BRAHMS
Scanning the phases of QCD

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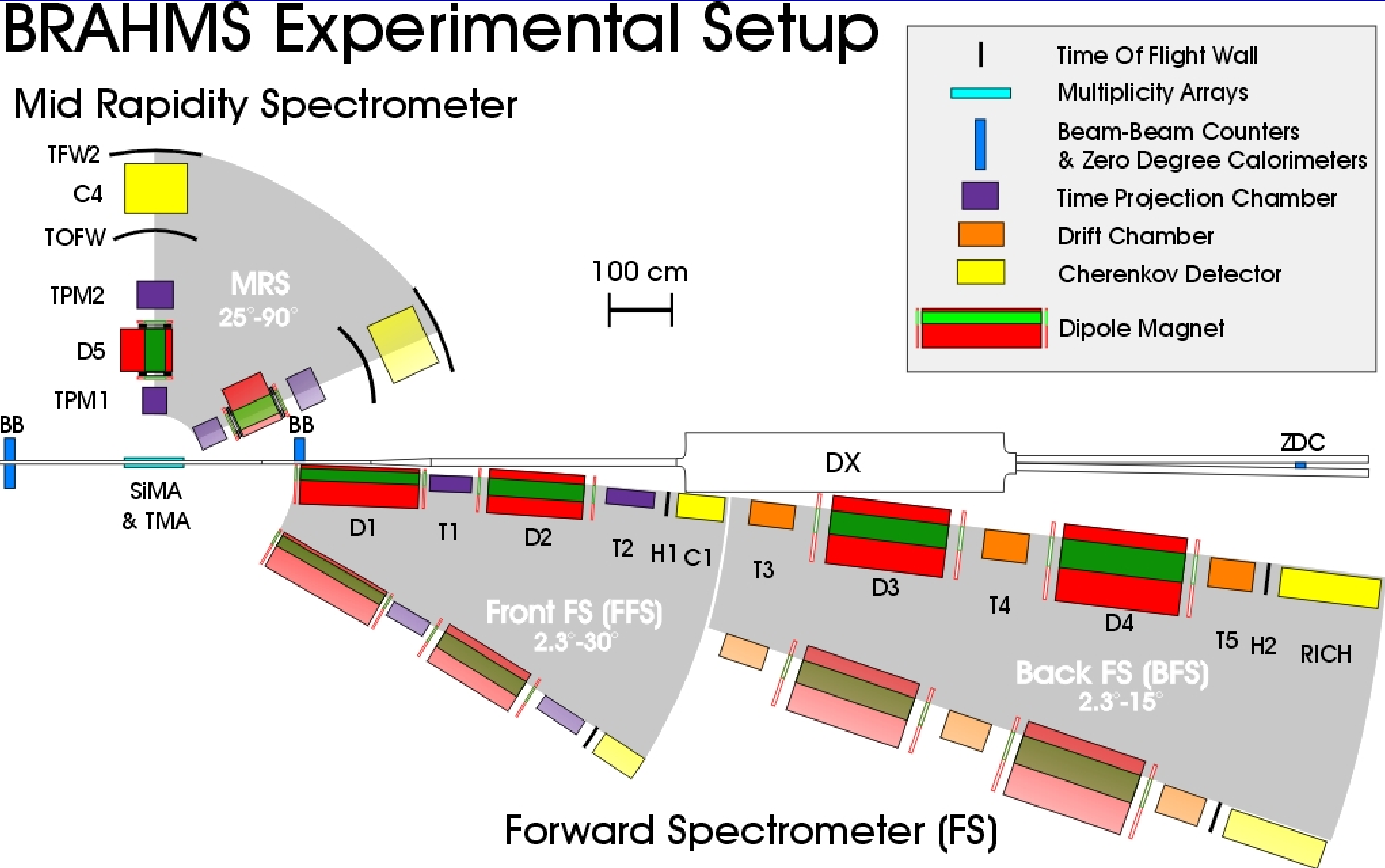
Brookhaven, Strasbourg, Krakov, Johns Hopkins, NYU, Niels Bohr.
Texas A&M, Bergen, Bucharest, Kansas, Oslo

Identifying high rapidity particles



Why study rapidity dependence?

- For AuAu we want to understand the limits of jet quenching?
- We also hope to understand the longitudinal dynamics of the source and measure the total energy loss, multiplicity strangeness etc.
- We may find that there is more than one source, i.e. different parts of the system lose causal contact.
- For dAu high rapidity allows us to study the Au nucleus with a faster probe $x = e^{-y} m_T / \sqrt{S}$

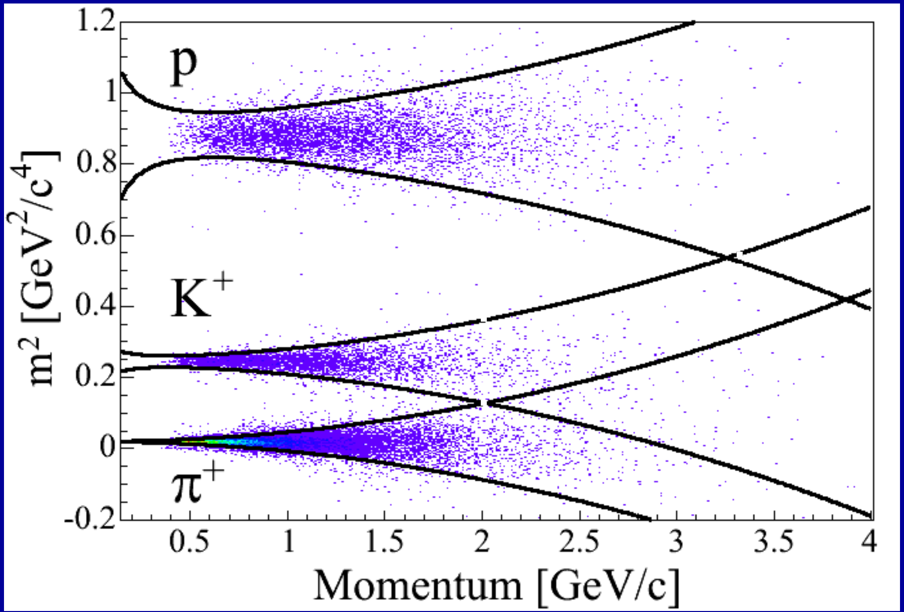
Particle Identification

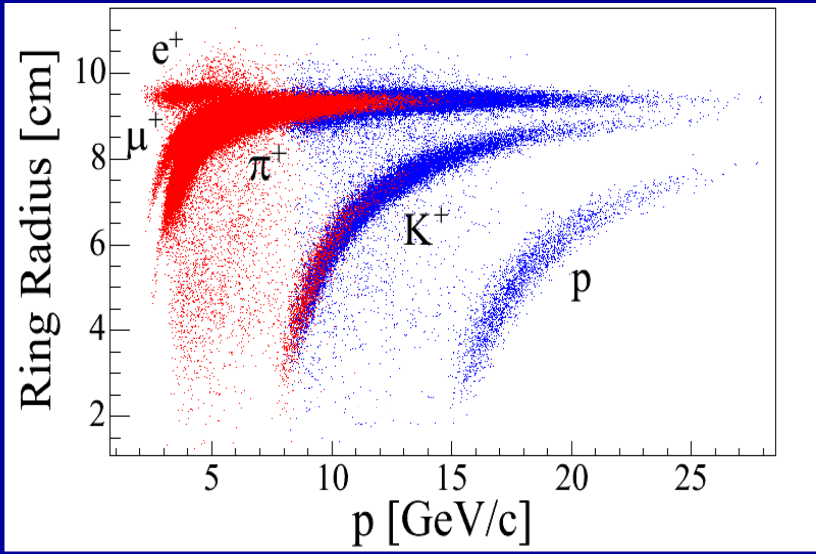
TIME-OF-FLIGHT

$$m^2 = p^2\left(\frac{c^2 TOF^2}{L^2} - 1\right)$$

Particle Separation: p_{max} (2σ cut)=

2σ cut	TOFW	TOF1	TOF2
π / K	2 GeV/c	3 GeV/c	4.5 GeV/c
K / p	3.5GeV/c	5.5GeV/c	7.5GeV/c





CHERENKOV

RICH: Cherenkov light focused on spherical mirror $\rightarrow$ ring on image plane

Ring radius vs........... momentum gives PID

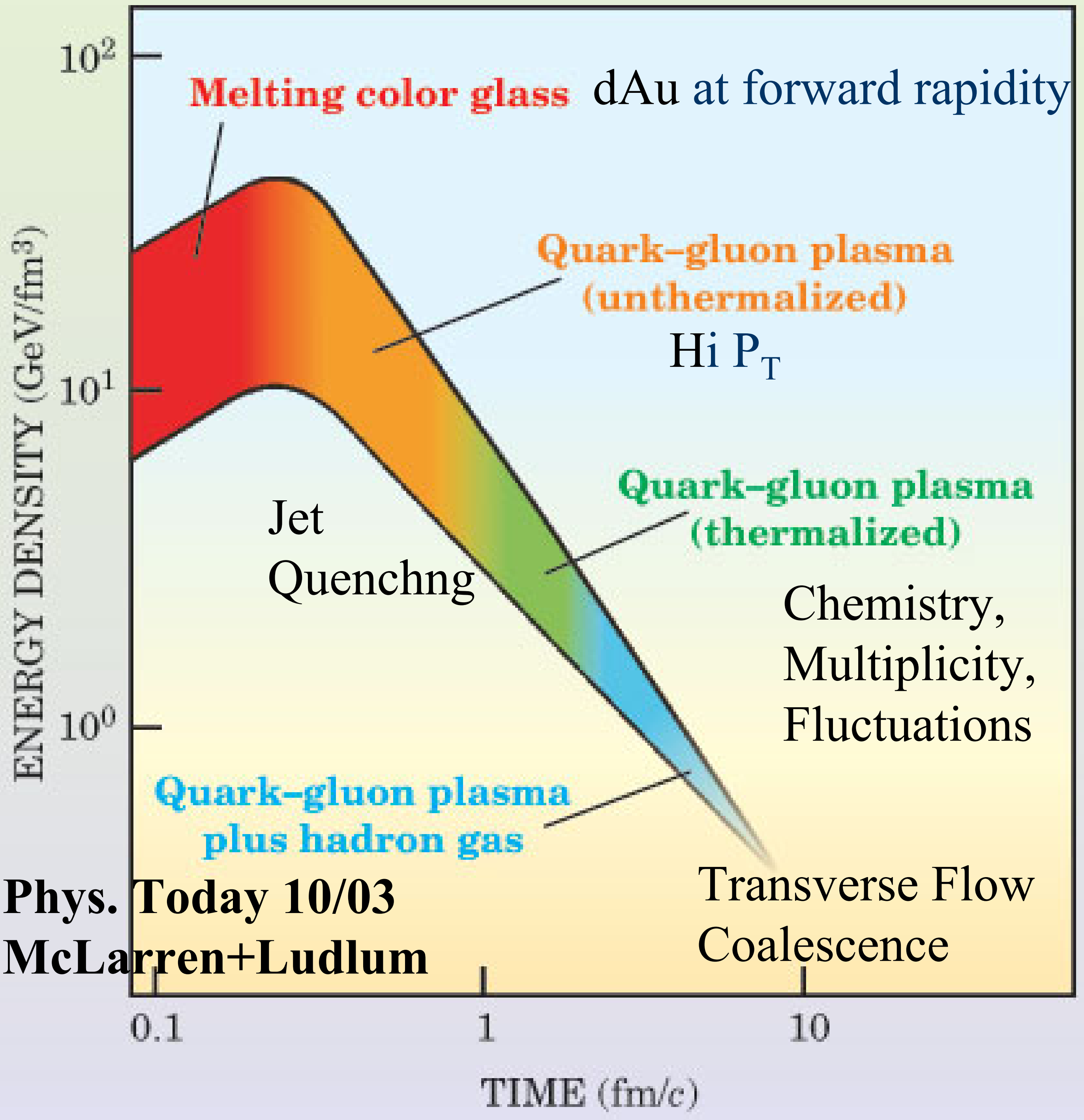
π / K separation 20 GeV/c

Proton ID up to 35 GeV/c

A possible time line for Au+Au collisions.

