Charged Particle Ratio Fluctuation from A Multi-Phase Transport (AMPT) Model

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Outline

- Introduction
- Results and Discussion

    parton interaction effect

    hadronization effect

    resonance decay effect

    hadron rescattering effect

    Energy dependence (from SPS to RHIC)

- Summary

Charged Particle Ratio Fluctuation

■ Charged Particle Ratio Fluctuation

$$D_Q = 4\frac{\langle(\delta Q)^2\rangle}{N_{ch}}$$

Q is net charge

N_{ch} is the total number of charged particles

Predictions

QGP phase	**Hadron phase**
$D \sim 1$	$D \sim 4$

Phys. Rev. Lett. 85, 2076 (2000)

- *One correction* C_μ *applied for the approximation* $\langle N_+\rangle_{\Delta y} = \langle N_-\rangle_{\Delta y}$ *is given by*

$$C_\mu = \frac{\langle N_+\rangle^2_{\Delta y}}{\langle N_-\rangle^2_{\Delta y}}$$

- *The other correction* C_y *is used for the assumption that fluctuation is independent in each rapidity window,*

$$C_y = 1 - \frac{\langle N_{ch}\rangle^2_{\Delta y}}{\langle N_{ch}\rangle^2_{total}}$$

Corrections for D_Q

So the correction considered the effects of the finite net charge and the finite acceptance window

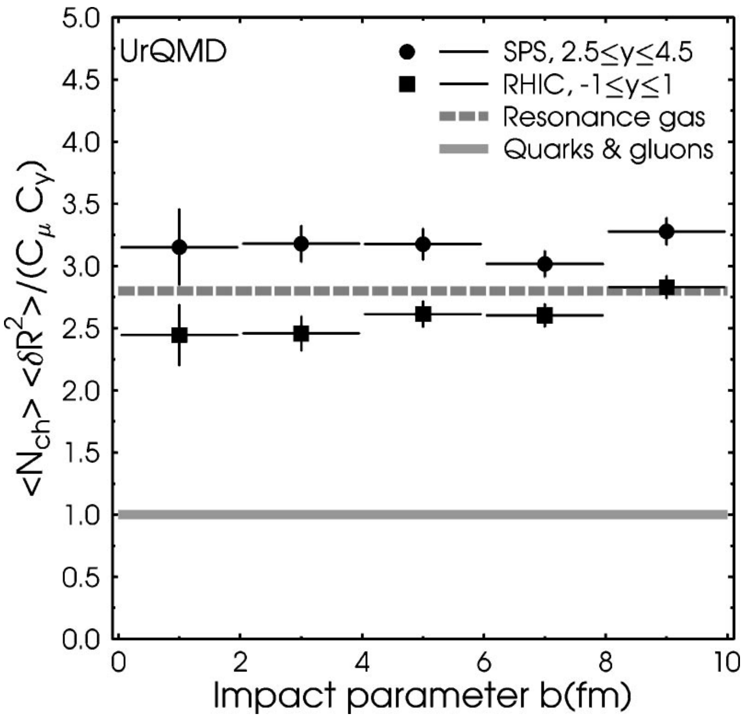
$$\tilde{D}_Q = \frac{D_Q}{C_\mu C_y} = \begin{cases} 1 & \text{quark gluon gas} \\ 2.8 & \text{resonance gas} \\ 4 & \text{uncorrelated pion gas} \end{cases}$$

