# Near light cone QCD

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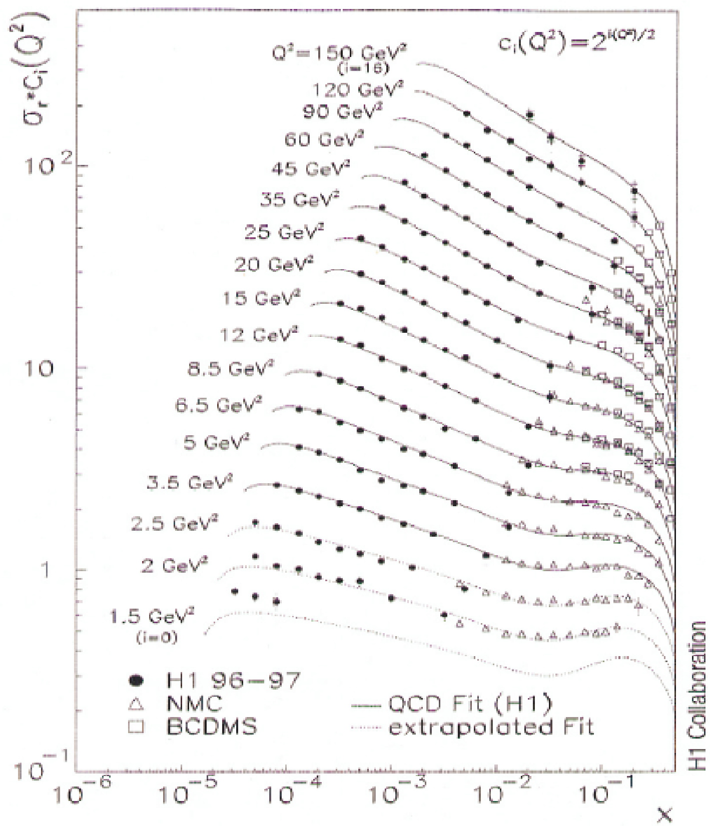
# Outline:

Motivation: High energy total cross sections

- Near light cone Hamiltonian for Quark Antiquark QCD vacuum near the light cone
- Nonperturbative Wilson Line correlations of the simplified vacuum Hamiltonian
- Diffractive cross section
- Lattice solution for the full Hamiltonian including transverse gauge fields

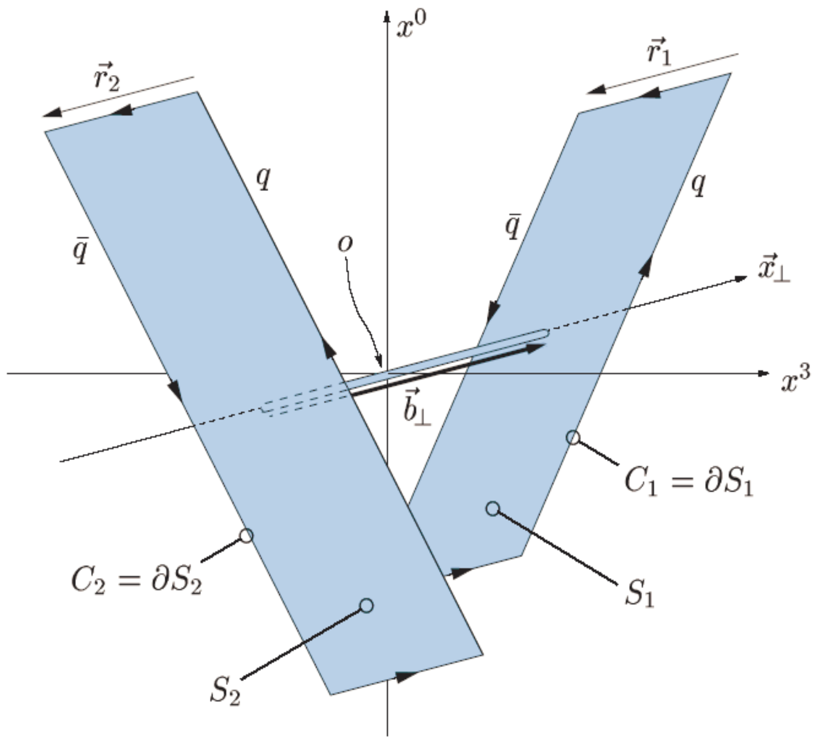
# HERA:strong energy dependence of gamma - proton cross section




