Beauty Production with the ZEUS HERA II Data

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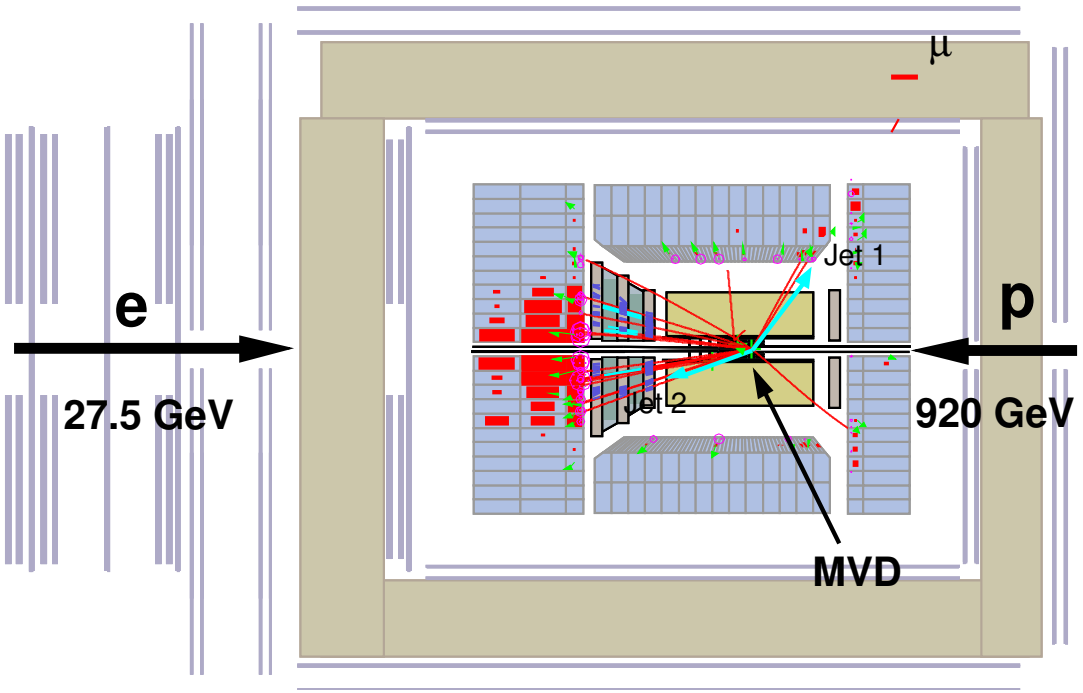
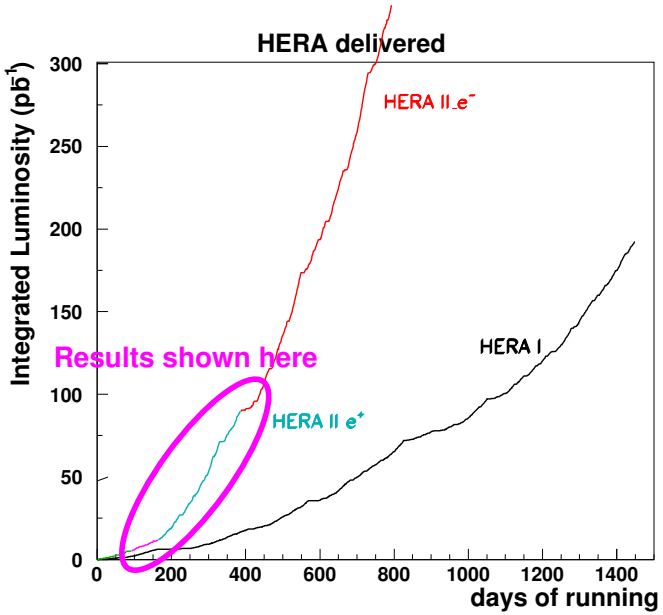
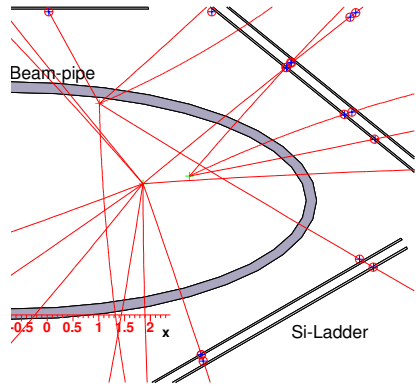
Outline

ZEUS and HERA II Running



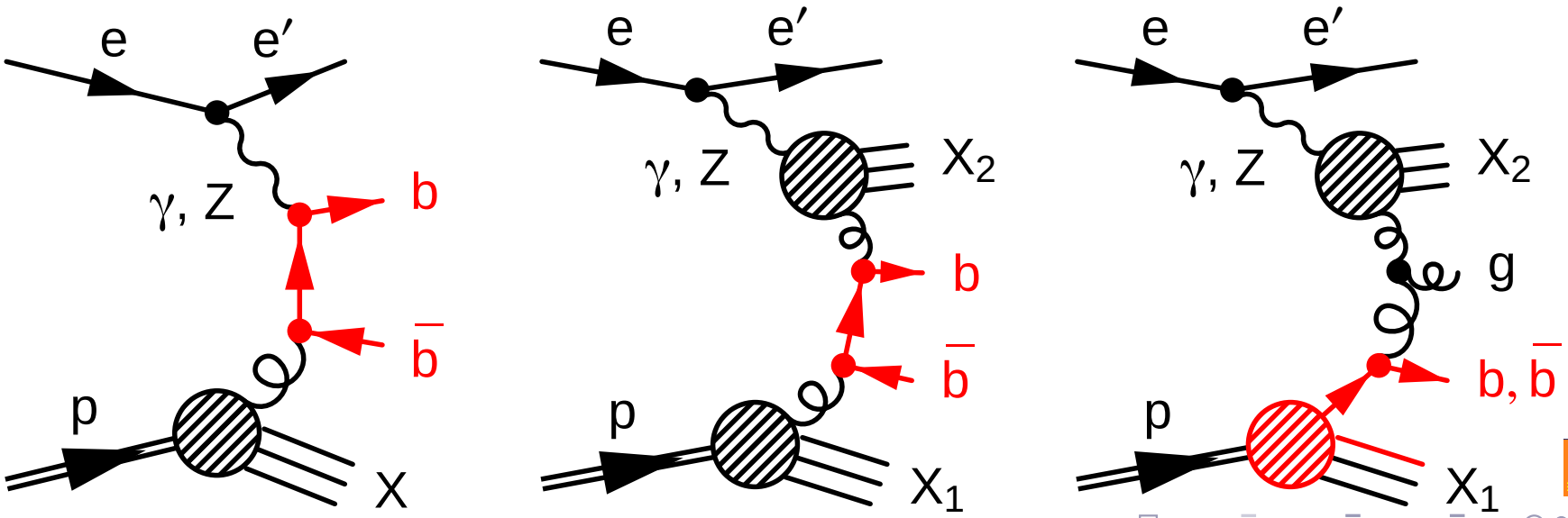


- HERA II upgrade: large increase of luminosity
- ZEUS micro-vertex detector taking data since 2003 (→ life-time tag)



Motivation

- Beauty production at HERA is good testing ground for pQCD
- Multiple scales: m_b, $p_\perp^b$ and Q^2
- Probe the b contribution to the proton structure function, $F_2^{b\bar{b}}$
- PYTHIA MC: LO + PS (includes flavour excitation diagrams)
- NLO QCD calculations available (FMNR, HVQDIS)



