第十三届全国粒子物理学术会议.山东大学(青岛)

Dependence of QGP Evolution on Smearing Velocity in HIC

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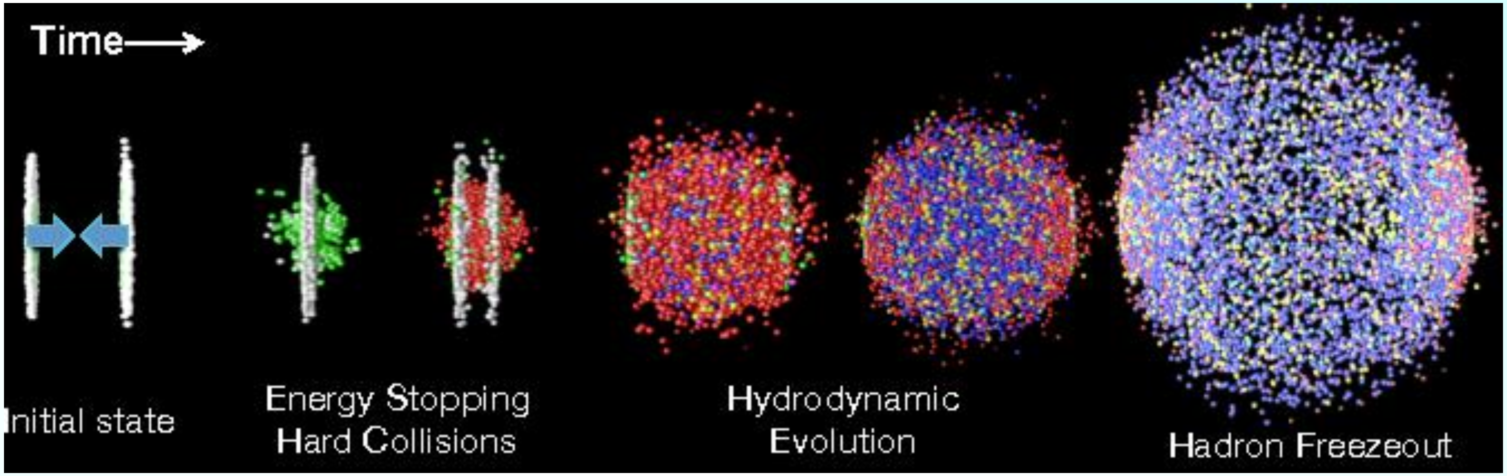
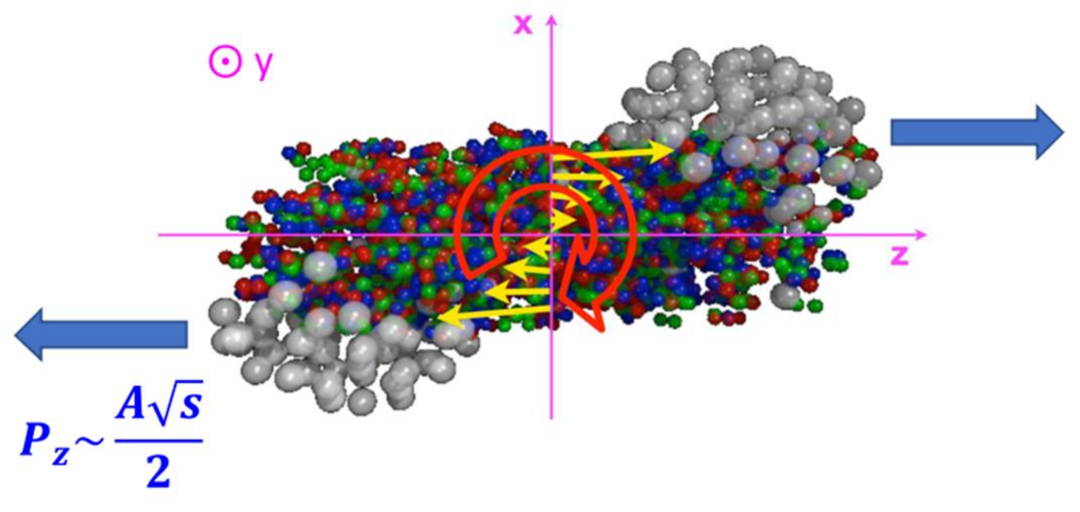
Motivation

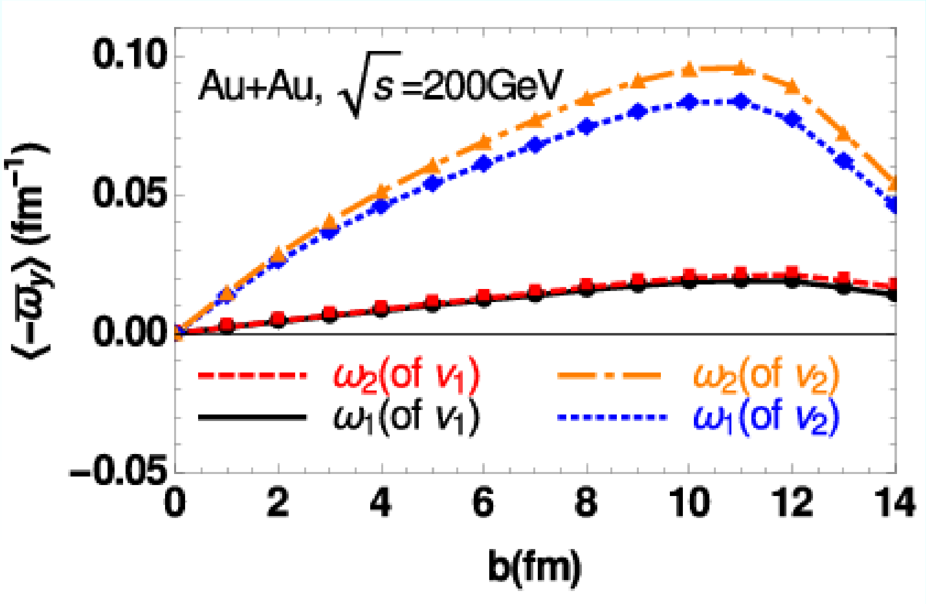


Due to fast, oppositely directed motion of two colliding ions, off-central heavy-ion collisions can create strong transient magnetic fields and strong vorticity.

