

LATHUILE 2002

MARCH 3-9

RECENT QCD RESULTS AT LEP

F. FABBRIO - INFN BOLOGNA

(ON BEHALF OF THE LEP EXPERIMENTS)

OUTLINE

- GLOBAL PROPERTIES OF HADRONIC EVENTS

- HOW DO THEY EVOLVE WITH ENERGY

- HOW WELL ANALYTIC PREDICTIONS AND QCD-BASED MODELS DESCRIBE THE DATA (OVER ~ 200 GEV RANGE)

- RECENT MEASUREMENTS OF α_s

- UNBIASED GLUON JET MULTIPLICITY

IMPRESSIVE PERFORMANCE OF LEP MACHINE

$$\int \mathcal{L} dt \gtrsim 200 \text{ pb}^{-1} / \text{YEAR}$$

(SINCE 1998)

$$\sqrt{s} \rightarrow 209 \text{ GeV}$$

(MAX)

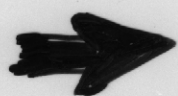
MORE STRINGENT
TESTS OF QCD
HAVE BECOME
POSSIBLE

IMPOSSIBLE TO MENTION ALL INTERESTING
RESULTS FROM THE 4 LEP EXPERIMENTS

CONCENTRATE ON MOST RECENT ONES

MOSTLY PRELIMINARY

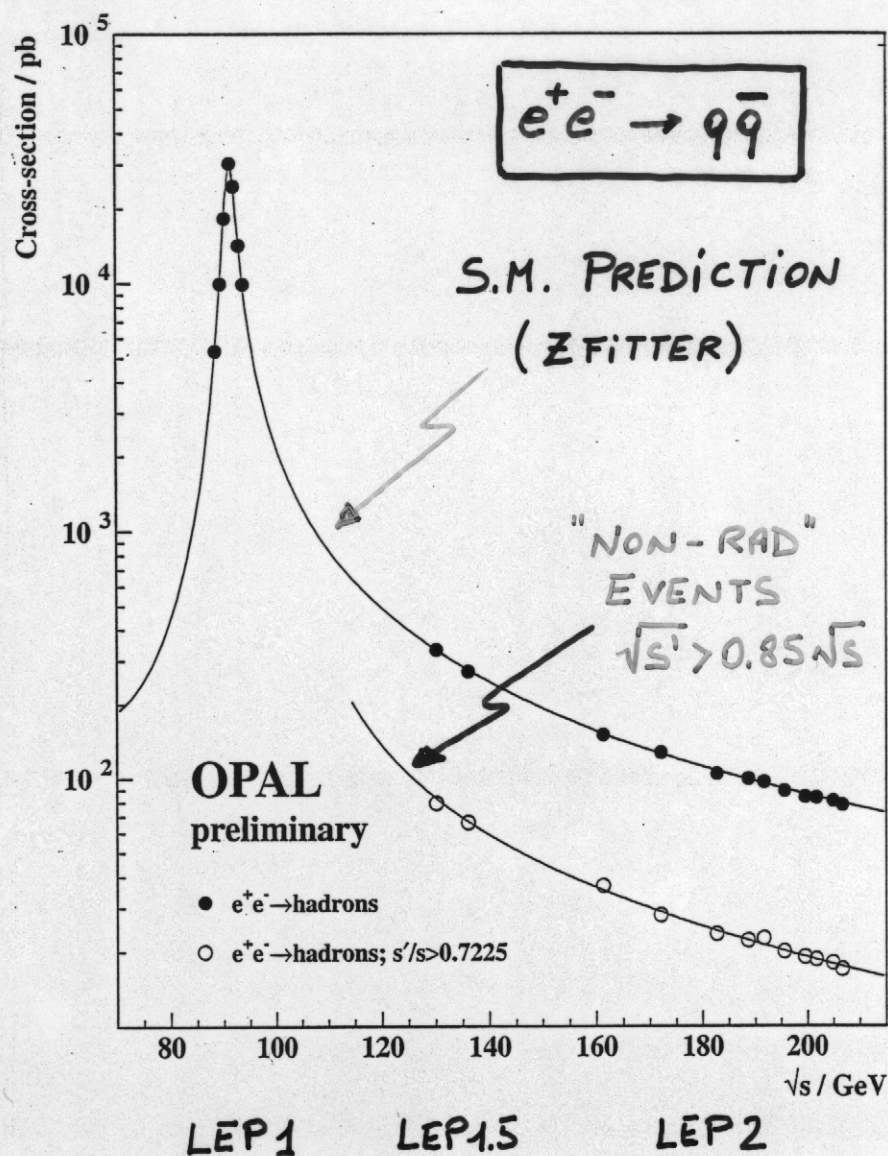
... AND NOT ONLY FROM LEP 2 DATA



NECESSARILY QUALITATIVE

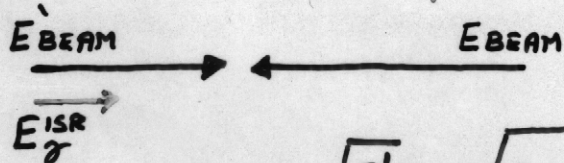
NO DETAILS

EXCELLENT AGREEMENT BETWEEN MEASURED $\sigma_{e^+e^- \rightarrow f\bar{f}}$ AND S.M. PREDICTIONS UP TO THE HIGHEST LEP ENERGIES



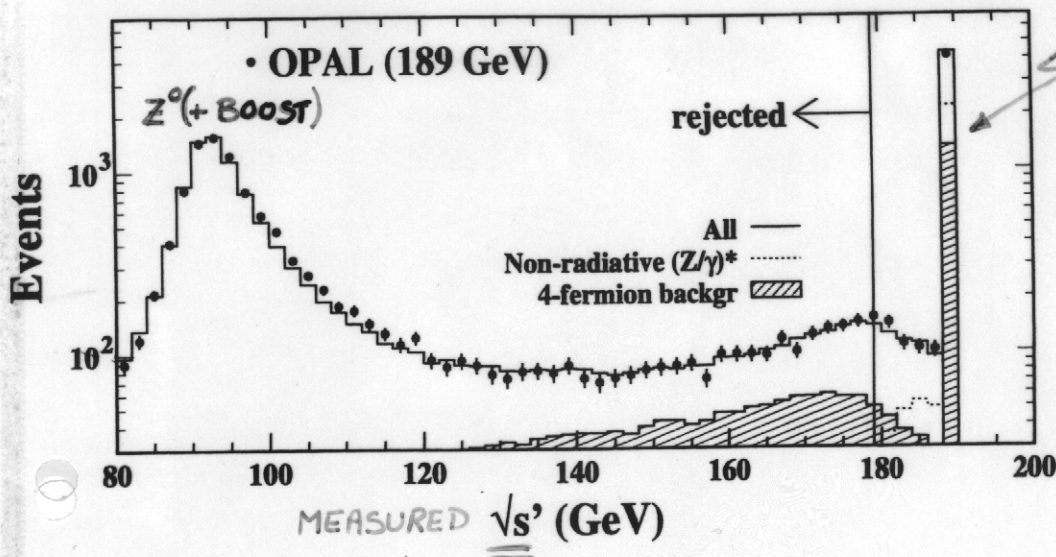
N.B. ABOVE Z^0 PEAK MOST DETECTED EVENTS ARE "RADIATIVE RETURNS" TO THE Z^0

- EFFECTIVE $\sqrt{s'}$ AVAILABLE TO PRODUCE THE HADRONIC SYSTEM AFTER I.S.R.



$$\sqrt{s'} = \sqrt{s - 2 E_{\gamma}^{ISR} \cdot \sqrt{s}}$$

- EASY TO SEPARATE RADIATIVE FROM NON-RADIATIVE EVENTS (BY RECONSTRUCTION OF EFFECTIVE $\sqrt{s'}$)
- BACKGROUND TO INTERESTING PROCESS $e^+e^- \rightarrow Z/\gamma^* \rightarrow q\bar{q}$ INCREASES WITH $\sqrt{s}$, MOSTLY FROM 4-FERMION PROCESS $e^+e^- \rightarrow W^+W^-$



NOMINAL ENERGY
EXAMPLE
SELECTION OF "NON-RADIATIVE" HADRONIC EVENTS

$$\sqrt{s} - \sqrt{s'} < 10 \text{ GeV}$$

BUT 4-FERMION BKG VERY HIGH (~30%)

↓
TO BE REDUCED

N.B.

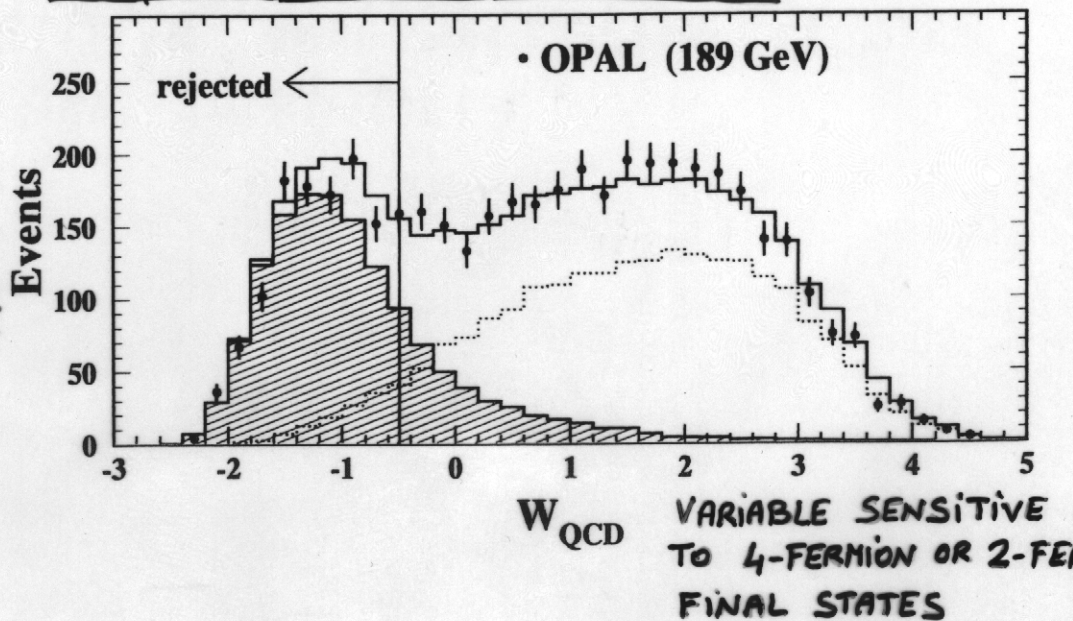
- DIFFERENT DEFINITIONS OF "NON-RAD" EVTS. ADOPTED BY EXP.
- + DIFFERENT TECHNIQUES TO DETERMINE $\sqrt{s'}$
- + DIFFERENT CUTS TO REDUCE 4-FERMION BKG.



DIFFERENT # SELECTED EVENTS
" " QUOTED PURITIES

EXAMPLE →

BKG. LEFT (IN THIS CASE) AFTER CUT ~ 10%



FINALLY

- SUBTRACT RESIDUAL BKG. USING MODELS { FULLY SIMULATED EVENTS, 4-FERM. AND $q\bar{q}$ (+ISR) }
- CORRECT DATA FOR DETECTOR EFFECTS, SELECTION BIAS, RESIDUAL I.S.

IT IS CLEAR THAT RELIABLE MODELS
ARE ESSENTIAL FOR EXPERIMENTALISTS

- MUST DESCRIBE MEASURED DISTRIBUTIONS
IN DETAIL
 - AT QUITE DIFFERENT ENERGIES
- ... AND MUST BE POSSIBLE TO INTERFACE
THEM TO THE DETECTOR SIMULATION

SEVERAL INTERESTING (WELL KNOWN)
"PRODUCTS" ON THE MARKET.

