DIS 2006

XIV International Workshop on Deep Inelastic Scattering Tsukuba, Japan

Jet cross sections in NC DIS and determination of α_s at ZEUS

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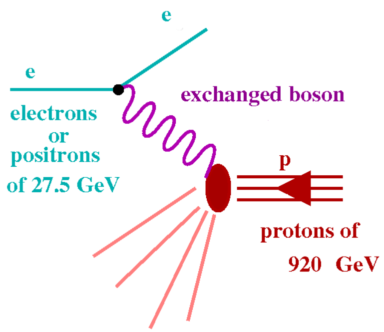
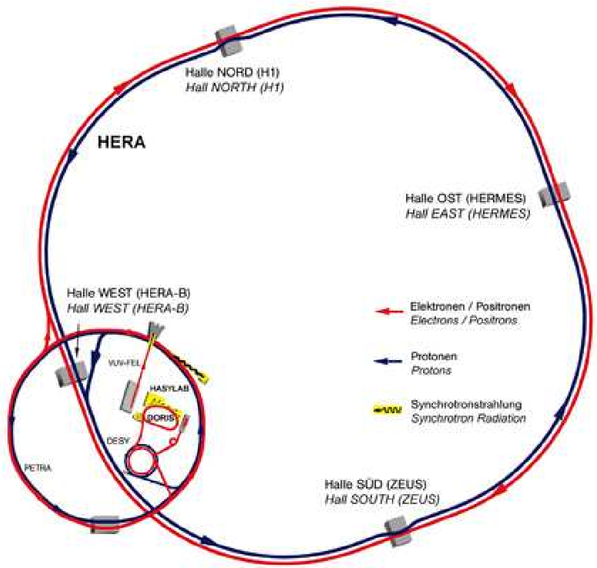
On behalf of the ZEUS collaboration

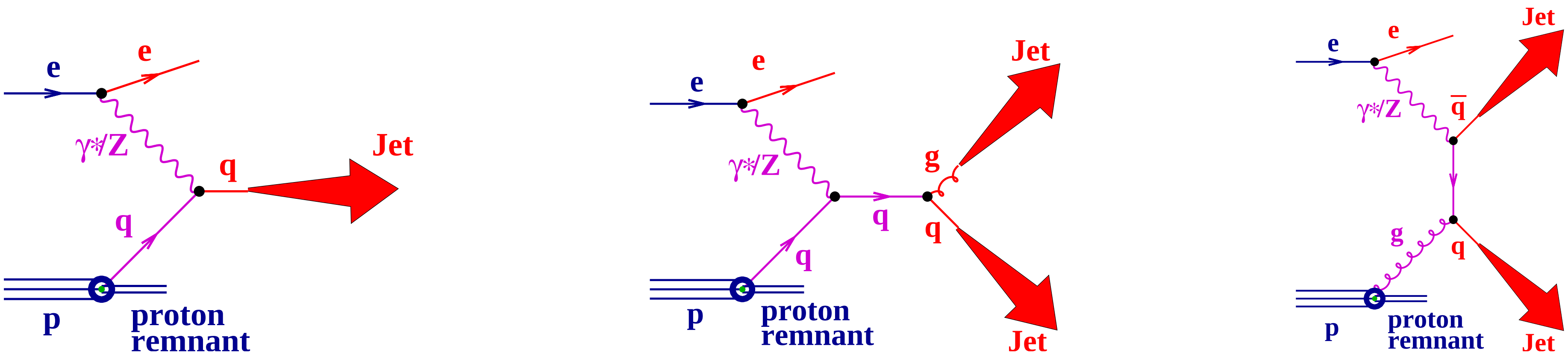




- $\longrightarrow$ **Introduction to NC DIS jet production**
- $\longrightarrow$ **NLO pQCD vs. measurements**
- $\longrightarrow$ **Determination of $\alpha_s(M_Z)$**

NC DIS cross section

- **Jet Production in NC DIS provides a testing ground for pQCD**
- **At $O(\alpha_s)$, these are the diagrams that contribute to the jet production cross section in DIS ($Q^2 \gg \Lambda^2_{QCD}$):**

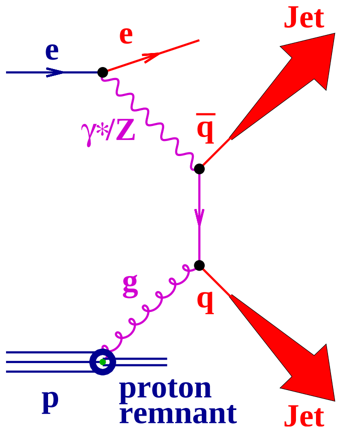


- **The cross section is given by:**

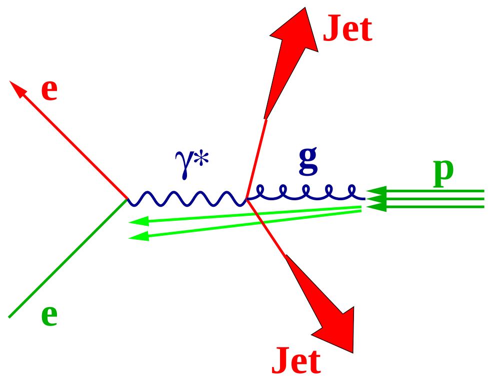
$$d\sigma_{\text{jet}} = \sum_{a=q,\bar{q},g} \int dx \; f_a(x,\mu_F) d\hat{\sigma}_a(x, \alpha_s(\mu_R), \mu_R, \mu_F)$$

