on High Energy Physics
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Multiplicities and particle production in Z decays at LEP

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OUTLINE

- Multiplicity flavour dependence
- Multiplicity distribution studies
- Particle production at LEP

- **OPAL**: *Charged particle multiplicities in heavy and light quark initiated events above the Z^0 peak*
  Phys. Lett. B 550 (2002) 33

- **L3**: *Measurement of the charged-particle multiplicity distribution of hadronic Z decays at LEP*
  L3 Note 2808 (June 2003)

- **DELPHI**: *Measurement of inclusive $f_1(1285)$ and $f_1(1420)$ production in Z decays with the DELPHI detector*
  Note 2003-013-CONF-633 (June 2003)

Hadronisation of heavy & light quarks. I

OPAL Collaboration, Abs. 763

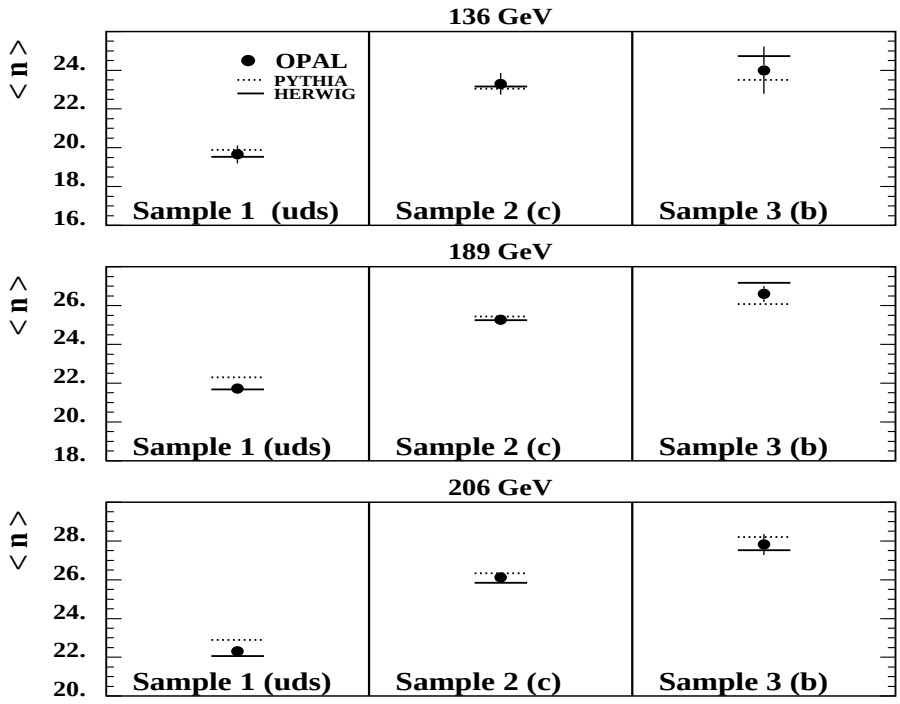
- **A basic test of QCD** is to search for

  $$\delta_{hl} = \langle n_{h\bar{h}} \rangle - \langle n_{l\bar{l}} \rangle$$

  $l = \{u, d, s, (c)\}$, $h = \{b, (c)\}$
- The QCD coherence predicts $\delta_{hl} = \text{const}(E_{\text{cm}})$
- The flavour-independent (naive) hadronisation model: δ_{hl} decreases with E_{cm}
- **Experimental** studies with $h = b$, $l = \{u, d, s\}$ in $e^+e^- \to Z^0/\gamma^* \to q\bar{q}$ events
  - radiative $q\bar{q}\gamma$ events reduction
  - multivariate b-tagging
  - $\langle n_{q\bar{q}} \rangle$ from uds-, c- and b-events (S = Sample 1, 2, 3)

$$\langle n^{(S)} \rangle = f_b^{(S)} C_b^{(S)} \langle n_{b\bar{b}} \rangle + f_l^{(S)} C_l^{(S)} \langle n_{l\bar{l}} \rangle + f_c^{(S)} C_c^{(S)} \langle n_{c\bar{c}} \rangle$$

