Recent QCD Results From OPAL

presented by
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- Measurement of the quark to photon fragmentation function.
- Multiplicity distributions of gluon and quark jets and test of QCD analytic predictions.
- Study of the running of α_s between LEP 1 and LEP 2.
- First preliminary result at $\sqrt{s} = 183\ \mathrm{GeV}$.

Quark to Photon Fragmentation Function

$\Rightarrow$ Signal: prompt photons radiated off of quarks

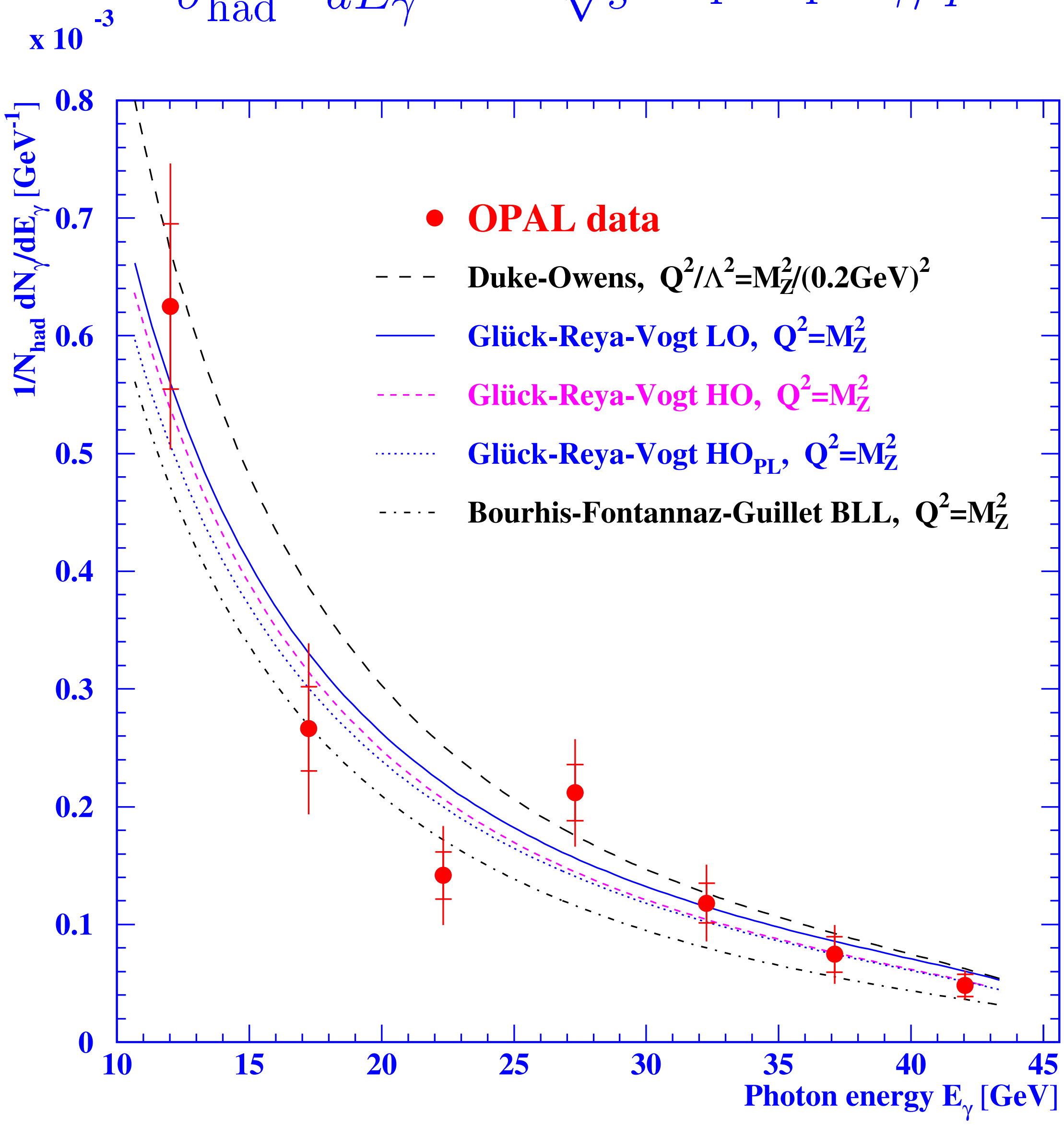
$\Rightarrow$ Background: mostly $\pi^0 \longrightarrow \gamma\gamma$ and $\eta \longrightarrow \gamma\gamma$.

