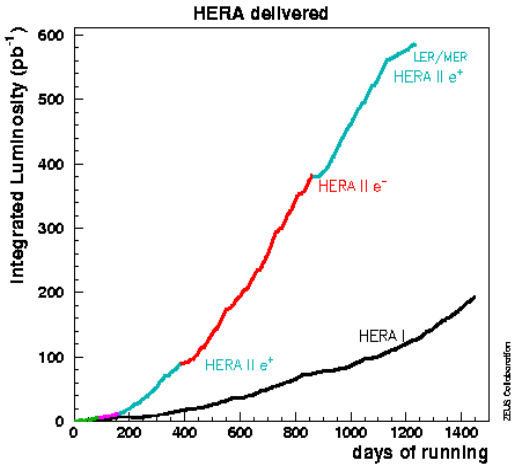
Measurement of beauty photoproduction at HERA II with the ZEUS detector

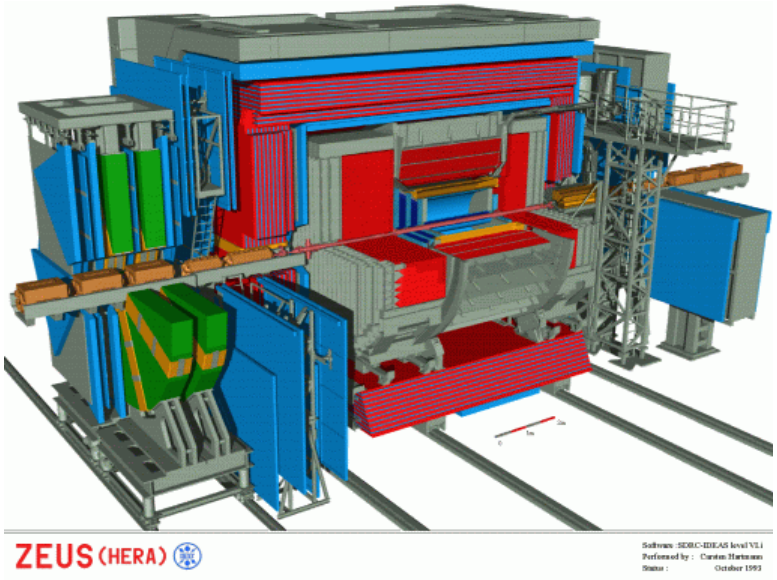
- What are HERA and ZEUS?
- Beauty in photoproduction
- Experimental method
- Some results
- Conclusions

HERA and ZEUS

- Located at DESY in Hamburg
- HERA collided electrons/positrons and protons
- Luminosity upgrade in 2001

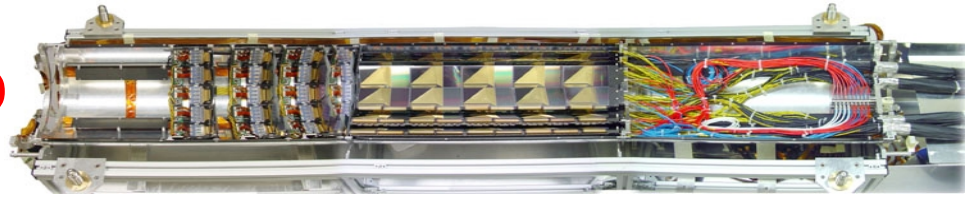


E_e = 27.6GeV E_p = 920GeV



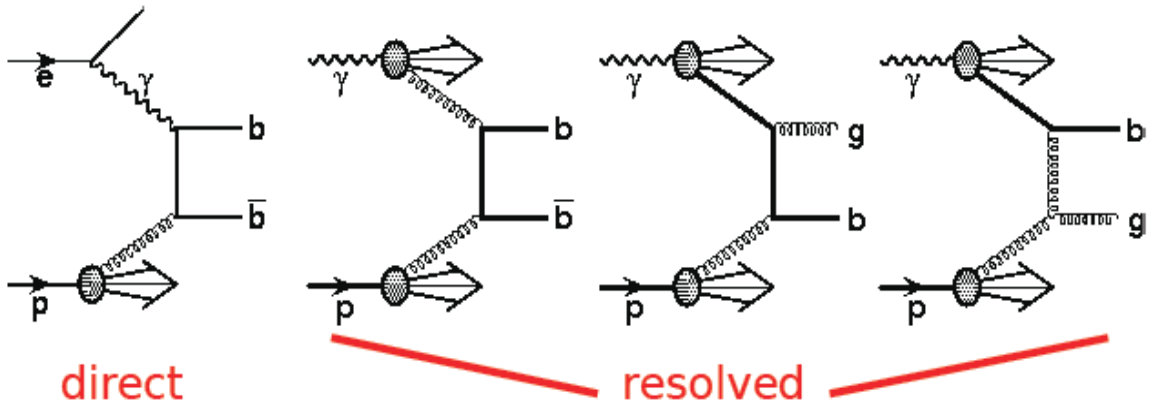
- During the upgrade, ZEUS installed the silicon MicroVertex Detector (MVD)
- Enables precision heavy flavour measurements

MVD



Heavy quark production

- Heavy quarks (b and c) predominantly by Boson-Gluon Fusion
- Production processes include those via direct and resolved photon



PDF

Proton and Photon structure functions
Direct sensitivity to gluon density in proton

