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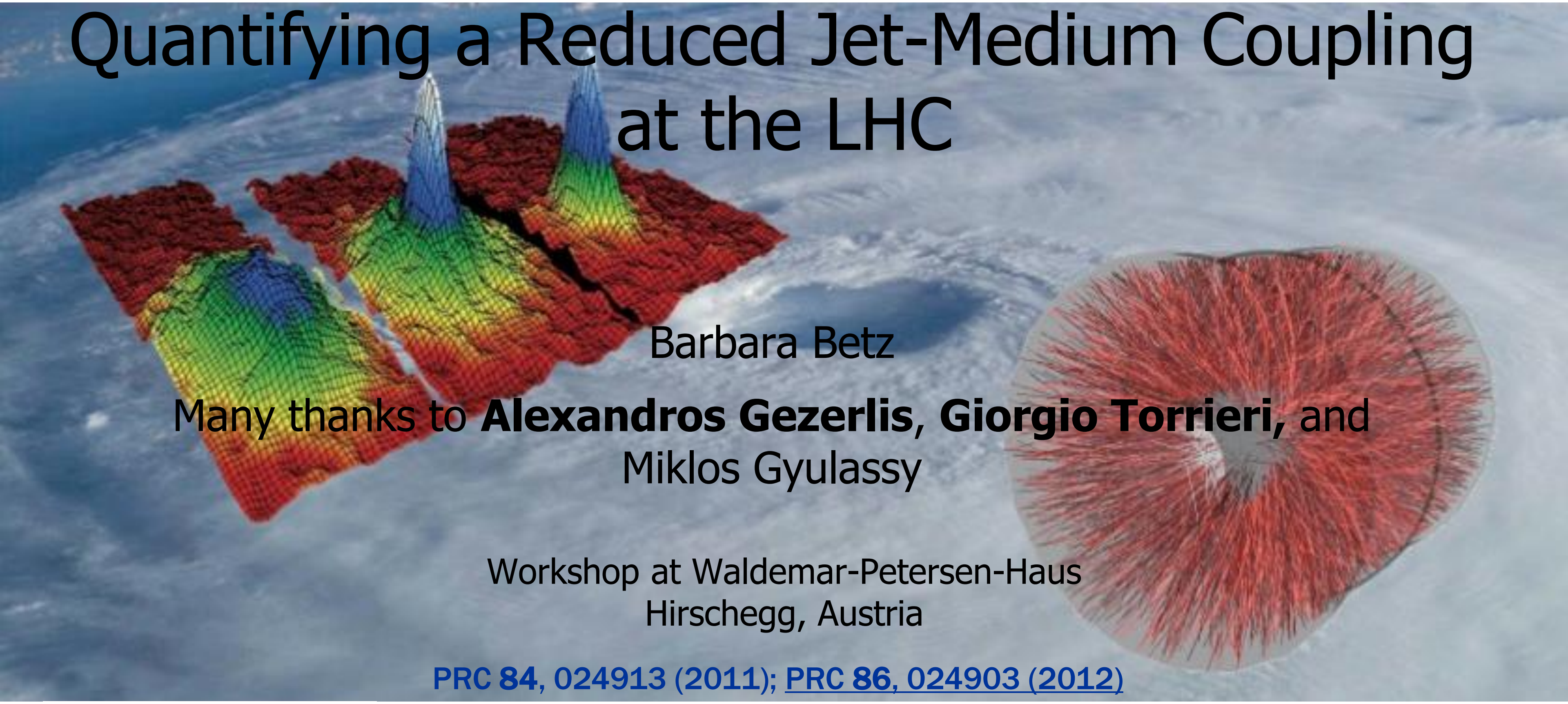

Quantifying a Reduced Jet-Medium Coupling at the LHC

Barbara Betz

Many thanks to **Alexandros Gezerlis**, **Giorgio Torrieri,** and
Miklos Gyulassy

Workshop at Waldemar-Petersen-Haus
Hirschegg, Austria

PRC **84**, 024913 (2011); PRC **86**, 024903 (2012)

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Jet-Quenching in a Quark-Gluon Plasma vs. Cold Atoms

Barbara Betz

Many thanks to **Alexandros Gezerlis**, **Giorgio Torrieri,** and Miklos Gyulassy

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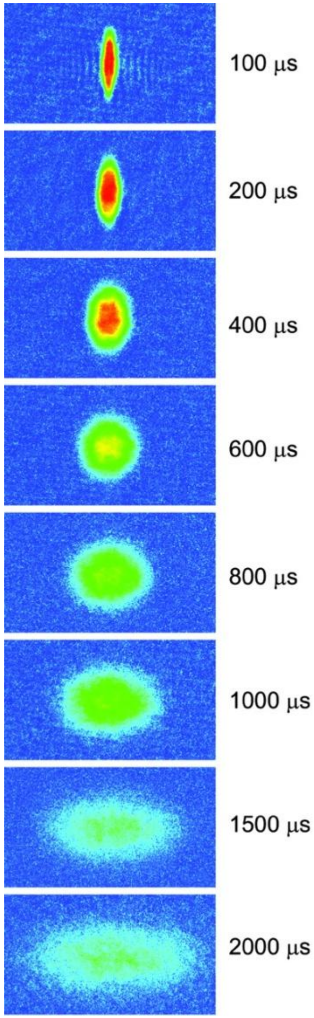
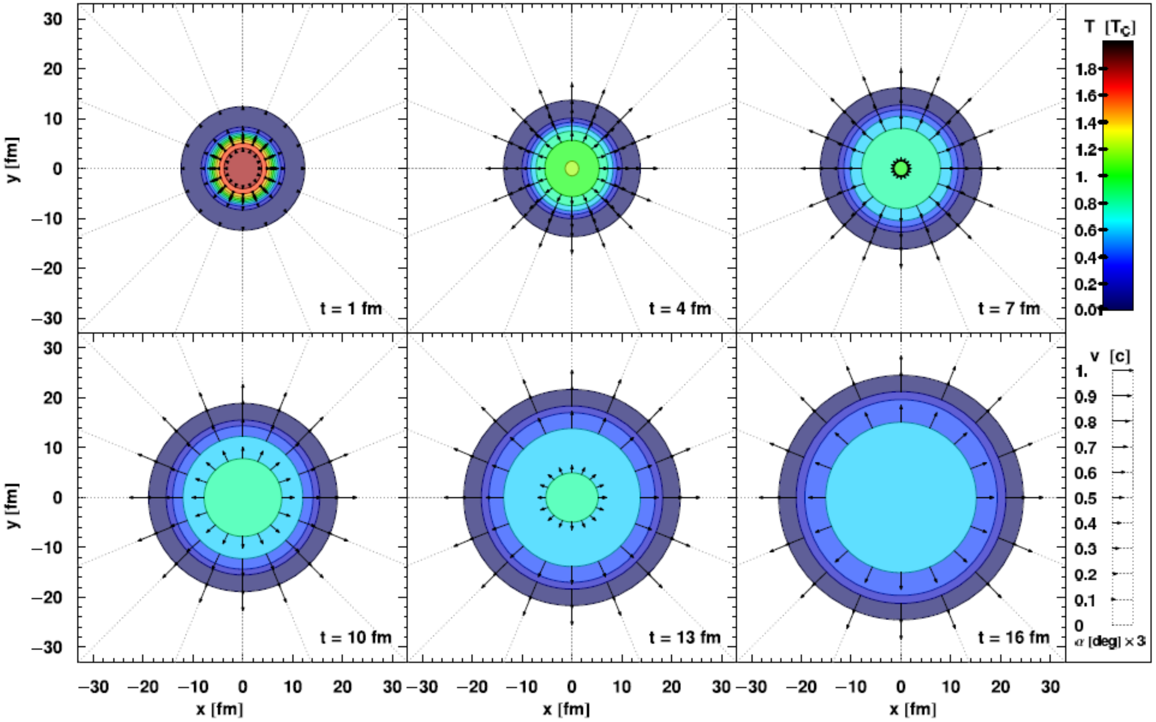
Are Cold Atoms similar to the QGP?

Fermi gas of ^{6}Li atoms



O'Hara et al, Science **298** (2002) 2179

Hydrodynamic simulation of an ideal QGP



Chojnacki et al., Phys. Rev. C **74** (2006) 034905

→ Similarity in time evolution of spatial anisotropy

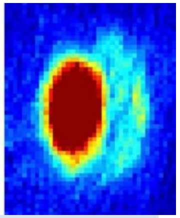
P. Kolb et. al., in Hwa, R.C. (ed.) et al.: Quark Gluon Plasma 634
Shuryak et al., Phys. Rev. C **70** (2004) 021901

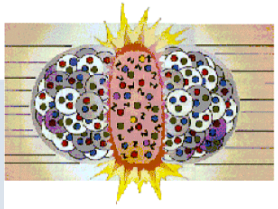
Lisa et al., New Journal of Physics **13** (2011) 065006

$$\frac{dN}{d\phi} = \frac{N}{2\pi}\left[1 + 2\sum_{n=1}^{\infty} v_n \cos(n\phi)\right]$$

v_2: elliptic flow

Cold Atoms vs. QGP





Cold Atoms	QGP
Cold, dilute gas	Hot, dense plasma
Strongly-coupled system	Strongly-coupled or weakly-coupled system
Low viscosity	Small η/s
Quantum liquid	„Perfect liquid“
Opaque???	Opaque

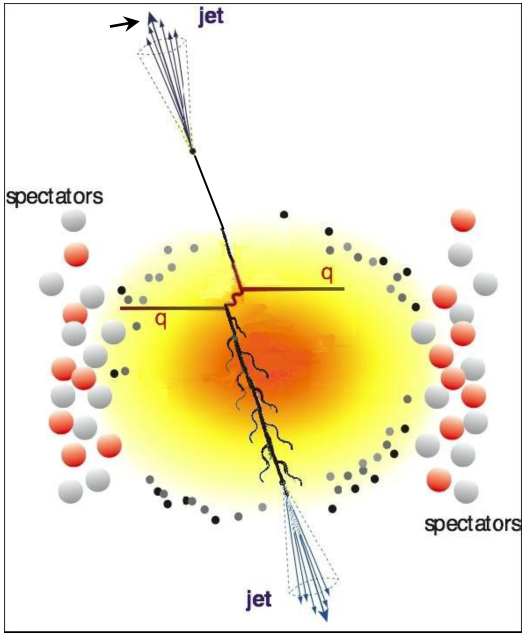
⇒ Are cold atoms transparent to “fast” atoms?

⇒ How can one learn about the opacity?

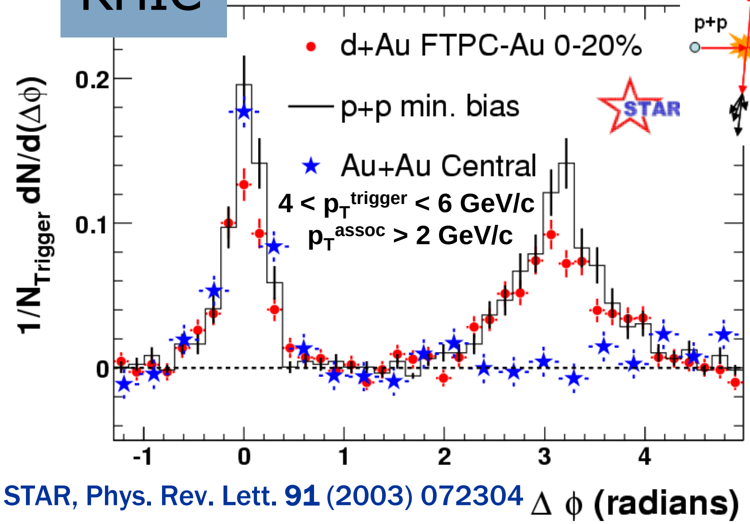
Jet Quenching

Jet Quenching is a way of learning about the opacity of a system

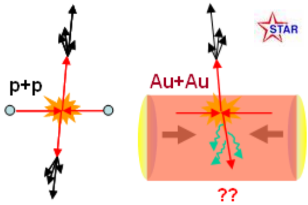
Idea: Jet moving through dense matter, depositing its energy should eventually disappear

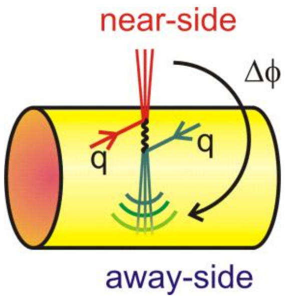


RHIC



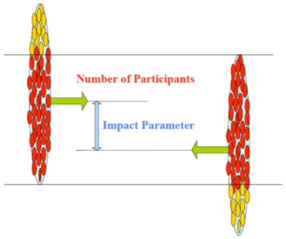
STAR, Phys. Rev. Lett. **91** (2003) 072304

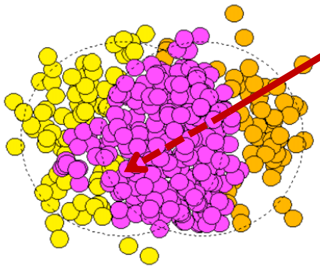


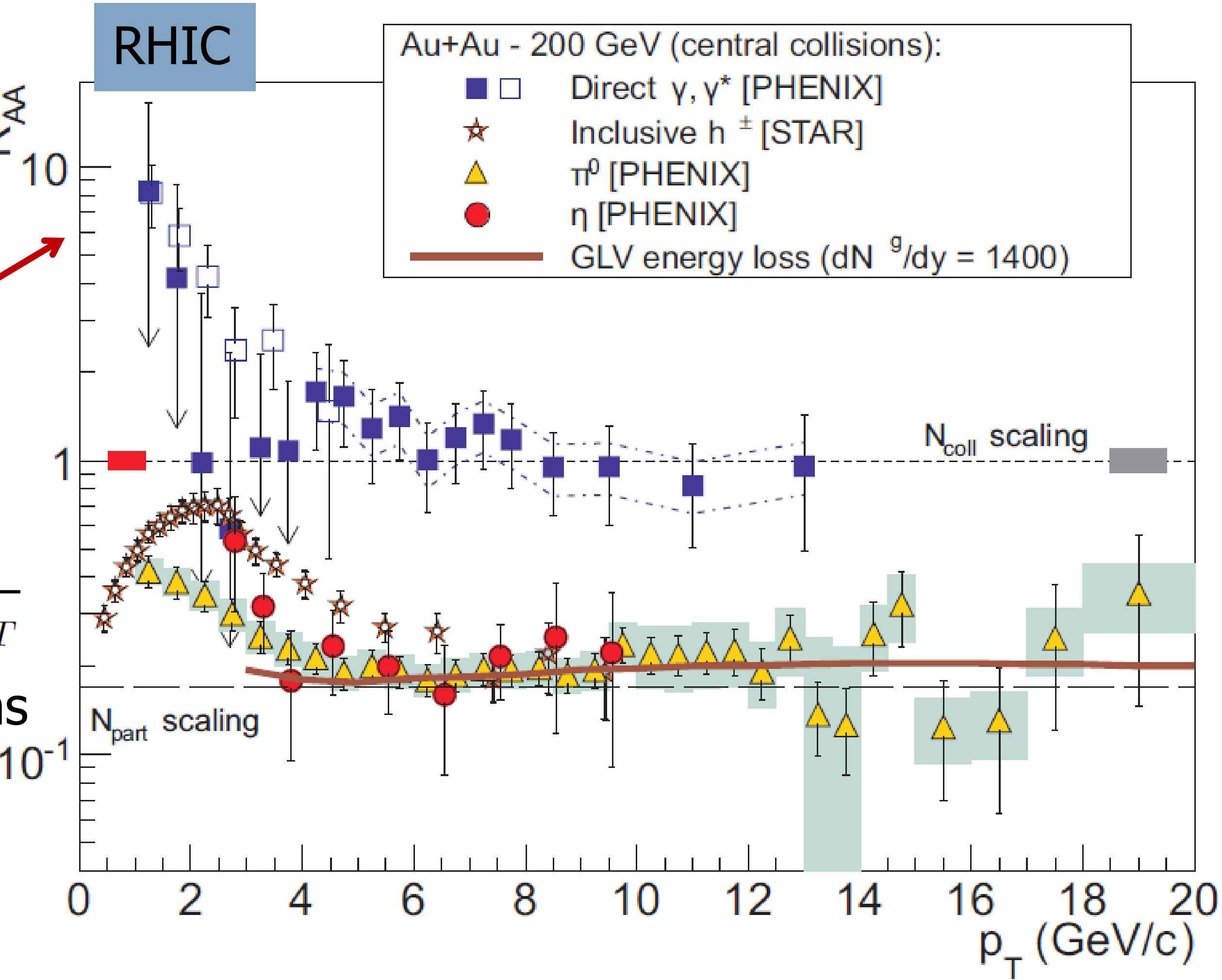


The Nuclear Modification Factor at RHIC

The nuclear modification factor parametrizes the jet suppression







D'Enterria et al., Springer Lecture Notes Physics (LNP) 2009

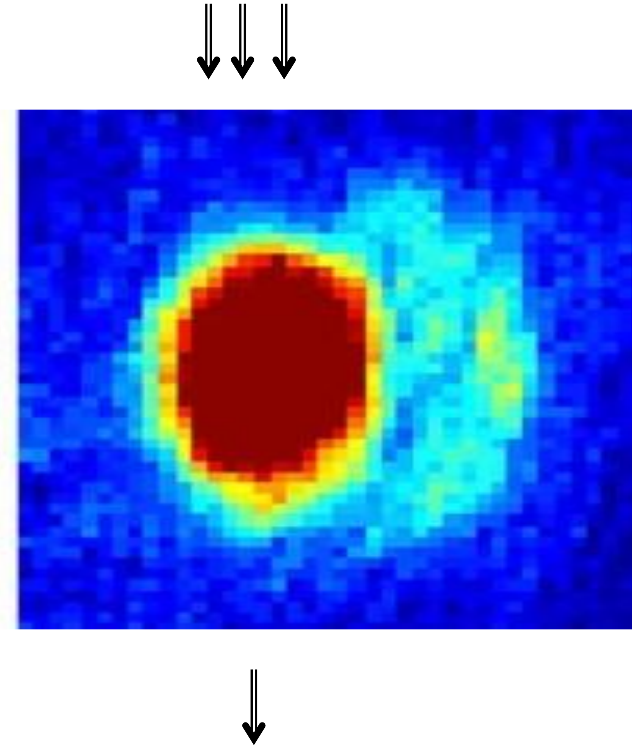
$$R_{\mathrm{AA}}(p_T) = \frac{dN_{\mathrm{AA}}/dp_T}{N_{\mathrm{coll}}\,dN_{\mathrm{pp}}/dp_T}$$

number of binary collisions

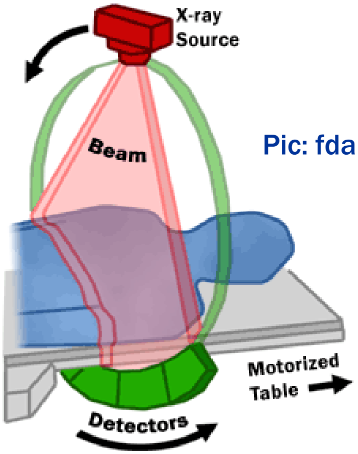
⇒ Clear hadronic suppression at around R_{AA}~0.2

