Inclusive jet production in proton-proton and copper-gold collisions at $\sqrt{s_{NN}} = 200$ GeV

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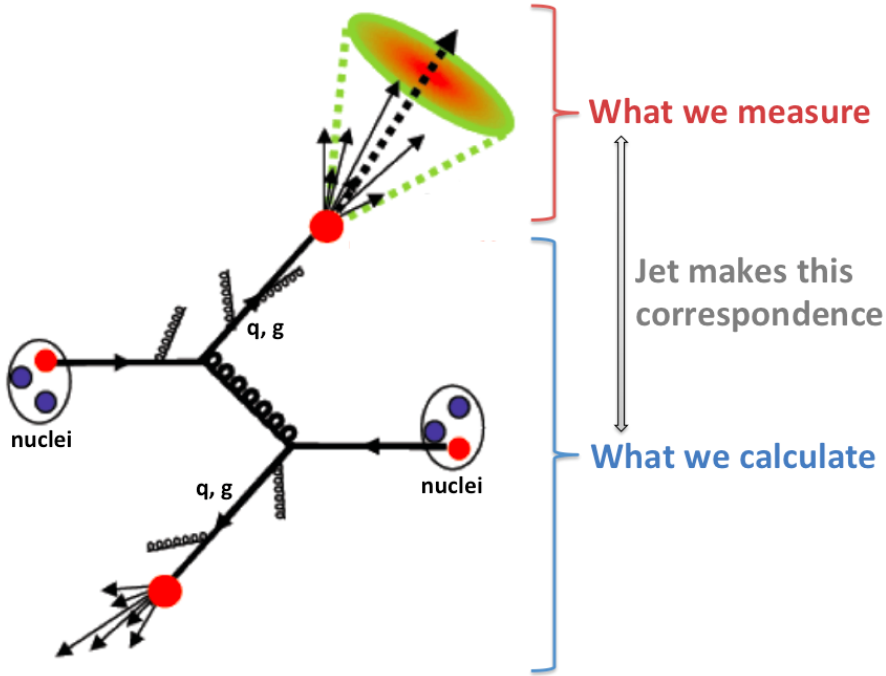
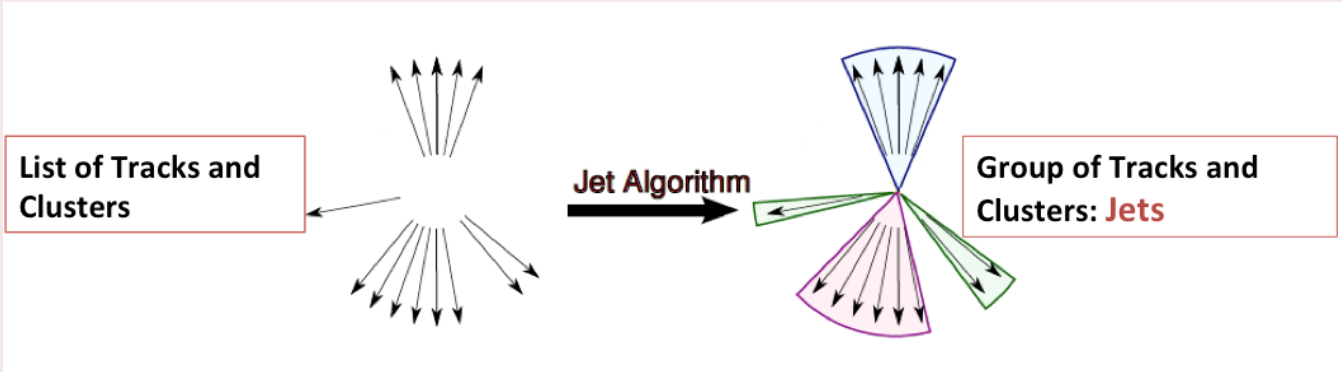
What is a jet?

A jet is an **experimental observable** that can be related to **theory predictions**.

