Measurement of Beauty production at HERA Using Events with Muons and Jets

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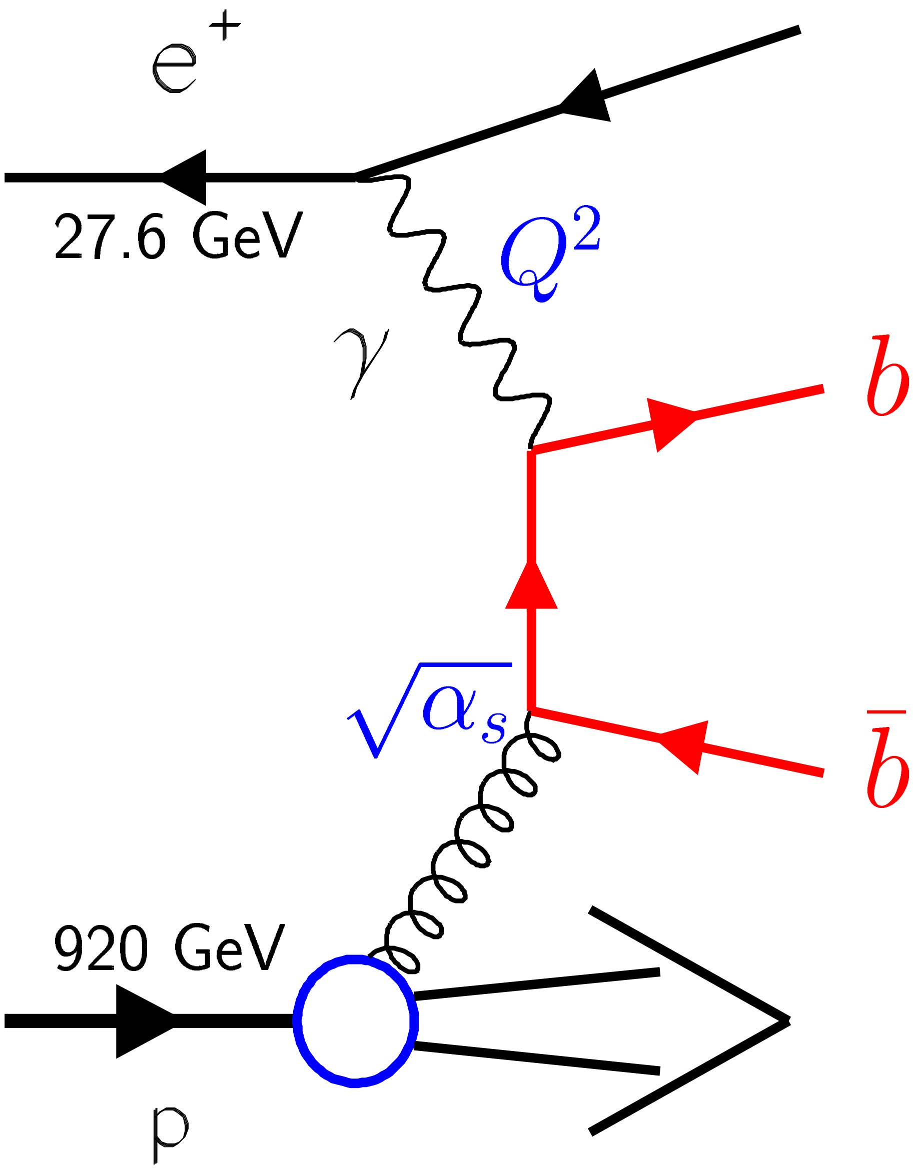
Beauty production at HERA



Key questions/points:

- Are available pQCD calculations in Next-to-leading order good enough?
- Multi-hard scale problem in pQCD: $[\alpha_s \ln(Q^2/m_b^2)]^n$ terms
  $\rightarrow$ pQCD approximations: Massive and Massless schemes (and variable s.)
- Probe hard scales over wide range:

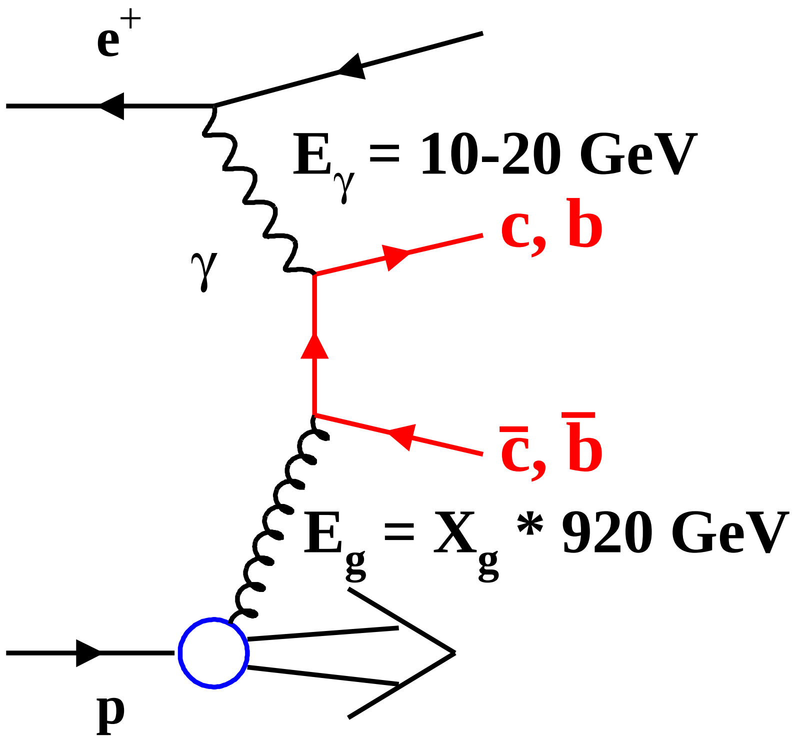
Kinematic region	Hard scales
γp: $Q^2 < 1$ GeV^2	m_b, p_T^b
DIS: $Q^2 > 1$ GeV^2	m_b, Q^2, p_T^b

Production rates at HERA

Total production rates at HERA:

$$\sigma_{\text{uds}} : \sigma_{\text{charm}} : \sigma_{\text{beauty}} \sim 2000 : 200 : 1$$

Main reason for Beauty suppression: phasespace!

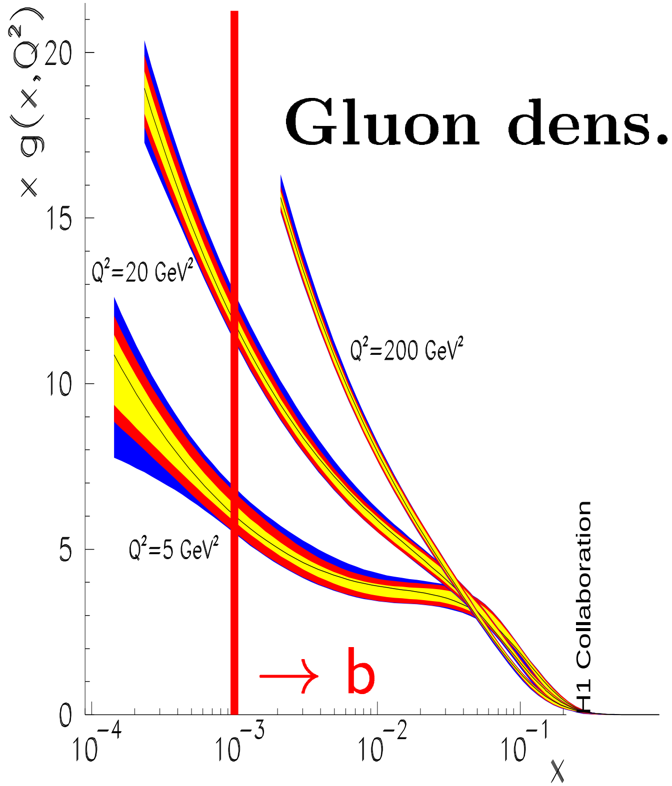


Kin. Threshold:

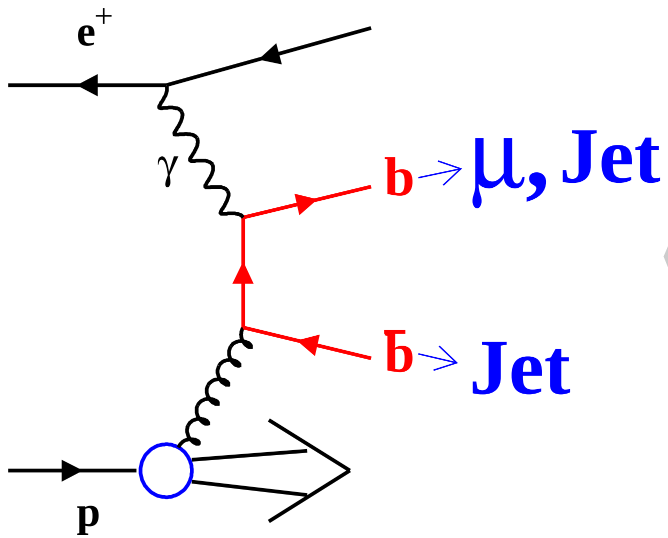
$$\mathbf{X}_g \geq \frac{m_Q^2}{E_\gamma \cdot 920\ \mathbf{GeV}}$$

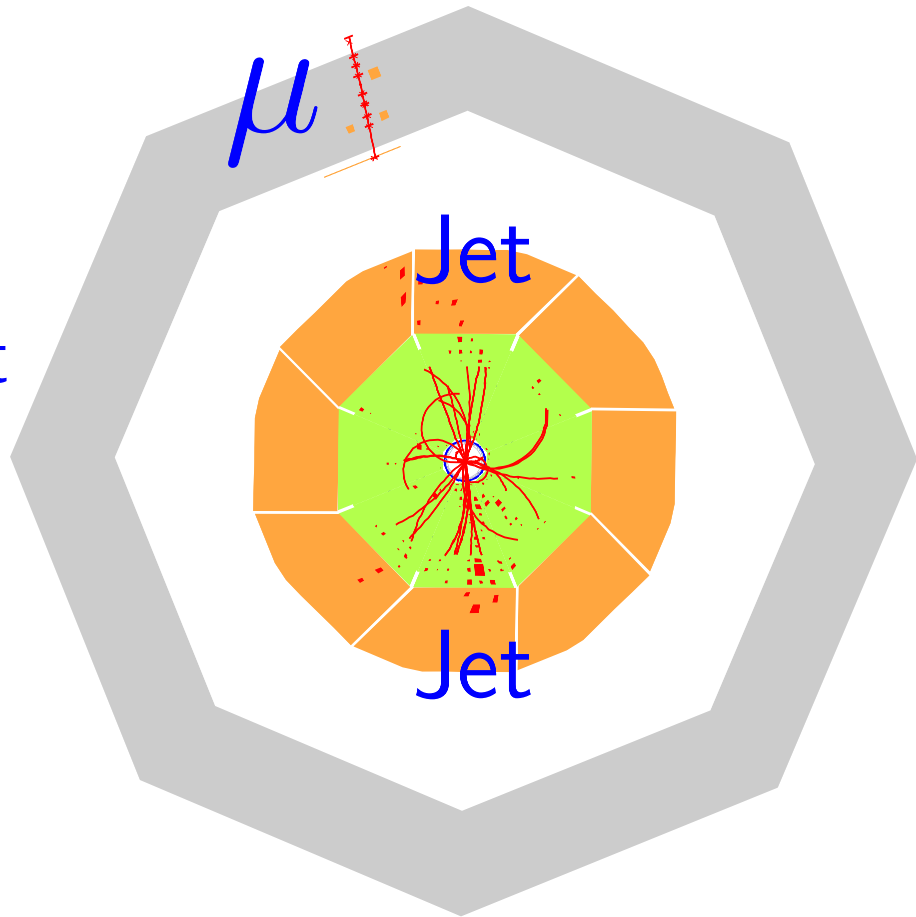
c: $\mathbf{X}_g \geq 10^{-4}$

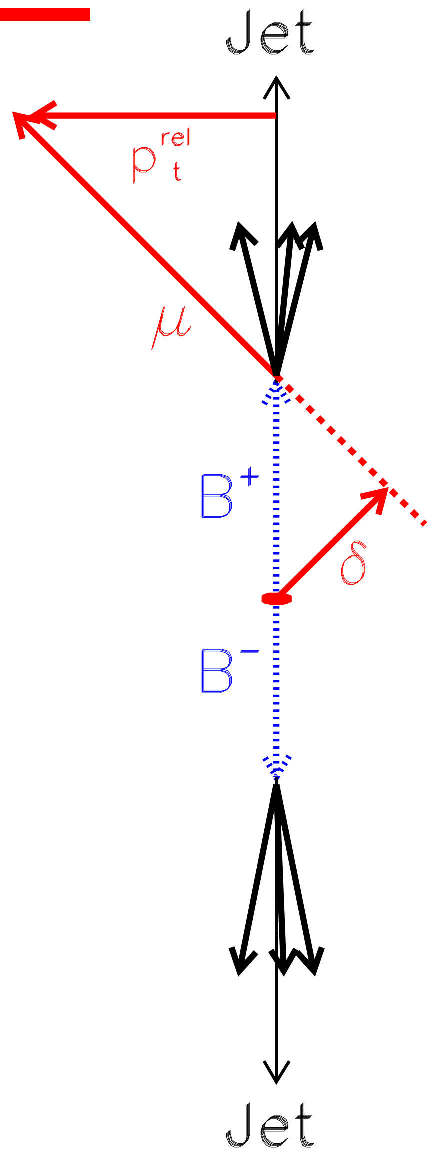
b: $\mathbf{X}_g \geq 10^{-3}$



Beauty *Tag* with muon and jets







Separate Beauty from c and uds:

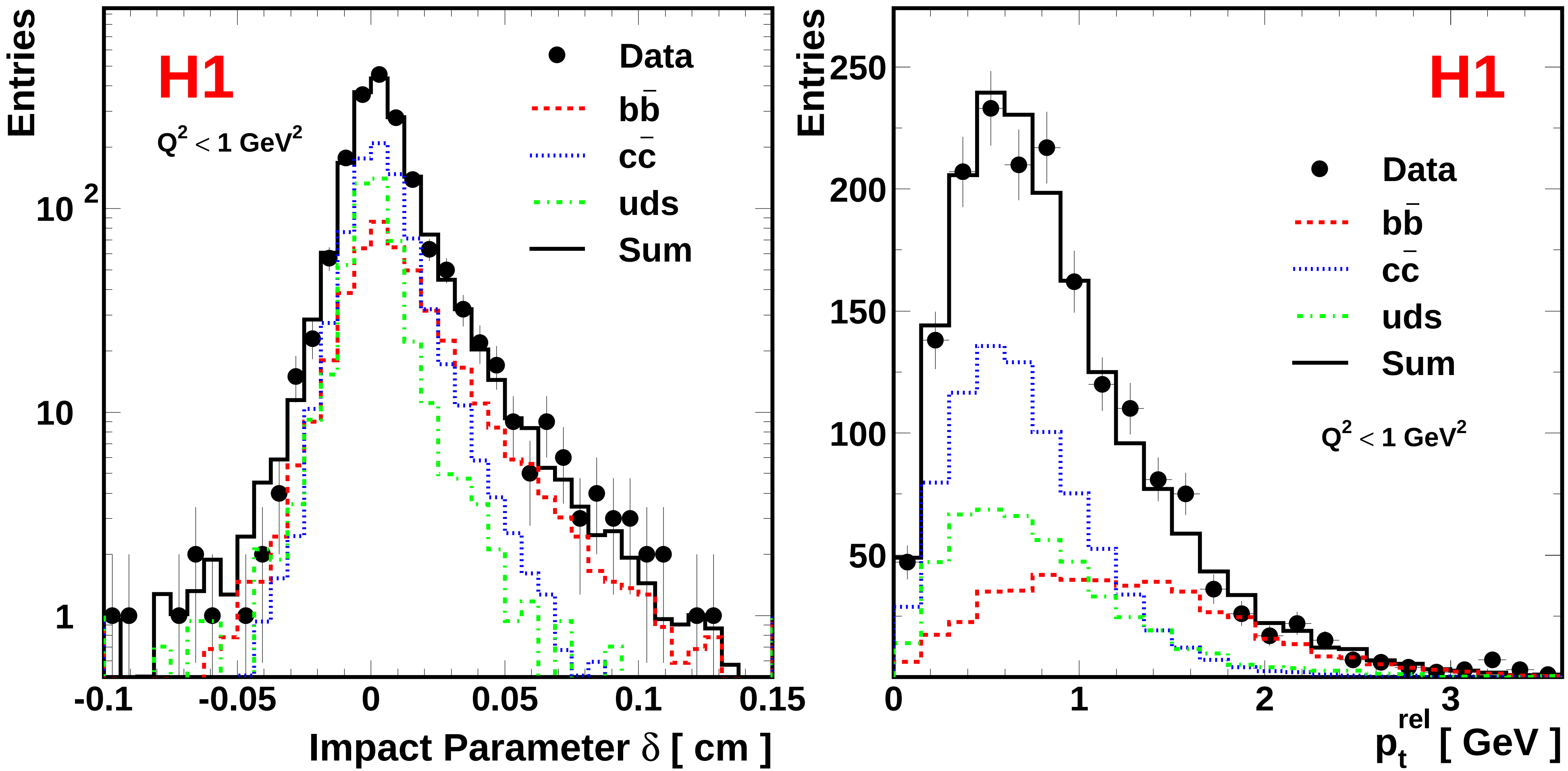
- Large b mass → Large Muon p_T^{rel}
- Long b lifetime → Large Muon Impactpar. δ

In the following focus on results

from the new H1 paper hep-ex/0502010

This measurement covers both γp and DIS

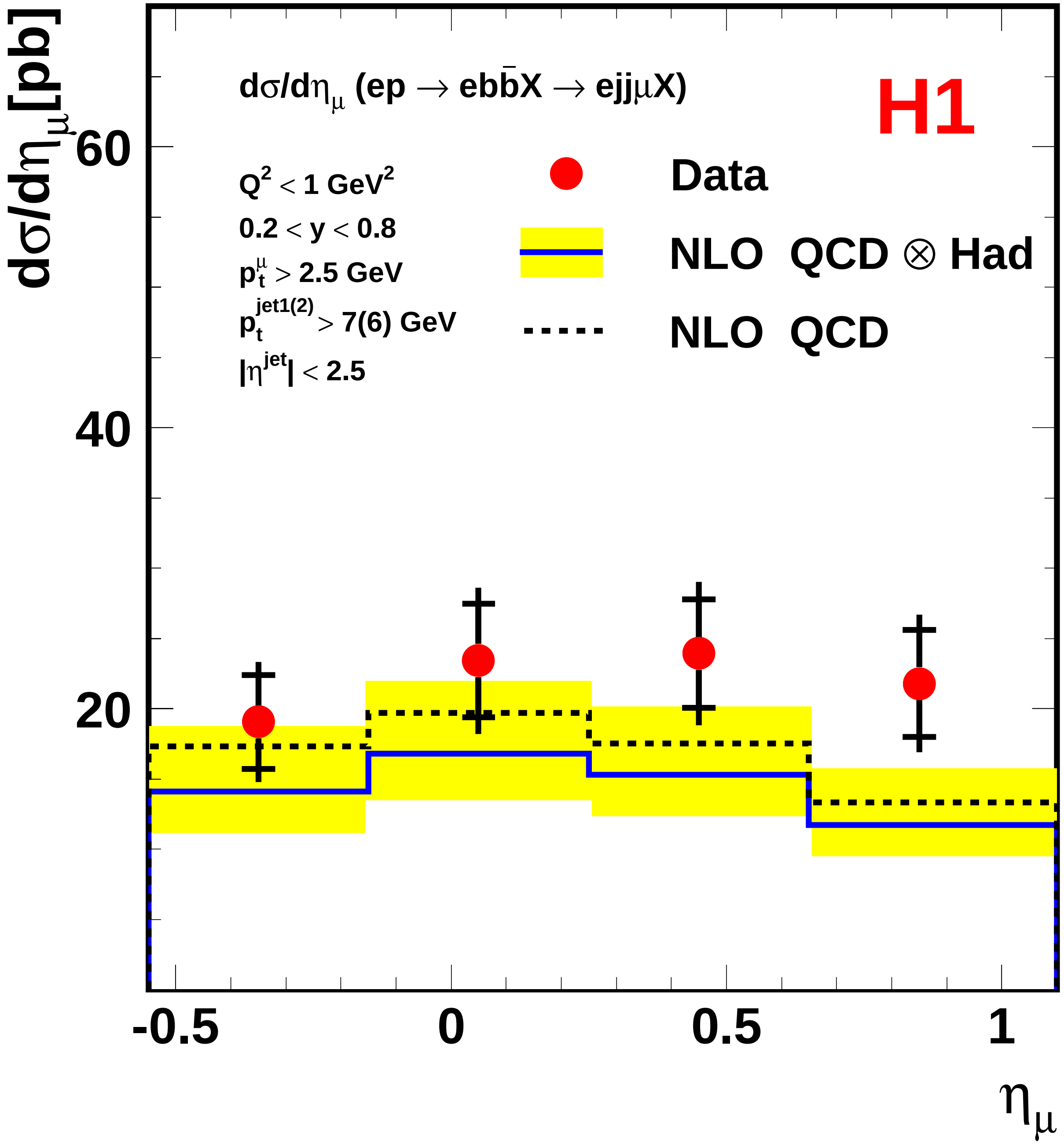
δ and p_t^{rel} in γp sample (≈ 1750 events)



Likelihood fit to 2-dimensional (δ, p_T^{rel}) distribution:

$\rightarrow f_b \sim 30\%$

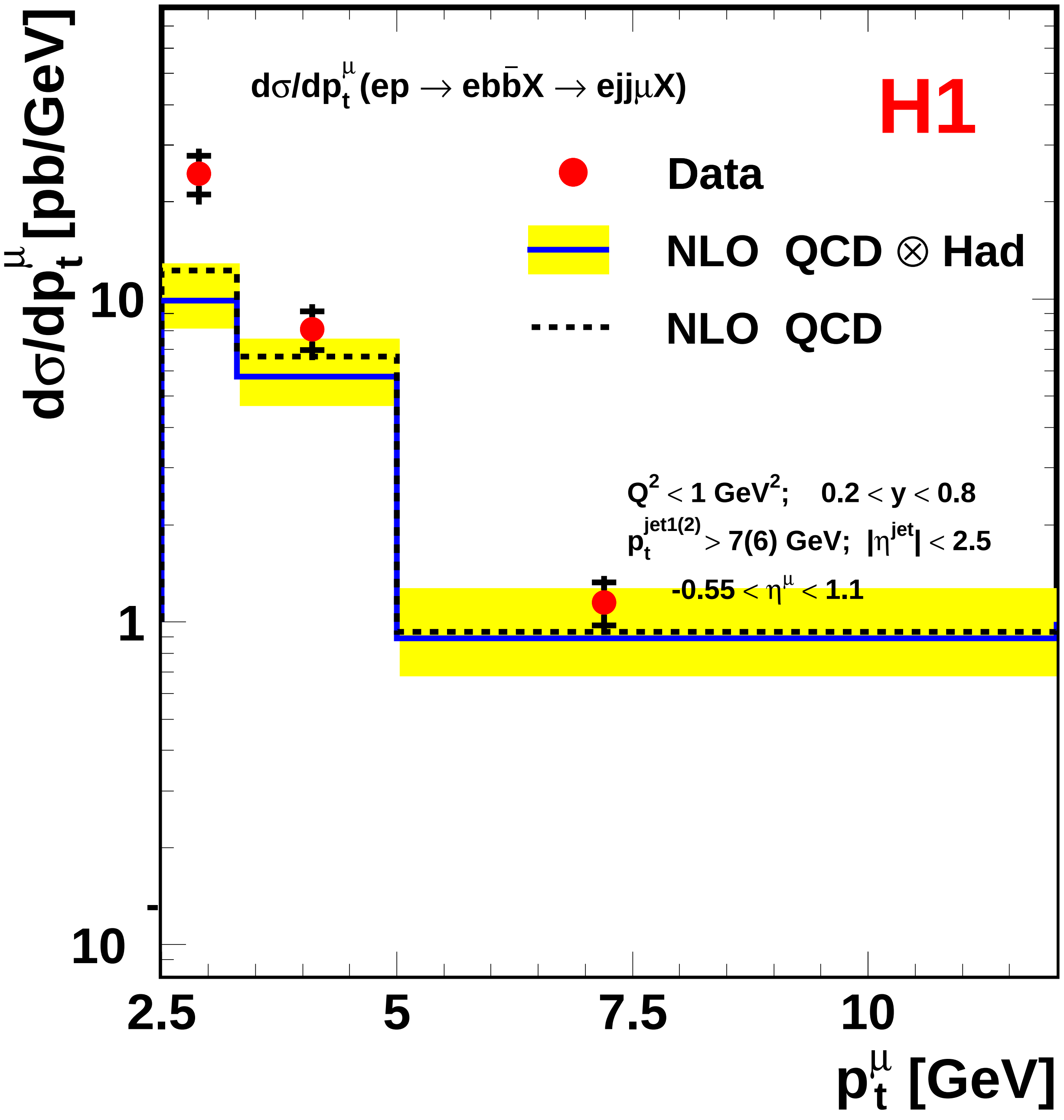
Beauty in γp: vs muon pseudorapidity



⇒ Flat distribution

⇒ Massive NLO (FMNR):
- somewhat too low
- describes shape

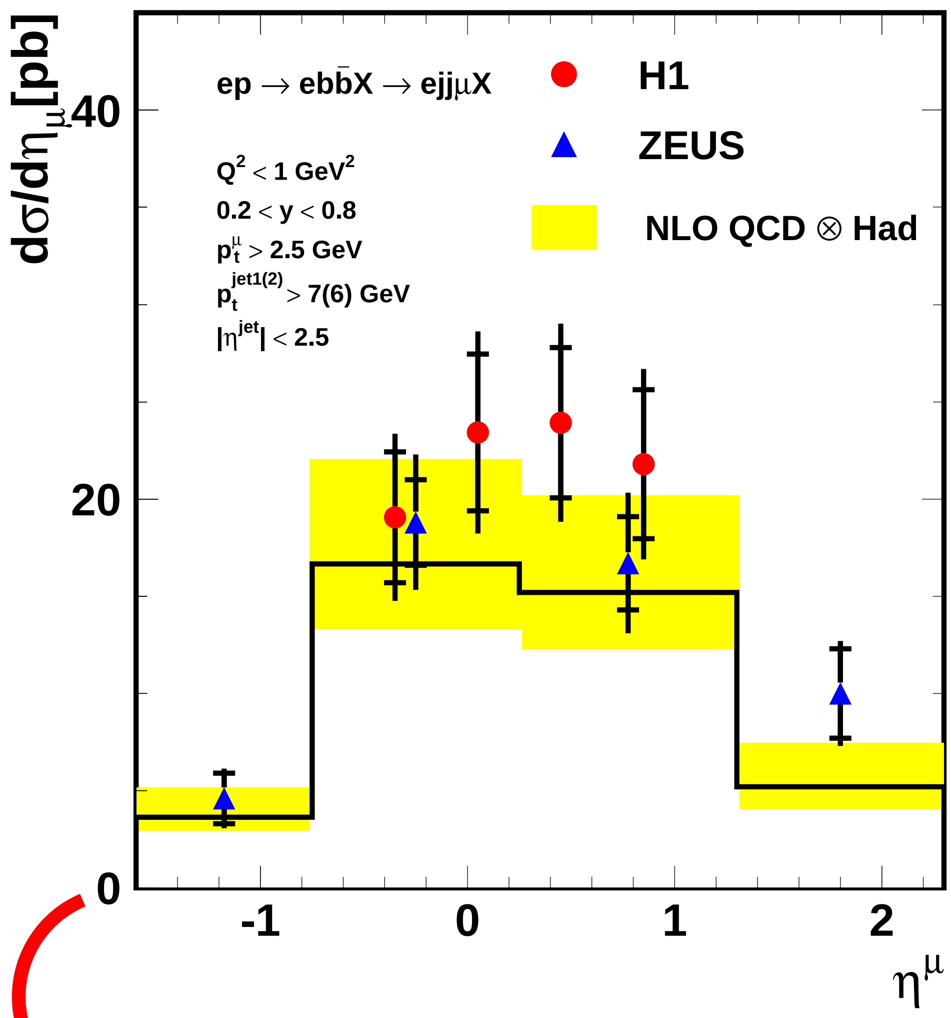
Beauty in γp: vs p_t^μ