Jet Tomography

“fast” atoms



detector



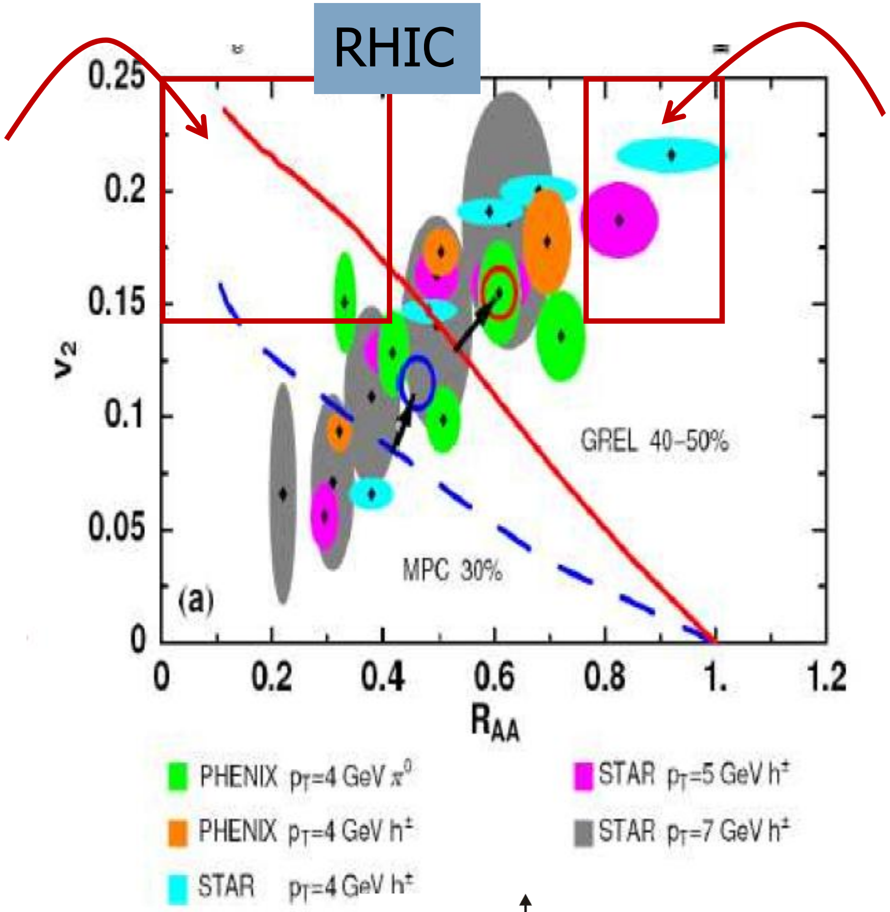
Pic: fda.gov

$$R_{AA} = N_{out} / N_{in}$$

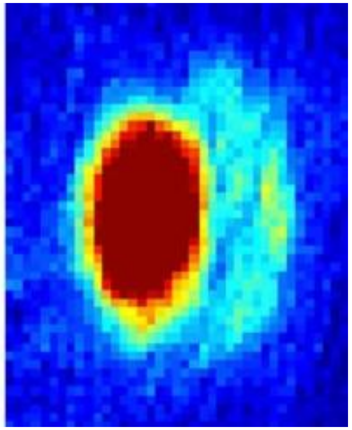
- ⇒ It might be easier to study jet suppression in cold atoms
- ⇒ Heavy-ion collisions (HIC): Different geometry & initial condition models are used

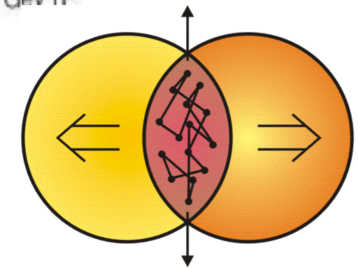
Jet Quenching and Elliptic Flow

low viscosity
high opacity

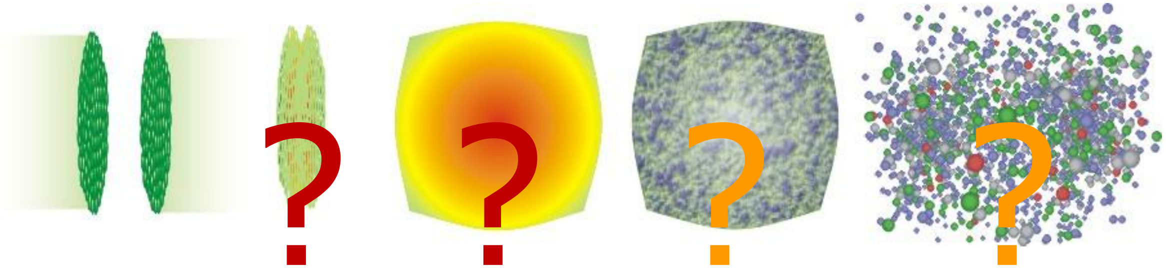


low viscosity
low opacity





Open Problems in HIC



S. Bass, Talk Quark Matter 2001

Basic questions in HIC:

- What are the initial conditions?
- Is the medium weakly-or strongly-coupled (pQCD vs. AdS/CFT)?
- How big is the jet-medium coupling?
- How does the jet-energy loss look like?
- What is the correct description of the freeze-out?

Two medium observables:

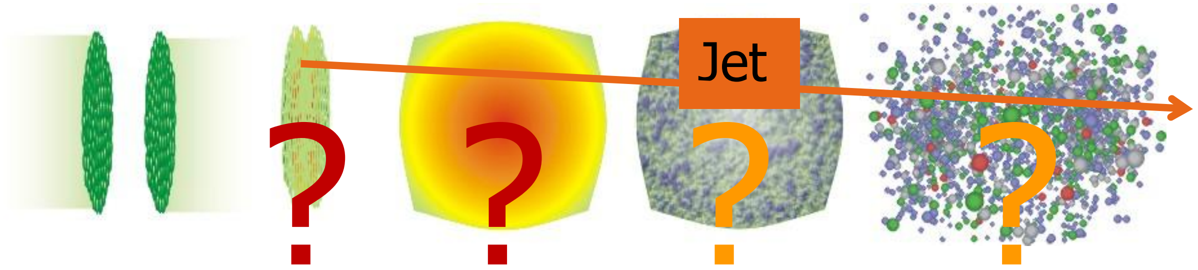
- jet quenching: opaque matter (QGP) formed

$$R_{AA}(p_T) = \frac{dN_{AA}/dp_T}{N_{coll} dN_{pp}/dp_T}$$

- elliptic flow: (nearly) perfect fluid created

$$\frac{dN}{d\phi} = \frac{N}{2\pi}\left[1 + 2\sum_{n=1}^{\infty} v_n \cos(n\phi)\right]$$

Jet Tomography in HIC

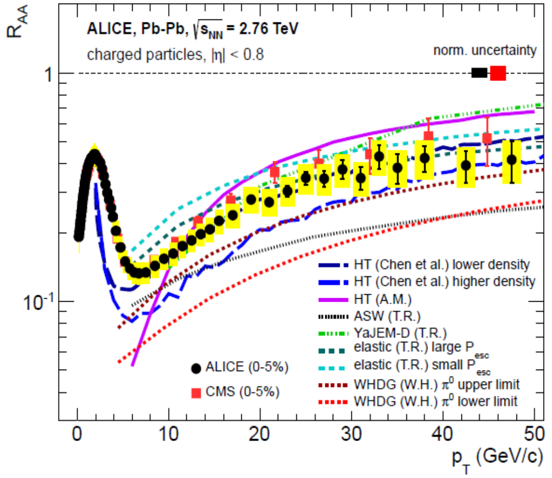


S. Bass, Talk Quark Matter 2001

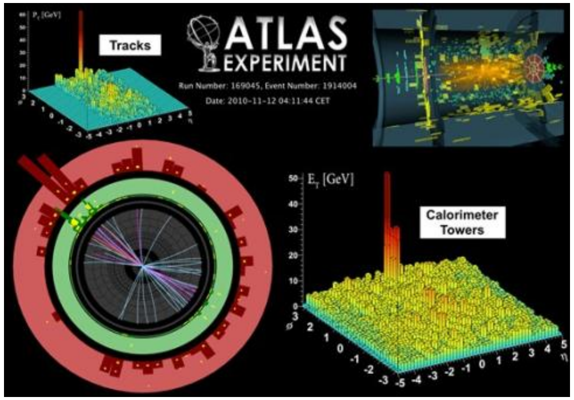
determine the R_{AA} and v_2 of of high- p_T particles

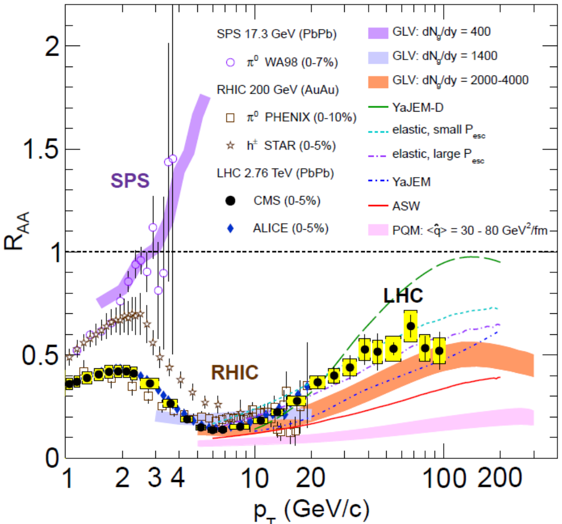
→ jet-medium interactions

→ medium properties



ALICE Collaboration, arXIv: 1208.2711





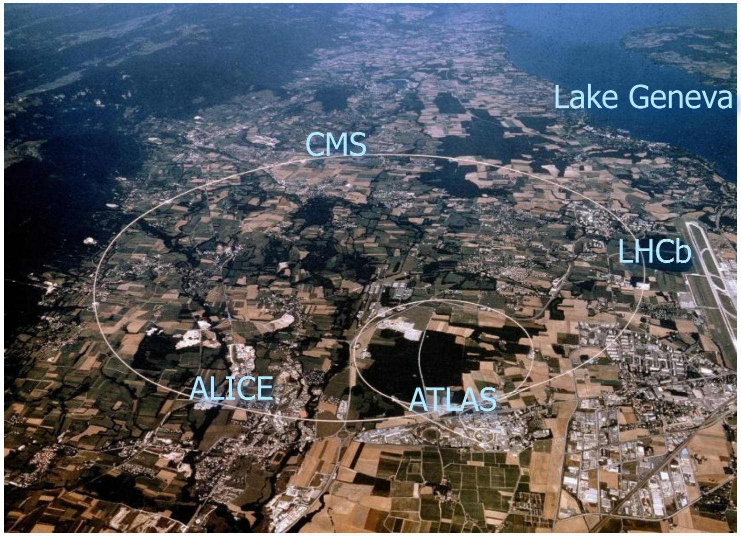
CMS Collaboration, Eur. Phys. J C **72**, 1945 (2012)

RHIC


RHIC
BOOSTER
LINAC
AGS
HTB
TANDEMS
HITL

vs.

LHC


Lake Geneva
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LHCb
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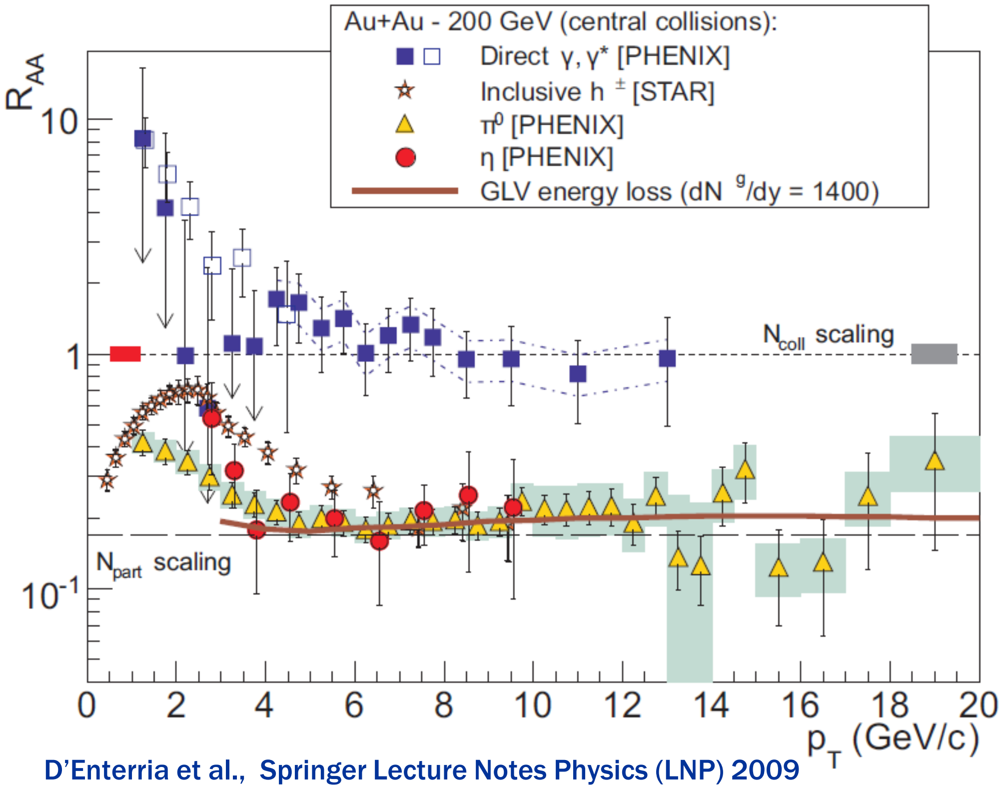
ATLAS

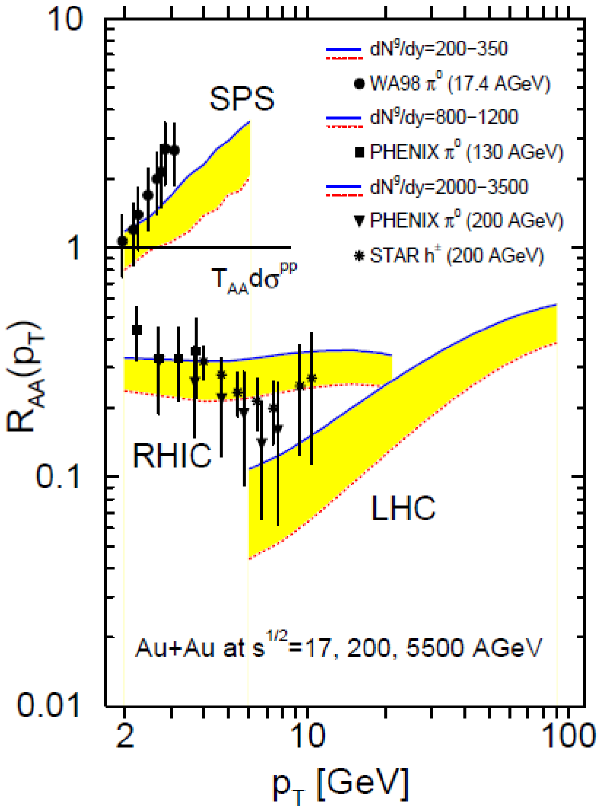
The Nuclear Modification Factor

RHIC & LHC

2002 prediction based on pQCD



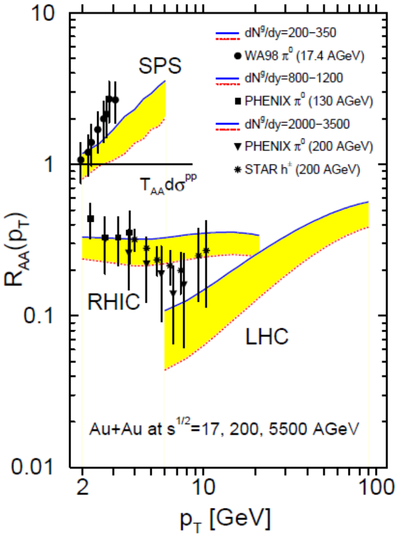
D'Enterria et al., Springer Lecture Notes Physics (LNP) 2009



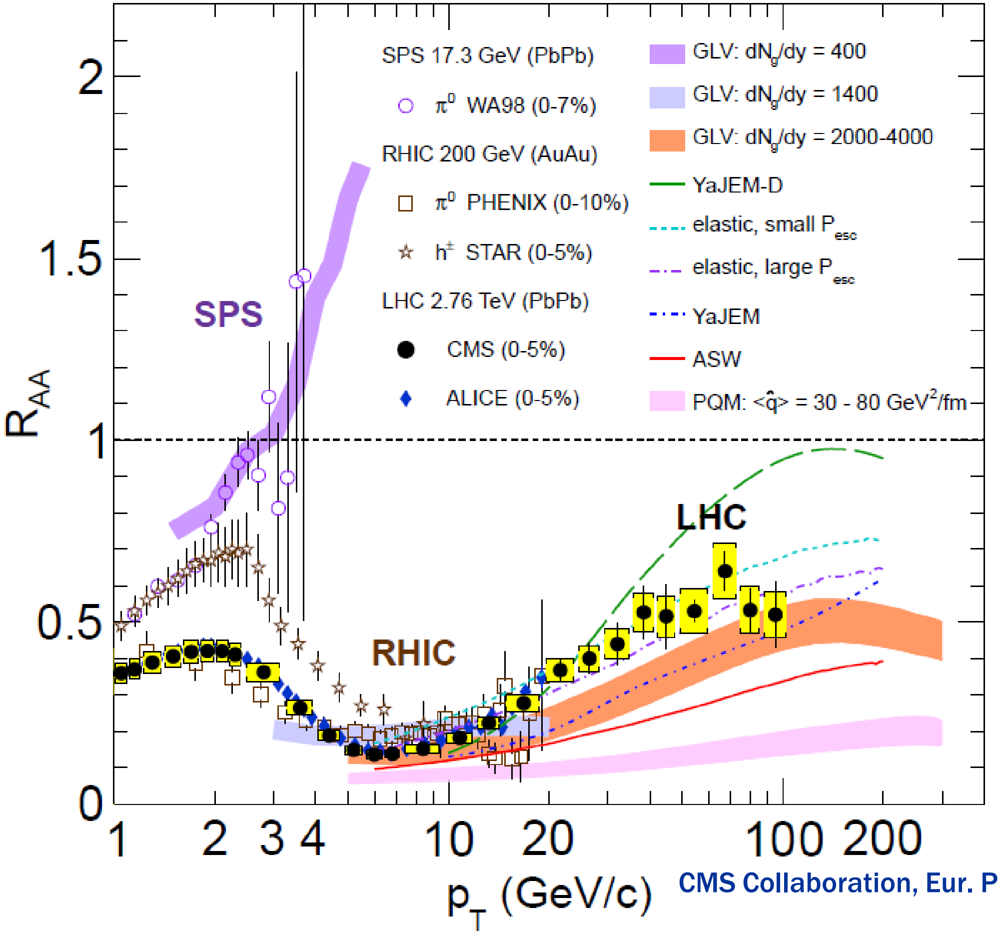
Vitev et al., Phys. Rev. Lett. **89**, 252301 (2002)

- ⇒ R_{AA}@RHIC is flat, R_{AA}@LHC strongly increases with p_T
- ⇒ p_T<20 GeV: R_{AA}@LHC < R_{AA}@RHIC

The R_{AA} at RHIC vs. LHC



Vitev et al., Phys. Rev. Lett. 89, 252301 (2002)



CMS Collaboration, Eur. Phys. J C 72, 1945 (2012)

⟹ Remarkable similarity of jet quenching at RHIC and LHC

⟹ Puzzle: RHIC constrained models tend to overquench R_{AA} @LHC

⟹ Is the jet-medium coupling at LHC weaker? By how much?

