Study of heavy quarks production in DIS at HERA using BGK dipole model

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Outline

- Dipole model of DIS
- Heavy-flavour production in DIS
- Description of the charm and beauty production cross section measurements in deep inelastic ep scattering at HERA using dipole model : results of the fits
- Summary

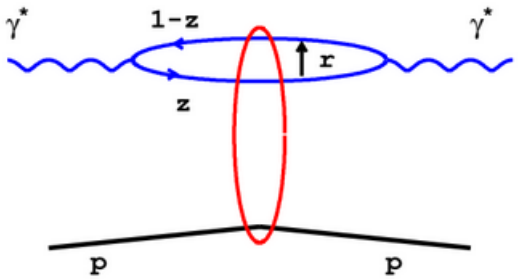
Analysis was done in xFitter framework using HERA data:

1.H.Abramowicz et al., Combination and QCD analysis of charm and beauty production cross section measurements in deep inelastic ep scattering at HERA, DESY 18-037 (2018)

2.H.Abramowicz et.al., Combination of Measurements of Inclusive Deep Inelastic ep Scattering Cross Sections and QCD Analysis of HERA Data, The European Physical Journal C 75, 580 (2015)

Dipole model of DIS

- Dipole picture of DIS at small x in the proton rest frame:



r - dipole size

z - longitudinal momentum fraction of the quark/antiquark

- Factorization: dipole formation + dipole interaction

$$\sigma^{\gamma p} = \frac{4\pi^2 \alpha_{em}}{Q^2} F_2 = \sum_f \int d^2 r \int_0^1 dz \, |\Psi^\gamma(r, z, Q^2, m_f)|^2 \;\; \hat{\sigma}(r, x)$$

- Dipole-proton interaction:

$$\hat{\sigma}(r, x) = \sigma_0 \left(1 - \exp\{-\hat{r}^2\}\right) \qquad \hat{r} = r/R_s(x)$$

Dipole cross section: BGK

- BGK (Bartels-Golec-Kowalski) parametrization:

$$\hat{\sigma}(r,x) = \sigma_0 \left\{1 - \exp\left[-\pi^2 r^2 \alpha_s(\mu^2) x g(x,\mu^2)/(3\sigma_0)\right]\right\}$$

- $\mu^2 = C/r^2 + \mu_0^2$ is the scale of the gluon density
- μ_0^2 is a starting scale of the QCD evolution: $\mu_0^2 = Q_0^2$
- gluon density is evolved according to the LO or NLO DGLAP eq.
- soft gluon:

$$xg(x,\mu_0^2) = A_g\, x^{\lambda_g}\, (1-x)^{C_g}$$

- soft + hard gluon:

$$xg(x,\mu_0^2) = A_g\, x^{\lambda_g}\, (1-x)^{C_g} (1 + D_g x + E_g x^2)$$

Heavy-flavour production in DIS

- The cross section for the production of a heavy flavour of type Q, with Q being either charm c or beauty b, may then be written in terms of the heavy-flavour contributions to the structure functions F_2 and F_L:

$$\frac{\mathrm{d}^2\sigma^{\mathrm{Q\overline{Q}}}}{\mathrm{d}x_{\mathrm{Bj}}\mathrm{d}Q^2} = \frac{2\pi\alpha^2(Q^2)}{x_{\mathrm{Bj}}Q^4}([1+(1-y)^2]F_2^{\mathrm{Q\overline{Q}}}(x_{\mathrm{Bj}},Q^2) - y^2F_{\mathrm{L}}^{\mathrm{Q\overline{Q}}}(x_{\mathrm{Bj}},Q^2))$$

- The results are presented in terms of reduced cross sections, defined as follows:

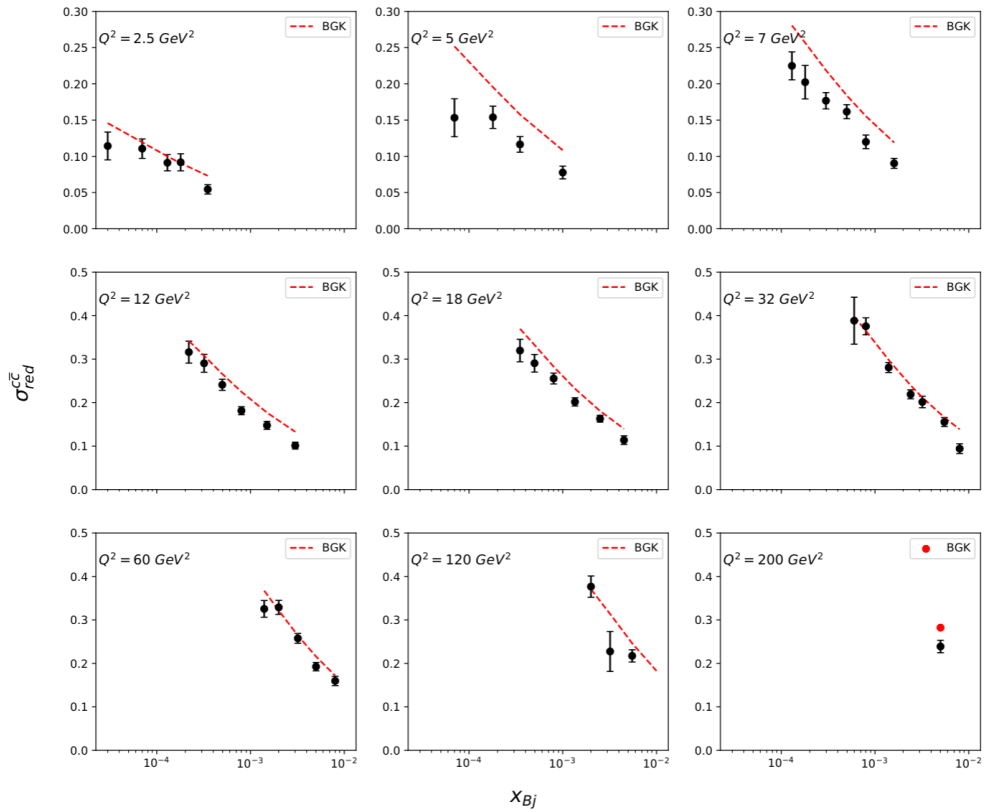
$$\begin{aligned}\sigma_{\mathrm{red}}^{\mathrm{Q\overline{Q}}} &= \frac{\mathrm{d}^2\sigma^{\mathrm{Q\overline{Q}}}}{\mathrm{d}x_{\mathrm{Bj}}\mathrm{d}Q^2}\cdot\frac{x_{\mathrm{Bj}}Q^4}{2\pi\alpha^2(Q^2)\,(1+(1-y)^2)} \\ &= F_2^{\mathrm{Q\overline{Q}}} - \frac{y^2}{1+(1-y)^2}F_{\mathrm{L}}^{\mathrm{Q\overline{Q}}}.\end{aligned}$$

Results of the fits

- Parameters from BGK dipole model fit with mc=1.3 GeV, mb= 4.05 GeV to charm and beauty HERA data]

$Q_0^2\ [GeV^2]$	$\sigma_0\ [GeV^2]$	A_g	λ_g	C_g	$C\ [GeV^2]$	Ndf	χ^2	χ^2/Ndf
1.9	152.35	1.2660	-0.1756	1.0670	4.0	64	112.81	1.763

