Medium modification of averaged jet charge in heavy-ion collisions

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Outline:

• Motivation

• Averaged jet charge in pp and heavy-ion collisions

• Results and discussion

• Summary and outlook
Motivation:

Jet quenching -- parton in medium energy loss

not only high $p_T$ hadrons, but also full jet observables

Xin - Nian Wang, M.Gyulassy, PRL68(1992)1480
Motivation: medium modification of full jet observables

Inclusive Jet supression


Di-jet momentum asymmetry

Y. He, I. Vitev and B. W. Zhang, PLB (2011)
Guang-You Qin, Berndt Muller PRL106 (2011) 162302

Bosons tagged jet imbalance


Jet shape modified

Yang-Ting Chien, Ivan Vitev JHEP 1605 (2016) 023
Guo-Liang Ma PRC 88 (2013) no.2, 021902
Motivation: medium modification of full jet observables

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Averaged jet charge?
**Averaged jet charge in pp collisions: baseline**

Definition of momentum weighted jet charge:

\[
Q_j = \frac{1}{(p_{Tj})^\kappa} \sum_{i \in Tr} q_i \times (p_T^i)^\kappa
\]

- \(q_i\): Electric charge of hadron inside jet cone
- \(p_{Tj}\): \(p_T\) of hadron inside jet cone
- \(p_{Tj}\): \(p_T\) of full jet
- \(k\): Free parameter

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Here we chose MC method for pp baseline
averaged jet charge in pp collisions: baseline

pythia6 Perugia 2012 tunes + FastJet

MC results fit experimental data well

the charge of quark and gluon jet is quite different

Nuclear effects: cold(initial) + hot(final)

Cold nuclear matter effects: nuclear shadowing

Parton distributions in free proton --> in nuclei

\[ f_i^A(x, Q) = R_i^A f_i^{CTEQ6}(x, Q) \]  


modifications from CNM effects:

\[ \text{ratio} = \frac{\langle Q \rangle_{pp}^{CNM}}{\langle Q \rangle_{pp}} \]

CNM effects slightly modify averaged jet charge

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parton energy loss in PYQUEN:

Collisional energy loss

\[
\frac{dE^{\text{col}}}{dl} = \frac{1}{4T\lambda\sigma} \int_{t_0}^{t_{\text{max}}} dt \frac{d\sigma_t}{dt},
\]

Radiative energy loss

BDMPSZ-Energy loss of partons

\[
\frac{dE^{\text{rad}}}{dl} = \frac{2\alpha_s(\mu^2)}{\pi L} \int_{\omega_{\text{min}}}^{\omega} d\omega \left[ 1 - y + \frac{y^2}{2} \right] \ln |\cos(\omega_1\tau)|
\]

\[
\omega_1 = \sqrt{i(1 - y + \frac{C_R}{3} y^2)\kappa \ln \left( \frac{16}{\kappa} \right)} - \frac{\mu^2\lambda_s}{\omega(1 - y)}
\]

\[
\frac{dE^{\text{total}}}{dl} = \frac{dE^{\text{col}}}{dl} + \frac{dE^{\text{rad}}}{dl}
\]

PYQUEN

Jet quenching results from PYQUEN:

**high p_T hadrons**

I.P. Lokhtin, A.M. Snigirev

**full jets**

I.P. Lokhtin, A.A. Alkin, A.M. Snigirev

**wide-angle radiation**

\[
\frac{dN^g}{d\theta} \propto \frac{1}{\theta}
\]

1+1D Bjorken expansion: T0 = 1.0 GeV, tau0 = 0.1 fm @PbPb 2.76 TeV

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3+1D event-by-event Ideal Hydrodynamic:

PYQUEN+(3+1D) Ideal Hydro

Initial condition: $T_0 = 0.43\text{GeV}$, $\tau_0 = 0.6\text{fm}$ @PbPb 2.76TeV
first result of averaged jet charge in PbPb collisions:

PYQUEN + (3+1D) Ideal Hydro

\[ Q_j = \frac{1}{(p_{Tj})^\kappa} \sum_{i \in Tr} q_i \times (p_T^i)^\kappa \]

\[ R = \frac{\langle Q_j \rangle_{PbPb}}{\langle Q_j \rangle_{pp}} \]

`p_Tcut,track` VS cone size

- averaged jet charge is significantly modified
- expected medium modification of jet charge
first result of averaged jet charge in PbPb collisions:

PYQUEN + (3+1D) Ideal Hydro

momentum weighted jet charge:

- why ratio > 1 at small k, but ratio < 1 at large k?
averaged jet charge as a probe for flavour dependence of Eloss:
flavour dependence of pp baseline and nuclear modifications

- no contribution from CNM
- no contribution from modifications for quark jets

$C_A / C_F = 9/4$  $\Delta E_g / \Delta E_q = 9/4$

who did this significant modification?

2016-9-27
Shi-Yong Chen, Ben-Wei Zhang and En-Ke Wang, in preparation
Jet charge is an excellent candidate observable

- no contributions from CNM
- no contributions from modifications for quark jets

p/π puzzle

\[ \frac{\Delta E_g}{\Delta E_q} = \frac{9}{4} \]
leads to stronger suppression

\[ \frac{\Delta E_g}{\Delta E_q} = 1 \]
closer to experimental data

\[ \frac{\Delta E_g}{\Delta E_q} = ? \]
still an open question

averaged jet charge as a probe for flavour dependence of $E_{\text{loss}}$:

- The medium modification of averaged jet charge is due to the changing portion of quarks and gluons.
- Precisely measurement of averaged jet charge in heavy-ion collisions in the future will highlight the flavour dependence of parton energy loss.

2016-9-27
Shi-Yong Chen, Ben-Wei Zhang and En-Ke Wang, in preparation
Summy and outlook

• averaged jet charge is significantly modified due to hot nuclear matter effect

• cone size dependence of medium modification is consistent with other jet observables

• medium modification of averaged jet charge is sensitive to the portion of quarks and gluons, providing opportunity to study flavour dependence of parton energy loss

• analytical study of jet charge in heavy-ion collisions could be done by using medium modified fragmentation functions
Thank you for your attention !