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Event Structure Evolution with the Average Event P_t in Multibody Final States

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Abstract

The structure of the event as described by some average variables, like the mean charged multiplicity and the mean multiplicity of the V° ($K_s^\circ + \Lambda^\circ$) as well as the strength of the intermittency like correlation, is analysed as a function of the average event p_t. Multibody final state from minimum bias and jet trigger events are examined for the two available center of mass energies 1800 and 630 GeV.

1 Introduction

In cdfnote 3866 some preliminary results of an analysis on the minimum bias event structure were described. The aim was a comparative, systematic investigation of the behaviour of various variables describing the average statistical properties of the multibody final state as a function of the same reference variable. In the present note we present some new results on this subject.

The more relevant new ideas come from a different way to combine minimum bias and some jet trigger data, from the inclusion, among the analysed variables of the factorial moments and from new Monte Carlo data. As in note 3866 the reference variable is the average event p_t, which is defined as:

$$\langle p_t \rangle = \frac{1}{n}\sum_{j=1}^{n} \mid p_t \mid_j \tag{1}$$

where n is the event multiplicity and $\mid p_t \mid_j$ the transverse momentum of the j^{th} track. Unless otherwise stated they are both measured in the $\mid \eta \mid \leq 1$ and $p_t \geq$ 0.4 GeV/c intervals as described below.

In the present analysis the global variables that have been analysed as a function of the above average event p_t are:
- the normalized event multiplicity;
- the mean number of K^0 plus Λ^0 in the event;
- the factorial cumulant of order three.

The detailed definition of each of these quantities will be given in the following. The first two were already examined in the previous note.

An importantant point is that, while in the previous studies we used MB1 Monte Carlo for comparison with experimental data, now we have used Pythia, after having tuned its generation parameters following the suggestions of the author. A significant improvement in the reproduction of the inclusive spectra with respect to MB1 is obtained.

As in the note 3866 the results from the two energies, 1800 and 630 GeV, are compared.

2 Experimental data and selection procedure

The results presented here come essentially from minimum-bias triggers recorded during the run 1A (about 1,200,000 triggers) and the run 1C (about 1,500,000 triggers at $\sqrt{s} = 630$ GeV). In addition one sample of about 300,000 JET_20, JET_50, JET_70, JET_100 (for 1800 GeV) and 380,000 JET_15, JET_20 (for 630 GeV) triggers has been analysed.

Only tracks measured by the CTC have been used. The almost standard event and track selection has been applied [1, 2]. In order to reject multiple interactions, events with two or more primary vertexes in a 60 cm interval have been rejected. To assure a good event acceptance in the CTC, the event vertex has been required to be in $\pm$ 60 cm from the origin of the coordinate system. The CTC track selection requires three dimensional tracks with an impact parameter less than 0.5 and the distance between the event vertex and the extrapolated Z0 of the track less than 5 cm.

Finally, in order to assure a full CTC tracking efficiency, only tracks with $p_t \geq$ 0.4 GeV/c and $\mid \eta \mid \leq 1$ have been accepted.

3 Analysis

3.1 Charged Multiplicity

Fig.1 shows a scatter plot where, for each event of the 1800 GeV minimum bias sample, the normalized event multiplicity is plotted versus the average event p_t as defined in (1). The first quantity is given by the number of tracks counted by the CTC in the above mentioned p_t and η regions, divided by the mean value of the multiplicity distribution. The full circles in fig.2 show the profile of the scatter plot, that is the average scaled multiplicity of the events laying in each slice of 0.2 GeV/c size of the $\langle p_t \rangle$, while for the jet trigger events the same quantities are plotted with open squares.

These two figures are essentially the same as in note 3866, apart from the statistics which is now two (or more) times higher. Fig.3 shows the same profile of fig.2, but now data from minimum bias and jet trigger samples are combined. This means that each minimum bias event enters the plot with a weight equal to 1 and each jet trigger event enters with a weight equal to the ratio of its cross-section to that of the minumum bias. In the vertical scale the multiplicity of each event is divided by the average multiplicity of the full sample of minimum bias and jet events, weighted as stated before.

