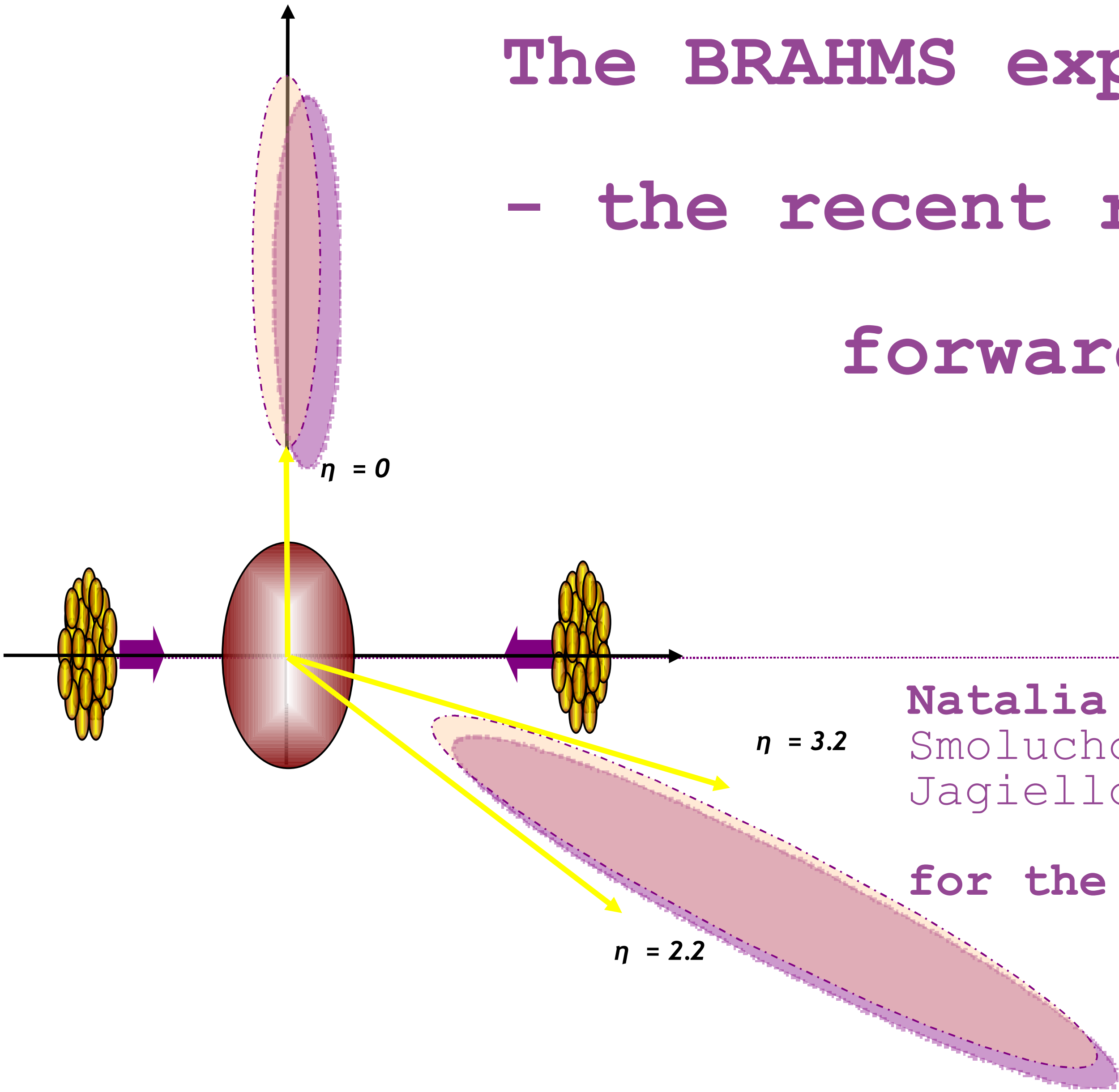
The BRAHMS experiment at RHIC – the recent results of forward regime studies



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BRAHMS

Outline

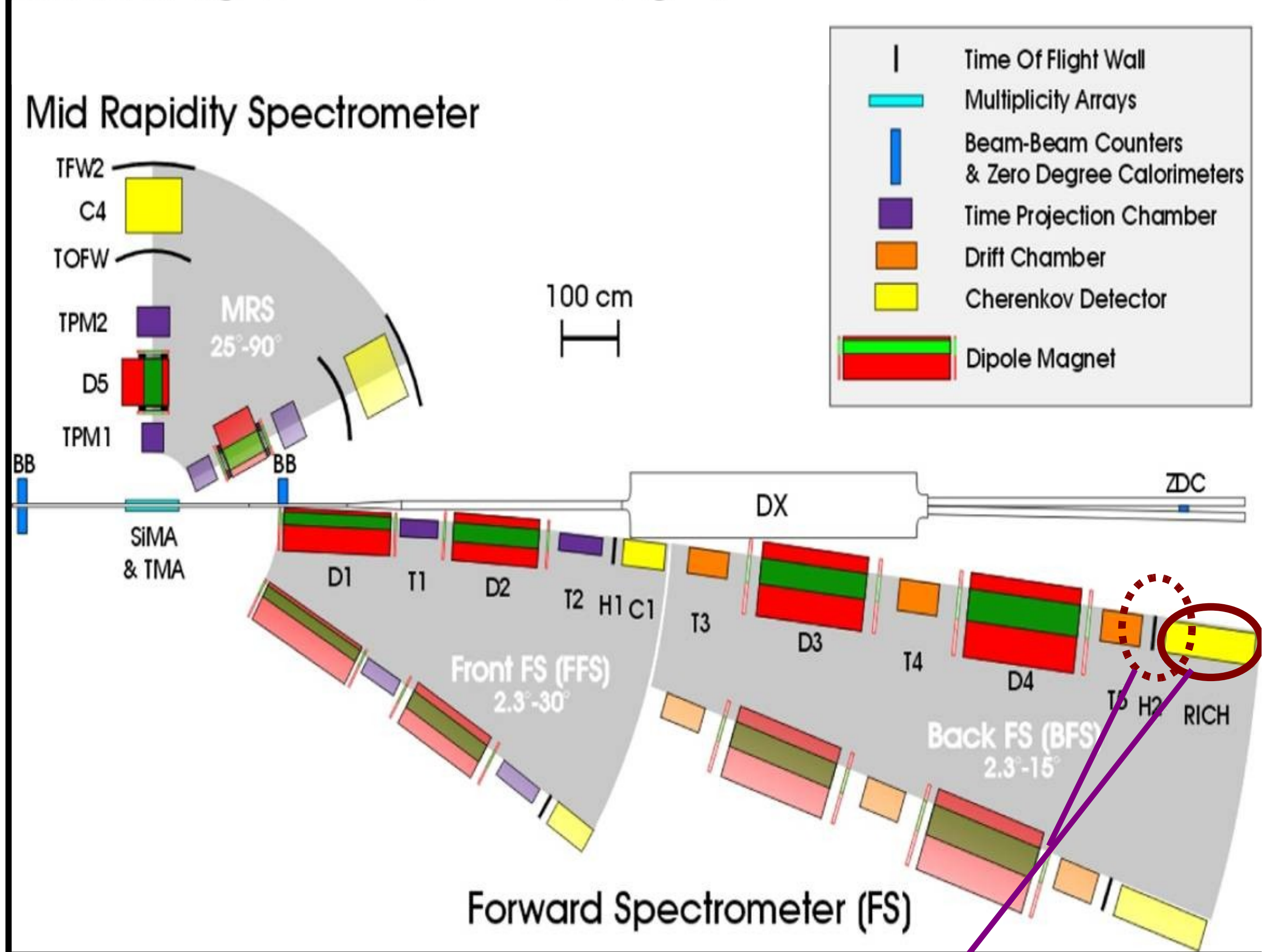
1. Overview of BRAHMS detector setup.

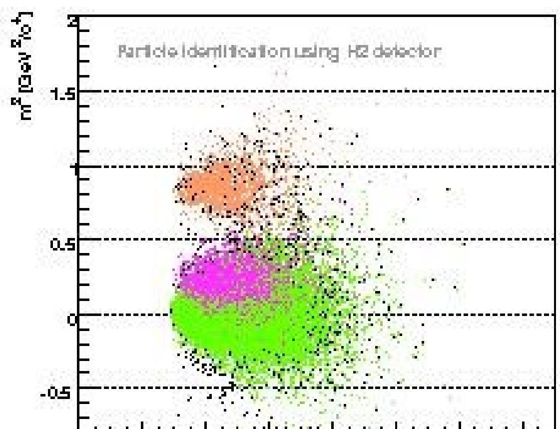
2. Net-bayon density for Au+Au collisions at 62.4 GeV and 200 GeV.

