

Inclusive distributions at the LHC as predicted from the DPMJET-III model with chain fusion

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- (1) DPMJET-III
- (2) Chain fusion in DPMJET-III
- (3) $dN/d\eta_{cm}$ distributions
- (4) N_{part} dependence
- (5) Scaling behaviour
- (6) Transverse momentum distributions in central collisions

(1) DPMJET-III Status and problems.

h-h collisions: PHOJET in DPMJET-III

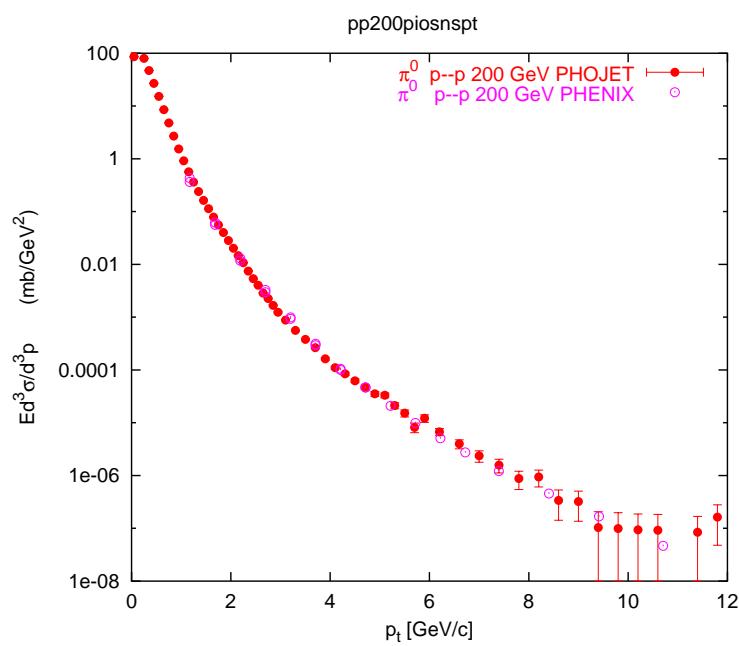
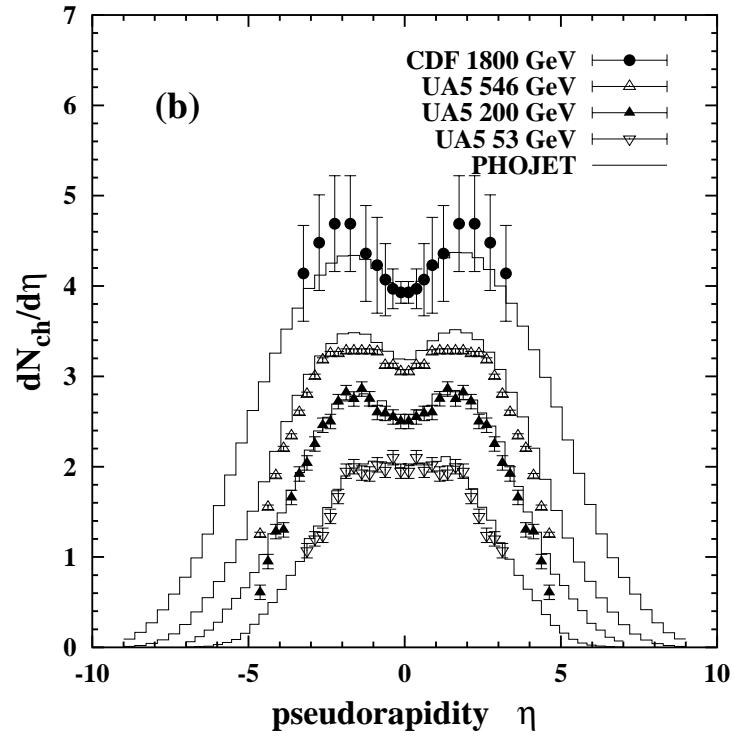
R.Engel Z.Phys. C66, 203, (1995)

R.Engel and J.Ranft Phys. Rev. D54, 4244, (1996)

h-A, A-A collisions: DPMJET-III

S.Roesler, R.Engel and J.Ranft Proc. of Monte Carlo 2000 (Lisboa), Springer, p.1033 (2000)

Not implemented in DPMJET-III: Jet quenching



(left) Energy-dependence of charged particle pseudorapidity density in $p\bar{p}$ collisions. PHOJET is compared to data from different colliders (right) Transverse momentum distribution of π^0 mesons as measured in p-p collisions at $\sqrt{s} = 200$ GeV by the PHENIX collaboration at RHIC compared to the calculation by PHOJET

(2) Percolation of hadronic strings, DPMJET–III

Using the original DPMJET–III with enhanced baryon stopping and a centrality of 0 to 5 % we compare to some multiplicities measured in Au–Au collisions at RHIC.

At $\sqrt{(s)} = 130$ GeV DPMJET–III gives $N_{ch} = 6031$, BRAHMS finds $N_{ch} = 3860 \pm 300$.

Again at $\sqrt{(s)} = 130$ GeV DPMJET–III gives a plateau $dN_{ch}/d\eta|_{\eta=0} = 968$, BRAHMS finds $dN_{ch}/d\eta|_{\eta=0} = 553 \pm 36$, PHOBOS finds $dN_{ch}/d\eta|_{\eta=0} = 613 \pm 24$ and PHENIX finds $dN_{ch}/d\eta|_{\eta=0} = 622 \pm 41$.

Percolation of hadronic strings in Dpmjet–III

More details on percolation and chain fusion, see Pajares et al.

We consider only the percolation and fusion of soft chains (transverse momenta of both chain ends below a cut-off $p_{\perp}^{fusion} = 2$ GeV/c

The condition of percolation is, that the chains overlap in transverse space.

We calculate the transverse distance of the chains L and K R_{L-K} and allow fusion of the chains for $R_{L-K} \leq R^{fusion} = 0.75$ fm.

The chains in DPMJET are fragmented using the Lund code

Only the fragmentation of color triplet–antitriplet chains is available in Jetset, however fusing two arbitrary chains could result in chains with other colors.

Therefore, we select only chains for fusion, which again result in triplet–antitriplet chains.

- (i) A $q_1 - \bar{q}_2$ plus a $q_3 - \bar{q}_4$ chain become a $q_1 q_3 - \bar{q}_2 \bar{q}_4$ chain.
- (ii) A $q_1 - q_2 q_3$ plus a $q_4 - \bar{q}_2$ chain become a $q_1 q_4 - q_3$ chain.
- (iii) A $q_3 - q_1 q_2$ plus a $q_4 - \bar{q}_1$ plus a $\bar{q}_3 - q_5$ chain become a $q_4 - q_2 q_5$ chain.
- (iv) A $q_4 - \bar{q}_1$ plus a $q_5 - \bar{q}_3$ plus a $\bar{q}_5 - q_1$ chain become a $q_4 - \bar{q}_3$ chain.

