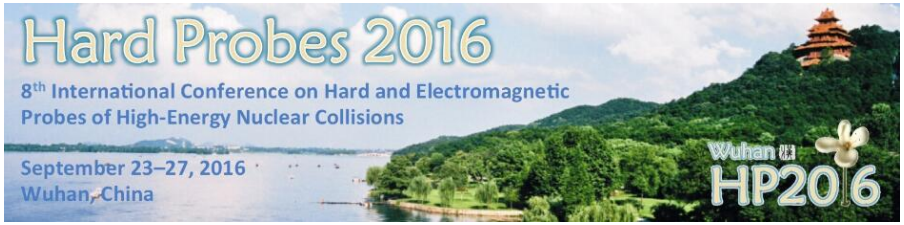
Medium modification of averaged jet charge in heavy-ion collisions

Shi-Yong Chen

(Central China Normal University)

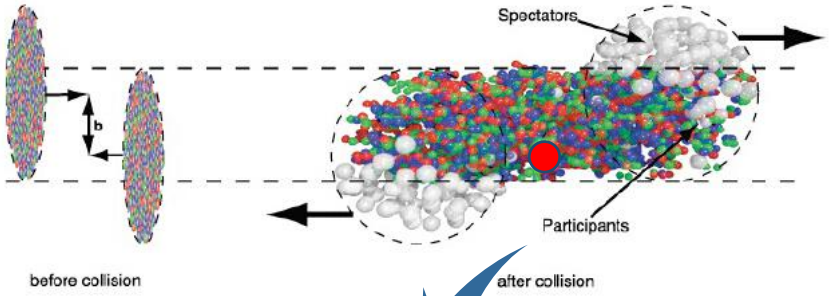
in collaboration with :Ben-Wei Zhang and En-Ke Wang



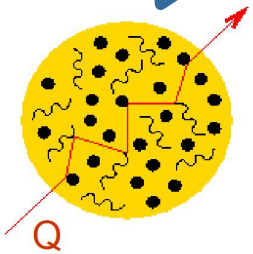
Outline:

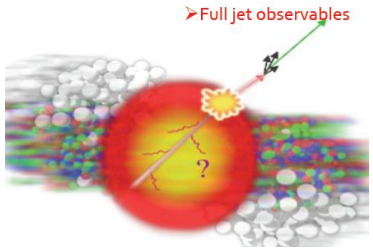
- Motivation
- Averaged jet charge in pp and heavy-ion collisions
- Results and discussion
- Summary and outlook

Motivation:



A new form of matter:
Quark Gluon Plasma(QGP)





Jet quenching -- parton
in medium energy losss

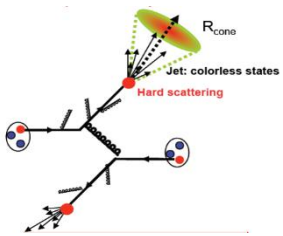
not only high p_T hadrons,
but also full jet observables

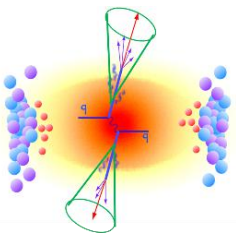
Xin - Nian Wang, M.Gyulassy, PRL68(1992)1480

Motivation: medium modification of full jet observables

Inclusive Jet supression

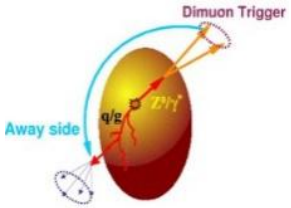
I. Vitev, S.Wicks and B. W. Zhang JHEP(2008)
I. Vitev and B. W. Zhang, PRL(2010)