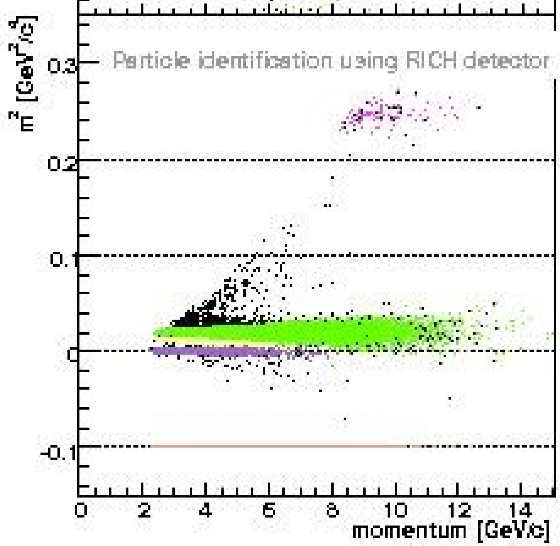
3. Proton-to-pion ratio versus transverse momentum in nucelus-nucleus and nucleon-nucleon collisions.

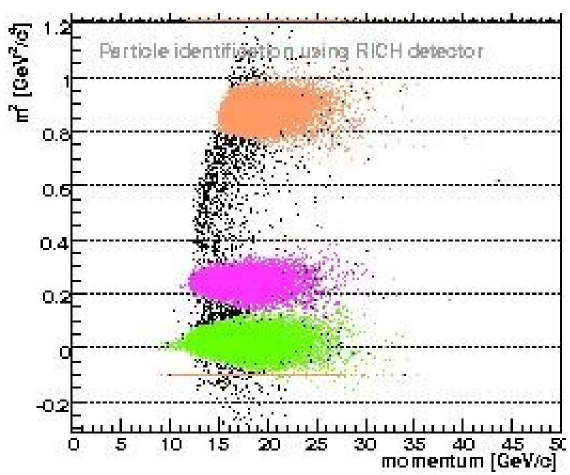
4. Summary.

Broad RAnge Hadron Magnetic Spectrometers at RHIC





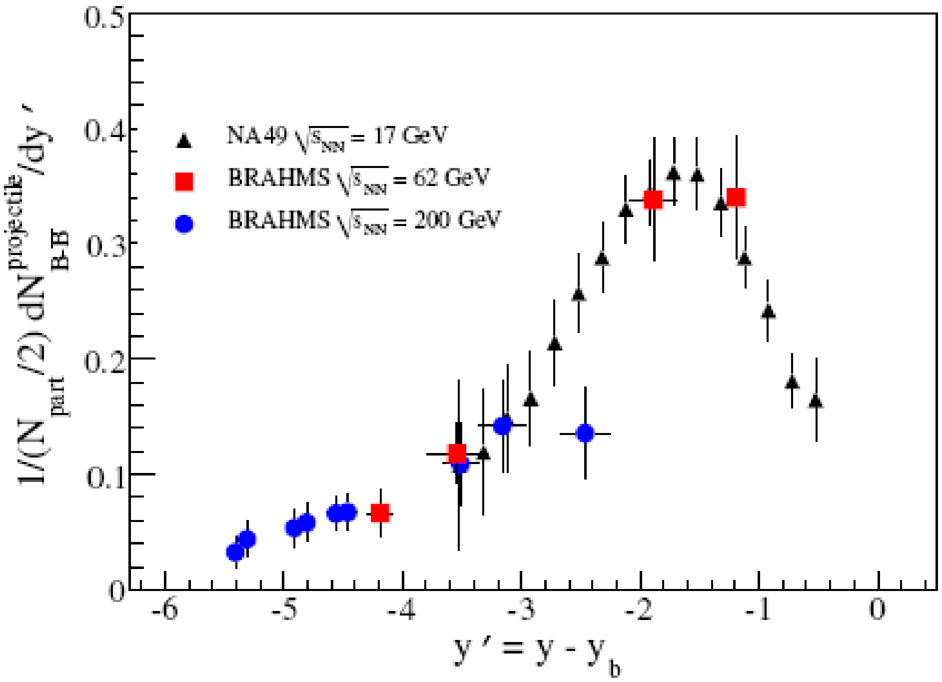




RICH detector situated in forward arm allows to identify high momentum particles (e^-,$\mu^{-/+}$, $\pi^{-/+}$, $K^{-/+}$, pbar/p);

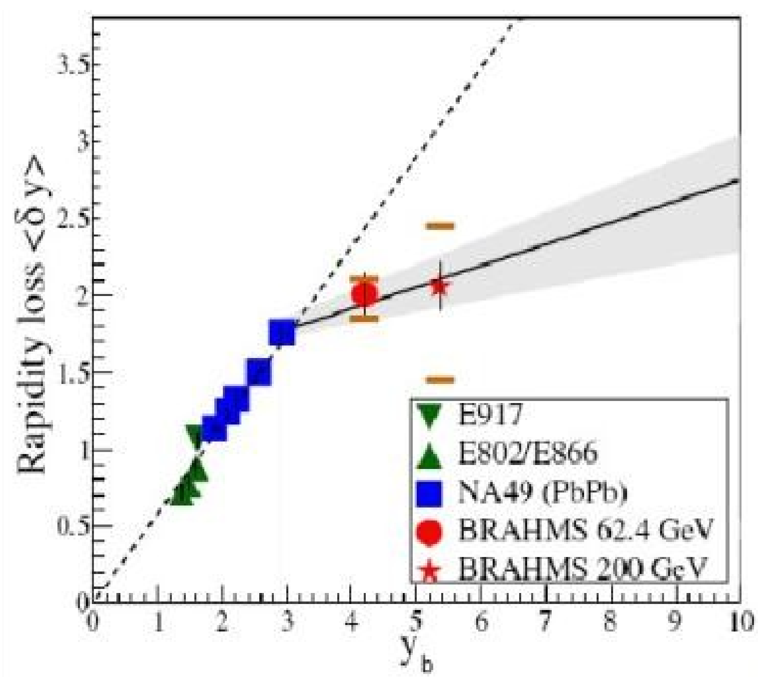
ToF H2 placed before RICH measures hadrons with lower velocity.

Net-baryon density at RHIC energies



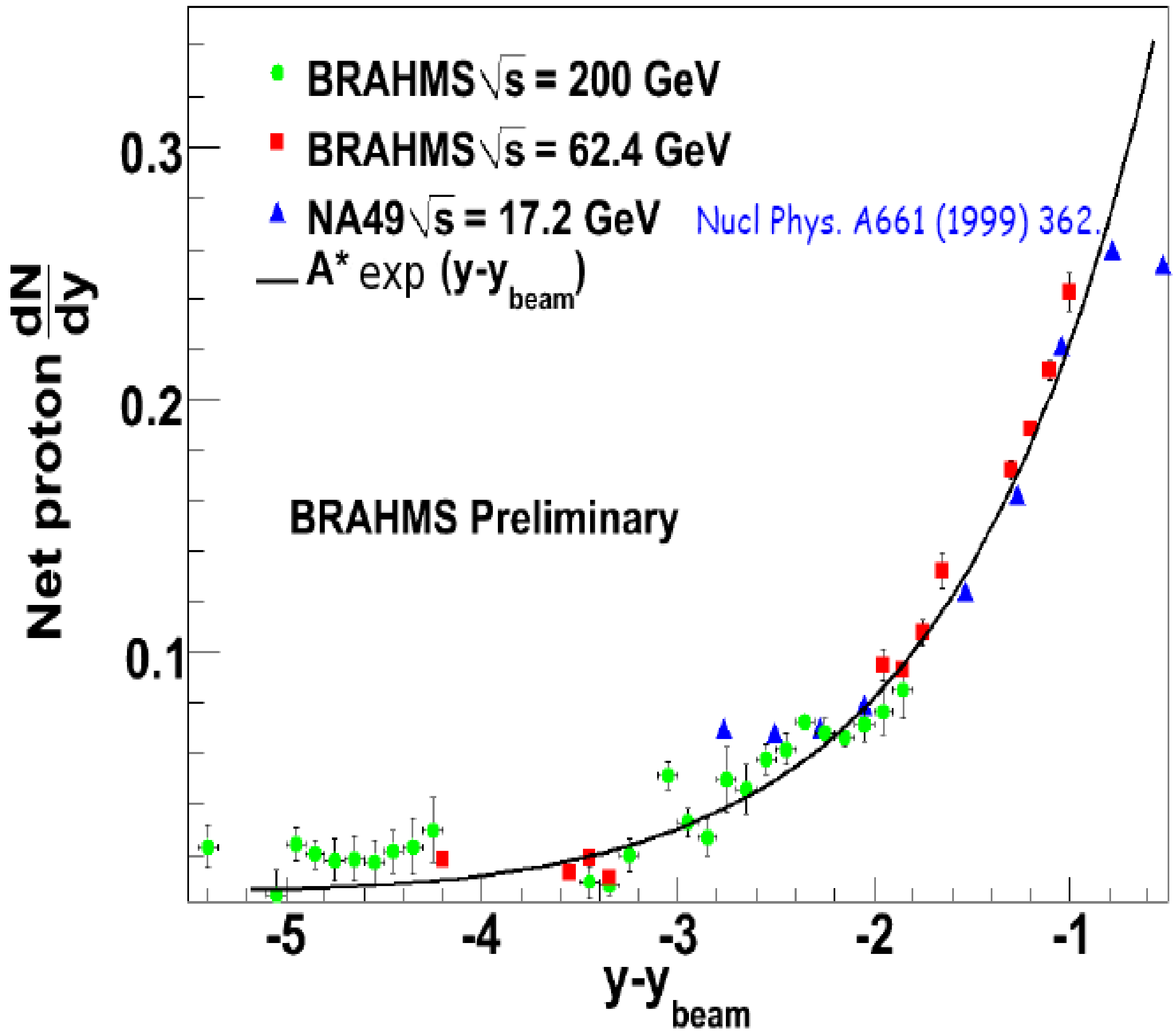
The projectile net-baryon distribution is obtained by subtracting the estimated contribution from the target component. The data seem to be consistent for all three values of colliding energy with the exception of y' ~ -3.

