Measurements of high-pT neutral mesons in $\sqrt{s_{NN}}$ = 200 GeV Au+Au and Cu+Cu Collisions at RHIC-PHENIX

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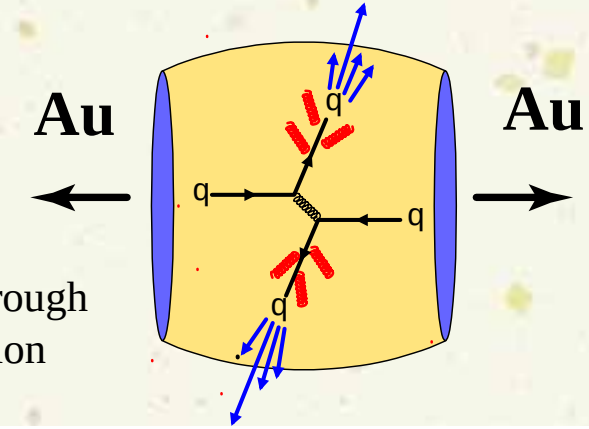
3. Result (pT spectra, R_{AA})
4. Summary

High-pT neutral mesons as hard probe

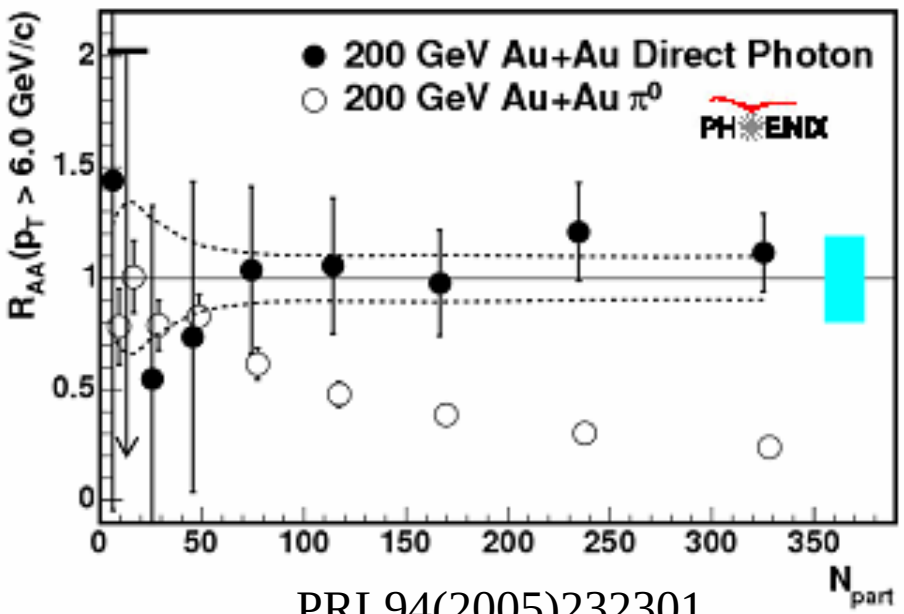
- Hard processes
  - High-pT partons produced by hard scattering
  - yield scales with N_{coll}
- Nuclear modification factor
  - divided by expected (binary scaled) yield from p+p result

$$R_{AA}(p_T) = \frac{d^2N^{AA}/dp_T d\eta}{T_{AA}\, d^2\sigma^{NN}/dp_T d\eta}$$

  - absence of nuclear effects: $R_{AA}=1$
- Suppression of π^0 at high-pT in central Au+Au collisions
  - Interpreted as energy loss of hard scattered partons in hot and dense matter
  - **Jet quenching**
    - Existence of dense matter



Energy loss through gluon radiation



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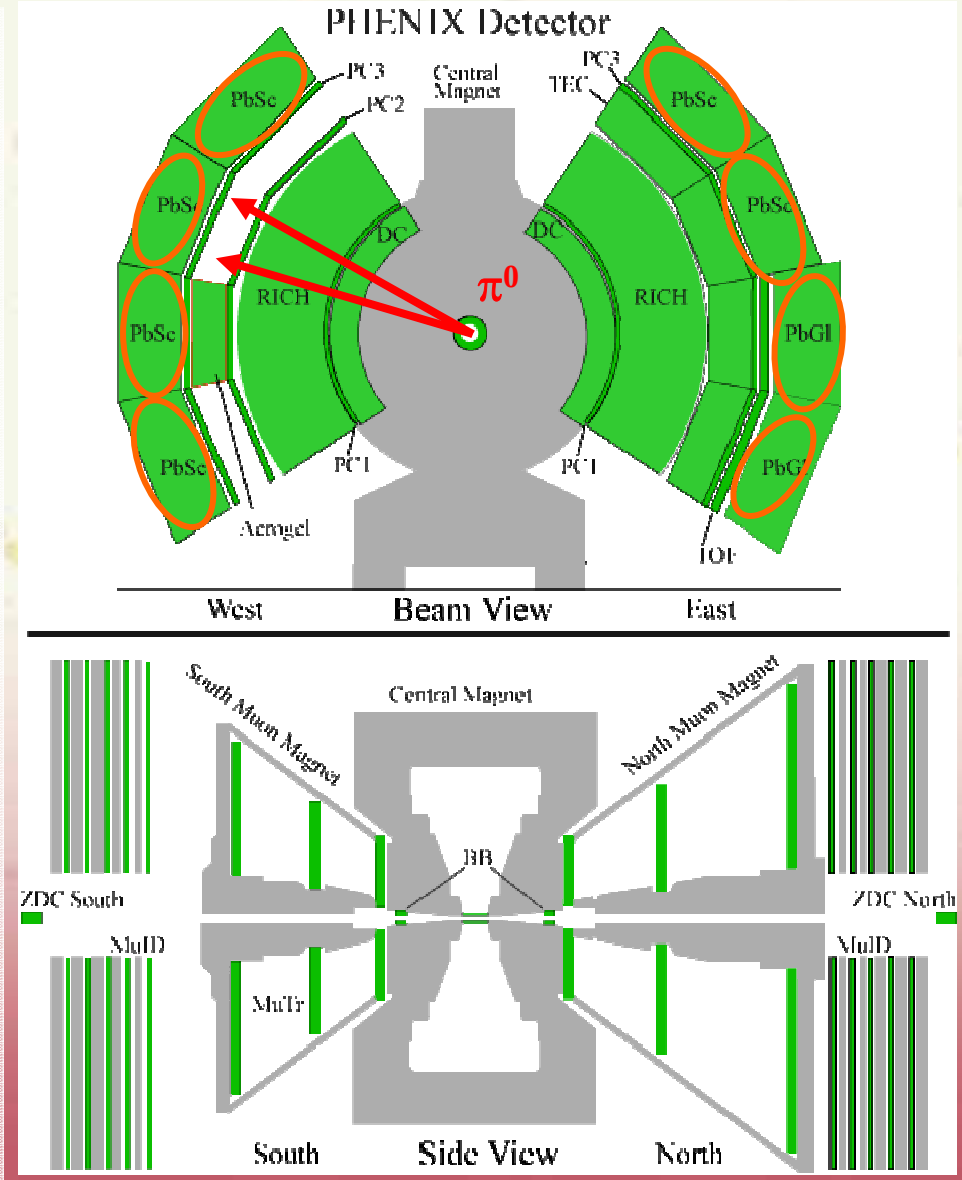
Direct photon is not suppressed.