The same things are shown, in fig's. 4 and 5, for the 630 GeV data. Fig. 6 contains the superposition of the profile plots of the combined samples, minimum bias plus jet events, from the two different energies $\sqrt{s} = 630$ GeV and $\sqrt{s} = 1800$ GeV. It is remarkable that, if the two horizontal scales were rescaled dividing each of them by the respective average p_t of the entire sample, the two plots would be completely overlapped.

We use Pythia generator tuned for production of soft interactions to produce Monte Carlo data to be compared with our distributions. Various samples of about 60,000 and about 23,000 events have been generated at 1800 and 630 GeV respectively. Jet trigger events have also been generated with Pythia (about 9,000 events). This Monte Carlo data have been simulated through the detector and fully reconstructed. The comparison of the Monte Carlo and real data is shown in fig.7 for the plots described in fig.'s 2 and 5.

3.2 K^0 and Λ^0 Production

We discuss now the production of V^0 as a function of the $\langle p_t \rangle$ of the event. The K^0 short and the Λ^0, decaying before entering the CTC, can be detected looking for couples of opposite sign off-vertex CTC tracks converging to a secondary vertex. The standard off-line module described in [4] and track segments from the CTCS bank have been used to search for K^0 and Λ^0 in our data samples. Fig.8 shows the average number of V^0 (K^0 plus Λ^0) per event divided by the average number of V^0 in the sample as a function of the event $\langle p_t \rangle$. This plot is the profile of a scatter plot obtained in the same way as described for fig.1, that is: each entry of the scatter plot is defined by the $\langle p_t \rangle$ of the events and by its number of V^0 divided by the mean number of V^0 in the analyzed sample.

A comparison between minimum bias and jet data, as in fig.2 for the charged multiplicity, is shown in fig.9 at $\sqrt{s} = 1800$ GeV. Finally in fig.10 the combined plots for jet and minimum bias data, obtained in the same way as described above for the charged multiplicity plots, are compared for 1800 and 630 GeV. A comparison with Monte Carlo for minimum bias and jet trigger combined data at 1800 GeV is shown in Fig.11.

3.3 Intermittency

Investigation of correlations among hadrons produced in high energy collisions have been done since several years through the study of the so called factorial moments computed in small pseudorapidity bins of decreasing size δ. The power-like increase of the factorial moments as a function of the bin size is referred to as *intermittency*. Intermittency has been observed in a very wide variety of multiparticle final state, although the effect changes with the different initial and/or final states analysed. We refer to reference [3] and references therein for the definition of the factorial moments and for a more detailed discussion about intermittency. In more recent years considerable improvements in the investigation of intermittency have been obtained with the introduction of more sophisticated techniques like the so called *correlation integrals* and the *star integrals* [5] and also with the use of three-dimensional bins in p_t, η and ϕ space instead of the original one-dimensional pseudorapidity bins. As a preliminary approach we have used factorial moments and factorial cumulants K_q ($K_2 = F_2 - 1; K_3 = F_3 - 3F_2 + 2$; etc. F_q is the factorial moment of order q) in one-dimensional pseudorapidity space [6]. This quantities have been studied, as for the charged and V^0 multiplicities, as a function of the average event p_t. Specifically factorial moments and factorial cumulants of order 2 and 3 have been calculated as a function of decreasing pseudorapidity bin size for different bins of the average event p_t. The *strength* of the effect for each bin of $\langle p_t \rangle_{ev}$ has been obtained taking the slope of the straight line fitted, in the limited region of pseudorapidity bin size in which linearity is observed, to the experimental points of the factorial moments (or factorial cumulants) versus the bin size dependence. In fig.12 this slope, the strength of the correlation, is shown as a function of the $\langle p_t \rangle_{ev}$ for the factorial cumulant of order three. Errors are still large, expecially for 1800 GeV data, but the dependence of the strength from the $\langle p_t \rangle_{ev}$ suggests a behaviour similar to what we observe in the combined plots of the charged and V^0 multiplicities shown in figures 6 and 10. A nearly flat region around $\langle p_t \rangle_{ev}$ 0.75 - 0.9, followed by a clear increase. In fig.12 minimum bias data at 1800 GeV (full circles) are compared with minimum bias data at 630 GeV (open triangles).