→

Hard Scatter

Dynamics of NLO QCD
Large quark mass allows pQCD calculations

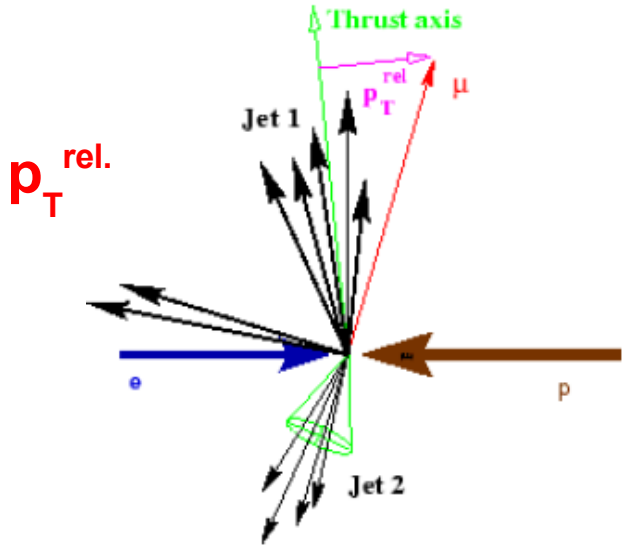
→

Fragmentation

Describes parton-hadron transition
Non-perturbative

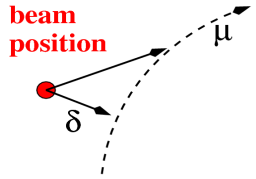
Finding beauty quarks

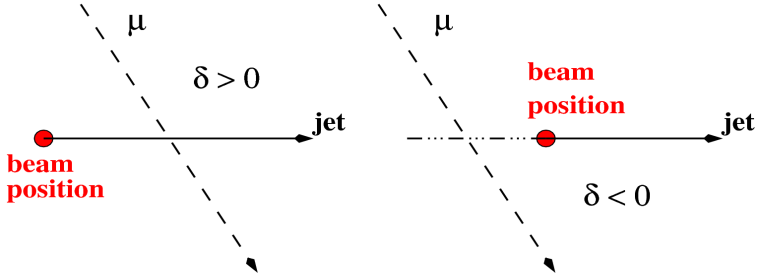
- Beauty production is relatively rare at HERA – need clean signature
- Predominant decay is b → c via virtual W emission
- Semi-muonic decay mode has B.R. ~10%
- Muon provides clean signature
- The two partons form two jets
- So, look for **2 jets** and a **muon**
- Use two variables to discriminate b from lighter quarks
- Properties of the b-quark:
  - Large mass m_b ~ 5GeV → Larger $p_T^{rel.}$
  - Long lifetime → Larger positive δ



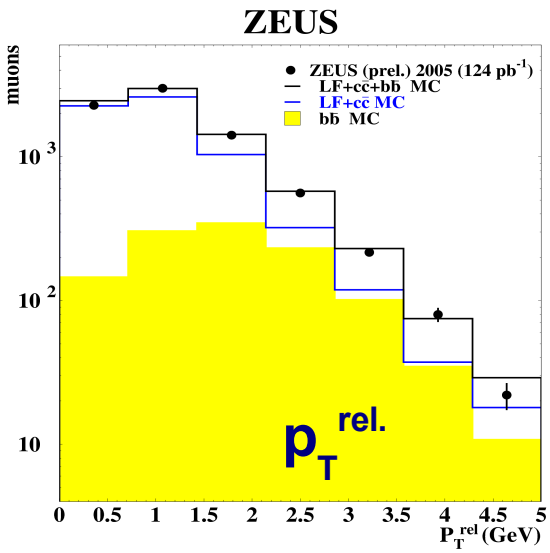
- This analysis uses e^-p data collected in 2005: ~124pb^{-1}
- $-2.5 < \eta^{jet} < 2.5$, $p_T^{jet1,2} > 7{,}6$ GeV
- $-1.6 < \eta^{\mu} < 2.3$, $p_T^{\mu} > 2.5$ GeV
- The muon must be associated with a jet
- Photoproduction Q^2 ~ 0GeV^2

