QCD Tests with Jets

at the LHeC

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HELMHOLTZ GEMEINSCHAFT

PHYSICS AT THE TERA SCALE
Helmholtz Alliance

DESY

CALCULATIONS AND SELECTION

- Calculations performed with DISENT using
  - CTEQ6.1 PDFs
  - $\mu_R = \mu_F = Q$.
- Corrections: Predictions were correct for Z^0 exchange and hadronisation (so plots at “hadron level”).
  - LEPTO LO ME+PS MC
- Inclusive Phase space:
  - $100 < Q^2 < 500.000\ \text{GeV}^2$
  - $0.1 < y < 0.7$ (reasonable?)
- Jets: inclusive k_T algorithm in the Breit frame
  - $-2 < \eta_{lab} < 3$ (reasonable?)
  - Inclusive jets: $E_T > 20$ GeV
  - Dijets: slightly asymmetric cut: $E_{T1(2)} > 25(20)$ GeV

UNCERTAINTIES

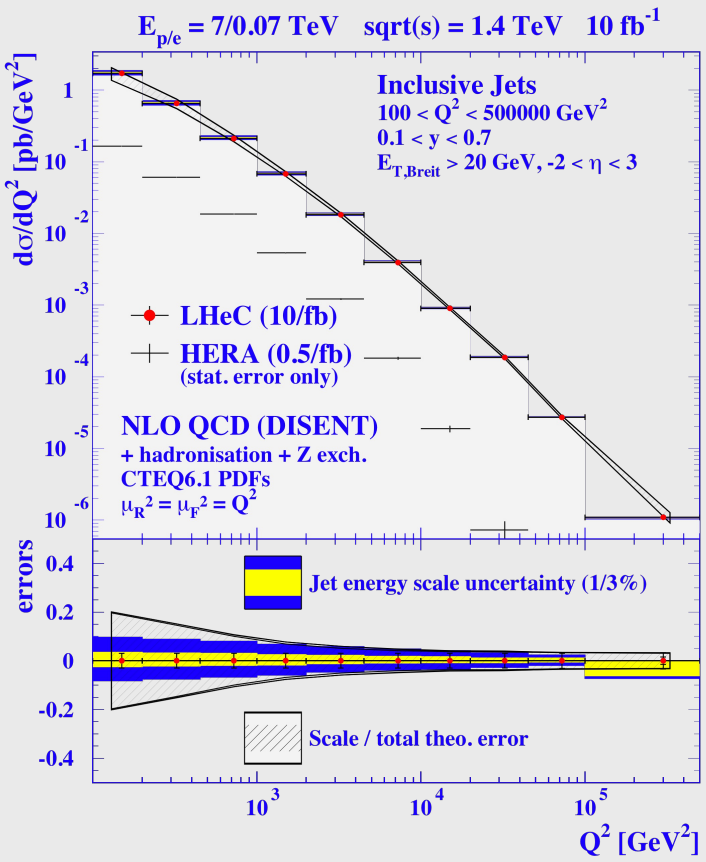
- Scale uncertainty: μ_R varied by factor 2 up and down → dominant!
- PDF uncertainty: evaluated using 40 error sets from CTEQ6.1
- α_S: evaluated using CTEQ6AB and scaling to world average error (0.001 from Bethke).

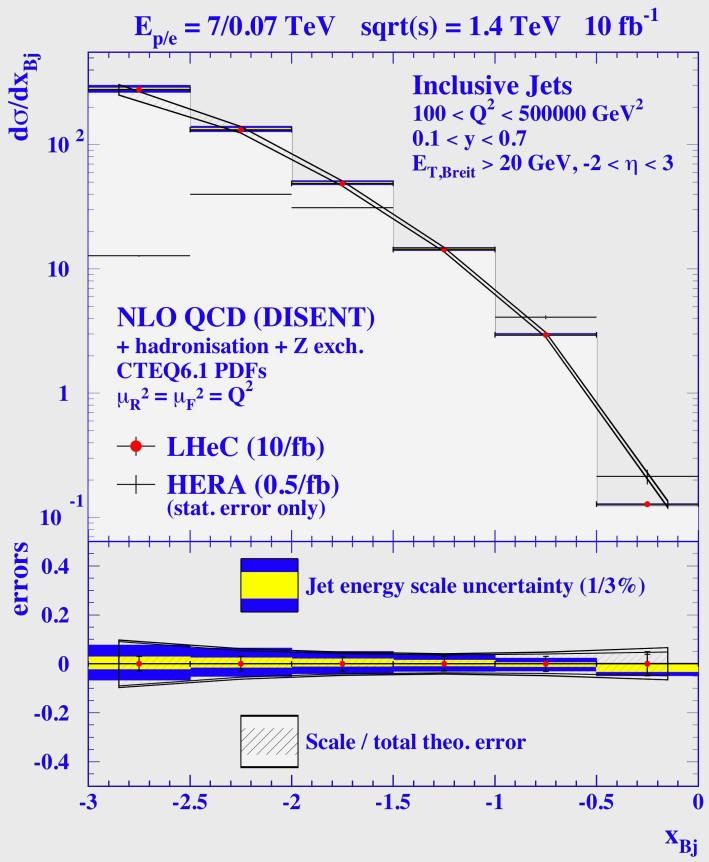
- Statistical uncertainty: assuming 10 fb^{-1}. Can mostly be neglected.
- Systematics:
  - Jet energy scale, indicated as coloured bands (plus/minus 1 and 3%) → dominant experimental uncertainty.
  - Model uncertainty: 3% throughout (→ not very realistic?).

