The Open Jet v2 Problem @ RHIC and LHC

M. Gyulassy 6/17/14 JET @ UC Davis

1) **Tomography** with **CUJET2.0** = rcDGLV + VISH(2+1)
J. Xu, A.Buzzatti, M.G., arXiv:1402.2956 [hep-ph]

2) Generic tomography vs holography vs Tc enhanced dEdx
B. Betz, Mg2 arXiv:1404.6378 [hep-ph]

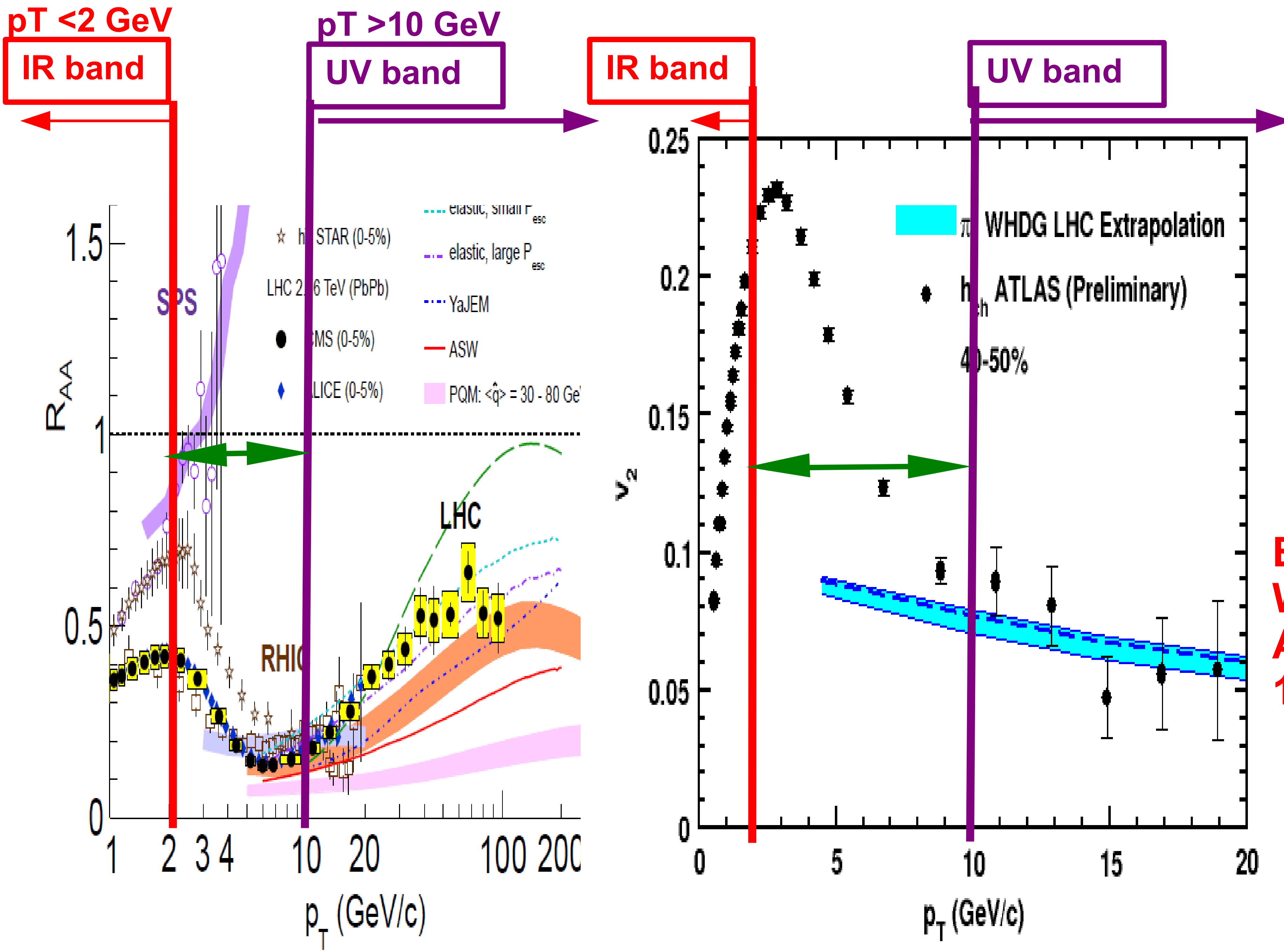
Multiple *non-standard* solutions to RAA vs v2 correlations

Collabs: Barbara Betz, Alessandro Buzzatti, Andrej Ficnar, Steven Gubser, Jorge Noronha, Giorgio Torrieri, Jiechen Xu. (Djordjevic, Horowitz, Wicks, Levai, Vitev)

Our JET v2 Albatross

Could this really be an Opportunity
to observe experimentally Tc ??)

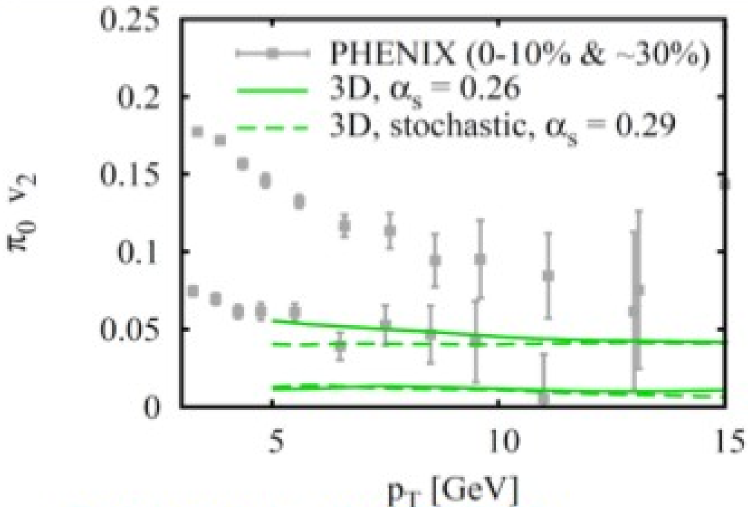
"The Big Picture" of Jet Quenching Observbles from SPS to LHC



Beware WHDG Assumed 1+1D

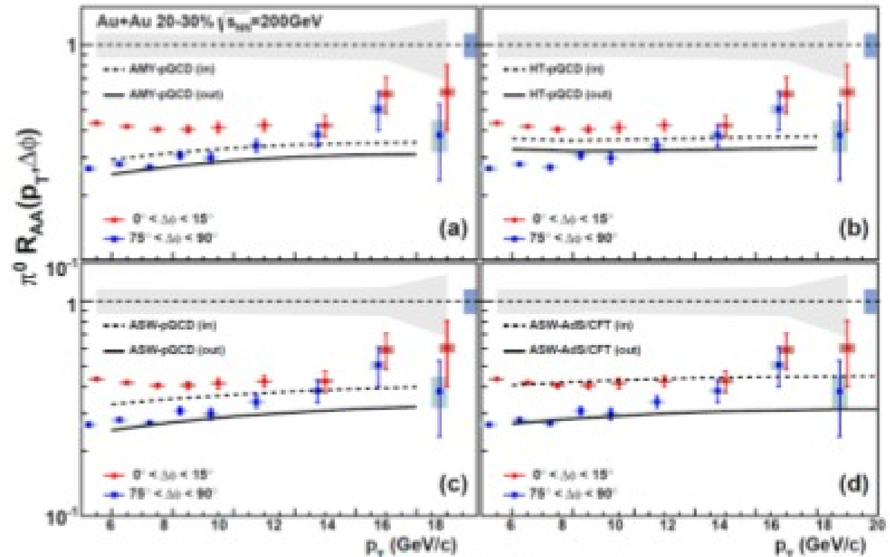
The main open problem that JET collab quantified was that in 2+1D viscous hydro/transport v2 is reduces by ~ ½ below data

The OPEN jet v2 Problem ! This should be JET collab's highest priority

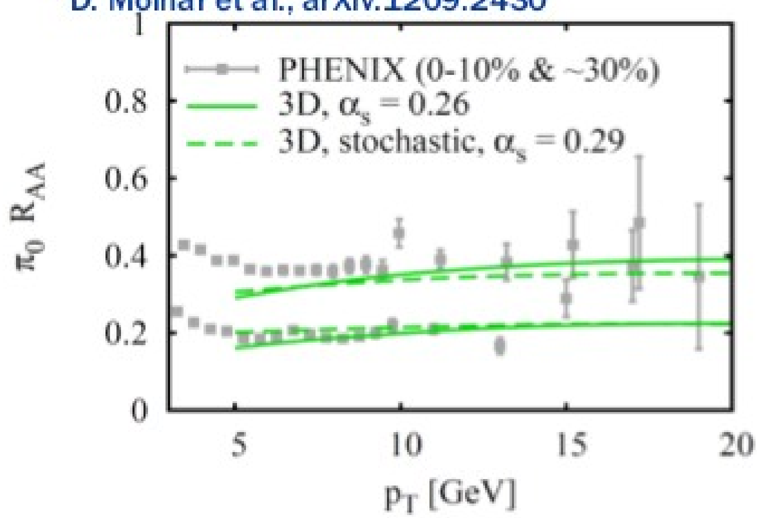


D. Molnar et al., arXiv:1209.2430

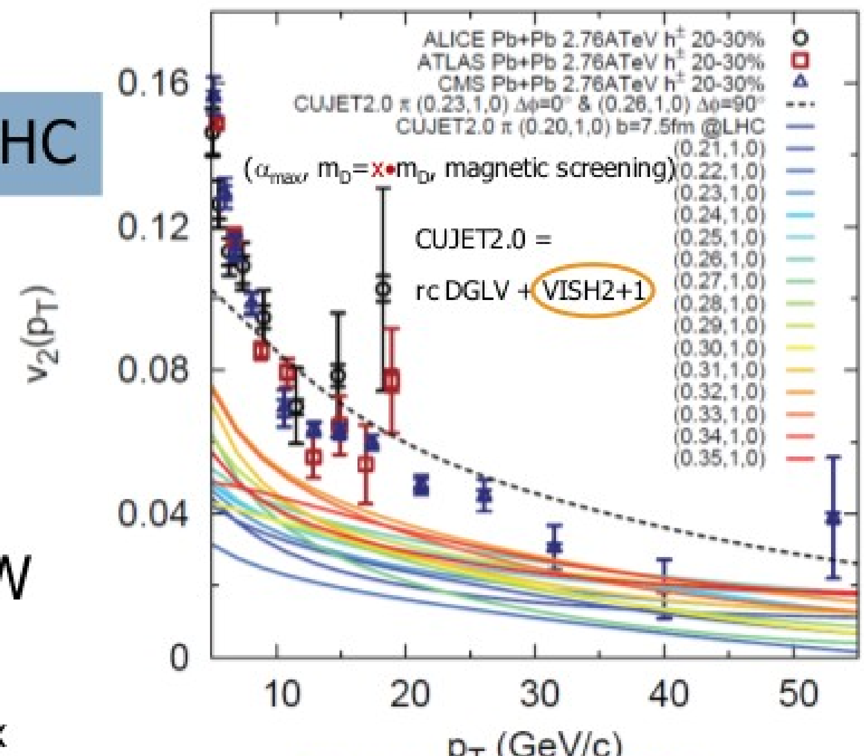
RHIC



A. Adare et al., PRC **87**, 034911 (2013)



LHC



J. Xu et al., arXiv:1402.2956

- High-p_T v_2 is about a factor of 2 too small for D. Molnar, AMY, HT, and ASW
- Yield of CUJET2.0 v_2 depends on α_{max}

The 21st century RAA vs v2 analog of the old 20th century nuclear Binding vs Saturation Density "Coester Line"

W. A. Horowitz @ QM05:

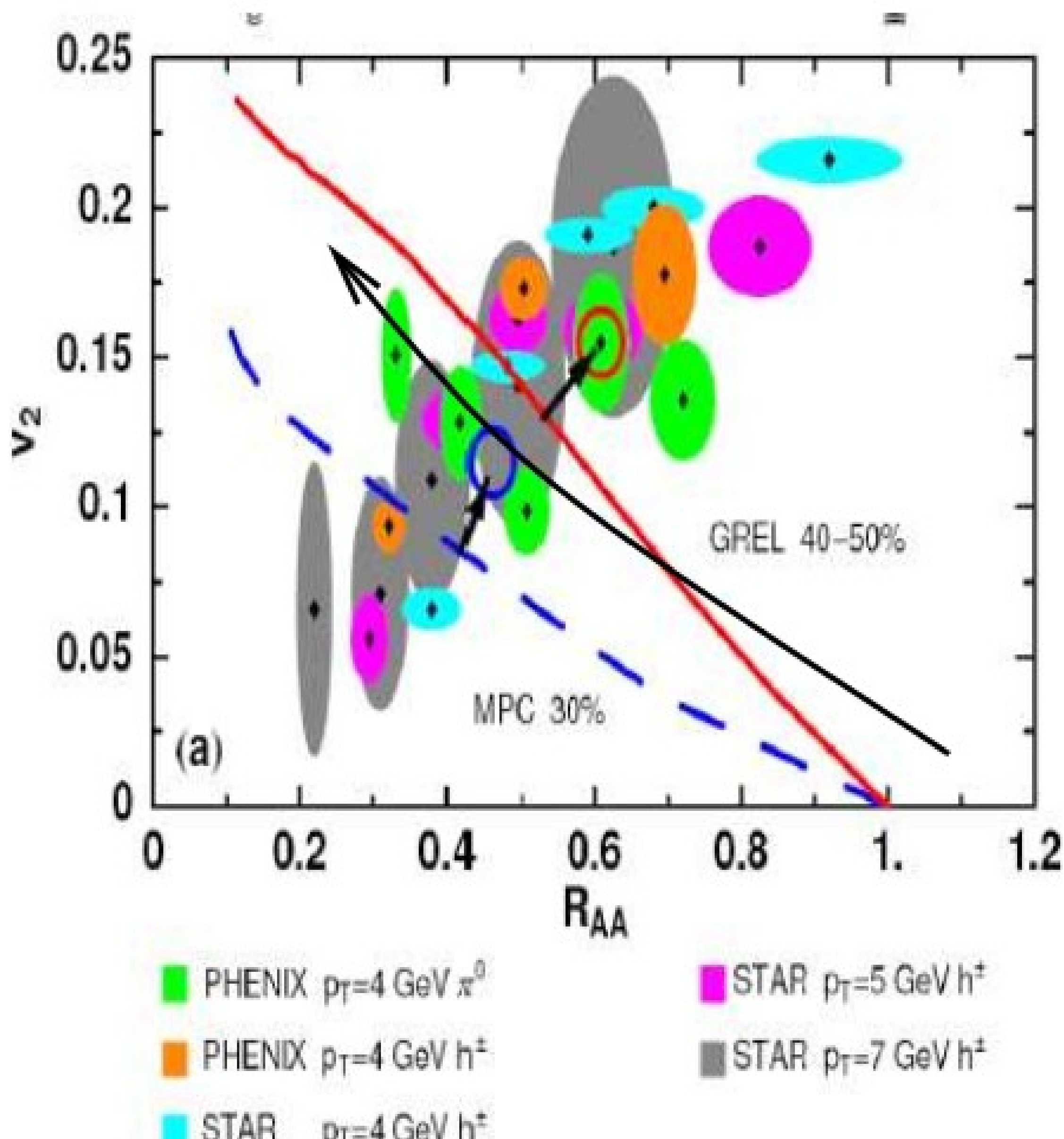
Molnar's parton cascade (MPC) succeeded in describing the low- and intermediate-p⊥ V2 results of RHIC by taking the parton elastic cross sections to be extreme, σt∼45 mb [5].

