

DIS2011

Measurement of heavy-quark jet photoproduction at HERA

ZEUS-pub-11-002 - to be submitted to EPJ C

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Newport News
13/04/2011

GEFÖRDERT VOM



Bundesministerium
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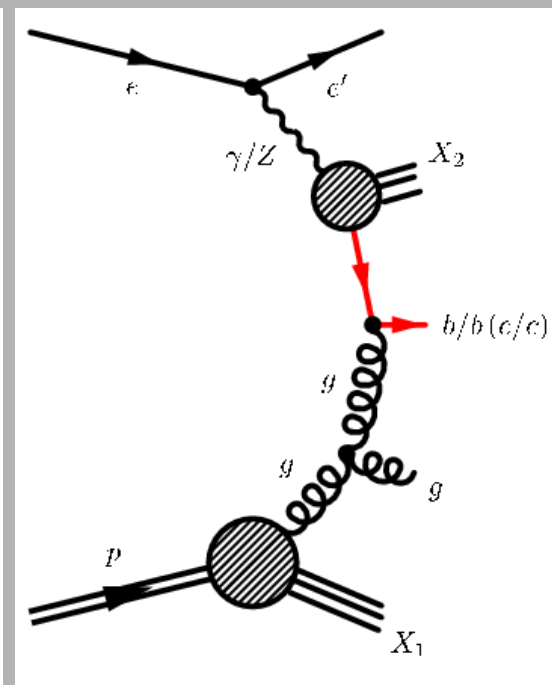
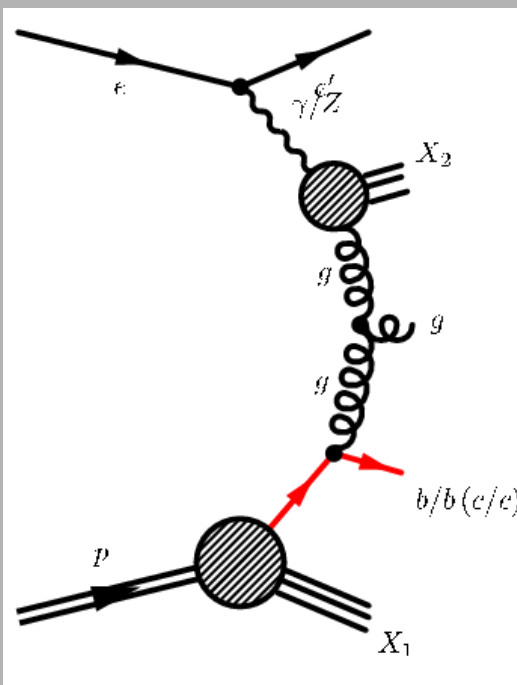
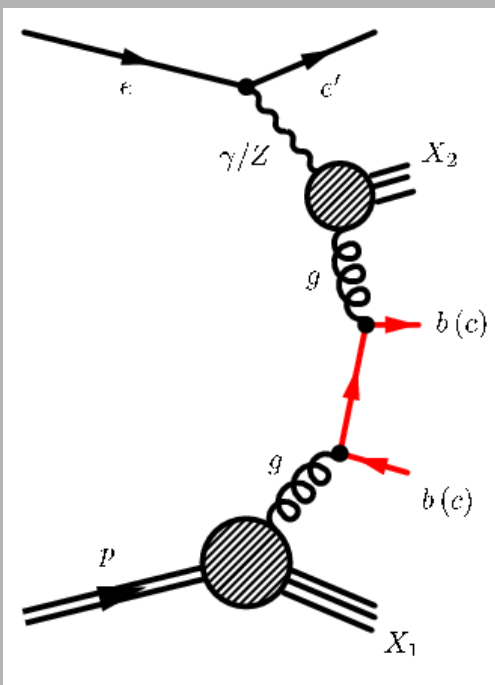
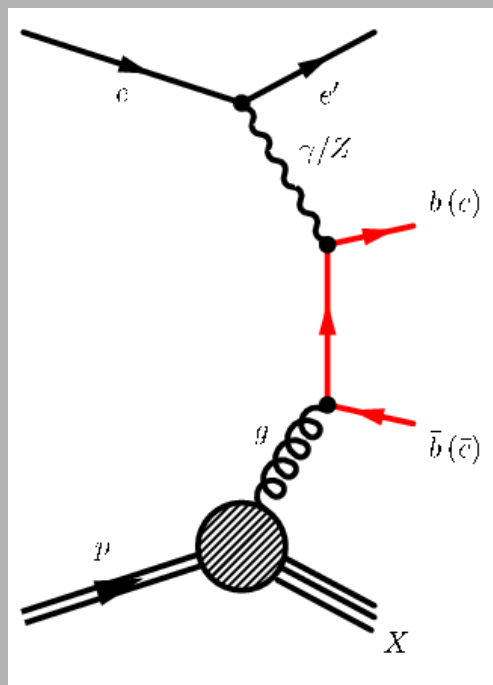
Outline

- Introduction
- Dataset and simulation
- Event selection
- Extraction of signal
- Cross-sections and comparison with NLO QCD
- Summary