4 Conclusions

These are the conclusions we can try at this point. The analysis of the dependence of the average normalized multiplicity, and of the normalized mean number of V^0 per event as a function of the event $\langle p_t \rangle$ show:

- for the minimum bias data a rapid increase with increasing $\langle p_t \rangle$ up to a $\langle p_t \rangle$ of about 0.8 - 1.1 GeV/c, followed by a descendig tails.
- Both for the multiplicity and the V^0 plot the two curves at 1800 and 630 GeV are very similar, showing a full agreement in the shape of the event $\langle p_t \rangle$ dependence.

  This region of event $\langle p_t \rangle$ around 0.8 - 1.1 GeV/c corresponds to the maximum of the event $\langle p_t \rangle$ distribution and contains great part of the total inelastic $p\bar{p}$ cross-section.
- The correspondent mean charged and V^0 multiplicities for trigger data show a clearly different behaviour as a function of the $\langle p_t \rangle$.
- The structure of the events as described by the above average quantities appears to change smoothly as a function of $\langle p_t \rangle$ when minimum bias and trigger data are combined with the proper weigth, showing a clear increase for $\langle p_t \rangle$ above 1.5-2 GeV/c, taht is above minimum bias range.
- A similar behaviour is shown by the evolution of the strength of the *intermittency* as a function of the same variable.

References

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[2] CDF Coll. - F.Rimondi. XXIV International Symposium on Multiparticle Dynamics, Vietri sul Mare, Italy, Sept. 12-19, 1994 (CDF/PUB/MIN_BIAS/PUBLIC/2879).

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[5] P.Lipa et al.: Phys. Lett. B285 (1992) 300; H.C. Heggers et al.:Phys. Rev. D48 (1993) 2040.

[6] K.Fialkoswki. Proc. Ringberg Workshop on Multiparticle Production. Ed. R.C Hwa, W.Ochs and N. Schmitz (World Sci., Singapore, 1994).

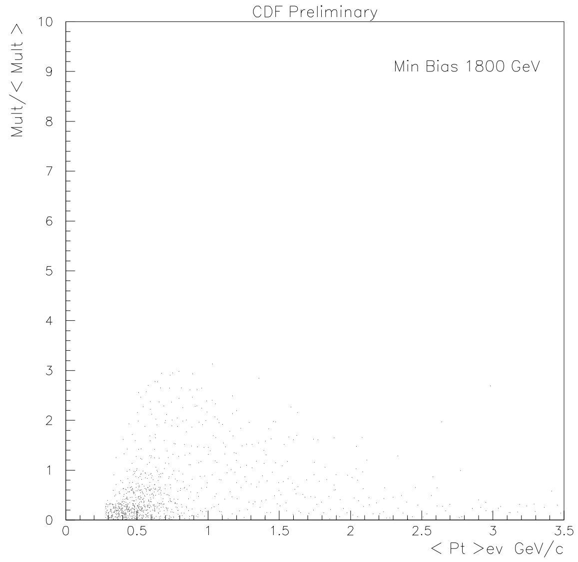

Figure 1: Scatter plot of minimum bias events at 1800 GeV. The variable on the horizontal axis is the average event p_t. On the vertical one there is the event charged multiplicity normalized to the total average multiplicity of the sample of events. Both variables are measured by the CTC.