No single value of the jet medium coupling parameter in GREL or σt in MPC can simultaneously matche the experimental

RAA and v2

At the same time.

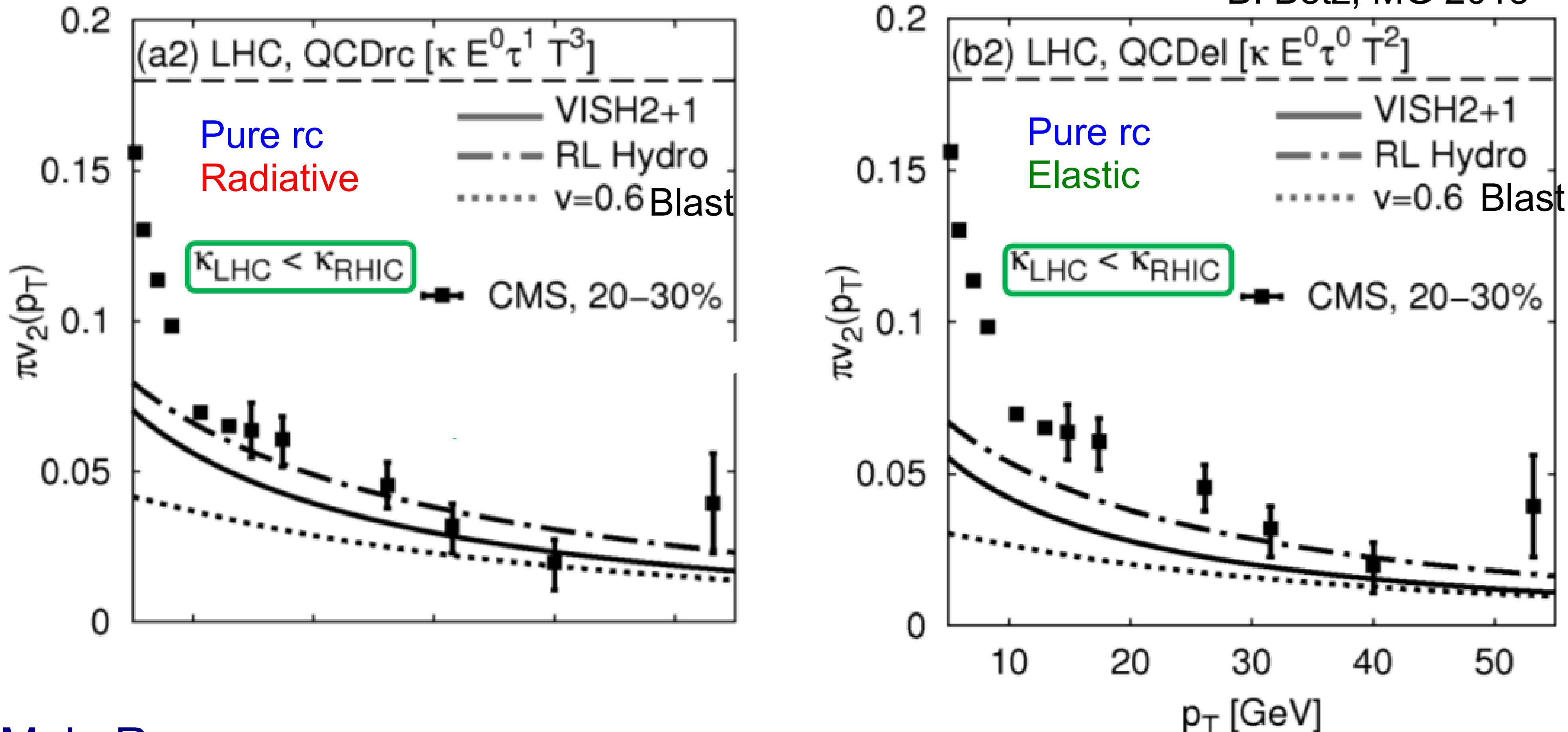
(GREL) = a simple geometric radiative energy loss model



Horowitz showed tat adding a 0.5 GeV "punch" or kick normal to QGP freezeout surface Could "post-dict" the RAA v2 correlation (consistent with Weierstrass)

What makes jet v2(pT) difficult to compute?

B. Betz, MG 2013



Main Reason:

v2 Jet ≈ ½ (dE/dx Model) + ½ (spacetime bulk hydro 2+1D flow) ← [Renk's (Di)Lemma"]

Depends on the complex interplay between *all details* of microscopic pT>10 jet dE/dx

And *all details* of the spacetime evolution of the bulk soft pT<2 GeV sQGP (I.C., η/s, t_π)

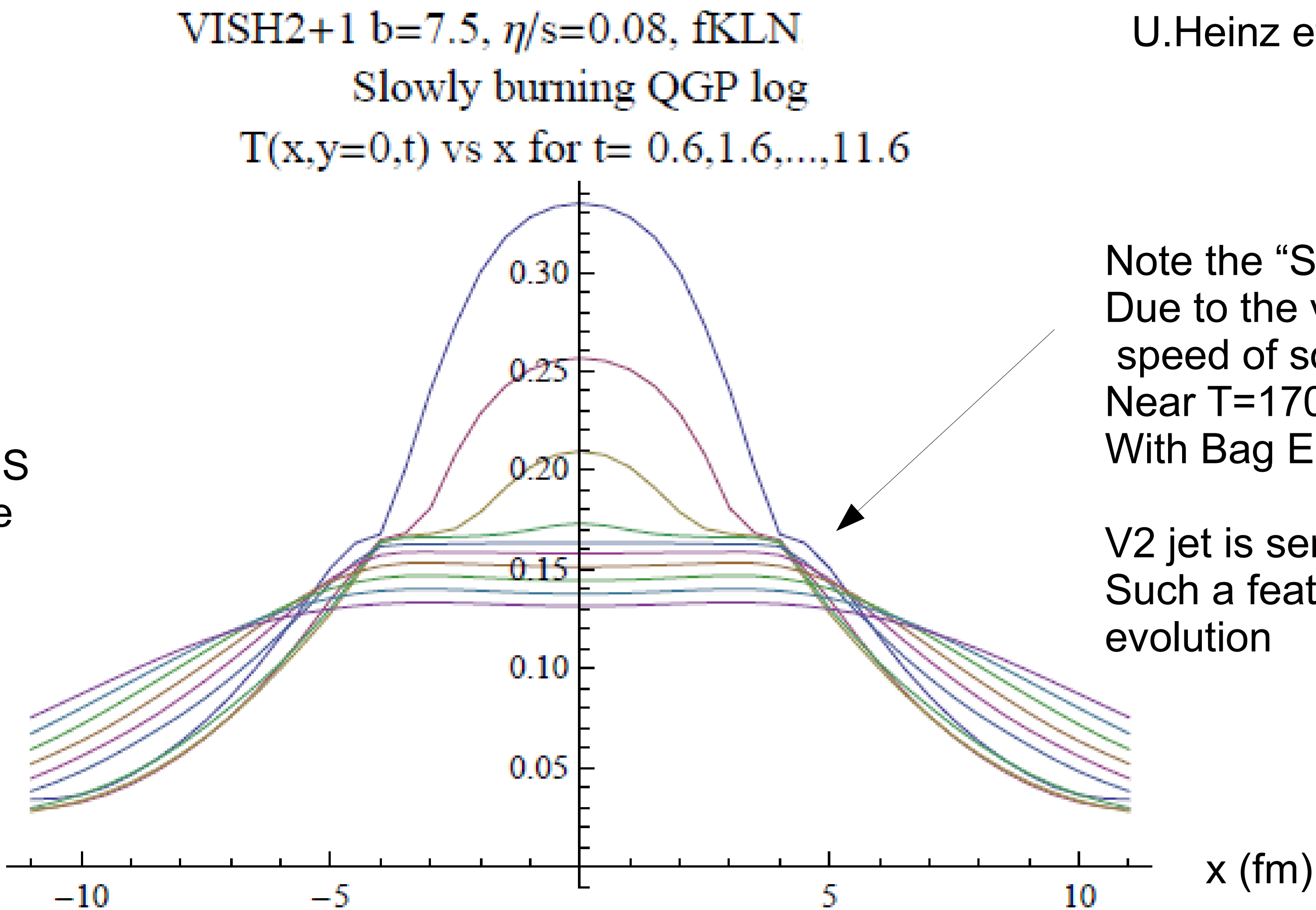
Azimuthal averaged RAA is much less sensitive to this Hard+Soft convolution

CUJET2.0 couples rcDGLV to Bj + 2D transverse expanding QGP fluid fields (T(x,t),v(x,t))

One of many Bulk Hydro Examples :

- **VISH2 + 1 with eta = 0.08 ideal fluid results for RHIC b = 7 fm**

U.Heinz et al



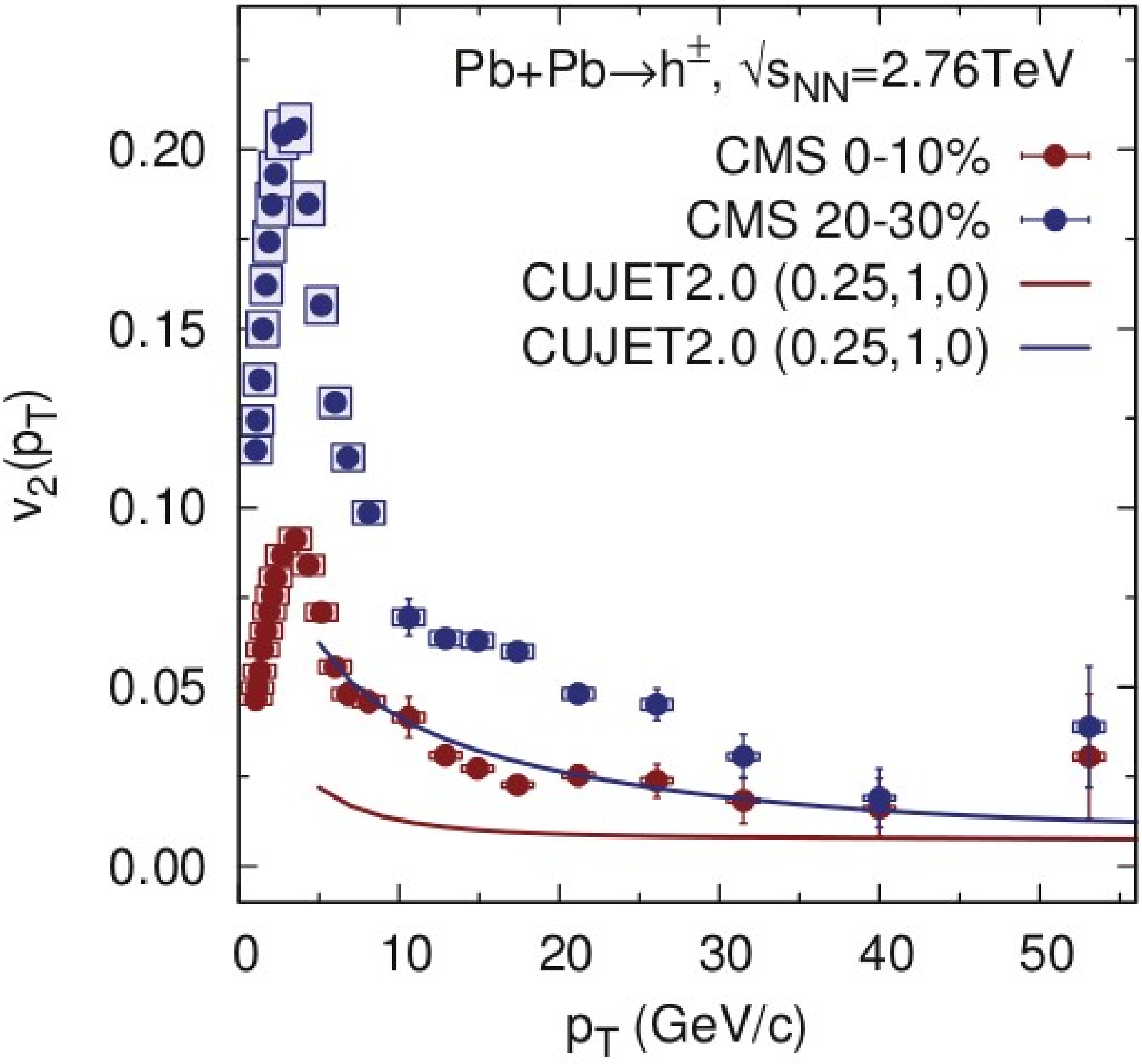
Bag EOS example

Note the "Stall"
Due to the vanishing speed of sound
Near T=170 MeV
With Bag EOS

V2 jet is sensitive to Such a feature of evolution

Note: Romatschke Luzum (RL) viscous hydro Thermal field evolution differ in detail

