STATI FINALI ADRONICI

1. CONSIDERAZIONI (LEP; MARCHESINI, BANFI)
2. CONTRIBUTI DI QCD A $\sigma_{TOT}(\gamma\gamma)$ (PANCHERI)
3. MISURE DI QCD A LEP2 (BONACORSI)
4. MISURE DI m_b (DISSERTORI)
5. CORRELAZIONI DI BOSE-EINSTEIN (CIOCCA, FUFFIANI, GG)
6. CONCLUSIONI

LEP TRIESTE
28/4/2000
G. GIACOMELLI

1. ALCUNE CONSIDERAZIONI

a. LEP2

1999 $\sqrt{s} = 200, 202$ GeV - ALTA LUMINOSITÀ INTEGRATA

2000 $\sqrt{s} > 204 - 206$ GeV

ALEPH, DELPHI, L3, OPAL IN PRESA DATI REGOLARE

b. α_s, IL PARAMETRO PIÙ IMPORTANTE DI QCD,

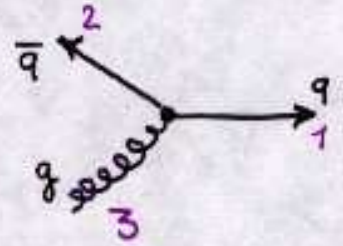
È ORA MISURATO SU UN AMPIO INTERVALLO DI Q

I DATI A LEP2 SONO GIÀ SUFFICIENTI PER STABILIRE IL "RUNNING" DI α_s IN QUESTO INTERVALLO DI ENERGIE

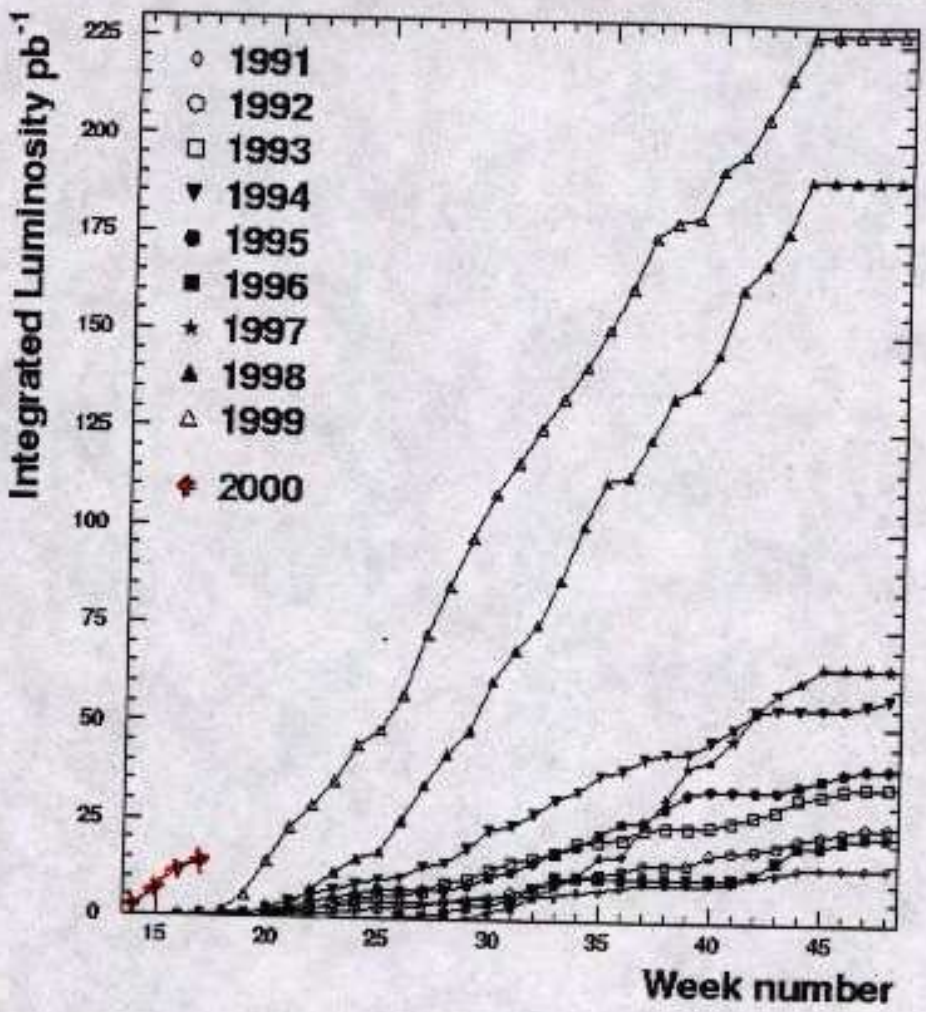
c. L'INTERESSE NELLO STUDIO DI EVENTI A 3 JETS È STATO SOTTOLINEATO DA MARCHESINI E BANFI

NEL PASSATO, UNO DEI MOTIVI DI TALI MISURE ERA CONNESSO CON LO STUDIO DELLE DIFFERENZE NEI JETS ORIGINATI DA QUARK E DA GLUONI

ORA L'INTERESSE INCLUDE LO STUDIO E IL CALCOLO DELLA PARTE HARD E DI QUELLA SOFT (NON PERTURBATIVA)



OPAL Online Data-Taking Statistics



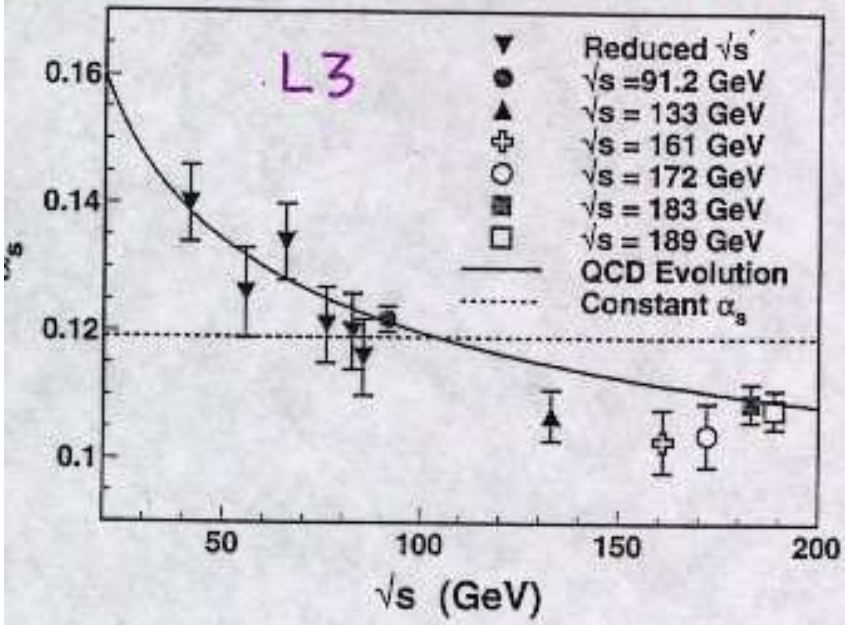
Breakdown by centre-of-mass energy AT START OF RUN (to nearest GeV):

Ecm = 91 GeV,	integrated luminosity	2662.3 inverse nb
Ecm = 200 GeV,	integrated luminosity	876.7 inverse nb
Ecm = 202 GeV,	integrated luminosity	833.1 inverse nb
Ecm = 203 GeV,	integrated luminosity	2083.4 inverse nb
Ecm = 204 GeV,	integrated luminosity	6576.8 inverse nb
Ecm = 205 GeV,	integrated luminosity	1067.3 inverse nb

Breakdown by centre-of-mass energy USING MINI-RAMPS (to nearest GeV):

Ecm = 91 GeV,	integrated luminosity	2662.1 inverse nb
Ecm = 200 GeV,	integrated luminosity	862.4 inverse nb
Ecm = 201 GeV,	integrated luminosity	4.6 inverse nb
Ecm = 202 GeV,	integrated luminosity	679.1 inverse nb
Ecm = 203 GeV,	integrated luminosity	1379.6 inverse nb
Ecm = 204 GeV,	integrated luminosity	4252.5 inverse nb
Ecm = 205 GeV,	integrated luminosity	2811.4 inverse nb
Ecm = 206 GeV,	integrated luminosity	1166.1 inverse nb
Ecm = 207 GeV,	integrated luminosity	248.8 inverse nb
Ecm = 208 GeV,	integrated luminosity	12.7 inverse nb

RUNNING OF α_s



FROM A SINGLE LEP EXPERIMENT

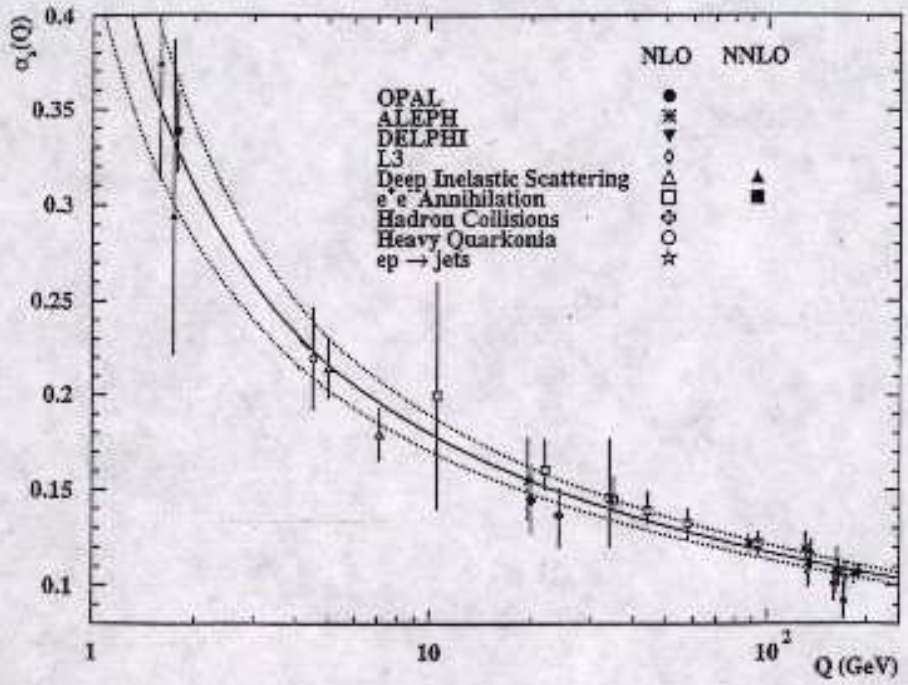
FIT AT EACH ENERGY OF 4 DISTRIBUTIONS (T, ρ, B_T, B_W)

A FIT ACCORDING TO QCD EVOLUTION YIELDS

$\alpha_s(m_Z) = 0.119 \pm 0.004$

WORLD AVERAGE

$\alpha_s(m_Z) = 0.119 \pm 0.004$



SL CORRECTIONS

A. BANFI

1) HARD PARTON RECOIL EXPONENTIATION
2) ARGUMENT OF THE RUNNING COUPLING
3) HARD INTRA-JET PARTON DECAY
4) SOFT INTER-JET GLUON RADIATION

2 JET EVENTS

1) + 2) + 3) $\Leftrightarrow$ COHERENT BRANCHING
CORRECTIONS DEPEND ONLY ON THE NATURE
OF HARD EMITTING PARTONS

3 JET EVENTS

ALSO 4) $\Leftrightarrow$ QUANTUM INTERFERENCE
CORRECTIONS ARE SENSITIVE TO 3 JET STRUCTURE

$\Downarrow$

PREDICTIONS ARE
GEOMETRY DEPENDENT!