Physics motivation for further study

- The suppression at high-pT is due to the final state interaction
- Study of medium property using high-pT mesons as hard probe
  - Initial gluon density
  - Time scale evolution
- Nuclear effect for higher pT region
  - pT>10GeV/*c*
- System size dependence
  - Au+Au (A=197), Cu+Cu (A=63)
    - Cu+Cu: more precise centrality determination for small systems
- Dependence on the particle species
  - π^0 and η

π^0/η measurement at RHIC-PHENIX

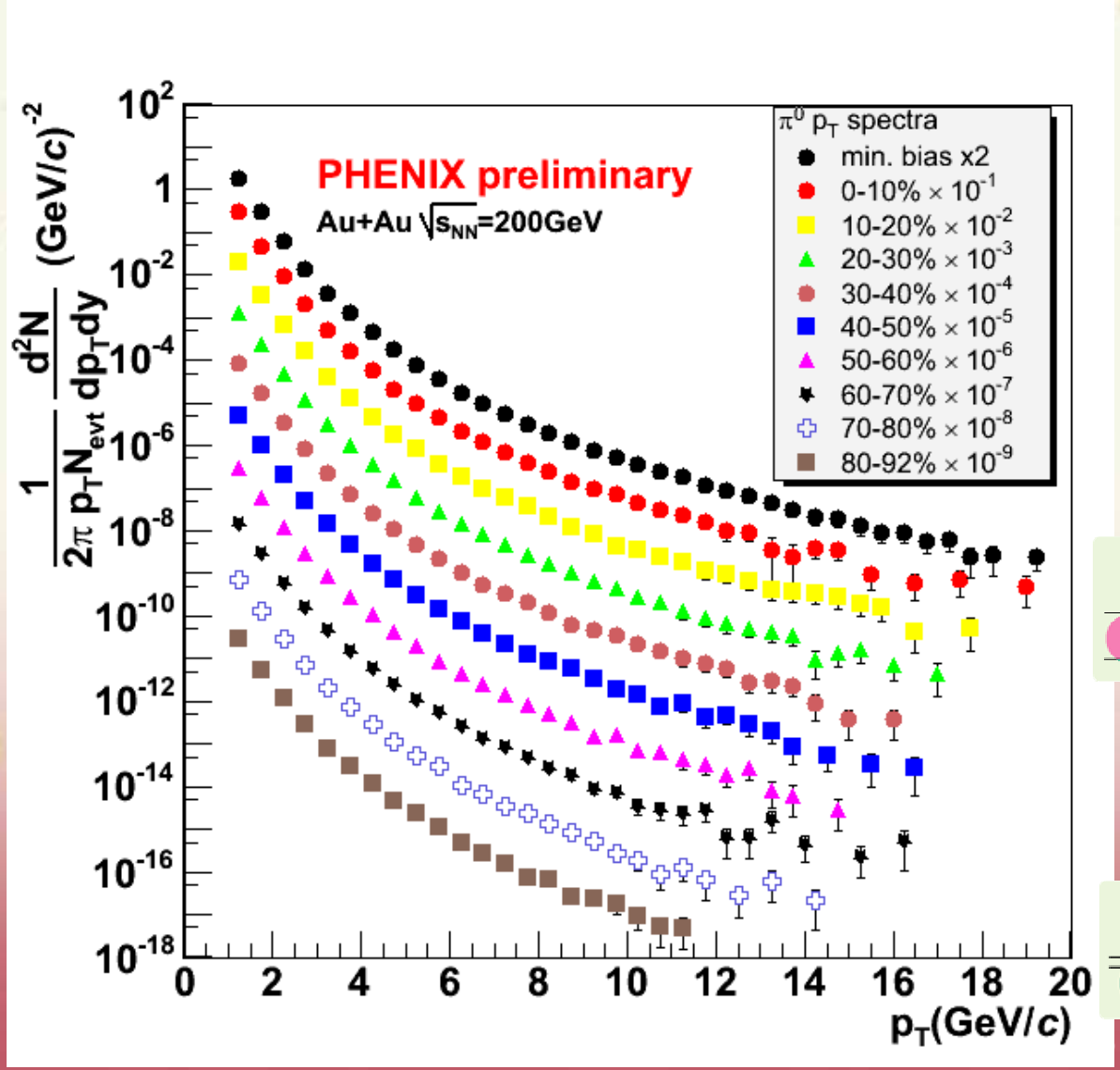
- $\pi^0/\eta \rightarrow 2\gamma$
- **<u>Photon measurement using Electro Magnetic Calorimeter (EMCal)</u>**
  - Distance from vertex point: 5m
    - $|\eta|<0.35$ $\phi = 2*90°$
  - 2 arm × 4 sectors
    - Lead Scintillator Type (PbSc)
      - 6sectors (15552 channels)
      - Radiation length: $18X_0$
    - Lead Glass Type (PbGl)
      - 2 sectors (9216 channels)
      - Radiation length: $16X_0$
  - Fine granularity
    - Possible to measure π^0 up to 30GeV
- **Min. Bias trigger from BBC-ZDC coincidence**
  - Also used for centrality determination
    - 0%: central, 100%: peripheral collision



