Jet quenching in high-energy nuclear collisions

QCD @ Work 2005

Conversano, June 19th, 2005

David d'Enterria
Nevis Labs, Columbia University, NY

Overview

0. Physics motivation: Jet production in QCD medium (AA) vs QCD vacuum (pp) as a signature of QGP formation at RHIC.

1. Empirical observation I: High p_T (leading) hadron suppression.

   - Magnitude of suppression (x5 in central AuAu @ RHIC-200 GeV) provides direct info on transport ($<q_0>$) & thermodynam. (dN^g/dy) properties of medium
   - Properties of suppression (p_T-, $\sqrt{s}$-, ... dependence) in agreement w/ non-Abelian gluon radiation off hard scattered partons.

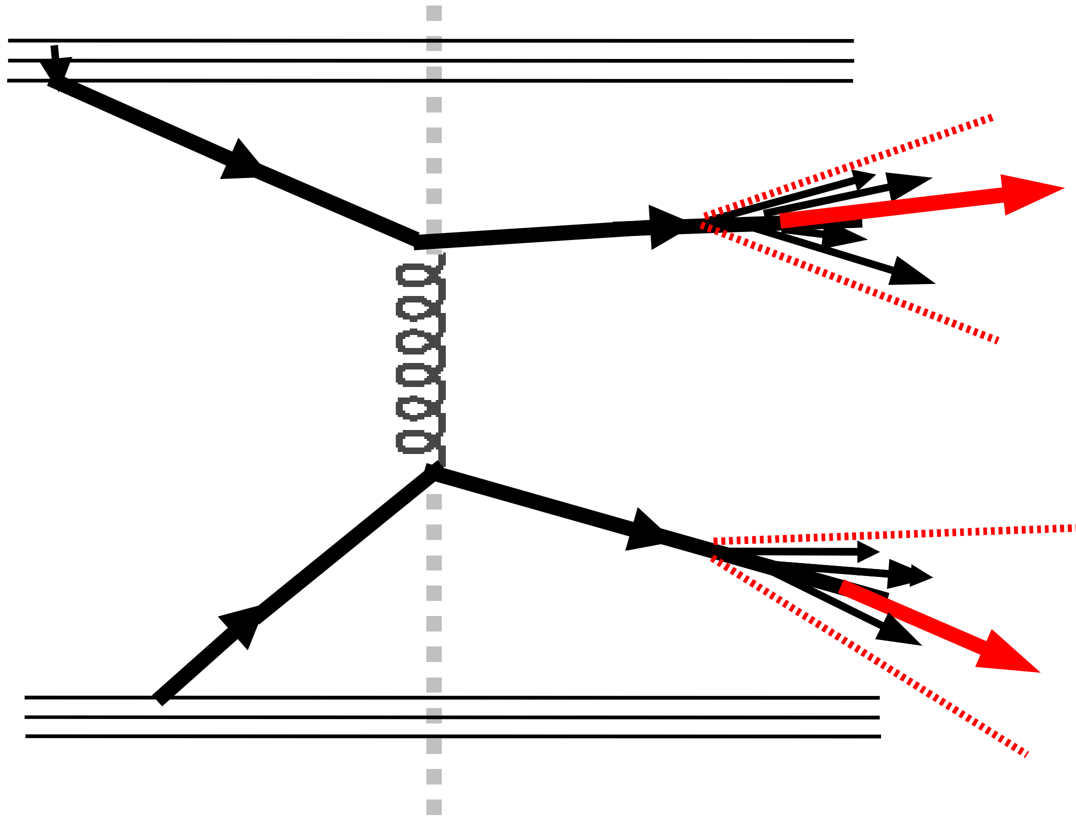
2. Empirical observation II: Modified high p_T di-hadron ϕ-,η-correlations.

   - Disappearance of back-to-back $dN_{pair}/d\phi$ peak ("monojets")
   - "Double peak" structure in away-side $dN_{pair}/d\phi$ ("Mach boom" in medium ?)
   - Di-jet pseudo-rapidity $dN_{pair}/d\eta$ broadening (coupling of g rad. w/ long. expansion ?)

3. Summary

Disclaimer: This is a limited selection of a vast number of exp. nucleus-nucleus data (no mention to high p_T baryon or heavy-Q spectra, no space for discussion on detailed jet properties $<j_T>$,$<k_T>$, ...)

Jet production in the "QCD vacuum" (pp collisions)



- Jet : Collimated spray of hadrons in a cone ($R = \sqrt{\Delta\eta^2 + \Delta\phi^2}$ ~ 0.7) with 4-momentum of original fragmenting parton
- Leading hadron takes away large fraction (**<z>** ~0.6 –0.8 @ RHIC) of parent parton p_T
- Jet balanced back-to-back by other hard-scattered "parton" (jet, direct γ, ...)

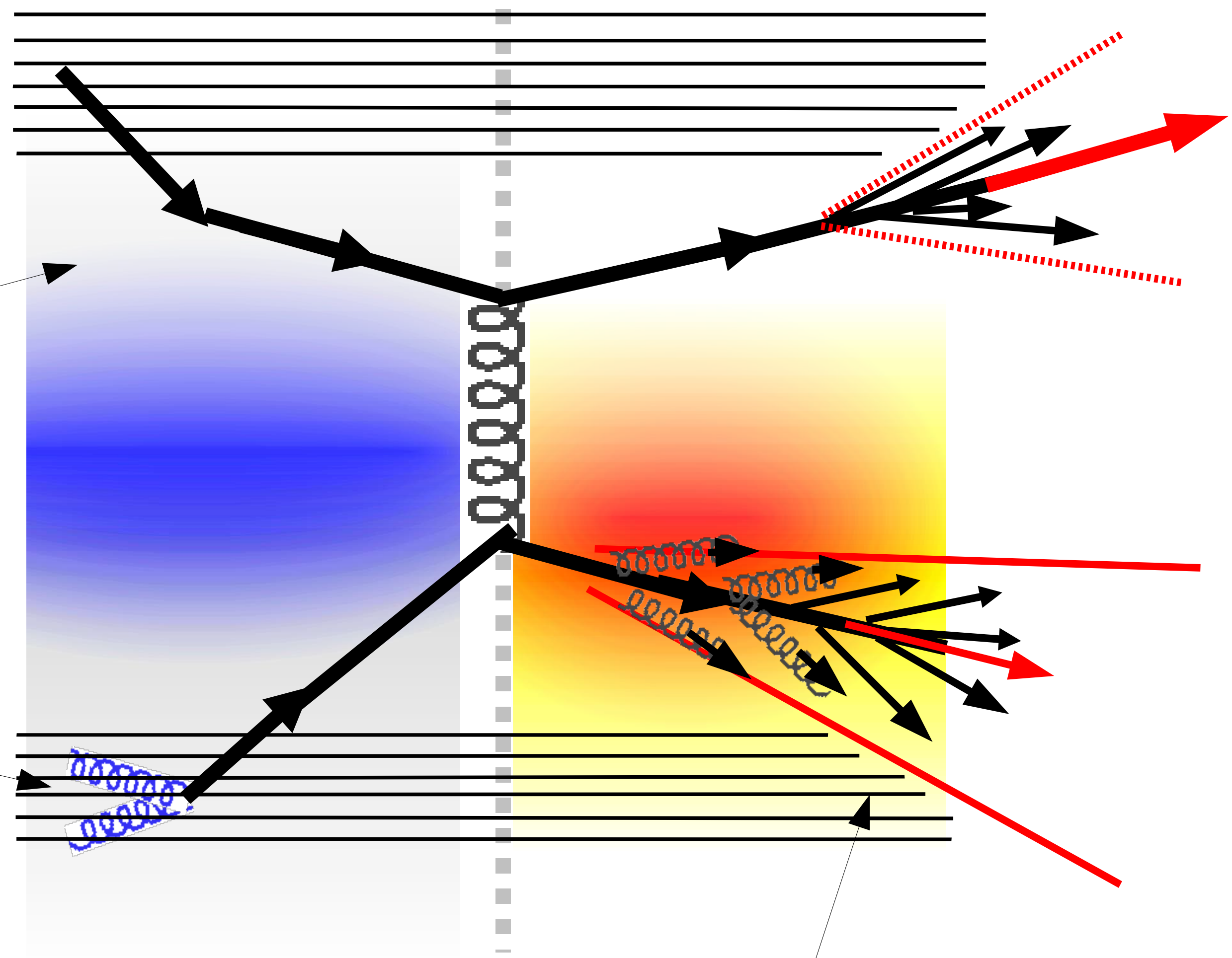
Jet production in "QCD media" (pA, AA collisions)

- Initial-state effects:

(accessible via pA colls.)

k_T broadening
(Cronin enhancement)

(Leading-twist) shadowing
or gluon saturation (**CGC**)



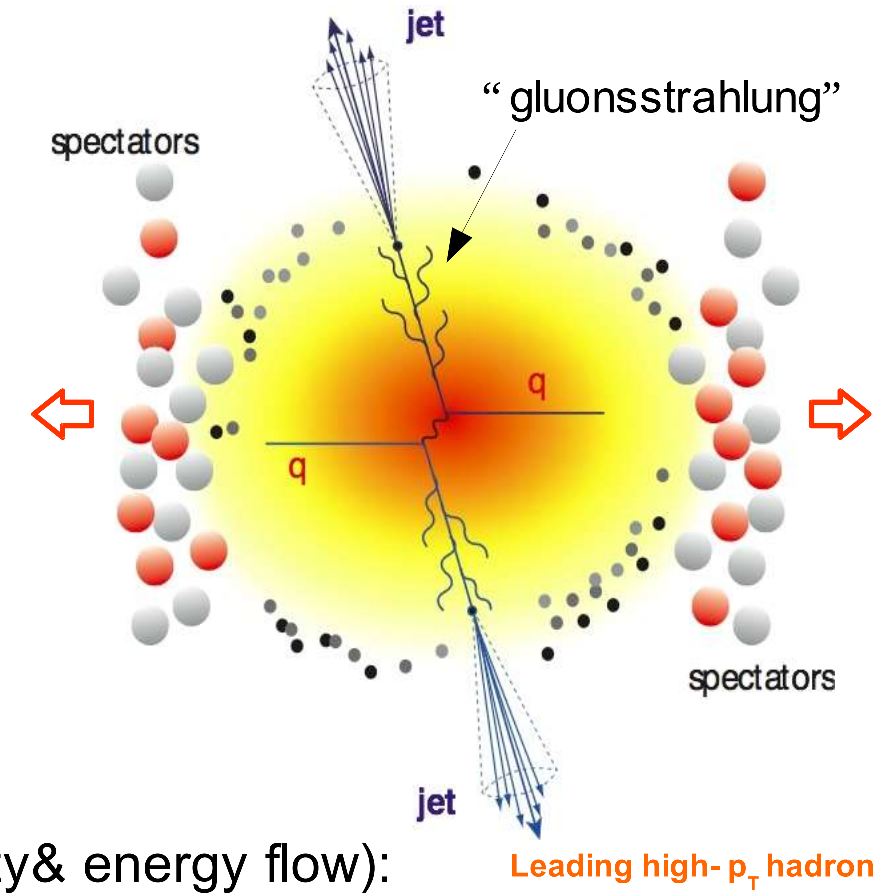
- Final-state effects:

(accessible in AA colls.)

Parton energy loss due to medium-induced gluon-strahlung in hot & dense environment

"Jet quenching" = QGP signal

- Multiple final-state non-Abelian (gluon) radiation off the produced hard parton induced by the dense QCD medium.



- Parton energy loss ∝ medium properties:

  $\Delta E_{loss} \sim \rho_{gluon}$ (gluon density)

  $\Delta E_{loss} \sim \Delta L^2$ (medium length)

- Energy is carried away by gluons emittted inside (broader) jet cone (modified multiplicity& energy flow):

  $dE/dx \sim \alpha_s \langle k_T^2 \rangle$

- Prediction I: Suppression of high p_T leading hadrons: dN/dp_T
- Prediction II: Modification of (di)jet correlations: $d^2N_{pair}/d\varphi d\eta$

Relativistic Heavy-Ion Collider (RHIC) @ BNL

Specifications:

- 3.83 km circumference
- 2 independent rings:
  - 120 bunches/ring
  - 106 ns crossing time

A + A collisions @ $\sqrt{s_{NN}}$ = 200 GeV

Luminosity: $2\cdot10^{26}$ cm^{-2} s^{-1} (~1.4 kHz)

p+p collisions @ $\sqrt{s}_{max}$ = 500 GeV

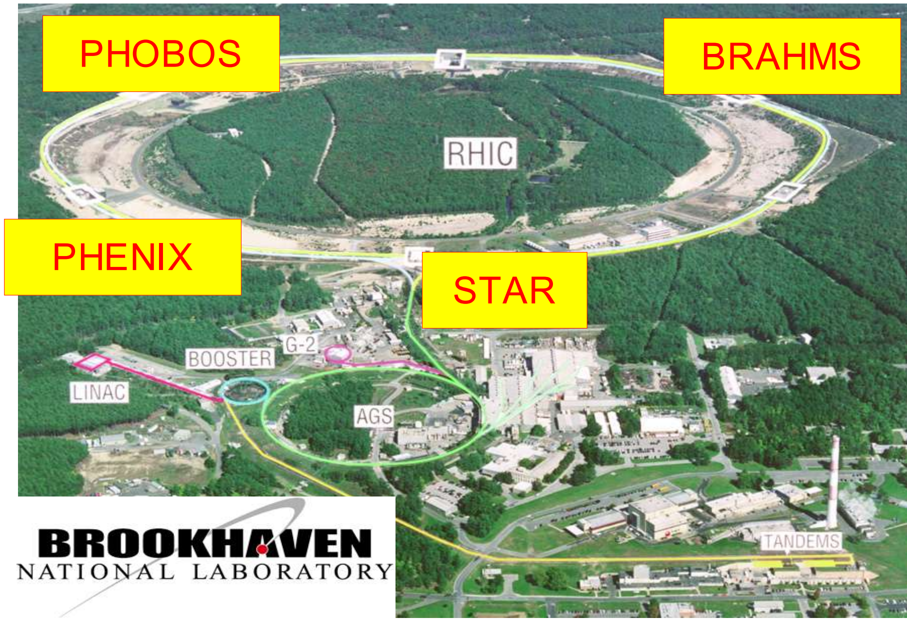
p+A collisions @ $\sqrt{s}_{max}$ = 200 GeV

4 experiments:

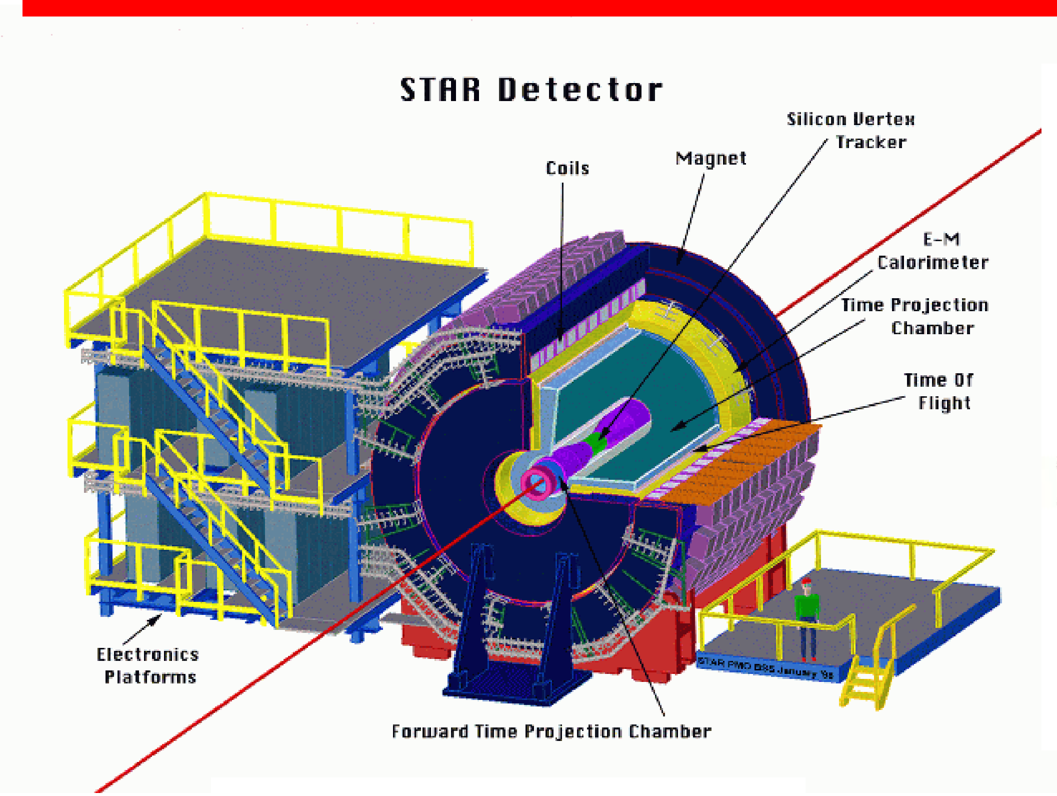
BRAHMS, PHENIX, PHOBOS, STAR

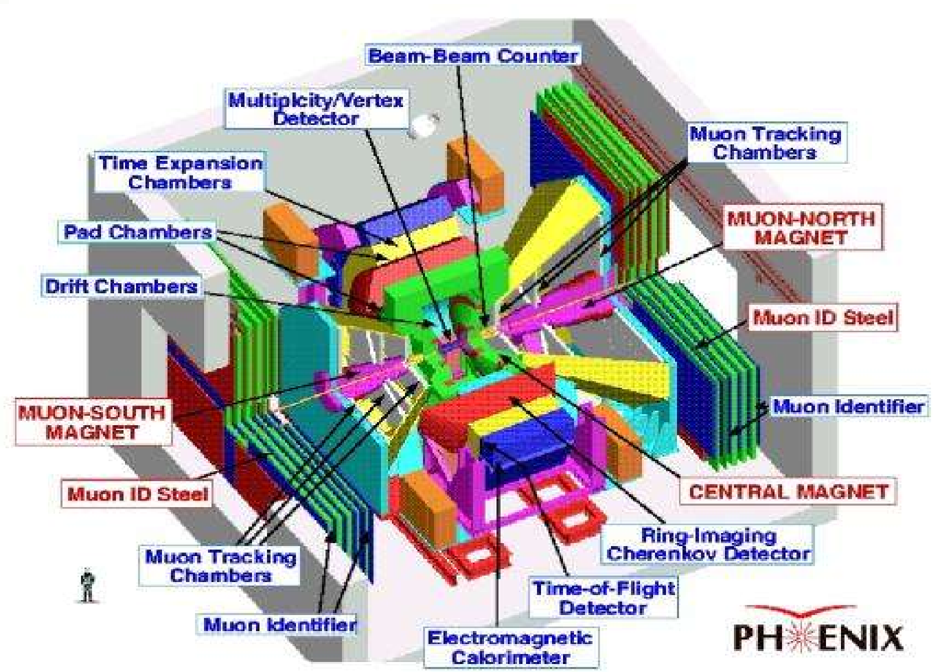
Runs 1 - 5 (2000 – 2005):

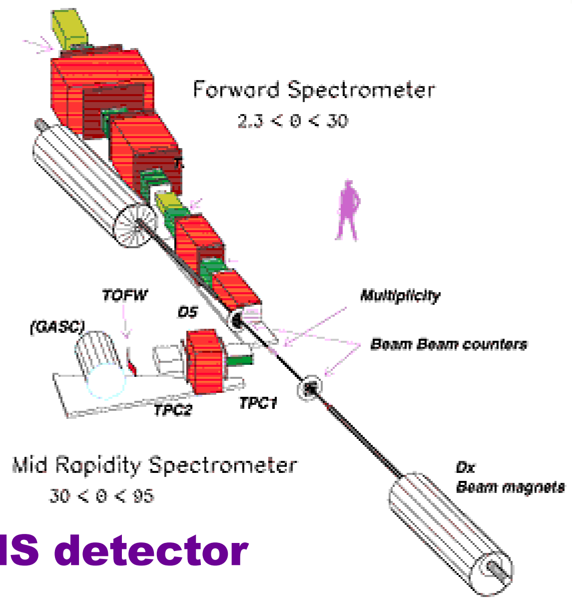
- Au+Au @ 200, 130, 62.4 GeV
- p+p @ 200 GeV
- d+Au @ 200 GeV
- Cu+Cu @ 200, 62.4 GeV



