ZEUS Results

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Outline

- QCD fits to structure functions and jet data
- $\alpha_S$ and jets at ZEUS
- Diffractive structure functions and final states
- Final states: strange and pentaquark states
- SUSY searches
- Heavy Flavours
- HERA II: first look at heavy flavour
- HERA II: CC and NC polarized cross-sections

Results based on 130 pb$^{-1}$ of $e^\pm p$ at HERA I and on 45 pb$^{-1}$ of $e^+p$ and 33 pb$^{-1}$ of $e^-p$ at HERA II.
ZEUS-JETS: NLO QCD DGLAP analysis on ZEUS (HERA I) data alone

- low $Q^2$ NC $\rightarrow$ sea and gluon at low $x$
- high $Q^2$ NC/CC $\rightarrow$ valence at high $x$
- Direct $\gamma p$ and DIS jets data from 96-97 included in the fit in a rigorous way $\rightarrow$ constrain the gluon at mid-to-high–$x$. 

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ZEUS Results-2
Energy scale uncertainty very small
Error on the jets cross-sections of the order of 5%

Improved gluon precision at middle-\(x\)
i.e. \(Q^2 = 7 \, GeV^2, x = 0.06\)
from 17% to 10%
ZEUS-JETS-$\alpha_s$ fit:

\[ \alpha_s(M_Z) \]

\[ \chi^2 - \chi^2_{\text{min}} \]

Summary of $\alpha_s$ at ZEUS:

\[ \alpha_s = 0.1183 \pm 0.0028(\text{exp.}) \pm 0.0008(\text{model}) \pm 0.005(\text{scale}) \]

First extraction of $\alpha_s$ from HERA data alone
BFKL-DGLAP in low-$x$ forward jets

$\gamma h > 90^\circ$, $E_{T,\text{jet}}^2 \simeq Q^2$, $2 < \eta_{\text{jet}} < 3$

Data slightly above NLO (DISENT) at low $x$, theoretical uncertainties are still large.

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ZEUS Results-5
Very high-$x$ in NC

- $Q^2$ reconstructed from electron
- If jet inside detector, $x$ from $E_{jet}, \theta_{jet}$
- If jet outside, take integral $x_{\text{limit}} < x < 1$ (last bin)
- Extend to $x > \sim 0.4$

First measurement of very high-$x$ at HERA, important for valence quarks

Uncertainties at very high-$x$ are similar to the other regions
Diffractive structure functions

- 10% of DIS events are diffractive, LPS data, NLO QCD fit to extract the diffractive pdfs

\[ F_2^D(3) = f_{IP}(x_{IP})F_{IP}^2(\beta, Q^2) \]

- charm data essential to constrain gluon. Gluon contribution

\[ = 82 \pm 8^{+5}_{-16} \text{\% at } Q^2 = 2 \text{ GeV}^2. \]

- QCD fit describes \( F_2^D(3) \) and \( F_2^D(3)_{cc} \) → diffractive hard scattering factorization

- Can diffractive pdfs describe djet-production?

NLO QCD fit for \( Q^2 > 2 \text{ GeV}^2, x_p < 0.01 \)

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ZEUS Results-7
Diffractive $\gamma p$ dijets

$\times \gamma > 0.75$

$\times \gamma < 0.75$

NLO QCD predictions (KlKr+H1 2002 fit) describe shape, but overall suppression factor of $R \simeq 0.5$ is needed, for resolved (close to $pp$ collisions) but also for direct.
Diffractive structure functions

- $F_2^D(3)$ determined with the $\ln M_x$ method, larger kinematic range, lower $Q^2 (> 2 \text{ GeV}^2)$, higher $M_X$ up to 35 GeV (extension in $\eta$ due to the FPC $5 < \eta < 4$), high statistics
- Positive scaling violations confirm perturbative effects
- At fixed $\beta$, $x_{IP}F_2^D(3)$ changes with $Q^2$ differently for different $x_{IP}$ bins
  observation of breaking of Regge factorization
Diffraction at High $Q^2$

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$\sigma_{diff}/\sigma_{tot}$ measured for NC $Q^2 > 200 \text{ GeV}^2$, $\sigma_{diff}/\sigma_{tot} = 2.9 \pm 1.2 (\text{stat.}) \pm 0.8 (\text{syst})\%$ for CC
$J/\psi$ production at high $t$

$J/\psi$ in $\gamma p$ at $1 < |t| < 20 \text{ GeV}^2$

$50 < W < 150 \text{ GeV}, z > 0.95$

BFKL gives reasonable description
DGLAP does not describe rise with $W$
Search for $R_{p}$-violating SUSY-I

All topologies e-J, e-MJ, $\nu$-MJ searched for

No evidence found, limit on stop

ZEUS

ZEUS (prel.) 99-00 e$^+p$
100 GeV $< M_2 < 300$ GeV
-300 GeV $< \mu < 300$ GeV
$\tan\beta$=6

Excluded at 95% CL

$\lambda^{'131}$ (APV)

Excluded in part of SUSY parameters

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ZEUS Results-12
Search for $R_p$-violating SUSY-II

Assume selectron-exchange dominant with $\chi'_{111}$

Discriminant method to distinguish from DIS background, requiring at least 2 high-$E_T$ jets.

