High P_T Suppression in Heavy Ion Collisions at RHIC

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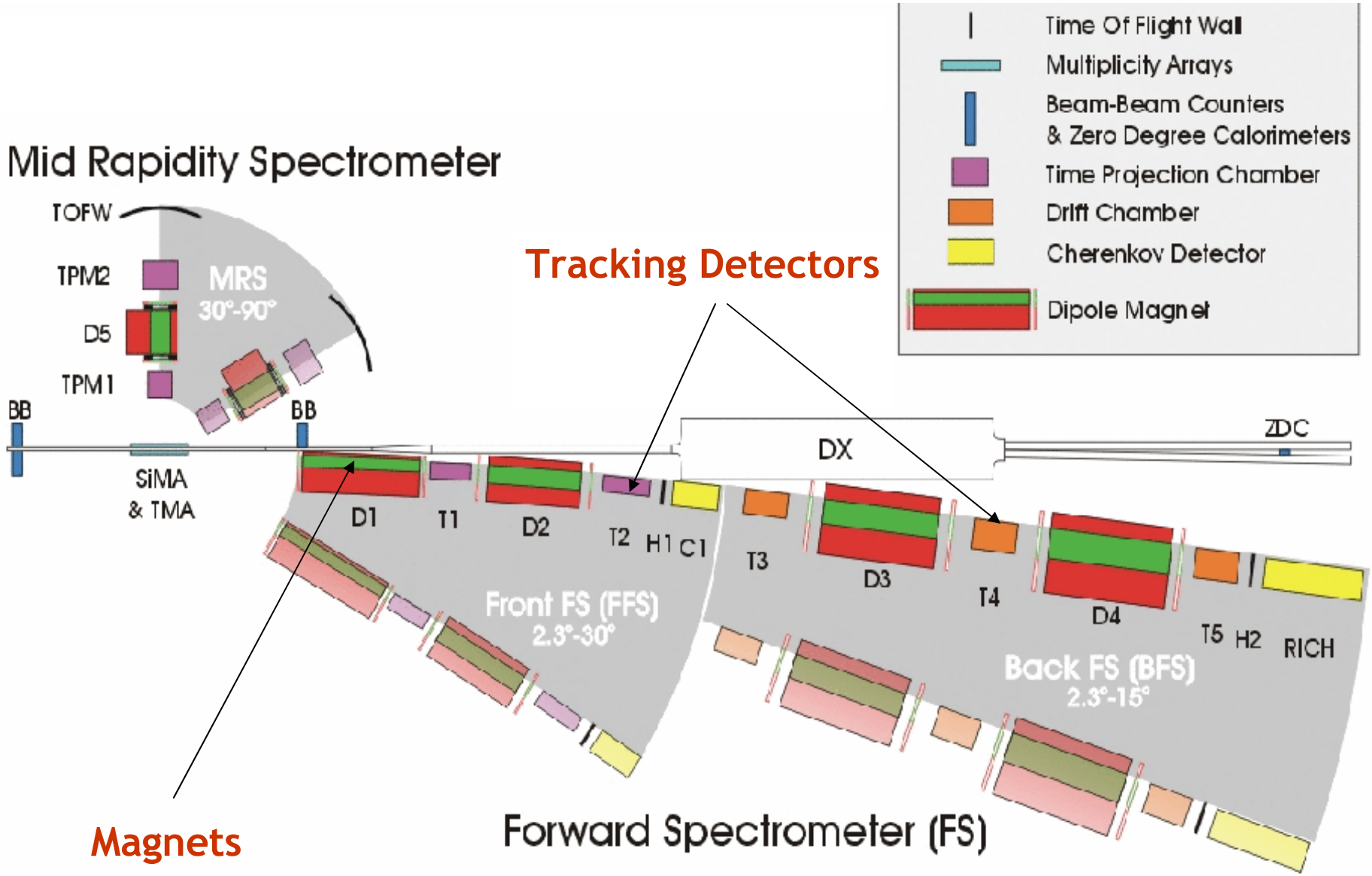
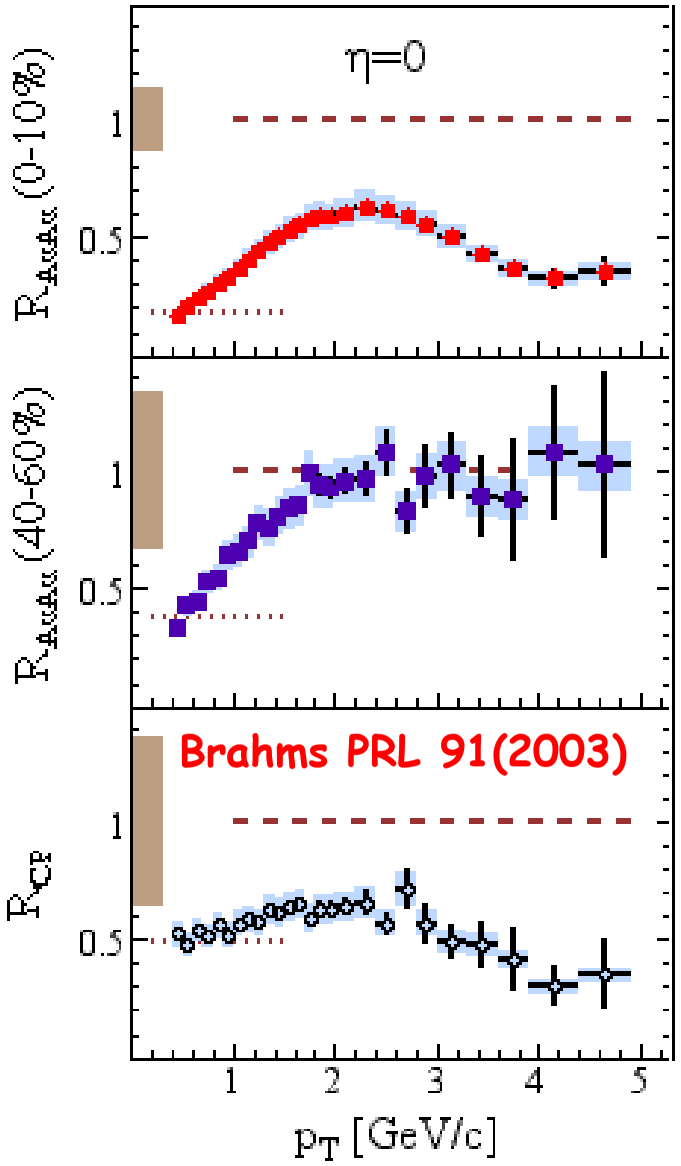
The BRAHMS Experiment



High p_t suppression at η = 0, (η = pseudo-rapidity)



