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e^+e^-, $\bar{p}p$ AND QCD JETS

by

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e^+e^-, $\bar{p}p$ AND QCD JETS+)

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In this talk I will speak about two different subjects. In the first part I will compare the fragmentation of jets observed in $p\bar{p}$ and e^+e^- collisions. In the second part I will compare the inclusive $p\bar{p}$ jet cross sections with the QCD predictions.

The comparison of $p\bar{p}$ and e^+e^- jet fragmentation is performed mainly in the region of large z ($z \geq 0.05$, $z = P_L/E^J$ where p_L denotes particle momenta along the beam axis and E^J the jet energy). In this region collider jets are almost background free since average transverse momenta of projectile debris are relatively low ($\sim$ 400 MeV/c) Ref.[1].

The $p\bar{p}$ and e^+e^- jet fragmentation functions and the p_T distributions within jets in the large z region are presented in Fig.1a and 1b, see also Ref.[2].

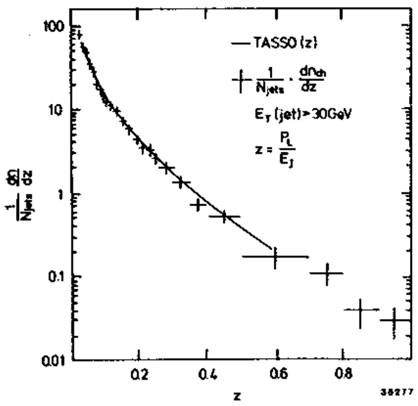

Fig.1a) Comparison of the jet fragmentation function as measured by UA1 ($\bar{p}p$ jets) and TASSO (e^+e^- jets) collaborations.

+) mini-rapporteur talk, Brighton HEP'83 Conference

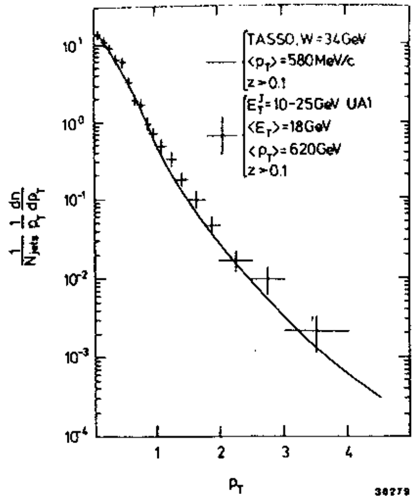

Fig.1b) Comparison of p_T distributions within the jet measured by UA1 and TASSO Collaborations.

From these figures it can be seen that we observe a very similar behaviour for e^+e^- and $p\bar{p}$ in the higher z region. Another quantity which can be compared is scaling violations i.e. the changes of fragmentation functions with jet energy. Scaling violations are investigated using the parametrisation

$$D(z, E^J) \sim 1 + C_1(z) \ln \frac{Q^2}{1\ \mathrm{GeV}^2}$$

where $D(z, E^J)$ denotes the jet fragmentation function. Q^2 was chosen to be equal to $4E_J^2$ in case of e^+e^- annihilation and $4p_J^{T2}$ (p_J^T denotes the transverse to the beam component of the jet momentum) in case of $p\bar{p}$ collisions. The scaling vilations are measured by the parameter C_1 whose values are compared for e^+e^- and $p\bar{p}$ collisions in Fig.2.

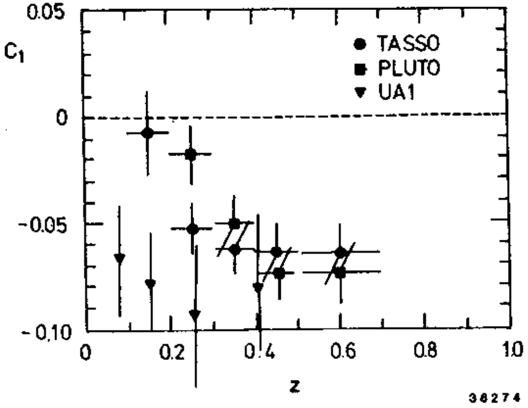

Fig.2 Comparison of scaling violations in e^+e^- and $p\bar{p}$ collisions.

From this figure we see that the scaling violations are relatively small for both e^+e^- and $p\bar{p}$ jets and that their magnitude is comparable.

The measurement of jet multiplicities gives insight in the low z fragmentation region. This measurement is difficult for the collider jets because of background from the projectiles fragmentation. The collider groups adapted therefore two different methods to measure multiplicities (see also Ref.[3,4]). In the first method, the background from projectiles debris is determined as a multiplicity per rapidity unit (UA1) or azimuth angle unit (UA2) in a region "far away" from the jet axis. In the case of UA1 this region is defined as a region distant by more then 1 rapidity unit from the jet axis (see Fig.5). For UA2 and TASSO data this region is defined as being around 90° in azimuth from the jet axis. The multiplicities determined in these regions are then scaled to the phase space volume of the jet and subtracted from the multiplicities observed in the jet region. The jet multiplicities obtained in this way are shown in Fig.3a as a function of jet-jet invariant mass (UA2) or $2 \cdot p_j^T$ (UA1).