$\Rightarrow$ Seperate signal from background:

- High granularity presampler
- Transverse profile of calorimeter clusters

Photon Energy Spectrum

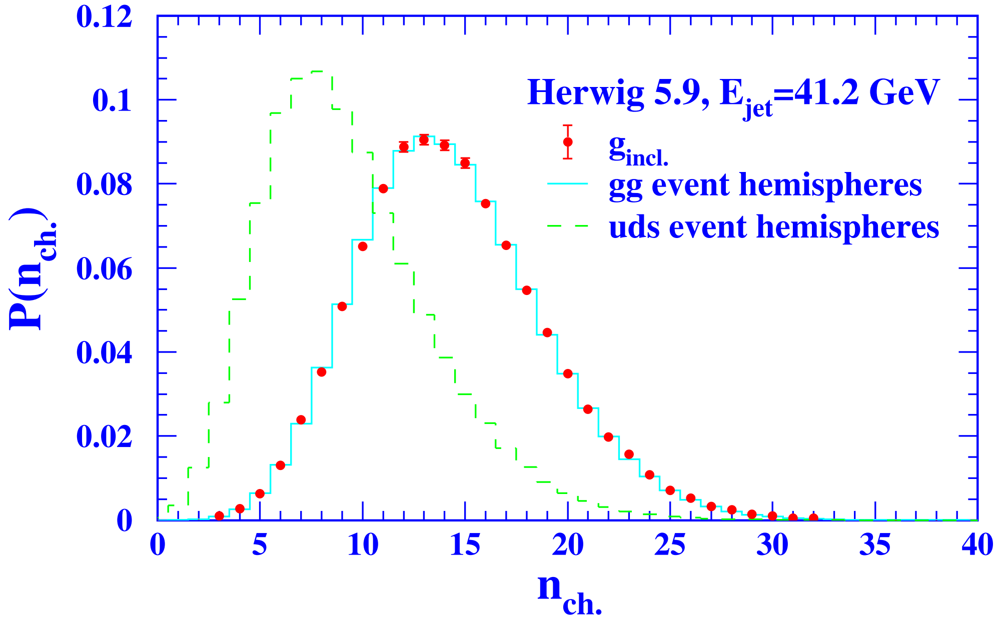
$$\frac{1}{\sigma_{\mathrm{had}}}\frac{d\sigma(E_\gamma)}{dE_\gamma} = \frac{4}{\sqrt{s}}\Sigma_{\mathrm{q}}\, w_{\mathrm{q}} D_{\gamma/q}$$



Good agreement with QCD predictions.
Statistical precision not sufficient to distinguish between them.

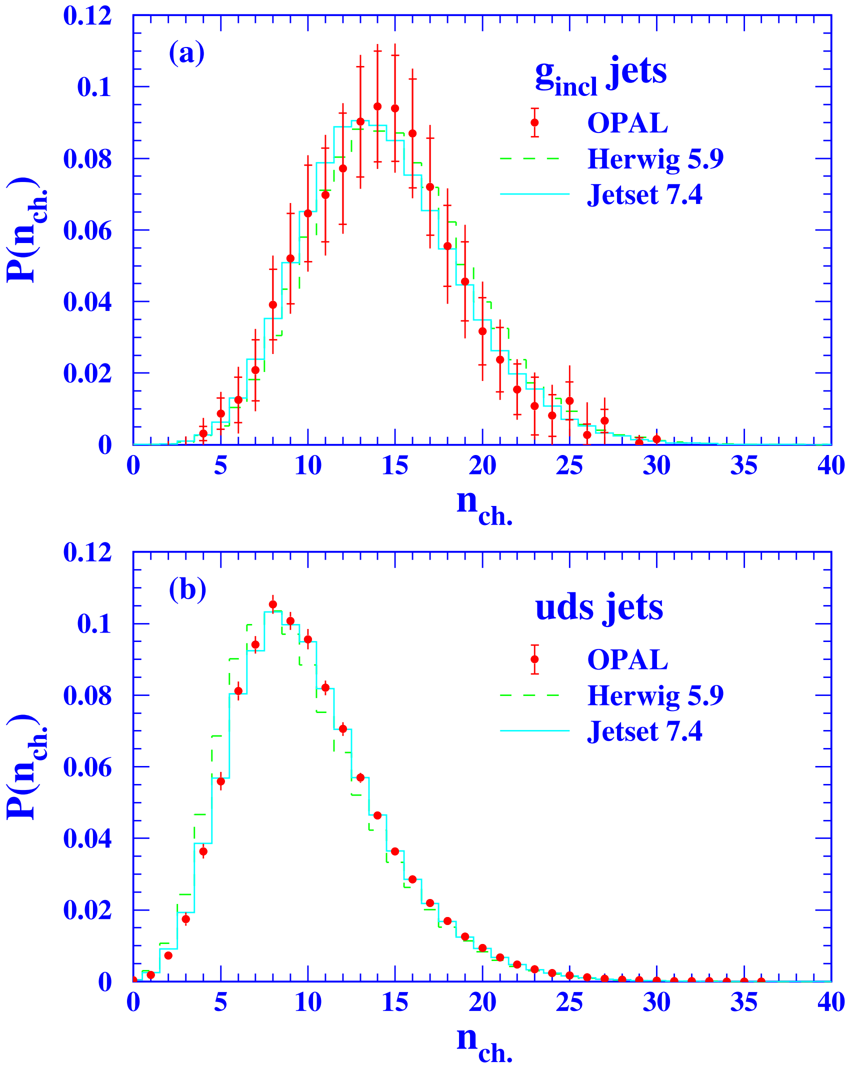
Quark and Gluon Jet Multiplicity Distributions