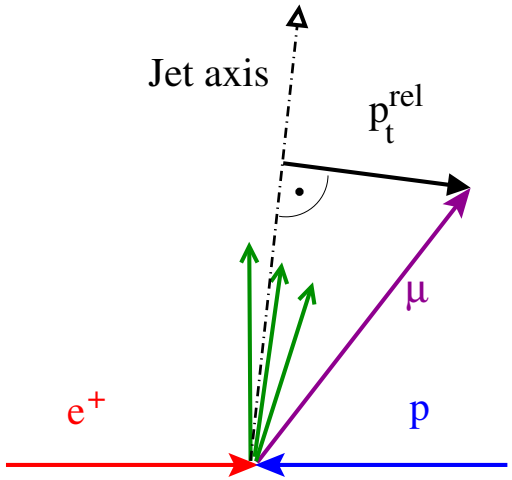
Beauty Extraction Methods

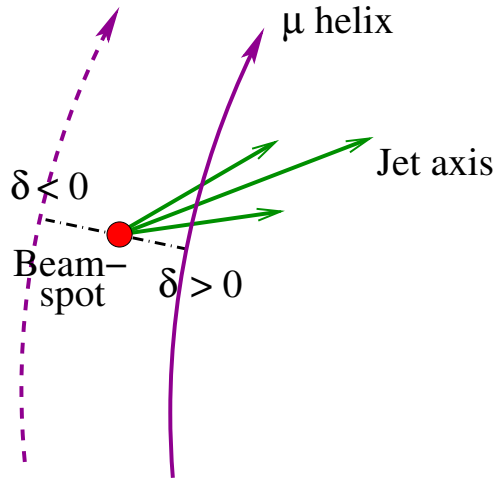
Component of μ momentum transverse to jet axis, $p_{\perp}^{rel}$

- Large for B decays because of large B mass

Signed μ impact parameter, δ

- Symmetrically distributed around zero for light flavours
- Positive tail for beauty and charm due to life-time

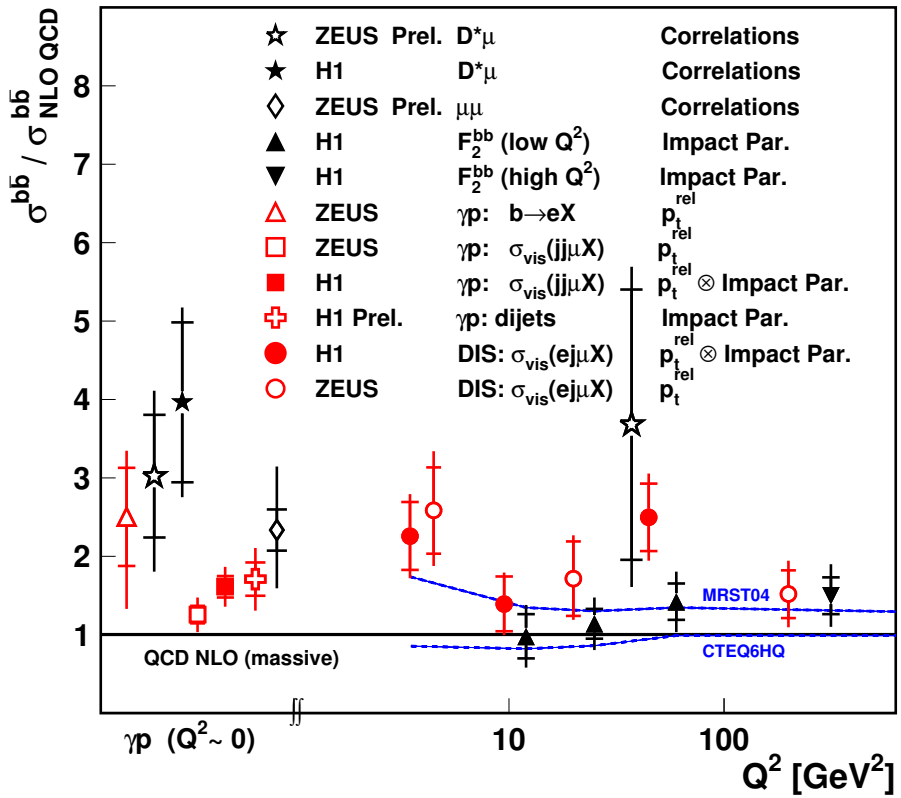




Previous Results

Situation:

- Most measurements agree with NLO QCD within 2σ
- Overall, NLO tends to somewhat underestimate the data especially towards low $p_\perp$ $\rightarrow$ investigate
- Statistics still low



Aim of HERA II:

- Increase statistics $\rightarrow$ single- and double-differential x-sections
- Reduce systematics by complementary measurements (B life-time)

Part I

Beauty in Photoproduction

Dijet PhP + μ Event Selection

2004 e^+p data: $\mathcal{L} = 33\,\text{pb}^{-1}$

Photoproduction:

- Veto on scattered e^+
- $0.2 < y_{JB} < 0.8$

Jet finding:

- $k_\perp$-clustering
- $N_{jets} \geq 2$
- $p_\perp > 7(6)\,\text{GeV}$
- $|\eta| < 2.5$

Associated μ:

- μ inside jet
- $p_\perp^\mu > 2.5\,\text{GeV}$
- $-1.6 < \eta^\mu < 2.3$
- μ-chambers + central tracking

Dijet PhP + μ Event Selection

Events selected: ≈ 1800

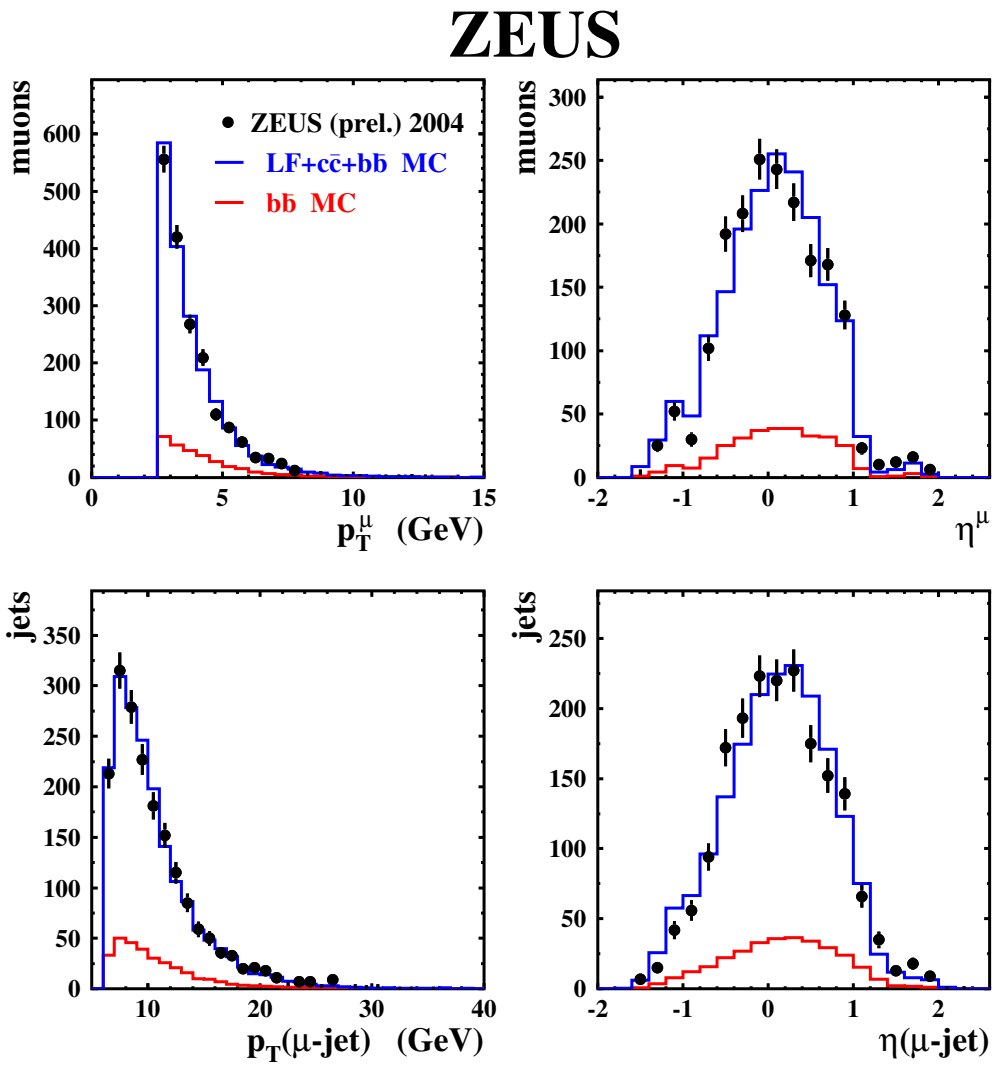
Signal:

- μ from SL decays of b and c

Background:

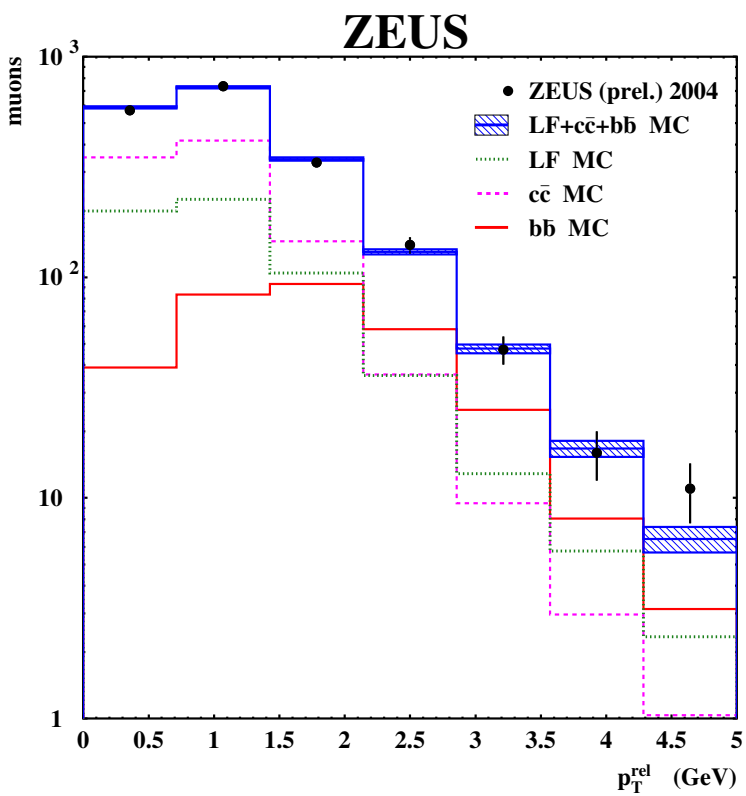
- Fake-μ from punch-through and in-flight decays from π, K

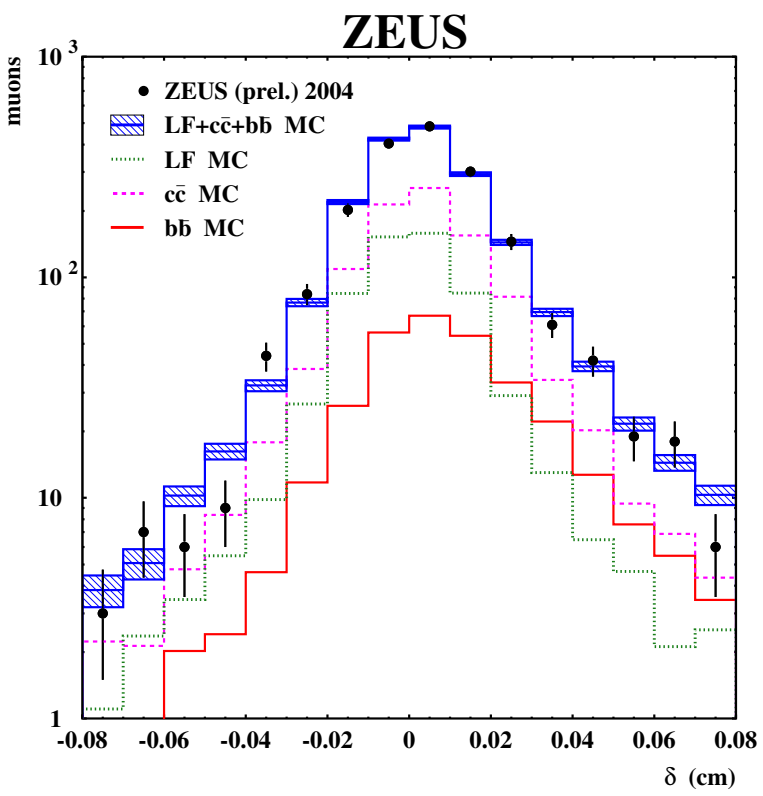
Shapes reproduced by PYTHIA 6.2



Beauty Extraction

- Combined fit of $p_{\perp}^{\mathrm{rel}}$ and impact parameter, δ





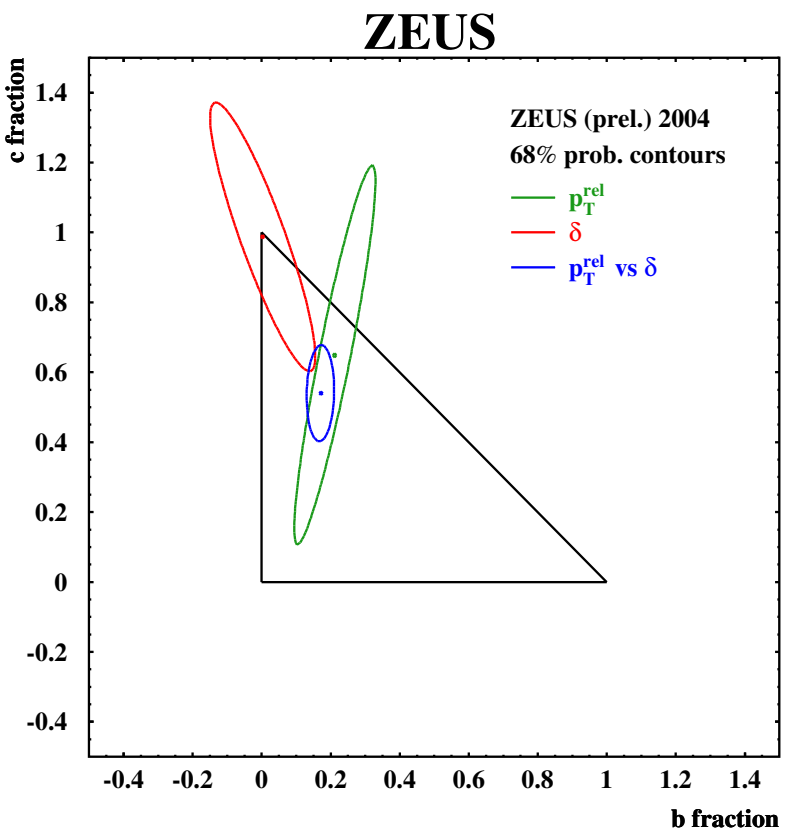
Beauty Extraction

Result:

$f_b = (16.7 \pm 2.6)\,\%$ $f_c = (52 \pm 10)\,\%$

Remarks:

- PYTHIA 6.2 templates used for b, c and light-flavours
- $p_\perp^{rel}$ shape of light-flavour MC corrected by inclusive dijet data
- Beam position measured run-by-run
- Resolution of δ in MC modeled on inclusive data
  (latest MVD alignment not in)



Results for $e^+p \to e^{+\prime} + b\bar{b} + X \to e^{+\prime} + \text{dijet} + \mu + X$

Kinematic region:

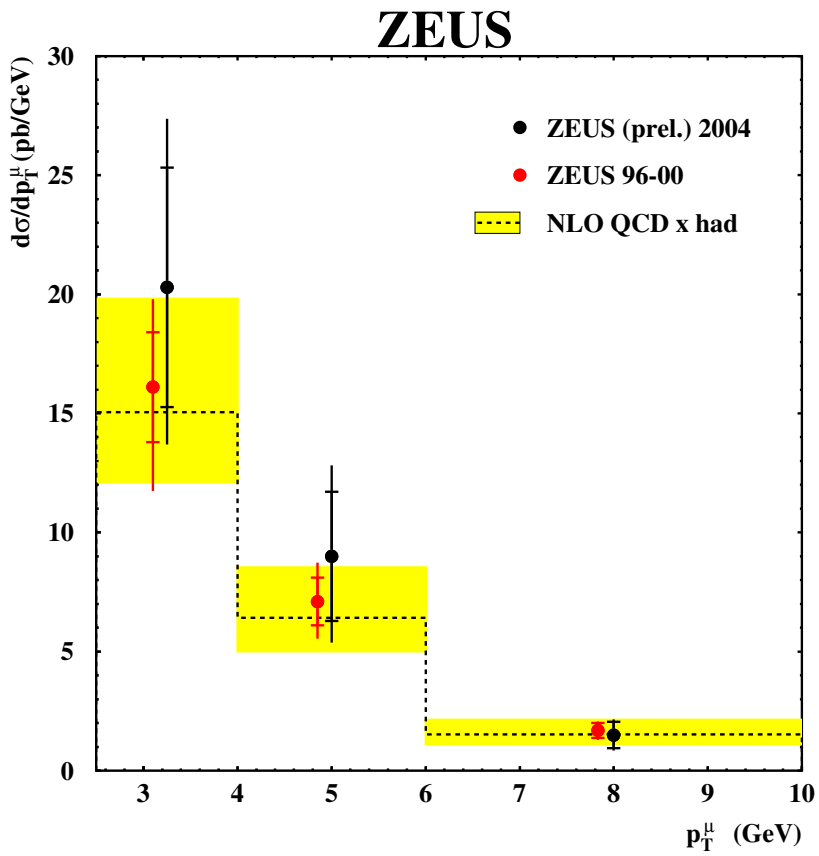
$Q^2 < 1\,\text{GeV}^2$ $\quad 0.2 < y < 0.8$