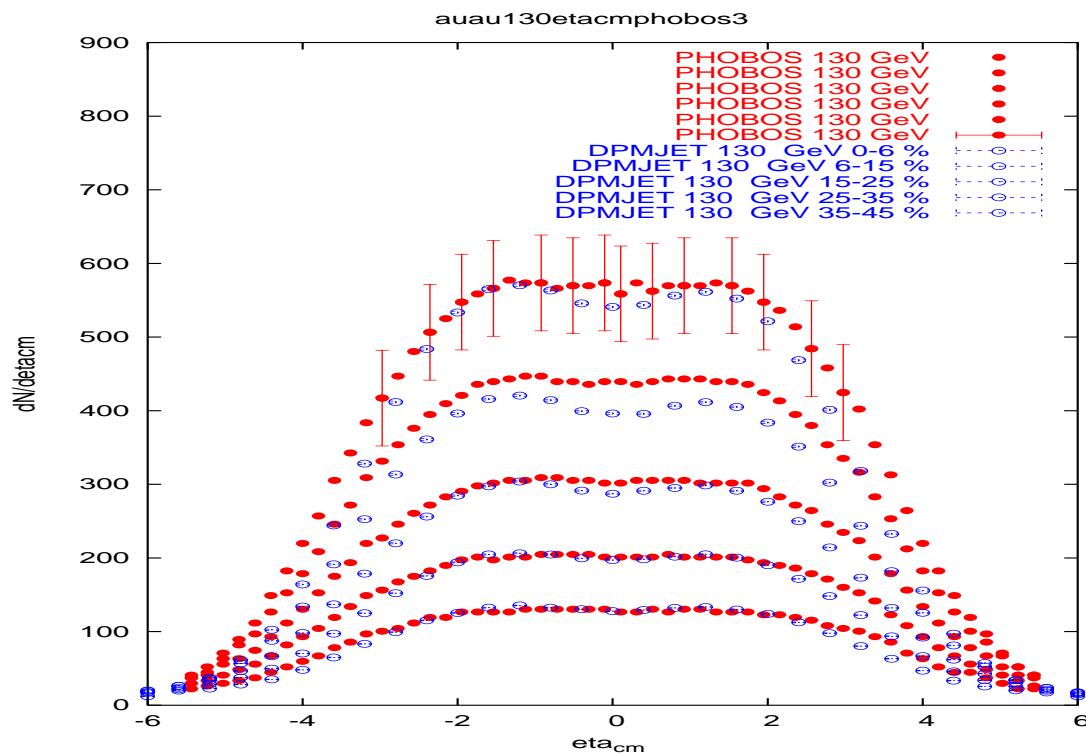
The expected results of these transformations are a decrease of the number of chains.

Even when the fused chains have a higher energy than the original chains, the result will be a [decrease of the hadron multiplicity](#) $N_{hadrons}$.

In reaction (i) we observe [new diquark and anti-diquark chain ends](#). In the fragmentation of these chains we expect baryon–antibaryon production [anywhere in the rapidity region of the collision](#).

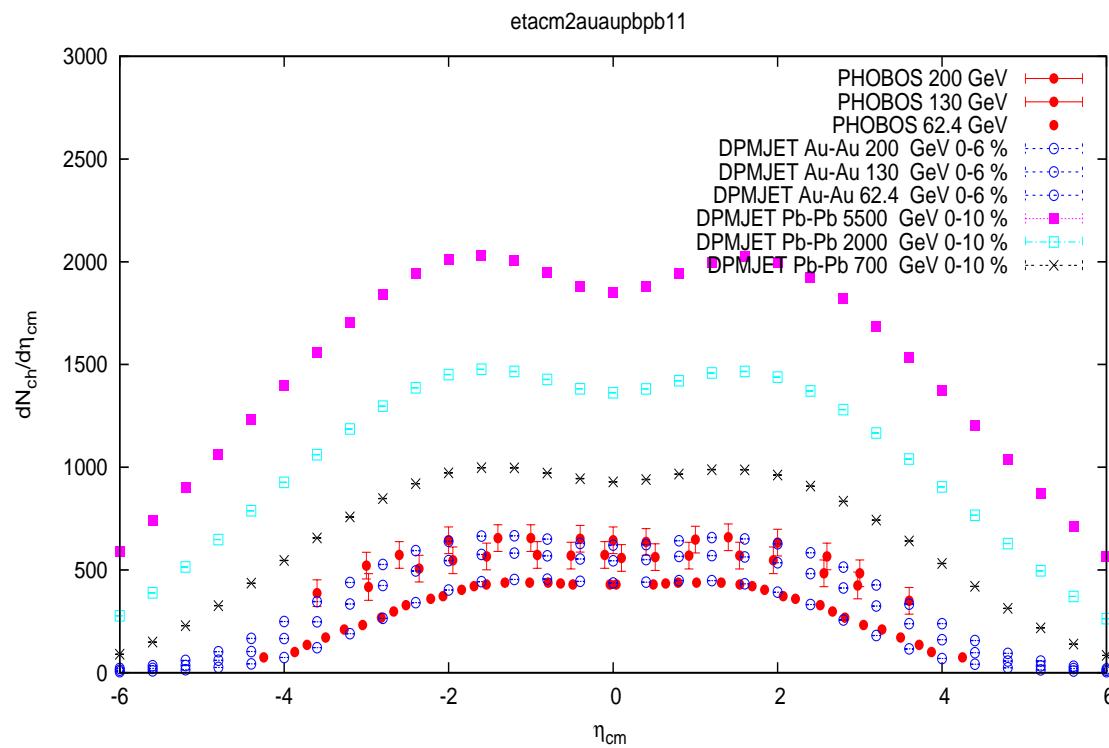
Therefore, (i) helps to shift the antibaryon to baryon ratio of the model into the direction as observed in the RHIC experiments.

