Recent (and older) progresses in heavy flavor physics in URHIC

4th International Conference on New Frontiers in Physics (Kolymbari, Greece)

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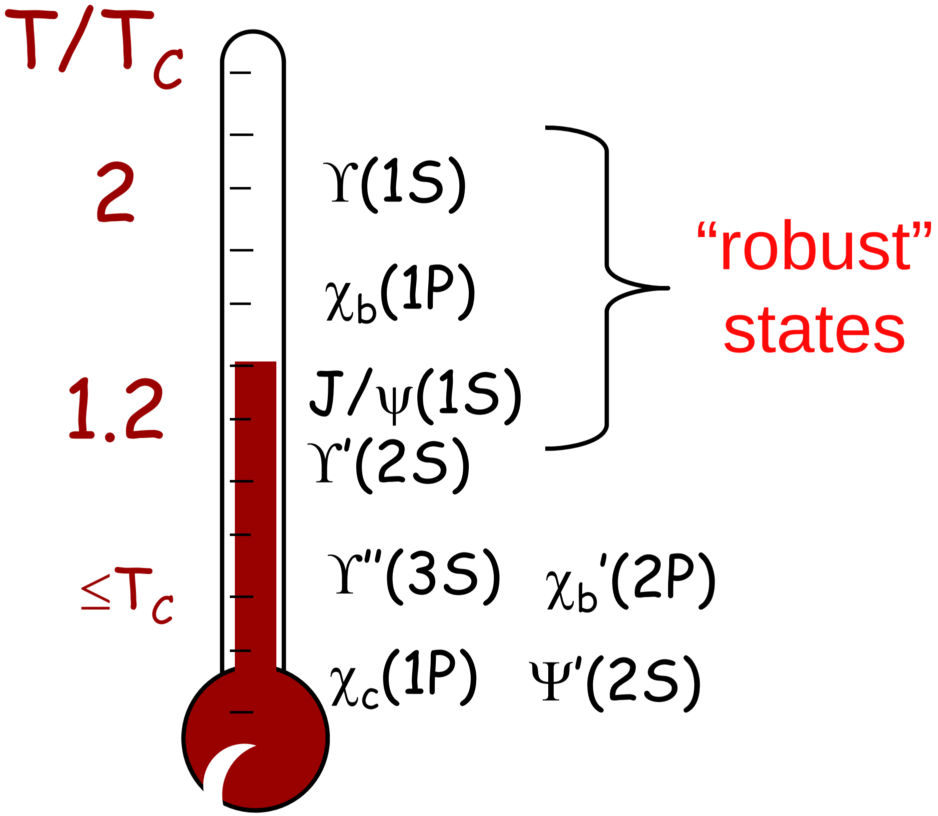
with

J. Aichelin, H. Berrehrah, R.Bierkandt, M. Bluhm, E. Bratkovskaya, W. Cassing, Th, Gousset, V. Guiho, B. Guiot, R. Katz, M. Nahrgang, V. Ozvenchuk, A. Peshier, M. Rohrmoser, S. Vogel, K. Werner,…

Sequential suppression in Stationary QGP…

Matsui & Satz (1986): QGP achieved in URHIC can lead to the deconfinement of Q-Qbar states and thus to an **anomalous** suppression of the (production of) quarkonia (as compared to the rescaled p-p production:

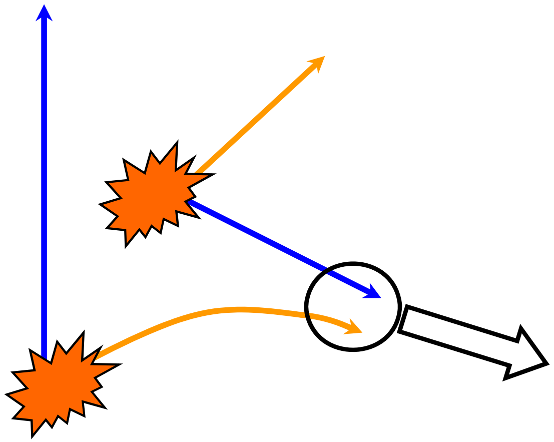
QGP Thermometer



However: quarkonia production in pp is a complicated issue (see B.K. lecture), so that dealing with its alteration (dynamically) is (very/too) much complicated.

… a dream or a nightmare ?

Early 2000:Thews, Rafelski & Schroedter



Main focus: « …a direct extrapolation of anomalous suppression (of J/ψ) from the SPS energy range could be supplanted by a new formation mechanism fueled by the presence of multiple pairs of charm quarks in each nuclear collision at sufficiently high energy».

Recombination of exogenous quarks, spatially uncorrelated => quadratic dependence in N_c. Indeed, for a given c-quark, the probability *P* to combine with a cbar quark to produce a J/ψ is:

$$P \,\alpha\, \frac{N_{\bar{c}}}{N_{\bar{u},\bar{d},\bar{s}}} \,\alpha\, \frac{N_{c\bar{c}}}{N_{\mathrm{ch}}}.$$

True for each available c-quark (N_c all together) => number of J/ψ's through exogenous kinetic (re)combination » :

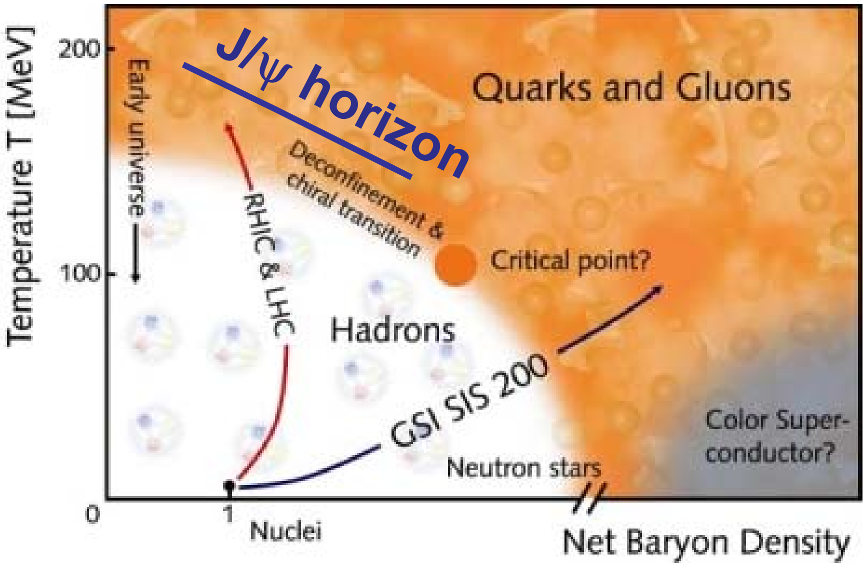
$$N_{J/\psi} \boxed{\alpha} \frac{N_{c\bar{c}}^{2}}{N_{\mathrm{ch}}}$$

Precise α-value: depends on the dynamics of the system

TRS: kinetic equation $$\frac{dN_{J/\psi}(\tau)}{d\tau} = \frac{\lambda_{\mathrm{F}}(\tau)}{V(\tau)} N_c N_{\bar{c}} - \lambda_{\mathrm{D}}(\tau)\rho_{\mathrm{g}}(\tau) N_{J/\psi}(\tau)$$

kinetic recombination within QGP

Even more interesting: momentum distribution could come with the Temperature at which those quarkonia are produced (beyond FO horizon)

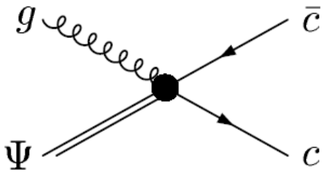


Main caveat: as kinematic (re)combination is local in space-time and in momentum, the total number of produced J/ψ strongly depends on phase-space distribution of c-quarks (some assumptions used in TRS and then later in Thews and Mangano)

Mid 2004:Gossiaux, Aichelin and Guiho

Ingredients of our calculation:

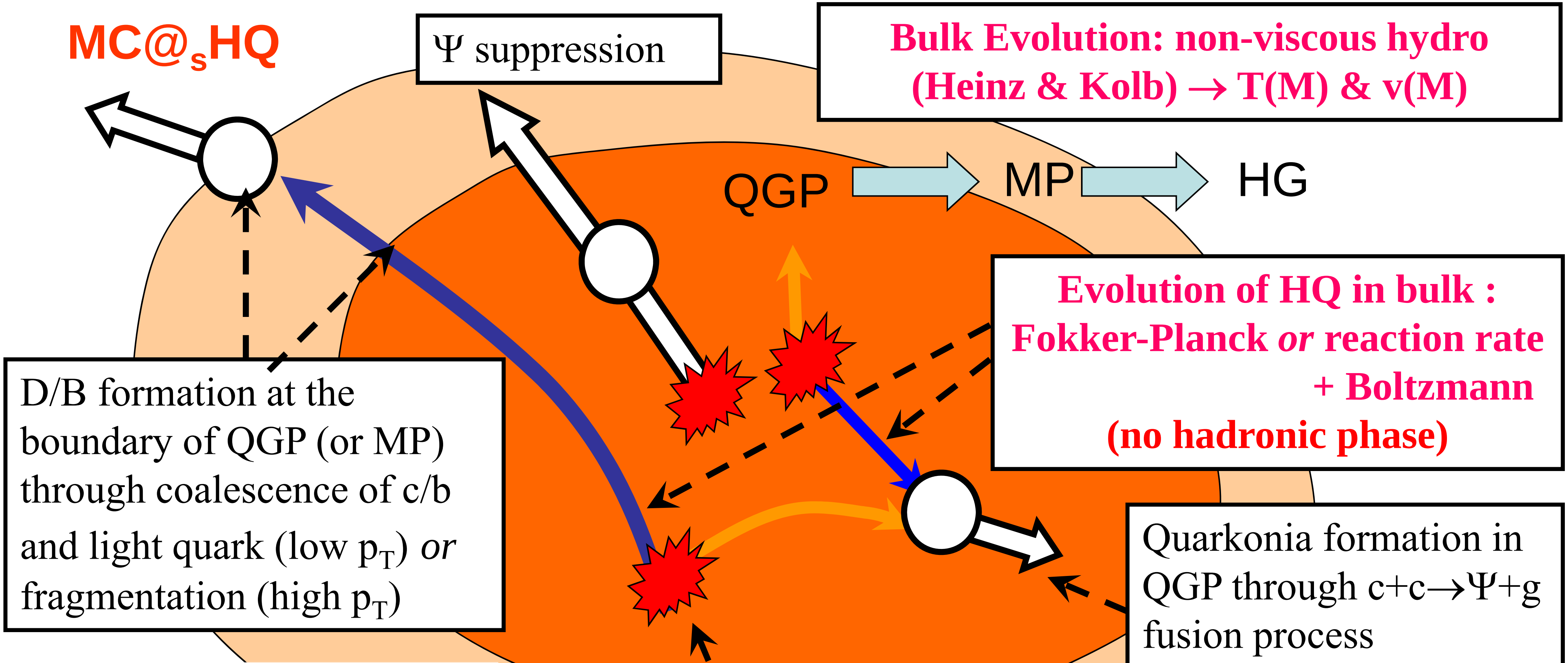
1. dissociation evaluated though g+J/ψ -> c+cbar cross section (Bhanot-Peskin)



$$\sigma_{(Q\overline{Q})g}(\omega) = \frac{2^{11}}{3^4} \alpha_s \pi a_0^2 \frac{(\omega/\varepsilon(0) - 1)^{3/2}}{(\omega/\varepsilon(0))^5} \Theta(\omega - \varepsilon(0))$$

2. (Re)combination evaluated through detailed balance mechanism.
3. Fokker Planck equation for heavy quark transport.
4. Transport coefficients evaluated according to Landau's treatment (so-called "grazing approximation" (as in Svetitsky 87, Mustafa 97) + LO qQ->qQ and gQ->gQ elastic cross section evaluated in-vacuum with fixed α_s and some regulator μ.
5. Some "soft" dissociation temperature above which no quarkonia formation is possible (following Matsui and Satz)
6. All of this implemented in a local transport approach.

Schematic view of the global framework



MC@$_s$HQ

Ψ suppression

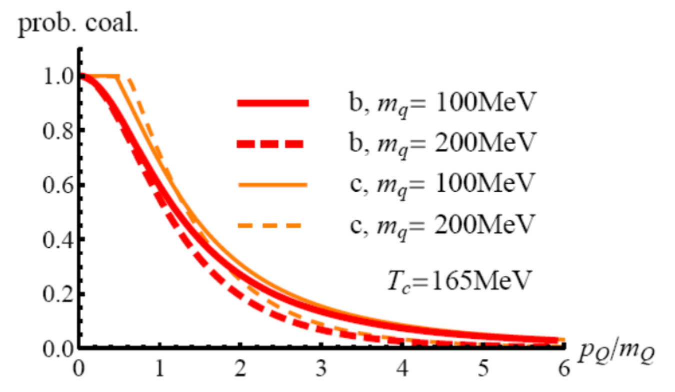
Bulk Evolution: non-viscous hydro (Heinz & Kolb) → T(M) & v(M)

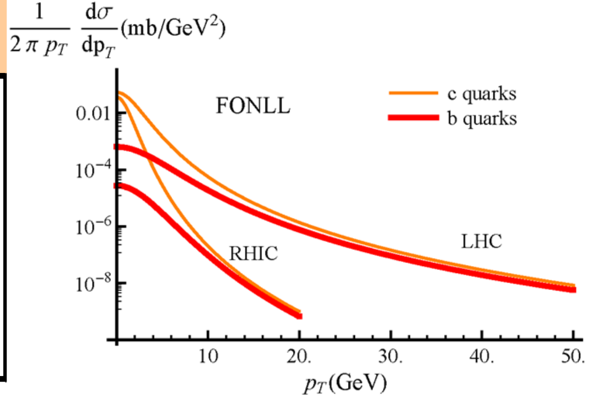
Evolution of HQ in bulk : Fokker-Planck *or* reaction rate + Boltzmann (no hadronic phase)

D/B formation at the boundary of QGP (or MP) through coalescence of c/b and light quark (low p_T) *or* fragmentation (high p_T)

Quarkonia formation in QGP through c+c→Ψ+g fusion process

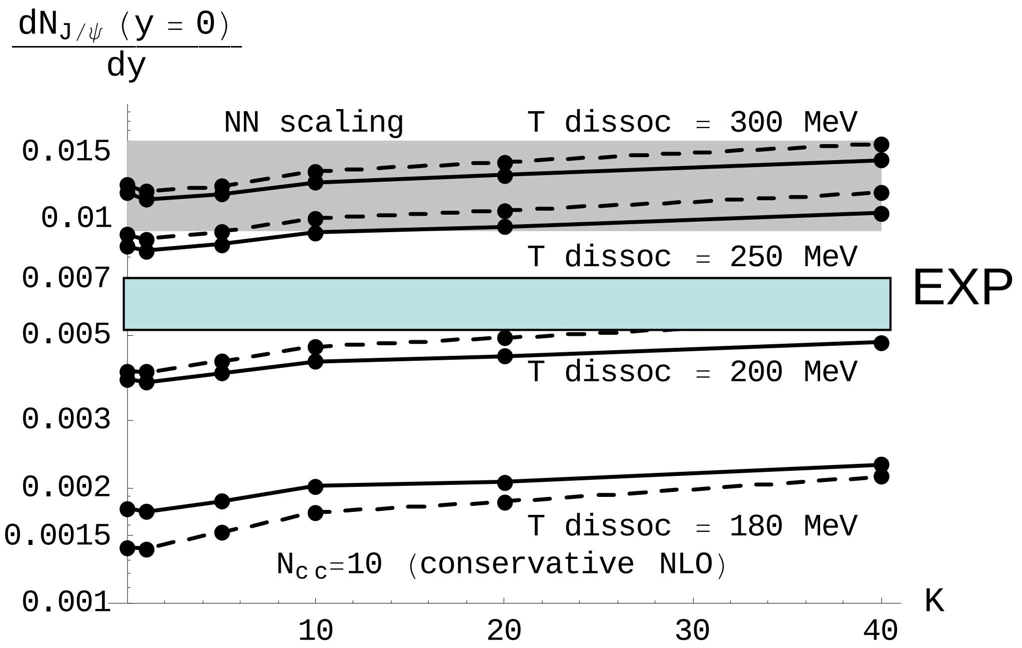
(hard) production of heavy quarks in initial NN collisions + k_T broad. (0.2 GeV^2/coll





Results from the calculations (2004)

J/ψ production in Au-Au, b=0, RHIC, mid rapidity



— Heinz & Kolb's hydro

- - - No radial exp. hydro

- N_c and T_{dissoc} : key parameters to explain global numbers.
- Larger thermalisation of c-quarks (larger K) leads to moderate increase of J/ψ production.

K: overall cranking factor of the FP coeff. A & B

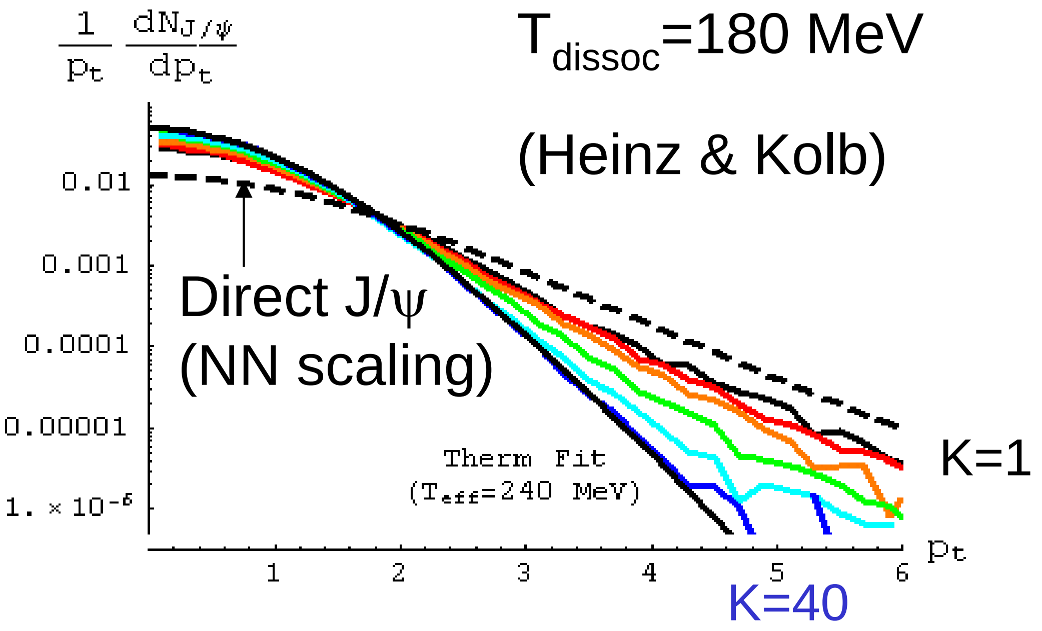
$$\frac{\partial f}{\partial t} = \vec{\nabla}_p \left[\vec{A}\, f + \vec{\nabla}_p \left(\overleftrightarrow{B}\, f \right) \right]$$

Larger K => larger thermalization => smaller effective T of the c-quark distribution.

Differential p_T spectra reflects this effect (indeed seen later on by PHENIX) →

T_{dissoc}=180 MeV

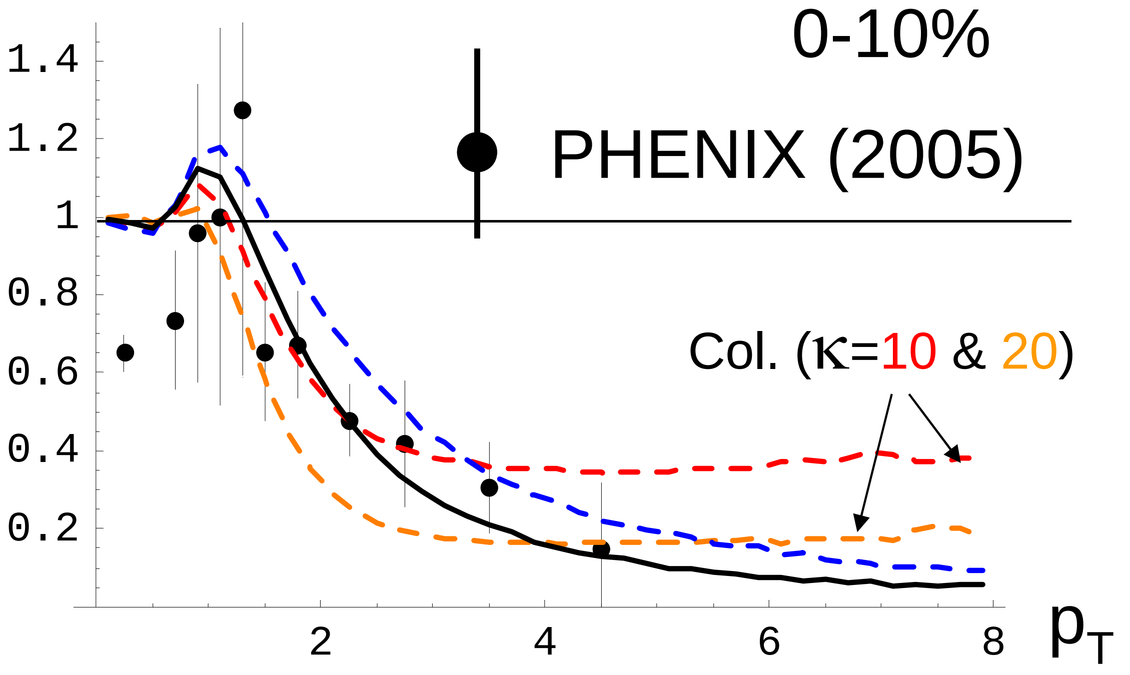
(Heinz & Kolb)



2000 -> 2005: growing interest for the measurement of open heavy flavor

Motivations: QGP tomography with well-controlled probes (initial distribution in phase space) that do not completely thermalize.

R_{AA} (Non photonic single electrons)

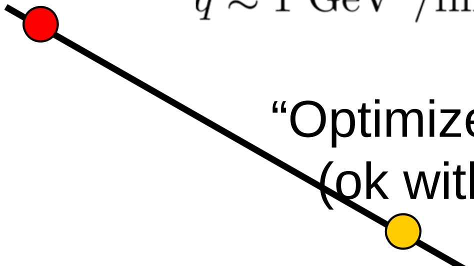


Suppression of decay electron from c and b quarks at “large” p_T due to HQ energy loss (quenching)… A big surprise, in fact !!!

Shape ok, but at the price of a large cranking factor K !!!