$$\delta y = y_b - \frac{2}{N_{part}} \int_0^{y_b} y \frac{dN_{B-\bar{B}}}{dy} dy$$



At SIS, AGS and SPS linear proportionality of <δy> is observed. The BRAHMS results show that this scaling is broken at RHIC energies. Assuming that underlying physics is the same at highest attainable energies the extrapolation to the LHC energies is displayed.

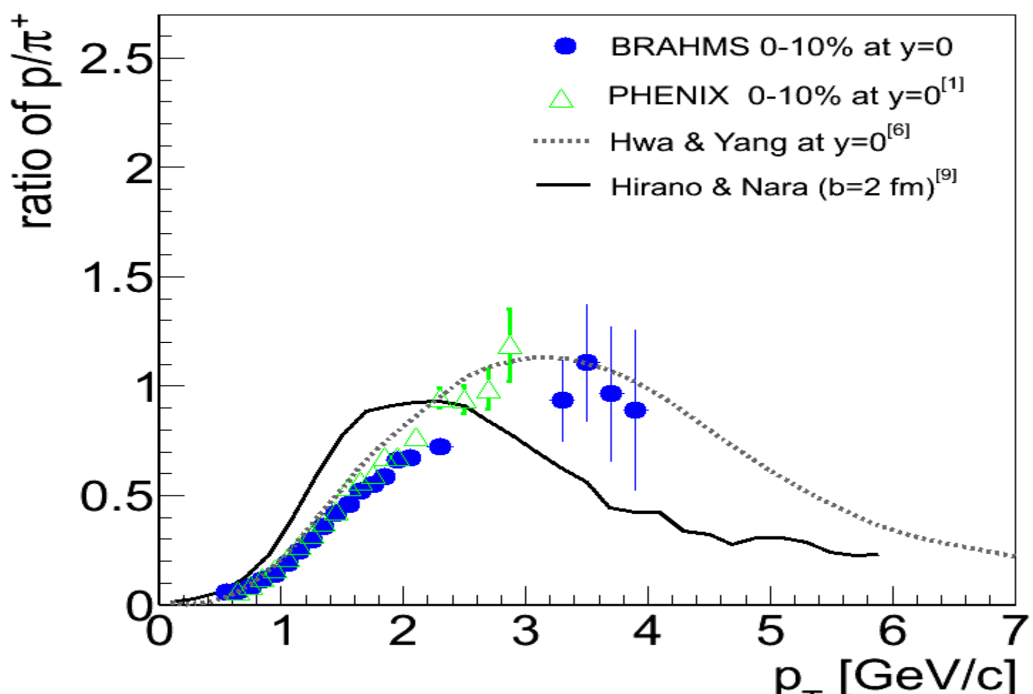
Limiting fragmentation in elementary reactions



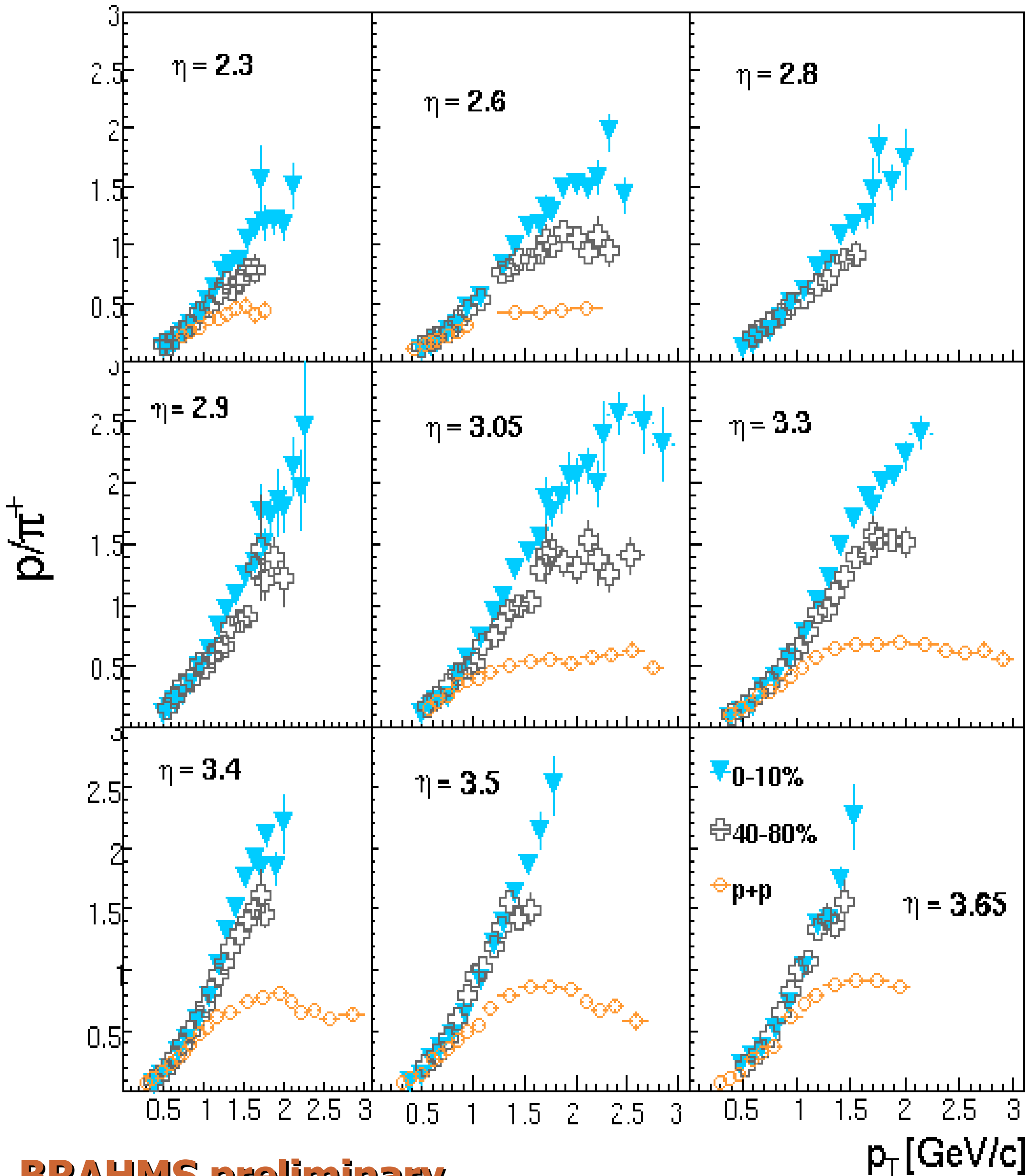
A remarkable overlap of dN/dy distributions at all energies (p+p @ 200 GeV, y_{beam} ~ 5.3; p+p @ 62.4 GeV, y_{beam} ~ 4.2) appears when viewed in their projectile frame.

p/π^+ ratio in Au+Au collisions @ 200 GeV

At midrapidity for Au+Au collisions the $p/\pi^+(p_T)$ ratio @ 200 GeV (μ_B = 26 MeV) seems to be more consistent with the recombination model predictions. The hydrodynamic scenario describes properly only low transverse momentum data associated for p_T < 1.8 (pions) and 3.5 (protons) GeV/c. These results might suggest that at low value of baryo chemical potential the hadronization process is well captured by the coalescence model.



