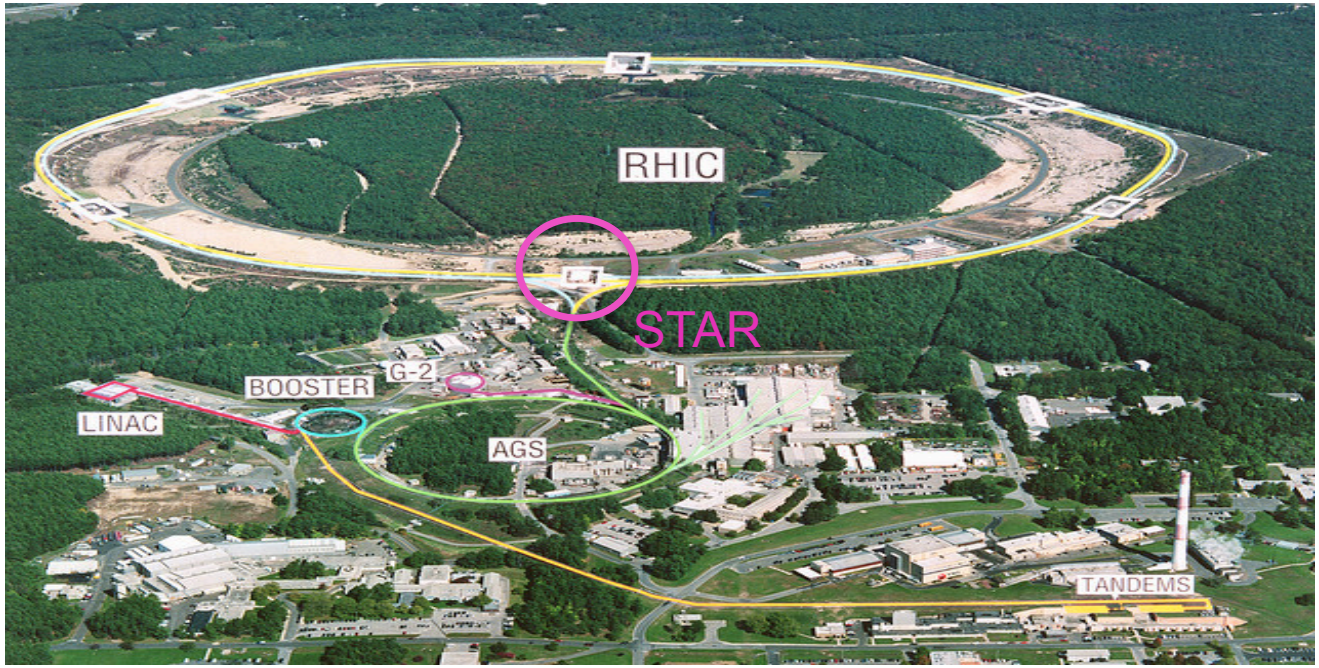
Forward di-hadron correlation study at STAR



Xuan Li for the STAR Collaboration

Temple University

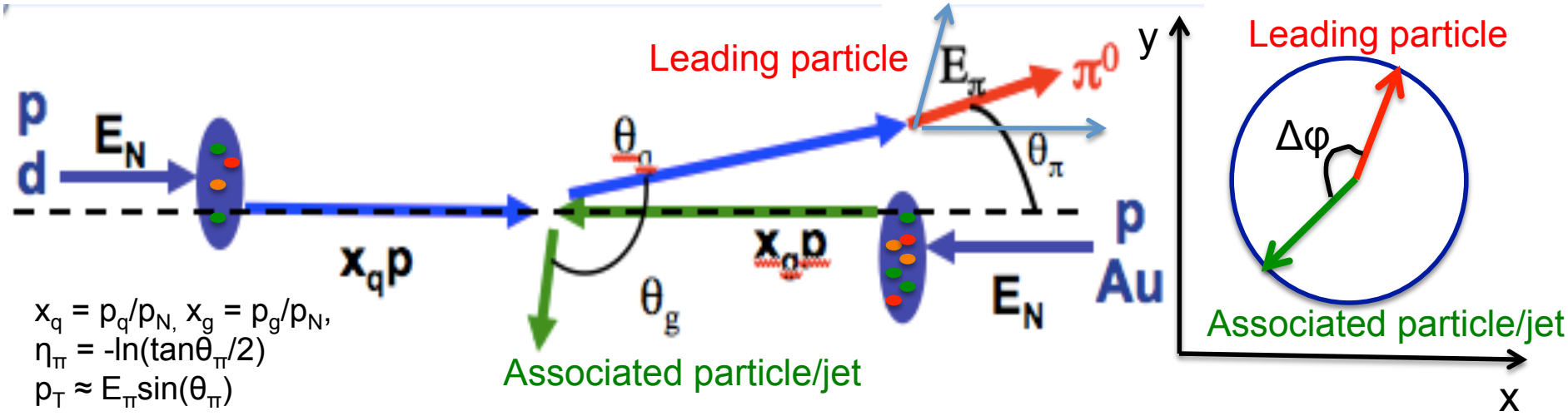
Outline

- Motivation
  - How sharp is the transition from dilute parton gas to saturated parton density: eg. Color Glass Condensate (CGC)?
- Forward π^0 and associated jet-like cluster correlations at STAR
  - Event reconstruction
  - Correlation results in p+p and centrality dependent d+Au collisions.
- Summary

How to probe low x gluons

- Forward particle production.