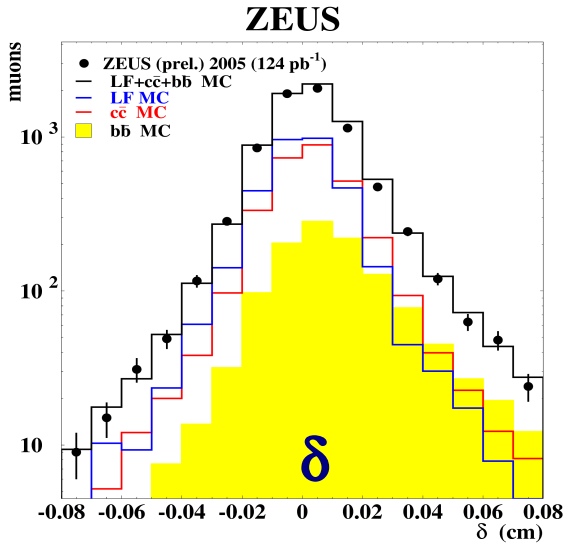
Signed Impact Parameter δ





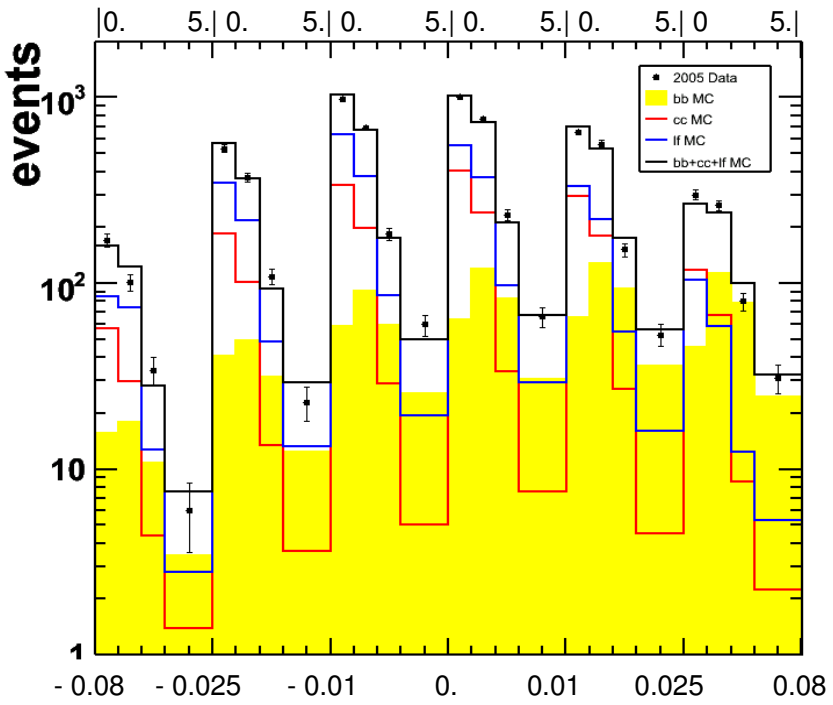
Extracting the beauty





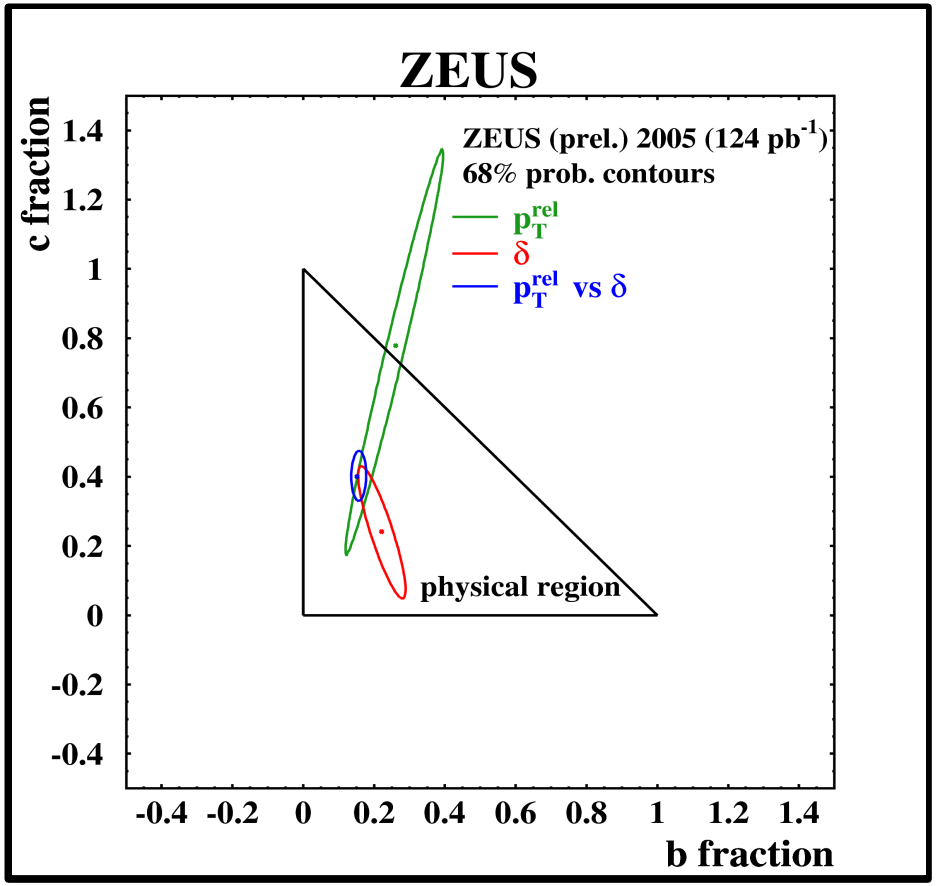
- Fraction of beauty events in the sample is extracted statistically
- Simultaneous 2-d fit of the data with the MC distributions

$$f = a_{b\bar{b}} f_{b\bar{b}} + a_{c\bar{c}} f_{c\bar{c}} + a_{lf} f_{lf}$$



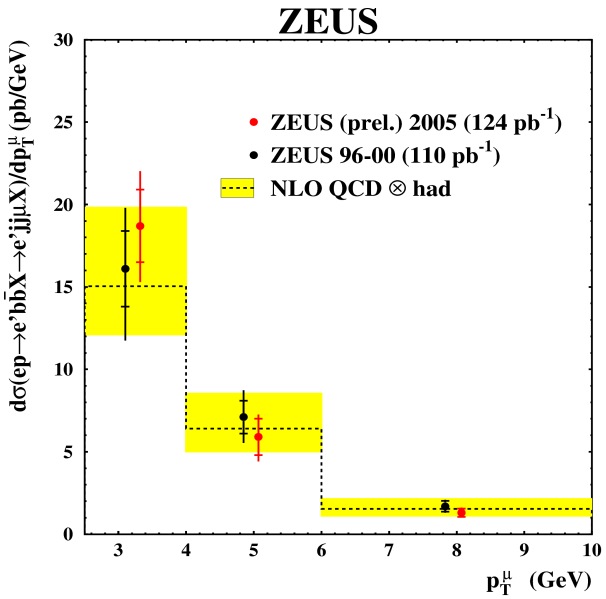
a_{bb} = 0.175 ± 0.013
a_{cc} = 0.316 ± 0.057
a_{lf} = 0.509 ± 0.055