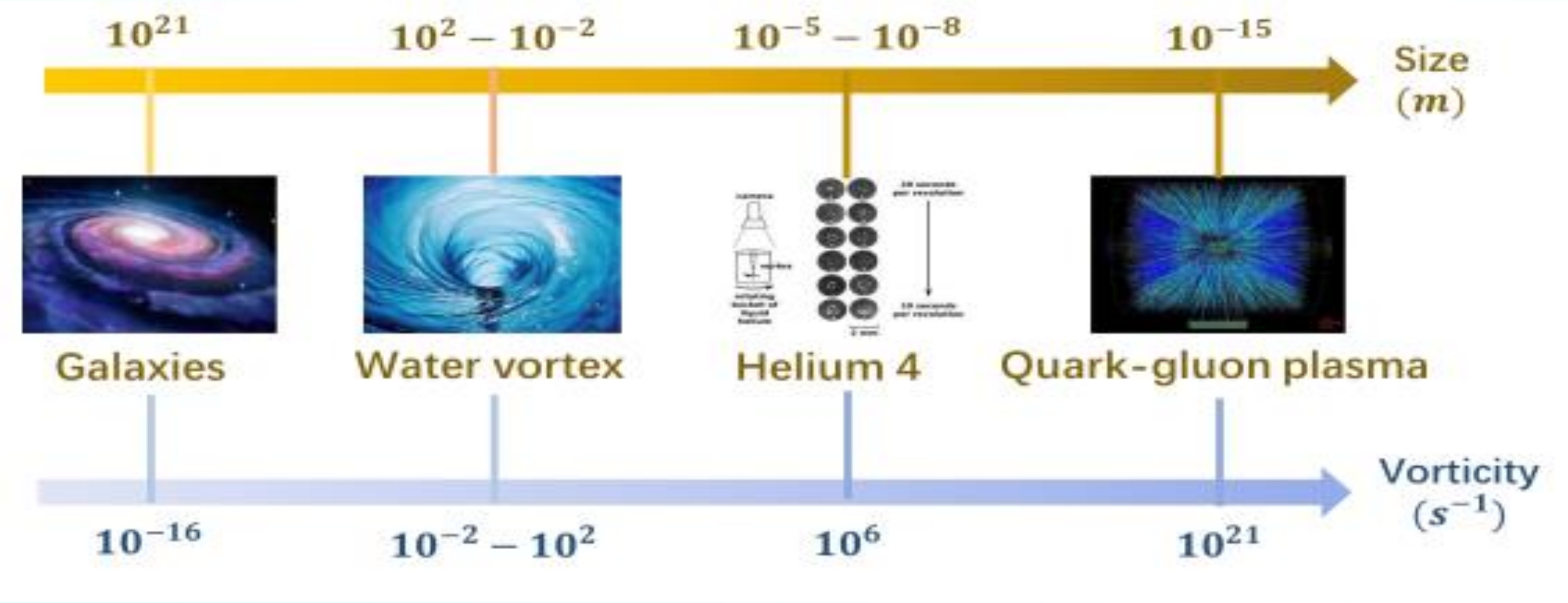


$$\boldsymbol{\omega}_1 = \nabla \times \boldsymbol{v},$$
$$\boldsymbol{\omega}_2 = \gamma^2 \nabla \times \boldsymbol{v},$$

WTD, X.-G. Huang
Phys.Rev. C93 (2016) no.6, 064907

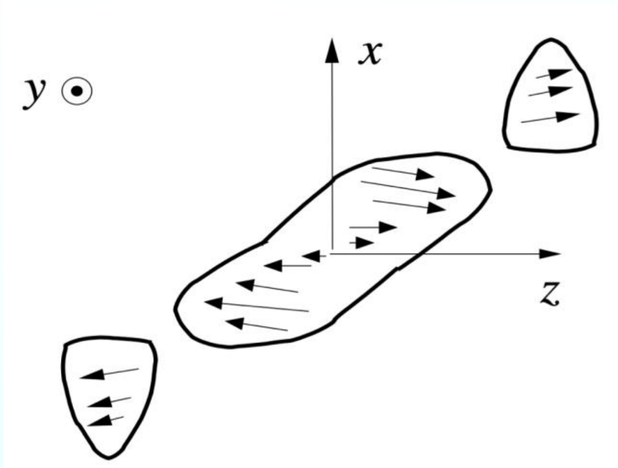


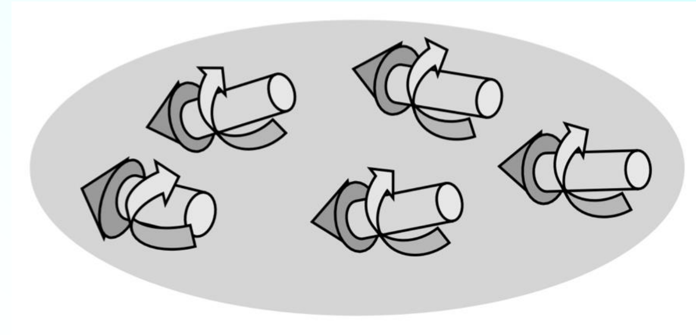
The Fastest Fluid Vortex

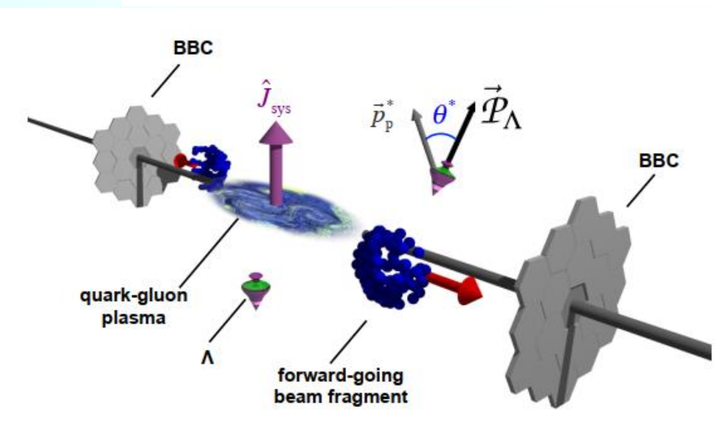


Vorticity → Spin polarization

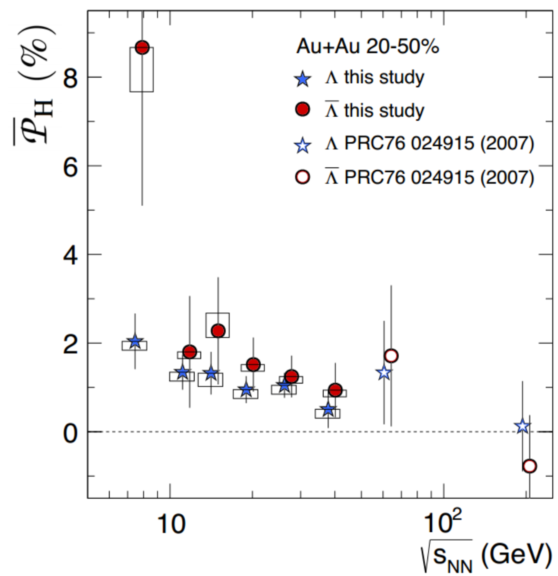
Liang and Wang, PRL 94,102301(2005);
PLB 629, 20(2005)

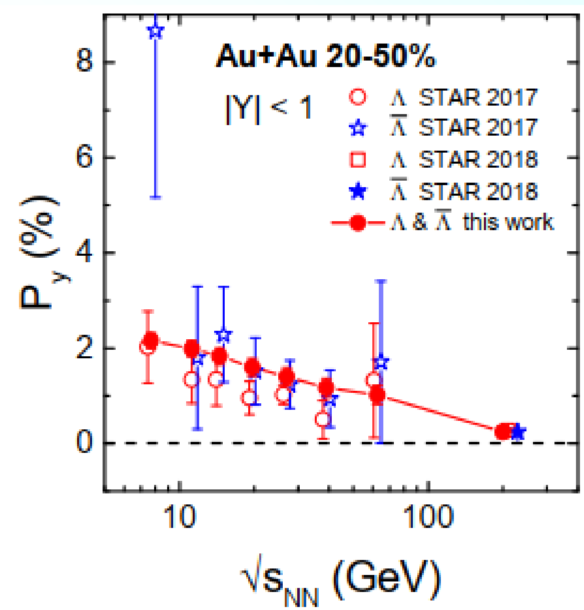






$$\frac{dN}{d\cos\theta^*} = \frac{1}{2}\left(1+\alpha_H|\vec{\mathcal{P}}_H|\cos\theta^*\right)$$