MOST COMPETITIVE AND SUCCESSFUL MODELS
SO FAR ARE DEFINITELY

QCD-BASED PARTON SHOWERS

HERWIG

PYTHIA/JETSET

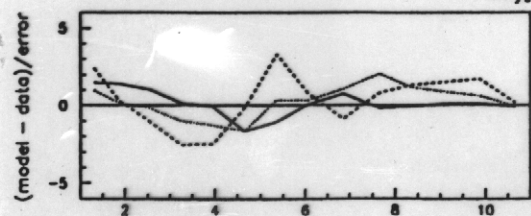
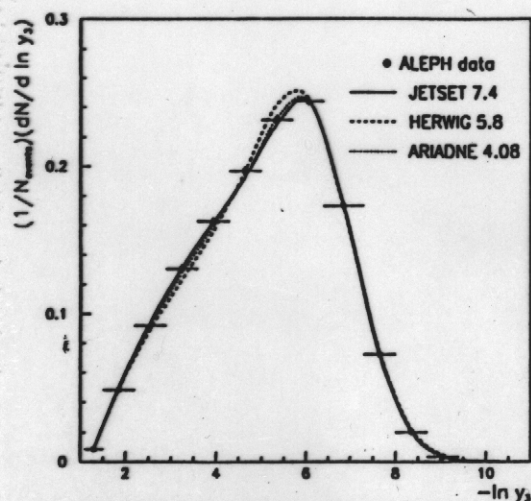
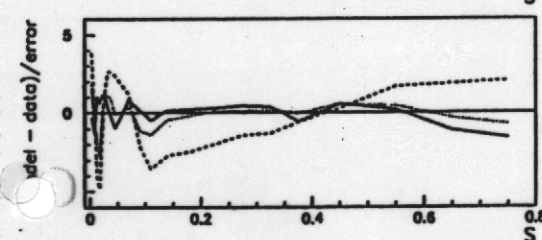
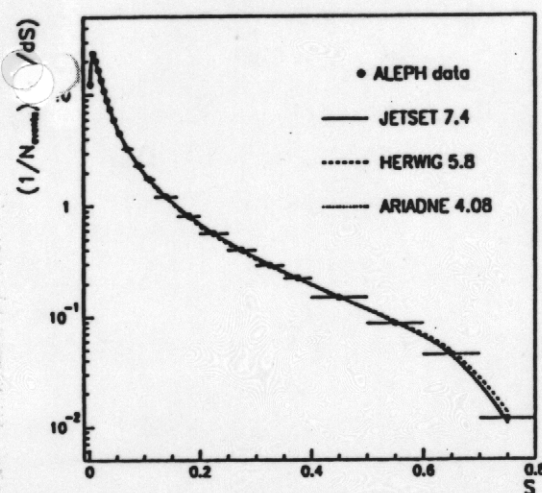
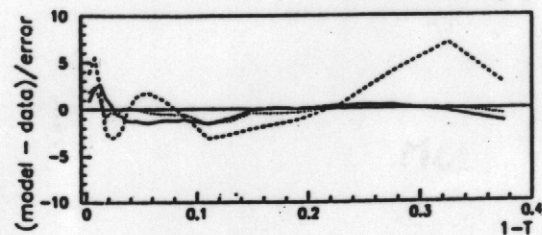
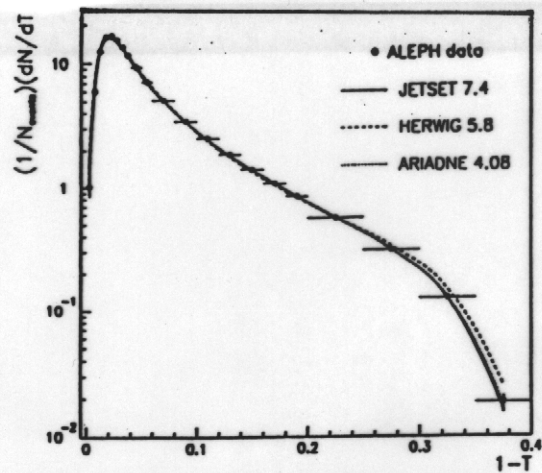
ARIADNE

... YES, THEY HAVE FREE PARAMETERS
(PERHAPS TOO MANY!)

WE HAVE A "SPECIAL PLACE" FOR A GOOD TUNING

LEP1 DATA

EXAMPLE : ALEPH TUNING [Phys. Rep. 294 (98)]



- CHOOSE SOME OBSERVABLES SENSITIVE TO FREE PARAMETER VALUES (SHAPES, INCLUSIVE PART. DISTR., ...)
- MEASURED AT LEP 1 (HIGH STATISTICS)
- AND OPTIMIZE FREE PARAMETERS

THEN

- TEST TUNED MODEL ON INDEPENDENT OBSERVABLES
- TEST HOW WELL MODELS WITH FREE PARAM. VALUES FIXED AT ONE $\sqrt{s}$ DESCRIBE HIGHER (LOWER) ENERGY DATA $\rightarrow$ PROVIDES AN INTERESTING CONSISTENCY CHECK OF QCD PREDICTIONS

N.B.

- QCD P.S. MODELS GIVE GOOD GLOBAL DESCRIPTION OF HADRONIC EVENTS BUT FAR FROM BEING PERFECT (SEE EXAMPLES)
- EACH EXP. FOLLOWS ITS OWN (LEGITIMATE) APPROACH FOR TUNING ...

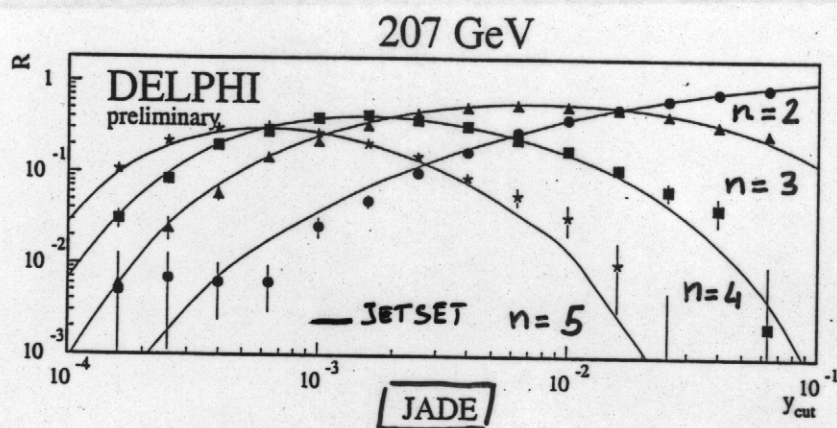


SAME MODELS BUT NOT EXACTLY SAME PREDICTIONS

JET RATES

FRACTION OF EVENTS WITH
 n OBSERVED JETS AT A
GIVEN RESOLUTION PARAM.

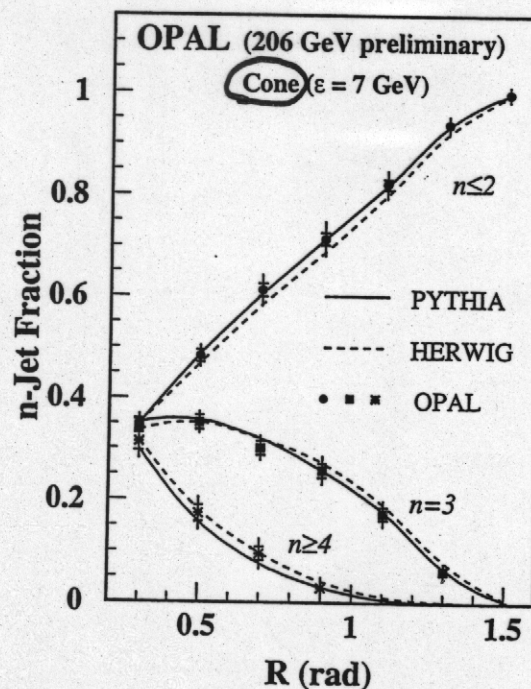
y_{cut}



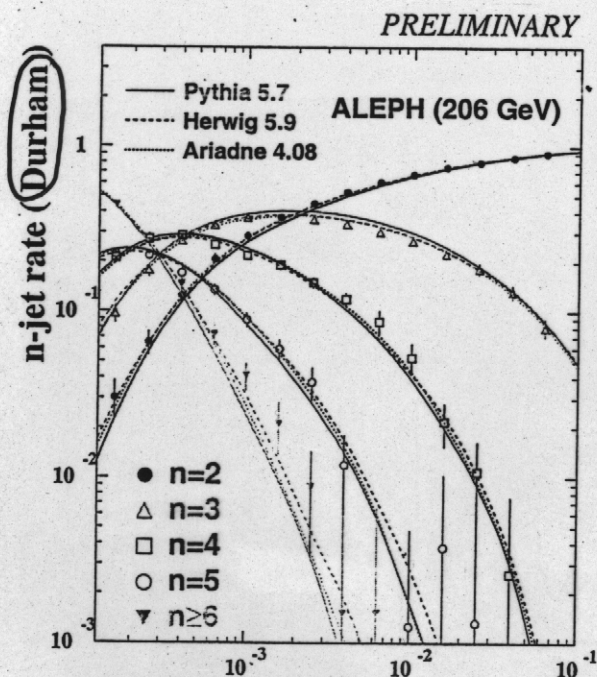
DELPHI NOTE 2001-059

IN GENERAL PARTON SHOWER MODELS
DESCRIBE WELL THE EXP. RESULTS

- FOR DIFFERENT JET FINDERS
- UP TO HIGH JET MULTIPLICITIES
- DOWN TO LOW y_{cut} VALUES



OPAL PN 462 - 2001



ALEPH NOTE 2001-007 y_{cut}

UP TO THE HIGHEST ENERGIES
NOTHING UNEXPECTED
OBSERVED IN THE DATA WITH
RESPECT TO QCD BASED
MODEL PREDICTIONS

EVENT SHAPE VARIABLES

ALWAYS A GOOD TESTING GROUND FOR TH. PREDICTIONS
(ANALYTICAL, QCD P.S. MODELS)

SEE α_s MEAS.

SEE EXAMPLES

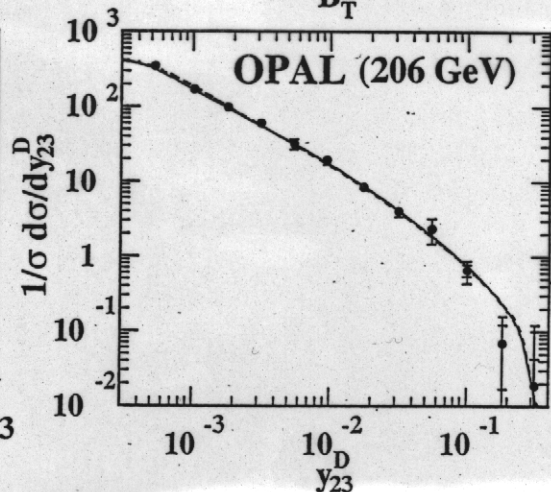
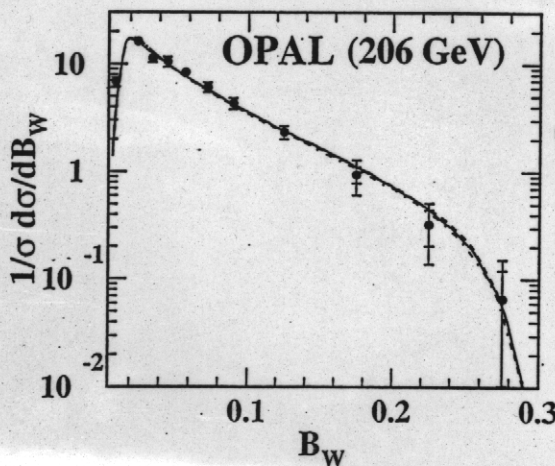
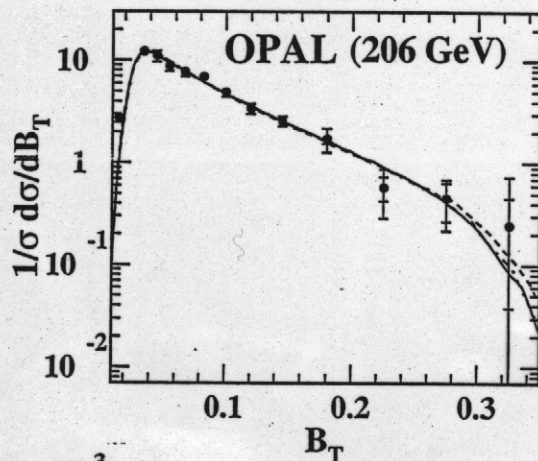
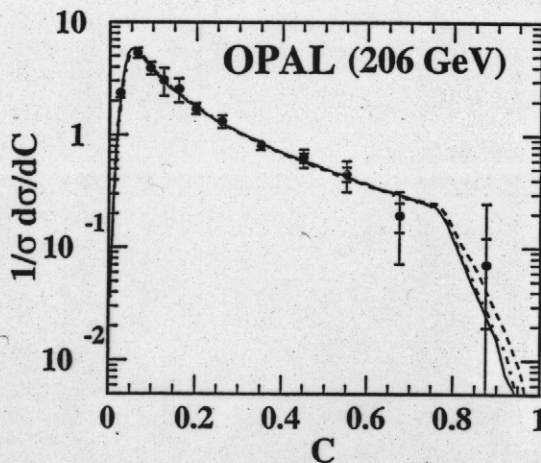
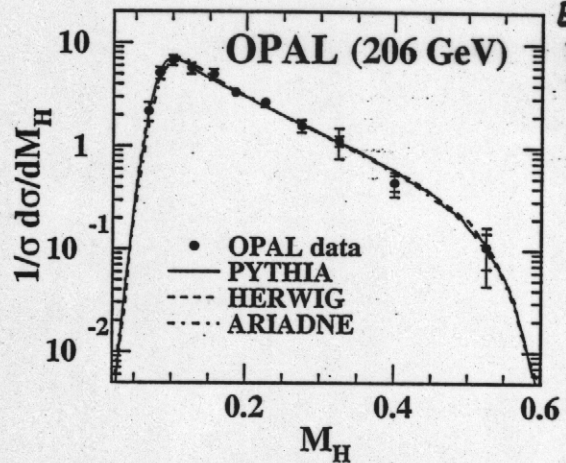
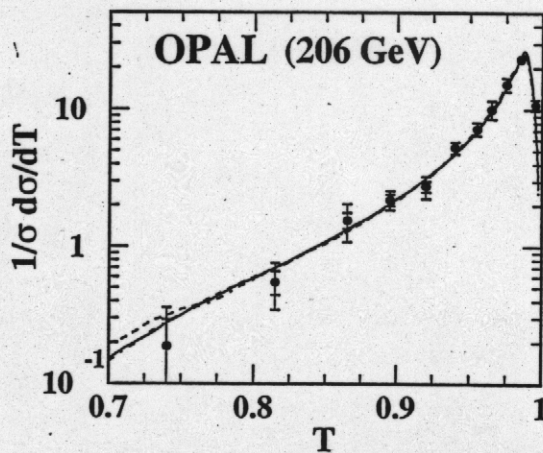
- MANY OBSERVABLES PROPOSED. ALL EXPERIMENTALLY TESTED
- SHAPE DISTRIBUTIONS EVOLVE WITH ENERGY (DUE TO α_s)
FOR EX.

