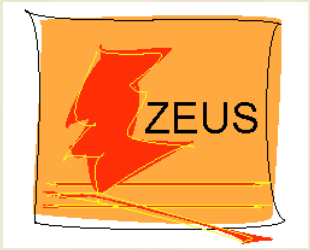
Leading Protons at HERA



M.S.Soares

Univ Autonoma de Madrid

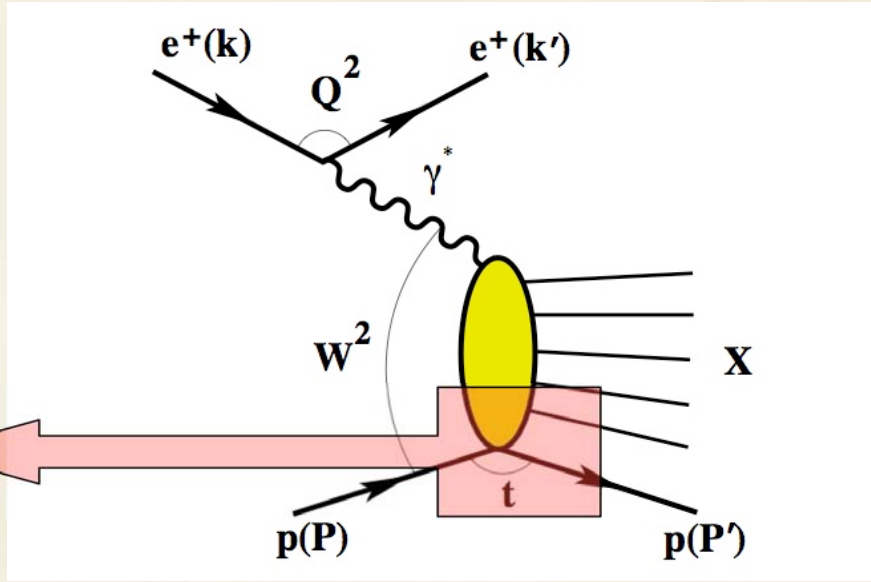
on behalf of H1 and ZEUS Collaborations

- Diffraction 08 -

La Londe-les-Maures, France,
September 9-14, 2008

Physics of the Leading Protons:

. A semi-inclusive reaction : ep→epX

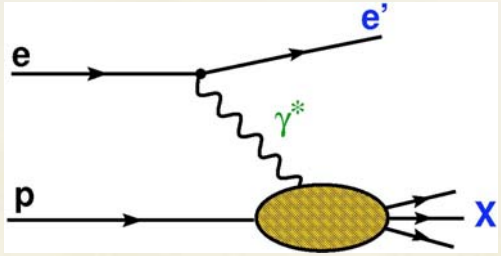


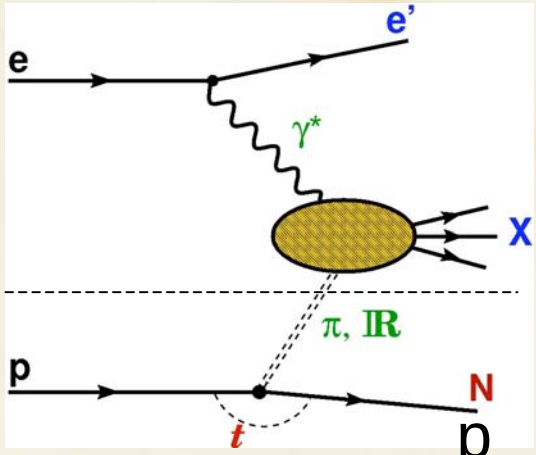
$x_L : E_{p'}/E_p$	BIG
$t : p(P)-p(P')$	small

. DIS regime: scale for secondary particle production Q^2 (hard) and low-p_T (soft)

. Photoproduction regime: $Q^2 \approx 0$

Typical models:





p

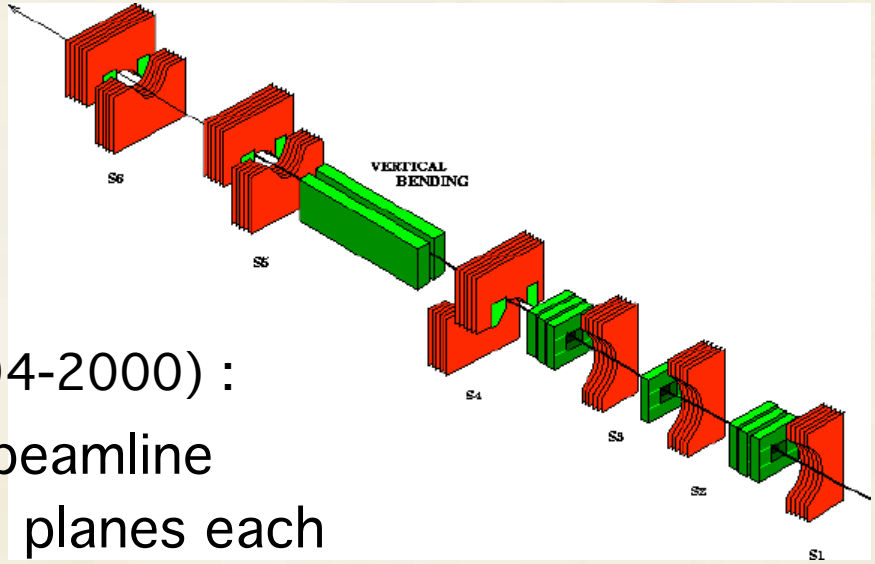
- Protons produced at high-x_L but low-p_T:
  non-perturbative approach

- Perturbative:
  standard fragmentation
  - usually implemented in MC : DJANGOH, RAPGAP

- Non-perturbative:
  Regge-based models
  - dynamical particle-exchange of virtual particles (ρ,IP,π,etc)
  - ~ vertex factorization