- Comparision with HERA data for charm production

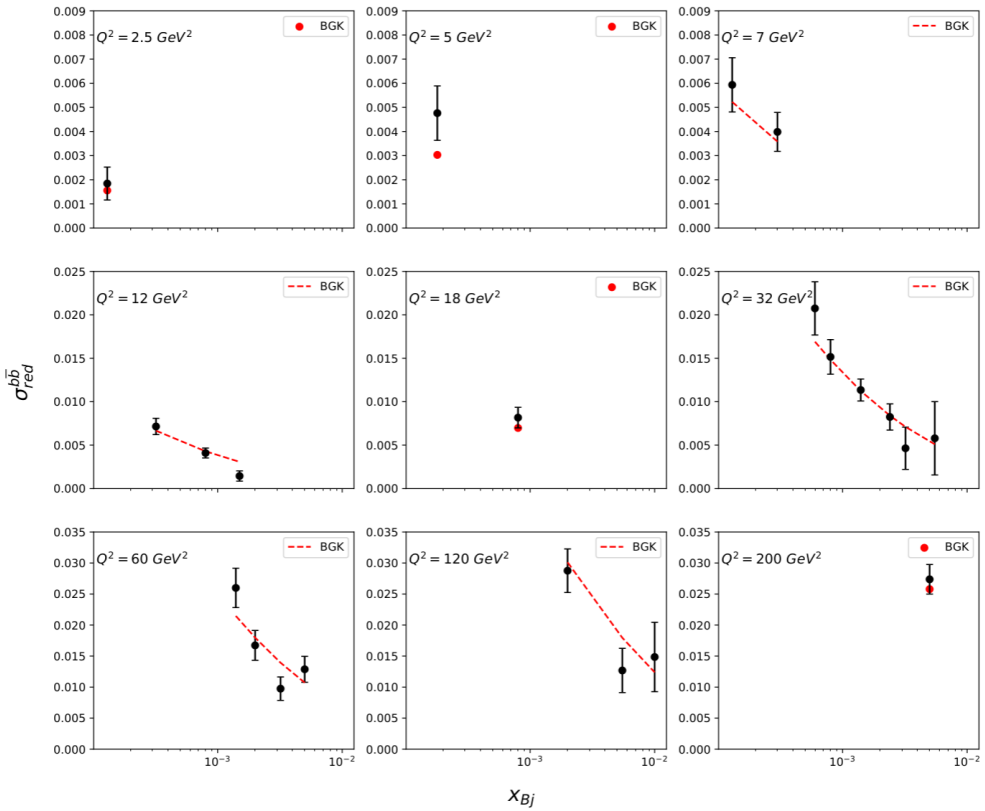


Results of the fits

- Parameters from BGK dipole model fit with mc=1.3 GeV, mb= 4.05 GeV to charm and beauty HERA data

$Q_0^2\ [GeV^2]$	$\sigma_0\ [GeV^2]$	A_g	λ_g	C_g	$C\ [GeV^2]$	Ndf	χ^2	χ^2/Ndf
1.9	152.35	1.2660	-0.1756	1.0670	4.0	64	112.81	1.763

- Comparision with HERA data for beauty production

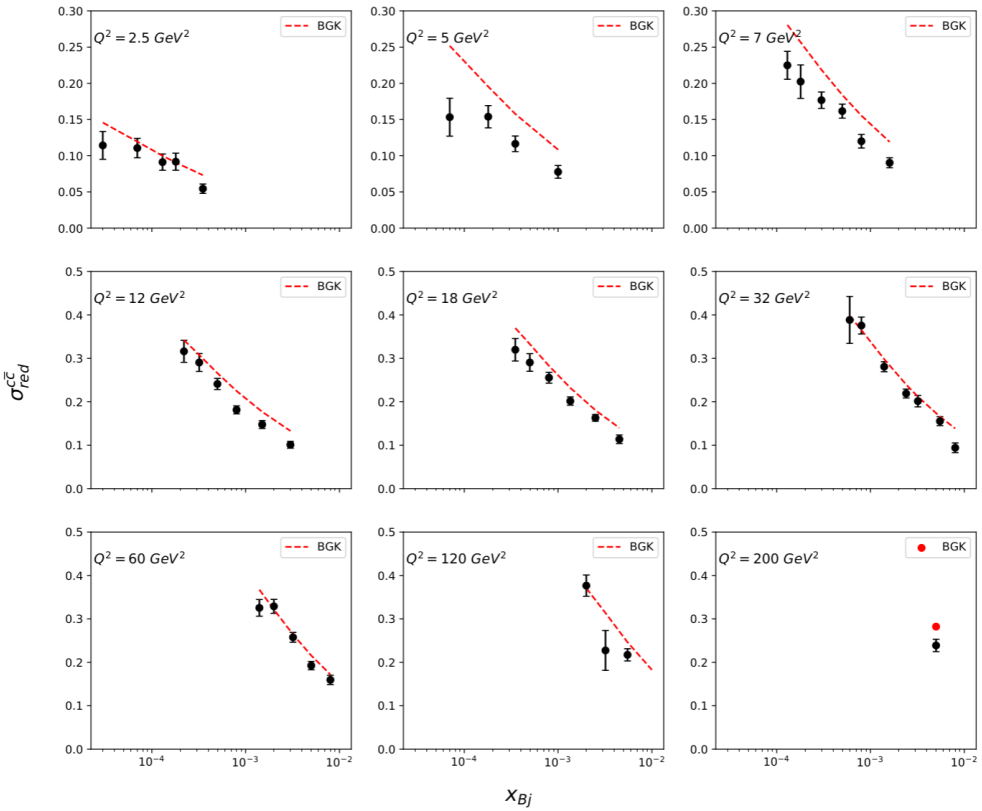


Results of the fits

- Parameters from BGK dipole model fit with mc=1.4 GeV, mb= 4.05 GeV to charm and beauty HERA data