P.S. MODELS (WITH FREE PARAMETERS TUNED AT ONE SINGLE $\sqrt{s}$)
PROVIDE A SATISFACTORY OVERALL DESCRIPTION OF ALL MEASURED
DISTRIBUTIONS, FROM LOW TO HIGH ENERGIES. M.E. MODELS.

OPAL preliminary

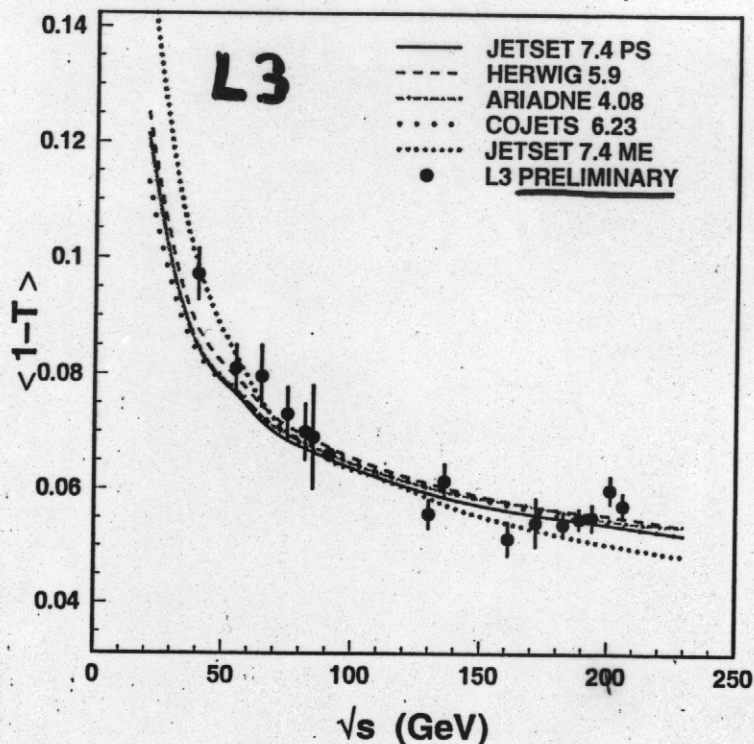
DON'T!

ENERGY
DEPENDENT
TUNING
NEEDED



EVENT SHAPE MEAN VALUES

L3 NOTE 2670 - 2001



N.B. DATA POINTS SHOWN IN THESE TWO EXAMPLES (L3) ARE ALL FROM ONE SINGLE EXPERIMENT

$30 < \sqrt{s} < 86 \text{ GeV}$ } HIGHLY RAD EVENTS AT LEP1

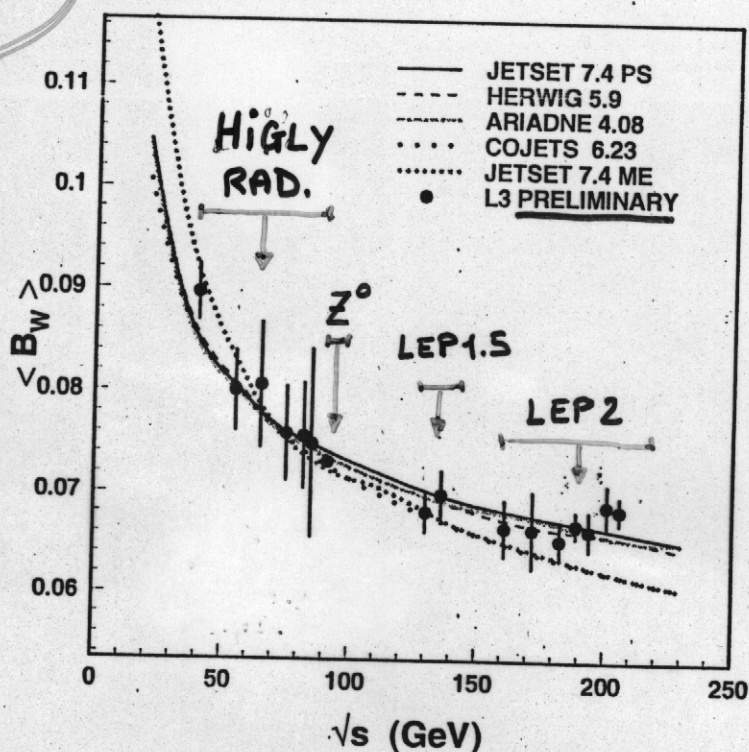
$\sqrt{s} = 91 \text{ GeV}$ } Z^0 PEAK

$130 < \sqrt{s} < 207 \text{ GeV}$ } LEP 1.5
LEP 2

QCD-BASED P.S. MODELS
WORK PRETTY WELL

(M.E MODEL LESS WELL)

- MEASURED ENERGY DEPEND. OF MEAN VALUES ALSO WELL REPRODUCED BY ANALYTIC PERT. QCD CALC. (SEE NEXT TOPIC)



MEASUREMENTS OF α_s

MANY NEW OR UPDATED
RESULTS FROM ALL EXP.
ONLY A FEW SHOWN HERE

SEVERAL
METHODS

- FIT ANALYTIC EXPRESSION TO SHAPE DISTR. } AT SINGLE $\sqrt{s}$
AND SIMULT.
- FIT " " " " TO MEAN VALUES VS $\sqrt{s}$
- $\hookrightarrow$ WITH POWER CORRECTIONS
- $\hookrightarrow$ WITH RENORMALISATION GROUP INVARIANT (RGI)
APPROACH (NEW)

EXAMPLE: SIX EVENT SHAPES ($T, M_H, C, B_W, B_T, -\ln y_3$)
AT 8 DIFFERENT ENERGIES.

FIT $O(\alpha_s^2) + \text{NLLA}$ QCD CALCULATIONS TO DISTR.

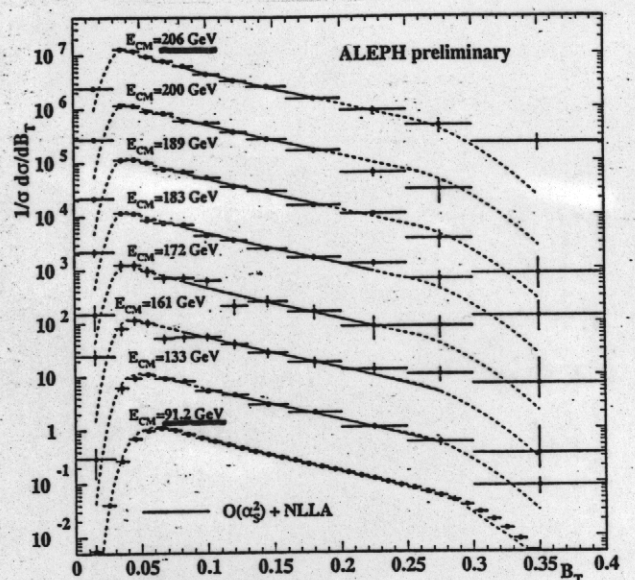
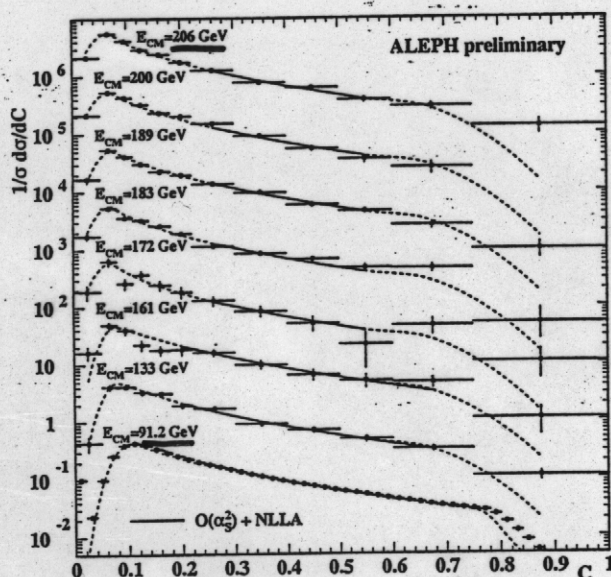
$\Rightarrow$ COMBINE 6 α_s AT EACH ENERGY (WEIGHTED AVG.)
AND FIND EXCELLENT AGREEMENT WITH $\alpha_s(Q)$ EVOLUTION

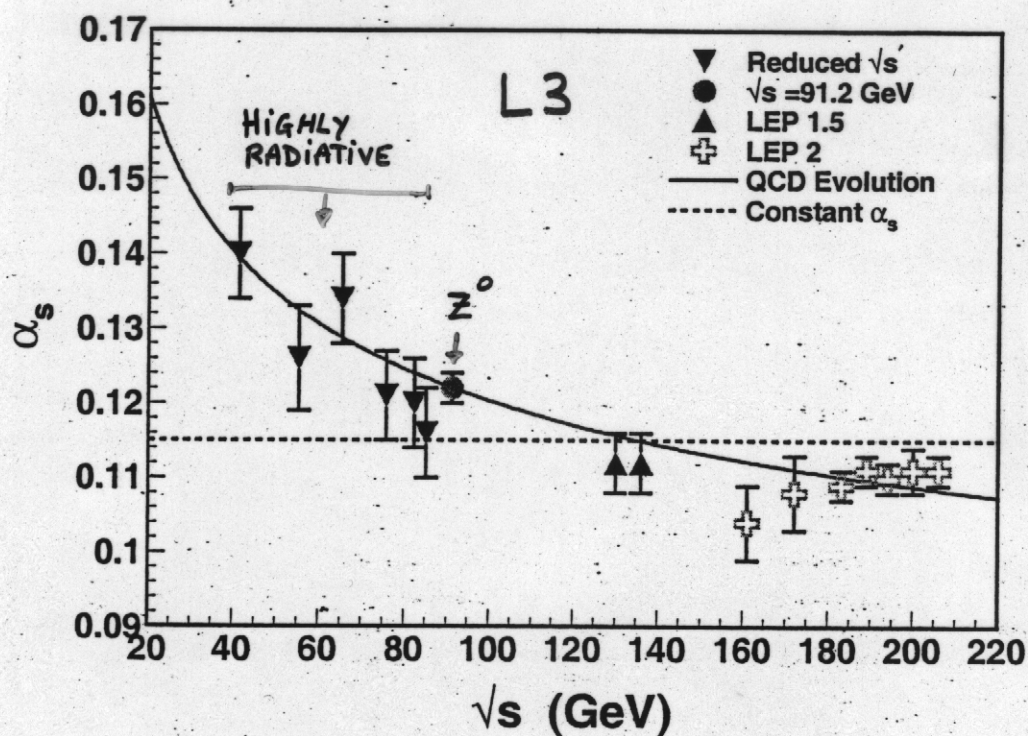
$\Rightarrow$ EVOLVE COMBINED MEASUREMENTS (133 - 206 GeV)
TO M_Z^0 SCALE AND COMBINE TO A SINGLE VALUE

LEP2 ONLY $\alpha_s(M_Z^0) = 0.1211 \pm 0.0056$ (TOT) [0.0052 TH.]
LEP2+LEP1 $\alpha_s(M_Z^0) = 0.1203 \pm 0.0048$ (TOT) [0.0046 TH.]