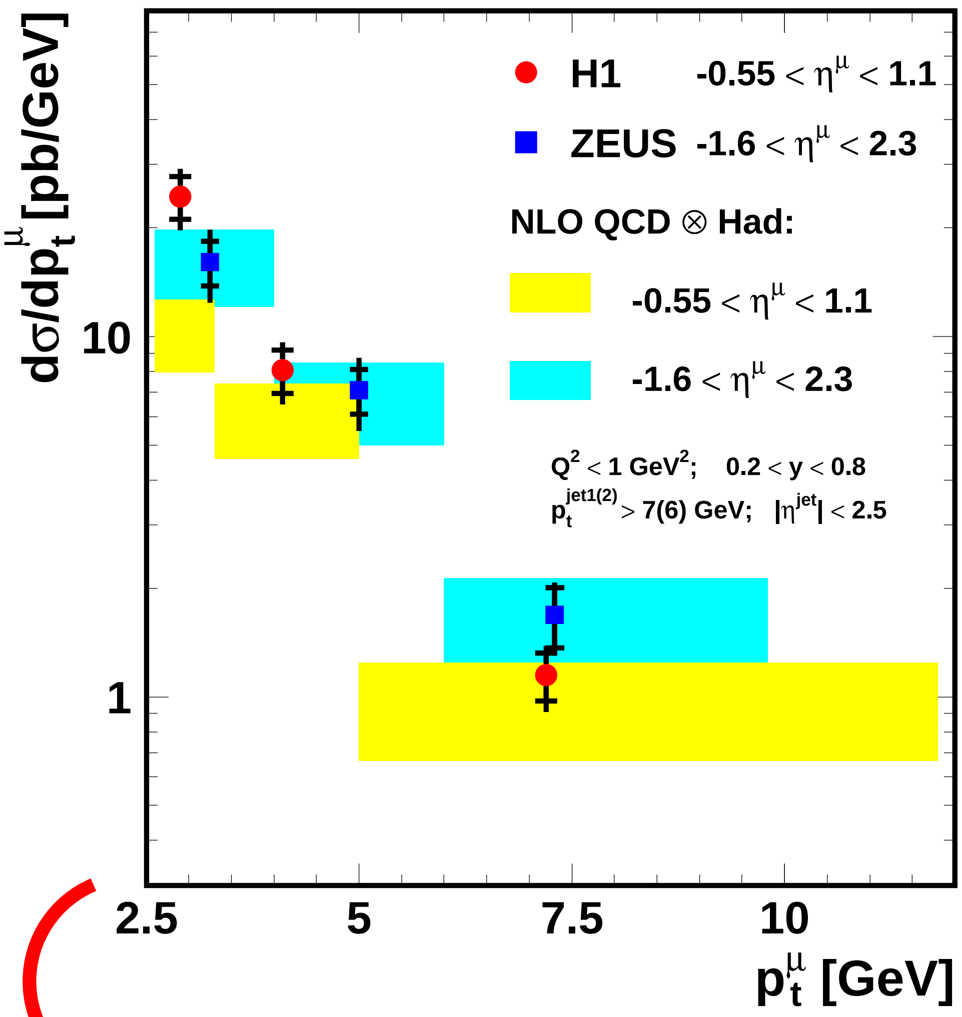


⇒ Steep drop-off

⇒ NLO too low at low p_t^μ

Comparison of H1 and ZEUS γp results

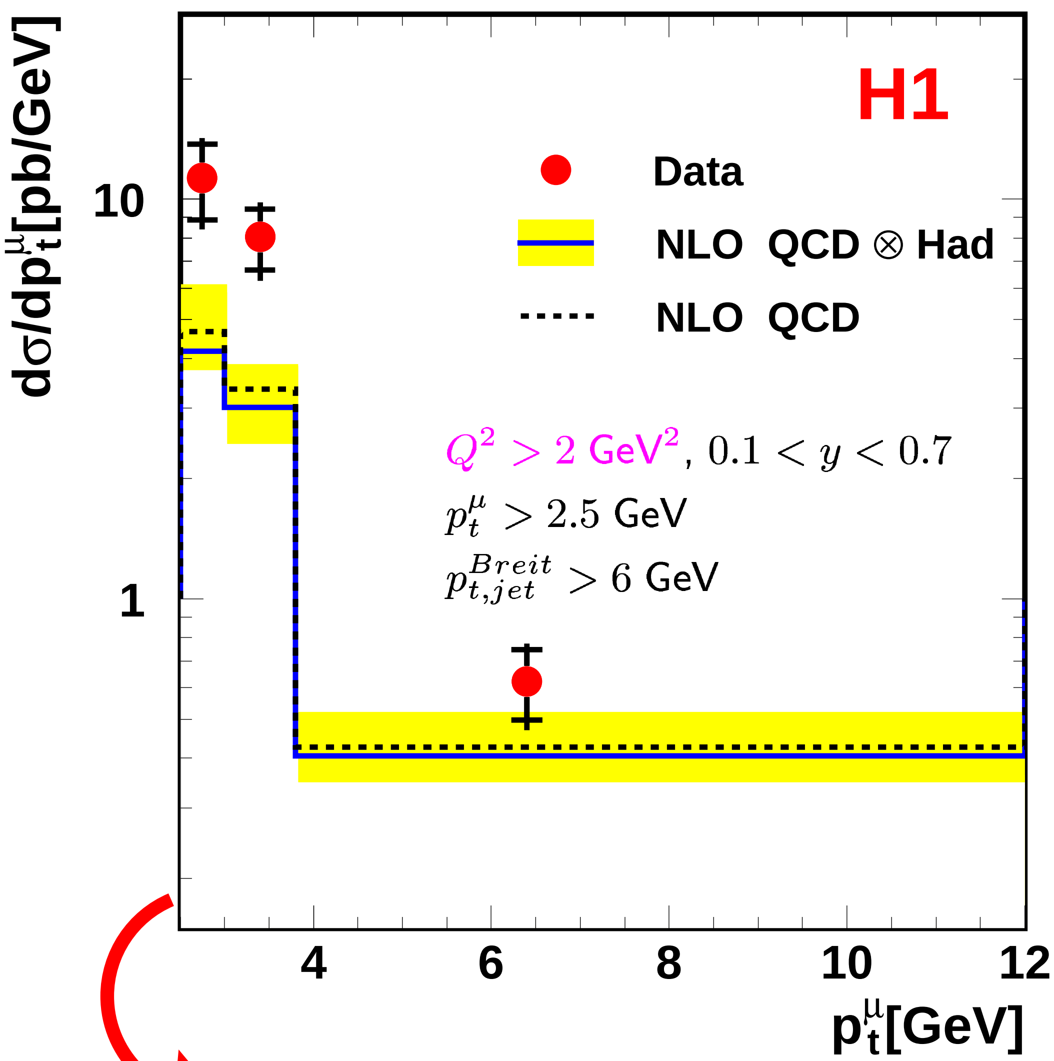


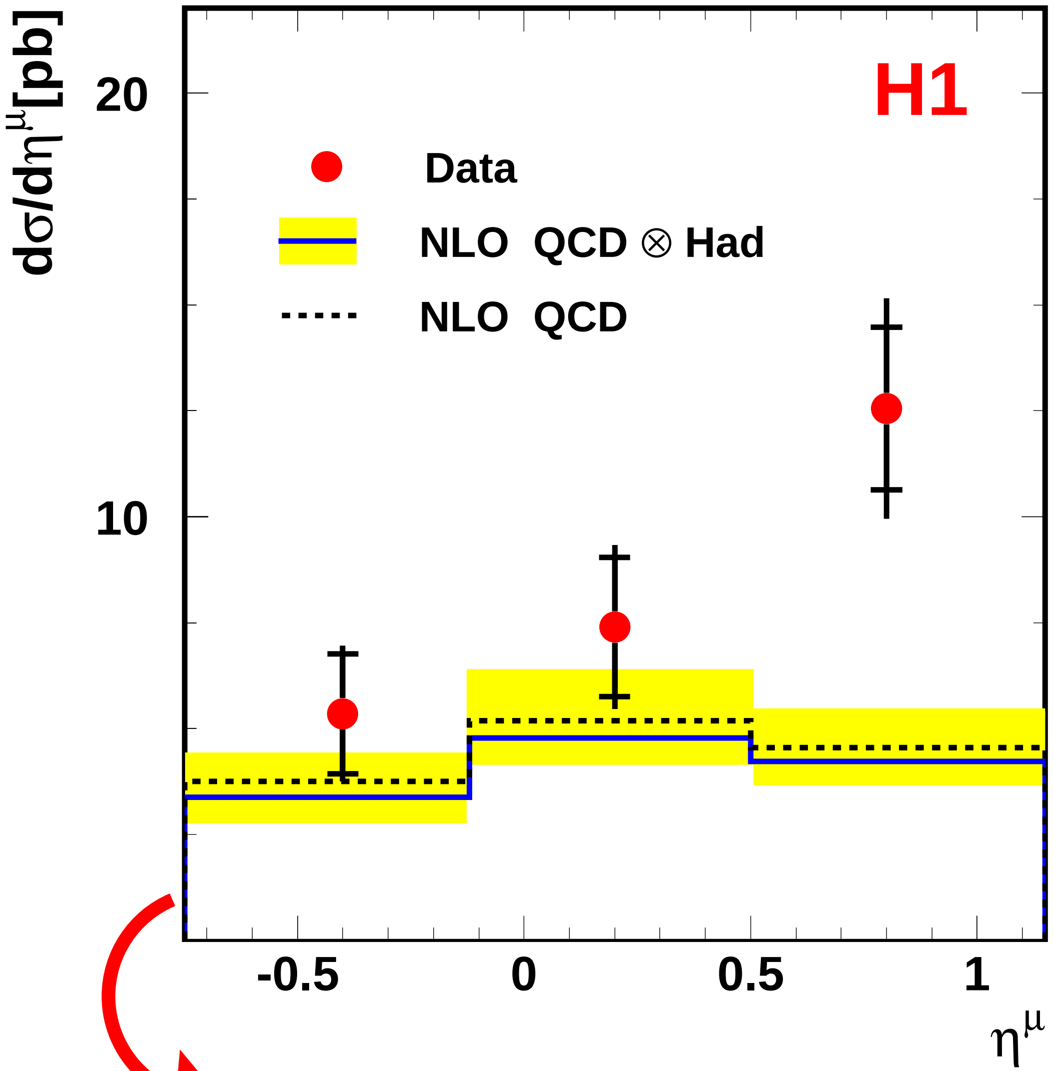


Good agreement H1 vs ZEUS

ZEUS: No excess at low p_t^μ

