Measurement of azimuthal decorrelation angle between the leading jet and the scattered lepton in deep inelastic scattering at HERA (second preliminary presentation)

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3. Acceptance and efficiency
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The azimuthal decorrelation angle between the leading jet and scattered lepton in deep inelastic scattering is being studied in the ZEUS detector at HERA. The data was taken in the HERA II data-taking period and corresponds to an integrated luminosity of ~ 330 pb^{-1}. Azimuthal angular decorrelation has been proposed to study the Q^2 dependence of the evolution of the transverse momentum distributions (TMDs) and understand the small-x region, providing unique insight to nucleon structure. Previous decorrelation measurements of two jets have been performed in proton-proton collisions at very high transverse momentum; these measurements are well described by perturbative QCD at next-to-leading order. The azimuthal decorrelation angle obtained in these studies shows good agreement with predictions from QCD calculations.

Event selection

Data:
040506e and 0607p ~**330** pb^{-1}

MC:
Ariadne_Low_Q2_NC_DIS_05e
Ariadne_Low_Q2_NC_DIS_06e
Ariadne_Low_Q2_NC_DIS_0607p

Phase Space:
$10 < Q^2 < 350\ GeV^2$
$y_{el} < 0.7$ && $y_{jb} > 0.04$

Cleaning cuts:
-40 < Zvtx/cm < 40
35 GeV < $E - p_z$ < 65 GeV (both Cal and Zufo)
Cal_pt / sqrt(Cal_et) < 2.5

Electron cuts:
10 GeV < Energy (Siecorr) ~~< 25 GeV~~
140^o < Theta < 180^o
Electron position sqrt($x^2 + y^2$) > 20.0
Sienin[0] > 0.1*(Siein[0] +Sienin[0]) (energy in cone*)
Chimney cut *
Siprob[0], the lepton with highest prob (> 0.9)*

Triggers:
SPP02 (Tltw[2] & (1 << 1)) for 0405e
SPP09 (Tltw[2] & (1 << 8)) for 06e and 0607p

Jet selection:
$E_T > 2.5$ GeV && $P_T < 30$
|eta| < 1.0
Using "Kt_etjet_b[0]" (massive), the leading (E_T) jet only

*Some cuts from: https://zeusdp.desy.de/ZEUS_ONLY/analysis/primer/DIS/index.html , and most cuts similar to slide 5 of: https://www-zeus.desy.de/ZEUS_ONLY/meetings/zems/group30/meet276/sess2812/pres12368/01_pr_photons_jets_04_05_2.pdf

Control plots

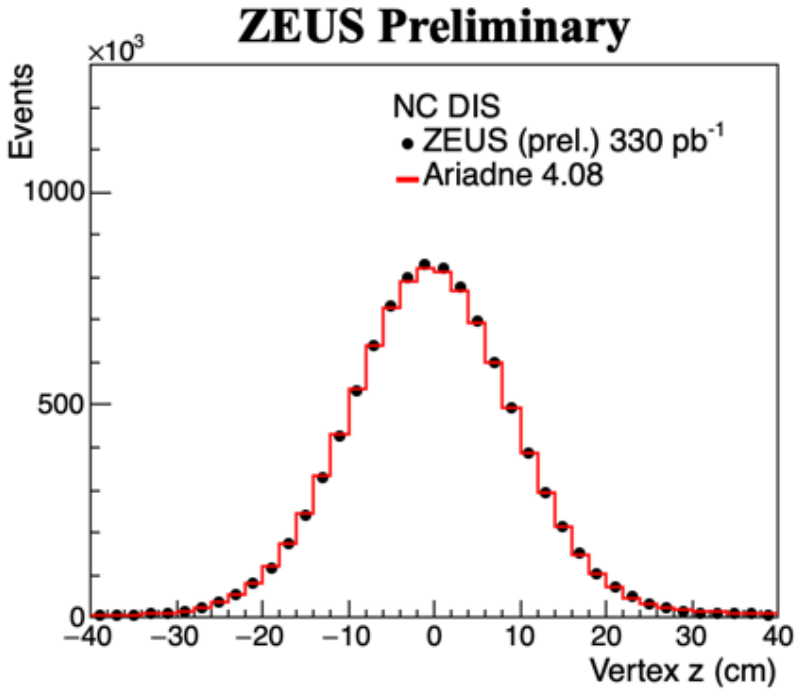
Total number of events:

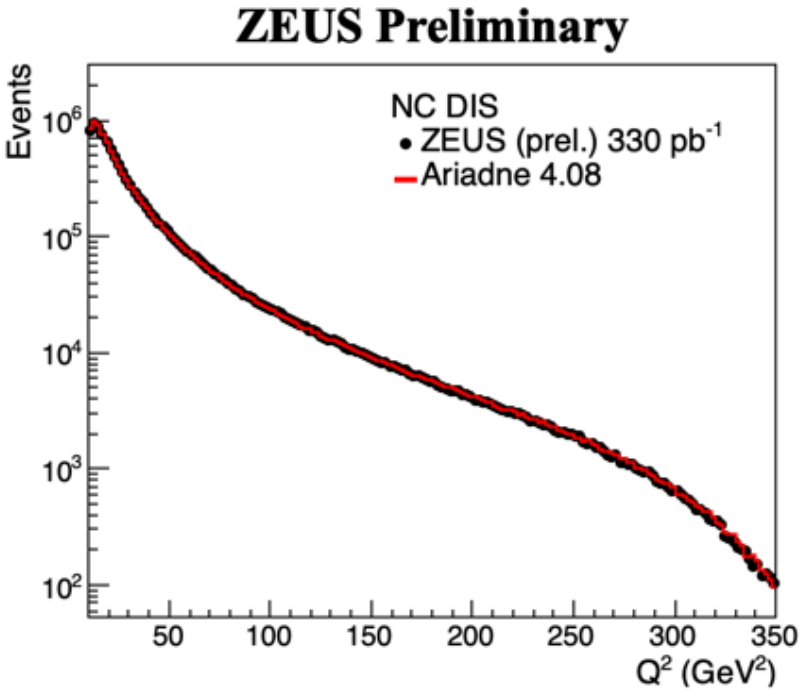
040506e and 0607p: 9 823 230

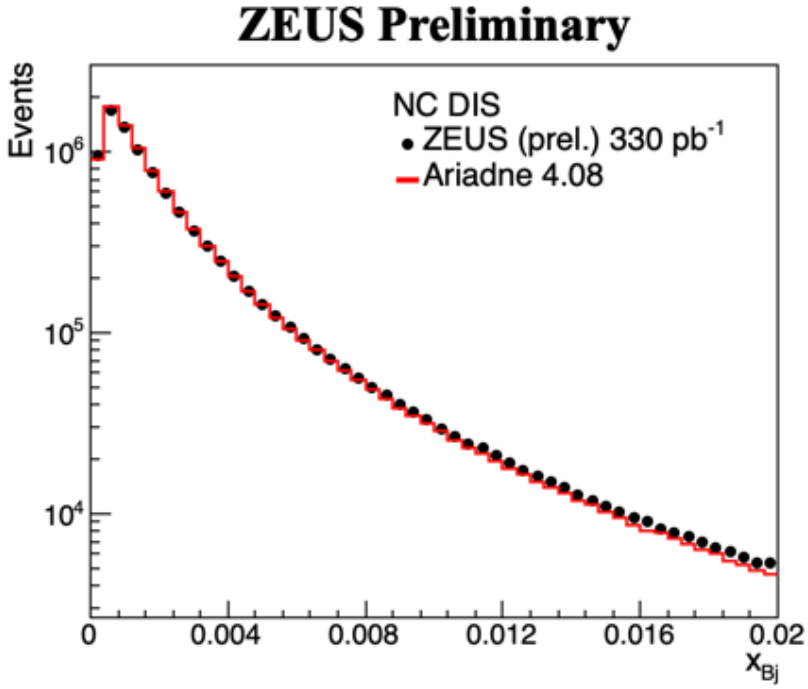
MC sample is not weighted by luminosity but normalized to the number of entries of the data.

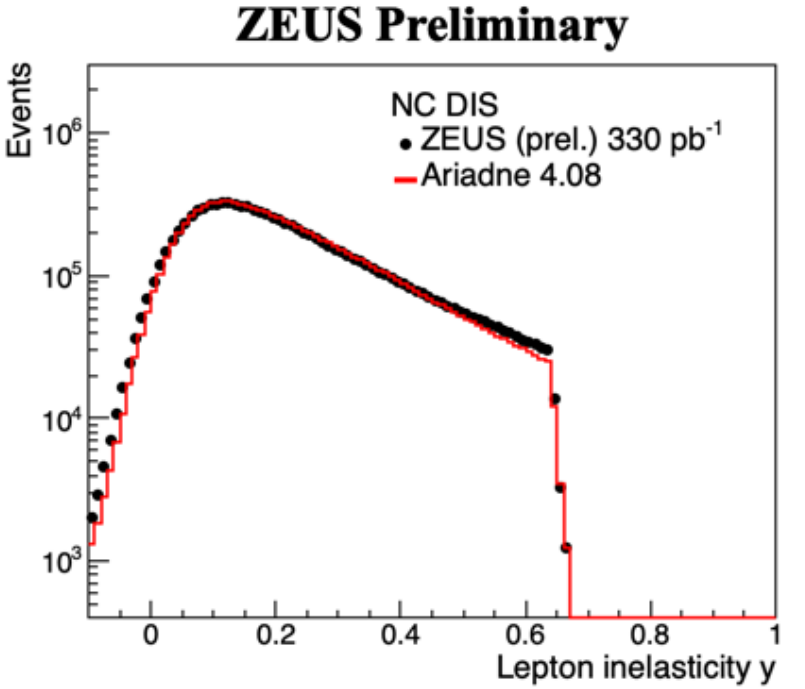
Brian Foster (for the abstract)
Luminosity: 040506e = 189 pb^{-1}
0607p = 143 pb^{-1}

➔ 330 pb^{-1}


ZEUS Preliminary
NC DIS
ZEUS (prel.) 330 pb-1
Ariadne 4.08
Events
×10³
Vertex z (cm)

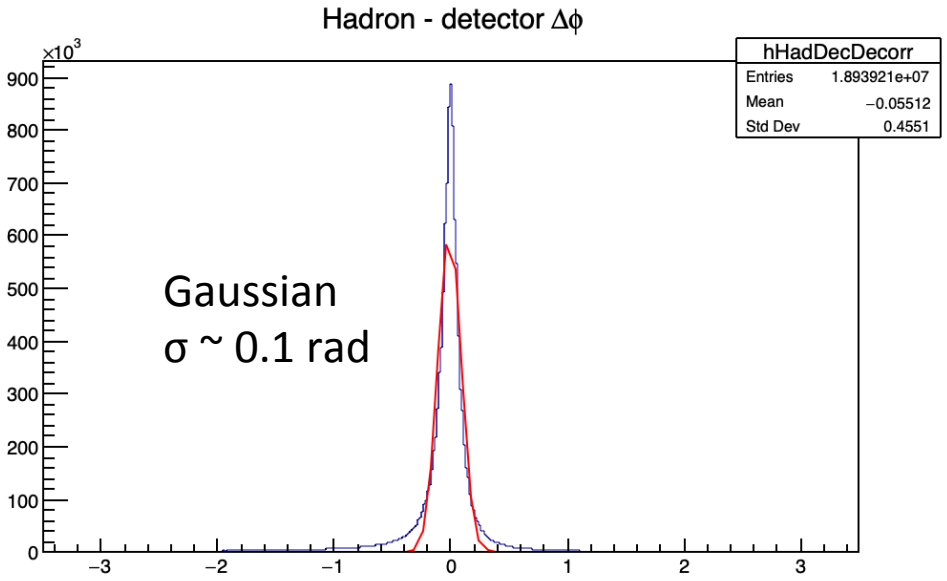

ZEUS Preliminary
NC DIS
ZEUS (prel.) 330 pb-1
Ariadne 4.08
Events
Q² (GeV²)


ZEUS Preliminary
NC DIS
ZEUS (prel.) 330 pb-1
Ariadne 4.08
Events
x_Bj


ZEUS Preliminary
NC DIS
ZEUS (prel.) 330 pb-1
Ariadne 4.08
Events
Lepton inelasticity y