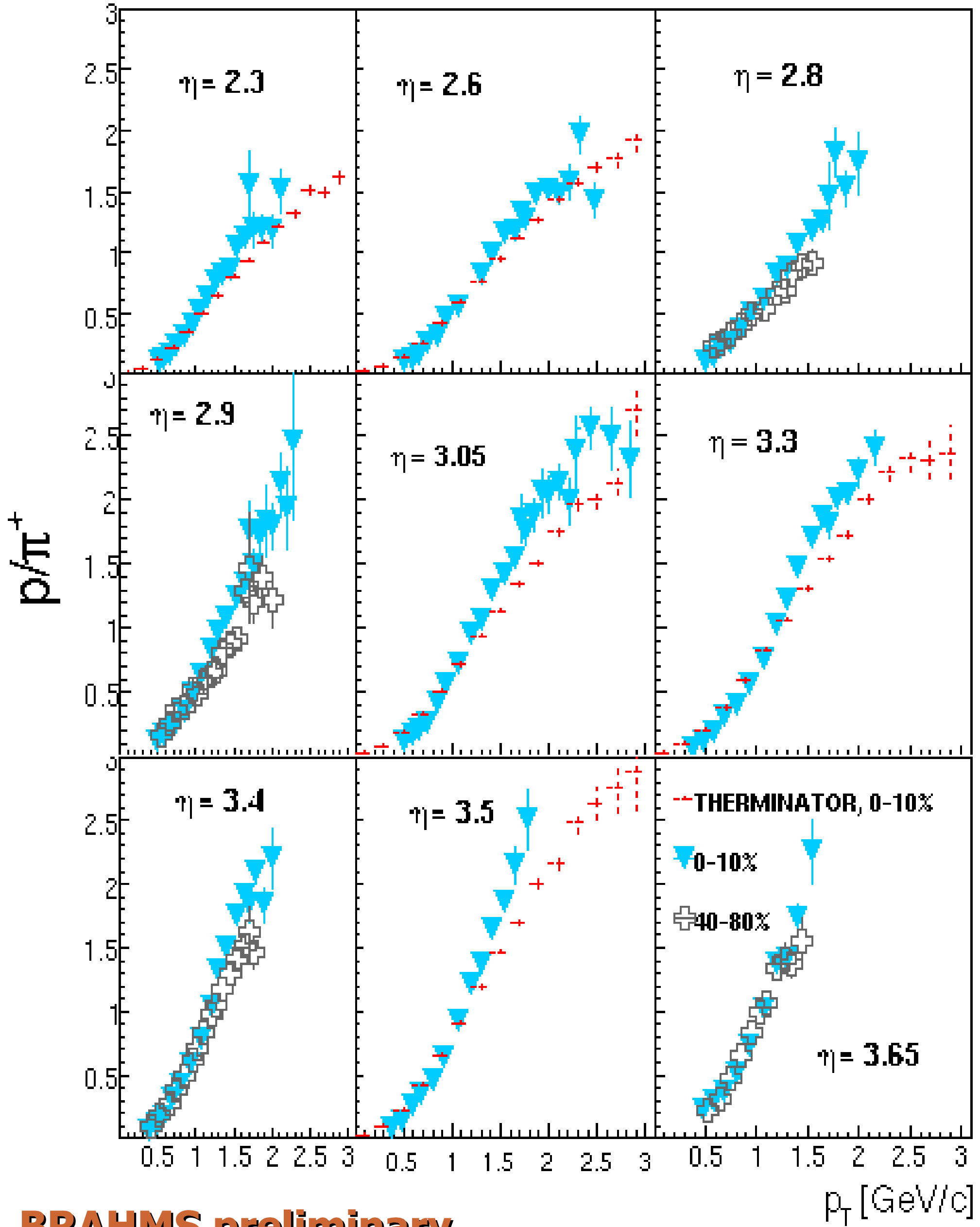
p/π^+ ratio in Au+Au collisions @ 200 GeV



BRAHMS preliminary

At forward region below p_T < 1 GeV/c the consistency of heavy ions results for central (0-10%) and semi-peripheral (40-80%) collisions with the outcome for p+p system is noticed. At p_T > 1 GeV/c the results for p+p collisions starts noticeably to deviate from results for Au+Au collisions. The shift of the peak of the ratio to higher p_T and overall increase of ratio at intermediate p_T give an evidence of existence of hot and dense medium created in nucleus-nucleus collisions.

p/π⁺ ratio in Au+Au collisions @ 200 GeV



The non-boost-invariant single-freezeout model that incorporates rapidity dependence of statistical particle production imposed on hydrodynamical flow. The model does not include jet production.

The THERMINATOR model provide good quantitive description of the data at forward rapidity, namely from ***η*** *= 2.3 to* ***η*** *= 3.5. This may indicate that in this domain, the final hadronic interaction take place long enough (before freezeout) to suppress the relative collectivity of different species, which is a remnant effect of earlier hadronization via parton coalescence.*

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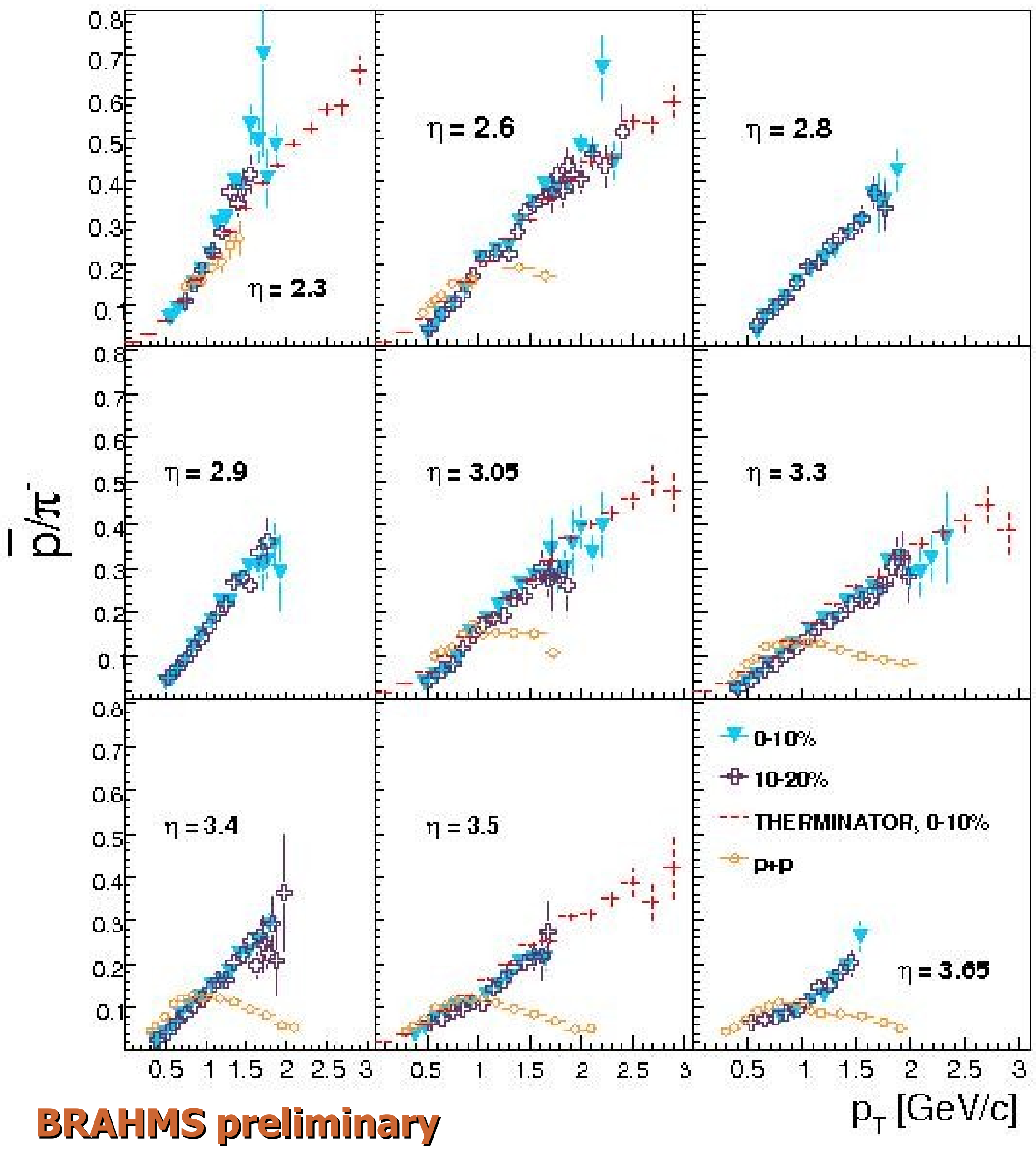
BRAHMS preliminary

$\bar{p}/\pi^-$ ratio in Au+Au collisions @ 200 GeV



Generally, the proton-to-pion ratio for negatively charged hadrons are much smaller than for positive particles. The shape of the ratio and position of the peak is the same for all pseudorapidity bins for both centralities. For Au+Au reactions the dependence of centrality collisions begins at p_T = 0.9 GeV/c.