- "In between": **SCI**
  - quarks,gluons+non-perturbative elements

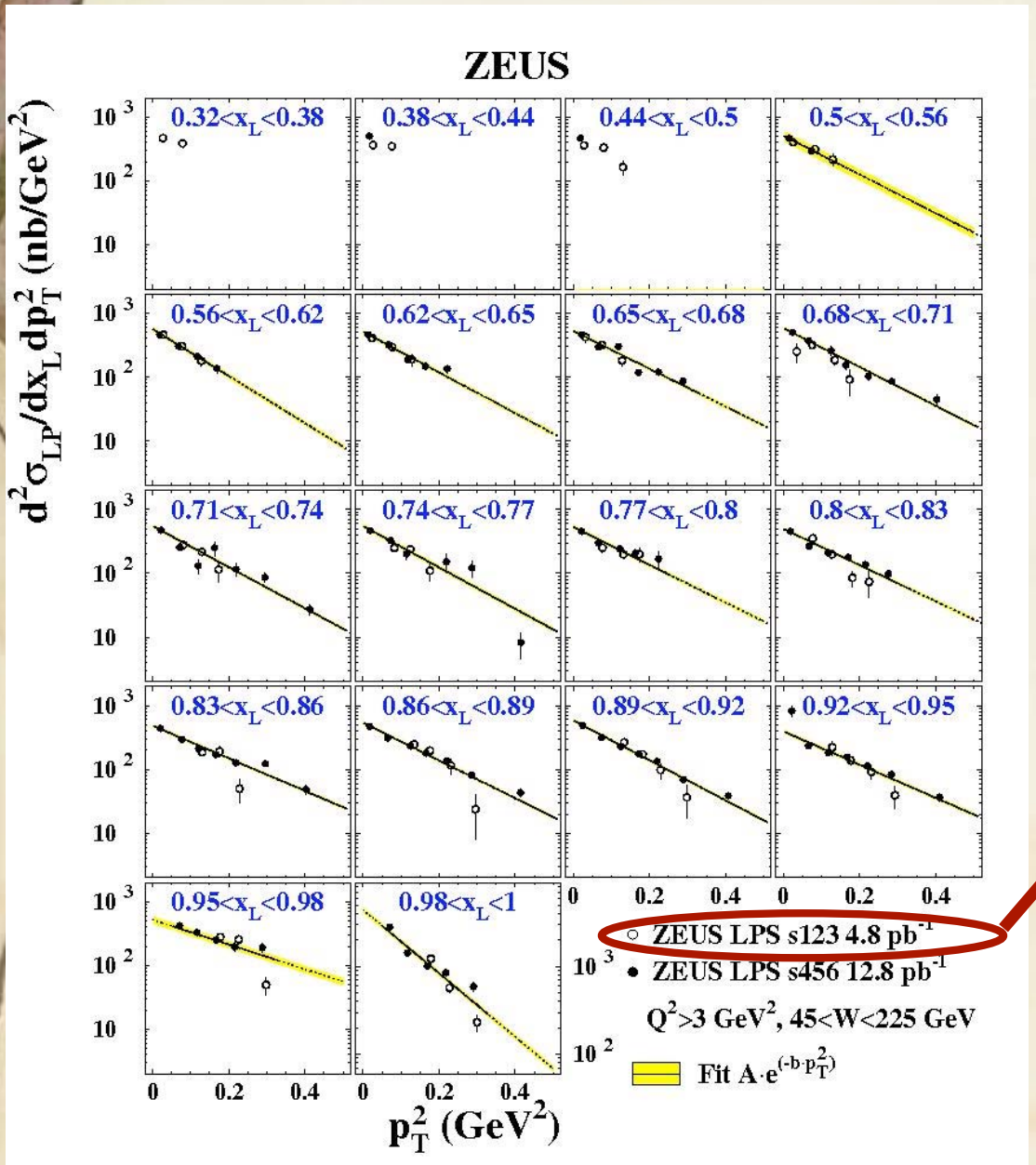
Detectors - H1 and ZEUS



- **ZEUS Leading Proton Spectrometer** (1994-2000) :
  . Six stations along proton beamline
  . 6 Silicon-strip detectors, 3 planes each
  . S123 and S456
  . $\sigma_{xL} < 1\%$, σ_{pT}^2 ~ a few MeV^2
  (better than p-beam spread ~ 50 – 100 MeV^2)

