TRANSVERSE ENERGY AND MULTIPLICITY DISTRIBUTIONS OF p-p AND A+A INTERACTIONS

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Data from AGS-E802 have been presented at the recent HIPAGS workshop at BNL¹, published in journals^{2,3,4} and in conference proceedings (St. Malo⁵, Moriond⁶), to which the reader is referred. Two results are mentioned here. The Lead Glass distribution $dE_T^0/d\eta$ from central O+Au collisions⁵ can be compared to the spectrometer $dn(\pi^-)/dy$ from central Si+Au collisions⁴. The agreement of the two distributions is excellent and confirms that the estimated^{5,6} position and value of the maximum in the distribution $\eta|_{max}$, $dE_T/d\eta|_{max}$, and the width $\Delta\eta_{FWHM}$ from the PbGl data are reasonable, and that nothing exceptional is occurring outside of the PbGl acceptance. Additionally, these data, and previous measurements of pseudorapidity distributions of multiplicity and Transverse Energy at both the AGS and CERN are analyzed in an acceptance-independent and model-independent method, with the conclusion that simple considerations of nuclear geometry do not provide an explanation of the different $\sqrt{s_{NN}}$ dependences observed in ¹⁶O+Au and p-p reactions.

1. "TRANSVERSE ENERGY" AND MULTIPLICITY DISTRIBUTIONS

Transverse Energy (E_T) distributions have recently become a respected analytical tool for soft multiparticle collisions, particularly in nucleus-nucleus reactions. It has been shown, by experiments^{2,3,7,8,9,10} at BNL and CERN, that E_T distributions from nuclear collisions are largely dominated by the nuclear geometry, at the present level of sensitivity. However, it is possible that dynamical effects also play a role.

Pseudorapidity distributions of transverse energy, $dE_T/d\eta$, are important in the discussion of "nuclear stopping" because one of the simplest concepts of stopping is that the projectile and target "participants" merge into a hadronic "fireball", which then decays isotropically^{7,8,9,10}. This would be quite distinct from the normal behavior of the "soft" multiparticle production processes that predominate in high energy collisions, in which produced particles have limited transverse momentum ($\langle p_T \rangle \simeq \frac{1}{3}$ GeV/c) and very broad and flat rapidity distributions, a situation usually described as "longitudinal phase space". In this limit, an E_T measurement is simply an analog method of counting particles: each particle produced has roughly the same value of $E_i \sin \theta_i \simeq \langle p_T \rangle$.

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2. E802 LEAD GLASS MEASUREMENTS

As part of AGS Experiment 802, an array of 245 Lead Glass blocks, covering half the azimuth, with a polar angular acceptance approximately $8^\circ \leq \theta \leq 32^\circ$, which corresponds roughly to a laboratory pseudo rapidity range $1.25 \leq \eta \leq 2.50$ with good acceptance, when edges and corners are taken into account, measured the transverse energy (E_T) distributions from primary beams of protons, ^{16}O , and ^{28}Si , at 14.6 A GeV/c, incident on targets of Be, Al, Cu and Au. The lead glass is most sensitive to electromagnetic radiation, but also responds to relativistic charged hadrons ($\beta > 0.8$). No attempt is made to correct for the Cerenkov light from charged hadrons on an event by event basis because an incalculably large point-by-point systematic error would have to be assigned. The response of the PbGl to Cerenkov light is linear to $< 1\%$ whatever the source, so that the total detector response provides a good measure of the global pion yield in the central rapidity region of these reactions¹.

Data from E802 have been presented at the recent HIPAGS workshop at BNL¹, published in journals^{2,3,4} and in conference proceedings (St. Malo⁵, Moriond⁶), to which the reader is referred. Also, correlations among the 4 detector systems in E802 have been shown to be a powerful diagnostic tool^{1,5}. In this brief discussion, some of these results are highlighted and compared. In figure 1, the pseudorapidity distribution in the Lead Glass, $dE_T^0/d\eta$, from central O+Au collisions⁵(diamonds) is compared to the spectrometer $dn(\pi^-)/dy$ from central Si+Au collisions⁴(squares). The agreement of the two distributions is excellent and confirms that the estimated^{5,6} position and value of the maximum in the distribution $\eta|_{\max}$, $dE_T/d\eta|_{\max}$, and the full width at half maximum $\Delta\eta_{FWHM}$, from the PbGl data are reasonable, and that nothing exceptional is occurring outside of the PbGl acceptance. It is evident that the parameters $\eta|_{\max}$, $dE_T/d\eta|_{\max}$, and $\Delta\eta_{FWHM}$, provide a simple and complete characterization of the measured (pseudo)rapidity distributions $dE_T/d\eta$ and dn/dy in a relatively acceptance-independent and model-independent fashion.

