POLYTECH
Peter the Great
St.Petersburg Polytechnic
University

Hard Probe Measurements in Cu+Au Collisions at PHENIX: Jets and Leading Particles

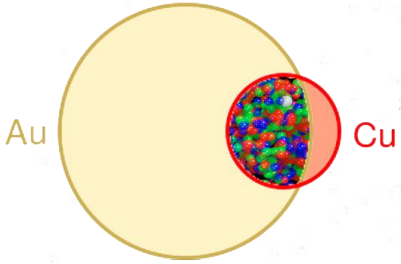
Sergei Zharko for the PHENIX Collaboration

PHENIX

Motivation

- **Jet-quenching** (**energy loss of high-energy partons**) - one of the evidences of sQGP formation in central heavy nuclei collisions, observed by particle yields suppression
- **Experimentally studied by measuring** nuclear modification factors:

$$R_{AA} = \frac{1}{N_{coll}} \cdot \frac{dN_{AA}}{dN_{pp}}$$

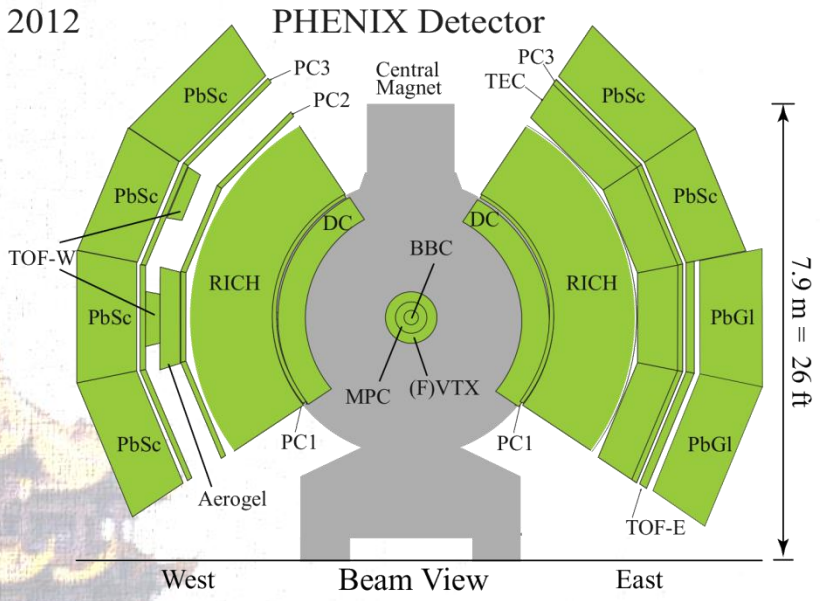


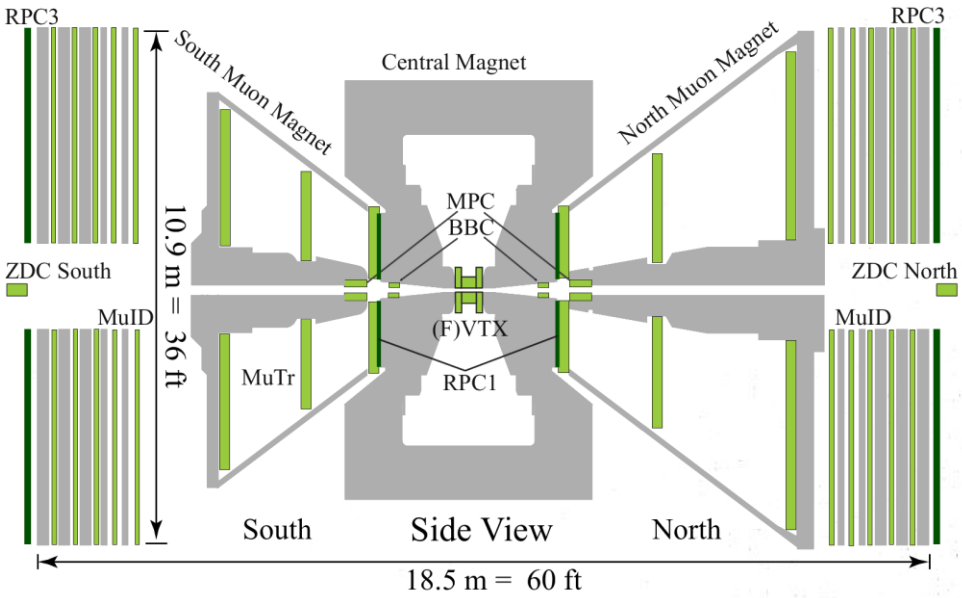
- Study of **asymmetric collision system** (Cu+Au):
  - ✓ first asymmetric heavy nuclei system
  - ✓ different overlap geometry to symmetric nuclei systems (Cu+Cu, Au+Au) - helps to discriminate between various theoretical models
  - ✓ more accurate description of partonic energy loss mechanisms
- **Reconstructed jets** – a good opportunity to study of sQGP kinematics:
  - ✓ direct association with partons, formed in the medium
- **Neutral pions** – an effective tool to study sQGP:
  - ✓ identified particle with good signal-to-background ratio
  - ✓ lots of statistics: measure yields at high p_T

