Information from leading neutrons at HERA

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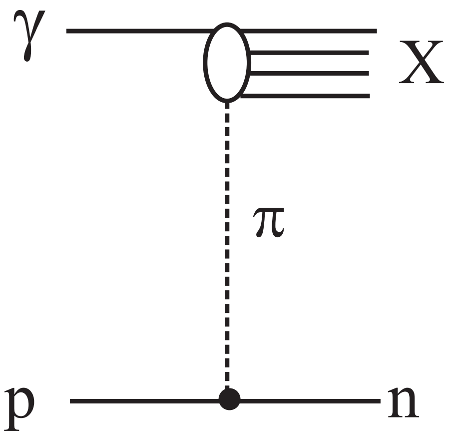
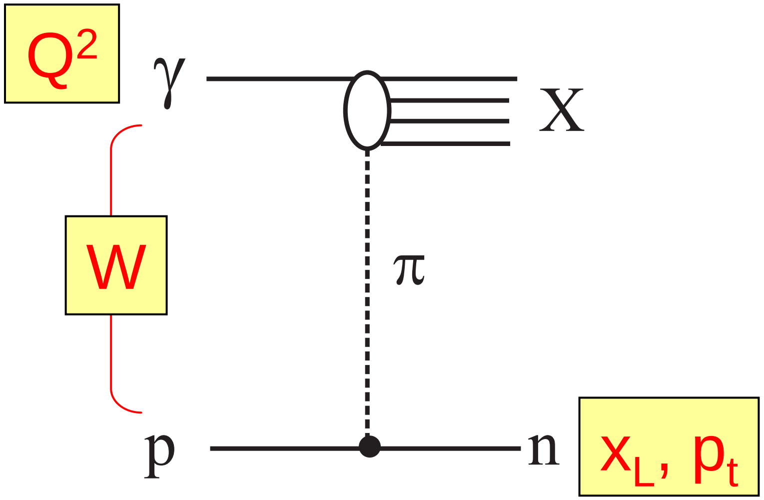
(also with A.B. Kaidalov)



Alan Martin (Durham)
2nd HERA-LHC Workshop
CERN, 6-9th June, 2006



π exchange dominates for $x_L > 0.6$,

but absorptive effects

Nikolaev, Speth, Zakarov; Alesio, Pirner

Leading neutron data (Q^2, x_L, p_t) →

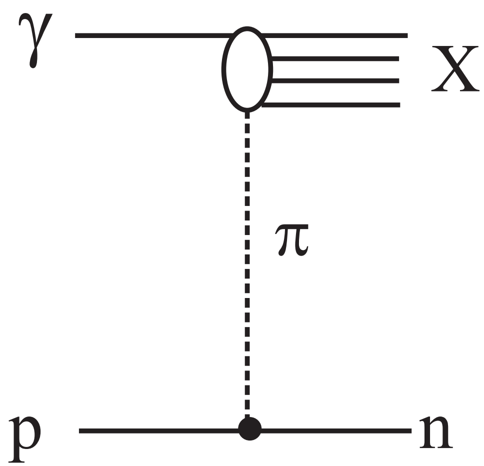
π structure fn, $F_2^{\pi}(x,Q^2)$ at small x → $f^{\pi}_{q,g}$

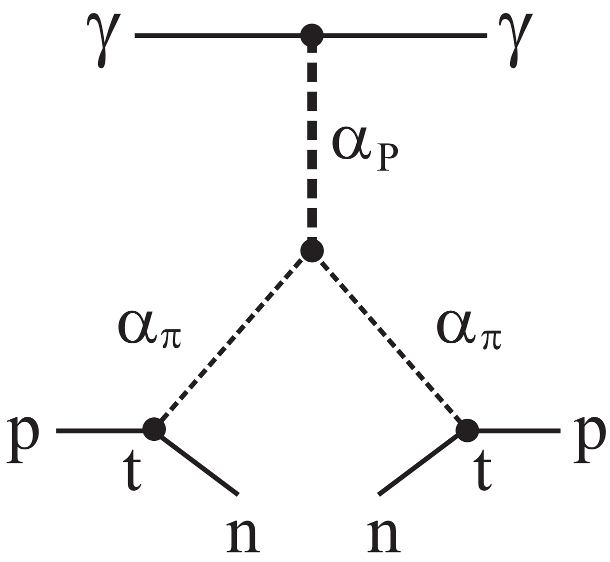
$\sigma_{abs}(q\bar{q}\text{-}N)$ → check of S^2

pion flux

This study inspired by prelim. ZEUS data

Bill Schmidke
Mara Soares
Michele Arneodo





$$\frac{d\sigma(\gamma p \to XN)}{dx_L dt} = S^2 \frac{G^2_{\pi^+ pn}}{16\pi^2} \frac{(-t)}{(t-m_\pi^2)^2} F^2(t)\,(1-x_L)^{1-2\alpha_\pi(t)}\,\sigma^{tot}_{\gamma\pi}(M^2)$$

