Backreaction of QGP fluids from recoil partons

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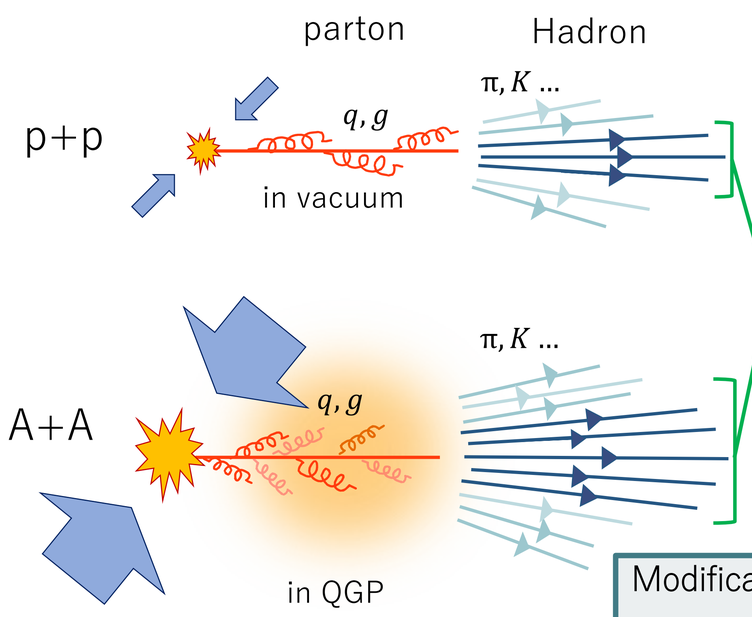
1. Introduction

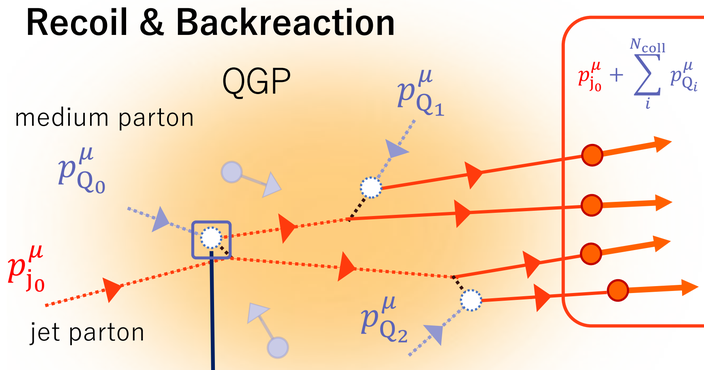


Jet

- Collection of particles originated from hard scatterings
- Propagation through QGP medium in heavy ion collision

Modification of jets is a powerful tool to diagnose a QGP

Recoil & Backreaction

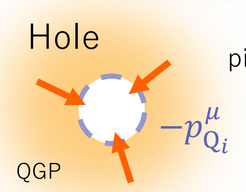


Recoil

Medium partons kicked out by jet partons
- acquire high energy and momentum
- become non-equilibrated partons

Energy-momentum and structure of jet partons are modified

Backreaction



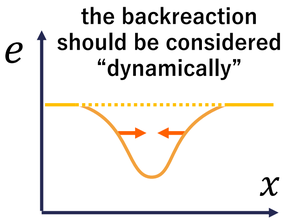
Energy-momentum of medium partons are picked up from QGP medium due to the recoils

Affect the time evolution of QGP medium

Motivation of this study

For more precise understanding of heavy ion collision reaction,

the backreaction should be considered "dynamically"



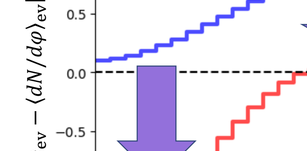
2. Model

Recoil process

■ **Scattering**

Leading order-pQCD + Debye mass of partons

$$\frac{d\sigma}{d\Omega_{CM}} = \frac{\alpha_s^2}{4s}|M(ab \to cd)|^2$$



$gg \to gg,$
$q\bar{q} \to q\bar{q},$
$gq \to gq$ ...

■ **Collision detection**

Stochastic method collision "stochastically"

collision probability

$$P = \sigma v_{rel}\frac{\Delta t}{\Delta V}$$

Z. Xu and C. Greiner, Phys. Rev. C **71**, 064901(2005)

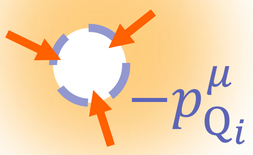
Backreaction

Hydrodynamic equation

$$\partial_\mu T^{\mu\nu}_{QGP} = \underline{-J^\nu}$$

"Negative" source

QGP



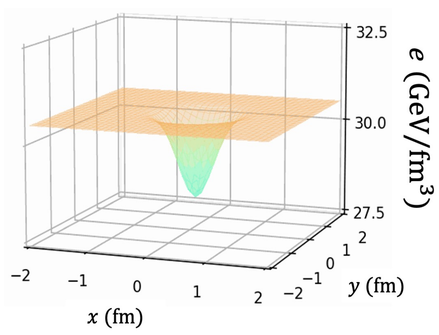
Gaussian source $G(x - x_{Q_i}) = \left(\frac{1}{2\pi\sigma_G^2}\right)^{\frac{3}{2}} \exp\left[-\frac{(x-x_{Q_i})^2}{2\sigma_G^2}\right]$

$$J^\nu = \frac{dp^\nu_{Q_i}}{dt} \underbrace{G(x - x_{Q_i})}_{\text{Gaussian function}}$$

