Response of Quark Gluon Plasma to two hard partons

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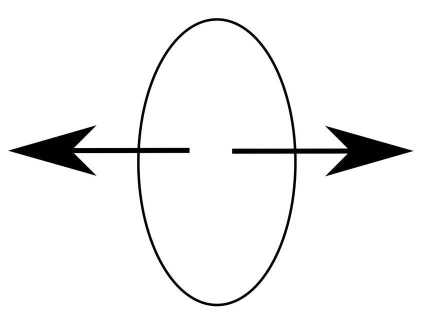
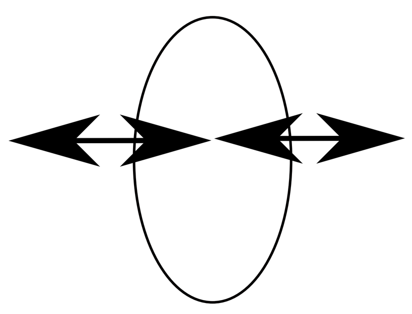
Introduction

One pair of jets



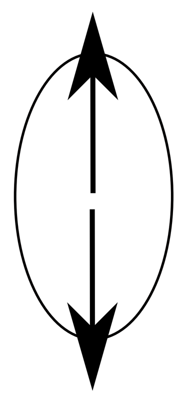
Higher contribution to the elliptic flow.

Two pair of jets

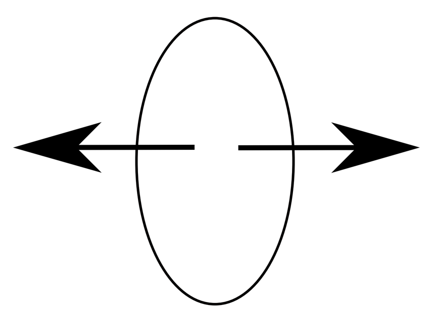


Momenta cancel out. Less generation of the elliptic flow.

Illustration of the likeness or unlikeness of two streams to meet

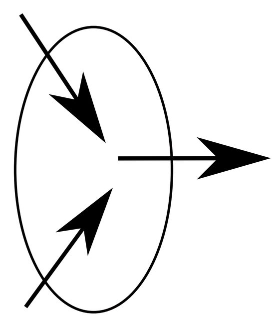


Two streams flowing in the out-of-plane direction are likely to meet.



As the fireball is elongated out of the reaction plane, two streams which flow in the in-plane direction have more space to pass each other without merging.

Merging of streams



Merging of wakes in out-of-plane direction will conttribute to the elliptic flow. Result of toy model presented in [2]

Can be this reproduced in hydrodynamics ? How do two wakes merge ?

Hydrodynamic simulation

Both punch through and fully stopped jets in medium leave behind streams [1].
Medium flows even after jet is fully stopped [1].
LHC: Minijets will be copious and deposit energy and momentum to the medium and will induce and influence collective flow.
From interaction of "streams" in the medium there will be second order anisotropy in collective flow correlated with the reaction plane.
3+1 D ideal hydrodynamic simulations including two evolving hard partons was performed.

