BRAHMS
Progress & Perspective

F.Videbæk
For
The BRAHMS collaboration

The BRAHMS Collaboration

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Brahms Physics Goals

Probing and characterizing Hot and Dense Nuclear Matter by studying:

- Particle Production
- Reaction Mechanisms and Dynamics
- Baryon Stopping
- Hard Processes (high p_t spectra)
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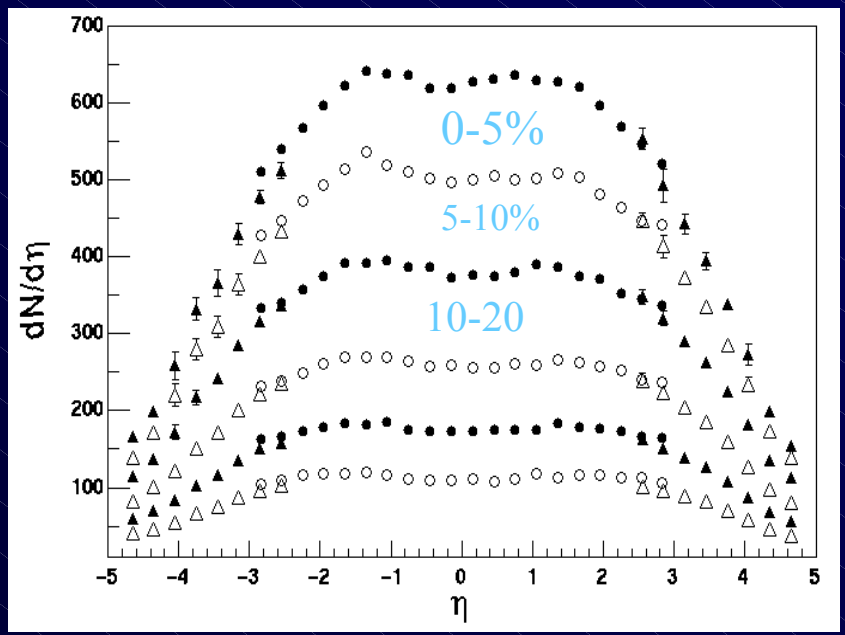
Through High Precision Measurements
of Identified Hadrons over wide range of

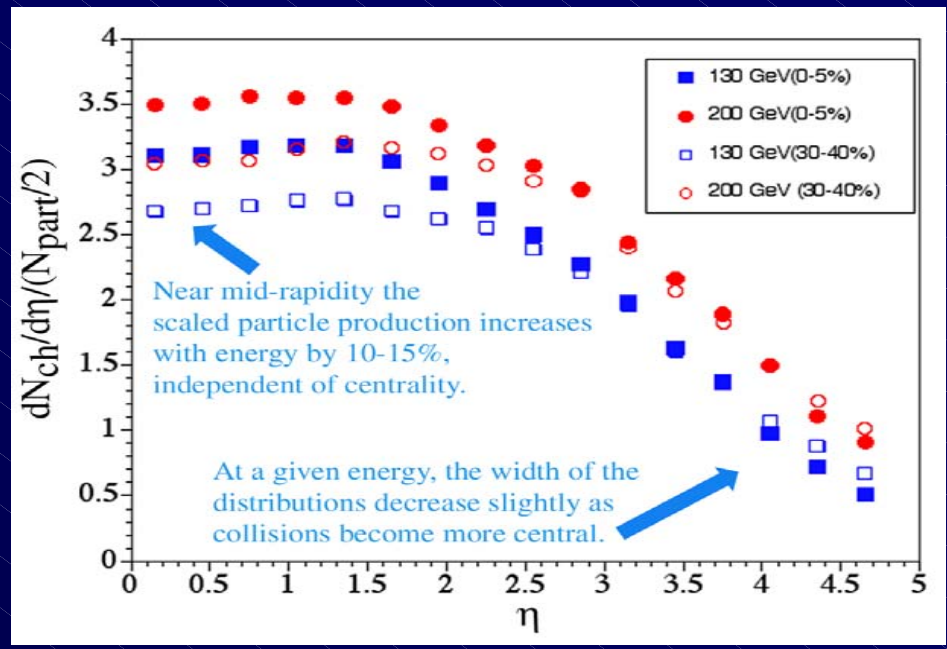
- Rapidity: $0 < y < 4$
  (Central and Fragmentation regions)
- Transverse momentum: $0.2 < p_t < 4$ GeV/*c*

BRAHMS measurement capabilities (PID and momentum) at large y are unique in the RHIC Program. The PID capability at y~0,1 is at par or better than other exp.

