Gamma+jet fragmentation functions and jet-induced medium excitation

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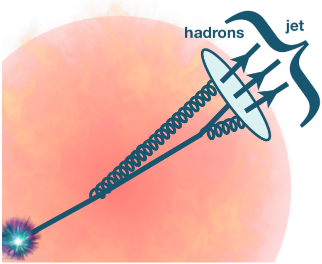
Outline

Introduction

jet tomography for the study of QGP

- suppression of leading hadrons
- dihadron and γ-hadron correlations
- jet specta modification
- dijet and γ-jet correlations
- jet profiles



from Yasuki Tachibana

How to determine the modification jet:

- energy loss of the leading shower partons
- the redistribution of the lost energy in the medium

we need a complete understanding of both **jet transport** and **jet-induced medium excitation**.

Introduction

In this case, we hope to develop a realistic model for simultaneous event-by-event simulations of jet transport and hydrodynamic evolution of the bulk medium including jet-induced medium excitation.

CoLBT-hydro: Linear Boltzmann jet transport model + (3+1)D hydrodynamics model

CoLBT-hydro model

Linear Boltzmann jet transport model (LBT)	$\Leftrightarrow$	**(3+1)D hydrodynamcis model (CLVisc)**
$\Downarrow$		$\Downarrow$
jet transport and propagation		hydrodynamic evolution of bulk medium

CLVisc:hydrodynamic evolution of bulk medium

Note:

- Kurganov and Tadmor(KT) algorithm (finite volume)
- QGP phase above 220GeV and hadron phase below 184GeV
- implemented in the GPU

(3+1)D hydrodynamcis model (CLVisc)

- hydrodynamic evolution
  use CCNU-LBNL CLVisc code to solve hydrodynamical equations with a parametrized equation of state(Eos)s95p-v1
- Cooper-Frye calculation

$$\frac{dN}{dYp_T dp_T d\phi} = \frac{g_s}{(2\pi)^3}\int_\Sigma p^\mu d\Sigma_\mu \frac{1}{exp((p\cdot u-\mu/T_{FO})\pm 1}$$

- hadron resonance decay

LBT:jet transport in QGP

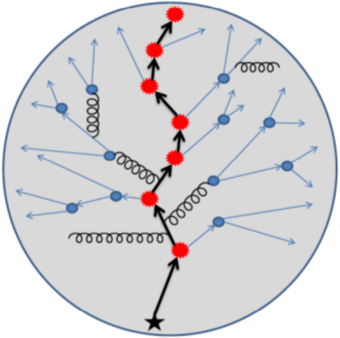
Linear Boltzmann jet transport model (LBT)

jet transport is simulated according to a linear Boltzmann equation

$$p_a \cdot \partial f_a = \gamma_b \int \prod_{i=b,c,d} d[p_i](f_c f_d - f_a f_b)|M_{ab\to cd}|^2$$

$$\times S_2(\hat{s},\hat{t},\hat{u})(2\pi)^4\delta^4(p_a+p_b-p_c-p_d) + inelastic,$$

- consider both elastic and inelastic processes
- keep track of jet shower parton and thermal recoiled parton
- take into account of back reaction and denote initial thermal partons in each scattering as "negative" partons



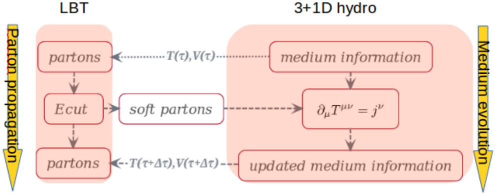
Hanlin Li, etc Phys.Rev.Lett. 106, 012301
Xin-Nian Wang, Yan Zhu Phys.Rev.Lett. 111, 062301
Yayun He, Tan Luo, Xin-Nian Wang, Yan Zhu Phys.Rev. C91 (2015) 054908

CoLBT-hydro model

CoLBT-hydro model

Linear Boltzmann jet transport model (LBT) ⇓ jet transport and propagation $\Leftrightarrow$ **(3+1)D hydrodynamcis model (CLVisc)** ⇓ hydrodynamic evolution of bulk medium

- formulated in the Milne coordinates $(\tau, \vec{x_\perp}, \eta_s)$
- simulated in sync with each other



$$J^\nu = \sum_{i=1}^{n} \frac{P^\nu_{i(soft)}}{\Delta\tau} \delta^3(\vec{X} - \vec{X_i}) - \sum_{i=1}^{m} \frac{P^\nu_{i(neg)}}{\Delta\tau} \delta^3(\vec{X} - \vec{X_i}) \quad (1)$$

soft: partons with $p \cdot u < Ecut$ neg: "negative" partons from back reaction

- **Assumption**:Instantaneous local thermalization of deposited energy and momentum

Initial condition and hadronization

	LBT	CLVisc
Initial condition	Pythia 8	AMPT model
Hadronization	recombination model	Cooper Frye

We do event-by-event simulation within CoLBT-hydro model.