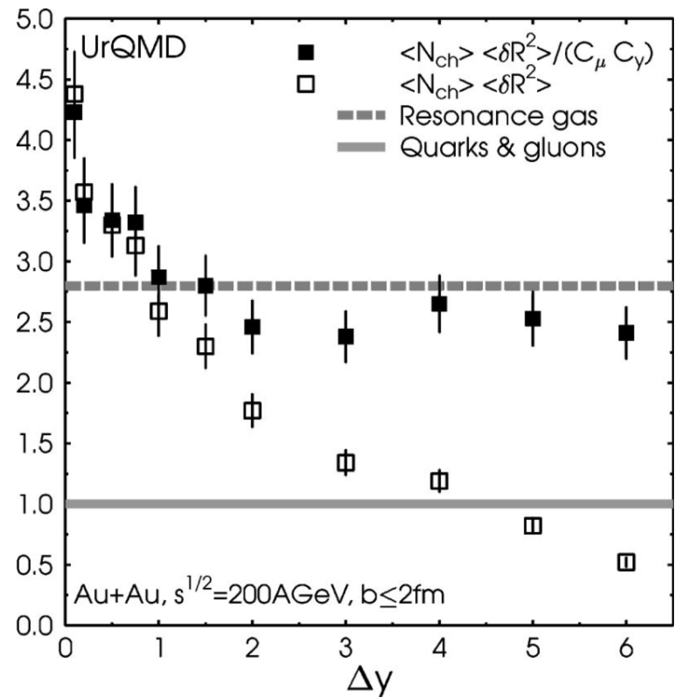
Experimental Value

$D = 3.2 \pm 0.1$ ***(STAR)*** ***Phys. Rev. C 68, 044905 (2003)***

$D \sim 3$ ***(PHENIX)*** ***Phys. Rev. Lett. 89 082301(2002)***

(central Au+Au collisions at $\sqrt{S_{NN}} = 130 GeV$ *)*

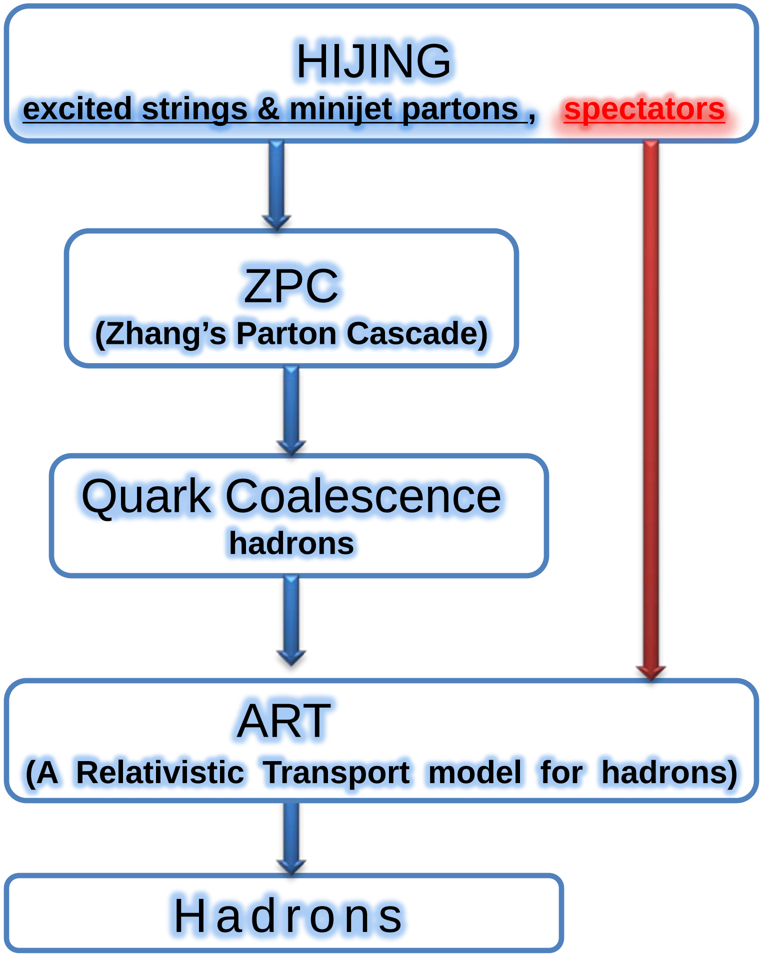




Structure of the AMPT-StringMelting

Z.W.Lin et al., *Phys. Rev. C 72 064901 (2005);*

Structure of the AMPT model with StringMelting



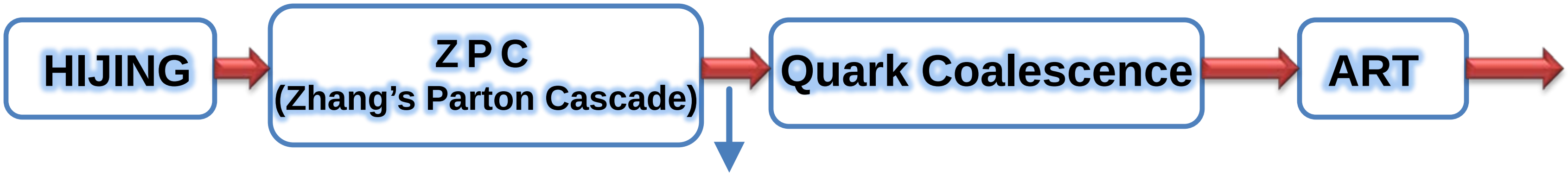
X. N. Wang and M. Gyulassy, Phys. Rev. D 44 3501 (1991);

B. Zhang, Comput, Phys. Commun. 109, 193 (1998)

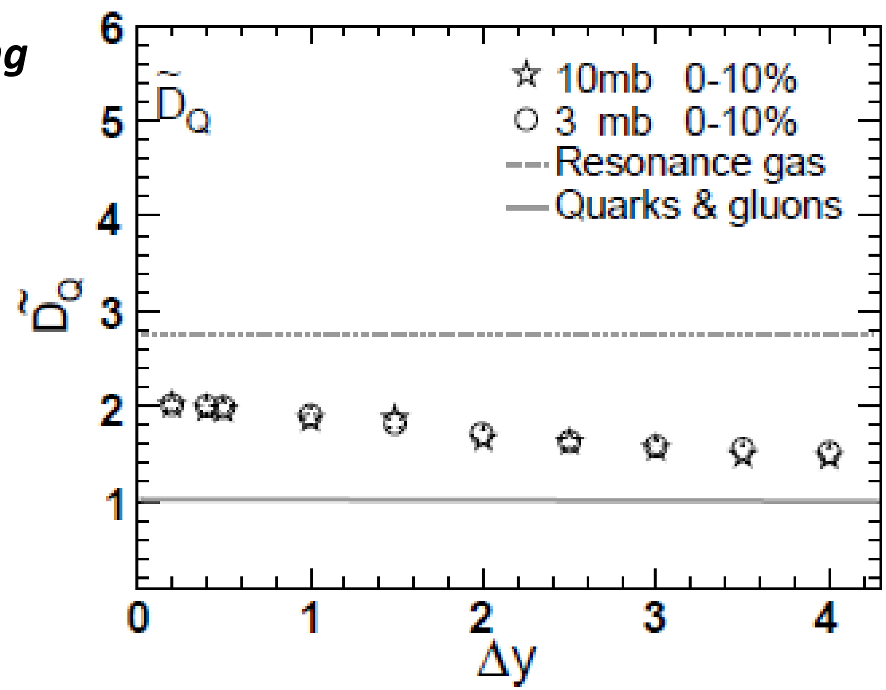
Z. W. Lin and C. M.Ko, J. Phys. G 30 S263 (2004)

