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PERTURBATIVE QCD DATA ARE CONSISTENT WITH LIGHT GLUINOS

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ABSTRACT

We discuss systematically the consistency of light gluinos with data on perturbative QCD from deep inelastic scattering, quarkonia, jets at LEP, and the total hadronic cross-section in e^+e^- annihilation on the Z peak and elsewhere. We demonstrate that, in addition to the well-known increase in the value of $\alpha_s(m_Z)$ inferred from lower-energy data due to the slower running of α_s in the presence of light gluinos, the value of $\alpha_s(m_Z)$ extracted from the LEP data must also be *increased*, as a result of including the effects of virtual light gluinos. The effect of these increases in other estimates of $\alpha_s(m_Z)$ is to make them more consistent with the value extracted from the total e^+e^- cross-section, which would otherwise appear distinctly higher. We discuss the possibility of looking for light gluinos in four-jet events at LEP, and their possible implications for scaling violations at HERA.

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1. Introduction

It is normally assumed in discussions of supersymmetric phenomenology that all the sparticles have masses so large that they are beyond the physics reach of accelerators now running. However, there is one persistent possible exception to this general assumption, namely that the gluinos are very light, weighing at most a few GeV [1]. This possibility has been severely constrained by a number of different experimental searches, notably at the CERN $p\bar{p}$ collider [2], in bottomonium decays, and in fixed-target experiments looking for metastable particles or missing energy [3],[4]. Nevertheless, there are two possible windows for light gluino masses and lifetimes that do not seem to be ruled out by these analyses. One is for gluinos weighing between 3 and 4 GeV with lifetimes around $10^{-13}s$, and the other is for gluinos weighing 3 GeV or more and having lifetimes between about 10^{-8} and $10^{-10}s$.

Two of us (J.E. and D.V.N.) argued some time ago together with I. Antoniadis [5] that these windows could be explored indirectly via the indirect effects of light gluinos in loop diagrams. Specifically, we pointed out that the consistency of low-energy determinations of α_s , for example in deep inelastic scattering, quarkonium or τ decays, with high-energy determinations of $\alpha_s(m_Z)$ constrains in principle the contributions of light coloured particles to the renormalization group running of α_s , and in particular the possible contributions of light gluinos. We showed that the LEP jet data then available disfavoured light gluinos, but we said that “This conclusion should be regarded as preliminary, pending further reduction of the experimental and theoretical uncertainties”. Subsequently, the LEP jet data and their theoretical understanding have advanced somewhat, and the preferred value of α_s extracted from LEP jet data has increased significantly. This has led to renewed questioning whether light gluinos are consistent with the LEP and other perturbative QCD data [6],[7].

In fact, as we show later in this paper, one cannot take blindly the values of $\alpha_s(m_Z)$ extracted from LEP jet data and compare them directly with lower-energy data extrapolated with the slower running of α_s caused by the presence of light gluinos. This is because the LEP values of $\alpha_s(m_Z)$ have been extracted from analyses using loop corrections [8] in which the possible effects of light gluinos have not been included. Any analysis claiming consistency of the perturbative QCD data must include light gluinos consistently in all loop diagrams, not just in running α_s up from the typical energies of deep inelastic scattering, quarkonium or τ decays to the energy of LEP.

The main purpose of this paper is precisely to furnish such a consistent analysis, including gluino loop effects in the analysis of LEP jet data and the total hadronic cross-section on the Z peak [†]). We find that including the virtual effects of light gluinos *increases* the jet values of $\alpha_s(m_Z)$ by about 10 percent, and also increases the value inferred from the total cross-section at LEP, although by less than 2 percent. The net effect of these increases, combined with the change in the running of α_s up from lower energies, is that the overall consistency of perturbative determinations of $\alpha_s(m_Z)$ is *improved* if light gluinos are present, since the other determinations of $\alpha_s(m_Z)$ are now in better agreement with that extracted from the total cross-section. However, this improvement is not very significant, and we do not claim that the data are inconsistent with the absence of light

[†]) This was not done in [6], [7].

gluinos. Nevertheless, we feel that our analysis reinforces the desirability of further direct searches for light gluinos. One way to do this is by examining the rate and characteristics of four-jet events at LEP. Another is by careful analysis of scaling violations at HERA, where the effective value of α_s would be about 10 percent higher in the presence of light gluinos than without them, and real gluinos might be observable at low values of the Bjorken scaling variable x .

