Jet Medium Excitation and γ-jet Asymmetry

XXIV QUARK MATTER DARMSTADT 2014

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I. Motivation

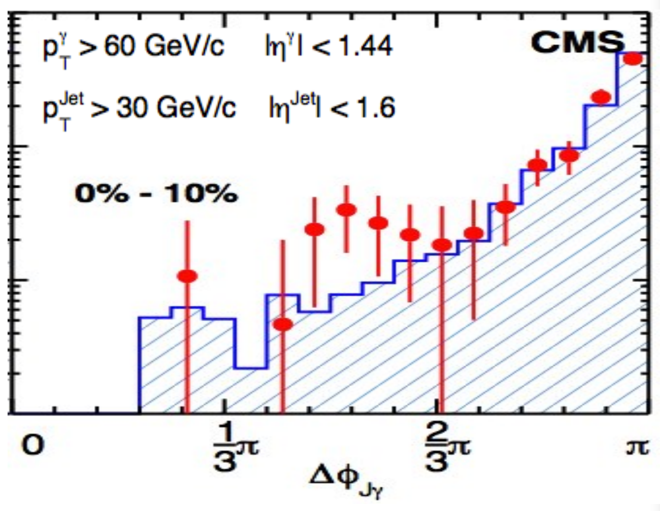
• Jet quenching, i.e., the suppression of high-PT hadrons' yield, the production of mono-jet, etc, has been observed in heavy ion collisions. This is one of the signals of production of QGP.

• In the meantime, lost energy and momentum of jet will be redistributed to medium by multiple scattering and eventually lead to collective medium excitations such as supersonic waves or Mach Cone.

✦ Large energy loss (suppression of R_{AA}, asymmetry of gamma-jet and dijet) in Pb+Pb collisions at 2.76TeV,

✦ Small gamma-jet azimuthal angle modification w.r.t P+P collisions,

✦ Jet fragmentation function has a big enhancement at low P_T but a small suppression at high P_T.



• A reasonable explanation is warmly welcome to give the idea of small azimuthal angle modification and the behavior of jet fragmentation function.

II. LBT Simulation

• Linearized Boltzmann jet transport (LBT) simulation:

$$p_1\cdot\partial f_1(p_1) = -\int dp_2dp_3dp_4(f_1f_2-f_3f_4)|M_{12\to34}|^2 \times (2\pi)^4\delta^4(P_1+P_2-P_3-P_4)$$

$$dp_i \equiv \frac{d^3p_i}{2E_i(2\pi)^3},\ |M_{12\to34}|^2 = Cg^2(s^2+u^2)/(t+\mu^2)^2$$

$$f_i = 1/(e_i^{p.u/T}\pm1)(i=2,4),\ f_i=(2\pi)^3\delta^3(\vec{p}-\vec{p}_i)\delta^3(\vec{x}-\vec{x}_i)(i=1,3)$$

i=1,3: jet shower parton before and after scattering.
i=2,4: thermal parton before and after scattering.
u: flow velocity of medium.
C=1(9/4) for qg(gg) interaction.

• Time step Δt_i between scatterings is determined by

$P_i = 1-exp[-\sum_j \Delta x_j\cdot u\ \sigma_i\rho(\vec{x}_j,t_j)]$ ρ: local energy density of medium