$p^\mu_{Q_i}, x_{Q_i}$: energy-momentum and position coordinate of recoiled medium partons

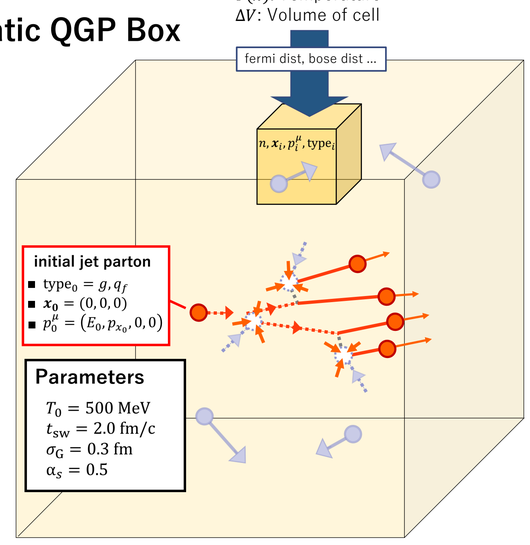
- (3+1)-D ideal hydro
- conformal EoS

energy density of QGP medium



Static QGP Box

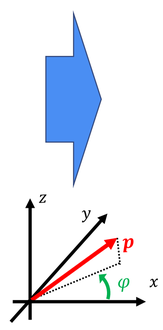
$T(x)$: Temperature
ΔV: Volume of cell



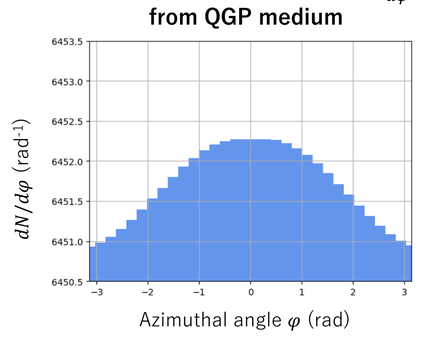
F. Cooper and G. Frye, Phys. Rev. D **10**, 186 (1974)

Particlization of QGP medium

$@t = t_{sw}$



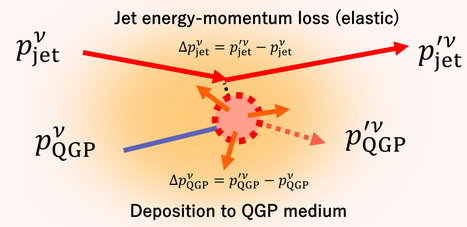
Azimuthal angle distribution $\frac{dN}{d\varphi}$ from QGP medium



E_{thr}: threshold of deposition and recoil

Energy loss & Deposition

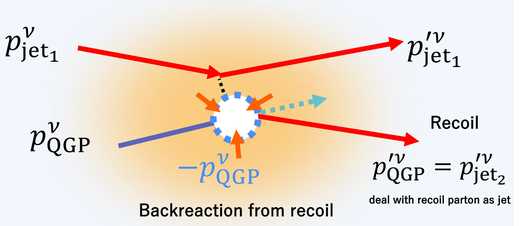
When $E'_{QGP} < E_{thr}$ after the scattering @LRF



$$\partial_\mu T^{\mu\nu} = +\frac{d(\Delta p^\nu_{QGP})}{dt} G(x - x_{QGP})$$

Recoil & Backreaction

When $E'_{QGP} \geqq E_{thr}$ after the scattering @LRF



$$\partial_\mu T^{\mu\nu} = -\frac{dp^\nu_{QGP}}{dt} G(x - x_{QGP})$$

3. Results

Setting: $\text{type}_0 = g,\ p_0^\mu = (50\text{ GeV},\ 50\text{ GeV},\ 0,\ 0),\ 5000$ events
w. **energy loss**, w. **deposition**, w. **recoil**

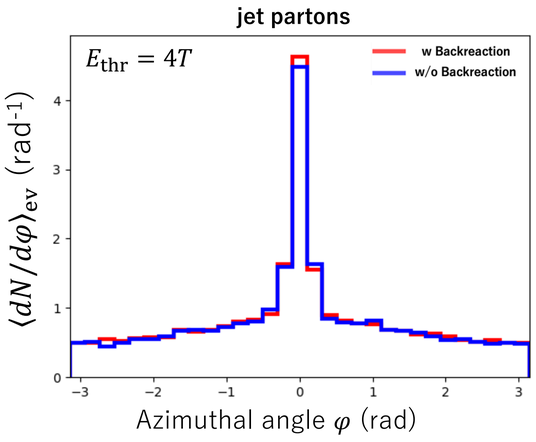
Azimuthal angle distribution of final state ($@\ t = t_{sw}$)

