Determination of the calorimeter jet energy scale using the ZEUS detector

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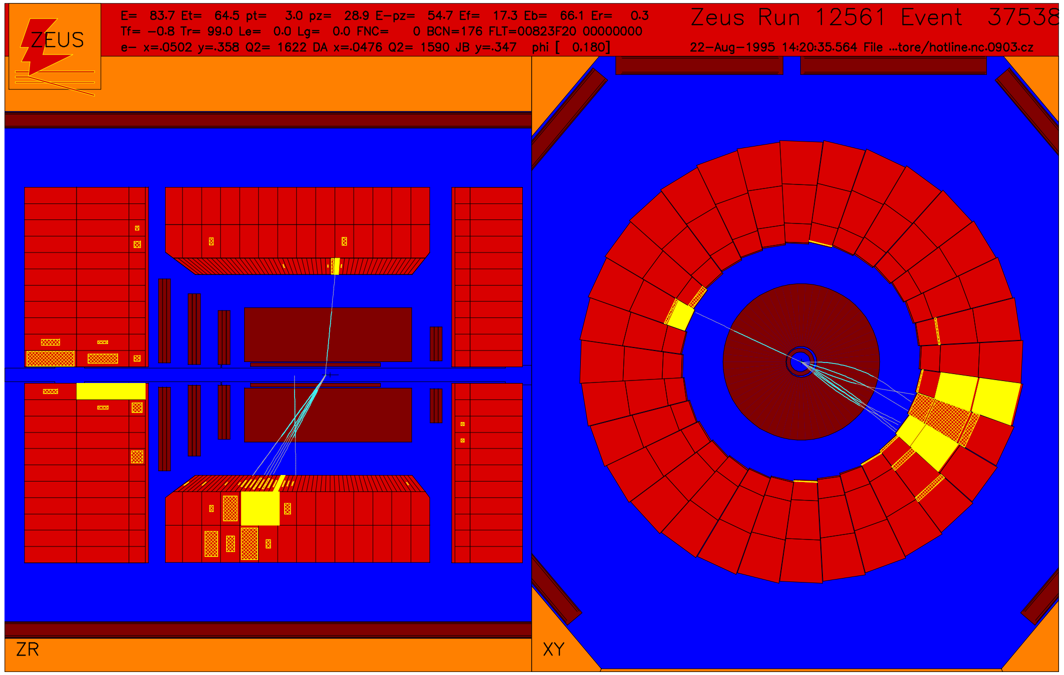
On behalf of the ZEUS Collaboration

- Introduction and motivation.
- Methods for correcting jet energies.
    - Use of energy flow-objects (EFOs) and momentum balance in NC DIS.
    - Correction using MC and tracking information in the jets.
- Energy scale difference between data and MC.
- Conclusions.

Introduction - physics at ZEUS

$$e + p \rightarrow e + X$$



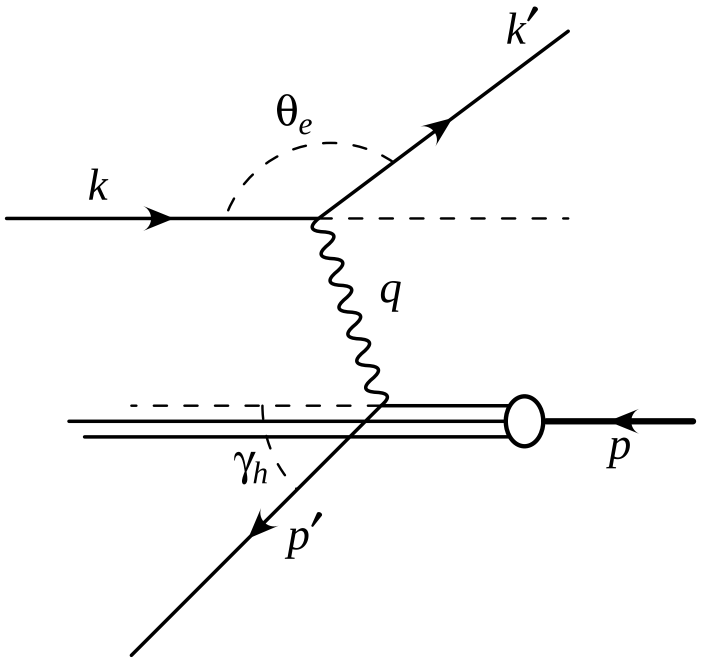
- **HERA collided 27.5 GeV e with 820 GeV p**
- **Use neutral current events as a tool where we can balance p_T of electron with hadronic system.**
- **Consider double angle (DA) reconstruction:**
  - **Angles more accurately measured than energies.**
  - **Roughly independent of calorimeter energy scale.**

Consider transverse (p_T) and longitudinal momentum ($y \sim E - p_Z$):

$$p_T^{\mathrm{DA}} = 2E_e \frac{\sin\gamma \cdot \sin\theta'_e}{\sin\gamma + \sin\theta'_e - \sin(\theta'_e + \gamma)}, \quad y^{\mathrm{DA}} = \frac{\sin\theta'_e(1 - \cos\gamma)}{\sin\gamma + \sin\theta'_e - \sin(\theta'_e + \gamma)}$$

θ'_e and γ are the scattering angle of the electron and current jet.

