Hadronisation of b quarks at OPAL

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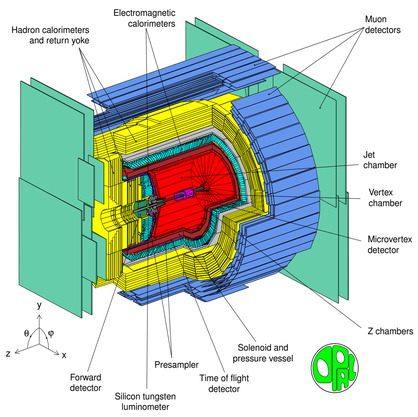
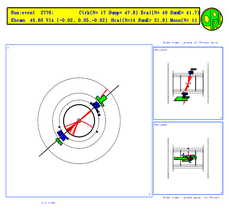
OPAL detector



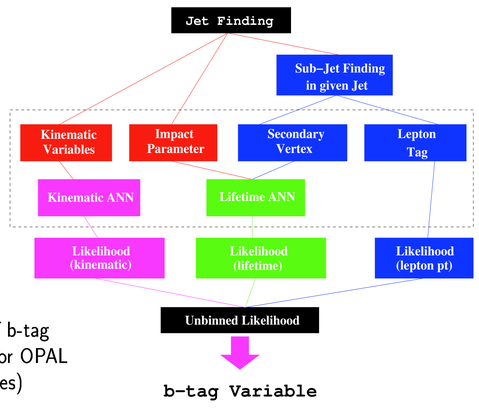
dataset: data at $\sqrt{s} = m_Z$, $m_Z \pm 2\,\mathrm{GeV}$ from 1992–2000 with silicon microvertex operational (3.9 million events)

Identification of b jets

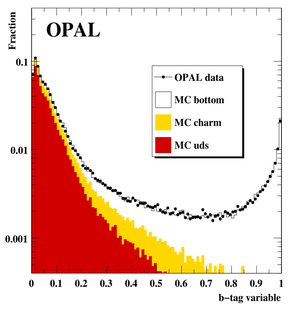


basic principle:
- divide event into two hemispheres
- apply b tag in one hemisphere, do analysis in other hemisphere

→ avoid correlations between b tag and B energy reconstruction



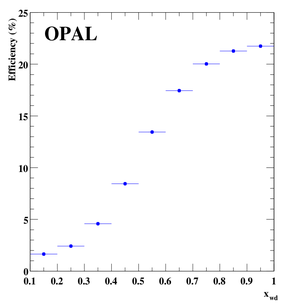
flow chart of b-tag (developed for OPAL Higgs searches)



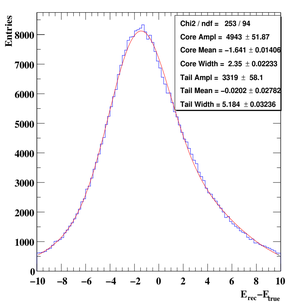
discrimination power of the hemisphere b-tag cut at 0.8: b efficiency ≈40%, b purity ≈96%

B hadron reconstruction

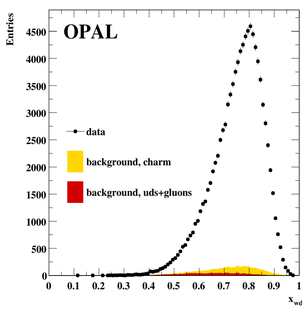
- artificial neural nets assign weights to tracks and clusters, taking into account e.g.
  - impact parameter with respect to primary and secondary vertex
  - impact parameter significance
  - transverse momentum with respect to jet axis
- weights are transformed to probability to come from B decay
- B hadron energy := weighted sum of track and cluster momenta



energy dependence of efficiency



energy resolution. RMS: 4.8 GeV

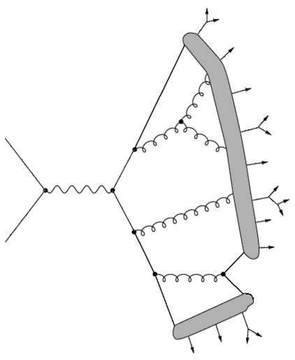


reconstructed B hadron energies

Why investigate hadronisation?
- test/development of non-perturbative techniques
- reduce important systematic uncertainty

Why heavy quarks?
- properties constrained due to quark mass
- hadron with primary quark easy to identify

Hadronisation models: Jetset/Pythia



string hadronisation fragmentation functions:

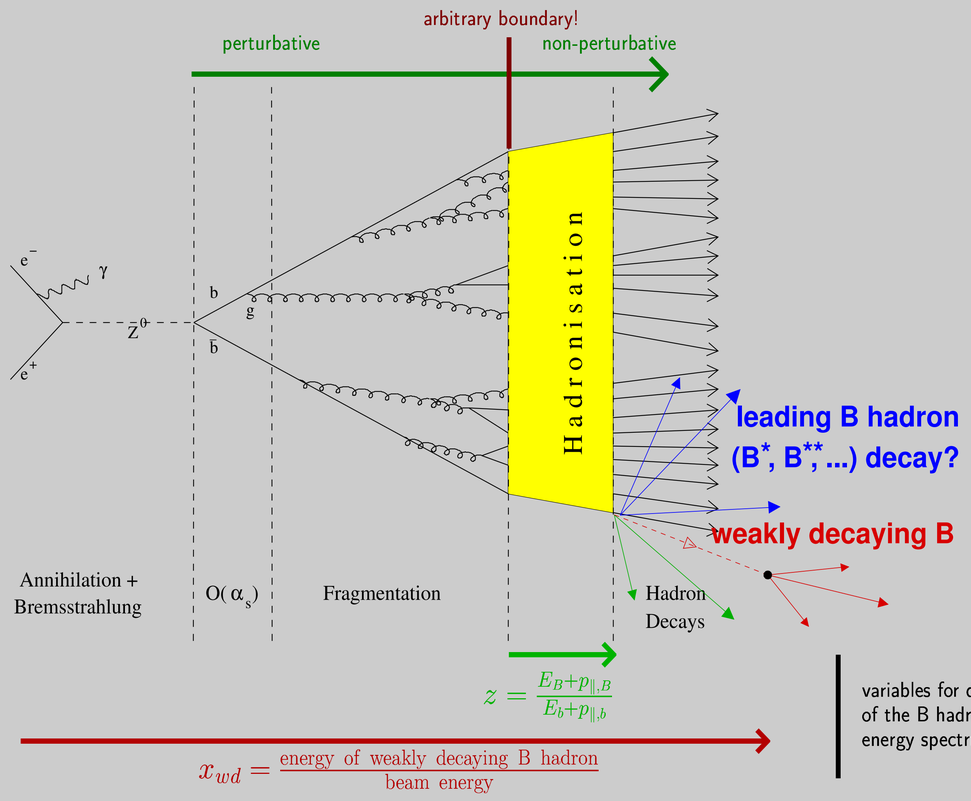
Peterson et al. $f(z) \propto \frac{1}{z(1-\frac{1}{z}-\frac{\varepsilon_c}{1-z})^2}$
→ estimate of transition matrix elements by energy difference

Collins/Spiller $f(z) \propto (\frac{1-z}{z}+\frac{(2-z)\varepsilon}{1-z})(1+z^2)(1-\frac{1}{z}-\frac{\varepsilon}{1-z})^{-2}$
→ from correspondence to heavy meson structure functions

Kartvelishvili et al. $f(z) \propto z^{\alpha}(1-z)$
→ from correspondence to different model of heavy meson structure functions

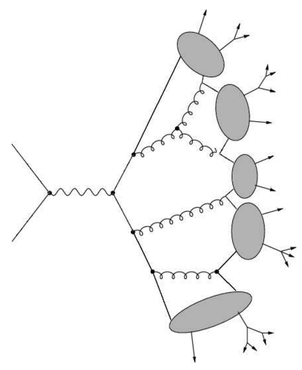
Lund symmetric $f(z) \propto \frac{1}{z}(1-z)^a \exp(-\frac{bm_t^2}{z})$
→ symmetry wrt. start of string hadronisation at either end of the string

Bowler $f(z) \propto \frac{1}{z^{1+rm_t^2}}(1-z)^a \exp(-\frac{bm_t^2}{z})$
→ constant probability per length and time for $q\bar{q}$ creation on the string



variables for description of the B hadron energy spectrum

Hadronisation models: Herwig

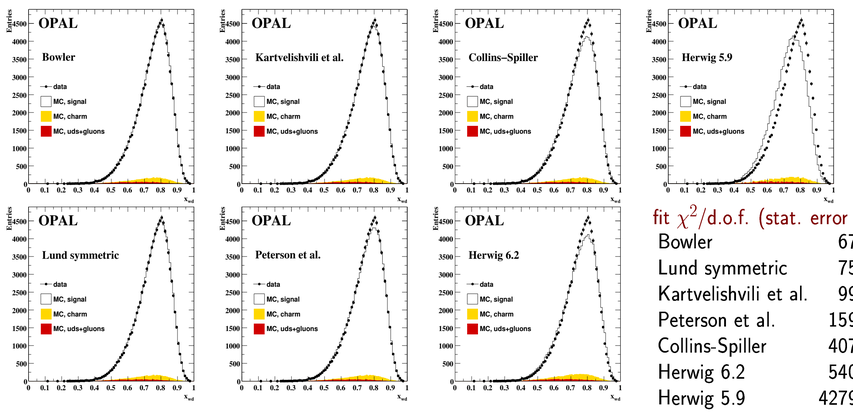


cluster hadronisation

no explicit fragmentation function
B hadron energy distribution mainly determined by cluster decay kinematics