Initial condition

- **fluctuating initial condition for the bulk medium evolution** : AMPT
- **energy-momentum of jet shower partons**: Pythia 8
- **initial production positions of jet shower partons**: sampled according to spatial distribution of binary hard processes from the same AMPT event

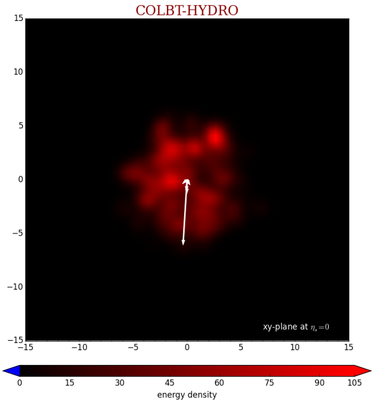
different in each event.

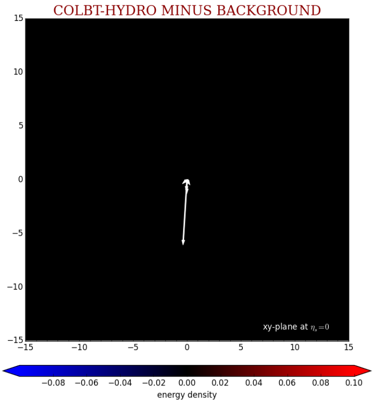
Hadronization

- use Cooper Frye for hydro part
- perturbative parton showers as input to recombination model from Texas A-M group
  Kyong Chol Han, Rainer J. Fries, Che Ming Ko J.Phys.Conf.Ser. 420 (2013) 012044

Jet propagation and jet-induced medium excitation

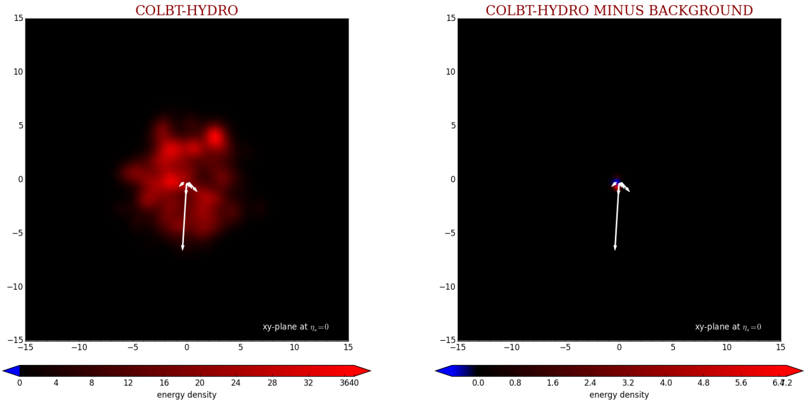
Jet propagation in hot medium at $\tau = 0.4 fm$





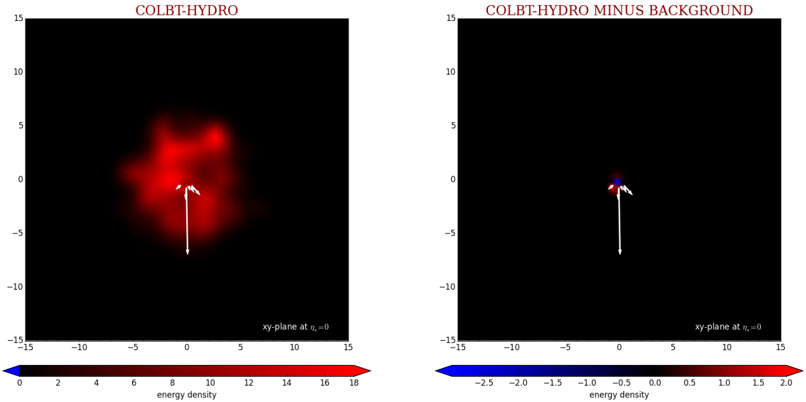
Jet propagation and jet-induced medium excitation