This curve itself is a function of rapidity.

This talk will try to run time backwards



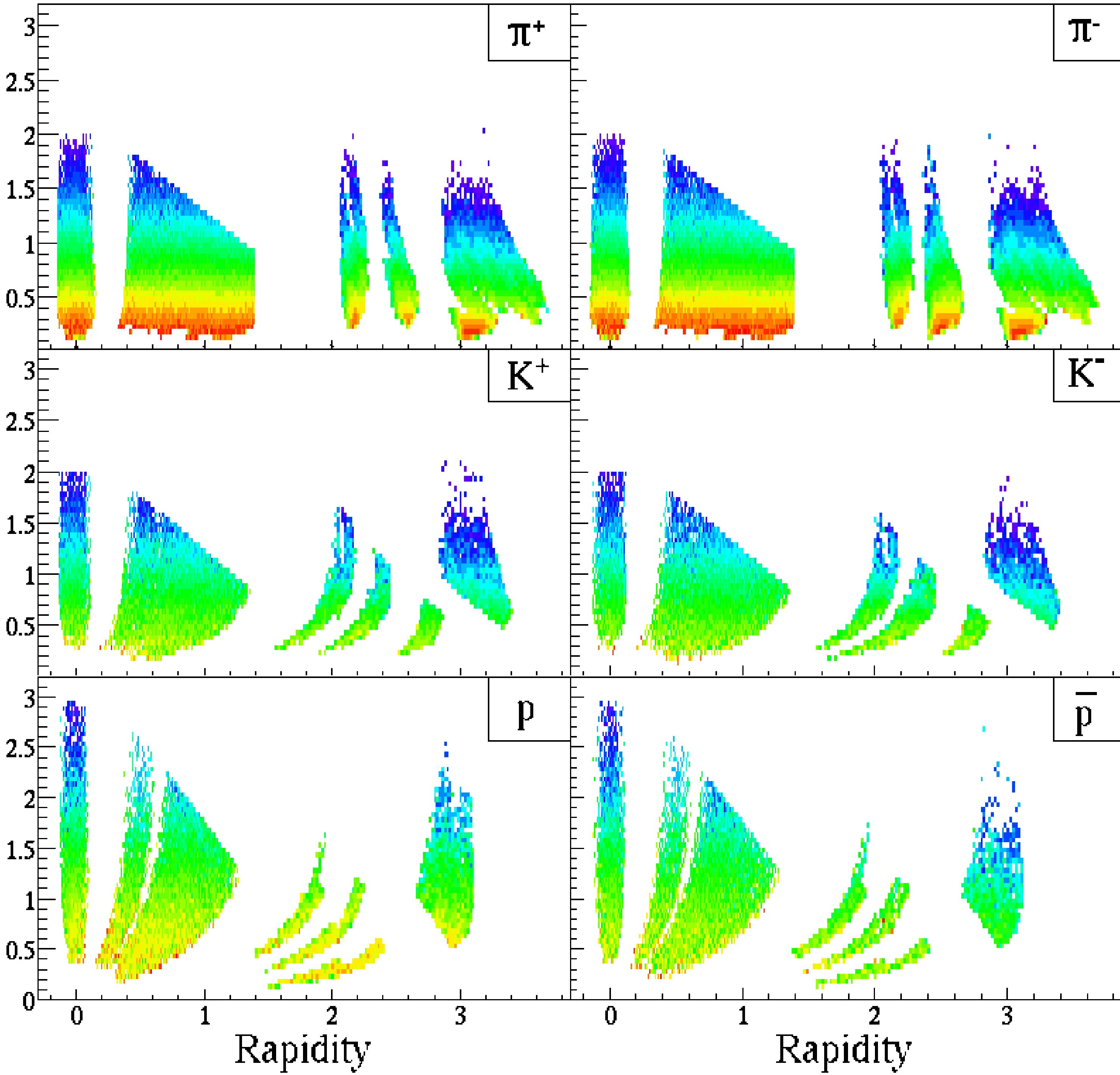
What questions can we attack?

- How much energy is available for particles?
- How many particles?
- What is the volume?
- How do particles flow in the transverse & longitudinal direction?
- What is the chemistry of the system?
- What is the rapidity dependence jet quenching
- What is the nature of the Au wave function at small Feynman x?