CAVEATS

- "Small" statistics (well, 100M events for both inclusive-jet and dijet distributions) in some areas of phase space
  → "bad" behaviour of scale and other uncertainties in some bins
  → will be cured in next iteration.
- Some areas with strange behaviour of theoretical uncertainties
  - Also statistics?
  - Something wrong? → cross checks are running. General picture should be okay.
  - Will cross-check also with other programs (NLOJET++)
- Problematic areas are indicated on the slides.
- For inclusive jet plots, also HERA prediction shown (NOT corrected for hadronisation and Z0 exchange)
  - Same selection, only change is CMS energy and $100 < Q^2 < 45.000\ \text{GeV}^2$.

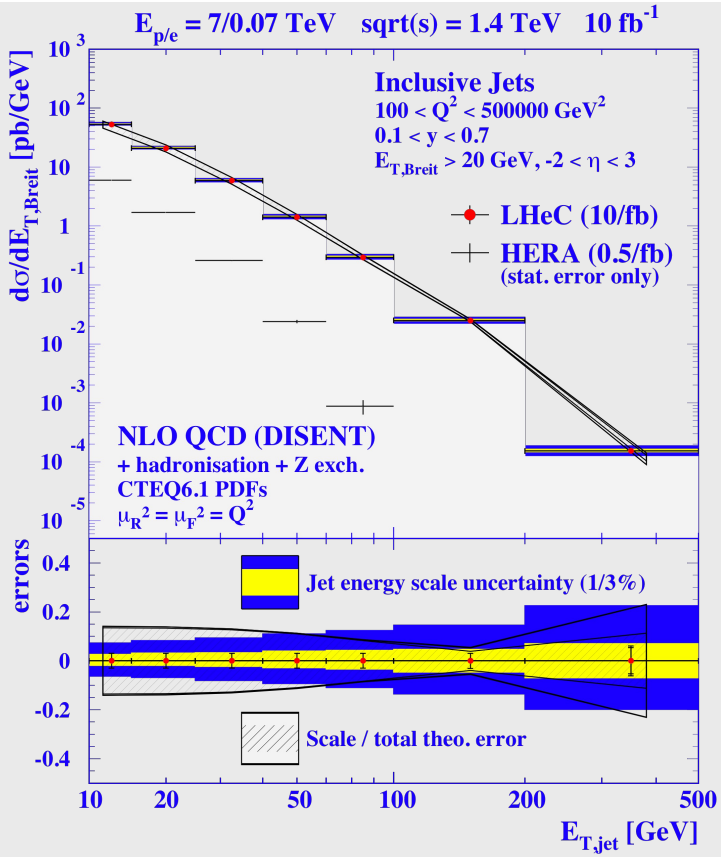
INCLUSIVE JETS: Q^2 AND x_{Bj}

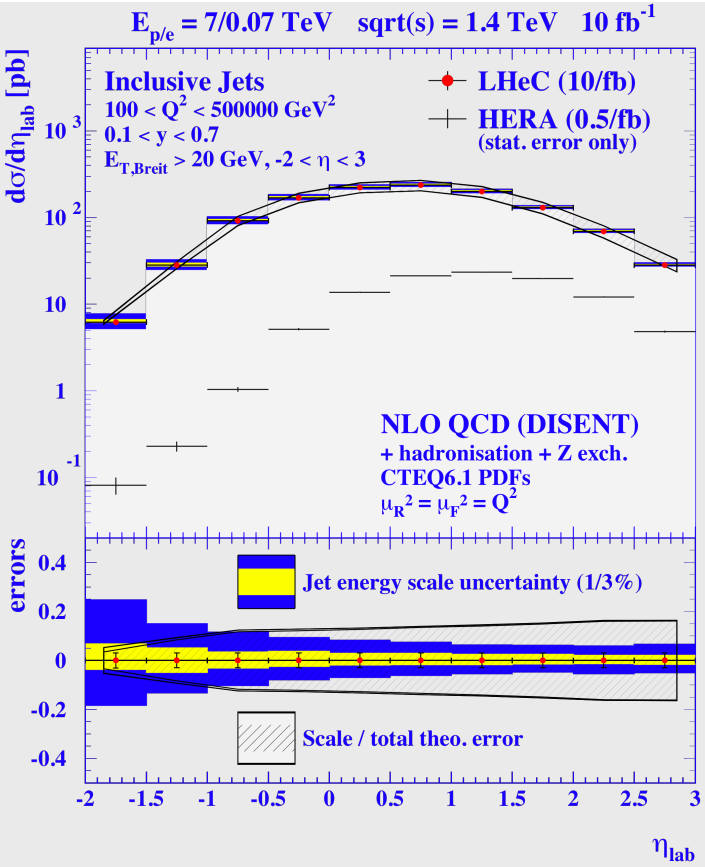




- Small Q^2 and x: scale error dominates; total exp. uncertainty 10%.
- Cross section 1-2 orders of magnitude larger than at HERA at same kinematic point.