$p_\perp^{\text{jet}} > 7(6)\,\text{GeV}$ $\quad |\eta^{\text{jet}}| < 2.5$

$p_\perp^{\mu} > 2.5\,\text{GeV}$ $\quad -1.6 < \eta^{\mu} < 2.3$

Conclusions:

- Agreement with NLO QCD prediction (FMNR)
- Agreement with ZEUS data from HERA I running
  - $p_\perp^{\text{rel}}$ only
  - $\approx$ 3 $\times$ statistics than '04 analysis



Part II

Beauty in Deep Inelastic Scattering

Event Selection: $ep \to e' + b\bar{b} + X \to e' + \text{jet} + \mu + X$

2003/4 ep data: $\mathcal{L} = 39\,\text{pb}^{-1}$

DIS:

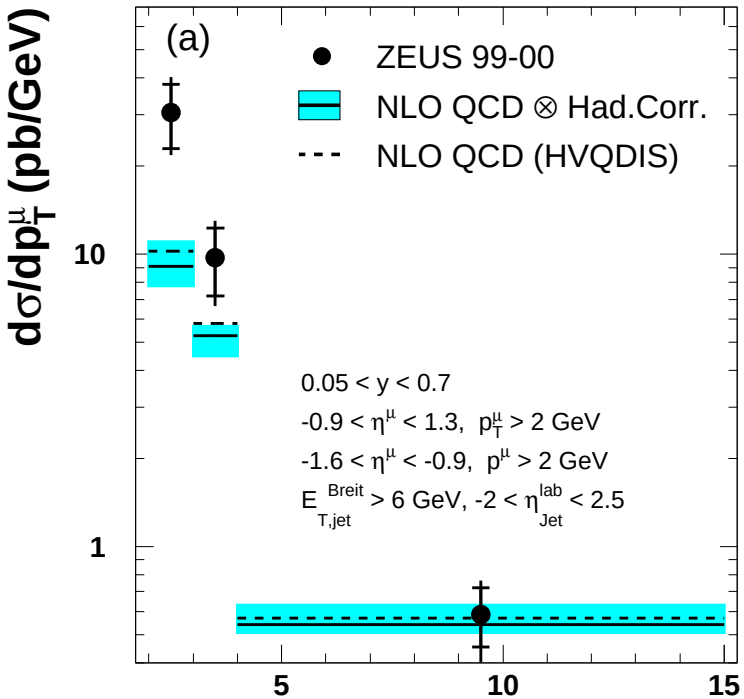
- $Q^2 > 4\,\text{GeV}^2$
- $E_{e'} > 10\,\text{GeV}$
- $y_{el} < 0.7$
- $40 < (E - p_z) < 65\,\text{GeV}$

Jet finding:

- $k_\perp$-clustering
- ≥ 1 jet with associated μ
- $E_\perp > 5\,\text{GeV}$
- $-2.0 < \eta < 2.5$

Associated μ:

- μ inside jet
- $p_\perp^\mu > 1.5\,\text{GeV}$
- μ-chambers + inner tracking



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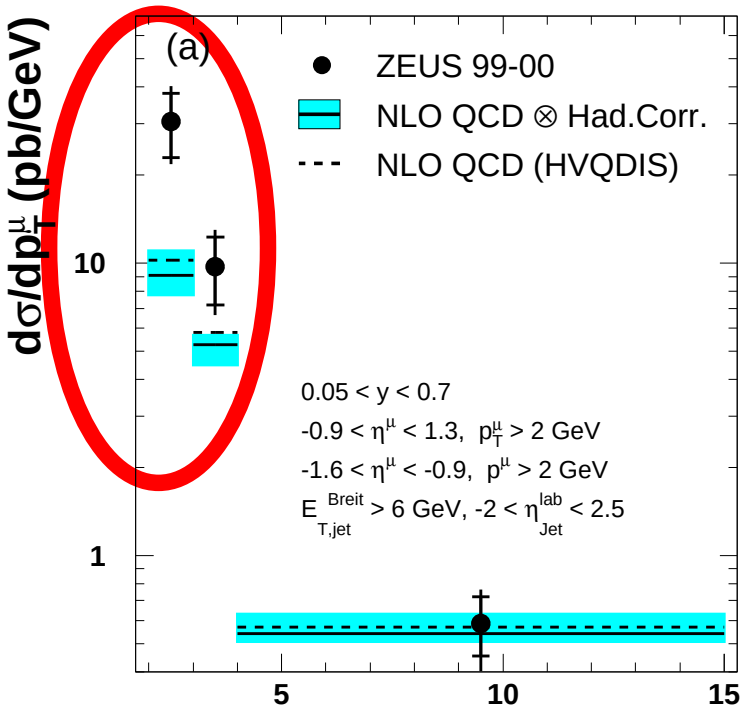
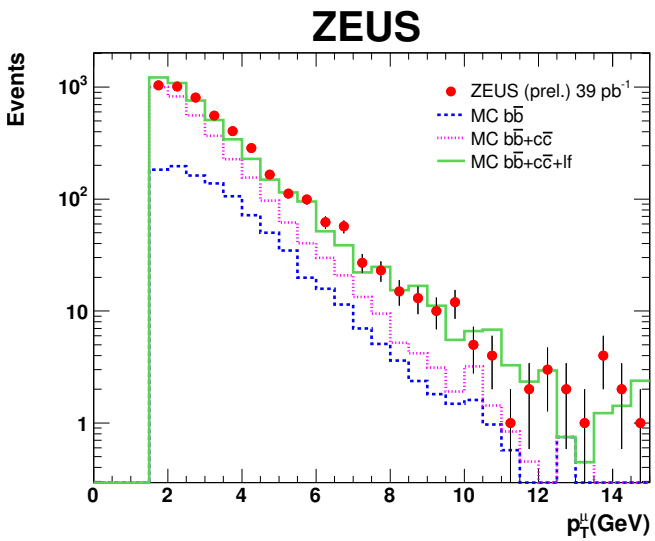
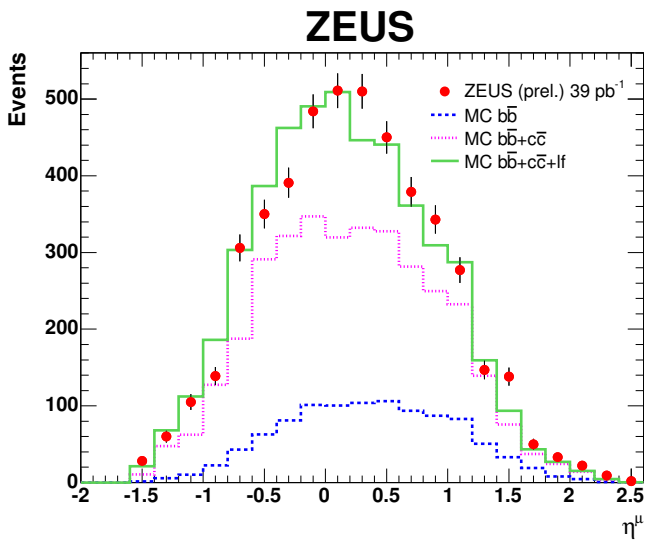
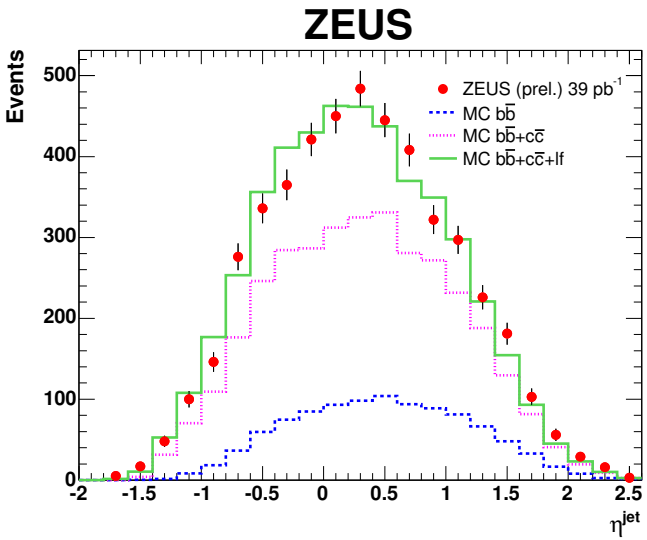
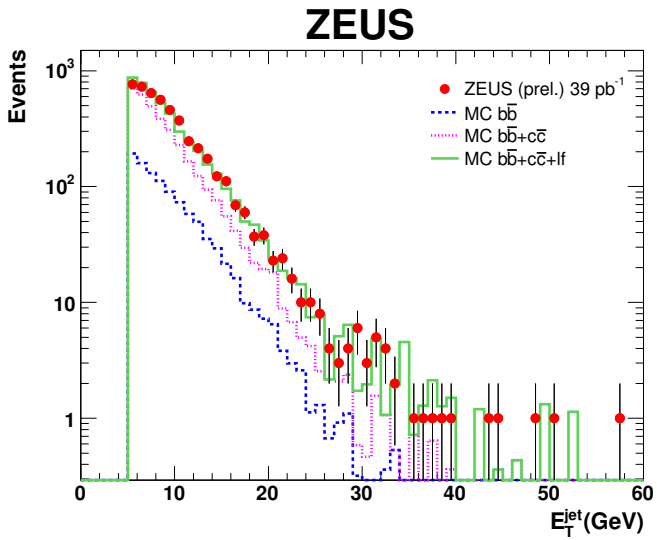


