Leading Baryons at HERA

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On behalf of the H1 and ZEUS collaborations

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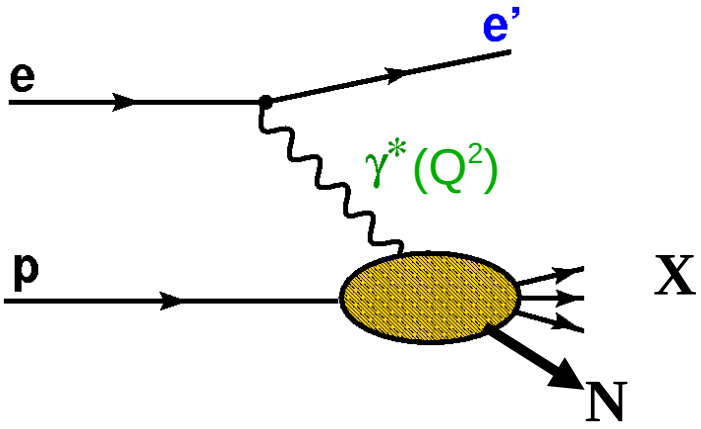
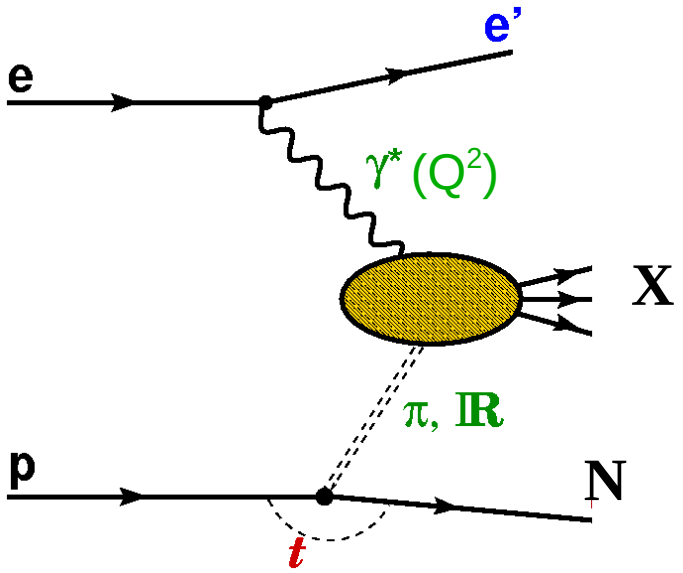
- Baryon production models: particle exchange
- Vertex factorization
- Vertex factorization violation: rescattering
- Pion structure function

Motivation: Production Mechanisms

ep scattering: baryon # has to go *somewhere*:



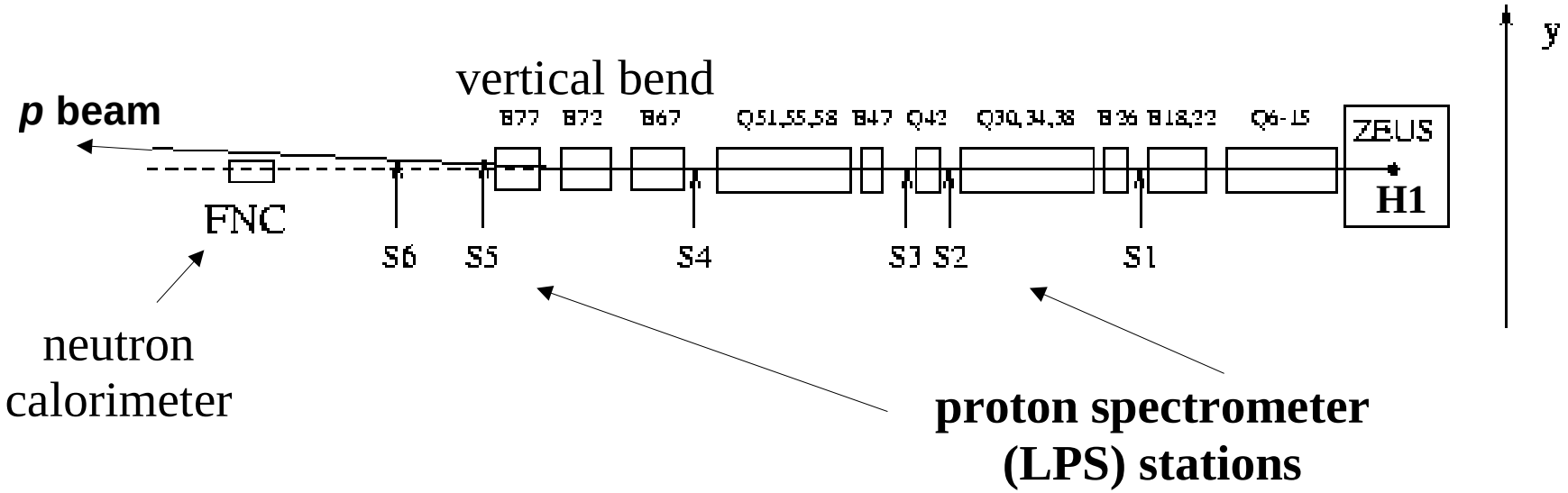
Standard fragmentation:
Final−state N in *p* remnant
MC models



Particle exchange:
ep scattering → eπ scattering (e.g.)
fast final state N

protons: isoscalar, isovector exch.
neutrons: isovector (e.g. π^+) exch.