(3) $dN/d\eta_{cm}$ distributions

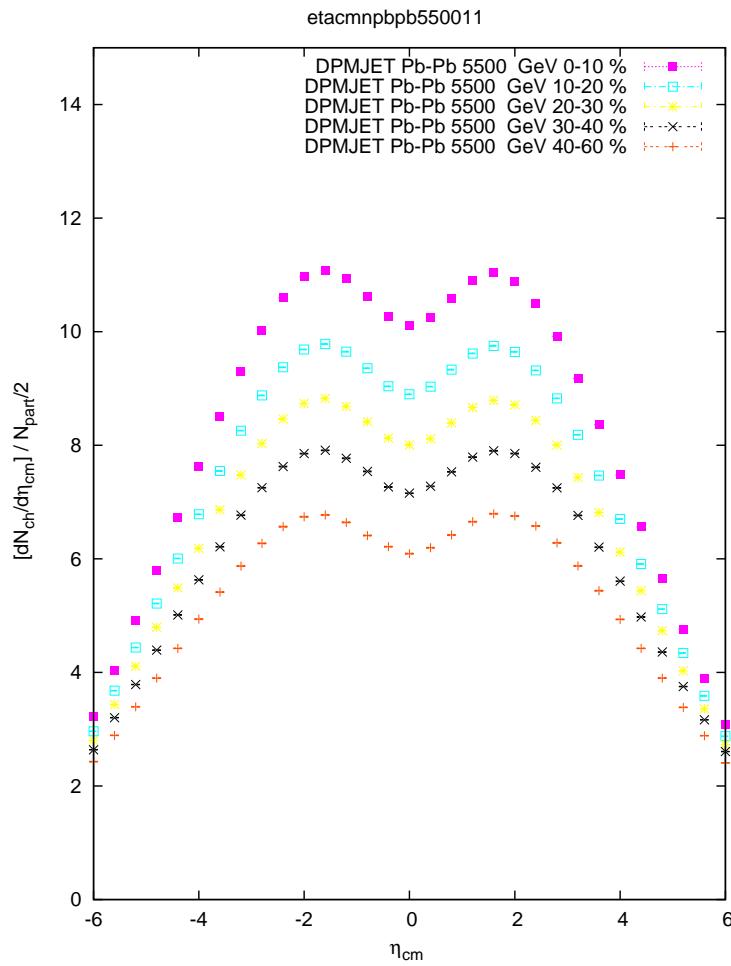
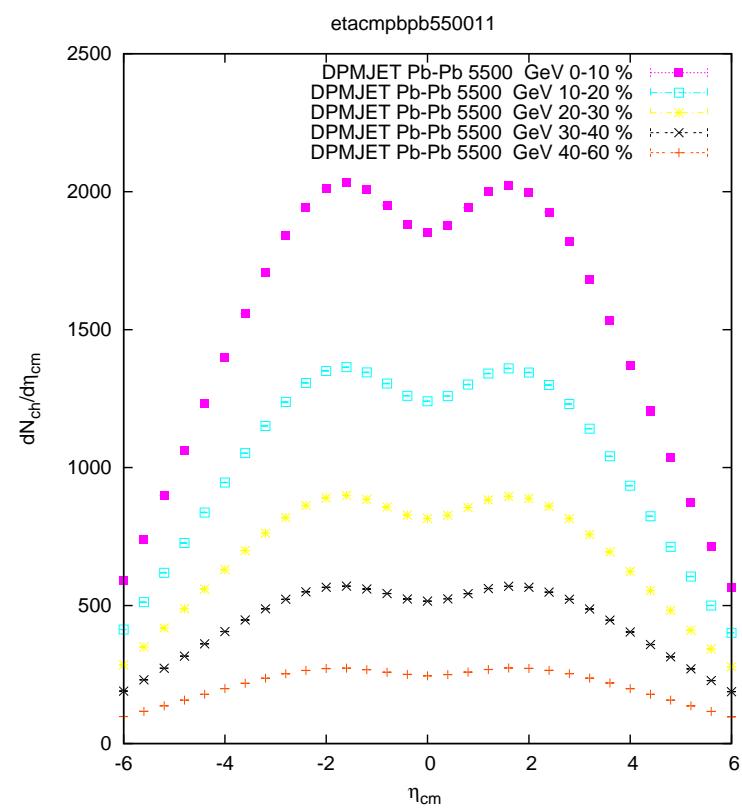


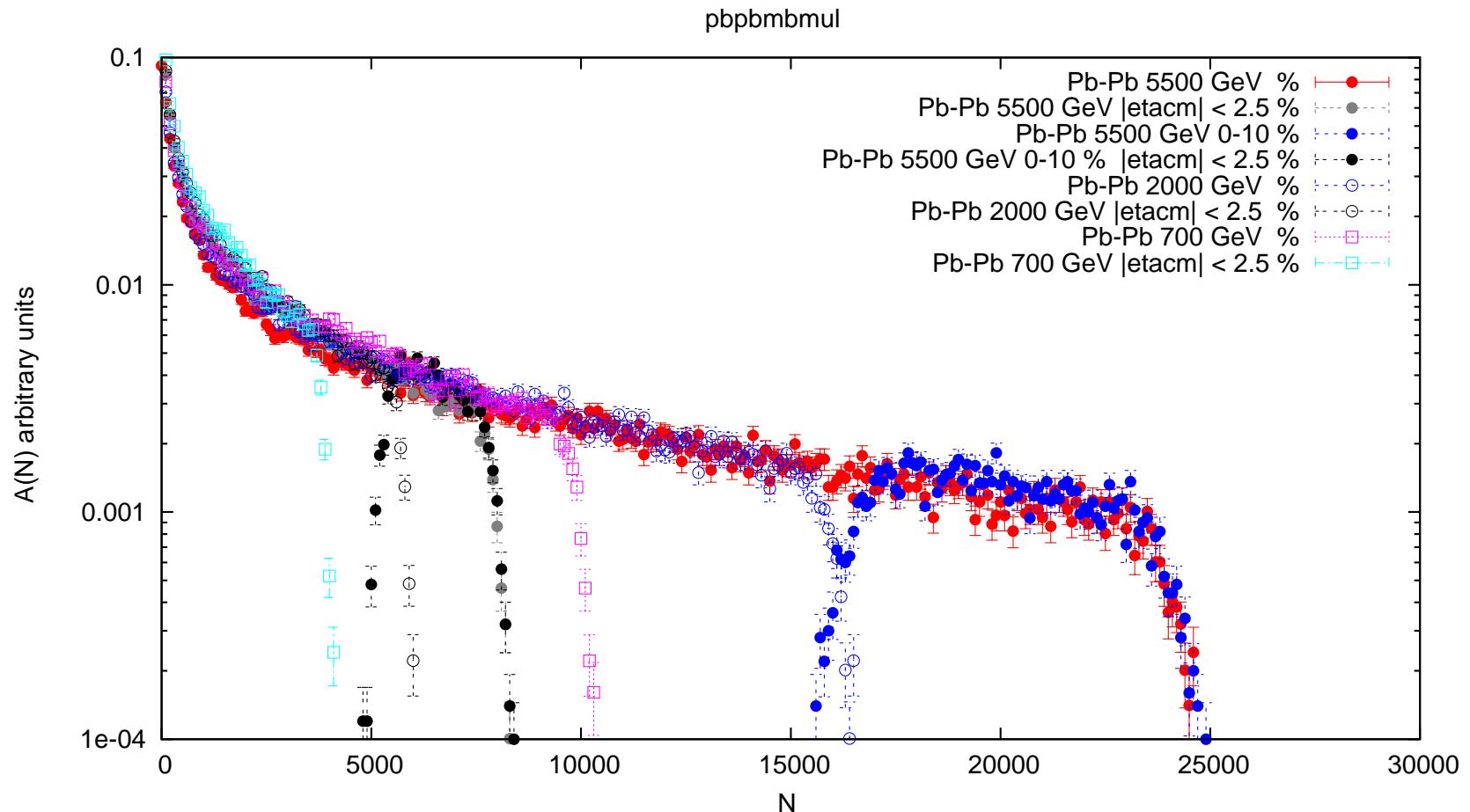
Pseudorapidity distributions of charged hadrons in Au–Au collisions at $\sqrt{(s)}= 130$ GeV for centralities 0–5 % up to 40–50 %. The data points are from the PHOBOS Collaboration

We apply DPMJET–III with chain fusion to central Pb–Pb collisions



Pseudorapidity distributions of charged hadrons in Au–Au collisions at $\sqrt{(s)}= 200, 130$ and 62.4 GeV for centralities $0\text{--}6\%$ and for Pb–Pb collisions at $5500, 2000$ and 700 GeV for centralities $0\text{--}10\%$. The data points are from the PHOBOS Collaboration





