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PHYSIC 92-166
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THE DIFFERENCES BETWEEN QUARK AND GLUON-JETS IN 3-JET EVENTS USING NEURAL NETWORK

QCD predicted that gluon jets have a softer particle energy spectrum, a larger width and a larger multiplicity than quark jets with the same energy.

String effect is the enhanced production of particles in the angular region between quark and gluon jets, as compared to the angular region between the two quark jets. String model predicts this enhancement because colour is conserved by stretching a colour string between the former two but not between the later.

1 Neural Network

Using neural network [1] the quark jets and gluon jets have been identified. The neural network is designed in 3 layers: 16 nodes (4-momentum of 4 leading particles in a jet) as inputs. 2 nodes for hidden layer. 1 node output. The neural network is trained by MC events and turns out that the efficiencies of the identification are 96% and 95% for quark jets and gluon jets respectively; the purities of that are 95% and 96% respectively.

2 Method

We followed the method used by OPAL[2] and T. Meid[3] . Assume that the most energetic jet is a quark jet (jet_1), and require the gluon jet (jet_3) has same energy approximately as the lower energy quark jet (jet_2). One choose the inter jet angles ψ_{12}= ψ_{13}= $(150 \pm 10)^\circ$. It corresponds to $E_{jet_2} = E_{jet_3} = (24.5 \pm 1.0)$ GeV. Thus the comparision of properties of quark jets and gluon jets is visualized in the figues in which plotting the distribution of a physical quantity versus azimuthal angle in the event plane. The distributions starts at high energy quark jet, then proceeds to the low energy quark jet (see the figues, with solid points). They show the other event halves, from high energy quark jet to the gluon jet (with solid line).

We used energy flow ENFLW to include the neutral objects, Jade jet finder with Ycut=.02 to find 3-jet events, YRMIST[4] to find K_s^0 and Λ.

To see the string effect one defines N_{13} = number of particles in the range (0.3 - 0.7) of ψ_{13}, and N_{12} = number of particles in the (0.3 - 0.7) of ψ_{12}, and string effect is displayed by R = $< N_{13} > / < N_{12} > > 1$.

3 Data Sample

Starting from a data sample of 62,088 multihadronic events taken in 1991 on the peak LEP energy, 441 three-jet events in above symmetric angular configuration are selected and jets are identified. Following cuts are applied to select tracks:

$$P_T(w.r.t.beam) > 0.2GeV,$$
$$20° < \theta < 160°,$$
$$D_0 < 2cm,$$
$$Z_0 < 5cm,$$
$$TPCcoord \geq 4.$$

The following cuts are applied to select events.

$$N_{jet} = 3,$$
$$E_{ch} \geq 15\ GeV,$$
$$N_{trk}(ch) \geq 5.$$
$$N_{trk} \geq 4.ineachjet$$

The direction of sphericity-axis must satisfied

$$35° < \theta(Sph) < 145°.$$

To exclude 2-jet events we require

$$0 < Sph < 0.2$$

To avoid non-coplanar events we require the sum of the angles between jet pairs to fulfil

$$358° \leq \sum_{i=1}^{3} \theta_i \leq 360°.$$

4 Results

From distributions we can calculate the widths or means for the central core region (50°).

Fig.1 shows the mean particle energy dE/dn versus the azimuthal angle in the 3-jet event plane. From Fig.2 the multiplicity distribution (1/Nev)dn/dψ we get the numbers of particles found in the jet core.

$$n^G = 13.2 \pm 0.2, \quad n^Q = 12.8 \pm 0.2.$$

All the errors given in this note are statistical only. From Fig.3 the energy distribution (1/Nev)dE/dψ the widths are

$$W(E^G) = (11.94 \pm 0.17)^\circ, \quad W(E^Q) = (9.02 \pm 0.23)^\circ.$$

From Fig.4 the widths of the momentum distributions (1/Nev)dp_{in}/dψ for the component in the event plane are

$$W({p_{in}}^G) = (11.88 \pm 0.30)^\circ, \quad W({p_{in}}^Q) = (8.90 \pm 0.23)^\circ.$$

From Fig.5 the means of the momentum distributions (1/Nev)dp_{out}/dψ for the component out of the event plane are

$$\overline{p}_{out}{}^G = (0.28 \pm 0.09), \quad \overline{p}_{out}{}^Q = (0.26 \pm 0.17).$$