Jet propagation in hot medium at $\tau = 0.8 fm$



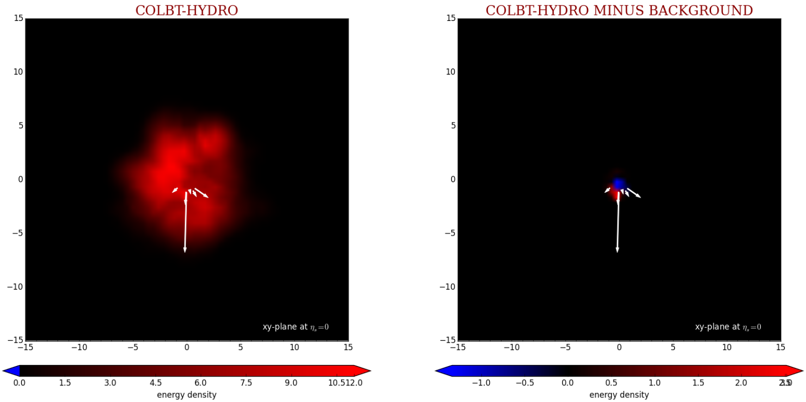
Jet propagation and jet-induced medium excitation

Jet propagation in hot medium at $\tau = 1.2 fm$



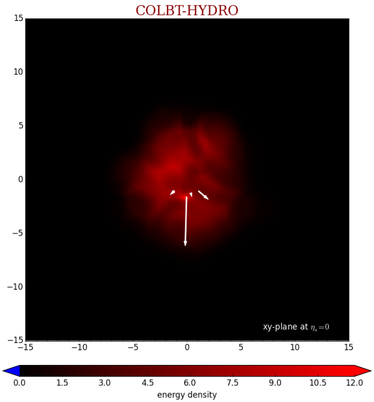
Jet propagation and jet-induced medium excitation

Jet propagation in hot medium at $\tau = 1.6 fm$



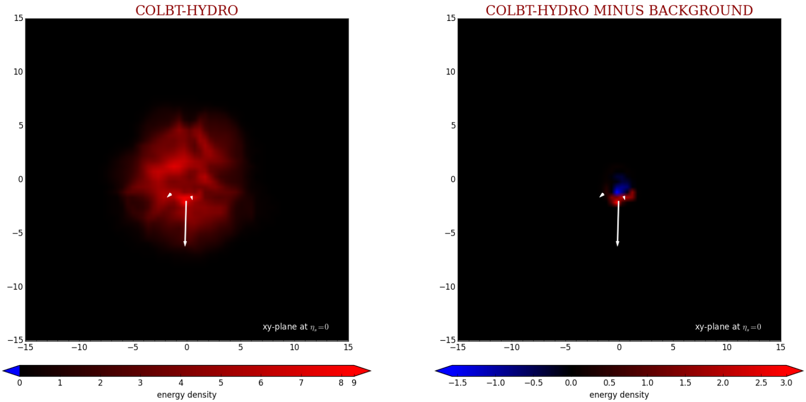
Jet propagation and jet-induced medium excitation

Jet propagation in hot medium at $\tau = 2.0 fm$



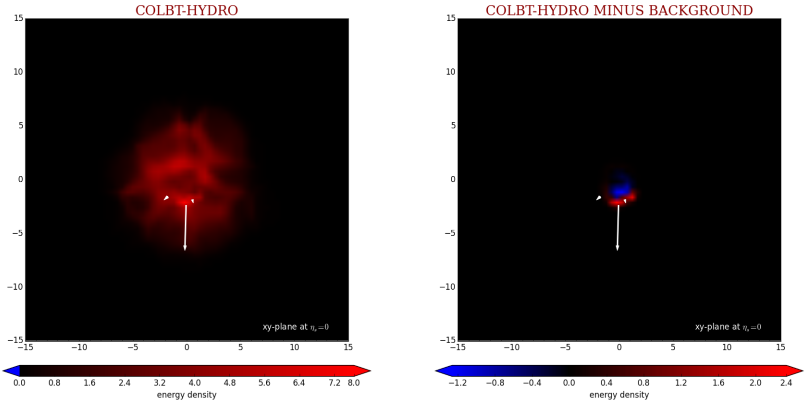
Jet propagation and jet-induced medium excitation

Jet propagation in hot medium at $\tau = 2.4 fm$



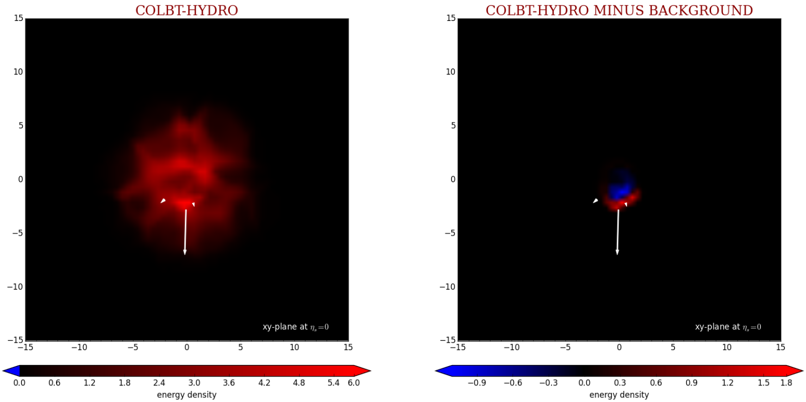
Jet propagation and jet-induced medium excitation