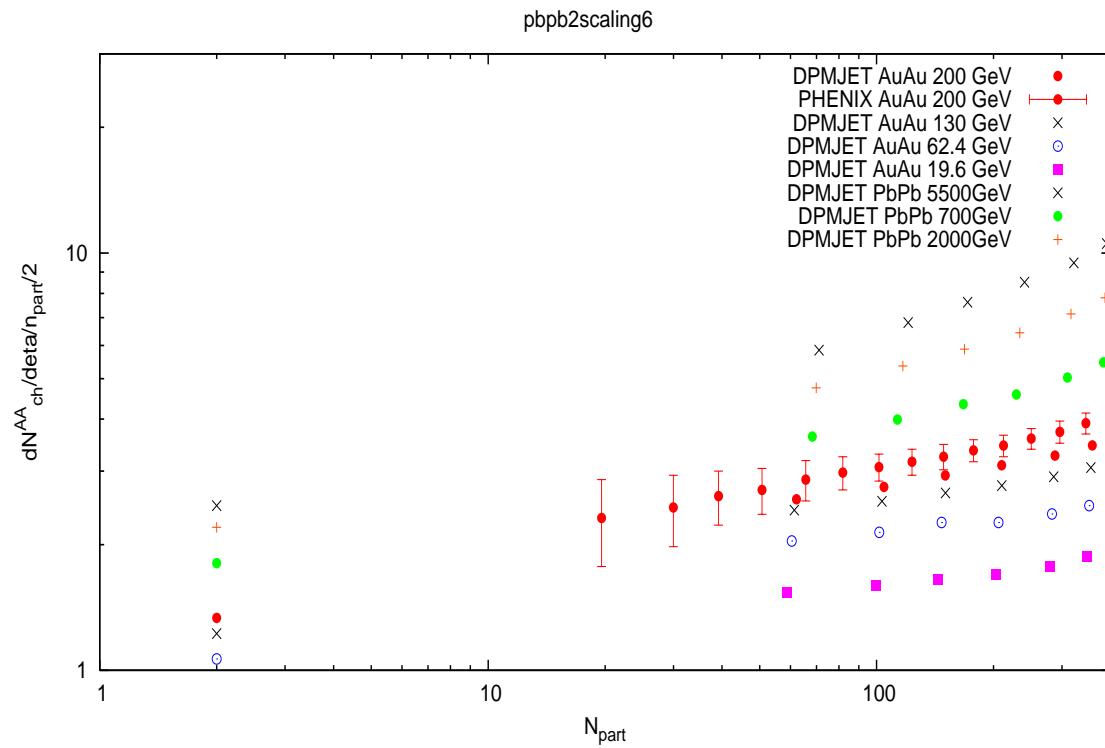
Multiplicity distributions in minimum bias and 0–10 % central collisions in Pb–Pb collisions in the full η_{cm} range and for $|\eta_{cm}| \leq 2.5$ (from DPMJET-III).

(4) N_{part} dependence

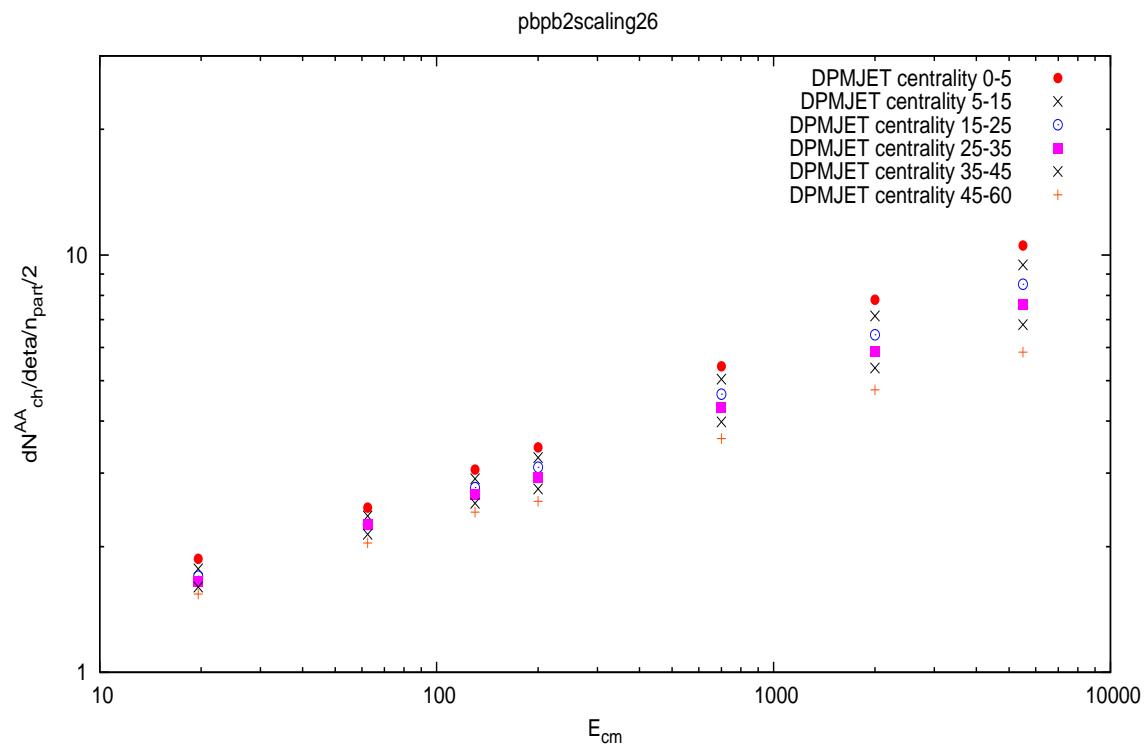
$dN^{AA}/d\eta_{cm}$ (we consider only the behaviour at $\eta_{cm} = 0$) shows a simple scaling behaviour in terms of the number of participants N_{part} .

In the DPMJET-III Monte Carlo we know the number of participants in each collision event.

We plot $\frac{dN^{AA}}{d\eta_{cm}}/\frac{N_{part}}{2}$ as function of N_{part} or as function of E_{CM} .



$\frac{dN_{\text{AA}}}{d\eta_{\text{cm}}} / \frac{N_{\text{part}}}{2}$ as function of N_{part} . The DPMJET-III calculations are for Au–Au at RHIC energies and for Pb–Pb at LHC energies.



$\frac{dN_{AA}}{d\eta_{cm}} / \frac{N_{part}}{2}$ as function of E_{CM} . The DPMJET-III calculations are for Au–Au at RHIC energies and for Pb–Pb at LHC energies.

