Heavy-quark production from Glauber-Gribov theory at LHC

K. Tywoniuk[1] I. C. Arsene[1] L. Bravina[1,2]
A. B. Kaidalov[3] E. Zabrodin[1,2]

[1]Department of Physics
University of Oslo

[2]Institute of Nuclear Physics
Moscow State University

[3]Institute of Theoretical and Experimental Physics

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"Heavy Ion Collisions at LHC - Last call for predictions"
CERN

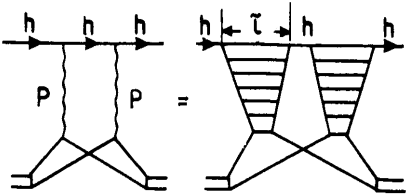
Outline

1. Introduction - why is LHC "high energy"?
2. Nuclear Modification Factor
   - results for J/psi in d+Au @ RHIC
   - predictions for p+Pb @ LHC
   - tools for Pb+Pb modelling
3. $\alpha(x_F)$ dependence
   - what happens at mid-rapidity with energy?
   - scaling - breaking - appearence
4. Conclusions

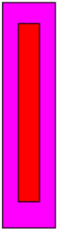
When is energy “high”?

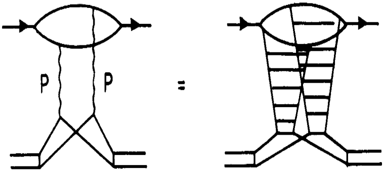
Coherence length in hadron-nucleus collision

Mandelstam Nuov. Cim. **30** (1963) 1113, 1127,1148

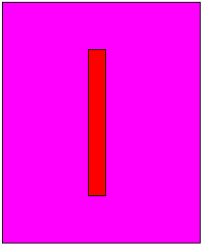


“Planar” diagram - Glauber model





“Non-planar” diagram



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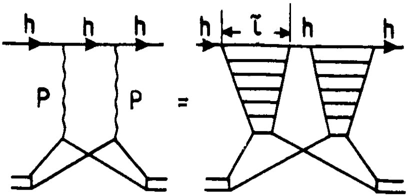

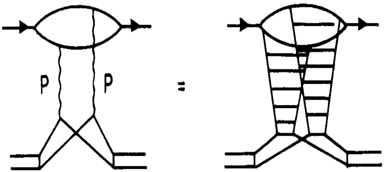

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- fluctuation prepared long before collision occurs
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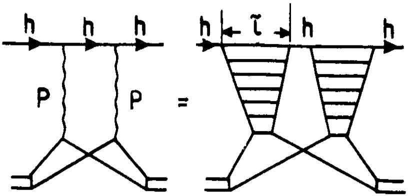

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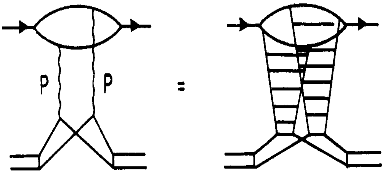

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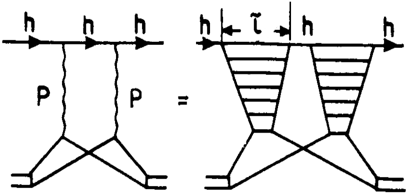

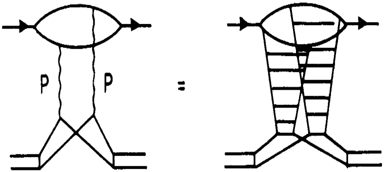

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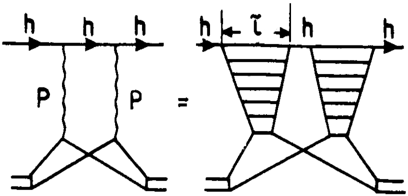

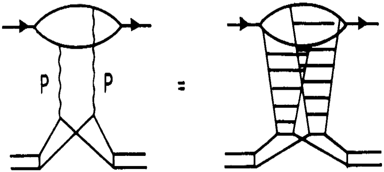

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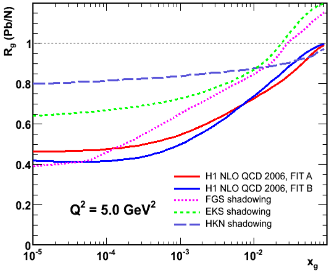
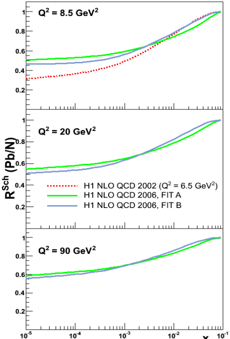
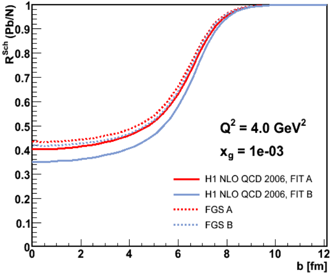
Results for gluon shadowing within Schwimmer model

Details - `hep-ph/0705.1596`

- Shadowing is connected with gluon diffractive distribution function, measured at HERA.
- Not strongly dependent of scheme at low-x.