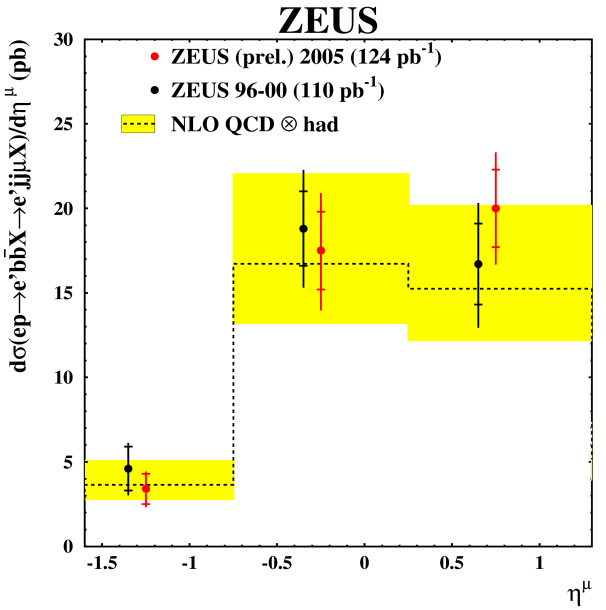
Extracting the beauty



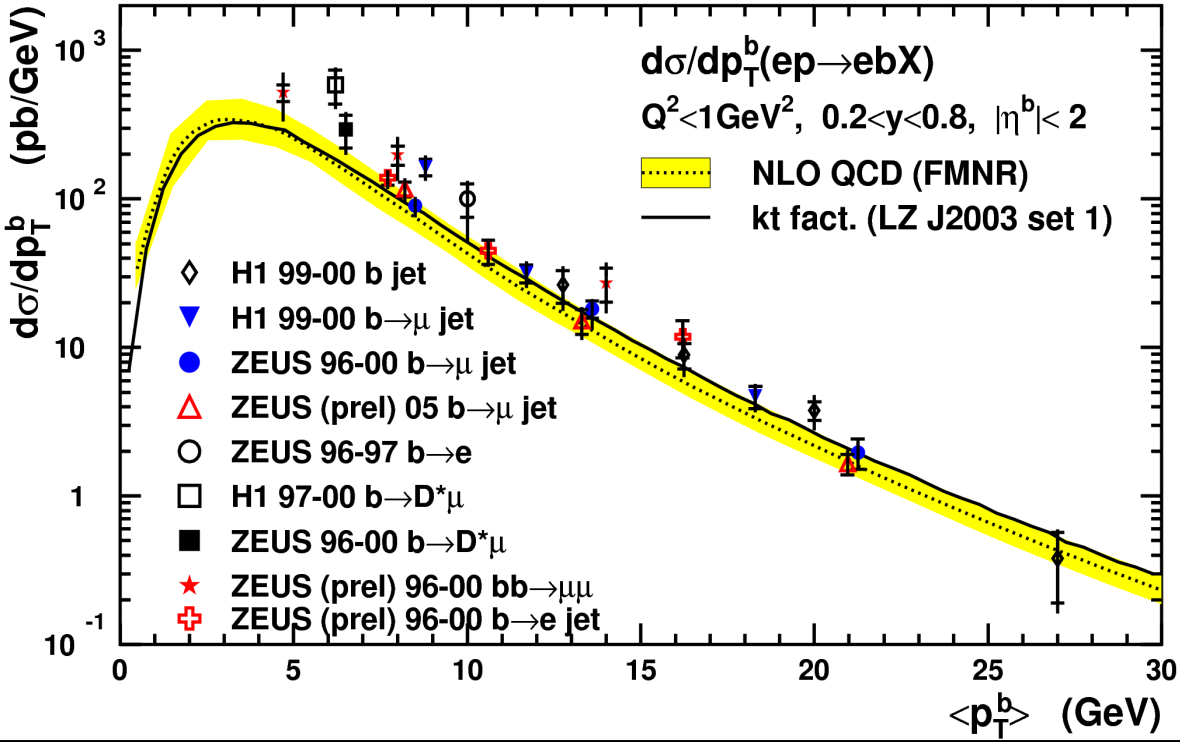
Using the two variables together provides a powerful tool for constraining the beauty fraction

