Charm and Beauty of RHIC and LHC

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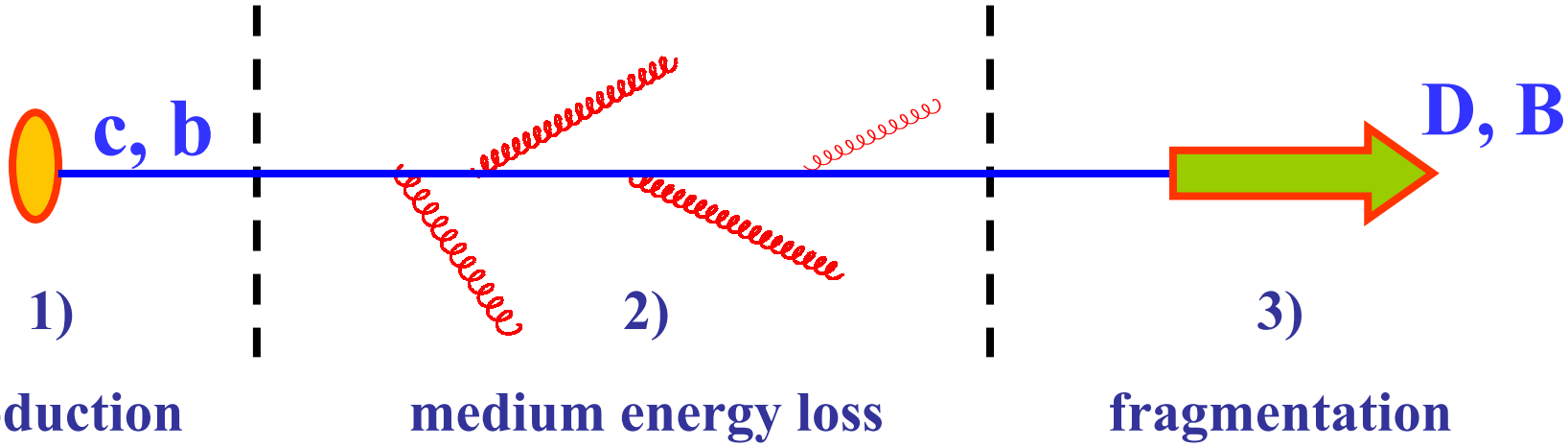
Important goals of RHIC and LHC experiments

Form, observe and understand Quark-Gluon Plasma (QGP).

Heavy quarks are considered to be excellent probe of this new form of matter.

In this talk we study the D and B meson suppression and compare the results at RHIC and LHC experiments.
(M.Djordjevic, M. Gyulassy and S. Wicks, hep-ph/0410372)

D and B meson suppression



To make theoretical predictions for D and B meson pt distributions we used GLV method described in PLB538:282-288,2002. To apply this method we need to know:

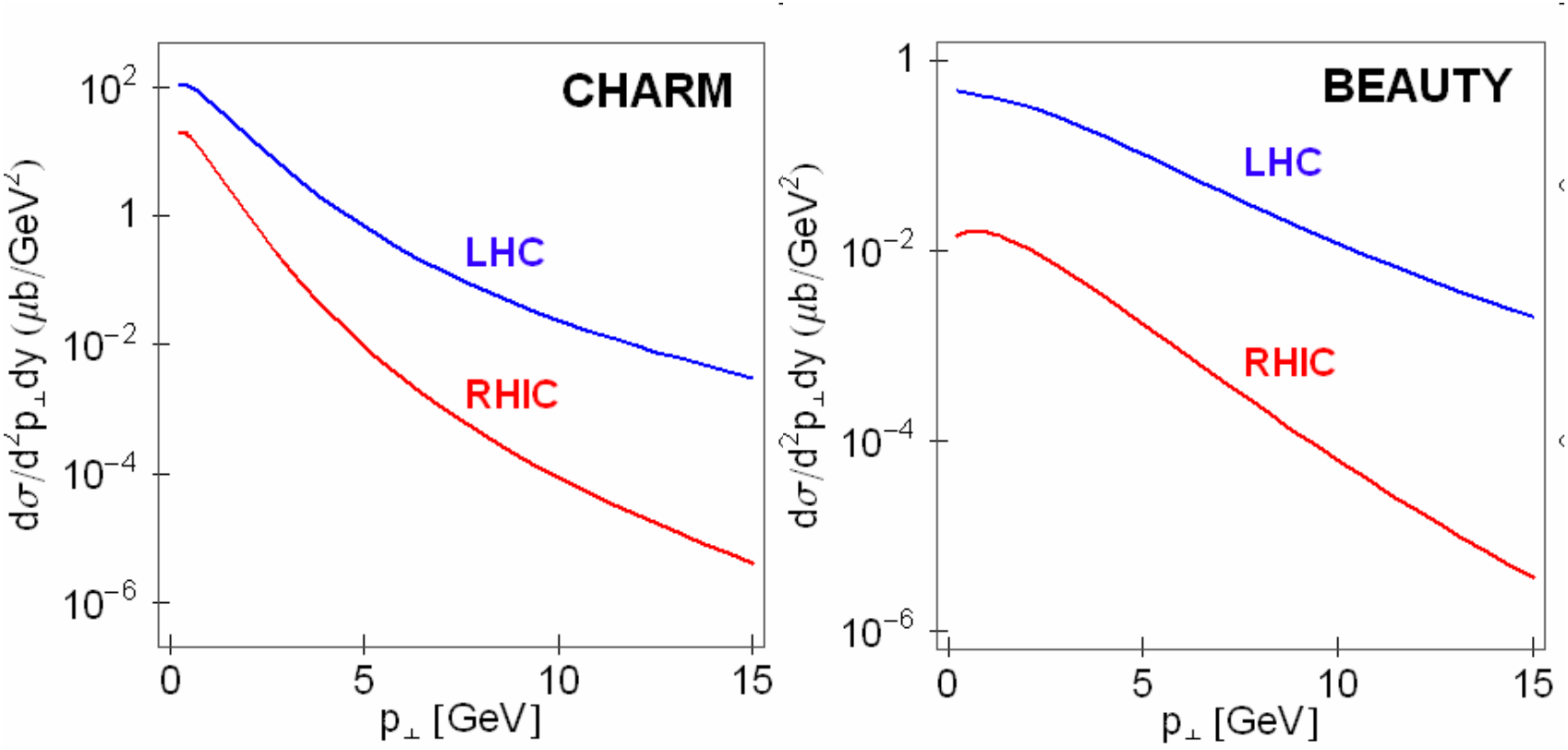
1) Initial pt distribution of heavy quarks

