BRAHMS overview

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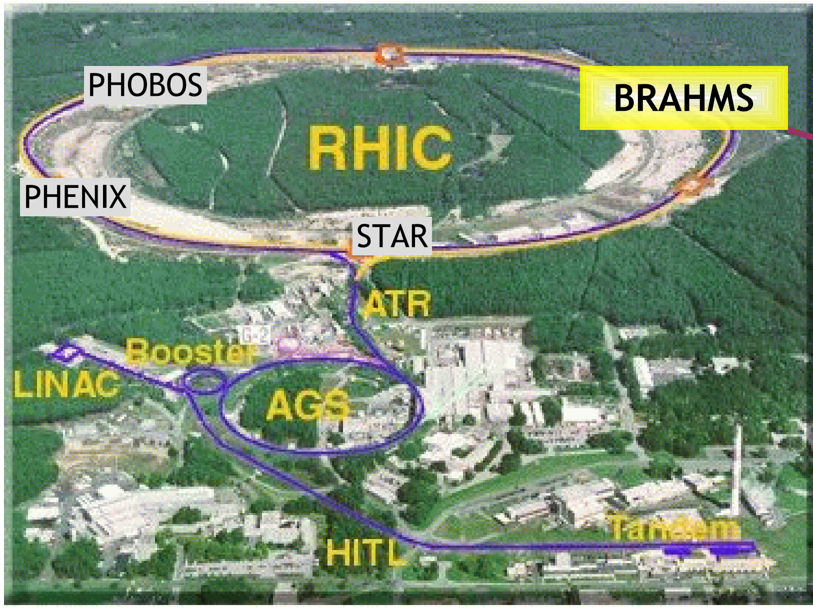
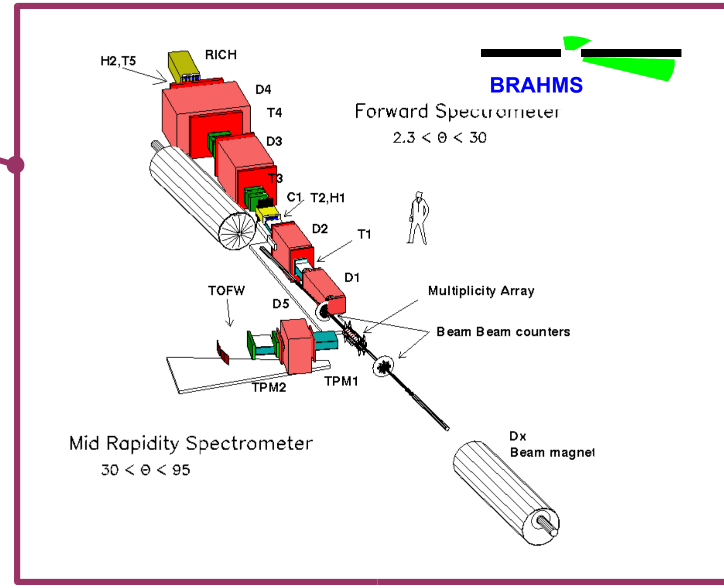
Quark Matter
Budapest, 4 – 9 August, 2005

The Relativistic Heavy Ion Collider

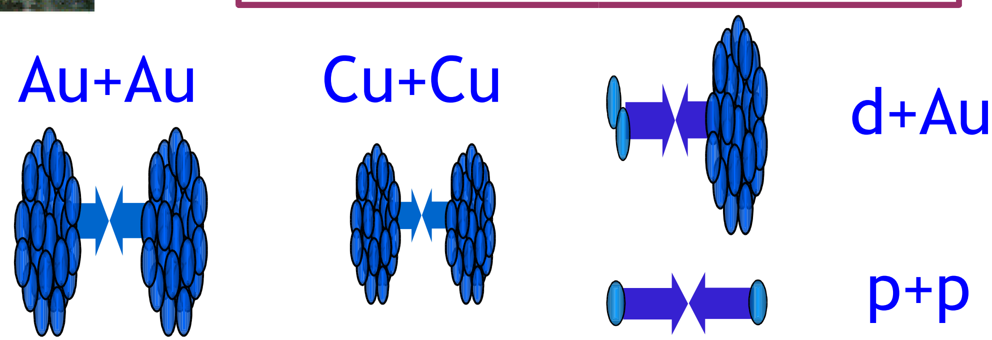




energies:

$\sqrt{s_{NN}}$=200GeV,

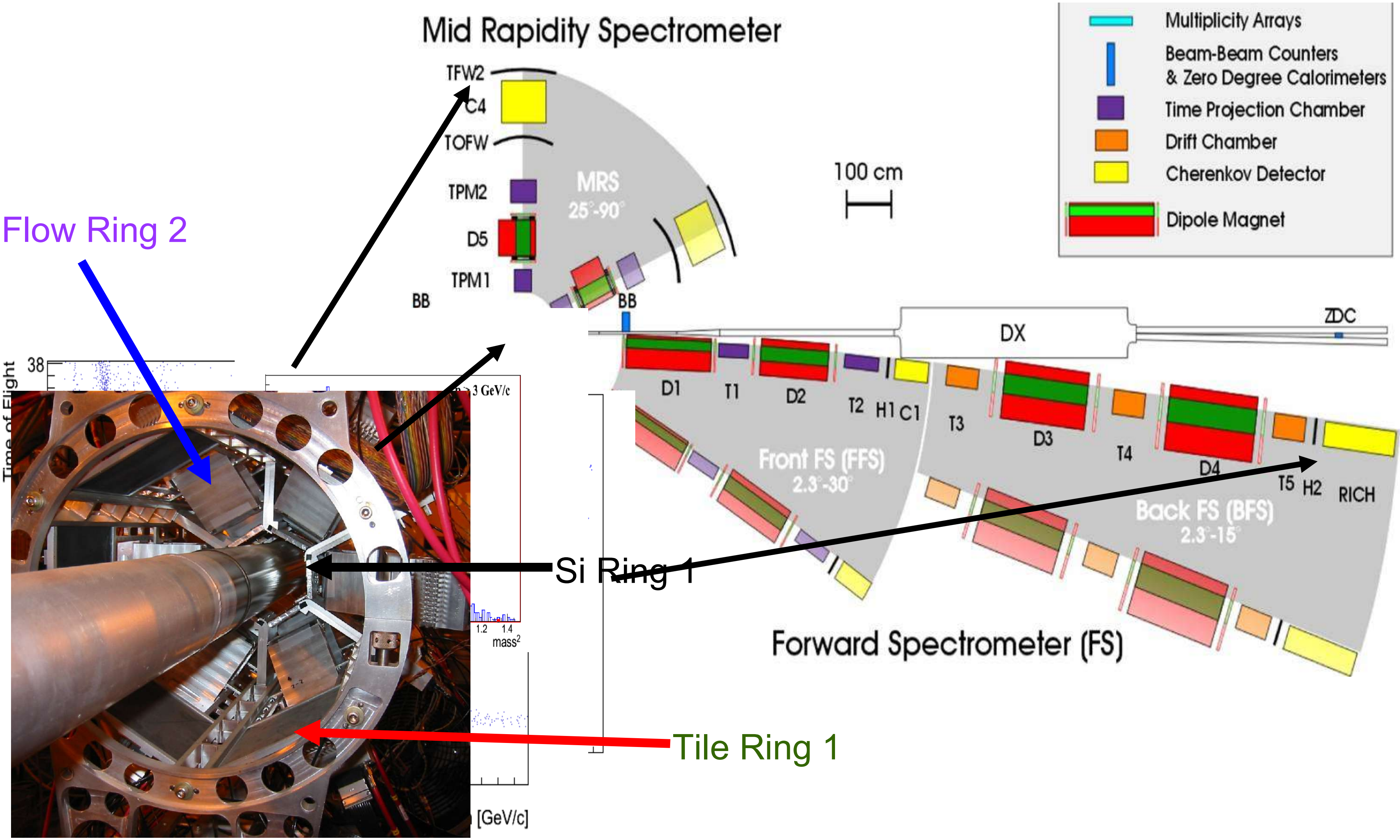
$\sqrt{s_{NN}}$=62GeV



Outline

1. Detector setup.
2. General (bulk) characteristics of nucleus-nucleus reactions.
3. Elliptic flow (for AuAu @ 200).
4. Baryon to meson ratios.
5. High p_T suppression.
6. Summary.

Broad Range Hadron Magnetic Spectrometers



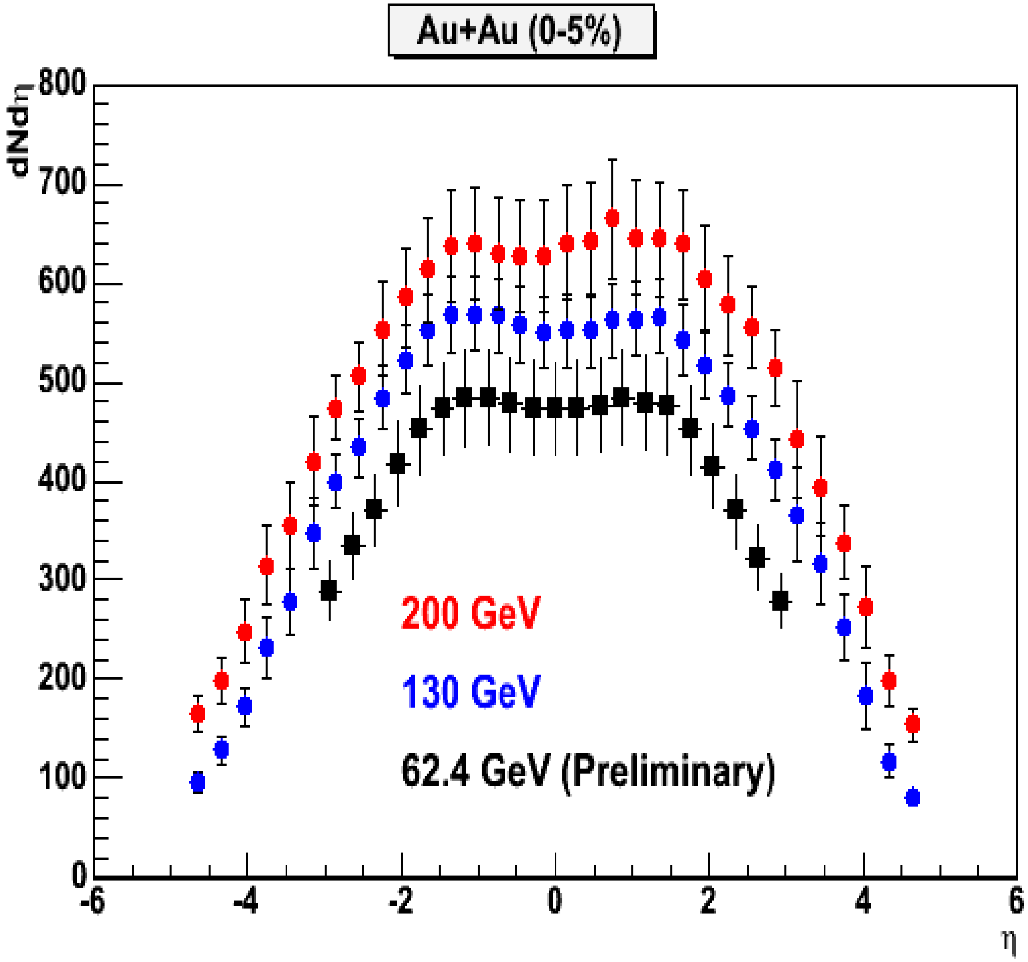
Particle identification summary

	$0<\eta<1$		$1.5<\eta<4$	
2 σ cut	TOFW	TOFW2	TOF1	TOF2
K/π	2.0 GeV/c	2.5 GeV/c	3.0 GeV/c	4.5 GeV/c
K / p	3.5 GeV/c	4.0 GeV/c	5.5 GeV/c	7.5 GeV/c