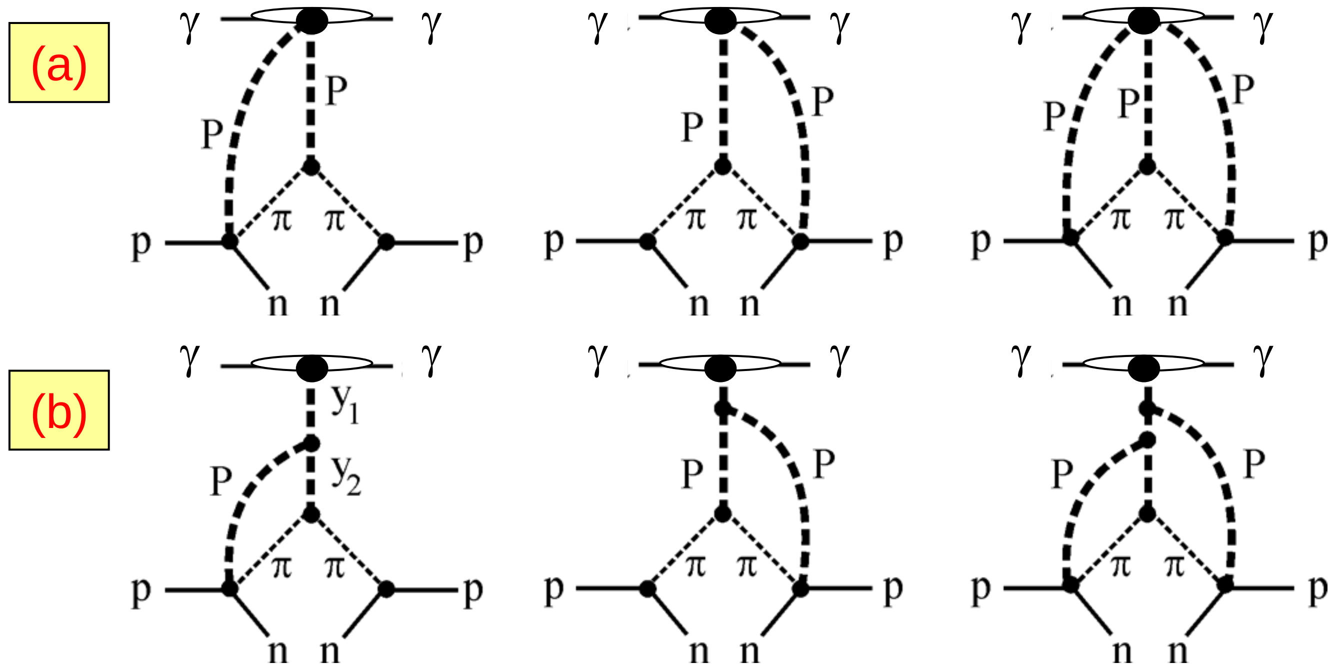
gap survival factor

$S^2 \sim 0.48$ for photoproduction

$$\sigma^{tot}_{\gamma\pi} = \frac{2}{3}\sigma^{tot}_{\gamma p}$$

Add^{ve}QM:

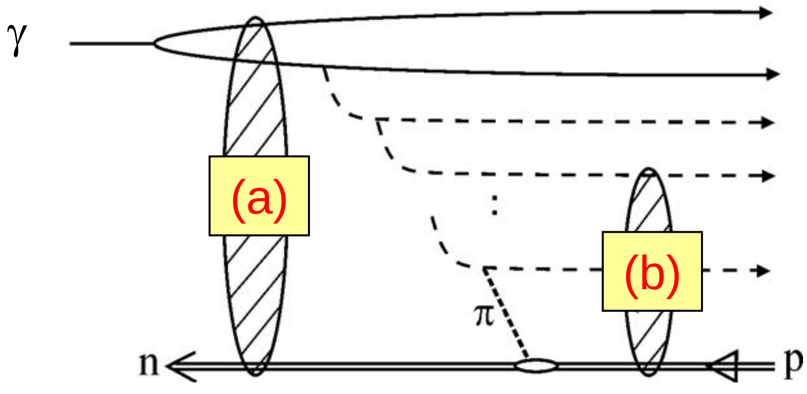
Calculation of survival factor, $S^2(x_L, p_t^2, Q^2)$