2) Difference between medium and vacuum heavy quark energy loss

3) D and B meson fragmentation function.

Initial heavy quark pt distributions

To compute the initial charm and beauty pt distributions we applied the MNR code (Nucl.Phys.B 373, 295 (1992)), and used the same parameters as in Vogt's paper (Int.J.Mod.Phys.E 12,211(2003)).

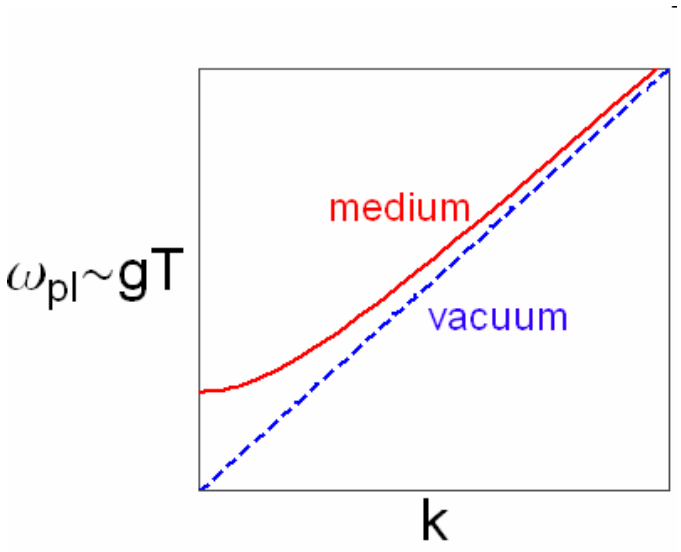


Initial heavy quark pt distributions tend to decrease the suppression from RHIC to LHC.

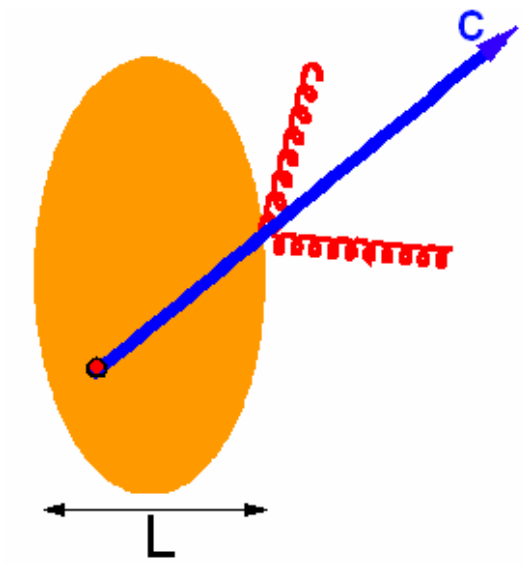
Radiative heavy quark energy loss

There are three important medium effects that control the radiative energy loss at RHIC and LHC.

1) **Ter-Mikayelian effect** (M. Djordjevic, M. Gyulassy, Phys.Rev.C68:034914,2003)
2) **Transition radiation** (B.G. Zakharov, JETP Lett.76:201-205,2002)
3) **Energy loss due to the interaction with the medium** (M. Djordjevic, M. Gyulassy Nucl.Phys.A 733, 265 (04)).



1)



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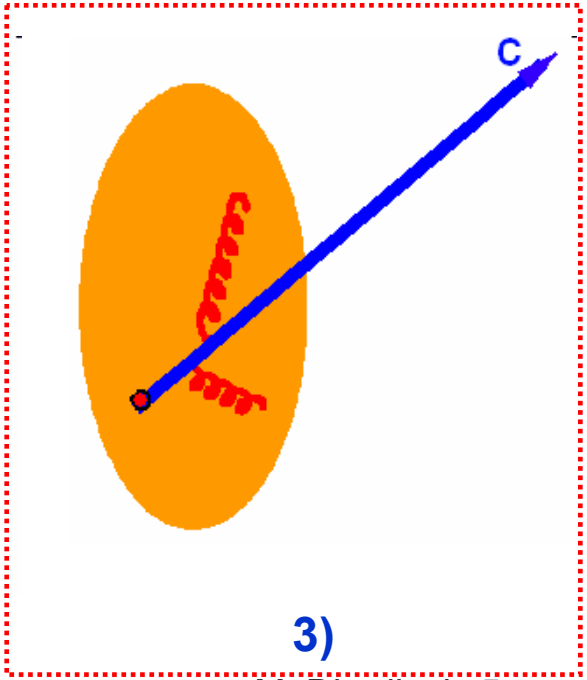


