BROOKHAVEN NATIONAL LABORATORY

March 31, 1999 BNL–

Draft of p-p run request

M. J. Tannenbaum
Brookhaven National Laboratory
Upton, NY 11973-5000 USA

1 Introduction

E_T distributions play an important role in RHI collisions to 'characterize' the 'nuclear geometry' of a reaction, typically by a certain upper percentile of the distribution, e.g. 5%. The typical '4π' hadron calorimetry of high energy physics is not necessarily the best method for event characterization since it combines baryons and mesons, produced particles and participating nucleons, the projectile, midrapidity and target fragmentation regions into one number, E_T. More restrictive quantities might be better. A systematic study of event characterization using mid-rapidity E_T distributions in an electromagnetic calorimeter which covered half the azimuth, as a function of the pseudo-rapidity acceptance (see Fig. 1), has been made by AGS E802[1] who concluded that an aperture as small as $\Delta\phi = \pi$, $\delta\eta = 0.32$ provided "an excellent characterization of the nuclear geometry of RHI collisions, from which important information about the dynamics can be inferred." One problem with the limited aperture, electromagnetic energy event characterization in comparison to '4π' hadron calorimeters is the difficulty in relating the endpoints of the energy spectra—i.e. ~ 32 GeV for $\delta\eta = 0.64$, ~ 22 GeV for $\delta\eta = 0.32$ in Fig. 1—to the total available energy for the reaction.

The situation changes dramatically when the energy scale for each aperture is plotted in units of the measured $\langle E_T \rangle$ in the same aperture for p-p (if available) or p+Au collisions (as done by E802), see Fig. 2. The dynamics of the reaction can now be read directly from the figure. The p+Au E_T distribution goes out to ~ 7 mean values over 3 orders of magnitude for $\delta\eta = 0.64$, and to ~ 10 mean values over 3 orders of magnitude for $\delta\eta = 0.32$, i.e. the fluctuations around the mean increase with decreasing aperture; the knees of the O+Cu and Si+Au E_T distributions occur roughly at 16 and 28 times $\langle E_T \rangle_{\mathrm{p+Au}}$ for both apertures, corresponding to the A of the projectiles, but the knee of the Au+Au distribution is roughly 150 and clearly not $A_{\mathrm{Au}} = 197$, apparently indicating some shadowing. Detailed analysis shows that this is actually an acceptance effect in the limited aperture (ϵ^{197} tends to be considerably less than unity for most reasonable values of ϵ), so that the 'Wounded Projectile Nucleon' actually represents the measurements rather well in all the intervals studied around mid-rapidity at the AGS.

[1] "Systematics of Mid-Rapidity E_T and multiplicity distributions in Nucleus and Nucleon Collisions at AGS Energies", M. J. Tannenbaum for the E802 Collaboration, PX-169 (BNL-65915) 1998.

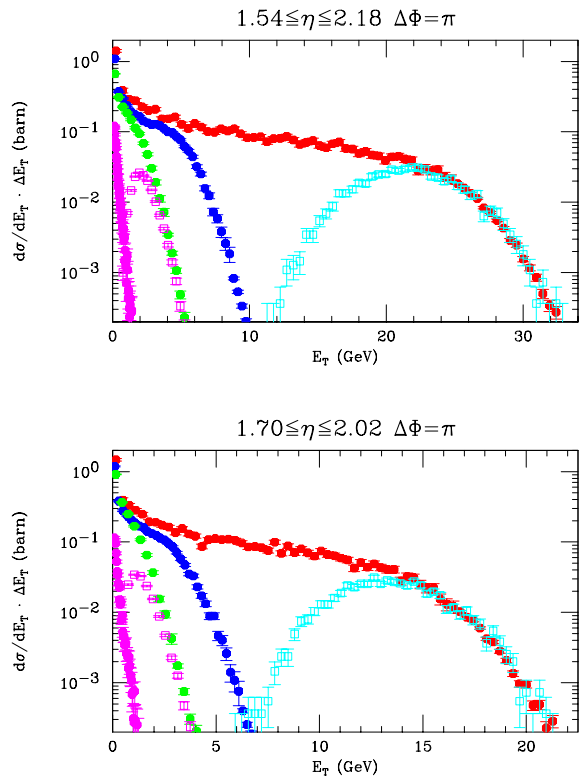

Figure 1: E802 E_T distributions in an EM calorimeter with acceptance $\Delta\phi = \pi$ for the intervals $\delta\eta = 0.64$ ($1.54 \leq \eta \leq 2.18$) and $\delta\eta = 0.32$ ($1.70 \leq \eta \leq 2.02$) around mid rapidity at the AGS (14.6 A GeV/c). The data shown are from left to right: p+Au, O+Cu, O+Cu(ZCAL), Si+Au, Au+Au, Au+Au(ZCAL).