Detectors and Data

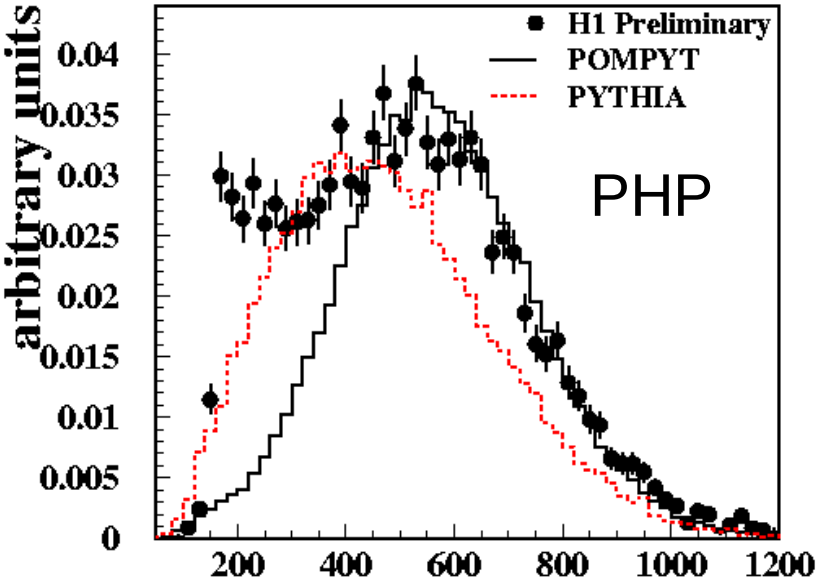


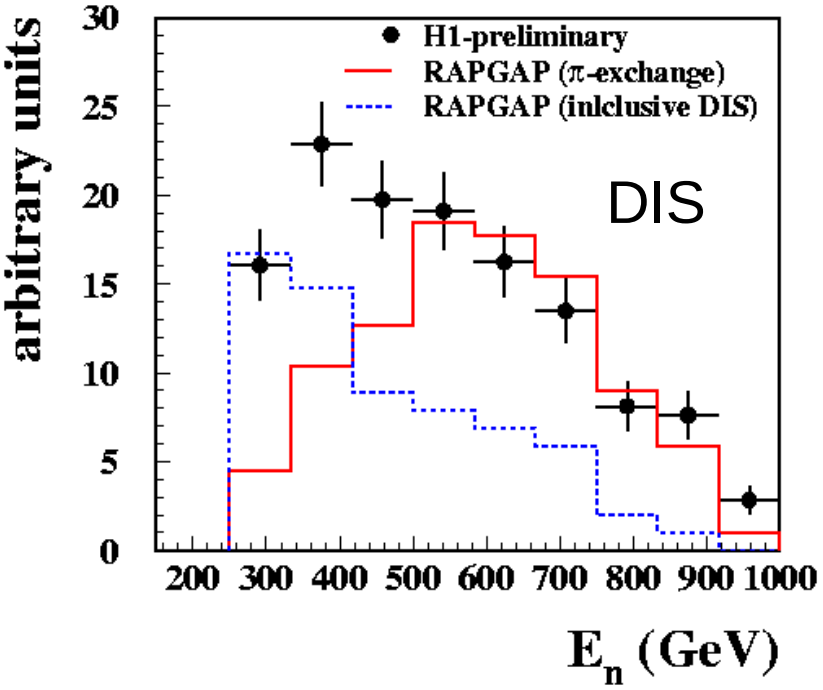
Measure leading baryon $x_L = E_{LB}/E_{beam}$, p_T (or t)

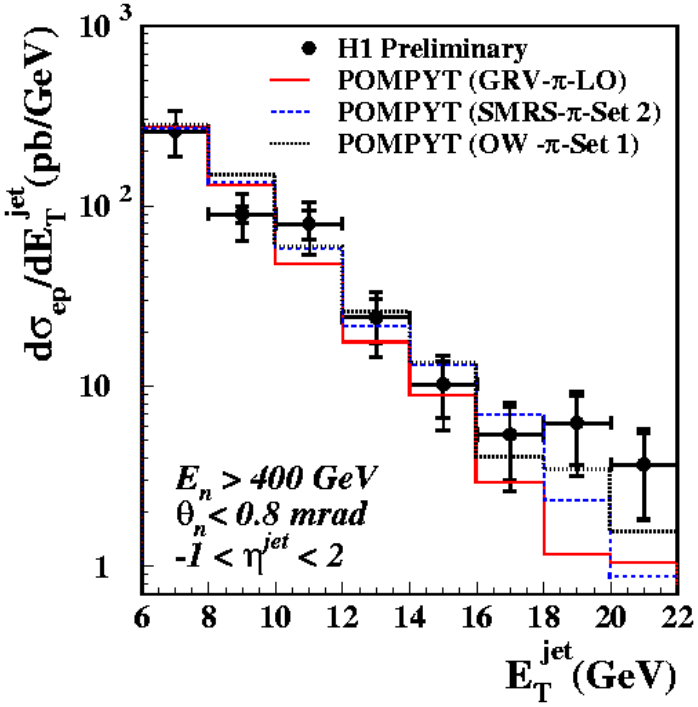
Data sets:
vary γ virtuality Q^2
$Q^2 \sim 0 \rightarrow$ photoproduction (PHP)
$Q^2 >$ few GeV$^2 \rightarrow$ deep inelastic scattering (DIS)