Scaling behaviour

Limiting fragmentation hypothesis in hadron–hadron collisions

Beneke, Chou, Yang, Yen, Phys.Rev. 188,2159 (1969)

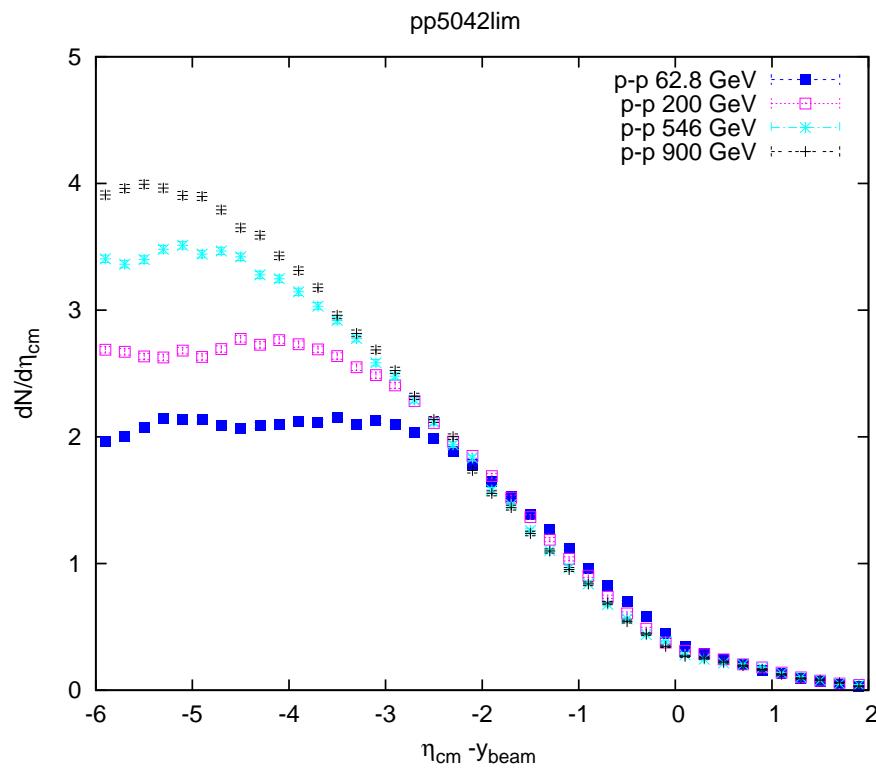
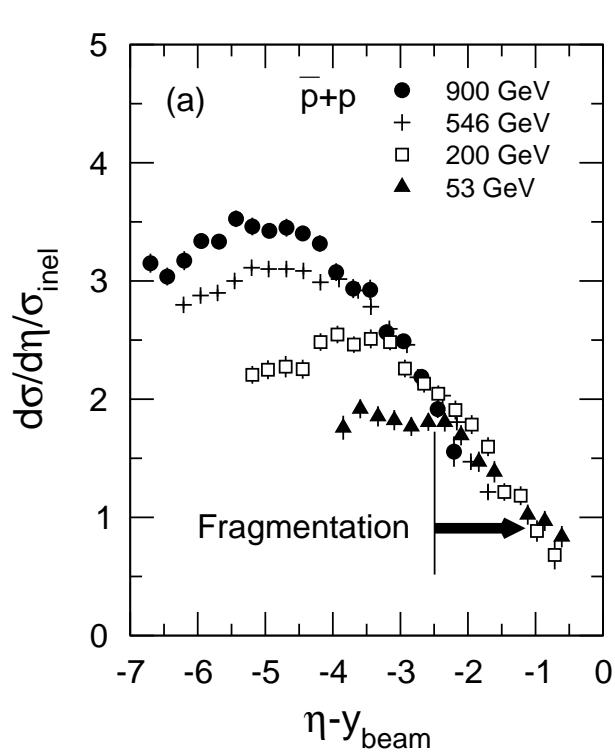
$$E \frac{d^3\sigma}{d^3p} = \frac{d^3\sigma}{dy d^2p_\perp} = G(y, p_\perp, s)$$

$$G(y, p_\perp, s) \xrightarrow{s \rightarrow \infty} \begin{cases} G(y, p_\perp) & \text{for } y < L \\ G(p_\perp) & \text{for } L < y < Y - L \\ G(Y - y, p_\perp) & \text{for } Y - L < y \end{cases}$$

$G(y, p_\perp)$ universal function in both fragmentation regions

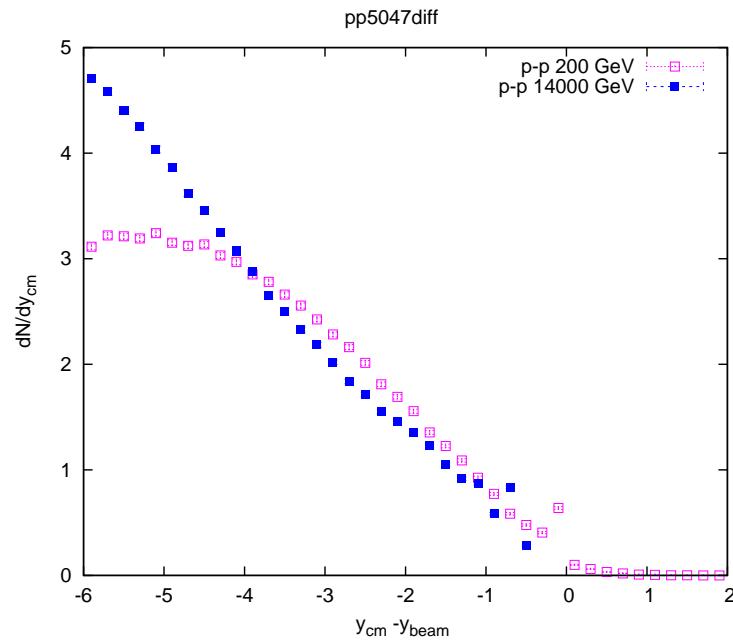
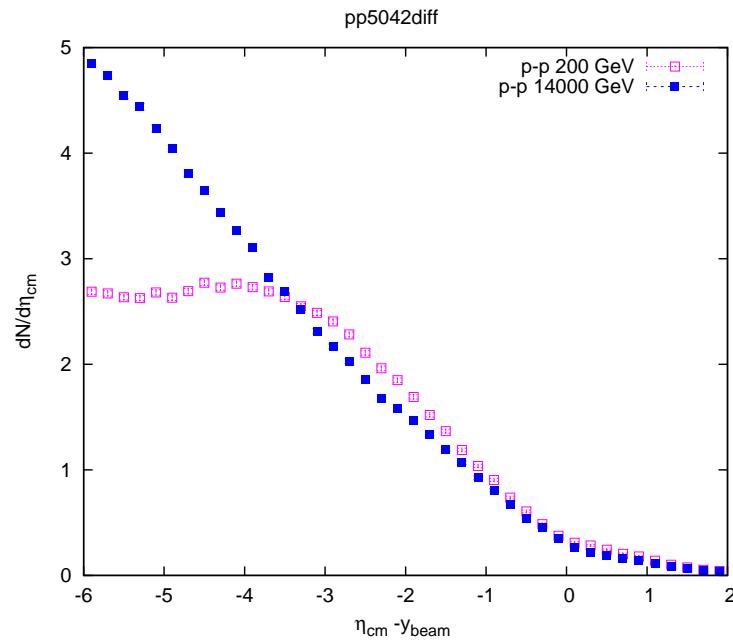
Today: $G(p_\perp)$ for $L < y < Y - L$ contradicted by rise of rapidity plateau