Jet propagation in hot medium at $\tau = 2.8 fm$



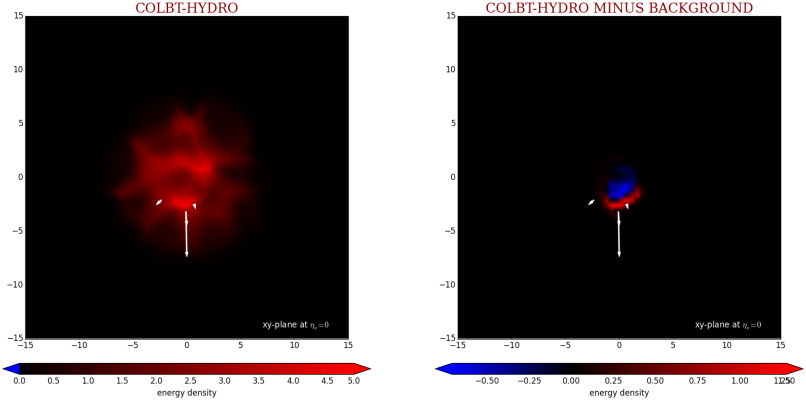
Jet propagation and jet-induced medium excitation

Jet propagation in hot medium at $\tau = 3.2 fm$



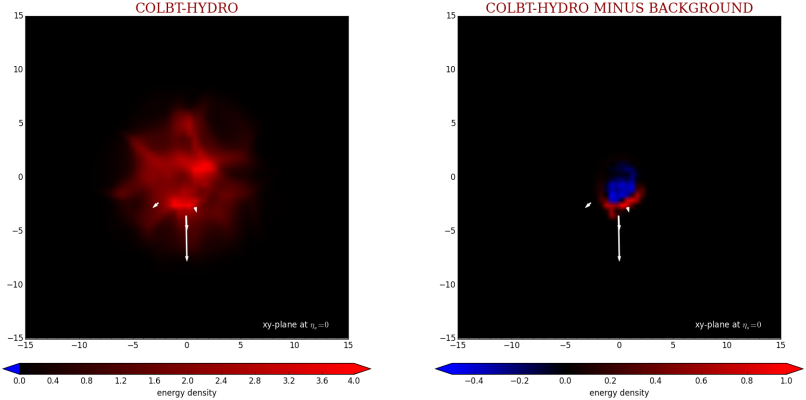
Jet propagation and jet-induced medium excitation

Jet propagation in hot medium at $\tau = 3.6 fm$



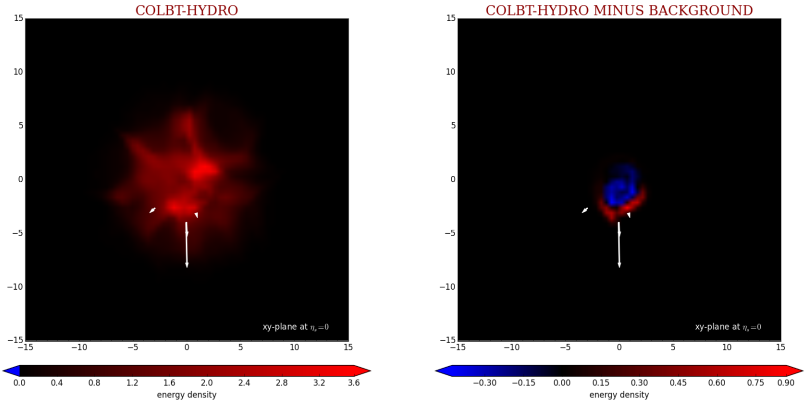
Jet propagation and jet-induced medium excitation

Jet propagation in hot medium at $\tau = 4.0 fm$



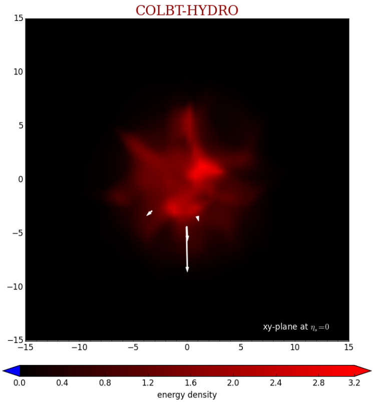
Jet propagation and jet-induced medium excitation