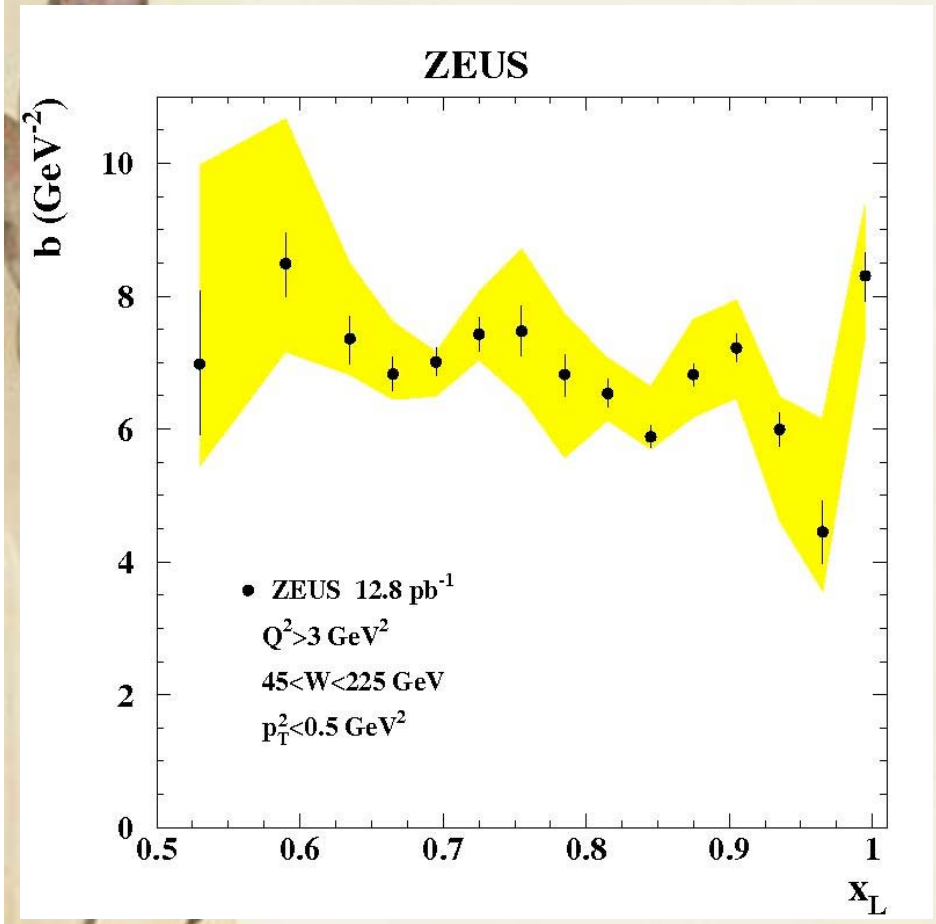
- **H1 Forward Proton Spectrometer** (until 2007):
  . new detector at 200 m from IP, VFPS (will gain acceptance)
  . two stations along proton beamline
  . 4 planes scintilator fiber hodoscope + trigger scintilator
  . $\sigma_{px} = \sigma_{py}$ ~ a few MeV (No H1 data today)

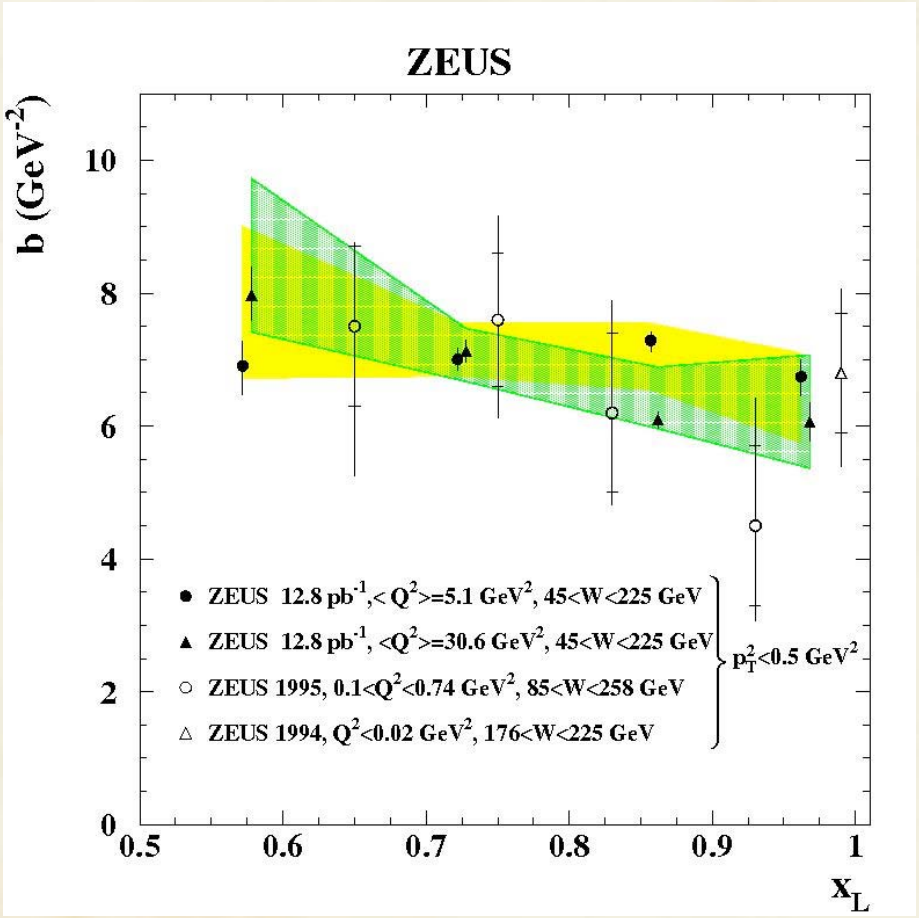
Results: transverse momentum



- Fits to exponential: $A.e(-bp_T^2)$
- b-slopes (next)
- **NEW:** first (and only) measurement with LPS S123
- S123 and S456 data in good agreement