- Increase depends on Q^2
- Is much stronger than in hadronic collisions
- Can also be obtained by DGLAP evolving suitably parametrized structure functions
- Many theoretical models

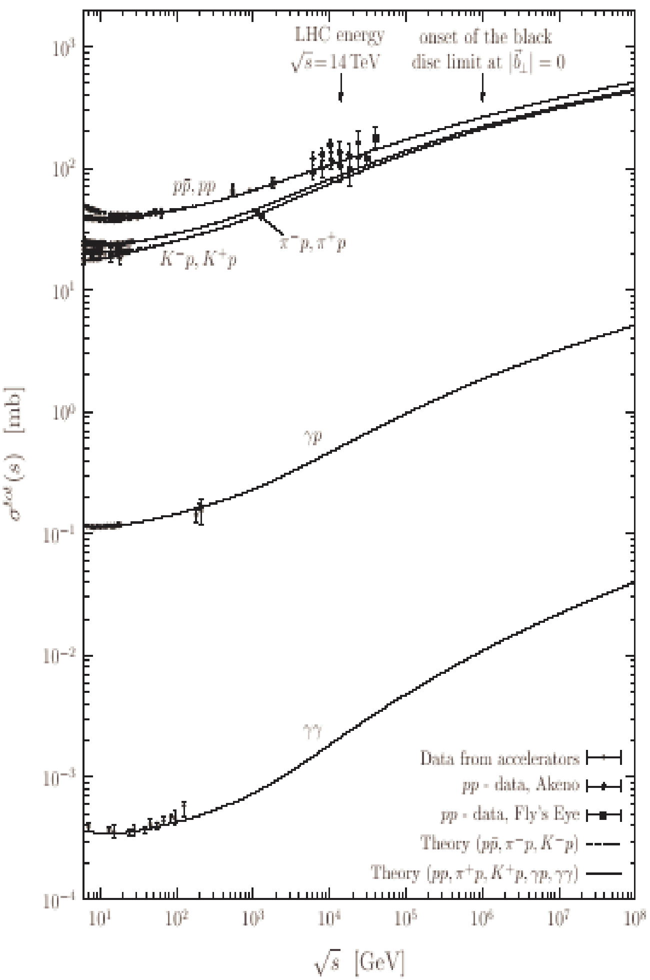
# Loop Loop Correlation Model

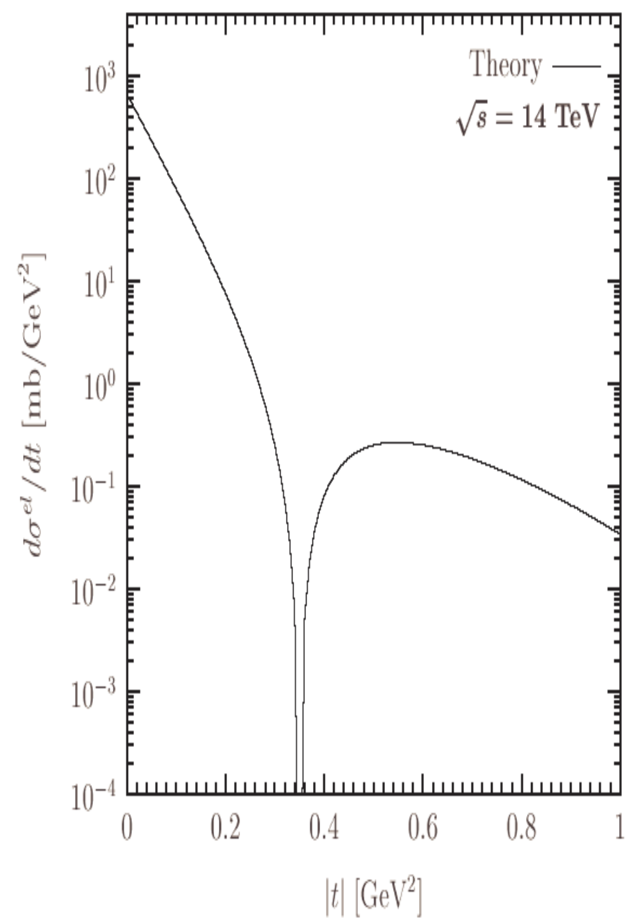
- The loop loop correlation model gives naively no s-dependence, but one can calculate NLO in Ln(1/x) contribution in the gluon distribution, then evolve with DGLAP