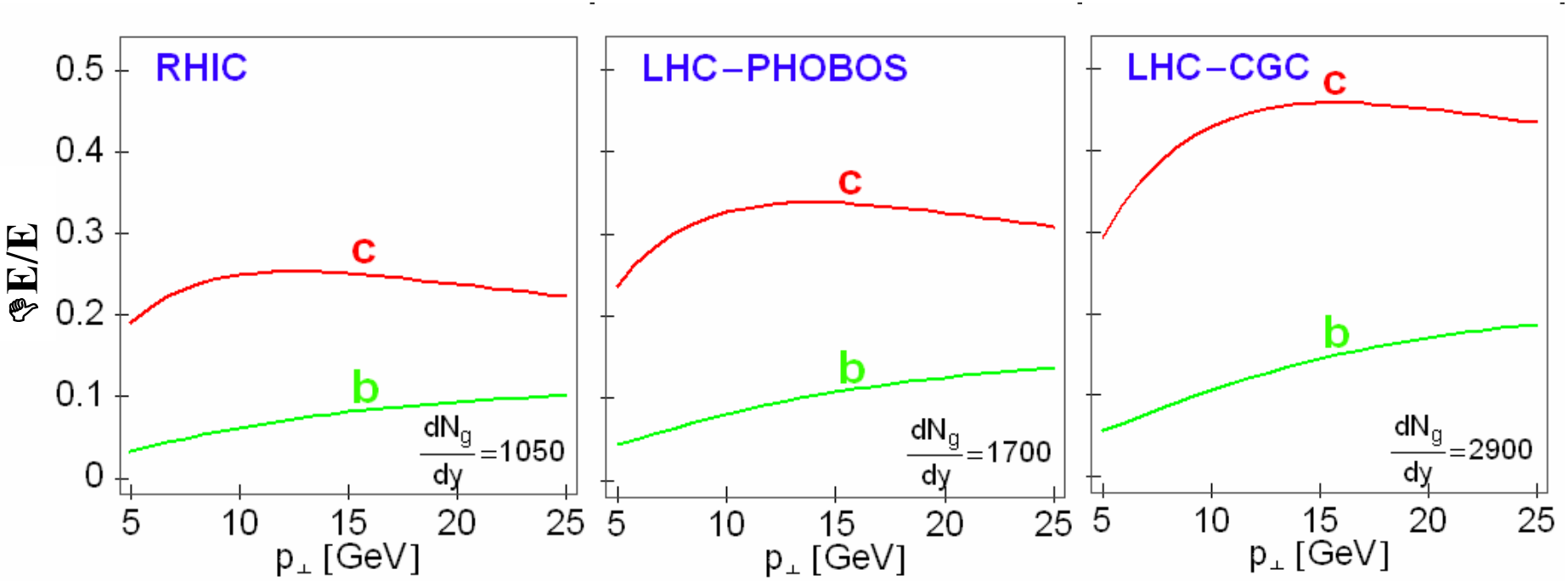
3)

To compute the heavy quark energy loss we used the DGLV formalism

(M. Djordjevic, M. Gyulassy Nucl.Phys.A 733, 265 (04), GLV, Nucl.Phys.B594(01)).

Numerical results for induced radiative energy loss are shown for first order in opacity, with assumed $R_x=R_y=6$ fm.

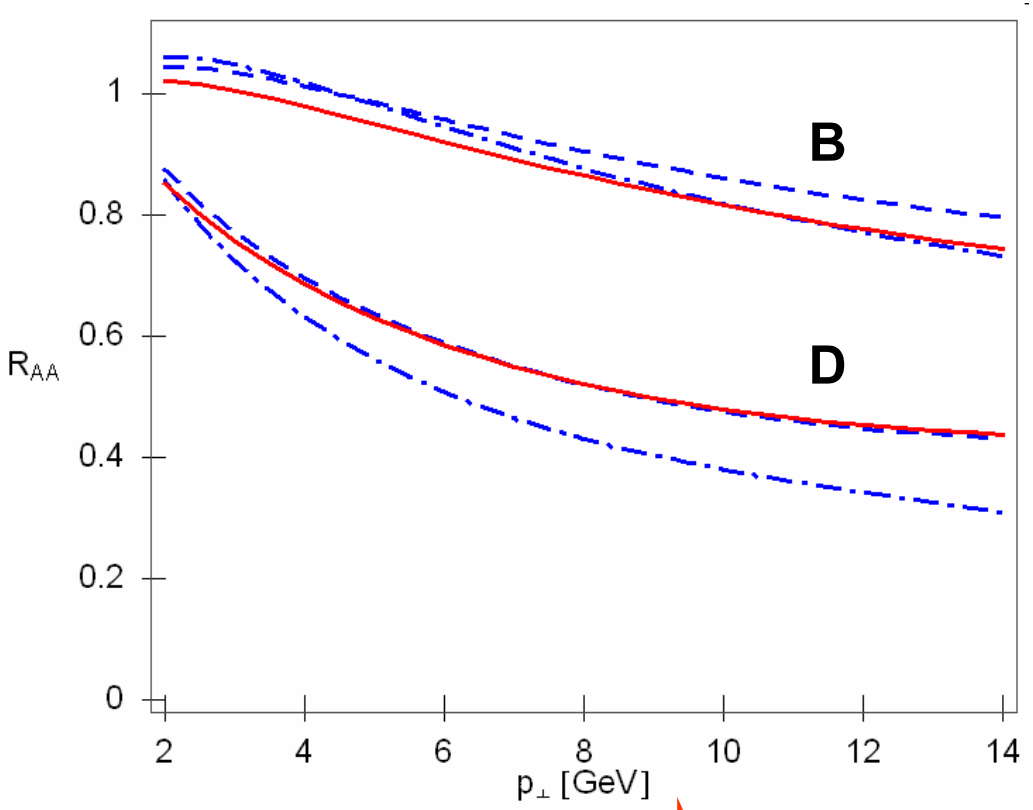
For RHIC $\sqrt{s}=200$ GeV, for LHC $\sqrt{s}=5.5$ TeV. $M_c=1.2$ GeV, $M_b=4.75$ GeV



Energy loss tends to increase the suppression from RHIC to LHC.

