
add energies of
B decay products

problem:
which tracks/cluster *are*
B decay products?

solution:
add energies of
all tracks/clusters,
weighted by
neural net B probability

≈10% energy resolution



picture by S. Robins, M. Thiergen

fragmentation functions (should be: “hadronization functions”)

Peterson et al. $f(z) \propto \frac{1}{z(1-\frac{1}{z}-\frac{\varepsilon}{1-z})^2}$

$\longrightarrow$ estimation of transition matrix element by energy difference

Collins/Spiller $f(z) \propto (\frac{1-z}{z} + \frac{(2-z)\varepsilon}{1-z})(1+z^2)(1-\frac{1}{z}-\frac{\varepsilon}{1-z})^{-2}$

$\longrightarrow$ from correspondence to heavy meson structure functions

Kartvelishvili et al. $f(z) \propto z^{\alpha}(1-z)$

$\longrightarrow$ from correspondence to different model of heavy meson structure functions

Lund symmetric $f(z) \propto \frac{1}{z}(1-z)^a \exp(-\frac{bm_t^2}{z})$

$\longrightarrow$ symmetry wrt. start of string hadronization at either end of the string

Bowler $f(z) \propto \frac{1}{z^{1+bm_t^2}}(1-z)^a \exp(-\frac{bm_t^2}{z})$

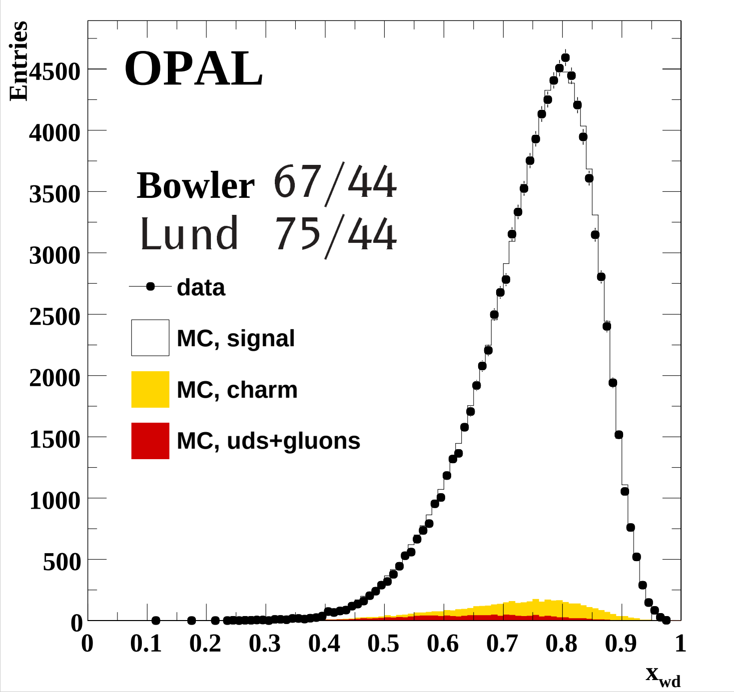
$\longrightarrow$ constant probability per length and time for $q\overline{q}$ creation on the string

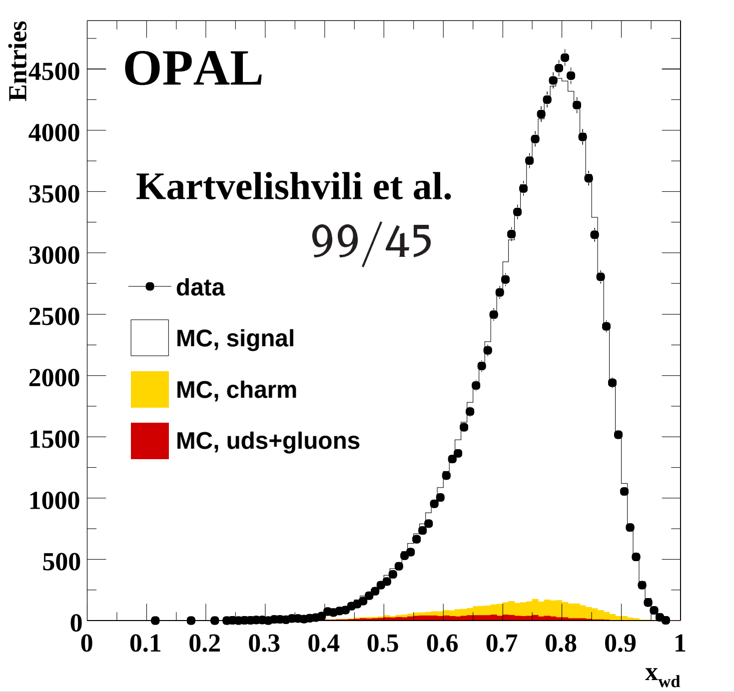
Comparison of the energy distribution with model predictions