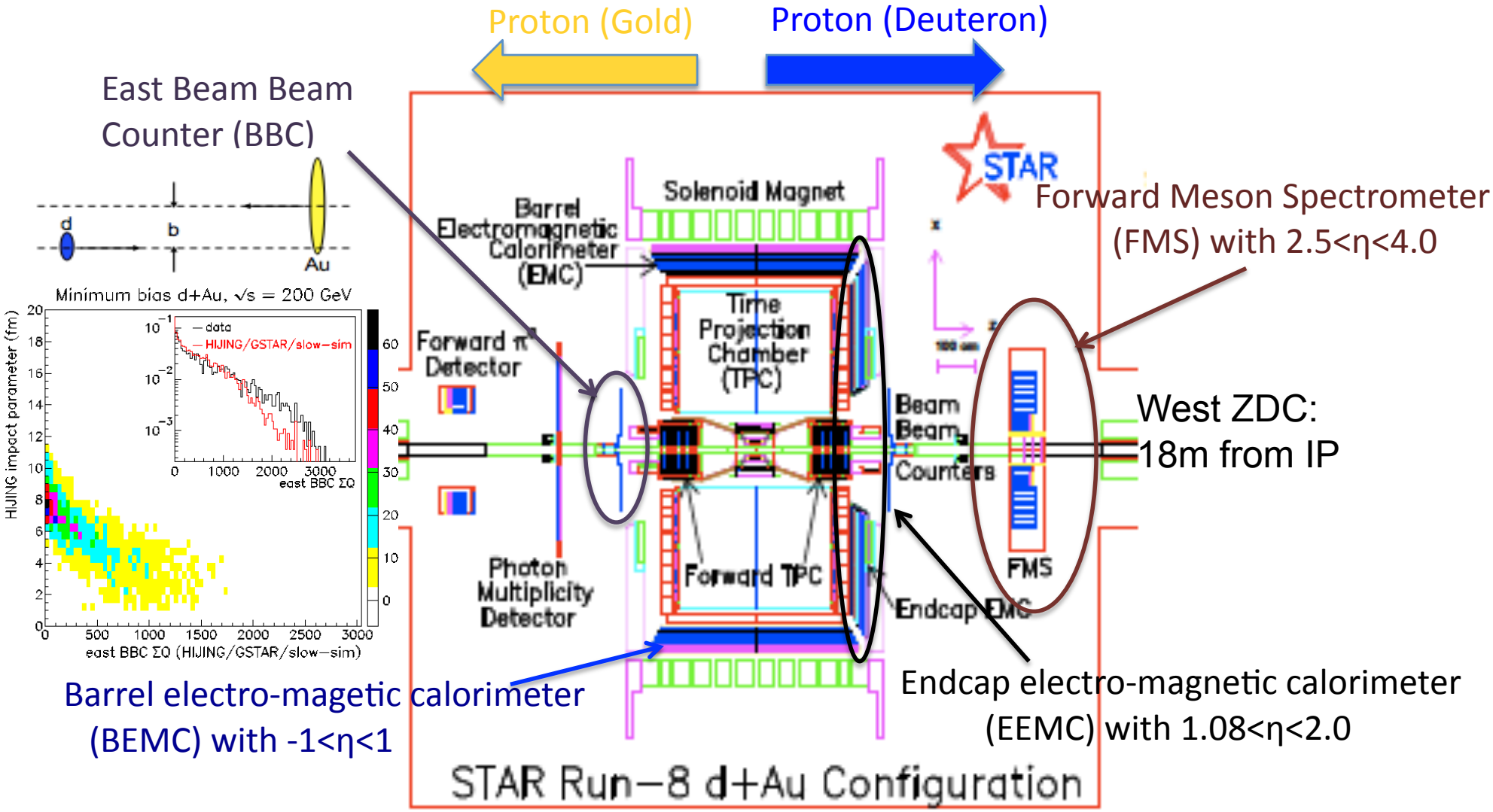
- The factorization mechanism is taken as universal and applied in nucleon (nucleus)+ nucleon (nucleus) collisions.



- Large rapidity (η_π~4) inclusive π production and correlations **probe asymmetric partonic collisions.**
- Mostly **high-x_q valence quark (x>0.2)** + **low-x_g gluon (x<0.01).**
- **Forward back-to-back correlations can probe low x gluon.**

STAR Detector setup

- The schematics of STAR in RHIC run8.

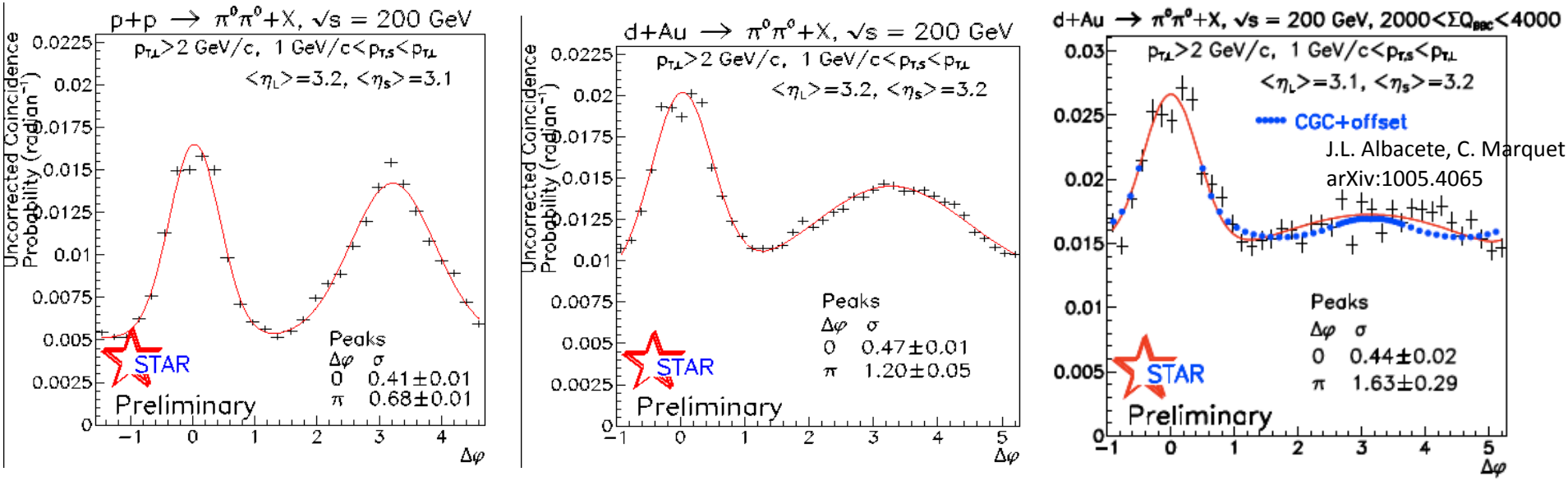


- We use the data of run8 p+p and d+Au collision at $\sqrt{s} = 200$GeV.

Motivation

- Suppression of forward π^0 + forward π^0 back-to-back correlations found in central d+Au collisions.