Heavy quark suppression as a function of pt

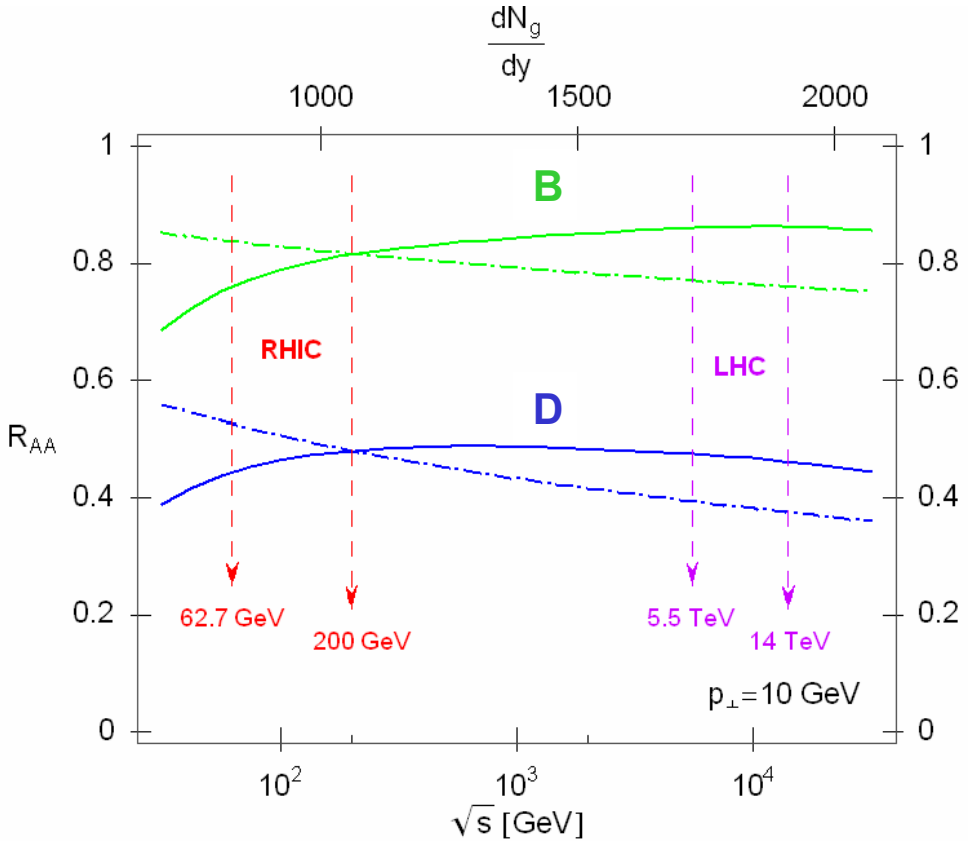
- **red solid curve: RHIC**
- **blue dashed curve: LHC (PHOBOS extrapolation assumed, (Phys.Rev.Lett 88, 2002))**
- **blue dot-dashed curve: LHC (CGC parameterization assumed (hep-ph/0408050)**