Decorrelation angle

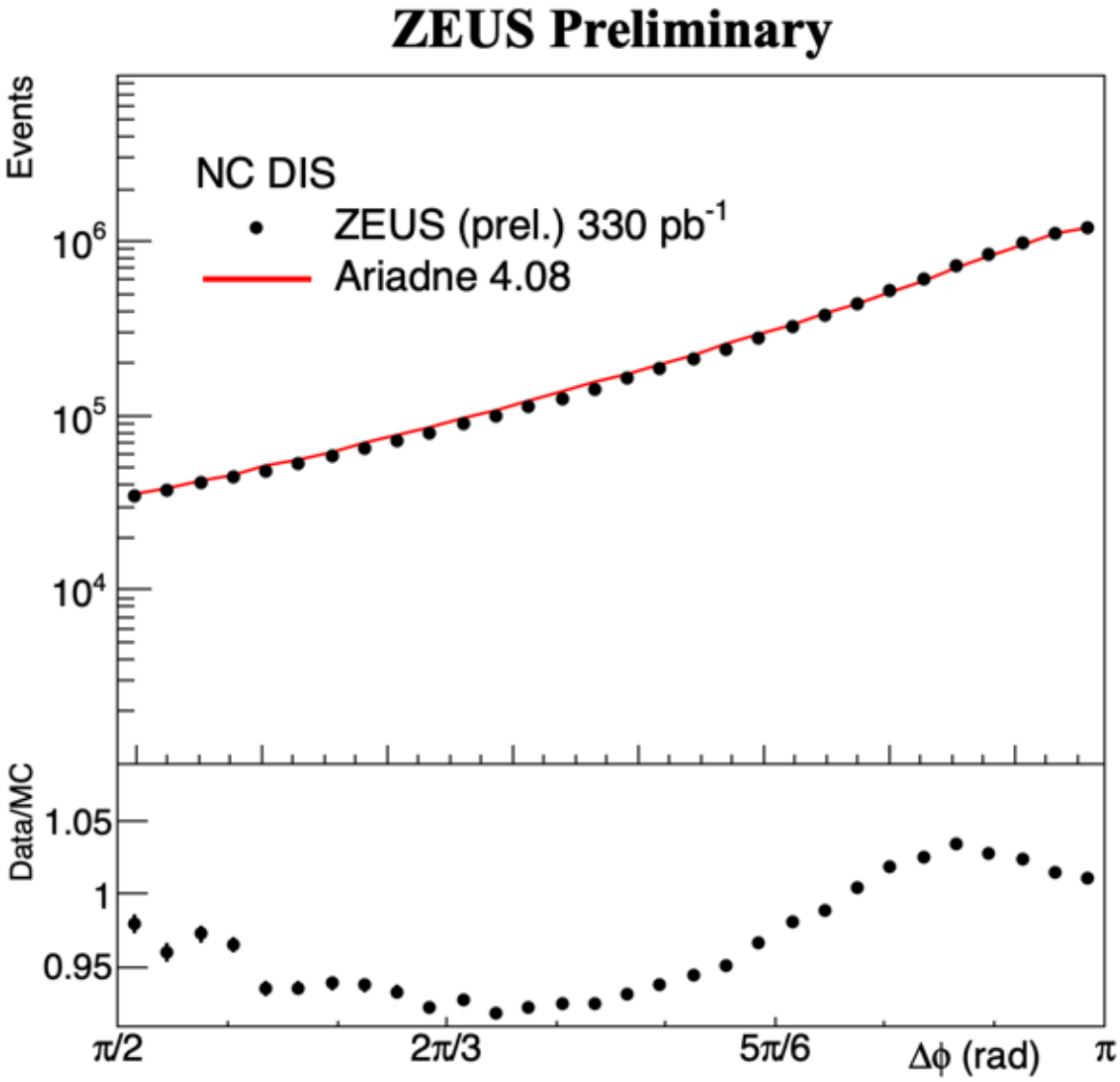
Matthew Wing: check the binning



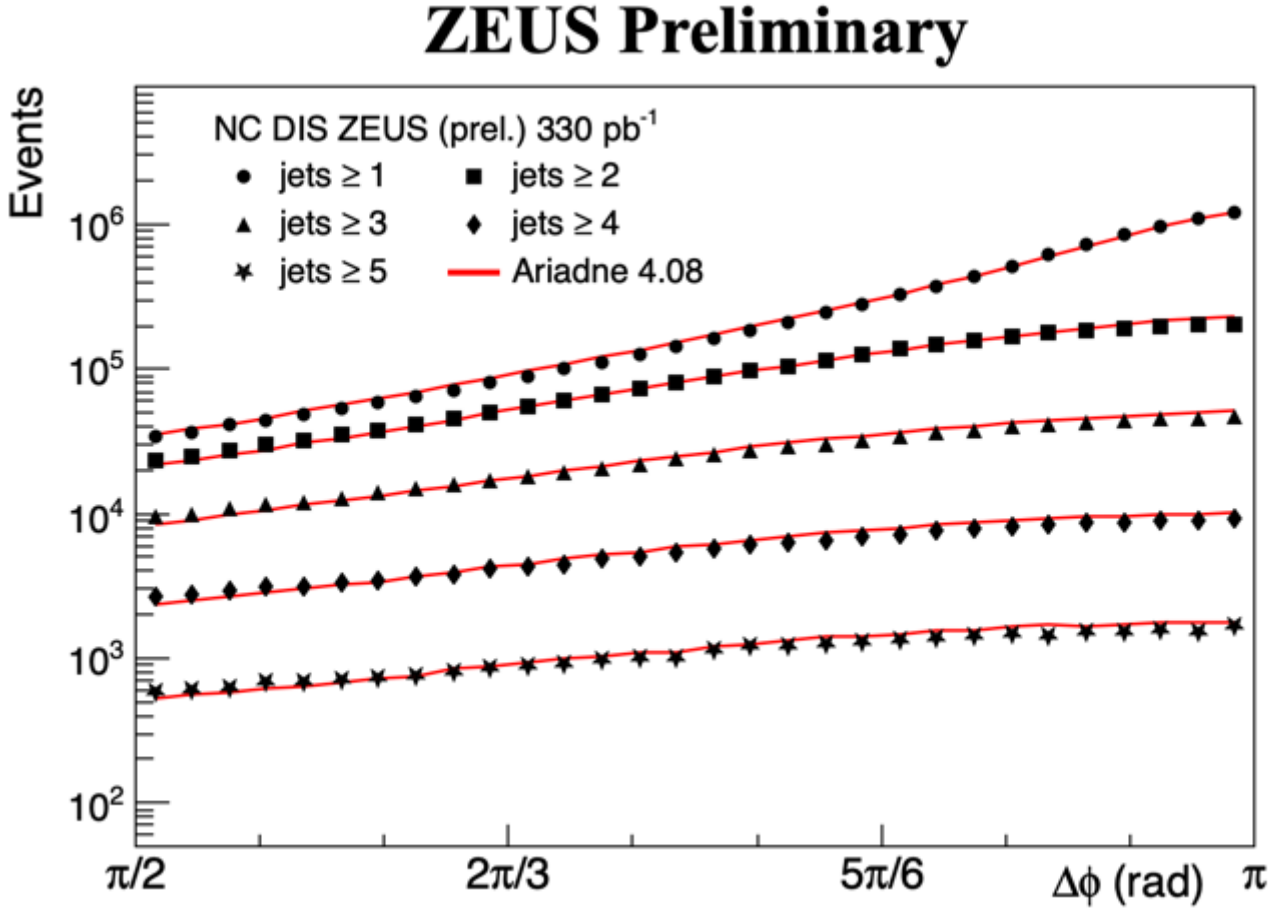
The Ariadne curves, on the next two slides are at the detector level using the cuts in slide 3.
The statistical errors are not visible because they are very small.

Binning:
Before ~0.1 rad
Now: ~0.2 rad
* The distribution is not entirely Gaussian

Decorrelation angle



Decorrelation angle (jet multiplicity)



Jet multiplicity per event is the number of jets reconstructed in one event.