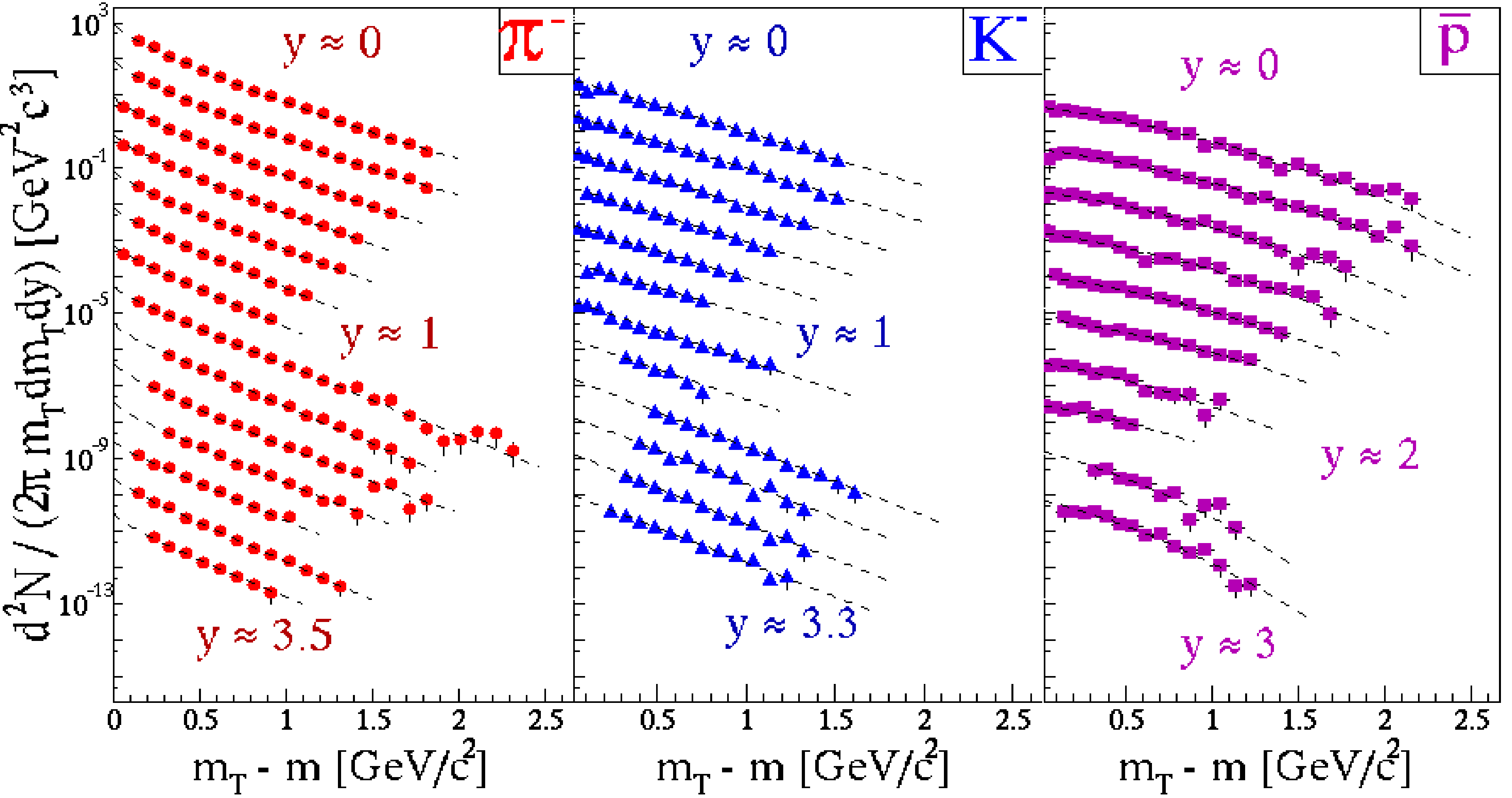
Spectra vs. Pt and rapidity

AuAu 10% Central

D. Ouerdane
Hadron Spec.
Thursday

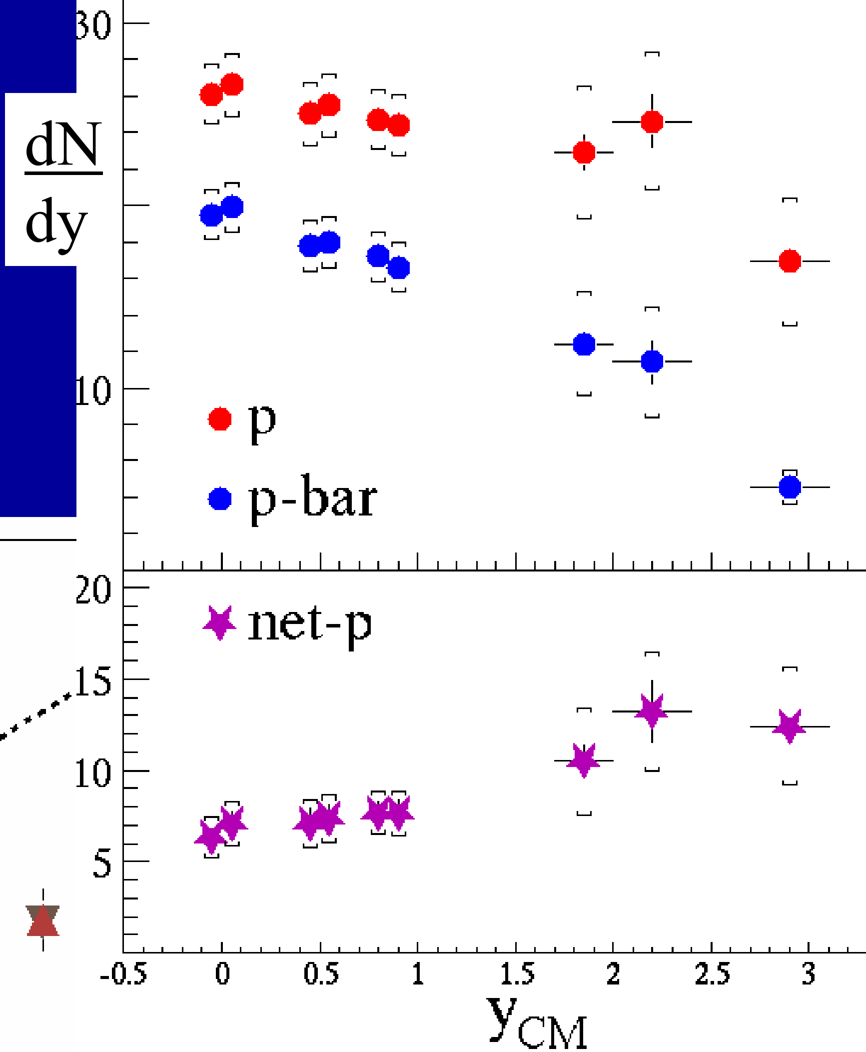


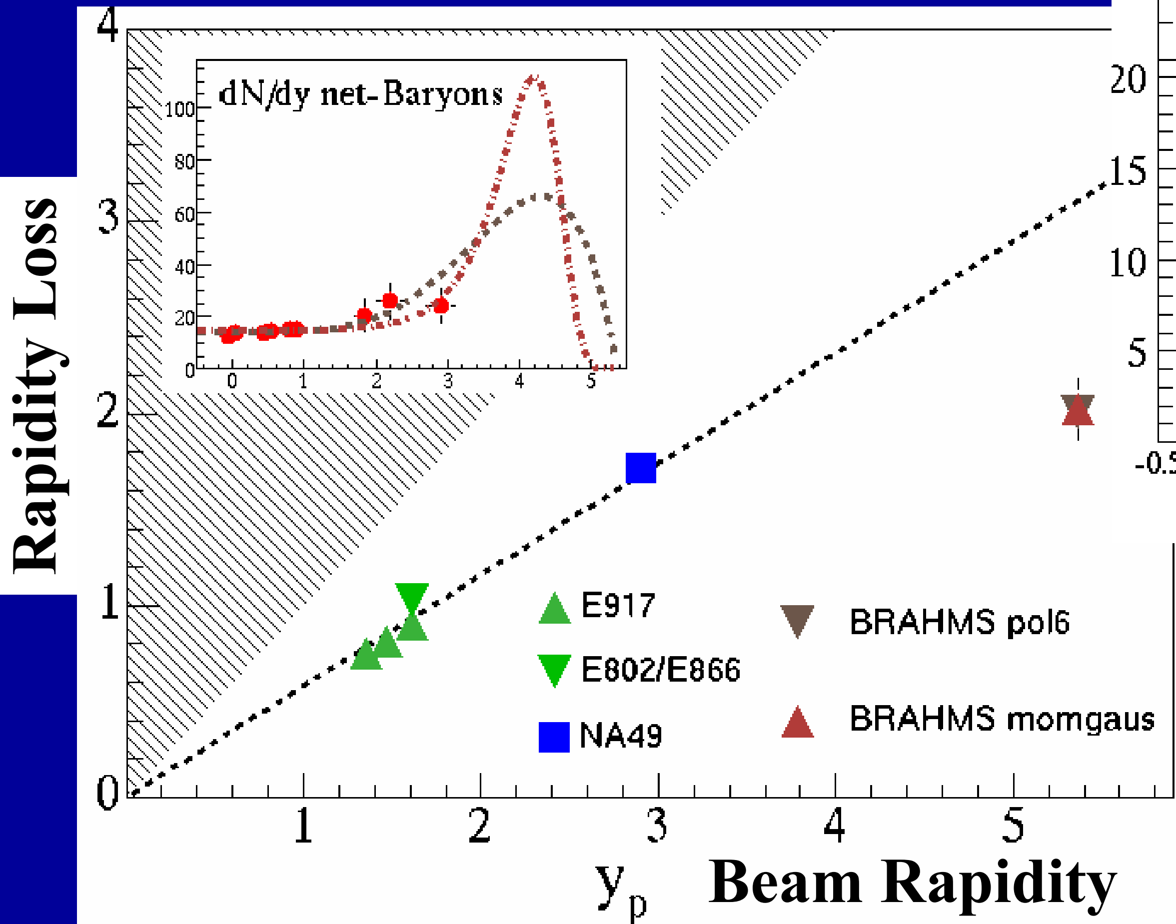
Spectra vs. Rapidity



Where do the protons go?

25 ± 1 TeV is liberated for particle production

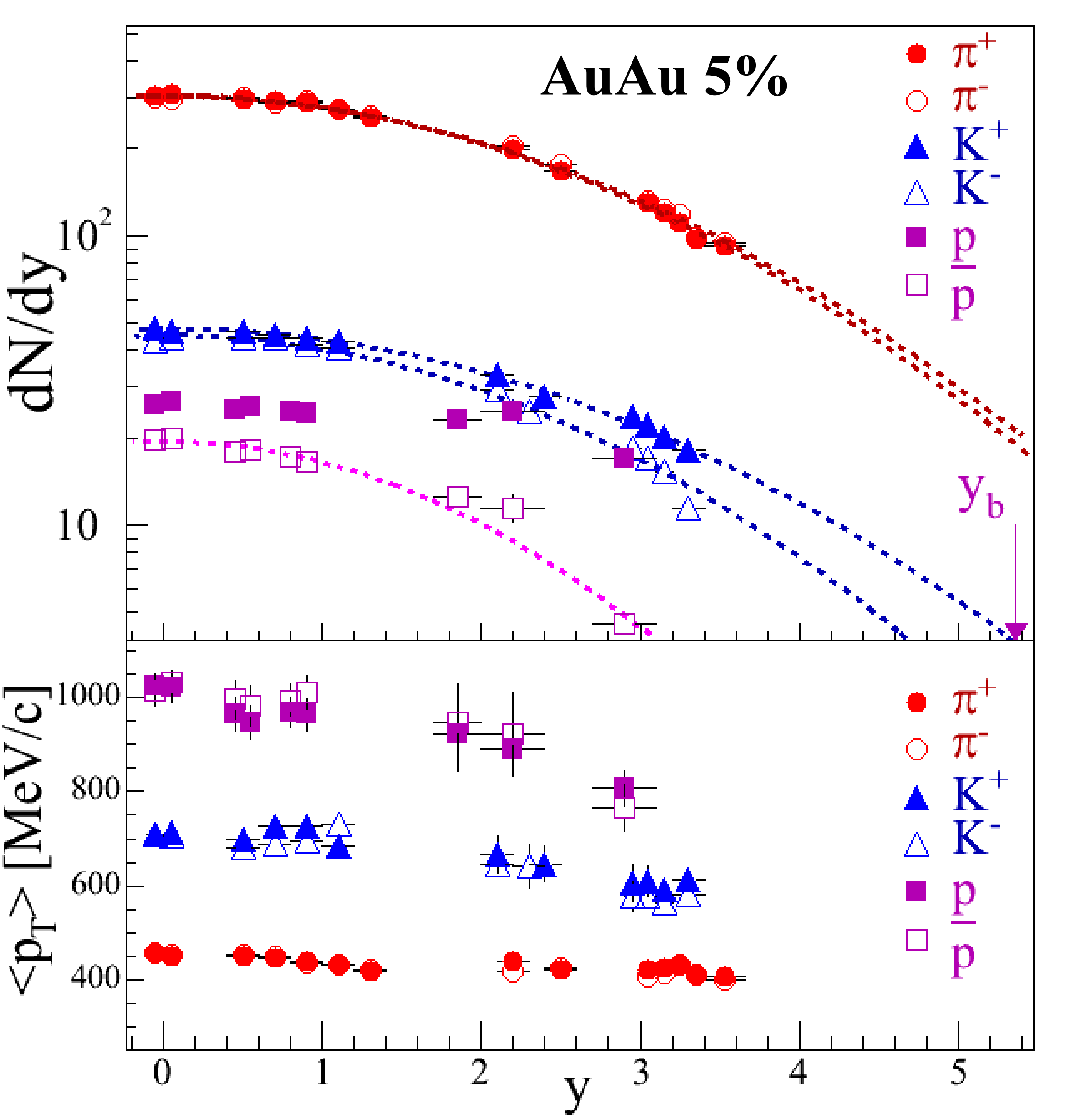




BRAHMS: nucl-ex/0312023
"Nuclear stopping in Au+Au collisions at $\sqrt{S_{NN}}$ = 200 GeV"

Similar effect for pA, see Buzza *et al* ARNS 88 150

What can you buy for 25TeV?



	+	-
π	1780	1760
K	290	240
P	85	85

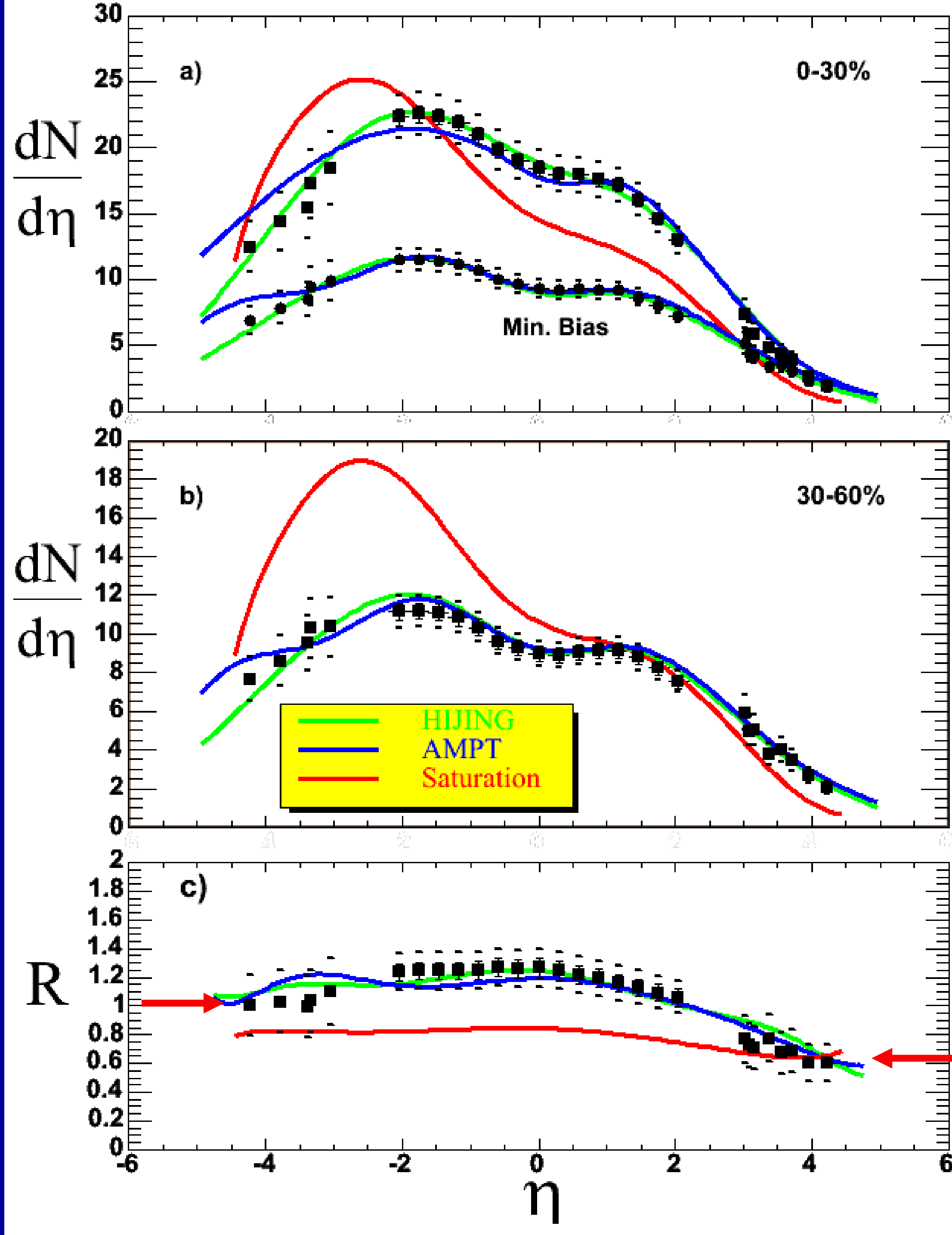
Integrating the energy seen in π, k & P and estimating other particles gives 25 ± 5 TeV

