Studies of the hadronic decays of Z bosons at LEP

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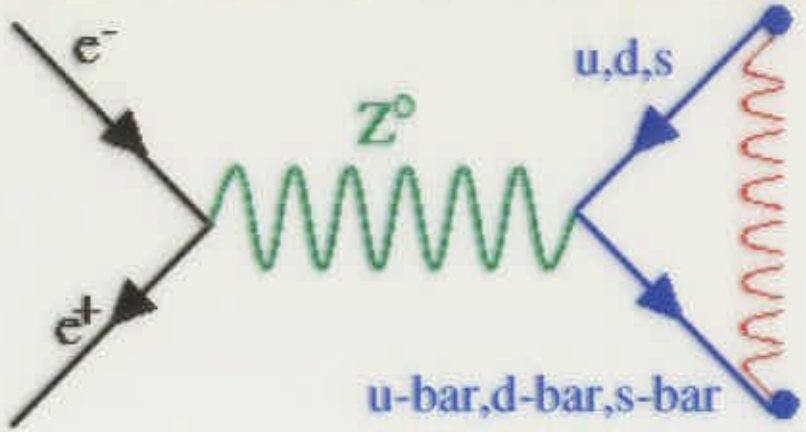
105) **OPAL**: Charge multiplicities in Z decays to u,d,s pairs
163) **ALEPH**: Inclusive Production of the $\omega(782)$
161) **ALEPH**: Inclusive Production of π^0, η, $\eta'(958)$, K^0 and Λ in 2- and 3-Jet Events
641) **DELPHI**: Rapidity-rank structure of p-pbar pairs

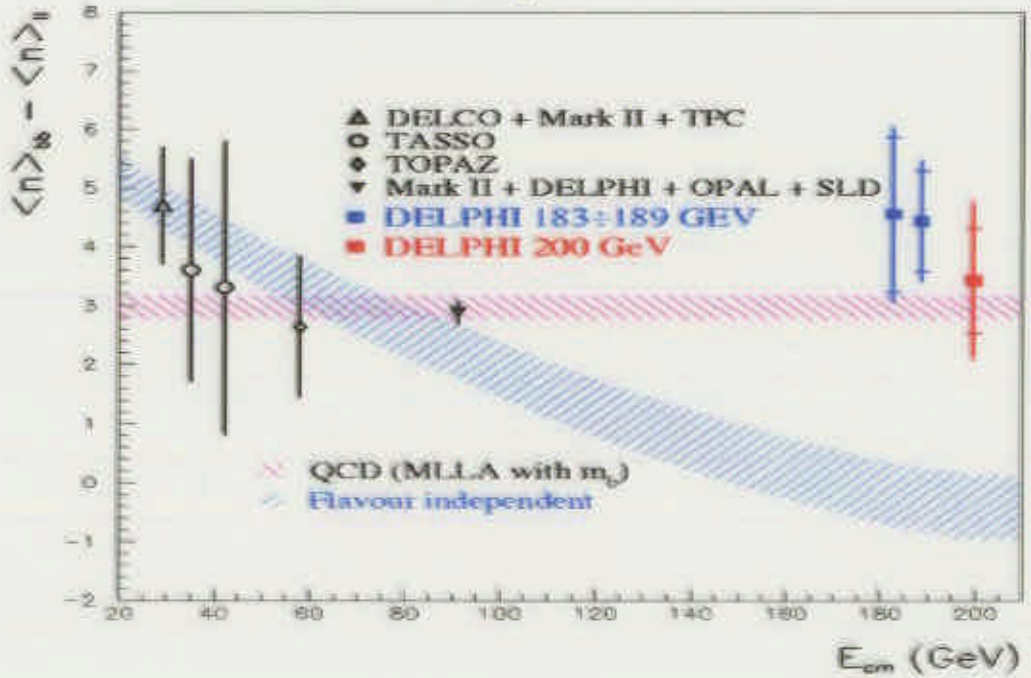
~ 4MZ / experiment recorded in 1990-95

ICHEP 2000 Osaka, July 2000

105) OPAL: Charged multiplicities in u-ubar, d-dbar, s-sbar events

- QCD: flavour symmetry
  - Investigate the multiplicity for Z decays into different flavours
  - Already studied in the case of the decay into b-bbar (mass effect demonstrated)