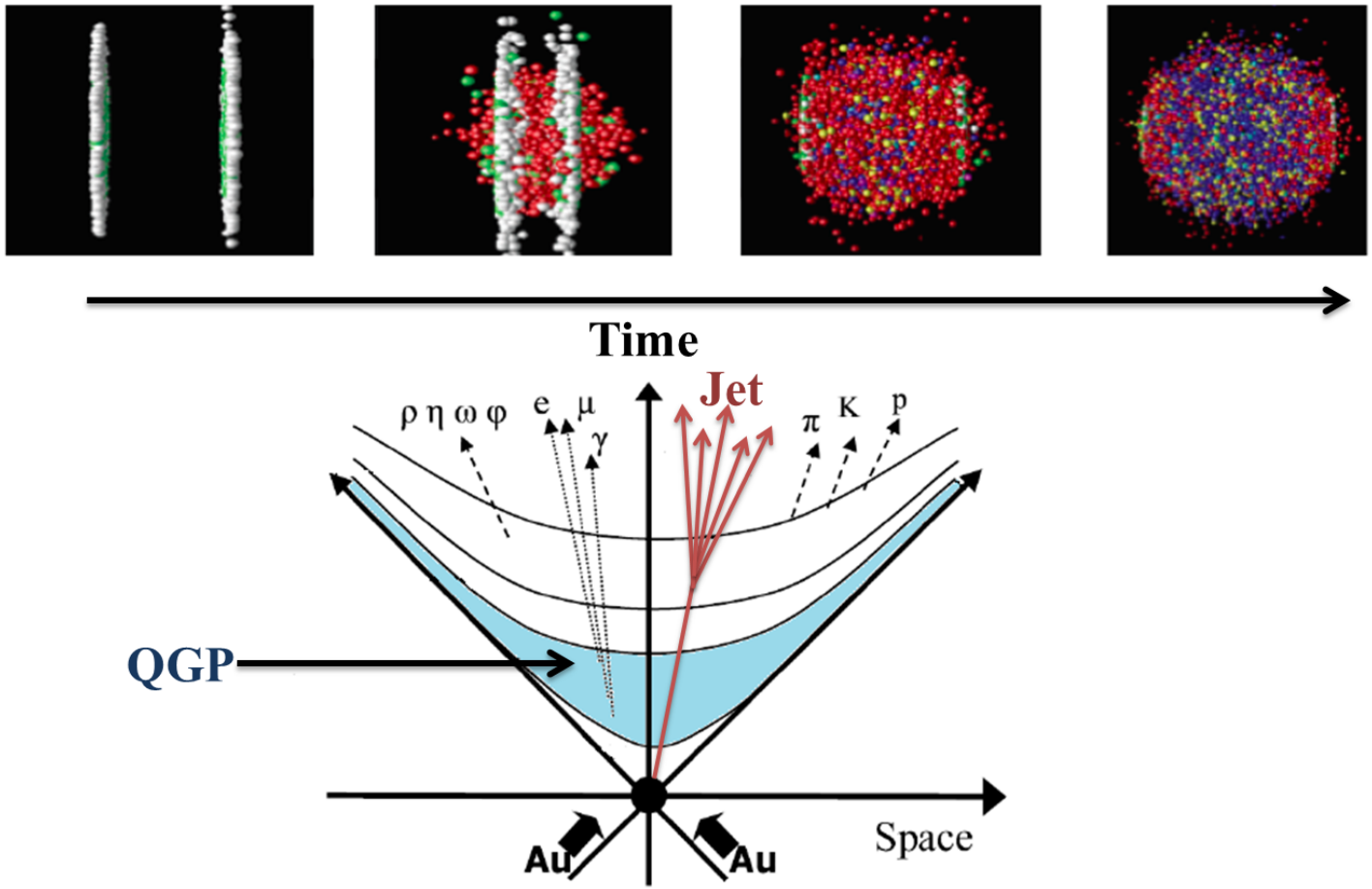
The kinematic properties of a jet of hadrons (p_T, η, ϕ) can be associated to the kinematic properties of the original partons produced from the hard scattering process.



Jet reconstruction algorithm defines how signals in a detector are grouped into jets.