dAu Multiplicity

Data show peaks at η=-1.9 and η=+1.1.

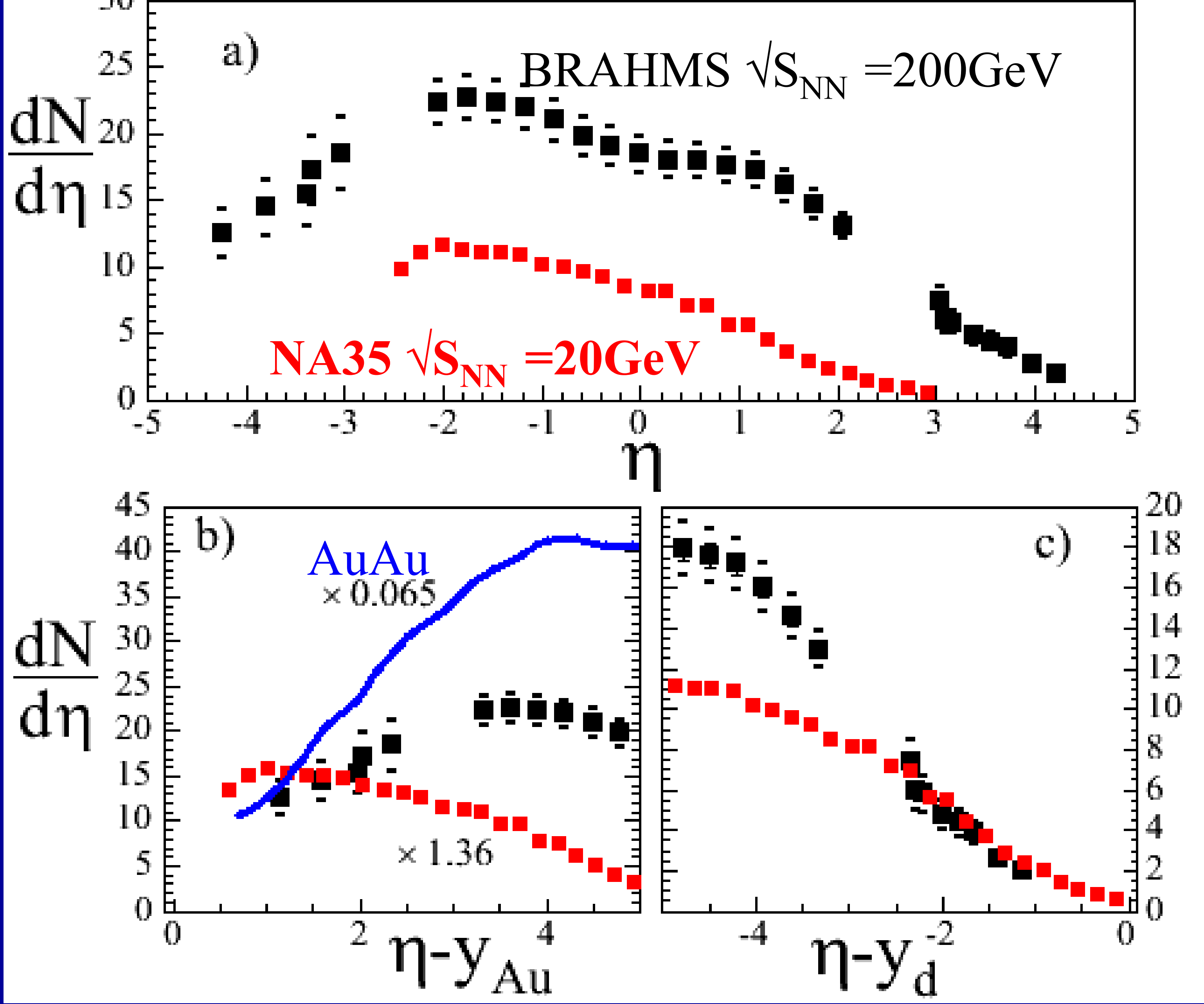
In Au and d regions dN/dη scales with the number of beam participants.

HIJING, & AMPT do well. Saturation model has problems.



dAu dN/dη v √S

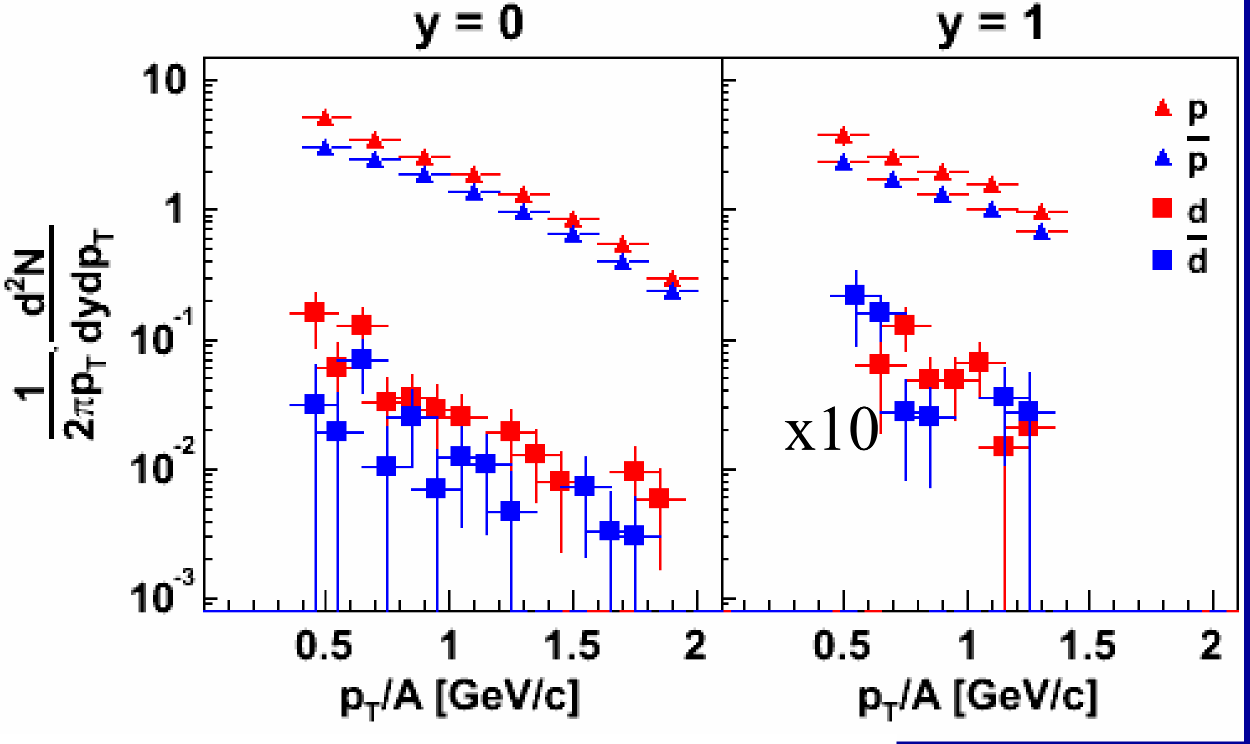
H. Ito Poster Spectra 18 :

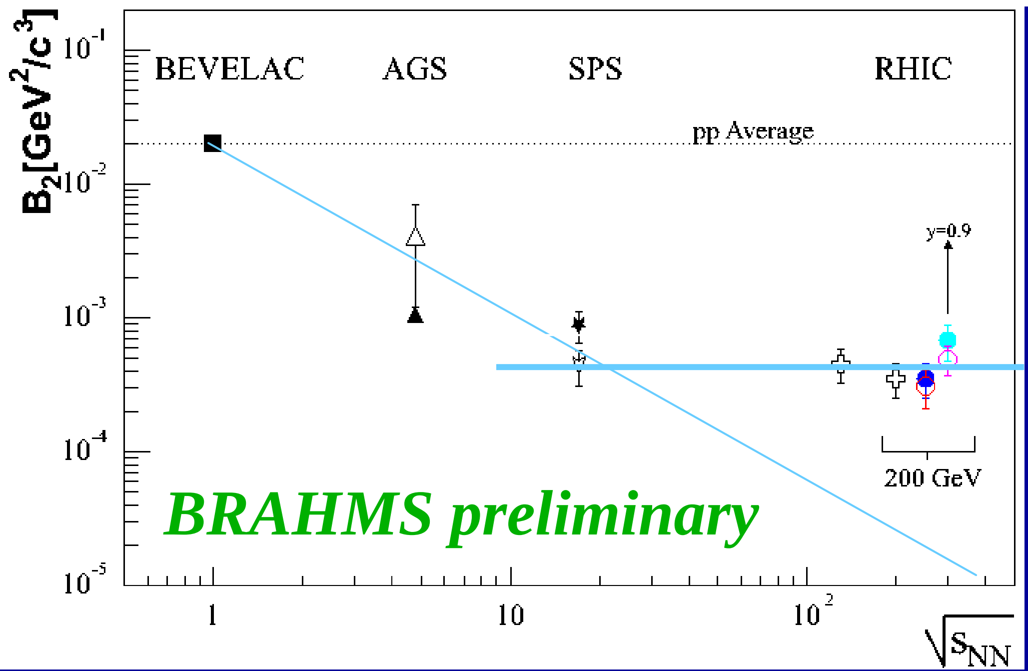


Gold Frame **Deuteron Frame**

Coalescence vs. Rapidity

- Compare p, d at same velocity
- Deuterons coalescence from nearby nucleons
- $B_2 = d/p^2$
- $B_2 \alpha$ 1/volume