ALEPH NOTE 2001-062

(GOOD FITS UP TO 206 GeV)





DATA FROM A SINGLE
EXPERIMENT

$$30 \lesssim \sqrt{s} \lesssim 206 \text{ GeV}$$

5 OBSERV. (T, P, B, B₁)

$O(\alpha_s^2) + \text{NLLA FIT}$

UNWEIGHTED AVG.

- FIT 16 DATA POINTS USING QCD EVOLUTION EQUATION WITH $\alpha_s(M_{Z^0})$ AS FREE PARAMETER

$$\alpha_s(M_{Z^0}) = 0.1220 \pm 0.0011 (\text{EXP}) \pm 0.0061 (\text{TH})$$

$$\chi^2_{\text{DOF}} = 1.23$$

○ ————— ○

POWER CORRECTIONS

INCREASING INTEREST, DURING THE PAST YEARS, TO THIS ALTERNATIVE APPROACH TO ACCOUNT FOR NON PERTURBAT. EFFECTS.

CONTRIBUTIONS FROM SOFT GLUONS AFFECTING EVT. SHAPE OBSERVABLES HAVE BEEN CALCULATED IN THE D.M.W. MODEL, WHICH ASSUMES THAT α_s REMAINS FINITE AT SCALES AROUND AND BELOW THE LANDAU POLE.

INTRODUCE A
NEW FREE PARAM.

(PREDICTED TO BE
INDEPENDENT FROM
THE OBSERVABLE)

$$\alpha_0(\mu_I) = \frac{1}{\mu_I} \int_0^{\mu_I} \alpha_s(k) dk$$

TO PARAMETRISE UNKNOWN
BEHAVIOUR OF $\alpha_s(Q)$ BELOW
AN INFRARED MATCHING SCALE μ_I

- HADR. EFFECTS ON THE DISTRIBUTIONS DESCRIBED BY A SHIFT OF THE PERTURBATIVE (PT) PREDICTION

$$\frac{d\sigma}{dy} = \frac{d\sigma_{PT}}{dy} (y - PD_y)$$

$$y = 1 - T, M_H^2, C, B_T, E$$

$$D_{1-T} = 2 \quad D_{M_H^2} = 1$$

$$D_C = 3\pi, \dots$$

DEPENDS ON THE OBSERV

$$P = \frac{4C_F}{\pi^2} M \frac{\mu_I}{Q} \left(\alpha_0(\mu_I) - \alpha_s(\mu_R) - \beta_0 \frac{\alpha_s(\mu_R)}{2\pi} \left(\ln \frac{\mu_R}{\mu_I} + \frac{K}{\beta_0} + 1 \right) \right)$$

$$M = \underline{1.49} \quad K = (67/18 - \pi^2/6) C_A - 5/9 n_f$$

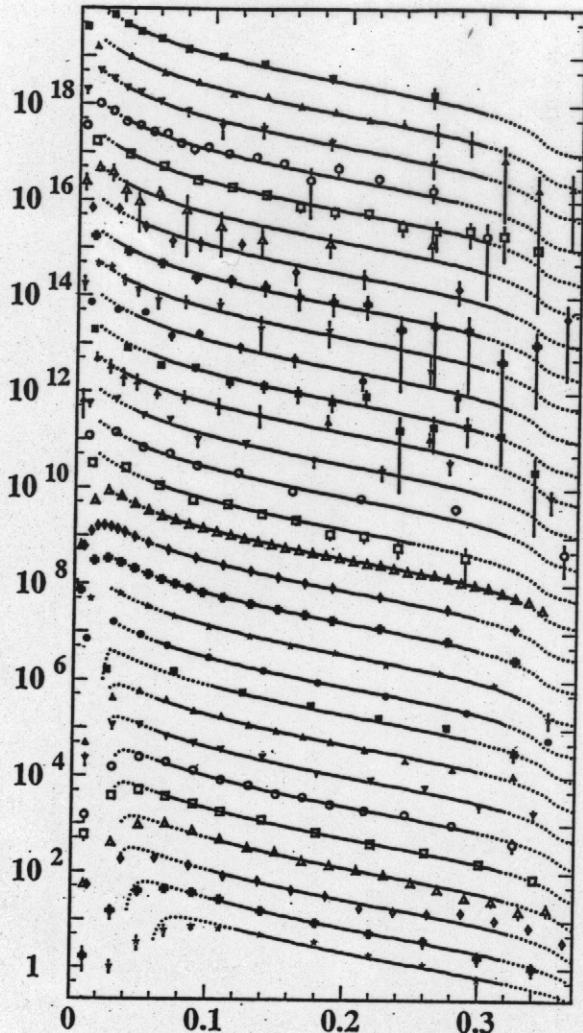
UNCERTAINTY $\approx 20\%$ DUE TO MISSING HIGHER ORDER CORR.

- POWER CORR
FOR MEAN VALUES

$$\langle y \rangle = \langle y \rangle_{PT} + PD_y$$

TEST OF POWER CORRECTIONS

$1/\sigma d\sigma/d(1-T)$



- OPAL 189 GeV
- ▲ L3 189 GeV
- ▼ OPAL 183 GeV
- DELPHI 183 GeV
- L3 183 GeV
- △ OPAL 172 GeV
- ◇ DELPHI 172 GeV
- ⊕ L3 172 GeV
- ★ OPAL 161 GeV
- DELPHI 161 GeV
- L3 161 GeV
- ▲ OPAL 133 GeV
- ▼ ALEPH 133 GeV
- DELPHI 133 GeV
- L3 133 GeV
- △ OPAL 91 GeV
- ◇ ALEPH 91 GeV
- ⊕ DELPHI 91 GeV
- ★ L3 91 GeV
- SLD 91 GeV
- AMY 55 GeV
- ▲ JADE 44 GeV
- ▼ TASSO 44 GeV
- JADE 35 GeV
- TASSO 35 GeV
- △ MARK2 29 GeV
- ◇ HRS 29 GeV
- ⊕ TASSO 22 GeV
- ★ TASSO 14 GeV

EXAMPLES

MANY NEW STUDIES AT LEP.

HERE, SHOWN ONLY A FEW RESULTS FROM A COMBINED ANALYSIS OF PUBLISHED RESULTS

hep-ex/0105059 Revised vers.
DEC 11, 2001

P.A. MOVILLA FERNANDEZ ET AL.

● USE 5 EVT. SHAPE DISTR.
 T, M_H, B_T, B_W, C
IN $O(\alpha_s^2) + NLLA$

● USE 6 EVT. SHAPE MEAN VAL.
ABOVE 5 AND y_3 (DIFF. 2-JET RATE)
IN $O(\alpha_s^2)$

● DATA SETS FROM PETRA TO LEP ENERGIES (14 - 189 GeV)

- GOOD FIT QUALITY
($\chi^2_{\text{DOF}} \approx 1$) FOR BOTH DISTRIBUTIONS AND MEANS
 $\alpha_s(M_Z)^{\text{P.C.}} < \alpha_s(M_Z)^{\text{MC-HADR.}}$

COMBINED RESULTS

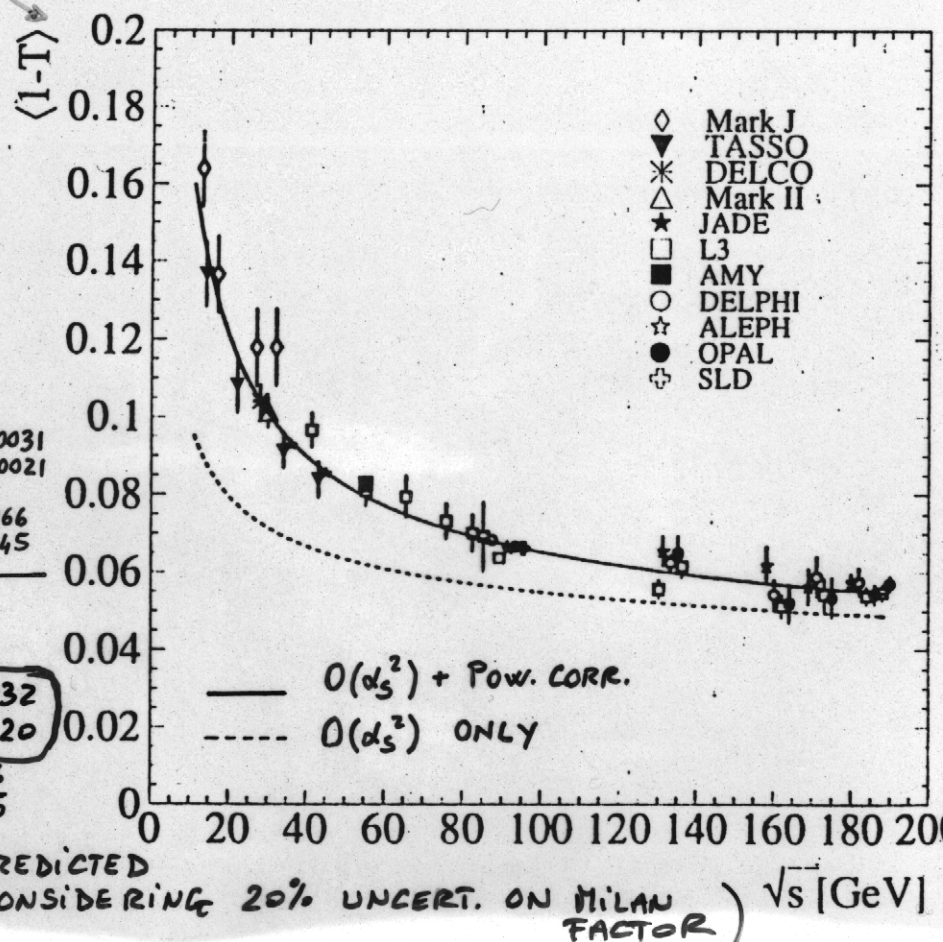
DISTRIB. MEANS

$\alpha_s(M_Z^0)$	0.1111 ± 0.0048 0.1111 ± 0.0037	0.1187 ± 0.0031 0.1187 ± 0.0021
$\alpha_0(2 \text{ GeV})$	0.579 ± 0.100 0.579 ± 0.072	0.485 ± 0.066 0.485 ± 0.045

COMBINING THE TWO

$$\left[\begin{array}{l} \alpha_s(M_Z^0) = 0.1171 \pm 0.0032 \\ \alpha_0(2 \text{ GeV}) = 0.513 \pm 0.066 \end{array} \right]$$

→ CONSISTENT WITH PREDICTED UNIVERSALITY (CONSIDERING 20% UNCERT. ON MILAN FACTOR)



IN A RECENT WORK FROM DELPHI (NOTE 2001-062), BESIDES AN EXTENSIVE STUDY ON POWER CORRECTIONS [UP TO 209 GEV AND INTRODUCING FOR THE FIRST TIME EEC], A NEVER USED BEFORE PT APPROACH WAS USED TO EXTRACT α_s FROM MEASURED MEAN VALUE