Suppression of high-p_T particle production is described in terms of the nuclear modification factor

$$R_{AA} = \frac{d^2N^{A+A}/dp_T d\eta}{N_{coll} d^2N^{p+p}/dp_T d\eta}$$

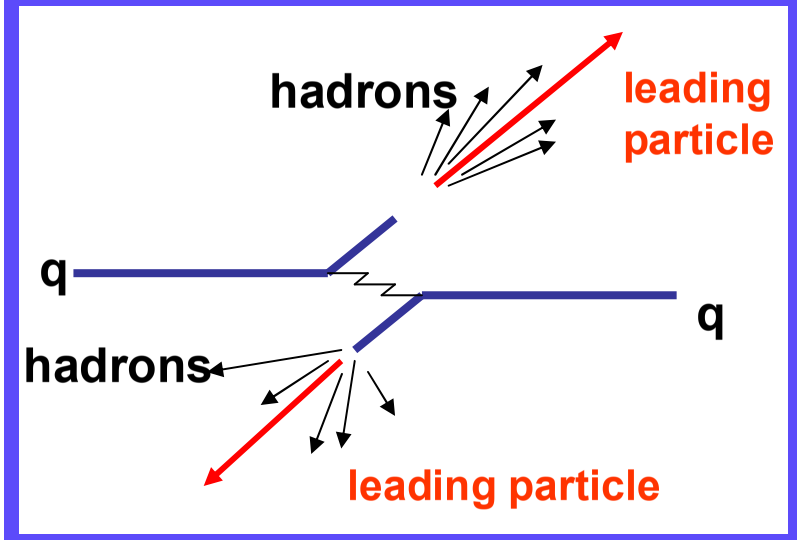
or in terms of the ratio of central to peripheral yield

$$R_{cp} = \frac{1/N^C_{coll} d^2N^C/dp_T d\eta}{1/N^P_{coll} d^2N^P/dp_T d\eta}$$

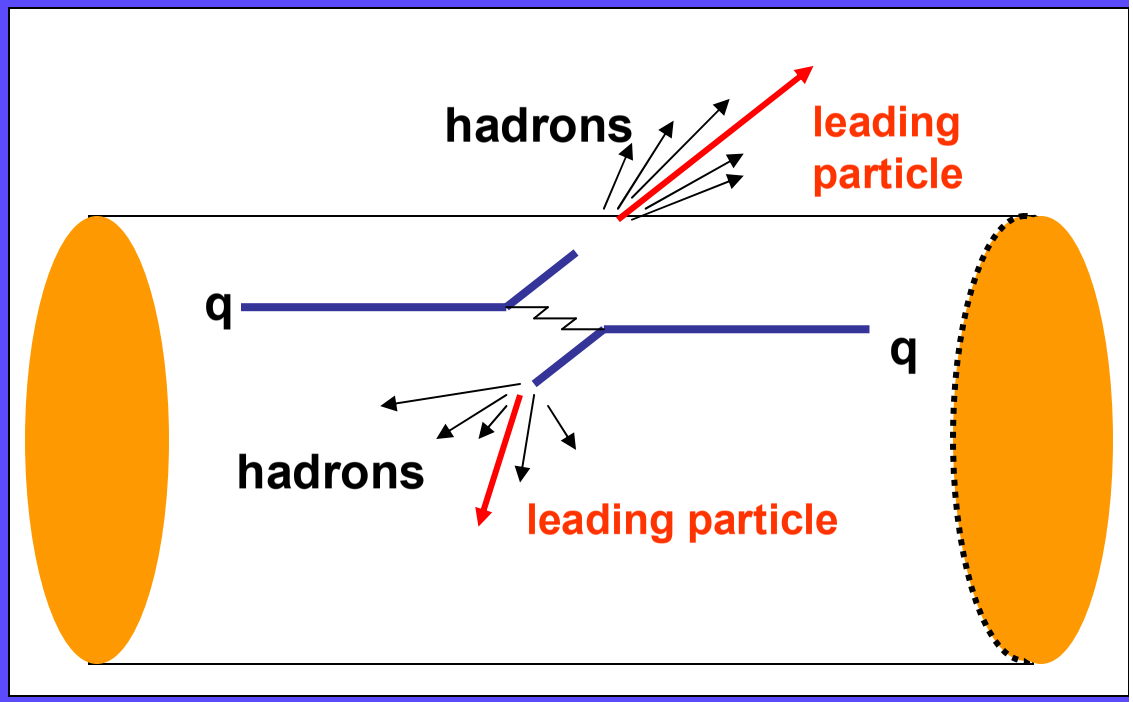
What is responsible for the suppression at high-pt? Interactions in the final state or effects from the initial state or a combination of both?