- f_a **are the experimentally determined parton distribution functions**
  $\longrightarrow$ **proton structure (long-distance structure of interaction)**
- $d\hat{\sigma}_a$ **is the subprocess cross section, calculable in pQCD**
  $\longrightarrow$ **hard process (short-distance structure of interaction)**

- **The Breit frame is the natural frame to measure NC DIS jet cross sections.**
  - $\longrightarrow$ defined as that in which: $2x_{Bj}\vec{p} + \vec{q} = 0$
  - $\longrightarrow$ suppression of the Born contribution **(struck quark has zero E_T)**
  - $\longrightarrow$ suppression of beam remnant jet **(zero E_T)**
  - $\longrightarrow$ lowest order non-trivial contributions from $\gamma^* g \longrightarrow q\bar{q}$ and $\gamma^* g \longrightarrow qg$



BREIT $\longrightarrow$

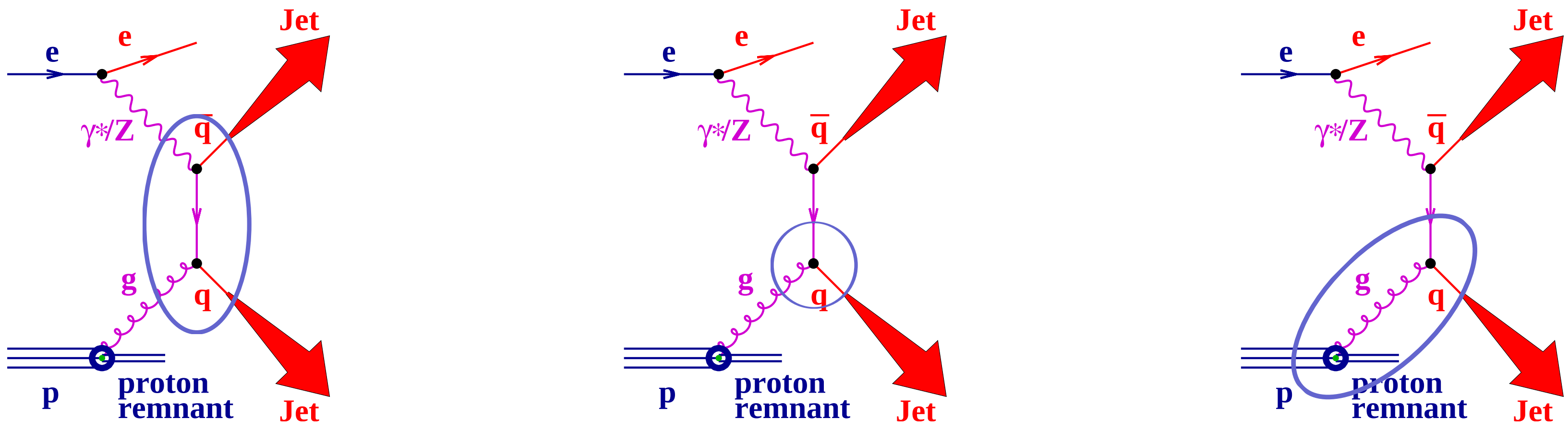


- **Jets are reconstructed in the Breit frame using a kt-cluster algorithm**
  - $\longrightarrow$ invariant under longitudinal boosts
  - $\longrightarrow$ infrared and collinear safe

$$d_{ij} = min(E_T^i, E_T^j)^2 \cdot (\Delta\eta_{ij}^2 + \Delta\phi_{ij}^2)$$

Motivation for NC DIS inclusive jet measurements

- **Jet production in NC DIS provides a testing ground for QCD**
  - $\longrightarrow$ **detailed studies of parton dynamics**
  - $\longrightarrow$ **precise determination of $\alpha_s(M_Z)$ and its scale dependence**
  - $\longrightarrow$ **constrain proton PDFs**

