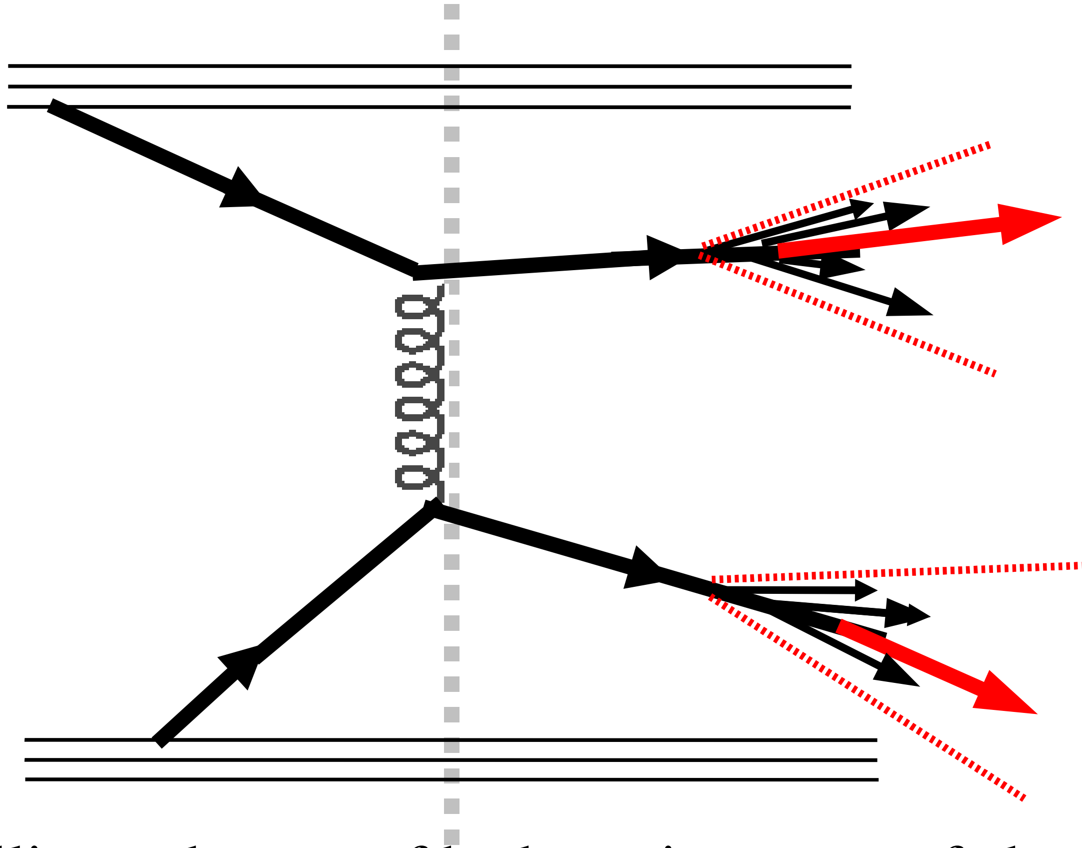
Jet production due to hard initial parton interaction