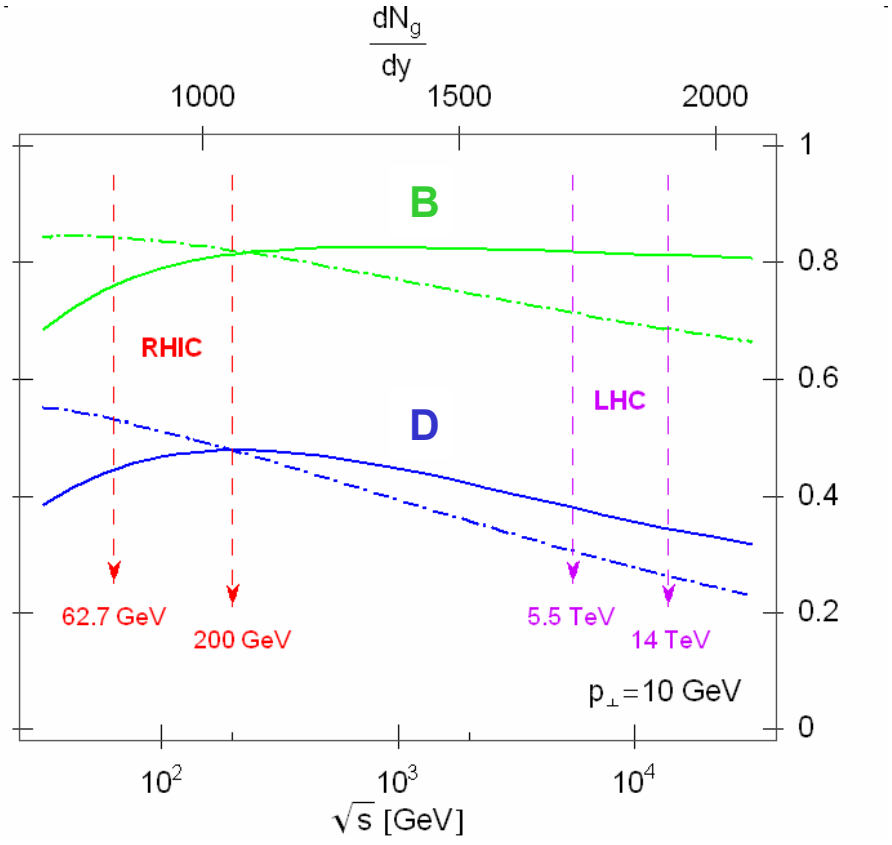
Two effects cancel → **RHIC ≈ LHC**

Heavy quark suppression as a function of collision energy

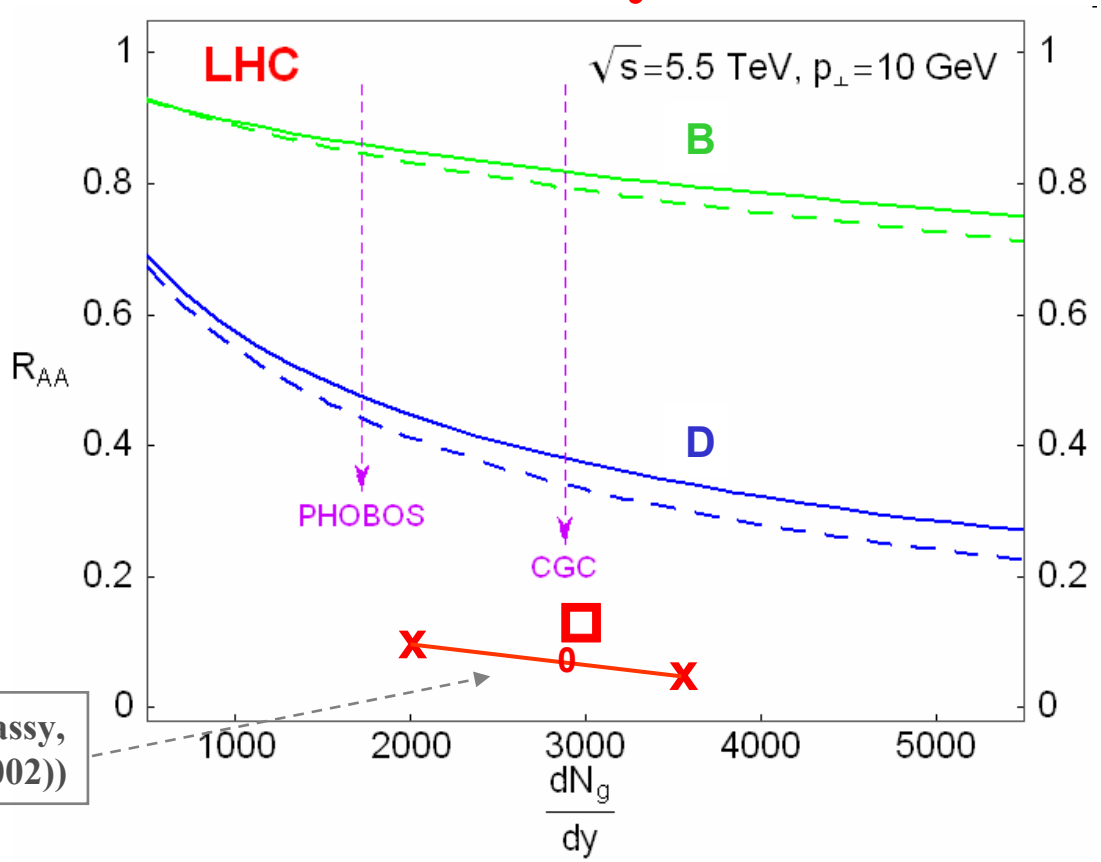
PHOBOS extrapolation



CGC parameterization



Heavy quark suppression at LHC as a function gluon density:



(I.Vitev and M.Gyulassy, Phys.Rev.Lett. 89 (2002))

Measurement of charm suppression at LHC may enable us to map the gluon density, and differentiate between different predictions, such as PHOBOS extrapolation and CGC parametrization.

