Miniworkshop difrakce a ultraperiferálních srážek
2-3 May, 2018
Děčín, Česká republika

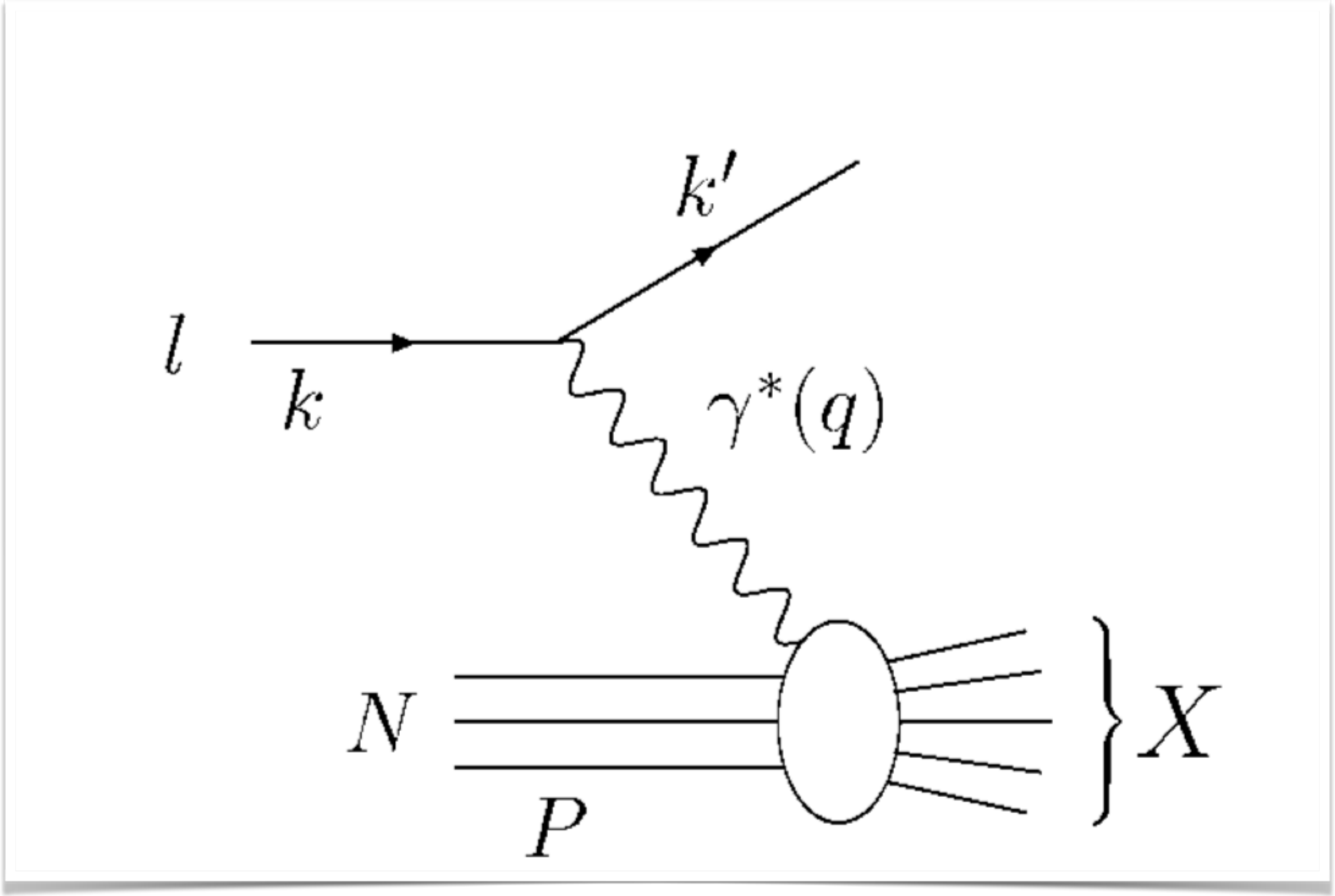
DIS at HERA

J. G. Contreras
Czech Technical University

May 2, 2018, Děčín

Workshop supported by grant SVK28/18/F4

The process we are interested in



A. Deshpande, R. Milner, R. Venugopalan, W. Vogelsang, Ann.Rev.Nucl.Part.Sci. 55 (2005) 165-228

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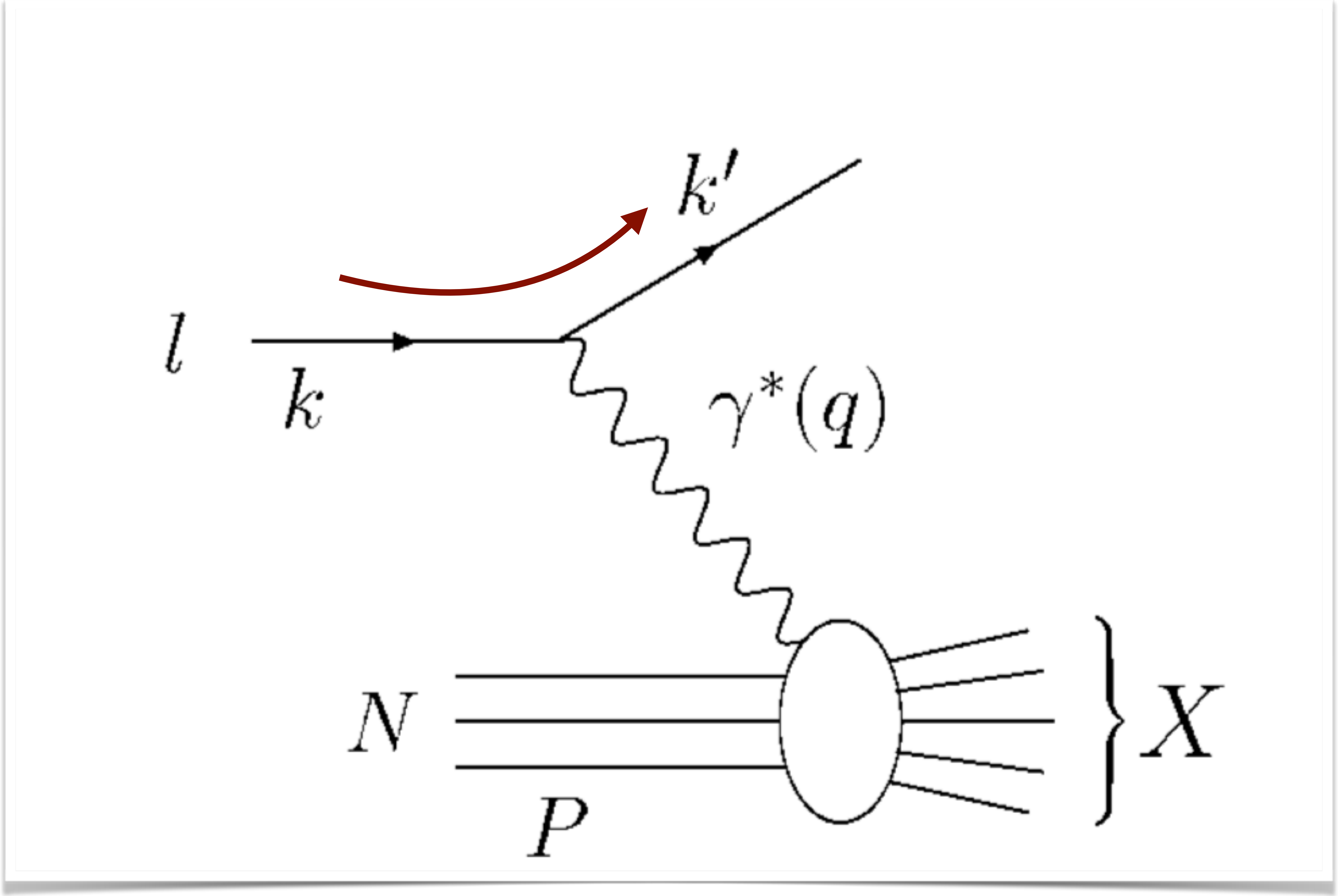
- The electromagnetic current.
  This is a vector, its square is a tensor: $L_{\mu\nu}$