Presented here:
ZEUS − neutrons, protons in DIS, PHP
H1 − neutrons in DIS, PHP with dijet in final−state

n with dijet







Compare shape and normalization of data:

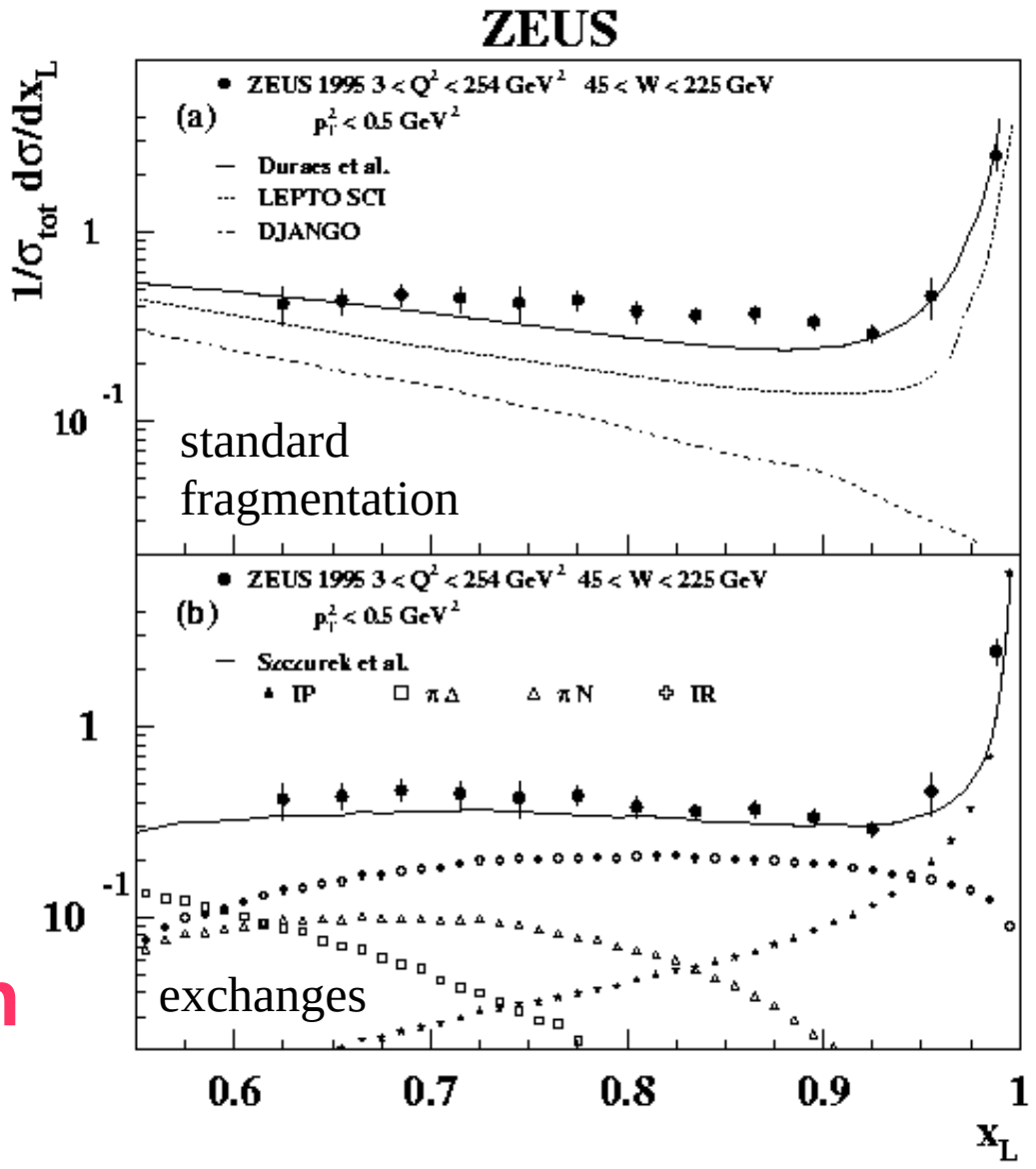
- Standard fragmentation models do not reproduce data
- π^+ exchange models E_n spectrum well at large E_n
- π^+ exchange models jet E_T well

Energy Spectra: *p* in DIS

Compare shape and normalization of data:

- Standard fragmentation models do not reproduce data
- Exchange models describe data
- Need multiple processes – Pomeron, Reggeon, π^0 exch.

⇒**Virtual particle exchange describes leading baryon rate, energy spectra**



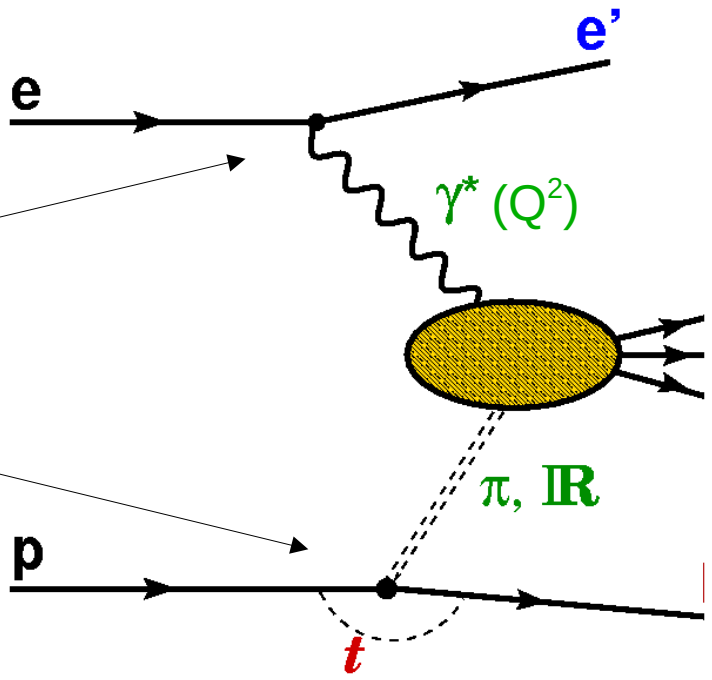
Vertex Factorization

In exchange models *ep* cross section factorizes, e.g. π exchange:

$$\sigma(ep \to e'NX) = f_{\pi/p}(x_L, t) \times \sigma(e\pi \to e'X)$$

flux π in *p*

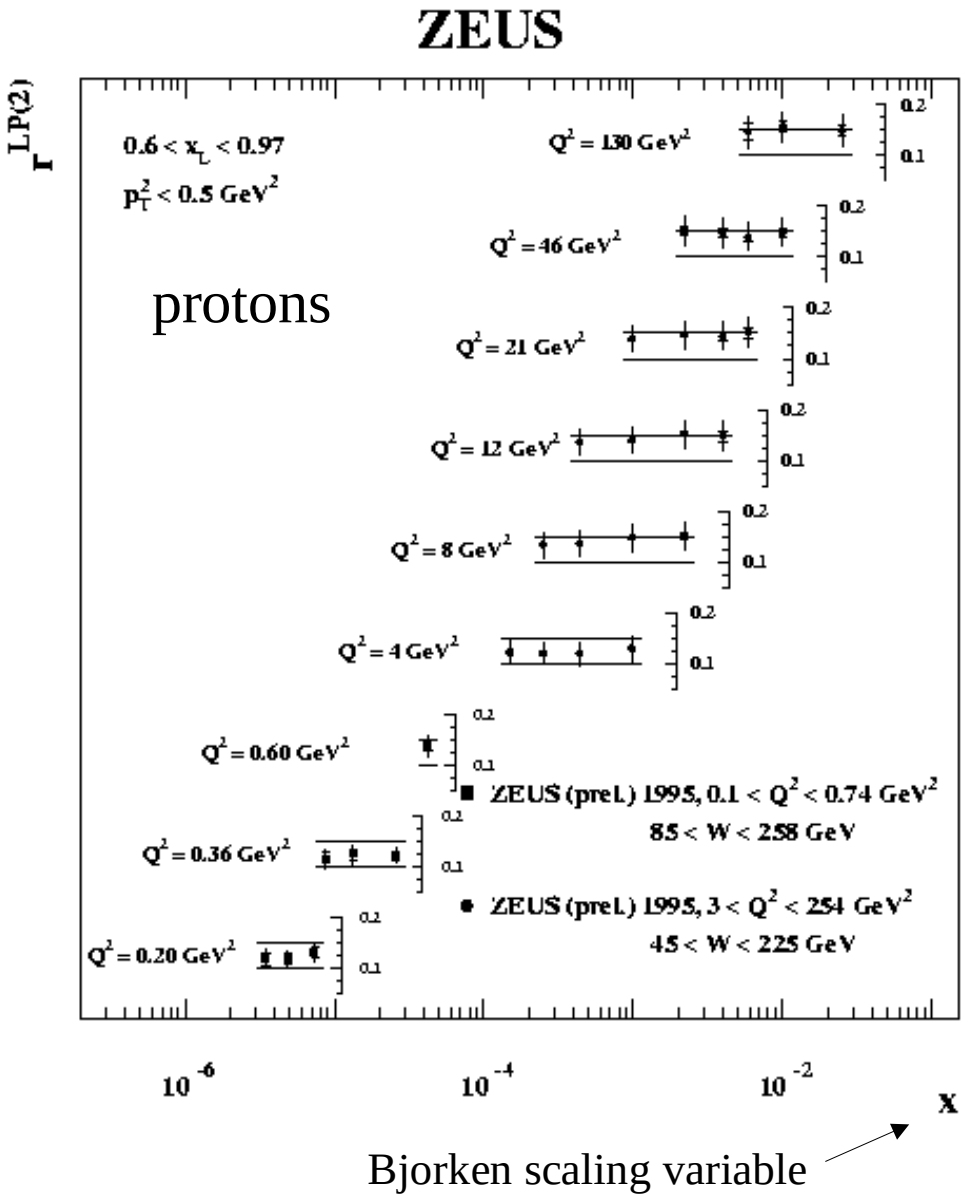
lepton vertex
$\sim$ independent of
baryon vertex