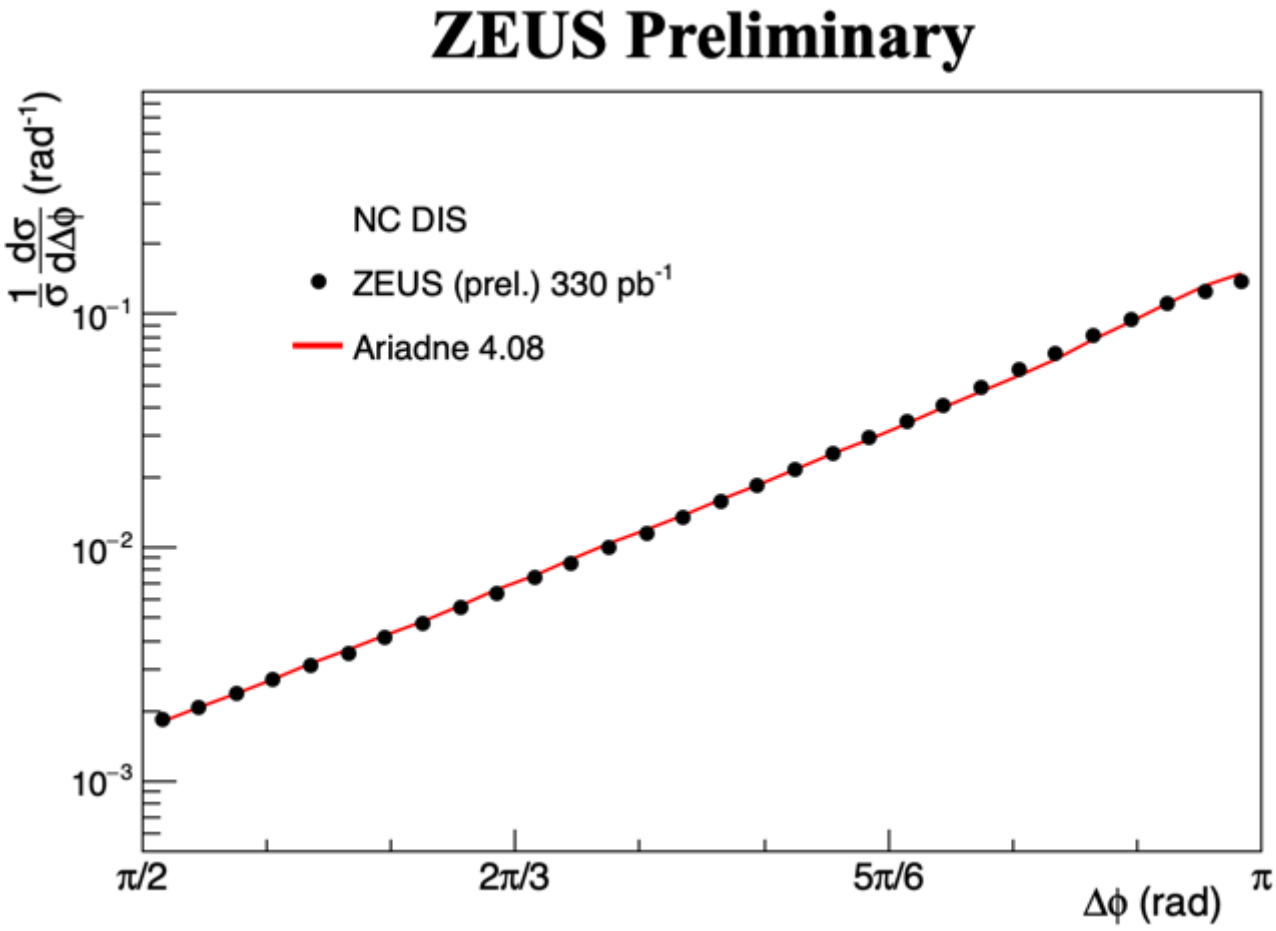
Cross Section Results

- Result are shown at hadron level (MCHMJets).
- For the true MC, using cuts in slide 18, which are almost the same than slide 3 but without any detector dependency.
- New binning applied (~0.2 rad)
- Acceptance and unfolding correction:

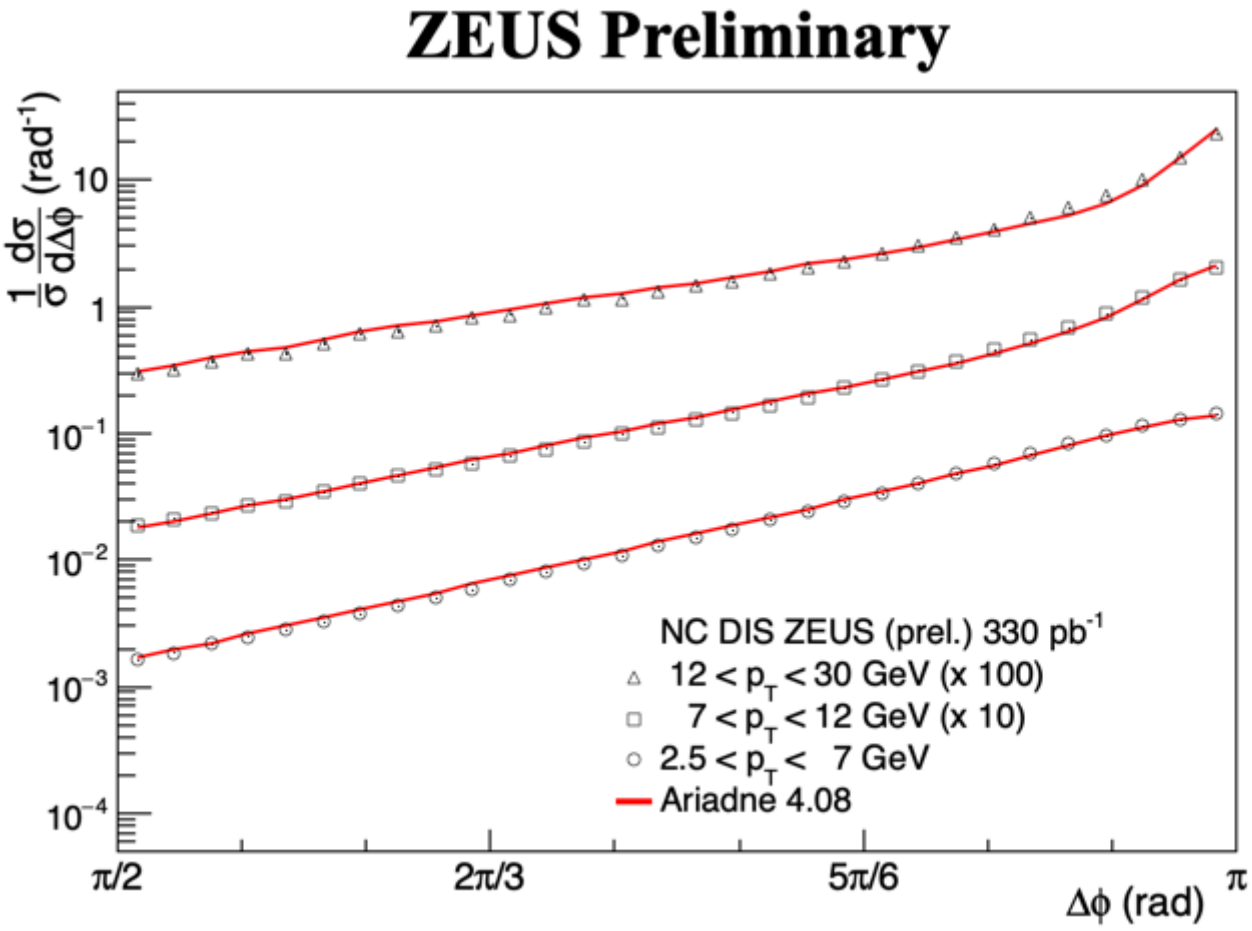
ε = MC (detector level with detector cuts) / MC_true (hadron level)

