DVCS and its $t$-dependence at HERA-II

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On behalf of

Content

- Data $e^{-}$ HERA II - 2005-06
- integrated lumi of 145 pb$^{-1}$
- Finalized cross section results
DVCS - Introduction

- **HERA (ep)**: wide range in $Q^2$, $W$ and $t$ accessible at high $Q^2$ and low $x$
- Sensitivity to GPD (gluons)
- Bethe-Heitler Process (Background + Interference)
- interference term $\rightarrow A_{DVCS}$ (asymmetry measurements)
QCD predictions

- Fully calculable in QCD
- NLO leading twist (+ twist three) calc. by A. Freund and M. McDermott
- Only input: GPDs

**GPD input:**

**DGLAP region:** $|x| > \xi$

\[
\mathcal{H}^q(x, \xi, t; \mu^2) = q(x; \mu^2) e^{-b|t|}
\]

$q$ singlet

\[
\mathcal{H}^g(x, \xi, t; \mu^2) = x g(x; \mu^2) e^{-b|t|}
\]

gluons

**ERBL region:** $|x| < \xi$

simple analytic function

\[
b = b_0 (1 - 0.15 \log(Q^2/2)) \text{ GeV}^{-2}
\]

- implemented MC MILOU.
H1 $e^-$ data 2005-06
Int. lumi = 145 pb$^{-1}$
2538 events.
After subtraction of Bethe-Heitler contribution,

\[
\frac{d^3\sigma_{ep\rightarrow e'\gamma p}}{dWdQ^2dt} = 
\Gamma(W, Q^2) \frac{d\sigma_{DVCS}}{dt}(W, Q^2)
\]

→ in agreement with previous results
→ improved precision
$W$ dependence for three $Q^2$ values

$\rightarrow$ Fit $W^\delta$:

Total sample gives:

$\delta = 0.74 \pm 0.11 \pm 0.16$

$\rightarrow$ indication of a hard regime

$\rightarrow$ in agreement with VM production
\[ b(Q^2) = A \left( 1 - B \log\left(\frac{Q^2}{2}\right) \right) \]

\( A \) and \( B \) fitted to:
\[ A = 6.98 \pm 0.54 \text{ GeV}^{-2} \quad B = 0.12 \pm 0.03. \]

\( \Rightarrow \) Similar behaviour with VM using the scale \( Q^2 + M_{VM}^2 \)

First \( t \) slope measured vs \( W \)
\[ \Rightarrow \text{no } W \text{ dependence} \]
DVCS: QCD interpretation

- correct $Q^2$ dependence of the propagator and of $b$ in the cross section:

$$S = \sqrt{\frac{\sigma_{DVCS} Q^4 b(Q^2)}{(1 + \rho^2)}}$$

- skewing factor: around 2

$$R = \frac{\Im A(\gamma^* p \rightarrow \gamma p)}{\Im A(\gamma^* p \rightarrow \gamma^* p)} = \frac{4 \sqrt{\pi} \sigma_{DVCS} b(Q^2)}{\sigma_T(\gamma^* p \rightarrow X) \sqrt{(1 + \rho^2)}}$$

- $\sigma_T(\gamma^* p \rightarrow X)$ taken from QCD analysis of inclusive DIS H1 measurement.

⇒ important skewing factor
⇒ $Q^2$ evolution close to the one of DIS (pure DGLAP)
Colour Dipole Models

In the proton rest frame

- $\gamma^*$ fluctuates in $q\bar{q} + q\bar{q}g + \ldots$

\[ A = \int dR^2 \, dz \, \psi^{in} \sigma_{\text{dipole}} \psi^{out} \]

- $\psi^{in}$ and $\psi^{out}$ calculable
- $\sigma_d$ is modeled

- many models for $\sigma_d$ exist.


- includes saturation given by the geometric scaling extended here to the off-forward case ($|t| > 0$)

\[ \sigma_{DVCS}(x, Q^2) = \sigma_{DVCS}(\tau), \quad \text{with} \quad \tau = \frac{Q^2}{Q_s^2(x)}. \]

$Q_s(x) = Q_0(x_0/x)^{-\lambda/2}$ using $Q_0 = 1$ GeV, $\lambda = 0.25$ and $x_0 = 2.7 \times 10^{-5}$
Dipole approach

- here lower $Q^2$ points from previous H1 publication [hep-ex/0505061] are included.

→ Data globally described by the geometric scaling approach
→ compatible with a saturation scale independent of $t$
Conclusions

**DVCS** cross sections as a function of $Q^2$, $W$ and $t$ have been measured with HERA-II $e^-$ data.

- int. luminosity used increased by factor 4 w.r.t. H1 HERA-I data
- improved precision achieved in the $t$ slope and the $W$ dependence measurements.
- First measurement of the $W$ dependence of the $t$ slope
- in good agreement with NLO QCD predictions, based on GPD model: no intrinsic skewing needed.
- set constraints on gluon and sea GPDs.
- in agreement with various dipole model predictions.
- in particular with geometric scaling: no $t$ dependence observed in the saturation scale.
Back-up Slides
Beam Charge Asymmetry

New H1 measurement based on 291 \( pb^{-1} \) of HERA II data (\( e^+ \) and \( e^- \)).

- First DVCS BCA measured at HERA.

\[
BCA \equiv \frac{\sigma(e^+p) - \sigma(e^-p)}{\sigma(e^+p) + \sigma(e^-p)} \sim p_1 \cos(\Phi)
\]

0.05 \(<\ |t| \(<\ 1 \text{ GeV}^2 \) - before deconvolution by the \( \phi \) resolution.