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A Study of Energy-Energy Correlations in e^+e^- Annihilations at $\sqrt{s} = 34.6$ GeV

PLUTO Collaboration

Ch. Berger, H. Genzel,
W. Lackas, J. Pielorz[a], F. Raupach, W. Wagner[b],
I. Phys. Institut der RWTH Aachen[c], Federal Republic of Germany

A. Klovning, E. Lilleстöl,
University of Bergen[d], Norway

J. Bürger, L. Criegee, A. Deuter, F. Ferrarotto[e], G. Franke, M. Gaspero[e],
Ch. Gerke[f], G. Knies, B. Lewendel, J. Meyer, U. Michelsen, K.H. Pape,
B. Stella[e], U. Timm, G.G. Winter, M. Zachara[g], W. Zimmermann,
Deutsches Elektronen-Synchrotron (DESY), Hamburg,
Federal Republic of Germany

P.J. Bussey, S.L. Cartwright[h], J.B. Dainton, B.T. King[i], C. Raine,
J.M. Scarr, I.O. Skillicorn, K.M. Smith, J.C. Thomson[j],
University of Glasgow[k], U.K.

O. Achterberg, V. Blobel, D. Burkart, K. Diehlmann, M. Feindt,
H. Kapitza[l], B. Koppitz, M. Krüger[m], M. Poppe, H. Spitzer, R. van Staa,
II. Institut für Experimentalphysik der Universität Hamburg[c],
Federal Republic of Germany

C.Y. Chang, R.G. Glasser, R.G. Kellogg, S.J. Maxfield[n], R.O. Polvado[o],
B. Sechi-Zorn[a], J.A. Skard, A. Skuja, A.J. Tylka, G.E. Welch, G.T. Zorn,
University of Maryland[p], U.S.A.

F. Almeida[q], A. Bäcker, F. Barreiro[r], S. Brandt, K. Derikum[s], C. Grupen,
H.J. Meyer, H. Müller, B. Neumann, M. Rost, K. Stupperich, G. Zech,
Universität-Gesamthochschule Siegen[c], Federal Republic of Germany

G. Alexander, G. Bella, Y. Gnat, J. Grunhaus,
University of Tel-Aviv[t], Israel

H. Junge, K. Kraski, C. Maxeiner, H. Maxeiner, H. Meyer, D. Schmidt,
Universität-Gesamthochschule Wuppertal[c], Federal Republic of Germany

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a) Deceased.
b) Now at University of California at Davis, Davis, Ca., USA.
c) Supported by the BMFT, Federal Republic of Germany.
d) Partially supported by The Norwegian Council for Science and the Humanities.
e) Rome University, partially supported by I.N.F.N., Sezione di Roma, Italy.
f) Now at CERN, Geneva, Switzerland.
g) Institute of Nuclear Physics, Cracow, Poland.
h) Now at Rutherford Appleton Laboratory, Chilton, UK.
i) Now at Univ. of Liverpool, Liverpool, UK.
j) Now at Glasgow College of Technology, Glasgow, UK.
k) Supported by the U.K. Science and Engineering Research Council.
l) Now at Carleton University, Ottawa, Ontario, Canada.
m) Now at Universität Karlsruhe, Federal Republic of Germany.
n) Now at Univ. of Massachussetts, Amherst, Mass., U.S.A.
o) Now at Northeastern University, Boston, Mass., U.S.A.
p) Partially supported by the Department of Energy, U.S.A.
q) On leave of absence from Inst. de Fisica, Universidad Federal do Rio de Janeiro, Brasil.
r) On leave of absence at Universidad Autonoma de Madrid, Spain.
s) Now at BESSY, Berlin, Federal Republic of Germany.
t) Partially supported by the Israeli Academy of Sciences and Humanities - Basic Research Foundation.

ABSTRACT

We present high statistics measurements of the energy-energy correlation (EEC) and its related asymmetry (AEEC) in e^+e^- annihilation at a c.m. energy of 34.6 GeV. We find that the energy dependence as well as the large angle behaviour of the latter are well described by perturbative QCD calculations to $O(\alpha_s^2)$. Non-perturbative effects are estimated with the help of fragmentation models in which different jet topologies are separated using (ε,δ) cuts, and found to be small. The extracted values of $\Lambda_{\overline{MS}}$ lie between 100 and 300 MeV.

Energy-energy correlations (EEC) have been proposed in the literature as a means of testing QCD in e^+e^- annihilation in the continuum. The EEC is defined |1| as follows

$$f(\chi)=\frac{d\Sigma}{d\cos\chi}=\frac{1}{\sigma_0}\sum\int\frac{d\sigma}{dx_i dx_j d\cos\chi}\, x_i x_j dx_i dx_j \qquad (1)$$

where the sum runs over all possible pairs of particles in a given final state , χ is the angle between them and $x_i=E_i/E_{CM}$ is the fractional energy carried away by the ith particle.

It is useful to define the forward-backward asymmetry (AEEC)

$$d\Sigma^A/d\cos\chi = f(\pi-\chi) - f(\chi) \qquad (2)$$

which for $|\cos(\chi)| < 0.8$ is known |1,3| to be free from the fragmentation effects induced by two-jet events.

Recently detailed calculations for the EEC and its related asymmetry including QCD corrections to $O(\alpha_s^2)$ have been reported |2,3|. These results can be summarized by stating that

1. the AEEC is better behaved in perturbation theory than any other quantity investigated so far, the second order corrections being only of the order of a few percent.

2. the AEEC, in contrast to the EEC itself, is infrared stable, i.e. insensitive to soft radiation and hence to the cut-offs introduced to separate two from three and four-jet events.