- The jets at detector level (both data and MC) are ordered by E_T however at hadron level the jets are ordered by $P_{T.}$ The effect of this ordering is estimated to be ~10% (mostly for jets with $E_T < 2.7$).

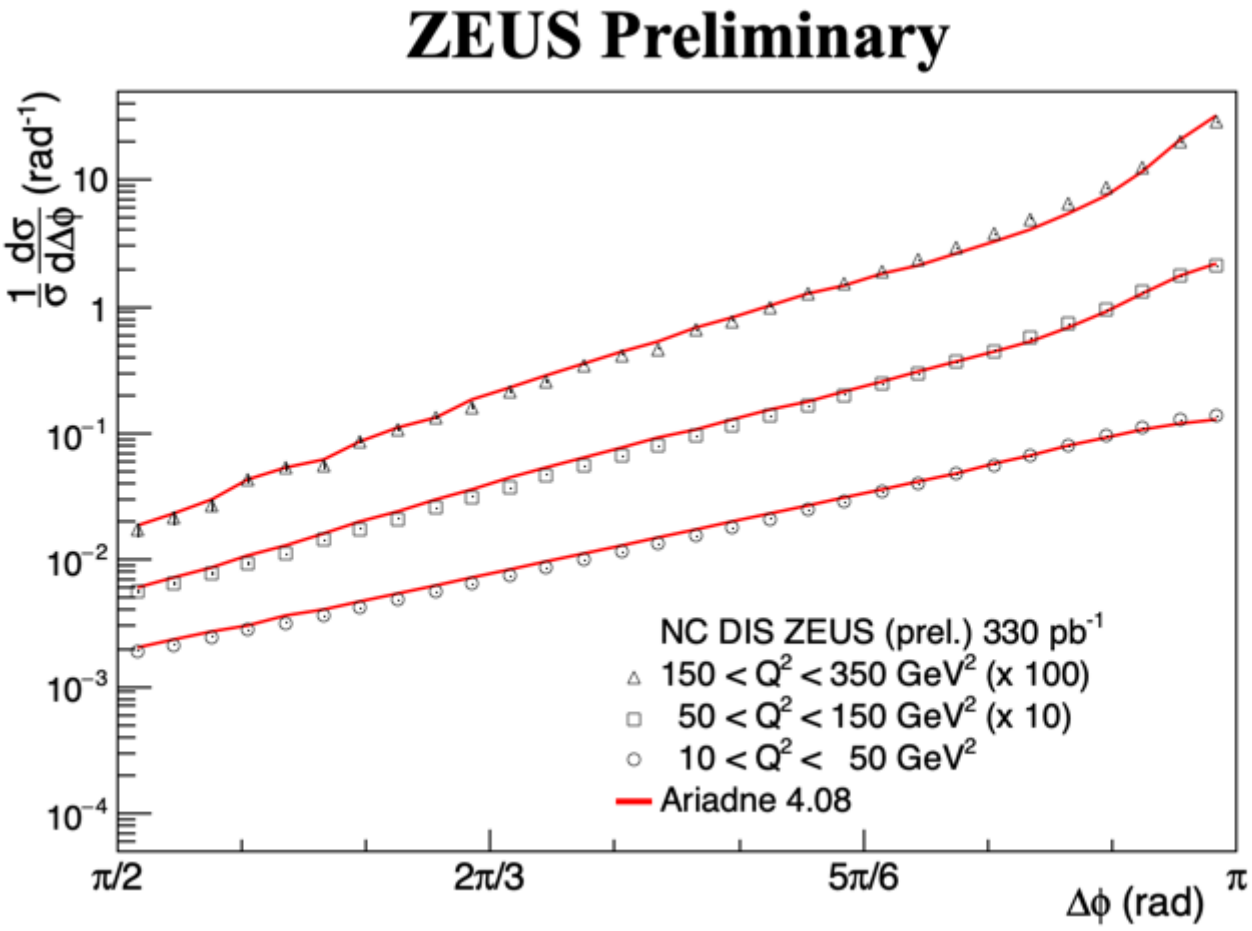
Integrated P_T and Q^2 plot

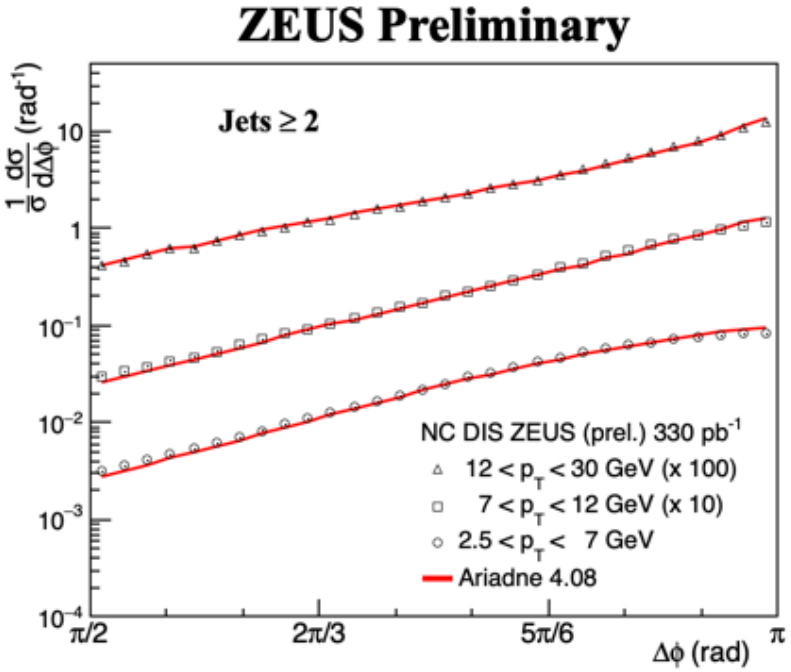


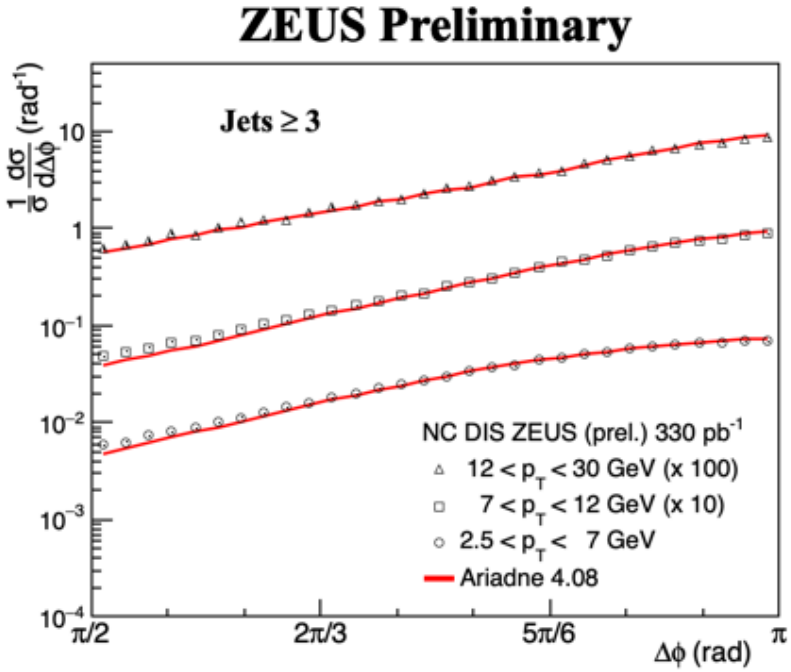
