Multi-particle correlation in a multi-phase transport model

Shanghai Institute of Applied Physics, CAS

Ma Guo-Liang (馬國亮)

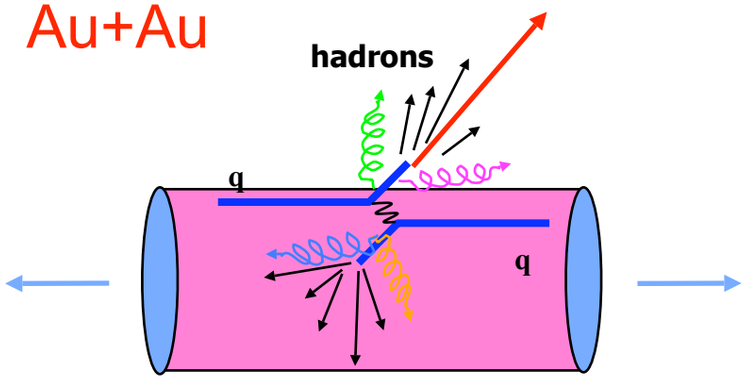
Collaborators: S. Zhang, Y. G. Ma, H. Z. Huang, X. Z, Cai, J. H. Chen,

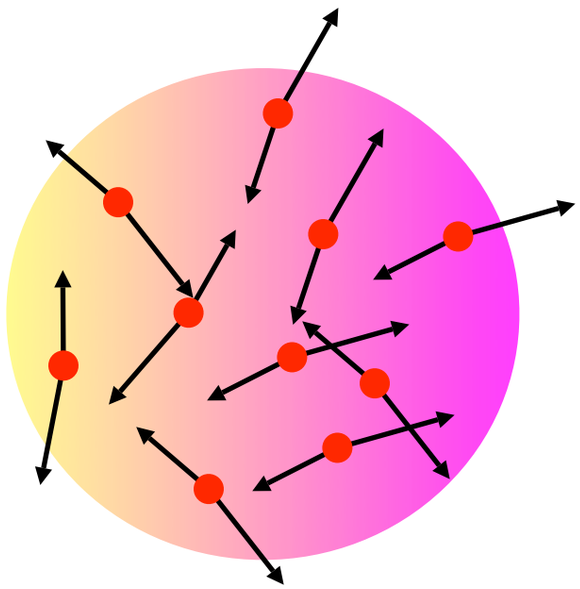
SINAP 中國科學院上海應用物理研究所

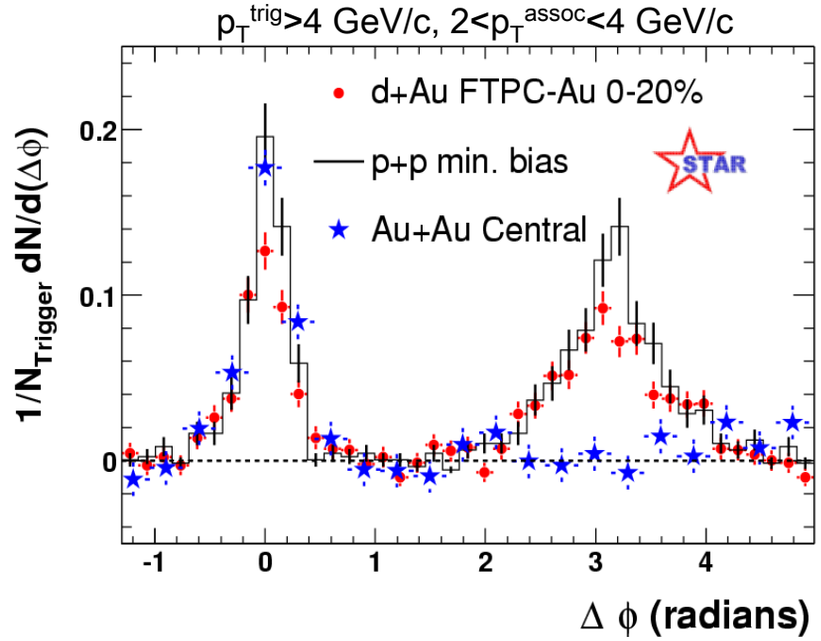
Outline

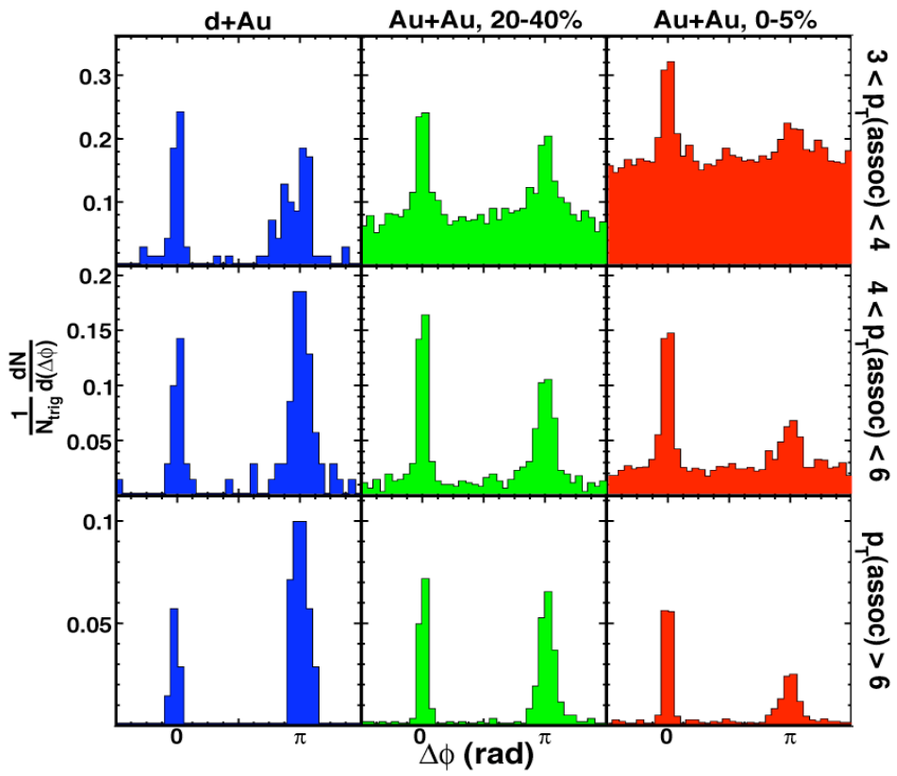
- *Introduction (Motivation and Model)*
- *Result and discussion:*
  - *Mach-like structure*
  - *Ridge phenomenon*
- *Conclusion*

Jet production and di-hadron correlation

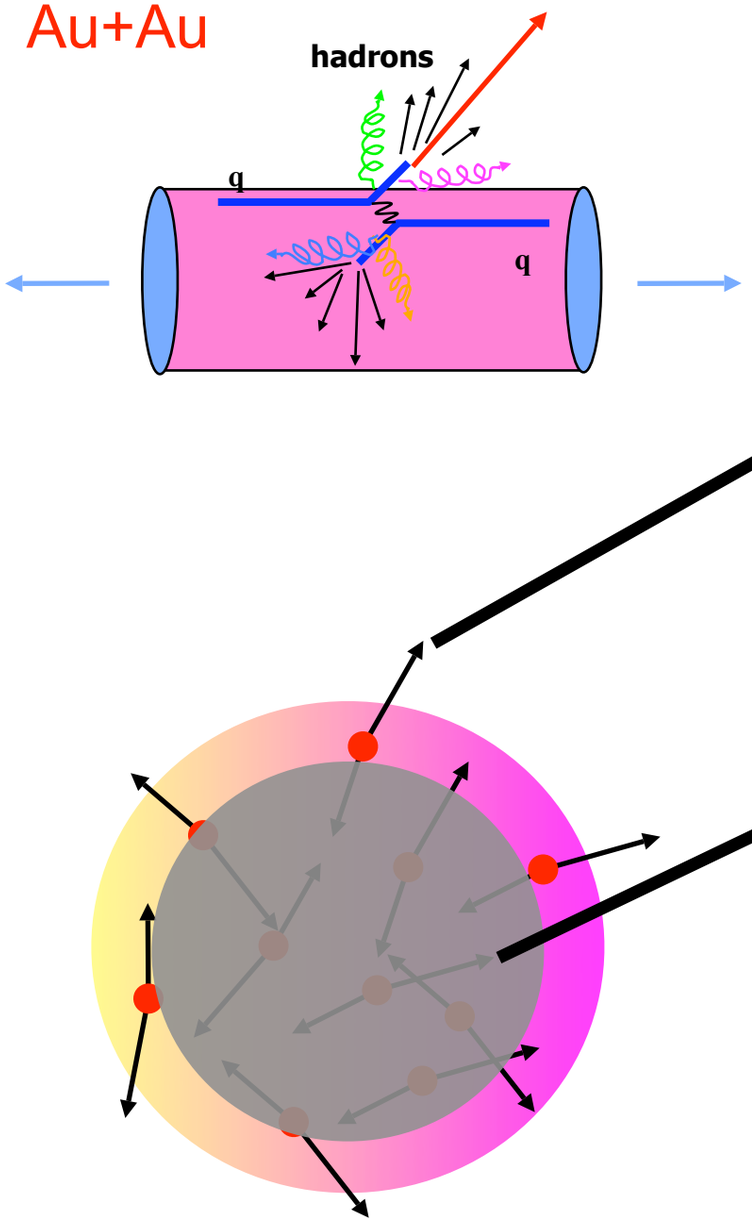


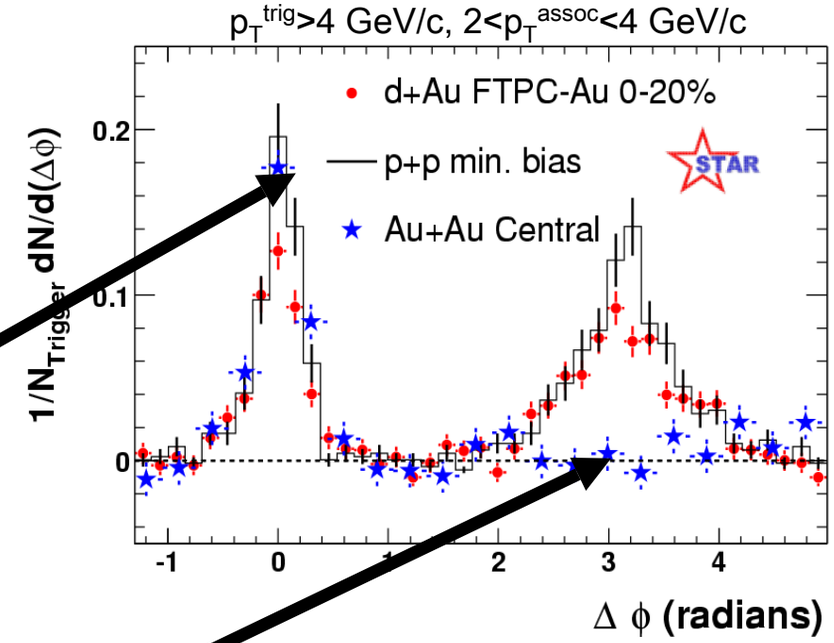


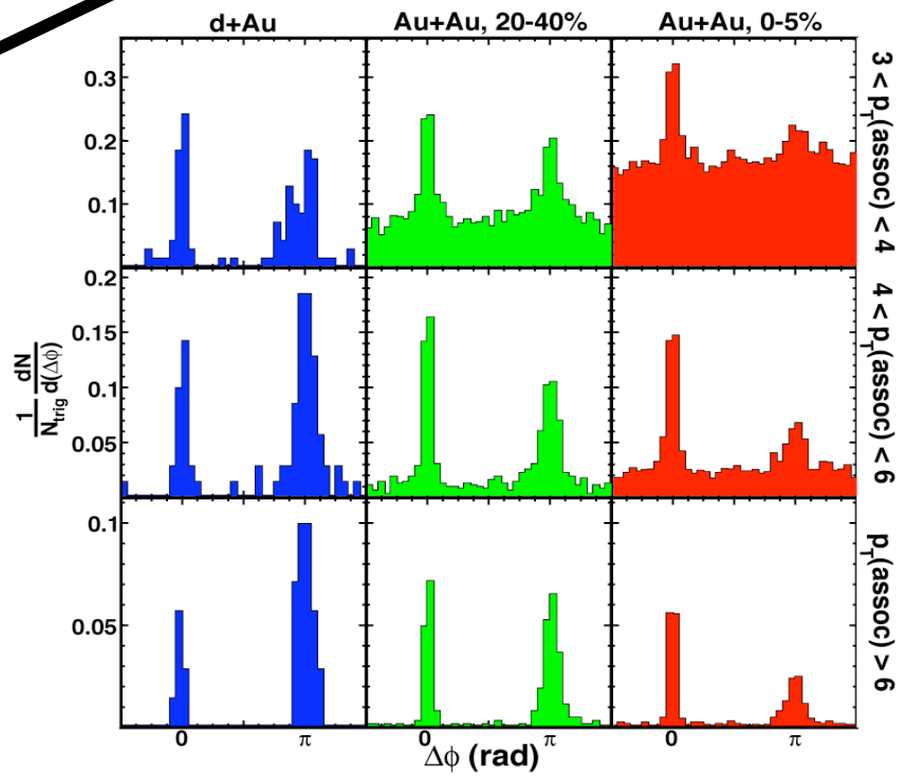




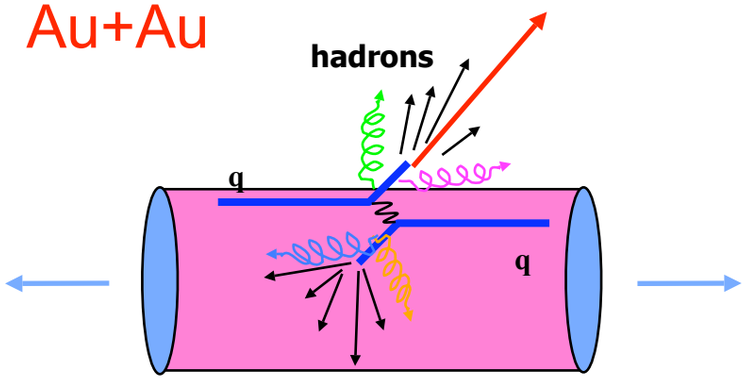
Jet production and di-hadron correlation