Jet propagation in hot medium at $\tau = 4.4 fm$



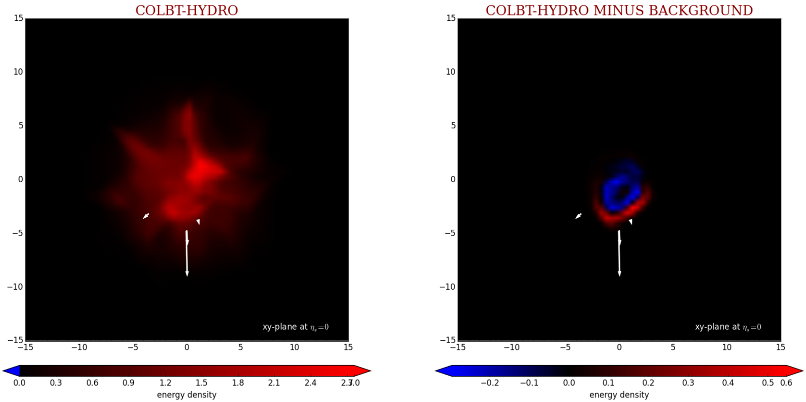
Jet propagation and jet-induced medium excitation

Jet propagation in hot medium at $\tau = 4.8 fm$



Jet propagation and jet-induced medium excitation

Jet propagation in hot medium at $\tau = 5.2 fm$



Jet propagation and jet-induced medium excitation

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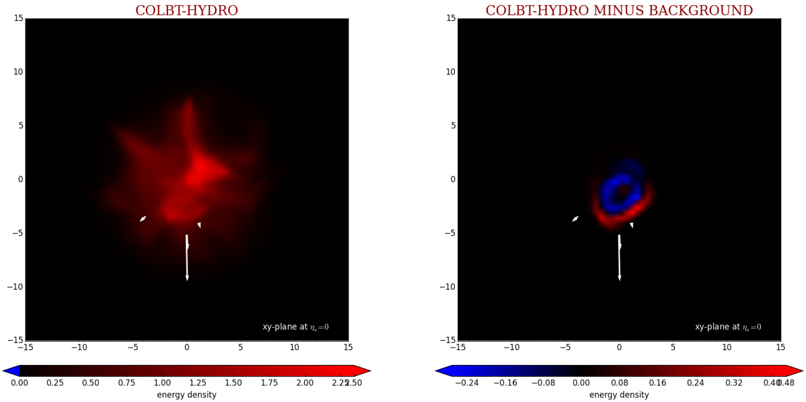
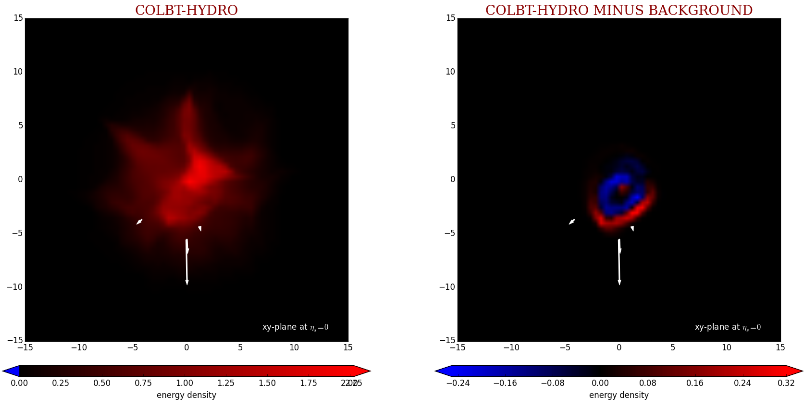


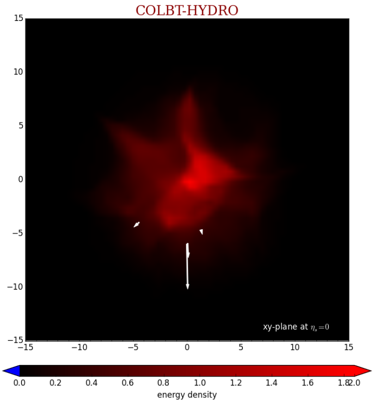
Jet propagation and jet-induced medium excitation

Jet propagation in hot medium at $\tau = 6.0 fm$



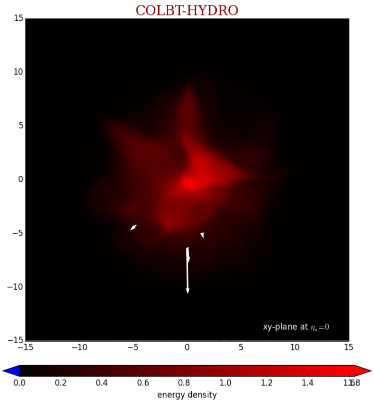
Jet propagation and jet-induced medium excitation