The weak to strong axis for HQ

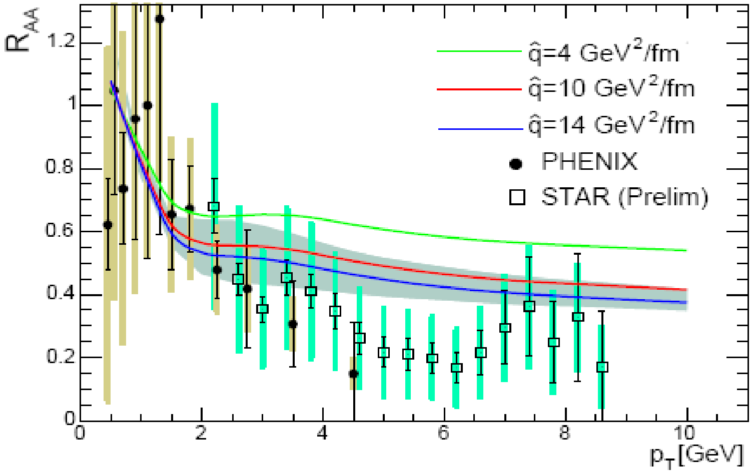
So-called "Failure of pQCD approach" aka "the non photonic single electron puzzle"



"Naive" pQCD
(WHDG, ASW,…)
$\hat{q} \approx 1\ \mathrm{GeV}^2/\mathrm{fm}$

"Optimized" pQCD
(ok with pions)

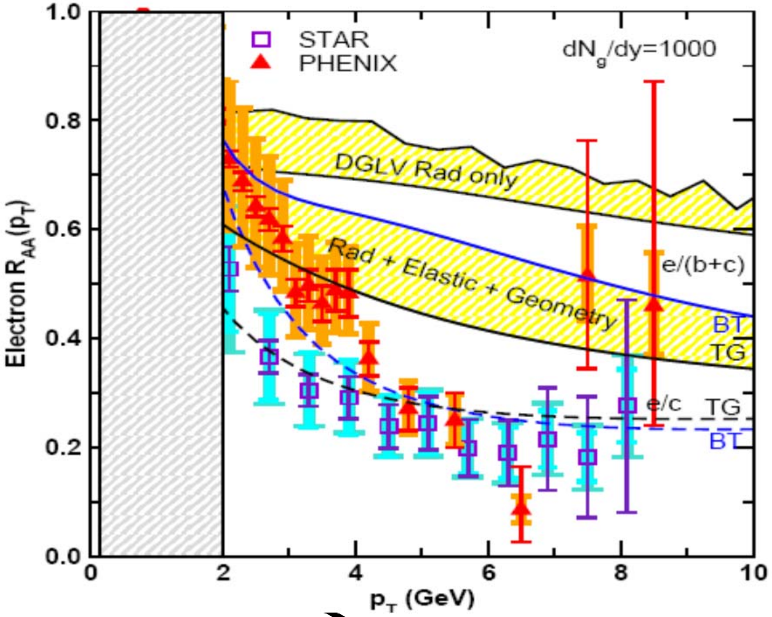
ASW (pure rad. energy loss; extended BDMPS)



Armesto et al Dainese, Phys. Rev D (hep-ph/0501225) &
Phys.Lett. B637 (2006) 362-366 hep-ph/0511257

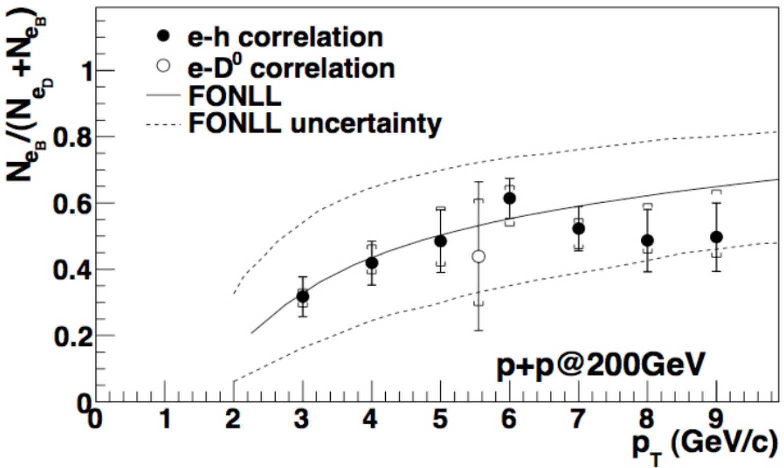
Conclude to rough agreement, subjected to b/c ratio in p-p

coll Eloss (BT and TG) + radiative Eloss



WHDG

Beauty is the problem… but beauty is found to contribute



M Aggarwal et al, STAR, PRL 105 202301

2008: Revisited model for HQ energy loss (Aichelin & Gossiaux)

Motivations:

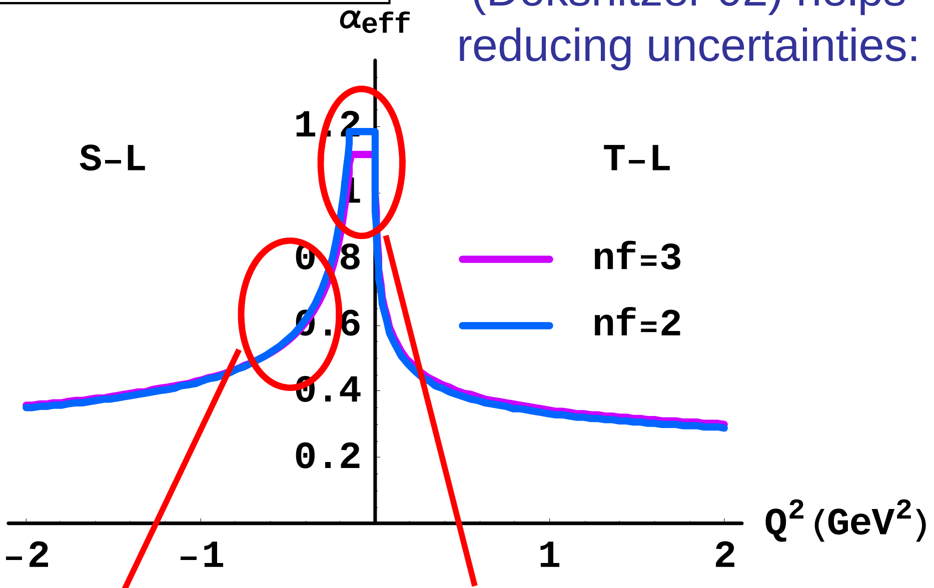
1) Even a fast parton with the largest momentum P will undergo collisions with moderate q exchange and large $\alpha_s(Q^2)$ => need for running coupling constant

2) From FP to Boltzmann transport => need for scattering amplitudes

Effective $\alpha_s(Q^2)$ (Dokshitzer 95, Brodsky 02)

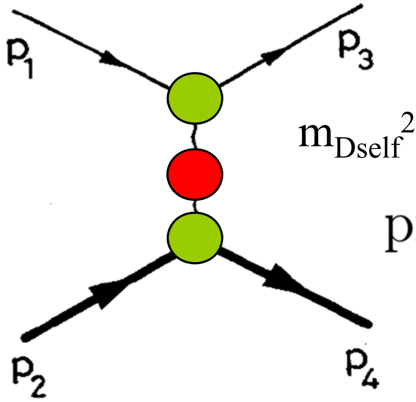
$$\frac{1}{Q_u}\int_{|Q^2|\le Q_u^2} dQ\,\alpha_s(Q^2) \approx 0.5$$

"Universality constrain" (Dokshitzer 02) helps reducing uncertainties:



IR safe. Q^2 close to 0 does not contribute to Eloss

Large values for intermediate momentum-transfer => larger cross section

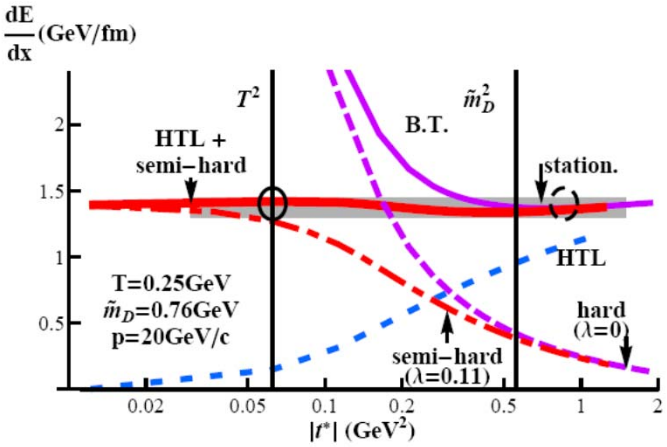


$$m_{\text{Dself}}^2\,(T) = (1+n_f/6)\;4\pi\alpha_{\text{eff}}(m_{\text{Dself}}^2)\;T^2$$

$$\text{prop} \propto \frac{1}{q^2 - \kappa m_{\text{Dself}}^2(T)}$$

+ u and s channels

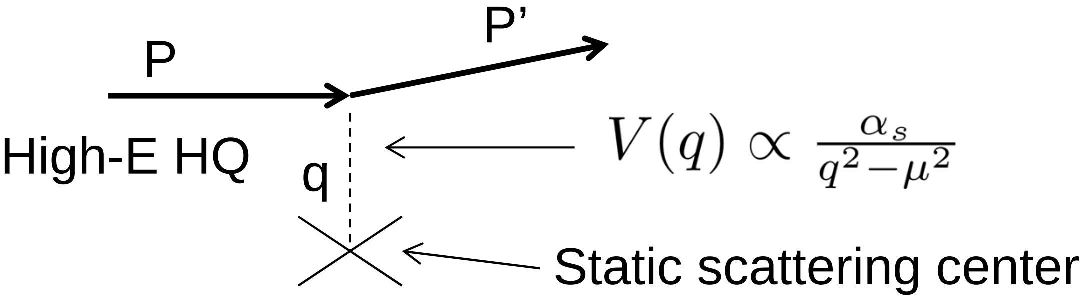
One gluon exchange effective propagator, designed in order to guarantee maximal insensitivity of dE/dx in Braaten-Thomas scheme



Insufficient control on energy loss theory

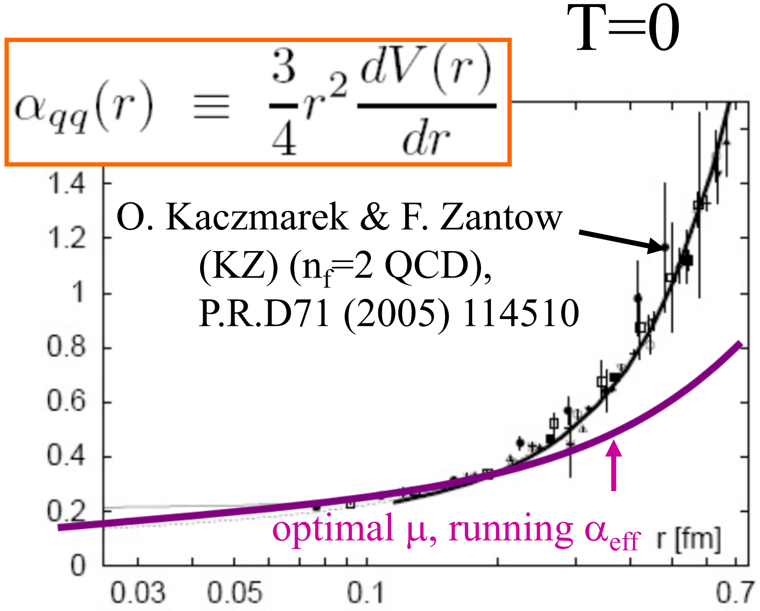
Non perturbative « corrections » even at large HQ energy

In most models:



$V(q) \propto \frac{\alpha_s}{q^2 - \mu^2}$

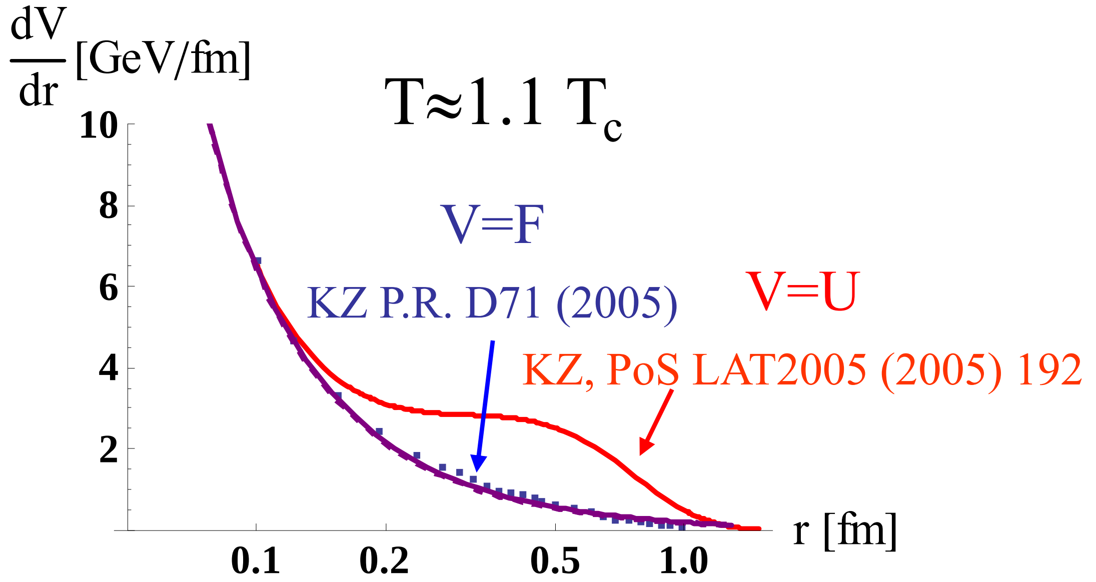
Lattice QCD :



$\alpha_{qq}(r) \equiv \frac{3}{4} r^2 \frac{dV(r)}{dr}$

O. Kaczmarek & F. Zantow (KZ) (n_f=2 QCD), P.R.D71 (2005) 114510

optimal μ, running $\alpha_{\rm eff}$



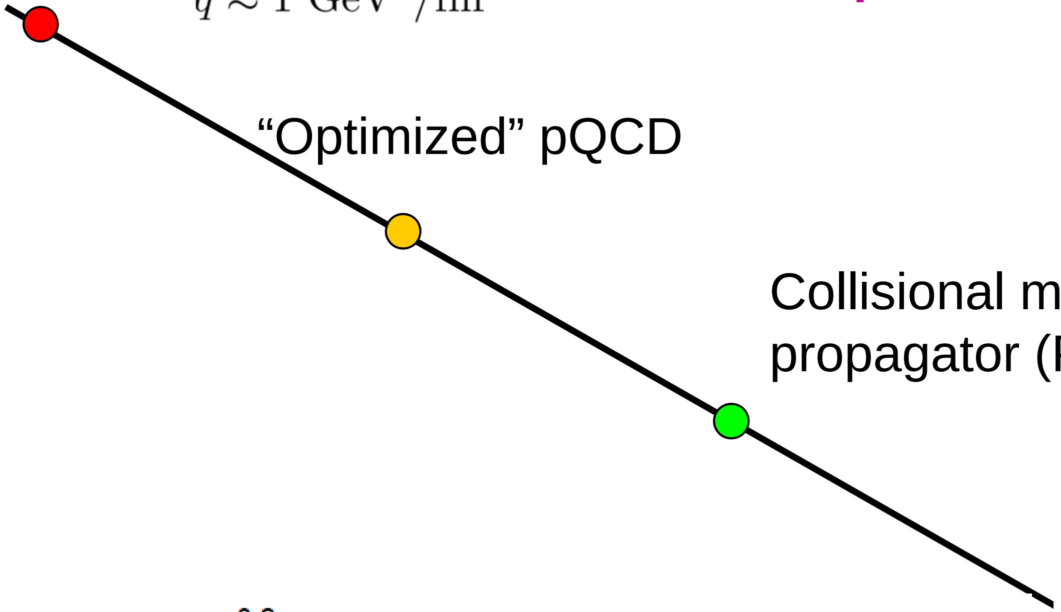
KZ P.R. D71 (2005)

KZ, PoS LAT2005 (2005) 192

Our force is close to the one extracted from the free energy as a potential

=> Still allow for some global rescaling of the interactions rates: "K" fixed on experiment

The weak to strong axis for HQ



“Naive” pQCD
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$\hat{q} \approx 1\ \mathrm{GeV}^2/\mathrm{fm}$

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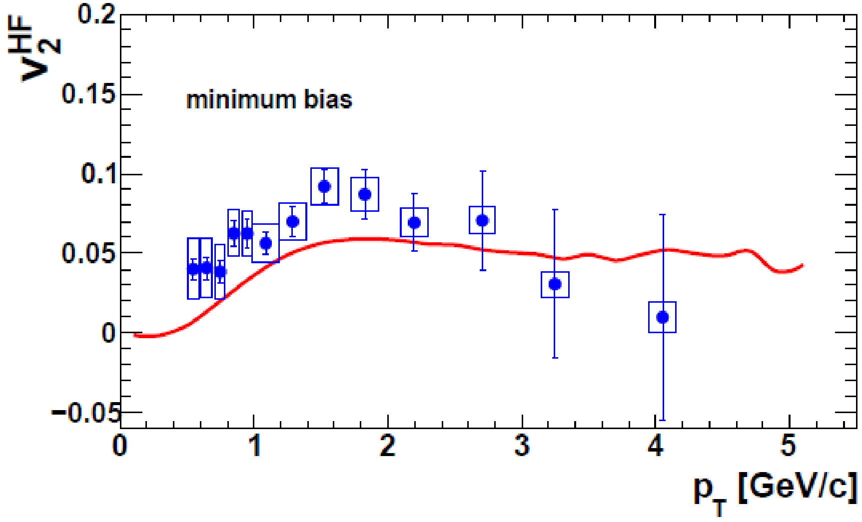
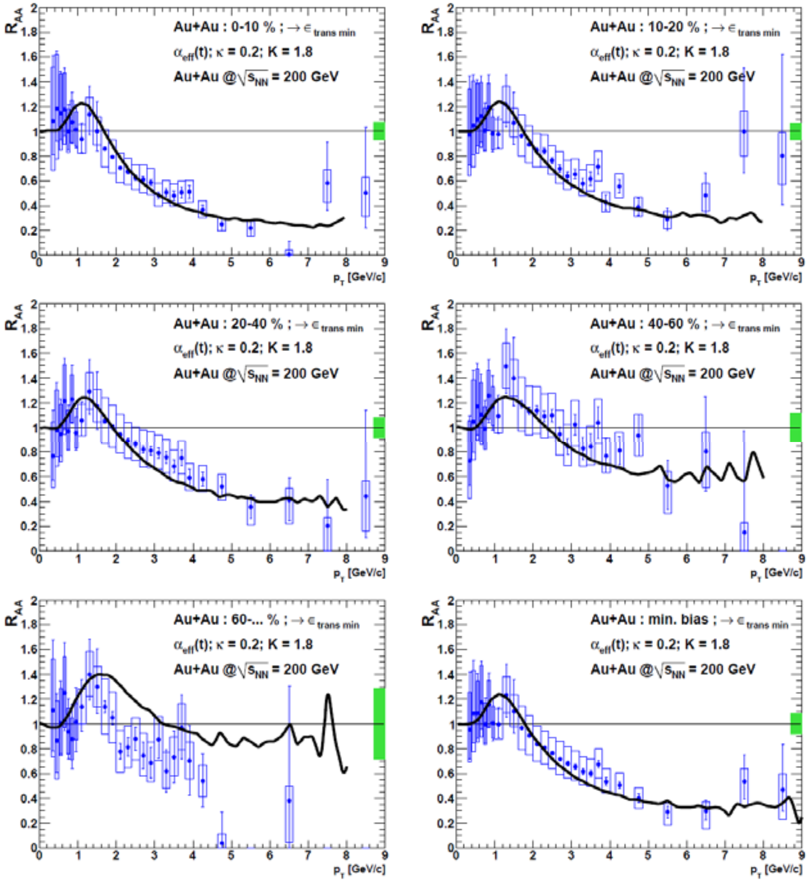
“Optimized” pQCD

Collisional model with running α_s and optimized gluon propagator (Peshier, Gossiaux and Aichelin, BAMPS)





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“Optimized” pQCD

Running α_s (Peshier, Gossiaux & Aichelin, Uphoff & Greiner)

Distorsion of heavy meson fragmentation functions due to the existence of bound mesons in QGP,
R. Sharma, I. Vitev & B-W Zhang
0904.0032v1 [hep-ph]

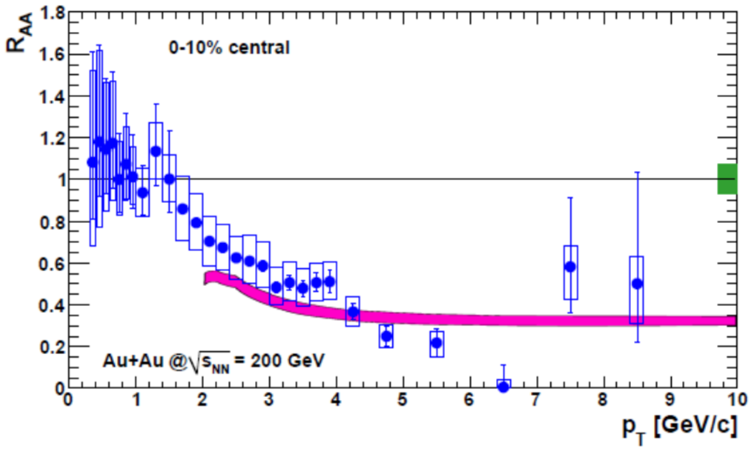

FIG. 41: (Color online) R_{AuAu} in 0–10% centrality class compared with a collisional dissociation model [78] (band) in Au+Au collisions.

The weak to strong axis for HQ

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Distorsion
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R. Sharma
0904.0032

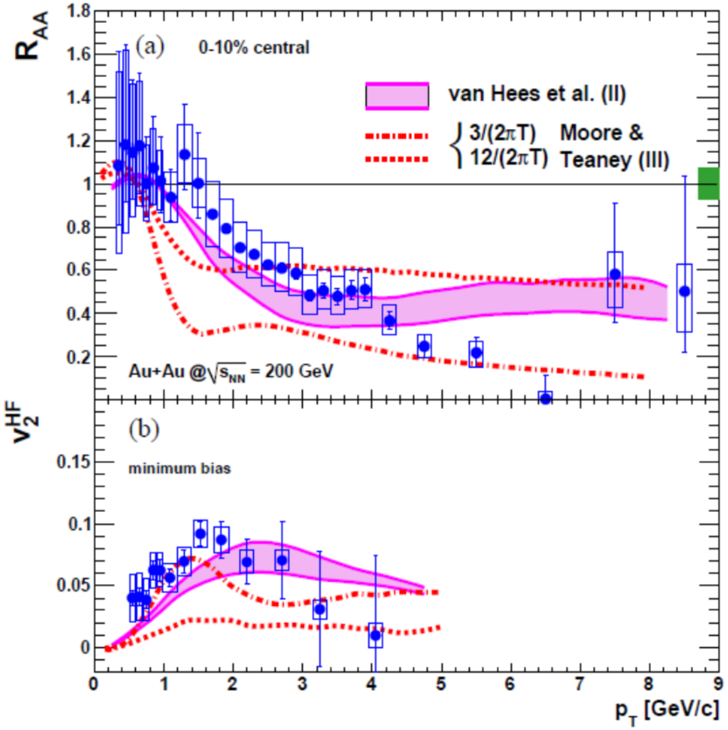

FIG. 40: (Color online) Comparison of Langevin-based models from [74–76] to the heavy flavor electron R_{AuAu} for 0–10% centrality and v_2 for minimum-bias collisions.

Bound states diffusion or non-perturbative, lattice potential scattering models (see R. Rapp and H Van Hees 0903.1096 [hep-ph] for a review)

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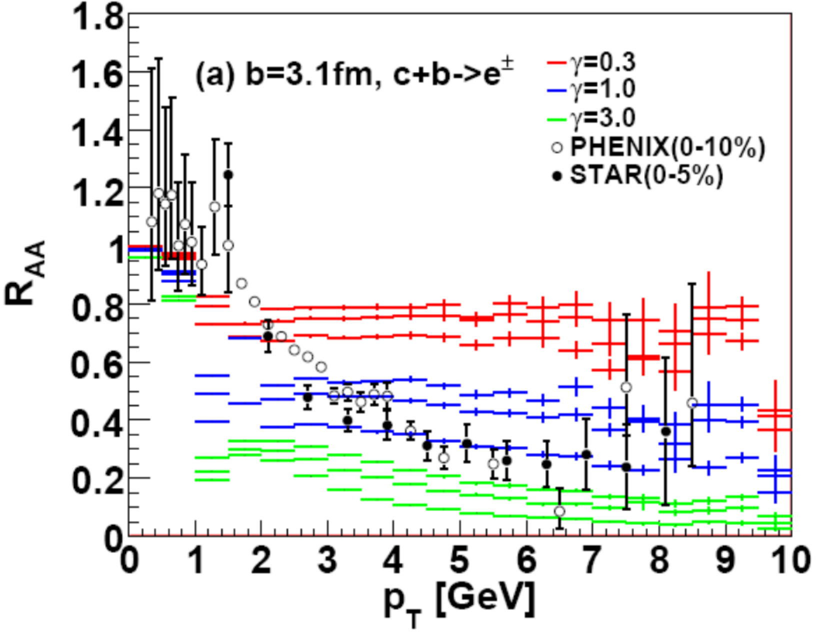

ADS/CFT
(akamatsu et al)

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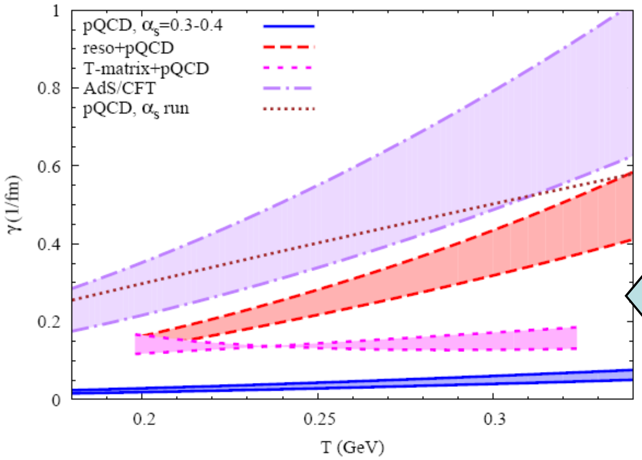
Non perturbative equivalent for g+Q ? No radiative !