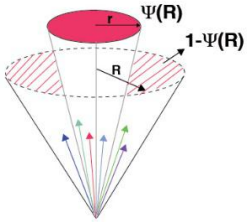
Di-jet momentum asymmetry

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



Bosons tagged jet immbalance

R. B. Neufeld and I. Vitev, PRL 108, 242001 (2012)
W.Dai, I.Vitev and B. W.Zhang, PRL(2013)



Jet shape modified

I. Vitev, S.Wicks and B. W. Zhang JHEP(2008)
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

Inclusive Jet supression

I. Vitev, S.Wicks and B. W. Zhang JHEP(2008)
I. Vitev and B. W. Zhang, PRL(2010)

Di-jet momentum asymmetry

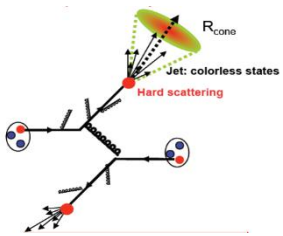
Y.He, I.Vitev and B.W.Zhang, PLB (2011)
Guang-You Qin, Berndt Muller PRL106 (2011) 162302

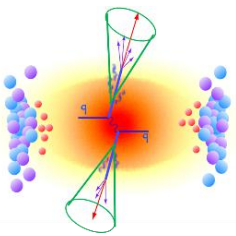
Bosons tagged jet immbalance

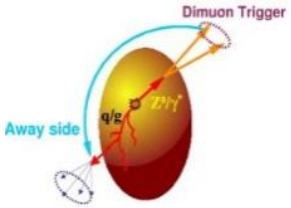
R. B. Neufeld and I. Vitev, PRL 108, 242001 (2012)
W.Dai, I.Vitev and B. W.Zhang, PRL(2013)

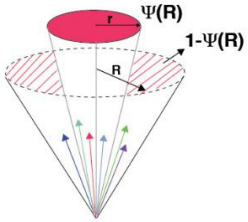
Jet shape modified

I. Vitev, S.Wicks and B. W. Zhang JHEP(2008)
Yang-Ting Chien, Ivan Vitev JHEP 1605 (2016) 023
Guo-Liang Ma PRC 88 (2013) no.2, 021902









Averaged jet charge ?

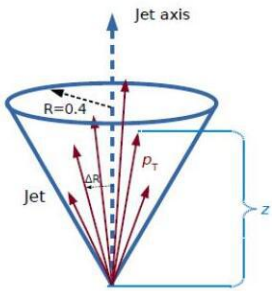
Field and R. Feynman, Nucl. Phys. B136, 1 (1978).

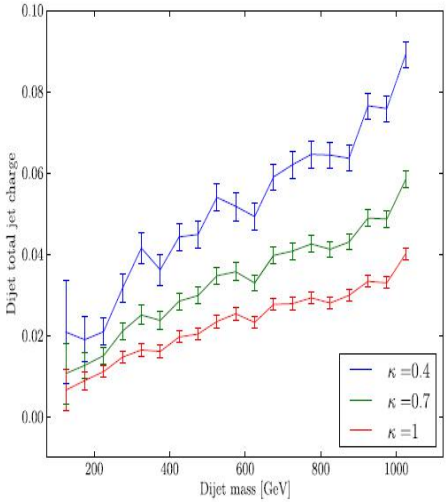
averaged jet charge in pp collisions: baseline

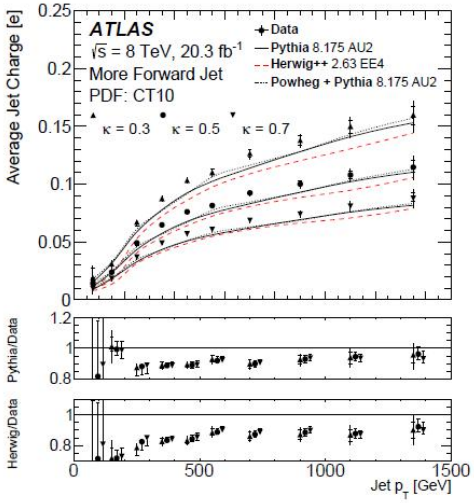
defination of momentum weighted jet charge:

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

q_i : eletric charge of hadron inside jet cone
p_Ti: p_T of hadron inside jet cone
p_Tj: p_T of full jet
k : free parameter







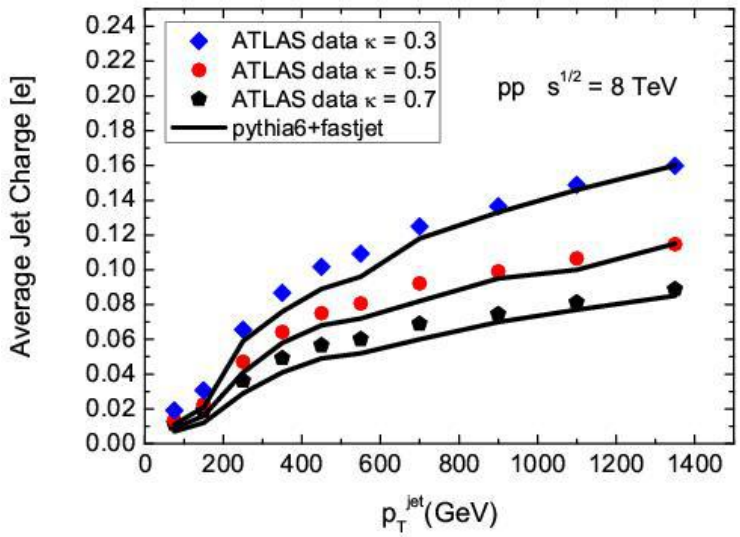
David Krohn et al... Phys. Rev. Lett. 110 (2013) 212001
Waalewijn, Wouter J. Phys.Rev. D86 (2012) 094030

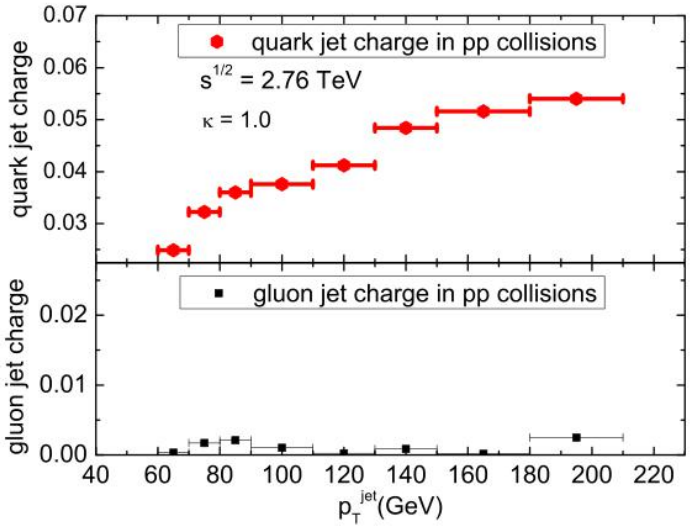
ATLAS Collaboration Phys.Rev. D93 (2016) no.5, 052003

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

ATLAS Collaboration Phys.Rev. D93 (2016) no.5, 052003

Matteo Cacciari , Gavin P. Salam , Gregory Soyez Eur.Phys.J. C72 (2012) 1896

Peter Zeiler Skands Phys.Rev.D82:074018,2010

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

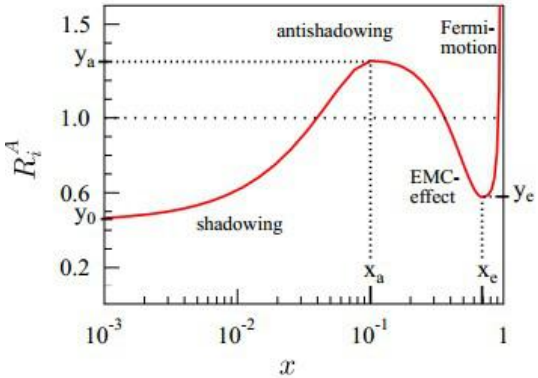
Cold nuclear matter effects: nuclear shadowing