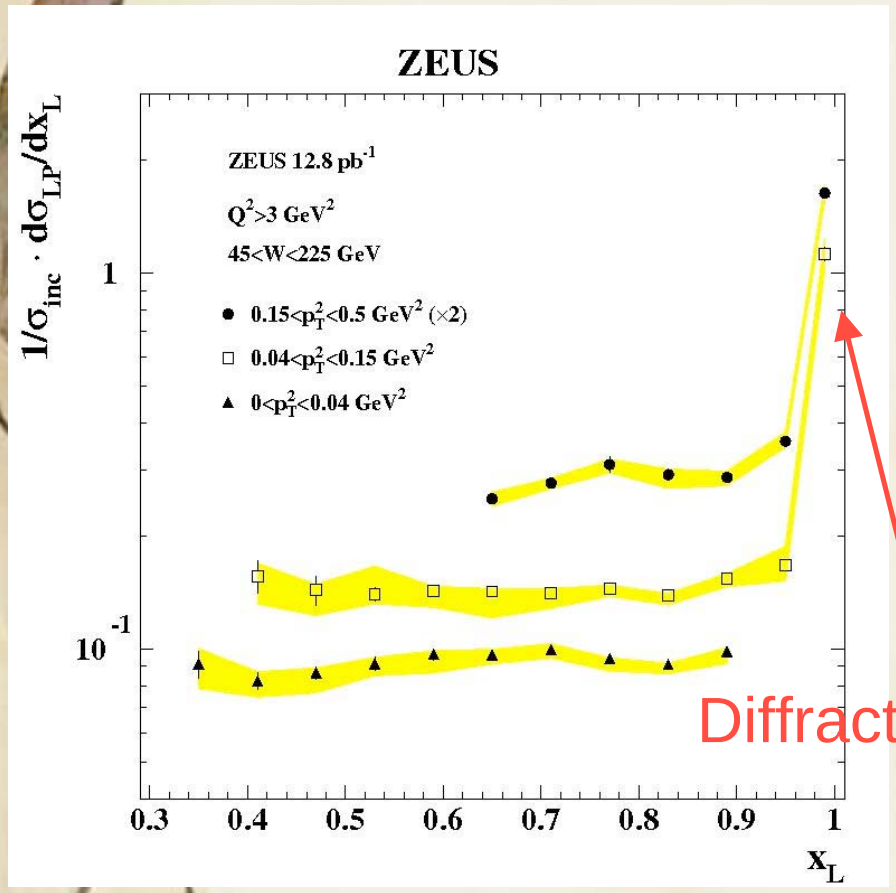
Results: transverse momentum

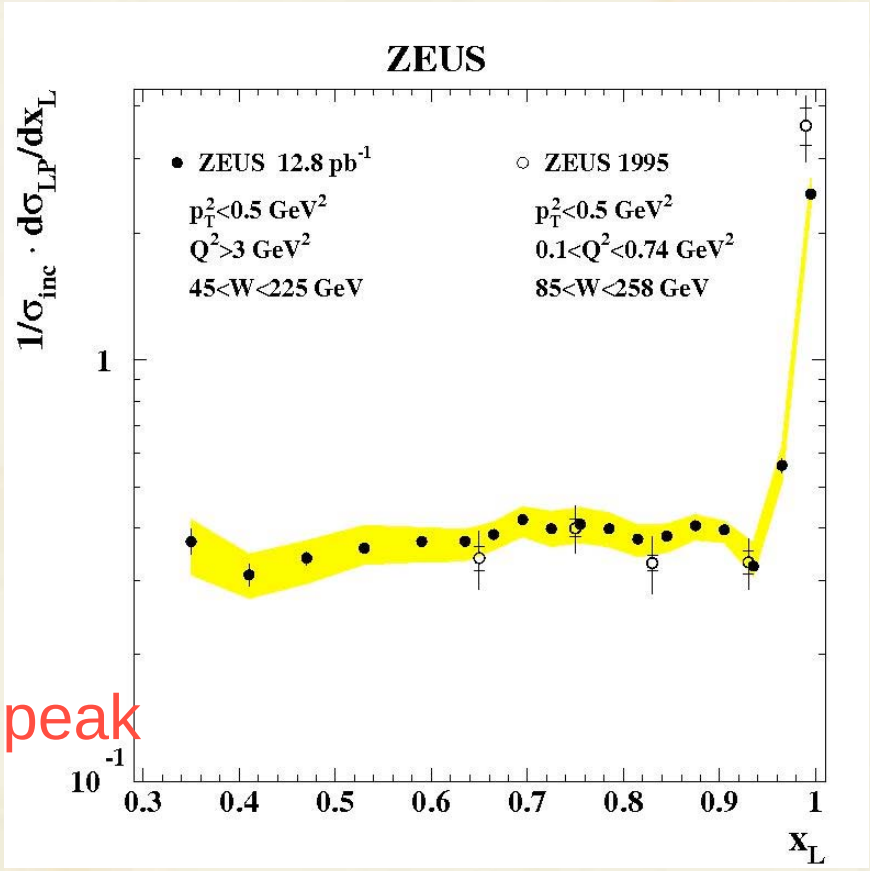




- *b*-slopes: no x_L dependence
- no Q^2 dependence

Results: longitudinal momentum

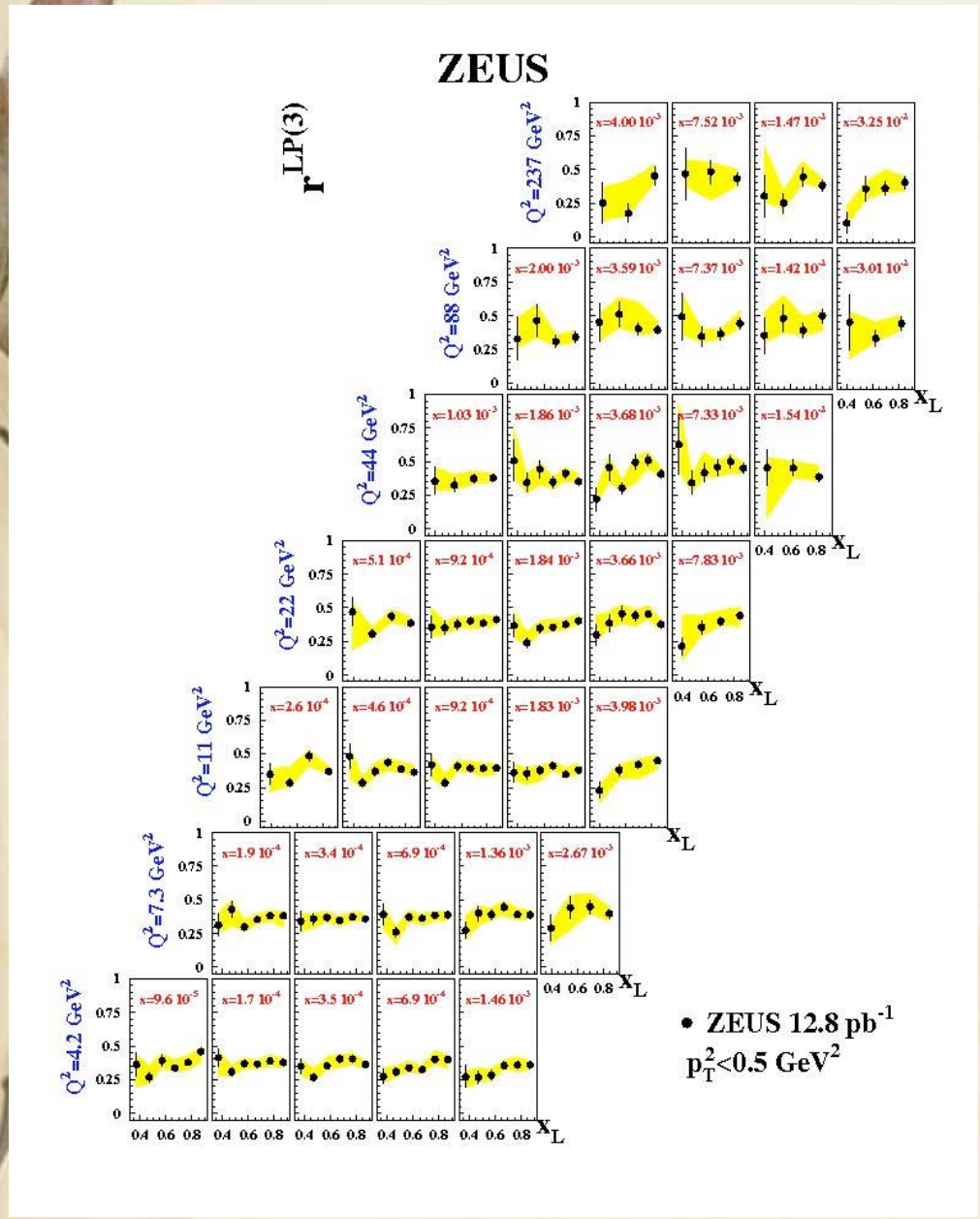