A. B., G. Marchesini, Yu. L. Dokshitzer, G. Zanderighi
hep-ph / 000427

ARGUMENT OF THE COUPLING

ONE GLUON EMISSION

$$w^{(1)}(k) = \frac{N}{2}\left(w^{(1)}_{13}(k) + w^{(1)}_{23}(k) - \frac{1}{N^2} w^{(1)}_{12}(k)\right)$$

$$w^{(1)}_{ab}(k) = \frac{\alpha_s}{\pi} \frac{2 p_a p_b}{(2p_a k)(2k p_b)} = \frac{\alpha_s}{\pi k^2_{\perp,ab}}$$

TWO PARTON "CORRELATED" EMISSION

$$w^{(2)}(k_1,k_2) = \frac{N}{2}\left(w^{(2)}_{13}(k_1,k_2) + w^{(2)}_{23}(k_1,k_2) - \frac{1}{N^2} w^{(2)}_{12}(k_1,k_2)\right)$$

$w^{(2)}_{ab}(k_1,k_2)$ may be found in

S. Catani and M. Grazzini hep-ph/9908523

ONE GLUON + TWO SOFT PARTONS

$$w^{(1)}_{ab}(k) \Rightarrow w^{(1)}_{ab}(k) + \int dk_1\, dk_2\, \delta(k-k_1-k_2)\, w^{(2)}_{ab}(k_1,k_2)$$

$$\frac{\alpha_s}{\pi k^2_{\perp,ab}} \Rightarrow \frac{\alpha_s(k^2_{\perp,ab})}{\pi k^2_{\perp,ab}}$$

Yu. L. Dokshitzer, A. Lucenti, G. Marchesini and G.P. Salam

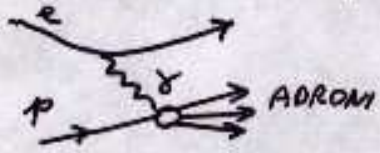
Nucl. Phys B 511 (1998) 396 hep-ph/9707532

2. QCD E SEZIONI D'URTO TOTALI

ANALISI DELLE DIPENDENZE ENERGETICHE DI
$\sigma_{TOT}(pp)$, $\sigma_{TOT}(\bar{p}p)$, $\sigma_{TOT}(\gamma p)$, $\sigma_{TOT}(\gamma\gamma)$

$\sigma_{TOT}(pp)$, $\sigma_{TOT}(\bar{p}p)$ AUMENTANO CON L'ENERGIA

$\sigma_{TOT}(\gamma p)$ AUMENTA CON L'ENERGIA, FORSE DI PIÙ DI $\sigma_{TOT}(pp)$



ANCHE $\sigma_{TOT}(\gamma\gamma)$ AUMENTA FORTEMENTE CON ENERGIA

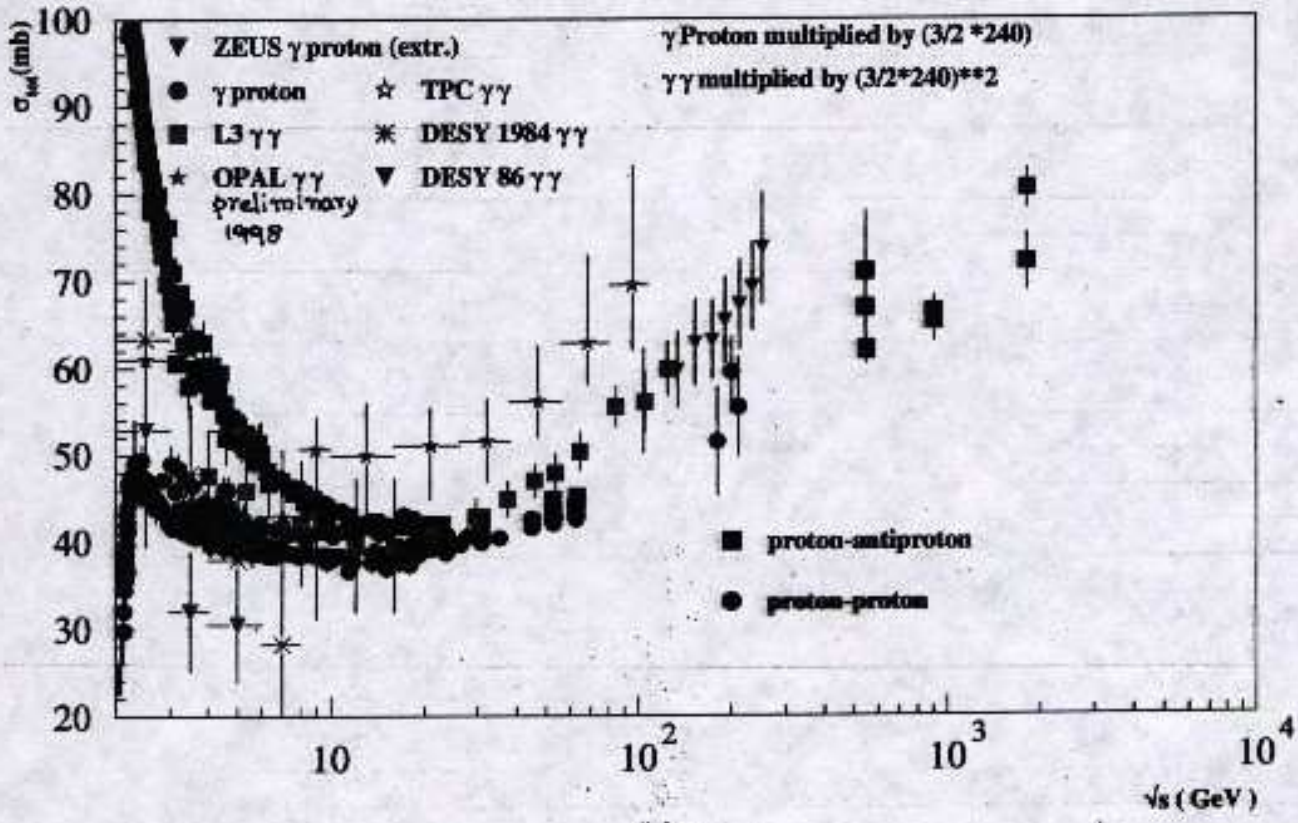
L'AUMENTO DI σ_{TOT} CON ENERGIA È CONNESSO CON L'AUMENTO DI MINIJETS

OCCORRONO MISURE DI $\sigma_{TOT}(\gamma\gamma)$ $\begin{cases} \text{- PIÙ ACCURATE} \\ \text{- A PIÙ ALTE ENERGIE} \end{cases}$

OCCORRE ANCHE MOLTO LAVORO TEORICO

Energy Behaviour of pp, $p\bar{p}$, γp, $\gamma\gamma$

- Scaling Factor $3/2$ aPM
- for each γ $\sum_v \frac{4\pi\alpha}{f_v^2}$ VMD



Eikonal Minijet Models

$$\sigma_{TOT} = 2\int d^2b\,(1 - e^{-n(b,s)/2})$$

$$n(b,s) = n_{soft}(b,s) + n_{hard}(b,s)$$

$n_{soft}(b,s)$ → basically fixed the "bulk"

→ $A_{FF}(b)$ → form factor model

$\mathcal{F}$(form factors) → γ: $\dfrac{q_0^2}{q^2+q_0^2}$; p: $\left(\dfrac{\nu^2}{q^2+\nu^2}\right)^2$

$\sigma_{soft}(s)$ → "a' la carte" VMD, QPM, Regge...

$n_{hard}(b,s)$ → describes the rise

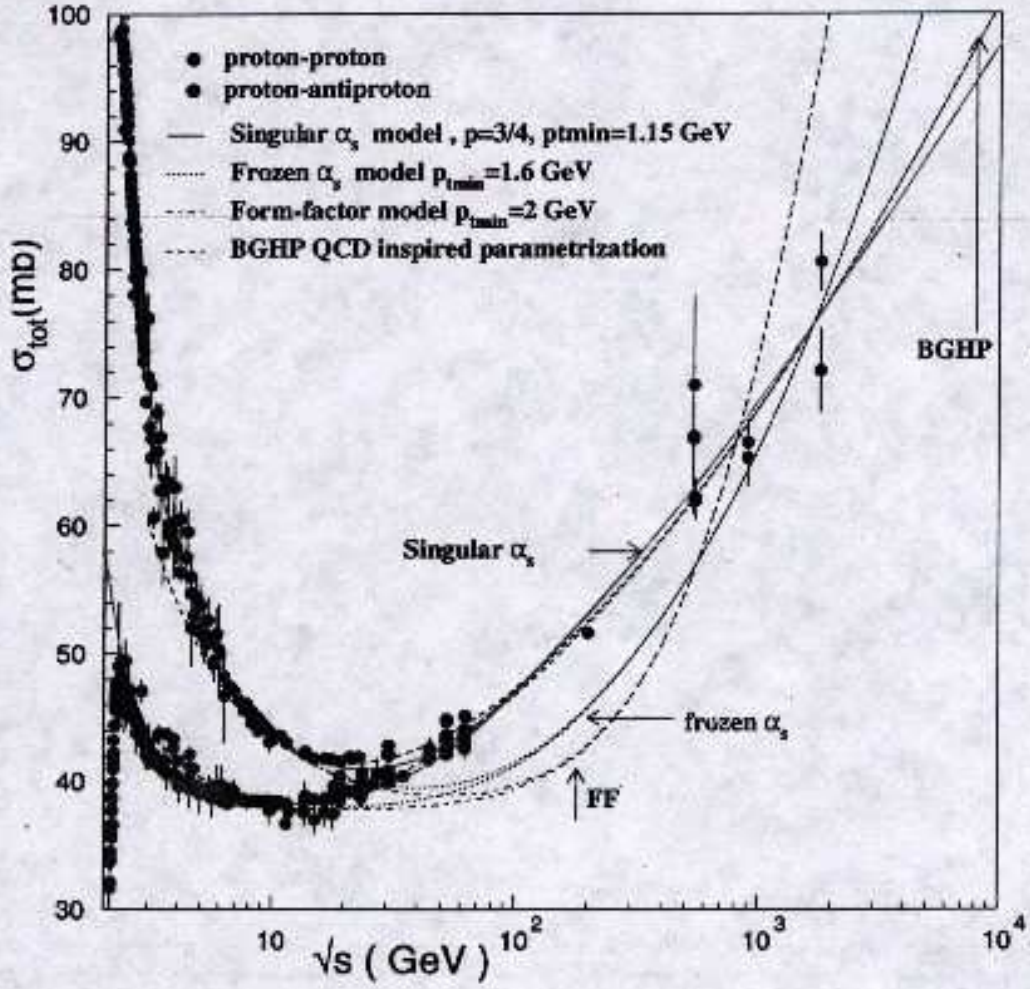
→ $A_{hard}(b,s)$ → form factor as in soft

→ NLO QCD with soft gluon summation

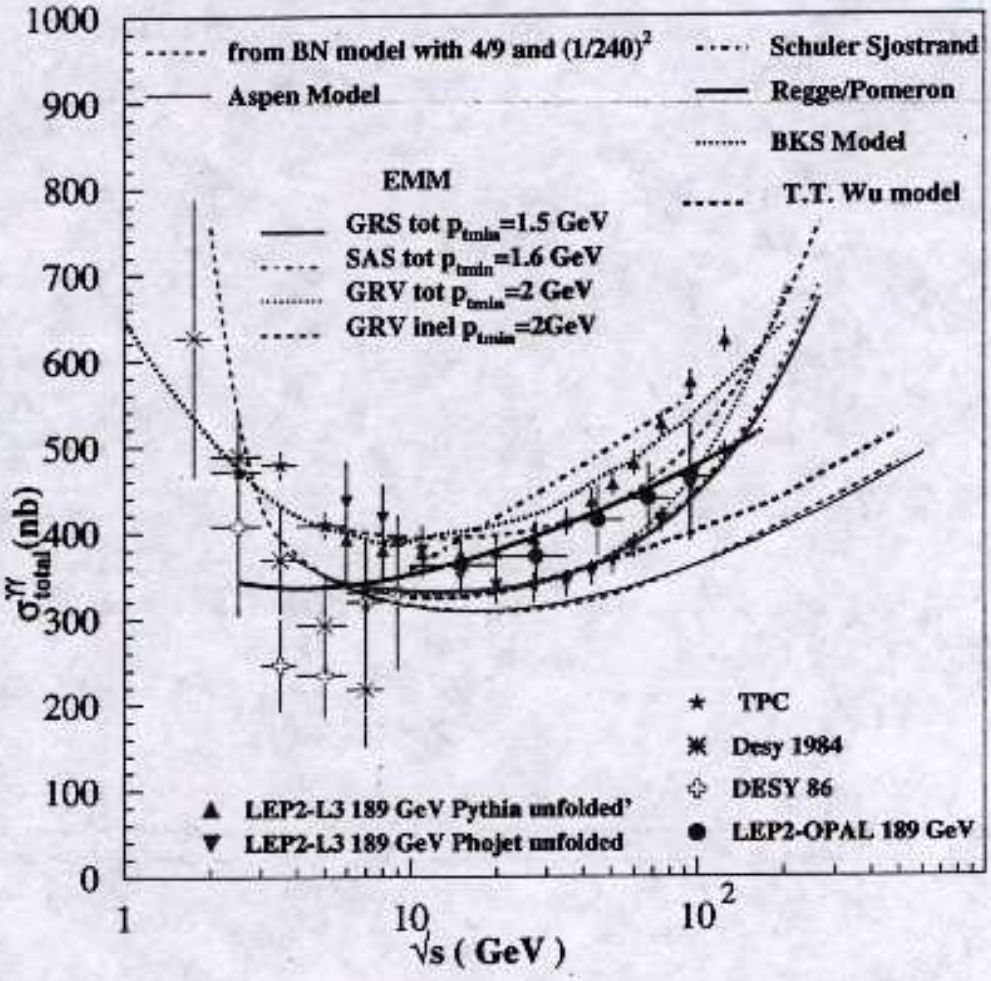
$\sigma_{Jets}^{QCD}(s)$ → calculable from QCD GRV, SAS GRS... $p_t \geq 1 \div 2\,\mathrm{GeV}$

Proton-proton and Proton-antiproton

The EMM model for protons using current parton densities like GRV does not reproduce well the initial rise with energy as indicated by the curve labelled FF



All Together Now!



3. MISURE DI QCD A LEP2

a. PRODUZIONE DI COPPIE $q\bar{q}$
RITORNO RADIATIVO ALLA Z^0

b. VARIABILI DI FORMA
CARATTERIZZANO GLI EVENTI M.A. NELLA LORO GLOBALITÀ
(THRUST, T_{MAJOR}, T_{MINOR}, S, O, A, C, ...)

c. JET RATES

d. VARIABILI DI "TRACCIA"
(RAPIDITÀ y, $p_\perp^{IN}$, $p_\perp^{OUT}$, x_p, ξ_p, ...)