Conclusions

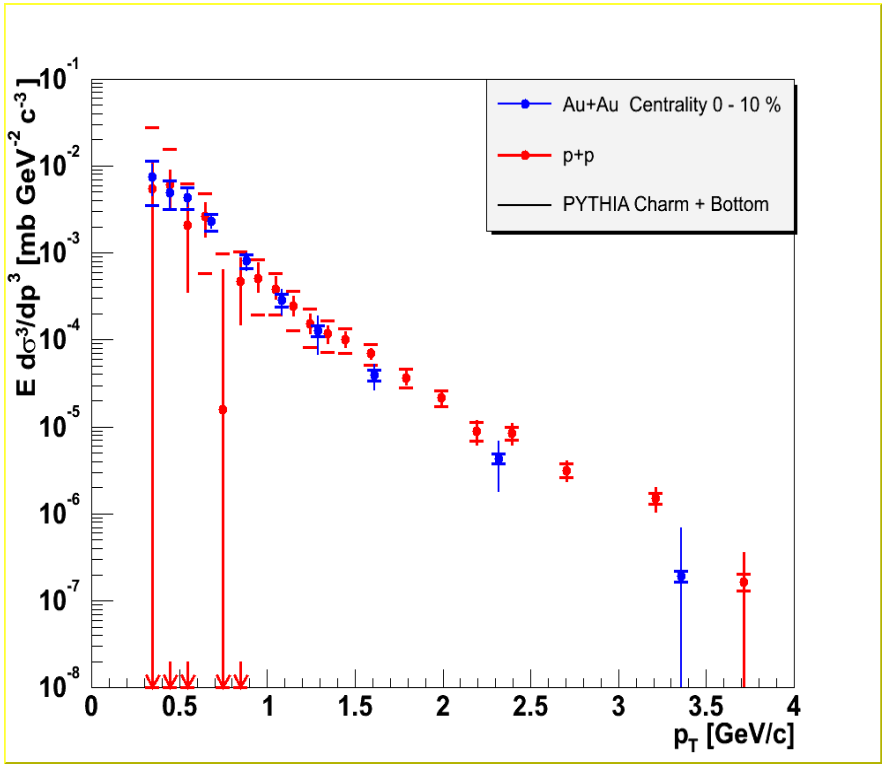
D meson data for 200 GeV *D-Au* and *Au-Au* results, should soon become available from STAR. We predict moderate D meson suppression ~ 0.5⊕0.1 at RHIC.

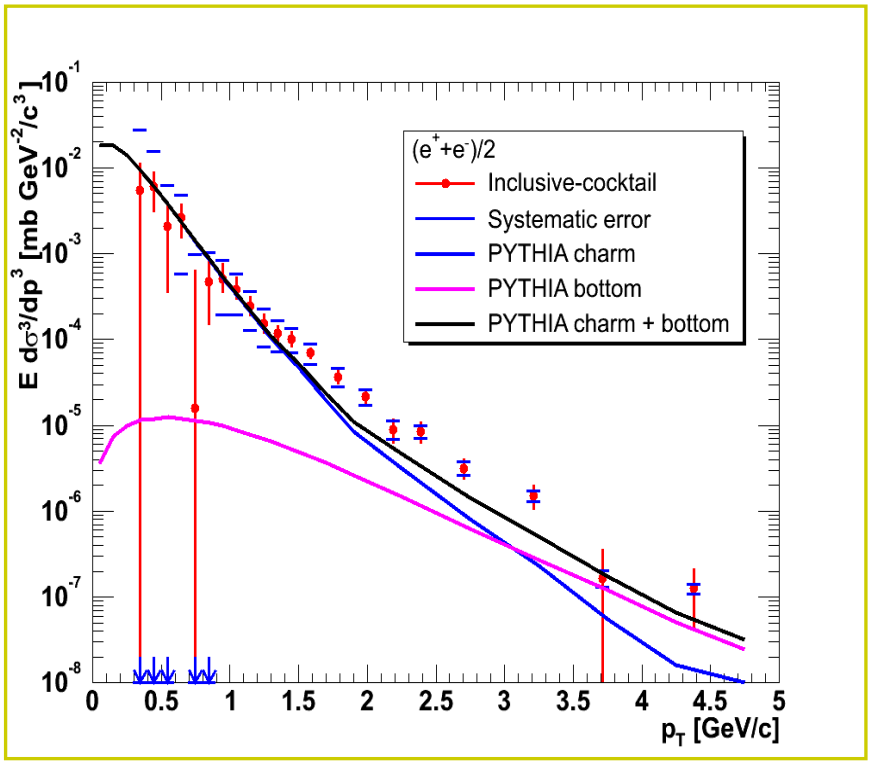
Surprisingly, our computations suggest similar suppression results at RHIC and LHC.

Our high pt predictions are robust within our approach, and significant experimental deviations would pose a serious challenge to pQCD theory of radiative energy loss at RHIC.

Backup

Comparison with available experimental results





Moderate p_T single electrons are not suppressed according to PHENIX.

Takashi Hachiya – QM2004.

Huge contribution from Beauty quarks for pt>2GeV single electrons.

Why is charm quark a good probe?

Charm quark can be produced only during the early stage of QCD matter.

Charm quark mass is large enough → M_C ? Λ_{QCD} → **Perturbative calculations of charm production and energy loss are possible**

Charm quark mass is small enough → **Significantly interacts with surrounding light quarks and gluons** → **Sensitive to the properties of the medium**

Disadvantages of charm quark

- **Theoretically:** **Computations are, technically, much harder with heavy quarks than with light quarks.**
- **Experimentally:** **Small number of charm quarks is produced, and it is not easy to detect them.**

Conclusion

If technical difficulties are solved, charm quark present very good probe of QCD matter.

What value of heavy quark suppression we can expect at RHIC?