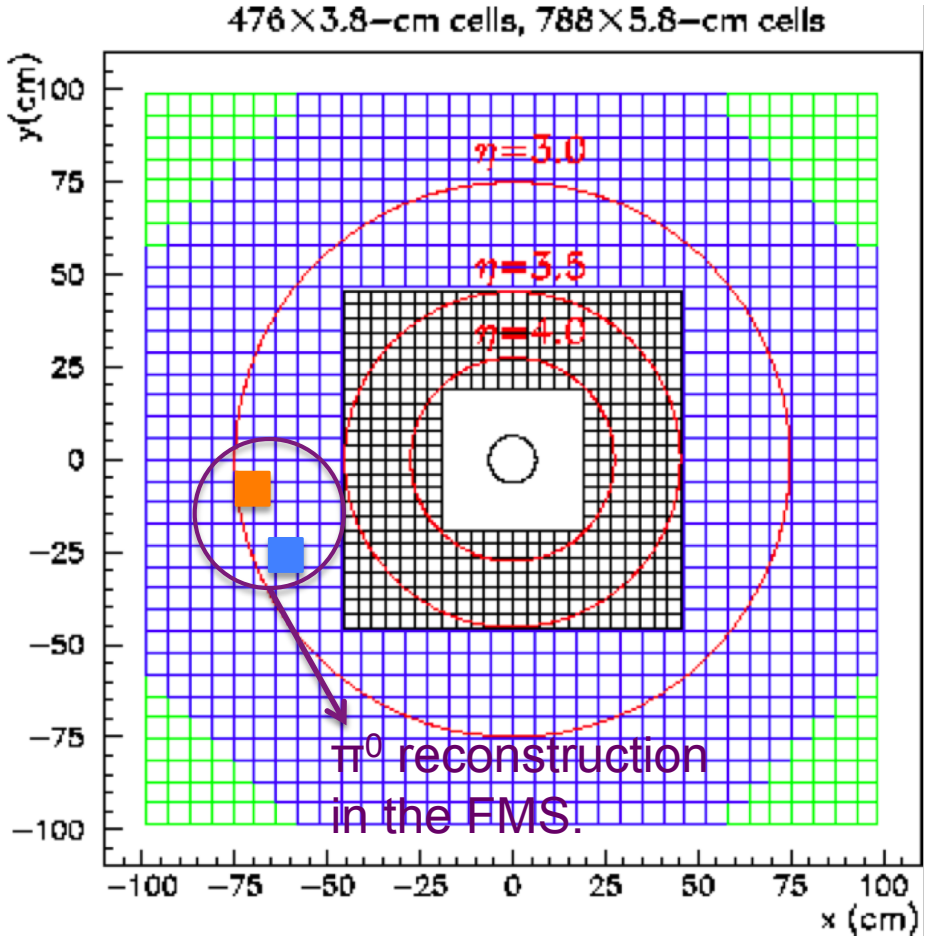
pp ArXiv:1108.3989 dAu Central dAu

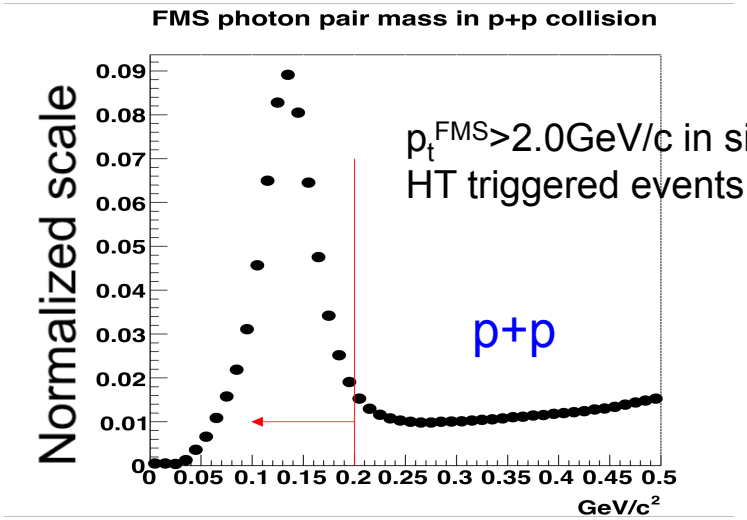


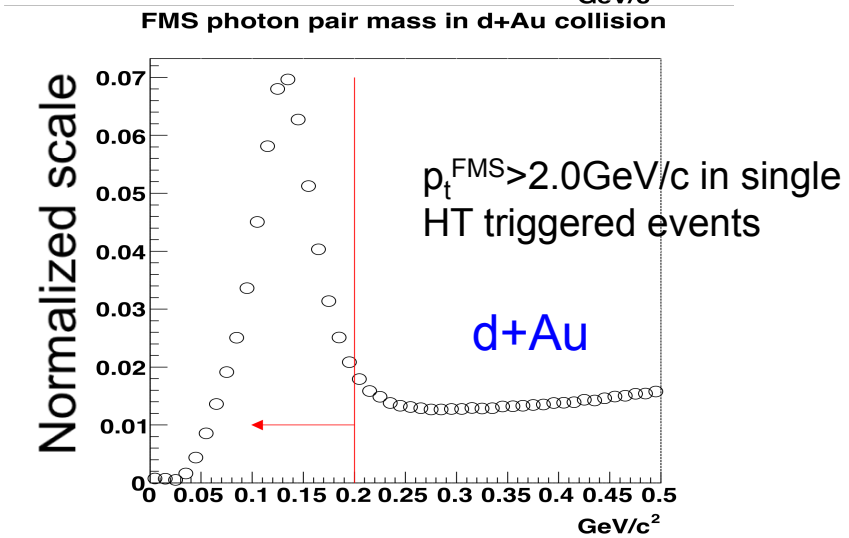
- Do the phenomenon exist in other forward correlations?
- Look at the π^0+jet-like cluster correlations.
- How sharp is the transition from dilute parton gas to Color Glass Condensate (CGC)?
- Reconstruct associated jet-like cluster in different pseudo-rapidity region.

π^0 reconstruction in the FMS

- Leading forward π^0 is reconstructed in the most forward detector — FMS with HT trigger.





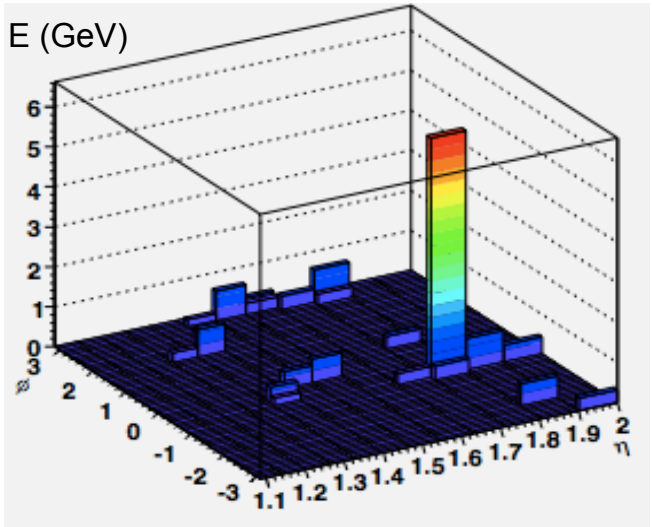


- There are clear π^0 peaks in the FMS during p+p and d+Au collisions.

Jet-like cluster reconstruction in the EEMC

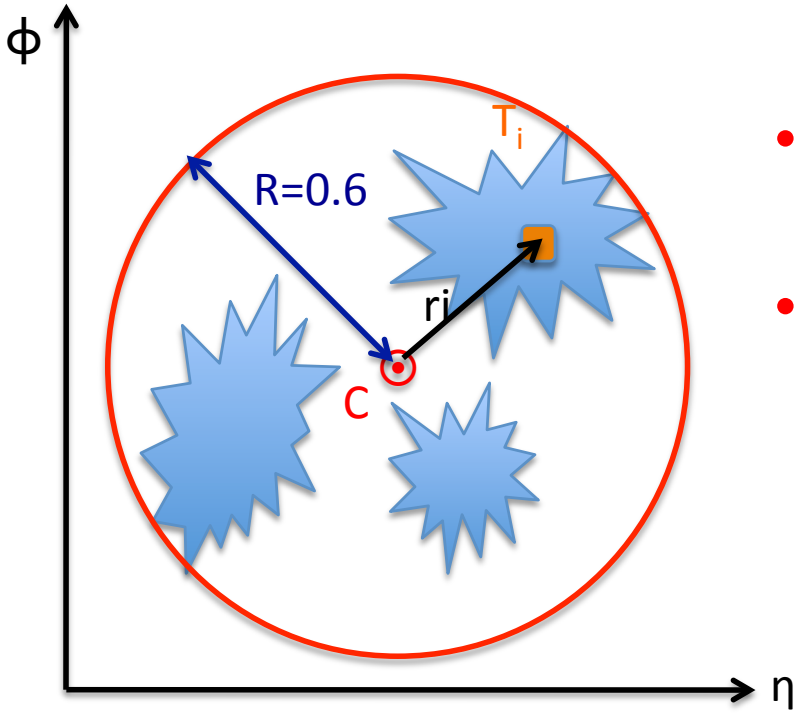
- The jet-like cluster are reconstructed based on cone algorithm.