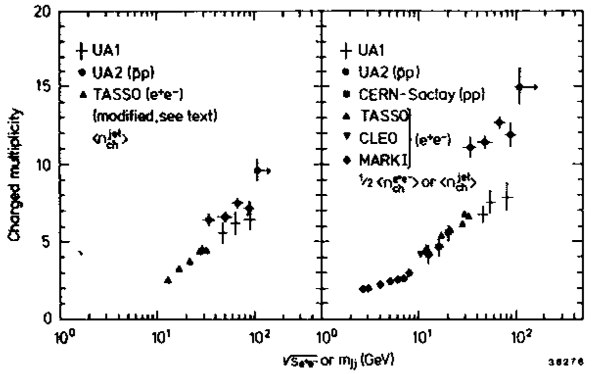

Fig.3 Comparison of jet multiplisities in e^+e^- and $p\bar{p}$ collision
a) jet multiplicities determined by method I (see text)
b) jet multiplicities determined by method II

The measurement of both collider groups using method I are in agreement with each other and consistent with a simple logarithmic extrapolation from PETRA measurements.

In the second method the subtraction level is also corrected with the help of the jet fragmentation Monte Carlo models. After Monte Carlo correction jet multiplicities of both the UA1 and UA2 groups differ considerably since the used fragmentation models are based on different physical assumptions. In addition neither measurement extrapolates simply to e^+e^- data. In our opinion this situation is due to the difficulties in describing the jet fragmentation by Monte Carlo in the low z region at the collider energies, which is in turn connected to the lack of detailed understanding of projectiles fragmentation.

In conclusion we can tell that in spite of the (theoretical) fact that a considerable amount of $p\bar{p}$ jets is of gluonic origin (see Fig.4) no significant differences have shown up between e^+e^- and collider jets. However, the investigation of the low z region in which these differences are expected to be more clear it is still not finished.

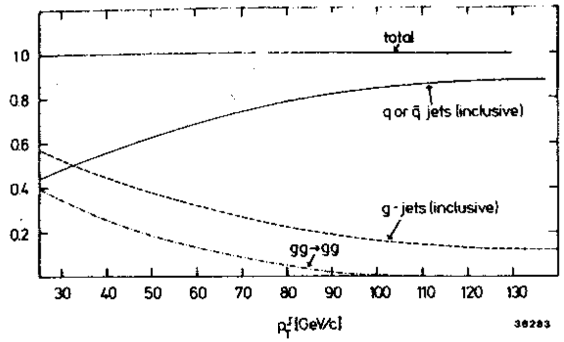

Fig.4 $q(\bar{q})$ or g (inclusive) jet fractions expected from QCD in $p\bar{p}$ collisions. Also shown is the contribution of the exclusive process $gg \rightarrow gg$.

As can be seen from Fig.5, the jet is much better defined as a function of energy then of multiplicity distribution.

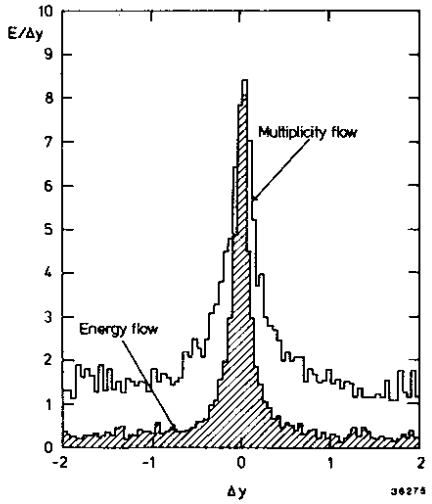

Fig.5 Energy and multiplicity flows as a function of rapidity difference to the jet axis. (UA1 data). The vertical scale is for the energy flow.

Therefore the jet energy is also much better defined than its multiplicity. The measurement of the jet energy is interesting since the rates of jets with given energies can be directly computed in QCD, see Ref. [5-10].

The single jet inclusive distribution measured by the UA1 and UA2 groups are presented in Fig.6 together with the QCD predictions of Ref.[7] and [8].

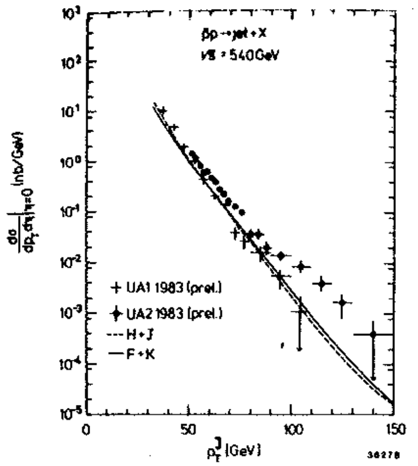

Fig.6 Inclusive jet cross section measured by the UA1 and UA2 groups. For clarity we present only the (preliminary) 1983 data. The dotted and full lines are QCD predictions from Ref.[7,8].