Four-momentum conservation with jet source term

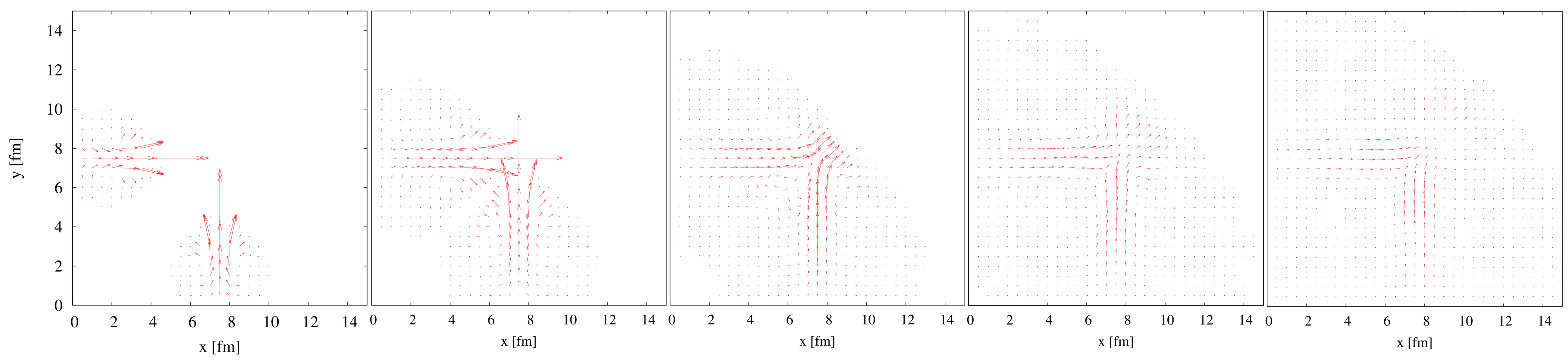
$$\partial_\mu T^{\mu\nu} = S^\nu$$

Energy-momentum deposited in medium by the jet gives rise to a source term [1]

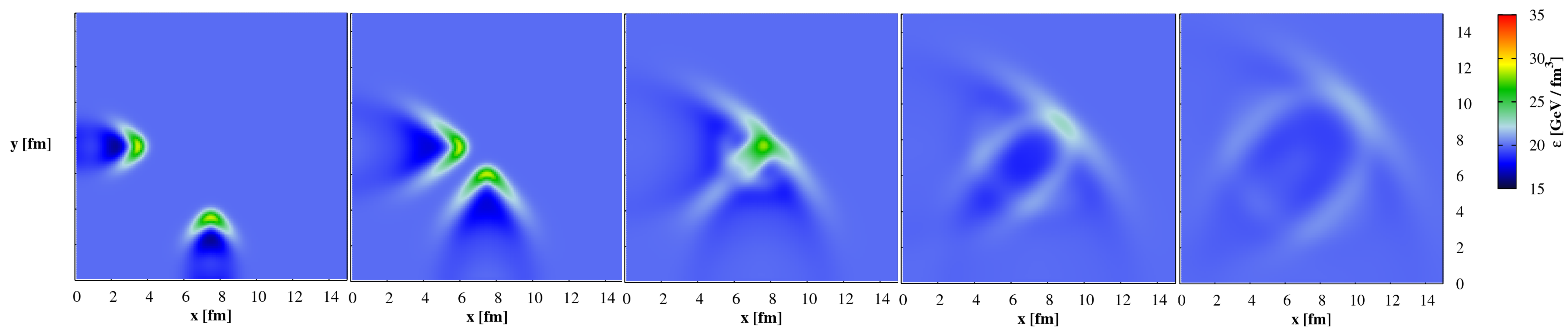
$$S^\nu = \int_{\tau_i}^{\tau_f} d\tau \frac{dM^\nu}{d\tau} \delta^{(4)} \left[x^\mu - x^\mu_{\mathrm{jet}}(\tau)\right]$$

Results

Two hard partons deposit energy and momentum into static medium. One enters from the left, one enters from the bottom. The initial energy loss is 4.15 GeV/fm. Unperturbed static energy density is 20 GeV/fm^3. Jet velocity is equal to 0.9999 c. Jets are fully quenched after 5 fm/c according to the simplified Bethe-Bloch model [1]. Used EoS is lattice inspired [3].