ADS/CFT (akamatsu et al)



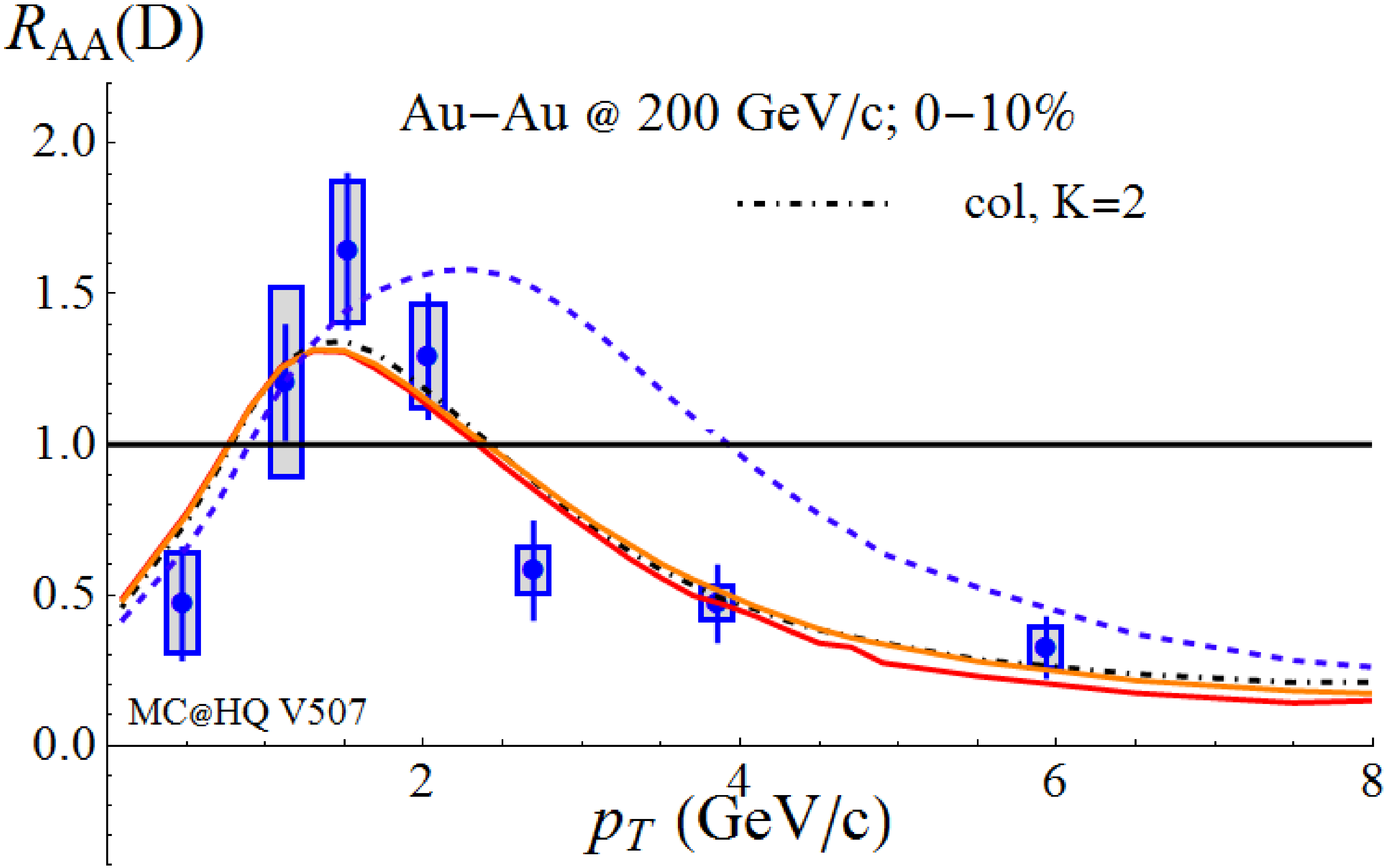
from Rapp & Van Hees 0903.1096

Lesson n°1:

Several models containing either non perturbative features or tunable parameters are able to reproduce the HQ data, but many questions remain… and how to reconcile them all stays a challenge

Elastic D mesons @ RHIC

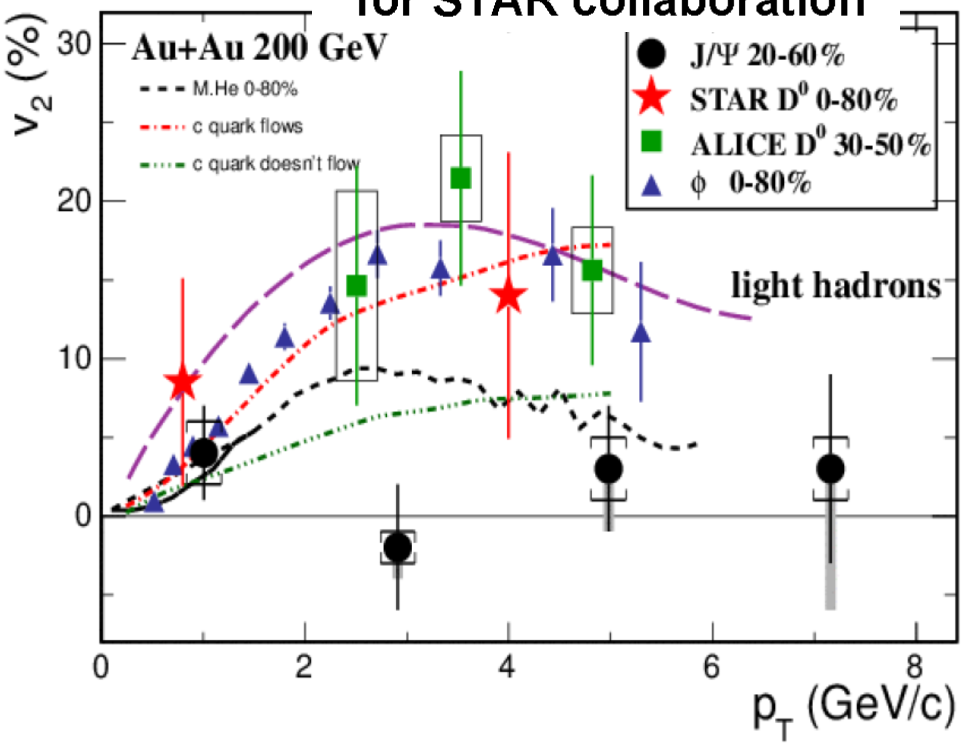
(Allow for some global rescaling of the rates: “K” fixed on experiment)

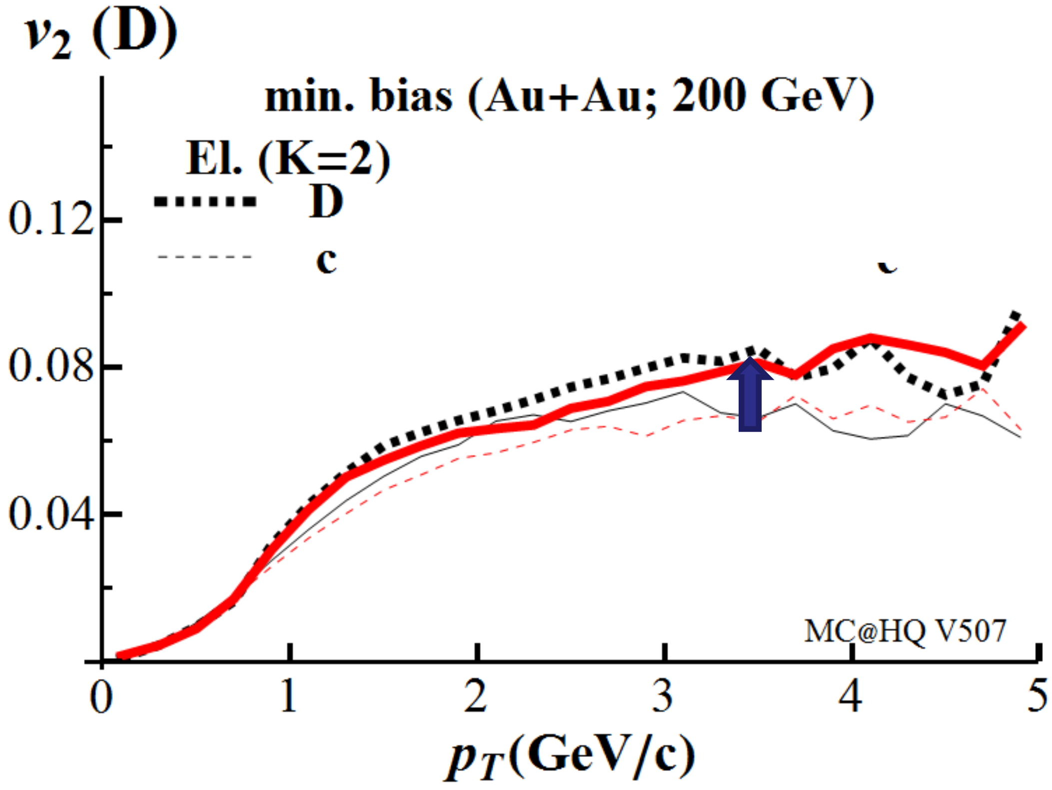


Elastic D mesons @ RHIC

Jaroslav Bielčík

for STAR collaboration





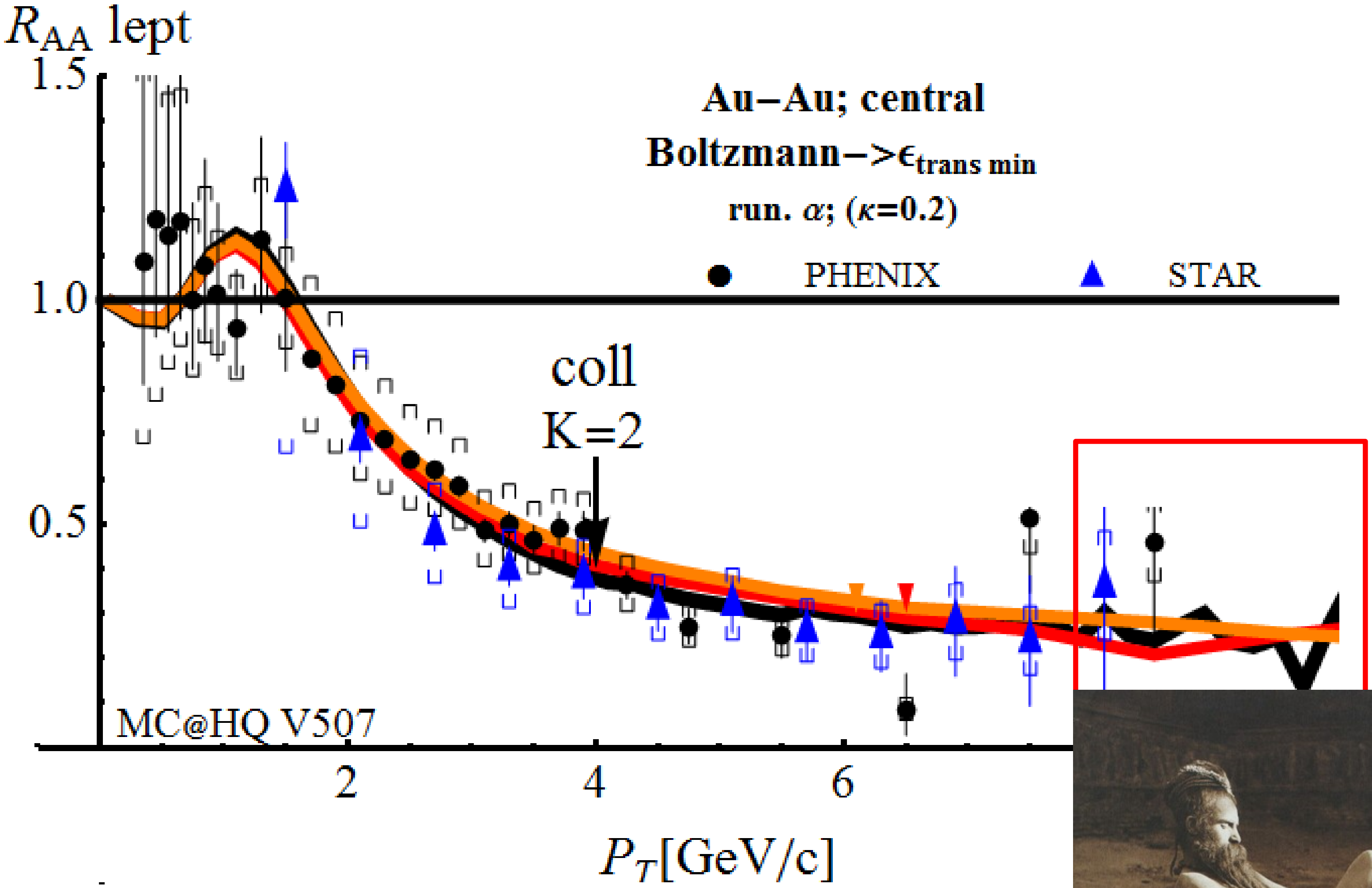
Rather little contribution from the light quark in our treatment… but conclusion may depend on the parameters (m_q, wave function)

Coalescence according to extended Dover framework

(PRC 79 044906)

$$N_\Phi = \int \frac{d^3 p_q}{(2\pi\hbar)^3 E_q} \frac{p_q \cdot d\hat{\sigma}}{u_Q \cdot d\hat{\sigma}} f_q(x_Q, p_q)(\sqrt{2\pi} R_c)^3 \times F_\Phi(p_Q, p_q),$$

Elastic for leptons @ RHIC



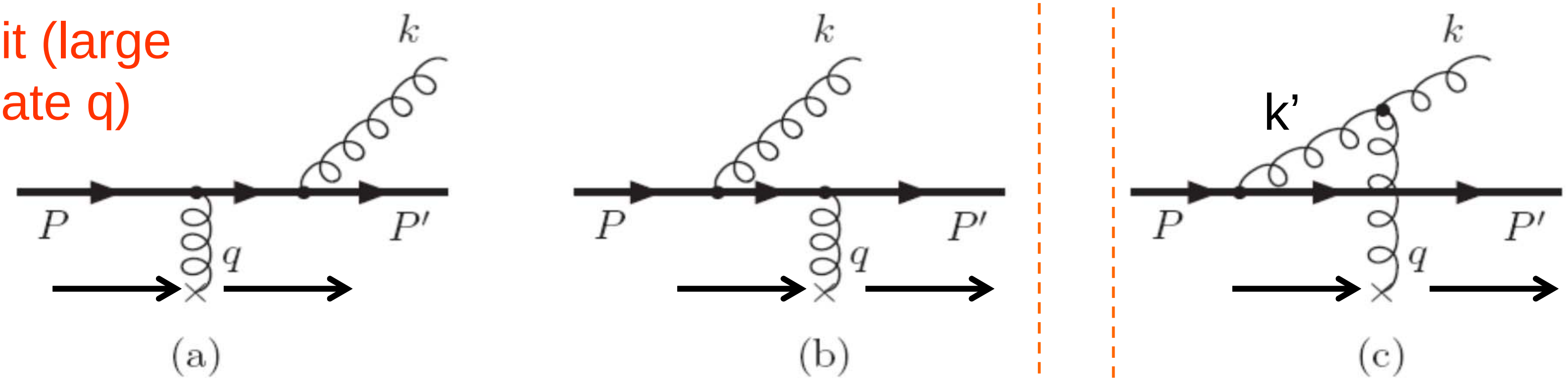
In principle:
Need for
radiative
energy loss…

Good agreement for NPSE as well

Induced Energy Loss

Generalized Gunion-Bertsch (NO COHERENCE) for finite HQ mass, dynamical light partons

Eikonal limit (large E, moderate q)



(a) (b) (c)

Dominates as small x as one “just” has to scatter off the virtual gluon k’

$$\omega \frac{d^3\sigma_{\rm rad}^{x\ll 1}}{d\omega\, d^2k_\perp\, dq_\perp^2} = \frac{N_c\alpha_s}{\pi^2}(1-x)\times\frac{J_{\rm QCD}^2}{\omega^2}\boxed{\times\frac{d\sigma_{\rm el}^{Qq}}{dq_\perp^2}}$$

with $$\frac{J_{\rm QCD}^2}{\omega^2} = \left(\frac{\vec{k}_\perp}{k_\perp^2 + x^2M^2 + (1-x)\underbrace{m_g^2}_{}} - \frac{\vec{k}_\perp - \vec{q}_\perp}{\left(\vec{k}_\perp - \vec{q}_\perp\right)^2 + x^2\underbrace{M^2}_{} + (1-x)m_g^2}\right)^2$$

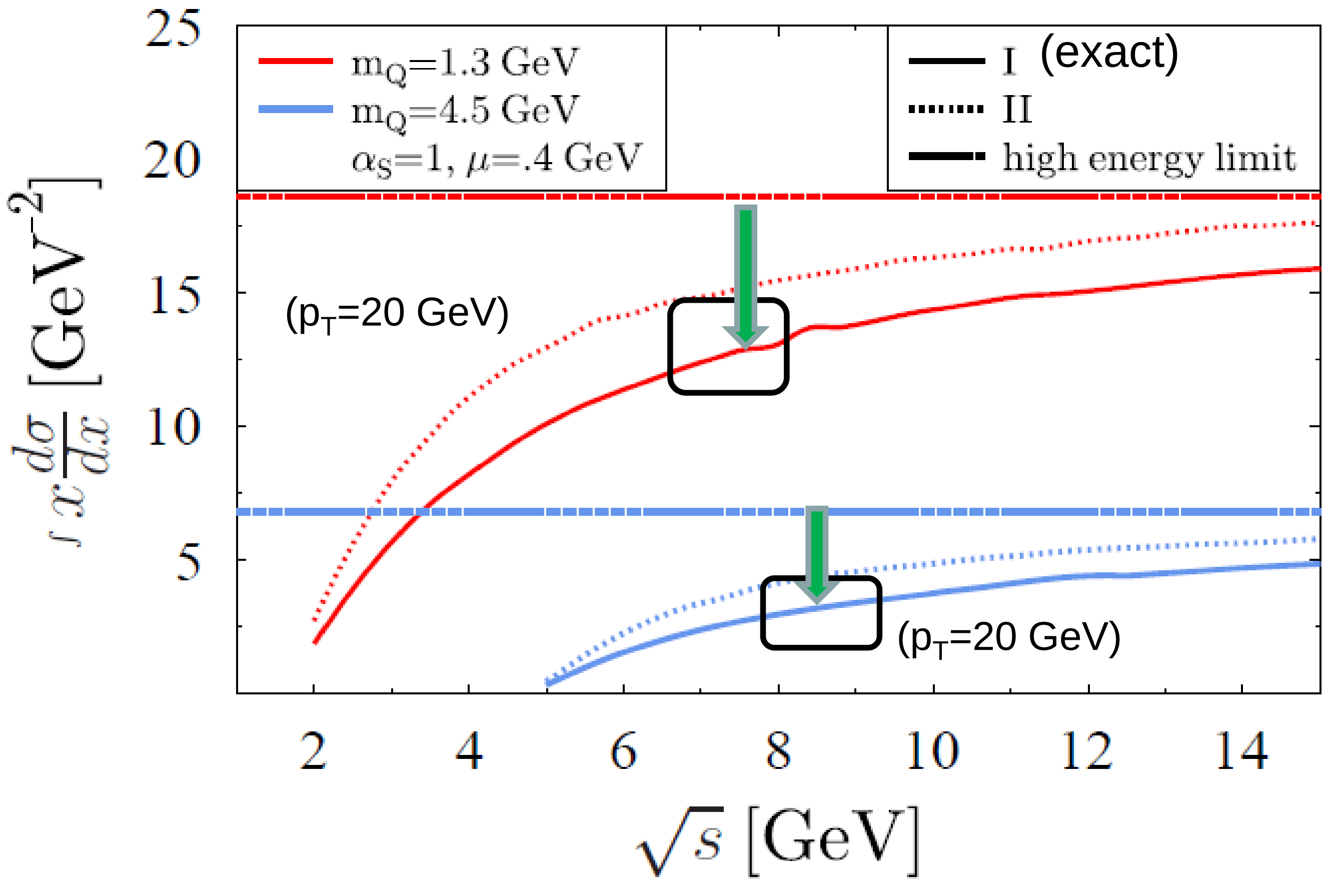
Gluon thermal mass ~2T (phenomenological; not in BDMPS)

Quark mass

Both cures the collinear divergences and influence the radiation spectra (dead cone effect)

Incoherent Induced Energy Loss

… & finite energy !



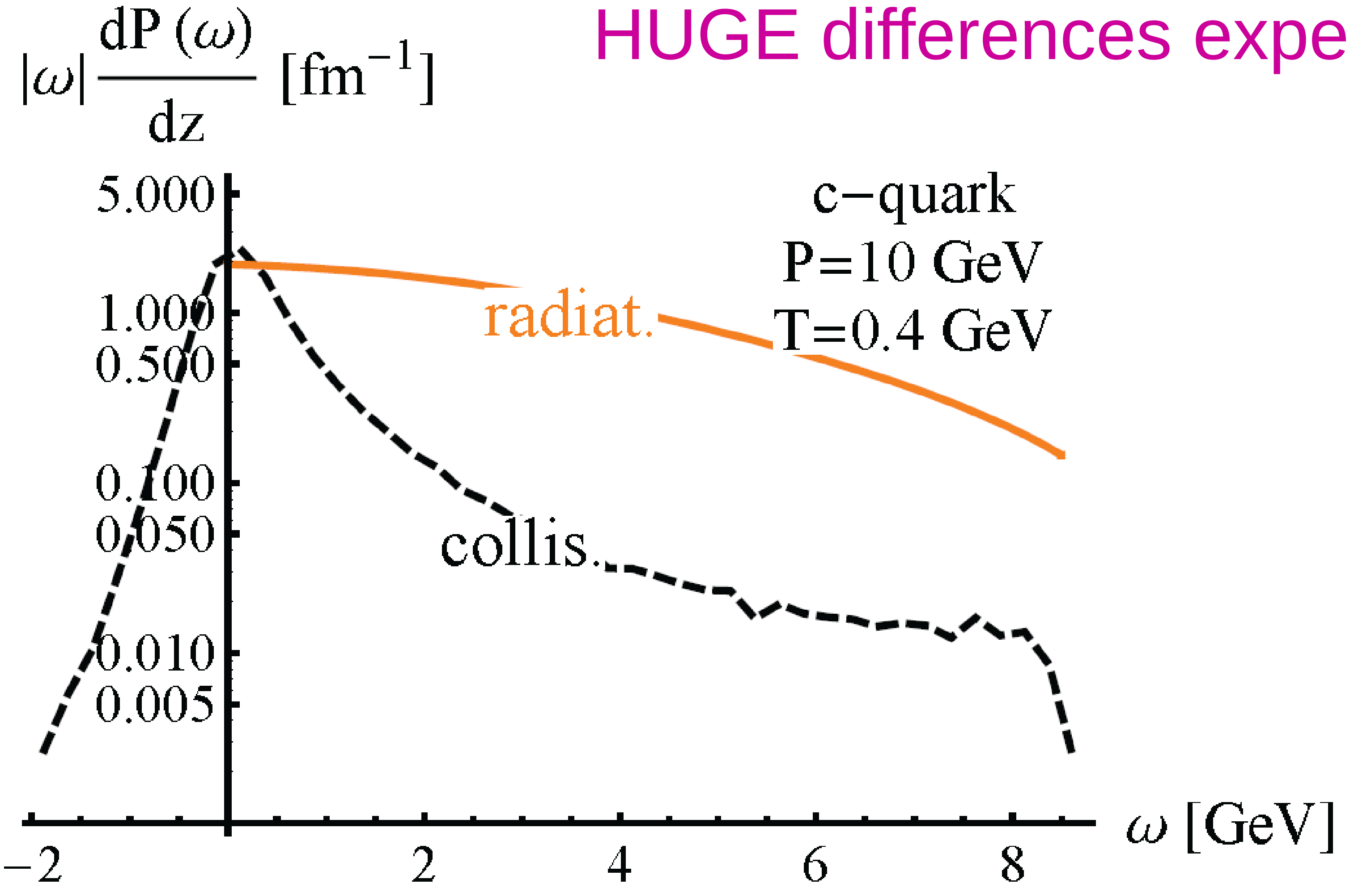
Gousset, Gossiaux & Aichelin, Phys. Rev. D 89, 074018 (2014)

Finite energy lead to strong reduction of the radiative energy loss at intermediate p_T

Incoherent Induced Energy Loss

Probability P of energy loss ω per unit length (T,M,…):

