Dijet Events in Charged and Neutral Current DIS at High $\mathbf{Q^2}$

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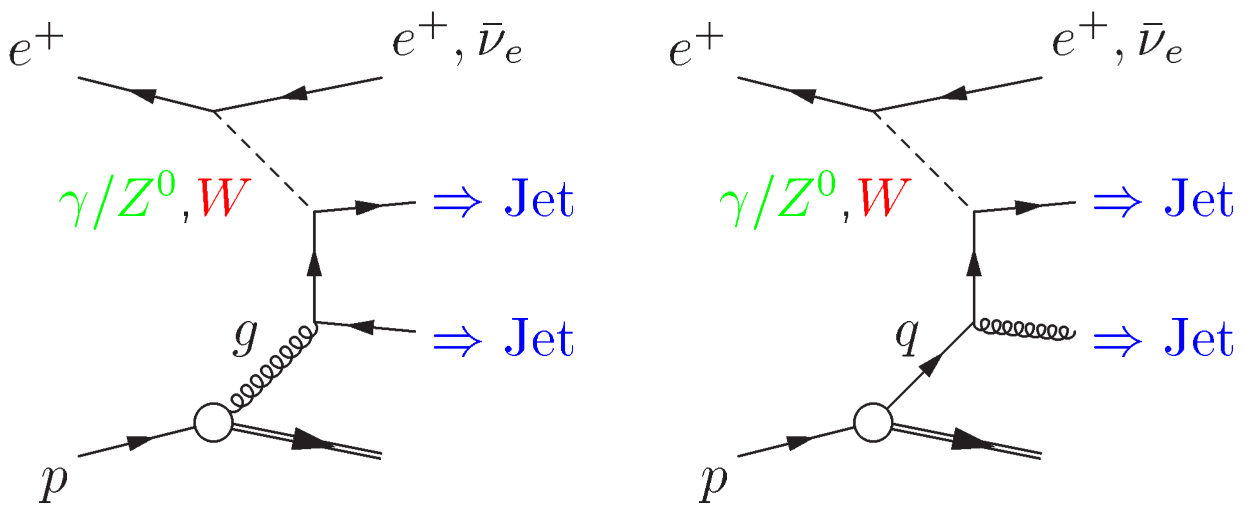


1. Differential NC Dijet cross sections at high Q^2
2. Comparison of dijet production in CC and NC events
3. NC Dijet events at $Q^2 > 10\,000$ GeV^2

Motivation

Existing:
Precise H1 and ZEUS measurements of inclusive and CC DIS X-sections up to $Q^2 \approx 35\ 000\ \mathrm{GeV}^2$

Less information on hadronic final state at very high Q^2

- No CC dijet distributions yet measured
- No NC jet distributions at $Q^2 > 5\ 000\ \mathrm{GeV}^2$
- No syst. comparison of CC and NC jet production

Can QCD describe jet production up to highest scales?

electroweak effects   Matrix elements

$$\sigma_{dijet}^{LO} \approx A(Q^2)\ \{q(\xi,Q^2)\,\sigma_{QCDC}(x_p,z_p,\phi) + g(\xi,Q^2)\,\sigma_{BGF}(x_p,z_p,\phi)\}$$

Parton densities

All contributions to dijet X-section strongly varying in kinematic ranges of following analyses

1. Differential NC dijet X-sections

Aim: Precision test of QCD at highest scales

- Data: ZEUS 1996-1997 e^+p with $\mathcal{L} \approx 38$ pb^{-1}
- Selected kinematic region:

$$\boxed{470 < Q^2 < 20\,000 \text{ GeV}^2 \quad 0 < y < 1}$$

- Jet finding in Breit frame
  $\longrightarrow$ long. boost invariant k_T algorithm
- Definition of dijet sample:
  Exactly 2 jets found fulfilling

$$\boxed{\begin{array}{c} E_T^{Jet1} > 8 \text{ GeV},\ E_T^{Jet2} > 5 \text{ GeV} \\ -1 < \eta_{Lab}^{Jet} < 2 \end{array}}$$

