Measuremet of azimuthal decorrelation angle between the leading jet and the scattered lepton in deep inelastic scattering at HERA

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We present measurements of the azimuthal decorrelation angle between the leading jet and scattered lepton in deep inelastic scattering. 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 with an electron-ion collider. 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 kinematic region covered by the HERA ep DIS data is revisited with the emphasis on the physics leading to azimuthal decorrelation. These measurements were obtained by the ZEUS experiment during the HERA II data-taking period, corresponding to integrated luminosities of 330 pb^{-1}, respectively. The measurements showing good agreement with predictions from QCD calculations.

From the previous presentation

- Use MC sample with diffractive processes included
- Estimate PHP contamination
  - Ari_inc no cuts: 23.7E7, with cuts: 2.08E7 (ratio $\sim$0.1)
  - Pythia PHP no cuts: 26.0E7, with cuts: 0.06E7 (ratio < 0.01)
- Check cut $45 <$ Empz
- Hadron vs Detector plots for pt, Q^2 and jet multiplicity

Event selection

Data

- 040506e $\sim 189\text{pb}^{-1}$
- 0607p $\sim 143\text{pb}^{-1}$

MC

- ari_incl_nc_DIS_lowQ2_040506e
- ari_incl_nc_DIS_lowQ2_0607p

Phase space

- $10 < Q^2 < 350\text{GeV}^2$
- $y_{el} < 0.7$ && $y_{jb} > 0.04$

Cleaning cuts

- $-40 < \text{Zvtx/cm} < 40$
- $45\text{GeV} < E - p_z < 65\text{GeV}$
- $\text{Cal\_pt}/\sqrt{\text{Cal\_et}} < 2.5$

Electron cuts

- 10 GeV $<$ Energy (Siecorr)
- $140^o < \theta < 180^o$
- Electron position $\sqrt{x^2 + y^2} > 20$
- Sienin[0] $>$ 0.1*(Siein[0]+Sienin[0])
- Chimney cut
- Siprob[0], the lepton with hightest prob (> 0.9)

Triggers

- SPP02 (Tltw[2] & ($1 \ll 1$)) for 0405e
- SPP09 (Tltw[2] & ($1 \ll 8$)) for 06e and 0607p

Jet selection

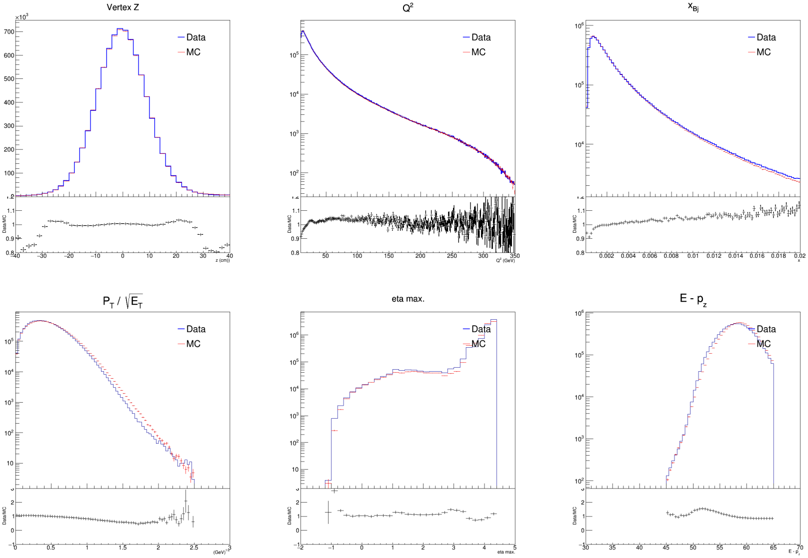
- $E_T > 2.5$ GeV && $P_T < 30$ GeV
- $|\eta| < 1.0$
- Using jet with highest E_T