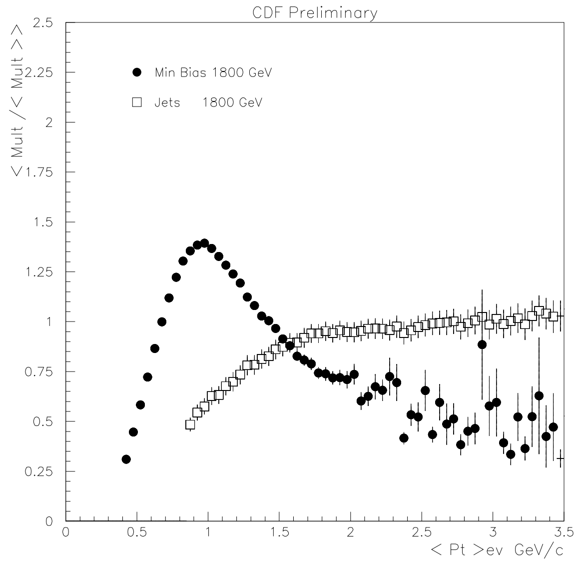

Figure 2: The full circles show the profile of the Fig. 1 scatter plot obtained using 0.2 GeV/c slices in p_t. The plot clearly shows a maximum at around 1 GeV/c. In this region is concentrated the maximum production of minimum bias events. The open squares are the same profile for jet trigger data

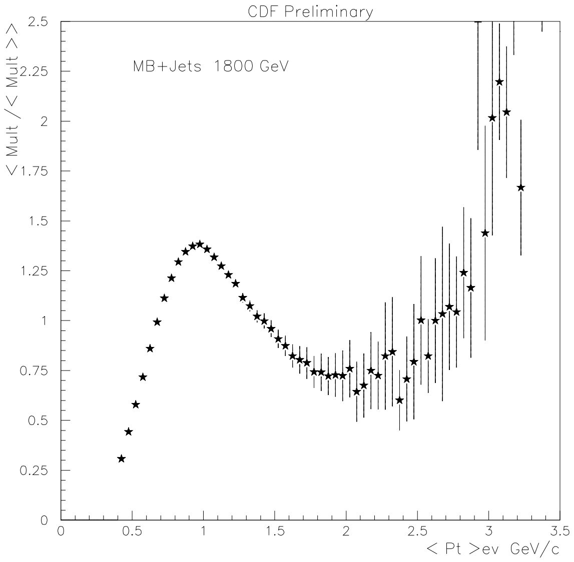

Figure 3: Same profile of fig.2, but here combined minimum bias and jet trigger data at 1800 GeV are shown. The jet trigger events are given a weight equal to the ratio of its cross section to minimum bias trigger cross section.

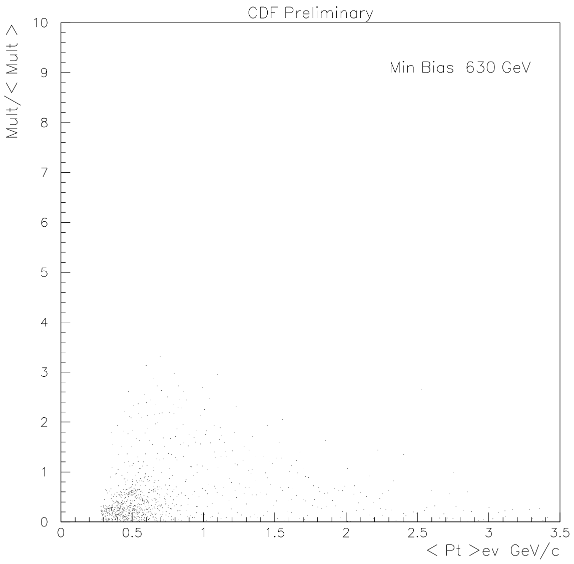

Figure 4: Scatter plot of minimum bias events at 630 GeV. The variable on the horizontal axis is the average event p_t. On the vertical one there is the event charged multiplicity normalized to the total average multiplicity of the sample of events. Both variables are measured by the CTC.