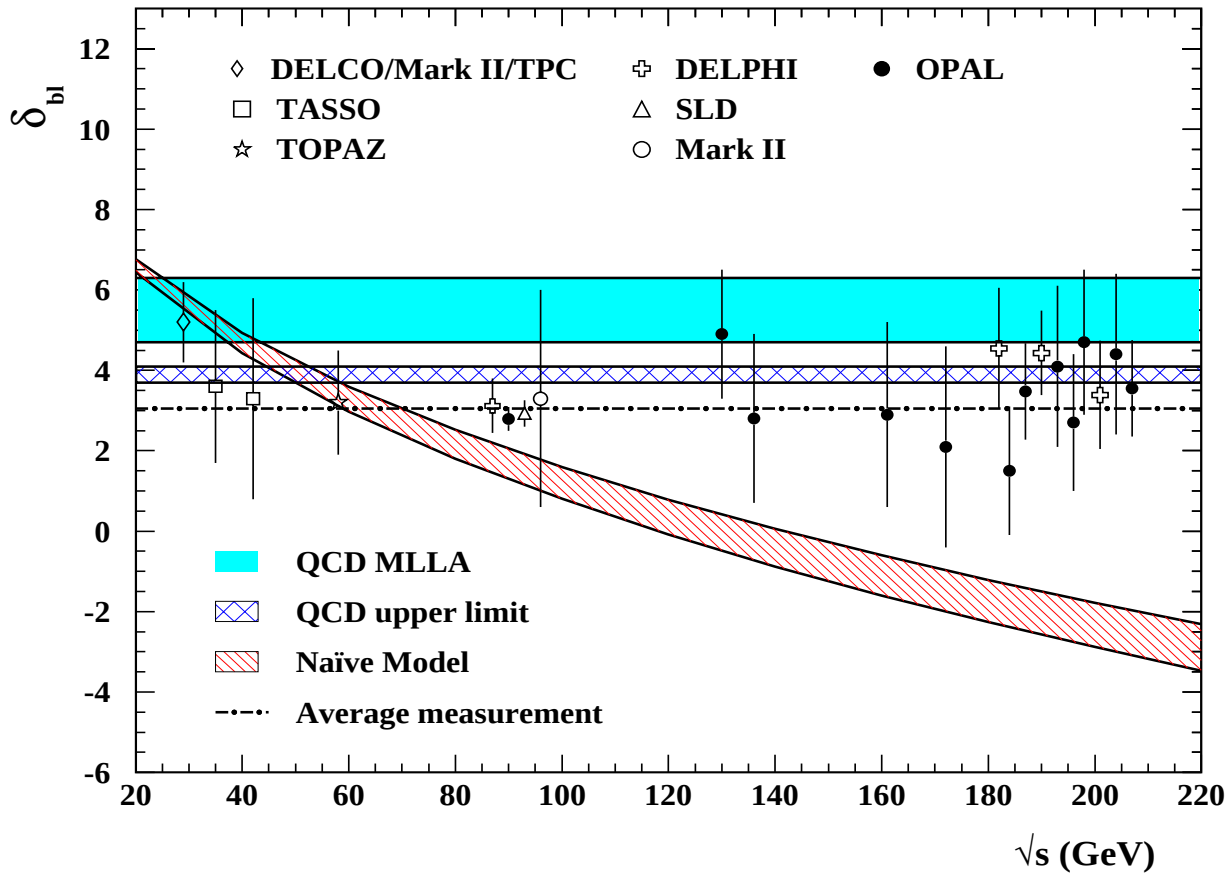
$f_q^{(S)}$ flavour fractions, $C_q^{(S)}$ correction factors from MC