Control plots

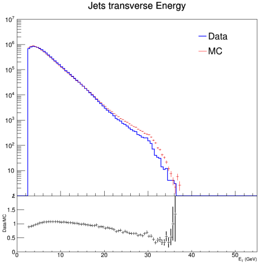
data: 8428266 events

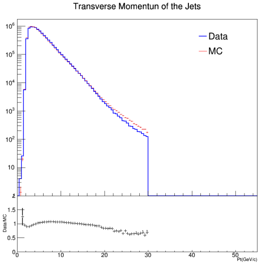
MC: 18976059 events

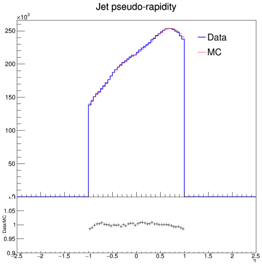
Control plots

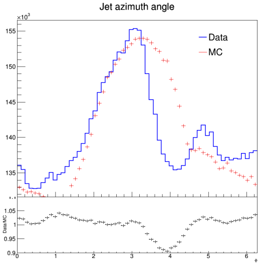


Control plots

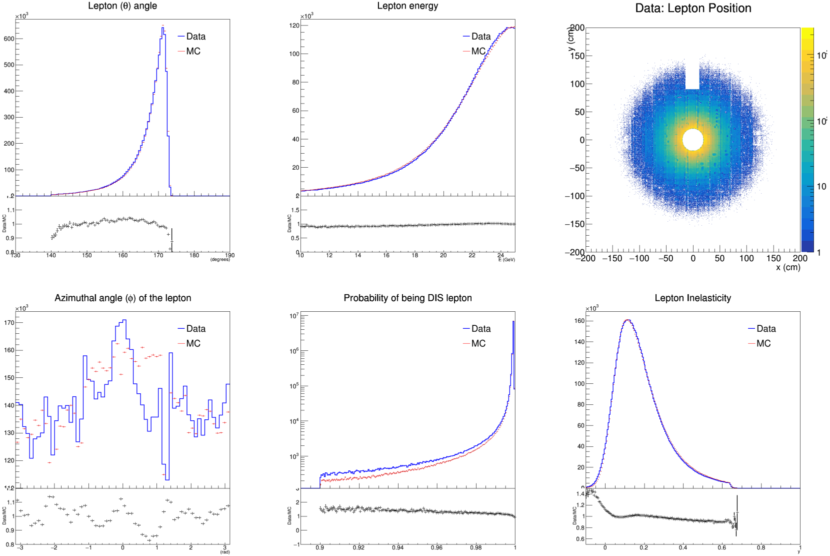




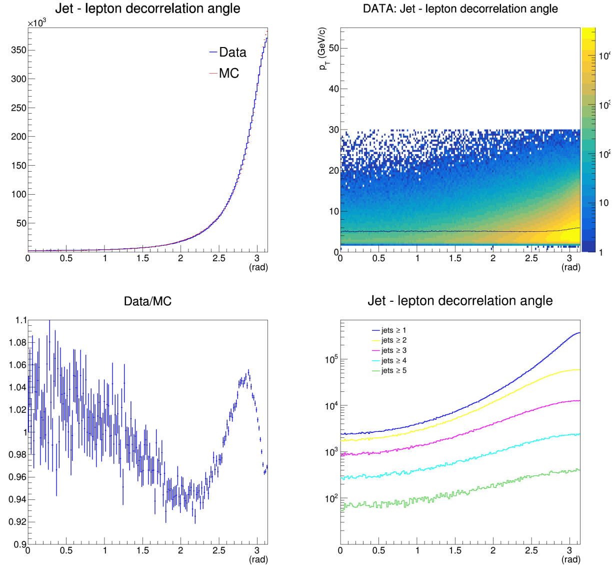




Control plots



Control plots



Note:
our measurement starts at $\underline{\Delta\varphi > 1.5}$

Control plots

Summary

- Minor decrease in high E_T^{Jet} and high P_T^{Jet} matching
- Improvement in η^{Jet} matching
- Better decorrelation angle matching for $\Delta\varphi < 2.3$ rad