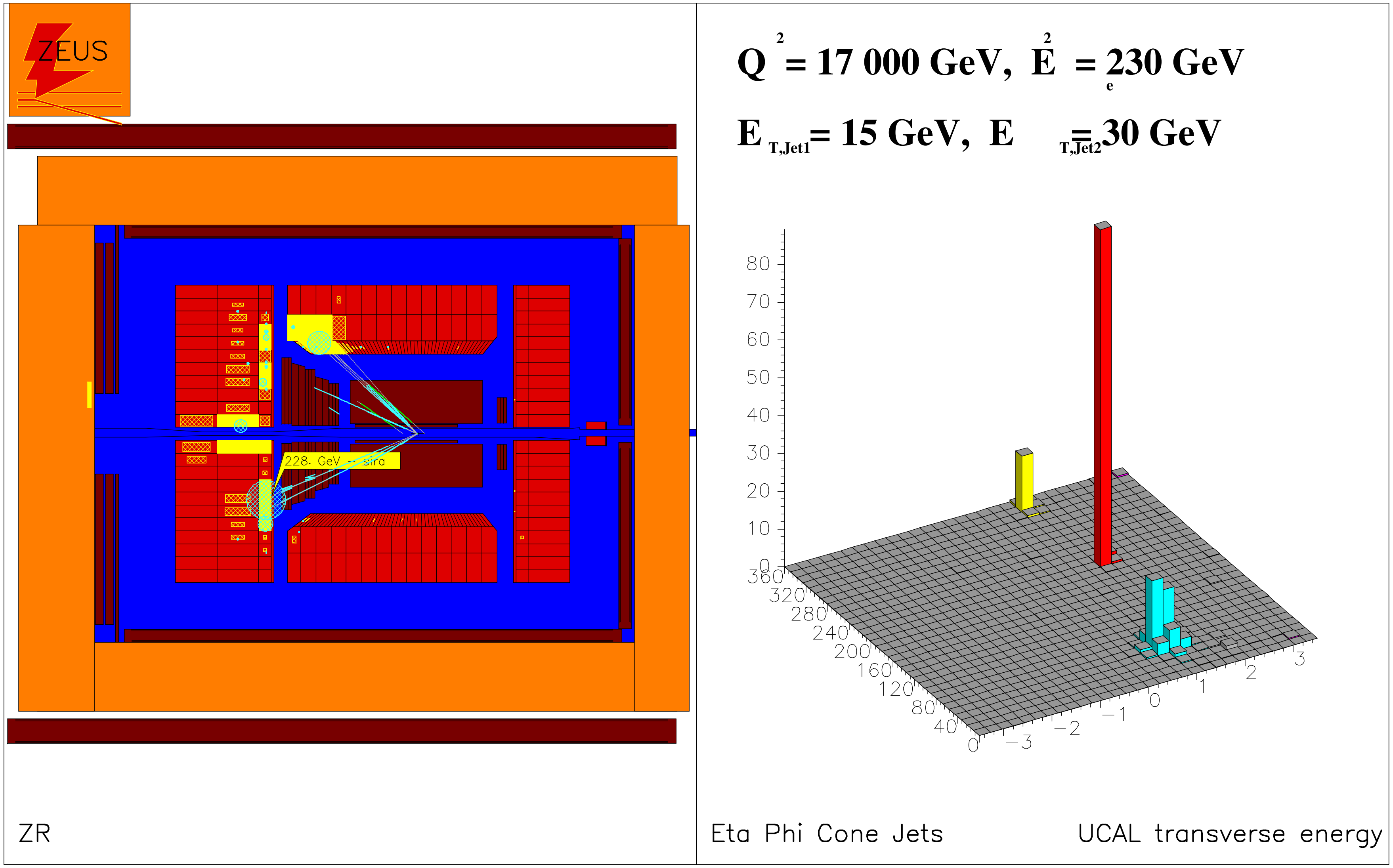
- Dijet X-sections as function of

  x, Q^2, inv. dijet mass M_{ij}

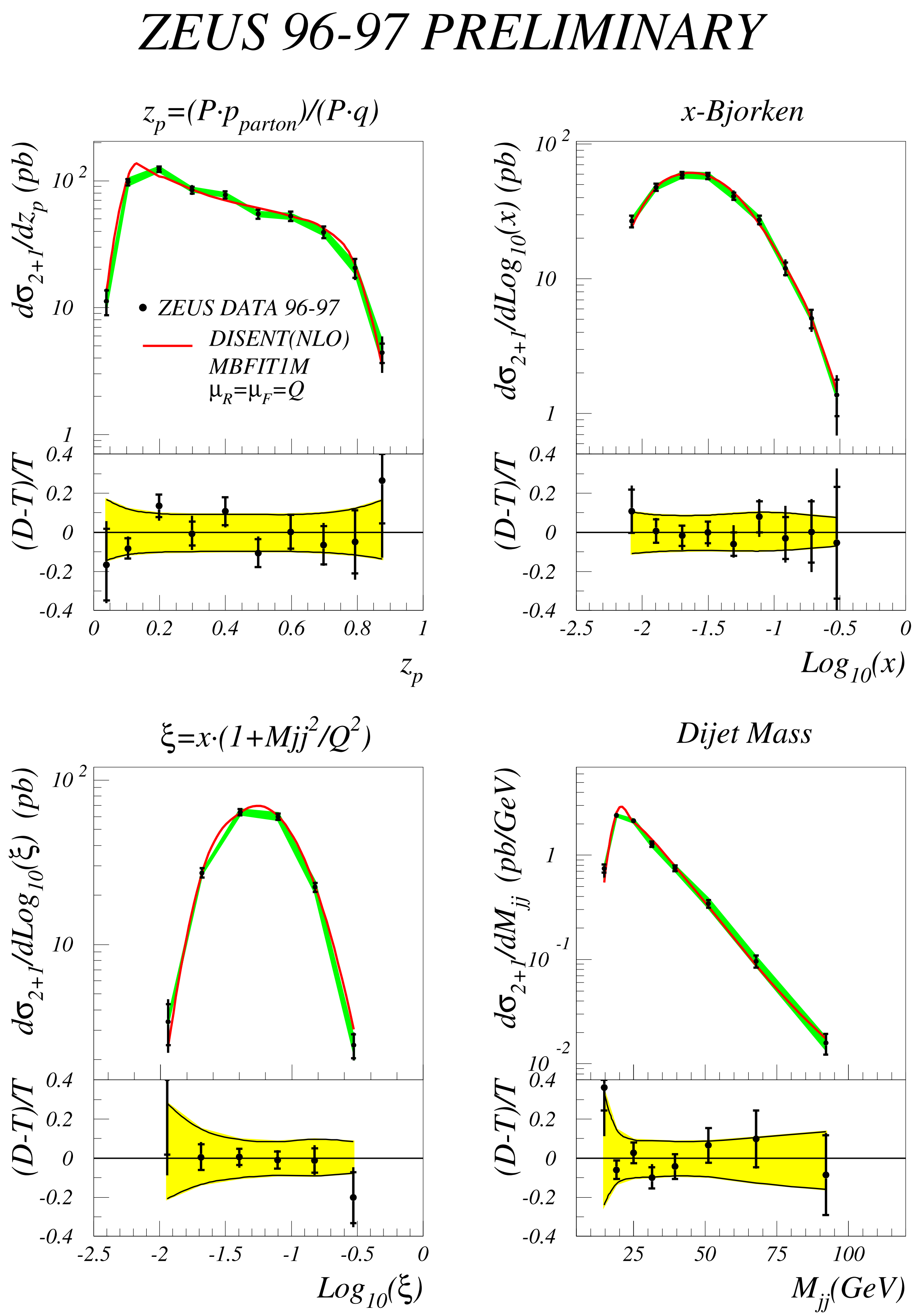
  $\xi = x \cdot (1 + \frac{M_{ij}^2}{Q^2}) = \frac{x}{x_p}$: Partons share of proton momentum

  $z_p(i) = \frac{p \cdot p_i}{p \cdot q} = \frac{E_i(1-\cos\theta_i)}{\sum_{k=1,2} E_k(1-\cos\theta_k)}$

ZEUS NC Dijet Event



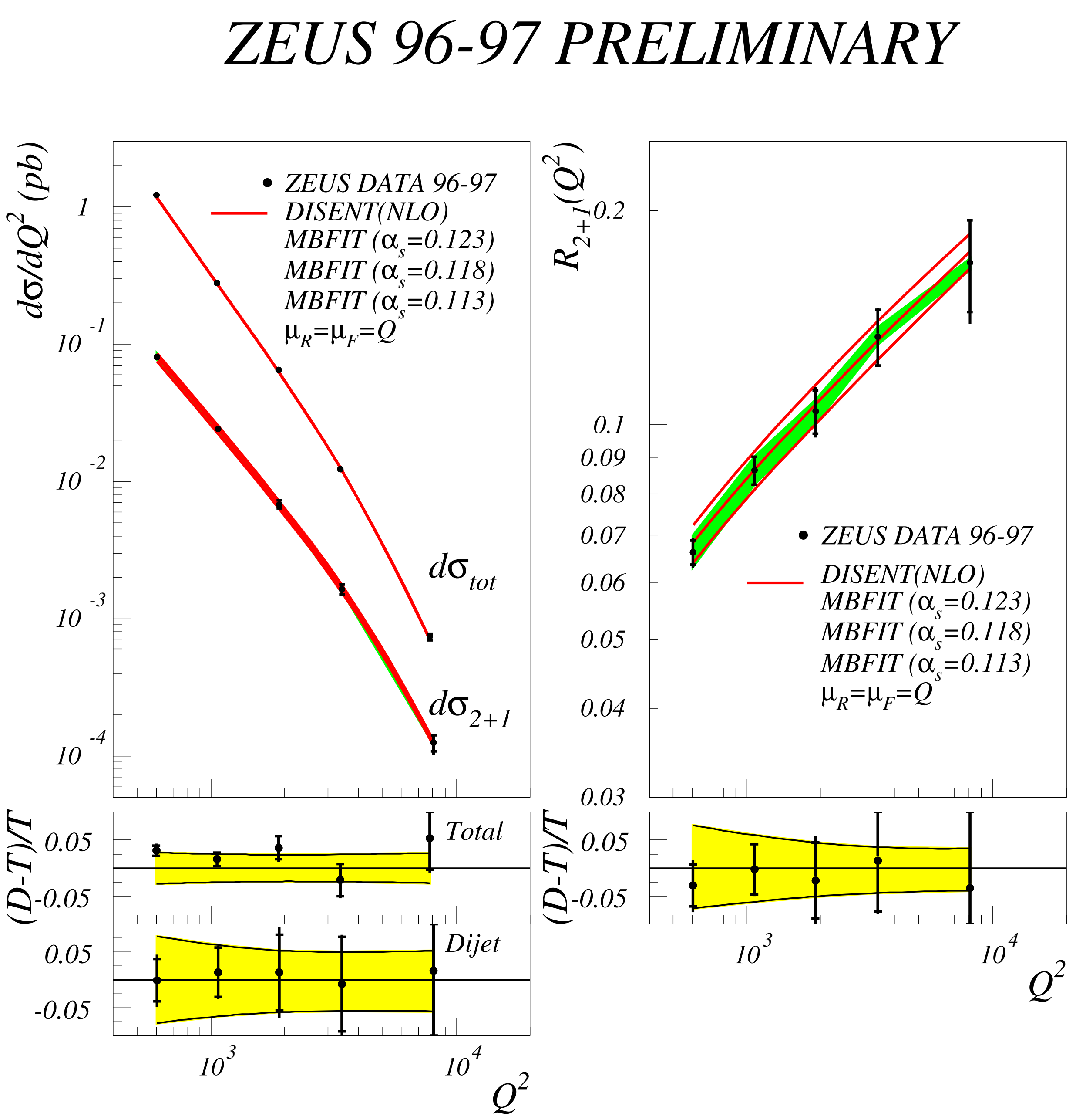
Differential NC dijet X-sections



- Good agreement between data and pQCD in NLO

- PDF uncertainties on NLO X-section treated properly

Differential NC dijet X-sections



- $\frac{d\sigma_2}{dQ^2}$ described by pQCD over 3 orders of magnitude
- Dijet rate strongly increasing with Q^2
- Precise measurement of $\alpha_s(Q^2)$ possible