For the whole covered pseudorapidity interval the ratio is lower for elementary reactions.

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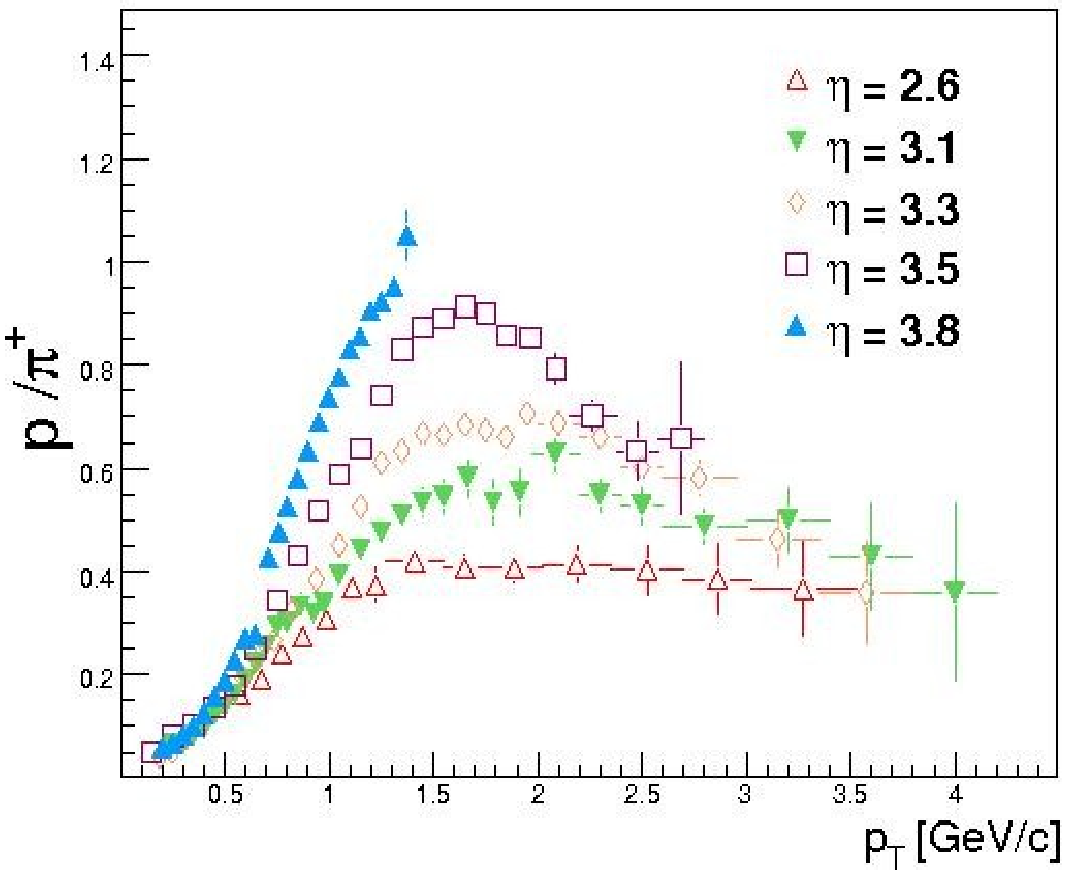
p/π^+ ratio in p+p reactions @ 200 GeV

BRAHMS preliminary

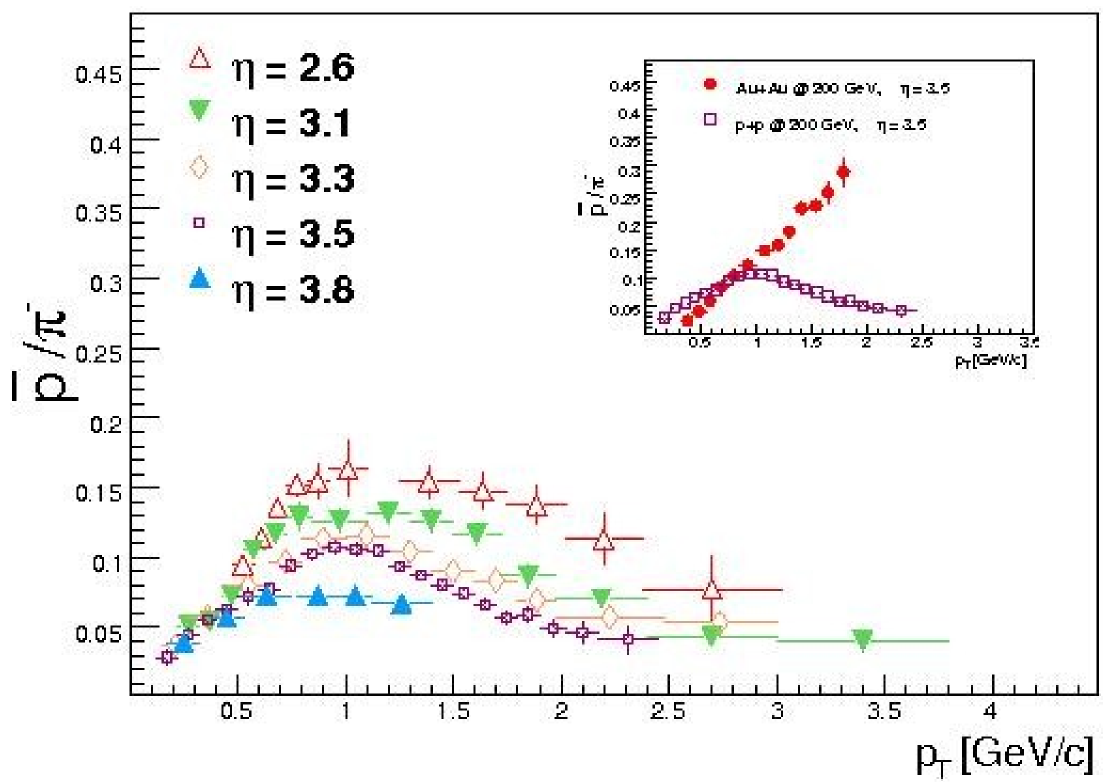


A very clear difference of p/π^+ is found as the pseudorapidity changes from η = 2.6 to = 3.8. The value of the ratio grows systematically with increasing η. That high value of ratio is indispensable connected with the large proton yield at high p_T. At highest covered p_T p/π^+ ratio seems to have a common value of 0.4 which is consistent with perturbative QCD predictions.

$\bar{p}/\pi^-$ ratio in p+p reactions @ 200 GeV

In comparison with p/π^+ ratio the difference of ratio is 5. The maximum of p/π^- ratio is shifted to the lower transverse momentum, p_T = 1 GeV/c, in relation to the positive particles. For soft p_T region the $\bar{p}/\pi^-$ ratio is even higher for elementary system than for Au+Au collisions. Below p_T = 1 GeV/c the $\bar{p}/\pi^-$ ratio increases towards more peripheral reactions and reaches the largest value for p+p collisions. This might be the evidences of medium effects in heavy ions collisions at relativistic energies.