Significant progress on the base program is achieved with the Au-Au data from RUN-2, in particular RUN-4 Au-Au, the d-Au, and pp data from Run-3

Multiplicity measurements





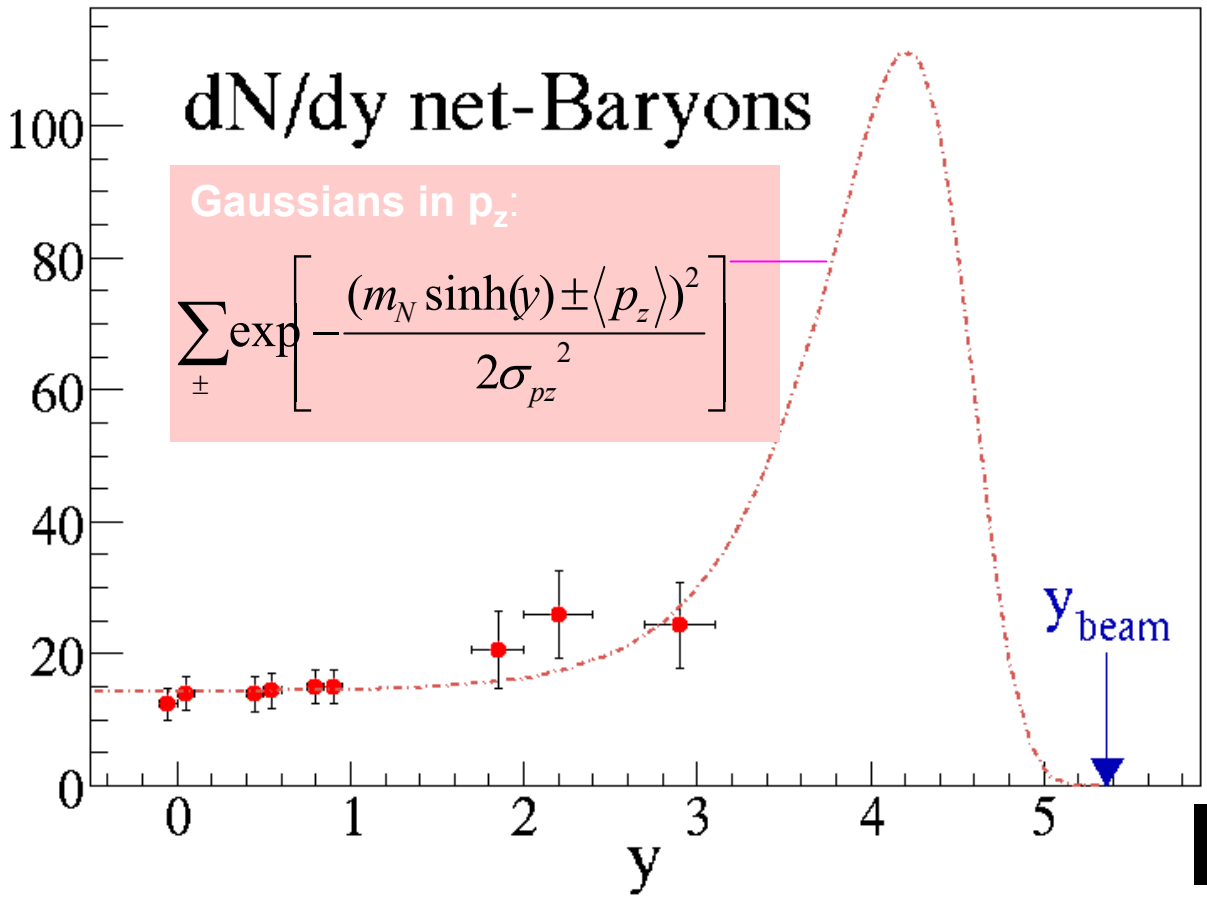
In the Bjorken scenario with t~ 1 fm/c => ε>5 GeV/fm^3

At mid-rapidity dN/dh in Au-Au is significantly enhanced compared to pp. The increase with beam energy is modest.

The present charged-particle pseudorapidity density data can be reproduced by the gluon saturation model.