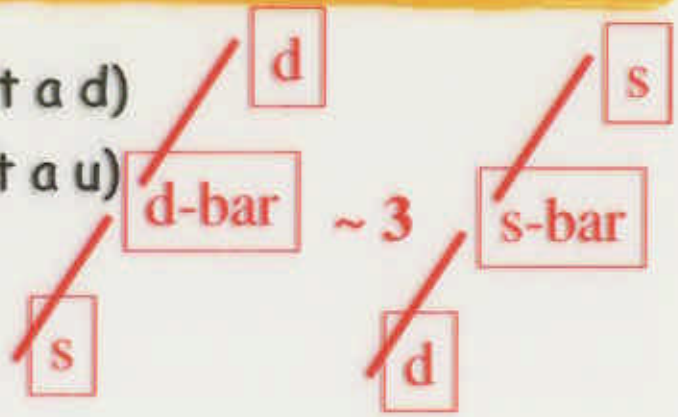


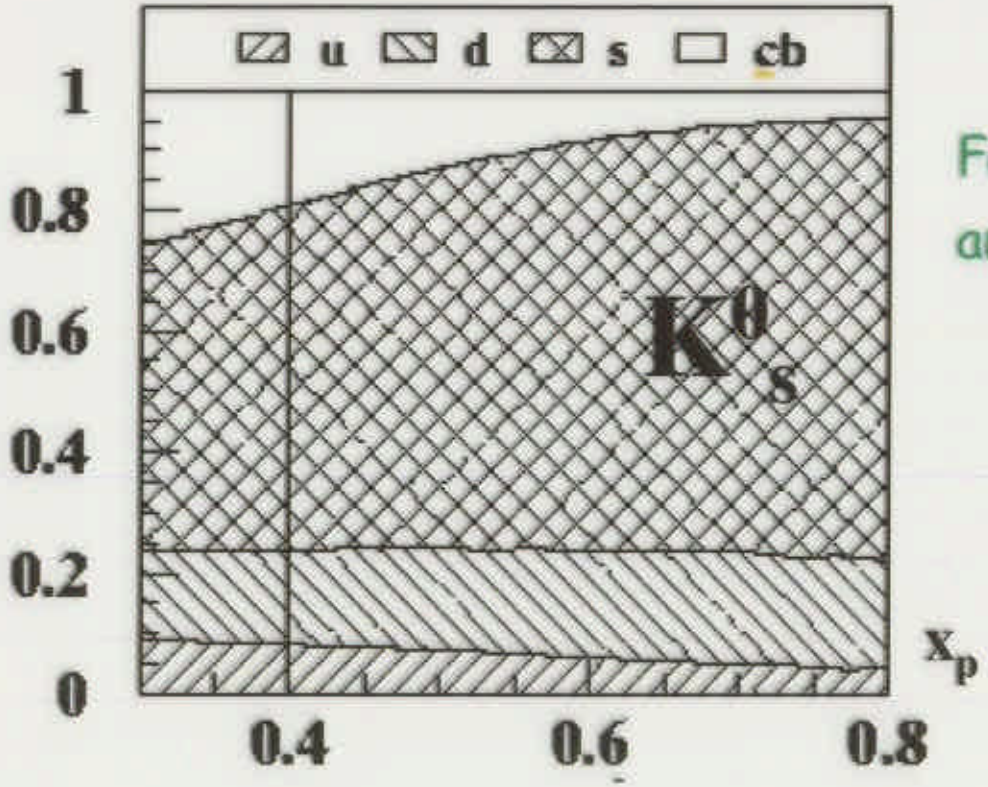
- Experimental problem: tag the decays into light quarks
  - Leading particle
- Calculation of the multiplicity in MLLA => α_s for light flavors

OPAL: Charged multiplicities in u-ubar, d-dbar, s-sbar events

Light flavour tagging: high-x K^0_S, K^+, charged particles

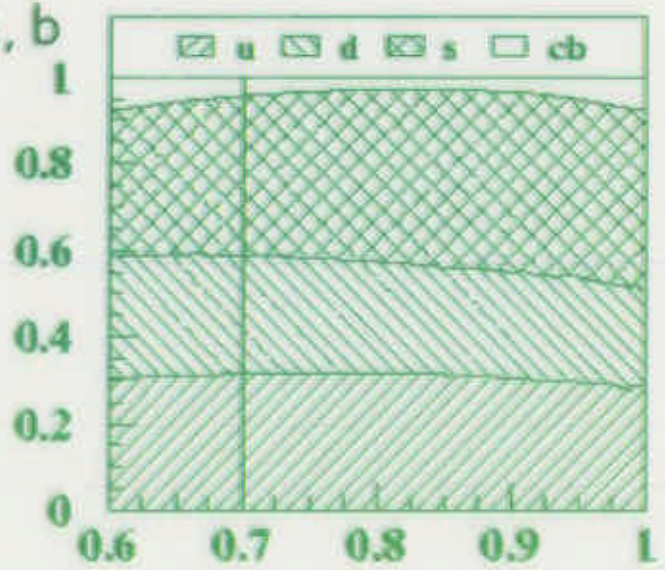
- Leading K^0: tags a primary s (and to a < extent a d)
- Leading K^+: tags a primary s (and to a < extent a u)





Fast leading charged particle:

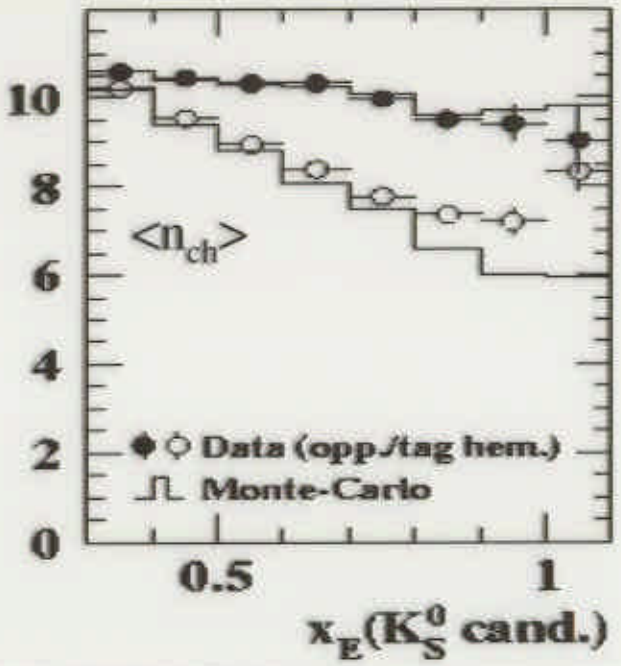
antitags c, b



OPAL: Charged multiplicities in u-ubar, d-dbar, s-sbar events
Results and conclusions

- 3 independent equations (one for each sample)
- Cross-checked for double tags
- To reduce the bias, study of the hemisphere opposite to the one used for tagging

$$n_u = 17.77 \pm 0.52^{+0.86}_{-1.20}$$
$$n_d = 21.44 \pm 0.69^{+1.46}_{-1.17} \quad C(n_u, n_d) = -0.89$$
$$n_s = 20.02 \pm 0.14^{+0.39}_{-0.37}$$



- Systematics from fragmentation, n_{heavy}

n_u/n_d consistent with 1 in 1.8σ, n_s/n_d in 0.9σ, n_s/n_u in 1.5σ

=> α_s values also consistent at precisions ~ 5% to 9%

163) ALEPH: Inclusive Production of the ω (782)

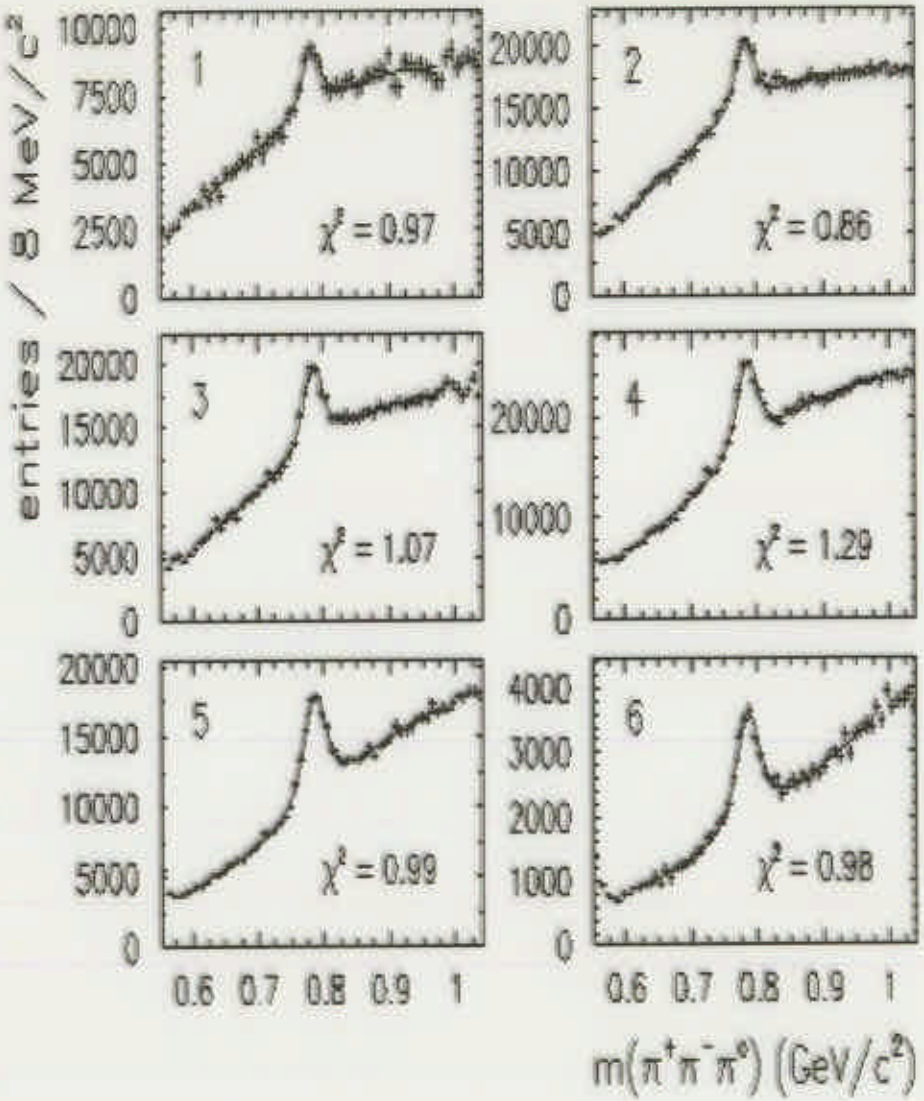
- Identified particles: a key test for hadronization models
  - in particular vector mesons, closer to the main event