H.J.Pirner,A.Shoshi G.Soyez Eur.Phys. C33, 2004,63-74

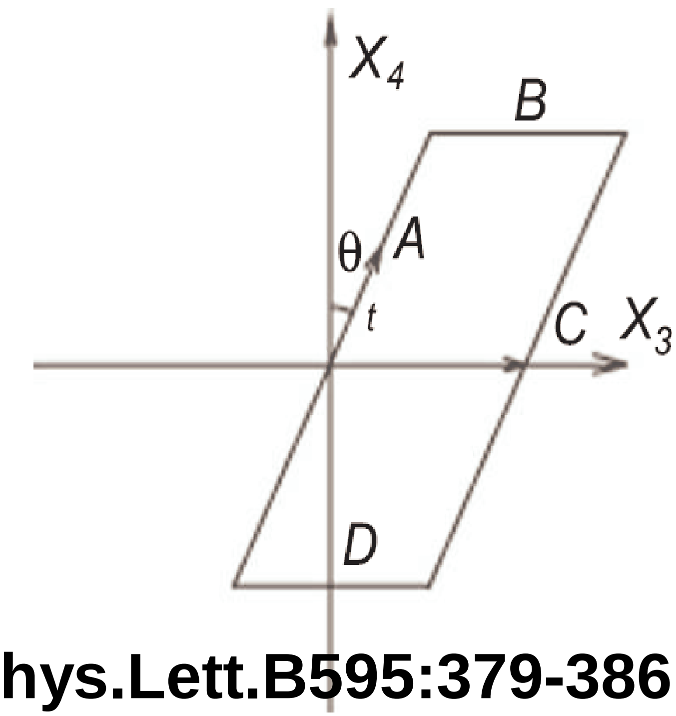
# Predictions: Total and elastic cross section



# Calculation of near light cone Hamiltonian

- Start from Wilson loop near the light cone
- Go to Minkowski space
- Find P^- =E-P_z from the phase factor




H.J. Pirner and N. Nurpeissov, **Phys.Lett.B595:379-386,2004**

# Light cone Hamiltonian for q qbar

$$u_\mu = (\gamma, 0_\perp, \gamma\beta).$$

Phasefactor= $e^{-ig\int d\tau(\gamma A^0 - \gamma\beta A^3)}$

$$< W_r[C] >= e^{-i\gamma(P^0 - P^3)}$$

$$P^- = \frac{(\mu^2 + k_\perp^2)P^+}{2(1/4P^{+2} - k^{+2})} + \frac{1}{\sqrt{2}}\sigma\sqrt{x_3^2 + x_\perp^2/\gamma^2}.$$

# Final Mass square Operator

$$M_c^2 = 2P^+P^- = \frac{(\mu^2 + k_\perp^2)}{1/4 - \xi^2} + 2\sigma\sqrt{\rho^2 + M_c^2 x_\perp^2}$$

The final light cone mass operator has a potential term which confines the quark antiquark pair by the string tension. This Hamiltonian has been solved and gives typical mass 1 GeV

# QCD Vacuum near the Light Cone

$$x^t = x^+ = \frac{1}{\sqrt{2}}\left\{\left(1+\frac{\eta^2}{2}\right)x^0 + \left(1-\frac{\eta^2}{2}\right)x^3\right\} ,$$

$$x^- = \frac{1}{\sqrt{2}}\left(x^0 - x^3\right) .$$

$\eta$

- Quantization on a space like interval
- Formalism with $\eta$

**Always related to equal time Hamiltonian by a boost**

:

H.Naus,H.J.P,T.Fields,J.P.Vary Phys. Rev. D 56,8062,1997
M.Ilgenfritz, Y.P.Ivanov, H.J.P. Phys. Rev D 62, 054006,2000

$\eta$

# Lattice Hamiltonian

$$
\begin{aligned}
T^{+}_{+} &= \frac{1}{2} g^2 \left( \frac{a_{\parallel}}{a_{\perp}} \right)^2 \Pi^{a^2}_{-} \\
&\quad -2 \frac{1}{g^2} \left( \frac{a_{\parallel}}{a_{\perp}} \right)^2 \mathrm{Tr}(U_{\Box}(1,2) - 1) \\
&\quad + \frac{1}{2} g^2 \frac{1}{\eta^2} \left[ \Pi^a_i + i \frac{1}{g^2} \mathrm{Tr}(\tau^a U_{\Box}(-,i)) \right]^2
\end{aligned}
$$

Lattice constants a in parallel and transverse directions are differentated. Lorentz factor for boosted transverse E and B fields is directly visible

# Two Strategies for $\eta \rightarrow 0$

- Calculate only terms diverging on the light cone
- Multiply Hamiltonian with eta
- Look for fixed point in the effective coupling
- Solution does not have transverse A-fields

- Find a wave function which allows a solution of the full Hamiltonian for infinitesimal eta
- Try quantum evolution of fast and classical evolution of slow fields

# I:Collective variables $\varphi$

- Wilson line integrals are the collective variables:
- Lattice Hamiltonian is defined with these variables

$$a_-^{c_0} = \frac{1}{L}\int_0^L dx^- A_-^{c_0}(\vec{x}_\perp, x^-)$$

$$\varphi^{c_0}(\vec{b}_\perp) = \frac{1}{2} g L a_-^{c_0}(b_\perp),$$

# Critical behaviour of Z(3)

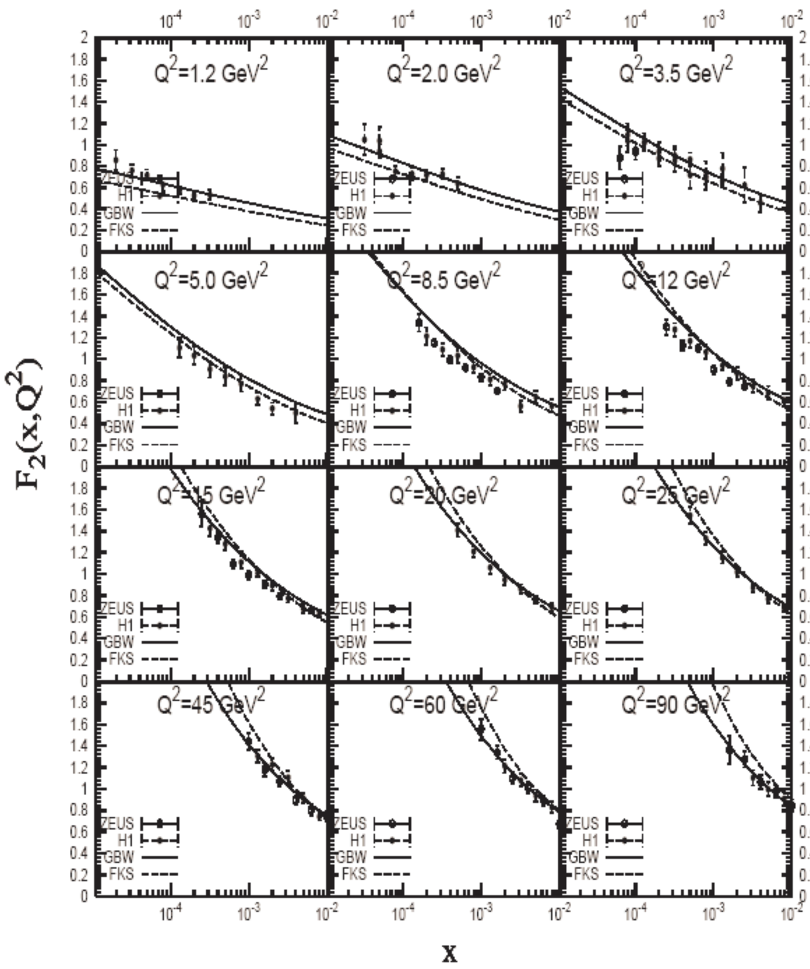
- The correlation length of Wilson lines grows with decreasing x