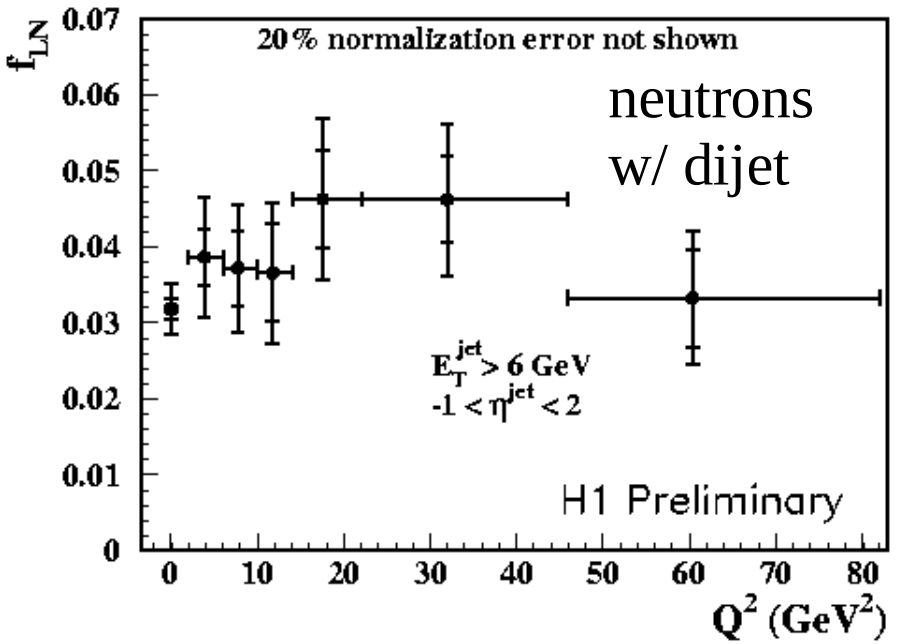


⇒ **Expect baryon rate, x_L spectra**

$\sim$ **independent of event kinematics, e.g. Q^2**

Baryon Rate vs. DIS Kinematics





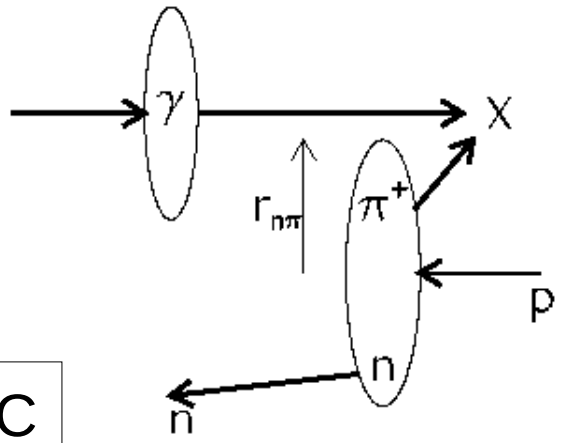
Baryon yield ~ independent of Q^2, x_{BJ}, ...

Factorization Violation

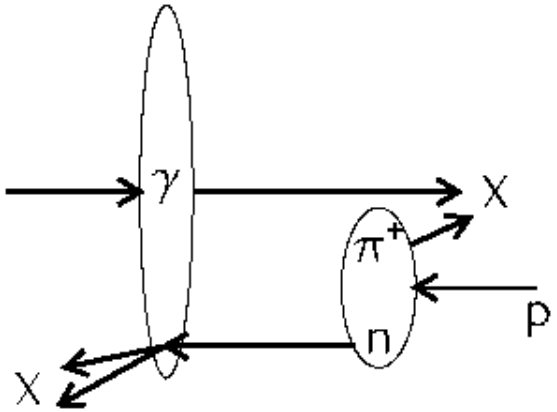
Within exchange picture can violate factorization⇒ rescattering model