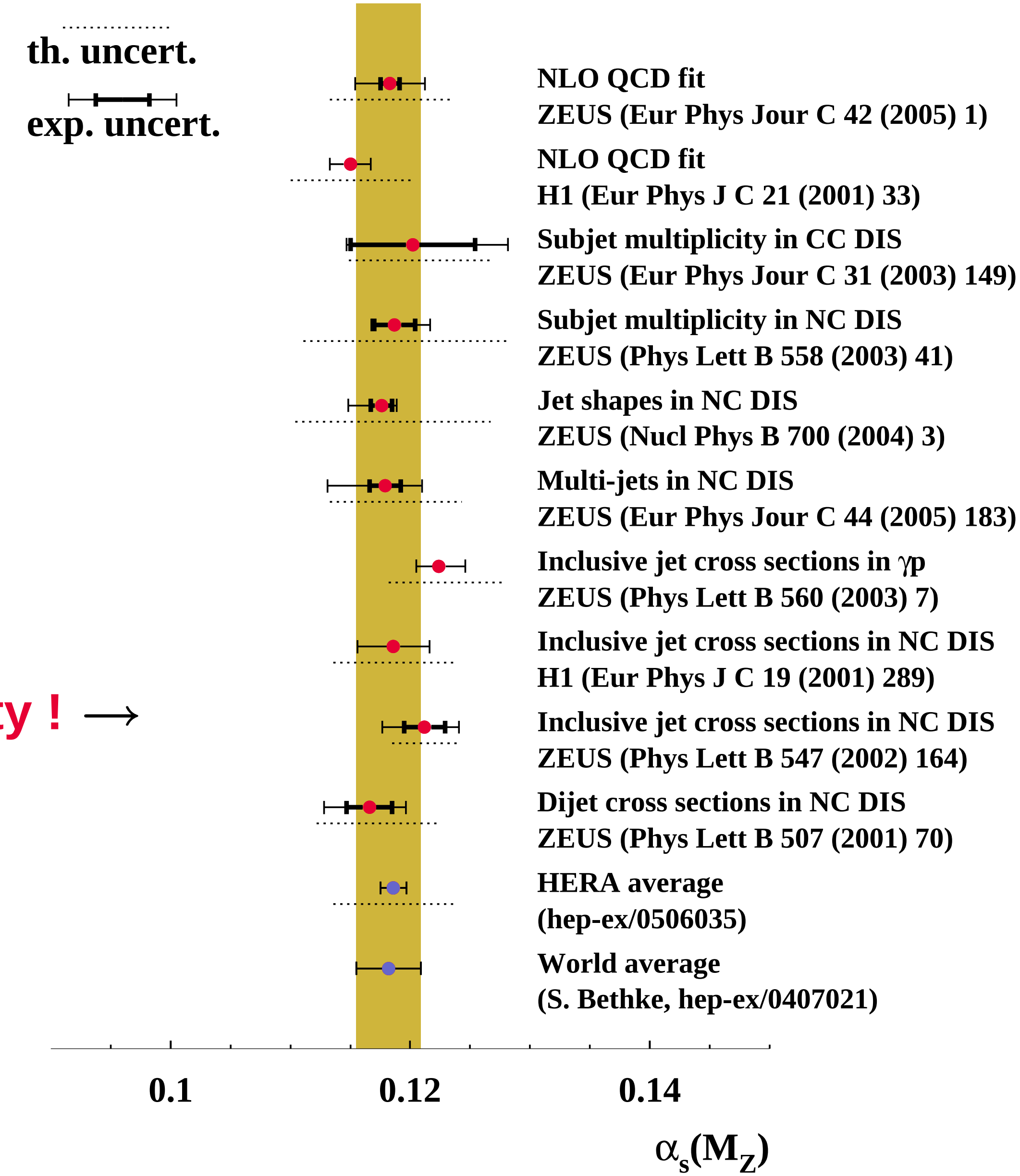


- **Previous $\alpha_s(M_Z)$ extractions at ZEUS have been carried through using:**
  - $\longrightarrow$ **jet substructure in NC and CC DIS**
  - $\longrightarrow$ **simultaneous fits of PDFs and α_s**
  - $\longrightarrow$ **jet cross sections in NC DIS and photoproduction**

Measured values of $\alpha_s(M_Z)$ at HERA

- Measurements compatible among themselves
- Compatible with world average

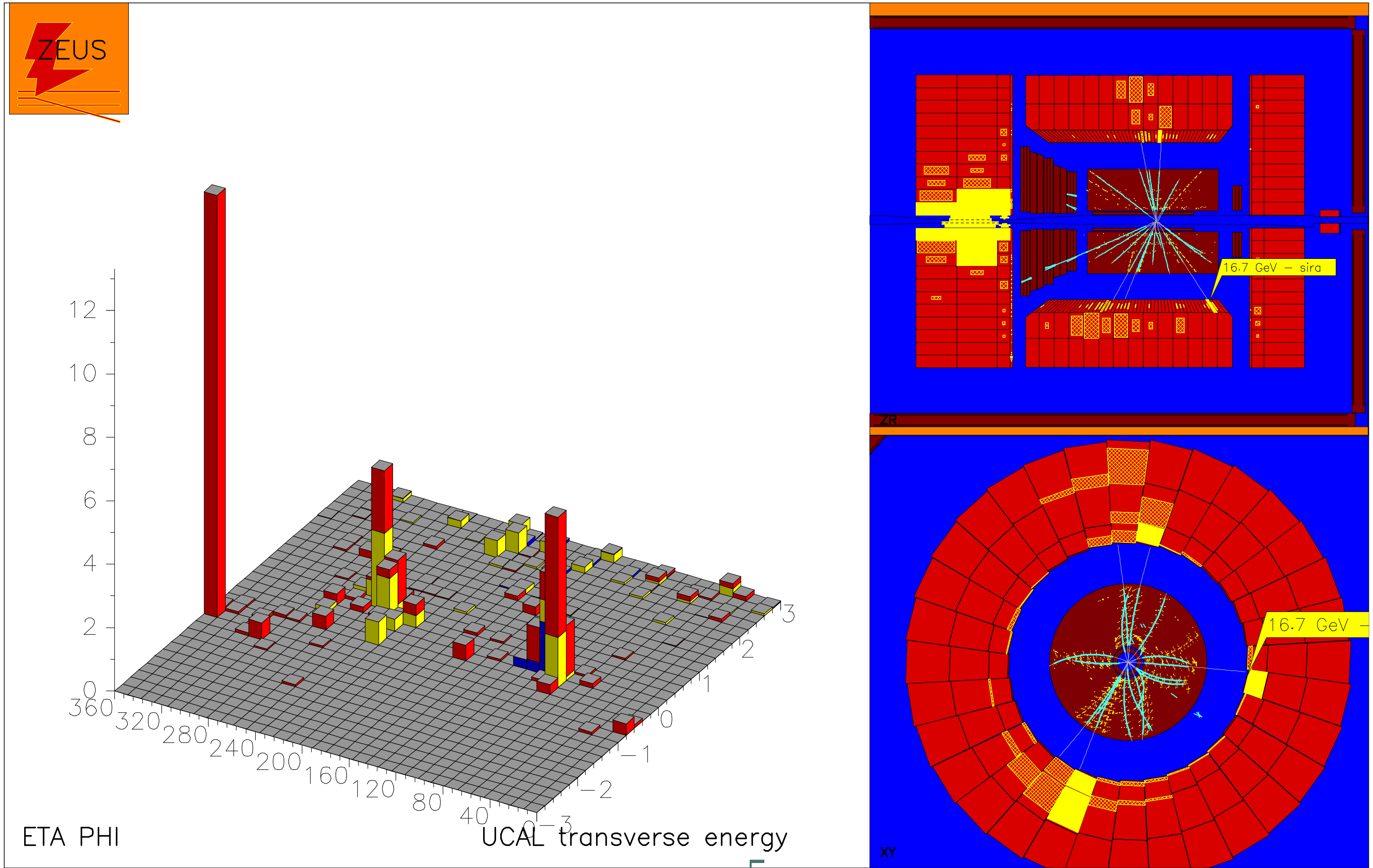
Inclusive jets yield smallest theoretical uncertainty ! →