pT spectra

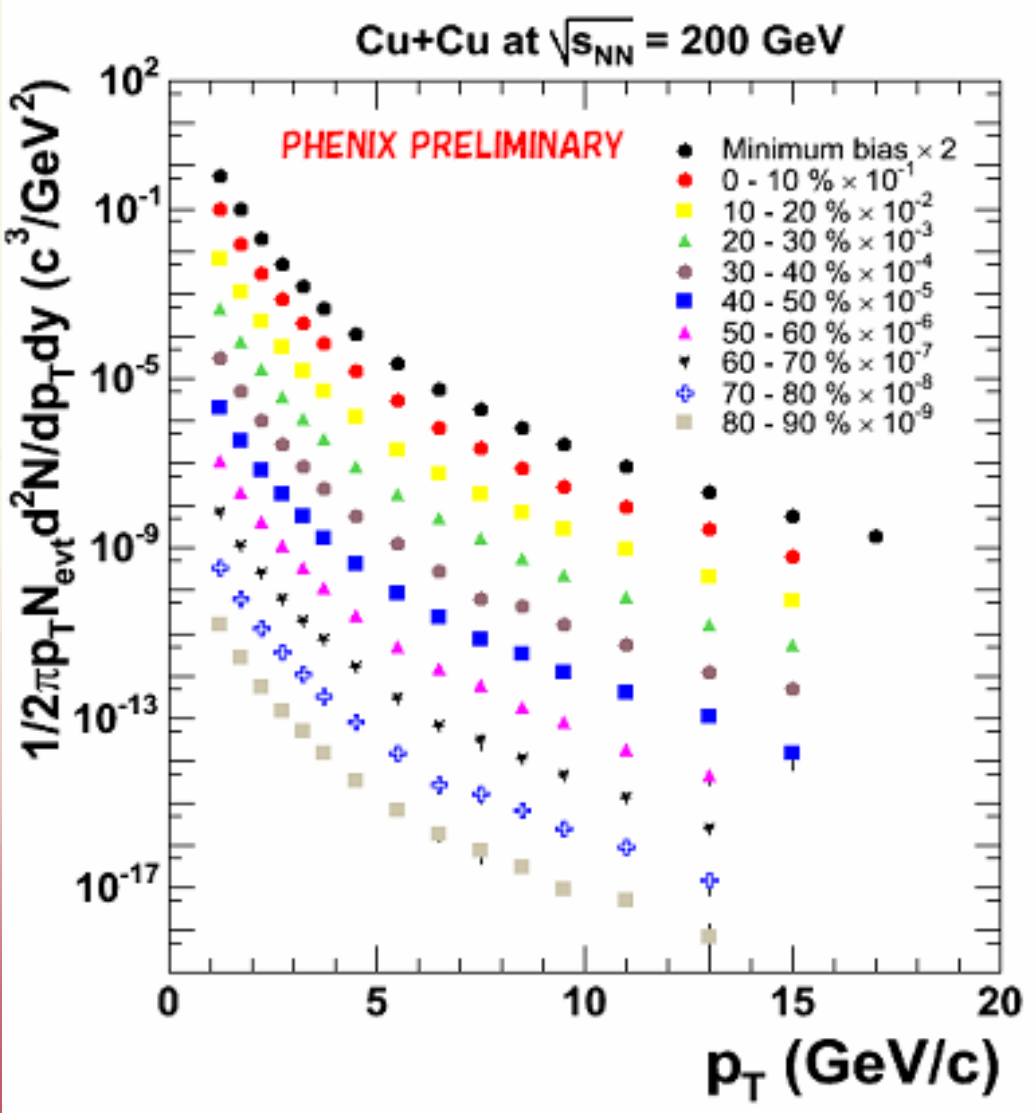
π^0 pT spectra in $\sqrt{s_{NN}}$ =200GeV (Au+Au)

- **Au+Au 200 GeV**
  - Sampled Luminosity 241μb^{-1}
    - 1.5B events
- π^0 pT spectra up to 20GeV.
  - Year2002: up to 12 GeV.
  - 10GeV/c π^0 even at most peripheral events



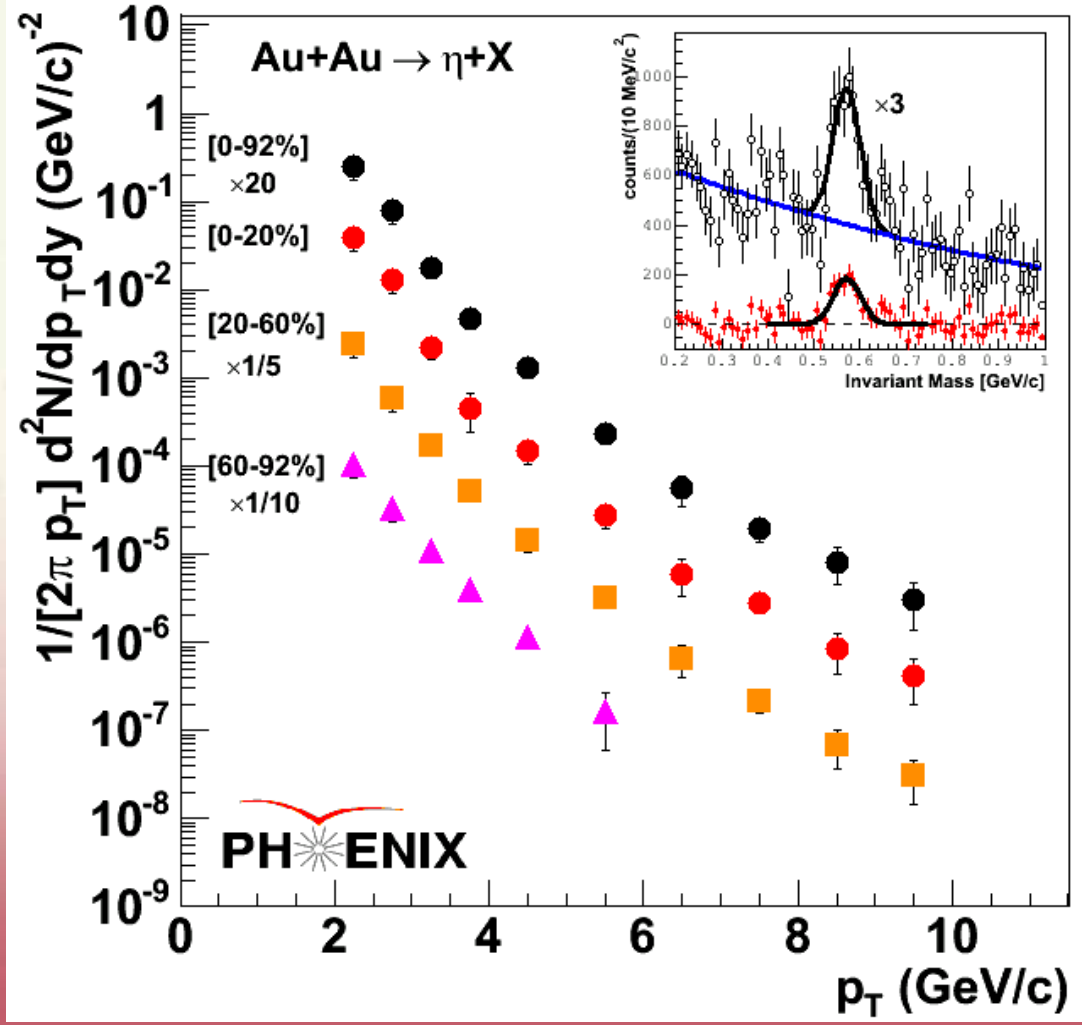
π^0 pT spectra in $\sqrt{s_{NN}}$=200GeV (Cu+Cu)

- **Cu+Cu 200 GeV**
  - 56 M minimum-bias events
  - 1.9 M high-p_T events recorded, 2.2 B sampled
- π^0 p_T range 1-17 GeV/*c*



η pT spectra in $\sqrt{s_{NN}}$ =200GeV (Au+Au)

- **<u>Au+Au 200 GeV</u>**
- η pT spectra up to 10GeV.