Muon differential cross sections

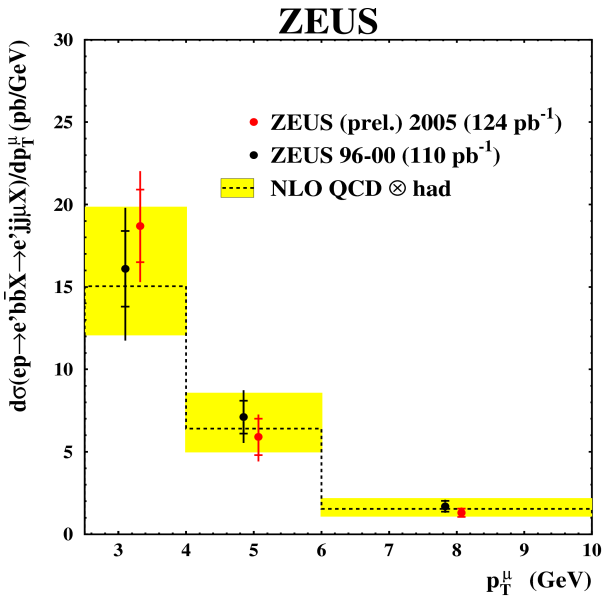


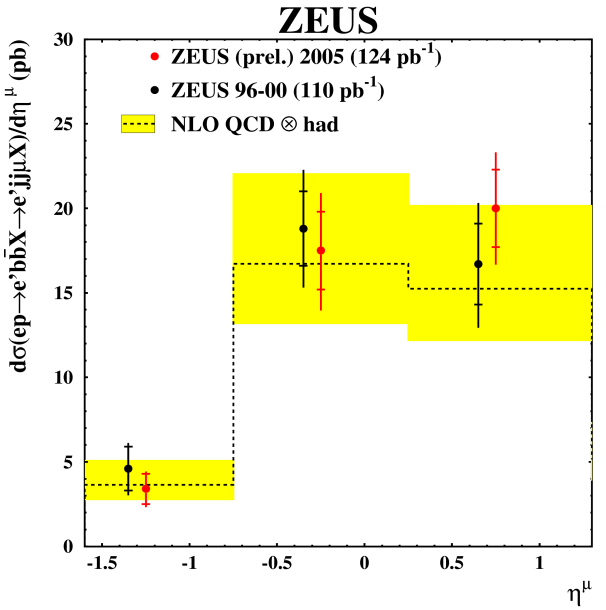


- Differential cross sections w.r.t muon p_T and η measured
- Compared to HERA I measurement made with $p_T^{rel.}$ fit only
- Also compared to NLO QCD prediction made with FMNR program (Frixione et al.)



Muon differential cross sections





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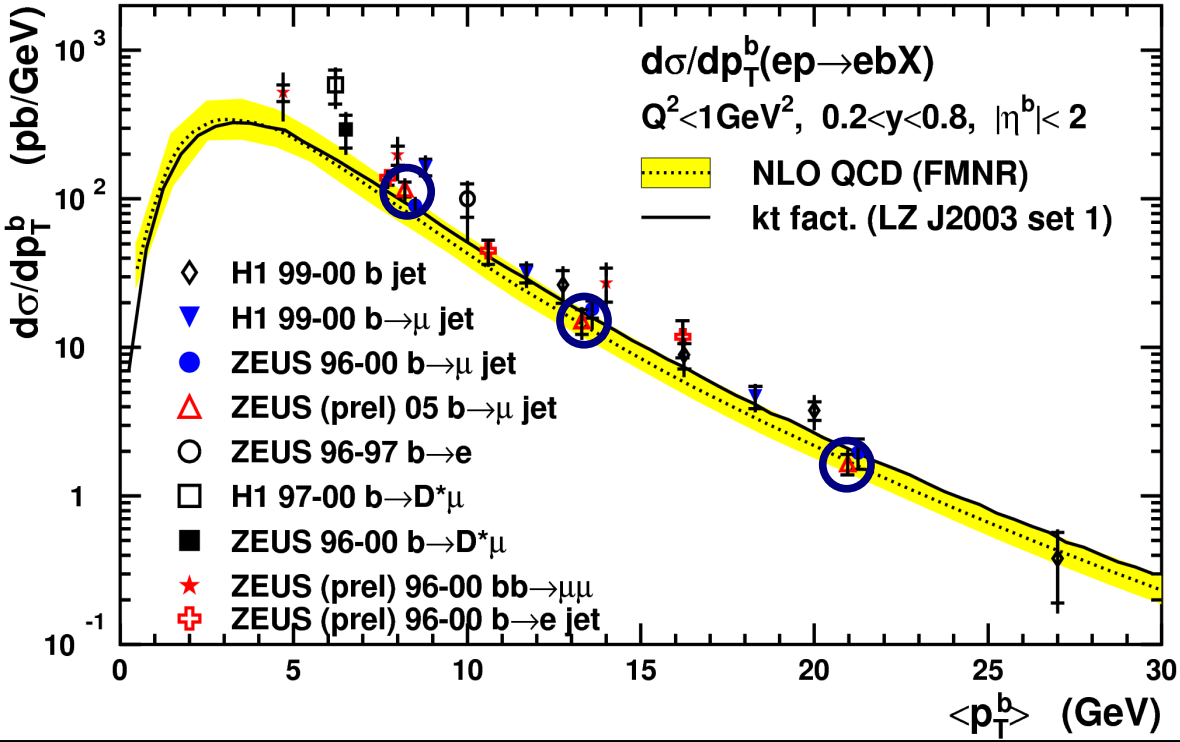
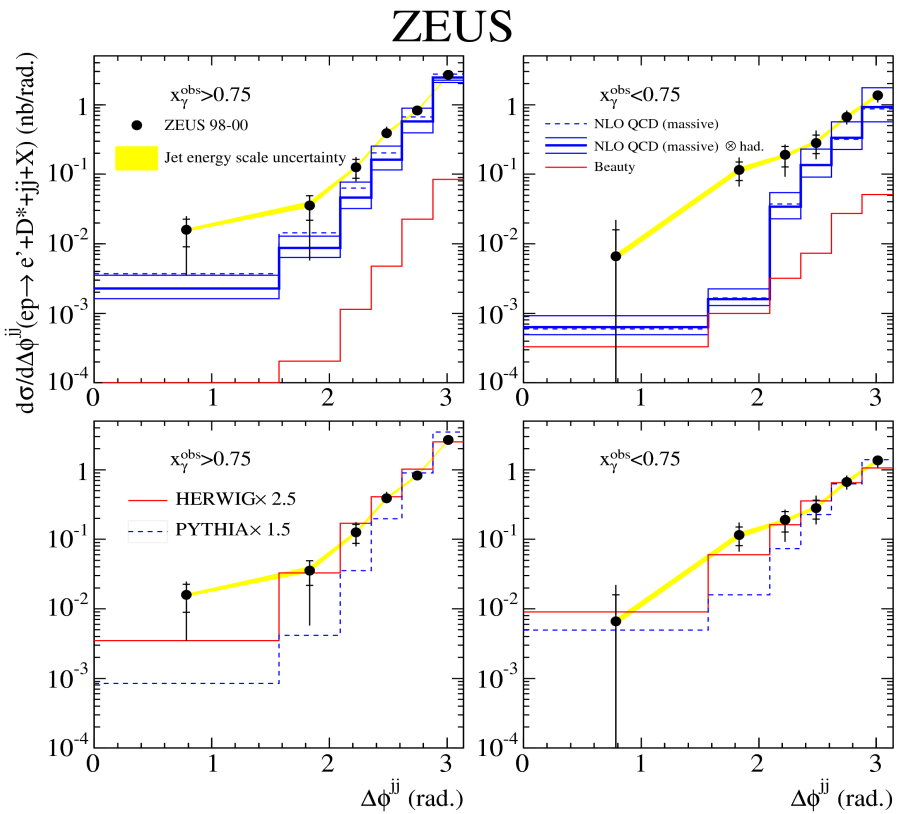
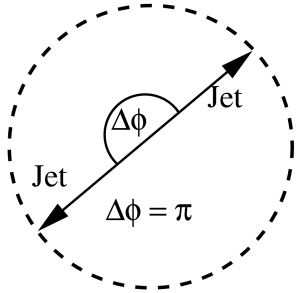