High-pt particles are produced in hard scatterings

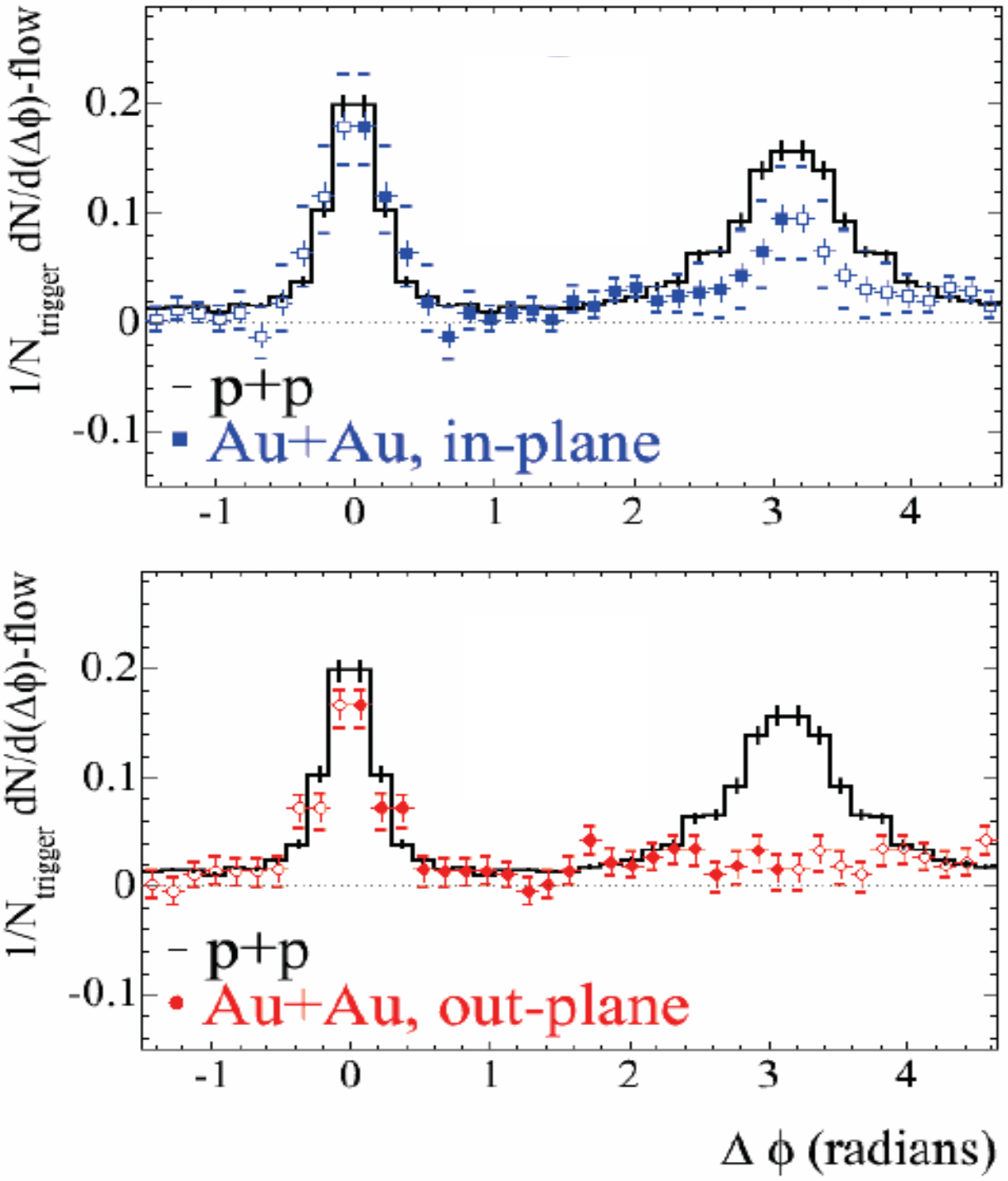
Nucleon-Nucleon collision

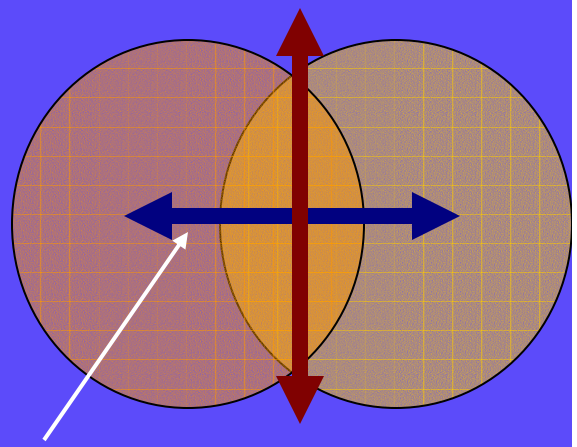


Heavy ion collision



Two particle azimuthal correlation measurements indicated that the distribution of the away side jets Is strongly suppressed in comparison with the near Side jets at high P_T pointing to a strongly interacting medium





Reaction plane

more suppression of particle spectra out of the reaction plane than in the reaction plane

high Pt suppression might be due to final state interactions

Results at mid-rapidity are consistent with partonic energy loss in the larger interaction volume corresponding to central collisions

…… QGP??

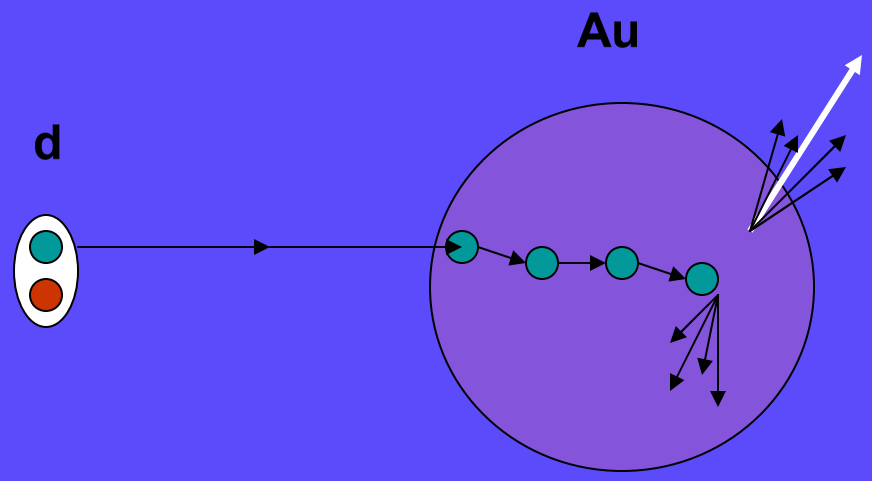
How can one be sure?

Is it possible to look at situations where final state interactions are expected to be less important?

Look at dAu collisions

If suppression is a final state effect $R_{dAu} \sim 1$

If suppression is an initial effect $R_{dAu} < 1$



High p_t suppression at $\eta = 0$ in dAu

No suppression has been seen in dAu collisions at $\eta = 0$

This observation seems to give credence to the hypothesis that high p_t suppression may indeed be a final state effect

But wait,

will this picture persist if one looks at forward rapidities?

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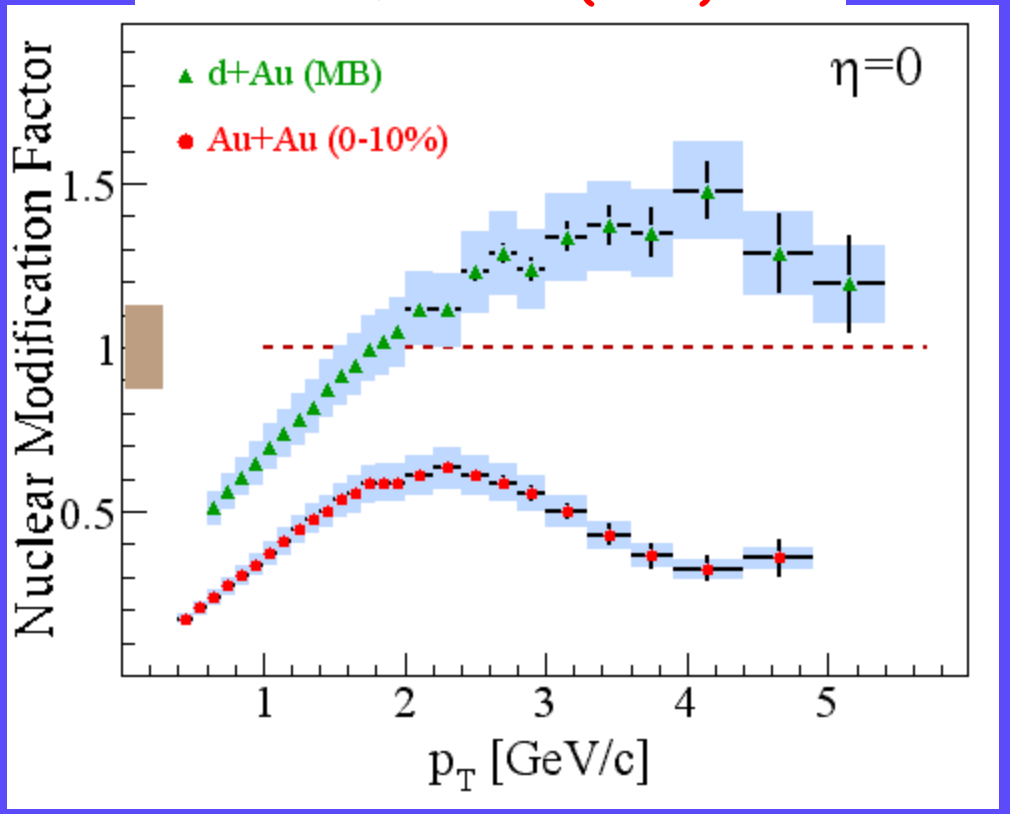


- Why is forward rapidity important?