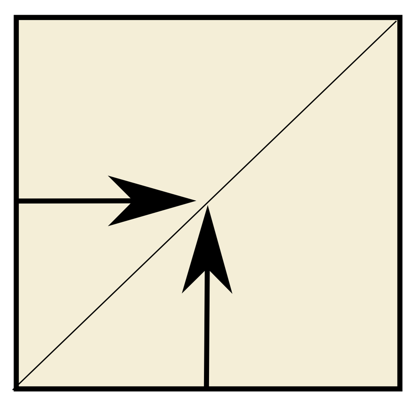


Sequence of flow velocity profiles (arrows) during a hydrodynamical evolution. First profile is taken after time t = 2.5 fm/c. Each other profile is taken after time Δt =2.5 fm/c from previous profile.

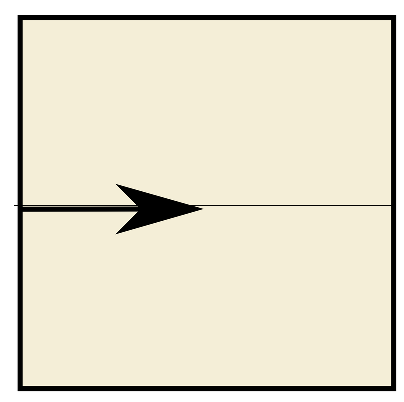


Sequence of energy density profiles during a hydrodynamical evolution. First profile is taken after time t = 2.5 fm/c. Each other profile is taken after time Δt =2.5 fm/c from previous profile.

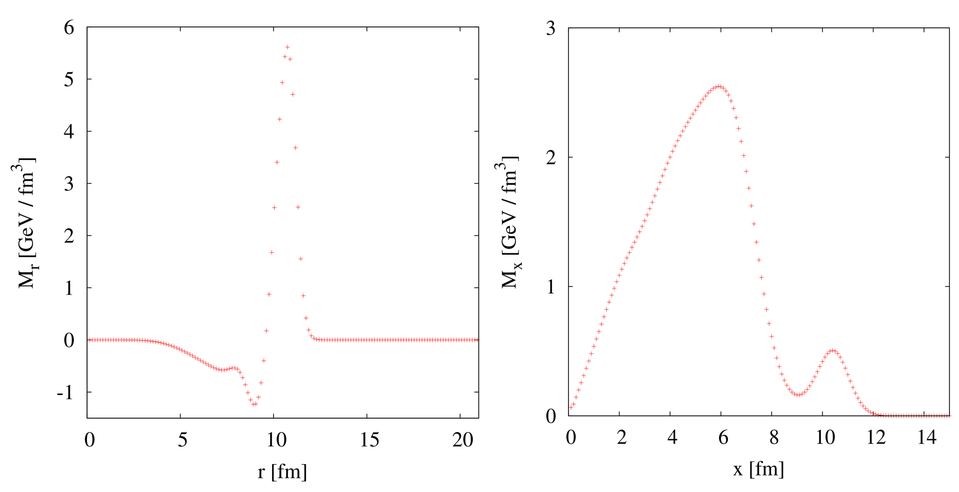
Arrows correspond to direction of the jets evolution. Silver line corresponds to the axis where the momentum density distribution is taken.