Production of a heavy-quark state at high-energy

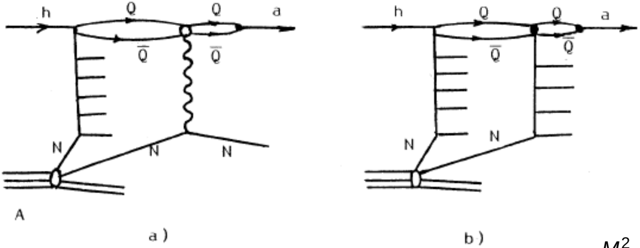
J/ψ production in pA collisions show interesting features at different energies:

- absorption in nuclear matter ($\sigma^{abs} \sim 5$ mb) at low energies, interpreted within a probabilistic Glauber model
- puzzle at RHIC, σ^{abs} much smaller (nobody expected this)
- at high energies, production of heavy state probes the very low-x distribution of the nuclear structure function

Also Υ production should follow a similar pattern.
Important to understand what happens in pA to get a hold on final-state effects in AA!

Production of a heavy-quark state at high-energy

Appearance of “high-energy regime”



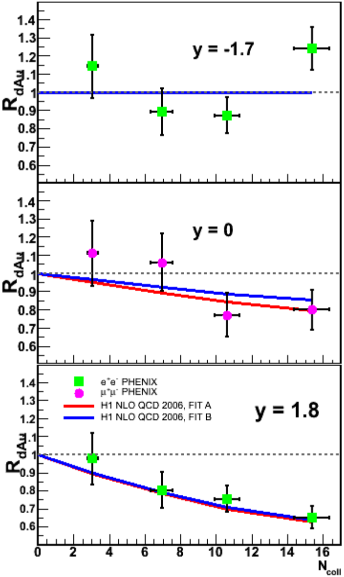
Critical energy for heavy quark production $E_C = \frac{M^2_{c\bar{c}}}{2x_+} \frac{R_A}{\sqrt{3}}$

- for $E < E_c$: AGK cancellation is not valid and absorptive corrections are present
  - $\longrightarrow$ low-energy absorption formula!
- for $E > E_c$: coherent production of the heavy state

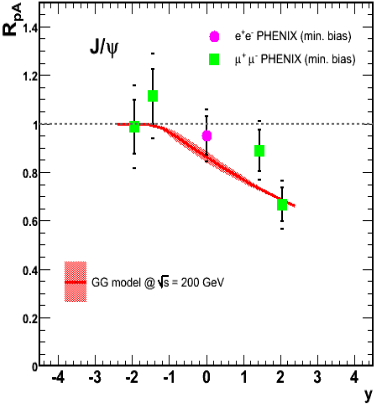
Boreskov, Capella, Kaidalov, Thanh Van, PRD **47** (1993) 919

J/ψ production @ RHIC

Shadowing and $\sigma_{abs} = 0$



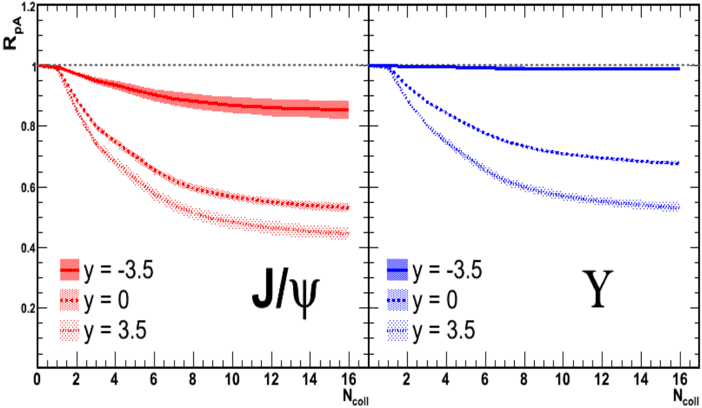
$\sigma_{abs} = 0$ and shadowing reproduce the data at RHIC.