One event of the energy deposition in the EEMC with FMS π^0 trigger(p_t>2.0GeV/c) in p+p collision at $\sqrt{s}$ = 200GeV.



The EEMC energy deposition is jetty.

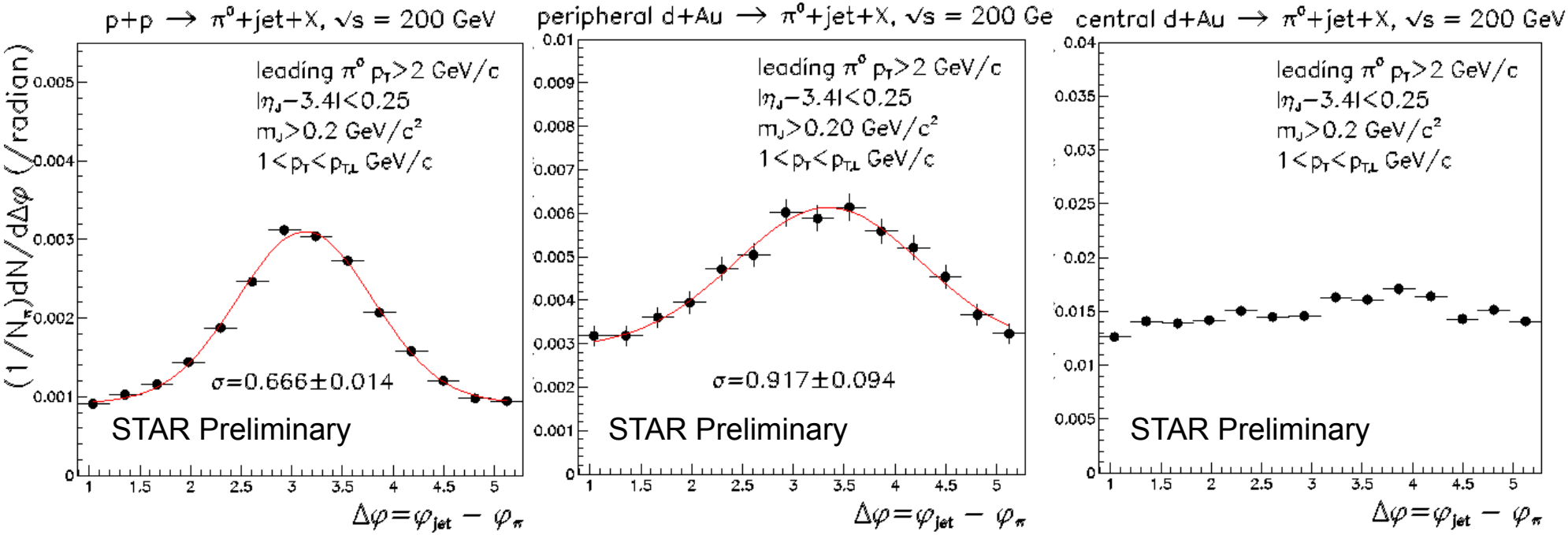
Study π^0+jet-like cluster correlations.

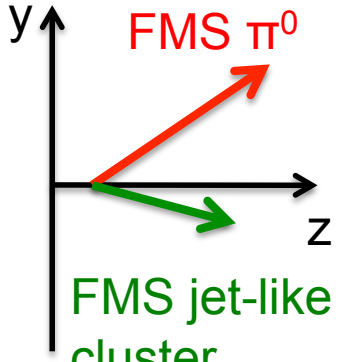


- Energy E_{jet}: $E_{jet} = \Sigma E_{Ti}$, E_{Ti} is the energy of tower i.
- Mass M_{jet}: (1) Assuming tower hits are zero mass. Projecting T_i energy to its center to get the momentum vector of the tower p_{Ti}. (2) The jet-like momentum vector $p_{jet} = \Sigma p_{Ti}$. (3) $M_{jet} = \mathrm{sqrt}(E_{jet}^2 - P_{jet}^2)$.

New: FMS (π^0)-FMS (jet-like cluster) correlations

Centrality dependence of π^0+jet-like cluster azimuthal correlations in FMS

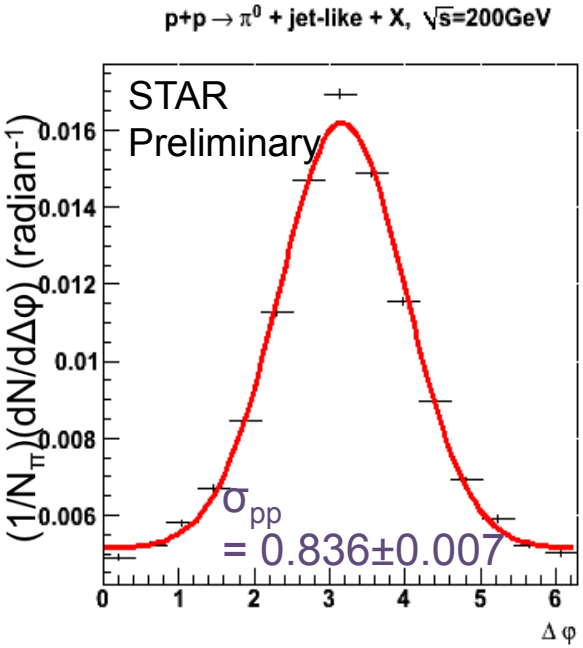


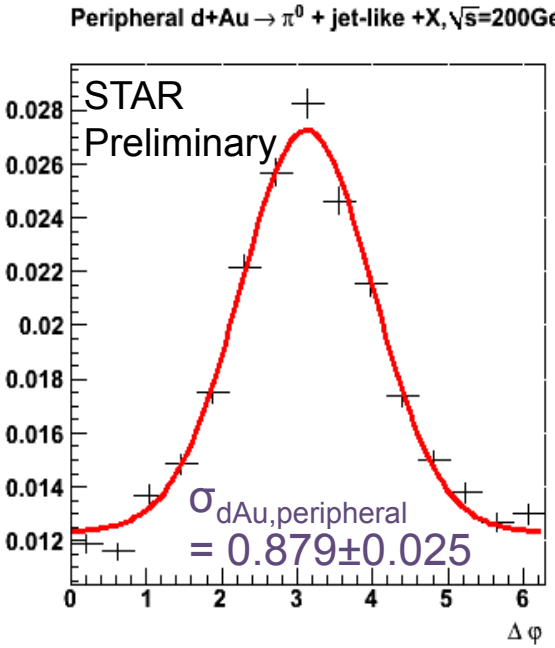


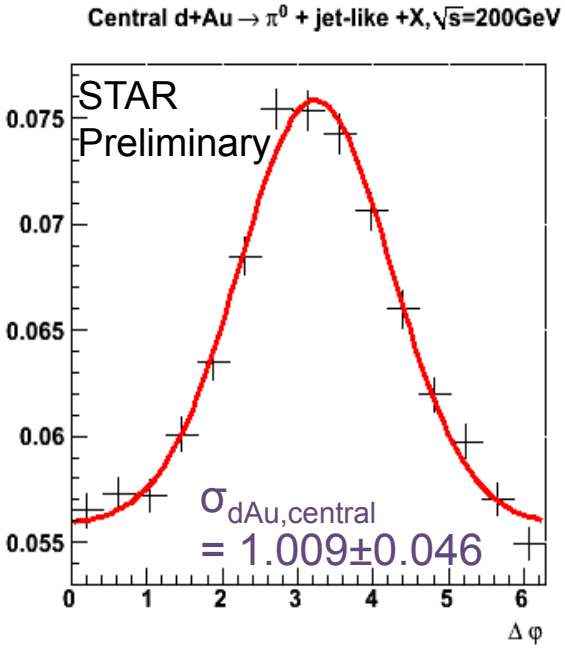
- Mixed-event corrections applied, resulting in ~15% bin-to-bin changes.
- Use beam-beam counter facing Au beam to select peripheral ($\Sigma Q<250$) and central ($2000<\Sigma Q<4000$) collisions.
- No evidence of away-side peak for central d+Au collisions.
- $\sigma_{dAu(peripheral)} - \sigma_{pp} = 0.25 \pm 0.10$.