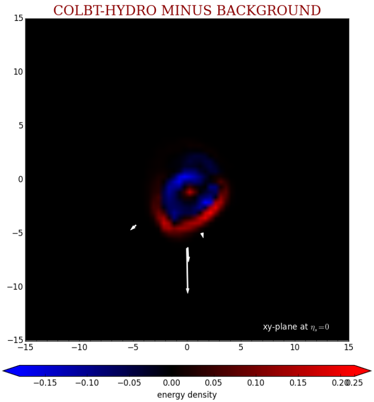
Jet propagation in hot medium at $\tau = 6.4 fm$



Jet propagation and jet-induced medium excitation

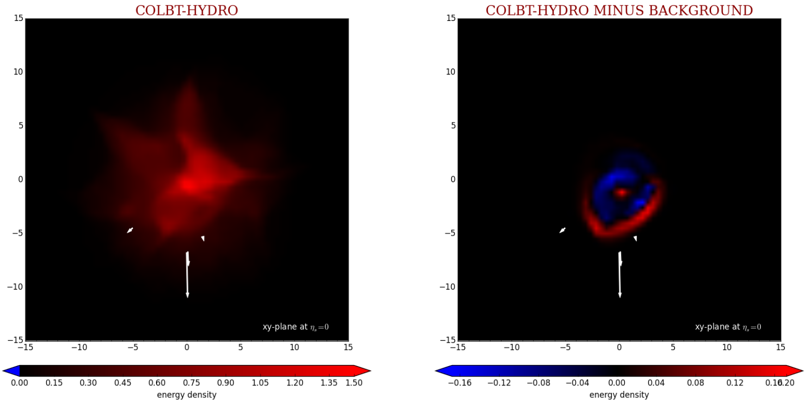
Jet propagation in hot medium at $\tau = 6.8 fm$





Jet propagation and jet-induced medium excitation

Jet propagation in hot medium at $\tau = 7.2 fm$



Jet propagation and jet-induced medium excitation

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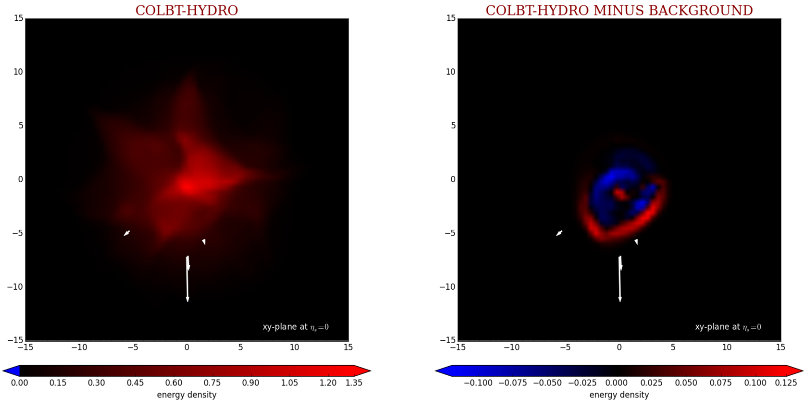
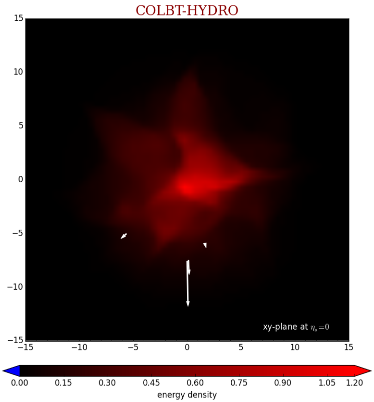
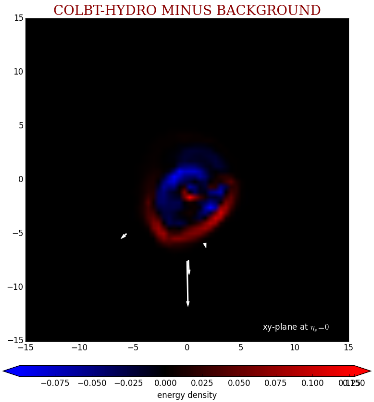


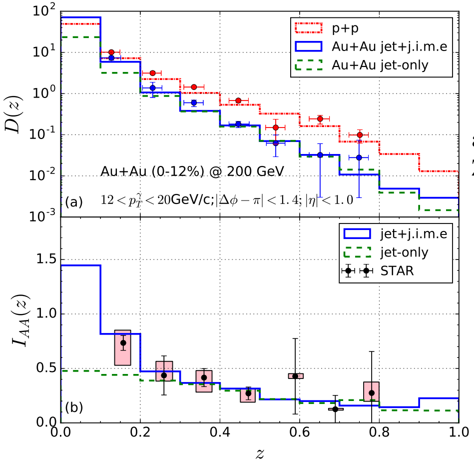
Jet propagation and jet-induced medium excitation