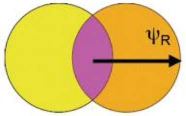
Energy-Loss Mechanisms I

RHIC & LHC

Generic model of jet-energy loss:

$$\frac{dP}{d\tau}(\vec{x}_0,\phi,\tau) = -\kappa P^a(\tau)\,\tau^z\, T^{c=2-a+z}[\vec{x}_\perp(\tau),\tau,b]$$

considering Bjorken expansion for τ_0 = 1fm, including fragmentation, and examining an "averaged scenario" for Glauber and CGC-like in. cond.



B.Betz et al., PRC **84**, 024913 (2011)

CGC-like, deformed Glauber in. cond. (dcgc1.2):

B.Betz et al., PRC **86**, 024903 (2012)

$$x \to s_x x, \quad y \to s_y y$$

$$s_x = \sqrt{\frac{\langle x^2\rangle_{\rm CGC}}{\langle x^2\rangle_{\rm Gl}}}, \quad s_y = \sqrt{\frac{\langle y^2\rangle_{\rm CGC}}{\langle y^2\rangle_{\rm Gl}}}$$

with the assumption

$$\epsilon_{\rm CGC} = f\cdot\epsilon_{\rm Gl} \qquad f = 1.2\pm0.1$$

Jet-energy and path-length dependencies (4 main scenarios):

a	z	c	in. cond.
0	1	3	Glauber
1/3	1	8/3	Glauber dcgc1.2
1	2	3	"Jia" dcgc1.2

$\Downarrow$ A. Ficnar, arXiv: 1201.1780

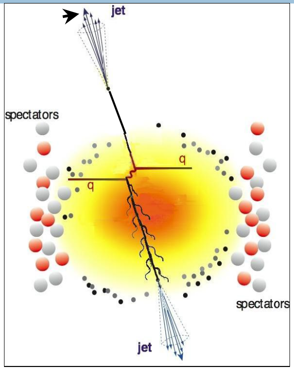
$\Downarrow$ **pure binary collisions** for a=1

J. Jia et al., PRC **82** (2010), 024902

Energy-Loss Mechanisms II

Generic model of jet-energy loss:

RHIC & LHC



$$\frac{dP}{d\tau}(\vec{x}_0,\phi,\tau) = -\kappa P^a(\tau)\,\tau^z\,T^{c=2-a+z}[\vec{x}_\perp(\tau),\tau,b]$$

- a=1, z=0: Bethe-Heitler limit

  energy loss of charged particles passing through matter, based on the Dirac equation and the Born approximation for the interaction of the particle with the field of a nucleus.

- a~0, z~1: Landau-Pomeranchuk Migdal (LPM) pQCD

  quantum interferences between successive scatterings (LPM effect) leads to a suppression of the radiation spectrum compared to Bethe-Heitler.

- a=1/3, z=1: lower bound of power a in falling string scenario

  A. Ficnar, arXiv: 1201.1780

- a=1, z=2: "AdS/CFT" model

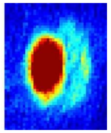
  J. Jia et. al., PRC **82** (2010), 024902

- a<0, z=0: cold atoms Y. Nishida, arXiv: 1110.5926

  Boltzmann eq. with 2 and 3-body scatterings.

a	z	c	in. cond.
0	1	3	Glauber
1/3	1	8/3	Glauber dcgc1.2
1	2	3	"Jia" dcgc1.2

A. Ficnar, arXiv: 1201.1780



→ If there are collective d.o.f. (phonons), radiative energy loss with z>0 is possible

RHIC


RHIC
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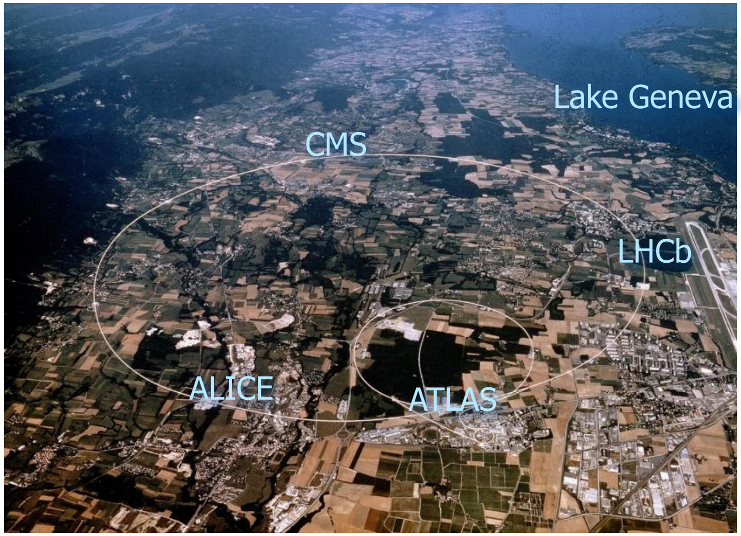
TANDEMS
HITL

vs.

LHC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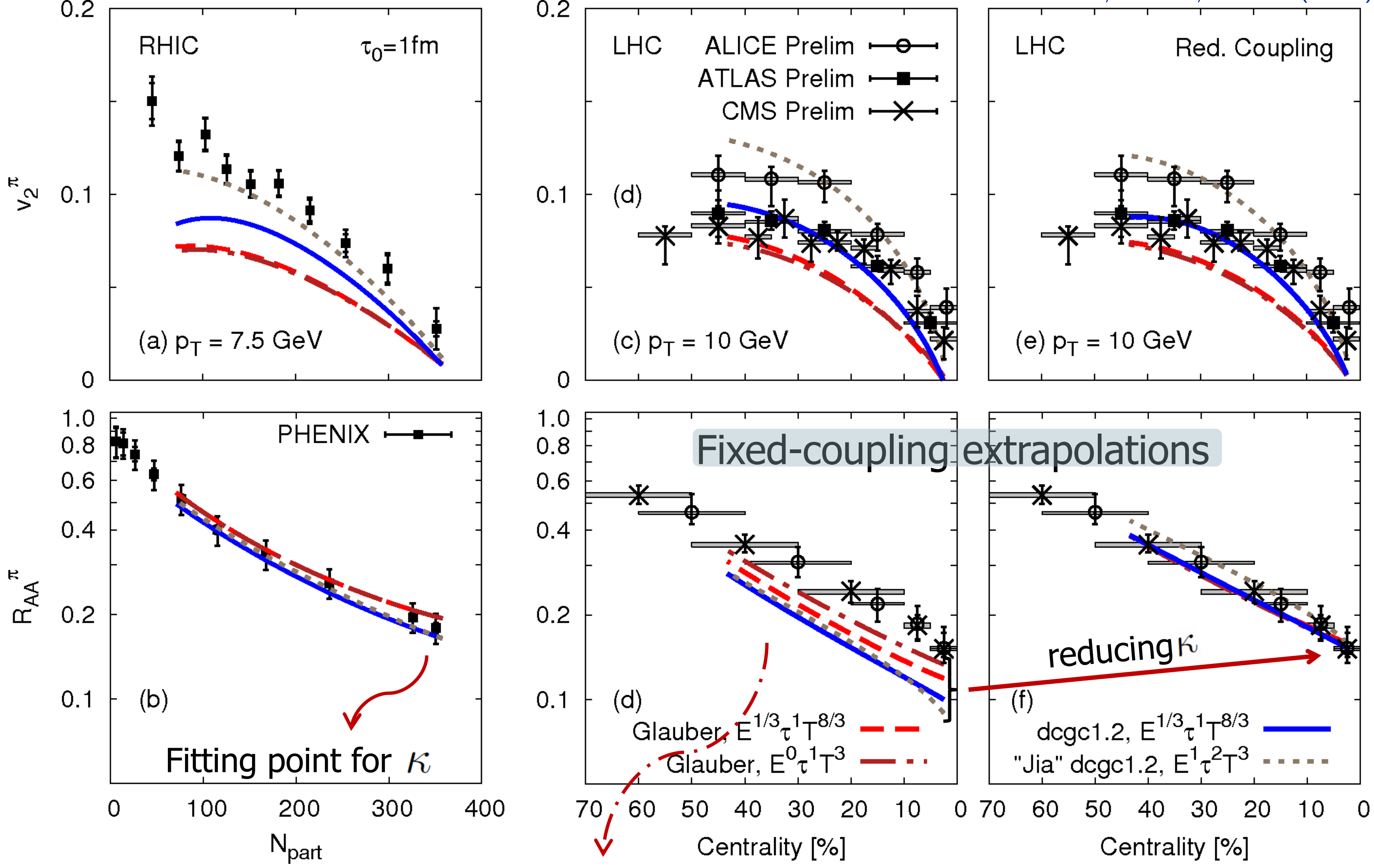
ATLAS

R_{AA} and v_2 at RHIC vs. LHC

B.Betz et al., PRC **86**, 024903 (2012)



Fixed-coupling extrapolations

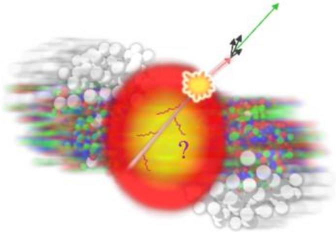
reducing κ

Fitting point for κ

Extrapolation from RHIC to LHC energies leads to an overquenching of the R_{AA} at LHC energies

W. Horowitz et al, Nucl. Phys. A **872** (2011) 265

Reduced Jet-Medium Coupling



What is the physical meaning of a reduced coupling?

pQCD: $\kappa \propto \alpha^3$

$$\alpha_{\mathrm{LHC}} = (\kappa_{\mathrm{LHC}}/\kappa_{\mathrm{RHIC}})^{1/3}\alpha_{\mathrm{RHIC}} \qquad \alpha_{\mathrm{RHIC}} \sim 0.3$$

fit to LHC most central data: $\alpha_{\mathrm{LHC}} \sim 0.24 - 0.28$

(independent of initial time)

B.Betz et al., PRC **86**, 024903 (2012)

$\Longrightarrow$ Reasonable moderate reduction of the running coupling

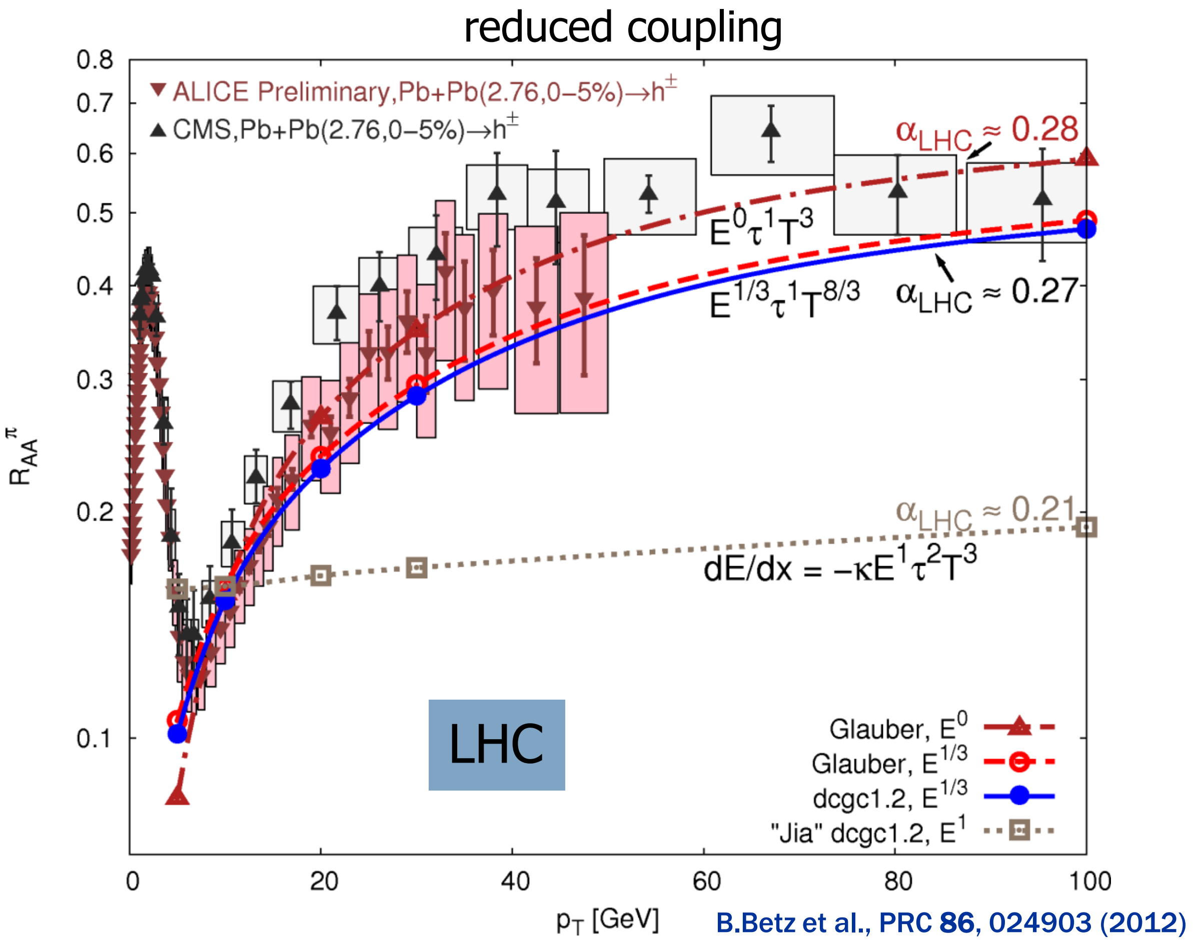
AdS/CFT: $\kappa \propto \sqrt{\lambda}$ ← t'Hooft coupling

$$\lambda_{\mathrm{LHC}} = (\kappa_{\mathrm{LHC}}/\kappa_{\mathrm{RHIC}})^2\, \lambda_{\mathrm{RHIC}} \qquad \lambda_{\mathrm{RHIC}} \sim 20 \text{ (heavy quarks)}$$

with the values used: $\lambda_{\mathrm{LHC}} \sim 5 - 10$

$\Longrightarrow$ Rather strong conformal symmetry breaking over a narrow temperature interval (1-2)T_C is required
Non-conformal gravity dual generalizations are under construction
(Mia, Ficnar, Noronha, ...)

$R_{AA}(p_T)$ at the LHC



reduced coupling

B.Betz et al., PRC **86**, 024903 (2012)

⇒ Linear p_T-dependent (a=1) model describes RHIC p_T<10 GeV data well but is falsified at LHC

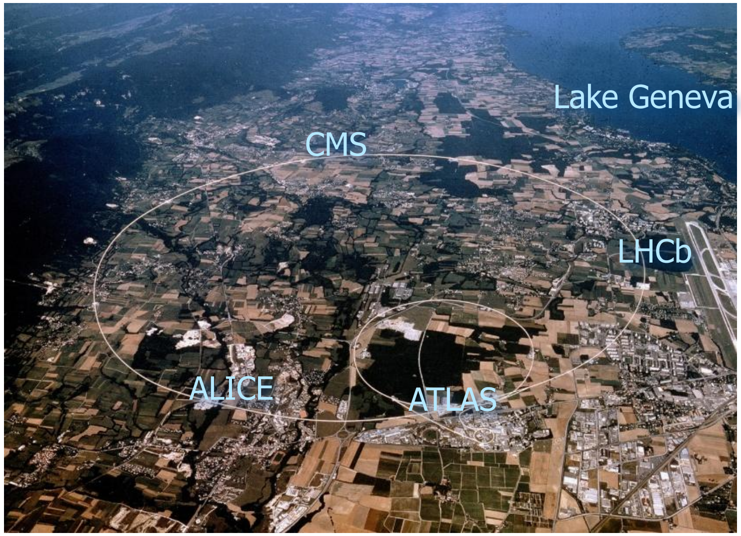
⇒ Rapid rise of $R_{AA}(p_T)$ rules out any model with $dE/dx \sim E^{a>1/3}$

RHIC


RHIC
BOOSTER
LINAC
AGS
HTB
TANDEMS
HITL

vs.