NC DIS data sample

- **Data from ZEUS 98-00 ($L = 81.7\ pb^{-1}$)**

→ **kinematic region:**
- $Q^2 > 125$ GeV^2
- $E_{T,B}^{jet} > 8$ GeV
- $-2 < \eta_B^{jet} < 1.5$
- $-0.65 < cos\gamma_h < 0.65$



- **Differential cross sections were calculated at $O(\alpha_s^2)$ using DISENT**

$$d\sigma_{\rm jet} = \sum_{a=q,\bar{q},g} \int dx\, f_a(x,\mu_F) d\hat{\sigma}_a(x,\alpha_s(\mu_R),\mu_R,\mu_F)$$

$\longrightarrow$ **pPDFs: MRST99 set**

$\longrightarrow$ **α_s was calculated at two loops with $\alpha_s(M_Z)$=0.1175**

$\longrightarrow$ **renormalisation scale $\mu_R = E_{T,B}^{jet}$ of each jet (or, alternatively, Q)**

$\longrightarrow$ **factorisation scale $\mu_F = Q$**

- **Contributions to the theoretical uncertainty have been considered as coming from:**

$\longrightarrow$ **terms beyond NLO: variation of μ_R by factors 2 and 1/2**

$\longrightarrow$ **uncertainty due to $\alpha_s(M_Z)$: 0.1182 ± 0.0027 (world average)**

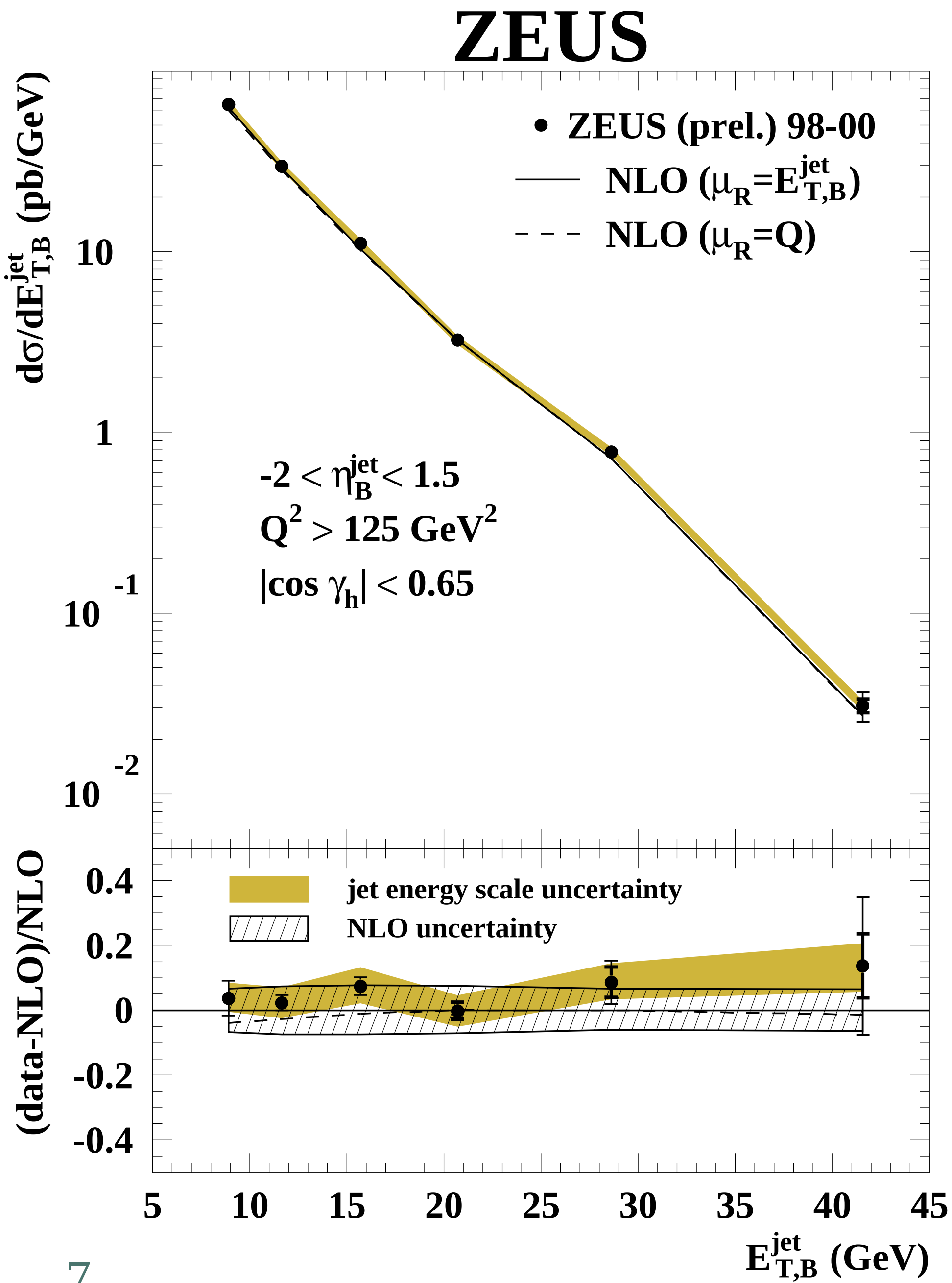
$\longrightarrow$ **proton PDFs: using the 40 sets of CTEQ6**