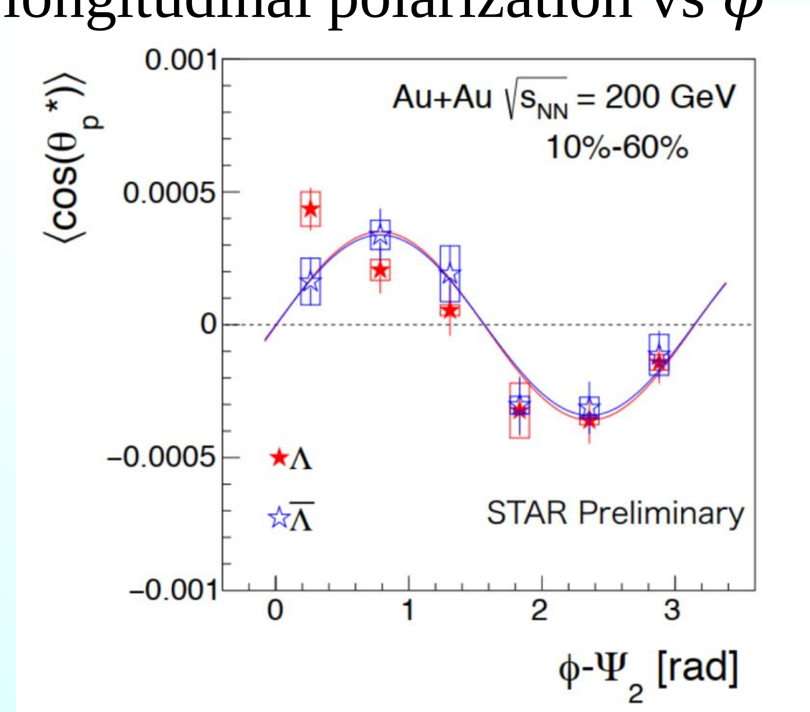


STAR, Nature 548, 62, 2017;
STAR, PRC 98, 014910, 2018

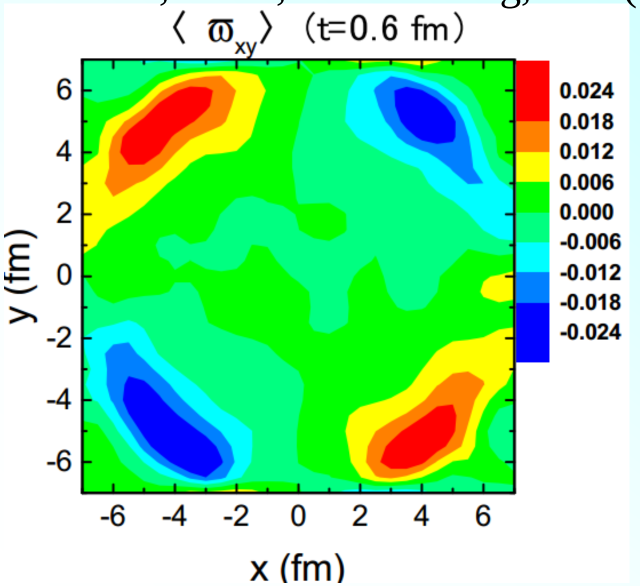
D.-X. Wei, WTD, X.-G. Huang
Phys.Rev. C99 (2019) no.1, 014905

“Sigh Problem”

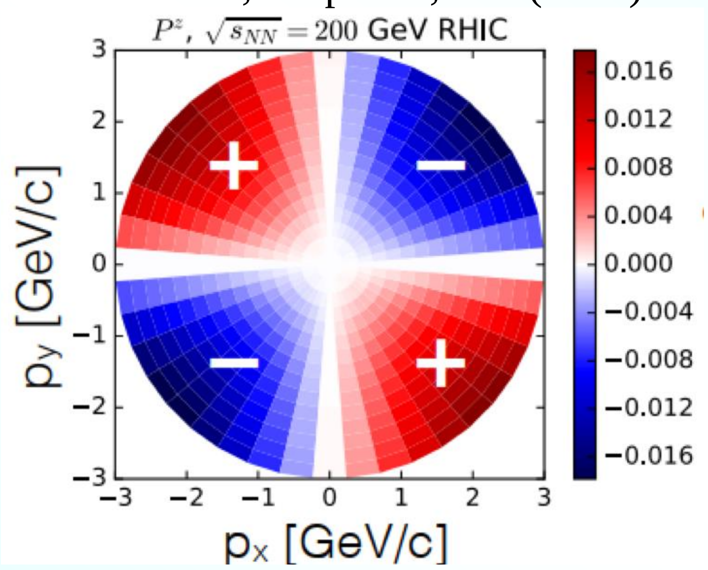
longitudinal polarization vs ϕ



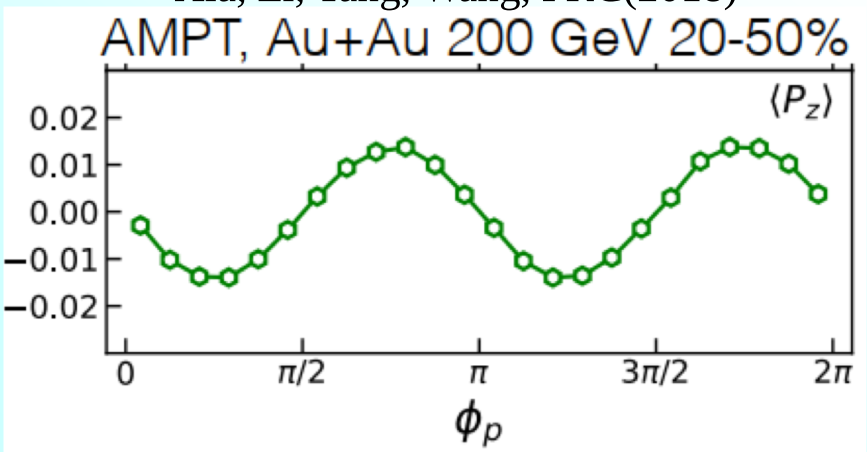
D.-X. Wei, WTD, X.-G. Huang, PRC(2019)



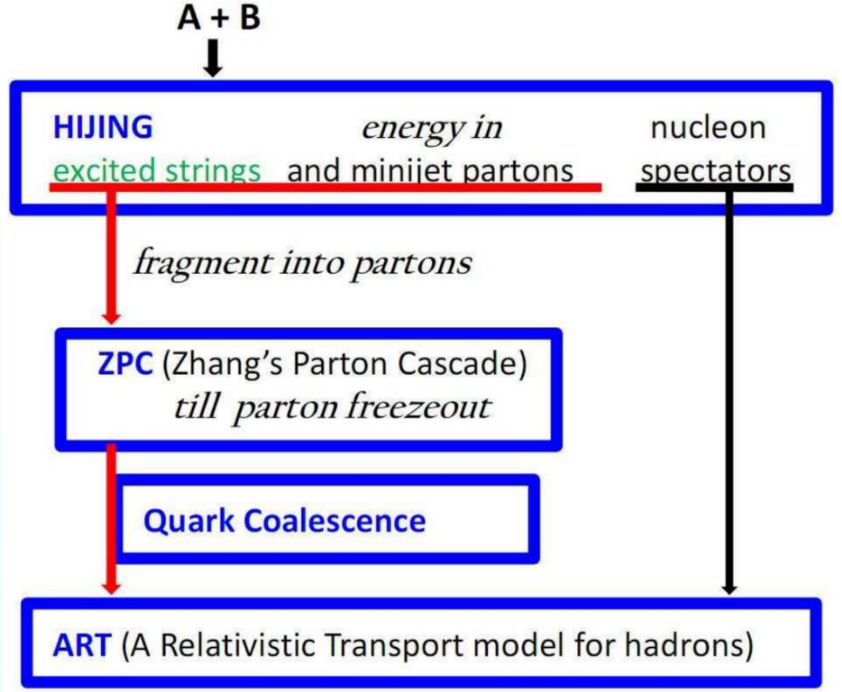
Becattini, Karpenko, PRL(2018)