We have published data on the EEC and its related asymmetry at c.m. energies between 7.7 and 31.6 GeV |4|. Although poor in statistics our data showed that

1. the large angle behaviour of the AEEC can be well described by the results of the perturbative calculations and

2. the large angle AEEC, in contrast to the EEC, varies smoothly with c.m. energy

These observations can be interpreted as a consequence of the different properties exhibited by the EEC and its related asymmetry in perturbation theory as discussed above. Therefore it is important to pursue this type of analysis at higher energies and with higher statistics. This is the aim of the present paper.

The data used in this analysis were obtained with the PLUTO detector working at PETRA, the e^+e^- storage ring at DESY, Hamburg, at the c.m. energy $\sqrt{s}$=34.6 GeV. PLUTO is a magnetic detector with a tracking device consisting of 11 layers of cylindrical proportional wire chambers and two layers of drift chambers, providing charged particle recognition over 87% of 4π. A magnetic field of 1.65 Tesla is provided by a 1m long superconducting coil. Mounted inside the coil are the barrel (8.6 radiation lengths) and endcap (10.5 radiation lengths) lead scintillator shower counters, covering 96% of 4π. These are used for detection of neutral particles. The data selection criteria require that

1. the visible energy is greater than 40% of the nominal c.m. energy

2. at least four charged tracks must belong to a common vertex, the charge imbalance being smaller than two units

3. the reconstructed interaction vertex lies within ±4 cm of the center of the bunch-bunch collision

4. the angle of the jet axis with respect to the beam, Θ_J, must satisfy the condition $|\cos\Theta_J| \leq 0.75$

5. the momentum imbalance in the beam direction as well as in the direction perpendicular to it should be smaller than 40% of the nominal c.m. energy

6. two jet events where one jet consists of one charged track, and the other jet consists of three charged tracks with an invariant mass smaller than 2 GeV, were removed to avoid contamination from τ pair production

The accepted sample of 6964 events contains a negligible number of background events (<2%).

Using jet simulation programs |5,6| we correct for acceptance, detector resolution, track analysis and selection criteria as well as for radiation in the initial state. The correction factor for the EEC is very close to unity in the central plateau and that for the AEEC is angle independent and close to 0.8. We have performed a number of detailed checks:

1. The method of determining the statistical error, which ignores inter-correlations between different angular bins, has been checked by conducting a series of Monte Carlo experiments. Each Monte Carlo sample consisted of the same number of events as contained in the experimental data sample. For each bin in $\cos\chi$ or χ the variance from statistical fluctuations in the Monte Carlo runs was compared to the variance calculated in the analysis of measured events. For sufficiently small bin widths, as used for the differential distributions, they were found to agree within 15%.

2. We repeated the analysis including in the input data only charged particles, for reasons of better angular resolution. The corrected distribution did not show any significant deviation from that obtained using all particles. The statistical errors were, however, approximately twice as large.

3. The correction factor for the EEC was found to depend only slightly on whether the independent |5| or the string |6| fragmentation model were used. The string corrected asymmetry, integrated in the angular region $\cos\chi<0.8$, turned out to be 8% lower than that obtained using the independent fragmentation model for the correction.

4. In an attempt to reduce the number of radiative two jet events, we imposed more stringent selection criteria. The momentum imbalance cut was reduced to 20% of the c.m. energy and events which according to our standard cluster algorithm |7| belonged to the multi-jet (>2) topology with one jet consisting of a single energetic neutral cluster were removed from the sample. Again the corrected distributions did not show any significant deviation from those previously obtained.

In fig. 1 and tables I and II we present our results for the corrected EEC, and in fig. 2 those for the AEEC. The "perturbative" tail for the latter, defined as $|\cos\chi|<0.75$, can be well fitted by the $O(\alpha_s^2)$ predictions |2,3|. The best estimate for the QCD scale parameter $\Lambda_{\overline{MS}}$, the only free parameter involved, is 112 ± 23 (stat.) ± 25 (syst.) MeV. Moreover this value is found not to depend on changes in the value of $\cos\chi$ below which the fit is performed, provided $|\cos\chi|< 0.75$. The systematic error reflects the systematic uncertainty in the absolute normalization of the AEEC introduced by the correction procedure.

In fig. 3 we show the asymmetry integrated over the range $30°<\chi<90°$ as a function of c.m. energy. The data at lower energies were obtained by PLUTO

operating at DORIS and in a lower statistics run at PETRA at 30.8 GeV |4|. It is interesting to note that the energy dependence of the integrated asymmetry is slight. In fact it is compatible with the logarithmic behaviour expected in perturbative QCD without the need for strong power correction terms as postulated by the MARK II collaboration in an analysis of their data at $\sqrt{s}$=29 GeV |8|.

A one parameter fit to the energy dependence of the integrated asymmetry yields for $\Lambda_{\overline{MS}}$ the value 91 ± 47 (stat.) ±50 (syst.) MeV. These results can be interpreted as a consequence of the infrared stability exhibited by the AEEC in perturbation theory and as an indication that fragmentation effects are not very important in the large angle region of the AEEC.

In contrast the EEC integrated in the angular region between 60° and 120°, shows a strong fall-off, see fig. 4 , similar to that exhibited by most other jet measures |9|. The energy dependence of the integrated EEC can be well fitted by the sum of two terms, a perturbative term obtained by properly integrating the $O(\alpha_s^2)$ results |2,3|, and a non-perturbative term phenomenologically parametrised as $C/\sqrt{s}$. The best estimates for the two parameters involved are $\Lambda_{\overline{MS}}$=253 ± 77 (stat.) ± 55 (syst.) MeV and C= 0.95 ± 0.16 (stat.) ± 0.10 (syst.). The results of this fit are represented by the solid line in fig. 4.