Capella, Ferreiro, **hep-ph/0610313**

Predictions for p+Pb @ LHC

J/ψ,Υ and open heavy-flavour



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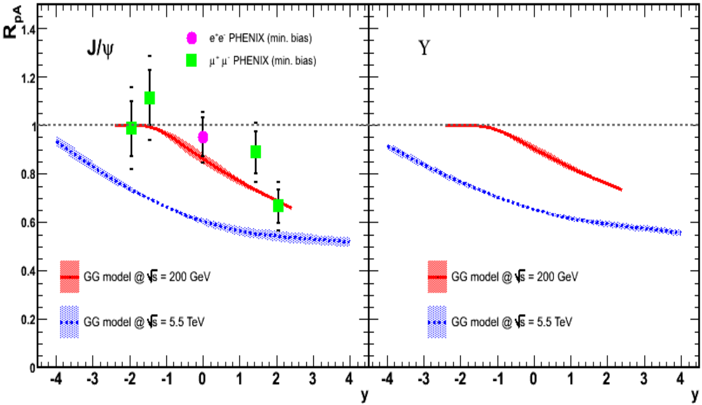

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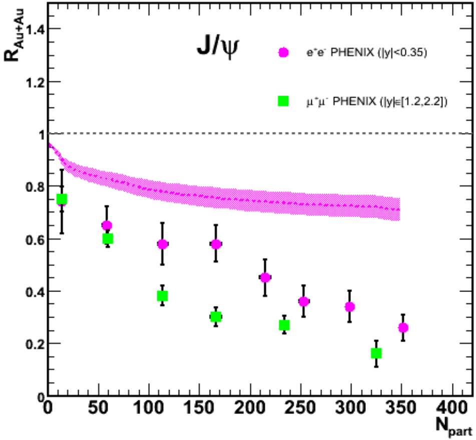
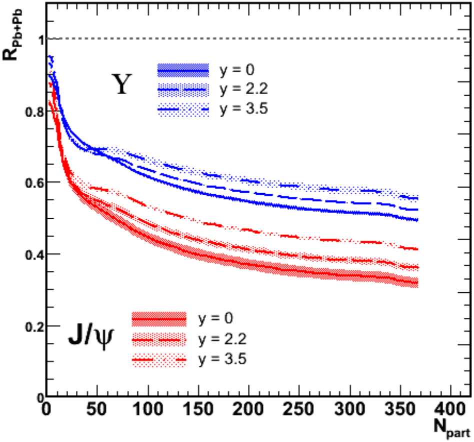


- 20% suppression from CNM effects alone
- important input - suppression from co-movers alone gives too strong effect!

Cold-nuclear matter effects in A+A collisions

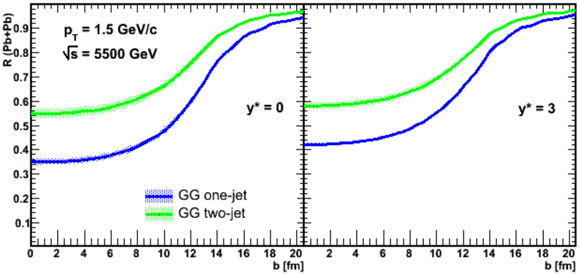
Shadowing

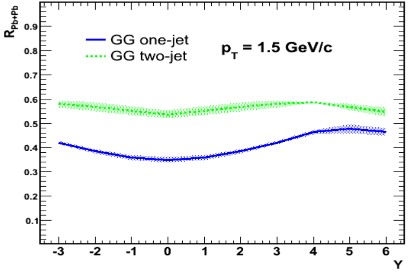


- strong shadowing effect, a factor of ~ 2.5
- shadowing decreases with rapidity

Cold-nuclear matter effects in A+A collisions

Density of produced particles

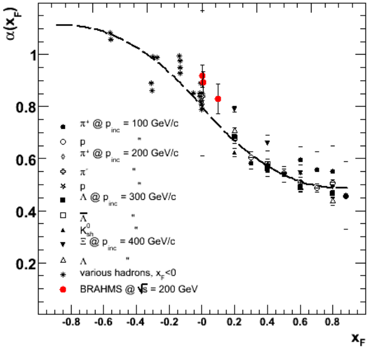


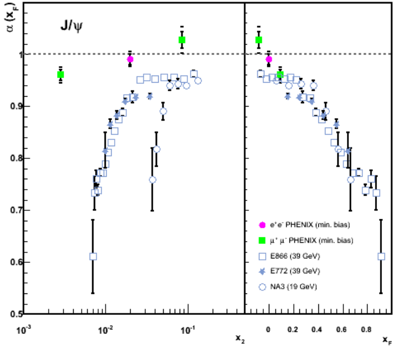


Shadowing effects are also crucial for total multiplicity and density of charged particles in the initial state of the collision.

$\alpha(x_F)$ for light and heavy particles

Breaking of scaling! Reappearance...





