Recent Results from BRAHMS

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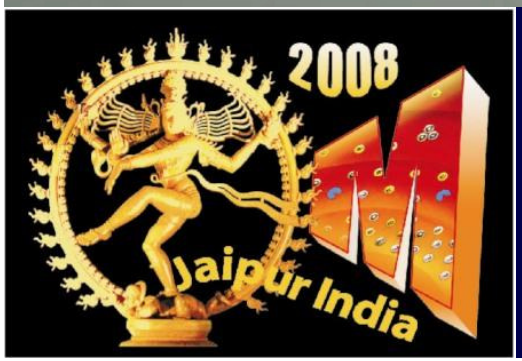


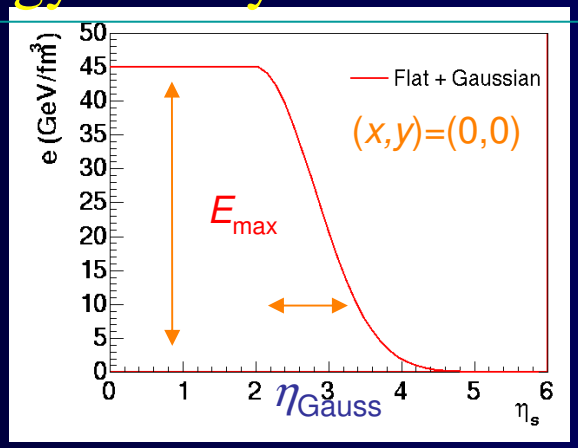
BNL Symposium, Feb 28 2008

Outline of presentation

- Extent of sQGP in rapidity space.
- Particle production (in rapidity space) as function of energy and system size.
- Strangeness production in AuAu collisions at 62.4 GeV
- Extracting high-x physics with the p/π^+ ratio and the R_{AuAu} of protons in Au+Au collisions.
- Systematics of baryon transport.

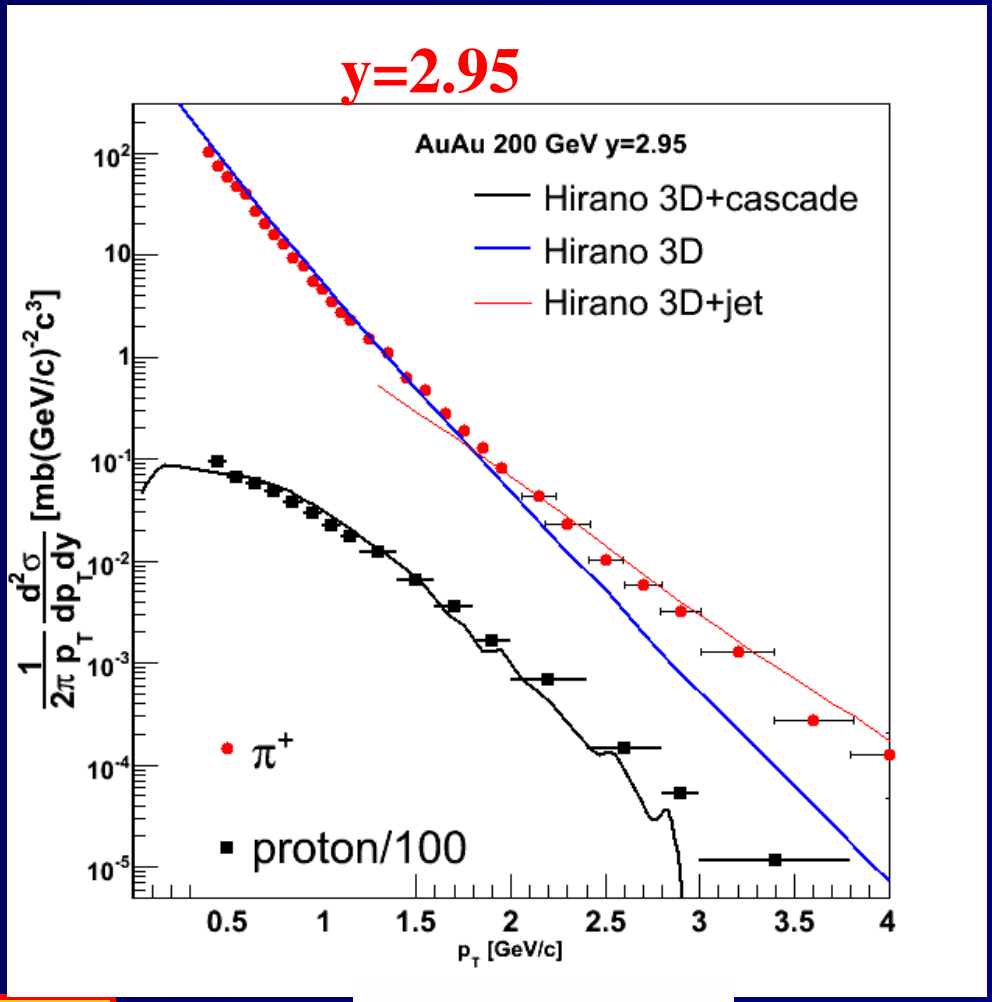
We will make use of a 3D+1 hydrodynamic model provided graciously by T. Hirano to guide the description of our results.

Parameterization of initial energy density



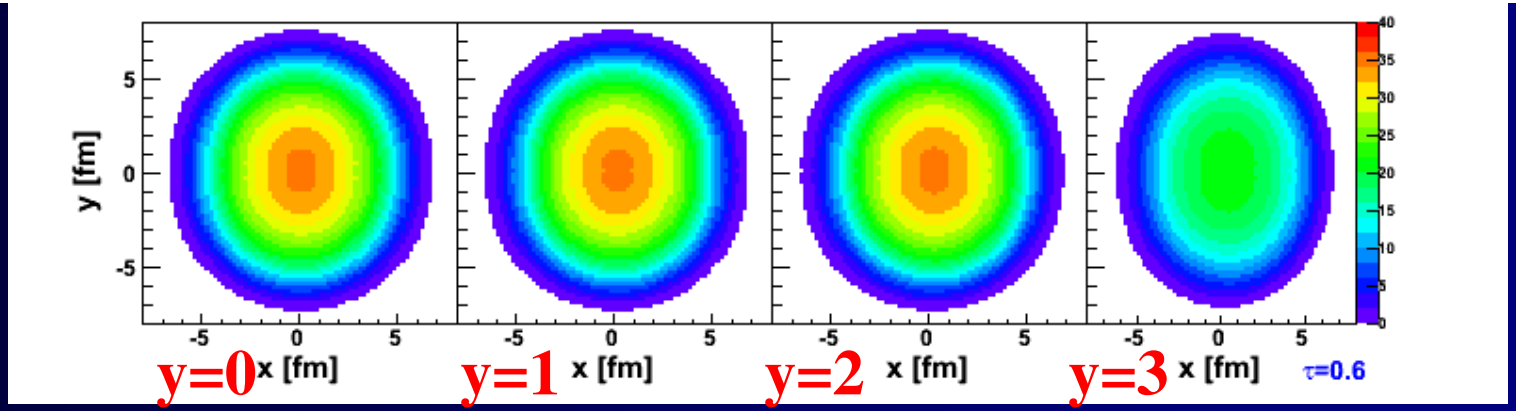
- E_{max}=45 GeV/fm³
- η_{flat} = 2.0
- η_{Gauss} = 0.8

τ_0 = 0.6 fm/c

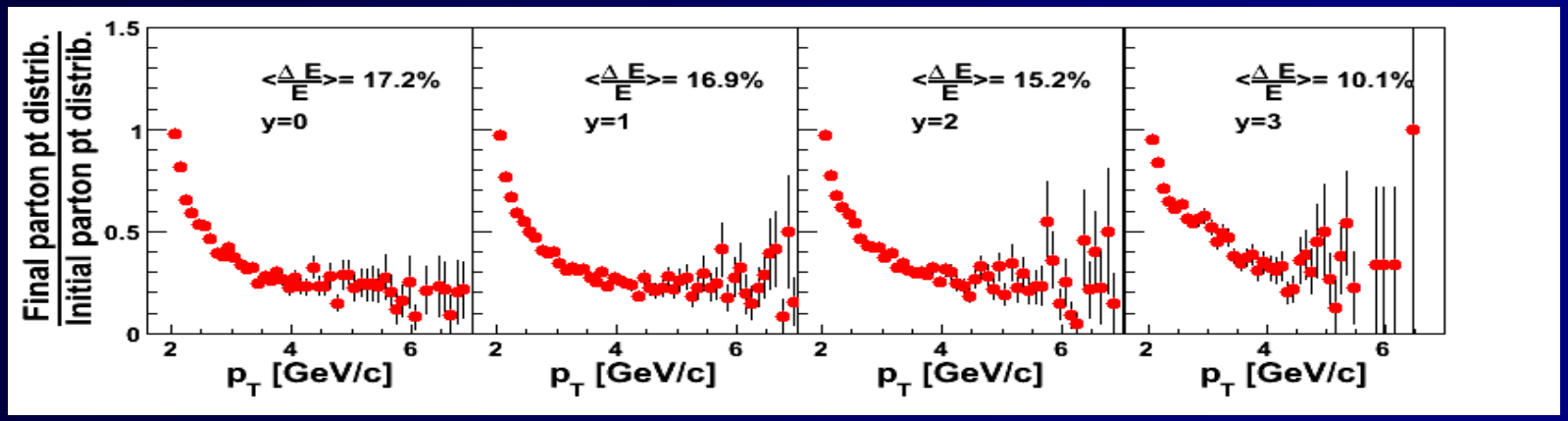


Energy loss: first order GLV

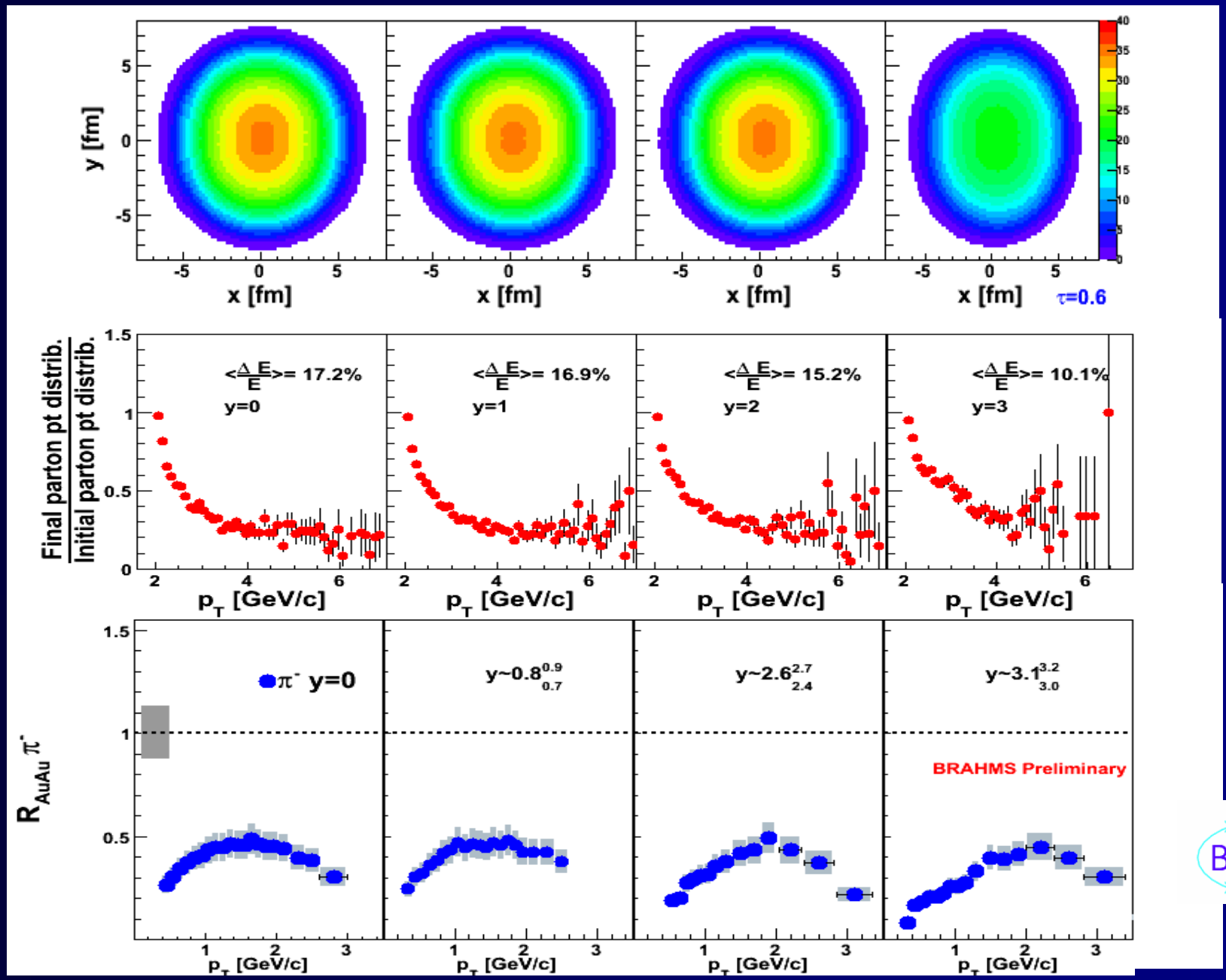
T.Hirano and Y.Nara, Nucl.Phys.A743(2004)305