C4 Threshold (MRS):
∀π / K separation 9 GeV/c

RICH (FS):
∀π / K separation 20 GeV/c
•Proton ID up to 35 GeV/c

Charged Particle Multiplicity



Energy density: Bjorken 1983

e_{BJ} = 3/2 $\times$(<E_t>/ $\pi R^2 \tau_0$) $dN_{ch}/d\eta$

assuming formation time t_0=1fm/c:

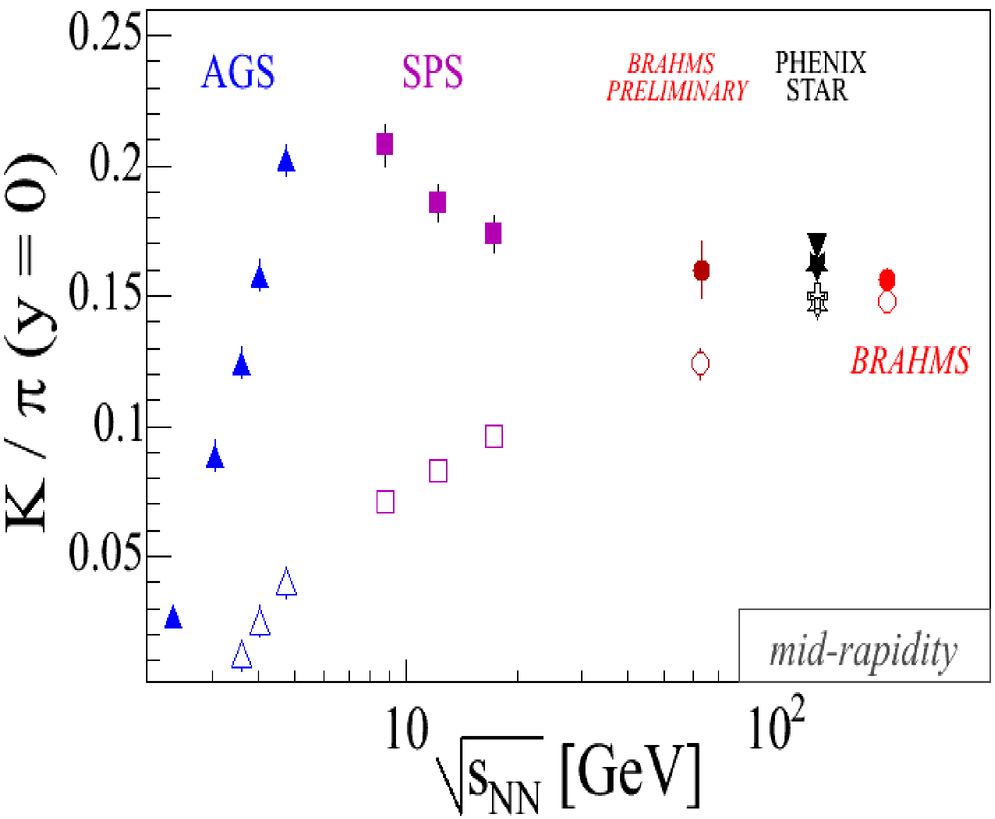
>5.0 GeV/fm^3 for AuAu @ 200 GeV

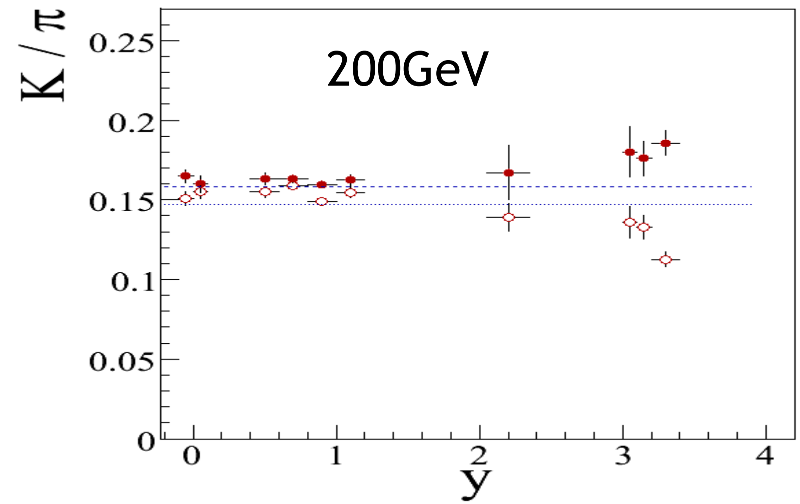
>4.4 GeV/fm^3 for AuAu @ 130 GeV

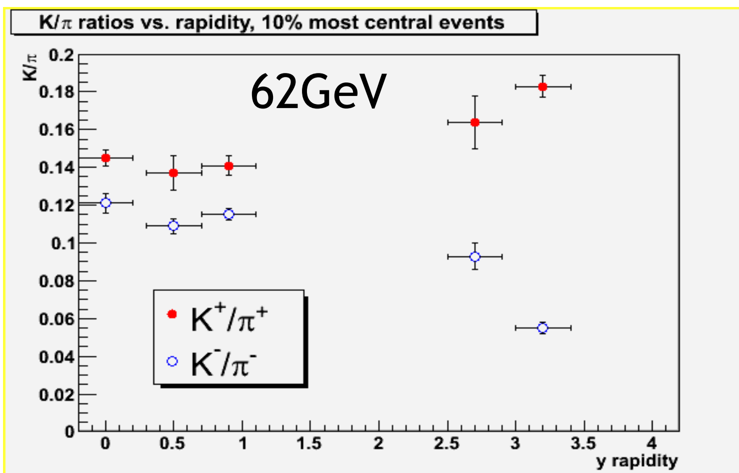
>3.7 GeV/fm^3 for AuAu @ 62.4 GeV

K/π energy dependence, AuAu

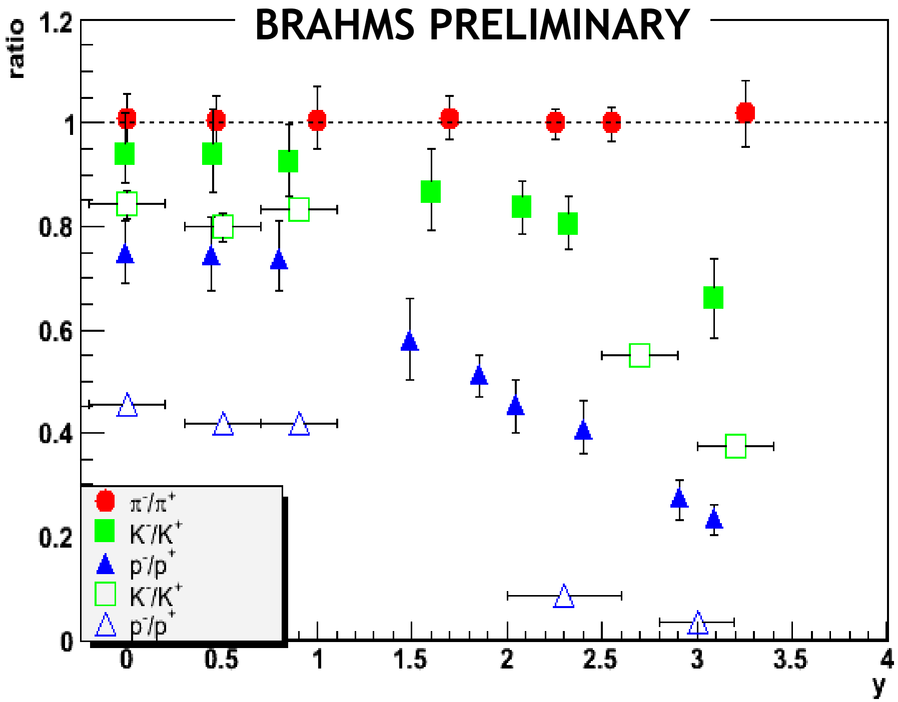
Ionat Arsene, poster #126

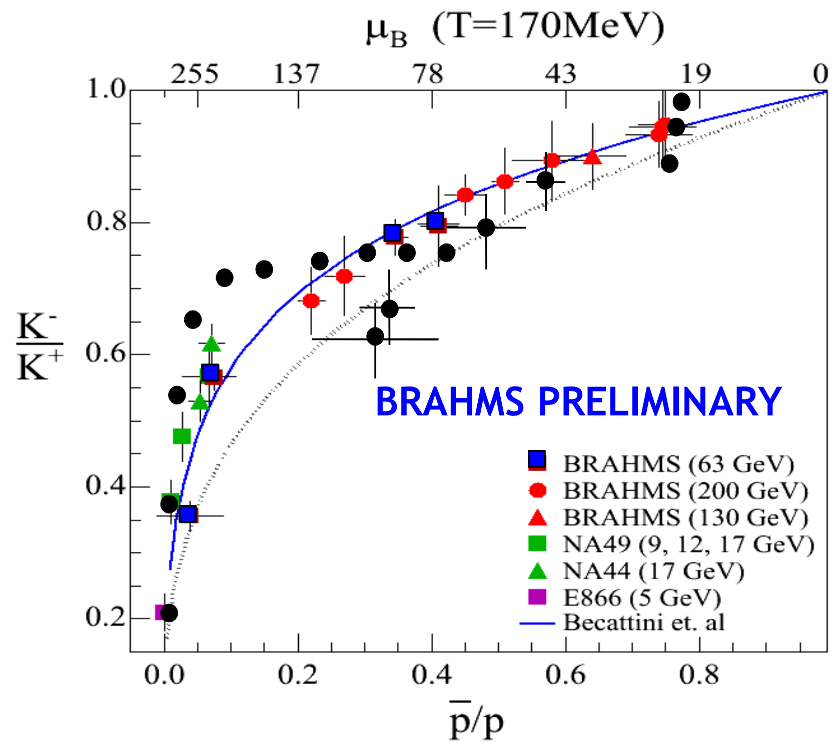






Anti-particle to particle ratios $\Rightarrow$ Chemical freeze-out





- **At 200 GeV:** π^-/π^+ = 1.0, K^-/K^+ = 0.95, pbar/p = 0.75
- **At 62 GeV:** π^-/π^+ = 1.0, K^-/K^+ = 0.84, pbar/p = 0.45,
- At |y|<1 matter⇔antimatter