- A very high energy hadron has contributions to its wave function from gluons, quarks and anti-quarks

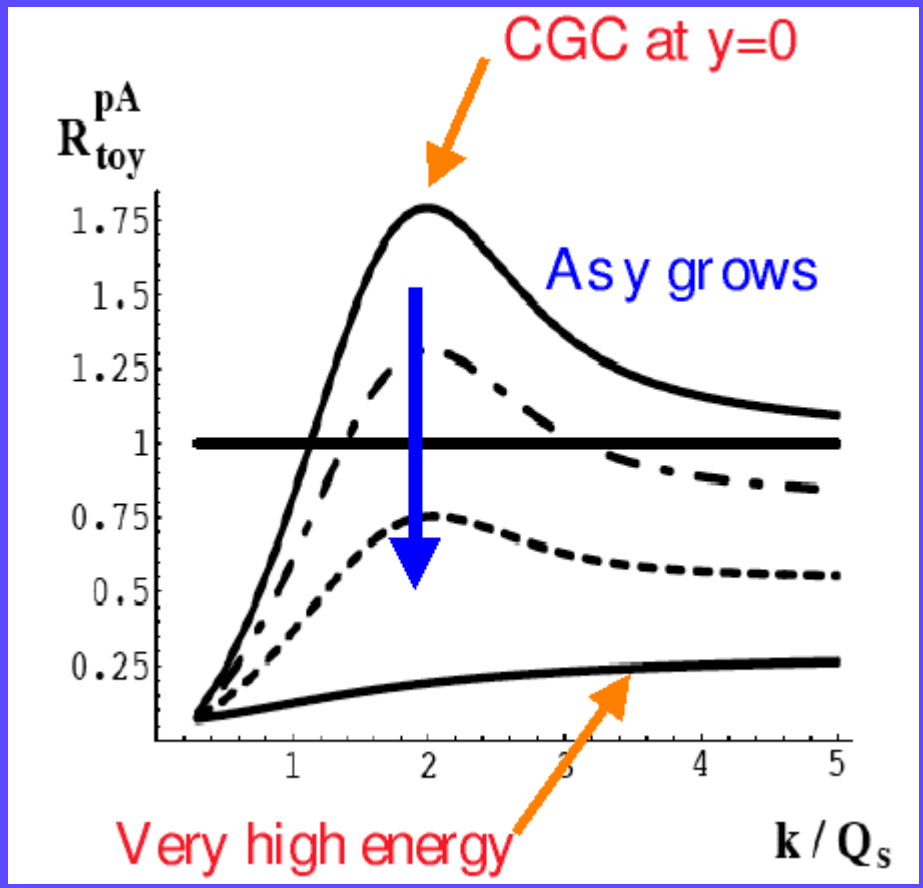
$$X = E_{parton}/E_{hadron}$$
$$x \sim e^{-y}$$

- Low X ←→ large rapidity
- The low x phenomena are described by the theory of the color glass condensate (CGC)

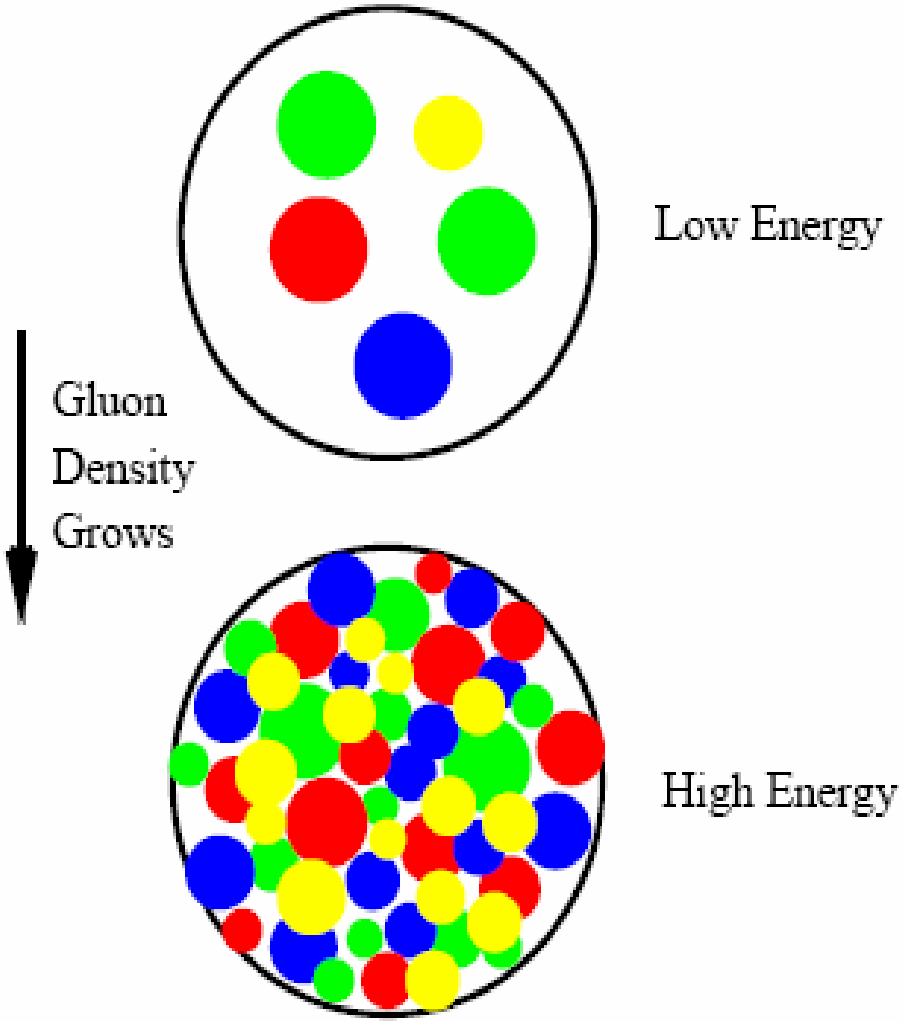
- Can be probed in nuclear system.

- P_t suppression can be related to
- modification (shadowing)
- Saturation (due to fusion processes)

D. Kharzeev hep-ph/030737



- Density of low x gluons grows as energy increases
- Leads to gluon saturation
- Parton scattering centers reduced as a result of gluon-gluon fusion
- Less number of hard scatterings
- Reduction in production of high pt hadrons