Jets in photoproduction

Boson-gluon fusion

Proton and photon excitation

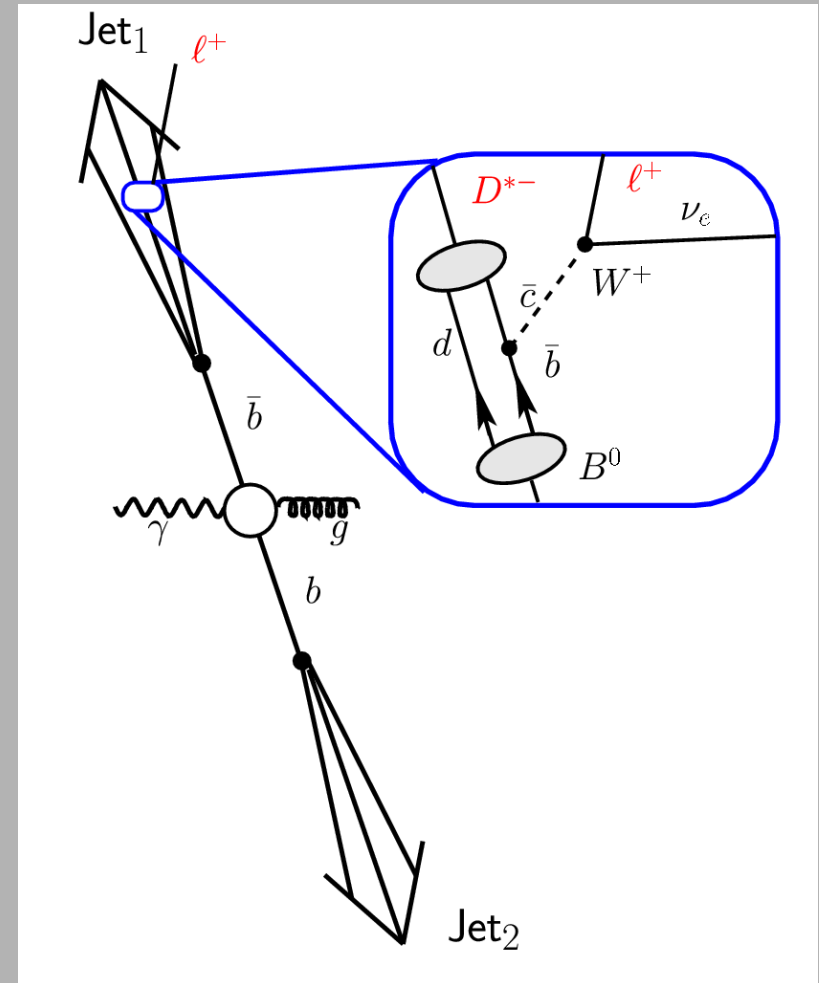


Direct

Resolved

Idea of analysis

- Compare measurements of b,c dijet cross-sections with MC and NLO QCD predictions
- Use long lifetime (0.5-1.5ps) and large mass of b,c quarks to separate b,c jets from each other and from light-quark jets
- Keep analysis inclusive
 - High statistics
 - Less dependence on branching fractions



Data and MC samples

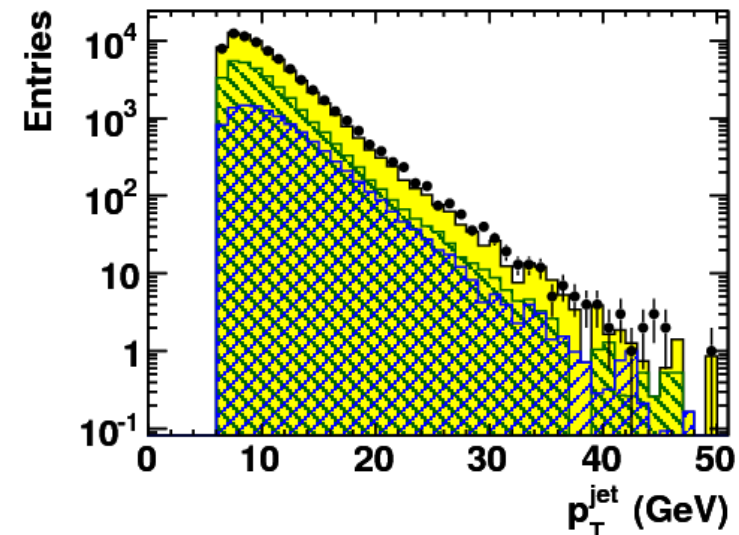
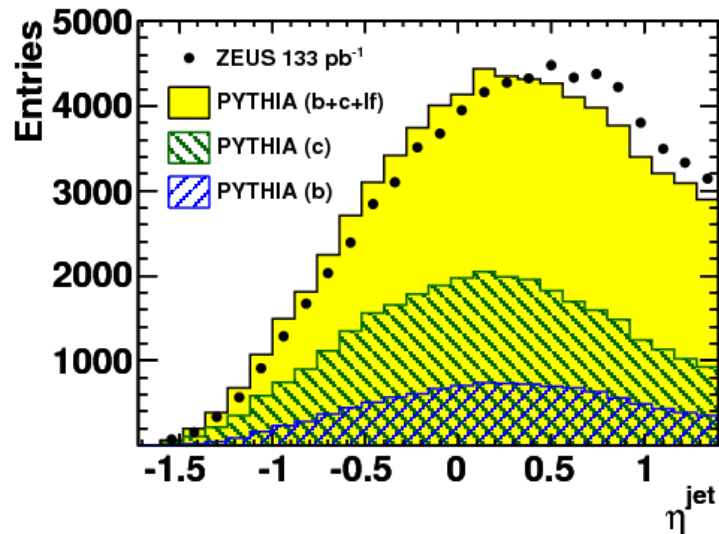
- 2005 e-p data - 133 pb⁻¹
- Monte Carlo (MC):
 - b, c samples (high statistics)
 - PYTHIA with CTEQ5L + GRV-G LO
 - $m_b = 4.75$ GeV, $m_c = 1.5$ GeV
 - Generate direct, resolved and excitation samples
 - Light flavour (lf) sample (1x data)
 - PYTHIA with CTEQ4L + GRV-G LO

Event selection

- No scattered electron
- $0.2 < y < 0.8$
- Two highest p_T jets
 - $|\eta| < 2.5, p_T > 7(6) \text{ GeV}$