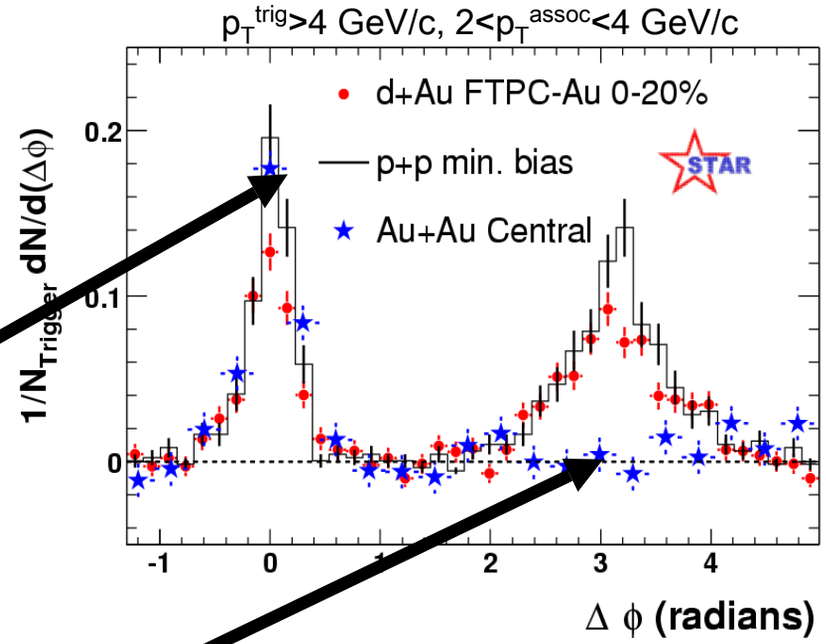


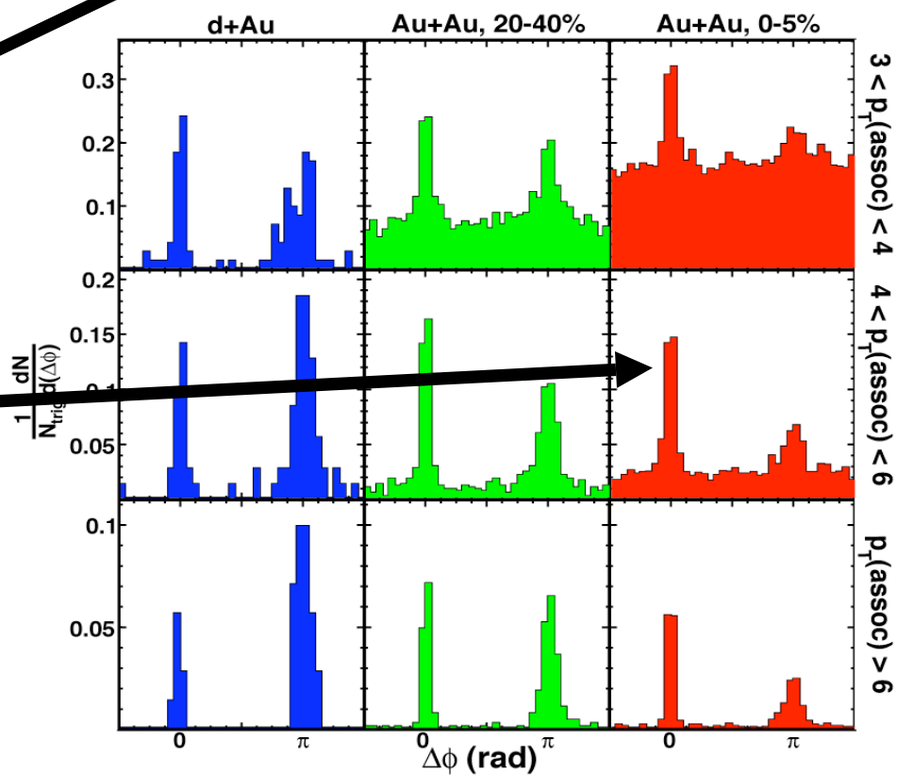




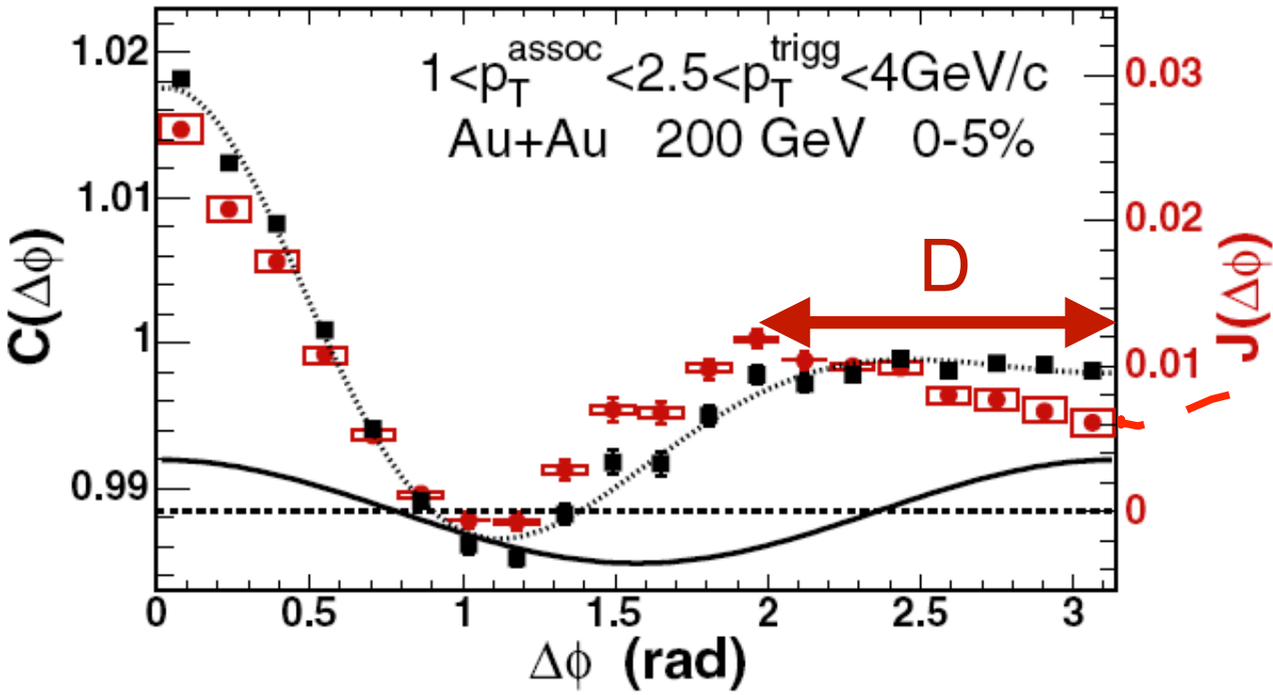
Jet production and di-hadron correlation

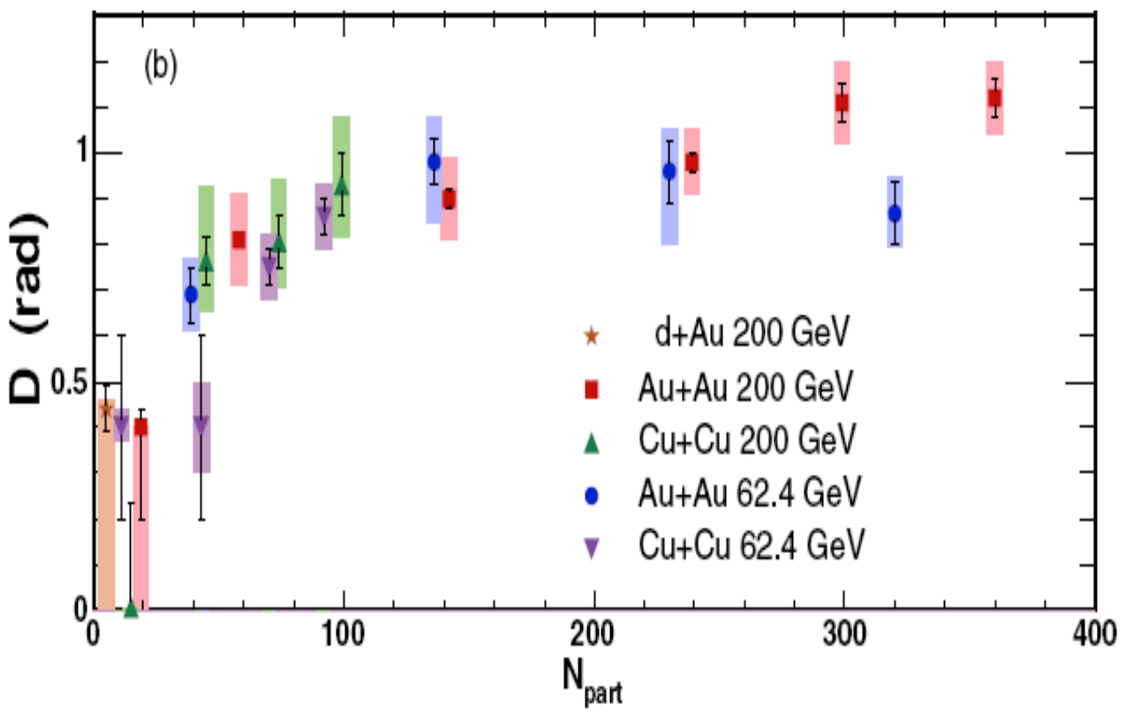


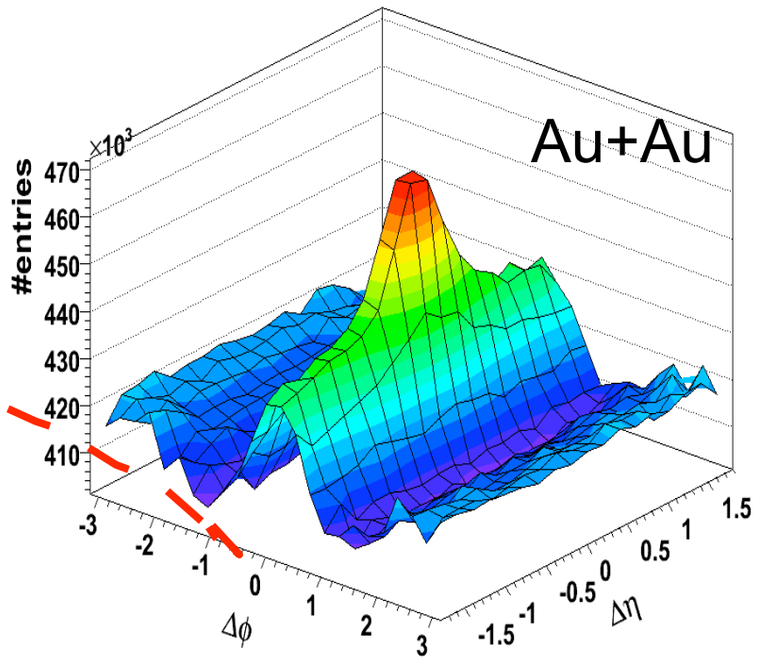


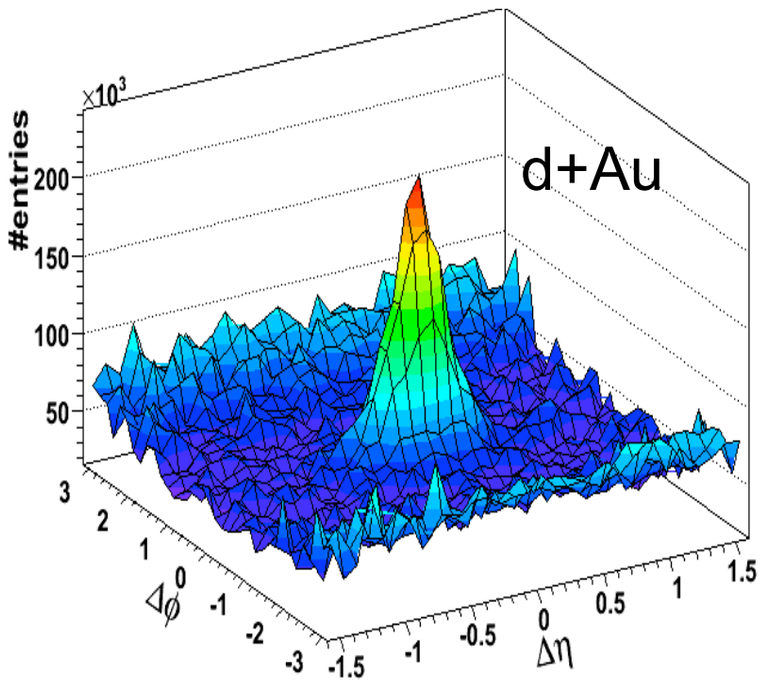


Mach-like and ridge structures



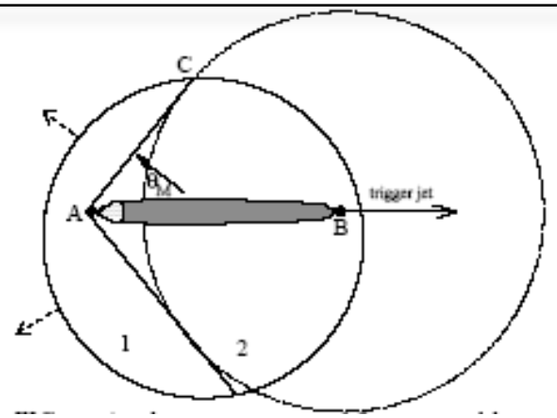






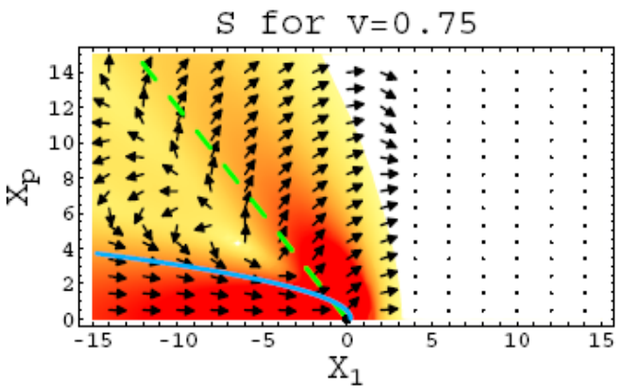
Theoretical interpretations of Mach-like structure (1)

Mach cone shock wave:

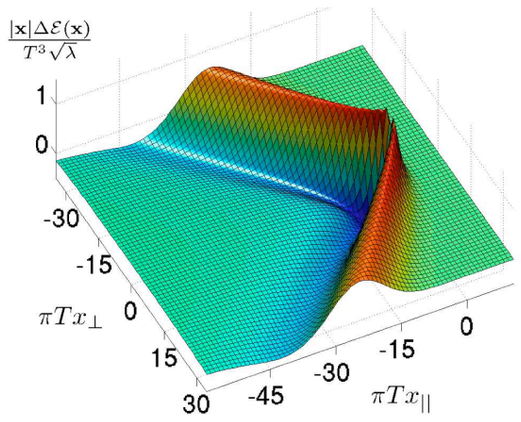


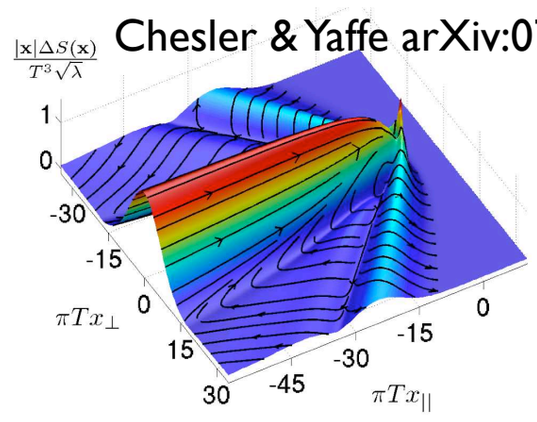
$$\frac{c_s}{v_{parton}} = \cos(\theta_M) \qquad c_s^{\,2} = \frac{\partial p}{\partial \varepsilon};\ v_{parton} \approx c$$

Casalderrey-Solana, Shuryak, Teaney, hep-ph/0411315



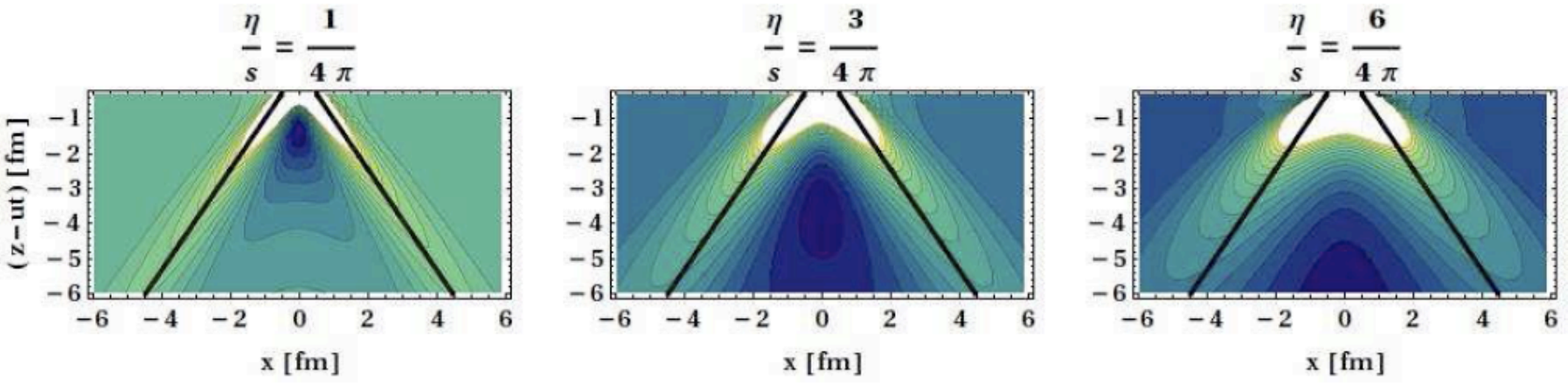
Gubser, Pufu, Yarom
arXiv:0706.4307





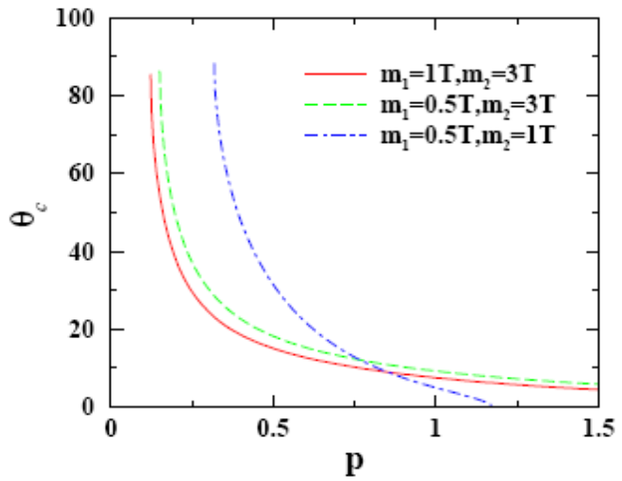
Chesler & Yaffe arXiv:0712.0050

Neufeld, arXiv: 0807.2996



Theoretical interpretations of Mach-like structure (2)

Cherenkov radiation:

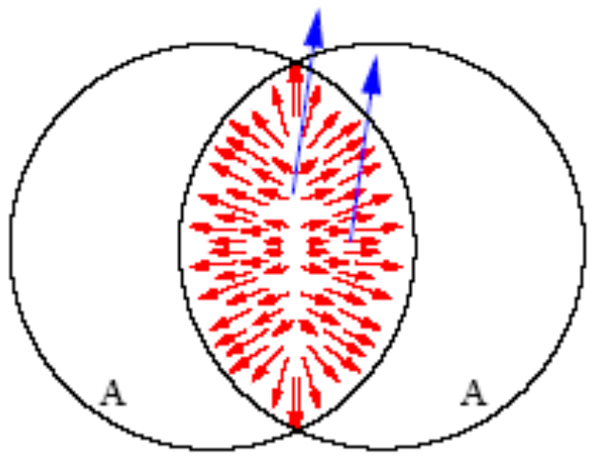


$\Theta_{emission} = \arccos\ (1/n(p))$

PRL 96, 172302 (2006)
Koch, Majumder, X.-N. Wang
NPA 767, 233 (2006) I.M. Dremin

Correlation of Jet with flowing medium:

PRC 72, 064910 (2005) Armesto

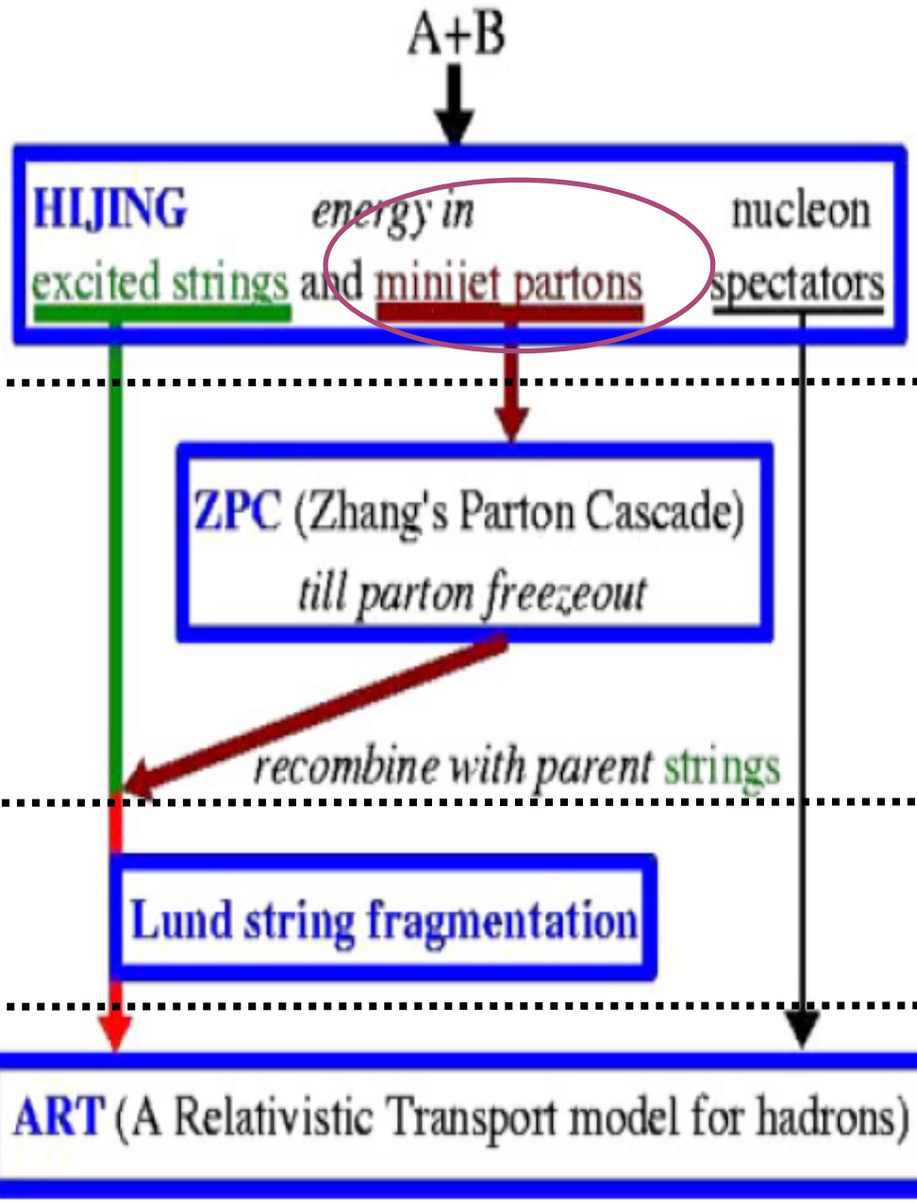


AMPT model

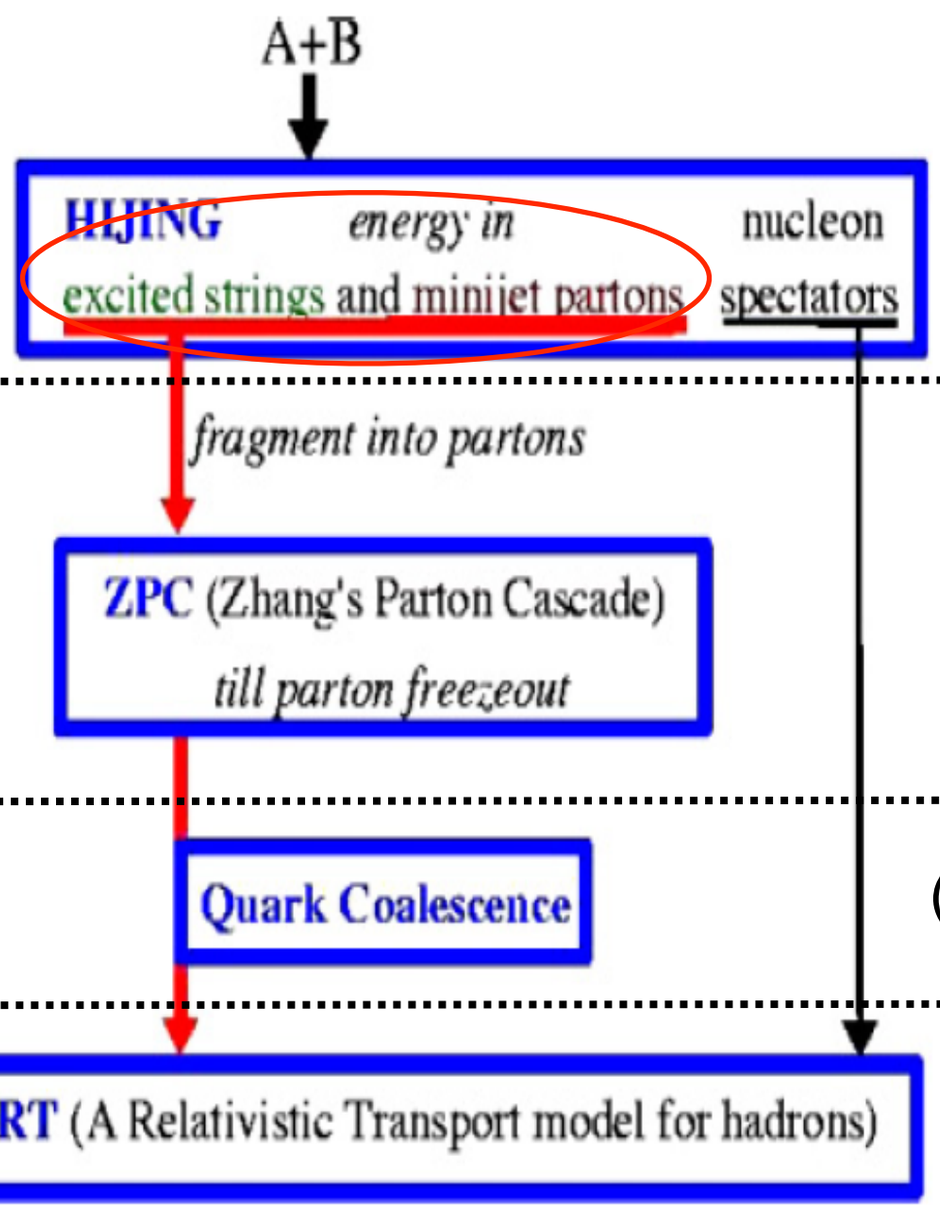
——*a multi-phase transport model* *(by C. M. Ko and Z. W. Lin et al.)*

PRC 72, 064901 (2005)