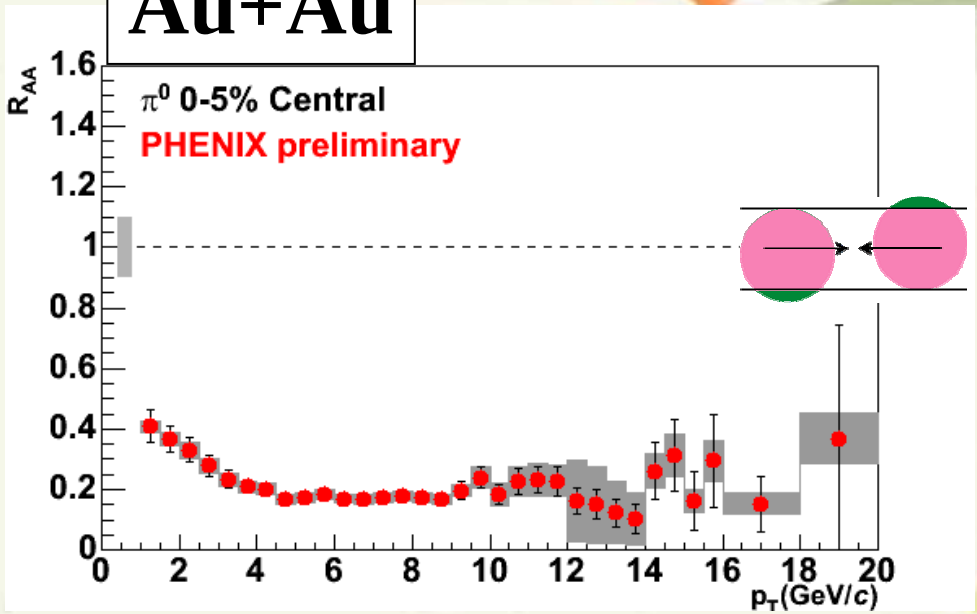


Nuclear modification factor (R_{AA})

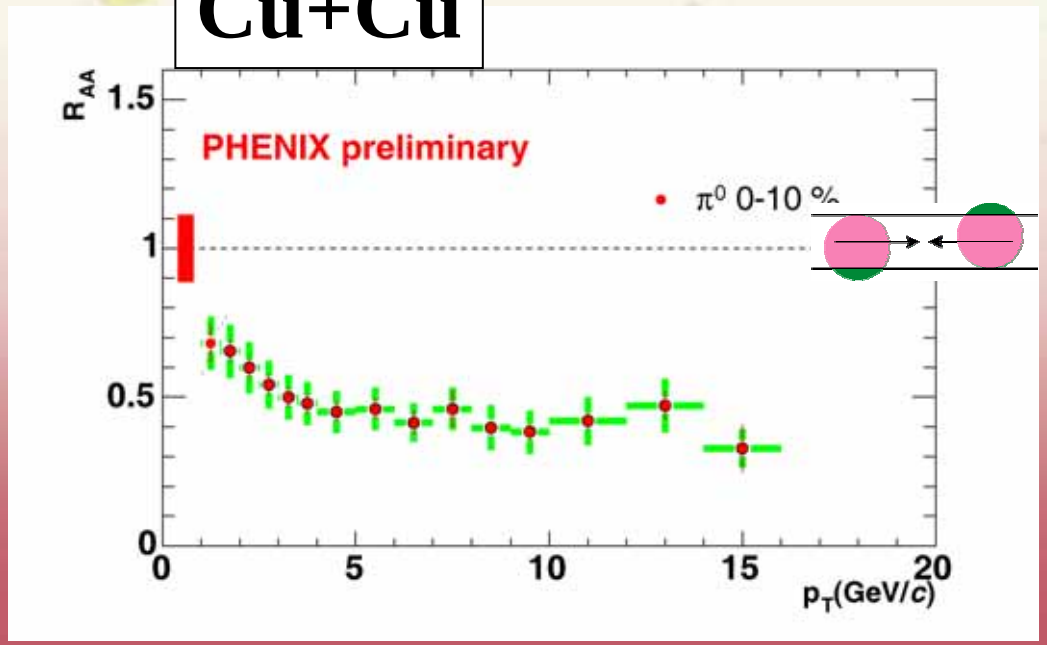
π^0 R_{AA}

- Use Run3 p+p π^0 data as reference.
- **R_{AA} on Au+Au result**
  - Strong suppression is seen even at high pT. (~ 0.2)
  - Almost flat up to 20GeV.
  - Constancy for pT>4GeV/*c* for all centralities
- **R_{AA} on Cu+Cu result**
  - R_{AA} ~ 0.4 for central collisions
  - Strong energy loss effects even in lighter colliding system