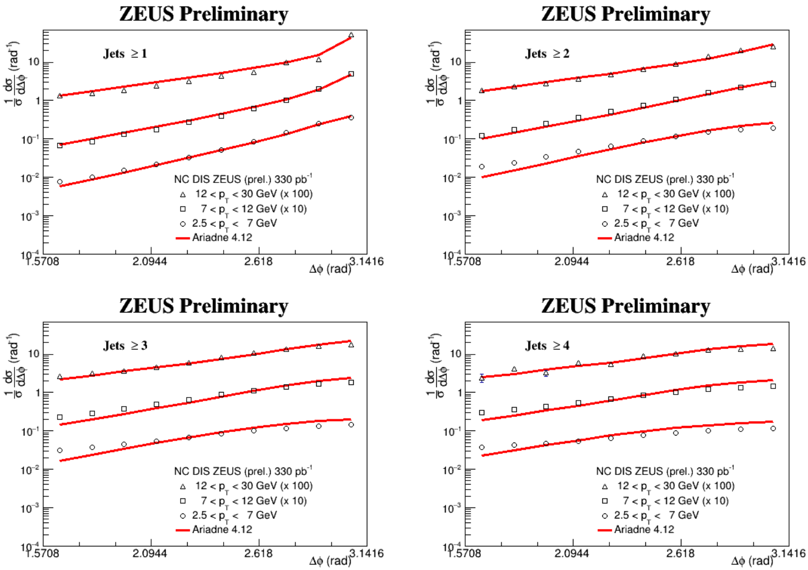
** see backups for control plots with previous setup*

Unfolding

TUnfold

- method: `TUnfoldDensity::ScanLCurve()`
- `kRegModeCurvature` :$<=>$ regularize the 2nd derivative of the output distribution
- `kEConstraintArea` :$<=>$ enforce preservation of the area
- `kDensityModeBinWidth` :$<=>$ *regularisation scale factors to construct the matrix L are taken from multidimensional bin width*
- $N_{bins}^{true} = 20, \; N_{bins}^{reco} = 180$

Unfolding



Note: *these are not preliminary plots*

Unfolding

L-curve

$$L_1 = (y - Ax)^T V_{yy}^{-1} (y - Ax),$$
$$L_2 = \tau^2 (x - f_b x_0)^T (L^T L)(x - f_b x_0)$$

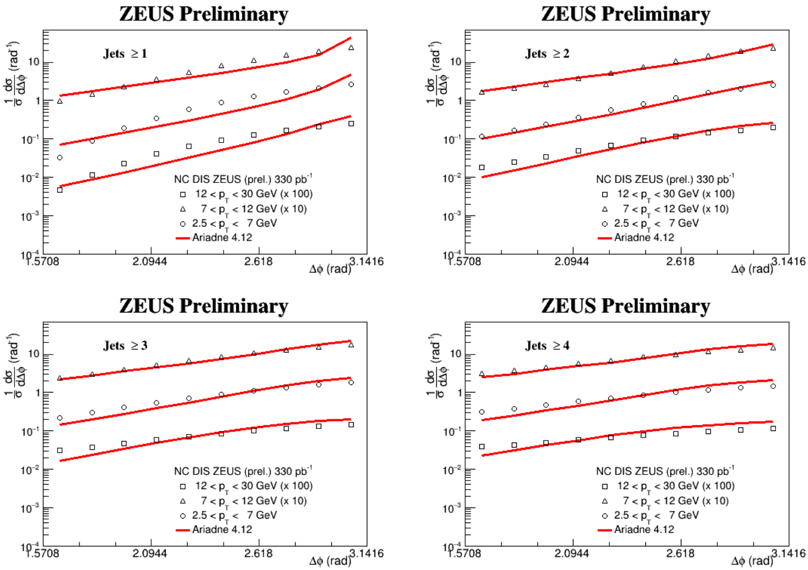
$$L_x^{curve} = \log L_1,$$
$$L_y^{curve} = \log \frac{L_2}{\tau^2}$$

Stefan Schmitt's advice

Eigenvalue analysis of the error matrix:

- run TUnfold without limits on τ
- extract covariance matrix V of the unfolded data
- determine the eigenvalues λ of this matrix
- limit τ with: $\tau_{min} = \frac{1}{\sqrt{\lambda_{max}}}$, $\tau_{max} = \frac{1}{\sqrt{\lambda_{min}}}$

Unfolding (constrained τ)