Parton distributions in free proton --> in nuclei

$$f_i^A(x,Q) = R_i^A f_i^{CTEQ6}(x,Q)$$

EPS09

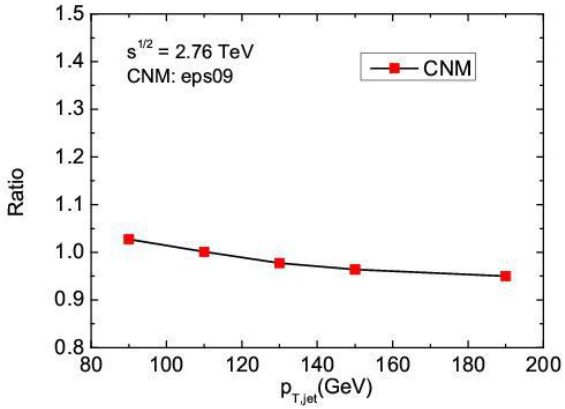
K. J. Eskola, H. Paukkunen, C. A. Salgado JHEP 0904:065,2009



modifications from CNM effects :

$$\text{ratio} = \langle Q \rangle_{pp}^{CNM} / \langle Q \rangle_{pp}$$

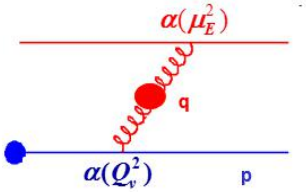
CNM effects slightly modify averaged jet charge



parton energy loss in PYQUEN :

Collisional energy loss

high-momentum scattering

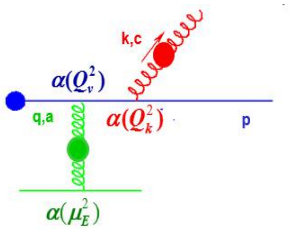


$$\frac{dE^{col}}{dl} = \frac{1}{4T\lambda\sigma}\int_{\mu_D^2}^{t_{\max}} dt\,\frac{d\sigma}{dt}t,$$

+

Radiative energy loss

BDMPSZ-Energy loss of partons



$$\frac{dE^{rad}}{dl} = \frac{2\alpha_s(\mu_D^2)}{\pi L}\int_{\omega_{\min}}^{E} d\omega\left[1-y+\frac{y^2}{2}\right]\ln\left|\cos(\omega_1\tau_1)\right|,$$

$$\omega_1 = \sqrt{i(1-y+\frac{C_R}{3}y^2)\bar{\kappa}\ln\frac{16}{\bar{\kappa}}},\ \bar{\kappa} = \frac{\mu_D^2\lambda_g}{\omega(1-y)}$$

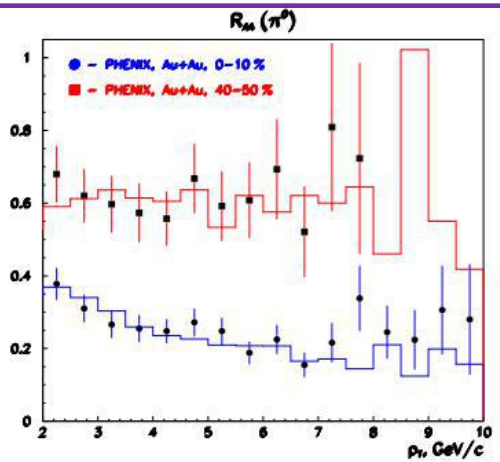
$$\boxed{\frac{dE^{total}}{dl} = \frac{dE^{col}}{dl} + \frac{dE^{rad}}{dl}}$$

→ PYQUEN

R. Baier, Yu. L. Dokshitzer, A.H. Mueller, D. Schiff, Phys. Rev. C 60, 064902 (1999)
I.P. Lokhtin, A.M. Snigirev, Eur. Phys. J. C 16, 527 (2000)
I.P. Lokhtin, A.M. Snigirev Eur.Phys.J. C45 (2006)