normal eikonal diagrams

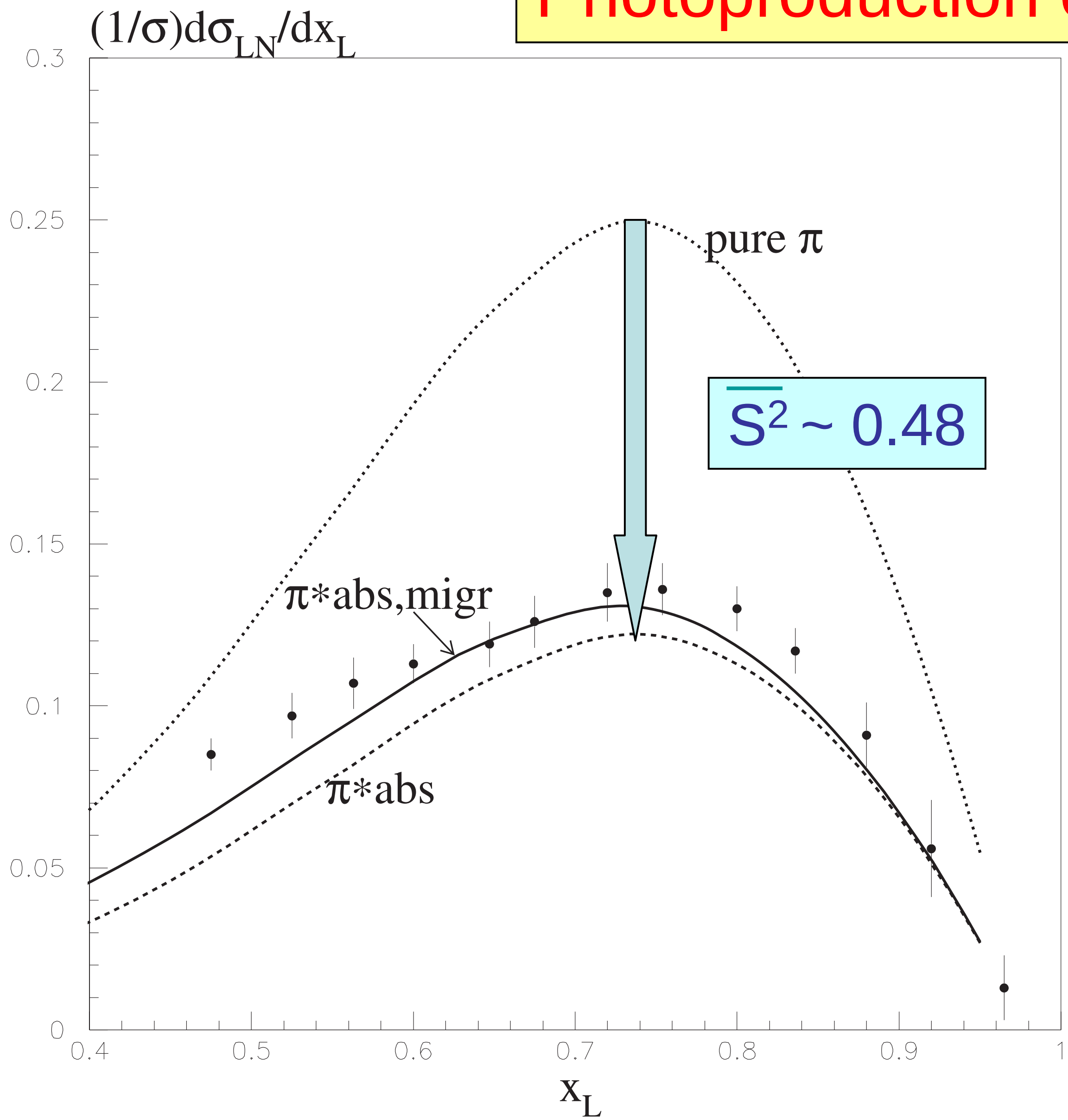
enhanced diag.
need y_i > 2-3:
result ~ 15%

space-time picture



If enhanced diag were important, then n yield would be energy dep. Not seen in data.

Photoproduction of leading n



Prelim. ZEUS data (DIS2006)

Deep inelastic production

$$\sigma^{\rm tot}_{\gamma^*\pi} = \frac{4\pi^2\alpha}{Q^2} F_2^\pi.$$

$$\frac{d\sigma(\gamma p \to XN)}{dx_L dt} = S^2 \frac{G^2_{\pi^+pn}}{16\pi^2} \frac{(-t)}{(t-m_\pi^2)^2} F^2(t)\,(1-x_L)^{1-2\alpha_\pi(t)}\,\sigma^{\rm tot}_{\gamma\pi}(M^2)$$

gap survival factor
expect S^2=1 for v.high Q^2

Add^{ve}QM:

$$F_2^\pi(x,Q^2) = \frac{2}{3} F_2^p(\frac{2}{3}x, Q^2)$$

---

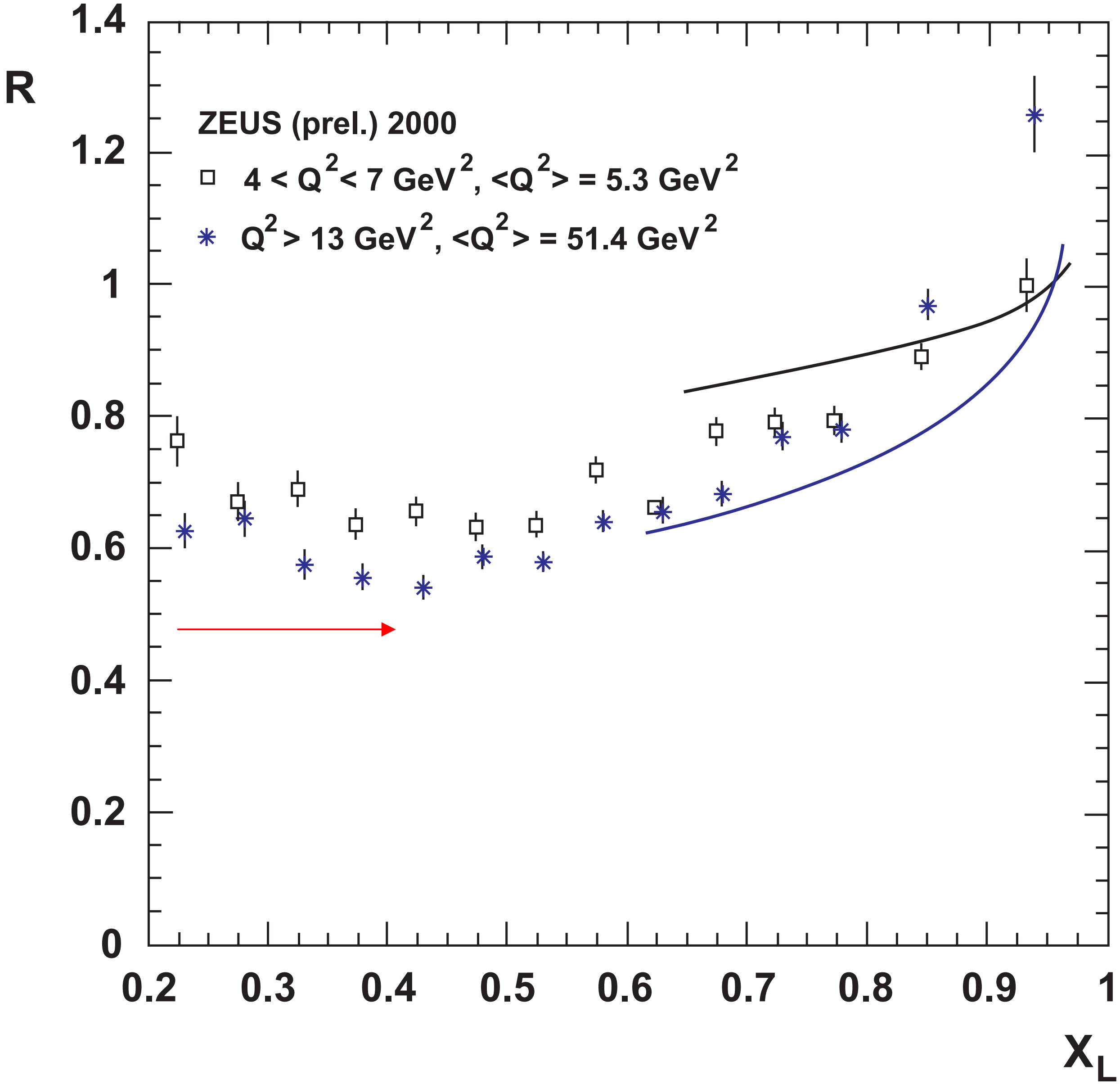
expect R = photoprod / DIS(v.high Q^2) ~ 0.48

In practice, at finite Q^2 abs. corr. remain;
use two-ch eikonal with $\sigma_{q\bar{q}\text{-}p} \sim \sigma_{\rho p} \sim \sigma_{\pi p}$ ~ 31mb;
compare with prelim. ZEUS data →