In the analysis presented so far we have stressed the importance of presenting corrected data and in particular the importance of a systematic study of the energy dependence of the integrated EEC and its asymmetry, as a model independent way to estimate the strong coupling constant. In doing so we rely upon naive, but simple and general, assumptions about the energy dependence of perturbative and non-perturbative effects. The results obtained for $\Lambda_{\overline{MS}}$ are compatible with those obtained from the gluonic width of heavy quarkonia |10|, from a measurement of the photon structure function |11| and from a study of the energy dependence of jet measures |9|.

If we wish to describe the asymmetry in the entire angular range, including the region $\cos\chi\rightarrow1$ where the contribution from two jets is dominant, we have to resort to Monte Carlo fragmentation models. In doing so we also investigate the sensitivity of the EEC and the asymmetry to different mechanisms proposed for the gluon fragmentation. We have used two Monte Carlo calculations, one |12| in which the gluon fragments independently of the parent quarks and another in which the fragmentation takes place along color strings |6|. Second order corrections have been taken into account following ref |3| and cut-off parameters (ε,δ), in the Sterman-Weinberg sense |13|, have been used to separate two from three and four-jet events. The values $\varepsilon=0.1$, ε=minimal energy of a parton/$\sqrt{s}$, and $\delta=0.4$ rad, δ=minimal angle between two partons, have been used. The parameters in the fragmentation models have been tuned to describe the gross features of the hadronic final states measured at DORIS and PETRA energies. From fits to the AEEC data shown in fig.5 we obtain for $\Lambda_{\overline{MS}}$ the values 183 ± 31 MeV in the Ali implementation of the independent fragmentation model, and 259 ± 40 MeV in the LUND implementation of the string fragmentation. These values are thus compatible with those given before. Moreover the values of $\Lambda_{\overline{MS}}$ obtained have been found to be independent of the (ε,δ) cut-offs within broad limits.

The values obtained for α_s from our comparison of the asymmetry data to Monte Carlo calculations including second order effects are compatible with those obtained in similar analyses by the MARK J and TASSO Collaborations [14,15]. They are roughly 20% lower than those obtained [15,16,20] implementing second order corrections following reference [17]. The origin of this discrepancy has been recently studied in detail by Gottschalk [18] who reports that they are due to approximations used in [17].

It is interesting to see whether Monte Carlos based on parton showers are also able to reproduce the data. To this end, we also show in fig. 5 a comparison between the expectations from the Webber Monte Carlo [19] and the corrected asymmetry. The parameters in the Webber Monte Carlo have been tuned to describe the gross features of the hadronic final states produced in e^+e^- annihilation at 35 GeV c.m. energy. The data lie a factor of two above Webber's predictions. The discrepancy is independent of the precise value of the cut-off parameter Λ used in the Monte Carlo. This should not be considered surprising, since hard gluon effects responsible for the asymmetry at large angles, are not fully accounted for in this type of parton shower Monte Carlos.

To summarize, we have presented a high statistics measurement of the EEC and its related asymmetry AEEC at $\sqrt{s}$=34.6 GeV. The data have been corrected for acceptance, detector resolution, selection criteria and radiation in the initial state. The large angle behaviour of the AEEC at $\sqrt{s}$=34.6 GeV can be well described by perturbative results to $O(\alpha_s^2)$, the values found for $\Lambda_{\overline{MS}}$ being of the order of 200 MeV. The energy dependence of the large angle AEEC is compatible with the logarithmic behaviour expected in perturbative QCD. Fitted values for $\Lambda_{\overline{MS}}$ agree with those just quoted. In contrast the EEC shows a strong energy dependence indicative of the importance of fragmentation effects. The values obtained for $\Lambda_{\overline{MS}}$ by fitting the energy dependence of the EEC plateau to the linear sum of a perturbative term and a fragmentation contribution parametrized as proportional to $1/\sqrt{s}$ are higher, of order 250 MeV. This can be interpreted as an indication that the effects of fragmentation on the AEEC are not com-

pletely negligible, though small. An alternative and more complete description of the data can be obtained with Monte Carlo fragmentation models. The values obtained for $\Lambda_{\overline{MS}}$ in the string fragmentation are systematically higher than those obtained in independent fragmentation models. It is reassuring to notice that the values obtained for $\Lambda_{\overline{MS}}$ lie within the range delimited above, fig. 6. We stress the importance of this type of measurement at yet higher energies as a precision test of perturbative QCD in e^+e^- annihilation in the continuum.

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REFERENCES

1. C.L. Basham et al., Phys. Rev. Lett. 41, 1585 (1978), Phys. Rev. D19, 2018 (1979)
2. A. Ali and F. Barreiro, Phys. Lett. 118B, 155 (1982)
3. A. Ali and F. Barreiro, Nucl. Phys. B236, 269 (1984)
4. PLUTO Coll., Ch. Berger et al., Phys. Lett. 99B, 292 (1981)
5. P. Hoyer et al., Nucl. Phys. B161, 349 (1979)
6. T. Sjöstrand, Comp. Phys. Comm. 27, 243 (1982) and 28, 229 (1983)
7. H.J. Daum, H. Meyer and J. Bürger, Z. Phys. C8, 167 (1981)
8. MARK II Coll., D. Schlatter et al., Phys. Rev. Lett. 49, 251 (1982)
9. PLUTO Coll., Ch. Berger et al., Z. Phys. C12, 297 (1982)
10. P. B. Mackenzie and G. P. Lepage, Phys. Rev. Lett. 47, 1244 (1981)
11. PLUTO Coll., Ch. Berger et al., Phys. Lett. 142, 119 (1984)
12. A. Ali, private communication
13. G. Sterman and S. Weinberg, Phys. Rev. Lett. 39, 1436 (1977)
14. MARK J Coll., B. Adeva et al., Phys. Rev. Lett. 50, 2051 (1983) and MIT-LNS Report No. 142, to be published in Phys. Rev. Lett.
15. TASSO Coll., M. Althoff et al., Z. Phys. C 26, 157 (1984)
16. JADE Coll., W. Bartel et al., Z. Phys. C 25, 231 (1984)
17. F. Gutbrod, G. Kramer and G. Schierholz, Z. Phys. C21, 235 (1984)
18. T.D. Gottschalk and M.P. Schatz, California Institute of Technology Reports: CALT-68-1173 and CALT-68-1199.
19. B.R. Webber, Nucl. Phys. B238, 492 (1984)
20. H. Maxeiner, Ph. D. Thesis, Wuppertal University, unpublished