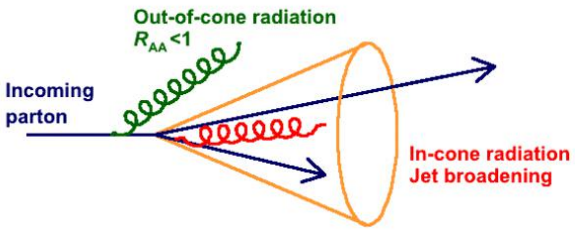
Jet quenching results from PYQUEN :

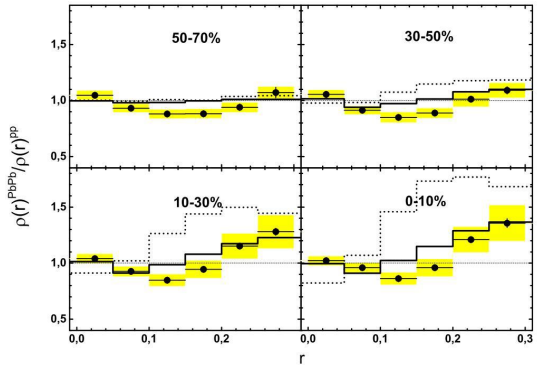
high p_T hadrons

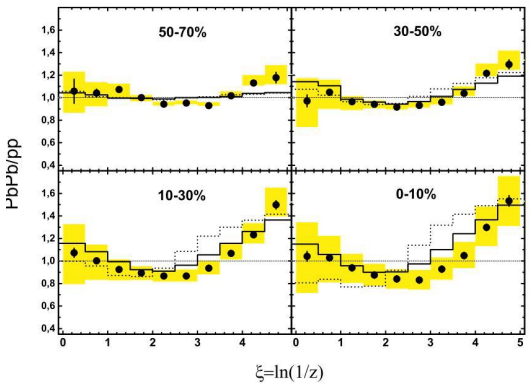


I.P. Lokhtin, A.M. Snigire
Eur.Phys.J. C45 (2006)

full jets







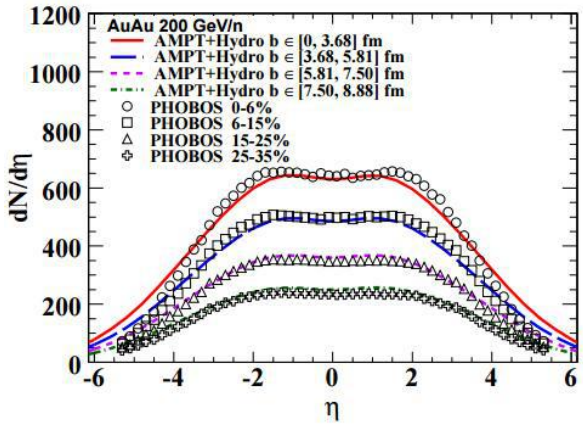
wide-angle radiation

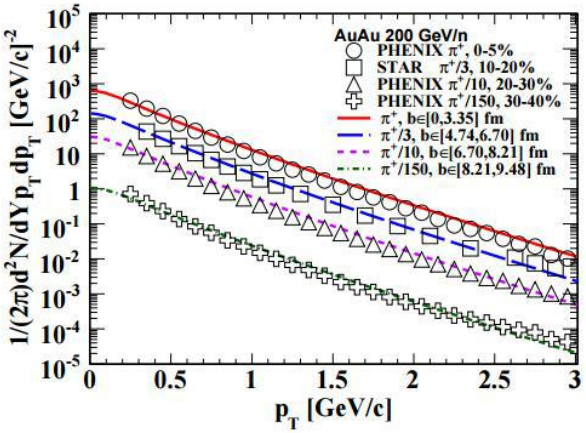
$$\frac{dN^g}{d\theta} \propto 1/\theta$$