High P_t suppression: R_{dAu} versus η

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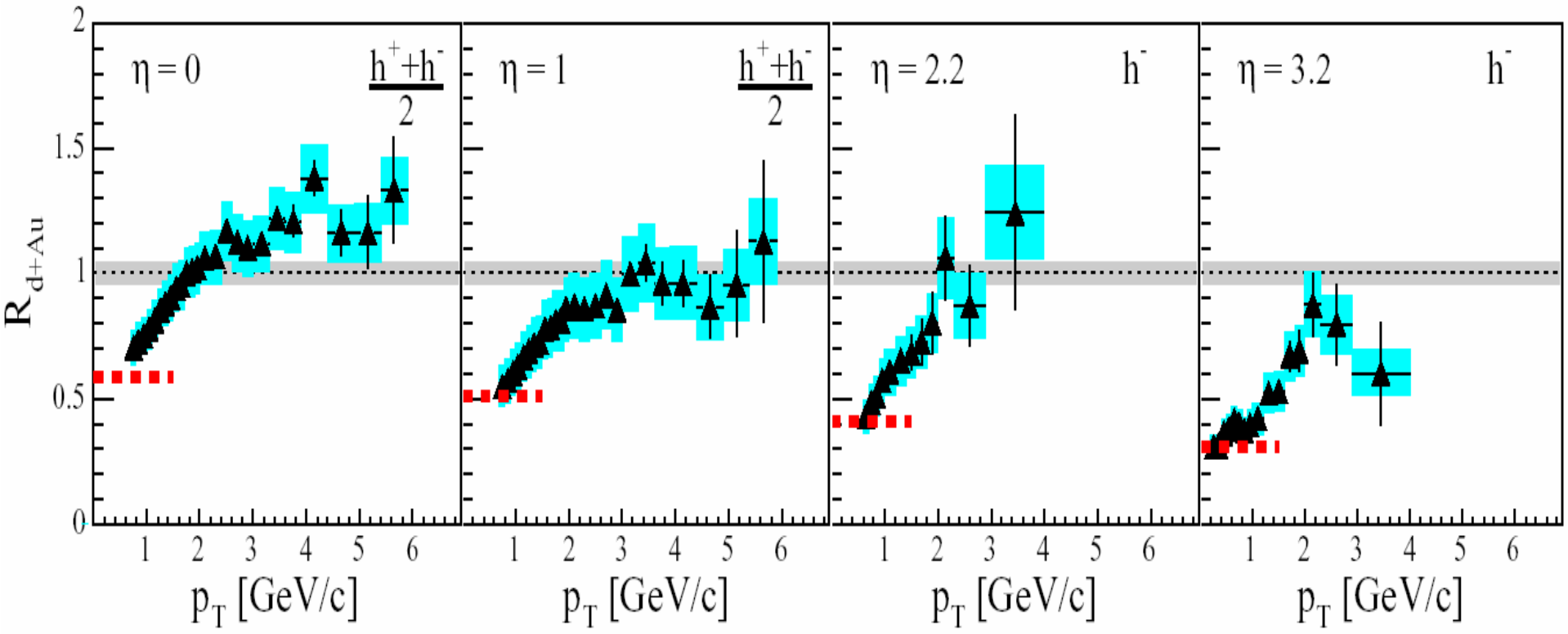
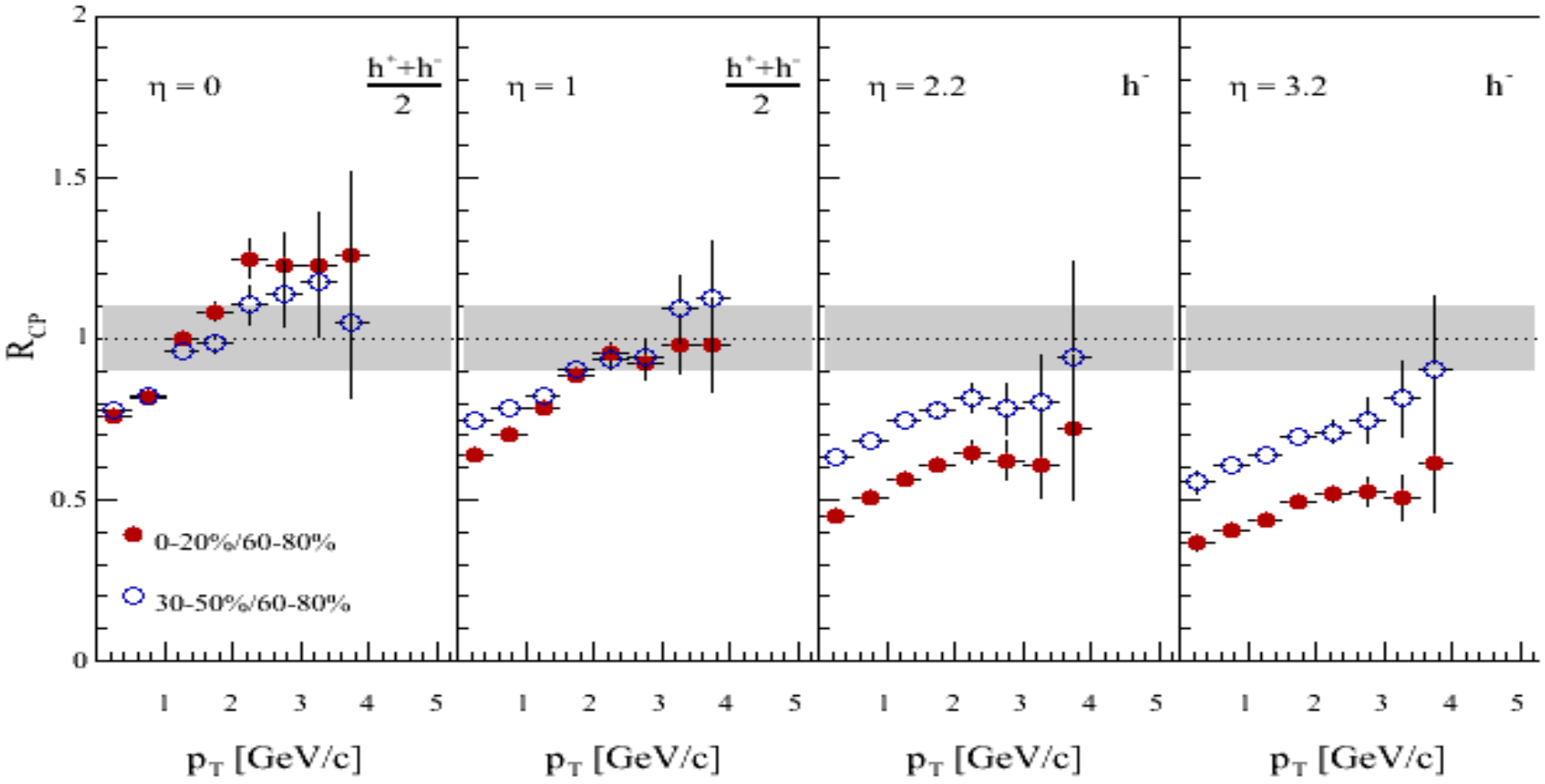


-Cronin like enhancement at η = 0
-Clear suppression as η changes from 0 to 3.2
-Suggest high-pt suppression may be due to initial state effects (e.g. gluon saturation)