Beauty in DIS: vs. Muon p_T und η

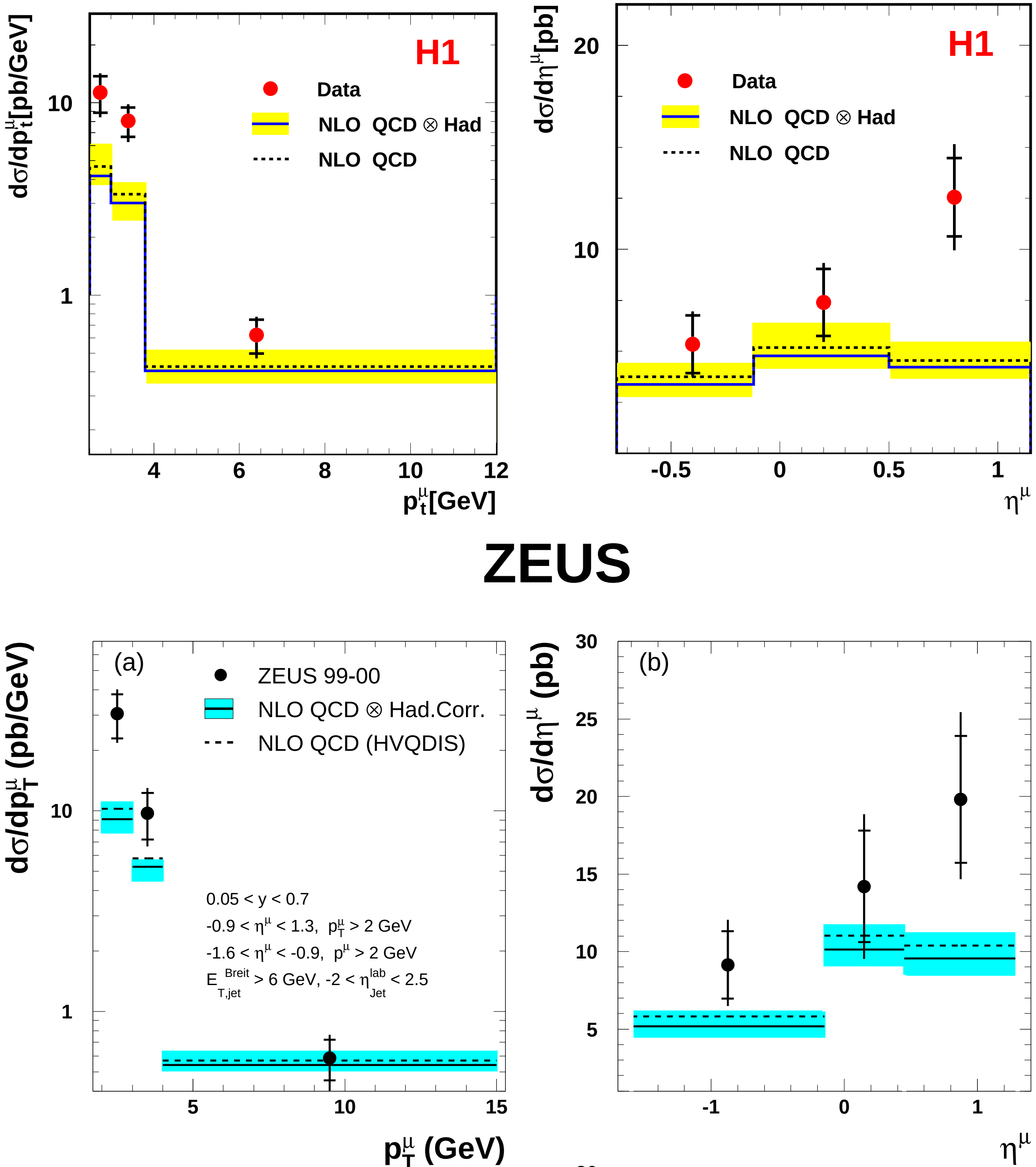




Massive NLO (HVQDIS): Too low at low p_T^μ

Massive NLO: Too low in forward direction

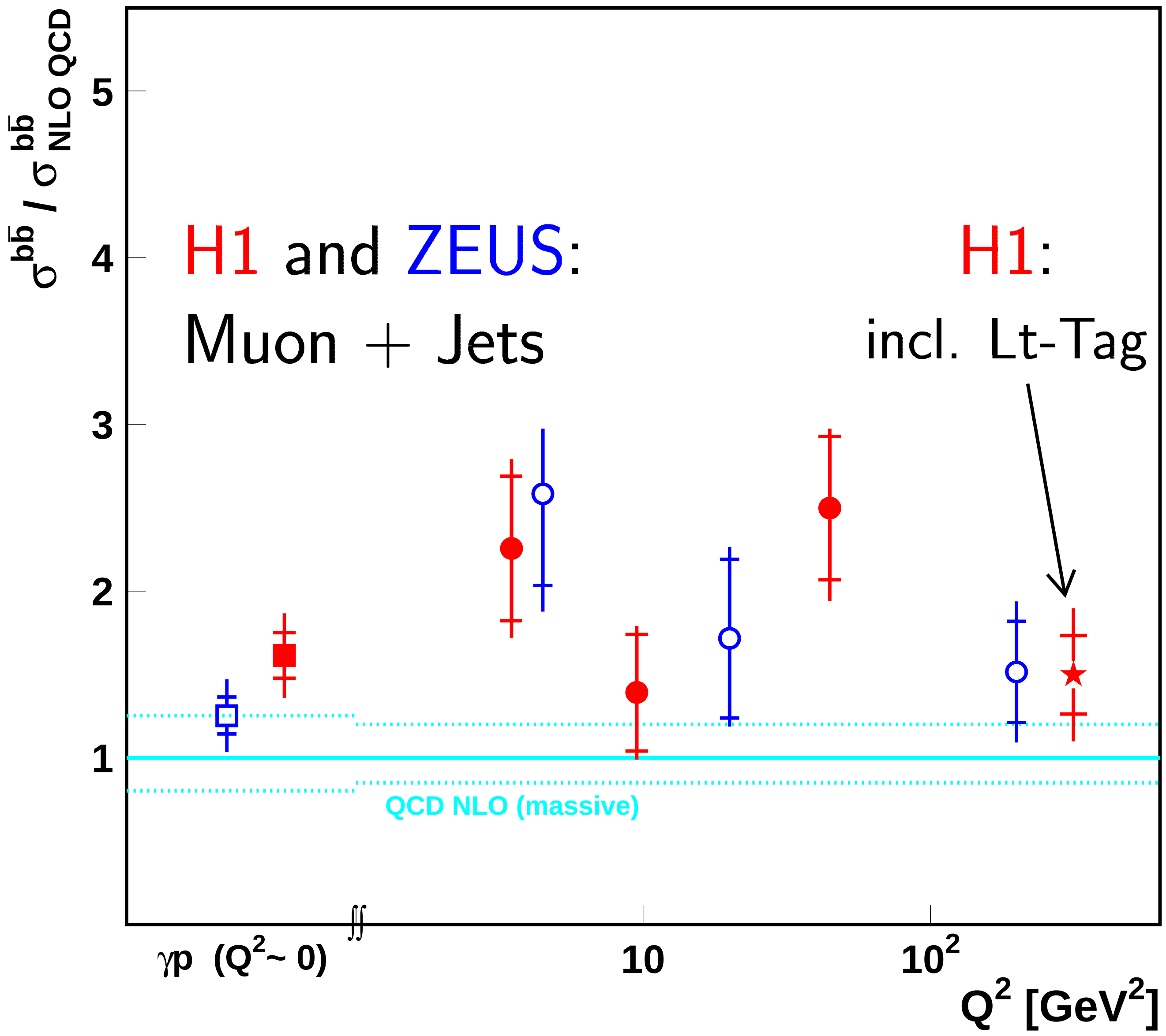
Beauty in DIS: Compare H1 and ZEUS results



⇒ Good agreement