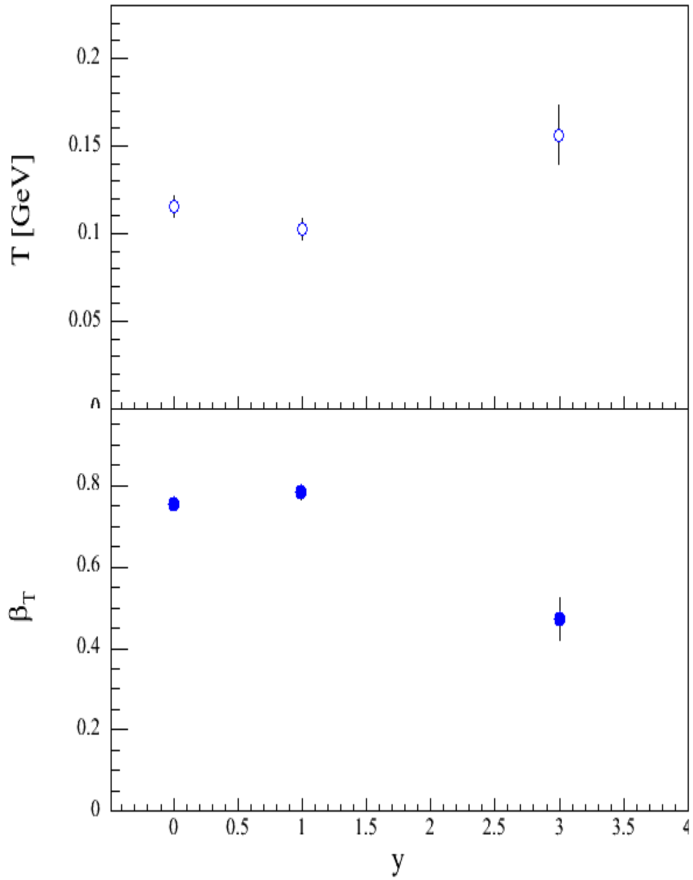
- pbar/p verus K^-/K^+ : good statistical model description with $\mu_B = \mu_B(y)$ with T~170MeV
- But this describes also energy depencency at y=0 $\Rightarrow$ only μ_B controls the state of matter
- STAR and NA47 measures pbar/p versus Ξ^-/Ξ^+

It is not true for p+p

Kinetic freeze-out: AuAu @ 200GeV

BRAHMS preliminary

- Flow velocity increases with centrality.
- Temperature decreases with centrality.



Comparing 200GeV and 62GeV data
In the same N_{part} bin, we see reduction in flow by ~10% and no change in T

the same anti-correlation is observed versus y:

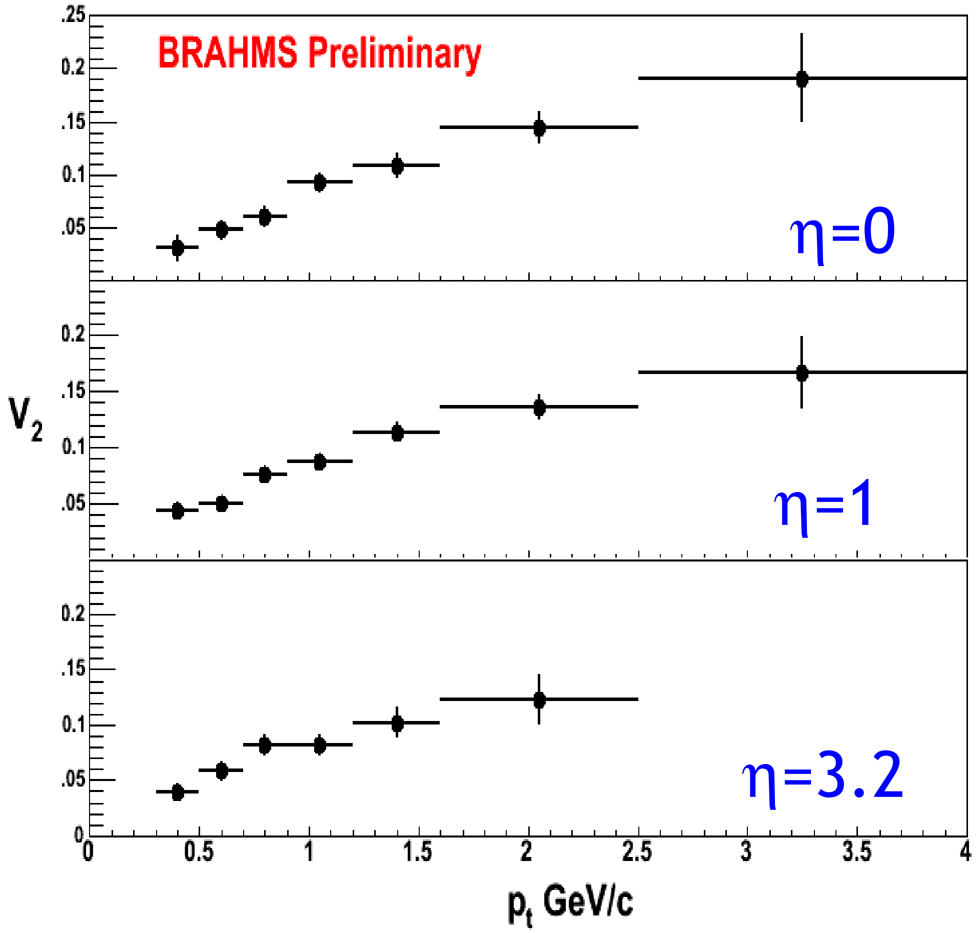
- Flow velocity decreases with rapidity.
- Temperature increases with rapidity

Lower density ⇒
lower pressure ⇒ less flow
faster freeze out ⇒ higher temperature

Oana Ristea poster #50

Elliptic flow (v2) AuAu @200GeV

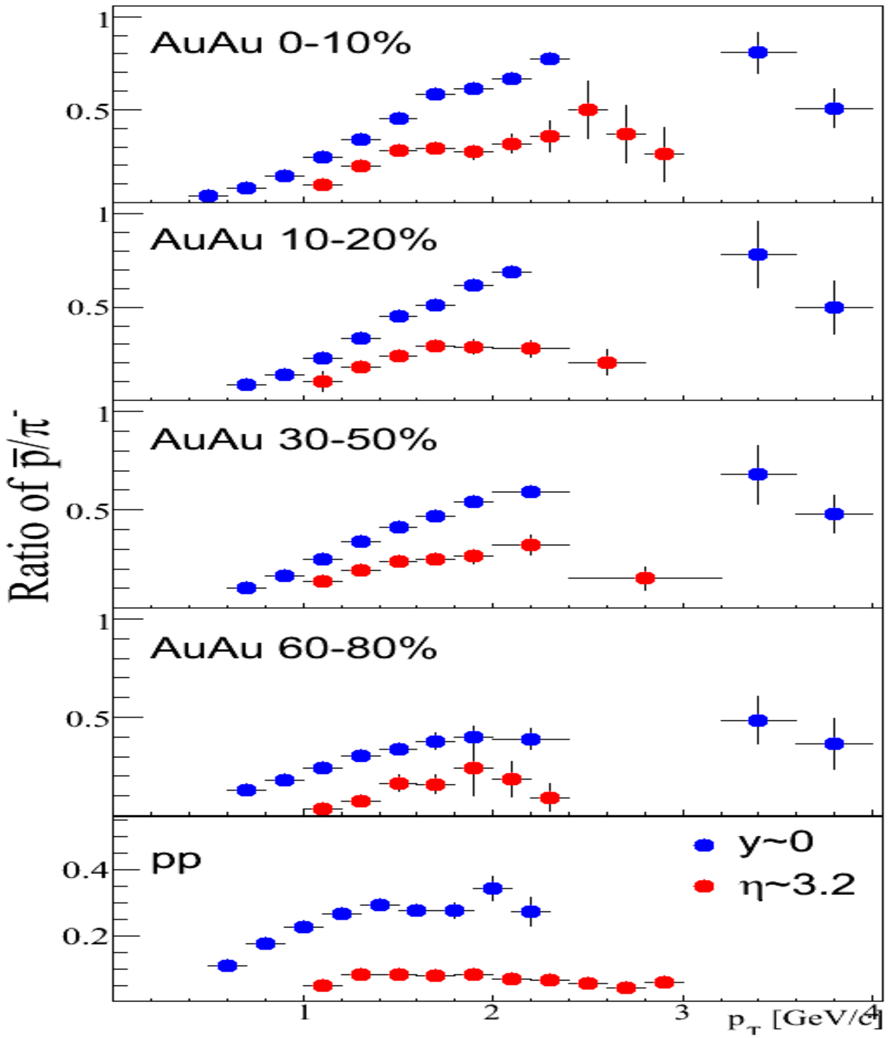
$$\frac{dN}{d\eta dp_t d\varphi} = \frac{dN}{d\eta dp_t}\frac{1}{2\pi}(1 + 2v_1\cos\varphi + 2v_2(\eta,p_t)\cos2\varphi)$$