The 4 RHIC experiments

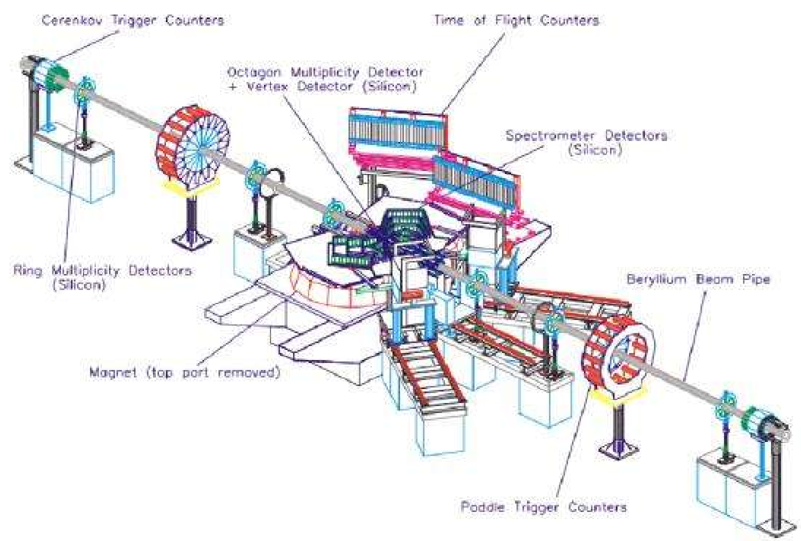






BRAHMS detector

PHOBOS Detector

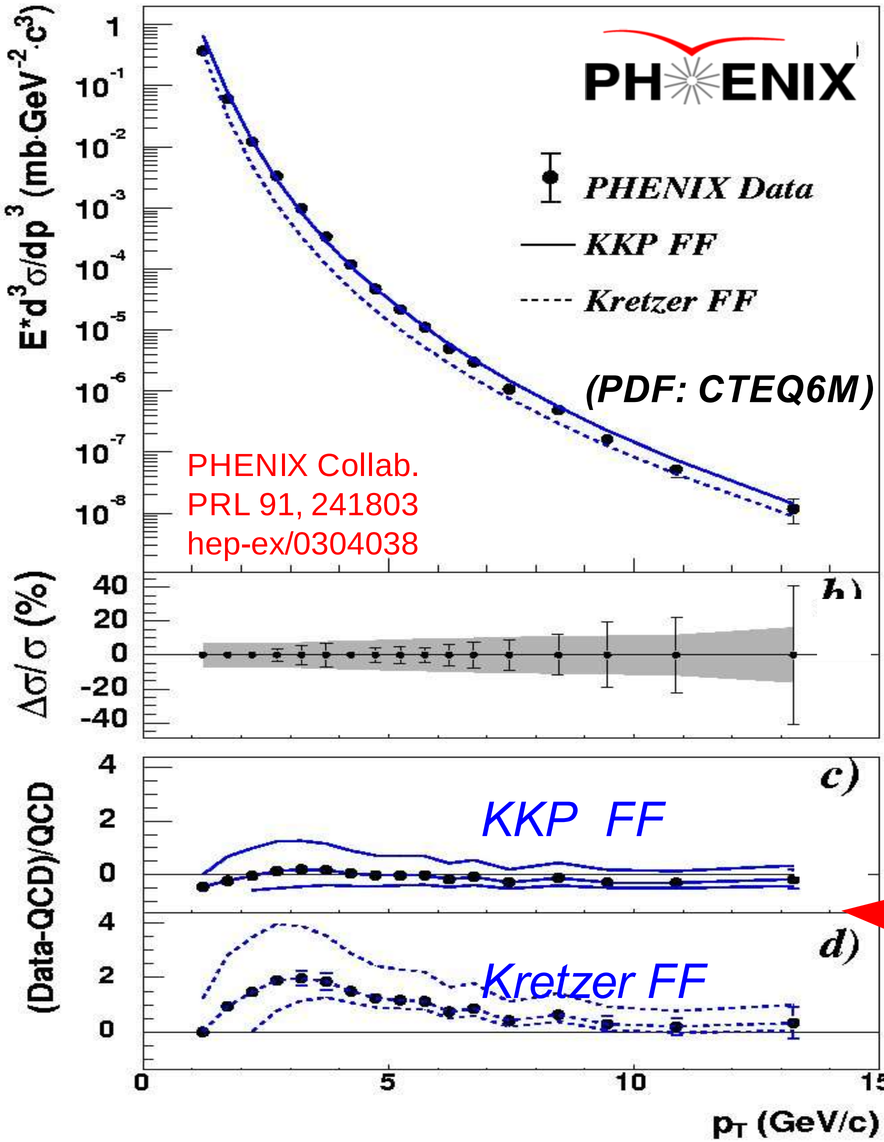


(1) High p_T leading hadron p_T spectra in high-energy pp, dA, AA collisions

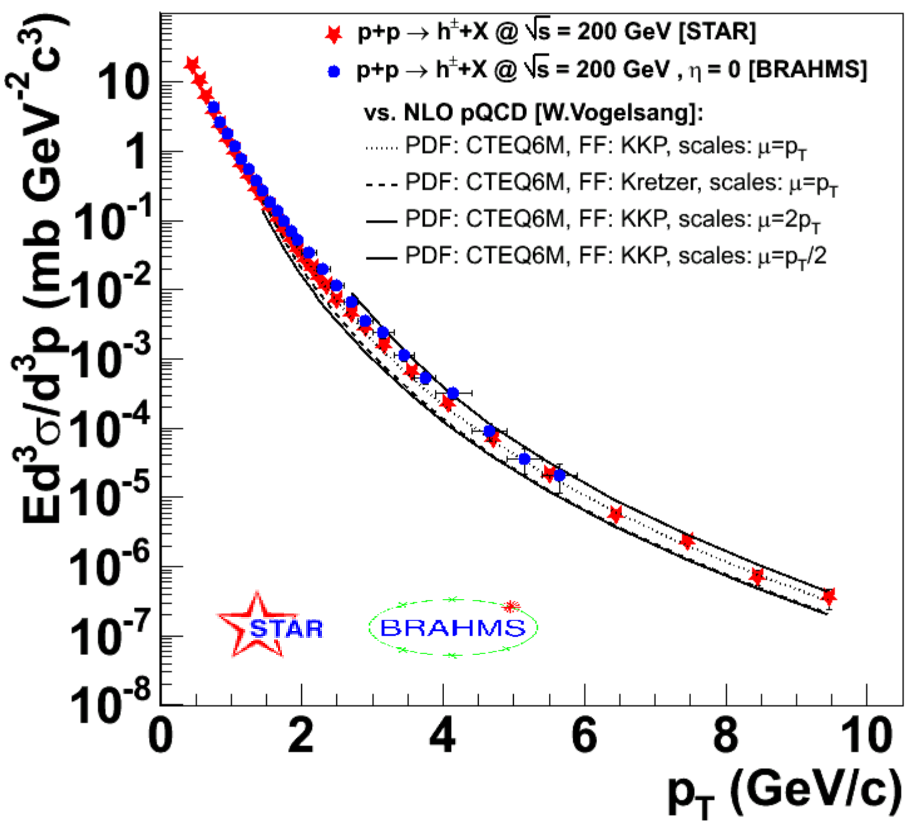
Leading hadron spectra in free space: pp @ 200 GeV

- High p_T π^0,$h^\pm$ spectra up to ~15 GeV/c. Good theoret. (NLO pQCD) description

p+p → π^0 X



p+p → $h^\pm$ X



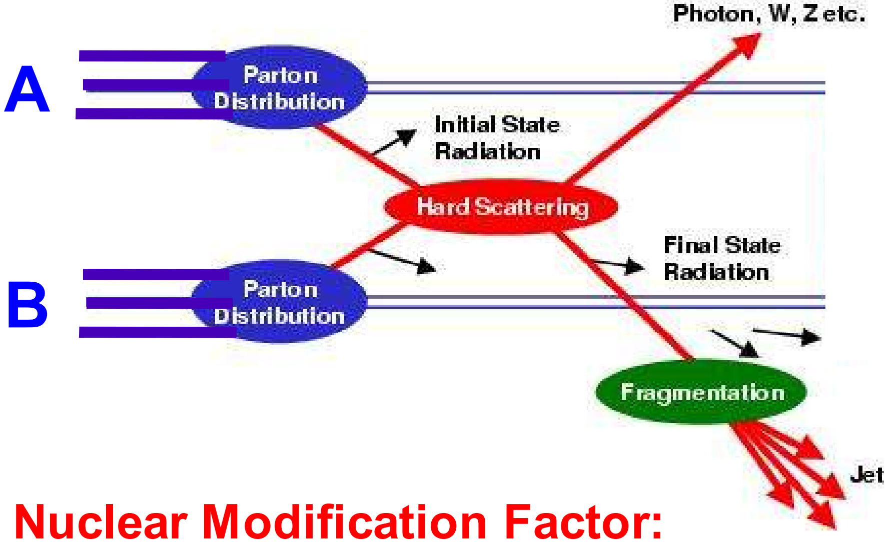
- High quality data: sensitive to different parametrizations of gluon FF
- Well calibrated (experimentally & theoret.) p+p baseline spectra at hand !

Hard spectra: AA = incoherent sum of pp

- Hard yields calculable via perturbative-QCD:

"Factorization theorem":

$$d\sigma_{AB\to hX} = A\cdot B\cdot f_{a/p}(x_a,Q^2_a)\otimes f_{b/p}(x_b,Q^2_b)\otimes d\sigma_{ab\to cd}\otimes D_{h/c}(z_c,Q^2_c)$$



Independent scattering of "free" partons:

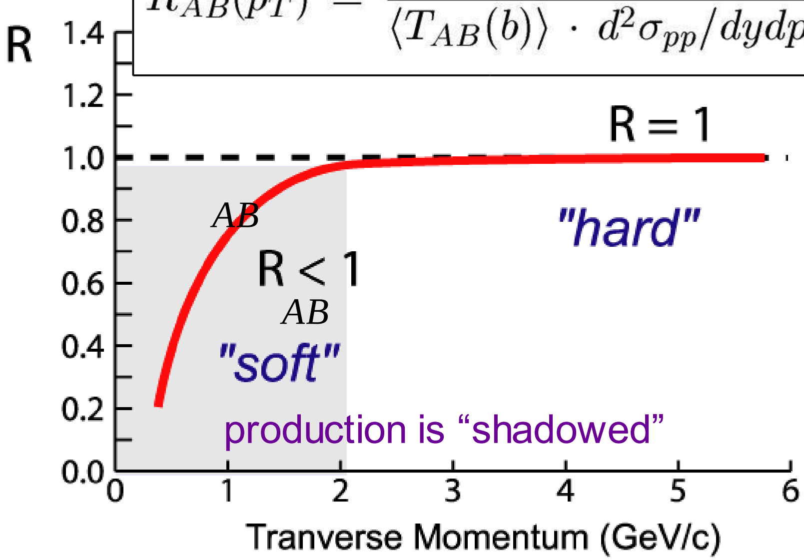
$$f_{a/A}(x,Q^2) = A\, f_{a/p}(x,Q^2)$$

A+B = "simple superposition of p+p collisions"

$$d\sigma_{AB\to hard} = A\cdot B\cdot d\sigma_{pp\to hard}$$

Nuclear Modification Factor:

$$R_{AB}(p_T) = \frac{d^2N_{AB}/dydp_T}{\langle T_{AB}(b)\rangle\cdot d^2\sigma_{pp}/dydp_T}$$



At impact parameter b:

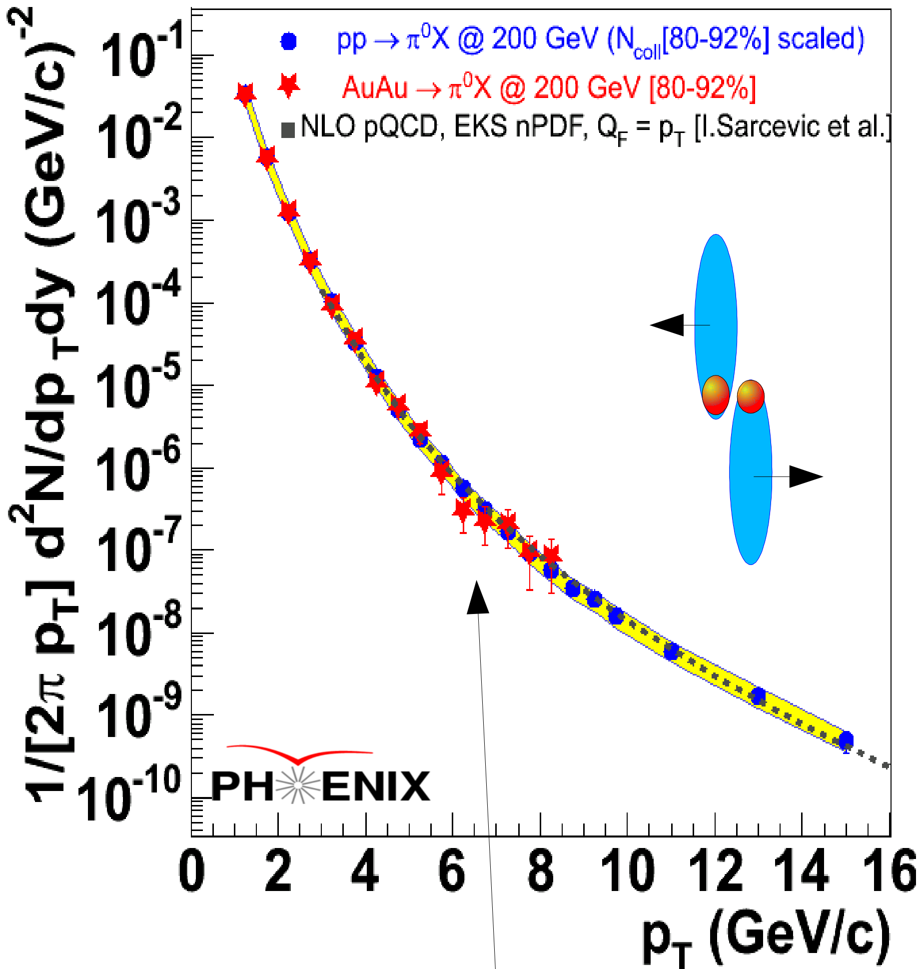
$$dN_{AB\to hard}(b) = T_{AB}(b)\cdot d\sigma_{pp\to hard}$$

geom. nuclear overlap at b

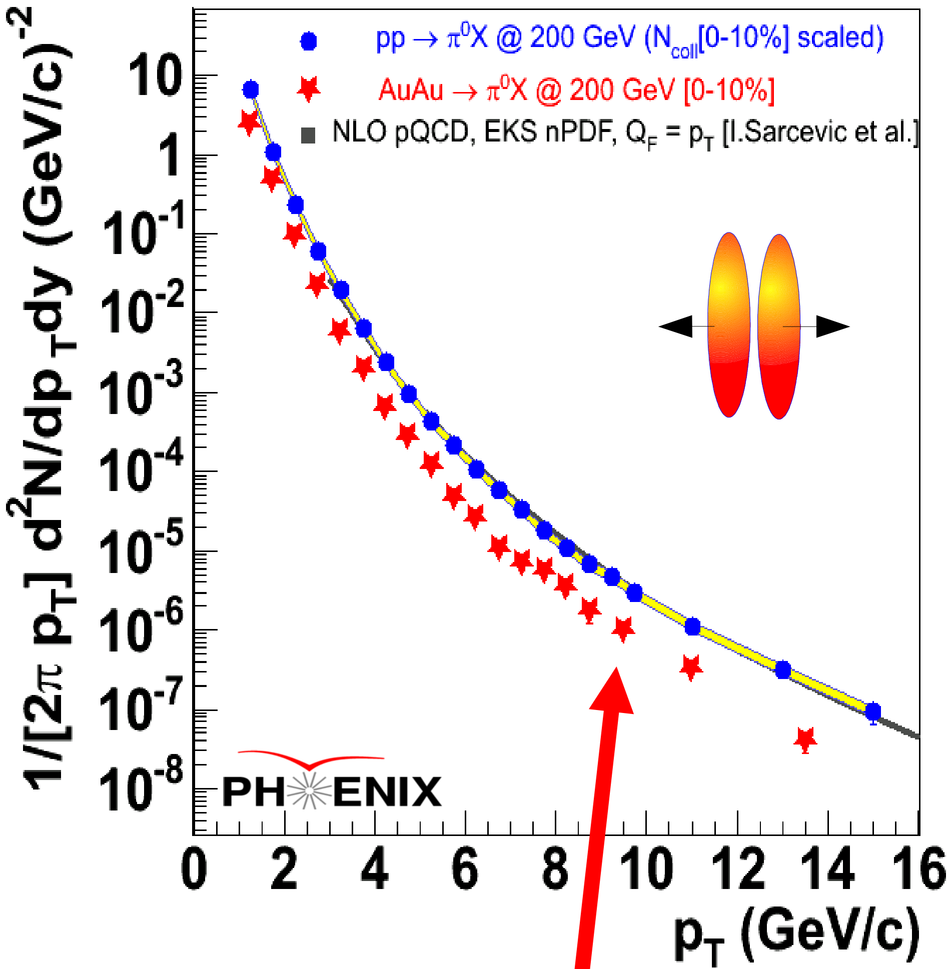
T_{AB} ~ # NN collisions ("N_{coll} scaling")

Leading hadron spectra in AuAu @ 200 GeV

Au+Au→ $\pi^0 X$ (peripheral)



Au+Au→ $\pi^0 X$ (central)

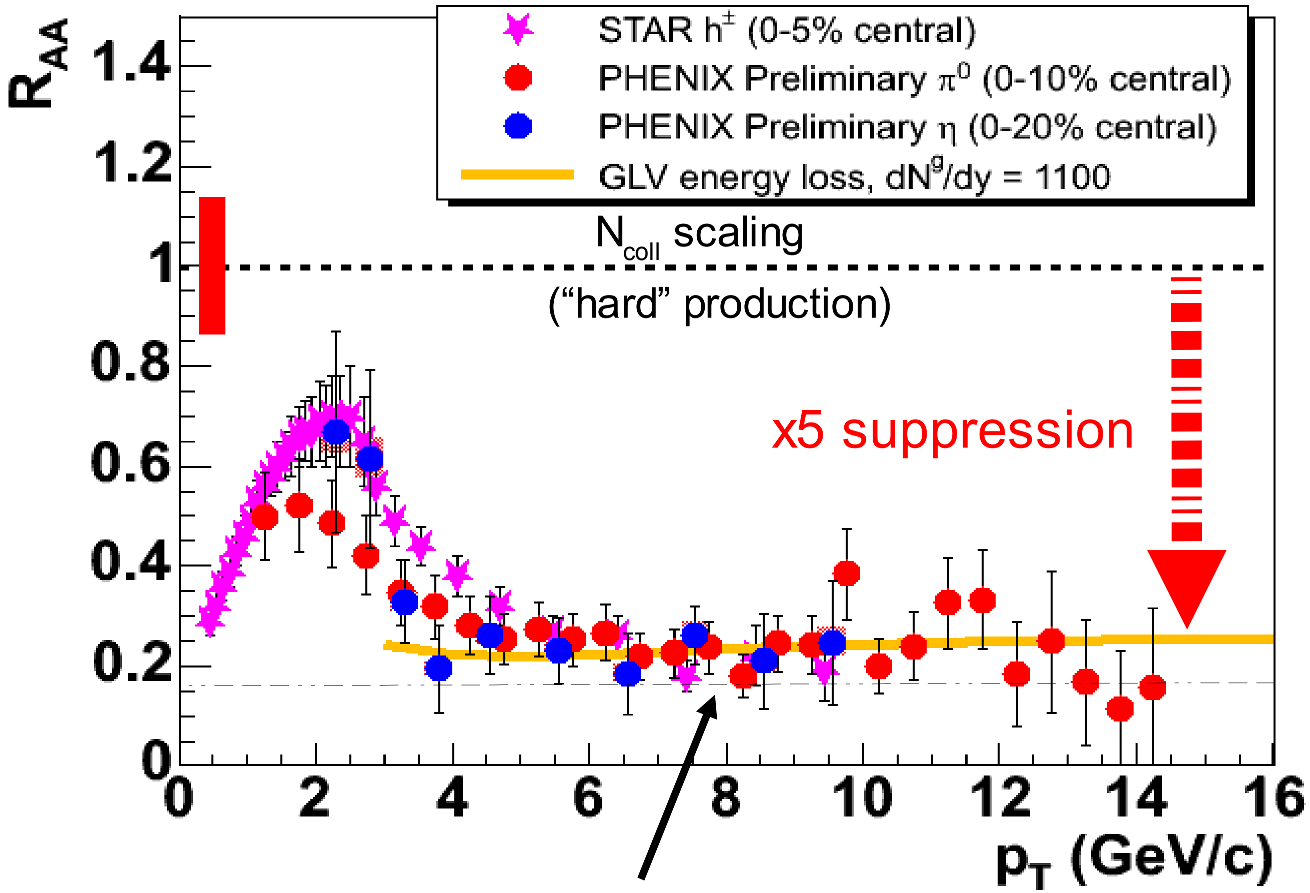


Peripheral data agree well with p+p (data & pQCD) plus N_{coll} scaling

Strong suppression in central Au+Au collisions !

Suppressed high p_T hadroproduction in central AuAu

PHENIX Collab.
PRL 88, 022301 (2002)
nucl-ex/0109003



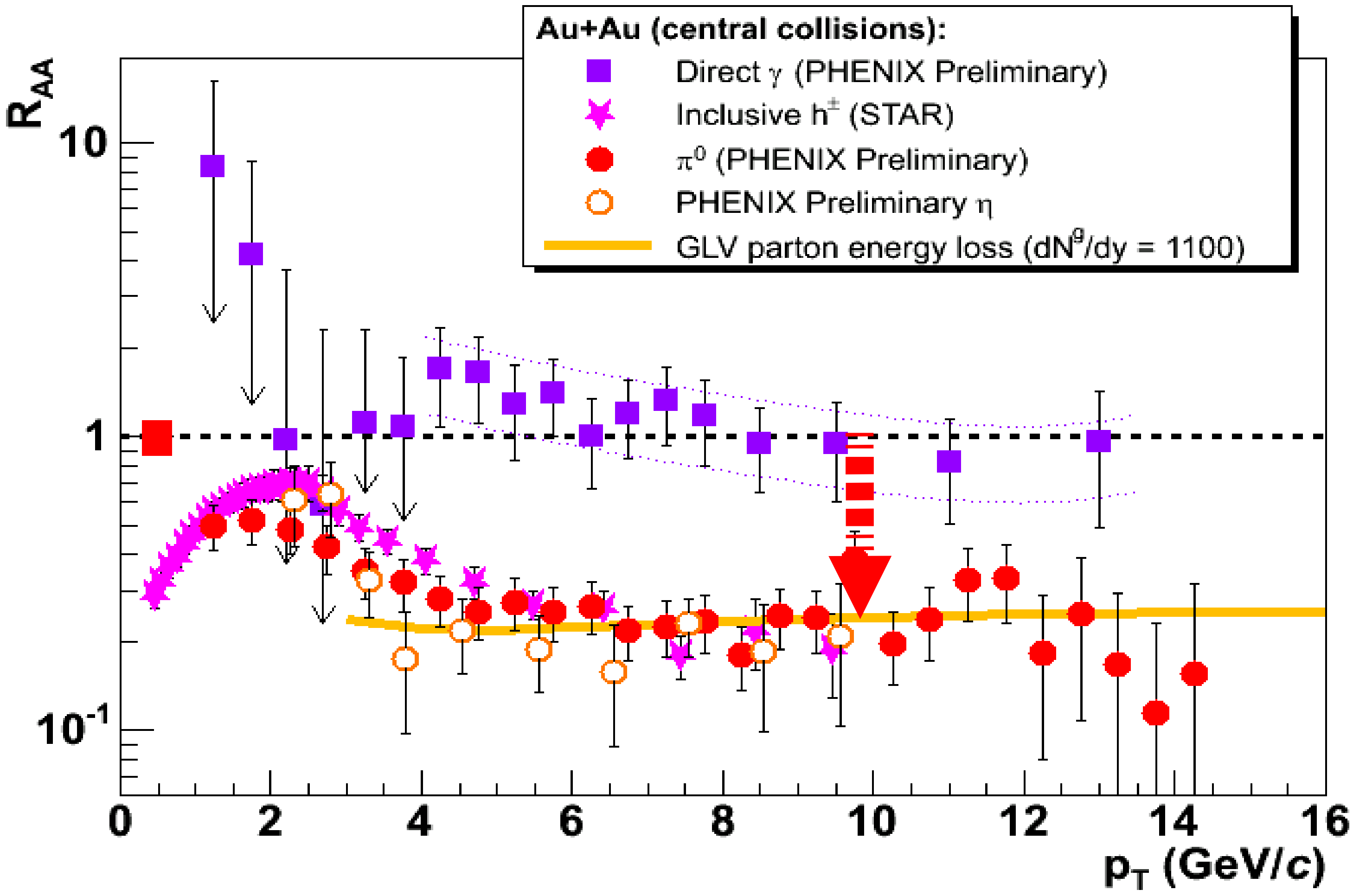
D.d'E., HP'04
nucl-ex/0504001

N_{part} scaling
(surface emission)

Discovery of high p_T suppression
(one of most significant results @ RHIC so far)

- "Universal" (pid-wise) suppression:
  R_{AA} ~ 0.2 up to p_T ~ 14 GeV/c for π^0, η, $h^\pm$
  well below pQCD expectations for hard cross-sections

Unquenched direct photon production in AuAu

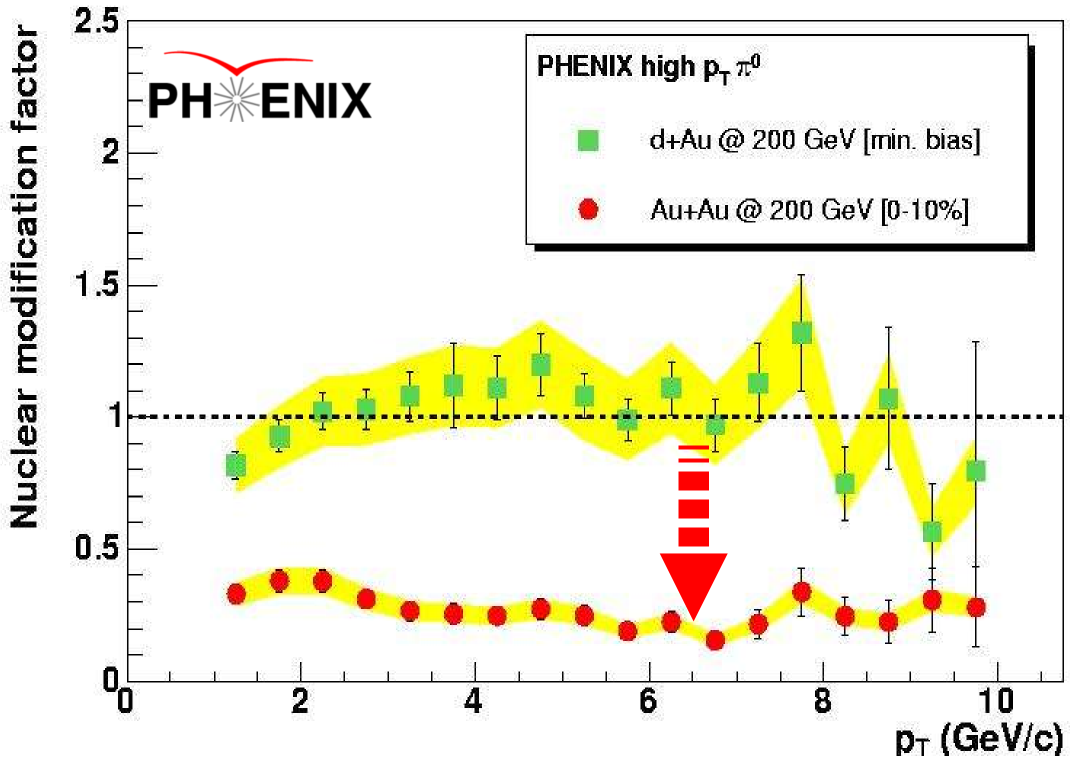


PHENIX.
PRL 94, 232301

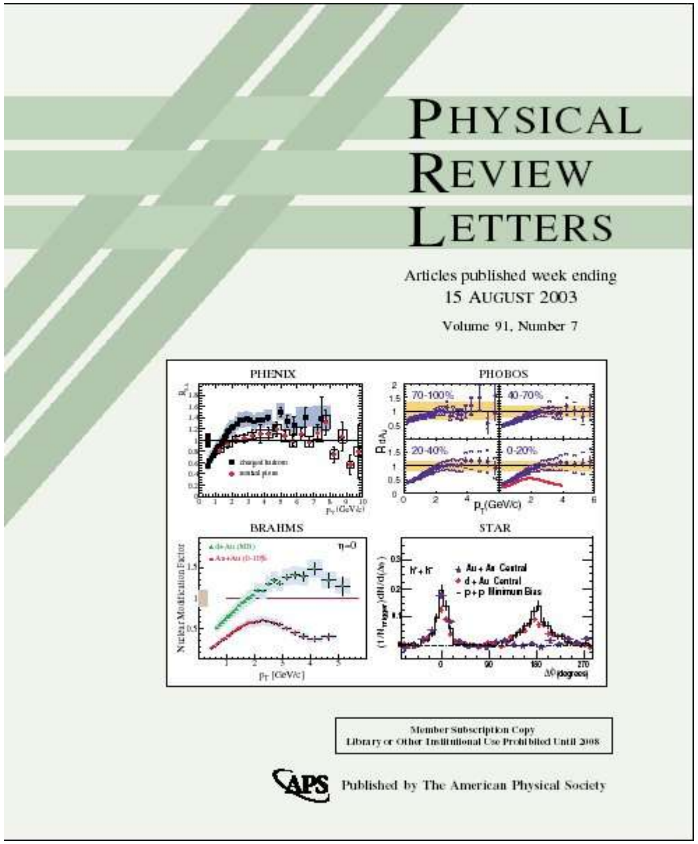
D.d'E, HP'04
EPJ C to appear
(nucl-ex/0504001)

- Color-less hard probes (direct γ) are unsuppressed.
- AuAu collision = incoherent sum of pp collisions (expected “N_{coll} scaling” for perturbative probes).