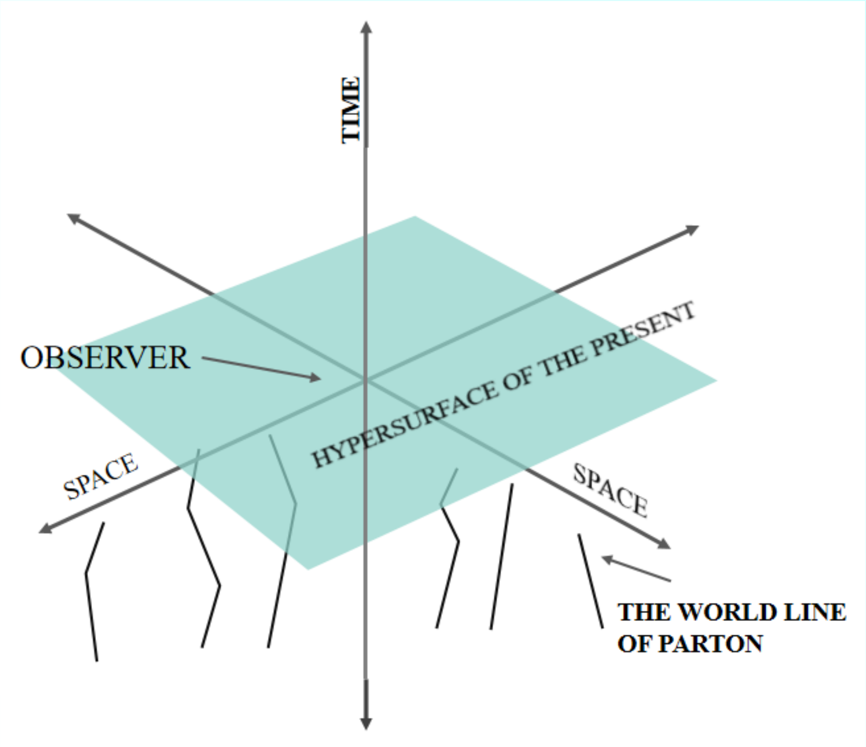


Xia, Li, Tang, Wang, PRC(2018)

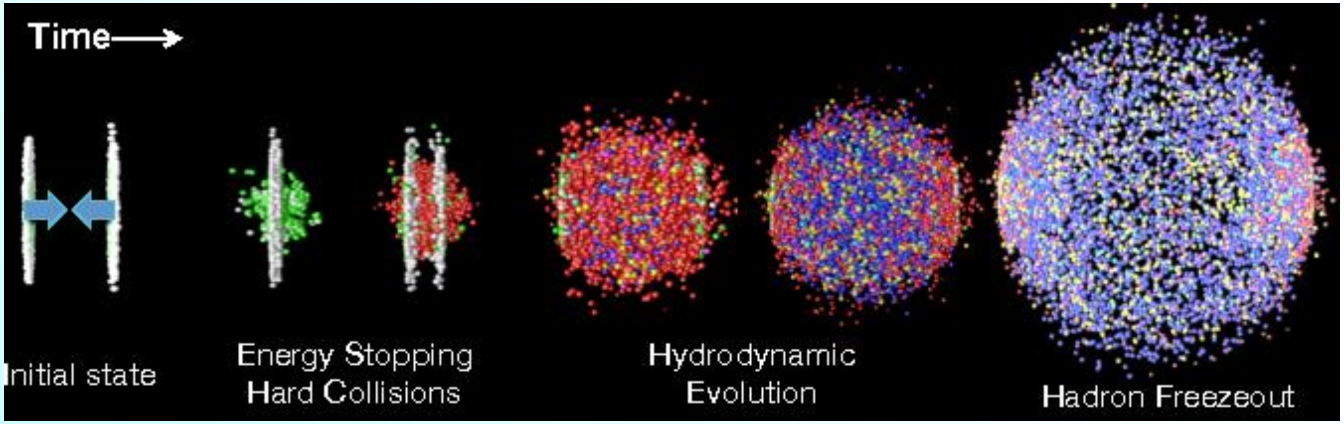


Framework: AMPT Model



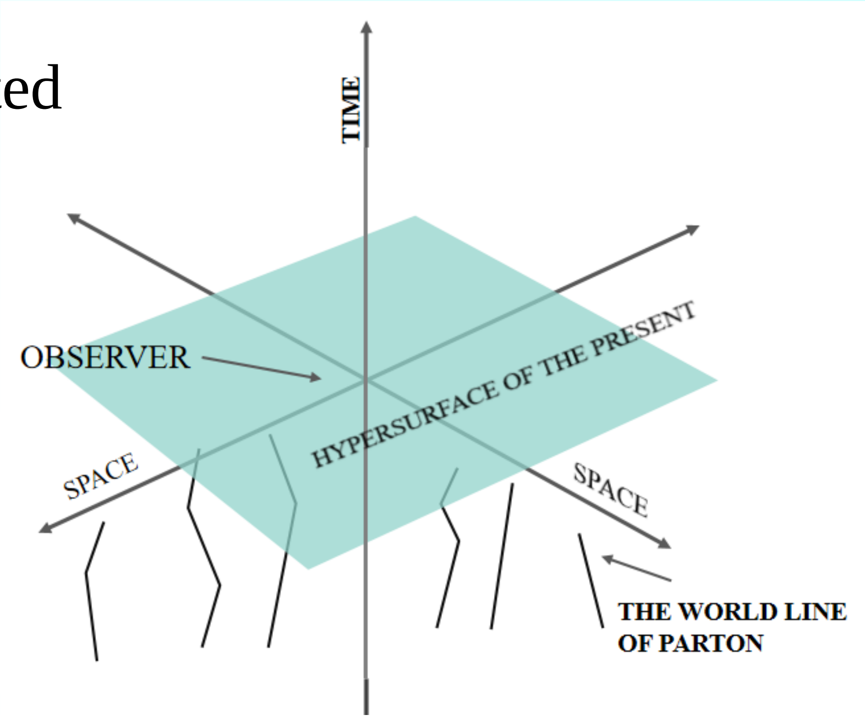


String Melting version



Framework: AMPT Model

Partons observed at time *t* distributed on corresponding x-y plane.