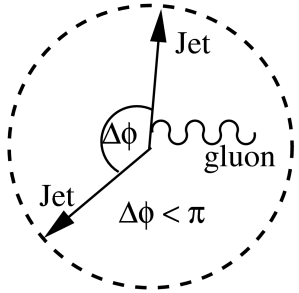
Dijet correlations in charm

- Dijet correlation cross sections, e.g. difference in azimuthal angle, have been measured in charm
- Such variables are sensitive to higher order topologies
- Discrepancies observed w.r.t NLO QCD prediction for low $\Delta\phi$
- Can we see this in beauty?



$$\Delta\phi_{jj} = \phi_{j1} - \phi_{j2}$$

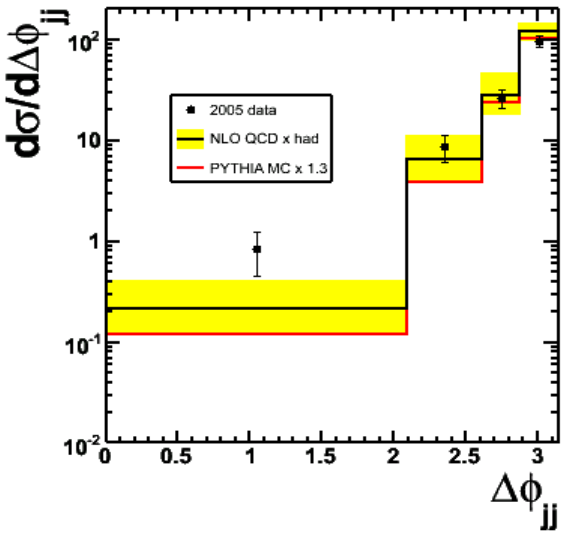


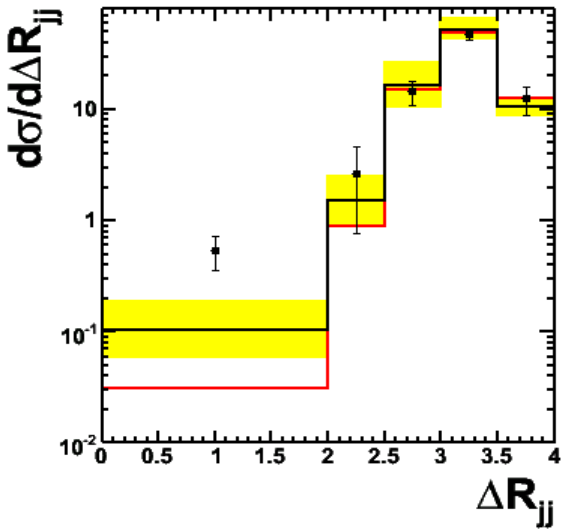


Inclusive Jet Cross Sections and Dijet Correlations in D* Photoproduction at HERA