Unquenched high p_T hadroproduction in dAu



PHENIX.
PRL 91, 072303 (2003)



- Initial-state cold nuclear matter effects (shadowing, Cronin) are small at RHIC mid-rapidity.

- High p_T suppression in central AuAu is due to final-state effects (absent in "control" dAu experiment)

Dense medium properties

- From data vs. model (pQCD+ non-Abelian parton energy loss) comparison:

  - Initial gluon densities:

    $dN^g/dy \sim 1000$ [Vitev & Gyulassy]

  - Opacities:

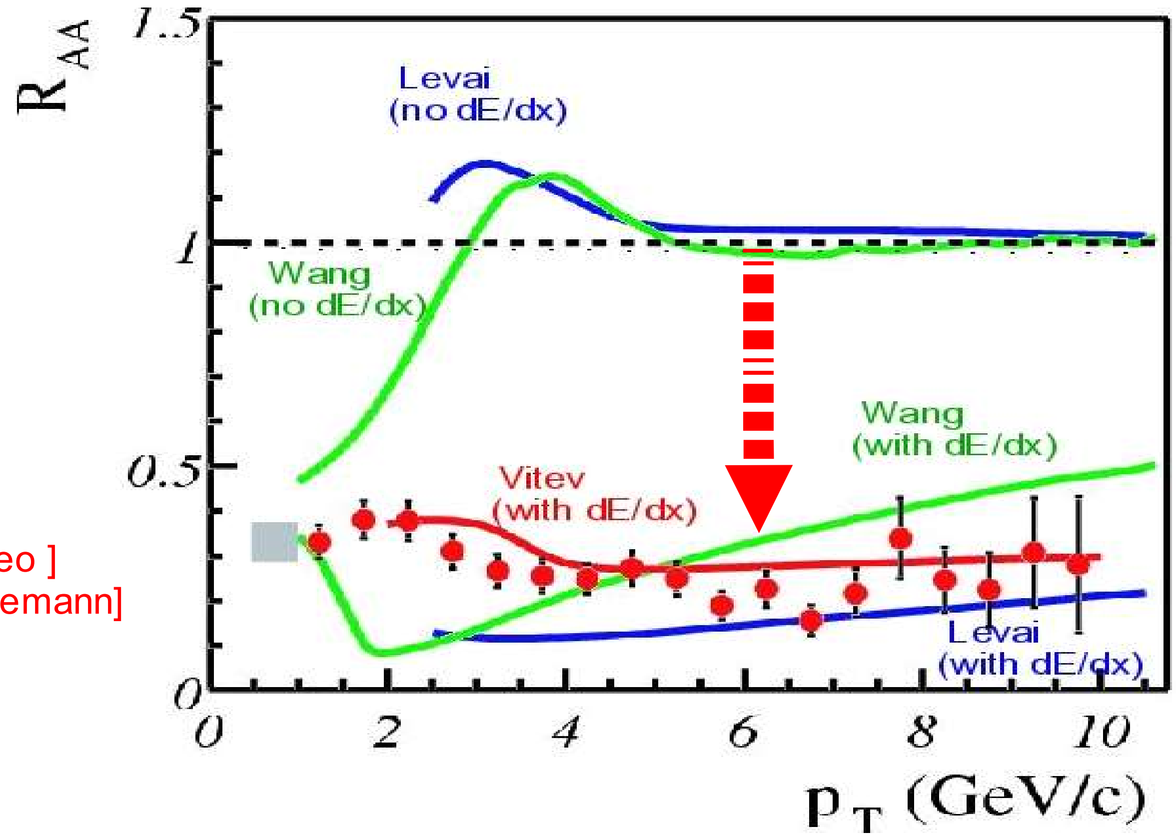
    $\langle n \rangle = L/\lambda \approx 3 - 4$ [Levai et al.]

  - Transport coefficients:

    $\langle q_0 \rangle \sim 14$ GeV/fm^2 [BDMPS, F.Arleo] [Salgado-Wiedemann]

  - Medium-induced radiative energy losses:

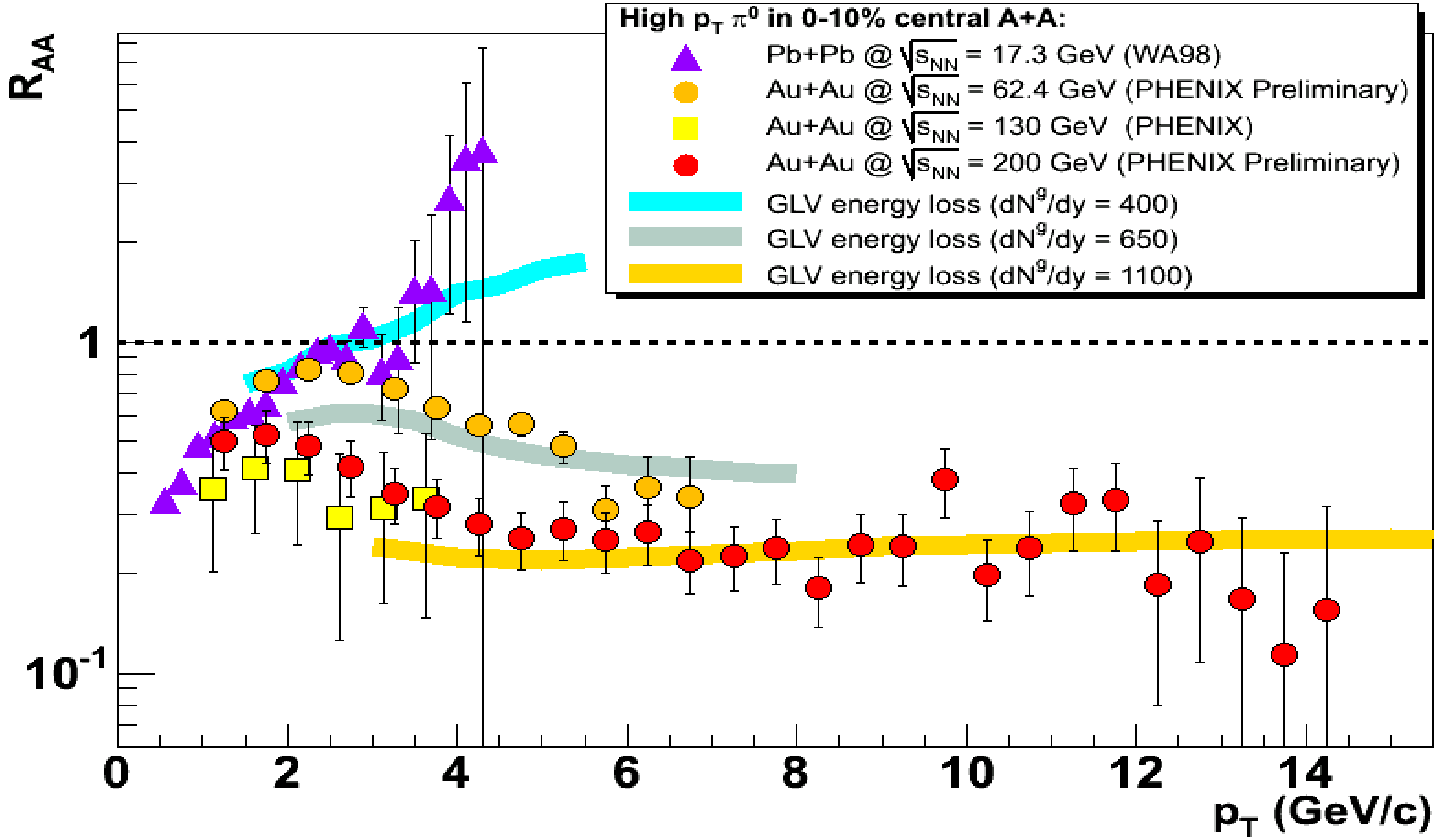
    $dE/dx \approx 0.25$ GeV/fm (expanding)
    $dE/dx|_{eff} \approx 14$ GeV/fm (static source) [X.N.Wang]



- Such large opacities imply fast thermalization.
- All transport & thermodynam. values imply energy densities well above $\varepsilon_{crit\ QCD}$

High p_T suppression: p_T- and sqrt(s)-dependence

- $\sqrt{s}$- and p_T- dependence in agreement with parton energy loss in increasingly dense (expanding) medium:



[Note: R_{AA} @ SPS uses "revised" pp ref.]

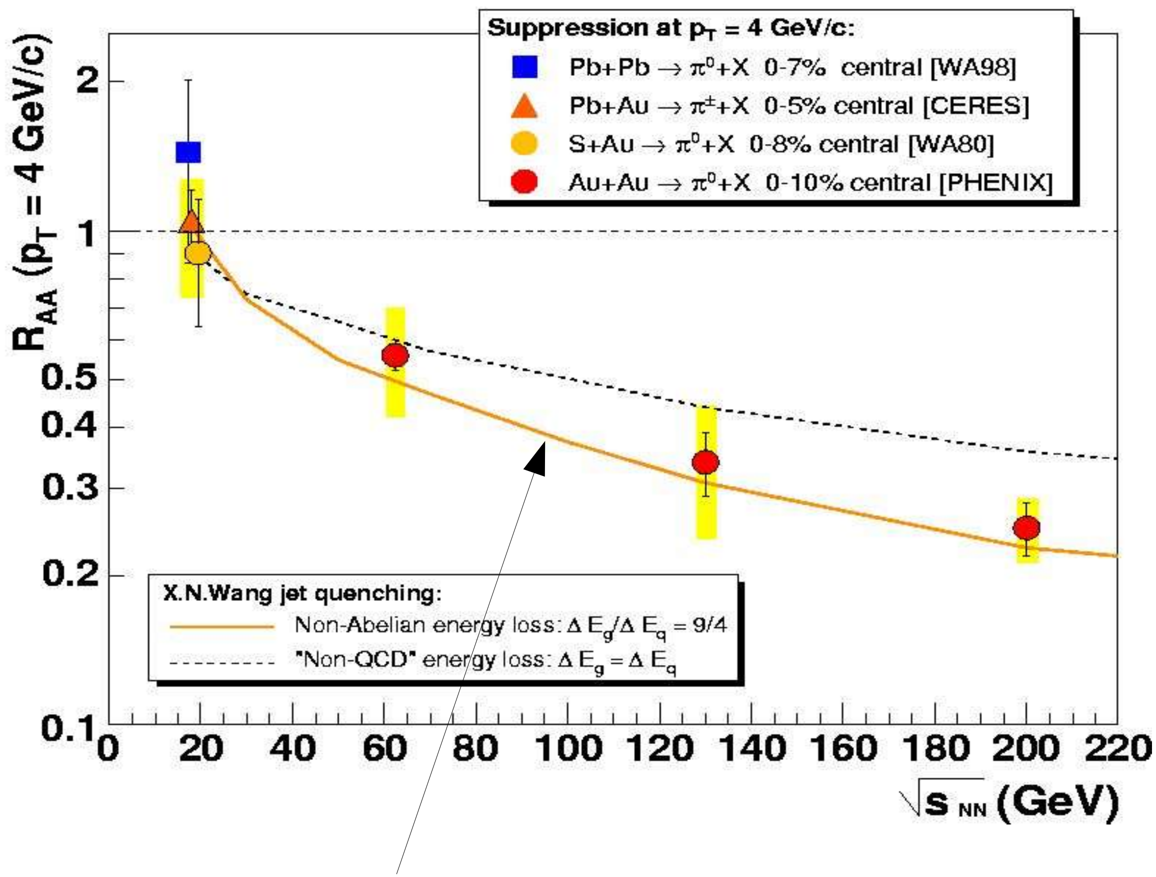
D.d'E., HP'04
EPJ C to appear
nucl-ex/0504001

Initial g density: Medium transport coeff.:

SPS	R_{AA} ~ 1 @ $\sqrt{s}$ ~ 20 GeV	$\Rightarrow$ dN^g/dy ~ 400	,	$\langle q_0 \rangle$ ~ 3.5 GeV/fm^2
RHIC	R_{AA} ~ 0.3 @ $\sqrt{s}$ = 62 GeV	$\Rightarrow$ dN^g/dy ~ 650	,	$\langle q_0 \rangle$ ~ 7 GeV/fm^2
RHIC	R_{AA} ~ 0.2 @ $\sqrt{s}$ = 200 GeV	$\Rightarrow$ dN^g/dy ~ 1100	,	$\langle q_0 \rangle$ ~ 14 GeV/fm^2

High p_T suppression: Excitation function

- $\sqrt{s}$-dependence (and non-Abelian nature of energy loss) in agreement w/ parton energy loss calculations:
  (i) rising initial parton density with $\sqrt{s}$
  (ii) increasing relative fraction of hard-scattered gluons (for fixed p_T) w/ $\sqrt{s}$



"Jet quenching" model + 2-D longitudinal plasma expansion

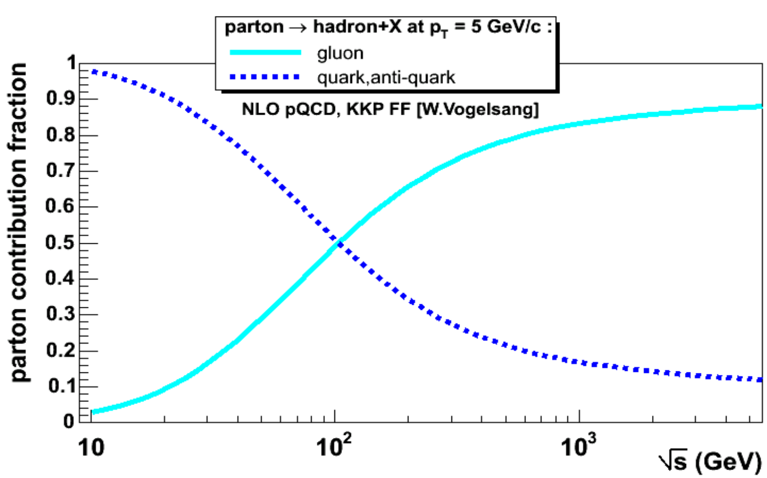
QCD radiation probability:

Gluon: $C_A = N_c = 3$

Quark: $C_F = (N_c^2-1)/N_c = 4/3$

$\} \; C_A/C_F = 2.25$

Relative fraction of q,g at p_T = 5 GeV/c:

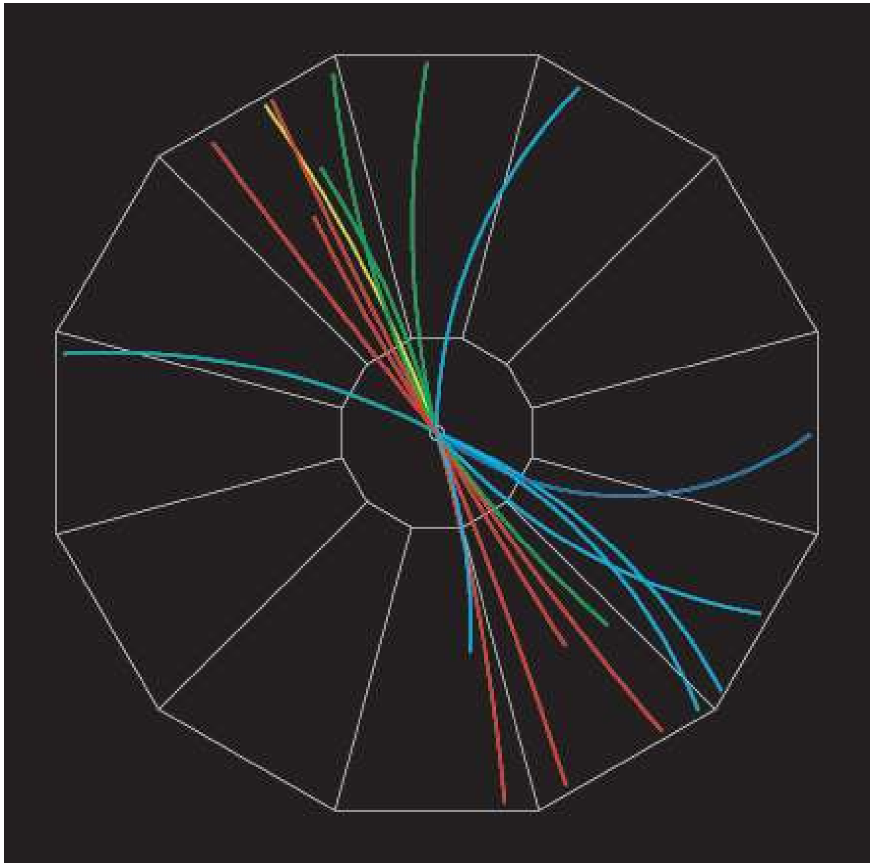


D.d'E., HP'04
nucl-ex/0504001

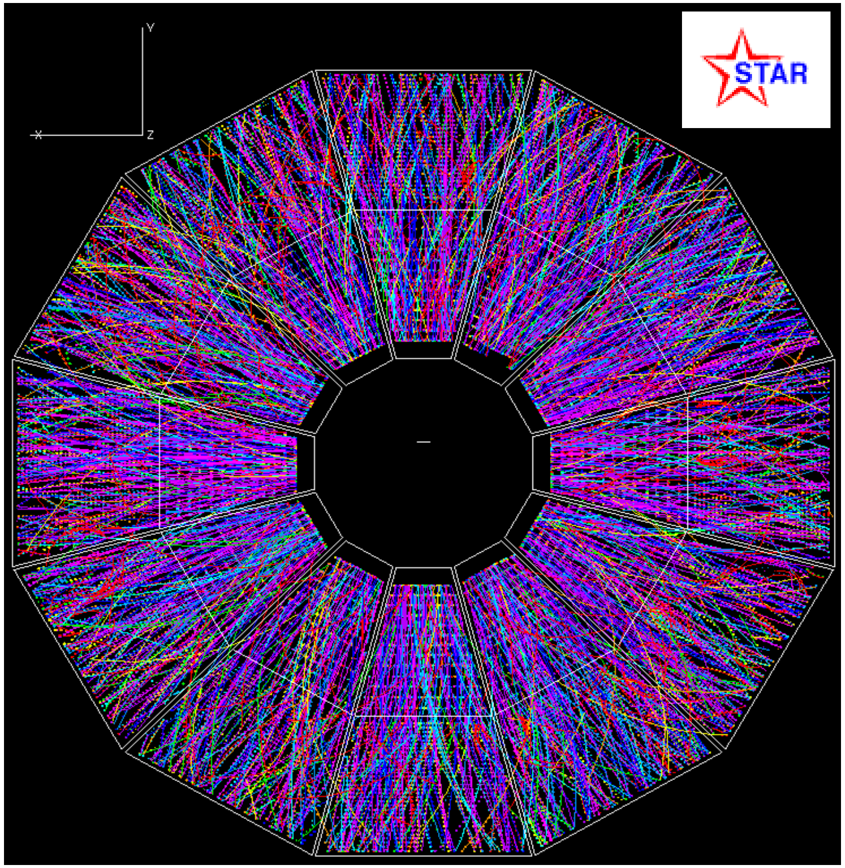
(2) High p_T di-hadron ϕ,η correlations in high-energy pp, dAu and AuAu collisions

Jets in AA collisions at RHIC

- Full jet reconstruction w/ standard algorithms is unpractical at RHIC due to huge soft background (large "underlying event"):



p+p → jet+jet [$\sqrt{s}$ = 200 GeV]
STAR @ RHIC (2003)