INCLUSIVE JETS: $E_{T,Breit}$ AND η_{lab}

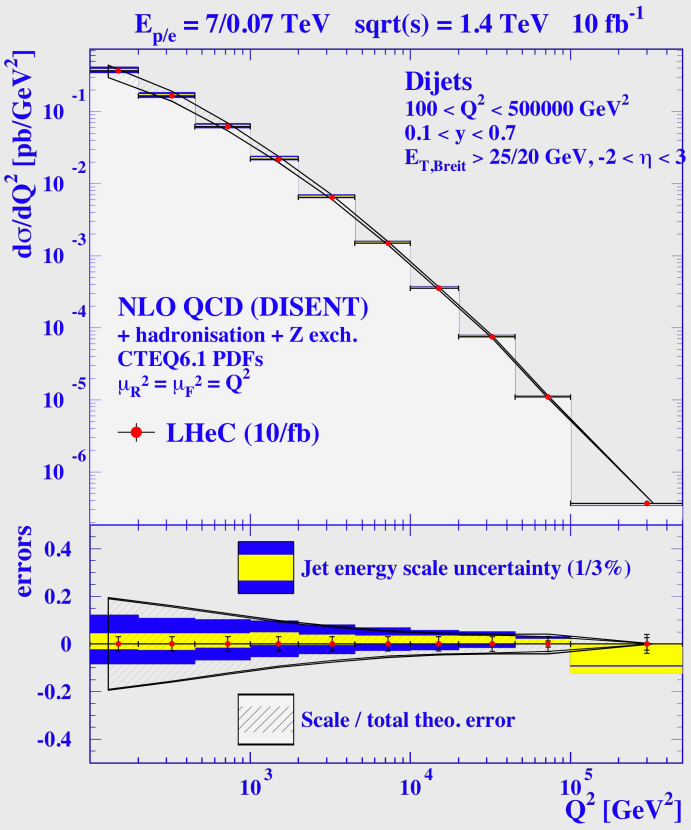


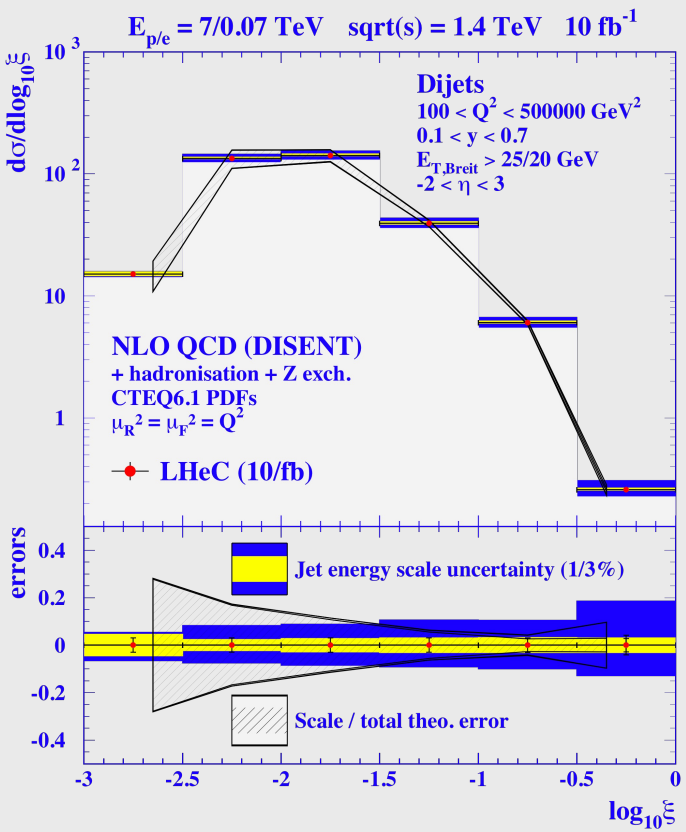


- Xsection much increased wrt HERA.
- Statistics too small at high E_T → strange theory error on E_T curve