Jet in heavy-ion collisions



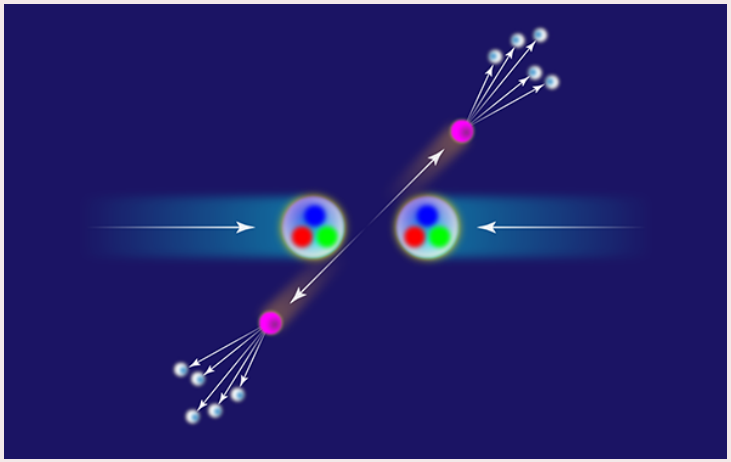
⇒ Hard scatterings happen early relative to medium formation time

⇒ High-p_T partons traverse the QGP medium and lose energy

⇒ Jets of hadrons can be used as a probe to study the QGP

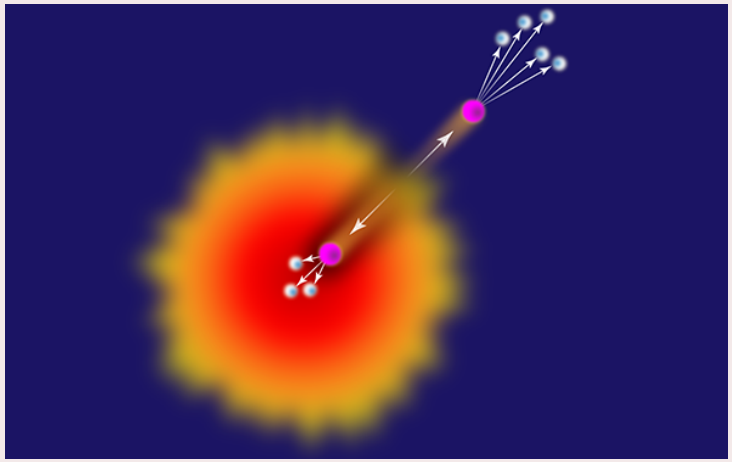
Probes of the QGP

In the p+p collisions, the hard scattered parton creates a shower of partons that eventually form a jet of hadrons.



APS/Alan Stonebraker

Due to the interactions of the high-p_T partons with the medium, jet production rate in the heavy-ion collisions is expected to be modified relative to p+p collisions.



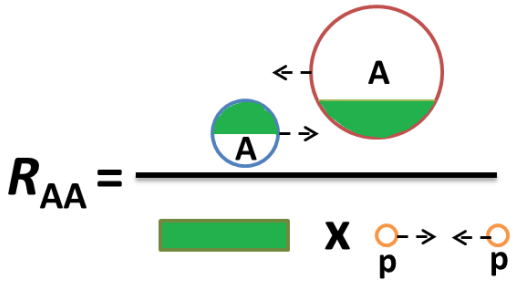
Quantifying energy loss

Null hypothesis: Heavy-ion collisions behave like geometrically equivalent p+p collisions.

⇒ Nuclear modification factor- important observable for studying jet energy loss in the medium

$$R_{\mathrm{AA}} = \frac{dN^{\mathrm{h}}_{\mathrm{AA}}}{\langle T_{\mathrm{AA}} \rangle d\sigma^{\mathrm{h}}_{\mathrm{pp}}},$$

where $\langle T_{\mathrm{AA}} \rangle$ is mean value of the nuclear thickness function.