B. A. Li and C. M. Ko, Phys. Rev.C 52 2037 (1995)

Parton cross section effect

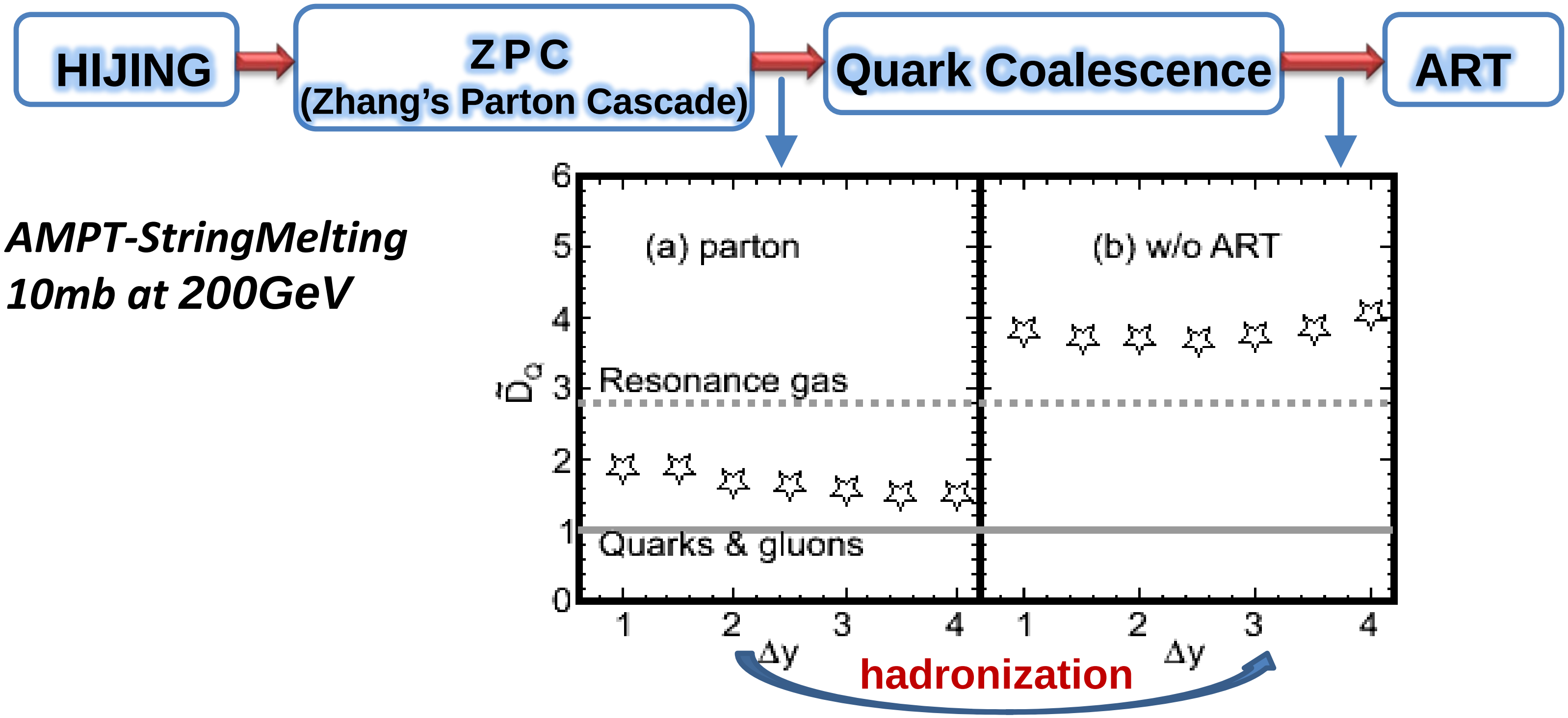


AMPT-StringMelting at 200GeV



we can find that the results of 10mb and 3mb are consistent with each other, parton interactions do change the results of $\tilde{D}_Q$.

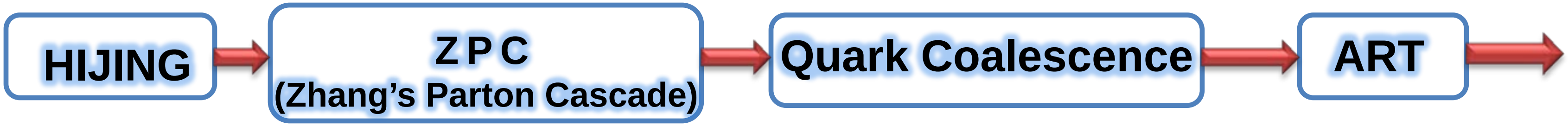
Hadronization effect

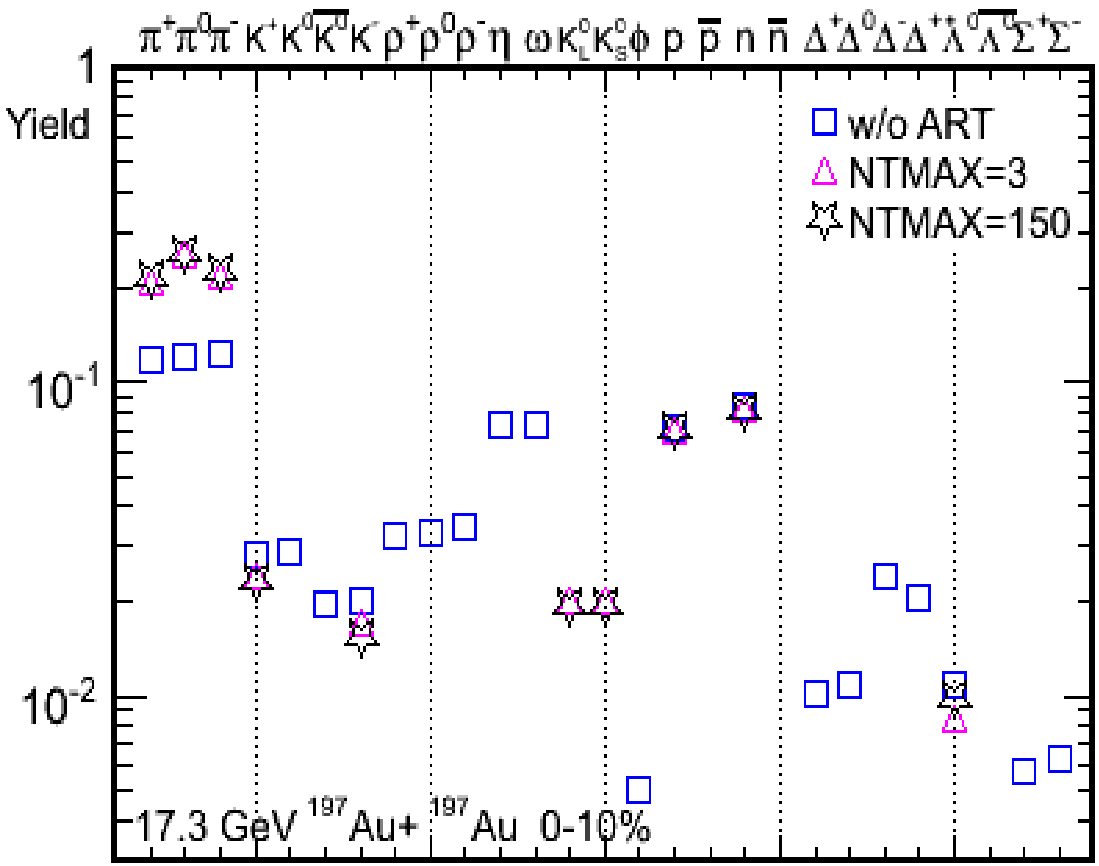


- *Compared (a) and (b), we find the quark coalescence like hadronization process raise the $\tilde{D}_Q$ value from about 1.5 which is compatible with QGP expectations to the value around 4 which related to uncorrelated pion gas.*

Hadronization procedure is responsible for the disappearance of the QGP signature.