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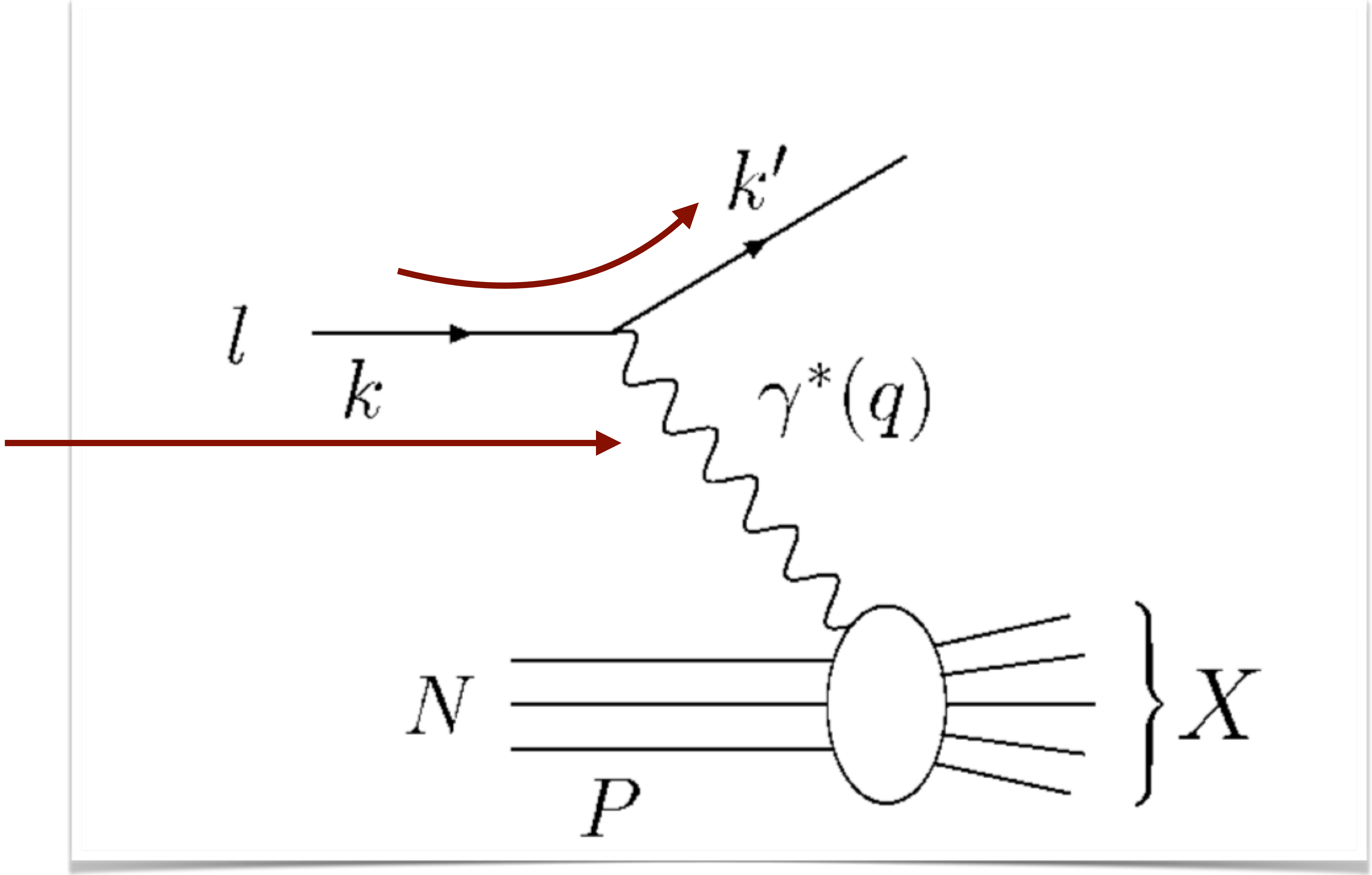
  Produces a factor $1/(Q^2+M^2)^2$ with $Q^2 = -q^2$.



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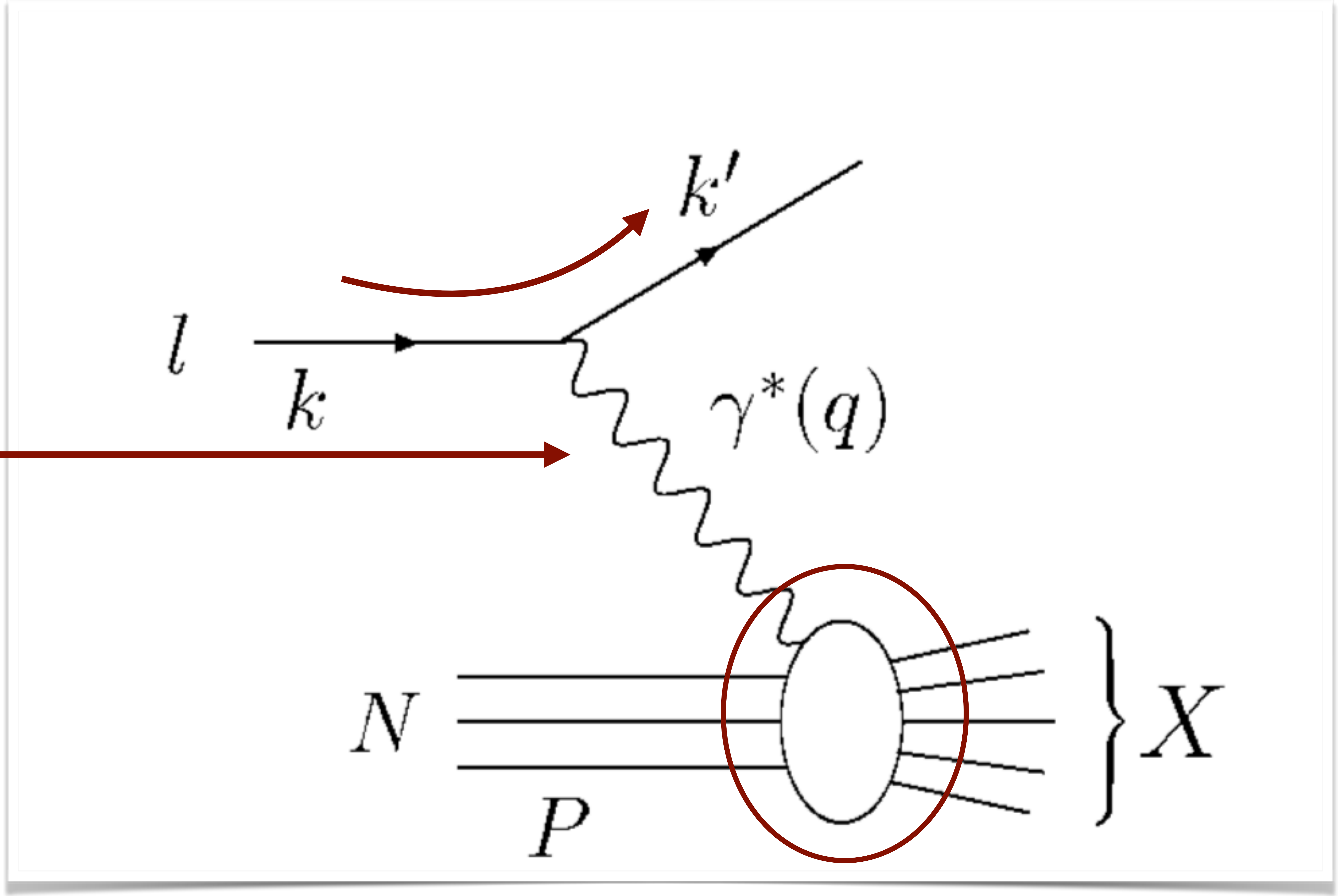

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The process we are interested in

$$\frac{d^2\sigma}{dx\,dy} \propto \mathcal{L}_{\mu\nu}(k, q, s)\,\mathcal{W}^{\mu\nu}(P, q, S),$$

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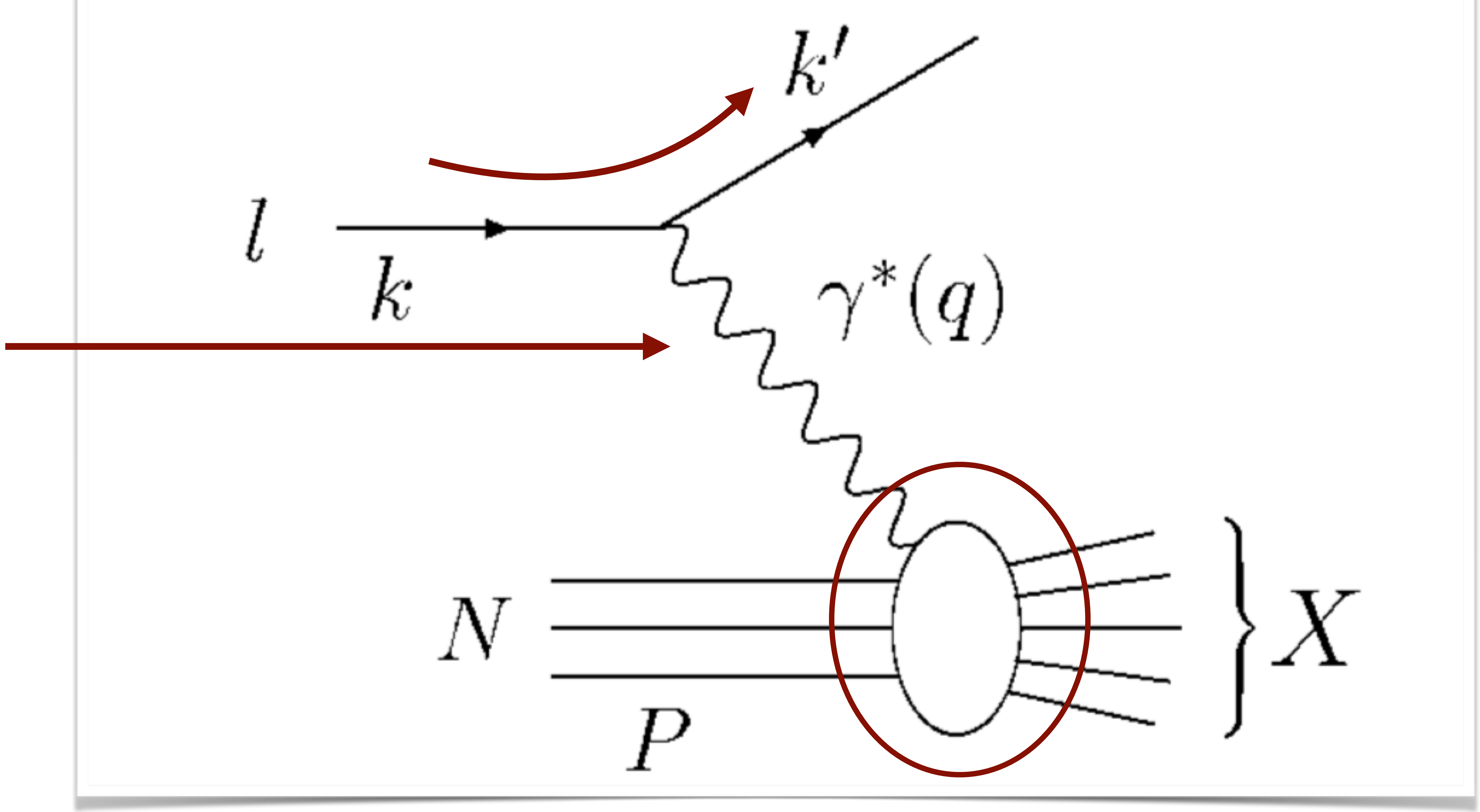