Point-like partons

Smearing function

$$\Phi_{\mathrm{G}}(x, x_i) = \frac{K}{\tau_0 \sqrt{2\pi\sigma_\eta^2 2\pi\sigma_r^2}} \exp\left[-\frac{(x-x_i)^2 + (y-y_i)^2}{2\sigma_r^2} - \frac{(\eta-\eta_i)^2}{2\sigma_\eta^2}\right]$$

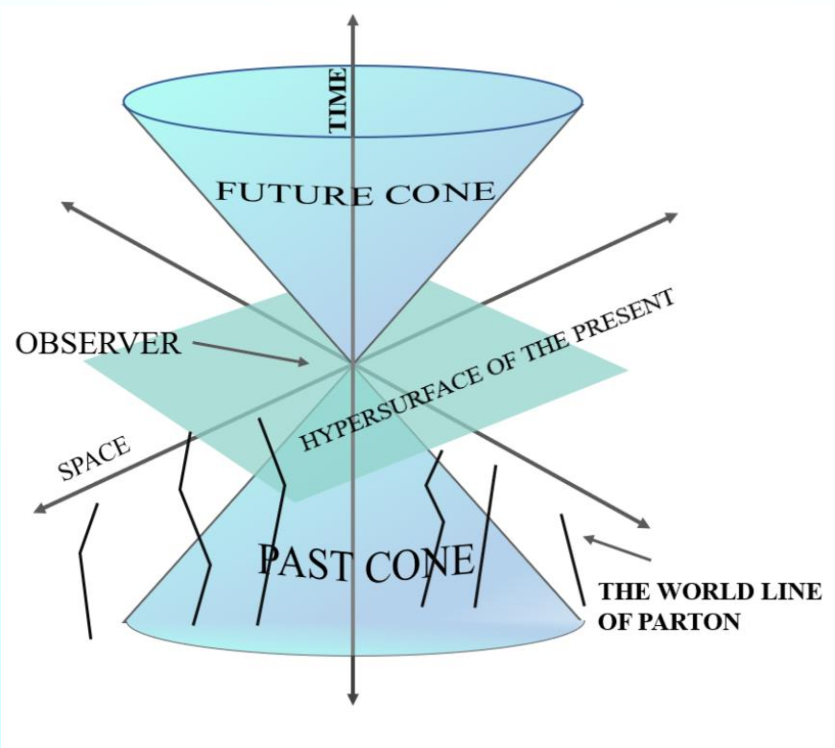
Energy-Momentum tensor

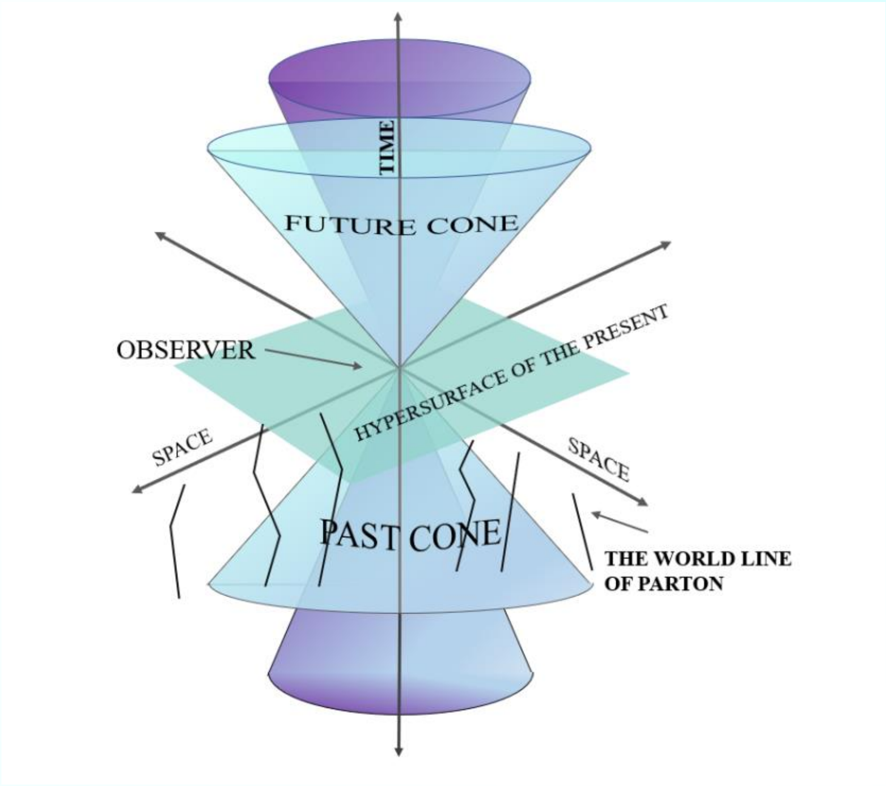
$$T^{\mu\nu} = \int \frac{d^3p}{(2\pi)^3} \frac{p^\mu p^\nu}{p^0} f(\boldsymbol{r}, \boldsymbol{p}) = \frac{1}{N} \sum_i \frac{p_i^\mu p_i^\nu}{p_i^0} \Phi(\boldsymbol{r}, \boldsymbol{r}_i)$$

But the smearing could not be Action-at-a-Distance

Considering smearing velocity C_S, partons observed at time t should distributed on a (light-) cone.

If $C_S < 1$, the cone is different



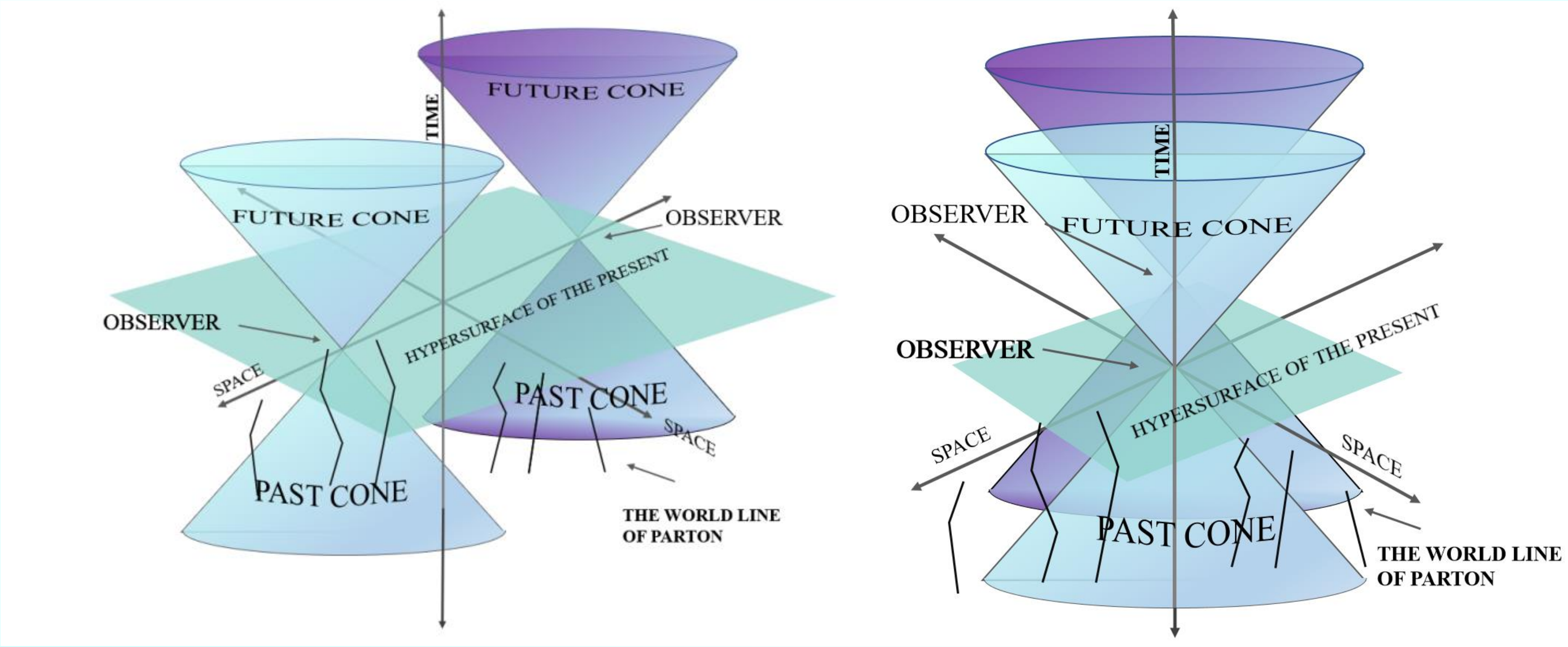


In our framework, let C_S as a free parameter.