2. Dijet Events in CC and NC DIS

First measurement of CC dijet distributions
Comparison between CC and NC jet production

Data: H1 1994-1997 $\mathbf{e^+p}$ with $\mathcal{L} \approx$36 pb^{-1}

- Main selection criterion CC:
  Observation of missing transverse momentum

$$P_T^h > 25\,\mathrm{GeV}$$

  Kinematic reconstruction from hadronic final state

- Main selection criterion NC:
  Identification of scattered positron with

$$P_T^e > 25\,\mathrm{GeV}$$

  Kinematic reconstruction from scattered Positron and/or HFS

- Further restriction of kinematic range: $0.03 < y < 0.85$

$\Longrightarrow$ Minimum $\mathbf{Q^2} \approx 640$ GeV^2

500 CC events | 8800-NC events

Jet Reconstruction

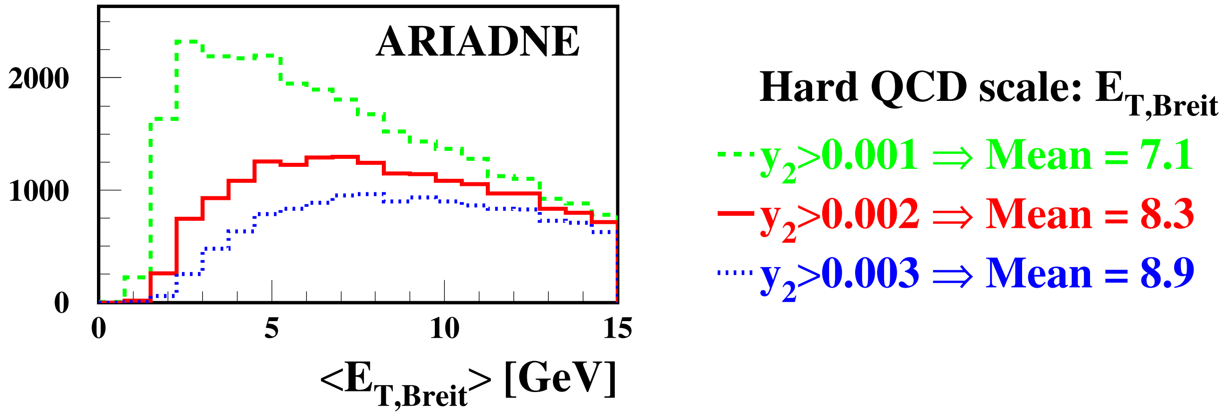
- Jet finding in laboratory frame
  $\longrightarrow$ **ep**-analogue to Durham algorithm:
  - ▷ distance measure: $k^2_{T,ij} \equiv 2 \cdot \min\,[E_i^2, E_j^2](1 - \cos\theta_{ij})$
  - ▷ pseudo-particle to account for proton remnant

- Iterate clustering until (2+1) jets remain

- Measure of jet-jet separation:
  $y_2 \equiv \min k_T^2/W^2$ of all 3 pairs of the (2+1) Jets

  $\Longrightarrow$ Selection of enriched dijet sample: $y_2 \; > \; 0.002$

- Interpretation of y_2 cut in Breit frame:

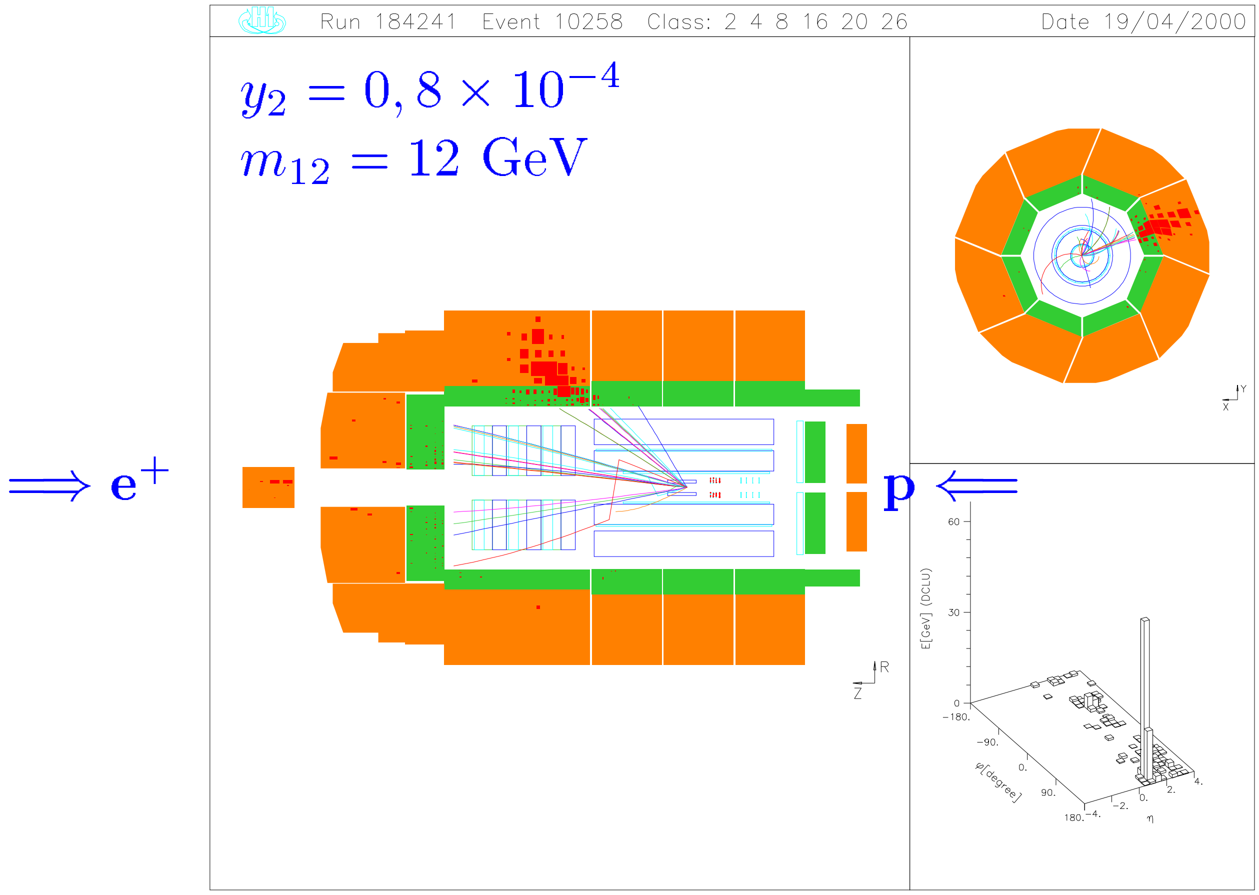


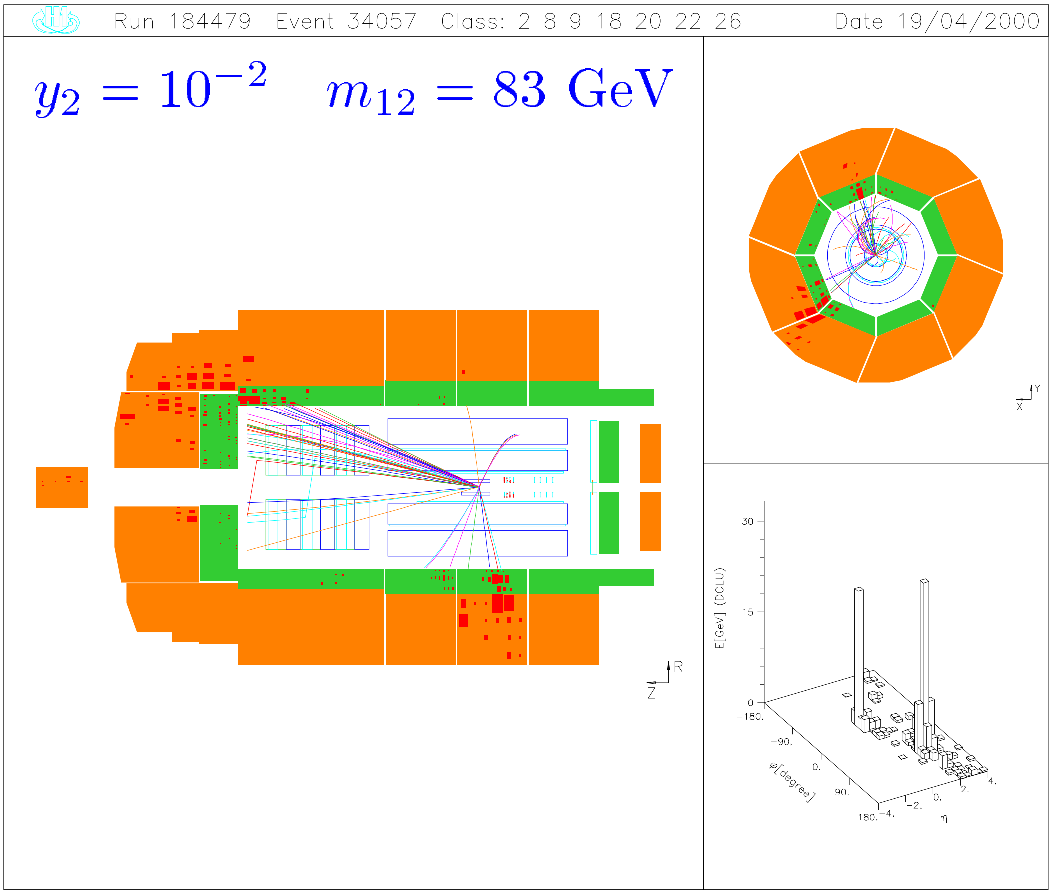
- No harder cut due to limited CC statistics!

- Cut on jet polar angle: $10^\circ < \Theta_{Jet} < 140^\circ$

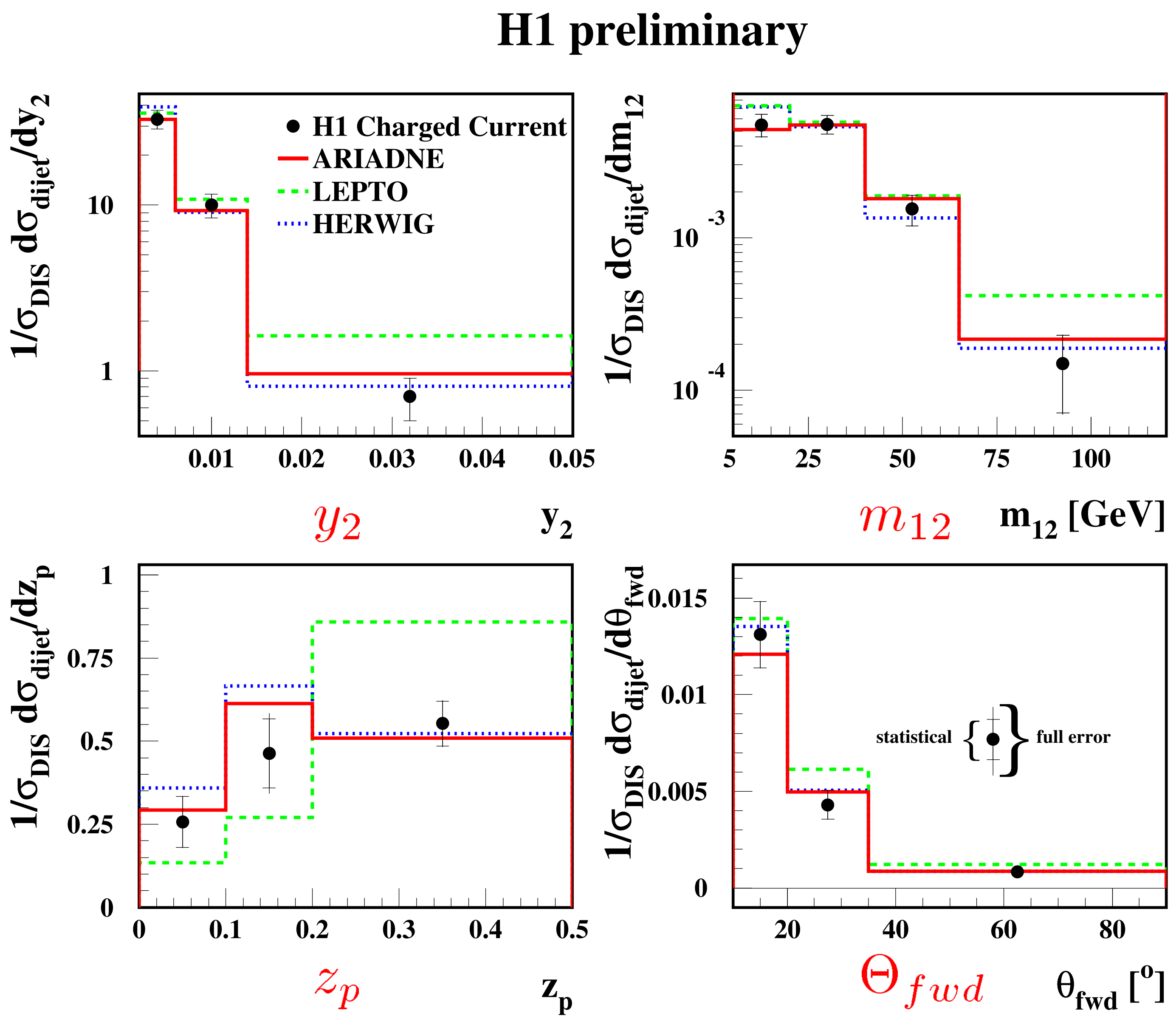
  $\Longrightarrow$ Dijet rate: $\approx$ 25% CC / $\approx$ 15% NC