No $v_2(p_T)$ rapidity dependence

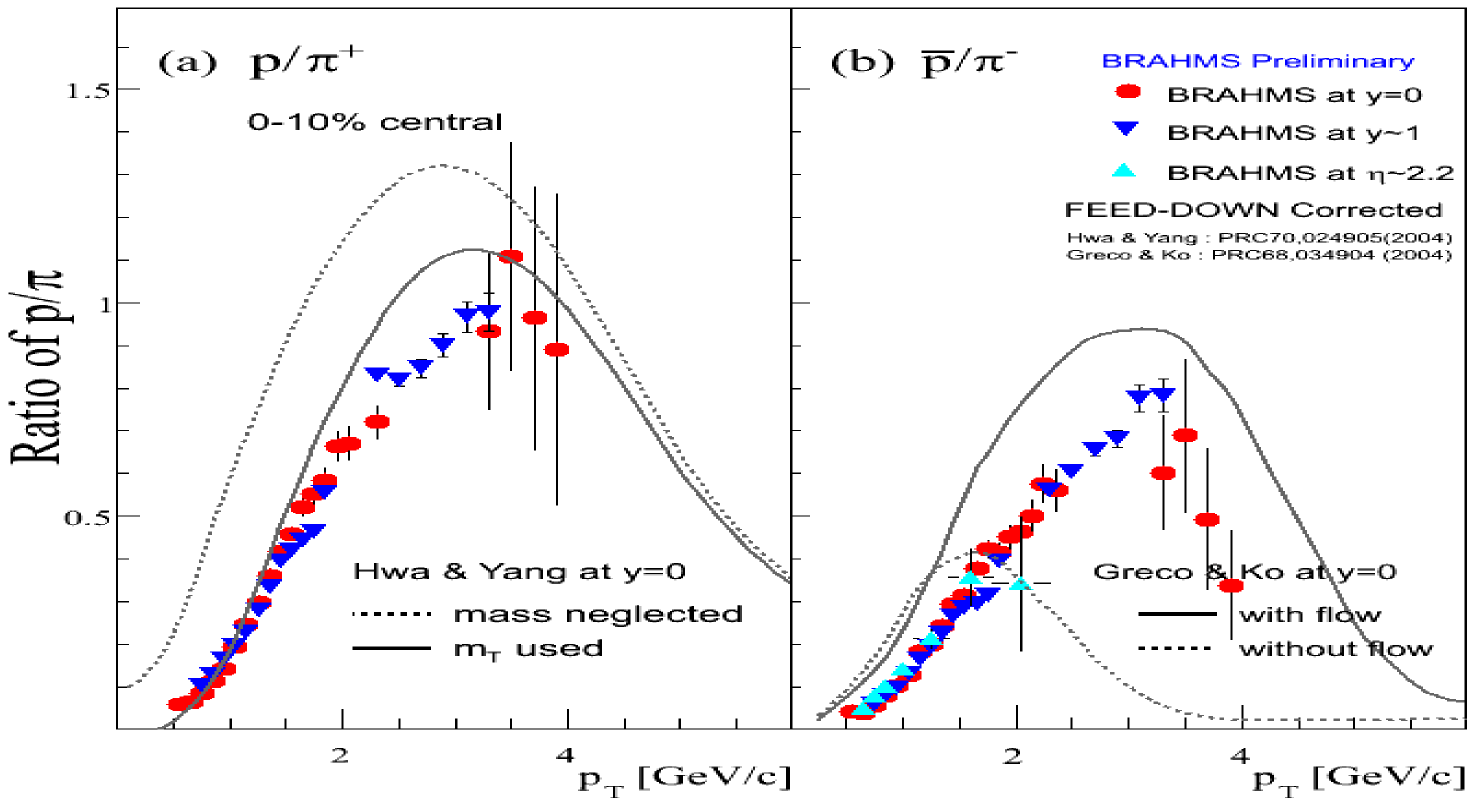
Hiro Ito, parallel sem. 2b, Fri.

pbar/π^- ratios vs. centrality and η (parton recombination)



- Smooth increase from peripheral to central in AuAu at $\sqrt{s_{NN}}$ = 200 GeV
- Centrality dependence is stronger at midrapidity than forward rapidity
- The maximum is shifted to low p_T at forward rapidity

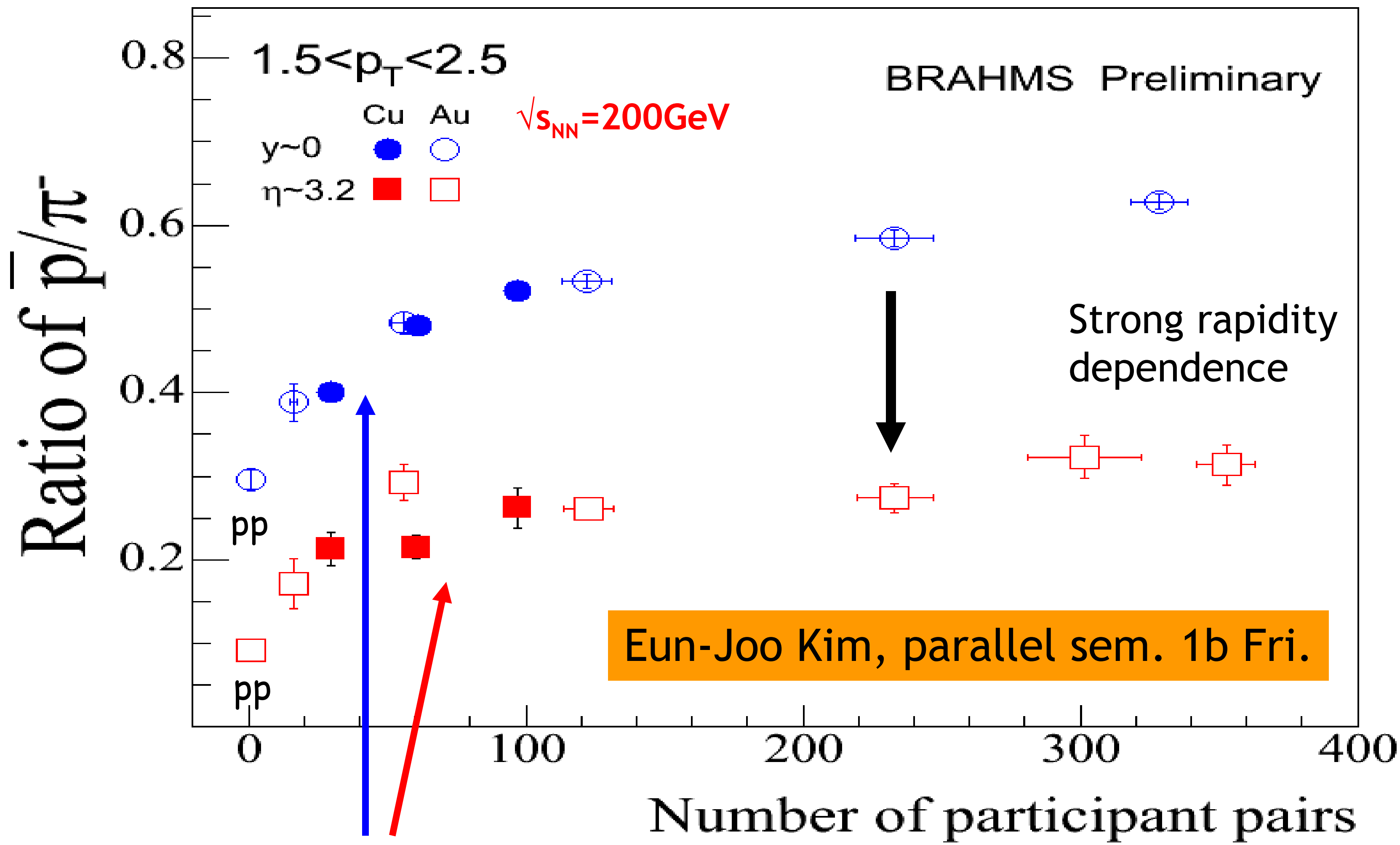
p/pi ratios vs p_t (parton recombination, hydro)



no significant difference between y=0 and y~1

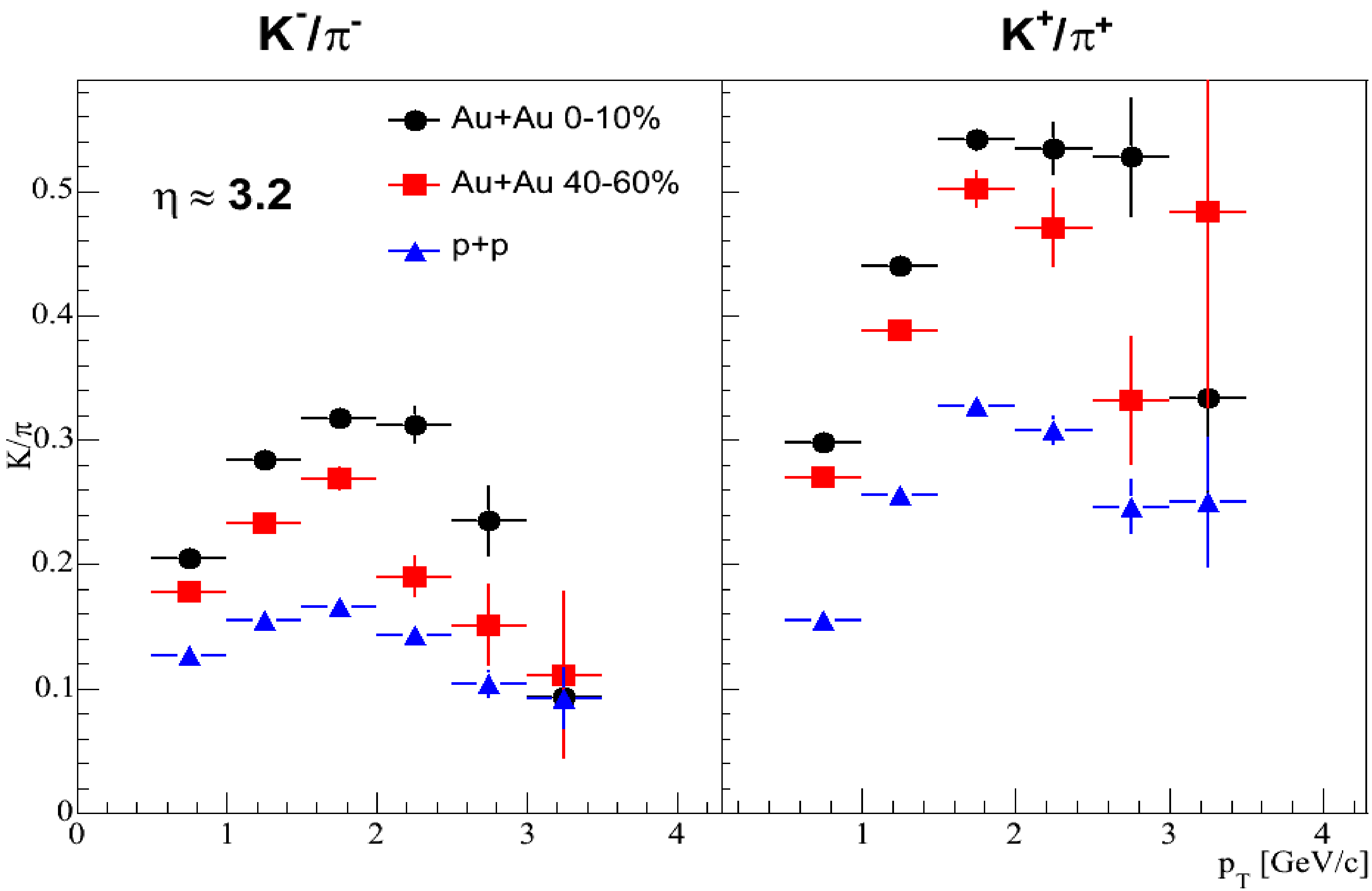
flow/mass effect ?