HERA kinematics



Momentum transfer (virtuality):

$$Q^2 = -q^2 = -(k - k')^2$$

Momentum fraction of struck parton:

$$x = \frac{Q^2}{2p \cdot q}$$

Inelasticity:

$$y = \frac{q \cdot p}{k \cdot p}$$

Inelasticity y can be calculated from the hadronic final state:

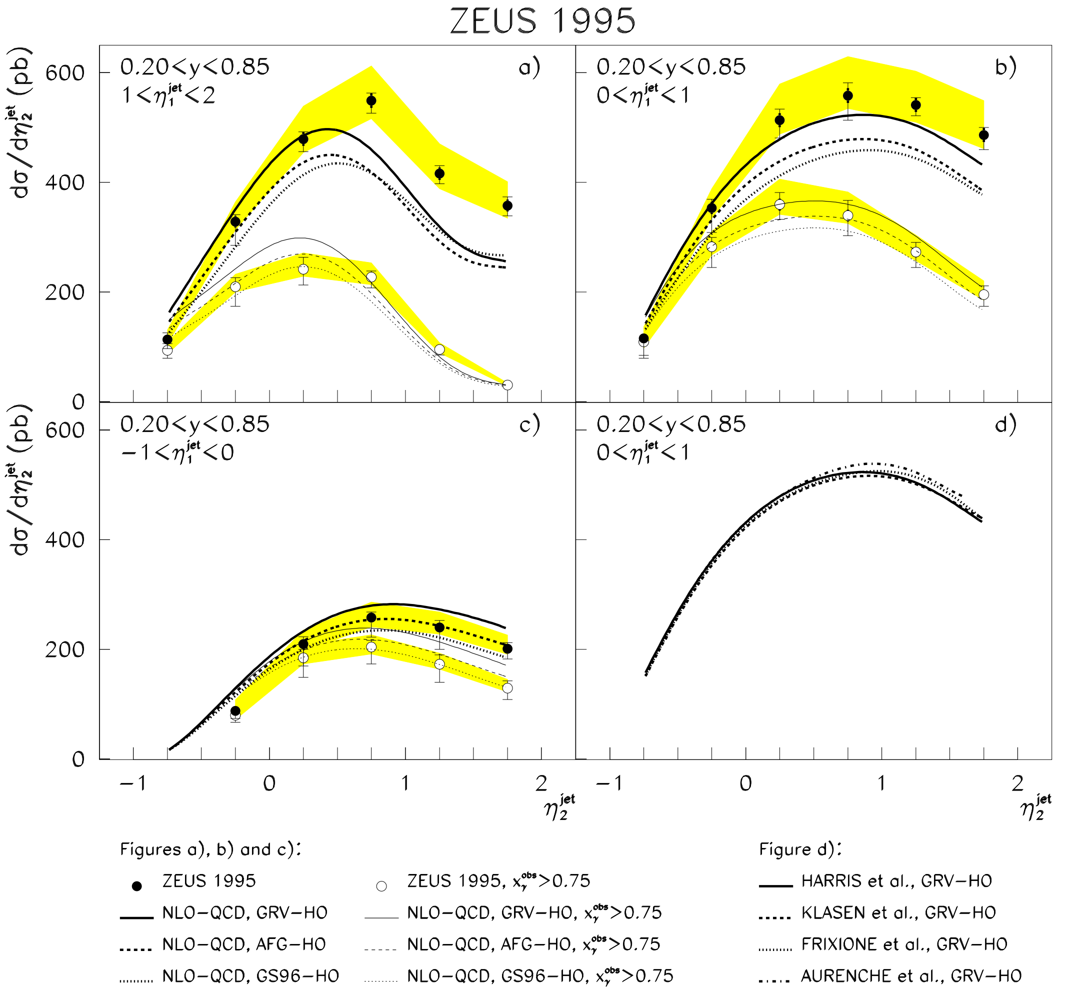
$$y_{\mathrm{JB}} = \frac{\sum_i (E_i - p_{Z_i})}{2E_e}$$

High $y \Rightarrow$ large hadronic activity in the central (not forward) region.