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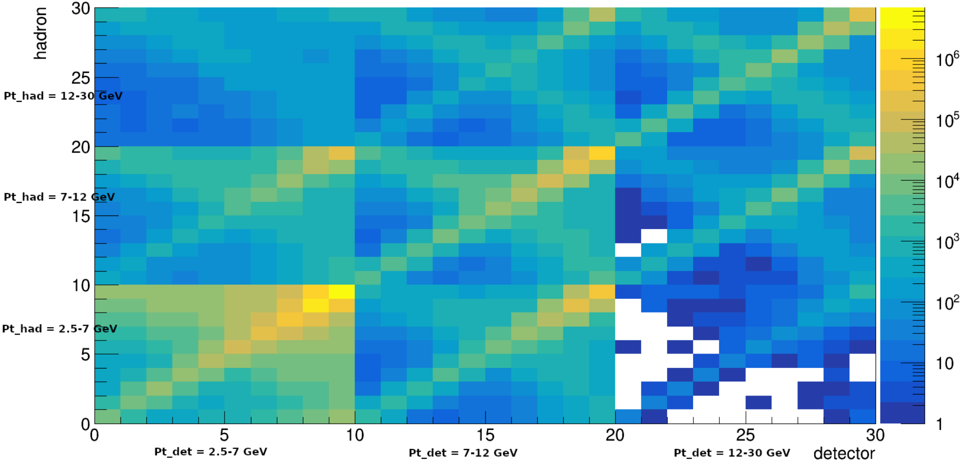
Unfolding, 4D correlation of $(\Delta\varphi, p_T)$



Unfolding

Summary

- 1D unfolding yields satisfactory result,
- but further investigation should be performed due to
  - doubts about shape of an L-curve (*see backups*), and
  - (maybe) underestimated uncertainties
- 2D unfolding is in progress

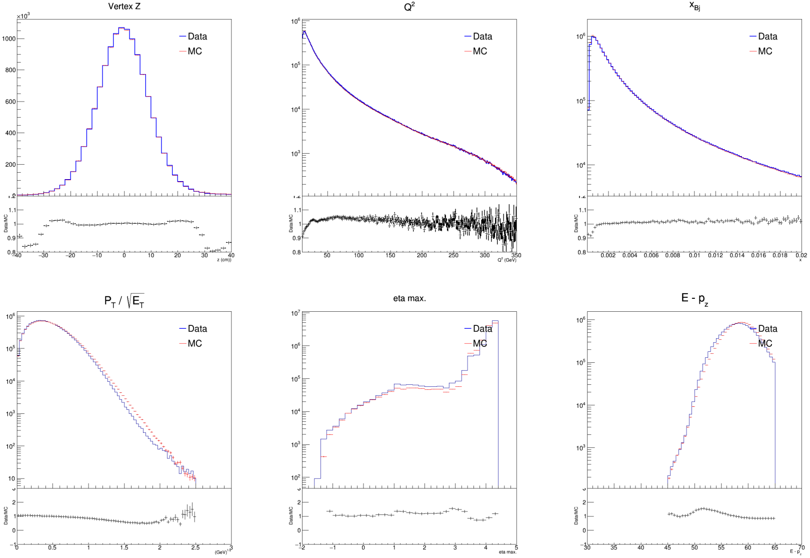
Wider η_{Jet} range

data: 12675772 events

MC: 29241421 events

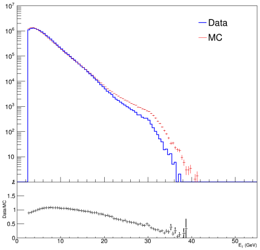
- $-1.5 < \eta_{Jet} < 1.8$

Control plots (wider η_{Jet})

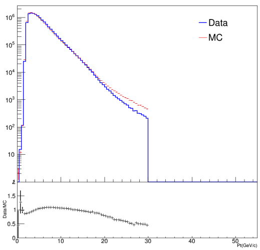


Control plots (wider η_{Jet})