$Q_0^2\ [GeV^2]$	$\sigma_0\ [GeV^2]$	A_g	λ_g	C_g	$C\ [GeV^2]$	Ndf	χ^2	χ^2/Ndf
1.9	152.35	1.2659	-0.1756	1.0667	4.0	64	112.81	1.763

- Comparision with HERA data for charm production

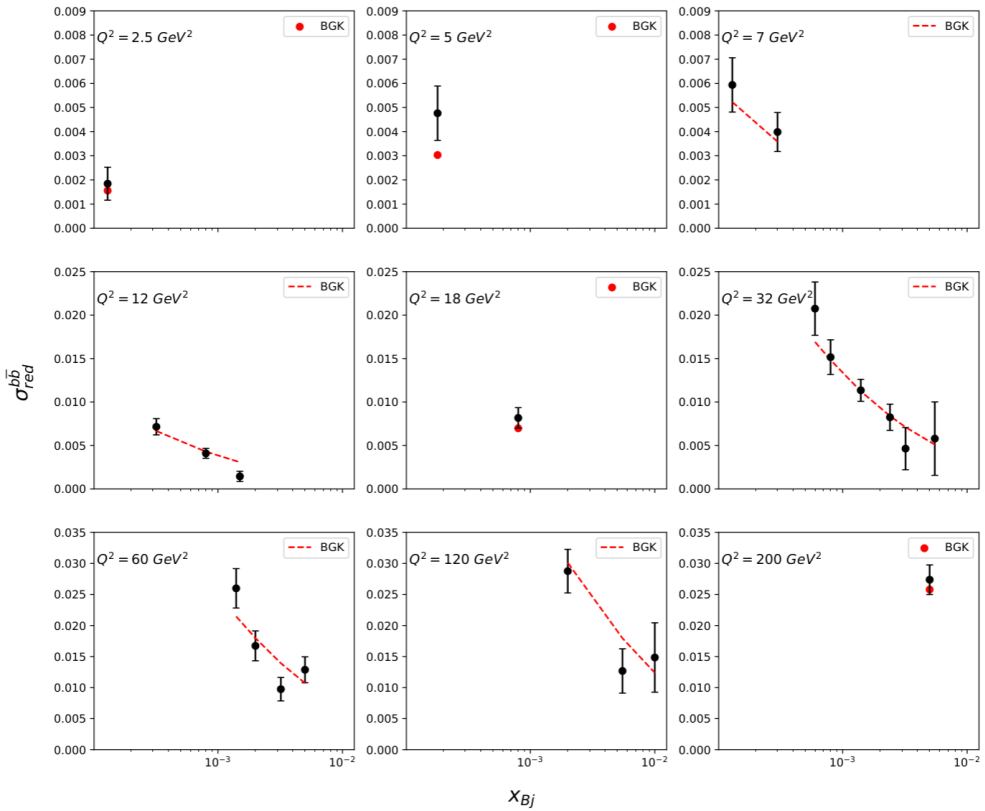


Results of the fits

- Parameters from BGK dipole model fit with mc=1.4 GeV, mb= 4.05 GeV to charm and beauty HERA data

$Q_0^2\ [GeV^2]$	$\sigma_0\ [GeV^2]$	A_g	λ_g	C_g	$C\ [GeV^2]$	Ndf	χ^2	χ^2/Ndf
1.9	152.35	1.2659	-0.1756	1.0667	4.0	64	112.81	1.763