R = photoprod / DIS

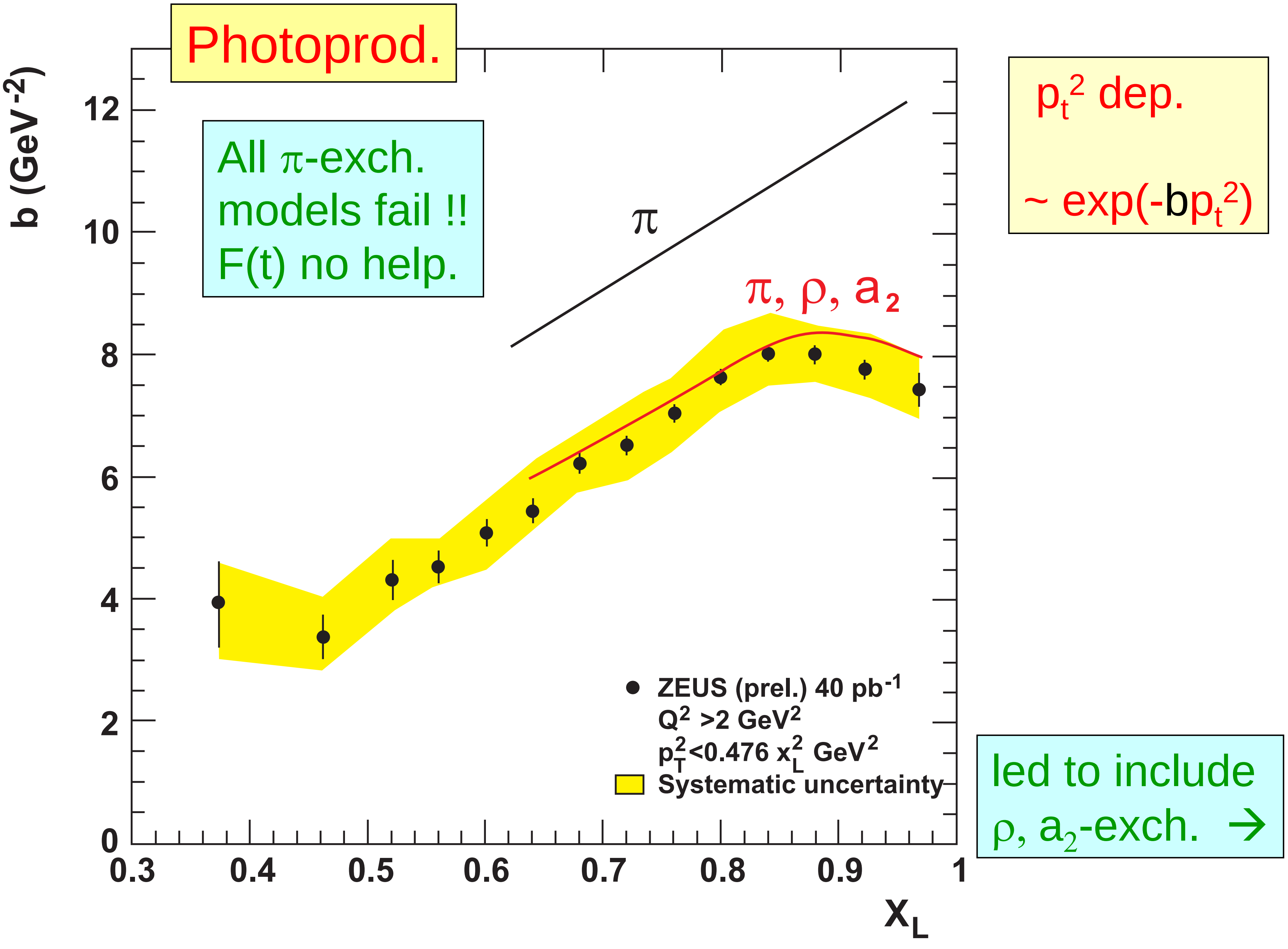
$\sigma_{incl} \sim x^{-\lambda}$

$(1 - x_L)^{\lambda(0) - \lambda(Q2)}$



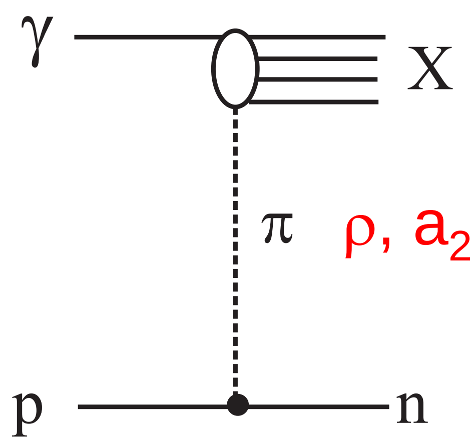
precise data will yield information on both F_2^{π} and S^2

…now the p_t dep.



Photoprod.
All π-exch.
models fail !!
F(t) no help.
π
π, ρ, a₂
p_t^2 dep.
~ exp(-bp_t^2)
b (GeV^{-2})
x_L
ZEUS (prel.) 40 pb^{-1}
Q^2 >2 GeV^2
p_T^2<0.476 x_L^2 GeV^2
Systematic uncertainty
led to include
ρ, a_2-exch. →

Including ρ and a_2 exchange



large flip

Irving, Worden

$$\frac{V_\rho^{\mathrm{flip}}}{V_\rho^{\mathrm{non-flip}}} \simeq 8\,\frac{p_t}{2m_N}$$