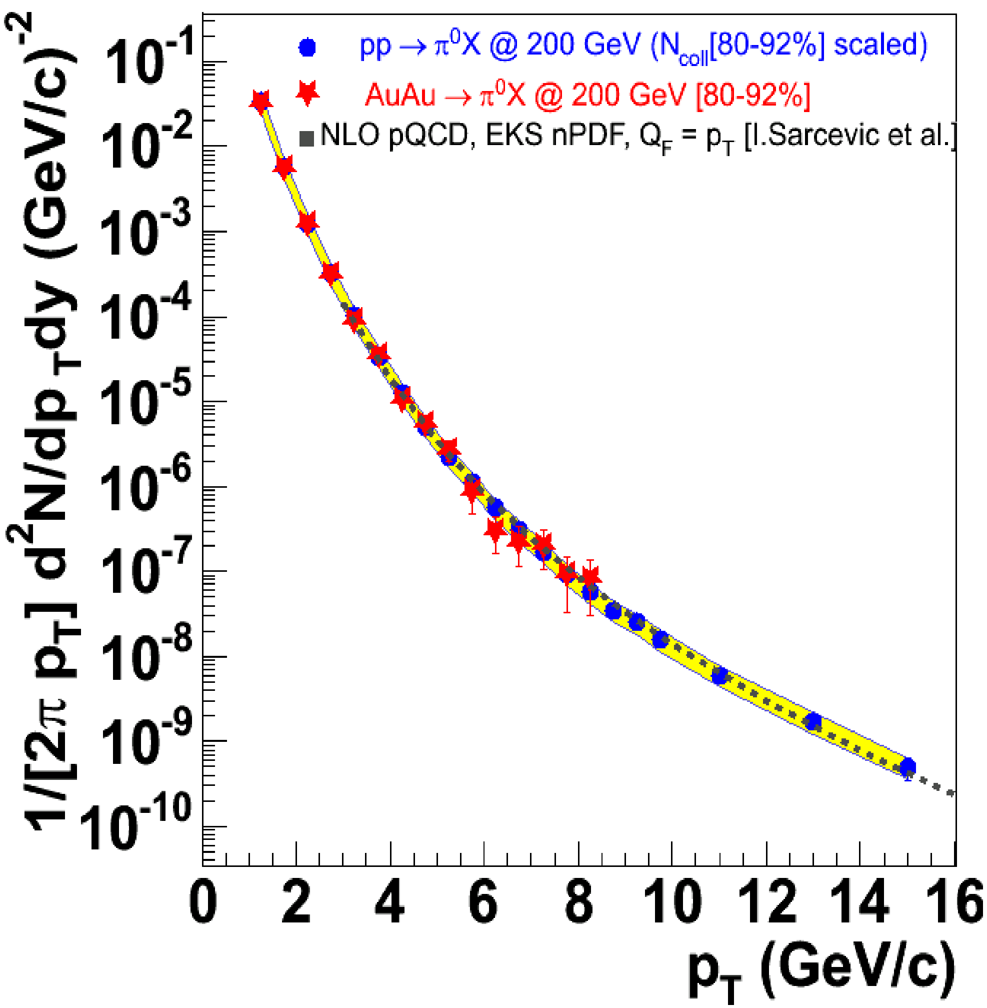


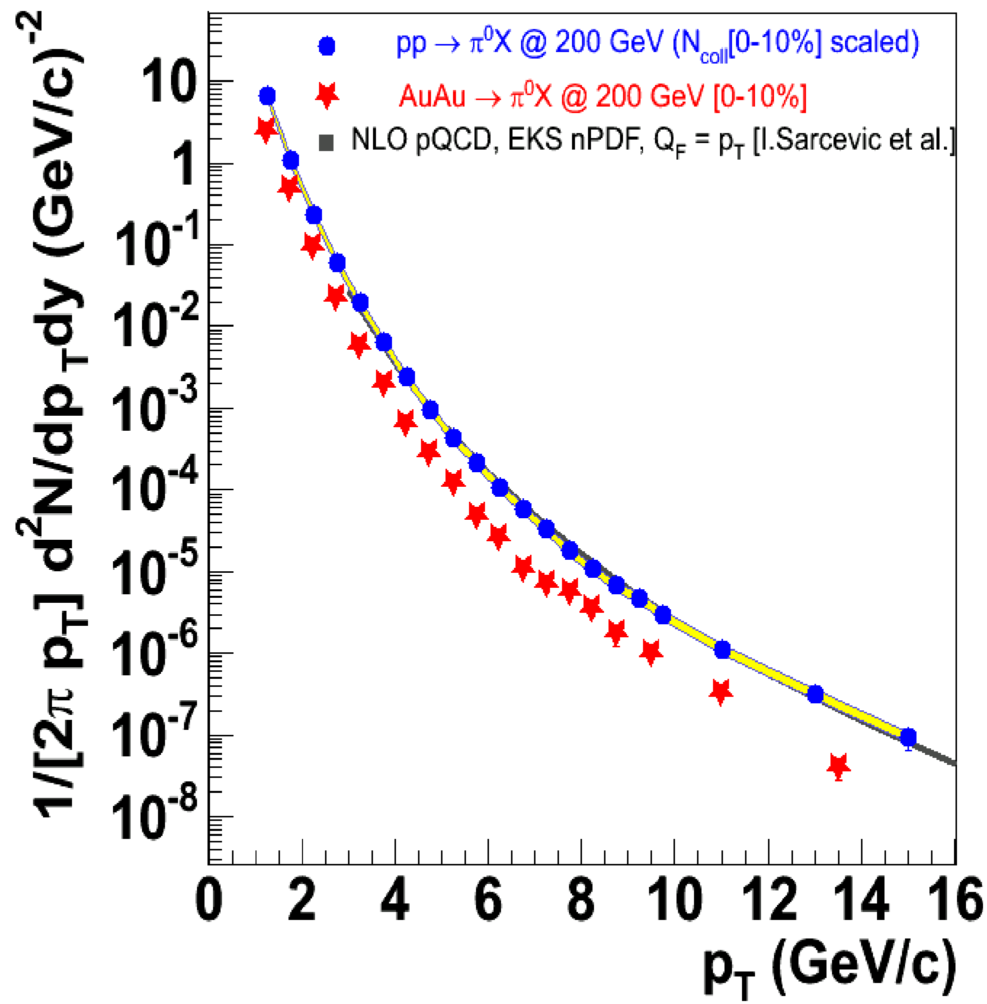
- a jet is a collimated spray of hadrons in a cone of about 0.7 rad with total 4-momentum of fragmenting parton - leading hadron carries 60-80 % of jet energy at RHIC energy
- balanced back-to-back in transverse plane by another jet or photon
- jet production calculable by perturbative QCD