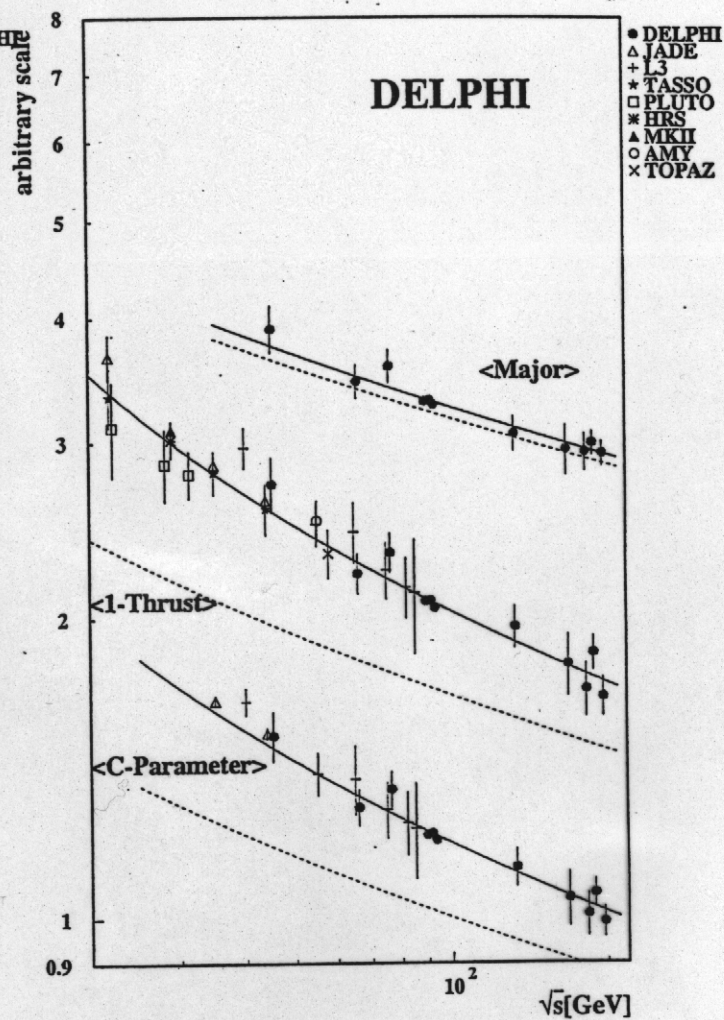
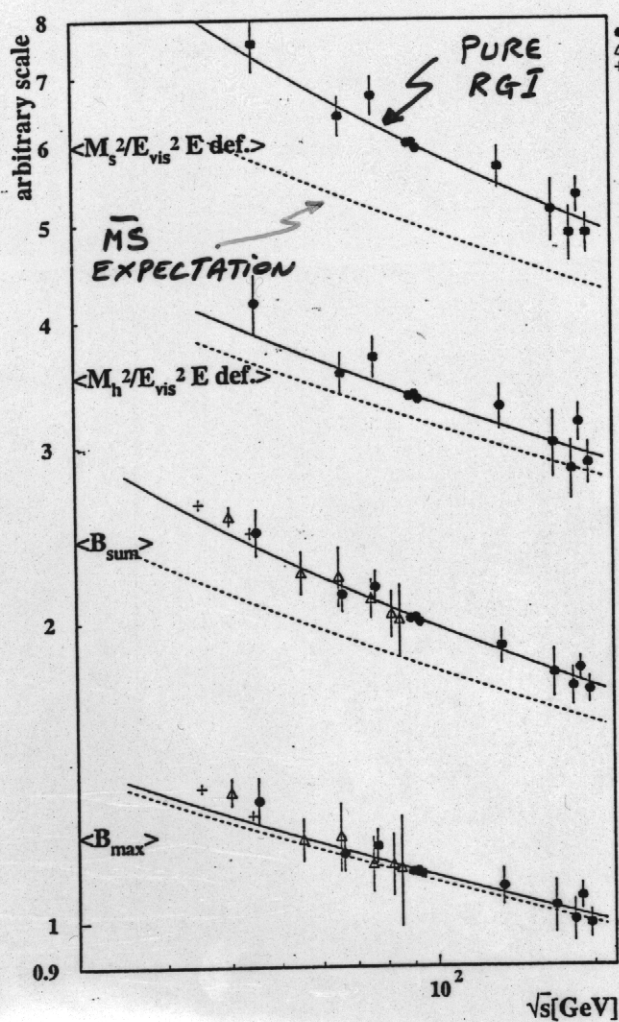
RENORMALISATION GROUP INVARIANT (RGI) METHOD, WHEN APPLIED TO FULLY INCLUSIVE OBS. LIKE EVT. SHAPE MEANS, DOES NOT NEED ANY RENORM. SCHEME, WHILE SCALE DEPENDENCE CANCELS OUT. AN OBSERVABLE R CAN BE EXPRESSED AS

$$Q \frac{dR}{dQ} = -b R^2 (1 + \underbrace{\rho_1 R + \rho_2 R^2 + \dots}_{\text{SCHEME INVARIANT AND CALCULABLE}})$$

THE SOLUTION OF THIS EQ. INTRODUCES AN R DEPENDENT SCALE Λ_R WHICH CAN BE CONVERTED TO $\Lambda_{\overline{MS}}$.

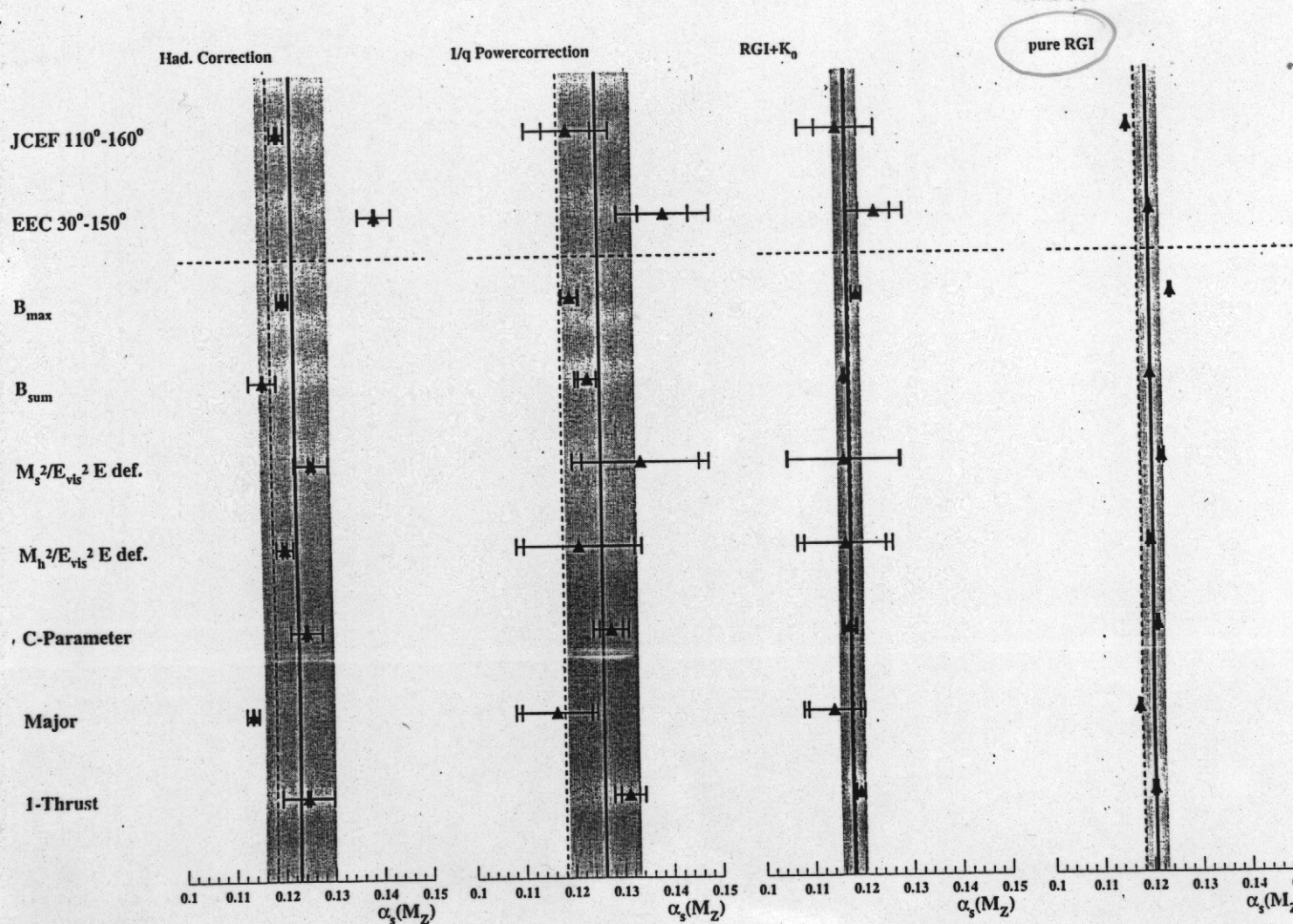
- POWER TERMS FOUND TO BE NEGLIGIBLE $\Rightarrow \Lambda_R$ ONLY FREE PARAMETER IN THE FIT

GOOD χ^2_{DOF} EXCEPT FOR M_H^2 (HAS TERMS IMPORTANT)



- RGI APPROACH LEADS TO A BETTER CONSISTENCY AMONG DIFFERENT OBSERVABLES WITH RESPECT TO OTHER METHODS

UNWEIGHTED MEAN $\alpha_s(M_Z) = 0.1201 \pm 0.0020$



LOOKS VERY PROMISING.

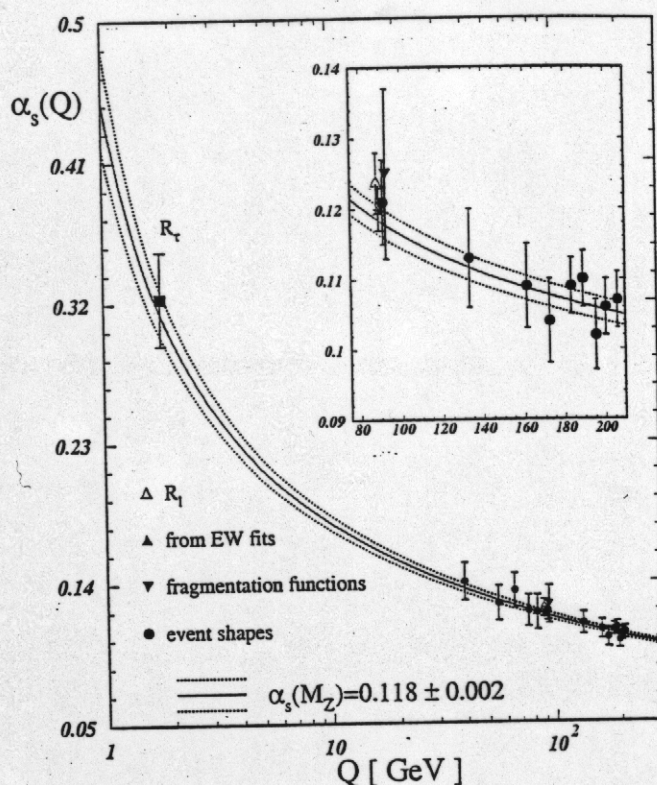
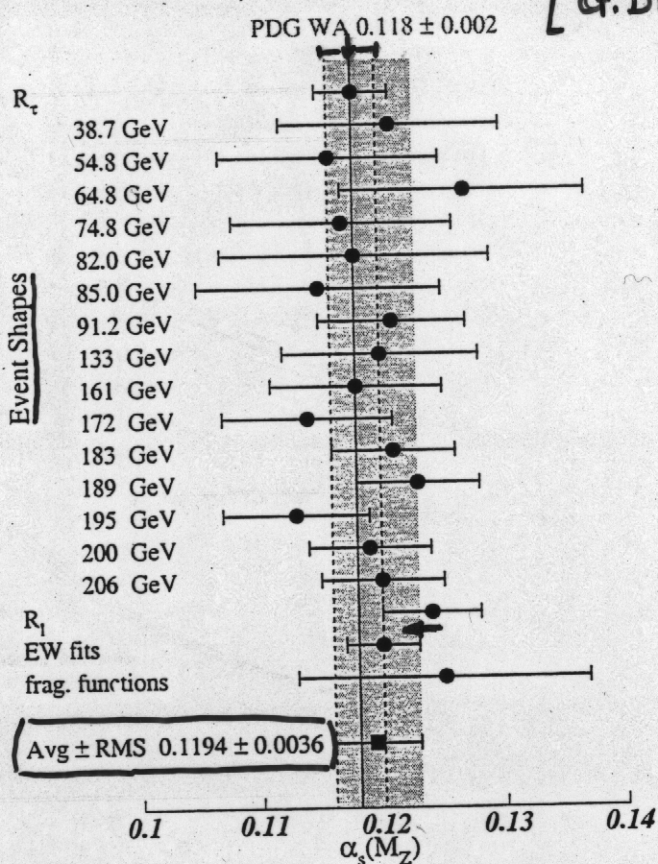
IMPRESSIVE (STILL GROWING!) COLLECTION OF RESULTS FROM LEP.