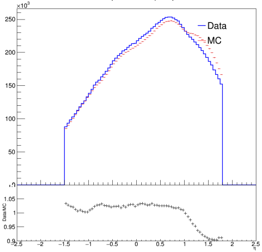
Jets transverse Energy



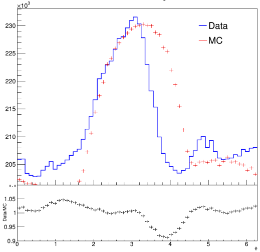
Transverse Momentun of the Jets



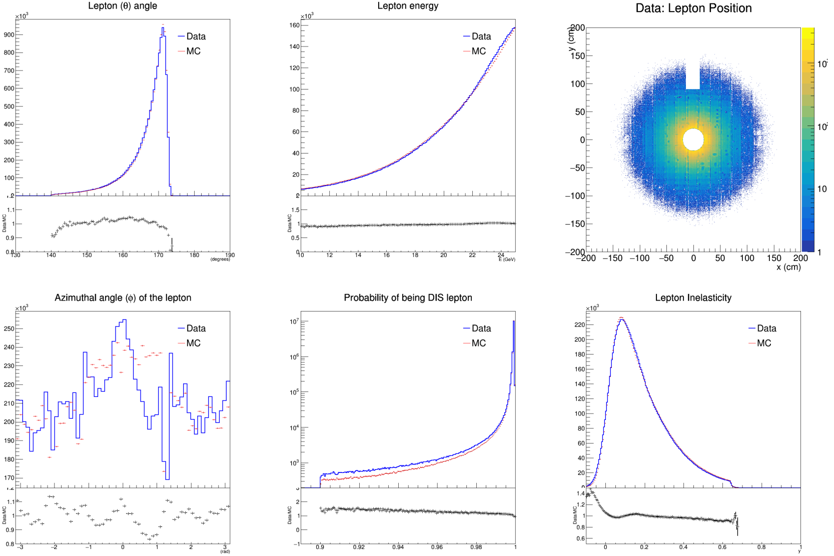
Jet pseudo-rapidity



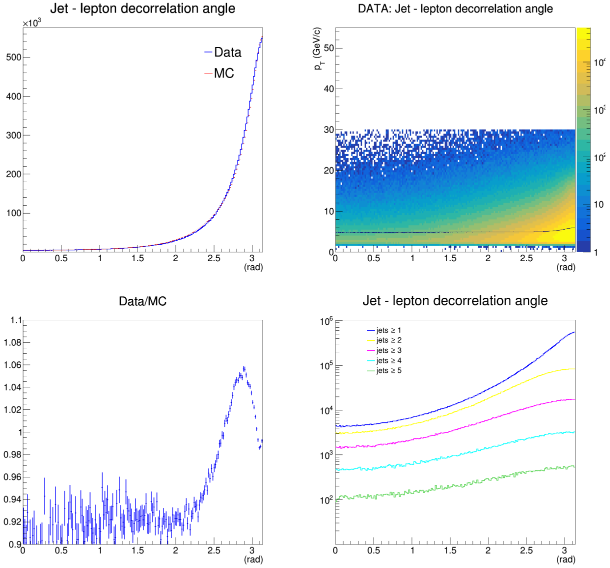
Jet azimuth angle



Control plots (wider η_{Jet})



Control plots (wider η_{Jet})



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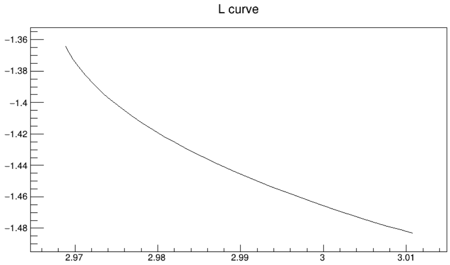
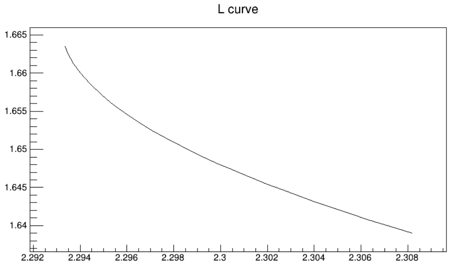
Wider η_{Jet} range

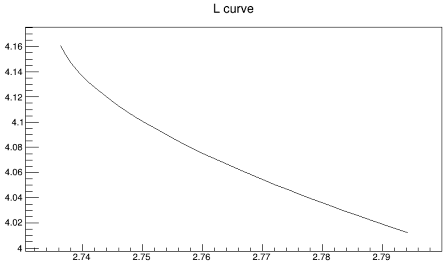
- still good matching at low η
- divergence at high η (known to exist), and
- it has no significant influence on $\Delta\varphi > 2.3$