(1) Default AMPT Model



(2) Melting AMPT Model



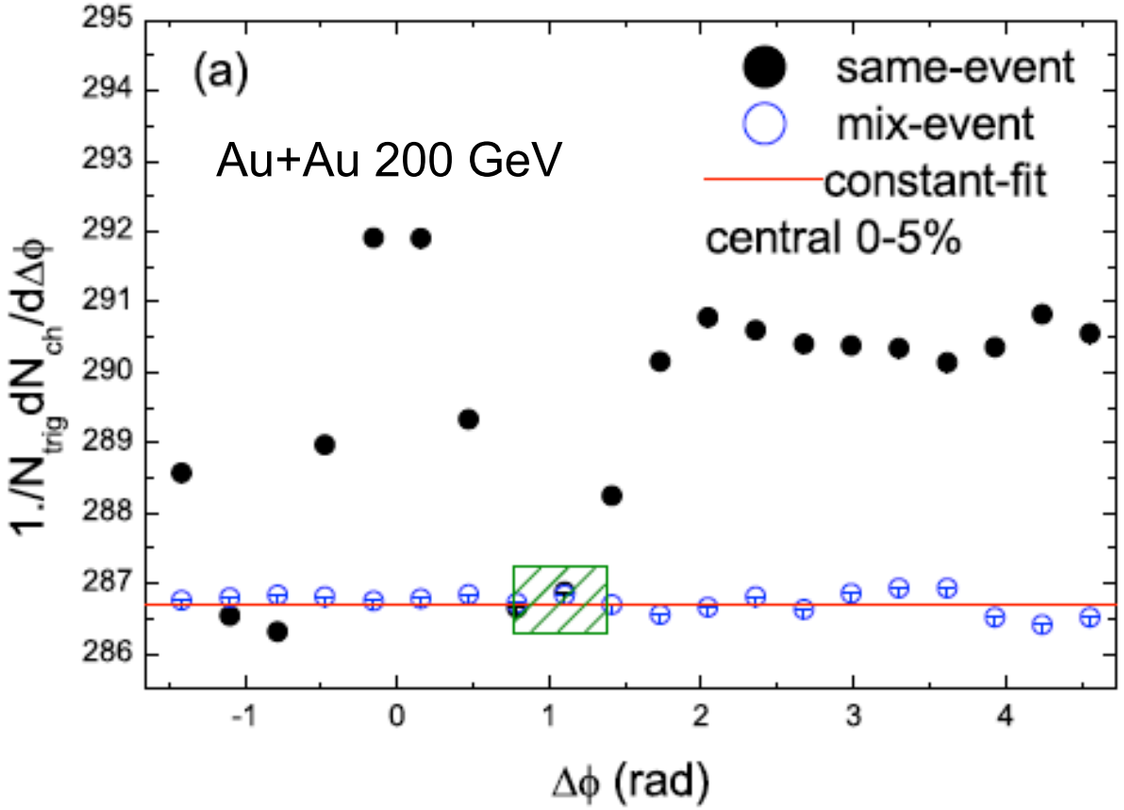
(1) initial condition

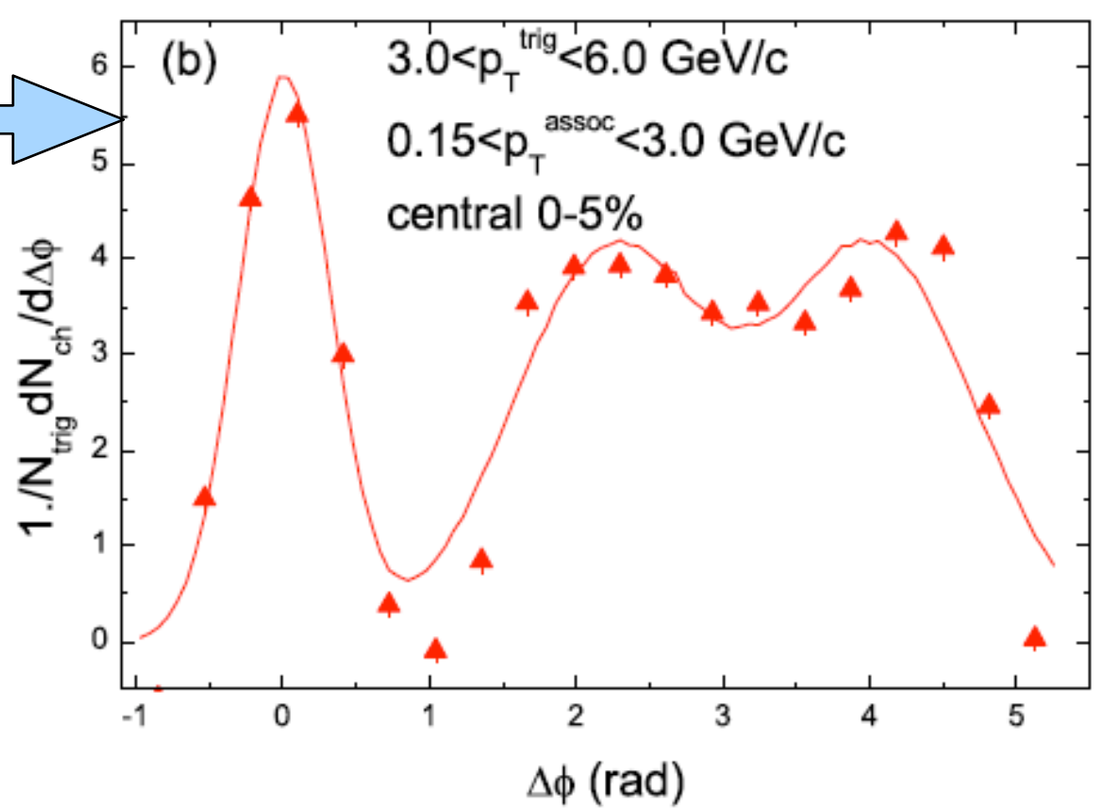
(2) parton cascade

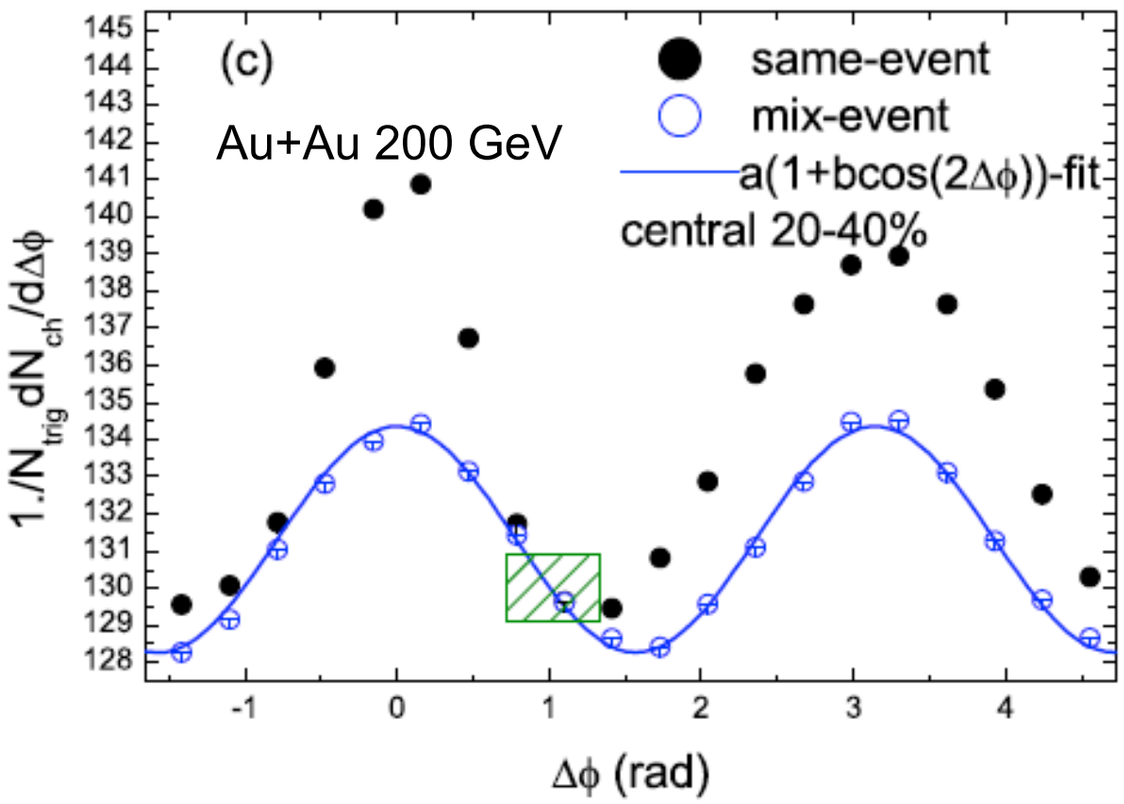
(3) hadronization

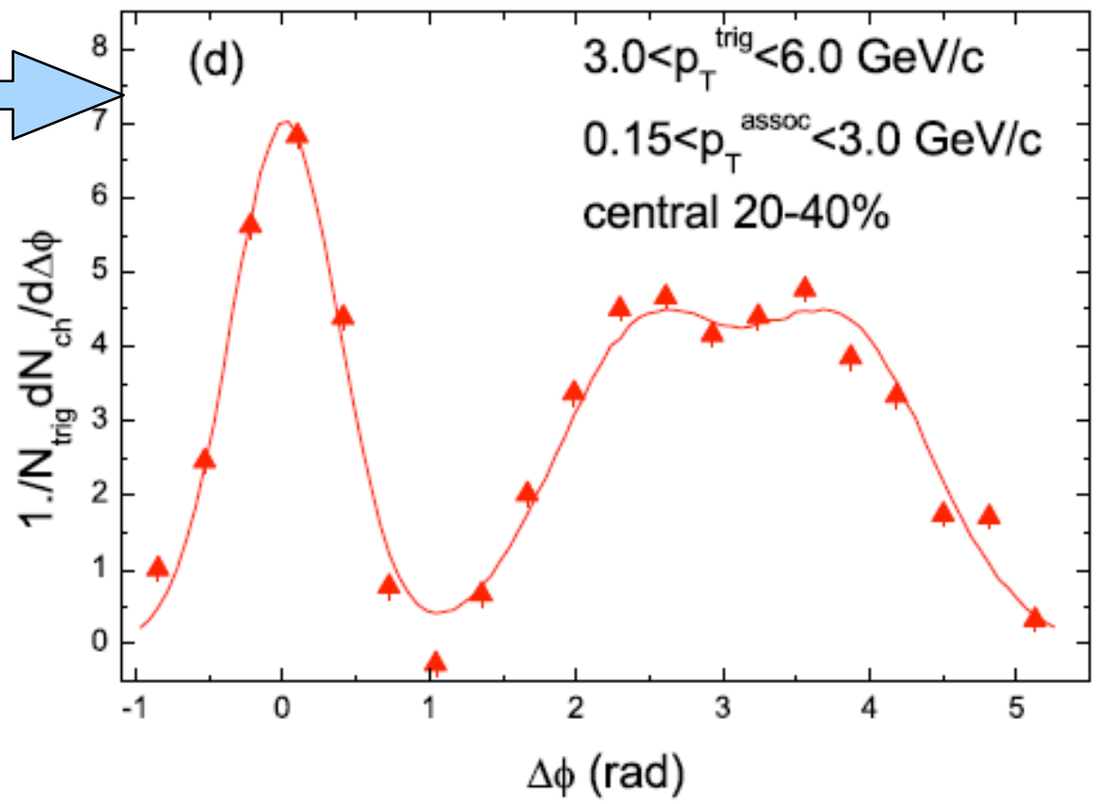
(4) hadronic rescattering

Mixing-event Technique



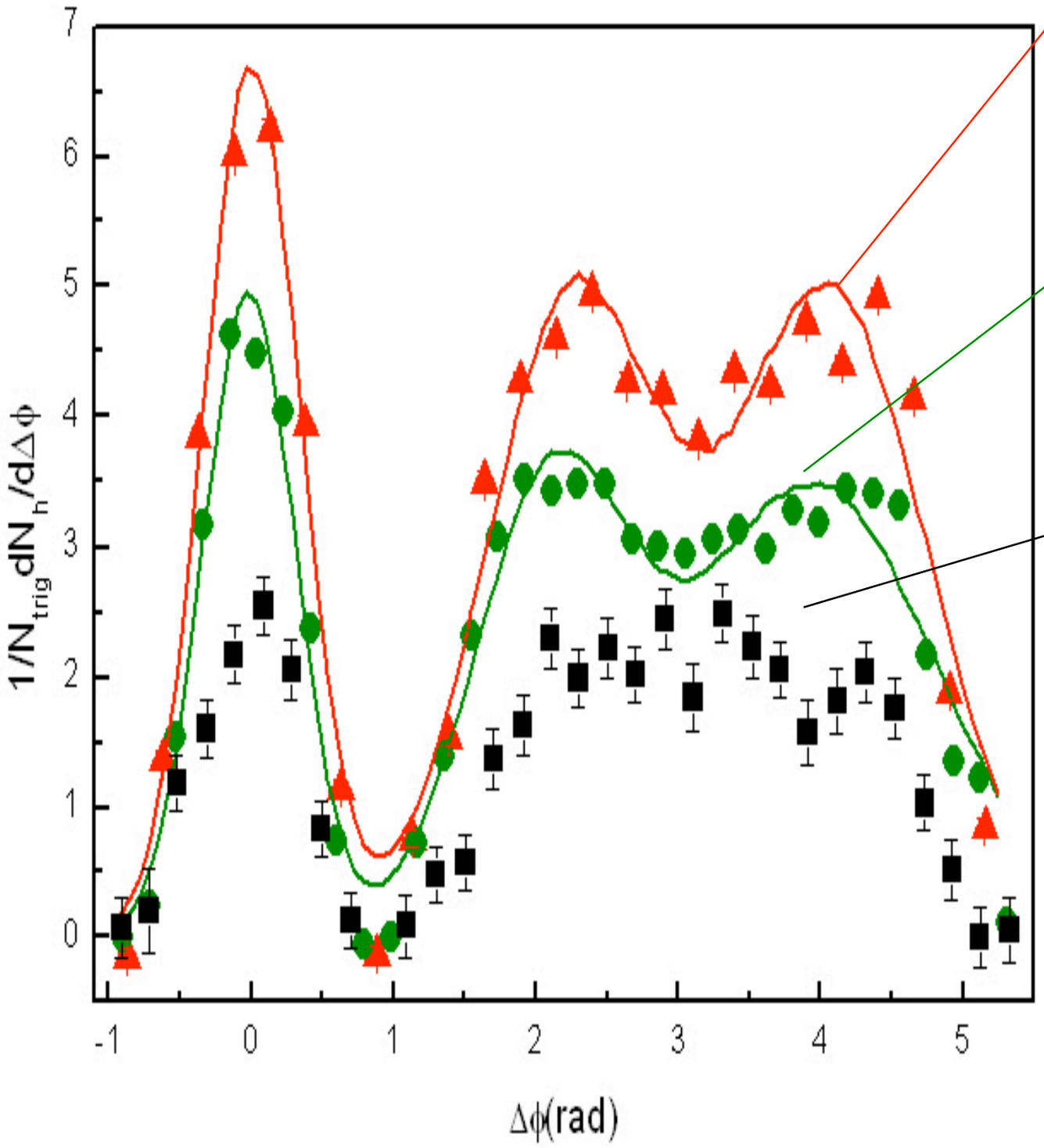






$\Delta\phi$ correlations from AMPT

($3<p_T^{trigger}<6$GeV/c , $0.15<p_T^{assoc}<3$GeV/c)



▲ melting version with hadronic rescattering (10mb)