2. The Running of α_s from Low Energies

As a warm-up exercise, we first discuss the running of the low-energy α_s data up to m_Z . The one-loop expression for the QCD β function ^{†)} including light gluinos is

$$-\frac{\alpha_s}{4\pi} \left(9 - \frac{4n_f}{3} \right) \quad (2.1)$$

and the two-loop expression is

$$-\left(\frac{\alpha_s}{4\pi} \right)^2 \left(54 - \frac{38n_f}{3} \right) \quad (2.2)$$

where n_f is the number of flavours.

These expressions are to be used for momenta Q larger than the threshold for gluino pair production, i.e. twice the gluino mass m_{gluino} , which we shall vary over the range 3 to 5 *GeV*. The most significant low-energy data are those extracted from τ decays, charmonium spectroscopy, bottomonium decays, and deep inelastic scattering in fixed-target ν and μ experiments [10]. The first two of these are at Q values below m_{gluino} , whilst the gluino threshold might be within the kinematic ranges of the latter two. The relevant average momentum transfers in the deep inelastic data are about 5 *GeV* for ν scattering and 7.1 *GeV* for μ scattering. We list in Table 1 the values of $\alpha_s(m_Z)$ extracted from the low-energy data, both without gluinos, as reviewed in ref. [10], and with gluinos of various different masses. We see that the effect of including gluinos is to increase the extrapolated value of $\alpha_s(m_Z)$ by as much as 15 percent. Since the low-energy data in the absence of gluinos tend to indicate a lower value of $\alpha_s(m_Z)$ than that inferred from LEP data, this increase is promising, but we re-analyze the LEP data themselves before drawing any conclusions.

^{†)} This is defined by

$$\frac{d\alpha_s(Q^2)}{d\log(Q^2)} = \beta\alpha_s(Q^2)$$

3. Virtual Gluino Effects on LEP Jet Cross-sections

In this section we shall mainly be concerned with the three-jet cross-section, which is given by [11]

$$\frac{1}{\sigma_0}d\sigma_0^{(3)}(y_{13}, y_{23}) = \frac{2\alpha_s(1-y_{13})^2 + (1-y_{23})^2}{3\pi y_{13}y_{23}} \quad (3.1)$$

at the tree level, where σ_0 is the leading-order contribution to the total cross-section, and $y_{ij} = (p_i - p_j)^2/m_Z^2$. The three-jet cross-section is given at the one-loop level [8] by an expression of the form

$$\frac{1}{\sigma_0}d\sigma_1^{(3)}(y_{13}, y_{23}) = \frac{1}{\sigma_0}d\sigma_0^{(3)}(y_{13}, y_{23})\frac{\alpha_s}{2\pi} \left[\frac{17}{6}\pi^2 + \rho(y_{13}, y_{23}) \right] \quad (3.2)$$

where we have pulled out explicitly a correction term proportional to π^2 , and the form of the residual correction $\rho(y_{13}, y_{23})$ will be discussed shortly. We assume that the infrared divergence in the three-jet cross-section has been regularized by combining it with the infrared part of the four-jet cross-section $d\sigma^{(4)}/\sigma_0$, which is also of order α_s^2 .

We now consider an arbitrary event shape variable X , which is given for three-jet final states by $X^{(3)}(y_{12}, y_{23})$, and for four-jet final states by $X^{(4)}(\dots)$. The corresponding differential cross-section is then given by

$$\begin{aligned} \frac{1}{\sigma_0} \frac{d\sigma}{dX} &= \int dy_{13}dy_{23}\theta(1-y_{13}-y_{23})\delta(X - X^{(3)}(y_{13}, y_{23}))\frac{d\sigma_0^{(3)}(y_{13}, y_{23})}{\sigma_0} \\ &\times \left\{ 1 + \frac{\alpha_s}{2\pi} \left[\frac{17}{6}\pi^2 + \rho(y_{13}, y_{23}) \right] \right\} \\ &+ \int d^{(4)}LIPS \frac{d\sigma_0^{(4)}}{\sigma_0} \delta(X - X^{(4)}(\dots)) \end{aligned} \quad (3.3)$$

and the generic correction factor, $\eta(X)$, defined in ref.[12] is given by

$$\begin{aligned} 6\eta(X) \int dy_{13}dy_{23}\theta(1-y_{13}-y_{23})\delta(X - X^{(3)}(y_{13}, y_{23}))\frac{d\sigma_0^{(3)}(y_{13}, y_{23})}{\sigma_0} &= \\ \int dy_{13}dy_{23}\theta(1-y_{13}-y_{23})\delta(X - X^{(3)}(y_{13}, y_{23}))\frac{d\sigma_0^{(3)}(y_{13}, y_{23})}{\sigma_0}\rho(y_{13}, y_{23}) & \\ + \frac{2\pi}{\alpha_s} \int d^{(4)}LIPS \frac{d\sigma_0^{(4)}}{\sigma_0} \delta(X - X^{(4)}(\dots)) & \end{aligned} \quad (3.4)$$