When $C_S = \infty$, we come back to Action-at-a-Distance

With a fixed *Cs*,

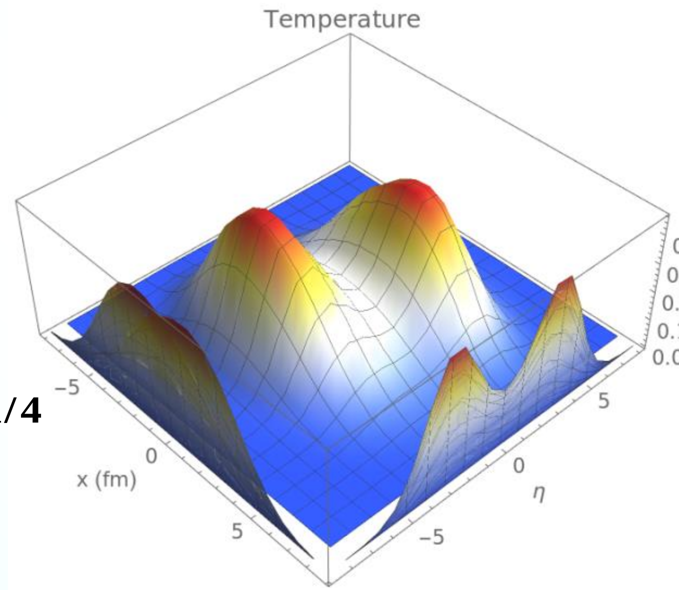
- we can change the **location** of observer to get the distribution of QGP;
- or change **time** of observer to get the evolution of QGP.

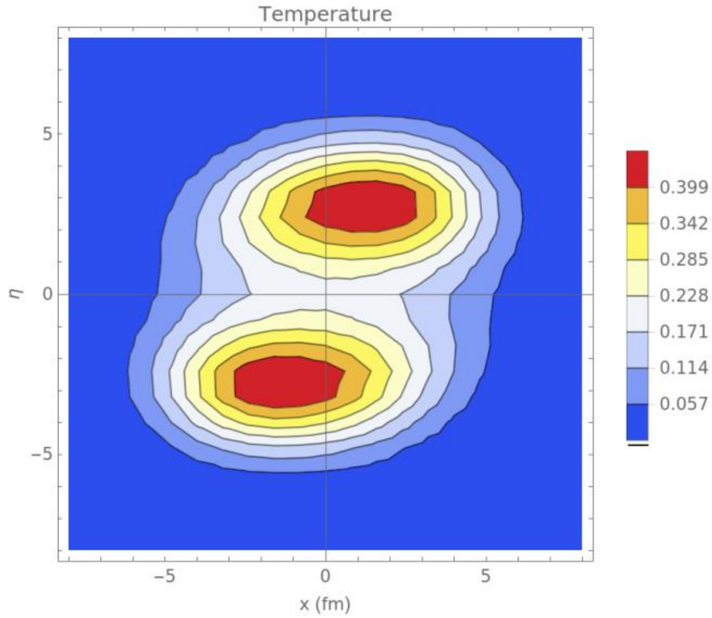


Evolution of QGP Temperature

$$\varepsilon = 3g_B \frac{T^4}{\pi^2}$$

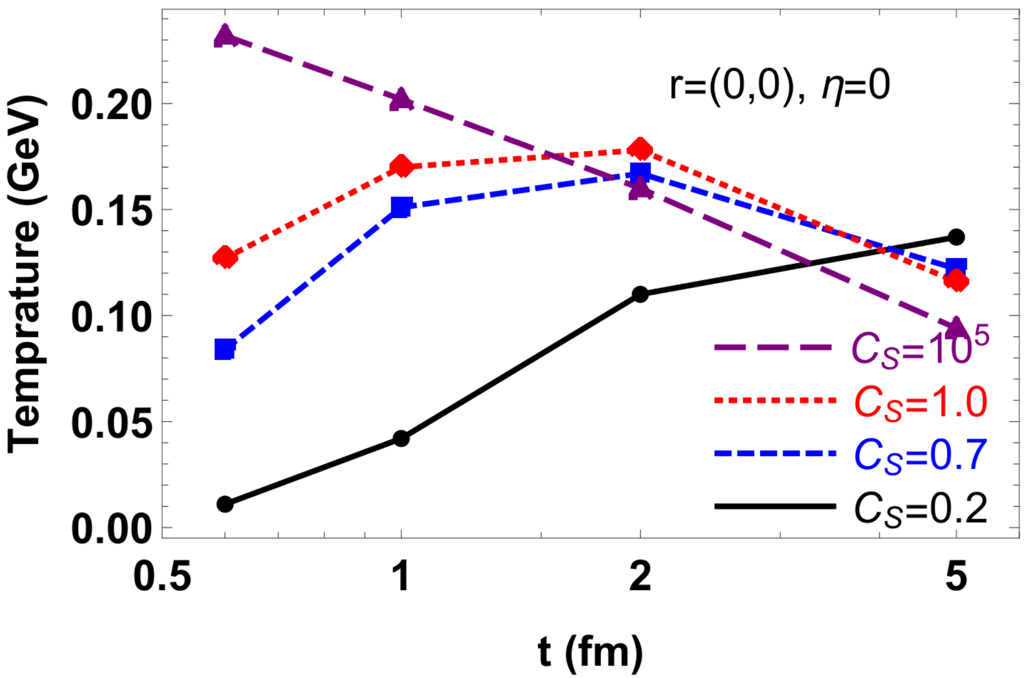
$$\Rightarrow T = \left(\frac{\varepsilon \pi^2}{3g_B}\right)^{1/4}$$





