Diffraction and Vector Meson Parallel Session
Summary

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$F_2^{D^3} \@ H1$

\[
\sigma_r^{D^3}(Q^2, \beta, x_{IP}) = \frac{\beta Q^4}{4\pi\alpha_{em}^2} \frac{1}{(1 - y + \frac{y^2}{2})} \int dQ^2 \frac{d^3\sigma_{ep \to eXY}}{d\beta \, dx_{IP}}
\]

### Data Set

<table>
<thead>
<tr>
<th>Data Set</th>
<th>$Q^2$ range (GeV$^2$)</th>
<th>Proton Energy $E_p$ (GeV)</th>
<th>Luminosity (pb$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999 MB</td>
<td>$3 &lt; Q^2 &lt; 25$</td>
<td>920</td>
<td>3.5</td>
</tr>
<tr>
<td>1999-2000</td>
<td>$10 &lt; Q^2 &lt; 105$</td>
<td>920</td>
<td>34.3</td>
</tr>
<tr>
<td>2004-2007</td>
<td>$10 &lt; Q^2 &lt; 105$</td>
<td>920</td>
<td>336.6</td>
</tr>
<tr>
<td>1997 MB</td>
<td>$3 &lt; Q^2 &lt; 13.5$</td>
<td>820</td>
<td>2.0</td>
</tr>
<tr>
<td>1997</td>
<td>$13.5 &lt; Q^2 &lt; 105$</td>
<td>820</td>
<td>10.6</td>
</tr>
<tr>
<td>1999-2000</td>
<td>$133 &lt; Q^2 &lt; 1600$</td>
<td>920</td>
<td>61.6</td>
</tr>
</tbody>
</table>

### Graphs

- **H1 LRG**: $x_{IP} = 0.01$
- **H1 FPS x 1.2**: $\beta = 0.005$, $\beta = 0.008$, $\beta = 0.013$,
  $\beta = 0.02$, $\beta = 0.03$, $\beta = 0.04$, $\beta = 0.05$, $\beta = 0.13$

- **H1 2006 DPDF Fit B**: $\beta = 0.005$, $\beta = 0.008$
- **(extrapol. fit)**: $\beta = 0.013$, $\beta = 0.013$

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**H1**: $\alpha_F(0) = 1.113 \pm 0.002$ (exp.) $^{+0.029}_{-0.015}$ (model)
\[ \sigma_r^D = F_2^D - \frac{y^2}{Y} F_L^D \]

\[ F_L^D \sim x g(x) \]

\[ Q^2 = x_{IP} \beta y s \]

- \( x_{IP} = 0.0005, 0.003 \)
- \( Q^2 = 4, 11.5, 44 \text{ GeV}^2 \)
- \( 0.033 < \beta < 0.7 \)
H1 FPS HERA II
Luminosity = 156.6 pb⁻¹
Visible range |t| = 0.1 - 0.7 GeV²
Norm unc ~ ± 4.8%

ZEUS LPS
Luminosity = 32.6 pb⁻¹
Visible range |t| = 0.09 - 0.55 GeV²
Norm unc ~ ± 7%

χ²/ndf = 52/58
Kinematic region covered by H1 and ZEUS data
Q² = 2.5 - 200 GeV²
β = 0.0018 - 0.816
x_{IP} = 0.00035 - 0.09
|t| = 0.09 - 0.55
**Diffractive Jets @ H1**

**Selection**

<table>
<thead>
<tr>
<th></th>
<th>two central jets</th>
<th>one central + one forward jet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DIS</strong></td>
<td>$4 &lt; Q^2 &lt; 110 \text{ GeV}^2$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$0.05 &lt; y &lt; 0.7$</td>
<td></td>
</tr>
<tr>
<td><strong>Leading Proton</strong></td>
<td>$x_p &lt; 0.1$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$</td>
<td>t</td>
</tr>
<tr>
<td><strong>Jets</strong></td>
<td>$P_{T,1}^* &gt; 5 \text{ GeV}$</td>
<td>$P_{T,1}^<em>, P_{T,2}^</em> &gt; 3.5 \text{ GeV}$</td>
</tr>
<tr>
<td></td>
<td>$P_{T,2}^* &gt; 4 \text{ GeV}$</td>
<td>$M_{jj} &gt; 12 \text{ GeV}$</td>
</tr>
<tr>
<td></td>
<td>$-1 &lt; \eta_{1,2} &lt; 2.5$</td>
<td>$-1 &lt; \eta_c &lt; 2.5$</td>
</tr>
<tr>
<td></td>
<td>$1 &lt; \eta_f &lt; 2.8, \eta_f &gt; \eta_c$</td>
<td></td>
</tr>
</tbody>
</table>