Backup

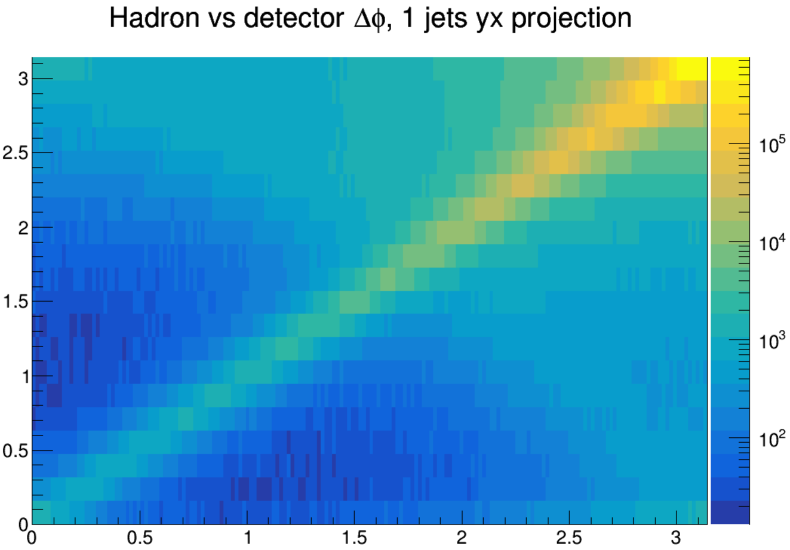
Unfolding, L-curves for $N_{Jet} \geq 1$



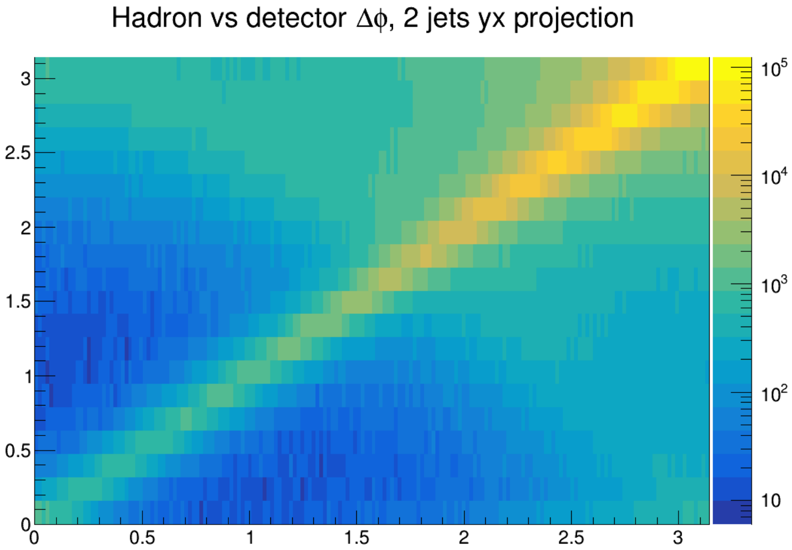




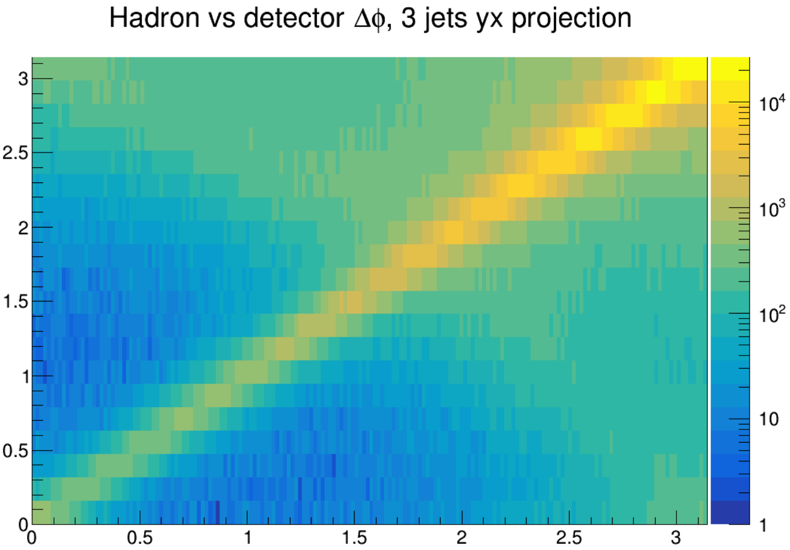
Unfolding, correlation matrix ($N_{Jets} \geq 1$)