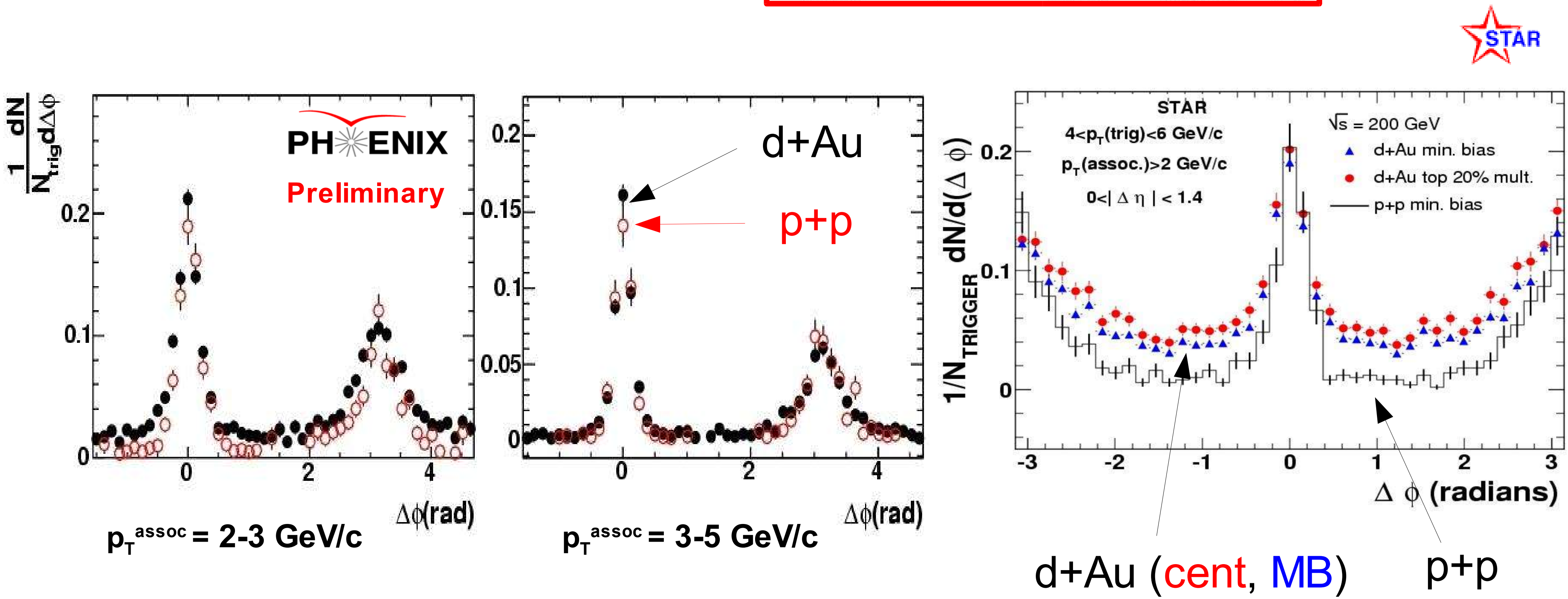


Au+Au → X [$\sqrt{s_{NN}}$ = 200 GeV]
STAR @ RHIC (2003)

Jets via high p_T di-hadron ϕ correlations: pp, dAu

- Two-particle correlations: $h^{\pm} - h^{\pm}$, $\pi^{0,\pm} - h^{\pm}$. Trigger: highest p_T (leading) hadron.
- Associated $\Delta\phi$ distribution (e.g. "assorted": 2 GeV/c < $p_T^{assoc} < p_T^{trigger}$)
- Normalized to number of triggers:

$$\frac{1}{N_{trig}}\frac{dN}{d\Delta\phi} = \frac{1}{N_{trig}}\frac{N_{cor}(\Delta\phi)}{N_{mix}(\Delta\phi)}$$

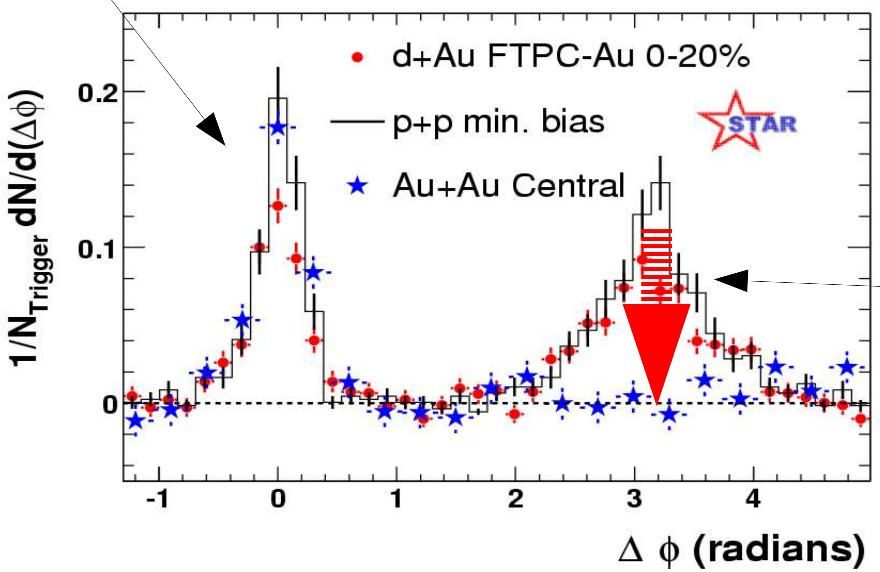


- Clear near- ($\Delta\phi \sim 0$) and away- ($\Delta\phi \sim \pi$) side jet signals

Di-hadron AuAu: $\Delta\phi$ correlations (I)

- Near-side: Jet-like Gaussian. Unmodified (AuAu ~ dAu ~ pp)

High p_T :

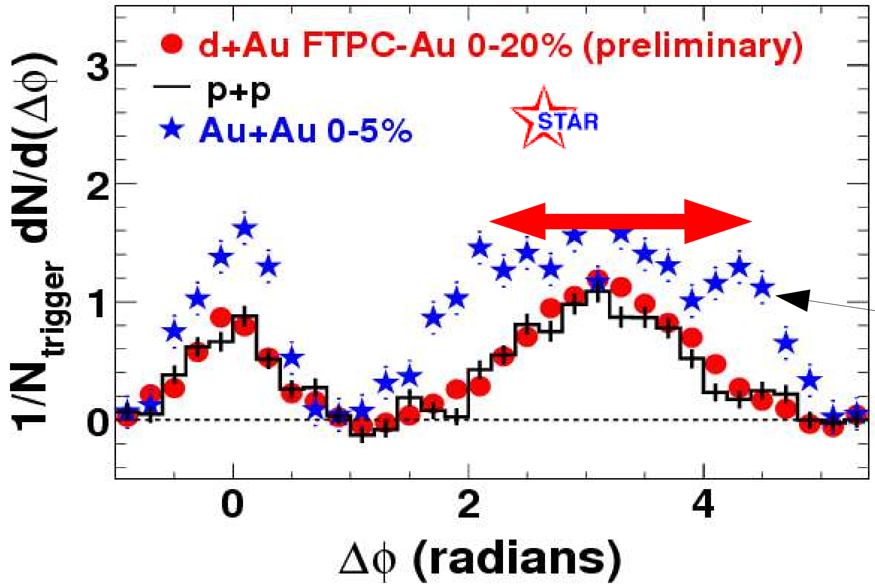


$p_{T\,trigg}$ = 4 – 6 GeV/c
$p_{T\,assoc}$ > 2 GeV/c

STAR, PRL 90, 082302 (2003)

- Away-side:
  peak disappearance.
  "monojet"-like topologies in central AuAu.

Lower p_T :



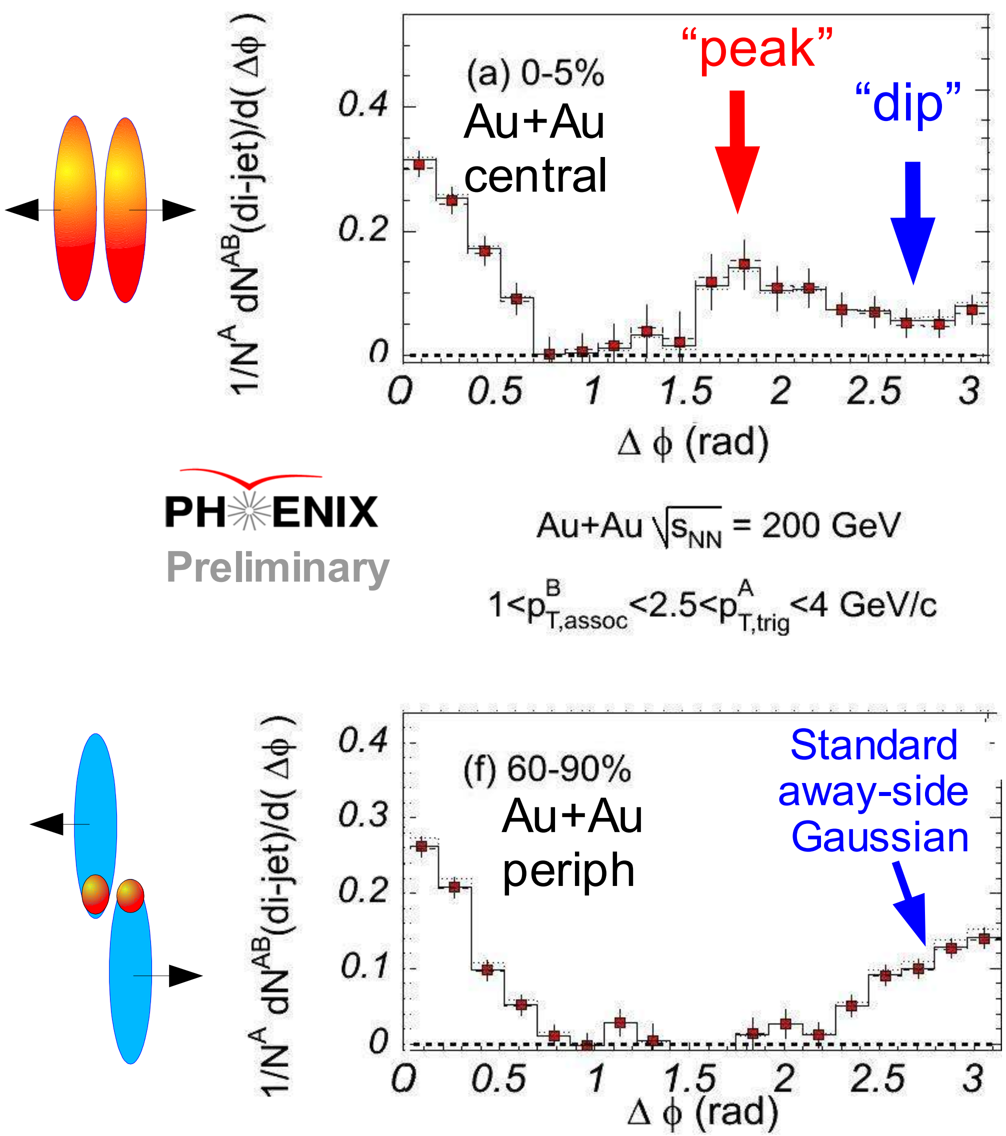
$p_{T\,trigg}$ = 4 – 6 GeV/c
$p_{T\,assoc}$ = 0.15 – 4 GeV/c

STAR, submitted to PRL
nucl-ex/0501016

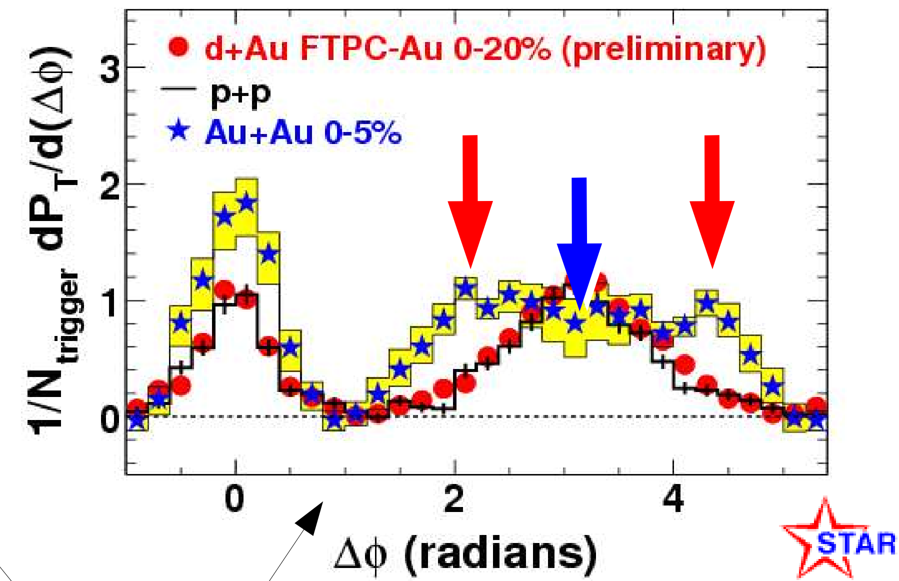
- Away-side:
  Broadened distribution of associated low p_T hadrons.

Di-hadron AuAu: Δφ correlations (II)

- Strongly modified away-side Δφ correlations in central AuAu:



PHENIX Collab. PRL to be submitted

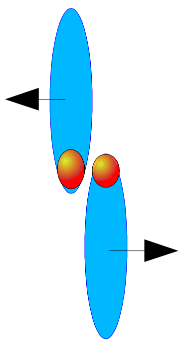


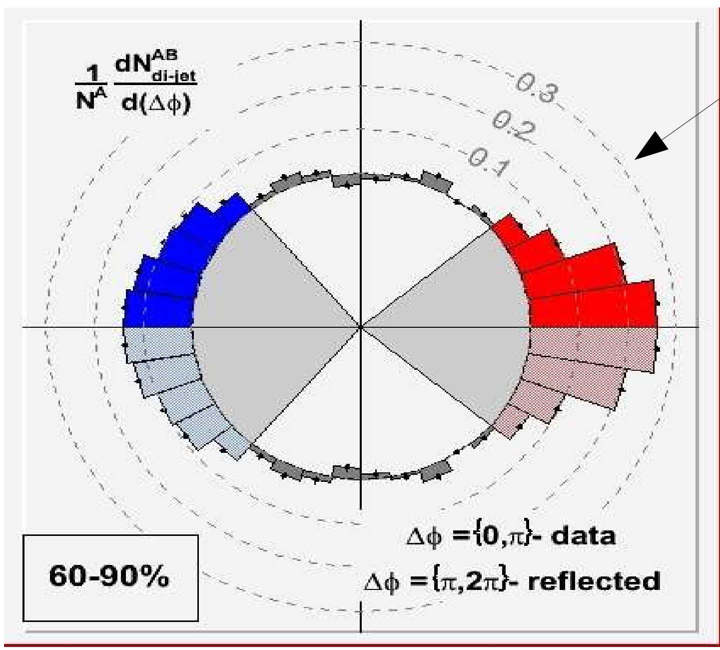
- Away-side (π) "dip" and excess of energy ("double peak") at π ±1

Di-hadron AuAu: Δφ correlations (III)

- Same $dN_{pair}/d\Delta\phi$ result in polar coords. now:

Au+Au peripheral

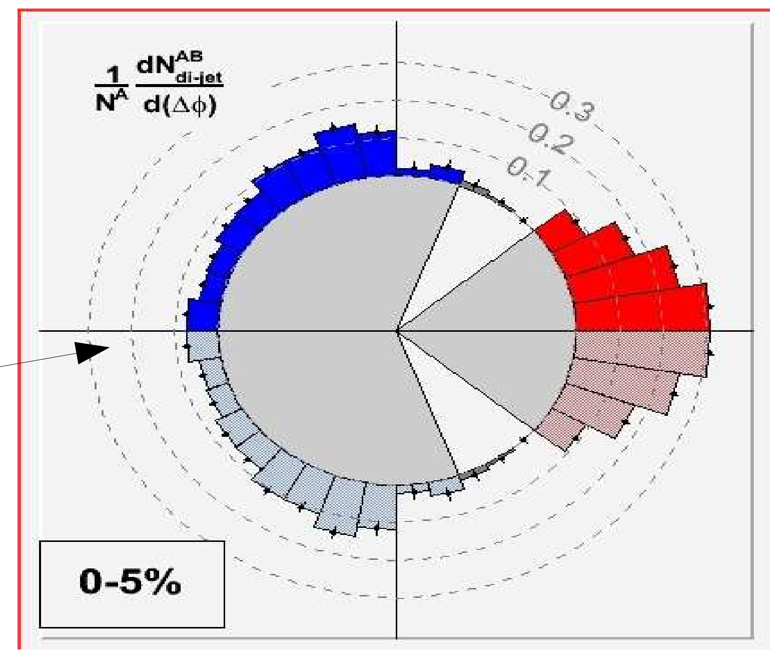


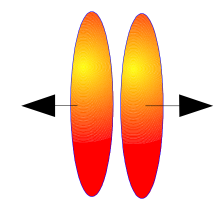


- Standard back-to-back di-jet topology.

PHENIX Preliminary

Au+Au central





- Strongly non-Gaussian away-side "peak".

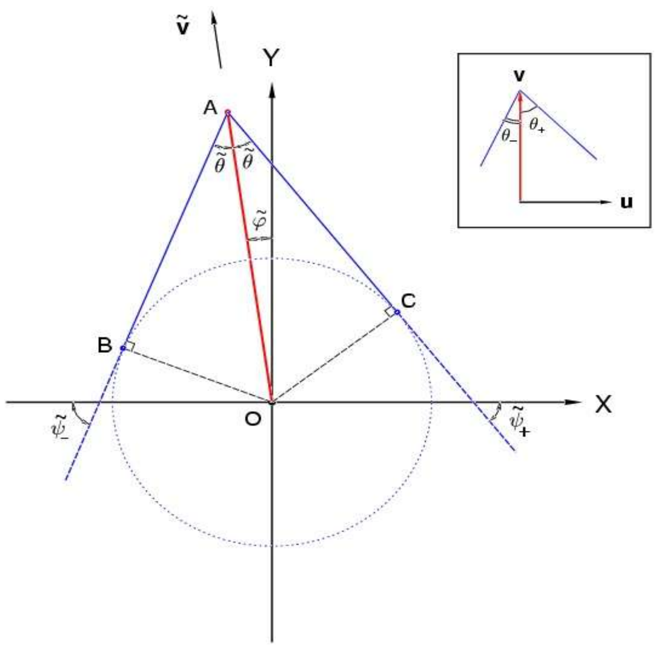
PHENIX

PHENIX Collab. PRL to be submitted

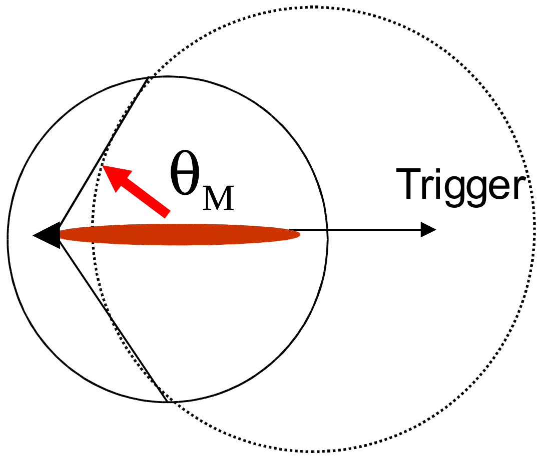
"Double peak" = Mach wave cone ?

- Double peak structure at at $\pi \pm 1$ rad reminiscent of ...
  Mach wave conical shock ("sonic boom") $\Rightarrow$ speed of sound accessible

Stoecker, Satarov, Mishutin, hep-ph/0505245.
Casalderrey, Shuryak, Teaney, hep-ph/0411315.



Mach cone: $\cos\theta_M = c_s$



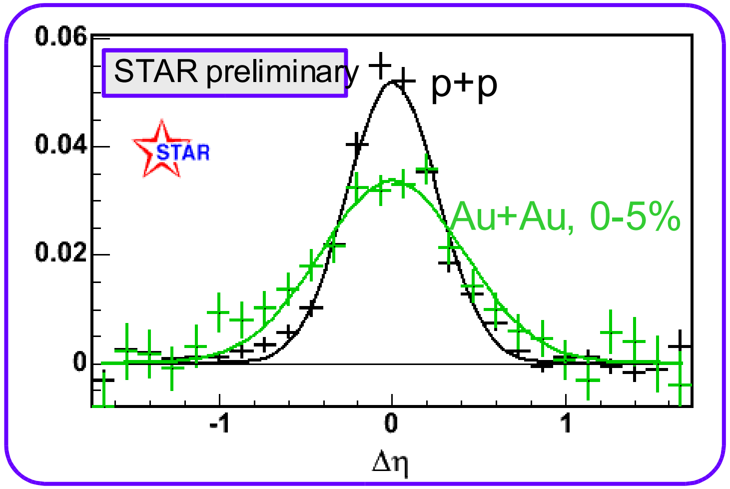
$c^2_s \neq$ constant:
QGP ($1/\sqrt{3}$) $\rightarrow$ phase transition (0.) $\rightarrow$ HRG ($\sqrt{0.2}$) :

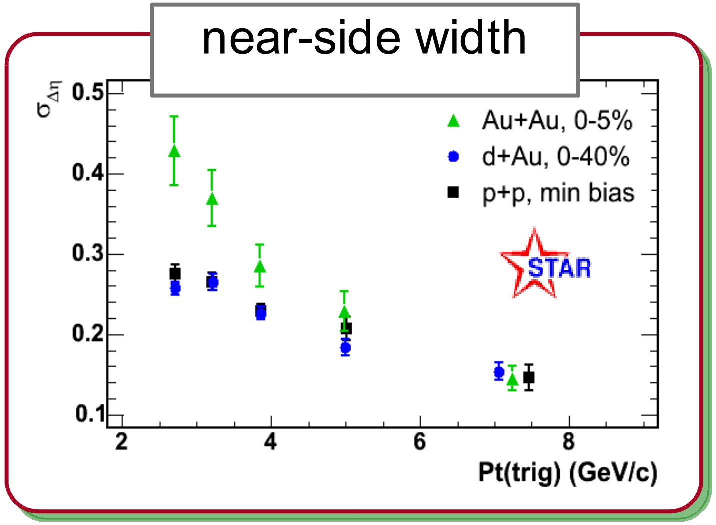
$$c_s^{av} = \frac{1}{\tau_f} \int d\tau c_s(\tau) = 0.33$$

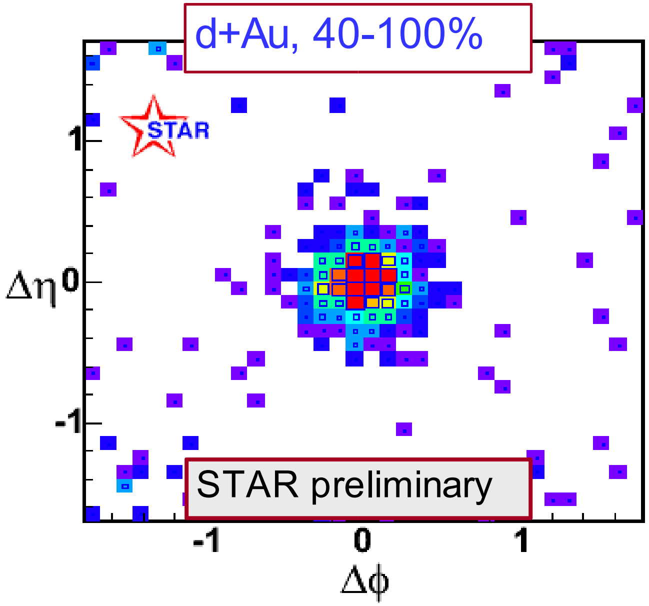
θ = arccos(c^{av}_s) = 1.2 rad = 71º (θ_{exp} ~ 1. rad ~ 57º)

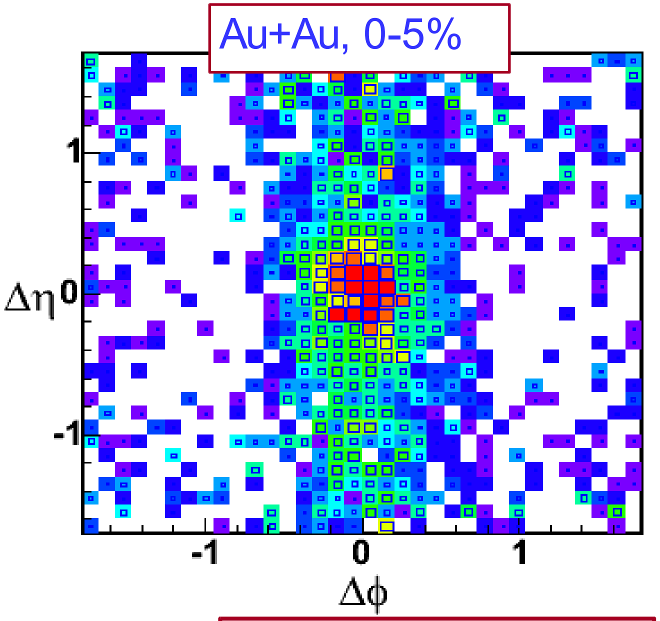
Di-hadron AuAu: $\Delta\eta$ correlations

- Significant broadening of pseudo-rapidity correlations in AuAu compared to pp, dAu. ("stretching" of jet cone along η).







