Polarization in heavy-ion collisions via local initial energy deposition

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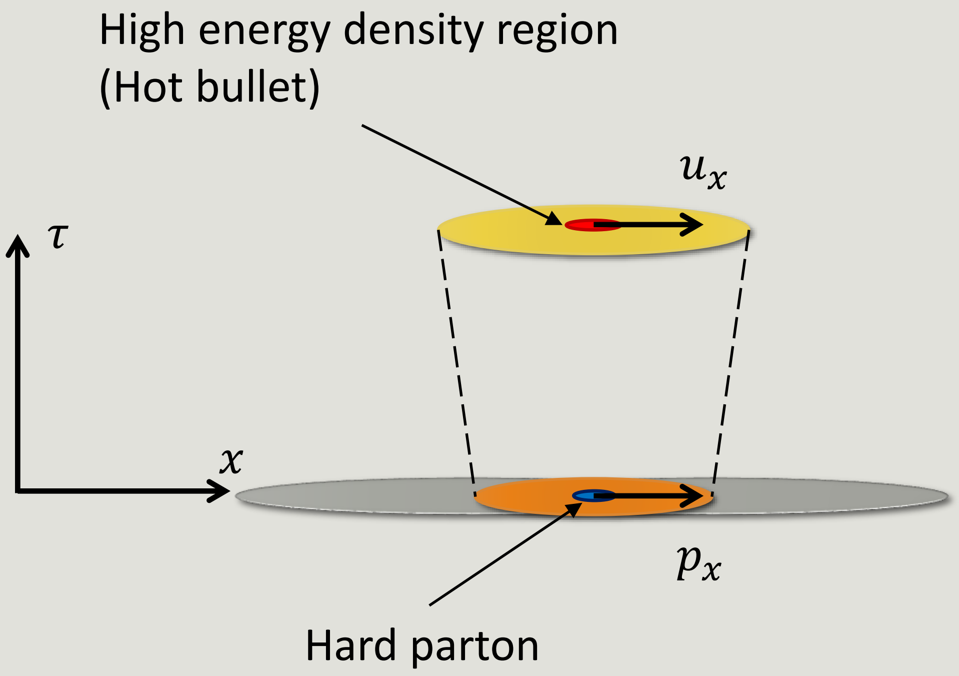
Jet quenching and polarization



High energy density region
(Hot bullet)