The sums of the p_{out} are

$$\sum {p_{out}}^G = (3.09 \pm 0.08), \quad \sum {p_{out}}^Q = (2.91 \pm 0.08).$$

From Fig.6 the multiplicity distribution for K^0_s: (1/Nev)dnK^0_s/dψ the numbers of K^0_s found in the jet core are

$$n_{K^0_s}{}^G = 0.15 \pm 0.02, \quad n_{K^0_s}{}^Q = 0.21 \pm 0.02.$$

From Fig.7 the multiplicity distribution for Λ: (1/Nev)dn_Λ/dψ the numbers of Λ found in the jet core are

$$n_\Lambda{}^G = 0.052 \pm 0.011, \quad n_\Lambda{}^Q = 0.048 \pm 0.010.$$

For the same data sample it turns out that the ratio R = 1.31 ± 0.14.

5 Discussions

In all the distributions gluon jet is shift in 5° compare to the low energy quark jet. This is due to the angles of ψ_{12} and ψ_{13} are not exactly equal (see Fig.8)

From Fig.1 it is easy to see that gluon jets have a softer particle energy spectrum. From Fig.3 one can see that gluon jets have a larger width with the amount of (for every difference it means quantity^G - quantity^Q)

$$\Delta W(E) = (2.93 \pm 0.38)^\circ.$$

From Fig.2 the difference of multiplicity is

$$\Delta n = .39 \pm .24.$$

It means gluon jet has a larger number of particles. Using same size of central core region to compare the multiplicity of the jets is not reasonable, because gluon jet is much broad. For K_s^0,

$$\Delta n_{K_s^0} = -0.06 \pm 0.03,$$

it seems having different behavours with the Λ,

$$\Delta n_\Lambda = 0.005 \pm 0.015.$$

But because low statistics it is not conclusive. For p_{in} distribution the difference of the widths is

$$\Delta W(p_{in}) = (2.98 \pm 0.38)^\circ.$$

For string effect we did see the enhancement with 9 standard deviations.

By MC study we found that the leptons decaying from b or $\bar{b}$ quarks are not always within the b or $\bar{b}$ jets. The efficiency of finding g-jet by lepton tagging is about 25%.

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References

[1] L. Lonnblad, *et al.*, Phys. Rev. Lett. 65 1321(1990).

[2] OPAL Collaboration, G.Alexander *et al.*, Phys. Lett. 265**B** (1991) 462.

[3] T. Meid, ALEPH 92-143, PHYSIC 92-131, 1992.

[4] B. Rensch, ALEPH 90-108, SOFTWR 90-009, 1990.

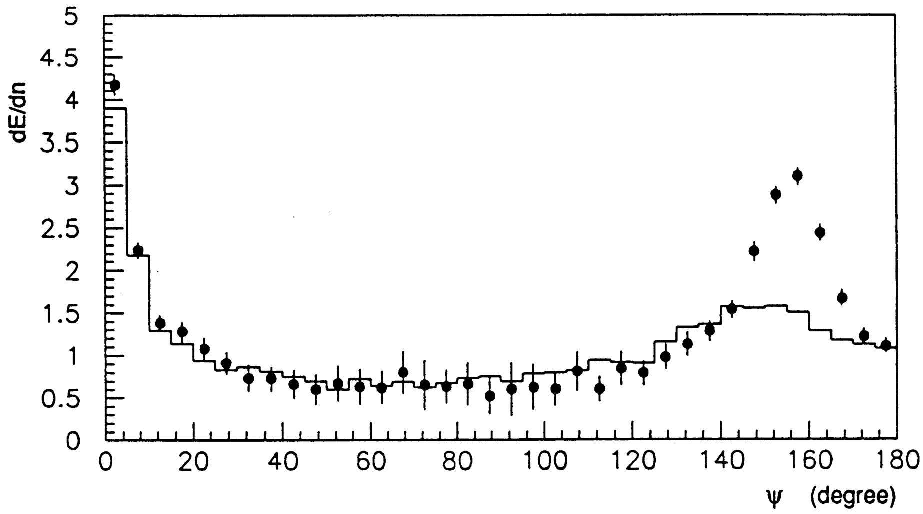


Fig.1 The mean particle energy dE/dn versus the azimuthal angle in the 3-jet event plane.

All the distributions are starting at high energy quark jet, then proceeds to the low energy quark jet (with solid points). They show the other event halves, from high energy quark jet to the gluon jet (with solid line).

