CONF-830140--5

DOE/ER/40033--43

DE83 016945

Rockefeller University
Report No. DOE/ER/40033-43

(RU 81/A-40)

# HIGH NEUTRAL TRANSVERSE ENERGY EVENTS AT THE CERN ISR

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Presented at
The XVIIIth Rencontre de Moriond
La Plagne (Savoie, France)
January 23-29, 1983

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ABSTRACT: The CERN-Oxford-Rockefeller (COR) collaboration has obtained neutral transverse energy, $E_T{}^0$, spectra in pp collisions at $\sqrt{s}$ = 30.5, 45.0, and 62.3 GeV. Evidence is presented for the increasing dominance of 2-jet events as $E_T{}^n$ increases.

The COR1) experiment R110, shown in Fig.1, consists of a superconducting solenoid enclosing a set of cylindrical drift chambers, a barrel hodoscope of scintillation counters (A), and four modules of lead-scintillator shower counters. Arrays of lead glass outside the magnet complete the total azimuthal coverage for electromagnetic (neutral) energy2). The acceptance is approximately $2\pi$ in azimuth, and ± 1.2 units of rapidity, centred on $y=0$.

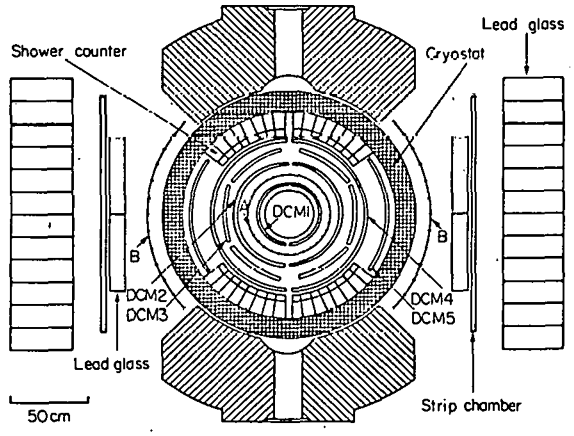

Figure 1: View of apparatus normal to beams

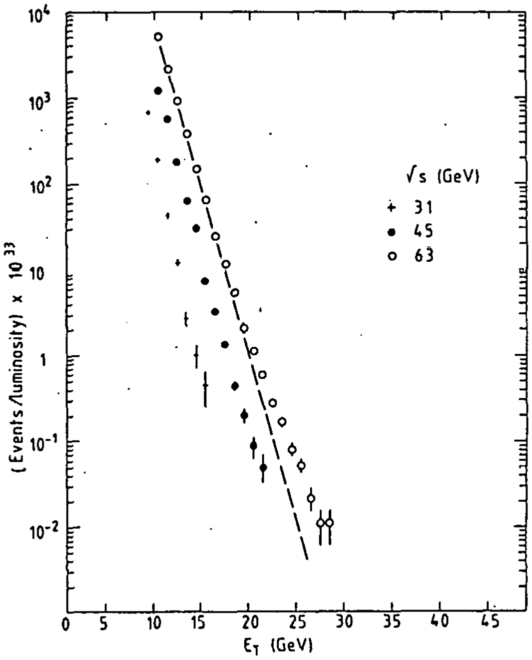

Figure 2: $E_T{}^0$ spectra at $\sqrt{s}$= 30.5, 45.0, and 62.3 GeV.

As part of the program of high $p_T$ physics studied with this detector we used a total energy trigger, in which all the pulse heights seen in the shower counters and lead glass blocks were summed, and the total required to be above some threshold, typically 20 GeV. The transverse energy $\varepsilon_T$ for each counter, in the pp centre-of-mass (CM), is $\varepsilon_T=\sqrt{(p_T{}^2)}$, assuming a zero mass particle coming from the event vertex measured with the charged tracks. The total neutral transverse energy is the sum over all counters containing energy, $E_T{}^0 = \Sigma\varepsilon_T$. Multiple events are a severe problem when using such a loosely constrained trigger at luminosities $\sim 5\times10^{31}$ $cm^{-2}s^{-1}$, our typical running luminosity. There are TDCs on every shower counter and scintillator, and by examining the time structure of the counter hits we can reject events with multiple time clusters. This is checked by studying data taken at four separate luminosities, and by searching for multiple vertices with the charged tracks. We reject ~90% of the triggers at this high luminosity. For this preliminary work we have only used data collected at a luminosity $\sim 1.5\times10^{31}$ where only ~50% of the triggers are rejected (this minimizes the computer time necessary for the analysis).