- Measured $d\sigma/dE_{T,B}^{jet}$ vs. NLO predictions

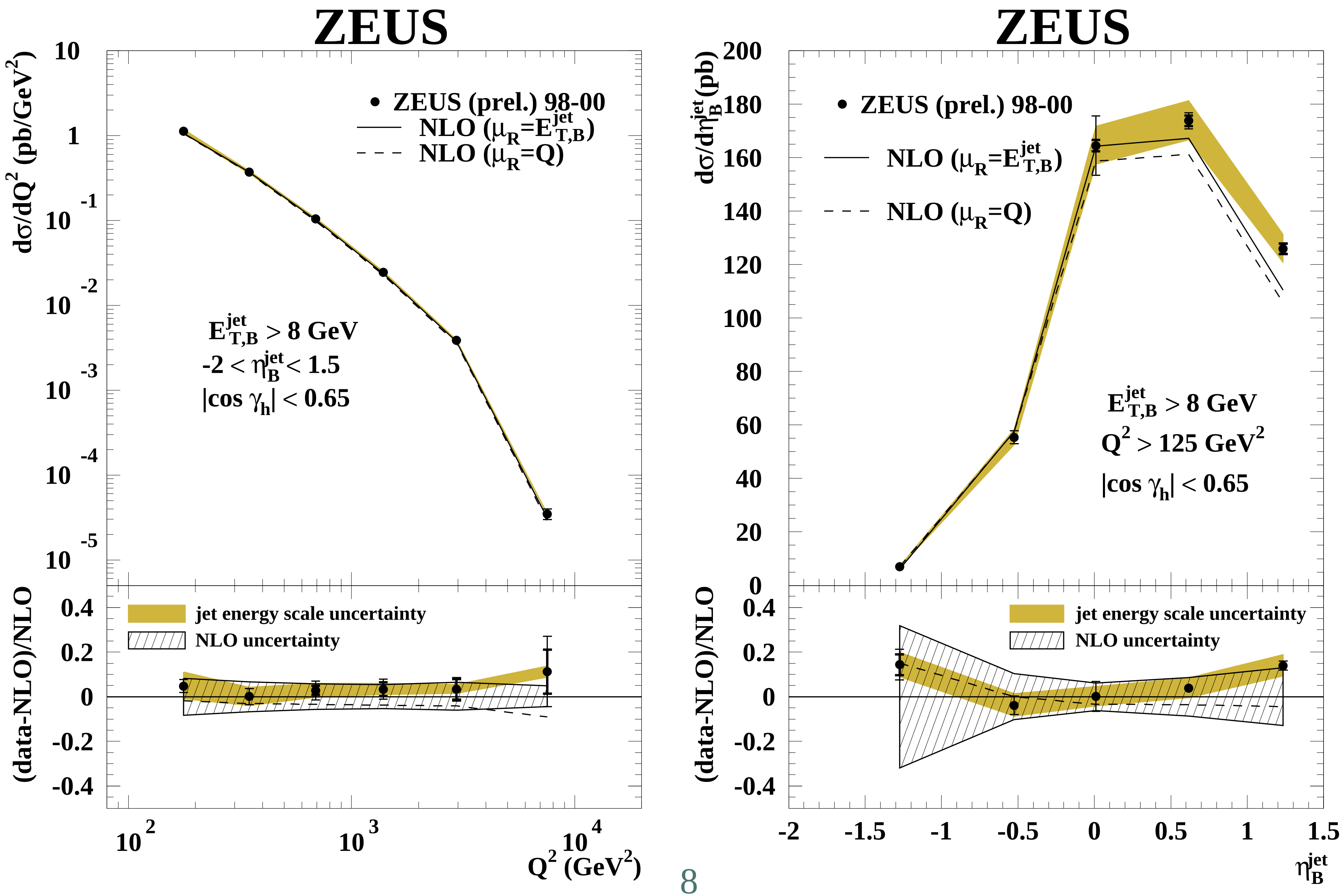
- Correction factors applied to:
  - $\longrightarrow$ DATA:QED and acceptance ($< 5\%$ and $< 10\%$)
  - $\longrightarrow$ NLO: Hadronisation and Z^0 ($< 10\%$ and $< 5\%$)