Nuclear Stopping

Rapidity loss: $\langle \delta y \rangle = y_p - \langle y \rangle = y_p - \frac{2}{N_{part}} \int_0^{y_p} y \frac{dN_{(B-\bar{B})}}{dy} dy$

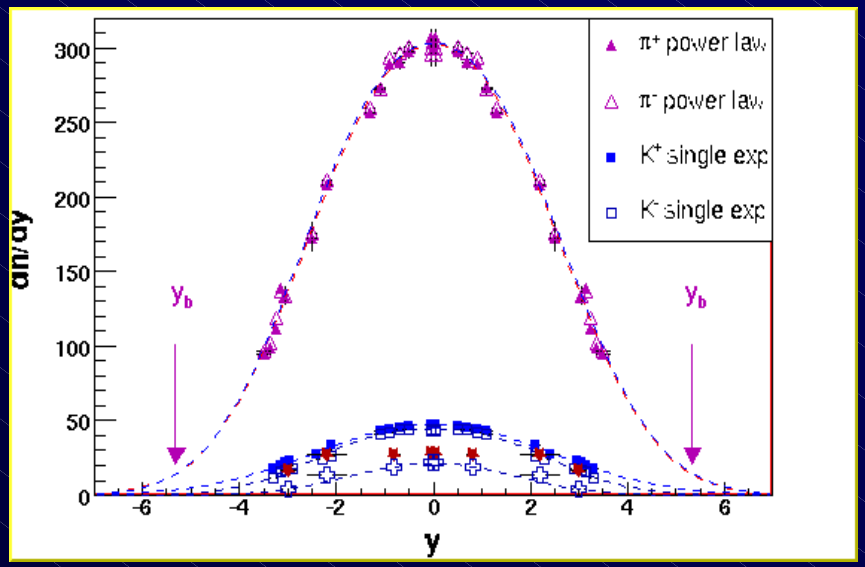


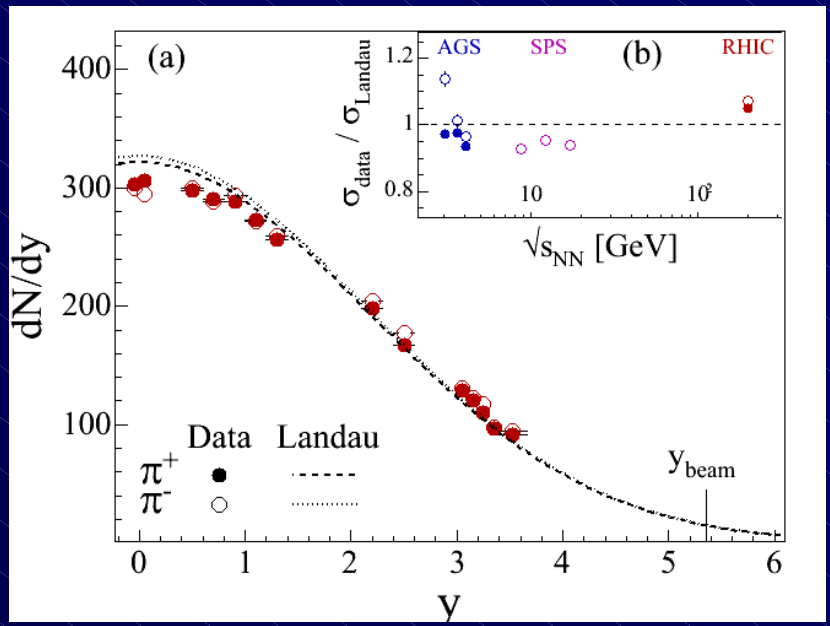
$\langle \delta y \rangle = 2.03 \pm 0.16$

Total $\Delta E = 25.7 \pm 2.1$TeV

-HI collisions are transparent at RHIC
-The finite baryon number at y~0 is important for QCD description of baryon number transport

Meson rapidity distributions





No wide "plateau" observed in rapidity for identified mesons. Close to a Gaussian shape ($\sigma(\pi+)$ =2.35 ~ σ(k+) =2.39) for all produced particles

The RMS of π distributions from low energy to RHIC is close to prediction of Landau Hydro model (Carruthers)

Data from AGS, SPS, RHIC

The agreement with this Landau hydro picture vs. energy is excellent and striking.