Two H1 Charged Current Events





Data/MC Comparison: Charged Current



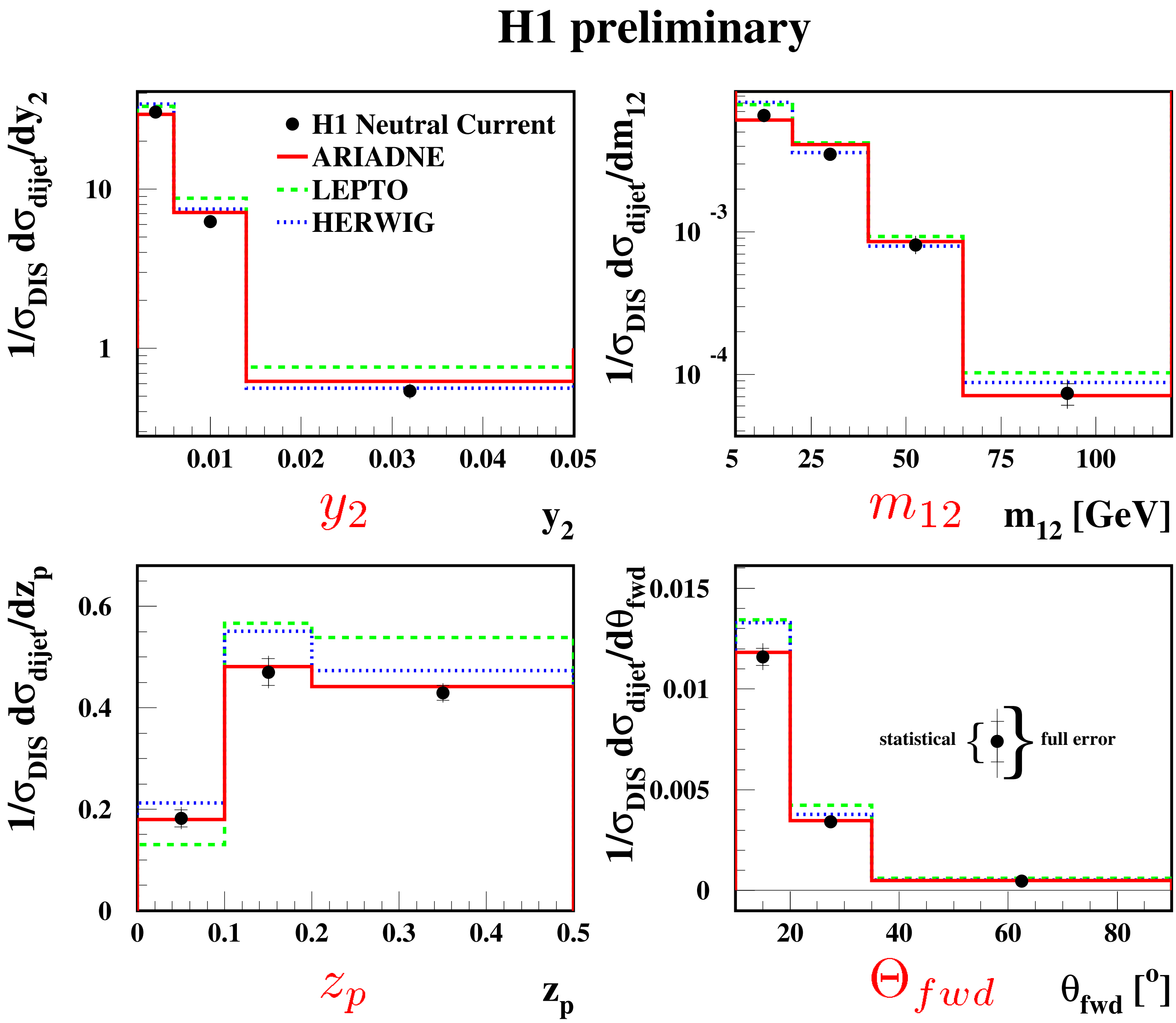
- Error dominated by statistics:

$$\langle \sigma_{tot}^{stat} \rangle \approx 20\% \longleftrightarrow \langle \sigma_{tot}^{sys} \rangle \approx 5\%$$

- Clear dijet structures at high m_{12} and y_2

- Description by ARIADNE and HERWIG rather good
  LEPTO with severe deficiencies especially in z_p

Data/MC Comparison: Neutral Current



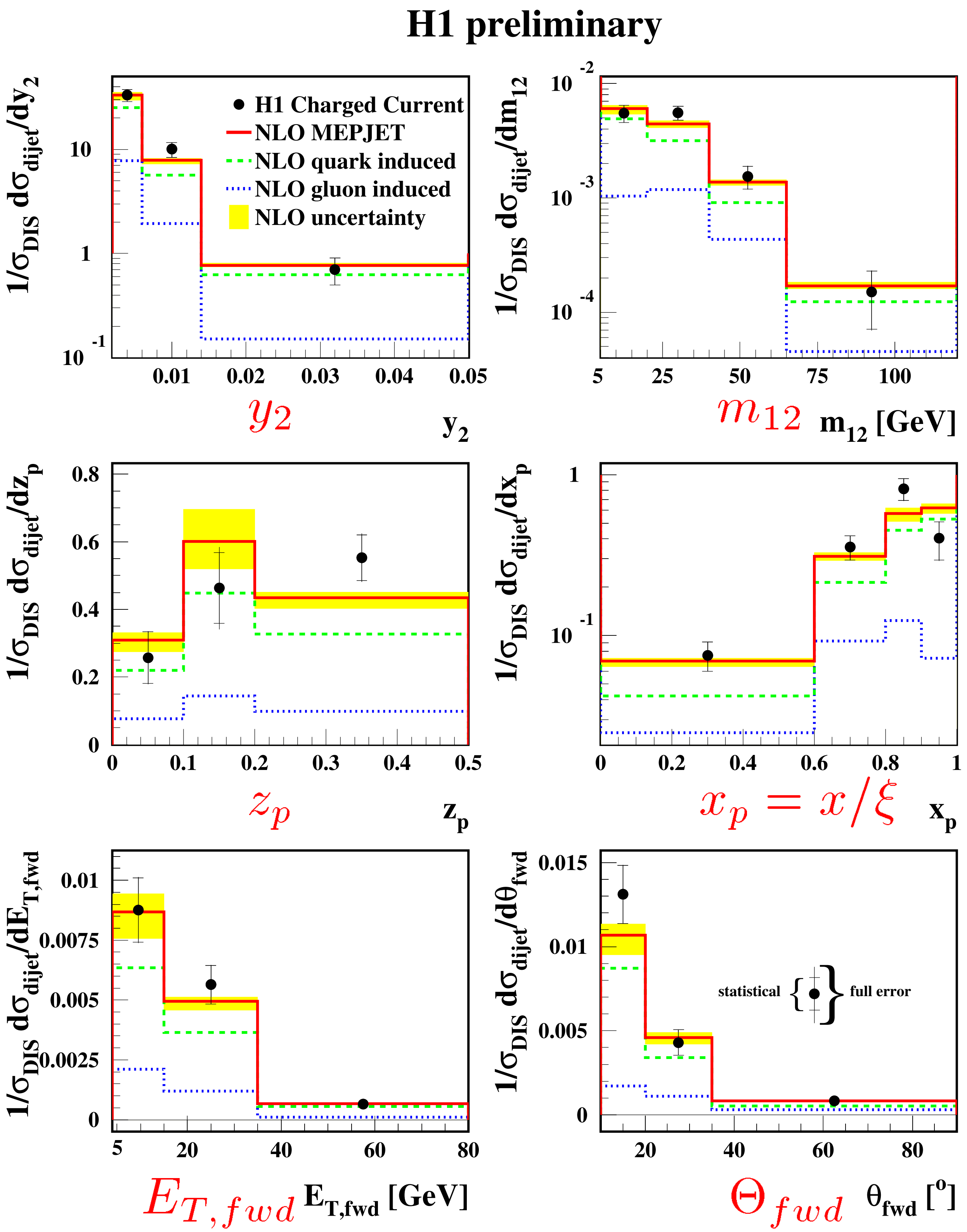
y_2 m_{12} z_p Θ_{fwd}

- Precise measurement of NC jet rates:

$$\langle \sigma_{tot}^{stat} \rangle \approx 6\% \longleftrightarrow \langle \sigma_{tot}^{sys} \rangle \approx 7\%$$