Monte Carlo Test of Method



Monte Carlo Test Shows Method Works

Charged Particle Multiplicity Distributions



(mean) $$\frac{\langle n_{\mathrm{ch.}}\rangle_{\mathrm{g\ incl.}}}{\langle n_{\mathrm{ch.}}\rangle^{41.8\ \mathrm{GeV}}_{\mathrm{uds\ hemis.}}} = 1.471 \pm 0.024\,(\mathrm{stat.}) \pm 0.043\,(\mathrm{syst.})$$

(dispersion) $$\frac{D_{\mathrm{g\ incl.}}}{D^{41.8\ \mathrm{GeV}}_{\mathrm{uds\ hemis.}}} = 1.055 \pm 0.046\,(\mathrm{stat.}) \pm 0.055\,(\mathrm{syst.})$$

(skew) $$\frac{\gamma_{\mathrm{g\ incl.}}}{\gamma^{41.8\ \mathrm{GeV}}_{\mathrm{uds\ hemis.}}} = 0.47 \pm 0.16\,(\mathrm{stat.}) \pm 0.21\,(\mathrm{syst.})$$

(curtosis) $$\frac{c_{\mathrm{g\ incl.}}}{c^{41.8\ \mathrm{GeV}}_{\mathrm{uds\ hemis.}}} = 0.19 \pm 0.37\,(\mathrm{stat.}) \pm 0.33\,(\mathrm{syst.})$$

⇒No analytic predictions for D, γ and c.

⇒Predictions exist for factorial moments (K_q).