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

I.P. Lokhtin, A.A. Alkin, A.M. Snigirev Eur.Phys.J. C75 (2015) no.9, 452

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

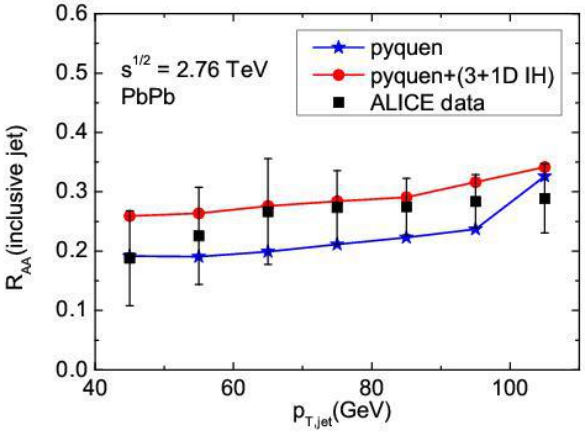




L. Pang, Q. Wang and X. N. Wang, Phys. Rev. C 86, 024911 (2012)

PYQUEN+(3+1D) Ideal Hydro

Initial condition:T0=0.43GeV,
tau0 = 0.6fm @PbPb 2.76TeV

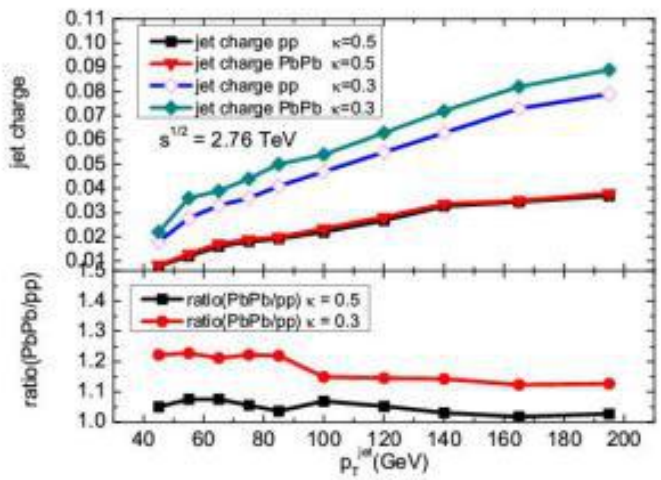


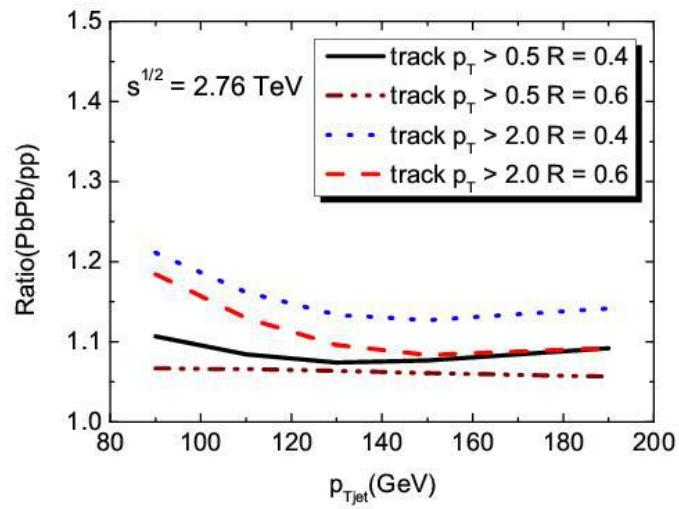
first result of averaged jet charge in PbPb collisions:

PYQUEN + (3+1D) Ideal Hydro

$$Q_j = \frac{1}{(p_{Tj})^{\kappa}} \sum_{i \in Tr} q_i \times (p_T^i)^{\kappa} \qquad R = \frac{\langle Q_j \rangle_{PbPb}}{\langle Q_j \rangle_{pp}}$$

p_Tcut,track VS cone size





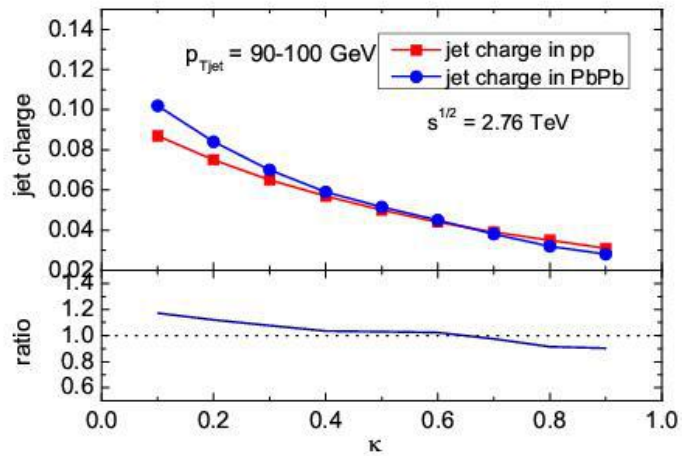
- averaged jet charge is significantly modified
- expected medium modification of jet charge

Shi-Yong Chen, Ben-Wei Zhang and En-Ke Wang, in preparation

first result of averaged jet charge in PbPb collisions:

PYQUEN + (3+1D) Ideal Hydro

momentum weighted jet charge:

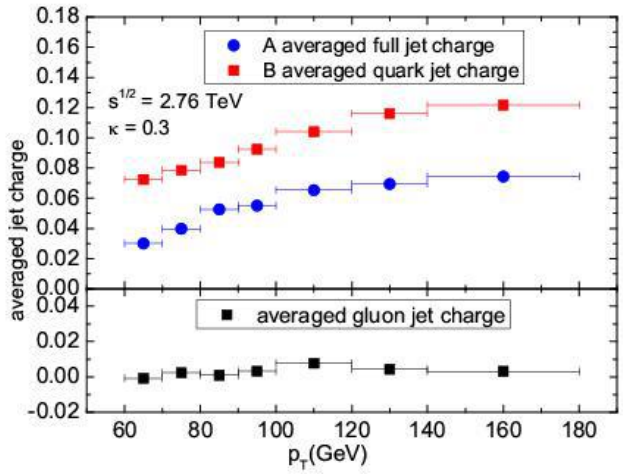


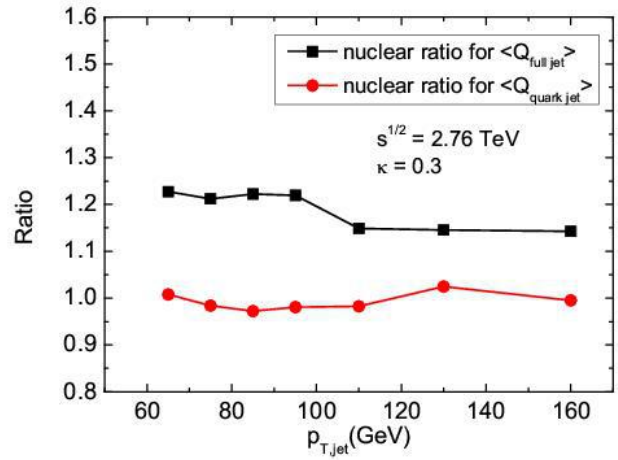
- why ratio > 1 at small k, but ratio < 1 at large k ?

Shi-Yong Chen, Ben-Wei Zhang and En-Ke Wang, in preparation

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

who did this significant modification ?