Perpendicular jets scenario

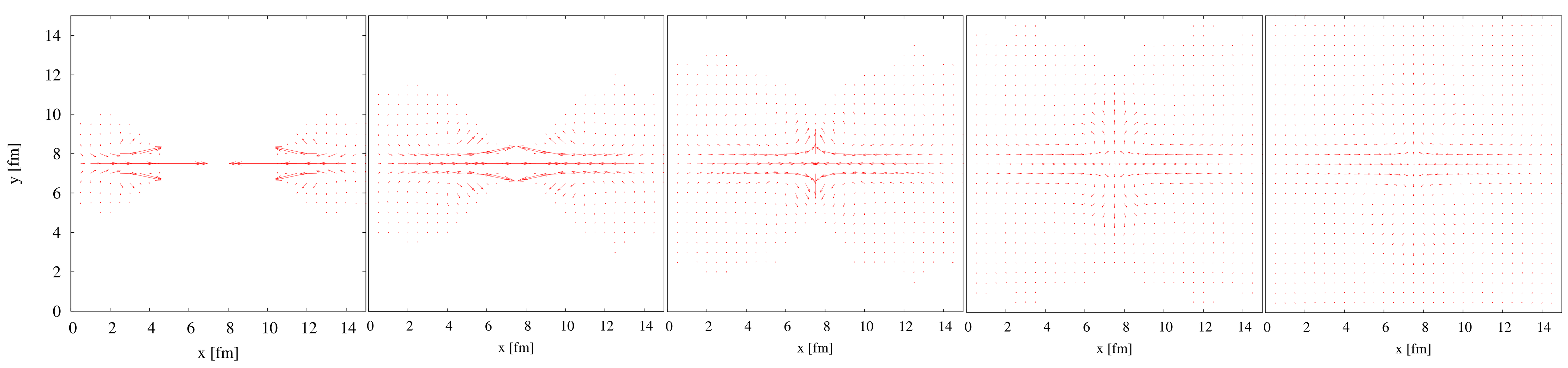


One jet evolving scenario



Momentum density comparison in time t = 7.5 fm/c. EoS is lattice inspired [3]. Left: diagonal momentum density in the diagonal for two perpendicular jets scenario. Right: momentum density in the axis of jet (only one jet is evolving).

Two hard partons deposit energy and momentum into static medium. One enters from the left, one enters from the right. The initial energy loss is 4.15 GeV/fm. Unperturbed static energy density is 20 GeV/fm^3. Jet velocity is equal to 0.9999 c. Jets are fully quenched after 5 fm/c according to the simplified Bethe-Bloch model [1]. Used EoS is lattice inspired [3].



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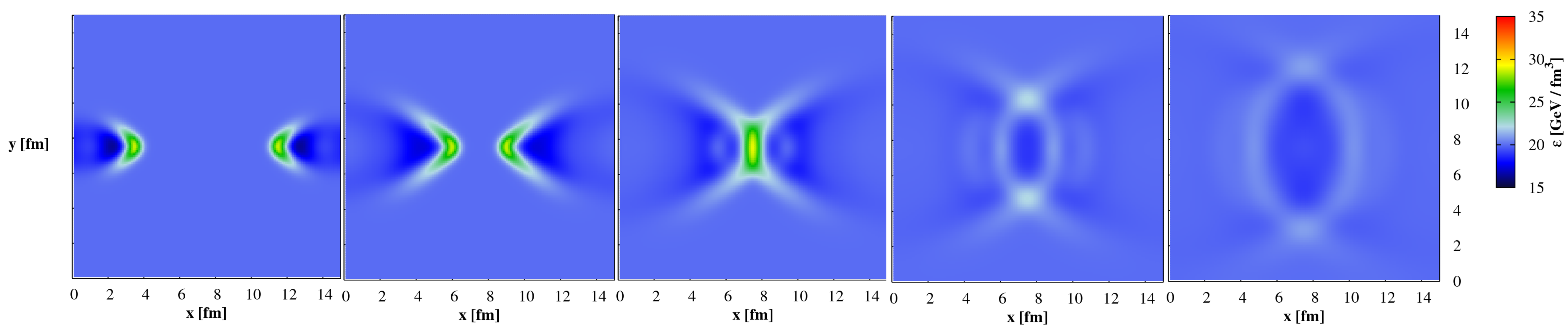

Sequence of energy density profiles during a hydrodynamical evolution. First profile is taken after time t = 2.5 fm/c. Each other profile is taken after time Δt =2.5 fm/c from previous profile.

Conclusions

We can perform 3+1D hydrodynamic two jets simulations in static QGP for any direction of jet.

Hydrodynamic simulation confirms the scenario by Tomášik and Lévai [2].

Two generated wakes merge.

Obtained results are qualitative similar for EoS in ultrarelativistic limit or lattice inspired EoS [3].-

References

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[3] M. Laine, Y. Schroder, Phys.Rev. D**73** (2006) 085009