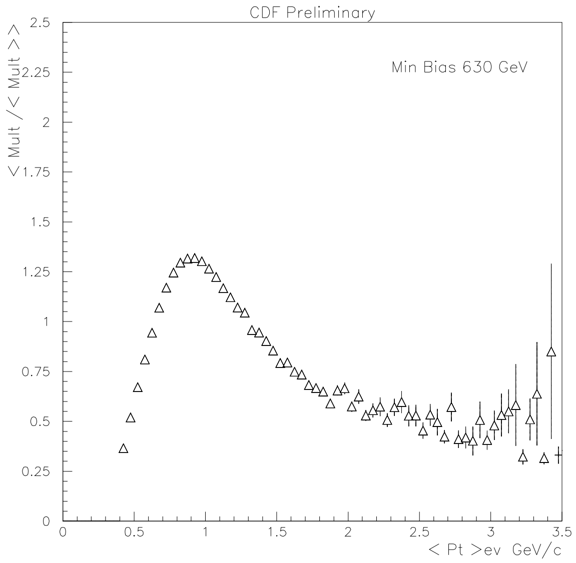

Figure 5: Profile of the fig.4 scatter plot obtained using 0.2 GeV/c slices in p_t.

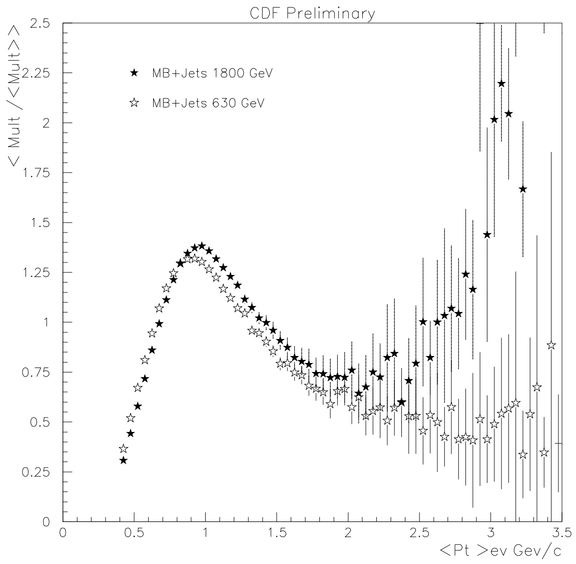

Figure 6: Superposition of the profiles for the combined minimum bias and jet trigger data for 1800 and 630 GeV. See fig.3 for the combination procedure.