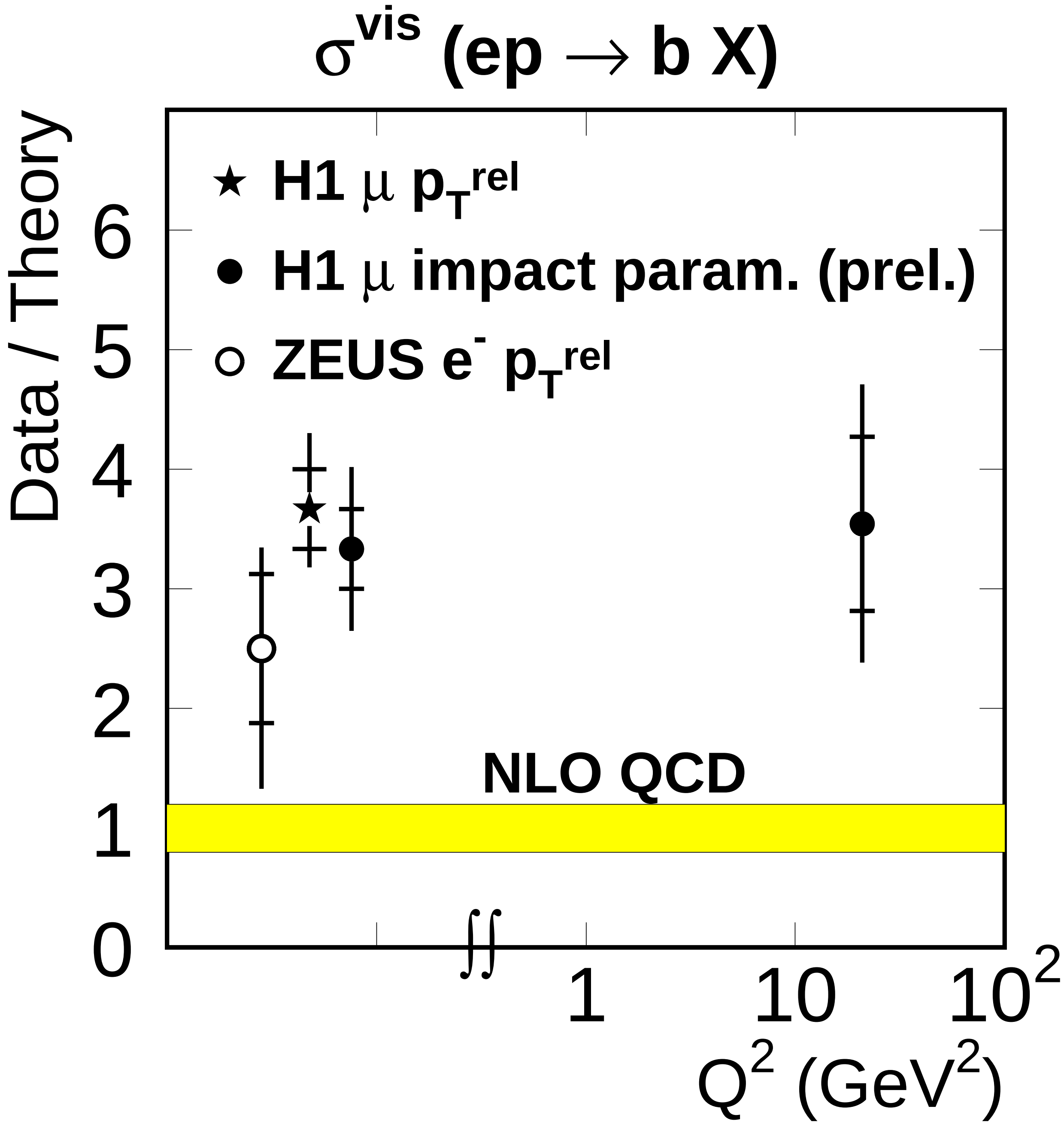
Recent HERA beauty results vs. Q^2

Ratio Data/Massive NLO



⇒ Data syst. above massive NLO

First HERA beauty results (Situation in 2001)

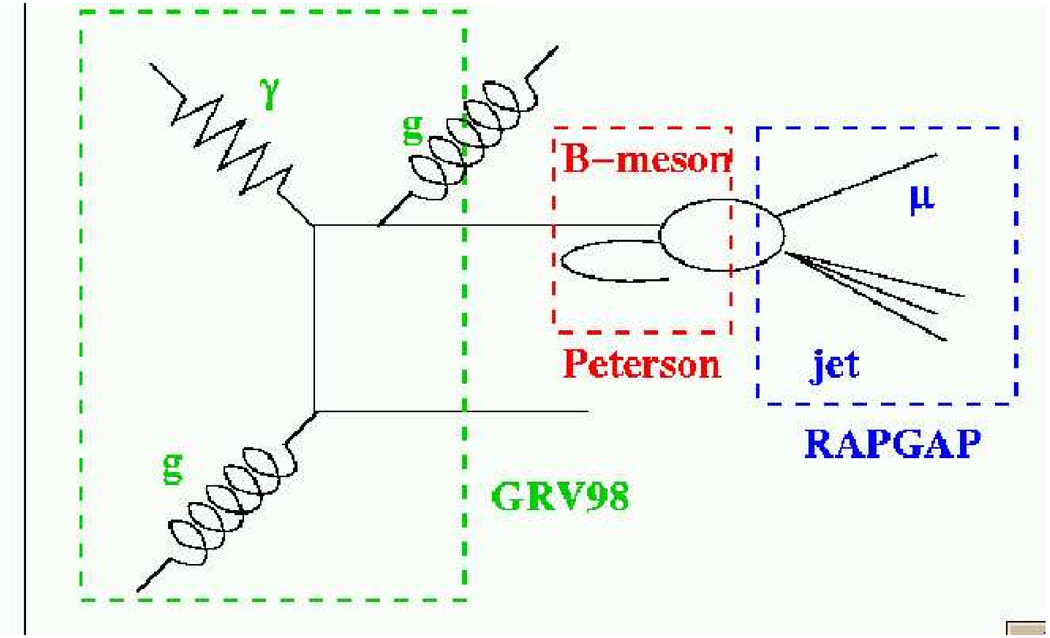


Why is the excess larger for the first H1 measurements???