RUPRECHT-KARLS-UNIVERSITÄT HEIDELBERG

spectra suppressed at high p_t in AuAu relative to pp

proton data scaled to AuAu with appropriate number of binary collisions

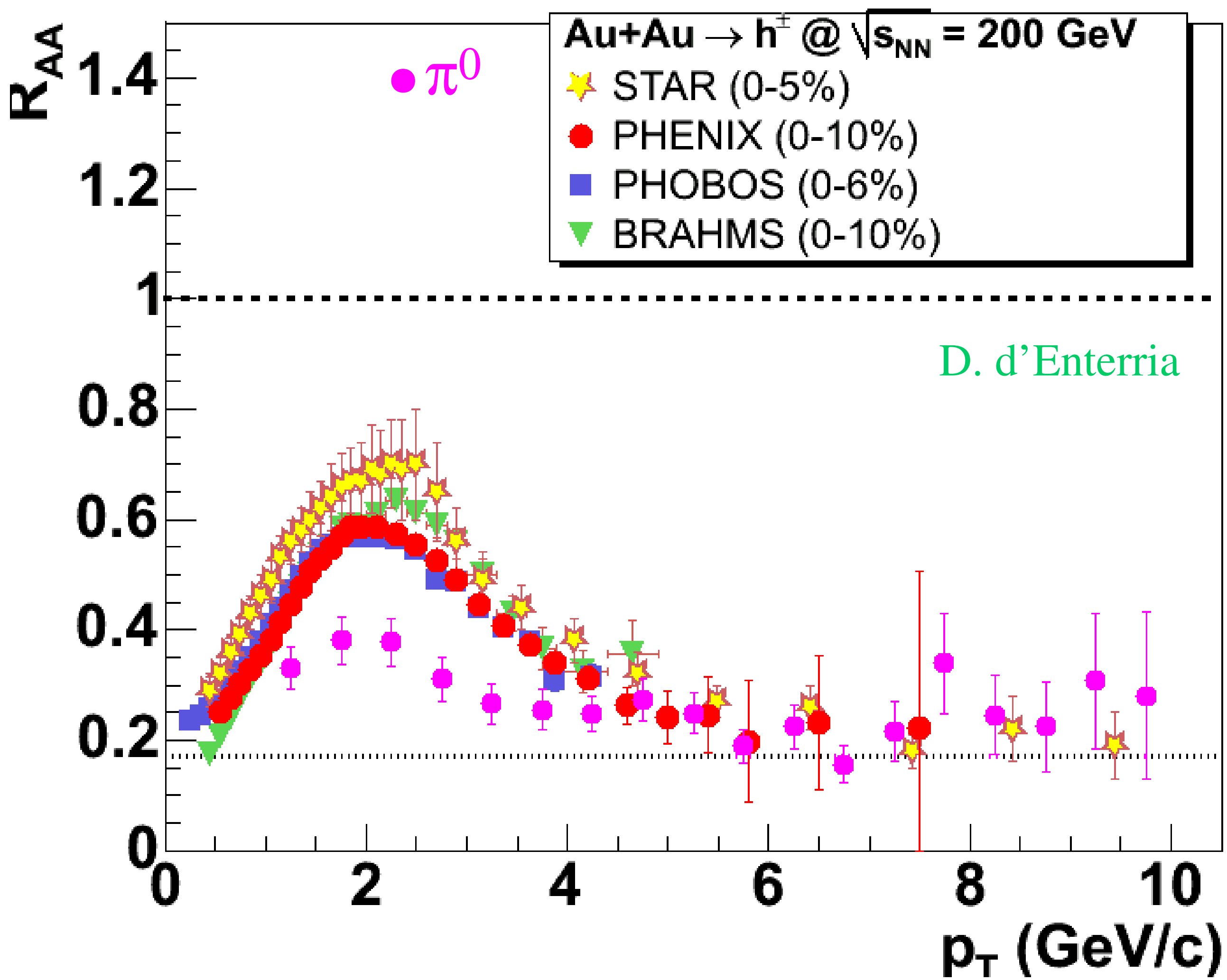




PHENIX PRL 91 (2003) 072305 and 241803

high p_t suppression seen by all experiments

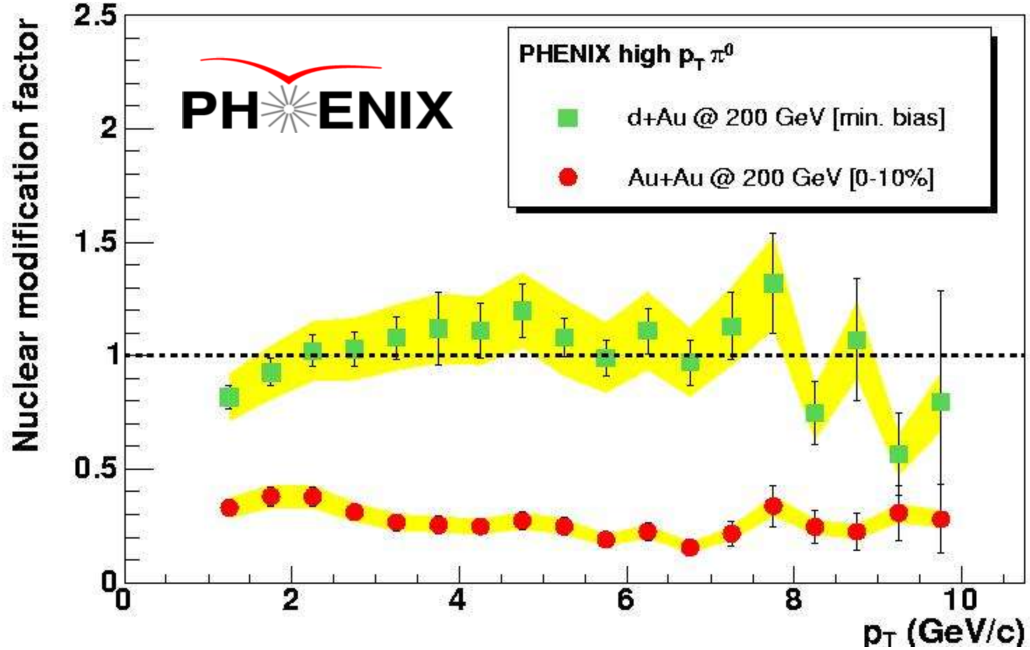
R_{AA}=yield(AuAu)/N_{coll} yield(pp)

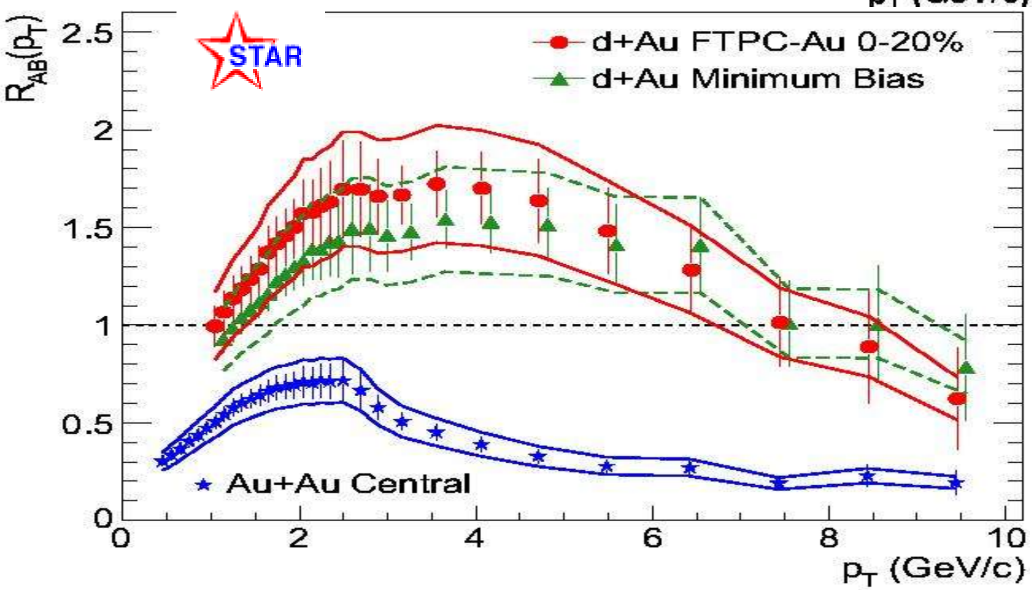


- all expts. see large suppression in AuAu
- π^0 lower than $h^{\pm}$
- no suppression in dAu rather
  Cronin enhancement
  → medium effect, not
  incoming partons