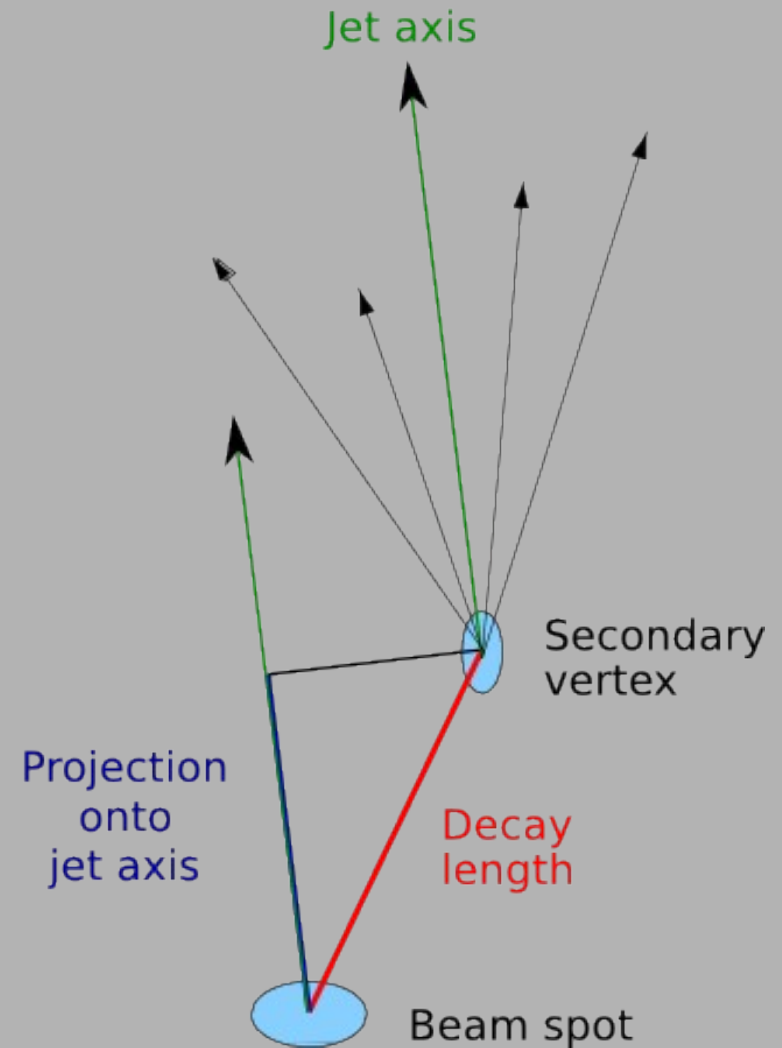
Secondary vertex
with $|\text{significance}| > 3$
required

ZEUS



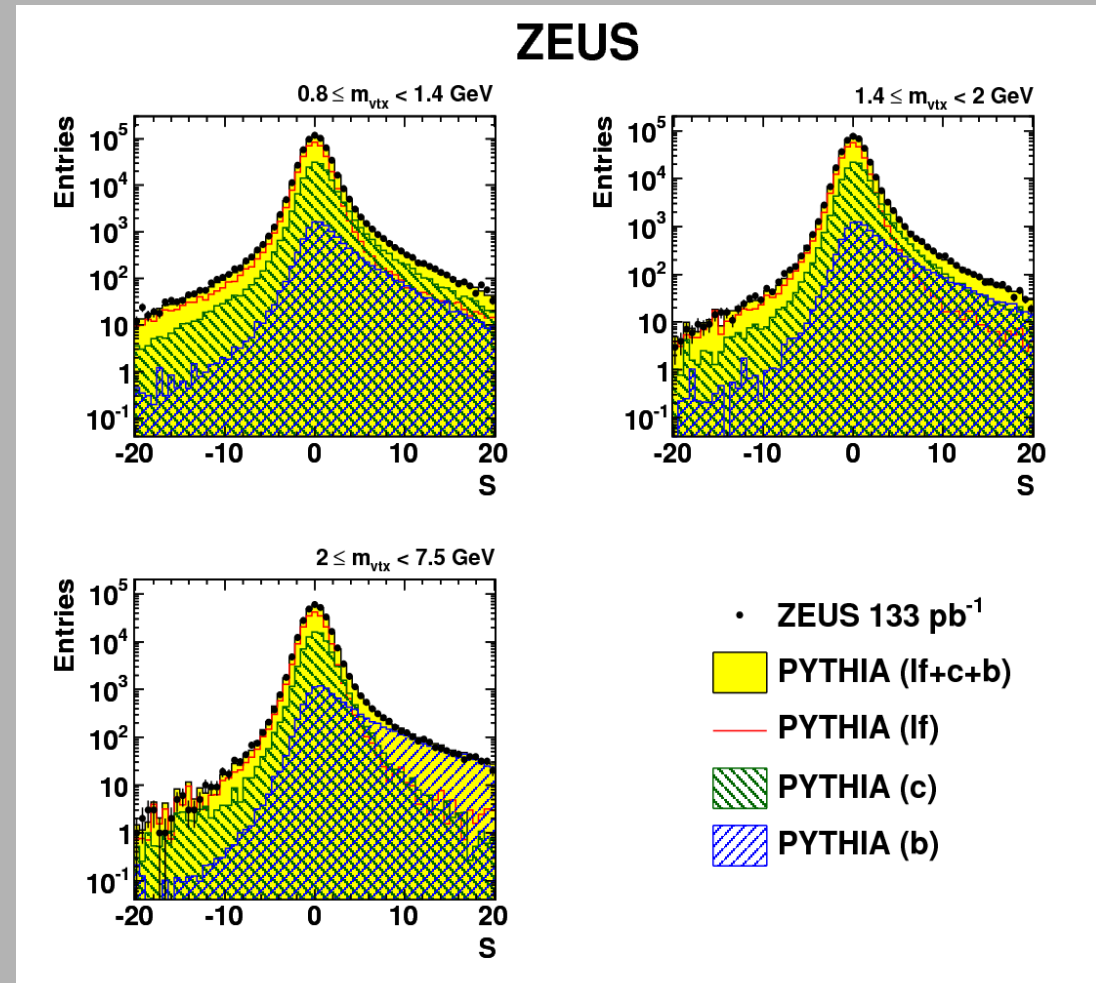
Secondary vertex procedure

- Secondary vertex:
 - Find 3-D vertex
 - Project onto XY plane
 - Project onto jet axis
- Also calculate invariant mass of tracks associated to vertex, m_{vtx}