MANY DIFFERENT AND INDEPENDENT MEASUREMENTS

EXCELLENT CONSISTENCY

RECENT COMBINATION
(STILL INCLUDING PREL. RESULTS)

[G. DISSERTORI hep-ex/0105070]



* FROM THE MOST RECENT "COMBINATION OF EW RESULTS..."
(LEP + SLC + ...) CERN-EP/2001-098 (17 DEC 2001)

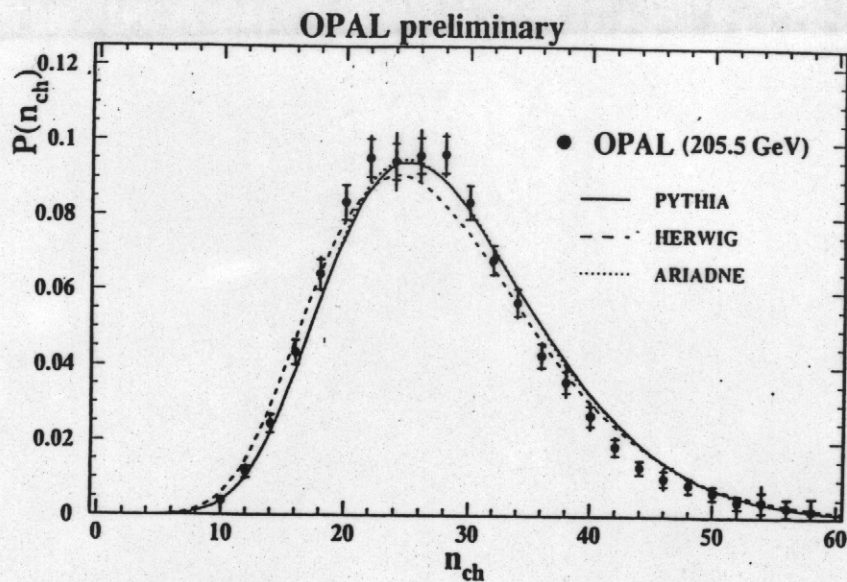
$$R_E = 20.767 \pm 0.025 \text{ (TOT)} \Rightarrow \alpha_s(M_Z^0) = 0.1224 \pm 0.0038$$

EW FITS (LEP DATA ONLY) UNCHANGED

$$\alpha_s(M_Z^0) = 0.1201 \pm 0.0030$$

" " (ALL DATA)

$$" " = 0.1183 \pm 0.0027$$



CHARGED PARTICLE MULTIPLICITY

- MULTIPLICITY DISTRIBUTIONS MEASURED AT ALL LEP2 ENERGIES ARE REASONABLY WELL REPRODUCED BY P.S. MODELS WHICH INCLUDE SIMULATION OF QCD COHERENCE (TUNED AT ONE $\sqrt{s}$)

- ENERGY DEPENDENCE OF MEAN VALUE $\langle n_{ch} \rangle$.

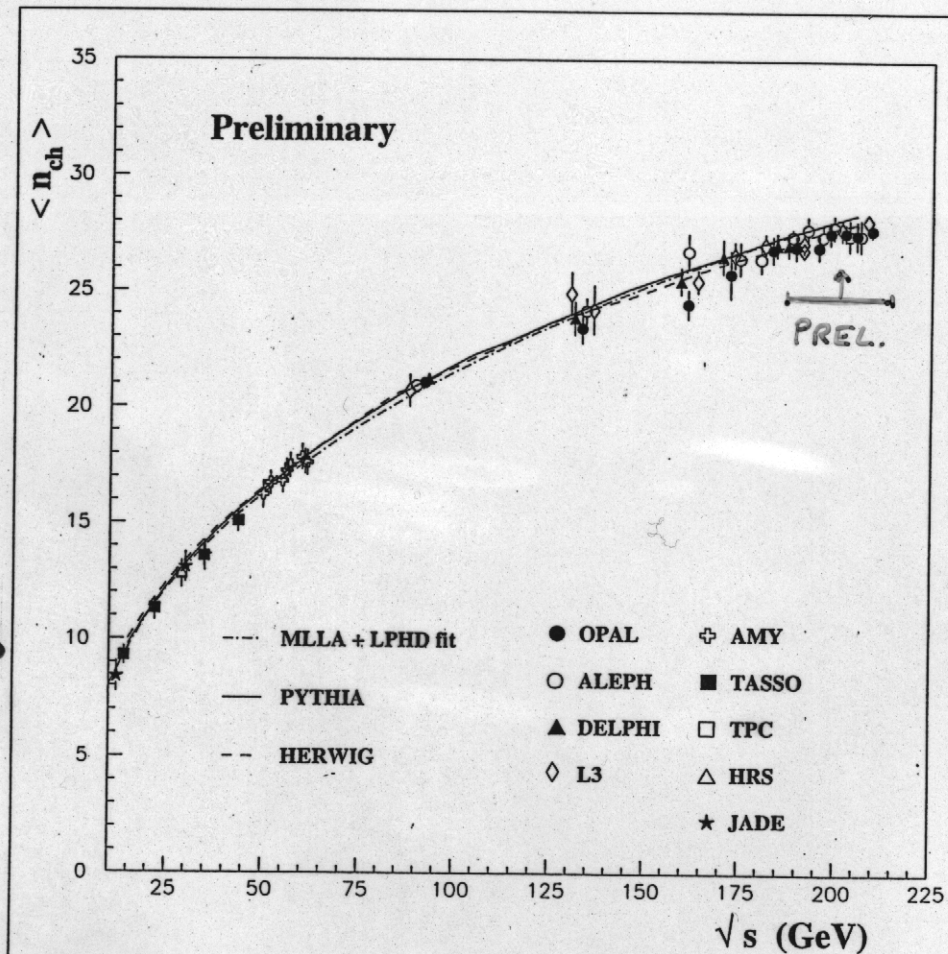
ASSUMING LPHD PERT. QCD PREDICTS $\langle n_{ch} \rangle$ ENERGY EVOLUTION THROUGH RUNNING OF α_s

$$\langle n_{ch} \rangle = a \cdot \alpha_s^b(\mu) \cdot e^{c/\sqrt{\alpha_s(\mu)}} + O(\sqrt{\alpha_s})$$

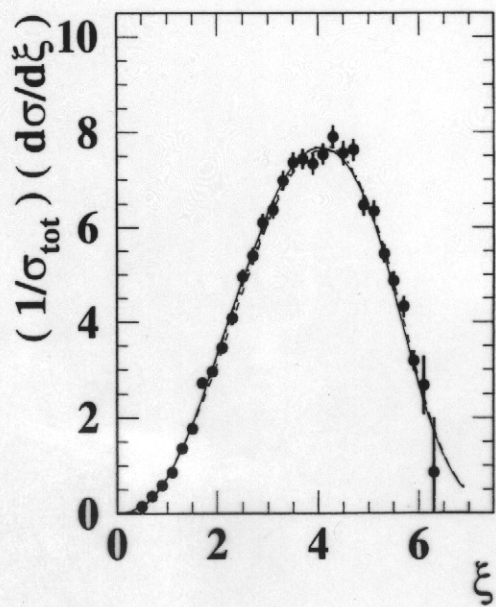
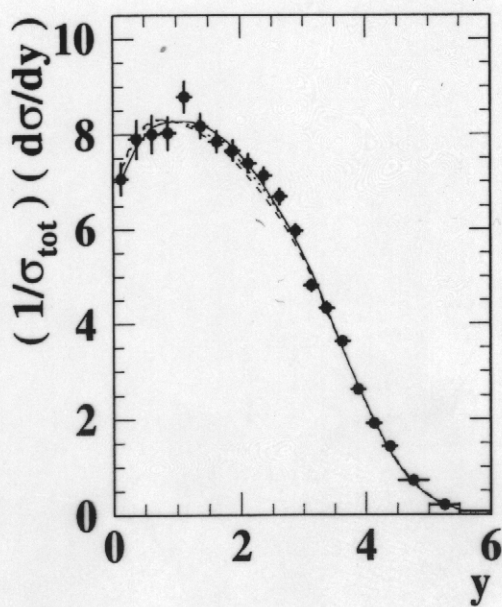
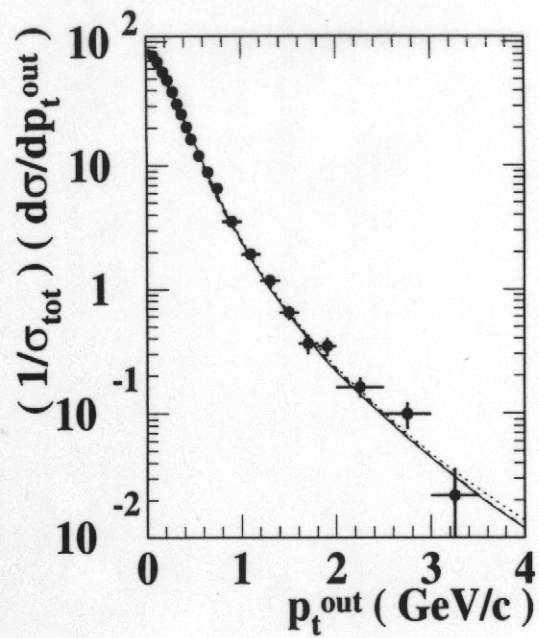
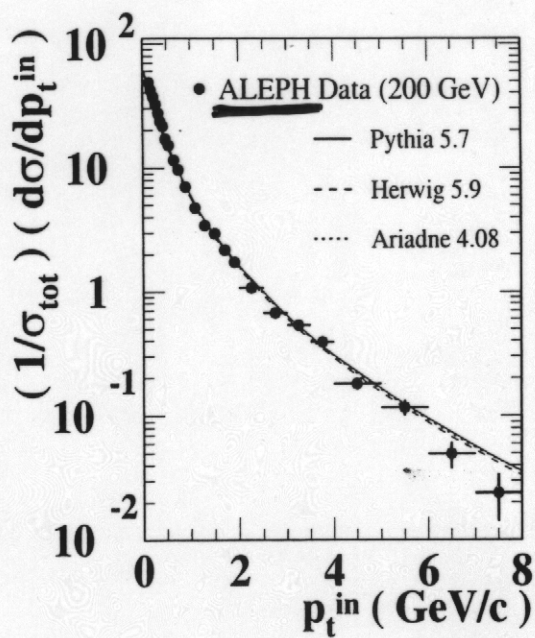
a = SCALE FACTOR
(FREE PARAMETER)

b, c = KNOWN CONST.
(FROM THEORY)

GOOD FIT FROM
 Υ RESONANCE UP
TO HIGHEST ENERGIES



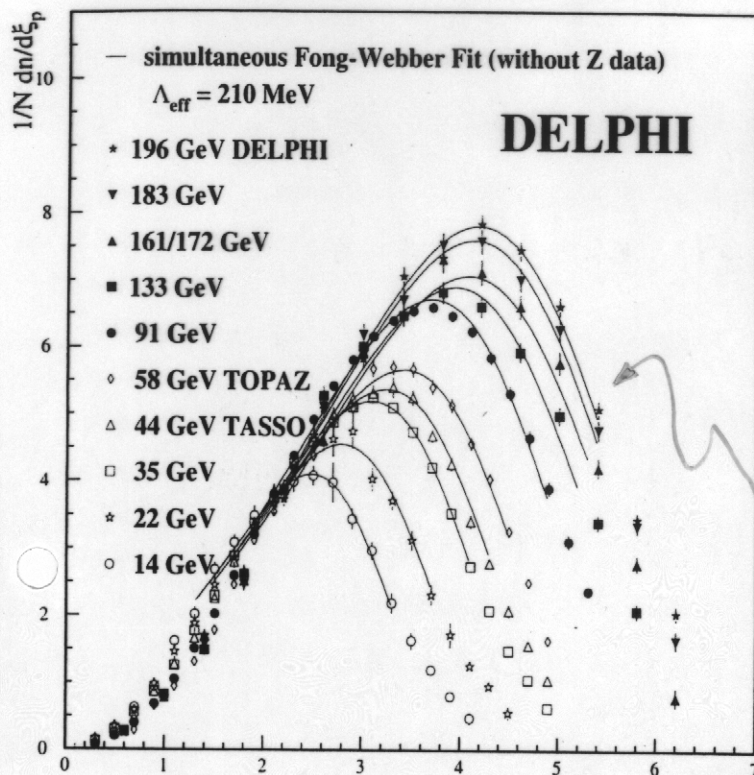
PRELIMINARY



STUDIES OF COHERENCE EFFECTS

DELPHI 2000-22 CONF 343 (MARCH 2000)

MLLA + LPHD



SINGLE PARTICLE FRACTIONAL
 MOMENTUM DISTRIBUTION $\xi_p = \ln\left(\frac{1}{x_p}\right)$
 PREDICTED TO BE A ~DISTORTED
 GAUSSIAN WITH "HUMP BACKED"
 PLATEAU DUE TO SOFT GLUON
SUPPRESSION.