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$$+\frac{P^\mu P^\nu}{Pq}F_2(x,Q^2) - i\varepsilon^{\mu\nu\rho\sigma}\frac{q_\rho P_\sigma}{2\,Pq}F_3(x,Q^2) + i\varepsilon^{\mu\nu\rho\sigma}q_\rho\left[\frac{S_\sigma}{Pq}\,g_1(x,Q^2)\right.$$
$$\left.+\frac{S_\sigma(Pq)-P_\sigma(Sq)}{(Pq)^2}\,g_2(x,Q^2)\right] + \left[\frac{P^\mu S^\nu + S^\mu P^\nu}{2Pq} - \frac{Sq}{(Pq)^2}P^\mu P^\nu\right]$$
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Parity violating terms: F_3, g_3, g_4 and g_5. Exchange of a weak vector boson!

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The measurements

HERA was operated in two phases: HERA I, from 1992 to 2000, and HERA II, from 2002 to 2007. From 1994 onwards, and for all data used here, HERA operated with an electron beam energy of $E_e \simeq 27.5\,\text{GeV}$. For most of HERA I and II, the proton beam energy was $E_p = 920\,\text{GeV}$, resulting in the highest centre-of-mass energy of $\sqrt{s} \simeq 320\,\text{GeV}$.

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$$\sigma^{\pm}_{r,\mathrm{NC}} = \frac{\mathrm{d}^2\sigma^{e^\pm p}_{\mathrm{NC}}}{\mathrm{d}x_{\mathrm{Bj}}\mathrm{d}Q^2} \cdot \frac{Q^4 x_{\mathrm{Bj}}}{2\pi\alpha^2 Y_+} = \tilde{F}_2 \mp \frac{Y_-}{Y_+} x\tilde{F}_3 - \frac{y^2}{Y_+}\tilde{F}_{\mathrm{L}}, \tag{1}$$

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Interpretation in Quark-Parton Model

QCD enters here, but without gluons

$$(F_2, F_2^{\gamma Z}, F_2^Z) \approx [(e_u^2, 2e_u v_u, v_u^2 + a_u^2)(xU + x\bar{U}) \\ + (e_d^2, 2e_d v_d, v_d^2 + a_d^2)(xD + x\bar{D})],$$

$$(xF_3^{\gamma Z}, xF_3^Z) \approx 2[(e_u a_u, v_u a_u)(xU - x\bar{U}) \\ + (e_d a_d, v_d a_d)(xD - x\bar{D})],$$

$$xU = xu + xc, \quad x\bar{U} = x\bar{u} + x\bar{c},$$
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$$xF_3^{\gamma Z} \approx \frac{x}{3}(2u_v + d_v)$$

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\end{aligned}
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$$
\begin{aligned}
W_2^+ &\approx x\bar{U} + xD, \quad xW_3^+ \approx xD - x\bar{U}, \\
W_2^- &\approx xU + x\bar{D}, \quad xW_3^- \approx xU - x\bar{D}.
\end{aligned}
$$

$$
xu_v = xU - x\bar{U}, \quad xd_v = xD - x\bar{D}.
$$

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\sigma_{r,CC}^+ &\approx (x\bar{U} + (1-y)^2 xD), \\
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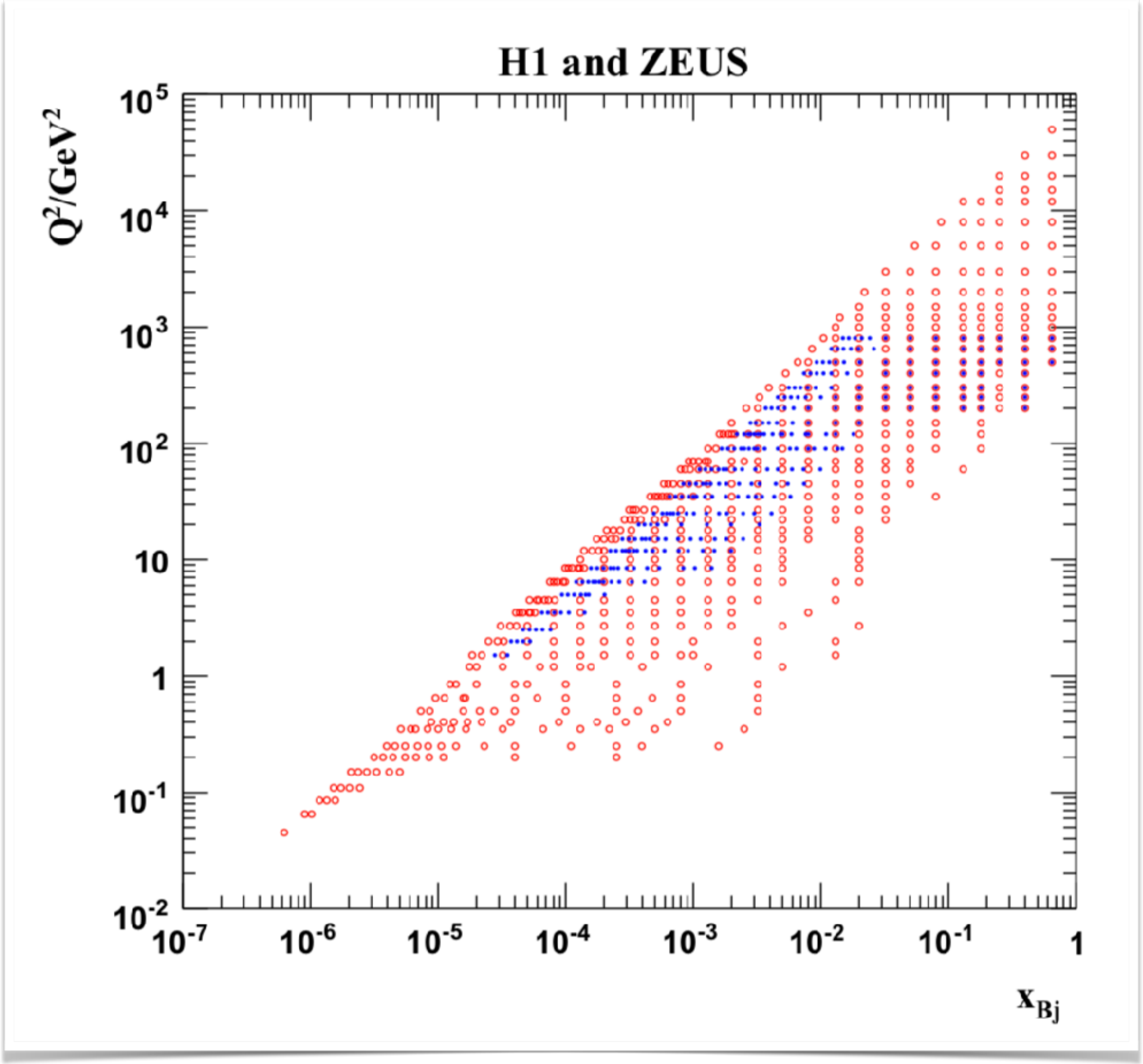
Phase space covered