The animations show equal energy density contours at four rapidity values in proper time steps of 0.2 fm/c

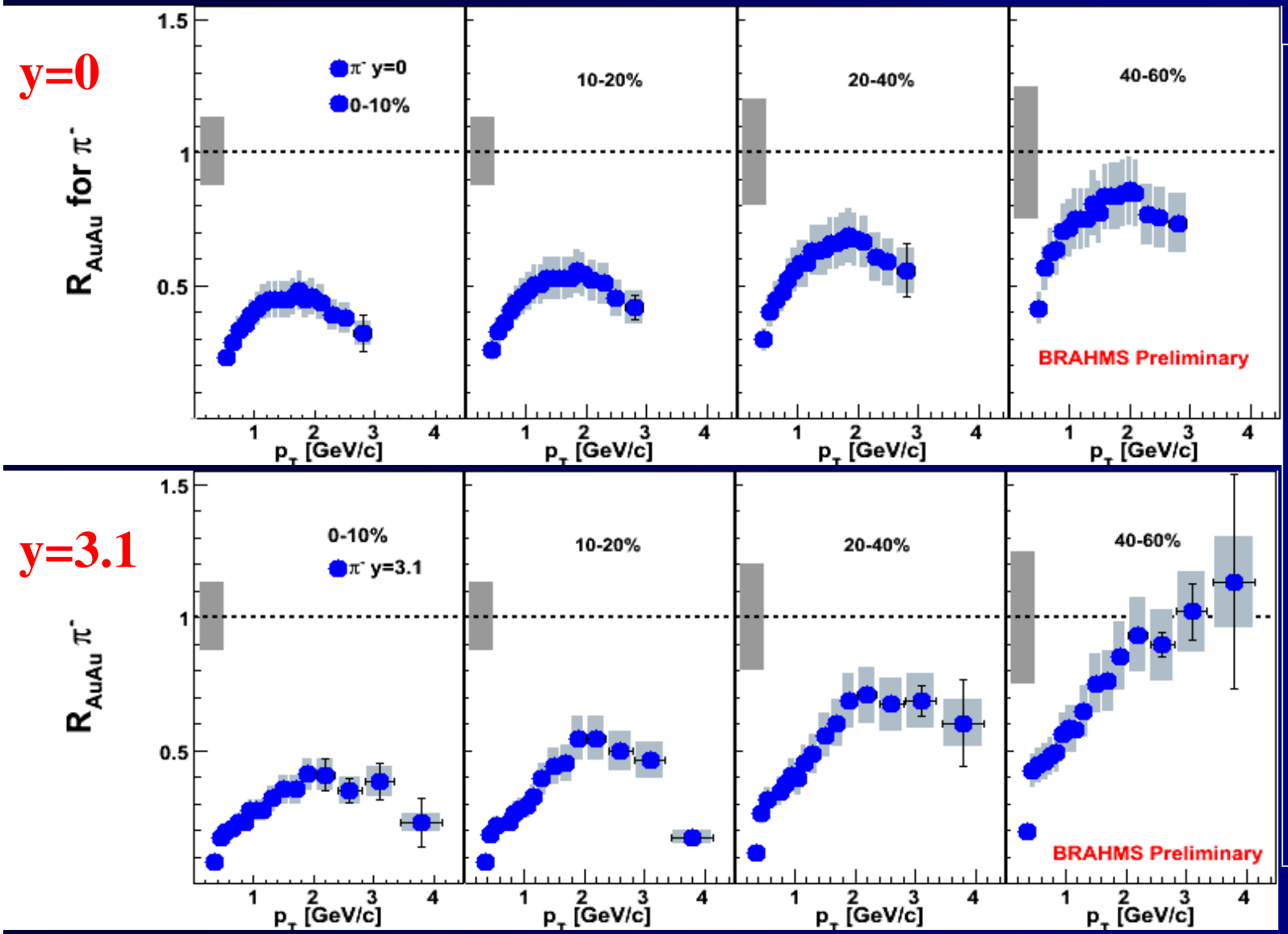


Partons simulated with Pythia are transported through the expanding system, average energy loss changes by ~X2 from y=0 to y=3, but the ratio of p_T distributions of partons is insensitive to that change.

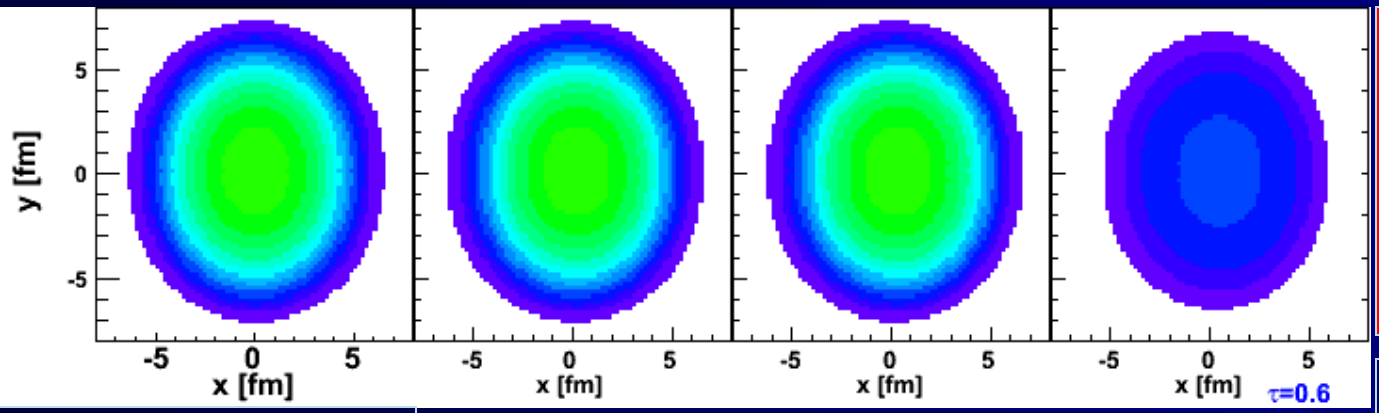


The R_{AuAu} at high y is consistent with reduced energy loss and leaves room for saturation effects

Centrality dependence of R_{AuAu} pi- at 200 GeV



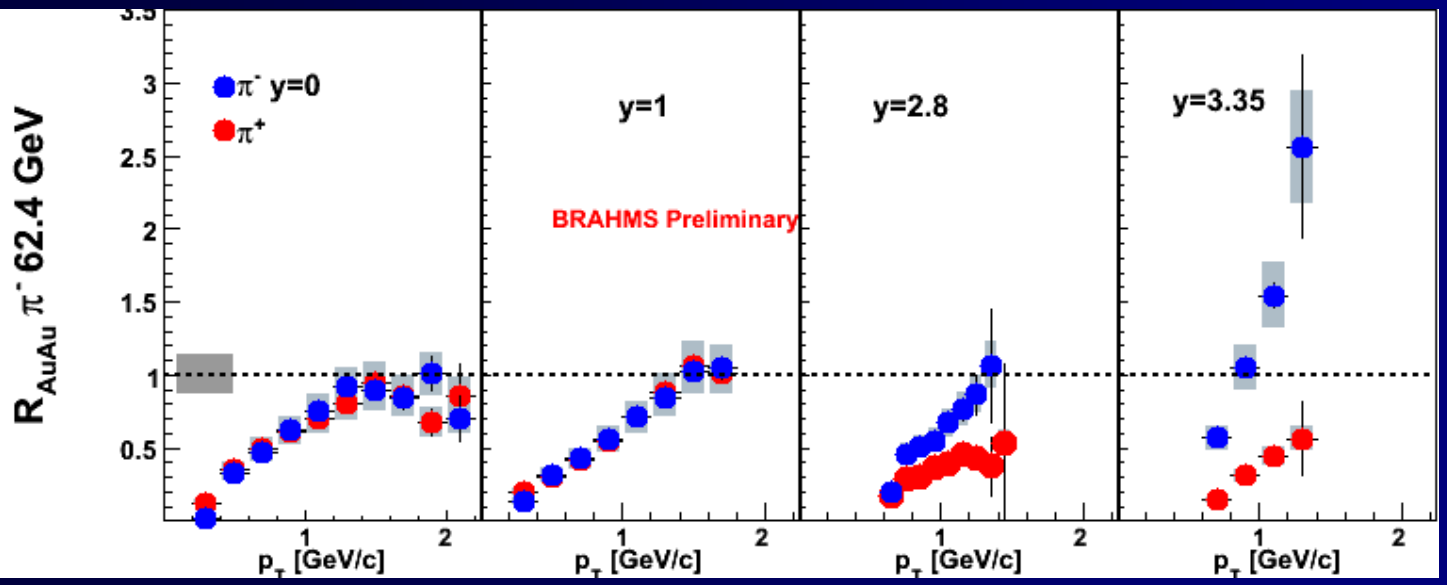
Consistent with dense medium effects not fully extending to high y, with binary coll. scaling restored at mid-central collisions.



At 62.4 GeV, dense system has shorter lifetime

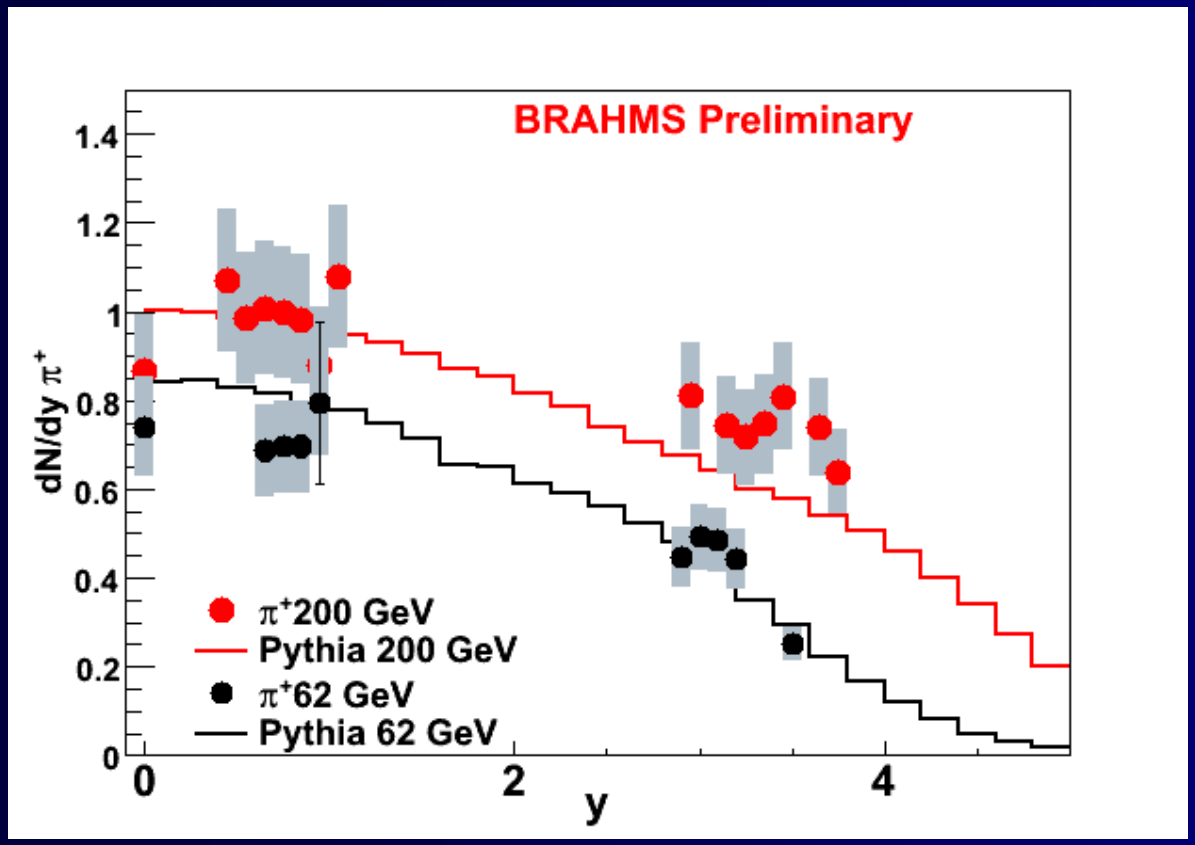
Au+Au 0-10% central

Top energy density ~20 GeV/fm^3



At high y(>2), effects of dense medium start to disappear. Isospin effects grow stronger