The spectra $(1/\mathscr{L})(dn/dE_T{}^0)$ are shown in Fig.2 for three $\sqrt{s}$ values. These are uncorrected for resolution, double hits within the same shower counter, and the contribution of hadronic energy to the energy seen in the calorimeter. These could increase the slope by up to 20%. The integrated luminosity, $\mathscr{L}$, is

Fig.4. The decrease as $E_T{}^0$ increases shows the increasingly back-to-back nature of the jets.

We defined a sphericity, S, by $S=S_1+S_2$, with $S_n = (3/2)\ \Sigma j_{Ti}{}^2/\Sigma p_i{}^2$, where n=1,2 labels the two jet axes, the sums were over all particles i associated with axis n, $p_i$ is the particle momentum, and $j_{Ti}$ its transverse momentum relative to its jet axis n. Fig.5 shows distributions of S for two sets of data, one with mean $E_T{}^0$ ~10 GeV, and the other with $E_T{}^0$ ~20 GeV. The tendency for S to decrease at higher $E_T{}^0$ is also demonstrated by Fig.6 in which the mean S at each $E_T{}^0$ is plotted.

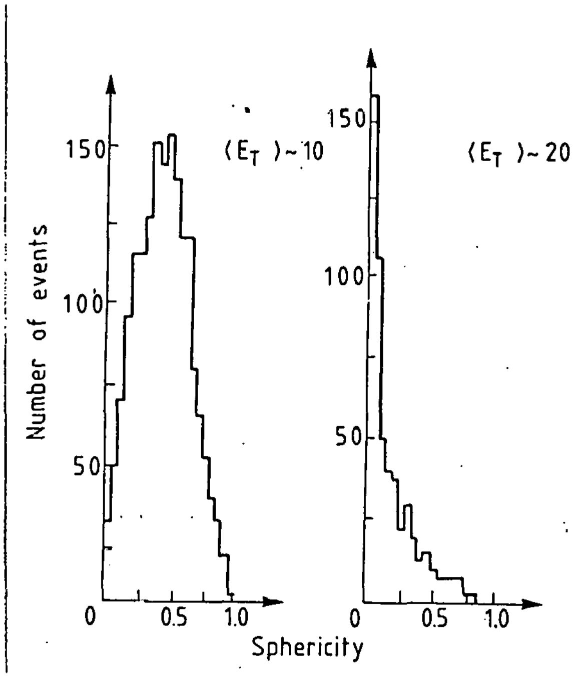

Figure 5: Distributions of S at $\langle E_T{}^0 \rangle$~10 and ~20 GeV.

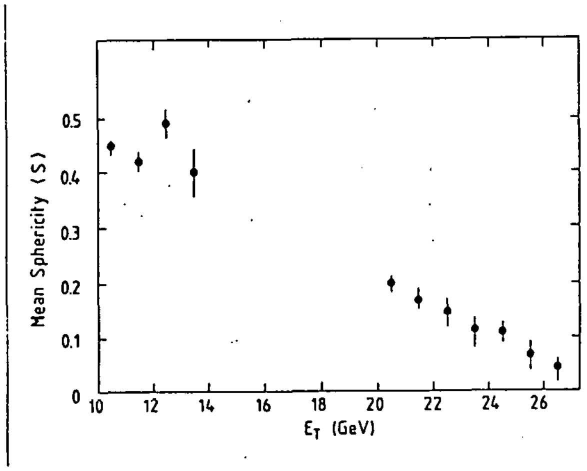

Figure 6: The mean sphericity vs $E_T{}^0$.