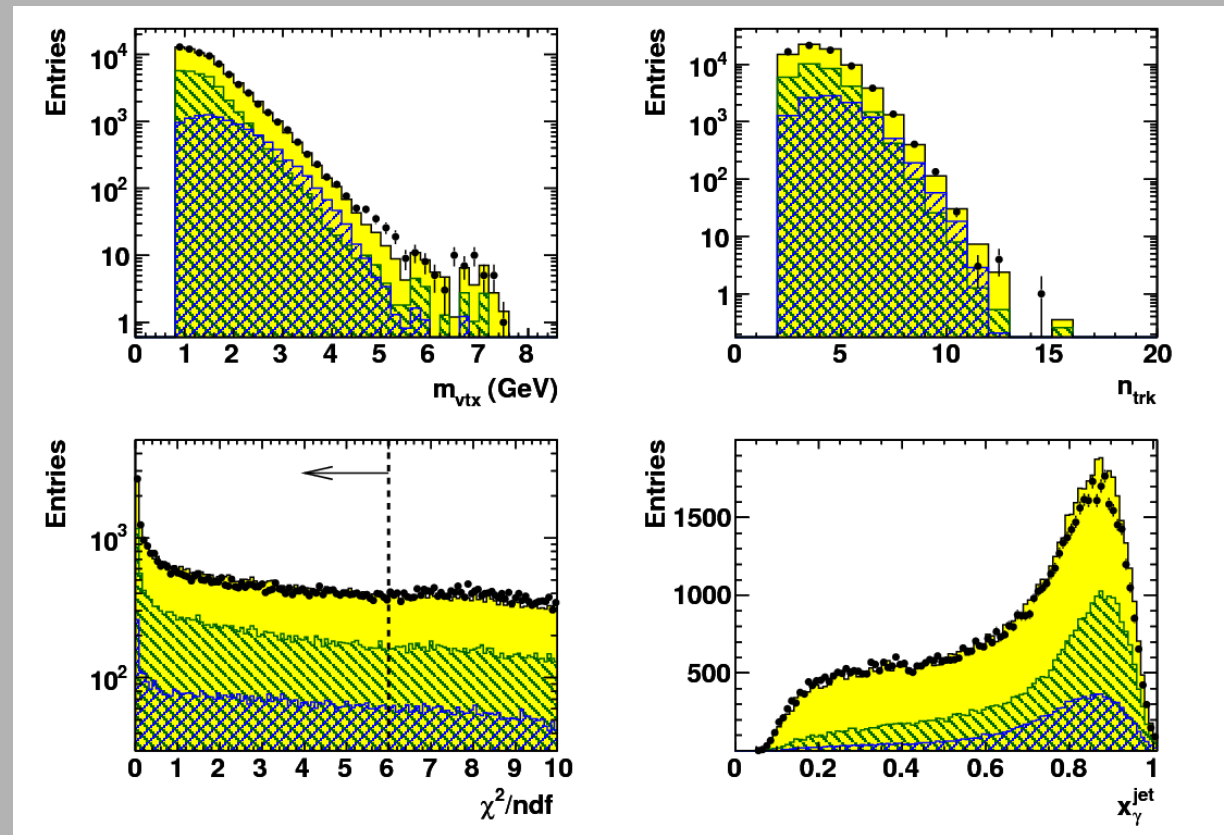
Significance distributions

- Use negative significance to check and tune MC resolution
- b, c, lf dominate in different mass bins and significance regions
- Subtract negative from positive significance to (almost) remove light flavour contribution