3. ACCEPTANCE-INDEPENDENT COMPARISON OF ALL EXPERIMENTS

The simple characterization of pseudorapidity distributions, illustrated above, allows a systematic comparison of E_T measurements from all the RHI experiments, in spite of the fact that the detectors cover nearly disjoint regions of pseudorapidity: WA80⁹, E814¹⁰—forward; NA34(Helios)⁸—backward; E802^{2,4}, NA35⁷—central. It is possible to compare these experiments independently of acceptance by first estimating E_T^{cent} , the E_T observed in “central collisions”, using the NA34–Helios⁸ definition (a factor of two in cross section down from the “knee” of the distribution), for all experiments. Then, the value of $dE_T^{\text{cent}}/d\eta|_{\max}$ at the maximum in the pseudorapidity distribution can be estimated^{6,11}. The results are shown in fig. 2, as a function of the nucleon-nucleon c.m.energy $\sqrt{s_{NN}}$ for $^{16}\text{O}+\text{Au}(\text{W})$ reactions. It is appropriate to compare the $\sqrt{s_{NN}}$ dependence of $dE_T^{\text{cent}}/d\eta|_{\max}$ to measurements of $dn/dy|_{\max}$ from $p-p$ collisions. The broken line on the figure is $16 \times dn/d\eta|_{y_{cm}^{NN}}$ for $p-p$ collisions¹². If geometry were the only nuclear effect, then the $\sqrt{s_{NN}}$ dependences would be identical in the $p-p$ and the $^{16}\text{O}+\text{Au}$ reactions. However, $dE_T^{\text{cent}}/d\eta|_{\max}$ in $^{16}\text{O}+\text{Au}$

Figure 1

Maximum $dE_T/d\eta$ for "central" collisions

Figure 2

increases by a factor of 3 from $\sqrt{s_{NN}} = 5.4$ to 19.4 GeV, which is much greater than the corresponding increase of a factor of 1.31 of the multiplicity density in $p - p$ collisions—a relative increase of $3/1.3 = 2.3$.

The estimates of E_T^{cent} are clearly dominated by systematic effects, the most notable being between the two NA35 measurements⁷. However, a similar conclusion on the relative $\sqrt{s_{NN}}$ dependence of nucleus-nucleus and $p - p$ collisions can be drawn from the emulsion data of E808¹³, where a direct comparison of pseudorapidity distributions for $^{16}\text{O} + \text{AgBr}$ central collisions at 14.5 GeV/c per nucleon, 60 GeV/nucleon and 200 GeV/nucleon is available for charged particle multiplicity. The maximum in the multiplicity distribution for “shower particles” ($\beta > 0.7$), $dn_s/d\eta|_{max}$, increases by a factor of 2.4 from $\sqrt{s_{NN}} = 5.4$ to 19.4 GeV, an increase of a factor of 1.8 relative to $p - p$.

It is evident from these considerations, that systematic comparison of the data from nucleus-nucleus, $p + A$, and $p - p$ interactions at AGS and CERN energies can lead to quantitative conclusions, without detailed recourse to particular models. Simple considerations of nuclear geometry do not provide an explanation of the different $\sqrt{s_{NN}}$ dependences observed in $^{16}\text{O} + \text{Au}$ and $p - p$ reactions. Dynamical effects, such as “energy stopping” at AGS energies and “transparency” at CERN energies, are also required.

REFERENCES

1. HIPAGS Workshop at BNL, March 5-7, 1990, to appear as BNL report.
2. E802 Collaboration, T. Abbott et al., Phys. Lett. B197 (1987) 285.
3. E802 Collaboration, Z. Phys. C38 (1988) 35,135.
4. E802 Collaboration, T. Abbott et al., Phys. Rev. Letters 64 (1990) 847.
5. M.J. Tannenbaum, Nucl. Phys. A488 (1988) 555c.
6. M.J. Tannenbaum et al., Proceedings of the 24th Rencontre de Moriond, ed. J. Tran Thanh Van, (Editions Frontieres, Gif-sur-Yvette, France, 1989), pp 581-586.
7. NA35 Collaboration, A. Bamberger, et al., Phys. Lett. B184 (1987) 271; W. Heck, et al., Z. Phys C38 (1988) 19.
8. NA34(Helios) Collaboration, Z. Phys. C38 (1988) 383; Phys. Lett. B214 (1988) 295.
9. WA80 Collaboration, S.P. Sorensen et al., Z. Phys. C38 (1988) 3,51; R. Albrecht, et al., Phys. Lett. B199 (1987) 297.
10. E814 Collaboration, P. Braun-Munzinger et al., Z. Phys. C38 (1988) 45.
11. M.J. Tannenbaum, International Journal of Modern Physics A 4(1989) 3377.
12. The parametrization for $p - p$ is $dn/d\eta|_{max} = 0.74(\sqrt{s})^{0.210}$, where the $\sqrt{s}$ is in GeV. UA5 Collaboration, Z. Phys. C33 (1986) 1.
13. E808 Collaboration, H. von Gersdorff, et al., Phys. Rev. C39 (1989) 1385.

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