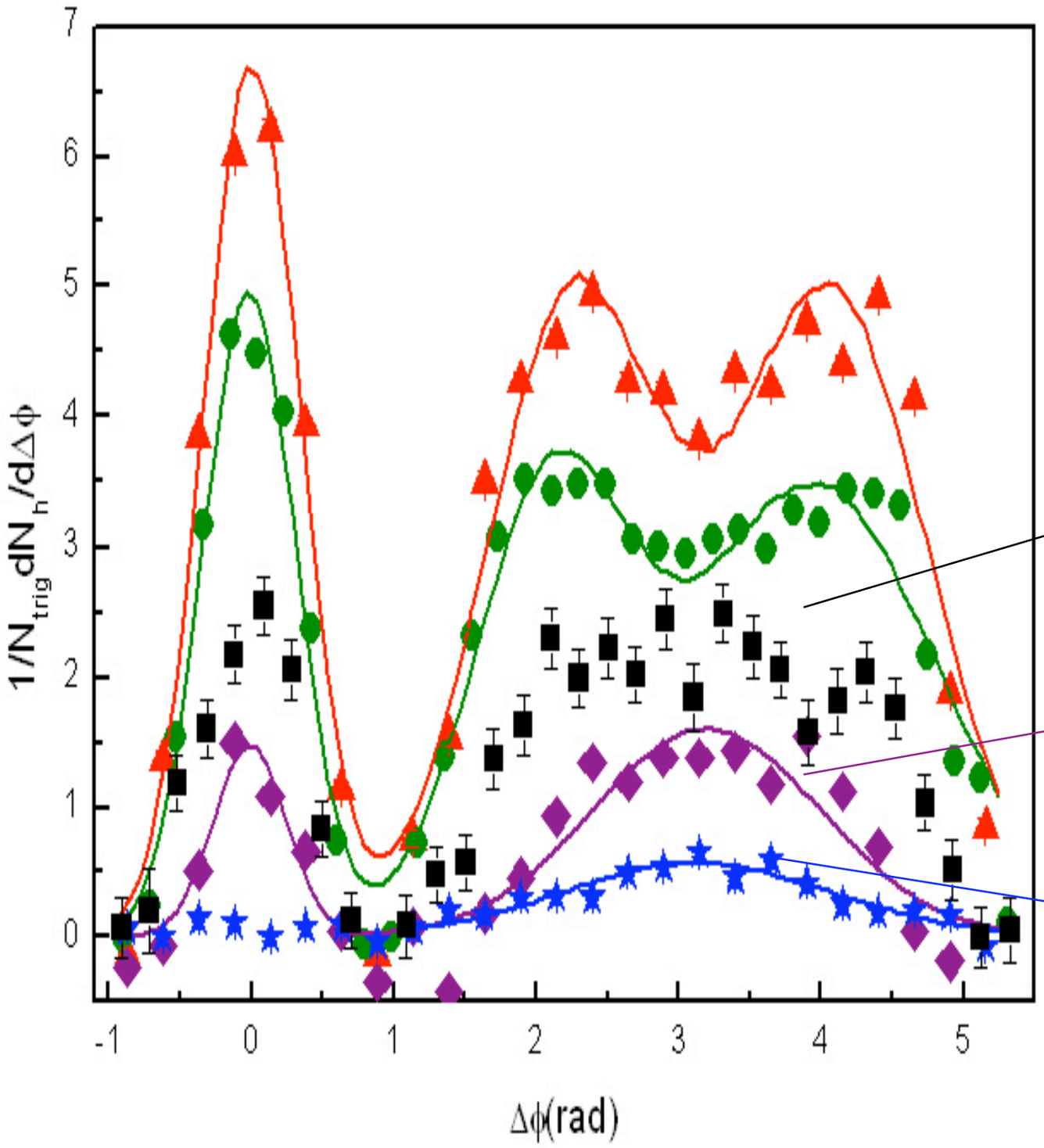
● melting version without hadronic rescattering (10mb)

■ *STAR data*
0-5% (4-6)x(0.15-4)GeV/c

- ***Mach-like structure is born in strong parton cascade process, and furthermore developed in hadronic rescattering process.***
- ***The problem of excessive correlation magnitude.***

PLB 641, 362 (2006) G. L. Ma et al.

$\Delta\phi$ correlations from AMPT ($3<p_T^{trigger}<6$GeV/c , $0.15<p_T^{assoc}<3$GeV/c)



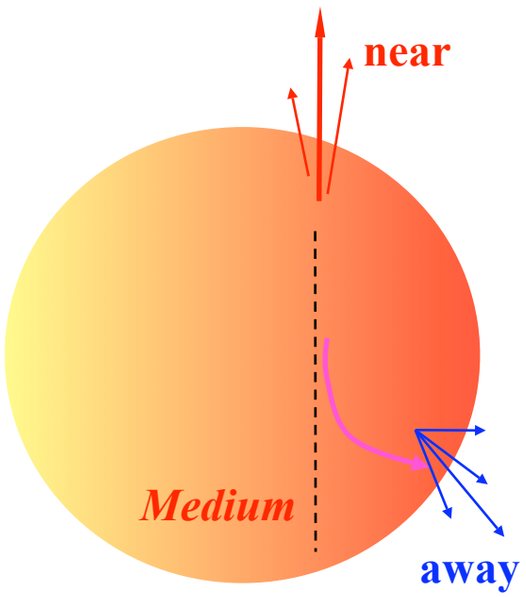
- ***No obvious splitting is seen on away side under the soft p_T cut in default version (only with hadronic resacttering)!***

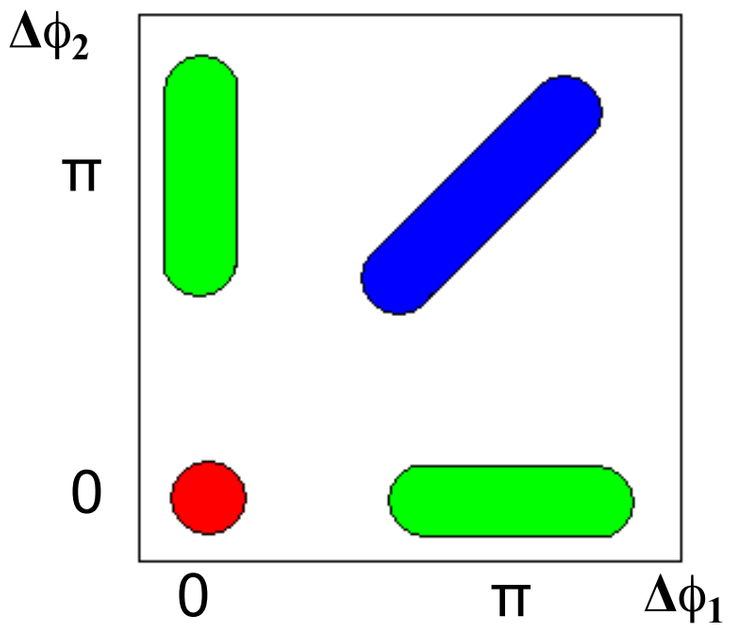
PLB 641, 362 (2006) G. L. Ma et al.

More information from 3-particle correlation

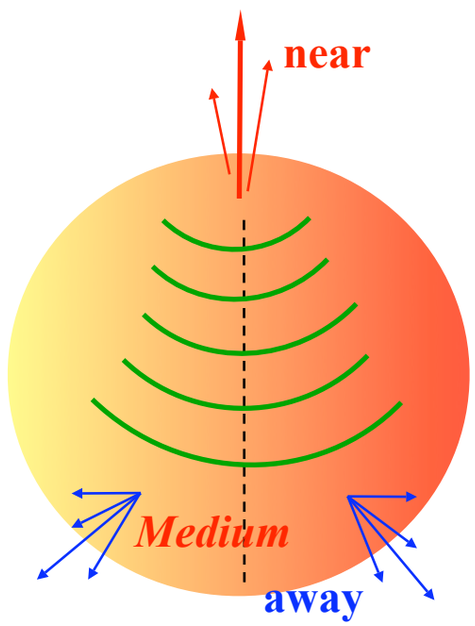
--- deflected jet or Mach cone shock wave?

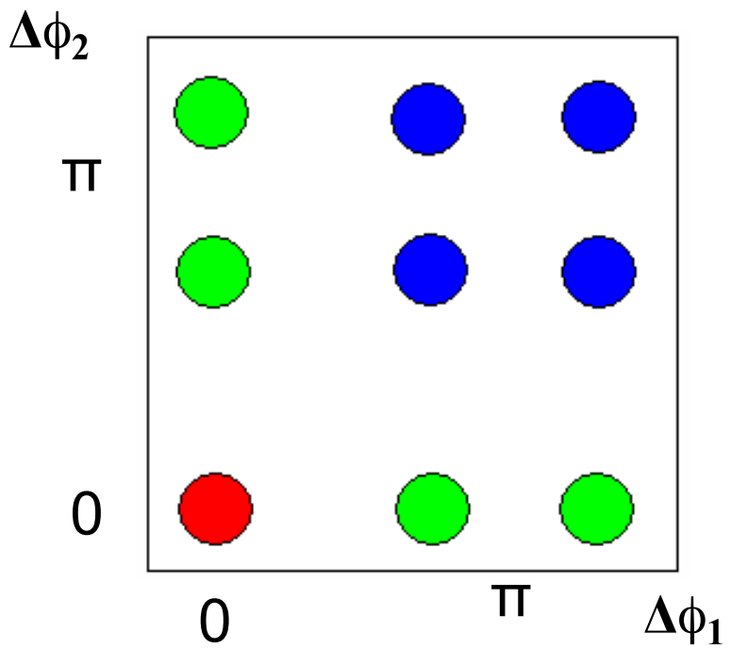
1. deflected-jet





2.Mach cone shock wave

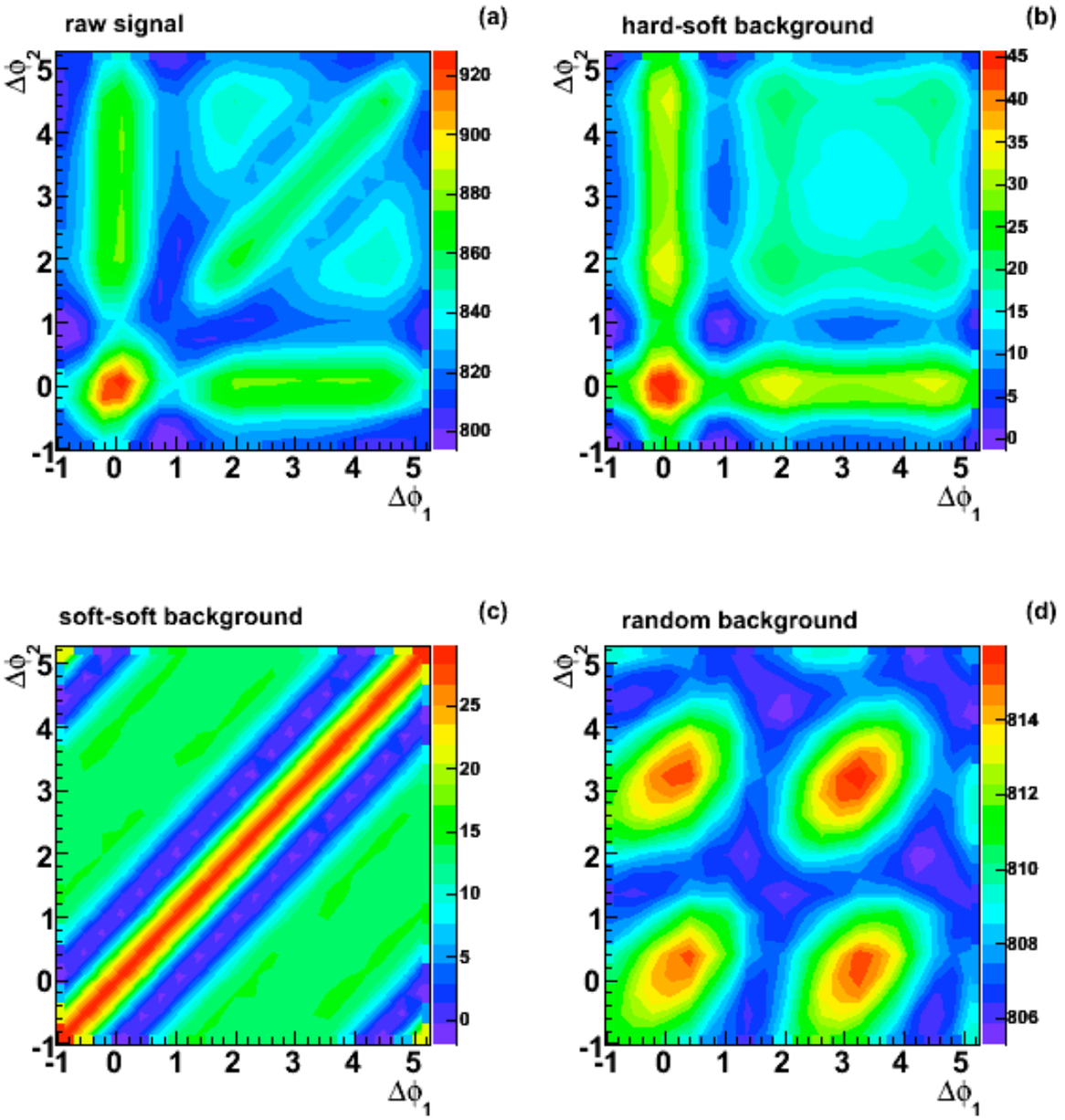




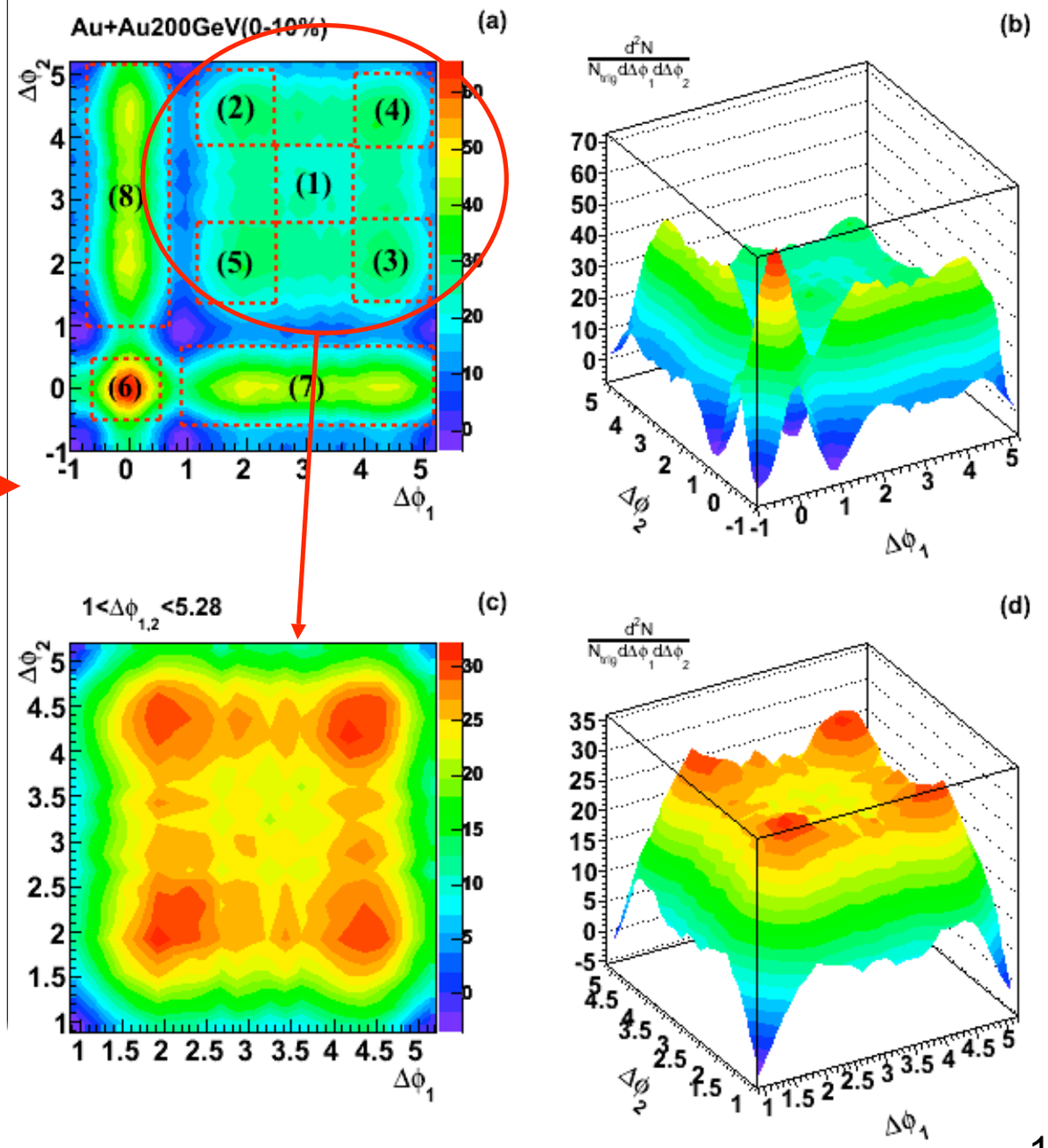
Three-particle correlations in AMPT

PLB 647, 122 (2007) G. L. Ma et al.