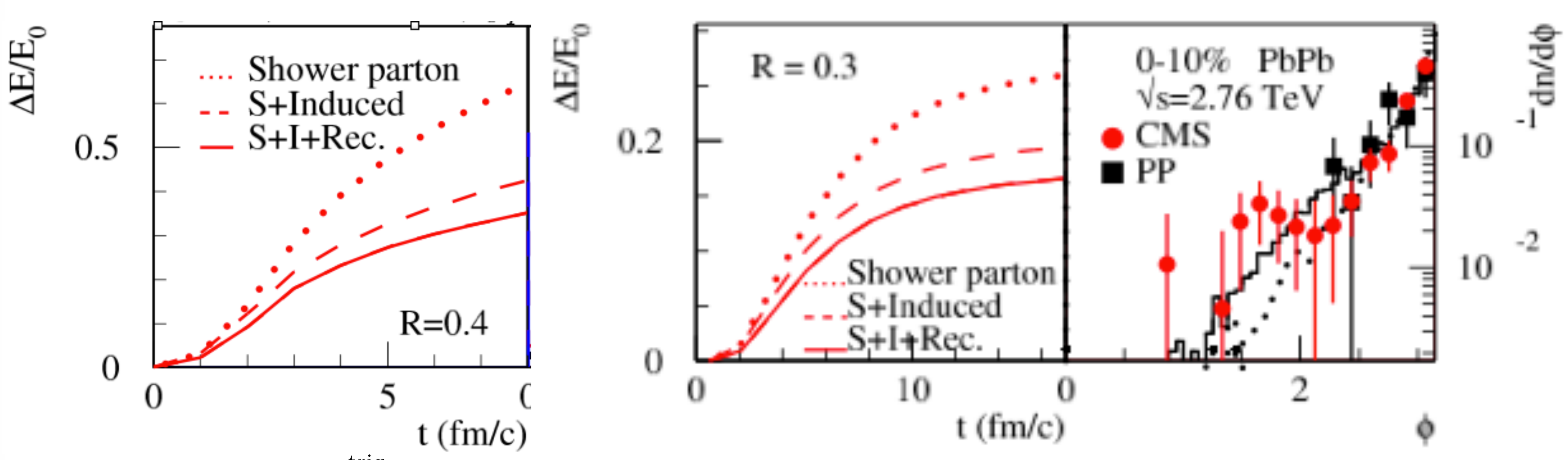
✦ Medium induced radiation companying elastic collisions is based on:

$$\frac{dN_g}{dxdk_\perp^2dt} = \frac{2C_A\alpha_sP(x)\hat{q}}{\pi k_\perp^4}\sin^2\frac{t-t_i}{2\tau_f},\quad P(x)=\frac{1+(1-x)^2}{x},\quad \tau_f=2Ex(1-x)/k_\perp^2,$$

• The number of partons from induced radiation satisfies Poisson distribution.

III. Jet Energy Loss and γ Jet Asymmetry

Uniform Medium VS Hydrodynamic Medium



$\alpha_s = 0.4,\ T = 300\mathrm{GeV},\ p_T^{\mathrm{trig}} \sim 30\mathrm{GeV}$

• According to the high twist approach, the radiative energy loss for a single parton is

$$\Delta E_a \approx \frac{3\alpha_s}{2}\int d\tau(\tau-\tau_0)(\hat{p}\cdot u)\hat{q}_a\ln\frac{2E}{(\tau-\tau_0)\mu_D^2}$$

• In the meantime, the corresponding p_T broadening is

$$\langle\Delta p_T^2\rangle = \int d\tau(\hat{p}\cdot u)\hat{q}_a$$

• For a constant jet transport parameter $\hat{q}_a = \hat{q}_a^0$n a uniform and static medium,