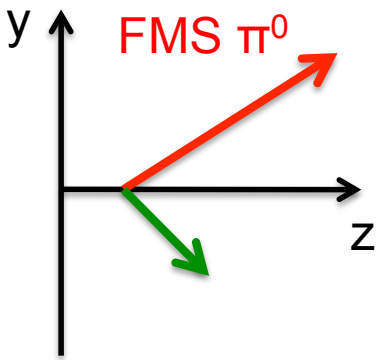
New: FMS (π^0)-EEMC (jet-like cluster) correlations

P_T(FMS) > 2.0 GeV/c ; 1.0 GeV/c < P_T(EEMC) < P_T(FMS)







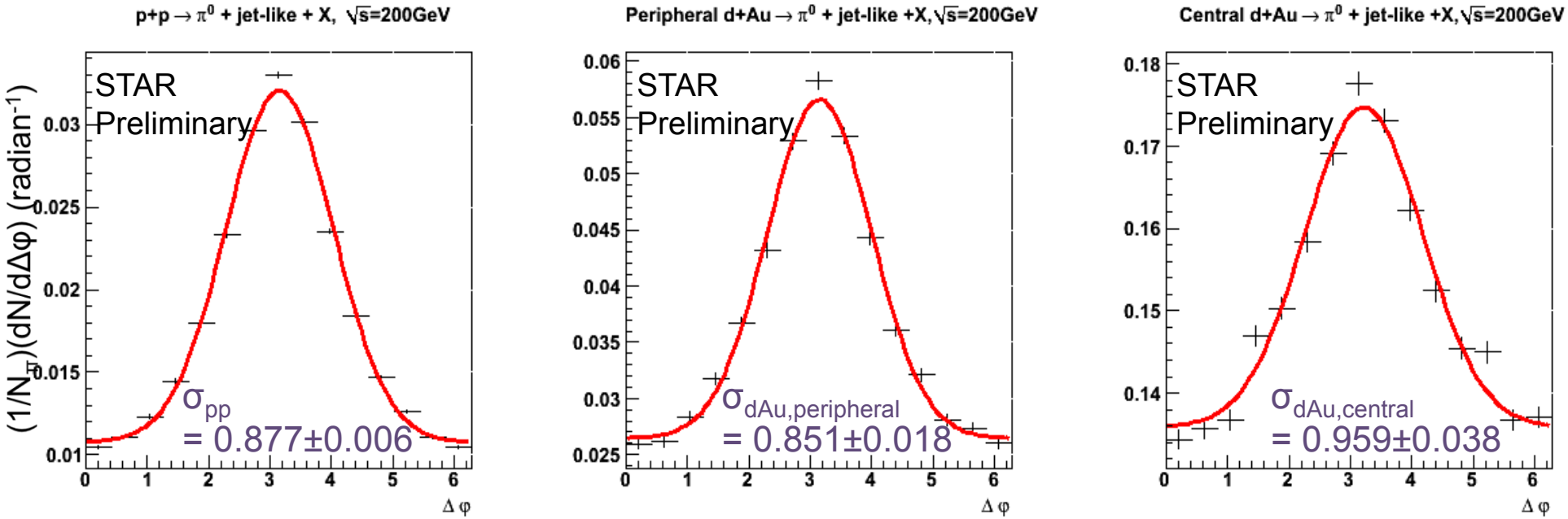


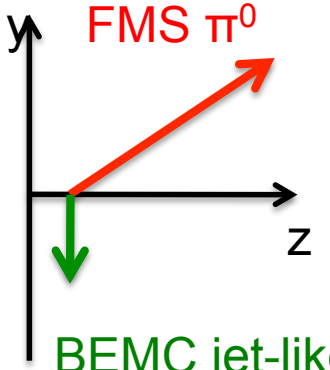
EEMC jet-like cluster

- FMS π^0 p_t^{FMS}>2.0GeV/c. With 400MeV tower threshold, cone R=0.6, EEMC jet-like cluster (M>0.2GeV/c^2) 1.3<η<1.7, 1.0GeV/c<p_t^{EEMC}<p_t^{FMS}.
- Mixed event corrections applied to the correlations. Use beam-beam counter facing Au beam to select peripheral (ΣQ<250) and central (2000<ΣQ<4000)d+Au collision.
- $\sigma_{dAu(peripheral)} - \sigma_{pp} = 0.04 \pm 0.03$, $\sigma_{dAu(central)} - \sigma_{pp} = 0.17 \pm 0.05$.

New: FMS (π^0)-BEMC (jet-like cluster) correlations

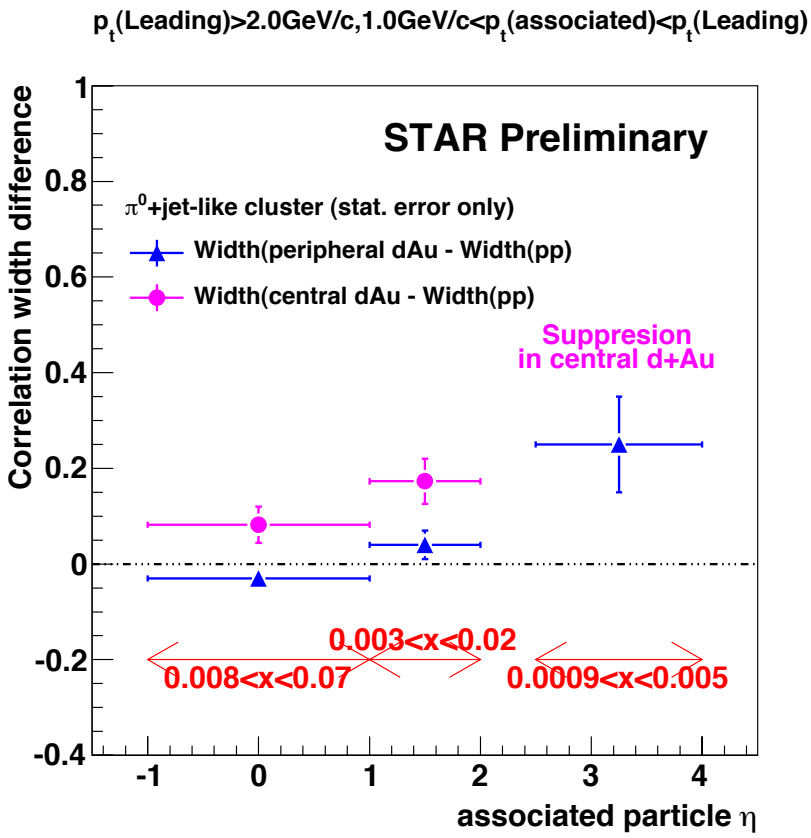
P_T(FMS) > 2.0 GeV/c ; 1.0 GeV/c < P_T(BEMC) < P_T(FMS)