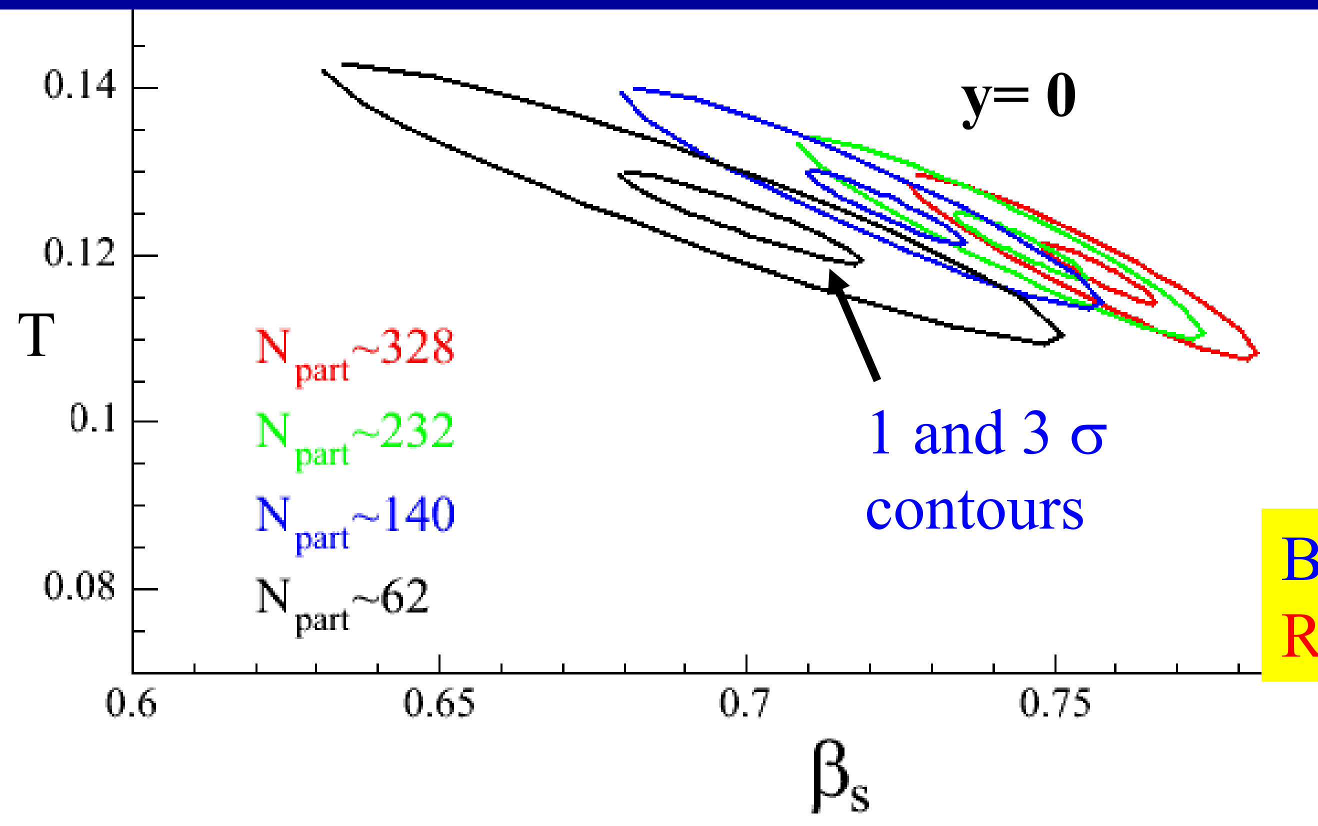
Gemanio + Bearden Poster S27

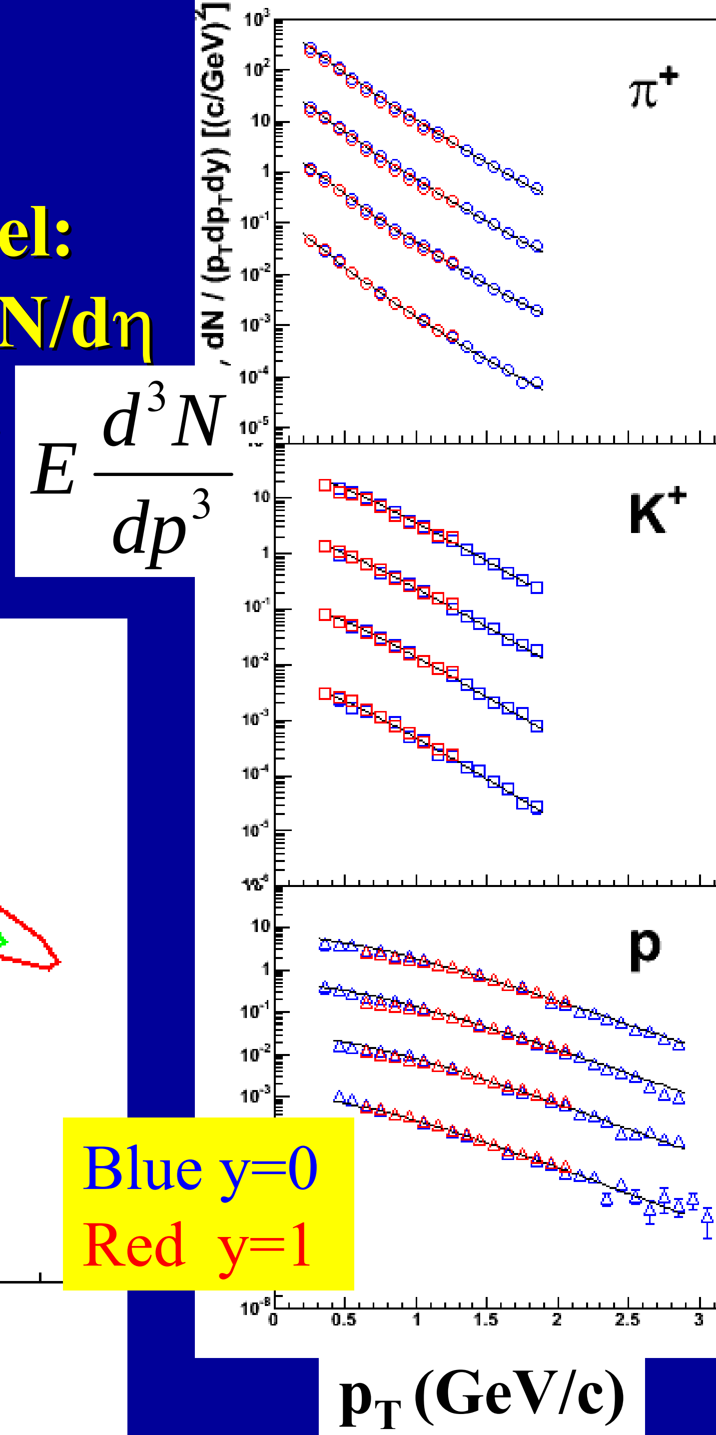
Flow vs. Centrality

Fit AuAu spectra to blast wave model:

- β_S (surface velocity) drops with $dN/d\eta$
- T (temperature) almost constant.