No evidence found $\rightarrow$ Limit on gaugino production

LEP2 excluded area from a scan in SUSY space obtained requiring $M(\chi^\pm) > 103$ GeV.
Strange production: BE correlations in $K^\pm$

BE effect: enhancement in the production of identical bosons with similar momenta

$R(p_1 \cdot p_2) = \rho(p_1 \cdot p_2)/\rho(p_1)\rho(p_2)$

$\rho$ particle density distribution functions for identical bosons, $Q^2_{12} = -(p_1 - p_2)^2$

Double ratio: Ref sample=mixed sample with pairs of kaons (no BEC)

$R \propto (1 + \lambda \exp(-r^2Q^2_{12}))$

$\lambda$ measure of the coherence

$r$ radius of emitting source

Comparison to $e^+e^-$ shows different $\lambda \rightarrow$

ZEUS mainly target region

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$K^\pm K^\pm$

$Q^2_{12}$ (GeV)

$R_{mix}(Q^2_{12})$

$\lambda = 0.31 \pm 0.06$ (stat.) $^{+0.09}_{-0.06}$ (syst.)

$r = 0.57 \pm 0.09$ (stat.) $^{+0.15}_{-0.06}$ (syst.) fm
Resonance in $K^0_{SP}(\bar{p})$ observed consistent with the $\Theta^+$ observed by low-energy experiments

Trying to understand production mechanism

Production rate is higher in the forward region (> 3 $\sigma$ in number of events) (not for the $\Lambda(1520)$)
No evidence for NA49 pentaquark → $\Xi\pi$

Upper limit $R = [\Xi_{3/2}^- (\Xi^-\pi^-) \text{ or } \Xi_{3/2}^0 (\Xi^-\pi^+)]/\Xi^0(1530)$ $< 0.29$ at 95% CL around 1860 GeV.

but fragmentation region, does not contradict NA49

No evidence for $\Theta_C$ in $> 60000D^*$ candidates
### Charm fragmentation fractions

| $f(c \to D^\pm)$  | $0.194 \pm 0.020^{+0.023}_{-0.011}$ | $0.249 \pm 0.014^{+0.004}_{-0.008}$ | $0.203 \pm 0.025$ | $0.232 \pm 0.025$ |
| $f(c \to D^0)$   | $0.584 \pm 0.039^{+0.024}_{-0.050}$ | $0.557 \pm 0.019^{+0.005}_{-0.013}$ | $0.560 \pm 0.071$ | $0.232 \pm 0.025$ |
| $f(c \to D_s^\pm)$ | $0.103 \pm 0.013^{+0.012}_{-0.017}$ | $0.107 \pm 0.009^{+0.005}_{-0.005}$ | $0.151 \pm 0.019$ | $0.101 \pm 0.019$ |
| $f(c \to \Lambda_c^\pm)$ | $0.104 \pm 0.048^{+0.018}_{-0.010}$ | $0.076 \pm 0.020^{+0.017}_{-0.001}$ | $0.076 \pm 0.007$ | $0.076 \pm 0.007$ |
| $f(c \to D^{*\pm})$ | $0.190 \pm 0.014^{+0.023}_{-0.009}$ | $0.223 \pm 0.009^{+0.003}_{-0.005}$ | $0.263 \pm 0.032$ | $0.235 \pm 0.007$ |

In agreement with universal charm fragmentation fractions

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ZEUS Results-17
Charm jets in $\gamma p$

- $m_c, p_T^{\text{jet}}$ provide the hard scales, hadronization effects are reduced using jets. Dijets sensitive to higher order effects.

- Comparison of NLO massive calculations (FMNR) to the data shows deviation of $d\sigma/d\Delta \phi^{jj}$ and $d\sigma/dp_T^{jj}$ at low $\Delta \phi^{jj}$ and high $p_T^{jj}$, especially for resolved-enriched.

- Additional Parton Shower in NLO needed or NNLO.
Beauty production in dimuon

- Both $b, \bar{b}$ required to decay to muons, tagging dimuon suppresses background due to charm and light flavour production
- $\rightarrow$ can move to lower $p_T^\mu$, i.e. low $p_T^b$.
- $\sigma_{tot}^b$ above NLO prediction

$\sigma_{tot}(ep \to b\bar{b}X)[318 \, GeV] = 16.1 \pm 1.8 \, (stat.) +5.3 \, (syst.) \, nb$

NLO (FMNR+HQVDIS) = $6.9 \, (+3.0) \, (-1.8) \, nb$
HERA II: $D^*$ production

Good agreement between $e^+$ and $e^-$ for 03/05 data
Excess in 98-00 data not confirmed

Data taken up to few weeks ago

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ZEUS Results-20
HERA II: Charged Current

In the Standard Model:

\[ \sigma^\pm = (1 \pm P)\sigma_{CC}(P = 0) \]

\[ \sigma_{CC} \rightarrow 0 \quad \text{for} \quad (P \rightarrow -1) \]

absence of right-handed W's

\[ P = +32\% \quad 14.1 \, pb^{-1} \]

\[ P = -40\% \quad 16.4 \, pb^{-1} \]

Measurements in agreement with ZEUS-S fit
HERA II : Neutral Current

\[ \frac{\sigma(P=+32\%)}{\sigma(P=0)} \text{ vs } Q^2 \]

\[ \frac{\sigma(P=-40\%)}{\sigma(P=0)} \text{ vs } Q^2 \]

Consistent with polarization dependence in NC

\[ \frac{\sigma(P=+32\%)}{\sigma(P=-40\%)} \text{ vs } Q^2 \]

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ZEUS Results-22
Outlook

Many more results and details → see parallel sessions.

More exciting results soon with $e^- p$ data