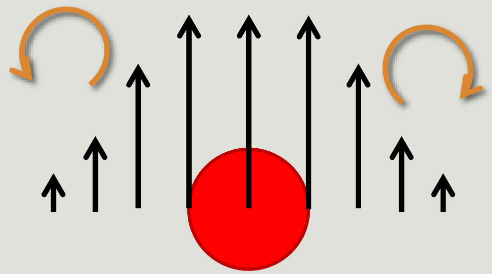
u_x

τ

x

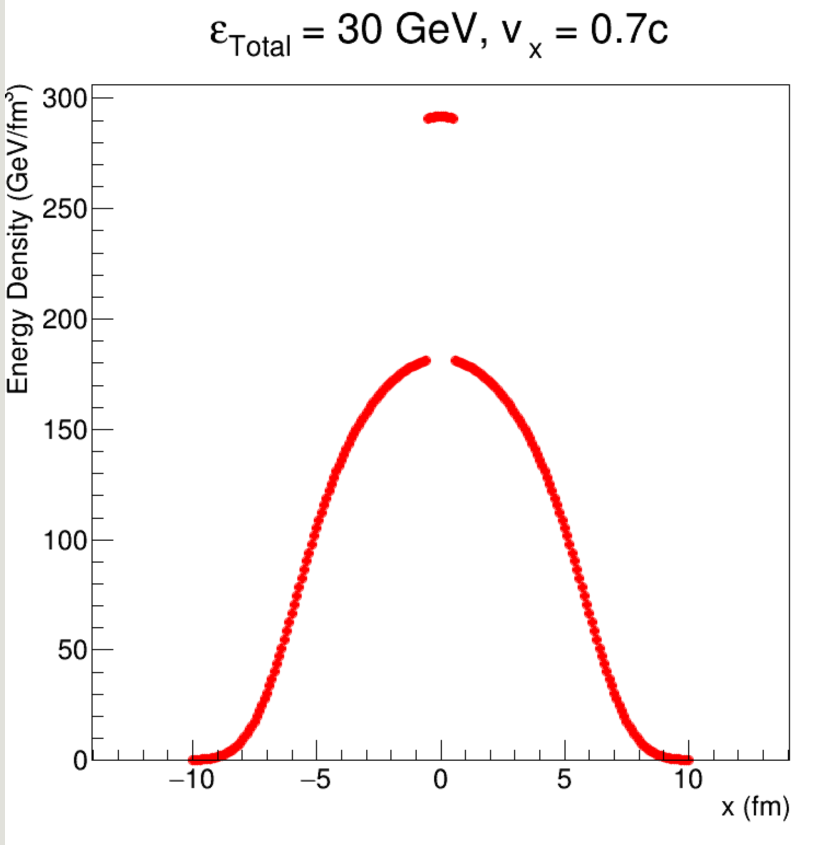
p_x

Hard parton



- Unknows:
  - How relate u_x and p_x
  - What should be the the total energy of the hot bullet

Smooth IC + Hot spot carrying momentum



$$T^{\mu\nu} = \frac{1}{V}\frac{p^\mu p^\nu}{E} = \frac{1}{V}\begin{pmatrix} E & p_x & 0 & 0 \\ p_x & p_x^2/E & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

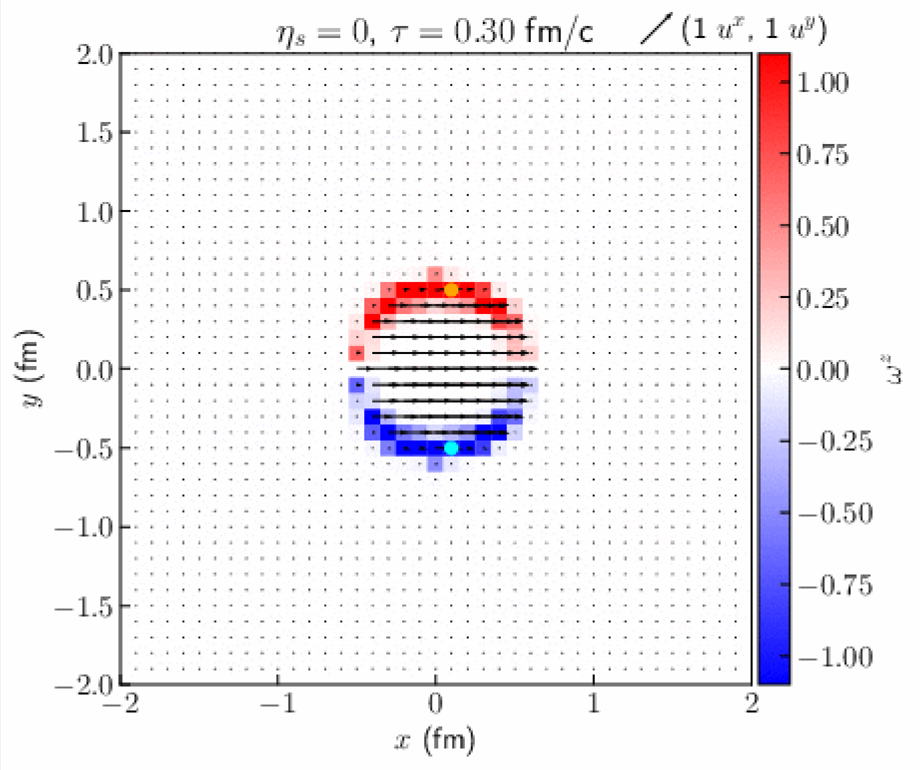
Then solve $T^{\mu\nu}u_\nu = \varepsilon u^\mu$

