Need for p-p and p+A comparison data for Photon Physics ?

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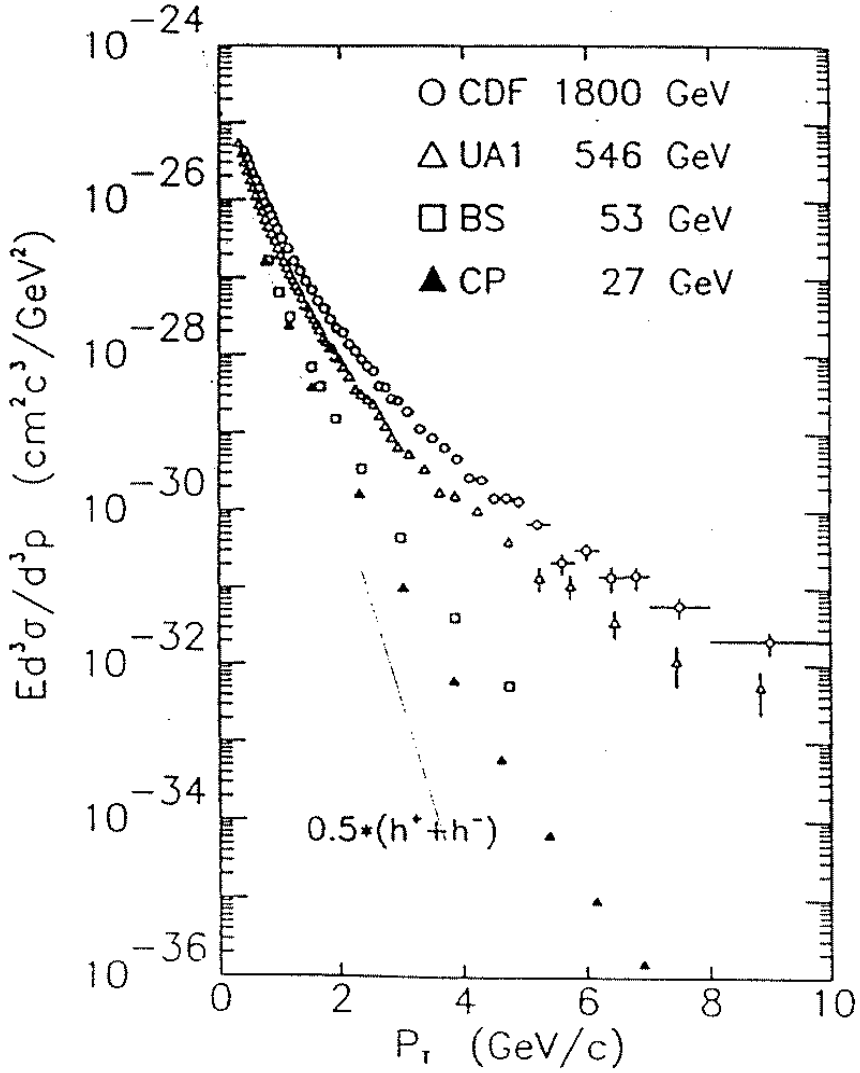
Recall My Best Bet on Discovering QGP From Costa Mesa Meeting



Invariant cross section for non-identified charged-averaged hadron production at 90° in the c.m. system as a function of the transverse momentum p_T tablulated by CDF for a range of C.M. energies $\sqrt{s}$. There is an exponential tail (e^{-6p_T}) at low p_T, which depends very little on $\sqrt{s}$. This is the soft physics region, where the hadrons are fragments of 'beam jets'. At higher p_T there is a power-law tail which depends very strongly on $\sqrt{s}$. This is the hard-scattering region, where the hadrons are fragments of the high p_T QCD jets from constituent-scattering. **My hope is that the QGP causes the high p_T quarks to lose all their energy and stop, so that the high p_T tail will 'vanish' for central Au+Au collisions**

A Real Theoretical Calculation
X-N. Wang and Z. Huang PRC 55, 3047 (1997)

dot-dashed line. However, one still has to face π^0's about 3 times higher than the direct photons at $p_T = 10$ GeV/c. At larger p_T, the situation improves, but one loses the production rate. Since the isolation cut method normally employed in pp collisions to reduce the background for direct photons does not work any more, the only way one can identify them with high accuracies has to be through the means of improved detectors.