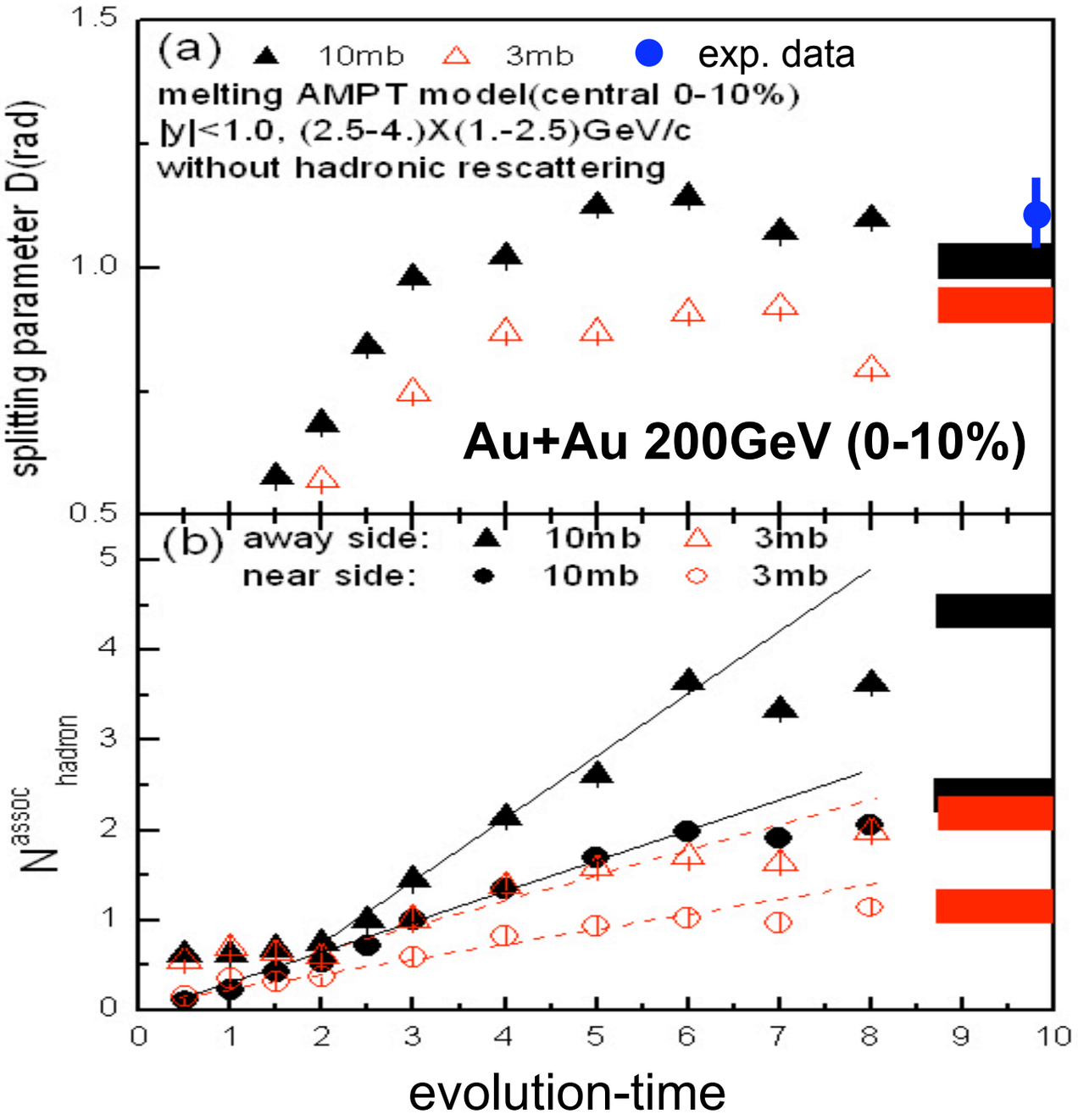
mix-event technique



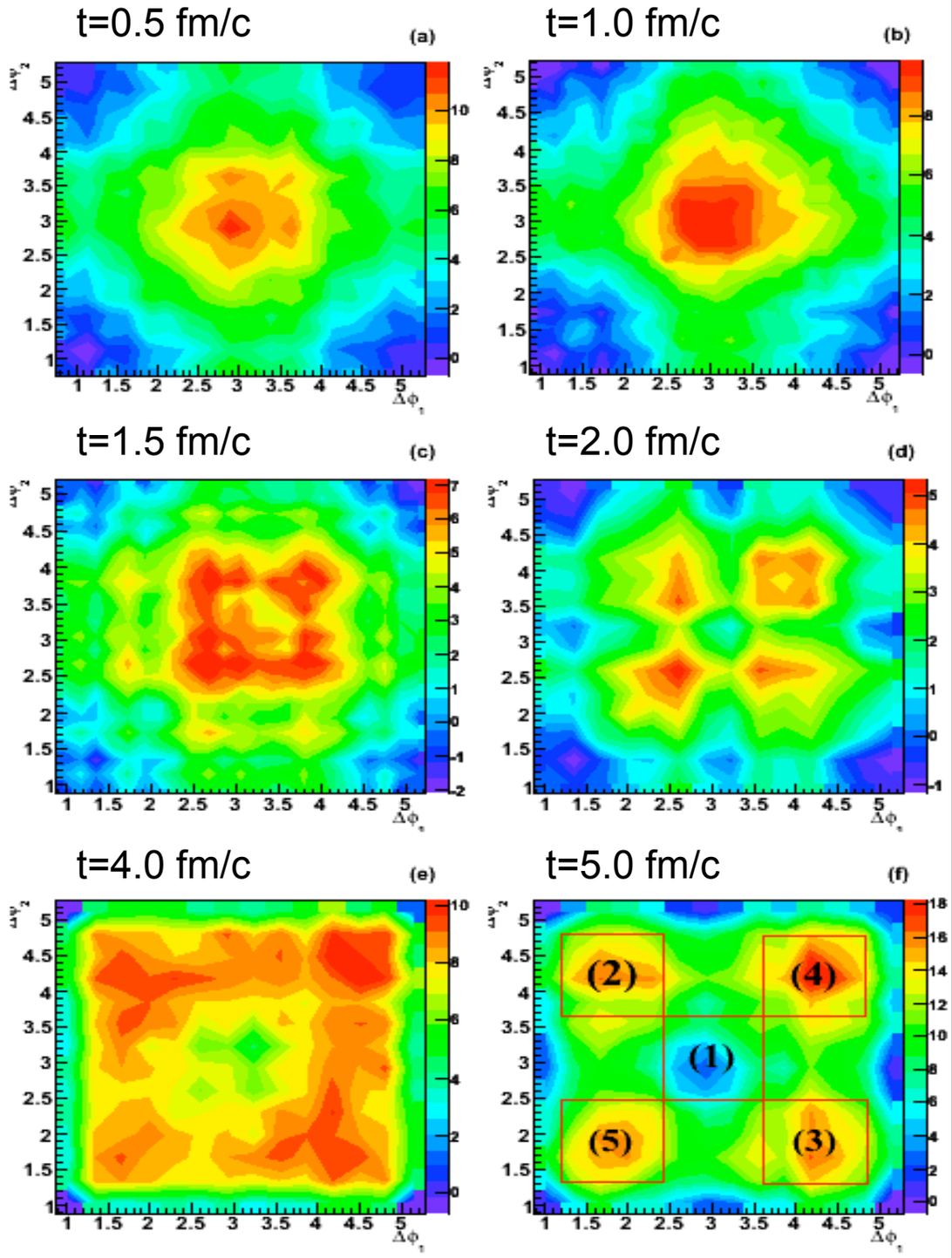
background subtracted 3-particle correlation signal



Partonic Mach-like Shock Waves



$$\eta/s \approx \frac{T}{5n\sigma}$$ → **Strong-coupling**

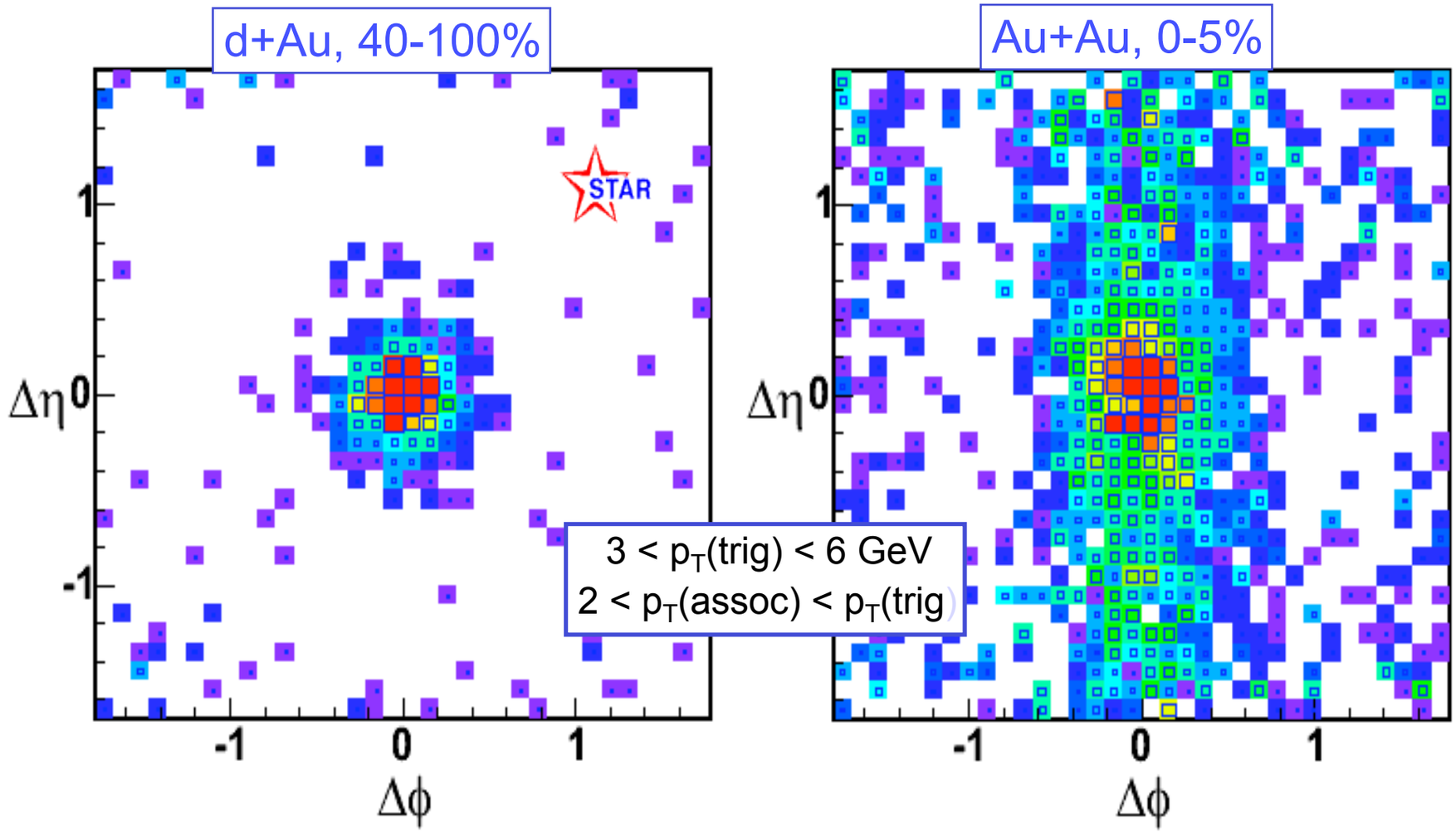


nucl-th/0610088, G. L. Ma et al.

“Ridge” observation

Additional near-side long range corrl. in $\Delta\eta$ (“ridge like” corrl.) observed.