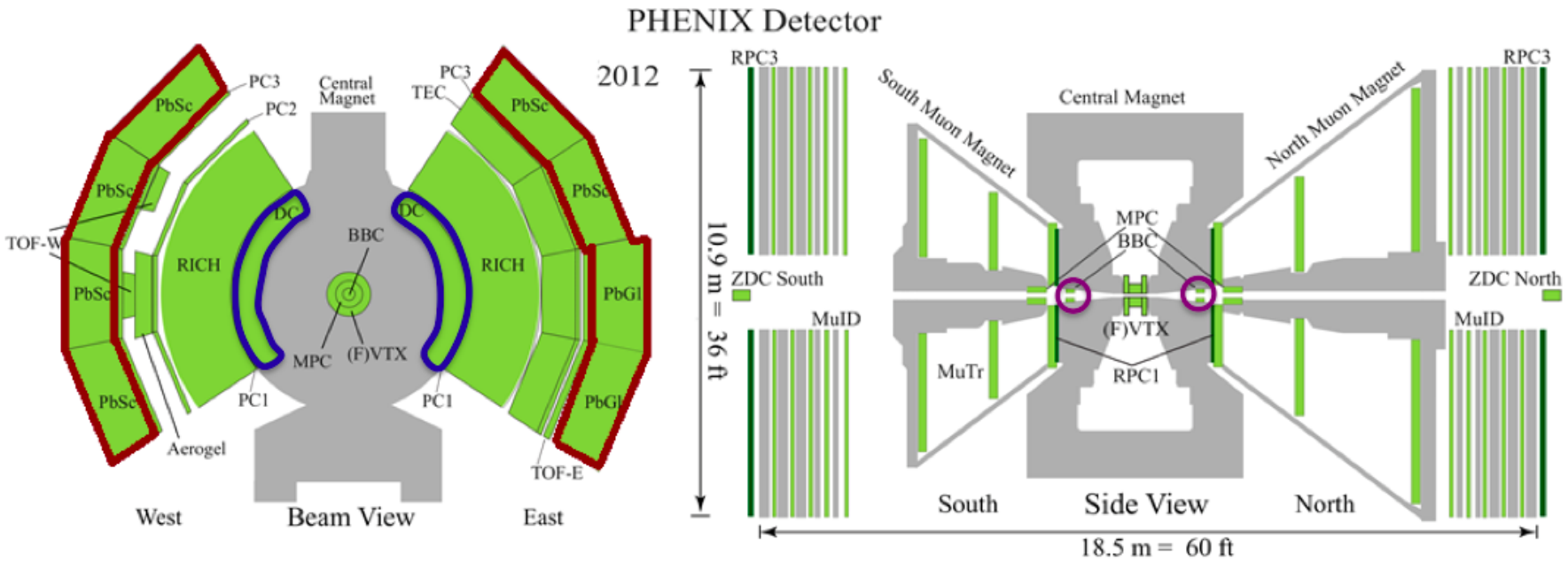


⇒ In the absence of nuclear effects, $R_{\mathrm{AA}} = 1$

⇒ $R_{\mathrm{AA}} < 1$ is referred to as suppression, indicating fewer final state particles at a given (p_{T}, η) than expected

⇒ $R_{\mathrm{AA}} > 1$ is referred to as enhancement, indicating excess final state particles than expected

Pioneering High Energy Nuclear Interaction eXperiment (PHENIX)



⇒ Charged particle tracks are reconstructed using the **Drift Chamber (DC)**, the Pad Chamber (PC), and the collision point