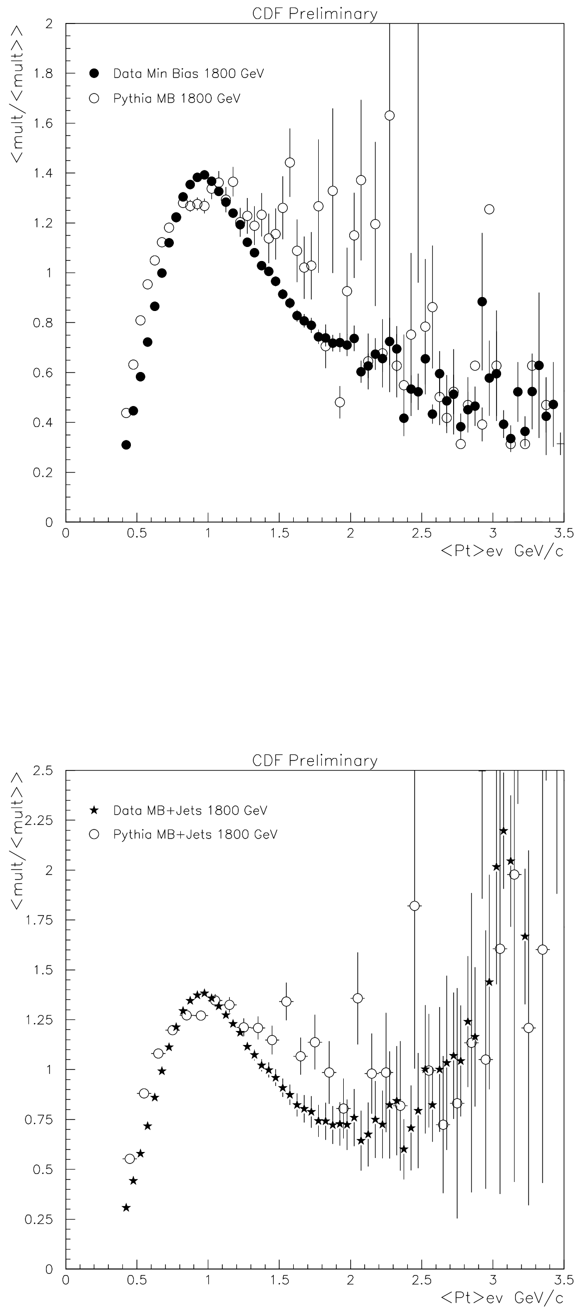

Figure 7: Comparison of the Monte Carlo and the real data of the figures 2 and 3 for 1800 GeV.

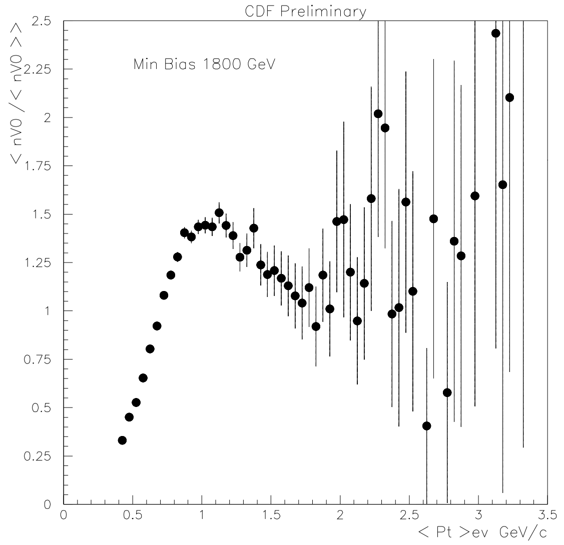

Figure 8: Strange particle production in minimum bias. The average number of V^0 events is plotted as a function of the average event p_t for two different energies, 1800 GeV (full circles) and 630 GeV (open triangles).

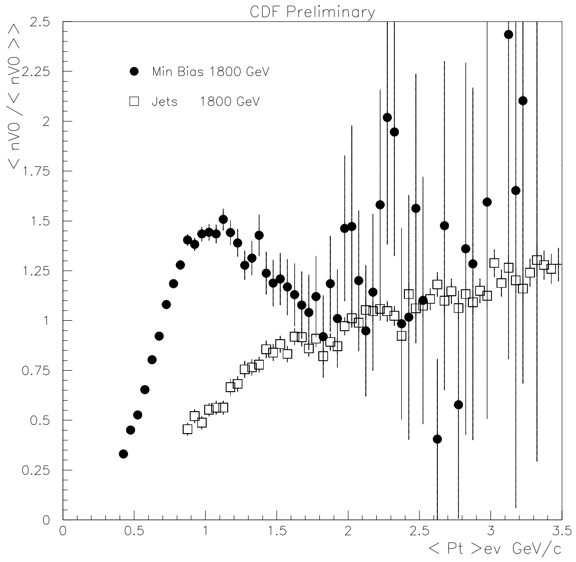

Figure 9: Comparison, between minimum bias and jet data, of the V^0 production as a function of p_t at 1800 GeV.