medium partons

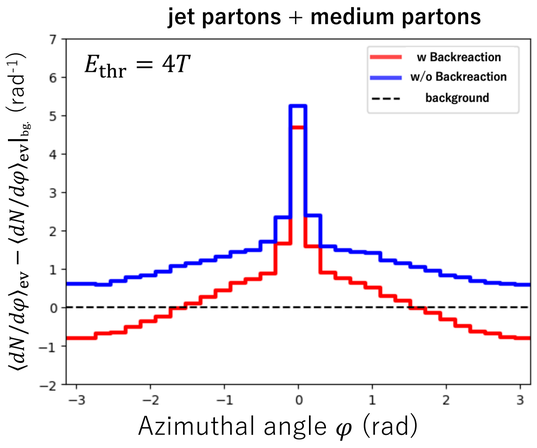
recoiled medium partons "before scattering"

- Medium partons with opposite momentum from jet partons are more likely to scatter with jet partons
- This asymmetry of collision probability is reflected in $dN/d\varphi$ of medium partons

jet partons

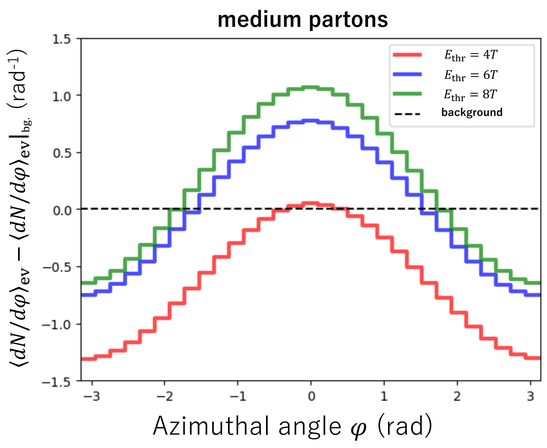


jet partons + medium partons

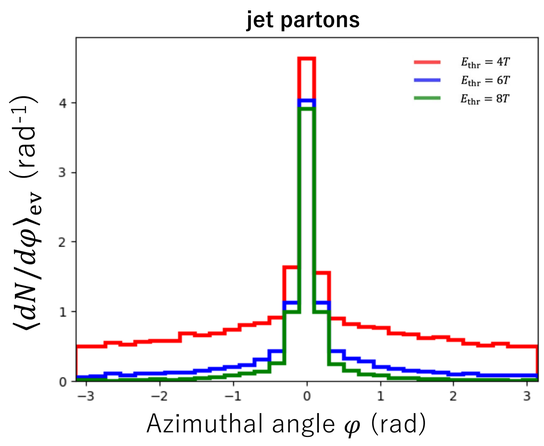


$E_{thr} = 4T, 6T, 8T$, w. backreaction

medium partons

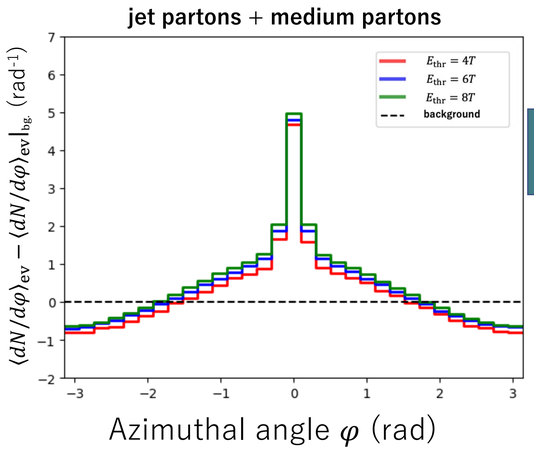


jet partons

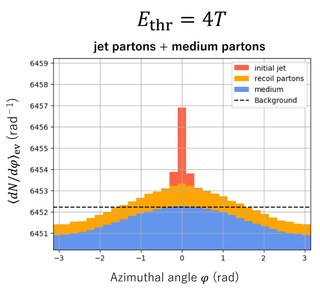


E_{thr} ↑ → the effect of deposition ↑, backreaction ↓

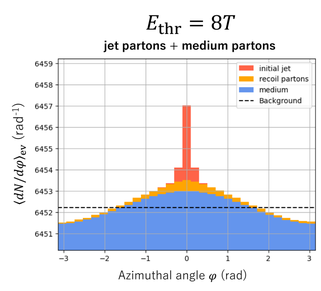
jet partons + medium partons



$E_{thr} = 4T$



$E_{thr} = 8T$



Outlook

Investigate the particle ratio of parton & hadron from the effect of deposition vs backreaction

4. Summary

- We introduced hydrodynamic equation with negative source term to describe the backreaction of QGP dynamically.
- We observed azimuthal angle distribution from QGP medium was modified due to the backreaction. Y. Kanakubo *et al.*, Phys. Rev. C **105** , 024905 (2022)
- We will update the Dynamical Core-Corona initialization (DCCI) including collision dynamics & backreaction of QGP.