enlarges σ, more at larger p_t
leading to smaller slope, b

Use ρ, a_2 exch. degeneracy, additive QM

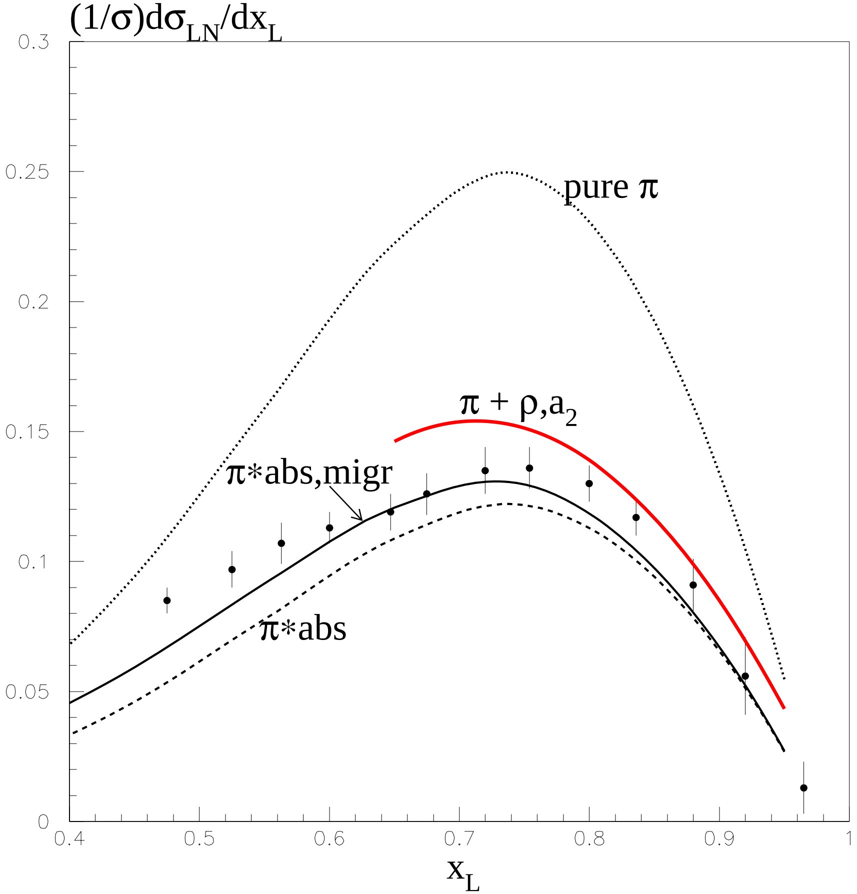
Slope b now OK --- σ too large --- adjust parameters to attempt to simultaneously describe σ and b

$$F_2^{\mathrm{meson}}(x,Q^2) = \frac{2}{3}\,F_2^p\left(\frac{2}{3}x, \frac{r_m^2}{r_p^2}Q^2\right)$$