- change of behaviour of $\alpha(x_F)$ going from low-energy to high-energy regime
- $\alpha(x_F = 0)$ sensitive to the disappearance of low-energy effects and onset of shadowing
- RHIC on the border both for light and heavy particle production

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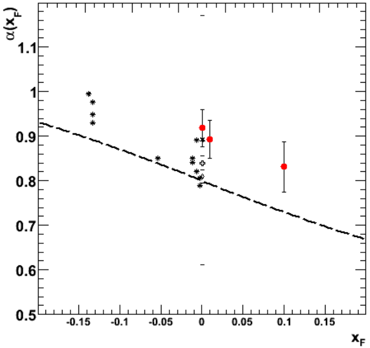

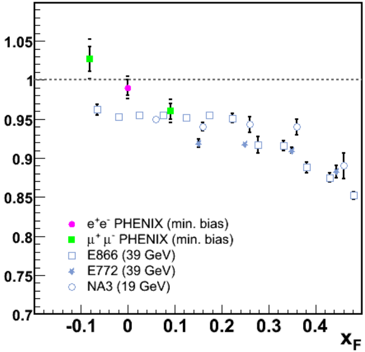

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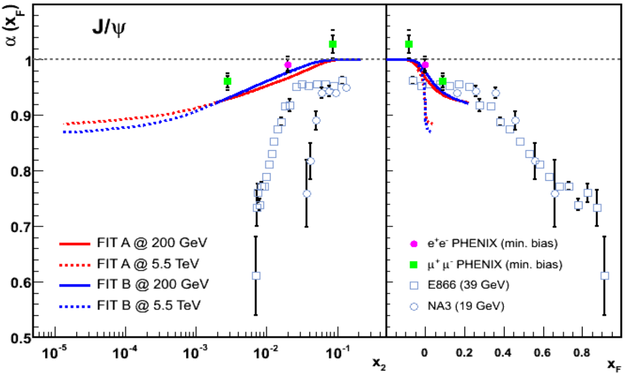

- scaling with x_F for low energies due to energy-momentum conservation
- scaling with x_2 will appear for RHIC and higher energies

Conclusions

- LHC is “high-energy regime” - different underlying space-time picture of the interaction
- strong shadowing effects are predicted, important in p+Pb collisions and as initial condition for Pb+Pb modeling of final-state effects
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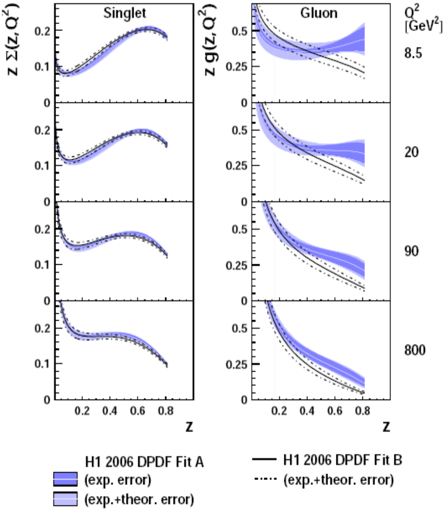
$$\left[\frac{d\sigma^{\mathcal{D}}_{\gamma^* N}}{dM^2 dt}\right]_{t=0} = \frac{4\pi^2\alpha_{em}B}{Q^2(Q^2+M^2)} x_{I\!P} F^{(3)}_{2\mathcal{D}}$$

FIT A

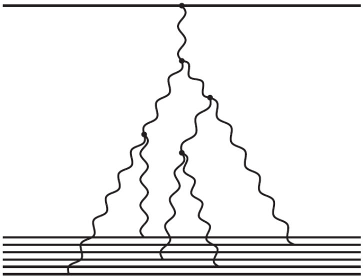
- parameterized at $Q_0 = 1.75$ GeV^2

FIT B

- parameterized at $Q_0 = 2.5$ GeV^2
- maximal uncertainty in gluon dPDF due to mixing with quarks at $\beta > 0.3$



H1 Collaboration, **hep-ex/0606003**, **hep-ex/0606004**



Schwimmer Nucl.Phys.B **94** (1975) 445

- similarity to the B-K equation of dipole splitting
- relevant for hA collisions at high energies
- exact solution of the Reggeon field theory

$$\sigma_{hA}^{Sch} = \sigma_{hN} \int d^2b \frac{AT_A(b)}{1 + (A-1)f(x,Q^2)T_A(b)},$$

$$f(x,Q^2) = 4\pi \int_x^{x_P^{max}} dx_{I\!P} B(x_{I\!P}) \frac{F_{2\mathcal{D}}^{(3)}(x_{I\!P},Q^2,\beta)}{F_2(x,Q^2)} F_A^2(t_{min.})$$

BACKUP III

Final-state effects for light particles - co-movers