- Comparision with HERA data for beauty production

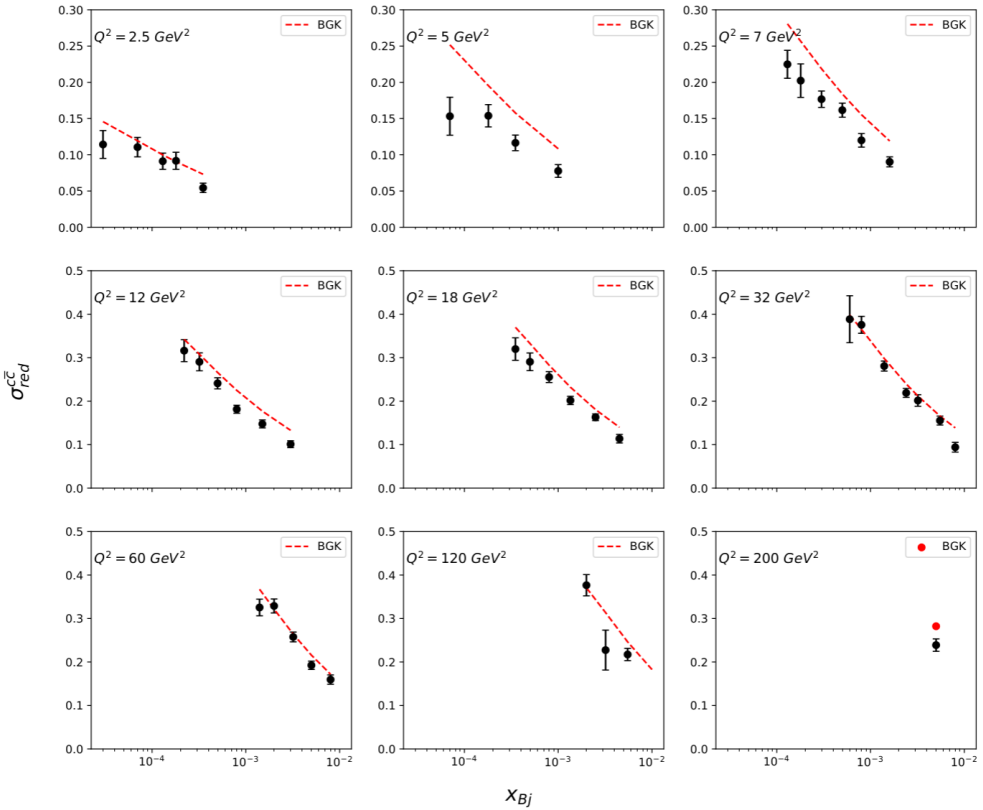


Results of the fits

- Parameters from BGK dipole model fit with mc=1.5 GeV, mb= 4.05 GeV to charm and beauty HERA data

$Q_0^2\ [GeV^2]$	$\sigma_0\ [GeV^2]$	A_g	λ_g	C_g	$C\ [GeV^2]$	Ndf	χ^2	χ^2/Ndf
1.9	152.35	1.2669	-0.1755	1.0685	4.0	64	112.81	1.763

- Comparision with HERA data for charm production

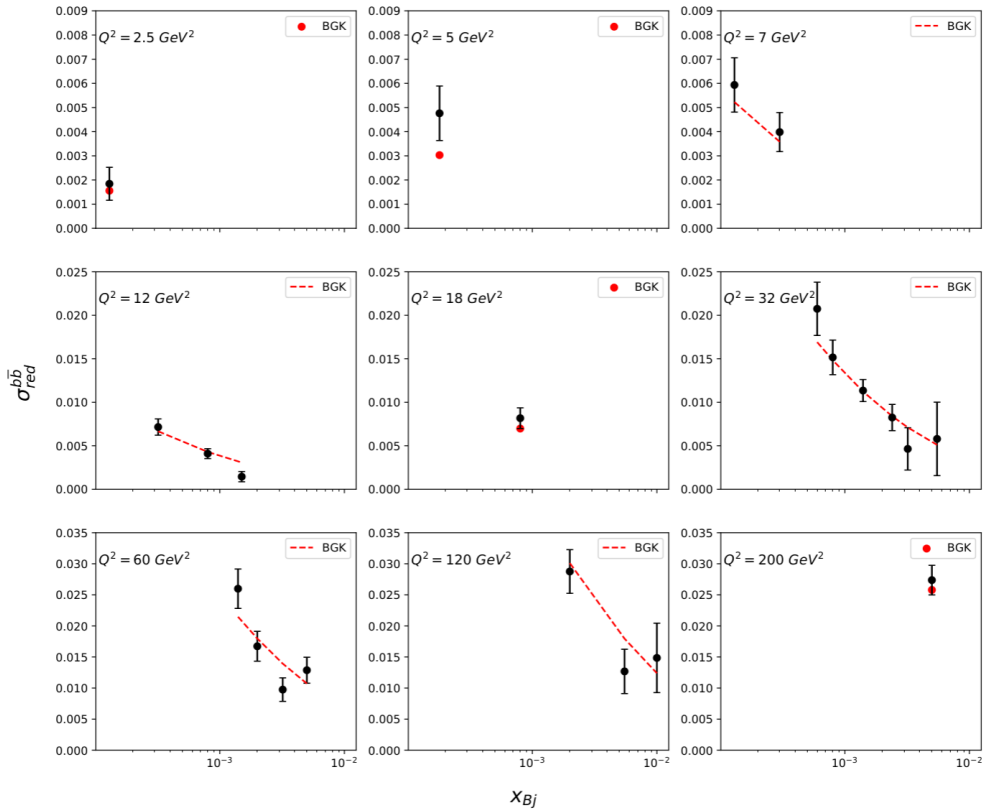


Results of the fits

- Parameters from BGK dipole model fit with mc=1.5 GeV, mb= 4.05 GeV to charm and beauty HERA data