$$\omega \to \pi^+\pi^-\pi^0 \ (\mathrm{BR} \sim 89\%)$$

$$\mathrm{eff.} \sim 0.17$$

$$\eta \to \pi^+\pi^-\pi^0 \ (\mathrm{BR} \sim 23\%)$$

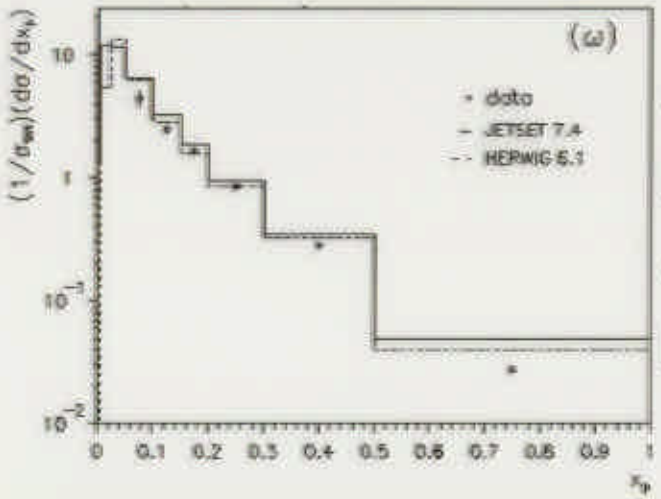
- Fit in 6 x_p intervals
  - 0.05 - 0.10 (not used for η)
  - 0.10 - 0.15
  - 0.15 - 0.20
  - 0.20 - 0.30
  - 0.30 - 0.50
  - 0.50 - 1.00



ALEPH: Inclusive Production of the ω (782)

Results

- Most precise measurement of <ω>, accuracy on <η> comparable with L3 & OPAL



$$<\eta>=1.06\pm0.03\pm0.06\pm0.08 \quad (\mathrm{PDG2000}: 0.95\pm0.07)$$

JETSET OK, HERWIG ~ TOO HIGH & STEEP

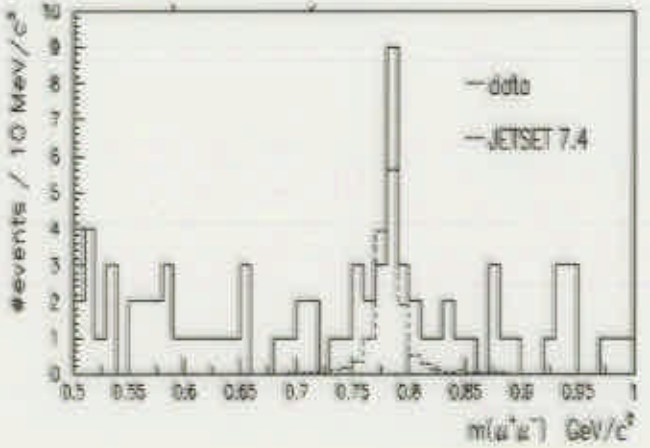
$$<\omega>=1.00\pm0.03\pm0.05\pm0.02 \quad (\mathrm{PDG2000}: 1.08\pm0.09)$$

BOTH JETSET & HERWIG TOO HIGH

- The observation of a peak of 18 events in ω -> $\mu^+\mu^-$ allows to estimate

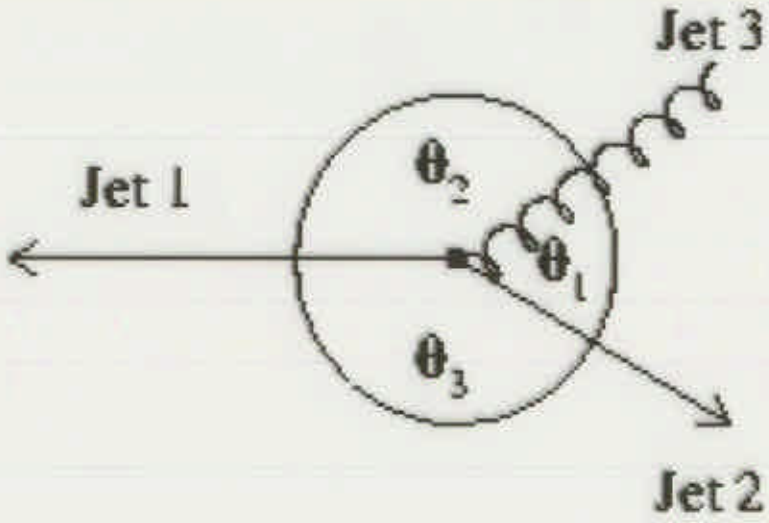
$$BR(\omega \to \mu^+\mu^-) = (9.0 \pm 2.9 \pm 1.1)\times 10^{-5}$$

improving the present upper limit, and consistent with theory (Van Royen and Weisskopf 67)



161) ALEPH: Inclusive Production of π^0, η, $\eta'(958)$, K^0 and Λ in 2- and 3-Jet Events