FIGURE CAPTIONS

Fig. 1 : The corrected EEC measured by PLUTO at $\sqrt{s}$=34.6 GeV. The solid line represents the Monte Carlo expectations.

Fig. 2 : The corrected AEEC measured by PLUTO at $\sqrt{s}$=34.6 GeV. The solid line represents the results of a fit to the $O(\alpha_s^2)$ QCD predictions.

Fig. 3 : The asymmetry integrated in the region $\chi>30°$ as a function of c.m. energy. The solid line represents the results of a fit to $O(\alpha_s^2)$ QCD predictions.

Fig. 4 : The energy-energy correlation integrated in the angular region $60°<\chi<120°$ as a function of c.m. energy. The solid line represents the results of a fit to the linear sum of a perturbative term and a fragmentation term falling as $1/\sqrt{s}$.

Fig. 5 : The corrected AEEC measured by PLUTO at $\sqrt{s}$=34.6 GeV. The solid line represents the expectations from fragmentation models ,be it independent or of the string type, with $O(\alpha_s^2)$ corrections included. The dashed (dashed-dotted) line represents the expectations from the Webber (resp. Field-Feynman) model.

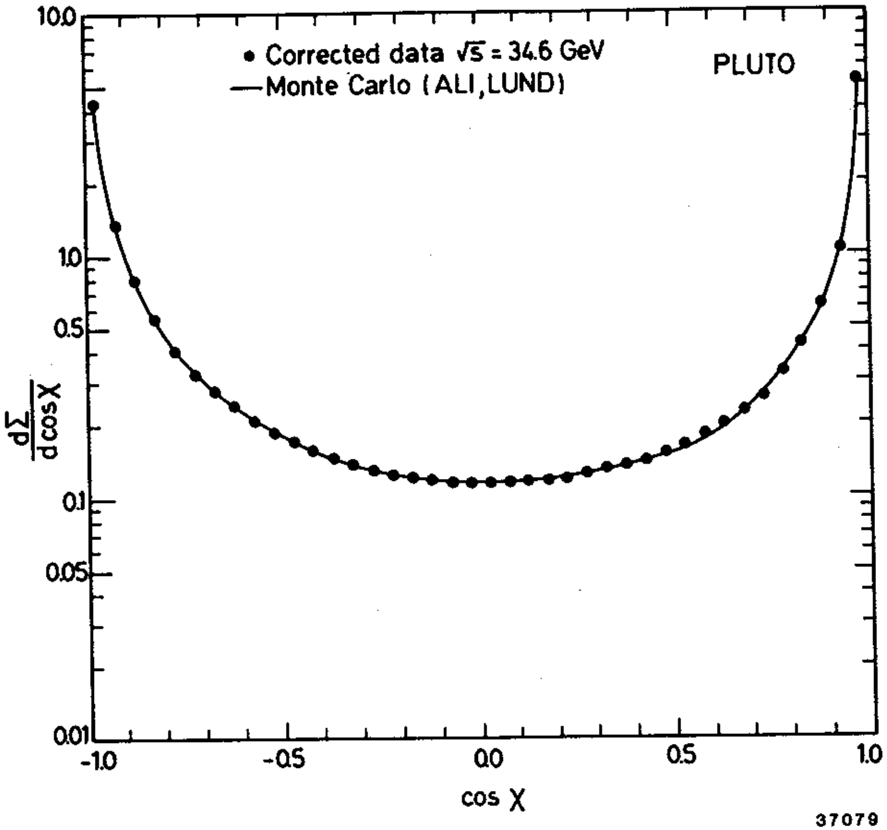
Fig. 6 : A compilation of the different values for $\Lambda_{\overline{MS}}$ obtained in this analysis using different assumptions about fragmentation effects. See text for more details. Only statistical errors are shown.