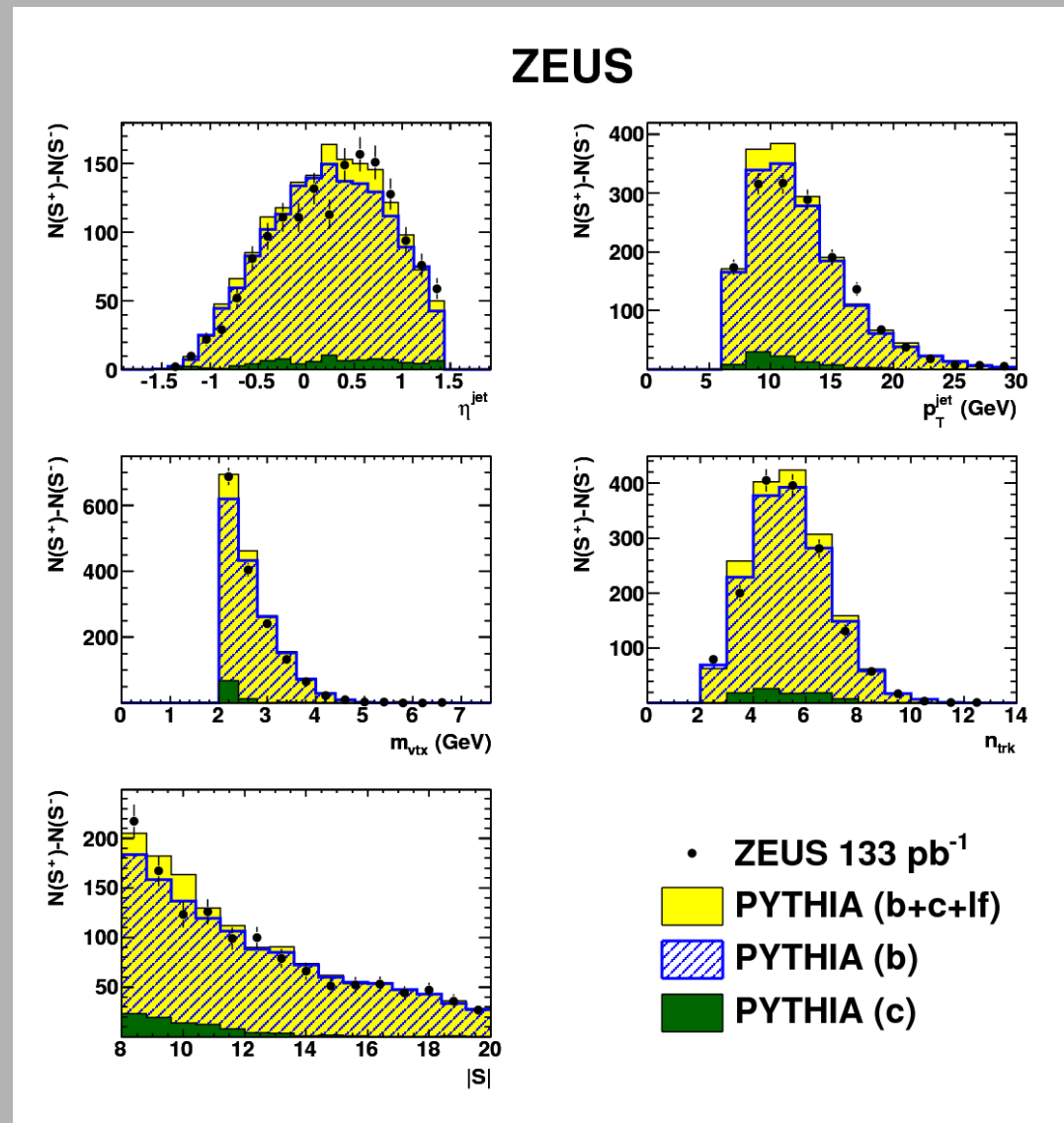
Control distributions

- Jets with associated secondary vertices used for cross-section
 - $-1.6 < \eta < 1.4$
 - $|S| > 3$
 - 70 433 jets remain



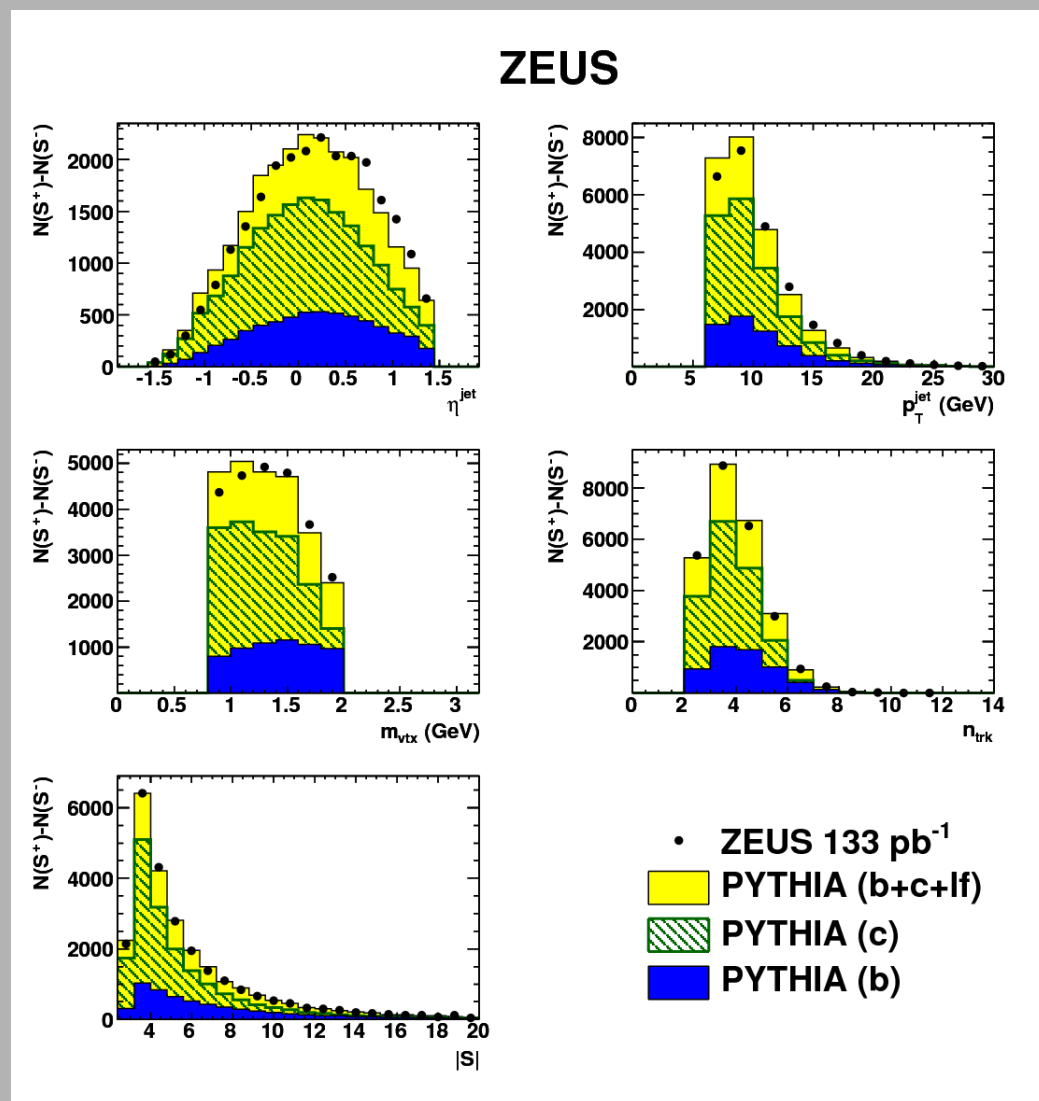
b-enriched sample

- As a cross-check, enrich b:
 - $m_{\text{vtx}} > 2.0 \text{ GeV}$
 - $|S| > 8$
- Pure sample
 - $> 90\%$
- Good agreement with Monte Carlo