- reasonable agreement between 4 experiments

jet production in deuteron - Au collisions

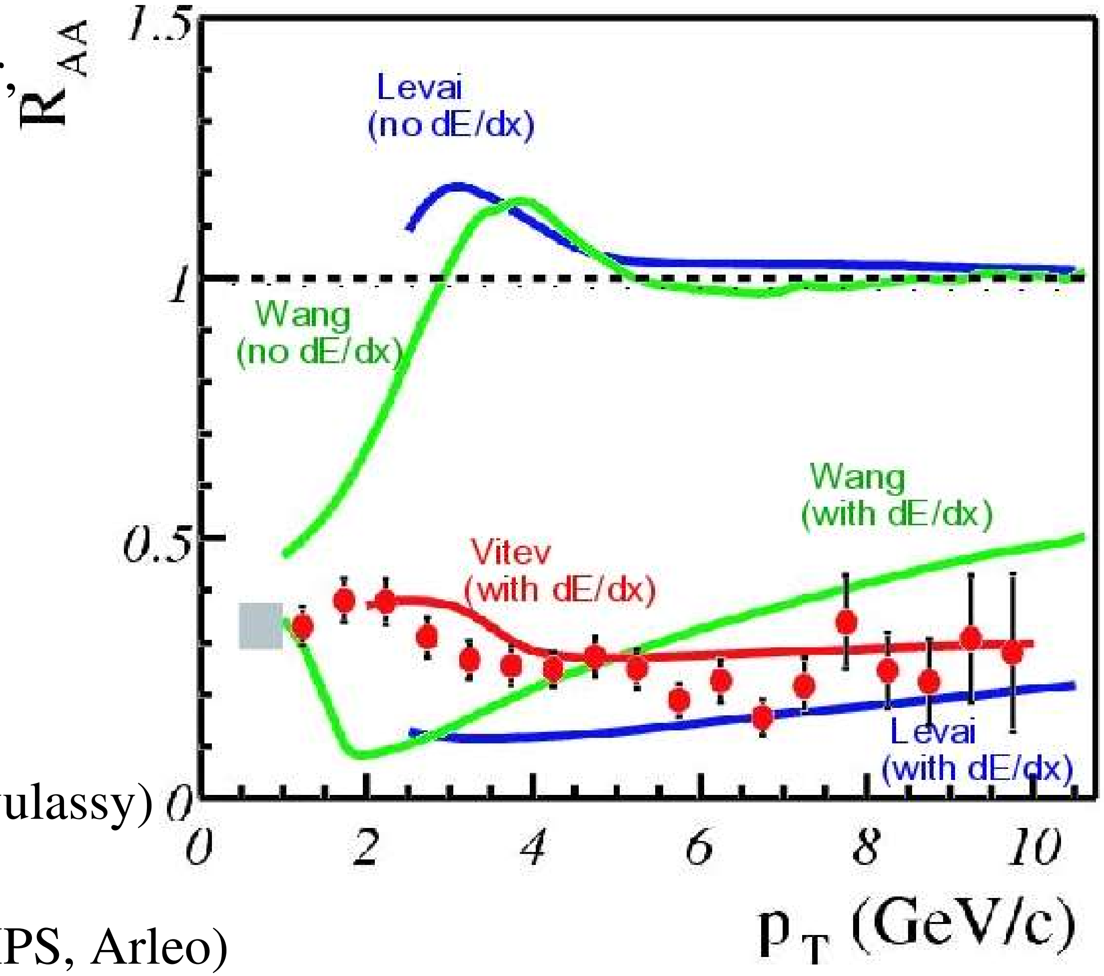




not suppressed but
rather enhanced due to
initial parton scattering
(Cronin effect)

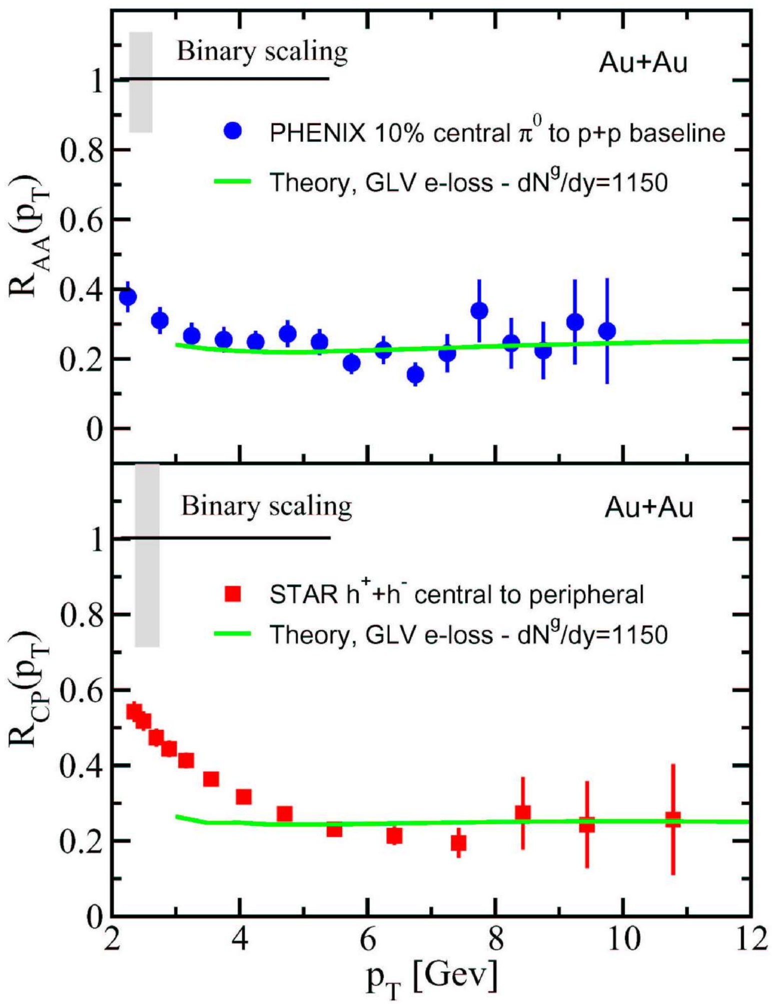
Suppression predicted due to energy loss of partons in hot matter "jet quenching"

H. Baier, Y.L. Dokshitzer, A.H. Mueller, S. Peigne, D. Schiff, Nucl. Phys. B483 (1997) 291 and 484 (1997) 265
energy loss of high energy parton traversing color charged medium ->
medium induced gluon radiation in high energy limit
$\Delta E \approx \alpha_s \mu^2 L^2/\lambda \, (1 + O(1/N))$



implemented in models in different ways:
high initial densities dN_g/dy=1100 (Vitev/Gyulassy)
large opacities <n> = $L/\lambda \approx$ 3-4 (Levai et al.)
transport coefficients q_0=3.5 GeV/fm^2 (BDMPS, Arleo)
plasma temperature T = 400 MeV (G. Moore)
medium induced ratiative energy loss
dE/dx(expanding)=0.25 GeV/fm or dE/dx(static source)=14 GeV/fm (S.N.Wang)