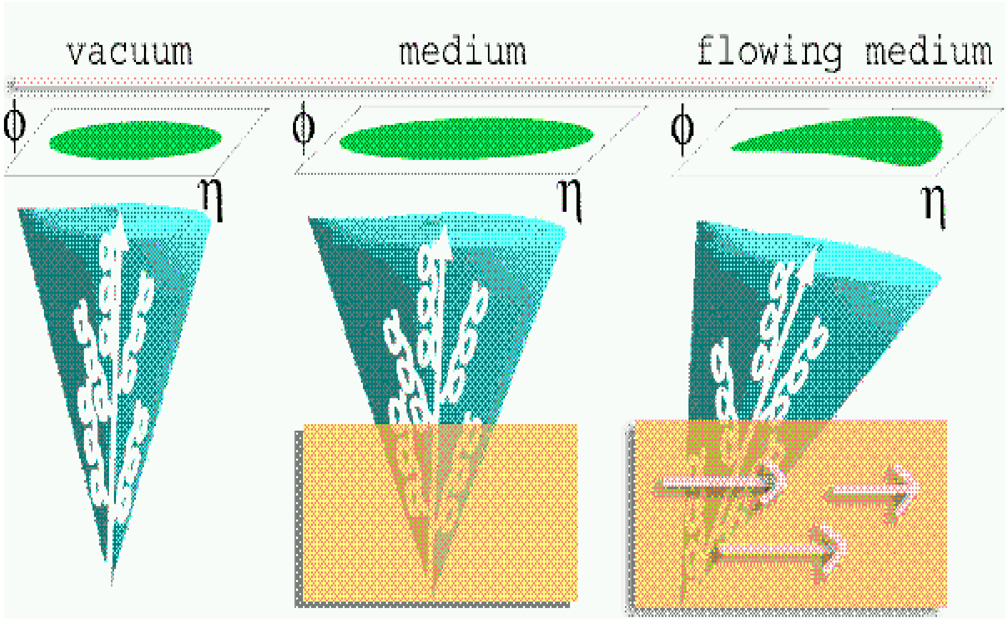


[D. Magestro, HP'04]

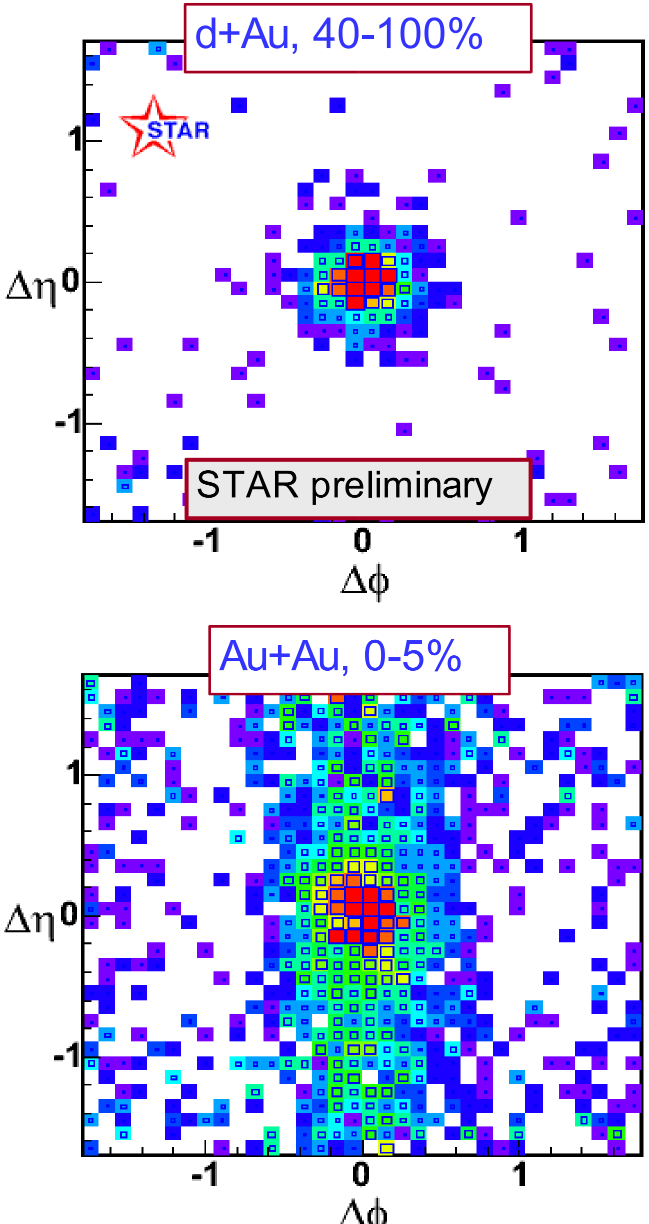
3 < p_T(trig) < 6 GeV
2 < p_T(assoc) < p_T(trig)

Di-hadron AuAu: $\Delta\eta$ correlations

- Significant broadening of pseudo-rapidity correlations in AuAu compared to pp,dAu. ("stretching" of jet cone along η).
- Coupling of *g* radiation w/ longitudinal expanding medium ?



Armesto, Salgado, Wiedemann
PRL 93, 242301 (2004)

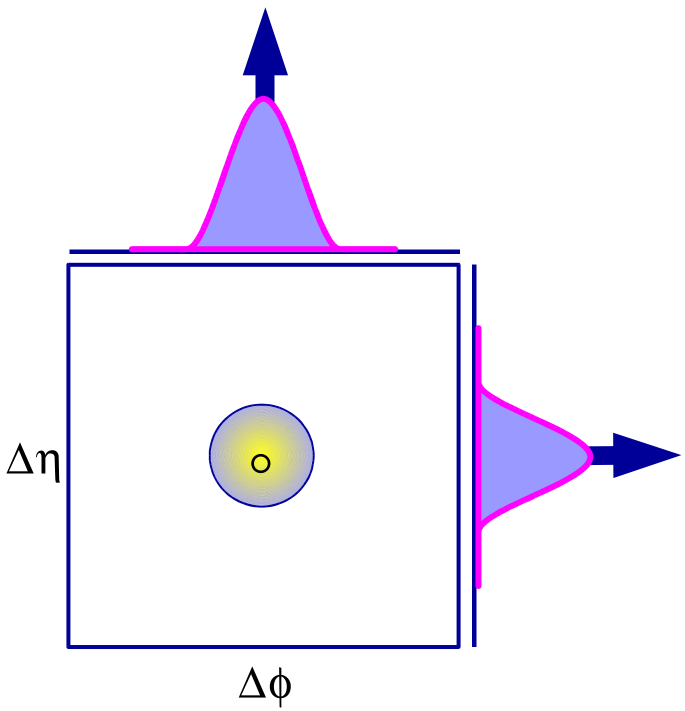


3 < p_T(trig) < 6 GeV
2 < p_T(assoc) < p_T(trig)

"Cartoon" Summary: Jet-quenching at RHIC

"QCD vacuum" & "cold QCD medium"

- Jet profile in pp (dAu) collisions:

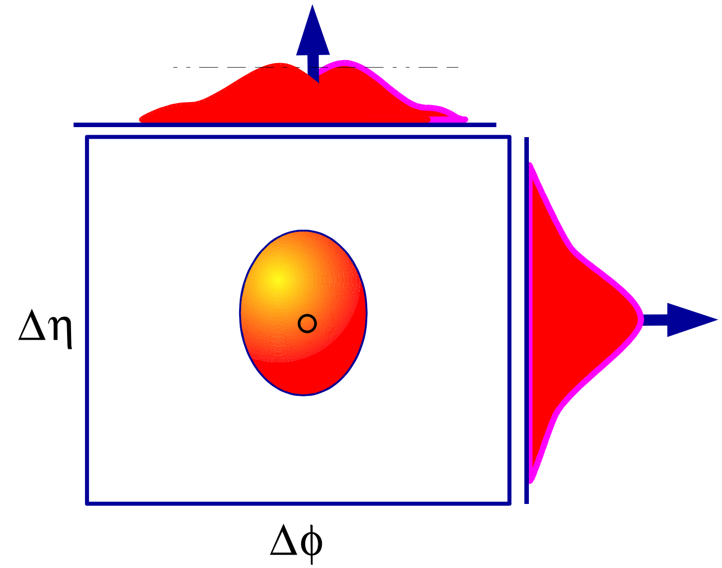


Near-side width: $\langle j_T \rangle$ ~ 600 MeV/c
unmodified in pp,dAu

Away-side width and acoplanarity
unmodified in pp and dAu

"hot & dense QCD Medium"

- Jet profile in AuAu central collisions:



Factor ~5 suppression of leading hadron
(very large initial parton densities: dN^g/dy~1000)

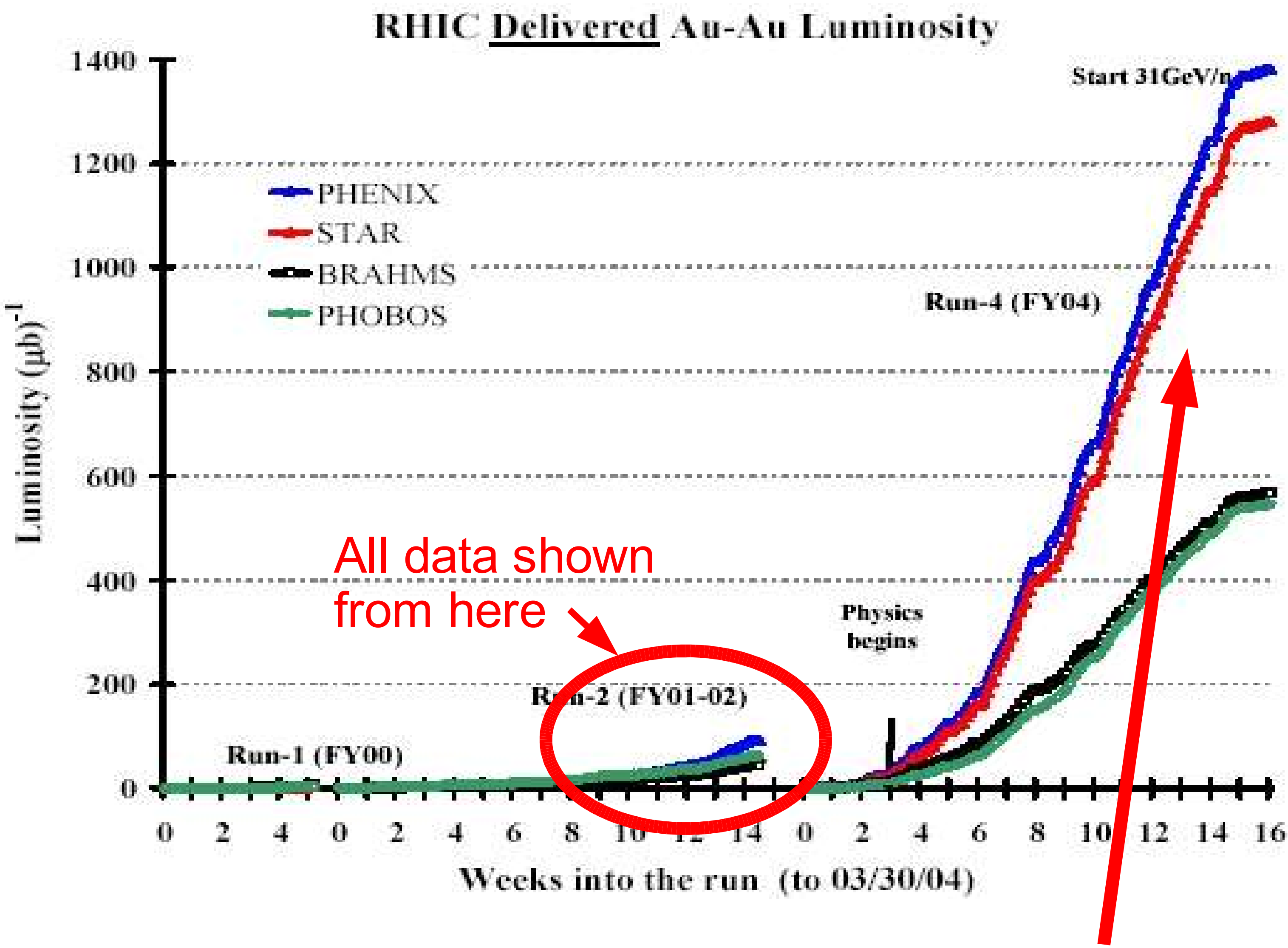
Disappearance of back-to-back peak ("monojets")

"Double peak" structure at lower p_T in away-side
("sonic boom" in medium ?)

Dijet broadening in η
(coupling of g radiation w/ expanding medium ?)

Strong QCD medium effects at work !

Outlook

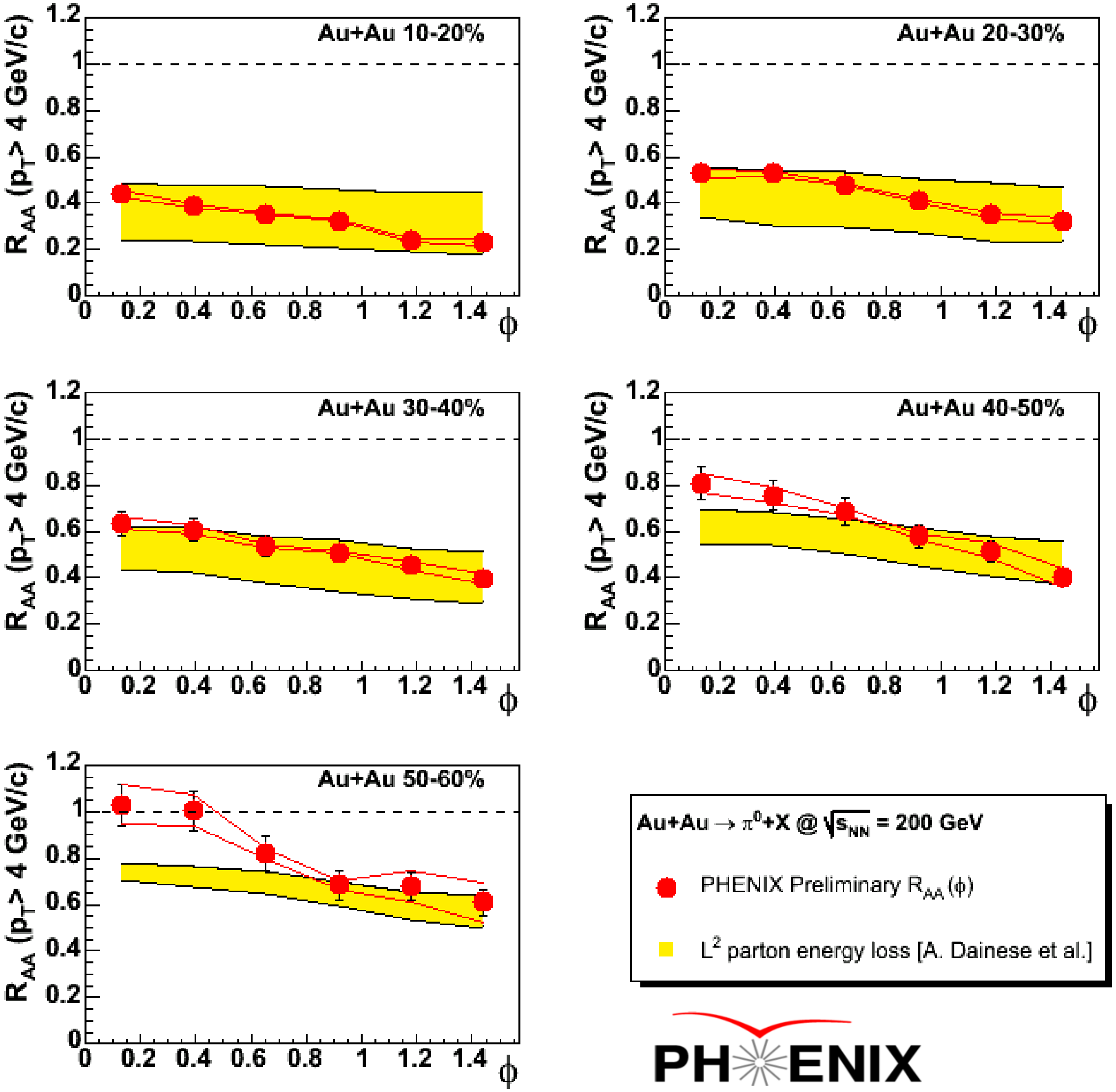


- 15 times more data available (ongoing DST production) !
- .. and exciting jet-physics expected ahead at LHC: γ-, Z-, jet-jet corrs., ...

backup slides ...

High p_T suppression: Reaction-plane dependence

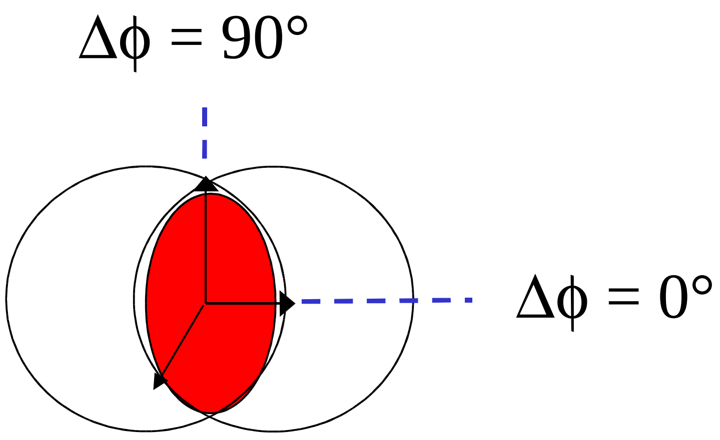
- $R_{AA}(\varphi)$ versus parton energy loss model:



PHENIX PRELIMINARY

[B. Cole, S. Mioduszewski HP'04]

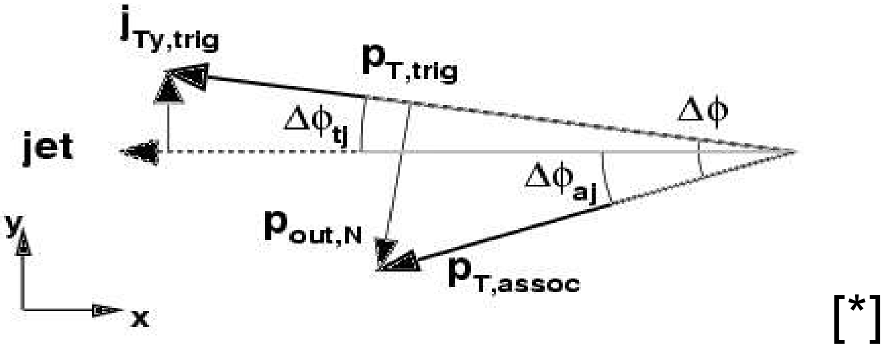
[D.d'E., HP'04, nucl-ex/0504001]



- 2 times more suppression out-of-plane ("long" direction) than in-plane ("short" direction).
- Glauber parton energy loss model predicts only ~50% increased "out-of-plane" vs "in-plane" π^0 emission
- Azimuthal anisotropy not reproduced by "canonical" L^2 (or L) path-length dependence.

Jet properties from dihadron correlations

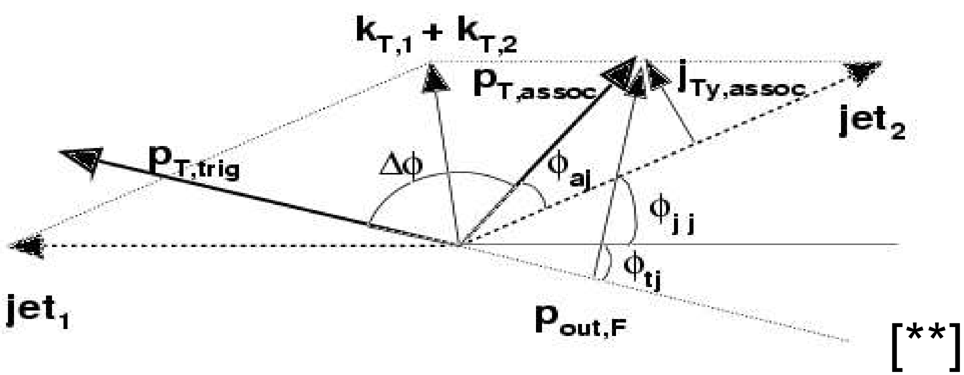
- Jet “width” j_T :



$$(j_{T_y})_{RMS} \simeq \frac{\sigma_N \langle p_{T,asso}\rangle}{\sqrt{1+\langle x_h^2\rangle}} \simeq \sigma_N \frac{\langle p_{T,trig}\rangle \langle p_{T,asso}\rangle}{\sqrt{\langle p_{T,trig}\rangle^2 + \langle p_{T,asso}\rangle^2}}$$

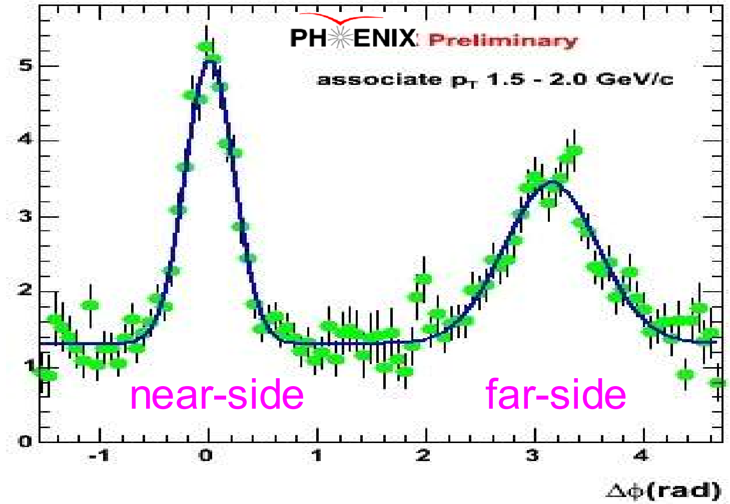
where $x_h = p_{T,asso}/p_{T,trig}$

- Di-jet acoplanarity k_T:



$$(k_{T_y} z_{trig})_{RMS} = \frac{1}{\sqrt{2\langle x_h^2\rangle}} \sqrt{\langle p_{T,assoc}\rangle^2 \sin^2\sigma_F - (1+\langle x_h^2\rangle)\,(j_{T_y})^2_{RMS}}$$

(1) 2-hadron correlation function:



(2) Fit to 2-gaussians:

$$\frac{1}{N_{trig}}\frac{dN}{d\Delta\phi} = B + \frac{Yield_N}{\sqrt{2\pi}\sigma_N} e^{\frac{-\Delta\phi^2}{2\sigma_N^2}} + \frac{Yield_F}{\sqrt{2\pi}\sigma_F} e^{\frac{-(\Delta\phi-\pi)^2}{2\sigma_F^2}}$$