2 Request for a limited p-p run at $\sqrt{s} = 200$ GeV in Year 1

The E_T distribution measurable in year-1 by PHENIX will look something like the Au+Au distribution shown for $\delta\eta = 0.64$, $\Delta\phi = \pi$ (top of Fig. 1). How will we be able to interpret the measured endpoint at RHIC? What would 30 GeV or 63 GeV imply for the physics? This problem can be cured with a limited run of 60,000 minimum bias events for p-p collisions at the same $\sqrt{s_{NN}}$ (roughly the number of events in the p+Au distributions shown) which would allow meaningful physics results to be read directly off the plot. For instance, if the result looked like Fig. 2 in terms of $E_T/\langle E_T\rangle_{\mathrm{p-p}}$, it would show simply and clearly that the Wounded Nucleon Model, which is operative in the SPS fixed target energy range, is also valid at RHIC. Note that this conclusion could be drawn purely from measurements—without any recourse to an event generator or a cascade monte carlo. Any different situation, for instance, more or less $E_T/\langle E_T\rangle_{\mathrm{p-p}}$ emission in Au+Au compared to the Wounded Nucleon Model would also instantly be revealed.

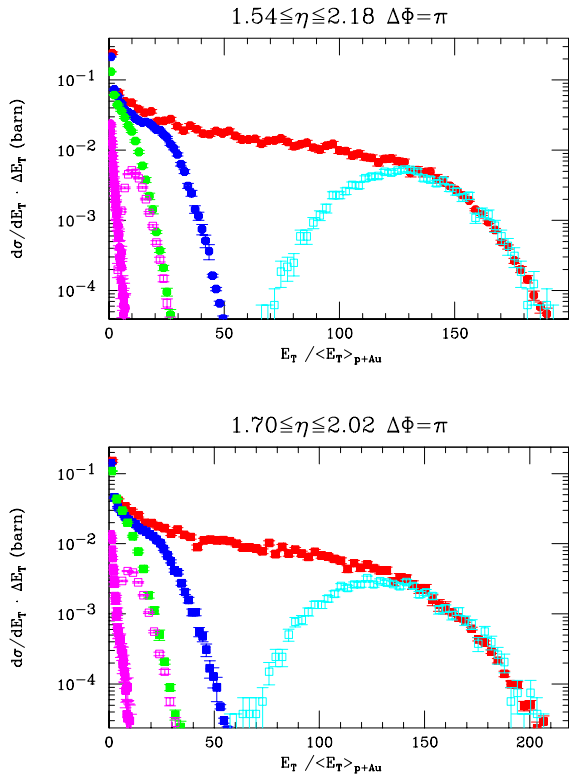

Figure 2: E802 E_T distributions in an EM calorimeter with acceptance $\Delta\phi = \pi$ for the intervals $\delta\eta = 0.64$ ($1.54 \leq \eta \leq 2.18$) and $\delta\eta = 0.32$ ($1.70 \leq \eta \leq 2.02$) around mid rapidity at the AGS (14.6 A GeV/c), where the E_T scales for each interval are normalized by the measured $\langle E_T \rangle_{\mathrm{p+Au}}$ in the interval. The data shown are from left to right: p+Au, O+Cu, O+Cu(ZCAL), Si+Au, Au+Au, Au+Au(ZCAL).

2.1 Running time request for 60000 minimum bias p-p collisions

The nominal p-p luminosity at RHIC is 2×10^{31} cm^{-2} s^{-1}. Using an inelastic interaction cross section of 30 mb (3×10^{-26} cm^2), the minimum bias interaction rate is 600,000 events/second. In this case, a 60K run would require 0.1 seconds, plus the setup time. Similarly, if the luminosity achieved were only 2×10^{28} cm^{-2} s^{-1}, 1/1000 of the nominal, corresponding to 600 events/second, the 60K run could be achieved in 100 seconds (less than 2 minutes), plus setup time. In conclusion, a few days of p-p running for data taking is requested in year-1, once the luminosity is steadily above 10^{27} cm^{-2} s^{-1}, roughly 1/20000 of the design value, corresponding to ≥ 30 Hz interaction rate, so as to accumulate 60,000 minimum bias interactions. Even at this low interaction rate, the data can be collected in 1 hour of live time. It is assumed most of the time will be devoted to setup, beam gas studies, luminosity studies, etc. It is also important to note that the measurement proposed (Fig. 2) does not require the knowledge of the (integrated) luminosity for either the Au+Au or p-p measurement.