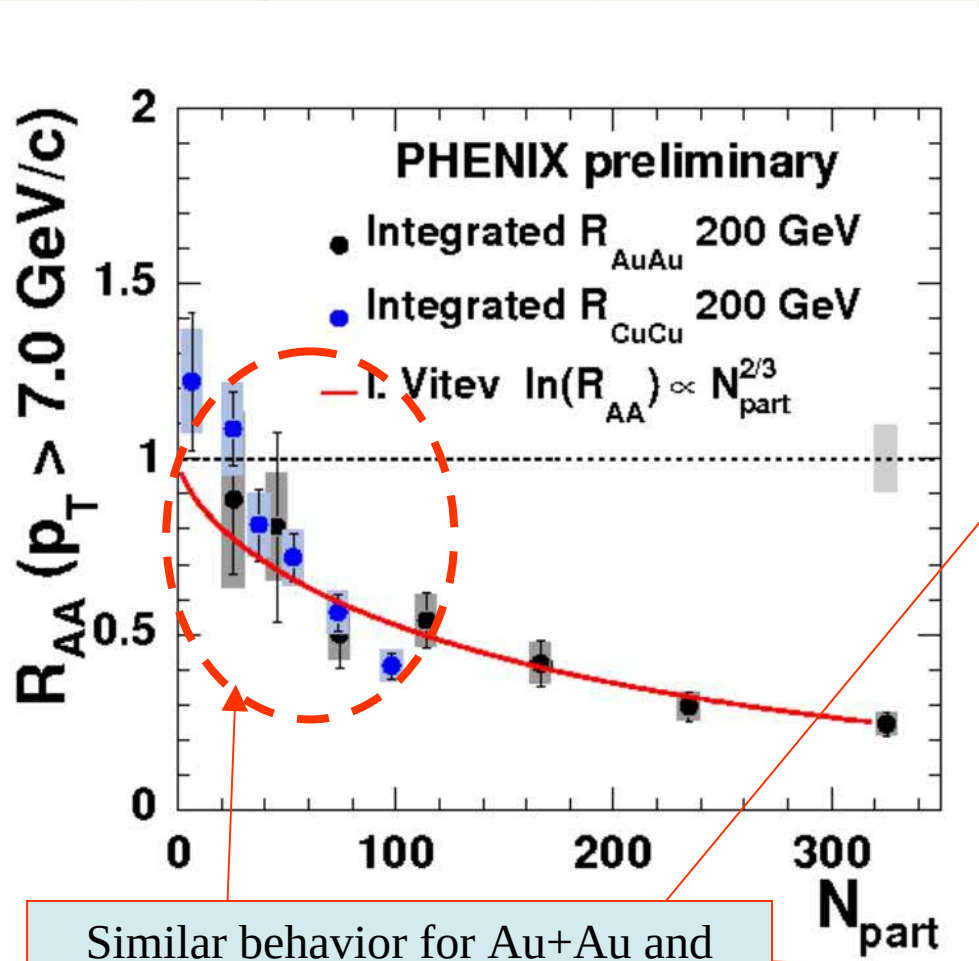
Au+Au

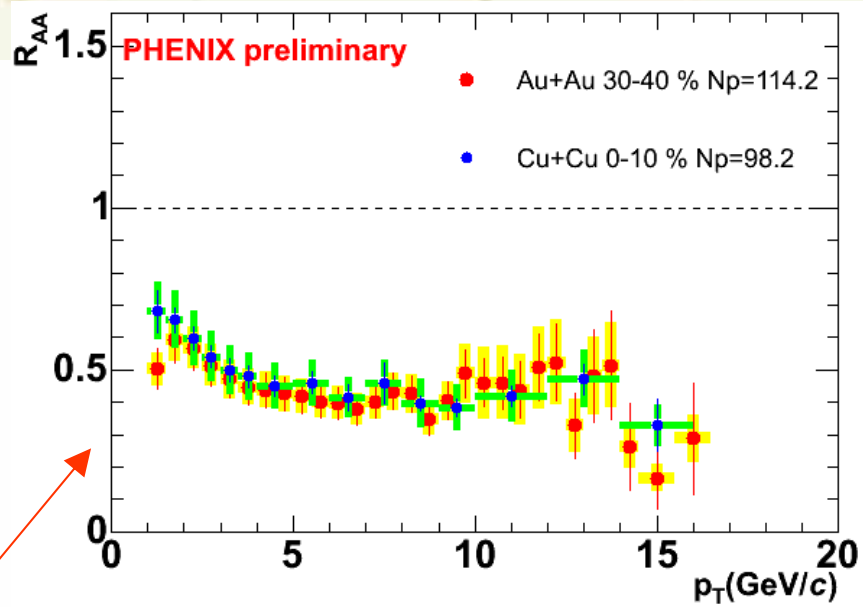


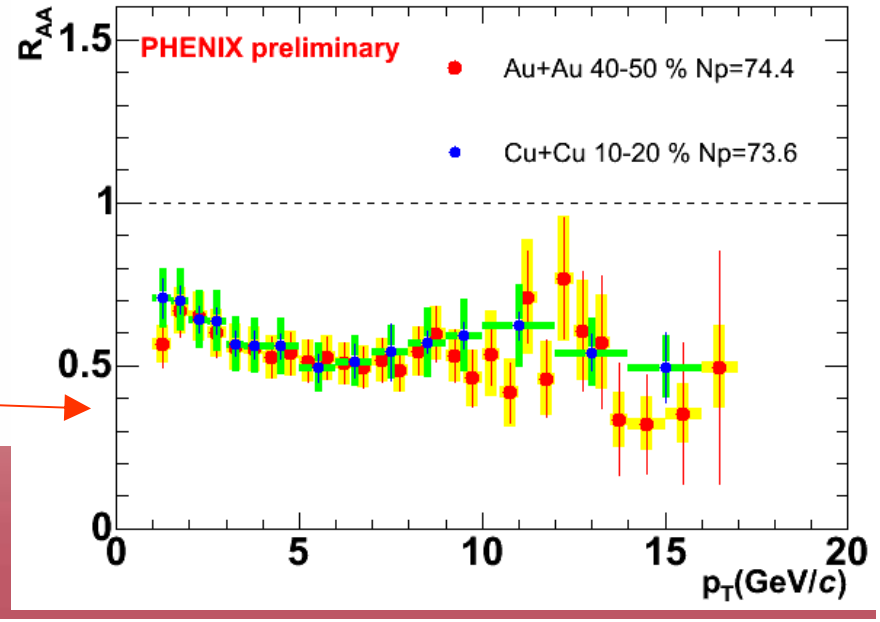
Cu+Cu



Comparing Au+Au and Cu+Cu



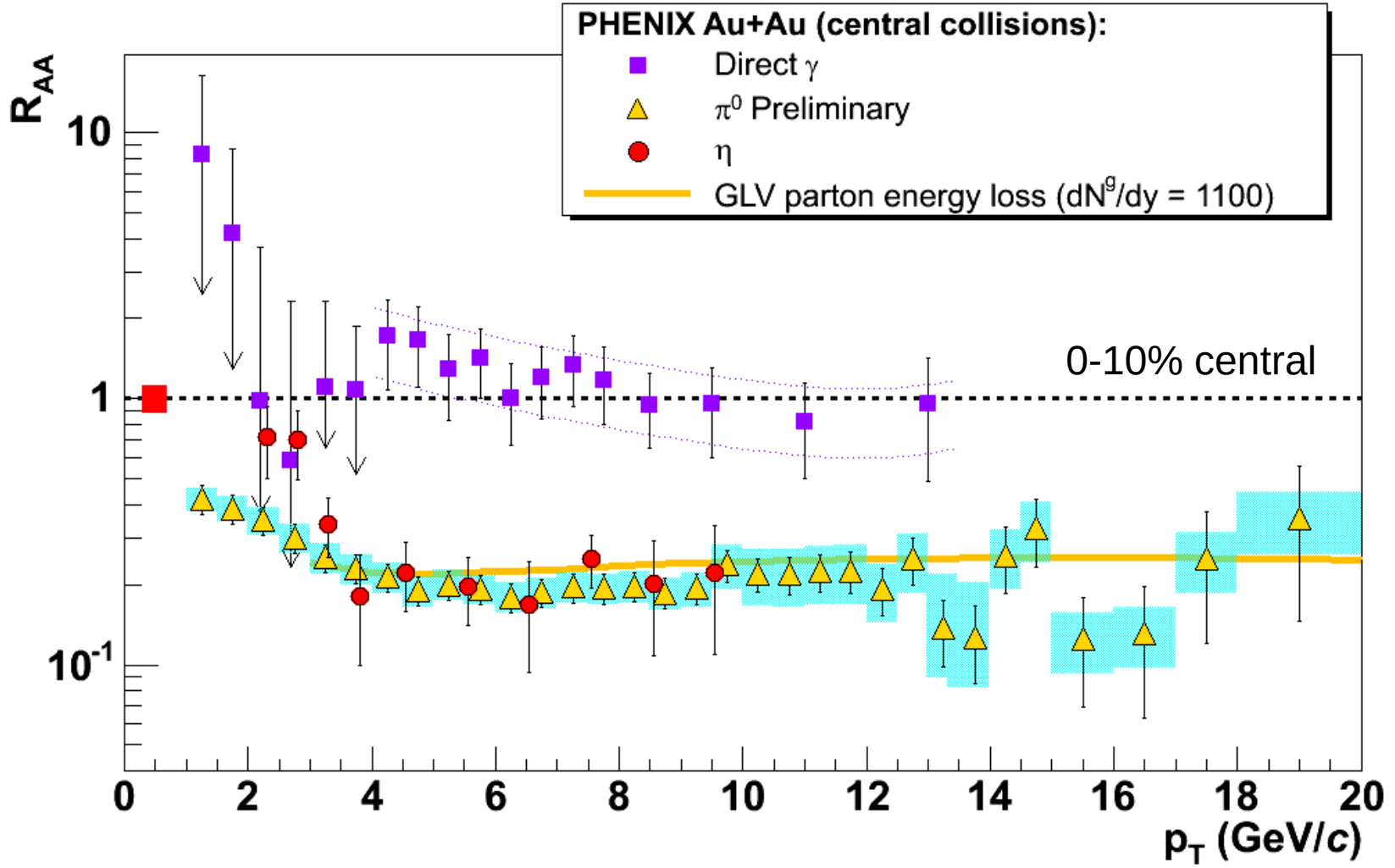




Similar behavior for Au+Au and Cu+Cu for same *N*part