Truth in Lending Act: CUJET2.0 's current v2 Albatross obeys Renk's Lemma



Jiechen Xu, Alessandro Buzzatti, MG CUJET2.0
=DGLV+running coupling + viscous 2+1 hydro

1402.2956 [hep-ph]

$$
\begin{aligned}
x_E \frac{dN_g^{n=1}}{dx_E}(\mathbf{x}_0, \phi) = & \frac{18 C_R}{\pi^2} \frac{4+n_f}{16+9n_f} \int d\tau\, \rho(\mathbf{z}) \int d\mathbf{k} \int d\mathbf{q} \\
& \times \alpha_s\left(\frac{\mathbf{k}^2}{x_+(1-x_+)}\right) \\
& \times \frac{\alpha_s^2(\mathbf{q}^2)}{(\mathbf{q}^2 + f_E^2 \mu^2(\mathbf{z}))(\mathbf{q}^2 + f_M^2 \mu^2(\mathbf{z}))} \\
& \times \frac{-2(\mathbf{k}-\mathbf{q})}{(\mathbf{k}-\mathbf{q})^2 + \chi^2(\mathbf{z})} \left(\frac{\mathbf{k}}{\mathbf{k}^2 + \chi^2(\mathbf{z})} - \frac{(\mathbf{k}-\mathbf{q})}{(\mathbf{k}-\mathbf{q})^2 + \chi^2(\mathbf{z})} \right) \\
& \times \left(1 - \cos\left(\frac{(\mathbf{k}-\mathbf{q})^2 + \chi^2(\mathbf{z})}{2 x_+ E} \tau \right) \right) \\
& \times \left(\frac{x_E}{x_+} \right) J(x_+(x_E)) \ .
\end{aligned}
\tag{2.4}
$$

where C_R is the quadratic Casimir of the jet ($C_F = 4/3$ for quark jets, $C_A = 3$ for gluon jets); $\mathbf{z} = (x_0 + \tau\cos\phi, y_0 + \tau\sin\phi; \tau)$ is the path of the jet created at (x_0, y_0) in the production plane along azimuthal angle ϕ; $\rho(\mathbf{z})$ and $T(\mathbf{z})$ is the number density and temperature evolution profile of the medium; $\chi^2(\mathbf{z}) = M^2 x_+^2 + m_g^2(\mathbf{z})(1-x_+)$ controls the "dead cone" and Landau-Pomeranchuck-Migdal (LPM) destructive interference, squared gluon plasmon mass $m_g^2(\mathbf{z}) = f_E^2 \mu^2(\mathbf{z})/2$, HTL Debye mass $\mu(\mathbf{z}) = g(\mathbf{z})T(\mathbf{z})\sqrt{1+n_f/6}$, $g(\mathbf{z}) = \sqrt{4\pi\alpha\,(4T^2(\mathbf{z}))}$; integration limit $0 \leqslant |\mathbf{q}| \leqslant \min(|\mathbf{k}|, \sqrt{4\mathrm{ET}(\mathbf{z})})$, $0 \leqslant |\mathbf{k}| \leqslant x_E E$.

Infrared cutoff pQCD running coupling (in vacuum T=0)

$$\alpha_s \longrightarrow \alpha_s(Q^2) = \begin{cases} \alpha_{max} & \text{if } Q \le Q_{min} \,, \\ \dfrac{2\,\pi}{9\,\log(Q/\Lambda_{QCD})} & \text{if } Q > Q_{min} \,. \end{cases}$$

where the saturation scale Q_{min} is fixed by α_{max} as $Q_{min} = \Lambda_{QCD} \exp\left\{\frac{2\pi}{9\alpha_{max}}\right\}$

1. Two powers $\alpha_s^2(Q^2)$ clearly originate from the jet-medium interaction vertices from the exchanged transverse momentum $\mathbf{q}$, and so for these we simply take $Q_1^2 = \mathbf{q}^2$.

2. One power $\alpha_s(Q^2)$ originates from the radiated gluon vertex. The off-shellness in the intermediate quark propagator for one of the three amplitudes where the gluon is emitted after the scattering is

$$\boxed{Q_2^2 = q^2 - M^2 = \frac{\mathbf{k}^2}{x_+(1-x_+)} + \frac{x_+ M^2}{1-x_+} + \frac{m_g^2}{x_+}}\,. \tag{2.2}$$

3. Running thermal couplings can arise from the Debye mass $\mu(\alpha_s(Q^2);T)$ and plasmon mass. We allow these to run with scale $\boxed{Q_3^2 = (2T)^2}$

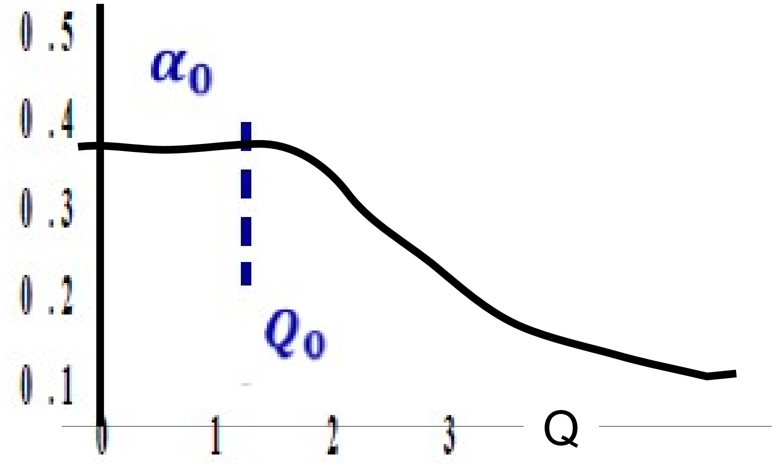
Note in the above choices of running scales there is no explicit dependence on the jet energy, which comes instead from the kinematic limits of the $\mathbf{q}$ and $\mathbf{k}$ integrations. $k_\perp^{MAX} = x_E E$ and $q_\perp^{MAX} = \sqrt{4ET}$.

Multi-scale running coupling

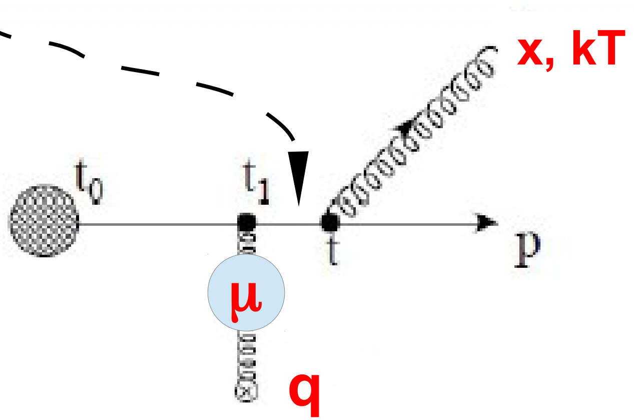
- Introduce one-loop alpha running

$$\alpha_s \to \alpha_s(Q^2)\begin{cases} \alpha_0 & if\ Q \le Q_0 \\ \dfrac{2\pi}{9\log(Q/\Lambda)} & if\ Q > Q_0 \end{cases}$$

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



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



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

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

CUJET2.0 running scales

$$
\begin{aligned}
x_E \frac{dN_g^{n=1}}{dx_E}(\mathbf{x}_0,\phi) = {} & \frac{18C_R}{\pi^2}\frac{4+n_f}{16+9n_f}\int d\tau\, \rho(\mathbf{z}) \int d\mathbf{k} \int d\mathbf{q} \\
& \times \boxed{\alpha_s\Big(\frac{\mathbf{k}^2}{x_+(1-x_+)}\Big)} \\
& \times \frac{\boxed{\alpha_s^2(\mathbf{q}^2)}}{(\mathbf{q}^2+f_E^2\mu^2(\mathbf{z}))(\mathbf{q}^2+f_M^2\mu^2(\mathbf{z}))} \\
& \times \frac{-2(\mathbf{k}-\mathbf{q})}{(\mathbf{k}-\mathbf{q})^2+\chi^2(\mathbf{z})}\left(\frac{\mathbf{k}}{\mathbf{k}^2+\boxed{\chi^2(\mathbf{z})}} - \frac{(\mathbf{k}-\mathbf{q})}{(\mathbf{k}-\mathbf{q})^2+\boxed{\chi^2(\mathbf{z})}}\right) \\
& \times \left(1-\cos\left(\frac{(\mathbf{k}-\mathbf{q})^2+\boxed{\chi^2(\mathbf{z})}}{2x_+E}\tau\right)\right) \\
& \times \left(\frac{x_E}{x_+}\right) J(x_+(x_E)) \ .
\end{aligned}
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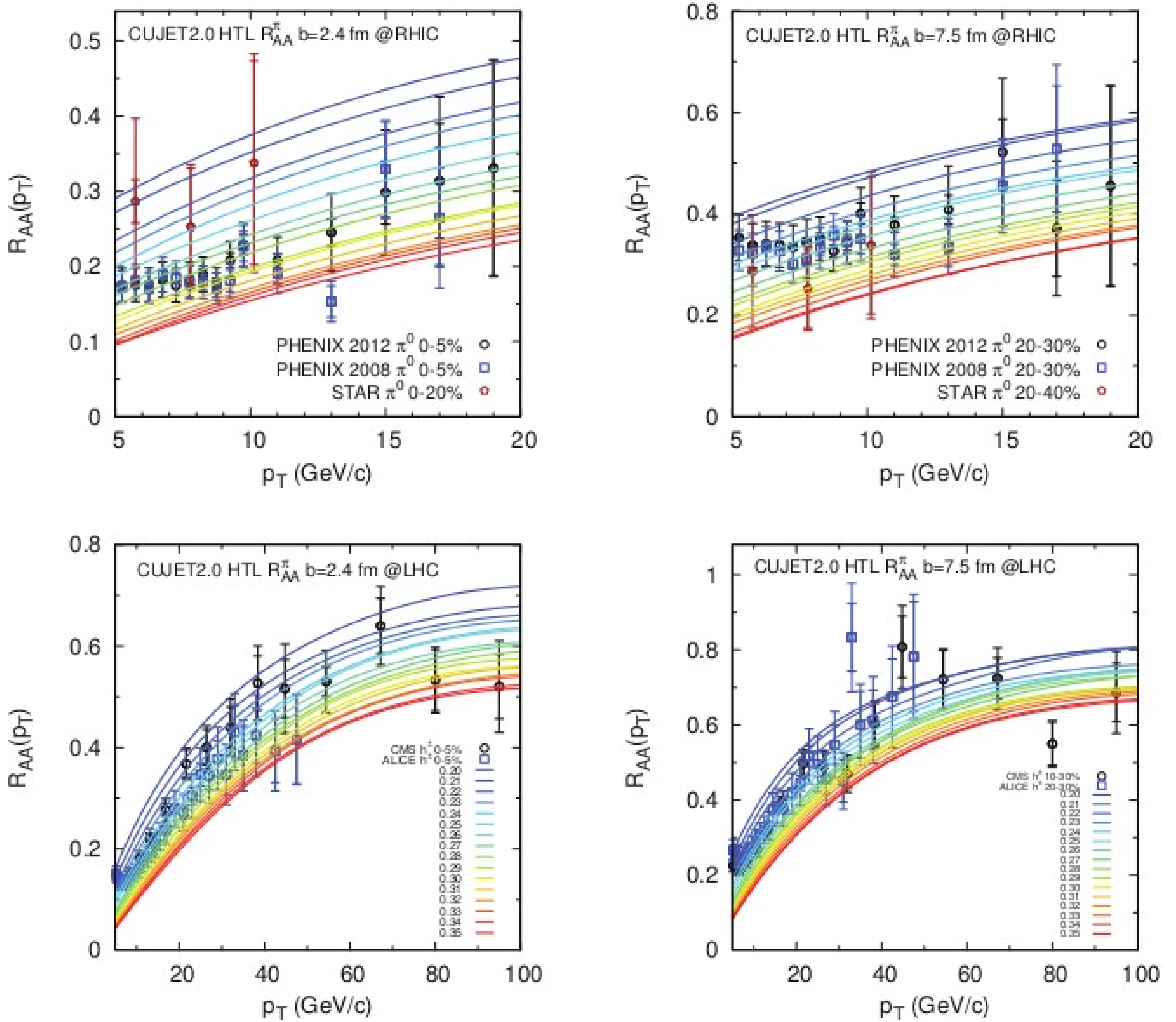
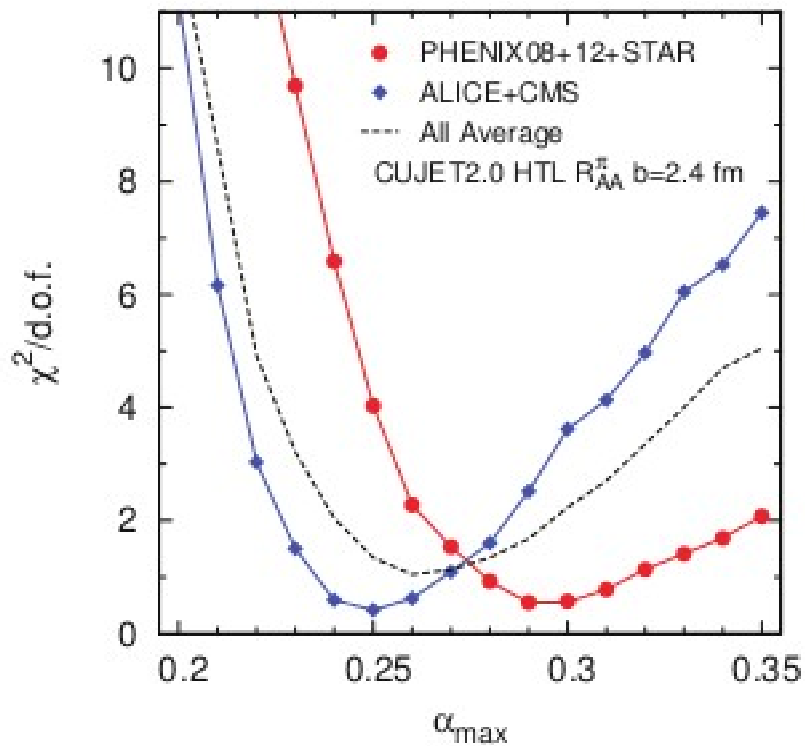
CUJET2.0