Particle production systematics

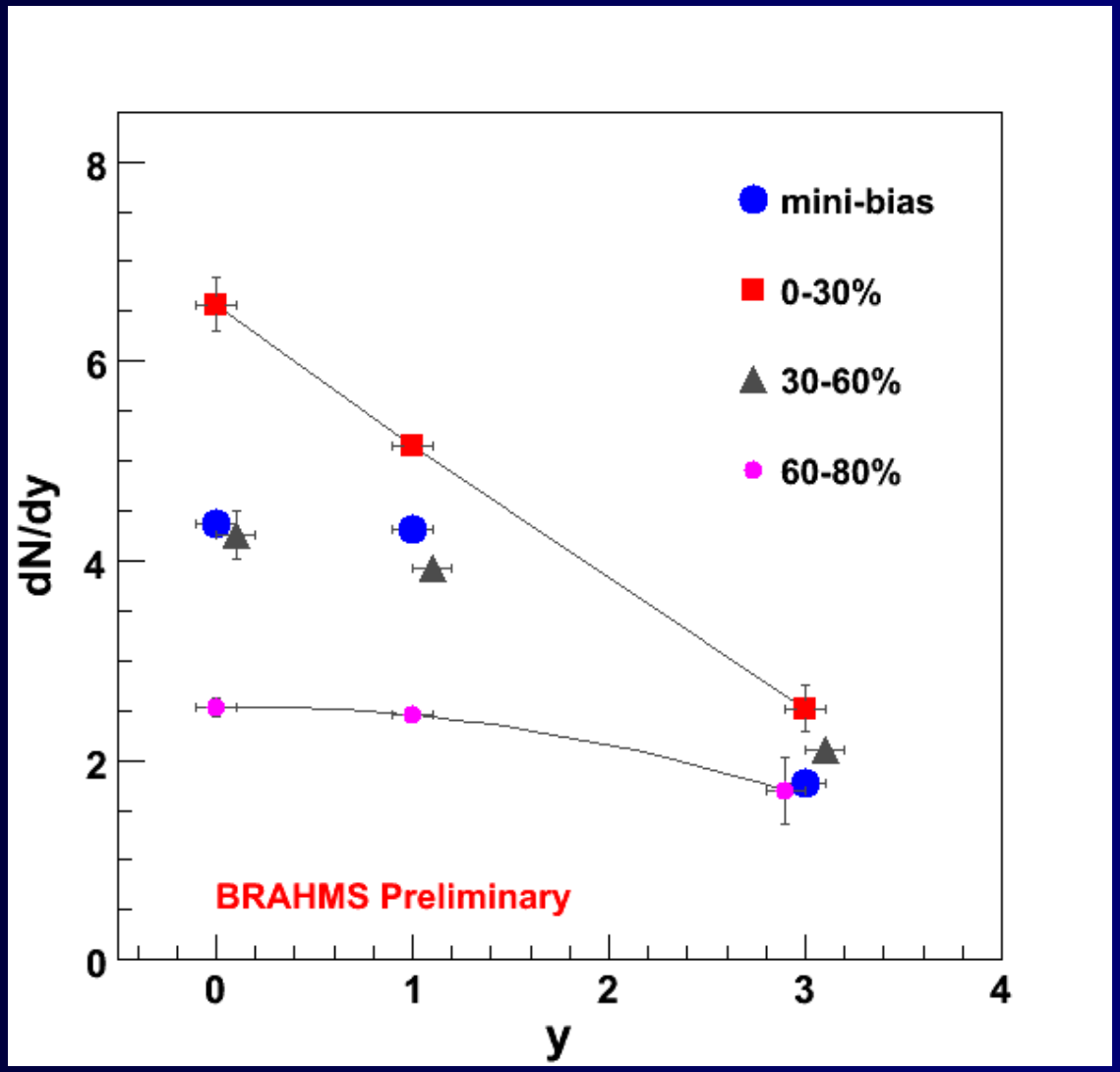


Positive pion production in p+p collisions at $\sqrt{s}$=200 and 62.4 GeV.

Systematic errors shown with gray boxes are mainly driven by extrapolations of p_T distributions.

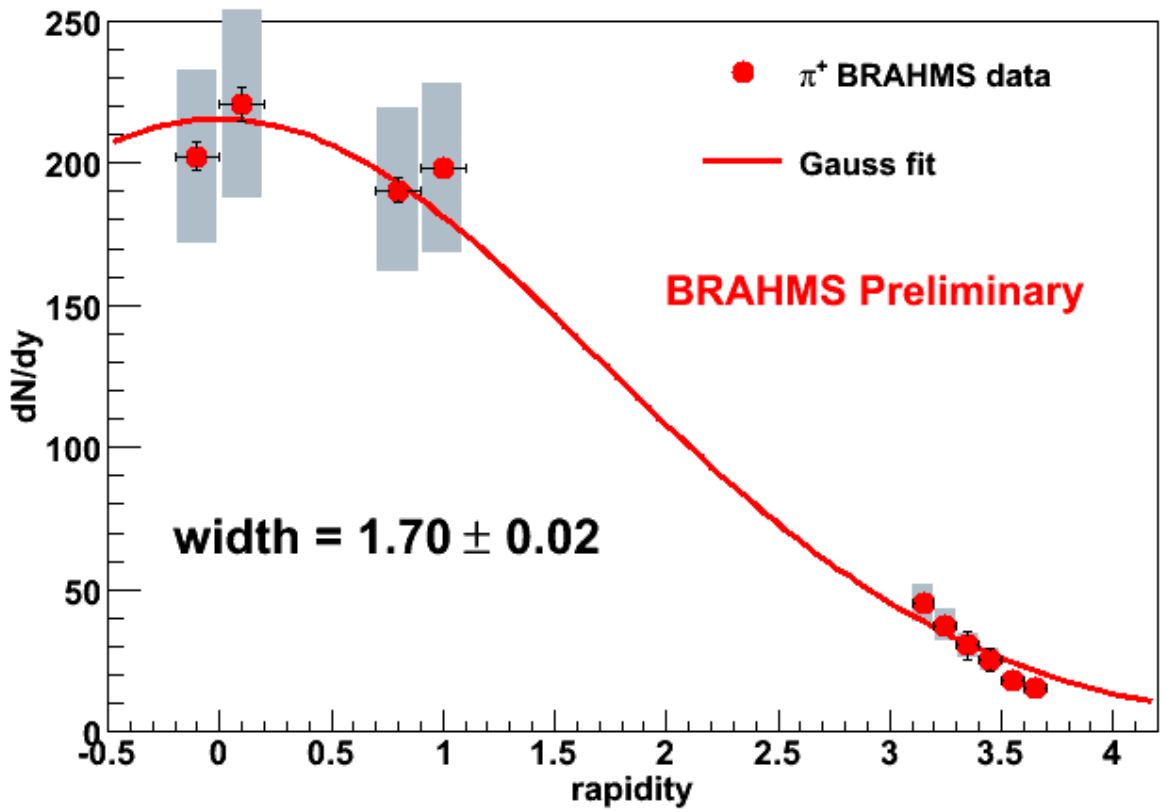
Measurements normalized to total inelastic cross section (41mb 200GeV and 36mb at 62.4 GeV)

Positive pion production in d+Au at 200 GeV



The centrality dependence shows the presence of the Au "target" source at negative rapidity, as well as the projectile d at high rapidity. The distribution becomes similar to p+p in the most peripheral sample.

Positive pion production in Au + Au at $\sqrt{s_{NN}}$ = 62.4 GeV



Positive pion produced in central (0-10%) Au+Au coll. at 62.4 GeV

Fit to single gaussian yields width consistent with Landau's model: $\sigma^2=\ln(\sqrt{s}/2m_p)$

σ_{Landau}= 1.87

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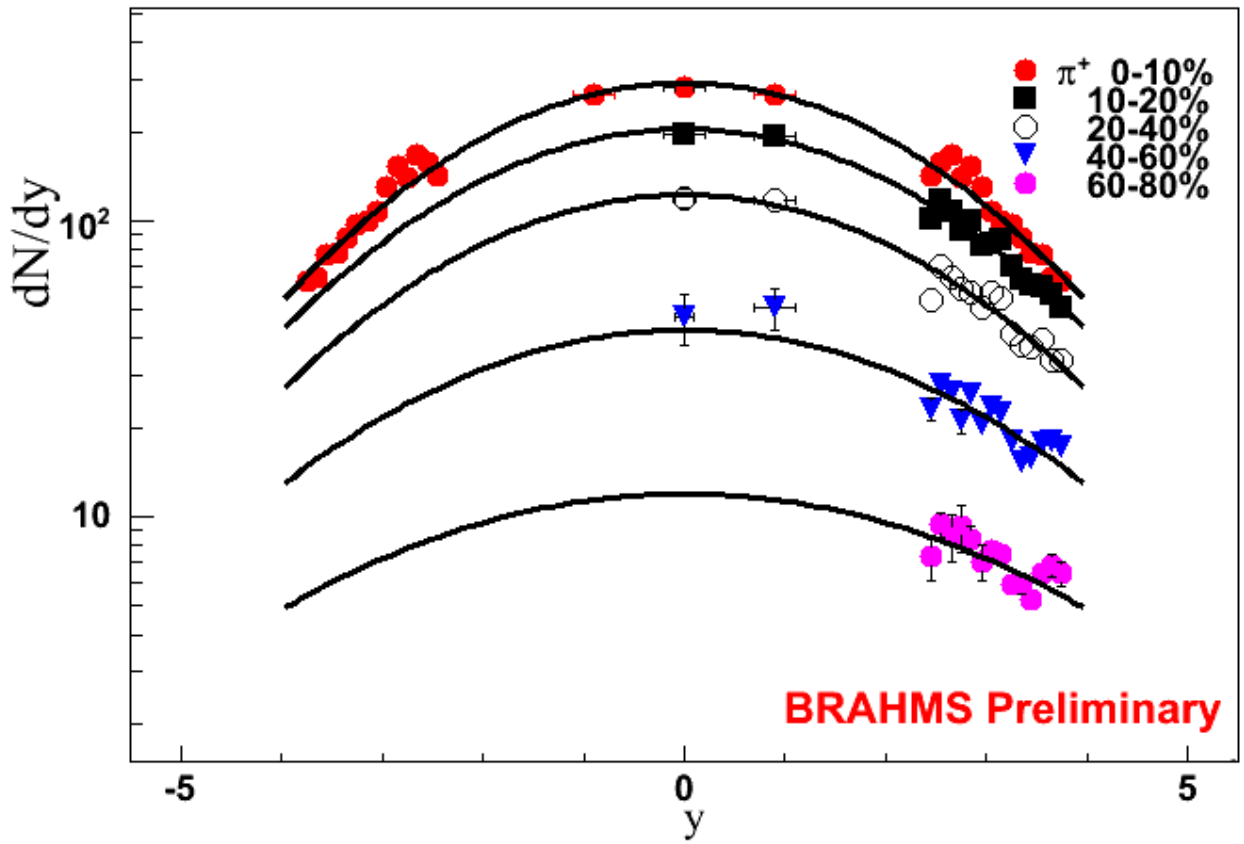
Positive pion production in Au+Au at 200 GeV