LHC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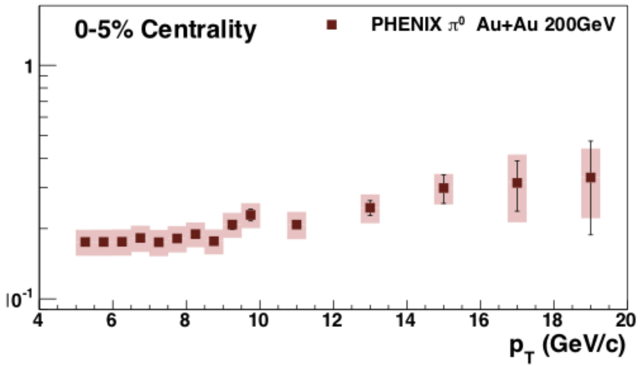
$R_{AA}(p_T)$ at RHIC



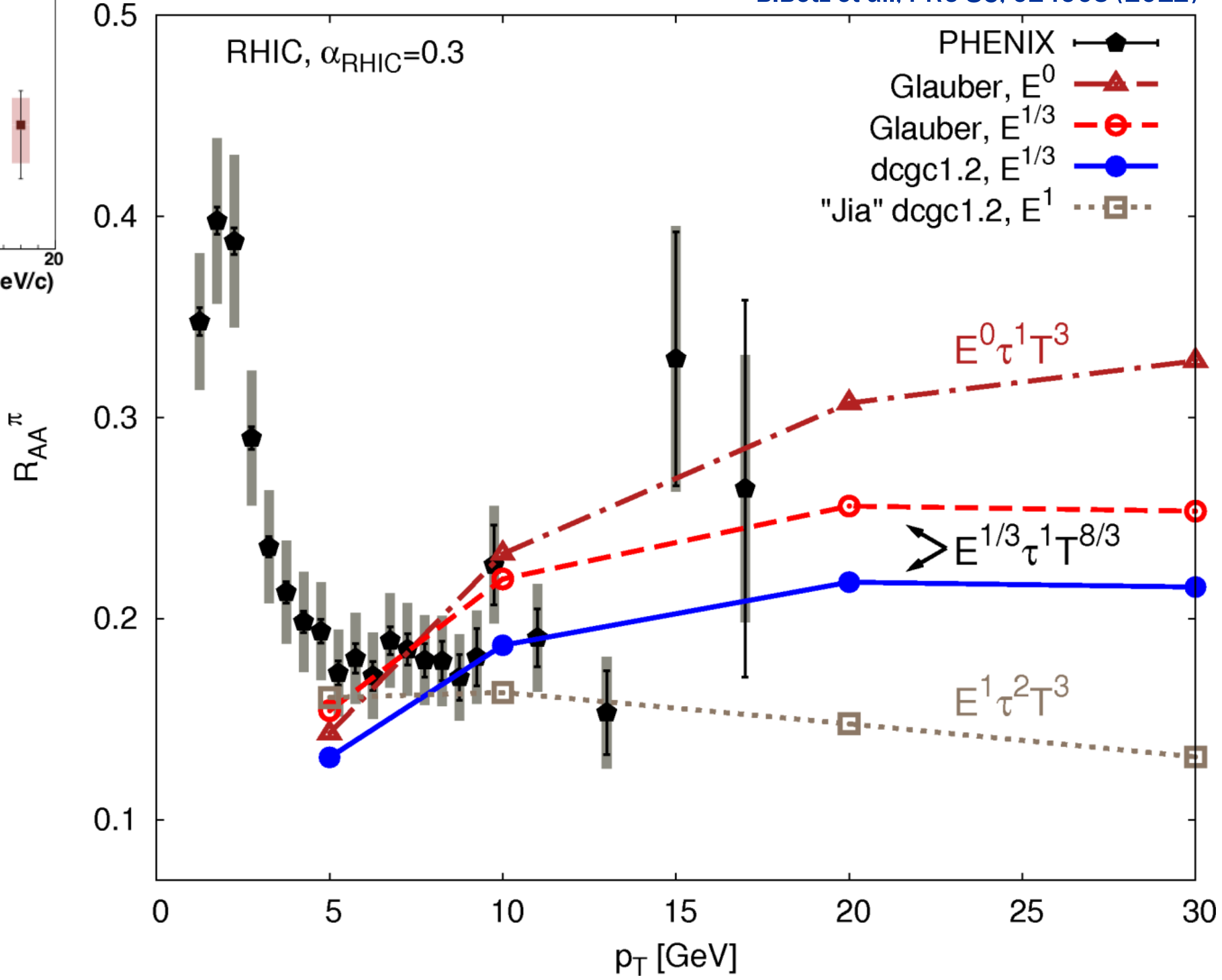
PHENIX Overview Talk, QM 12

- a= 0 and a=1/3 energy exponents are consistent with data within error bars

⇒ Higher statistics measurements at RHIC with $5 < p_T < 30$ GeV are needed

sPHENIX Upgrade Concept, arXiv:1207.6378

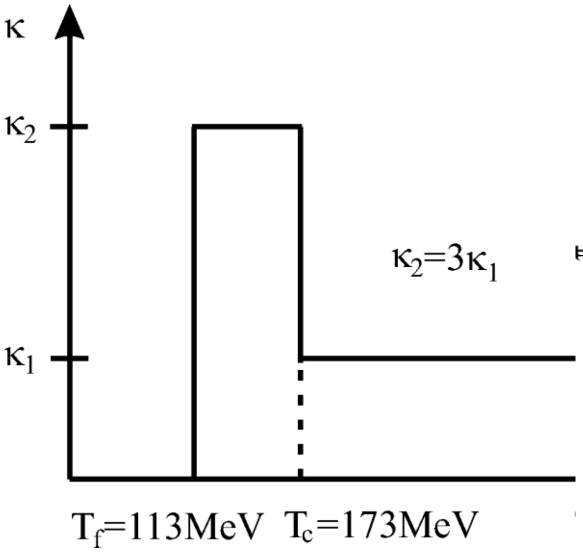
B.Betz et al., PRC **86**, 024903 (2012)



Fixed vs. Temperature-Dependent Coupling

Temperature-dependent Coupling

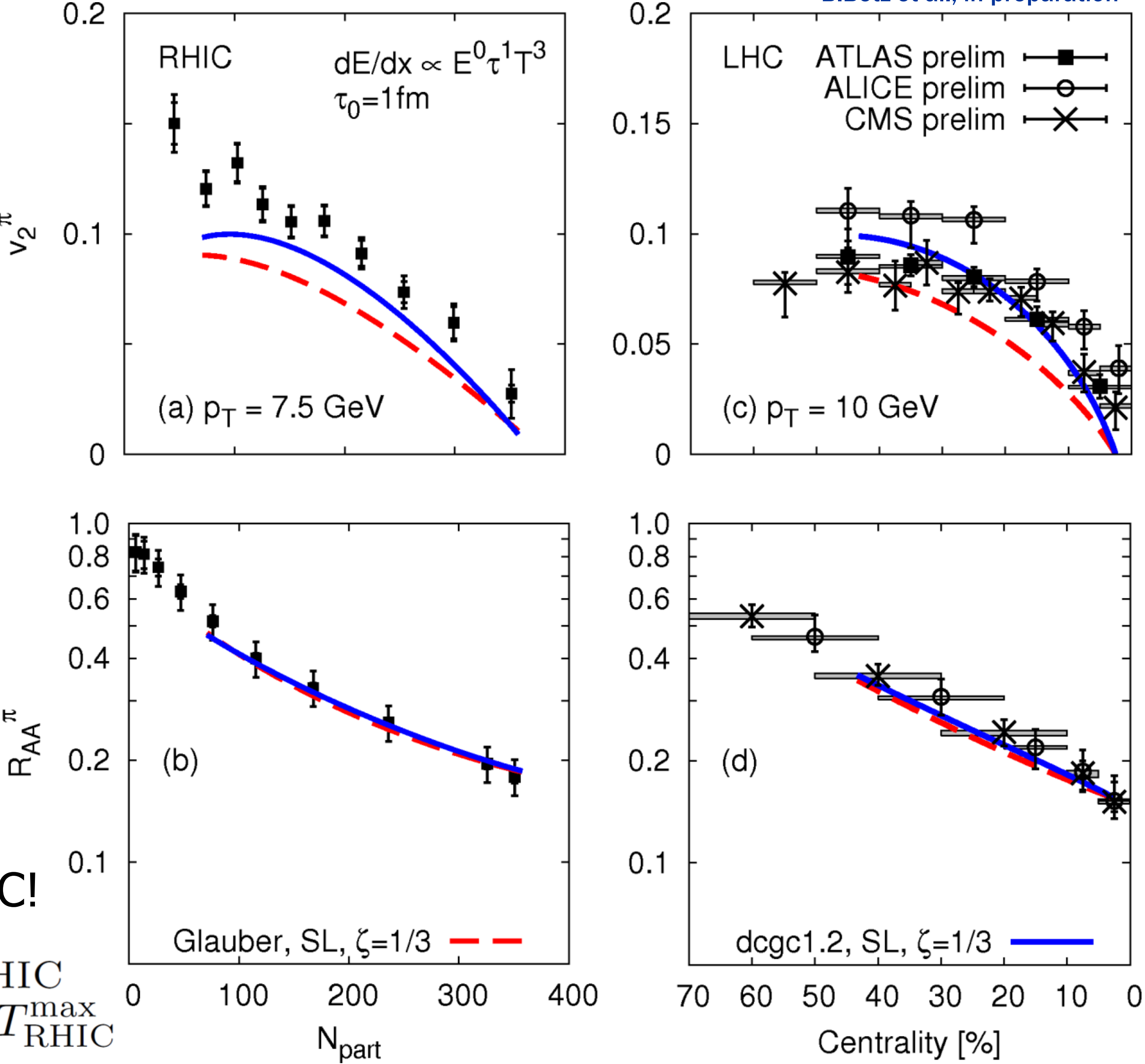
B.Betz et al., in preparation



J.Liao et al,. PRL **102** (2009) 202302

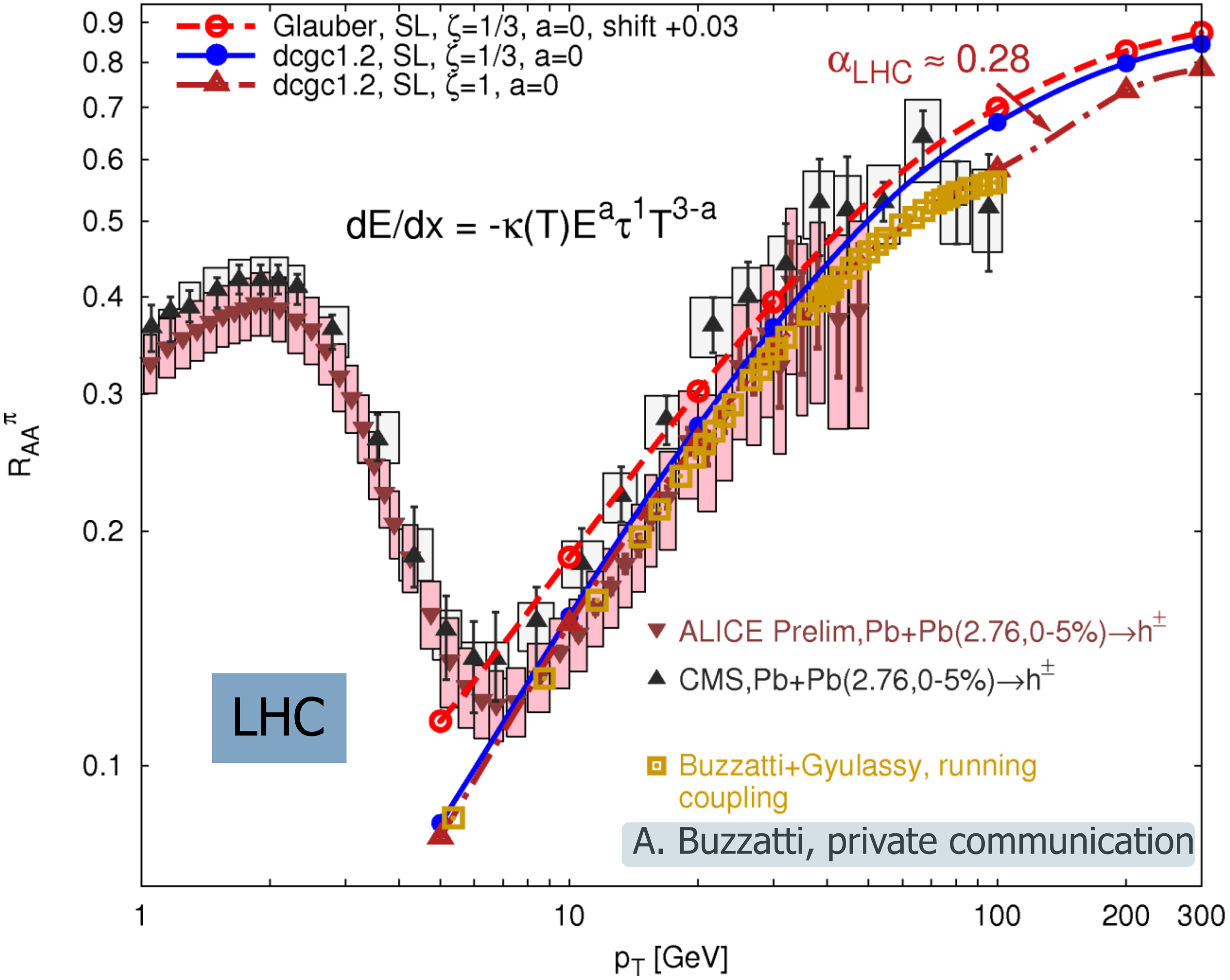
$$\boxed{\zeta = \kappa_1/\kappa_2}$$

- ⟹ Assumes the same κ(T) at RHIC and LHC!
- ⟹ $\mathrm{eff}\ \kappa_{\mathrm{LHC}} < \mathrm{eff}\ \kappa_{\mathrm{RHIC}}$ because $T^{\max}_{\mathrm{LHC}} \sim 1.3\ T^{\max}_{\mathrm{RHIC}}$

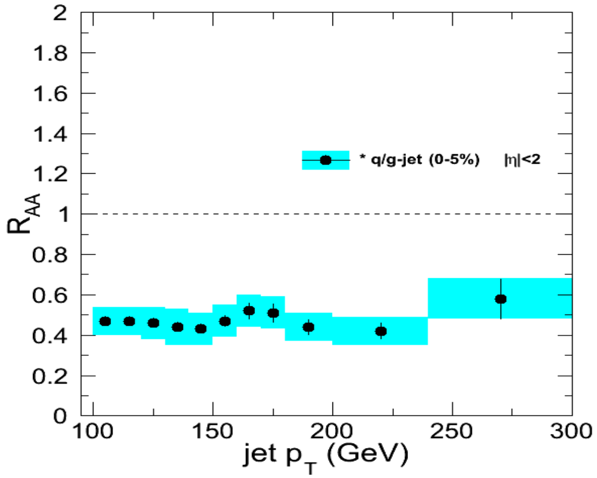


$R_{AA}(p_T)$ at LHC

B.Betz et al., in preparation



A. Buzzatti, private communication



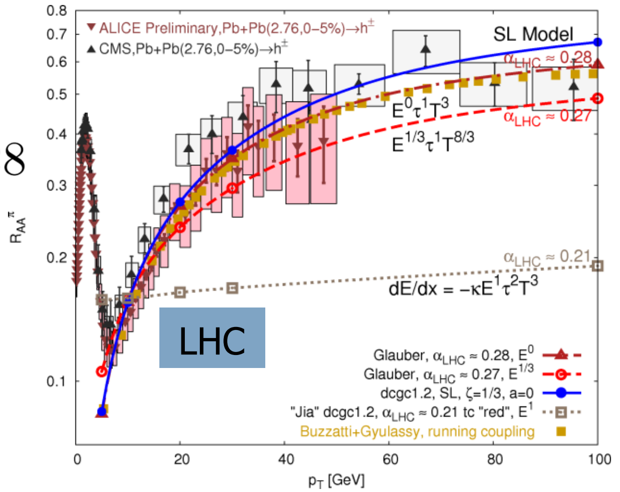
CMS Overview Talk, QM 12

- ⇒ Temperature-dependent and reduced couplings lead to similar $R_{AA}(p_T)$
- ⇒ Running coupling CUJET and SL a=0 ζ=1/3,1 all similar for p_T >10 GeV

Summary & Open Problems

- It would be really interesting to measure jet suppression in cold atoms for a more direct comparison with heavy-ion collisions and to learn if cold atoms are opaque.

- Puzzle of overquenching R_{AA} @LHC can be solved:
  - reduced jet-medium coupling at LHC, $\alpha \sim 0.27 - 0.28$
  - running coupling A. Buzzatti, private communication
  - temperature-dependent jet-medium coupling
  - or a combination



- Rapid rise of $R_{AA}(p_T)$ rules out any model with $dE/dx \sim E^{a>1/3}$

⟹ Cross checking RHIC vs. LHC at all combinations of available data is essential to test consistency of all models

Backup

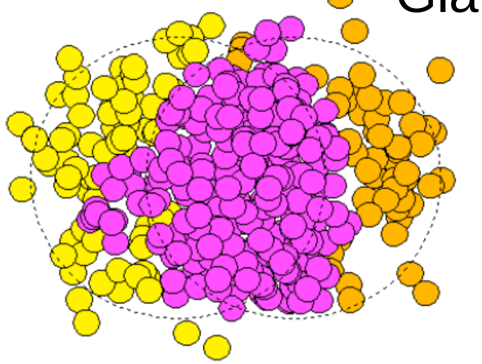
Initial Conditions

Studying heavy-ion collisions requires a good understanding of the role of the initial conditions:

- Glauber model:
  incoherent superposition of
  p+p collisions

- Color Glass Condensate (CGC):
  saturation effects are included

Glauber



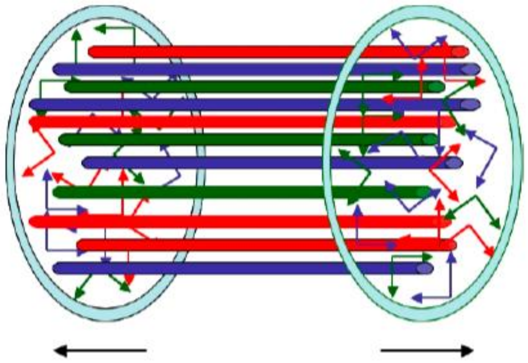
B. Alver, Talk at the Glasma Workshop, BNL, May 2010

They differ:

- initial temperature gradients
- initial high-p_T parton distribution
- distance travelled by each parton

➔ Leads to a different opacity estimate

CGC

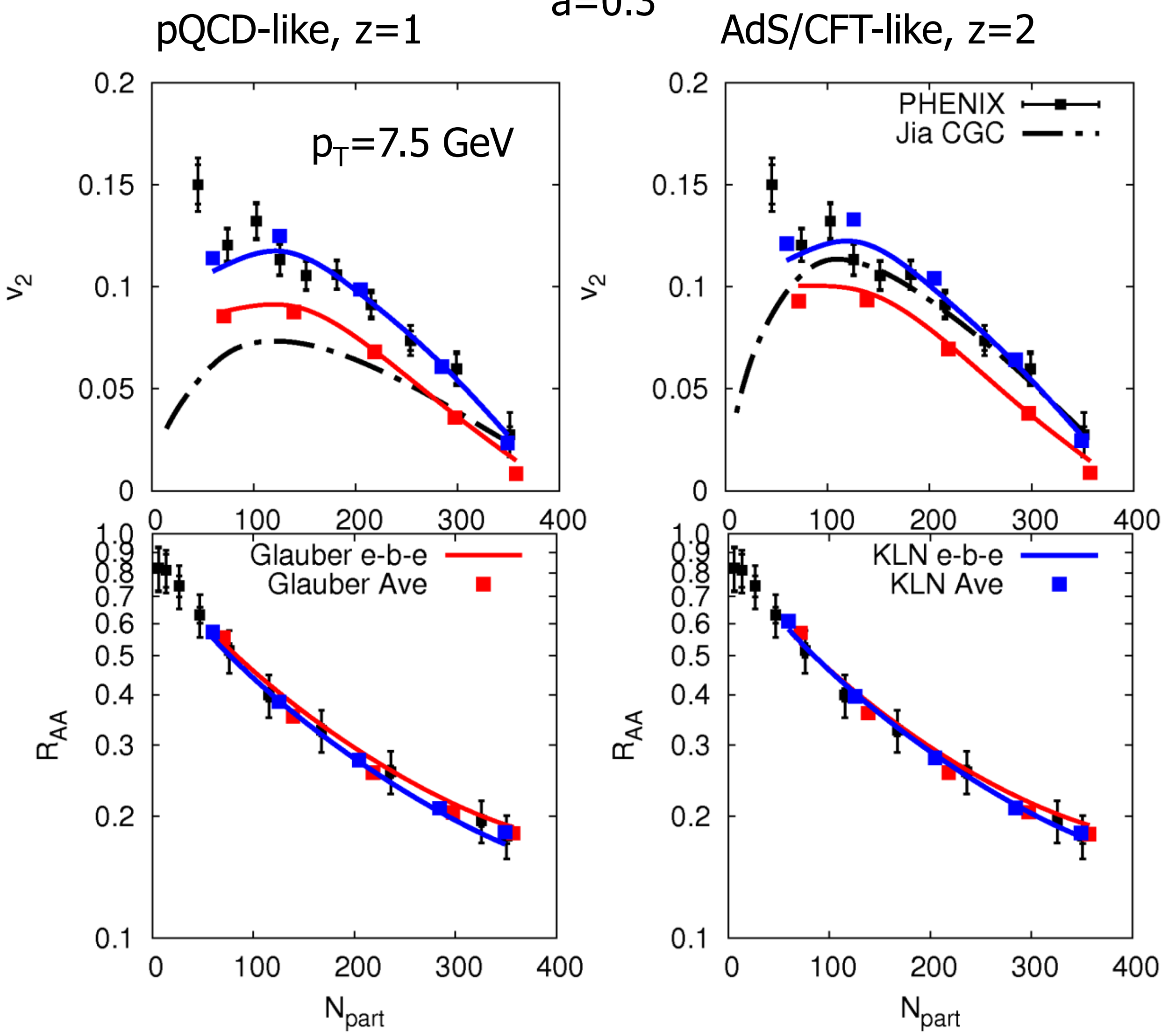


L. McLerran, Talk at a the CP Violation Workshop, BNL, April 2010

R_{AA} and v_2 at RHIC

Similar results for event-by-event and averaged scenarios

a=0.3



B.Betz et al., PRC **84**, 024913 (2011)