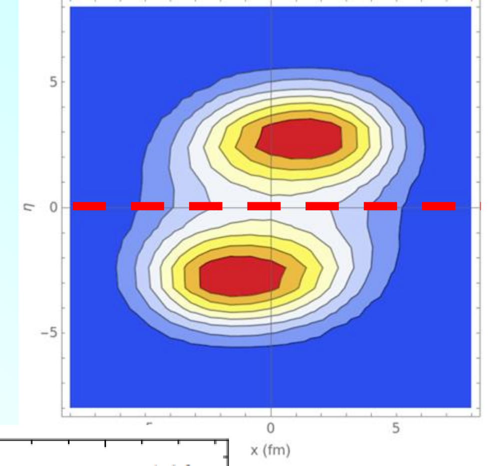
Zi-Wei Lin PRC.90.014904

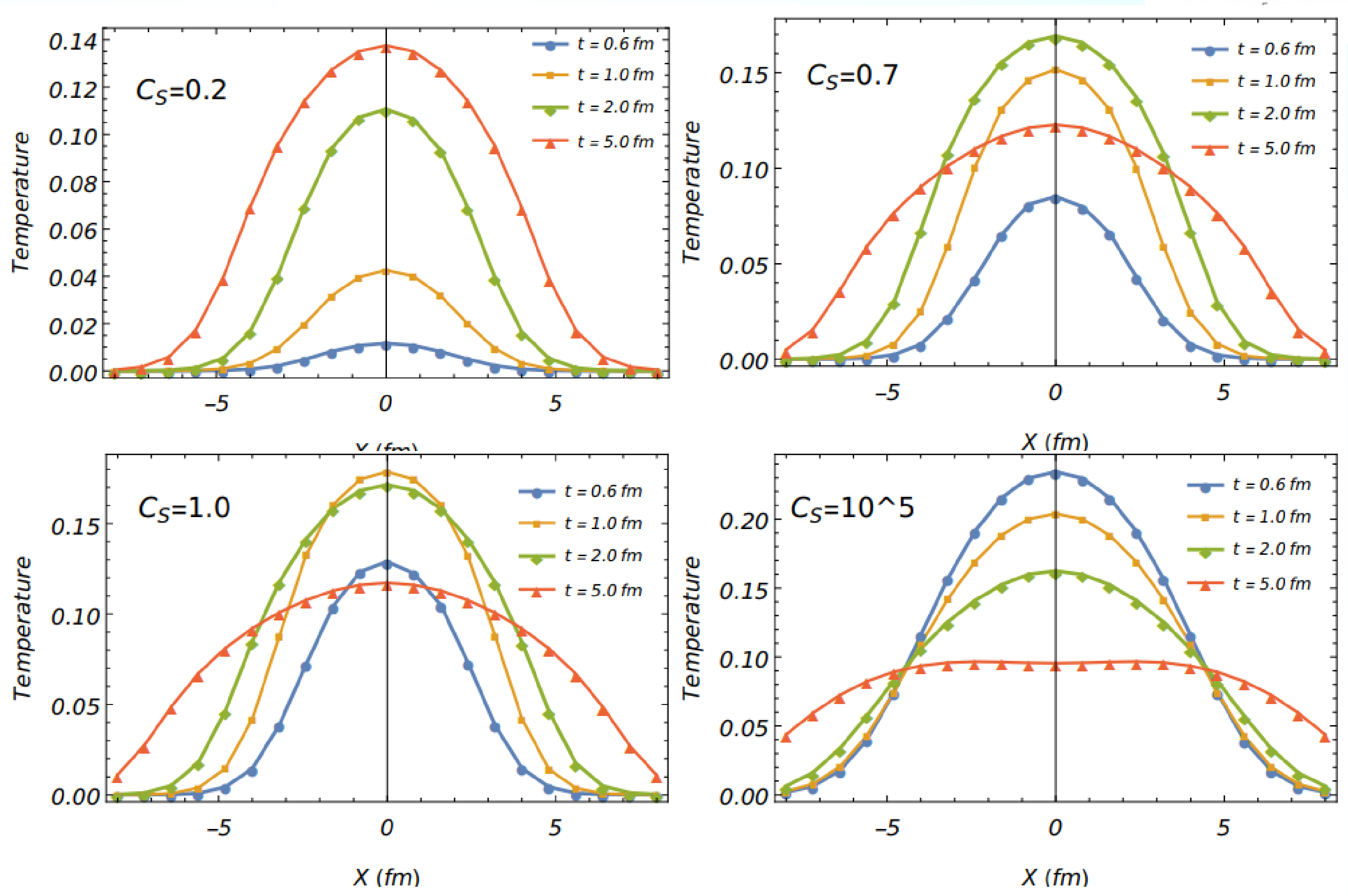
Temperature Vs. C_S :