pbar/π^- scaling with N_{part}



CuCu data consistent with AuAu for the same N_{part}

K/π ratios at η=3.1, Au+Au @200GeV



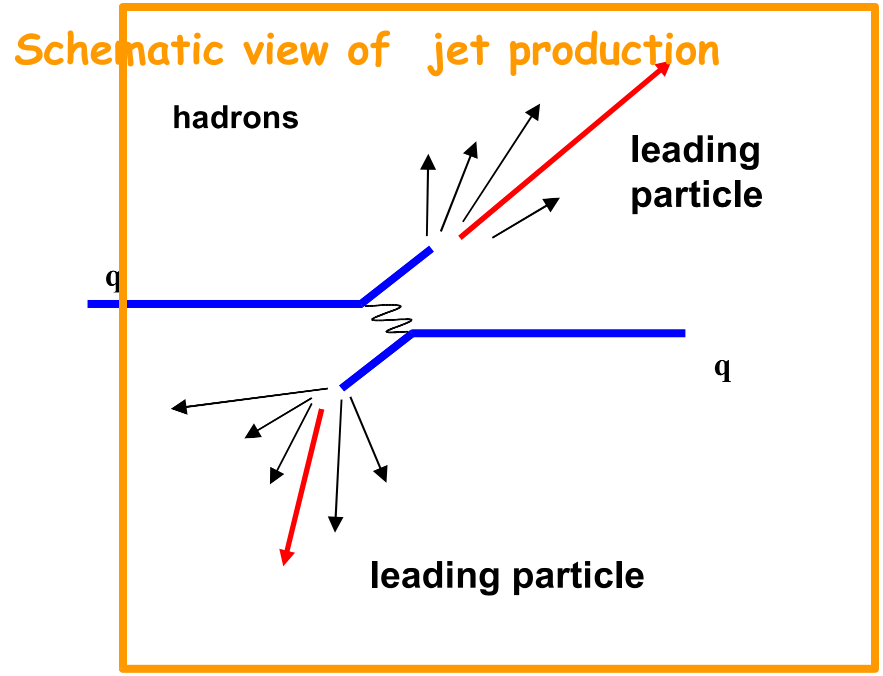
High p_t Suppression & Jet Quenching

Particles with high p_t's (above ~2GeV/c) are primarily produced in hard scattering processes early in the collision

p+p experiments $\rightarrow$ hard scattered partons fragment into jets of hadrons

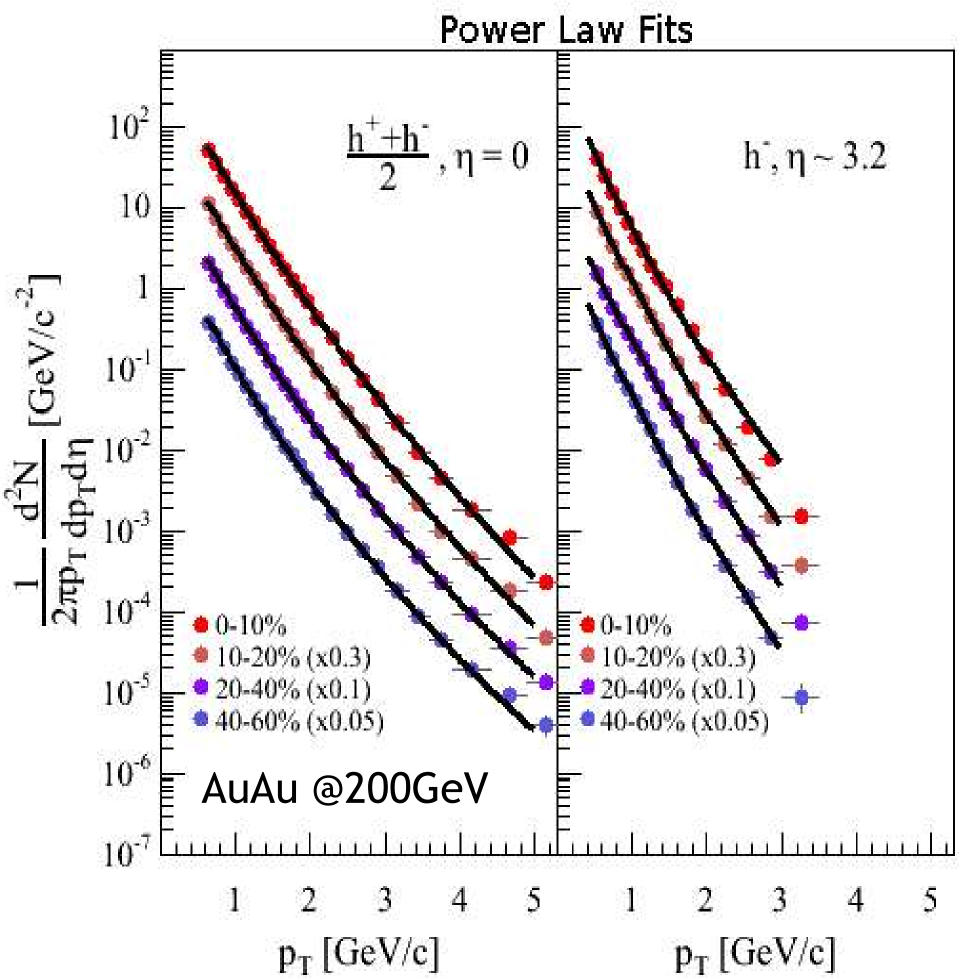
In A-A, partons traverse the medium
$\rightarrow$ Probe of the dense and hot stage

If QGP $\rightarrow$ partons will lose a large part of their energy (induced gluon radiation)
$\rightarrow$ suppression of jet production
$\leftrightarrow$ Jet Quenching



Experimentally $\rightarrow$ depletion of the high p_t region in hadron spectra

Charged hadron invariant spectra



Nuclear Modification Factor

$$R_{AA} = \frac{\text{Yield(AA)}}{N_{COLL}(AA) \times \text{Yield(NN)}}$$

Scaled N+N reference

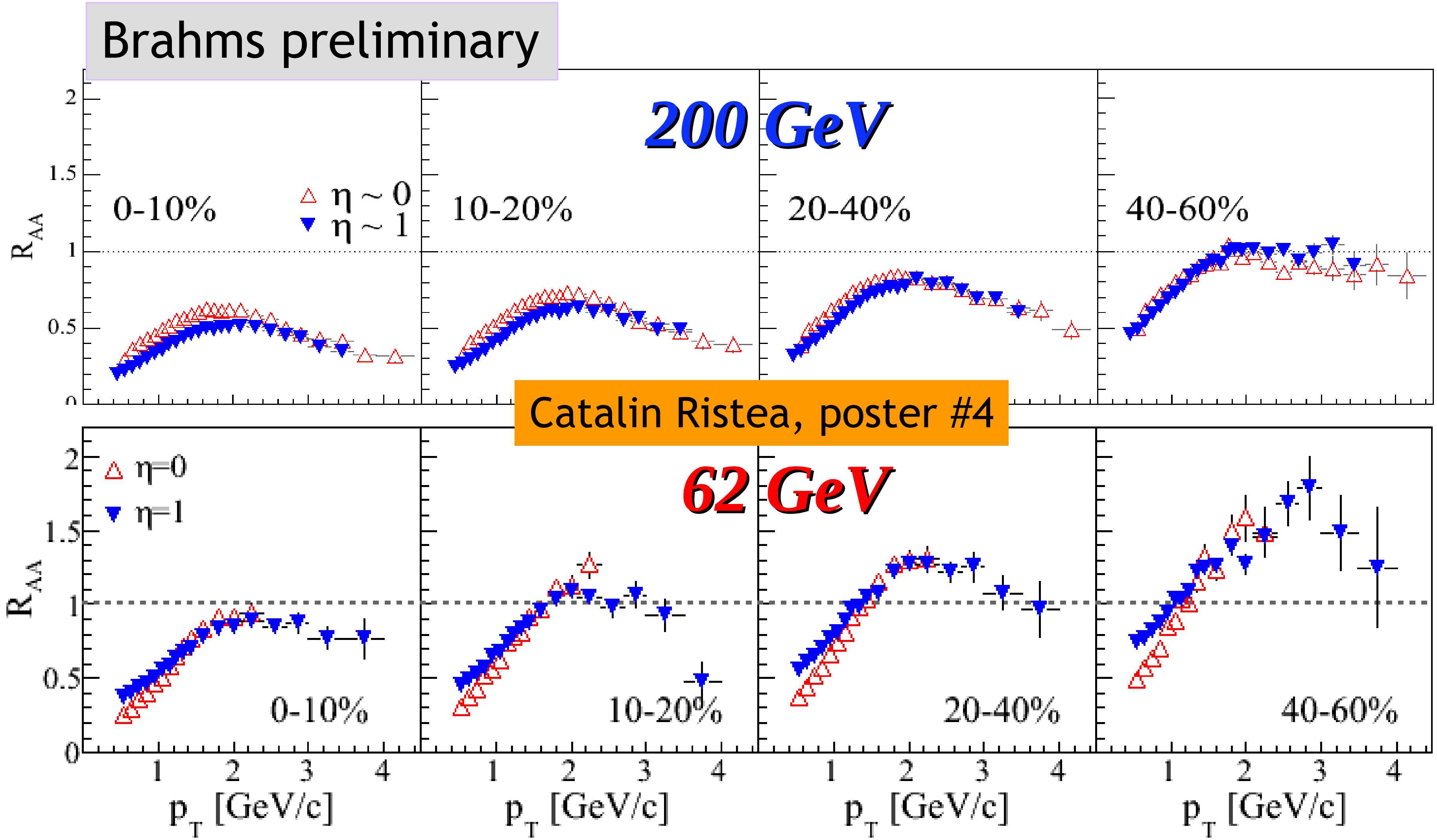
$R_{AA}<1 \leftrightarrow$ Suppression relative to scaled NN reference

SPS:

data do not show suppression enhancement ($R_{AA}>1$) due to initial state multiple scattering ("Cronin Effect")

$$R_{CP} = \frac{\text{Yield(0-10\%)}/N_{COLL}(0\text{-}10\%)}{\text{Yield(40-60\%)}/N_{COLL}(40\text{-}60\%)}$$