Diffractive peak

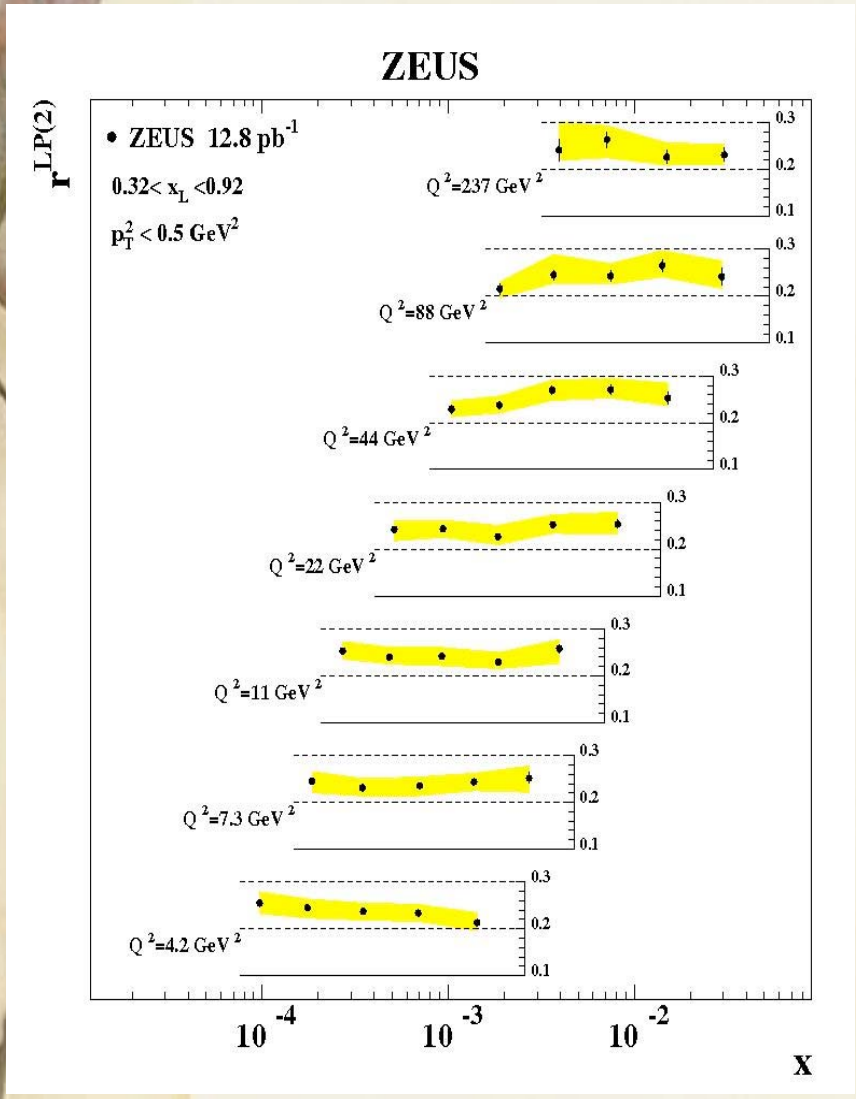
- Data normalized by total (no *p*-tag) DIS cross section
- Below diffractive peak: no x_L dependence
- Comparison to very low-Q^2 data : no Q^2 dependence