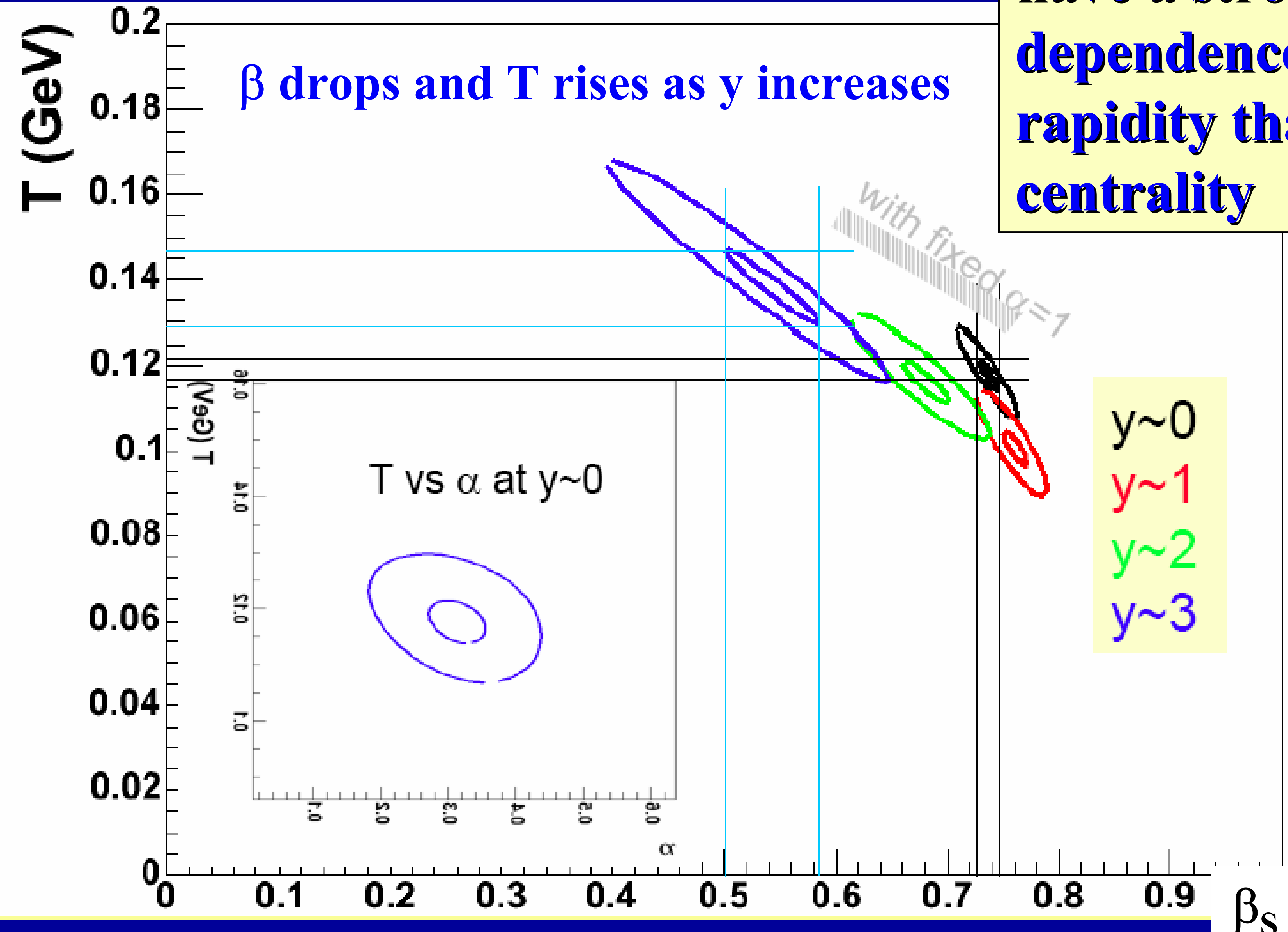
E.J. Kim Poster Spectra 19





Flow vs. Rapidity

Flow parameters have a stronger dependence on rapidity than on centrality



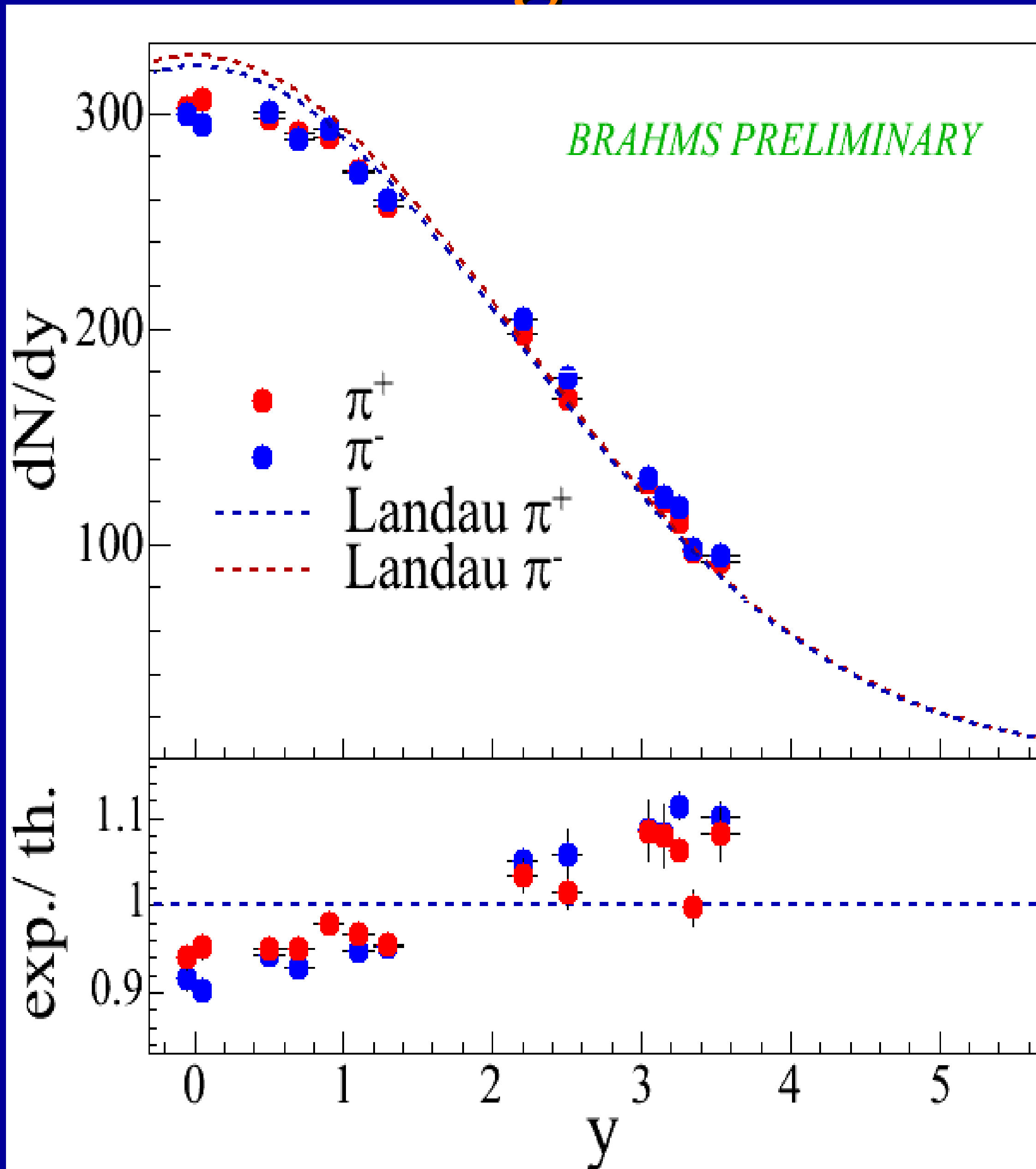
Landau hydrodynamics along beam axis

Assumptions:

- **Isentropic expansion driven by equation of state**
- **Mass-less particles**
- **Pt and rapidity factorize**

Implications:

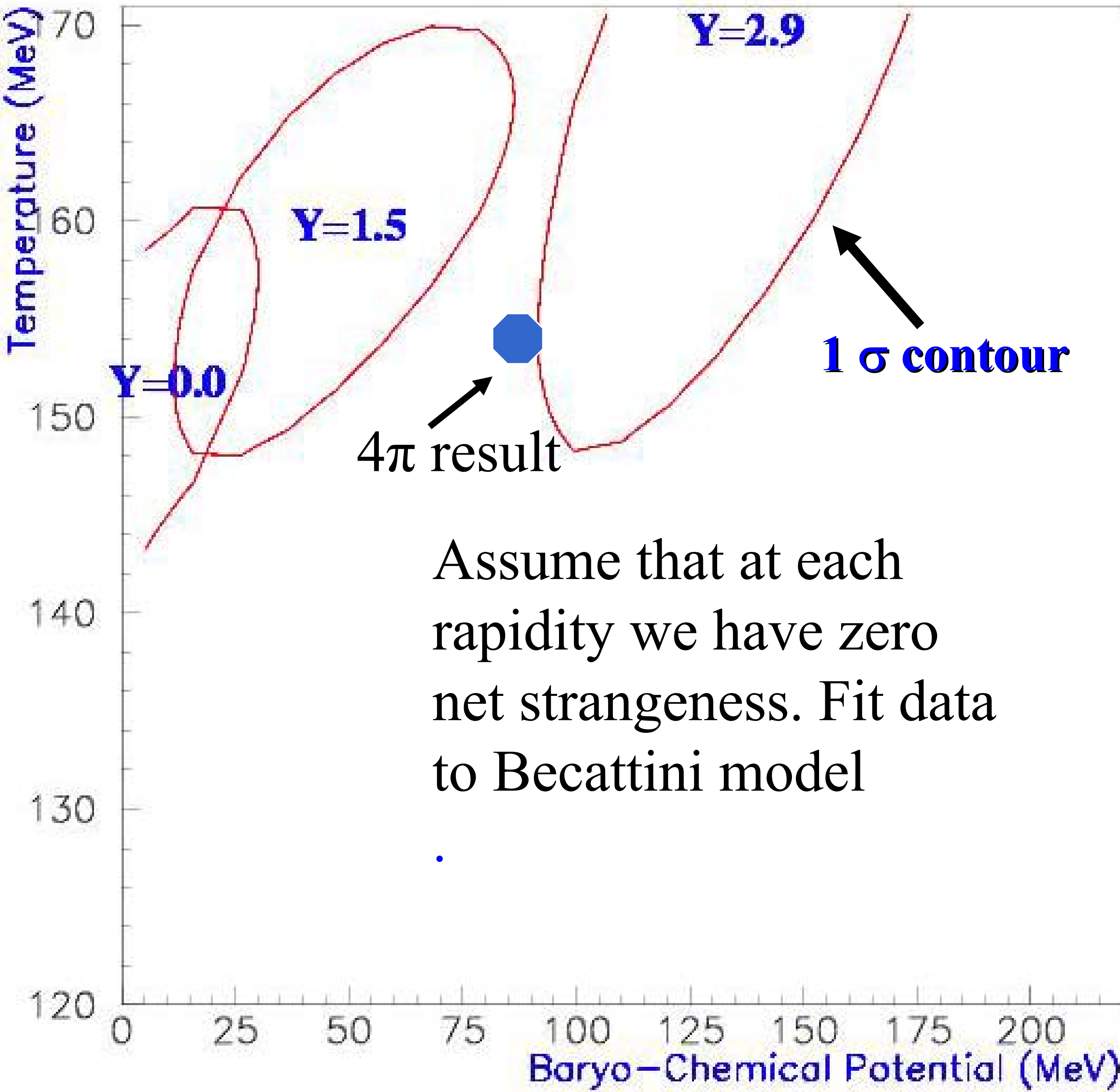
- **dN/dy Gaussian**
- **$\sigma = \log(\sqrt{S_{NN}}/2m_p)$ $\approx \log(\gamma_{beam})$**
- **Model consistent with "limiting fragmentation"**



Chemical analysis vs. rapidity

The system may have fewer degrees of freedom at high rapidity

J.I Jørdre, Poster Strange 15



Assume that at each rapidity we have zero net strangeness. Fit data to Becattini model

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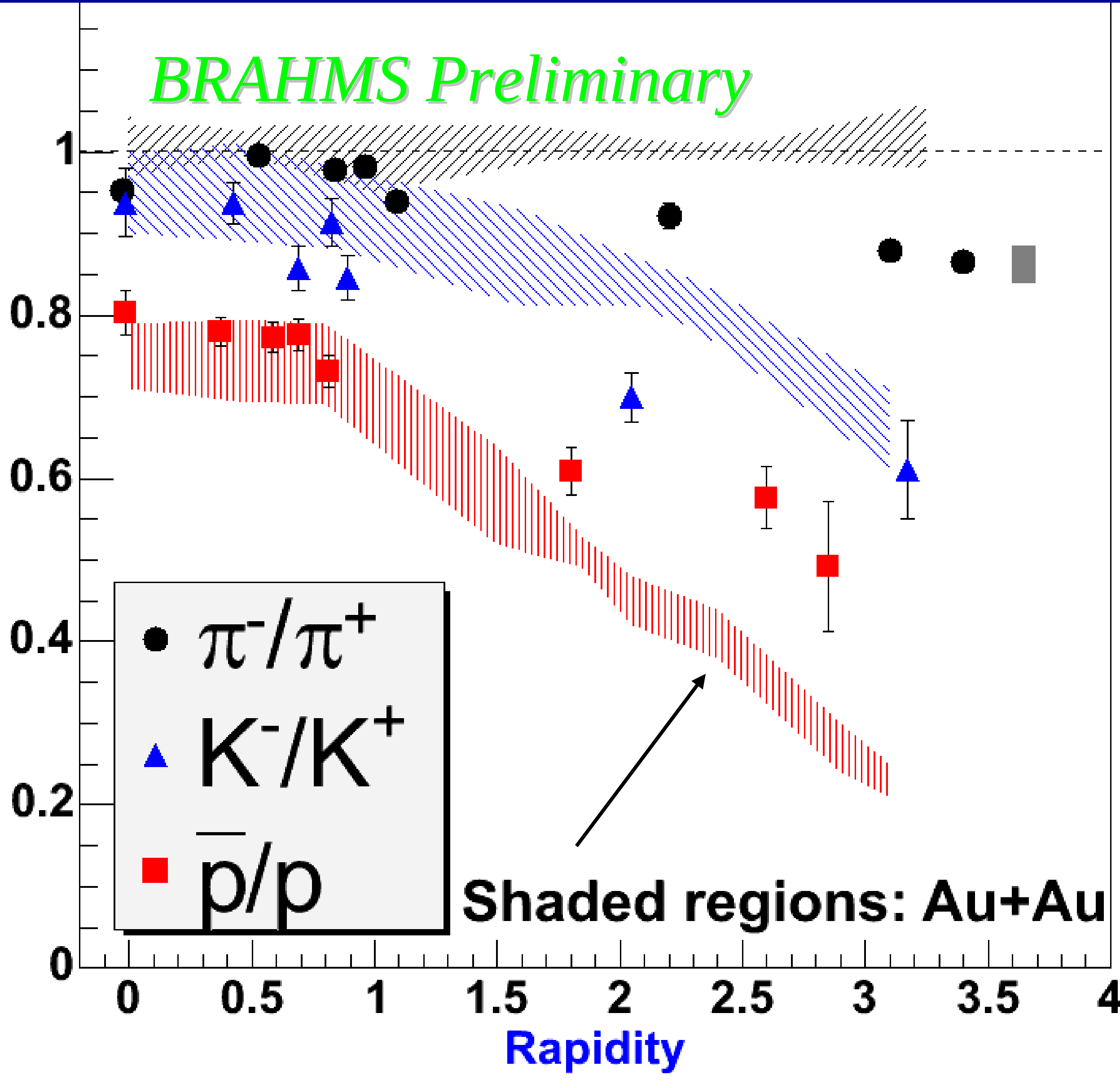
Particle ratios in pp vs. AuAu