Consistent with pure density and path-length dependence

Comparison with η and direct γ R_{AA}

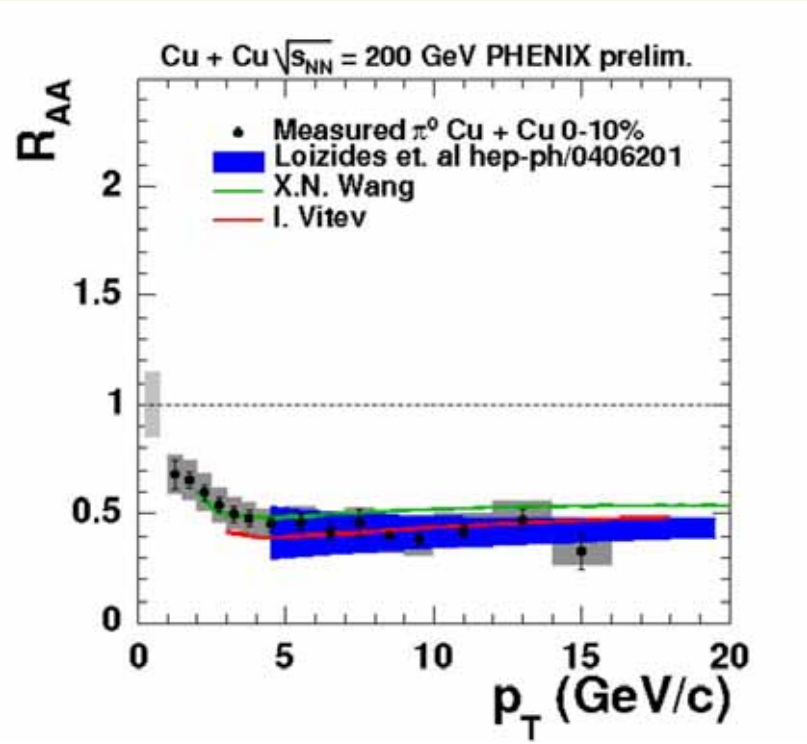


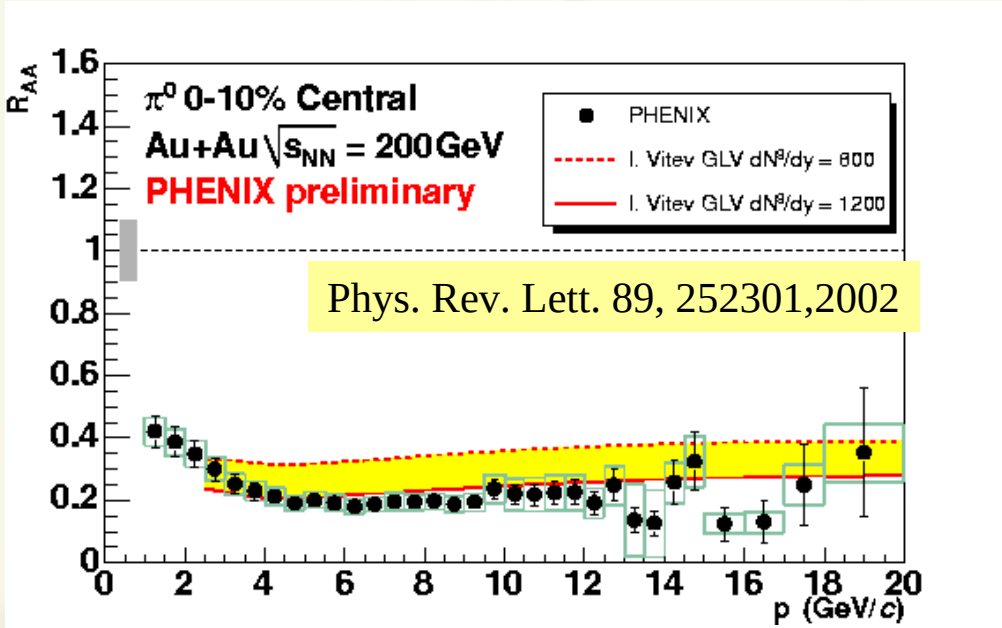
✓η suppression is similar to π^0 (indicates partonic level)