Initial time

We set τ_0 = 1fm

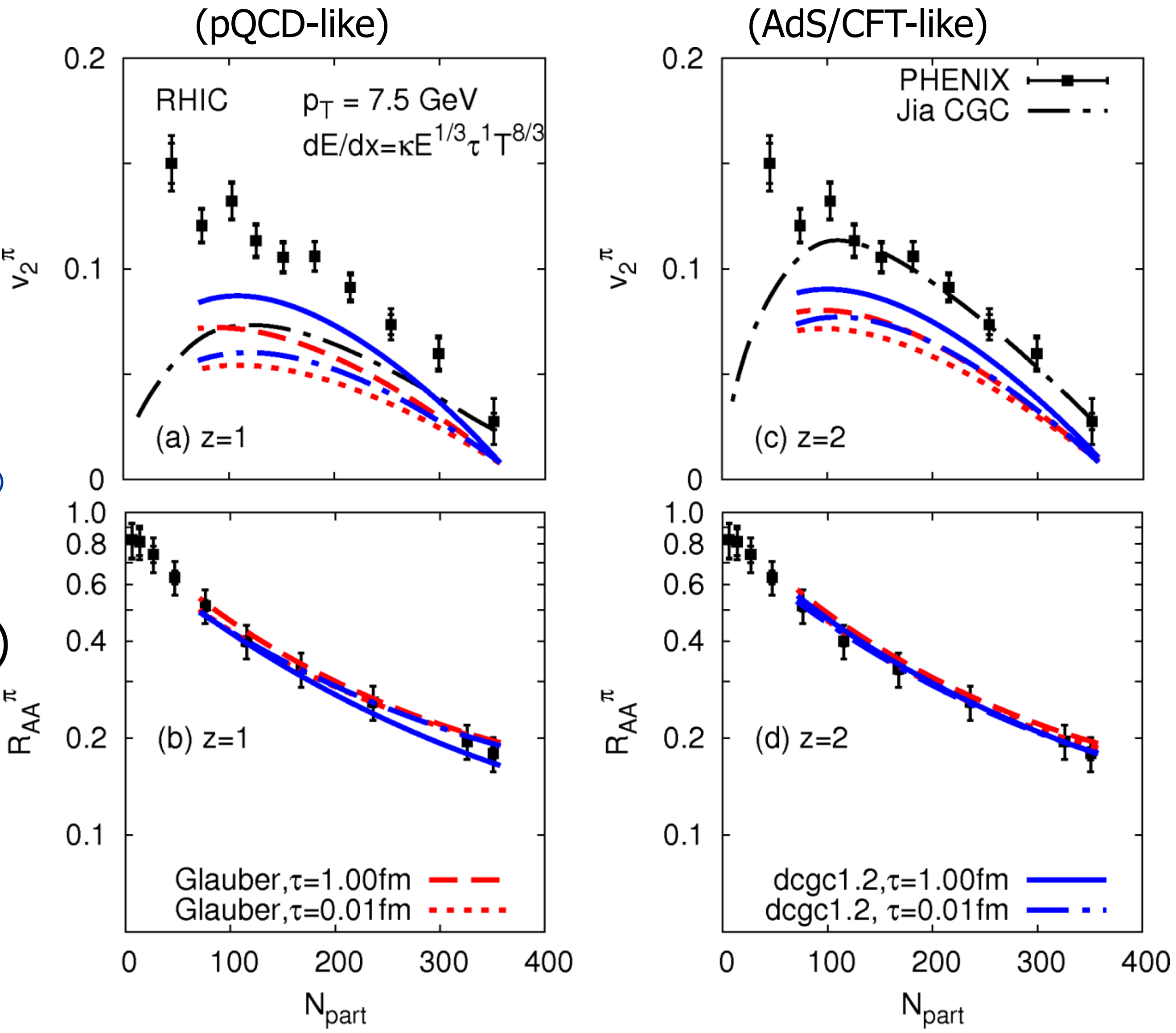
H. Song et al., PRL **106**, 192391 (2011)

Jia's model has

τ_0 = 0fm

A. Adare et al., PRL **105**, 142301 (2010)

⇒ A smaller τ_0 reduces the v_2(Centr.) and increases the difference between the pQCD and AdS/CFT results



Initial time

τ_0 = 1fm → Assumption: NO energy loss within 1fm

- pQCD does not give excuse for this ansatz, τ_0 = 0fm most natural assumption

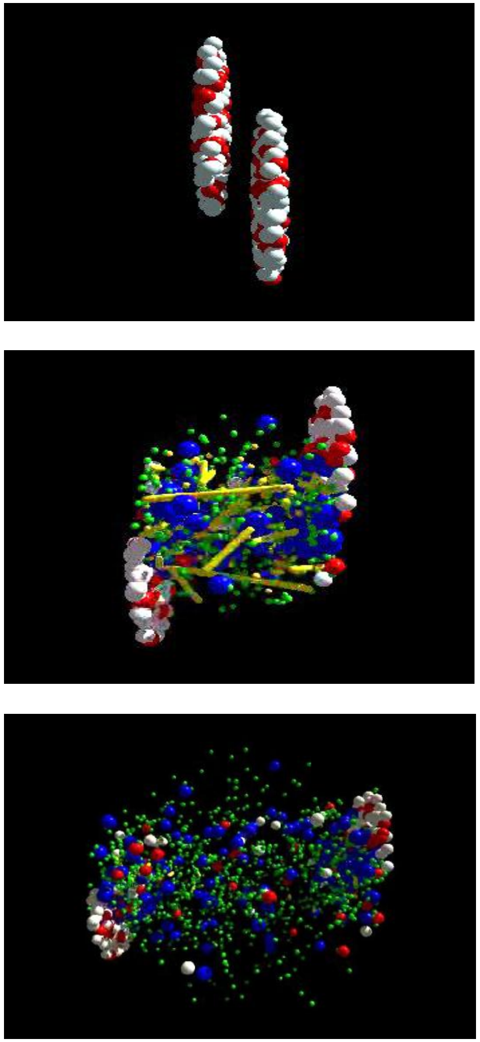
Adare et al, Phys. Rev. Lett. **105**, 142301 (2010)

- describes formation time of hydrodynamics → no pressure at early times, everything is free flow

τ_0 = 1fm → essentially equivalent to AdS/CFT energy loss suppression of early times

⇒ v_2(high- p_T) not sensitive to long distance $dE/dx \sim l^1$ vs. $dE/dx \sim l^2$, but to short distance properties < 1fm!

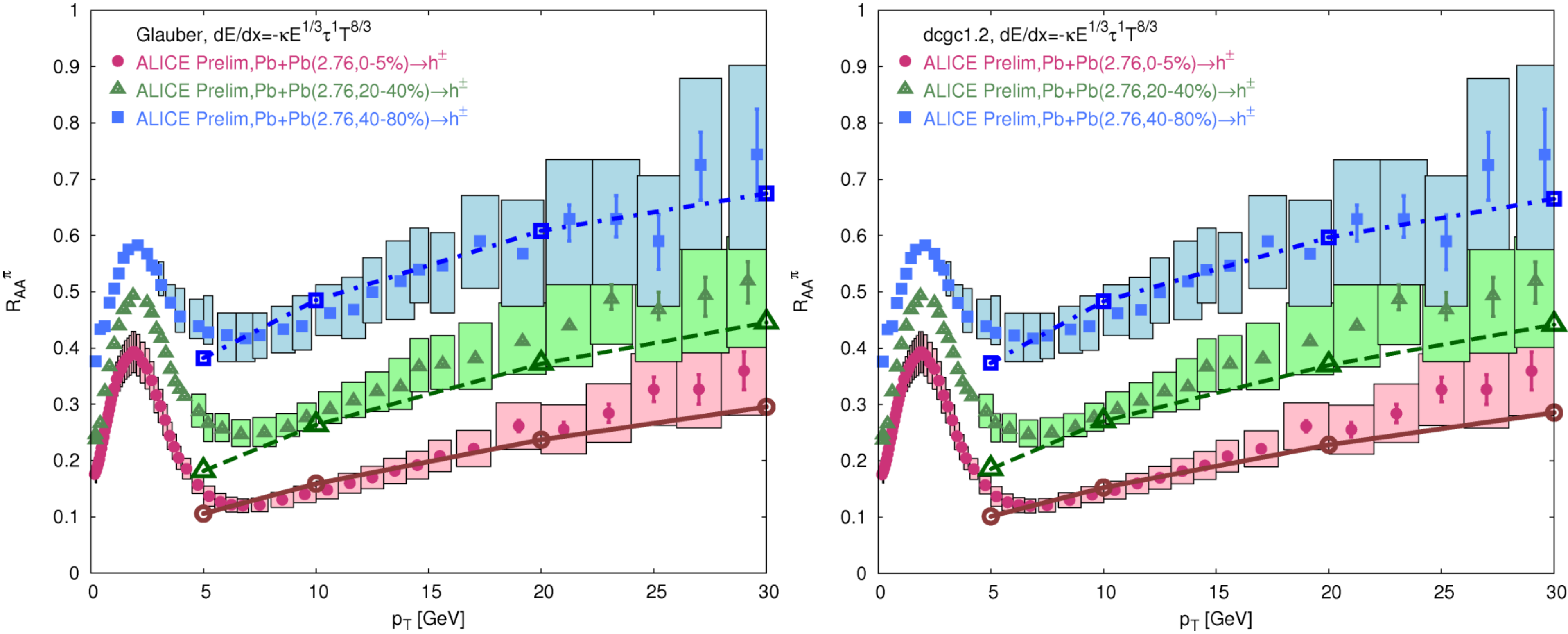
⇒ We cannot access the center of the collision!



UrQMD Simulartion, H. Weber

$R_{AA}(p_T$, Centrality) at LHC

B.Betz et al., PRC **86**, 024903 (2012)

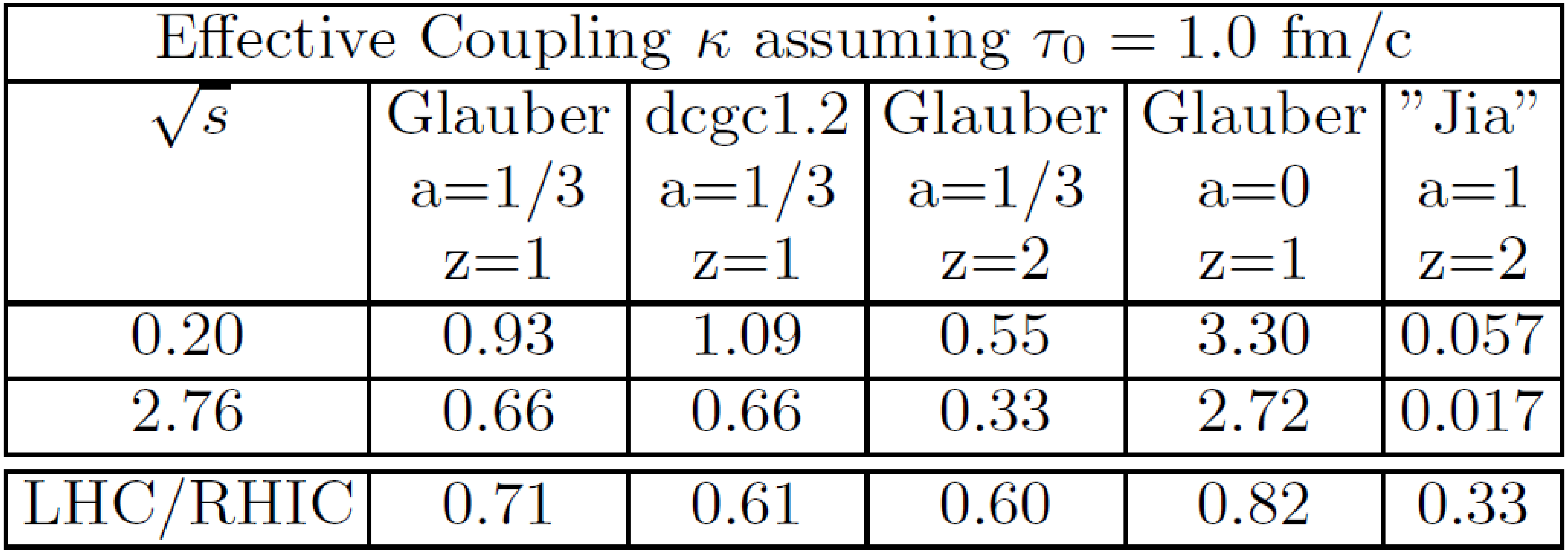


Remarkably insensitive to the initial conditions

⟹ It’s NOT sufficient to just study ONE variable!

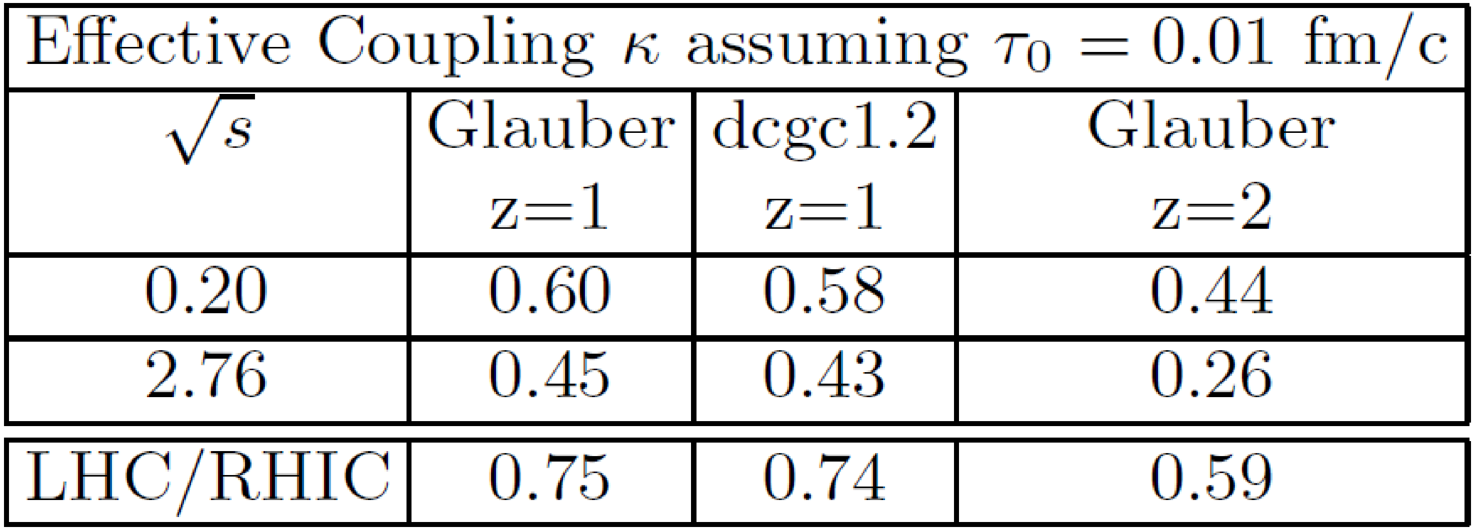
Reduced Jet-Medium Coupling

B.Betz et al., PRC **86**, 024903 (2012)



Effective Coupling κ assuming $\tau_0 = 1.0$ fm/c

$\sqrt{s}$	Glauber a=1/3 z=1	dcgc1.2 a=1/3 z=1	Glauber a=1/3 z=2	Glauber a=0 z=1	”Jia” a=1 z=2
0.20	0.93	1.09	0.55	3.30	0.057
2.76	0.66	0.66	0.33	2.72	0.017
LHC/RHIC	0.71	0.61	0.60	0.82	0.33



Effective Coupling κ assuming $\tau_0 = 0.01$ fm/c

$\sqrt{s}$	Glauber z=1	dcgc1.2 z=1	Glauber z=2
0.20	0.60	0.58	0.44
2.76	0.45	0.43	0.26
LHC/RHIC	0.75	0.74	0.59

Energy-Loss Mechanisms III

R_{AA} is a ratio of jet penetrating a QGP to the initial jet spectrum

$$R^{q,g}_{AA}(P_f,\vec{x}_0,\phi) = \frac{dN^{jet}_{QGP}(P_f)}{dy\,d\phi\,dP_f^2} \Big/ \frac{dN^{jet}_{vac}(P_f)}{dy\,d\phi\,dP_0^2} = \frac{dP_0^2}{dP_f^2}\,\frac{dN^{jet}_{vac}[P_0(P_f)]}{dy\,d\phi\,dP_0^2} \Big/ \frac{dN^{jet}_{vac}(P_f)}{dy\,d\phi\,dP_0^2}$$

One needs to determine the $P_0(P_f)$ from the $dP/d\tau$ ansatz

$$P_0(P_f) = \left[P_f^{1-a} + K\int_{\tau_0}^{\tau_f} \tau^z T^c[\vec{x}_\perp(\tau),\tau]\,d\tau\right]^{\frac{1}{1-a}}, \qquad K = (1-a)\kappa C_2$$

Fragmentation:

$$R^{\pi}_{AA}(p_\pi,\phi,N_{part}) = \frac{\left\langle \sum\limits_{\alpha=q,g}\ \int\limits_{z_{min}}^{1} \overset{\text{momentum of the observed pion}}{\frac{dz}{z}}\ \overset{\text{pQCD cross-sections}}{d\sigma_\alpha}\left(\frac{p_\pi}{z}\right) R^{\alpha}_{AA}\left(\frac{p_\pi}{z},\phi\right) \overset{\text{fragmentation functions}}{D_{\alpha\to\pi}}\left(z,\frac{p_\pi}{z}\right)\right\rangle_{\vec{x}_0,N_{part}}}{\sum\limits_{\alpha=q,g}\ \int\limits_{z_{min}}^{1} \frac{dz}{z}\ d\sigma_\alpha\left(\frac{p_\pi}{z}\right) D_{\alpha\to\pi}\left(z,\frac{p_\pi}{z}\right)}$$