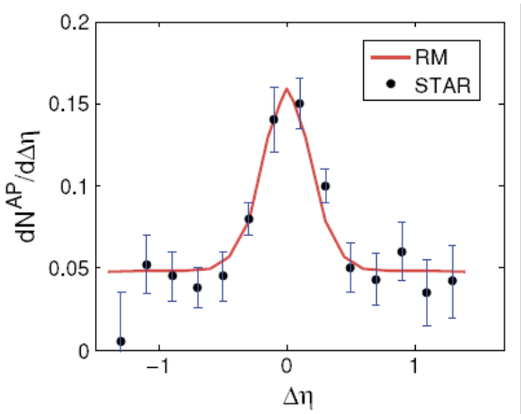
Dan Magestro, Hard Probes 2004,
STAR, nucl-ex/0509030 and P. Jacobs,
nucl-ex/0503022



Theoretical interpretations of ridge

1. Recombination model

Chiu and Hwa, PRC 72, 034903 (2005)



2. Longitudinal expansion of QGP

L.M. Satarov, H. Stöcker et al., PLB 627 (2005) 64

$$\eta_{\pm} = \pm c_s \log\left(\frac{\tau}{\tau_0}\right).$$

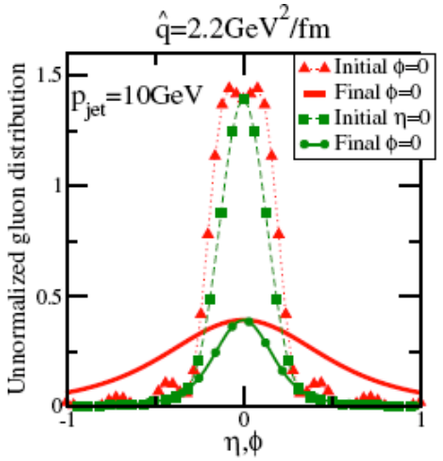
3. Collisional energy loss of heavy Q

Paul Romatschke, PRC 75, 014901 (2007)

$$\kappa_z/\kappa_\perp \simeq \frac{\langle \Delta\eta \rangle}{\langle \Delta\phi \rangle}.$$

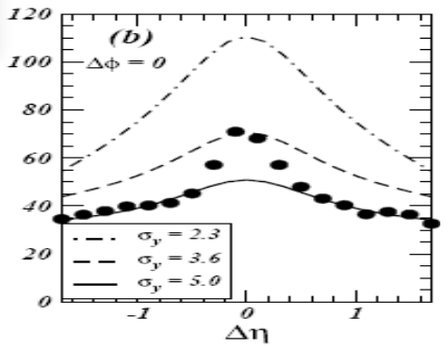
4. Turbulent color field

A. Majumder, B. Muller et al., PRL 99, 042301 (2007)



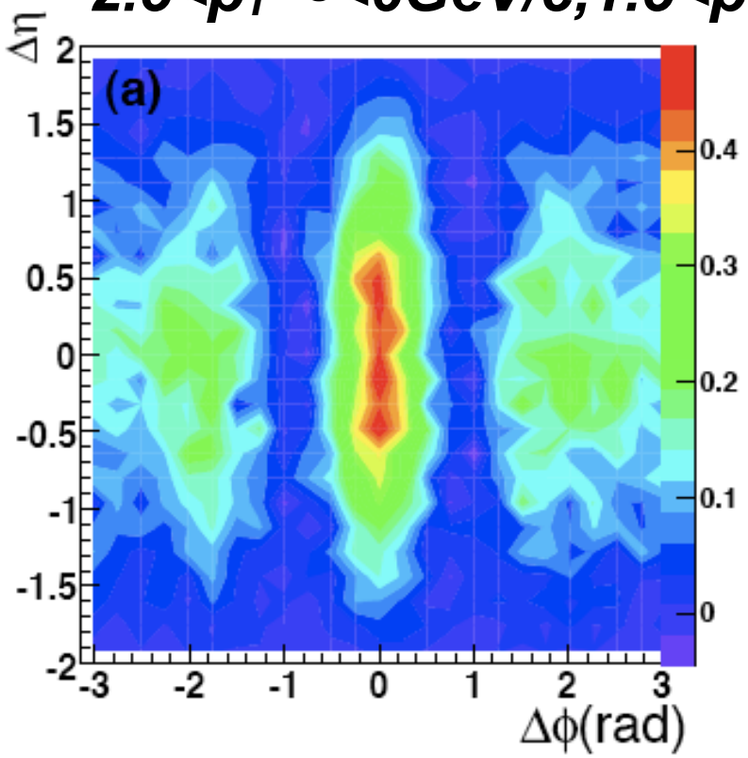
5. Momentum kick model

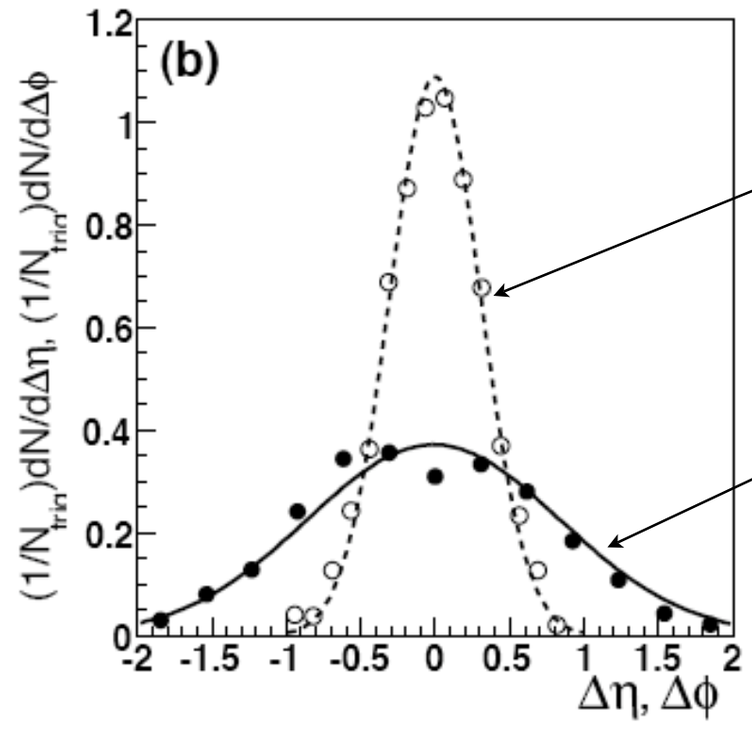
C.Y. Wong Phys. Rev. C 76, 054908 (2007)



Ridge correlation @ AMPT

2.5<p_T^{trig}<6GeV/c,1.5<p_T^{asso}<2.5GeV/c, |η|<1.0

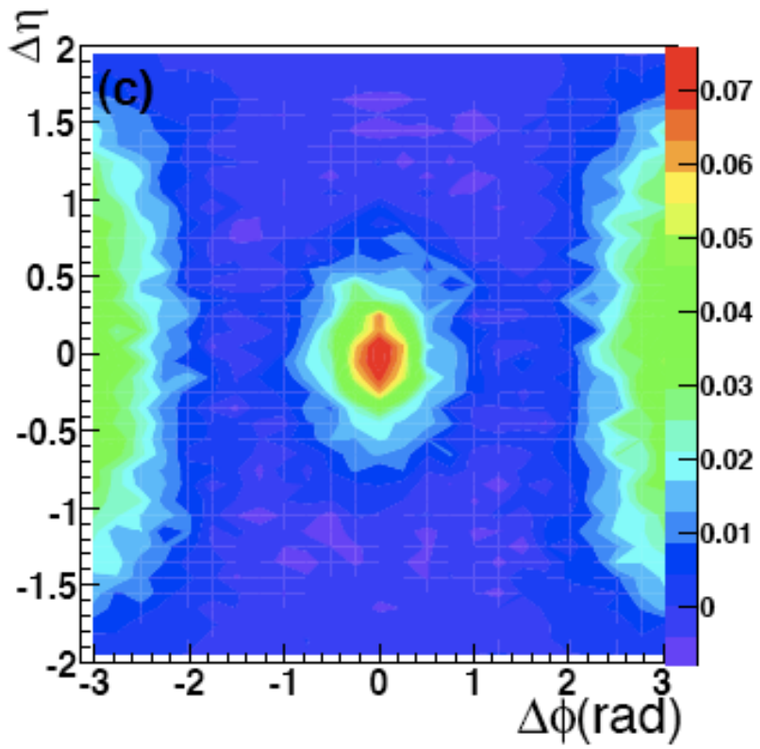


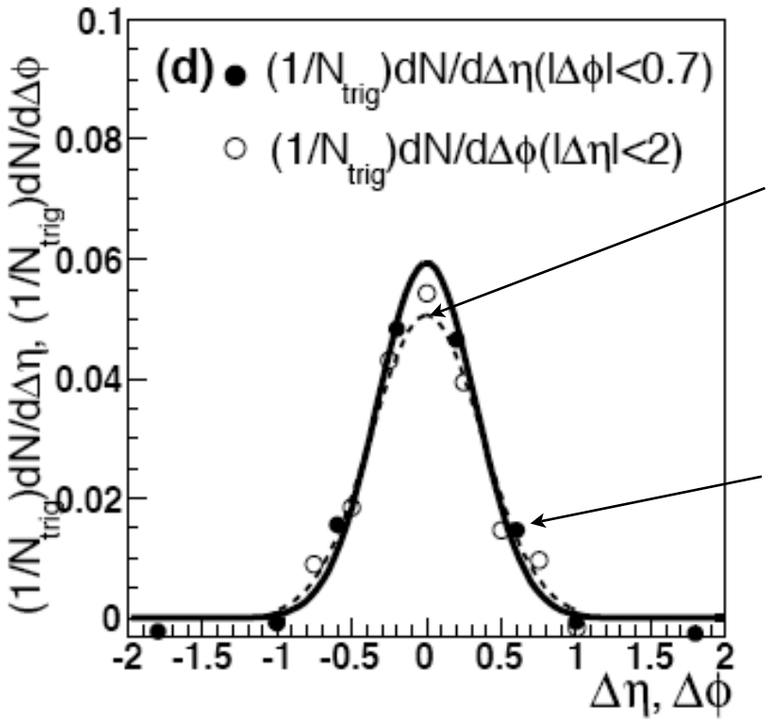


Au+Au 200GeV(0-10%) from Melting AMPT model:

○ *the projected Δϕ distribution in Au+Au 200 GeV(0-10%)*

● *the projected Δη distribution in Au+Au 200 GeV(0-10%)*





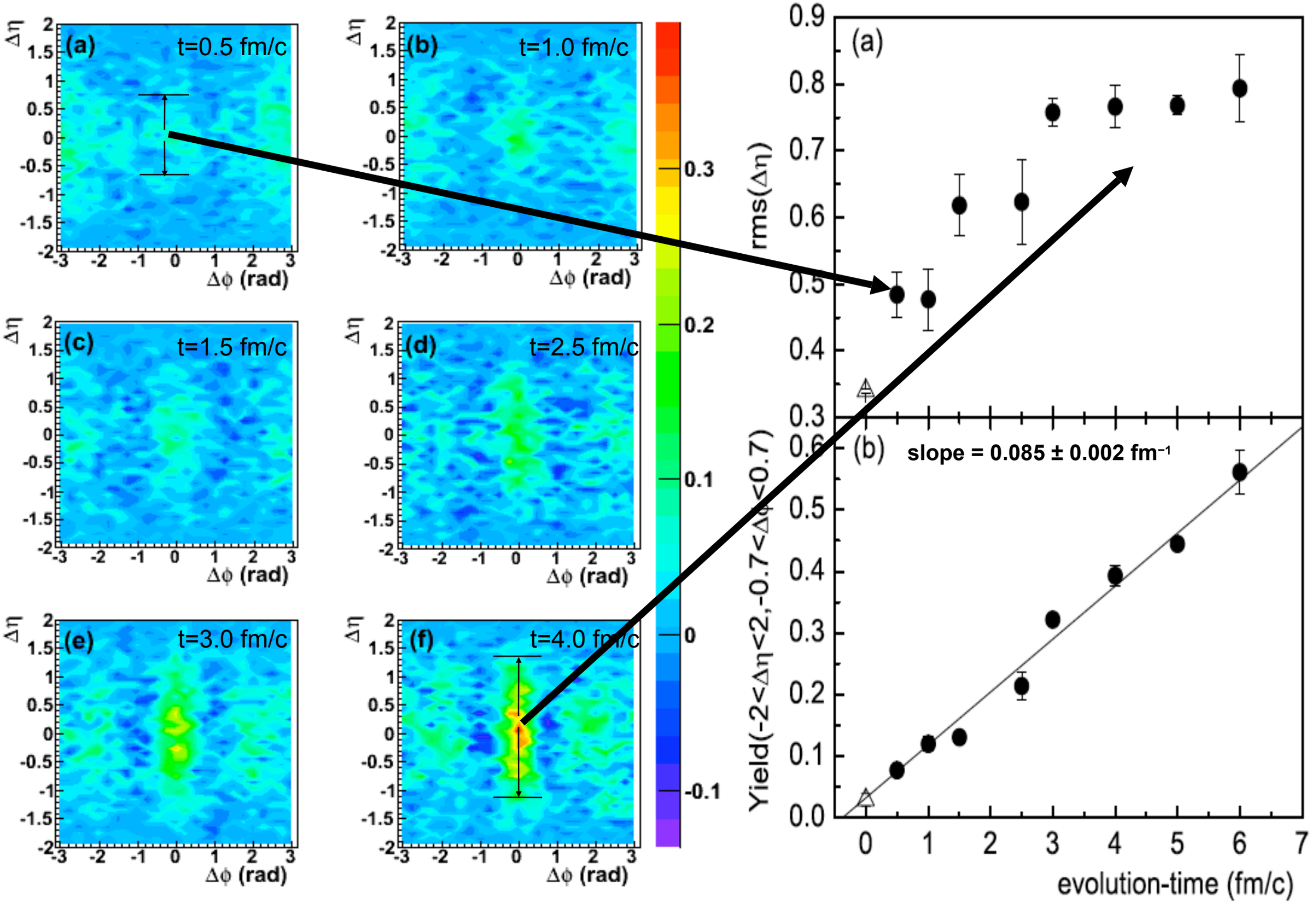
p+p 200GeV from Default AMPT model:

○ *the projected Δϕ distribution in p+p 200 GeV*

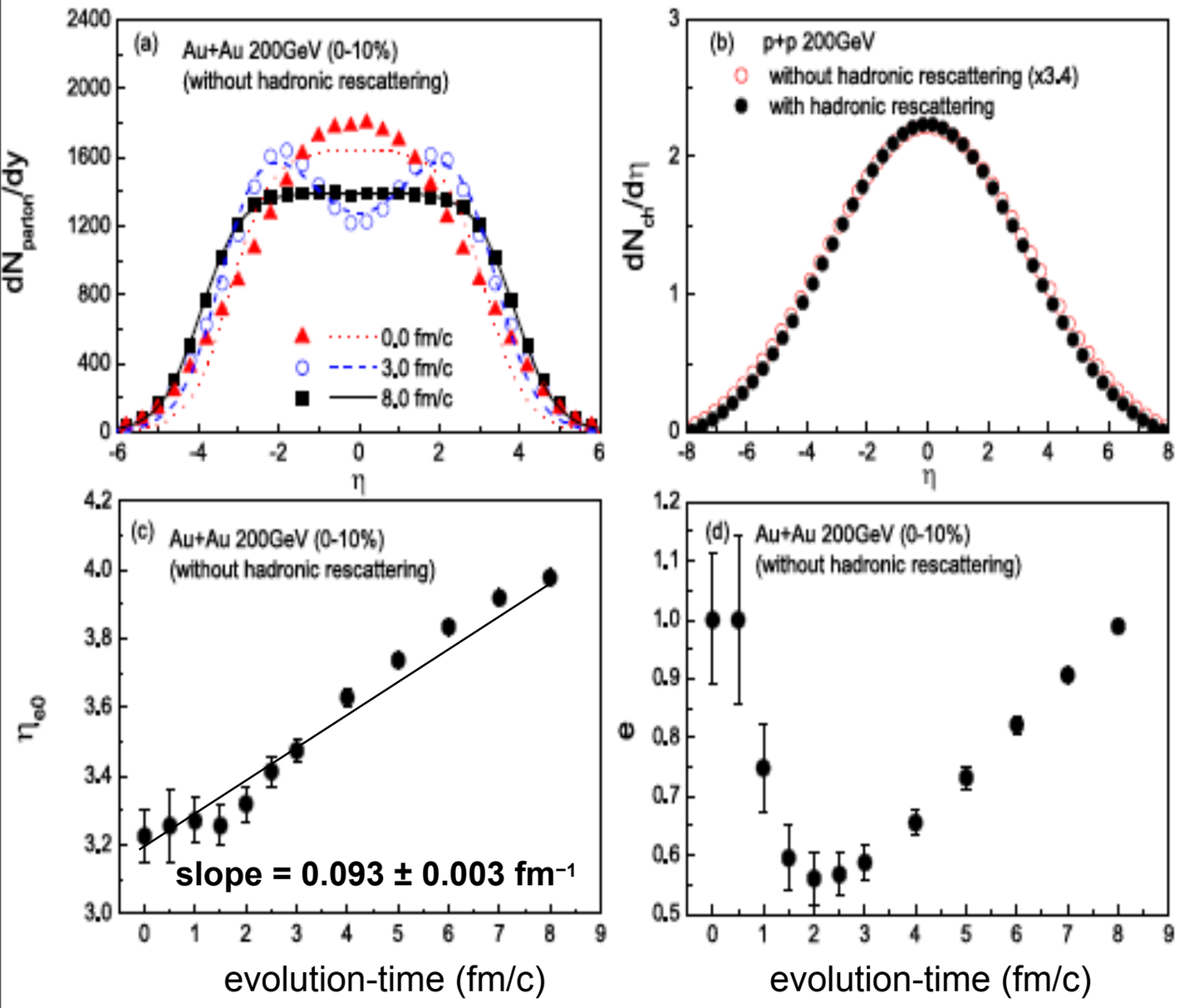
● *the projected Δη distribution in p+p 200 GeV*