⇒ Neutral clusters are measured in the **Electromagnetic Calorimeter (EMCal)**

⇒ **Beam Beam Counters (BBCs)** provide vertex and centrality classification

Jets in PHENIX

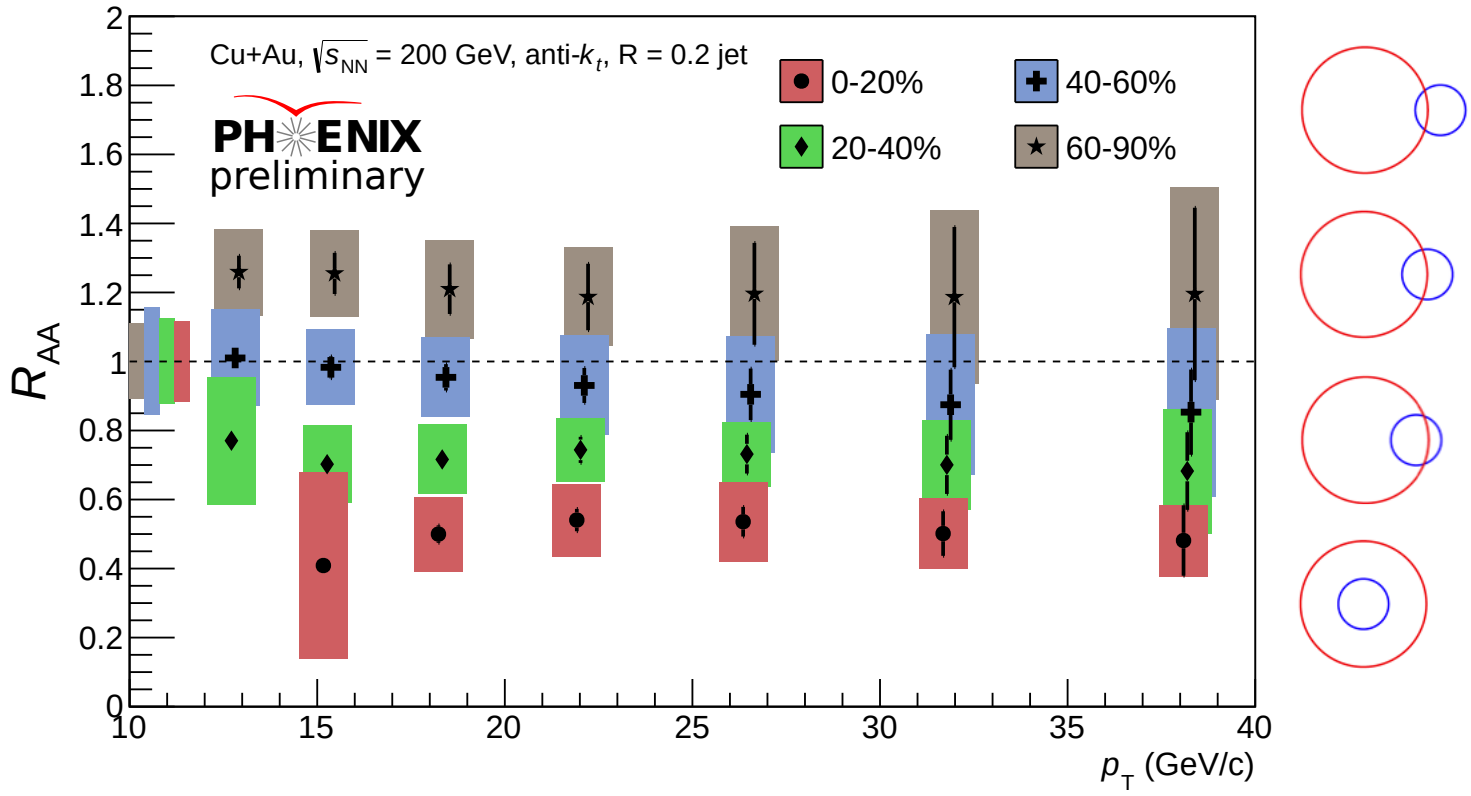
⇒ 2012 $\sqrt{s_{NN}} = 200$ GeV p+p and Cu+Au collisions

⇒ Jets reconstructed using anti-k_t algorithm with $R = 0.2$
- EMCal cluster energy + charged particle tracks

⇒ Jet-level requirements
- number of constituents $>= 3$
- restriction on contribution of charged constituents
- jet axis required to be away from the detector edges

⇒ Correction procedure
- Fake jet contribution statistically subtracted
- Centrality-dependent response matrices generated by embedding PYTHIA p+p jets into real Cu+Au events
  - Spectra corrected for detector effects and underlying event fluctuations with unfolding procedure