Hadron cascade①: resonance decay





Yield = N_x / N_{total}

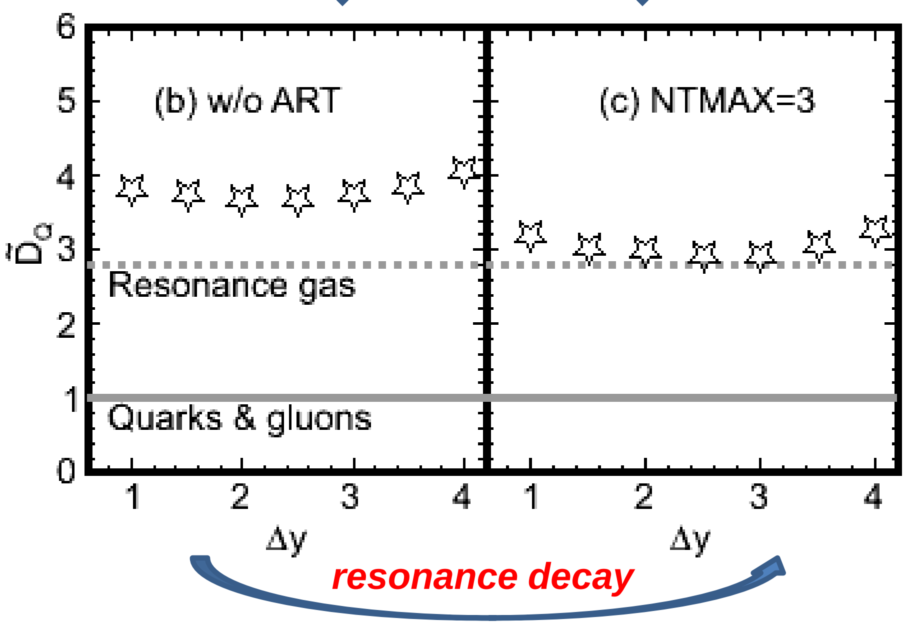
NTMAX :

number of time-step (in AMPT)

Larger NTMAX means longer hadrons rescattering time

Hadron cascade①: resonance decay

Quark Coalescence → **ART**
A Relativistic Transport model for hadrons



Compared the results from w/o ART to NTMAX=3,
the influence of resonance decay on $\tilde{D}_Q$ are obviously.

Resonance decay plays an important role in $\tilde{D}_Q$.

Hadron cascade ②:rescattering effect

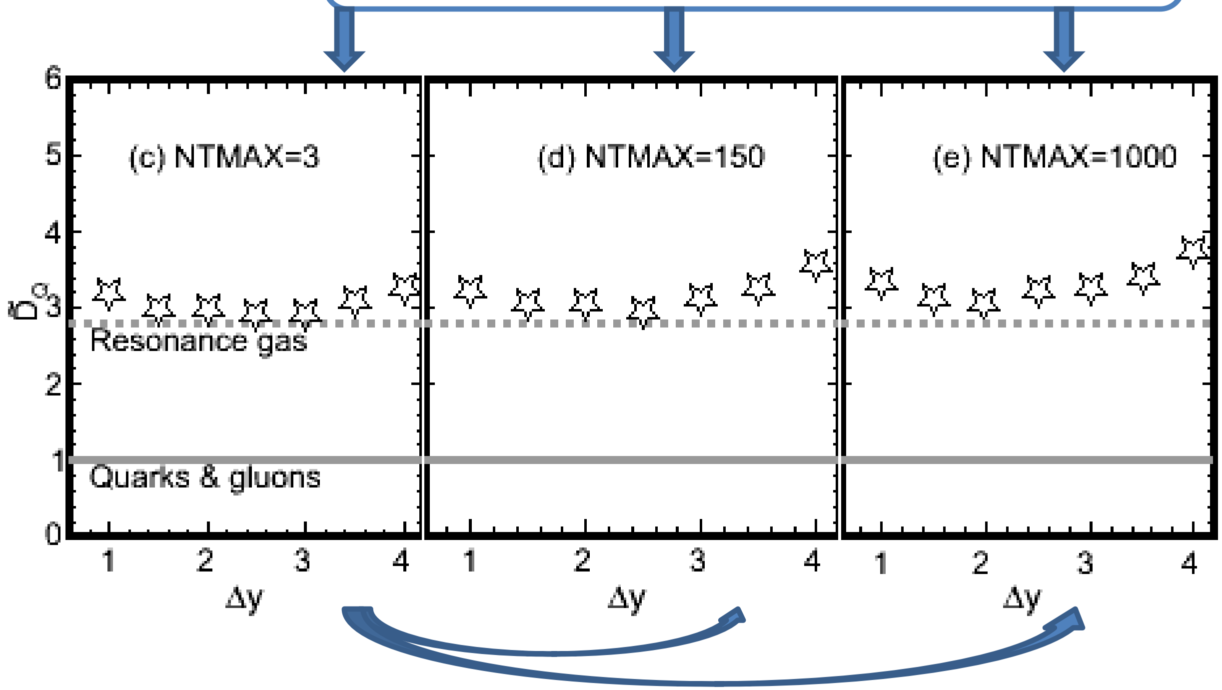
Phys. Rev. C 66 014909

- Rescattering effect depend on two factors:
  1. the time particles go through collision region;
  2. density in the collision region

- At fixed energy, we can’t changed the density in the collision regions within AMPT model, but we can study the rescattering effect on D-measure by controlling the time that particles passed the collision region.