⇒ TUTTO IN ACCORDO CON I MONTECARLI

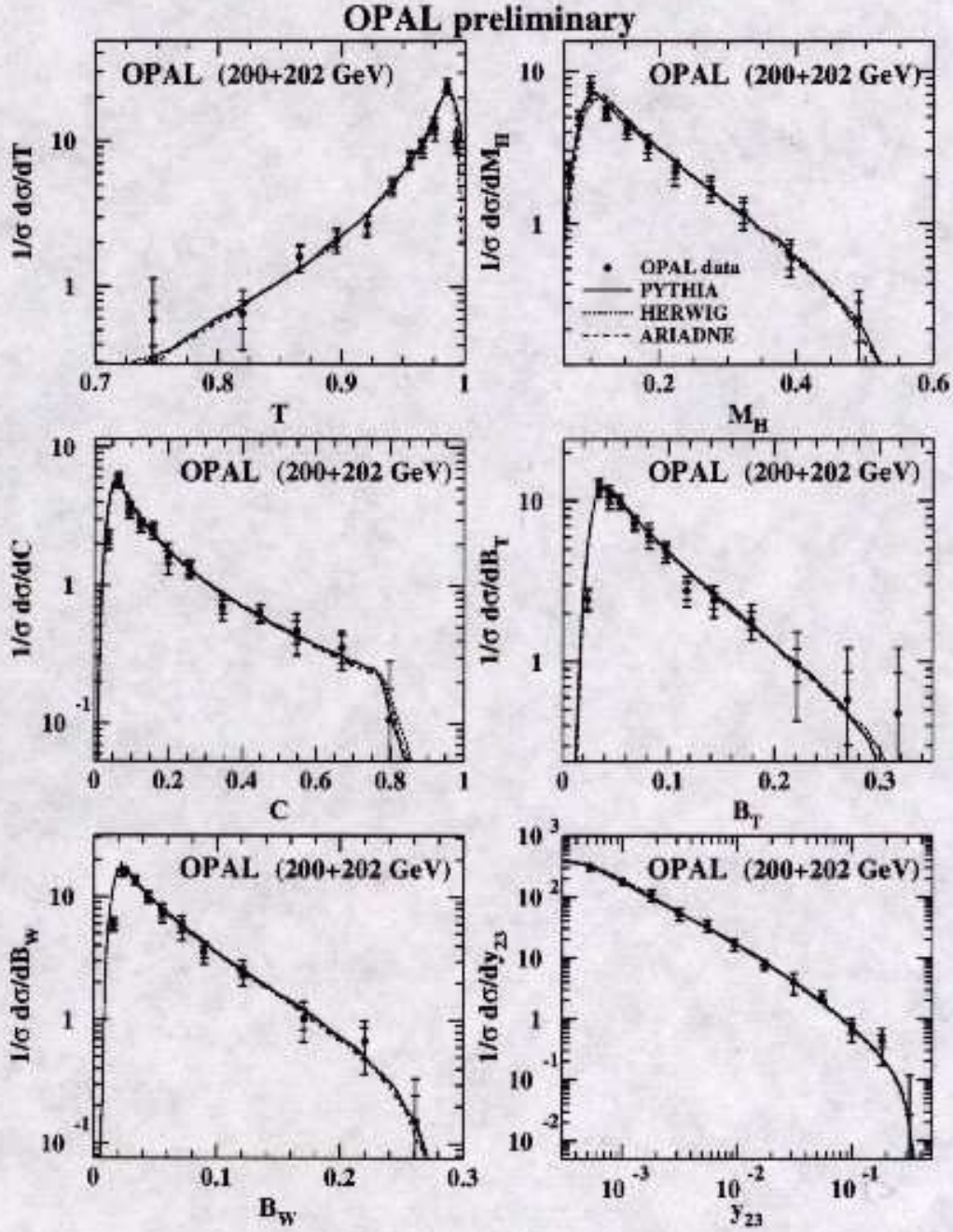
e. DISTRIBUZIONI IN MOLTEPLICITÀ CARICA

f. DIPENPENZA DA $\sqrt{s}$ DI
- MOLTEPLICITÀ MEDIA CARICA
- VALORI MEDI DELLE VARIABILI DI FORMA
- $(\xi_p)_{PEAK} = (\ln 1/x_p)_{PEAK}$

g. $\boxed{\alpha_s}$ AD UNA SINGOLA ENERGIA: FIT DELLE VARIABILI DI FORMA CORRETTE A LIVELLO PARTONICO
ANALISI DELLA DIPENDENZA ENERGETICA
α_s "È RUNNING" ANCHE A LEP2

Variabili "event shape"

- Studio della struttura globale di un evento mh mediante l'analisi delle variabili di forma (T, T_{major}, T_{minor}, O, S, A, C-param., M_H, B_T, B_W)



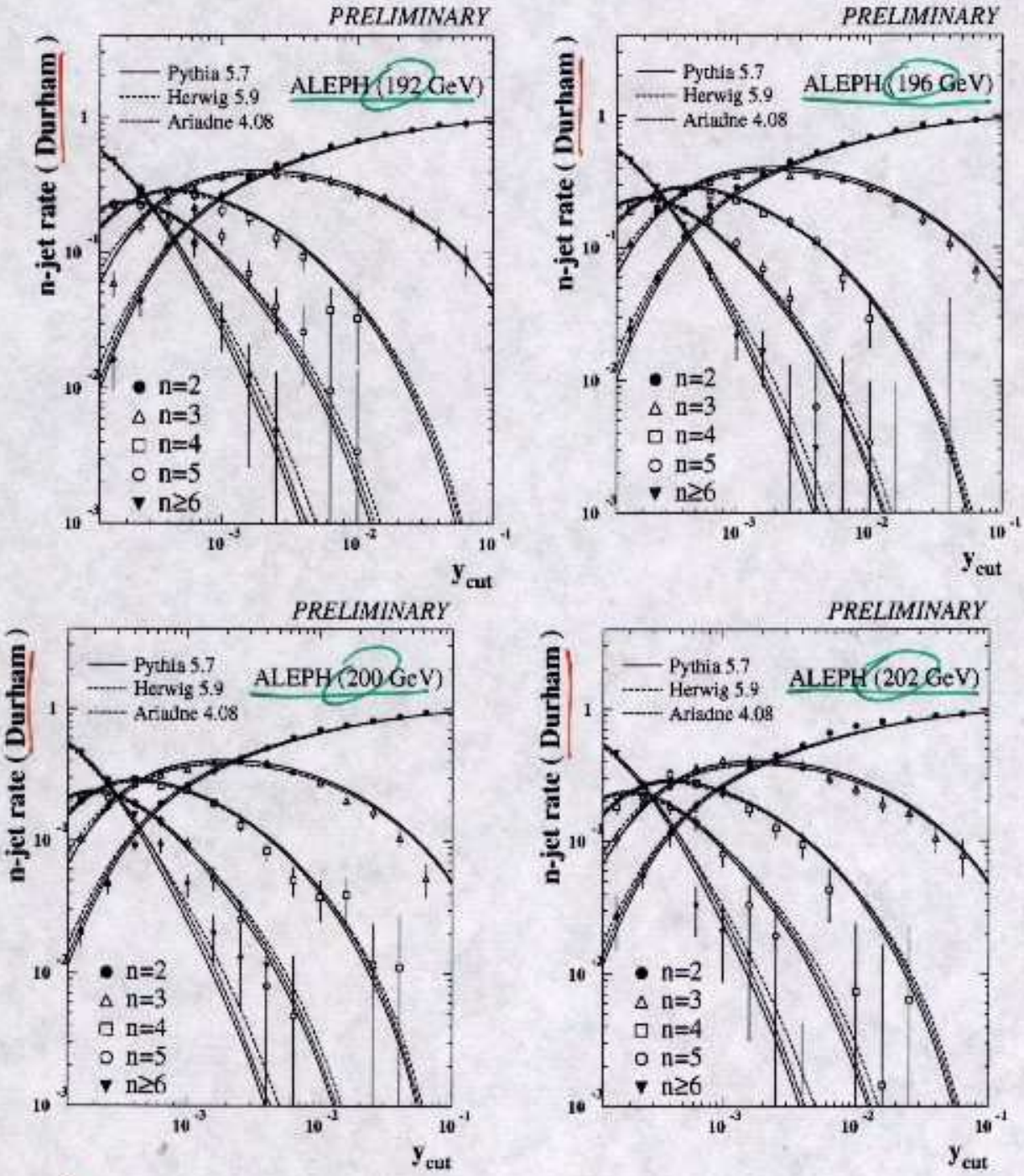
200 GeV
L=76 pb^{-1}
# 1105

202 GeV
L=23 pb^{-1}
# 347

- Nessuna deviazione significativa dalle previsioni dei modelli PS a ciascuna energia di LEP2 indagata
  (NB: i modelli usati implementano la frammentazione partonica in modi differenti)

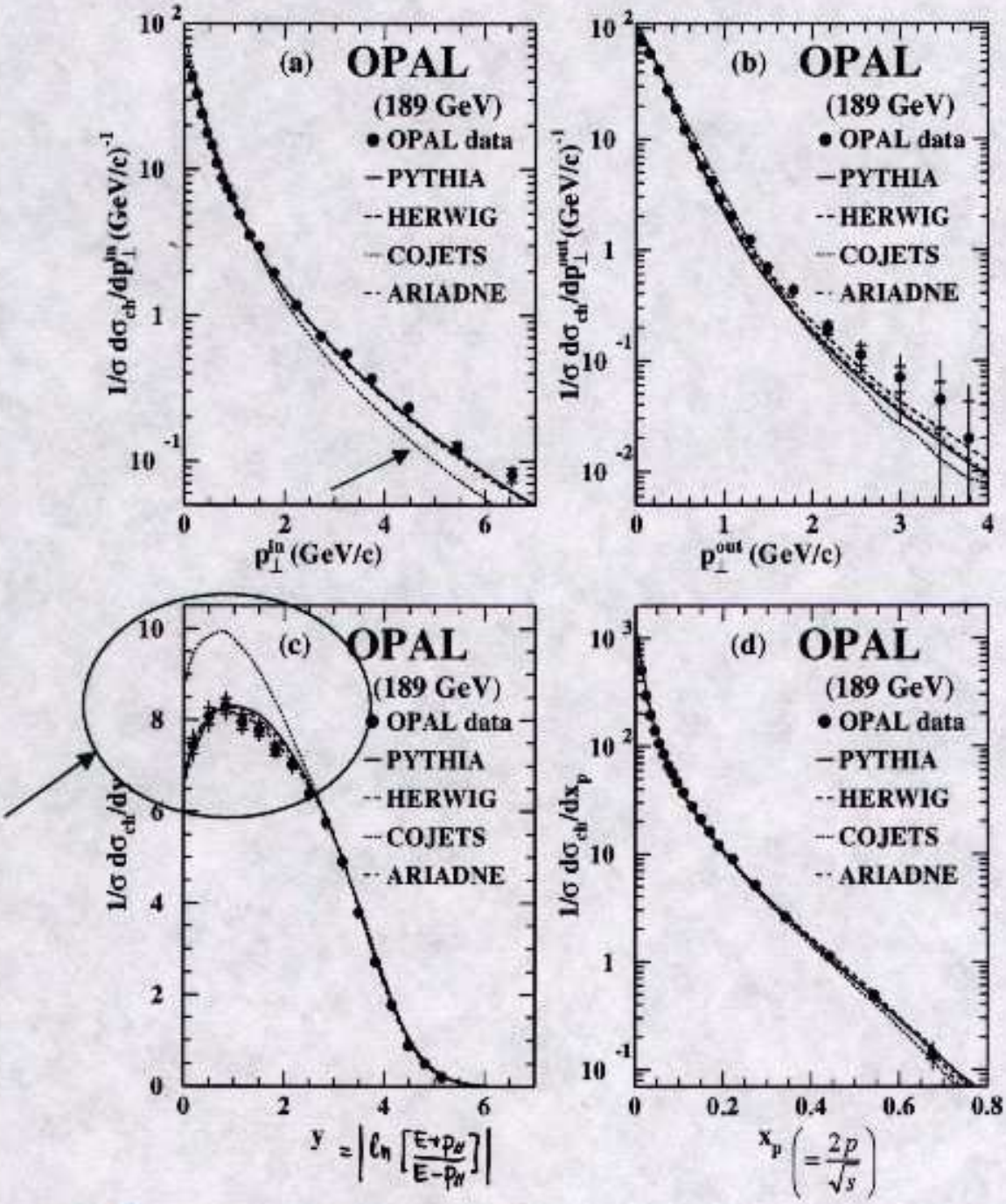
"Jet rates"

✓ Frequenze relative di eventi a più jets rispetto alla totale produzione mh (schemi usati: Jade (E0), Durham, Cone)



✓ Differenti modelli PS in accordo con i dati sperimentali ("meglio HW"?)
(indipendentemente dallo schema di ricombinazione utilizzato)