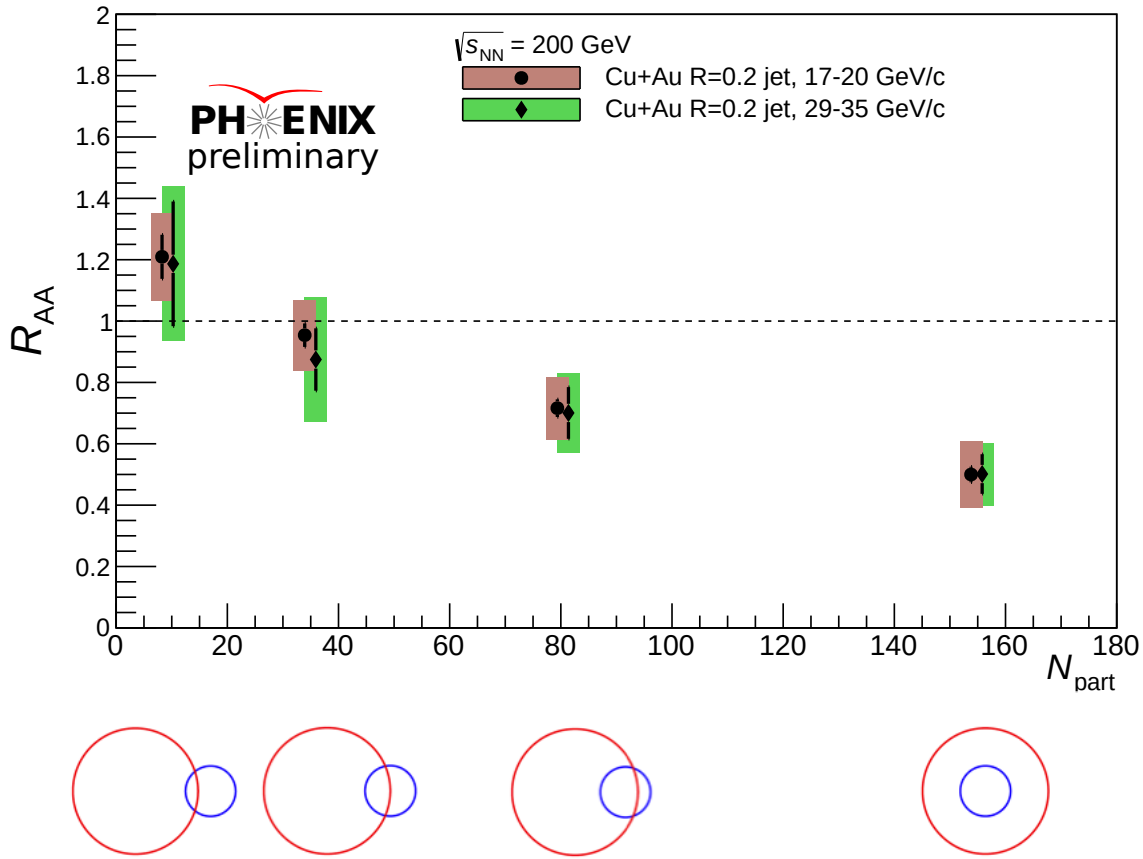
Jet suppression: R_{AA} vs. p_T



R_{AA} probes jet production modification relative to p+p expectation

- ⇒ Suppression shows centrality dependence
- ⇒ No p_T dependence
- ⇒ For central collisions, jets are suppressed by approximately a factor of two