Jet P_T bins

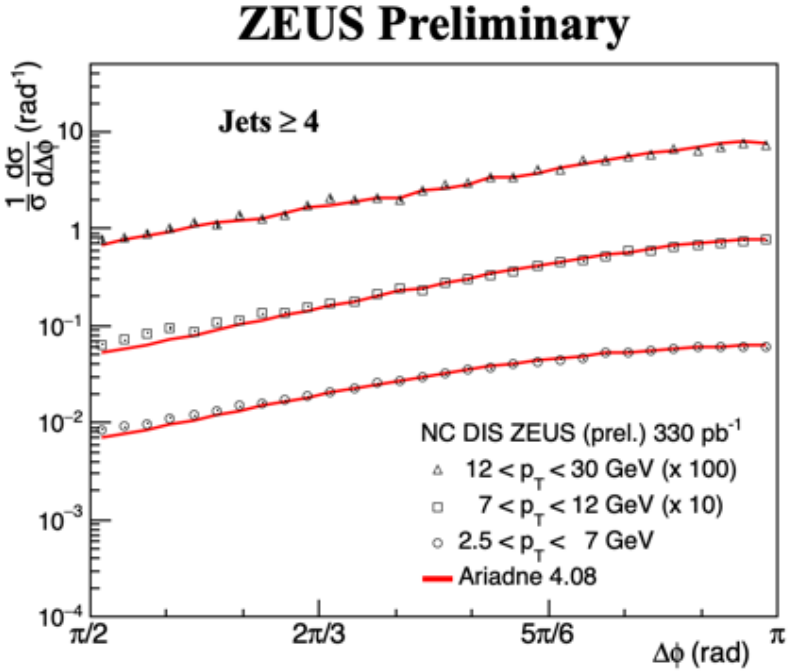

ZEUS Preliminary
$\frac{1}{\sigma}\frac{d\sigma}{d\Delta\phi}$ (rad^{-1})
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
NC DIS ZEUS (prel.) 330 pb^{-1}
$12 < p_T < 30$ GeV (x 100)
$7 < p_T < 12$ GeV (x 10)
$2.5 < p_T < 7$ GeV
Ariadne 4.08
π/2
2π/3
5π/6
π
Δφ (rad)