$\Longrightarrow$ near-side σ_N, far-side σ_F widths

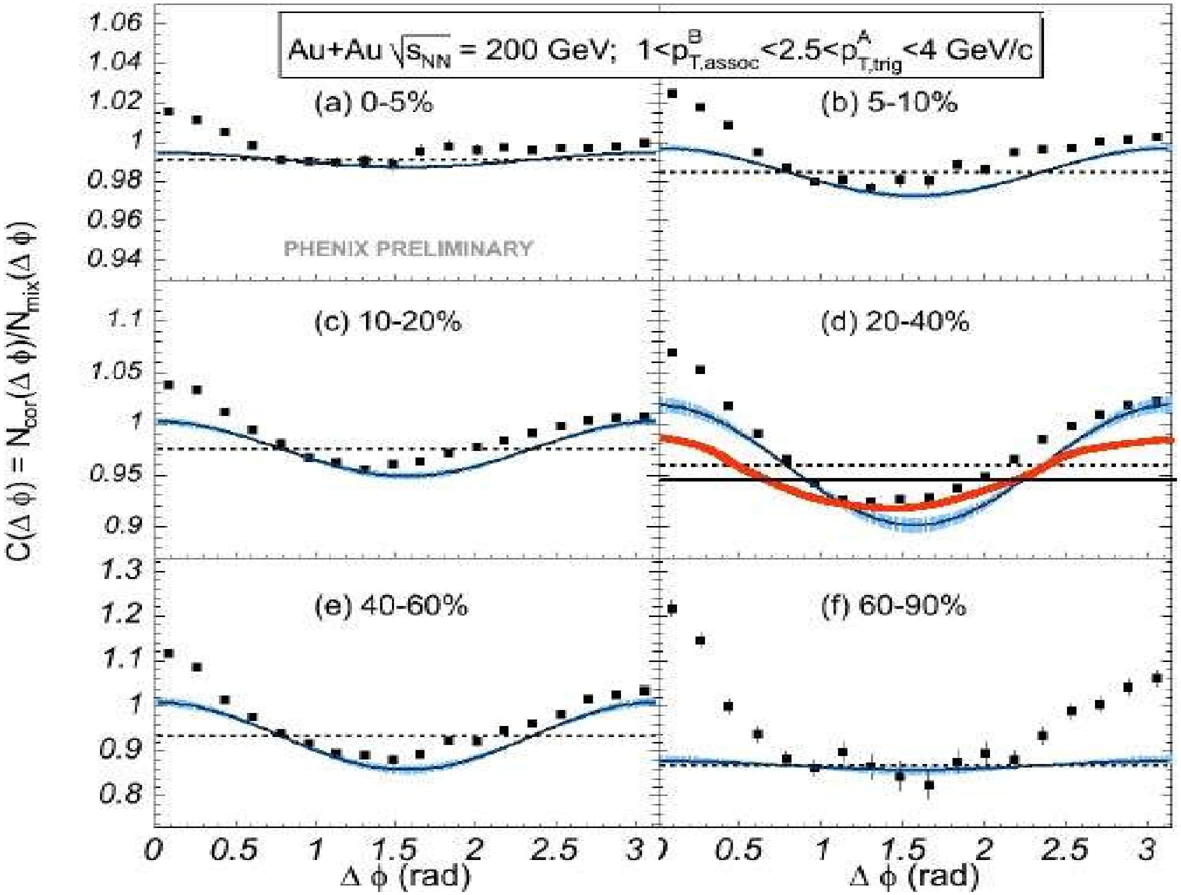
(3) Extraction of j_T, k_T from σ_N, σ_F via [*], [**] (and dN/dx_E from $Yield_{N,F}$)

[details in J.Jia, nucl-ex/0409024]

Jets via high p_T di-hadron ϕ correlations: AuAu

- Same $dN_{pair}/d\varphi$ analysis as in pp (dAu) but 2 extra "complications":
  - (1) Increased "underlying event" background
  - (2) Collective elliptic flow (harmonic) contribution

$$\overbrace{C(\Delta\phi)}^{\text{Correlation Function}} = a_0 \left[\overbrace{H(\Delta\phi)}^{\text{Harmonic}} + \overbrace{J(\Delta\phi)}^{\text{Jet Function}} \right]$$



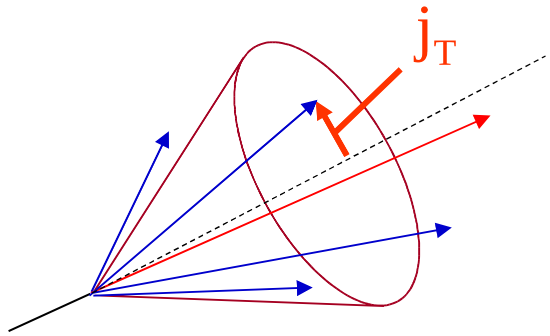
PHENIX

Ajitanand, ICPAQGP'04 and nucl-ex/0501025

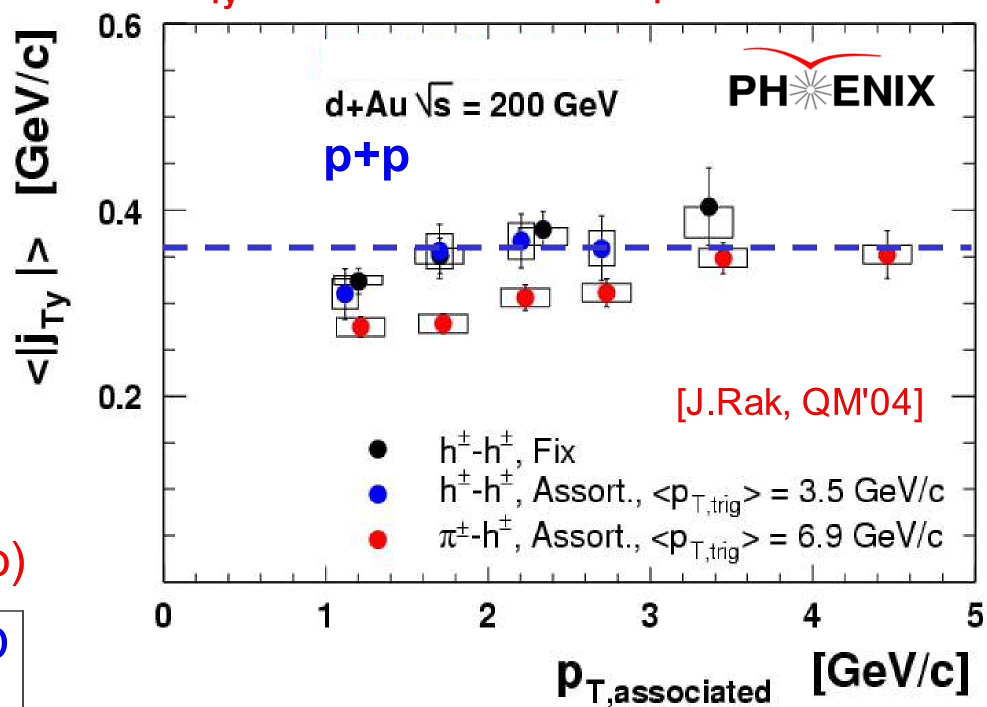
- Delicate subtraction procedure (esp. in finite acceptances).

Mean transverse momentum of jet hadrons (j_T): pp, dAu

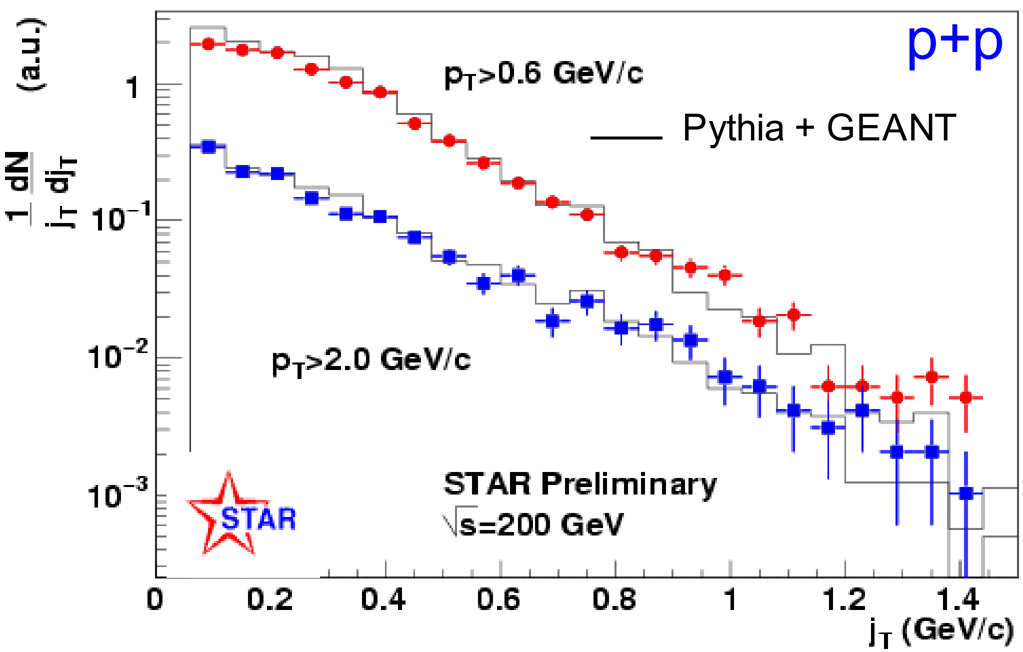
- Jet (near-angle) "width" j_T :



$< j_{Ty}>$ ~350 MeV/c ≡ $< j_T>$ ~ 500 MeV/c



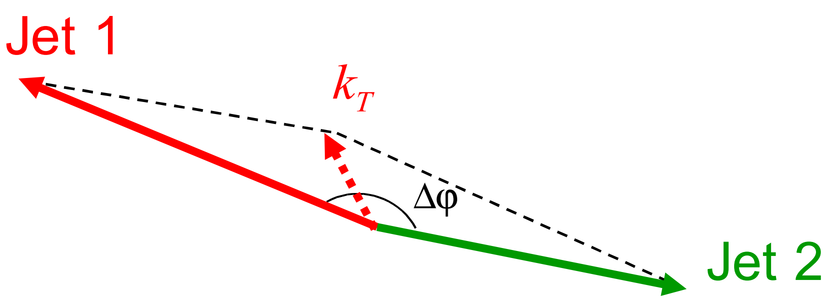
$< j_T>$ ~ 500 MeV/c (from full jet reco)



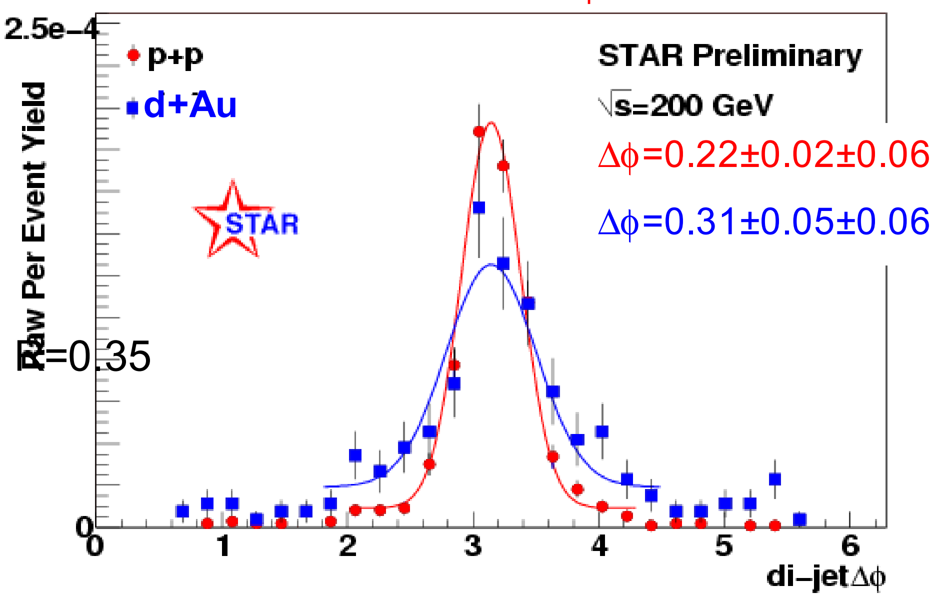
- $< j_T>$ ~ 500 MeV/c: Agreement between RHIC and ISR data.
- No apparent difference between dAu and pp.
- Fragmentation not affected by cold QCD medium.

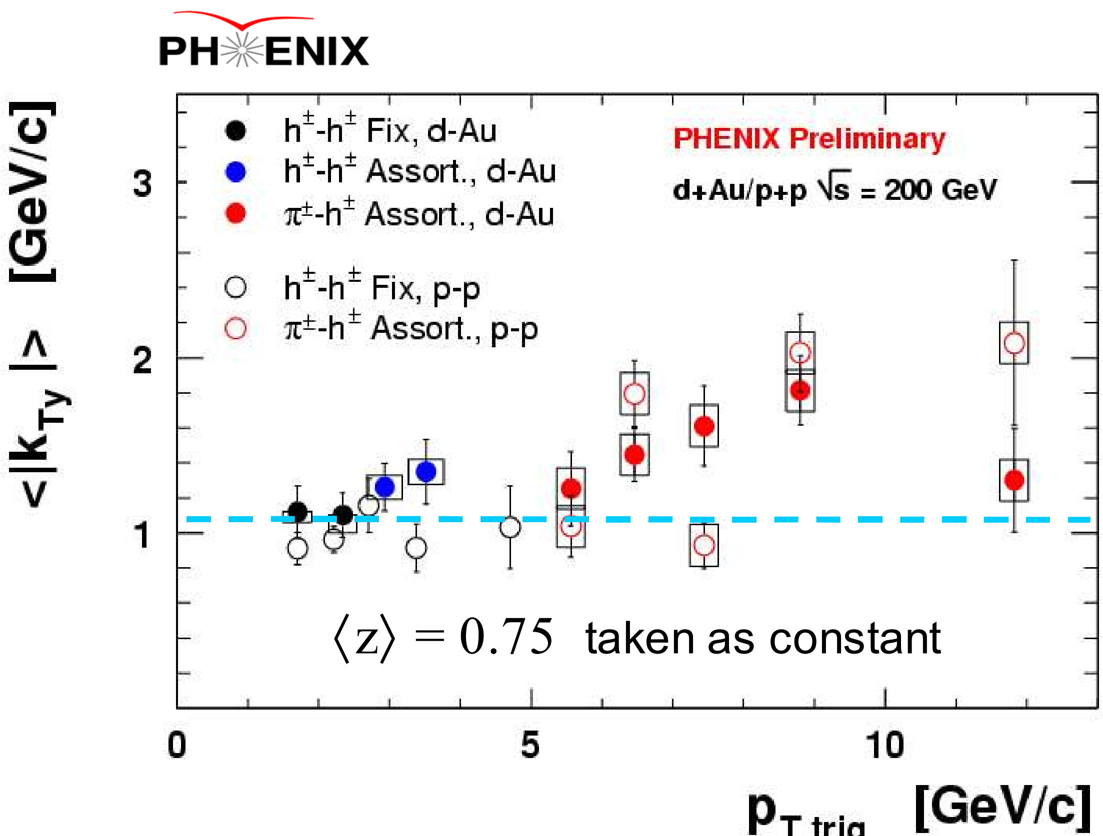
Di-jet acoplanarity (“intrinsic” k_T) : pp, dAu

- Intrinsic k_T (di-jet acoplanarity):



(from full jet reco: E_T~13 GeV)



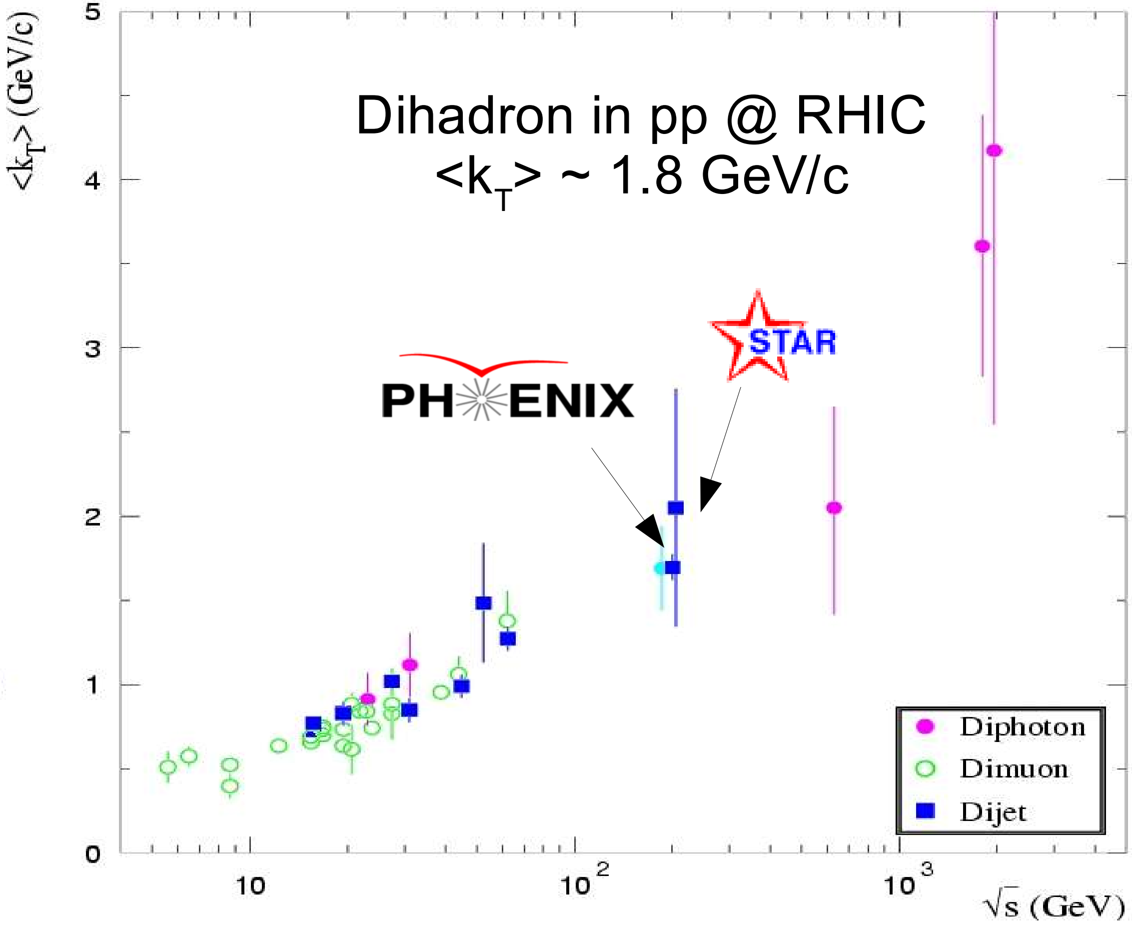


$\langle z \rangle = 0.75$ taken as constant

- Non-negligible **k_T broadening in pp: $\langle k_{Ty} \rangle \sim 1.1$ GeV/c**
- In dAu: $\langle k_T^2 \rangle_{dAu} \equiv \langle k_T^2 \rangle_{pp} + \langle k_T^2 \rangle_{nuclear}$
- Non-null (but small) **$\langle k_T \rangle_{nuclear}$** (constraints models of multiple scattering in cold nuclear medium)

Excitation function of pp di-jet acoplanarity ("intrinsic" k_T)

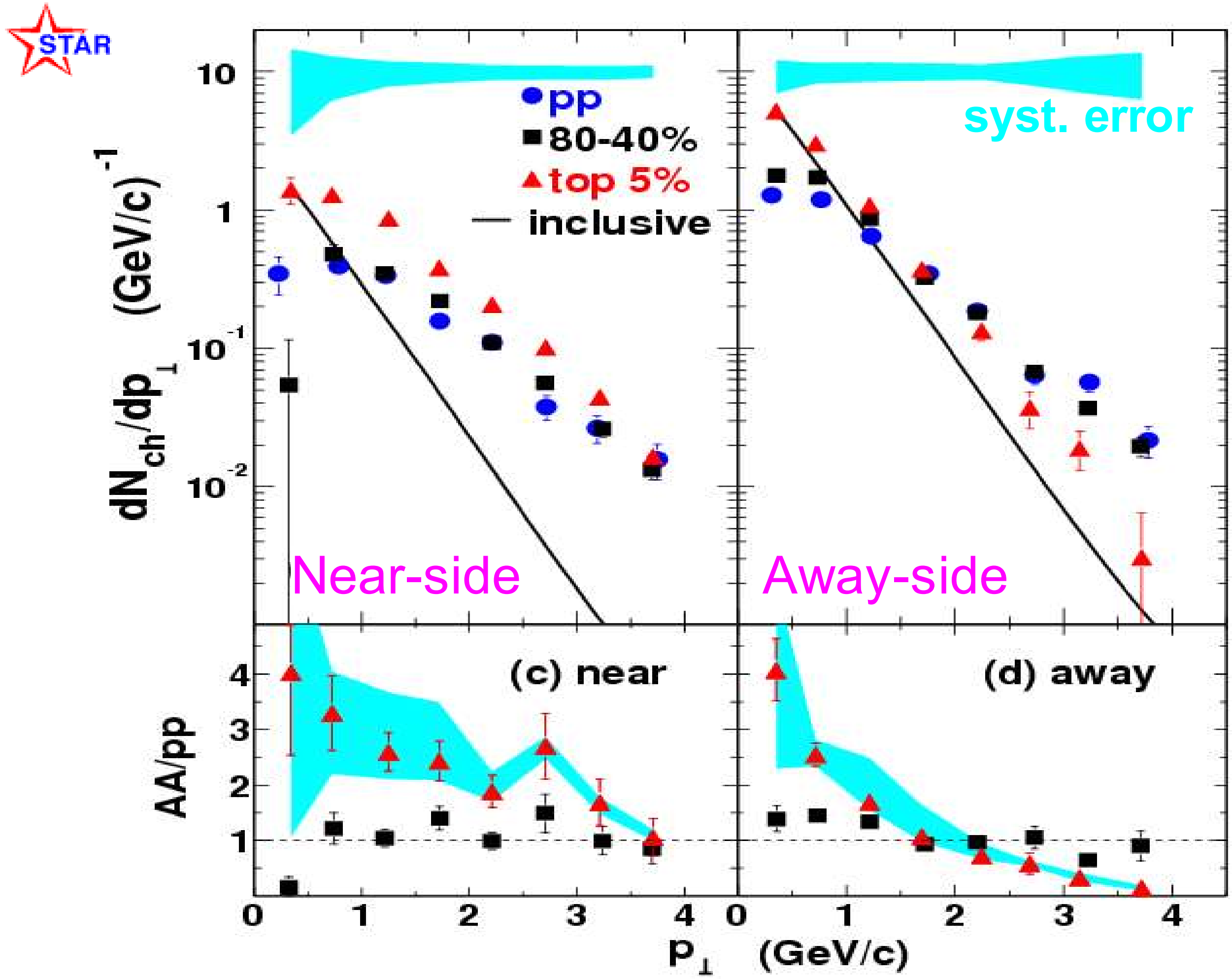
- sqrt(s)-dependence of $\langle k_T \rangle_{pair}$:



- (Logarithmic) increase with sqrt(s) consistent with growing gluon radiation contribution (not just intrinsic parton Fermi motion).