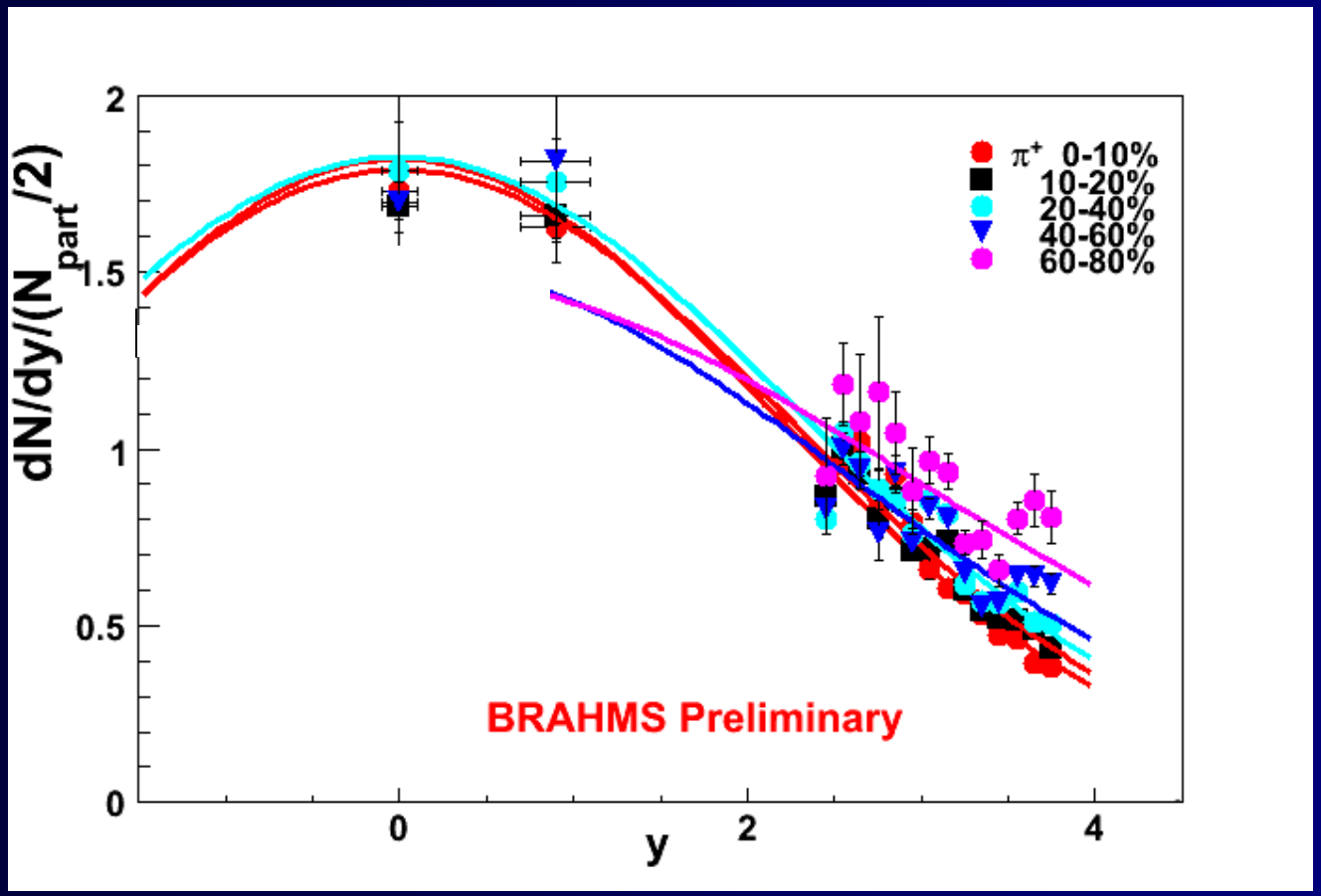
To first order, all distributions are described with a single gaussian. Width of central events consistent with Landau's value:

$\sigma_{Landau} = 2.16$

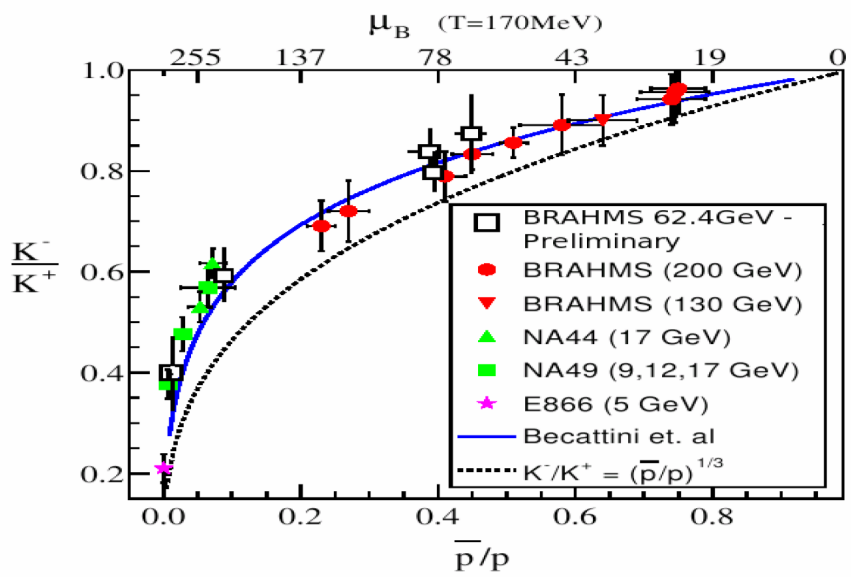
$\sigma_{meas.} = 2.23 \pm 0.06$

Evolution of the multiplicity dist. Shapes with centrality

Au+Au collisions at 200 GeV

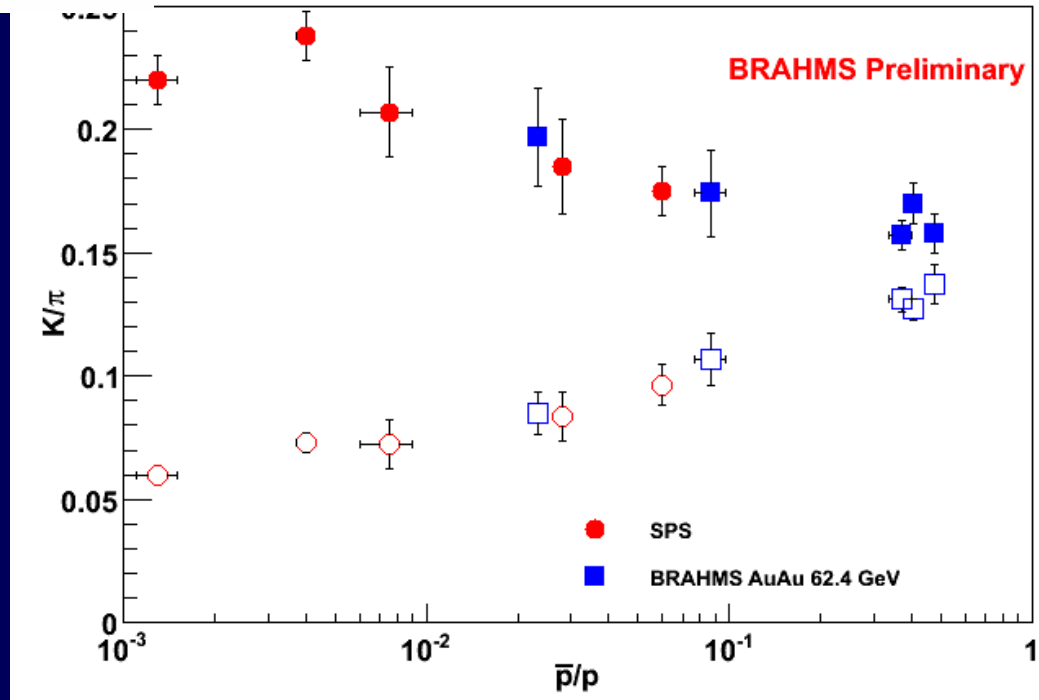


Central collisions, (up to 40%) scale with N_{part}. The tails of the peripheral distributions deviate from that scaling. (This has been attributed to pion emission from spectators. PHOBOS PRL91 052303)

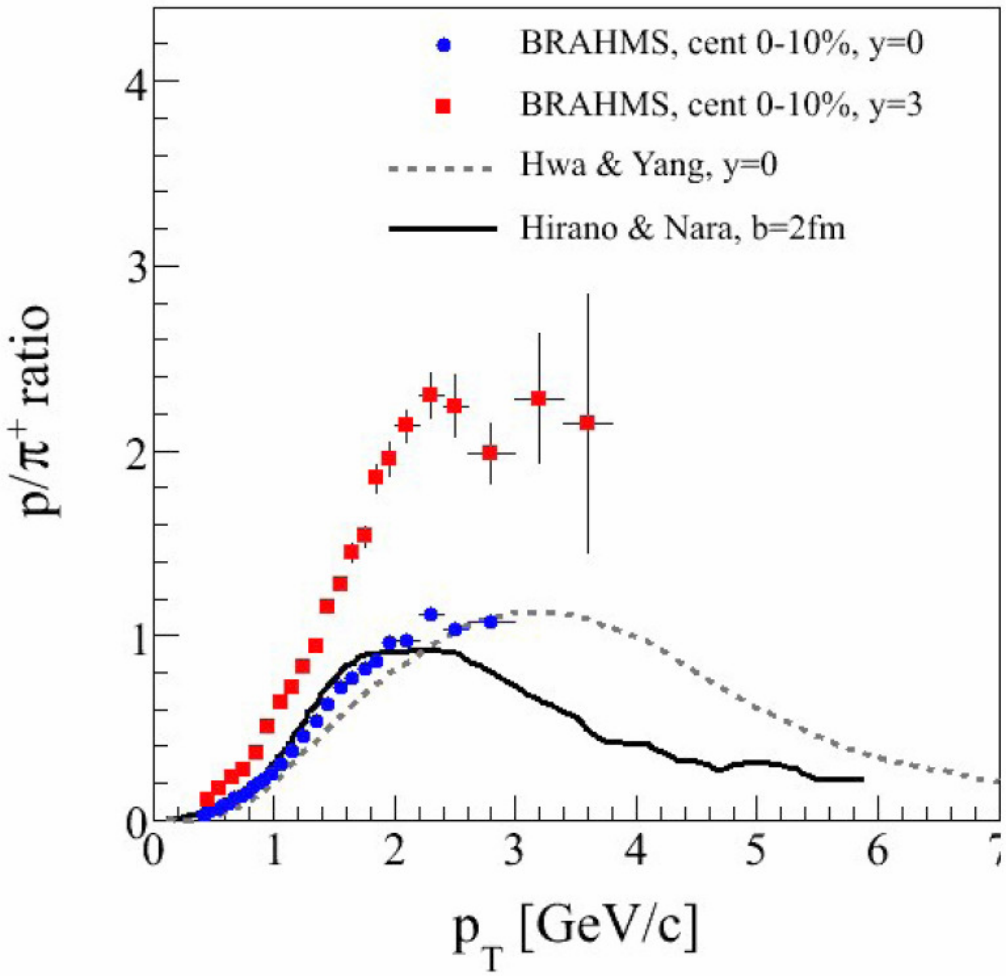


One can tune the baryo- chemical potential using the pbar/p values measured at different rapidities.

The high y K/pi+ ratios at RHIC (62.4 GeV) are very similar to the SPS results from the high energy slope of the "MarekHorn". (At same pbar/p ratio and thus same range of the baryo-chemical potential.)