- Sources of theoretical uncertainty in NLO calculations due to:
  - $\longrightarrow$ that in the value of $\alpha_s(M_Z)$ ($\sim 4\ \%$)
  - $\longrightarrow$ that in the PDFs ($\sim 3\ \%$)
  - $\longrightarrow$ terms beyond NLO ($\sim 5\ \%$)

- Systematic uncertainty due to
  - $\longrightarrow$ jet energy scale ($\sim 5\ \%$)



- **Measured $d\sigma/dQ^2$ and $d\sigma/d\eta_B^{jet}$ vs. NLO predictions**

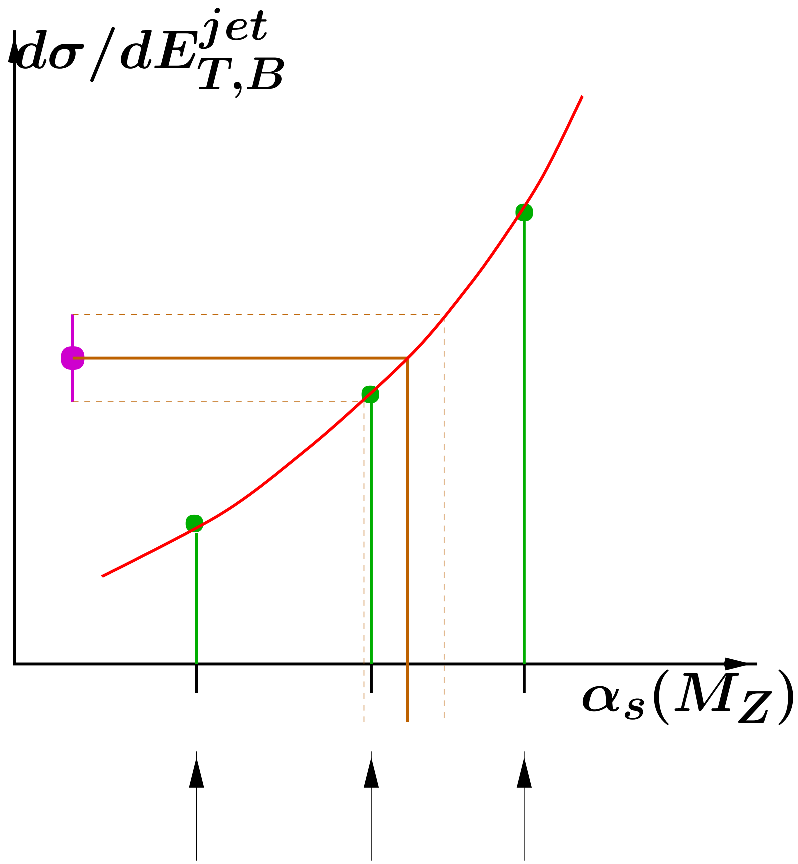


Method for the determination of $\alpha_s(M_Z)$

- **Three different values of α_s are assumed in the NLO calculations (also in the MRST99 fits)**

- **The dependence of the $d\sigma/dE_{T,B}^{jet}$ (or $d\sigma/dQ^2$) cross section on $\alpha_s(M_Z)$ is parametrized according to:**

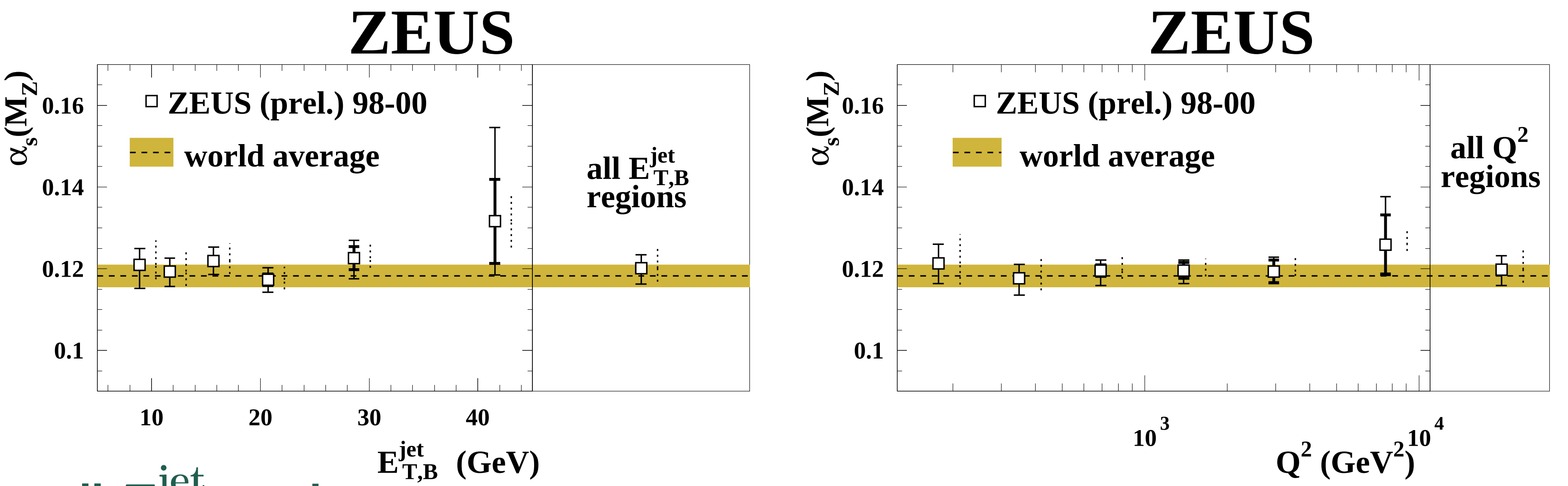
$$[d\sigma/dE_{T,B}^{jet}(\alpha_s(M_Z))] = A_1^i \alpha_s(M_Z) + A_2^i \alpha_s^2(M_Z)$$