BRAHMS preliminary



p/π^+ ratio @ 62.4 GeV

BRAHMS preliminary

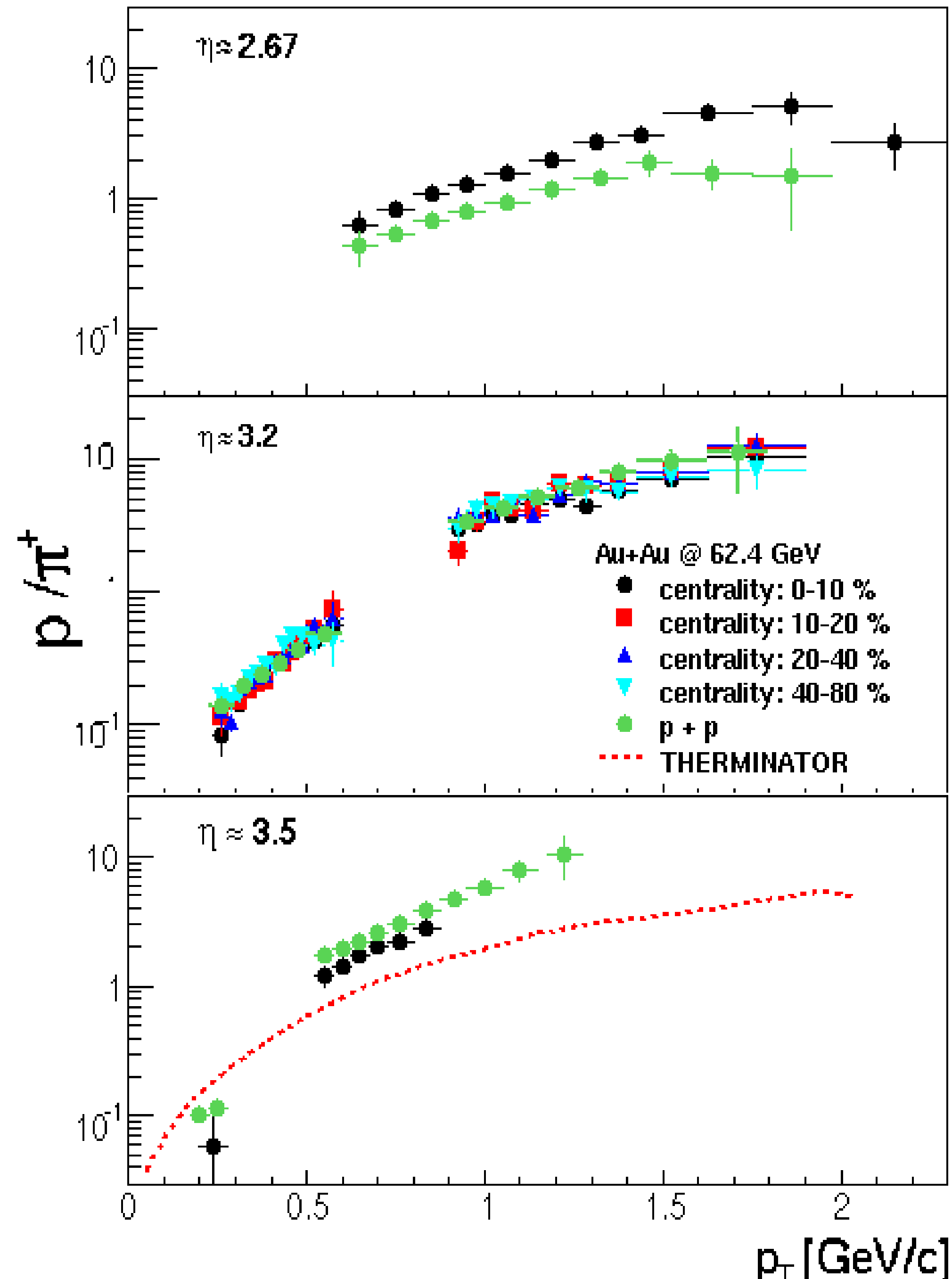
For all pseudorapidities the large value of p/π^+ at p_T = 1 GeV/c is observed = 10.

This is remarkably little difference in the p/π^+ ratios from a wide range of systems.

The consistency between the results for p+p reactions and Au+Au system for all centrality bins for = 3.2 is reckoned as the crossing point in pseudorapidity. The crossing point was predicted by UrQMD, HIJING and AMPT model calculations, however in the interval 2 < y < 2.5.

The data show an increased baryon transport towards midrapidity in central collisions. Such increased stopping power dissipates the longitudinal beam energy to form a denser system where recombination favour proton production at intermediate p_T.

Both effects produce higher values of the ratio in extended systems.



Summary

* the linear proportionality of rapidity loss at SPS energies is broken at RHIC and slowly depends on beam rapidity that might be interpreted in the light of gluon saturation

* the p/π^+ ratio for central Au+Au collisions @ 200 GeV increases with increasing pseudorapidity: from ~ 1 at midrapidity to < 3 for $\eta \sim 3.4$

* the opposite trend is exhibited by the ratio for negative particles

* for elementary reactions the rapidity dependence of ratios is significant for both charges of hadrons; at $p_T < 0.9$ GeV/c the p/π^- ratio for p+p system is higher than for Au+Au collisions for forward η

* at 62.4 GeV the crossing point in pseudorapidity is observed; surprisingly consistency of p/π^+ ratio for nucleon-nucleon and all centrality bins for nucleus-nucleus collisions is presented

* the experimental data are quantitatively well-described by the single freezeout model at transverse momentum $p_T < 3$ GeV/c

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Back-up slides

d+Au collisions @ 200 GeV

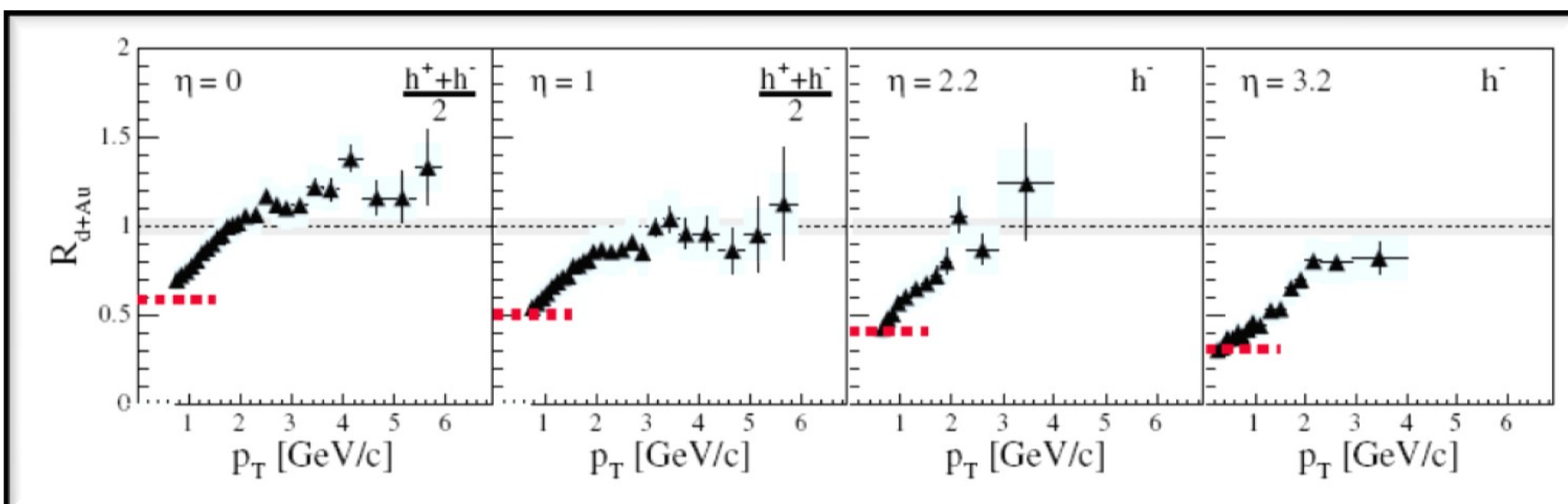
$$R_{dAu} = \frac{1}{\langle N_{coll} \rangle} \frac{\dfrac{d^2 N^{d+Au}}{dp_T d\eta}}{\dfrac{d^2 N^{p+p}_{inel}}{dp_T d\eta}}$$