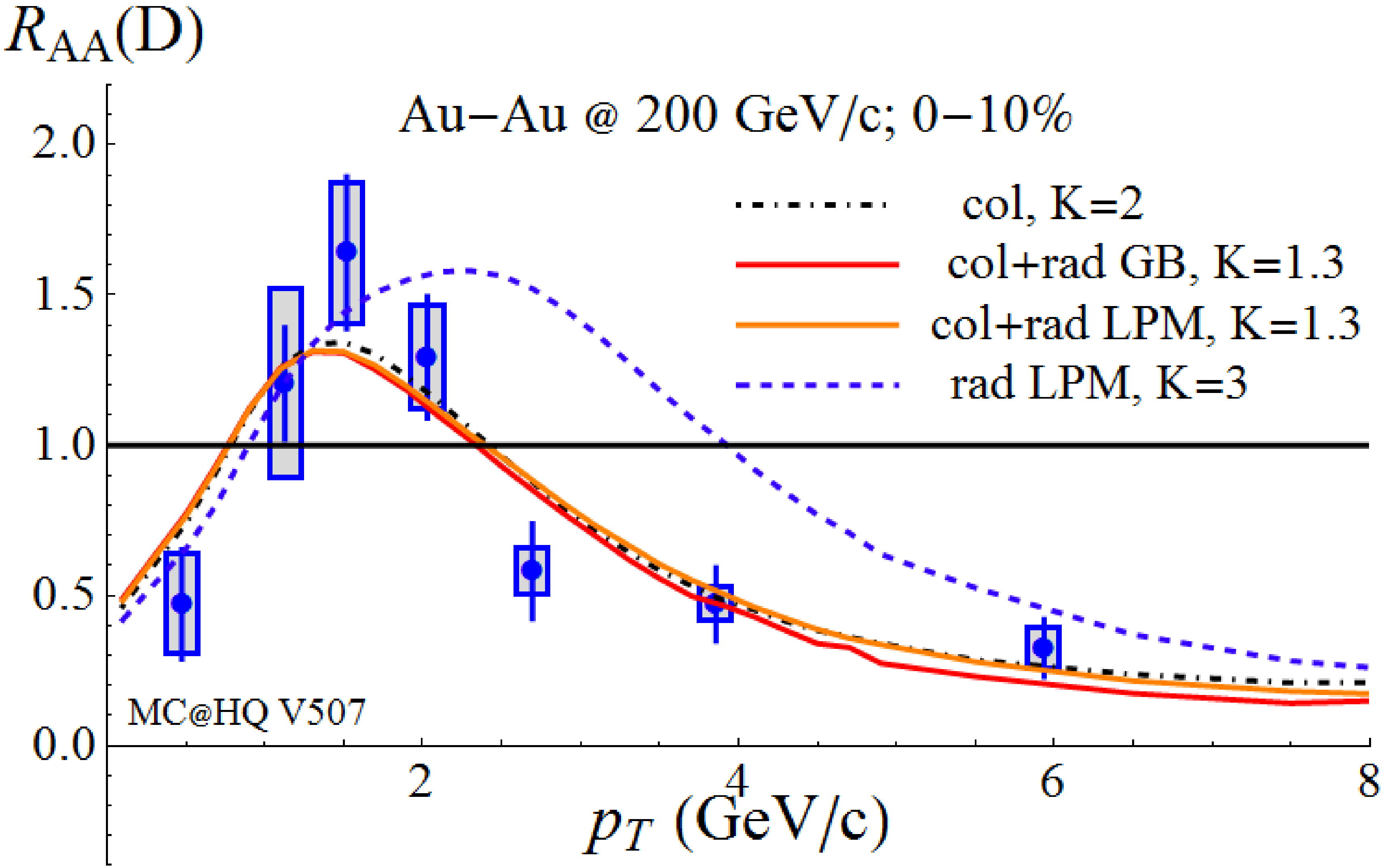
HUGE differences expected



Caveat: no detailed balance implemented yet

{Radiative + Elastic} vs Elastic for D mesons @ RHIC

=> Allow for some global rescaling of the rates: “K” fixed on experiment



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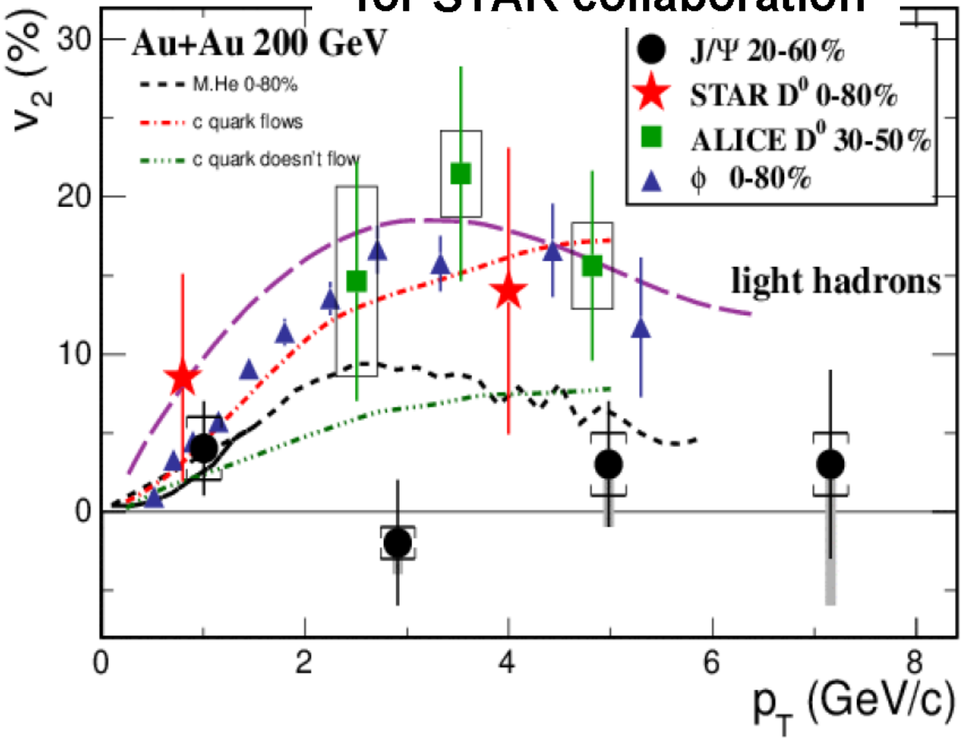
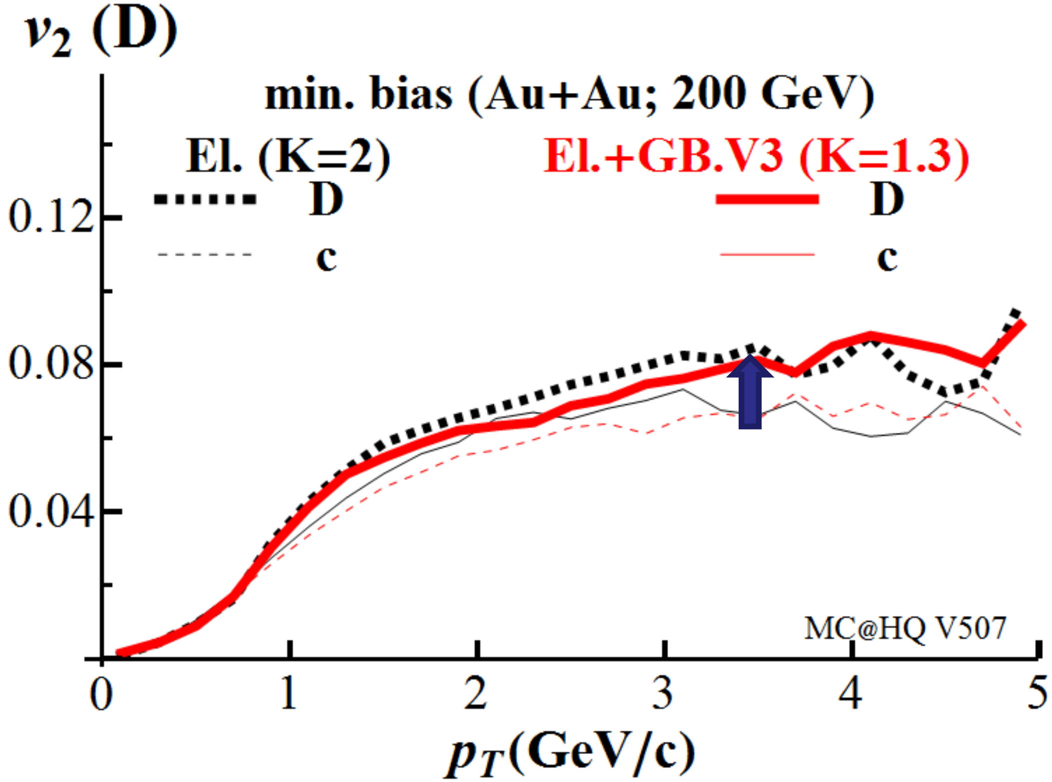
for STAR collaboration





No lack of elliptic flow wrt pure elastic processes

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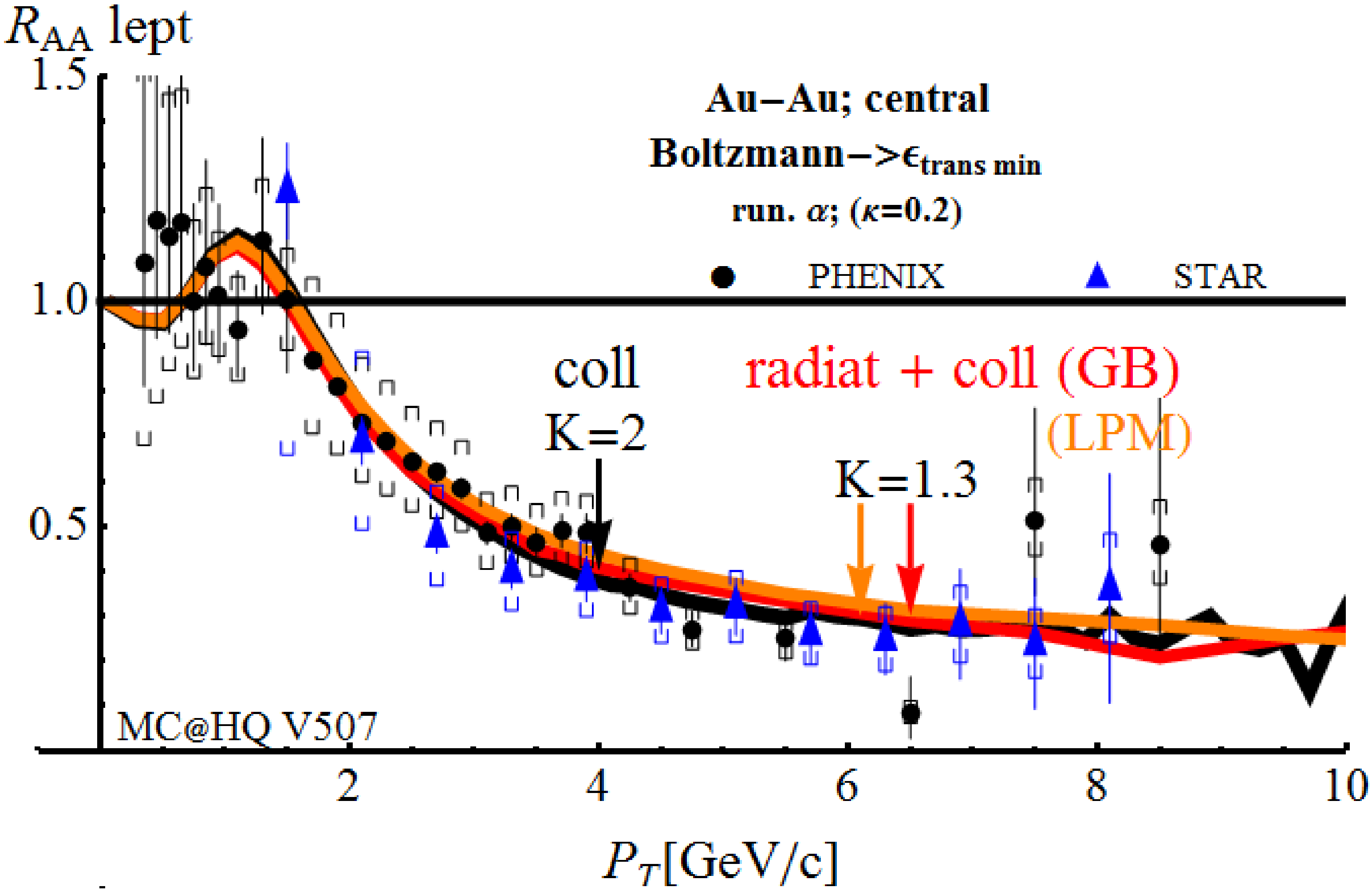
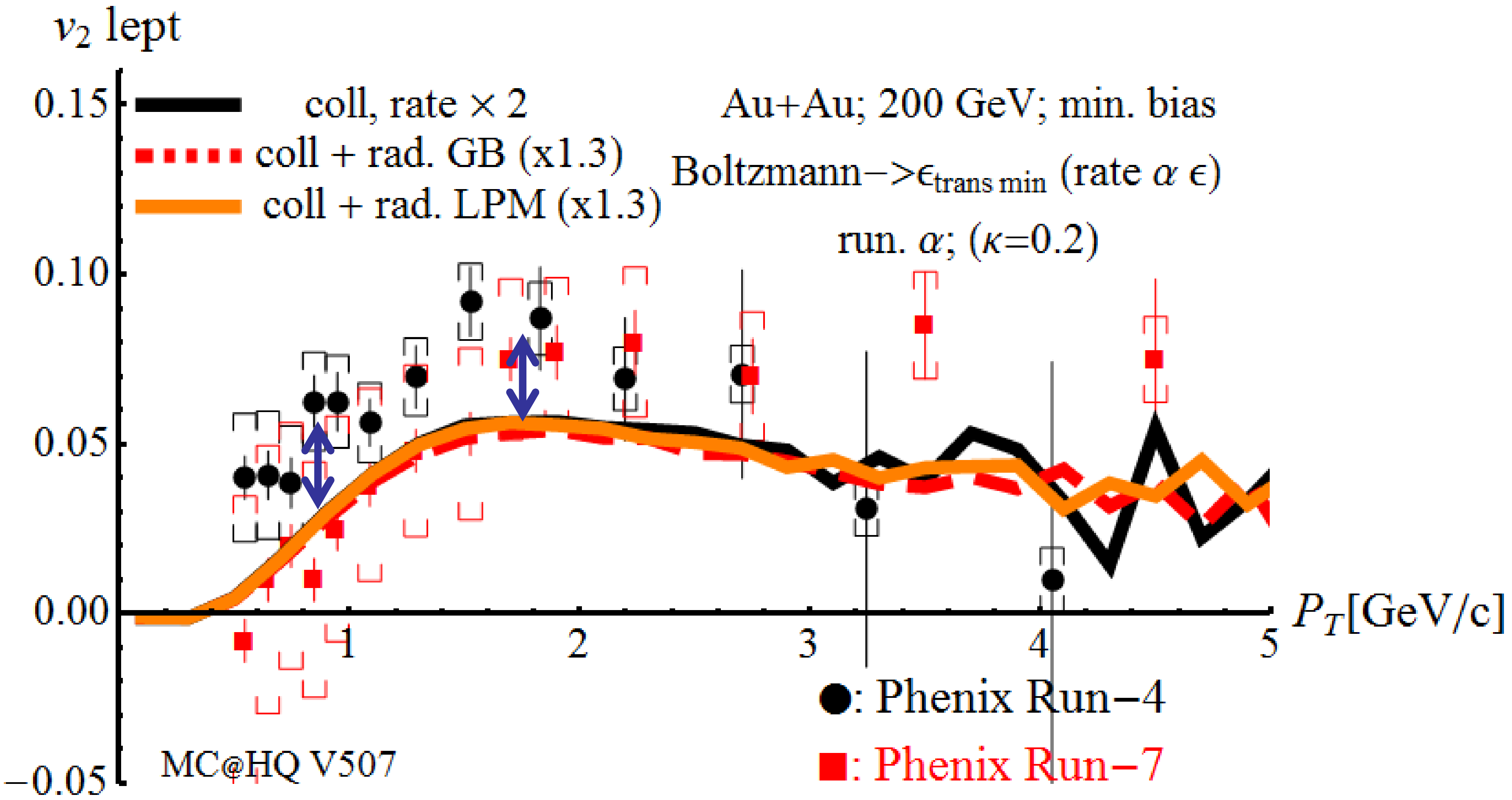
$$N_\Phi = \int \frac{d^3 p_q}{(2\pi\hbar)^3 E_q} \frac{p_q \cdot d\hat{\sigma}}{u_Q \cdot d\hat{\sigma}} f_q(x_Q, p_q)(\sqrt{2\pi}\, R_c)^3 \times F_\Phi(p_Q, p_q),$$

{Radiative + Elastic} vs Elastic for leptons @ RHIC



Good agreement for NPSE as well

{Radiative + Elastic} vs Elastic for leptons @ RHIC



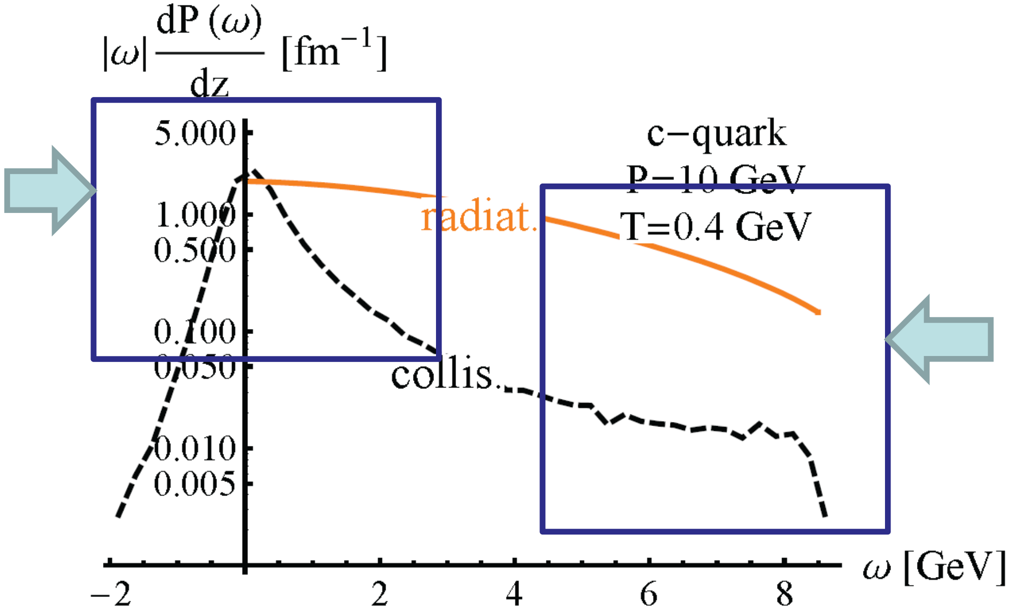
Good agreement for NPSE as well

Conclusions from RHIC

- ➢ Good consistency between NPSE and D mesons (10% difference in K values)…
- ➢… within a model with mass hierarchy
- ➢ ΔE radiative < ΔE elastic

➢ Present data at RHIC cannot decipher between the 2 local microscopic E-loss models (elastic, elastic + radiative GB) ⇒ Not sensitive to the large-ω tail of the Energy-loss probability (thanks to initial HQ p_T-distribution)

“Fokker Planck” regime

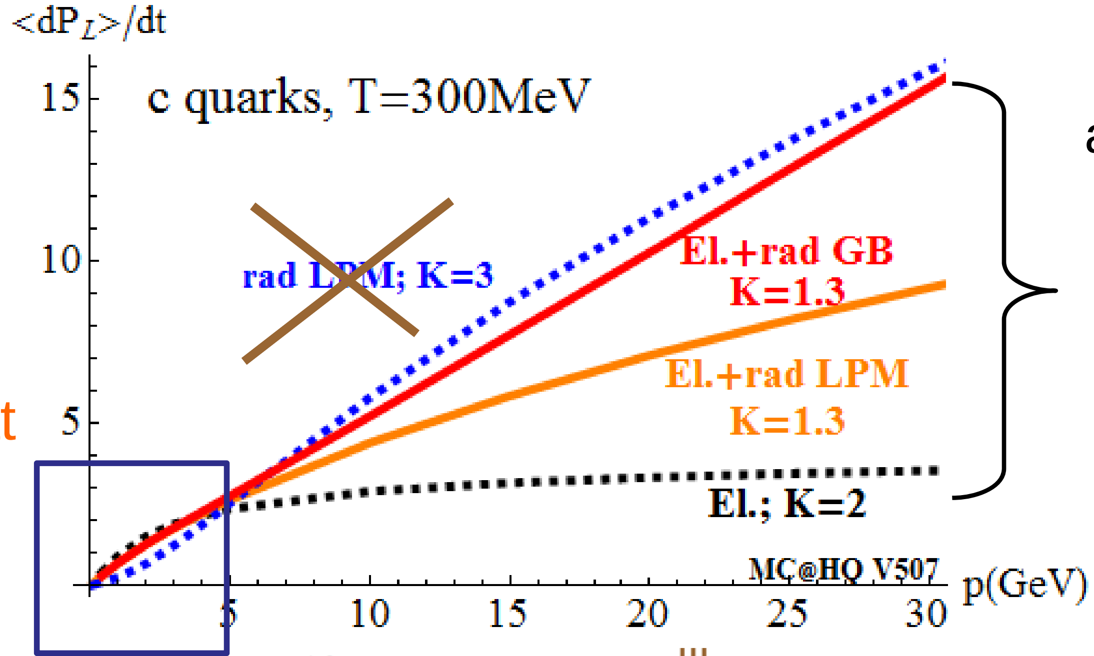


“hard scattering” regime

QGP properties from HQ probe at RHIC (why do we care ?)

Gathering all *rescaled* models (*coll. and radiative*) compatible with RHIC R_{AA}:

Similar diffusion coefficient at low p



the drag coefficient reflects the average momentum loss (per unit time) => large weight on *x* ~ 1

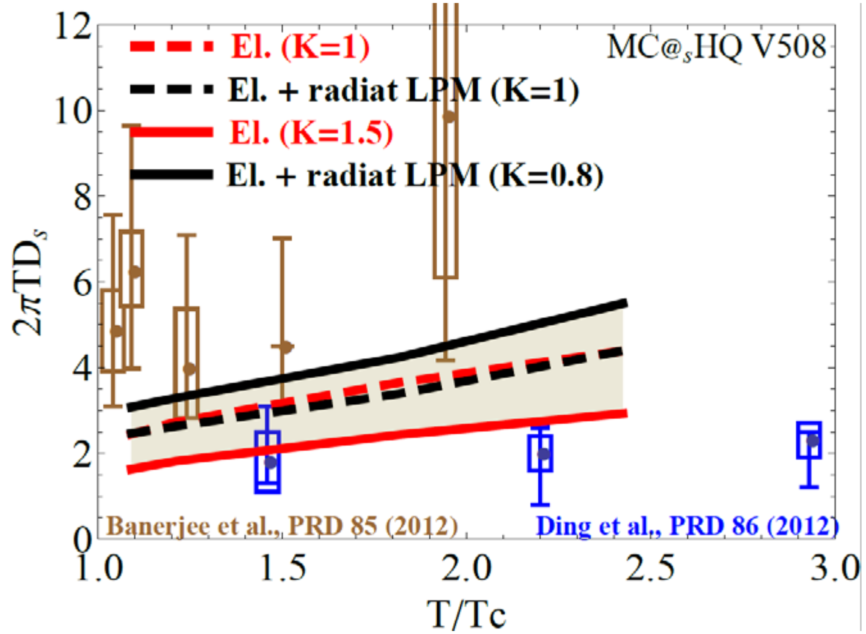
Present RHIC experiments cannot resolve between those various trends

Hope that LHC can do !!!

We extract it from data

(starting from SQM 2008)

We compare with recent lattice results

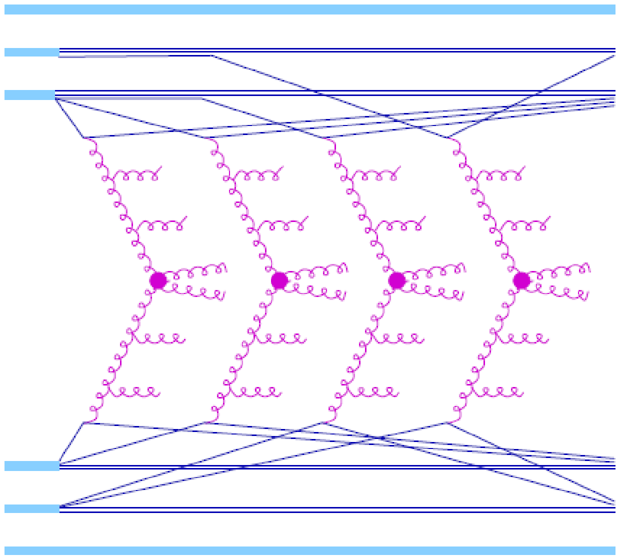


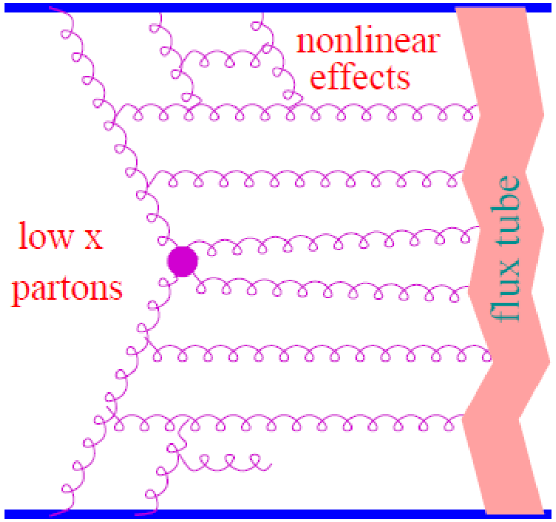
Main message

It is possible to reveal some fundamental property of QGP using HQ probes

Going LHC: EPOS + Hydro as a background for MC@sHQ

EPOS + Hydro : state of the art framework that encompass pp, pA and AA collisions





EPOS (initial conditions):

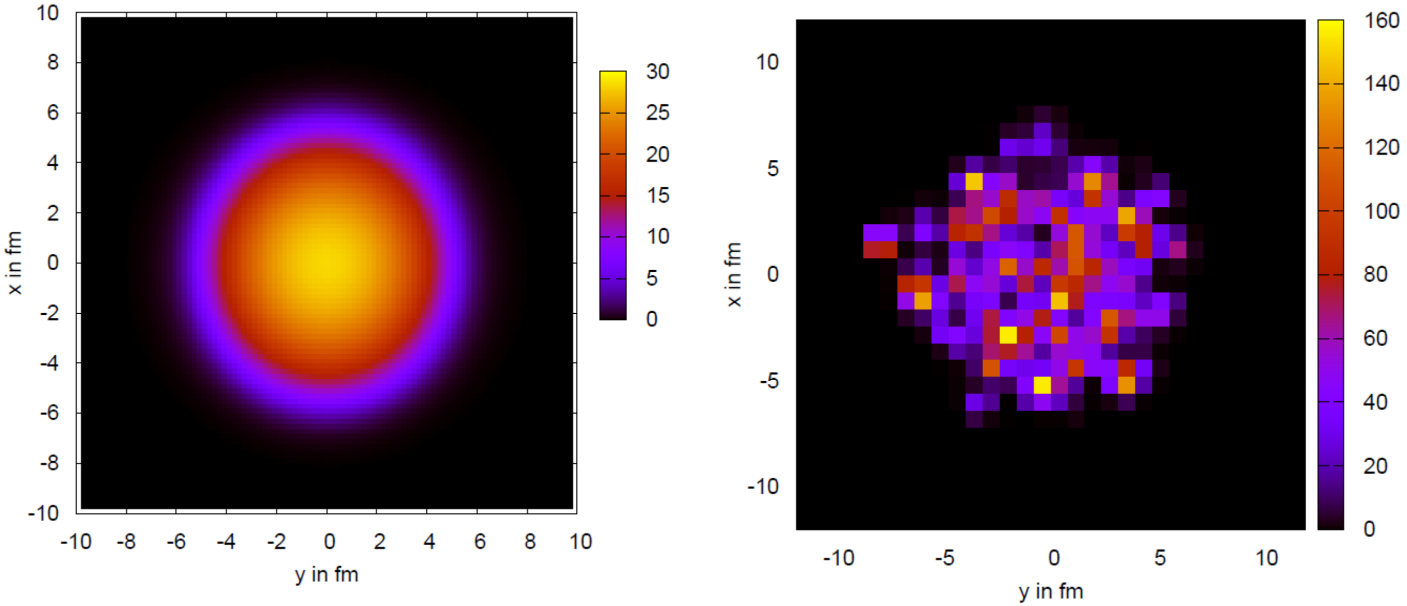
- Model based on Gribov-Regge multiple pomeron interactions
- Particle production in cut (semi-hard) pomerons, seen as partons ladder
- Soft particles form a flux tube (string, with its own dynamics, incl. string breaking)… lots of them in A-A
- Slow string segments, far from the surface, are mapped to fluid dynamic fields (-> hydro)
- Hard particles -> jets

Ref: K. Werner, Iu. Karpenko, M. Bleicher, T. Pierog, and S. Porteboeuf-Houssais Phys. Rev. C 85 (2012), 064907

Going LHC: EPOS as a background for MC@sHQ

EPOS: state of the art framework that encompass pp, pA and AA collisions

Initial energy density



Kolb Heinz (used previously)