For the first H1 measurements

- Data were extrapolated from the Muon+jets level to the Muon level using leading order AROMA MC and then compared to NLO. Reinvestigation → LO and NLO extrapolation consistent, no problem
- Softer p_T^{Jet} and p_T^{μ} cuts applied (e.g. $p_T^{\mu} > 2$ GeV instead of 2.5 GeV) → different kinematic phasespace!

NLO calculations: How it is done today to compare with HERA data: Example: HVQDIS



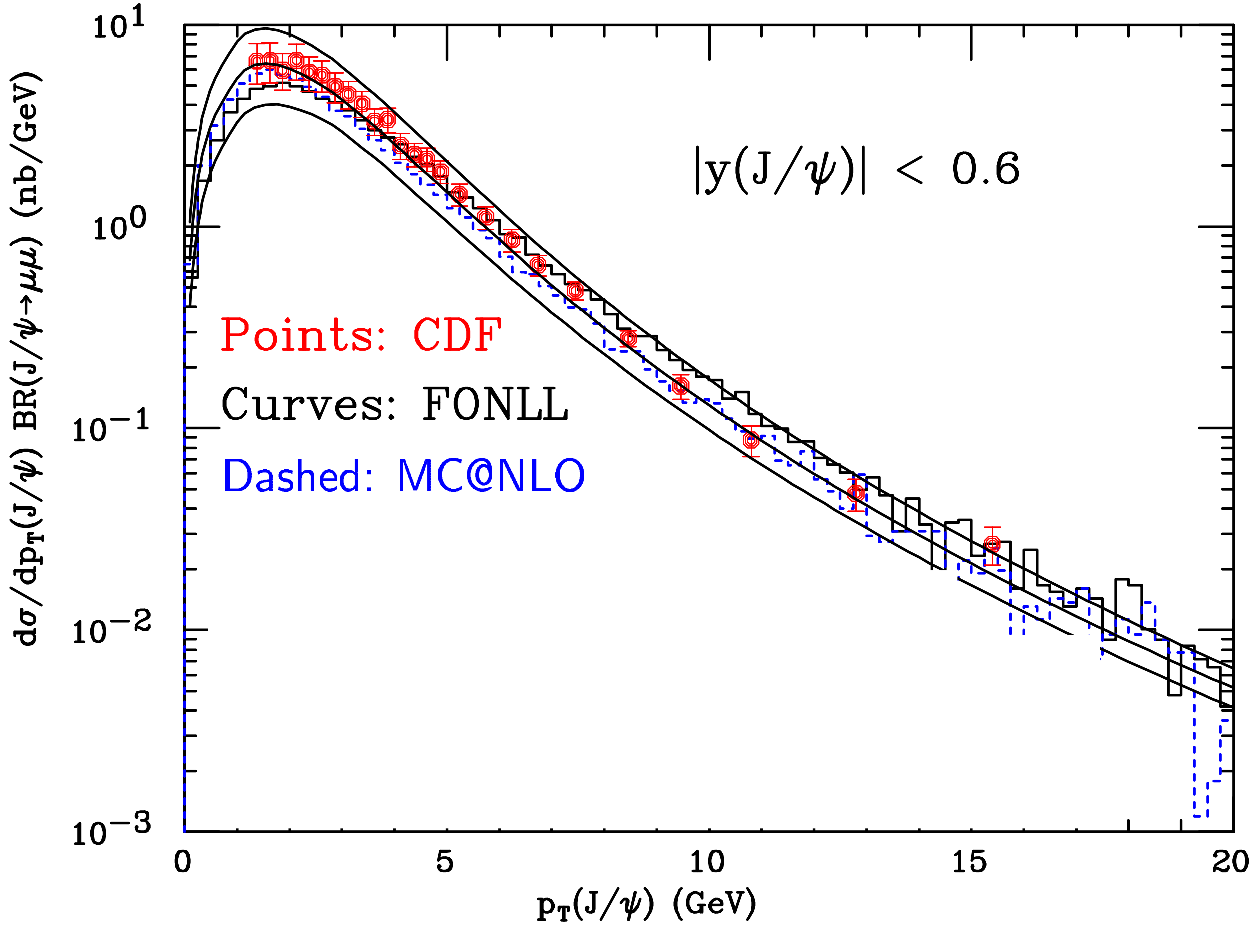
- Apply purely longitudinal Peterson fragmentation to b-quark
- Fragmented b-quark is 'decayed' using muon decay spectrum (e.g. from JETSET)
- Apply hadronisation corrections for parton jets using MC

$\Rightarrow$ Kniehl et al.: Fragmentation is arbitary $\rightarrow$ what is the uncertainty?

$\Rightarrow$ Fragm., Muon-decay and Hadronisation corr. for parton jets
$\rightarrow$ All sources for considerable syst. uncertainties of calculation!

Beauty at Tevatron Run-II

Improved NLO calculations available with e.g. more consistent treatment of fragmentation



$\Rightarrow$ Much improved description!

We want to have the improved models for HERA too!

Conclusions

- Recent results on B-production at HERA with Muons and Jets:
  - Generally good agreement between H1 and ZEUS data
  - Data are systematically above predictions from Massive NLO
  - Trend: Data above NLO at small hard scales p_t^b, Q^2 and in forward direction
  - Need for improved models: Theoreticians: Please provide them, e.g. MC@NLO!

Backup slides

Beauty with muon and jets: Theory models

	Leading order +P.S. MC's			*Massive NLO*	
	PYTHIA	**RAPGAP**	**CASCADE**	**FMNR**	**HVQDIS**
Version	6.1	2.8	1.00/09; 1.2		1.4
Proton PDF	CTEQ5L	CTEQ5L	JS2001	CTEQ5M	CTEQ5F4
			J2003		
Photon PDF	GRV-G LO			GRV-G HO	
$\Lambda_{QCD}^{(4)}$ [GeV]	0.192	0.192	0.2	0.326	0.309
Renorm. scale μ_r^2	$m_q^2 + p_{tq\bar{q}}^2$	$Q^2 + p_{tq\bar{q}}^2$	$\hat{s} + p_{tq\bar{q}}^2$	$m_b^2 + p_{tb\bar{b}}^2$	$m_b^2 + p_{tb\bar{b}}^2$
Factor. scale μ_f^2	$m_q^2 + p_{tq\bar{q}}^2$	$Q^2 + p_{tq\bar{q}}^2$	$\hat{s} + Q_t^2$	$m_b^2 + p_{tb\bar{b}}^2$	$m_b^2 + p_{tb\bar{b}}^2$
m_b [GeV]	4.75	4.75	4.75	4.75	4.75
m_c [GeV]	1.5	1.5	1.5		
Peterson ϵ_b	0.0069	0.0069	0.0069	0.0033	0.0033
Peterson ϵ_c	0.058	0.058	0.058		