Rescattering effect

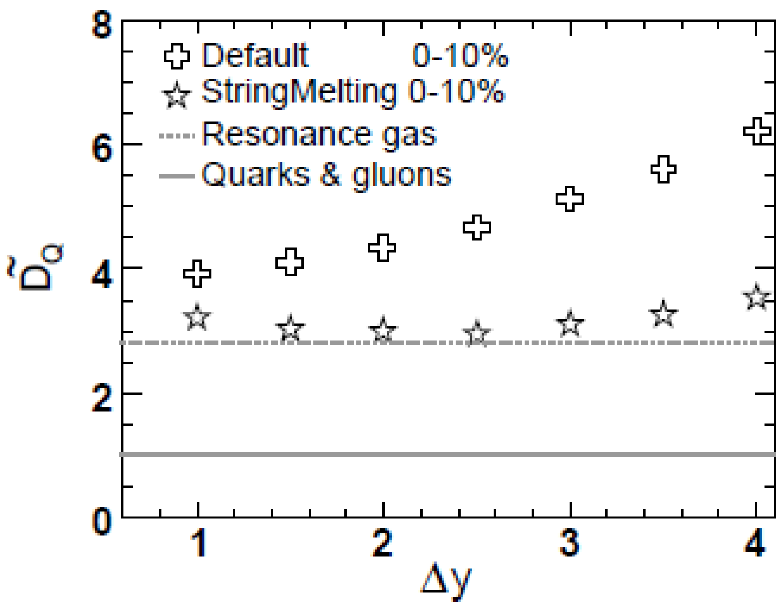
Quark Coalescence → **ART** A Relativistic Transport model for hadrons

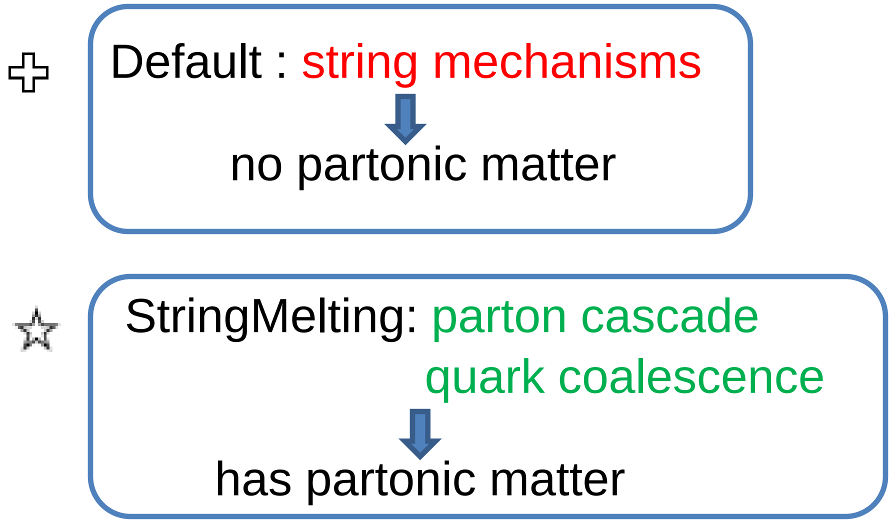


No matter how long the hadrons cascade last, the value of $\tilde{D}_Q$ *doesn't change.*

It means the hadron interactions don't have clear effect on $\tilde{D}_Q$.