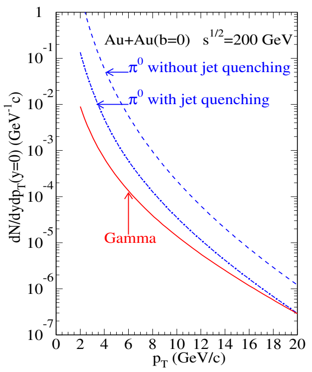


FIG. 13. The spectrum of direct photon production (solid) as compared to π^0 spectrum with (dot-dashed) and without (dashed) parton energy loss ($dE_q/dx = 1$ GeV/fm, $\lambda_q = 1$ fm) in central $Au + Au$ collisions at $\sqrt{s} = 200$ GeV.

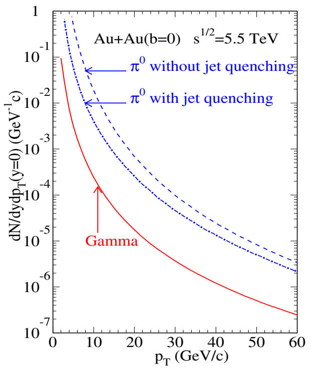


FIG. 14. The same as Fig. 13, except at $\sqrt{s} = 5.5$ TeV.

Similarly, we also list in Table III the number of γ +jet events per year per unit rapidity and unit (GeV) E_T at the LHC energy. We assume a luminosity of $\mathcal{L} = 2 \times 10^{27}$ cm^{-2}s^{-1} with 50 operation days per year for $Au + Au$ collisions. The production rates are reasonably high due to both the high luminosity and collider energy. However, the corresponding background of π^0's is also high (see Fig. 14) which may make the detection of direct photons more difficult.

At the LHC energy, $\sqrt{s} = 5.5$ TeV, the production rate for Z^0 +jet becomes large even for reasonably large $P_T^{Z^0}$. Listed in Table IV are the number of Z^0 +jet events per year per unit rapidity integrated over $P_T^{Z^0}$ with different low cut-off values. The production cross sections are provided by T. Han based on calculations as described in Ref. [30]. Note that the given Z^0 production rates are integrated ones, thus appearing to be larger than the differential rate of direct photon production at the same transverse momentum. One can detect Z^0 through the dilepton channel which has almost no background in the range of the dilepton invariant mass near M_{Z^0}. One can then apply the same procedure as we have discussed in this paper for direct photon events and measure the modification of the effective jet fragmentation function due to parton energy loss. However, the drawback of using the dilepton channel of Z^0 decay is that the effective number of events via this channel is about 6.7% of the total number of Z^0 events.

E_T^γ (GeV)	7	10	15	20
$dN^{\gamma-jet}/dydE_T$/year	20500	3550	400	70

TABLE II. Rate of direct photon production in central $Au + Au$ collisions at $\sqrt{s} = 200$ GeV, with luminosity $\mathcal{L} = 2 \times 10^{26}$ cm^{-2}s^{-1} and 100 operation days per year.

E_T^γ (GeV)	40	50	60
$dN^{\gamma-jet}/dydE_T$/year	2880	1070	490

TABLE III. Rate of direct photon production in central $Au + Au$ collisions at $\sqrt{s} = 5.5$ TeV, with luminosity $\mathcal{L} = 2 \times 10^{27}$ cm^{-2}s^{-1} and 50 operation days per year.

$P_T^{Z^0}$ (GeV)	> 20	> 40	> 60
dN^{Z^0-jet}/dy/year	21100	7700	3470

TABLE IV. Rate of Z^0 production in central $Au + Au$ collisions at $\sqrt{s} = 5.5$ TeV, with luminosity $\mathcal{L} = 2 \times 10^{27}$ cm^{-2}s^{-1} and 50 operation days per year.