Nuclear Physics B 729 (2005) 492-525

Dijet correlations in beauty

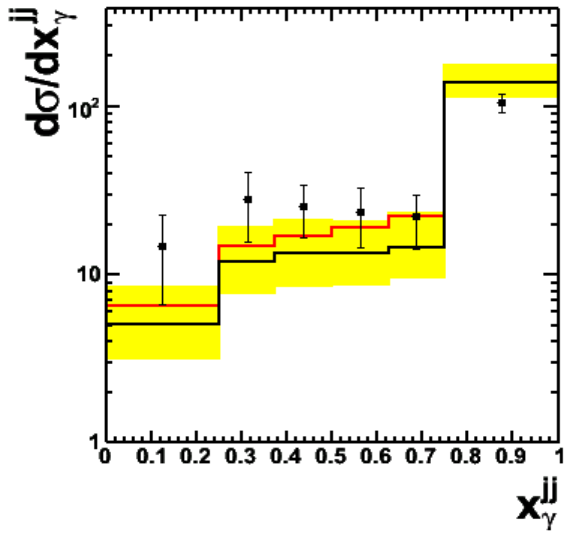




$$\Delta\phi_{jj} = \phi_{j1} - \phi_{j2}$$

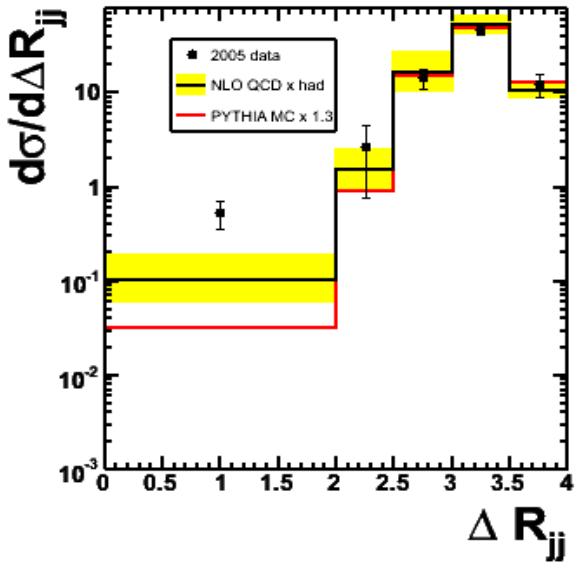
$$\Delta R_{jj} = \sqrt{(\eta_{j1} - \eta_{j2})^2 + (\phi_{j1} - \phi_{j2})^2}$$

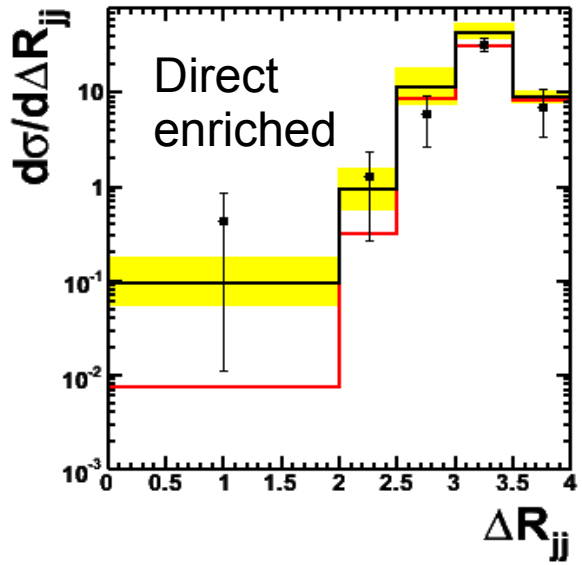
$$x_\gamma^{jj} = \frac{(E - P_z)_{j1} + (E - P_z)_{j2}}{2 E_e y}$$

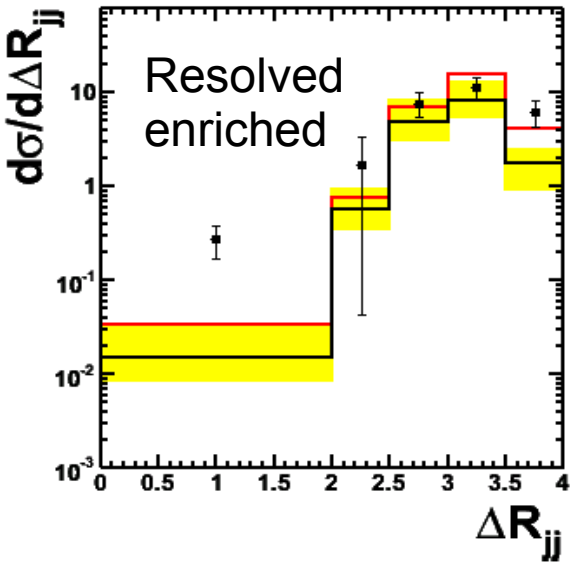


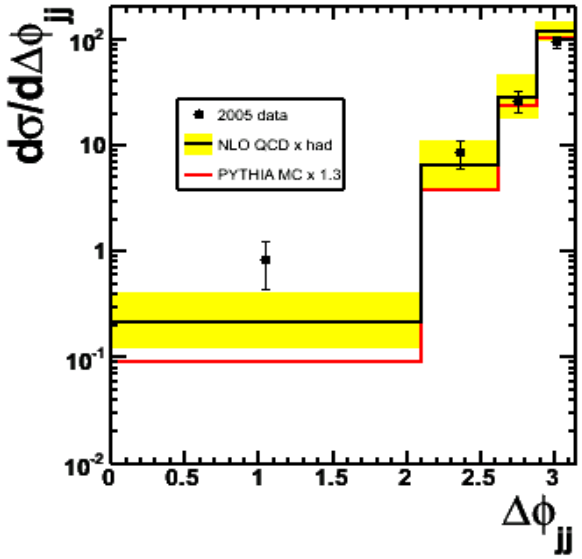
- Dijet variables were calculated using the two highest p_T jets
- Cross sections compared to NLO QCD prediction made with FMNR program (Frixione et al.)
- Hadronisation correction is included allowing the calculation made with parton level jets to be compared with the hadron level cross sections