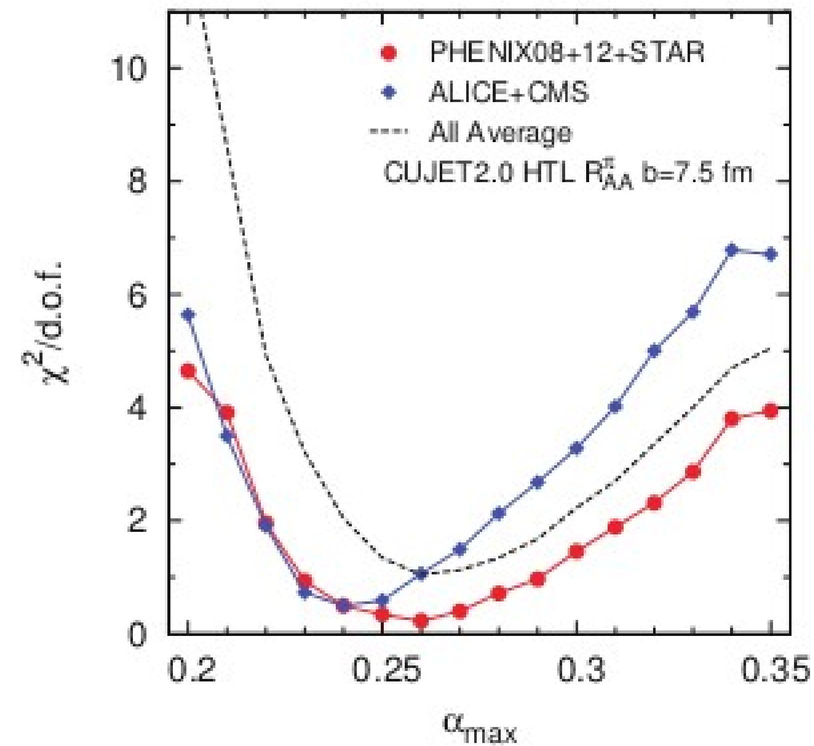
alf_max dependence



Evidence for moderate tempertaure dependence of alf_max(T)

From QGP temperature increase by ~ 2^(1/3) from RHIC to LHC





Weaker reduction for lower Temp peripheral AA

To compare to other JET models we cpompute the qhat(T, E) field as follows:

assumed homogeneous QCD medium as partonic quasi-particles, and the transport parameter $\hat{q}$ in CUJET2.0 is related to the effective partonic differential cross section by the relation:

$$\hat{q}(E,T;\alpha_{max},f_E,f_M) = \rho(T)\int_0^{4ET} d\mathbf{q}^2\mathbf{q}^2\frac{d\sigma_{\text{eff}}}{d\mathbf{q}^2}\ , \tag{3.3}$$

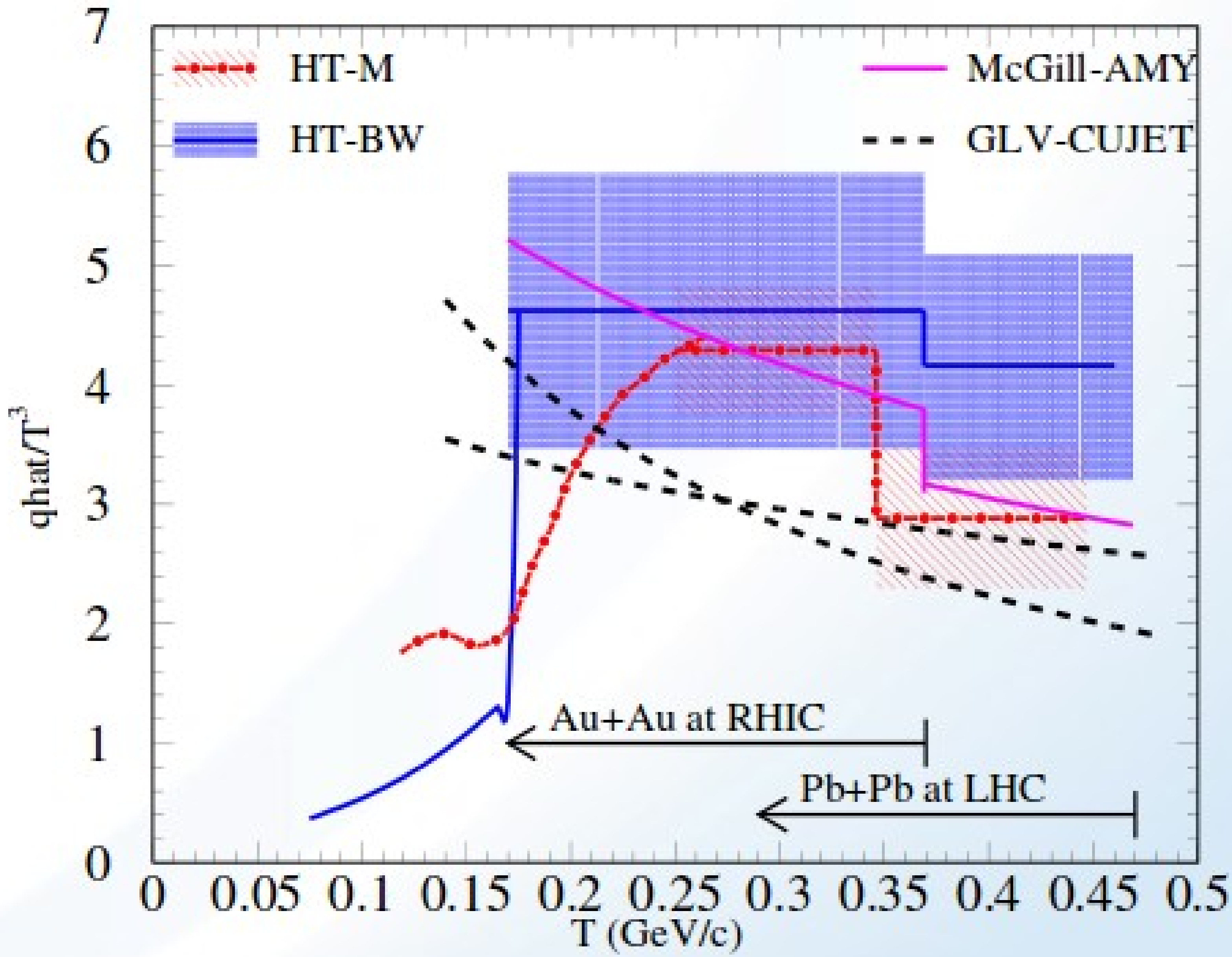
where the energy E and temperature T dependence comes in naturally from the partonic kinematics and plasma density. In CUJET2.0, $\hat{q}$ depends also on the maximum strong coupling constant α_{max}, as well as electric and magnetic screening mass deformation parameters (f_E, f_M), all of which originate from the effective cross section of the quark-gluon process:

$$\frac{d\sigma_{\text{eff}}}{d\mathbf{q}^2} = \frac{\boxed{\alpha_s^2(\mathbf{q}^2)}}{(\mathbf{q}^2+\boxed{f_E^2\mu^2(T)})(\mathbf{q}^2+\boxed{f_M^2\mu^2(T)})}, \tag{3.4}$$

with the Debye mass $\mu(T) = T\sqrt{4\pi\alpha_s(4T^2)(1+n_f/6)}$.

Comparison of JET Collab's present results qhat(T,E)

X.N.Wang et al



The qhat/T^3 field in CUJET2 is not a constant

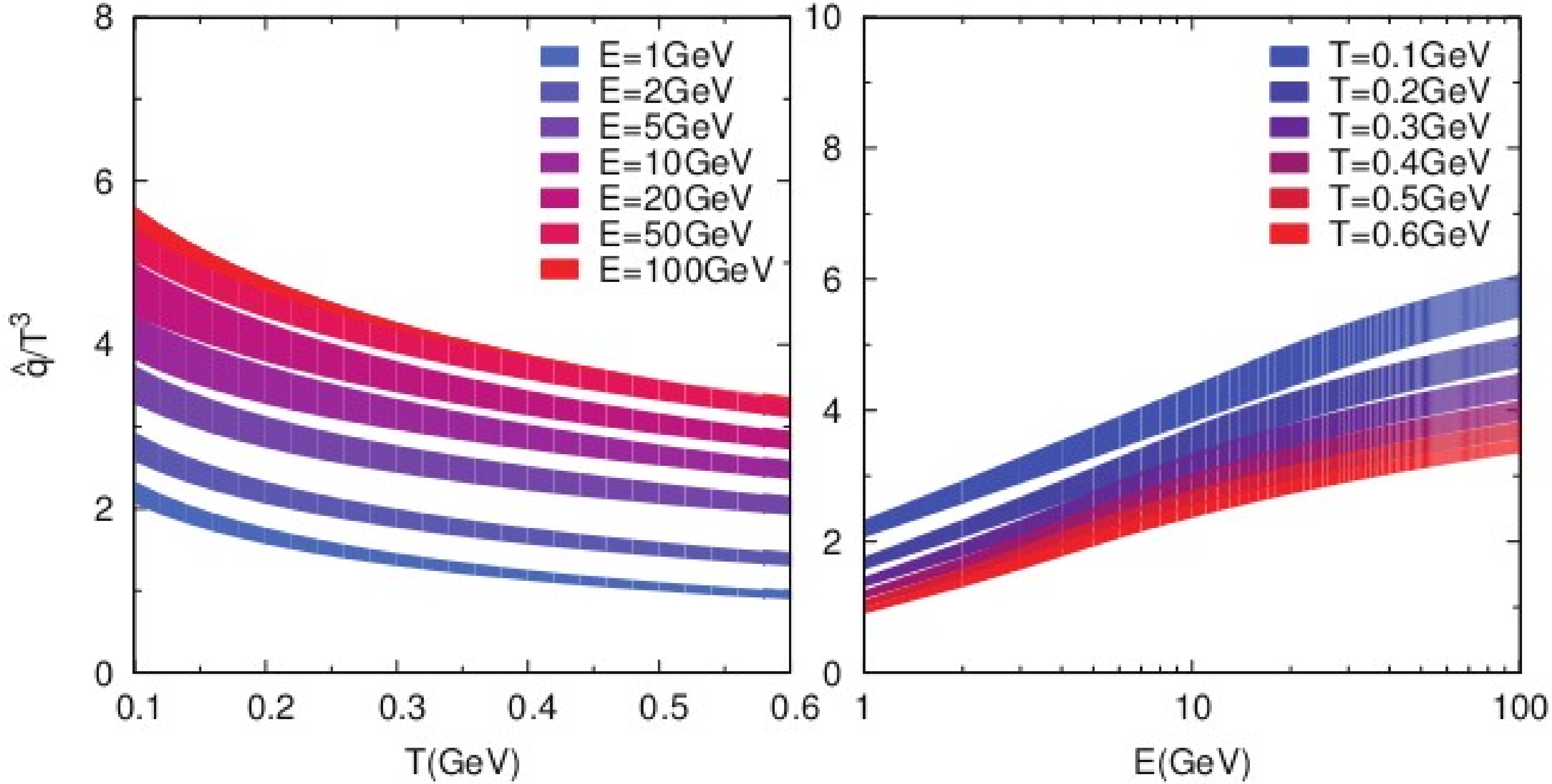
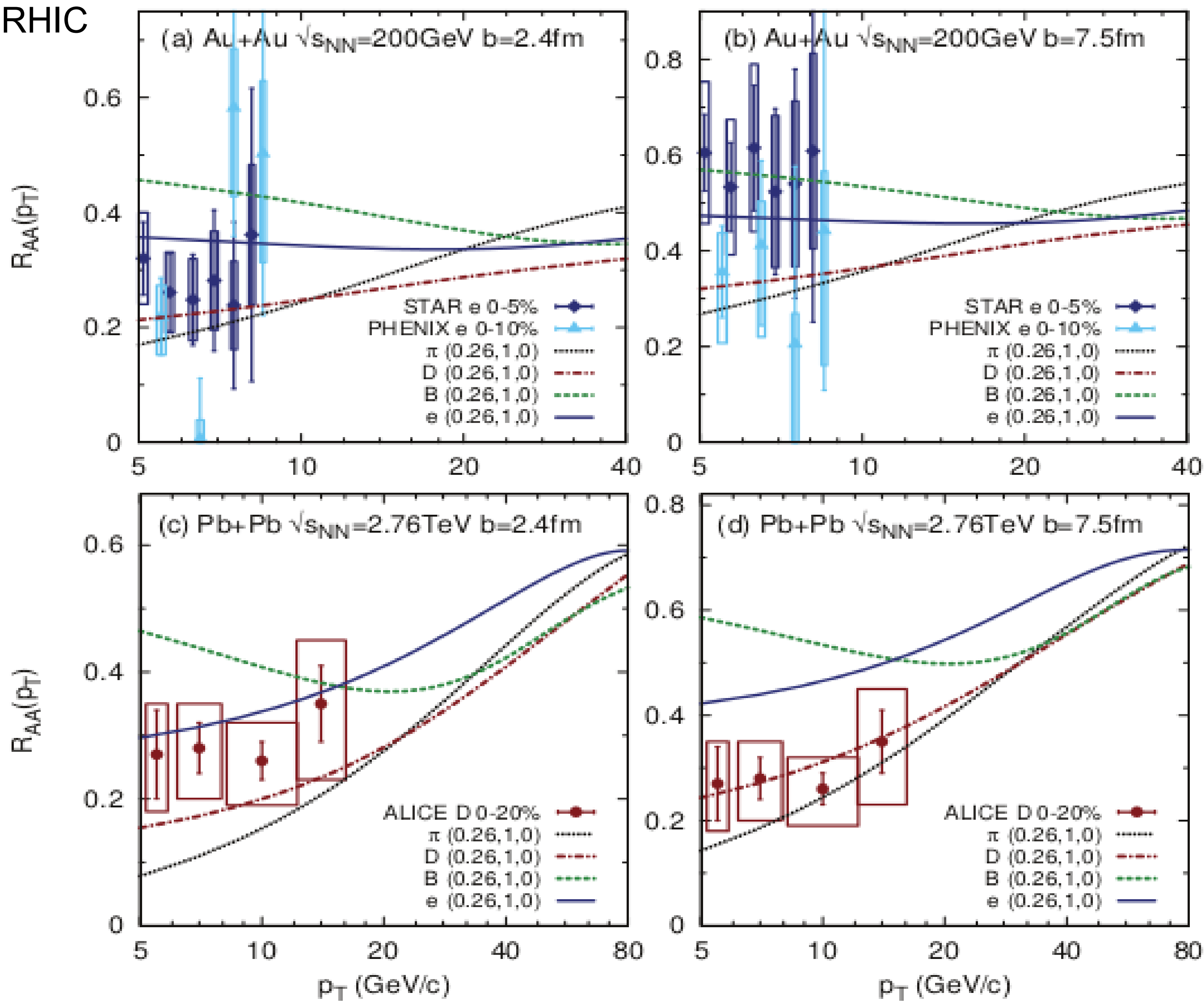