suppression of hadron yields at high p_t in central AuAu collisions



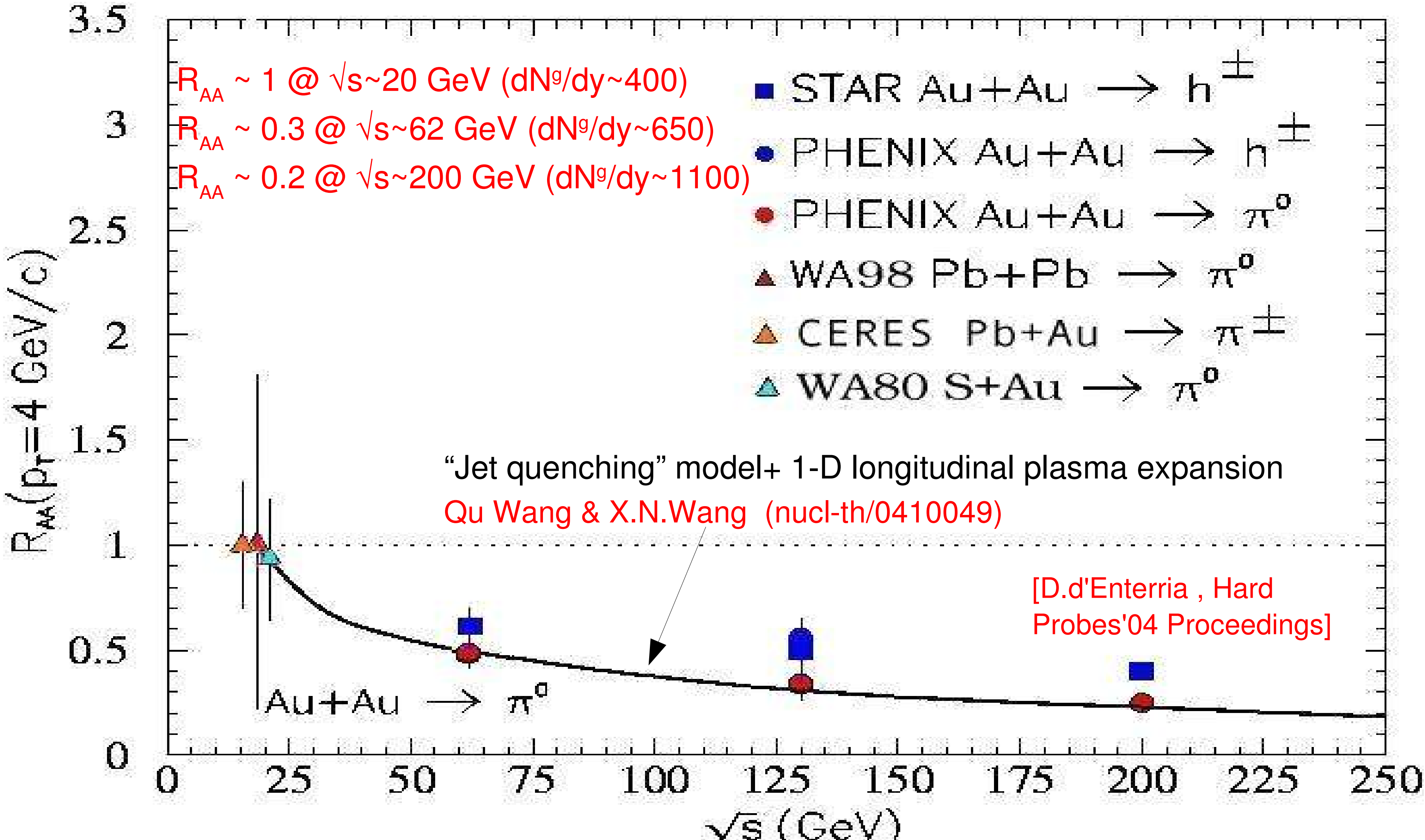
AuAu compared to pp scaled with number of binary collisions

AuAu central collisions compared to peripheral collisions scaled with number of binary collisions

in central collisions hadron yields suppressed indicative of jet quenching due to parton energy loss due to high gluon density

R_{AA} at lower beam energies

√s dependence of R_{AA} consistent w/ parton E_{loss} models (ΔE_{loss}~ dN/dy) + Bjorken expansion:

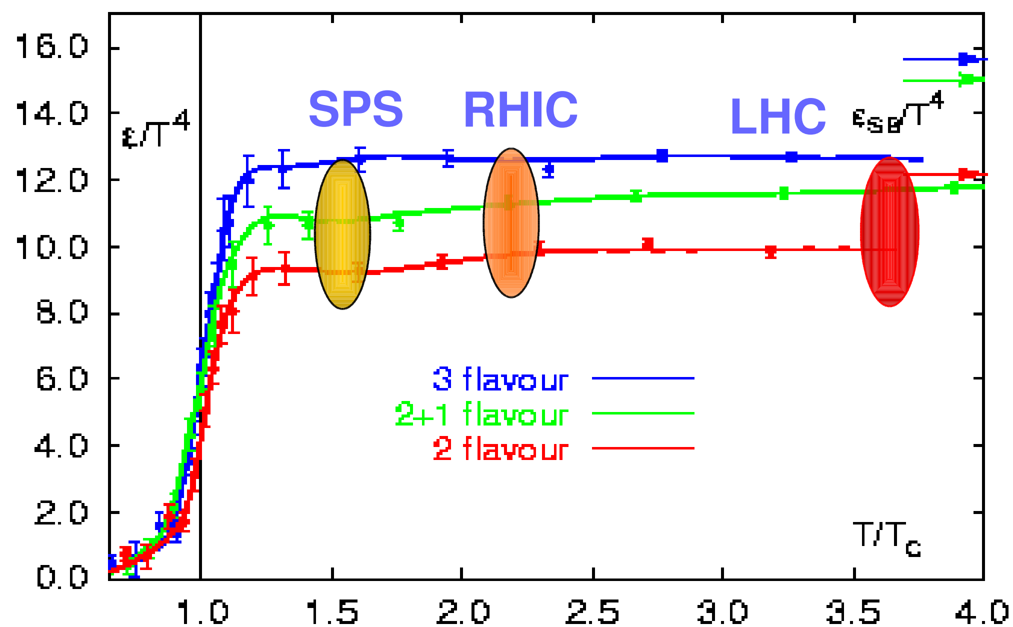


jet quenching indicative of gluon rapidity density

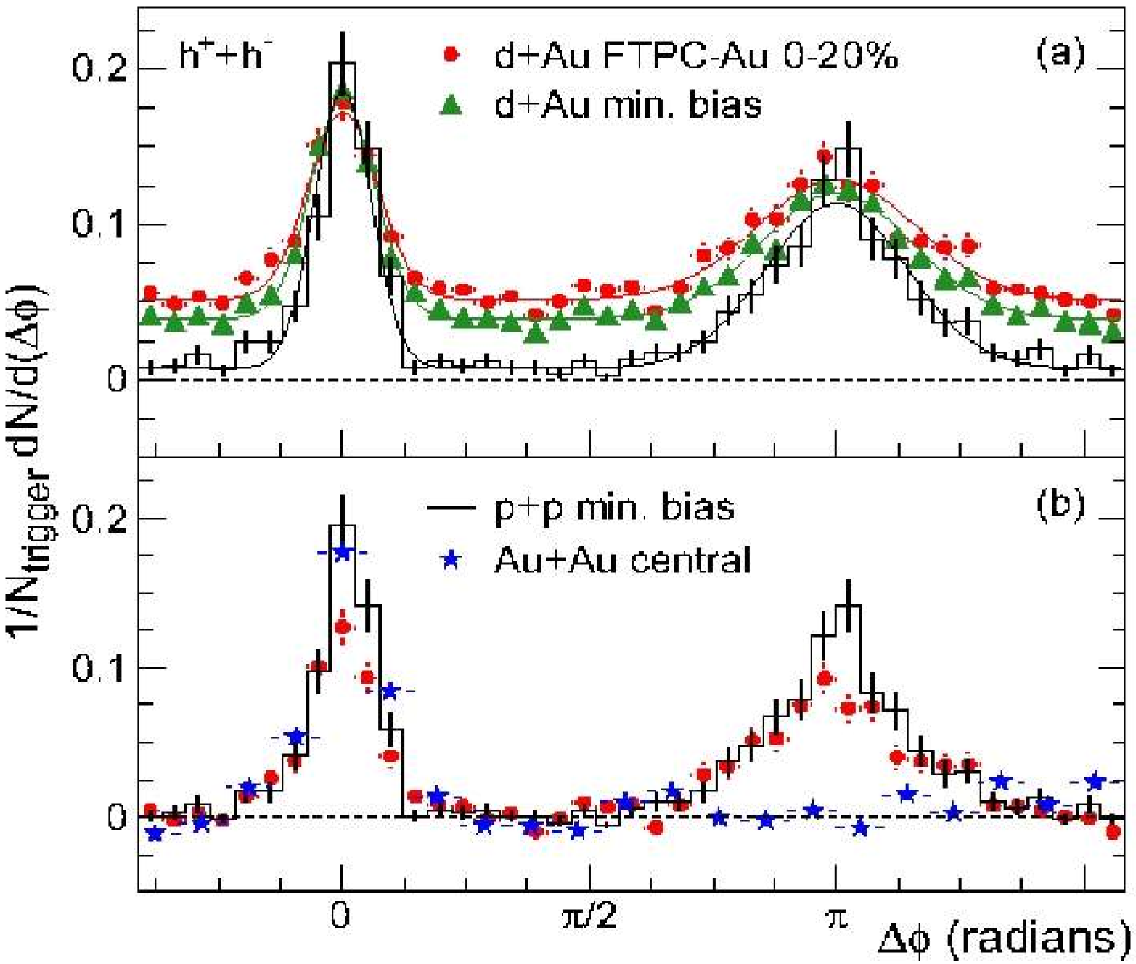
	$\tau_0[fm]$	$T[MeV]$	$\varepsilon[GeV/fm^3]$	$\tau_{tot}[fm]$	dN^g/dy
SPS	**0.8**	**210-240**	**1.5-2.5**	**1.4-2**	**200-350**
RHIC	**0.6**	**380-400**	**14-20**	**6-7**	**800-1200**
LHC	**0.2**	**710-850**	**190-400**	**18-23**	**2000-3500**