cosχ	value and error
-1.00 to -0.95	4.3453±0.0412
-0.95 to -0.90	1.3620±0.0161
-0.90 to -0.85	0.7998±0.0106
-0.85 to -0.80	0.5530±0.0081
-0.80 to -0.75	0.4124±0.0065
-0.75 to -0.70	0.3313±0.0057
-0.70 to -0.65	0.2798±0.0023
-0.65 to -0.60	0.2440±0.0021
-0.60 to -0.55	0.2097±0.0022
-0.55 to -0.50	0.1904±0.0022
-0.50 to -0.45	0.1716±0.0022
-0.45 to -0.40	0.1585±0.0020
-0.40 to -0.35	0.1465±0.0021
-0.35 to -0.30	0.1368±0.0020
-0.30 to -0.25	0.1285±0.0018
-0.25 to -0.20	0.1220±0.0019
-0.20 to -0.15	0.1198±0.0019
-0.15 to -0.10	0.1149±0.0018
-0.10 to -0.05	0.1142±0.0018
-0.05 to 0.00	0.1141±0.0019
0.00 to 0.05	0.1106±0.0018
0.05 to 0.10	0.1133±0.0018
0.10 to 0.15	0.1155±0.0018
0.15 to 0.20	0.1137±0.0017
0.20 to 0.25	0.1174±0.0018
0.25 to 0.30	0.1249±0.0018
0.30 to 0.35	0.1311±0.0017
0.35 to 0.40	0.1340±0.0016
0.40 to 0.45	0.1369±0.0015
0.45 to 0.50	0.1524±0.0016
0.50 to 0.55	0.1605±0.0015
0.55 to 0.60	0.1816±0.0025
0.60 to 0.65	0.1977±0.0034
0.65 to 0.70	0.2280±0.0037
0.70 to 0.75	0.2618±0.0040
0.75 to 0.80	0.3333±0.0048
0.80 to 0.85	0.4242±0.0058
0.85 to 0.90	0.6163±0.0075
0.90 to 0.95	1.0739±0.0116
0.95 to 1.00	5.2184±0.0412

Table 1. Energy-energy correlation , corrected data

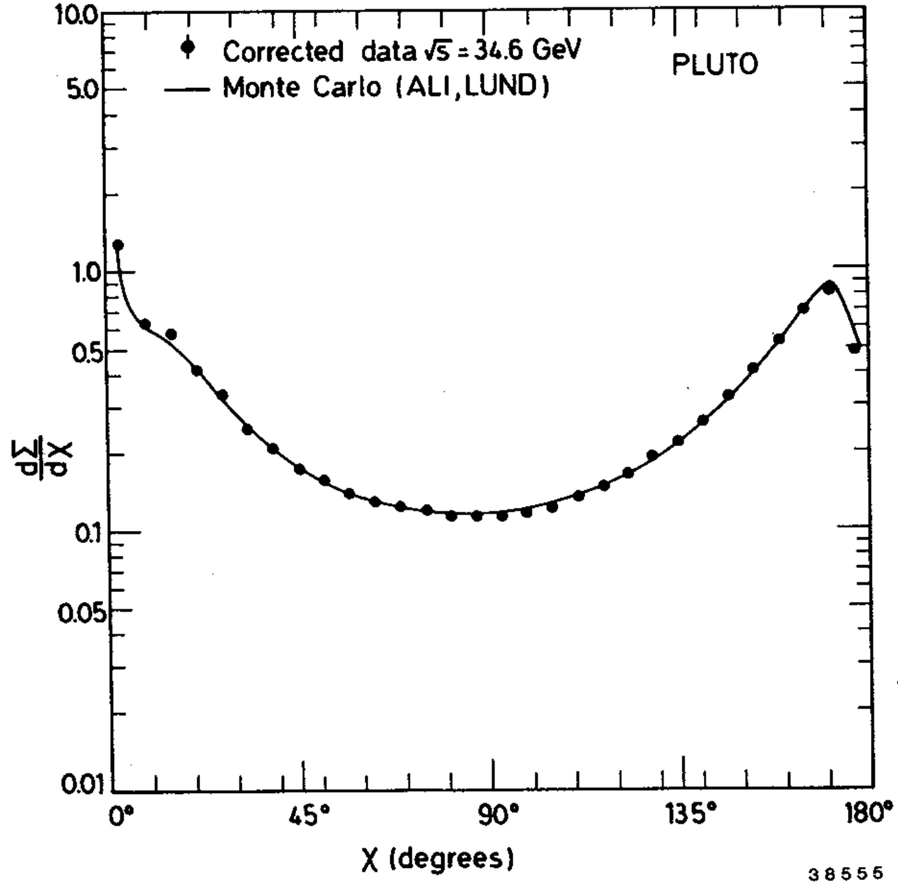
χ (degrees)	value and error
0.0 to 6.0	1.2870±0.0149
6.0 to 12.0	0.6315±0.0088
12.0 to 18.0	0.5825±0.0073
18.0 to 24.0	0.4249±0.0052
24.0 to 30.0	0.3201±0.0039
30.0 to 36.0	0.2525±0.0031
36.0 to 42.0	0.2117±0.0027
42.0 to 48.0	0.1744±0.0022
48.0 to 54.0	0.1586±0.0021
54.0 to 60.0	0.1416±0.0020
60.0 to 66.0	0.1297±0.0019
66.0 to 72.0	0.1245±0.0018
72.0 to 78.0	0.1197±0.0019
78.0 to 84.0	0.1130±0.0018
84.0 to 90.0	0.1124±0.0018
90.0 to 96.0	0.1142±0.0018
96.0 to 102.0	0.1166±0.0018
102.0 to 108.0	0.1225±0.0019
108.0 to 114.0	0.1350±0.0021
114.0 to 120.0	0.1481±0.0023
120.0 to 126.0	0.1653±0.0025
126.0 to 132.0	0.1930±0.0029
132.0 to 138.0	0.2199±0.0032
138.0 to 144.0	0.2635±0.0036
144.0 to 150.0	0.3267±0.0044
150.0 to 156.0	0.4174±0.0055
156.0 to 162.0	0.5356±0.0071
162.0 to 168.0	0.6966±0.0094
168.0 to 174.0	0.8232±0.0125
174.0 to 180.0	0.4875±0.0117