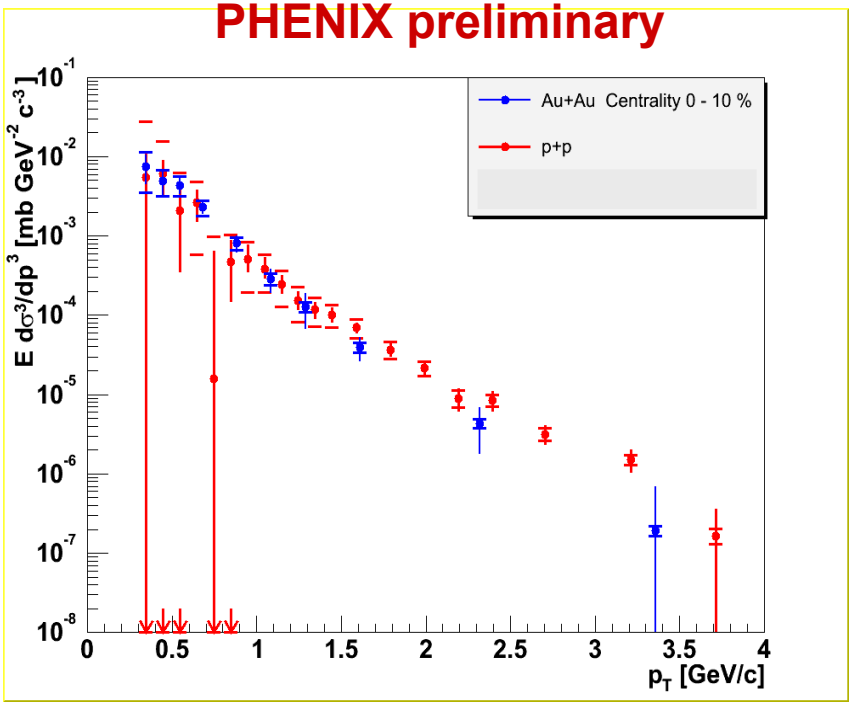
1997 Shuryak proposed that charm quarks will have large energy loss in QGP => large suppression of D mesons.

2001 Dokshitzer and Kharzeev proposed "dead cone" effect => charm quark small energy loss

First Au+Au->e X data show no hint of Charm energy loss ! ??
PHENIX Collaboration (K. Adcox *et al.*) **Phys.Rev.Lett.88:192303,2002**

Moderate p_T single electrons not suppressed according to PHENIX.

Takashi Hachiya – QM2004.



What we wanted to do?

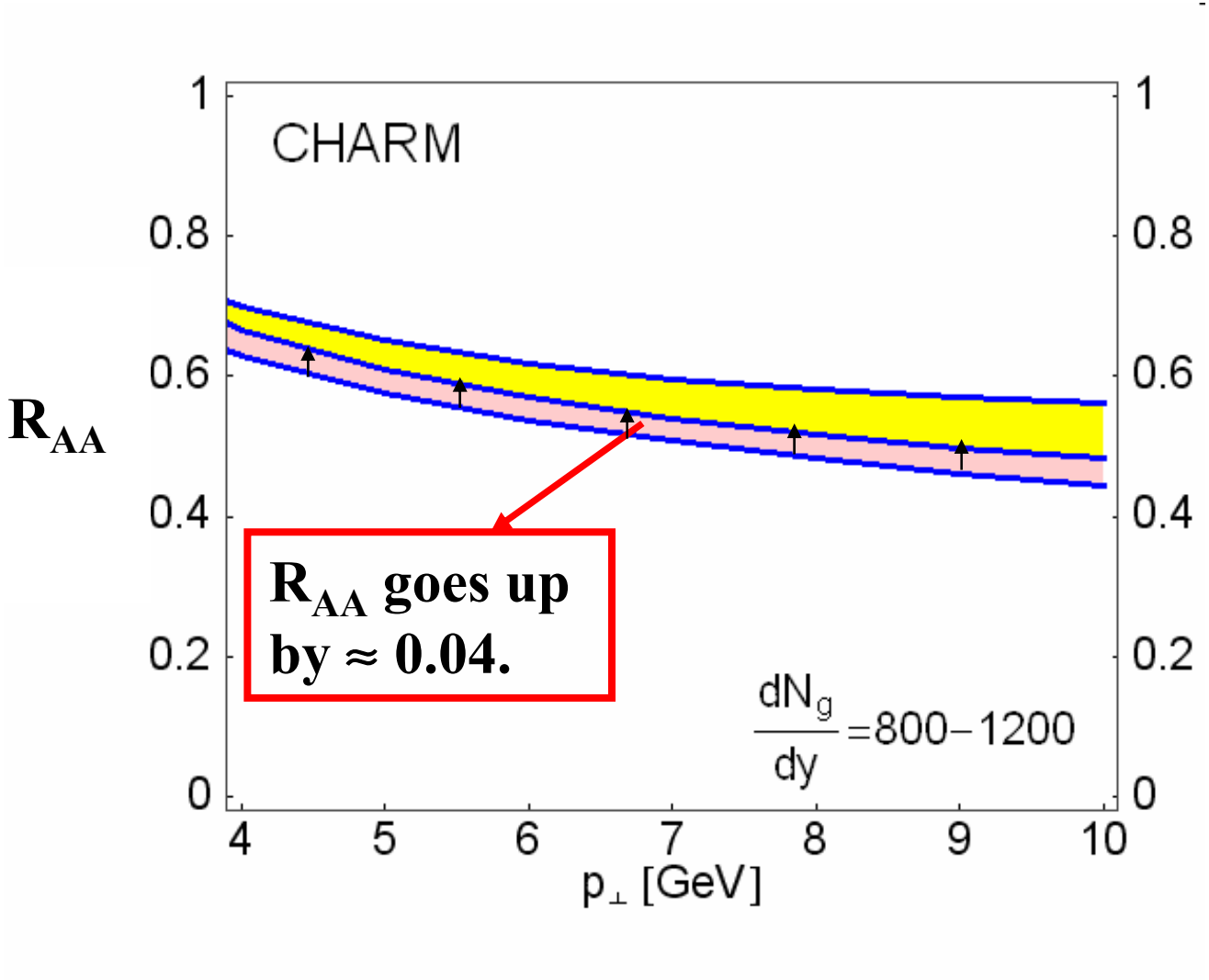
We wanted to compute quantitatively radiative energy loss for heavy quarks including dielectric and collision sources.