Strangeness with Kaons

RAPIDITY DEPENDENCE

Y < 1 : consistent with Hadron Gas Stat. Model

K^+/π^+ : 15.6 ± 0.1 % (stat)

K^-/π^- : 14.7 ± 0.1 % (stat)

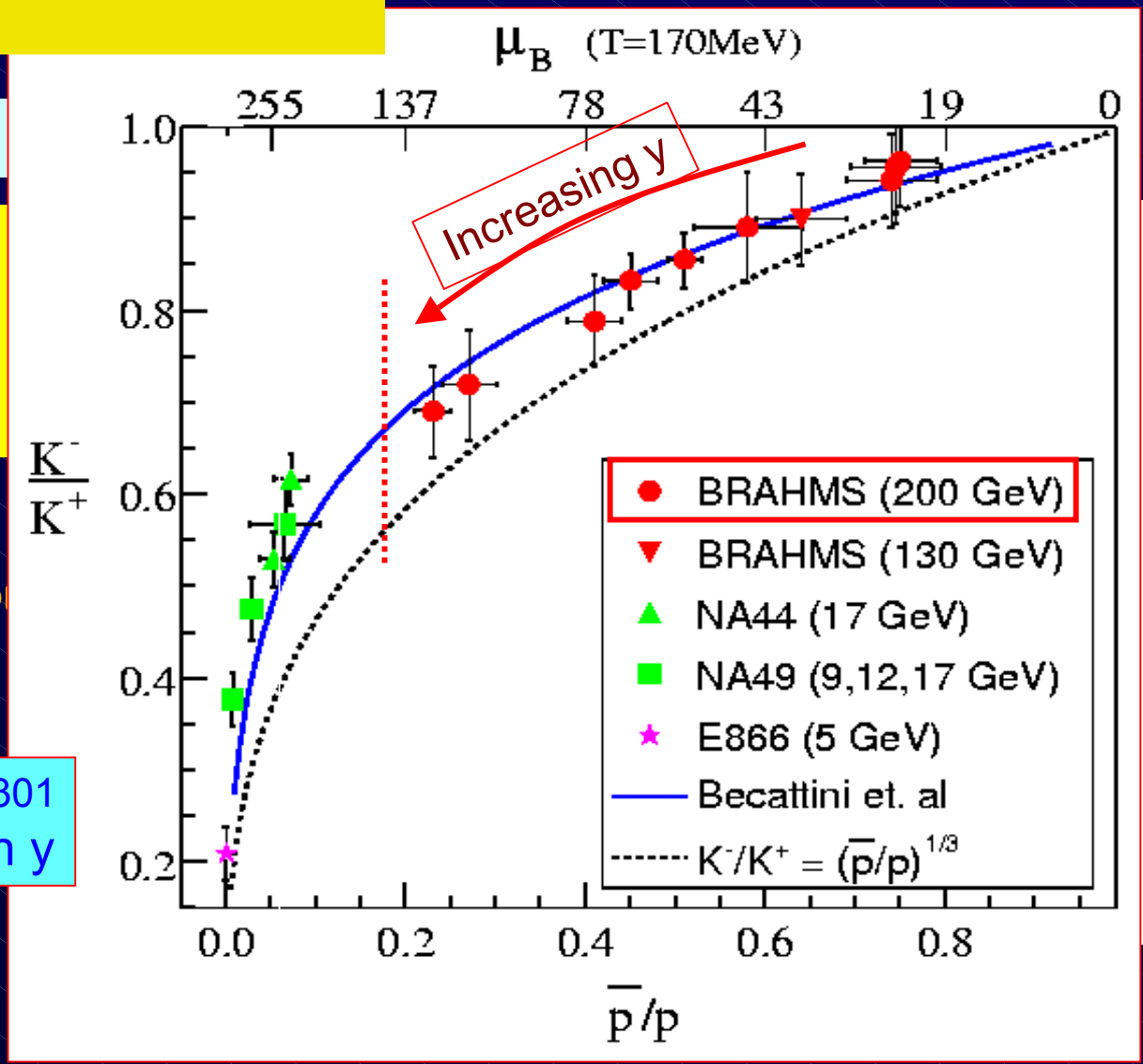
[Phys. Lett. B 518 (2001) 41]