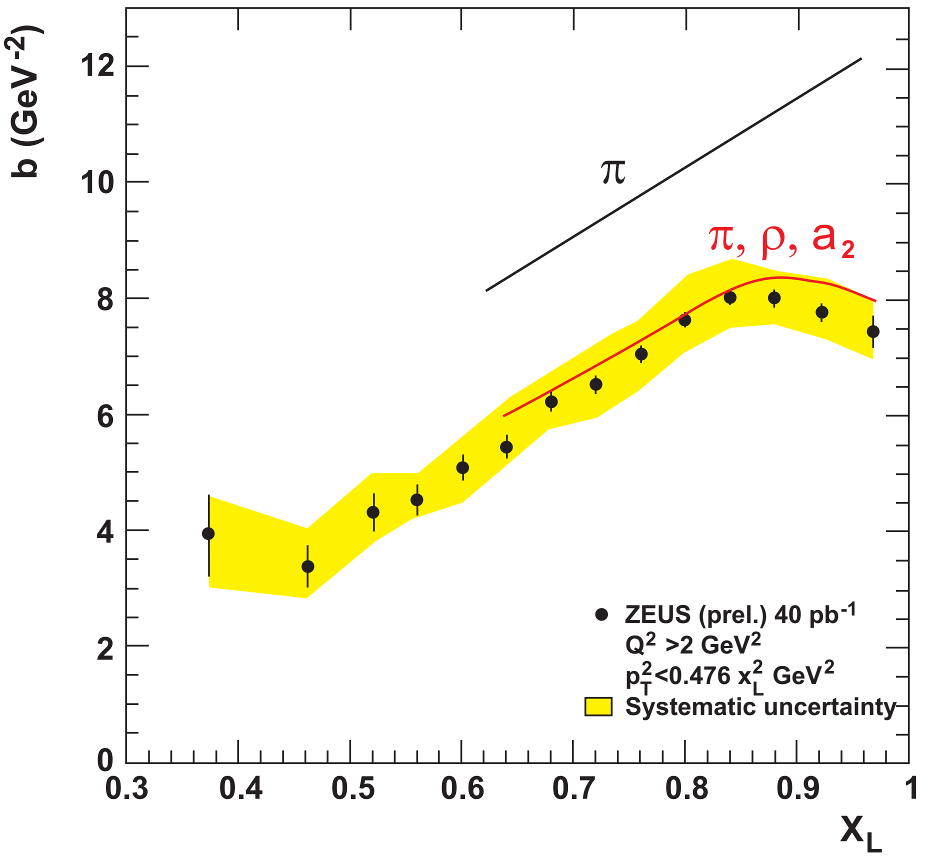
$\sigma \sim \alpha_S^2\, r^2$

now $\overline{S^2} \sim 0.4$

cross section

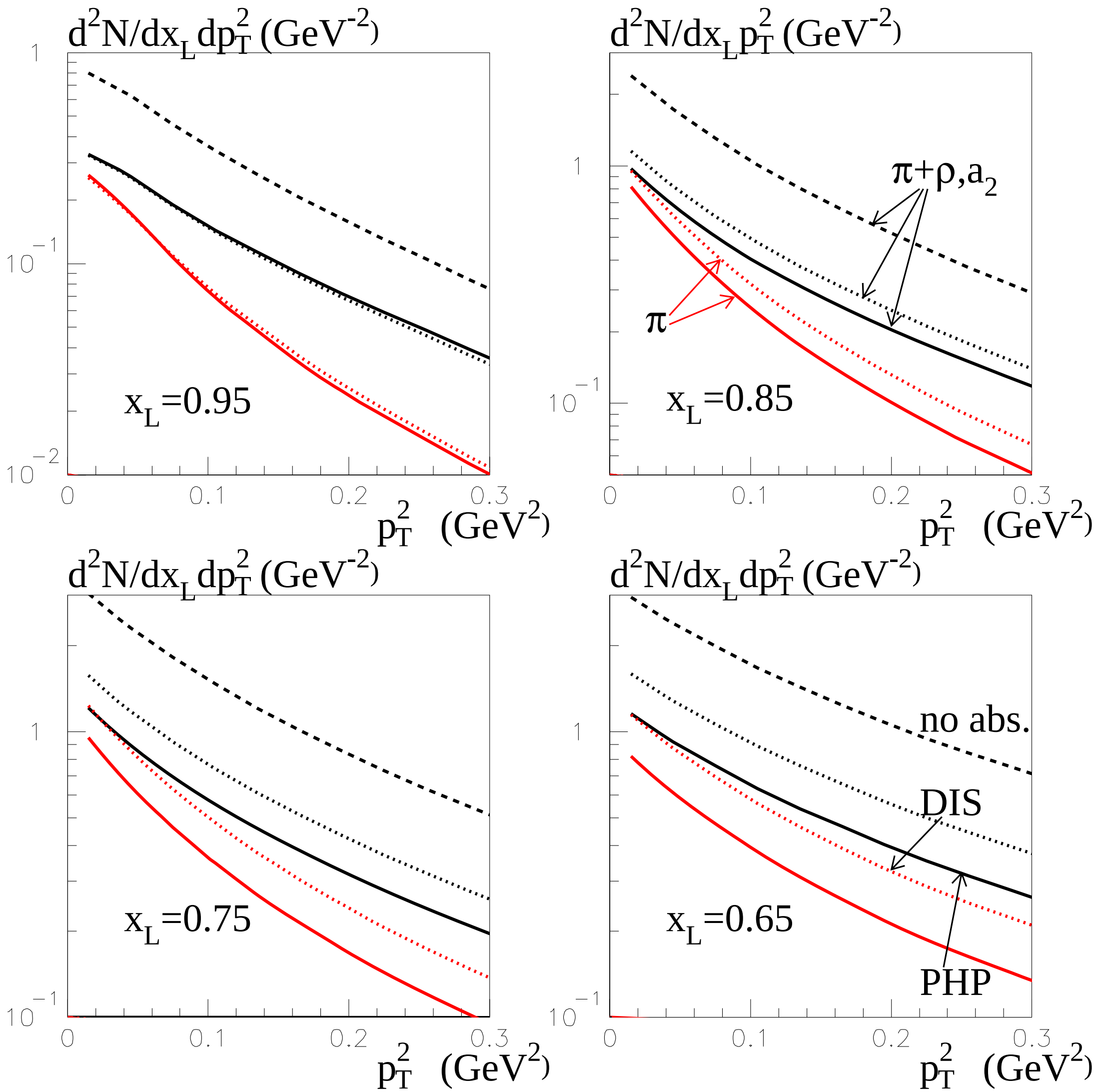


p_t^2 slope

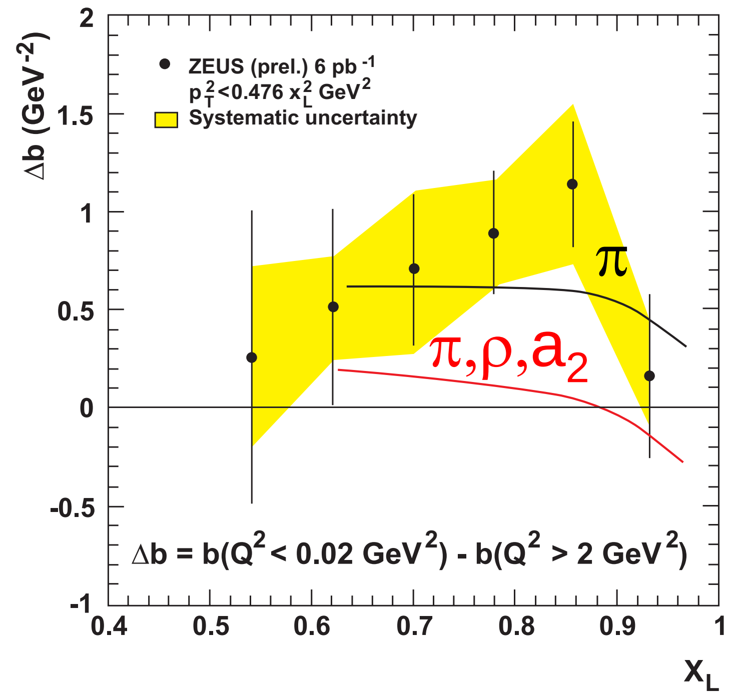


now $\overline{S^2} \sim 0.4$, instead of 0.48

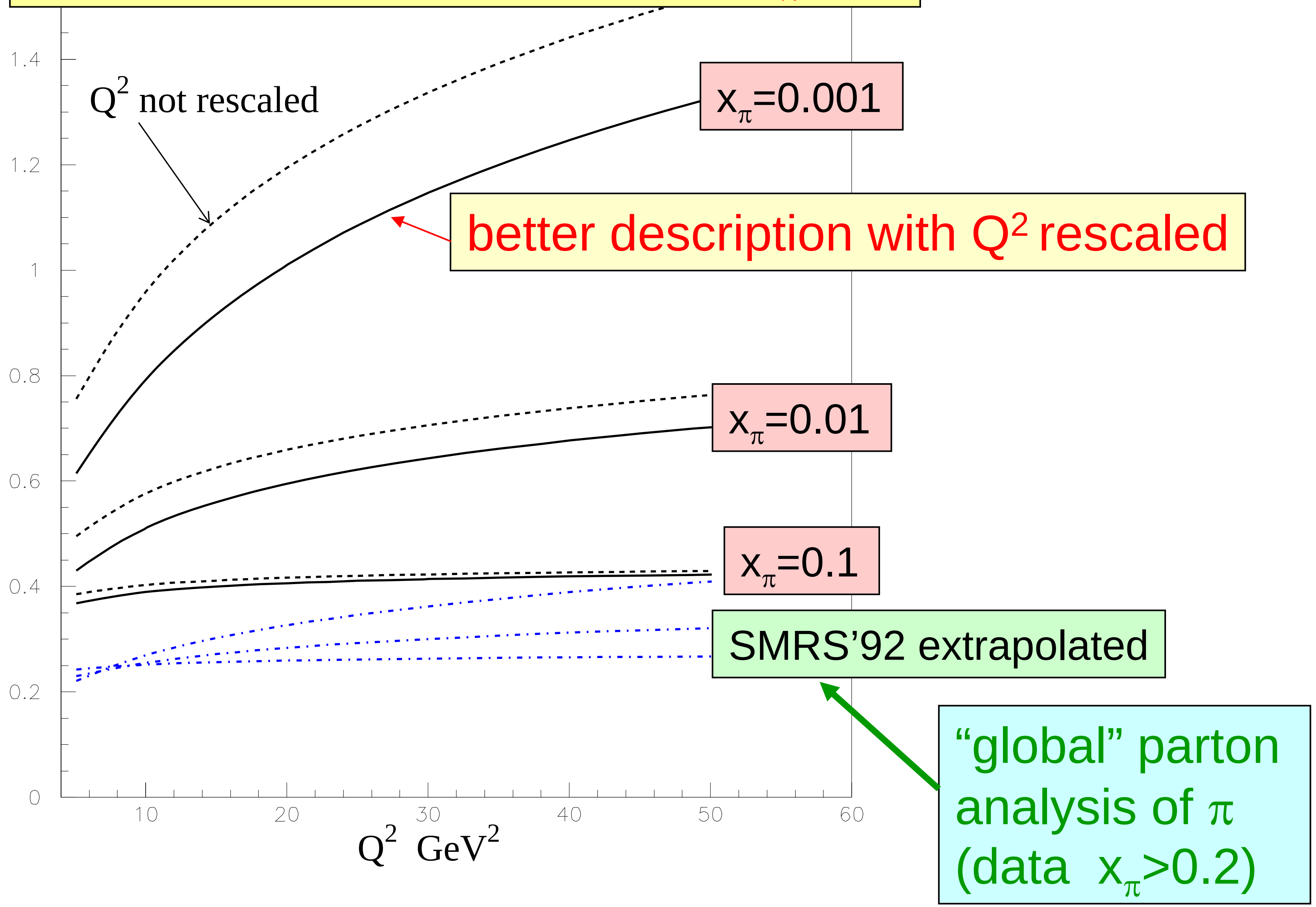
Slope b of p_t^2 distrib.



$\Delta b = b(\gamma prod) - b(DIS)$



pion structure function $F_2^{\pi}(x_{\pi},Q^2)$



Conclusions on leading neutrons at HERA

- Exploratory study of prelim. ZEUS data (Q^2, x_L, p_t, W) very informative

- π exch (with abs.) describes σ, but not p_t^2 slope b
  $\rightarrow$need also ρ, a_2 exchange

  turnover of slope as $x_L \rightarrow 1$ ($t_{min} \rightarrow 0$) may be used to determine ρ, a_2 versus π exchange contributions

- Absorptive corrections important $\overline{S}^2 \sim 0.4$
  Small contrib. from enhanced diagrams

  important for LHC

- Simultaneous description all data (Q^2, x_L, p_t dep.) difficult

- This is good. Precise LN data should determine $F_2^{\pi}(x,Q^2)$ at small x and $S^2(x_L,p_t,Q^2)$