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

Shi-Yong Chen, Ben-Wei Zhang and En-Ke Wang, in preparation

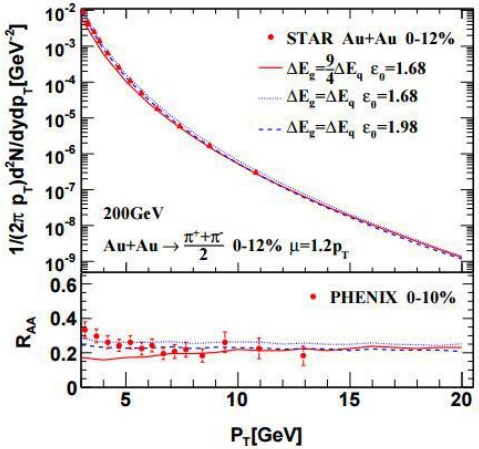
averagedjet charge as a probe for flavour dependence of Eloss:

p/π puzzle

$\Delta E_g / \Delta E_q = 9/4$ leads to stronger suppression

$\Delta E_g / \Delta E_q = 1$ closer to experimental data

$\Delta E_g / \Delta E_q = ?$ still an open quenstion



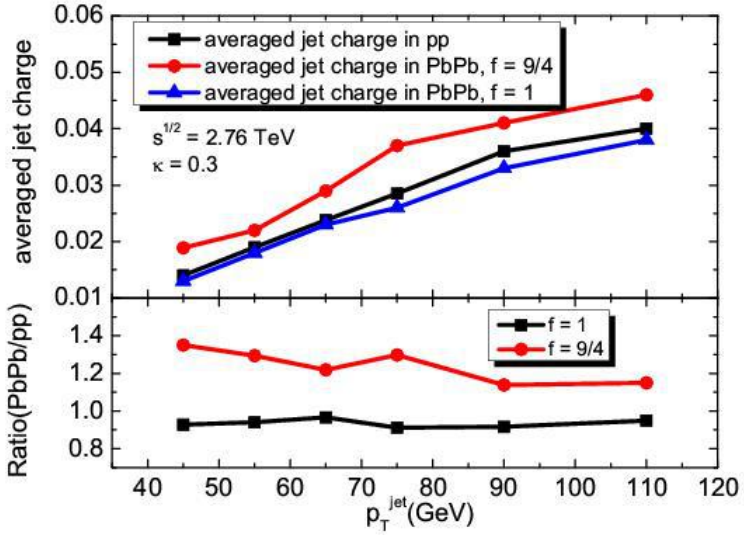
Xiaofang Chen , Hanzhong Zhang , Ben-Wei Zhang, Enke Wang J.Phys. 37 (2010) 015004

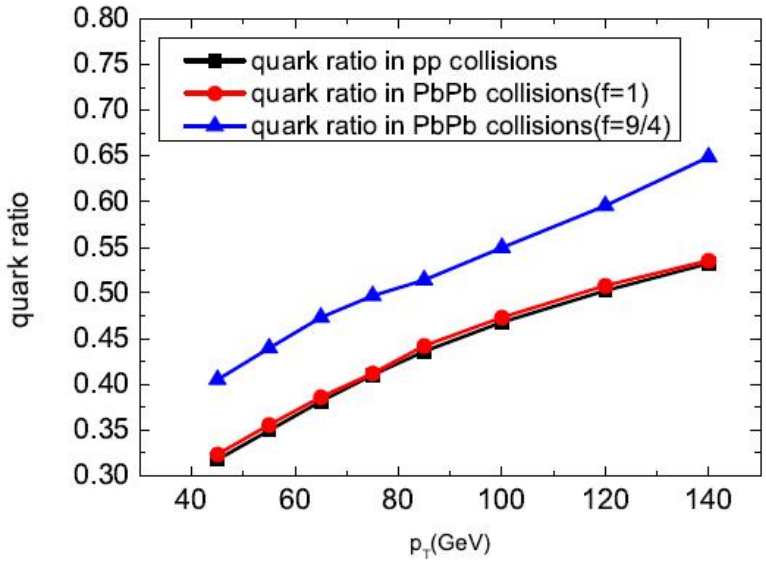
jet charge is an excellant candidate observable

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

→ nuclear modifications mainly from the changed portion of quark and gluon jets

averaged jet charge as a probe for flavour dependence of Eloss:





- the medium modification of averged 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

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 !