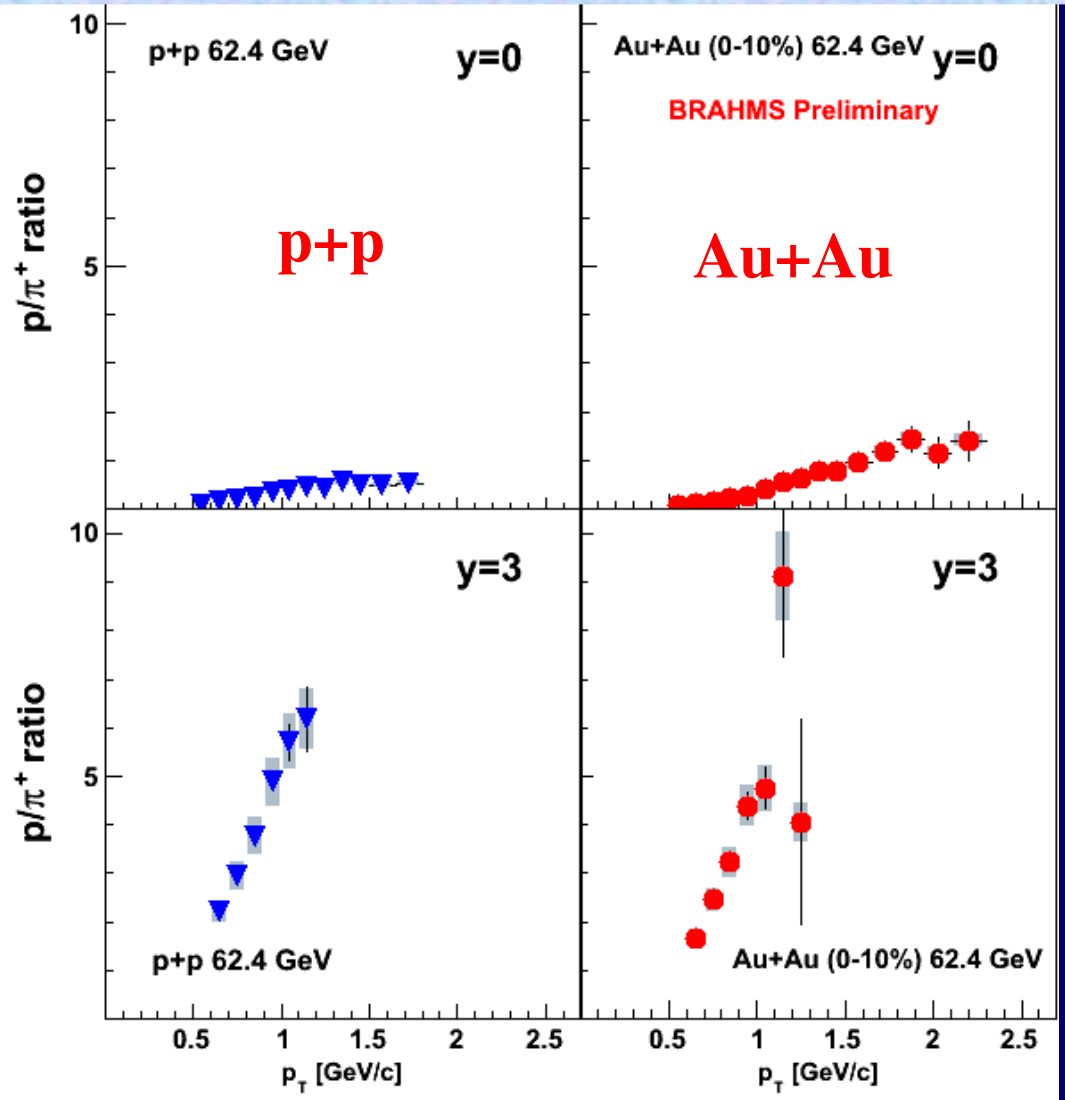
High-x physics accessible with the p/π^+ ratio



The puzzling abundance of protons with respect to pions has been attributed to recombination effects that do reproduce the data at mid-rapidity for pt values that range up to ~6 GeV/c.

Our results at high y indicate that this ratio may rather be driven by beam fragmentation.

Comparison of the p/π^+ in p+p and Au+Au systems at 62.4 GeV

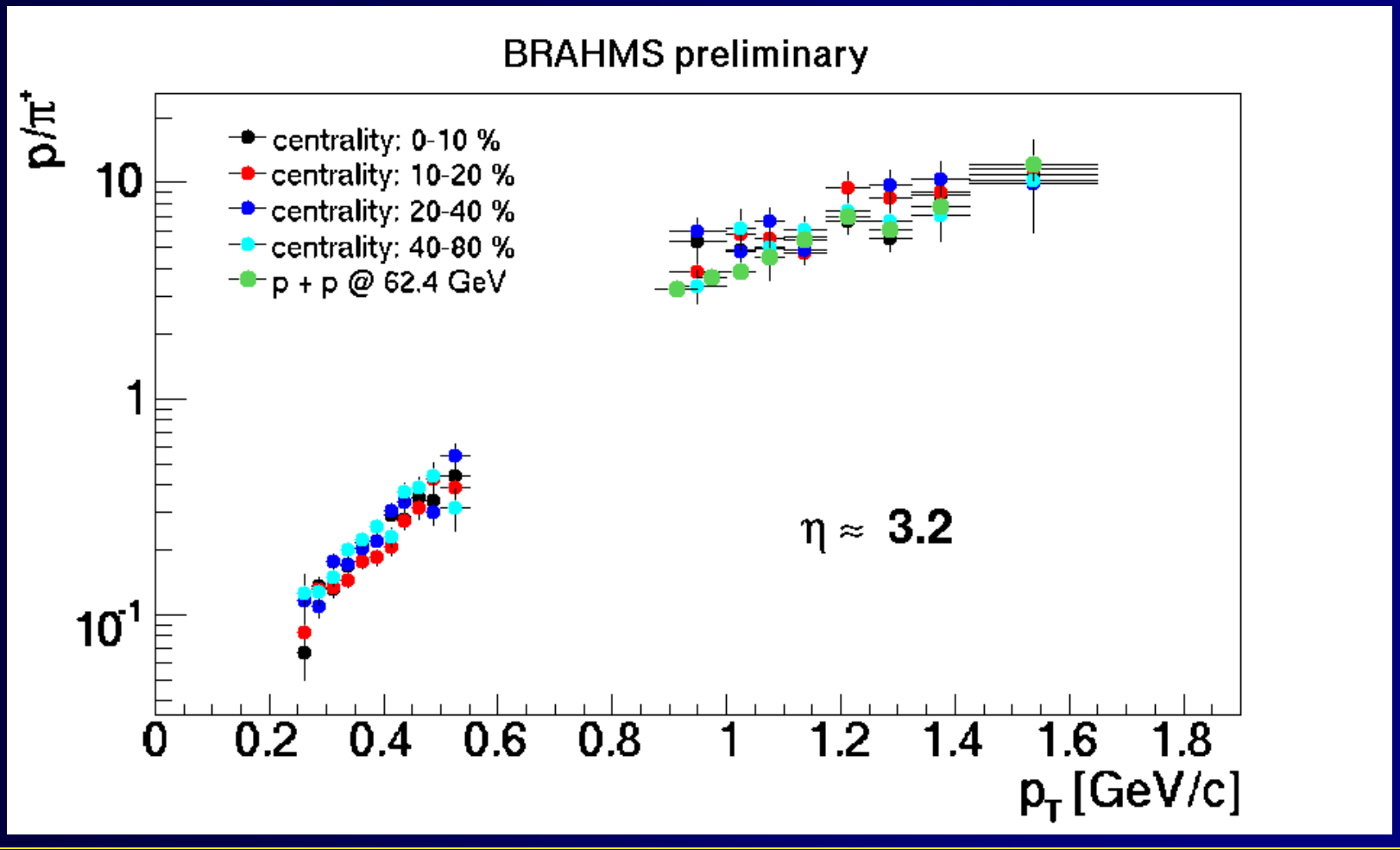


The overall difference between the ratio measured in pp and AuAu is consistent with the favored interpretation based on coalescence in Au+Au

The similarity of the ratio in both systems may be driven by incoherent proton fragmentation.

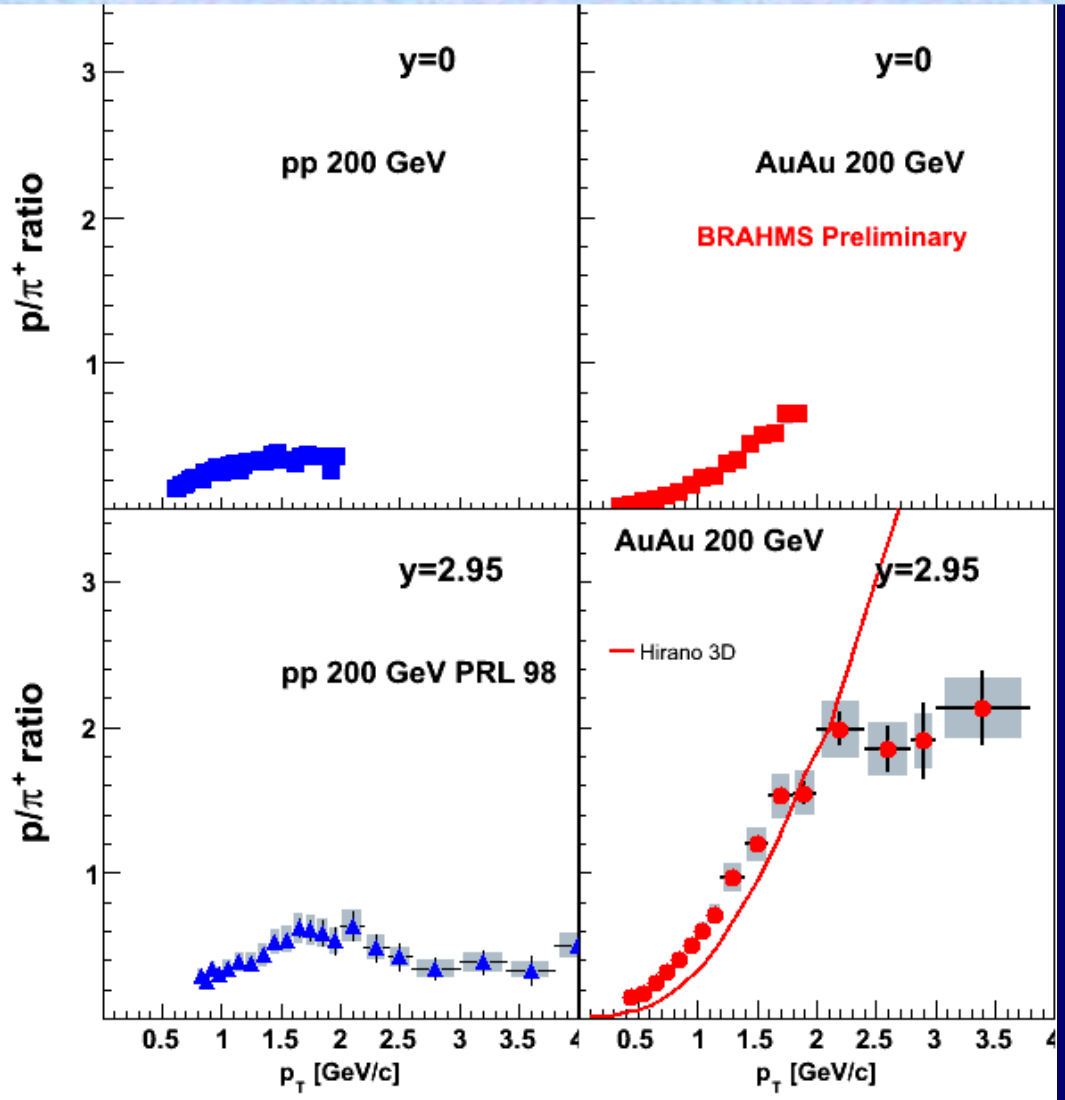
Large p+p value of ratio may be driven by proximity to beam rapidity.

The p/pi ratio as function of centrality Au+Au 62.4 GeV



The ratio appears to be "target" independent or Npart dependence is same for numerator and denominator.

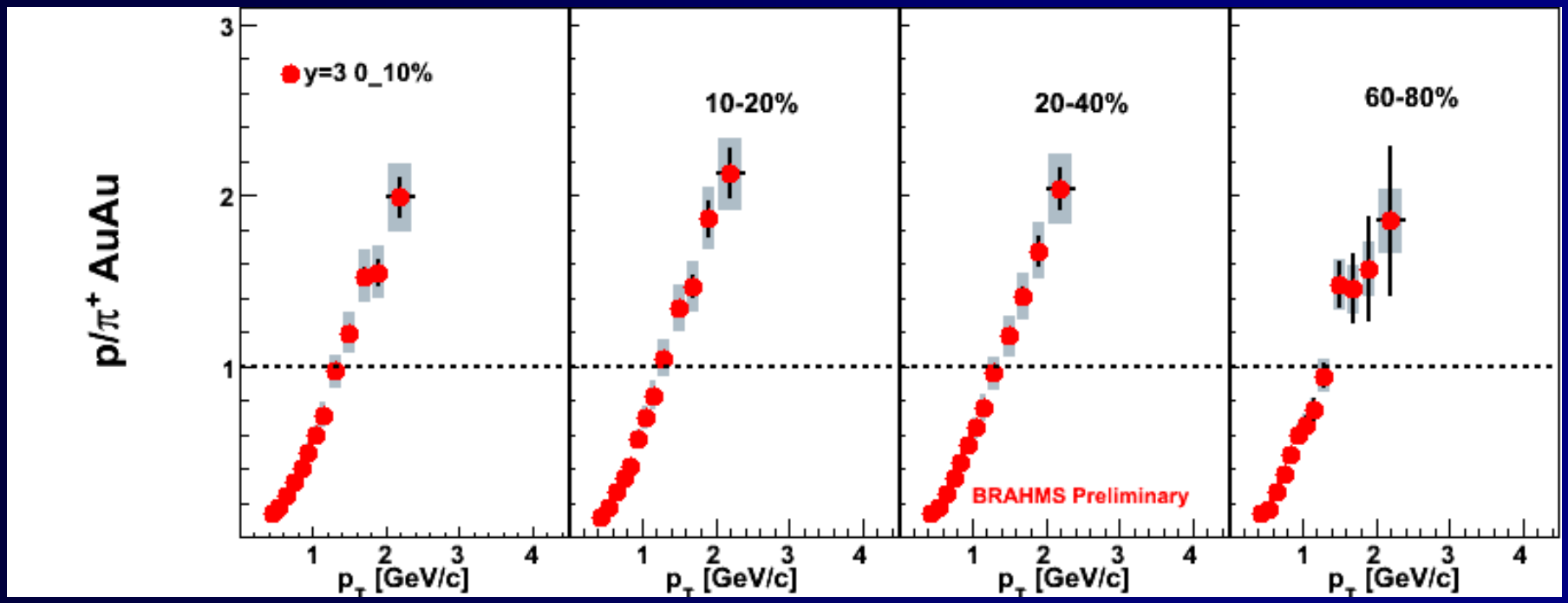
Comparison of the p/π^+ in p+p and Au+Au systems at 200 GeV



At mid-rapidity the difference between pp and AuAu system can be related to re-combination which favors proton production.