$Q_0^2\ [GeV^2]$	$\sigma_0\ [GeV^2]$	A_g	λ_g	C_g	$C\ [GeV^2]$	Ndf	χ^2	χ^2/Ndf
1.9	152.35	1.2669	-0.1755	1.0685	4.0	64	112.81	1.763

- Comparision with HERA data for beauty production

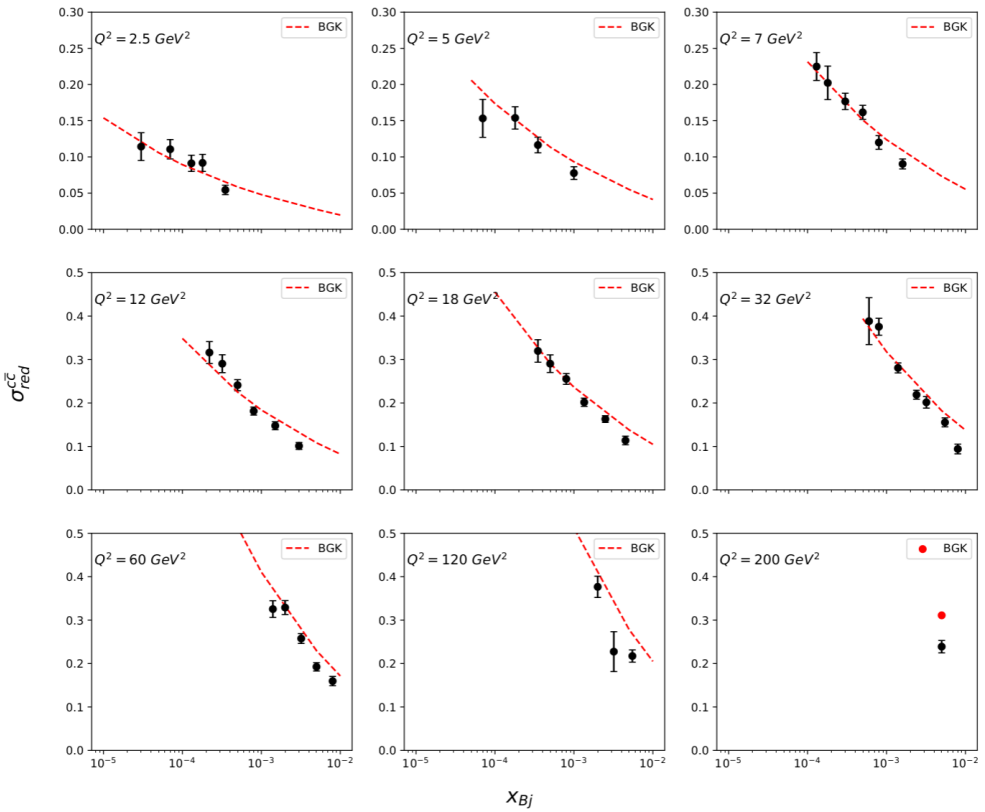


Results of the fits

- Parameters from BGK dipole model fit with mc=1.3 GeV to the high precision combined HERA data

$Q_0^2\ [GeV^2]$	$\sigma_0\ [GeV^2]$	A_g	λ_g	C_g	$C\ [GeV^2]$	Ndf	χ^2	χ^2/Ndf
1.9	270.16	2.4788	-0.0663	6.9093	4.0	538	554.78	1.031

- Comparision with HERA data of the charm production cross section determined from BGK dipole model and the high precision HERA data



Summary

- We analysed the charm and beauty production cross section measurements in deep inelastic ep scattering at HERA using BGK dipole model
- We added the contribution from beauty quarks to BGK dipole model in xFitter framework
- The obtained results from BGK dipole model fits are reasonable and similar to other global PDF fits