Control Plots

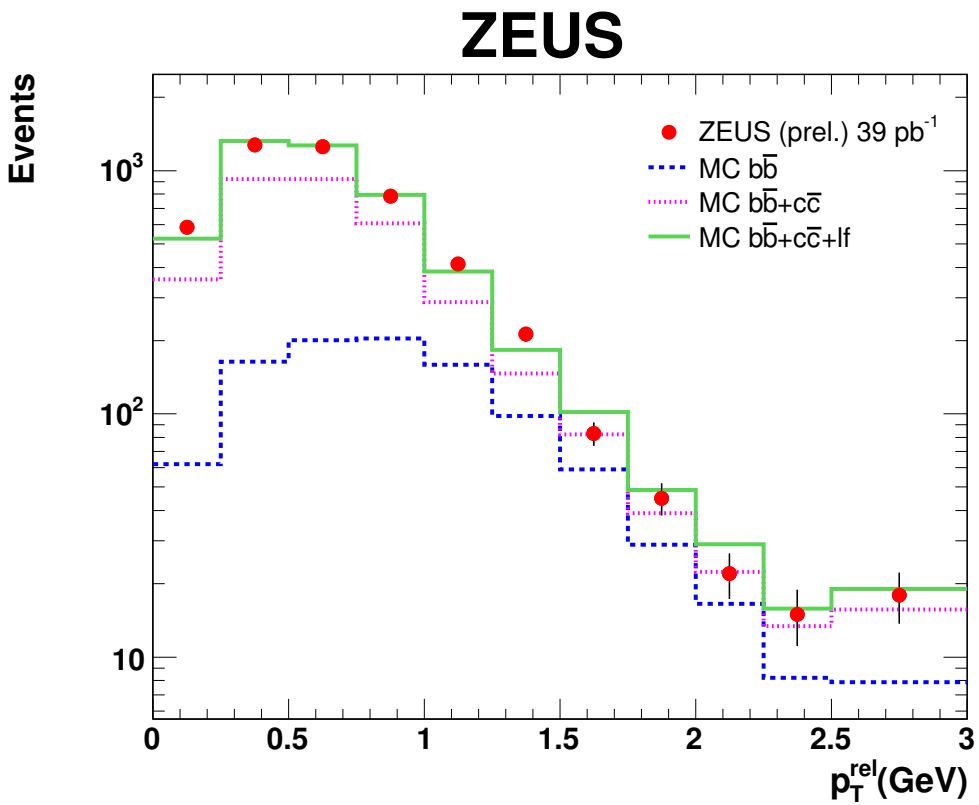






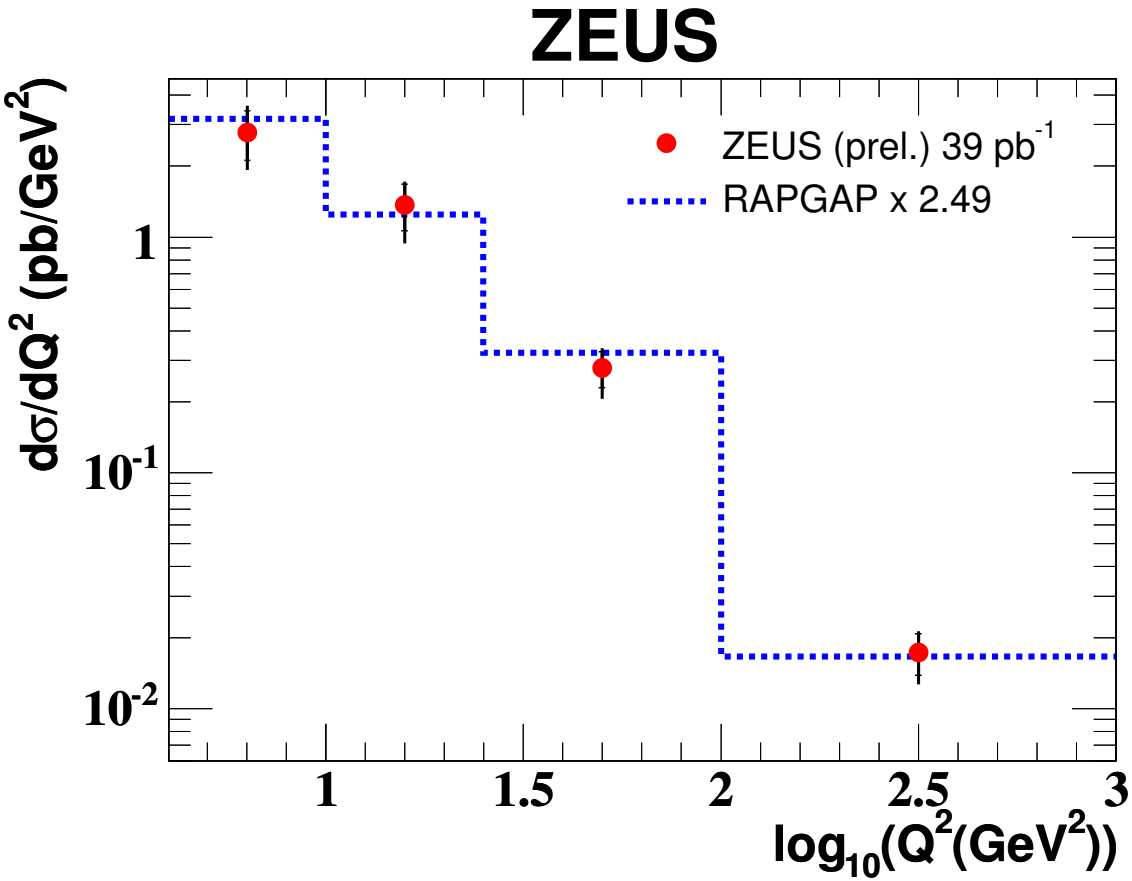


Beauty Extraction by $p_{\perp}^{rel}$



- Fit result: $f_b = (21.4 \pm 2.1)\,\%$ i.e. $\gtrsim 1000\,\mathrm{b}$ events$/39\,\mathrm{pb}^{-1}$
- K-factor for Beauty LO+PS MC (RAPGAP) of 2.49
- Impact parameter analysis ongoing