e.g. *n* production via π^+ exch.: D'Alesio & Pirner

FNC



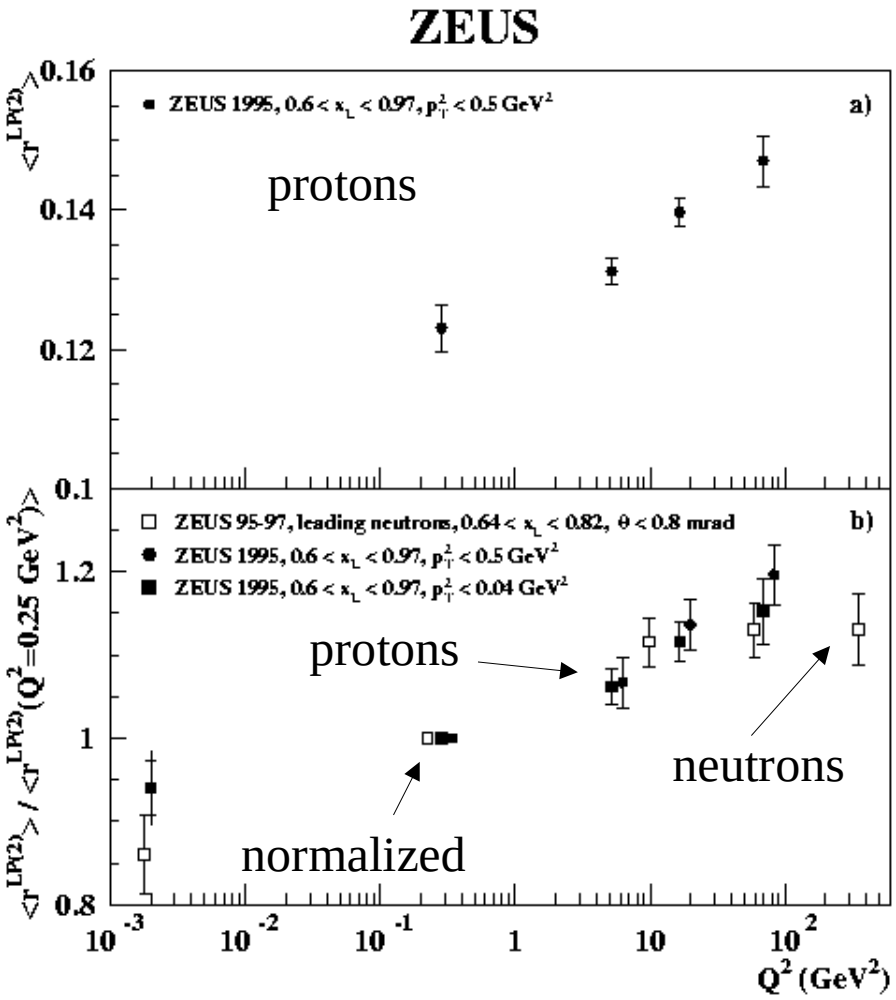
No rescattering,
n detected

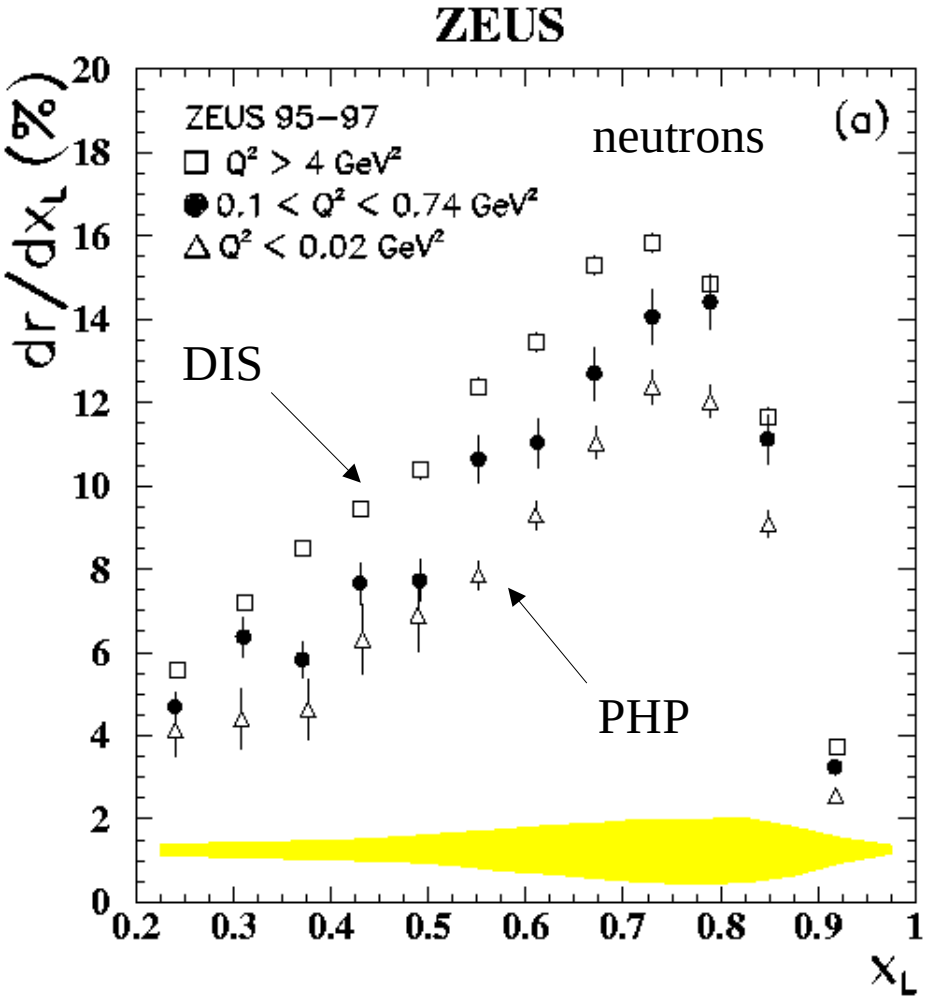


Rescattering, *n* lost
(lower x_L, higher p_T)

- In π exchange models, $<r_{n\pi}>$ smaller at lower x_L ⇒ more rescattering at lower x_L
- γ size ~ 1/Q ⇒ more rescattering at lower Q^2