Correlation Matrix

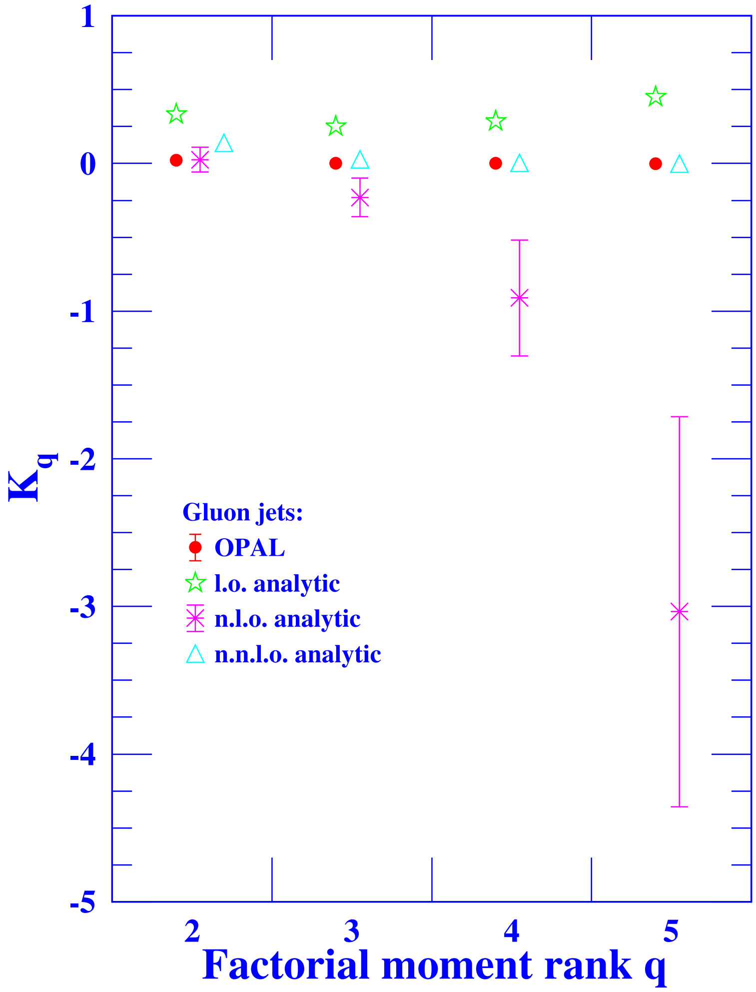
	D	γ	c	K_2	K_3	K_4
D	1.00	0.36	0.14	$\boxed{0.97}$	0.36	-0.02
γ		1.00	0.77	0.33	$\boxed{0.99}$	0.42
c			1.00	0.14	0.78	$\boxed{0.90}$
K_2				1.00	0.33	-0.01
K_3					1.00	0.43