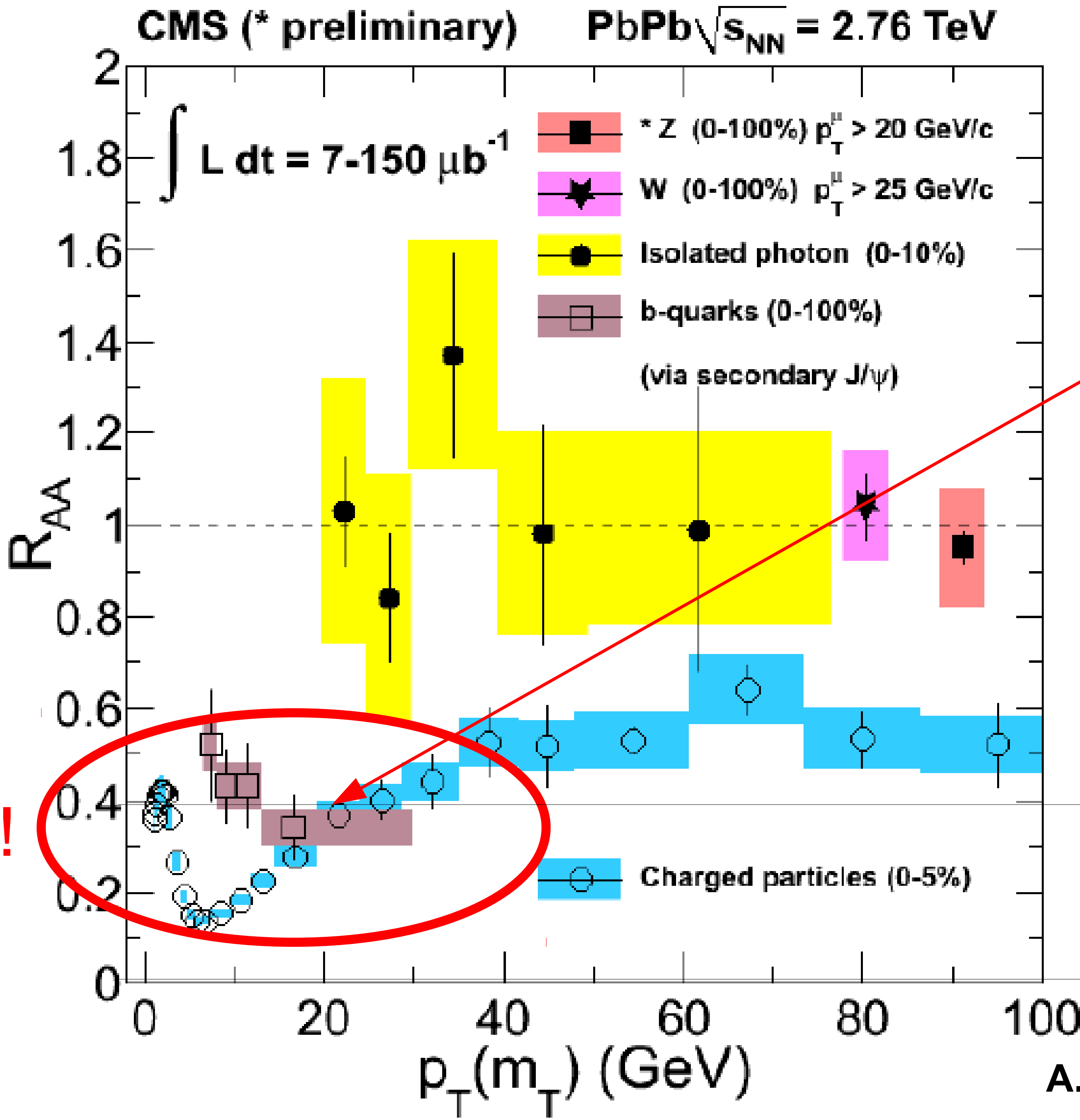
Figure 6. The absolute jet transport coefficient $\hat{q}/T^3$ calculated in CUJET2.0 according to Eq. (3.3)(3.4) with parameters $\alpha_{max} = 0.25 - 0.27, f_E = 1, f_M = 0$, which set of parameters generates consistent fits to neutral pion and charged hadron suppression factor R_{AA} at both RHIC and LHC both central and semi-peripheral A+A collisions. $\hat{q}/T^3$ versus QGP temperature T at fixed incoming jet energy E is plotted on the *left* panel; the *right* panel shows $\hat{q}/T^3$ versus E at fixed T. When E is fixed, the decrease of $\hat{q}/T^3$ with the increasing T follows approximately a logarithmic

Jet Flavor tomography
With CUJET2.0
Is consitent with
Non photonic e at RHIC
And
D meson at LHC



M Gyulassy JET

G.Roland QM12: First evidence for B quark quenching



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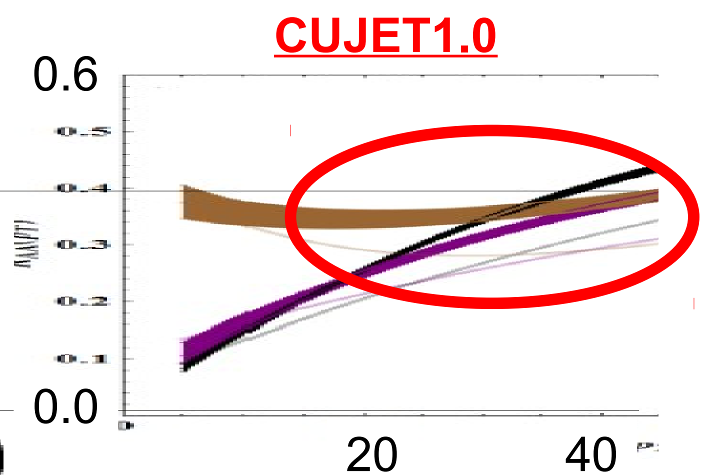
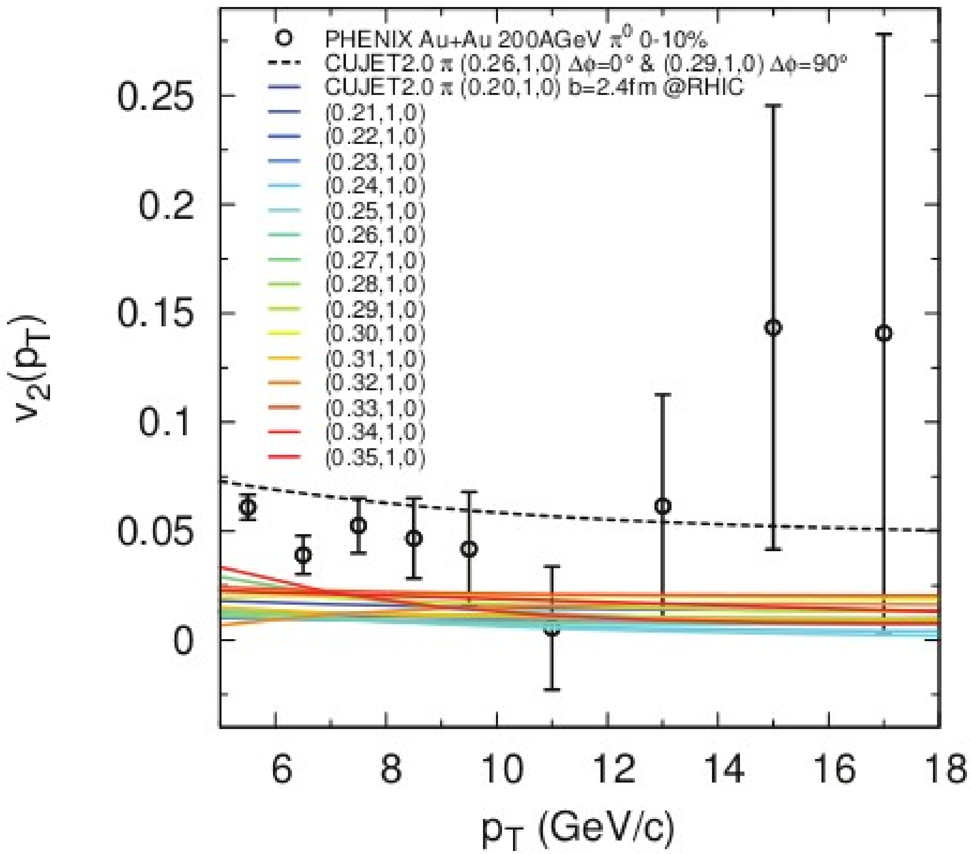
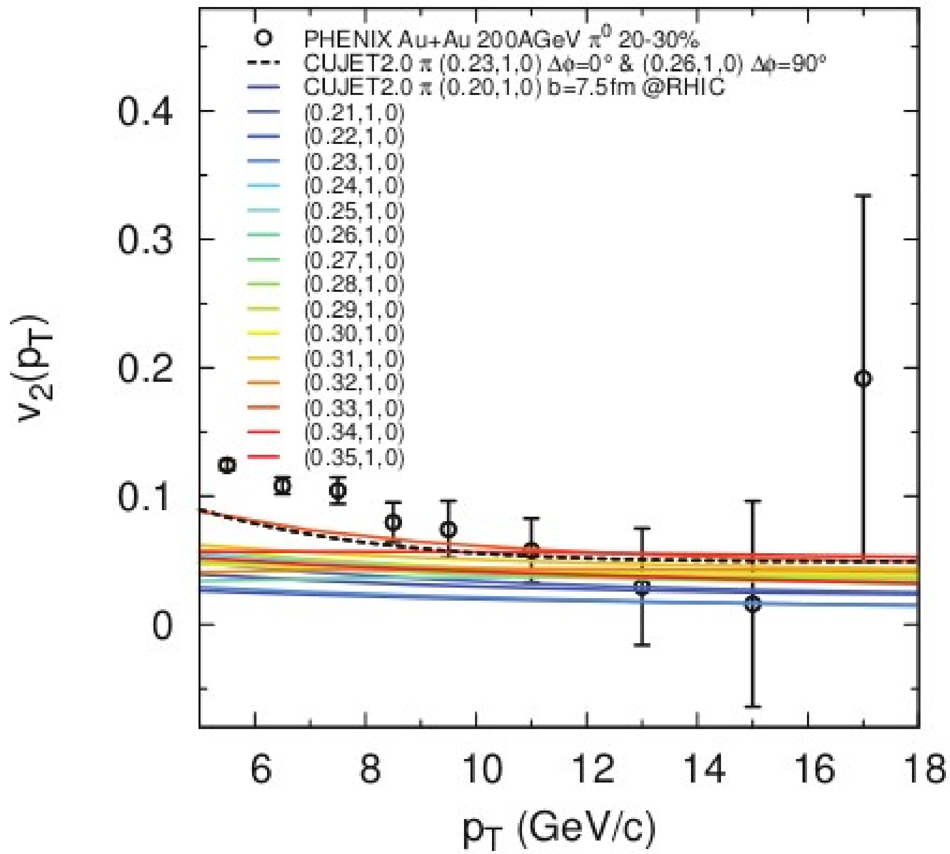
Has CMS seen
A hint of our predicted
RAA "Level Crossing"
Of B and pion RAA
??