(down) (central) (up)

NLO calculations (with 3 MRST99 sets)

- Values of $\alpha_s(M_Z)$ have been determined from the measured $d\sigma/dE_{T,B}^{jet}$ and $d\sigma/dQ^2$ cross sections:



- for all $E_{T,B}^{\rm jet}$ regions

  $\rightarrow \alpha_s(M_Z)$ = **0.1201 $\pm$ 0.0006**$(stat.)^{+0.0033}_{-0.0038}(exp.)^{+0.0049}_{-0.0032}$**(th.)**

- for all Q^2 regions

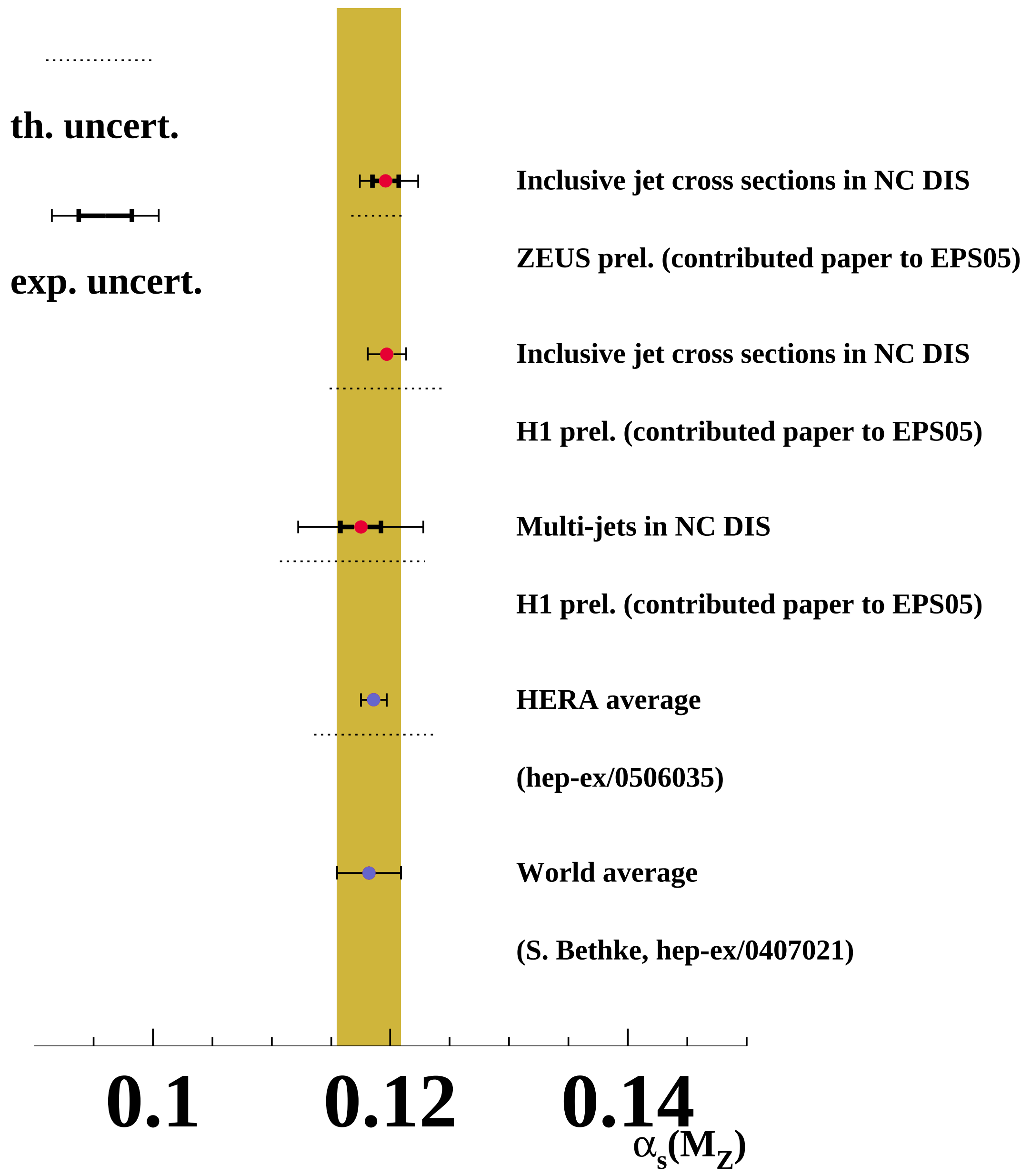
  $\rightarrow \alpha_s(M_Z)$ = **0.1198 $\pm$ 0.0006**$(stat.)^{+0.0034}_{-0.0039}(exp.)^{+0.0049}_{-0.0033}$**(th.)**

- for $Q^2 > 500$ GeV^2 (smallest uncertainties):

  $\rightarrow \alpha_s(M_Z)$ = **0.1196 $\pm$ 0.0011**$(stat.)^{+0.0019}_{-0.0025}(exp.)^{+0.0029}_{-0.0017}$**(th.)**