K_4						1.00

$K_2 \longrightarrow$ measurement of width

$K_3 \longrightarrow$ measurement of asymmetry

$K_4 \longrightarrow$ measurement of Gaussian-ness

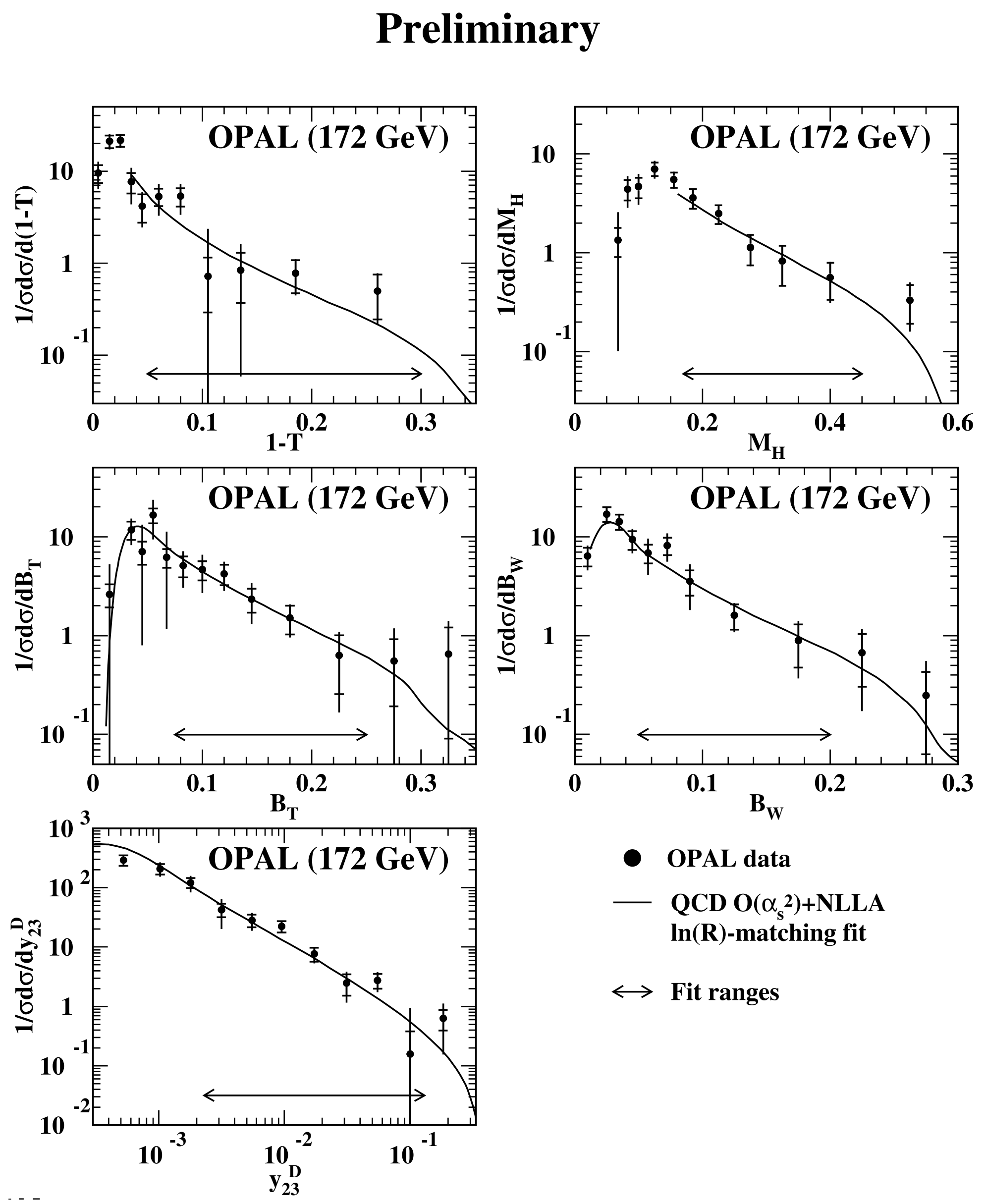
Analytic Predictions for Factorial Moments