A. Buzzatti, MG, PRL 108 (2012)

BUT CUJET2.0 v2 at RHIC and LHC is robustly too small for all alf_max !





<u>*Postulating*</u> alf_max = 0.26 → 0.29 from in to out of reac plane can account
For extra the higher elliptic anisotropy observed ,
but what is the source of such extra alf_max dependence?

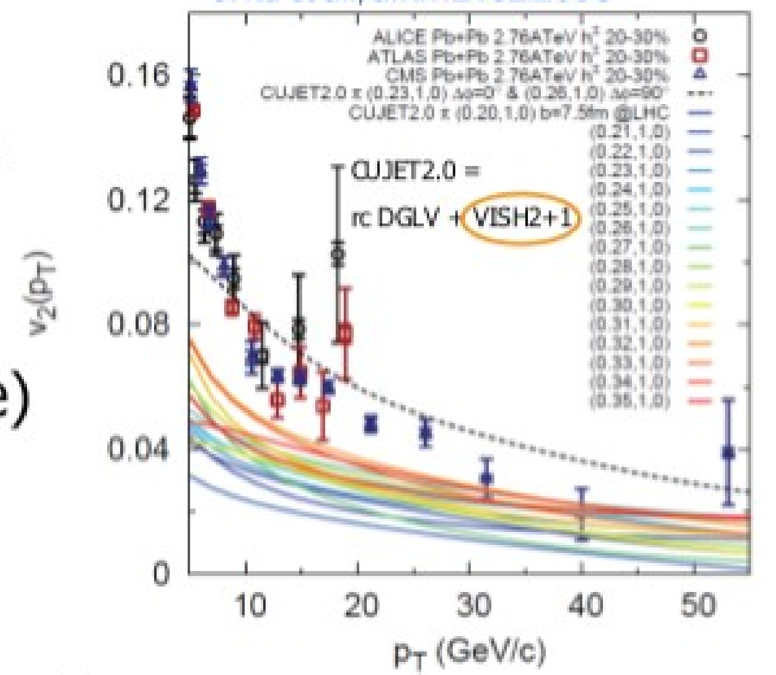
Path-variation of the jet-medium coupling

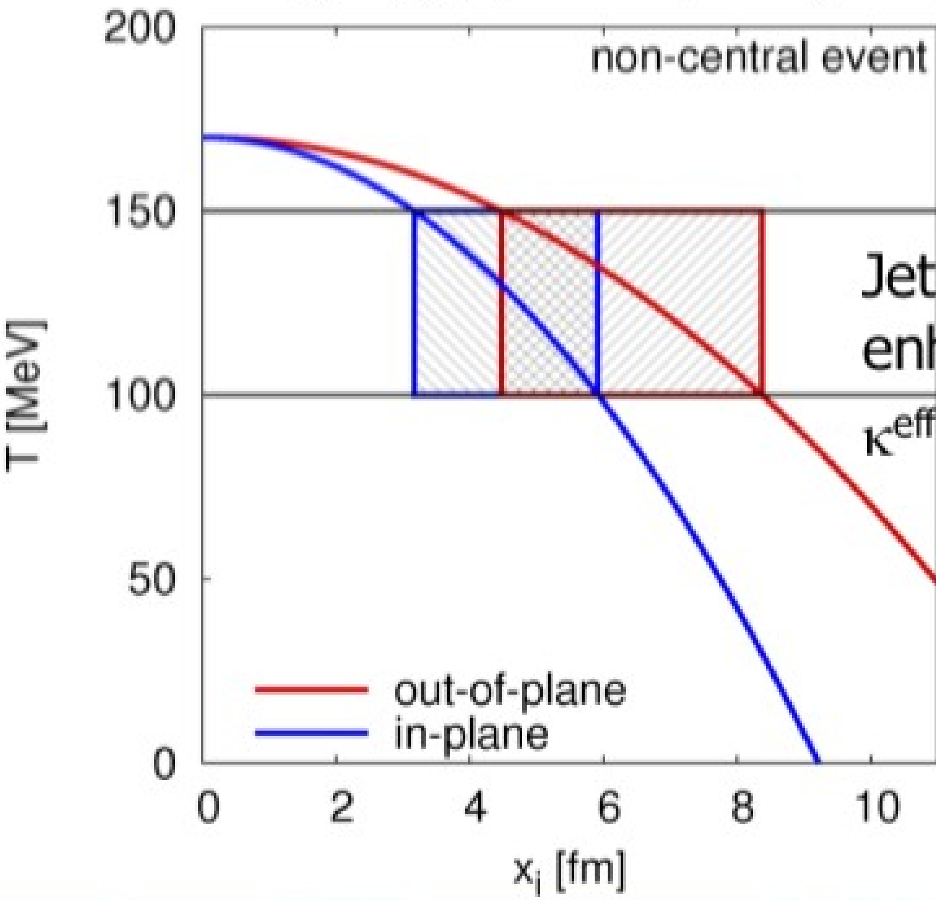
Ansatz to solve the high-p_T v_2-puzzle:

Assume a modest variation of the jet-medium coupling in- and out-of-plane, corresponding to a temperature dependence of α_{max}.

Effectively, α_{max} (out-of-plane) > α_{max} (in-plane)

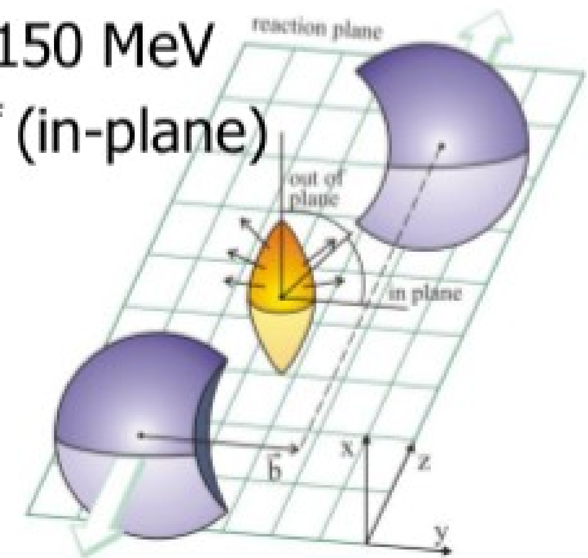
J. Xu et al., arXiv:1402.2956





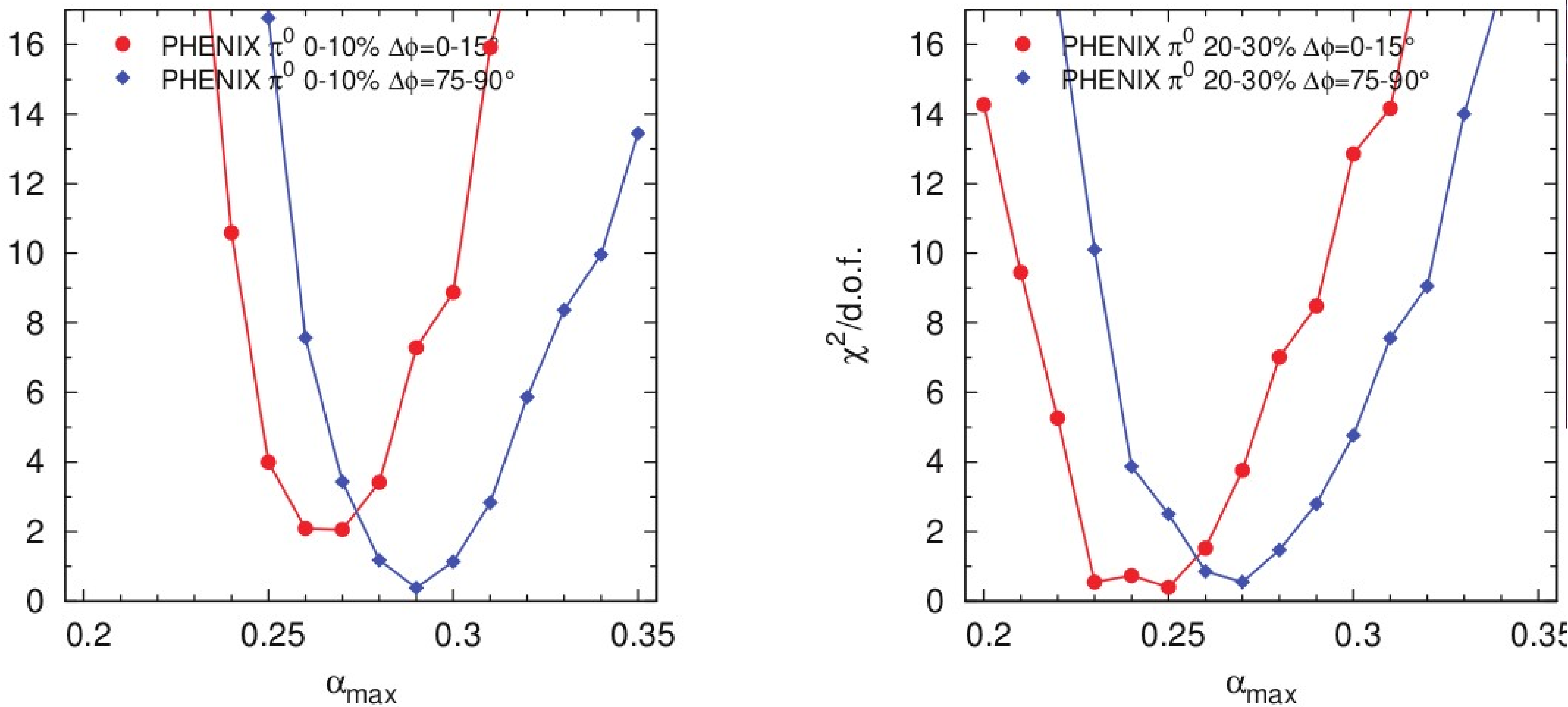
Jet-medium coupling enhanced for 100<T<150 MeV

κ^{eff} (out-of-plane) > κ^{eff} (in-plane)



Chi^2 prefers stronger alf_max out of plane

In plane T(x=t,y=0,t) cools faster than out of plane



A future plan is to study detailed alf(Q, T) dual running coupling fields with Q AND T

Azimuthal Jet Flavor Tomography with CUJET2.0 of Nuclear Collisions at RHIC and LHC

Jiechen Xu[a] Alessandro Buzzatti[a,b] Miklos Gyulassy[a,b,c,1]

$\chi^2/d.o.f.$ ($b = 7.5$ fm)	v_2, RHIC	v_2, LHC	R_{AA}, RHIC	R_{AA}, LHC
$\alpha^{in}_{max} = 0.23$, $\alpha^{out}_{max} = 0.23$	3.72	43.03	0.93	0.73
$\alpha^{in}_{max} = 0.26$, $\alpha^{out}_{max} = 0.26$	2.06	24.89	0.23	1.06
$\alpha^{in}_{max} = 0.23$, $\alpha^{out}_{max} = 0.26$	0.50	4.92	0.42	0.54

Table 3. $\chi^2/d.o.f.$ for v_2 and azimuthally averaged R_{AA} in semi-peripheral $b = 7.5$ fm collisions at RHIC Au+Au 200AGeV and LHC Pb+Pb 2.76ATeV, with different choices of α_{max} values for R^{in}_{AA} (α^{in}_{max}) and R^{out}_{AA} (α^{out}_{max}) in the CUJET2.0 HTL scenario. Reference curves are shown in Fig. 4, Fig. 8, and Fig. 10. The $p_T > 8$ GeV range is chosen for both RHIC R_{AA} and LHC R_{AA} for safer preservation of eikonal and soft approximations, $p_T > 8$ GeV and $p_T > 12$ GeV range is chosen for RHIC v_2 and LHC v_2 to avoid the avalanche region. The choice of $\alpha^{in}_{max} = 0.23$, $\alpha^{out}_{max} = 0.26$ significantly reduces the $\chi^2/d.o.f.$ for v_2 at both RHIC and LHC, especially the latter one. By the mean time, this set of α_{max} parameters maintains almost perfect agreement with both RHIC and LHC for azimuthally averaged R_{AA}.