Factorization Violation



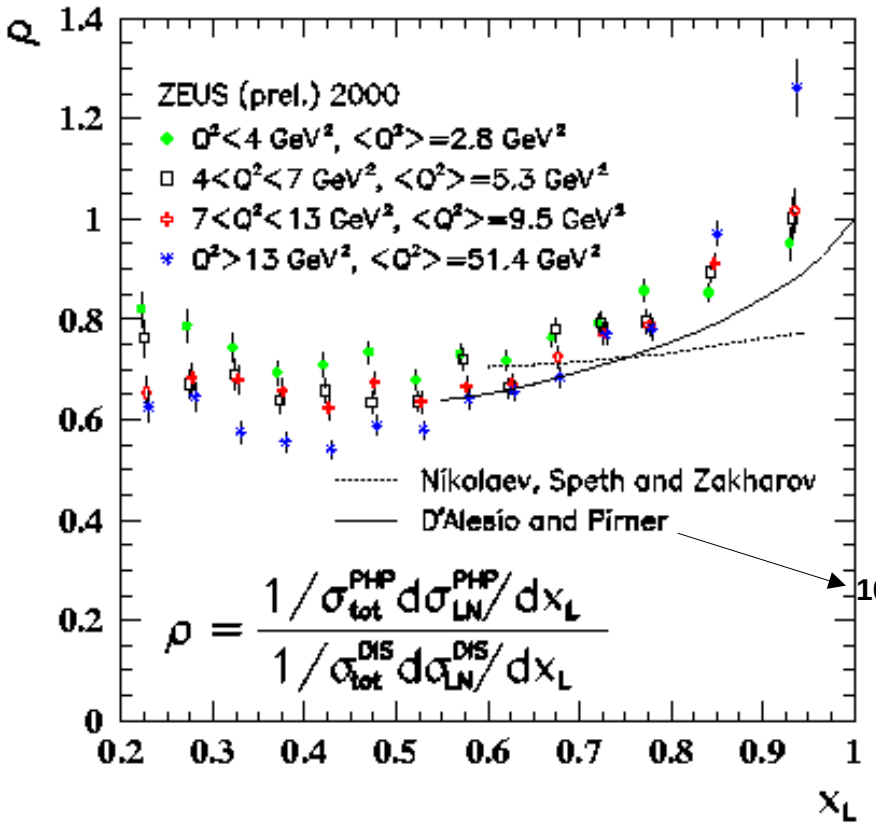


fewer baryons at lower Q^2

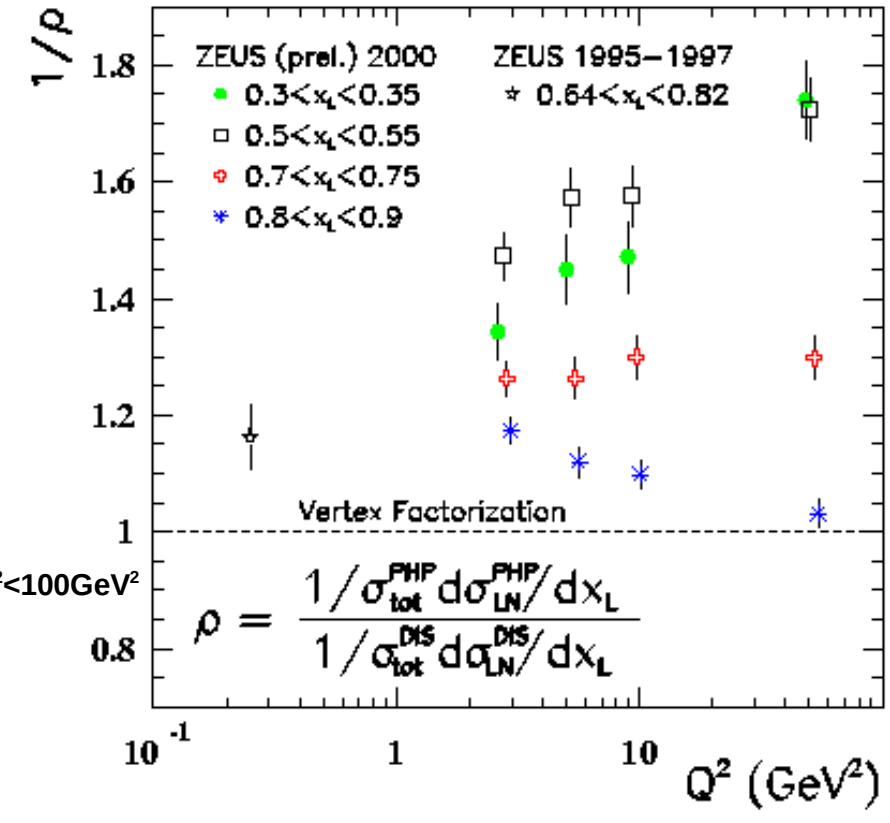
lower Q^2
lower x_L
$\Rightarrow$ fewer neutrons

Neutron x_L Spectra vs. Q^2

Ratio PHP/DIS: ZEUS



Ratio DIS/PHP: ZEUS



$10<Q^2<100 GeV^2$

- Fewer neutrons with decreasing x_L, decreasing Q^2
- Qualitative agreement with rescattering model

Pion Structure Function

- In region where factorization ~valid (high Q^2, high x_L)

  and π exchange dominates

- Like cross section, structure function factorizes:

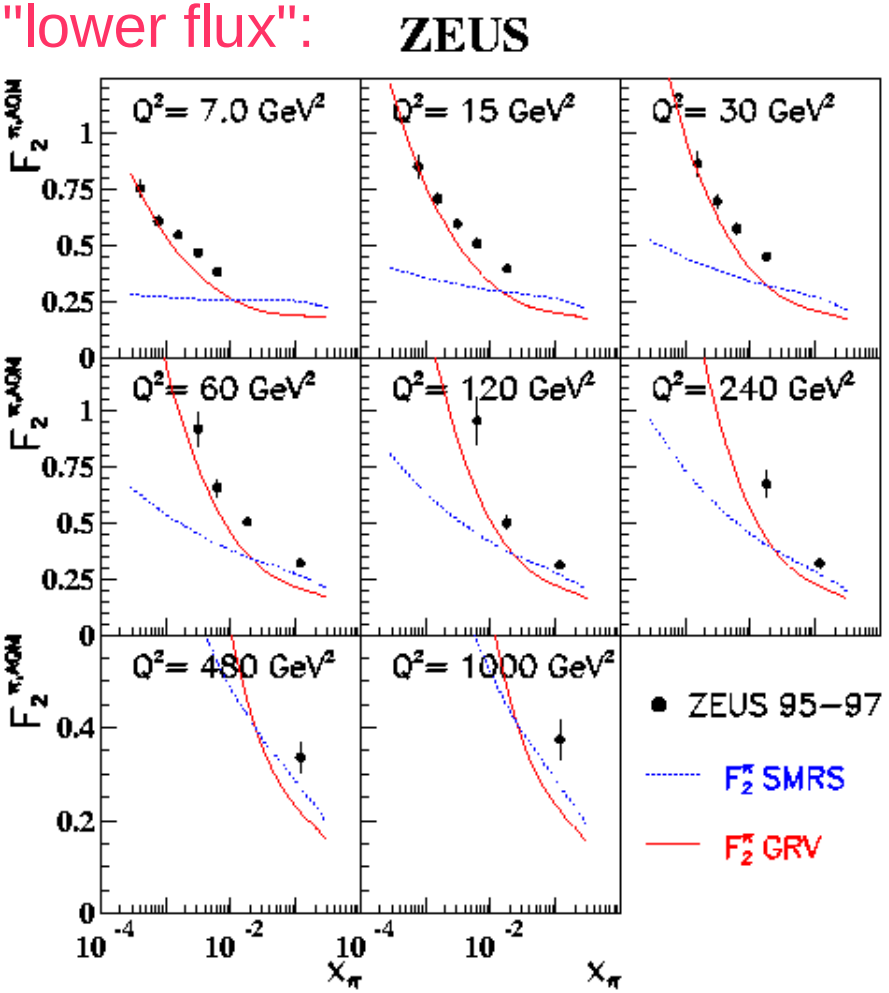
$$F_2^{LN}(x_{BJ}, Q^2, x_L, t) = f_{\pi/p}(x_L, t) \times F_2^{\pi}(x_{BJ}/(1-x_L), Q^2)$$

- Measure F_2^{LN}
- $f_{\pi/p}$ from exchange models $\rightarrow$ factor of 2 variation in normalization
- Can extract F_2^{π} (use extremes of flux)
- Compare to parameterizations

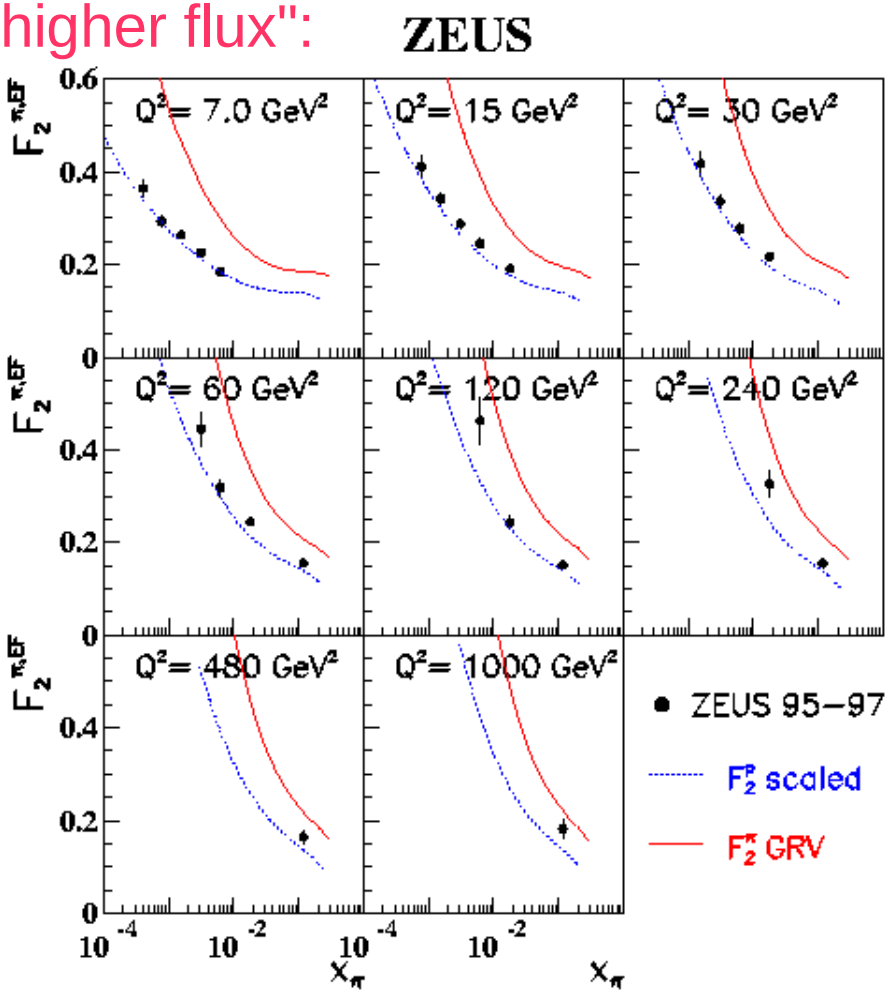
  (based on low Q^2, high x_{BJ} fixed target data)

Pion Structure Function

"lower flux":



"higher flux":



Can discriminate between parameterizations at high Q^2, low x_{BJ}

F_2^π approx. $\propto F_2^p$

Summary: Leading Baryons

- Standard fragmentation models fail to describe baryon production
- Particle exchange models describe rate, spectrum of baryons
- Vertex factorization approximately valid at high Q^2
- Vertex factorization broken at low Q^2, form of violation varies with x_L
- Violation consistent with particle exchange, rescattering
- F_2^{π} measured at high Q^2, low x_{BJ}
- $F_2^{\pi} \propto F_2^{p}$