Table 2. Energy-energy correlation , corrected data



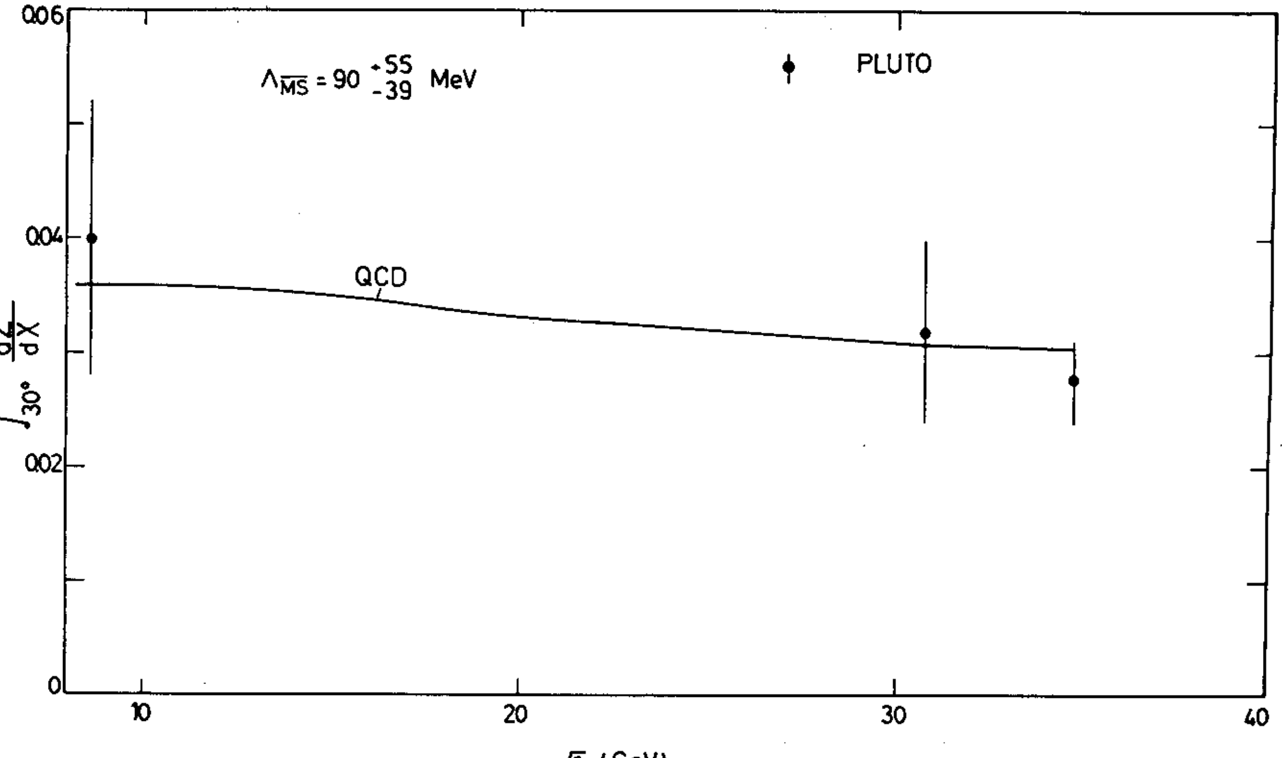
10.0
1.0
0.5
0.1
0.05
0.01
-1.0
-0.5
0.0
0.5
1.0
• Corrected data √s = 34.6 GeV
—Monte Carlo (ALI, LUND)
PLUTO
dΣ/d cos χ
cos χ
37079

Fig. 1a



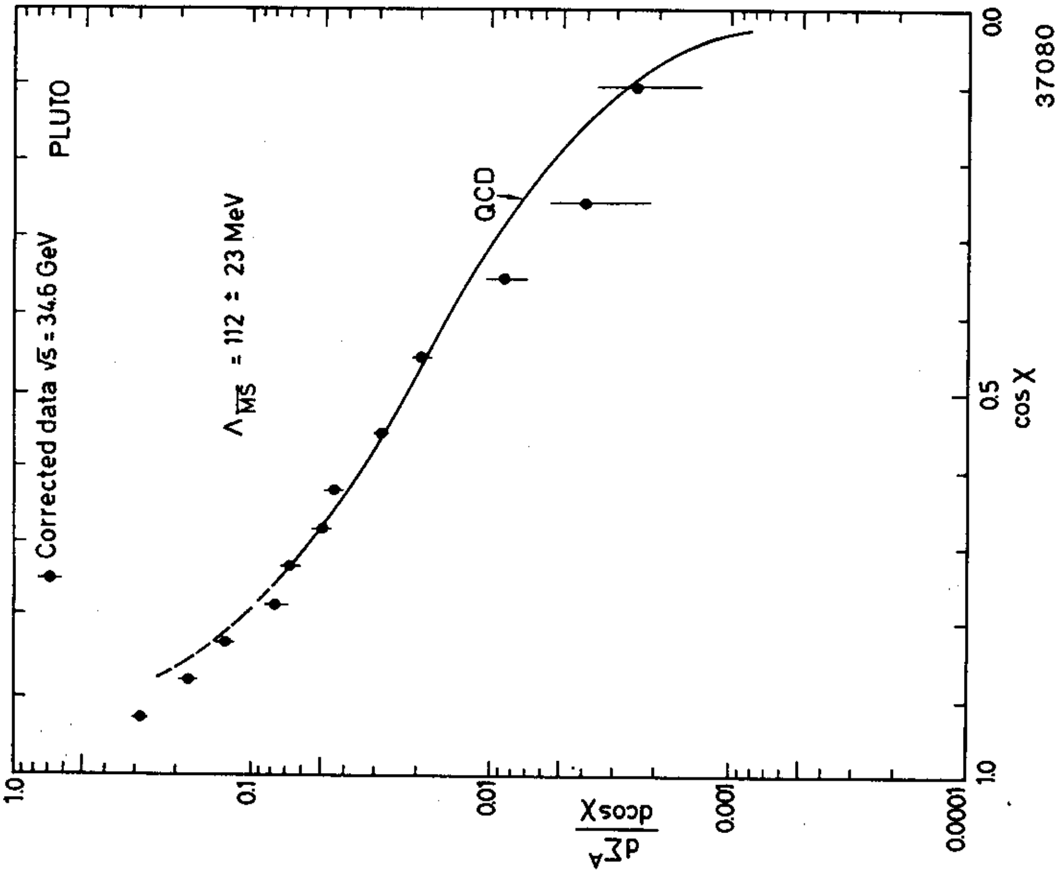
10.0
5.0
1.0
0.5
0.1
0.05
0.01
0°
45°
90°
135°
180°
Corrected data √s = 34.6 GeV
— Monte Carlo (ALI, LUND)
PLUTO
dΣ/dχ
χ (degrees)
38555