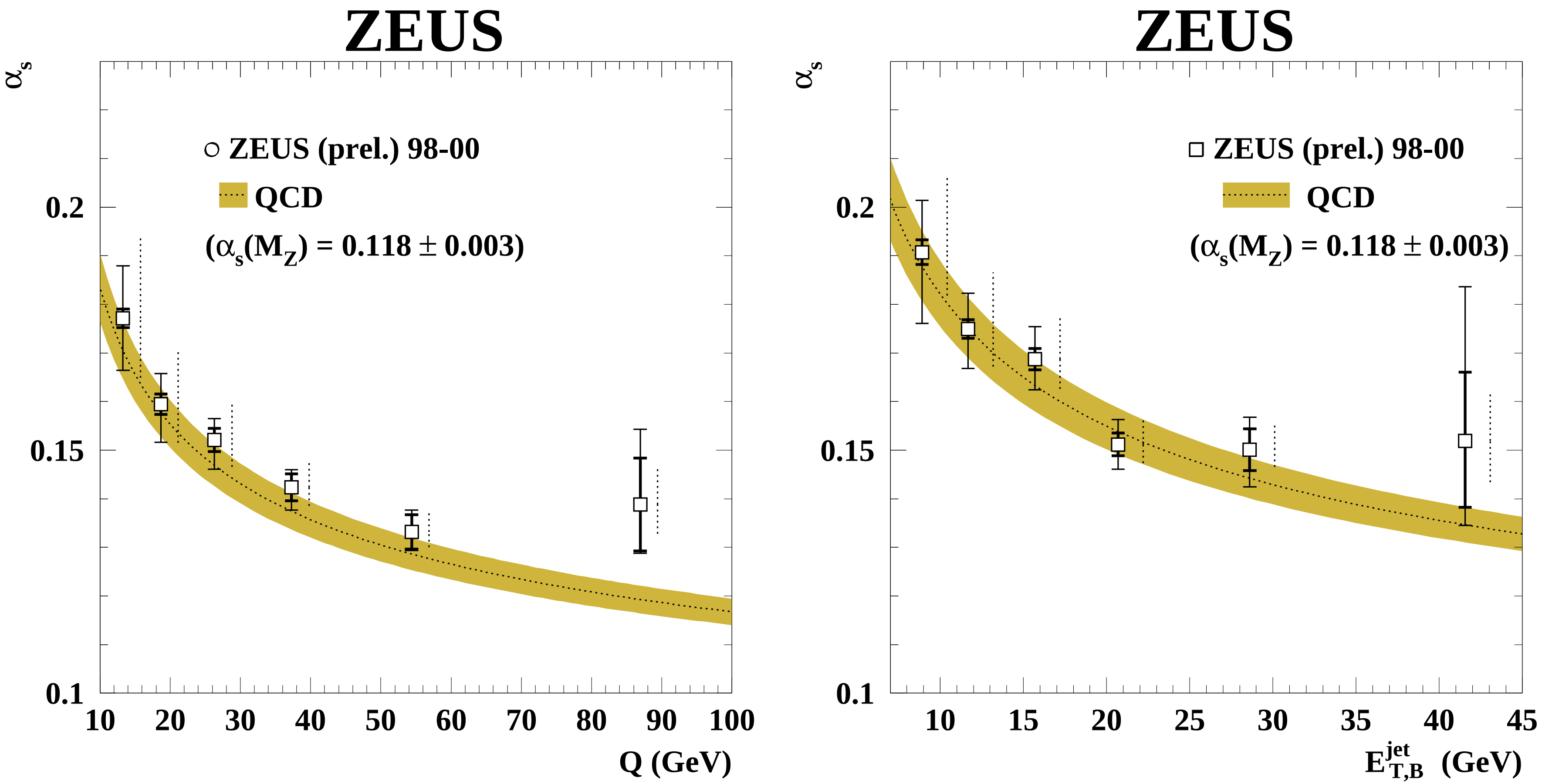
Measurements of $\alpha_s(M_Z)$

current measurement⟶



Determination of energy-scale dependence

- The measured $d\sigma/dE_{T,B}^{jet}$ and $d\sigma/dQ^2$ have been used to test the energy-scale dependence of α_s:



→ The measured energy-scale dependence of α_s is in agreement with the QCD prediction over a large range in $E_{T,\mathrm{B}}^{\mathrm{jet}}$ and Q

- **Measurements of $d\sigma/dE_{T,\mathrm{B}}^{\mathrm{jet}}$, $d\sigma/dQ^2$, and $d\sigma/d\eta_B^{jet}$ have been made using 98-00 ZEUS data ($L = 81.7\ pb^{-1}$):**

  $\longrightarrow$ The results are well described by the pQCD NLO calculations

- **Values of $\alpha_s(M_Z)$ have been extracted from $d\sigma/dE_{T,\mathrm{B}}^{\mathrm{jet}}$ and $d\sigma/dQ^2$**

  $\longrightarrow$ they are in agreement with each other, with previous HERA determinations and with the world average

  $\longrightarrow$ a value with very high precision has been obtained:

$$\alpha_s(M_Z) = 0.1196 \pm 0.0011(stat.)^{+0.0019}_{-0.0025}(exp.)^{+0.0029}_{-0.0017}(\mathrm{th.})$$

- **The energy-scale dependence of α_s has been measured as a function of $E_{T,\mathrm{B}}^{\mathrm{jet}}$ and Q:**

  $\longrightarrow$ in agreement with the running of α_s as predicted by QCD