- MLLA (+ LPHD) CAN DESCRIBE
 HADRON LEVEL DISTRIBUTION
 UP TO THE HIGHEST ENERGIES

$$\xi_p = \ln\left(\frac{1}{x_p}\right) ; x_p \equiv \text{FRACTIONAL MOMENTUM}$$

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

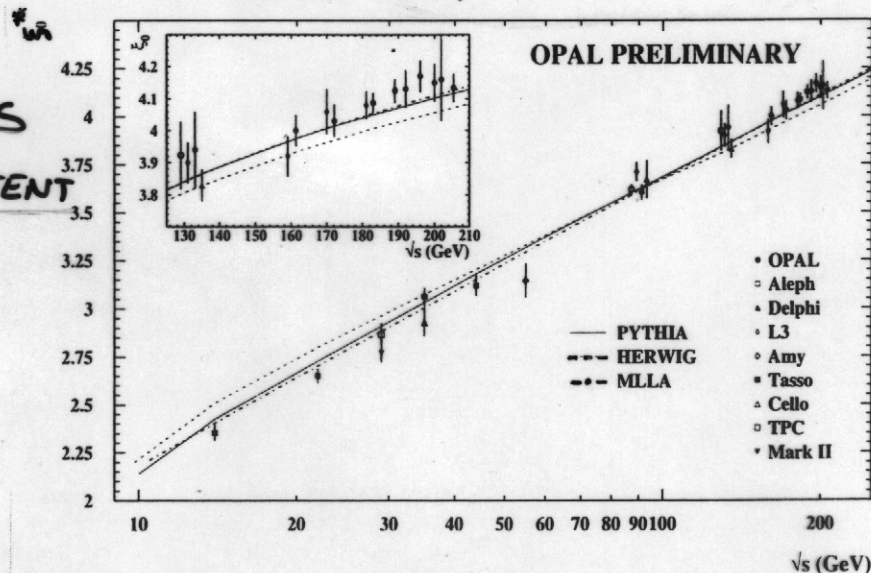
$$\xi^* = 0.5 \cdot \ln \frac{E_{\text{BEAM}}}{\Lambda_{\text{EFF}}} + \sqrt{C} \cdot \sqrt{\ln \frac{E_{\text{BEAM}}}{\Lambda_{\text{EFF}}}} - C$$

$\Lambda_{\text{EFF}} = \text{FREE PARAM.}$

$C = \text{CONST.}$
 WEAKLY DEPENDENT
 ON ACTIVE FLAVOUR

BOTH P.S. PREDICTIONS
 AND MLLA FIT CONSISTENT
 WITH EXP. RESULTS

OPAL PN 437



PARTICLE MULTIPLICITY OF UNBIASED GLUON JETS

PARTICLE MULT. OF q AND g JETS, IN PARTICULAR THEIR RATIO $r = N_g/N_q$, IS ANOTHER TOPIC EXTENSIVELY STUDIED AT LEP SINCE MANY YEARS.

- TH CALCULATIONS FOR INCLUSIVE gg SYSTEM IN OVERALL COLOR SINGLET STATE. (INDEPENDENT OF A JET FINDER). EXPERIMENTALLY DIFFICULT. (γ DECAY AND RARE Z^0 EVENTS ~~→~~)

- RECENTLY PROPOSED METHOD TO EXTRACT UNBIASED g JET MULT. FROM BIASED $e^+e^- \rightarrow q\bar{q}g$ EVENTS ($N_{q\bar{q}g}$)

$$N_{q\bar{q}g} = N_{q\bar{q}}(L, k_{\perp, Lu}) + \frac{1}{2} N_{gg}(k_{\perp, Lu}) \quad \left. \vphantom{N_{q\bar{q}g}} \right\} \text{VALID TO NLO (MLLA)}$$

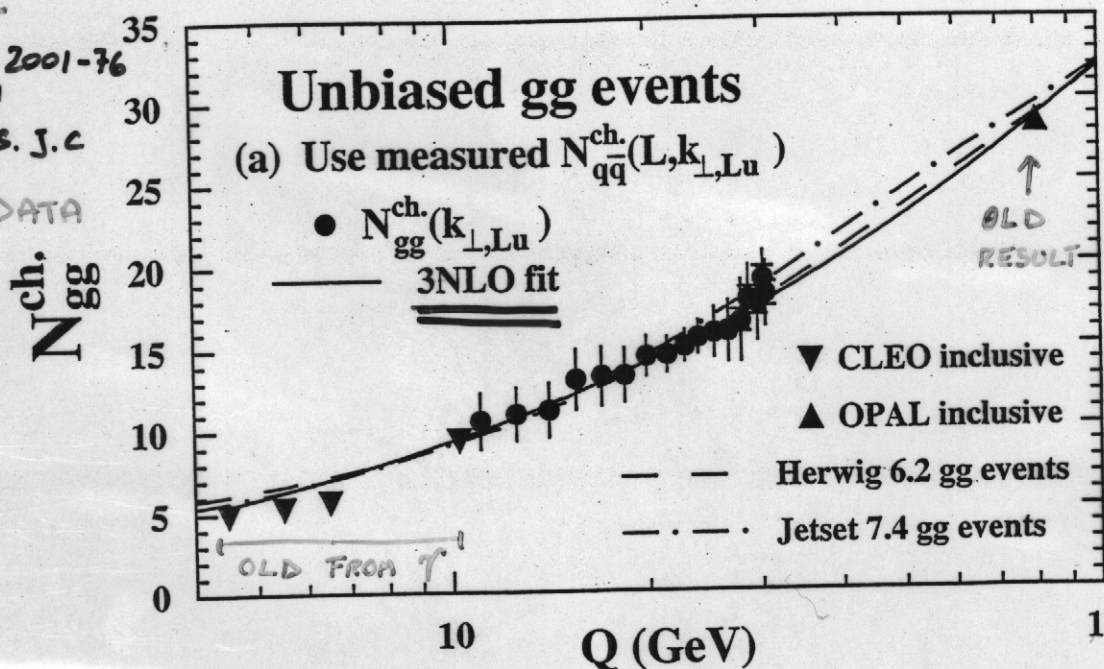
$$N_{q\bar{q}g} = N_{q\bar{q}}(L_{q\bar{q}}, k_{\perp, Lu}) + \frac{1}{2} N_{gg}(k_{\perp, Le}) \quad \left. \vphantom{N_{q\bar{q}g}} \right\} \text{AMBIGUITY IN } g \text{ JET}$$

$Lu = LUND \quad Le = LEVIN$

IN THIS FORMALISM N_{gg} DEPENDS ON A SINGLE SCALE

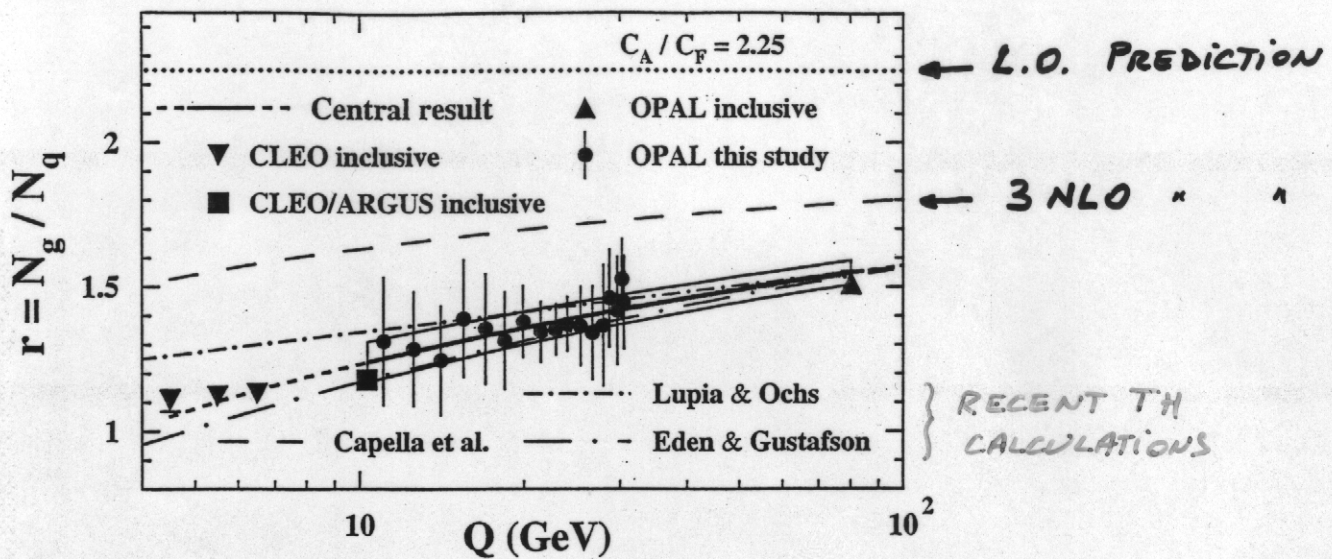
$N_{q\bar{q}g}$ AND $N_{q\bar{q}}$ EXPERIMENTALLY ACCESSIBLE $\Rightarrow N_{gg}(k_{\perp})$

OPAL
CERN-EP 2001-76
OCT. 2001
EUR. PHYS. J. C
LEP I DATA



GOOD CONSISTENCY WITH PREVIOUS LOW AND HIGH SCALE RESULTS

GOOD TEST FOR ANALYTICAL CALC. AND MC MODELS



- THE 3NLO PREDICTIONS FOR r , $r^{(1)}$ (FIRST DERIVATIVE) EXCEED THE EXP. VALUES BY $\sim 22\%$ AND $\sim 6\%$. FINE FOR $r^{(2)}$. SEEMS TO INDICATE SMALLER H.O. EFFECTS WITH INCREASING LEVEL OF DIFFERENTIATION