B. H. Samset
Poster Spec. 34

pbar/p higher than AuAu while k^-/k^+ and π^-/π^+ are lower in pp

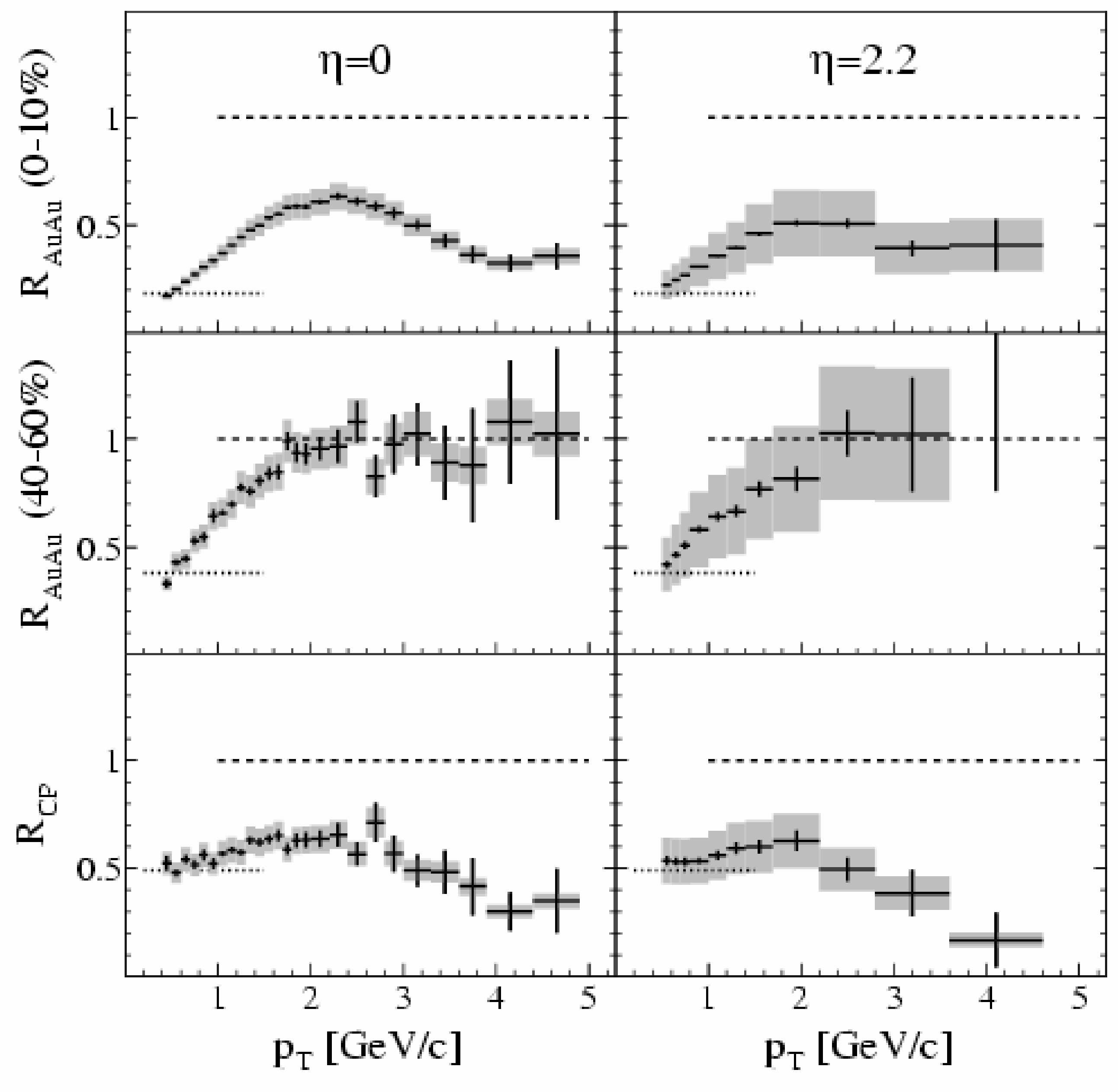
Conservation of isospin and strangeness more important for pp. Stopping different.



Rapidity dependence of jet quenching

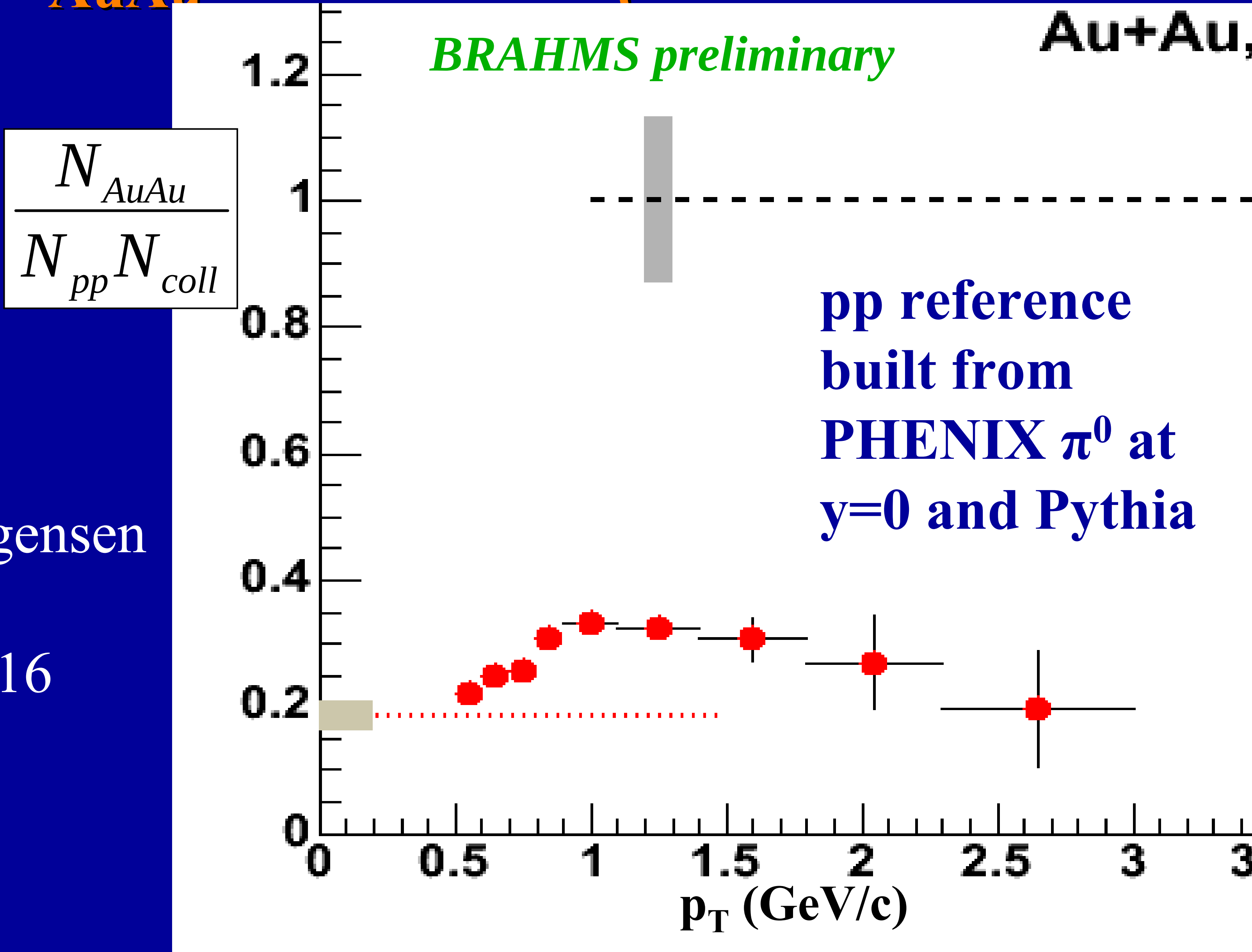
$$R_{AuAu} = \frac{N_{AuAu}}{N_{pp} N_{coll}}$$

- **$R_{AuAu} < 1$ for central collisions**
- **R_{AuAu} at $\eta=0$ and $\eta=2.2$ are similar**



BRAHMS: PRL 91072305 (2003).