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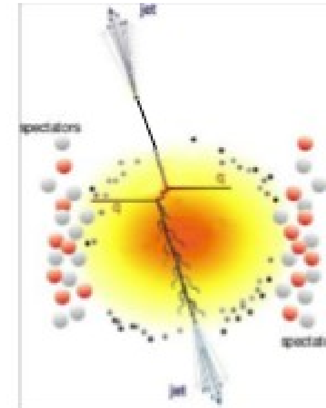
Constraints on the Path-Length Dependence of Jet Quenching in Nuclear Collisions at RHIC and LHC

<u>Barbara Betz (Frankfurt U.)</u>, M Gyulassy (Columbia U. & LBNL & Wigner RCP)

e-Print: arXiv:1404.6378 [hep-ph] |w

Generic model of jet-energy loss:

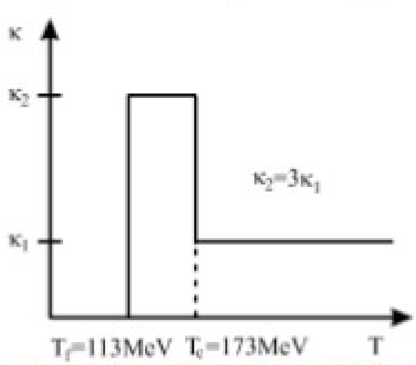


$$\frac{dP}{d\tau}(\vec{x}_0, \phi, \tau) = -\kappa(T) P^a(\tau)\, \tau^z\, T^{c=2-a+z}\, \zeta_q$$

calculate R_{AA}^{in} and R_{AA}^{out} @RHIC & R_{AA} and v_2 @LHC for:

BB et al., arXiv: arXiv:1404.6378

- QCDrad: a=0, z=1, const. κ
- QCDel: a=0, z=0, const. κ
- AdS: a=0, z=2 , const. κ
- SLTc: a=0, z=1, κ(T)



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

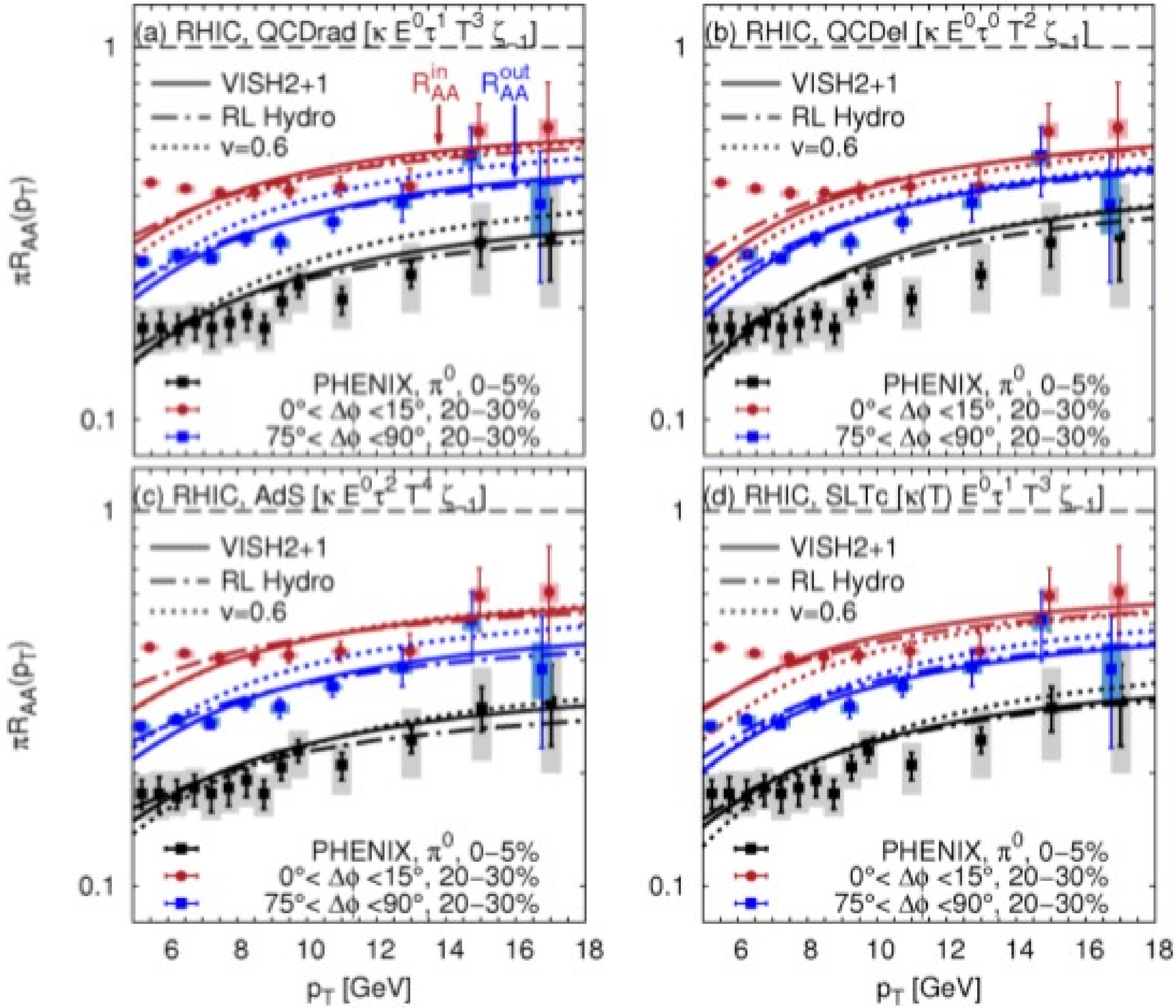
M. Gyulassy et al,. PRL **86**, 2537 (2001)

- Blast wave model: v=0.6
- VISH2+1 C. Shen et al. , PRC **82**, 054904 (2010); PRC **84**, 044903 (2011)
- RL Hydro M. Luzum et al., PRC **78**, 034915 (2008); PRL **103**, 262302 (2009).

We asked for hydro expansions that reproduce the bulk properties. For the results used, some parameters (viscosity, ...) differ between RHIC and LHC.

SEEMED to FIT with assumed

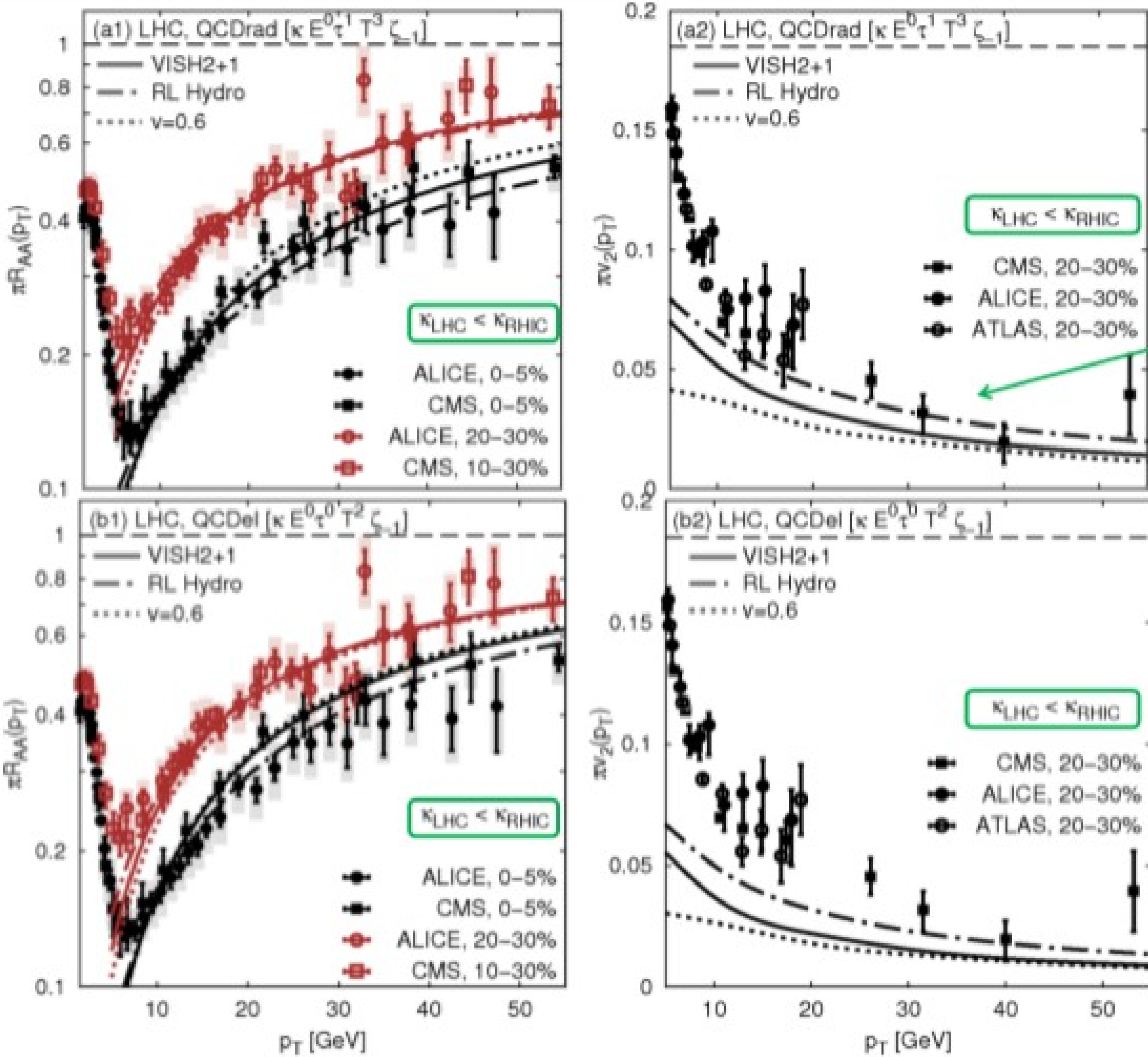
R^{in}_{AA} and R^{out}_{AA} @RHIC, no fluctuations



All scenarios based on (visc.) hydro background account for p_T>8 GeV data, while blast wave model (v=0.6) fails

Qualitative difference to PHENIX results due to details of hydro simu-lation and jet-energy loss prescription.

pQCD-like models @LHC, no fluctuations



$dE^{rad}/dx \sim E^0\tau^1T^3$ reproduces BOTH R_{AA} and v_2 within the uncertainties of bulk space time evolution (IC, η/s, τ_0

Running coupling radiative QCDrad ($\sim E^0\tau^1$) appears to be preferred over running coupling QCDel ($\sim E^0\tau^0$).

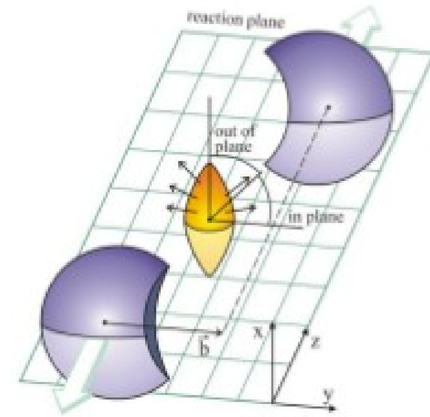
BBMG confirmed CUJET2.0 azimuthal variation solution to v2 problem

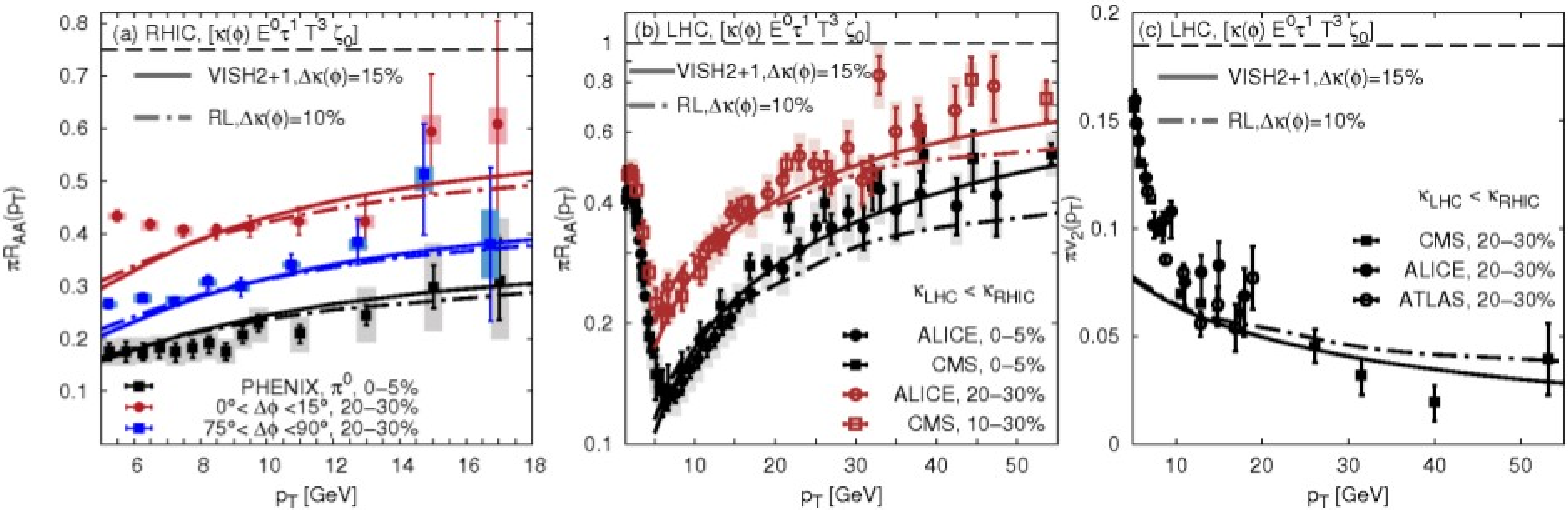
To mimic this ansatz with

α_{max} (out-of-plane) > α_{max} (in-plane)

we assume an increase of the jet-medium coupling out-of-plane

$\kappa(\phi) = \kappa \cdot (1 + |\sin(\phi)| \cdot X)$ X: value in percentage



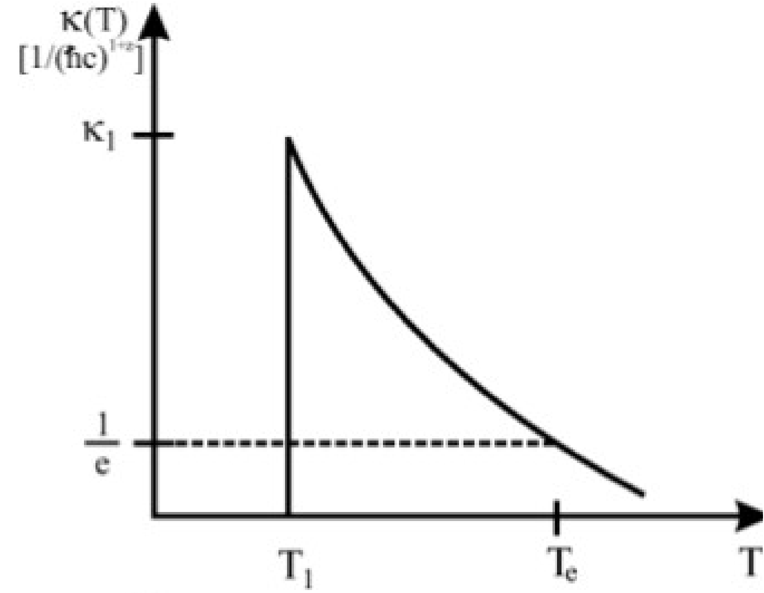


→ R_{AA} and v_2 can be described BOTH @RHIC & @LHC, assuming running coupling and a fluctuating, pQCD-like $dE^{rad}/dx \sim E^0 \tau^1 T^3$