EPOS

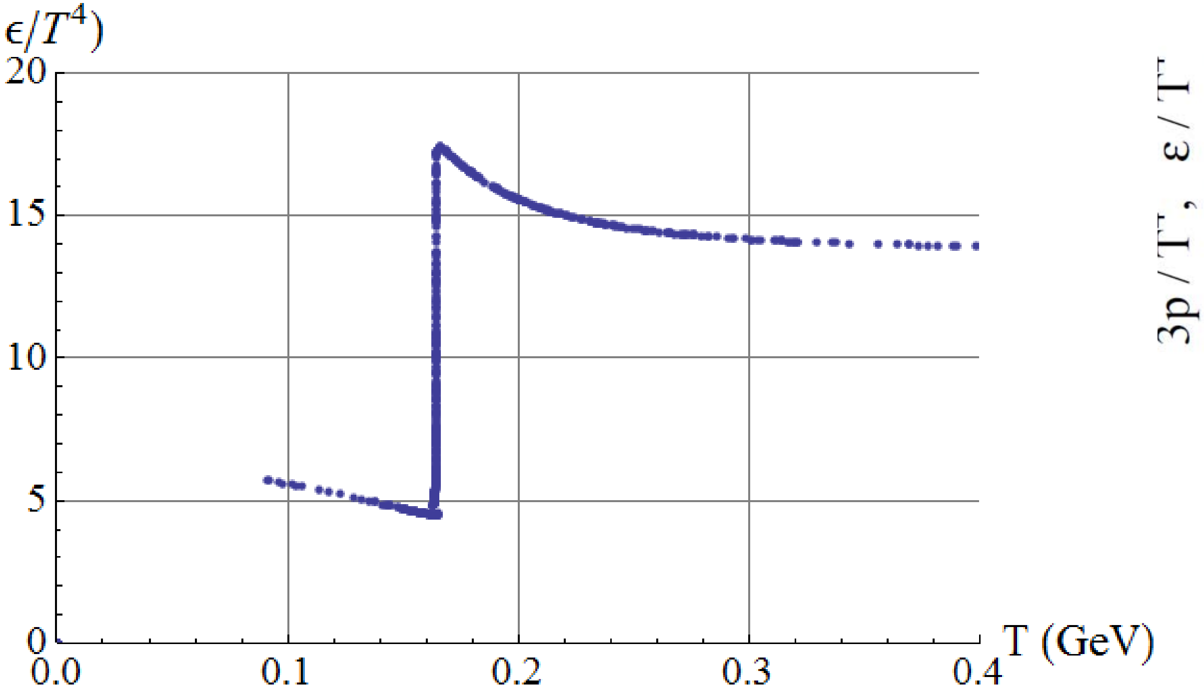
Beware: ≠ color scales

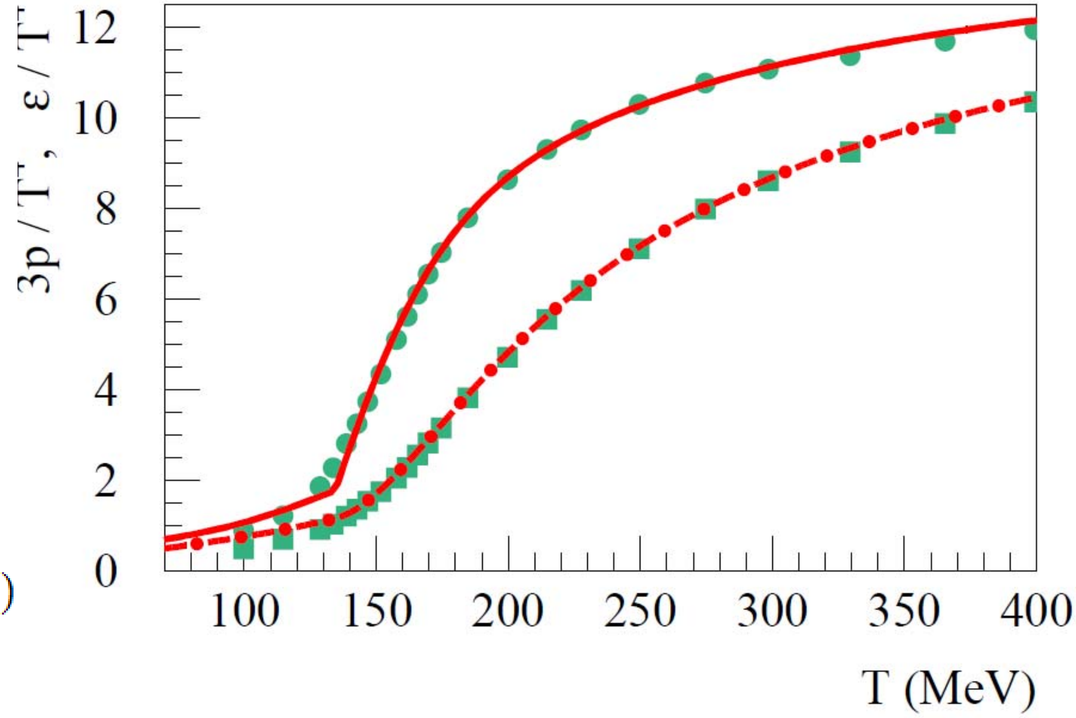
More realistic hydro and initial conditions => original HQ studies such as:

1) fluctuations in HQ observables (some HQ might « leak » through the « holes » in the QGP)

2) correlations between HF and light hadrons

Large differences in the EOS !





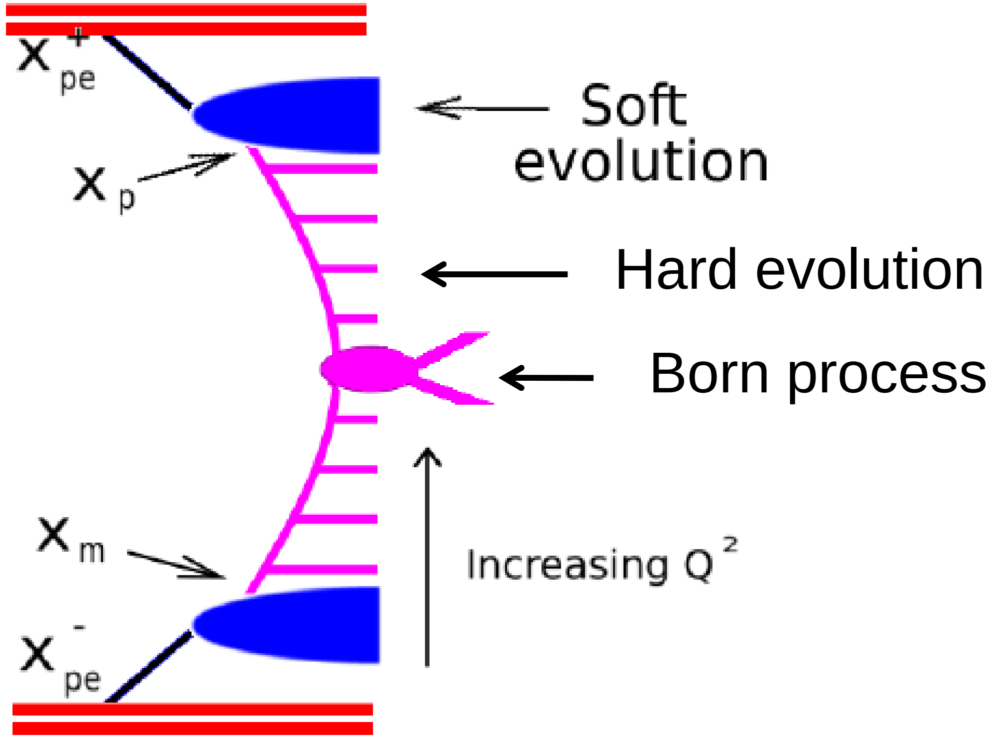
Kolb Heinz: bag model (1rst order transition btwn hadronic phase and massless partons)

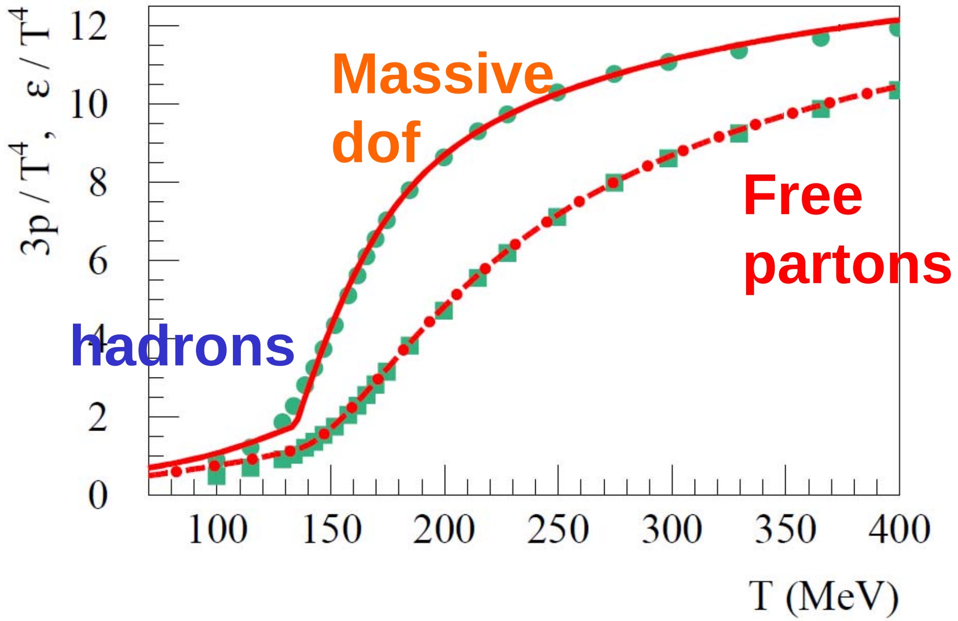
EPOS2: fitted on the lattice data from the Wuppertal-Budapest collaboration: cross-over

Coupling EPOS and MC@sHQ

Two main (physical) issues:

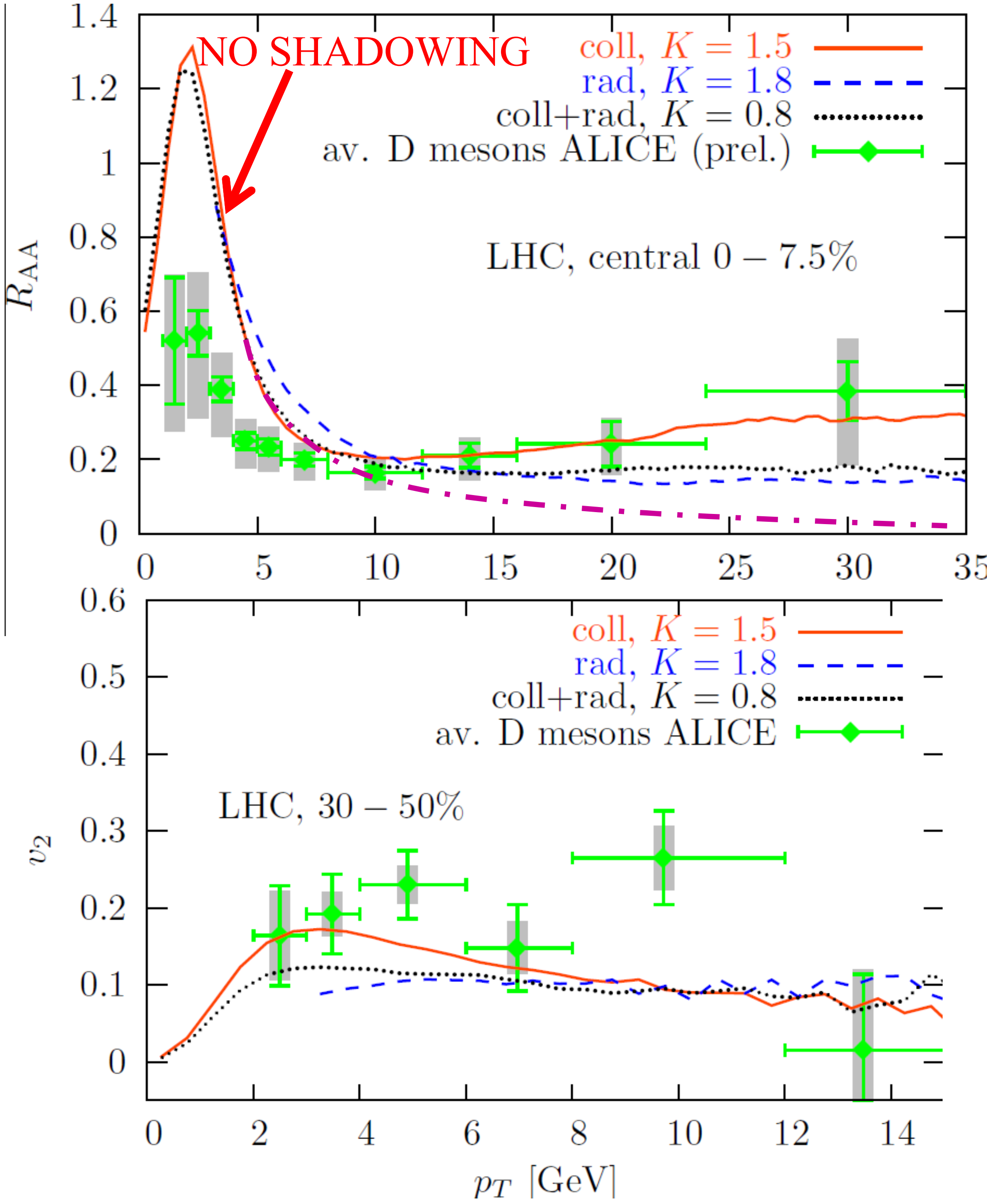
1) Generating initial HQ consistently with the multi-partonic approach in EPOS (done in EPOS3; B. Guiot)





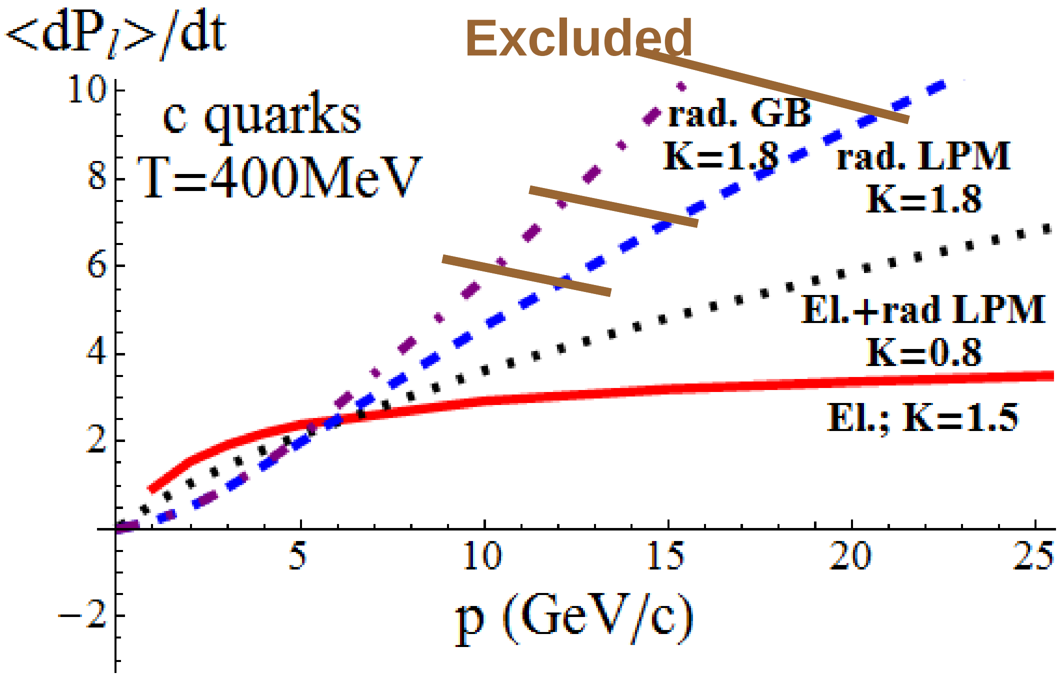
2) Dealing properly with the underlying degrees of freedom in a crossover evolution btwn hadronic phase and QGP.

Going LHC: EPOS2 as a background for MC@sHQ



Same microscopic ingredients as for RHIC (ΔE α L);

N.B.: K values: slightly smaller then what obtained from RHIC

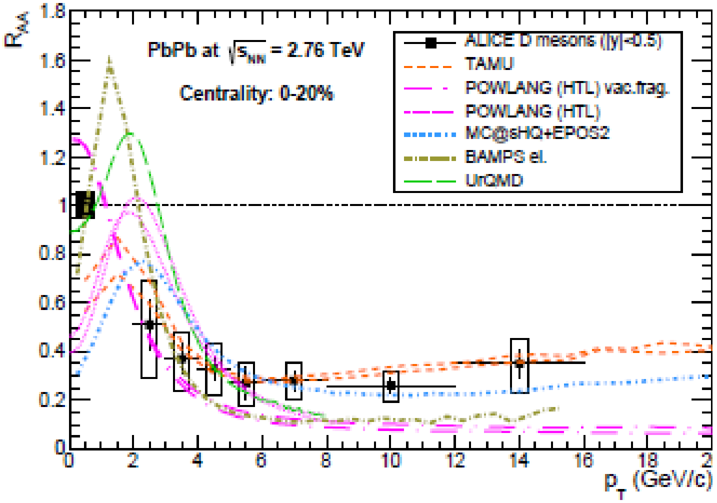


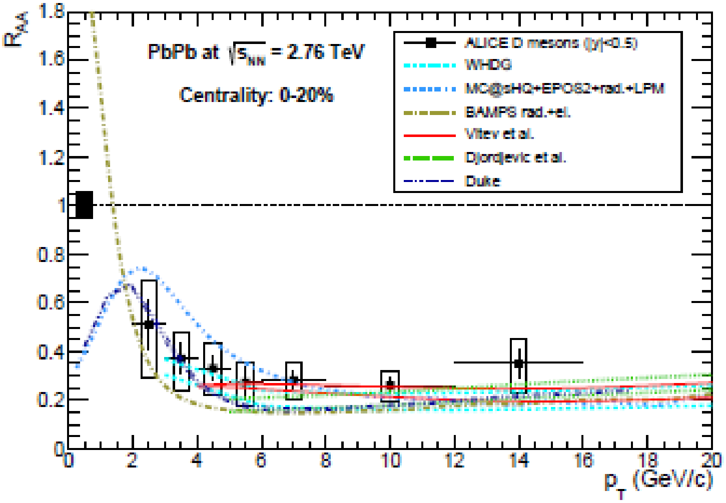
Data at large p_T seems to favor « Collisional only »- like average momentum loss

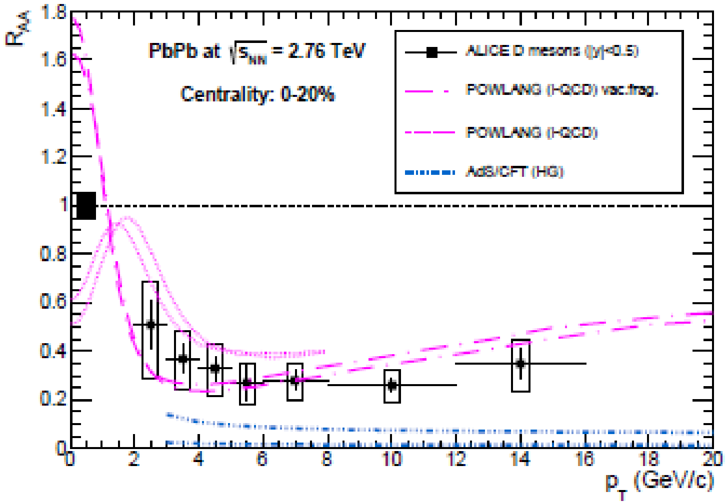
Further comparison with model calculations at LHC

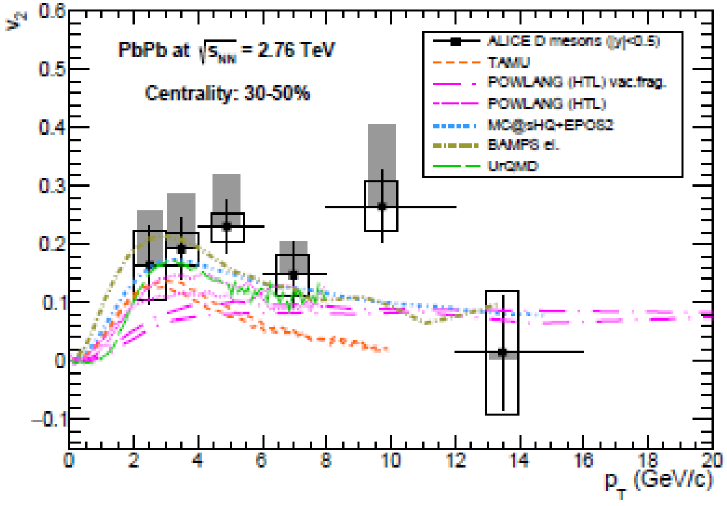
Sapore Gravis report (arxiv 1506.03981)

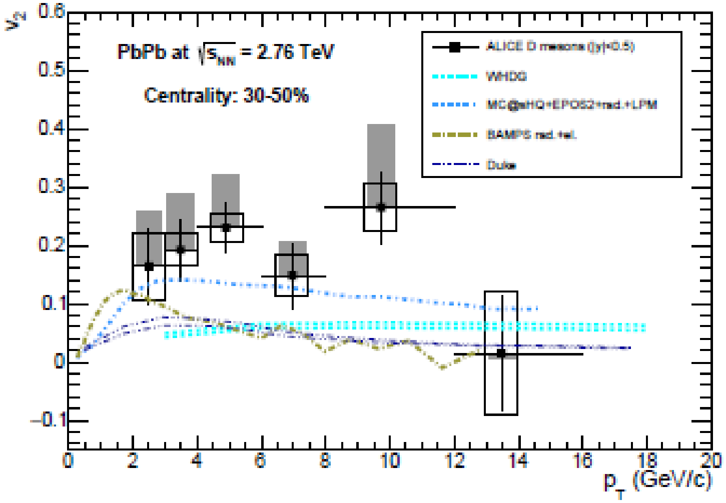
Elastic **(Elastic +) Radiative** **Other**

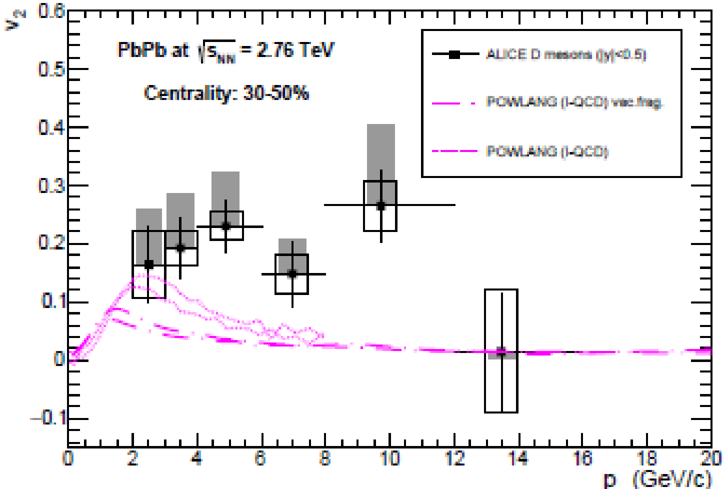










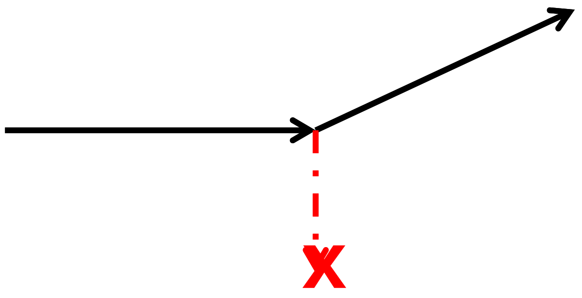


Moving forward…

<u>Central question (to better understand the probe)</u>:

How to distinguish between

Typical - Collisional



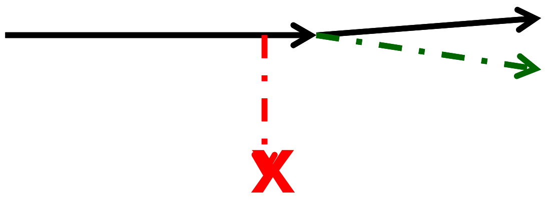
Large cross-section,

moderate E-loss per collision

large angular deflection

Mass comes as a scale in a log

Typical - Radiative



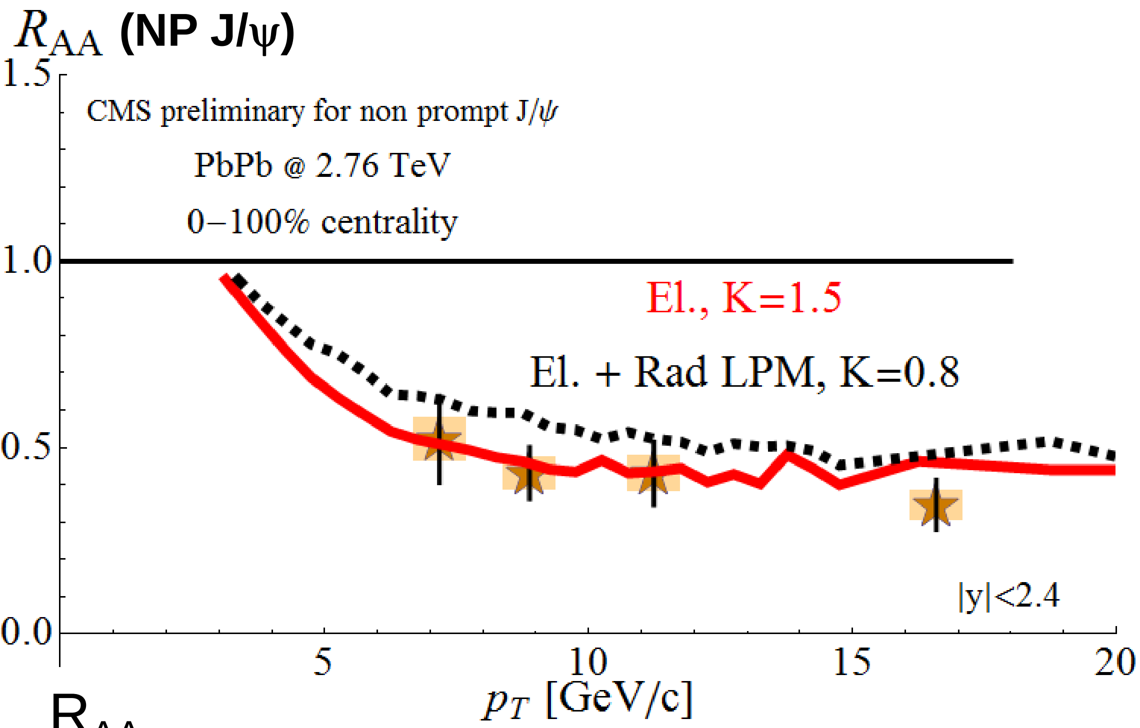
Small cross-section,

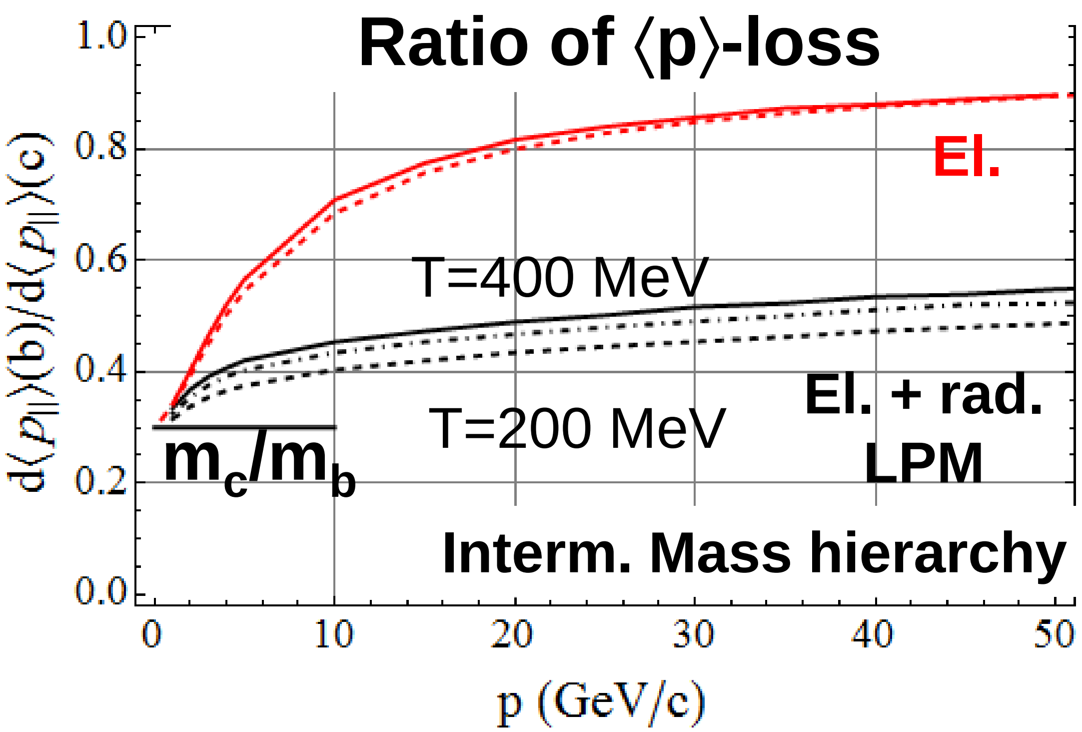
large E-loss per collision

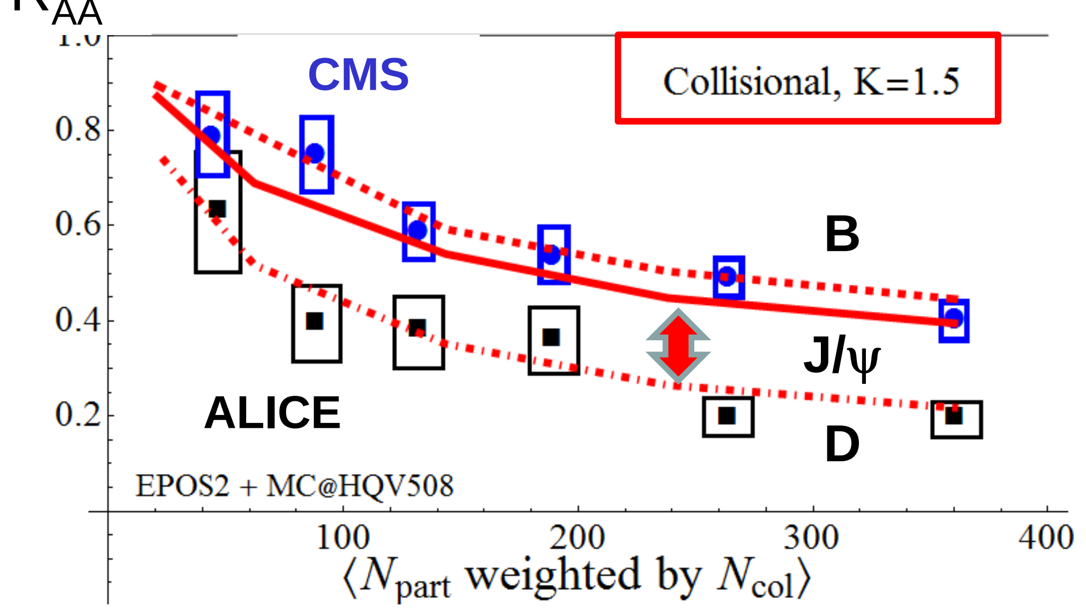
small angular deflection

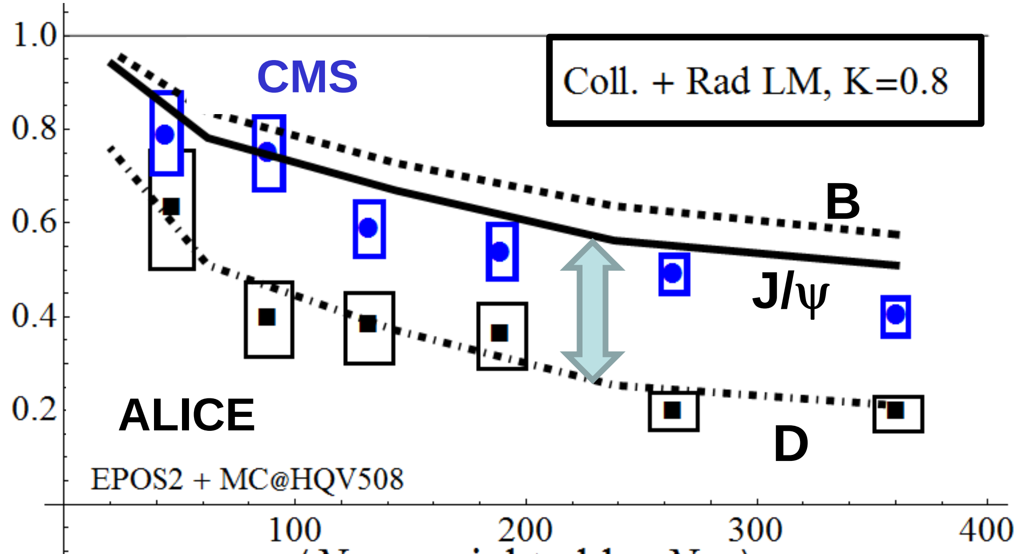
Mass regularizes collinear divergence
=> stronger mass-influence

Distinguishing btwn the models: mass dependence





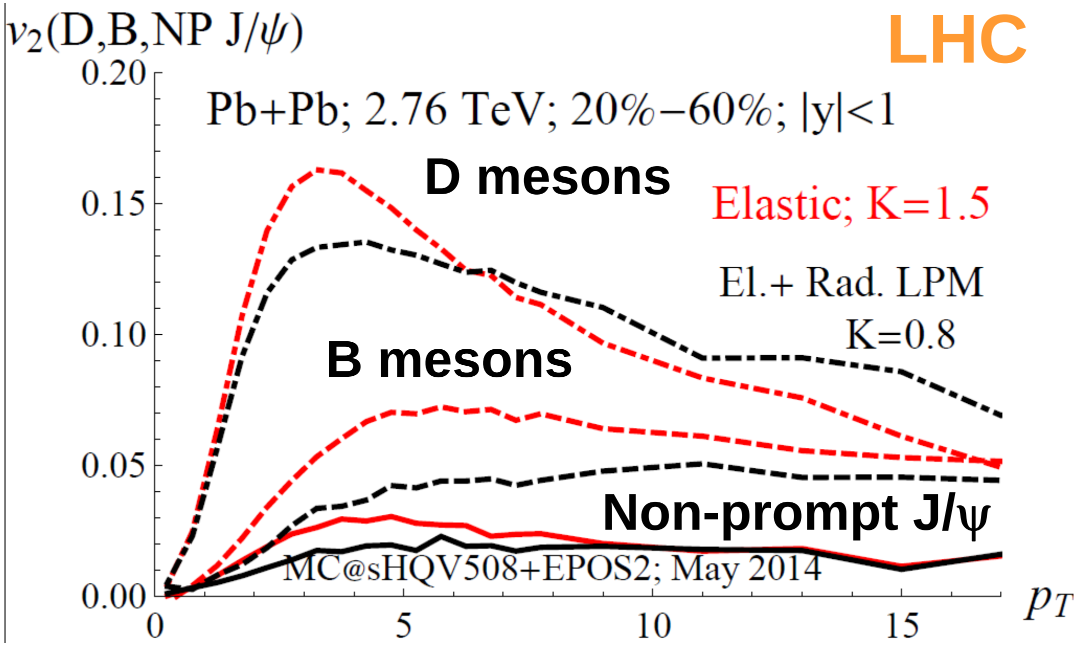


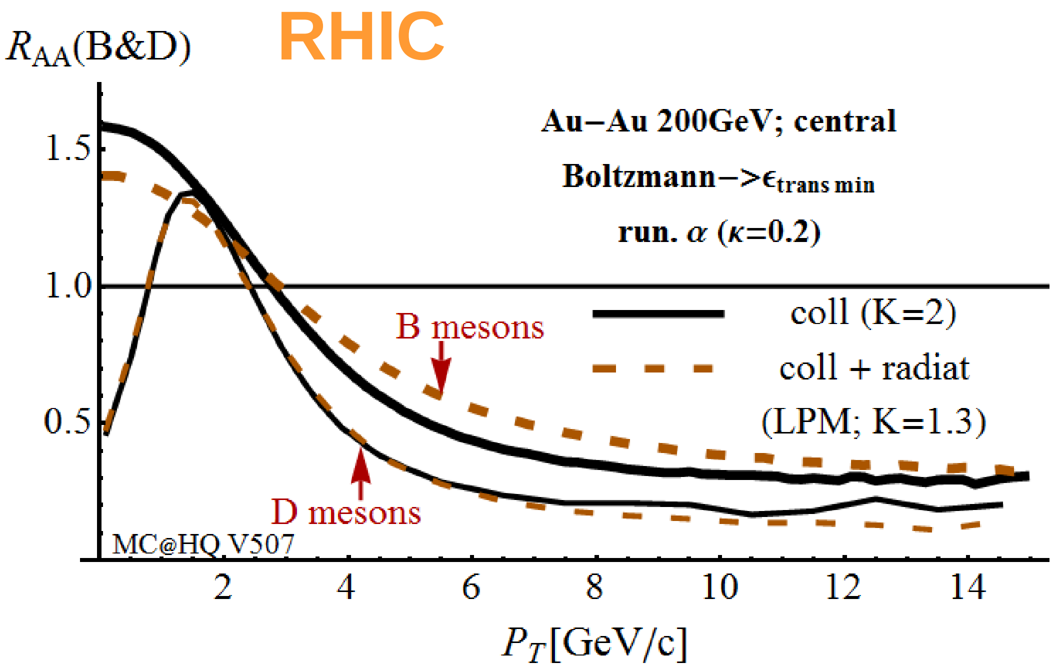


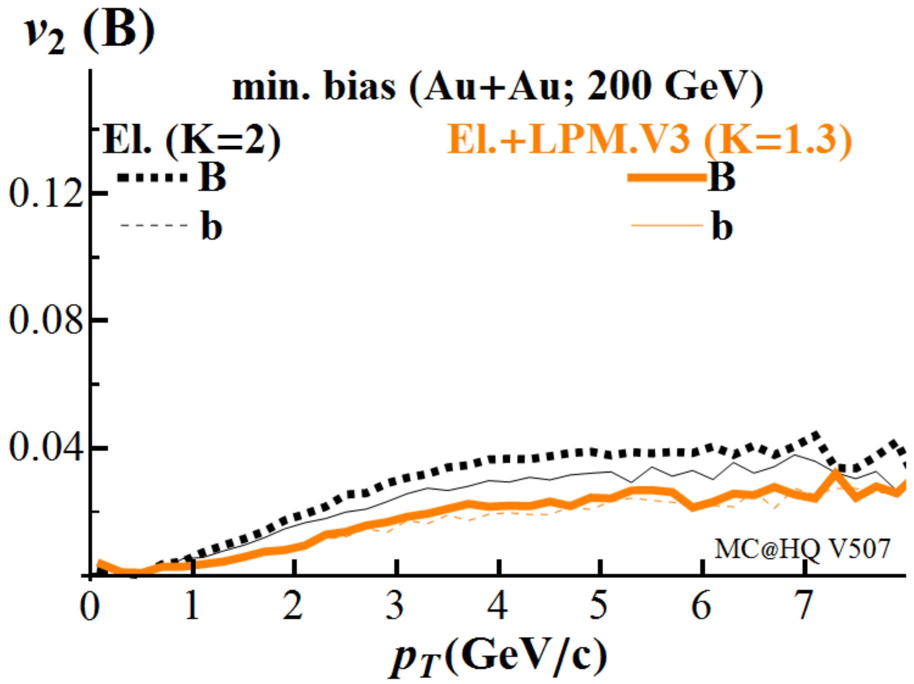
Distinguishing btwn the models: mass dependence

Predictions:

(moderate but finite difference… to be seen)







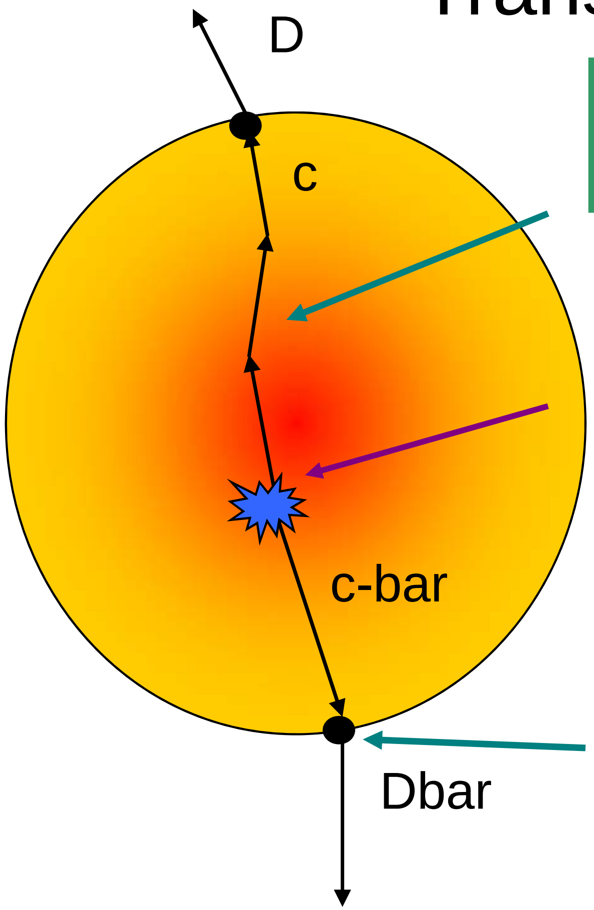
Distinguishing btwn the models: angular correlations…

2-body observables

Large cross-section,
moderate E-loss per collision
large angular deflection,

Small cross-section,
large E-loss per collision
small angular deflection,

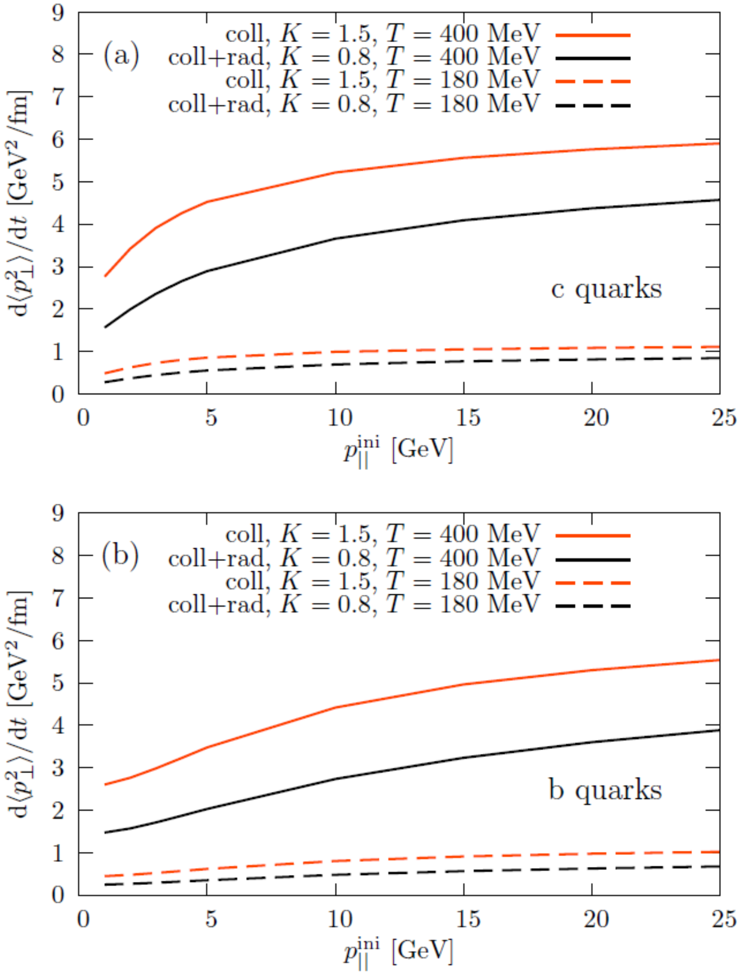
Transverse plane



Transverse broadenning ./. Initial direction

Initial correlation ; back to back at leading order

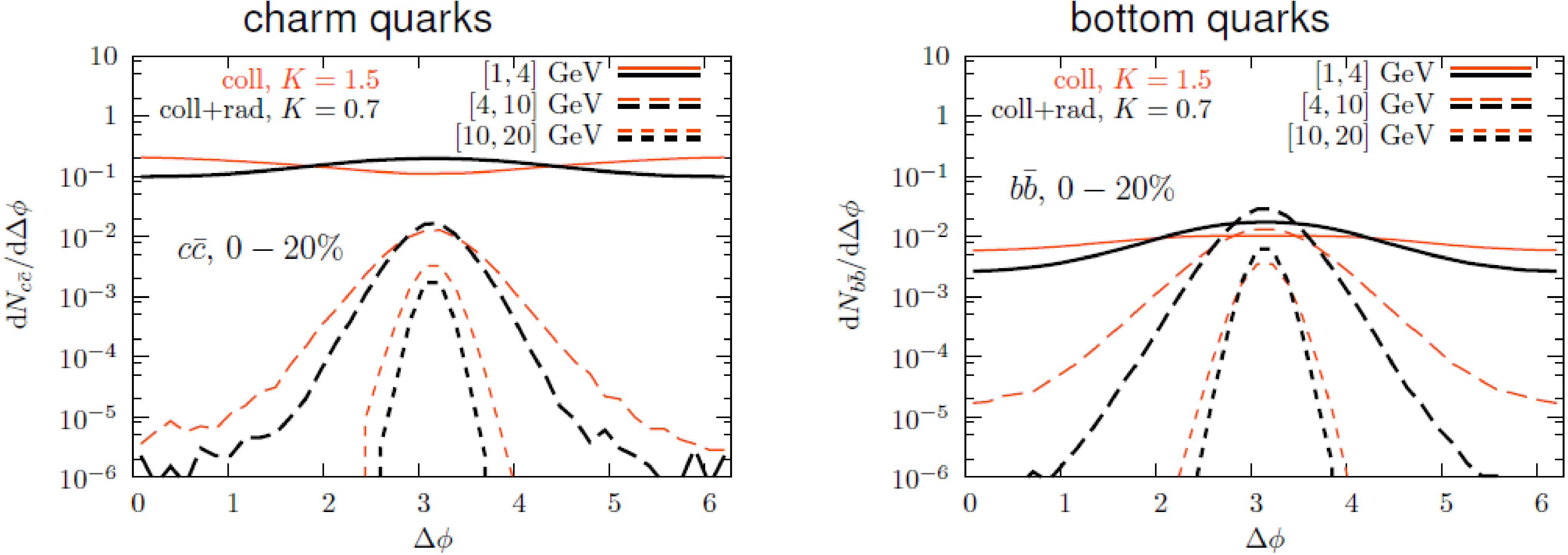
Effect of hadronization on angular correlation ?



Nahrgang et al Phys. Rev. C 90, 024907 (2014)

Heavy quarks azimuthal correlations: Back-to-back

Pb-Pb at LHC, HQ initialized back-to-back, no background from uncorrelated pairs, eff.deg=1; decoupling at T=155 MeV



- Stronger broadening in a purely collisional than in a **collisional+radiative** interaction mechanim
- At low pT, initial correlations are almost washed out. Some collectivity seen in the purely collisional scenario
- Variances in the intermediate pT range (4 GeV-10 GeV): 0.18 vs **0.094** (charm) and 0.28 vs **0.12** (bottom)
- At higher pT, initial correlations survive the propagation in the medium

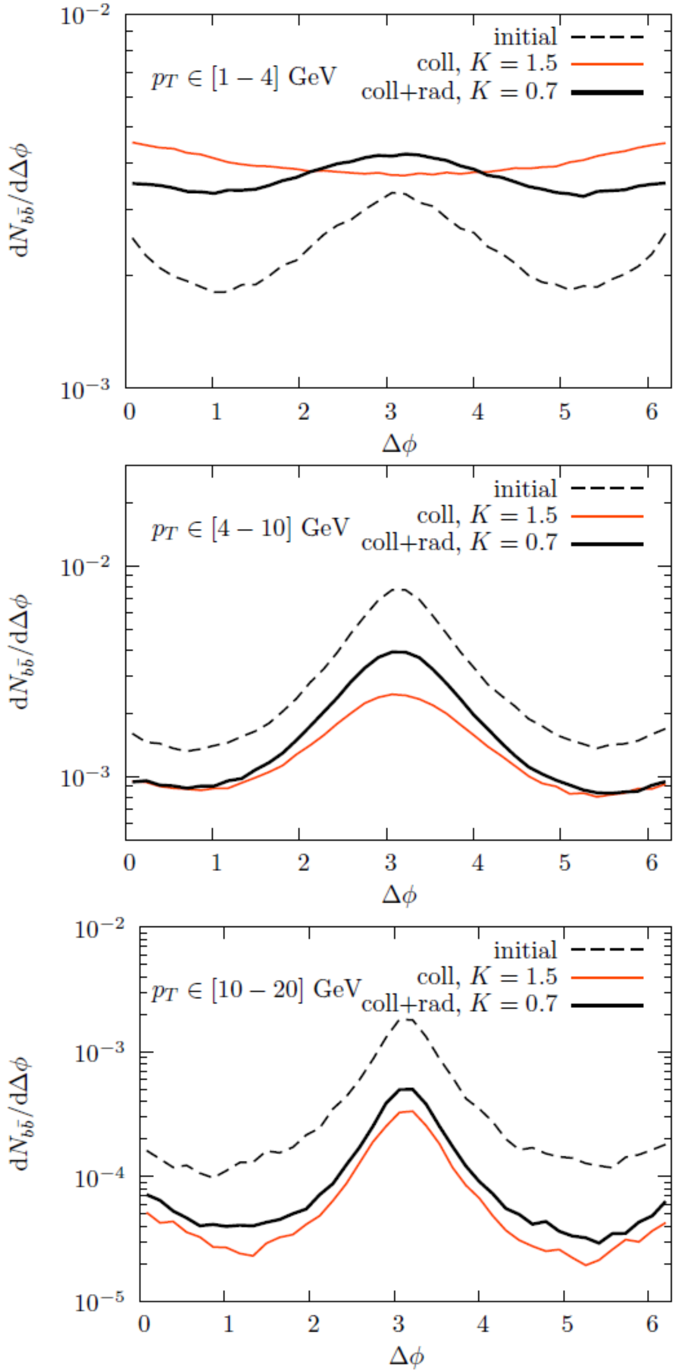
Nahrgang et al Phys. Rev. C 90, 024907 (2014)

… and with Realistic initial distributions: MC@NLO

Next-to-leading order QCD matrix elements coupled to parton shower (HERWIG) evolution: MC@NLO

S. Frixione and B. R. Webber, JHEP **0206** (2002)
S. Frixione, P. Nason and B. R. Webber, JHEP **0308** (2003)

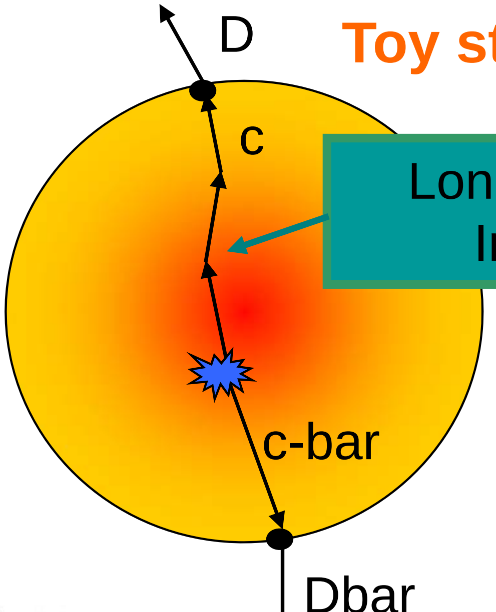
- Gluon splitting processes lead to an initial enhancement of the correlations at $\Delta\phi \approx 0$.
- For intermediate pT : increase of the variances from 0.43 (initial NLO) to 0.51 (≈ 20%) for the purely collisional mechanisms and to 0.47 (≈ 10%) for the interaction including **radiative** corrections (no additivity with initial width).
- At larger pT, the deviations from back to back correlations are mostly due to initial NLO corrections.
- Different NLO+parton shower approaches agree on bottom quark production, differences remain for charm quark production!