To an extremely good approximation, as good as the accuracy of the Monte Carlo routine used to perform the phase space integral for the higher order corrections, the part of the

higher-order correction (3.2) that depends on the light fermions is given throughout the three-jet region by

$$\rho^{Fermi}(y_{13}, y_{23}) = T_R \left(\frac{2}{3} \log(y_{13}y_{23}) - \frac{10}{9} \right) \quad (3.5)$$

where quarks contribute $n_f/2$ to T_R , and we can neglect $e^+e^- \rightarrow q\bar{q}q'\bar{q}'$, so that $d\sigma^{(4)} = 0$ throughout the three-jet kinematic range. For the case of the Fox-Wolfram variable, C , the accuracy of this approximation can be seen by a direct comparison with the fermionic part of the higher-order correction displayed explicitly in [8]. The key point for this analysis is that whereas the gluon corrections to the three jet cross section are positive the fermion-dependent contribution (3.5) is *negative*. This means that, when T_R is increased by the appearance of some new species of fermion such as a light gluino, the one-loop correction to the three-jet cross-section is *decreased* by virtual fermion effects. This phenomenon is exhibited in the figure for the thrust variable T and the Fox-Wolfram variable C . It is evident, therefore, that the value of $\alpha_s(m_Z)$ extracted from a fit to such a distribution will be *increased*.

Before analysing this effect numerically, we first make some comments about the mathematical formulae to be used in the fits. We have argued previously [12] that the π^2 terms in the one-loop correction (3.2) are likely to exponentiate over most of the three-jet kinematic range when higher orders are calculated. We are well aware that this exponentiation has not been proved, but we assume it here as a working hypothesis. In this case, the one-loop expression becomes

$$\begin{aligned} \frac{1}{\sigma_0} \frac{d\sigma}{dX} &= \int dy_{13} dy_{23} \theta(1 - y_{13} - y_{23}) \delta(X - X^{(3)}(y_{13}, y_{23})) \frac{d\sigma_0^{(3)}(y_{13}, y_{23})}{\sigma_0} \\ &\times \left\{ \exp\left(\frac{17\alpha_s\pi}{12}\right) \left[1 + \frac{\alpha_s}{2\pi} \rho(y_{13}, y_{23}) \right] \right\} \\ &+ \int d^{(4)}LIPS \frac{d\sigma_0^{(4)}}{\sigma_0} \delta(X - X^4(\dots)) \end{aligned} \quad (3.6)$$

The recipe for including gluinos is simply to add to $\rho(y_{13}, y_{23})$ the expression (3.5) for ρ^{Fermi} with an extra contribution to T_R of $3/2$, so that the differential cross-section becomes $d\sigma^{w.g.}$, given by

$$\begin{aligned} \frac{1}{\sigma_0} \frac{d\sigma^{w.g.}}{dX} &= \int dy_{13} dy_{23} \theta(1 - y_{13} - y_{23}) \delta(X - X^{(3)}(y_{13}, y_{23})) \frac{d\sigma_0^{(3)}(y_{13}, y_{23})}{\sigma_0} \\ &\times \left\{ \exp\left(\frac{17\alpha_s\pi}{12}\right) \left[1 + \frac{\alpha_s}{2\pi} \left(\rho(y_{13}, y_{23}) + \log(y_{13}y_{23}) - \frac{5}{3} \right) \right] \right\} \\ &+ \int d^{(4)}LIPS \frac{d\sigma_0^{(4)}}{\sigma_0} \delta(X - X^4(\dots)) \end{aligned} \quad (3.7)$$