$$\Delta E_a \sim L^2$$
$$\langle\Delta p_T^2\rangle \sim L$$

• In a 3D expansion medium, $\hat{q}_a = \hat{q}_a^0(\tau_0/\tau)^{1+\alpha}$

$$\Delta E_a \sim (\leq L)$$
$$\langle\Delta p_T^2\rangle \sim (\leq \ln L)$$

Setup

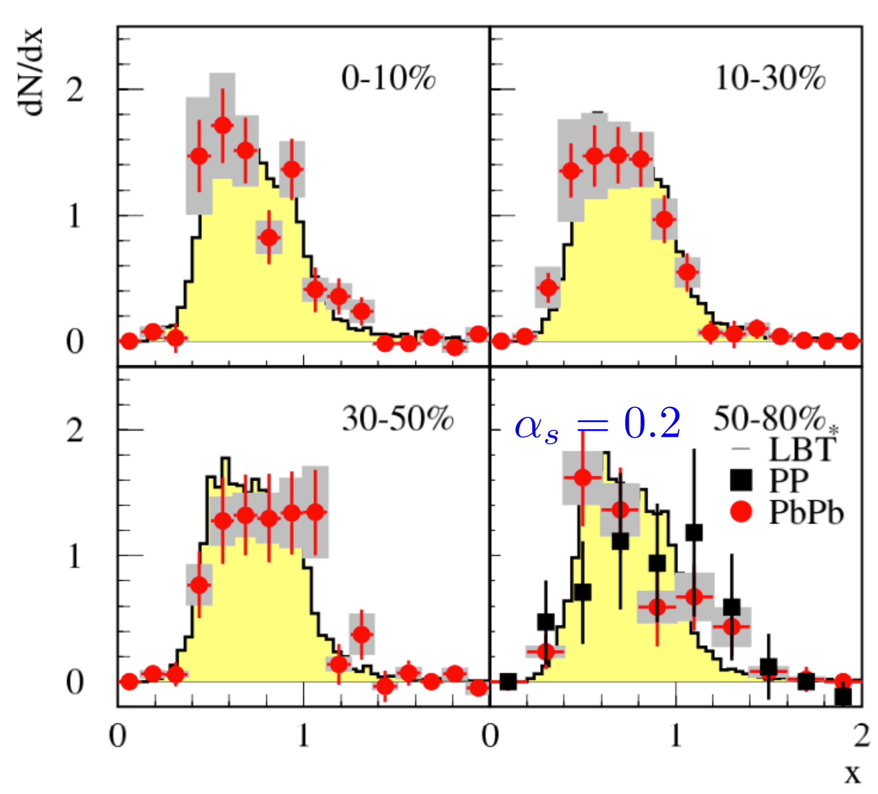
- Trigger a gamma-jet with $P_T \sim 60$GeV in P+P @ 2.76TeV from HIJING:
  - CMS $P_{T\gamma} > 60\mathrm{GeV}, |\eta_\gamma| < 1.44,$
  - ATLAS $60\mathrm{GeV} < P_{T\gamma} < 90\mathrm{GeV}, |\eta_\gamma| < 1.3.$
- 3+1D hydro T. Hirano, *et al.*, Phys. Lett. B **636**, 299 (2006).

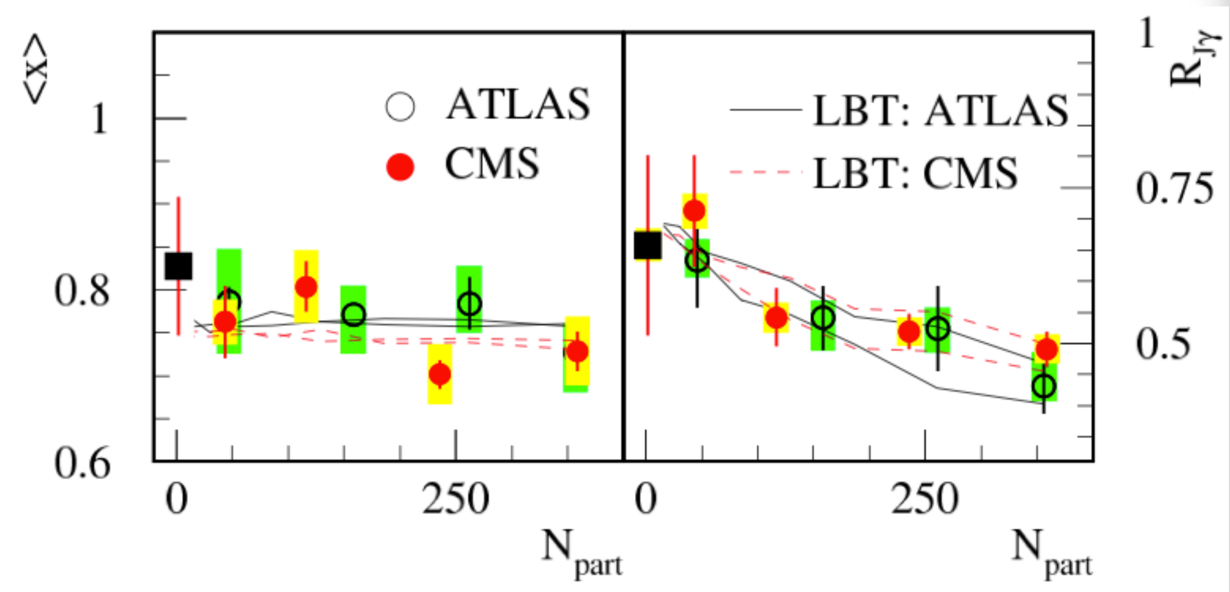
(τ, x, y, η)

$\varepsilon, T, f_{\mathrm{QGP}}, u$

- Location of gamma-jet is decided according to the Wood-Saxon distribution.