Divergence at higher y : Associated K^+ productio

No single source with unique T and μ_B

BRAHMS, PRL90 (2003) 102301

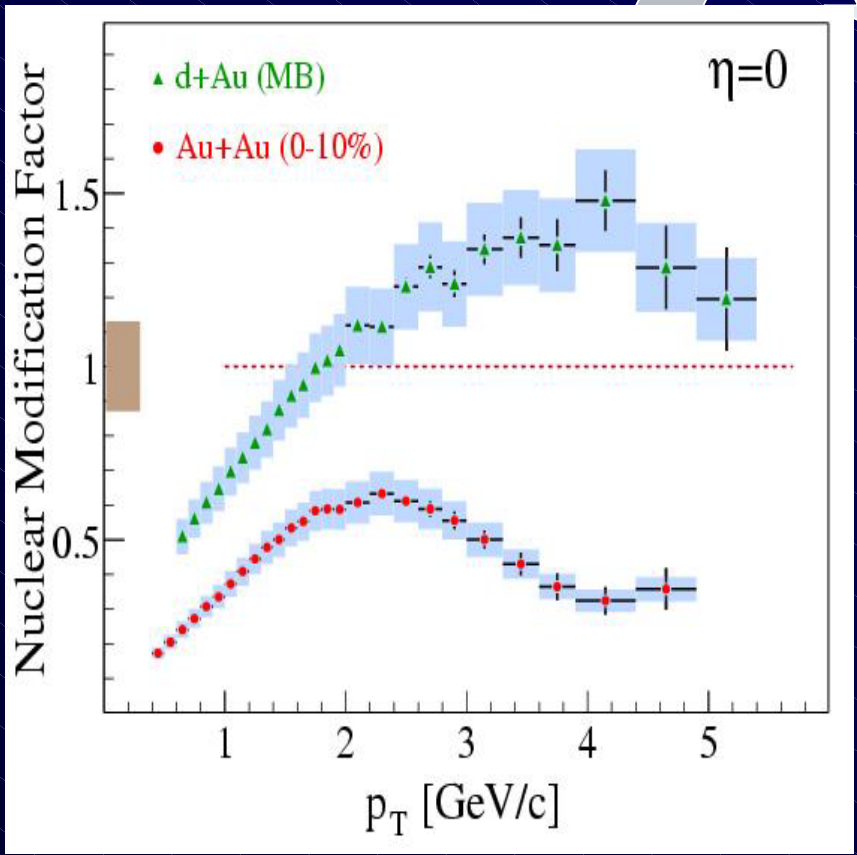
T~constant, μ_B varies with y



Bulk properties

- The estimated energy density from particle production and reaction times is large enough to create energy densities at least ~ 5 GeV/fm**3.
- The longitudinal expansion is, surprisingly, consistent with the Landau picture that also relies on short formation time and a hydrodynamic expansion of the matter formed.
- Composition of particle production (π,K,p) is determined from essentially the μ_B , with an overall rapidity independent freeze-out temperature. Such analysis does not necessarily prove that equilibration has been reached.