I. Vitev, JPG 30 (2004) S791

- **Consistent estimate with hydrodynamic analysis**



Azimuthal correlations of high p_t particles

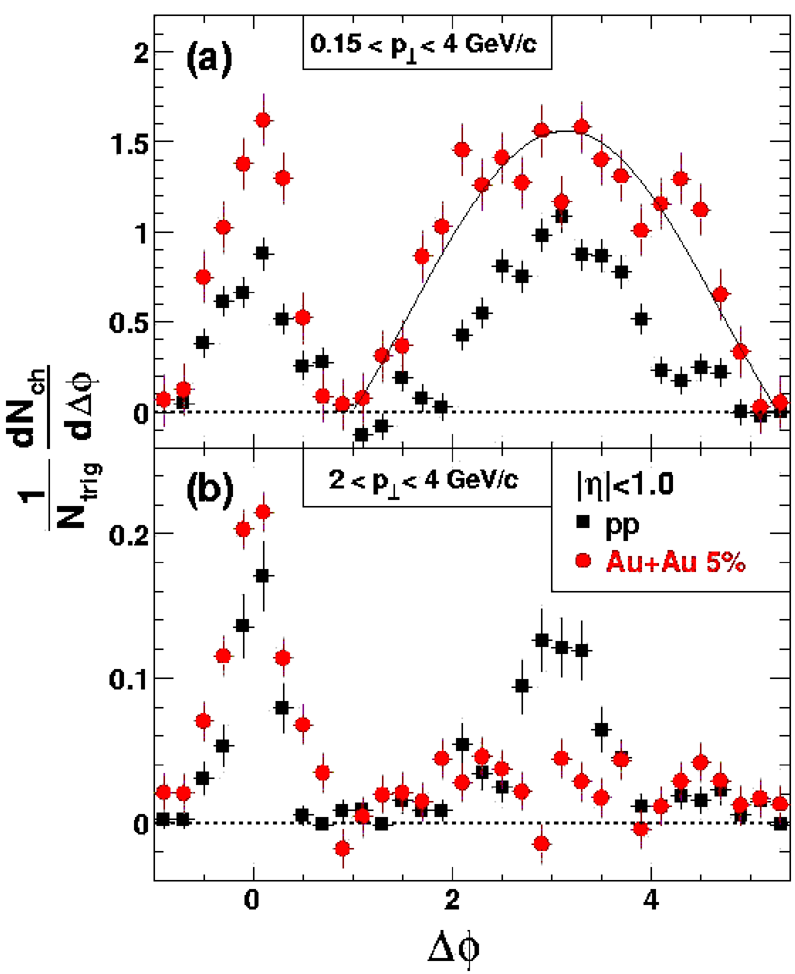


trigger particle: 4-6 GeV/c
correlated with all others
with p_t=2-4 GeV/c

STAR: PRL 91 (2003) 072304

away-side associated hadrons at lower p_t

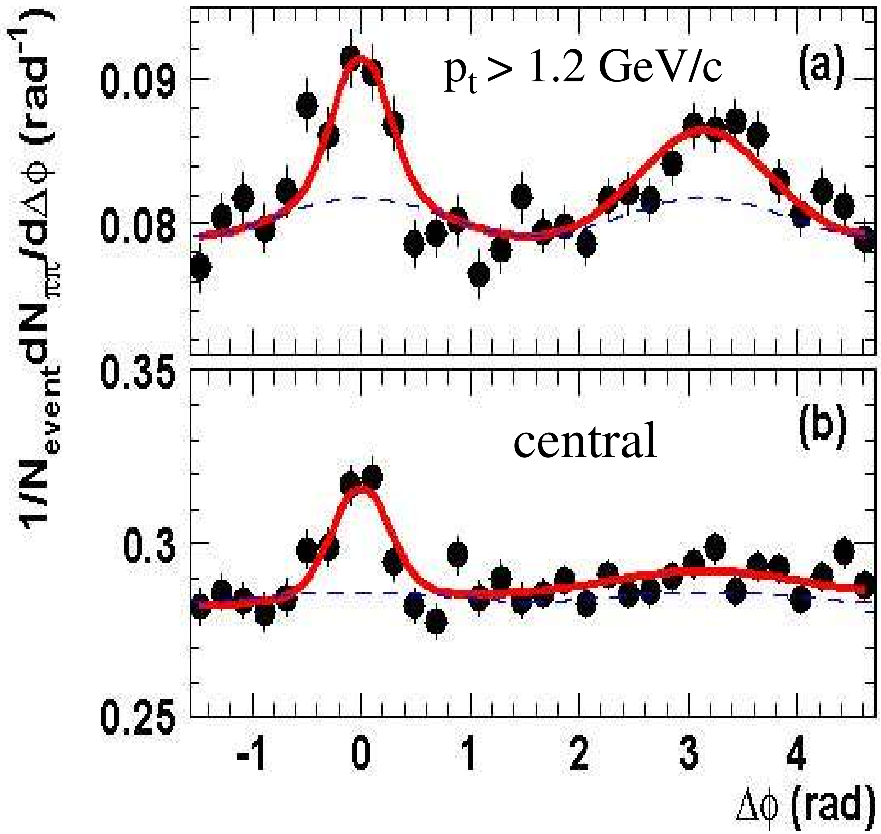
STAR 200 GeV nucl-ex/0501016



4 < p_T(trig.) < 6 GeV/c

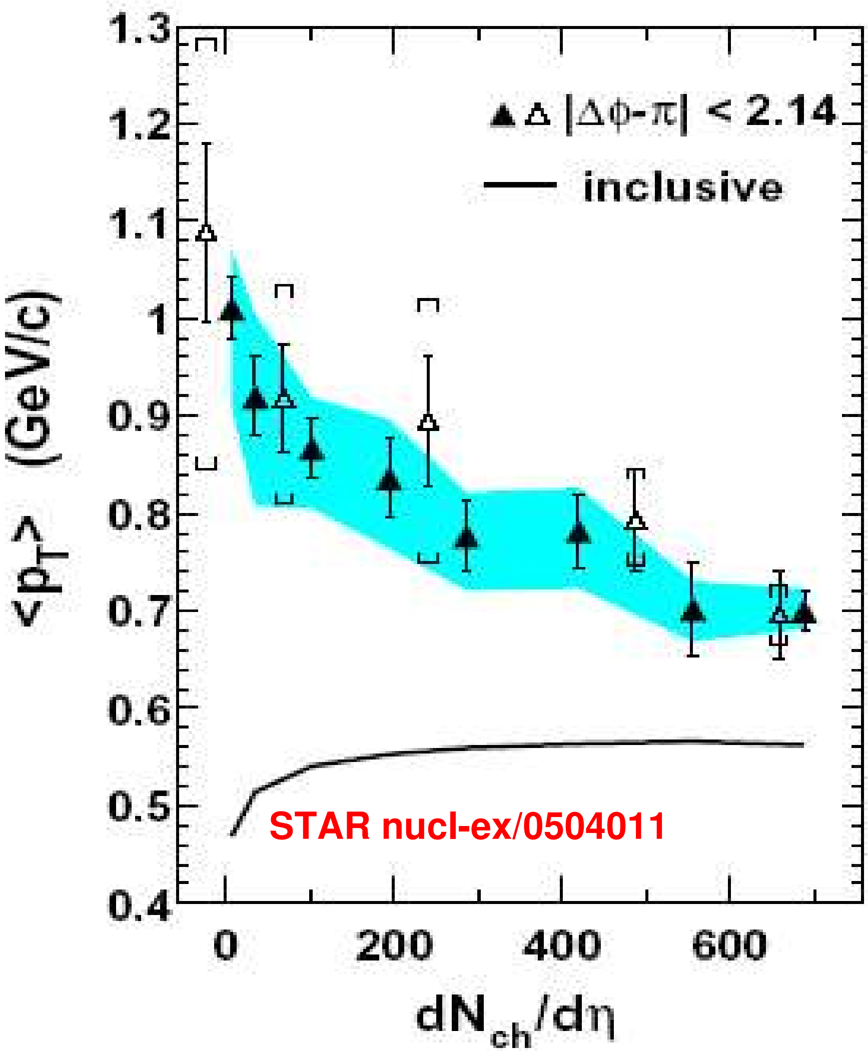
$\sqrt{s}$ = 17.2 GeV

CERES/NA45 PRL92(2004)032301



shape of away side peak
changes (broadens)
momenta reduced

mean p_t in cone opposite to leading trigger particle



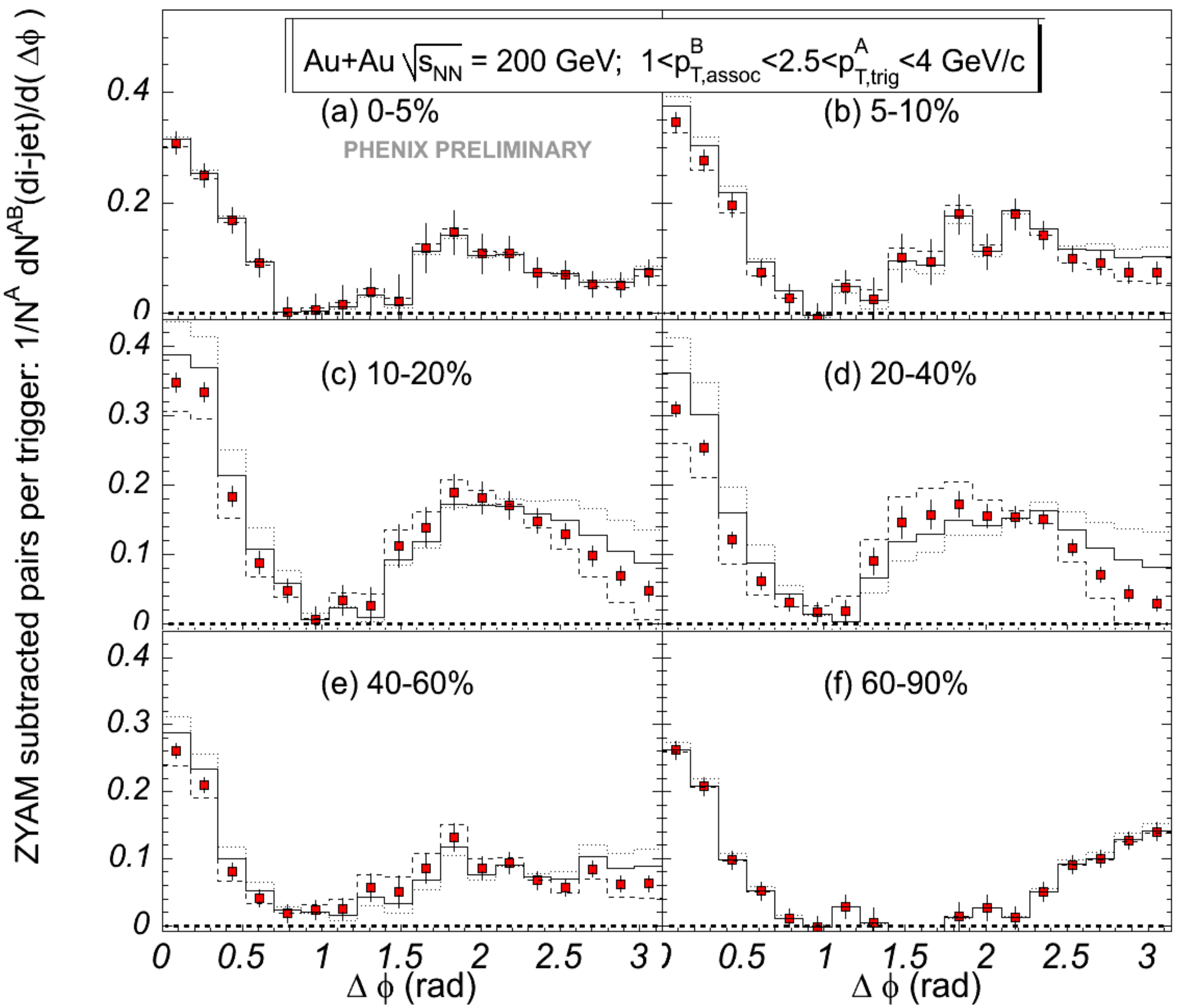
for central collisions mean p_t on opposite side looks nearly thermalized