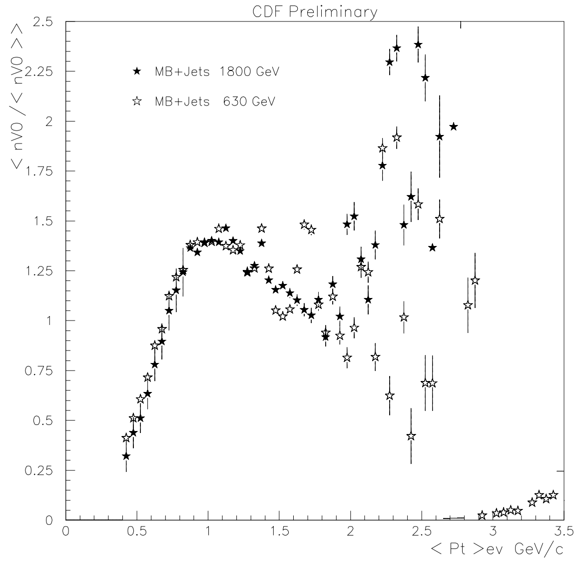

Figure 10: V^0 production as a function of p_t for combined minimum bias and jet data, obtained in the same way as described for the charged multiplicity. Full stars 1800 GeV, open stars 630 GeV.

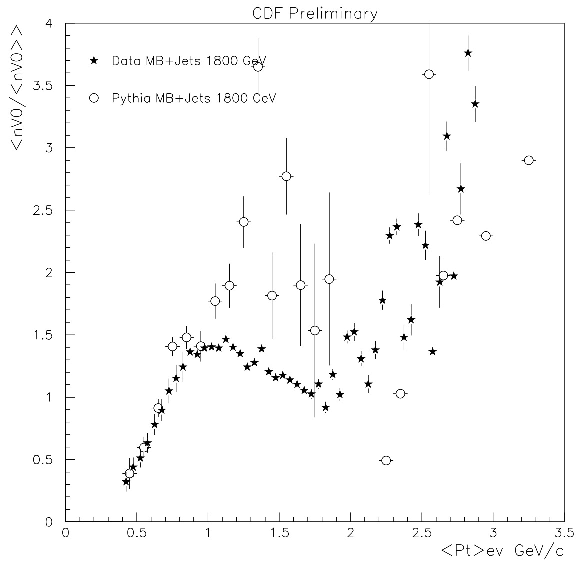

Figure 11: Comparison of Monte Carlo production of V^0 (minimum bias and jet trigger combined data) as a function of p_t (open circles) with 1800 GeV minimum bias and jet trigger combined data (full stars).

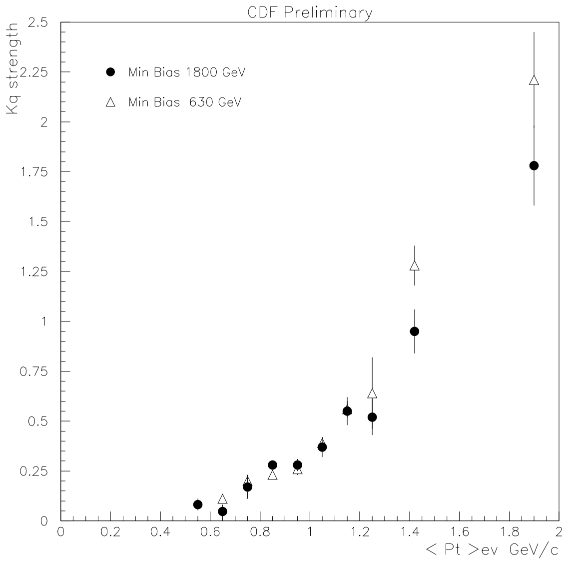

Figure 12: Short range correlation for E_t trigger superimposed to 1800 GeV data. Jet trigger data show a constant increase as a function of the event $\langle\ p_t\ \rangle$