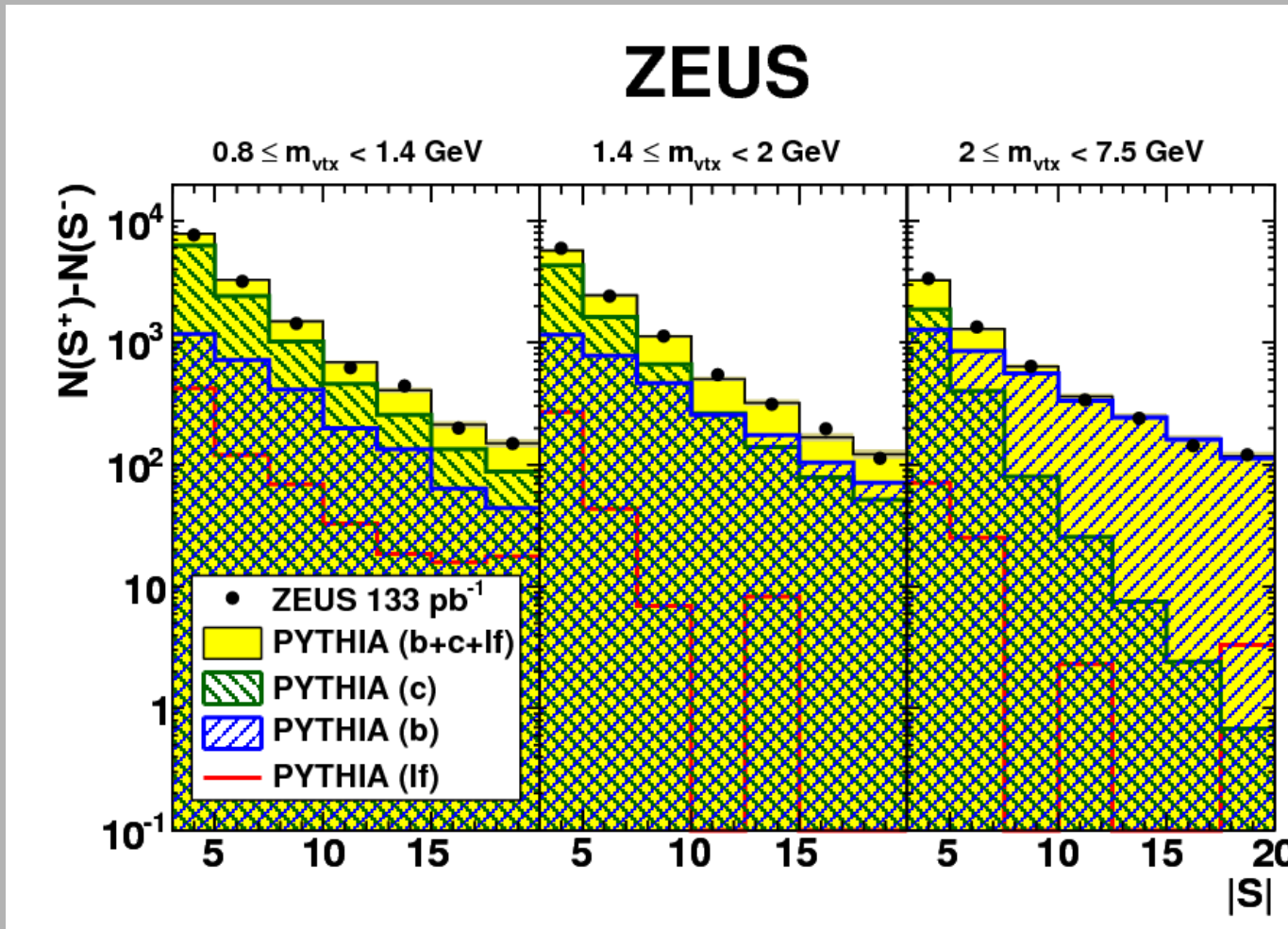


c-enriched sample

- As a cross-check, enrich c:
 - $0.8 < m_{\text{vtx}} < 2.0 \text{ GeV}$
- Sample purity
 - $\sim 70\%$
- Good agreement with Monte Carlo
 - Ongoing studies to improve m_{vtx}



Mirrored significance



Scale factors

$$k_b = 1.11$$

$$k_c = 1.35$$

- Fit distribution to 3 contributions
- Use unsubtracted distribution to constrain overall normalisation

Systematic uncertainties

- Uncertainties for total cross-section

Parameter	Uncertainty (%)	
	b	c
Trigger efficiency	+4.2/-3.9	+4.5/-3.2
Jet energy scale	± 0.6	± 4.3
Tracking/Decay length	+6.0/-1.0	+1.2/-0.7
Jet reweighting	-5.6	-1.5
Charm mesons	-1.8	+0.6/-2.2
Fragmentation	+1.8/-2.1	+1.2/-1.3
Luminosity	± 1.8	± 1.8
Total	+7.8/-7.7	+6.7/-7.0