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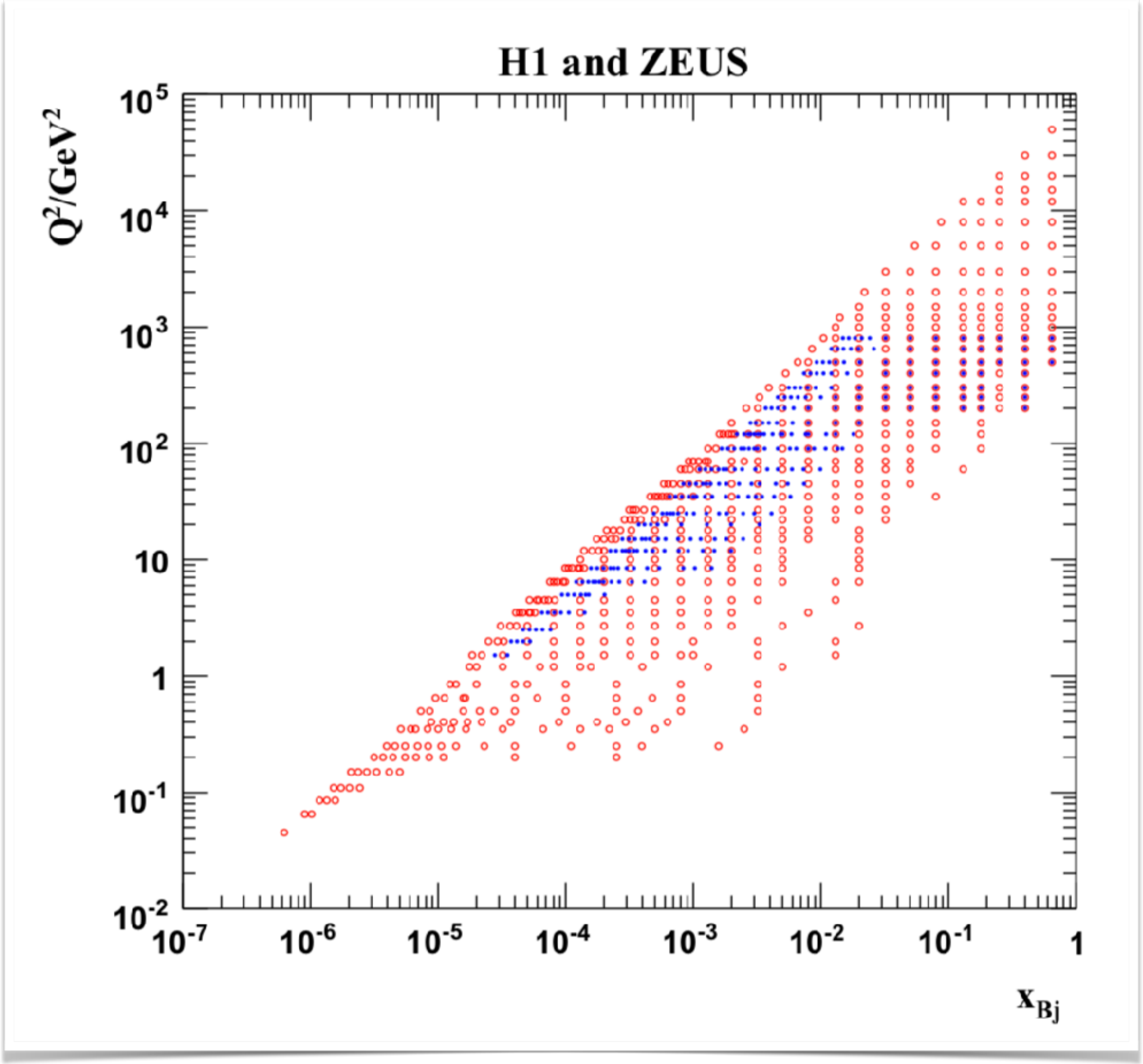
Phase space covered

- Data covers **six orders of magnitude** in x and **six order of magnitude** in Q^2!
- There is a correlation between them due to finite centre-of-mass energy.
- Data from 1994 to 2007 and from two different collaborations!



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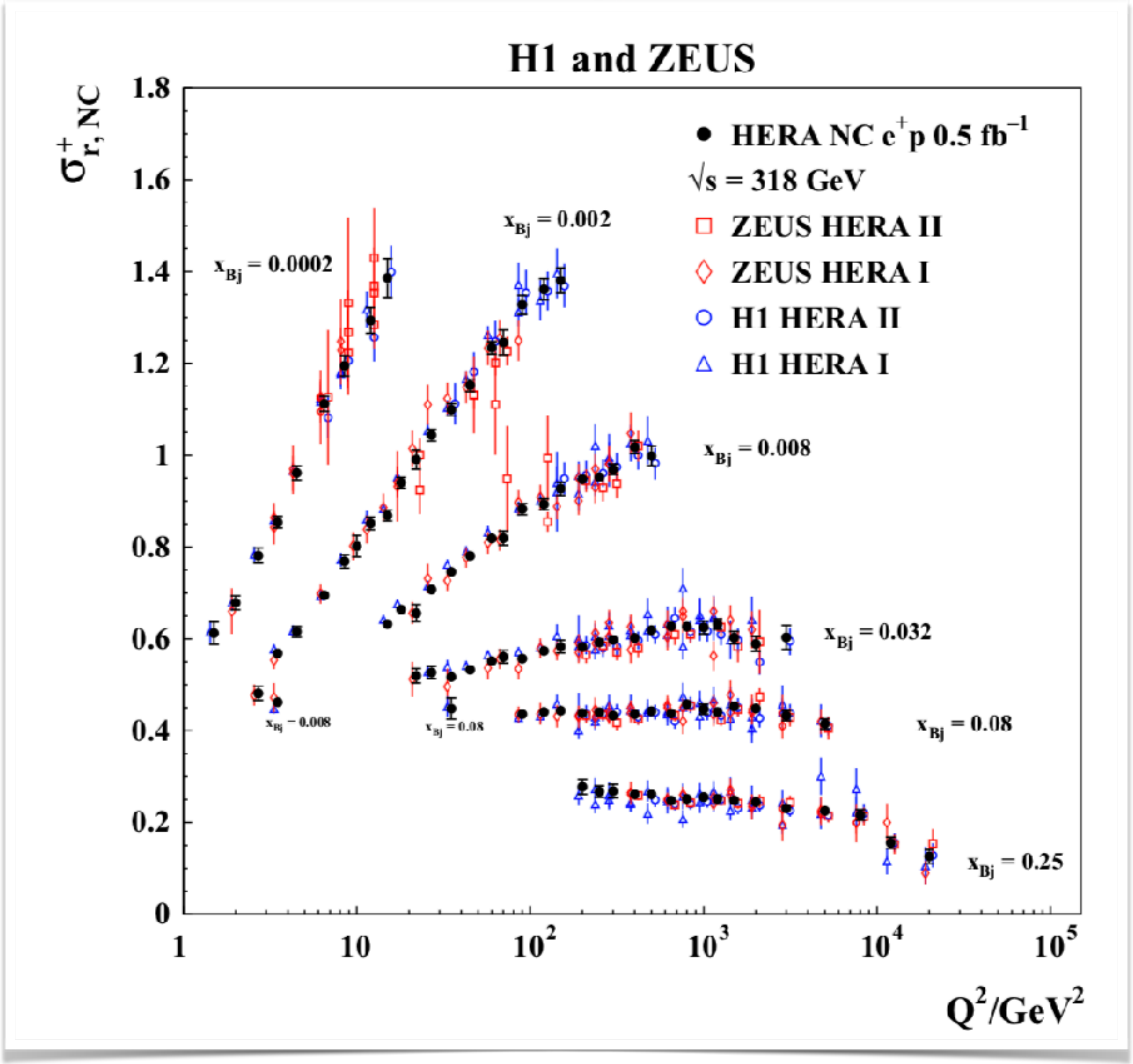
Neutral current results



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Scaling violations are clearly observed