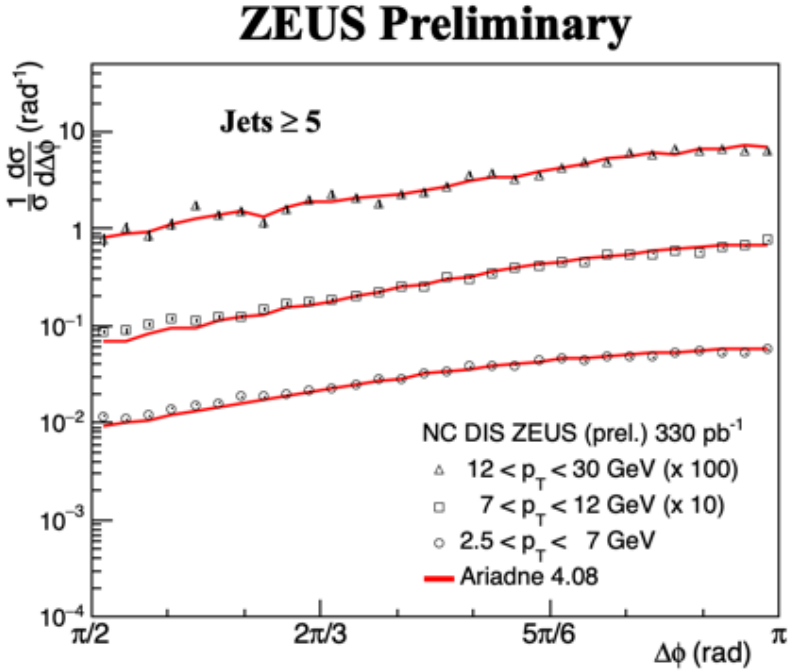
Q^2 bins

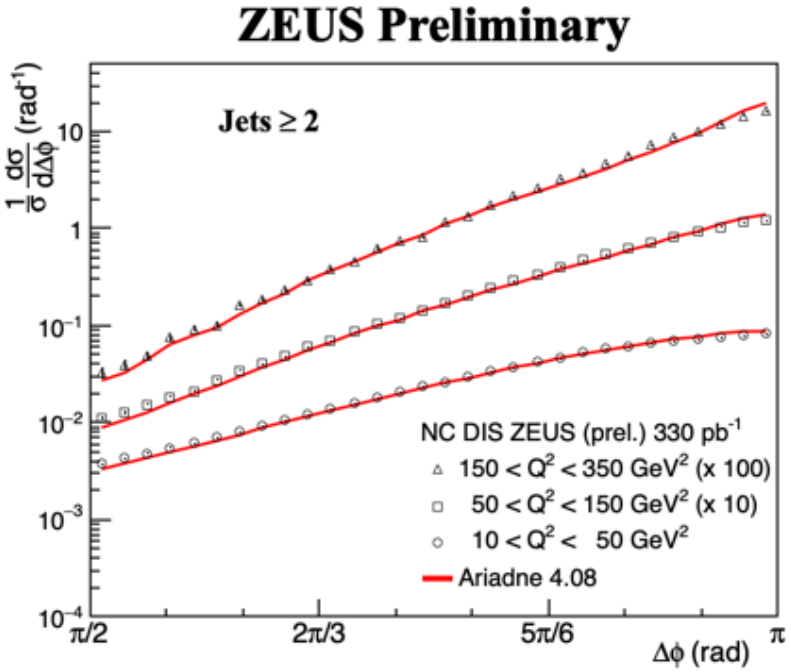

ZEUS Preliminary
$\frac{1}{\sigma}\frac{d\sigma}{d\Delta\phi}$ (rad^{-1})
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
NC DIS ZEUS (prel.) 330 pb^{-1}
$150 < Q^2 < 350$ GeV^2 (x 100)
$50 < Q^2 < 150$ GeV^2 (x 10)
$10 < Q^2 < 50$ GeV^2
Ariadne 4.08
π/2
2π/3
5π/6
π
Δφ (rad)

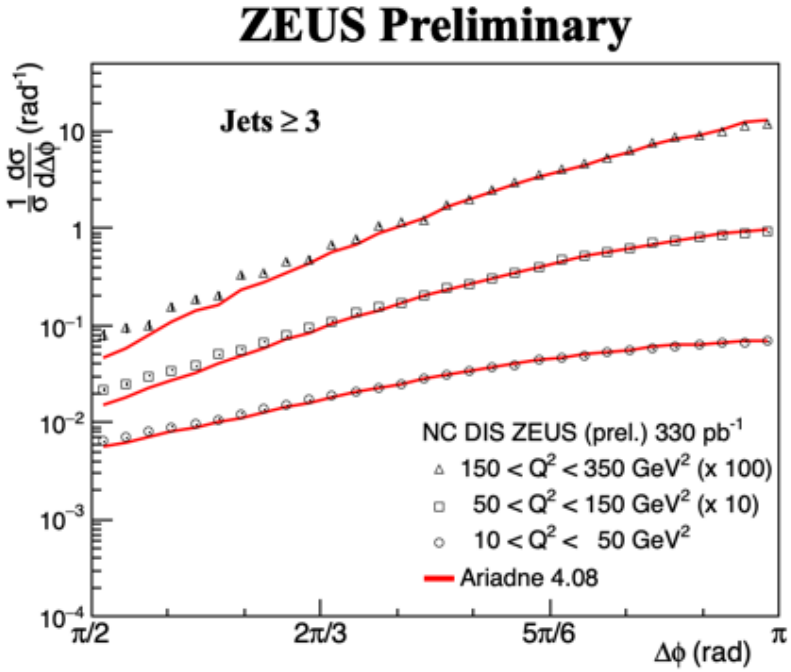

ZEUS Preliminary
Jets ≥ 2
$\frac{1}{\sigma}\frac{d\sigma}{d\Delta\phi}$ (rad^{-1})
NC DIS ZEUS (prel.) 330 pb^{-1}
12 < p_T < 30 GeV (x 100)
7 < p_T < 12 GeV (x 10)
2.5 < p_T < 7 GeV
Ariadne 4.08
π/2
2π/3
5π/6
π
Δφ (rad)

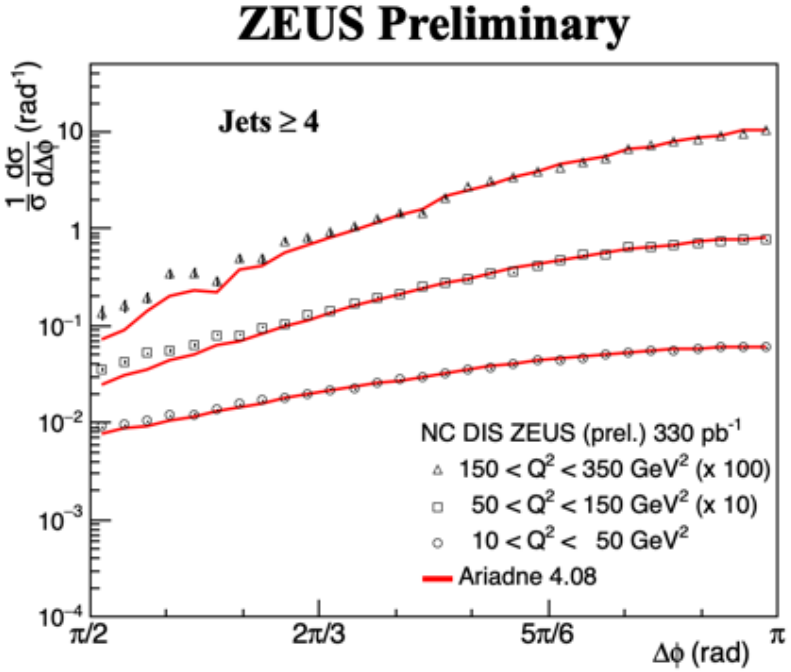

ZEUS Preliminary
Jets ≥ 3
$\frac{1}{\sigma}\frac{d\sigma}{d\Delta\phi}$ (rad^{-1})
NC DIS ZEUS (prel.) 330 pb^{-1}
12 < p_T < 30 GeV (x 100)
7 < p_T < 12 GeV (x 10)
2.5 < p_T < 7 GeV
Ariadne 4.08
π/2
2π/3
5π/6
π
Δφ (rad)