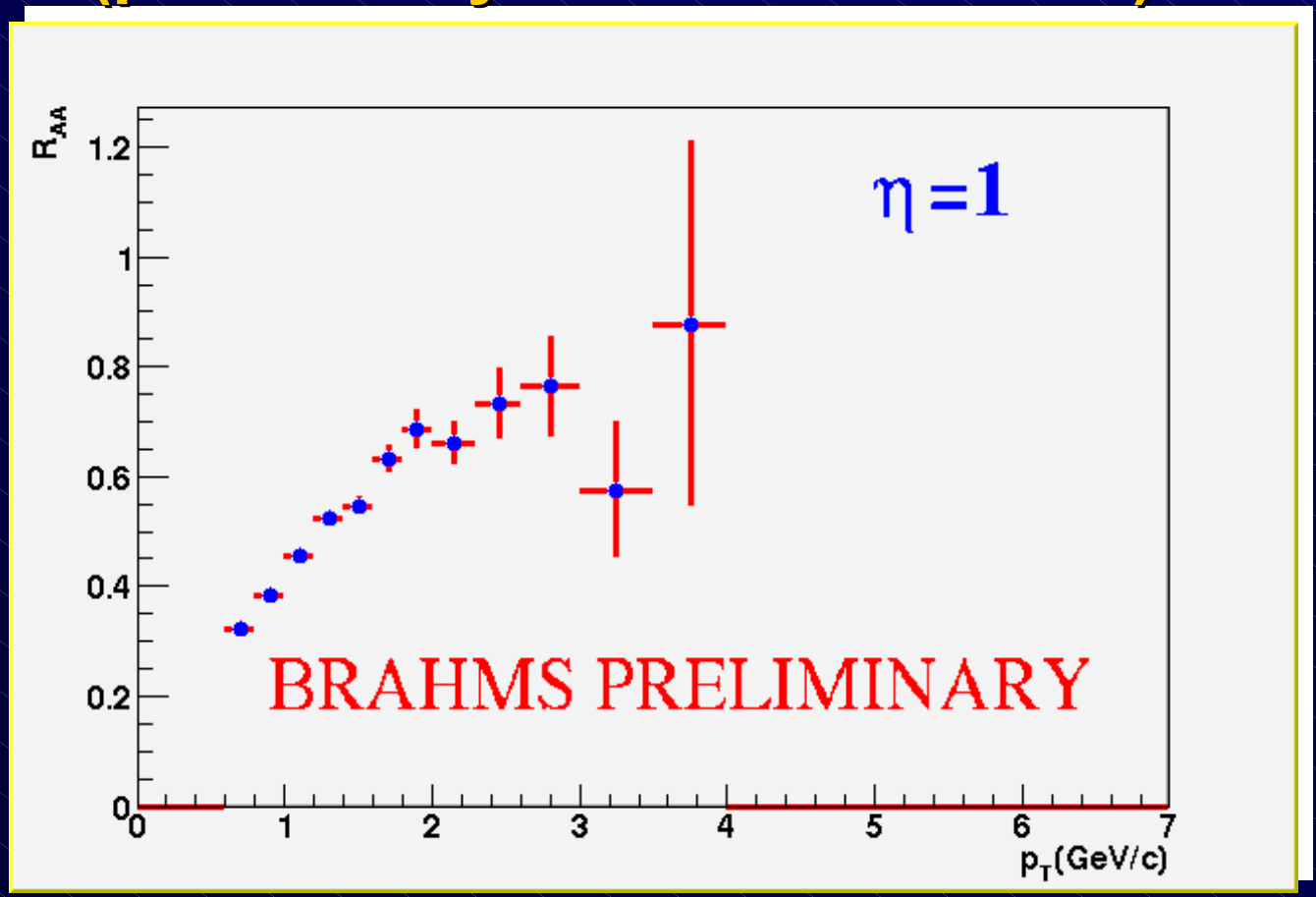
d+Au Nuclear Modification η =0



High p_T enhancement observed in d+Au collisions at $\sqrt{s_{NN}}$=200 GeV consistent with Cronin effect.

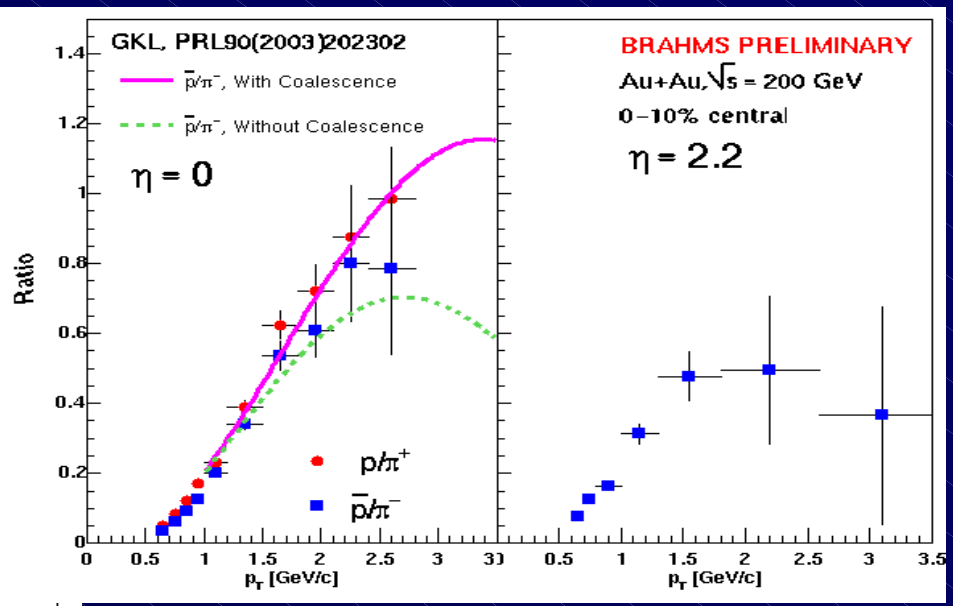
Comparing Au+Au to d+Au
⇒ strong effect of dense nuclear medium