Outline

- PHENIX Detector
- Jet and neutral pion reconstruction
- Production of p_T spectra and R_{AA}
- Model comparison

PHENIX Detector





|η|<0.35, Δφ – 2x90º

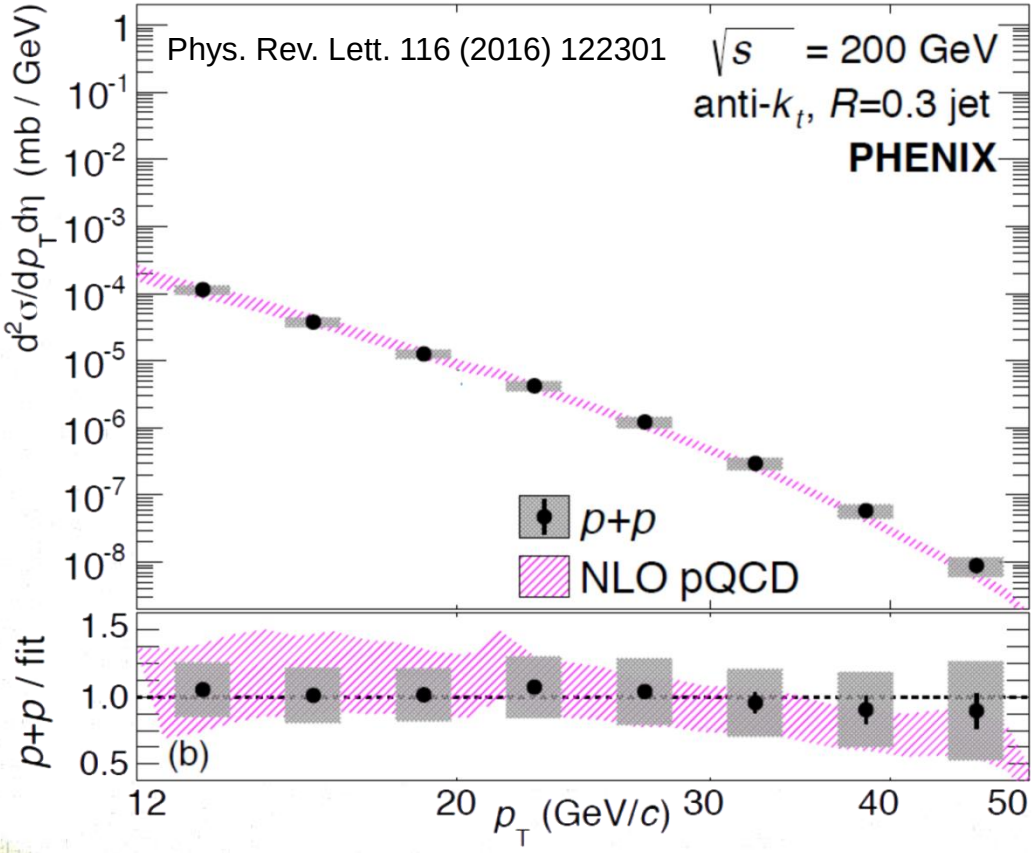
1.2< η <2.2, Δφ – 360º

- Vertex and centrality classification: **Beam-Beam Counters (BBC)**
- Jet measurement:
  - ✓ **Drift Chambers (DC)** and **Pad Chambers (PC)** – charged tracks reconstruction
  - ✓ **Electromagnetic Calorimeter (PbSc / PbGl)** – neutral clusters measurement
- $\pi^0 \rightarrow \gamma\gamma$ measurement:
  - ✓ **Electromagnetic Calorimeter (PbSc / PbGl)** – γ clusters measurement