Proton–Proton collisions



(left) data from ISR and SPS show limiting fragmentation

(right) DPMJET-III in this energy range has also limiting fragmentation



DPMJET lim. frag. in limited energy range, LHC curves different

but notice the differences are outside the fragmentation region

(left) Pseudorapidity distribution (right) Rapidity distribution

Nucleus–Nucleus collisions

Number of participants: $N_{part} = N_A + N_B$

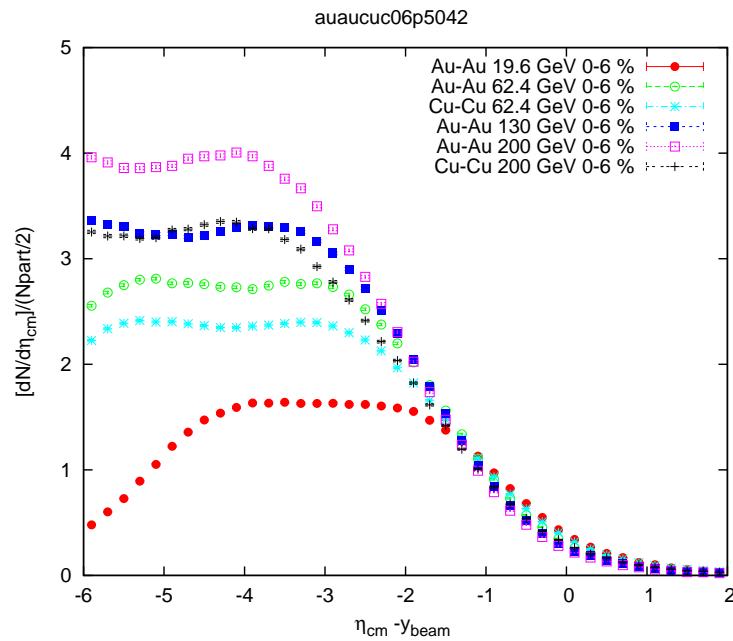
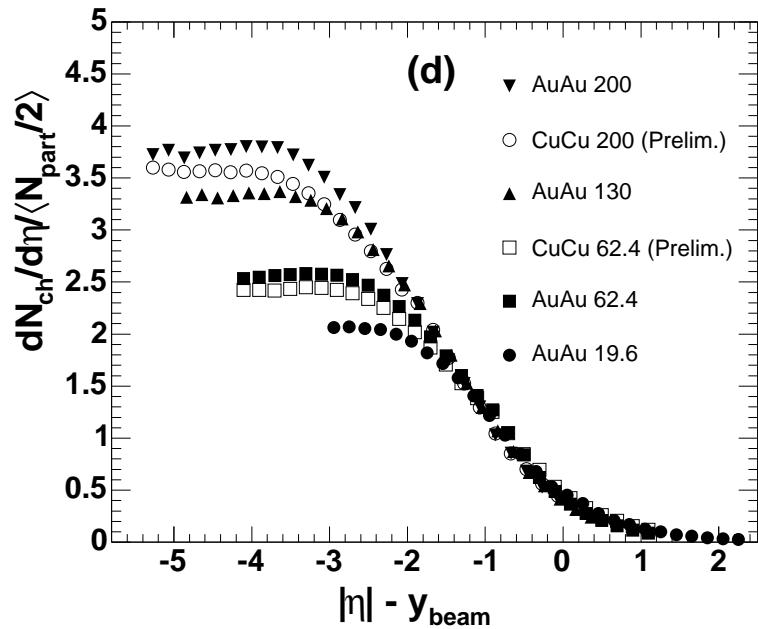
Number of collisions: $N_{coll} = N$ (needed for collision scaling)

Limiting fragmentation in nuclear collisions $A + A \rightarrow X$

$$R(y, p_\perp, s) = \frac{d^3 N}{(N_{part}/2) dy d^2 p_\perp}$$

$$R(y, p_\perp, s) \xrightarrow{s \rightarrow \infty} \begin{cases} R(y, p_\perp) & \text{for } y < L \\ R(Y - y, p_\perp) & \text{for } Y - L < y \end{cases}$$

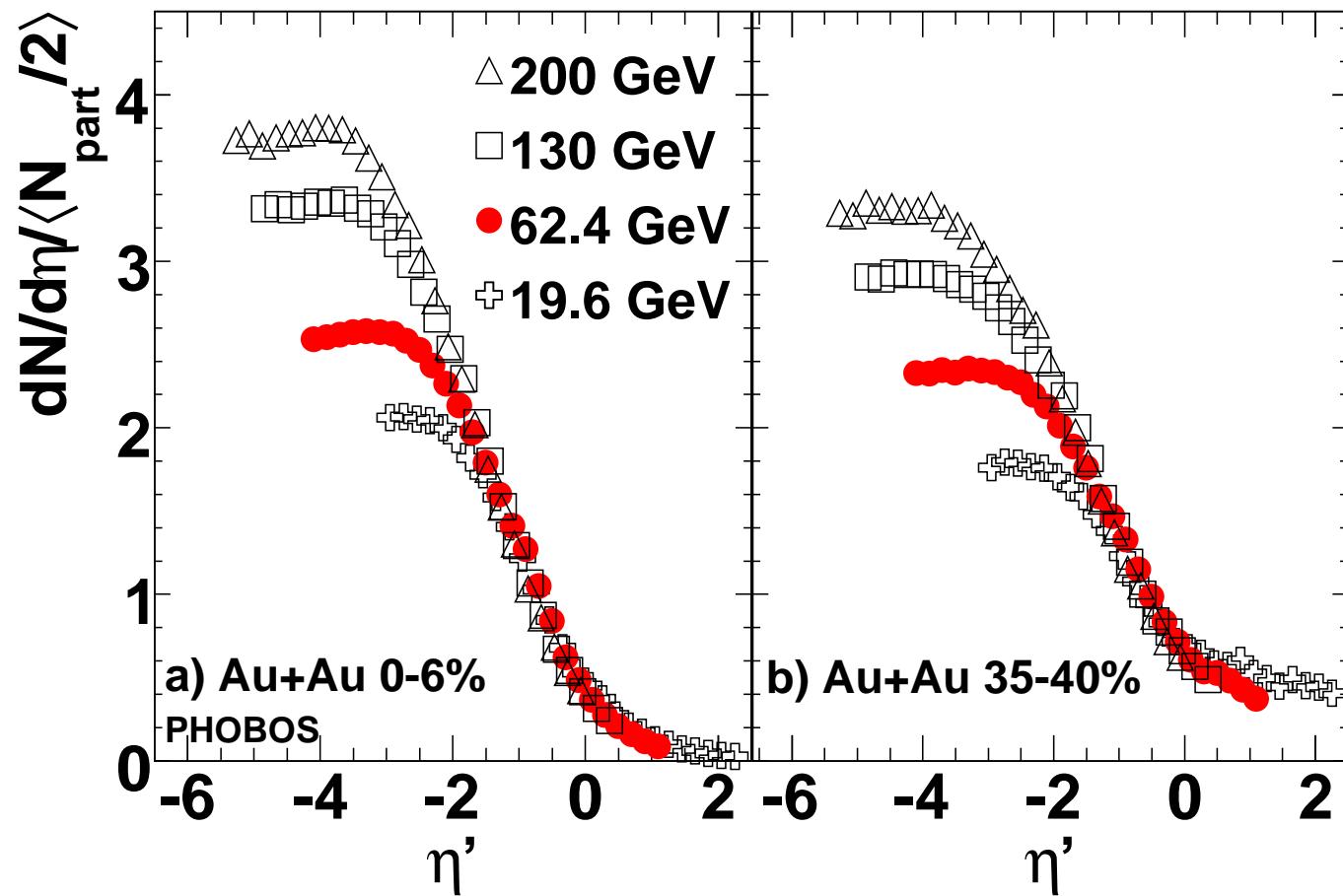
$R(y, p_\perp)$ universal function in both fragmentation regions