A much pronounced effect at higher rapidity may be an interplay between fragmentation effects, parton coalescence and baryon transport.

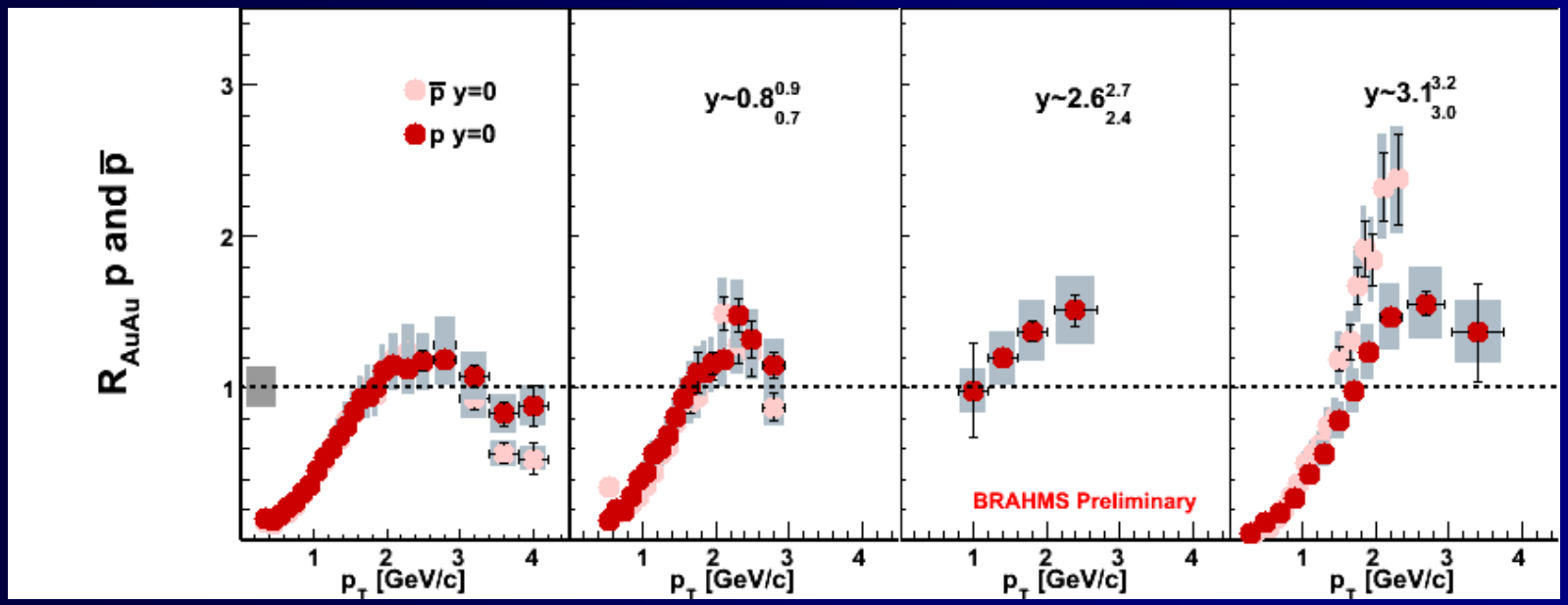
Centrality dependence of the p/pi ratio at y=3 AuAu 200 GeV



Within errors the ratio doesn't change with centrality. A change would occur if protons were produced through quark exchange as small objects unaffected by the medium, whereas the pions in the denominator are "absorbed" by the medium. (R. Blankenbecler and S. Brodsky)

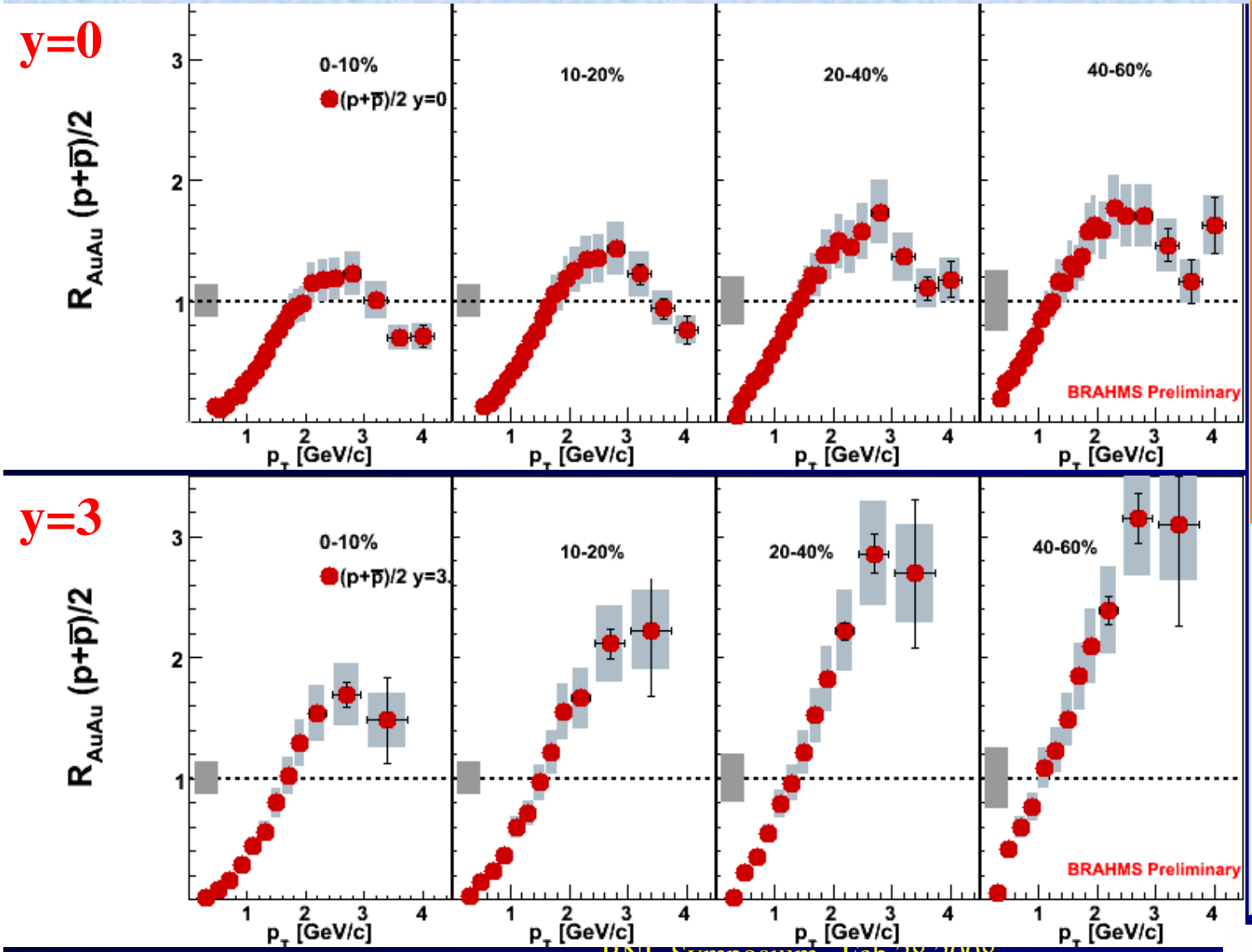
Nuclear modification factor for protons as function of y in AuAu 0-10% 200 GeV

protons anti-proton



As already seen with the p/π^+ ratio, baryons do not behave as mesons; this R_{AuAu} shows the increased proton production at high y. Strong enhancement of pbars at y~3 is not understood, yet.

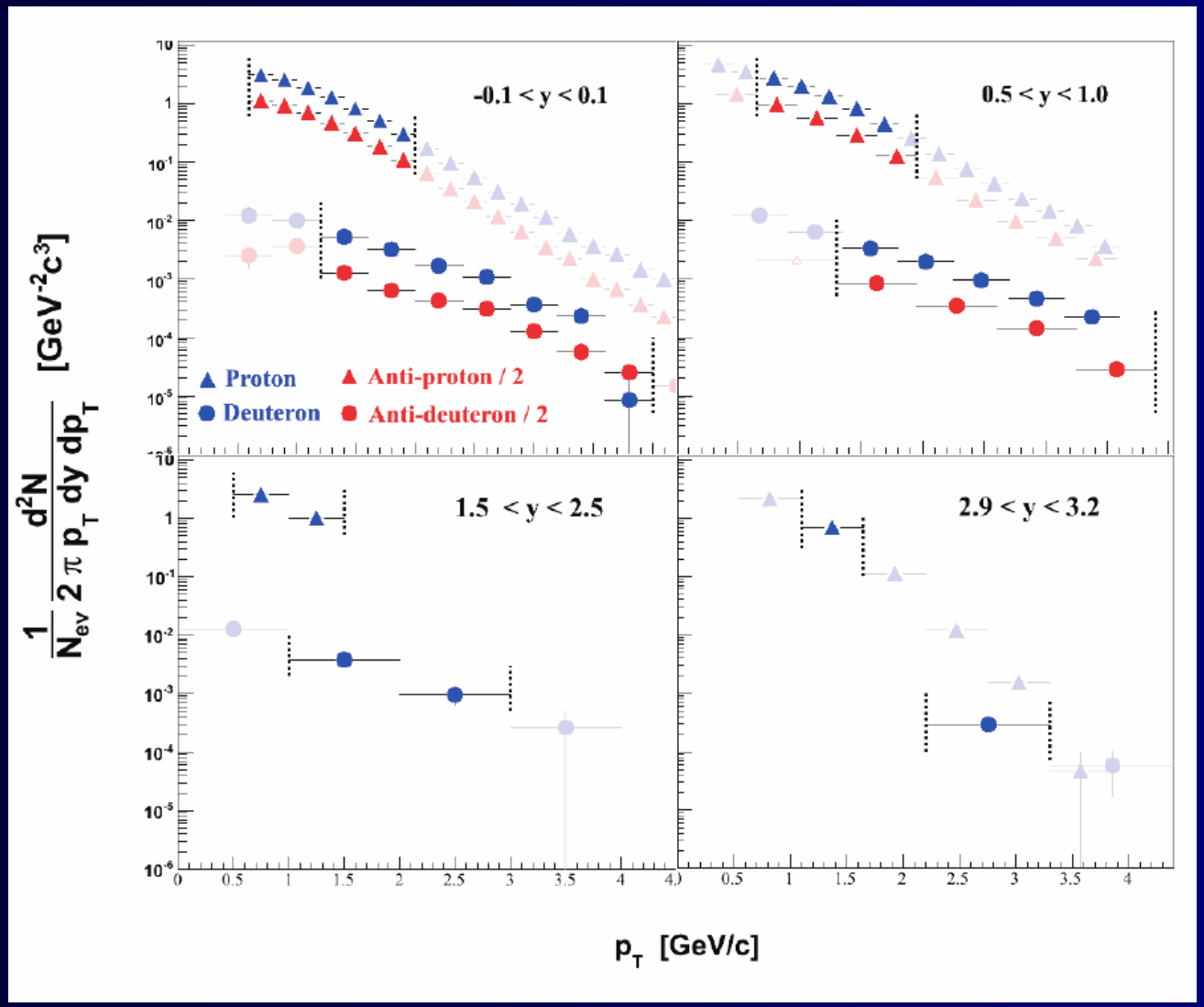
R_{AuAu} of (p+pbar)/2 as function of centrality in AuAu 200 GeV



Consistent with interplay of energy loss and multiple scattering effects. As well as radial flow.