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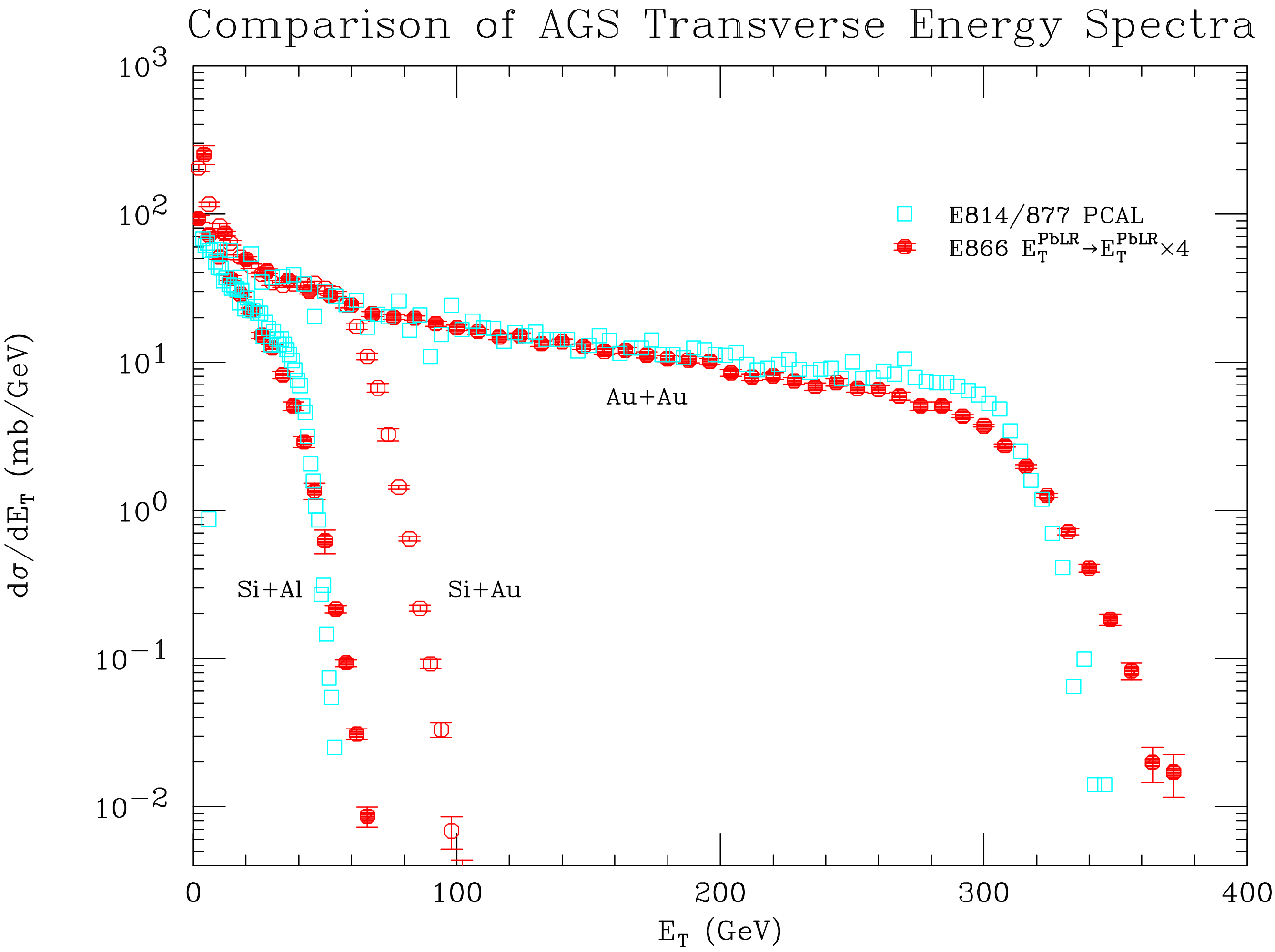
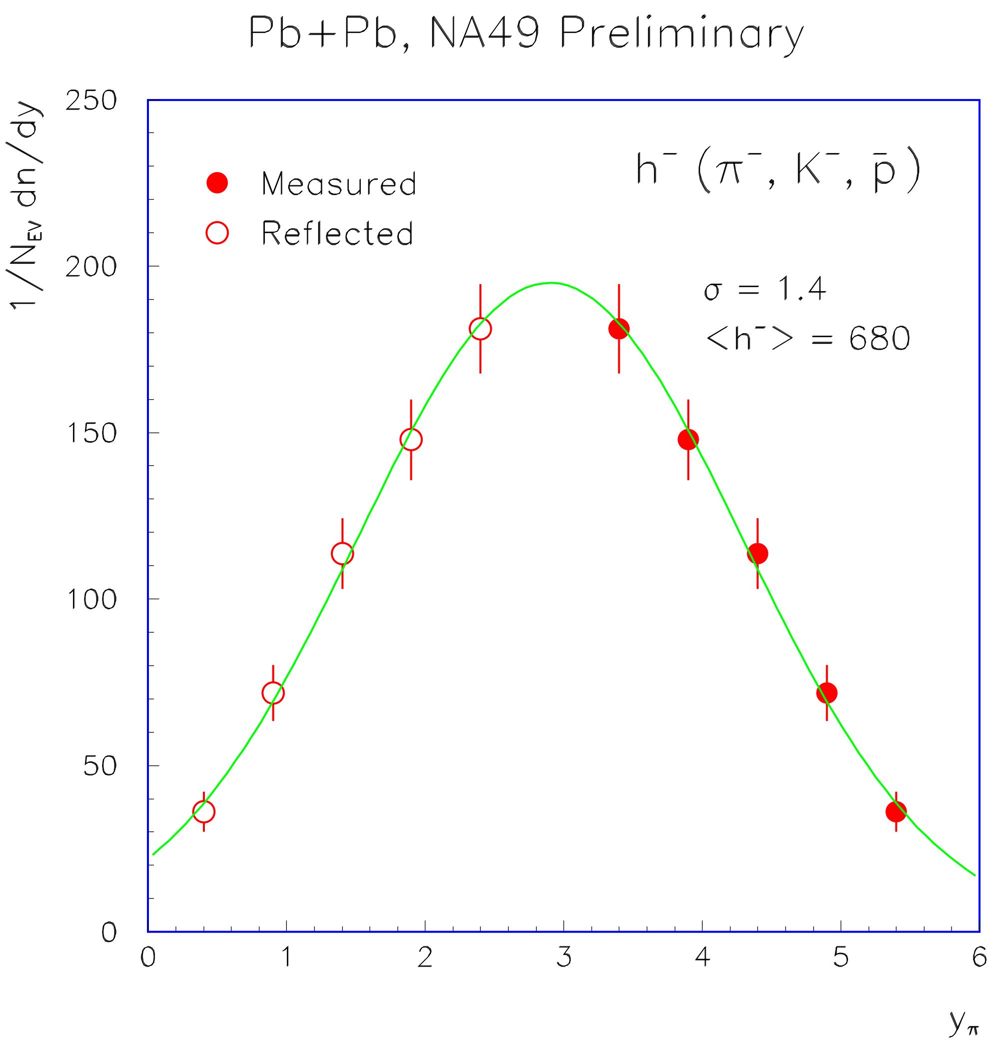
Note the predicted π^0 suppression by jet quenching is a factor of 10. The direct Gammas are not reduced making $\gamma/\pi^0 > 10\%$ (where even I can make the measurement) for $p_T > 3$ GeV/c. **Note that this much larger than for p-p collisions since the π^0 background has been suppressed by an order magnitude—if the theorists are right!**