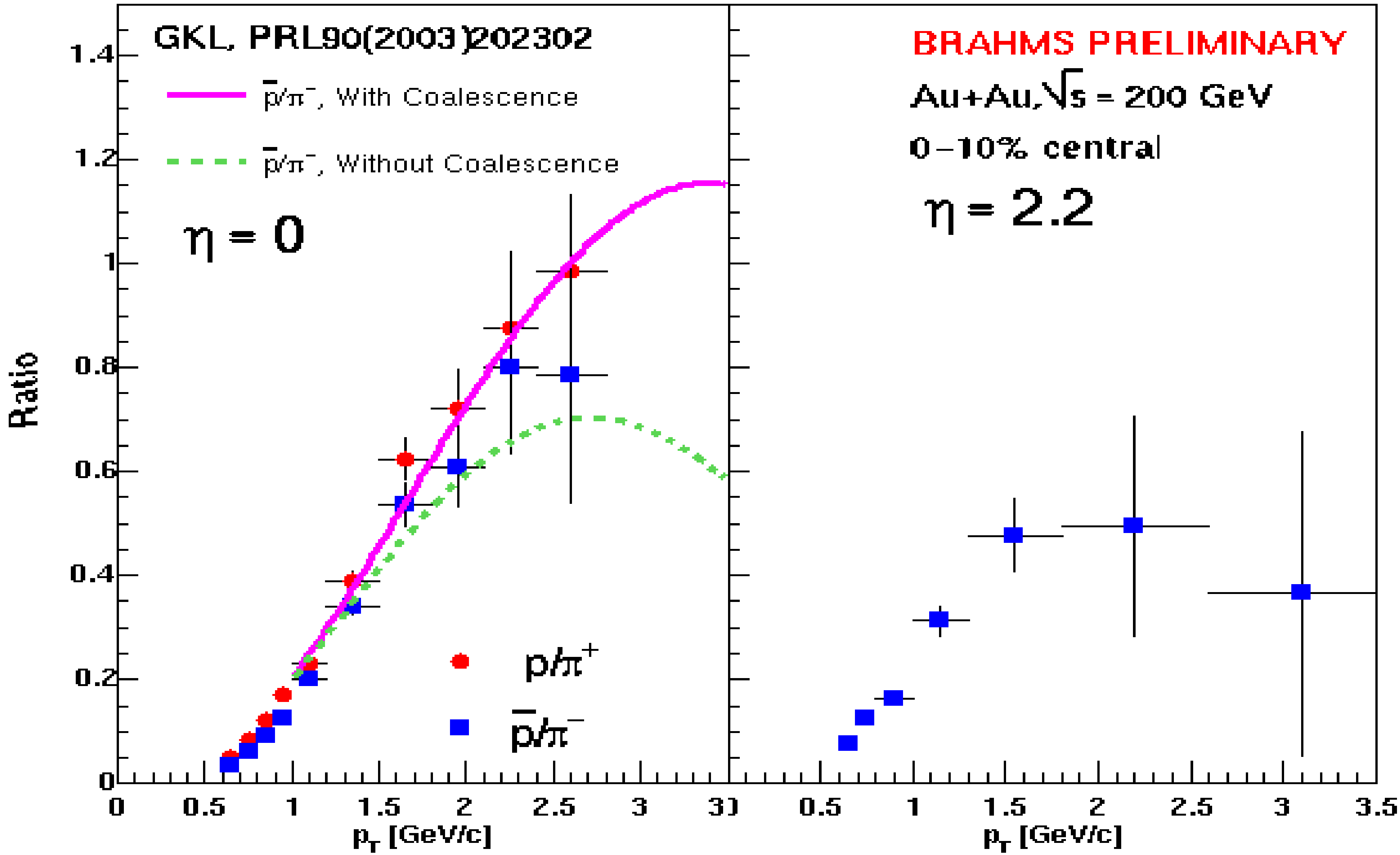
R_{AuAu} for π^- at η=2.2



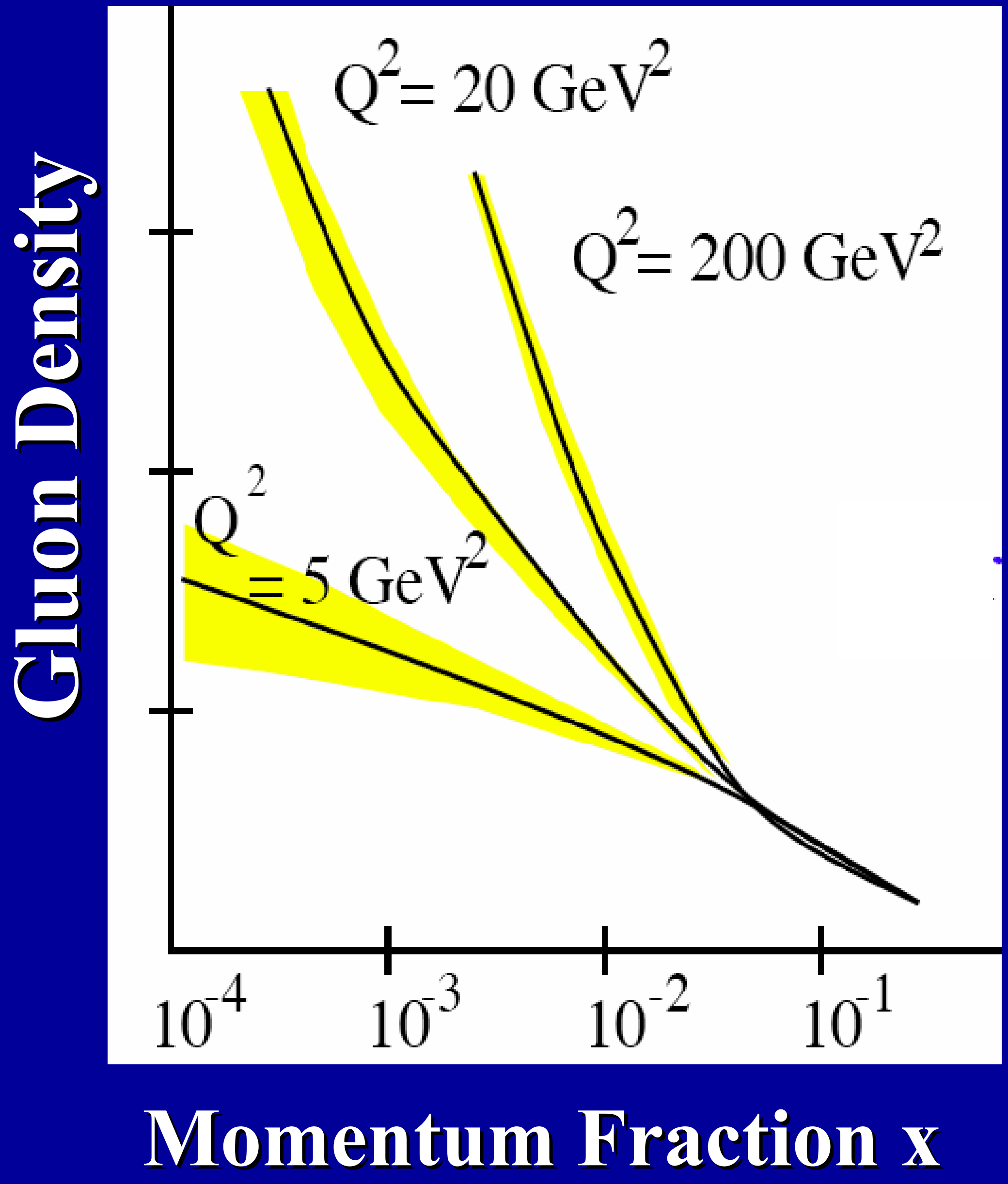
C.E. Jørgensen
Poster
High p_T 16

Ratios: anti-protons to pions

Z. Yin Tuesday High p_T parallel



Deep inelastic scattering at HERA



HERA measures the density of gluons as a function of the **momentum transfer Q** and the gluon's **momentum fraction x.** For small x there is a universal density function

$D = D(x, Q/Q_S)$

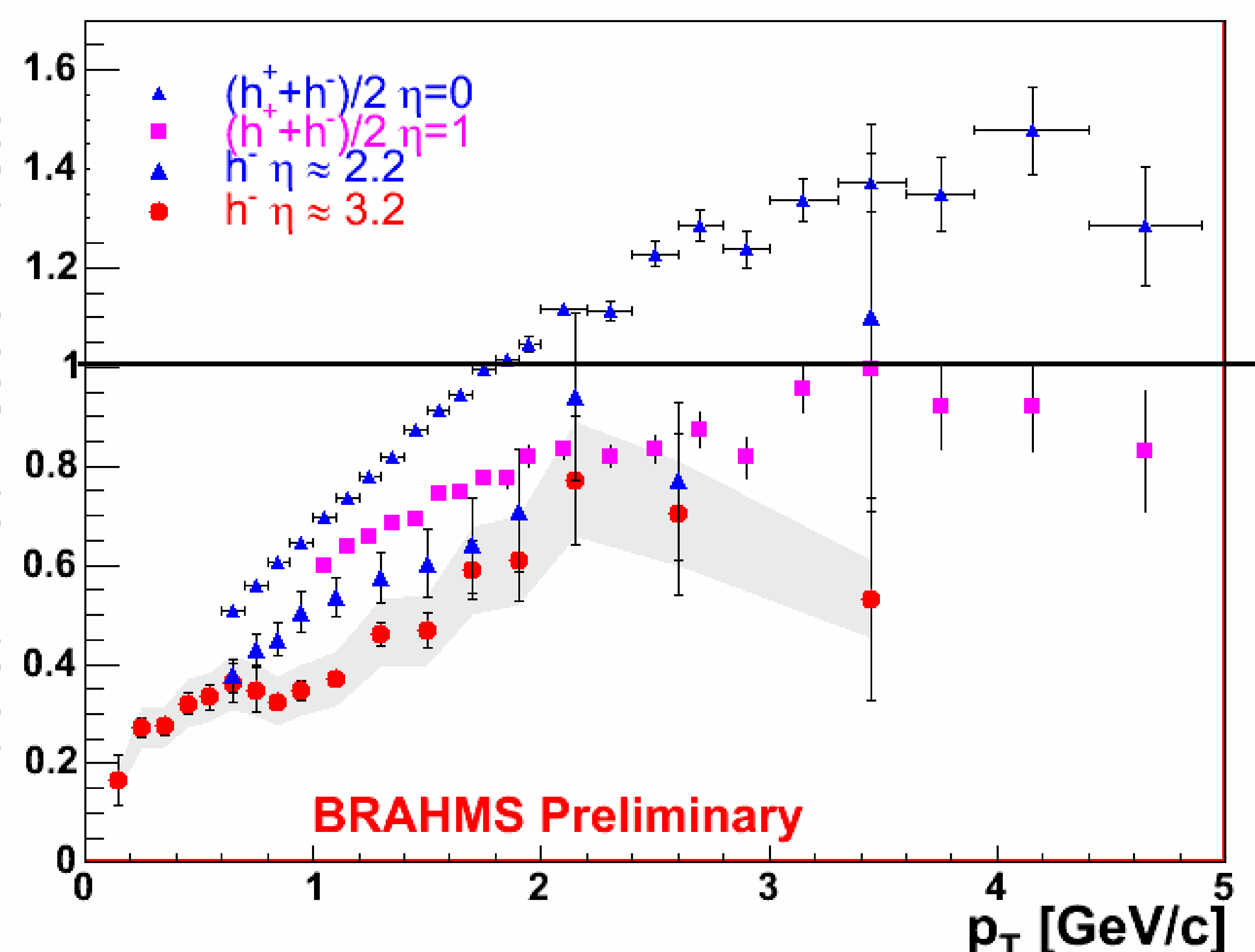
Q_S is the saturation scale below which gluons fuse.

Look at a nucleus at high speed

Take the normalized ratio of dAu and pp spectra

$$\frac{N_{dAu}}{N_{pp} N_{coll}}$$

R. Debbe Tuesday morning



Moving Forward

- Keep pushing to higher p_T and rapidity with more data and better particle identification.
- Add reaction plane as another “axis” to each measurement.
- Extend coalescence to higher rapidity
- Get more data for dAu (and Au - d) ASAP
- Design new experiment for forward region.

What has rapidity taught us?

- $\delta E = 25 \pm 1$ TeV in AuAu, broken scaling.
- dAu multiplicity follows beam participant scaling
- Landau hydrodynamics gives rough rapidity dependence of particle production.
- Chemical + kinetic temperatures increase slightly with y, maybe fewer degrees of freedom.
- Jet quenching persists at least to $\eta = 2.2$.
- R_{dAu} at y:0 => 3 suggests gluon saturation.

Backups

Systematics of thermal fits