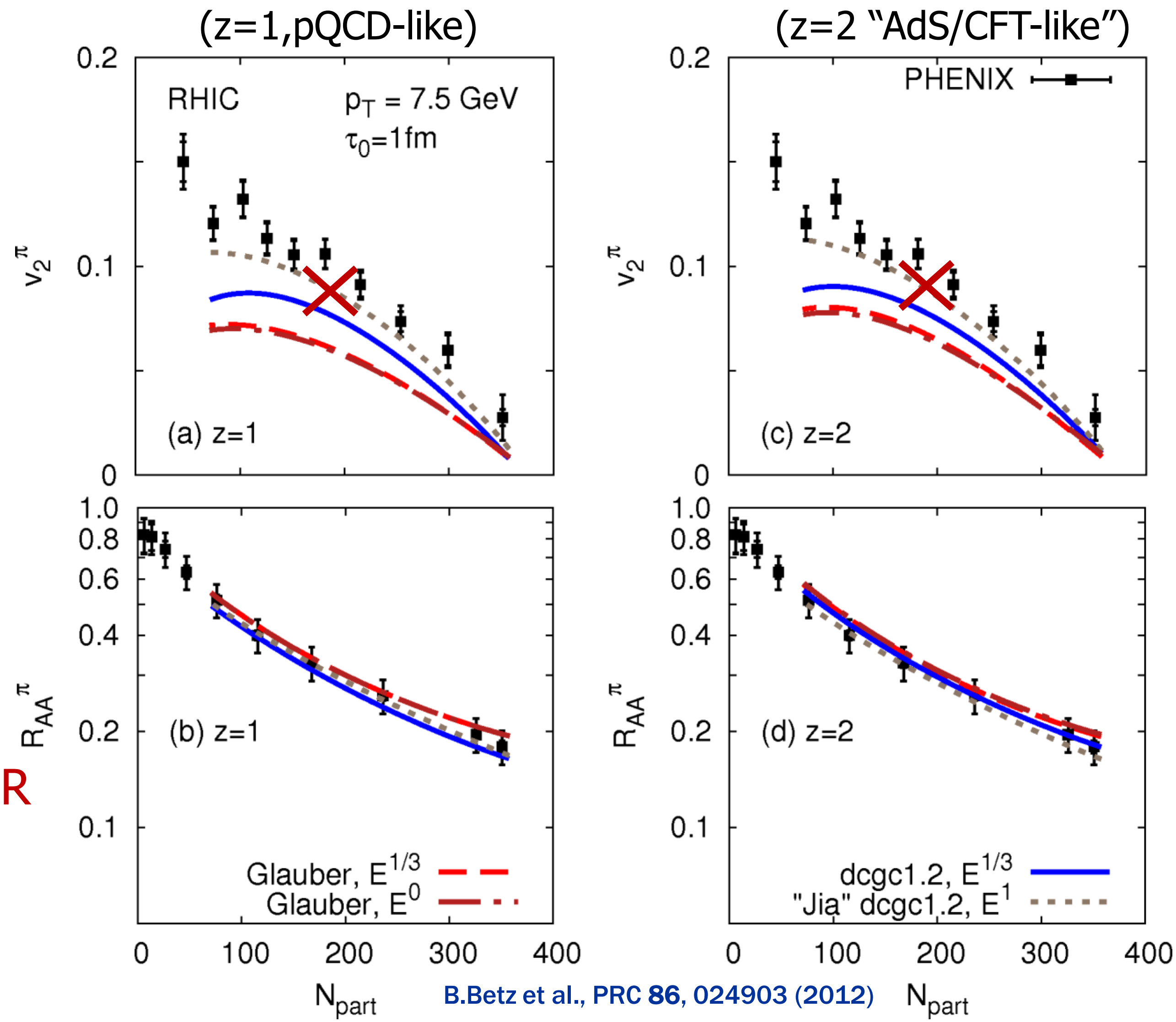
Elliptic Flow: $$v_2^{\pi}(N_{part}) = \frac{\int d\phi \cos\{2\phi\}\ R^{\pi}_{AA}(N_{part},\phi)}{\int d\phi\, R^{\pi}_{AA}(N_{part},\phi)}$$

R_{AA} and v_2 at RHIC

- “Jia” dcgc1.2 model is excluded by the p_T-dependence of the R_{AA} at LHC

- a=0, 1/3 scenarios fail to describe the v_2(Centr.)

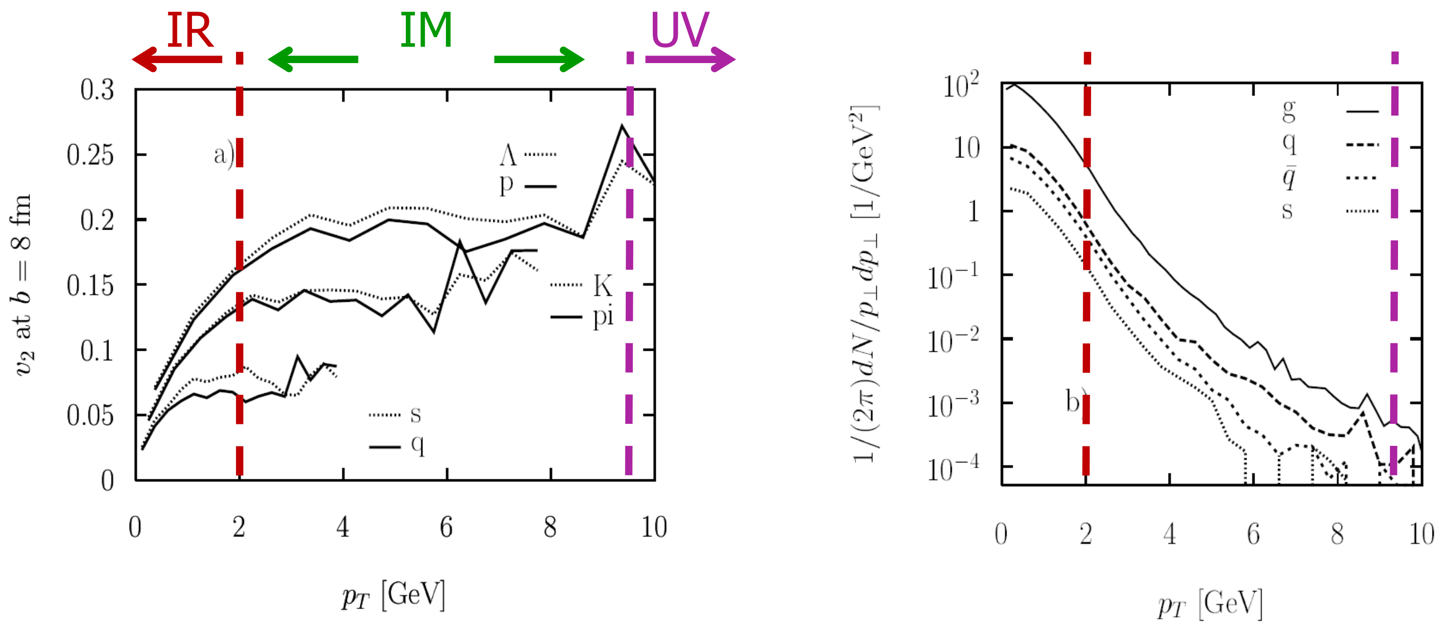
⇒ Disagreement with v_2 data at RHIC FOR THIS intermediate p_T -regime

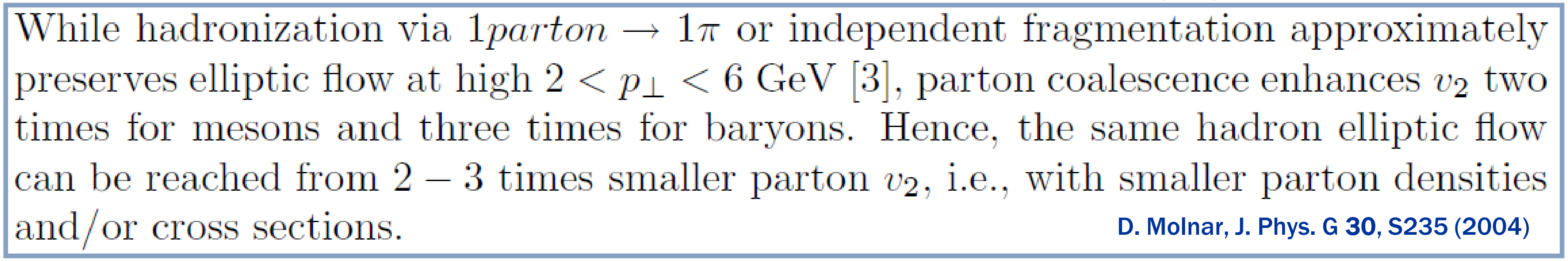


B.Betz et al., PRC **86**, 024903 (2012)

⇒ SMALL difference between path-length dependence z=1 and z=2

Intermediate $v_2(p_T)$ range ($2<p_T<10$ GeV)





While hadronization via $1parton \to 1\pi$ or independent fragmentation approximately preserves elliptic flow at high $2 < p_\perp < 6$ GeV [3], parton coalescence enhances v_2 two times for mesons and three times for baryons. Hence, the same hadron elliptic flow can be reached from $2-3$ times smaller parton v_2, i.e., with smaller parton densities and/or cross sections.

D. Molnar, J. Phys. G **30**, S235 (2004)

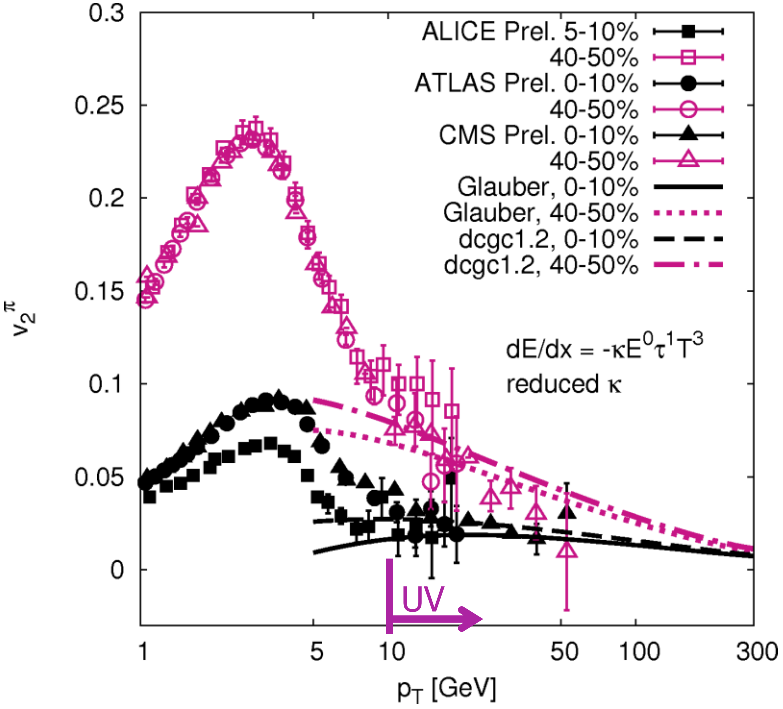
- ⇒ parts of the v_2(intermediate p_T) could originate from bulk tails

  see Eqs. (16) – (18) in M. Gyulassy et al., Phys. Rev. Lett. **86**, 2537 (2001)

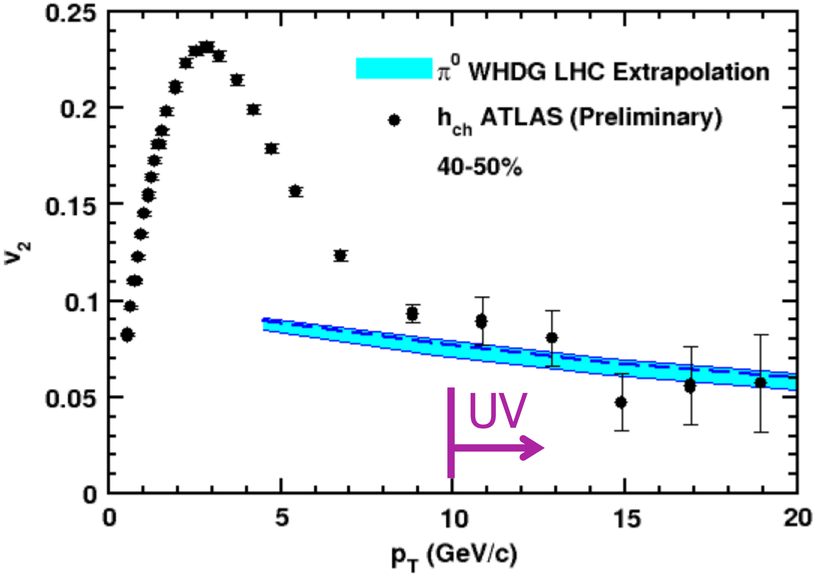
- ⇒ pure jet fragmentation and absorption models should NOT be expected to fully describe the intermediate p_T -range

$v_2(p_T$, Centrality) at LHC

B.Betz et al., in preparation



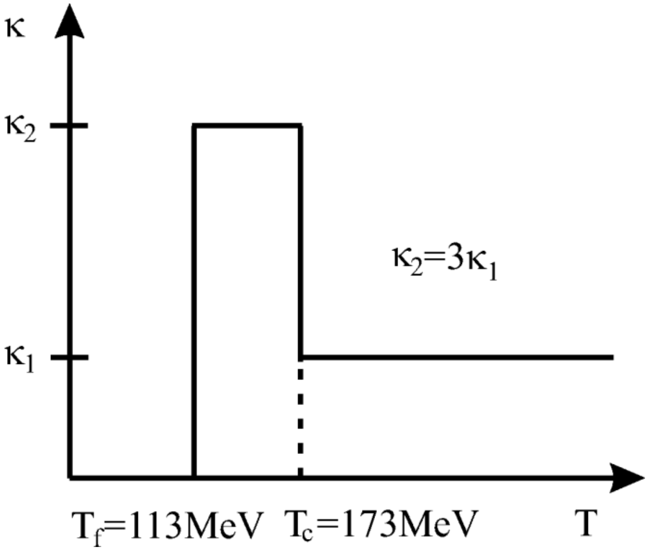
W. Horowitz et al., J. Phys. G **38**, 124064 (2011)



- Unlike the intermediate p_T, the deep ultraviolet p_T>10 GeV is much better explained by standard jet tomography at LHC
- For 1< p_T< 5 GeV, it is difficult to separate the jet contribution to v_2 from the high-p_T tails of the bulk QGP elliptic flow

⇒ Very high p_T>10 GeV v_2 is rather insensitive to 20% variations in the eccentricity between Glauber and CGC