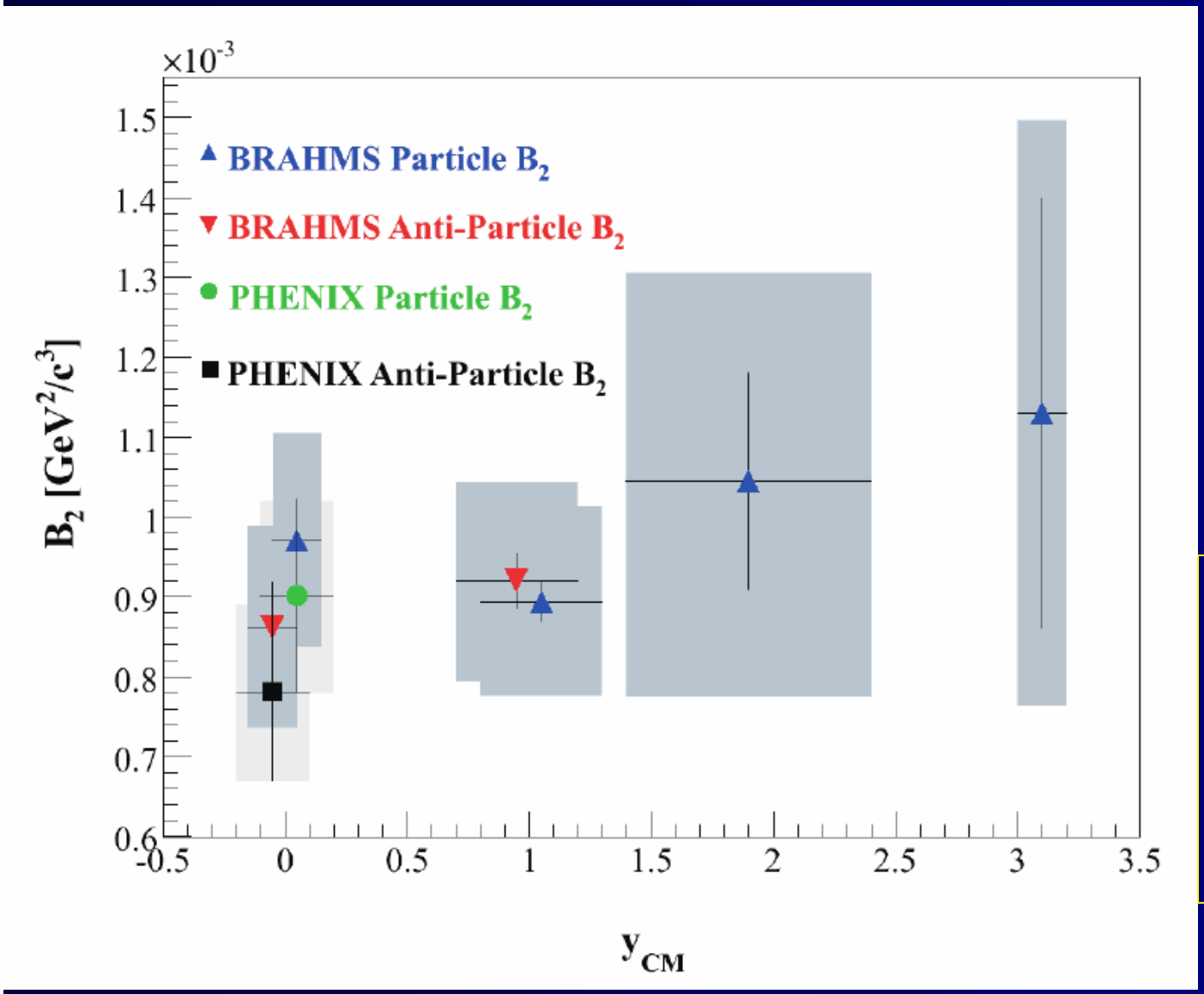
Remarkable enhancement of proton prod. In peripheral coll.

Deuteron coalescence studies in AuAu 200Gev in rapidity space



Probes the collision at the outermost spatial regions where re-interactions are sufficiently rare.

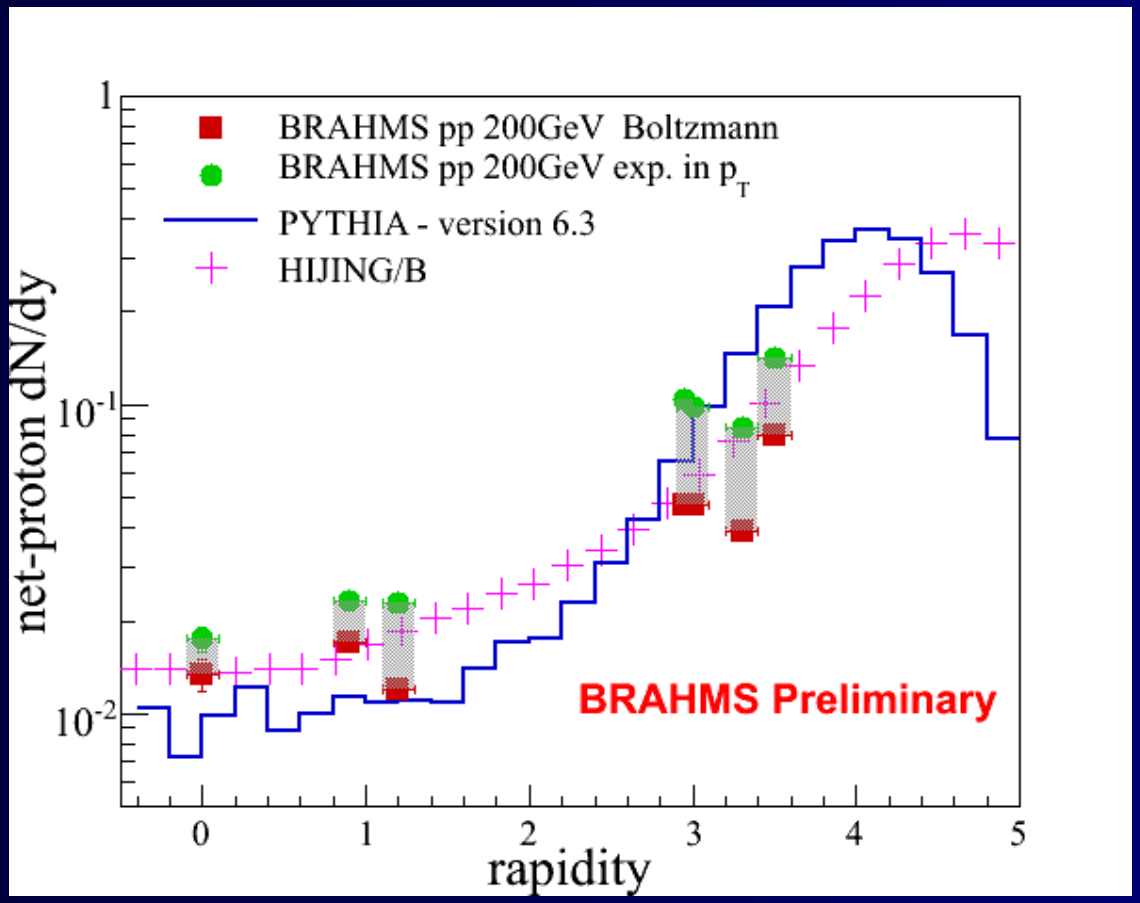
Assume neutron spectra are similar to the measured proton and anti-proton distributions.



Various models connect B_2 with the inverse of the emitting volume.

Within errors, the B_2 parameter remains constant over the measured rapidity range