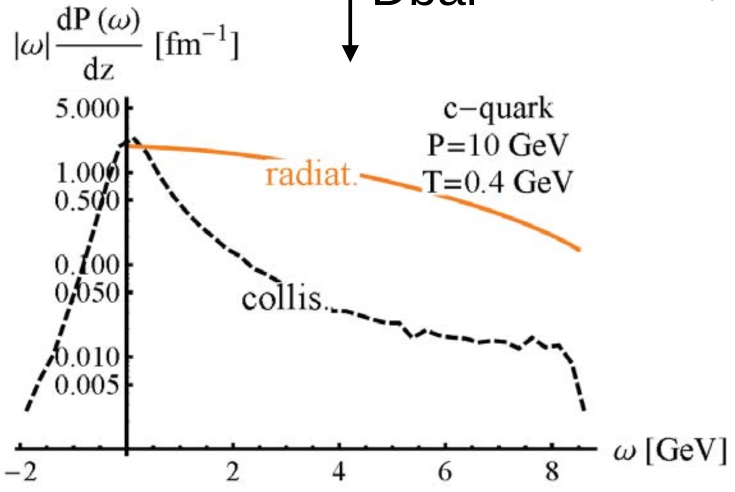
Nahrgang et al Phys. Rev. C 90, 024907 (2014)

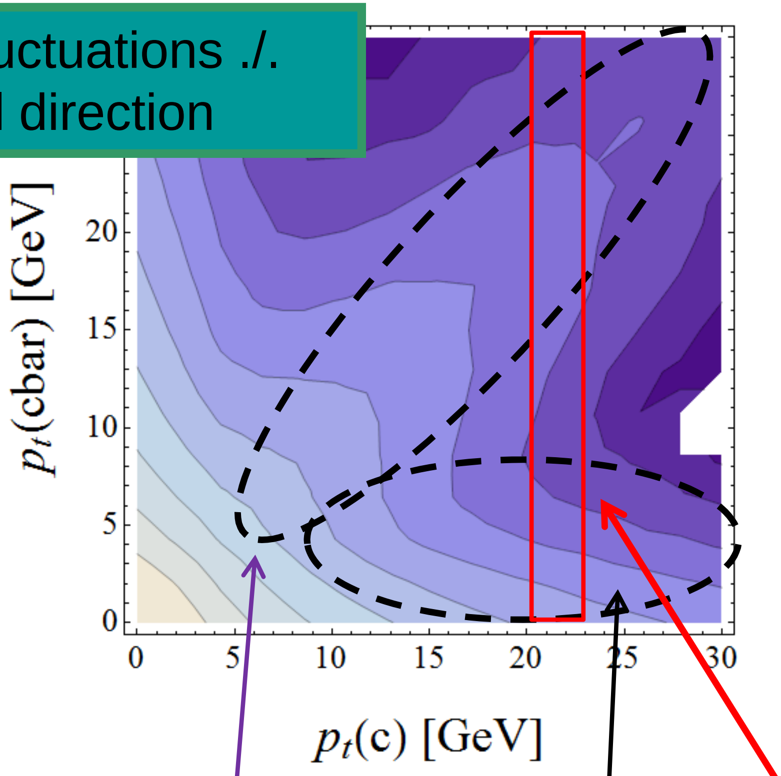
Consequences on the observables: $p_T(c)$-$p_T(\text{cbar})$ correlations

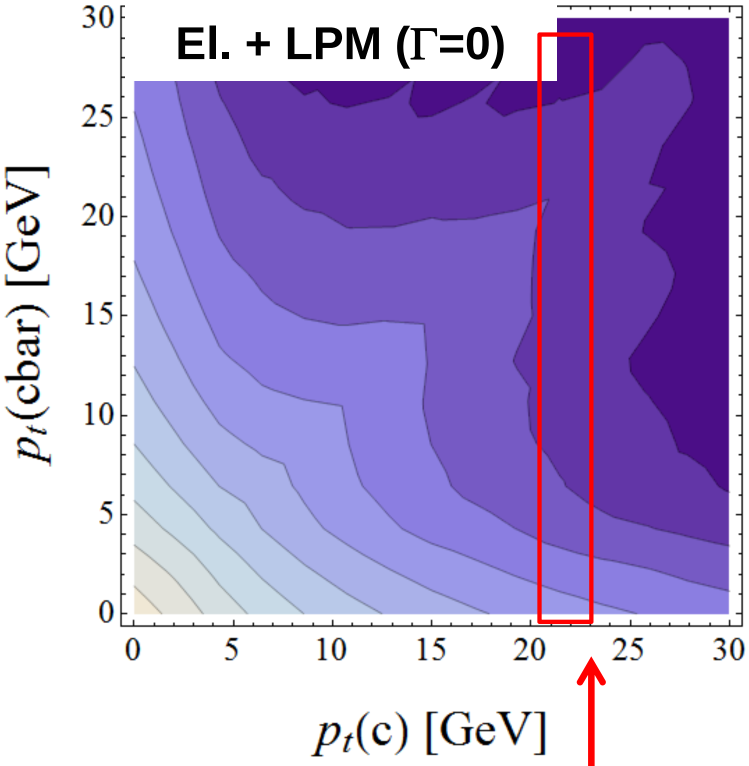
Toy study: back to back c-cbar (LO). Pb-Pb @ 2.76 TeV; 40-60%.



Long. fluctuations ./. Initial direction







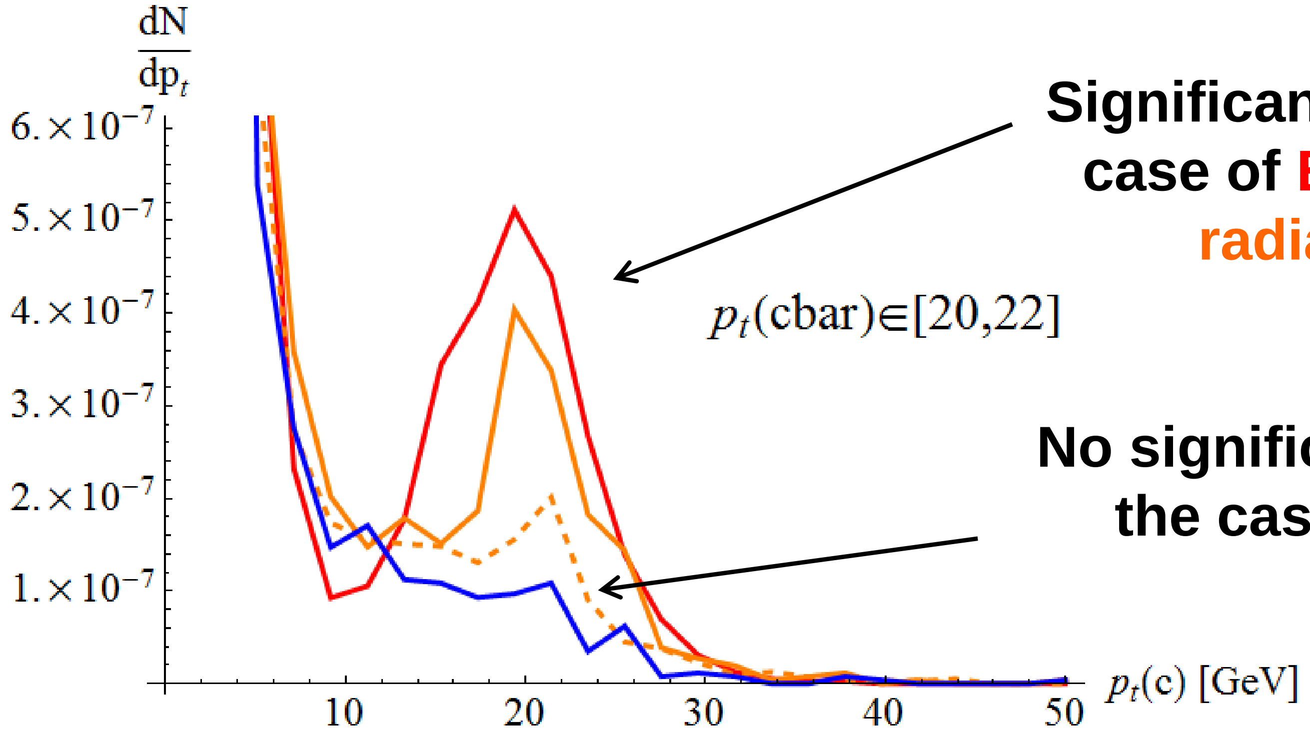
Background at small p_t

Tagging on 1 high p_T Qbar:

Residual correlation after evolution through QGP
(similar path length for most of HQ produced in the core of the reaction)

Consequences on the observables: p_t-$p_t$bar correlations

Toy study: back to back c-cbar (LO). Pb-Pb @ 2.76 TeV; 40-60%.



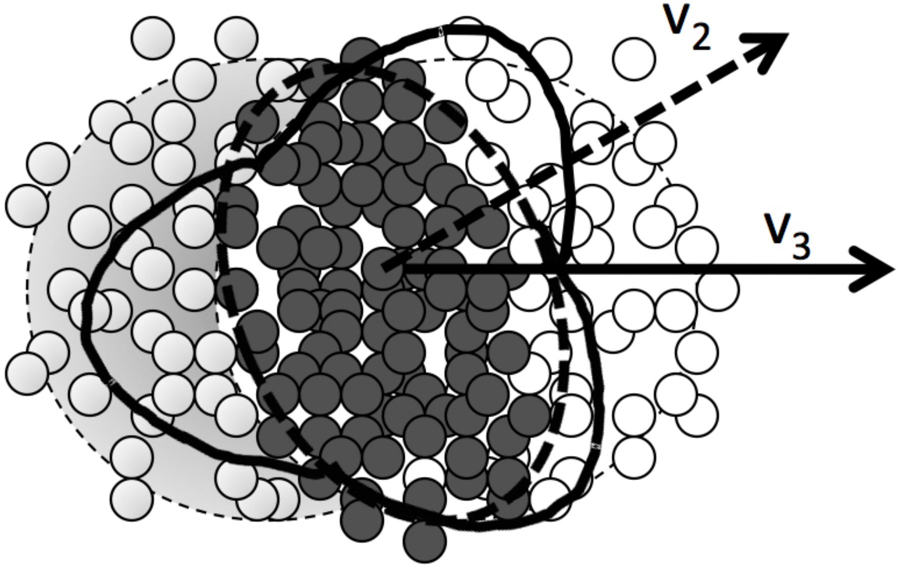
Significant residual correlation for the case of Elastic energy loss (or LPM radiative + gluon damping)

No significant residual correlation for the case of radiative GB or LPM radiative

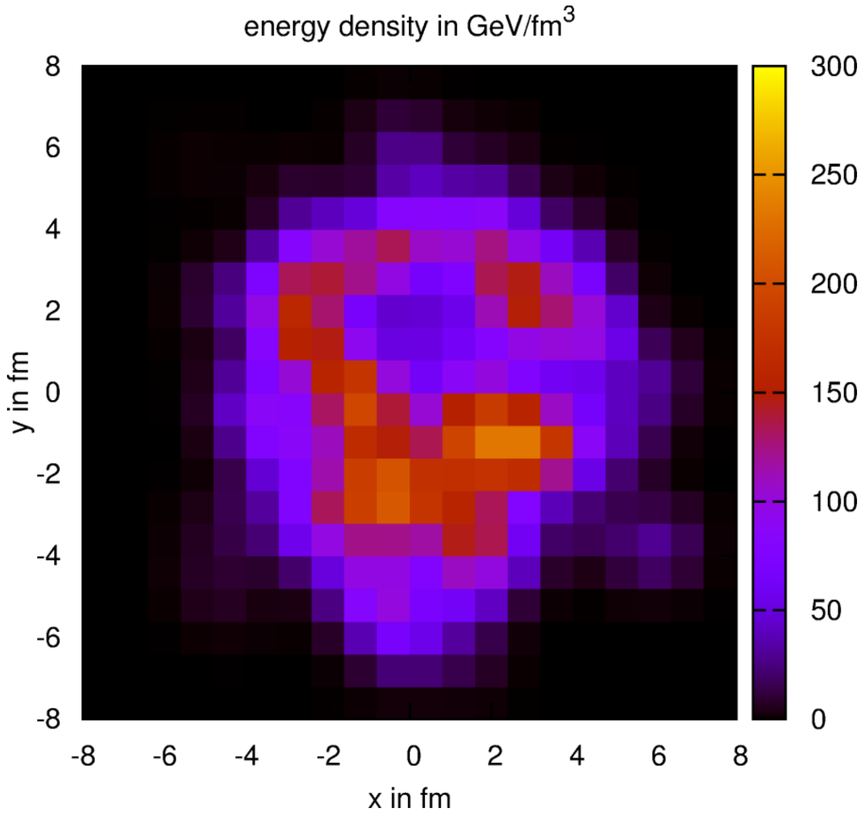
Background at small p_T

More recent observables: Higher HQ flow components

Fluctuations in the Initial energy-density profile => odd components of the flow: v_3, v_5, … (seen indeed in the light particle spectra)



sketch

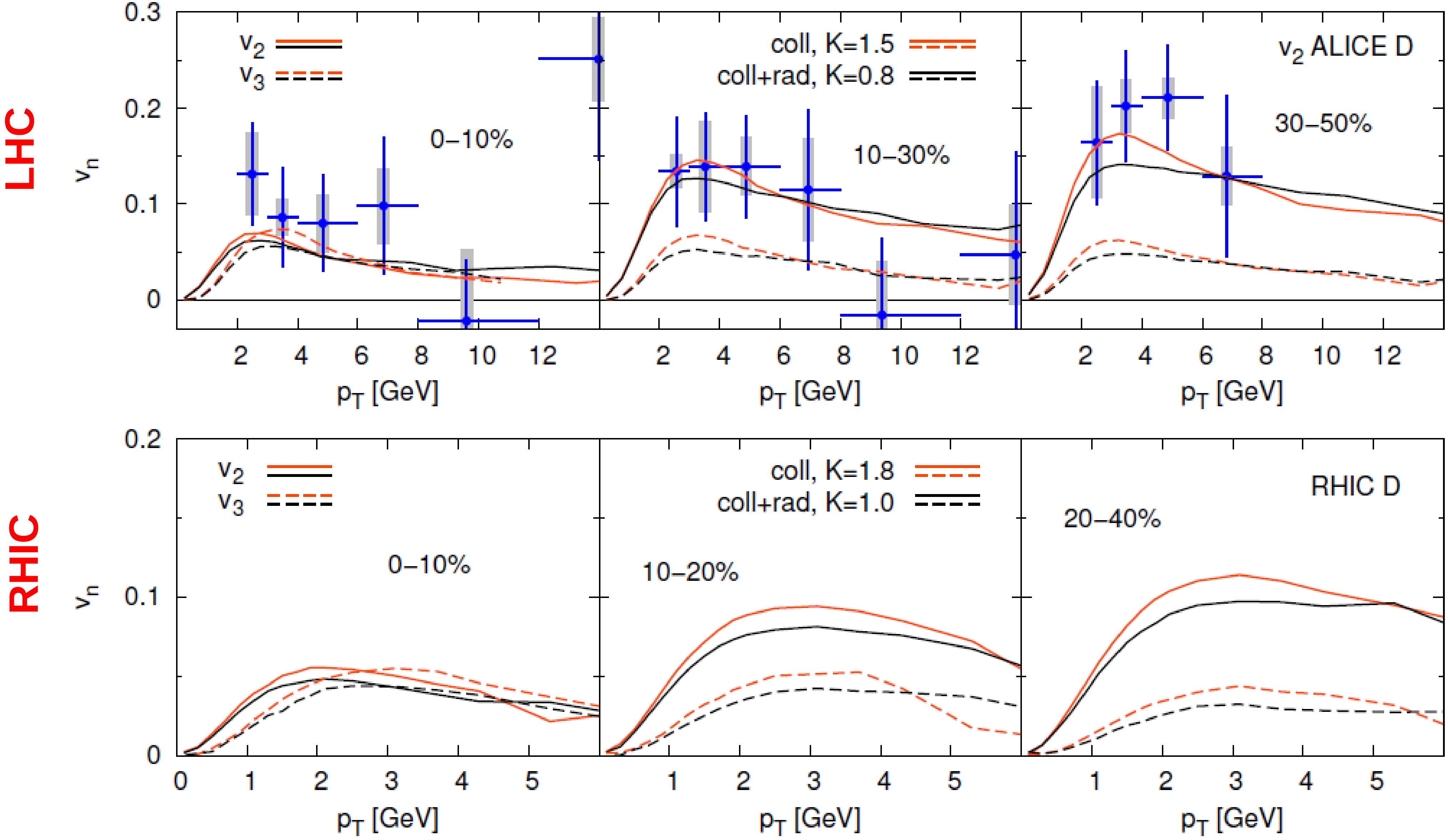


EPOS initial conditions

As heavy quarks couple to the expending QGP, same trend should be observed

More recent observables: Higher HQ flow components

Nahrgang et al, Phys. Rev. C 91 (2015), 014904

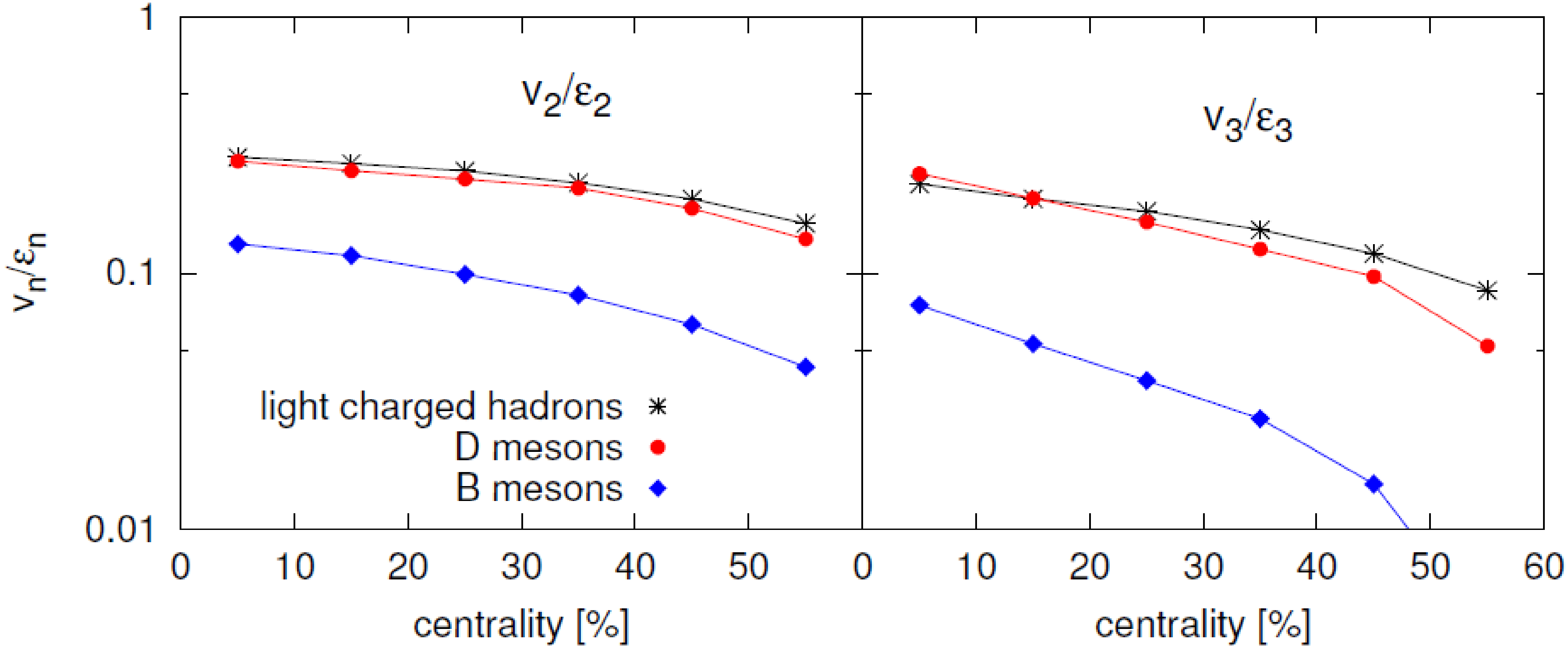


Indeed finite v3 observed at all centralities, both at RHIC and LHC

More recent observables: Higher HQ flow components

In 1^{rst} approximation: $v_n \propto$ excentricity ε_n => look at the ratio for less trivial effects

LHC



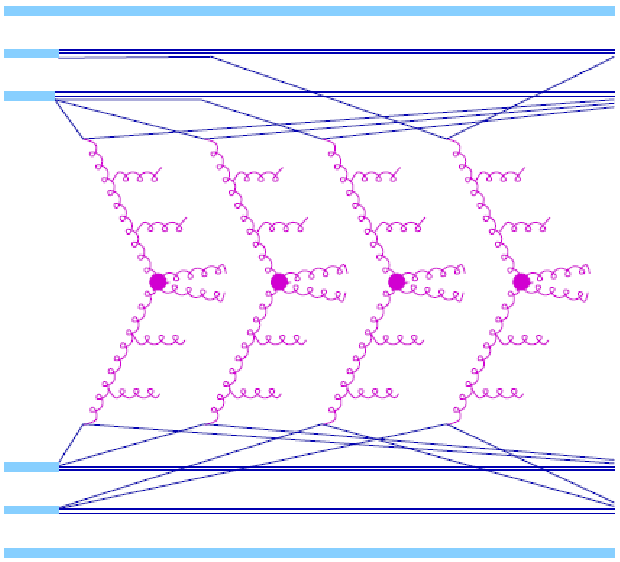
More detailed analysis reveals that HQ benefit less and less from the flow of the bulk at large centrality, especially for higher harmonics.

Possible inertia effect: HQ need a longer time to develop their flow => earlier freeze out at larger centrality prevents the v_n to develop fully.

This may offer a different perspective on the probing of the system evolution

HQ collectivity in “small” systems: the pp case at LHC.

Vogel et al. Phys. Rev. Lett. 107 (2011), 032302

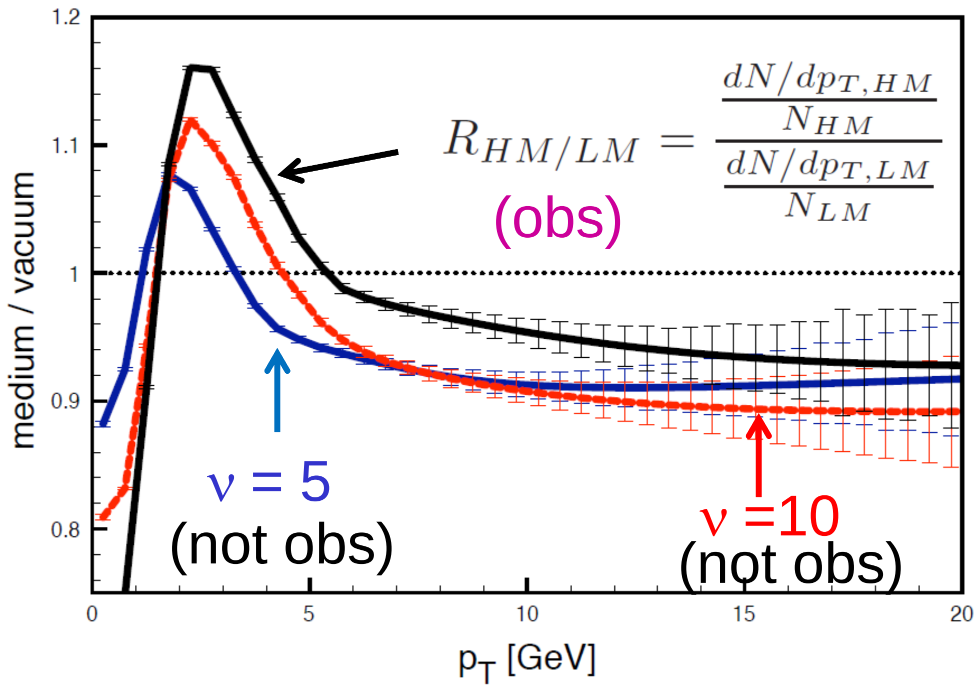


Even in p-p collisions: several (ν) pomerons exchange, up to ν =10

$$\left.\frac{dN_{\rm ch}}{dy}\right|_{y=0} \approx 29$$

Similar to Cu-Cu (RHIC)

Test whether HQ quenching in p-p



$$R_{HM/LM} = \frac{\frac{dN/dp_{T,HM}}{N_{HM}}}{\frac{dN/dp_{T,LM}}{N_{LM}}}$$

(obs)

ν = 5
(not obs)

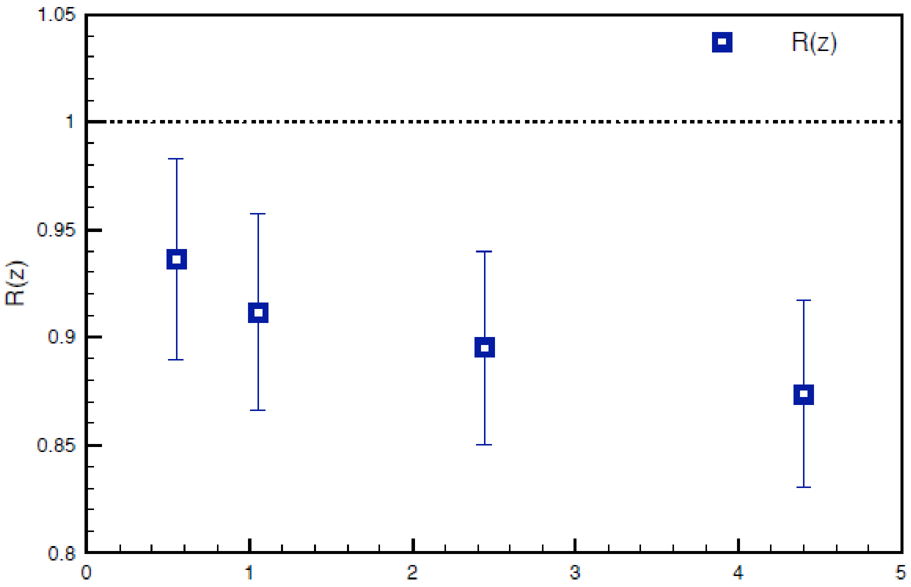
ν =10
(not obs)

Some (10%) quenching seen indeed in the model

HQ collectivity in “small” systems: the pp case at LHC.