⇒Factorial moments compared to QCD analytic predictions for the first time.

⇒n.n.l.o predictions including energy conservation provide good agreement with data.

Event Shapes Used For α_s Determination



$$\alpha_s(172\ \mathrm{GeV}) = 0.093 \pm 0.005(\mathrm{stat.}) \pm 0.006(\mathrm{syst.})$$

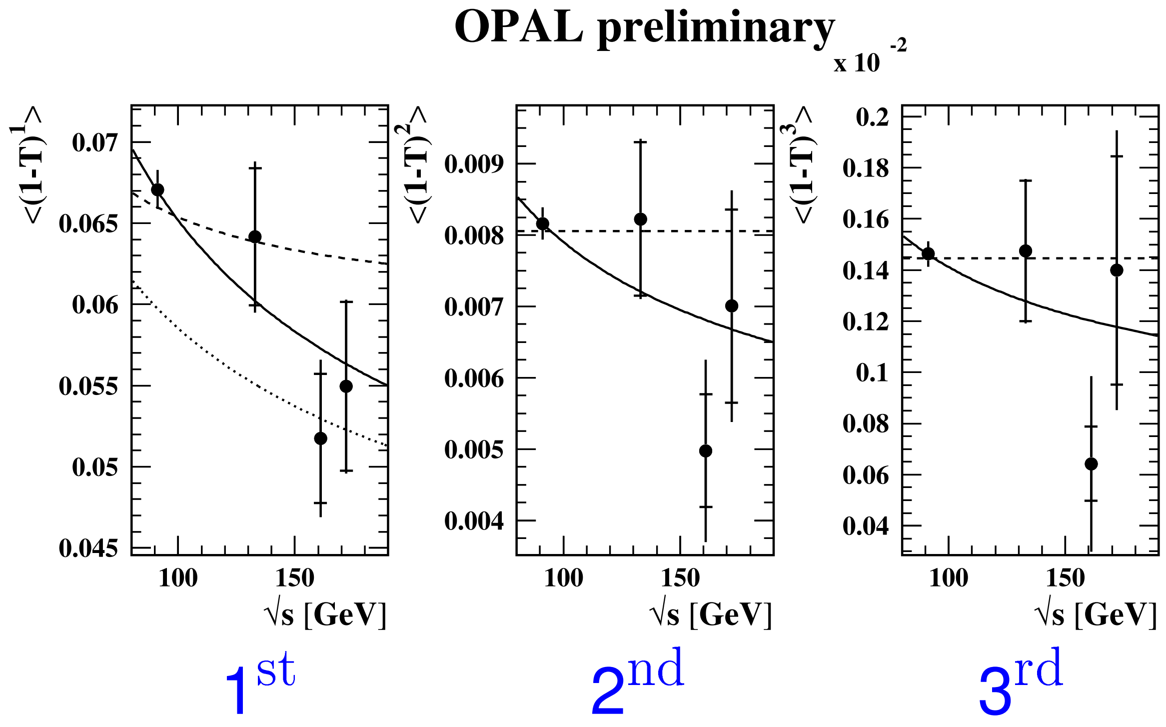
QCD $\mathcal{O}(\alpha_s^2)$ + NLLA

Running of α_s Between LEP 1 and LEP 2

$$\langle y^n \rangle = 1/\sigma \int dy\, y^n d\sigma/dy$$

$$\langle y^n \rangle = \langle y^n \rangle_{pert} + \langle y^n \rangle_{pow}$$

$$\langle y^n \rangle_{pow} \sim \left(\frac{1}{Q}\right)^n$$



⇒Fit to all moments: α_s and x_μ free

⇒α_s running: $P_{\chi^2} \sim 50\%$

α_s constant: $P_{\chi^2} \sim 5\%$

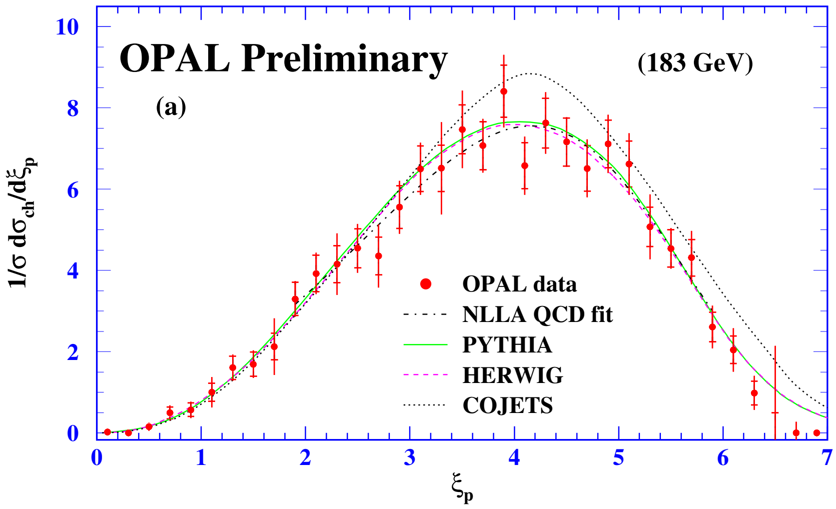
Model with constant α_s disfavored.

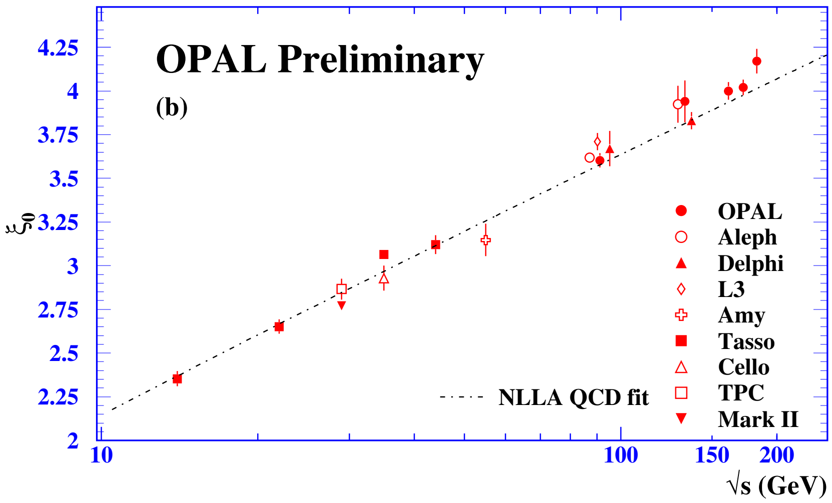
QCD Studies at Highest e^+e^- Energies

⇒ 1501 multihadron events (as of 7 days ago)