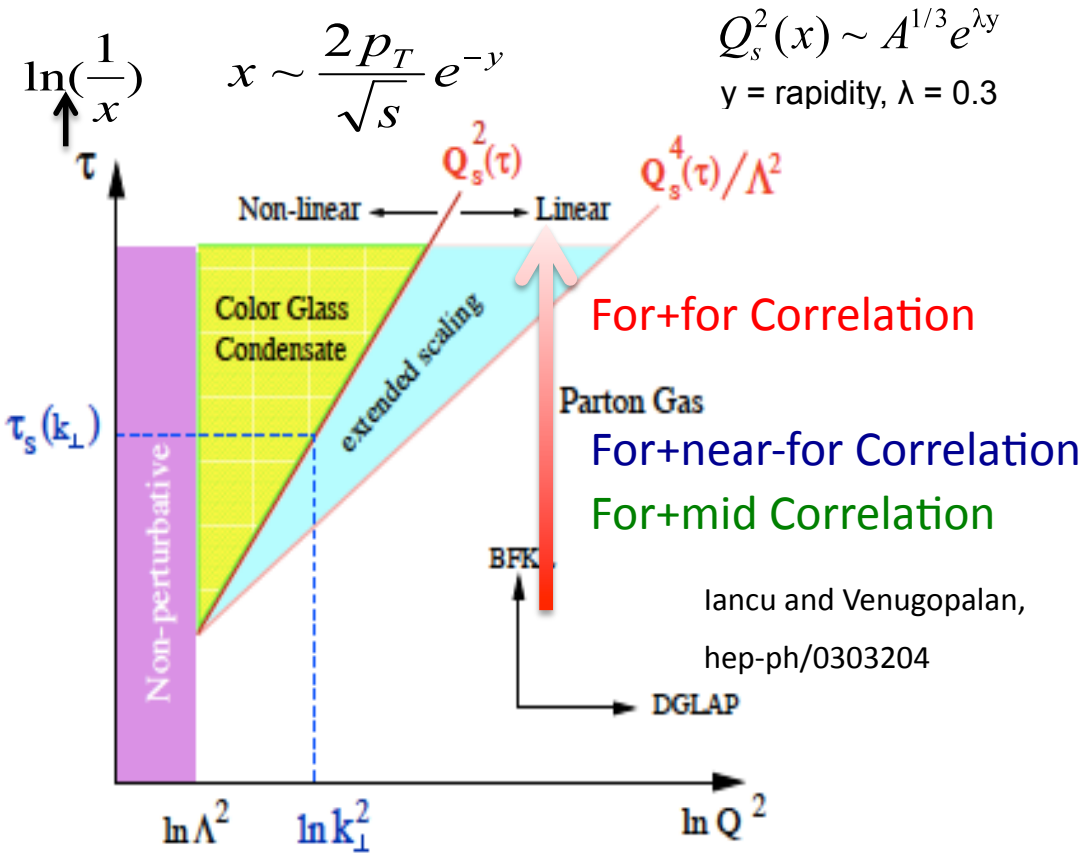




- FMS π^0 p_t^{FMS}>2.0GeV/c. With 400MeV tower threshold, cone R=0.6, BEMC jet-like cluster ($M>0.2GeV/c^2$) $-0.9<\eta<0.9$, $1.0GeV/c<p_t^{BEMC}<p_t^{FMS}$.
- Mixed event corrections applied to the correlations. Use beam-beam counter facing Au beam to select peripheral ($\Sigma Q<250$) d+Au collisions.
- $\sigma_{dAu(peripheral)} - \sigma_{pp} = -0.03 \pm 0.02$, $\sigma_{dAu(central)} - \sigma_{pp} = 0.08 \pm 0.04$.

Summary on the correlation peak





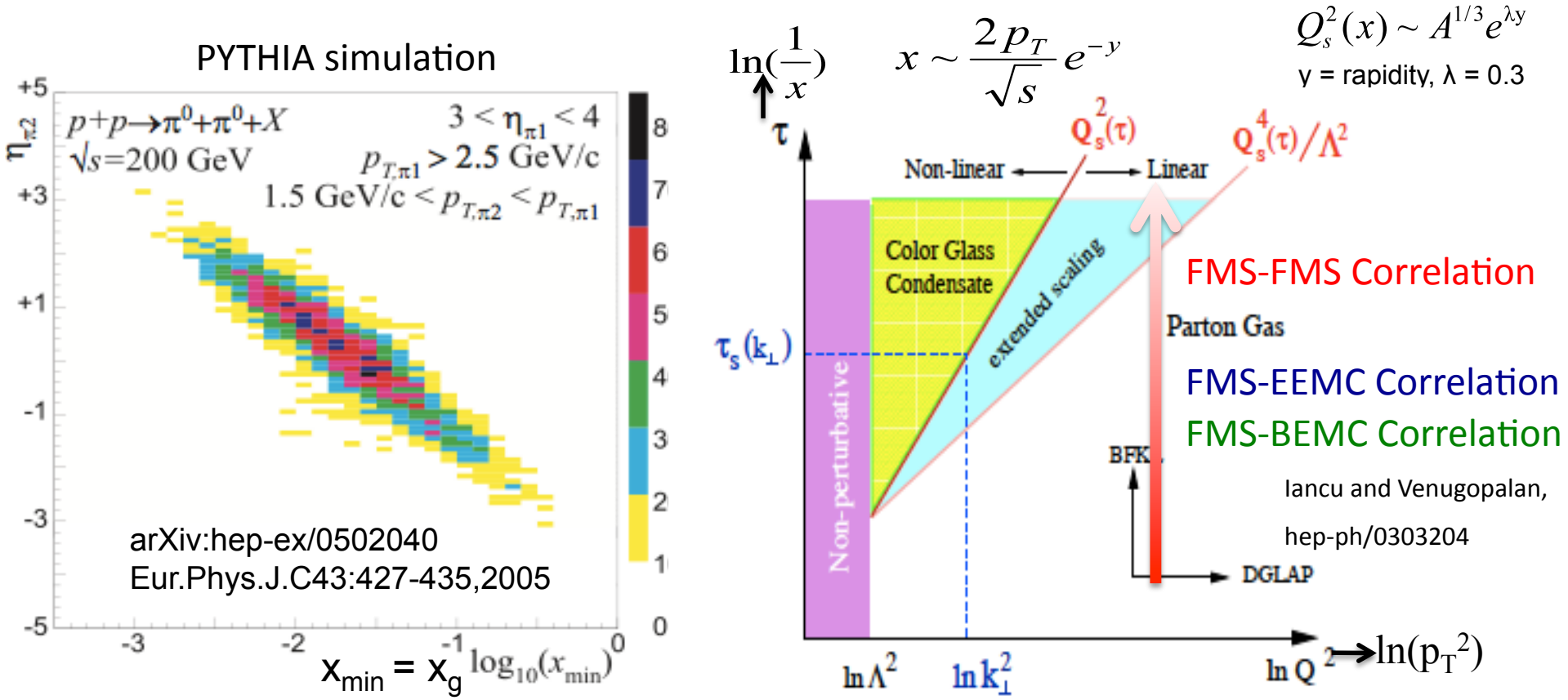
- Does the evolution of results in assoc particle η indicate a smooth transition?
- Studies relating jet-like cluster energy to parton energy are underway.