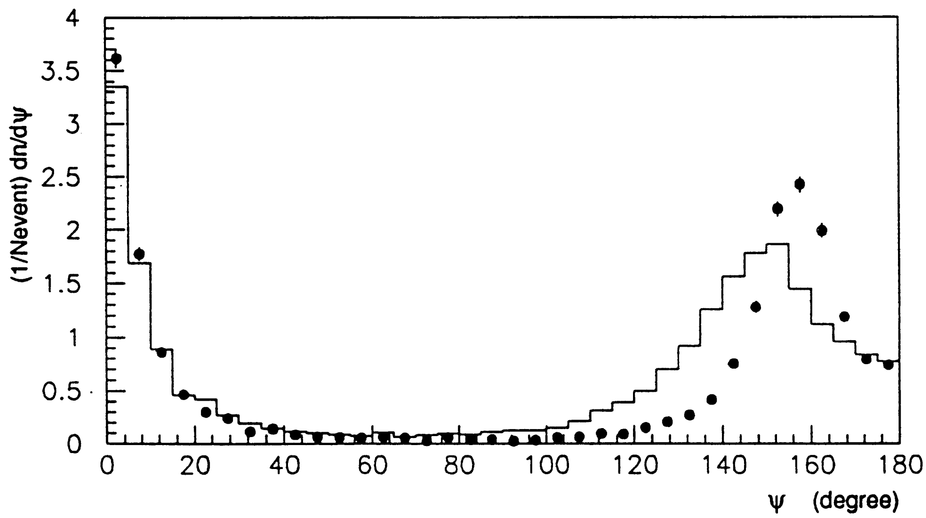


Fig.2 The multiplicity distribution.

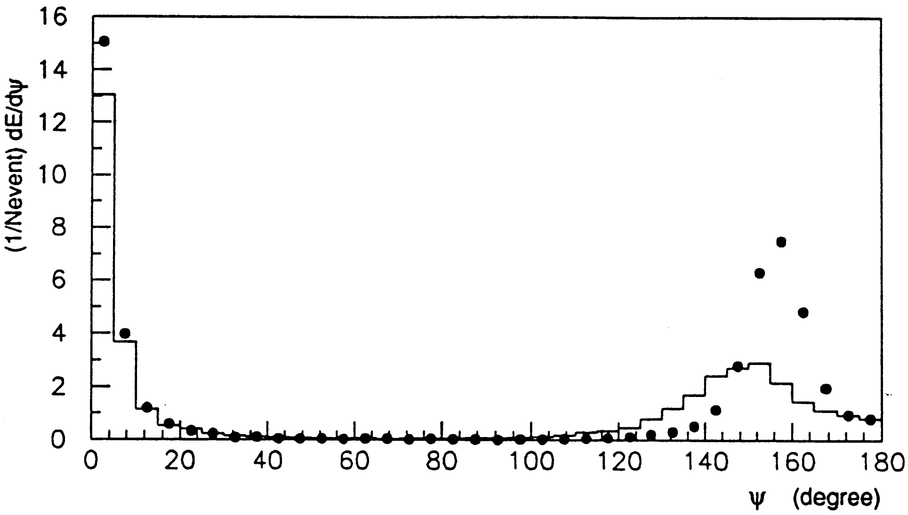


Fig.3 The energy distribution.

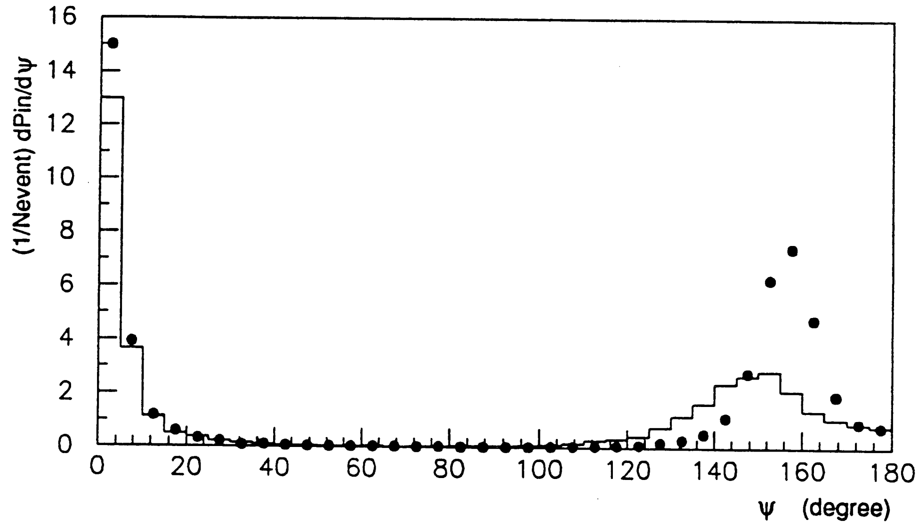


Fig.4 The momentum distribution for the component in the event plane.