- Why does scale error INCREASE with E_T?

DIJETS: Q^2 AND $\log_{10}\xi$

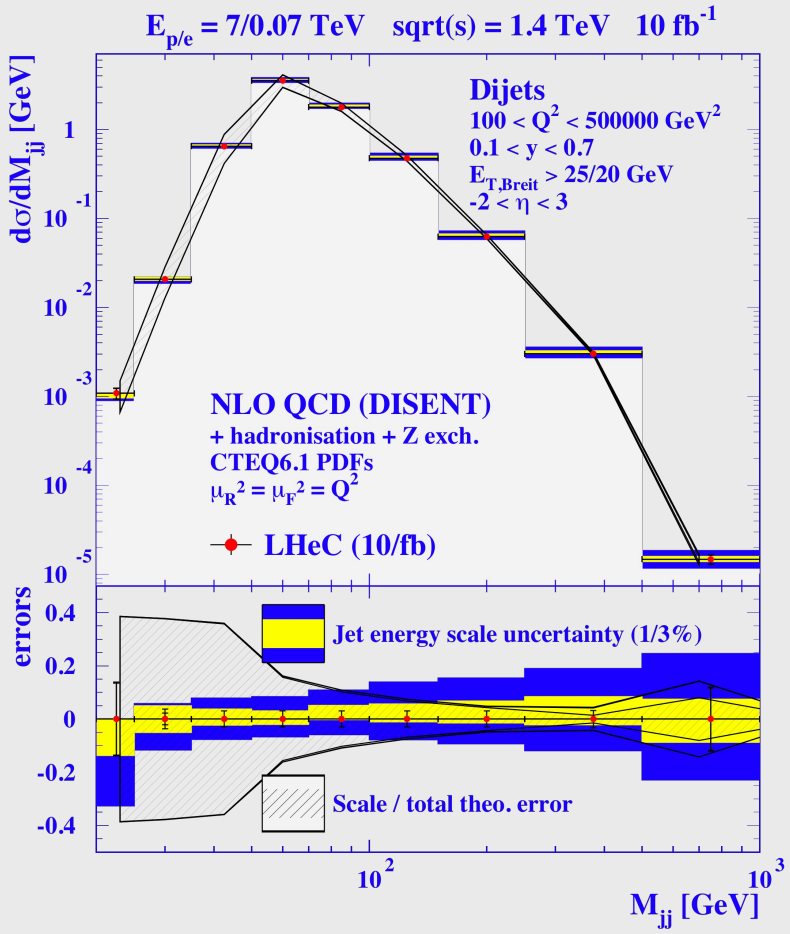
- Note: $\xi = x_{Bj}(1+M_{jj}^2/Q^2)$, directly related to x in PDF.