We can use Centrality Cuts
To see if the power-law tail returns at low E_T

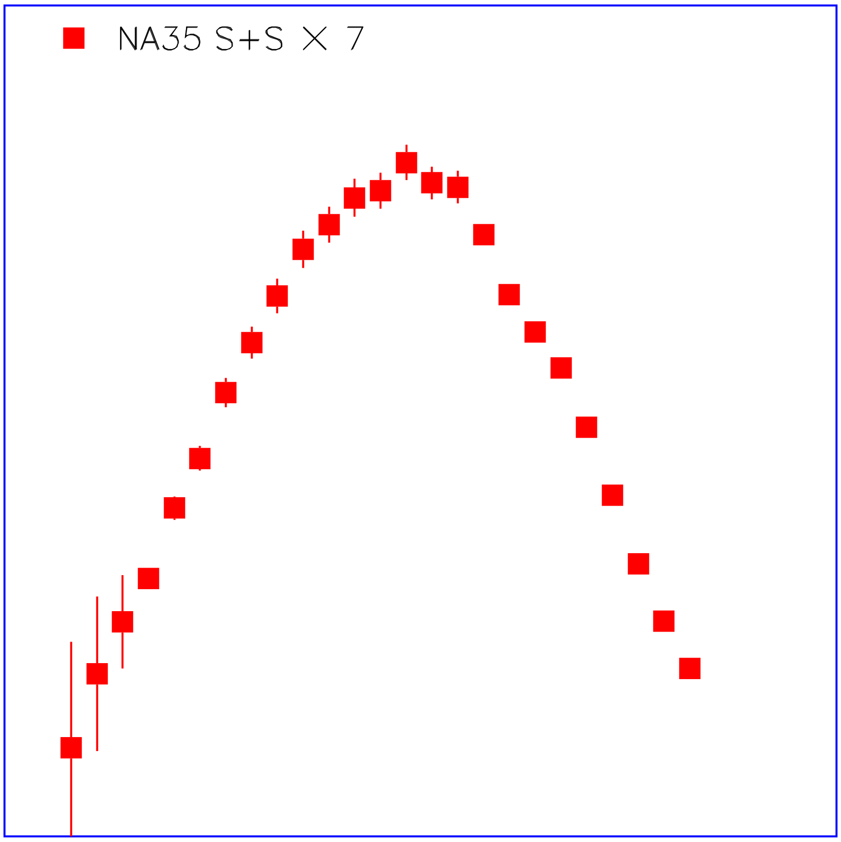


Of course, using E_T for centrality may introduce a bias since E_T is dominated by low p_T π^0 and thus may distort the data. Another possibility is to use a gentle $E_T > 70$ GeV (see above) cut to define not-peripheral and then use the neutron cal, with few-neutrons and not-peripheral, to define centrality. Also, the MVD may be very useful as a centrality trigger, since we could use the part of the MVD either inside or outside the EMcal acceptance and see whether these were different.
However, I think minimally we will have to run Si+Si to prove the effect, and also p-p and p+Au In fact measurements of direct gamma in p-p and p+A would be **extremely useful** as a measurement of the Gluon Structure function.

Illustration of the power of even A crude measurement in S+S to help understand Pb+Pb—NA49