However, there is an ambiguity in this procedure: should the exponential factor also appear in front of the non- π^2 correction term $\rho(y_{13}, y_{23})$? No-one knows, and we consider this as a theoretical uncertainty in the extraction of $\alpha_s(m_Z)$. Thus, we consider in our subsequent numerical results two possible expressions for the gluino corrections to the differential cross-section for a generic three-jet variable: one without exponentiation of the gluino correction:

$$\begin{aligned} \frac{1}{\sigma_0} \frac{d\sigma^{w.g.}}{dX} &= \frac{1}{\sigma_0} \frac{d\sigma}{dX} + \frac{\alpha_s}{2\pi} \int dy_{13} dy_{23} \theta(1 - y_{13} - y_{23}) \delta(X - X^{(3)}(y_{13}, y_{23})) \\ &\quad \times \frac{d\sigma_0^{(3)}(y_{13}, y_{23})}{\sigma_0} \left(\log(y_{13}y_{23}) - \frac{5}{3} \right) \end{aligned} \quad (3.8)$$

and one with exponentiation of the gluino correction:

$$\begin{aligned} \frac{1}{\sigma_0} \frac{d\sigma^{w.g.}}{dX} &= \frac{1}{\sigma_0} \frac{d\sigma}{dX} + \frac{\alpha_s}{2\pi} \int dy_{13} dy_{23} \theta(1 - y_{13} - y_{23}) \delta(X - X^{(3)}(y_{13}, y_{23})) \\ &\quad \times \exp\left(\frac{17\alpha_s\pi}{12}\right) \frac{d\sigma_0^{(3)}(y_{13}, y_{23})}{\sigma_0} \left(\log(y_{13}y_{23}) - \frac{5}{3} \right) \end{aligned} \quad (3.9)$$

where the first term on the R.H.S. in each case is the differential cross section in the absence of light gluinos.

In the histograms shown in the Figure which display the effects of including light gluinos, the thickness of the solid line is a measure of the uncertainties in the effects, given by the difference between the two above expressions.

We have studied the following three-jet variables: thrust T , oblateness O , energy-energy correlations EEC , the asymmetry in energy-energy correlations $AEEC$, the Fox-Wolfram variable C , the heavy jet invariant mass M_H , and the quantity M_D , which measures the difference between the light and heavy jet invariant masses. The experimental values of these quantities have been taken from the review [10]. The corresponding values of $\alpha_s(m_Z)$ extracted assuming the presence and absence of gluinos are shown in Table 2. In each case, the ranges quoted for the estimates with gluinos accounts for the above-mentioned ambiguity, and the gluino mass is assumed to be much lighter than M_Z . We see that the inclusion of gluinos increases $\alpha_s(M_Z)$ by about 10 percent. The bottom row of Table 2 gives the weighted average values of $\alpha_s(M_Z)$. For the reason given in ref. [12], namely that the non- π^2 correction η (3.4) is particularly large for these variables, we prefer to exclude oblateness and the $AEEC$ from the weighted average, but we *do* include the effect of exponentiation of the π^2 part of the correction factor discussed in [12]. This has the effect of reducing the average value of $\alpha_s(M_Z)$, as shown in the last line of Table

2. We find that in the presence of light gluinos

$$\alpha_s(M_Z) = 0.124 \pm .007 \quad (3.10)$$

for the value of $\alpha_s(M_Z)$ extracted from weighted averages of three-jet data on the Z peak. The error is obtained from the errors quoted in [10] added in quadrature with the theoretical error on the effect of the gluinos. This is to be compared with the value of $\alpha_s(m_Z) = 0.113 \pm .006$ in the absence of gluinos but with π^2 exponentiation. The penultimate line of Table 2 gives the corresponding values of $\alpha_s(m_Z)$ with and without gluinos, but without π^2 exponentiation.

4. Total e^+e^- Cross-section Data

These can be used to extract a value of $\alpha_s(M_Z)$ using the next-to-leading order formula [13]

$$\sigma^{tot}(e^+e^-) = \sigma_0^{tot}(e^+e^-) \left[1 + \frac{\alpha_s}{\pi} + \left(\frac{\alpha_s}{\pi} \right)^2 (1.98 - 0.230T_R) \right] \quad (4.1)$$