Fig. 1b



$\Lambda_{\overline{MS}} = 90 {}^{+55}_{-39}$ MeV
PLUTO
QCD
$\int_{30°}^{90°} \frac{d\Sigma^A}{dX}$
0.06
0.04
0.02
0
10
20
30
40
$\sqrt{s}$ (GeV)
37081

Fig. 3



PLUTO
Corrected data $\sqrt{s}$ = 34.6 GeV
$\Lambda_{\overline{MS}}$ = 112 ± 23 MeV
QCD
1.0
0.1
0.01
0.001
0.0001
$\frac{d\Sigma^A}{d\cos X}$
0.0
0.5
1.0
cos X
37080

Fig. 2

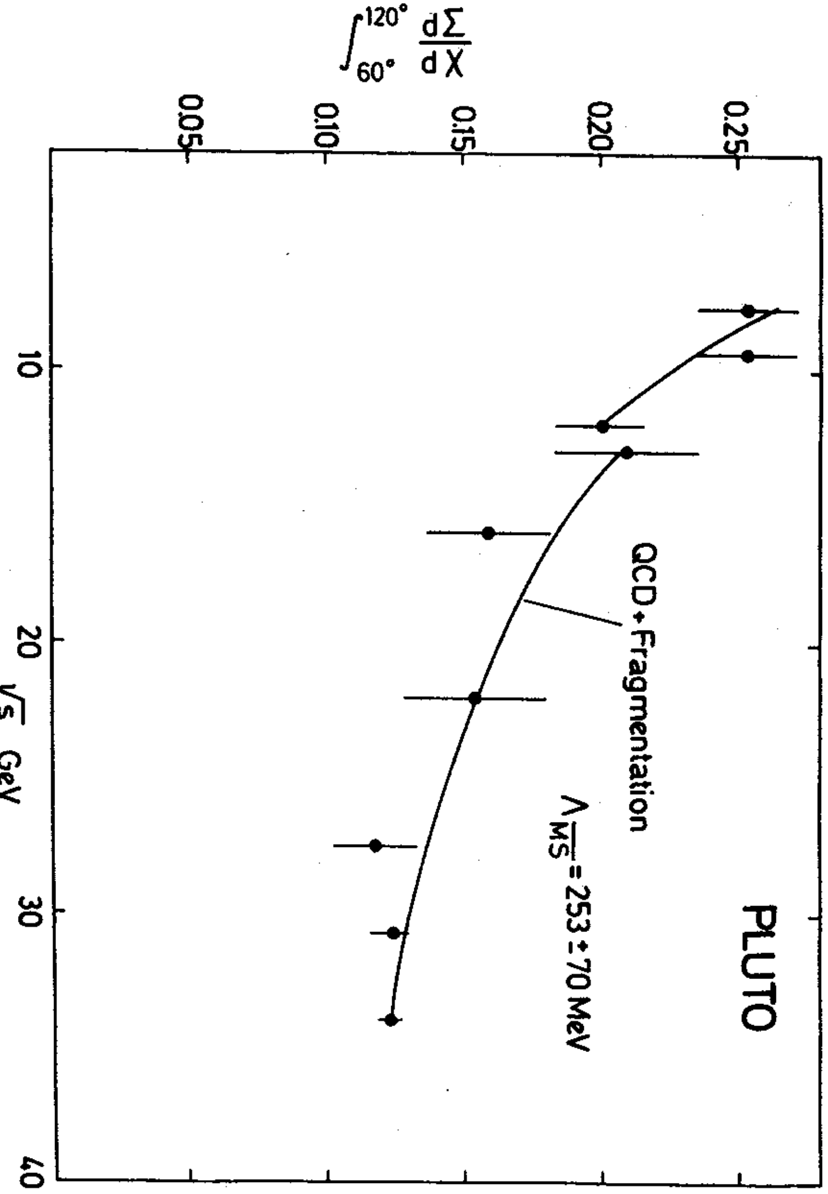
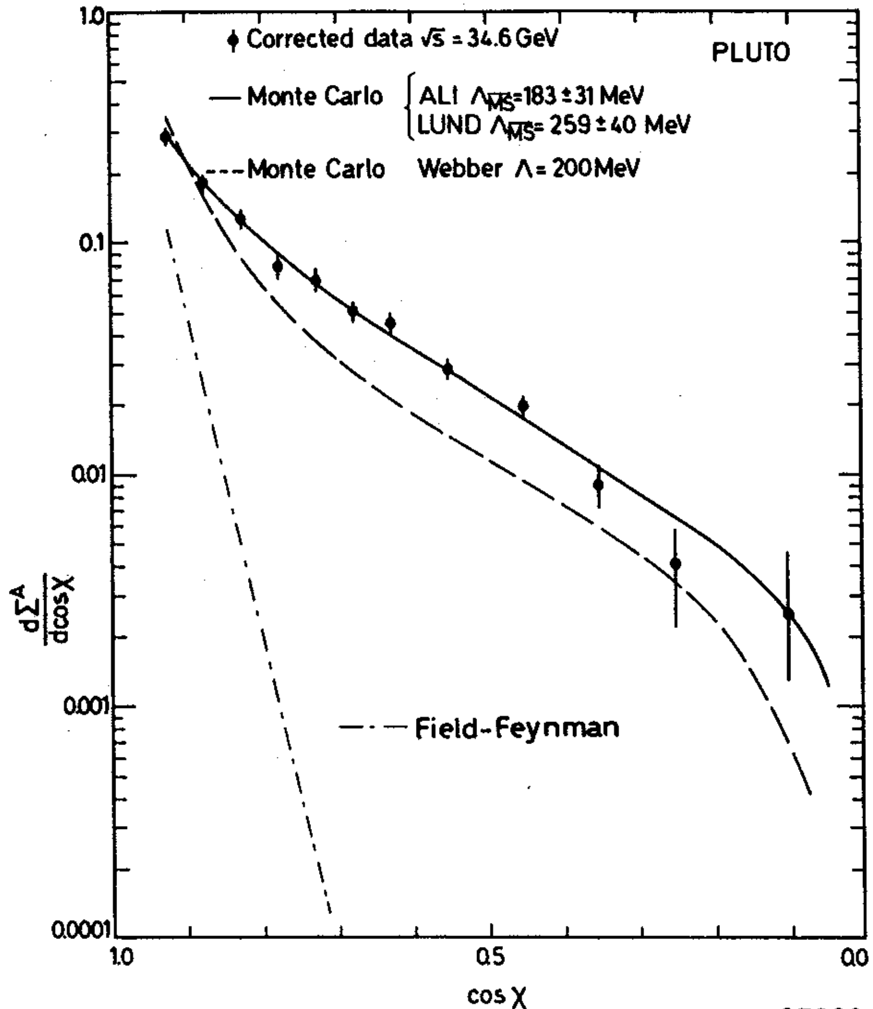