Deconfined matter effect



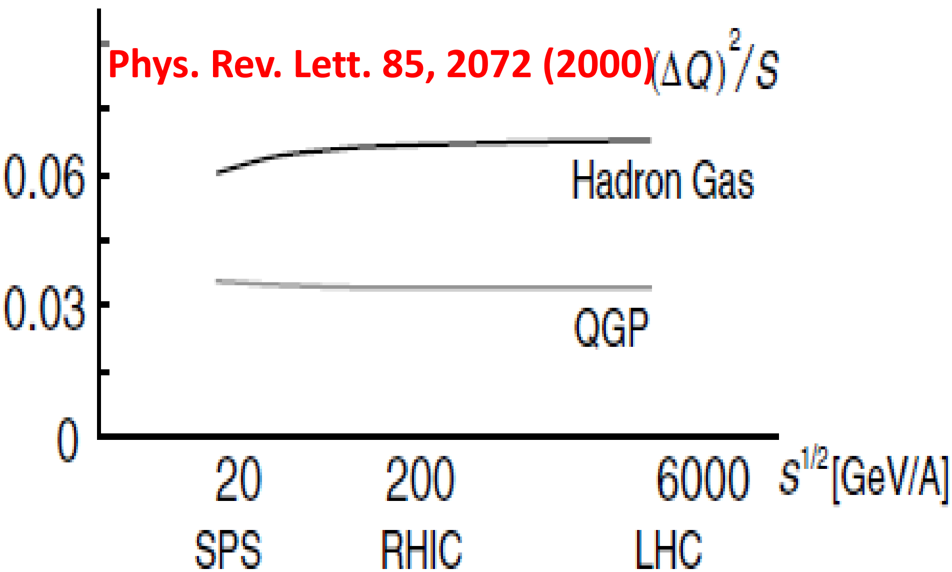


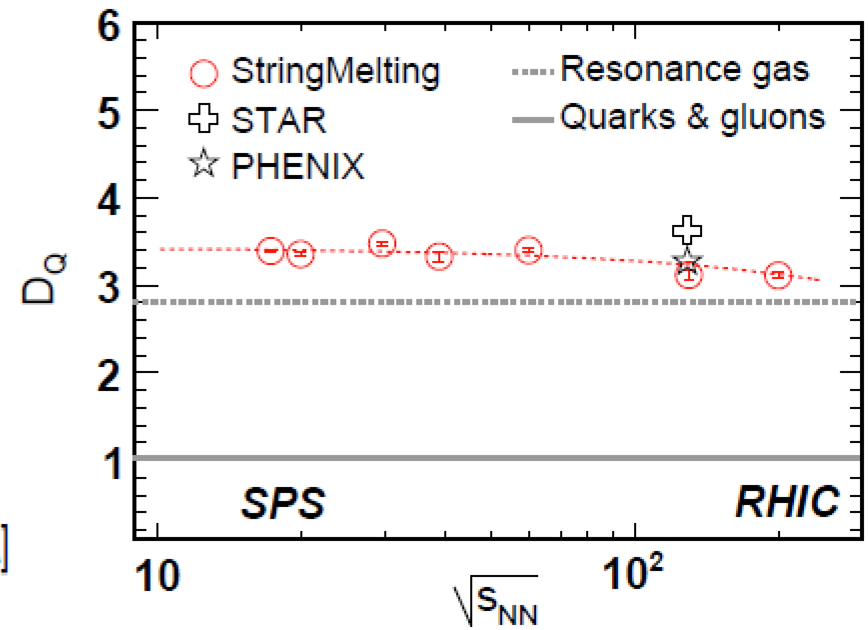
- One of the important differences between two versions of AMPT model is whether the partonic matter has been created in the early stage of collisions.

- We can find a large diverge when comparing the $\tilde{D}_Q$ value from AMPT-Default and AMPT-StringMelting.

- It sufficiently shows that deconfined matter once created in the early stage definitely affects the value.

Energy dependence





We choose the width of rapidity window when the C_y =0.5, we regard that the corrected effects are at the same level for all energy. We find that the $\tilde{D}_Q$ values keep roughly constant from SPS energy to top RHIC energy, they are larger than expectations for Resonance Gas(RG).

Also this fluctuation will be a valuable observable if a much smaller $\tilde{D}_Q$ value will be measured at LHC energy.

Summary

- We study charged particle ratio fluctuation in Au+Au collisions within AMPT model.

  1. quark coalescence blurs the QGP signal
  2. resonances decay decrease the fluctuation
  3. partonic interactions and hadronic rescattering don't play roles
  4. created deconfined matter reduce the $\tilde{D}_Q$ *value*

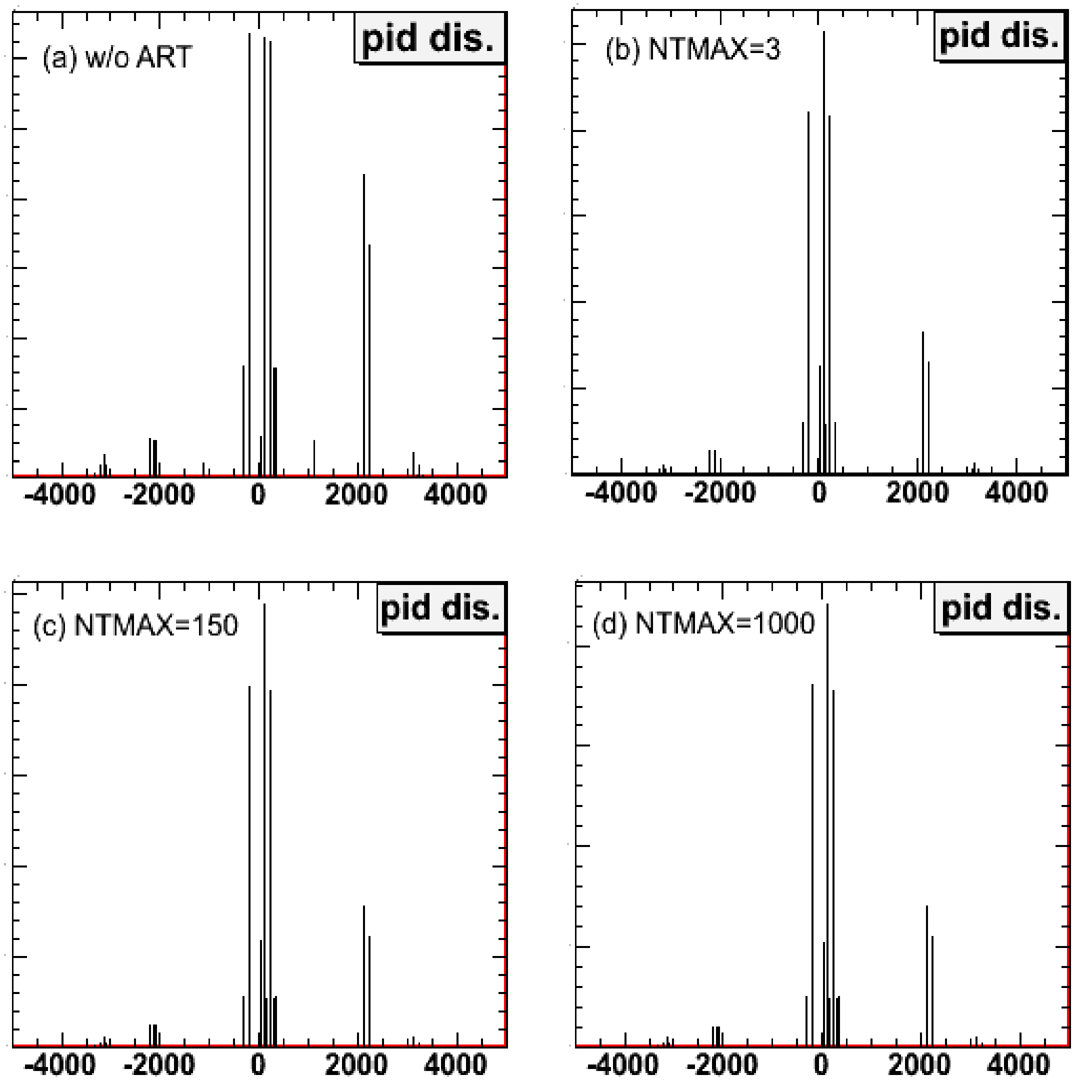
- If a much decreasing trend of $\tilde{D}_Q$ will be observed at LHC, it should demonstrate the QGP signal.

Thanks for your attention!