The available data are well known to give a value of $\alpha_s(M_Z)$ that is consistently higher than other determinations, though only about one standard deviation higher than the latest three-jet measurements on the Z peak, in the absence of light gluinos. To extract the value of $\alpha_s(M_Z)$ in the presence of light gluinos, we can to this order simply add three more effective flavours and equate

$$\frac{\alpha_s(M_Z)}{\pi} + 1.41 \left(\frac{\alpha_s(M_Z)}{\pi} \right)^2 = \frac{\alpha'_s(M_Z)}{\pi} + 1.06 \left(\frac{\alpha'_s(M_Z)}{\pi} \right)^2 \quad (4.2)$$

where $\alpha'_s(M_Z)$ is the value which would be extracted from the total cross-section if gluinos were included, and $\alpha_s(M_Z)$ is the value of $0.130 \pm .012$ quoted in [10]. This yields

$$\alpha'_s(M_Z) = 0.132 \pm .012 \quad (4.3)$$

Thus we find yet another increase in the extracted value of $\alpha_s(M_Z)$, but by less than 2 percent this time. For the total cross-section the higher-order corrections are smaller (both for the gluon and fermion corrections) because of a partial cancellation by the two-loop correction to the two-jet cross-section. In fact it can be seen from (3.5) that the effect of adding light gluinos actually diverges logarithmically as one goes to the two-jet region ($y_{13} \rightarrow 0$ or $y_{23} \rightarrow 0$), and this divergence is cancelled by an infrared-divergent correction

to the two-jet cross-section.[†]). The net effect is a reduction in the higher-order correction for the total cross-section compared with the jet event shape differential cross-sections.

The overall consistency of the available data on $\alpha_s(M_Z)$ is therefore improved by the inclusion of light gluinos, in that the spread of central values is reduced from 0.112-0.130 to 0.124-0.136, but this effect is not conclusive. The most significant effect of virtual gluinos is not to reconcile the low-energy and LEP jet data, whose central values are not brought closer together (0.124-0.136 compared with 0.112-0.121 previously). We suspect that this is because the three-jet data effectively measure the α_s at a momentum scale significantly below M_Z . On the other hand, including light gluinos does bring other determinations of $\alpha_s(M_Z)$ into better agreement with the value extracted from the total hadronic cross-section at the Z peak, in that a maximum possible discrepancy of 0.112 vs 0.130 is reduced to 0.124 vs 0.132. It has been a long-standing puzzle that total cross-section measurements consistently give larger values of α_s , although the difference has never been more than one standard deviation or so. Thus, there has never really been a problem. Nevertheless the improved agreement is interesting and may become significant as the statistical errors on the measurement of $\alpha_s(M_Z)$ are further reduced. Even though there must be less exotic solutions to the potential problem of a mismatch in the values of $\alpha_s(M_Z)$ extracted from different data, the fact that data on the running of α_s from low energies to M_Z cannot rule out light gluinos, together with the improved consistency of the LEP data when gluinos are included, re-awakens our interest in possible direct searches.

5. Search for Light Gluinos in Four-Jet Events at LEP

It was suggested several years ago [9] to look for light gluinos in four-jet events in e^+e^- annihilation, produced by gluon splitting after bremsstrahlung from an initial q or \bar{q} . Neglecting the gluino mass, which should be a good approximation for events passing the selection criteria of the LEP experiments, the differential cross-section is proportional to that for $q\bar{q}q'\bar{q}'$ final states in e^+e^- annihilation, where q and q' are both light flavours. The differential cross-section for this process can be found in [8]. Note that, as mentioned in ref. [9], there is a factor of 3 relative to the cross-section calculated for light quarks in ref. [8]: this is composed of a factor 6 for colour, and 1/2 for the Majorana nature of the gluinos.

Two of the LEP collaborations have recently published [14, 15] detailed analyses of

[†]) The divergence is actually regulated by the gluino mass, but for light gluinos we can neglect this for energies of order M_Z .

four-jet final states in which they make a kinematic separation of the contributions due to double gluon bremsstrahlung, gluon splitting to gluons, and gluon splitting to fermions. These studies were motivated by the wish to measure independently the colour charges of gluons and quarks, and the results were consistent with the Standard Model. In the presence of light gluinos, the value of $T_R = n_f/2$ for quarks measured in these experiments would be enhanced to

$$n_f/2 + 3/2 \tag{5.1}$$

The data published so far are also consistent with this enhanced value.