- Isoscalars (η, η', ω, ϕ) could be enhanced in gluon compared to quark jets
  - Peterson & Walsh 80: isoscalars produced directly in g fragmentation
  - Hwa & al. 77,81; Migneron & al. 82
  - Ball, Frère & Tytgat 96: significant gg component in η'
  - Fritzsch 97: large coupling of η' to g
- ARGUS 96, Crystal Ball 91 (~ 10 GeV); JADE 85 (~ 34 GeV) don't see any effect; L3 96 sees a η rate OK in 2-jet events, but a harder production than in QCD-inspired models for 3-jet events



- ALEPH: selection of 3-jet events with DURHAM, $y_{cut} = 0.01$
  - 64% of the events are 2-jet
  - 31% of the events are 3-jet
- Jets ordered by **energy**, and jet 3 is the gluon (OK with 71% probability)

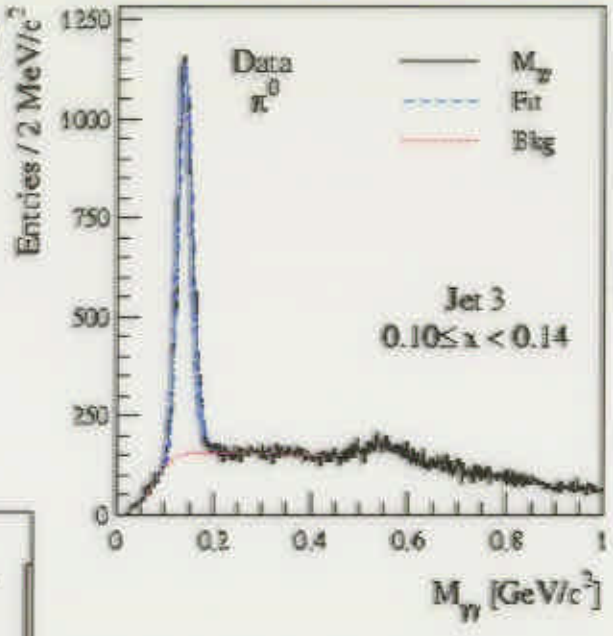
ALEPH: Production of π^0, η, $\eta'(958)$, K^0 and Λ in 2- and 3-Jet Events

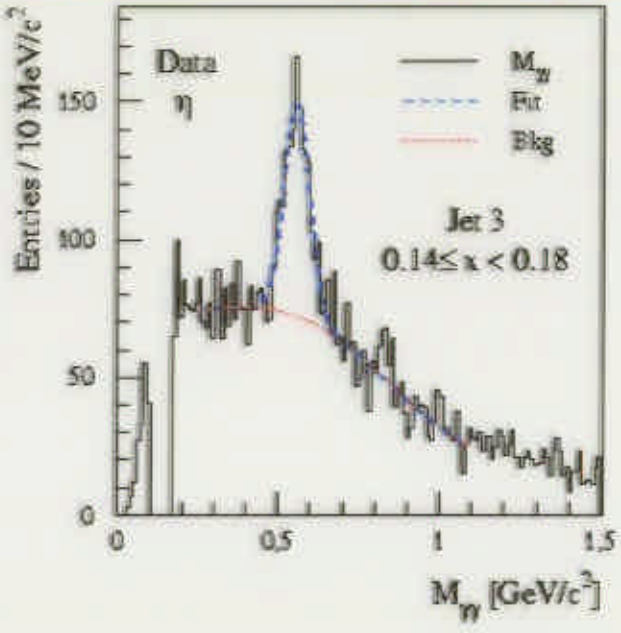
Reconstruction of π^0, η, $\eta'(958)$

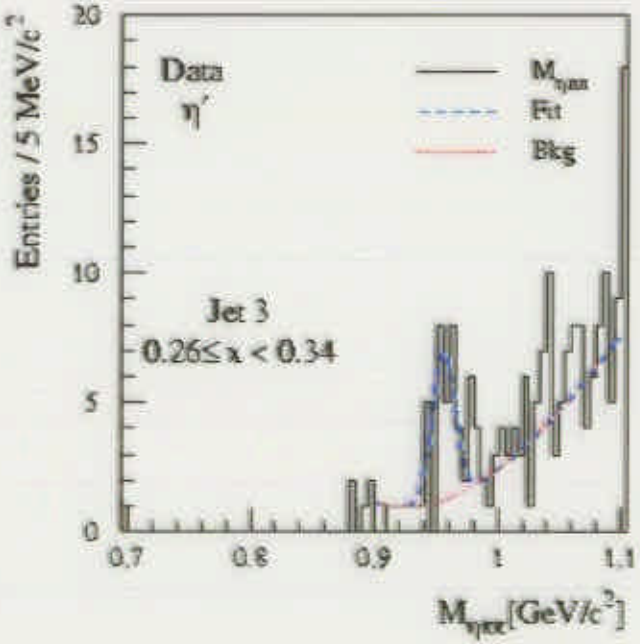
$\pi^0 \to \gamma\gamma\ (\mathrm{BR} = 99\%)$