Backup

PID distribution

PID distribution for $0 < p_T < 1$ & $\delta y = 1$



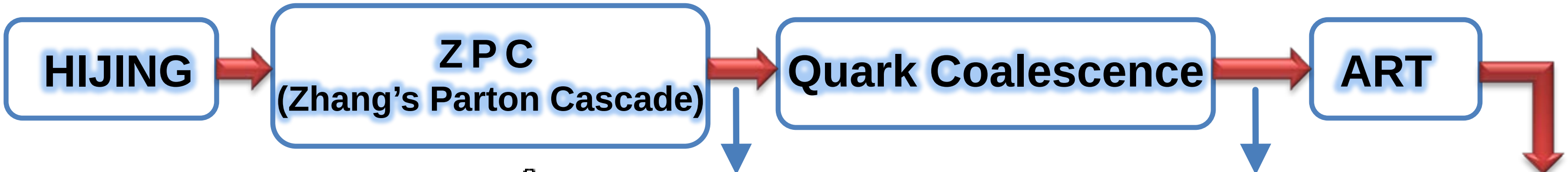
$$R = \frac{\Sigma + \Xi + \Delta + \Omega}{p + \pi + k}$$

Ratio	
w/o ART	0.0563235
NTMAX = 3	0.0143835
NTMAX = 150	0.0145565
NTMAX = 1000	0.0146631

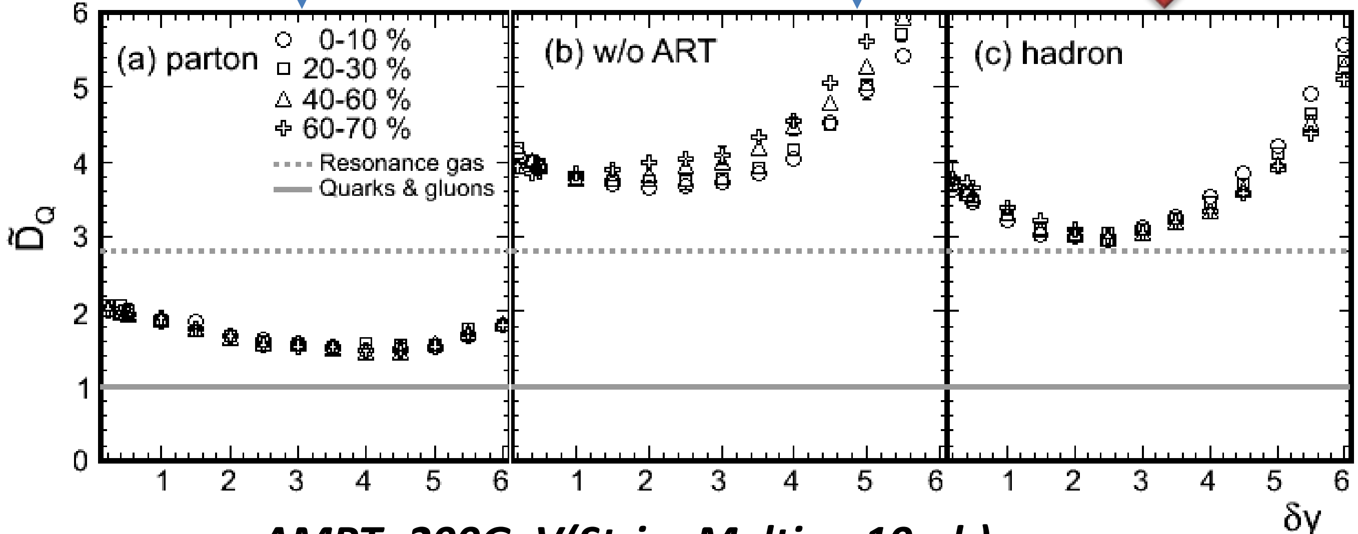
$$N_Q = \Sigma + \Xi + \Delta + \Omega + p + \pi + k$$

Nch	
w/o ART	59.388
NTMAX = 3	160.012
NTMAX = 150	159.885
NTMAX = 1000	158.509

Rapidity window size dependence



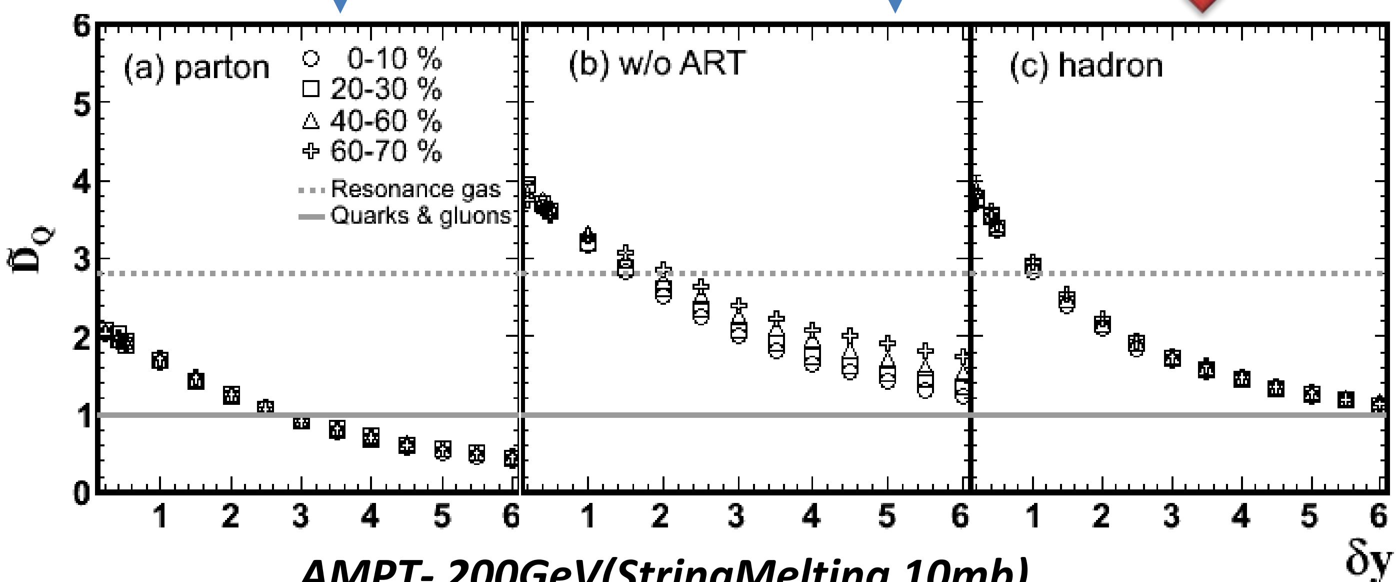
$$\tilde{D}_Q = \frac{D_Q}{C_\mu C_y}$$



AMPT- 200GeV(StringMelting 10mb)