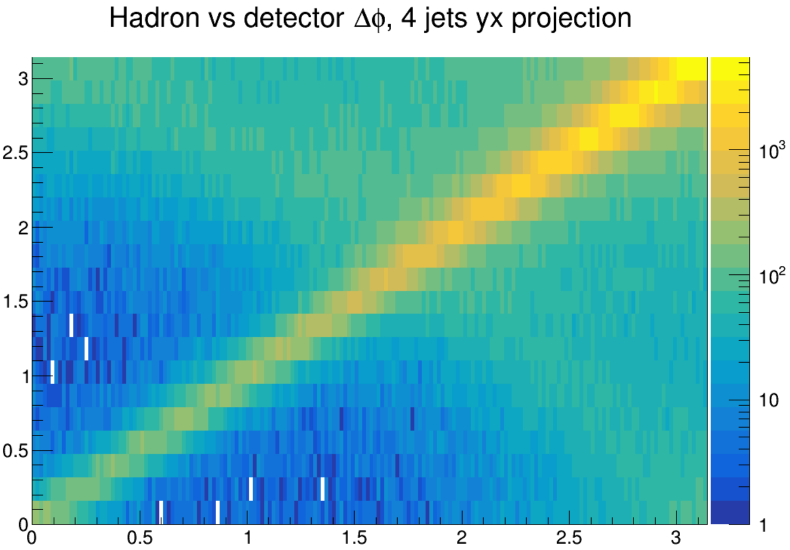
Unfolding, correlation matrix ($N_{Jets} \geq 2$)



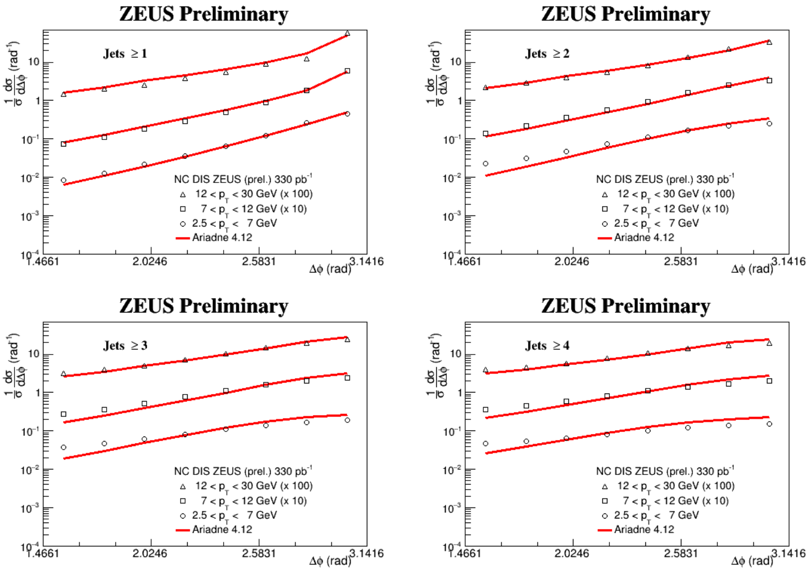
Unfolding, correlation matrix ($N_{Jets} \geq 3$)



Unfolding, correlation matrix ($N_{Jets} \geq 4$)



Unfolding, $N_{bins}^{true} = 15$, $N_{bins}^{reco} = 180$



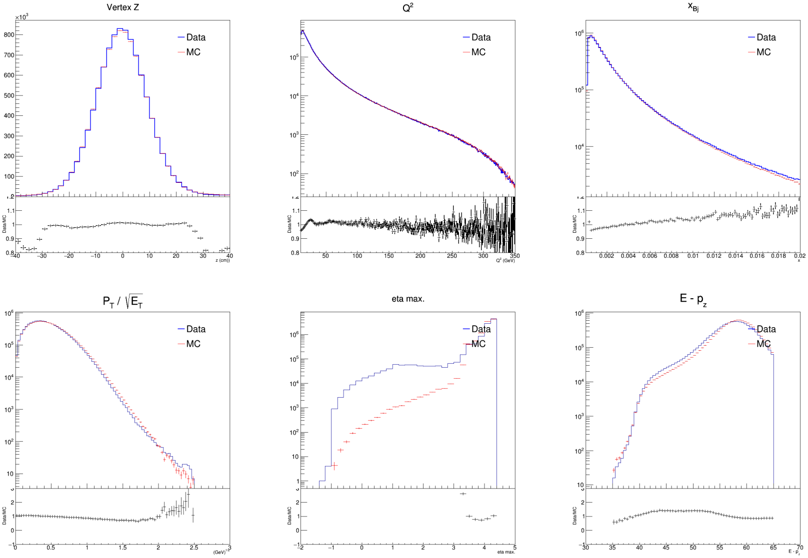
Note: *these are not preliminary plots*

Old setup

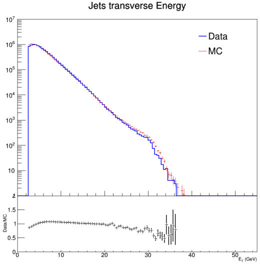
data: 9823230 events
MC: 18246736 events