✓Direct photon is not suppressed (*N*coll scaling properly works)

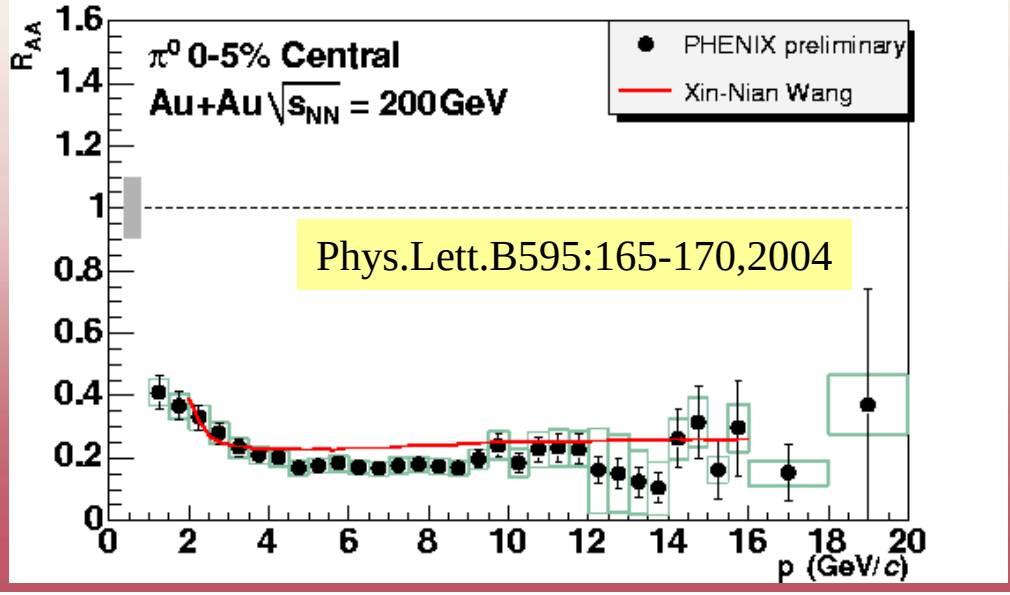
Theoretical comparison

- Flat R_{AA} is mixture of nuclear effects.
  - Jet quenching
  - Cold nuclear effect
    - Nuclear shadowing
    - Cronin effect





Phys. Rev. Lett. 89, 252301,2002



Phys.Lett.B595:165-170,2004

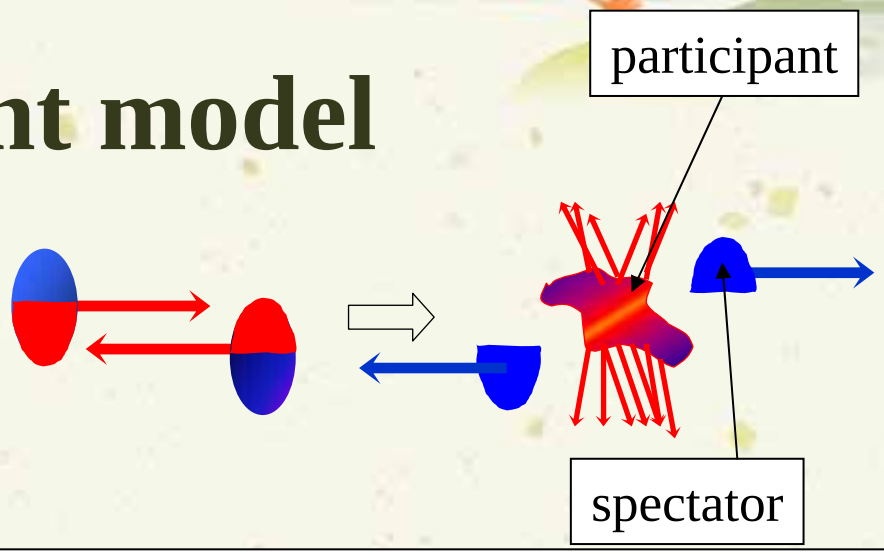
Summary

- High-pT π^0 suppression in central Au+Au and Cu+Cu at 200 GeV
  - GLV calculation describes data well
    - dNg/dy ~ 1100 in 200GeV Au+Au
  - Strong energy loss effects even in lighter colliding system
- η has a similar suppression pattern as π^0
  - Energy loss on partonic level
- Suppression similar for same *N*part
  - Consistent with pure density and path-length dependence
- More information from reaction-plane dependence
  - Tomography of dense matter
  - Details will be given by D. Winter (Section I.6)