HIJING → ZPC (Zhang's Parton Cascade) → Quark Coalescence → ART

$$D_Q = 4\frac{\langle(\delta Q)^2\rangle}{N_{ch}}$$



AMPT- 200GeV(StringMelting 10mb)

Resonance decay effect

$$R = \frac{\Sigma + \Xi + \Delta + \Omega}{p + \pi + k}$$

$$N_Q = \Sigma + \Xi + \Delta + \Omega + p + \pi + k$$

Ratio	
w/o ART	0.0563235
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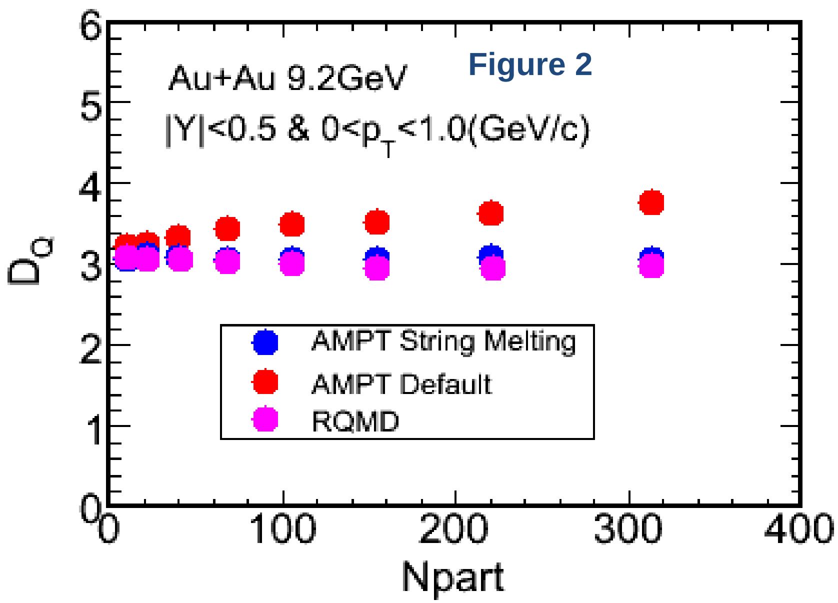
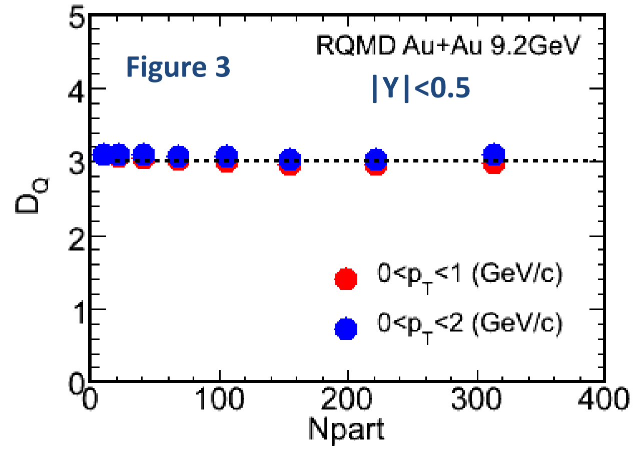
■ Charged Particle Ratio Fluctuation

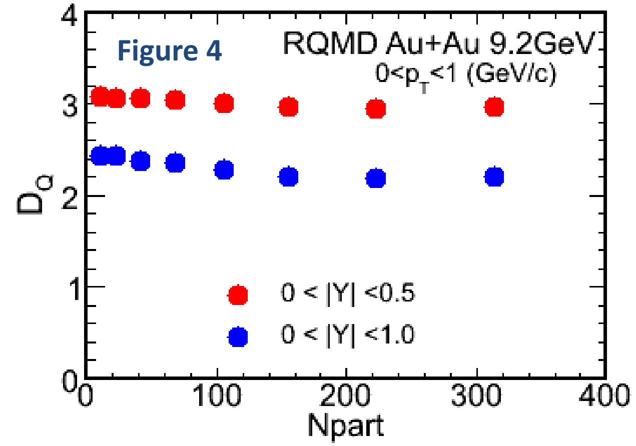


AMPT-StringMelting	*3.072 ±0.006*
AMPT-Default	*3.772 ±0.009*
RQMD	*2.977 ±0.001*

pT cut



Y cut



measured values of D_Q quantity depends on the acceptance

Charged Particle Ratio Fluctuation

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Experimental Value

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$D \sim 3$ *(PHENIX) Phys. Rev. Lett. 89 082301(2002)*

(central Au+Au collisions at $\sqrt{S_{NN}} = 130GeV$ *)*

Charged particle ratio fluctuation in hadronic gas is expected to be significantly larger (by a factor 3–4) than a quark gluon plasma .

The experimental values from STAR and PHENIX equal to about 3, which are much larger than expected D value in QGP and closed to the predicted D value in Hadron phase.

M.Bleicher et al. , Phys. Rev. C 62, 061902(R)

- In order to correct for the finite net charge within the acceptance due to baryon stopping, one has to apply a factor C_μ given by

$$C_\mu = \frac{\langle N_+ \rangle^2_{\Delta y}}{\langle N_- \rangle^2_{\Delta y}}$$

to the experimental data and the model calculations to compare

with the pion gas and quark gas result of S. Jeon and V. Koch, hep-ph/0003168

- In order to correct for the finite bin size in rapidity, and in order to incorporate global charge conservation one has to rescale the experimental data and the transport model predictions by a factor of

$$C_y = 1 - \frac{\langle N_{ch} \rangle^2_{\Delta y}}{\langle N_{ch} \rangle^2_{total}}$$