"Fragmentation functions": Central AuAu

- Associated ($p_{T\,assoc}$ = 0.15 – 4 GeV/c) near- and away- side hadron p_T spectra:



$p_{T\,trigg}$ = 4 – 6 GeV/c
$p_{T\,assoc}$ = 0.15 – 4 GeV/c

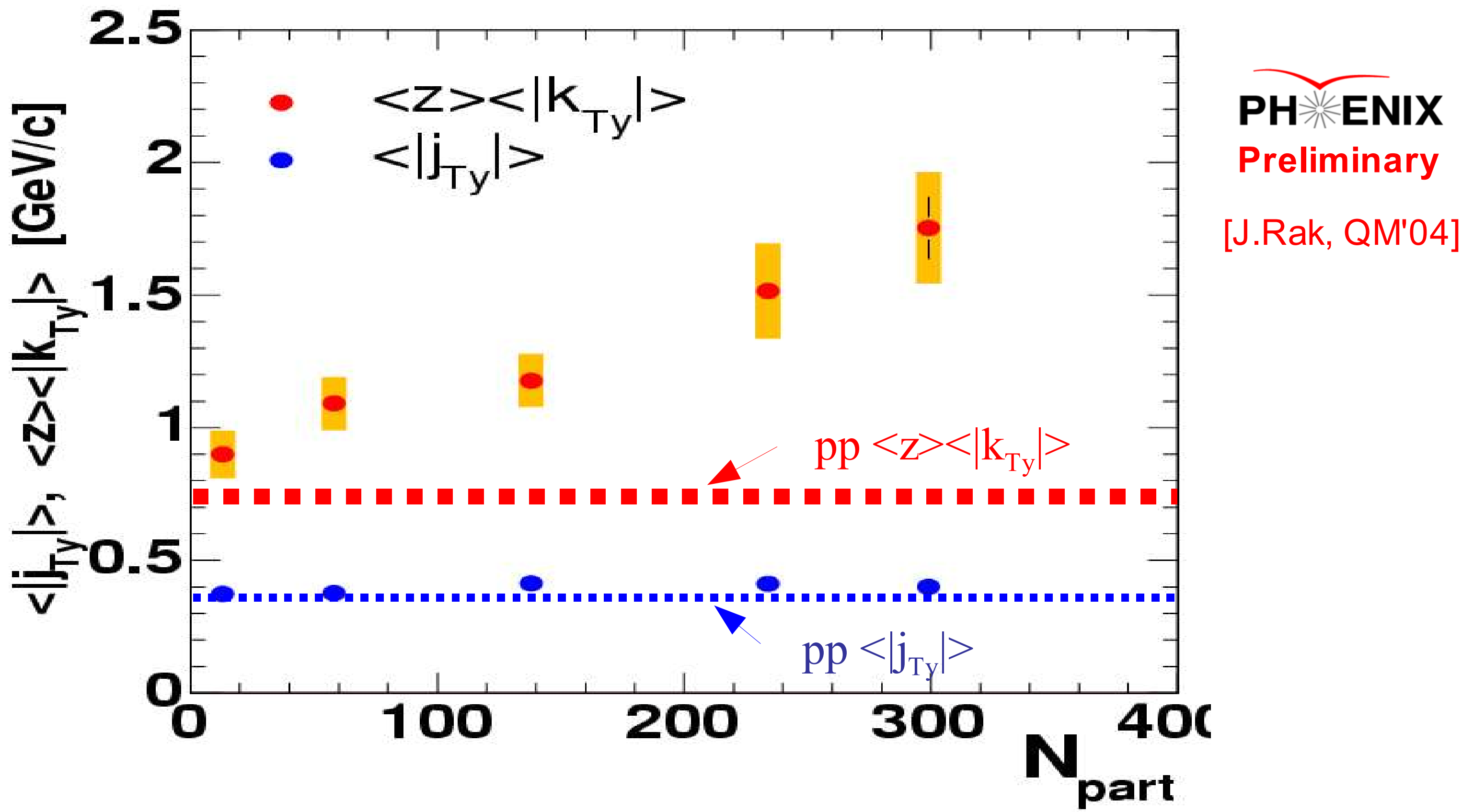
STAR, submitted to PRL
nucl-ex/0501016

- Associated near-side jet yields overall enhanced (enhanced underlying evt.)
- Associated away-side jet yields "shifted down" in p_T: spectra closer to pure "soft" inclusive hadron production ("thermalized")

Centrality dependence of AuAu jet properties: j_T, k_T

- $\langle j_T \rangle_{AuAu} \approx \langle j_T \rangle_{pp}$: Near-side fragmentation unaffected by QCD medium.

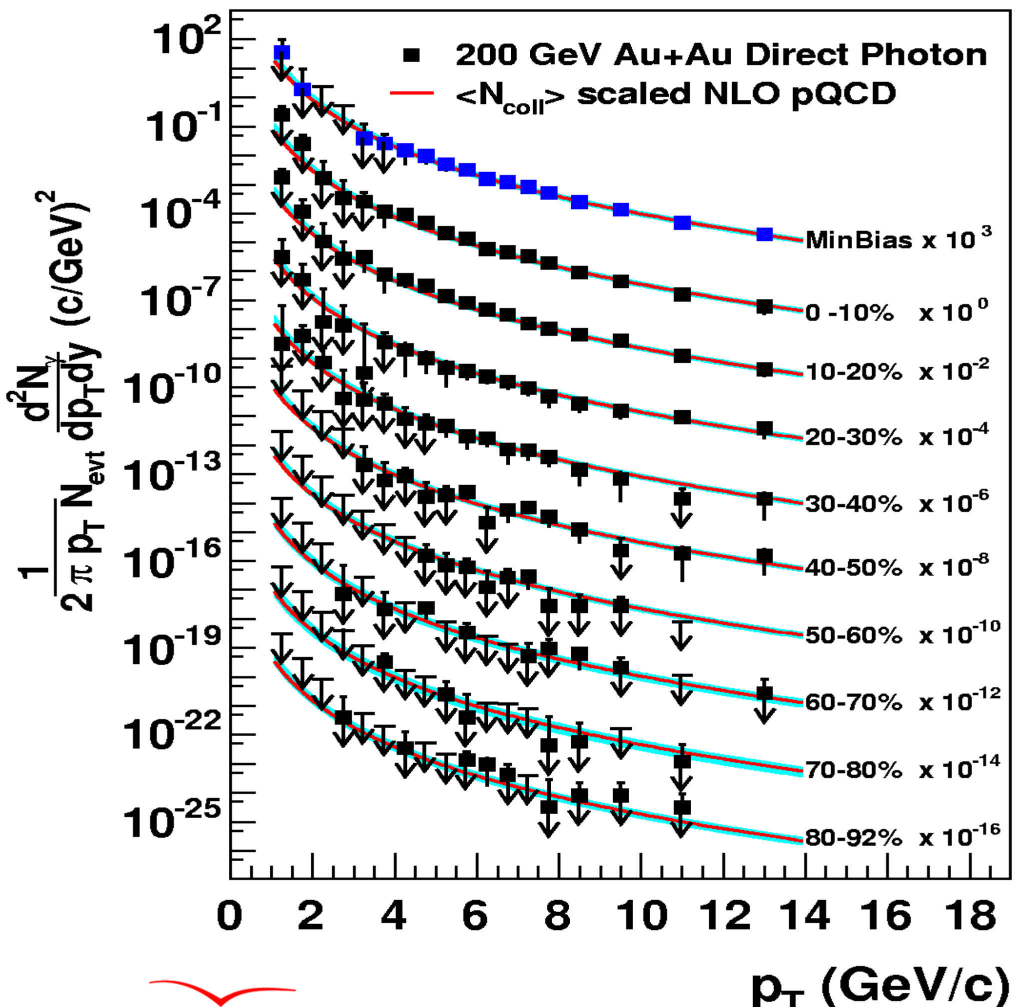
p_{Ttrigg} =2.5 – 4.0 GeV/c , p_{Tassoc} = 1.0 – 2.5 GeV/c



- $\langle k_T \rangle_{AuAu} \approx$ 3 GeV/c: Significant k_T broadening (strongly centrality dependent) indicating substantial final-state rescattering of away-side fragmenting parton.

Unquenched direct photons in AuAu collisions

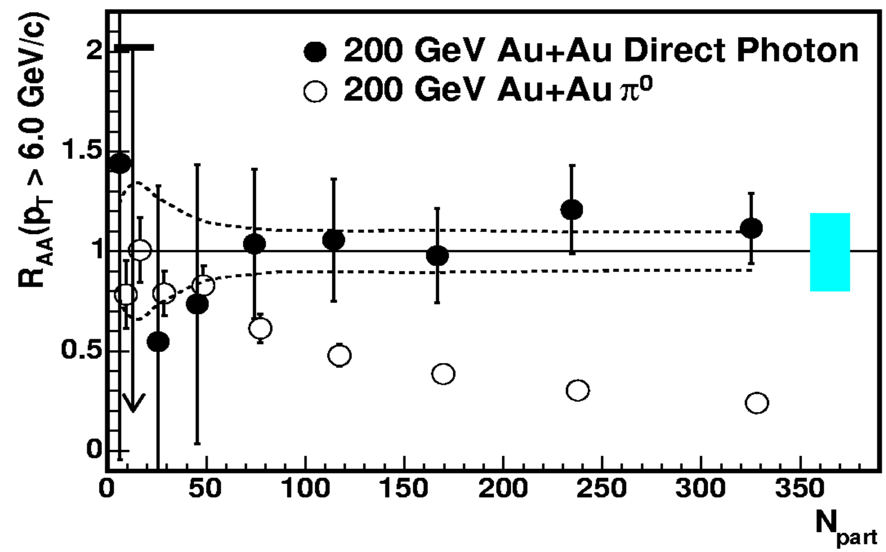
- Direct photon production in Au+Au (all centralities) consistent w/ p+p incoherent scattering (“NN-scaled” pQCD) predictions:



PHENIX

Submitted to PRL
nucl-ex/0503003

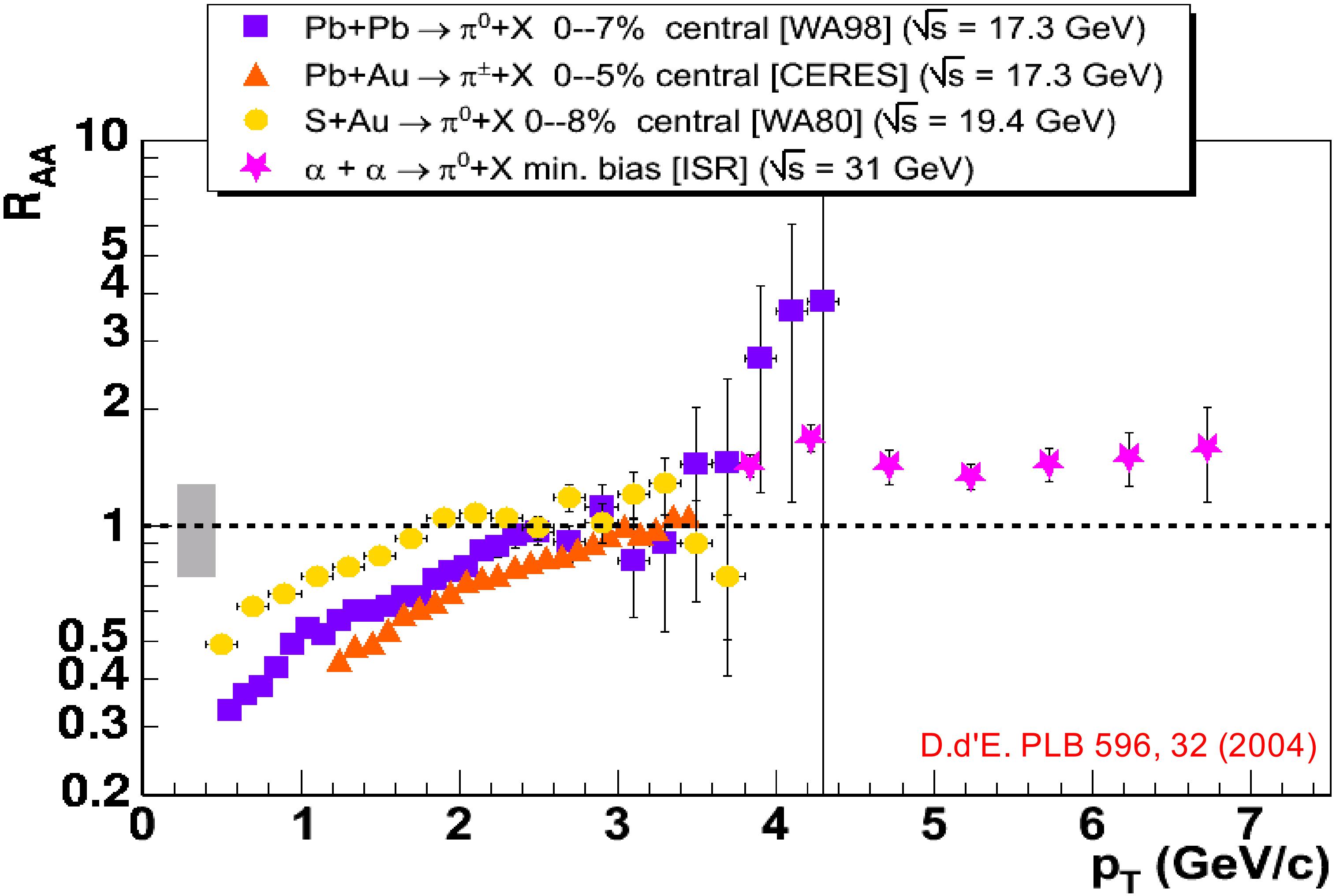
$$R_{AA}(p_T, y; b) = \frac{\text{“hot/dense QCD medium”}}{\text{“QCD vacuum”}} = \frac{d^2N_{AA}/dydp_T}{\langle T_{AA}(b)\rangle \cdot d^2\sigma_{pp}/dydp_T},$$



- pQCD parton scattering holds for hard (colorless) QCD processes in AuAu (all centralities).

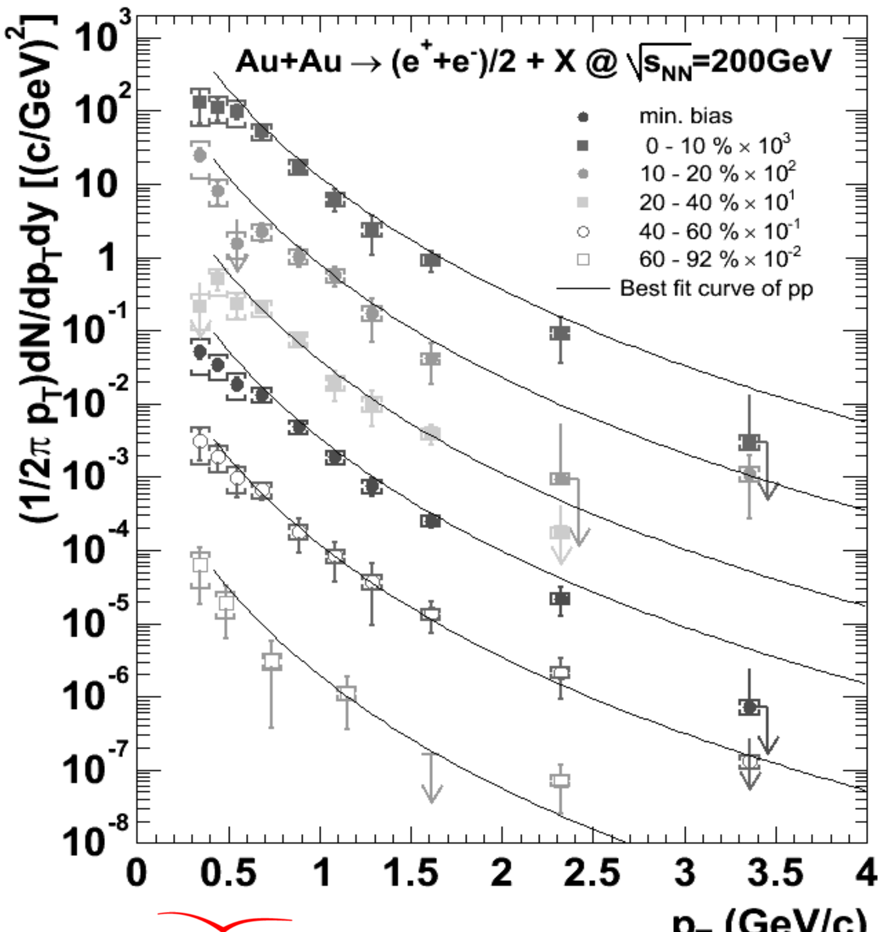
"N_{coll} scaling" in A+A @ 17, 31 GeV: High p_T hadrons

- High p_T π^0 production in (0-10%) central A+A at SPS (and $\alpha+\alpha$ @ ISR) energies consistent w/ "N_{coll}-scaling" (or Cronin enhancement):



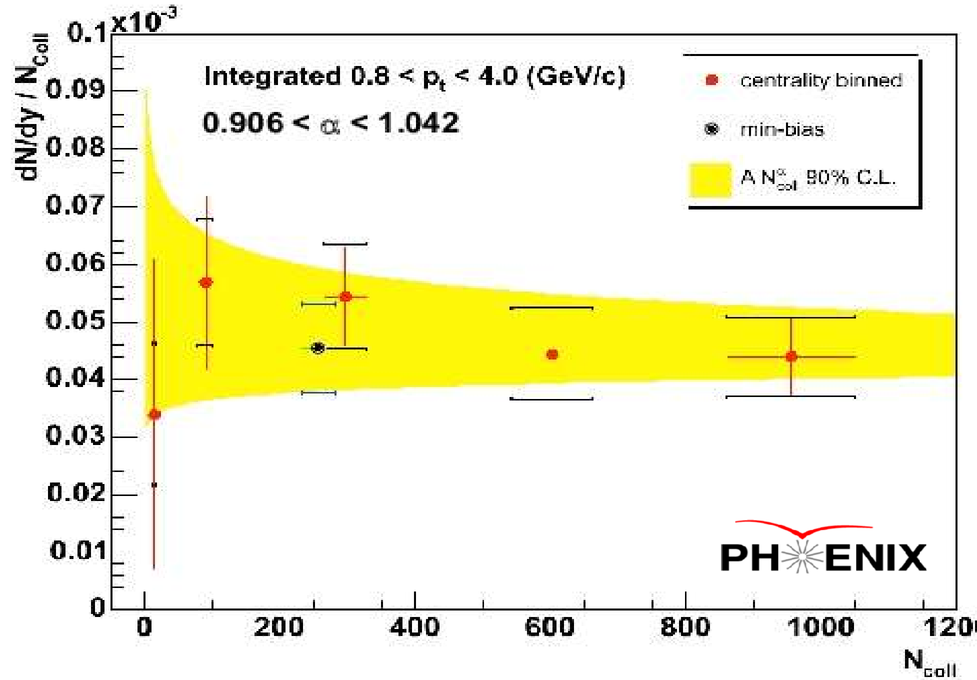
Charm production in AuAu: "NN scaling"

- Open-charm (indirect) measurement via semi-leptonic channel: $D \rightarrow e^{\pm} + X$
- Single $e^{\pm}$ AuAu spectra ($p_T \sim 0.3 - 2$ GeV/c) & total cross-section consistent w/ N_{coll} -scaled pp charm production:



PHENIX

$$N_{charm}^{AuAu} = (N_{coll})^{\alpha} * A$$



Note: $\alpha = (0.906 - 1.042) \Rightarrow$
$N_{coll}^{\alpha} \approx (0.6 - 1.2) * N_{coll}$

PHENIX.
PRL94, 082301 (2005)

High p_T suppression: charm quark (theory)

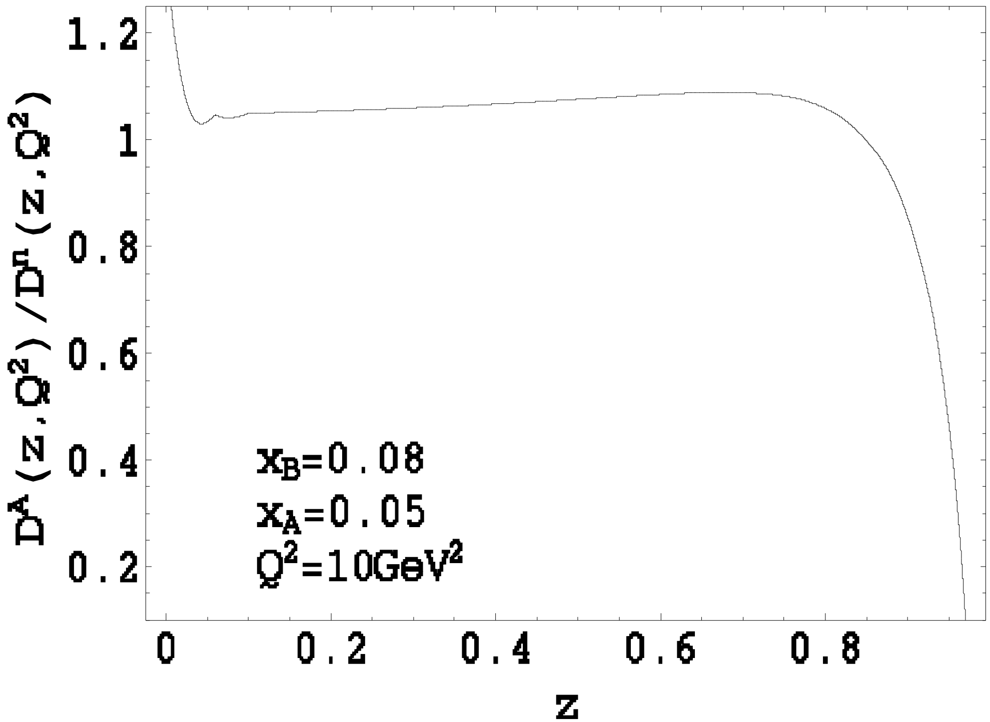
(1) Slow clock for formation time

(2) Color factor

(3) Dead cone effect

$$\tau_f^H = \frac{1}{1/\tau_f + (1-z)M^2/2zq^-}$$

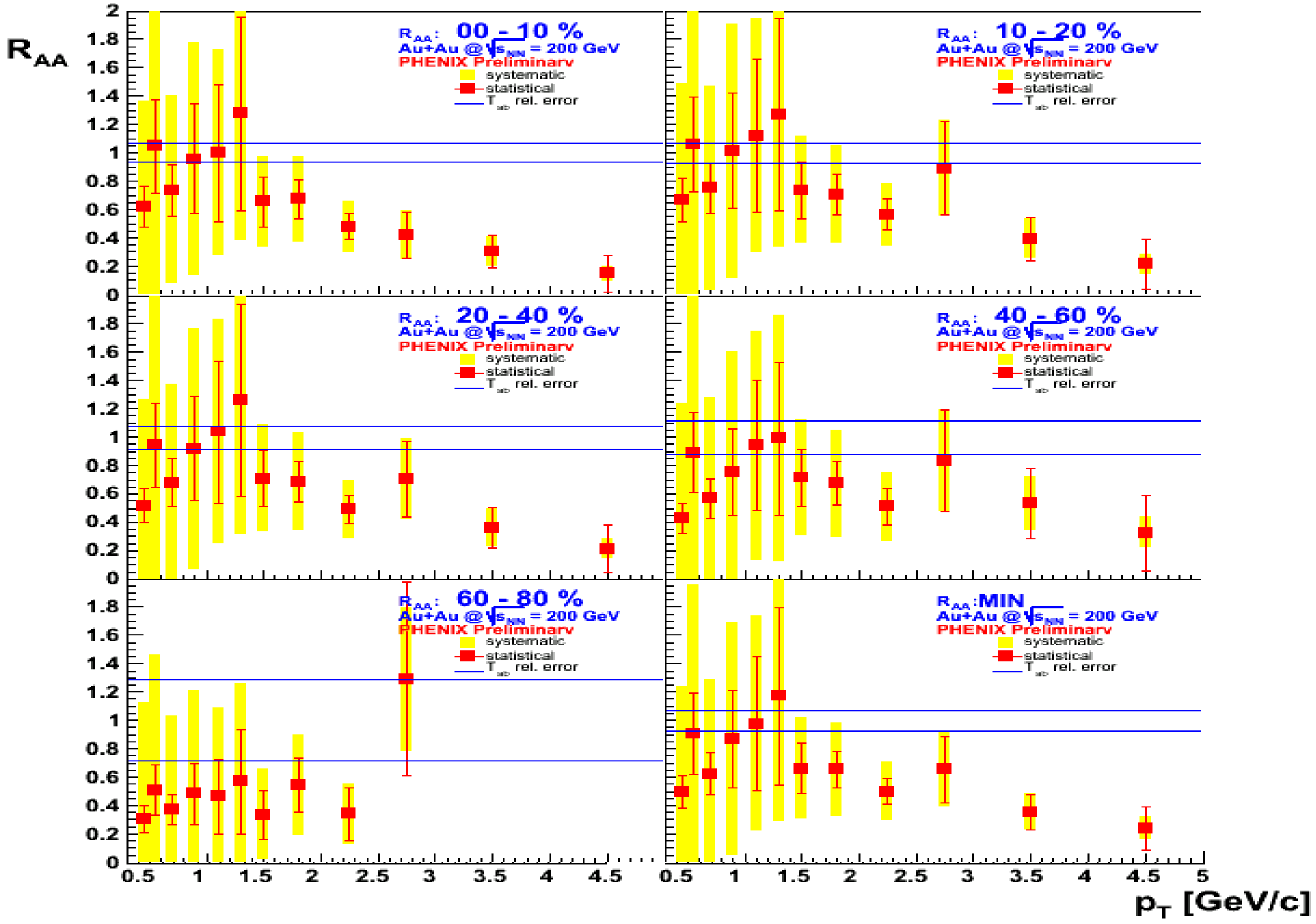
$\Delta E_Q < \Delta E_g, \Delta E_q$



Djordjevic & Gyulassy
Zhang & XNW
Armesto,Dainese, Salgado & Wiedemann

Charm quark suppression at high p_T ?