Plug hadronization model into Monte Carlo sample,
fit parameters to data using the B hadron energy distribution

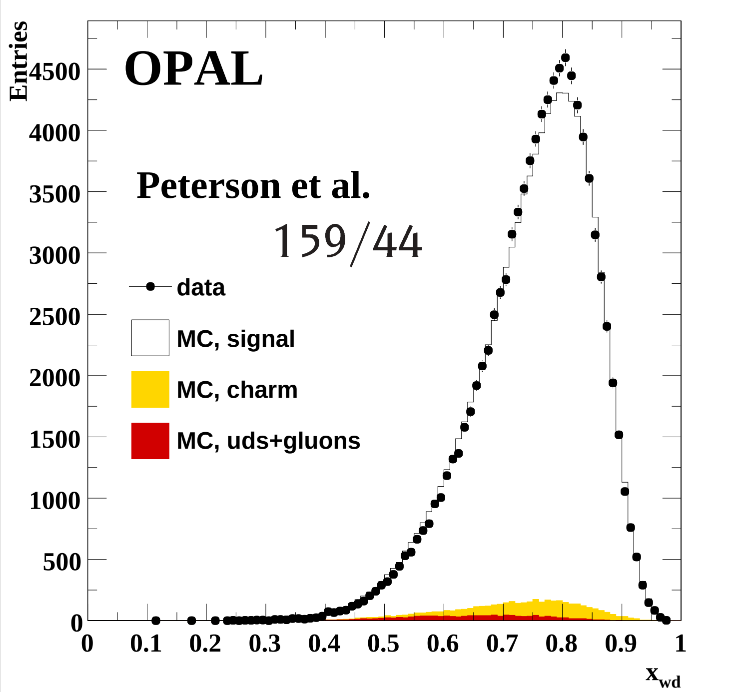
plots show scaled energy $x_E =$ B hadron energy / beam energy

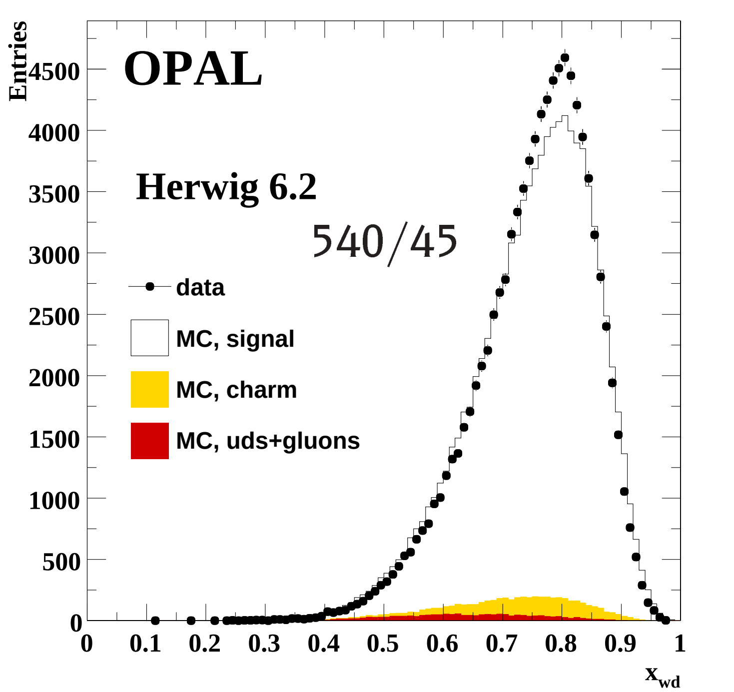
best agreement with data (χ^2/degree of freedom, only statistical uncertainty):





some worse examples:





Clear distinction between models!
Same ranking seen in recent ALEPH, SLD, DELPHI analyses

→ important input for QCD phenomenology

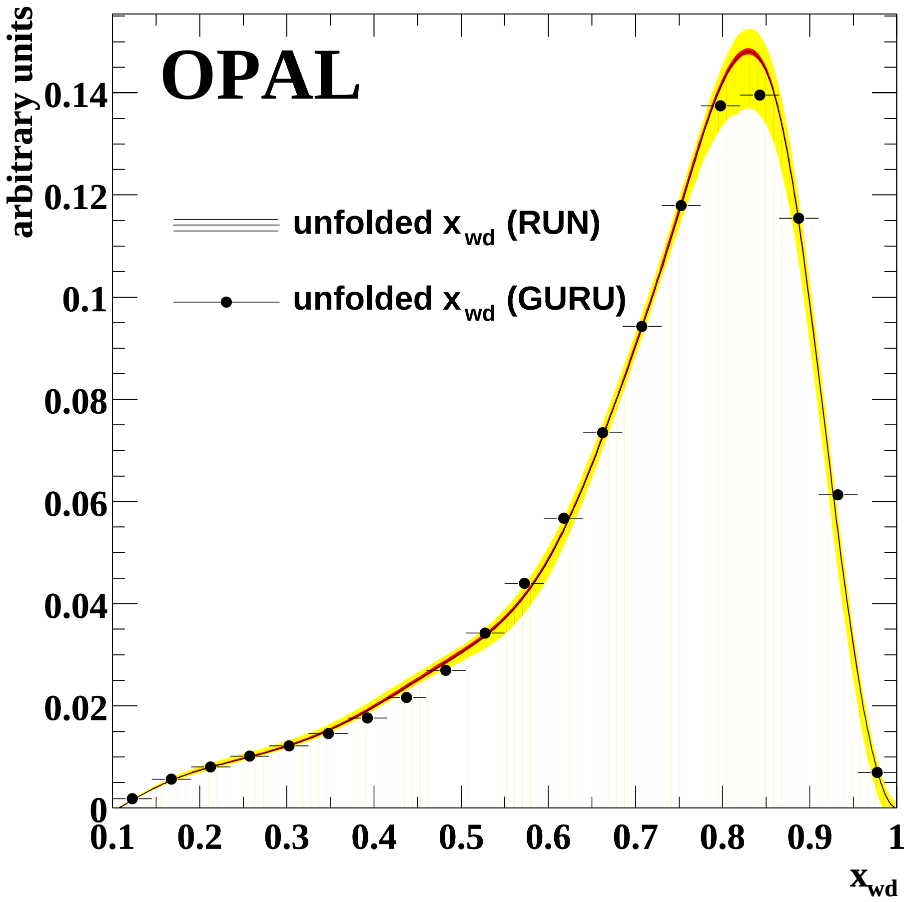
BUT: need model-independent description of the spectrum

model-independent description of the B hadron energy spectrum

have to use unfolding to correct for

- energy dependent efficiency
- finite detector resolution
- energy dependent reconstruction bias