LBT VS CMS data

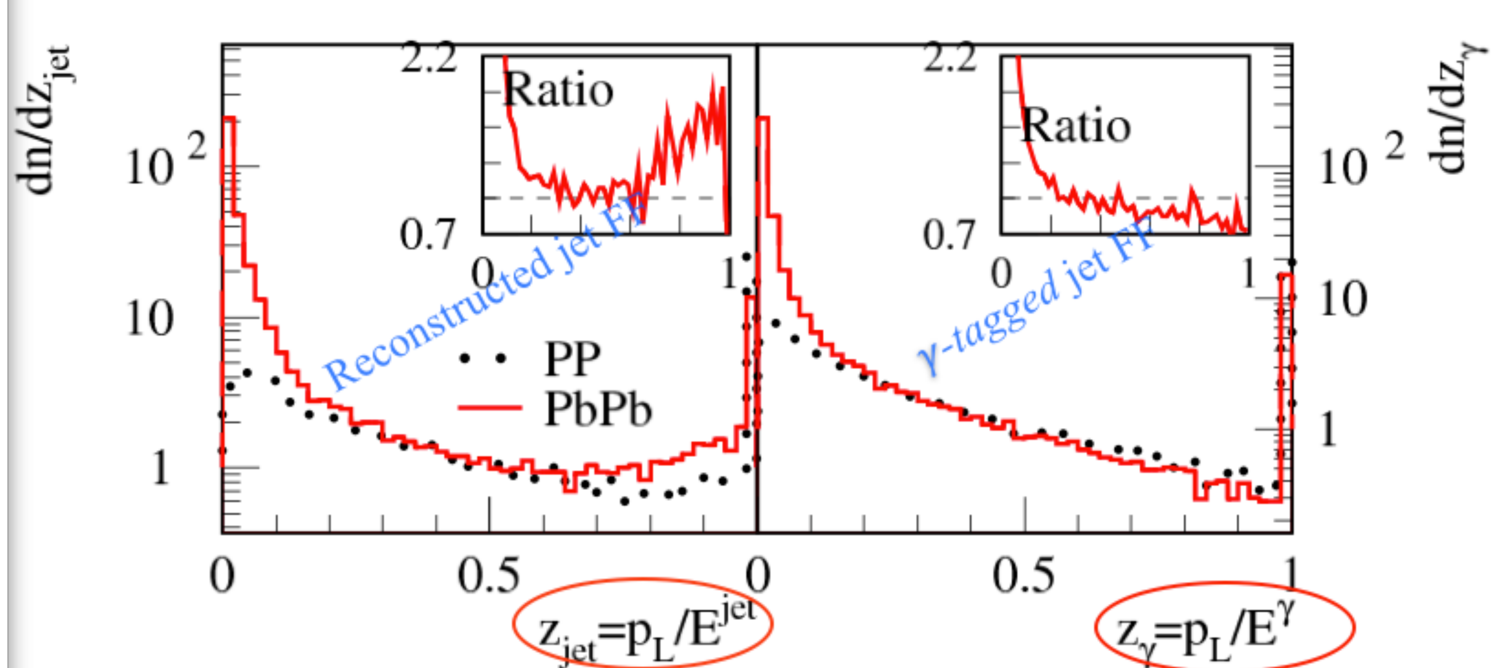




✦ **Gamma jet asymmetry dN/dx is reproduced with LBT.**

✦ **Averaged x has a very good agreement between data and LBT simulation for** $\alpha_s = 0.15-0.23\ (0.2-0.27)$ **CMS (ATLAS).**

IV. Jet Fragmentation Function



✦ **Reconstructed jet FF: The reconstructed jet energy is dominated by leading partons.**

✦ **γ-tagged jet FF: Fragmentation function is strongly suppressed w.r.t. the initial jet energy.**

V. Conclusions

- A medium induced radiation included multiple scattering linearized Boltzmann transport is used to study the jet medium interaction.
  - The lost jet energy is taken away by recoiled and radiation partons outside the jet cone.
  - Jet structure is distorted by the interaction with thermal partons.
- Simulation results for γ-jet correlation describe the experiment data successfully.
- A γ-tagged jet FF was suggested as a more sensitive probe to jet medium interaction.

VI. Reference

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