$$M_{eff} = \sqrt{E^2 - p_x^2}$$

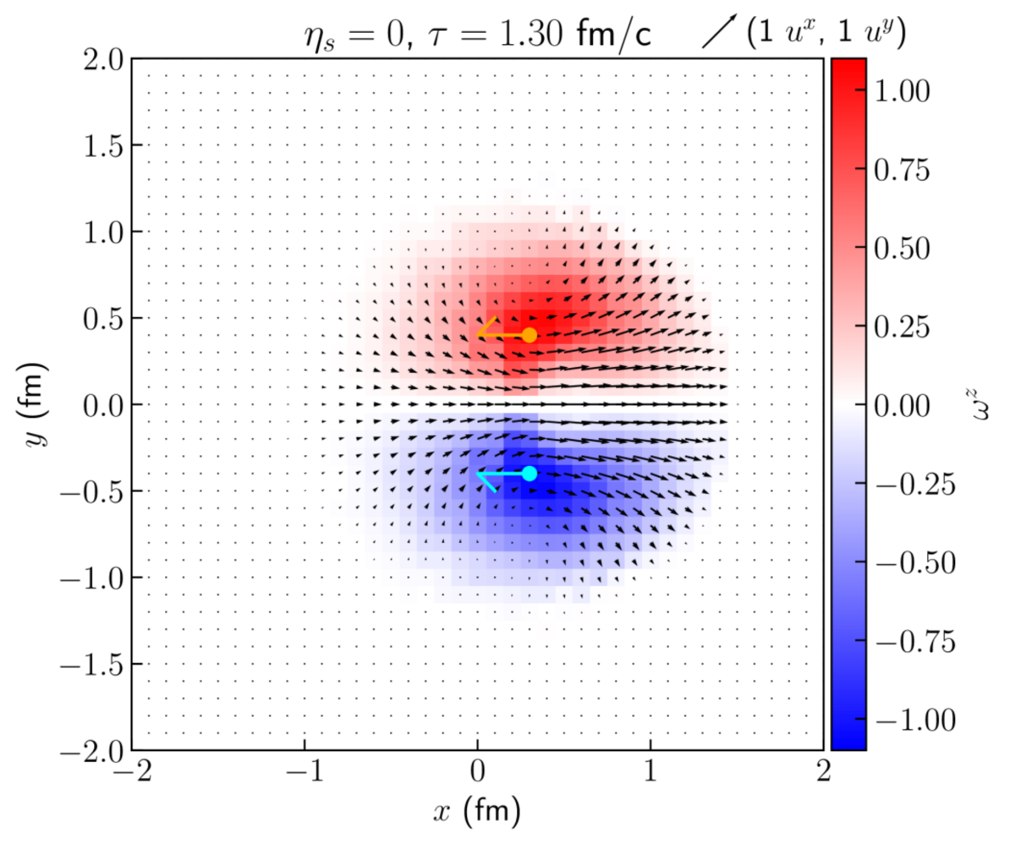
$$\varepsilon = \frac{1}{V}\frac{M_{eff}^2}{E} = \frac{1}{V}\ 30\text{ GeV};$$

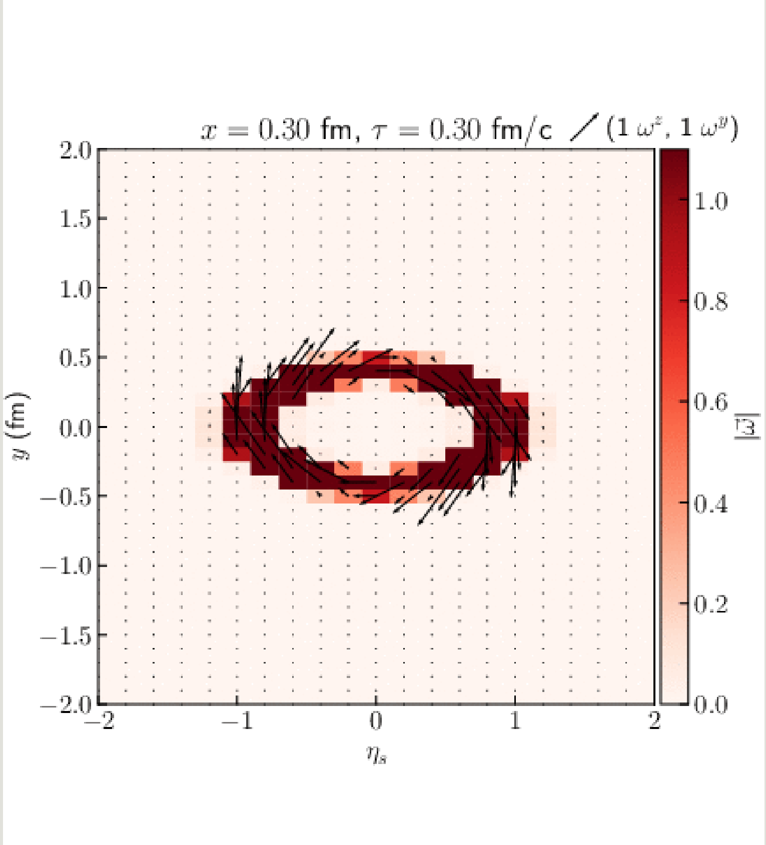
$$u^x = \frac{p_x}{M_{eff}} = 1.27; \quad u^\tau = \sqrt{1 + (u^x)^2}$$