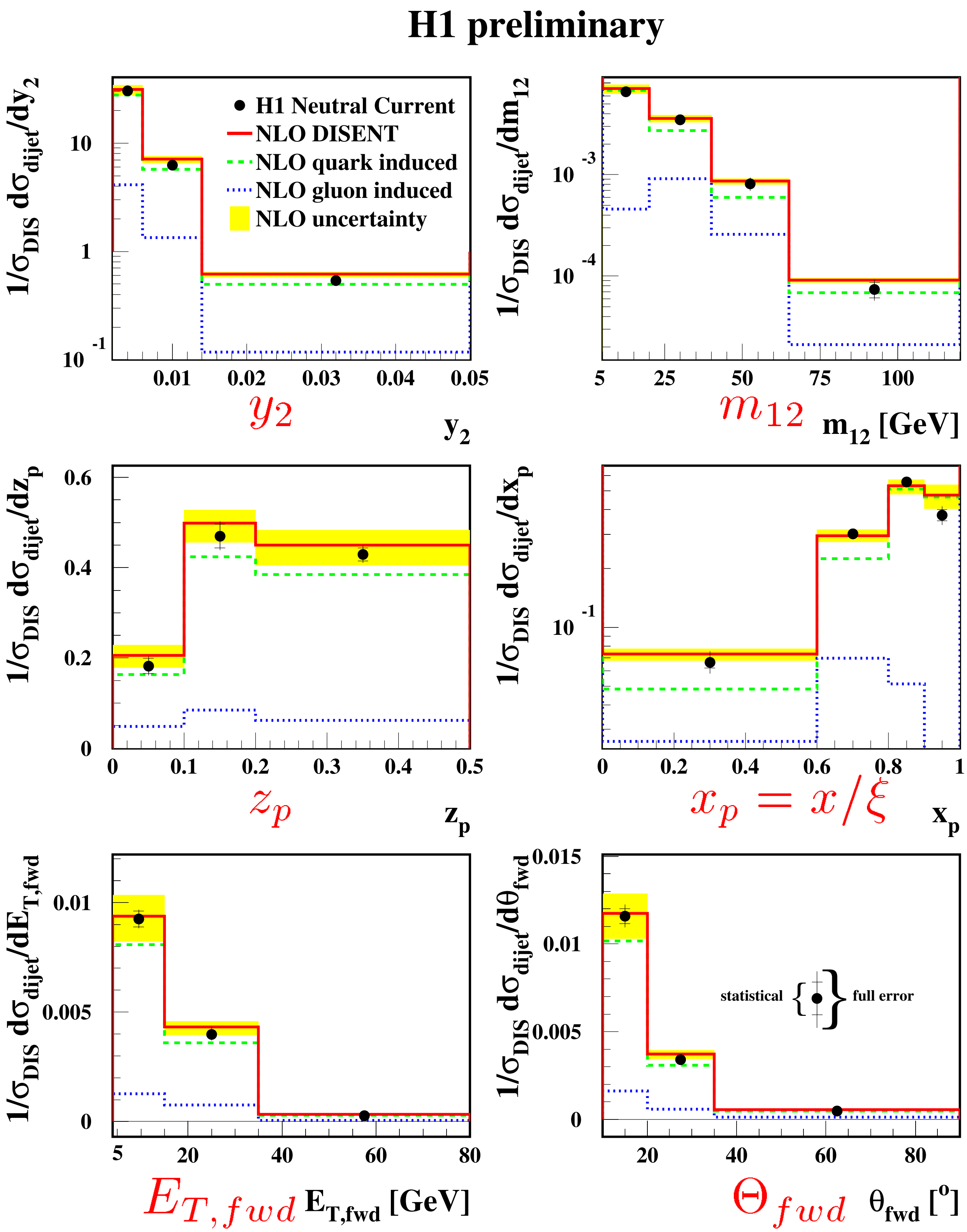
- Good description of corrected data by ARIADNE
  LEPTO problems also present in NC

Data/NLO Comparison: Charged Current



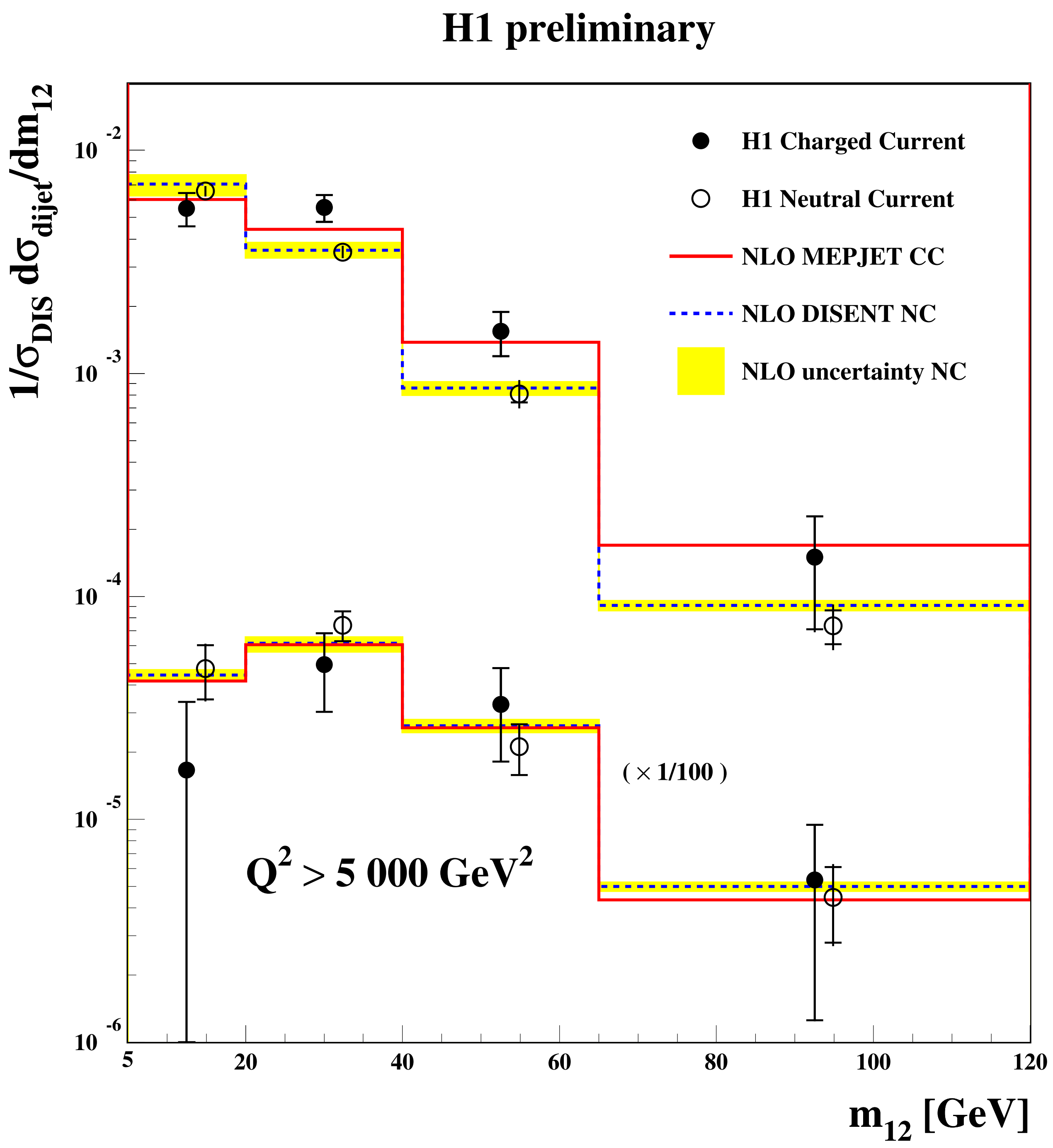
- Data described by pQCD in NLO within errors
- Both quark and gluon induced processes needed

Data/NLO Comparison: Neutral Current



- Data well described by pQCD in NLO
- Agreement in x_p, z_p: Test of QCD matrix elements