Jet Reconstruction Info

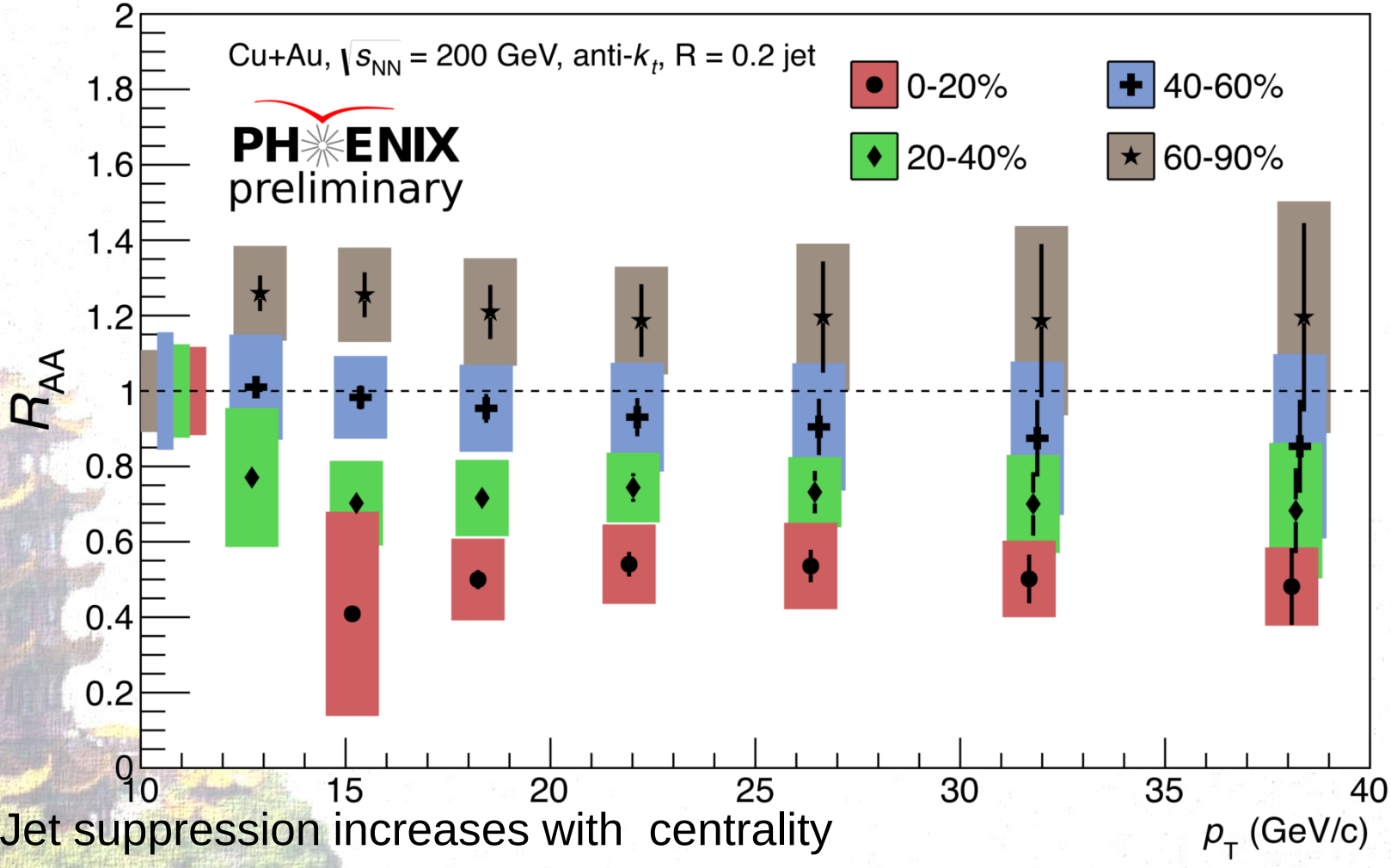
- Jets are reconstructed using **Anti-k_T algorithm** with R = 0.2:
  - ✓ charged track p_T > 500 MeV/c
  - ✓ cluster energy > 500 MeV
  - ✓ clusters, associated with tracks, were discarded
- **Jet-level cuts**:
  - ✓ number of constituents ≥ 3
  - ✓ 0.2 < charged fraction < 0.7
  - ✓ jet axes are required to be away from the detector edge
- **Jet correction**:
  - ✓ Fake jets contribution statistically subtracted with data-driven method
  - ✓ Centrality-dependent response matrices generated by embedding PYTHIA p+p jets into real Cu+Au events
  - ✓ Jet spectra corrected for detector effect and underlying event with unfolding by **Singular Value Decomposition** (**SVD) method**

Jets in p+p at √s = 200 GeV



- Jets are measured up to 50 GeV/c
- Good agreement with **NLO pQCD calculations:**
  - ✓ understand jet production in elementary collisions
  - ✓ validates jet reconstruction procedure in PHENIX