Model tests

reweighting fit at detector level



fit χ^2/d.o.f. (stat. error only):

Bowler	67/44
Lund symmetric	75/44
Kartvelishvili et al.	99/45
Peterson et al.	159/45
Collins-Spiller	407/45
Herwig 6.2	540/46
Herwig 5.9	4279/46

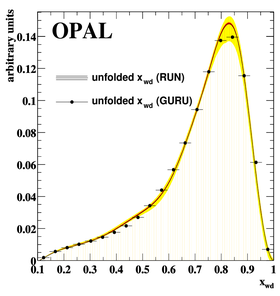
Model-independent analysis of x_{wd} spectrum

unfolding of detector effects with RUN software package (unbinned spline fit):

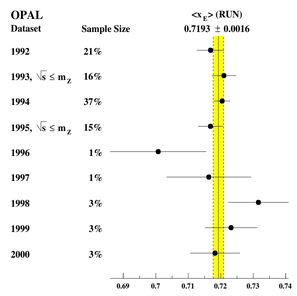
$\langle x_{wd} \rangle = 0.7193 \pm 0.0016^{+0.0036}_{-0.0031}$

most precise measurement!

cross-checks:
- unfolding with SVD-GURU (matrix inversion) ✓
- $\langle x_{wd} \rangle$ of model fits ✓
- subsample tests ✓

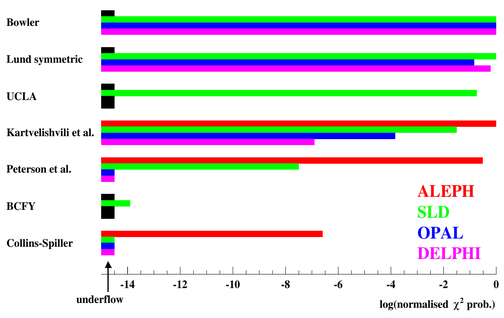


unfolded x_{wd} spectrum, with stat + syst error bands for RUN result



subsample consistency check

LEP/SLD comparison: model tests

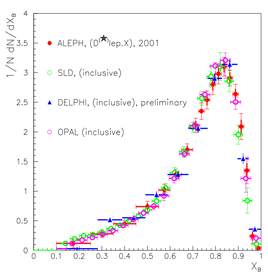


log(χ^2 probability), normalised to prob(best model)=1

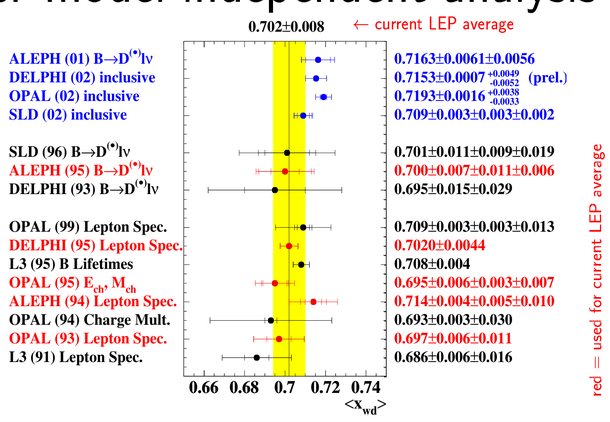
all experiments see exactly the same ranking!

references:
ALEPH Collaboration, Phys. Lett. B512 (2001) 30.
DELPHI Collaboration, ICHEP 2002, Abstract 583.
OPAL Collaboration, CERN-EP-2002-051, accepted by Eur. Phys. J. C.
SLD Collaboration, Phys. Rev. D65 (2002) 092006.

LEP/SLD results: model-independent analysis



new LEP/SLD x_{wd} distributions



This poster includes figures fully or partially made by S. Yamashita, N. Nakamura (b-tag flow chart), B.R. Webber (Jetset/Herwig fragmentation schemes), A. Leins (hadronic e^+e^- event scheme), U. Kerzel, L. Ramler (LEP/SLD x_{wd} distribution plot), P. Bechtle ($\langle x_{wd} \rangle$ overview plot), and numbers provided by D. Dong (SLD x_{wd} distribution). All other non-OPAL information taken from the respective publications. The OPAL analysis is part of the PhD thesis of Kristian Harder.