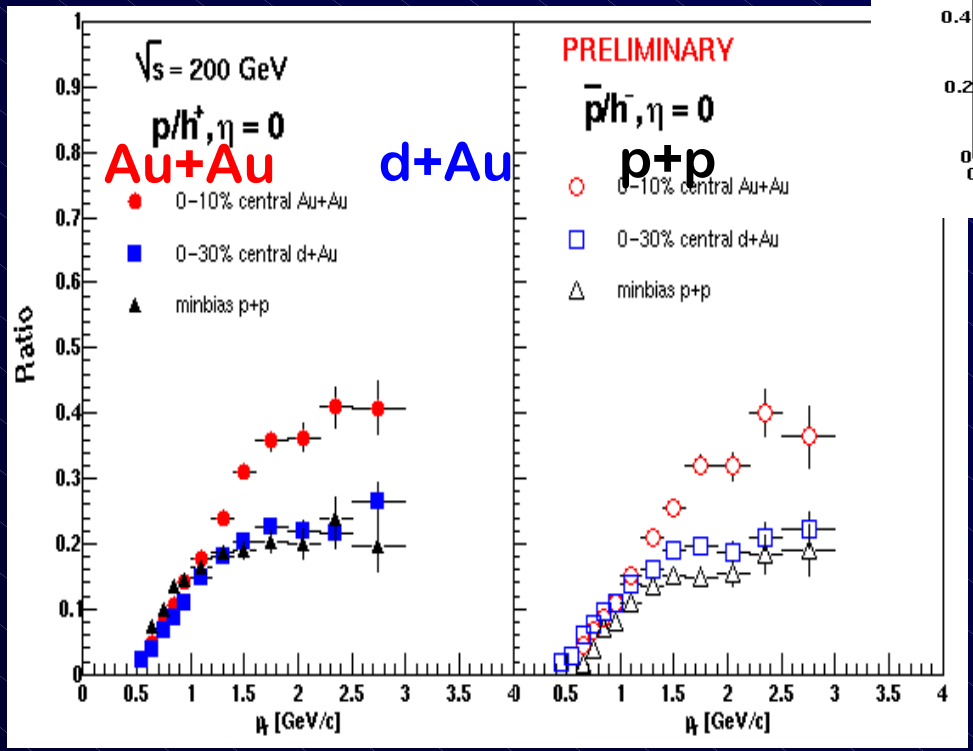
Suppression at Lower Energies (preliminary data from 63 GeV)



Rcp Yield (0-10)% vs (40-60%) scaled by mean number of binary collisions.