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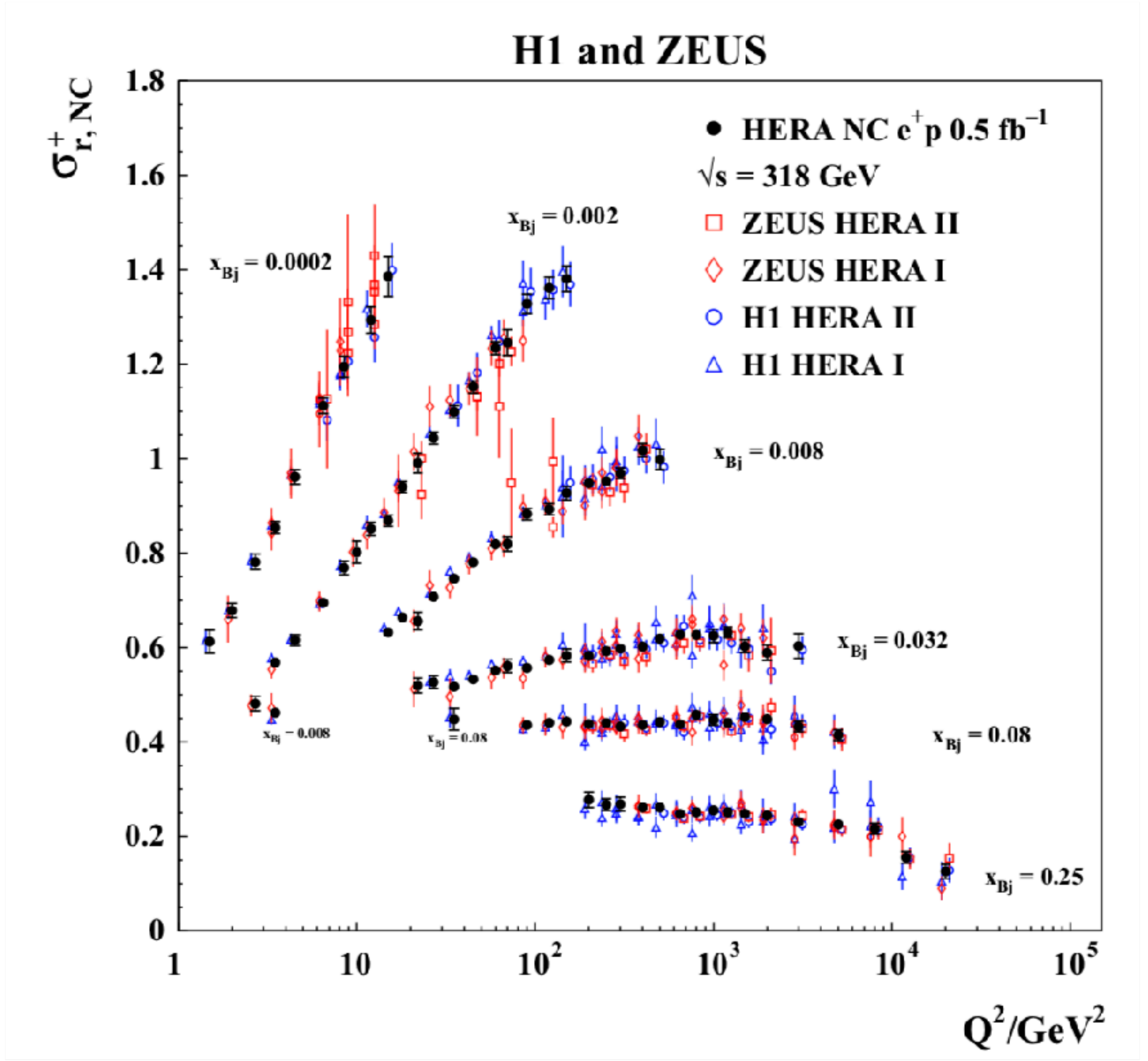
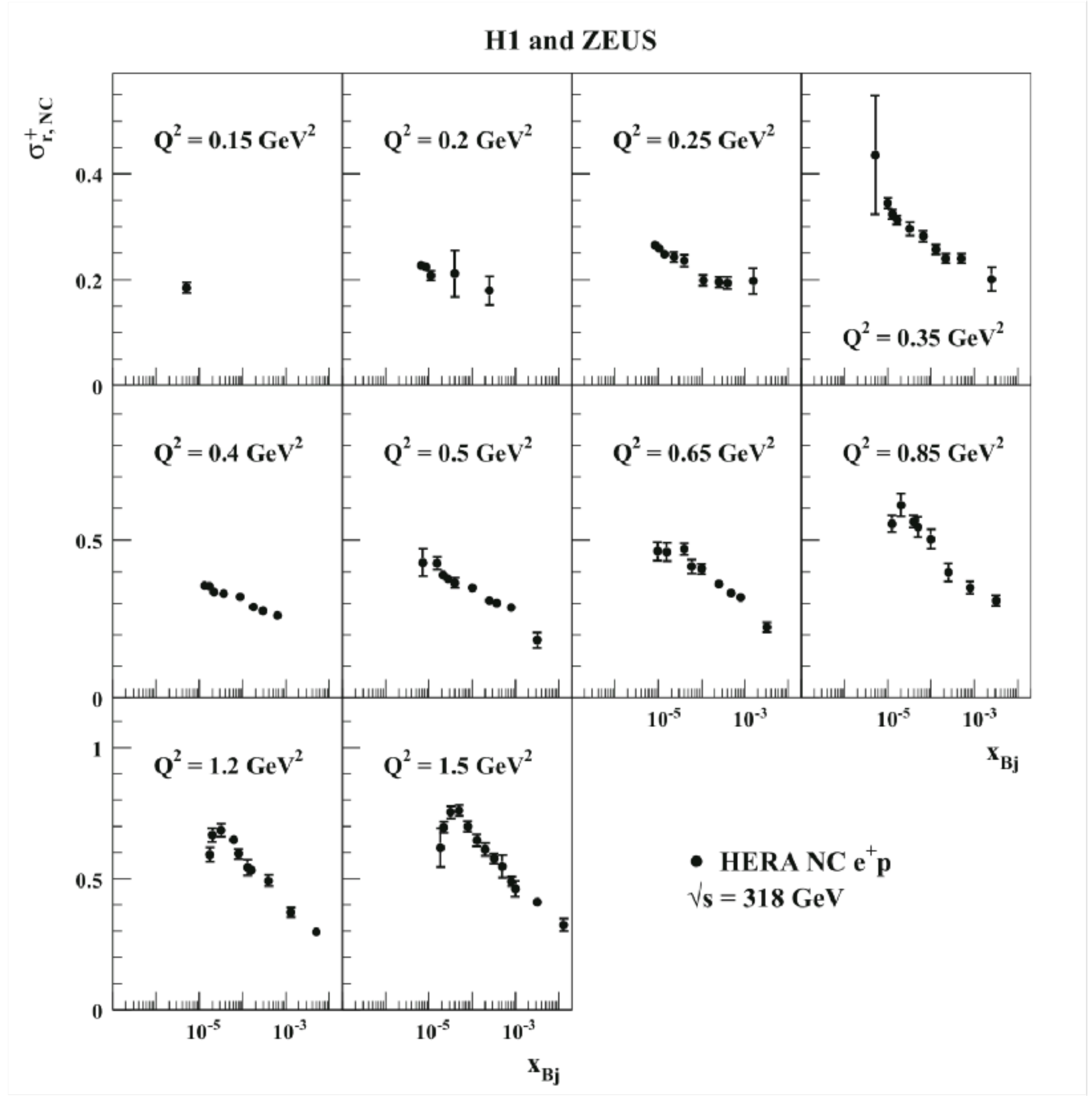


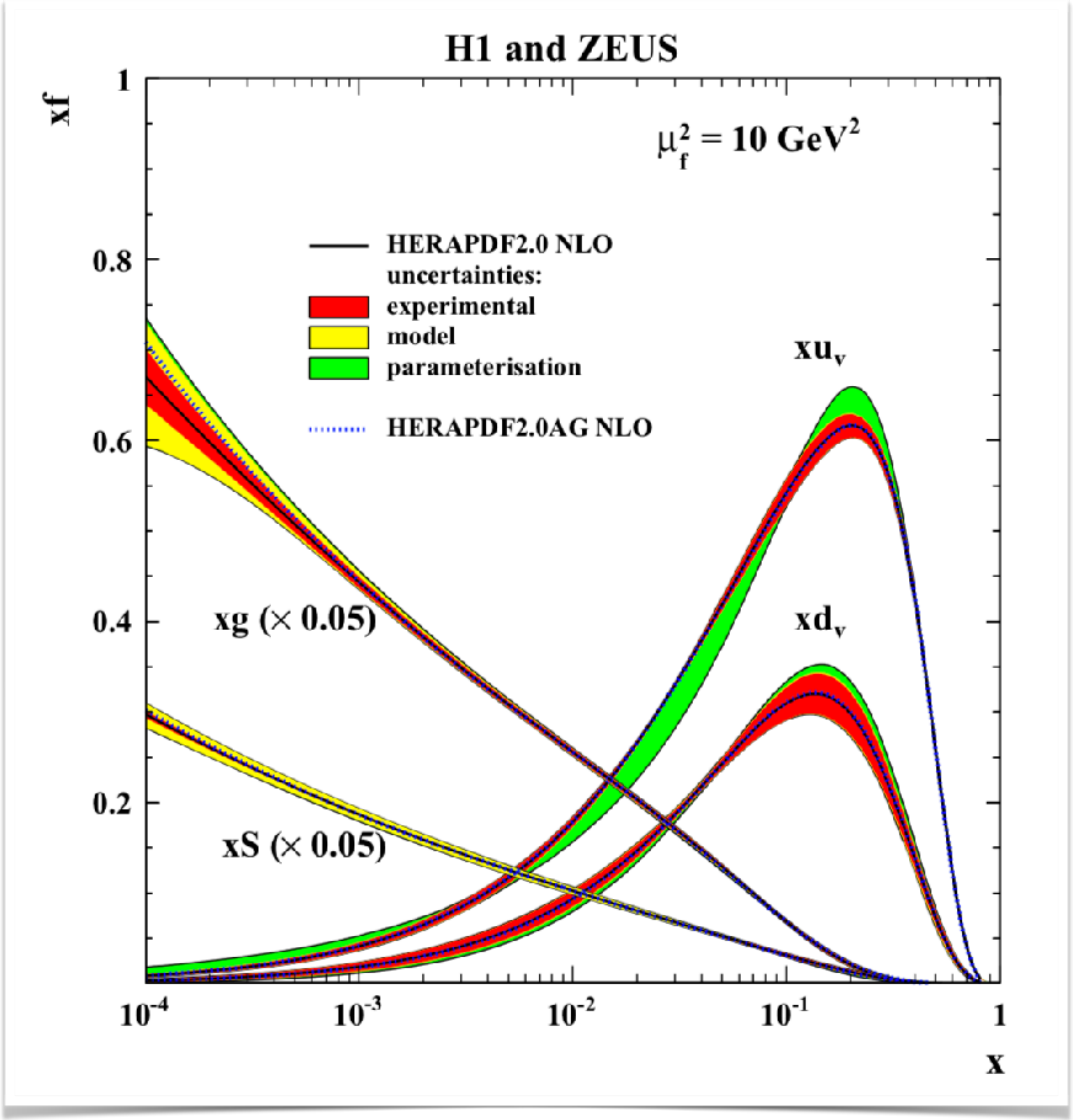


Scaling violations are clearly observed

Power law and effect of F_L clearly seen

PDF extraction

Use a parameterisation of partons at a given scale and use DGLAP equations to evolve them.