nucelar modification factor

* Cronin enhancement at midrapidity

* suppression at high p_T

* expected Color Glass Condensate state (gluon saturation) at forward rapidity



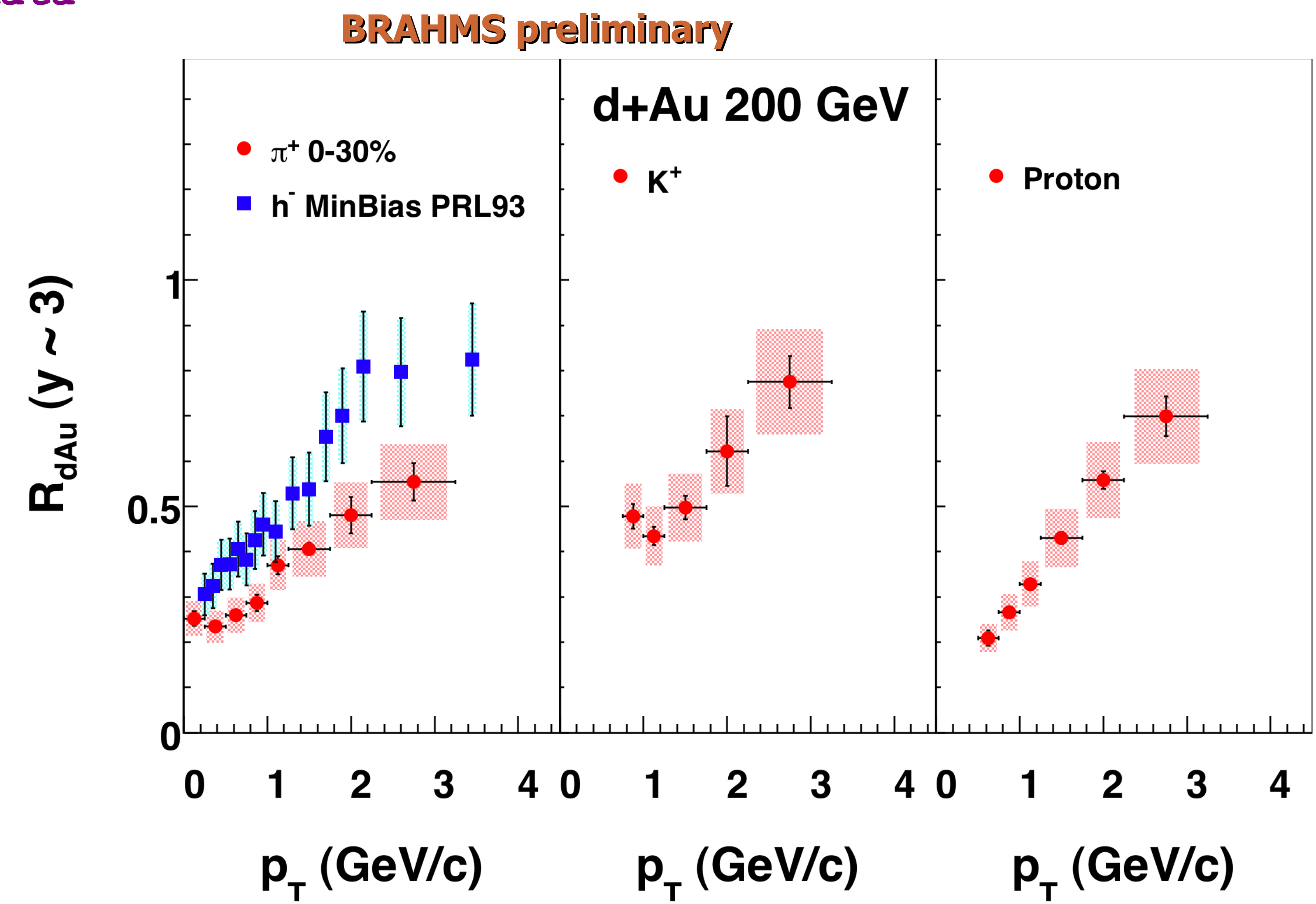
d+Au collisions @ 200 GeV

$$R_{dAu} = \frac{1}{\langle N_{coll} \rangle} \frac{\dfrac{d^2 N^{d+Au}}{dp_T d\eta}}{\dfrac{d^2 N^{p+p}_{inel}}{dp_T d\eta}}$$

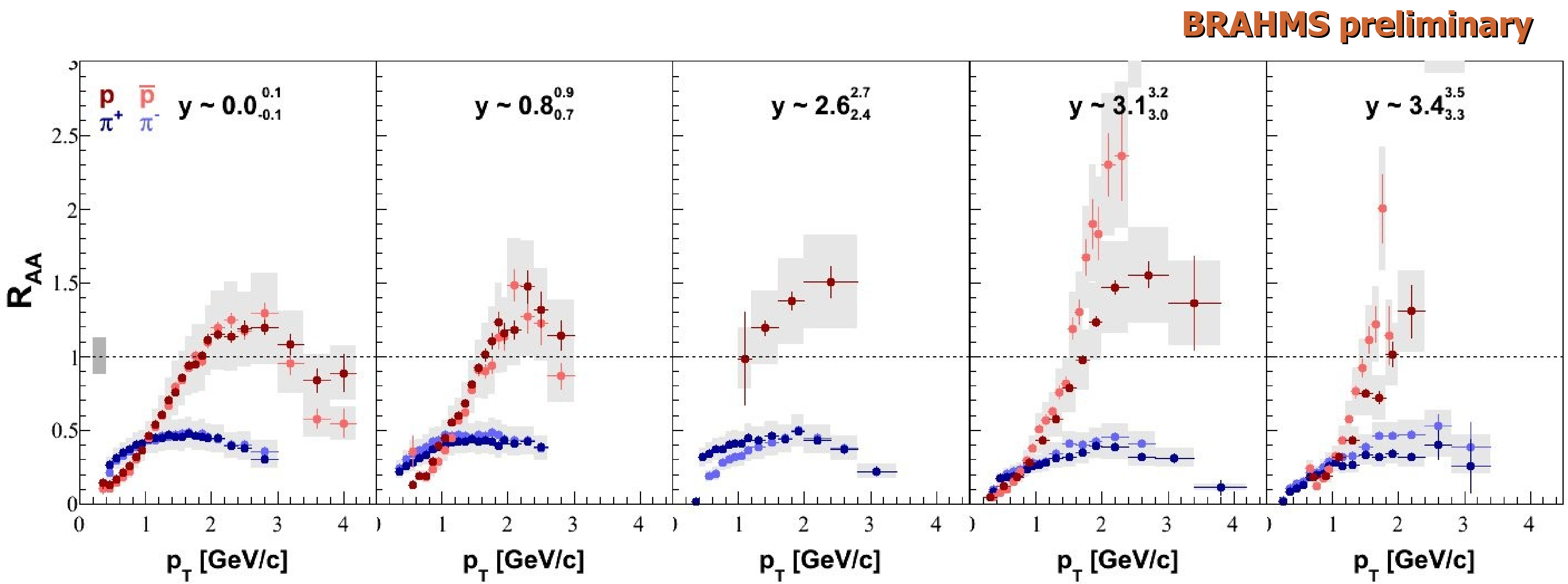
nucelar modification factor

* in the covered transverse momentum interval for all measured positive charged particles $R_{dAu} < 1$

* the suppression is noticed, especially for π^+ data



Nuclear modification factor for Au+Au system @ 200 GeV



* the positive and negative pions are significantly suppressed and no rapidity dependence of nuclear modification in the covered y interval is observed

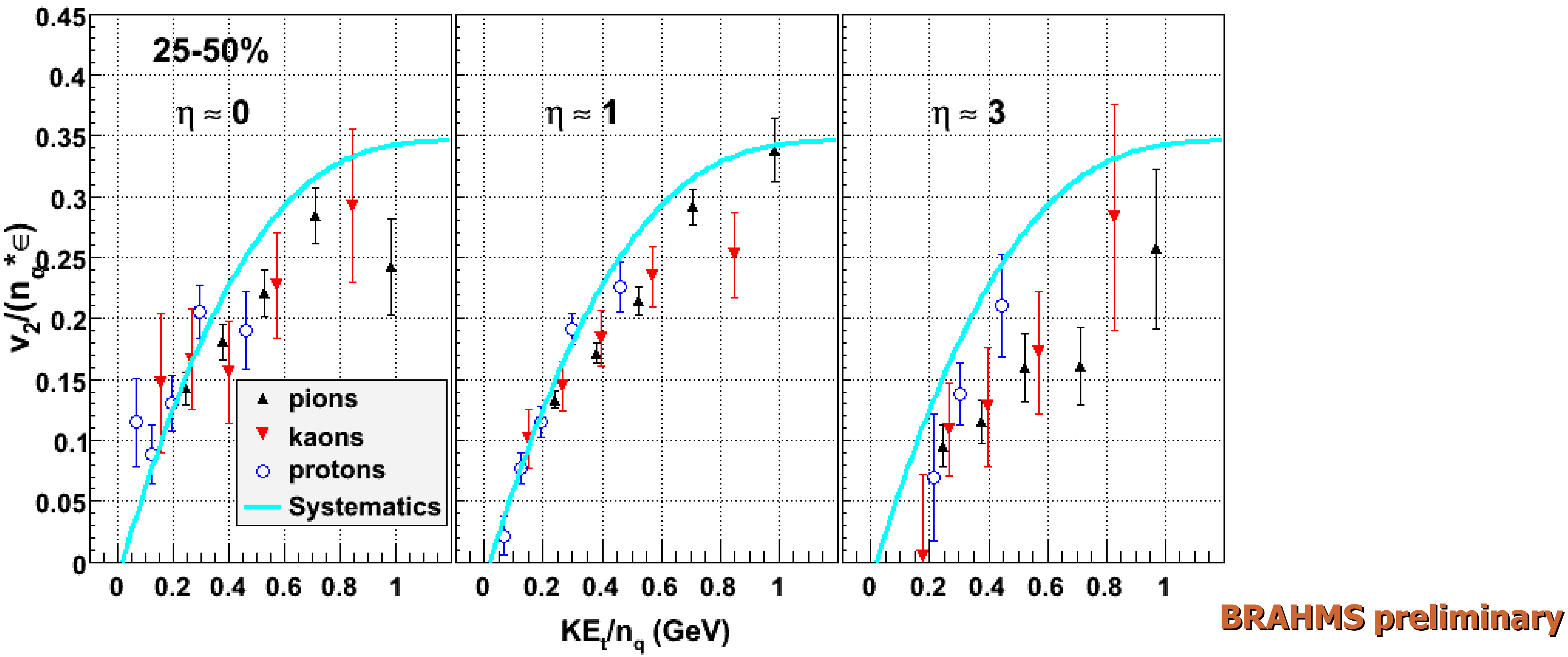
* protons are not suppressed => R_{AuAu} > 1 and slightly depends on rapidity