We can examine the mean $p_T$ of the dijet system, as yet uncorrected for our resolution. This has a mean value of 2.9 GeV/c at a dijet effective mass of ~15 GeV, and 4.0 GeV/c at a mass of ~25 GeV. These are very similar to the mean $p_T$'s of $\pi^0\pi^0$ pairs of similar mass.

Finally, we have studied the components of the transverse momentum, $j_T$, of the charged particles relative to the T jet axis. We define the scattering plane as the plane containing the pp beams and the T jet vector. Then $j_{T\theta}$ is the component of $j_T$ in the scattering plane, and $j_{T\phi}$ is the component out of the plane. Figs.7(a) and (b) show the mean $j_{T\theta}$ and $j_{T\phi}$ as functions of the $p_T$ of the charged particles. The flattening of these values is not due to the acceptance alone, as can be seen from the points labelled 'random'. For these the directions of the tracks, relative to the jet, were randomized by generating random $\theta$ (in the $j_{T\theta}$ case) or $\phi$ (in the $j_{T\phi}$ case) according to the actual $\theta$ and $\phi$ distributions, and then $j_T$ was recalculated. The random values are larger than the real ones, indicating that the jets do show the expected limited $j_T$ behaviour$^{3)}$. The actual values depend upon the cuts used and the jet definition of course, so that this still needs some work.

$1.8\times10^{36}$ $\text{cm}^{-2}$. The straight line is a fit to an exponential, $\sim\exp(-0.86E_T{}^0)$, over the 10 to 20 GeV range in $E_T{}^0$. Notice the deviation from exponential above about 20 GeV.

We studied the event structure of the $\sqrt{s}=62$ GeV data by first clustering the neutral energies. Something over 94% of the energy appears in clusters. Then we can find the two clusters with highest transverse energy, $(E_T{}^0)_1$ and $(E_T{}^0)_2$, and form the ratio of their sum to the total $E_T{}^0$ in the event. The mean of this ratio is shown as a function of $E_T{}^0$ in Fig.3. The rise to a value $\sim0.80$ is a clear indication of the two-component structure of the events. We also note that triggering on only the electromagnetic part of the energy induces an $E_T{}^0$ dependence in the ratio of the total $E_T$ in charged particles to that in neutrals. This decreases from 0.50 to 0.25 over the same $E_T{}^0$ range.

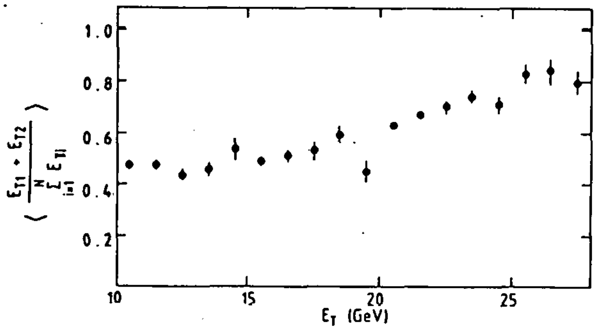

Figure 3: $((E_T{}^0)_1+(E_T{}^0)_2)/E_T{}^0$ vs $E_T{}^0$, described in the text.

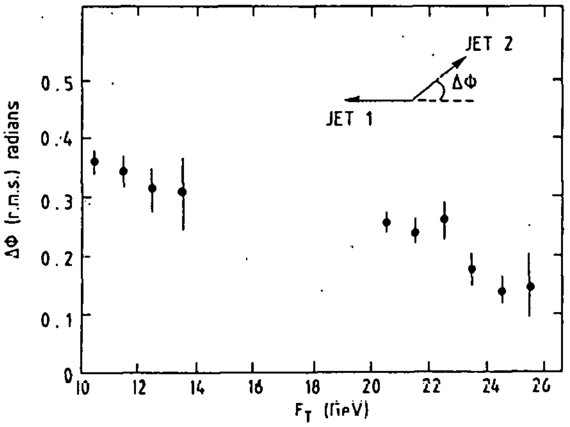

Figure 4: The mean $\Delta\phi$(r.m.s.) between the jet axes vs $E_T{}^0$.