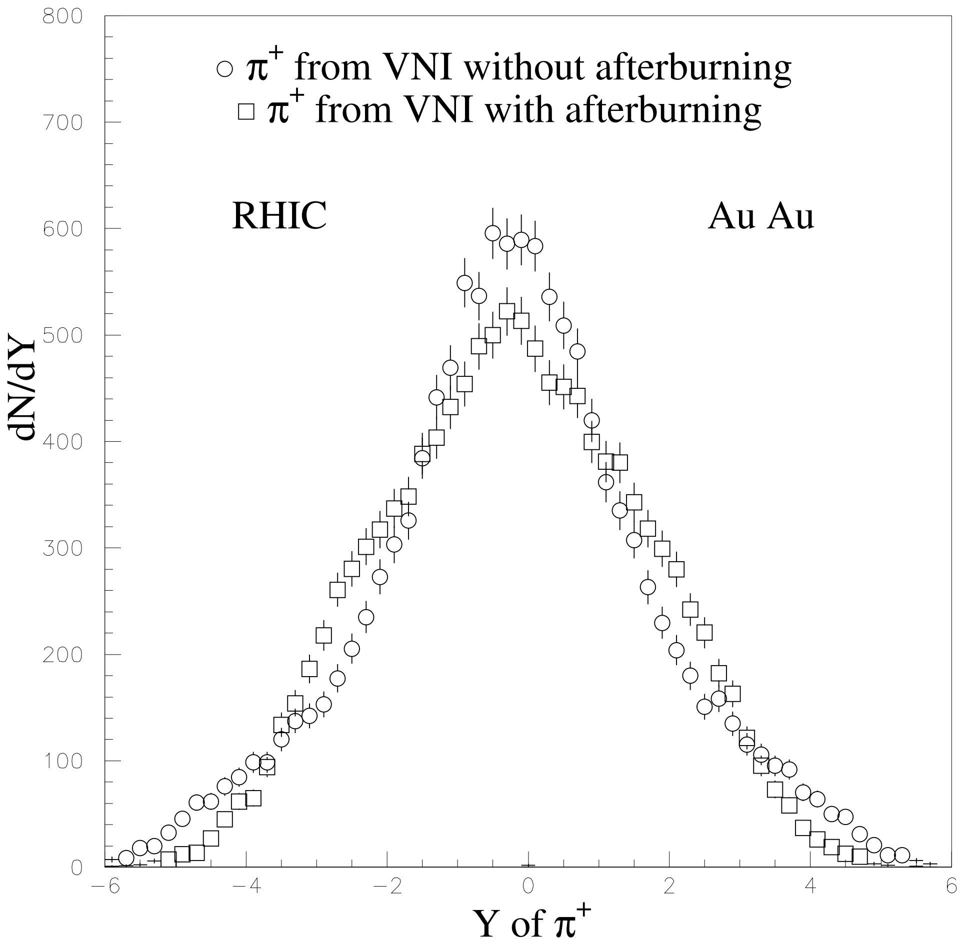


The NA49 measurement of non-identified negative hadrons in Pb+Pb central collisions (top) at beam energy 158 GeV$\cdot A$ is not much on its own.