G. L. Ma et al., arXiv:0807.3987

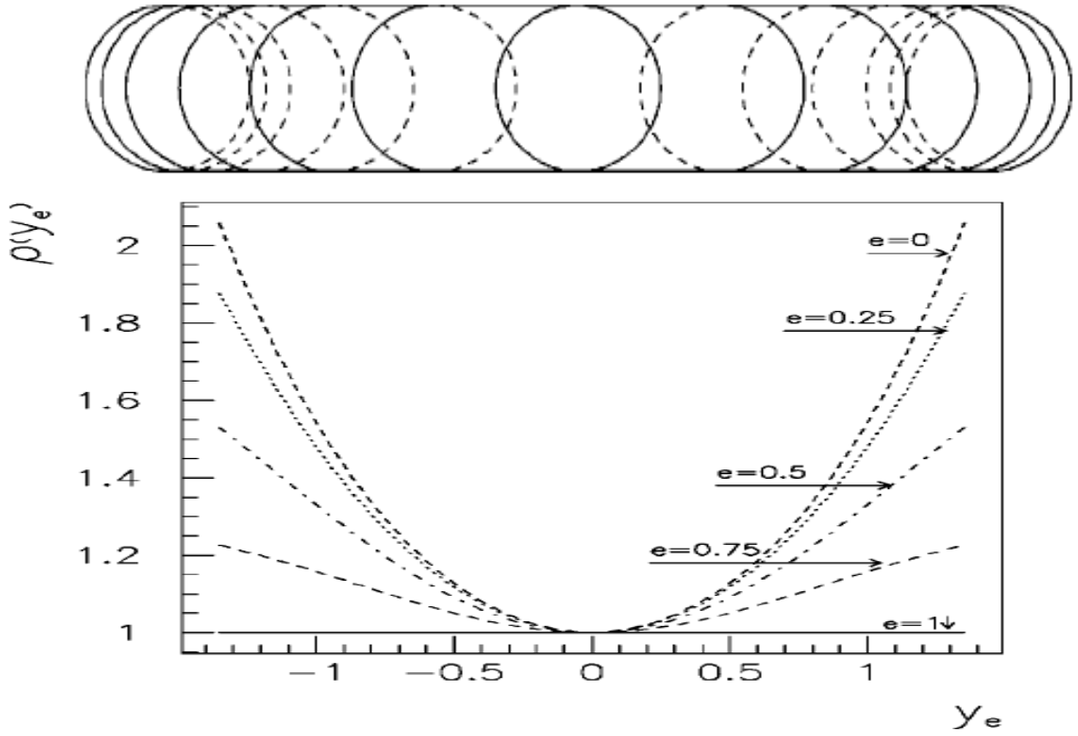
How the 'ridge' grows up?



Longitudinal flow from parton cascade



NUFM Fit (PRC, 63, 014901(2000)) **:**
(a nonuniform longitudinal flow model)



$$\frac{dn_{\mathrm{NUFM}}}{dy} = eKm^2T\int_{-y_{e0}}^{y_{e0}}\left(1+\frac{2T}{m\cosh(y-y_e)}+\frac{2T^2}{m^2\cosh^2(y-y_e)}\right)\times\exp(-m\cosh(y-y_e)/T)\rho(y_e)dy_e, \quad (1)$$

$$\rho(y_e)=\sqrt{\frac{1+\sinh^2(y_e)}{1+e^2\sinh^2(y_e)}}. \quad (2)$$

The ridge is attributed to the longitudinal flow due to strong parton cascade.

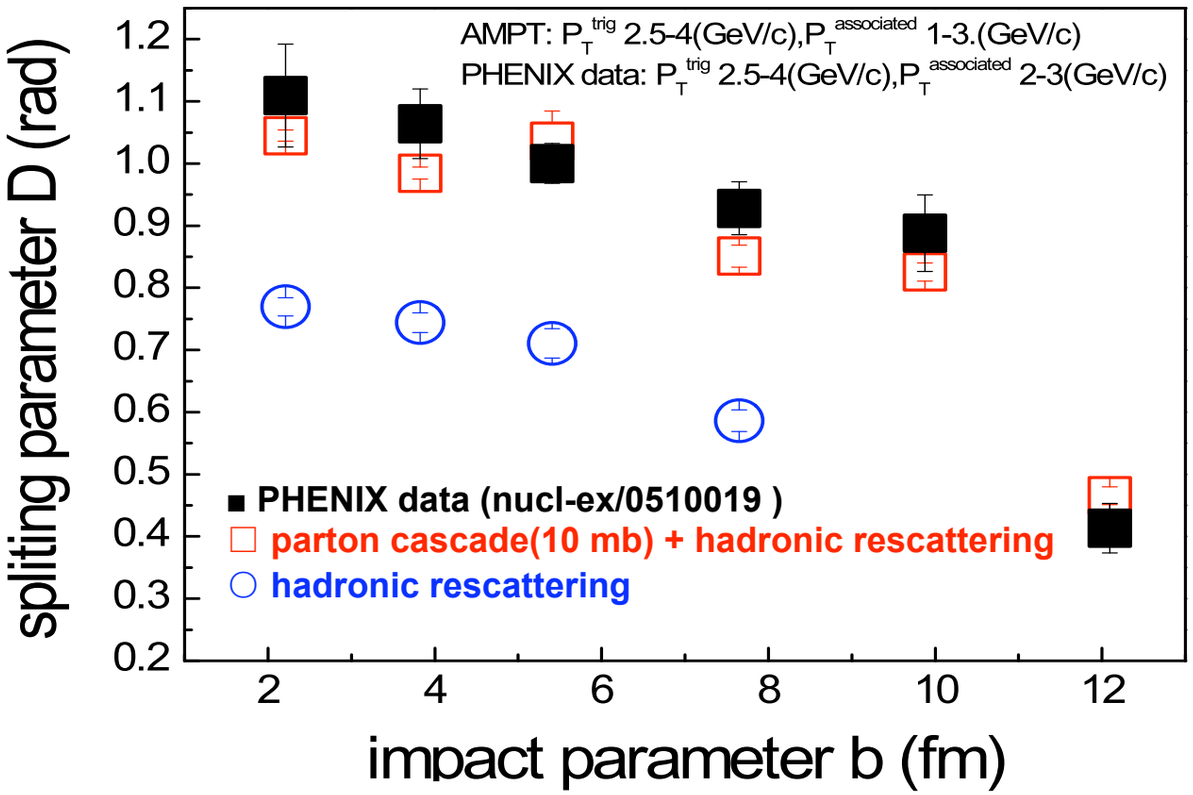
Conclusions

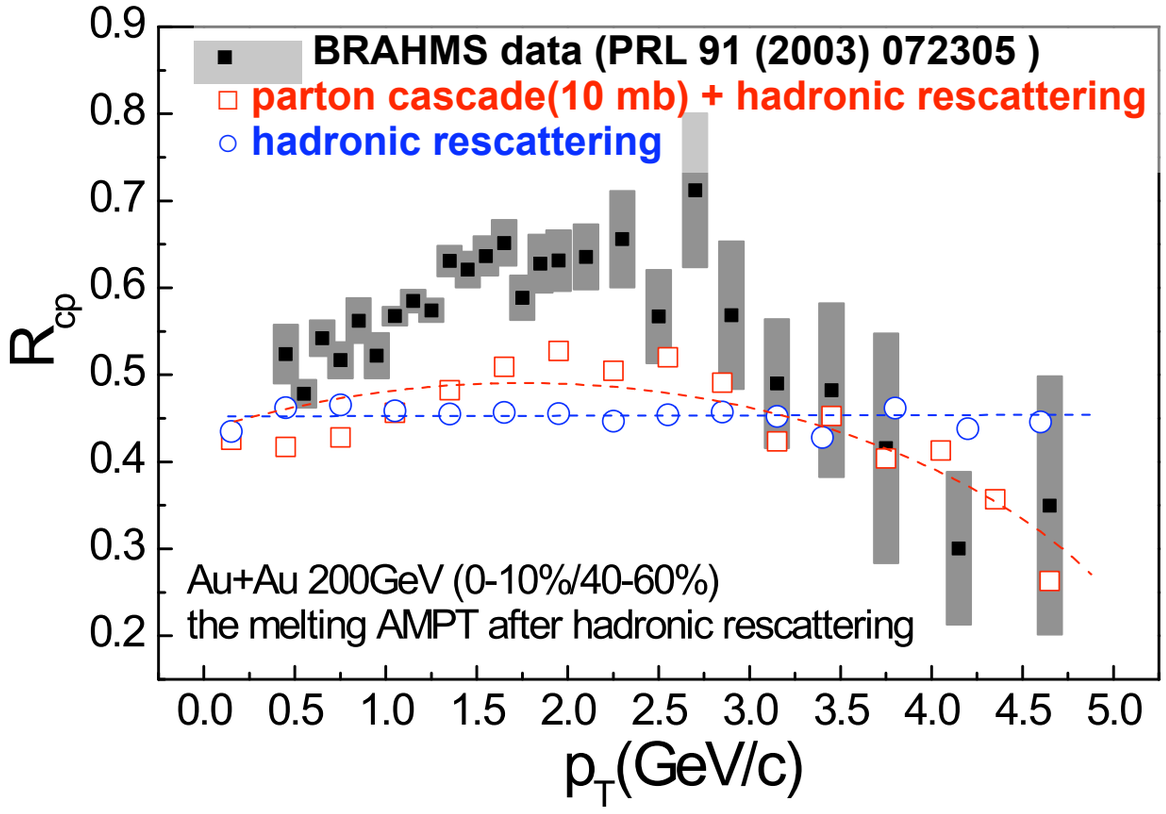
- Mach-like shock wave is born in the strong parton cascade and developed in hadronic rescattering.
- Splitting amplitude of Mach-like structure can be reproduced by a partonic cross section 10 mb instead of 3 mb, which indicates a strongly coupling matter at RHIC.
- The longitudinal broadening of near side is due to the longitudinal flow produced by strong parton cascade.

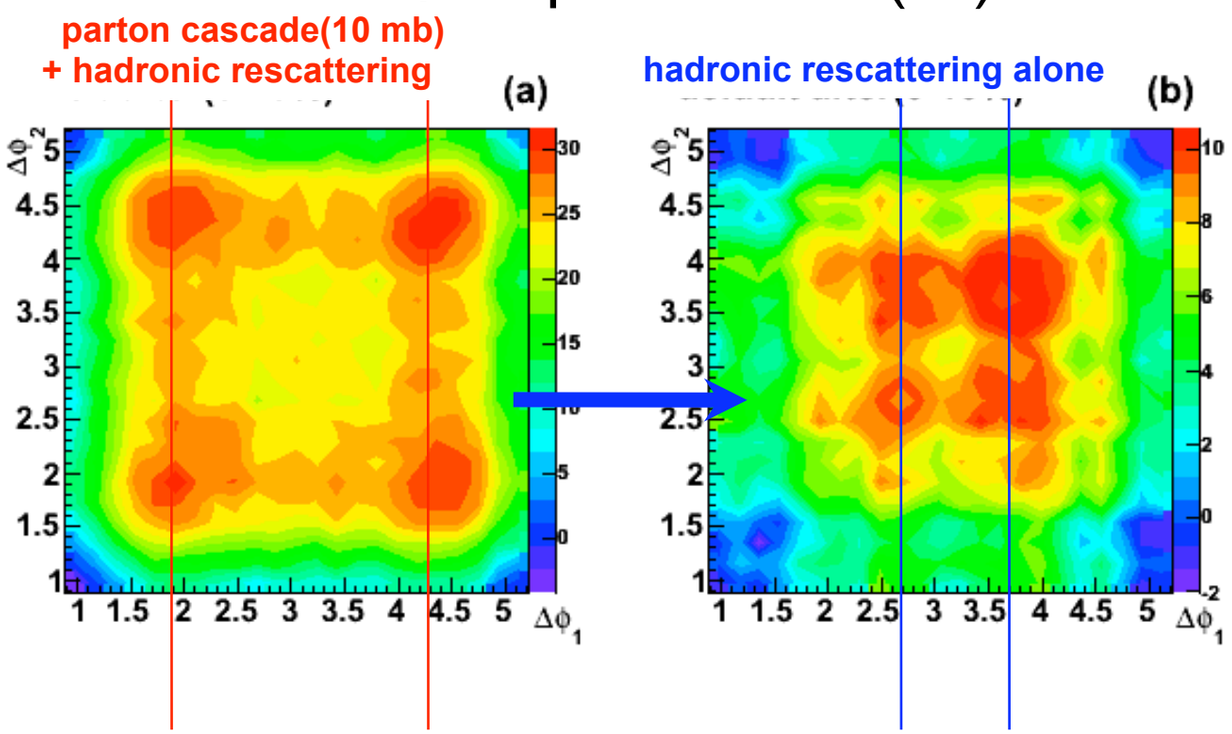
Thank you!

Back up

Parton cascade effect on 2- and 3-particle correlations







- ***Hadronic rescattering mechanism alone can not give big enough splitting parameters and correlation areas.***
- ***Parton cascade mechanism is essential for describing the splitting amplitude of experimental Mach-like structure.***
- ***large energy loss in dense partonic medium.***