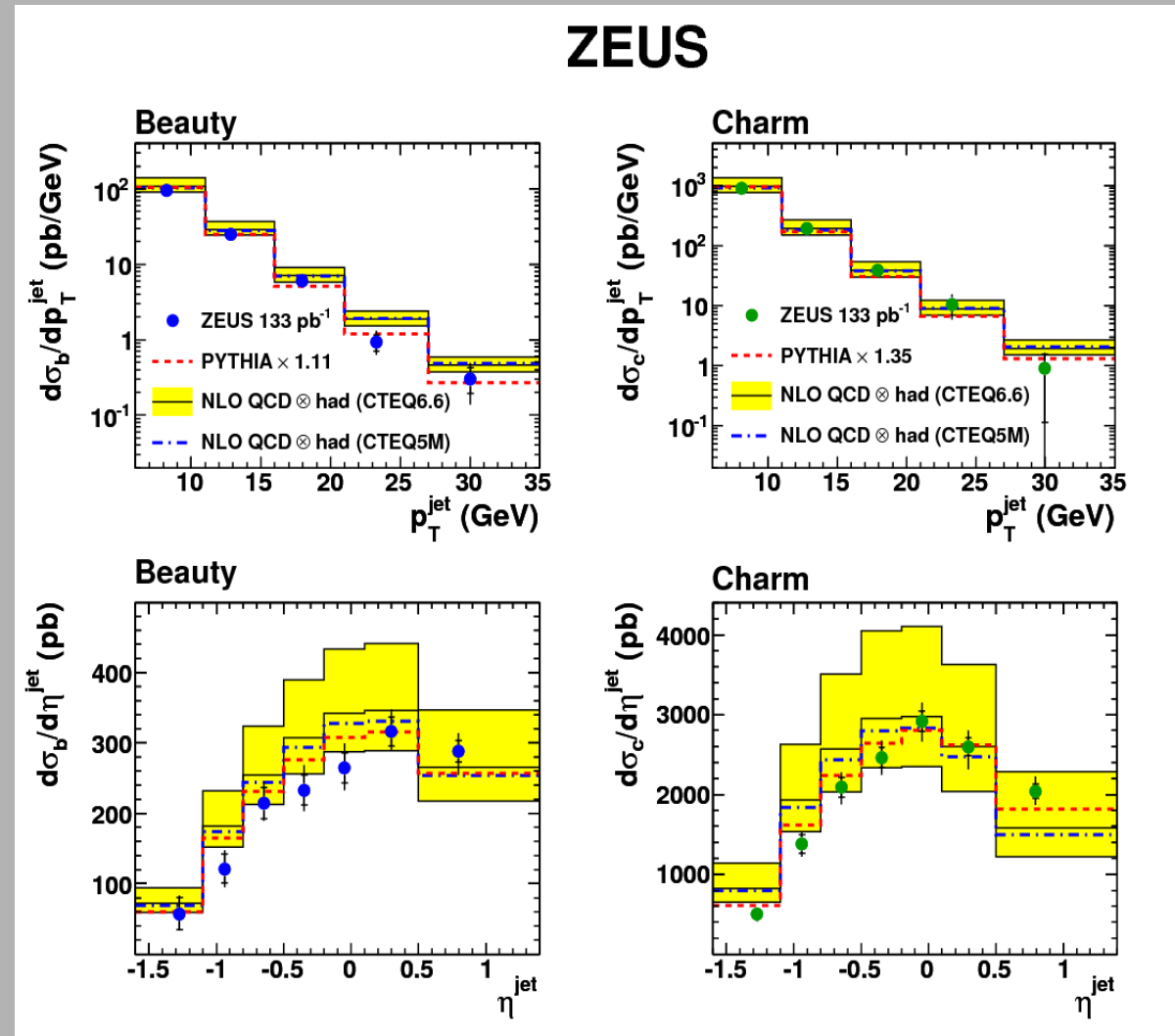
- No single dominant contribution

NLO QCD predictions

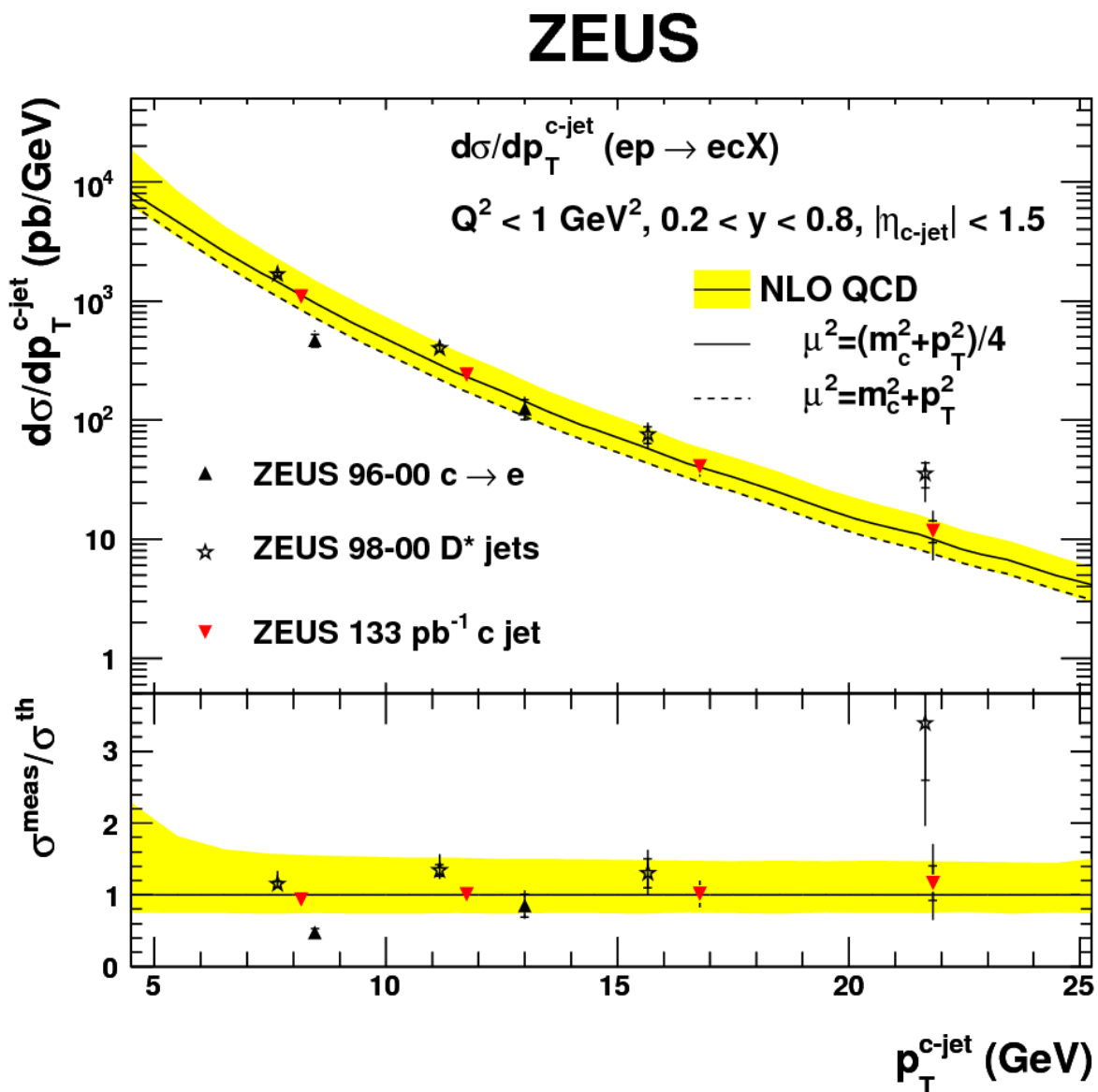
- Use FMNR program for predictions
 - $m_b = 4.75 \text{ GeV}$, $m_c = 1.5 \text{ GeV}$
 - $\mu_F = \mu_R = 0.5 \sqrt{(m_Q^2 + p_T^2)}$
- Vary masses and scales (by a factor of 2) to get theory uncertainty
- Dominant uncertainty comes from scale variation