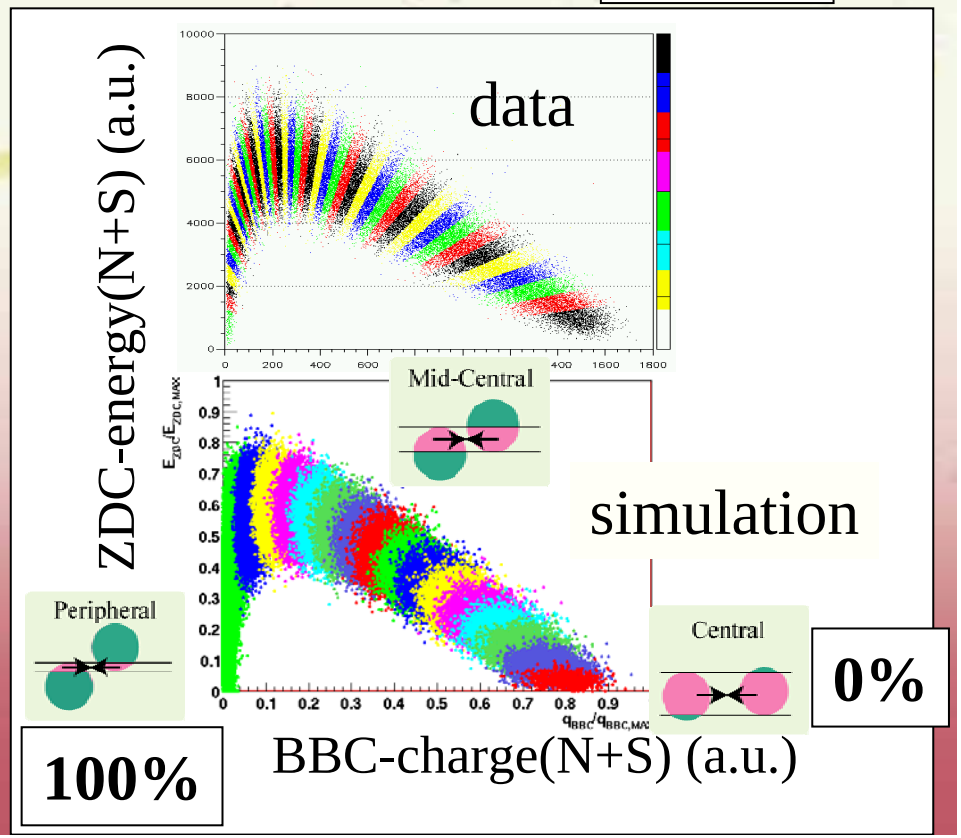
PHENIX collaboration

Backup slides

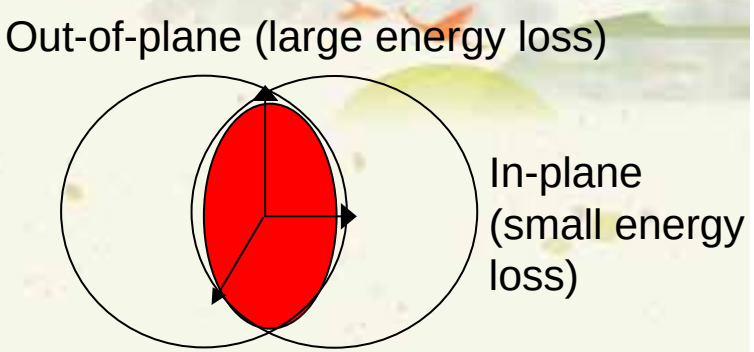
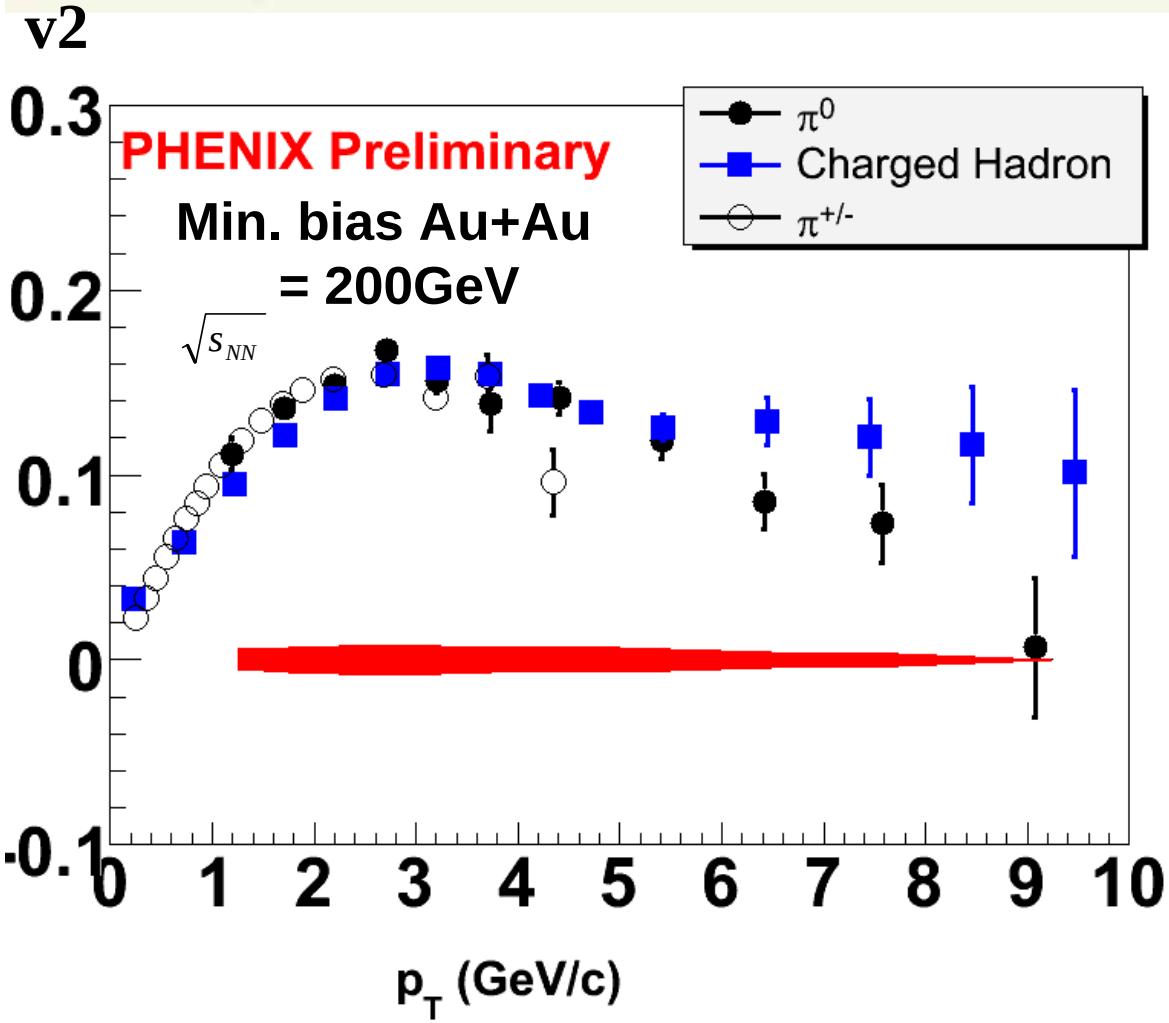
Participant model



- **Participant and spectator**
  - *N*part: number of participant nucleons in collision
  - *N*coll: number of binary N-N collision
- **Centrality**
  - Determined with BBC and ZDC correlation
  - *N*part, *N*coll is obtained from MC with Galuber model.
  - 0%: central, 100%: peripheral collision



π^0 v2



- Measured up to pT:10GeV/c
- v2 at high pT
  - azimuthal variation in energy loss
- Observation of v2 peak at pT = 2-3GeV/c and decreasing v_2 at high p_T
- Approach for understanding energy loss mechanism
  - So far, we observe integrated yield
  - π^0 production respect to reaction plane
    - energy loss as a function of pass length