$\eta \to \gamma\gamma\ (\mathrm{BR} = 39\%)$

eff. ~ 0.2 - 0.5







$\eta'(958) \to \eta\pi^+\pi^-\ (\mathrm{BR} = 44\%)$

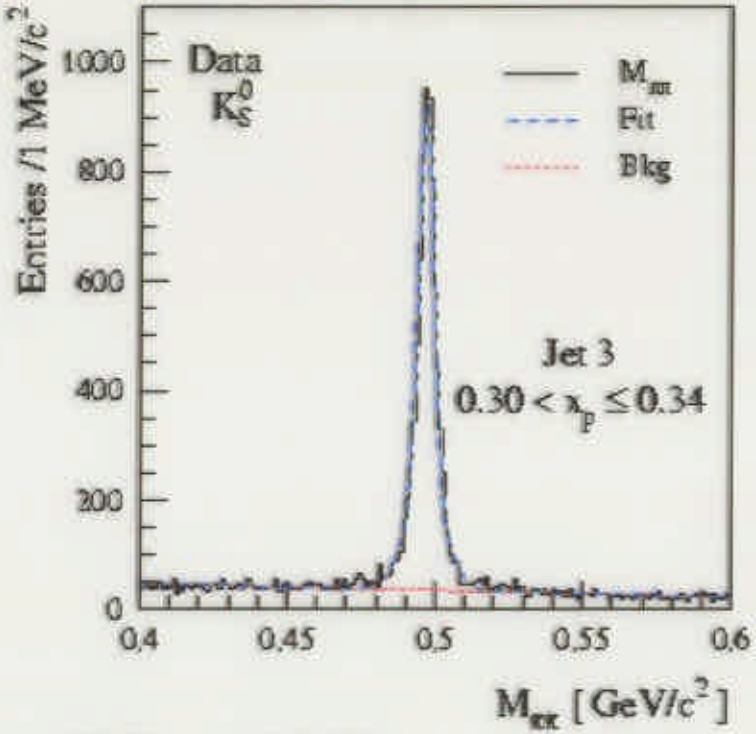
eff. ~ 0.1 - 0.3

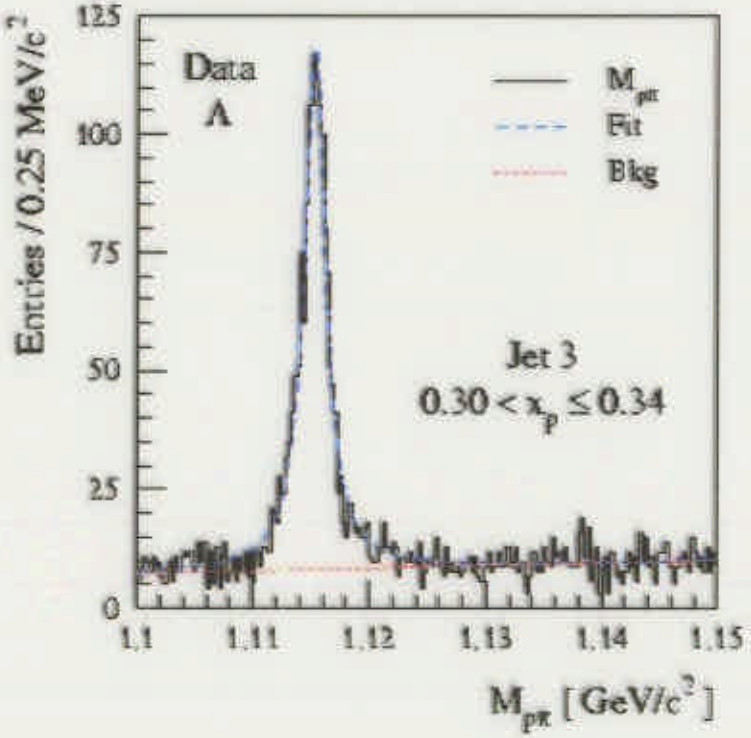
ALEPH: Production of π^0, η, $\eta'(958)$, K^0 and Λ in 2- and 3-Jet Events