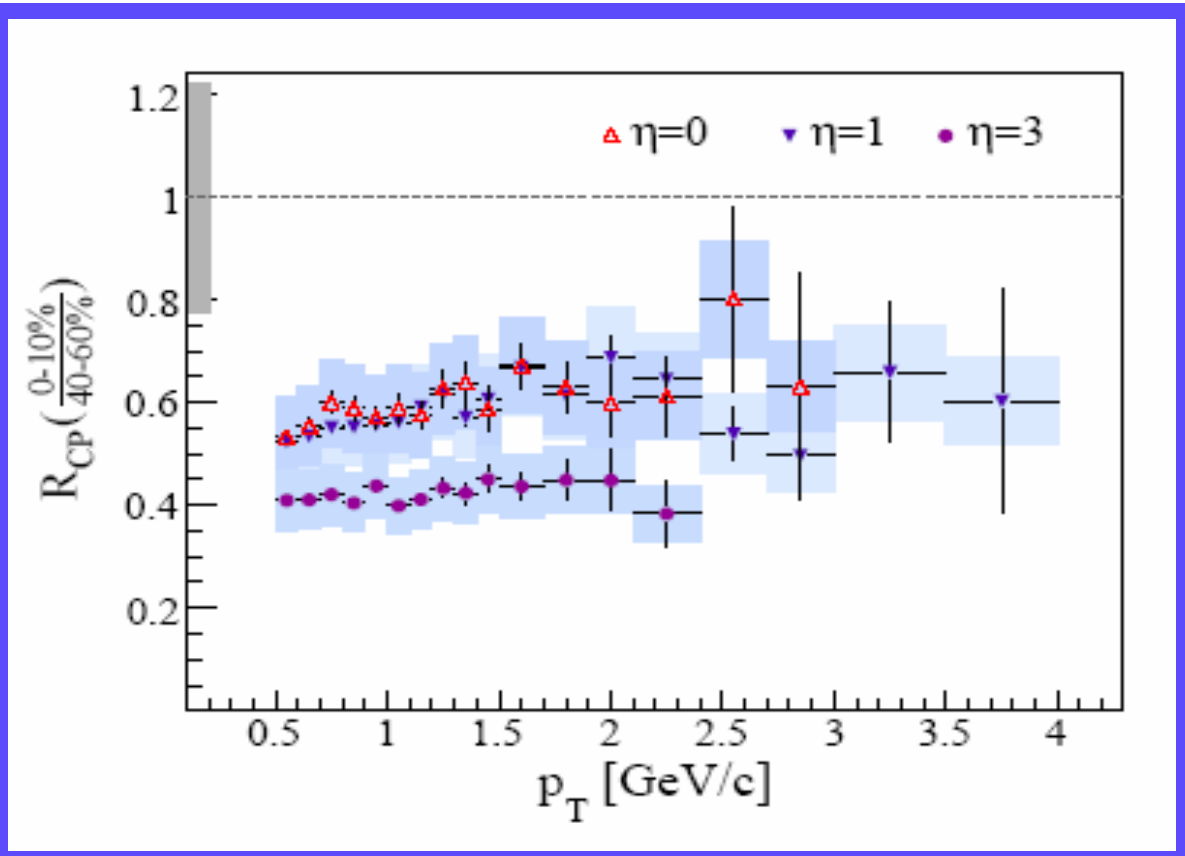
AuAu @ $\sqrt{S_{NN}}$ = 200 GeV



-At η =0 R_{cp} for central events systematically above that of semi-central events.

-More suppression as one goes to forward rapidity

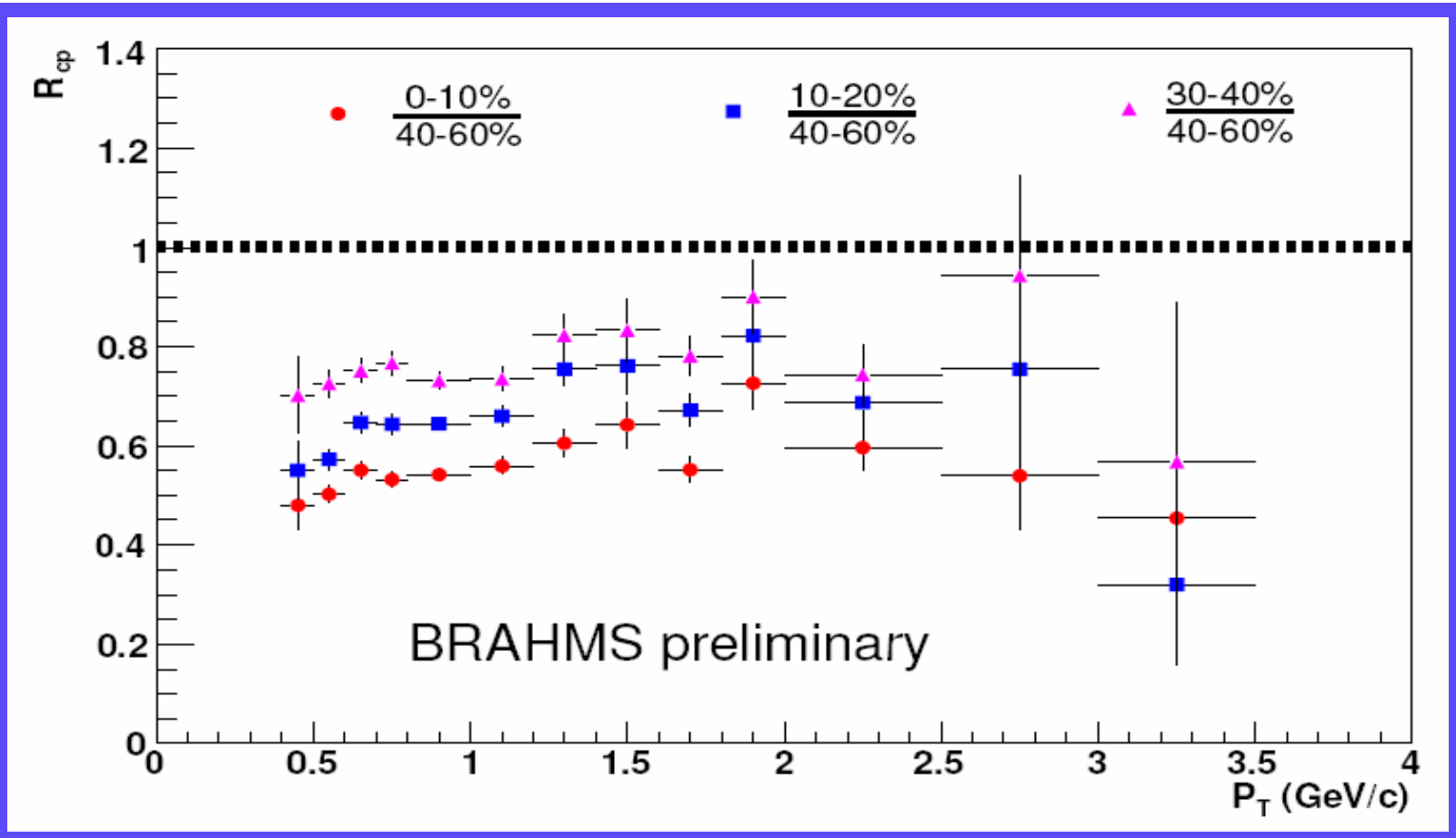
AuAu @ $\sqrt{S_{NN}}$ = 62.4 GeV



Similar R_{cp} at η = 0 and η=1.

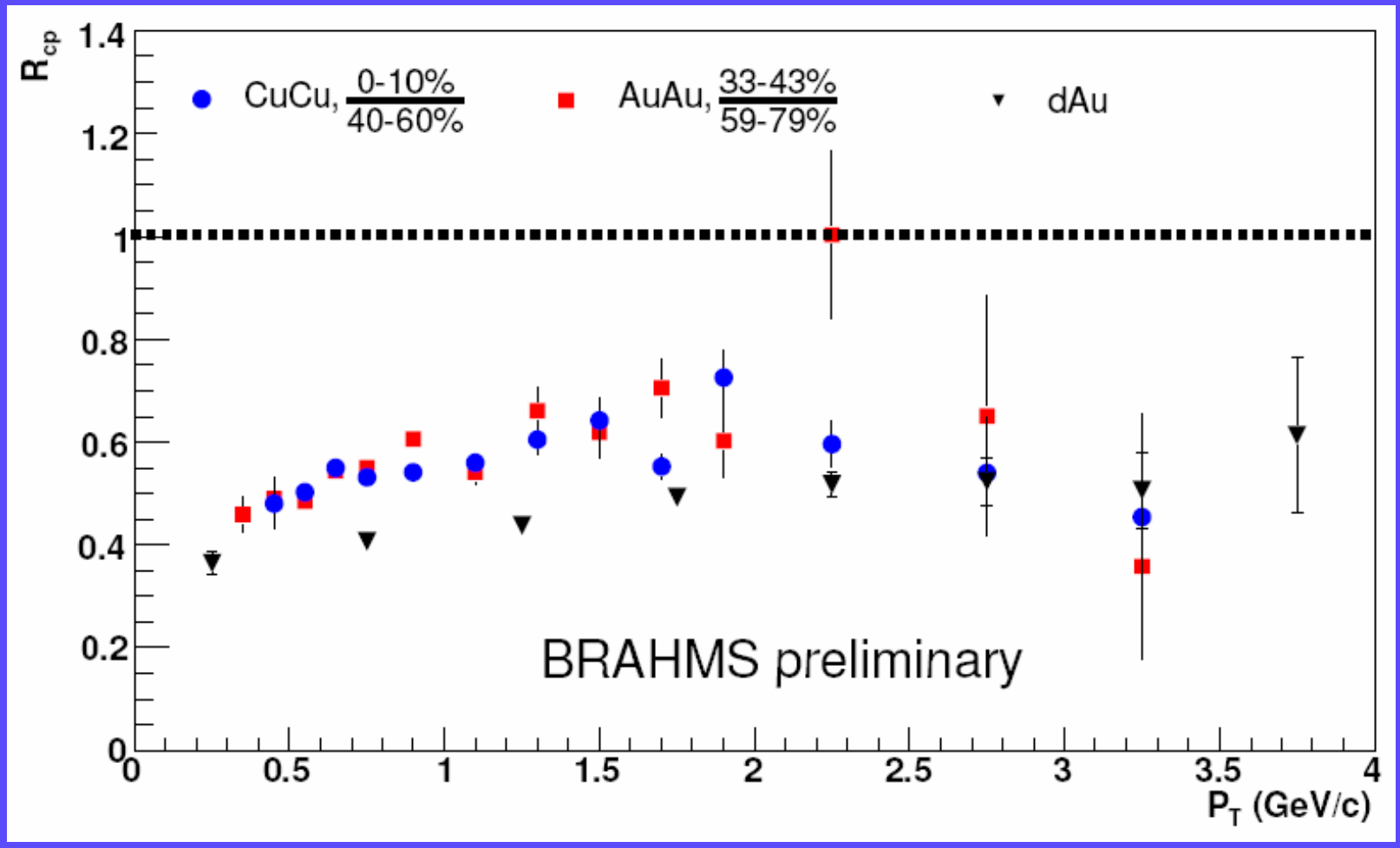
More suppression at very forward η compared to AuAu @ 200 GeV and little p_T dependence