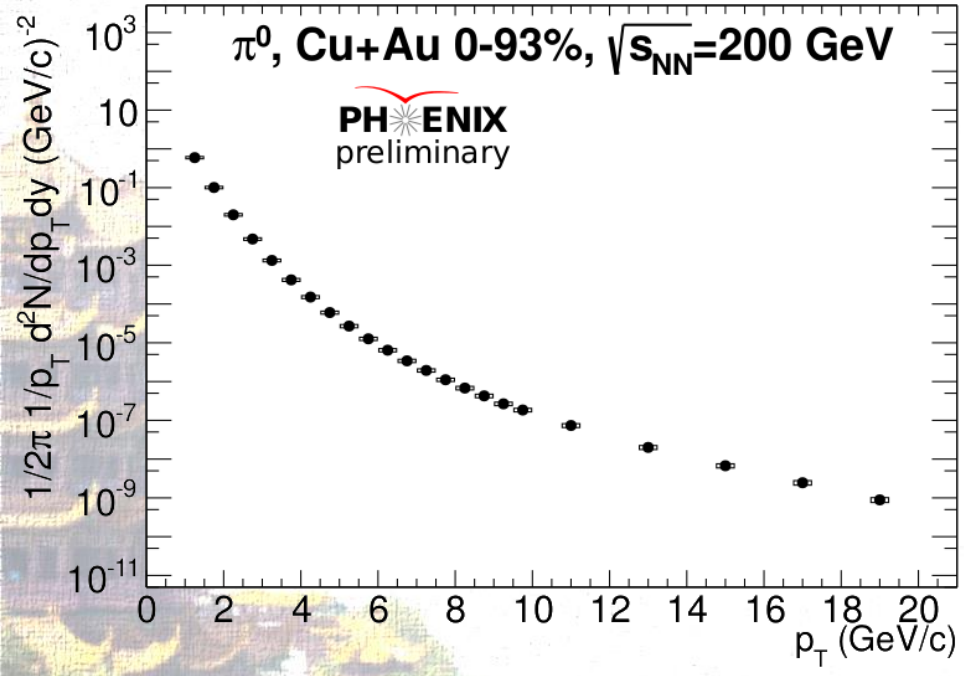
Jet R_{AA}

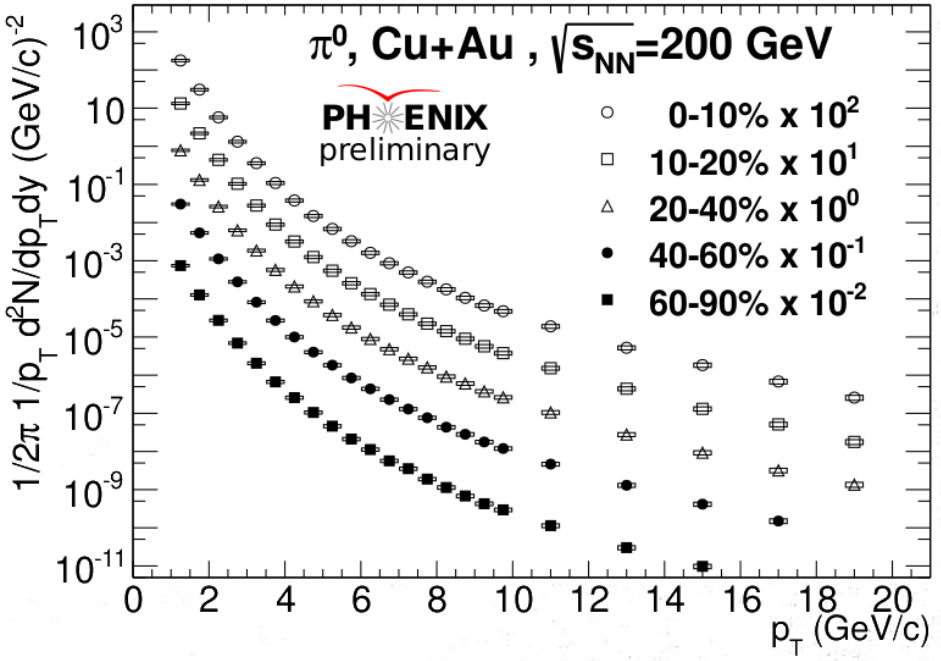


- Jet suppression increases with centrality
- Suppression has very weak p_T dependence
- In **central** collisions jets are suppressed by a factor of ~ 2
- **Enhancement** in peripheral collisions