(left) Data for limiting fragmentation in Au–Au and Cu–Cu collisions of different energies

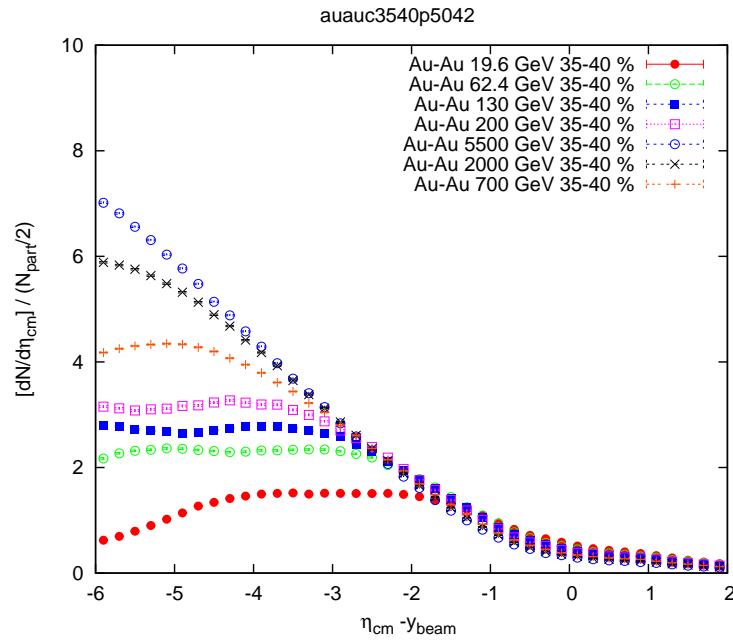
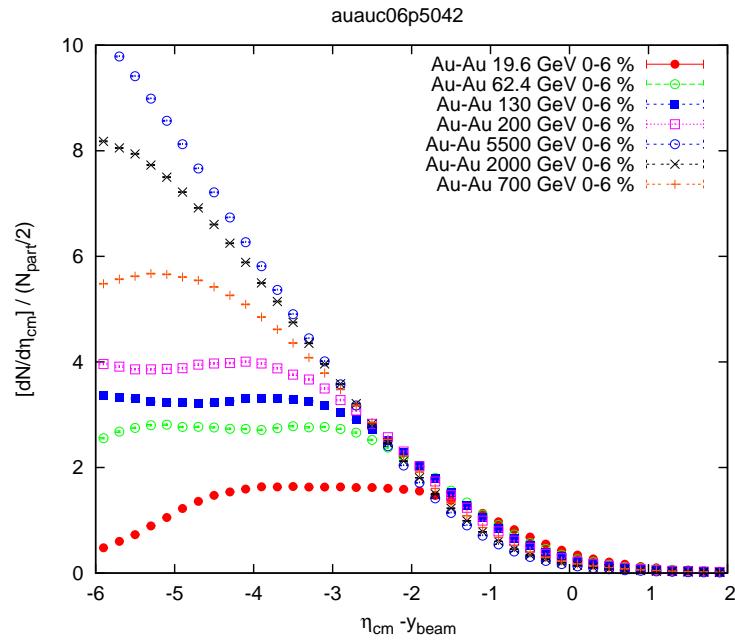
(0-6 % central)

(right) DPMJET–III results for the same collisions



Data for limiting fragmentation in Au–Au collisions

(left) (0–6 %) centrality (right) (35–40 %) centrality



DPMJET–III results for limiting fragmentation in Au–Au collisions at two different centralities
 (left) (0–6 %) centrality (right) (35–40 %) centrality