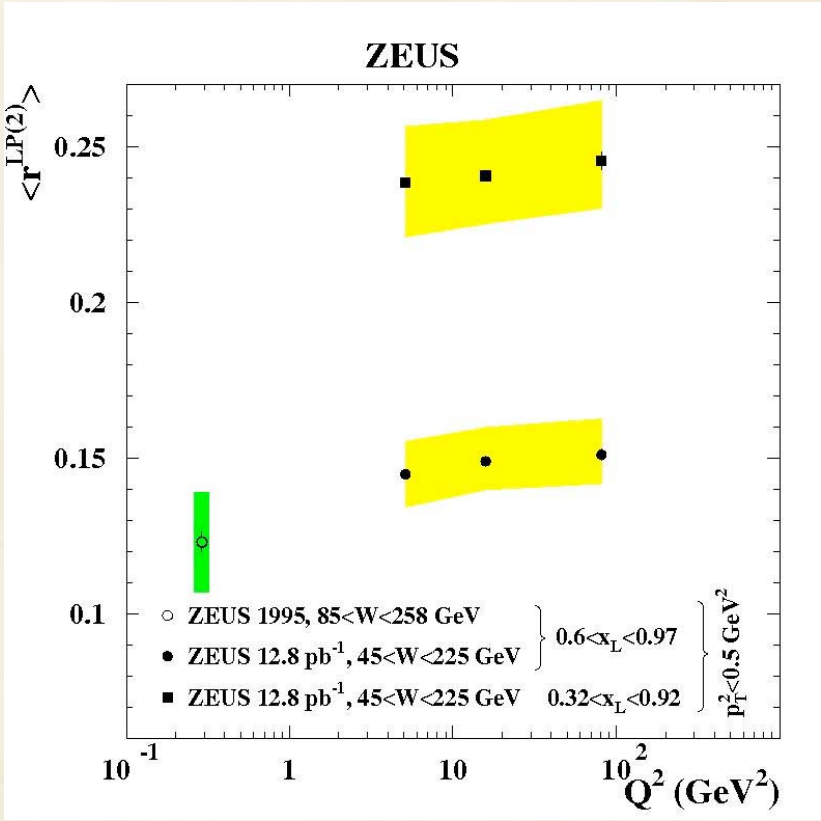
Results: $F_2^{LP(4)}/F_2$



- $F_2^{LP(4)}$ analogous to proton F_2 for events containing a leading proton
- Known as *Fracture functions* in some models
- LP: apart from (x,Q^2) is also function of (x_L,p_T)
- no x_L,p_T dependence

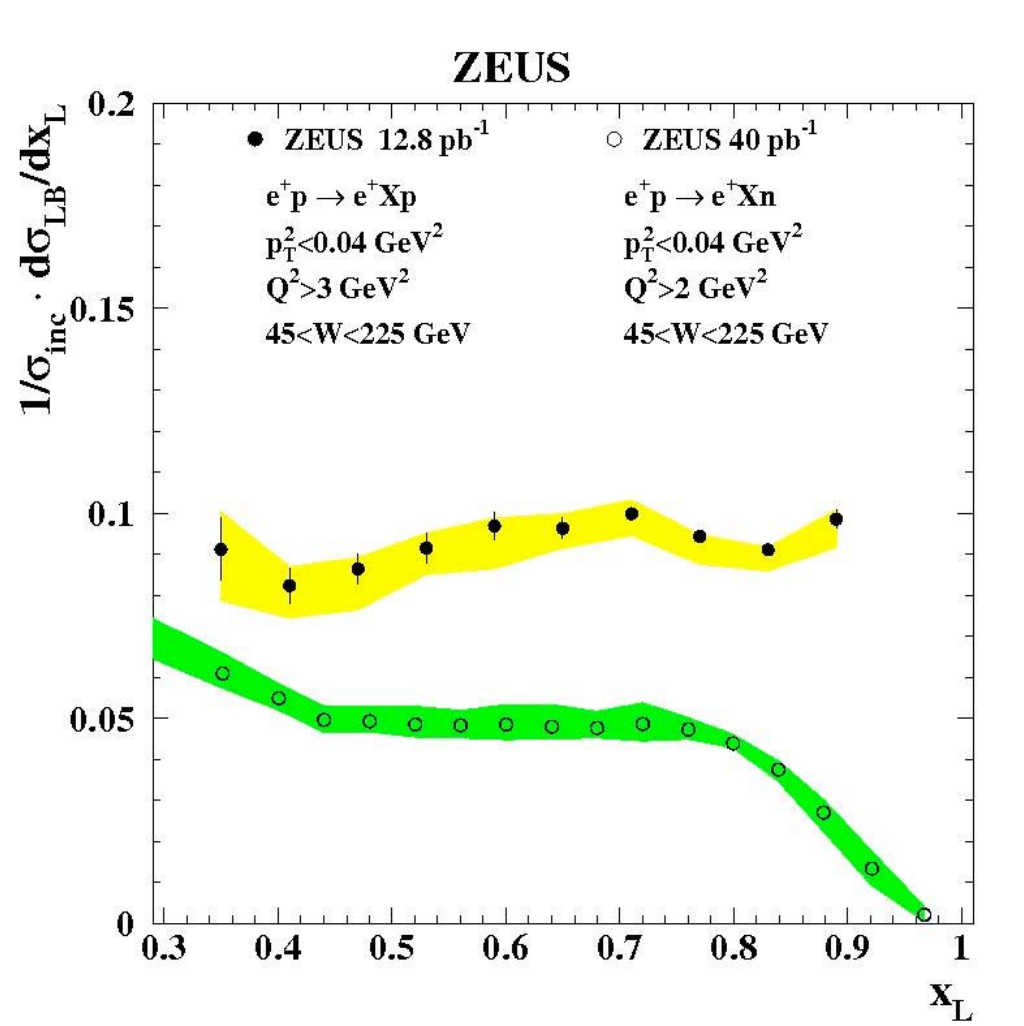
Results: $F_2^{LP(4)}/F_2$





- Rates ~ flat
- Mild Q^2 dependence not excluded
- Compatible with particle-exchange prediction

Comparison with leading neutrons: yield (see talk by V.Dodonov)