π^0 spectra in Cu+Au

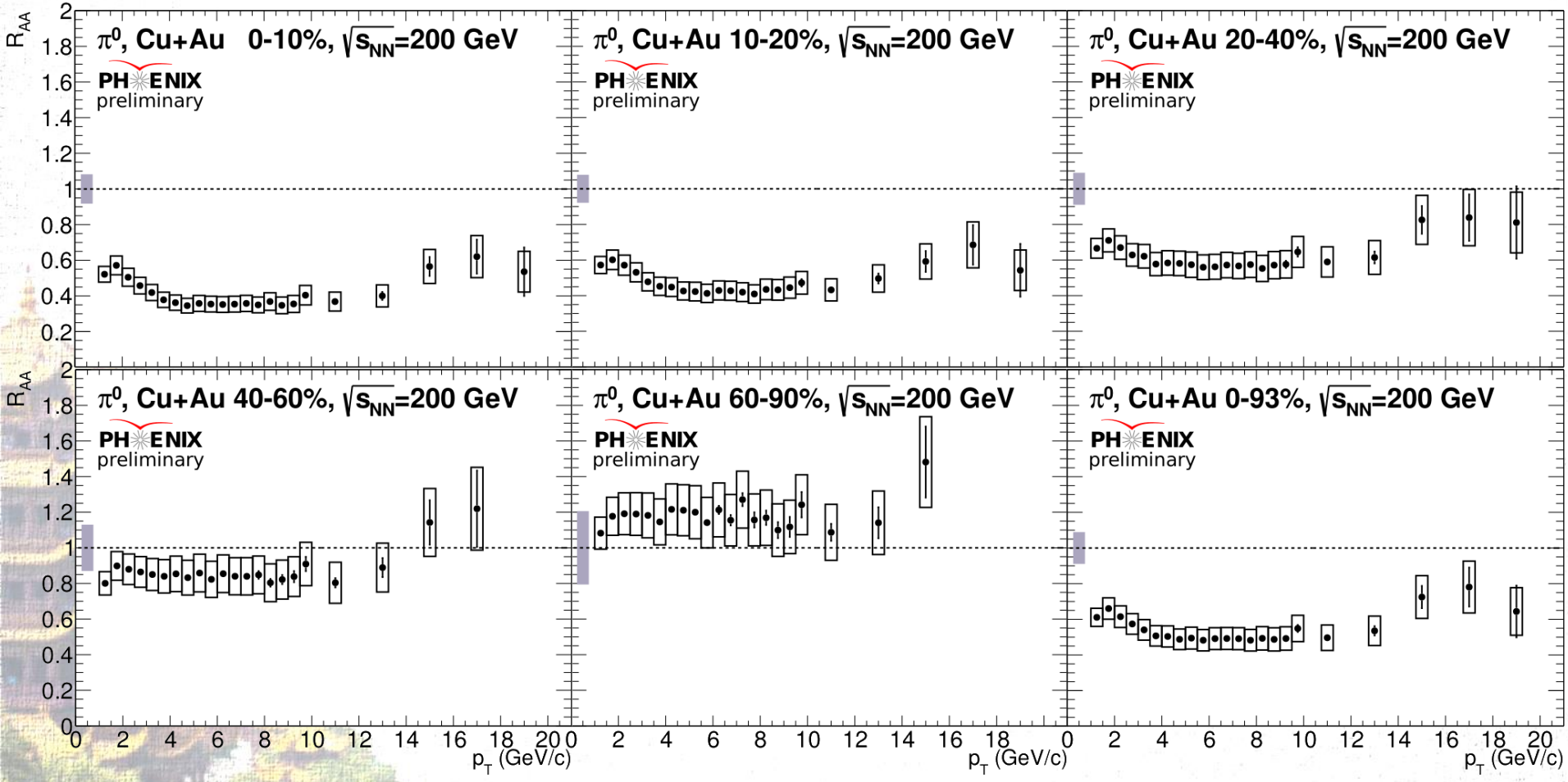
- π^0 gives another look at energy loss in heavy ion collisions





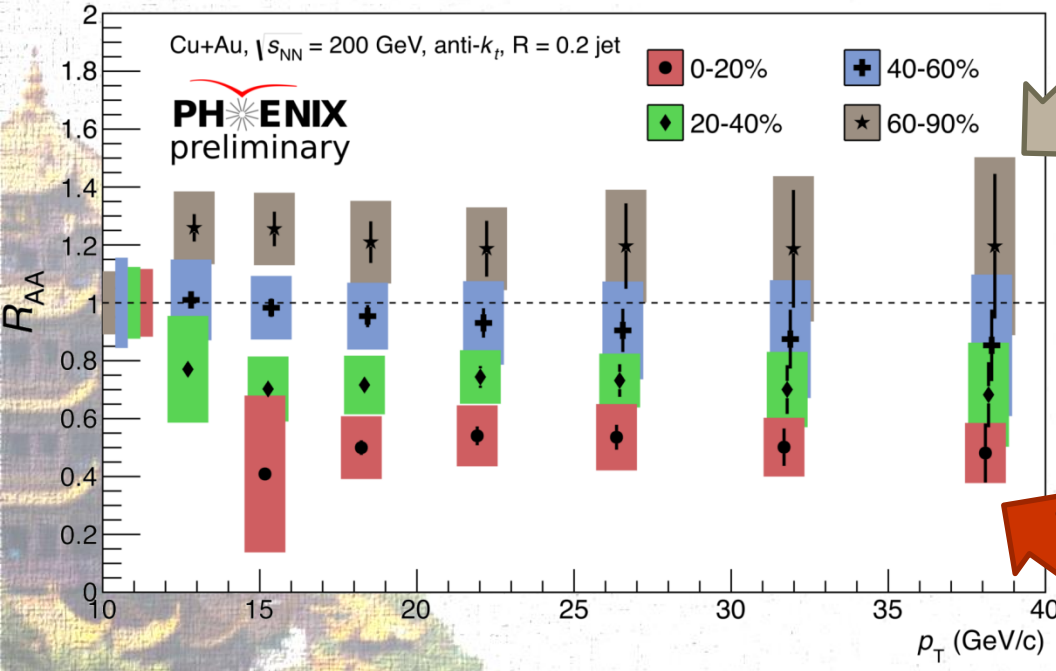
- Measured up to 20 GeV/c in different centrality bins