Spettri d'impulso di particella carica

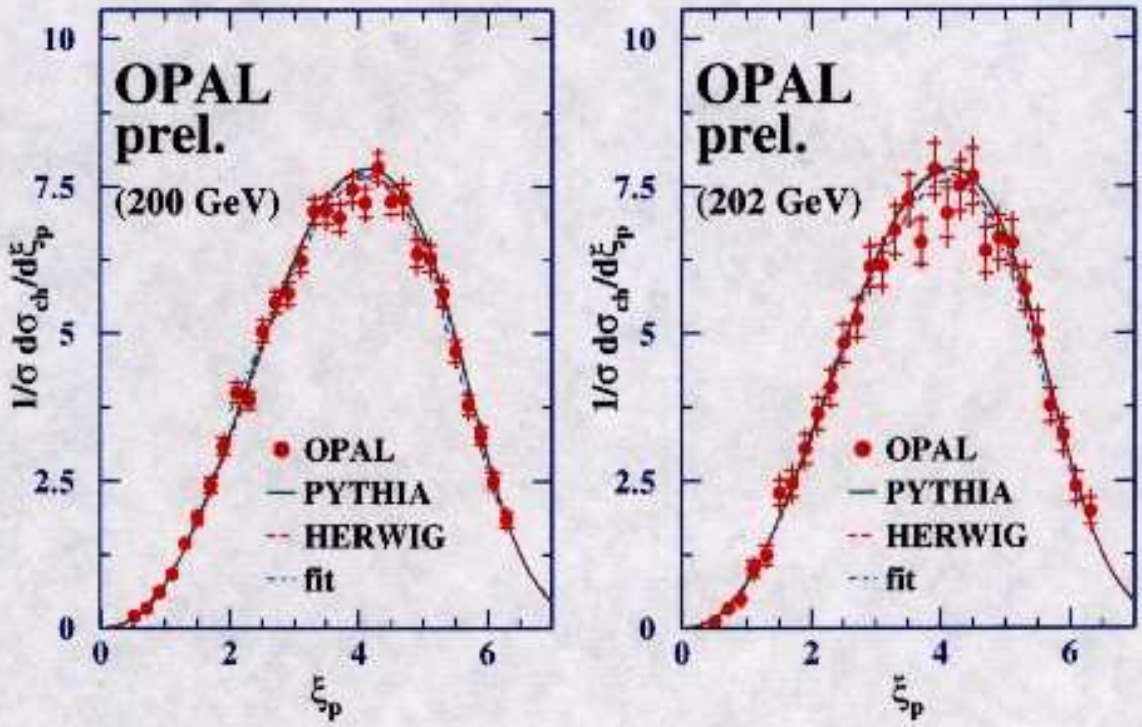


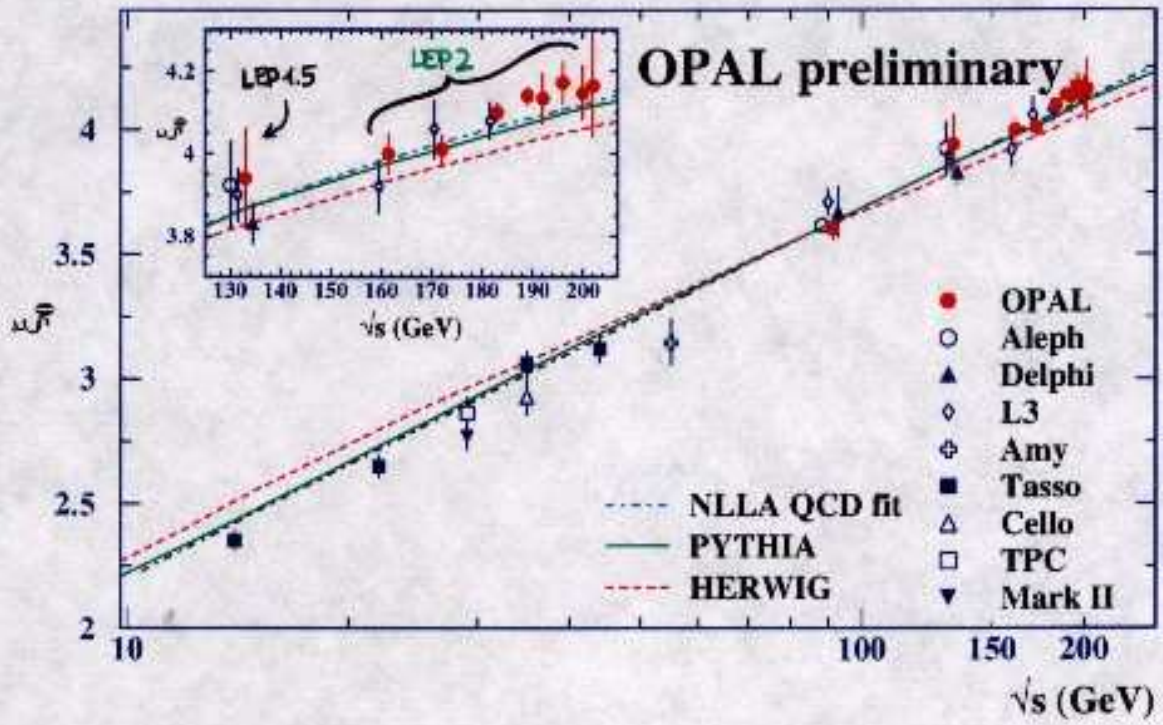
L=186.3 pb^{-1}
# 3277

- ✓ buon accordo con PY, HW, AR
- ✓ produzione particelle cariche a bassa *y* sovrastimata da CJ

200 GeV L=76 pb^{-1} # 1105

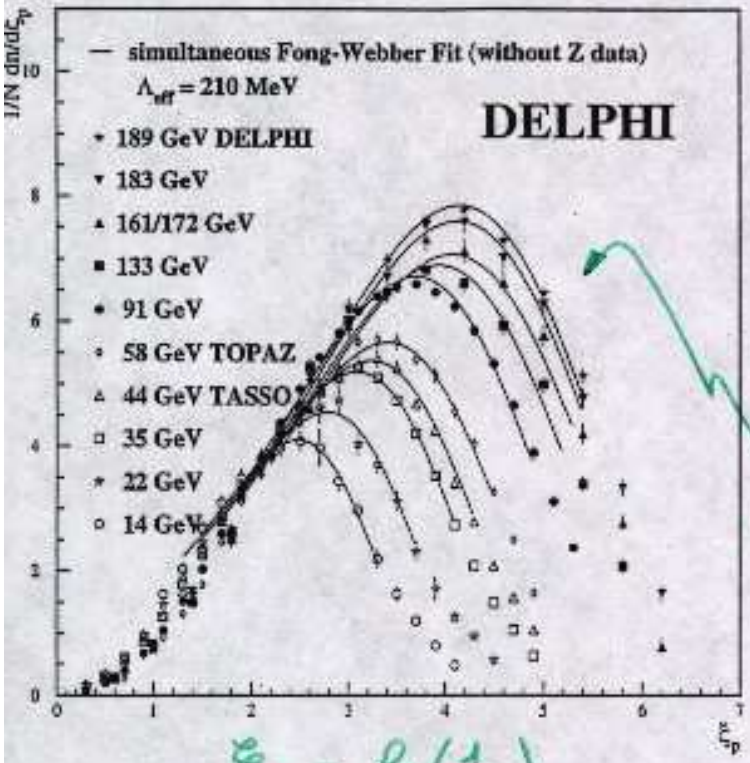
202 GeV L=23 pb^{-1} # 347





STUDIES OF COHERENCE EFFECTS.

DELPHI 99-19 (MARCH '99)

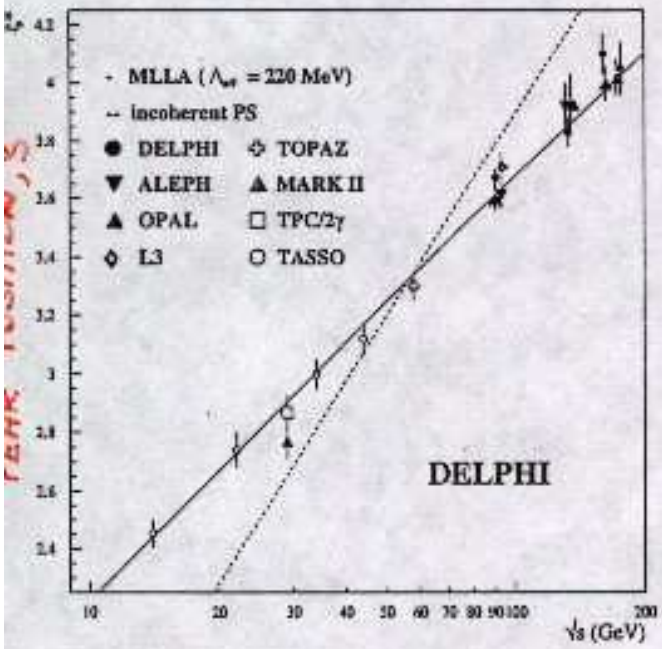


$$\xi_p = \ln\left(\frac{1}{x_p}\right)$$

SHAPE OF "PARTONIC" ξ_p DISTRIBUTION PREDICTED IN MLLA OF QCD (DOKSHITZER ET AL.)

~ DISTORTED GAUSSIAN WITH "HUMP BACKED" PLATEAU DUE TO SOFT GLUON SUPPRESSION

- MLLA (+ LPHD ASSUMPTION) CAN DESCRIBE "HADRON LEVEL" DISTR. UP TO HIGHEST LEP2 ENERGY

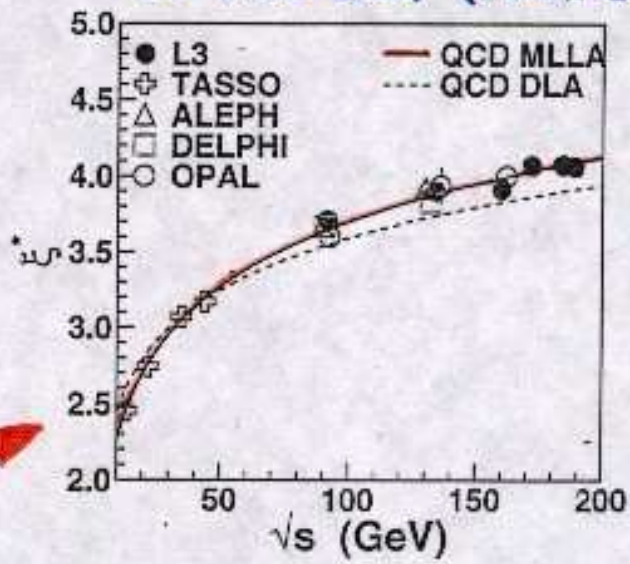


- PEAK POSITION, ξ^*, (INSENSITIVE TO NON-PERT. EFFECTS) PREDICTED TO EVOLVE WITH ENERGY:

$$\xi^* = 0.5 \cdot \ln\frac{E_{BEAM}}{\Lambda_{EFF.}} + \sqrt{c} \cdot \sqrt{\ln\frac{E_{BEAM}}{\Lambda_{EFF.}}} - c$$

PREDICTION CONSISTENT WITH DATA

L3 NOTE 2364 (MARCH '99)



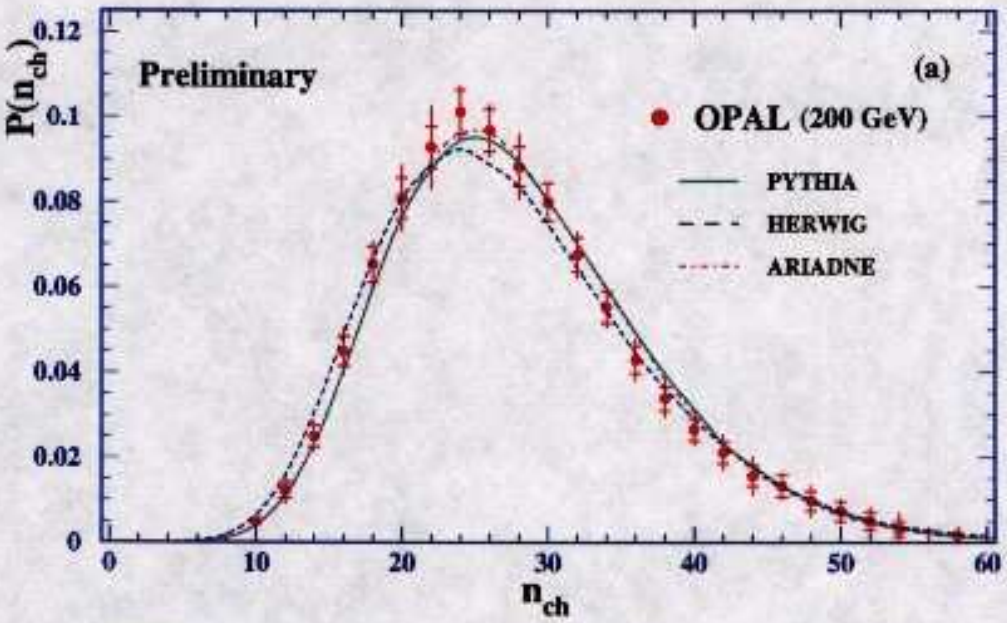
FIRST TERM IN ξ^* $\left(= 0.5 \ln\frac{E_{BEAM}}{\Lambda_{EFF.}}\right)$ IS THE DOUBLE-LOG-APPROX.