Jet propagation in hot medium at $\tau = 8.0 fm$





Medium modification of γ-triggered fragmentation functions in RHIC energy



Phys.Lett. B760 (2016) 689-696 STAR

In our calculation

$$D(z) = \frac{dN_h}{dydz}\Big|_{LBT} + \frac{dN_h}{dydz}\Big|_{hydro}^{w/jet} - \frac{dN_h}{dydz}\Big|_{hydro}^{no/jet}$$

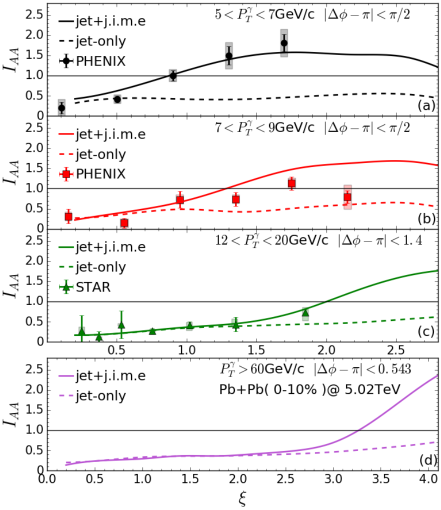
a constant background is subtracted using ZYAM as in the experimental analyses

- the suppression of leading hadrons at intermediate and large z
  $\Leftarrow$ energy loss of hard partons
- enhancement of soft hadrons at small z
  $\Leftarrow$ jet-induced medium excitation
  ($\alpha_s = 0.3$ and $p^0_{cut} = 2$GeV/c)

$$z \equiv p_T^h / p_T^\gamma$$

$$I_{AA}(z) = D_{AA}(z)/D_{pp}(z)$$

Medium modification of γ-triggered fragmentation functions in RHIC energy



the suppression of hadrons at small ξ as well as the enhancement at large ξ

With p_T^γ range increasing:

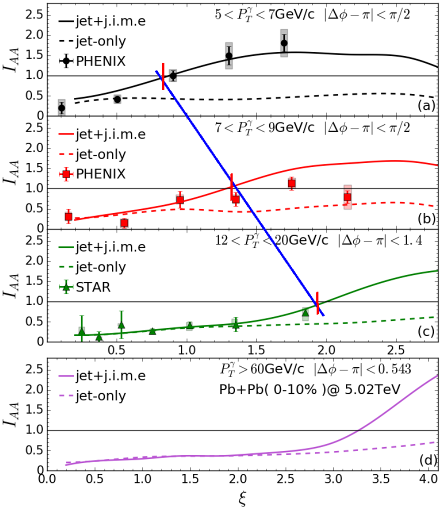
- Transition point from suppression to relative enhancement shifts to larger ξ
- Transition point corresponds to the fixed p_T range

$$\xi = log\frac{1}{z}$$

$$z \equiv p_T^h/p_T^\gamma$$

soft hadrons from j.i.m.e. carry an average thermal energy that is independent of the jet energy

Medium modification of γ-triggered fragmentation functions in RHIC energy



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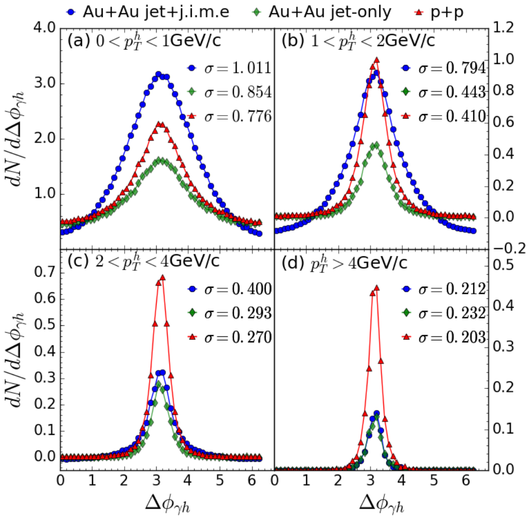
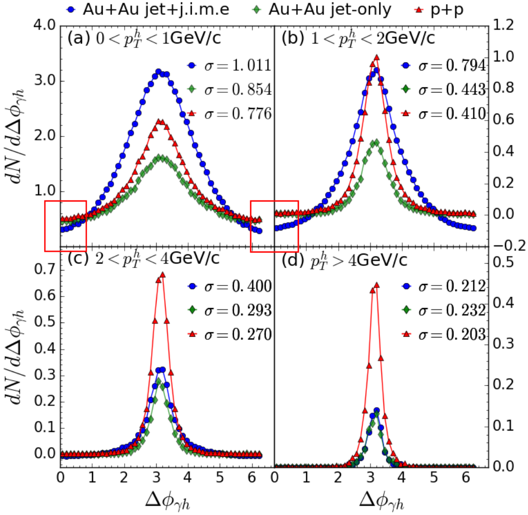
γ-hadron azimuthal correlation in RHIC energy