CC and NC at High Q^2 and High Masses



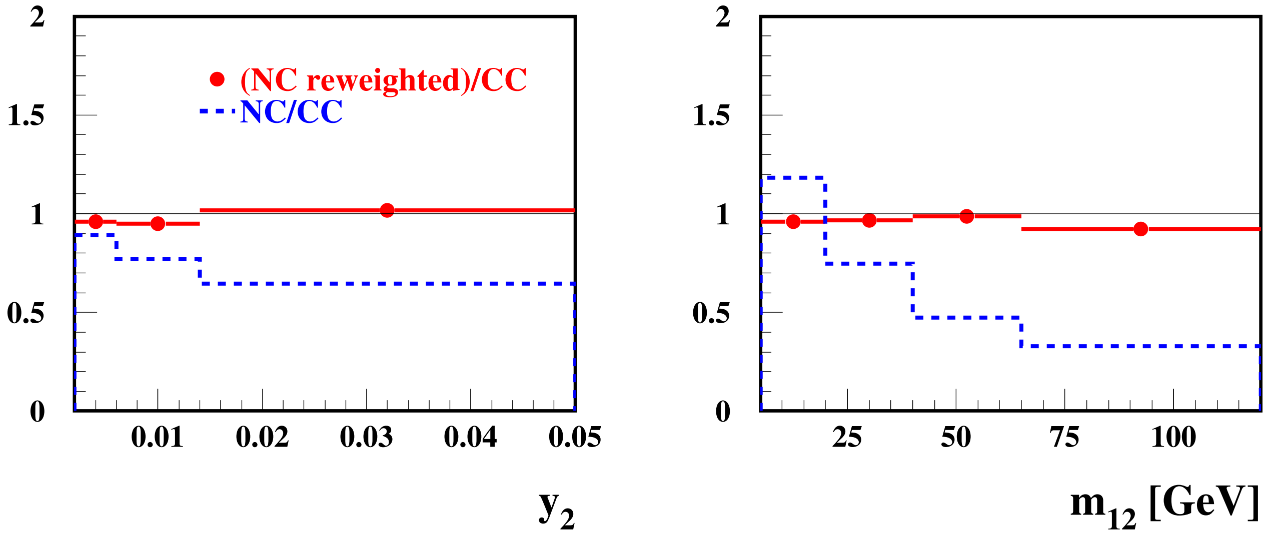
- CC and NC dijet mass distributions at highest Q^2 described by pQCD in NLO

- Effect of Z^0 exchange small (1-2%) due to $1/\sigma_{DIS}\ldots$ DISENT predictions for $Q^2 > 5\ 000\ \mathrm{GeV}^2$ corrected

- NC and CC jet distributions similar at higher Q^2

Model Independent CC/NC Comparison

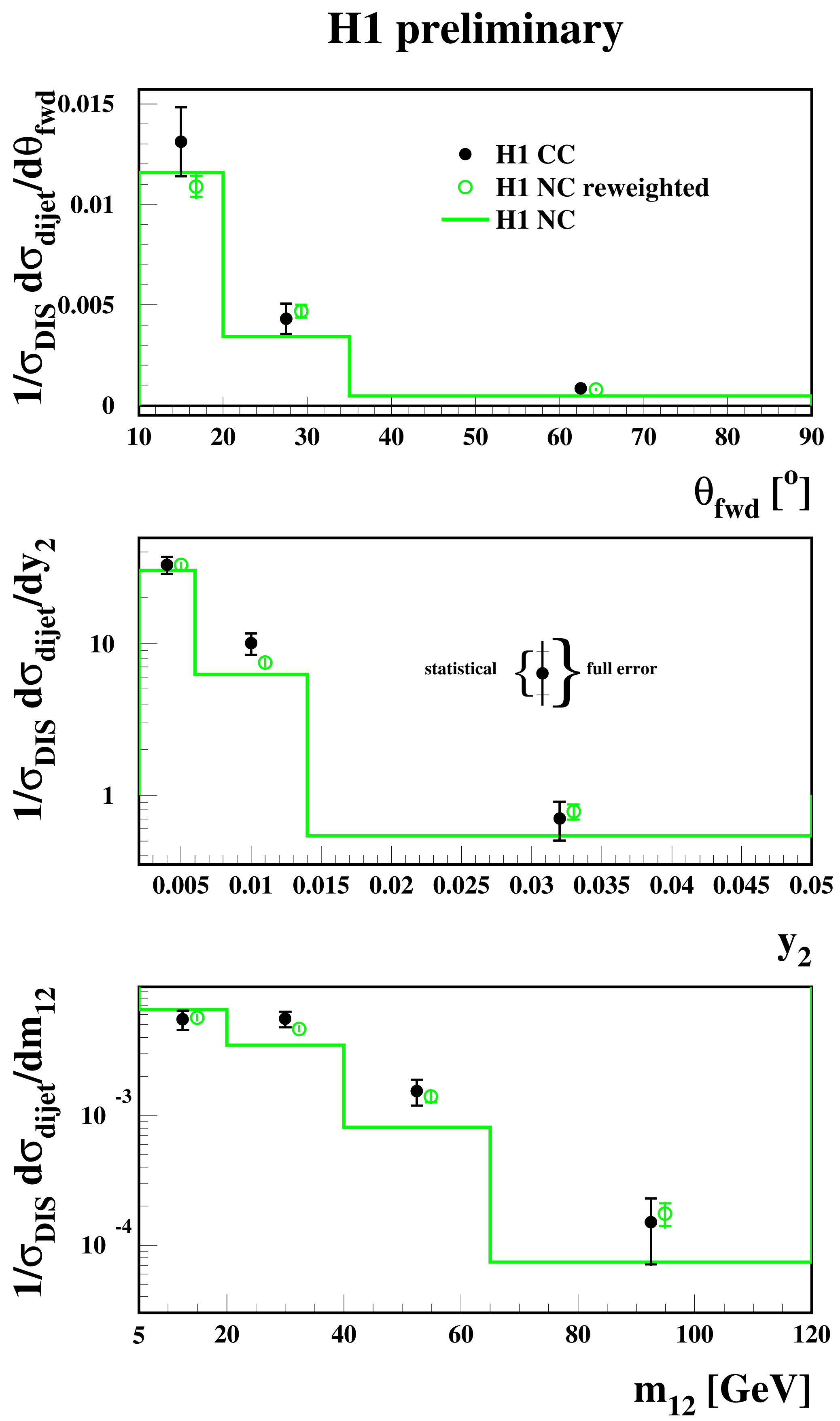
- QCD dynamics of CC and NC expected to be the same
- But direct comparison complicated:
  Different electroweak couplings and propagators affect jet system
- Solution: Reweight NC events in x and Q^2 to σ_{tot}^{CC}
  Test of reweighting with ARIADNE



Remaining differences typically 2-3%

- Method essentially model independent!
- Measured jet distributions not used as input
- Effects of different PDF's in CC and NC folded out
- Not considered: Different BGF and QCDC fraction

Model Independent CC/NC Comparison



- HFS independent of underlying electroweak process

3. NC Jets at Highest $\mathbf{Q^2}$

Exploiting the higher NC statistics:

1. Measurement of jet rates differential in Q^2

2. Extend measurement to highest scales reached so far:

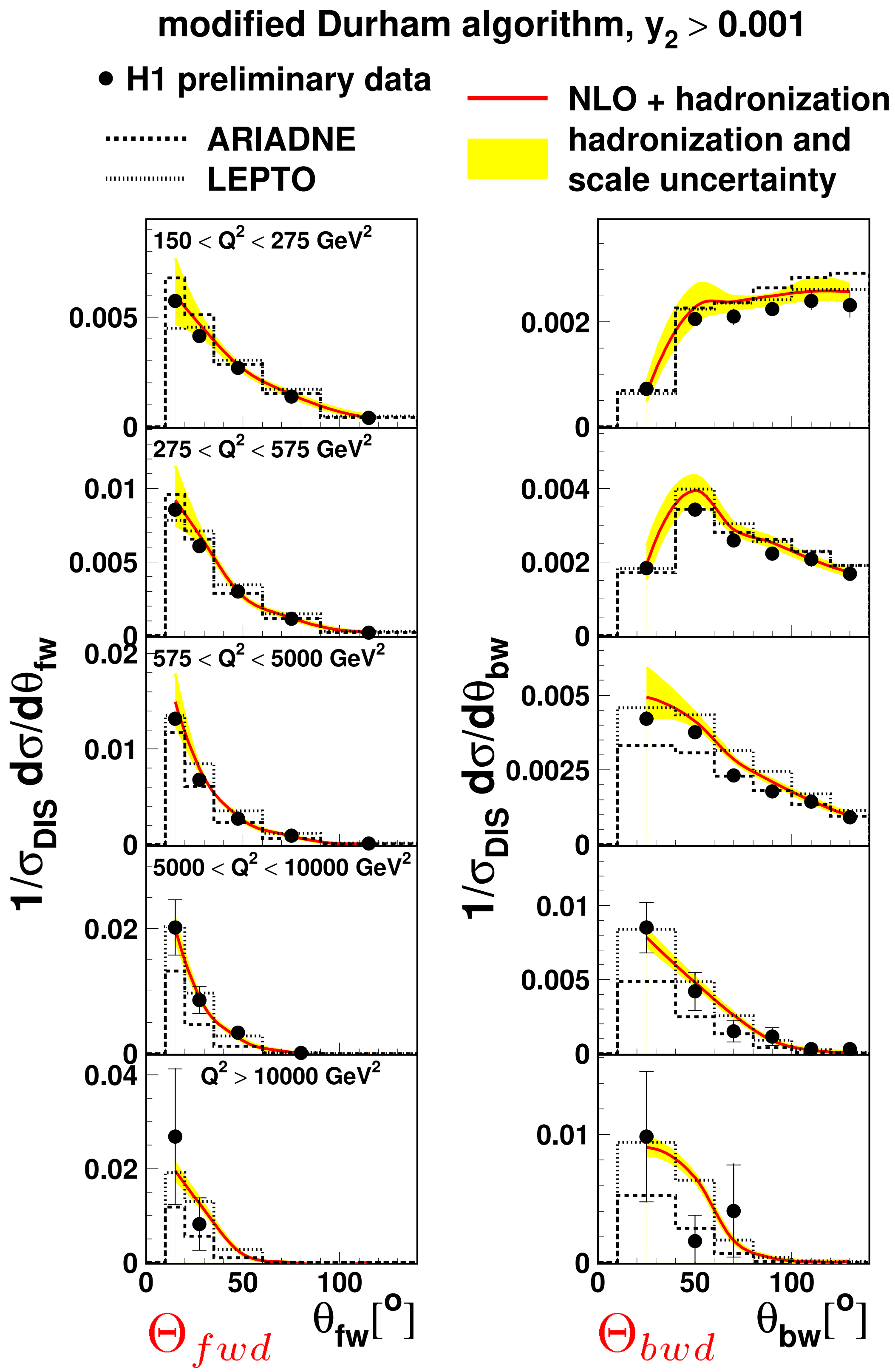
$$\boxed{Q^2 > 10\,000\ \mathrm{GeV}^2}$$

- NC selection from H1 1995-1997 $\mathbf{e^+p}$ data
- Kinematic region: $Q^2 > 150\ \mathrm{GeV}^2, 0.1 < y < 0.7$
- Jet finding with Durham algorithm in lab. frame
- Jet selection cuts:

$$y_2 > 0.001$$
$$10^\circ < \Theta_{Jet} < 140^\circ$$

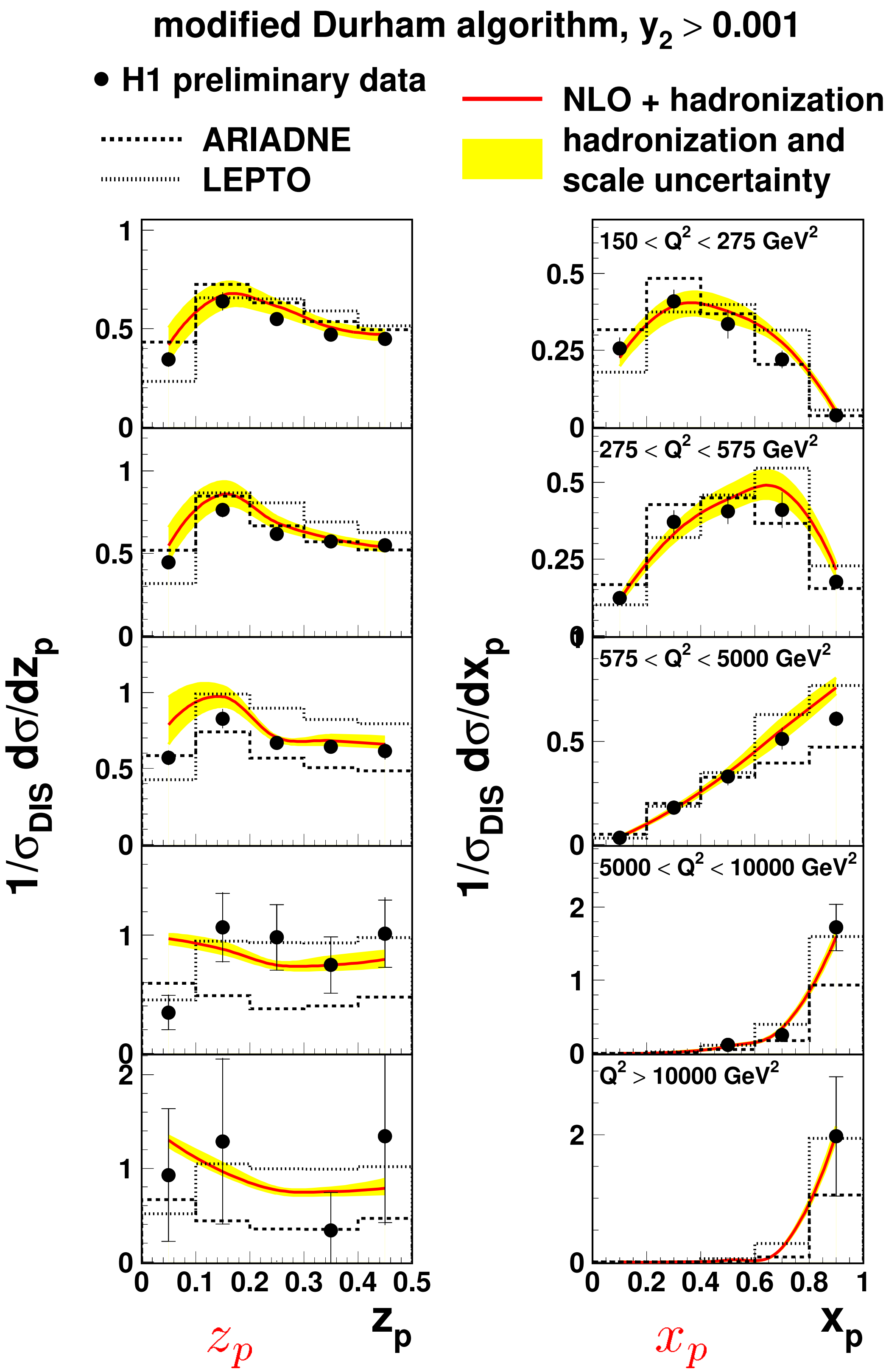
- Relatively weak jet cut to keep high Q^2 events

NC Jets at Highest $\mathbf{Q^2}$



- Best description by NLO prediction
- Implicit test of PDF's, QCD matrix elements, inset of electroweak effects

NC Jets at Highest $\mathbf{Q^2}$



z_p x_p

- Data described over 3 orders of magnitude in Q^2!
- No particularities at $Q^2 > 10\,000$ GeV^2

Summary

- Precise ZEUS measurement of NC differential dijet X-sections at highest scales:
  Good agreement between data and pQCD in NLO
  $d\sigma_2/dQ^2$ described by QCD over 3 orders of magnitude

- H1: First measurement of CC dijet distributions:
  Measured distributions reproduced by pQCD in NLO
  Clear evidence for dijet structures
  QCD test at highest accessible scales $Q^2 > 5\,000$ GeV^2

- Model independent comparison of CC and NC data:
  QCD dynamics independent of electroweak process

- H1: Analysis of jet production for $Q^2 > 10\,000$ GeV^2:
  No significant deviations from QCD predictions