Importance of precise determination of the jet energy scale

Hadronic CAL scale uncertainty between data and MC and E_T^{jet} resolution are dominant systematics in jet measurements, $E_T^{\mathrm{jet}} \sim 10 - 100$ GeV.

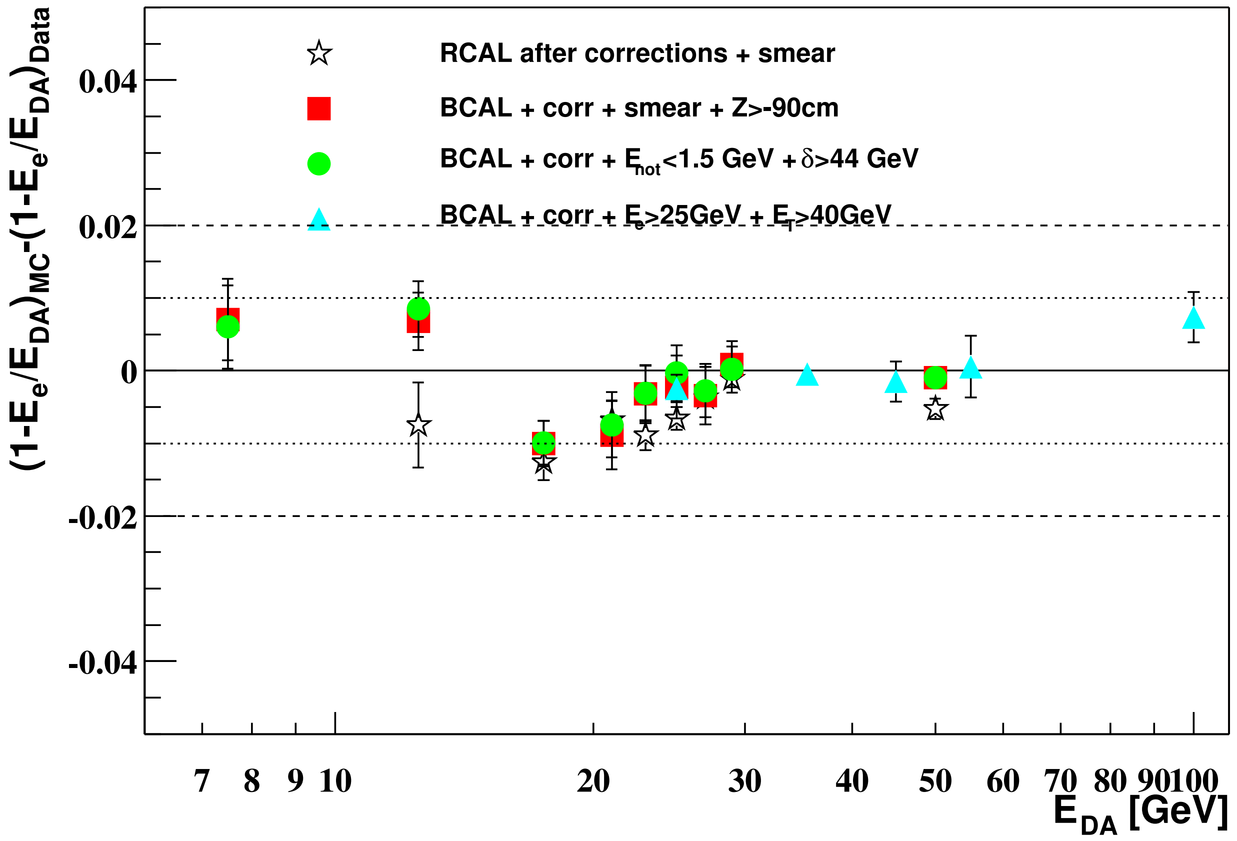
- **Previous studies lead to assigning an uncertainty on jet energy scale of ± 3%.**
- **Uncertainty of ± 3% ⇒ ± 15% error (yellow band) on cross section measurement.**
- **Precise measurements of jet physics (photon structure, α_s, etc.) need smaller uncertainty.**



$\eta = -\ln[\tan(\theta/2)]$, θ is measured from proton beam direction.

Electron energy scale uncertainty[*]

Electron energy scale found by comparing E_e with E_{DA} and p_{trk}.



Electron energy scale uncertainty is $\sim\ \pm\ 1\%$.

Jet energy scale is dependent on modelling, algorithm, etc..

Can we achieve similar value for jet reconstruction?

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[*] A. Lopez-Duran-Viani, DESY-THESIS-2001-056

Method I† - Energy flow-objects (EFOs)

EFOs use a combination of track and CAL cluster (island) information.

Where possible, use tracking information.

Energy corrections determined for CAL information for data and MC separately.