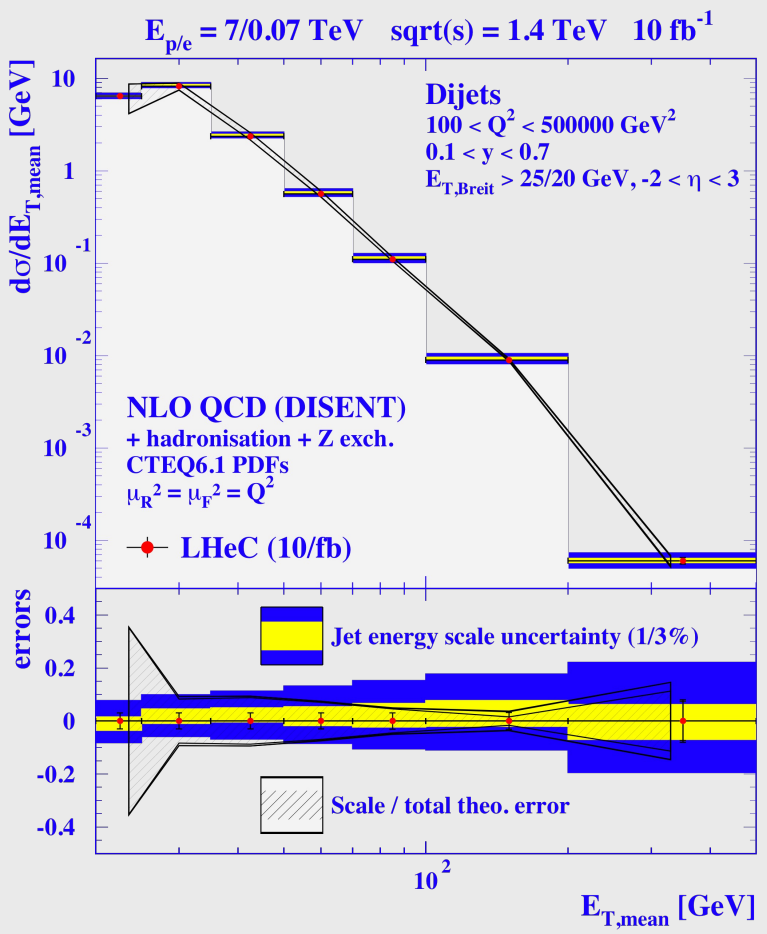




- Overall high precision even at highest Q^2!
- Sensitivity to PDFs at high values of ξ!

DIJETS: M_{jj} AND MEAN $E_{T,Breit}$

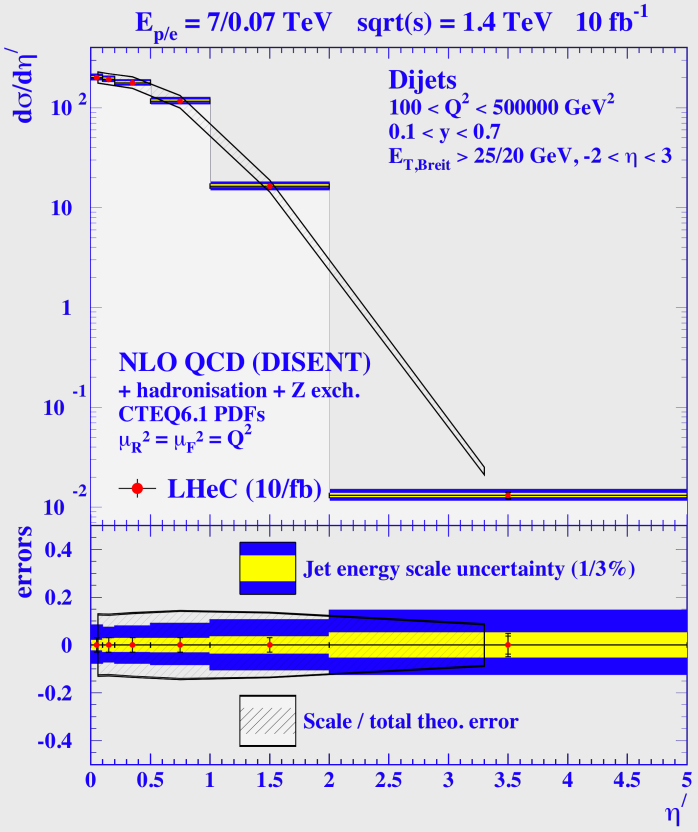




- Some statistics limitations in predictions at high scales! Sorry!
- Strange theory errors at small scales??? → Study in more detail.

DIJETS: $\eta' = 1/2 * |\eta_1 - \eta_2|$

- Sensitivity to QCD matrix element



- Relatively constant uncertainties.

SUMMARY AND OUTLOOK

- Inclusive-jet and dijet predictions for LHeC were studied, including some uncertainties.
  - Significant extension of phase space and statistics with respect to HERA ;-)
  - In many regions theoretically dominated by scale uncertainty → need NNLO!
  - Large potential for precise QCD tests at high scales!
  - So far no regions with specifically high sensitivity to PDFs observed. Theory error always dominated by scale (→ necessity of NNLO!).
- Next on the agenda:
  - Double-differential distributions (E_T and $\log_{10}\xi$ in bins of Q^2)
  - Cross-check DISENT predictions with NLOJET++.
  - Use MC programs to cross-check and compare to NLO.
  - Think about more realistic detector scenario (pseudorapidity, inclusive selection)
  - More realistic error estimates and discussion of potential for PDF fits.
  - Separate discussion of corrections (hadronisation, Z^0, …)
  - … and hopefully compare to NNLO in one year from now?