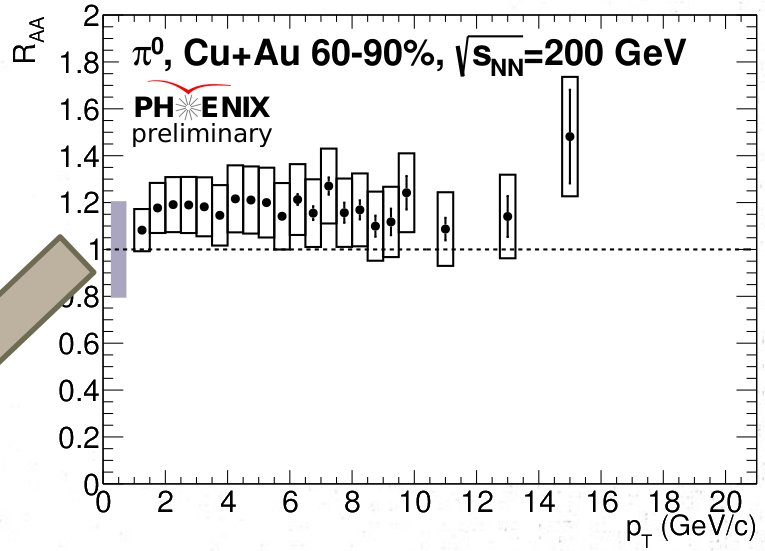
π^0 R_{AA} in Cu+Au

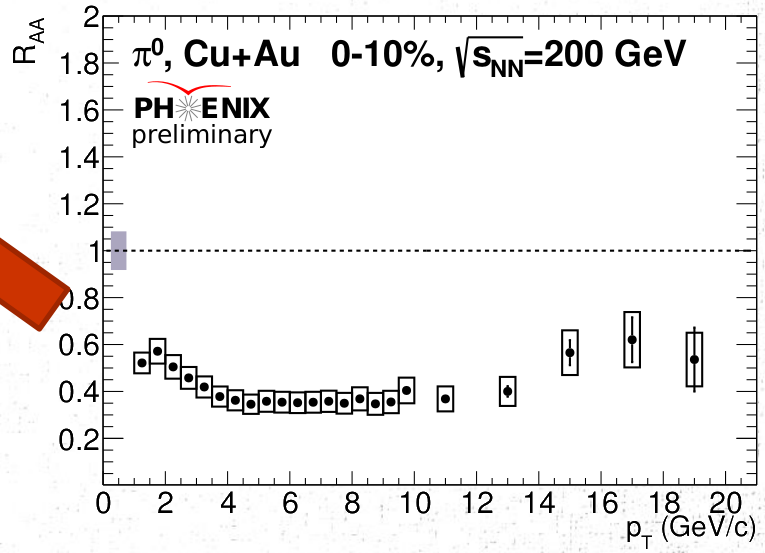


- In **central** and **semi central** collisions π^0 production is suppressed
- In **peripheral** collisions – hint on enhancement