OPAL Collab., Phys. Lett. B 550 (2002) 33

Hadronisation of heavy & light quarks. II

OPAL Collaboration, Abs. 763



OPAL Collab., Phys. Lett. B 550 (2002) 33

$e^+e^- \to Z^0/\gamma^* \to$hadrons at $\sqrt{s} = 130 - 206$ GeV

- **Results**

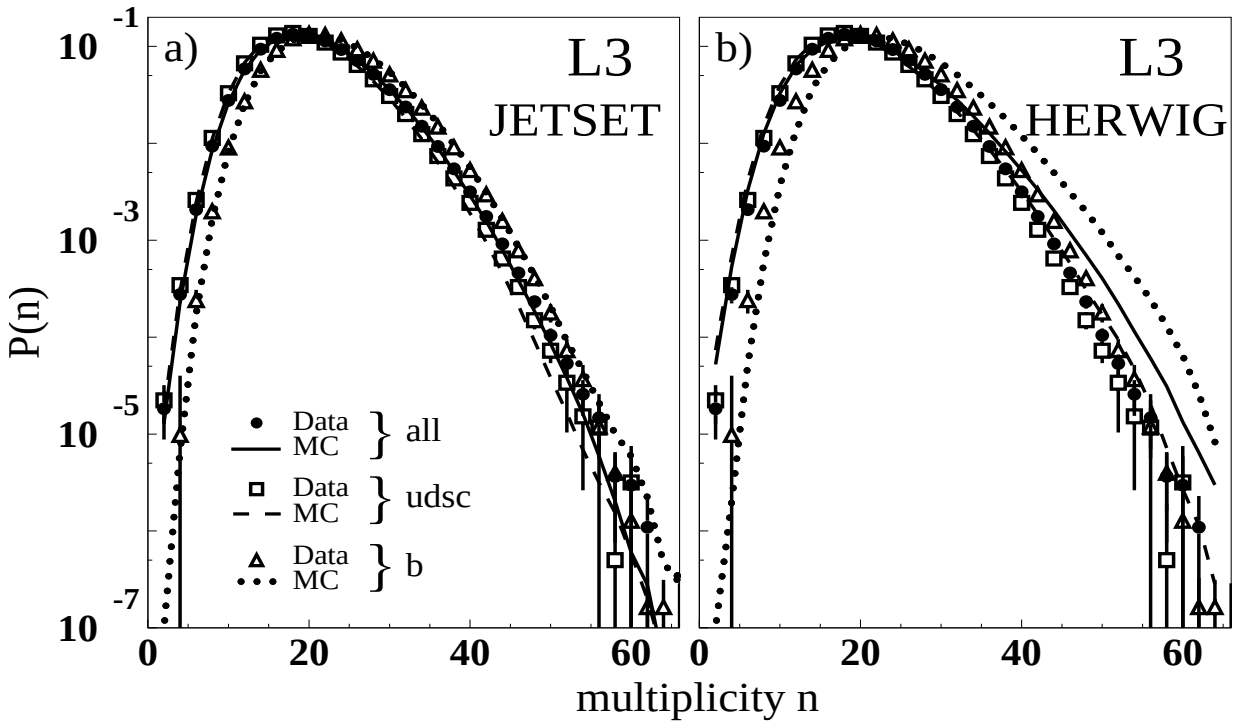
  $\delta_{bl} = 3.44 \pm 0.40(\text{stat}) \pm 0.79(\text{syst})$

  $\langle n_{b\bar{b}} \rangle \simeq 26 - 31$, $\langle n_{l\bar{l}} \rangle \simeq 21 - 28$

- favoured by the **QCD coherence** calculations
- inconsistent with **flavour-independent** model