As a function of “centrality”

$$R(z) = \left.\frac{dN/dp_T(N_{ch})}{dN/dp_T(MB)}\right|_{p_T>10GeV} \times \frac{N_{MB}}{N_{ch}},$$



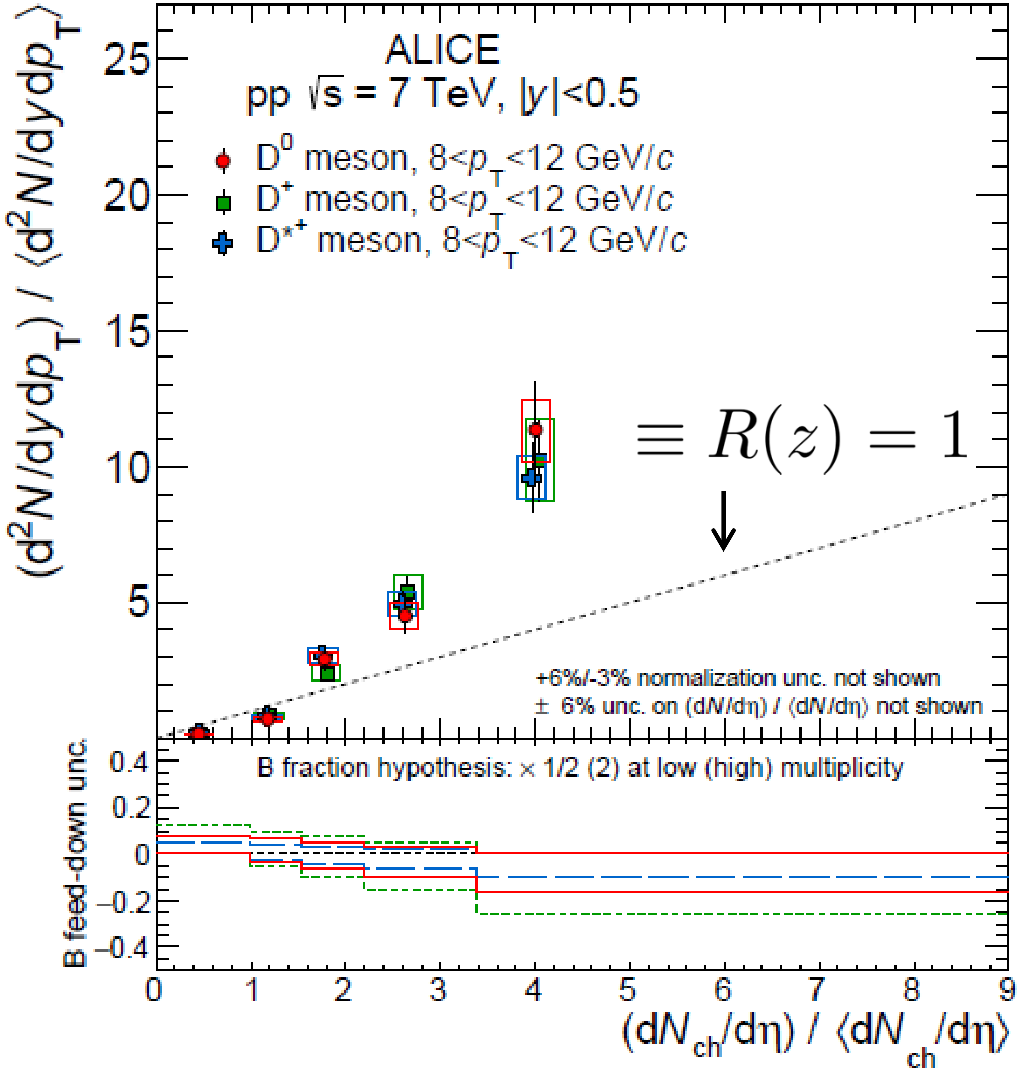
$$z = \frac{dN_{\rm ch}}{dy}/\langle\frac{dN_{\rm ch}}{dy}\rangle_{\rm MB}$$

(Self-normalizing)

Opposite trend seen in data…

(Working hypothesis: N_{ch} a ν, but hydro created in pp leads to a strong reduction.)

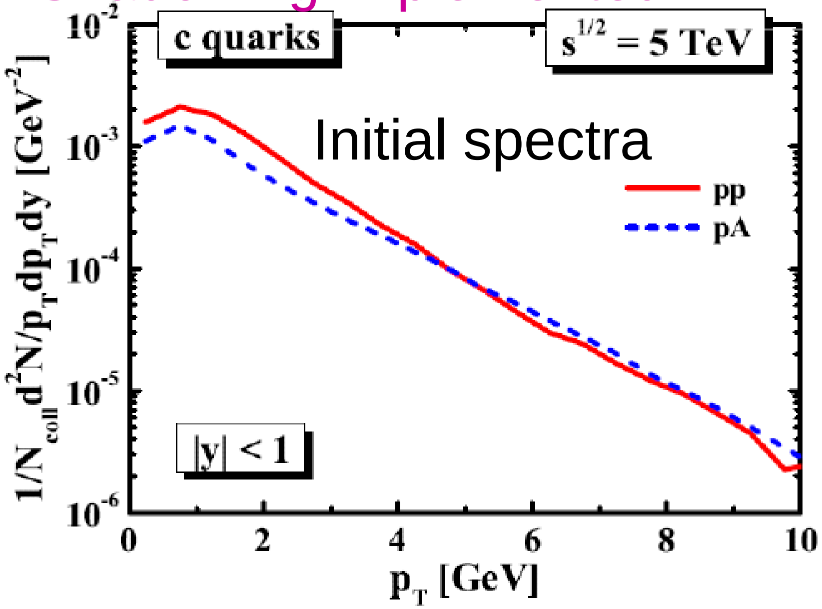
ALICE (arxiv 1505.00664)



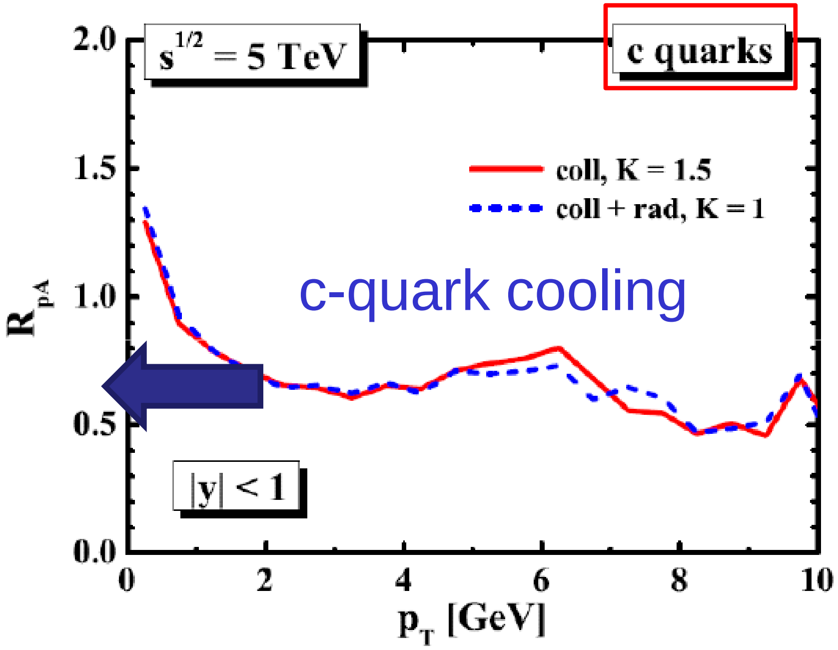
(b) D meson with $8 < p_{\rm T} < 12$ GeV/c

2015: HQ collectivity in p-Pb at LHC.

Shadowing implemented in EPOS3



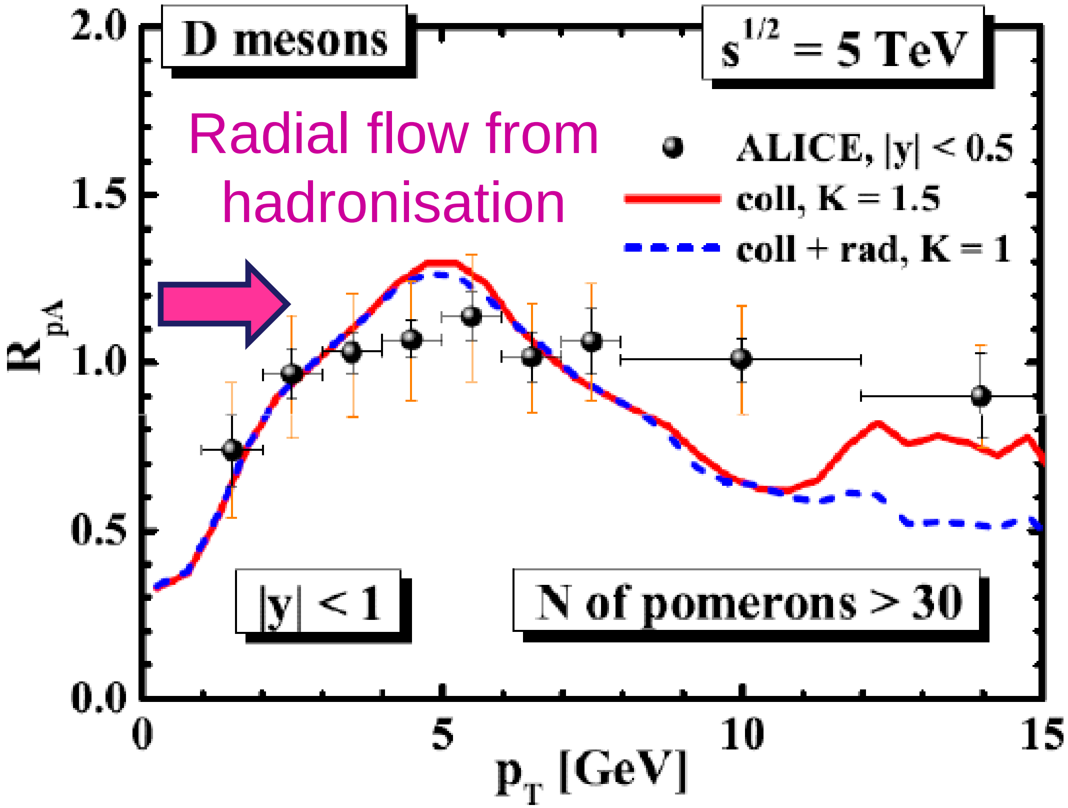
Initial spectra



c-quark cooling

Vitalii Ozvenchuk, 2nd Conference on HIC in the LHC Era and Beyond (Quy Nhon, Vietnam)

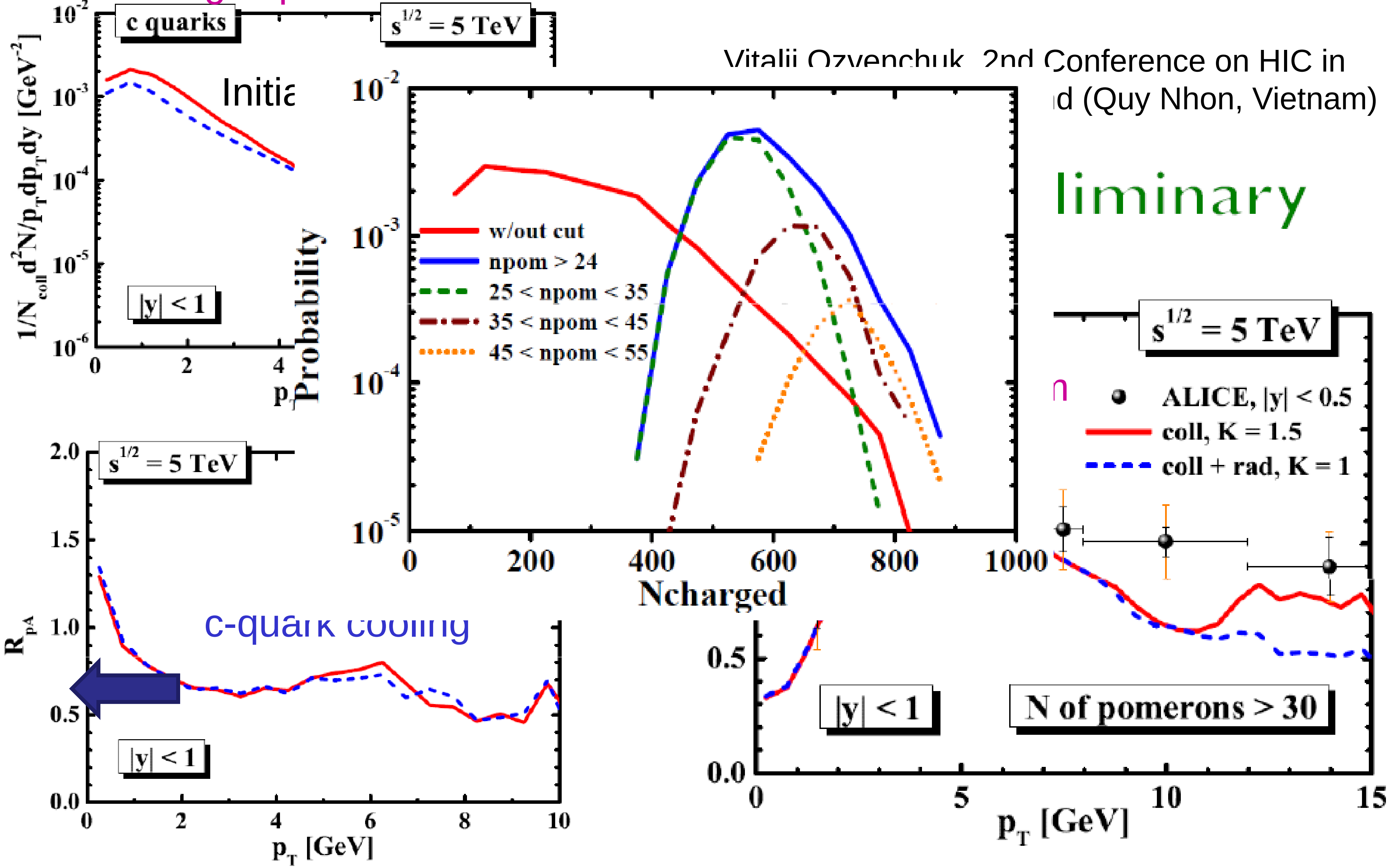
Very preliminary



Radial flow from hadronisation

2015: HQ collectivity in p-Pb at LHC.

Shadowing implemented in EPOS3



Vitalii Ozvenchuk, 2nd Conference on HIC in

d (Quy Nhon, Vietnam)

Initia

liminary

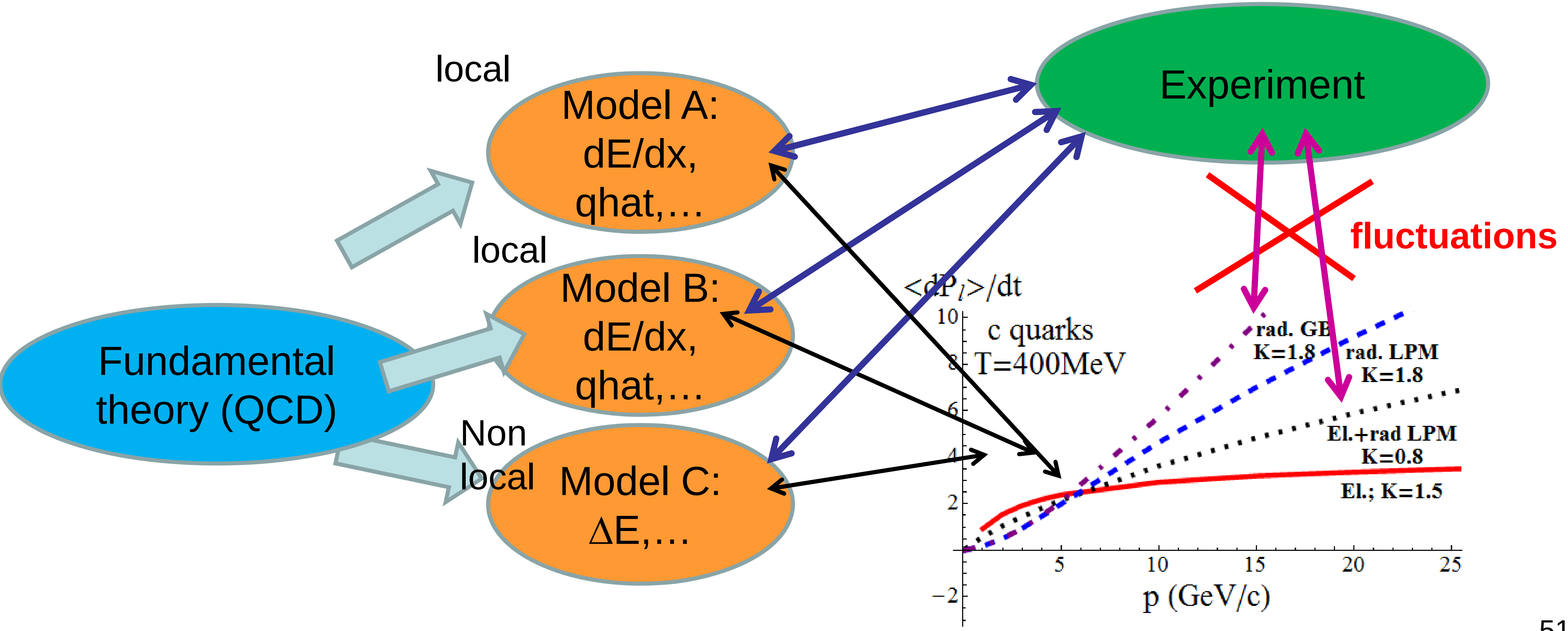
n

c-quark cooling

Conclusion

Despite all progresses made in the field of URHIC probing the “quark gluon soup” with heavy flavour and assessing unambiguously its physical properties is still a delicate task.

This is partially due to the abundance of models and the lack of constrains from the fundamental theory.



Fundamental theory (QCD)

local

Model A: dE/dx, qhat,…

local

Model B: dE/dx, qhat,…

Non local

Model C: ΔE,…

Experiment

fluctuations

Conclusion: Antique view of QGP probing with HQ

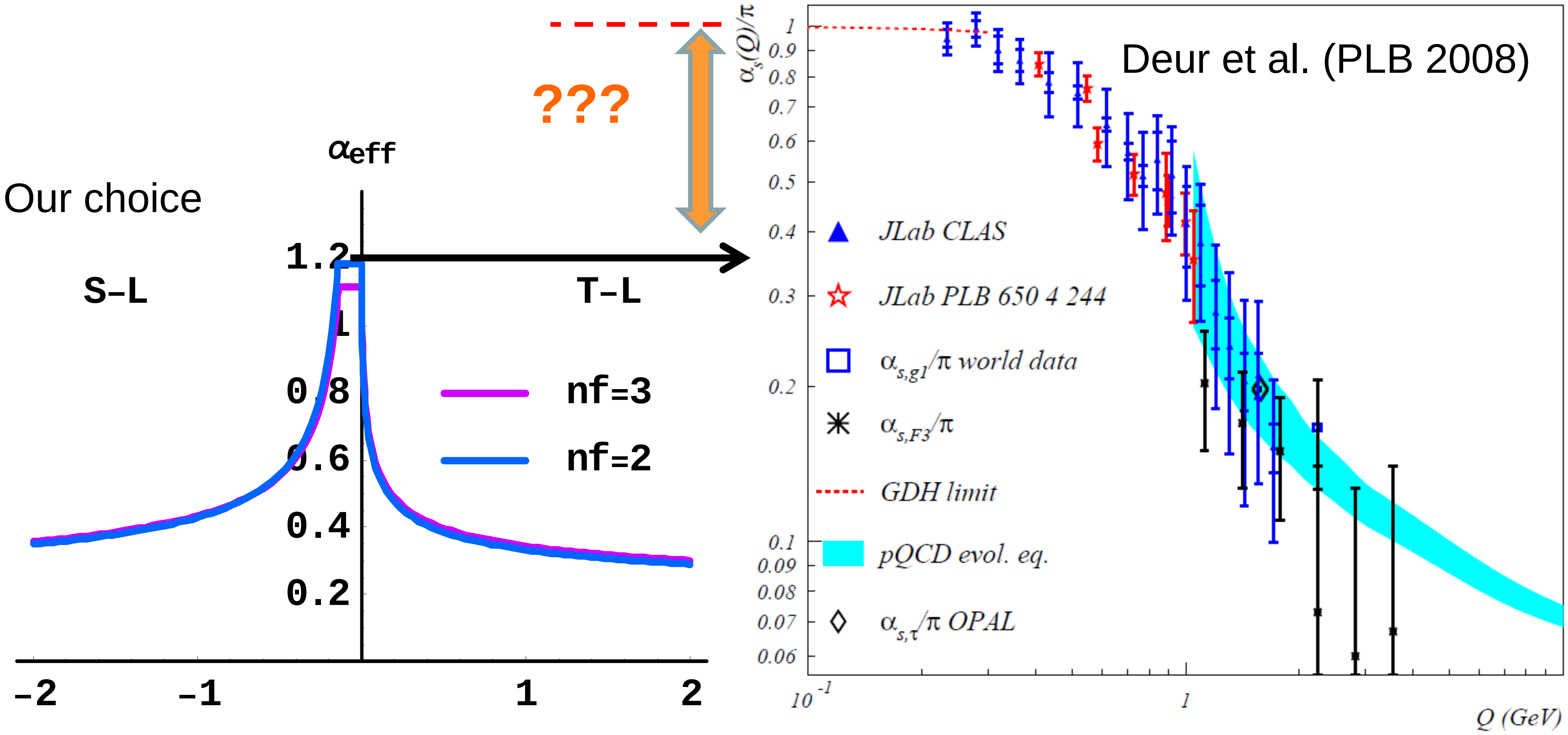
The blind

The paralytic

… but they go forward together !

Elastic Eloss @ RHIC

We “explain” it all provided we allow for a multiplication of our pQCD (inspired) cross section by a factor 2…



Our choice

Deur et al. (PLB 2008)

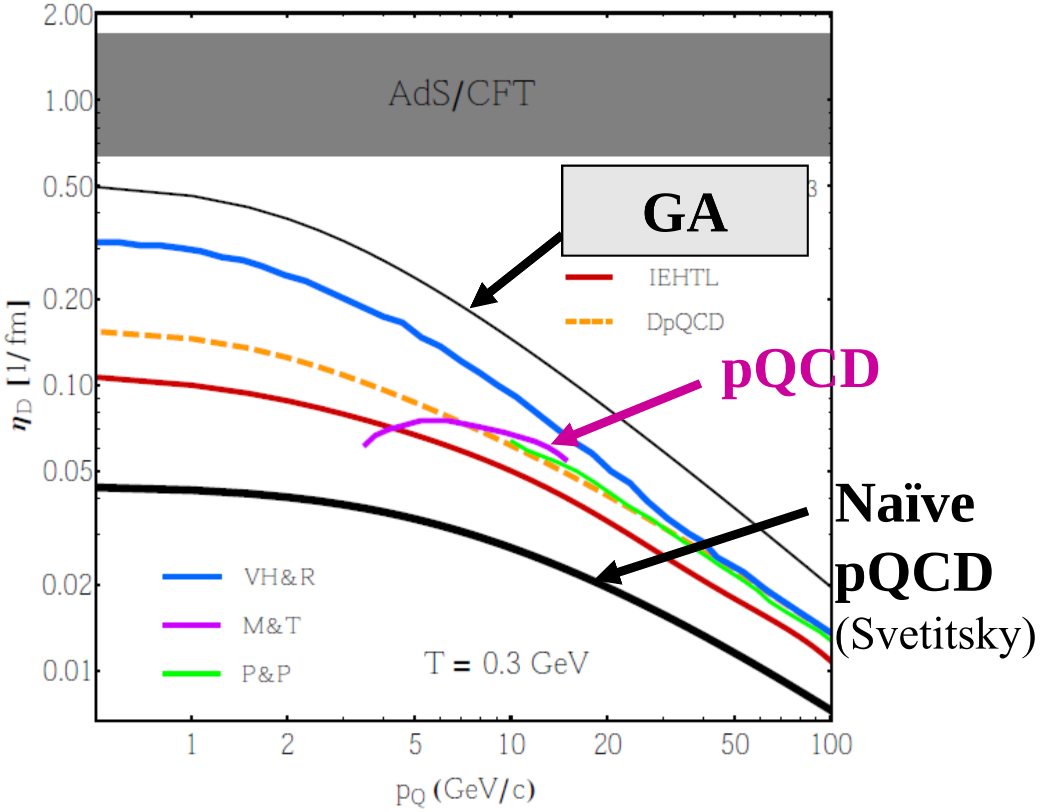
Running α_s : some Energy-Loss values

$$\frac{dE_{coll}(c/b)}{dx}$$

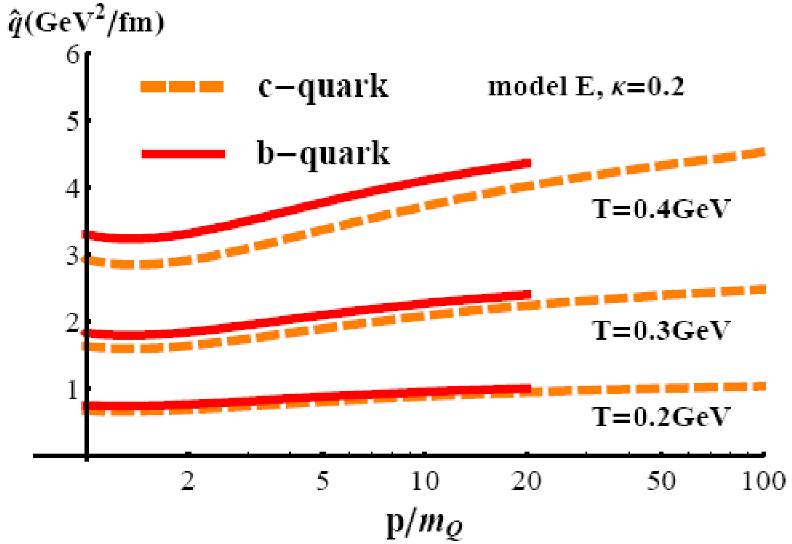
T(MeV) \p(GeV/c)	10	20
200	**1 / 0.65**	**1.2 / 0.9**
400	**2.1 / 1.4**	**2.4 / 2**

≈ 10 % of HQ energy

Drag coefficient (inverse relax. time)



Transport Coefficient



… of expected magnitude to reproduce the data (we "explain" the transp. coeff. in a rather parameter free approach).