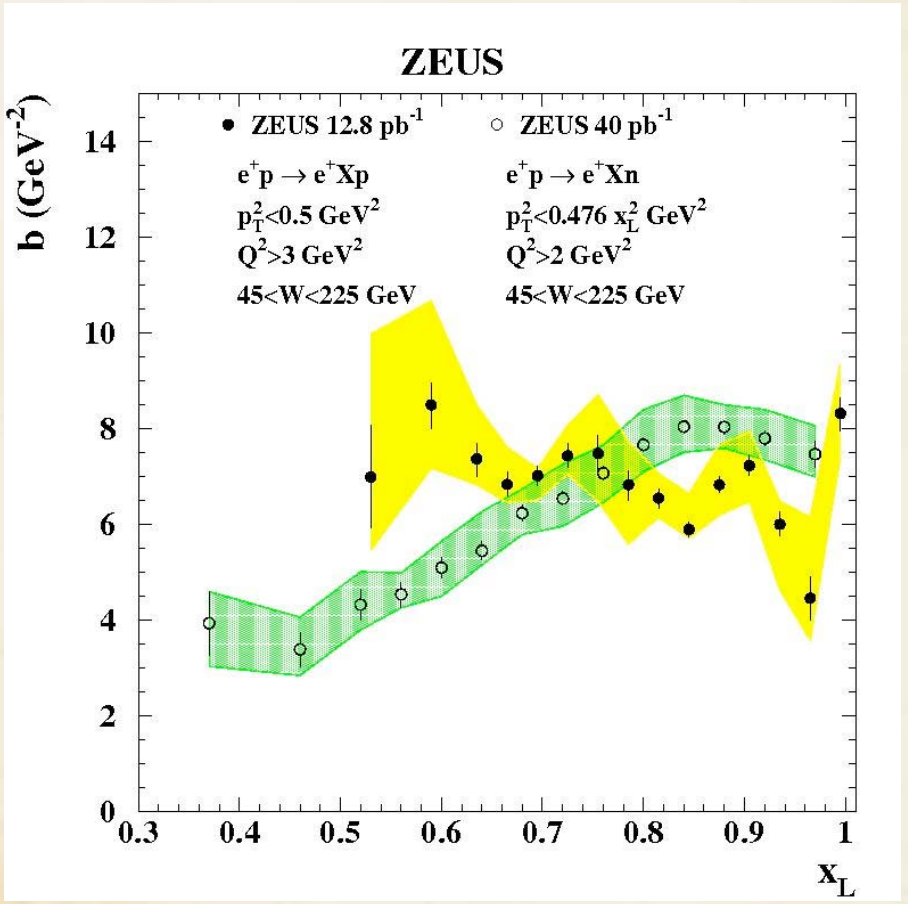
- Expected in case of pure isovector exchange: LP = 1/2 LN (Clebsh-Gordan)
- Data: LP = 2 LN

(compared at same p_T range, p_T^2<0.04 GeV^2)

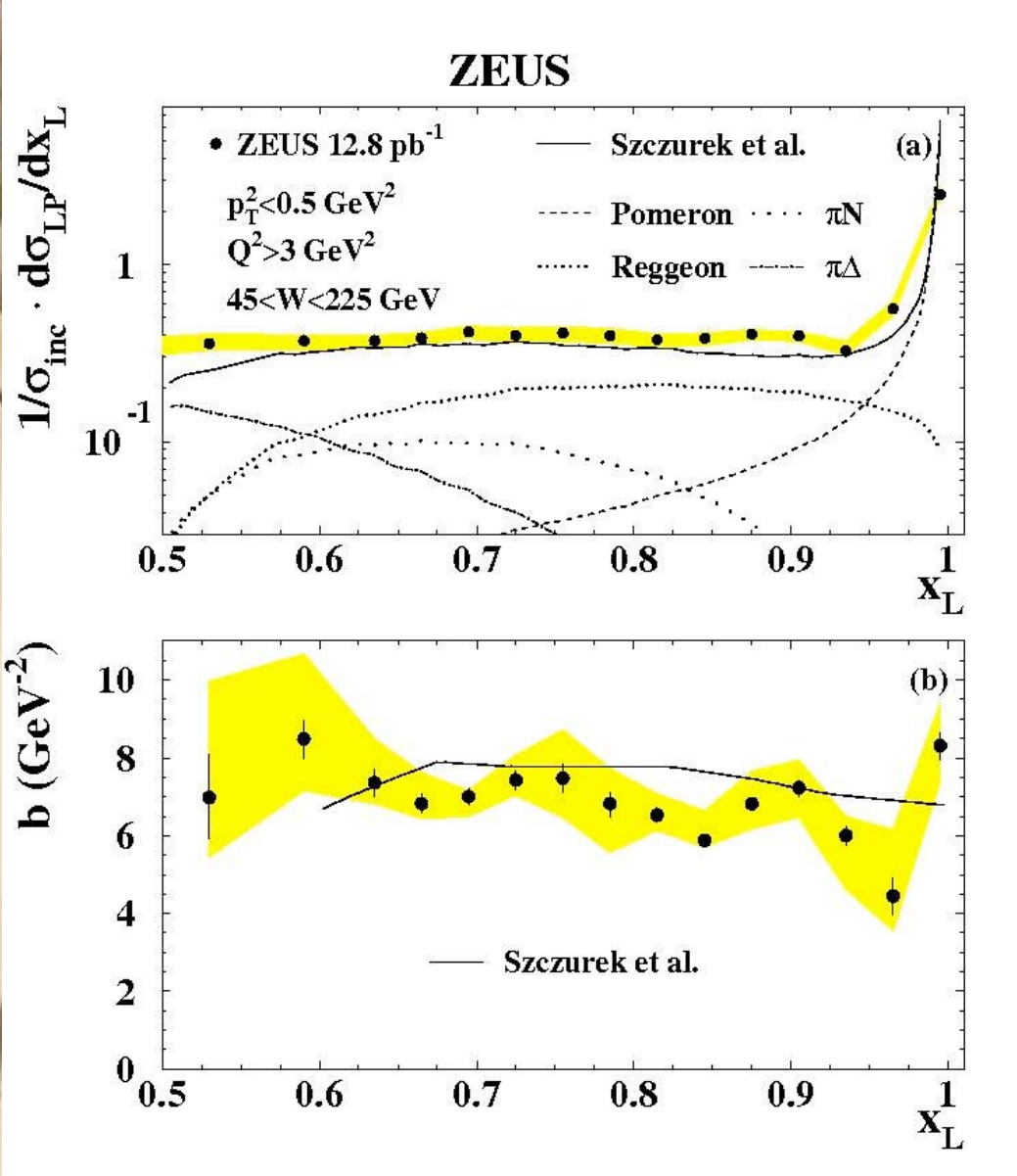
- Conclusion: leading proton production involves other IR contributions (isoscalar)