Summary

- Centrality dependence of both forward di-pions and forward pion + forward jet-like clusters in d+Au show correlations for peripheral collisions but not for central collisions.
- Correlations between a leading forward π^0 and a jet-like cluster over a broad pseudo-rapidity range $-1<\eta<4$,
  - ✓ p+p correlations become narrower as η increases.
  - ✓ peripheral d+Au correlations become broader as η increases.
- The rapidity dependences of the correlations suggest a smooth transition process from dilute parton gas to dense CGC state.
  - ✓ Studies of the energy scale for the jet-like cluster from different detectors are ongoing.

Backup

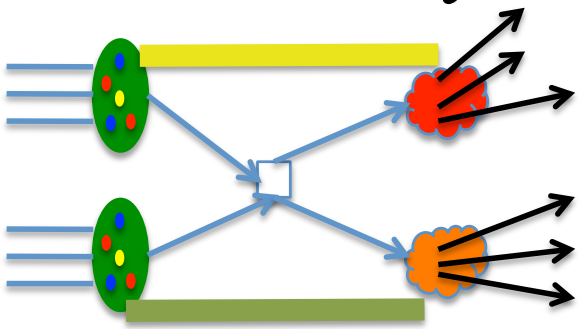
The soft gluon x is related to associated particle in correlations



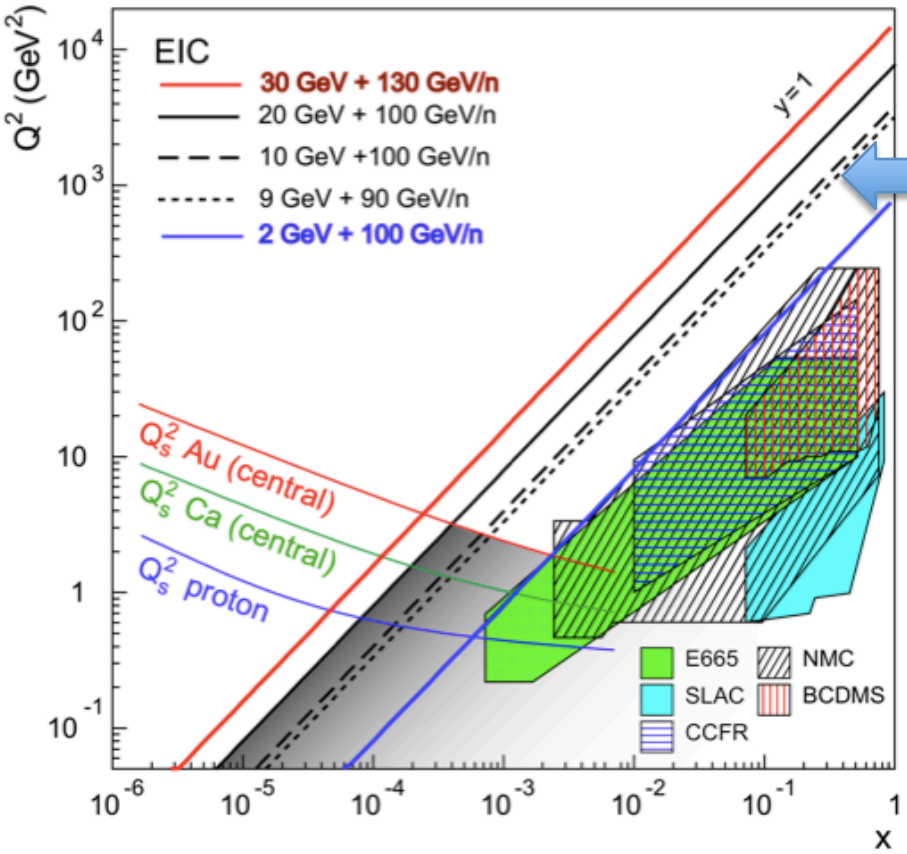
- The pseudo-rapidity of the associated particle is strongly correlated with soft gluon x in the asymmetric parton scattering.

Outlook of nucleus gluon saturation study

The final state π^0s or jet-like clusters are complex objects that can include not only color interactions from initial states but also from final states.



- A Electron Ion Collider (EIC)?



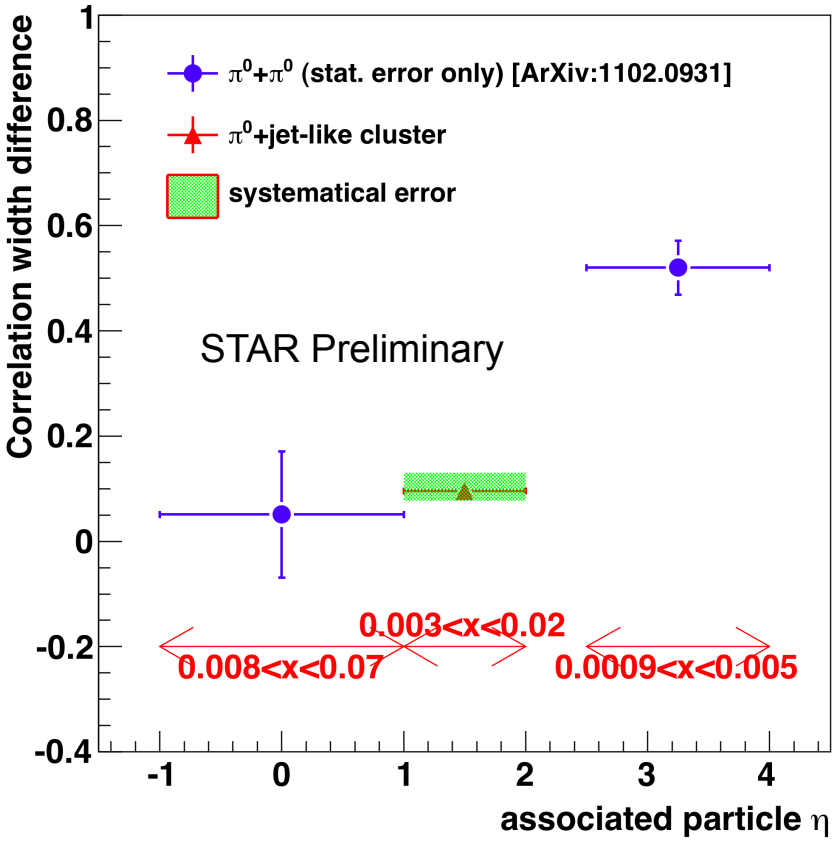
- Go to lower x than fixed target experiment.
- DIS process is much cleaner than the hadron-hadron interaction.

Summary on the correlation peak

- Compare the width differences from p+p to d+Au collisions for different di-hadron correlations.