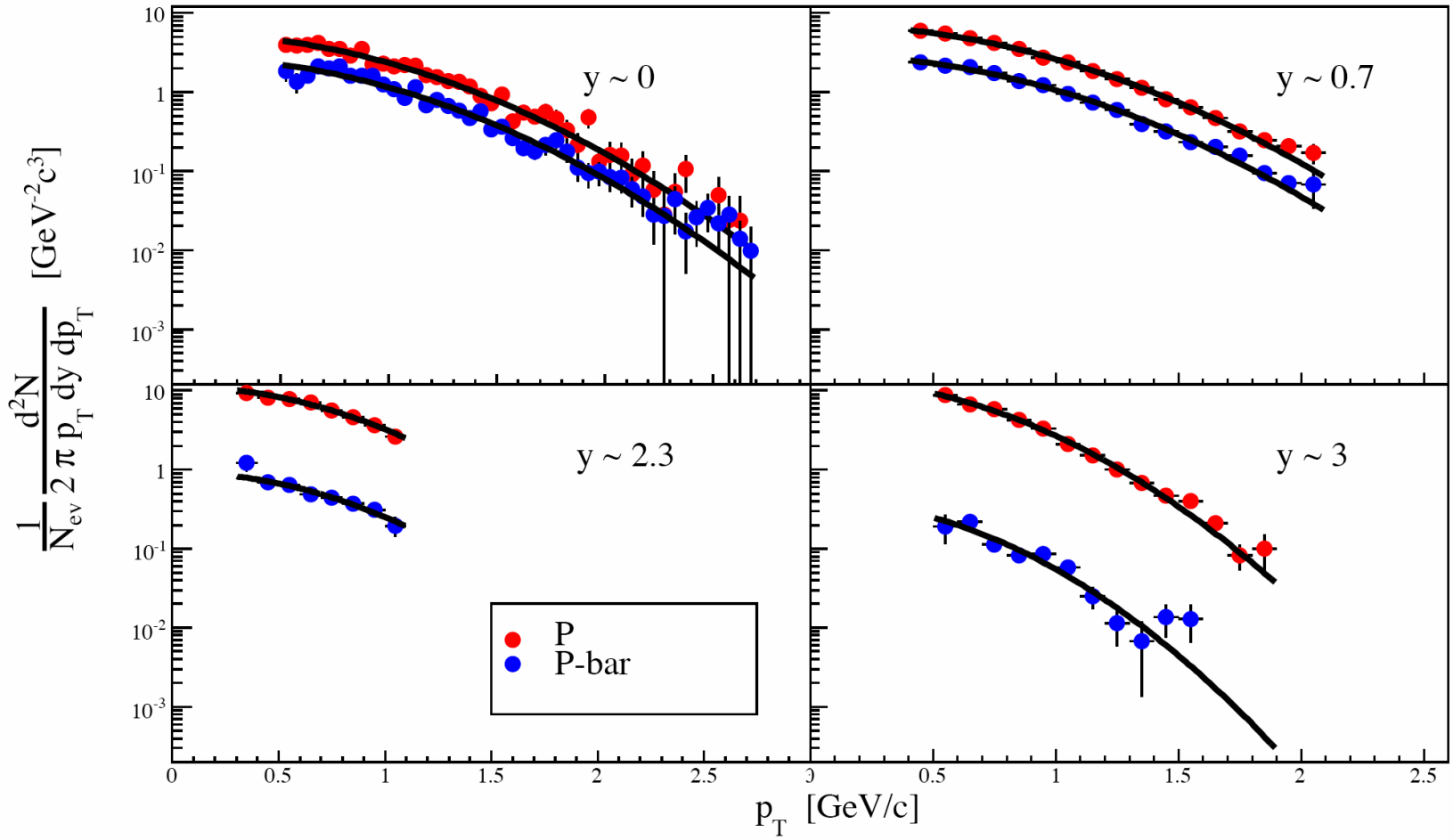
Baryon transport studies



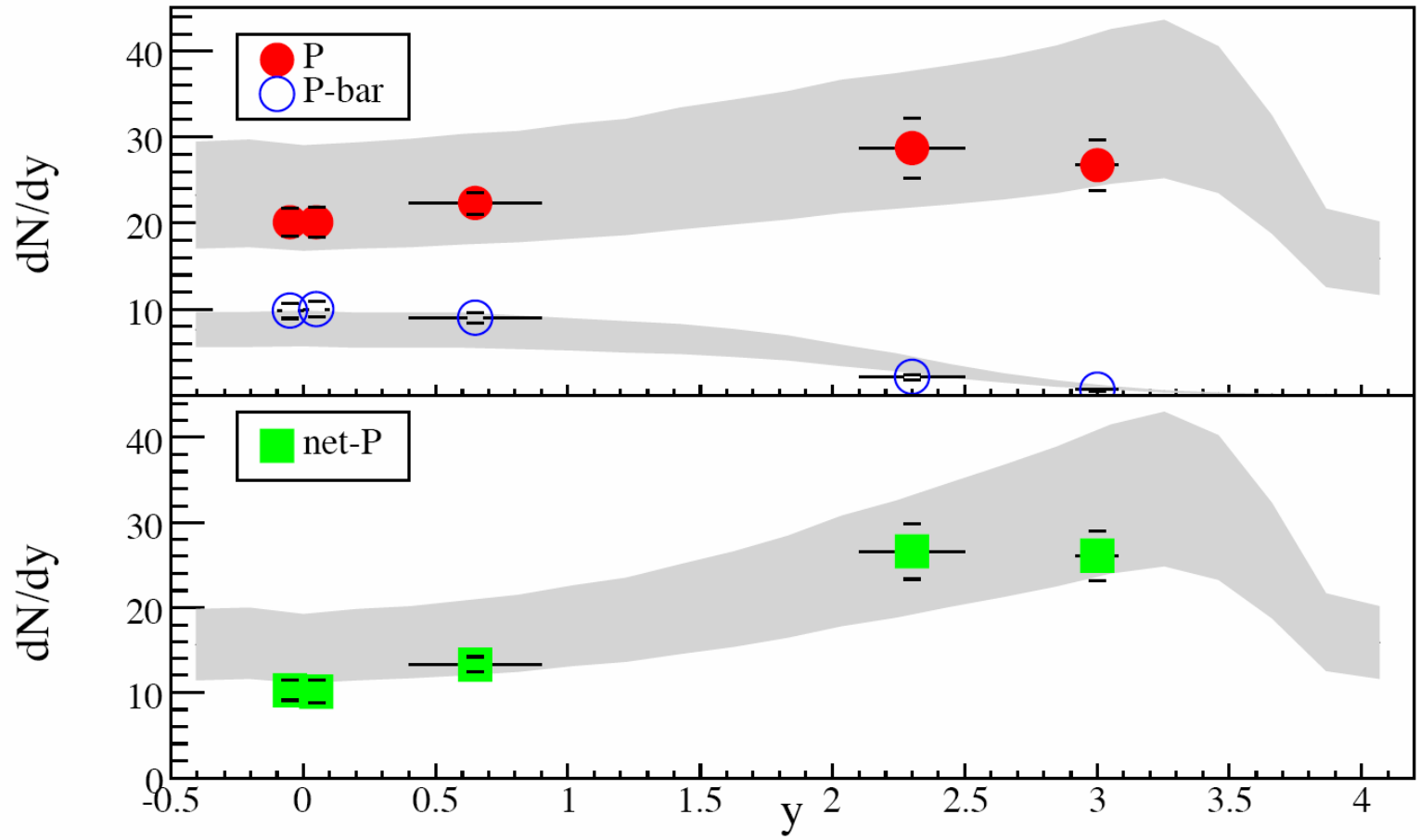
p+p collisions at 200 GeV

BRAHMS experimental program will deliver a wealth of information on baryon transport with results that range from p+p collisions at 62.4 and 200 GeV to bigger systems like Cu+Cu and Au+Au at both energies an different centralities

Net-proton distributions in Au+Au 62.4 GeV

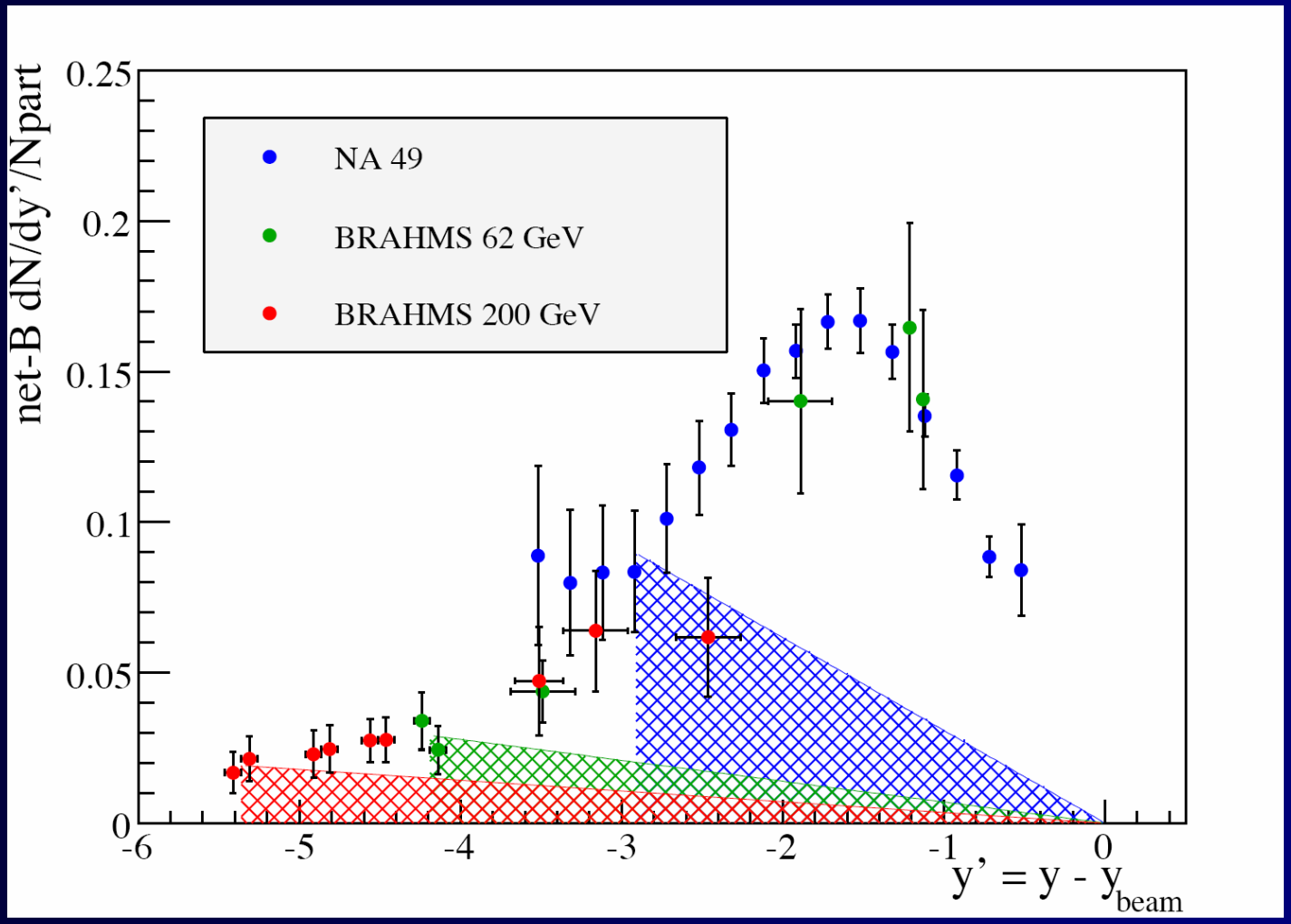


Hijing/B v1.1 and the data (AuAu 62.4 GeV 0-10% central)



The event generator has been modified to decay hyperons.

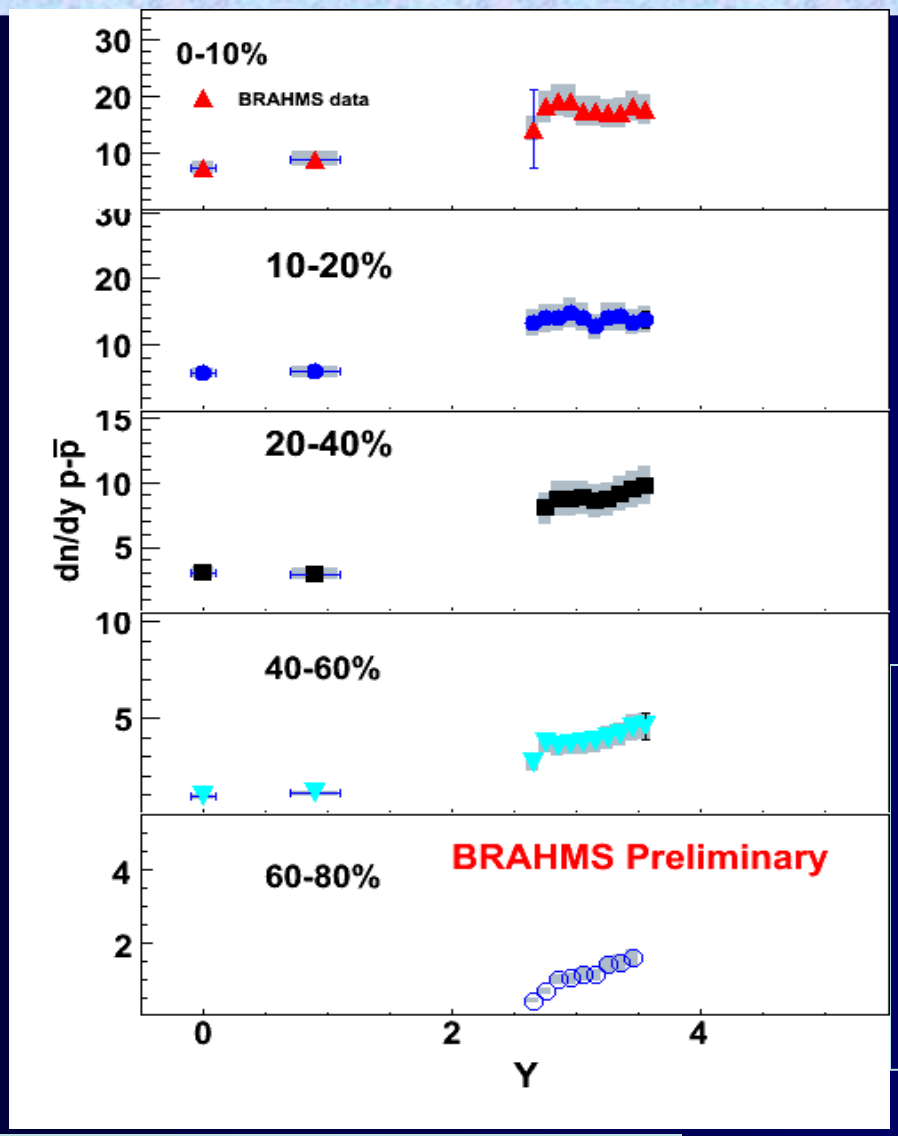
Longitudinal scaling of net-proton rapidity distributions

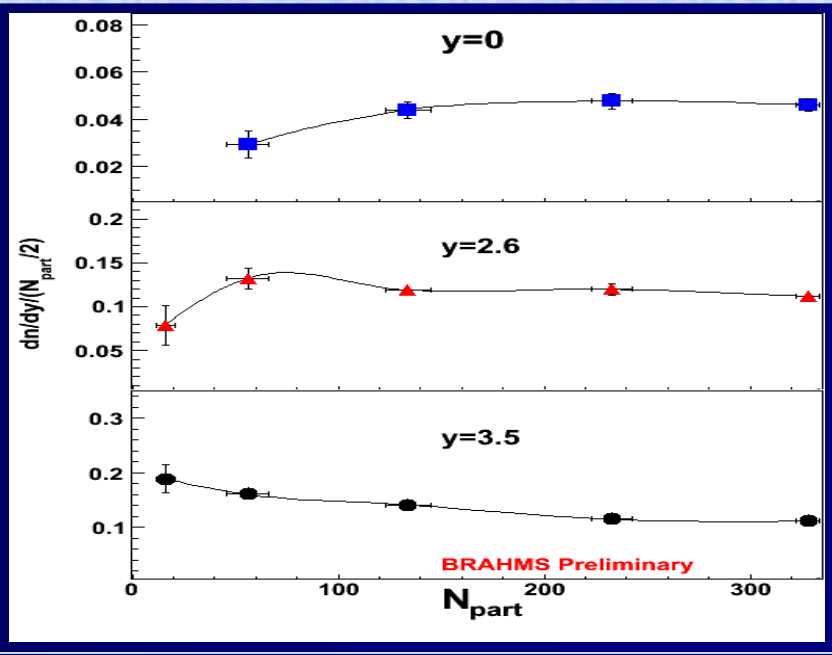


The contribution from the "target" is assumed as being linear, and dropping to zero. This target contribution is subtracted from the "projectile"

$y-y_{beam}$ appears as a good variable to describe net-proton per participant.

Centrality dependent net-proton distributions AuAu 200 GeV





N_{part} scaling in semi-central to central coll. (below 40%). Similar scaling appears to extend to ~high rapidity. Shape changes are evident at the "rapidity shifted" peak.

No correction for hyperon feed-down applied.

Summary and outlook

- Using some guidance from 3D+1 hydro dynamical expansion calculation, we find that, the fact that nuclear modification factors remain constant as function of y, is an indication that other factors besides energy loss do contribute to the overall small measured value. The strength of these effects would grow with y.

- We have described ongoing analysis of particle production in all the measured systems.

- We have reported interesting effects related to protons at moderate p_T at high rapidity.

- We presented results on baryon transport, with special focus on the AuAu system.

BRAHMS Collaboration

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