$$\xi \propto \left(\frac{x}{x_0}\right)^{-\frac{1}{2\lambda_2}} f_h(0).$$

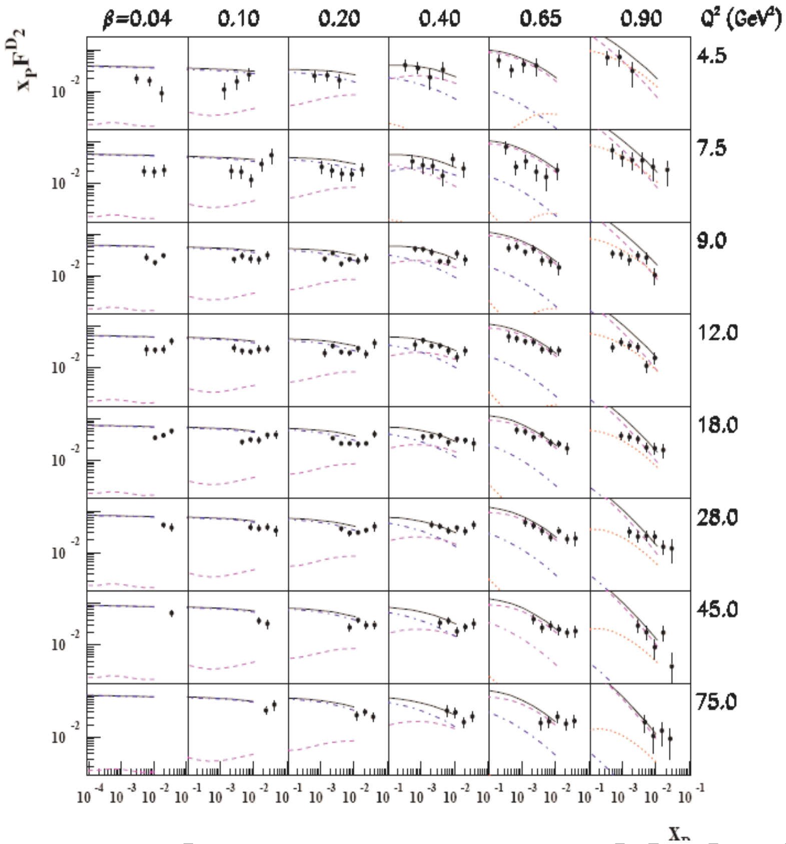
- The correlation length becoming bigger than 1/Q signals the dipole gas to dipole liquid transition

# Results:

H.J. Pirner and Yuan Feng
**Phys.Rev.D66: 034020,2002**



# Diffractive Structure Function




With S.Munier unpublished

- Contributions from transverse photons via q antiq
- Contributions from longitudinal photons
- Triple Pomeron contribution from quark antiquark gluon states

# II:Exact Wave Function for the diverging terms

- For A_-=0 one can find a starting solution for the leading term in the Hamiltonian
- This solution contains only positive frequency terms of the (fast) A_i fields
- In the classical evolution step the P_-fields are updated with Gauss Law
- The A_- (slow) fields are updated with the classical equations of motion

M. Ilgenfritz, H.J. Pirner ,D. Grünewald and E. Prokhlatilov
work in progress

# Conclusions

- Near light cone valence wave quark Hamiltonian can be generated from tilted Euclidean Wilson loops
- Simplified Lattice Hamiltonian gives Wilson line correlations which give a consistent nonperturbative picture of F2 and F3
- Full Lattice Hamiltonian is solvable near the light cone including including zero mode fields and transverse gluon fields