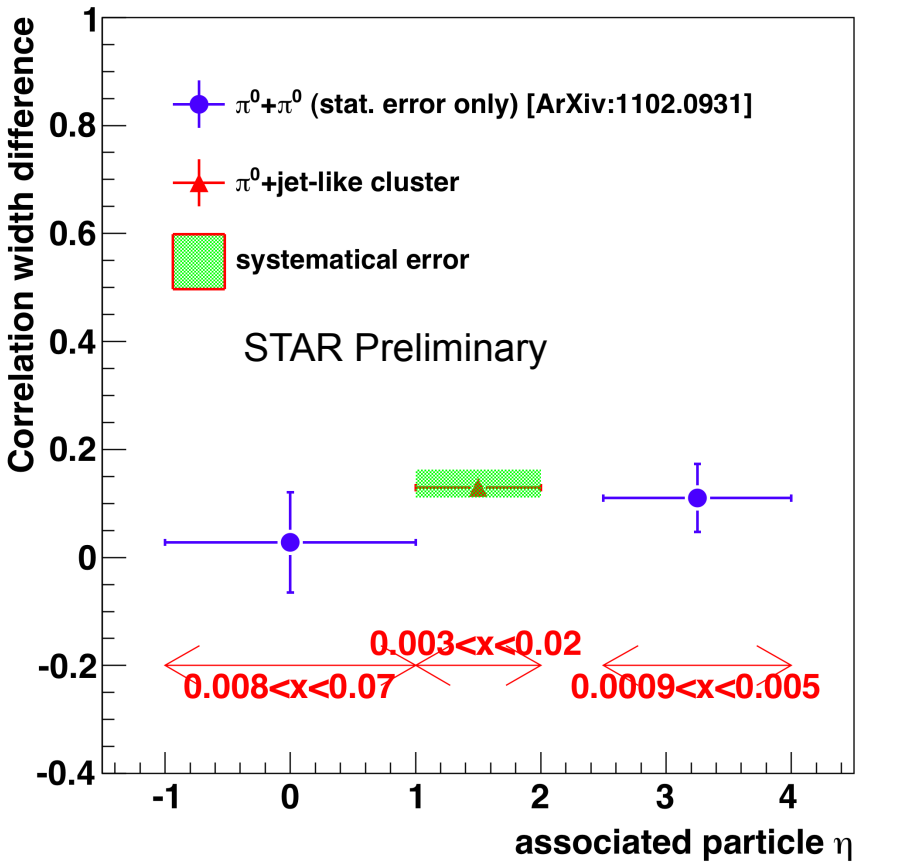
Low p_t

p_t(Leading)>2.0GeV/c,1.0GeV/c<p_t(associated)<p_t(Leading)



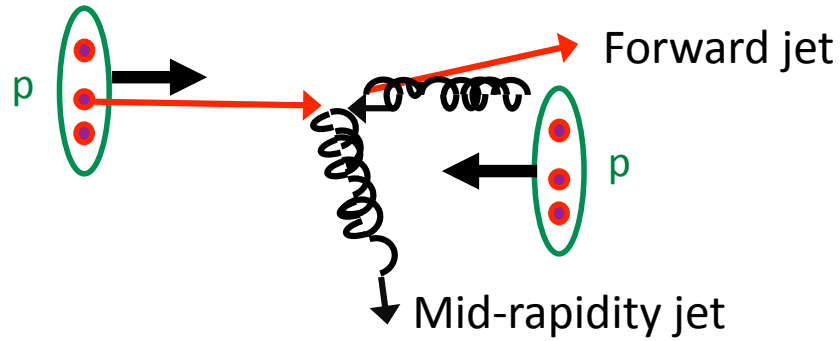
High p_t

p_t(Leading)>2.5GeV/c,1.5GeV/c<p_t(associated)<p_t(Leading)



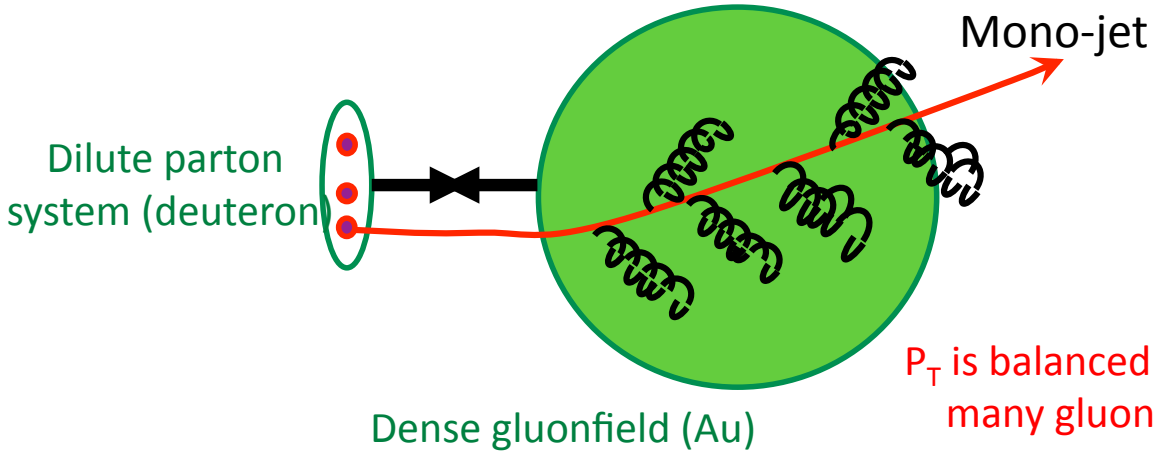
Back-to-back Angular Correlations

pQCD 2➔2 process =back-to-back di-jet (Works well for p+p)



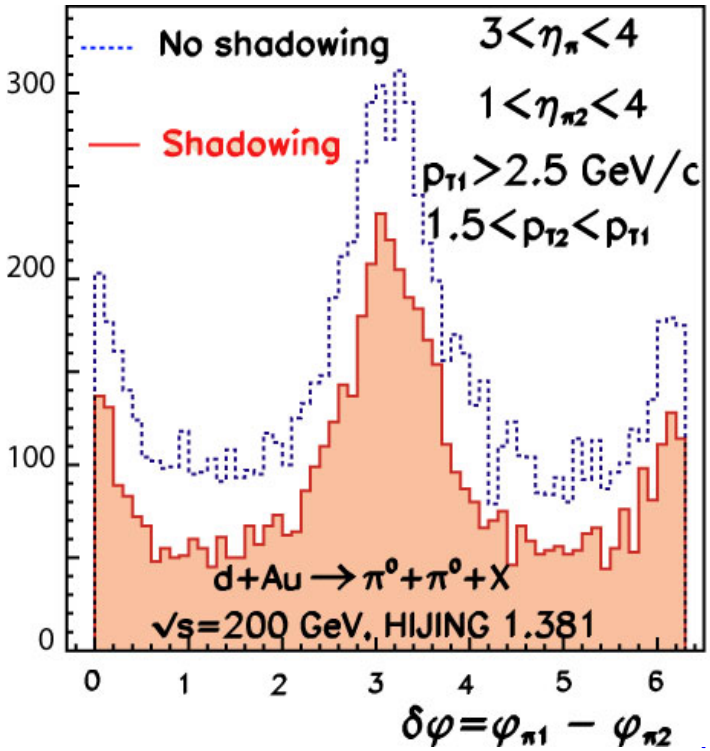
With high gluon density

2➔1 (or 2➔many) process = Mono-jet ?



P_T is balanced by many gluons

d+Au in HIJING



CGC predicts suppression of back-to-back correlation

Conventional shadowing changes yield, but not angular correlation