$AuAu200GeV0 \sim 12\%$
$12 < P_T^\gamma < 20GeV/c$
$|\Delta\phi - \pi| < 1.4; |\eta| < 1.0$
σ: gaussian width

- Large p_T hadron yields from γ-jet in Au+Au are suppressed but the width of their angular distributions remain approximately unchanged from p+p
- The angular distributions for the enhanced soft hadrons in Au+Au are significantly broadened

γ-hadron azimuthal correlation in RHIC energy



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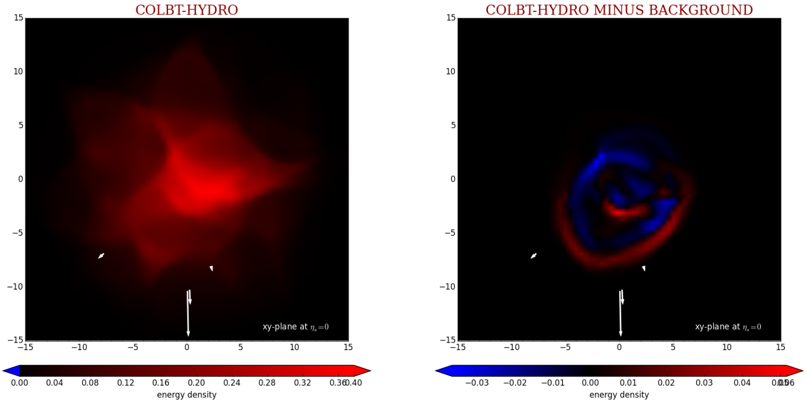
- Large p_T hadron yields from γ-jet in Au+Au are suppressed but the width of their angular distributions remain approximately unchanged from p+p
- The angular distributions for the enhanced soft hadrons in Au+Au are significantly broadened
- soft hadrons yield in Au+Au collision along gamma direction become smaller than one in pp collision.

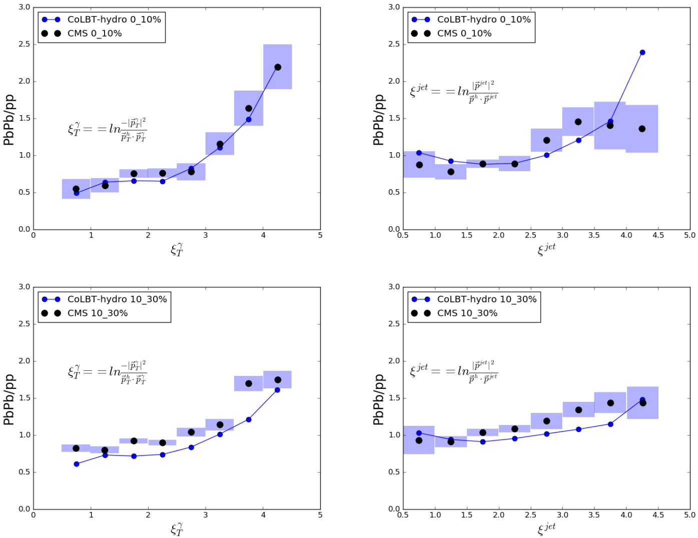
γ-hadron azimuthal correlation in RHIC energy

Jet propagation in hot medium at $\tau = 10.8 fm$



negative distribution at gamma direction is due to the effect of diffusion wake caused by the deposition of energy-momentum into the medium

jet FF with ξ^{jet} and ξ_T^{γ}



For both ξ^{jet} and ξ_T^{γ}, the modification of jet FF indicates the enhancement of low p_T particles and the depletion of large p_T particles.

Summary and outlook

- We develop CoLBT-Hydro model for simultaneous event-by-event simulations of jet propagation and hydrodynamic evolution of the bulk medium including jet-induced medium excitation.
- CoLBT-hydro describes well both the suppression of leading hadrons due to parton energy loss and enhancement of soft hadrons due to jet-induced medium excitation.
- The onset of soft hadron enhancement at a constant p_T^h with broadened angular distribution and depletion of soft hadrons in the γ direction

Outlook:

- 3+1D viscous hydro
- different jet type
- different collision energy and centrality