MLLA CORRECTION TERMS ADDED PROVIDE BETTER DESCRIPTION OF THE DATA.

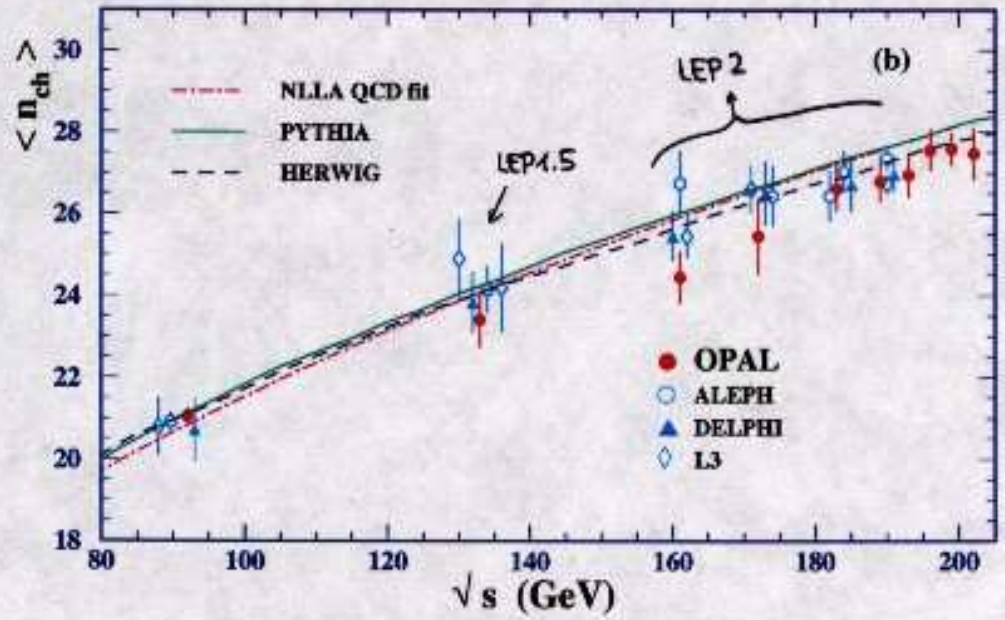
Molteplicità adronica carica

Previsione analitica
NLLA QCD+LPHD

$$< n_{ch} > = K_{LPHD} \cdot \alpha_s^{\,b} \cdot \exp \frac{c}{\sqrt{\alpha_s}} \cdot \left(1 + d \cdot \sqrt{\alpha_s}\right)$$

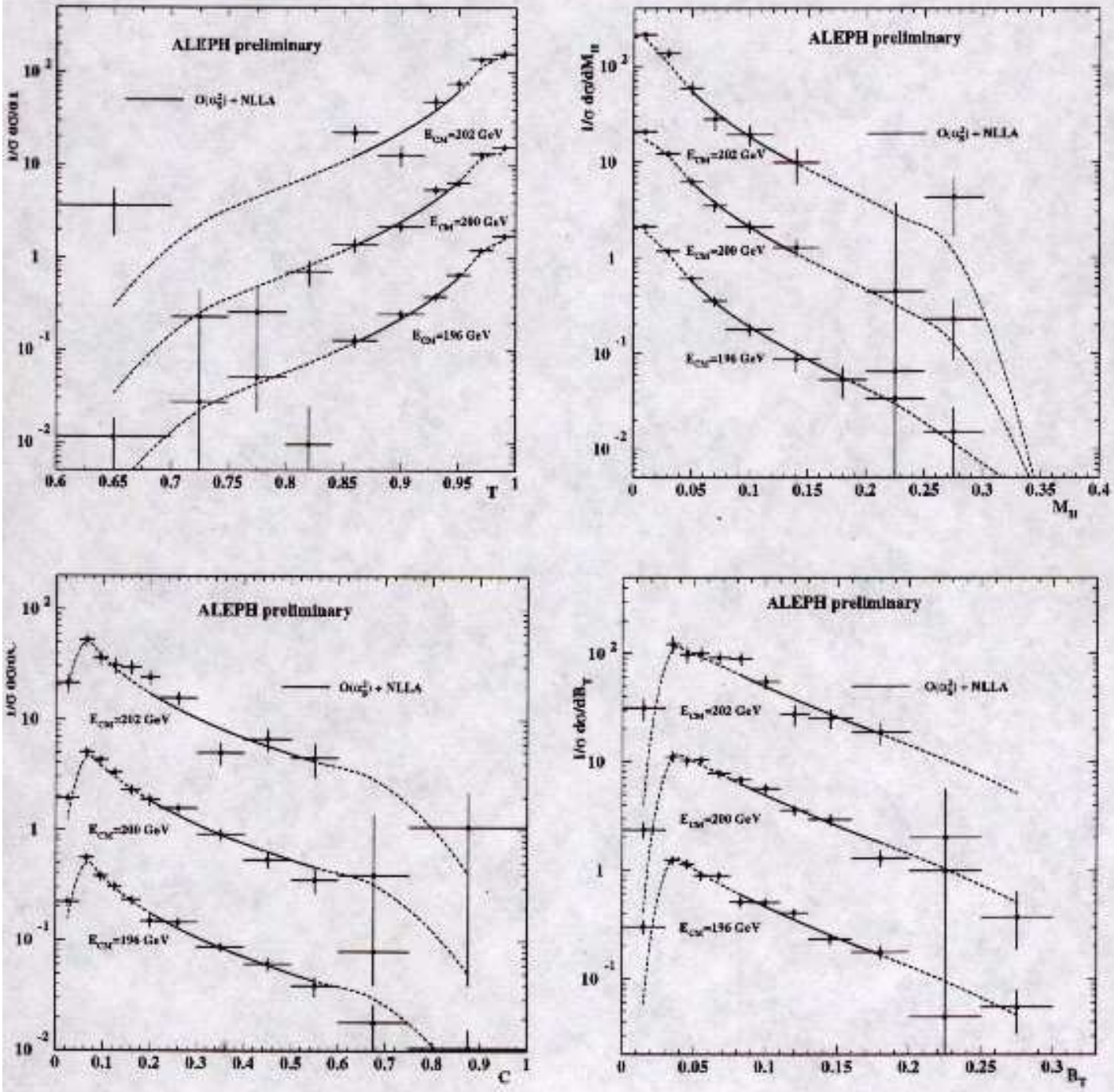


L=76 pb^{-1}
# 1105

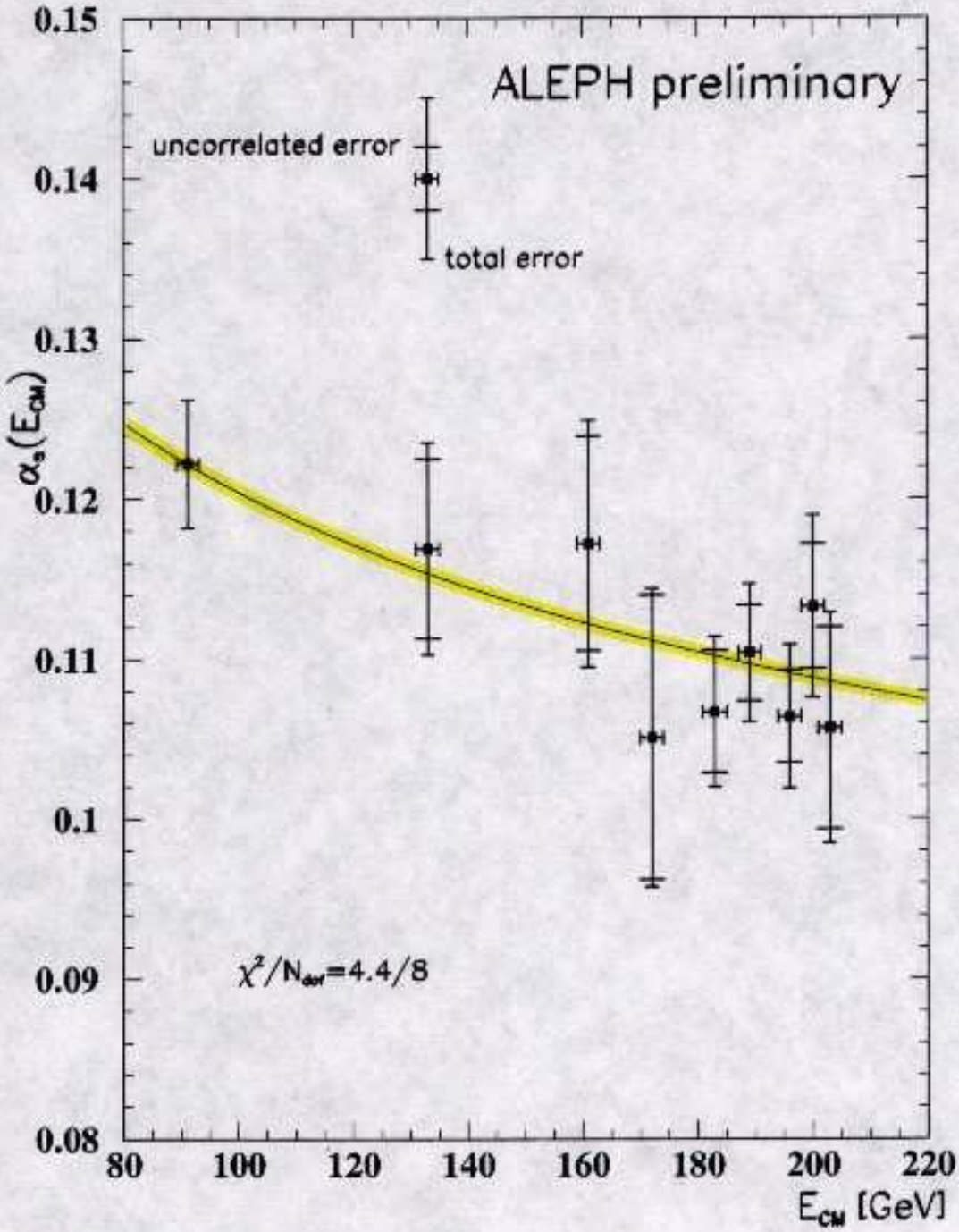


✓ Le distribuzioni in molteplicità, a tutte le energie di LEP2, sono ben riprodotte dai modelli PS (tranne CJ)

Misura di α_s da **distribuzioni** di variabili "event shape"