The systematic differences between the UA1 and UA2 measurements are compatible with the systematic errors quoted by the two groups (60% for UA1 and 40% for UA2) and reflect the difficulty of right normalization of collider jet cross sections. Strictly speaking only part of the systematic errors are due to normalization errors (eg. luminosity determination errors); however, other systematic errors (like the energy scale errors) act like effective normalization errors, see also Ref. [3,4].

To compare more precisely the measured jet cross sections with the QCD predictions we plotted in Fig.7 the inclusive jet cross section divided by the (reference) QCD prediction.

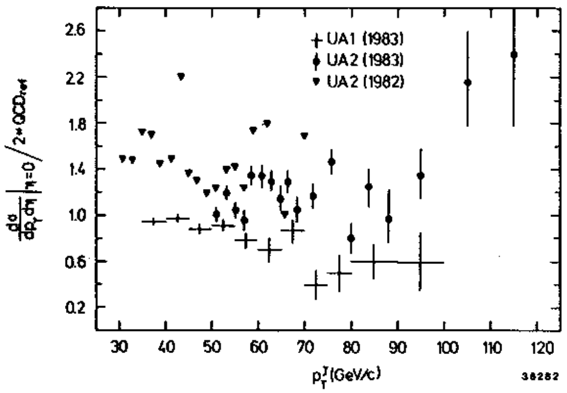

Fig.7 Inclusive jet cross sections divided by the reference QCD prediction (see text). In this picture we included also the 1982 UA2 data. For clarity these data are plotted without errors (which are relatively large).

As a reference QCD prediction we used the QCD prediction of ref. [8] with $Q^2 = 1/2\ p_T^2$, $\Lambda = 0.5$ GeV, quark structure of CDHS experiment and gluon structure function given by $xG(x) \sim (1-x)^\beta$ with $\beta = 5$. We observe in this plot that the data of both experiments do not differ substantially from a horizontal straight line. This means that the shape of the measured cross section is similar in both experiments and in good agreement with the QCD prediction. In order to visualize the information contained in the shape alone we plotted in Fig.8 and 9 the ratios of QCD predictions with different Λ and β parameters over our reference QCD prediction.

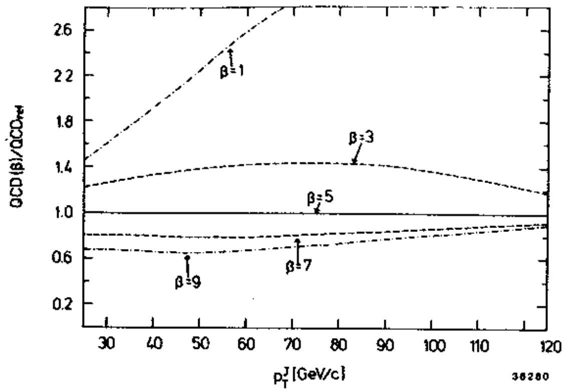

Fig.8 Ratios of QCD predictions with different β parameters over the reference QCD prediction plotted as a function of jet transverse momenta

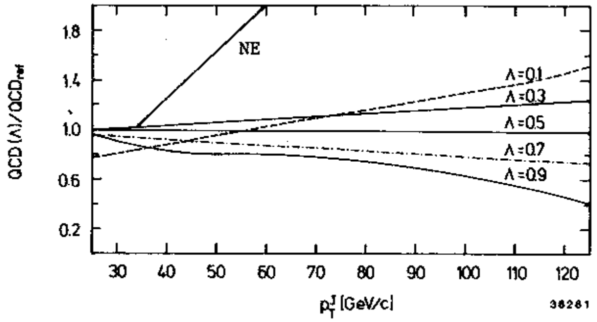

Fig.9 Ratio of QCD predictions with different Λ parameters over the QCD reference prediction. The curve denoted by NE shows the QCD prediction without A-P evolution, see text

The fits to the shape alone (i.e. the effective normalization of the data is a free parameter) varying both β and Λ parameters at the same time indicates that values for β smaller than 4 and Λ smaller than 0.4 are incompatible with the data of both experiments, Ref.[11]. It is also interesting to note that the shape of the data is not compatible with the QCD predictions without A-P evolution. This is shown by the curve denoted NE in Fig. 9. (This curve was obtained from a standard QCD computation, Ref. [8], without applying A-P evolution and with constant α_s. The conclusion is not changed by applying a running α_s.)

I would like to thank my colleagues from UA1, UA2 and TASSO Collaboration for fruitful and stimulating discussions during the preparation of this talk.

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