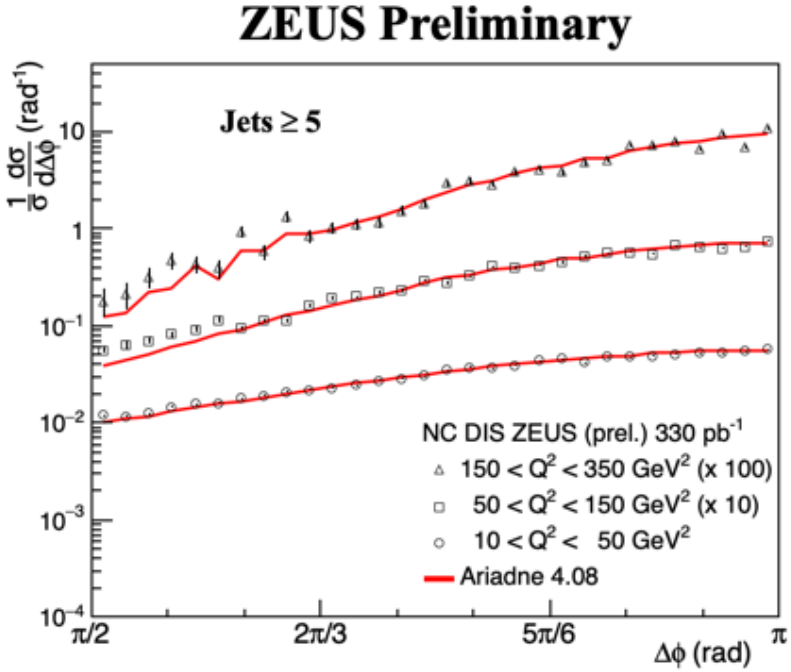

ZEUS Preliminary
Jets ≥ 4
$\frac{1}{\sigma}\frac{d\sigma}{d\Delta\phi}$ (rad^{-1})
NC DIS ZEUS (prel.) 330 pb^{-1}
12 < p_T < 30 GeV (x 100)
7 < p_T < 12 GeV (x 10)
2.5 < p_T < 7 GeV
Ariadne 4.08
π/2
2π/3
5π/6
π
Δφ (rad)


ZEUS Preliminary
Jets ≥ 5
$\frac{1}{\sigma}\frac{d\sigma}{d\Delta\phi}$ (rad^{-1})
NC DIS ZEUS (prel.) 330 pb^{-1}
12 < p_T < 30 GeV (x 100)
7 < p_T < 12 GeV (x 10)
2.5 < p_T < 7 GeV
Ariadne 4.08
π/2
2π/3
5π/6
π
Δφ (rad)


ZEUS Preliminary
Jets ≥ 2
$\frac{1}{\sigma}\frac{d\sigma}{d\Delta\phi}$ (rad^{-1})
NC DIS ZEUS (prel.) 330 pb^{-1}
150 < Q^2 < 350 GeV^2 (x 100)
50 < Q^2 < 150 GeV^2 (x 10)
10 < Q^2 < 50 GeV^2
Ariadne 4.08
π/2
2π/3
5π/6
π
Δφ (rad)


ZEUS Preliminary
Jets ≥ 3
$\frac{1}{\sigma}\frac{d\sigma}{d\Delta\phi}$ (rad^{-1})
NC DIS ZEUS (prel.) 330 pb^{-1}
150 < Q^2 < 350 GeV^2 (x 100)
50 < Q^2 < 150 GeV^2 (x 10)
10 < Q^2 < 50 GeV^2
Ariadne 4.08
π/2
2π/3
5π/6
π
Δφ (rad)


ZEUS Preliminary
Jets ≥ 4
$\frac{1}{\sigma}\frac{d\sigma}{d\Delta\phi}$ (rad^{-1})
NC DIS ZEUS (prel.) 330 pb^{-1}
150 < Q^2 < 350 GeV^2 (x 100)
50 < Q^2 < 150 GeV^2 (x 10)
10 < Q^2 < 50 GeV^2
Ariadne 4.08
π/2
2π/3
5π/6
π
Δφ (rad)


ZEUS Preliminary
Jets ≥ 5
$\frac{1}{\sigma}\frac{d\sigma}{d\Delta\phi}$ (rad^{-1})
NC DIS ZEUS (prel.) 330 pb^{-1}
150 < Q^2 < 350 GeV^2 (x 100)
50 < Q^2 < 150 GeV^2 (x 10)
10 < Q^2 < 50 GeV^2
Ariadne 4.08
π/2
2π/3
5π/6
π
Δφ (rad)

Summary

- All comments are applied:
  - Update selection cuts.
  - Figures details applied.
  - Results at hadron level.
  - Binning checked.
- The results are consistent with the MC model.

Backup

Minutes from first meeting

1. the cross sections plotted should be hadron (particle) level cross sections.
2. for the cross section definition: z-vertex cut is removed; upper electron E cut is removed; no reweighing is used.
3. cuts: y cut is changed from 0.95 to 0.70
4. the results will be presented for combined NC e+p and e-p events.
5. statistical uncertainties will be added to the figures.
6. figures showing cross sections in various electron E bins will be removed.
7. cross section figure for inclusive sample will be added (similar to figures 5&6 in the drafts, just for the cross sections, not events).
8. figures will be improved according to all comments during the meeting.
9. The draft and the abstact will be improved (all comments welcome!), for example a conclusion will be added that ARIADNE gives a very good description of the data, also in case of events with high jet multiplicity.
10. the Authors will talk to Feng Yuan about his predictions and details required for the analysis (for possible improvements or changes in the future)

Acceptance and efficiency

The observable: $\frac{1}{\sigma_{mes}}\frac{d\sigma_{mes}}{d\Delta\varphi}$ where σ_{mes} : the measured cross section

ε : efficiency correction*

$\sigma = \sigma_{mes}/\varepsilon$: cross section at parton level

Use true level MC to estimate the efficiency:

ε = MC (detector level with detector cuts) / MC_true (parton level)

$$\Rightarrow \frac{1}{\sigma}\frac{d\sigma}{d\Delta\varphi} = \frac{\varepsilon}{N}\frac{d(N/\varepsilon)}{d\Delta\varphi}$$

N: events measured

*This is a first approximation correction.

Event selection for true MC

~~Data:~~
~~040506e ~189 pb^{-1}, 0607p ~143 pb^{-1}~~

MC:
Ariadne_Low_Q2_NC_DIS_05e
Ariadne_Low_Q2_NC_DIS_06e
Ariadne_Low_Q2_NC_DIS_0607p

Phase Space:
$10 < Q^2 < 350$ GeV^2
~~$y_{el} < 0.95$ && $y_{jb} > 0.04$~~ $0.04 < y <$ ~~0.7~~

Cleaning cuts:
~~-40 < Zvtx/cm < 40~~
~~35 GeV < E – p_z < 65 GeV (both Cal and Zufo)~~
~~Cal_pt / sqrt(Cal_et) < 2.5~~

Electron cuts:
10 GeV < ~~Siecorr~~ Mc_pfsl[3]~~< 25 GeV~~
$140^o <$ Theta $< 180^o$
~~Electron position sqrt($x^2 + y^2$) > 20.0~~
~~Sienin[0] > 0.1*(Siein[0] +Sienin[0]) *(energy in cone)~~
~~Chimney cut~~
~~Siprob[0], the lepton with highest prob (>0.9).~~

Triggers:
~~SPP02 (Tltw[2] & (1 << 1)) for 0405e~~
~~SPP09 (Tltw[2] & (1 << 8)) for 06e and 0607p~~

Jet selection:
$E_T > 2.5$ GeV && $P_T < 30$
|eta| < 1.0
Using "MCHMJets" (massive), the leading (P_T) jet only
Hadron level

* Use all the true MC variables and remove all the detector dependences