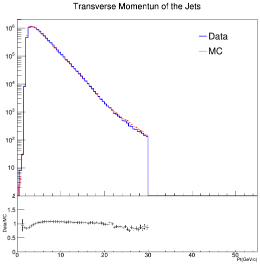
- MC: Ariadne_Low_Q2_NC_DIS
- $35 < E - p_z < 65$

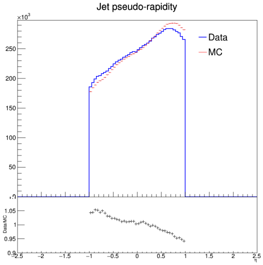
Control plots (old setup)

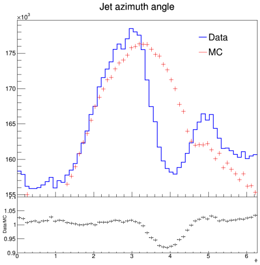


Control plots (old setup)

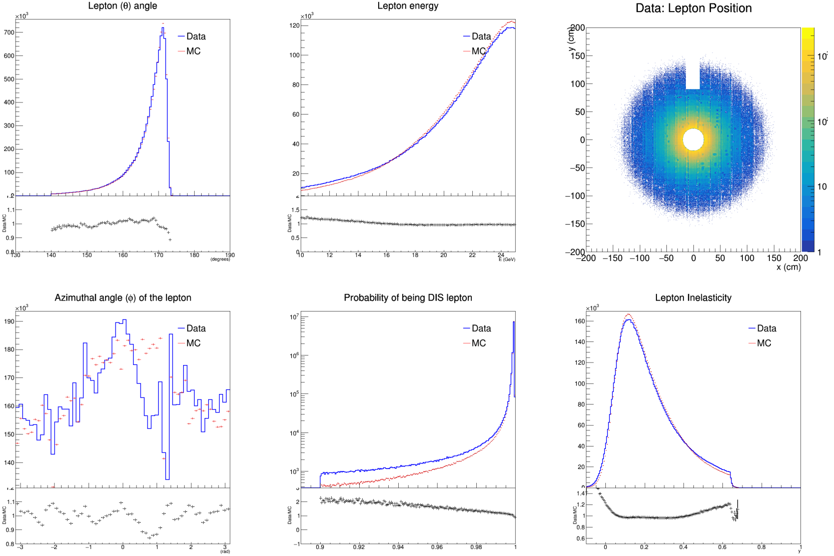




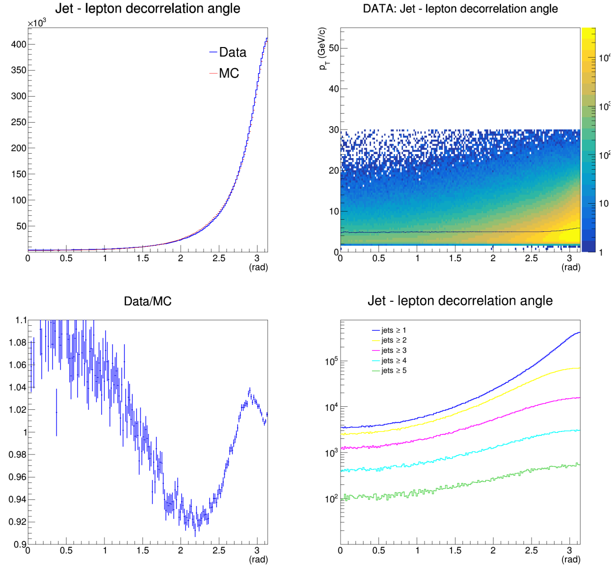




Control plots (old setup)



Control plots (old setup)



Note:
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