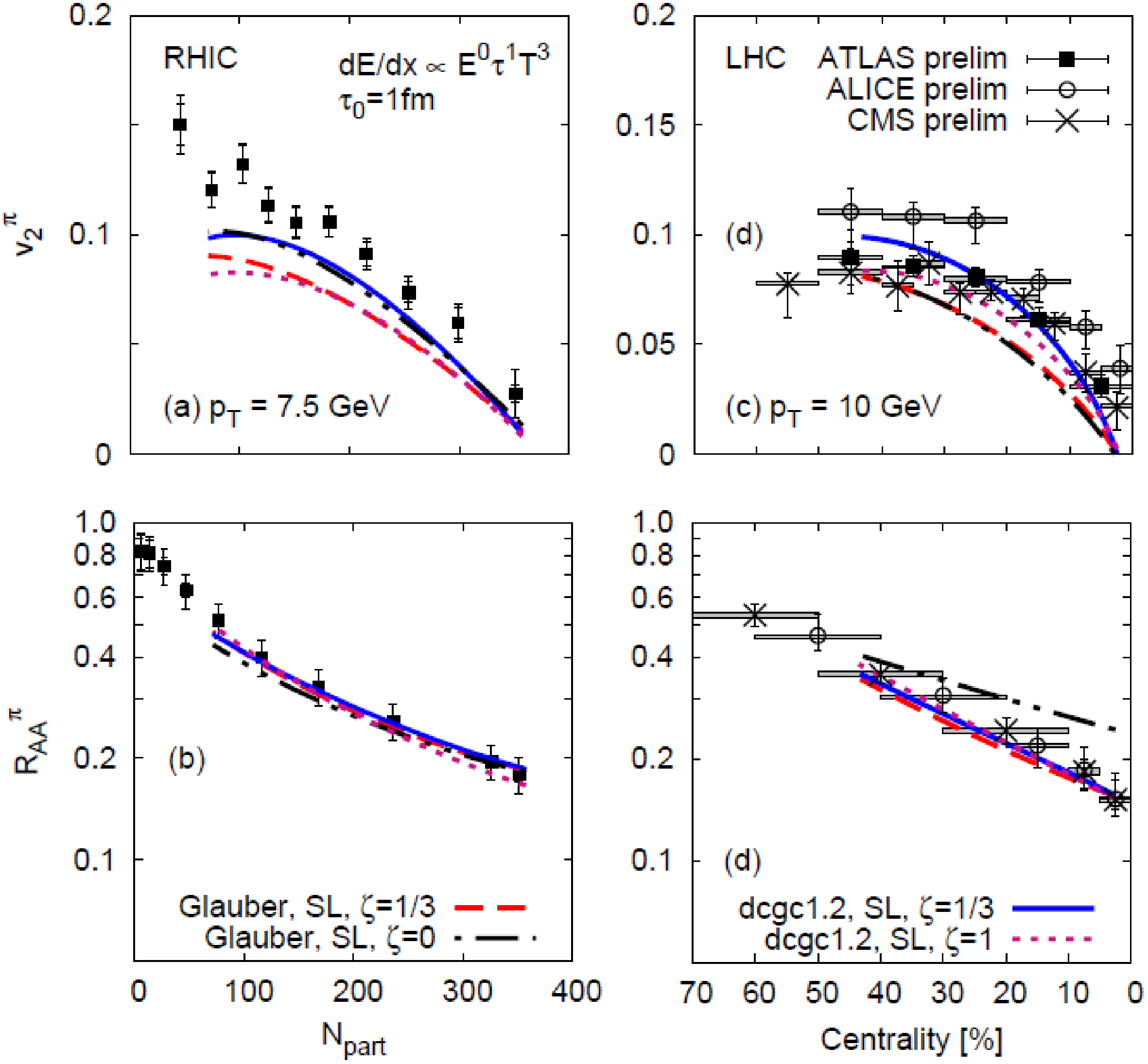
Temperature-dependent Coupling



J.Liao et al,. PRL **102** (2009) 202302

$$\boxed{\zeta = \kappa_1 / \kappa_2}$$

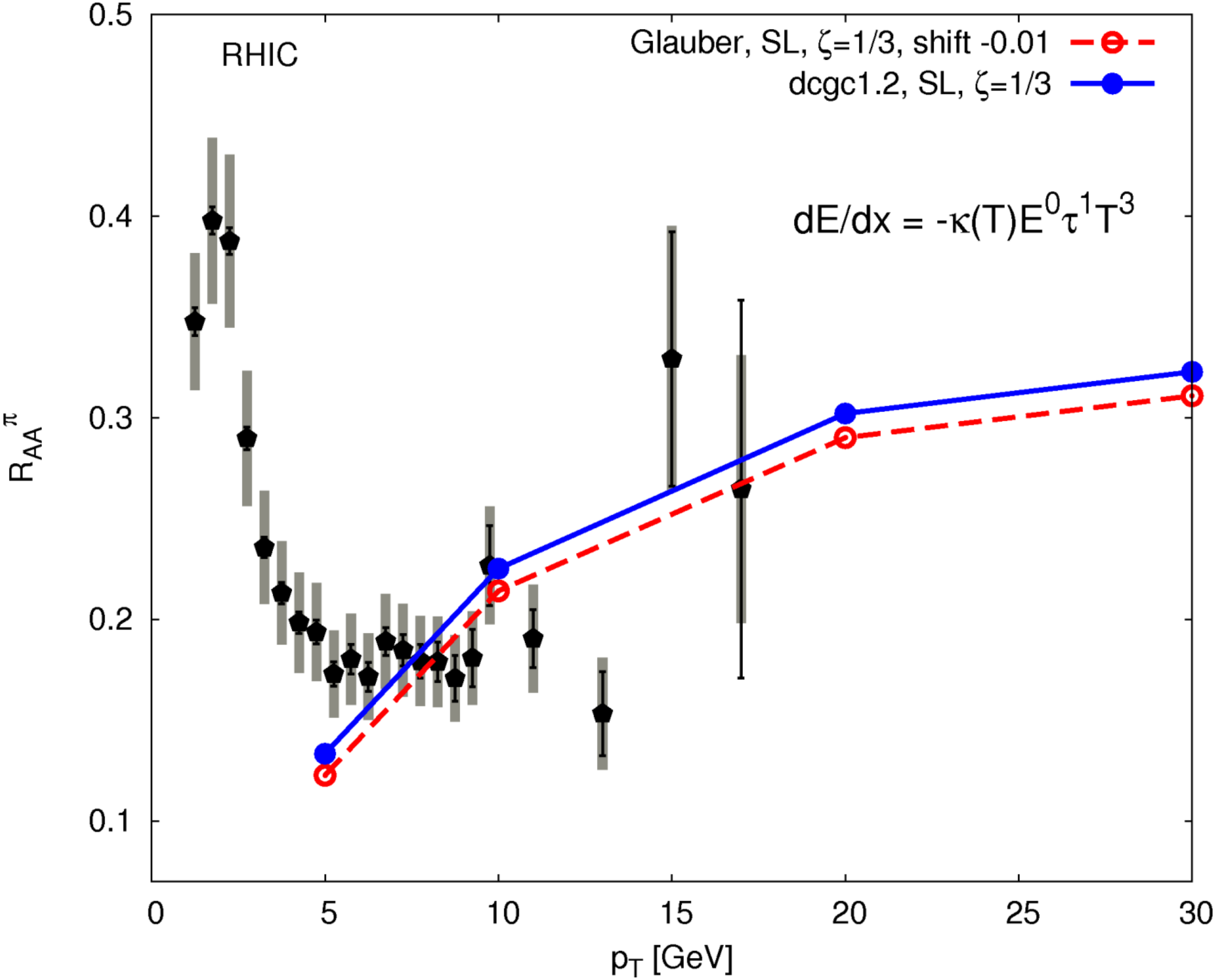
B.Betz et al., in preparation



$R_{AA}(p_T)$ at RHIC, LS model

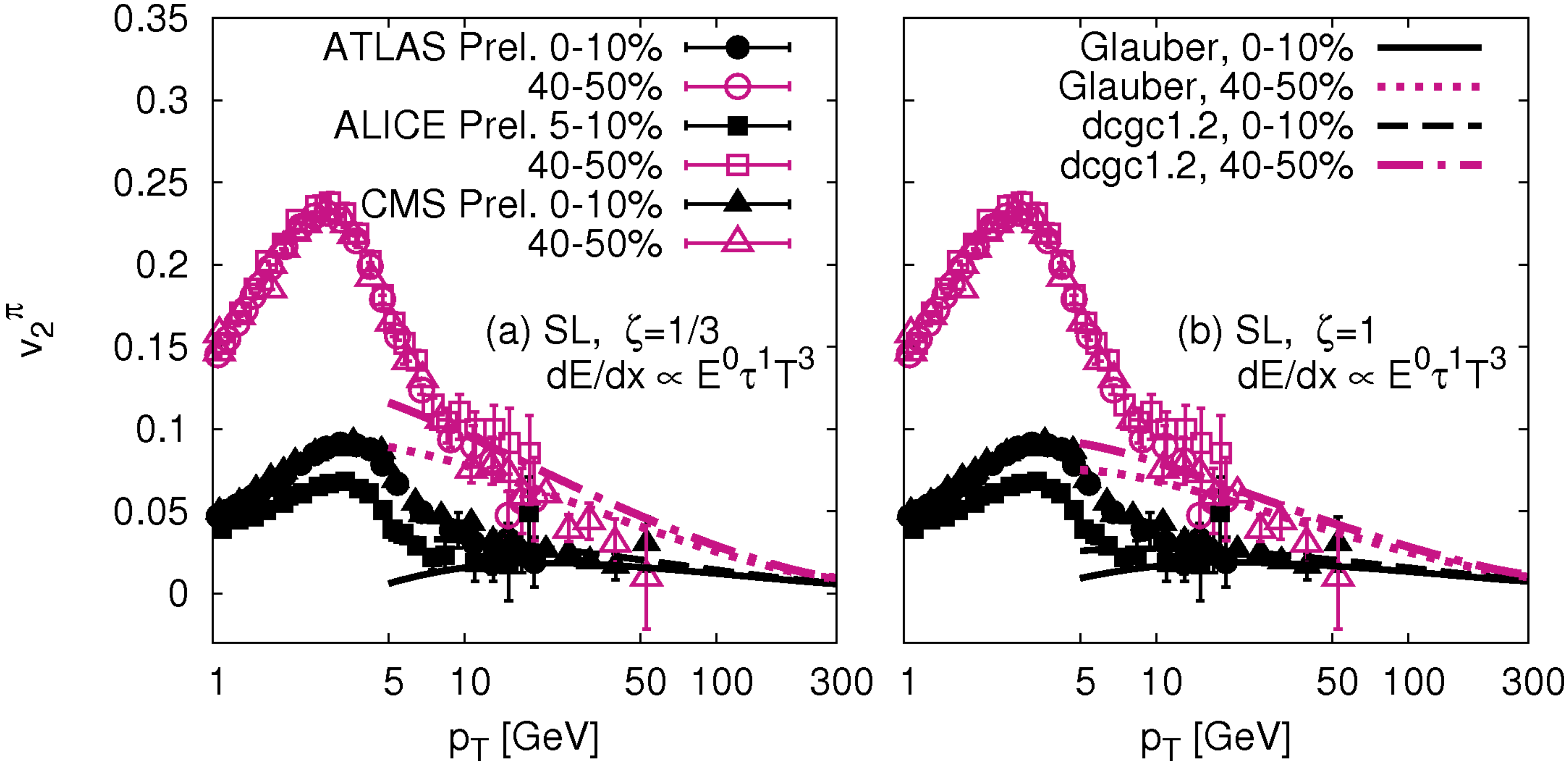
B.Betz et al., in preparation

ζ=1/3 scenario consistent with RHIC data on $R_{AA}(p_T)$



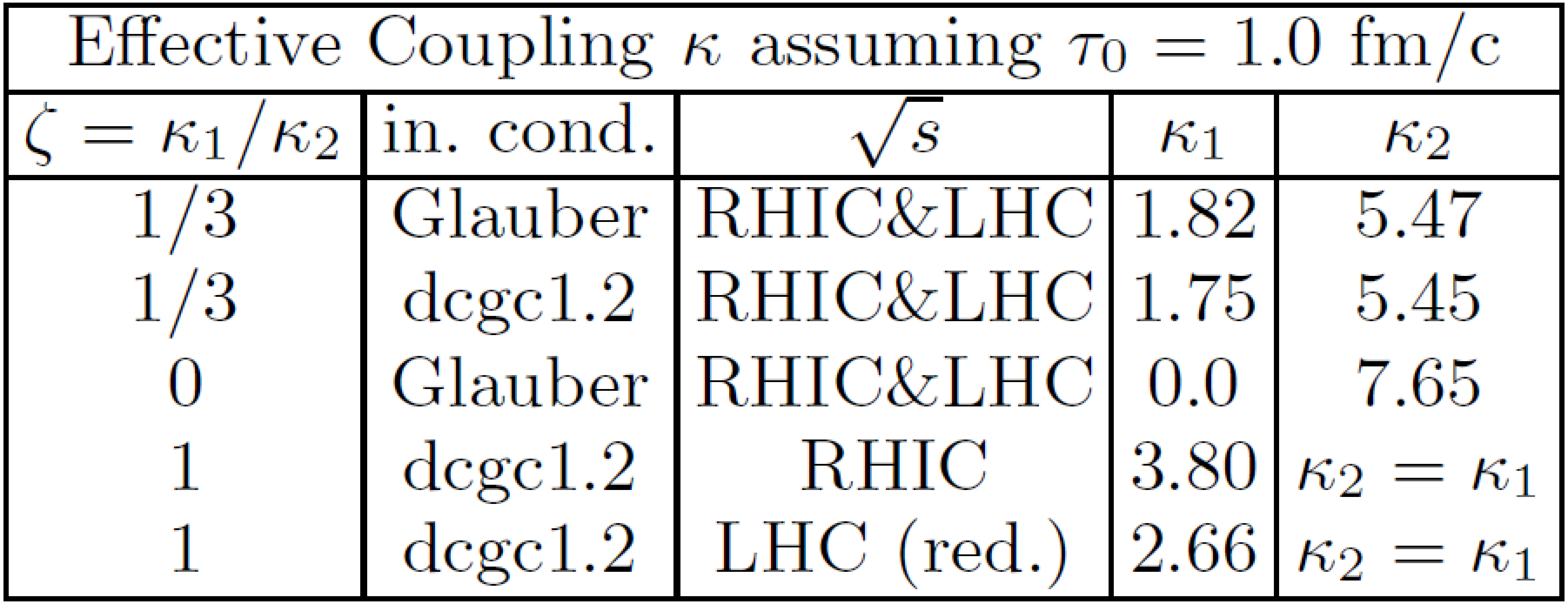
$v_2(p_T$, Centrality) at LHC, LS model

B.Betz et al., in preparation



Small difference between ζ=1/3 and ζ=1

Effective Coupling in the LS Model



Effective Coupling κ assuming $\tau_0 = 1.0$ fm/c

$\zeta = \kappa_1/\kappa_2$	in. cond.	$\sqrt{s}$	κ_1	κ_2
1/3	Glauber	RHIC&LHC	1.82	5.47
1/3	dcgc1.2	RHIC&LHC	1.75	5.45
0	Glauber	RHIC&LHC	0.0	7.65
1	dcgc1.2	RHIC	3.80	$\kappa_2 = \kappa_1$
1	dcgc1.2	LHC (red.)	2.66	$\kappa_2 = \kappa_1$

B.Betz et al., in preparation

The “Geometric Optics” Limit

For the generic energy-loss model

$$\frac{dP}{d\tau}(\vec{x}_0, \phi, \tau) = -\kappa P^a(\tau)\, \tau^z\, T^{c=2-a+z}[\vec{x}_\perp(\tau), \tau, b]$$

the initial parton momentum depends on the final parton momentum

$$P_0(P_f) = \left[P_f^{1-a} + K \int_{\tau_0}^{\tau_f} \tau^z T^c[\vec{x}_\perp(\tau), \tau] d\tau\right]^{\frac{1}{1-a}}, \quad K = (1-a)\kappa C_2$$

For a=1, this leads to a pure exponential dependence of the initial parton momentum

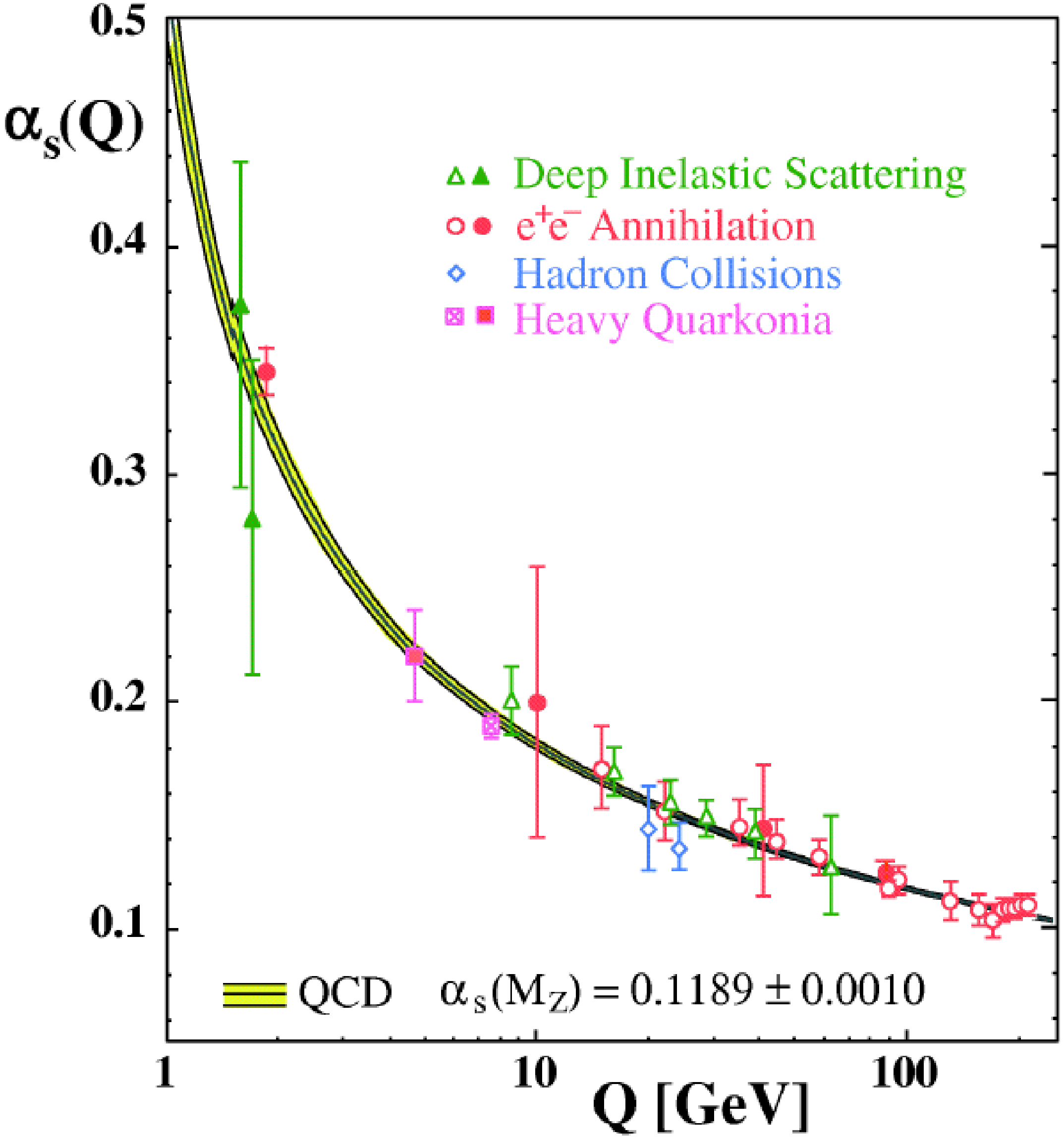
$$P_0(P_f) = P_f\, e^{\chi_{z,c}}$$

with the jet-energy independent effective opacity

$$\chi_{z,c}(\phi) = \kappa C_2 \int_{\tau_0}^{\tau_f} d\tau \tau^z T^c(\tau, \phi)$$

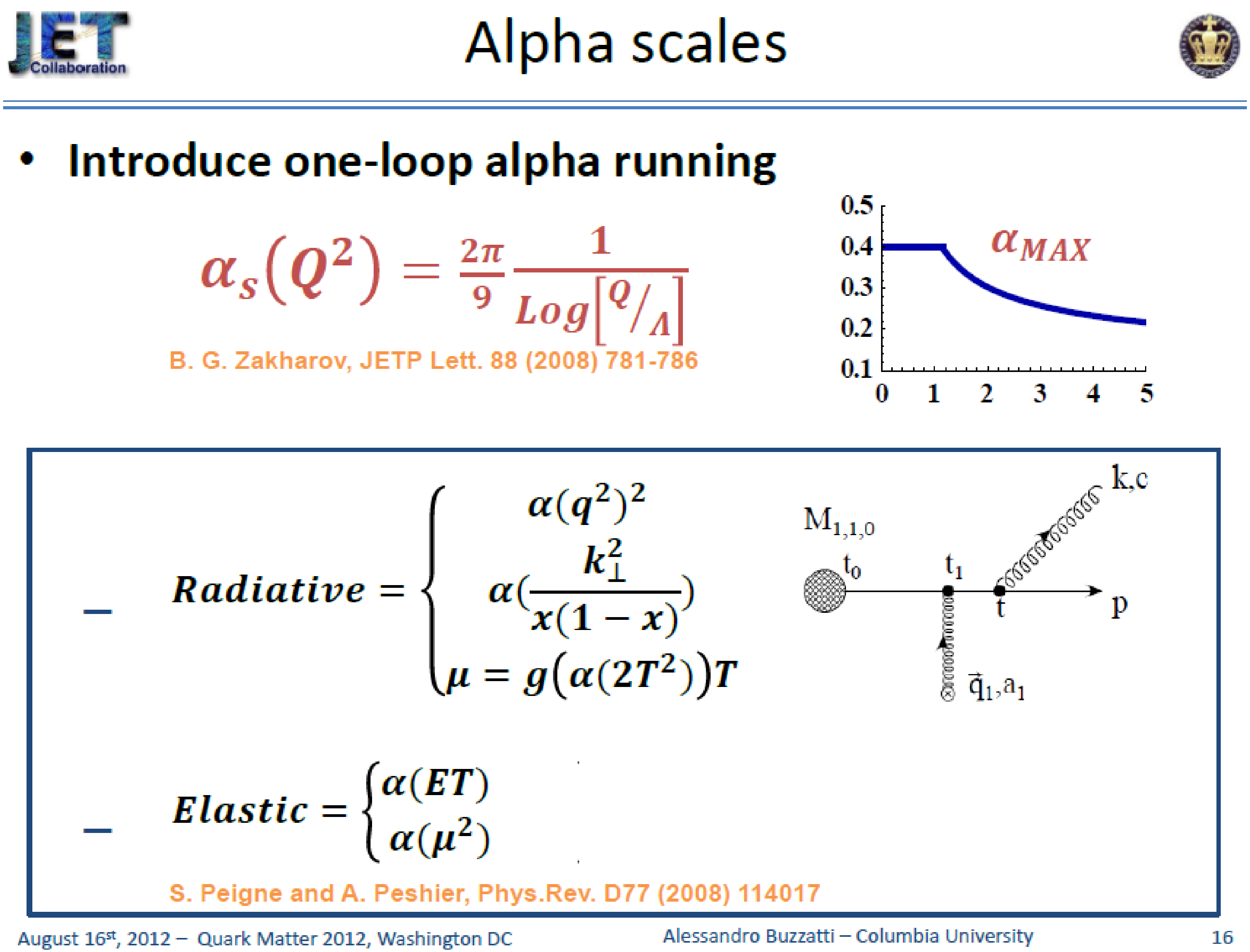
This corresponds to a generalized “geometric optics” limit.