Multiplicity distribution

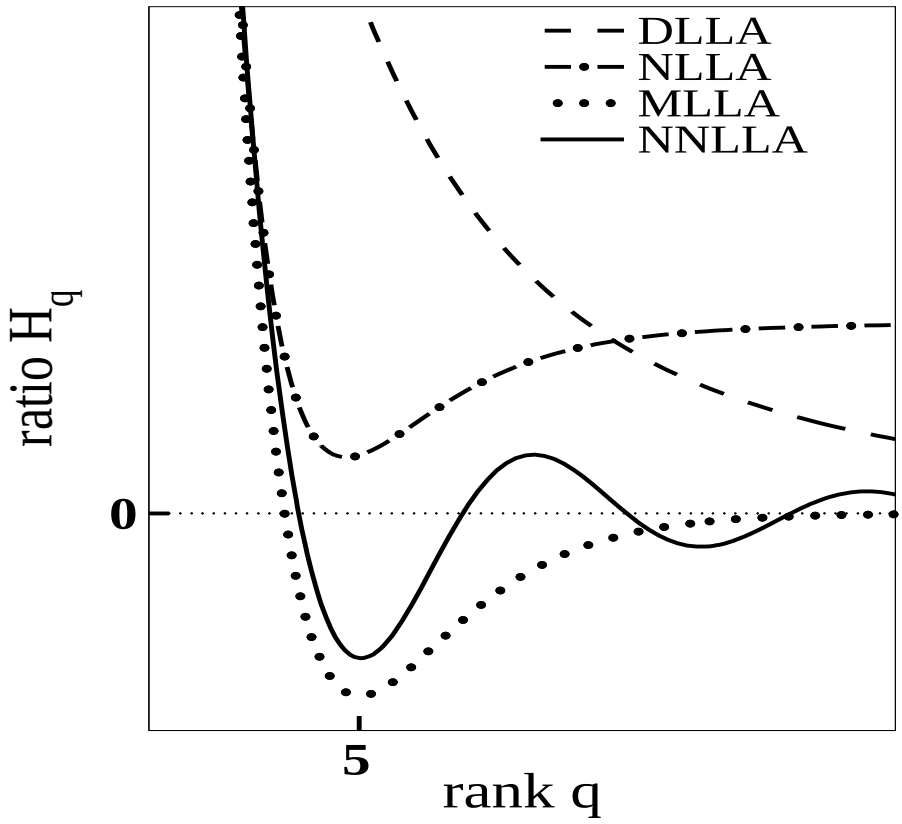
L3 Collaboration, Abs. 190



L3 Note 2808 (2003)

- Data **well** described by JETSET; HERWIG faces **problems**
- A set of **different** moments (up to **4th order**) of P(n) studied: $\langle n \rangle$, ... $\langle n^4 \rangle$,
  dispersion $D^2 = \langle (n - \langle n \rangle)^2 \rangle$,
  skew $S = \langle (n - \langle n \rangle)^3 \rangle / D^3$,
  curtosis $K = \langle (n - \langle n \rangle)^4 \rangle / D^4 - 3$
- **significant** flavour dependence observed