Vorticity evolution in (3+1)D viscous hydrodynamics

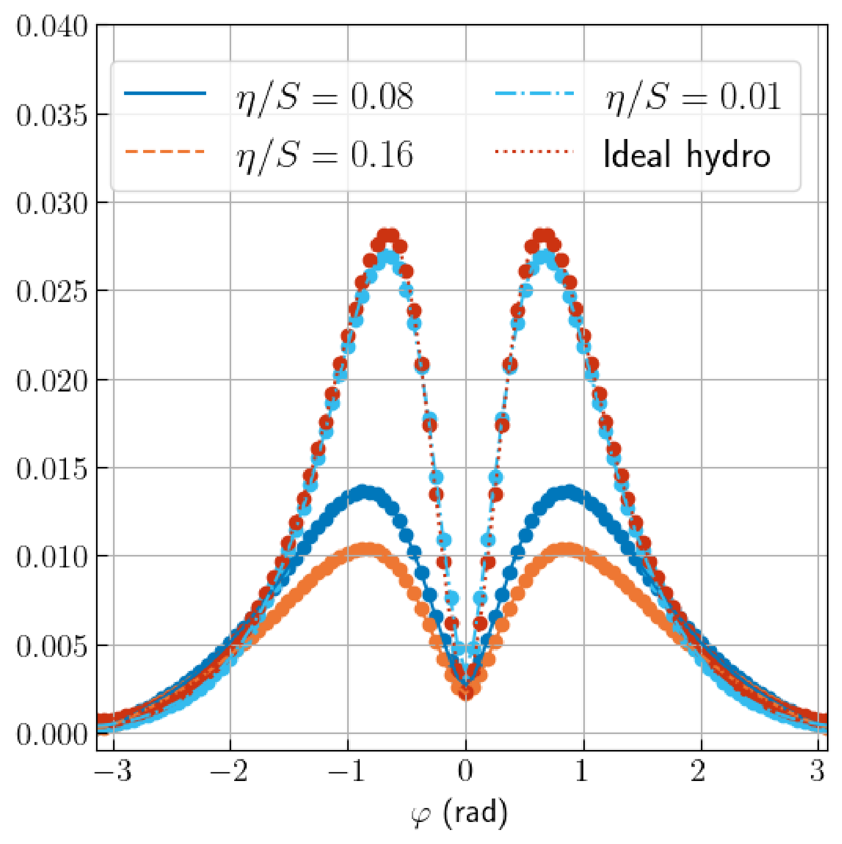


Vorticity evolution in (3+1)D viscous hydrodynamics





R-observable:$R^{\hat{J}}(\vec{p}) = \frac{\vec{P}\cdot(\hat{J}\times\vec{p})}{|\hat{J}\times\vec{p}|}$



- $P^{\mu} = -\frac{1}{8m}\varepsilon^{\mu\nu\rho\sigma}p_{\sigma}\frac{\int d\Sigma^{\lambda}p_{\lambda}(1-n_F)\omega_{\nu\rho}}{\int d\Sigma^{\lambda}p_{\lambda}n_F}$

  $n_F = \frac{1}{1+\exp(\beta^{\mu}p_{\mu}-\mu Q/T)}$

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- Strength of $R_{\hat{J}}$ is heavily dependent of shear viscosity
  - Position of peak changes very little (in the limit of the grid)
- Ideal hydro and $\frac{\eta}{s} = 0.01$ are very similar

Conclusion

- If a hard parton deposits (part of) its energy and momentum and thermalizes with the medium, it will generate a vortex ring.
- This can be quantified by the ring observable $R^{\hat{J}}(\vec{p}) = \frac{\vec{P}\cdot(\hat{J}\times\vec{p})}{|\hat{J}\times\vec{p}|}$
- It shows strong sensitivity to medium shear viscosity.

THANKS

Processes: # 2017/05685-2
2019/05700-7