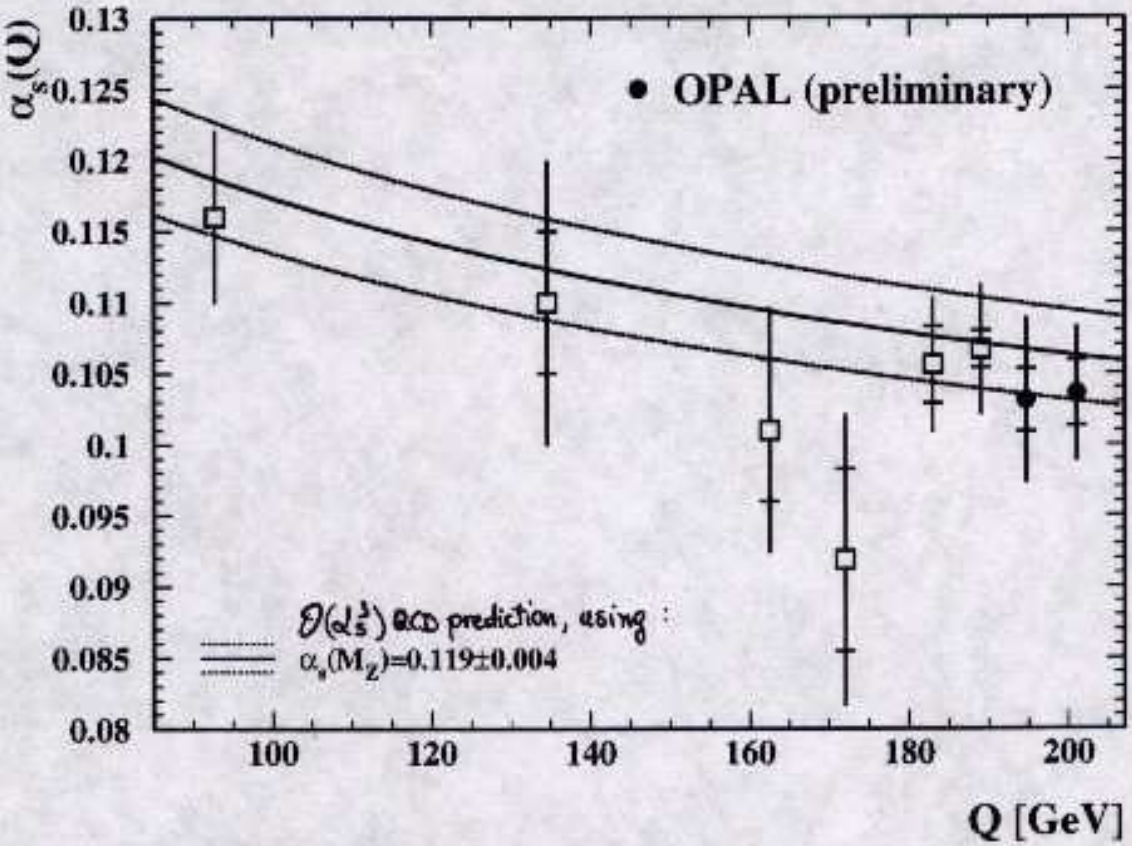
Daniele Bonacorsi - OPAL, INFN Bologna

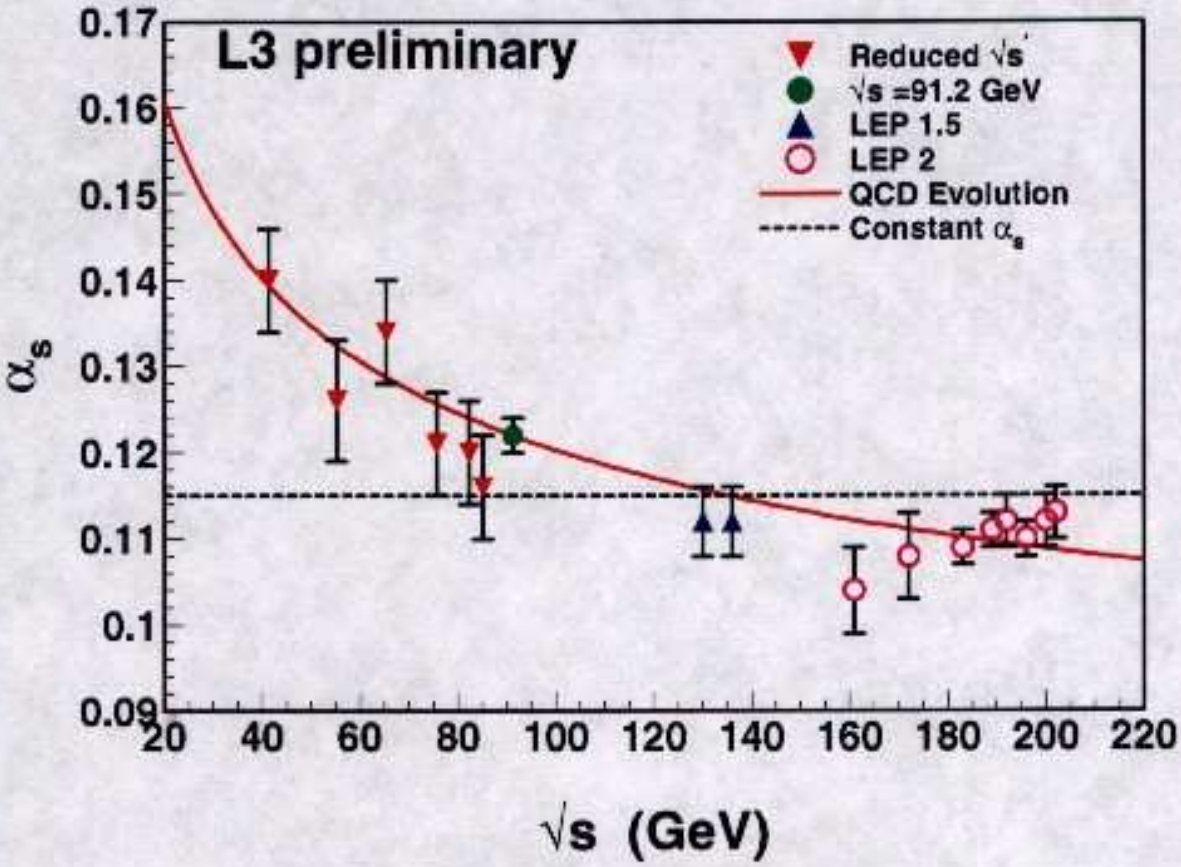


α_s (196 GeV) = 0.1065 ± 0.0027 (stat) ± 0.0018 (sist) ± 0.0035 (theo)

α_s (200 GeV) = 0.1133 ± 0.0030 (stat) ± 0.0018 (sist) ± 0.0042 (theo)

α_s (202 GeV) = 0.1051 ± 0.0046 (stat) ± 0.0018 (sist) ± 0.0034 (theo)


$\alpha_s(Q)$
• OPAL (preliminary)
$\mathcal{O}(\alpha_s^3)$ QCD prediction, using :
$\alpha_s(M_Z)$=0.119±0.004
Q [GeV]


L3 preliminary
Reduced √s
√s =91.2 GeV
LEP 1.5
LEP 2
QCD Evolution
Constant α_s
α_s
√s (GeV)

4. MISURA DELLA MASSA DEL QUARK b

m_b È UNO DEI PARAMETRI FONDAMENTALI DI QCD

m_b È STATA MISURATA SOLO A BASSA ENERGIA

IL SIGNIFICATO DI m_b RICHIEDE SPIEGAZIONI

SI MISURA IL RAPPORTO $\left\{ \dfrac{R_{3,\,b\,tag}}{R_{3,\,uds\,tag}} \right.$ (ALEPH, DELPHI)

DA RAPPORTO SI CALCOLA m_b

IL VALORE OTTENUTO, $m_b(M_Z) = (3.14 \pm 0.44)\,GeV$, È COMPATIBILE CON I VALORI OTTENUTI A BASSA ENERGIA, ASSUMENDO IL RUNNING DI m_b

SI STA CERCANDO DI UTILIZZARE LE VARIABILI DI FORMA DEGLI EVENTI, MA PER ORA NON SI SONO OTTENUTI VALORI ATTENDIBILI DI m_b

Introduzione

1) Particelle accelerate emettono radiazione
2) Sotto l'influenza della stessa forza, particelle pesanti sono meno accelerate di quelle leggere

$$F = m\,a$$

Particelle pesanti emettono meno radiazione

La frazione di eventi a 3-jet per quarks b e' piu' piccola di quella per quarks leggeri

Ma cos'e' m_b?

- Due schemi (ben definiti solo in QCD perturbativa):
  - Pole mass scheme

    La massa e' definita come posizione del polo del propagatore del quark, e non viene modificata da correzioni radiative

$$\propto \frac{1}{q^2 - M_b^2}$$

  - Running mass scheme ($\overline{MS}$)

    La massa e' un parametro renormalizabile nella lagrangiana, e quindi dipende da correzioni a ordini superiori

$$m_b(\mu^2)$$

Relazione tra i due schemi

$$M_b^2 = m_b^2(\mu^2)\left[1+\frac{\alpha_s}{2\pi}\left(\frac{16}{3}-4\log\frac{m_Z^2}{\mu^2}\right)\right]+O(\alpha_s^2)$$

$$m_b(\mu^2) = m_b(m_Z^2)\left(\frac{\alpha_s(m_Z^2)}{\alpha_s(\mu^2)}\right)^{-\frac{8}{\beta_0}}$$

Metodo sperimentale (DELPHI)

Da estrarre

$$\left(\frac{R_{3,btag}}{R_{3,udstag}}\right)^{measured} = \frac{R^{pert}_{3,b/l}\, H_{b/l}\, D_{bb} + R^{pert}_{3,c/l}\, H_{c/l}\, D_{cb} + D_{lb}}{R^{pert}_{3,b/l}\, H_{b/l}\, D_{bl} + R^{pert}_{3,c/l}\, H_{c/l}\, D_{cl} + 1}$$

$$D_{xy} = \frac{DC_x}{DC_l}\,\frac{T_{xy}\,P_{xy}}{T_{xl}\,P_{xl}} \;;\quad DC = \frac{R^{Detlevel}_{3,x}}{R^{Hadlevel}_{3,x}}$$

dalla 'full simulation'

Correzione per il tag | purezza | Detector Corrections

$$H_{x/l} = \frac{HC_x}{HC_l} \;;\quad HC_x = \frac{R^{Hadlevel}_{3,x}}{R^{Partlevel}_{3,x}}$$

→ Correzione di adronizzazione:
da vari modelli MC

Risultati *preliminari*

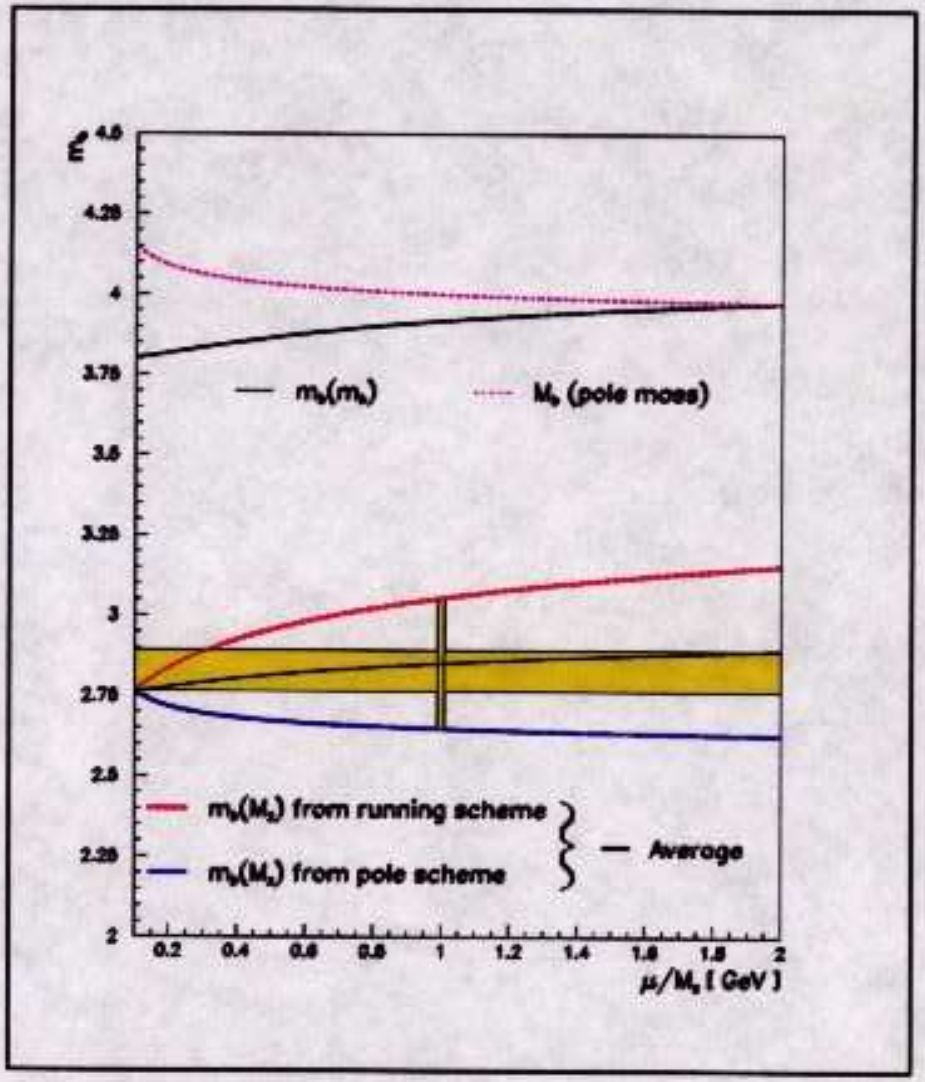
ALEPH $R_{3b/uds}(0.02) = 0.963 \pm 0.005\,(stat) \pm 0.005\,(exp) \pm 0.007\,(had)$

DELPHI $R_{3b/uds}(0.02) = 0.962 \pm 0.005\,(stat) \pm 0.004\,(exp) \pm 0.007\,(had)$