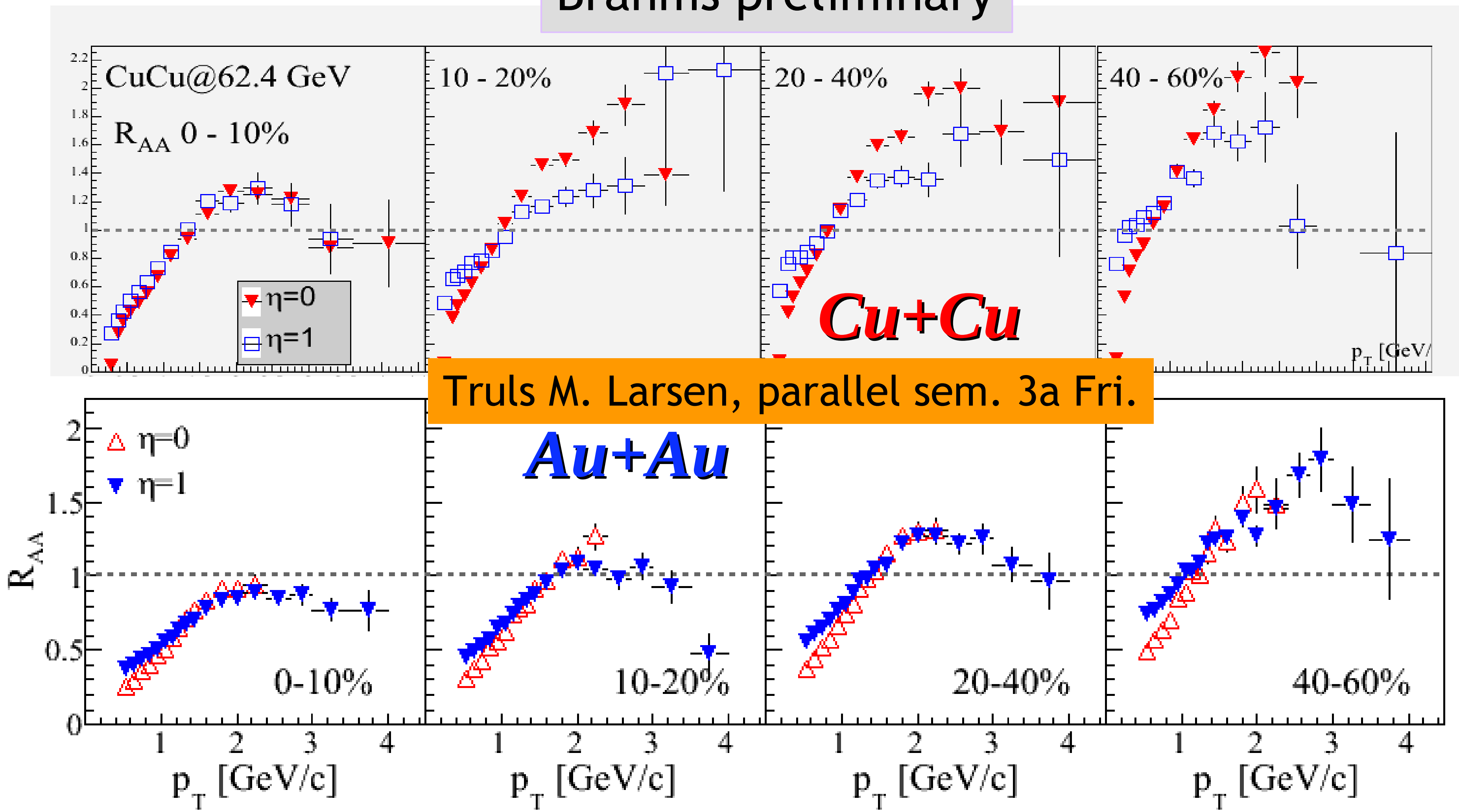
Au+Au: comparison 200 GeV between 62 GeV



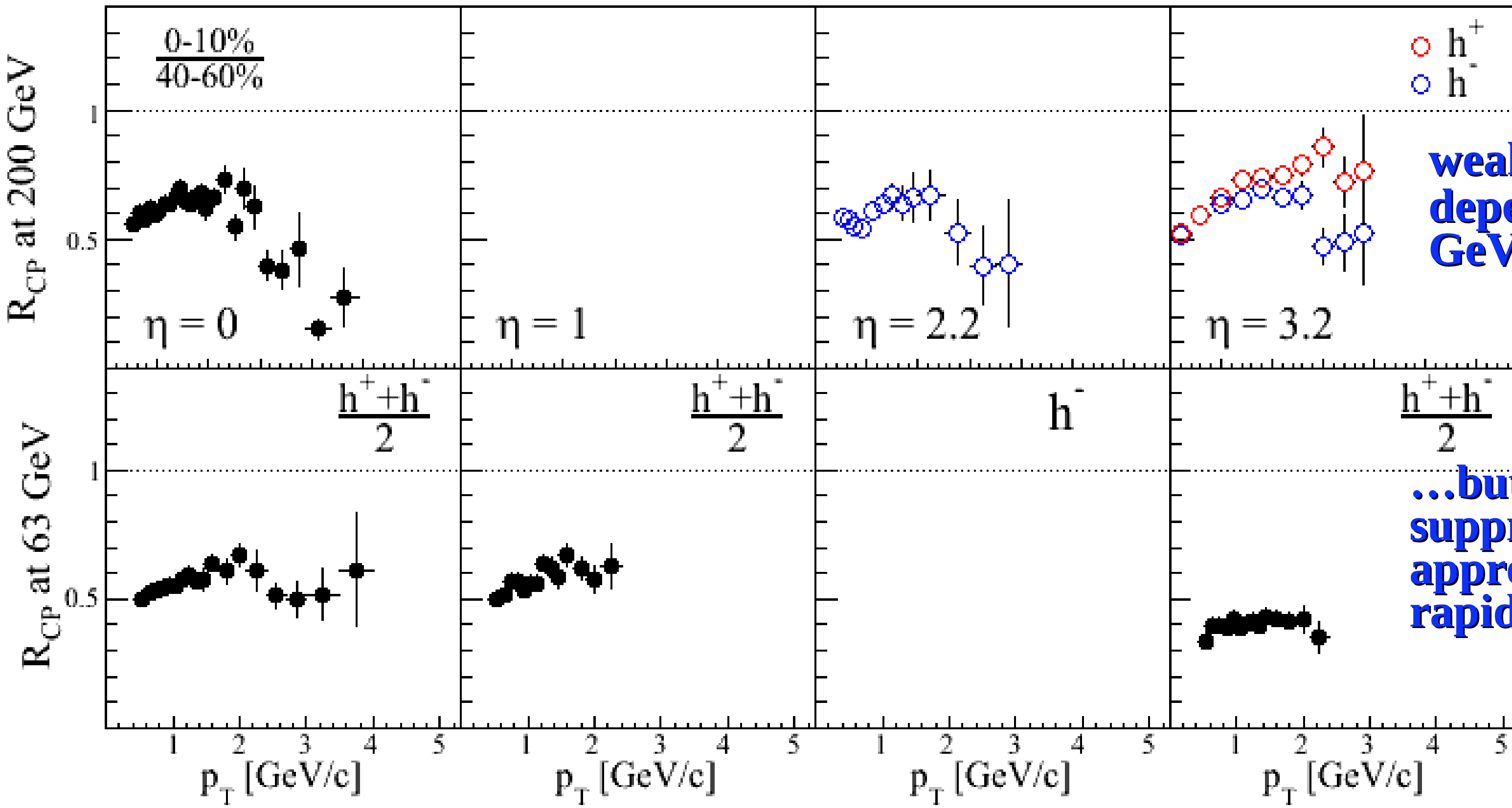
(pp reference is based on ISR collider data)