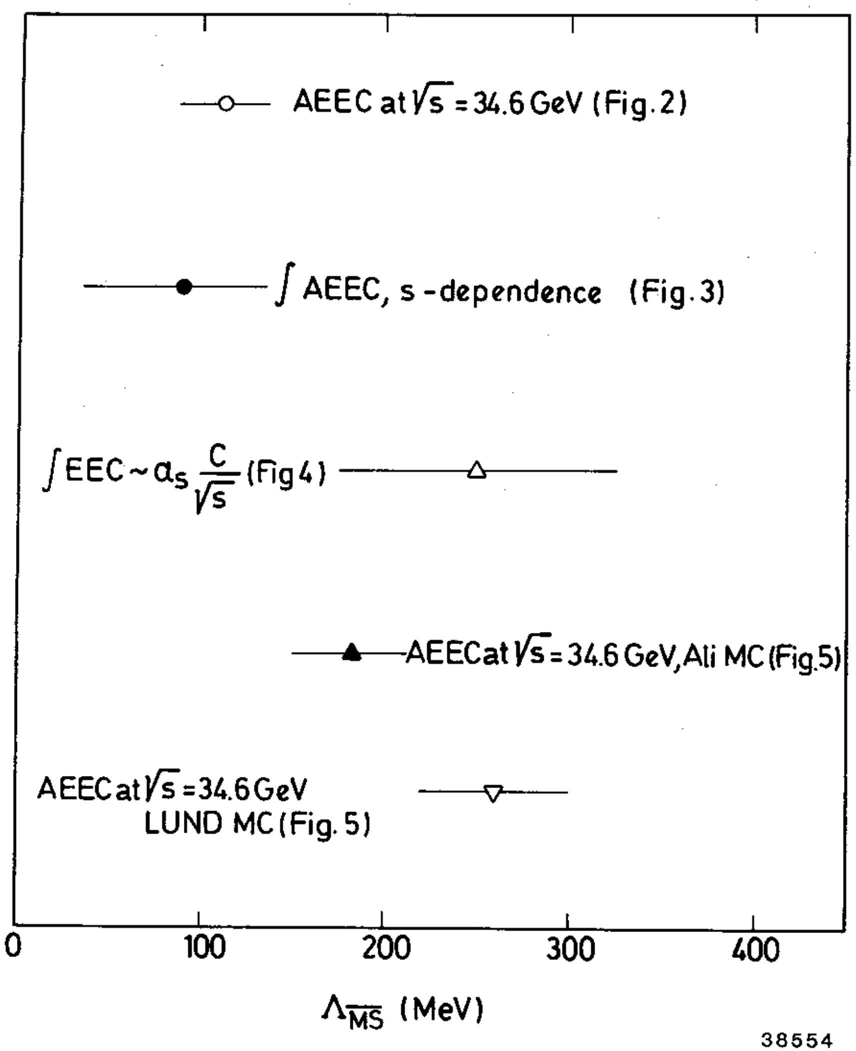
Fig.4

37082



37083

Fig. 5



AEEC at $\sqrt{s}$ = 34.6 GeV (Fig. 2)
∫ AEEC, s - dependence (Fig. 3)
$\int EEC \sim \alpha_s \frac{C}{\sqrt{s}}$ (Fig 4)
AEEC at $\sqrt{s}$ = 34.6 GeV, Ali MC (Fig.5)
AEEC at $\sqrt{s}$ = 34.6 GeV
LUND MC (Fig. 5)
0
100
200
300
400
$\Lambda_{\overline{MS}}$ (MeV)
38554

Fig. 6