π^0 and Jets R_{AA} Comparison

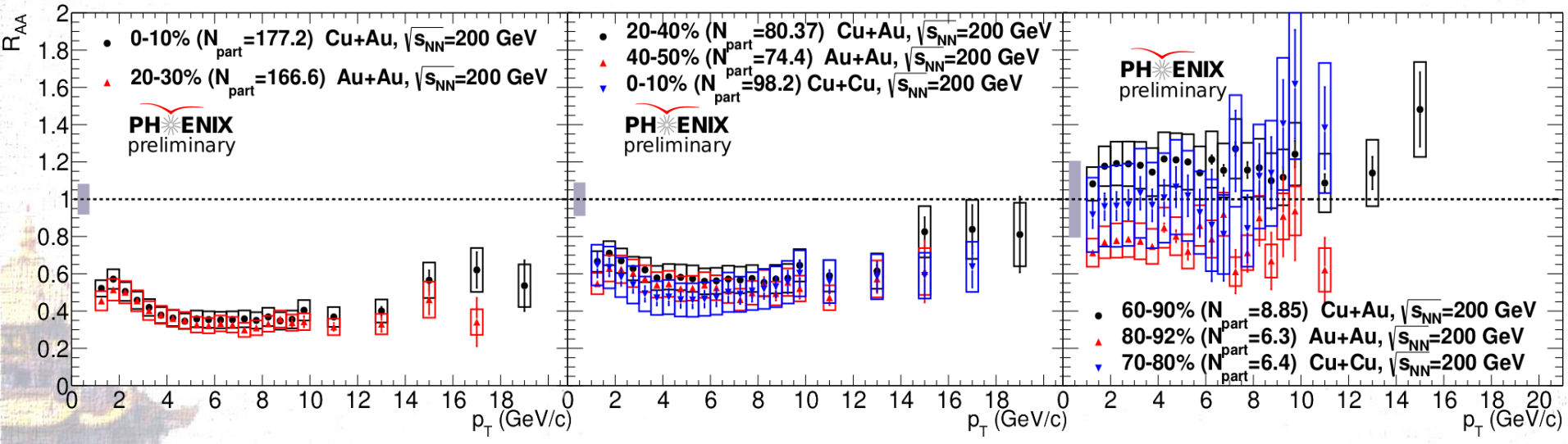






- π^0 suppression is similar to that for reconstructed jets

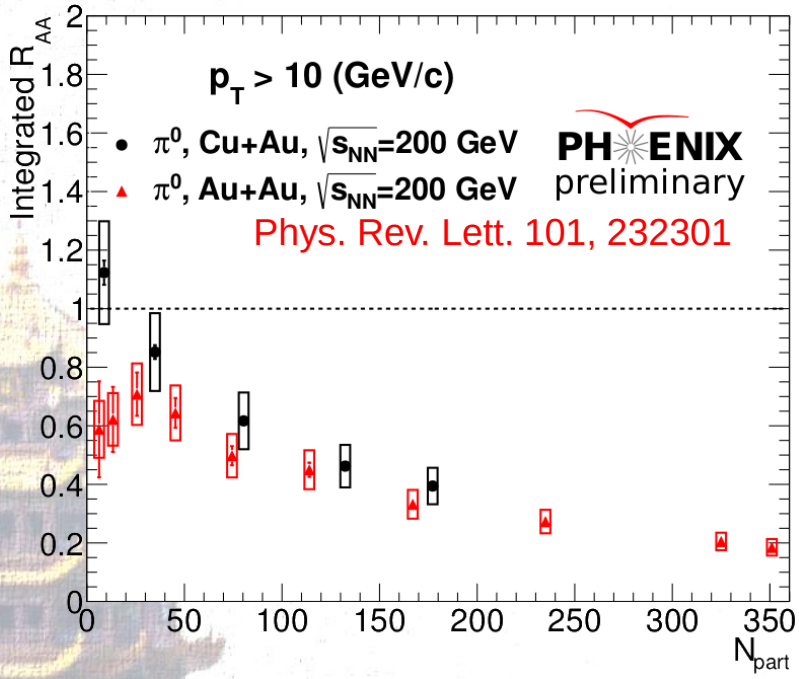
π^0 R_{AA} in Cu+Au, Cu+Cu and Au+Au

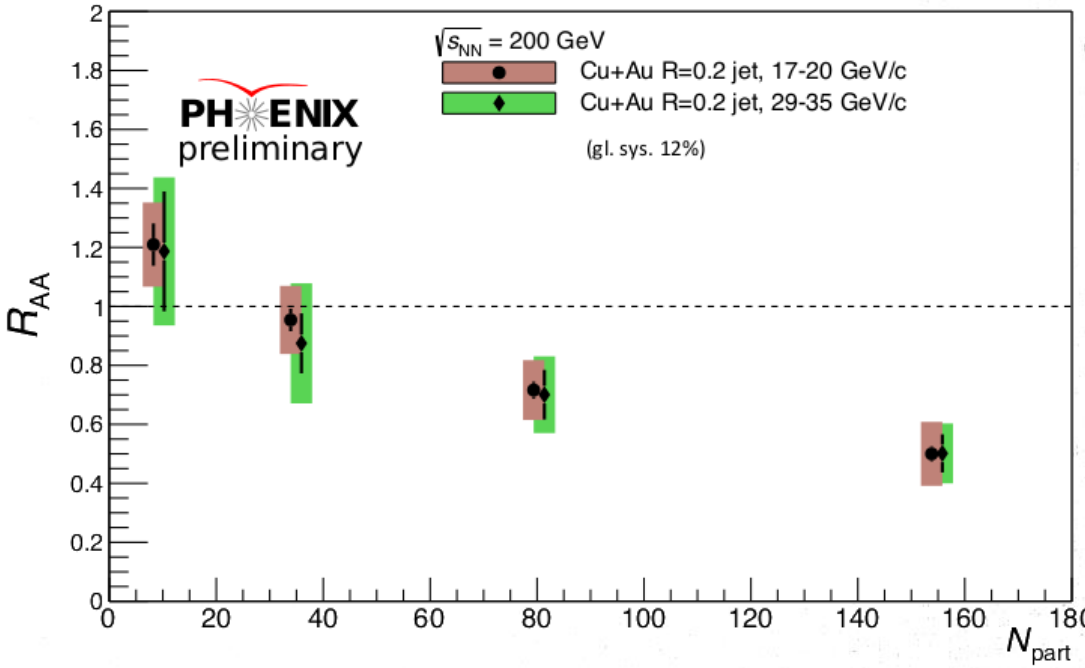


Phys. Rev. Lett. 101, 232301
Phys. Rev. Lett. 101, 162301

- In **central** and **semi central** Cu+Au collisions π^0 yields are suppressed similar to Cu+Cu and Au+Au:
  - ✓ π^0 production depends on the size of the nuclear overlap, but not on it's shape.
- In **peripheral** Cu+Au collisions π^0 yields show a hint on enhancement, while in Au+Au – suppression, Cu+Cu lies in the middle.

π^0 R_{AA} in Cu+Au, Cu+Cu and Au+Au

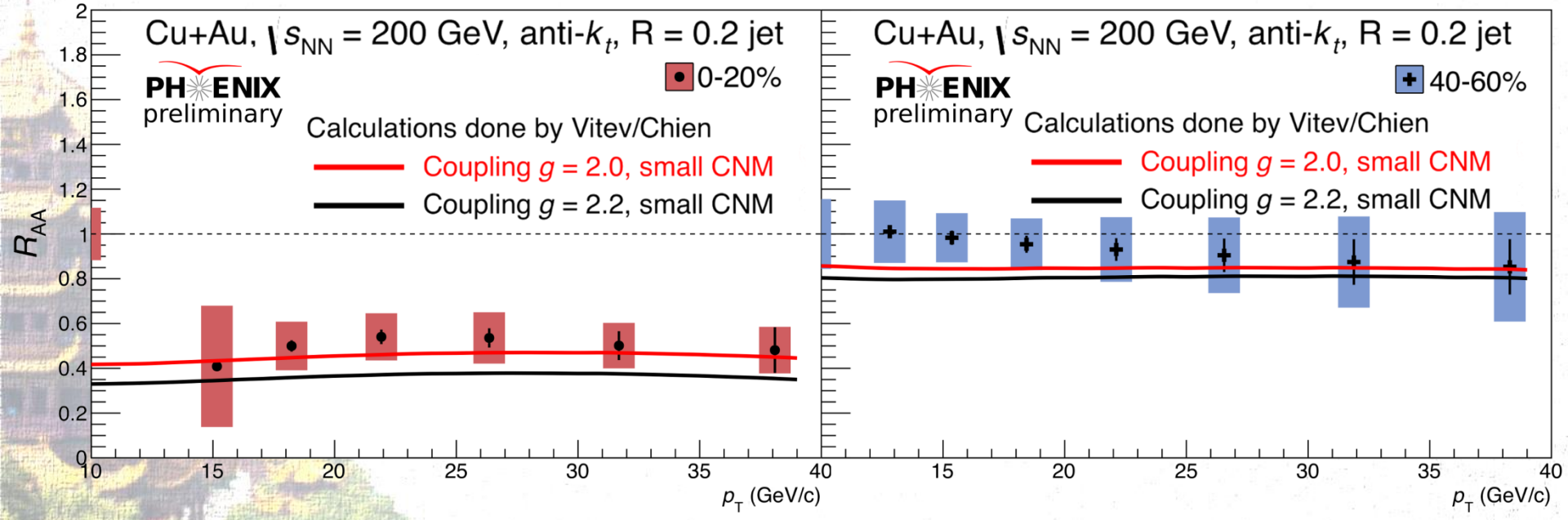




- π^0 production is compatible in Cu+Au and Au+Au collisions at $N_{part} > 50$.
- π^0 is less suppressed in Cu+Au at $N_{part} < 50$.

Model Comparison

- **SCET$_G$** – effective theory of jet propagation in matter:
  - ✓ allows to go beyond the traditional energy loss approximation and unify the treatment of vacuum and medium-induced parton showers
  - ✓ input parameter: coupling (g) between jet and medium



[hep-ph] 1509.07257

- Measured R_{AA} are consistent with **SCET$_G$ calculation** with couplings g = 2 and g = 2.2

Summary

- PHENIX has measured invariant p_T spectra and nuclear modification factors for π^0 and jets in Cu+Au collisions at 200 GeV
- π^0 production is suppressed in central and semicentral collisions in a same way, as in Au+Au and Cu+Cu at similar N_{part} :
  - ✓ the suppression level is dependent on overlap size, not on its geometry
- In peripheral collisions there is a hint on π^0 and jet enhancement
- Jet nuclear modification factors are compatible with $SCET_G$ calculations for couplings g=2 and g=2.2
- There is no model calculations for π^0 production yet