pbar/π^- ratio probes extent of dense medium in y



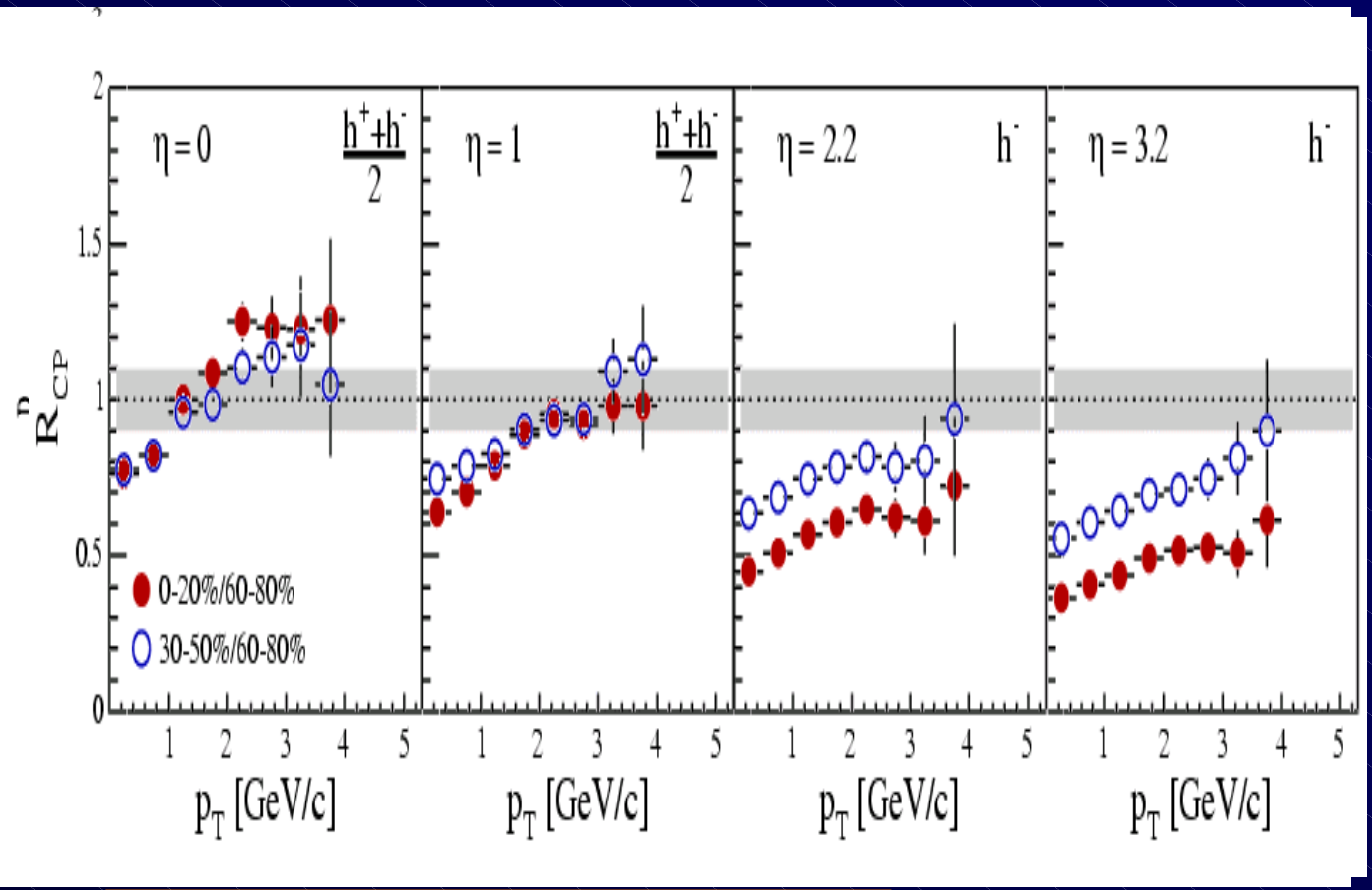


P/π LOWER AT HIGHER RAPIDITIES IN AA WHILE SUPPRESSION PERSISTS.

High-pt

- The high-pt suppression has been firmly established at RHIC AA collisions
  - Suppression of charged particle production at y~0 and 2.
  - Pions are suppressed at large rapidity where the dN/dy is ~ 2/3 of that at mid-rapidity.
  - The onset of suppression is smooth with energy; present at 63, 130 and 200 GeV.
  - Interplay between pre-hadronic (gluonic degrees of freedom) and hadronic absorption/re-scattering in hot system has to be quantified.

R_{dAu}



$$R_{dA} = \frac{1}{\langle N_{coll} \rangle} \frac{d^2N^{d+Au}/dp_T d\eta}{d^2N^{pp}_{inel}/dp_T d\eta}$$

where $\langle N_{coll} \rangle = 7.2 \pm 0.3$

Cronin like enhancement at $\eta=0$.

Clear suppression as η changes up to 3.2

Same ratio made with $dn/d\eta$ follows the low p_T R_{dAu}

Centrality dependence reversed at large η.

Initial State
the color glass condensate ?

- Initial State
  - The particle production is slowly growing consistently with both the parton saturation models, and the slow logarithmic growth in the pp multiplicities.
  - The forward suppression R_{cp}, R_{da} in d-Au collisions shows a reaction picture consistent with the parton saturation in the Au-wawe function.

Summary

The BRAHMS results on rapidity dependence of multiplicities, particle production have shed important light on:

- Energy densities
- High-p_t suppression (2-4 GeV/c) persist to large y.
- Initial state in AA and dA can be described by parton saturation (CGC), albeit not uniquely

The analysis of the large data set from Run-4 and the near-term run with lighter specie(s) will give much more detailed information of the properties of the hot and dense matter created in HI collisions.