Scanning individual events of $E_T{}^0 > 24$ GeV showed that in a large proportion of them the neutral energy was indeed deposited in two localized clusters, with most of the charged particles pointing towards them. We now performed a simple jet analysis. Our algorithm was to divide all the momenta in an event into two hemispheres, calculate the vector sum in each, and choose the normal to the larger sum to define a new split. This was repeated until the vector sums stabilized. The larger sum was then taken to define the Toward (T) jet axis, and the sum in the other hemisphere defined the Away (A) axis. Note that the axes need not be back-to-back. In this preliminary work we used only the neutrals to define the axes, although this is not necessary. The particles in the event were associated with the T jet if they fell in the T jet hemisphere; otherwise they were assigned to the A jet. The azimuthal correlation between the two jet axes can be seen by examining $\Delta\phi=\pi-(\phi_1-\phi_2)$, where $\phi_i$ is the azimuth of jet i. The r.m.s. width of the $\Delta\phi$ distribution, $\Delta\phi$(r.m.s.), is plotted in

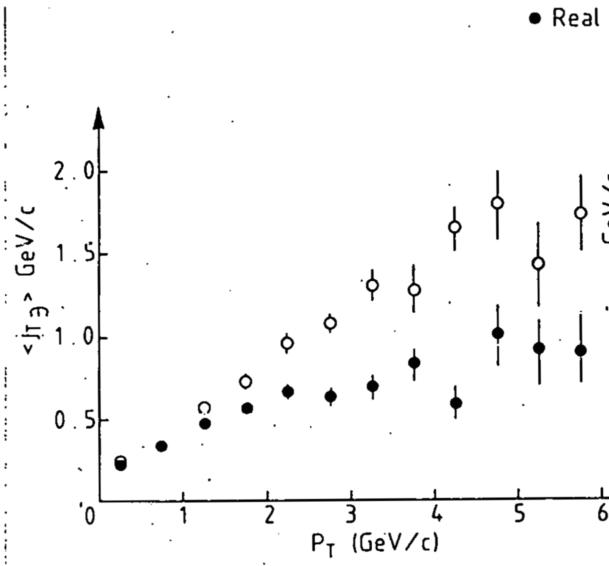

Figure 7(a): The mean $j_{T\theta}$ vs $p_T$ of charged particles.

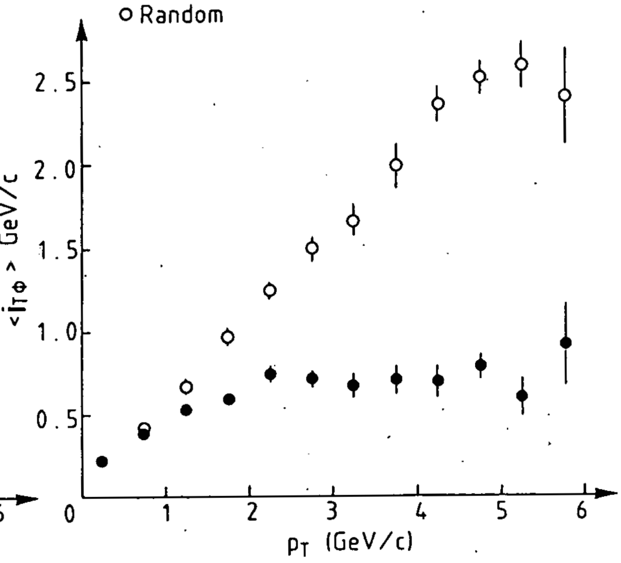

Figure 7(b): The mean $j_{T\phi}$ vs $p_T$ of charged particles.

I have presented $E_T^0$ spectra at $\sqrt{s}$ = 30.5, 45.0, and 62.3 GeV, and shown that there is clear evidence of the emergence of jet structure at $E_T^0$'s above 24 GeV. This is confirmed by the decrease of the mean sphericity as $E_T^0$ increases, and the limited $j_T$ behaviour of the charged particles. For the future we expect to extend our $E_T^0$ range for the study of 2 and 3-jets, and hence continue the study of parton-parton scattering angular distributions started with $\pi^0\pi^0$ data$^{4)}$.

## References

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