two methods used: RUN, SVD-GURU



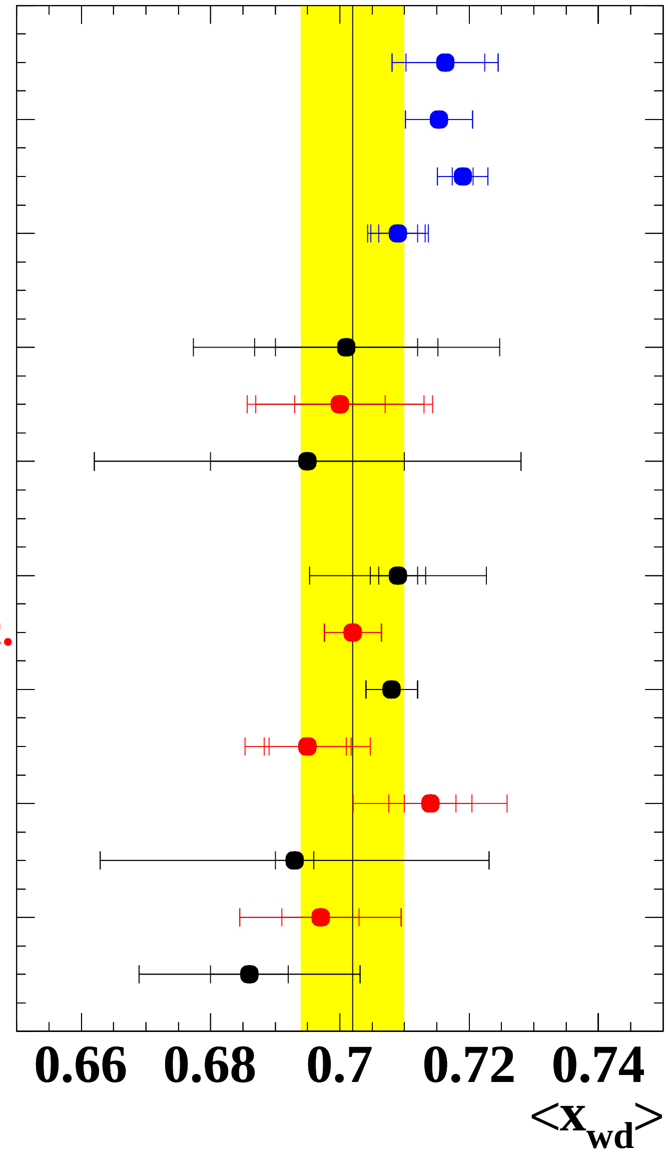
mean scaled energy of weakly decaying B hadrons:

$$\langle x_E \rangle = 0.7193 \pm 0.0016^{+0.0038}_{-0.0033}$$

dominant systematic uncertainty: detector resolution modeling

Overview of $\langle x_E \rangle$ measurements

0.702±0.008 ← current LEP average



ALEPH (01) $B \rightarrow D^{(*)} l\nu$	0.7163±0.0061±0.0056
DELPHI (02) inclusive	$0.7153 \pm 0.0007 ^{+0.0049}_{-0.0052}$ (prel.)
OPAL (02) inclusive	$0.7193 \pm 0.0016 ^{+0.0038}_{-0.0033}$
SLD (02) inclusive	0.709±0.003±0.003±0.002
SLD (96) $B \rightarrow D^{(*)} l\nu$	0.701±0.011±0.009±0.019
ALEPH (95) $B \rightarrow D^{(*)} l\nu$	0.700±0.007±0.011±0.006
DELPHI (93) $B \rightarrow D^{(*)} l\nu$	0.695±0.015±0.029
OPAL (99) Lepton Spec.	0.709±0.003±0.003±0.013
DELPHI (95) Lepton Spec.	0.7020±0.0044
L3 (95) B Lifetimes	0.708±0.004
OPAL (95) E_{ch}, M_{ch}	0.695±0.006±0.003±0.007
ALEPH (94) Lepton Spec.	0.714±0.004±0.005±0.010
OPAL (94) Charge Mult.	0.693±0.003±0.030
OPAL (93) Lepton Spec.	0.697±0.006±0.011
L3 (91) Lepton Spec.	0.686±0.006±0.016

Plot by P. Bechtle

CONCLUSIONS

- **new b hadronization measurement by OPAL "almost" published**
  (hep-ex/0210031; EPJ referee's comments answered last week)
  compatible with new ALEPH, DELPHI, SLD results
  compatible with old results; errors at least factor 2 smaller

- **clear hierarchy of hadronization models established**
  Bowler, Lund clearly favored; Peterson et al., Herwig worse

- **model-independent description of B hadron energy spectrum**
  e.g. to improve hadronisation modeling for the Tevatron:

Cacciari/Nason, hep-ph/0204025: moment space fit $\rightarrow B^+$ Data/Theory reduced from 2.9 to 1.7 (ALEPH data)