Two systems comparison @ 62.4GeV

Brahms preliminary



R_{CP} dependence on η for AuAu @200 GeV and 62.4 GeV

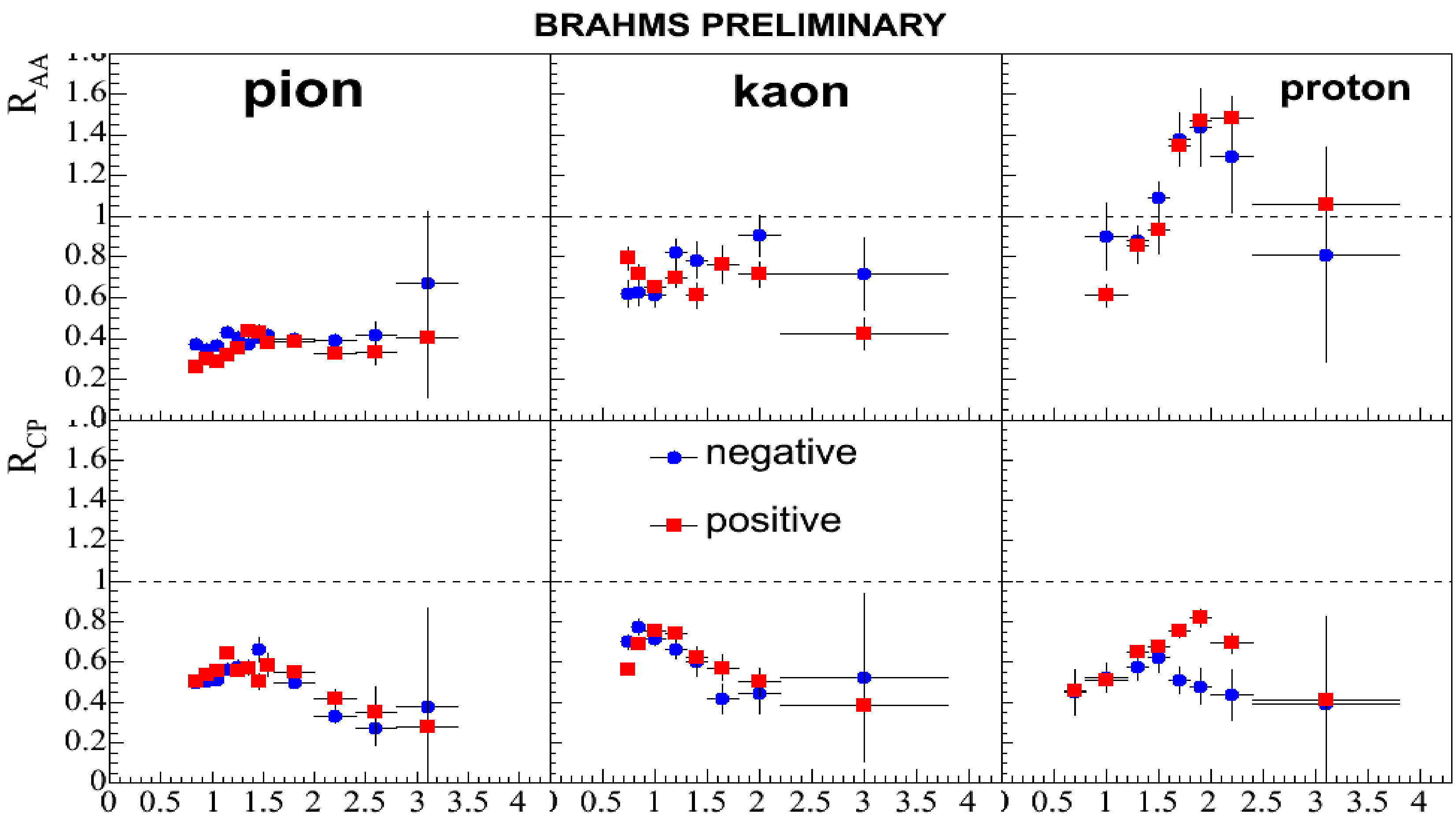


weak η dependence at 200 GeV…

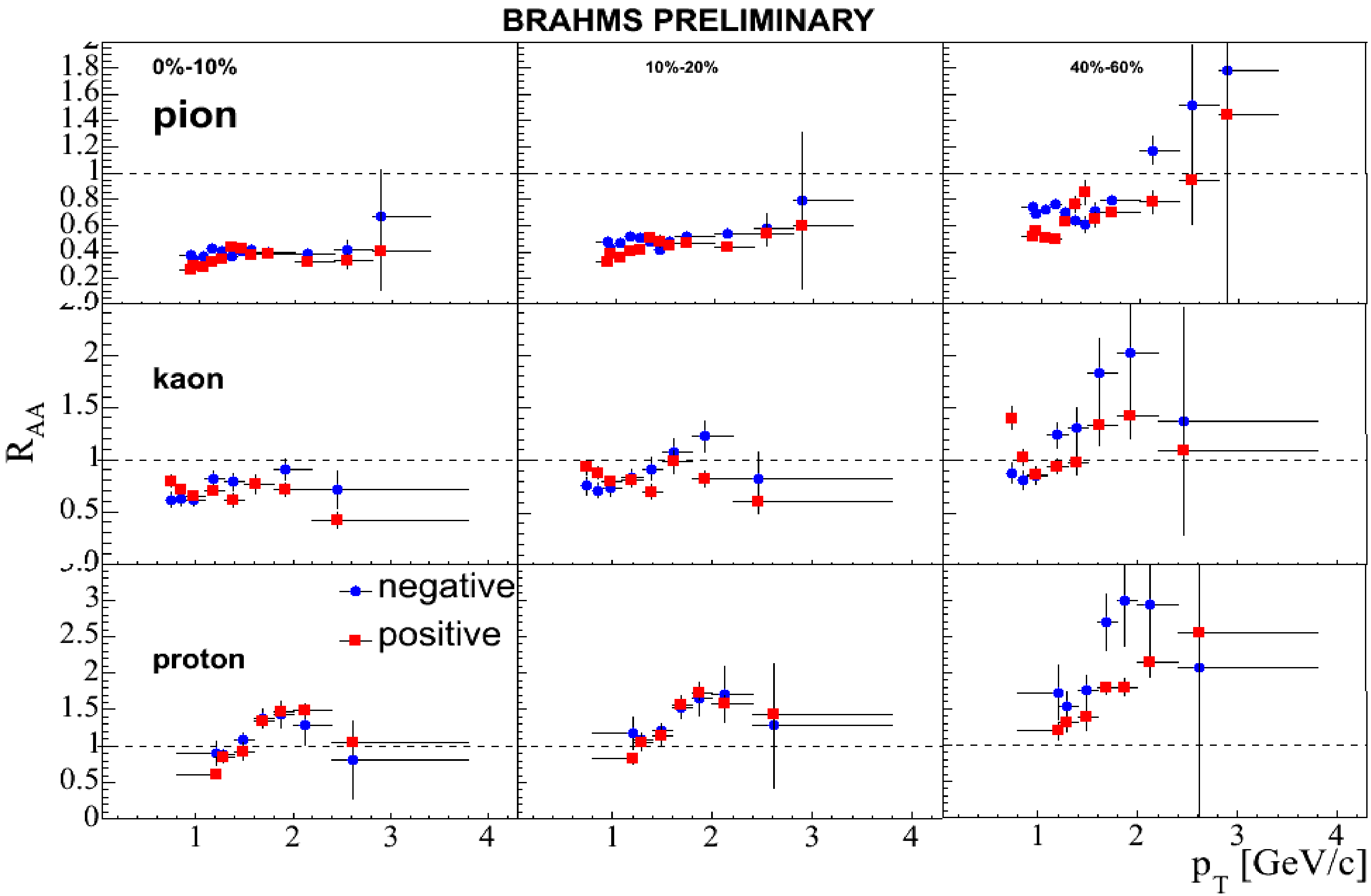
…but greater suppression approaching beam rapidity at 63 GeV.

peripheral collision ≠ pp collision

R_{CP} and R_{AA} for identified hadrons at y~3.1, Au+Au @ 200GeV

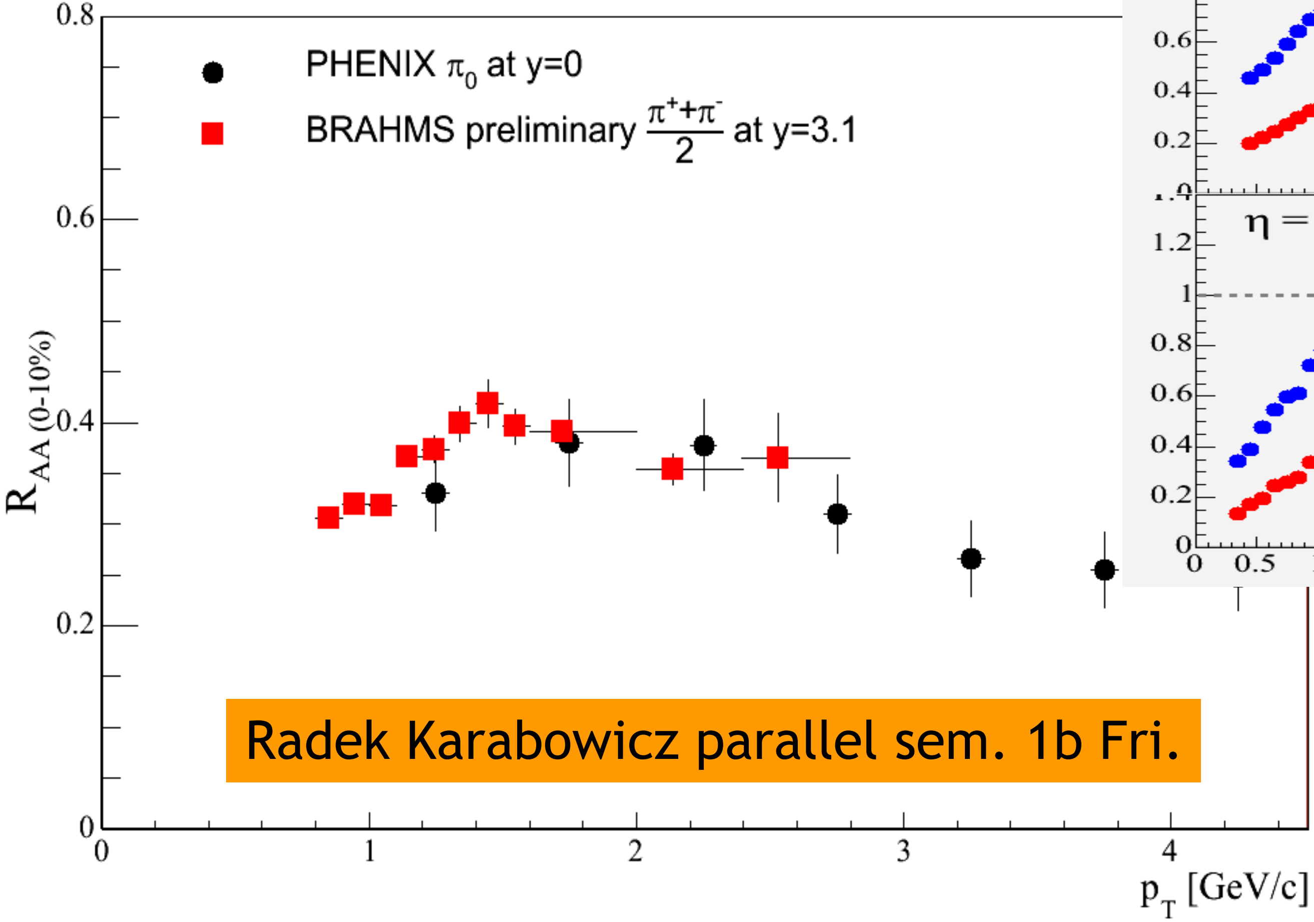


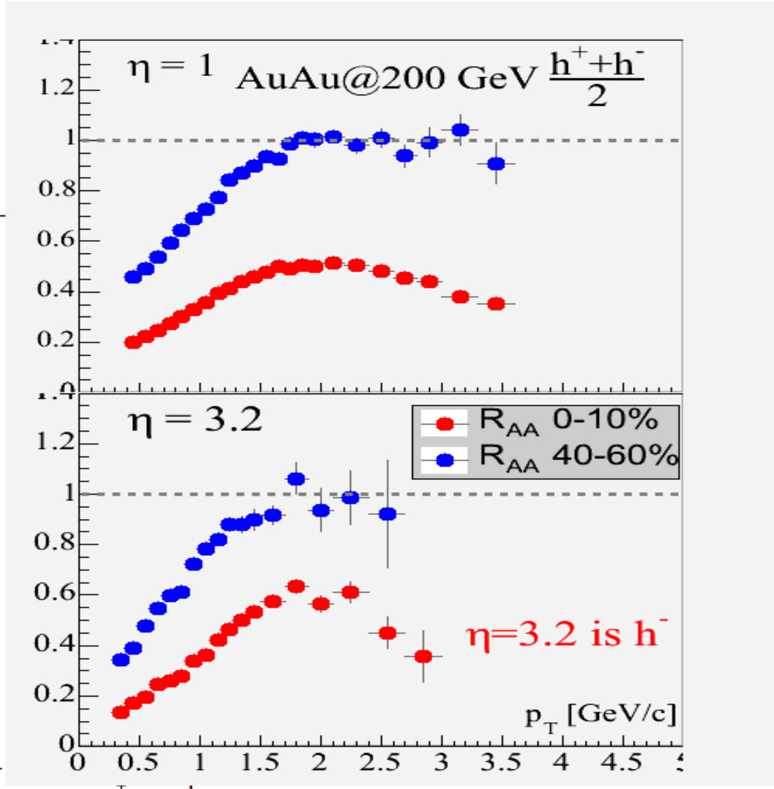
R_{AA} versus centrality for identified hadrons



....more on R_{AA} rapidity dependence

Au+Au @200GeV





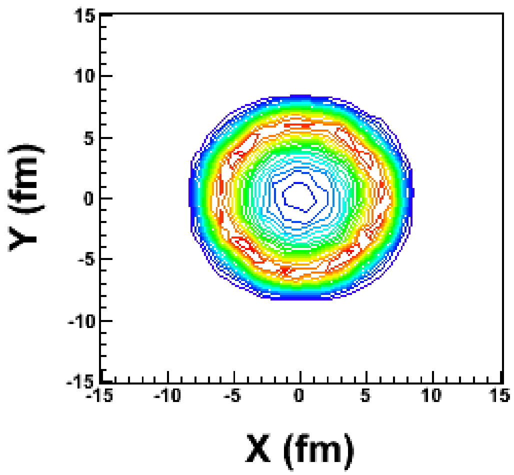
Radek Karabowicz parallel sem. 1b Fri.