**Two Central Jets**

- no hints for physics beyond DGLAP
- consistency with LRG
- amount of proton dissociation same as in iDDIS
- consistent with proton vertex factorisation

**One Central + One Forward Jet**

$B = 5.89 \pm 0.5 \text{ GeV}^{-2}$
F. A. Ceccopieri  QCD analyses of HERA data  S.T. Monfared

\[ \Sigma(\beta, x_P, Q^2_0) = A_q(x_P) \beta^{B_q(x_P)} (1 - \beta)^{C_q(x_P)} e^{-0.01/1-\beta} \]

\[ g(\beta, x_P, Q^2_0) = A_g(x_P) e^{-0.01/1-\beta} \]

\[ M_X^2 > 4 \text{ GeV}^2, Q^2_{\text{min}} \geq 8.5 \text{ GeV}^2, 190 \text{ points} \]

\[ z \sum(z, Q^2_0) = A_\Sigma z^{B_\Sigma} (1 - z)^{C_\Sigma} (1 + D_\Sigma z + E_\Sigma z^{F_\Sigma}) \]

\[ zg(z, Q^2_0) = A_g e^{a-0.01/1-z} \]

\[ 1 \times 10^6 \]

\[ \chi^2/\text{dof} \]

<table>
<thead>
<tr>
<th>Label</th>
<th>\chi^2/\text{dof}</th>
<th>Data points</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1-LRG-06</td>
<td>0.79</td>
<td>190</td>
</tr>
<tr>
<td>H1-FPS-06</td>
<td>0.53</td>
<td>40</td>
</tr>
<tr>
<td>H1-FPS-10</td>
<td>0.91</td>
<td>100</td>
</tr>
<tr>
<td>ZEUS-LPS-04</td>
<td>0.23</td>
<td>27</td>
</tr>
<tr>
<td>ZEUS-LPS-09</td>
<td>0.78</td>
<td>42</td>
</tr>
<tr>
<td>ZEUS-LRG-09</td>
<td>1.08</td>
<td>155</td>
</tr>
<tr>
<td>H1-LRG-11</td>
<td>0.89</td>
<td>67</td>
</tr>
</tbody>
</table>

Eager to test both approaches on the latest data
Low Q2 region and higher twists

- Rapid deviation of the fit from data with decreasing $Q^2$
- Indication of higher twists?

F2 - strong cancellations: a striking result! 1% effect of higher twists

FL - up to O(40%) effects of higher twists – still not sufficient to provide good constraints

Inclusive data leave a lot of freedom for higher twists

- Eikonal saturation model – not supported by theory, that suggest coupling of one t-channel gluon per one s-channel quark line
- Eikonal saturation model may and should be modified to represent better higher twist coefficient functions

attempt to describe DIS, DDIS, VMs,...
Exclusive production @ LHCb

- 2010 data analyses
- gg → μμ ideal for lumi measurement
- exclusive J/Ψ, Xc production

- cross sections are consistent with theoretical predictions
- 2011 data on the way
Central Exclusive Production at CDF II

- **QED Production**
  - Exclusive $e^+ e^-$ Production
  - Exclusive $\mu^+ \mu^-$ Production

- **Photoproduction**
  - Exclusive $J/\Psi$ Production
  - Search for Exclusive $Z$ Production

- **Double Pomeron Exchange**
  - Exclusive Dijet Production
  - Exclusive Charmonium and $\chi_c$ Production
  - Exclusive $\gamma\gamma$ Production

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**Exclusive Photon-Pair Production**