Evolution of QGP Temperature

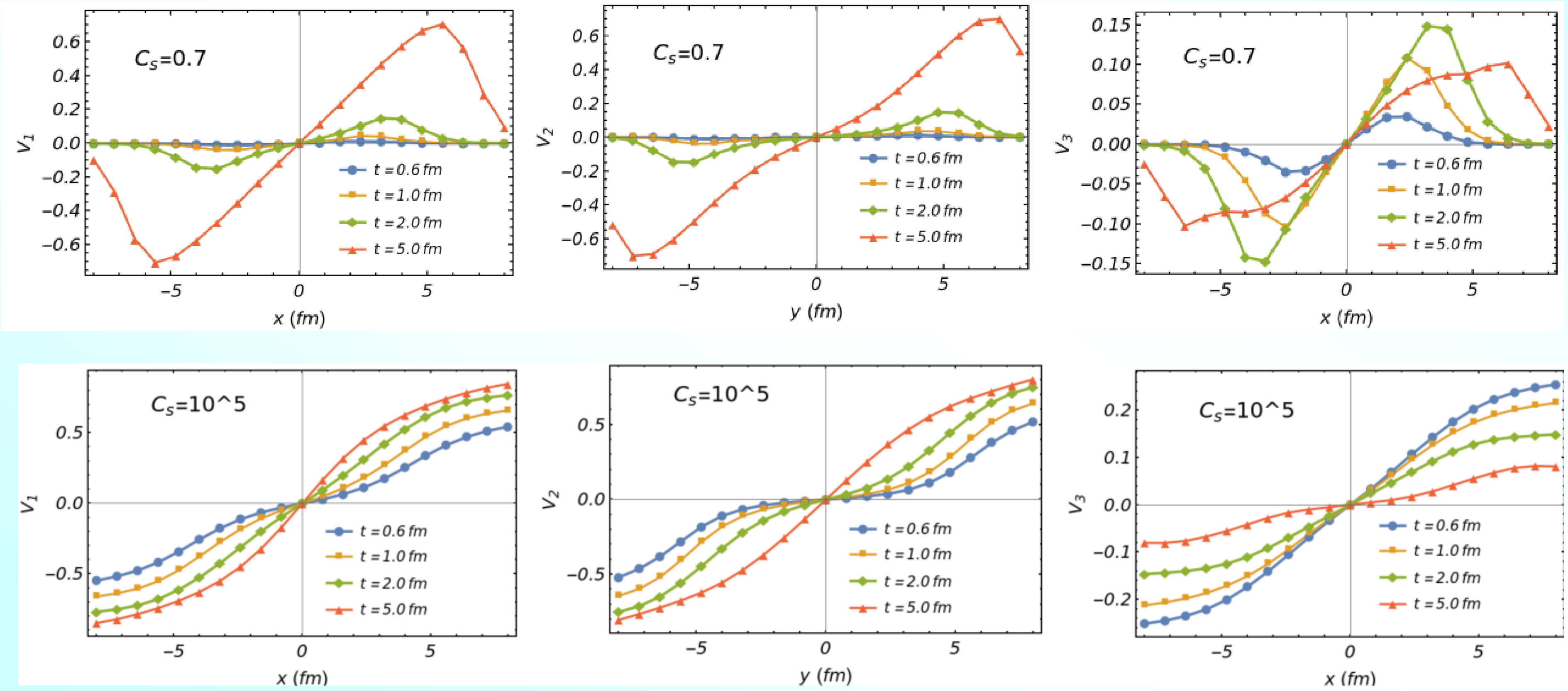
$y = 0, \eta = 0$





Evolution of QGP Velocity

Velocity of energy flow: $$v^a = \frac{T^{0a}}{T^{00} + T^{aa}}$$

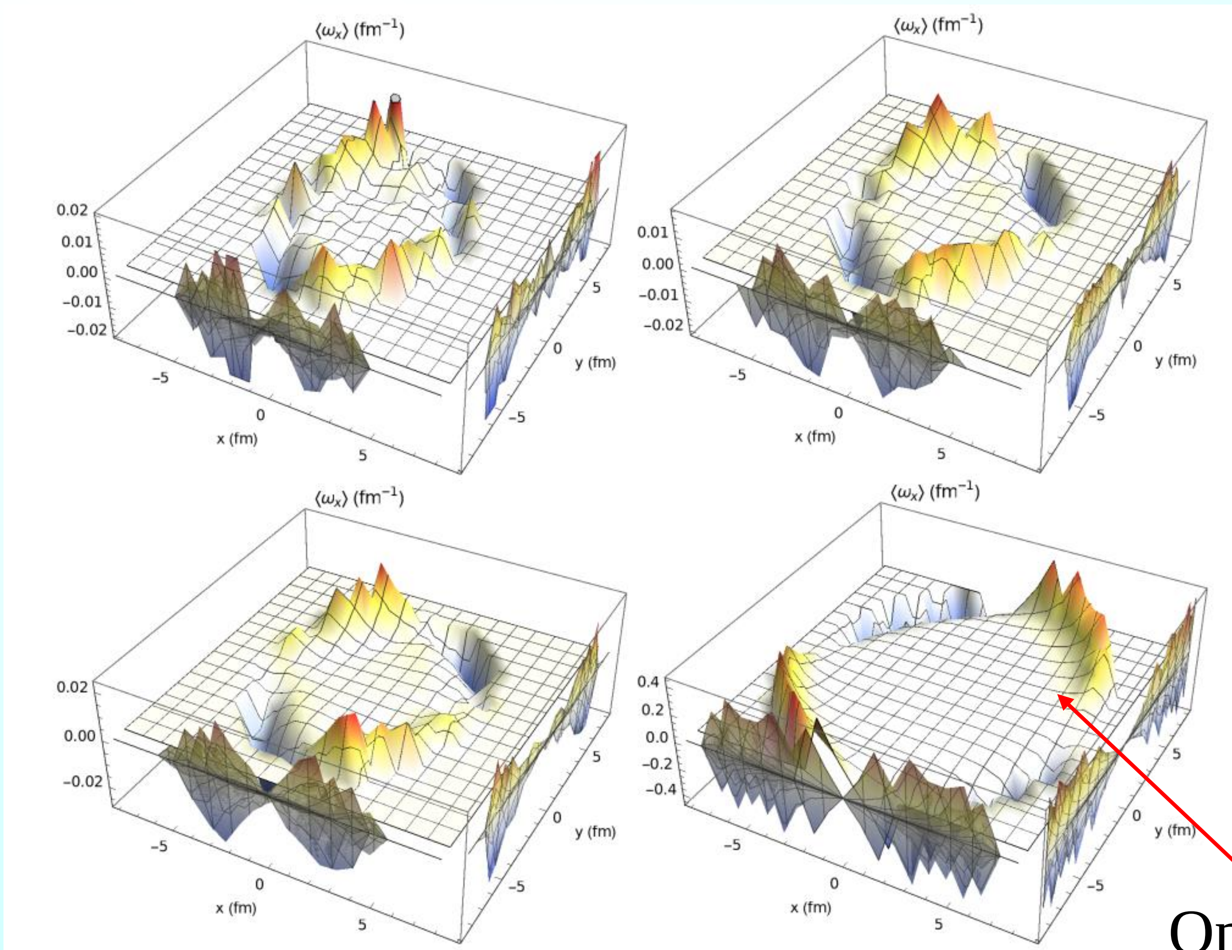


Evolution of QGP Vorticity

$$\vec{\omega}(\vec{x},t)=\frac{1}{2}\nabla\times\vec{v}$$

t =0.6 fm, distribution of ω_x

C_S=0.2 C_S=0.7



C_S=1.0 C_S=10^5

Opposite Sign !

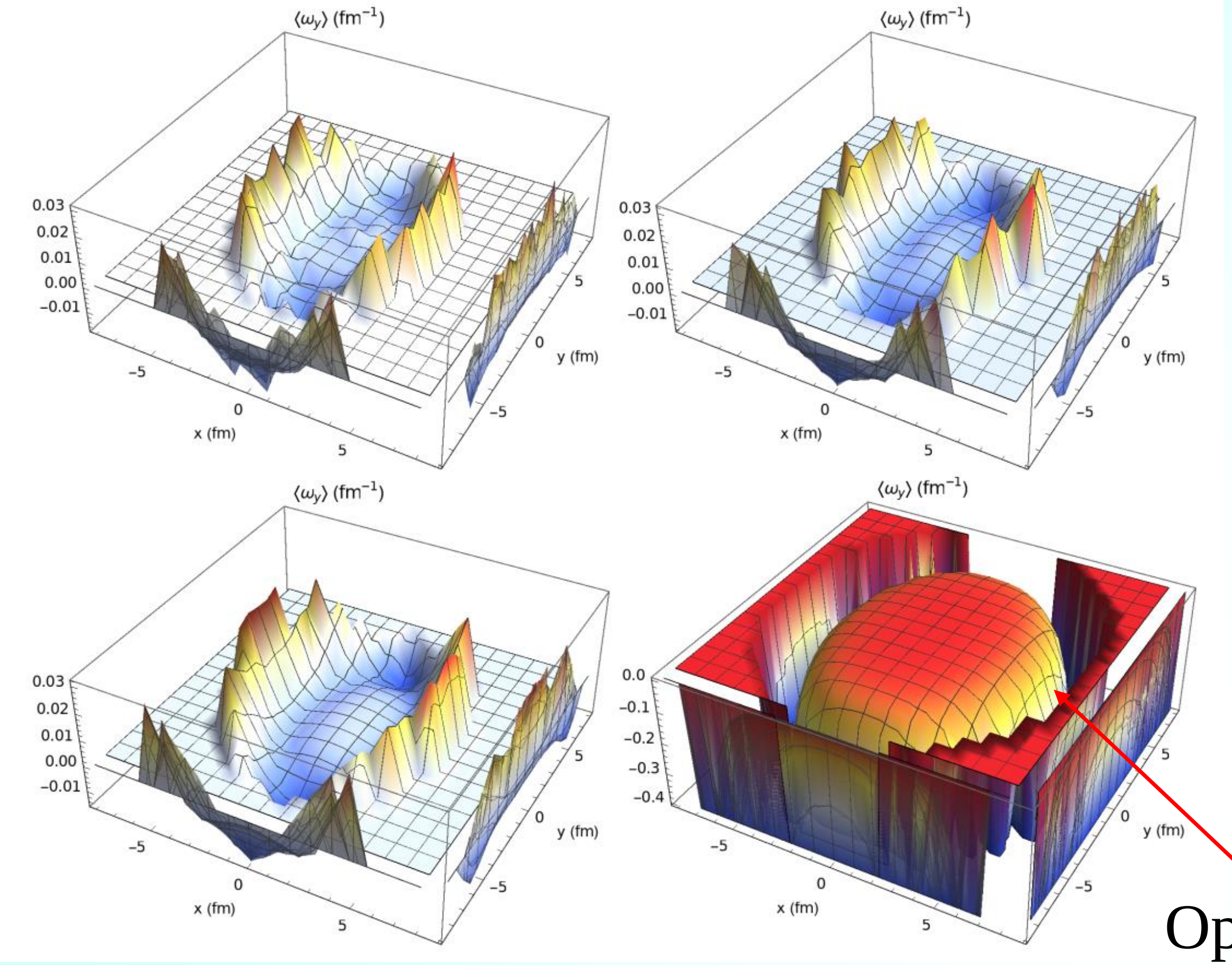
Evolution of QGP Vorticity

$$\vec{\omega}(\vec{x},t)=\frac{1}{2}\nabla\times\vec{v}$$

t =0.6 fm, distribution of ω_y

C_S=0.2 C_S=0.7

C_S=1.0 C_S=10^5



Opposite Sign !

Conclusion

- We constructed a framework based on AMPT model with finite smearing velocity to study evolution of QGP properties.
- Our results show that the evolution of QGP is dependent on the smearing velocity significantly.
- The opposite result of vorticity with different C_S maybe help us to understand the “sign problem” of global polarization observed in STAR experiment.

Thanks!