Discriminating between the Standard Model and the presence of light gluinos will require further work on at least two fronts: the QCD radiative corrections to the four-jet cross-section should be evaluated, and the distinctive properties of gluino jets should be investigated. Gluinos are expected to decay into invisible, weakly-interacting neutral particles that carry away missing energy. Any experiment looking at four-jet events needs to consider carefully whether such an energy loss could bias the jet energy determination, possibly shifting gluino events to lower apparent energies where there is more background, or even pushing gluino jets below the experimental cuts. On the other hand, gluinos in the longer-lived part of the light gluino window, namely with a lifetime between 10^{-8} and 10^{-10} s, might yield events with detectable separated vertices in the four-jet region.

We therefore think that the light gluino window could be closed (or opened) by determined searches at LEP.

6. Light Gluino Effects at HERA

If gluinos are indeed light, they could have both indirect and direct effects at HERA. As we have discussed above, the preferred value of $\alpha_s(M_Z)$ extracted from LEP and lower-energy data is increased by about 10 percent, to around 0.13, if light gluinos are present.[†] This difference should show up clearly as enhanced scaling violations at large momentum transfers at HERA, due to the reduction in the value of β . In addition to this indirect effect, there could also be an observable direct effect via the production of real light gluino pairs at small values of the Bjorken scaling variable x . Their production would be a higher-order QCD effect whose evaluation, as well as that of the conventional low- x background, goes beyond the scope of this paper. However, we recall that, as discussed

[†]) Although it lies beyond the scope of this paper, we note that such a large value of $\alpha_s(m_Z)$ would endanger the high degree of consistency of LEP data [16] with minimal supersymmetric GUTs.

in case of four-jet events at LEP, gluino pair production events could have distinctive missing energies and possibly separated vertices.

We therefore think that the light gluino window could also be closed (or opened) by thorough searches at HERA.

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Table 1
Extraction of $\alpha_s(M_Z)$ from low energy data

Process	$\alpha_s(M_Z)$			
	Without gluinos	$m_{gluino} = 3 \text{ GeV}$	$m_{gluino} = 4 \text{ GeV}$	$m_{gluino} = 5 \text{ GeV}$
$\frac{\Gamma(\Upsilon \rightarrow ggg)}{\Gamma(\Upsilon \rightarrow \mu^+ \mu^-)} (LEP)$	$0.121 \pm .005$	$0.140 \pm .006$	0.137 ± 0.006	$0.136 \pm .006$
$\frac{\Gamma(\Upsilon \rightarrow ggg)}{\Gamma(\Upsilon \rightarrow \mu^+ \mu^-)} (World)$	$0.118 \pm .005$	$0.136 \pm .006$	0.134 ± 0.006	$0.132 \pm .006$
$J/\Psi, \Upsilon$ decays	$0.113 \pm .005$	$0.129 \pm .006$	$0.127 \pm .006$	$0.126 \pm .006$
D.I.S.	$0.112 \pm .004$	$0.129 \pm .005$	$0.127 \pm .005$	$0.125 \pm .005$

Table 2
Extraction of $\alpha_s(M_Z)$ from jets data at LEP

Event Shape Variable	$\alpha_s(M_Z)$	
	Without gluinos	With gluinos
C	0.120 (N)	0.129-0.134
	0.124 (Delphi)	0.134-0.139
	0.127 (Opal)	0.137-0.142
T	0.126 (N)	0.134-0.139
	0.123 (Delphi)	0.131-0.135
	0.118 (L3)	0.126-0.130
	0.127 (Opal)	0.135-0.140
EEC	0.126 (N)	0.143-0.152
	0.129 (Delphi)	0.147-0.156
	0.128 (Opal)	0.152-0.162
M_H	0.132 (N)	0.141-0.145
	0.125 (Delphi)	0.133-0.137
	0.128 (Opal)	0.136-0.141
M_D	0.141 (N)	0.150-0.155
	0.122 (Delphi)	0.130-0.134
	0.118 (Opal)	0.126-0.130
O	0.113 (N)	0.122-0.127
	0.122 (Delphi)	0.132-0.137
	0.121 (Opal)	0.130-0.136
AEEC	0.110 (N)	0.114-0.115
	0.114 (Delphi)	0.118-0.120
	0.116 (Opal)	0.120-0.122
Weighted Average	0.120±.006	0.132±.007
After π^2 Exponentiation	0.113 ± .006	0.124 ± .007

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Figure Caption

Histograms of the C and thrust distributions for the three-jet region, showing the lowest-order differential cross-section (dotted line) and the higher-order differential cross section without gluinos (thin solid line) and with gluinos (thick solid line). The thickness of the solid line is a measure of the theoretical uncertainty in the gluino effect.