<table>
<thead>
<tr>
<th>Theoretical</th>
<th>Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma_{</td>
<td>\eta</td>
</tr>
<tr>
<td>$\sigma_{</td>
<td>\eta</td>
</tr>
<tr>
<td>$\sigma_{\gamma\gamma$ excl.}</td>
<td>$2.48^{+0.40}<em>{-0.35}$ (stat) $^{+0.40}</em>{-0.51}$ (syst) pb</td>
</tr>
</tbody>
</table>
Central Exclusive Production @ CMS

<table>
<thead>
<tr>
<th>exclusive diphoton analysis</th>
<th>exclusive dielectron analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>selection criterion</td>
<td>selection criterion</td>
</tr>
<tr>
<td>Trigger</td>
<td>Trigger</td>
</tr>
<tr>
<td>Photon reconstruction</td>
<td>Photon reconstruction</td>
</tr>
<tr>
<td>Photon identification</td>
<td>Photon identification</td>
</tr>
<tr>
<td>Cosmic ray rejection</td>
<td>Cosmic ray rejection</td>
</tr>
<tr>
<td>Exclusivity requirement</td>
<td>Exclusivity requirement</td>
</tr>
<tr>
<td>events remaining</td>
<td>events remaining</td>
</tr>
<tr>
<td>3 023 496</td>
<td>3 023 496</td>
</tr>
<tr>
<td>1 683 526</td>
<td>132 271</td>
</tr>
<tr>
<td>40 692</td>
<td>2 648</td>
</tr>
<tr>
<td>32 775</td>
<td>2 023</td>
</tr>
<tr>
<td>0</td>
<td>17</td>
</tr>
</tbody>
</table>

σ = 3.38^{+0.58}_{-0.55} (stat.) ± 0.16 (syst.) ± 0.14 (lumi.) pb

not a cross section measurement
Central Exclusive Production in Theory

M. Taševský

\[ J_z = 0, \text{C-even, P-even} \] selection rule leads to a clear determination of quantum numbers of the centrally produced resonance. A few events are enough.

MSSM: large enhancement for \( H/h \rightarrow bb \) enables to measure \( H_{bb} \) Yukawa coupling!

- gluon amplitude calculated up to twist 3
- photon wave function factorizes in the WW approximation
- Saturation effects to be included
LHC up to 4 orders of magnitude more sensitive than LEP

Effect of LHC on the Sudakov FF uncertainties in CEP

- \( \sigma(\text{diffractive } WW) \ll \sigma(\gamma\gamma \rightarrow WW) \)
- Very promising laboratory for testing of VB triple and quartic couplings
Q: Does factorisation breaking affect t-distributions?

A: No

- t slope Q2 independent
- data agree with DL for $t \leq \sim 0.5$ GeV2
- flattening larger by $\sim 10$ than DL
Hard diffraction @ CMS

measurements give constraint to the hard diffractive processes @ LHC
Peripheral d+Au collisions are similar to p+p collisions

- suppression depends strongly on centrality
- get stronger towards forward rapidities
- do we see nuclear shadowing?
- more results with new data and pPb @ LHC
Forward Photons at HERA

- measurement of forward photons in DIS and comparison to inclusive DIS MC models and Cosmic Rays MCs

- measurements show sensitivity to fragmentation models => input for MC tuning
- \( \text{yield}_{\text{MC}} > \text{yield}_{\text{Data}} \)
- Lepto - shape ok, CDM - harder spectra
- CRs - over by 30 - 50%, different spectra
- limited fragmentation hypothesis (independence of \( Q^2 \) and \( x_{\text{Bj}} \)) supported by the data
Azimuthal correlations at HERA

L. Goerlich

DGLAP - strong $k_T$ ordering (RapGap)
BFKL - strong ordering in $x_i$ (CDM)
CCFM - angular ordering (CASCADE)

$Y = \ln(x_{fwdjet} / x)$

Forward jets originate from parton showers and not ME (NLO ~ LO)
- well described by CDM
- DGLAP undershoots
- CCFM (A0) good at high $Y$, but very PDF dependent

- best description by BFKL-like CDM
- NLO DGLAP within uncertainties

Enhances radiation, delta eta > 2
All models fine for low $Y$
Jet reconstruction in LHCb

- Z+jet production
- Data agree well with simulation
- Constraining power on PDFs