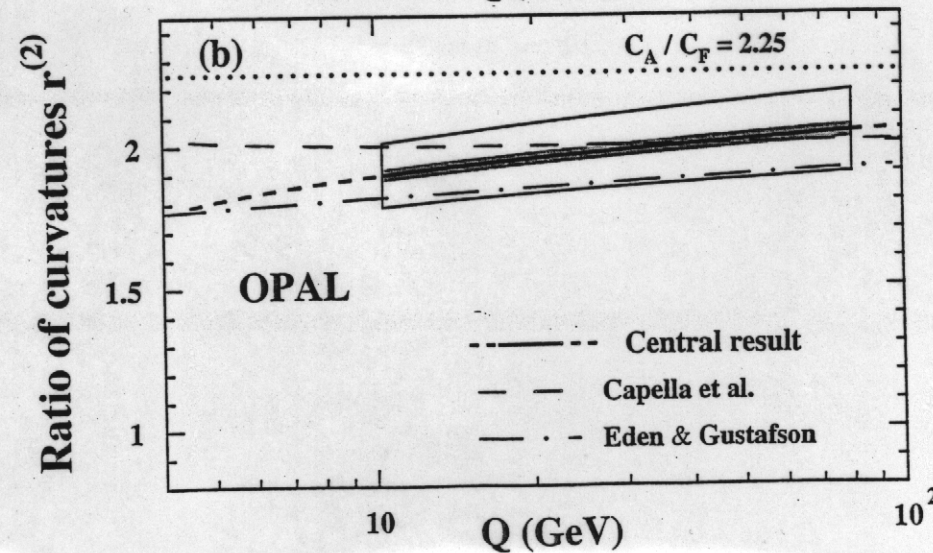
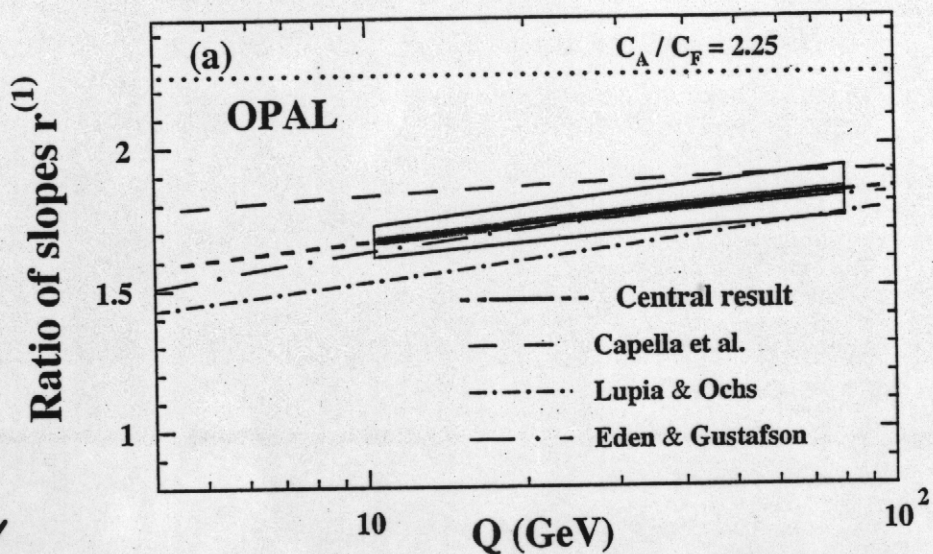
- AT A GIVEN SCALE $r < r^{(1)} < r^{(2)} < C_A/C_F$, AS PREDICTED BY QCD

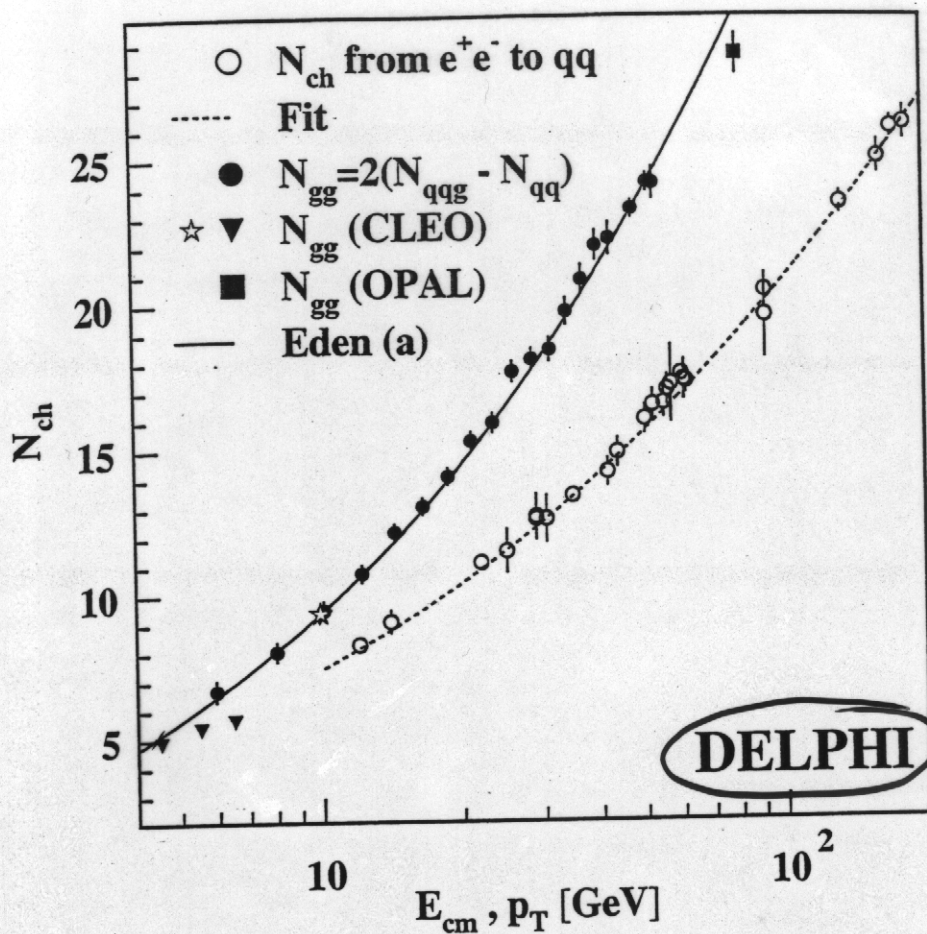
OVERALL AGREEMENT BETWEEN EXP. AND TH RESULTS

- ALSO POSSIBLE TO DERIVE C_A/C_F FROM THE ENERGY DEPENDENCE OF $N_{q\bar{q}}$ AND $N_{g\bar{g}}$, WHICH WAS FOUND TO BE

$$\frac{C_A}{C_F} = 2.232 \pm 0.14 \text{ (TOT)}$$

(QCD EXPECTATION 2.25)





DELPHI NOTE 2000-134

NOTE 2001-067

PRELIMINARY

SIMILAR TO THE OPAL
 ANALYSIS BUT EXTENDING
 TO "GENERAL TOPOLOGIES"
 (NOT RESTRICTED TO
 ONE-FOLD SYMMETRIC EVENTS)

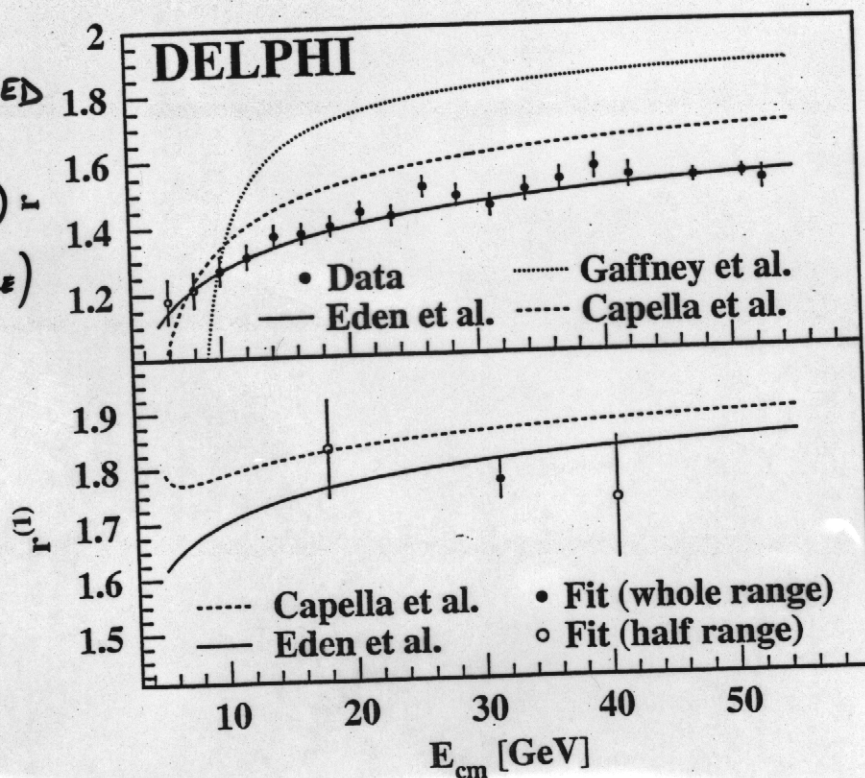


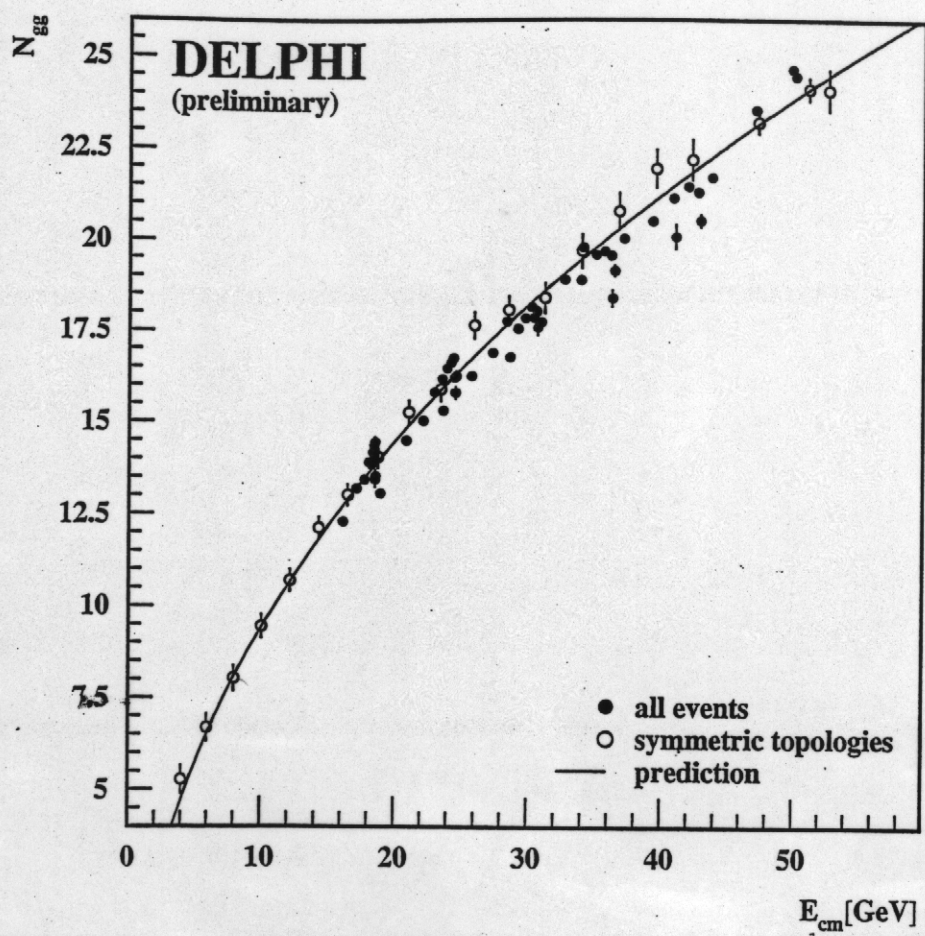
LEP I DATA

- N_{gg} IN AGREEMENT WITH PREVIOUS RESULTS BASED ON
 Y TOPOLOGIES ONLY (SEE NEXT TRANSP.)
 AND IN REASONABLY GOOD AGREEMENT WITH TH PREDICTIONS

- C_A/C_F ALSO DETERMINED

$$C_A/C_F = 2.294 \pm 0.003 \text{ (LC SCALE)} \\
= 2.262 \pm 0.003 \text{ (LU SCALE)}$$





CONCLUSIONS

THANKS TO THE EXCEPTIONAL PERFORMANCE OF LEP
A LARGE ENERGY DOMAIN WAS EXPLORED WITH
AN UNPRECEDENTED LEVEL OF ACCURACY

MORE AND MORE STRINGENT TESTS OF QCD
➡ AND PRECISE MEASUREMENTS WERE POSSIBLE
... SOME STILL TO COME

- WITHIN CURRENT UNCERTAINTIES NOTHING UNEXPECTED
WITH RESPECT TO TH. PREDICTIONS HAS BEEN OBSERVED
- NEW, MORE PRECISE AND MORE COMPLETE MEASUREMENT
OF α_s FURTHER INCREASE OUR CONFIDENCE IN ITS
RUNNING CHARACTER (CONSISTENT WITH THAT EXPECT. IN QCD)
- QCD-BASED P.S. MODELS (WITH SIMULATION OF COHERENCE
WITH FREE PARAMETERS TUNED AT ONE SINGLE ENERGY
PROVIDE A GOOD OVERALL DESCRIPTION OF M.H. EVENTS
FROM THE LOWEST UP TO THE HIGHEST ENERGY
 - ➡ IMPORTANT TEST OF CONSISTENCY
 - ➡ FUNDAMENTAL TOOL FOR OTHER PHYSICS