CuCu @ $\sqrt{S_{NN}}$ = 200 GeV; **η = 3.2**



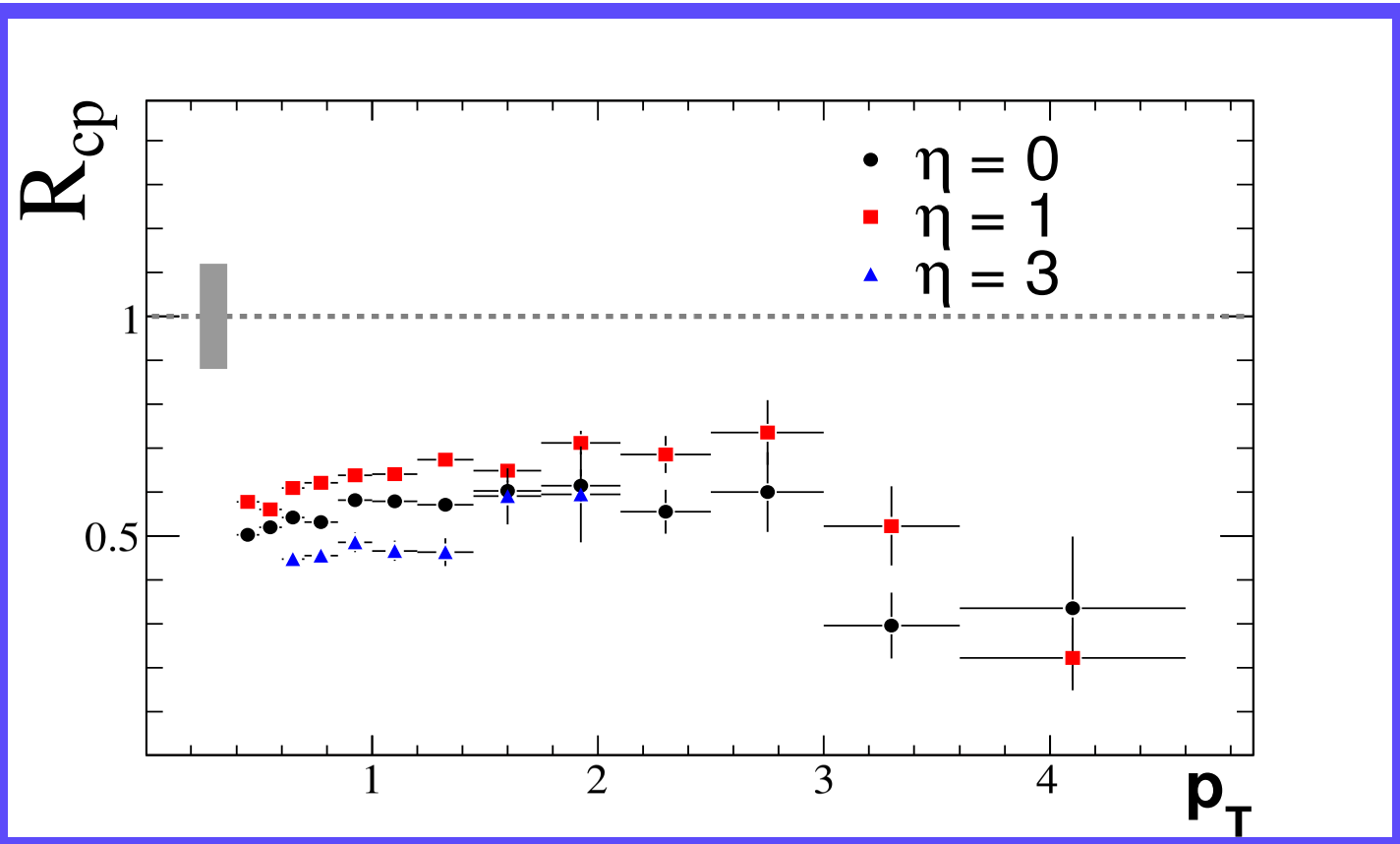
Centrality dependence of R_{cp} in CuCu shows more suppression in central than peripheral collisions in line with quark energy loss in the larger medium