H_q moments

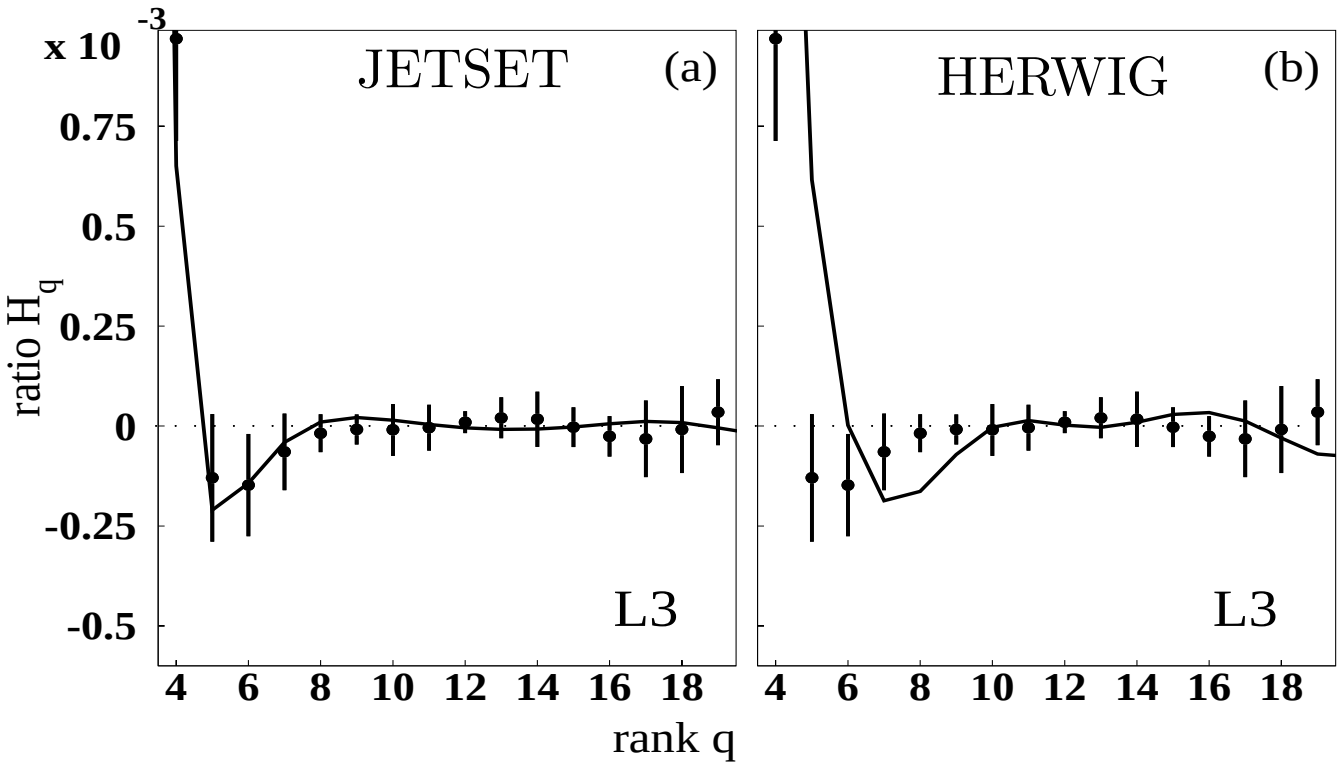


- $H_q = K_q/F_q$
  ratio of cumulants K_q to factorial moments F_q
- Sensitivity to the approximation used
- pQCD predicts H_q for partons
  - to have $H_q^{\text{1st min}} < 0$ at $q = 5$ (MLLA, NNLLA)
  - to oscillate around zero (NNLLA)
- pQCD+LPHD extention: partons $\Leftrightarrow$ hadrons
- Asymptotic energies assumed ✓
- No energy-momentum conservation; just in MC ✓
- Observed experimentally (by SLD, L3)

I.M. Dremin, J.W. Gary, Phys. Reports 349 (2001) 301

H_q moments

L3 Collaboration, Abs. 190

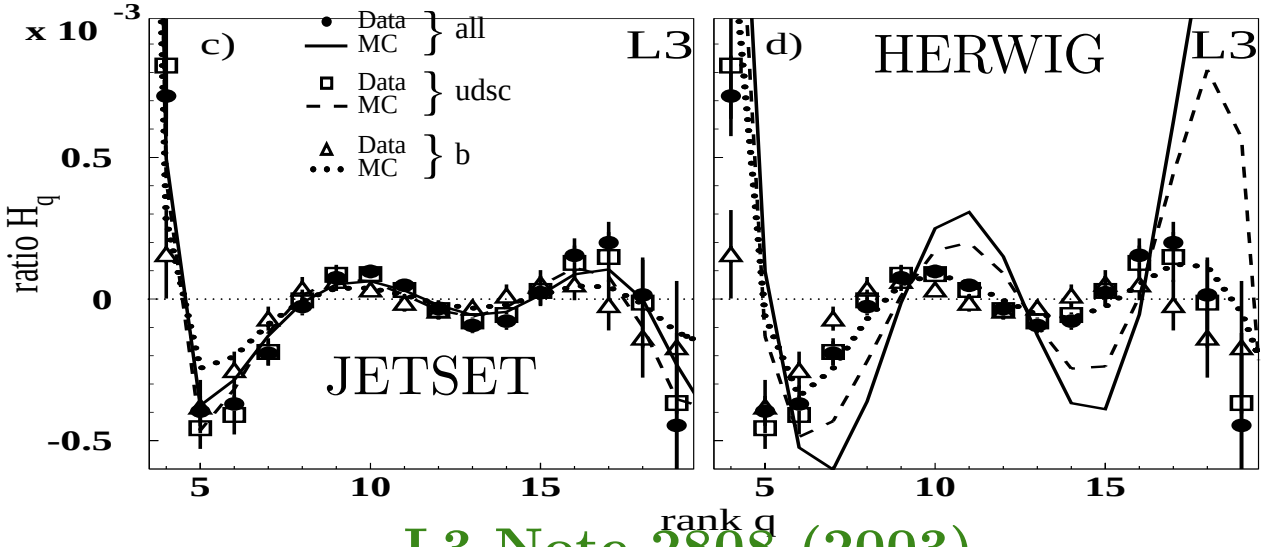


L3 Note 2808 (2003)

- A negative minimum **at q = 5**
- Data **well** described by JETSET; HERWIG faces **problems**
- **Agrees** qualitatively with MLLA, NNLLA
- No **oscillations** as NNLLA predicts... but...