Why?

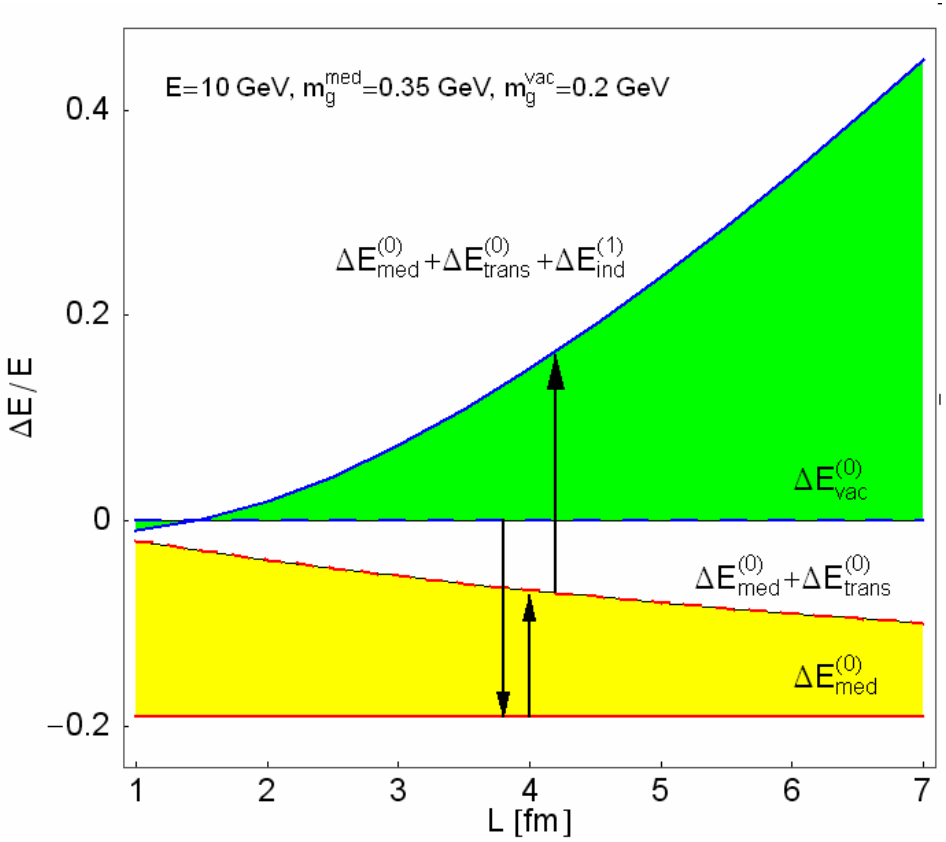
To present theoretical predictions that can be compared with upcoming experimental results in order to test the QGP theory.

backup

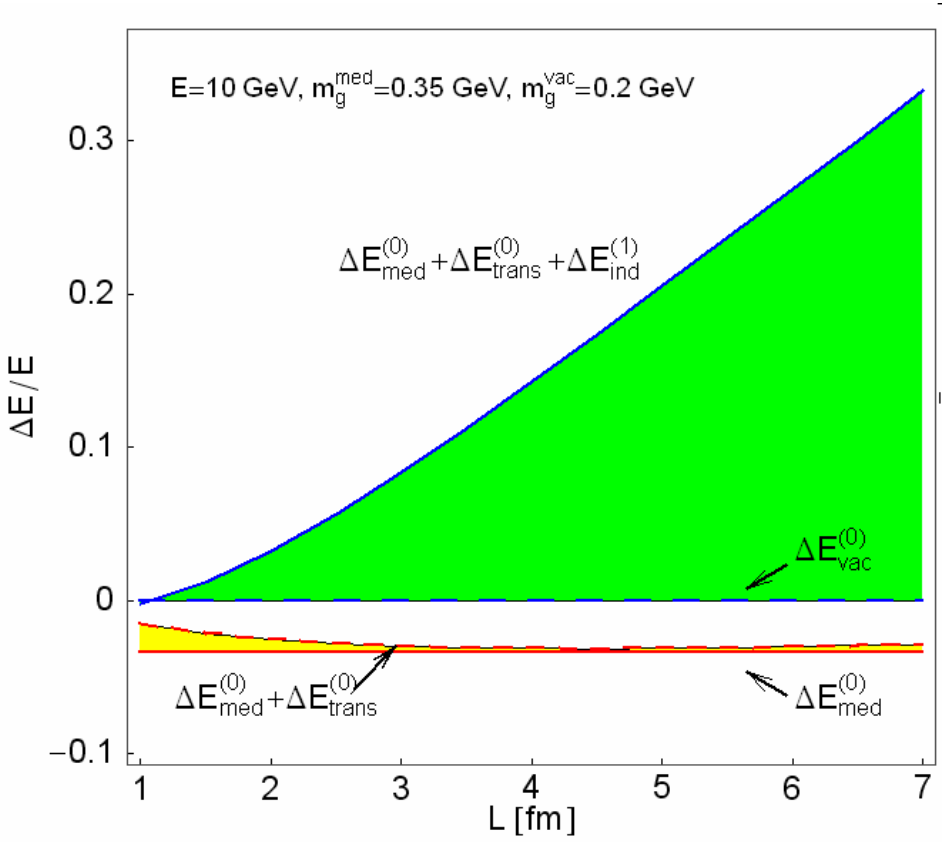
What is the influence of TM effect and transition radiation to the suppression result?



Light quark



Charm quark



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