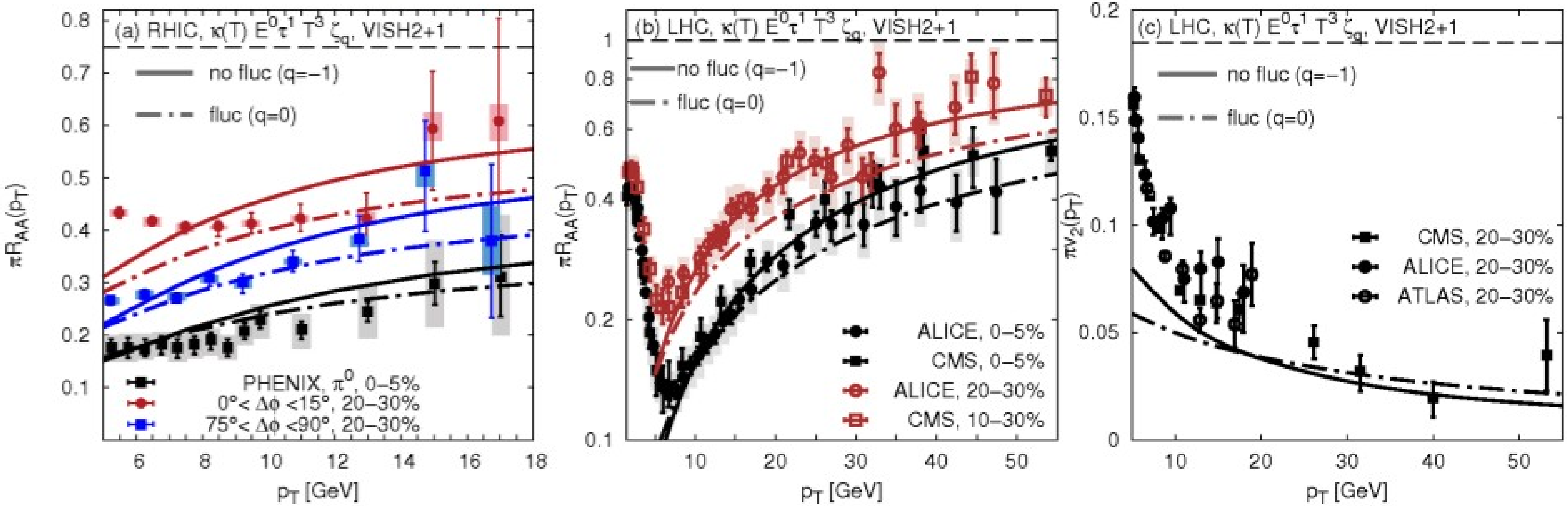
But CUJET2.0 solution is NOT unique ! Consider the following SLTc like solution

Inspired by the SLTc model that did NOT reproduce opacity of the LHC medium, we consider an exponential ansatz:

$$\kappa(T) = \kappa_1 e^{-b(T-T_1)}$$



⇒ One possible ansatz to describe the LHC transparency.



⇒ Data are fairly described.

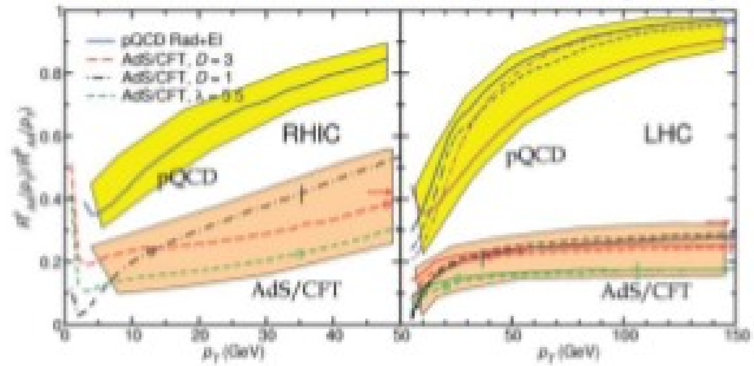
Non-conformal Holography @LHC

Is yet another solution

Conformal AdS: scale cannot change,

i.e. the coupling cannot run

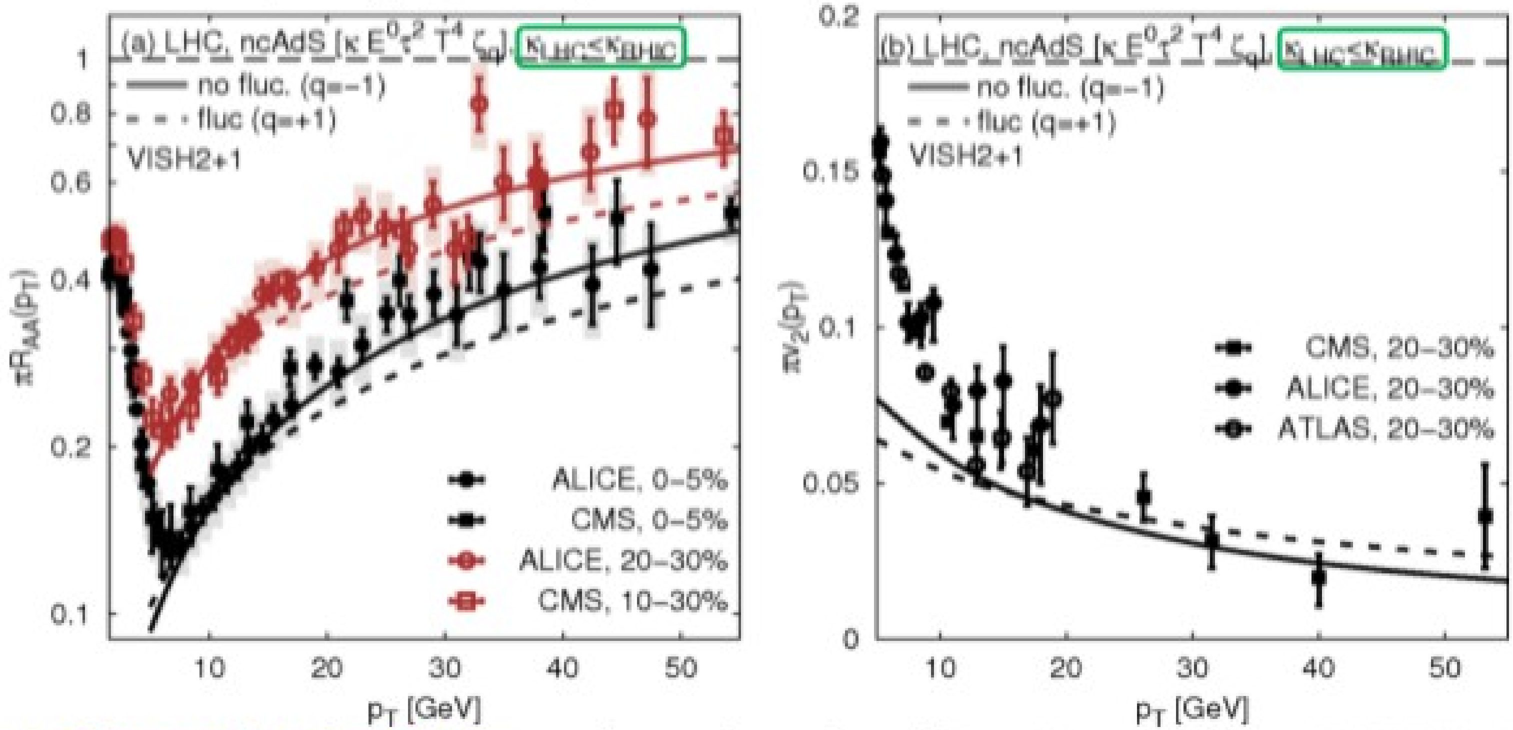
W. A. Horowitz et al, PLB 666, 320-323 (2008)



Using conformal AdS, a flat $R_{AA}(p_T)$@LHC was predicted, in contrast to measured data

Allowing for **non-conformal, non-standard AdS** (i.e. $dE/dx \sim E^0\tau^2T^4$ with a red. coupling @LHC):

A. Ficnar et al., arXiv: 1311.6160



→Only conformal AdS fails to describe the (R_{AA} & v_2) data BOTH @RHIC & LHC

Summary

Comparison of R_{AA} & v_2 @RHIC & LHC with pQCD & AdS/CFT-inspired energy-loss models for various hydrodynamic backgrounds

Conformal AdS seems to be ruled out
However, non-conformal generalizations of AdS may provide an alternative

Running coupling is essential to describe data @LHC

There is a high degeneracy of solutions
- $dE^{rad}/dx \sim E^0\tau^1T^3$ or $dE^{el}/dx \sim E^0\tau^0T^2$ without fluctuations,
- $dE^{rad}/dx \sim E^0\tau^1T^3$ with jet-energy loss fluctuations and $\kappa(\phi)$,
- $dE^{rad}/dx \sim E^0\tau^1T^3$ with an exponential $\kappa(T)$,
- and non-conformal $dE/dx \sim E^0\tau^2T^4$

provide a decent description to BOTH RHIC & LHC data.

⇒ Path-length exponent cannot be constrained narrower than z=[0-2]
⇒ New jet observables and reduced experimental errors are needed

The evolution of the bulk medium influences the jet-energy loss & **all details** of both bulk evolution and jet-energy loss **matter!**

Current model landscape score board   BBMG 2014

BB et al., arXiv: 1404.6378

name	fluct.	(z,c,q)	temp. profile	RHIC R_{AA}^{centr}	RHIC $R_{AA}^{in,periph}$	RHIC $R_{AA}^{out,periph}$	LHC R_{AA}^{centr}	LHC R_{AA}^{periph}	LHC v_2^{periph}	Score Sum
QCDrad	no	$(1,3,-1)$	VISH2+1	✓	✓	✓	✓	✓	(✓)	5
QCDrad	no	$(1,3,-1)$	VISH2+1	✓	✓	✓	(✓)	(✓)	(✓)	3
QCDrad	no	$(1,3,-1)$	RL Hydro	✓	✓	✓	✓	✓	(✓)	5
QCDrad	no	$(1,3,-1)$	$v=0.6$	(✓)	✓	no	✓	✓	no	1
QCDel	no	$(0,2,-1)$	VISH2+1	✓	✓	✓	(✓)	(✓)	(✓)	3
QCDel	no	$(0,2,-1)$	RL Hydro	✓	✓	✓	✓	(✓)	(✓)	4
QCDel	no	$(0,2,-1)$	$v=0.6$	✓	no	✓	(✓)	(✓)	no	0
AdS	no	$(2,4,-1)$	VISH2+1	✓	✓	✓	no	no	✓	2
AdS	no	$(2,4,-1)$	RL Hydro	✓	✓	✓	no	no	no	0
AdS	no	$(2,4,-1)$	$v=0.6$	✓	✓	no	no	no	(✓)	-1
SLTc	no	$(1,3,-1)$	VISH2+1	✓	✓	✓	no	no	✓	2
SLTc	no	$(1,3,-1)$	RL Hydro	✓	✓	✓	no	no	✓	2
SLTc	no	$(1,3,-1)$	$v=0.6$	(✓)	no	no	no	no	no	-5
QCDrad	yes	$(1,3,+1)$	VISH2+1	✓	(✓)	(✓)	(✓)	no	(✓)	0
QCDrad	yes	$(1,3,+1)$	VISH2+1	✓	(✓)	(✓)	✓	(✓)	(✓)	2
QCDel	yes	$(1,3,+1)$	VISH2+1	✓	no	no	✓	no	no	-2
AdS	yes	$(2,4,+1)$	VISH2+1	✓	✓	(✓)	no	no	(✓)	0
ncAdS	no	$(2,4,-1)$	VISH2+1	✓	(✓)	✓	✓	✓	✓	5
ncAdS	yes	$(2,4,+1)$	VISH2+1	✓	✓	(✓)	no	no	✓	1
$\kappa(\phi)$ QCDrad	yes	$(1,3,0)$	VISH2+1	✓	✓	✓	✓	✓	✓	6
$\kappa(\phi)$ QCDrad	yes	$(1,3,0)$	RL Hydro	✓	✓	✓	no	no	(✓)	1
exp. $\kappa(T)$ QCDrad	no	$(1,3,-1)$	VISH2+1	✓	(✓)	✓	✓	✓	✓	5
exp. $\kappa(T)$ QCDrad	yes	$(1,3,0)$	VISH2+1	✓	✓	(✓)	(✓)	no	✓	1
exp. $\kappa(T)$ ncAdS	no	$(2,4,-1)$	VISH2+1	✓	✓	(✓)	✓	✓	✓	5
exp. $\kappa(T)$ ncAdS	yes	$(2,4,0)$	VISH2+1	✓	✓	✓	(✓)	no	✓	3