Reconstruction of K^0_s and Λ

$$K^0_S \to \pi^+\pi^- \ (BR = 69\%)$$

eff. ~ 0.5





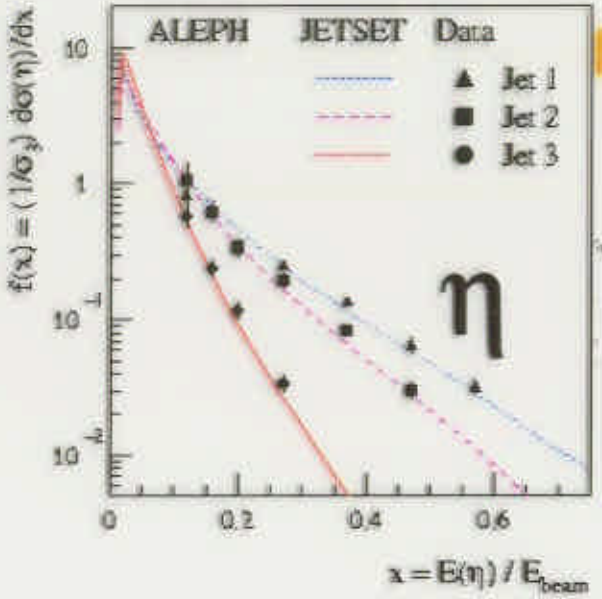
$$\Lambda \to p\pi^- \ (BR = 64\%)$$

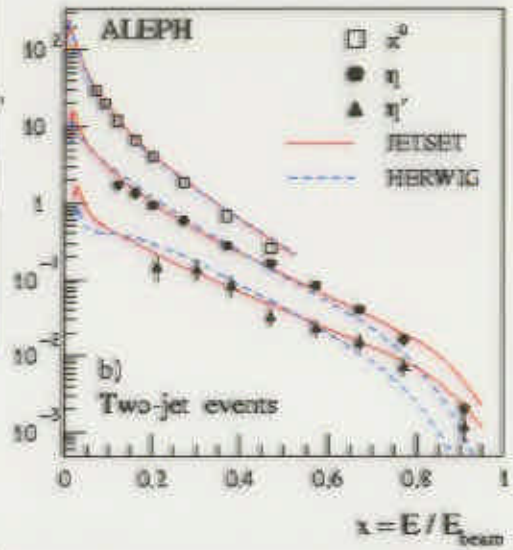
eff. ~ 0.5

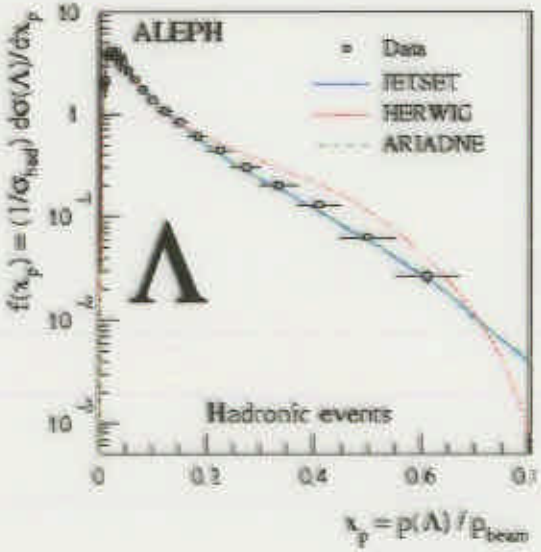
ALEPH: Production of π^0, η, $\eta'(958)$, K^0 and Λ in 2- and 3-Jet Events

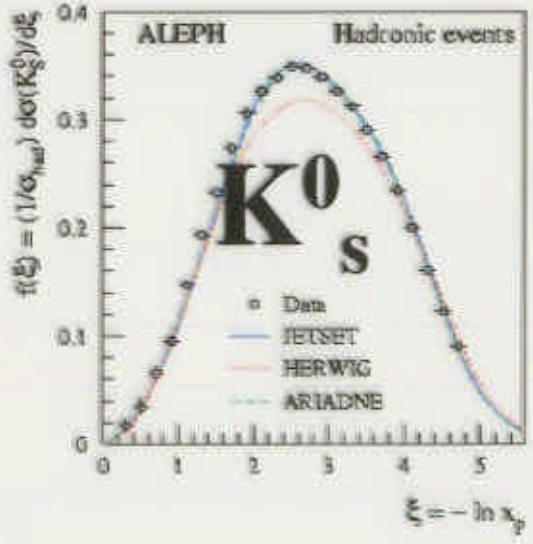
Conclusions

- Isoscalar sector consistent with JETSET for 2- and 3-jet (η' : extra "ad hoc" suppression of 0.275)
  - Too steep x dependence predicted by HERWIG 5.8 & 5.9 in 2-jets
- K^0 and Λ spectra: OK in JETSET, ARIADNE; not in HERWIG (best determination of K^0 and Λ multiplicity)



