ZEUS results on large rapidity gap events in NC and CC DIS at high $Q^2$

Leszek Adamczyk
UST Cracow

On behalf of the ZEUS Collaboration

- Motivation
- MC models
- LRG selection
- Results
Neutral current

\[ e \rightarrow e' \gamma/Z \]

Charged current

\[ e \rightarrow e' \nu \]

High \( Q^2 \) DIS

Event topology
- NC  
electron with large transverse momentum in central detector
- CC  
neutrino carries away large transverse momentum

Kinematic variable:
- \( Q^2 \) – virtuality of the boson
- \( x \) – fraction of proton momentum carried by struck quark
- \( x_{IP} \) – fraction of proton momentum carried by diffractive exchange
- \( \beta \) – momentum fraction of the exchange carried by struck quark

Relation  \[ x = x_{IP} \beta \]
Motivation

- Measure diffractive parton density functions (dPDF) of the proton at large scale (200 < $Q^2$ < 2000 GeV$^2$). Important for predictions of diffractive production of large mass states in proton–proton collisions. For example, diffractive Higgs (need dPDF at scale up to $M_H^2$).

- Compare NC and CC diffraction to test factorisation in hard diffractive scattering.

\[ \sigma_{\text{tot}} = \sum_a \int \sigma_{\gamma/Z/W}^{a} \otimes f_a \]

\[ \sigma_{\text{dif}} = \sum_a \int \sigma_{\gamma/Z/W}^{a} \otimes f_{a}^{\text{dif}} \]

- NC
  - mainly EM exchange
  - symmetric target $\gamma(u\bar{u}, d\bar{d}, s\bar{s})$

- CC
  - purely weak exchange
  - asymmetric target $W^+(u\bar{d}, c\bar{s})$

- Ratio $\sigma_{\text{dif}} / \sigma_{\text{tot}}$ sensitive to dPDF/PDF. Is it independent of the target (NC vs. CC)?
MC models

1. Mixture of DJANGOH interfaced with ARIADNE (colour dipole model) $e^+p \rightarrow e^+(\nu) X$ and RAPGAP diffractive MC with H1 fit 2 dPDF of the Pomeron $e^+p \rightarrow e^+(\nu) X p$

2. MEPS (parton shower) with SCI (soft colour interaction) mechanism. Alternative model to produce LRG topology.
LRG selection

\( \eta_{\text{max}} \) – rapidity of most forward energy deposition in central detector \( \eta < 4 \)

Forward Plugin Calorimeter \( 4 < \eta < 5 \)

Rapidity gap: at least \( 4 - \eta_{\text{max}} \) or with FPC veto \( 5 - \eta_{\text{max}} \)
Good description of data using ARIADNE + RAPGAP

\[ \eta_{\text{max}} < 2.9 \quad \&\& \quad E_{\text{FPC}} < 1 \text{ GeV} \]

\[ \downarrow \]
rapidity gap of at least 2 units (LRG selection)

ARIADNE not sufficient to describe \( \eta_{\text{max}} \) distribution

Use \( E_{\text{FPC}} < 1 \text{ GeV} \) to suppress non-diffractive contribution
ARIADNE + RAPGAP describes inclusive and LRG data well

$e^+ p \rightarrow e^+(\nu) X Y$ signal obtained by subtracting non-diffractive ARIADNE & other bkg contributions
SCI model does not describe $\eta_{\text{max}}$ and charged-track multiplicity in inclusive sample

NC LRG data exceeds SCI prediction by factor of 2

Indication of similar effect in CC:
9 CC LRG data events
3.9 $^{+1}_{-0.7}$ SCI prediction
Ratio \( \sigma_{e^+p \rightarrow e^+(\nu) X} (x_{IP} < 0.05) / \sigma_{e^+p \rightarrow e^+(\nu) X} (x_{Bj} < 0.05) \) vs. \( Q^2 \)

**Ratio of cross sections**
calculated using RAPGAP and ARIADNE for acceptance corrections

NC ratio decreases with increasing \( Q^2 \)

CC and NC ratio compatible
Summary

• LRG events observed in CC and NC DIS at $Q^2 > 200 \text{ GeV}^2$
• CC and NC inclusive and LRG samples well described by mixture of ARIADNE and RAPGAP samples
• SCI model does not describe NC data, indication of similar effect in CC
• Ratio $\sigma_{e^+p \rightarrow e^+(\nu) X Y (x_{IP} < 0.05)} / \sigma_{e^+p \rightarrow e^+(\nu) X (x_{Bj} < 0.05)}$ in CC process consistent with that in NC process