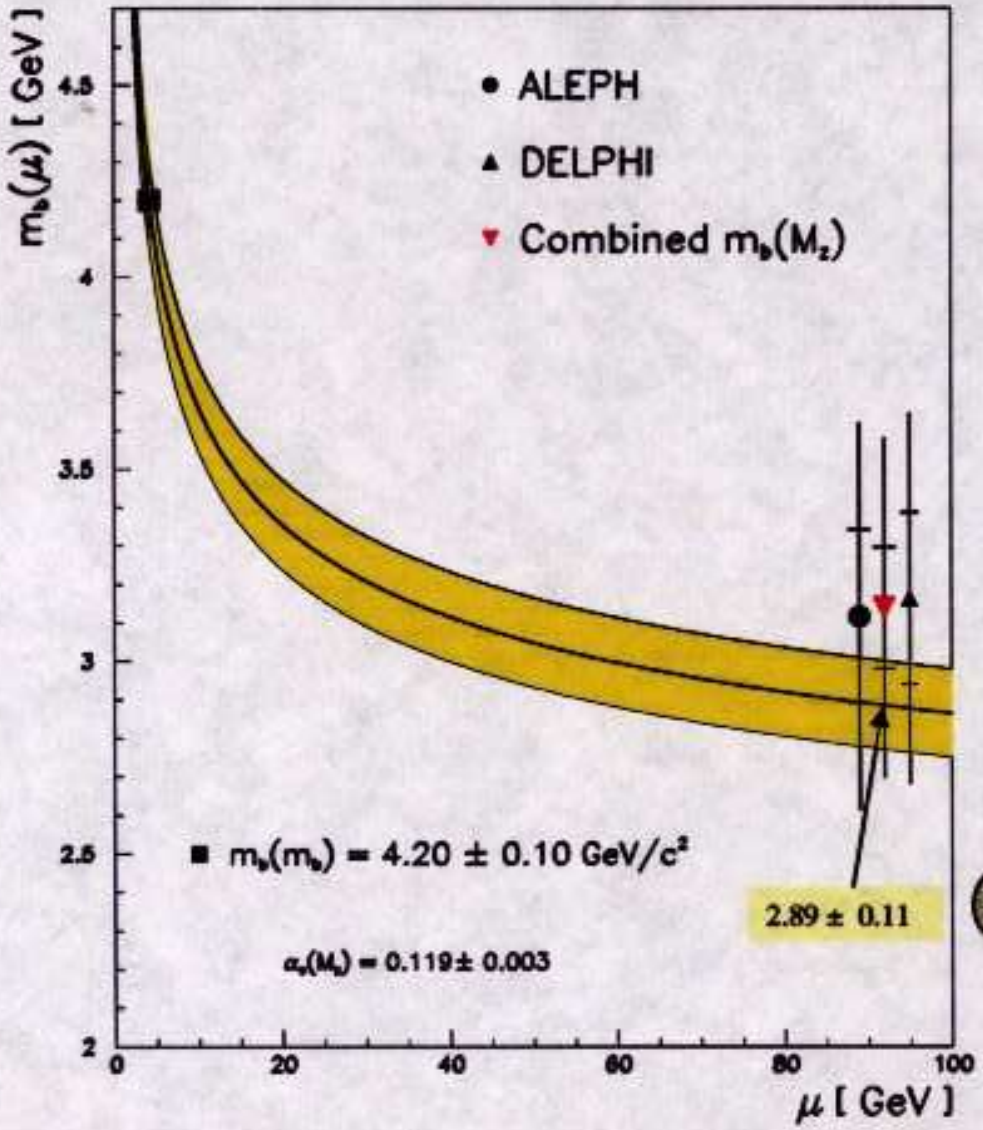
COMB $R_{3b/uds}(0.02) = 0.9625 \pm 0.0035(stat) \pm 0.0031(exp) \pm 0.0070(had)$

Estrazione della massa

- Due schemi
  - Running Scheme - Pole Scheme
  - si prende la media e poi meta' della differenza come errore
- Dipendenza dalla scala
  - variazione della scala di rinormalizzazione μ da $0.1M_Z$ a $2M_Z$



Risultato



Prendendo la combinazione

$$m_b(M_z) = 3.14 \pm 0.16\ (\text{stat}) \pm 0.14\ (\text{exp}) \pm 0.31\ (\text{had}) \pm 0.23\ (\text{theo})$$

$$= 3.14 \pm 0.44\ \text{GeV}$$

$$\approx \pi$$

5. CORRELAZIONI DI BOSE EINSTEIN

2 O PIU' BOSONI IDENTICI TENDONO AD ESSERE VICINI NELLO SPAZIO DELLE FASI

a. 2π RAGGIO DELLA REGIONE DI EMISSIONE (R.di E.)

$$Q^2 = (P_2 - P_1)^2 = m_{12}^2 - 4m_1^2$$

$$C_2(P_1, P_2) = \frac{\rho(P_1, P_2)}{\rho(P_1)\,\rho(P_2)} \Rightarrow \frac{N_{LIKE}}{N_0} = \frac{N_{LIKE}}{N_{MIXED\ PARTICLES\ FROM\ DIFFERENT\ EV.}} = \left(\frac{N_{LIKE}}{N^{+-}}\right)_{DATA} \Big/ (\quad)_{MC}$$

FIT ALLA FORMULA DI GOLDHABER $\Rightarrow (R, \lambda)$

$$C_2(Q) = N\left(1 + \lambda e^{-Q^2R^2}\right)\left(1 + \varepsilon Q + \delta Q^2\right)$$

RIMUOVENDO REGIONI CON RISONANZE

b. DIPENDENZA DI R DALLA MOLTEPLICITA'

c. $\pi\pi$ IN 3 VARIABILI PER VEDERE FORMA DELLA R.di E.

SISTEMA DI RIFERIMENTO LMCS, VARIABILI $Q_\ell, Q_{t\,SIDE}, Q_{t\,OUT}$

ANALISI DI L3, DELPHI, OPAL ALLA Z°

FUNZIONE DI CORRELAZIONE

CORREZIONI PER EFFETTI COULOMBIANI, FONDO RISONANZE, ..

RISULTATI IN 3-DIMENSIONI

FIT ALLA FORMULA DI GOLDHABER - ESTESA

RISULTATI $(\chi^2/DOF) \simeq 1.04 - 1.06$

$\lambda \simeq 0.26, 0.41, 0.44$

$$R = \frac{R_{t\,SIDE}}{R_L} = 0.818 \pm 0.018_{STAT} \pm {}^{0.008}_{0.050}{}_{SYST} \quad \text{OPAL}$$

$$= 0.80 \pm 0.02 \quad \pm {}^{0.03}_{0.18} \quad \text{L3}$$

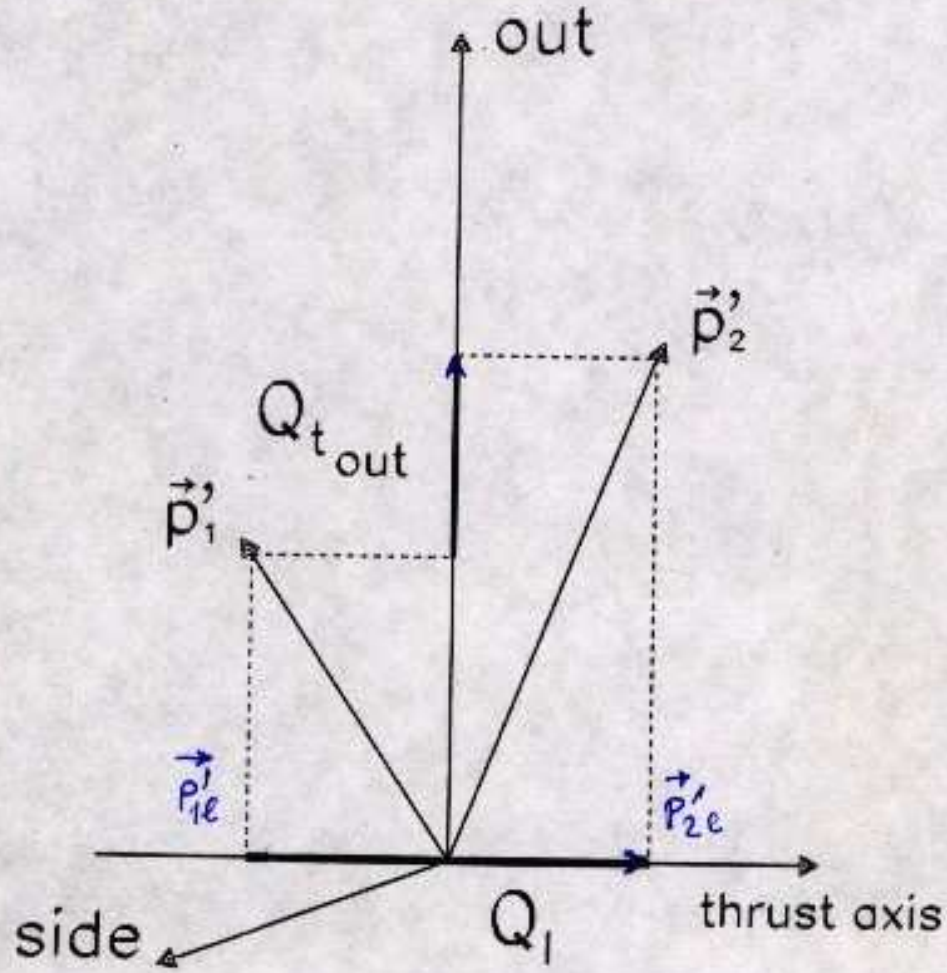
$$= 0.62 \pm 0.02 \quad \pm 0.05 \quad \text{DELPHI}$$

DEBOLE DIPENDENZA DA y_{CUT}

CONCLUSIONE : SORGENTE ELLISSOIDICA

d. $R_{2\pi}$ DIPENDE DA MASSA DELLE PARTICELLE

e. CORRELAZIONI TRIPLE



LONGITUDINALLY COMOVING SYSTEM (LCMS)

$$Q_t^2 = \left(p'_{t\,out\,2} - p'_{t\,out\,1}\right)^2 + \left(p'_{t\,side\,2} - p'_{t\,side\,1}\right)^2$$

$$Q_\ell^2 = \left(p'_{\ell 2} - p'_{\ell 1}\right)^2$$

The Correlation Function

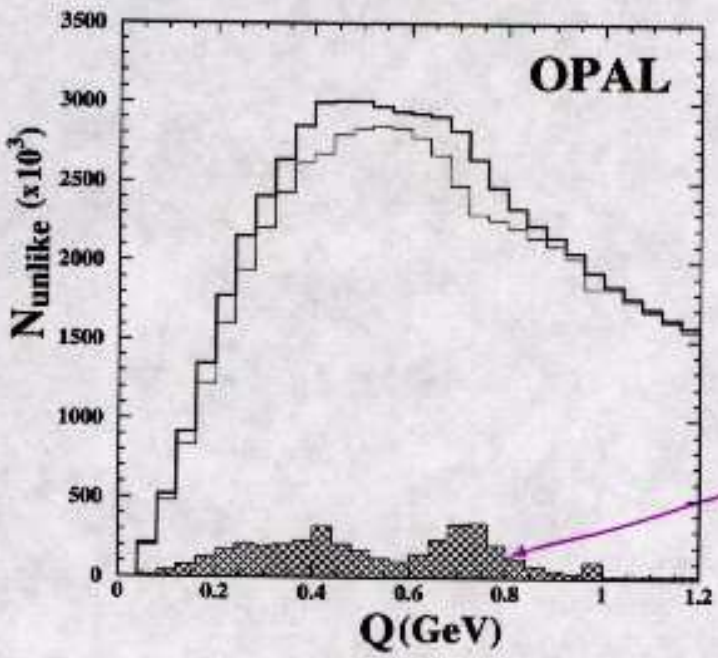
$$C(p_1, p_2) = \frac{\rho(p_1,p_2)}{\rho(p_1)\,\rho(p_2)}$$

OPAL

$$C'(Q_{t,out};Q_{t,side};Q_l) = \left(\frac{N_{like}}{N_{unlike}}\right)_{DATA} \Big/ \left(\frac{N_{LIKE}}{N_{UNLIKE}}\right)_{MC}$$

Divided by the same ratio computed using Jetset (noBE) events

correction for Coulomb interactions



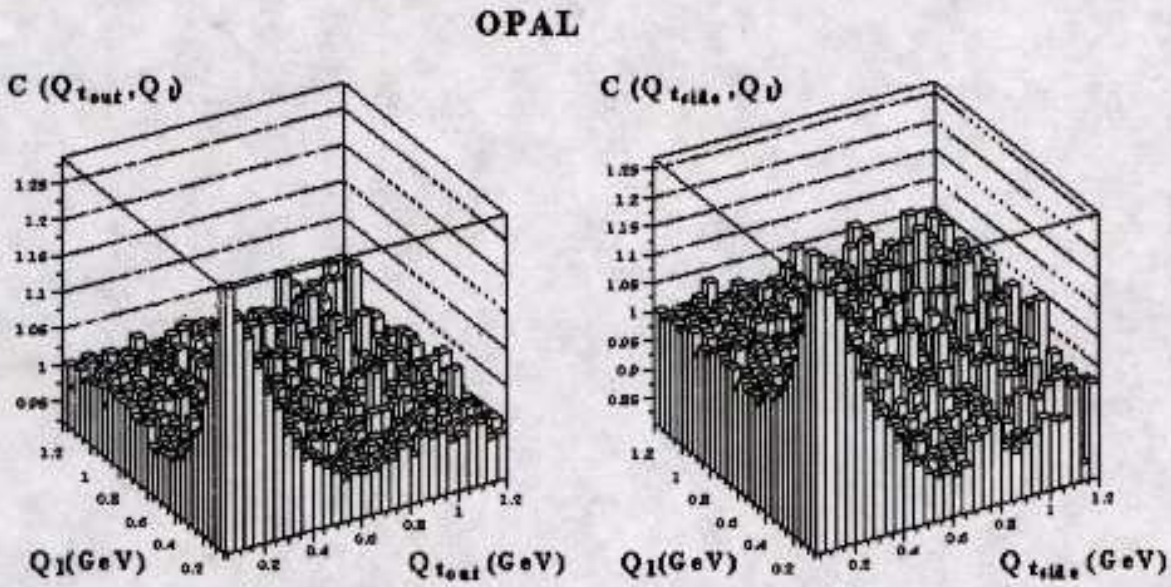
subtract $\pi^+\pi^-$ pairs from resonance decays