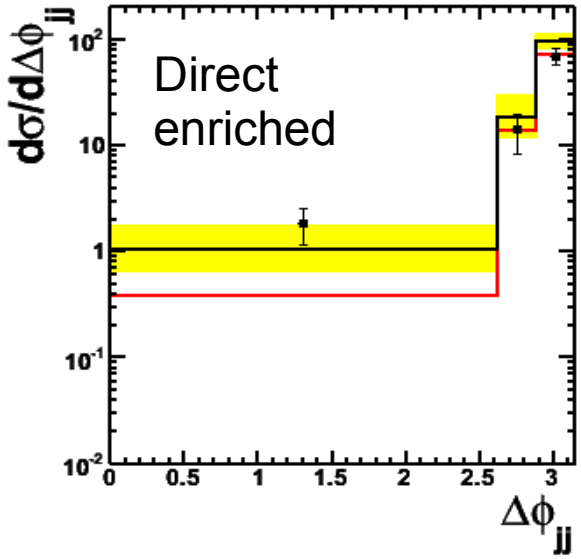
Dijet correlations in beauty

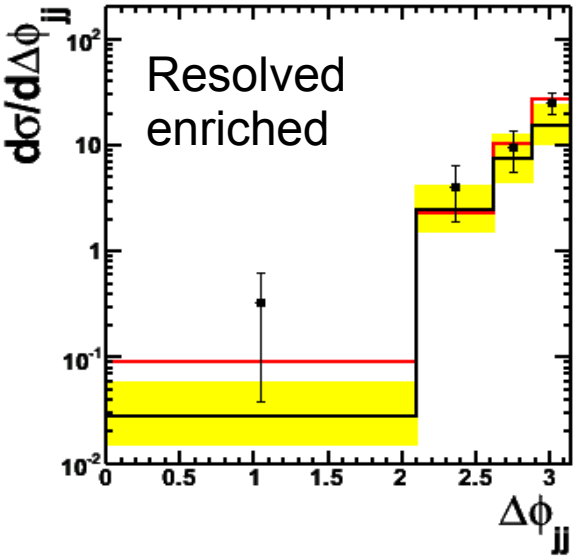






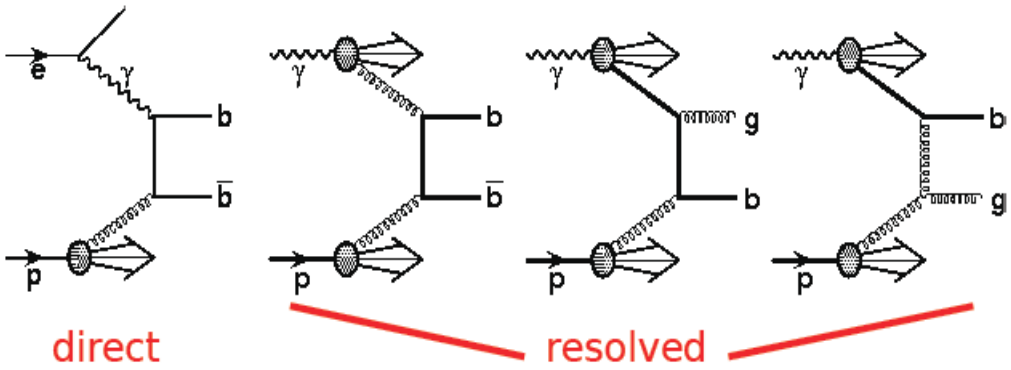






Conclusions

- The MVD has been used for the first time to measure beauty production
- The impact parameter method has been combined with the traditional $p_T^{rel.}$ method
- Muon cross sections have been measured and found to agree with previous measurements
- They have been compared with NLO QCD calculations and are well described
- Dijet correlations have been measured in beauty and compared with NLO predictions
- Agreement is reasonable and future measurements may reveal more
- Plan:
    - Evaluate the systematic errors on the dijet cross sections
    - Finalize the publication



- DIRECT PHOTON: interacts directly with the hard subprocess
- RESOLVED PHOTON: acts as a source of partons
- Experimental separation is defined as x_γ, the photon energy fraction (summing over the partons)

$$x_\gamma = \sum_i \frac{E_T^i e^{-\eta_i}}{2 E_e y}$$

- The observable quantity x_γ^{obs}, sums over the jets instead of the partons

$$x_\gamma^{obs} = \frac{(E - P_z)_{j1} + (E - P_z)_{j2}}{2 E_e y}$$

- Direct processes populate the highest regions of x_γ so we define:

DIRECT: $x_\gamma^{obs} \geqslant 0.75$ RESOLVED: $x_\gamma^{obs} < 0.75$