CuCu @ $\sqrt{S_{NN}}$ = 200 GeV; **η = 3.2**



For the same number of participants, R_{cp} in CuCu is similar to that in AuAu

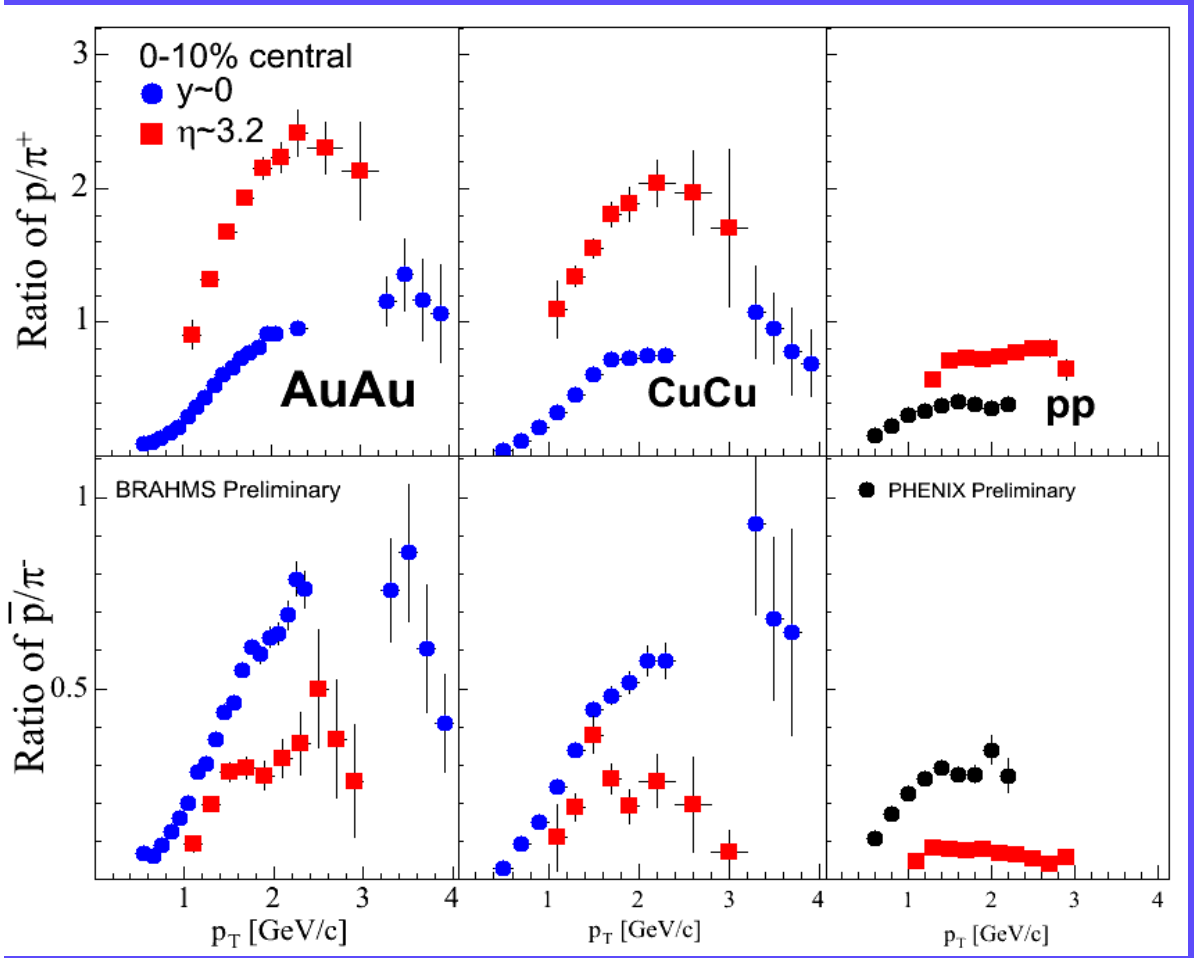
CuCu @ $\sqrt{s_{NN}}$ = 62.4 GeV



R_{cp} at η = 0 and η=1 seem different in CuCu

More suppression at very forward η compared to AuAu @ 200 GeV

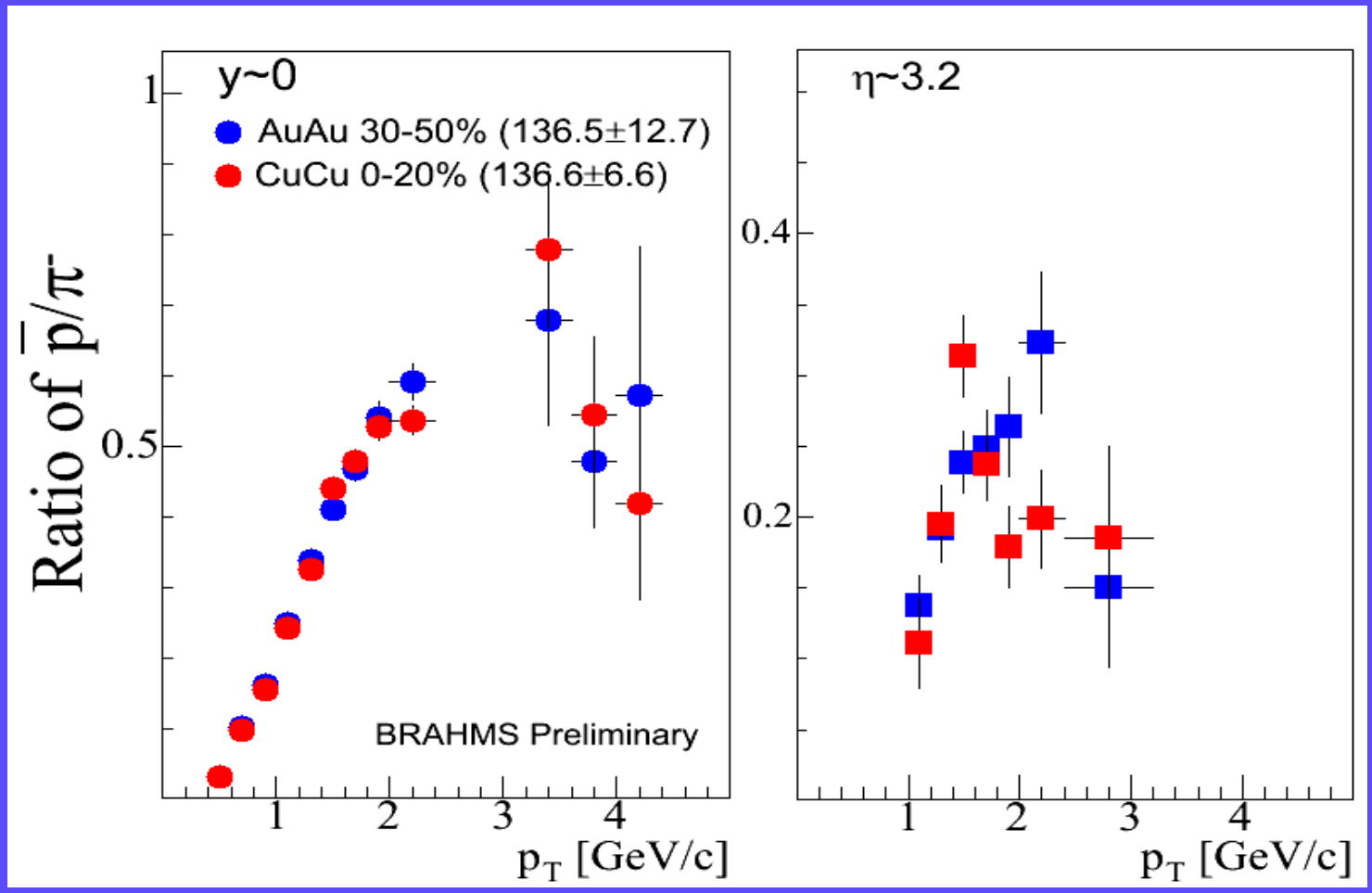
system size dependence of p/π



The transition point from soft to hard processes seems to shift to lower values for CuCu

A larger proton to pion ratio at forward rapidity than at mid rapidity in CuCu

Comparison of AuAu & CuCu



pbar to pion ratios in different collision systems are similar for comparable number of participants

Summary

- Preliminary results on suppression of high p_t hadron production relative to binary scaling in Au+Au and Cu+Cu collisions at $\sqrt{s_{NN}}$ = 200, 62 GeV
- R_{cp} in CuCu similar to AuAu for the same number of participants
- Mid-rapidity results suggest high-p_t suppression is due to final state effects (e.g. Jet quenching)
- Forward rapidity results suggest high-p_t suppression is due to initial state effects (e.g. gluon saturation)
- pbar to pion ratios in different collision systems are similar for comparable number of participants
- System mass systematics being extended to mid-rapidity region

BRAHMS Collaboration

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48 physicists from 12 institutions