(6) Chain-chain interactions in DPMJET-III

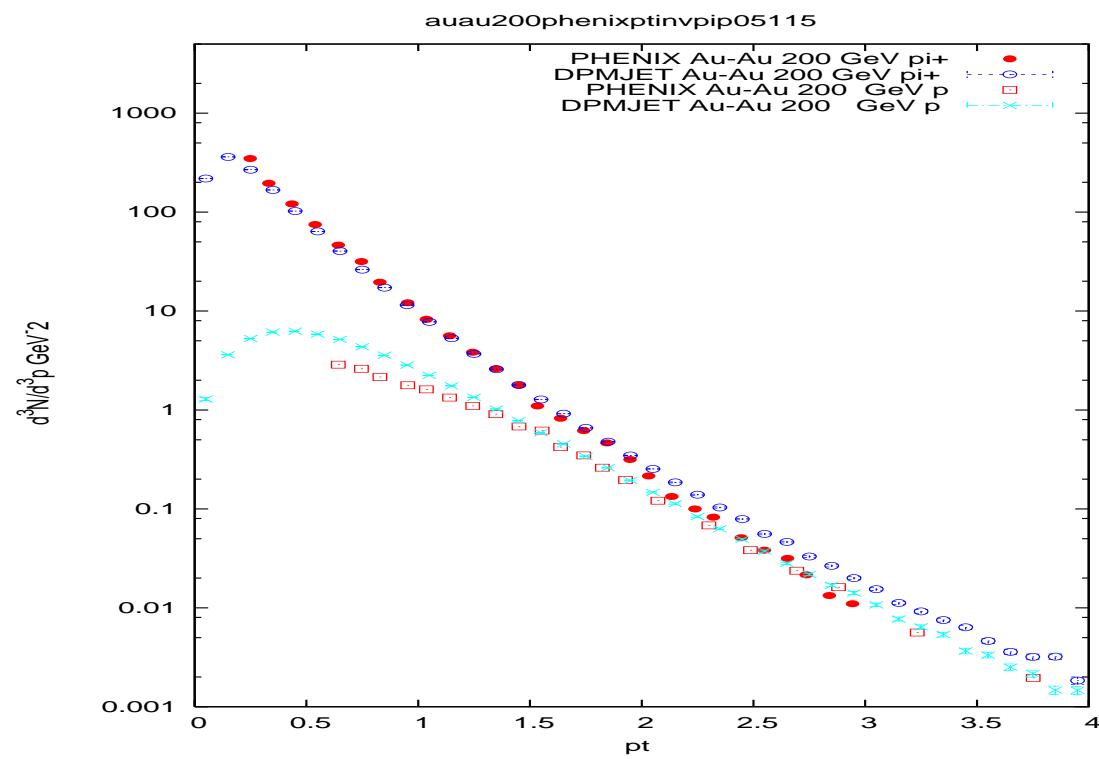
Density of chains in transverse x - y space, one central Au-Au event

```
*****  
*****  
*****6**7*12*14**1**1*****  
*****3*20*61*52*50*30*11*****  
*****9*36*75*81*77*42*17**5*****  
*****3*13*79125119*91*50*49**8*****  
*****4*24*79100138107101*32**4**2*****  
*****1*26*82*72*86*85*55*12**7*****  
*****9*23*64*50*30*27**6**2*****  
*****4*14*29*25*13**3*****  
*****6**2*****  
*****  
*****
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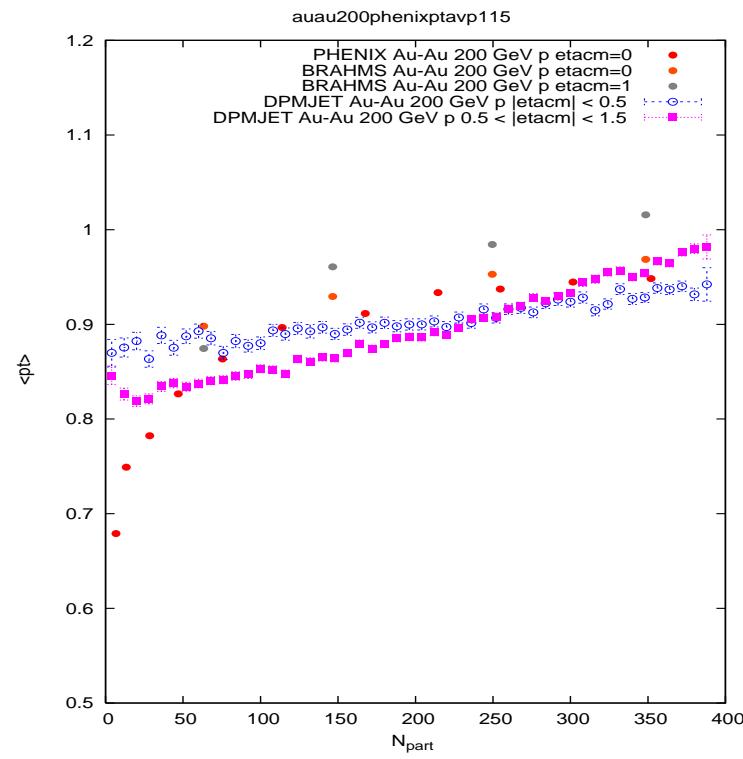
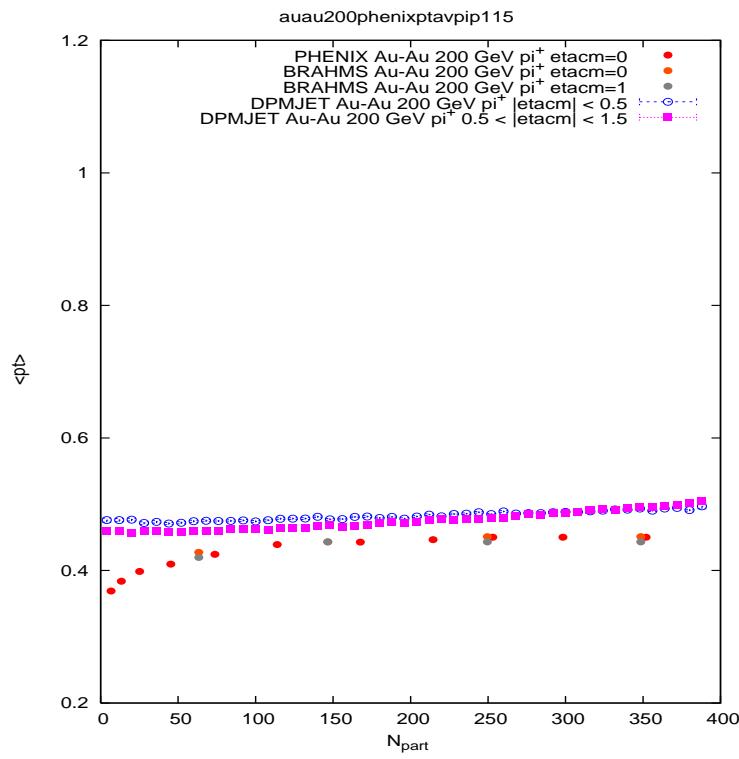
The transverse force on chain is proportional to density gradient of chains

The chain gets an additional transverse velocity proportionat to this force

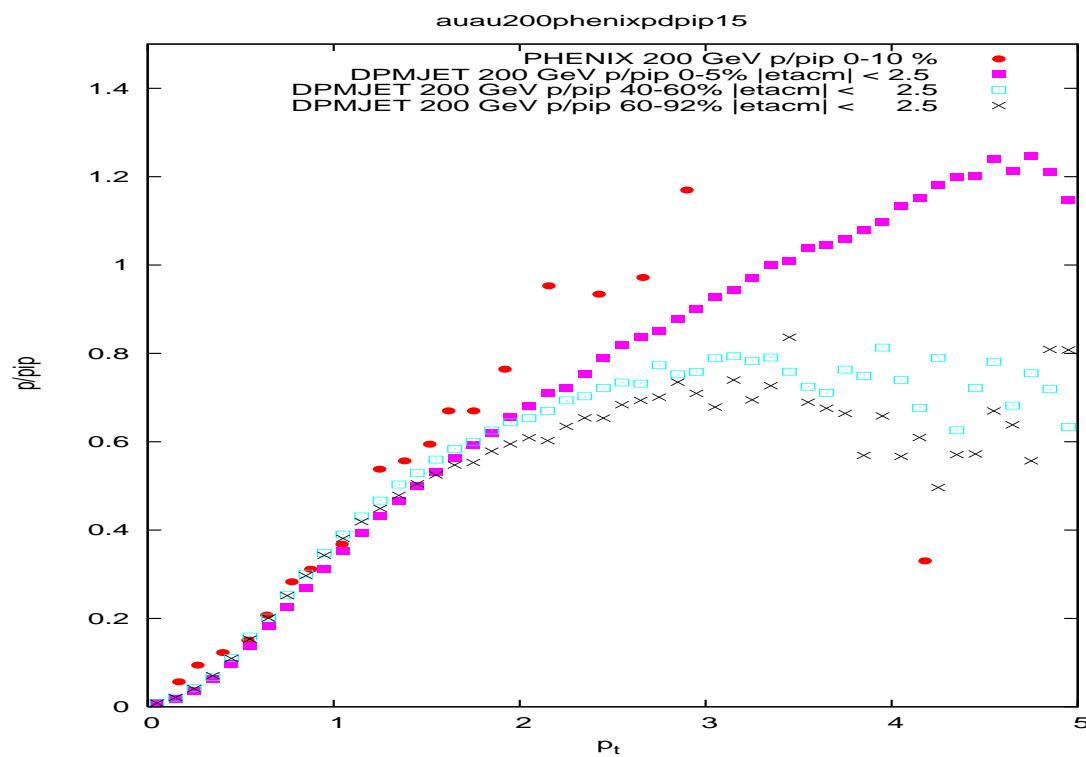
(6.1) Transverse momentum distributions according to DPMJET-III, Protons and π^+



(6.2) Average transverse momenta as function of N_{part} , π^+ and protons



(6.3) Proton to pion ratios as function of p_{\perp}



Conclusions

DPMJET–III works stable and fast for any nuclear collisions

Simple N_{part} dependence

Excellent limiting fragmentation in fragmentation region

Main application of model: h–h collisions, h–A collisions and nuclear collisions of light nuclei

Not implemented: jet quenching

No good implementation: Elliptic flow