- Latest single $e^{\pm}$ R_{AA} at higher p_T < 4.5 GeV/c (large uncertainties still @ low p_T):



PHENIX Preliminary

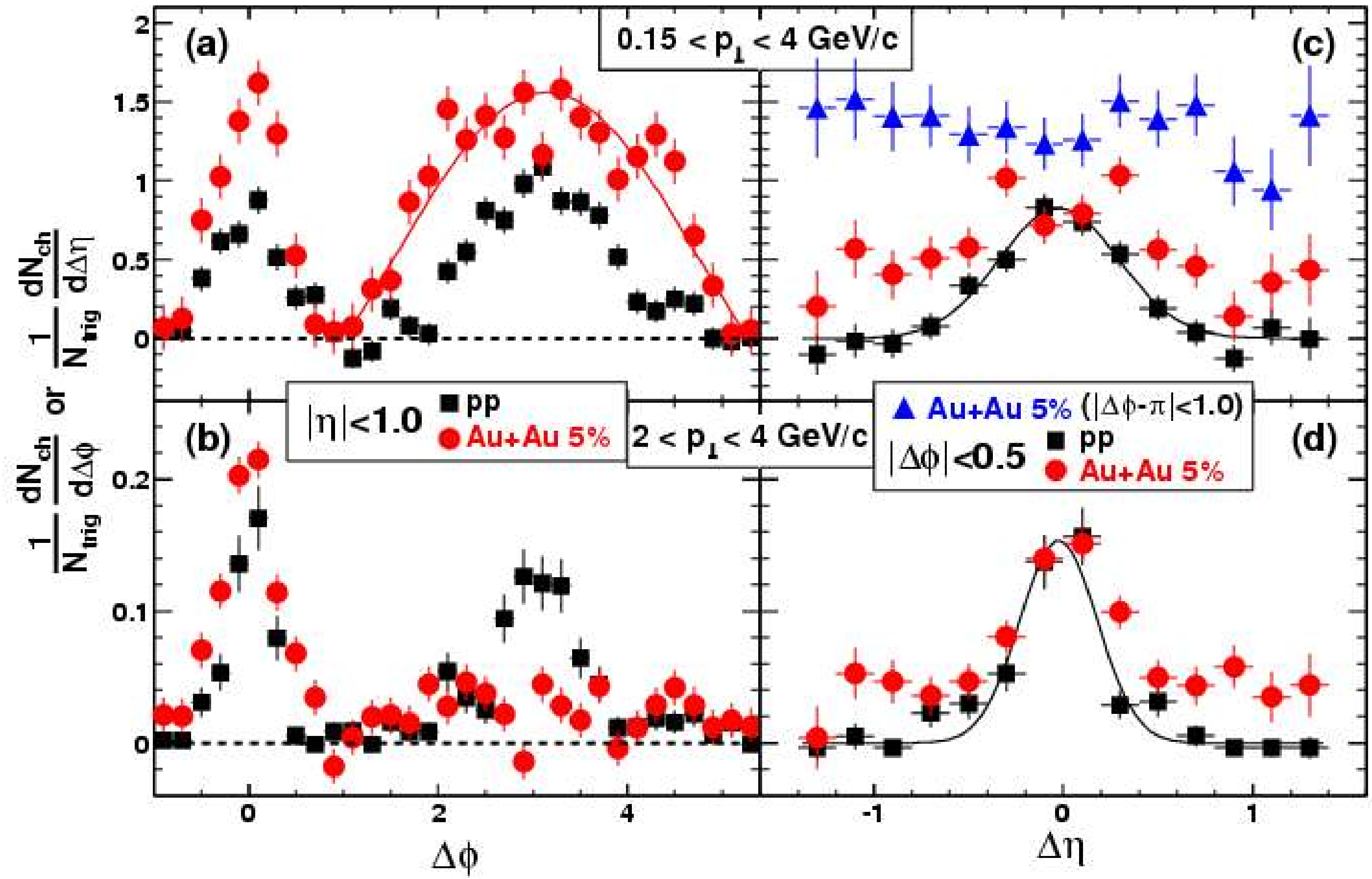
- Suppressed charm production above p_T~2 GeV/c ?

- New kinematic domain accessible with heavy-Q: Hard production at low p_T
- R_{AA}(lo p_T) ~1 >> R_{AA}(hi p_T) ~ $R_{AA}(\pi^0)$: Energy loss for <u>fast</u> heavy Q shifts them down to low p_T? No en. loss effect for slow Q (flatter charm dN/dp_T at low p_T) ?

“Jet quenching”: modified (di)jet structure

- Strongly modified away-side $dN_{pair}/d\varphi$ correlations in central AuAu:

STAR, nucl-ex/0501016.



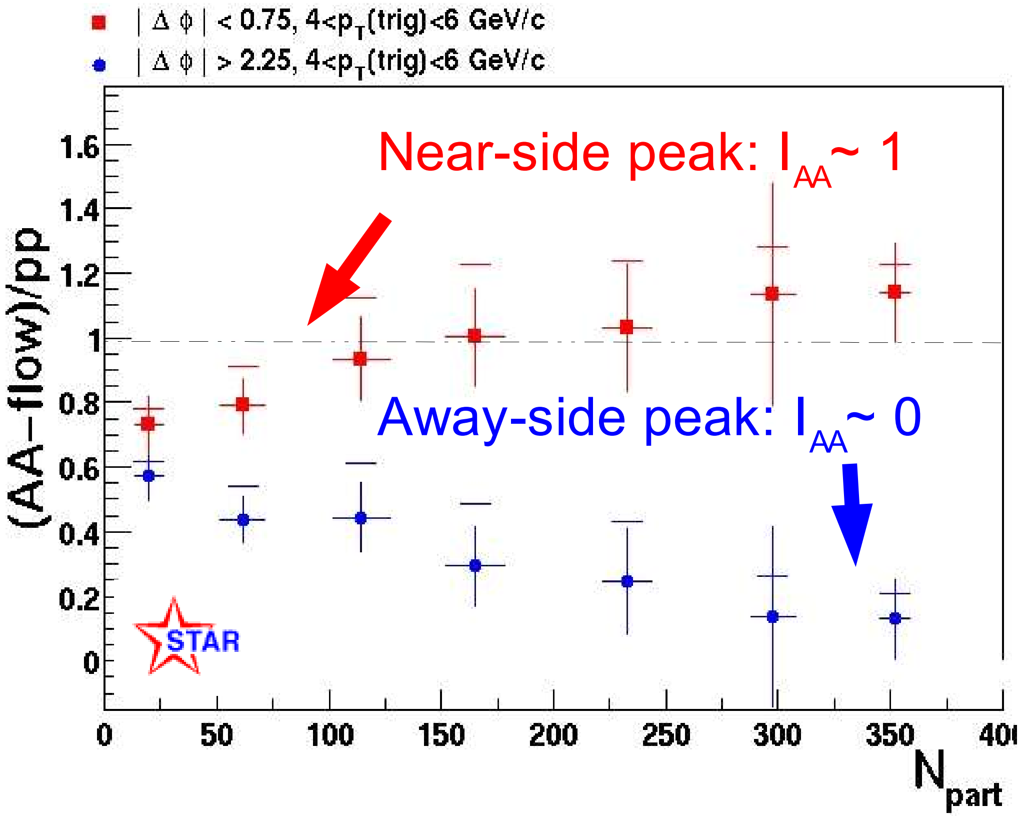
Enhanced and broadened distribution at low pT.

Away side suppression at high pT.

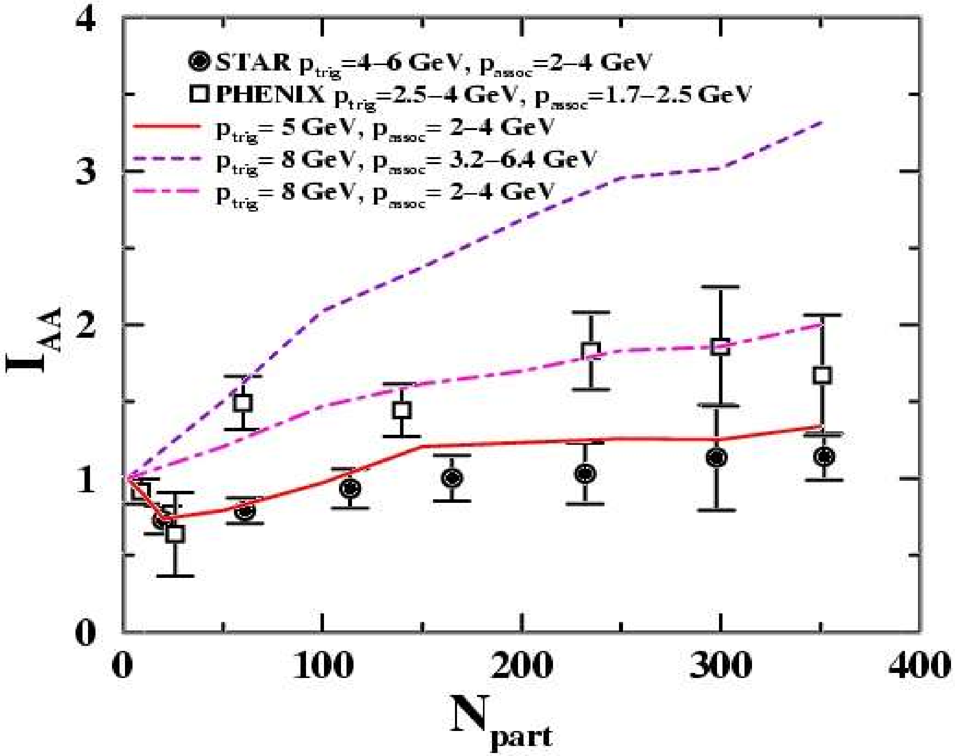
Dihadron azimuthal correlations: AuAu "mono-jets"

- Centrality dependence of near- and away- side correlations "strengths":

$$I_{AA}(\Delta\phi_1, \Delta\phi_2) = \frac{\int_{\Delta\phi_1}^{\Delta\phi_2} d(\Delta\phi)[D^{\mathrm{AuAu}} - B(1 + 2v_2^2 \cos(2\Delta\phi))]}{\int_{\Delta\phi_1}^{\Delta\phi_2} d(\Delta\phi) D^{\mathrm{pp}}}$$



STAR, PRL90, 082302 (2003)

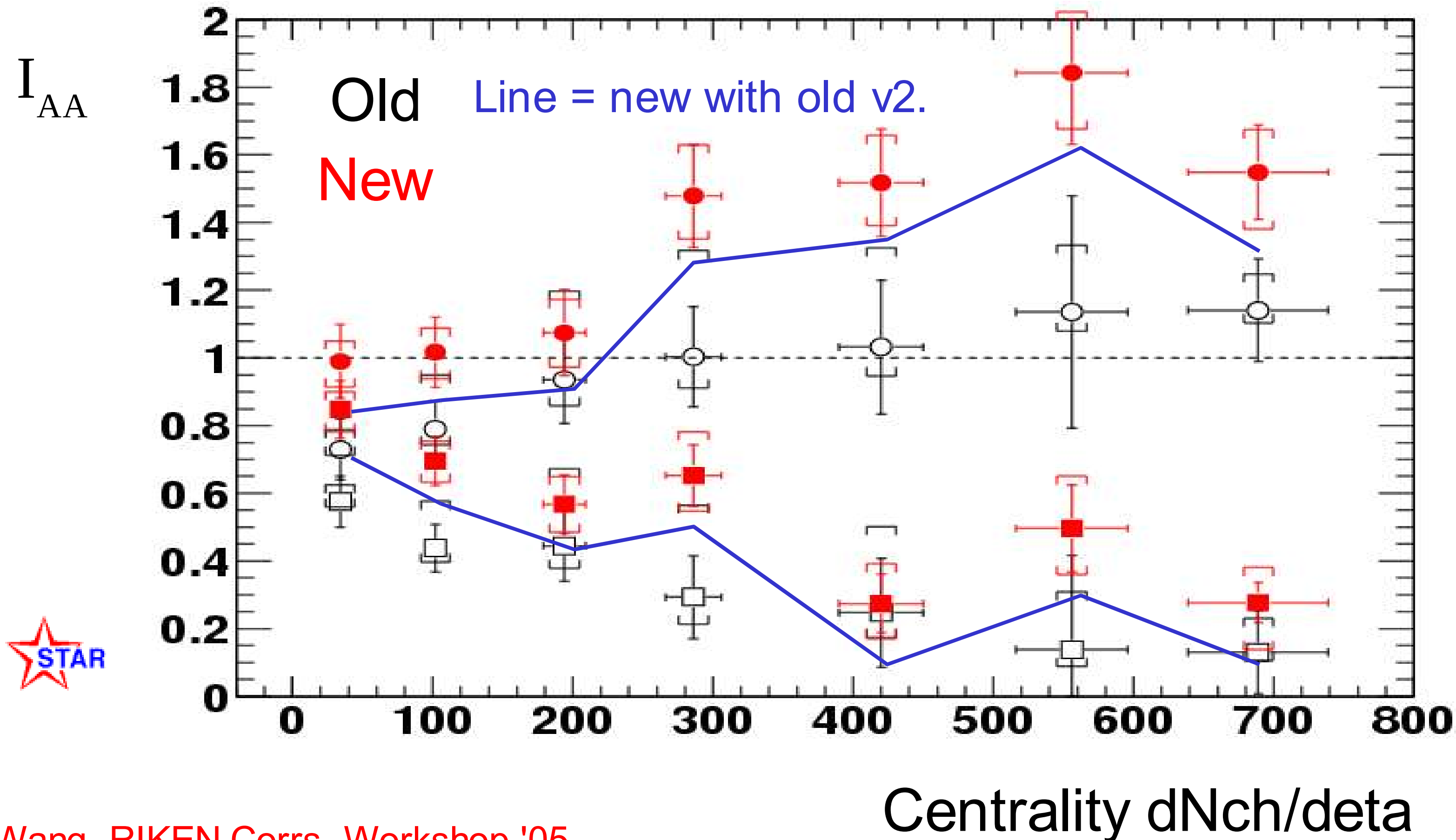


[A.Majumder, nucl-th/041261]

Dihadron azimuthal correlations: AuAu "mono-jets"

- Centrality dependence of near- and away- side correlations "strengths":

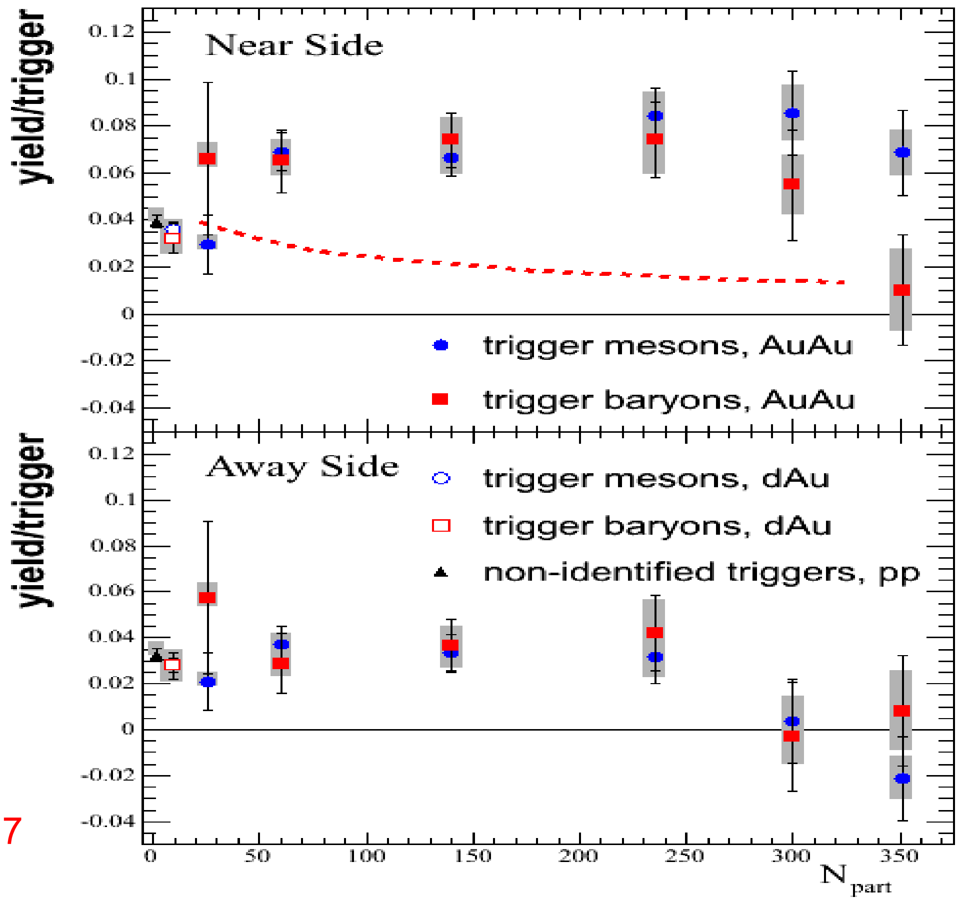
$$I_{AA}(\Delta\phi_1, \Delta\phi_2) = \frac{\int_{\Delta\phi_1}^{\Delta\phi_2} d(\Delta\phi)[D^{\mathrm{AuAu}} - B(1 + 2v_2^2\cos(2\Delta\phi))]}{\int_{\Delta\phi_1}^{\Delta\phi_2} d(\Delta\phi) D^{\mathrm{pp}}}$$



F.Wang. RIKEN Corrs. Workshop '05

"Fragmentation functions": Central AuAu (200 GeV)

- Baryon-meson dependence of associated near- and away- side hadron p_T spectra:



$p_{T\,trigg}$ = 2.5 – 4 GeV/c
p_{Tassoc} = 1.7 – 2.5 GeV/c

Near-side

Away-side

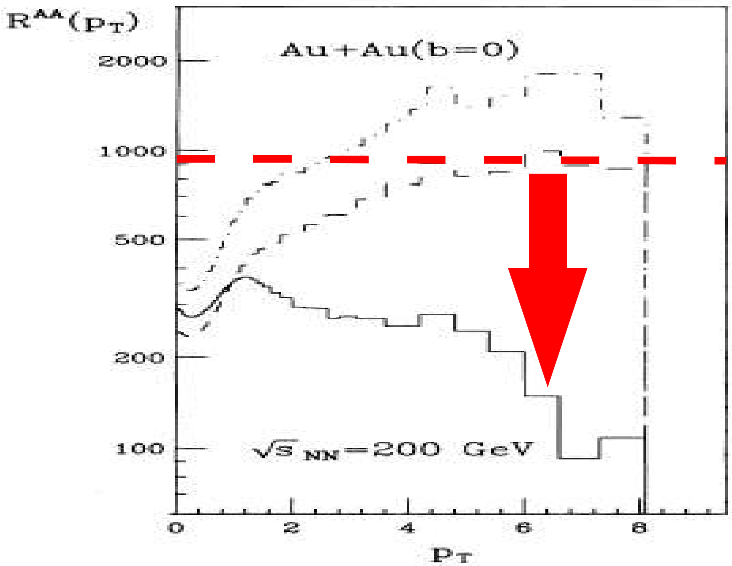
PHENIX
nucl-ex/0408007

- Associated yields similar for meson & baryon triggers (perhaps weak reduction for baryons in very central collisions).
- Slight increase of associated near-side jet yields in mid-central AuAu.
- Jet-like production but different suppression for leading baryons and mesons !?

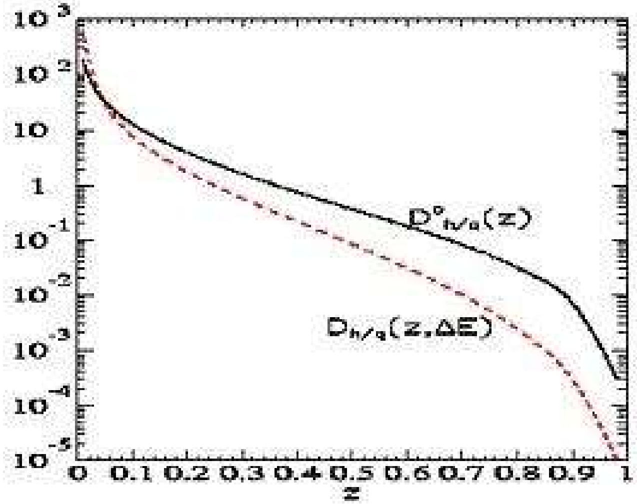
Jet production in AA : (a few) theoretical expectations

- Leading hadron suppression:

Wang&Gyulassy PRL 68, 1480 (1992)



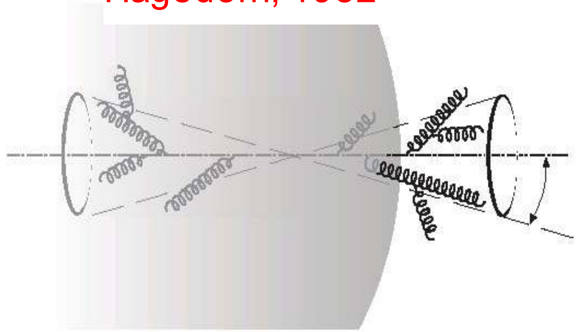
- Medium-modified FFs:



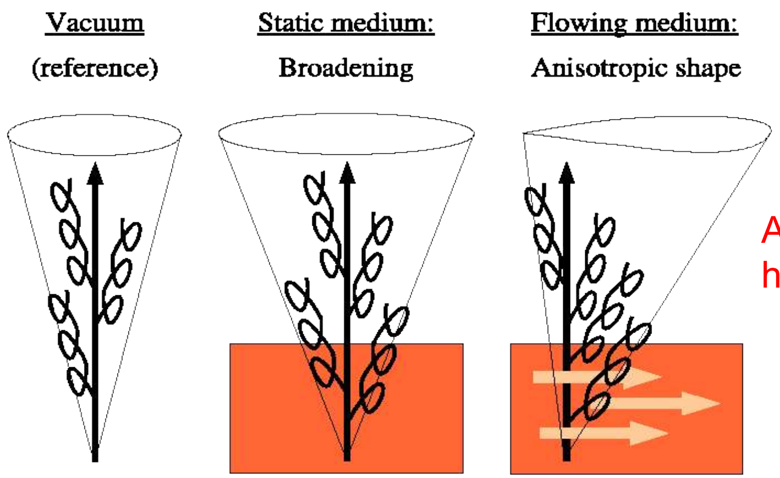
X.N.Wang;
Salgado&Wiedem.
Arleo, ...

- Mono-jets:

Hagedorn, 1982



- Jet broadening in eta:



Armesto et al
hep-ph/0405301

➜ Valuable diagnostic tools of QCD medium (dN^g/dy, $<q_0>$, ...)