Cross-sections

- Compare measured cross-sections with scaled MC and NLO QCD predictions
- Large theory uncertainty!
 - Small dependence on proton PDF



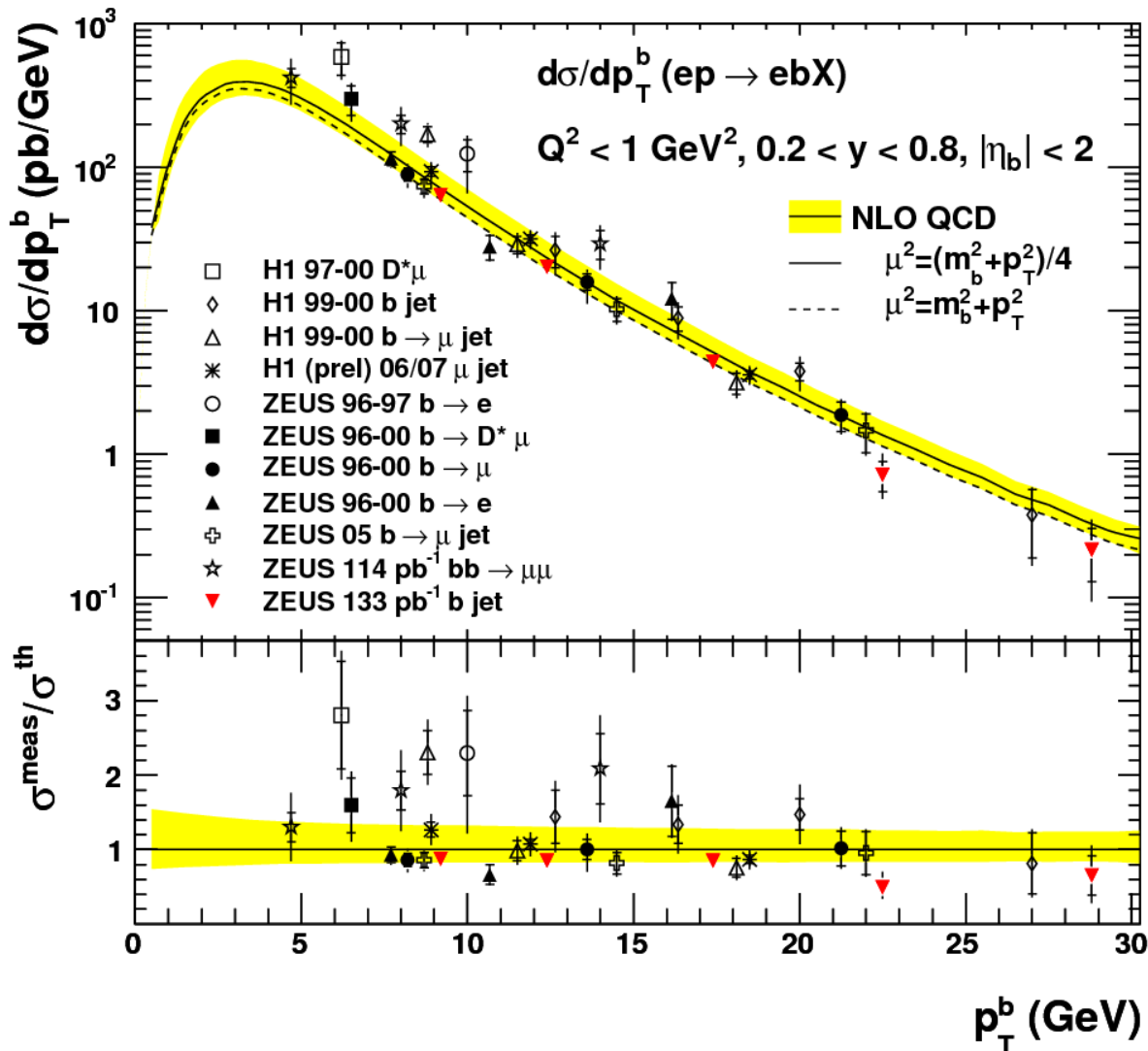
$p_T^{c\text{-jet}}$ comparison



- Reasonable agreement with previous ZEUS measurements
- Good agreement with NLO QCD predictions
- Addition of H1 measurements ongoing

p_T^b comparison

HERA



- Good agreement with previous ZEUS and H1 measurements
- Good agreement with NLO QCD predictions

Summary

- Precise inclusive measurement of b- and c-quark dijet cross-sections made in photoproduction regime at HERA
- Comparison of different measurements leads to a consistent picture of heavy quark production in ep collisions
- NLO QCD predictions agree with data
 - Theory errors are rather large
 - NNLO calculations?

Backup

Theory uncertainty

- Assess theory uncertainty by requiring physical observable to be independent of scale for a given order of calculation

$$\frac{d}{d \ln \mu^2} \sigma_{pp \rightarrow X} = O(\alpha_S^{l+1})$$

Equation motivates commonly adopted approach of varying renormalisation and factorisation scale by $\frac{1}{2}$ and 2