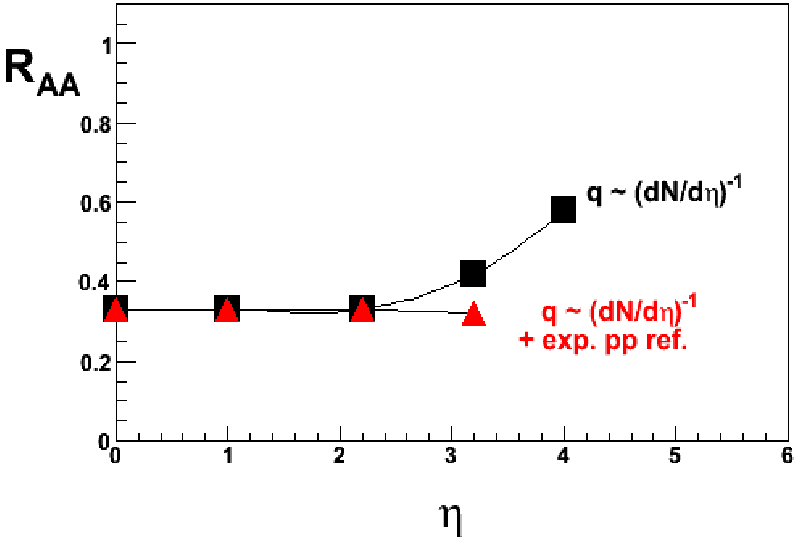
Strong energy absorption model from a static 2D matter source. (Insprired by A.Dainese (Eur.Phys.J C33,495) and A.Dainese , C.Loizides and G.Paic (hep-ph/0406201))

- Parton spectrum using pp reference spectrum
- Parton energy loss ΔE ~ q.L**2
- q adjusted to give observed R_{AA} at η~1.

The change in dN/dη will result in slowly rising R_{AA} .

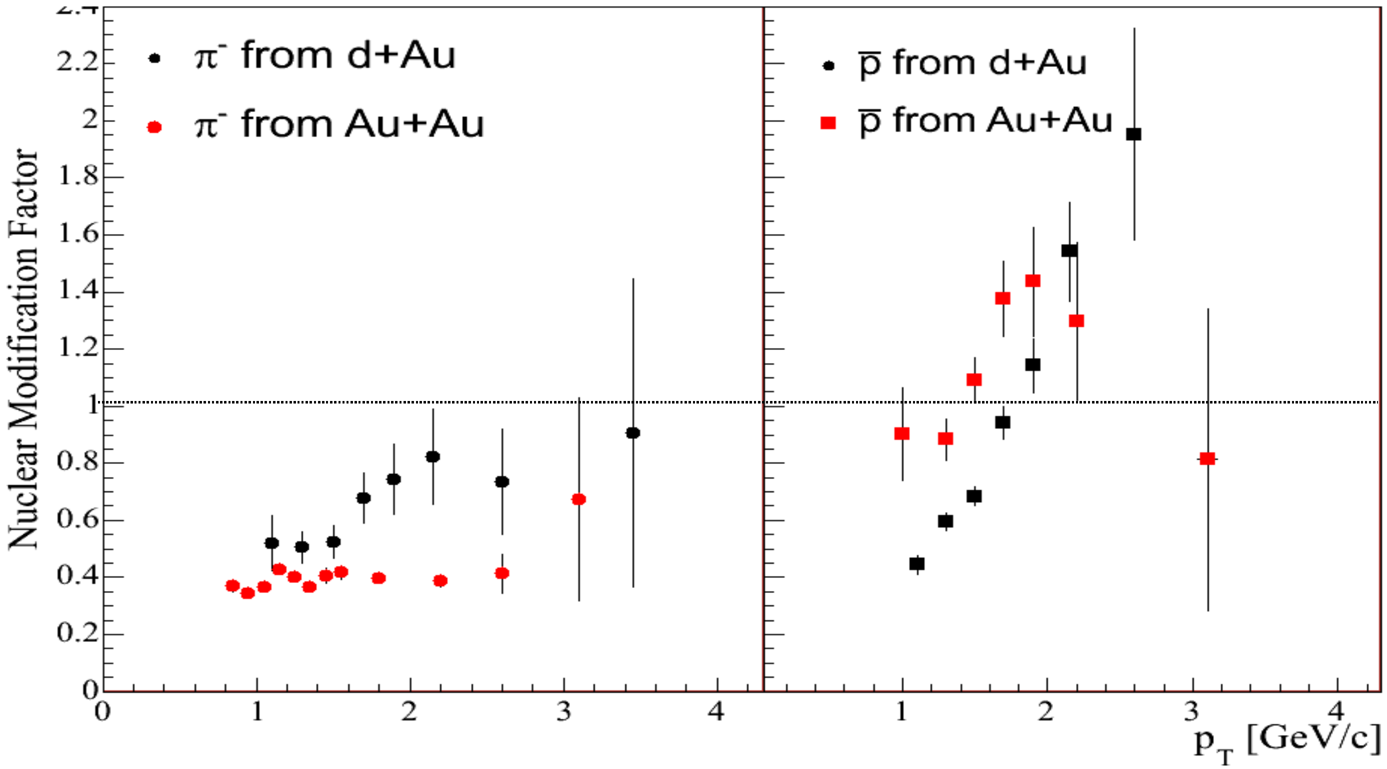
The modification of reference pp spectrum causes the R_{AA} to be approximately constant as function of η .





R_{dAu} and R_{AA} for anti-protons and pions @200

BRAHMS PRELIMINARY



- suppression for π^- but stronger for AuAu
- both R_{dA} and R_{AA} show enhancement for p-bar

Summary

Large hadron multiplicities

- Almost a factor of 2 higher than at SPS energy(↔ higher ε)
- Much higher than pp scaled results(↔ medium effects)

Identified hadron spectra

- Good description by statistical model
- Large transverse flow consistent with high initial density

v2(pt) is seem to not depend on rapidity

p/π

- show strong η dependency
- for given energy depend only on N_{par}

High-p_T

- suppression increases with energy for given centrality bin
- weak dependency on rapidity of R_{AA} which is consistent with surface jet emission
- R_{CP} can hide or enhance nuclear effects
- At y=3.2 R_{AA} shows larger suppression than R_{dA}

The BRAHMS Collaboration

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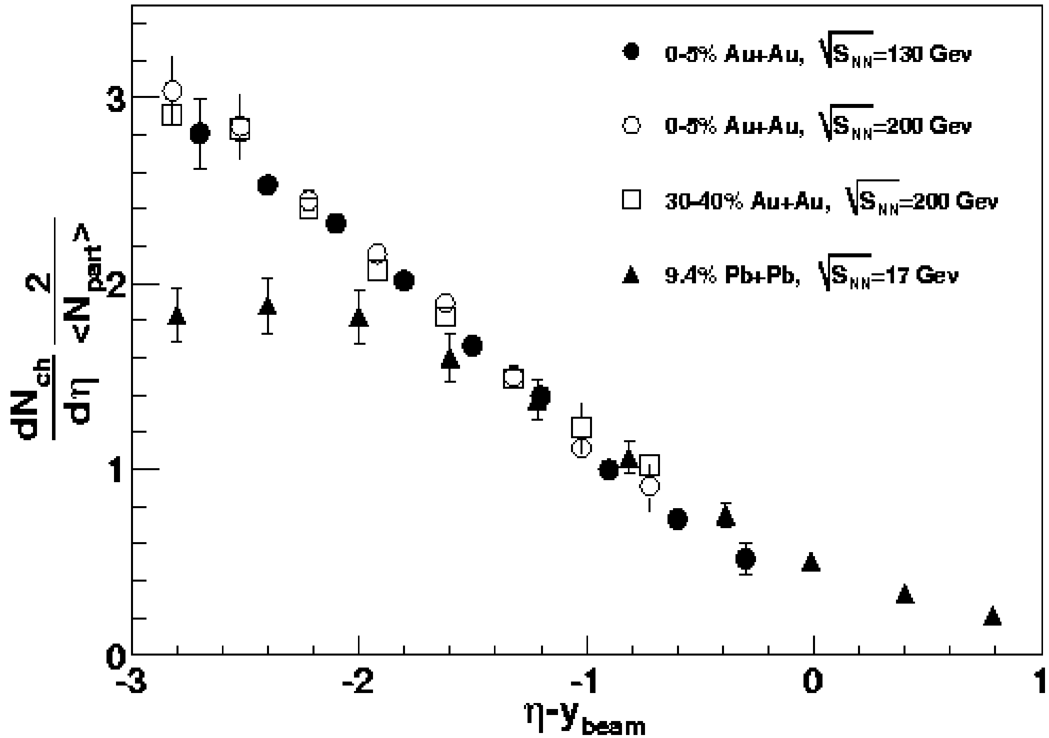
[11] University of Oslo Norway

48 physicists from 11 institutions

Limiting Fragmentation

Shift the $dN_{ch}/d\eta$ distribution by the beam rapidity, and scale by $\langle N_{part} \rangle$.
Lines up with lower energy ⇒ limiting fragmentation



Au+Au $\sqrt{s_{NN}}$=200GeV (0-5% and 30-40%)
Au+Au $\sqrt{s_{NN}}$=130GeV (0-5%)
Pb+Pb $\sqrt{s_{NN}}$=17GeV (9.4%)