Results for $ep \to e' + b\bar{b} + X \to e' + \text{jet} + \mu + X$



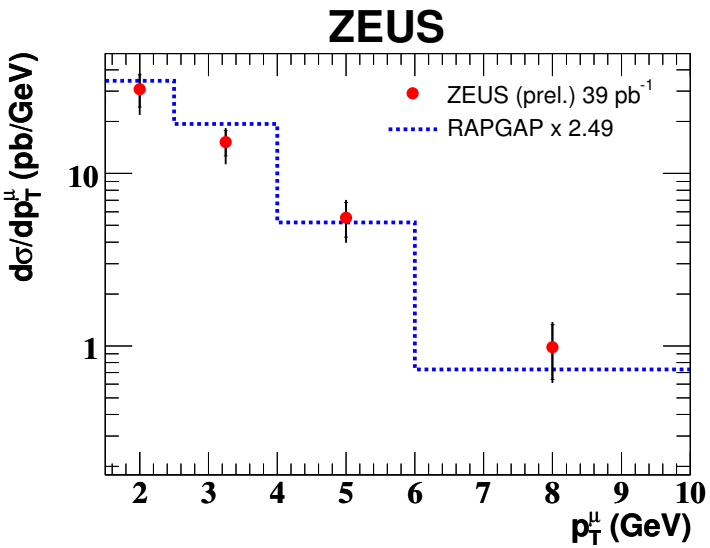
Kinematic region:

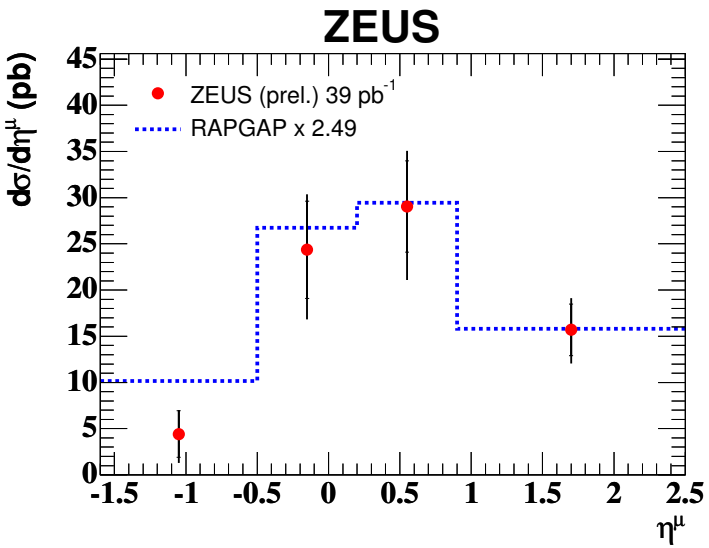
- $Q^2 > 4\,\text{GeV}^2$
  $0.05 < y < 0.7$
- $E_\perp^{\text{jet,lab}} > 5\,\text{GeV}$
  $-2 < \eta^{\text{jet}} < 2.5$
- $p_\perp^\mu > 1.5\,\text{GeV}$
  $\eta^\mu > -1.6$

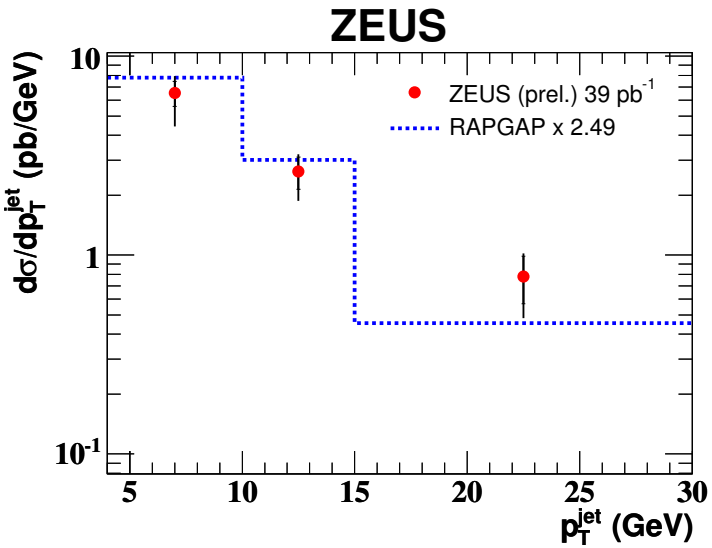
Result: $\sigma_{b\bar{b}} = (77.1 \pm 7.8^{+9.6}_{-14.9})\,\text{pb}$

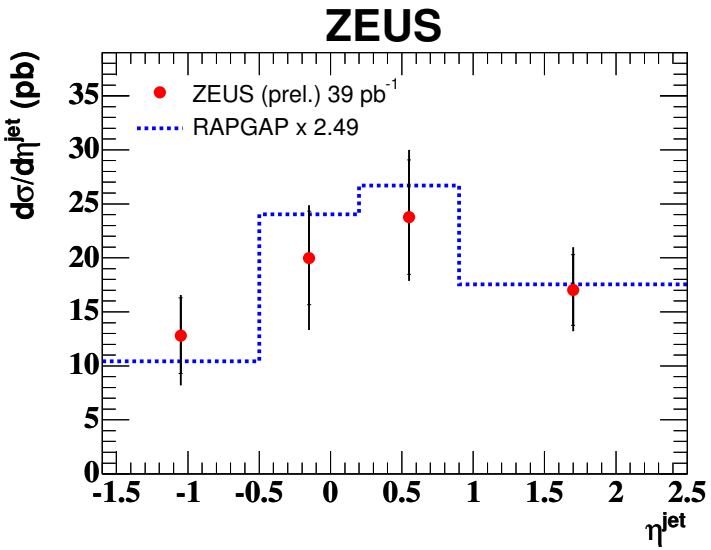
NLO predictions not yet calculated (in progress)