The Running Coupling



S. Bethke, Prog. Part. Nucl. Phys. **58** (2007) 351

Running Coupling rc-CUJET



Alpha scales

- Introduce one-loop alpha running

$$\alpha_s(Q^2) = \frac{2\pi}{9}\frac{1}{Log\left[{}^{Q}/_{\Lambda}\right]}$$

B. G. Zakharov, JETP Lett. 88 (2008) 781-786

– $$Radiative = \begin{cases} \alpha(q^2)^2 \\ \alpha\left(\frac{k_\perp^2}{x(1-x)}\right) \\ \mu = g\left(\alpha(2T^2)\right)T \end{cases}$$

– $$Elastic = \begin{cases} \alpha(ET) \\ \alpha(\mu^2) \end{cases}$$

S. Peigne and A. Peshier, Phys.Rev. D77 (2008) 114017

August 16st, 2012 – Quark Matter 2012, Washington DC
Alessandro Buzzatti – Columbia University
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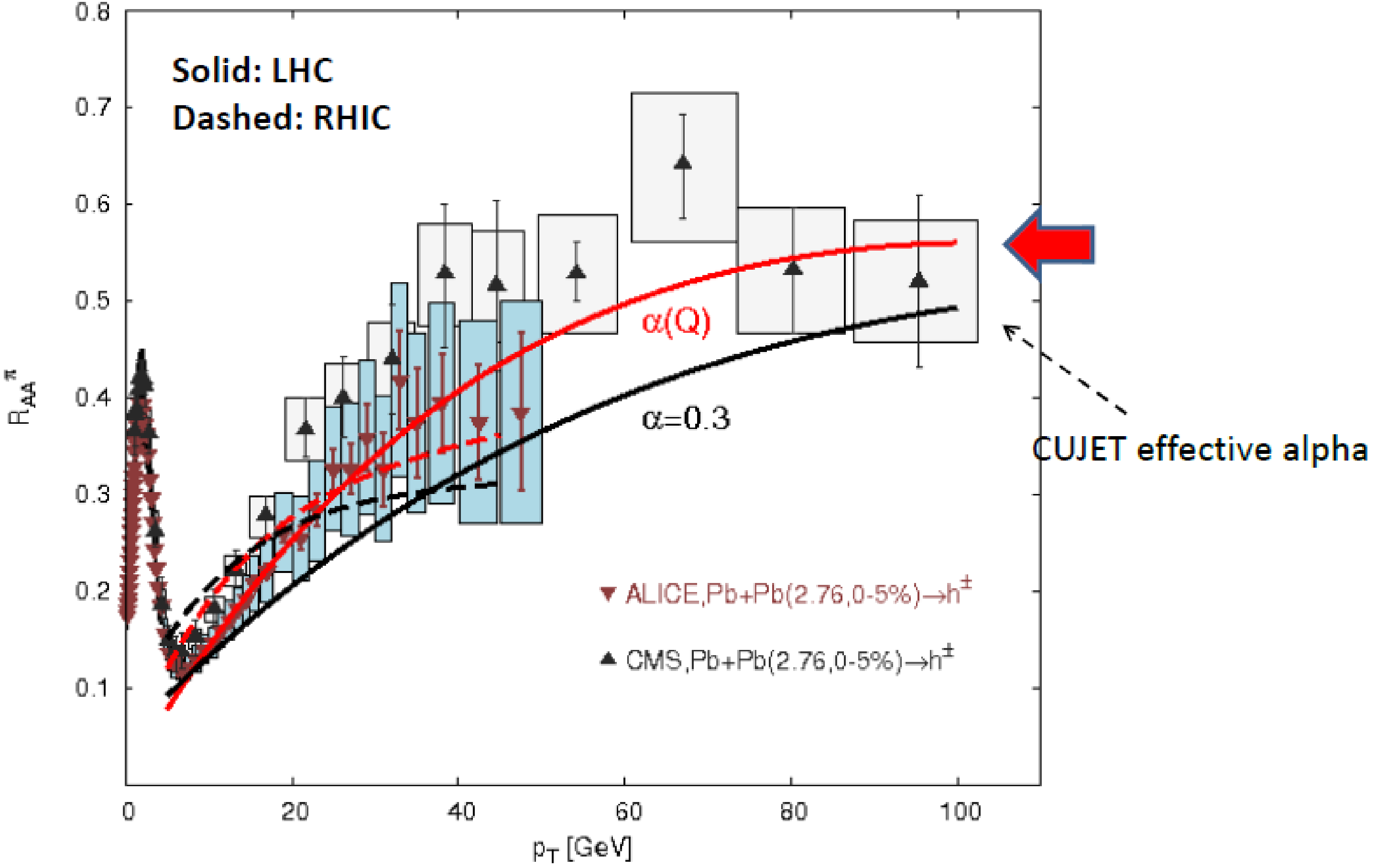
Running Coupling rc-CUJET

LHC Pions

See also B. Betz and M. Gyulassy, arXiv:1201.02181



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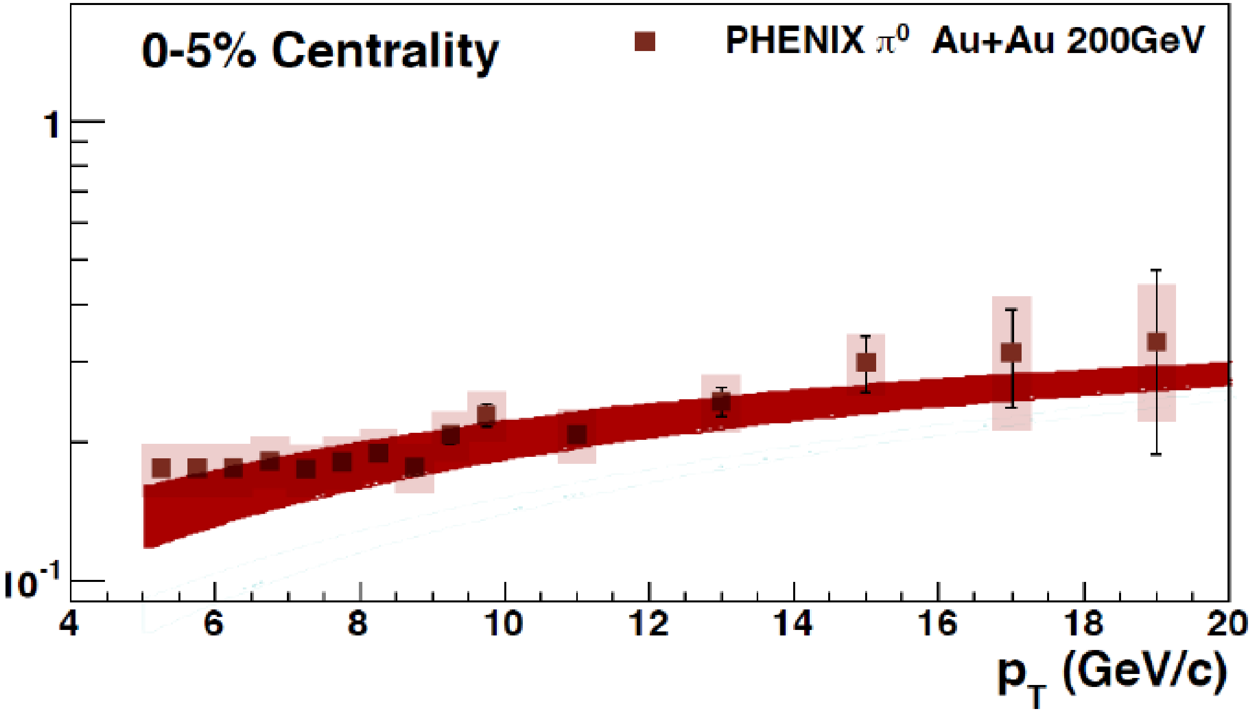
Running Coupling rc-CUJET

PHENIX Pions

PHENIX Collaboration



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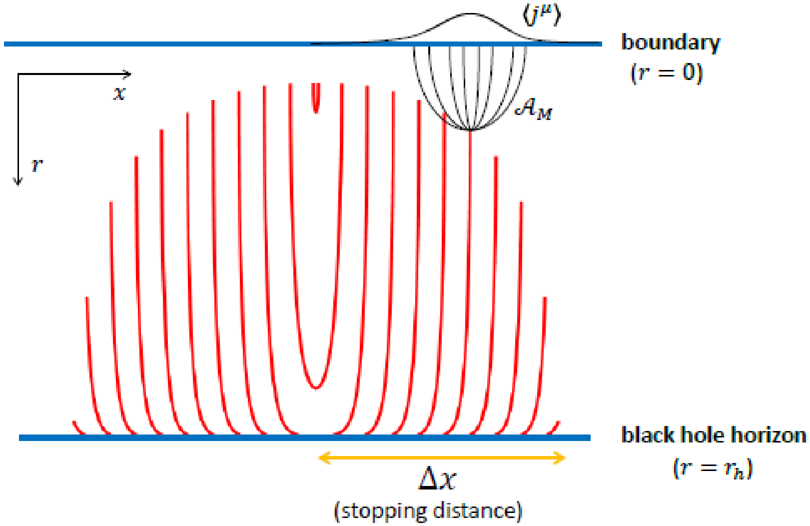
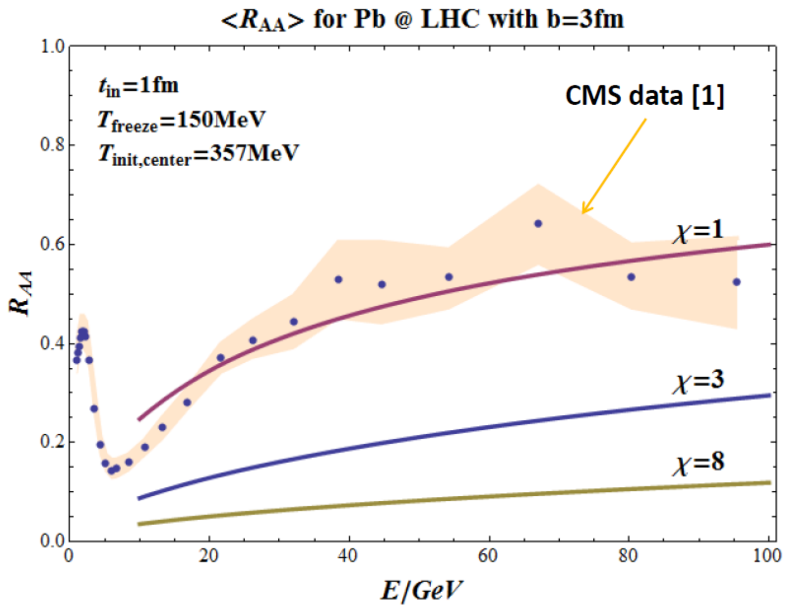
Falling String Scenario

Light quarks in AdS/CFT

Dressed quarks of mass m_Q are dual to strings in the bulk with one or both endpoints on the D7-brane spanning from $r = 0$ (boundary) to some $r_m \sim 1/m_Q$ and physics of the energy loss of these quarks is related to the dynamics of their dual strings. For light quarks, the D7-brane fills the entire *AdS-BH* geometry and a way to study their energy loss is to investigate the free motion of the strings that have both of their endpoints on the D7-brane (representing dressed $q\bar{q}$ pairs), the so-called falling strings [2].



A. Ficnar, QM'12 Poster



Using $\kappa \approx 0.5$ [2] and an unphysically small $\lambda = 1$, we obtain a minimal value of $\chi \approx 8$. Such a high value of χ gives an R_{AA} of a rather low magnitude, indicating strong quenching. Using even lower values of χ, we see that R_{AA} actually has the correct qualitative behavior as displayed by the LHC data [1]. This suggests that the main problem here could be simply in the magnitude of the quenching.

Falling String Scenario

A. Ficnar, arXiv: 1201.1780

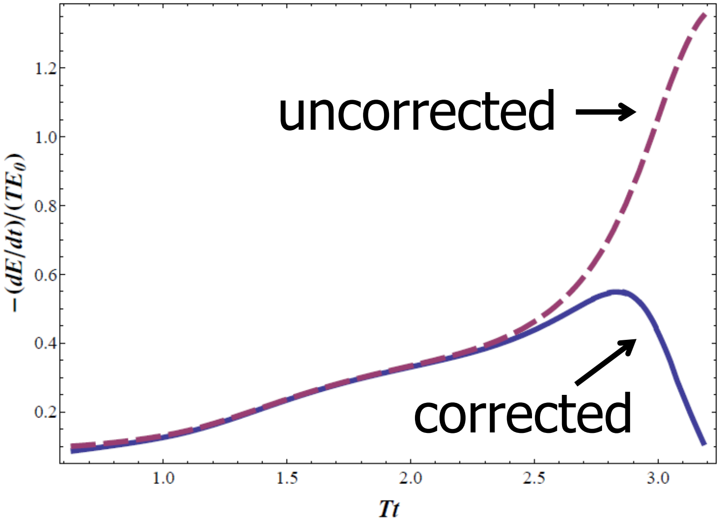
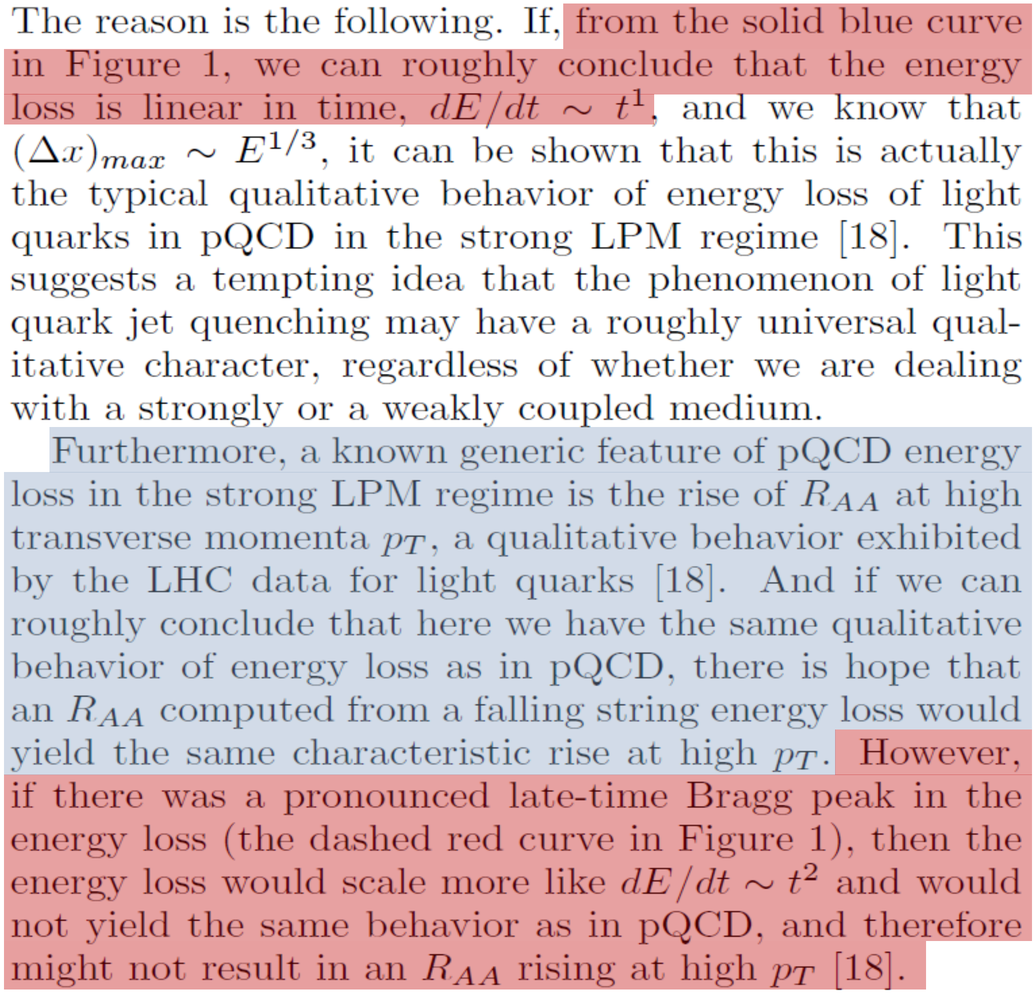


FIG. 1. Comparison of the (normalized) instantaneous energy loss as a function of time with and without the correction in (4.8). The dashed red curve shows the (uncorrected) dp_0/dt in the radial $\sigma = r$ parametrization, while the solid blue curve is the actual energy loss $d\tilde{p}_0/dt$, as given by (4.8). The energy loss was evaluated at points at a fixed spatial distance from the string endpoint, chosen in such a way that the correction in (4.8) appears clearly. The normalization constant E_0 is the energy of half of the string and $T = 1/(\pi r_h)$ is the temperature. The numerical parameters used are $r_h = 1$, $A = 50$ and $r_c = 0.1$.



The reason is the following. If, from the solid blue curve in Figure 1, we can roughly conclude that the energy loss is linear in time, $dE/dt \sim t^1$, and we know that $(\Delta x)_{max} \sim E^{1/3}$, it can be shown that this is actually the typical qualitative behavior of energy loss of light quarks in pQCD in the strong LPM regime [18]. This suggests a tempting idea that the phenomenon of light quark jet quenching may have a roughly universal qualitative character, regardless of whether we are dealing with a strongly or a weakly coupled medium.

Furthermore, a known generic feature of pQCD energy loss in the strong LPM regime is the rise of R_{AA} at high transverse momenta p_T, a qualitative behavior exhibited by the LHC data for light quarks [18]. And if we can roughly conclude that here we have the same qualitative behavior of energy loss as in pQCD, there is hope that an R_{AA} computed from a falling string energy loss would yield the same characteristic rise at high p_T. However, if there was a pronounced late-time Bragg peak in the energy loss (the dashed red curve in Figure 1), then the energy loss would scale more like $dE/dt \sim t^2$ and would not yield the same behavior as in pQCD, and therefore might not result in an R_{AA} rising at high p_T [18].