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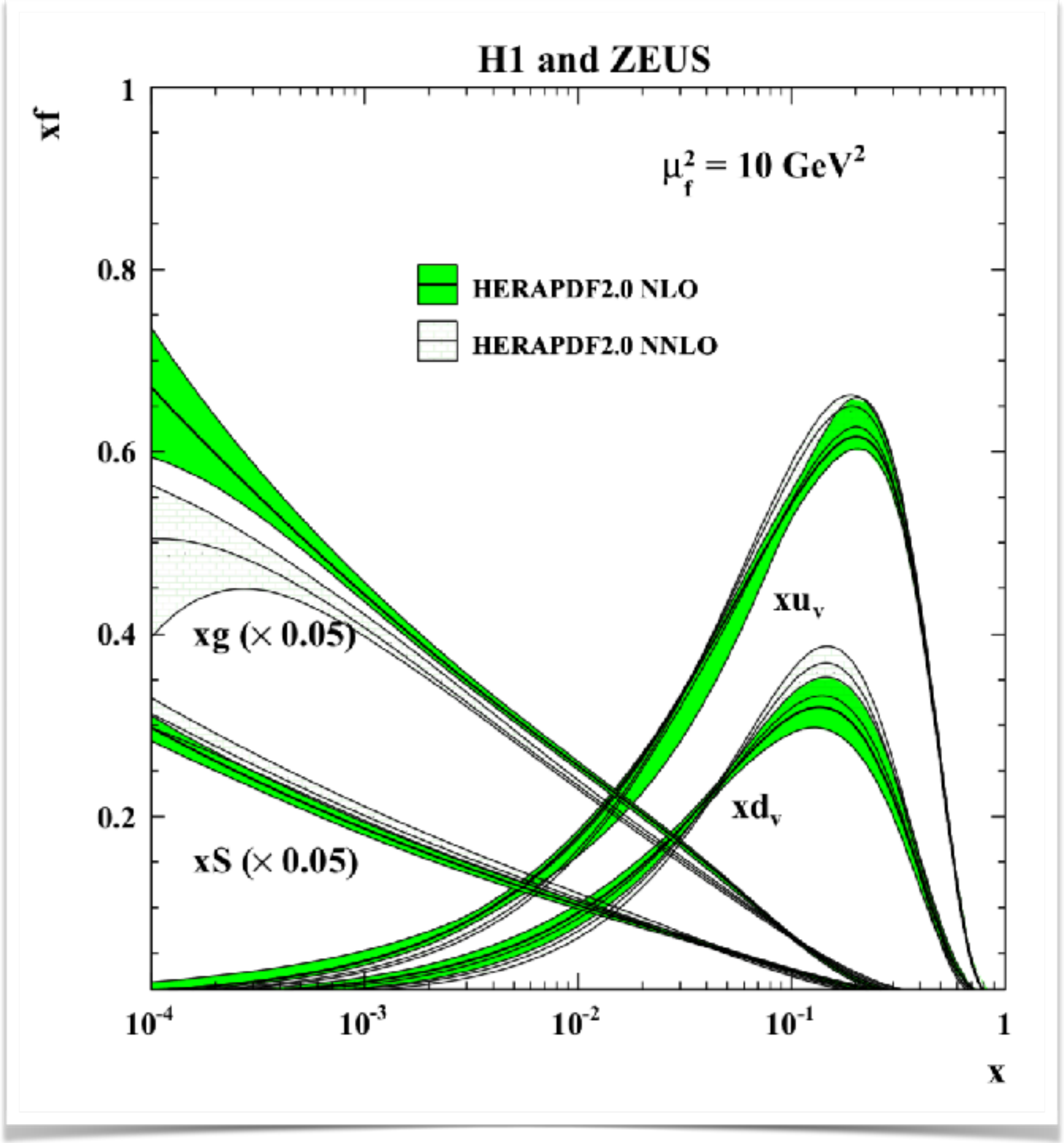

