Jet shower evolution in medium and dijet asymmetry in Pb+Pb collisions at the LHC

Guang-You Qin Duke University

Quark Matter 2011 May 22-28 Annecy , France

Outline

• Jet study in HIC

• Jet shower evolution in medium

• Dijet asymmetry at the LHC

• Summary and outlook

Jet study in HIC





Jet study in HIC





- <u>How are jet showers</u> <u>modified in the medium?</u>
- 2. How does the medium respond to the jet shower propagation?



Jet shower = leading parton E_L + radiated gluons $f_q(w,k_t^2)$

A partonic jet shower in medium



Leading parton:

Transfers energy to medium by elastic collisions

Radiates gluons due to scatterings in the medium (*inside* and *outside* jet cone)

Radiated gluons (vacuum & medium-induced):

Transfer energy to medium by elastic collisions Be kicked out of the jet cone by multiple scatterings after emission



Jet shower evolution is governed by:

$$\begin{split} E_{L}(t) &= E_{L}(t_{i}) - \int \hat{e}_{L} dt - \int \omega d\omega dk_{\perp}^{2} dt \frac{dN_{g}^{med}}{d\omega dk_{\perp}^{2} dt} \\ \frac{df_{g}(\omega, k_{\perp}^{2}, t)}{dt} &= \hat{e} \frac{\partial f_{g}}{\partial \omega} + \frac{1}{4} \hat{q} \nabla_{k_{\perp}}^{2} f_{g} + \frac{dN_{g}^{med}}{d\omega dk_{\perp}^{2} dt} \end{split}$$

• Energy loss from the jet cone is obtained as: $\Delta E_J(R) = \int_R \omega d\omega dk_{\perp}^2 \Big[f_g(\omega, k_{\perp}^2, t_i) - f_g(\omega, k_{\perp}^2, t_f) \Big] + \int \omega d\omega dk_{\perp}^2 dt \frac{dN_g^{med}}{d\omega dk_{\perp}^2 dt} + \int \hat{e}_L dt$

Inputs

- Obtain jet vacuum radiation spectrum from PYTHIA
 - Only gluons with the formation time $t_{form}\, smaller\, than\, t_i$ are radiated

$$f_g(\omega, k_{\perp}^2, t_i) = f_g^{PYTHIA}(\omega, k_{\perp}^2)\theta(t_i - t_{form})$$

Medium-induced radiation from higher twist formalism

dN_g^{med} _	$2\alpha_s x P(x)\hat{q}(t)$	sin^2	$\left(\underline{t-t_{i}} \right)$
$d\omega dk_{\perp}^2 dt$	$\pi\omega k_{\perp}^4$	5111	$\left[2t_{form}\right]$

Wang, Guo, 2001 Majumder, 2009

 Transport coefficients scaled with the temperature/entropy of the medium

$$\hat{q} = 4T\hat{e} \propto T^3$$

Jet cone energy loss in a brick of QGP



Medium effect on vacuum radiation dominates earlier times Medium-induced radiation effects catch up later Leading parton collisional E-loss is small

Dijet asymmetry measurements



Di-jet asymmetry increases with centrality Di-jet angular distribution is largely unchanged (similar results from CMS: arXiv:1102.1957)

Background fluctuations: Cacciari, Salam and Soyez, arXiv:1011.2878

Initialization for the LHC

- Scale \hat{q} with entropy density s $\Box T^{3}\Box \rho_{part}$
- Wood-Saxon for nuclear density function
- Medium thermalized at t₀=0.6fm/c, T₀=520MeV
- 1-D Bjorken expansion for the medium
- No jet-medium interaction below T=160MeV

Calculate dijet asymmetry for the LHC

Proton + Proton

Generate p+p events from PYTHIA including ISR and FSR Reconstruct jets using anti-kt Select di-jets according to EXP Calculate p+p di-jet asymmetry

Lead + Lead

Sample di-jets production points according binary collision distr. Apply jet cone cone energy loss in medium to p+p di-jets Calculate Pb+Pb di-jet asymmetry

$$A_{J} = \left(E_{T,1} - E_{T,2}\right) / \left(E_{T,1} + E_{T,2}\right)$$

A₁<0.1

<u>No trigger bias:</u> Jet 1 and Jet 2 treated with equal footing



Extreme trigger bias: Jet 1 along shorter path Jet 2 along longer path

ATLAS result



CMS result



20% difference for \hat{q} between CMS and ATLAS

Summary and outlook

- A simplified but realistic framework for studying jet shower evolution in medium
 - Includes collisional energy loss and momentum broadening
 - Includes vacuum radiation and medium-induced radiation
- Compare to dijet asymmetry in Pb+Pb collisions at the LHC
 - 20% difference in \hat{q} for CMS and ATLAS
 - The extracted \hat{q} values consistent with RHIC results
- Other observables (jet R_{AA}, jet structure, reaction plane dependence, gamma-jets ...)
- Complete Monte-Carlo simulation
- Realistic simulation of background fluctuations
- Medium response to jet shower propagation

Je vous remercie de votre attention!