RESONANCE CONTRIBUTIONS

K^0_S
ω
η
η'
ρ^0
f_0 (980)
f_2 (1270

DURHAM $y_{CUT} = 0.04$

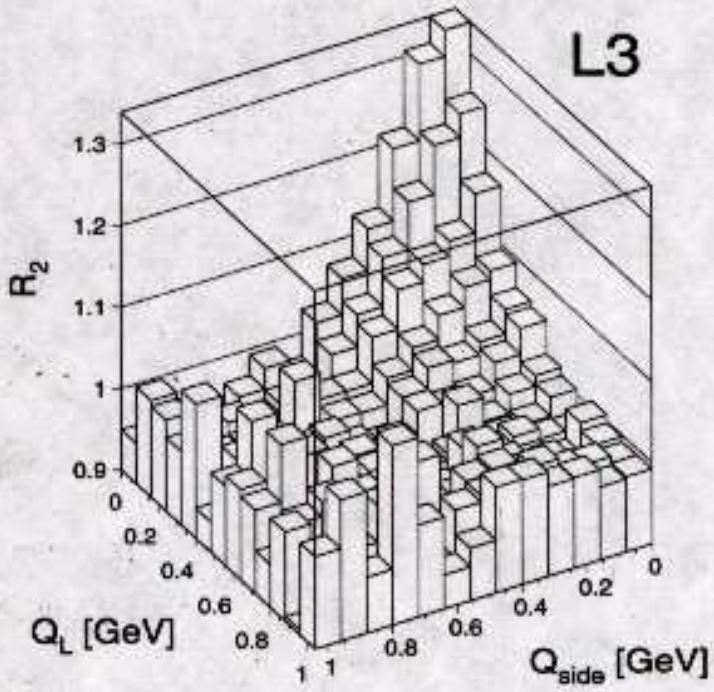
OPAL (two-jets)



Q_{tout} DEPENDS ALSO ON THE DIFFERENCE IN EMISSION TIME

DEPENDS ONLY ON THE DIFFERENCE IN EMISSION SPACE

L3 (inclusive)



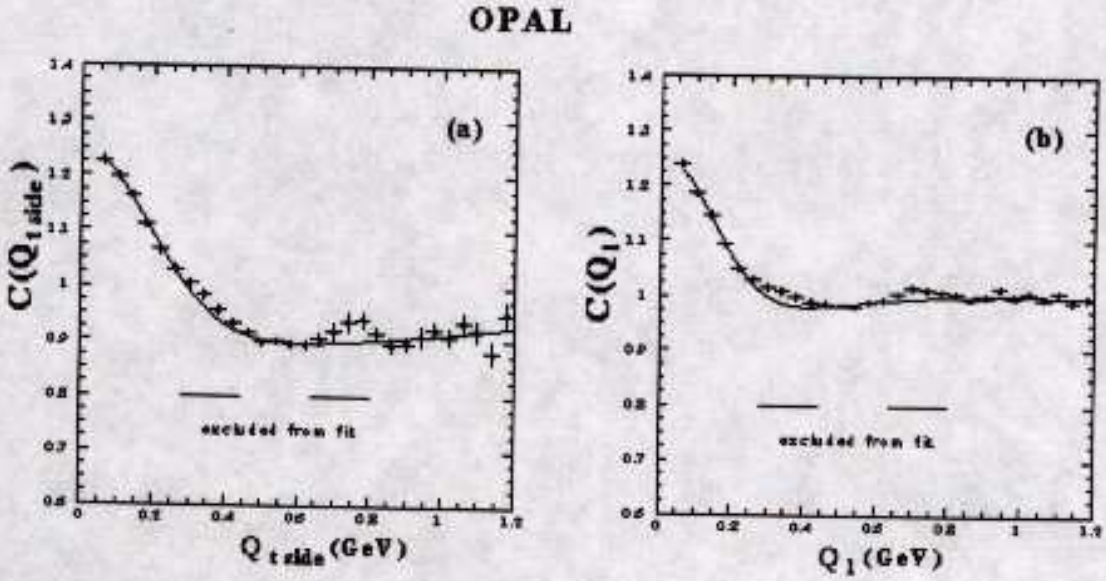
the component Qi not plotted is restricted to values < 200 (240) MeV

EXTENDED GOLDHABER

$$C(Q_{t,o}, Q_{t,s}, Q_\ell) = N\left[1+\lambda\, e^{-(Q_{to}^2 R_{to}^2 + Q_{ts}^2 R_{ts}^2 + Q_\ell^2 R_\ell^2)}\right] F$$

$$F(Q_{tout}, Q_{ts}, Q_\ell) = \left(1+\delta_o Q_{to} + \delta_s Q_{ts} + \delta_\ell Q_\ell + \varepsilon_o Q_{to}^2 + \varepsilon_s Q_{ts}^2 + \varepsilon_\ell Q_\ell^2\right)$$ OPAL

F factor $= (1 + \delta Q_l + \varepsilon Q_{t,out} + \xi Q_{t,side})$ (L3) with Q_i^2 terms (OPAL) to take into account long-range correlations due to energy, momentum and charge conservation.



residual effects of pairs from resonance decays ➡ regions excluded from the fit range

Results

FOR 2-jet EVENTS
USING $y_{CUT} = 0.04$

OPAL

$$R_{t,out} = (0.647 \pm 0.011(\text{stat}) \pm {}^{0.024}_{0.124}\ (\text{syst}))\ \text{fm}$$

$$R_{t,side} = (0.809 \pm 0.009(\text{stat}) \pm {}^{0.019}_{0.032}\ (\text{syst}))\ \text{fm}$$

$$R_l = (0.989 \pm 0.011(\text{stat}) \pm {}^{0.030}_{0.015}\ (\text{syst}))\ \text{fm}$$

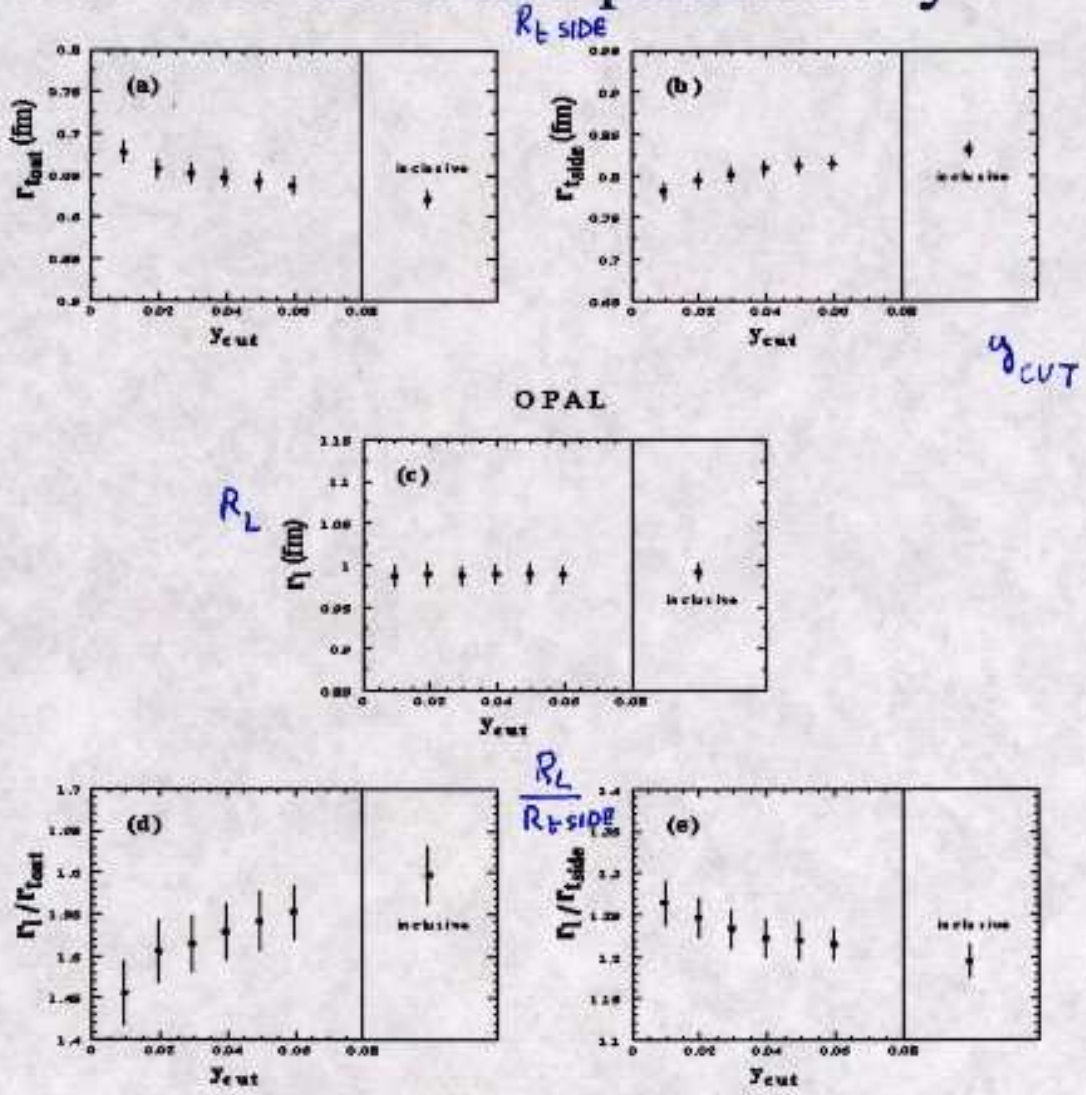
$$\boxed{\frac{R_l}{R_{t,side}} = 1.222 \pm 0.027(\text{stat}) \pm {}^{0.075}_{0.012}\ (\text{syst})}$$

corresponding to

$$\boxed{\frac{R_{t.side}}{R_l} = 0.818 \pm 0.018(\text{stat}) \pm {}^{0.008}_{0.050}\ (\text{syst})}$$

Dependence on y_{cut}

OPAL ➡ select two-jet events with the Durham algorithm and different values of the resolution parameter y_{cut}



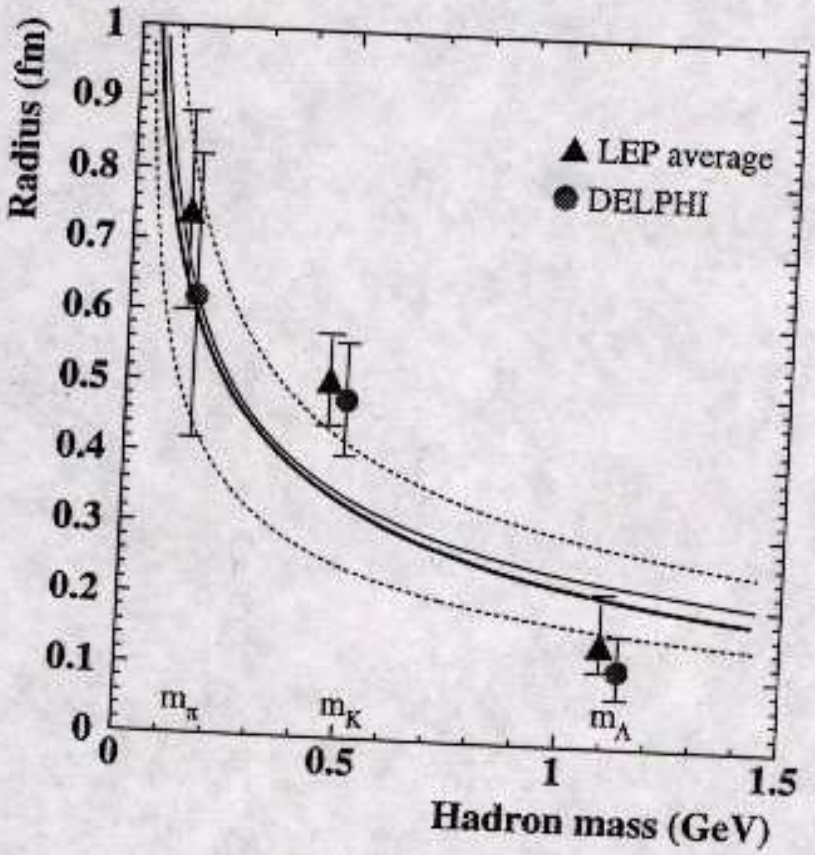


Figure 3: The measured emitter radius r as a function of the hadron mass m compared to some theoretical predictions (see text).

6. CONCLUSIONI

LE MISURE CON ALTA STATISTICA DEGLI STATI ADRONICI ALL'ENERGIA DELLA Z° CONTINUANO A FORNIRE INTERESSANTI INFORMAZIONI

- MASSA DEL QUARK b
- CORRELAZIONI DI B.E.
- EVENTI A 3 JETS , ...

LE MISURE DI QCD A LEP2 HANNO PORTATO A NUOVE VERIFICHE DEL M.S. E DEI MONTECARLI UTILIZZATI
HANNO ULTERIORMENTE CONFERMATO IL RUNNING DI α_s

NUOVI DATI E NUOVE ANALISI PERMETTERANNO DI AFFRONTARE MEGLIO GLI EVENTI $\gamma\gamma$