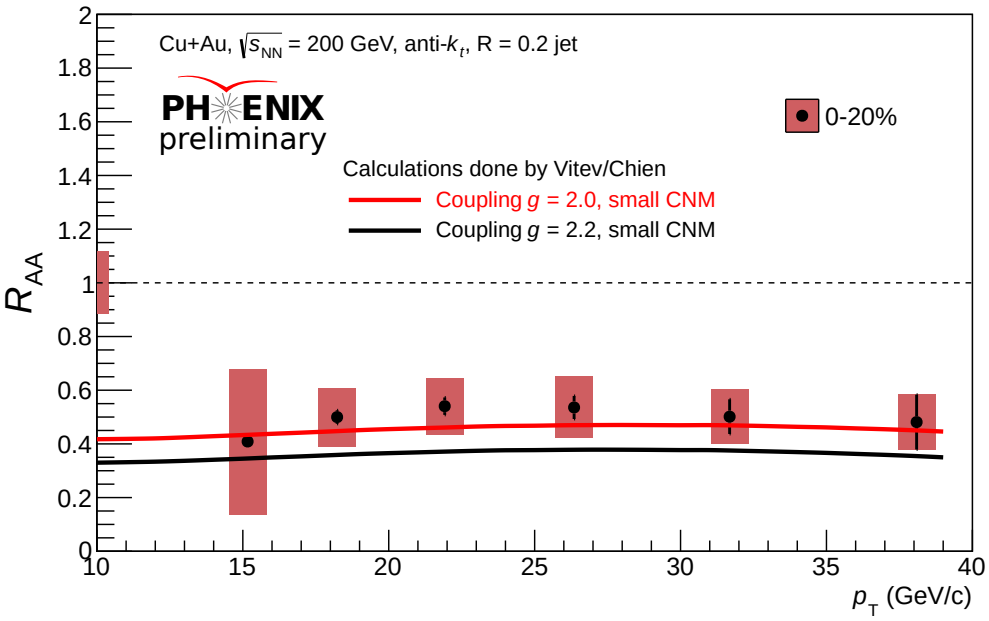
Jet suppression: R_{AA} vs. N_{part}

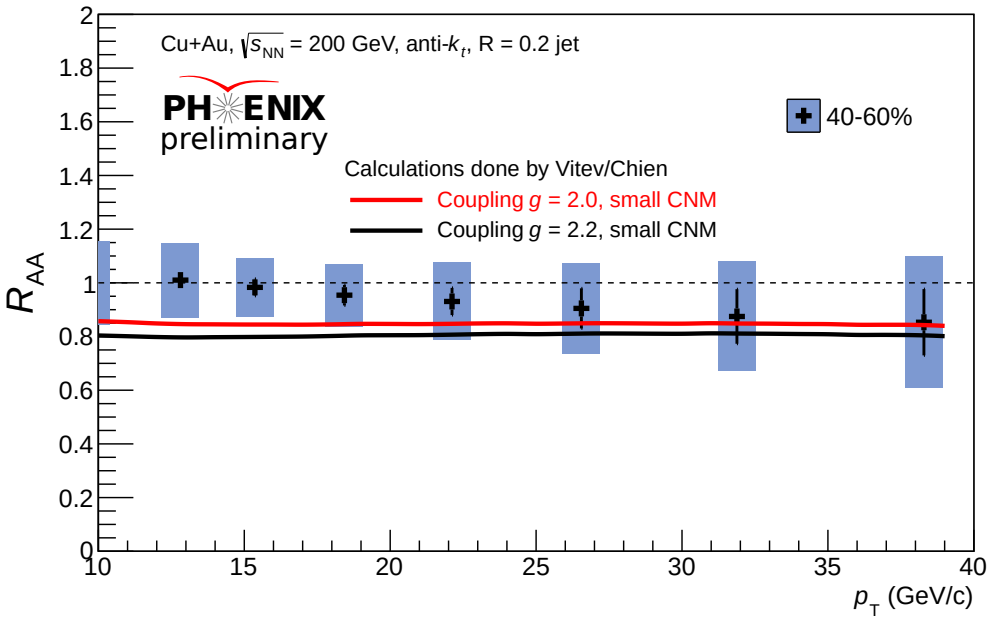


Another look at suppression: N_{part} dependence

- $\Rightarrow$ N_{part} is the number of participating nucleons
- $\Rightarrow$ R_{AA} shows strong N_{part} dependence and no p_T dependence

Jet suppression: comparisons to theory





- ⇒ Left: 0–20%; right: 40–60%
- ⇒ Calculations done for 2 different couplings between the jet and the medium (g=2.0 and g=2.2)
- ⇒ Quantitatively in line with state-of-the-art jet quenching calculations

Summary

⇒ Jet measurements play an important role in understanding the properties of the QGP

⇒ The ratios of jet spectra from different centrality selections of Cu+Au collisions show a strong modification of jet production at all p_T
- jets are found to be suppressed by approximately a factor of two in central Cu+Au collisions as compared to p+p collisions
- suppression shows no p_T dependence

⇒ Progress on jet measurements with PHENIX detector- good guidance for future heavy ion jet program at RHIC