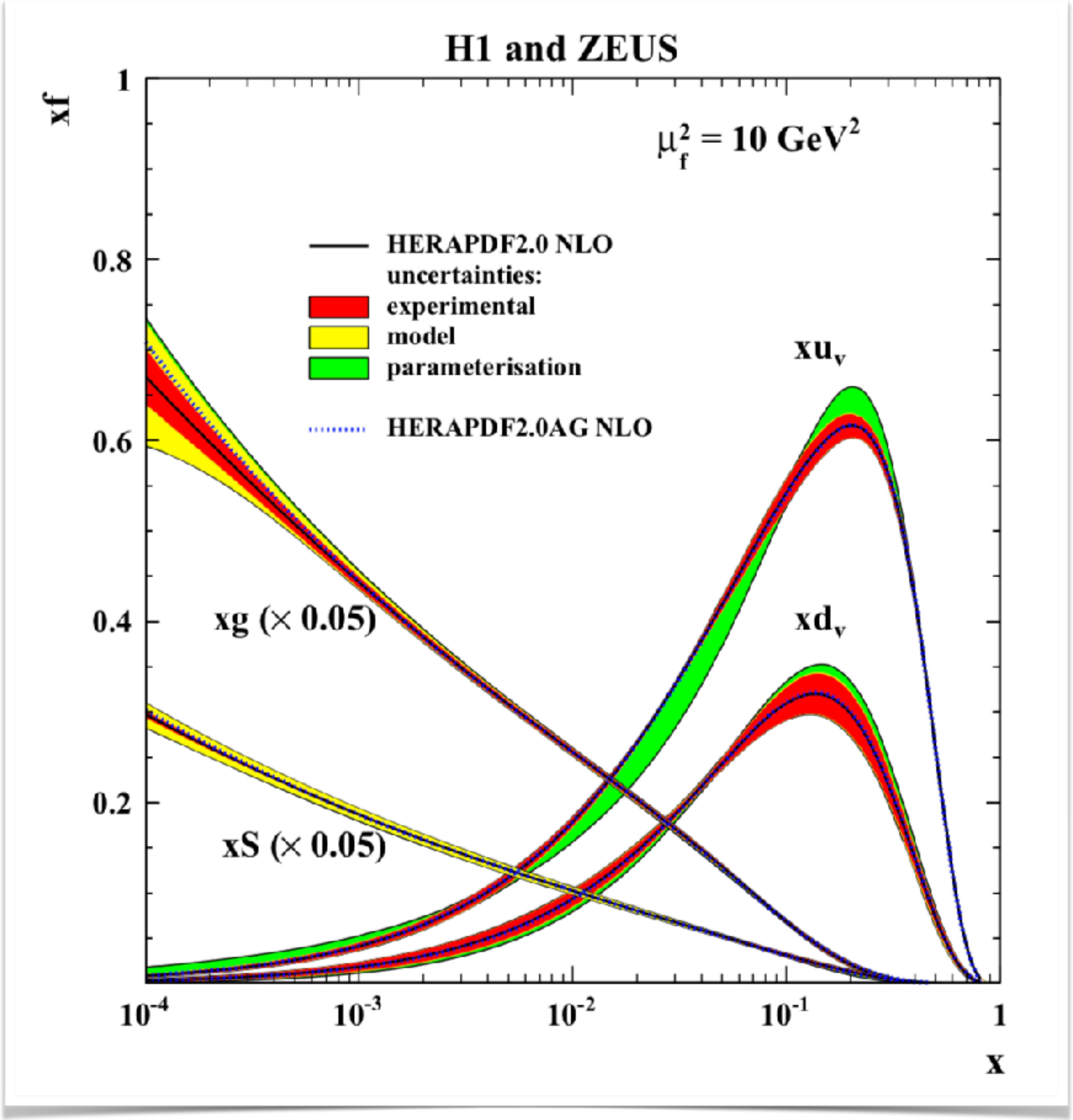

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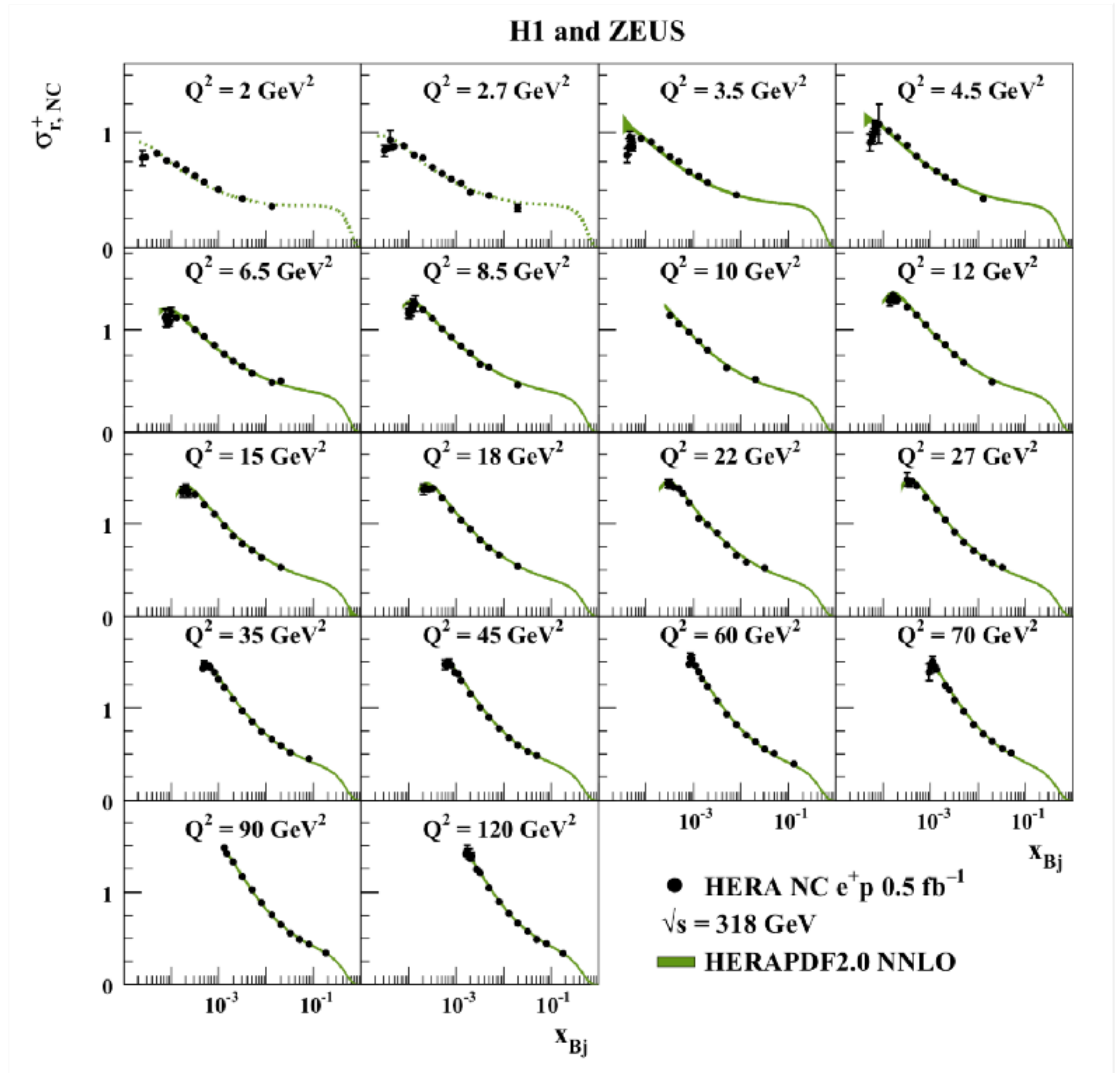
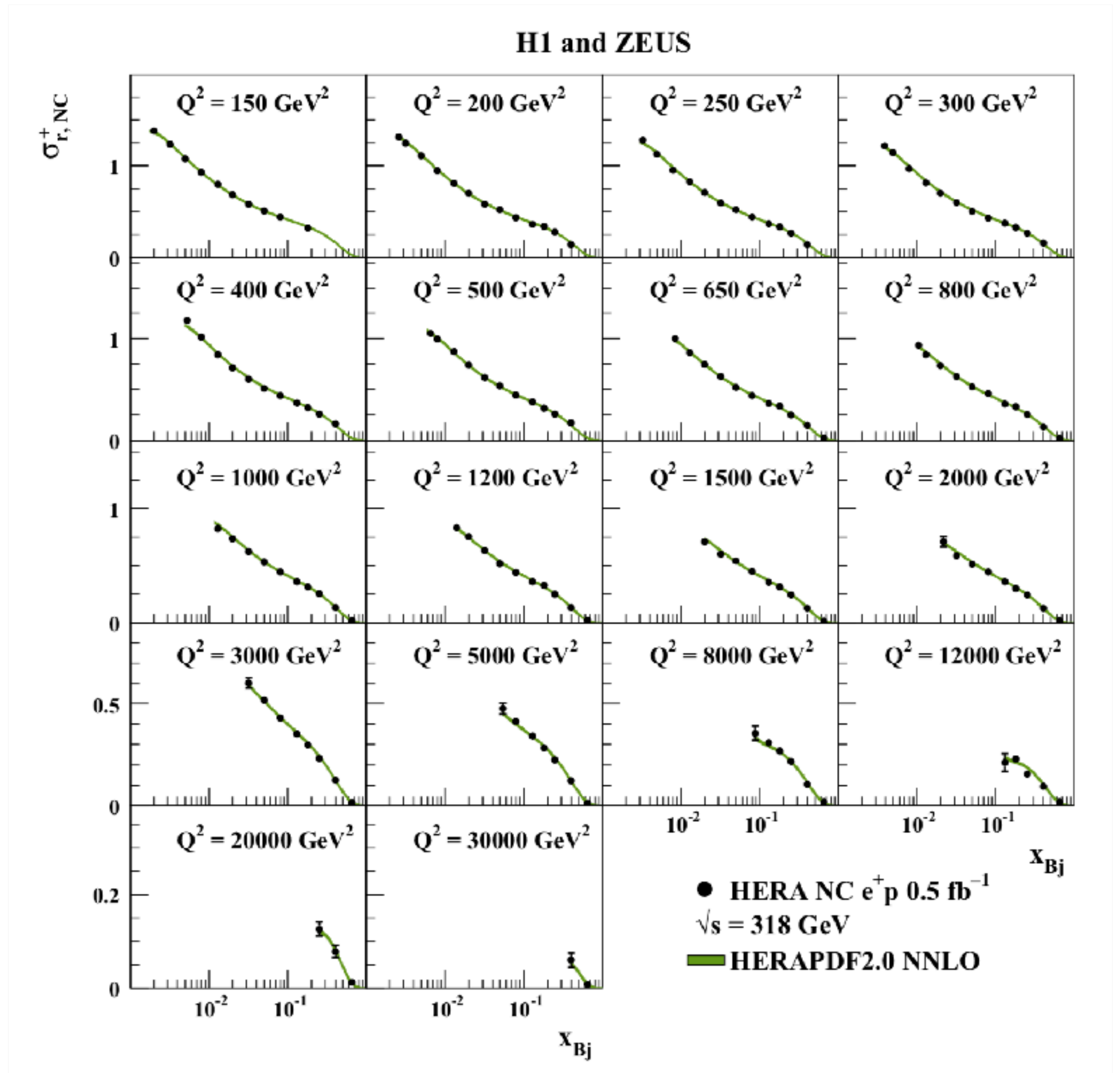
Data DGLAP comparison





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A text book plot!