Results for $ep \to e' + b\bar{b} + X \to e' + \text{jet} + \mu + X$

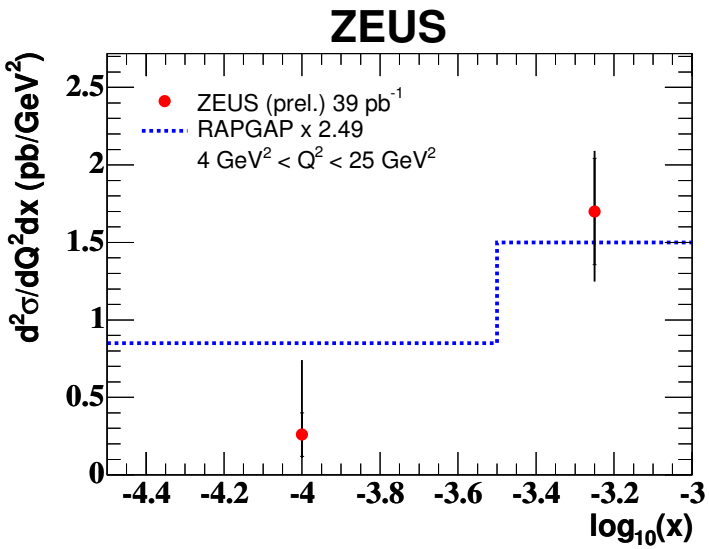


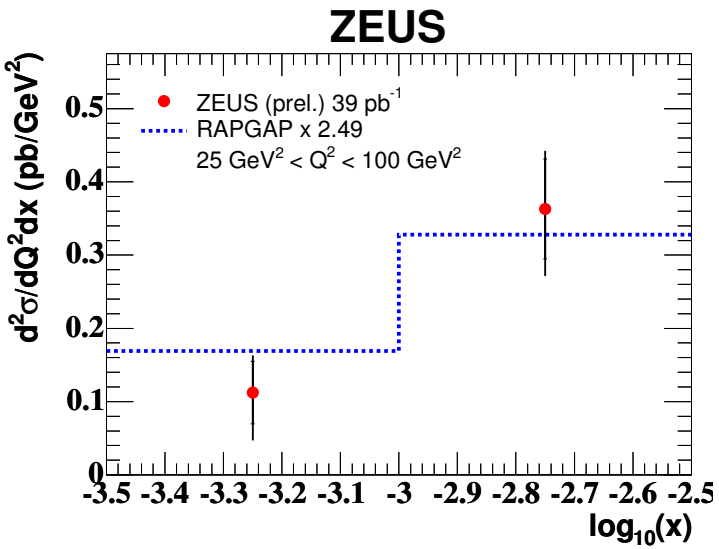


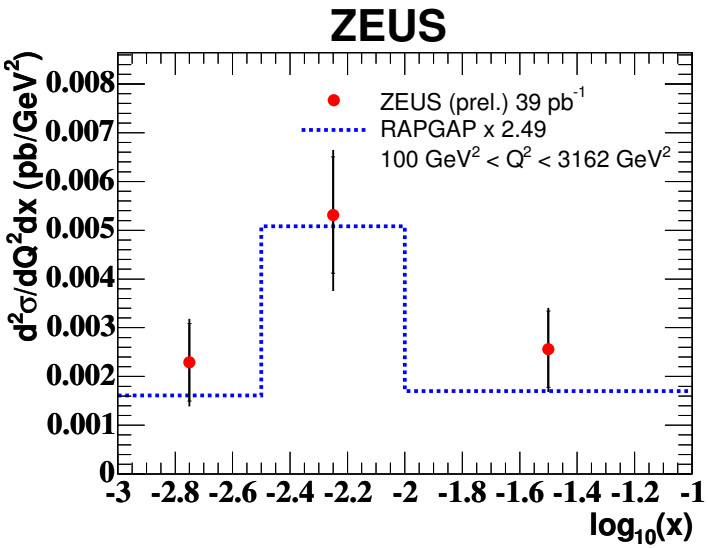




Results for $ep \to e' + b\bar{b} + X \to e' + \text{jet} + \mu + X$







double-differential
x-sections in x and Q^2

Summary

PhP analysis:

- 1^{st} B analysis @ZEUS exploiting the MVD
- B extraction by combining $p_{\perp}^{rel}$ and impact parameter
- Results consistent with NLO QCD and HERA I measurements

DIS analysis:

- $p_{\perp}^{rel}$-analysis of 2003/04 data
- Results consistent with LO+PS MC shapes
- NLO calculations in progress
- Looking forward to $F_2^{b\bar{b}}$ measurement

Part IV

Back-up Slides

Event Selection in Detail

Pre-selection:

- All good events
- Trigger on
  - jets in PhP
  - SL μ in PhP
  - jets + μ

Vertex:

- $-40 < Z_{vtx} < 4\,\text{cm}$

Tracking:

- ≥ 2 vtx tracks
- $\frac{\text{No. of all tracks}}{\text{No. of vtx tracks}} \leq 10$

Veto on e′:

- $\mathcal{P} > 0.9$
- $E_e > 5\,\text{GeV} \wedge y_{el} < 0.9$

EFOs:

- $0.2 < y_{JB} < 0.8$

Calorimetry:

- $E_\perp$ – 2 inner rings $\geq 10\,\text{GeV}$
- $p_\perp / E_\perp < 0.5$

Event Selection in Detail

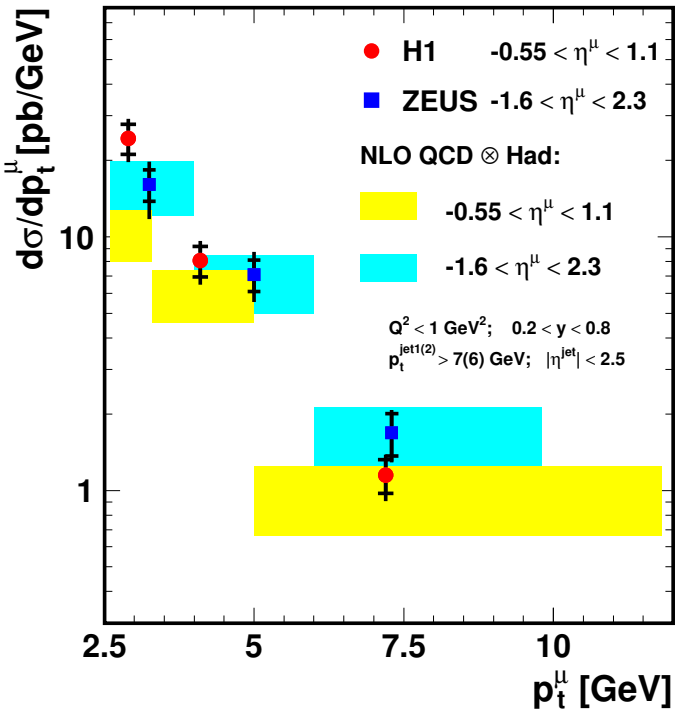
Jets:

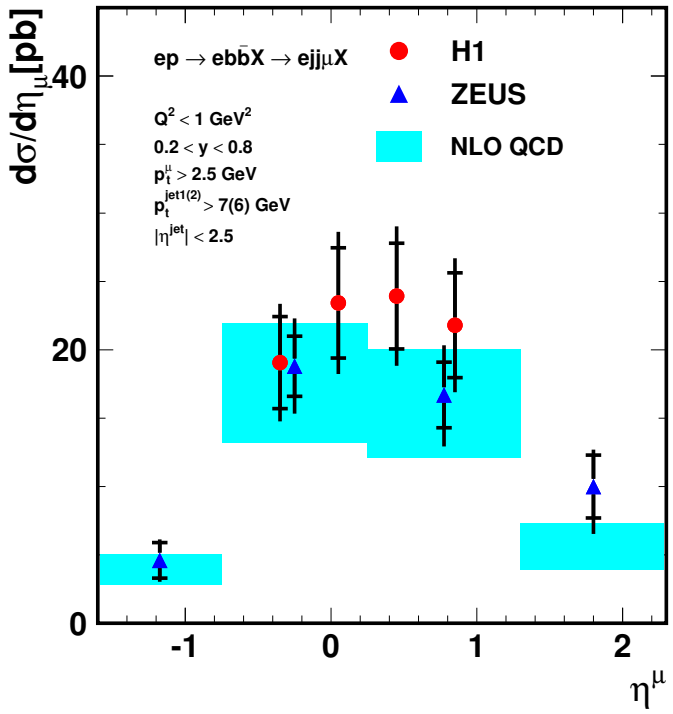
- ≥ 2 jets found with $k_\perp$-clustering in E recombination scheme (massive mode, 3211) and
  - $p_\perp > 7(6)\,\text{GeV} \wedge |\eta| < 2.5$

μ finding:

- $p_\perp^\mu > 2.5\,\text{GeV}$
- $-1.6 < \eta < 2.3$

Previous Results





Data Sets

Set		$\mathcal{L}$
ZEUS 2003/04 data		$39\,\text{pb}^{-1}$
Beauty MC	RAPGAP	$990\,\text{pb}^{-1}$
Charm MC	RAPGAP	$990\,\text{pb}^{-1}$
Light-flavour MC	ARIADNE	$990\,\text{pb}^{-1}$

- MCs comprise LO matrix-elements with DGLAP parton showers
- Shapes are described but not normalisation
- Normalisation by fitting the MC $p_{\perp}^{\text{rel}}$-distributions to data

Event Selection in Detail

Pre-selection:

- All good events
- No explicit trigger

Vertex:

- $-50 < Z_{\text{vtx}} < 50\,\text{cm}$

Electron finder:

- $\mathcal{P} > 0.9$
- $E_e > 10\,\text{GeV}$
- $Q^2_{\text{el}} > 4\,\text{GeV}^2$
- $y_{\text{el}} < 0.7$
- $y_{\text{JB}} > 0.05$

EFOs:

- $40 < (E - p_z) < 65\,\text{GeV}$
- $\not{p}_\perp < 10\,\text{GeV}$

Calorimetry:

- $E_\perp - 10°\text{cone} \geq 10\,\text{GeV}$

Tracking:

- $N_{\text{trk}} > 8$

$p^{\text{rel}}_\perp$ calculation:

- use all jets with $E^{\text{jet}}_\perp > 5\,\text{GeV}$

Event Selection in Detail

μ finding:

- $p_{\perp}^{\mu} \geq 1.5\,\text{GeV}$
- GMuon quality > 4
- Forward track muon quality modification
- μ regions
  - forward: $1.2 < \eta$
  - barrel: $-0.9 < \eta < 1.2$
  - rear: $-1.6 < \eta < -0.9$
- HAC2 (rear) $> 0.3\,\text{GeV}$ and no MV
- HAC2 (forward) $> 0.4\,\text{GeV}$

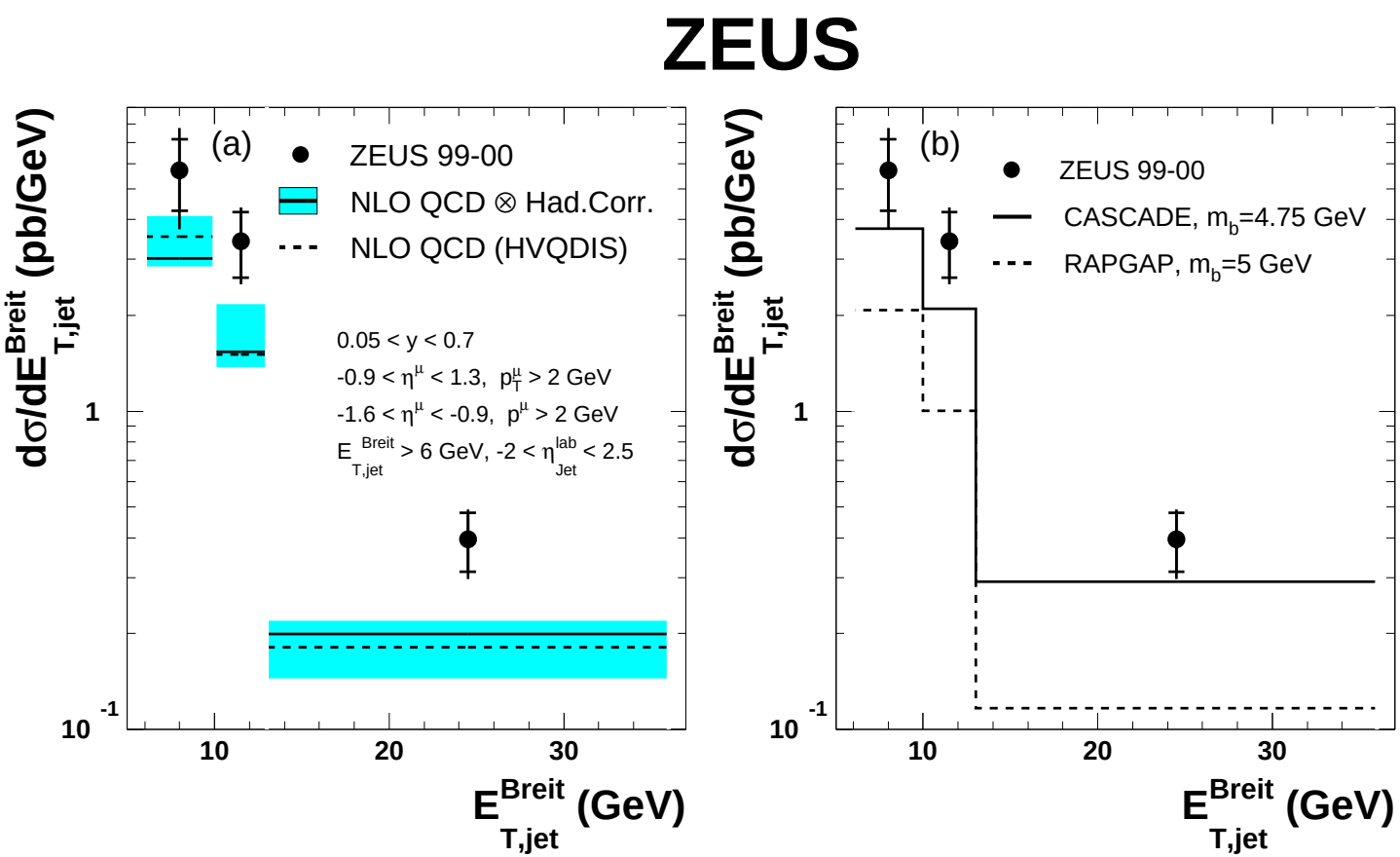
Jets:

- ≥ 1 jet found with $k_{\perp}$-clustering in E recombination scheme (massive mode, 3211), w/o DIS electron EFO and
  - $-2 < \eta < 2.5$
  - $E_{\perp}^{\text{lab}} > 5\,\text{GeV}$
- $p_{\text{jet}} - p_{\mu} > 0.7\,\text{GeV}$ anti-isolation

μ-Efficiency Corrections

- μ-efficiencies differences between data and MC
- Correction factors obtained by independend J/ψ, Bethe-Heitler data-sets
- Binned in $p_{\perp}^{\mu}$ and η^{μ}
- Efficiencies/inefficienies combined for all μ-detectors
- MC μ weighted with combined correction factors
- Significant improvement of μ description
- Half of the correction assigned as syst. error (±10 %)

Previous Results of Beauty in DIS



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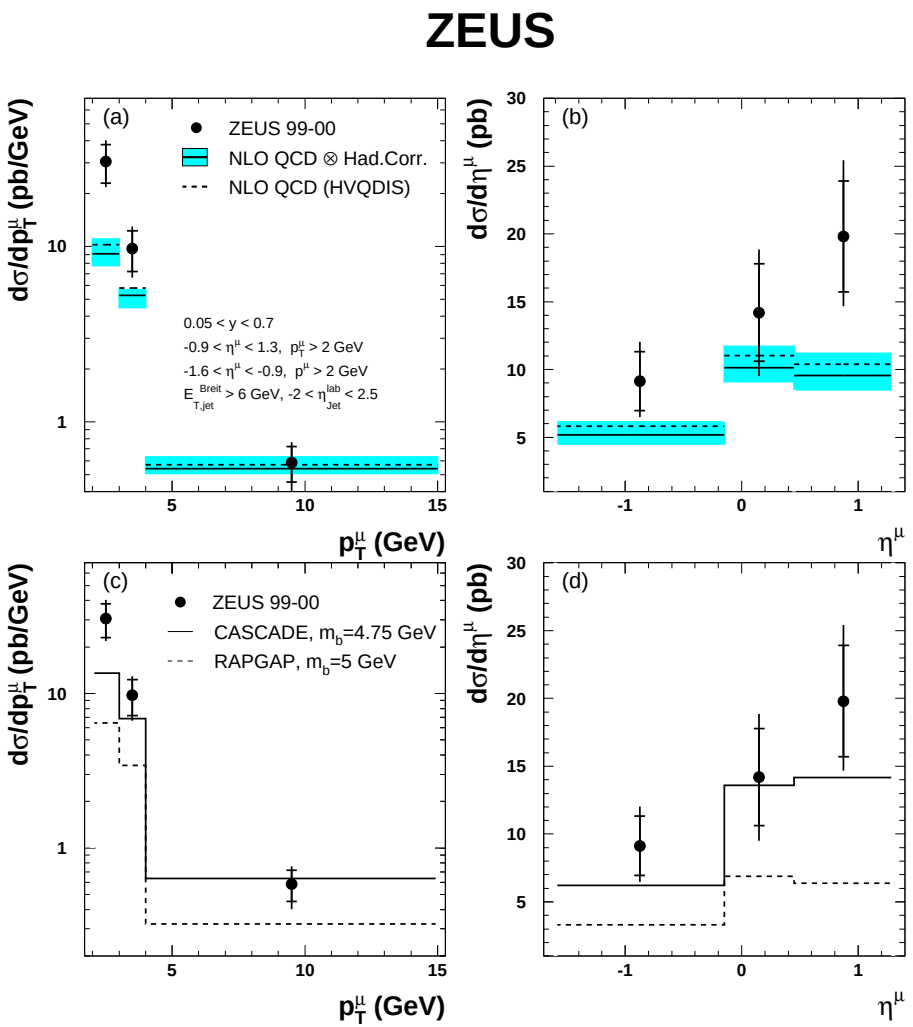

Previous Results of Beauty in DIS