* the quarks constituent of particles remains

Rapidity dependent elliptic flow for identified hadrons

* the dependence of $\nu_2/\varepsilon n_q(p_T)$ vs. KE/n_q with rapidity is observed
* data compared to the universal systematics for $\nu_2/\varepsilon n_q(p_T)$ at y = 0 for measurements taken at RHIC

* the common trend of perfect fluid features is followed
* at the most forward region a lower value of $\nu_2/\varepsilon n_q(p_T)$ might indicate that other mechanisms are important



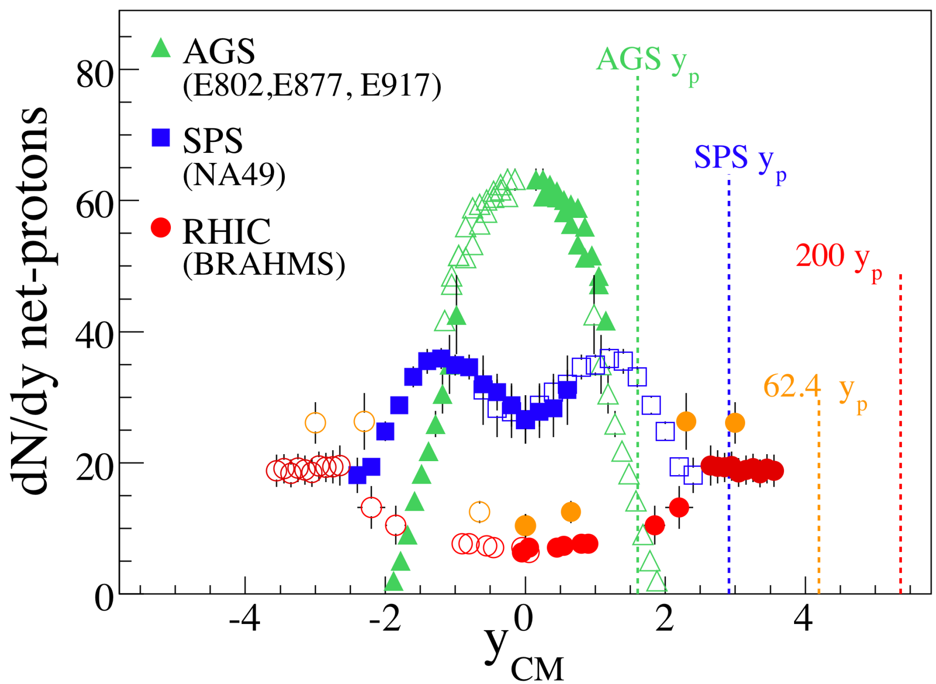
Net-baryon density at RHIC energies

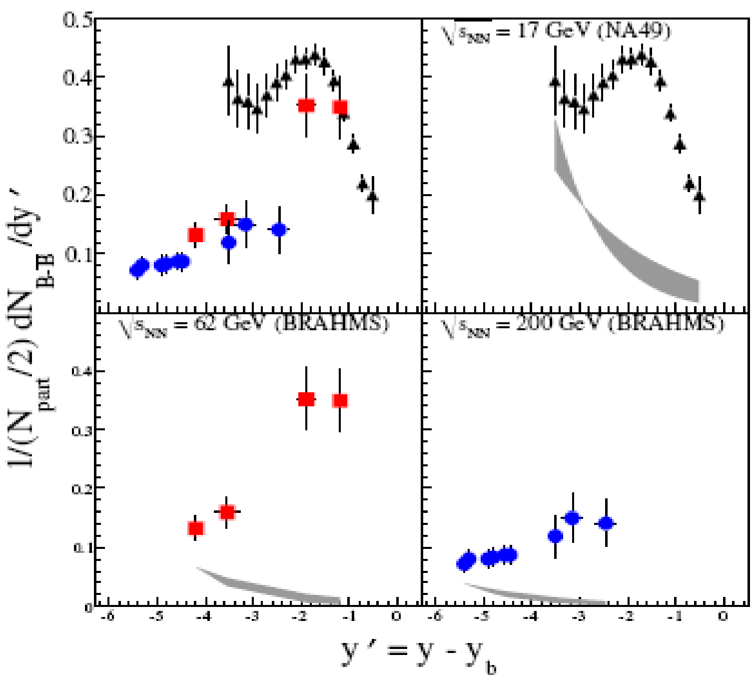
$$\delta E = E_b - \frac{2}{N_{part}} \int_0^{y_b} \langle m_T \rangle \cosh y \frac{dN_{B-\bar{B}}}{dy} dy$$

* while the nuclei are colliding, the nucleons, at first bounded up inside nuclei, loose their kinetic energy:

δE = 21 +/- 2 GeV for Au+Au @ 62.4 GeV
δE = 73 +/- 6 GeV for Au+Au @ 200 GeV

=> this energy is transformed mainly to particle production and transverse longitudinal expansion





* with the assumption that at y = 0 target nucleons comprise half of the net-baryons and at y_{beam} the contribution is negligible, two scenarios are expected:

1) exponential rapidity dependence exp(-y')
2) rapidity dependence with gluon junction component exp(-y'/2)

* the target contribution is estimated as the substraction of the average value from these functions

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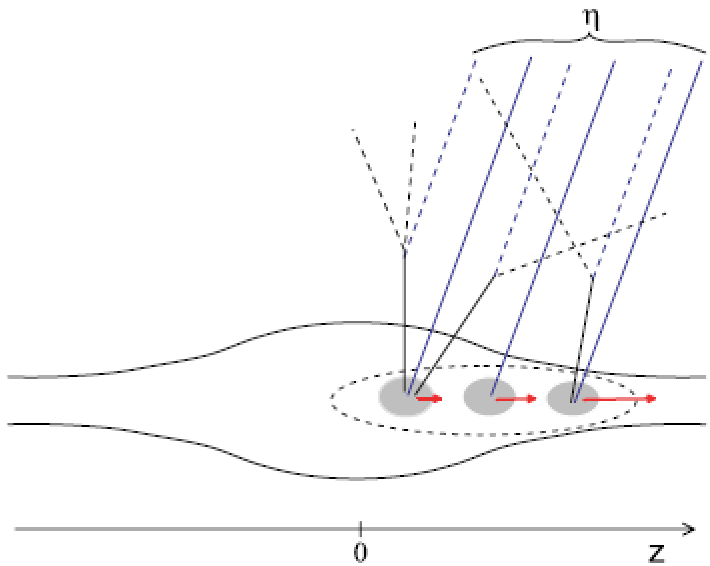
Single freezeout model (with the THERMal heavy IoN generATOR)



* emission of particles from a boost-non-invariant fireball

* well-defined shape of freezeout hypersurface Σ and collective expansion

* at the successive stages of the evolving fireball the particles are generated in the equilibrium of the system

* the velocity field of the collective flow is based on the Hubble flow formula

* the decays of resonances are included

* thermodynamic parameters: baryon (μ_B), strange (μ_S) and related to the third component of isospin (μ_{I3}) and temperature T

* the temperature is set for both chemical and kinematical freezeout T = 165 MeV

* the local net-strangeness conservation is reached