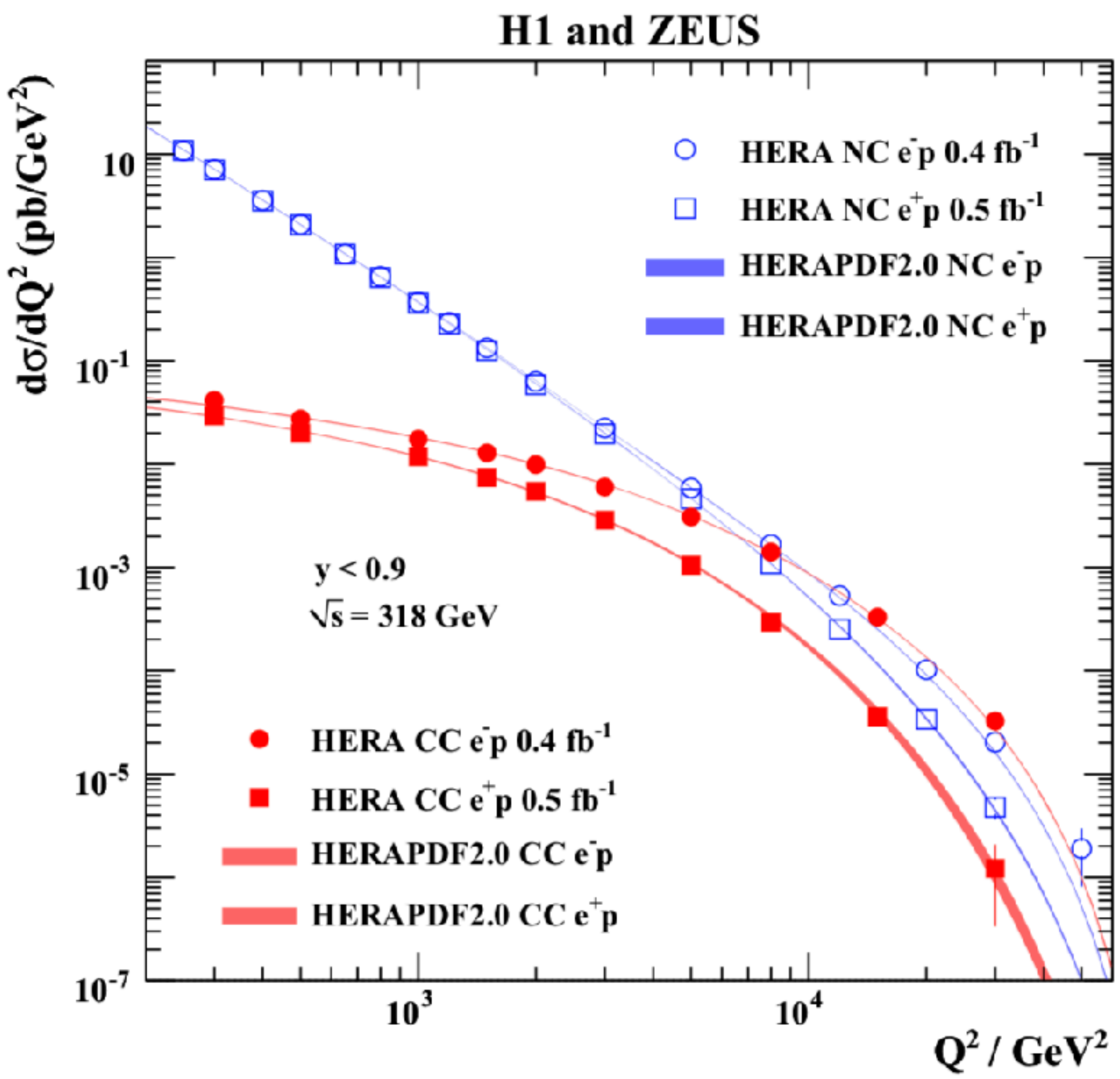

Fig. 74 The combined HERA NC and CC $e^- p$ and $e^+ p$ cross sections, $d\sigma/dQ^2$, together with predictions from HERAPDF2.0 NLO. The *bands* represent the total uncertainty on the predictions

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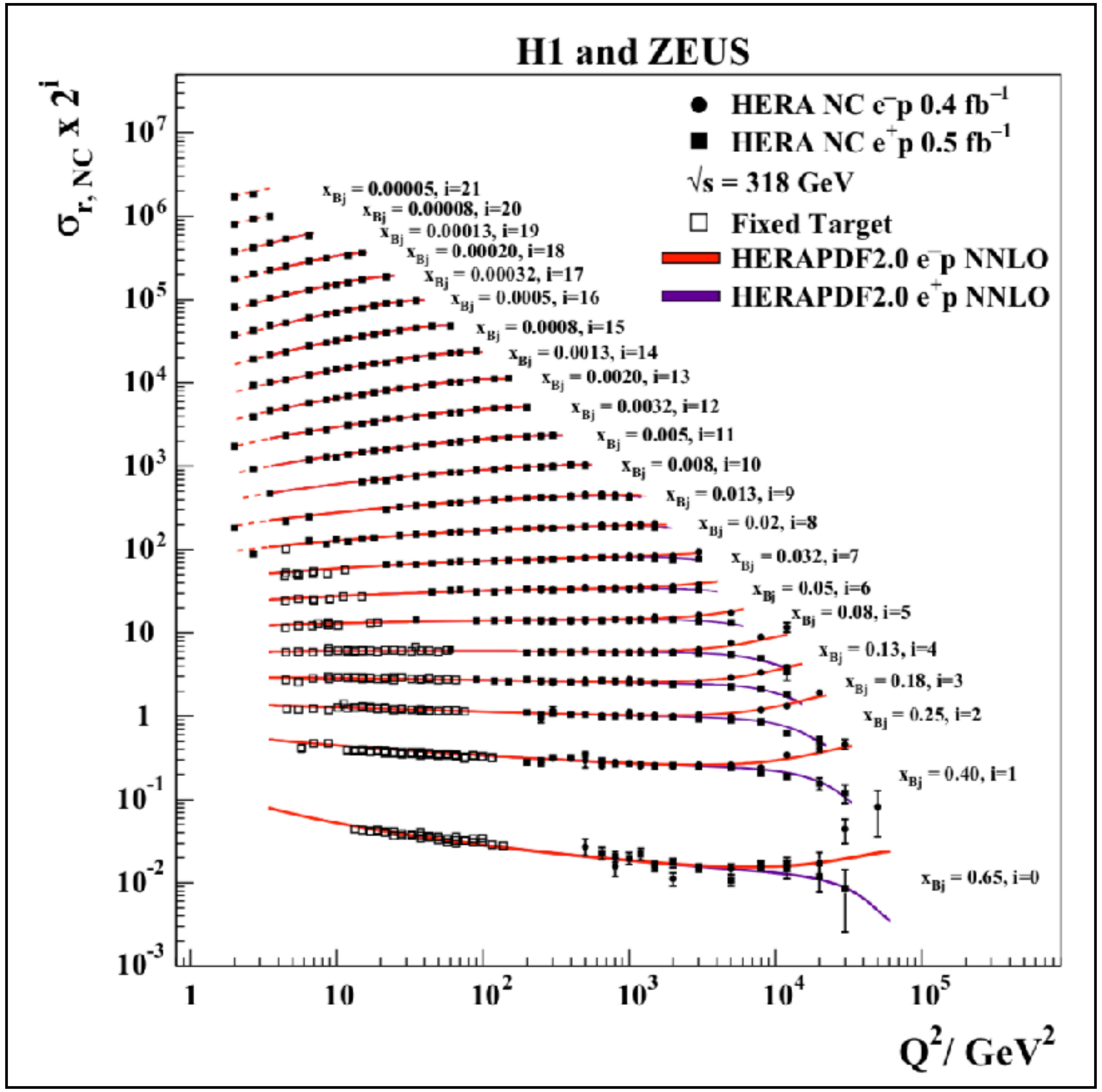
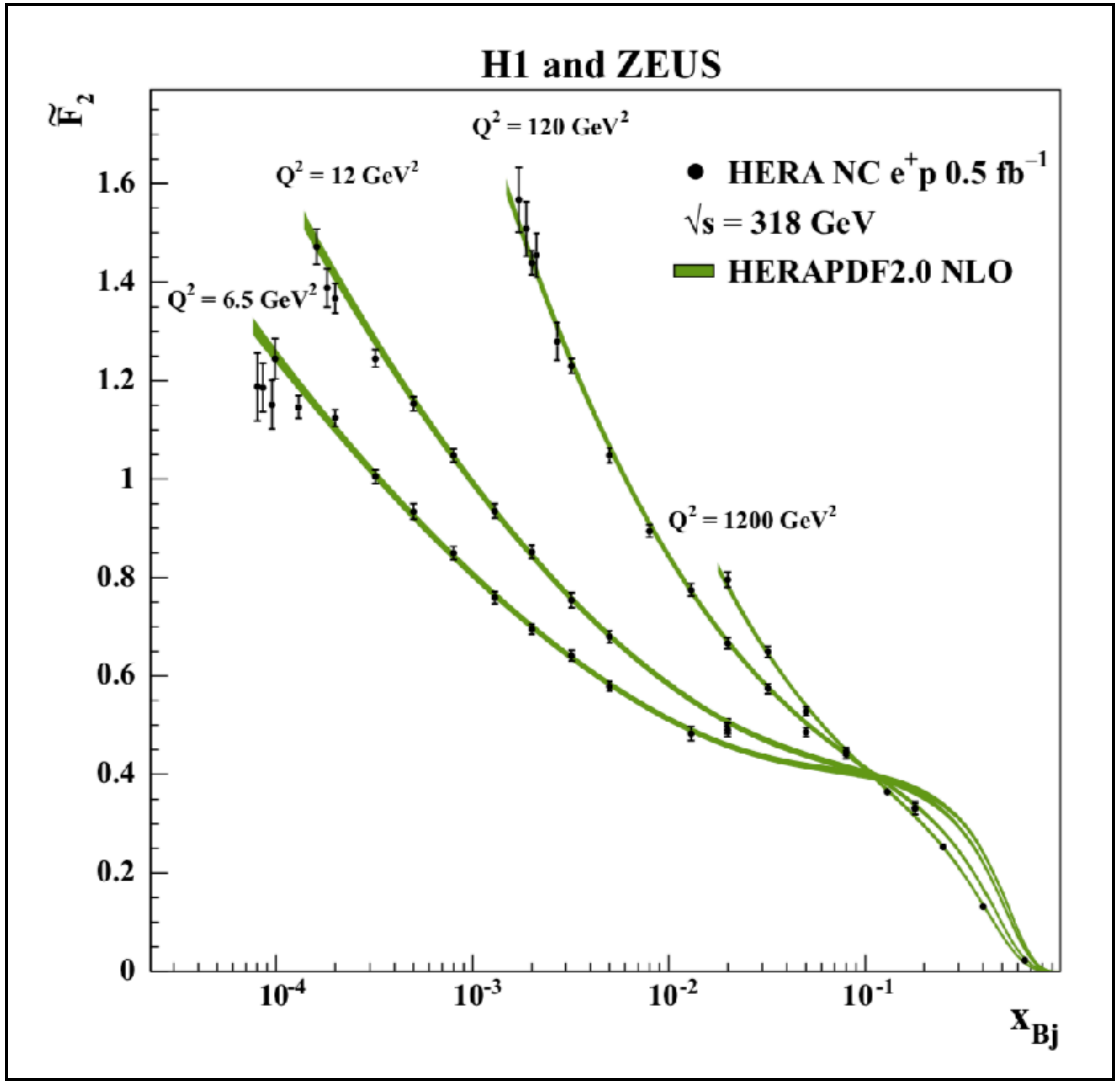
An another two :)





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