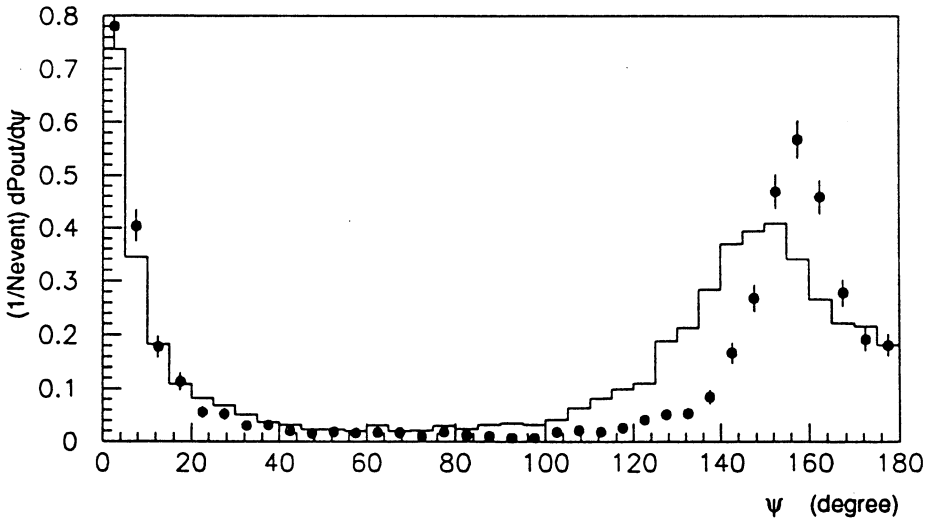


Fig.5 The momentum distribution for the component out of the event plane.

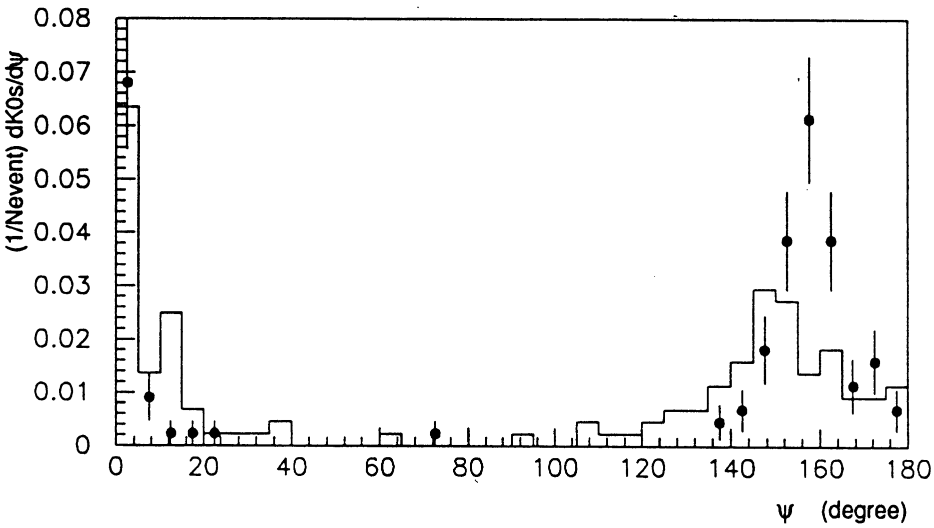


Fig.6 The multiplicity distribution for K_s^0.