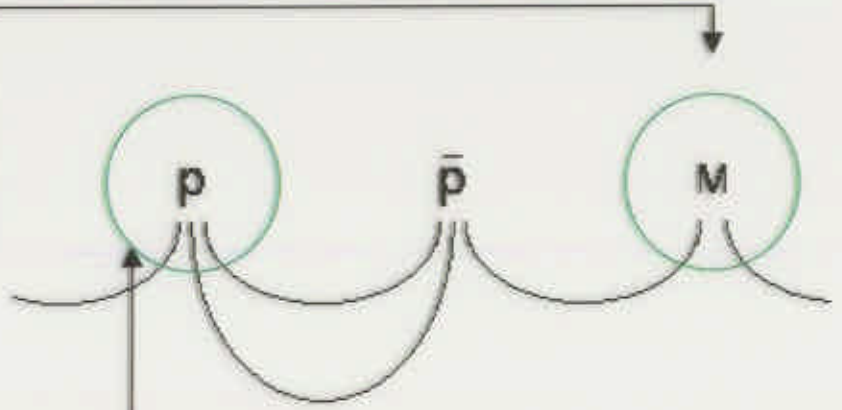




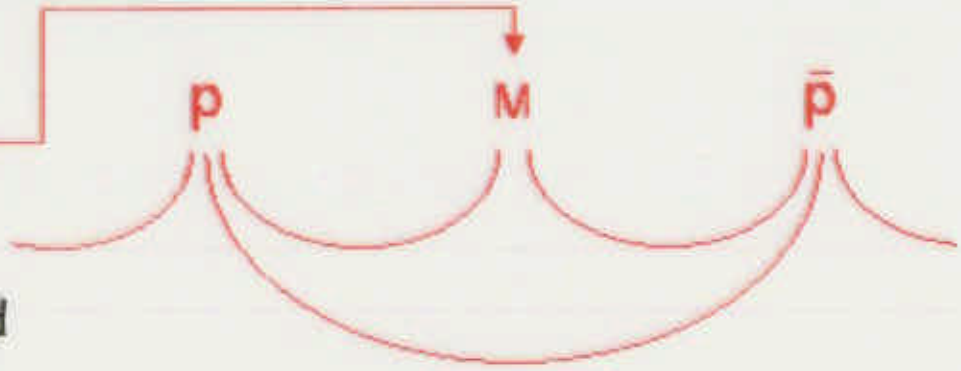


641) DELPHI: Rapidity-rank structure of p-pbar pairs

- **The baryon sector in the QCD-inspired Monte Carlos is critical. Neither the cluster nor the string models are fully OK, but the latter give a better picture**

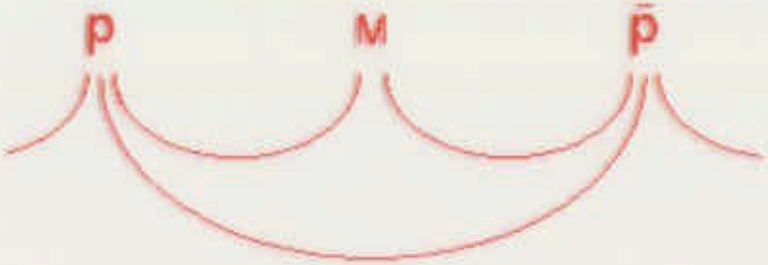


- **Meson fragmentation** within the string model: quark-antiquark pairs created from the string potential
- **Baryons** come from the creation of diquark-antidiquark pairs
- **Popcorn mechanism:** mesons can possibly "pop up" in an effective diquark-antidiquark pair
  - Free parameter in Jetset, related to the probability of B-M-Bbar



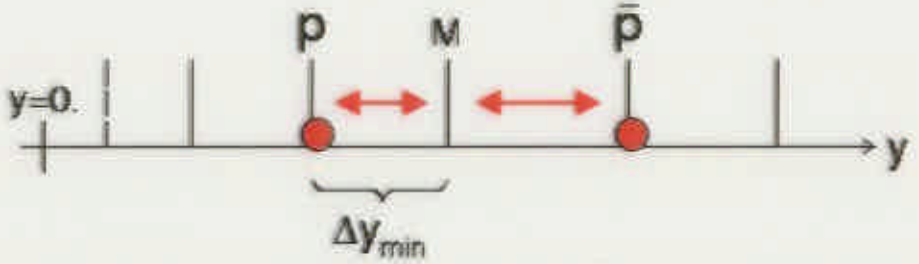
DELPHI: Rapidity-rank structure of p-pbar pairs

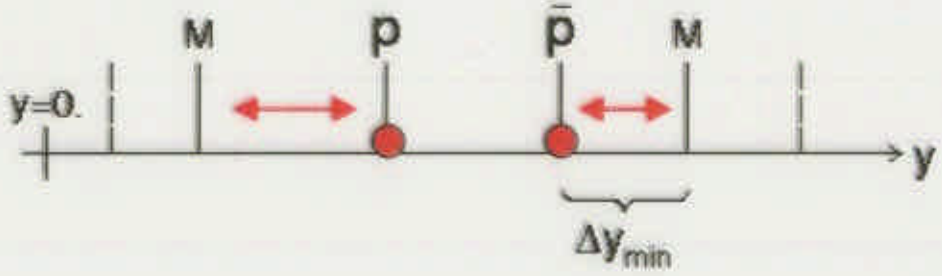
The technique of the rapidity ordering



- The popcorn probability influences the Δy distribution of baryon-antibaryon pairs

- Previous studies of the Δy distribution of Λ–Λbar pairs (OPAL93, DELPHI93, ALEPH94) indicate that popcorn can be important (~50-80%)
- DELPHI 2000 proposes a more direct test: the study of the rapidity ordering of p-pbar pairs





DELPHI: Rapidity-rank structure of p-pbar pairs

Conclusion: no need for the popcorn mechanism !

- Observable: relative amount of the p-M-pbar configuration wrt Δy_{min}
- Selection: ~27,000 events with one p and one pbar in a hemisphere
  - purity 63%

  Background subtracted (pp)
- Consistency with no popcorn !

  Popcorn < 15% @ 90% CL
- **The results contradict the Λ case pointing to inconsistencies in the baryon sector of the Lund model**