H_q from truncated P(n)

L3 Collaboration, Abs. 190

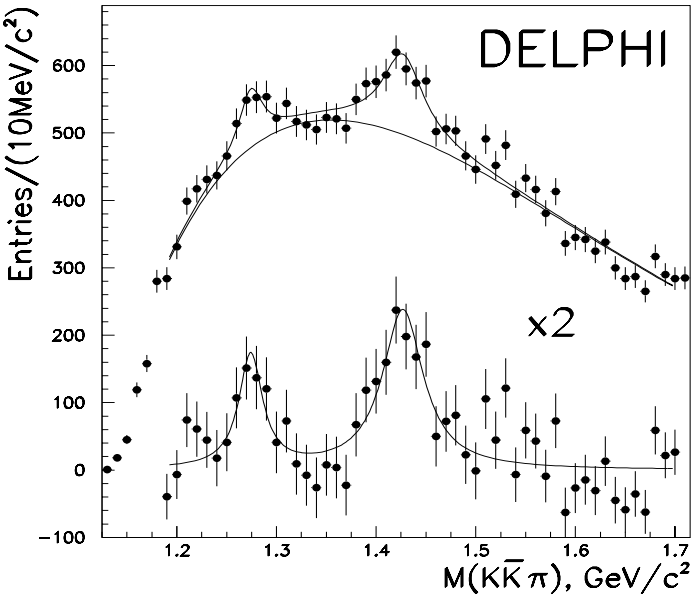


L3 Note 2808 (2003)

- P(n) truncated for **high** (~ 50) multiplicities
  $\Rightarrow$ **low** statistics at high n (0.005% of events) but large influence on H_q
- A negative minimum **at q = 5** and oscillations
- No flavour dependence
- Data **well** described by JETSET; HERWIG faces **problems**

DELPHI Collaboration, Abs. 323

- **First** LEP observation of $J^{PC} = 1^{++}$ ($^3P_1$) meson
- **3-body** decay in $Z \to (K_S\, K^{\pm}\, \pi^{\mp}) + X^0$
  - $\Rightarrow$ $K_S\, K^{\pm}\, \pi^{\mp}$ **mass spectra**
  - $\Rightarrow$ partial-wave analysis (**PWA**)
- Mass spectra **Breit-Wigner fit + background**



- The **masses and widths** for $f_1(1285)$ and $f_1(1420)$:
  - Masses: 1274 ± 6, 1426 ± 6 MeV/c^2
  - Widths: 29 ± 12, 51 ± 14 MeV/c^2
- **Confirmed** by PWA
- Hadronic production **rates** / Z decay:
  0.165 ± 0.051 ($f_1(1285)$), 0.056 ± 0.012 ($f_1(1420)$)
  - A **quark content**: mainly $u\bar{u}$, $d\bar{d}$

DELPHI 2003-013-CONF-633 (June 2003)

Conclusions

- The difference δ_{bl} in mean charged particle multiplicities for $b\bar{b}$ and light ($l\bar{l} \equiv u\bar{u}$, $d\bar{d}$, $s\bar{s}$) quarks is found to be independent of center-of-mass energy, as **pQCD predicts**

- The H_q moments of the multiplicity distrib. show a negative minimum at $q = 5$ as **predicted** by MLLA and NNLLA, but do not oscillate as NNLLA **predicts**. The measurements are in **agreement** with JETSET predictions.

- The inclusive production of two $(K\overline{K}\,\pi)^0$ states in hadronic Z decays is studied. The measurements are shown to be **consistent** with the $f_1(1285)$ and $f_1(1420)$ mesons.