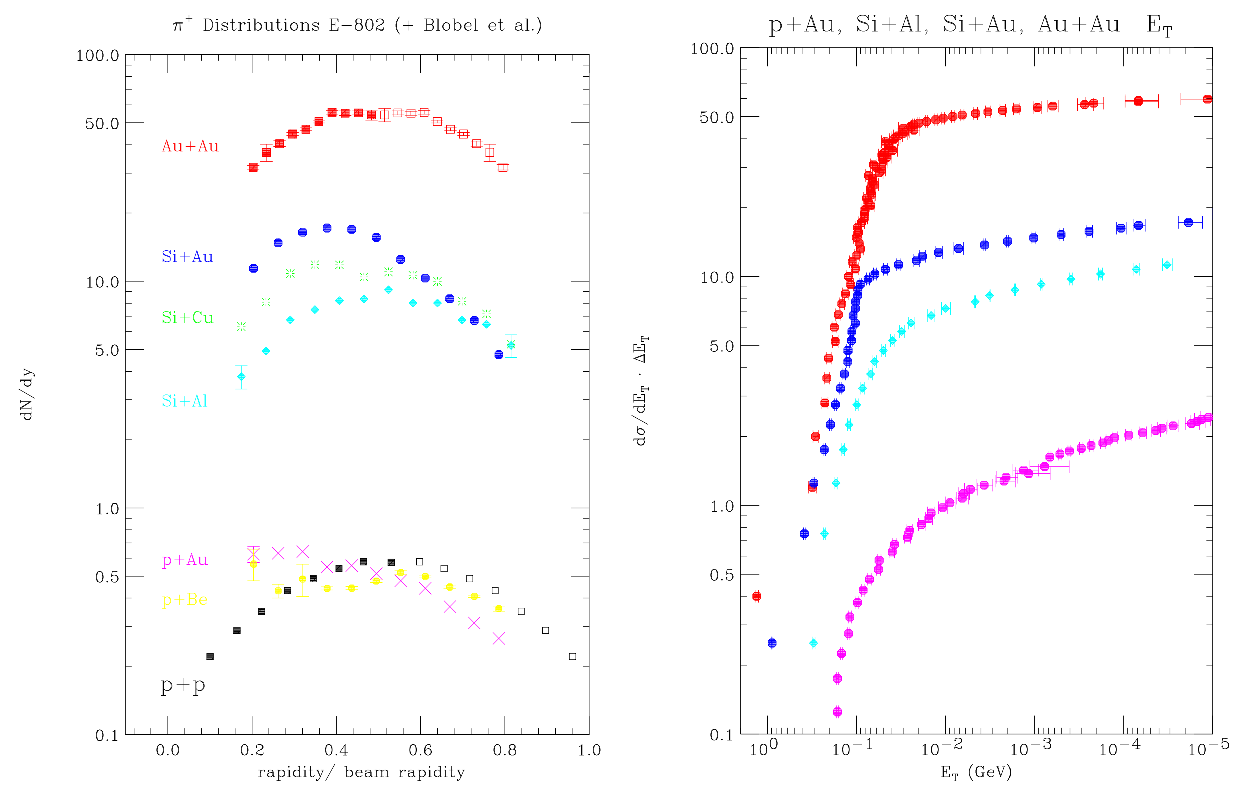
However the same measurement in S+S at 200 GeV$\cdot A$ multiplied by 7 (which very close to the ratio of 208/32=6.5) lies on top of the Pb+Pb measurement, which shows that particle production in central collisions A+A collisions is proportional to A, a clear indication of the Wounded nucleon Model.

Suppose that we should be so lucky in PHENIX at RHIC to get a measurement of E_T or dn/dy for π^0 as predicted by KKG and Ron Longacre (for π^+)



This predicted distribution would be particularly nice for PHENIX for several reasons. 1) $dn/dy|_{\pi^+} = 540$, and we go blind at 750 per pion. 2) dn/dy peaks strongly at $y = 0$ (in the PHENIX detector), and is down a factor of 1.4 at $y = 1$, and 2.0 at $y = 2$. **Of course, it sure would be nice to be able to compare this distribution with say Si+Si central collisions to see whether the Au+Au/Si+Si ratio scales like A, a factor of 7, at RHIC as it does at CERN.** *I bet against since* $dn/d\eta = 2.5$ *for non-identified charged particles in* $p - \bar{p}$ *collisions at* $\sqrt{s} = 200$ *GeV, thus should be* $197 \times 2.50/2 = 250$ *at RHIC compared to 540 shown.*

Systematic measurements of dn/dy and E_T in A+A collisions at the AGS (E802...)



On the left, the $dn/dy|_{\pi^+}$ distributions for p+A inclusive and A+A central make it easy to show that Au+Au/p-p∼Au+Au/p+Au=100, much less than 197. Also the p-p or p+Be to p+Au ratios evidently don't follow the wounded nucleon model, since dn/dy doesn't vary at mid rapidity, but it does vary in the beam fragmentation region. The comparison Au+Au/Si+Al is intriguing since the Au+Au/Si+Al data for both dn/dy and E_T (right) are close to the WNM ratio of 7. **However,** from the E_T distributions, it is obvious that the exact value of this ratio depends on the "centrality" cut; since the "shapes" of the distributions are different, a centrality definition using a fixed upper percentile may be too simplistic. The asymmetric Si+Au,Cu,Al collisions show very interesting systematic behavior, but for PHENIX (as in E802 E_T), the asymmetric collisions are a problem since the maximum in dn/dy moves out of our acceptance region. **Evidently, we really need p-p collisions to get a full understanding of the systematics, but Si+Si will also be exceedingly useful and interesting.**