⇒ 6.6 pb^{-1} total integrated luminosity

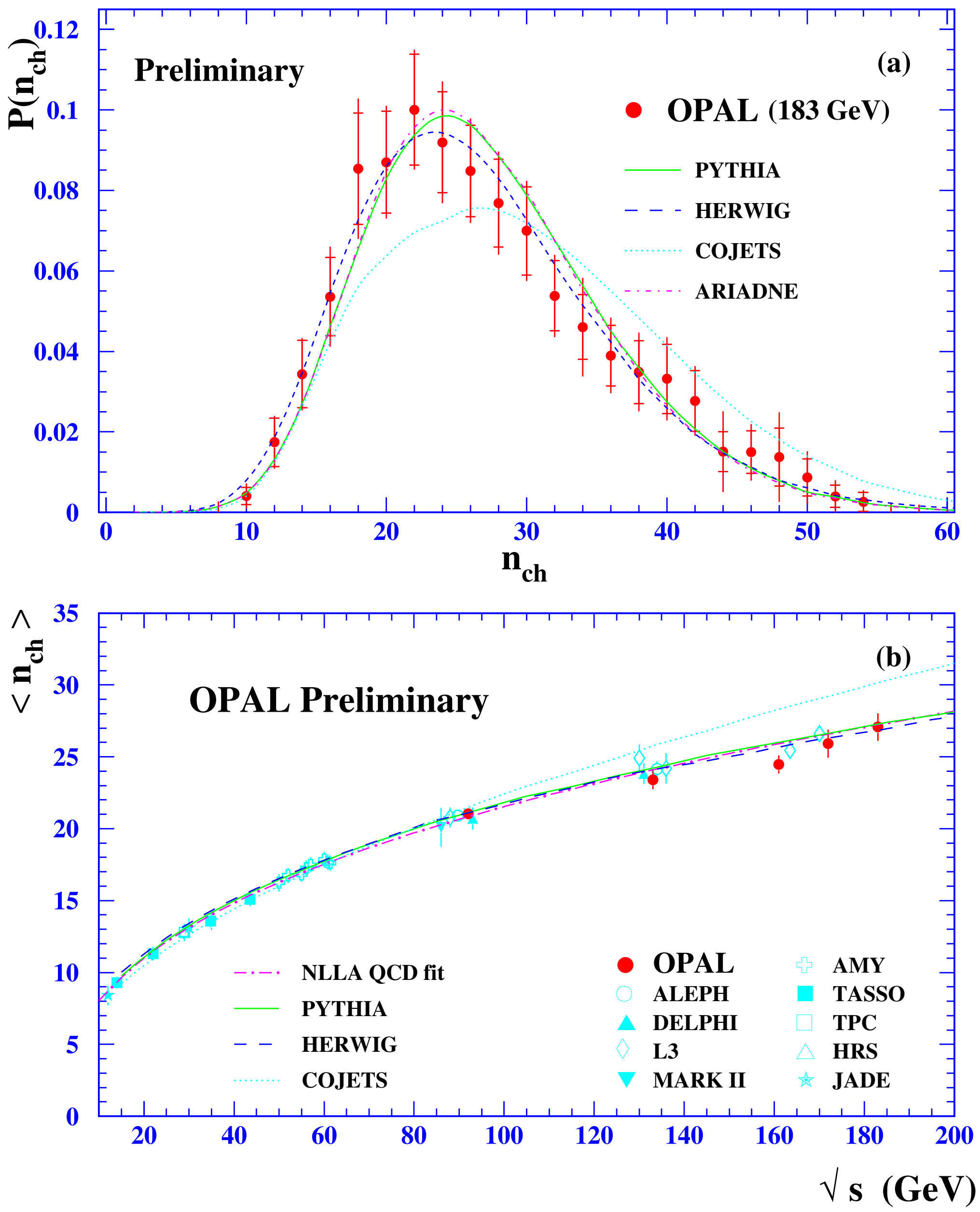
⇒ 150 events with $\sqrt{s} - \sqrt{s'} < 10.0$ GeV





$$\xi_0(183\ \mathrm{GeV}) = 4.17 \pm 0.05(\mathrm{stat.}) \pm 0.04(\mathrm{syst.})$$

Charged Particle Multiplicity



$$\langle n_{ch} \rangle (183\ \mathrm{GeV}) = 27.1 \pm 0.8(\mathrm{stat.}) \pm 0.4(\mathrm{syst.})$$

Summary

- First ever inclusive measurement of quark to photon fragmentation function. Agreement with QCD predictions.
- Studied the difference between multiplicity distributions of gluon and quark jets. Differences in mean, skew and curtosis. Dispersion the same.
- Running of α_s using moments of event shape variables. Hadronization effects modeled with power corrections. Constant α_s has been excluded with greater than 95% confidence level.
- First results at $\sqrt{s} = 183\ \mathrm{GeV}$. The energy evolution of ξ_0 and $\langle n_{\mathrm{ch}} \rangle$ are consistant with QCD predictions.