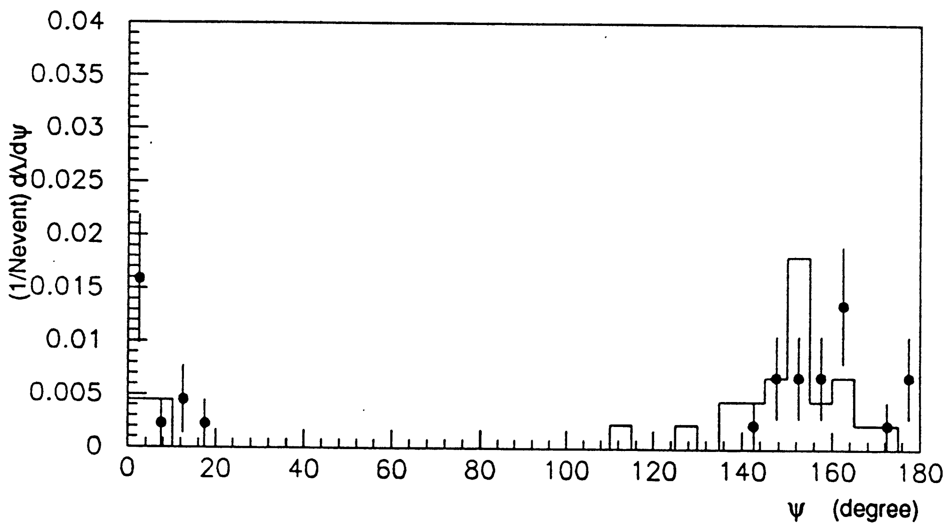
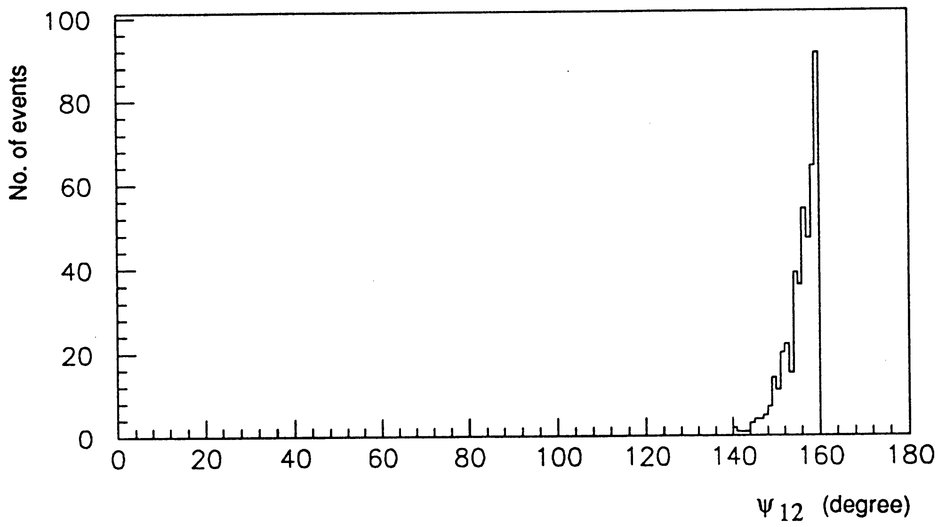


Fig.7 The multiplicity distribution for Λ.



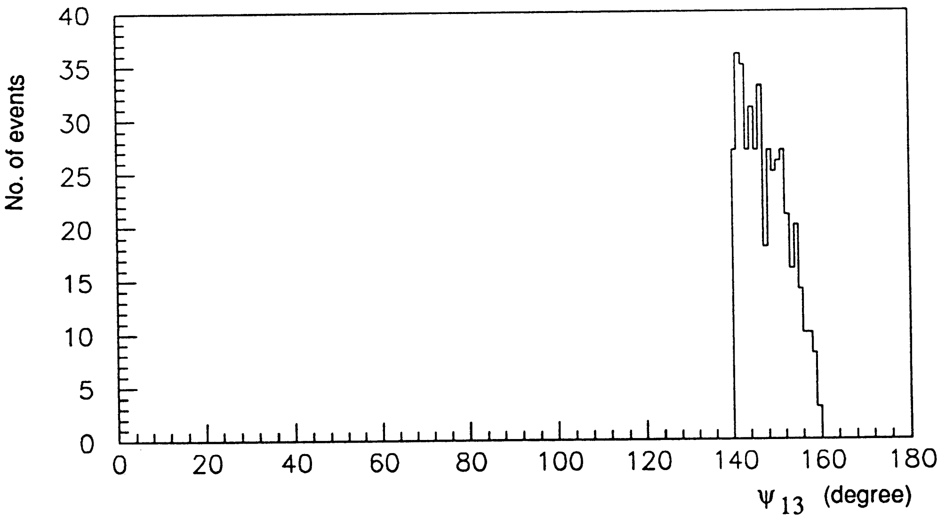


Fig.8 Number of event versus ψ.