Comparison with leading neutrons: slopes (see talk by V.Dodonov)

- Similar kinematic region
- Clear rise with x_L for LN
- Flat distribution for LP
- Similar slopes for $x_L>0.7$ where pion exchange dominates



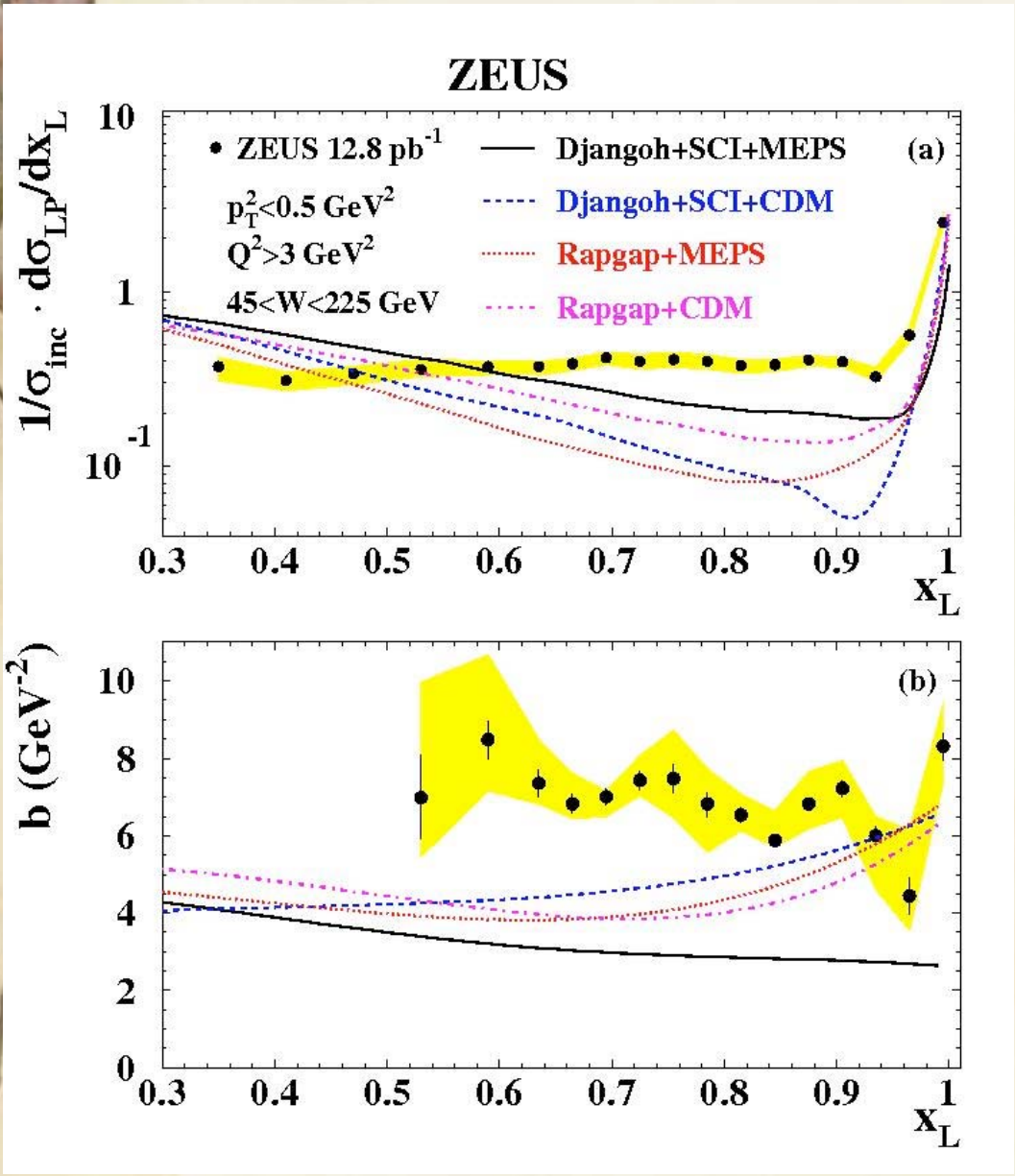
Comparison to models



- Particle exchange is able to describe the data
- Different exchanges populate different regions of leading-proton energy spectra
- b-slopes (angular distribution) also well described

A.Szczurek,N.N.Nikolaev,J.Speth, Phys.Lett. B428 (1998) 383

Comparison to models



- DJANGOH with Soft Color Interaction + MEPS describes reasonably well x_L spectra
- Same MC describes reasonably well b-slopes in shape but not normalization
- Other MC models fail to describe the data

Conclusions and final remarks:

- HERA data on leading protons are in agreement with the hypothesis of particle-exchange
- Comparison with leading neutrons suggests isoscalar-IR contributions are present
- Model incorporating this hypothesis is in agreement with the data
- First measurements with ZEUS LPS s123 are presented
- H1 HERA-II data still being analysed
- Leading protons analyses at HERA are not yet finished