$\sqrt{s_{NN}}$ = 200 GeV Au+Au results:

- Closed symbols ⇔ $4 < p_T^{trig} < 6$ GeV/c
- Open symbols ⇔ $6 < p_T^{trig} < 10$ GeV/c

Assoc. particles: $0.15 < p_T < 4$ GeV/c

opening angle correlations between high p_t particles



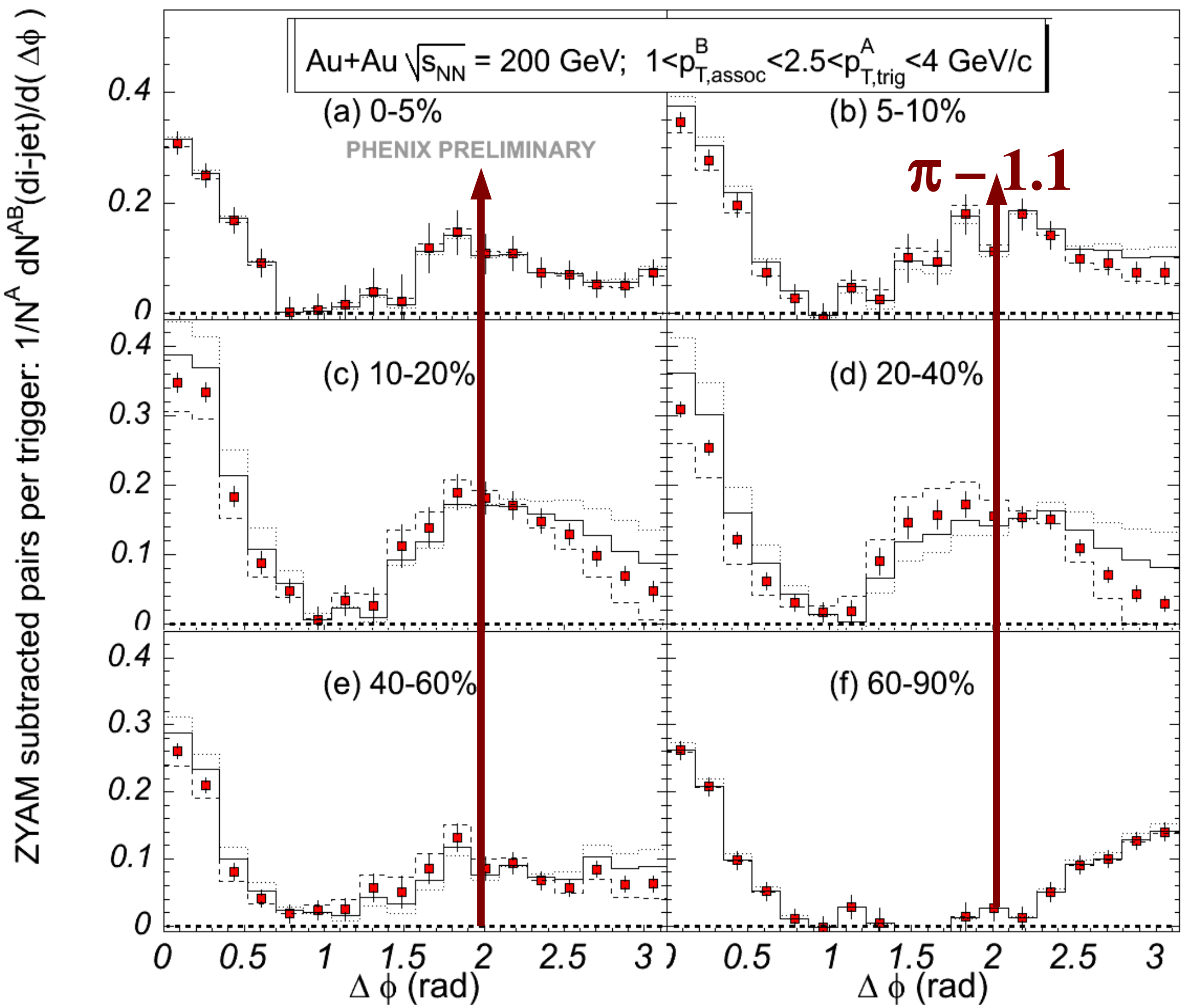
when asking for softer particle opposite hard trigger particle: dip (2 σ) at $\Delta\varphi = \pi$ except for most peripheral bin

PHENIX Coll., S.S. Adler et al., nucl-ex/0507004

Mach cone due to sonic boom from quenched jets?

original idea:
Stöcker/Greiner 1976
for nuclear reactions;
Stöcker 2004:
60º cone for jets in QGP

J.Casalderrey-Solana,E. Shuryak, D. Teaney,hep-ph/0411315



if this can be established
far reaching consequences:
sensitivity to speed of
sound and EOS

experimental challenge:
can one see cone in 2d?
rel to reaction plane?

Observations at RHIC after 3 years running

- hadron yields in chemical equilibrium, due to very rapid increase in densities close to T_c drive multi-particle collisions system to equilibrium
- hadron spectra and azimuthal asymmetries (flow) quantitatively described by hydrodynamics (multidifferential distributions)
  - requires rapid local thermalization i.e. large cross sections
  - implies initial $\varepsilon_0 \approx$ 11-14 GeV/fm^3 well above $\varepsilon_c = 0.7$ GeV/fm^3 and $T_0 \approx 2\ T_c$
- high p_t hadrons suppressed in central AuAu collisions
  - medium effect, since not seen in dAu
  - jet quenching in hot medium expected
  - modelling with high parton density etc. successful but still schematic
  - different magnitude for baryons (quark coalescence?)
- azimuthal correlations of high p_t particles:
  - disappearance of away-side peak for central AuAu collisions when p_t high enough
  - lower partner p_t: away-side peak broadened, momenta thermalized